BALTEX

Baltic Sea Experiment

World Climate Research Programme / Global Energy and Water Cycle Experiment
WCRP GEWEX

Minutes of

Fifth Meeting of the BALTEX Science Steering Group

at
Latvian Hydrometeorological Agency
in Riga, Latvia
April 14–16, 1997

edited by
Hans-Jörg Isemer

International BALTEX Secretariat
Publication No. 10
January 1998

International BALTEX Secretariat
GKSS Research Center
Max Planck Straße
D-21502 Geesthacht
Germany
Phone : + 49 4152 87 1536
Fax : + 49 4152 87 2020
e-mail : isemer@gkss.de

Printed on 50 % - recycled, chlorine-free bleached paper

Minutes of

Fifth Meeting
of the
BALTEX Science Steering Group

at
Latvian Hydrometeorological Agency
in Riga, Latvia
April 14-16, 1997

Contents

List of Appendices

Introduction

The fifth meeting of the BALTEX Science Steering Group (SSG) was hosted by the Latvian Hydrometeorological Agency (LHMA) in Riga, Latvia. The meeting opened on Monday, 14 April, at 3 p.m. and closed at 4 p.m. on Wednesday, 16 April 1997. The agenda of the meeting is given in Appendix 1 of these minutes. The participants of this meeting are listed in Appendix 2.

The Monday afternoon session of the meeting was held at the main building of LHMA, while on Tuesday and Wednesday the meeting was continued at Hotel *Riga* in the centre of Riga.

1 Opening

In his opening speech Mr. Andris Leitass, the director of the Latvian Hydrometeorological Agency, expressed his cordial welcome to the meeting participants. He pointed out the importance of scientific and organisational meetings such as the present SSG meeting for LHMA and Latvia and expressed his satisfaction that the SSG meets in Latvia for the first time. He pointed out that contributions to international scientific programs like BALTEX are a demanding effort for countries like Latvia which experiences strong economical constraints at the time being leading to quite limited resources for scientific research. He continued to note that on the other hand the participation in international experiments constitutes the necessary scientific stimulation for national developments in the research and development area. Contribution to BALTEX will continue to have high priority at LHMA, but continuous additional external funding will have to be assured to guarantee Latvia's future contributions to BALTEX.

In his response the Chairman of the BALTEX SSG, Professor Lennart Bengtsson, thanked Mr. Leitass and his team at LHMA for hosting the SSG meeting in Riga. He acknowledged LHMA's contribution to the BALTEX program and expressed his and SSG's hope for a mutually beneficial co-operation of LHMA and Latvian research institutions with other research groups in BALTEX.

2 Introduction to LHMA

The meeting started with an introduction and subsequent visit to several departments of LHMA. Mr. Leitass introduced the main tasks of LHMA in its capacity as the national Hydrometeorological Service of Latvia. LHMA is in charge of operational duties in both hydrometeorology and oceanography. The latter refers in particular to the Gulf of Riga and parts of the Baltic Proper. A joint visit of the meeting participants to three forecast departments of LHMA gave a lively and interesting overview on the daily work at LHMA.

3 BALTEX Hydrological Symposium

Following earlier practice the SSG meeting continued with a scientific symposium, which was dedicated to hydrological issues at this meeting. See Appendix 3 for the agenda of this symposium and Appendix 4 for abstracts of the talks given at the symposium.

The chairman of the symposium, Professor Zdzislaw Kaczmarek, closed the first part of the symposium at 6.30 p.m. Both meeting participants and speakers at the symposium were invited by LHMA to a relaxing and delicious evening dinner in a nearby restaurant.

The symposium continued on Tuesday morning at 8.30 a.m. in a conference room at hotel *Riga* and closed at 10.30 a.m. the same day.

4 Report of the BALTEX SSG Chairman

Professor Bengtsson briefly reviewed the general status of the BALTEX program. He expressed his satisfaction that BALTEX has developed to a functioning international research project. Important research tasks as detailed in the BALTEX Initial Implementation Plan are now being funded through both EU projects [e.g. NEWBALTIC (BALTEX research network A), Baltic Sea coupled modelling (network C), BASIS (network F), data preparation in Russia and Belarus)] and several national projects (e.g. in Germany and Sweden). Additional funding applications in several countries (e.g. for BALTEX research networks D, E and G) have recently been submitted and document the increasing interest of research institutions and groups to participate in the BALTEX program. Numerous research results from BALTEX are already being presented at several international conferences and meetings such as the 2nd International GEWEX Conference (in Washington D.C. June 1996) and at specific BALTEX sessions on EGS conferences in both 1996 (The Hague) and 1997 (Vienna).

The status of the BALTEX Data Centres have continuously been developed and rules for data delivery to BALTEX data users are now implemented. Further activities of those institutions operating the BALTEX Data Centres (DWD, SMHI, FIMR) together with the various national agencies which hold observational data important for BALTEX are necessary to extend the BALTEX data base and to streamline the data exchange with as little as necessary restrictions.

The Chairman mentioned various occasions at international conferences and meetings where his presentation of the BALTEX program was very well accepted and has caused new contacts for future contributions to BALTEX. He mentioned in particular his overview presentation at the recent GEWEX SSG meeting in Hamburg, Germany, January 1997.

The Chairman continued saying that the most urgent task now is to prepare details for the Main BALTEX Experiment (*BRIDGE*) which was suggested at the 4th SSG meeting in Sopot, Poland. A draft plan for *BRIDGE* has been prepared by a special working group (BALTEX Task Force) during recent months. This plan was sent out to SSG members before this meeting for further discussion at the present meeting (see items 11 and 12). The Chairman thanked the Task Force for the preparation of the draft plan in due time. He stressed that the important duty of the present meeting is an extended discussion of the draft plan for *BRIDGE* in order to finalise the plan as soon as possible, however, at latest during the autumn of 1997.

5 Report of the BALTEX Secretariat

Dr. Hans-Jörg Isemer, head of the BALTEX Secretariat at GKSS Research Centre at Geesthacht, Germany, gave the report of the Secretariat. Major issues are summarised in the following.

5.1 New Staff Member at the BALTEX Secretariat

The BALTEX Secretariat has a new staff member since October 1996. Dr. Cord Ruhe is a hydrologist, he received his PhD from Hanover University, Germany. His dissertation was on water and nutrients budgets in a medium-sized (800 km^2) river basin. He will support in particular those organisational and scientific duties of the Secretariat which are related to hydrological issues. He has also started to contribute to the regional-scale hydrological modelling presently performed at GKSS in the frame of BALTEX. His position is financed for 2 years by GKSS.

The present staff of the Secretariat now includes:
- Dr. Hans-Jörg Isemer (financed at present by the German Research Ministry, BMBF, until December 1997)
- Rüdiger Brandt (financed by BMBF until December 1997)
- Dr. Cord Ruhe (financed by GKSS until October 1998)
- Wiebke Jansen (financed by GKSS, permanent).

The SSG acknowledged the engagement of GKSS in its support of the Secretariat. SSG further took the opportunity to appreciate the German contributions by both BMBF and GKSS to maintain the Secretariat. SSG repeated earlier offers to scientists to take sabbaticals at the Secretariat and work on any BALTEX-related issues.

5.2 2nd Study Conference on BALTEX

Following the earlier decision of SSG made at its 4th meeting a Conference location and a date for conducting the Conference have been explored. The 2nd Study Conference on BALTEX will be held at Hotel Aquamaris in Juliusruh on the island Rügen, Germany, 25-29 May 1998. In spring 1997 when this date had been prepared no time conflict with any other major European conference was apparent. Aquamaris is a new hotel complex located at the northern coast of Rügen which offers all facilities to host a conference with up to 300 participants.

The future time table for the preparation of the Conference is as follows:

- May 1997: First announcement to be distributed.
- October 1997: Second announcement including the call for papers to be distributed.
- December 1997: Deadline for submitting papers.
- February 1998: Third announcement including the preliminary program to be distributed.

Invited and contributed papers will be presented in plenary along with a parallel poster session. The Conference language will be English. A pre-print volume containing submitted abstracts is planned as a special report of the BALTEX Secretariat to be distributed at the beginning of the Conference. It is planned to apply for financial support of the Conference at national and international research agencies and also at other sources in the commercial area.

The SSG agreed with these plans. SSG set up a scientific program committee for the Conference with the task to detail the Conference program and time table, and to invite key note and guest speakers. The members of the scientific program committee are

Jerzy Dera, Poland,
Carl Fortelius, Finland,
Zdzislaw Kaczmarek, Poland,
Sirje Keevallik, Estonia,
Wolfgang Matthäus, Germany,
Anders Omstedt, Sweden,
Ehrhard Raschke, Germany, (Chair)
Valery Vouglinsky, Russia.

Complete addresses of the group members are given in Appendix 5.

SSG thanked the Secretariat for the preparation activities. The Secretariat was charged to act further as the local and technical organiser of the Conference.

5.3 BALTEX Data Collection and Exchange Issues

BALTEX data collection and exchange issues have improved since the 4th BALTEX SSG meeting. Using the overview diagram given in Appendix 6 Dr. Isemer briefly reviewed the status of the three BALTEX Data Centres (see also items 8, 9 and 10 for details). Important facts are as follows.

The sampling strategy, the status paper, and data exchange agreements have been defined for the BALTEX Hydrological Data Centre (BHDC) at SMHI and are presented for approval at this SSG meeting (see item 8). The BALTEX Hydrology Workshop in Warsaw was an important event in this context (see item 6.2). The data collection of both real and meta data (in addition to the monthly runoff data, which were available at SMHI and BHDC) has been started at BHDC. SMHI additionally supports the BHDC now with a full-time position for Mr. Ola Pettersson. He is a hydrologist and is in charge of BHDC since October 1996.

The data base at the BALTEX Meteorological Data Centre (BMDC) at DWD is continuously increasing along the lines of the BMDC status paper approved by SSG at earlier meetings.

Some data exchange agreements between BMDC and some of the data suppliers are however still not signed due to different reasons. However, almost all of the required data are nevertheless being submitted to BMDC.

Little progress has been achieved at the BALTEX Oceanographic Data Centre (BODC) at FIMR. One reason is that almost no requests has so far been submitted to BODC. Anyway FIMR is establishing the meta data base as stated in the BODC status paper which was approved at the 4th SSG meeting.

The identification of registered BALTEX data users, as defined at the 4th SSG meeting (see Appendix 13 to the respective minutes), has successfully been implemented. Dr. Isemer stressed again that only registered data users are authorised to obtain data from the BALTEX Data Centres. 18 different research groups in 8 countries (see Appendix 7) have registered so far at the BALTEX Secretariat. Copies of the registration forms have been forwarded to the Data Centres after signature of a BALTEX SSG member.

SSG asked the Secretariat to forward the complete set of registration forms including the project descriptions to all members of the SSG.

Dr. Isemer noted that, at present, delivery of meteorological and hydrological data from East-European countries to both BMDC and BHDC is unfortunately almost entirely dependent on continuous financial support. The present funding sources for these activities were summarised by Dr. Isemer and are given in Appendix 8. Dr. Isemer also stressed that financial support for data collection and preparation activities is increasingly difficult to obtain from funding agencies. National hydro-meteorological Services as the primary data holders are requested to show their own interest in participation and support of BALTEX by delivering necessary data for BALTEX free of charge to the BALTEX Data Centres.

Dr. Isemer noted a particular problem which still exists with respect to data from Denmark. The Danish Meteorological Institute (DMI) has not so far agreed to provide observational meteorological data free of charge, except for the PIDCAP period August to November 1995. DMI has not changed its earlier attitude and continues to request additional funding for data preparation activities for BALTEX. SSG expressed concern on this matter and again requested the SSG Chairman and in particular the Danish SSG member to undertake any possible action to change the restrictive attitude of DMI.

5.4 BALTEX Reports and Newsletters

Dr. Isemer reviewed the presently available BALTEX reports. The BALTEX Newsletter have started to be published and two issues were delivered since the 4th BALTEX SSG meeting (see Appendix 9).

5.5 2nd PIDCAP Progress Report

The 2nd PIDCAP progress report has been compiled to be presented to the BALTEX SSG at this meeting. It is given in Appendix 10. Dr. Isemer pointed out that this report does not cover all activities which are related to PIDCAP because the possibility of having individual contributions included in the report was *offered* to research groups. A comprehensive overview on PIDCAP-related results is planned for the 2nd Study Conference on BALTEX. The report was not discussed in detail because of the shortness of time.

5.6 Inventory of BALTEX Publications

SSG recommended to establish an electronically available library containing all BALTEX publications which have been prepared in the frame of BALTEX or are triggered by the BALTEX program. It should include both reviewed journal articles as well as 'grey literature' (e.g. institute reports). SSG asked Dr. Isemer to build up and update such a library at the Secretariat. As a first step all SSG members were asked to submit respective pre-prints or citations to the BALTEX Secretariat.

5.7 BALTEX-related Funding Proposals to EU

An overview on recently submitted BALTEX-related funding proposals to EU has been compiled at the Secretariat for input to the SSG meeting, see Appendix 11.

SSG thanked Dr. Isemer and the staff at the BALTEX Secretariat for their continuous and effective support of the BALTEX program.

6 Report on the BALTEX Hydrology Workshop

The SSG, at its 4th meeting in Sopot, Poland in June 1996, noted the need for a specification of the BALTEX hydrology data sampling strategy and a more detailed overview on existing hydrological models to be applied in the frame of BALTEX. The SSG further suggested to clarify related issues on a specific BALTEX hydrology workshop. As a response to these suggestions Professor Zdzislaw Kaczmarek, vice-chairman of the BALTEX SSG, organised the First BALTEX Hydrology Workshop. This workshop took place 9 to 11 September, 1996, at the Polish Academy of Sciences in Warsaw, Poland. Minutes of this workshop have been separately published, a shortened version is given in Appendix 12.

Professor Kaczmarek summarised the results of this workshop, see Appendix 12.

6.1 Model Intercomparison Project

SSG supported strongly the plan of conducting a hydrological model intercomparison project within the frame of BALTEX. Guidance for this project should be taken from the recent PILPS project and earlier hydrological model intercomparison projects of WMO. The intercomparison project shall be performed with data from the Wartha River basin, a sub-basin of the Odra River (see item 3 in Appendix 12). Professor Kaczmarek and Dr. Pruchnicki suggested Professor Kundzewicz at the Polish Academy of Sciences in Poznan, Poland, to organize the project and to lead its conduction. A particular task of Professor Kundzewicz and his group will be to prepare and distribute all necessary input data (meteorological, runoff, land surface characteristics) from the Wartha catchment. This may require a close cooperation with the regional centres of the Polish Institute for Meteorology and Water Management (IMGW, the Polish Hydromet Service) in Poznan and Wroclaw, in co-operation with the relevant centres of the Polish Hydromet Service.

It was stressed that the model intercomparison should include both the land surface model components and the river routing models, thus extending the recent PILPS-2c initiative.

The BALTEX Secretariat was suggested to provide a list of potential project participants, i.e. groups or researchers who are maintaining and developing hydrological models.

6.2 Hydrological Data Sampling Strategy for BALTEX

SSG discussed the proposed hydrological data sampling strategy for BALTEX (see item 8 in Appendix 12). In general, the strategy, as outlined in item 8, was approved by SSG. However, the following changes were introduced:

- Item 8.2: The Vistula River basin will not be included as a special BALTEX test catchment for higher data sampling densities and specific modelling activities. The special test catchments in BALTEX are defined to be Torneälv (including Kalix), Neva, Daugava, and Odra.
- Item 8.7: BMDC will initiate no extra efforts in order to collect data which are necessary for hydrological modelling. Data mentioned under item 8.7 (snow depth and soil temperature) will be collected by BMDC only in the frame of the anyway-performed data collection based on GTS telegrams, in accordance with the tasks noted in the BMDC status paper. Data exchange between BMDC and BHDC in this respect will have to be discussed directly between SMHI and DWD.
- Item 8.8: After discussion SSG suggested that data needed for hydrological modelling should be concentrated in one data centre for an easy access for data users. Hence, SSG concluded that meteorological observations required as input for hydrological modelling shall be collected by BHDC (not by BMDC).
- Item 8.13: The suggested data sampling strategy has no considerable implications for the BALTEX Meteorological Data Centre (BMDC).

Confirming the results of the Warsaw meeting (item 8 and Appendix 9 in the minutes of the Warsaw meeting) and considering additionally the above-mentioned changes SSG approved the BALTEX hydrological data sampling strategy as is given in Appendix 13. This revised strategy has implications for both the data sampling strategy and status paper of the BHDC as well as Appendix A of the data exchange agreement draft of BHDC (see item 8 below).

7 Report on the BALTEX Neva Workshop

Professor Valery Vouglinsky of the Russian State Hydrological Institute (RSHI) at St.Petersburg, Russia, reported on a 2-days BALTEX Neva workshop conducted at RSHI during February 25 and 26, 1997. This workshop was prepared and organised by RSHI and the BALTEX Secretariat as a response to the recommendation of the BALTEX Hydrology Workshop in Warsaw (see item 6 above) where the catchment basin of the Neva had been suggested as one special BALTEX test basin for intensive data collection and modelling activities. Participants at the Neva workshop included scientists from RSHI, the North-West Administration of the Hydrometeorological Service in Russia (NWAHMS), SMHI, GKSS and the BALTEX Secretariat.

The objectives of the workshop included

- to review existing hydrological models and modelling experience in particular for the river Neva catchment and its subcatchments,
- to summarise future BALTEX hydrological modelling plans for the Neva catchments and to recommend future time plans and co-operation in the frame of BALTEX,
- to focus in particular on how lakes are presently represented in hydrological models and discuss future modelling strategies,
- to detail the presently available hydrological data base for the Neva catchment and asses its availability and accessibility for research purposes in BALTEX,
- to precisely define the data requirements in order to meet future hydrological modelling plans in BALTEX for the Neva catchment,
- to plan for future data collection activities at the national data holding agencies in Russia and Finland, and at the BALTEX Hydrological Data Centre.

Professor Vouglinsky reported that a brief analysis of the following hydrological models was conducted which could be applied for runoff modelling in the Neva River basin:

- Model SEWAB-HTM (developed at GKSS, Germany)
- Model HBV (developed at SMHI, Sweden)
- Model HYDROGRAPH (developed at RSHI, Russia).

Characteristics of these models are described in the annex of the minutes of the Hydrology Workshop in Warsaw, which is given in Appendix 12.

It was decided to use the above models for hydrological modelling in the Neva River basin. The models will be first applied to small watersheds (the Msta river basin was selected to be the first where these models will be applied); then the area to be modelled will be increased until it covers the whole drainage area of the Neva River. Thirty control gauge-lines will be selected where the results of modelling will be checked. The list of these gauge-lines was prepared after detailed discussion at the workshop and is prepared now for co-ordination.

Furtheron, the available information and data resources for the Neva River basin have been discussed. It was noted that there were about 60 synoptic stations, 5 observation sites for radiation balance measurements and 25 observation sites for soil moisture content measurements in the Neva River basin. Data of ice break-up in rivers are also required for modelling. A list of six meteorological parameters was defined, which are the minimum requirements for meteorological input data in order to model the local water balance at the land surface (SVAT model). These parameters include

- precipitation
- 2 m air-temperature
- 2 m humidity
- air-pressure
- 10 m windspeed
- radiation // cloud cover // sunshine duration.

These data should be prepared in a computer format for the period of 1980 - 1997. Professor Vouglinsky pointed out that almost none of these data are at present available in electronic form but have to be digitised from yearbooks. This will be a major undertaking which requires additional financial support. This task cannot be performed by the Russian institutions by means of their own budgets.

A recommendation has been made during the workshop that, as a first step, discharge rating curves at the head of the Neva River and of the Svir River, related to mean water levels in Lake Ladoga and Lake Onega, shall be prepared by RSHI.

It was further noted that more accurate boundaries of the Baltic Sea catchment region, in particular in the part of the Neva River basin, are required. The presently available variant does erroneously not include the Msta River basin, and has other deficiencies. The appropriate material on the more accurate boundaries of the Neva River region has meanwhile been prepared at RSHI.

To support the work on the hydrological modelling of the Neva River basin and the preparation of the necessary data (which will have to be conducted at RSHI and NWAHMS) it was decided at the workshop to submit a funding proposal to the EU-INTAS program. The proposal was co-ordinated by Dr. Hans-Jörg Isemer at the BALTEX Secretariat with contributions by RSHI, NWAHMS, SMHI and GKSS. The proposal was submitted to INTAS at the end of March 1997. See also the report of the BALTEX Secretariat, item 5.

The SSG thanked Professor Vouglinsky and the BALTEX Secretariat for this initiative, and expressed the hope for a successful outcome of the funding application.

8 Report of the BALTEX Hydrological Data Centre (BHDC)

Professor Sten Bergström introduced Mr. Ola Pettersson who is in charge of the BHDC at SMHI since October 1996. Mr. Pettersson is a hydrologist; he has a full-time position at SMHI and is financed entirely from SMHI budgets.

Mr. Pettersson gave the report for BHDC (see Appendix 14). Major progress has been achieved in the development of BHDC during recent months. The key point is that BHDC has started to build up a runoff data base, which consists of *daily* data. BHDC has prepared its infrastructure to create the BALTEX data base and has also drafted the exchange agreement to be signed by data suppliers and BHDC (see Appendix 15).

The BALTEX Hydrology Workshop in Warsaw (item 6), a BALTEX workshop in Tallinn, Estonia in October 1996 with representatives of East-European Hydrometeorological Services, and the Neva workshop (see item 7) were milestones in creating the data sampling strategy for BALTEX, and, hence, for BHDC.

Both Mr. Pettersson and Professor Bergström stressed that SMHI's policy does not foresee to allocate SMHI financial support in order to buy data from other countries and Services in these countries for building-up the BALTEX hydrological data base. It is not obvious to SMHI that the delivery of data for the BALTEX Data Centres is depending entirely on additional financial support. SMHI takes the view that the national Services have to show some interest themselves in participation in BALTEX and thus should provide data for the BALTEX data base without external funding.

The SSG acknowledged with satisfaction the development of BHDC. The discussion on the data sampling strategy is summarized under item 6.2 of these minutes. The following changes shall be introduced in the status paper of BHDC (Object and Division of Task, see Appendix 14) and also in Appendix A of the draft agreement (Appendix 15):

- The BALTEX special study basins include Torneälv, Neva, Daugava and Odra. Vistula is not a BALTEX special study basin.

- The collection of meteorological data required for hydrological modelling shall be the task of BHDC.

- SSG further noted that BALTEX does not intend to create climatological data bases. The length of the required data sets should be restricted to really needed data. Hence, extension to periods before 1980 shall only be done after thorough discussion with data users.

SSG asked BHDC to adjust the status paper and the agreement accordingly along the lines given in Appendix 13.

SSG thanked in particular Mr. Pettersson and Professor Bergström for their engagement in building up the BHDC, and all other individuals who have contributed to this development.

9 Report of the BALTEX Oceanographic Data Centre (BODC)

Dr. Pekka Alenius, head of BODC at FIMR, could not attend the meeting but his report on the status of BODC was available as a written document and is given in Appendix 16.

SSG confirmed BODC to act mainly as a meta-data centre but stressed the importance of a physical storage of in particular water level data from as many stations as are available at the coast of the Baltic Sea.

10 Report of the BALTEX Meteorological Data Centre (BMDC)

The report was given by Professor Eberhard Müller of DWD, Offenbach. The data base at the BMDC is continuously increasing along the lines of the status paper approved by SSG at earlier meetings. Professor Müller introduced the first comprehensive annual report of BMDC which describes the status of the data base at BMDC as of January 31, 1997, in quite a detail. This report has been sent to all data suppliers as agreed upon in the data exchange agreements signed by BMDC and the data suppliers. The report will also be sent to SSG members. Copies may be requested at BMDC or at the BALTEX Secretariat.

Professor Müller mentioned 11 registered data users who requested and received data from the archives of BMDC. He further pointed out that data in particular from the earlier BALTEX periods (1986/87 and 1992/93) arrived in various formats which required (and still requires) considerable time to homogenize the data. An additional quality check of the data at BMDC is not possible at the moment; this would require additional staff.

Professor Müller stressed his view that those meteorological data which are necessary for hydrological modelling purposes should be collected in the archives of the BHDC at SMHI (see also items 6.2 and 8).

11 Report of the BALTEX Task Force

Dr. Mikko Alestalo of FMI, the chairman of the BALTEX Task Force, shortly summarised the activities of the Task Force. Two meetings of the Task Force were conducted, one at FMI, Helsinki, in October 1996, and the other at DWD, Offenbach, in February 1997. The Task Force membership has changed during this time, see item 15.4. The draft plan for the Main BALTEX Experiment (for which the acronym *BRIDGE* has been chosen) has been finalised in due time before this SSG meeting, as has been requested at the 4th SSG meeting. In order to prepare for this meeting the draft plan was mailed to SSG members in early April 1997.

Dr. Alestalo pointed out that the Main Baltic Sea Experiment (*BRIDGE*) is planned as the central observational and modelling phase of the BALTEX program to be carried out in the years 1999 to 2001. The draft plan discusses the present deficiencies in the observational systems as well as in the data assimilation and modelling systems. Numerous specific recommendations are made for a beneficial realisation of the experiment. These include administrative and financial implications. The remaining two year period before the initiation of the *BRIDGE* will have to be used for building up of the necessary new resources and methods.

Dr. Alestalo listed the central recommendations that require special attention to be realised for a succesful conduction of *BRIDGE*:

- Six-hourly radio soundings from all stations in the study area.
- Additional radiosonde (RS) stations in Bornholm, Gotland and Åland during *BRIDGE*.
- Collection of hydrological information from the whole study area in a timely way.
- The continuos measurement of temperature, salinity and ocean currents at the Darss and Drodgen Sills, and in the straits connecting the deep basins.
- Two new weather radar installations at the eastern/south-eastern coast of the Baltic Sea.
- A radar data centre for managing of the radar-based precipitation and wind data.
- A satellite data centre for managing non-GTS satellite data.
- Two data assimilation centres with the task to run independent delayed-mode data assimilation systems.
- An intercomparison and validation of hydrological models.
- To develop coupled atmosphere-ice-ocean-hydrology models.

Dr. Alestalo finished pointing out that a very important task after the approval of this draft plan will be to draw up an agreement with all participating institutions on their commitments to carry out all the desired components of the plan.

12 Discussion on the *BRIDGE* Draft Plan

The Chairman opened the discussion on the *BRIDGE* draft plan. He stressed that the draft plan is an excellent first start for further discussions on the plan. He congratulated the Task Force for its work. As immediate reaction he pointed out that the draft plan is thought to be primarily addressed to funding agencies. This will require some adjustment in the present wording of the draft. He also pointed out that a number of the recommendations made in the draft (e.g. enhancing RS ascents to 6-hourly intervals in the entire BALTEX modelling region, or, the establishment of a BALTEX Satellite Data Centre) have considerable financial implications. These recommendations need an in-depth scientific justification and an additional BALTEX-internal review with respect to their likelihood of realisation.

Other immediate reactions from the SSG members are briefly summarised in the following. Almost all of the participants acknowledged the draft plan as a good starting point for discussions, which may need adjustments. The following summary focuses mainly on critical comments.

Both Professors Ehrhard Raschke and Eberhard Müller questioned the realisation of a specific BALTEX Satellite Data Centre because the necessary financial problems are unlikely to be solved within a two year period. The present draft should give stronger importance to surface radiation measurements.

Dr. Jerzy Pruchnicki, representing the Polish Hydromet Service, congratulated the authors of the *BRIDGE* draft plan for a sound scientific basis of the document which contains a clear statement of the BALTEX objectives, well defined model and data requirements, and a set of recommendations on how to proceed in order to implement the plan. He continued to point out that the plan, however, seems to be unrealistic as it imposes serious organisational and technical burden on Hydromet Services which cannot be resolved without ensuring sufficient funding of these activities. He expressed the view that prior to making the plan available for a broader review, it should be re-drafted to match the priorities of the BALTEX research teams and those of the national Services and to provide sound arguments for successful funding application. In this connection, he referred to a letter of February 1997 to the BALTEX SSG Chairman in which the Polish Hydromet Service had defined its data policy for the BALTEX purposes.

Professor Zdzislaw Kaczmarek suggested to re-formulate parts of the draft to make it more readable for funding agencies. He shared the opinion of Dr. Pruchnicki concerning funding problems. National Services have only very limited resources for additional funding of experiments like *BRIDGE*. He questioned that all recommendations of the draft plan can be realised until 1999.

Professor Wolfgang Krauß pointed out that the plan is very ambitious. The realisation will require major additional funding. As far as the suggested additional oceanographic measurements are concerned it will probably be very hard to convince institutes to harmonise their own research plans (in particular ship cruises) with the *BRIDGE* time table. He also requested to be more specific in explaining the objectives of *BRIDGE*.

Professor Valery Vouglinsky recommended further discussions on the plan. It might be too early to finalise the plan at this meeting.

Professor Jerzy Dera criticised the oceanographic part to be written too general in some parts. He suggested to co-ordinate research ship cruises of oceanographic institutes in the Baltic Sea region during the *BRIDGE* period. He also suggested to use radio-equipped buoys in the Gdansk Bay and elsewhere in the Baltic Sea.

Professor Jouko Launiainen suggested to improve the observational aspects in the oceanographic part. Improvement is necessary concerning the level of details in describing data requirements.

Professor Anders Omstedt suggested to construct a closer link between modelling requirements and observations in the plan. The present structure of the draft plan in this respect is too loose.

In reviewing the discussion and contributions at this stage the Chairman considered in particular the concern of some SSG members about the accomplishment and implementation of the plan. He suggested a review of the draft plan in the following stages:

1. by SSG members during this meeting, to be performed in sub-groups,
2. by the Task Force, considering the suggestions of SSG resulting from this meeting, until June 1997,
3. by members of the BALTEX research community, until the end of July 1997,
4. again by the Task Force, considering suggestions from the BALTEX community,
5. finally by the chair-persons of the BALTEX SSG (L. Bengtsson, E. Raschke, Z. Kaczmarek) at the end of August.

The plan shall be finalised in autumn 1997 at latest to be presented to e.g. funding agencies and national Hydrometeorological Services.

SSG agreed with these suggestions.

SSG split into 4 sub-groups (meteorological, hydrological, oceanographic and general organisational aspects) to work on specific suggestions and corrections. Sub-groups worked through the evening and morning hours of 15 and 16 April, respectively. The SSG re-convened late morning on Wednesday, 16 April. Various specific suggestions and also general recommendations from the sub-groups were again reviewed. The Task Force was asked to re-write the respective parts of the plan accordingly and to organise further steps of the review process as outlined above.

Finally, Professor Bengtsson again noted the excellent preparatory work of the Task Force and thanked the SSG meeting participants for additional input. He expressed his hope that the future review steps will contribute to additional improvements.

13 Report of BALTEX Network and Project Co-ordinators

Due to the extended discussion on the *BRIDGE* draft plan only limited time could be spent on the reports on BALTEX research networks and projects.

13.1 Network A: Full-scale Studies on the Energy and Water Cycle

Professor Bengtsson, the co-ordinator of the EU-NEWBALTIC project, which covers various aspects of the BALTEX research network A („Full-scale studies on the Energy and Water Cycle of the Baltic Sea catchment region"), gave his report on NEWBALTIC, which he submitted in written form to SSG (see Appendix 17). Professor Bengtsson noted that a funding proposal NEWBALTIC II was submitted to EU (see Appendix 11).

Note to the protocol (as of August 1997): The NEWBALTIC II proposal has been accepted for funding by EU.

13.2 Network C: Coupled Modelling of the Baltic Sea

The report was given by Professor Wolfgang Krauß. Network C receives international funding through the MAST-III project BASYS (SP6: Baltic Sea and Sea-Ice Modelling, co-ordinator Professor Krauß). The main objectives include the development of sea-ice models for the Baltic Sea and the coupling of sea-ice models to 3-dimensional circulation models of the Baltic Sea. Participants at BASYS/SP6 include IfMK, SMHI and Helsinki University. At IfMK a control run with the IfMK 3-dimensional Baltic Sea circulation model without considering sea-ice has been performed for the 2-years period 1992/93. Different sea-ice models have been developed at IfMK, SMHI and Helsinki University. Test runs with coupled ocean circulation - sea-ice models for the winters 1992 and 1993 are currently being conducted. A sea-ice model intercomparison is planned.

Professor Krauß also mentioned another BALTEX project conducted at IfMK and being funded now by the Deutsche Forschungsgemeinschaft (DFG). This project is co-ordinated by Professor Krauß and Professor Peter Lembke at IfMK and aims at coupling the 3-dimensional Baltic Sea model to the BALTEX atmospheric model REMO (version at MPIfM Hamburg).

13.3 Network F: Baltic Air-Sea-Ice Study - A Field Experiment of BALTEX

Professor Jouko Launiainen (FIMR Helsinki) briefly reported on the on-going preparation for the Baltic Air-Sea-Ice Study (BASIS). BASIS has been accepted recently to be funded by EU through the MAST-III program (see also Appendix 11). Participants at BASIS include FIMR, Hamburg University, SMHI, Hanover University, Uppsala University and the University of Helsinki. BASIS aims at an improved understanding and modelling of energy and water cycles during winter conditions by conducting a winter field experiment in the ice edge zone of the Baltic Sea in February-March 1998. A map of the experimental site and outline is given in Appendix 18. BASIS will be the first field experiment in the Baltic Sea covering the various branches of physical oceanography, sea ice research, marine meteorology and remote sensing. BASIS will collect data particularly of

- exchange of heat, moisture and momentum between the air, ice and sea,
- structure of atmospheric and oceanic boundary layers and their interaction with the exchange processes,
- ice motion and the atmospheric and oceanic driving forces, and
- interaction between thermodynamic and dynamic processes in the air, sea and ice.

Research vessels, research aircraft and helicopters, meteorological balloon stations and a good set of automatic weather stations, turbulence equipment, and drifting buoys will be used. Analyses of the data sets will result in improved remote sensing algorithms and, in particular, better parameterisations of air-ice-ocean interaction processes for development, validation, and optimisation of the coupled atmosphere-ice-ocean models.

The duration of the project is 1997-2000.

13.4 Network D: Cloud/Precipitation/Air-Sea Interaction Field Experiment

The co-ordinator of this field experiment, Professor Ann-Sofi Smedman of Uppsala University, could not attend the SSG meeting. Professor Anders Omstedt shortly reported that a new funding proposal in order to support activities of network D was submitted to EU (see also Appendix 11). The BALTEX Pilot Study of Evaporation and Precipitation in the Baltic Sea (PEP) is designed as a pilot experiment to the BALTEX Main Experiment *BRIDGE* (see items 11 and 12), with the specific scope to study precipitation and evaporation over the sea and to test, improve and validate radar estimates of precipitation against in situ measurements. PEP will also provide data sets for the improvement of numerical models over the sea.

Note to the protocol (as of August 1997): The PEP proposal has been accepted for funding by EU.

13.5 Network G: Baltic Sea Vertical Advection and Mixing Field Experiment

Professor Anders Stigebrandt of Gothenburg University, the co-ordinator of this network, could not attend the SSG meeting. Professor Omstedt briefly reported on recent developments.

A funding proposal for the DIAMIX field experiment (Dynamics of Wind-forced Diapycnal Mixing in the Stratified Ocean) was submitted to EU-MAST III (see Appendix 11) but was unfortunately not supported. DIAMIX is a planned oceanographic field experiment to evaluate the dynamics of wind-forced diapycnal mixing in the stratified ocean. It will concentrate on measurements of vertical mixing and advection in the Gotland Basin. It is intended to estimate the distribution of kinetic and potential energy in an experimental box extending from the shoreline of the island Gotland to the maximum depth of the eastern Gotland Basin. DIAMIX is planned so far for the years 1997 and 1998. It is foreseen to conduct a summer experiment with a seasonal, essentially thermal stratification in the surface layers, and a winter experiment when the water is homogeneous down to the halocline at about 60 m depth. Each of the experiments should last for about 2 weeks.

The measurements will comprise moorings with current meters and CT-sensors and continuous ADCP and CTD recordings. Four ships are expected to participate. Two of these will do continuous CTD and ADCP measurements along transects perpendicular to the coast. Vessel-mounted ADCP and a vertically undulating vehicle carrying the CTD are planned to be used. The other ships will take CTD profiles and profiles of turbulent dissipation from the sea surface to the sea bed in many verticals each day. The meteorological measurements during PEP at Oestergarnsholm and elsewhere will provide high-quality meteorological data and independent estimates of the air-sea exchange of heat, water and momentum.

The DIAMIX data sets will be useful for testing ocean circulation models with respect to e.g. meso-scale dynamics.

At a recent meeting the DIAMIX participants concluded to try to carry out DIAMIX even with a reduced measurement plan due to the problem of funding. A pilot experiment is planned to be conducted during June 1997 east of Gotland with participation of at least two research vessels in parallel at the same time. Moorings will be laid out along two of the originally planned DIAMIX legs. A workshop is planned for autumn 1997 to discuss preliminary results of the pilot experiment and future steps for a complete implementation of DIAMIX.

13.6 Network E: Cloud/Precipitation/Air - Land Surface Field Experiment

Professor Gerd Tetzlaff of Leipzig University is the co-ordinator of this network; he unfortunately could not attend this SSG meeting. He had submitted a summary paper on BALINEX (BALTEX Lindenberg Land Surface Experiment) to the SSG meeting (Appendix 19). BALINEX is a field experiment proposal submitted to EU for funding at the beginning of 1997 (see Appendix 11). The objectives of BALINEX include

- the description of the subgrid-scale variability in meso-scale atmospheric models (landscape heterogeneity effects),
- the representation of forests and forest edges in SVAT-Models,
- investigation of the surface components of the water cycle as process study paralleling the field experiment,
- modelling of the hydrological cycle during the drying process of a typical landscape after a rainfall event.

Professor Eberhard Müller of DWD noted that DWD is planning and conducting a long-term monitoring program LITFASS. The scientific objective of LITFASS (Lindenberg Inhomogeneous Terrain - Fluxes between Atmosphere and Surface - a Long-term Study) is to determine and to model and parameterise the fluxes of momentum, heat, water and other substances, representative for the horizontal scale of the order of 10 km over heterogeneous land surfaces. The planning foresees LITFASS to be executed in stages from 1995 up to the year 2000. The investigation area for LITFASS is located around the Lindenberg Observatory of DWD south-east of Berlin. This region exhibits a moraine landscape with heights above sea level between 40 m and 120 m, which is typical for large areas in the south-east part of the Baltic Sea catchment region. The LITFASS area is fixed around the central point of one grid-box of the Deutschlandmodell (DM), which is the high-resolution (15 km x 15 km) operational forecast model of DWD.

A concentrated field measurement campaign (LINEX) is planned for June 1998 in the LITFASS region. The BALTEX contribution to LINEX is comprised in BALINEX with participation of 8 different groups in 5 countries (Appendix 11).

13.7 BALTRAD

The need for accurate high-resolution precipitation fields for the Baltic Sea catchment region has been recognised and a proposal for a radar research project BALTRAD (Accurate High Resolution Precipitation Fields for the Baltic Region from Weather Radars, Satellites and Numerical Models) was submitted to EU (see also Appendix 11). The co-ordinator of this project, Mr. Jarmo Koistinen of FMI, summarised the objectives of BALTRAD as follows:

- To develop, apply and evaluate methods for consistently calibrating and processing data from an international network of 25 European weather radar systems,
- To diagnose, analyse and correct well-known errors in radar data using surface observations, satellite remote sensing, and model data,
- To correct the flow distortion error of rain gauge observations using NWP winds at the height of 2 m,
- To enable the generation and archiving of homogenous radar-based precipitation products in real or near-real time,
- To establish previously unavailable fields of precipitation for the Baltic Region (including the Baltic Sea area itself) into one data archive, covering a time period of 6 months,
- To provide a dynamic interface between remote sensing observational and numerical modelling fields of research within a European logistical framework,
- To provide the Baltic Sea Experiment and the respective national weather services with highly valuable and prioritised information and methods.

Mr. Koistinen stressed that BALTRAD consists of both scientific and logistical components by setting up radar data preparation and management structures for BALTEX (in particular for *BRIDGE*) which however may be used in future also in the general frame of the operational duties of national Weather Services.

14 Report on NOPEX

Professor Lars Gottschalk of Oslo University attended the SSG meeting as the representative of the NOPEX program. He referred to his paper given at the hydrological symposium the day before which discussed scientific matters and recent findings of NOPEX research (see Appendix 4 for details).

In addition, he noted the WINTEX experiment which, as a part of NOPEX, aims at exploring land-surface-atmosphere interactions in a winter-time boreal landscape through a Concentrated Field Effort (CFE) conducted at Sodankylä. The Sodankylä Meteorological Observatory, located in a subarctic forest area in northern Finland (67°29' N; 26°39' E; 179 m a.s.l.), is one of the two main meteorological observatories of FMI. The observatory acts as a routine, synoptic, and aerosounding station. It also participates in several upper-air research campaigns. Present focus in Sodankylä is given on atmospheric vertical soundings of ozone and particulate concentrations, and measurements on UV radiation. Both lidar and balloon-borne analysers are used to obtain particulate content at various heights up to the top of the entire atmosphere.

Professor Gottschalk mentioned that a WINTEX funding proposal was granted by EU thus assuring the necessary financial background for a successful conduction of the CFE of WINTEX. The EU-funded core group of WINTEX is organised around three themes:

A. Atmospheric and hydrological modelling
A1 Meso-scale atmospheric modelling of winter-time atmospheric processes
A2 Modelling of snow and frozen soils

B Development of remote-sensing methodologies
B1 Development and testing of algorithms to derive surface properties
B2 Incorporation of remote-sensing data in atmospheric meso-scale modelling

C Test and development of measurement techniques
C1 Test and development of measurement equipment and methodologies
C2 Development of the CCM programme with special regard to winter conditions

The CFE of WINTEX (which is CFE3 in the entire NOPEX history) was conducted on 3 March - 11 April, 1997, with an intensive observation period during 12 - 21 March 1997. The main objective of WINTEX is to prepare the best possible planning for a full-scale wintertime CFE (CFE4 in NOPEX) towards the end of the 1990s. The timing of CFE4 will be co-ordinated within an IGBP-BAHC and a WCRP-GEWEX context, especially with respect to the timing of the Main BALTEX Experiment *BRIDGE*.

15 Membership of BALTEX Panels

15.1 SSG

The Chairman announced with regret the wish of the following four SSG members to resign from their SSG membership:

- **Professor Eero Holopainen, Finland,**
- **Dr. Jens-Christian Refsgaard, Denmark,**
- **Professor Gert Schultz, Germany,**
- **Dr. Evgeny Zaharchenko, Latvia.**

In the name of the SSG Professor Bengtsson acknowledged their various contributions to BALTEX during its preparational and build-up phases. He thanked all four scientists and expressed SSG's hope that they nevertheless may continue to support BALTEX issues in other ways in the future.

The Chairman suggested two new members of the BALTEX SSG.

Dr. Dan Rosbjerg of the Institute of Hydrodynamics and Water Resources at Technical University of Denmark will support the BALTEX planing and co-ordination in particular in hydrological issues. Dr. Rosbjerg, who could not attend the present meeting, had indicated his willingness to become SSG member. SSG agreed with the Chairman's suggestion and approved Dr. Rosbjerg's appointment.

Mr. Andris Leitass, director of LHMA, was suggested to represent the Latvian Hydrological and Meteorological Service. Mr. Leitass expressed his gratitude for his nomination and agreed that LHMA shall be represented in the BALTEX SSG in future. He indicated his concern that his full time-table might not allow him to contribute in the way he wished to do. He will decide in due time whether he himself or one of his co-workers at LHMA will attend the BALTEX SSG.

The present SSG membership (as of May 1997) is given in Appendix 20.

15.2 BALTEX Working Group Radar

The chairmanship of the BALTEX Working Group Radar (WGR) changed. SSG thanked the former chairman, **Mr. Jan Svensson** of SMHI, Sweden, for his valuable contributions to BALTEX. **Mr. Jarmo Koistinen** of Finnish Meteorological Institute was suggested by the SSG as the new chairman of WGR. Mr. Koistinen, who attended the meeting, agreed with his nomination.

15.3 BALTEX Working Group Process Studies

The following changes in the membership of the BALTEX Working Group Process Studies (WGP) were suggested and approved by the SSG:

Professor Wojcieck Majewski of Gdansk Technical University, Poland, resigned from his membership.

The following scientists were suggested as new members of WGP:

Professor Ann-Sofi Smedman of Uppsala University, Sweden,
Professor Gerd Tetzlaff of Leipzig University, Germany,
Dr. Joachim Neisser of the DWD-Observatory at Lindenberg, Germany.

The BALTEX Secretariat was asked to write official letters to the respective old and new members.

Notes to the protocol:
As of 10 June 1997, both **Professor Smedman** and **Professor Tetzlaff** have agreed to become members of WGP.

An additional change in the membership of WGP took place during May 1997. **Professor Martin Claußen** resigned from his membership. Both the SSG Chairman and the WGP Chairman, Professor Eberhard Ruprecht, suggested **Professor Hannu Savijärvi** of Helsinki University, Finland, to replace Professor Claußen and to become a new member of WGP. Professor Savijärvi has meanwhile approved his membership in WGP.

The list of WGP members, as of June 1997, is given in Appendix 21.

15.4 BALTEX Task Force

The chairman of the BALTEX Task Force (the planning group for *BRIDGE*), Dr. Mikko Alestalo, noted the following changes in its initial membership (see Appendix 20 of the minutes of the 4th BALTEX SSG meeting).

Dr. Jens-Christian Refsgaard resigned from the group.

Professor Sten Bergström of SMHI, Norrköping, Sweden, **Dr. Theo Mengelkamp** of GKSS Forschungszentrum Geesthacht, Germany, and **Dr. Hans-Jörg Isemer**, head of the BALTEX Secretariat at GKSS Forschungszentrum Geesthacht were appointed new members of the BALTEX Task Group.

SSG approved the mentioned membership changes.

16 Further Items

No further items were discussed.

17 Next SSG Meeting

The Danish Meteorological Institute, Copenhagen, agreed to host the next meeting of the BALTEX SSG. The suggested date for this meeting is March 2 - 4, 1998.

SSG suggested to start the next SSG meeting again with a scientific symposium which should focus on meteorological aspects.

18 Closing of the Meeting

The Chairman closed the SSG meeting at 4 p.m. on Wednesday, 16 April 1997. He thanked all participants for engaged and constructive discussions. The participants of the meeting appreciated the excellent conduction of both the symposium and the SSG meeting at LHMA and Hotel *Riga* and expressed their thanks to Mr. Andris Leitass, director at LHMA and his team.

19 List of Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
BAHC	Biospheric Aspects of the Hydrological Cycle, IGBP subprogram
BALINEX	BALTEX Land Surface Experiment at Lindenberg
BALTEX	Baltic Sea Experiment
BALTRAD	BALTEX Radar Network
BASIS	Baltic Air-Sea-Ice Study
BASYS	Baltic Sea and Sea-Ice Modelling
BHDC	BALTEX Hydrological Data Centre
BMBF	Bundesministerium für Forschung und Technologie, Bonn, Germany
BMDC	BALTEX Meteorological Data Centre
BODC	BALTEX Oceanographic Data Centre
BRIDGE	The Main BALTEX Experiment, planned for 1999-2001
CCM	Continuous Climate Monitoring
CFE	Concentrated Field Effort
CT	Conductivity - Temperature
CTD	Conductivity - Temperature - Depth
DFG	Deutsche Forschungsgemeinschaft, Germany
DIAMIX	Diapycnal Mixing in the stratified ocean; Field experiment in BALTEX
DM	Deutschlandmodell, operational NWP model of DWD
DMI	Danish Meteorological Institute, Copenhagen, Denmark
DWD	Deutscher Wetterdienst, Offenbach / Germany
EGS	European Geophysical Society
EU	European Union
FIMR	Finnish Institute of Marine Research, Helsinki / Finland
FMI	Finnish Meteorological Institute, Helsinki / Finland
GEWEX	Global Energy and Water Cycle Experiment
GKSS	GKSS Research Centre, Geesthacht / Germany
GTS	Global Telecommunication System
HBV	Swedish Conceptual Hydrological Model for Runoff Simulation
HTM	Horizontal Transport Model
IfMK	Institut für Meereskunde Kiel, Germany
IMGW	Institute for Meteorology and Water Management, Polish Hydromet Service
INTAS	International Association for the promotion of cooperation with scientists from the New Independent States of the former Soviet Union
IGBP	International Geosphere Biosphere Program
LHMA	Latvian Hydrometeorological Agency, Riga, Latvia
LINEX	Lindenberg Experiment
LITFASS	Lindenberg Inhomogeneous Terrain Fluxes between Atmosphere and Surface - a DWD long-term Study 1995 - 2000
MAST	Marine Action in Science and Technology
MPIfM	Max-Planck-Institut für Meteorologie, Hamburg, Germany
NEWBALTIC	EU project for BALTEX: Full-sclae studies on the energy and water cycle of the Baltic Sea catchment region

NOPEX	Nordic Pilot Experiment
NWAHMS	North-West Administration of the Russian Federal Service for Hydrometeorology and Environmental Monitoring, St.Petersburg, Russia
NWP	Numerical Weather Predciction
PEP	Pilot Study of Evaporation and Precipitation in BALTEX
PIDCAP	Pilot Study for Intensive Data Collection and Analysis of Precipitation
PILPS	Project for Intercomparison of Land Surface Parameterization Schemes
REMO	Regional Model
RS	Radiosonde
RSHI	Russian State Hydrological Institute, St. Petersburg, Russia
SEWAB	Surface Energy and Water Balance Model
SMHI	Swedish Meteorological and Hydrological Institute, Norr-köping/Sweden
SSG	Science Steering Group
SVAT	Surface-Vegetation-Atmosphere-Transfer
UV	Ultraviolett
WCRP	World Climate Research Program
WGP	BALTEX Working Group on Process Studies
WGR	BALTEX Working Group on Radar
WINTEX	Winter Experiment in NOPEX
WMO	World Meteorological Organization

Appendix 1

5th BALTEX SSG Meeting

at Latvian Hydrometeorological Agency
Riga, Latvia

14 - 16 April 1997

Agenda

Monday, 14 April 1997

3.00 pm

1 Opening, Welcome
A. Leitass, Director of LHMA
L. Bengtsson, Chairman of SSG

2 Introduction to LHMA
A. Leitass

4.00 pm - 6.30 pm

3 Hydrological symposium (see separate agenda)

Tuesday, 15 April 1997

8.30 am - 10.30 am

3 Hydrological symposium (continued)

11.00 am - 12.30 pm

4 Opening of the SSG meeting
Report of the BALTEX SSG Chairman (L. Bengtsson)

5 Report of the BALTEX Secretariat (H.-J. Isemer)

Lunch

2.00 pm - 6.30 pm

6 Report on the BALTEX Hydrology Workshop Warsaw September 1996 (Z. Kaczmarek)

7 Report on the BALTEX Neva Workshop February 1997 (V. Vuglinsky)

8 Report of BALTEX Hydrological Data Centre (O. Pettersson)

9 Report of BALTEX Oceanographic Data Centre (P. Alenius)

10 Report of BALTEX Meteorological Data Centre (A. Lehmann)

11 Report of BALTEX Task Force (M. Alestalo)

12 Discussion on the BALTEX Main Experiment

Wednesday, 16 April 1997

8.30 am - 12.30 pm

12 Discussion on the BALTEX Main Experiment (continued)

Lunch

2.00 pm - 6.30 pm

13 Report of BALTEX Network co-ordinators, status of funding applications (L. Bengtsson, W. Krauss, J. Launiainen, A.S. Smedman, G. Tetzlaff, J. Koistinen, A. Stigebrandt)

14 Report on NOPEX (L. Gottschalk)

15 SSG membership, WG membership, Task Force membership

16 Further items

17 Next SSG meeting

18 Closing

Appendix 2

Participants of 5th BALTEX SSG Meeting

Name	Institution
1. Mikko Alestalo	FMI, Helsinki / Finland
2. Lennart Bengtsson	MPIfM, Hamburg / Germany
3. Sten Bergström	SMHI, Norrköping / Sweden
4. Grigory Chekan (for Ivan M. Skuratovich)	Hydromet. Minsk / Belarus
5. Jerzy Dera	PAS, Sopot / Poland
6. Lars Gottschalk	University Oslo / Norway
7. Hans-Jörg Isemer	GKSS Geesthacht / Germany
8. Zdzislaw Kaczmarek	Inst. of Geophysics,Warsaw / Poland
9. Sirje Keevallik (for Peeter Karing)	EMHI, Tallinn / Estonia
10. Jarmo Koistinen	FMI, Helsinki / Finland
11. Juozas Karkozas (for Petras Korkutis)	LHMS, Vilnius / Lithuania
12. Wolfgang Krauß	IfM, Kiel / Germany
13. Jouko Launiainen	FIMR, Helsinki / Finland
14. Andris Leitass	LHMA, Riga / Latvia
15. Henrik Madsen (for Dan Rosbjerg)	DHI, Horsholm / Denmark
16. Eberhard Müller	DWD, Offenbach / Germany
17. Anders Omstedt	SMHI, Norrköping / Sweden
18. Ola Pettersson	SMHI, Norrköping / Sweden
19. Jerzy Pruchnicki	IMWM, Warsaw / Poland
20. Ehrhard Raschke	GKSS Geesthacht / Germany
21. Valery S. Vuglinsky	SHI, St. Petersburg/Russia

A 4

Appendix 3

Hydrological Symposium
at the 5th BALTEX SSG Meeting
Latvian Hydrometeorological Agency, Riga, Latvia
14 and 15 April 1997

Chair: Zdzislaw Kaczmarek, Institute of Geophysics, Warsaw, Poland

Monday, 14 April 1997

4.00 pm: Ehrhard Raschke, GKSS Forschungszentrum Geesthacht, Germany
GEWEX hydrological modelling requirements - A short overview

4.15 pm: Henrik Madsen, DHI Hørsholm, Denmark
The MIKE-SHE model

4.45 pm: Ansis Ziverts, Latvia University of Agriculture, Riga, Latvia
Description and application of the Model METQ96

5.15 pm: Sten Bergström, SMHI Norrköping, Sweden
Conceptual hydrological modelling of the overall water balance of the Baltic Sea basin - The HBV approach

5.45 pm: Yuri Vinogradow, State Hydrological Institute, St. Petersburg, Russia
Description and application of the model HYDROGRAPH

6.15 pm: End of first section

Tuesday, 15 April 1997

8.30 am: Theo Mengelkamp, GKSS Forschungszentrum Geesthacht, Germany
Land surface processes in hydrological and atmospheric models

9.00 am: Lars Gottschalk, Oslo University, Norway
Problems of coupling distributed hydrological and meteorological models

9.30 am: Lydia Dümenil, MPIfM Hamburg, Germany
Hydrological cycle: Modelling of vertical and lateral flows in GCMs

10.00 am: Anders Omstedt, SMHI Norrköping, Sweden
Modelling the lake energy and water cycles

10.30 am: End of the symposium

A 6

Appendix 4

Abstracts of Contributions at the Hydrological Symposium

Ansis Ziverts, Latvia University of Agriculture, Riga, Latvia
Description and application of the Model METQ96

Sten Bergström, SMHI Norrköping, Sweden
Conceptual hydrological modelling of the overall water balance of the Baltic Sea basin - The HBV approach

Yuri Vinogradow, State Hydrological Institute, St. Petersburg, Russia
Description and application of the model HYDROGRAPH

Theo Mengelkamp, GKSS Forschungszentrum Geesthacht, Germany
Land surface processes in hydrological and atmospheric models

Lars Gottschalk, Oslo University, Norway
Problems of coupling distributed hydrological and meteorological models

Lydia Dümenil, MPIfM Hamburg, Germany
Hydrological cycle: Modelling of vertical and lateral flows in GCMs

Anders Omstedt, SMHI Norrköping, Sweden
Modelling the lake energy and water cycles

A 8

Description and application of the model METQ96

A.Ziverts, I.Jauja
Latvia University of Agriculture
Akademijas Str. 19, Jelgava LV-3001, Latvia

The METQ96 model is a conceptual hydrological model for simulation of runoff processes with several physically based parameters. Input data include daily mean air temperature and vapor pressure deficit, as well as the total amount of daily precipitation. The structure of the model is presented in Figure 1.

The model consists of four parts: 1) snow accumulation and melt routine (Figure 2), 2) root zone moisture balance routine (Figure 3), 3) vadose and groundwater balance routine (Figures 4,5), 4) runoff routing in a subbasin.

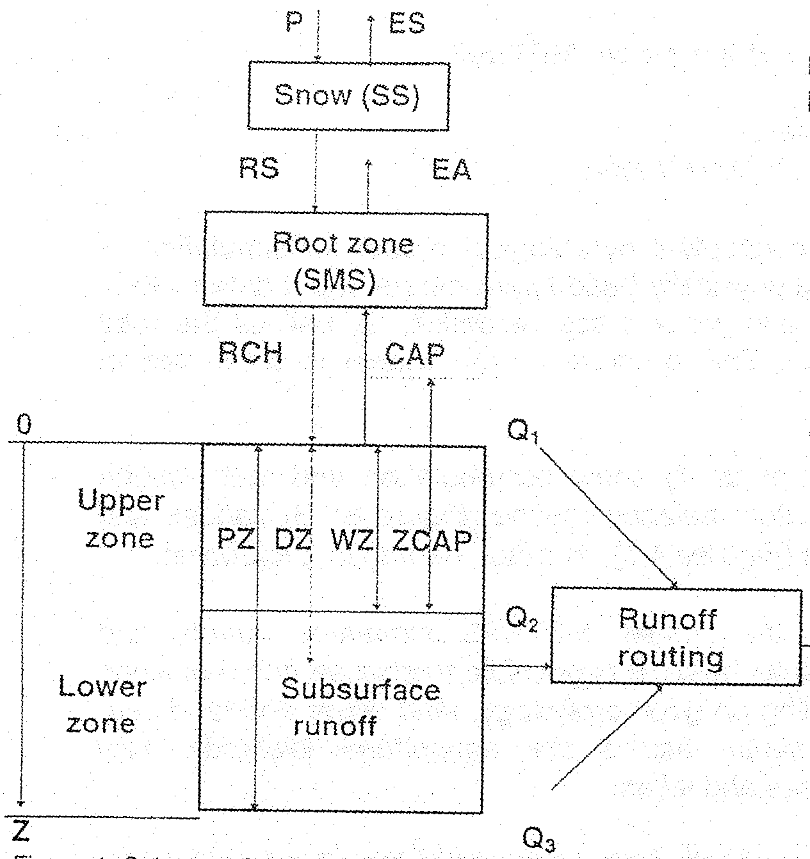
The first three parts of the model METQ96 simulates runoff and evapotranspiration for elemental basin. It is possible to choose different kinds of elemental basins depending on geomorphology, land cover and land use. Typical kinds of the elemental basins are agricultural lowlands, hilly agricultural lands, forests, bogs and lakes.

The runoff is generated independently from each one of the elemental basins. Then generated runoff is routed through a transformation function in order to get a proper shape of the hydrograph. The transformation function is a simple filter technique with the distribution of the weights. Time lag could vary in range from 1 to 9 days according to the size of basin or subbasin.

Total amount of parameters which are used in the model for one elemental basin is 20. Parameters are estimated by calibration for the Vienziemite brook (A=5.92 km^2). Location of the basin is shown at the Figure 7. Visual inspection of the simulated and observed hydrographs is used for calibration (Figure 8). Values of parameters used for simulations are shown at the Table 1.

The first attempt to use the model METQ96 for river with relatively large basin was application of the model for the Daugava river basin (A=84000 km^2). For simulations the Daugava river basin is divided into 22 subbasins (Figure 9 and Table 2). Runoff routing through the channel is done by the method of linear reservoirs and in the Lubana subbasin runoff routing is done by hydraulic method. Observed and simulated hydrographs at Daugava-Dzelzlejas are shown in the Figure 10.

Proposals about coupling of the model METQ96 with the atmospheric models are shown at the Figure 11 and Table 3. The river "N" basin shown at the Figure 11 consists of 17 grids of the atmospheric model. Characteristics of the grid-net necessary for the modeling are given at the Table 3 and parameters of the model are given at the Table 1.



P-precipitation, mm/day
ES-evaporation from snow,mm/day
RS-rain and snowmelt water, mm/day
EA-evaporation from root zone ,mm/day
RCH-recharge to groundwater, mm/day
CAP-capillary flow,mm/day
SMS-water content in root zone,mm
GW-free pore capasity above groundwater level, mm
DZ-depth of upper drain,cm
PZ-depth of lower drain, cm
WZ-depth of groundwater,cm
Z-depth from ground surface,cm
Q_1, Q_2, Q_3-runoff components, mm/dnn
SS-water content in snow cover, mm

Figure 1. Scheme of the model METQ96

SNOW ACCUMULATION AND ABLATION ROUTINE

If T≤ T2 , then RS = 0
SSE =SSB + P - ES

If T2<T≤T1 , then RS=WMELT - WHC × SSB
SSE = SSB + P - RS - ES

If T >T1 , then RS=P + WMELT
SSE=SSB + P - RS - ES

Daily total amount of melted snow WMELT

WMELT = CMELT * (T - T2)

Evaporation from snow ES

ES = KS * DEF

where
DEF - daily mean vapour pressure deficit, hPa;
T- daily mean air temperature, °C;
P - daily precipitation, mm.

PARAMETERS

T1-threshold temperature below which snow accumulation begins °C;
T2 - threshold temperature above which snow melting starts °C;
KS - evaporation coefficient from snow,
CMELT - degree-day factor (mm/°C),
CREFR - reffreezing factor,
WHC - snow water holding capacity.

Figure 2

ROOT ZONE ROUTINE

Water balance in the root zone

$$SMSE = SMSB + RS - EA - RCH1 + CAP$$

where
RCH1 - potential recharge to groundwater, mm/day
SMSB and SMSE - water content in root zone at the beginning and at the end of day

If SMSB=WMAX, then

$$EA = KU * DEF$$

If SMSB = 0 and WZB≥ZCAP, then

$$EA = KL * DEF$$

If 0<SMSB<WMAX and WZB ≤ ZCAP, then

$$EA = [KU - WZB /(ZCAP \times (KU - KL))* *(1 - SMSB /WMAX)] * DEF$$

If WZB > ZCAP, then

$$EA = [KU - (KU - KL) * (1 - SMSB / WMAX)] \times DEF$$

PARAMETERS

WMAX - the threshold water storage in the root zone, mm.
KU - the upper limit of the evaporation coefficient.
KL - the lower limit of the evaporation coefficient.
ZCAP - height of capillary fringe, cm.

Figure 3

VADOSE AND GROUNDWATER ZONE ROUTINE

Capacity of empty ground pores GW

$$GW= 10 * ALFA * WZ$$

$$GWE = GWB - RCH + CAP + Q_1 + Q_2 + Q_3$$

where
GWB and GWE - capasity of empty ground pores at the beginning and the end of day

Subsurface runoff

$$Q2= A2 * (DZ - WZE)^2 , \text{ if } WZE < DZ$$
$$Q2 = 0 , \text{ if } WZE \geq DZ$$

Base flow

$$Q3 = A3 * (PZ - WZE),$$

Surface runoff

$$Q1 = QN , \text{ if } GWE \geq 0$$
$$Q1 = QN - GWE , \text{ if } GWE < 0$$

where QN - the part of surface runoff (Q1)

$$QN= 0 , \text{ if } RCH1 < ROB1$$

$$QN=RCH1-ROB1- ROB2* th((RCH1-ROB2)* *(ROR1*ROBK)^{-1}), \text{ if } RCH1>ROB1$$

$$RCH=RCH1-QN$$

$$Q = Q1 + Q2 + Q3$$

Figure 4.

PARAMETERS FOR VADOSE AND GROUNDWATER ZONE ROUTINE

ZCAP- height of capillary fringe, cm
A2- coefficient of the drainage intensity of the upper zone
DZ- depth of upper drain, cm
A3- coefficient of the drainage intensity of the lower zone
PZ- depth of lower drain, cm
ALFA- specific yield
ROB1, ROB2, ROBK - threshold infiltration parameters

Figure 5.

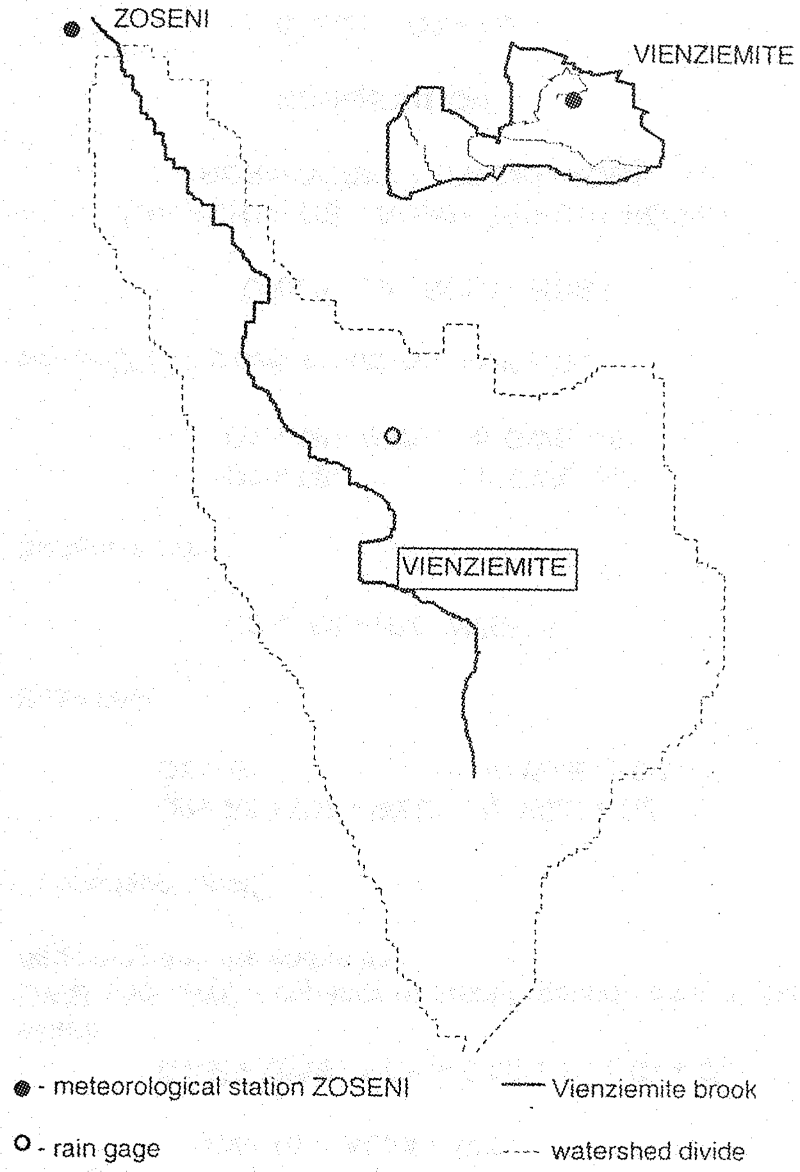
Total runoff from each subbasin

$$Q = (Q_{ALL} \times W_{ALL} + Q_{AHL} \times W_{AKL} + Q_F \times W_F + Q_B \times W_B + Q_L \times W_L)/100,$$

where Q - total runoff from the subbasin;
Q_{ALL}, Q_{AHL}, Q_F, Q_B, Q_L - runoff from each of 5 kinds of elemental basins
(agricultural lowlands, hilly agricultural lands, forests, bogs and lakes);
W_{ALL}, W_{AHL}, W_F, W_B, W_L - weights corresponding to 5 kinds of elemental basins,%.

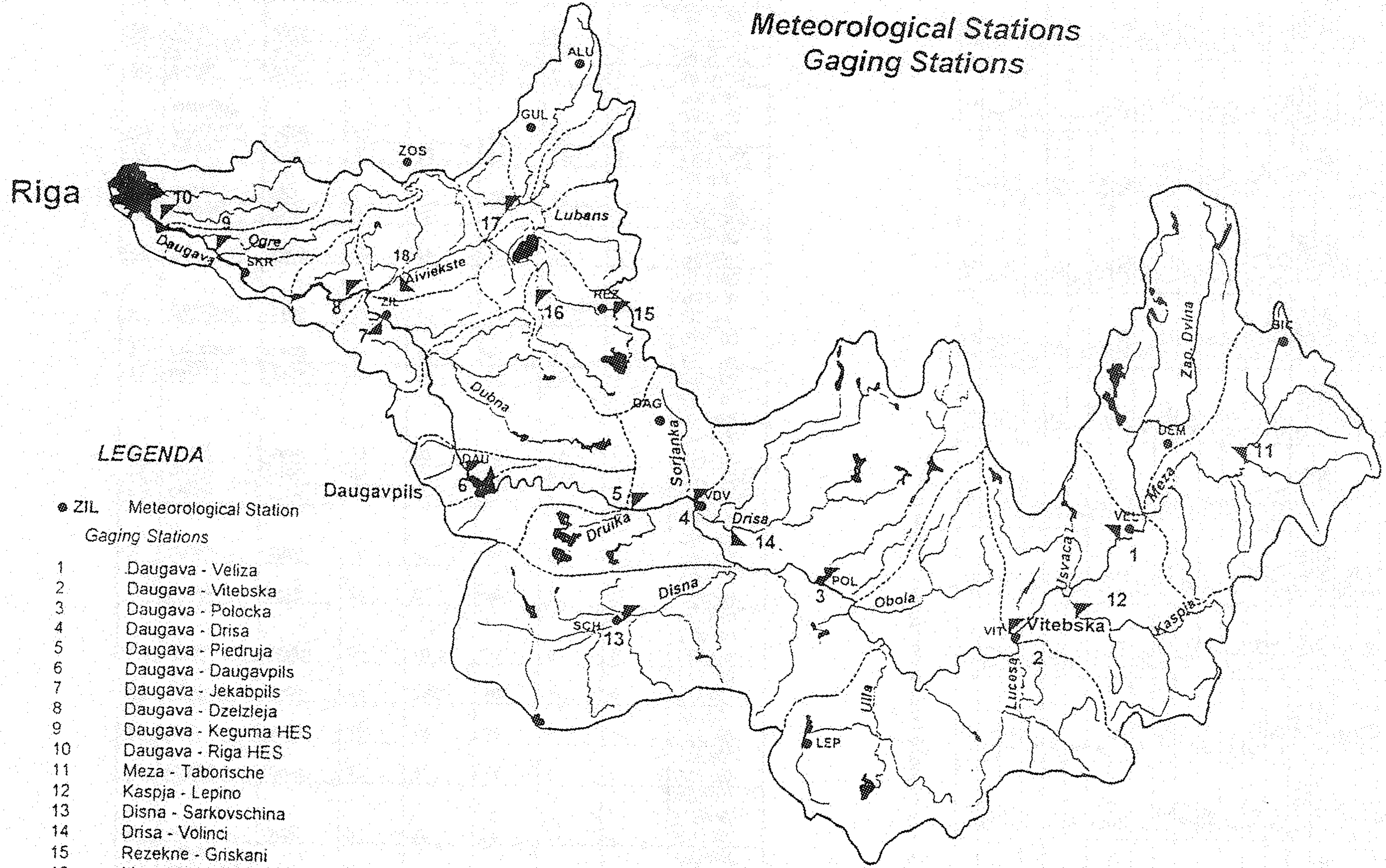
Figure 6.

Figure 7. Location of the Vienziemite basin ($A=5.92\ km^2$)



Basin of the river Daugava

Meteorological Stations
Gaging Stations



LEGENDA

● ZIL Meteorological Station

Gaging Stations

1 Daugava - Veliza
2 Daugava - Vitebska
3 Daugava - Polocka
4 Daugava - Drisa
5 Daugava - Piedruja
6 Daugava - Daugavpils
7 Daugava - Jekabpils
8 Daugava - Dzelzleja
9 Daugava - Keguma HES
10 Daugava - Riga HES
11 Meza - Taborische
12 Kaspja - Lepino
13 Disna - Sarkovschina
14 Drisa - Volinci
15 Rezekne - Griskani
16 Malta - Vilani
17 Aiviekste - Lubana
18 Aiviekste Aiviekste HES

Table 1. Parameters of the model METQ96

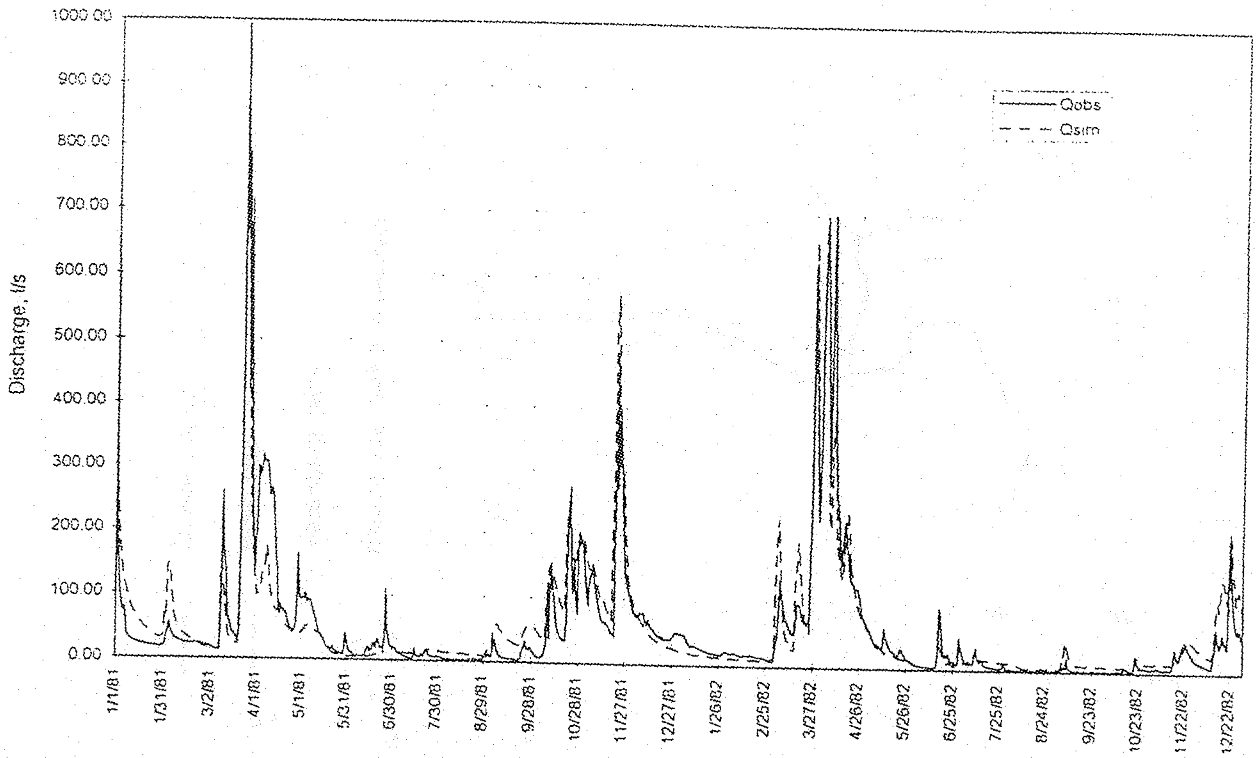
Parameters	Highlands			Lowlands			Forests			Bogs		
	Vien-ziemite	Dau-gava	Recom-mended	Vien-ziemite	Dau-gava	Recom-mended	Vien-ziemite	Dau-gava	Recom-mended	Vien-ziemite	Dau-gava	Recom-mended
WMAX	30	30	30	30	30	30	30	30	30	20	20	20
ALFA	0.07	0.07	0.07	0.05	0.05	0.05	0.12	0.12	0.12	0.30	0.30	
ZCAP	150	150	150	250	250	250	150	150	150	60	60	60
A2	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0002	0.0002	0.0002
A3	0.0007	0.0007	0.0007	0.0002	0.0002	0.0002	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
KU	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
KL	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
CMELT	4.5	4.5	4.5	4.5	4.5	4.5	2.5	2.5	2.5	4.5	4.5	4.5
T1	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	0.5	0.5	0.5
T2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.1	0.1	0.1	-0.1	-0.1	-0.1
KS	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
DZ	50	50	50	90	90	90	60	60	60	50	50	50
PZ	300	600	400	150	250	200	100	500	250	90	150	110
ROB1	8	8	8	10	10	10	15	15	15	25	25	25
ROB1Z	3	3	3	3	3	3	3	3	3	4	4	4
ROB2	12	12	12	15	15	15	10	10	10	60	60	60
ROB2Z	6	6	6	6	6	6	6	6	6	8	8	8
ROBK	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
WHC	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CFR	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Recomended - recomended for one atmospheric model grid

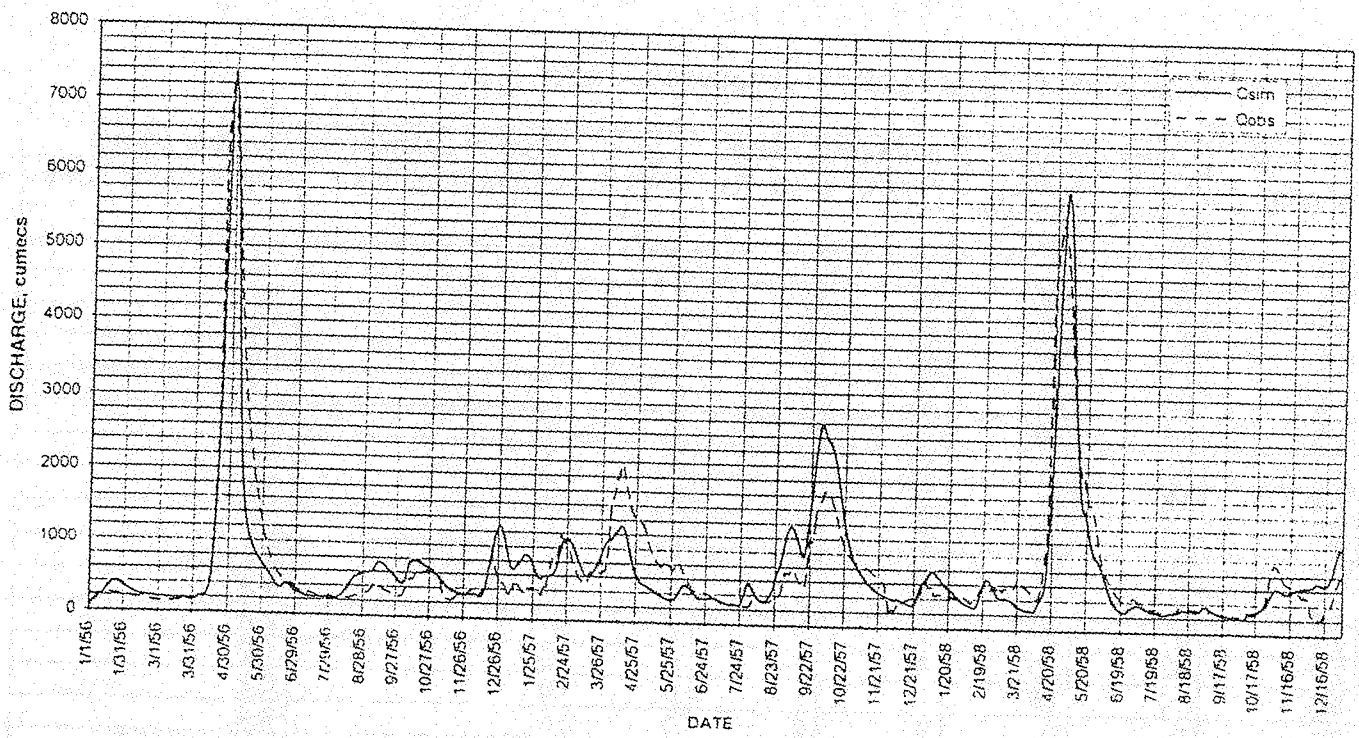
Table 2. Description of subbasins of the river Daugava

Nr.	Name of the subbasin	Catch-ment area, A km^2	Land use in the subbasin, %					Weight of the meteo-rological station, %
			hilly land	low-land	forest	bog	lake	
1	2	3	4	5	6	7	8	9
1.	Zapadna-ja Dvina	7820	45	5	42	5	3	SIC-40 DEM-60
2.	Meza	9080	25	30	36	8	1	SIC-30 DEM-50 VEL-20
3.	Kaspla	10400	36	36	17	6	1	VEL-70 VIT-30
4.	Ulla	9040	29	40	25	4	2	LEP-80 VIT-20
5.	Obol	3580	34	35	18	11	2	VIT-60 POL-40
6.	Disna	11890	34	40	17	6	3	LEP-10 POL-20 SCH-70
7.	Drissa	6780	37	25	28	5	5	POL-20 VDV-80
8.	Druika	3610	46	20	20	8	6	VDV-30 SCH-20 DAG-50
9.	Lauce	2004	48	25	21	4	2	DAU-100
10.	Ilūkste	1158	30	38	24	6	2	DAU-100
11.	Dubna	3416	29	20	36	11	4	DAU-30 DAG-30 REZ-20 ZIL-20
12.	Nereta	1466	10	19	52	18	1	ZIL-100
13.	Pededze	1690	34	15	44	6	1	ALU-70 GUL-30
14.	Rēzekne	2160	47	15	15	9	4	ZIL-30 REZ-50 GUL-20
15.	Iča	1060	32	15	28.7	24	0.3	REZ-50 GUL-50
16.	Bolupe	936	3	40	44	12	1	GUL-100
17.	Mierānu kanāls	727	1	39	30	29	1	GUL-50 ZIL-50
18.	Liede	698	23	23	40	13	1	GUL-100
19.	Aiviekstes lejas gals	2022	40	2	44	13	1	ZIL-40 ZOS-40 SKR-20
20.	Pērse	713	35	20	33	6	6	SKR-100
21.	Kegums	926	30	21	38	8	3	SKR-100
22.	Ogre	2013	22	22	46	6	4	SKR-70 ZOS-30

Calibration of the model METQ96 for the Vienziemite brook A=5.92 km^2 1981-1982



DISCHARGE HYDROGRAPH at DAUGAVA-PLAVINAS HPP (1956.-1958.y.y.) A= 81 300 km2



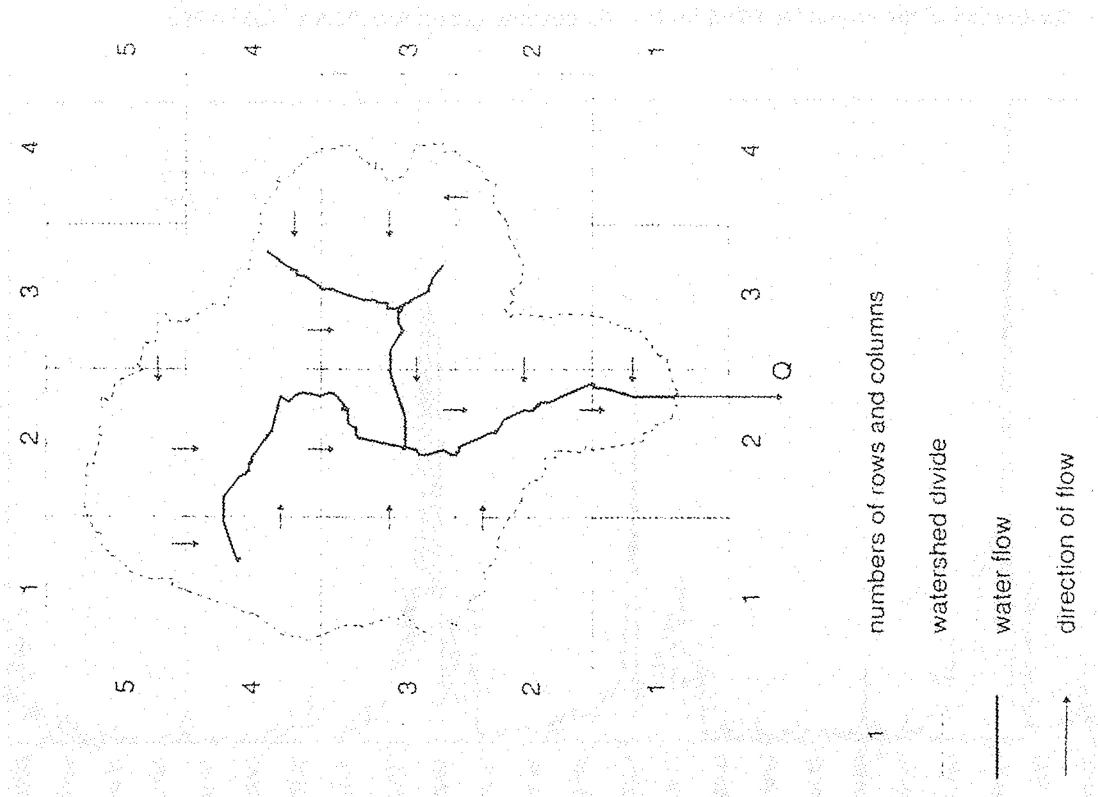


Figure 11. Fit of the river basin into the grid-net of the atmospheric model

Table 3. Characteristics of grid-net of the atmospheric model

Number of grid	Weight of types of elemental basins					Type of calculation of runoff routing	Number of grid where runoff flows
	Agricult. lowlands, W_{ALL}	Hilly agri-cult. land, W_{AHL}	Forests, W_F	Bogs, W_B	Lakes, W_L		
5-1	5	7	12	0	0	0	4-1
5-2	15	30	25	3	1	0	4-2
5-3	0	10	5	0	0	0	5-2
4-1	15	35	25	5	1	1	4-2
4-2	30	30	35	5	0	1	3-2
4-3	14	40	26	4	1	0	3-3
4-4	0	10	18	0	0	0	3-4
3-1	12	31	25	6	0	0	3-2
3-2	23	35	35	7	0	1	2-2
3-3	22	33	40	5	0	1	3-2
3-4	0	16	20	0	0	0	3-3
2-1	0	5	11	0	0	0	2-2
2-2	32	30	23	4	0	2	1-2
2-3	10	25	17	1	0	0	2-2
2-4	0	0	9	0	0	0	3-4
1-2	10	5	13	0	0	2	Q-total runoff
1-3	2	6	7	0	0	0	1-2

Contribution to the BALTEX Hydrological Symposium in Riga, April 14, 1997.

Conceptual hydrological modelling of the overall water balance of the Baltic basin - the HBV approach

Sten Bergström, Göran Lindström
Swedish Meteorological and Hydrological Institute, Norrköping
L. Phil Graham
Royal Institute of Technology, Stockholm
Daniela Jacob
Max-Planck-Institute for Meteorology, Hamburg

Contribution to the NEWBALTIC project, contract No. ENV4-CT95-0072

Introduction

Recently the problems of scale, sub-grid variability and macro-scale modelling have come into focus as the water cycle has been identified as a key issue in climate modelling and research is now looking at the linking of hydrological and atmospheric models (Wheater, et al., 1993; Blöschl and Sivapalan 1995; Wood, 1995; Dooge, 1995; Kite et al., 1995; Becker, 1995). Scaling and macroscale modelling are also problems which have to be addressed by the Continental Scale Experiments (CSEs) carried out under the GEWEX research umbrella, such as the GCIP (Mississippi), the LBA (Amazonas), the MAGS (Mackenzie) and the BALTEX (Baltic Sea) programmes. The typical scale of the catchments of these CSEs is in the order of magnitude of millions of km^2 and they cover some of the major river basins of the earth.

For a physically-based modeller, with an interest in detailed small-scale modelling of processes, the expansion to these macro-sized basins might appear insurmountable in the light of the tremendous variability in the basin. For the conceptual modeller, with experience from relatively straightforward water balance or runoff modelling, the larger scale might not be more dramatic than small research basins, provided adequate data are at hand. The magnitude of the problem of scale thus depends on the problem to solve and the scientific approach.

Within the NEWBALTIC project links between hydrological models and climate models are established on the macro-scale. The conceptual HBV hydrological model is applied to the entire Baltic basin and its subbasins and will be used for intercomparison and validation of output from the ECHAM-4 and UM climate models. The following presentation summarises this work as it stands in April 1997.

The HBV model

The HBV hydrological model has a long history and the model has found applications in more than 30 countries. Its first application dates back to the early 1970s (Bergström and Forsman, 1973). Originally the HBV model was developed at the Swedish Meteorological and Hydrological Institute (SMHI) and was intended for runoff simulation and hydrological forecasting, but the scope of applications has increased steadily (Bergström, 1995). The model has also been subject to many modifications over time, although the basic modelling philosophy has been unchanged. This philosophy acknowledges that the model complexity and data demand must not be in conflict with the operational requirements.

Today there exist many versions of the HBV model and new codes are constantly being developed by different groups (See, for example, Renner and Braun, 1990, Killingtveit et al., 1990 and Vehviläinen, 1986). The standard at SMHI has long been a version which is best characterised as a semi-distributed conceptual model. In 1993 the Swedish Association of River Regulation Enterprises (VASO) and SMHI initiated a major revision of the model structure. The new HBV-96 is the final result of this model revision (Lindström et al., 1997).

The standard snow routine of the HBV model is a degree-day approach with a water holding capacity of snow which delays runoff. Melt is further distributed according to the temperature lapse rate and is modelled differently in forests and open areas.

The soil moisture accounting is based on a modification of the bucket theory in that it assumes a statistical distribution of storage capacities in a basin. This simple assumption has followed the model ever since its introduction in 1972 and has proved to be very important as it makes the model scale independent as long as the distribution function of the basin-wide variability of field capacity is independent of scale. Nowadays the idea of using a statistical, rather than a fully explicit physical or physiographic description of the soil, has found acceptance and is used in several hydrological models. Experience has shown that calibration of this kind of soil moisture routine is normally not a great problem.

The response function controls the dynamics of the generated runoff and thus its distribution in time once the water balance is set by the snow and soil moisture routines.The HBV model has gradually been developed into a semi-distributed model. This means that a basin may be separated into a number of sub-basins and that each one of these is distributed according to elevation and vegetation. Lakes have a significant impact on runoff dynamics and the routing in major lakes is therefore modelled explicitly.

The ECHAM-4 model

The ECHAM spectral general circulation climate model (Roeckner et al.,1996) has been developed from the ECMWF numerical weather prediction model. It is available from T21 to T106 resolution. The top of the 19 layer hybrid pressure-sigma system is at 10 hPa. Vorticity, divergence, temperature, surface pressure, specific humidity and cloud water are standard prognostic variables.

The soil model comprises the budgets of heat and water in the soil, the snow pack over land and the heat budget of land ice.Vegetation effects such as the interception of rain and snow in the canopy and the stomatal control of evapotranspiration are parameterized in a highly idealized way.

The local runoff scheme is based on catchment considerations and takes into account subgrid-scale variations of field capacity over inhomogeneous terrain.

Application of HBV-96 to the continental scale

The application of the HBV model to the Baltic basin is rather straightforward. Only the scale is different and the database is much more complicated than in traditional applications.

Thanks to the Swedish research programme "Large-scale Environmental Effects and Ecological Processes in the Baltic Sea", however, both meteorological and hydrological data are available for model calibration. The meteorological database originates from the network of synoptic stations covering the area, which was interpolated into grid-squares of 1 by 1 degree. The hydrological database consists of monthly flow from all major rivers in the area and interpolated data in the 15% of land area not covered by measurements (Bergström and Carlsson, 1994).

In a preliminary model attempt, the entire catchment was divided into 19 subbasins and the model was applied to each one of these in the traditional way. One simplification was that no hypsometric curve was used to account for topography in the subbasins. The results showed that it is relatively easy to match river flow on this large scale with a simple model, but analyses of the inflow from smaller areas (sub-basins) show increasing difficulties with this crude model approach as catchment sizes decrease (Bergström et al., 1996).

At present a more comprehensive hydrological model, although yet conceptual, is being developed for the area. This model consists of 25 subbasins and includes a hypsometric distribution, classification into forests and open land, and explicitly accounts for the effects of larger lakes on river runoff by a routing procedure. While the preliminary model was merely calibrated to total inflow to subbasins of the Baltic Sea, this new model version is calibrated against several runoff records inland as well. Figure 1 shows the simulation for the Gulf of Riga catchment with this model.

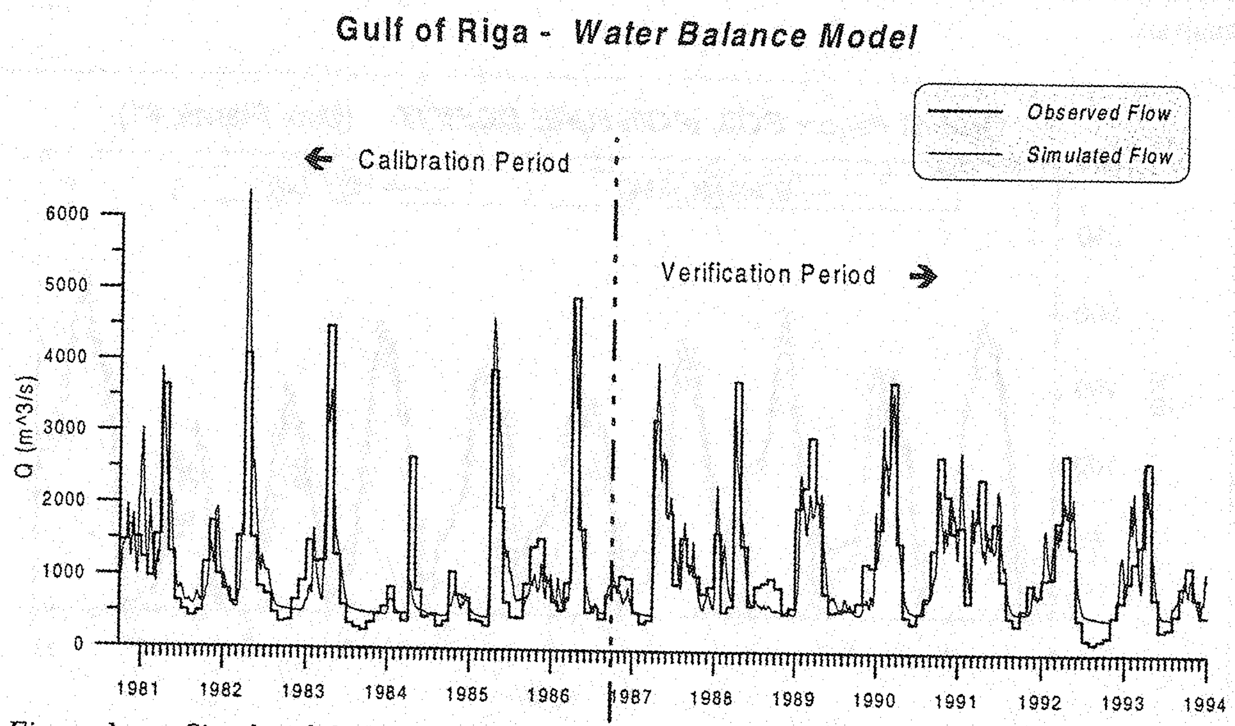


Figure 1. *Simulated daily river flow and observed monthly data for the drainage basin of the Gulf of Riga.*

Problems

The more complete model application has revealed problems, which mainly seem to be related to the homogeneity of the databases used. Most significant are long term homogeneity problems, showing up as increasing bias between model output and observations in some catchments. This problem has been discussed with our Polish colleagues, in particular, and some of the origin has been traced to inconsistent precipitation data in parts of the record available at SMHI. It is quite obvious that long term homogeneity has to be addressed in future BALTEX work. The routines for data collection and correction have to be considered as well as possible human impact on runoff records.

Comparison to GCM output

One objective of the development of a macro-scale hydrological model for the Baltic basin is intercomparisons between process descriptions in hydrological models and climate models and validation of the latter against runoff. So far preliminary intercomparisons have been made between the ECHAM-4 model and HBV-96 in some of the basins. Figure 2 shows a comparison between the soil moisture accounting routines of the two models as driven by precipitation and temperature data for 11 fictitious years from ECHAM-4 for the Gulf of Riga drainage basin. This means that the precipitaiton and air temperatures used as input are identical.

The results show great similarities as concerns modelled soil moisture dynamics. This is not so surprising as these models have a similar philosphy in the treatment of sub-grid or sub-basin variability of the field capacity of the soil. Comparisons between the modelled snow conditions and runoff simulations of the models reveal deviations which are still subject to analysis.

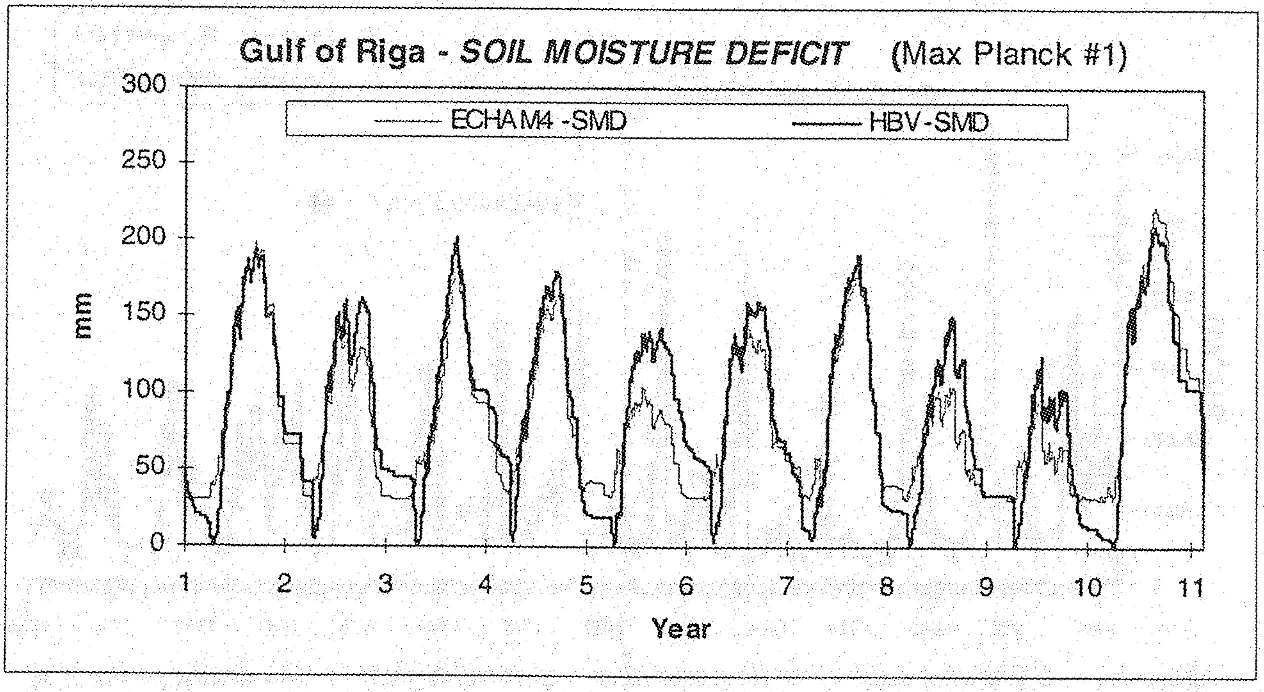


Figure 2. Comparison between the dynamics of the soil moisture accounting of the ECHAM-4 model and HBV-96 for the Gulf of Riga catchment. The HBV model is driven by precipitation and air temperature data from ECHAM-4 in this case.

Internal validation

Compensating errors are a source of frustration for modellers. This makes it difficult to exclude the suspicion that the model might give good results, but for the wrong reason. In forecasting this might not be so critical, but for our understanding of the climate system the proper modelling of each process is important. In the case of runoff modelling it has been shown several times that similar results can be obtained with quite different model structures and even with one model under different parameter settings. Validation of internal processes in a model is one way of counteracting the problem.

Figure 3 shows how the HBV-model has been applied to several processes simultaneously in a small research basin, Svartberget, outside Umeå in Northern Sweden. The results were obtained by using a criteria of agreement expressed as a weighted sum of deviation between modelled and observed snow depth, groundwater levels and runoff. The fact that all these curves show reasonable agreement strengthens our confidence in the entire model structure. It is planned to supplement this study by validation against soil moisture data in the future.

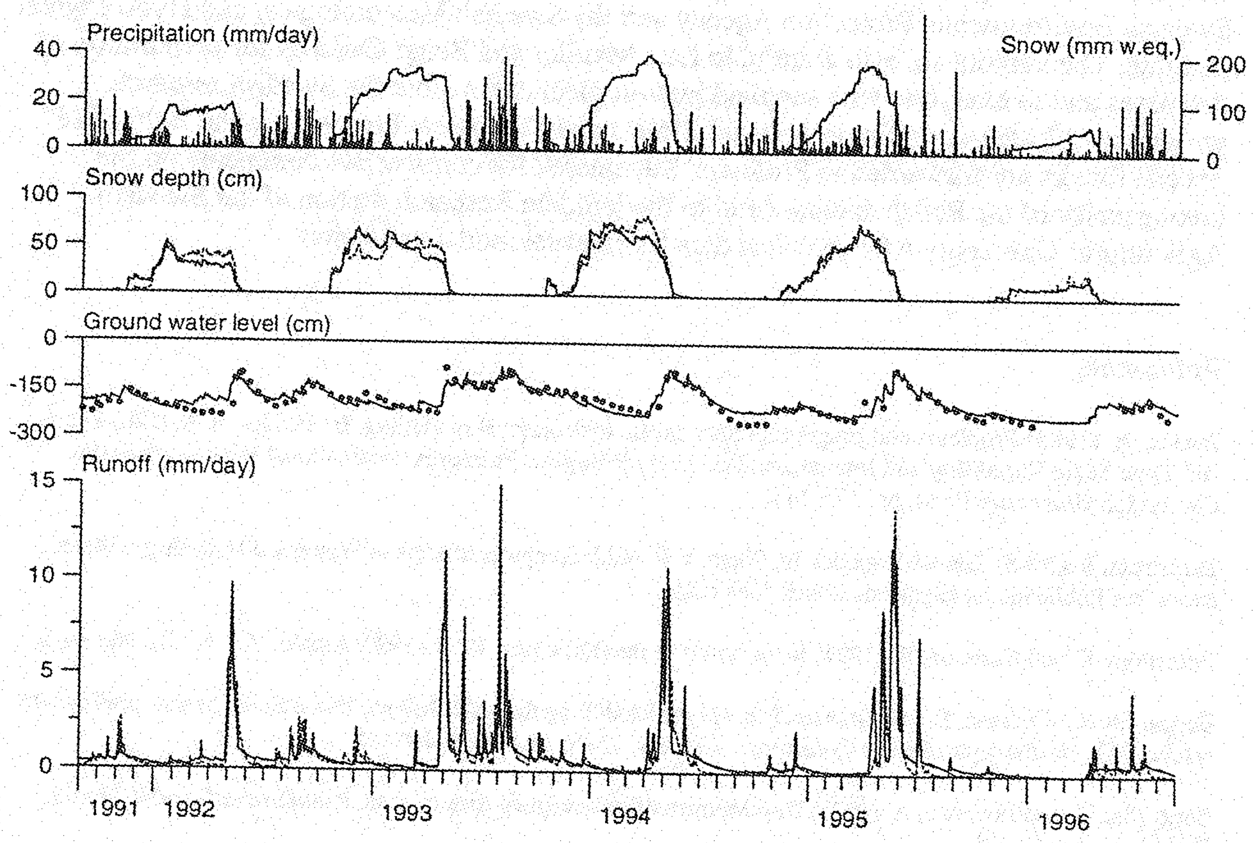


Figure 3. *Simultaneous calibration of the HBV model to snow depth, groundwater levels and runoff in the Svartberget research area in Northern Sweden. Dotted lines represent observations. The figure shows a five year sequence extracted from a*

16 year calibration period. Observed data are obtained from the Vindeln Research Station of the Swedish Agricultural University.

Conclusions

So far the application of the HBV model to the continental scale is encouraging as concerns runoff, although some problems related to homogeneity of the databases have been identified. The preliminary comparisons with the ECHAM-4 model output show relatively good agreements for soil moisture while snow and runoff differ considerably.

The application of the HBV-model to a research area in Northern Sweden showed that it was possible to carry out a simultaneous calibration of snow depth, groundwater levels and runoff. It is strongly felt that this approach should be explored further to avoid compensating errors in hydrological models. Of particular interest is the inclusion of soil moisture data in this process.

Acknowledgements

This work was carried out within the NEWBALTIC project with funds from the European Commission's Programme Environment and Climate (Contract No. ENV4-CT95-0072), the Swedish Environmental Protection Agency and the Swedish Meteorological and Hydrological Institute. The authors are also grateful to Lars Meuller and Bengt Carlsson for preparation of databases and to everyone who supplied hydrological data within the Swedish research programme "Large-scale Environmental Effects and Ecological Processes in the Baltic Sea". Special thanks are forwarded to Professor Kaczmarek for constructive comments on the homogeneity of the Polish database and to the Vindeln Research Station of the Swedish Agricultural University who provided data for internal model validation.

References

Becker, A. (1995) Problems and progress in macroscale hydrological modelling. In: Feddes, R.A. (Ed.) Space and Time Scale Variability and Interdependence in Hydrological Processes. International Hydrology Series, Cambridge University Press, pp. 135-143.

Bergström, S. (1995) The HBV model. In: Singh, V.P. (ed.) Computer Models of Watershed Hydrology. Water Resources Publications, Highlands Ranch, Colorado.

Bergström, S. and Carlsson, B. (1994) River runoff to the Baltic Sea: 1950 - 1990. Ambio, Vol. XXIII, No. 4 - 5.

Bergström, S., Carlsson, B. and Graham, L.P. (1996) Modelling the water balance of the Baltic basin - preliminary results. XIX Nordic Hydrological Conference, Akureyri 13-16 Aug. 1996, Iceland.

Bergström, S. and Forsman, A. (1973) Development of a conceptual deterministic rainfall-runoff model. Nordic Hydrology, 4, 147-170.

Blöschl, G. and Sivapalan, M. (1995) Scale issues in hydrological modelling: A review. Hydrological processes, Vol. 9, pp. 251 -290.

Dooge, J.C.I. (1995) Scale problems in surface fluxes. In: Feddes, R.A. (Ed.) Space and Time Scale Variability and Interdependence in Hydrological Processes. International Hydrology Series, Cambridge University Press, pp. 121-32.

Killingtveit, Å., Saelthun, N.R. Saether, B., Taksdal, S. and von Hirsch, R. (1990) Programmet till HBV-modellen. (The program code for the HBV model, in Norwegian). SINTEF, Norwegian Hydrotechnical Laboratory, Rapport STF 60 A90033, Trondheim.

Kite, G.W., Soulis, E.D. and Kouwen, N. (1995) A hierarchical approach to the connection of global hydrological and atmospheric models. In: Feddes, R.A. (Ed.) Space and Time Scale Variability and Interdependence in Hydrological Processes. International Hydrology Series, Cambridge University Press, pp. 111-118.

Lindström, G., Johansson, B., Persson, M., Gardelin, M. and Bergström, S. (1997) Development and test of the distributed HBV-96 hydrological model. Accepted for publication in Journal of Hydrology.

Renner, C.B. and Braun, L. (1990). Die Anwendung des Niederschlag-Abfluss Modells HBV3-ETH (V 3.0) auf verschiedene Einzugsgebiete in der Schweiz. (The application of the HBV3-ETH (V 3.0) rainfall-runoff model to different basins in Switzerland, in German). Geographisches Institut ETH, Berichte und Skripten Nr 40, Zürich.

Roeckner, E., Arpe, K., Bengtsson, L., Christoph, M., Claussen, M., Duemenil, L., Esch, M., Giorgetta, M., Schlese, U., and Schulzweida, U. (1996) The atmospheric general circulation model ECHAM-4: Model description and simulation of present-day climate, Max-Planck-Institut für Meteorologie, Report No.218, Hamburg

Vehviläinen, B. (1986) Modelling and forecasting snowmelt floods for operational forecasting i Finland. Proceedings from the IAHS symposium: Modelling Snowmelt -Induced Processes, Budapest, IAHS Publ. No: 155.

Wheater, H.S., Jakeman, A.J. and Beven, K.J. (1993). Progress and directions in rainfall-runoff modelling. In: Jakeman, A.J., Beck, M.B. and M.J. McAleer (Eds.) Modelling Change in Environmental Systems. John Wiley & Sons Ltd.

Wood, E.F. (1995) Heterogeneity and scaling land-atmospheric water and energy fluxes in climate systems. In: Feddes, R.A. (Ed.) Space and Time Scale Variability and Interdependence in Hydrological Processes. International Hydrology Series, Cambridge University Press, pp. 3 -19.

"HYDROGRAPH GGI-96" Model and Peculiarities of Modelling of the Neva River Hydrograph

Yu.B.Vinogradov
State Hydrological Institute
St. Petersburg, Russia

"HYDROGRAPH GGI-96" (6th version) is a deterministic mathematical model of runoff formation with distributed input and parameters. It covers all types of runoff and may be applied to any physiographic region and river basin of any size. Parameters are distributed over basin area (improved system of representative points) and over vertical within a soil-plant column, i.e. litho-pedo-phyton (design soil layers). The model takes into account local space heterogeneity of the snow cover.

Design time interval - 24 hours or shorter.
Model input - precipitation depth, duration of liquid precipitation, air temperature, air humidity deficit.
Model output - continuous runoff hydrograph, discrete in accordance with the design time interval.
Model algorithms, describing runoff formation, contain blocks of the following components of the land phase of the water cycle:

(1) Formation and melting of the snow cover
(2) Evapotranspiration
(3) Infiltration and surface flow formation
(4) Soil water dynamics and formation of soil outflow
(5) Dynamics of heat energy and phase transitions in soil
(6) Subsurface runoff formation
(7) Pre-channel and channel transformation of runoff
(8) Runoff at the outlet.

"HYDROGRAPH" model is a component of a developed more sophisticated "Runoff - Erosion - Contamination" Modelling system. The following modes of the System operation, and, consequently, the "Hydrograph" model operation, are to be provided:

(1) Research (estimation of parameters and numeric experiments)

(2) Chronological (computation of hydrographs from the observed meteorological data)

(3) Probabilistic (deterministic-stochastic modelling, computation of the coordinates of runoff distribution curves)

  (a) observed meteorological data

  (b) meteorological data modelled from "Stochastic weather model"

(4) Prognostic (modelling of runoff hydrograph and extrapolation of input meteorological data; specified and probabilistic forecasts)

(5) Simulation (under expected or predicted conditions of the anthropogenic changes in landscapes and climate)

(6) Training (learning principles of modern hydrology, preparation of Modelling system users).

Two main designer's ideas have been realized in the "Hydrograph" model:

- a necessity of achievement of a conventional equilibrium in the search if most simple solutions at the attempt to reflect the natural processes and laws most adequately;

- to follow the universality principle: a complete set of probable situations during runoff formation, basins of any size, mountain and lowland conditions, any landscapes, possible conjugation of erosion and basin contamination models, orientation to minimal standard information.

The principle of universality should not contradict the peculiarities of runoff formation under specific conditions.

The essence and algorithmic content of the "HYDROGRAPH" model differs greatly from any other model. This primarily concerns some erroneous ideas on the adequacy of differential equations of water conductivity (moisture diffusion) and water motion in the basin to the actual processes in Nature.

The basic idea is as follows: a basin is not a set of different surfaces down which water flows as a complete layer or as jets, but it is a system of runoff components. Runoff components are surface or subsurface basin areas restricted by microwatershed-divides; and these basin areas are faced by their open "spillway" side to the overland non-channel or subsurface drainage network. The sizes of surface runoff components vary inversely from 10   up to 10 sq.m, depending on the slope; subsurface components are larger than surface components. For runoff component, the outflow from it is non-linearly connected with the volume of water accumulated by its capacity. It should be noted that runoff components are not some idealization suitable for computations; they may be easily identified to natural formations.

Another important moment is an account of slope effect on numerous hydrometeorological processes. Besides a direct effect of the angle of the plane slope on the direct solar radiation income, the slope influence on the dynamics of heat and moisture is much more significant as it seems to be at first sight. The area of moisture and heat exchange between the slope and the atmosphere, finally affecting evaporation and energy income to soil, tends to increase with the increase of the slope steepness. It should be also kept in mind that at any slope the systems of coordinates suitable at the description of energy and water fluxes do not coincide, which should be taken into consideration.

One more interesting problem is: as rain duration does not coincide with the duration of the design time interval, the surface runoff layer for hat interval should be determined by an appropriate stochastic equation which takes into account the duration of precipitation fall directly.

The model is oriented to the simplest network meteorological information (air temperature and humidity deficit, precipitation depth and rainfall duration), but with a simultaneous use of some factors which make the model efficiency higher. These factors are: the use of effective temperature and humidity deficit which differ from usual temperature and humidity deficit by an additional addend proportional to that computed for the data on latitude, altitude, slope and orientation to the income of direct solar radiation. It is very important to specify input meteorological components at representative points (RP), i.e. in the nodes of the space grid, which is accomplished for the temperature with the account of climate altitudinal gradients, and for precipitation - as a result of interpolation of not immediate values but of the magnitudes relative to the annual total amount estimated independently.

Model parameters distribution is possible over area and over soil depth. The regulated system of representative points is arbitrary combined with the map of the river basin. In our case the points are located in the centres of similar circles which are located on the plane as densely as possible (hexagonal package). The RP is characterized by the coordinates, elevation above sea level, exposure, slope and in general it may be identified to "a point" on a locality. Meteorological information from meteorological stations is interpolated in the RP. Since the RPs appear to be within some runoff-forming complex (RFC) these points get the parameters of this RFC.

All computations for each RP are repeated in several variants in accordance with the areal heterogeneity of water equivalent of snow pack on a slope.

A list of data essential for runoff formation modelling is given below.

1. Basic characteristics: basin area, the order of the main stream at the outlet (according to Horton-Strahler), design time interval, number of representative points (RP), number of design (quantile) points in the RP, number of subsurface regulating capacities (SRC), number of design soil layers (DSL).

2. RP characteristics: latitude, orientation, elevation above sea level, slope angle, percentage of ravines, percentage of lakes, percentage of swamps, glaciation, orographic shading rate, time lag.

3. Landscape (runoff-forming complex, ecosystem) parameters: phenological dates, shading rate of the land surface by the tree crowns, interception rate, parameters of evaporation rate from soils and plants, parameter of evaporation from the interception capacity, parameter of heat energy delivery to the soil surface, landscape albedo, interception capacity albedo, coefficients of snow storage in ravines and depressions, space coefficient of variation of water equivalent of snow pack, maximum percentage of pools, coefficient of clogging of pool bottom, maximum depth of surface retention, hydraulic parameters of surface and subsurface regulating capacities, density of the DSL matter, DSL porosity, maximum water-holding capacity of the DSL, coefficient of filtration of the DSL, specific mass heat capacity of the DSL matter, specific heat conductivity of the DSL matter, factor of ice percentage effect on filtration to the DSL, contribution of the DSL to the evapotranspiration.

4. Hydrogeological parameters of the RP: hydraulic parameters of the SRC and the share of the SRC contribution to the river recharge.

5. Climate parameters of the RP: mean annual cloudiness, mean number of days with precipitation (with daily precipitation layer $H\ ^{2}\ 1$ mm), nonlinearity factor of rainfall duration dependence upon its depth, coefficient of liquid precipitation duration, mean annual temperature of soil at the depth of 1.6 m, amplitude of the approximating sinusoid of the annual variation in soil temperature at the depth of 1.6 m, sinusoid phase, mean annual precipitation, mean annual gradient of air temperature, mean annual deficit of air humidity.

Runoff modelling in the Neva river basin is characterized by some peculiarities which in general should be included into such a universal model as "HYDROGRAPH GGI-96". The required supplements to the algorithms and to the model software are being made. These supplements are as follows:

1. Account of specific "transit" points on the basin watershed-divide (e.g., discharge is accomplished across these points from the above lakes) and "points of bifurcations" (across these points water may flow from the other basins and discharge beyond the basin).

2. Account of "lake percentage", i.e. numerous small lakes within certain landscapes. The estimation whether the lake is big or small is connected with the dimensions of the river basin to be modelled and with the rate of generalization.

3. Introduction the "Large lake" module to the algorithmic system, which takes into account the water inflow to the lake, precipitation onto the lake surface and evaporation from the lake. Water outflow from the lake may be considered in two variants, i.e. natural and artificial control. In the first case a dependence of water discharge from the lake upon water level in the lake is used (see Fig.); in the second case data on water discharges released across the dam are used.

Figure caption

Dependence of water discharges at the Neva river upper head upon water level in Lake Ladoga in case of ice cover available and free from ice.

Land surface processes in hydrological and atmospheric models

Heinz-Theo Mengelkamp and Kirsten Warrach

GKSS Research Center, Institute for Atmospheric Physics, D-21502 Geesthacht

1. Introduction

Understanding the two-way interactions in the soil-vegetation-atmosphere system and its appropriate parameterization in atmospheric and hydrological models is essential for climate simulations and climate change studies, weather prediction and water resources research. The atmospheric circulation on a wide range of spatial and temporal scales and processes like cloud formation and rainfall are influenced by the transfer of energy and water from the earth's surface. These transfer processes in turn depend on atmospheric parameters (air temperature, humidity, windspeed and radiation), surface characteristics (vegetation, topography) and soil quantities (temperature and moisture content). Soil moisture is a key parameter for the hydrological cycle as it controls the partitioning of precipitation into overland flow and subsurface runoff, water storage in the soil column and evapotranspiration.

Various parameterization schemes for the soil-vegetation-atmosphere-transfer (SVAT schemes) have been developed during the last decade and were implemented in atmospheric circulation models as well as in hydrological models. While for the atmospheric circulation the transport of sensible and latent heat and the net radiation are of major importance, the controlling processes for the transport and storage of water in the soil are precipitation and evapotranspiration. It is for this reason that SVATs designed for atmospheric models are often calibrated with the intention of optimizing the description of the energy balance, and that those coupled to a hydrological model focus on the water budget; and sometimes they even ignore components of the energy balance.

The SVAT scheme SEWAB (Surface Energy and Water Balance) was designed to be implemented in an atmospheric mesoscale model. In this paper we describe its validation with data from two atmospheric field experiments, concentrating on the sensible and latent heat fluxes, and a first attempt to compare the runoff production with observatios.

2. Validation of the SVAT scheme SEWAB

The one-dimensional SVAT scheme SEWAB has been designed to be coupled to an atmospheric mesoscale model. It solves the coupled system of the surface energy and water balance equations considering partly vegetated surfaces. Following Noilhan and Planton (1989) and Deardorff (1978) it is based on the so-called one-layer concept for vegetation cover with separate calculation of evaporation from bare soils and wet leaves and of transpiration from dry vegetation. Precipitation is partitioned into evapotranspiration, runoff and change in soil moisture storage. The net radiation flux is balanced by the sensible, latent and soil heat flux. Within the soil column the vertical diffusion equations for soil temperature and soil moisture are solved semi-implicitely at a vairable number of layers. In its basic version runoff is produced only from saturated soils.

A data set from the FIFE experiment (FIFE special issue, 1992) for the period of 30 June to 11 July 1987 was used to validate SEWAB with emphasis on the turbulent fluxes of heat and moisture. 30 minute averages of the atmospheric forcing data were supplied as site averages from 10 stations, the flux data were averaged from 6 eddy correlation sites and 11 Bowen ratio sites. The soil type was given as silty loam and the vegetation as grass. Figures 1 and 2 show the latent heat flux and surface temperature, respectively, as observed and calculated.

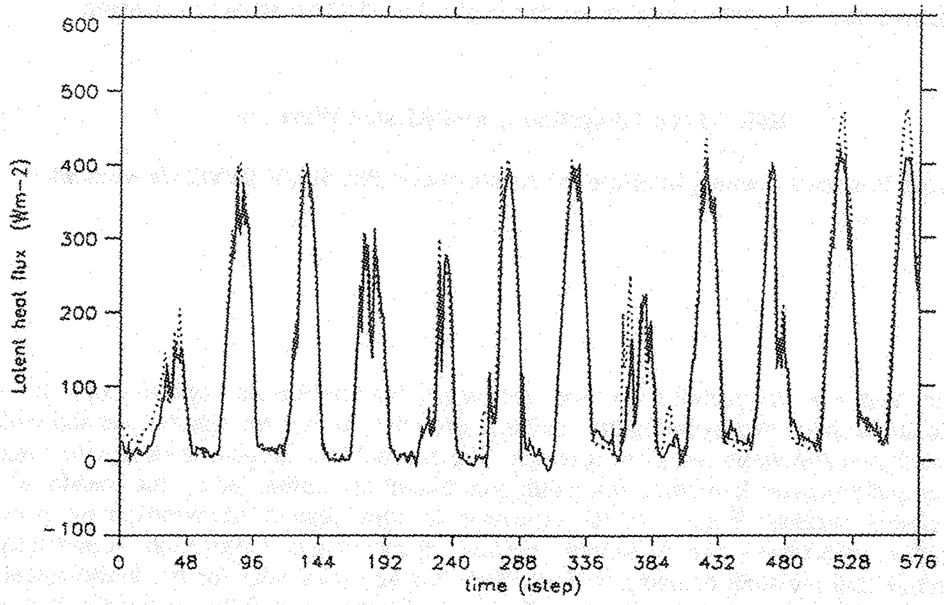


Fig. 1: Comparison with a FIFE data set: observed (solid) and calculated (dotted) latent heat flux

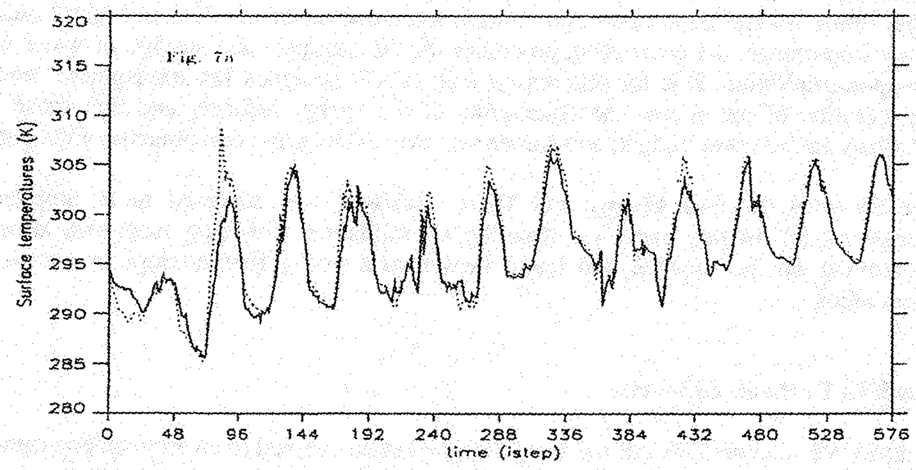


Fig. 2: Comparison with a FIFE data set: observed (solid) and calculated (dotted) surface temperature

In the framework of the GEWEX project PILPS (Project for Intercomparison of Land-surface Parameterization Schemes, (Chen, Henderson-Sellers, Qu, 1996) during phase 2a meteorological data for the year 1987 from the CABAUW tower in the Netherlands were used as atmospheric forcing to drive 23 land-surface schemes designed for use in climate and weather forecast models. Sensible heat flux into the atmosphere, net radiation, upward longwave radiation and heat flux into the ground were measured independently, and latent heat flux was derived by energy balance. These fluxes were compared with SVAT scheme results. Figure 3 shows the annually averaged sensible versus latent heat flux. The runoff versus evapotranspiration is depicted in Fig. 4. The range of the annual mean of sensible and latent heat fluxes is between 30 W/m^2 and 25 W/m^2, respectively. Evapotranspiration and runoff have ranges of 315 mm per year (Chen et al. 1996). SEWAB obviously calculates too less evapotranspiration and consequently too much runoff at least if applied on a yearly time period.

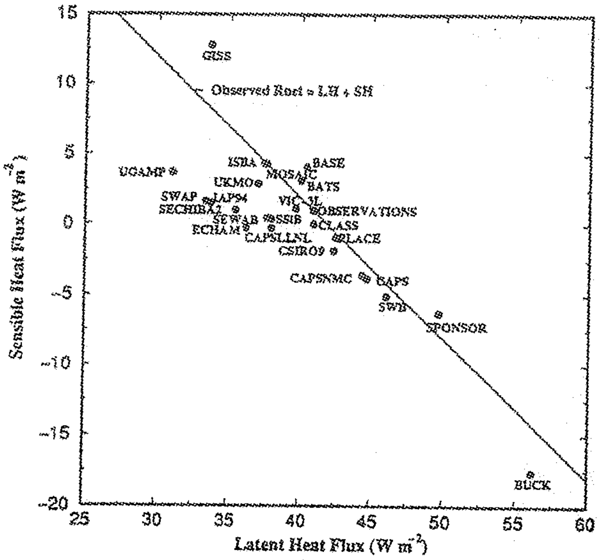


Fig. 3: Annual averaged sensible versus latent heat flux

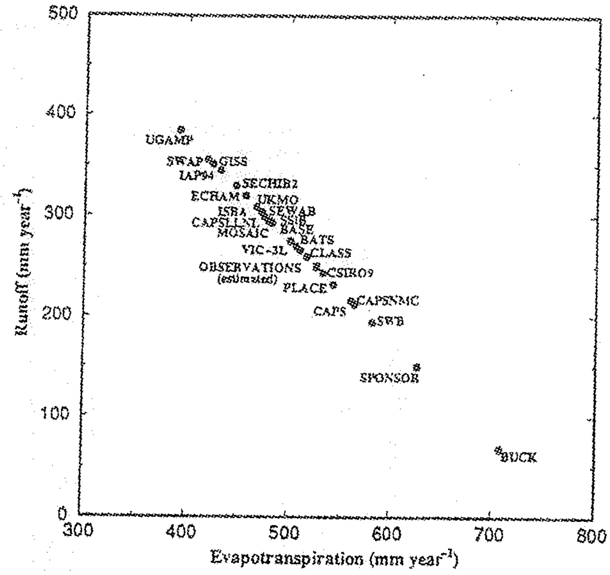


Fig. 4: Annual averaged evapotranspiration and runoff

3. Sensitivity of runoff production to soil moisture processes

For PILPS phase 2c (Lettenmaier, 1996) we were provided among other data with the hourly meteorological and daily hydrological data for the period from 1979 to 1987 of the semi-arid Black Bear River catchment of 1491 km^2 (36 N, -97 E). Table 1 shows the characteristics of the catchment. The atmospheric forcing was homogeneous over the catchment. From Table 2 we see that the basic version of SEWAB (run 1) produces too much runoff for 6 of 8 years.

Parameter	Black Bear River
soil depth	1 m
root depth (90 % of roots)	0.3 m
saturated soil moisture	0.48
saturated hydraulic conductivity	2.64E-6
saturated suction head	-0.479
sand	23 %
clay	19 %
Clapp and Hornberger parameter b	4.55

Table 1: Parameter of the Black Bear River

Year	precipitation [mm/y]	meas. runoff [mm/y]	run1* runoff [mm/y]	run 2* runoff [mm/y]	run 3* runoff [mm/y]	run 4* runoff [mm/y]
1980	914	144	209	211	217	217
1981	781	15	40	47	17	25
1982	753	101	143	141	137	131
1983	890	111	163	171	141	143
1984	653	87	48	50	26	29
1985	1016	188	252	249	213	208
1986	1314	348	544	549	549	549
1987	1000	234	204	208	194	196

Table 2: Annual runoff of the Black Bear River
run 1: basic SEWAB version
run 2: run 1 with variable infiltration capacity
run 3: run 2 with ARNO baseflow scheme
run 4: run 3 with variable saturation conductivity

Figure 5 shows the observed runoff and the results from the basic version of SEWAB (run 1) for a 60 day period. No runoff was caculated before day 1228 when a major precipitation event occured. The runoff calculated due to this precipitation event starts later and is smaller than the observed runoff whereas more runoff than observed is

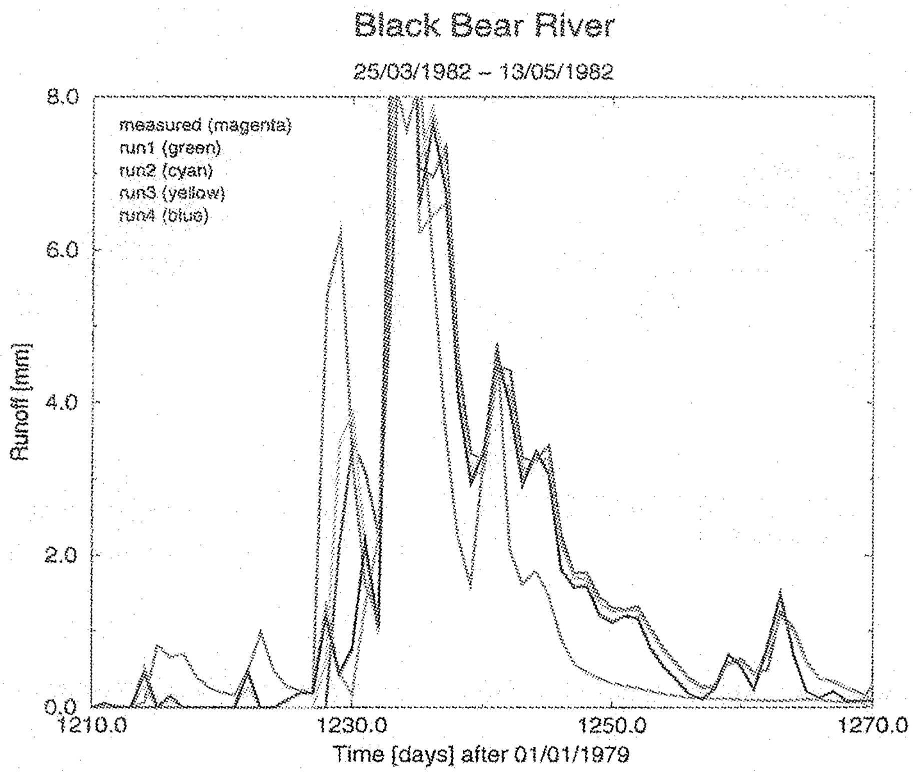


Fig. 5: Measured and calculated runoff of the Black Bear River

calculated after day 1240. The inclusion of a variable infiltration capacity after the Nanjing model (run 2) (e.g. Wood et al. 1992) allows surface runoff already before day 1228. Here it is assumed that runoff is produced even before the whole grid element is saturated due to heterogeneities over the area. However, no improvement is seen in the annual runoff. Additionally to the variable infiltration capacity the calculation of the subsurface runoff was modified after the Arno model conceptualization (Francini and Pacciani, 1991) (run 3). With this the runoff curve gets closer to the observations (Fig. 5) and slightly reduces the annual runoff averaged over all years. A third modification of the soil model was tested regarding the vertical profile of the saturation hydraulic conductivity. Instead of a constant value over the soil column we applied an exponential function with a large value at the surface and decreasing values with increasing depth (run 4) (Beven, 1984). This was supposed to allow the water to drain faster through the uppermost layers which ,however, had only a minor effect on the runoff production. The mean annual runoff was measured as 154 mm/y. The difference to the calculated runoff is 65 mm/y for runs 1 and 2 and was reduced mainly by inclusion of the Arno baseflow scheme to 59 mm/y in run 3. Run 4 shows a difference of 57 mm/y.

The FIFE data set was prepared by Alan Betts and gratefully provided by Yongkang Xue and Izuru Takayabu. Figures 3 and 4 are taken fom Chen et al. (1996).

References

Beven, K., In V.K. Gupta et al (eds) 1984: Scale problems in hydrology, 107-151
Chen, T.H., A. Henderson-Sellers and W. Qu, 1996: IGPO Publ. Series (PILPS).
Deardorff, J.W., 1978: J. Geophys. Res., **83**, 4, 1889-1903
FIFE special issue, 1992: J. Geophys. Res., **97**, D17
Francini, M. and M. Pacciani, 1991: J. Hydrol., **122**, 161-219
Lettenmeier, D.P., D. Lohmann, E.F. Wood and X. Liang, 1996: PILPS-2c draft workshop report
Noilhan, J. and S. Planton, 1989: Mon. Weath. Rev., **117**, 536-549
Wood, E.F., D.P. Lettenmeier and V.G. Zartarian, 1992: J. Geophys. Res., **97**, 3, 2717-2728

NOPEX modelling activities: Towards a coupled hydrological and meteorological mesoscale model.

Lars Gottschalk, Dep. of Geophysics, University of Oslo, Norway.
Sven-Erik Gryning, Dep. of Meteorology and Wind Energy, Risø National Laboratory, Denmark.
Yuri Motovilov, Institute of Applied Ecology, Moscow, Russia.
Stein Beldring, Dep. of Geophysics, University of Oslo, Norway.

1. Introduction

The inter-European multi-disciplinary NOPEX (NOrthern hemisphere climate Process land surface EXperiment) project is one out of a few prioritised full-scale land-surface experiments within the IGBP-BAHC framework. Together with projects like EFEDA and HAPEX-Sahel it forms a full-fledged European contribution to the international research about land-surface-atmosphere exchange and the climate system. It is also an essential component in connection to WCRP, both in terms of the strategy formed by the joint IGBP-WCRP working group on land-surface experiments and as an element in the BALTEX initiative. The NOPEX region has furthermore been selected as a key target area for ESA's EMAC campaign. NOPEX is an official Swedish contribution to UNESCOs IHP V programme and the major project within the Environment Research Programme 1993-95 of the Nordic Council of Ministers. WINTEX - Land -surface-atmosphere interactions is a part of NOPEX intended to study the wintertime boreal landscape (co-ordinated by Prof. Sven Halldin in Uppsala). WINTEX is funded by the European Commission.

The problem of spatial integration of land surface parameters over a non-homogeneous land surface and especially the estimation of regional (grid) surface fluxes is a central issue for the land surface experiments performed and being performed (André, et. al 1986, Sellers et. al. 1988, Bolle et. al. 1990). The focus for these experiments has recently changed from dry climates to the boreal zones of the northern hemisphere (Halldin et.al. 1995, Halldin et. al. 1996, Sellers et.al. 1995). The spatial integration has up till now been approached in simplistic manners in the analyses of data from these experiments (Shuttleworth, 1994). A standard procedure is to compare averaged point flux estimates for a period of one day with those calculated for a certain grid from a meso-scale meteorological model (Betts et. al. 1993, Nichols & Cuenca 1993, Noilhan & Lacarrère 1992). Although the modelling studies referenced above have provided pointers there is a clear need of more methodological studies of this type. To what extent is meteorological prediction sensitive to hydrological-atmosphere coupling processes? To what extent can meteorological predictions be hydrologically interpreted, and how can models of relevant hydrological-atmospheric coupling processes be improved to enhance meteorological and hydrological predictions?

Presently the water and energy budget in weather prediction models rarely include a description of the transport of water masses at the land surface - the hydrology. Meteorological mesoscale models describe the atmospheric transformation with a resolution corresponding to the numerical grid size -a few km- over landscapes with high heterogeneity (landuse and topography). Various methods are used to describe the influence of heterogeneity to meteorological relevant parameter within a subgrid box of meteorological models (mosaic type: Avissar and Pielke 1989, explicit subgrid: Seth et. al., 1994). Under such high resolution the lateral transport of water across grid boxes influences the mass and energy balance at the surface.

There is a well documented interaction between evapotranspiration, cloud and precipitation formation and runoff (Mölders and Raabe 1996). But the large differences in the average evapotranspiration between simulations with and without consideration of subgrid heterogeneity require research in all types of subgrid processes. The hydrology is from the side of the numerical meteorological model a scale which must be handled as a physically subgrid process (Mölders et. al. 1996c).

Heat and mass fluxes associated with landscape discontinuities, for instance, are typically larger than turbulent fluxes and may contribute significantly to subgrid scale fluxes. Thus, the consideration of heterogeneity introduces changes in evapotranspiration over land surfaces which plays an important role in determining surface temperature, lower tropospheric moisture and runoff. The impact of ground water level, flooding and soil moisture on cloud and precipitation formation as well as the related feedback processes have to be investigated. In this context it is noteworthy that there might be a different forcing and different possible feedback processes if the soil moisture and ground water are coupled or decoupled.

Valuable insight may be gained by comparison of high-quality data sets and model calculations, Betts et. al. (1993), which gives incitements for model development. The NOPEX two concentrated field efforts (CFEs) during June 1994 and April-July 1995 provide such high quality data sets for a Boreal environment. The theoretical development of regional hydrological and atmospheric modelling has until now been going on independently but with many parallels. The intention is to utilise the synergistic potential in a multi-disciplinary project like NOPEX in a joint systematic approach to the coupling between the atmospheric and hydrological processes, aiming at regional estimates of energy and water exchange. A distant goal is to develop a tool for regional assimilation consistent with meteorological and hydrological processes.

A distributed hydrological model (ECOMAG) and a meso-scale meteorological model (MIUU) have both separately already been applied to the NOPEX area. These are the two basic components that at present are modified to allow coupling experiments and will be shortly presented below. The ongoing activity within the NOPEX to compare and evaluate different methods for regional flux estimation has also relevance as a step in validating and conforming the model structures. A third activity of importance is related to scale issues. The final coupling is planned to start in 1998, if required research funding is made available.

2. NOPEX

The model development is centred around the data from the NOPEX experiment. The southern NOPEX region consists of surface elements of which totally 59 % is coniferous and mixed forest, 27% agricultural land, 7% mires and 4% lakes. The area is therefore well suitable for studying the inter- and intra-patch variability of energy and mass exchange processes. The landscape information to be used in this project is available in the GIS component of the NOPEX data base SINOP (Halldin and Lundin 1994). Measured meteorological and hydrological as well as remotely sensed data from NOPEX CFE2 will be used and also these are contained in SINOP.

The data sets of special interest here are:

- Two forest sites equipped with eddy correlation instruments for flux measurements of latent and sensible heat fluxes.

- Three agricultural sites equipped with eddy correlation instruments for flux measurements of latent and sensible heat fluxes

- At two lakes micro-meteorological studies were performed. Heat energy exchange over the lake water was measured by applying the bulk aerodynamic (profile) and the eddy correlation techniques.

- Detailed hydrological studies were concentrated to five experimental basins during the NOPEX CFE2. They included measurements of discharge, groundwater levels and soil moisture as well as standard climatological variables. The sites for groundwater and soil moisture measurements are also chosen to represent different geomorphologic situations (hollow, slope, nose) within the experimental basins.

- The weather radar at Arlanda airport is the main instrument for mapping precipitation fields across the NOPEX region. It has a resolution of 2x2 km^2 and covers the whole region. The system was in operation during CFE2. In addition data from the regular precipitation network will be used including automatic precipitation stations.

- The regular hydrological discharge observation network in the NOPEX area has 11 standard observation stations and the corresponding drainage basins cover its total area.

- All turbulence flights during NOPEX CFE2 can be used for the validation of the coupled models.

3. Hydrological Model Formulation.

Distributed hydrological models allow the determination of water balance and its variation across river basins. Several such models are in common use (i.e. SHE-model, TOPMODEL) but none of them explicitly contains components reflecting important characteristics of the Boreal landscape like mires, lakes and the dense interrelationship between soil moisture and groundwater in the till soils. Preliminary analyses of surveys of runoff data indicate that the main factors to explain their spatial variation are the frequency of lakes and mires in upstream areas (Erichsen et.al., 1995). Here a distributed hydrological model ECOMAG (Motovilov and Belokurov, 1995) developed for application to Boreal conditions will be used. The model describes the processes of soil infiltration, evapotranspiration, thermal and water regimes of soil, surface and subsurface flow and groundwater and river flow and also snow accumulation and snowmelt. It thus has a potential for later application to the EU-funded WINTEX project. A drainage basin is approximated by irregular triangular or trapezoidal elements considering peculiarities of topography, soil types, vegetation and land use in a GIS frame (see Fig. 2.1). The model has already been widely applied and tested in Russia for many years. It is based on a 15-years experience of the development and application of distributed physically based hydrological models (Kuchment et al., 1983,1986, 1989, 1990, 1993, Demidov & Motovilov, 1984, Motovilov 1986, 1987, 1993).

ECOMAG has already been calibrated and validated against standard climatological and hydrological data for the four main drainage basin of the NOPEX area for the period 1981-1995, which includes the NOPEX CFE1 and CFE2 (Motovilov et al.,1997). The model structure has been improved to allow precipitation input evaluated from weather radar data on a grid 2x2 km^2. This spring the results of model runs with standard input data and with radar based data are evaluated against distributed data on soil moisture, ground water levels and synoptic river discharge measurements. New improved components will be implemented into the ECOMAG model for mires and lakes. Dependent on the results of the validation also other modifications can be found necessary.

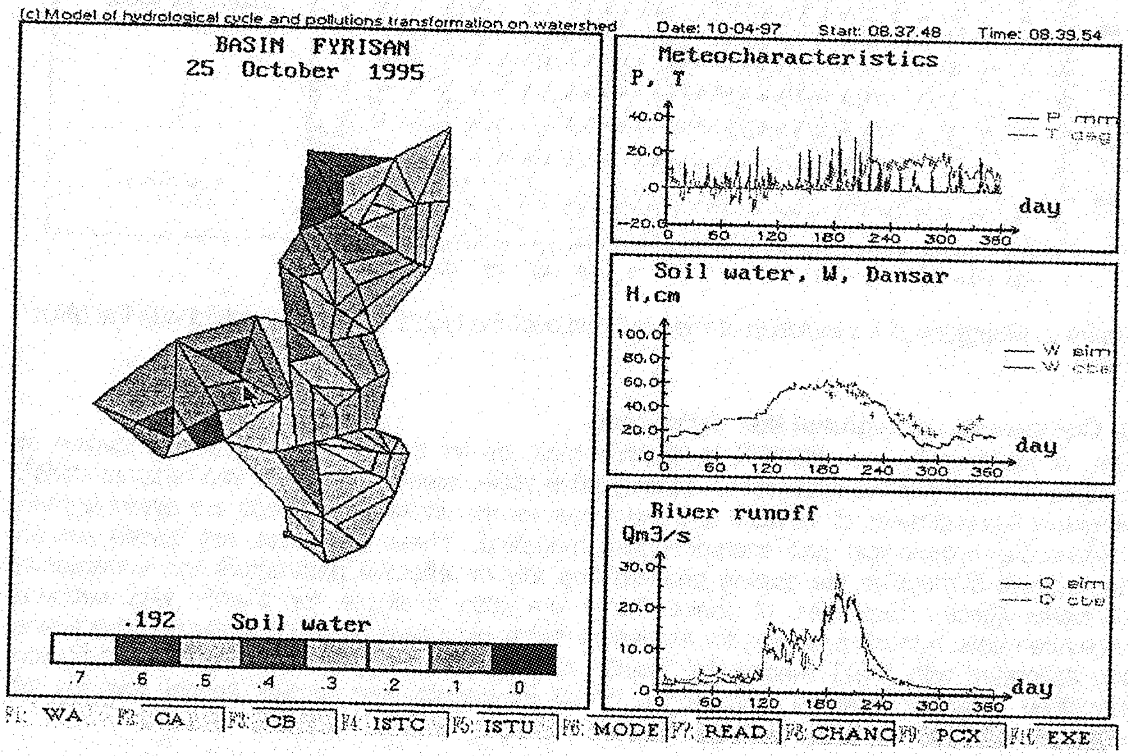


Figure 1. Illustration of a model run with the ECOMAG model for Fyrisån, the largest drainage basin (950 km^2) within the NOPEX area.

4. Meteorological Model Formulation

A dynamic meso-scale model is employed in the present study that is developed at the

Department of Meteorology, Uppsala University (MIUU). The MIUU model is a three-dimensional meso-scale meteorological model that uses a higher order turbulence closure scheme. It is designed for studies in the meso-gamma-scale i.e. roughly in the interval 2-20 km. The model consists of prognostic equations for the u and v wind components, liquid water, potential temperature, mixing ratio of total water and turbulent kinetic energy, all transformed in a terrain influenced co-ordinate system. The prognostic equations are solved by using a third-order scheme both in space and time for the advection terms. The diffusion terms are solved by finite implicit scheme. Temperature at the surface is determined from the surface energy balance equation. A prognostic equation involving the soil and other fluxes is used for predicting the soil temperature (known as the force-restore method). The MIUU model has already been implemented and run for the NOPEX area. This spring (1997) detailed model validation is performed using available observations (Fig. 2). The vegetation parameterisation in the model is improved. Dependent on the results of the validation also other modifications can be found necessary. These improvements will all be ready before the start up of the present project.

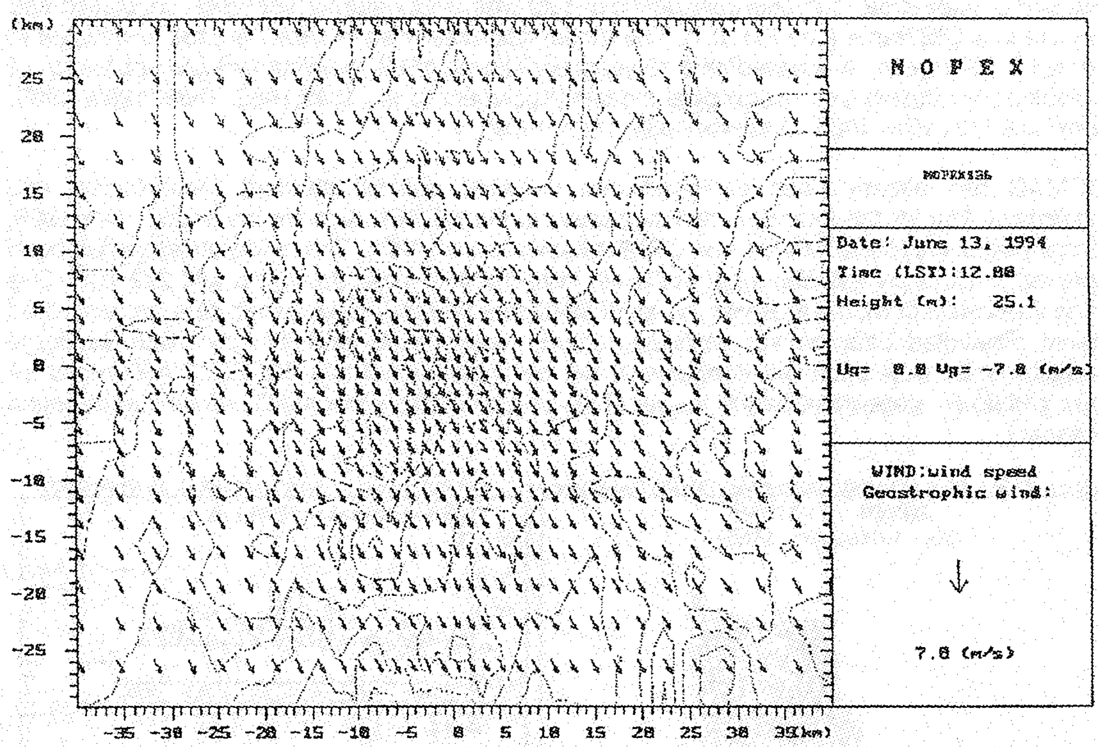


Figure 2. Illustration of a simulation of the wind field over the NOPEX area performed with the MIUU model

5. Comparison of regional flux estimates.

One of the objectives of NOPEX is "Explore methods for aggregation and disaggregation of parameters between the three spatial scales; patch scale, intermediate scale and regional scale". Regional flux estimates of sensible and latent heat for the whole and/or parts are available from meso-scale hydrological and meteorological modelling. These estimates are based on an aggregation strategy to the scaling problem and rely on effective parameters for fundamental elements (grids). Estimates of these fluxes are also available for events with airborne measurements. A fourth possibility for estimation is to apply a disaggregation strategy where fluxes are estimated with SVAT models for "points" and these are aggregated in space either with simplified weighted average approaches or by integration over known spatial patterns or distributions of state variables and parameters.

At present a study is carried through to critically compare flux estimates from airborne measurements and mast measurements with those from meso-scale hydrological and meteorological modelling. The result of this intercomparison of flux estimates between models and between models and measurements is also of a vital importance as a preparation for coupling of models.

6. Scale issues

In meteorology and also in subsurface hydrology there is a tradition to distinguish between spatial variability in different scales. In surface hydrology it is a quite recent way of thinking. Basic is the concept of Representative Elementary Volume (REV) at which scale basic theoretical equations are founded. Wood et. al. (1988, 1990) have introduced a complementary concept of Representative Elementary Area (REA). At a certain scale a landscape element (a drainage basin or a grid cell) might contain a sufficient sample of the geomorphologic, soil and other relevant characteristics of the region. It is then no longer necessary to take account of the pattern of those characteristics but only their distribution. The underlying variability may still be important in controlling both discharges and evaporation fluxes, but the patterns are less important. The scale at which this happens defines the REA. The REA concept is not a direct analogy with the REV in subsurface hydrology. In the latter the REV denotes a scale at which average quantities of potential and moisture content can be used in a continuum description of the fluxes. In the former the distribution of characteristics may still be important in determining the fluxes but the REA denotes a scale at which the pattern of those fluxes is no longer important.

For the atmospheric surface layer the concept of blending height is central when discussing principles for aggregation. Mason (1988) more explicitly defines the blending height as a scale height at which the flow is approximately in equilibrium with the non homogeneous surface. This actually implies that the surface patterns are of no importance at this height and the fluctuations in fluxes from an area over which these conditions prevail can be represented by their distribution functions. The REA concept is thus also applicable.

Climate models are sensitive to the representation of the land surface. Two sources of uncertainty can be identified (Frank et al., 1997):

* one associated with the inherent scale problems in representing heterogeneous landscapes at the model grid element scale, and

* the lack of good estimates of parameter values at the grid scale over many grid elements.

Much of the discussion and theoretical development in the past has centred on the possibility of using "effective" parameter values, effective in the sense of taking into account of all the local scale heterogeneity of soil and vegetation type, topographic position, surface roughness, water stress, and meteorological variables that influence the landscape scale integrated fluxes.

Surface hydrologists are the last to enter the arena to cope with the scaling problem which is mainly due to the fact that they traditionally applied lumped models with calibrated effective parameters. When extending them to spatially distributed more "physically based" models effective parameters and calibration still plays an important role. Beven (1995) has questioned the possibility to apply hydrological theories, to large scale problems by assuming that the same equation holds and that effective parameters can be found appropriate to the scale required. Beven suggest a disaggregation framework and uses weighted averages that describes linear interactions but with non-linear models. The weights are determined applying fuzzy disaggregation. This is meant to avoid the over-parameterisation, similar functional behaviour and equifinality of behaviour in the parameter space in other approaches.

The alternative to effective parameters is to resolve the small scale variability in terms of probability density function (PDF). For the parameterisation of intra-patch heterogeneity Avissar suggests such a PDF approach. This is also the base for recently developed schemes for "Bottom up" hydrological macro-models for GCM applications (Entekabi & Eagleson, 1989, Johnson et al. 1993, Wood et. al. 1988, 1990, Wood 1994).

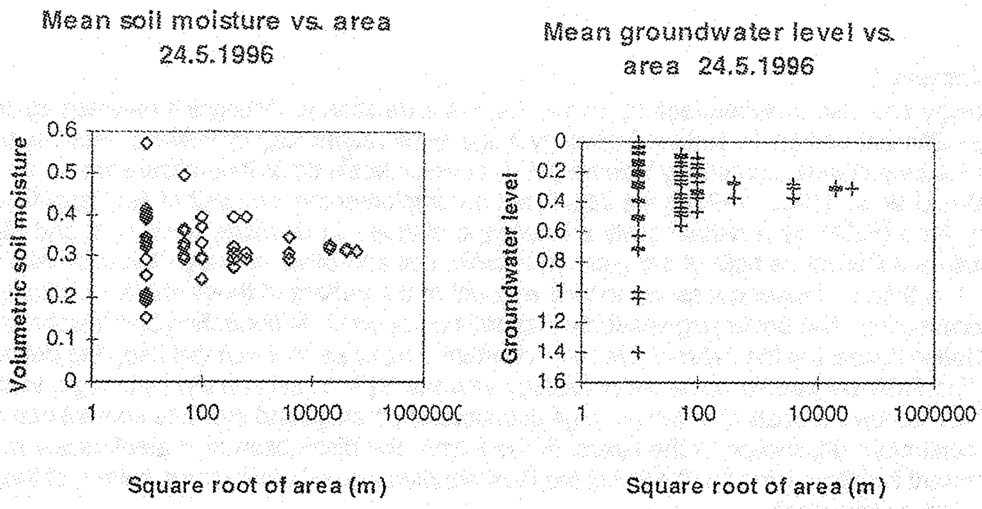


Figure 3. Spatial variation of soil moisture and groundwater levels as a function of scale of aggregation.

An ambition within the NOPEX project is to bring insight into the scale of variation patterns. For this purpose spatial data (digital terrain data; topography ,land use, soil types and remotely sensed data) have been analysed for the NOPEX area with respect to homogeneity, uniformity, correlation lengths and the effect of spatial aggregation (scaling) on these properties (Sulebakk et al.,1997). Soil moisture, groundwater and synoptic runoff measurements are analysed with the aim to identify spatial scales (patches, representative areas, REA) of relevance for aggregation approaches. Fig. 3 gives examples of plots used to identify REA for terrain with till soils. A preliminary conclusion is that for this type of terrain the main part of the spatial variability in soil moisture and groundwater fluctuations is contained in the grid size of 2kmx2km used for modelling. Theoretical distribution functions have been developed that can take into account this variability (Beldring & Gottschalk, 1997).

7. Coupling

Mölders et al. (1996) have gained experience in running a coupled hydrological and meteorological model. The meso-scale meteorological model GESIMA was coupled with a hydrological model developed at the University of Braunschweig (NASMO, Maniak 1996). GESIMA is a physically non-hydrostatic meso-scale β meteorological model (Geesthacht's Simulation Model of the Atmosphere, Kapitza & Eppel, 1992, Eppel et al., 1995). The processes of land surface hydrology are considered by a soil/vegetation/atmosphere transfer scheme. It includes among other things two schemes describing subgrid surface heterogeneity of evapotranspiration (Mölders & Raabe, 1996, Mölders et al., 1996). In the University of Leipzig version of GESIMA several cloud modules are available that are developed for various applications.

The intention is to modify the hydrological (ECOMAG) and meteorological (MIUU) model structures so that they can be processed in parallel on a computer and linked physically by an interface and also with on line access to the SINOP data base. The technical problem associated with the coupling of the two models and the data base is a major undertaking. The hydrological model, which simulates the thermal and water regimes of the soil, is intended to provide state variables at the soil surface i.e. temperature and moisture content. This gives the lower boundary condition to the meteorological model. It is intended to be updated every 15 minutes. The meteorological model will provide the hydrological model with input flux data i.e. sensible heat flux, evapotranspiration and precipitation with 15 minutes time steps. New modules for the meteorological model structure will be developed to allow this interaction. An additional interface between both the meteorological model and hydrological models and the SINOP data base need to be developed. The MIUU model does not simulate rainfall, while this is included in the GESIMA model. In the first case distributed precipitation data for a 2x2 km grid derived from weather radar. data (Crochet, 1997) will be used instead and imported to the model every 15 minutes. These data are available in the SINOP data base. The restart of the meteorological models also needs new meteorological data each 24 hours.

The specific activities linked to the coupling of the ECOMAG model with a meteorological model are the following:

- At present the model is based on a time step of one day. The time step will be changed to 15 min to fit with the time resolution of the weather radar evaluated precipitation data.
- The present irregular triangular and trapezoidal elements has been made to consider peculiarities in topography, soil types, vegetation and land use. A new regular grid network (Fig. 4) is constructed that conforms with the basic 2x2 km grid net of the meteorological model and the weather radar data.
- The hydrological process parameterisation have to be modified and adjusted so that the interface operates properly.

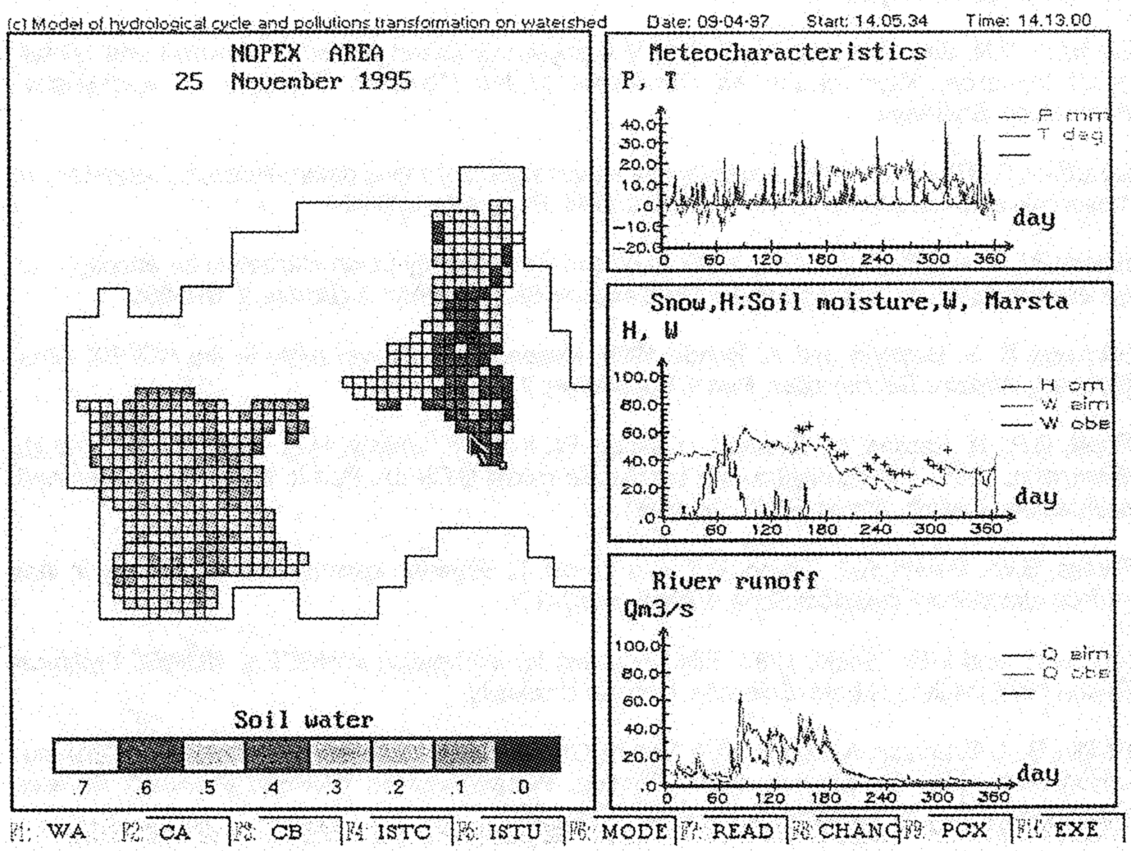


Figure 4. Illustration of a model run with ECOMAG model for a grid network for four basins - Fyrisån, Lillån, Sagaån and Örsundaån.

8. References

Andre, J.C., J.-P.Goutorbe and A.Perrier 1986, HAPEX-MOBILHY: A hydrological atmospheric experiment for the study of water budget and evapotranspiration at the climate scale. Bull.Am.Meteorol.Soc.67: 134- 144.

Avissar, R. and R.A.Pielke 1989, A parametrization of heterogeneous land surfaces for atmospheric models and its impact on regional meteorology. *Monthly Weather Review* 117:2113-2136.

Beven, K. 1995, Linking parameters across scales: sub-grid parametrizations and scale dependent hydrological models. Hydrological Processes 9:507-526.

Beldring, S. and Gottschalk, L. Distribution of soil moisture and groundwater levels in the patch and catchment scale. Submitted to the NOPEX special issue of Journal of Agricultural and Forest Meteorological Research.

Betts, A.K., J.H. Ball and A.C.M. Beljaars 1993, Comparison between the land surface response of the ECMWF model and theFIFE-1987 data. *Q.J.R. Meteorol. Soc.* 119:975-1001.

Bolle, H.J., J.C.Andre, J.L.Arrue, H.K.Barth, P.Bassemoulin, H.A.R.de Bruin, J.de Cruces, G.Dugdale, E.T.Engman, D.L.Evans, R.Frantechi, F.Fiedler, A.A.Van de Griend, A.C.Imeson, A.Jochum, P.Kabat, T.Kratzsch, J-.P.Lagouarde, L.Lunger, R.Llamas, E.Lopez-Baeza, J. Melia Miralles, L.S.Muniosguren, F.Nerry, J.Noilhan, H.R.Oliver, R.Roth, S.S.Satchi, J.Sanchez Diaz, M.de Santa Ollala, W.J.Shuttleworth, H.Søgaard, H.Strieker, J.Thornes, M.Vauclin and D. Wickland 1993, EFEDA: European Field Experiment in a Desertification threatened Area. *Annales Geophysicae,* 11:173-189.

Crochet Philippe (1997). Radar assessment of rainfall for the NOPEX area. To appear as a NOPEX Technical Report

Demidov, V.N. and Motovilov, Yu.G. (1984) A physiccaly based model of snowmelt and rainfall runoff formation. *Proc. of the XII Conference of the Danubian Countries on Hydrological Forecasting.* Bratislava.

Devantier, R., Raabe,A., 1996: Application of an quasispectral cloud parameterization scheme to a mesoscale snowfall event over the Baltic Sea. Beitr. Phys. Atm. 375-384

Entekhabi, D. and Eagleson, P.S. 1989, Land surface hydrology parameterization for atmospheric general circulation models including subgrid scale spatial variability, *J. Climate*, **2**, 816-831.

Erichsen, B. S. Beldring and A. Rohde 1995, Mesoscale runoff variability in the NOPEX Area (Abstract) *Annales Geophysicae,* Part II, Supplement II to Volume 13.

Eppel, D.P., H. Kapitza, M. Clausen, D. Jacob, W. Koch, L. Levkov, H.-T. Mengelkamp, and N. Werrmann, 1995. The non-hydrostatic mesoscale model GESIMA. Part II: Parameterizations and applications. *Contrib. Atmos. Phys.*, **68**, 15-41.

Franks, S.W., Beven, K.J., Quinn, P.F. and Wright, I., Bayesian estimation of uncertainty in land surface atmosphere flux predictions, submitted to J.G.R.

Halldin, S. and L-C. Lundin, 1994, SINOP-system for information in NOPEX. *NOPEX Technical Report No. I,* Institute of Earth Sciences, Uppsala University.

Halldin, S., L-C. Lundin, A.Jochum, A.A. Van de Griend, L.Gottschalk, M.Heikinheimo, S-E.Gryning, U.Högstrom 1996, Boreal Forest and Climate, Perspectives on NOPEX. (Abstract) *Annales Geophysicae,* Part II, Supplement II to Volume 13: C520.

Halldin,S., L.Gottschalk, A.A. Van de Griend, S-E.Gryning, M.Heikinheimo U.Högstrom A.Jochum, L-C. Lundin 1995, Science plan for NOPEX. Technical report No. 12.

Johnson,K.D., Entekabi,D. and Eagleson,P.S., 1993. The implementation and validation of improved land surface hydrology in an atmospheric general circulation model, Journal of Climate 6:1009-1026.

Kapitza and Eppel, 1992 : The non-hydrostatic model GESIMA. Part 1 : Dynamical equations and tests. Beitr. Phys. Atmos. 65, 129-146.

Kuchment, L.S., Demidov, V.N. and Motovilov, Yu.G. (1983) *River runoff formation (physicaly based models).* Nauka. Moscow, (in Russian).

Kuchment, L.S., Demidov, V.N. and Motovilov Yu.G. (1986) A physically based model of the formation of snowmelt and rainfall runoff. In: *Modelling Snowmelt-Induced Processes* (Proc. Budapest Symp., July 1986), IAHS Publ., 155.

Kuchment, L.S., Demidov, V.N., Motovilov, Yu.G., Nazarov, N.A. and Smakhtin, V.Yu. (1993) Estimation of disastrous floods risk via physically based models of river runoff generation. In: *Extreme Hydrological Events: Precipitation, Floods and Droughts* (Proceedings of the Yokohama Symposium, July 1993), IAHS Publ., 213.

Kuchment, L.S., Motovilov, Yu.G. and Nazarov, N.A. (1990) *Sensitivity of hydrological systems.* Nauka, Moscow.

Kuchment, L.S., Motovilov, Yu.G. and Startseva, Z.P. (1989) Sensitivity of evapotranspiration and soil moisture to possible climatic change. *Proc. Conf. on Climate and Wat.*, vol 1., Government Printing Centre, Helsinki, ISBN 951-861-668-X.

Maniak, U., 1996. Gitterpunktgestütztes Flußgebietsmodell als Abflußmodell eines Wasserhaushals- bzw. Klimamodells. Zw.ber. Verbunvrh. Wasserkreislauf För.kz. 521-400 VWK01.

Nichols, W.E. and R.H.Cuenca 1993, Evaluation of the evaporative fraction for parametrization of the surface energy balance. Water Resources Research 29(11):3681-3690.

Mason, P.J. 1988, The formation of areally-averaged roughness lengths. *Quart. J. Roy. Met. Soc.* 114:399-420.

Motovilov, Yu.G. (1986) A model of snow cover formation and snowmelt processes. In: *Modelling Snowmelt-Induced Processes* (Proc. Budapest Symp., July, 1986), IAHS Publ., 155.

Motovilov, Yu.G. (1987) Modelling the effects of agrotechnical measures on spring runoff and water erosion. In: *Large Scale Effects of Seasonal snow Cover* (Proceedings of the Vancouver Symposium, August 1987). IAHS Publ., 166.

Motovilov, Yu.G. (1993) The modelling of snowcover formation and snowmelt. In: The Modelling of the Hydrological Cycle for River Basins. Results of Research on the Inernational Geophysical Projects. Russ. Nat. Geoph. Comm., Moscow.

Motovilov, Yu.G. and Nazarov, N.A. (1991) Modelled estimates of changes in the water balance of forested northern river basins. In: *Nothern hydrology: selected perspectives.* NHRI Science Report No.2.

Motovilov, Yu., and Vehvilainen, B. (1987) Snow cover and snowmelt runoff model in the forest zone. In: *Proc. International Soviet-Finnish Simposium in Water Research in Moscow*, 1986. VYH monistesarja Nro 27, Helsinki.

Motovilov, Yu., Engeland, K. and Gottschalk, L. Validation of a distributed hydrological model against observed spatial data. Submitted to the NOPEX special issue of Journal of Agricultural and Forest Meteorological Research.

Mölders, N., H. Hass, H.J. Jakobs, M. Laube, A. Ebel. Some effects of different cloud parameterizations in a mesoscale model and a chemistry transport model. J. Appl. Met. (1994) **33** 527-545.

Mölders and Raabe, 1996 : Numerical investigation on the influence of subgrid-scale surface heterogeneity an evapotranspiration and cloud processes. J. Appl. Meteorol. 35, 782-795

Mölders, N., Raabe, A., Tetzlaff G., 1996a. A comparison of two strategies on land surface heterogeneity used in a mesoscale β meteorological model. Tellus 48A, 733-749

Mölders N., Kramm G., Laube M., Raabe A., 1996b: On the influence of bulk parameterization schemes of cloud relevant microphysics on the predicted water cycle relevant quantities - a case study. Meteorol. Zeitschr. (in press)

Mölders N., Beckmann, Th., Raabe, A., 1996c: A module to couple an atmospheric an a hydrologic model - description and preliminary results. Wiss. Mitteilungen aaus dem Inst.f. Meteorol. Univ. Leipzig. Bd. 4, (in press)

Noilhan, J. and P.Lacarrere 1992, GCM grid scale evaporation from mesoscale modelling. In: Proceedings of a workshop held at ECMWF on fine scale modelling and the development of parametrization schemes, 16-18 Sept. 1991:245-274.

Sellers, P.J., F.G.Hall, G.Asrar, D.E.Strebel and R.E.Murphy 1988, The first ISLSCP Field Experiment (FIFE). Bull. Meteorol. Soc. 69:22-27.

Sellers, P.J., F.G.Hall, J.Ranson, H.Margolis, B.Kelly, J.den Hartog, J.Cihlar, M.Ryan, B.Goodison, P.Crill, D.Lettenmaier, D.E.Wickland. The Boreal Ecosystem-Atmosphere Study (BOREAS) (1995). (Abstract) *Annales Geophysicae,* Part U, Supplement II to Volume 13:C524.

Seth, A., Giorgi, F., Dickinson, R.E., 1994. Simulating fluxes from heterogeneous land surfaces: explicit subgrid method employing the biosphere-atmosphere transfer scheme (BATS). J. Geophys. Res. 99 D9, 18651-18667

Shuttleworth, W.J. 1994, Hydrological models, regional evaporation and remote sensing: Lets start simple and maintain perspective. Unpublised notes from BACH workshop, Tucson.

Sulebakk, J.R., Tallaksen, L and Erichsen, B. Estimation of areal soil moisture using terrain data. Submitted to the NOPEX special issue of Journal of Agricultural and Forest Meteorological Research.

Wood, E.F., M.Sivapalan, K.J.Beven and L.Band 1988, Effects of Spatial Variability and Scale with Implications to Hydrological Modelling, *J. Hydrol.* 102:29-47.

Wood, E.F., M.Sivapalan and K.J.Beven 1990, Similarity and scale in catchment storm response, *Rev. Geophys.* 28:1-18.

Wood, E.F. 1994, Scaling, soil moisture and evapotranspiration in runoff models. Advances in Water Resources 17:25-34.

COMPARISON OF SIMULATED DISCHARGE USING INPUT FROM AN ATMOSPHERIC GCM AND A REGIONAL CLIMATE MODEL IN THE BALTEX REGION

Stefan Hagemann and Lydia Dümenil
Max Planck Institute for Meteorology, Hamburg

The representation of hydrological land surface processes is still not being treated adequately in atmospheric global circulation models (GCMs). In particular the lateral waterflows from the continents into the ocean have so far been described in an insufficient way. A model was developed which describes the translation and retention of the lateral discharge on the global scale as a function of the spatially distributed land surface characteristics which are globally available. Here, global scale refers to the resolution of 0.5° and lower, corresponding to a typical average GCM gridbox area of about 2500 km^2.

The **Hydrological Discharge model** or **HD model** separates between several flow processes such as overland flow, baseflow and riverflow. As both the retention and translation of a flow process need to be simulated, a two-parameter model is required. In the HD model this is applied to overland flow and riverflow. For baseflow a one-parameter model is sufficient. A first parameterization approach using gridbox characteristics was developed.

The HD model is applied to the BALTEX region using input from an atmospheric GCM (ECHAM4-T42) as well as from a regional climate model (REMO with DWD physics). The simulated inflows into the Baltic Sea and its subcatchments are compared to observed and naturalized inflows which were provided by Bengt Carlsson, SMHI.

Table 1, 2 and 3 show observed and simulated data for the Baltic Sea and its two subcatchments Bothnian Bay and Bothnian Sea. Figure 1 shows a comparison between the annual cycles of the simulated and naturalized inflow into these two subcatchments. The naturalized inflow is used instead of the observed inflow, since many rivers in this region are anthropogenically influenced.

Table 1.: Observed characteristics of the considered Baltic catchments (Nat. Infl. = Naturalized Inflow)

	Bothnian Bay	Bothnian Sea	Baltic Total
Area (Obs.)	261 000 km^2	230 000 km^2	1729 000 km^2
Discharge: 1950 - 90	98 km^3/year	90 km^3/year	483 km^3/year
Discharge: 1979 - 82	99 km^3/year	91 km^3/year	523 km^3/year
Nat. Infl.: 1981 - 91	105 km^3/year	84 km^3/year	--

Table 2.: Atmospheric model output on the 0.5° grid (R = Runoff, D = Drainage)

	Bothnian Bay	Bothnian Sea	Baltic Total
Area (0.5° dataset)	265 189 km^2	229 016 km^2	1718 196 km^2
ECHAM4: R+D	95 km^3/year	91 km^3/year	512 km^3/year
REMO: R+D	131 km^3/year	104 km^3/year	537 km^3/year
Area Coverage	102 %	100 %	99 %
ECHAM4 / 40 y	98 %	102 %	108 %
REMO / 4 y	135 %	116 %	104 %

Table 3.: Simulated Inflow using the HD Model

	Bothnian Bay	Bothnian Sea	Baltic Total
Model Area (HD)	255 378 km^2	197 107 km^2	1841 246 km^2
ECHAM4 --> Inflow	90 km^3/year	78 km^3/year	538 km^3/year
REMO --> Inflow	120 km^3/year	86 km^3/year	553 km^3/year
Area Fraction	98 %	86 %	107 %
ECH4_HD / 40 y	93 %	88 %	113 %
REMO_HD / 4 y	123 %	95 %	107 %

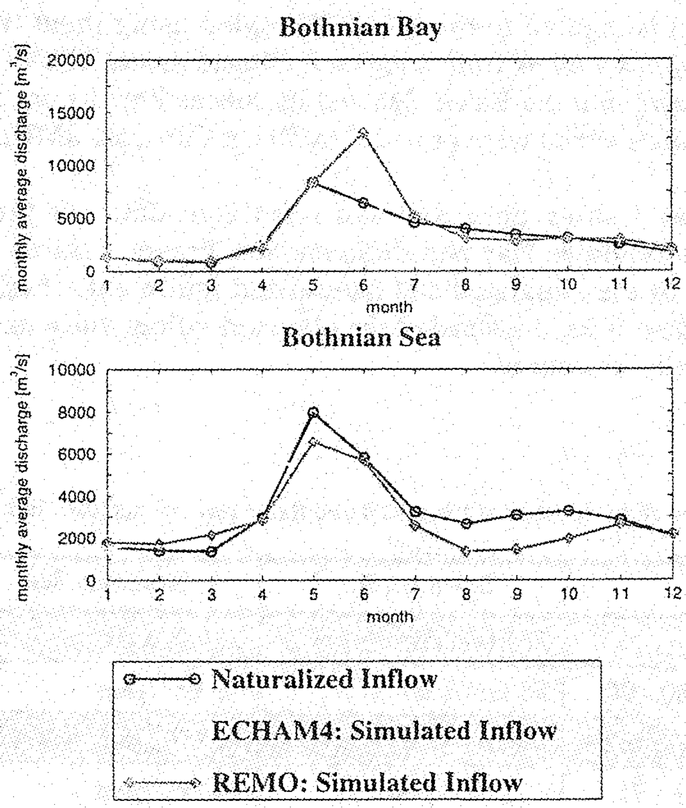


Fig. 1: Comparison of simulated and naturalized inflow

1997-04-07
RIGA2.DOC

Modelling water and energy budgets of lakes

by
Anders Omstedt and Patrik Ljungemyr
SMHI, Norrköping, Sweden

One of the main role in BALTEX is to explore and model the various mechanisms determining the space and time variability of energy and water budgets. In this presentation the role of lakes in the BALTEX region is discussed based upon some modelling activities at SMHI. The focus is on lake thermodynamics and the coupling to the atmosphere and the models calculates properties as lake temperatures, ice and evaporation.

In the BALTEX region, the number of lakes is very large and the size and depth distribution also large. For the modelling of shallow and small lakes a zero-dimensional (slab) lake/ice model has been developed and verified. This model have also been applied to HIRLAM (Ljungemyr et al. 1996), by representing all lakes by four different size classes. In larger lakes the development of a shallow thermocline and ice ridging implies that vertical as well as horizontal dimensions needs to be considered. The thermocline formation and the break down can be well simulated by one-dimensional vertically resolved models, (Svensson,1978, Sahlberg,1988, Omstedt 1984, Elo,1994) For ice ridging a one-dimensional horizontal ice edge model have been applied (Omstedt, 1990). At SMHI a coupled one-dimensional lake/ice model for the modelling of large lakes is now introduced and coupled to the HIRLAM system during the BALTEX re-analysis.

In general it is clear that the lake thermodynamics, including ice, need to be considered in the BALTEX region. Zero-dimensional models give good results for shallow and small lakes, while one-dimensional lake/ice models need to be introduced for larger lakes. Ice formation, break-up and surface temperature in lakes are of main importance for the understanding of the energy and water budgets.

For references see : Ljungemyr,P., Gustafsson,N., and A., Omstedt, 1996. Parametrization of lake thermodynamics in a high resolution weather forecasting model. Tellus,48A,608-621.

A 46

Appendix 5

Second Study Conference on BALTEX
Members of Scientific Program Committee
(as of 30 April 1997)

Jerzy Dera
Polish Academy of Sciences
Institute of Oceanology
Powstanców Warszawy 55
PL-81712 Sopot / Poland
phone: +48-58-517283 fax:+48-58-512130 e-mail: dera@iopan.gda.pl

Carl Fortelius
University of Helsinki
Department of Meteorologie
P.O. Box 4, Yliopistonkatu 3
FIN-00014 Helsinki / Finland
phone: +358-9-191-2423 fax:+358-9-191-2150 e-mail:carl.fortelius@cc.helsinki.fi

Zdzislaw Kaczmarek
Polish Academy of Sciences
Institute of Geophysics
Ks. Janusza 64
PL-01-452 Warsaw / Poland
phone: +48-22-377858 fax:+48-22-370522 e-mail: kaczmar@seismol1.igf.edu.pl

Sirje Keevallik
Estonian Meteorological and Hydrological Institute
Toom-Kooli 9
EE-0001 Tallinn / Estonia
phone: +372-2-441295 fax:+372-2-441610 e-mail: sirje@nimbus.emhi.ee

Wolfgang Matthäus
Institut für Ostseeforschung
Universität Rostock-Warnemünde
Seestraße 15
D-19119 Warnemünde / Germany
phone: +49-381-5197-140 fax:+49-381-5197-440
e-mail:matthaeus@physik.io-warnemuende.d400.de

Anders Omstedt
Swedish Meteorological and Hydrological Institute
S-60176 Norrköping / Sweden
phone: +46-11158284 fax:+46-11170207 e-mail: aomstedt@smhi.se

Ehrhard Raschke (Chair)
GKSS Forschungszentrum GmbH
Institut für Atmosphärenphysik
Postfach 1160
D-21494 Geesthacht / Germany
phone: +49-4152-871533 fax:+49-4152-872020 e-mail: raschke@gkss.de

Valery S. Vouglinsky
Russian State Hydrological Institute
23, Second Line
St. Petersburg 199053 / Russia
phone: +7-812-213-3517 fax:+7-812-213-1028 e-mail: admin@vggi.spb.ru

Appendix 6

BALTEX Data Exchange
- Status of the BALTEX Data Centres -
(as of 16 April 1997)

Progress made since the 4th SSG meeting is encircled.
This diagram also indicates the progress made during the 5th SSG meeting.

	BMDC (DWD)	BHDC (SMHI)	BODC (FIMR)
Sampling Strategy	A	(a)	(a)
Status Paper	a	(a)	(a)
Rules, Agreements	(a - A - I)	(a)	P
Data Collection, real	(S - O)	(S)	P
Data Collection meta	(S - O)	(S)	(S)

P Planning Stage
a Approved by SSG and Data Centre
A Approved by SSG, Data Centre and Data Suppliers
I Implemented
S Started
O Ongoing

Hans-Jörg Isemer
International BALTEX Secretariat
16 April 1997

Appendix 7

BALTEX Data User Identification

User Groups identified

(as of 10 April 1997)

Austria:	I	1
Denmark:	I	1
Estonia:	IIIII	5
Finland:	I	1
Germany:	IIIIII	6
Great Britain:	I	1
Poland:	II	2
Sweden:	I	1

		18

Hans-Jörg Isemer
International BALTEX Secretariat
16 April 1997

Appendix 8

Funding Sources for BALTEX Data Collection and Preparation

1. Source: German Research Ministry (BMBF), co-ordinated by BALTEX Secretariat

   Data Preparation in Eastern BALTEX Countries
   Approved for 1997

2. Source: Deutscher Wetterdienst (DWD) co-ordinated by BALTEX Secretariat

   Data Preparation in Eastern BALTEX Countries
   Approved for 1996

3. Source: INTAS 95-872 co-ordinated by BALTEX Secretariat

   Data Preparation in RU and BEL, 2 years
   Approved

4. Source: INTAS 1997 co-ordinated by BALTEX Secretariat

   Data Preparation and Modelling for the Neva river basin
   Applied April 1997

Hans-Jörg Isemer
International BALTEX Secretariat 16 April 1997

Appendix 9

International BALTEX Secretariat Publication Series

(as of April 1997)

No. 1 : Minutes of First Meeting of the BALTEX Science Steering Group at GKSS Research Center in Geesthacht, Germany, May 16-17, 1994. August 1994.

No. 2 : Baltic Sea Experiment BALTEX - Initial Implementation Plan. March 1995, 84 pages.

No. 3 : First Study Conference on BALTEX, Visby, Sweden, August 28 - September 1, 1995. Conference Proceedings. Editor: A.Omstedt, SMHI Norrköping, Sweden. August 1995, 190 pages.

No. 4 : Minutes of Second Meeting of the BALTEX Science Steering Group at Finnish Institute of Marine Research in Helsinki, Finland, January 25-27, 1995. October 1995.

No. 5 : Minutes of Third Meeting of the BALTEX Science Steering Group at Strand Hotel in Visby, Sweden, September 2, 1995. March 1996.

No. 6 : BALTEX Radar Research - A Plan for Future Action. October 1996, 46 pages.

No. 7 : Minutes of Fourth Meeting of the BALTEX Science Steering Group at Institute of Oceanology PAS in Sopot, Poland, June 3-5, 1996. February 1997.

Also available:

Minutes of First BALTEX Hydrology Workshop at Polish Academy of Sciences in Warsaw, Poland, 9-11 September 1996. March 1997

BALTEX Newsletter
#1 October 1996
#2 March 1997

Copies are available upon request at the International BALTEX Secretariat.

Appendix 10

PIDCAP

Progress Report

No 2

31 March 1997

Upon request of the BALTEX Science Steering Group individual BALTEX research groups submitted short reports on the progress of PIDCAP-related research. A first PIDCAP progres report had been compiled in May 1996 (see Appendix 7 of the minutes of the 4th BALTEX SSG meeting). The present document contains additional reports which arrived at the BALTEX Secretariat as of 31 March 1997.

Hans-Jörg Isemer
BALTEX Secretariat
GKSS Forschungszentrum Geesthacht

Contents

Three Months Continuous Monitoring of the Atmospheric Water Vapor with a Network of Global Positioning System Receivers

T. Ragne Carlsson, Gunnar Elgered, and Jan M. Johansson
Onsala Space Observatory - Chalmers University of Technology
Onsala, Sweden

1. Introduction

In the study presented here we have estimated the integrated water vapour (IWV) using a relatively dense network (the shortest baseline is approximately 100 km) with data from 20 of the continuously operating GPS stations in Sweden, and 5 sites in Finland, belonging to the Finnish permanent GPS network. The study has been concentrated in time to the period August to October 1995, the PIDCAP period. For this data set we have made comparisons with the microwave radiometer at the Onsala Space Observatory as well as radiosonde data from sites close to the GPS antennas.

The different techniques used here will be briefly described in section 2, and 3 followed by results and comparisons in section 4. Finally conclusions and future work are dealt with in section 5.

2. GPS analysis

Figure 1 shows the geographical locations for the 25 GPS sites. We processed the GPS data from this network with the GIPSY/OASIS software (Webb and Zumberge, 1993). The GIPSY software uses a Kalman filter technique to estimate the unknown parameters. In this study we incorporated precise orbits distributed by the International GPS Geodynamics Service (IGS), see Blewitt (1993). Using this *a priori* information we estimated site positions, satellite, and receiver clocks, and tropospheric delay at all sites in the processing. A no fiducial approach was applied (Heflin, 1992), meaning no site positions were hold fixed during the solution. The receiver clocks were estimated as white noise processes. To estimate the tropospheric delay an a priori hydrostatic and wet component were withdrawn from the total neutral delay. The residual delay was then estimated as a random walk process using the Lanyi mapping function (Lanyi, 1984) to relate measurements at certain elevation angles to zenith. The elevation cutoff angle was set to 15 degrees, meaning no observations below an elevation angle of 15 degrees were used in the solutions. An empirical algorithm is finally used to estimate the IWV from the wet delay.

3. Independent techniques for assessment of the accuracy

The Water Vapor Radiometer (WVR) at Onsala is a dual frequency microwave radiometer measuring the emission at 21.0 GHz and 31.4 GHz (Elgered and Lundh, 1983). From the measured brightness temperatures the zenith wet delay is calculated according to Elgered

(1993). The IWV values are then determined using the same algorithm as used with the GPS data. The WVR was during the period of study mapping the sky continuously during repeated cycles of eight minutes of duration. This procedure resulted in 40 measurements per each cycle, i.e., 5 measurements per minute. The distance between the radiometer and the GPS antenna at Onsala is less than 10 meters, and the heights are about equal.

Data from radiosondes were used at 4 different sites, Landvetter, Sundsvall, Sodankyla, and Froson. The IWV was determined by integrating the measured humidity profiles. Typically two measurements a day are available from this technique. The great-circle distances between the GPS stations and the nearby radiosonde sites varies between 13 and 38 km.

4. Results

Time series of the IWV at each GPS site have been made using the data available at each site. The overall variations are most of the time consistent with the results from nearby sites. An expected systematic increase in the mean IWV as well as the variability with decreasing latitude is clearly seen. We can also notice a seasonal effect, where the mean IWV values are lower for the October month than for September, which in turn is lower than the August values.

Figure 2 shows time series for the three months August to October 1995 of the GPS estimated IWV at the Onsala site together with the data measured with the WVR. The upper curves show the WVR data offset by 20 kg/m^2 in order to improve the visual comparison. On the average the WVR data are 0.9, 1.2, and 1.6 kg/m^2 above the GPS estimates for the months of August, September, and October, respectively.

Table 1 gives the statistics from the comparisons with radiosonde data from the sites available. Note that the offset in the Onsala-Landvetter comparison is somewhat larger than for the GPS-WVR comparison. The trend is however consistent between the two comparisons. As for the GPS-WVR comparison the monthly mean difference between the GPS and radiosonde data are biggest in October, and least in August.

5. Conclusions and Discussion

We have used a permanent network of GPS receivers to estimate the amount of atmospheric water vapor on a mesoscale level. Comparing the GPS estimated IWV with values derived from the WVR shows an agreement on 1 - 2 kg/m^2. Much of the rms difference between the estimates can be derived from the slowly varying bias between the data. This bias should be possible to reduce significantly since the level of the GPS estimates very much can be influenced by the choice of elevation cutoff angle. Taking this into consideration we can estimate the quality of our GPS estimates by looking at the rms scatter off differences around the mean difference. This is the same quantity as the total rms difference if we removed the bias between the estimates. The mean daily value for this bias is 0.75 kg/m^2. We believe that it is possible to further reduce this bias, by taking measures to isolate systematic effects in the GPS data processing. Efforts will also be made to reduce the time between the data acquisition and the appearance of the final IWV estimates. The limiting factor today is largely the time consuming process to determine the satellite orbits. Having the results in almost real-time would presumably make it possible to use the GPS data to estimate IWV for meteorological forecasts.

Table 1. Distances between GPS stations and radiosonde sites, and statistics for the comparison of IWV values from the two methods.

GPS/Radiosonde sites	Distance (km)	August-October 1995 No. of paired observations	RMS difference [kg/m^2]	Mean difference [kg/m^2]
Sundsvall/Sundsvall	35	268	2.1	1.3
Ostersund/Froson	34	20	1.8	1.4
Sodankyla/Sodankyla	13	159	2.0	0.5
Onsala/Landvetter	38	298	2.6	1.7

References

Blewitt, G., Advances in Global Positioning System Technology for Geodynamics Investigations: 1978-1992, in Contributions of Space Geodesy to Geodynamics: Technology, eds. Smith and Turcotte, Geodynamics Series, 25, 195-213, AGU, Washington D.C., 1993.

Elgered G., and P. Lundh, A dual channel water vapor radiometer system, Res. Rept. No 145, Onsala Space Observatory, Chalmers Univ. of Tech., 1983.

Elgered, G., Tropospheric Radio Path Delay from Ground-Based Microwave Radiometry in Atmospheric Remote Sensing by Microwave Radiometry, ed. M. Janssen, Wiley and Sons, pp. 215-258, 1993.

Heflin, M., W. Bertiger, G. Blewitt, A. Freedman, K .Hurst, S. Lichten, U. Lindqwister, Y. Vigue, F. Webb, T. Yunck, and J. Zumberge, Global Geodesy using GPS without Fiducial Sites, Geophys. Res. Lett., 19, 131-134, 1992.

Lanyi, G., Tropospheric delay affecting radio interferometry, TDA Progress Report 42-78,152-159, Jet Propul. Lab., Pasadena, Calif., 1984.

Webb, F. H. and J. F. Zumberge, An Introduction to the GIPSY/OASIS-II, JPL Publ. D-11088, Jet Propulsion Laboratory, Pasadena, California, 1993.


NEWBALTIC
70°N
65°N
60°N
55°N
10°E
20°E
Kiruna
Sodankylä
Överkalix
Arjeplog
Oulu
Skellefteå
Vilhelmina
Umeå
Östersund
Vaasa
Sundsvall
Sveg
Leksand
Mårtsbo
Tuorla
Metsähovi
Karlstad
Lovö
Vänersborg
Norrköping
Jönköping
Visby
Onsala
Oskarshamn
Hässleholm

Fig. 1

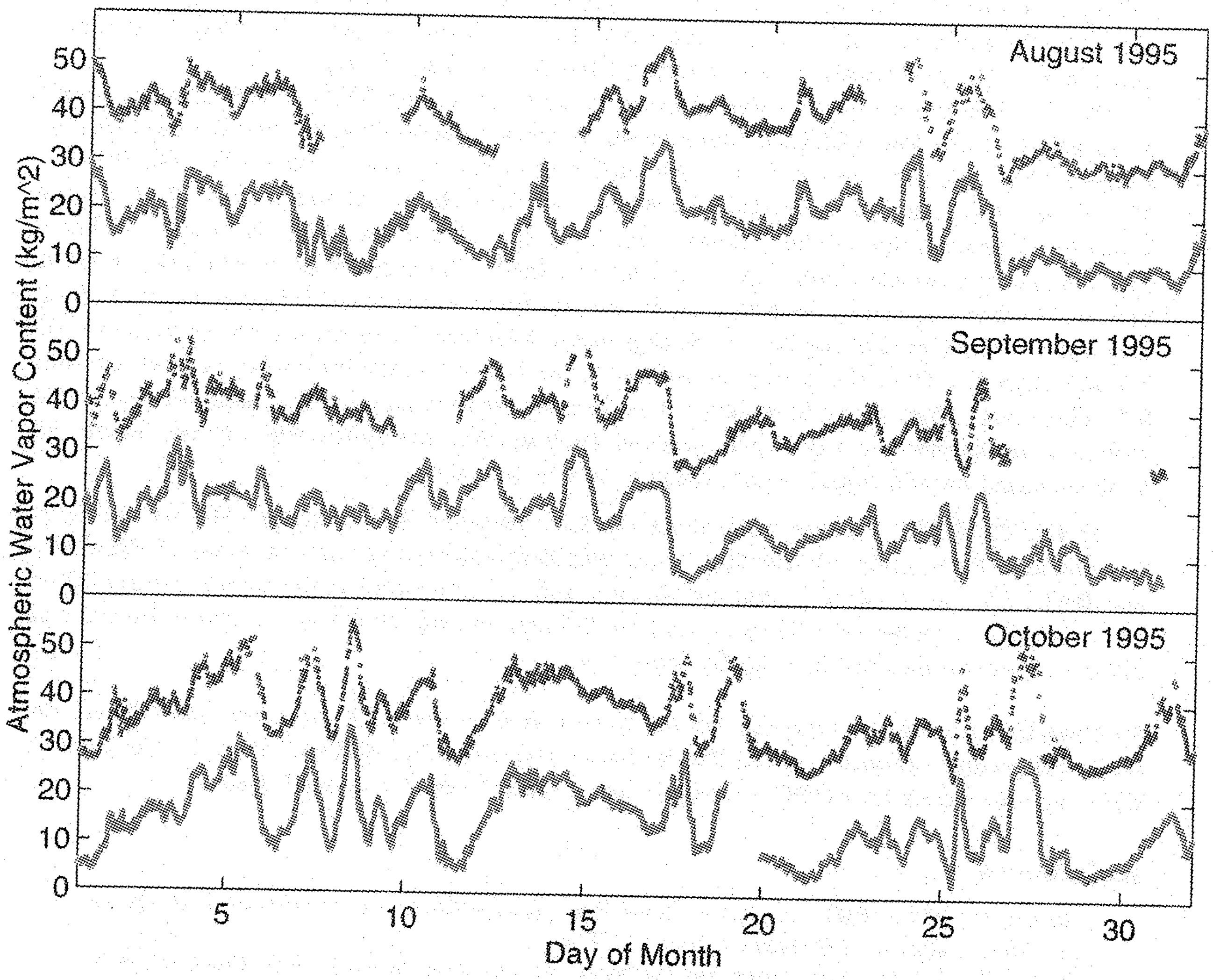

August 1995
September 1995
October 1995
Atmospheric Water Vapor Content (kg/m^2)
Day of Month
0
10
20
30
40
50
5
10
15
20
25
30

Fig. 2

Mesoscale Precipitation Analysis for PIDCAP[1]

F. Rubel[2], M. Hantel[2], F. Hamelbeck[3]

University of Vienna, Institute for Meteorology and Geophysics (IMG) - Hohe Warte 38, A-1190 Vienna, Austria
Tel.: +43-1-36026-3001; Fax: +43 1 3685612; email: michael.hantel@univie.ac.at

1) OVERVIEW The IMG is undertaking an effort to supply analysed fields of surface precipitation for the PIDCAP period (Aug. - Nov. 1995) as background verification for the other groups. At present, the precipitation analysis runs in two modes. The coarse mode corresponds to the EM resolution and the fine mode to the resolution of REMO.

2) ACHIEVEMENTS Using SYNOP rain gauge data only, IMG has analysed twice daily precipitation fields over the BALTEX region for the complete PIDCAP period. This coarse mode analysis with a space/time resolution of 55 km × 12 hours is thought to give a quick look of the precipitation events during PIDCAP (Rubel, 1996a).

For the fine mode precipitation analysis, in addition to the SYNOP rain gauges, about 3 700 gauges from the BALTEX Meteorological Data Centre (BMDC) are included in the analysis. *Fig. 1* shows the location of the surface stations for 3 September 1995, 06:00 UTC. The objectively analyzed precipitation field for the same date is shown in *Fig. 2*. Note the logarithmic progression of the isolines. Here the space/time resolution is 18 km × 24 hour. *Fig. 3* shows the corresponding interpolation error field. The normalized interpolation error is bounded by 0 and 1, and by definition lower or equal than the variance of the precipitation field. Over most of the region of the Baltic drainage basin the interpolation error for 3 September 1995 is lower than 0.1. Over the data poor regions of the Baltic Sea the interpolation error exceeds 0.4. This error values seems to be lower than forecast errors from numerical weather prediction models and therefore justify a precipitation analysis over the Baltic Sea. Nevertheless, an analysis based on additional remote sensing data is desirable.

3) OUTLOOK Further work along the lines sketched is in progress. We are trying to concentrate efforts upon (i) selecting meteorologically interesting cases on basis of PIDCAP- and BALTEX-specific data (including Radar); and (ii) improving the optimum interpolation algorithm by considering both a skewed probability density function for precipitation and different autocorrelation functions for land/sea.

Acknowledgments This research was partly supported by the *EC Environment and Climate Research Programme - Climatology and Natural Hazards* (Contract No. ENV4-CT95-0072). Cooperation with, and data supply by, BMDC (Offenbach) and ZAMG (Vienna) is acknowledged.

References

Rubel, F., 1996a: PIDCAP - Quick Look Precipitation Atlas. *Österreichische Beiträge zu Meteorologie und Geophysik*, Heft 15, 97pp.

Rubel, F., 1996b: Scale dependent statistical precipitation analysis. *The Proceedings of the International Conference on Water Resources & Environmental Research: Towards the 21st Century, 28-31 October 1996*, Kyoto, Japan, Volume I: 317-324.

[1] Progress Report for BALTEX Science Steering Group, March 1997
[2] Principal Investigators, Contribution of IMG to PIDCAP
[3] IMG, Vienna

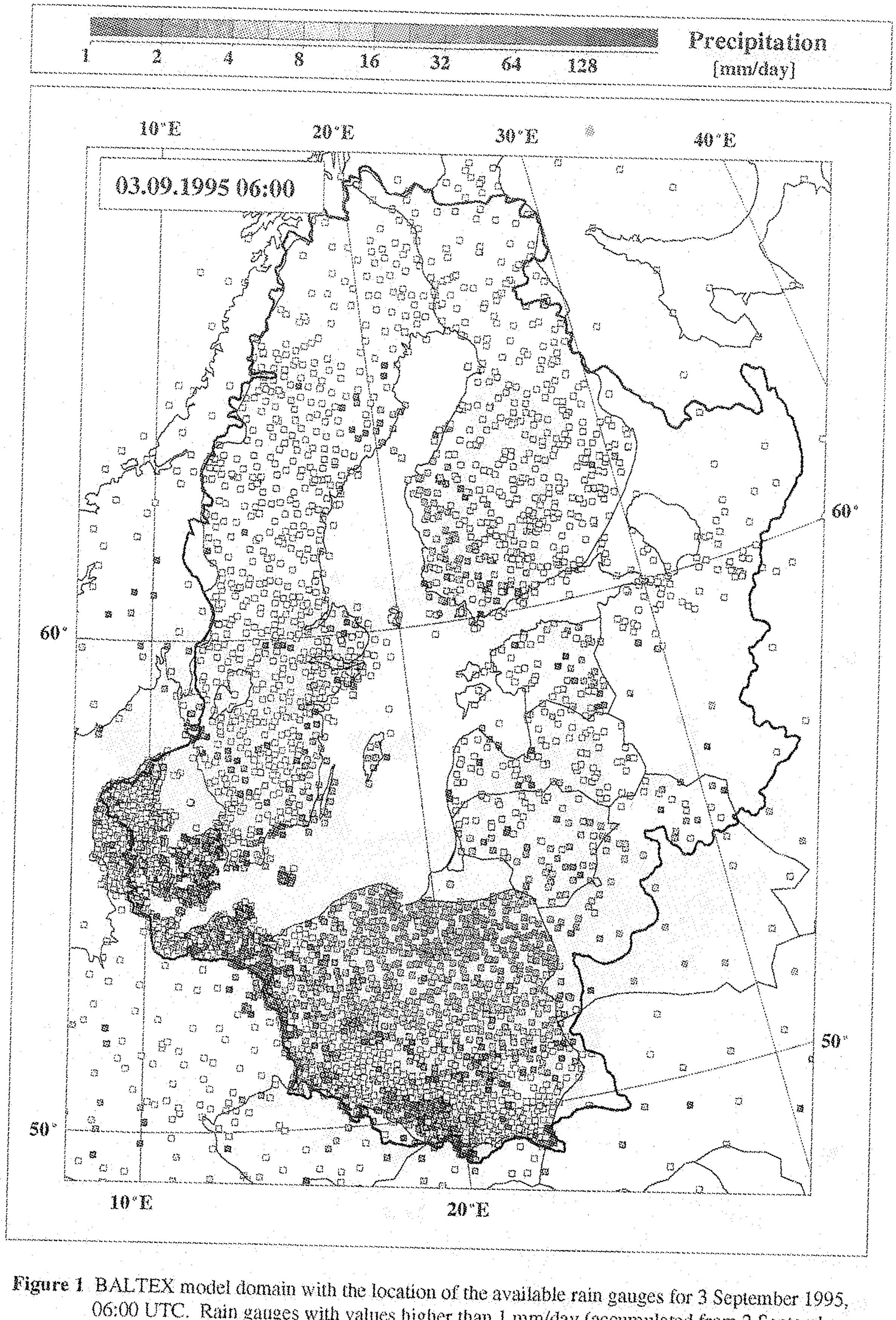


Figure 1 BALTEX model domain with the location of the available rain gauges for 3 September 1995, 06:00 UTC. Rain gauges with values higher than 1 mm/day (accumulated from 2 September 1995, 06:00 UTC to 3 September 1995, 06:00 UTC) are colored.

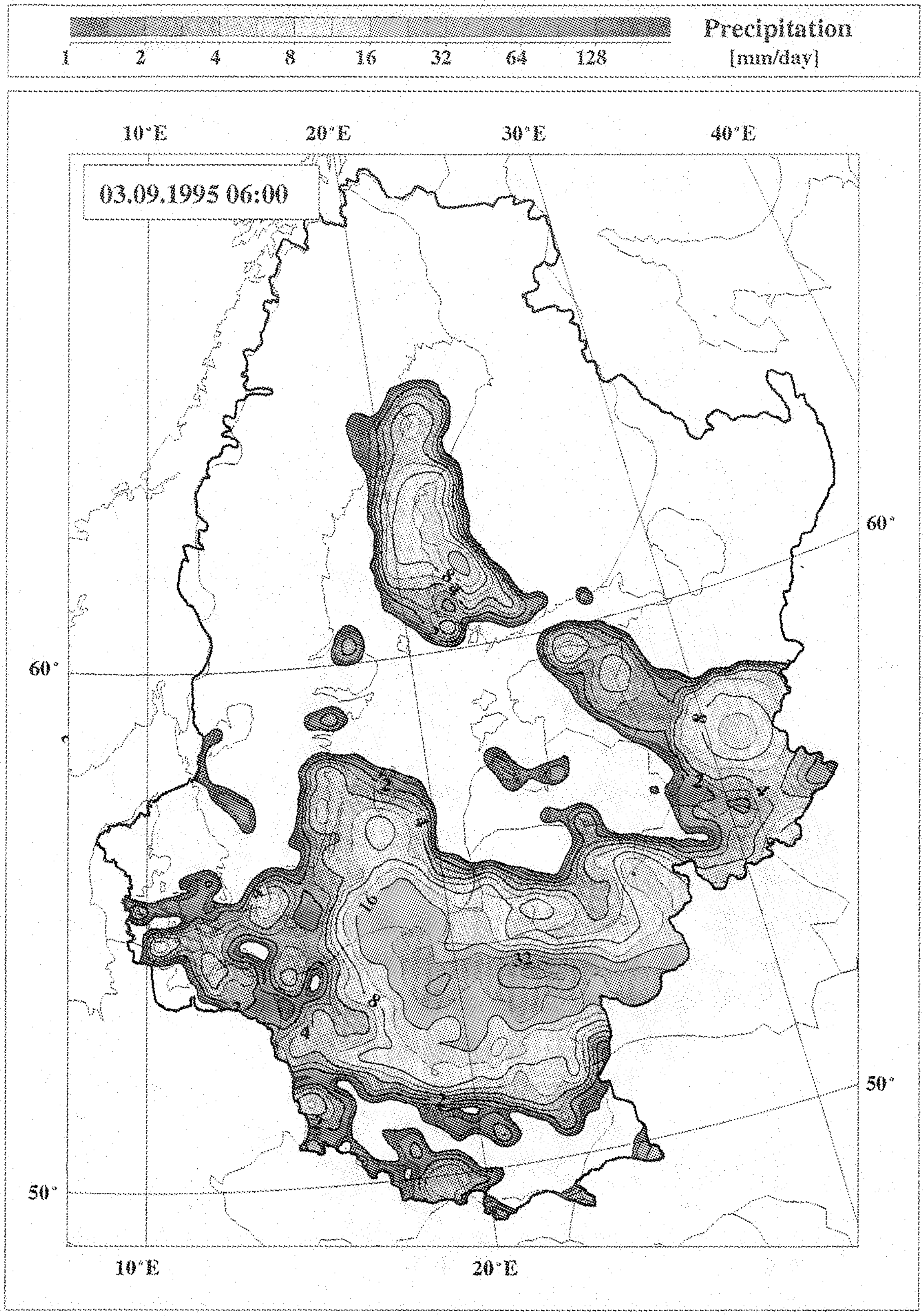


Figure 2 Objectively analyzed precipitation field for 3 September 1995, 06:00 UTC. Units are in mm/day.

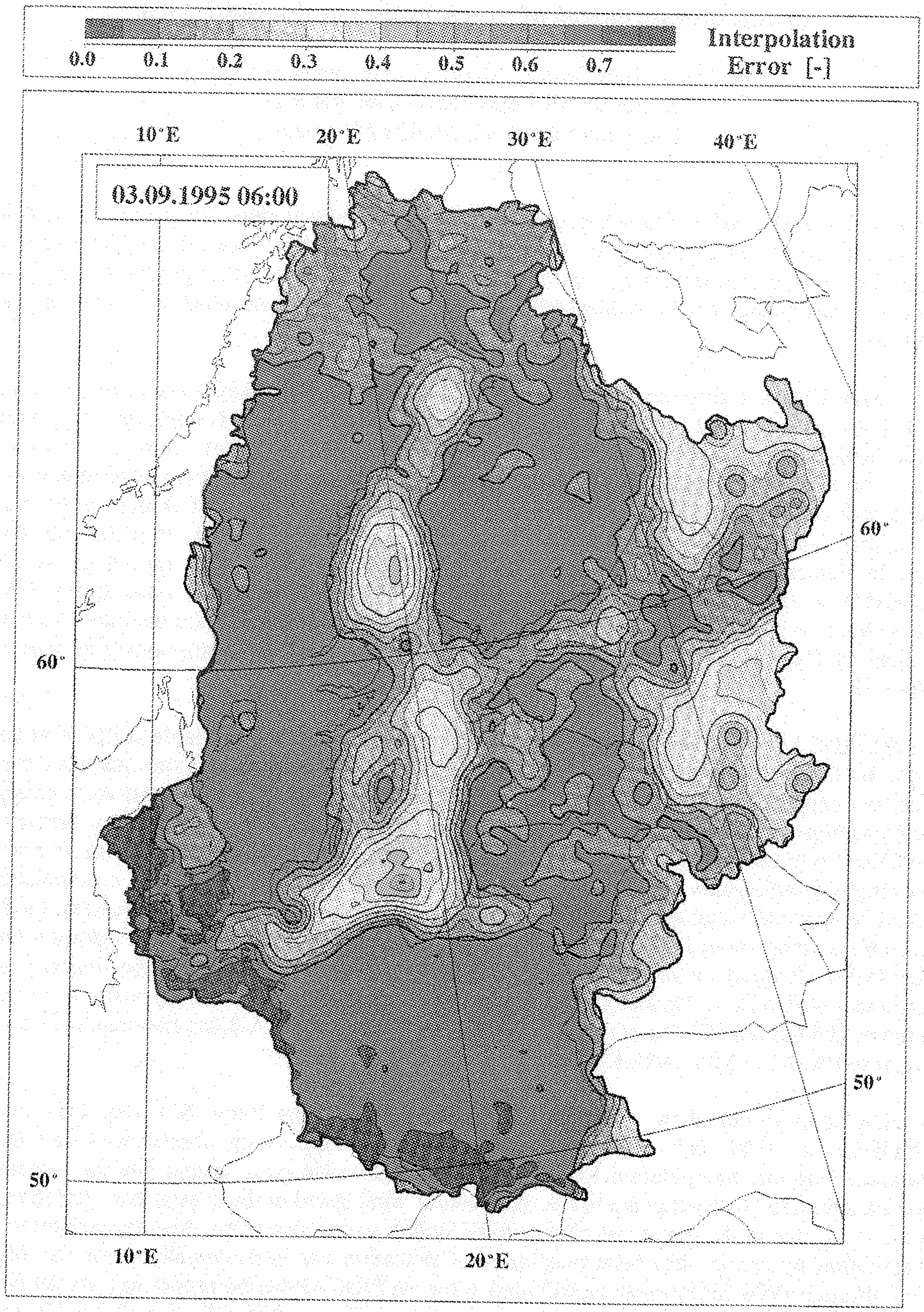


Figure 3 Normalized interpolation error (estimation variance) of the objectively analyzed precipitation field for 3 September 1995, 06:00 UTC.

In situ measurement of precipitation at the Baltic Sea

Lutz Hasse, Karl Bumke, Martin Grossklaus, Klaus Uhlig
Institut für Meereskunde, Universität Kiel
Düsternbrooker Weg 20, Kiel / Germany

Precipitation at the Baltic Sea is measured *in situ* by specialized ship rain gages. These data are suitable to obtain precipitation climatologies along the ships tracks through the central Baltic Sea. Extrapolation to areal estimates is possible with aid of other products, e.g. from numerical modelling or radar remote sensing, where the *in situ* measurements can be used as sea truth.

Since May 1995 five ship rain gages are operated in the Baltic Sea area. Four of these are installed at ferry ships that travel between Helsinki and Lübeck. A fifth is deployed at an automatic station of the IOW (Institut für Ostseeforschung, Warnemünde) north of the island Darss. Additional data are available from RV ALKOR that carries an optical disdrometer and a ship rain gage. The disdrometer measures dropsize distributions of rainfall and can be used to classify rainfall events to check parameterizations of convective and stratiform rains as used in numerical models. Additional data are expected from a ship rain gage at RV ARANDA of the FIMR (Finnish Institute of Marine Research, Helsinki) since spring 1996 and a ship rain gage at the island Oestergarnsholm/Gotland operated by the Institute of Meteorology of Uppsala University. These measurements are obtained continuously as part of BALTEX.

For the PIDCAP period the precipitation data form the ferry link are available at IfM Kiel and at the BALTEX Meteorological Data Center at the DWD. The precipitation data have been used for comparison with model data. To this purpose one needs to consider that ships change their positions continuously. Best results were obtained by interpolating the model predicted precipitation to time and location of *in situ* measurements and compare the totals (in this way meaningful comparisons are obtained, for determination of areal sums, however, extrapolation would be needed). Comparison with the Europa-model of DWD gave good agreement, model predictions being about 10 % higher than *in situ* measurements (see PIDCAP progress report May 1996). Comparison with earlier model outputs of REMO-MPI/DKRZ gave similar good agreement within 10 %. However, the latter result may be fortuitous since the positions of rain in the model did not fully coincide with the observed rain events. A more elaborate investigation with REMO in MPI and GKSS version is under way.

In addition to precipitation, evaporation was calculated for the Baltic Sea, too. This study (Bumke et al, 1997) is based on 6-hourly coastal and ship synop observations and bulk parameterizations, Interpolation to a regular 1° grid is made by a special analysis scheme. Special attention has been given to the reduction of wind speed in the coastal zone (relative to open water) due to the roughness change from land to sea or vice versa. Also the reduction of evaporation by sea ice has been considered. Calculation has been completed for the years 1992 through 1994. Unfortunately, calculation for the PIDCAP-period proper has not yet been completed due to late income of the data. The study indicates that influence of ice coverage may reduce annual evaporation by up to 10 %. The influence of roughness transition in coastal areas on wind speed systematically reduces of evaporation by about 10 % compared to open water assumption. (The effect is more pronounced in coastal areas, 10 % is the net effect for the total Baltic Sea). Mean annual precipitation is given in Table 1 together with long term estimates of Henning (1988). In general, the period 1992 through 1994 seems to represent typical years. This statement is based on a comparison with long term data from COADS (Comprehensive Ocean and Atmosphere Data Set).

Even more interesting are the results of evaporation calculated with use of different bulk parameterization for momentum and water vapour. Only some of the better known bulk parameterizations have been included, that are also often used in numerical modelling. The mean annual evaporation (1992 - 1994) for the total Baltic Sea would vary between 477 mm/year and 638 mm/year depending on choice of parameterization only. This certainly points to the importance of additional field experiments to obtain improved bulk transfer co-efficients for the Baltic Sea, such as attempted during PIDCAP. A repeat experiment to PIDCAP has taken place in summer 1996, where simultaneous eddy flux measurements of water vapour have been obtained at Oestergarnsholm (by Meteorological Institute, Uppsala University) and RV ALKOR (IfM Kiel), operating near Oestergarnsholm. The data are presently evaluated. It is already evident that the data base is not yet sufficient to achieve BALTEX goals and additional field experiments will be needed. Given an uncertainty of ± 10 % in the bulk transfer coefficients used in numerical models even the sign of the freshwater balance of the Baltic Sea remains uncertain.

Table 1: Evaporation at subbasins of the Baltic Sea for 1992 - 1994, estimated from IfM Kiel analysis (Bumke et al., 1997), compared to long term averages by Henning (1988).

Subbasin	evaporation [mm/year] Henning (1988)	evaporation [mm/year] this study, 1992 - 1994
Bothnian Bay	364	472
Bothnian Sea	460	498
Gulf of Finland	361	437
Gulf of Riga	439	451
Baltic Proper North	564	542
Baltic Proper Central	542	555
Baltic Proper West, Belt Sea, Oeresund, Danish Straits	542	500
Total Baltic Sea	498	511

References

Bumke, K., U. Karger, L. Hasse, and K. Niekamp, 1997:
Evaporation at the Baltic Sea for 1992 to 1994 (submitted to Tellus, 1996).

Henning, D., 1988: Evaporation, water and heat balance of the Baltic Sea; Estimates of short- and long-term monthly means. Meteorologische Rundschau 41, 33-53.

Weather Radar Data for PIDCAP

Progress Report

Igor Dölling[1], Johann Riedl[1], Elmar Weigl[2]

Deutscher Wetterdienst

[1] Meteorologisches Observatorium Hohenpeißenberg

[2] Geschäftsfeld Hydrometeorologie, Offenbach

1 Introduction

At a workshop on BALTEX in Germany (Hannover, 1994) the need for cooperation between different groups within the German BALTEX contribution and in other countries has been recognized. As a consequence the working group on precipitation measurements for BALTEX pointed out the need for an initative for collection of precipitation data from different sources and its comparison and validation. As a first step the workshop suggested to organize an intensive observation period, the Pilot Study for Intensive Data Collection and Analysis of Precipitation (PIDCAP).

2 Objectives

The objectives of the DWD, Met. Observatory Hohenpeißenberg (MOHp) PIDCAP-participation are the provision of radar reflectivity data and area precipitation data from the Rostock weather radar. In particular

- investigations of filtering techniques for clutter reduction
- improvement of area precipitation data by adjustment through surface data and
- precipitation coverage of the BALTEX area by compositing NORDRAD and DWD radar data.

3 Measurements, Data Collection

The Rostock weather radar is part of the DWD operational weather radar network; the radar was operationally available since March 95. The DWD operational radars perform every 15 minutes a volume scan with 5 minutes interleaved precipitation scans at a low elevation angle (For details see the progress report at the first PIDCAP workshop, Norrköping, 1996).

The additional capability to store the raw volume radar data in polar coordinates from each scan together with the standard products on DAT tapes on site could be provided in time before beginning of PIDCAP. The optimal filter adjustment prior to the project period was not possible due to delay of application software grade up. The above mentioned data and products have been archived during the originally allocated PIDCAP period (Aug. - Okt. 95); the information about the extension to November did not reach us. The composite images of Germany (and also the contributions e. g. from the Hamburg, Berlin and Hannover radars) have been archived at Offenbach.

Drop size distribution was also measured by a Joss-Waldvogel distrometer at Rostock and the one-minute spectra were archived, too.

4 Evaluations

4.1 Event catalogue

An overview catalogue of the precipitation events was produced based on the German composite, the daily rain amount image product (100 km radius) from the Rostock radar and 13 rain gauge sites in this area. In the catalogue it was tried to characterize the precipitation situation over northeast Germany (wide spread/showers) and the intensity (light, moderate, heavy) and to give additional information on the clutter situation and missing data. The catalogue is available from MOHp (I. Dölling, K. Brückner, J. Riedl, J. Seltmann: Übersicht über die Rostocker Radarmessungen während PIDCAP 1995).

First evaluations showed more clutter from coastal lines and sea as well as from ships and ferry boats than expected.

4.2 Estimation of precipitation tops

For the investigation of the precipitation tops, especially the differences over land and sea, the raw polar data were used and the area between 15 and 40 km radius from the radar was selected to avoid clutter from the coastal lines (at far distances) as well as to avoid data gaps (at close ranges) due to the maximum antenna elevation angle of 37°. A software module was written to visualize the echo height distribution over the sea-resp. land area (s. 1. Progress report). Up to now only few cases could be investigated which did not show general trends.

4.3 Drop size data

The investigation of data sets from several years of drop size measurements at different locations in northern Germany has been started with the objective to quantify differences in the Z-R-relations of different precipitations types versus regional differences. First results on "Systematic variations of raindrop size distributions measured in northern Germany during 7 years" were presented at the 12th International Conference on Clouds and Precipitation (I. Dölling, J. Joss, J. Riedl; Zürich, CH, 19. - 23. August 1996).

4.4. Area precipitation

According to the discussion and agreement at the first PIDCAP-Workshop (10./11. June 96, Norrköping), radar data of up to 10 days from the Rostock weather radar should be converted to daily precipitation heights. Preference was given to the period of 27. - 31. August for model output validation. Up to now 9 days of radar data have been evaluated and adjusted by a statistical numerical procedure using the surface raingauge data available for the particular day. The list of processed days is given in table 1. The date in the file name refers to the "precipitation day", e. g. 95 09 04 means the accumulated precipitation amount from Sept, 4th, 06:30 UTC till Sept. 5th, 06:30 UTC. This example is shown in figure 1. Besides the daily values also hourly rain amounts have been computed.

5 Data exchange

The data are available from the Meteorological Observatory Hohenpeißenberg. Prior to the data exchange the users are asked to sign the User Registration and the Licence Agreement via the BALTEX MDC at Offenbach.

6 Future Investigations

The investigations on the use of filtering techniques for clutter reduction will be continued as well as the evaluations of the precipitation height extension over land and sea. But it has to be recognized that the amount of further investigations will be reduced by the loss of the contracted scientist in February '97 due to the end of the project within the German BALTEX contribution.

Special BALTEX related radar research (e. g. wide area precipitation calculation based on improved and standardized radar calibration procedures) may be extended if a proposed EU-project (BALTRAD) will be launched by the EU.

Table 1: List of PIDCAP-days with evaluated precipitation amount from the Rostock weather radar during August and September 1995.

Aug. 26, 6:30 UTC - Aug. 27, 6:30 UTC
Aug. 27, 6:30 UTC - Aug. 28, 6:30 UTC
Aug. 28, 6:30 UTC - Aug. 29, 6:30 UTC
Aug. 29, 6:30 UTC - Aug. 30, 6:30 UTC
Aug. 30, 6:30 UTC - Aug. 31, 6:30 UTC
Aug. 31, 6:30 UTC - Sep. 01, 6.30 UTC
Sep. 01, 6.30 UTC - Sep. 02, 6:30 UTC
Sep. 03, 6:30 UTC - Sep. 04, 6:30 UTC
Sep. 04, 6:30 UTC - Sep. 05, 6:30 UTC

**Fig. 1 (see next page) : Example of daily precipitation (4. Sept. '95) amount [mm] from the Rostock weather radar, adjusted by surface rain gauges.
Notice: The data in the centre area (distorted by side lobe returns) and at 72° - 74° Azimuth (distorted by beam screening) might be improved by a further processing step.**

A 72

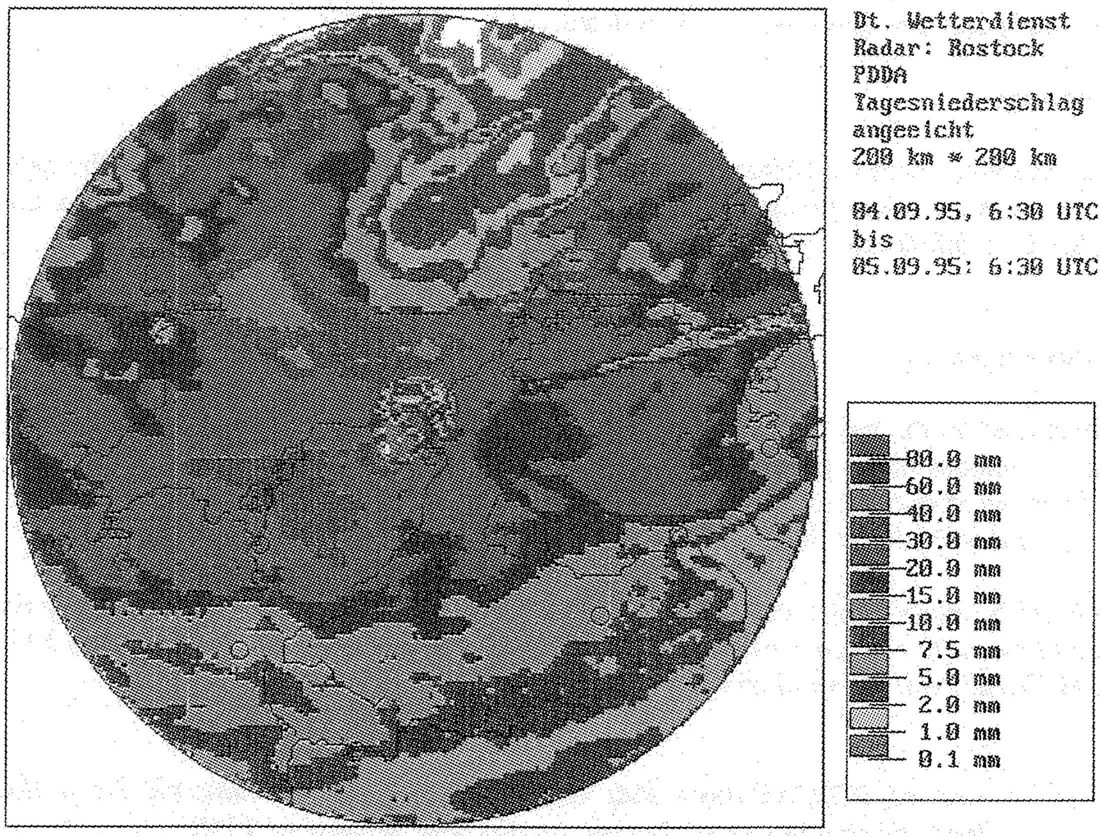

Dt. Wetterdienst
Radar: Rostock
PDDA
Tagesniederschlag
angeeicht
200 km * 200 km
04.09.95, 6:30 UTC
bis
05.09.95: 6:30 UTC
80.0 mm
60.0 mm
40.0 mm
30.0 mm
20.0 mm
15.0 mm
10.0 mm
7.5 mm
5.0 mm
2.0 mm
1.0 mm
0.1 mm

Fig. 1:

PROGRESS REPORT - REMO AT MPI AND DKRZ

Daniela Jacob, Ralf Podzun, Martin Windelband
Max-Planck-Institut für Meteorologie
Hamburg, Germany

For regional studies of the hydrological and energy cycles over the Baltic Sea and its drainage basin the hydrostatic model REMO based on the operational forecast model of the DWD was used. In close coorperation with the DKRZ an additional physical parameterization scheme, identical to the one of the global MPI climate model (ECHAM4) for the atmosphere was successfully implemented. The REMO model can now be used with two complete physical parameterization schemes, the original one (DWD-physics) and the new on (ECHAM4-physics).

The water and energy cycles over the Baltic Sea are influenced by meteorological phenomena on a variety of scales, therefore an intense study of weather events on a wide range of spatial and temporal scales will be done using REMO in forecast mode as well as in climate mode.

During the PIDCAP period observations were taken which can and will be used to validate model results on a timescale from days to 3.5 months. Two time periods were defined for model intercomparison studies, first the whole PIDCAP period of three month and second a 6 day period from 27.8.95 to the 2.9.95. REMO has been driven by analyses data provided by the german (first period) or danish (second period) weather services as lateral boundary conditions. For each physical parameterization scheme two simulations have been performed, one with 50 km and a second one with 18 km resolution on the horizontal scale. Therefore it is possible to compare the different physical parameterization schemes against eachother. The use of different boundary data sets gives some information about the influence of the driving fields onto the regional model results.

Up to now the intercomparison between model results and observations shows that the spatial distribution of precipitation is very similar in all simulations and agrees well with the observations. In particular, local phenomena like the relatively dry regions over south-east Sweden and northern Denmark and the increase of precipiation (close to the long term climatology) over Poland during August 1995 are realistically simulated. Much more details are resolved on 18 km resolution and the amount of precipitation is in better agreement with the observations.A more detailed validation of REMO results for the 3 months period against observations is under way.

As a part of the model intercomparison 6 30-h forecasts (the first 6 hours are not taken into account in order to avoid spin-up problems) and a 6-day forecast using REMO with ECHAM4-physics on 18 km resolution driven by analyses from DMI for the second period have been performed. Figure 1 shows the precipitation (a and b) and the evaporation (c and d) for the third 30-h forecast, eg. the 29th of August, 6am, to the 30st of August, 6 am, (a and c) and the third day of the 6-day forecast (b and d). After 3 days a difference in the spatial distribution of precipitation (a and b) especially east of the Baltic Sea can be seen.The precipitation band seems to be shifted towards the east and it seems to be a bit wider. This is also clearly seen in the evaporation pattern (c and b).

An intercomparison of the above mentioned results to a simulation using DWD analyses data is planned.

Figure 1 (see next page) :

Precipitation (a,b) and evaporation (c,d) for the time period of 24 hours (29th of August, 6 am, to the 30th of August, 6 am) calculated during a 30-h forecast (a,c) and a 6-day forecast (starting on the 27th of August,0 am) in mm.

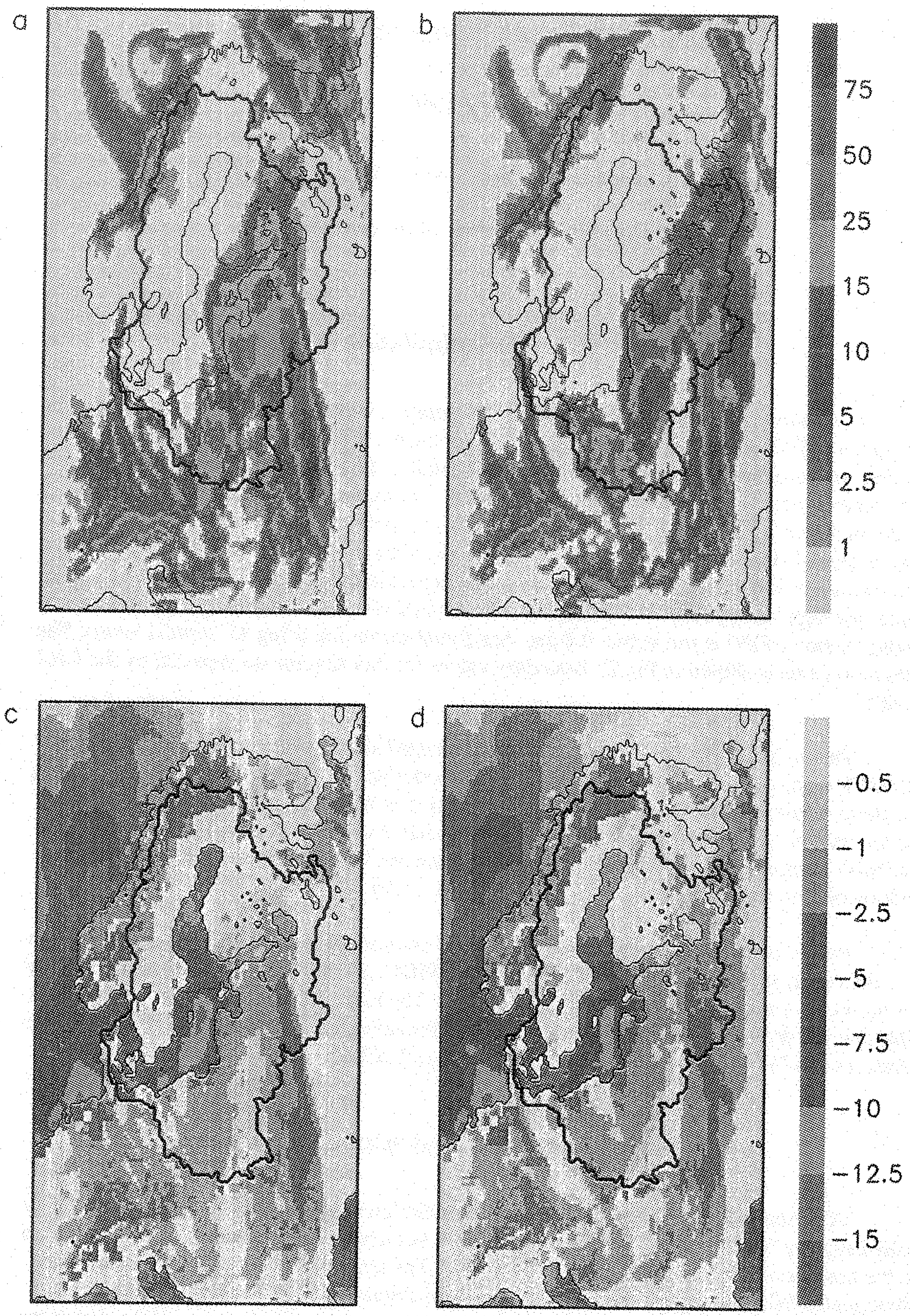


Fig. 1

PIDCAP related research at DMI

February 1997

Bent H. Sass and Xiaohua Yang

Danish Meteorological Institute

1. Design of a data-assimilation system

A framework has been set up for data assimilation with the HIRLAM forecasting system in the NEWBALTIC project. The goal is to produce a high quality data assimilation in a suitable area around the Baltic Sea. This enables detailed diagnostic studies related to the atmospheric water and energy cycle in the BALTIC drainage area. The HIRLAM forecast model includes 'cloud water' as a prognostic model variable. A double-nested system has been designed. The integration area of the coarse resolution version (CRS) is shown in Fig.1. The resolution is 0.4 deg. in the horizontal and 24 levels in the vertical. The lateral boundary values are supplied by ECMWF fields with a horizontal resolution of 1.5 deg. The fine mesh model version (FIN) is run with a 0.2 deg. horizontal resolution using 31 vertical levels. The integration area is shown in Fig.2. Boundary values for this version are supplied by the CRS model.

The main reasons for choosing the double nested solution are the following. First, the ECMWF fields do not include 'cloud water' as a model variable. By running the CRS version the cloud water field from that model can be supplied as lateral boundary values to the FIN model version. Also the double -nested solution avoids potential numerical problems associated with a large change in horizontal resolution between boundary model (ECMWF) and a high resolution internal model, in this case the FIN model version.

Before carrying out data-assimilations over extensive periods , e.g. the period of intensive data colloection and analysis of precipitation (PIDCAP) in the Baltic Sea area, the system set-up was evaluated and tested on smaller periods. The tests included an investigation of possible spin-up problems and quality assessment of climatological fields such as sea surface temperatures (SST) for use in data-assimilations during PIDCAP

2. Investigation of potential spin-up problems

A common experience in global data-assimilation experiments is the occurrence of so-called spin-up features in the analysed fields. Such behaviour has for example been described in the context of the ECMWF re-analysis project . The interaction between observations and 'first guess' fields is responsible for this type of behaviour. Prior to data-assimilations for extensive periods it is important to investigate whether spin-up effects are prominent features also in the present system, run on a limited area around the Baltic Sea. This has been investigated for a number of forecast parameters , i.e. cloud water , total precipitation and the mean sea level absolute pressure tendency. Forecasts at different ranges up to + 18 hours have been compared at the same valid time to the corresponding analysis. The results of such investigations show that the spin-up effect in the present model setup is not a major issue, but not completely negligible up to a forecast range of about +12 hours. This result also applies to the various budget terms in the energy and hydrological balance studies. For the surface fluxes there is almost no spin-up. In the light of the results a forecast length of 12 hours has been chosen in the assimilation runs for the entire PIDCAP period.

3. Improved SST- analyses.

When investigating the quality of climatic surface fields such as sea surface temperature (SST) it has been found that substantial deviations from climatic values occurred during the PIDCAP period. This conclusion is based on the comparison between manually analysed SST charts and the climatic values. It has been concluded that digitized SST data , in a 1*1 degree resolution, should be produced on the basis of weekly analysed charts covering the Baltic Sea , the North Sea and the Norwegian Sea. The data valid for the Baltic Sea have been taken from charts produced by SMHI whereas the SST data from other regions have been taken from maps issued by the Norwegian Meteorological Institute. This task has implied a considerable amount of manual work.

4. Diagnostics

Various enhancements to the HIRLAM forecasting system have been developed in order to study matters related to the atmospheric water and energy cycle over a limited area. A number of new fields have been added to study horizontal structures over the entire integration area, e.g.

a) Net radiation at the 'top' of the atmospere, and at the 'bottom' of the atmosphere. Separate fields are avilable for solar radiation and infrared radiation. These fields enable a comparison of radiative fields with various observations of radiation, e.g. from satellite data.

b) Instantaneous precipitation fluxes. A distinction between rain and snow flux , and between stratiform and convective precipitation is possible. A comparison of these fields to observations from weather radar is possible. Instantaneous precipitation intensities up to several hundreds of mm/day have been diagnosed for low pressure systems crossing the Baltic drainage area during late August 1995. Intensities of this order of magnitude seems to be realistic for mid-latitude precipitation systems. For example , Rogers (1976) is mentioning that the main contribution to a year's total rainfall in the Montreal area comes from intensities of about 240 mm/day.

c) Special diagnostics have been made in a 1*1 degree geographical grid covering the BALTEX catchment area. Moisture and energy budget components are computed expressing vertical dependencies and vertical integrals of the parameters. An example of diagnosed area mean components of the moisture budget in the catchment area is shown in Fig. 3a-c for the month of August 1995. The results apply to the CRS model version. The computations are based on

consecutive data-assimilations using forecast data from +6 to +12 hours of forecast range . Fig.3a shows the total area averaged day to day change in moisture consisting of humidity plus cloud water (red line). Also are shown the corresponding separate daily changes due to dynamics (green line) and due to physics (black line). Fig. 3b shows a further splitting of the contribution due to physics , into the average diurnal effect due to the surface evaporation flux (black line), and due to the precipitation plux (green line). Fig. 3c shows a more detailed presentation of the components of the physics based on hourly values. This presentation allows for diagnosing a diurnal cycle in the evaporation flux.The results presented in Fig.3 a-c reveal a considerable day to day variability among the different moisture flux components. The different partitioning between the contributions from dynamics and physics can be related to specific weather conditions. A preliminary assessment of accumulated precipitation on a monthly basis (August and September 1995) indicates a fair agreement between the HIRLAM based precipitation and corresponding estimates from the UK-model and the REMO model. The results are also in reasonable agreement with the analysed results from Rubel (1996).
A more detailed comparison, however, remains to be done. In addition, it is planned to utilize the extensive synoptic precipitation data for PIDCAP, as released by the BALTEX data centre.

A Webpage describing the assimilation data sets for the PIDCAP period is available on the internet (http://gate.dmi.dk:8080 /pub/PIDCAP)

References.

Rogers, R.R., 1976:
A Short Course in Cloud Physics, (p. 143) *(Pergamon Press).*

Rubel, F.R., 1996:
PIDCAP Quick Look Precipitation Atlas. *(Institute for Meteorology and Geophysics , Univ. Vienna. pp 95, ISSN 1016-6254).*

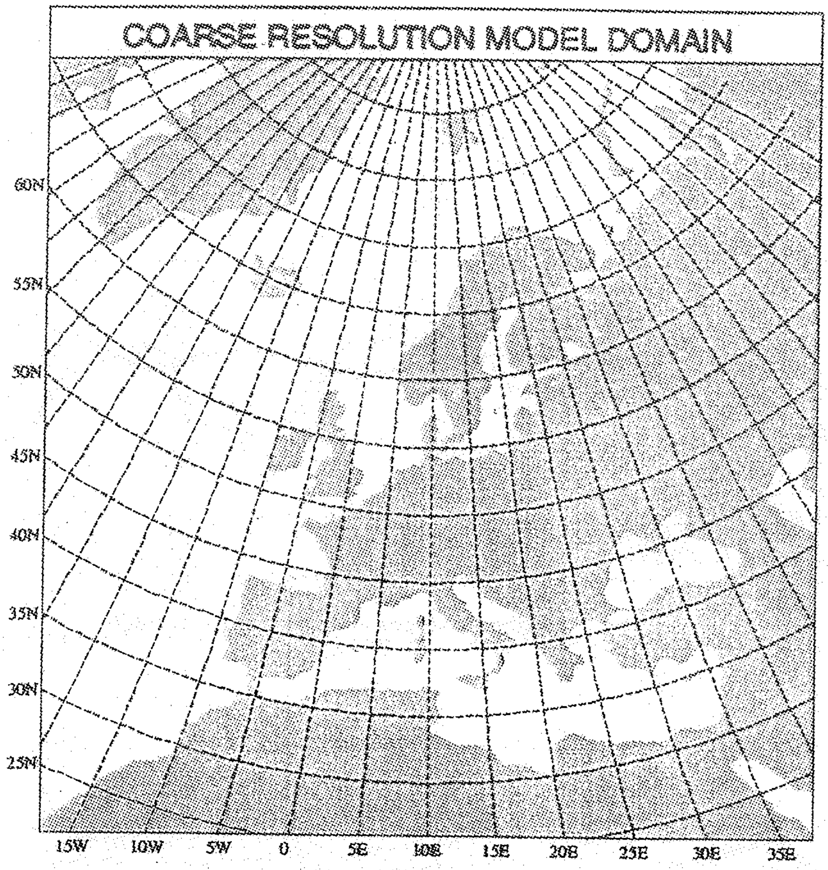

COARSE RESOLUTION MODEL DOMAIN
60N
55N
50N
45N
40N
35N
30N
25N
15W
10W
5W
0
5E
10E
15E
20E
25E
30E
35E

Fig. 1

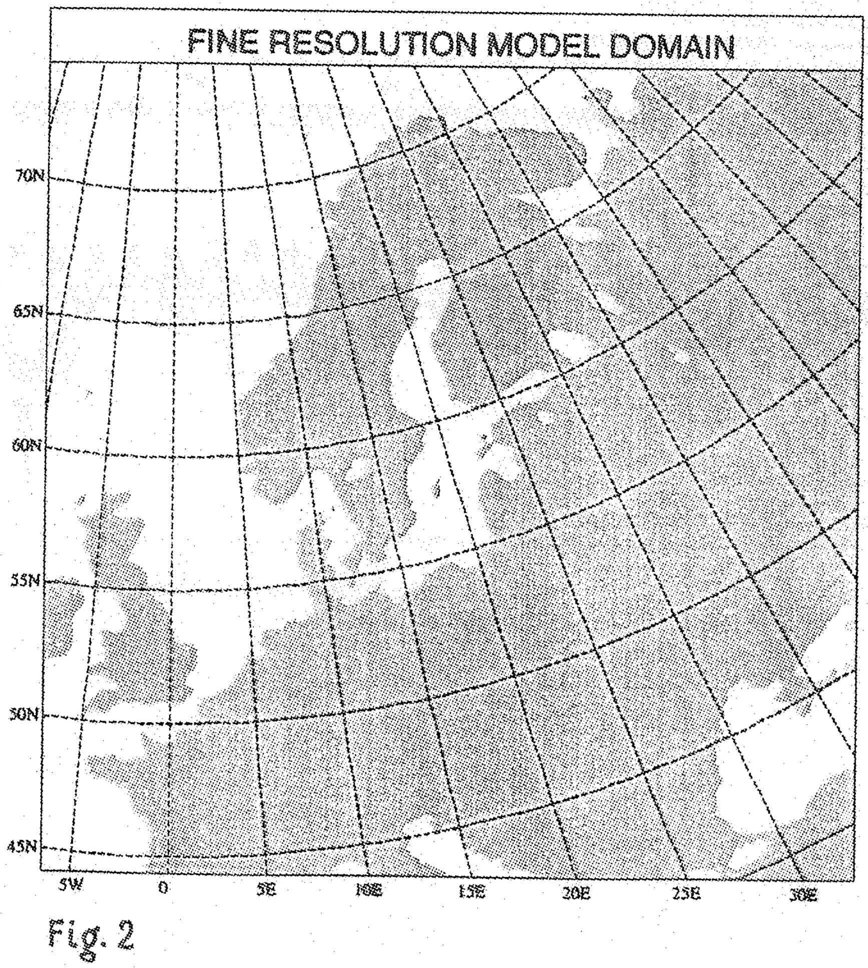

FINE RESOLUTION MODEL DOMAIN
70N
65N
60N
55N
50N
45N
5W
0
5E
10E
15E
20E
25E
30E

Fig. 2

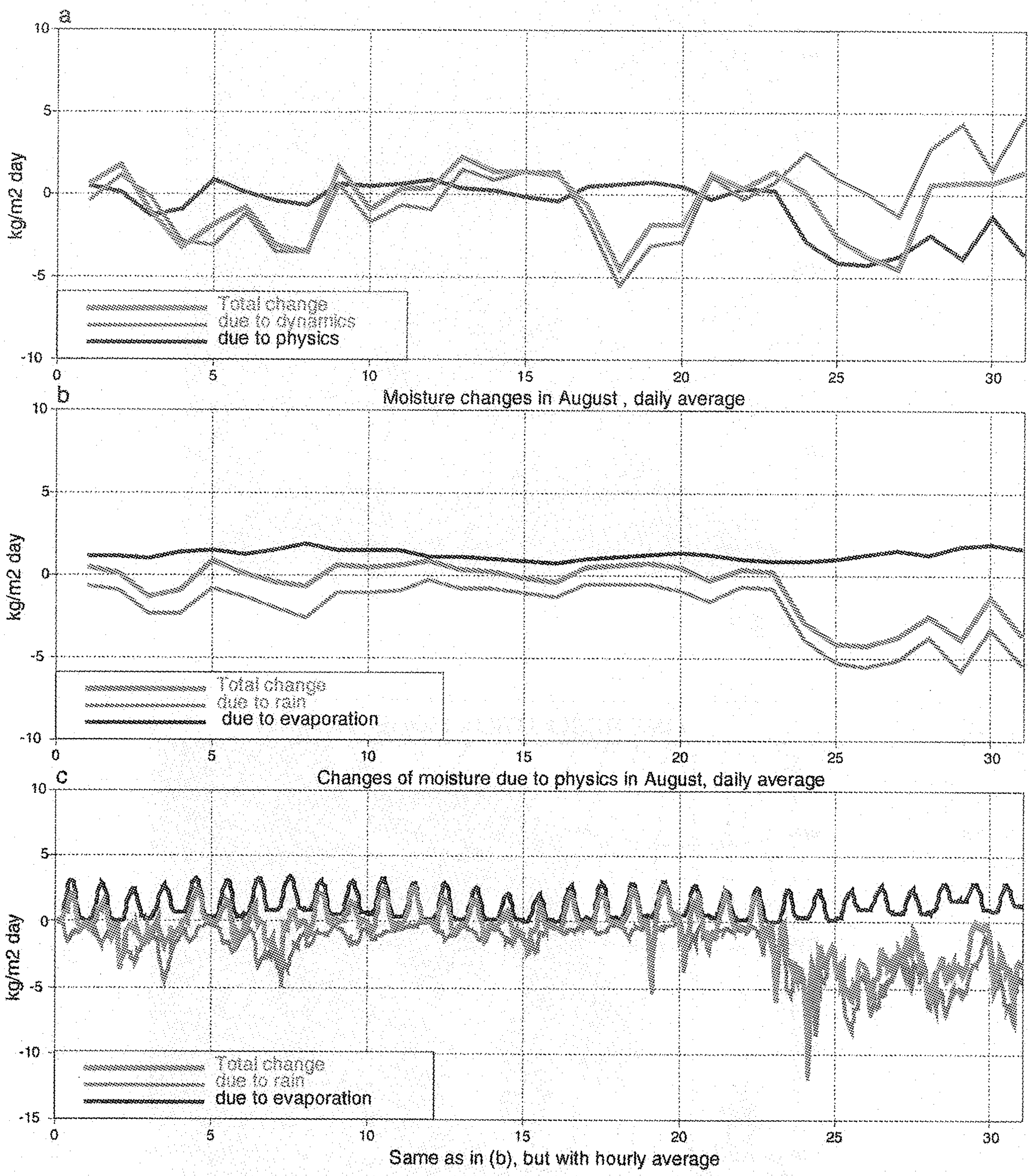

a
Total change
due to dynamics
due to physics
kg/m2 day
Moisture changes in August , daily average
b
Total change
due to rain
due to evaporation
kg/m2 day
Changes of moisture due to physics in August, daily average
c
Total change
due to rain
due to evaporation
kg/m2 day
Same as in (b), but with hourly average

Fig.3

Number of precipitation land stations during PIDCAP

Hans-Jörg Isemer
BALTEX Secretariat
GKSS Forschungszentrum Geesthacht

Through initiative of both the BALTEX Secretariat and the BALTEX Meteorological Data Centre (BMDC) daily precipitation depths from more than 3800 land stations in the BALTEX area (see Table 1) have been collected into the data archive of BMDC. Most of these data are available now at BMDC for BALTEX research purposes. Table 2 gives the number of stations and the related station density for five major river basins in the Baltic Sea catchment region. Note, that the statistics given in Tables 1 and 2 are valid in particular for the period August to October 1995, the data base for November 1995 is being completed at present. Meteorological surface observations at synoptic stations as well as data on soil moisture, soil temperature and radiation are also being collected from all available stations in the BALTEX area.

Table 1 : Number of precipitation land stations during PIDCAP

(Status as of 31 March 1997)

Country	Number
Belarus	39
Denmark	620
Estonia	60
Finland	517
Germany	290
Latvia	73
Lithuania	72
Poland	1265
Russia	199
Sweden	762
Total	3897

Table 2 : Number of precipitation stations during PIDCAP for 5 selected river basins in the Baltic Sea catchment region. Station density is expressed as number of stations per REMO model gridbox (18 km * 18 km).

River	Catchment area [km^2]	Area of BALTEX Region [%]	Number of stations	Density
Torneälv	41375	2.4	**23**	**0.19**
Neva	281000	16.5	**103**	**0.13**
Daugava	91920	5.4	**54**	**0.20**
Vistula	191800	11.3	**702**	**1.26**
Odra	118800	7.0	**541**	**1.56**

Appendix 11

BALTEX-related Funding Proposals to EU

(Status as of 10 April 1997)

Summary for the 5th BALTEX SSG meeting

I have taken notice of 7 recent EU funding proposals, which are related to the Baltic Sea Experiment (BALTEX). A short overview on these proposals is enclosed in the following. Four of them were submitted before 15 January 1997 to the ENVIRONMENT and CLIMATE Program. Two were submitted to MAST-III to meet the deadline on 15 October 1996. These six applications have been the subject of an earlier summary which I circulated January this year. A recent application has been submitted to the EU-INTAS Program.

This overview does not contain earlier EU applications which are already funded and ongoing.

Hans-Jörg Isemer
International BALTEX-Secretariat
10 April 1997

Proposal submitted to ENVIRONMENT and CLIMATE (January 15, 1997)

Title: **Pilot Study of Evaporation and Precipitation in the Baltic Sea**

Acronym: PEP

Objectives:

It is envisaged to have the main BALTEX experiment phase in 1999-2000 to integrate observations by numerical modelling and thus achieve a description of the energy and water cycle in all of the Baltic Sea Catchment area. PEP is designed as a pilot experiment to the main experiment, with the specific scope to study precipitation and evaporation over the sea. For determination of precipitation at sea the main experiment needs to rely heavily on radar measurements. To test, improve and validate radar estimates of precipitation against in situ measurements, a pilot study prior to the main experiment is necessary. At the same time, PEP will provide data sets for the improvement of numerical models over the sea. PEP in this way is designed to sharpen our tools for the main BALTEX experiment.

Co-ordinator: A.- S. Smedman, Uppsala University, Sweden

Participants:

1	IfM Kiel,	Germany
2	MPIfM Hamburg,	Germany
3	Risö National Laboratory,	Denmark
4	Uppsala University,	Sweden
5	SMHI Norrköping,	Sweden
6	FMI Helsinki,	Finland

Requested budget: 787 kECU

Proposed Duration of the project: 2 years

Proposal submitted to ENVIRONMENT and CLIMATE (January 15, 1997)

Title: **Accurate High Resolution Precipitation Fields for the Baltic Region from Weather Radars, Satellites and Numerical Models**

Acronym: BALTRAD

Objectives:

A homogenous precipitation database with high spatial and temporal resolution which can be used to validate model data will be generated in this project. Methods for assimilating radar-derived precipitation information into NWP modelling activities will also be developed and evaluated. Four of the six partners in this collaboration are national weather services whose mandates are to provide society with meteorological and hydrological nowcasts and forecasts with higher accuracy than those available today. This implies that the methods developed in this project will directly serve society to help prevent loss of lives and damage to property. The workpackages include in particular

- To develop, apply and evaluate methods for consistently calibrating and processing data from an international network of 25 European weather radar systems,
- To diagnose, analyse and correct well-known errors in radar data using surface observations, satellite remote sensing, and model data,
- To correct the flow distortion error of rain gauge observations using NWP winds at the height of 2 m,
- To enable the generation and archiving of homogenous radar-based precipitation products in real or near-real time,
- To establish previously unavailable fields of precipitation for the Baltic Region (including the Baltic Sea area itself) into one data archive, covering a time period of 6 months,
- To provide a dynamic interface between remote sensing observational and numerical modelling fields of research within a European logistical framework,
- To provide the Baltic Sea Experiment and the respective national weather services with highly valuable and prioritised information and methods.

Co-ordinator: J. Koistinen, Finnish Meteorological Institute (FMI), Finland

Participants:

1.	DMI Copenhagen,	Denmark
2.	DWD/Radar Group,	Germany
3.	Finnish Meteorological Institute,	Finland
4.	GKSS-Research Centre,	Germany
5.	SMHI Norrköping,	Sweden
6.	University of Salford,	UK

Requested budget: 883 kECU

Proposed Duration of the project: 2 years (9.1997 to 8.1999)

Proposal submitted to ENVIRONMENT and CLIMATE (January 15, 1997)

Title: **BALTEX Lindenberg Land Surface Experiment**

Acronym: BALINEX

Objectives:

The Baltic area is a heterogeneous one and the energy as well the mass balance must take into consideration the inhomogeneity / heterogeneity effects. At present the energy and mass balance is described as an interaction process of fluxes at a surface. This process uses parameterised relations, which are derived experimentally under homogeneous surface conditions. The present project is directed towards the validation of parameterised relations under natural, heterogeneous conditions. The objectives of BALINEX include

1. the description of the subgrid-scale variability in mesoscale atmospheric models (landscape heterogeneity effects),
2. the representation of forests and forest edges in SVAT-Models,
3. investigation of the surface components of the water cycle as process study paralleling the field experiment,
4. modelling of the hydrological cycle during the drying process of a typical landscape after a rainfall event.

Co-ordinator: G.Tetzlaff, University of Leipzig, Germany

Participants:

1	Groningen University,	The Netherlands	
2	Risoe Research Centre,	Denmark	
3	University College Cork,	Ireland	
4	GKSS Research Centre,	Germany	
5	University of Leipzig,	Germany	
6	Berlin University FU,	Germany	
7	Tech. University Dresden,	Germany	
8	Meteo Bulgaria,	Bulgaria	(support through INCO)

Requested budget : 1 054 kECU

Proposed Duration of the project : 3 years

Proposal submitted to ENVIRONMENT and CLIMATE (January 15, 1997)

Title: Numerical Studies of the Energy and Water Cycle of the Baltic Region

Acronym: NEWBALTIC II

Objectives:

This project will mainly focus on the validation of the water and energy cycle of the entire Baltic Sea catchment area simulated by climate models and the preparation for the main BALTEX field experiment. The project includes also an optimisation of the observational network including the use of radar and new types of satellite information (GPS-data) as well as the development of a new four-dimensional data-assimilation system to assimilate radar and satellite data as well as soil moisture information. The objectives of this project include

- to minimise spin-up effects,
- to diagnose and assess new parameterisation schemes for convection,
- systematic model intercomparison,
- the coupling of atmosphere and hydrological models and validation,
- to assess the role of land-surface sub-grid scale heteorogenieties,
- to assess the role of snow and ice cover.

The improvement of the understanding of the Baltic energy and water cycle will be beneficial for short range weather prediction, medium and long term climate prediction, climate impact studies, observational techniques and network design, water resources assessment and management, as well as environmental aspects.

Co-ordinator: L. Bengtsson, MPIfM Hamburg, Germany

Participants:

1	SMHI,	Sweden
2	Chalmers University of Technology,	Sweden
3	DMI,	Denmark
4	University of Helsinki,	Finland
5	KNMI,	The Netherlands
6	DWD,	Germany
7	MPIfM,	Germany
8	IfM,	Germany
9	GKSS,	Germany
10	IMG University of Vienna,	Austria

Requested budget: 1600 kECU

Proposed Duration of the project: 2 years (1.1998 to 12.1999)

A 88

Proposal submitted to MAST-III (October 15, 1996)

Title: **Baltic Air-Sea-Ice Study - A Field Experiment of BALTEX**

Acronym: BASIS

Objectives :

Numerical modelling of the dynamics and thermodynamics of sea-ice need verification and optimisation by observations. BASIS aims at an improved understanding and modelling of the energy and water cycles during winter conditions by conducting a winter field experiment in the marginal ice zone (MIZ) of the Baltic Sea. This project will establish a detailed and multidisciplinary observational data set of various physical processes in the wintertime atmosphere, ice and the sea. Overall objective is to create and analyse an experimental data set for optimisation and verification of coupled atmosphere-ice-ocean models. Specific objectives include

- the investigation of water budget and momentum and thermal interaction at the air-ice, air-sea and sea-ice boundaries,
- the investigation of the winter time boundary layer, especially close to the sea ice margin,
- the investigation of the ocean boundary layer,
- the validation of coupled atmosphere-ice-ocean models.

Co-ordinator : J. Launiainen, Finnish Institute of Marine Research, Finland

Participants:

1	Hannover University,	Germany
2	Hamburg University,	Germany
3	SMHI Norrköping,	Sweden
4	University of Uppsala,	Sweden
5	FIMR Helsinki,	Finland

Requested budget: 1004 kECU

Proposed Duration of the project: 1997 - 2000

Proposal submitted to MAST-III (October 15, 1996)

Title: **Dynamics of Wind-forced Diapycnal Mixing in the Stratified Ocean.**

Acronym: DIAMIX

Objectives:

DIAMIX aims at a novel investigation of diapycnal mixing in the stratified parts of a virtually tide-less sea. This will lead to improved parameterisations of atmospherically forced diapycnal diffusivity, including its dependence on wind and buoyancy forcing, horizontal and vertical distances to the sea bed and vertical stratification, that are required for studies of bio-geochemical, ecological and climate change. The DIAMIX data sets, collected in the Baltic Sea, will also provide the first serious possibility to test the coastal and meso-scale dynamics of 3D circulation models. Both the improved parameterisations for diapycnal mixing (both for the coastal zone and the open sea!) and the possibility to test the coastal and meso-scale dynamics of the models should greatly contribute to improvements of BALTEX ocean models.

Co-ordinator: A. Stigebrandt, Göteborg University, Sweden

Participants:

1	IOW,	Germany
2	FIMR,	Finland
3	SMHI,	Sweden
4	SAI,	Italy
4.1	(Main subcontractor to SAI: ME-GmbH, Germany)	
5	IOPAS,	Poland
6	SUMO,	Sweden
7	EMI,	Estonia

Requested budget: 1505 kECU (of which 300 kECU should come from INCO)

Proposed Duration of the project: 3 years

A 90

Proposal submitted to INTAS (April 2, 1997)

Title: **Hydrological Modelling of the River Neva Drainage Basin and Related Data Processing - A Contribution to BALTEX**

Acronym:

Objectives:

This project includes two major objectives. The first is the establishment of a long-term, digitised data set of hydrological and meteorological quantities from the river Neva drainage basin required for calibration and validation of different hydrological models in the frame of BALTEX. The hydro-meteorological data set to be established will be included in the comprehensive hydrological data set at the BALTEX Hydrological Data Centre (BHDC). It will be made available in homogeneous formats to the entire BALTEX scientific community. A major part of the financial support will go to the Russian State Hydrological Institute and the Russian Weather Service, which have the task to digitalise and prepare the data set.

The second objective focuses on the application of different classes of hydrological models to the entire Neva basin and its sub-catchments in order to get an improved understanding of the hydrological processes in this area. Within the BALTEX scientific community different hydrological models are applied and further developed. These models cover a range of approaches from more simple water balance models to advanced combined energy and water balance models (BALTEX 1997). This objective focusses on the preparation of different model types and a process-oriented model intercomparison and validation for the Neva basin. Modelling activities at the Russian State Hydrological Institute will be primarely funded through this project.

This project is preparatory for the Main BALTEX Experiment period (BRIDGE) planned for 1999 onwards, where improved hydrological models will be applied to the entire Baltic Sea catchment region. Both objectives are closely interrelated because the establishment of the data base is essential for the modelling activities.

Co-ordinator: H.-J. Isemer, BALTEX Secretariat, GKSS Geesthacht, Germany

Participants:

1.	RSHI St. Petersburg	Russia
2.	NWAHM St. Petersburg	Russia
3.	GKSS Geesthacht	Germany
4.	SMHI Norrköping	Sweden

Requested budget: 60 kECU

Proposed Duration of the project: 3 years

Appendix 12

Minutes of
First BALTEX Hydrology Workshop

at
Polish Academy of Sciences
Warsaw, Poland
September 9-11, 1996

Only three parts of the complete minutes are reproduced here:

- the minutes text,
- Appendix 4, including model descriptions,
- Appendix 9, including the draft hydrological data sampling strategy (written by Professor Sten Bergström, SMHI)

A copy of the complete meeting minutes may be obtained upon request at the BALTEX Secretariat.

1 Introduction

The BALTEX Science Steering Group (SSG), at its 4th meeting in Sopot, Poland in June 1996, noted the need for a specification of the BALTEX hydrology data sampling strategy and a more detailed overview on existing hydrological models to be applied in the frame of BALTEX. The SSG further suggested to clarify related issues on a specific BALTEX hydrology workshop.

As a response to these suggestions Professor Zdzislaw Kaczmarek, vice chairman of the BALTEX SSG, organised the First BALTEX Hydrology Workshop. This workshop took place 9 to 11 September, 1996 at the Polish Academy of Sciences in Warsaw, Poland.

Participants at this workshop and the agenda are given in Appendices 1 and 2, respectively.

The present minutes summarise the main results and findings of the workshop.

2 Hydrological Models

Seven different hydrological models were presented at the workshop. These include

- CLIRUN 3 developed in Poland,
- HBV developed in Sweden,
- VIC-2L combined with a horizontal transport scheme developed in the US and Germany,
- Hydrological Discharge (HD) model developed in Germany,
- Simplified Land Surface Scheme combined with HD developed in Germany,
- MOREMAZ-1 developed in Poland,
- WB10 developed in Russia.

In order to describe these models in a homogeneous form, 16 keywords have been defined (see Appendix 3). Description of the models which were presented at this workshop is summarised in Appendix 4 following these 16 keywords. In addition to the models presented at the workshop the following models are additionally included in Appendix 4:

- HYDROGRAPH developed in Russia,
- MIKE-SHE developed in Denmark.

The following general points were noted in particular at the workshop:

2.1 Some preliminary applications of the HBV model to major river basins in the Baltic Sea catchment are currently being performed at SMHI, however, none of the models presented at the workshop has been applied so far to the entire Baltic Sea catchment or its major sub-basins with satisfactory results for both water and surface energy budgets.

2.2 Not all of the models presented include

- runoff production
- channel delivery (surface and base flow)

- river routing (stream flow).

2.3 Traditional hydrological modelling has been aiming at an accurate representation of the water budget. In particular, most of the hydrological models are dedicated to forecast stream flow in rivers as an end-product for operational purposes. Only few of the hydrological models include an explicit description of both water budget and the energy budget. However, the latter is required to meet the objectives of BALTEX.

2.4 It was noted that a fully distributed, physically-based model (like e.g. the MIKE-SHE) was unfortunately not represented at the workshop. See however Appendix 4 for a description of the MIKE-SHE.

2.5 In order to compare model performances directly a BALTEX hydrology model intercomparison project was suggested.

3 Model Intercomparison Project for BALTEX

Stimulated by the success of the Project for Intercomparison of Land Surface Parameterisation (PILPS) the workshop participants suggested to organise a model intercomparison project for hydrological models. BALTEX would provide a useful frame for such an intercomparison because

- there is a number of different hydrological models used within the BALTEX community,
- the BALTEX region provides for catchments of different characteristics in climate, landscape (e.g. soil and vegetation) and structure (e.g. lakes);
- there are long time series of PTQ (precipitation, temperature, runoff) data existing in the participating countries.

It was also noted that a separate intercomparison project for BALTEX will need considerable efforts and, in particular, man power and other resources at an institute or laboratory which will have to act as the organiser of this project.

The subject of the intercomparison should include

- runoff production
- energy budget
- channel delivery
- stream flow.

Details will have to be defined at a later stage.

As a preliminary suggestion the Wartha catchment was suggested as a suitable test basin for this intercomparison project. The landscapes of the Wartha catchment are typical for much of the southern and south-eastern parts of the BALTEX region. The Wartha is a sub-catchment of the river Odra and covers an area of about 55000 km^2 (i.e. about 50 % of the Odra catchment). Its mean annual discharge is about 215 m^3/s. There are more than 60 runoff stations and several hundreds of precipitation stations located inside the Wartha basin. The Wartha catchment is located entirely on Polish territories, hence, data collection and preparation could be in the hand of one national or regional authority. Being part of the Odra basin the Wartha catchment belongs to one of the five potential hydrological test basins (see section 8 of the present minutes) for which e.g. a denser data sampling is planned anyway in the frame of BALTEX.

Professor Kaczmarek and Dr. Pruchnicki agreed to investigate possibilities of realisation of this Wartha intercomparison project to be organised and led by a Polish research institution with support and co-operation of other groups or institutions being engaged in BALTEX.

4 BALTEX Data Centres

The status of the three BALTEX Data Centres was summarised (see Appendix 5). The BALTEX Meteorological Data Centre (BMDC) which is hosted by the German Weather Service (DWD) in Offenbach was considered the most advanced in terms of planning and implementation. Both the status of BMDC in BALTEX and the data sampling strategy has been developed and approved by the BALTEX SSG, and collection of both meta and real data has been started. For the BALTEX Hydrological Data Centre at the Swedish Meteorological and Hydrological Institute (SMHI) in Norrköping the data sampling strategy and the related status in BALTEX needs to be determined, the latter being a topic of the present workshop. The data sampling strategy for the BALTEX Oceanographic Data Centre (BODC) at the Finnish Institute for Marine Research (FIMR) in Helsinki was approved by the BALTEX SSG at its recent meeting in June 1996.

5 BALTEX Hydrological Data Centre (BHDC)

The present contents of the BHDC is restricted to monthly runoff data from stations which are mostly located at the mouth of the main rivers in the BALTEX area (Appendix 6). The total catchment area covered by these stations amounts to 86 % of the entire Baltic Sea catchment region.

Professor Sten Bergström introduced Mr. Ola Pettersson of SMHI who will in future be in charge of the further development of the BHDC at SMHI.

6 Global Runoff Data Centre (GRDC)

The objectives of the Global Runoff Data Centre (GRDC) include the collection and dissemination of hydrological data both generally and specifically to support projects within the World Climate Research Program (WCRP) of the World Meteorological Organisation (WMO). GRDC aims at providing mechanisms and support for the international exchange of data related to *river flow* and *surface water runoff* on a continuous, long-term basis. The present criteria for GRDC´s runoff data collection strategy are:

- rivers with mean annual discharge greater than 100 m^3/s,
- rivers of catchments comprised of a basin area greater than 1.000.000 km^2,

- rivers with basins containing more than 1.000.000 inhabitants.

Recently, an inventory of runoff data from the Baltic Sea catchment portion of the GRDC archives has been compiled at the BALTEX Secretariat. This report may be obtained upon request from the BALTEX Secretariat. Appendix 7 gives an overview on monthly and daily runoff records in the Baltic Sea catchment region which are available from the GRDC archives. It has to be noted that the length of the individual records which are listed in Appendix 7 varies considerably ranging from months to decades. Also, the size of the respective catchments belonging to the individual runoff stations ranges from a few 100 km^2 (in contradiction to the GRDC criteria mentioned above) to more than 100.000 km^2.

Based on this report it was concluded that the runoff data at GRDC has a somewhat inhomogeneous coverage for the Baltic Sea catchment (in particular with respect to number of stations, lengths of records, and sizes of catchments covered) compared to the requirements in BALTEX. Although the records already stored at GRDC are useful to be used in BALTEX additional data collection efforts of the BALTEX Hydrological Data Centre are required to meet the objectives of BALTEX (see section 8 below).

7 WMO Congress on Data Exchange

During the workshop consideration was also given to decisions of the World Meteorological Organisation (WMO) regarding data exchange policies. Resolution 40 (Cg-XII) of WMO was discussed in some detail. In this resolution Members of WMO are reminded to facilitate world-wide co-operation in the establishment of observing networks, and to promote the exchange of meteorological and related information. Further, WMO commits itself to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products. Resolution 40 states that Members shall provide on a free and unrestricted basis *essential* data and products which are required to sustain WMO programmes at the global, regional, and national levels. Resolution 40 also states that Members should provide on a free and unrestricted basis *additional* data and products which are required to sustain WMO programmes at the global, regional, and national levels. Finally, following Resolution 40, Members should provide to the research and education communities, for their non-commercial activities, free and unrestricted access to all data and products exchanged under the auspices of WMO.

The workshop participants considered this resolution instrumental to be referred to in cases when national Meteorological Services seem to be too restrictive in preparing necessary observational data for BALTEX. A letter to WMO notifying those national Meteorological Services which upon data requests do not seem to follow Resolution 40 was suggested to be written by the Chairman of the BALTEX SSG. It was however also stated that WMO has only limited influence on national Meteorological Services (Members) in this respect. Convincing Members to deliver necessary data through scientific arguments was considered as the most appropriate and useful way.

8 Hydrological Data Sampling Strategy for BALTEX

A detailed discussion on the future BALTEX data sampling strategy led to the following conclusions:

8.1 The most important data to be collected and prepared by the BALTEX Hydrological Data Centre (BHDC) for dissemination to the BALTEX community are **daily runoff data** from operational networks.

8.2 For some river catchments in the BALTEX region data from all runoff stations with reliable data should be collected. These special test catchments include

- Torne,
- Neva,
- Daugava,
- Odra, or Vistula.

These five catchments cover about 710 000 km^2 , which is approximately 40 % of the entire Baltic Sea catchment region. For locations of these catchments see Appendix 8. The total number of runoff stations in the entire Baltic Sea catchment was roughly estimated to 800. Assuming an equal distribution of the stations in the entire catchment daily river runoff data from about 300 stations should build the base for these five catchments. It was noted that an absolute minimum requirement is an average station density of one station per 4000 km^2 leading to a total minimum number of about 180 stations for all the five mentioned catchments. It was also noted that the establishment of a comprehensive hydrological data set for both the Odra and Vistula catchments will be a major task for the Polish Services. Hence, restriction to either Odra or Vistula as a BALTEX test catchment with a high coverage of observational data may be a more feasible option for the BALTEX hydrological data sampling strategy.

8.3 For the other catchments in the BALTEX region (about 1 million km^2) a somewhat reduced data coverage (data from about 200 runoff stations) was considered sufficient.

8.4 The daily runoff data mentioned under items 8.1 to 8.3 are required for both tuning and validation of models. This requires a minimum of 5 to 10 years of runoff data depending on the type of model (see e.g. Appendix 4). It was suggested to include runoff data for the period 1980 onwards in the archives of the BHDC. In particular the Vistula catchment experienced a number of dry years in the 1980s, hence, extension to periods before 1980 (e.g. from 1970 onwards) might be necessary in order to avoid tuning biases. This extension should however be exceptional. In general, the 1980s were found to be the wettest decade out of seven decades in this century for the entire Baltic Sea catchment (see Bergström and Carlsson 1994, reference in Appendix 6).

8.5 For climatological studies a few very long key runoff records (longer than a century) preferably based on daily data shall be collected by BHDC.

8.6 The following additional data will be collected and archived by BHDC depending on their availability:

- snow equivalent water
- soil moisture
- information on ground water
- lake level
- lake and river temperatures
- ice observations.

In principle, these data should be collected for the same time periods as runoff data. Most of the mentioned data are however not measured routinely but are only available from specific experiments. Hence, continuous records with high resolution in time (e.g. daily) are unlikely to be available at all. Hence, the mentioned data should be collected by BHDC depending on their availability and specific requirements from the BALTEX modelling community.

8.7 The following data are suggested to be collected and archived by the BALTEX Meteorological Data Centre (BMDC):

- snow depth
- soil temperature.

Both parameters are measured at most synoptic stations; and the data are disseminated as part of the data telegram on GTS with a time resolution of 3 hours.

8.8 Meteorological observations required as input for hydrological modelling are suggested to be also collected by BMDC. These data must cover the same time periods as mentioned under 8.4. In particular, the following data will have to be included:

- meteorological observations (the full telegram including precipitation) made at synoptic stations, including the enhanced number of stations recently achieved at BMDC for BALTEX, time resolution is 3-hourly,
- precipitation measurements from all accessible stations, as recently achieved during the PIDCAP period, this includes more than 3500 stations for the entire Baltic Sea catchment region,
- measurements from climate stations,
- radiation measurements at ground from all existing stations.

8.9 Professor Sten Bergström of SMHI agreed to draft a data sampling strategy for the BHDC based on the recommendations of this workshop. This paper is given in Appendix 9. This BALTEX data sampling strategy for hydrological data will have to be finally approved at the next BALTEX Science Steering Group meeting.

8.10 SMHI was asked to draft data exchange agreements and license agreements which shall regulate legal rights of the data suppliers, the data users and BHDC. These agreements shall be designed in close agreement with those already in use by BMDC. The BALTEX data user identification procedure which was approved by the BALTEX SSG at its 4th meeting in June 1996 shall be valid also for BHDC.

8.11 BHDC and the BALTEX Secretariat were asked to contact national Hydrological Services and other data suppliers in order to build up the BALTEX data archive as suggested at this workshop. The BALTEX Secretariat has already build up contacts to Hydrological Services in particular in east European BALTEX countries which were suggested to be used for future negotiations.

8.12 It was noted by the workshop participants that the large amount of data which have been suggested at this workshop to build the BALTEX hydrological archive may require considerable efforts at both the individual data suppliers and at BHDC. Negotiations between BHDC and individual data suppliers will have to be started immediately in order to determine ways and possibilities of implementing the here suggested BALTEX data sampling strategy.

8.13 The suggested data sampling strategy has considerable implications also for the BALTEX Meteorological Data Centre (BMDC). Negotiations between BMDC and individual data suppliers will have to be started immediately in order to determine ways and possibilities of implementing the suggested BALTEX hydrological data sampling strategy also at BMDC.

8.14 The suggested data sampling strategy will be discussed at the forthcoming BALTEX SSG meeting in April 1997 and needs final approval by the BALTEX SSG.

9 Closing

In closing the workshop Professor Kaczmarek thanked all participants for lively and constructive discussions. The participants expressed their appreciation to Professor Kaczmarek for organising and hosting this workshop.

Hans-Jörg Isemer
International BALTEX Secretariat

Draft
25 January 1997

Approved by Workshop participants
28 February 1997

Final version
6 March 1997

Description of Hydrological Models

- CLIRUN 3
- HBV
- VIC-2L combined with a horizontal transport scheme
- Hydrological Discharge (HD) model
- Simplified Land Surface Scheme combined with HD
- MOREMAZ-1
- WB10
- HYDROGRAPH
- MIKE-SHE

1. CLIRUN 3

Z. Kaczmarek
Polish Academy of Sciences
Warsaw, Poland

2. Type of model
lumped, conceptual, with four optimised parameters.

3. Energy balance included ? How ?
included in the Penman formula for PET

4. Evapotranspiration parameterisation used
PET time series as input, ET time series as output

5. Vegetation included ? How ?
not included

6. Snow included ? How ?
simple temperature formula to calculate snow accumulation and snow melting processes - done *outside* of the main model in a separate procedure used to calculate adjusted values of precipitation time series;

7. Lateral flow within the basin (catchment) included ? Type of approach ?
not included

8. Lateral flow from basin to basin included? Type of approach ?
not included;
9. Time step
10 days to one month

10. Horizontal and vertical resolutions
as required

11. Output variables, method of calculation
time series of catchment storage, runoff and actual evapotranspiration

12. Internal variables, method of calculation (which of them should be used in a model intercomparison ?)
four optimised parameters

13. Which parameters have to be calibrated ?
internal variables: four optimised parameters

14. Input data needed, specification of resolution in time and space
time series of P and PET (estimates outside the model by separate computational procedures)

15. Length of data periods needed for

15.1 model calibration: minimum 10 years

15.2. model validation:

16. References

Kaczmarek Z. (1993), Water Balance Model for Climate Impact Analysis, Acta Geophysica Polonica, V. 41, 4, 421-437.

1. HBV

Sten Bergström
Swedish Meteorological & Hydrological Institute
60176 Norrköping
Sweden

2. Type of model

deterministic - conceptual - semi-distributed

3. Energy balance included ? How ?
No

4. Evapotranspiration parameterisation used
Standard mean values for potential evapotranspiration (calculated or measured) are input and corrections are applied for soil moisture and temperature anomalies.
Calculated values: Standard are Penman type calculations (typically on a monthly basis, but higher frequency can be used). Optional are either simpler Thornwaite type calculations ore, more complex - Priestly-Taylor type calculations which take into account radiation.

5. Vegetation included ? How ?
Yes,
Land use in 3 categories: open land/field, forest, lake

6. Snow included ? How ?
Yes,
Degree-day factor calculations of snow accumulation melt

7. Lateral flow within the basin (catchment) included ? Type of approach ?
No, lumped

8. Lateral flow from basin to basin included ? Type of approach ?
Yes,
Routing with simplified Muskingam and also storage routing for lakes and reservoirs

9. Time step
Typically daily, but smaller time steps are possible.

10. Horizontal and vertical resolutions
horizontal: no known restrictions, depends primarily on the specific application, has been used on small basins (1 km^2) up to large basins (200000 km^2).
vertical: each basin divided into average elevation intervals (typically 50-150 m).

11. Output variables, method of calculation
snow accumulation and melt (degree-day factor)
runoff (2 linear reservoirs & a time filter make up the runoff response routine)

12. Internal variables, method of calculation (which of them should be used in a model intercomparison?)
soil moisture (index of wetness taking into account soil moisture deficit),
evapotranspiration (PE adjusted according to soil moisture and temperature anomalies),
(Note: for HBV, these are also output variables.)
(Note: not so easy to directly compare internal variables between models.)

13. Which parameters have to be calibrated ?
snow - 4 parameters
runoff response - 5 parameters
soil moisture - 3 parameters
evapotranspiration - 1 parameter
(Note: some of these may be pre-set by experience.)

14. Input data needed, specification of resolution in time and space
precipitation (daily, spatial resolution variable)
temperature (daily, spatial resolution variable)
potential evaporation (measured or calculated mean standard values - typically monthly, but smaller time periods possible)
physio-geographic data (catchment characteristics, e.g. soil type, vegetation type)
land use (open land, forest, lake topography, lake storage characteristics, if known)

15. Length of data periods needed for
15.1 model calibration: 5-10 years
15.2 model validation: 5-10 years

16. References

Bergström, S. (1992). The HBV Model - its structure and applications. SMHI, RH No. 4, Norrköping, Sweden.

Bergström, S., Harlin, J., and Lindström, G. (1992). Spillway Design Floods in Sweden. I. New guidelines. Hydrological Sciences Journal, 37, 5, 10/1992, 505-519.

Bergström, S. (1995). The HBV Model. In: Singh, V. P. (ed.) Computer Models of Watershed Hydrology. Water Resources Publications, Highlands Ranch, Colorado, USA.

1. VIC-2L + horizontal transport scheme

Dag Lohmann, Kirsten Warrach, Ralf Nolte-Holube
GKSS, Max-Planck-Str., 21502 Geesthacht, Germany
e-mail : lohmann@gkss.de, warrach@gkss.de, nolte@gkss.de

2. Type of model
lumped conceptual

3. Energy balance included ? How ?
Yes

4. Evapotranspiration parameterisation used
Yes, Penman-Monteith

5. Vegetation included ? How ?
Yes
Fractional cover
Vegetation types

6. Snow included ? How ?
Yes
Temperature-index-model

7. Lateral flow within the basin (catchment) included ? Type of approach ?
Yes
Unit-hydrograph

8. Lateral flow from basin to basin included ? Type of approach ?
Yes
Unit hydrograph

9. Time step
Minute to day

10. Horizontal and vertical resolutions
Horizontal: regional (10 km)
Vertical: 2 layers (3 layer scheme available)

11. Output variables, method of calculation
Evapotranspiration (Penman-Monteith), drainage (Richards equation), surface runoff (via variable infiltration), baseflow (soil moisture), soil moisture (water balance), effective surface temperature (from energy balance, using an iterative scheme).

12. Internal variables, method of calculation (which of them should be used in a model intercomparison?)
Evaporation from canopy (Penman-Monteith), evaporation from bare soil (Penman-Monteith), transpiration (Penman-Monteith), surface runoff (variable infiltration capacity), base flow (soil moisture), soil moisture (water balance), drainage (Richards equation), aerodynamic

resistance (Brutsaert, 1982), stomata resistance (Campbell, 1985), hydraulic conductivity (Brooks and Corey,1964), water content of snow storage (DWD, 1995)

13. Which parameters have to be calibrated ?
Infiltration parameter b, maximum soil moisture, fraction of maximum subsurface flow Ws, parameter for filling slow flow storage, half-life of the slow flow storage,
decay time (tmax) of unit hydrograph.

14. Input data needed, specification of resolution in time and space
Precipitation (at least daily, at least every 200x200 km^2)
Air pressure (at least daily, at least every 200x200 km^2)
Air temperature (at least daily, at least every 200x200 km^2)
Sunshine duration or cloud cover (daily)
Relative humidity (at least daily, at least every 200x200 km^2)
Wind speed (at least daily, at least every 200x200 km^2)
Discharge at several gauging stations
Physio-geographic data (catchment characteristics, e.g. soil type, vegetation type)
Roughness length (for each grid box)
Leaf area index (for each grid box)
Fraction of vegetation cover (for each grid box)
Porosity (for each grid box)
Saturated hydraulic conductivity (for each grid box)
Elevation (for each grid box).

15. Length of data periods needed for
15.1 model calibration: 1 year, REMO-grid
15.2 model validation: 10 years, REMO-grid

16. References
D. Lohmann, 1996. Hydrologische Modellierung auf der regionalen Skala. Dissertation, 94pp.

D. Lohmann, R. Nolte-Holube, E. Raschke, 1996. A large-scale horizontal routing model to be coupled to land surface parameterisation schemes.
Tellus Vol 48a, No 5, 708-721.

X. Liang, 1994. A two-layer variable infiltration capacity land surface representation for general circulation models.
Water Resources Series, Technical Report No. 140, 280pp.

A 106

1. HD Model

Hydrological Discharge Model
Model is operationally coupled to the ECHAM4-physics

Hagemann, Stefan, and Dümenil, Lydia
Max Planck Institute for Meteorology
Bundesstr. 55
20146 Hamburg
Tel.: +49 (40) / 41173 -101 and -310
Fax.: +49 (40) / 41173 -366
E-Mail: Hagemann@dkrz.de, Dumenil@dkrz.de

2. Type of model
Lumped conceptual empirical

3. Energy balance included ? How ?
ECHAM4-physics

4. Evapotranspiration parameterisation used
ECHAM4-physics

5. Vegetation included ? How ?
Yes, ECHAM4-physics

6. Snow included ? How ?
Yes, ECHAM4-physics

7. Lateral flow within the basin (catchment) included ? Type of approach ?
Overland flow using a cascade of linear reservoirs,
baseflow using a linear reservoir

8. Lateral flow from basin to basin included ? Type of approach ?
Riverflow using a cascade of linear reservoirs

9. Time step
1 day, (for riverflow: 0.25 days)

10. Horizontal and vertical resolutions
Horizontal : ECHAM4: T106, T42
Vertical: 1 soil layer for soil moisture
REMO: 0.5 * 0.5 degrees on a rotated grid
HD model: 0.5 * 0.5 degrees

11. Output variables, method of calculation
HD model: Monthly mean inflow per gridbox.
The outflow from a gridbox is the sum of overland flow, baseflow and riverflow.

12. Internal variables, method of calculation
(which of them should be used in a model intercomparison?)
ECHAM4:
Evapotranspiration, snowmelt, accumulated snowpack, temperature, total precipitation
HD Model:
River Discharge of large catchments.

13. Which parameters have to be calibrated ?
No!
The HD model is designed for global applications WITHOUT the need of calibration.

14. Input data needed, specification of resolution in time and space
Measured data:
ECHAM4: Sea Surface Temperature for more than 10 years, resolution: T106 , T42
(Available at MPI)
Physio-geographic data: (Available at MPI)
Resolution 0.5*0.5 degrees:
- Catchment Areas of US Army Corps of Engineers
- Soil-Total water Holding capacities of Patterson
- Plant-Extractable Water of Dunne
- Vegetation Fraction of Dunne
- Land-sea mask of Hagemann and Schulzweida
- Glacier mask of Schulzweida
- River direction file of Hagemann

Resolution 1*1 degrees:
- Wetland fraction of ISLSCP
- Lake area fraction of ISLSCP and Hagemann

Resolution 5 Min * 5 Min:
Topography --> derived at 0.5*0.5 degrees by Hagemann:
- Average Topography
- Model topograpy
- Inner slope per gridbox

Physio-geographic data: (not available at MPI)
Resolution 0.5 * 0.5 degrees:
- Wetland fraction
- Lake area fraction
- Anthropogenic influences

Topography with best resolution available (finer than 5Min x 5 Min):
- to derive better values of inner slope

15. Length of data periods needed for
15.1 model calibration: NO
15.2 model validation : 5 years or more

16. References

S. Hagemann and L. Dümenil, 1996
Development of a parameterisation of lateral discharge for the global scale.
Max Planck Institute for Meteorology, Report No. 219

Roeckner et al., 1996
The atmospheric general circulation model ECHAM4: Model description and simulation of present-day climate. Max Planck Institute for Meteorology, Report No. 218

Further references:

Author:	Dunne, K.A. and C.J. Wilmott, 1996
Title:	Global distribution of plant-extractable water capacity of soil
Source:	International Journal of Climatology, Vol. 16, p. 841-859

Author:	Patterson, K.A., 1990
Title:	Global Distributions of Total and Total-Avaiable Soil Water-Holding Capacities
Source:	University of Delaware

1. SL scheme with HD model

Simplified Land Surface Scheme: SL scheme in co-operation with the HD model

Hagemann, Stefan, and Dümenil, Lydia
Max Planck Institute for Meteorology
Bundesstr. 55
20146 Hamburg
Tel.: +49 (40) / 41173 -101 and -310
Fax.: +49 (40) / 41173 -366
E-Mail: Hagemann@dkrz.de, Dumenil@dkrz.de

2. Type of model (e.g. lumped, distributed, as precise as possible)
Lumped conceptual empirical

3. Energy balance included ? How ?
No

4. Evapotranspiration parameterisation used
Potential Evapotranspiration: Thornthwaite Formula (Chebotarev, 1977)
Actual Evapotranspiration: Following ECHAM4 and Warrilow et al. (1986)

5. Vegetation included ? How ?
We use a global dataset of vegetation fraction to separate the actual evapotranspiration into transpiration and bare soil evaporation

6. Snow included ? How ?
Daily degree formula following the HBV model (Bergström, 1992).

7. Lateral flow within the basin (catchment) included ? Type of approach ?
see HD model

8. Lateral flow from basin to basin included ? Type of approach ?
see HD model

9. Time step
1 day, (for riverflow: 0.25 days)

10. Horizontal and vertical resolutions
SL scheme:
T106, 0.5 * 0.5 degrees (coarser resolutions possible without much additional effort)
Vertical: 1 soil layer, such as in ECHAM4
HD model:
0.5 * 0.5 degrees

11. Output variables, method of calculation
SL scheme:

- Runoff, ARNO scheme (ECHAM model, Dümenil and Todin, 1992)
- Drainage, ARNO scheme (ECHAM model, Dümenil and Todin, 1992)
- Actual Evapotranspiration = Transpiration + Bare Soil
- Evaporation, (ECHAM model, Roeckner et al., 1992 and Warrilow et al., 1986)
- Soil moisture, 1 soil layer, derived from water balance
- Accumulated snowpack, separation of rain and snow fall, Wigmosta (1994)
- Snowmelt, daily degree formula, (Bergström, 1992).

HD model:
Monthly mean inflow per gridbox.
The outflow from a gridbox is the sum of overland flow baseflow and riverflow.

12. Internal variables, method of calculation
(which of them should be used in a model intercomparison?)
SL scheme: Evapotranspiration, snowmelt, accumulated snowpack, soil moisture.
HD Model: River discharge of large catchments.

13. Which parameters have to be calibrated ?
NO!

14. Input data needed, specification of resolution in time and space
Measured data:
Daily time series of precipitation and temperature
Resolution: 0.5 x 0.5 degrees, 1 x 1 degrees or T106

Physio-geographic data: see description of HD model above.

15. Length of data periods needed for
15.1 model calibration: No
15.2 model validation: 6 years or more

16. References
S. Hagemann and L. Dümenil, 1996
Development of a parameterisation of lateral discharge for the global scale.
Max Planck Institute for Meteorology, Report No. 219

Further references:

Author: Bergström, S., 1992
Title: The HBV Model - its structure and applications
Source: SMHI Reports Hydrology No. 4

Author: Chebotarev, A.I., 1977
Title: Compendium of Meteorology Vol. II: Part 1 - General Hydrology
Source: WMO-No. 364

Author: Dümenil, L. and E. Todini, 1992
Title: A rainfall-runoff scheme for use in the Hamburg climate model
Source: Ed.: J.P. Kane: Advances in theoretical hydrology
a tribute to James Dooge, S. 129-157

Author: Dunne, K.A. and C.J. Wilmott, 1996
Title: Global distribution of plant-extractable water capacity of soil
Source: International Journal of Climatology, Vol. 16, p. 841-859

Author: Patterson, K.A., 1990
Title: Global Distributions of Total and Total-Avaiable Soil Water-Holding Capacities
Source: University of Delaware

Author: Roeckner et al., 1992
Title: Simulation of the present-day climate with the ECHAM model: Impact of model physics and resolution
Source: Max Planck Institute for Meteorology, Report No. 93

Author: Roeckner et al., 1996
Title: The atmospheric general circulation model ECHAM4: Model description and simulation of present-day climate
Source: Max Planck Institute for Meteorology, Report No. 218

Author: Warrilow, D.A , A.B. Sangster and A. Slingo, 1986
Title: Modelling of land surface processes and their influence on European Climate
Source: Dynamical Climatology Technical Note No. 38

Author: Wigmosta, M.S. et al., 1994
Title: A distributed hydrology-vegetation model for complex terrain
Source: Water Resources Research Vol. 30, No. 6, S. 1665-1679

1. MOREMAZ-1

Regional Model of Small Watershed MOREMAZ-1
Janusz Ostrowski
Institute of Meteorology and Water Management (IMWM)
Warsaw, Poland
phone: +48 22 34 16 51 ext. 594
fax: +48 22 34 54 66
e-mail: imigw@atos.warman.com.pl

2. Type of model
MOREMAZ-1 model is a linear rainfall-runoff relations model, stationary for floods. Watersheds are treated as a lumped parameter system.

3. Energy balance included ? How ?
No, in this version of model MOREMAZ-1.

4. Evapotranspiration parameterisation used
No, in this version of model MOREMAZ-1.

5. Vegetation included ? How ?
Yes, in form of land cover and land use characteristics of watershed area (e.g. forests area, meadows area, swamps area, plough-lands area).

6. Snow included ? How ?
No, in this version of model (MOREMAZ-1); in next version (MOREMAZ-2) modulus of degree day method with discrete-distributed parameters and energy balance of snow cover.

7. Lateral flow within the basin included ? Type of approach ?
Lateral inflow to streams network - theory of the geomorphology of instantaneous unit hydrograph (GIUH) [Rodriguez-Iturbe I., et al., 1979] on the base of Strahler's structure of river network and Horton's - Schumm ratios.

8. Lateral flow from basin to basin included? Type of approach ?
No.

9. Time step
One hour or multiple of one hour.

10. Horizontal and vertical resolutions
Horizontal resolution limited: watersheds up to 300 sq. km area
Vertical resolution: not included.

11. Output variables, method of calculation
Flood characteristics (e.g. peak [m^3/s], time of peak [h] and volume [m^3]) and stormflood hydrograph as result of the transformation of the storm rainfall hyetograph into a flow hydrograph using Nash linear reservoirs cascade. The model enables simulation of flood characteristics and hydrographs for small, ungauged watersheds up to 300 sq. km.

12. Internal variables, method of calculation (which of them should be used in a model intercomparison ?

In the best version of the model - after verification - the flood hydrograph contains two components:

1. Direct runoff: Rainfall excess hyetograph (modulus of rainfall excess: modified version of the US Soil Conservation Service method) obtained by transformation of the storm rainfall hyetograph in direct runoff hydrograph (modulus of transformation: Using Nash linear reservoirs cascade).
2. Groundwater flow: Base flow hydrograph (modulus of groundwater flow is a function of watershed initial conditions (constant for flood)).

13. Which parameters have to be calibrated ?

Six model parameters are identified from regional equations (which have contained 18 watersheds physiographic characteristics):

No	PARAMETER	DEFINITION	UNIT	RANGE
1.	CN	SCS runoff curve number	-	0 ÷ 100
2.	N	Number linear reservoirs of Nash cascade	-	1.0 ÷ 7.45
3.	K	Storage time of single reservoir	h	> 0
4.	TL	Lag time	h	> 0
5.	QPF	Base flow	m^3/s	> 0
6.	TQ	Flood time duration	h	> 0

14. Input data needed, specification of resolution in time and space

Data recorded:

Rainfall hyetograph,

Initial watershed conditions (antecedent moisture index), which are represented by the total (sum) of rainfall over the nine days preceding the storm rain (or precise: start of storm rainfall)

Data elaborated:

18 physio-geographic characteristics from hydrographic or topographic maps in scale of 1 : 25000 (see table on next page).

15. Length of data periods needed for

15.1 model calibration : a few years, minimum is 5 to 10 flood waves from about 20 watersheds,

15.2. model validation: a few years of measurements in several watersheds as independent data sets to assess simulated model efficiency by statistic criterions, for example relative errors of stormflood hydrograph characteristics and model quality index (ratio).

No.	PHYSIOGRAPHIC CHARACTERICIS	DIMENSION	NOTATION
	Characteristics of basin area		
1.	Area	km^2	x 1
2.	Average width	km	x 5
3.	Extension (elongation) index	-	x 10
4.	Compactness index	-	x 11
5.	Average hill length	m	x 13
6.	Shape (form) index	-	x 29
	Horton's ratios		
7.	Bifurcation ratio	-	x 14 (RB)
8.	Length ratio	-	x 15 (RL)
9.	Area ratio	-	x 16 (RA)
	Characteristics of river network		
10.	Main river length	km	x 17
11.	Tributaries length	km	x 18
12.	River network density	km/km^2	x 20
13.	Stream number all „w" order	-	x 21
14.	Main river slope	%	x 25
	Characteristics of land use and vegetation cover		
15.	Swamps area	%	x 2
16.	Forests area	%	x 26
17.	Plough-lands area	%	x 27
18.	Meadows area	%	x 28

16. References

Ostrowski J., 1990: A rainfall-runoff model for small ungauged watersheds in Poland. Proc. of the IAHS Internat. Symp. on „Regionalization in Hydrology", Ljubljana. IAHS Publ. no 191, 203-210 p. (preliminary version of MOREMAZ-1 model)

Ostrowski J., 1994: Model Regionlny Malej Ziewni MOREMAZ-1. A Regional Model of Small Watershed (in polish; summary in english). Mat. Badawcze, Seria: Hydrologia i Oceanologia, Nr. 17. IMGW, Warszawa.

Ostrowski J., 1990: Opracowanie i wdrozenie modelu regionalnego MOREMAZ-1 dla potrzeb systemow informatycznych gospodarki wodnej i oceny stanu strodowiska. Elaboration and implementation of the Regional Model of Small Watershed MOREMAZ-1 for practical use within water management informatics system and for assessment of envrionment state (in polish) IMGW, Warszawa.

1. WB10 Model

Alexander V. Yezhow
Russian State Hydrometeorological Institute (RSHI)
St. Petersburg / Russia

2. Type of model
WB10-model can be considered as lumped-distributed, where space-effect is reached by dividing a large (or heterogeneous) basins into sub-basins and river-segments with lateral inflow. At the same time the model parameters for sub-basins are lumped.

3. Energy balance included ? How ?
Optionally, if the relevant method for computation of the potential evapotranspiration is used (see also 4.).

4. Evapotranspiration parameterisation used
Evapotranspiration is computed as follows:
E=b*PET*(W/FC), where PET may be calculated by different methods, though Zubenok approach is applied most frequently.

5. Vegetation included ? How ?
Yes. When evapotranspiration is computed, the factor b (see 4.), which depends on the type of vegetation and it's phase of growing, is used.

6. Snow included ? How ?
Yes, as a sum of precipitations during cold period of year.

7. Lateral flow within the basin (catchment) included ? Type of approach ?
Yes, large basins are divided into subbasin-indicators and reaches with lateral inflow.

8. Lateral flow from basin to basin included ? Type of approach ?
No

9. Time step
10 days

10. Horizontal and vertical resolutions
Watersheds are considered as a set of subbasins and plots of three-layered media (root zone and up to two aquifers).

11. Output variables, method of calculation
Runoff, soil moisture content, evaporation (and other state variables, if necessary) may be represented in different forms (time series, time averaged values, distributions and traces).

12. Internal variables, method of calculation (which of them should be used in a model intercomparison?)
Water content of all layers considered (see 10.) and water exchange among them.
13. Which parameters have to be calibrated ?
Field capacity of the root zone, the infiltrability of soil and the parameters of recession curve (provided the assessment has not made before). So, total amount of parameters to be calibrated may vary from two to five.

14. Input data needed, specification of resolution in time and space
Hydrometeorological data: precipitation, temperature, any index of the air humidity and river-discharge time series on daily basis (in fact, 10-days or monthly averaged data are used); this is a minimum required package of data; if other then default method of PET computation will be recommended, the relevant data should be provided.
Physio-geographic data: prevailing types of soil and vegetation; the areas of basins and it's segments (total and partial), or a map.
Climatological data (are desired only): the main water balance components for territory in question.

15. Length (resolution and other details) of data periods needed for
15.1 model calibration: At least 10 years (the more the better for to represent different climate conditions),
15.2 model validation: As in previous item.

16. References (at least one in English language, if available!)

There is no description of the model in English language available.

1. HYDROGRAPH

„Runoff-erosion-pollution" modelling system
by Yu. B. Vinogradov,
State Hydrological Institute,
23 second line, St. Petersburg 199053, Russia

2. Type of model
Distributed model, deterministic mode (for runoff hydrographs) and deterministic-stochastic mode (for distribution curves of runoff characteristics).

3. Energy balance included ? How ?
Yes.
Surface heat flux is taken into account; heat conductivity of soil under the conditions of variable soil moisture content and phase water transitions are taken into account.

4. Evapotranspiration parameterisation used
Evapotranspiration parameterisation is used.

5. Vegetation included ? How ?
Yes. Vegetation is taken into account through evaporation, soil surface shading and interception which are variable during a year.

6. Snow included ? How ?
Snow cover formation, melting and water yield from snow pack are taken into account.

7. Lateral flow within the basin (catchment) included ? Type of approach ?
Natural horizontal flow within the basin is not taken into account directly. Indirect effect is taken into account by the blocks of runoff transformation before it reaches the channel. Artificial canalisation may be taken into account by the block of channel transformation.

8. Lateral flow from basin to basin included ? Type of approach ?
Natural lateral flow from basin to basin is not taken into account. Artificial canals and waterways may be taken into account.

9. Time step
Any time step may be used depending on the objective. 24-hours and shorter time intervals are preferable.

10. Horizontal and vertical resolutions
Horizontal resolution is associated with the degree of generalisation depending on the basin size. Vertical resolution: 10 design soil layers of 0.1 m depth each. Any change is possible; the equality of layer depth is not obligatory.

11. Output variables, method of calculation
Deterministic modelling mode: runoff hydrograph (discharges at the outlet), integral and extreme runoff characteristics.

Mode of deterministic-stochastic modelling: co-ordinates of distribution curves of different runoff characteristics (annual, extreme, daily, etc). Algorithms are presented in the form suitable for direct analytical computation.

12. Internal variables, method of calculation (which of them should be used in a model intercomparison ?)
Variables of the state: water layers in the snow pack, capacities of interception, pools, soil, underground regulating capacities, channel network; temperature of the snow cover and soil; density and humidity of the snow cover. Comparison with observed data is possible.

13. Which parameters have to be calibrated ?
Evaporation parameters are specified a priori, but they may be improved (calibrated) on the basis of observational data of soil moisture content. Parameters of heat exchange may be improved from the data on soil temperature. Coefficient of filtration of the upper design soil layer and parameters of runoff transformation before it reaches the channel may be improved in case of comparison of the observed and computed hydrographs.

14. Input data needed, specification of resolution in time and space
Input data needed:

- meteorological data (temperature and humidity deficit of the air, precipitation, duration of rainfall) observed from interpolated data of meteorological stations or generalised with the help of the stochastic model of weather;

- characteristics (areas, slopes, ravines, latitudes, orientation);

- parameters (mechanical, energy and hydro-physical properties of soils, phenological data, maximum and minimum parameters of evapotranspiration, interception and shading rate caused by the plants, pools, hydraulic parameters of runoff components, etc.) generalised according to the types of landscape.

Time step is 24-hours period or shorter.
Distance between representative points depends on the basin size and on the information available, i.e. on the desired rate of generalisation.

15. Length of data periods needed for
15.1 model calibration: 3 - 5 years
15.2 model validation: 15 - 25 years.

16. References
Vinogradov Yu. B., 1988:
Mathematical modelling of runoff formation. Experience of the critical analysis.
Leningrad, Gidrometeoizdat, 312 pp (in Russian).

Vinogradov, Yu. B., 1996:
Hydrological modelling of Arctic river run-off. Proceedings of the Workshop on the ACSYS solid precipitation climatology project. Reston, VA, USA, 12-15 September 1995.
WMO/TD No. 739, p. 144-158.

1. MIKE SHE

Danish Hydraulic Institute
Agern Alle 5
DK-2970 Hørsholm
DENMARK

Dr. Anders Refsgaard,
Head of Hydrological Modelling Department
or
Mr. Jens Christian Refsgaard,
Head of Research and Development

2. Type of model
Distributed, physically-based.

3. Energy balance included ? How ?
No

4. Evapotranspiration paramerisation used
Two options exist:
(a) Rutter model + Penman Monteith equation
(b) Kristensen-Jensen model
See further details in Refsgaard and Storm (1995). In both cases the actual evapotranspiration depends on soil moisture content in the root zone and on leaf area index.

5. Vegetation included ? How ?
Yes.
At every grid point the vegetation characteristics are described by time series of leaf area index and root depth. The number of vegetation types can be arbitrarily high, but is typically between 4 and 10.

6. Snow included ? How ?
Yes.
A simple degree-day factor calculation of snow accumulation and melt.

7. Lateral flow within the basin (catchment) included ? Type of approach ?
Yes.
Overland flow routing as 2-d kinematic wave routing. River routing by 1-d dynamic wave approximation of the St. Venant equation.

8. Lateral flow from basin to basin included ? Type of approach ?
Yes.
MIKE SHE does not operate on basins but on geographical areas, which may include several basins.

9. Time step
The basic time steps are user defined; however the program makes automatic control of numerical water balance errors and subsequent automatic stepping down (and up) in time step.

Different time steps are used in the different components .Typically the basic time step varies from 3 hours in the unsaturated zone to 24 hours in the saturated zone. The smallest program defined time steps are typically a few minutes in situations with heavy rainfalls.

10. Horizontal and vertical resolutions
User defined and very much depending on the purpose of the specific modelling exercise. Horizontal resolutions (grid sizes) in the range 2 m to 4,000 m have been reported so far. Typical vertical resolutions in the unsaturated zone are a few cm in the top and 10-50 cm at the middle and bottom of the unsaturated zone column. In the saturated zone the vertical resolution can range from only one layer (i.e. 2-d groundwater model) to a few meters.

11. Output variables, method of calculation
All calculations with finite difference techniques. The output variables include the following variables at every grid:

- water levels and discharges in rivers,
- water depth and flow velocities on the terrain,
- snow depth
- interception, soil evaporation and transpiration,
- soil moisture and tension (pressure) at all grids in the vertical unsaturated zone profile,
- ground water level/piezometric head of aquifers, and
- fluxes among the various components.

In addition, modules exist for calculation of advection-dispersion (solute transport) and chemical/biological processes.

12. Internal variables, method of calculation
The same as those listed above under output variables.

13. Which parameters have to be calibrated ?
A large number of parameters exist. Most of them can be assessed directly from field data, however most often some of them have to be estimated through calibrated. See Refsgaard and Storm (1995) for a list of parameters and Refsgaard (1997) for a calibration methodology.

14. Input data needed, specification of resolution in time and space
Basically, all climate and physical data which exist from a given area can be made use of. For parameters for which no data exist estimates by use of transfer functions can be made.

15. Length of data periods needed for
15.1 model calibration: 1-3 year (more, if groundwater is dominating)
15.2 model validation: 1-3 years.
Obviously, the longer time series, the more reliability of the model validation tests.

16. References

Abbott, M.B., Bathurst, J.C., Cunge, J.A., O'Connel, P.E. and Rasmussen, J. (1986) : An introduction to the European Hydrological System - Systeme Hydrologique "SHE", 2: Structure of a physically-based distributed modelling system.
Journal of Hydrology, 87, 61-77.

Refsgaard, J.C. (1997) : Parameterisation, calibration and validation of distributed hydrological models.
Accepted for publication in Journal of Hydrology.

Refsgaard, J.C., Seth, S.M., Bathurst, J.C., Erlich, M., Storm, B., Jørgensen, G.H. and Chandra, S (1992) : Application of the SHE to catchments in India. Part 1. General results. Journal of Hydrology, 140, 1-23.

Refsgaard, J.C. and Storm, B. (1995) : MIKE SHE. In: Singh, V.P. (Ed): Computer Models of Watershed Hydrology, Water Resources Publications, 809-846.

Refsgaard, J.C. and Knudsen, J. (1996) : Operational validation and intercomparison of different types of hydrological models.
Water Resources Research, 32(7), 2189-2202.

Hydrological data sampling strategy for BALTEX- BHDC

Draft by Sten Bergström

based on conclusions and recommendations of the BALTEX hydrology workshop at Warsaw, 9-11 September 1996

Runoff data

The establishment of the runoff data base will be the most important task of the BALTEX Hydrological Data Centre, BHDC. It will have the following features:

1. The hydrological runoff data base shall generally be based on daily (24 h) data except for some long records where these data are not easily available.

2. Data will preferably be collected from 1970 and onwards to cover the entire BALTEX research period. In cases early data are not available the period will start in 1980.

3. Data from a **basic network** of hydrological runoff stations covering the entire Baltic basin shall be collected. This network consists of some 100 stations, selected to give a good areal coverage and to include the mouths of all major rivers.

4. Four river basins will be subjects to more complete data sampling. These **special study basins** are Vistula/Oder, Daugava, Neva and Torne (possibly including Kalix due to the bifurcation). The minimum average data coverage in these basins will be about one station per 4000 km^2.

5. A special data base on the longest runoff records in the Baltic basin will be created for climatological studies.

6. A data base of meta data for all stations will be created and maintained by the BHDC.

Other hydrological data

Other hydrological data will be collected depending on their availability.

1. **Snow depth** data will be the task of the BMDC. Data on the **water equivalent of snow** will be collected by the BHDC as available, mostly from special studies.

2. Data on **soil temperatures** will be the task of the BMDC.

3. Data on **soil moisture** will be collected by the BHDC as available from special studies.

4. Data on **lakes** consisting of **levels, ice observations and water temperatures** will be collected by the BHDC as available.

Appendix 13

Hydrological Data Sampling Strategy for BALTEX
Approved by BALTEX SSG
16 April 1997

1 The most important data to be collected and prepared by the BALTEX Hydrological Data Centre (BHDC) for dissemination to the BALTEX community are **daily runoff data** from operational networks.

2 For 4 river catchments in the BALTEX region data from a dense runoff station network with reliable data should be collected. These special test catchments include

- Torneälv,
- Neva,
- Daugava,
- Odra.

It was noted that a minimum requirement is an average station density of one station per 4000 km^2 leading to a total minimum number of about 150 stations for all the four mentioned catchments.

3 For the other catchments in the BALTEX region a reduced data coverage (data from a basic network of about 100 runoff stations) was considered sufficient.

4 The daily runoff data mentioned under items 1 to 3 are required for both tuning and validation of hydrological models. This requires a minimum of 5 to 10 years of runoff data depending on the type of model. It was suggested to include runoff data for the period 1980 onwards in the archives of the BHDC. In cases when specific catchments experienced a number of dry years in the 1980s, extension to periods before 1980 (e.g. from 1970 onwards) might be necessary in order to avoid tuning biases. This extension should however be exceptional.

5 For climatological studies a few very long key runoff records (longer than a century) preferably based on daily data shall be collected by BHDC.

6 The following additional data will be collected and archived by BHDC depending on their availability:

- snow equivalent water
- soil moisture
- information on ground water
- lake level
- lake and river temperatures
- ice observations.

In principle, these data should be collected for the same time periods as runoff data. Most of the mentioned data are however not measured routinely but are only available from specific experiments. Hence, continuous records with high resolution in time (e.g. daily) are unlikely to be available at all. Hence, the mentioned data should be collected by BHDC depending on their availability and specific requirements from the BALTEX modelling community.

7 The following data are suggested to be collected and archived by the BALTEX Meteorological Data Centre (BMDC):

- snow depth
- soil temperature.

Both parameters are measured at most synoptic stations; and the data are disseminated as part of the data telegram on GTS with a time resolution of 3 hours. These data shall be collected by BMDC in the frame of the anyway performed data collection based on GTS telegrams, in accordance with the tasks noted in the BMDC status paper. Data exchange between BMDC and BHDC in this respect will have to be discussed directly between SMHI and DWD.

8 *Meteorological* observations required as input for different hydrological models shall be collected by BHDC. These data must cover the same time periods as mentioned under 4. In particular for the 4 river basins mentioned under 2, the following data may have to be included:

- meteorological observations (including precipitation) made at all accessible synoptic stations, time resolution will have to be specified according to individual model requirements,
- precipitation measurements from all accessible non-synoptic stations (e.g. climate stations and special precipitation stations), time resolution at least 24 hours,
- accessible measurements from climate stations,
- radiation measurements at ground from all accessible stations, time resolution at least 24 hours.

In order to meet the input requirements of different hydrological models the following meteorological parameters shall be at least included in the data base:

- precipitation
- 2 m air-temperature
- 2 m humidity
- air-pressure
- 10 m windspeed
- radiation // cloud cover // sunshine duration.

9 SMHI is asked to draft data exchange agreements and license agreements which shall regulate legal rights of the data suppliers, the data users and BHDC. These agreements shall be designed in close agreement with those already in use by BMDC. The BALTEX data user identification procedure which was approved by the BALTEX SSG at its 4th meeting in June 1996 shall be valid also for BHDC.

10 BHDC and the BALTEX Secretariat are asked to contact national Hydrological Services and other data suppliers in order to build up the BALTEX hydrological data archive as suggested above. The BALTEX Secretariat has already build up contacts to Hydrological Services in particular in east European BALTEX countries which are suggested to be used for future negotiations.

11 It is noted by SSG that the large amount of data which have been suggested at this workshop to build the BALTEX hydrological archive will require considerable efforts at both the individual data suppliers and at BHDC. Negotiations between BHDC and individual data suppliers will have to be started immediately in order to determine ways and possibilities of implementing the here suggested BALTEX data sampling strategy.

A 126

Appendix 14

THE BALTEX HYDROLOGICAL DATA CENTRE
(BALTEX - HDC)

Ola Pettersson
Swedish Meteorological and Hydrological Institute - BALTEX - HDC
SE - 60176 Norrköping, Sweden

1. OBJECT AND DIVISION OF TASK

SMHI in Norrköping, Sweden, hosts the BALTEX Data Centre for hydrology with the main objective to concentrate specific types of hydrological data and information about this data. BALTEX HDC has the special duty to make runoff data accessible from runoff stations in the BALTEX region.

SMHI has earlier collected runoff data from all countries around the Baltic Sea. This has resulted in an operational data base that consists of monthly runoff data from gauge stations and calculated monthly runoff for 122 coast-segments. The time period for the monthly runoff data base is: 1950 - 93 (-95 for Sweden, Finland and Lithuania).

A first BALTEX Hydrology Workshop was held in Warsaw, September 9-11, 1996, in order to specify the further demands of hydrological data from the BALTEX community. As a result of this workshop the following tasks for the BHDC was determined.

The most important data to be collected and prepared by the BALTEX HDC for dissemination to the BALTEX community are daily runoff data from operational runoff networks in the BALTEX area.

Runoff data from dense networks in four specific catchments shall be collected. These special study basins are: Torne, Neva, Daugava, and Odra. The total area of the special study basins is about 710 000 km². A minimum requirement is an average of one runoff station per 4000 km², which gives a minimum of 180 runoff stations for all the special study basins.

For the other catchments runoff data shall be collected from a basic network less dense than for the special study basins. It is considered that 200 runoff stations will be sufficient from this basic network.

For climatological studies a few very long runoff records, preferably based on daily data, shall be collected by the BALTEX HDC.

Other hydrological data that will be collected from the BALTEX area are: snow equivalent of water, soil moisture, information on ground water, ice observations, lake levels, lake and river temperature. These data will be collected from the contributing national institutes as available.

To accomplish these tasks the BALTEX HDC will use the infrastructure and routine services of the SMHI.

2. DATA MANAGEMENT

The data collected by the BALTEX HDC is supplied mainly by different national institutes in the countries participating in BALTEX. The structure of the daily runoff data base is identical to the one that SMHI currently use for the Swedish national runoff network. In that way BHDC can benefit from any progress being made to the current data base structure at SMHI. Meta data and other hydrological data will be stored in a different databases designed solely for these purposes. Information on the contents of the BALTEX HDC will be made available through internet/WWW. Data will be provided to BALTEX Data Users upon request.

2.1 TIME PERIODS OF DATA

The daily runoff data are required for both tuning and validating of models. This requires a minimum of 5 to 10 years of runoff data depending on the type of model. The Warsaw hydrology workshop suggested to include runoff data for the period 1980 onwards in the archives of BHDC. In particular the Vistula catchment experienced a number of dry years in the 1980s, hence, extension to the periods 1970 onwards might be necessary to avoid tuning biases. This extension should however be exceptional.

Other hydrological data will be collected depending on their availability and specific requirements from the BALTEX modelling community. Most of these data are not measured routinely but are only available from specific experiments. The data will be collected from within the same time span as the runoff data.

3. DATA POLICY

The regulations for the use of data are set through agreements between the

- SMHI - BALTEX HDC and the providing institute
- User of the data and the SMHI - BALTEX HDC

Data delivery by the BALTEX HDC is strictly limited to groups of scientists which are officially registered as BALTEX Data Users

The delivery of data from the supplying institute will be free of charge

The distribution costs at the BALTEX HDC will be covered by the user

4. STATE OF BHDC DAILY RUNOFF DATA BASE

(as of April 1997)

4.1 PRESENT DATA

The following data are stored or will soon be stored in a SQL-data base. The structure of this data base is the same as SMHI currently use for the Swedish national runoff network. In that way BALTEX HDC can benefit from any progress being made to the current data base structure at SMHI.

4.1.1 SPECIAL STUDY BASINS

- **Torne**, complete data set with all available runoff stations, ice observations, river temperature, and selected Swedish meteorological stations.
- **Neva**, Russian stations are selected, date of delivery is under discussion. Data from winter 1986 and 1992/93 stored. Data from Finnish stations are selected and stored at the BALTEX HDC.
- **Daugava**, the BALTEX International Secretariat - GKSS are discussing a selection of Belarussian data for hydrological modelling. Data from Latvian stations are selected, data from 1986/87, 1992/93 and 1995 stored. Data from the Russian stations are selected, data from winter 1986 and 1992/93 stored.
- **Odra/Vistula**, data from Nov. 1990 - Oct. 1995 from 26 runoff stations in the Odra catchment stored.

4.1.2 BASIC NETWORK

- **Finland**, the Finnish stations are selected, and runoff data has been delivered.
- **Russia**, a selection of runoff stations has been decided, date of delivery is under discussion. Data from winter 1986 and 1992/93 stored.
- **Estonia**, a selection has been decided, date of delivery is under discussion. Data from 1986/87 and 1992/93 stored.
- **Latvia**, a selection has been decided, date of delivery is under discussion. Data from 1986/87, 1992/93 and 1995 stored.
- **Lithuania**, a selection has been decided, date of delivery is under discussion. Data from 1986, 1992/93, PIDCAP and 1996 stored.
- **Belarus**, the BALTEX International Secretariat - GKSS are discussing a selection of Belarussian data for hydrological modelling. Data from 1986/87 and 1992/93 stored.
- **Poland**, data from the Odra catchment, under negotiation. Data from the Vistula region has not yet been discussed. Data from Nov. 1990 - Oct. 1995 from 26 runoff stations in the Odra catchment stored.
- **Germany**, information on runoff stations and data will be delivered as soon as possible.
- **Denmark**, no active discussion with NERI, The National Environmental Research Institute/Danmarks Miljøundersøgelser.
- **Sweden**, a first selection of runoff stations has been made, data has not yet been transferred to BHDC daily runoff data base.

4.1.3 OTHER RUNOFF DATA COLLECTED:

Daily runoff data has been collected by the BALTEX International Secretariat - GKSS from all available runoff stations in Russia, Estonia, Latvia, Lithuania, Belarus and Poland. The data is mainly from the periods 1986/87, 1992/93 and from the PIDCAP period 1995 (Aug.-Oct.).

4.1.4 OTHER HYDROLOGICAL DATA

Ice observations and river temperature from Torne special study basin. No other hydrological data has so far been collected.

4.2 PLANS FOR THE FUTURE

Daily runoff, meta data and other hydrological data, as indicated in the sampling strategy for BHDC, will be collected as soon as possible.

4.2.1 TIME PLAN

- **Russia**, as soon as possible, date of delivery will be determined in bilateral discussion.
- **Belarus**, BALTEX International Secretariat - GKSS is discussing the possibilities to receive data.
- **Baltic states**, as soon as possible, date of delivery will be determined in bilateral discussion.
- **Poland**, as soon as possible, a more active dialogue must be established with the Vistula region.
- **Scandinavia**, as soon as a decision on the selection of stations is made for each country. As for Denmark a more active dialogue must be established.
- **Germany**, very soon, probably before the end of August 1997.

After the first collection of daily runoff data, that is data from 1970 if available, or from 1980 until last years data, additional data will be collected annually on demand by BHDC.

5. DATA DELIVERED:

From monthly data base to:
Department of Systems Ecology, University of Stockholm, Sweden
Department of Water and Environment Studies, University of Linköping, Sweden
Umeå Marine Sciences, University of Umeå, Sweden
National Board of Waters and Environment, Finland
Institut für Meereskunde an der Universität Kiel, Germany
Max Planck Institute for Meteorology, Germany
Institut für Ostseeforschung Warnemünde, Germany
Danish Institute for Fisheries Research

From daily data base:
No data delivered.

DRAFT *Appendix 15*

A G R E E M E N T

Between the Swedish Meteorological and Hydrological Institute (SMHI) as the operator of the Hydrological Data Centre for BALTEX,

and

the................., hereinafter referred to as **the Supplier**,

has the following agreement been reached.

1. Background

1.1 BALTEX, the Baltic Sea Experiment, will explore, model and quantify the various processes determining the space and time variability of the energy and water cycles of the Baltic sea and its catchment area. Organisations and institutions from more than 10 countries are participating and co-operating in the BALTEX Research Programme. BALTEX is planned to extend over a ten-year period.

1.2 Data support from the national meteorological, hydrological and oceanographic services is of the greatest importance for a successful outcome of the BALTEX Research Programme. This Agreement has the dual purpose of safeguarding the access to data for scientists participating in BALTEX as well as protecting the commercial rights and intellectual property rights of the data suppliers.

1.3 For the purpose of the BALTEX International Research Project the Hydrological Data Centre, hereinafter referred to as **BHDC**, has been set up. The BHDC coordinates the collection and exchange of project-related data and information relevant to the data (metadata) from the BALTEX-area. The BHDC uses the infrastructure and the routine services of SMHI.

2. Scope

2.1 Subject to the terms and conditions herein, the Supplier shall deliver data and/or documentation to the BHDC free of information charge and delivery costs. The BHDC is allowed to distribute the delivered data and/or documentation in accordance with this Agreement to any party which is officially registered as a BALTEX data user, hereinafter referred to as **the User**.

2.2 This agreement permits the distribution of data and/or documentation to Users only for the sole purpose of scientific utilisation within the scope of BALTEX. The data and/or documentation can not be used, either by BHDC or Users, for commercial exploitation, business use, resale or re-distribution.

2.3 The Users shall have the right to obtain data and/or documentation from BHDC free of charge. The distribution cost shall be covered by the User.

2.4 The BHDC may not, either against remuneration or not, grant the use to the data and/or documentation by way of ownership or licence, to any third party without the written consent of the Supplier.

3. Specification of data

3.1 The data in general comprise hydrological data, as described in the Hydrological data sampling strategy for BALTEX-BHDC is appended to this Agreement as Appendix A. The specification of data supplied by this agreement, together with the schedule for delivery, is appended as Appendix C.

3.2 The data shall be delivered to BHDC in the format that is commonly used by the Supplier. If necessary, the access software shall also be delivered accordingly.

4. Licence Agreement

4.1 The BHDC guarantees to have a Licence Agreement signed by the User before transfer of the aforementioned data and/or documentation is conducted. The Licence Agreement shall have the same form as the one appended to this agreement, Appendix B.

5. Intellectual Property Rights

5.1 The intellectual property rights to the data deposited in accordance with this Agreement shall be retained by the Supplier.

5.2 The Supplier reserves the right to require acknowledgements and, where appropriate, co-authorship to any scientific publication arising out of the use of the aforementioned data and/or documentation supplied by the Supplier.

5.3 The Supplier shall have joint intellectual property right, together with the User to the results of the research which has been performed with data and/or documentation licensed from BHDC in accordance with this agreement. The Supplier and the User shall have the right to use said results in its Governmental Services.

6. Remedies

6.1 The BHDC shall safeguard the interest of the Supplier with regards to data and/or documentation supplied in accordance with this agreement.

6.2 The BHDC shall, on its own initiative or on demand by the Supplier, exclude any User or group of Users from further data supply in connection with BALTEX if non-fulfilment of the Licence Agreement is proven. In combination herewith the BHDC shall obtain a formal confirmation from the data User or group of Users in question that all data supplied by the Supplier within the scope of BALTEX has been destroyed or erased.

7. Feed-back

7.1 The BHDC shall annually, not later than before end of March each year, issue a report containing a list of data and/or documentation which has been distributed the year before and all Users which have received data.

8. Validity of this Agreement

8.1 This Agreement enters into force when signed by both parties and shall be valid up to and including December 31, 1998. Unless cancelled by either party in writing giving three month notice the agreement shall be prolonged for a further period of one year. Such a prolongation shall be possible also for the following years.

8.2 The Supplier may terminate this Agreement with immediate effect if BHDC is in breach of any condition herein and fails to rectify such breach of contract within thirty days after written notice from the Supplier.

8.3 Cancellation or termination of this agreement, in accordance with this section, shall not affect the Users right to use data and/or documentation within the scope of BALTEX.

8.4 If this Agreement is terminated in accordance with this Section 8, BHDC shall, not later than thirty day after termination, give the Supplier a formal confirmation that all data supplied by the Supplier within the scope of BALTEX has been destroyed or erased.

This Agreement has been drawn up in two identical originals, of which the Parties have taken one each.

Date:...	Date:...
For the Swedish Meteorological and and Hydrological Institute	For the ....
....	....
The Director of Government Services Division	

Hydrological data sampling strategy for BALTEX - BHDC

Runoff data

The establishment of the runoff data base will be the most important task of the BALTEX Hydrological Data Centre, BHDC. It will have the following features:

1. The hydrological runoff data base shall generally be based on daily (24 h) data except for some long records where these data are not easily available.

2. Data will preferably be collected from 1970 and onwards to cover the entire BALTEX research period. In cases early data are not available the period will start in 1980.

3. Data from a **basic network** of hydrological runoff stations covering the entire the Baltic basin shall be collected. This network consists of some 100 stations, selected to give a good areal coverage and to include the mouths of all major rivers.

4. Four river basins will be subjects to more complete data sampling. These **special study basins** are Vistula/Oder, Daugava, Neva and Torne (possibly including Kalix due to the bifurcation). The minimum average data coverage in these basins will about one station per 4000 km^2.

5. A special data base on the longest runoff records in the Baltic basin will be created for climatological studies.

6. A data base of meta data for all stations will be created and maintained by the BHDC.

Other hydrological data

Other hydrological data will be collected depending on their availability.

1. **Snow depth** data will be the task of the BMDC. Data on the **water equivalent of snow** will be collected by the BHDC as available, mostly from special studies.

2. Data on **soil temperatures** will be the task of the BMDC.

3. Data on **soil moisture** will be collected by the BHDC as available from special studies.

4. Data on **lakes** consisting of **levels, ice observations and water temperatures** will be collected by the BHDC as available.

DRAFT LICENCE AGREEMENT *APPENDIX B*

Between the Hydrological Data Centre for BALTEX at the Swedish Meteorological and Hydrological Institute, hereinafter referred to as **BHDC**,
and

the ...., hereinafter referred to as **the Licensee**,

the following agreement has been reached.

Preamble

This agreement has as its purpose the release of data, hydrometeorological and metadata, with documentation within the bounds of the BALTEX Research Programme.

1. Licence

1.1 Subject to the terms and conditions herein, the BHDC grants to the Licensee a non-exclusive licence to data and/or documentation for scientific purposes within the BALTEX Research Programme. The specification of data is appended to this licence agreement as Appendix I. The data have been supplied to the BHDC by individual participants in BALTEX, **the Suppliers**. The Suppliers are institutions in the countries of the BALTEX research Community[1].

1.2 The Licensee shall have the right to obtain the licence to data and/or documentation from the BHDC free of charge. The distribution cost shall be covered by the Licensee.

1.3 The Licence does only permit the use of data and/or documentation for the sole purpose of scientific utilisation within the scope of the BALTEX Research Programme. The data and/or documentation may not be used for commercial exploitation, business use, resale or re-distribution.

2. Proprietary Rights

2.1 The intellectual property rights to the data licensed in accordance with this Licence Agreement shall be retained by the Suppliers.

2.2 The Suppliers reserves the right to require acknowledgements and, where appropriate, co-authorship to any scientific publication arising out of the use of the aforementioned data and/or documentation supplied by the Supplier. However, the Licensee himself will give proper reference to Suppliers contributing to his data supply.

2.3 The Suppliers shall have joint intellectual property right, together with the Licensee to the results of the research which has been performed with data and/or documentation licensed from BHDC in accordance with this Agreement. The Suppliers and the licensee shall have the right to use said results in its Governmental Services.

[1]) Countries of the BALTEX Research Community are (as of January 1997):
Belarus, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden.

2.4 The Licensee may not, either against remuneration or not, grant the use to the data and/or documentation mentioned in this Agreement by way of ownership or licence, to any third party without the written consent of the Supplier.

3. Feed-back

The Licensee shall send 1 copy of his study results gained from The Suppliers data to each country (i.e. to a national institution) which contributed to the Licensees data supply. The delivery will be unrequested and free of charge.

4. Warranties

4.1 The BHDC warrants that it is authorised by the Suppliers to grant licences as stipulated in this Agreement.

4.1 The BHDC accepts no liability for errors or gaps in the data or in the enclosed documentation. Also no guarantee is given for usability on the Licensees technical equipment.

5. Validity of this Agreement

5.1 This Licence Agreement enters into force when signed by both parties and shall be valid until the specific research efforts, for which the data has been supplied, has been completed. Should the BALTEX Research Programme be terminated before the completion of the specific research effort, an early termination of this License Agreement shall be possible. Its date is subjected to the decision of the BALTEX Science Steering Group.

5.2 The BHDC may terminate this Agreement with immediate effect if the Licensee is in breach of any condition herein and fails to rectify such breach of contract within thirty days after written notice from BHDC.

4.3 If this Licence Agreement is terminated in accordance with this section the Licensee shall, not later than thirty day after termination, give BHDC a formal confirmation that all data supplied by BHDC within the scope of BALTEX has been destroyed or erased.

This Licence Agreement has been drawn up in two identical originals, of which the Parties have taken one each.

Date:..

For the Hydrological Data Centre for BALTEX at the Swedish Meteorological and Hydrological Institute	For the Licensee
....	....

Specification of data and schedule for delivery

1 Runoff data

2 Other hydrological data

THIS APPENDIX MUST BE DRAWN UP INDIVIDUALLY FOR EACH NATIONAL INSTITUTE ACCORDING TO THE DATA EACH INSTITUTE CAN SUPPLY.

A 138

Appendix 16

BALTEX Oceanographic Data Center: BALTEX ODC

Status report, April 1997

Pekka Alenius
Finnish Institute of Marine Research
P.O.Box 33, FIN-00931 Helsinki
tel: 358-9-613 94 439
fax: 358-9-612 94 494
e-mail: alenius@fimr.fi

Object and division of the task

The Finnish Institute of Marine Research (FIMR) has offered to act as the Oceanographic Data Center (BODC) for the BALTEX international research project. The BODC acts as a service center for all BALTEX participants in oceanographic data questions.

The BODC is mainly a meta-data center providing links to the data originators around the Baltic Sea. The BODC can, however, act as a real data center for certain specified data sets if so needed and decided. An example of such data are the water level data sets all around the Baltic Sea coasts.

The quite common opinion of BALTEX oceanographers has been that meta data information for most of the data is sufficient. Lot of oceanographic data is also stored in other international data centers like ICES and HELCOM data bases the services of which should be used. Department of Geophysics in University of Helsinki has collected a Baltic Sea Climate Data Bank.

Data types

The oceanographic data can be categorized as several types. These could be the following:

1. data for model initializations (e.g. SST, salinity, sea level)
2. data for model verification and validation (e.g. SST, salinity, sea level, currents)
3. meteorological data (e.g. wind, air pressure, humidity)
4. ship data from cruises (e.g. position, time, temperature, salinity, ADCP current measurements, CTD data)
5. buoy data (e.g. temperature, salinity, currents, meteorological data)
6. sea ice data (e.g. area of ice, ice thickness)

Information on these types of data should be included in the BODC.

Time periods of data

BALTEX key periods are 1986-1987, 1992-1993 and 1995. Other important periods are the BALTEX oceanographic experiments, BASIS and DIAMIX (previously called as

BAVAMEX) in 1997 and 1998. As complete data sets as possible from the key years are most probably needed. The Baltic Sea Climate Data Bank is an example of such an effort. Cooperation with that data bank is still suggested, because the data originators of that data bank are also BALTEX participants.

Long term time series are needed for model verifications and validations. Specially widely used data type has been sea level data. Data sets from selected sea level stations around the Baltic Sea from last 10-20 years could be well motivated.

Meta data information

Meta data contains the contact addresses and persons of data originators as well as information on their data holdings and availability of data. Such a list should include the oceanographic institutions around the Baltic Sea and the international oceanographic organizations where data is available on certain conditions. This meta data will be put available in internet. The FIMR has a WWW server where a home page for BODC is under construction. That home page will be linked to the BALTEX secretariat home page right after it has been made public.

Physical data storage

Although the opinion among oceanographers has been that meta data could be sufficient for most purposes, some important widely used data sets could be collected physically into the BODC. This process is proceeding slowly and no real data sets has been collected to BODC so far.

Data sets from the oceanographic experiments, where many different institutions take part, can be collected in a consistent way physically together in BODC if so decided between the projects and the BODC. The FIMR has facilities to produce e.g. CD-ROM's on limited amounts.

Need for physically accessible data base or files via FTP should be negotiated further. An FTP site is easily build up, but an internationally accessible online data base needs much more efforts. If the BODC should collect data physically, the originators should be responsible for basic quality control of the data before submission to the ODC.

Activities so far

The BODC has been very slowly proceeding effort up to now because of limited man power. On the other hand, the number of requests from data users has been very small, too; only 2-3 annually. The BODC has served as a meta-data center for those requests.

Appendix 17

Report to the BALTEX SSG Meeting Riga 14-16 April 1997

Report of the Baltex Research Network A:
Full-scale studies on the Energy and Water Cycle

Lennart Bengtsson
Coordinator of the NEWBALTIC Project

I. Introduction

This project was supported by the EU (NEWBALTIC project) for the period January 1996 until November 1997. A new application requesting an extension for 2 more years was submitted by 15 January 1997. No result of this evaluation is presently available.The overall goal of the project is to reduce the uncertainties in our understanding of the hydrological and energy cycle through modelling and quantification of the various processes which determine the space and time variability of the energy and water cycle of the Baltic Sea and its catchment areas. The proposal covers in particular:

- regional-scale atmospheric high resolution reanalysis,
- development of adequate data assimilation,
- diagnostic evaluation of several region-scale atmospheric models,
- coupled atmospheric and hydrological modelling.

II. Program of work

The project identifies 12 workpackages covering diagnostic studies as well as associated reanalysis, data-assimilation and model development.

1. Reanalysis of a cold winter 1986/87, a mild winter 1992/93 and the PIDCAP period Aug-Oct 1995.

The reanalysis for the cold winter 1986/87 has been completed with a data assimilation system at 22 km resolution and with 24 vertical levels. A number of model and assimilation improvements have been implemented including improved numerical techniques, additional radiosonde data and improved sea surface temperatures and sea ice cover.

The reanalysis for the mild winter period 1992/93 and PIDCAP are in preparation.

2. Development of a high resolution, delayed mode, stable data assimilation system.

Several delayed mode data assimilation are being developed for the reanalyses. The data assimilation efforts incorporate additional observations not available for the operational data assimilation as well as improved handling of Baltic SST and sea ice, incorporation of lakes as well as the incorporation of the effect of soil moisture by 3DVAR. Efforts are also going on to assimilate radar data.

3. Retrieval of atmospheric water vapour, cloud water and radiation fluxes.

An important aspect of the Newbaltic project is to systematically make use of novel satellite data information for an independent assessment of water vapour, cloud water and radiation fluxes.

Profiles of the integrated water vapour have been derived from GPS data for the period 1 August to 31 October 1995 (the PIDCAP period) and preliminarily evaluated. Presently 20 sites in Sweden and 5 sites in Finland have been used. There is good agreement with radiosonde data when such data are available. There are all indications that water vapour profiles retrieved from the GPS data will make a very important contribution to the project as well as being an important part of a future operational meteorological observing system.

Major efforts have gone into detailed processing of the SSM/I radiometer data for obtaining the total water vapour and the liquid water information. Particular problems exist for the handling of low frequency information due to irregular coastlines and complex archipelagoes. Preliminary evaluation of these data as well as cloud and radiation data from ISCCP look very promising.

4. Evaluation of the HIRLAM data assimilation system by validating the implied atmospheric energy and water budgets.

Comprehensive diagnostic systems have been developed and tested for the different models, HIRLAM, REMO and UKMO. During the first phase of the project the key emphasis has been put on a better handling of the spin-up effect and consistent ways of undertaking the energy and flux calculations. It is found that it is necessary to undertake the calculations within the framework of the model and not from the archived data in pressure coordinates. Spin-up or spin-down is still a problem, although it is suggested that the most advanced schemes can provide adequate results after 6-12 hours into the assimilation.

Since model derived fluxes probably is the most accurate method available, detailed intercomparison for the three available models will be undertaken using the same horizontal and vertical resolution and thus concentrate on the specific role of the different parameterization schemes.

5. Validation of the regional-scale model REMO with physics of the EM/DM system and ECHAM4 system

Preliminary calculations of the energy and water fluxes over the Baltic region have been undertaken with ECHAM4 and REMO in multi-year climate mode integrations. Calculated river run-off data as well as the interannual variability is in broad agreement with available statistical data. Validation against available precipitation data, though, suggest that the models have a more even precipitation over the years then what is found from the observation. A better understanding of this will be a key objective in 1997.

6. Validation of the components of the energy and water cycle in the Baltic region as predicted by the UKMO Unified Model

This work is well under way but efforts will concentrate on using the data sets in 1. as well as using agreed upon standardization of the regional models as mentioned in 4.

7. Development of the hydrological HBV model for the Baltic basin

The HBV model has now been extended to incorporate the whole Baltic. Simulated run-off data based on observed surface temperatures and precipitation data agrees well with observations. Inferred data for evapotranspiration, snow water equivalent and soil moisture deficit will be compared with other estimates directly obtained from the models. Furthermore, arrangements have been made to drive the HBV model directly from model outputs.

8. Diagnostic of the convective heat flux and the rain flux in the free atmosphere

Precipitation analysis for the PIDCAP period has been completed and an atlas of twice daily analysed fields of precipitation has been published. Convective heat fluxes have been calculated for specific episodes using the diagnostic model DIAMOD. These data will be used to validate the present parameterization of convection in the REMO model.

9. Development of data assimilation scheme for soil moisture and soil temperature

A comprehensive evaluation has been completed. The technique will next be incorporated into the DWD data assimilation system for real-time evaluation (see also 2).

10. Analysis of the climatological energy and water budget of the Baltic region from the global-scale MPIfM climate model ECHAM

This work is in progress and coupling tests have been undertaken between REMO and the hydrological HBV system.

11. Implementation of the MPIfM snow model into REMO

The work has been concentrated on a systematic evaluation of the simulated snow cover and snow mass in the ECHAM model. Preliminary evaluation shows that both snow area coverage and snow mass generally are well captured by the model, although snow mass in spring is overestimated. The main reason is not obvious, but is apparently a combination of too high precipitation and too low temperatures. A part of the deficiency could be overcome by a more advanced parameterization of snow. Test with such an improved snow model is in progress.

12. Implementation of a flux aggregation scheme into the ECHAM4 physics package

Numerical experiments have been undertaken by a high resolution meso-scale model at the University of Helsinki. Experiments show that the effect of surface heterogeneity induces much larger relative difference for the momentum flux than for the sensible heat flux. Nest step will be to test the technique in a comprehensive model.

III. Participating groups

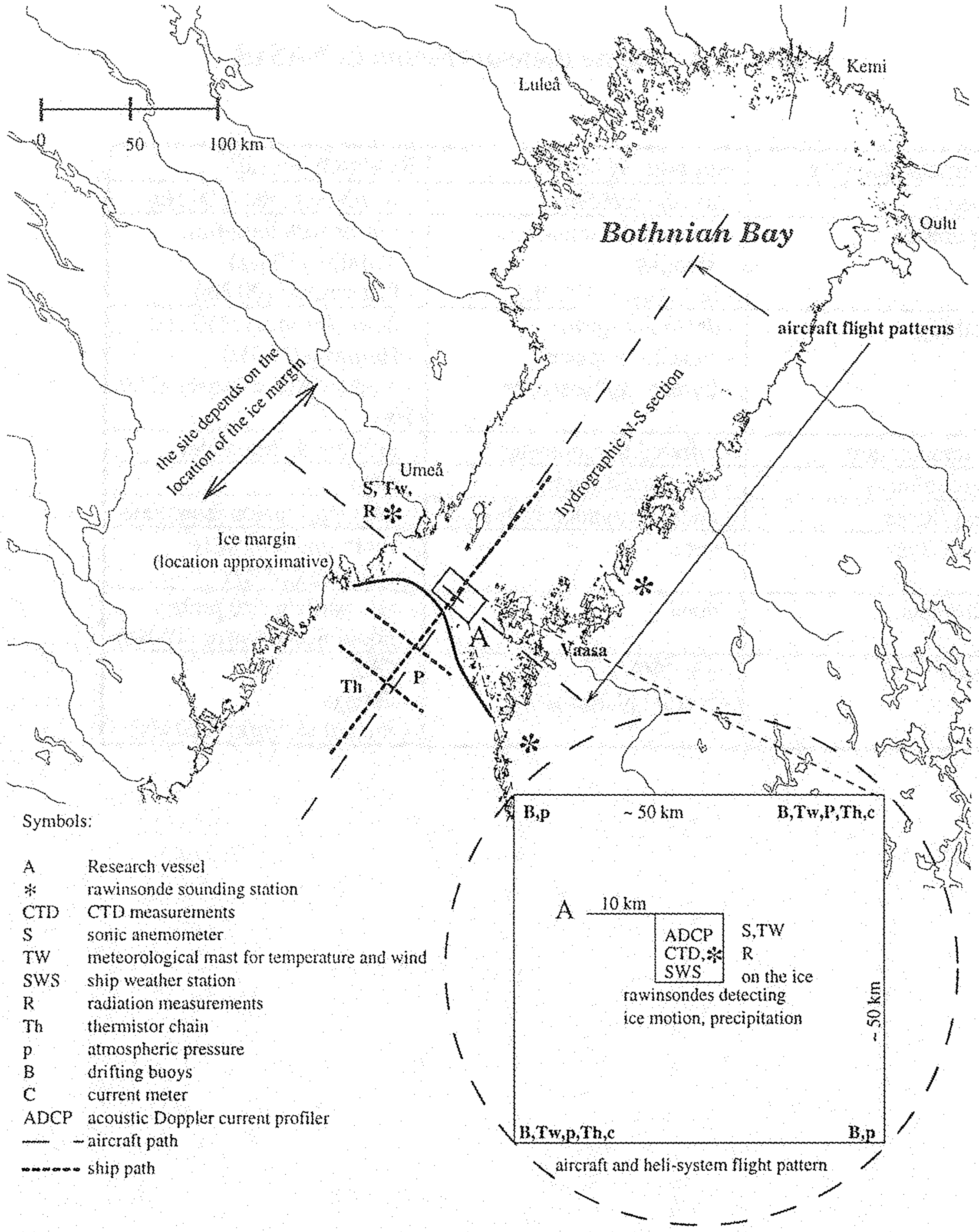
10 different groups from 6 different countries including UK and Austria as non-original BALTEX countries are also participating.

To date the NEWBALTIC project has been very successful with some excellent scientific results. Systematic model intercomparison of data from PIDCAP and the re-analysed data from PIDCAP and from the winters 1986/87 and 1991/92 with standardized resolution and grids stand in the forefront.

Participants

Partner No.	Abbreviation	Name of Institute and	Principal Investigator
1.	MPIfM	Max-Planck-Institut für Meteorologie	Lennart Bengtsson
2.	IMG	University of Vienna - Institute for Meteorology and Geophysics,	Michael Hantel
3.	DMI	Danish Meteorological Institute	Bent Hansen Sass
4.	UH	University of Helsinki	Carl Fortelius
5.	DWD	Deutscher Wetterdienst	Angela Lehmann
6.	GKSS	Research Center Geesthacht	Dieter Eppel
7.	IfM	Institut für Meereskunde, University of Kiel	Eberhard Ruprecht
8.	SMHI	Swedish Meteorological and Hydrological Institute,	Sten Bergström
9.	CHALMERS	Chalmers University of Technology	Gunnar Elgered
10.	UKMO	UK Meteorological Office	Roderick Smith

Appendix 18



Map of the BASIS research area. The measurement activities at the main experiment site are shown in the lower right-hand corner. The experiment data will be completed by meteorological synoptic and sounding station data. The airborne measurements are listed in Table 1.

Table 1: Airborne measurements in BASIS

Measurement quantity	Helipod- system	Research aircraft
Wind speed	- five-hole probe	- five-hole probe (100 Hz)
Air temperature	- sensor with long-time stability - fast sensor (100 Hz)	- sensor with long-time stability (10 Hz) - fast sensor (100 Hz)
Air Humidity	- dewpoint mirror - capacitive sensor - Lyman-Aplha sensor	- dewpoint mirror (10 Hz) - Humicap (10 Hz) - Lyman-Alpha sensor (100 Hz)
Surface temperature	- infrared thermometer	- infrared thermometer
Surface roughness	- laser profilometry	none
Turbulent fluxes	- eddy-correlation technique	- eddy-correlation technique
Radiative fluxes	none	- short- and longwave radiation (10 Hz)
Cloud droplets	none	- two particle size probes - liquid water sensor (10 Hz)
Navigation	- 3 x GPS - inertial platform	- GPS - Omega - inertial platform (100 Hz)

Appendix 19

BALINEX - BALTEX Lindenberg Land Surface Experiment

by Gerd Tetzlaff, Leipzig University, Germany

Summary

Studies with all types of numerical models, i.e. mesoscale models, general circulation models, and numerical weather prediction models have clearly demonstrated the strong response of the atmospheric circulation on landsurface processes. The exchange of energy and water at the surface is dominated by the absorption of solar radiation and the availability of water. These two factors are controlled by vegetation cover and soil type which have to be described appropriately in all models for correct results.

The horizontal resolution of atmospheric models at present ranges from about 1 km for mesoscale and regional models to some 100 km while the water exchange at the surface is governed by the very small-scale processes reacting even to individual plants. Thus these small processes have to be aggregated in order to allow formulations of the horizontally integrated water transport processes. There is a long history of such aggregation procedures and parameterizations. However, the parameterisations still are deficient for some specific land surface conditions. i.e. in heterogeneous surface covers, and over specific canopies, such as forests.

Variations in soil and surface properties create small-scale atmospheric structures such as internal boundary layers, the actual role of which is not clearly understood, and circulations which may result in a subgrid variability of atmospheric variables. This again does influence the exchange of energy and water at the surface. The formulation of specific modules, considering different approaches to quantify the role of heterogeneity structures such as roughness changes, more detailed modelling of the processes within forests, with an emphasis on interception, and their implementation into mesoscale models is the major goal of this proposal. This however, goes with the investigation of the effect of small scale processes.

To achieve this goal it is very strongly felt that some new specific experimental data are necessary. The selected region around Lindenberg is representative for large area of central Europe. Major parts of this region are forest covered, as are wide parts of the rest of Europe. There are however, very little reliable data available allowing to validate any parameterization for different types of models. Therefore, the key part of this proposal is to closely connect newly gained experimental results with the different types of models using them for validation and improved formulation of small and mesoscale parameterization schemes. Consequently, the results should be transferred to the use in larger scale models.

The concrete focus will be on :

- small scale models of forest properties (interception, canopy layer, flux aggregation)

- new formulations of the landscape heterogeneity effects in mesoscale models using the height of the boundary layer as a control, based on the improved small scale models

- the investigations concentrate on the feedback between surface and atmosphere and the water budget during the drying out phase after a rainfall event.

- taking new field data on forest properties and scale aggregation for the validation of small and mesoscale model results.

From the results of these investigations weather forecast and climate simulations as well as flood forecast and water resources research on various spatial and time scales will benefit. This study will have a major impact on various socio-economic events on Earth through both, the atmospheric and the hydrological component.

Appendix 20

Membership of the BALTEX Science Steering Group
(as of May 1997)

Mikko Alestalo
Finnish Meteorological Institute
Meteorological Research
P.O. Box 503, Vuorikatu 24
FIN-00101 Helsinki / Finland
phone: +358-9-19294100
fax: +358-9-19294103
e-mail: mikko.alestalo@fmi.fi

Lennart Bengtsson **(Chair)**
Max-Planck-Institut für Meteorologie
Bundesstraße 55
D-20146 Hamburg / Germany
phone: +49-40-41173349
fax: +49-40-41173366
e-mail: bengtsson@dkrz.de

Sten Bergström
Swedish Meteorological and Hydrological Institute
Research and Development
S-60176 Norrköping / Sweden
phone: +46-11-158292
fax: +46-11-170208
e-mail: sbergstrom@smhi.se

Jerzy Dera
Polish Academy of Sciences
Institute of Oceanology
Powstanców Warszawy 55
PL-81712 Sopot / Poland
phone: +48-58-517283
fax: +48-58-512130
e-mail: dera@iopan.gda.pl

Zdzislaw Kaczmarek **(Vice-Chair)**
Polish Academy of Sciences
Institute of Geophysics
Ks. Janusza 64
PL-01-452 Warsaw/ Poland
phone: +48-22-377858
fax: +48-22-370522
e-mail: kaczmar@seismol1.igf.edu.pl

Peeter Karing
Estonian Meteorological and Hydrological Institute
Rävala 8
EE-0001 Tallinn / Estonia
phone: +372-6-461563
fax: +372-2-454277
e-mail: emhi.karing@torn.ee

Petras Korkutis
Lithuanian Hydrometeorology Service
Rudnios 6
LIT-232600 Vilnius / Lithuania
phone: +370-2-751194
fax: +370-2-724160

Wolfgang Krauß
Institut für Meereskunde an der Universität Kiel
Düsternbrooker Weg 20
D-24105 Kiel / Germany
phone: +49-431-5973800
fax: +49-431-565876
e-mail: wkrauss@ifm.uni-kiel.de

Leif Laursen
Danish Meteorological Institute
Research and Development Department
Lyngbyvej 100
DK-2100 Copenhagen / Denmark
phone: +45-39157420
fax: +45-39157460
e-mail: ll@dmi.min.dk

Andris Leitass
Latvian Hydrometeorological Agency
165, Maskavas Str.
LV-1019 Riga / Latvia
phone: +371-7-112040 -144390
fax: +371-7-145154
e-mail: janis@lhma.org.lv

Pentti Mälkki
Finnish Institute of Marine Research
B.O. Box 33
FIN-00931 Helsinki/ Finland
phone: +358-9-61394400
fax: +358-9-61394494
e-mail: malkki@fimr.fi

Eberhard Müller
Deutscher Wetterdienst
Forschung und Entwicklung
Postfach 10 04 65
D-63004 Offenbach / Germany
phone: +49-69-8062-2720
fax: +49-69-8236-1493
e-mail: mueller@f1.za-offenbach.dwd.de

Anders Omstedt
Swedish Meteorological and Hydrological Institute
S-60176 Norrköping / Sweden
phone: +46-11-158284
fax: +46 11-170207
e-mail: aomstedt@smhi.se

Jerzy Pruchnicki
Institute of Meteorology and Water Management
Podlesna 61
PL-01-673 Warszawa / Poland
phone: +48-22-347985
fax: +48-22-341801
e-mail: jerzy_pruchnicki@imgw.pl

Ehrhard Raschke (Vice-Chair)
GKSS Forschungszentrum
Institut für Atmosphärenphysik
Postfach 1160
D-21494 Geesthacht / Germany
phone: +49-4152-871533
fax: +49-4152-872020
e-mail: raschke@gkss.de

Dan Rosbjerg
Institute of Hydrodynamics and Water Resources
ISVA - Technical University of Denmark
Building 115
DK-2800 Lyngby / Denmark
phone: +45-4525-1449
fax: +45-4593-2860
e-mail: dan@isva.dtu.dk

Ivan M. Skouratovich
Committee for Hydrometeorology of Belarus
110 Skarina Avenue
Minsk 220 023 / Belarus
phone: +375-172-640436
fax: +375-172-640335
e-mail: rakn@gimet.belpak.minsk.by

Hilding Sundqvist
Stockholm University
Department of Meteorology
S-10691 Stockholm / Sweden
phone: +46-8162534
fax: +46-8157185
e-mail: hildings@misu.su.se

Valery S. Vouglinski
Russian State Hydrological Institute
23, Second Line
St. Petersburg 199053 / Russia
phone: +7-812-213-3517 -3447
fax: +7-812-213-1028
e-mail: admin@vggi.spb.ru

Ex-officio:

Hans-Jörg Isemer
GKSS Forschungszentrum Geesthacht
International BALTEX Secretariat
Postfach 1160
D-21494 Geesthacht / Germany
phone: +49-4152-87-1536
fax: +49-4152-87-2020
e-mail: isemer@gkss.de

Appendix 21

Membership of the Working Group on Process Studies
(as of June 1997)

Sven Halldin
Uppsala University
Department for Hydrology
Norbyvägen 18B
S-75236 Uppsala / Sweden
phone: +46-18-182262
fax: +46-18-551124
e-mail: sven.halldin@hyd.uu.se

Lutz Hasse
Institut für Meereskunde
Universität Kiel
Düsternbrooker Weg 20
D-24105 Kiel / Germany
phone: +49-431-5974019
fax: +49-431-565876
e-mail: lhasse@ifm.uni-kiel.de

Hans-Ulrich Lass
Institut für Ostseeforschung
an der Universität Rostock
Postfach 301038
D-18111 Rostock
phone: +49-381-5197130
fax: +49-381-5197440
e-mail: lass@physik.io-warnemuende.d400.de

Jouko Launiainen
Finnish Institute of Marine Research
B.O. Box 33
FIN-00931 Helsinki / Finland
phone: +358-9-613 941
fax: +358-9-331 025, +358961394494
e-mail: jouko.launi@fimr.fi

Anders Omstedt
Swedish Meteorological and Hydrological Institute
S-60176 Norrköping / Sweden
phone: +46-11158284
fax: +46-11170207 +46 11170208
e-mail: aomstedt@smhi.se

Eberhard Ruprecht (Chair)
Institut für Meereskunde
an der Universität Kiel
Düsternbrooker Weg 20
D-24105 Kiel / Germany
phone: +49-431-5973872
fax: +49-431-565876
e-mail: eruprecht@ifm.uni-kiel.de

Ann-Sofi Smedman
Uppsala University
Department of Meteorology
P.O. Box 516
S-75120 Uppsala / Sweden
phone: +46-18-542792
fax: +46-18-544706
e-mail: annsofi@big.met.uu.se

Hannu Savijærvi
University of Helsinki
Department of Meteorology
P.O. Box 4
FIN-00014 Helsinki / Finland
phone: +358-9-191-22423
fax: +358-9-191-22150
e-mail: savijarvi@cc.helsinki.fi

Gerd Tetzlaff
Universität Leipzig
Institut für Meteorologie
Stephanstraße 3
D-04103 Leipzig / Germany
phone: +49-341-9732851
fax: +49-341-9730099
e-mail: gppnm@convex.rz.uni-leipzig.de

Niels Woetmann Nielsen
Danish Meteorological Institute
Lyngbyvej 100
DK-2100 Copenhagen / Denmark
phone: +45-39157500
fax: +45-39271080
e-mail: nwn@dmi.min.dk

International BALTEX Secretariat Publication Series

No. 1 : Minutes of First Meeting of the BALTEX Science Steering Group
at GKSS Research Center in Geesthacht, Germany, May 16-17, 1994.
August 1994.

No. 2 : Baltic Sea Experiment BALTEX - Initial Implementation Plan.
March 1995, 84 pages.

No. 3 : First Study Conference on BALTEX, Visby, Sweden, August 28 - September 1, 1995.
Conference Proceedings. Editor: A.Omstedt, SMHI Norrköping, Sweden.
August 1995, 190 pages.

No. 4 : Minutes of Second Meeting of the BALTEX Science Steering Group
at Finnish Institute of Marine Research in Helsinki, Finland, January 25-27, 1995.
October 1995.

No. 5 : Minutes of Third Meeting of the BALTEX Science Steering Group
at Strand Hotel in Visby, Sweden, September 2, 1995.
March 1996.

No. 6 : BALTEX Radar Research - A Plan for Future Action.
October 1996, 46 pages.

No. 7 : Minutes of Fourth Meeting of the BALTEX Science Steering Group
at Institute of Oceanology PAS in Sopot, Poland, June 3-5, 1996.
February 1997.

No. 8 : *Hydrological, Oceanic and Atmospheric Experience from BALTEX.*
Extended Abstracts of the XXII EGS Assembly, Vienna, Austria, April 21-25, 1997.
Editors: M. Alestalo and H.-J. Isemer.
August 1997, 172 pages.

No. 9 : The Main BALTEX Experiment 1999-2001 - ***BRIDGE***. Strategic Plan.
October 1997, 78 pages.

No. 10: Minutes of Fifth Meeting of the BALTEX Science Steering Group
at Latvian Hydrometeorological Agency in Riga, Latvia, April 14-16, 1997.
January 1998.

Copies are available upon request at the International BALTEX Secretariat.