BALTEX
Baltic Sea Experiment

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

Minutes of

First Meeting of the BALTEX Science Steering Group

at
GKSS Research Center in Geesthacht, Germany
May 16-17, 1994

International BALTEX Secretariat
Publication No. 1
August 1994

Participants of first meeting of the BALTEX Science Steering Group,

May 16-17, 1994 at Geesthacht, Germany.

First Meeting of the
BALTEX Science Steering Group
at GKSS Research Center in Geesthacht, Germany
May 16-17, 1994

The meeting of the BALTEX Scientific Steering Group (BSSG) opened on Monday, May 16, 1994 at 11 am. A revised list of participants is presented in Appendix 1.

1. E. Raschke welcomed the participants. S. Herms, the Managing Director of GKSS gave a short introduction to the historical development of GKSS and acknowledged the BALTEX activities at GKSS as part of the present GKSS research- and development programme.

2. The preliminary agenda of the BSSG meeting was confirmed by the participants. Discussions on i) data policy, and ii) the First Study Conference on BALTEX were included as additional items to be discussed (Appendix 2).

3. E. Raschke reviewed the general status and structure of BALTEX as detailed in the BALTEX science plan and gave an overview of past and future BALTEX activities (Appendix 3). He pointed out that BALTEX is now generally accepted as one of the Regional Projects of the GEWEX. In order to further facilitate the necessary coordination of BALTEX projects an International BALTEX Secretariat has now formally been implemented at GKSS. H.-J. Isemer was introduced as project scientist at the BALTEX secretariat. This implementation of the International BALTEX Secretariat at GKSS and its status for BALTEX as outlined in a document, which had been distributed to all members of BSSG, was later welcomed by the BSSG.

4./5. L. Bengtsson was elected as chairman of BSSG. Z. Kaczmarek and E. Raschke were elected as vice-chairmen. Present members of BSSG are listed in Appendix 4. The term of office for both chairpersons and members of BSSG was defined to be three years, in accordance with accepted WCRP-rules. Re-nomination or re-election of both chairpersons and members are possible.

6. National representatives of all 10 participating countries presented short reports on national activities related to BALTEX. Details as presented to BSSG are given in Appendices 5 to 12, only major items are noted here.

Denmark: A Danish national BALTEX committee with members from 9 national institutions has been established. Planned Danish activities in accordance with the BALTEX science plan were outlined (Appendix 5).

Sweden: The Swedish IGBP-WCRP Committee has established a subcommittee for the co-ordination of research within BALTEX. A report on the Swedish BALTEX research programme has been published and distributed to BSSG (Appendix 6).

Sweden committed to host and operate the BALTEX hydrological data center. Sweden will also host the first Study Conference on BALTEX at Visby, Gotland in August 1995.

Finland: A national BALTEX working group has been established. Finnish interests and possible contributions to BALTEX are summarized in Appendix 7. The necessity of considering sea ice and its interaction with ocean and atmosphere in both modelling and process studies was especially noted. Finland committed to host and operate the BALTEX oceanographic data center.

Russia: A meeting of Russian scientists was held in St. Petersburg in May 1993. At that meeting, possible items of a Russian contribution to BALTEX were discussed and defined (Appendix 8). Hydrometeorological and hydrochemical data for the Baltic Sea area are available in the Hydrometeorological Yearbooks but only until 1989. Since 1990 the information is distributed among different institutions and must be purchased.

Belarus: The Meteorological Service of Belarus has begun to collect hydrometeorological data for the BALTEX special periods 1986-87 and 1992-93. Requirements for the continuation of this activities were given (Appendix 9).

Estonia: Microclimatic maps are available on a gridnet with 7.5 km resolution for the whole country and on a 100 m resolution gridnet for special parts of Estonia. Most data are still available only in manuscript form.

Latvia: A detailed list of available data (meteorological, oceanographic and hydrological) was presented (Appendix 10).

Lithuania: A detailed list of available hydro-meteorological data was presented (Appendix 11).

Poland: A national committee for international hydrologic and meteorologicl programmes exists at the Polish Academy of Sciences. It will be responsible for the coordination of national BALTEX activities. A Polish contribution to BALTEX was proposed (Appendix 12). The existence of a GRID data center in Warzaw, Poland, was brought to the attention of BSSG. One digital radar station is already operating in central Poland, another is planned for the southwestern region of the country. It was especially pointed out that the continuity of funding of long term projects like BALTEX might be problematic. This was acknowledged by BSSG as a general problem for all participating countries.

Germany: A German national GEWEX-commission was formed in 1992 to coordinate all research activities which are relevant for the fulfillment of scientific objectives of GEWEX and BALTEX. A preliminary BALTEX-Secretariat began its work at GKSS Research Center in 1992 to support international and national preparations for BALTEX. It has been formally implemented at GKSS in April 1994 with a project scientist and secretariat support; further scientific staff and guest scientists are planned. Germany has committed to host the meteorological data center for BALTEX at the Deutsche Wetterdienst in Offenbach, it also hosts the precipitation data center and the run-off data center for WCRP (Appendix 20). Within the German climate research programme a special research effort "Water Cycles" has been defined supporting research dealing with the catchment areas of the rivers Elbe and Weser, and of the Baltic Sea (BALTEX). About 25 research groups at universities , research - and governmental organizations are participating in this effort which is funded now by BMFT for the period 1994-96.

7. Reports of the three BALTEX Working Groups (WGs) and further suggestions for the BALTEX Implementation Plan (B-IP) have been submitted by the WG chairmen and were distributed as written documents and presented orally to BSSG at the present meeting.

J. Willebrand (chairman of WG "Numerical Experimentation", WG-N) stressed the necessity to establish coupled ocean-atmosphere models for the Baltic Sea. Also, data assimilation systems should be developed for ocean models and for coupled ocean-atmosphere models. Hence, WG-N is planning a special data assimilation workshop to be held later this year. A comparison of results of different models when applied to the BALTEX area should be performed. It was especially recommended to put effort into sea ice modelling. It was suggested Dr. Leppäranta from Finland should be asked to join WG-N. Detailed reports and suggestions for the BALTEX Implementation Plan of WG-N are given in Appendices 13 and 14.

E. Ruprecht's report as chairman of WG "Process Studies", WG-P, includes a list of possible BALTEX field campaigns (see Appendix 15 for further details). BSSG recommended to consider further experiments with emphasize on oceanographic and land-atmosphere processes. Especially, a winter air-ice experiment in the northern Baltic Sea should be considered. Further preparatory discussions were postponed to an ad-hoc group to be formed later at the present meeting.

P. Alenius, as vice-chairman of WG "Data Management and Data Studies", WG-D, suggested a closer discussion with both WG-P and WG-N in order to identify in more detail data requirements for BALTEX. Based on this discussion a further investigation on the availability of data for BALTEX should follow. BSSG suggested that WG-D should concentrate on technical aspects of the data management. A respective re-formulation of the WG-D tasks was suggested. The WG-D workshop minutes are presented as Appendix 16.

The first session of the BSSG meeting closed on Monday at 6.30 pm. It was followed by a reception, opened by the vice-director for science and technology at GKSS, Mr. H. Schmidt.

8. The morning session on Tuesday, May 17 started with a report of H.-J. Isemer of the BALTEX secretariat on the availability of two climatological data sets relevant to BALTEX (the ~~WMO project "Climate of the Baltic Sea Basin"~~, CBSB, and "Comprehensive Ocean-Atmosphere Data Set", COADS). A preliminary list of data requirements for atmospheric and hydrological modelling was presented in order to prepare for a BALTEX workshop to be hold in Vilnius, Lithuania, June 6-8, 1994. The aim of the latter is to initialize and support projects in each of the eastern BALTEX countries, coordinated by the BALTEX Secretariat, in order to collect and digitize input data for modelling. BSSG agreed that this German initiative should be coordinated with other BALTEX activities in this field. BSSG was informed that the Nordic HIRLAM modelling group had started to gather the relevant data for the Swedish and Finnish region and plans to include further BALTEX regions.

9. BSSG noted and supported the Swedish offer to host and organize the First Study Conference on BALTEX in Visby in August 1995.

10. The availability of data for BALTEX was extensively discussed. A general commercialization of hydrological and meteorological data tends to hamper data exchange and data availability. The chairman of BSSG will send letters to national weather services and other national and international data-holding institutions concerning data policy in relation to BALTEX. Suitable addresses should be forwarded to L. Bengtsson.

11. BSSG decided to establish a drafting group for the BALTEX Implementation Plan (B-IP). This group will consist of up to 7 specialists to be nominated until the end of May 1994. A second version of B-IP should be drafted until November 1994, based on the first version written during a workshop in Uppsala, Sweden. Further detailed work on the B-IP is facilitated now because a number of national weather services and institutions provided commitments on model - and data management availabilities.

12. For further detailed discussions BSSG splitted up into two ad-hoc groups on "Data Requirements for BALTEX Modelling" (chaired by J. Willebrand) and "Priorities for BALTEX Process Studies" (chaired by E. Ruprecht).

13. Recommendations of these two groups (see Appendices 17 and 18) were discussed in plenary and accepted by BSSG for further discussion. N. Gustafsson introduced a reanalysis project of January 1987 for BALTEX at SMHI (Appendix 19). BSSG requested to extent this project to the complete BALTEX key period 1986/87. V. Vent-Schmidt was asked to investigate whether DWD can re-analyse at least the BALTEX key period 1992/93, providing for the boundary data of the Europa Modell for use in the BALTEX regional model developed at GKSS and MPI. WG-P was asked to work out detailed plans in order i) to implement BALTEX measurement campaigns, and ii) to identify further needs. WG-D was requested to outline a possible BALTEX radar network taking into consideration existing radar stations or networks (e.g. NORDRAD). A special radar BALTEX WG will be implemented. Dr. Riedl of the DWD should be ask to chair this WG.

14. A calendar of future BALTEX activities was agreed upon as follows:

May 1994	: Nomination of drafting group for B-IP
June 6-8, 1994	: BALTEX workshop in Vilnius, Lithuania
Fall 1994	: Meeting of the drafting group
Fall 1994	: Workshops of all three BALTEX WGs
November 1994	: Review of second draft of B-IP
January 25-27, 1995	: 2nd BSSG meeting in Helsinki, Finland
August 28 - September 2, 1995	: First Study Conference on BALTEX, Visby, Sweden

15. The BSSG meeting closed in the evening of Tuesday, May 17 1994.

Appendices

to the Minutes of

First Meeting of the

BALTEX Science Steering Group

at GKSS Research Center in Geesthacht, Germany

May 16 - 17, 1994

List of Appendices

Appendix 1

Meeting of the

BALTEX Science Steering Group

at GKSS in Geesthacht, Germany, May 16-17, 1994

Participants

Dr. Pekka **Alenius**,	Finland
Prof. Dr. Lennart **Bengtsson**,	Germany
Prof. Dr. Jerzy **Dera**,	Poland
Dr. Nils **Gustafsson**,	Sweden
Prof. Dr. Eero **Holopainen**,	Finland
Dr. Hans-Jörg **Isemer**,	Germany
Prof. Dr. Zdzislaw **Kaczmarek**,	Poland
Dr. Peeter **Karing**,	Estonia
Mrs. Dalia **Smelstoriuté**,	Lithuania
Prof. Dr. Wolfgang **Krauß**,	Germany
Dr. Jouko **Launiainen**,	Finland
Prof. Dr. Anders **Omstedt**,	Sweden
Prof. Dr. Ehrhard **Raschke**,	Germany
Prof. Dr. E. **Ruprecht**,	Germany
Mr. S. **Herms**,	Germany
Dr. Ivan M. **Skouratovitch**,	Belarus
Mr. V. **Vent-Schmidt**,	Germany
Prof. Dr. Valery S. **Vuglinsky**,	Russia
Prof. Dr. Jürgen **Willebrand**,	Germany
Dr. N. **Woetmann Nielsen**,	Denmark
Dr. Sc. Evgenij **Zaharchenko**,	Latvia

Appendix 2

Meeting of the

BALTEX Science Steering Group

at GKSS Research Center in Geesthacht, Germany
May 16 -17, 1994

Agenda

Monday, May 16, 1994

10.15		Pickup service at hotels
11.00	1.	Welcome S. Herms, GKSS
	2.	Agenda of the meeting
	3.	Structure of BALTEX, recent developments, BALTEX Secretariat (Raschke)
	4.	Terms of reference of BALTEX SSG
	5.	Election of chairman and vice-chairman
13.00	Lunch	
14.00	6.	Reports from all BALTEX countries (one report at any given time) Denmark (Woetmann-Nielsen) Sweden (Omstedt) Finland (Launiainen, Holopainen) Russia (Vuglinsky) Belarus (Skouratovitch) Estonia (Karing) Latvia (Zaharchenko) Lithuania (Smelstoriuté) Poland (Kaczmarek) Germany (Raschke, Vent-Schmidt)
16.30	7.	Reports of Working Group Chairmen WG Numerical Experimentation (Willebrand) WG Process Studies (Ruprecht) WG Data Management and Data Studies (Alenius)
18.30	Reception by GKSS	

Tuesday, May 17, 1994

08.30		Pickup service at hotels
09.00	8.	Vilnius Workshop, June 6 - 8, 1994
	9.	1. Study Conference on BALTEX
	10.	Data policy for BALTEX
	11.	Implementation Plan
12.30	Lunch	
13.30	12.	Parallel Sessions on a) - Data Requirements for Modelling b) - Process Studies
14.30	13.	Implementation Plan Plenary discussion
16.00	14.	Calendar of future activities
17.00	15.	Closing of the meeting

Appendix 3

BALTEX - History

E. Raschke (16.05.1994)

Past:

First Plans:	Summer 1990 as contribution to GEWEX
Several Internal Meetings:	BMFT, GKSS, DFG, others
Workshop in Norrköping:	26. - 30. Oct. 1992
First BALTEX Conference:	30. Nov. - 1. Dec. 1992 in Geesthacht
Workshop in Uppsala:	09. - 11. August 1993 (Implementation Plan)

- Formulation of German contributions to BALTEX -

January 1994:	Meetings of all 3 Working Groups
March 1994:	Meeting of WG-Chairmen with Bengtsson, Raschke, Isemer
16 -18 May 1994:	1. Meeting of BSSG !

Future:

6 - 8 June 1994:	Workshop in Vilnius
Fall 1994:	Workshop of Working Groups
End of 1994:	Work on Implementation Plan !
August 1995:	First Study Conference on BALTEX

Appendix 4

BALTEX Science Steering Group

Prof. Dr. Lennart **Bengtsson** (Chairman) Max-Planck-Institut für Meteorologie	Germany
Prof. Dr. Sten **Bergström** Swedish Meteorological and Hydrological Institute	Sweden
Prof. Dr. Jerzy **Dera** Institute of Oceanology PAS	Poland
Prof. Dr. Eero **Holopainen** University of Helsinki	Finland
Prof. Dr. Zdzislaw **Kaczmarek** (Vice-Chairman) Institute of Geophysics	Poland
Dr. Peeter **Karing** Estonian Meteorological and Hydrological Institute	Estonia
Dr. Petras **Korkutis** Lithuanian Board for Hydrometeorology	Lithuania
Prof. Dr. Wolfgang **Krauß** Institut für Meereskunde Kiel	Germany
Mr. Leif **Laursen** Danish Meteorological Institute	Denmark
Dr. Pentti **Mälkki** Finnish Institute of Marine Research	Finland
Prof. Dr. Eberhard **Müller** Deutscher Wetterdienst	Germany
Prof. Dr. Ehrhard **Raschke** (Vice-Chairman) Institut für Physik, GKSS	Germany
Prof. Dr.-Ing. Gert A. **Schultz** Lehrstuhl für Hydrologie, Bochum	Germany
Dr. Ivan M. **Skouratovitch** Administration of Hydrometeorology	Belarus

Prof. Dr. Anders **Stigebrandt** University of Göteborg	Sweden
Prof. Dr. Hilding **Sundqvist** Stockholm University	Sweden
Prof. Dr. Valery S. **Vuglinsky** State Hydrological Institute	Russia
Dr. Sc. Evgenij **Zaharchenko** Hydrometeorological Agency of Council	Latvia

Ex-officio:

Dr. Hans-Jörg **Isemer** BALTEX Secretariat, GKSS	Germany

Appendix 5

A danish national BALTEX commitee has been estabilshed

Members from

* Danish Meteorological Institute (DMI)
* Danish Hydraulic Institute (DHI)
* Technical University of Denmark (DTU)
* National Environmental Research Institute (DMU)
* Danish Land Development Service (DDH)
* Risø National Laboratory (RISØ)
* Danish Geological Investigations (DGU)
* Farvandsvæsenet (FV)
* Danmarks Fiskeri- og Havundersøgelser (DFHU)

Activities

BALTEX-plan: Formulation of a danish profile in relation to BALTEX.

In final form 1/7-94.

The BALTEX-plan contains three three program points

1: Flow through the Danish Straits.

2: Integrated meteorological and hydrological modelling and process studies.

3: Environmental technology to East European BALTEX partners.

Planned activeties

Work on specific project formulations starts as soon as possible after the agreement on the BALTEX-plan.

Organisation FV (Farvandsvæsenet).

Summer 1994: Oceanographic stations across the Great Belt (in the link area) and at Hatter Rev and Drogden will be established. Measured quantities are: current. salinity, temperature, waves, sea level height and wind velocity.

Organisation FV in cooperation with Ostseeforschung Warnemunde:

Summer 1994: Oceanographic station at the Gedser-Darss sill. Parameters: Temperature, salinity and current.

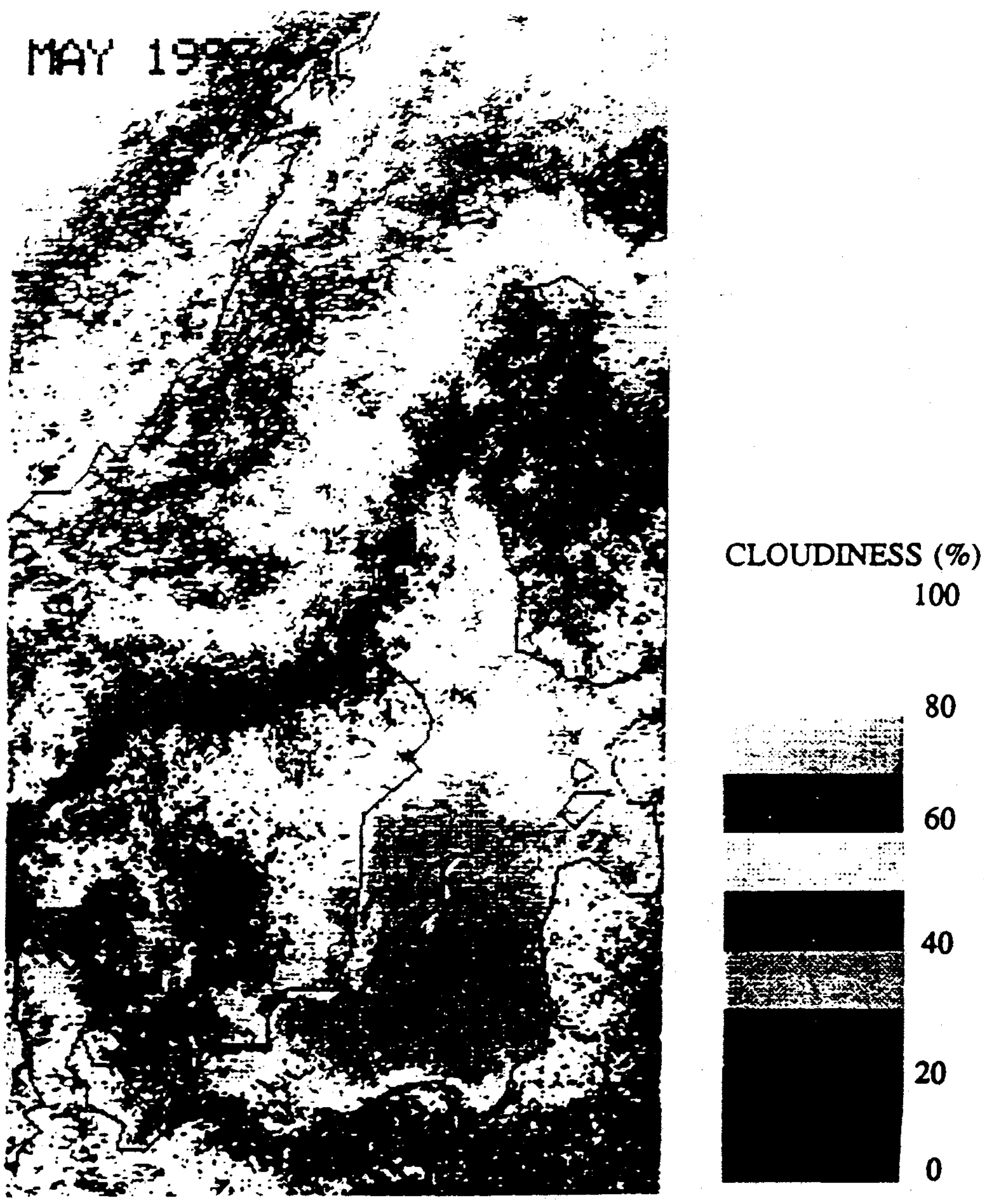
Appendix 6

January 1994

BALTEX

— Swedish research potential

Sten Bergström and Anders Omstedt (editors)



Prepared by the Swedish IGBP-WCRP Subcommittee for BALTEX.

1994-01-10

BALTEX
— Swedish research potential

S. Bergström and A. Omstedt (eds.)

FOREWORD

During a workshop on Swedish climate research arranged by the IGBP-WCRP Committee of the Royal Swedish Academy of Science in May, 1993, the need for a Swedish subcommittee for the co-ordination of research within the BALTEX framework was identified. The following members of this subcommittee were formally appointed at the meeting of the Swedish IGBP-WCRP Committee on September 22, 1993:

Prof. Sten Bergström	The Swedish Meteorological and Hydrological Institute, Norrköping
Act. Prof. Sven Halldin	Dept. of Hydrology, Uppsala University
Prof. Ulf Högström	Dept. of Meteorology, Uppsala University
Assoc. Prof. Anders Omstedt	The Swedish Meteorological and Hydrological Institute, Norrköping
Prof. Anders Stigebrandt	Dept. of Oceanography, University of Gothenburg
Prof. Hilding Sundqvist	Dept. of Meteorology, University of Stockholm

The subcommittee was given the task to identify the specific Swedish research potential within the international BALTEX programme. A preliminary report was discussed by the Swedish IGBP-WCRP Committee on December 17, 1993, and was adopted after minor adjustments. This is the final report from the subcommittee.

Cover picture: Estimated cloud frequencies for the Baltic Sea for the month of May, 1993, derived from NOAA-AVHRR data. (Data processing by Karl-Göran Karlsson, SMHI.)

TABLE OF CONTENTS

1. INTRODUCTION

Global modelling of the present climate as well as future climate scenarios require a good understanding of energy and water cycles in the climate system. Considerable deficits in our knowledge still exist, and within the WCRP a specific programme, GEWEX, has been defined to improve present means to model and measure energy and water transfer in the climate system.

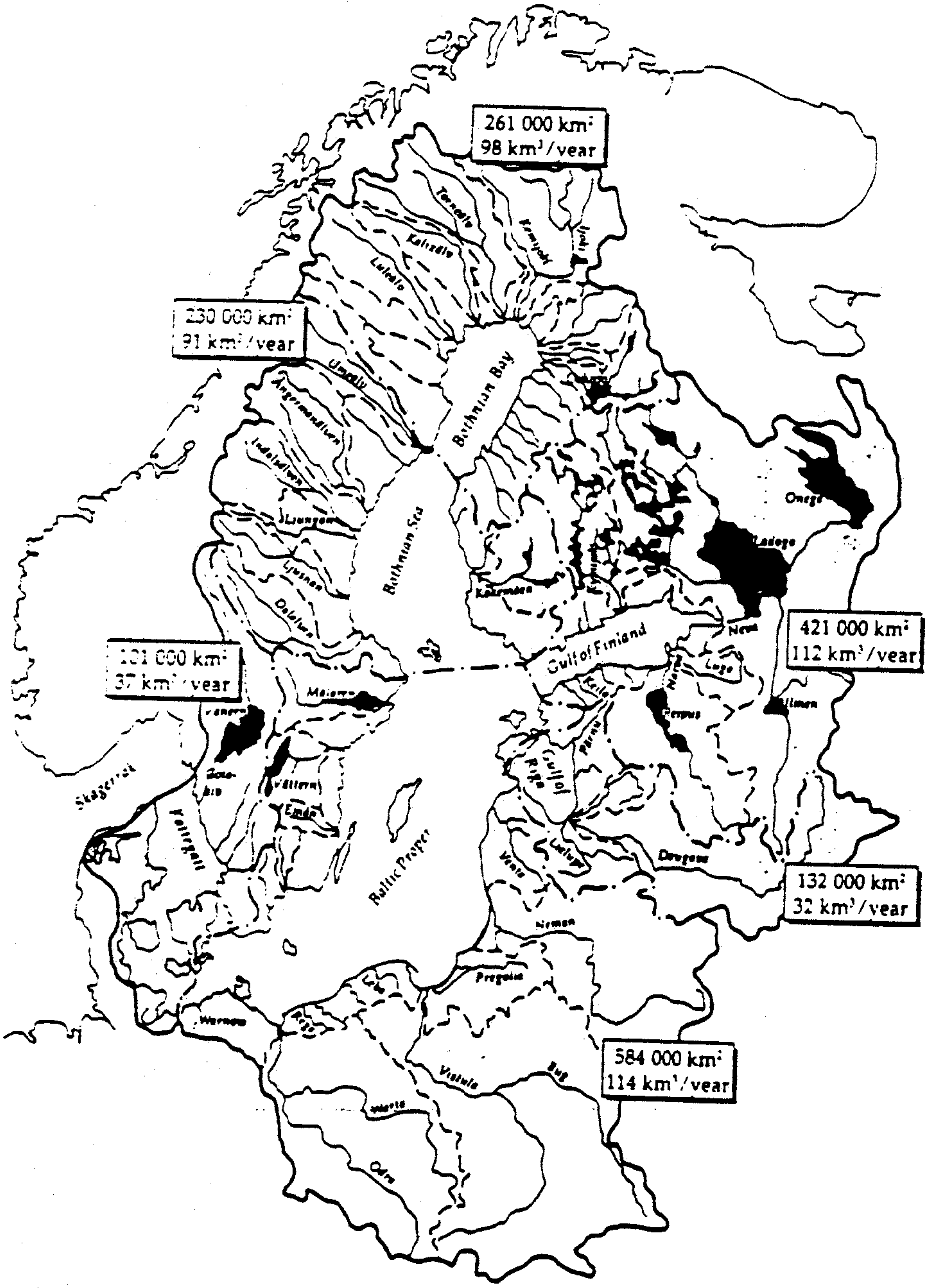


Figure 1. The drainage basin of the Baltic Sea, the Danish Sounds and the Kattegat and mean annual inflow from rivers for the period 1950 - 1990. (Bergström and Carlsson, 1993.)

Within GEWEX, regional experimental programs are now being planned. One of these is the BALTEX program (Raschke, 1992). The scientific objectives of BALTEX are in agreement with those of GEWEX and are defined as:

A. To determine the various mechanisms determining the space and time variability of energy and water budgets of the BALTEX area and their interactions with surrounding regions.

B. To relate them to the large-scale circulation systems in the atmosphere and oceans over the globe.

The Baltic Sea with its drainage area (Figure 1) forms an excellent test basin for energy and water balance studies. The large seasonal, annual and interannual variations in the system and the close coupling between atmosphere, land and sea are important to understand from climate point of view. Nine countries share the shoreline of the Baltic Sea, and over 70 million people living in the area are dependent on the environment and climate.

The present report summarizes the Swedish research potential related to BALTEX. The research is focused on physical processes and conditions, but it is highly relevant for the environmental status and problems of the Baltic drainage basin and the Baltic Sea as well. The land phase of the BALTEX research programme has also common interests with the issues addressed under the IGBP/BAHC programme "Biospheric Aspects of the Hydrological Cycle" (IGBP, 1993). The NOPEX programme will serve as the natural link between these two programmes.

2. IMPORTANT QUESTIONS

The program is focused on the interaction between the Baltic drainage basin, the Baltic Sea and the atmospheric conditions of northern Europe. Important questions are, for example:

Which are the most significant physical processes governing the water and energy exchange between land, atmosphere and sea and how can they be modelled?

How are the atmospheric conditions interacting with the conditions in the Baltic Sea?

How are long-term variations of water and salt exchange via the Danish straits coupled to variations in atmospheric conditions and the hydrology of the Baltic drainage basin?

Which is the role of sea ice and waves in the exchange processes between the sea and the atmosphere?

What drives the turbulent mixing in the surface and deep layers of the Baltic Sea and how should it be parameterized?

How is the abundance of lakes influencing the water and energy exchange of the drainage basin?

Which and how strong is the human impact on the large-scale physical processes in the Baltic Sea area?

How can we best integrate all sources of information on the atmospherical, hydrological and oceanographical conditions to increase our understanding of the behaviour of the system?

3. SWEDISH RESEARCH POTENTIAL

The following eleven research areas have been identified by the Swedish IGBP-WCRP Subcommittee for BALTEX:

- development of data bases,
- development and verification of methods to retrieve data from remote sensors such as satellite and radar,
- development of consistent field experiments on atmospheric, hydrologic and oceanographic processes,
- development and verification of atmospheric models including improvements of cloud and boundary layer physics,
- development and verification of physically based large-scale hydrological models,
- development and verification of oceanographic models for highly stratified seas as the Baltic Sea,
- development and verification of water budget modelling of the Baltic Sea,
- development and verification of sea ice models,
- the role of land surface in climate,
- the role of lakes in climate,
- the role of snow in climate.

The motivation for each of these is further discussed below.

3.1 Development of data bases

A great deal of work related to BALTEX has already been carried out in Sweden, and it is therefore important to take the advantage of the results from these efforts. Within the Swedish research programme "Large-scale environmental effects and ecological processes in the Baltic Sea" (Wulff, 1990) much work has been done towards creating an easily accessible data base for hydrological, meteorological and oceanographical data; see, for example, Figure 2.

This data base can also serve as an important contribution to BALTEX and needs to be updated and further developed during the BALTEX program. For example, a more advanced reanalysis of the mesoscale meteorological fields using modern data assimilation techniques is needed. Such a mesoscale reanalyse for e.g. a ten year period is a huge effort, involving also model development issues, and could be considered as an important contribution to BALTEX.

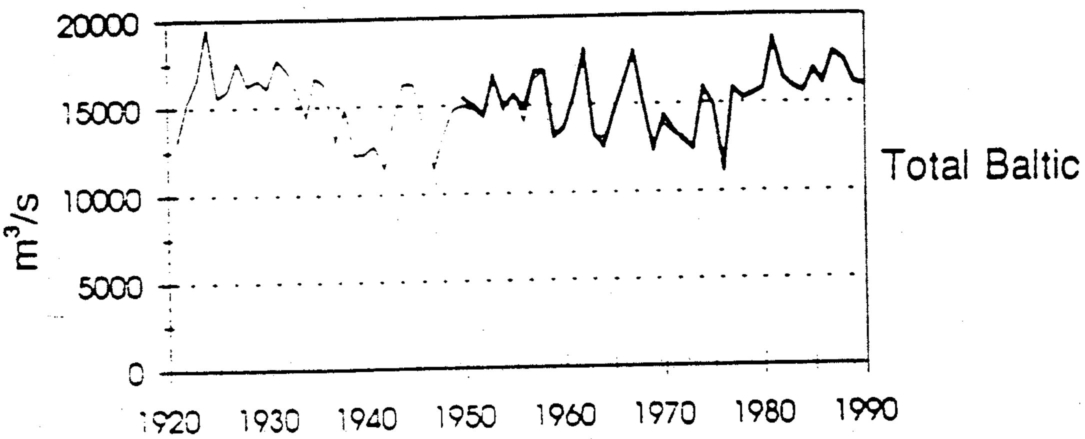


Figure 2. *Total annual contribution of fresh water (m^3/s) to the Baltic Sea for the period 1921 - 1990. (Bergström and Carlsson, 1993.)*

3.2 Development and verification of methods to retrieve data from remote sensors such as satellite and radar

The total precipitation is one of many significant factors in the water budget of the Baltic Sea drainage basin. The annual precipitation over the Baltic Sea is today estimated from crude methods (Dahlström, 1986). Recent progress in the use of information from remote sensors offers an opportunity to improve estimates of areal precipitation amounts for a large part of the area of interest. Three kinds of remote sensing data can be of special interest for the Baltic sea area for precipitation studies:

1. A weather radar network covering a large part of the area (with a central radar site on Gotland.
2. Multispectral AVHRR data from the polar orbiting NOAA satellites.
3. Passive microwave radiometers on polar orbiting satellites (SSM/I instrument — Special Sensor Microwave Imager — on the DMSP satellites).

Algorithms for estimating precipitation rates have been (and are presently) used and tested in the Global Precipitation Climatology Project (GPCP) — as subprogram to GEWEX. Sweden has contributed to the latest algorithm intercomparison project (GPCP

AIP-2) by submitting precipitation intensity estimates from an algorithm described by Karlsson and Liljas (1990). Results were comparable to the more well established SSM/I algorithms and suggests that the two data sources could be used together (the AIP-2 final report will be published in the beginning of 1994).

In addition, visible and infrared information from the geostationary satellite METEOSAT is believed to be of some value in order to increase the temporal resolution. Estimations of accumulated precipitation amounts over the Baltic Sea are believed to be feasible by using the above-mentioned data sources within a framework of an objective analysis scheme based on a high resolution atmospheric model (e.g. HIRLAM).

Accurate analyses of cloudiness and precipitation are, of course, crucial to the development and verification of atmospheric model with a realistic treatment of clouds (see Section 3.4). The SMHI cloud classification algorithm (Karlsson and Liljas, 1990, and cover picture) can be one tool for realizing such analyses. Another tool can be algorithms based on SSM/I data.

Remote sensors could also provide complementary information to in situ measurements of surface conditions in the Baltic Sea. Sea surface temperatures and ice cover are parameters that can be assessed from NOAA/AVHRR data and SSM/I data. Detailed surface information (related to wave heights, wave spectra and ice distribution) can also be given by active microwave sensors (e.g. sensors on the European ERS-1 satellite).

3.3 Development of consistent field experiments

The turbulent exchange in the atmospheric surface layer over the Baltic Sea is the subject of a field experiment conducted by the Department of Meteorology, Uppsala. During at least a year turbulent fluxes at two or three levels, vertical profiles of meteorological parameters and wave height will be recorded on a continuous basis on the small, desolate island Utklippan south of Blekinge. Simultaneous measurements of characteristics of the entire planetary boundary layer will be carried out in selected situations. This field experiment is planned to start in 1994.

The mechanics of turbulence and diapycnic mixing processes in the whole water column of the sea are poorly understood. In oceanographic models one has to rely on tuning of uncertain parametrizations of these processes. The situation is particularly unsatisfactory with regard to the diapycnic mixing beneath the seasonal pycnocline. Carefully designed experiments would increase our understanding of mixed-layer dynamics, the vertical propagation of near-inertial internal gravity waves and the energetics of turbulence and diapycnic mixing beneath the seasonal pycnocline. These experiments should be carried out close to Utklippan in order to utilize simultaneous meteorological measurements of the air-sea exchange. Further field experiments both during summer and winter periods — as for example NOPEX — need, however, to be developed and coordinated, within the BALTEX program.

3.4 Development and verification of atmospheric models including improvements of cloud and boundary layer physics

There are still large gaps in our understanding of the atmospheric water cycle, and present atmospheric models do not properly describe or resolve all of the important processes involved.

The HIRLAM forecasting system (Machenhauer, 1988; Källberg, 1989; Gustafsson, N., 1993) was and is being developed within the framework of a joint research project between the Nordic countries, Ireland and the Netherlands. The development of HIRLAM (Figure 3) with respect to clouds, air-sea interaction including sea ice and data assimilation is the logical Swedish contribution to BALTEX.

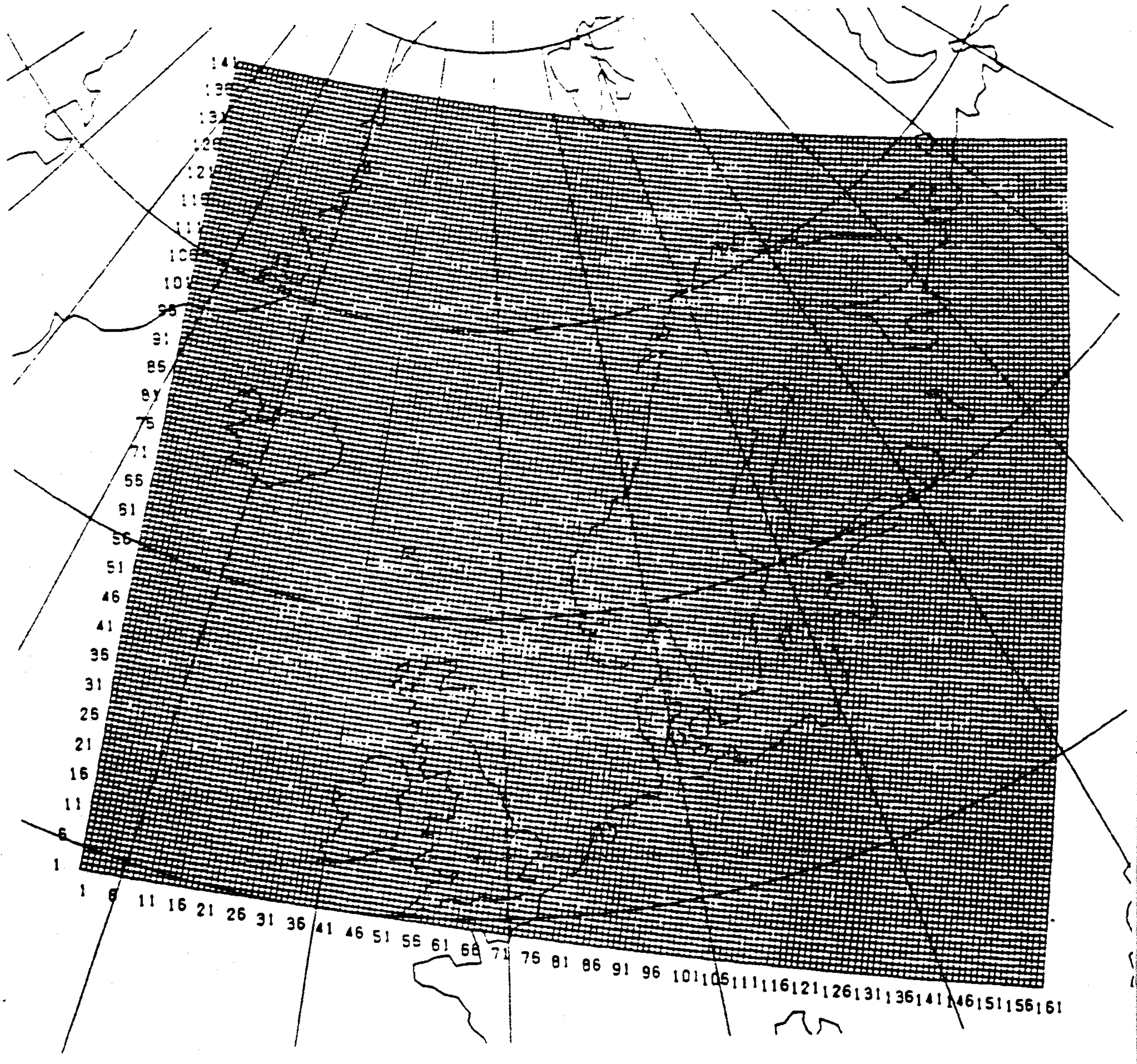


Figure 3. An example of an integration area for HIRLAM. Grid distance: approx. 22 km, number of vertical levels: 24 (Gustafsson, N., 1993).

The modelling of intensive weather systems and their role in the Baltic Sea and vice verse is of great interest; see, for example, Andersson and Gustafsson (1993). The study has also indicated that atmospheric secondary circulation systems, forced by land-sea differences, play an important role in the circulation and precipitation patterns over the Baltic Sea area. It is therefore important to resolve the secondary circulation system in the data assimilation and modelling of the atmospheric water cycle.

Increased experimental studies of the atmospheric boundary layer over the Baltic Sea are also needed. Here several important studies during the last decade have been performed in Sweden, e.g. by Tjernström and Smedman (1993) and Smedman et al. (1993a, b). These studies have demonstrated that the boundary layer and the turbulent exchange have certain distinct characteristics over the Baltic, which are not adequately described by the present HIRLAM formulation. Stratification is stable during most of winter, spring and early summer. A persistent feature, related to the stable stratification is a low level jet, which dynamically is an analogy in space to the well known nocturnal jet. It has proved to influence the turbulent exchange processes in an important way. Another dynamically important feature of the Baltic Sea is related to its limited size, giving rise to shorter and hence steeper waves than over the world ocean, which implies increased drag at high wind speeds. Systematic studies of these and related phenomena are the subject of a field experiment planned to take place south of Blekinge during the next few years; see 3.3.

3.5 Development and verification of physically based large-scale hydrological models

The hydrology of the Baltic region is characterized by long cold winters in the north, with pronounced low winter flows and large spring floods, and more variable flow regimes in the south. Several of the rivers are subject to regulation, mostly for hydropower production. This is particularly pronounced in the northern rivers and must be considered in simulations of the annual course of fresh-water supply to the Baltic Sea.

During the last 20 years hydrologic modelling for engineering purposes has been developed in Sweden. The models are mainly semi-empirical (Bergström, 1992). This means that they normally are calibrated against runoff before application. Better insight into physical processes governing orographic effects on precipitation, evaporation and snow conditions is needed in order to increase the physical description of the models. A better areal representation is also needed. The development of coupled atmospheric-hydrologic models is a logical next step, from which both atmospheric and hydrological models will benefit.

The model development may greatly benefit from studies of the turn-over of stable isotopes (oxygen-18 or deuterium) in the river basins. Such studies have traditionally been carried out in rather small basins for detailed studies of the transit time of water (Rodhe, 1987; Lindström and Rodhe, 1986). A large-scale basin-wide experiment over one of the main river basins, including sampling of the isotopic concentration of precipitation, snow, soil moisture, groundwater, river flow and lakes would provide a useful data base for model development and verification.

3.6 Development and verification of oceanographic models for highly stratified seas as the Baltic Sea

Within the BALTEX program much efforts are planned to be concentrated on the development of 3-Dimensional Ocean Models (3DOM). When reviewing the 3DOM it becomes quite clear that many aspects of the ocean are treated in a coarse way in these models. For example, the 3DOM models have not yet improved our understanding of hydraulic effects associated with flow through channels or sills (Killworth, 1992). The horizontal resolution is still less than the internal Rossby radius, and the vertical resolution does not resolve the vertical shear correctly. In the 3DOM models the subgrid-scale processes, like diapycnic diffusion, are also in general poorly parameterized. It is therefore clear that process-oriented models are needed as a complement to 3DOM, particularly for the Baltic Sea, where the in- and outflows are highly transient and active in thin layers.

During the last decade several important aspects of the dynamics and thermodynamics of the Baltic Sea have been investigated in Sweden. The modelling approach has been to develop 1-Dimensional Ocean Models (1DOM) with high vertical resolution, and to focus on important processes in the modelling, as for example: in- and outflows, ventilation of the deep water, surface-, intermediate- and deep-water mixing, thermodynamics and sea ice. For example, in the model of the Baltic Sea by Stigebrandt (1987), the vertical circulation of the Baltic Sea was simulated using a 1DOM with vertical resolution 1 m. This model was used by Stigebrandt and Wulff (1987) to model the dynamics of nutrients and oxygen in the Baltic Proper. Another example is the model by Omstedt (1990a), in which the Baltic Sea was treated as 13 coupled subbasins with vertical resolution, when modelling the thermodynamics.

There are several physical processes of importance for the circulation of the Baltic Sea which are poorly understood. To develop oceanographic models these processes have to be better known. As a contribution to BALTEX, Sweden should increase efforts on research on:

1) turbulence and diapycnic mixing in the whole water column,
2) large-scale dynamics of dense gravity-driven bottom currents,
3) the dynamics of time-dependent, stratified strait flows.

The development of process-oriented models like 1DOM is an important step towards increasing our knowledge about the energy and water cycles of the Baltic Sea and for the improvement of 3DOM. The interaction between 1DOM and 3DOM should be supported, as well as coupled meteorologic-oceanographic models and the development of 3DOM. See also discussion in Section 3.7.

3.7 Development and verification of water budget modelling of the Baltic Sea

One of the key processes in the water and salt balance of the Baltic Sea is the water exchange trough the channel-like entrances. The flow in the entrance area (Great Belt and the Sound) is driven mainly by the water level differences between the southern part of the Baltic Sea and the Kattegat. The flow is strongly oscillatory on a time scale of one day (Figure 4). There are also variations on a seasonal time scale due to changes in evaporation, precipitation, river runoff and density. All these factors influence the water levels in the Kattegat and the Baltic Sea, and hence the flow in the Great Belt and the Sound.

The salinity of the water flowing into the Baltic Sea is determined by the prehistory of: outflows from the Baltic Sea into the Kattegat/Belt Sea, the mixing in the Kattegat/Belt Sea and the water exchange between the Kattegat and the Skagerrak. This has been modelled using box models by Stigebrandt (1983) and later by Gustafsson, B. (1993). Deep-water exchange and mixing properties based upon temperature and salinity data from 1970 - 1990 have also recently been analysed by Kõuts and Omstedt (1993).

Occasionally large amounts of highly saline water invade the Baltic Sea. This saline and oxygen-rich water plays a crucial role for the biological life in the deeper parts of the Baltic Sea. Oceanographic models for the calculation of in- and outflows in the entrance area of the Baltic Sea are therefore crucial for the water budget modelling.

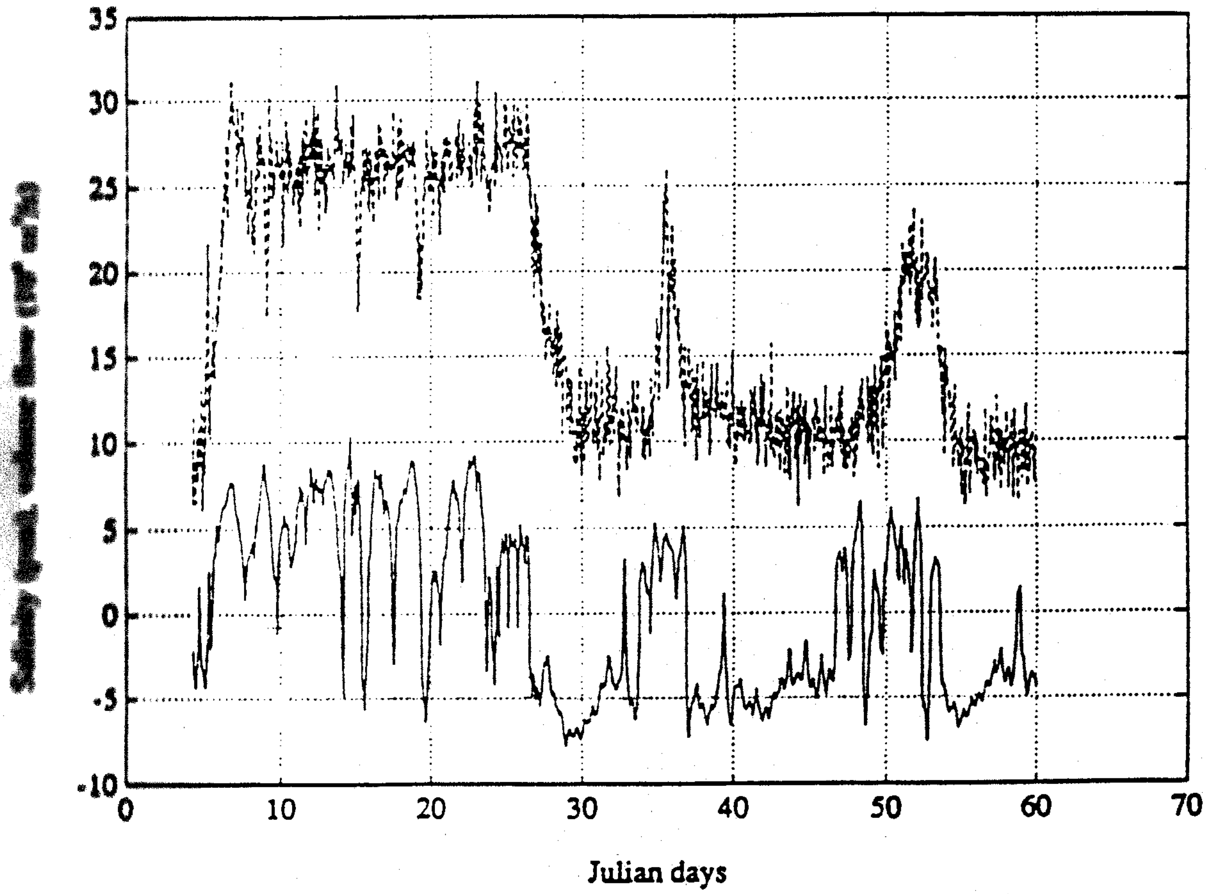


Figure 4. Calculated volume flow (solid) and measured salinity (dashed) in the Sound during the Baltic major inflow event in January 1993. (Håkansson et al., 1993.)

Different kinds of models for the exchange in the entrance area are available; there is, however, a need for an increased understanding of the large-scale forcing of the inflows. The use of 2-Dimensional Ocean Models (2DOM), applied to the whole North Sea-Skagerrak-Kattegat-Baltic Sea system should be an important contribution to the understanding of the in- and outflows. The 2DOM have since the 1950ies played an important role in the forecasting of water level variations and storm surges. The modelling efforts should be closely related to process-oriented studies, for example the modelling of the mixing of water properties associated with inflows and interleaving of inflow water to the Baltic Sea.

3.8 Development and verification of sea ice models

Understanding the role of sea ice in the energy and water cycles of the Baltic Sea is of fundamental importance. On the average the annual maximum sea ice extent is 50 % and the length of the ice season is 6 months. The seasonal, annual and interannual variability of ice and surface temperature in the Baltic Sea is, however, large. Freezing and melting of sea ice can be regarded as the high latitude analogies to evaporation and precipitation. With salt rejected out in the water column during freezing and fresh water mixed into the water column during melting, sea ice also influences the water balance of the Baltic Sea. The phase changes associated with freezing and melting, and changes in albedo, highly influence the energy cycle and could, for example, delay the spring warming in the northern waters by 1 - 2 months (Omstedt, 1990a).

Forecast models for water and ice, including both dynamics and thermodynamics, have been developed within a joint Swedish-Finnish winter navigation program since the beginning of 1970; e.g. Leppäranta (1981), Omstedt (1990b), Omstedt et al. (1994) and Zhang and Leppäranta (1992). A logical Swedish contribution should be to develop these models and examine the effects of sea ice to the air-sea energy exchange of the Baltic Sea.

3.9 The role of land surfaces in climate

Simulations in climate models have shown a great interdependence between the climatic behaviour and land surface processes. In recent years vegetation processes have been found to be important for the interaction between the land surface and the atmosphere. Vegetation processes are included in some weather forecast models and various climate models.

In vegetation schemes surface stomatal resistance and the rainfall interception on the vegetation canopy are fundamental. The surface resistance is given as a function of soil wetness, incoming radiation, air humidity and temperature (see, for example, Noilhan and Planton, 1989). Rainfall interception depends on the canopy density. It reduces water yield to the soil and gives a modified total evaporation to the atmosphere. These processes are especially important for forest-covered areas where the surface resistance directly regulates the transpiration flux. In the NOPEX programme, evapotranspiration and other energy fluxes from the earth surface will be measured in an area north of

Uppsala, Sweden. One important aim is to evaluate the effect on the regional ensemble fluxes of the small-scale patchiness typical of many landscapes consisting of e.g. agricultural fields, forests and lakes. Since the Baltic Sea is largely surrounded with land areas of different types, these effects are important to consider in BALTEX.

3.10 The role of lakes in climate

In the Baltic Sea drainage area a large number of lakes influence the meteorological and hydrological conditions. Lakes cover some 10 % of the total land area of Finland and Sweden. The energy and water cycles of individual lakes are reasonably well known and can be well simulated by models (Sahlberg, 1988). However, the role of lakes in relation to the climate is not well understood. Therefore the importance of evaporation, energy exchange and ice in lakes needs further studies. The main efforts should be oriented towards the development and validation of parametrization schemes to be applied in meteorologic and hydrologic models.

3.11 The role of snow in climate

The accumulation and melting of snow and the drastic changes in albedo due to snow play an important role in the modelling of the interaction between atmosphere and ground, as well as in hydrologic modelling.

In the northern parts of the Baltic basin as much as half of the annual precipitation may be stored as snow, while the snow conditions are more variable further south. The effect of snowmelt can be clearly identified in the annual inflow from rivers to the Baltic Sea (Figure 5). The snowpack and also the frozen ground thus have a strong effect on regional water and energy balances of the area.

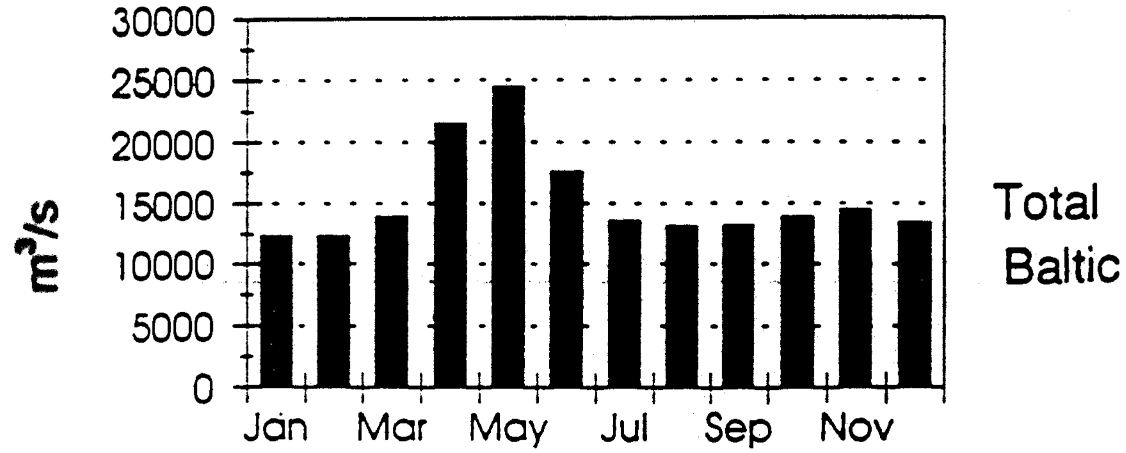


Figure 5. The monthly means of inflow from rivers to the Baltic Sea system for the period 1950 - 1990, illustrating the significance of snowmelt in spring (Bergström and Carlsson, 1993).

The modelling of snow accumulation is traditionally made by a simple degree-day method and attempts are under way to improve the results by more detailed energy balance. The methods have so far come short on the basin scale (see, for example, WMO, 1986.) Still the performance of the snowmelt models often proves to be insufficient. The coupled-model approach, which is one characteristic of the planned BALTEX research, offers an opportunity to improve the snowmelt models and will thus contribute to both hydrological and atmospheric modelling.

Evaporation losses from snow-covered grounds and from intercepted snow on vegetation is another area of great interest, where much remains to be done. It is probable that the atmospheric models may, in this respect, contribute to make the hydrological models less empirical. The problem requires consideration of the patchiness which is observed at the end of a melt period as well as larger-scale areal variabilities of evapotranspiration of the kind studied within the NOPEX programme.

4. TIME PLAN AND ORGANIZATION

The full international BALTEX programme will cover some ten years (Raschke, 1992). It will start with a build-up phase during 1993-96, followed by an observational phase in 1997-98. The final years will be concerned with scientific evaluation of the experiments and summarizing of the main results. The time plan for the Swedish research will be harmonized with the international programme.

The Swedish research programme will be coordinated by the IGBP-WCRP subcommittee for BALTEX within the Swedish Royal Academy of Science. The subcommittee will take an active part in the international BALTEX cooperation by participation in the international Steering Group for BALTEX. Through the national representatives, close contact will be maintained with the three international working groups on Data Management and Data Studies, Numerical Experimentation and Process Studies, where more detailed research plans will be outlined.

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6. LIST OF ACRONYMS

BALTEX	= Baltic Sea Experiment
GEWEX	= Global Energy and Water Cycle Experiment
HIRLAM	= High Resolution Limited Area Model
NOPEX	= Northern Hemisphere Land-surface Climate Processes Experiment
SST	= Sea Surface Temperature
WCRP	= World Climate Research Programme
IGBP	= International Geosphere-Biosphere Program
1DOM	= One-Dimensional Ocean Models
2DOM	= Two-Dimensional Ocean Models
3DOM	= Three-Dimensional Ocean Models
NOAA	= National Oceanic and Atmospheric Administration in USA
AIP	= Algorithm Intercomparison Project
GPCP	= Global Precipitation Climatology Project
AVHRR	= Advanced Very High Resolution Radiometer
DMSP	= Defence Meteorological Satellite Program in USA
SSM/I	= Special Sensor Microwave Image
METEOSAT	= Meteorological Satellite
ERS-1	= European Remote Sensing Satellite number 1.

Appendix 7

Finnish BALTEX

(Launiainen)

- **Finnish National BALTEX Working Group established III/1994**

  Finnish Institute of Marine Research (FIMR)

  Finnish Meteorological Institute (FMI)

  Hydrological Office, Finnish Nat. Board of Waters (FNBW/HE)

  Department of Meteorology, University of Helsinki (DMUH)

  Department of Geophysics, University of Helsinki (DGUH)

  chair: Pentti Mälkki }
  secr.: Kai Myrberg } FIMR

- **Interests / Contribution**

FIMR
- AWS-, ship-, sounding observations
- oceanographic data bank
- air/sea, air/ice/sea studies and modelling
- coupling of atmopheric and marine models
- remote observation of sea ice

FMI
- observational and data network
- development and output of atmospheric models

FNBW
- components of hydrological balance
- (regional) hydrological modelling
- NOPEX

DMUH
- energy and water budget of the atmosphere (theory, model based)

DGUH
- sea ice studies / modelling
- (climatological) air-sea coupling

Appendix 8

PROTOCOL

Working Meeting of Dr. L. Levkov (Germany), the Representative of the BALTEX Project Secretariat, with Scientists and Specialists of Russian Institutions on the Question of Possible Participation of the Russian Party in the BALTEX Project

St. Petersburg, May 17-18, 1993

At the meeting, the following specialists were present from the Russian Party:

State Hydrological Institute (GGI):
Prof. Valery S. Vuglinsky, Deputy Director
Dr. Shamil R. Pozdnyakov, Chief,
Department for International Cooperation
Ms. Valentina G. Yanuta, Chief, Translation Unit.

Voeikov Main Geophysical Observatory (GGO):
Prof. Valentin P. Meleshko, Deputy Director.

St. Petersburg Branch of the State Oceanographic Institute (SPSOI):
Dr. V.A. Rozhkov, Director
Dr. D.P. Savchuk, Chief, the Laboratory for the Baltic Sea Problems
Dr. A.I. Smirnova, Senior scientist
Dr. S.V. Klyachkin, a scientist.

Central Aerological Observatory (CAO):
Dr. Vitaly I. Khvorostjanov, Chief, the Laboratory for Numerical Modelling of the Influence on Clouds.

North-Western Branch of the Administration on Hydrometeorology (NWBAH)
Dr. Yu. D. Malashin, Chief, the Leningrad Region Center on Hydrometeorology.

Kaliningrad Region Center on Hydrometeorology (KRCH):
Dr. G.P. Masyagin, Chief of the Center.

Dr. L. Levkov in his introductory speech informed the participants of the meeting about the goals and aims of the BALTEX Project and made some proposals on the fulfillment of the first phase of the project.

As a result of exchanging opinions, the Russian participants agreed with the following major items.

1. The BALTEX Project is an important regional international project to be fulfilled within the GEWEX Program. Participation of Russian scientists and specialists in fulfillment of the project is useful and expedient.

2. The following research areas are proposed as possible for the Russian party to take part and implement the project:

2.1 Exchange of input data on hydrometeorological elements for the continental part of the Baltic Sea basin and the Baltic Sea itself with the Baltic countries at the agreed dates and format to be used in modelling of the heat-and-moisture exchange on the regional and all-basin scales.

2.2 Adapting the regional atmospheric model developed at GGO (resolution 50 - 100 km) to the Baltic region conditions, its validation and testing by observational data in the countries of the region. This model is suggested to be subsequently used as a block in the global spectral model (T21 L14) also created at GGO.

2.3 Adapting the baroclinic hydrodynamical model developed at SPSOI and its validation to describe water exchange in the Baltic Sea including that via the Denmark straits and modelling of salt water invasions.

2.4 Developing hydrological model of water system with lake control over monthly time intervals, its calibration and testing by observational data in the Neva River basin and other river basins of the region.

2.5 Preparation with participation of the Baltic countries of a Reference book on hydrometeorological and hydrochemical elements of the Baltic Sea and their variations on the basis of the methods for processing and analysis of information developed at SPSOI.

2.6 Estimation of modern Baltic Sea level and its background forecast for the nearest future.

2.7 Estimation of total fresh water inflow to the Baltic Sea and other water balance elements for the region over the monthly time intervals and analysis of their time variations.

2.8 Application of the meso-scale models developed at CAO (2DT and 3DT) for modelling of precipitation in various regions of the Baltic Sea basin taking into account topography, breeze circulations and other factors.

2.9 Estimation of possible anthropogenic climate change in the region and its impact on the elements of regional heat-and-moisture exchange and Baltic Sea water level.

3. More detailed proposals will be prepared by the Russian party as for its participation in the BALTEX Project after receiving additional information from Prof. E. Raschke about the state-of-the-art of the development or the project and discussing these questions at the next meeting of Workshop on the BALTEX Project to be held, as planned, in the end of 1993.

4. In order that the Russian party be able to completely fulfill under hard economic conditions the planned research on the project an additional technical aid (HC's and periphery equipment) could me required to create data bases, computer time to run the models as well as financing to pay for the participation of Russian representatives at the meetings of the Working Group. The Russian party has a favour to ask Prof. E. Raschke to find possibilities to solve this problem.

5. For qualified discussion of the question of the Russian party participation in the BALTEX Project implementation, it seems to be expedient that Russian scientists engaged in the three major areas of the project (hydrology, oceanology, meteorology) be involved.

The PROTOCOL is signed

from the Secretariat:	from the Russian party:
Dr. L. Levkov	Prof. V.S. Vuglinsky Deputy Director State Hydrological Insitute

Appendix 9

INFORMATION ON BALTEX PROJECT ACTIVITIES IN THE REPUBLIC OF BELARUS

The present status of hydrometeorological data for 1986-1987 and 1992-1993 on observational points at Neman and West Dvina river basins has been analysed.

Exact location of agreed grid over the Baltic area, including Belarus, has been calculated, based on the programme, provided by Prof. Dr. E. Rashke.

Climatic data of multi-annual observations, conducted at bench-mark meteorological stations of the given area, has been fed into a computer. Description of physical and geographical features (orography, soil, vegetation etc.) of Neman and West Dvina river basins has been prepared.

We can prepare the required data for 1986-1987 and 1992-1993 to test global models, but this will require the following:

(i) to determine the list of elements and the form of their presentation;

(ii) to fed into a computer the required initial data, coded by agreement of the Baltex member-states;

(iii) to determine numerical model, required for computing the available data for regular grid location;

(iv) we think it is appropriate to relate the data to the grid in Minsk and to transfer the computated results in agreed form to the centers of regional and global modeling;

(v) for the first stage of entering and relating initial data to the grid it will be necessary to provide Republic of Belarus with 2 sets of PC386 and 1 set of PC486 computers;

(vi) to hand over the required software to the national data processing centers.

Appendix 10

LATVIAN REPUBLIC

ACTIVITIES WITHIN THE BALTEX PROJECT IN 1993

by
Dr. Evgeny Zaharchenko
Latvian Hydrometeorological Agency
19, K. Valdemara Str., Riga, LV-1010,
LATVIA

Since 1992 a first Preliminary Plan for the Baltic Sea Experiment has been fulfilled,and the Latvian national contribution to the BALTEX started. The following institutions are involved:

-Latvian Hydrometeorological Agency as an owner of all the hydrometeorological data and as a state Institute responsible for all the hydrometeorological observations in the state hydrometeorological network;

- Latvian Agricultural Academy as an owner of the topographic data;

- Latvian State University as an additional source for technical and research work.

On the BALTEX first stage the main goals for our activity are the data base creation and its analysis.

DATA BASE

All the hydrometeorological data available in Latvia consist of:

- meteorological data from the synoptical stations and posts;

- meteorological data from the coastal stations;

- meteorological data from the hydrological stations and posts;

- hydrological data from the hydrological stations and posts;

- oceanographic data from the coastal stations;

- oceanographic data from the open Gulf of Riga and the Baltic proper;

- oceanographic data from the automated stations;

- ship data from the open Gulf of Riga and the Baltic proper;

- radar data;

- aerological data;

A block-scheme of the existing Hydrometeorological Data Base is shown in Fig.1.
Before 1992 all the hydrometeorological data were in manuscript forms only. Since 1992 the process of data digitization has started. Now not only current data are driven into the computer, but a lot of historical data has been digitized too. Being a high priority data, data from the coastal stations and from the open Gulf of Riga and the Baltic proper, as well as ship data were digitized first of all. Now the data are available in the computer form, as follows:

- oceanographic and meteorological data from 10 coastal stations for the period 1977-1993;

- oceanographic data for the open Gulf of Riga and the Baltic proper stations (cruises data) for the period 1903-1990, a total of 14.701 oceanographic stations;

- ship data for the open Gulf of Riga and the Baltic proper for the period 1902-1990, a total of 107.572 stations. All the ship data were placed in the Marsden squares with a size of the sides 30' 30'.

The oceanographic data from the coastal stations include such parametres as follows: water temperature and salinity, waves and swell, ice conditions, sea water level. The meteorological data include: atmospheric pressure, wind, surface temperature, humidity, precipitation. clouds, visibility.
The oceanographic data from the cruises include the following parametres: water temperature and salinity, water transparency, oxygen, hydrochemistry and hydrobiology.
The ship data include the following oceanographic parametres - water temperature, waves, swell, ice conditions and the meteorological parametres: atmospheric pressure, wind,surface temperature, humidity,clouds.

There are also a lot of oceanographic data at LHMA from the automated stations obtained in different years in the Gulf of Riga which include the following parametres: currents, water temperature and salinity,hydrostatic pressure These data have a high temporal resolution of ten minutes to one hour for each measurment and partly are available now on magnetic tapes.

The hydrological data sets from 67 hydrological stations and posts are available in computer forms since 1992 only, but for the main Latvian rivers the water discharge monthly values and for the Lielupe river basin and precipitation daily values since 1977 were drived into the computer too. The other hydrological data are available in manuscript forms and include the following parametres: water discharge, water level, water temperature, ice cover, evaporation data from two stations. The meteorological parametres include precipitation and surface temperature data.

The meteorological data from 24 synoptical stations and 91 posts are available in the computer forms since 1993 and consist of the following parametres: atmospheric pressure, wind, surface temperature, solar radiation, precipitation, clouds, visibility, humidity, dew point. For the period before 1993 the meteorological data are available in the manuscript forms only.

The aerological data from 2 stations are available in the manuscript forms only and consist of the following atmospheric cross-section parametres: atmospheric pressure, wind, humidity, air temperature.

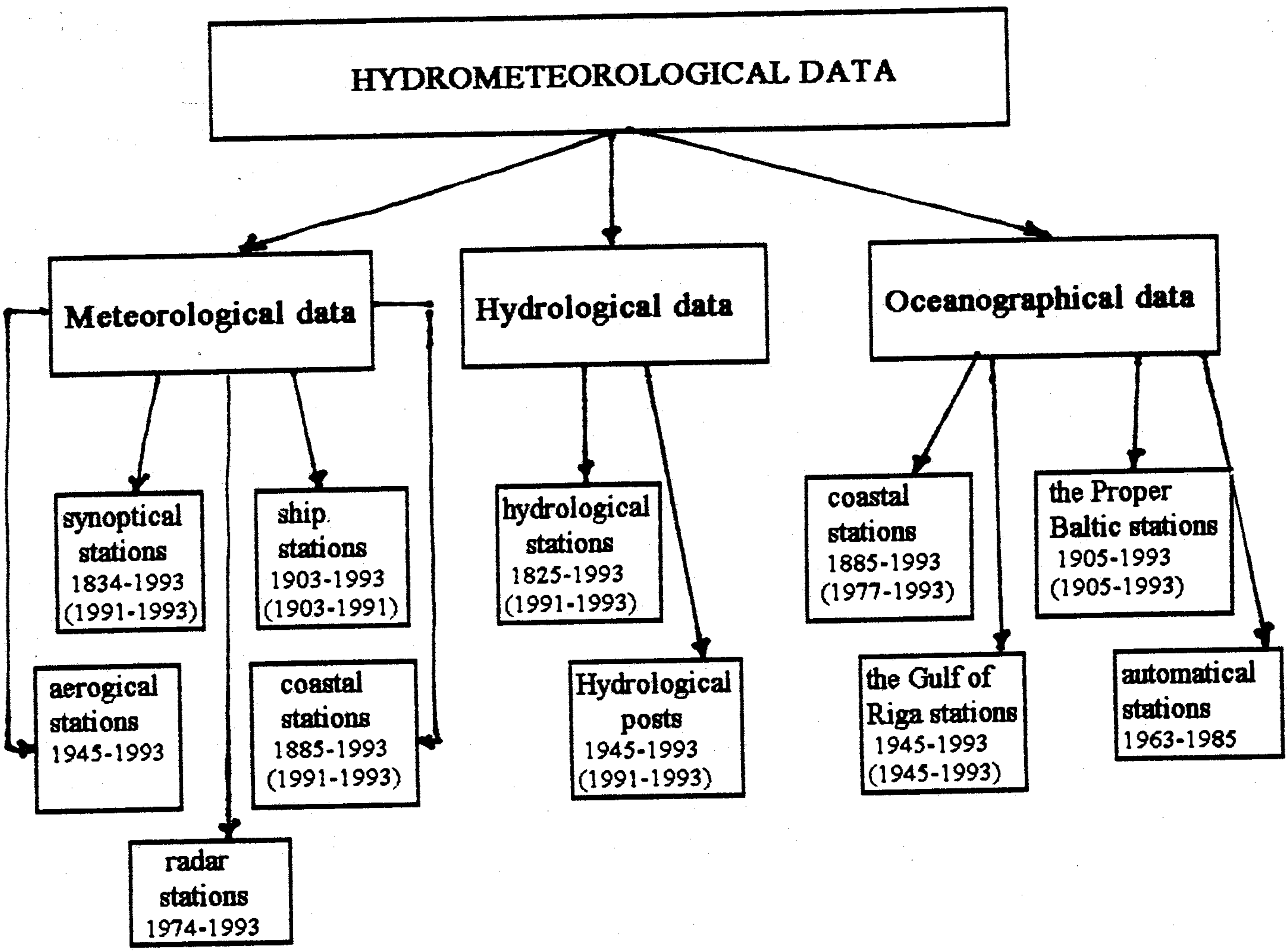
The radar data from 2 stations are available in the map forms only and consist of the cloud images.

Further the process of the meteorological data base digitilization may be provided by the software CLICOM- 3 installation in the summer 1994 in Latvia. In this case the next step is possible on the basis of a joint project with Russia regarding re-recording of our meteorological data from the magnetic tapes into floppy disketes.

LATVIAN REPUBLIC

HYGDOMETEOROLOGICAL DATA BASE STRUCTURE

Latvian Hydrometeorological Agency



notes: 19..-19.. - available in manuscript forms only;
(19..-19..) - available in computer forms

Appendix 11

HYDROLOGICAL NETWORK of the LITHUANIAN BOARD for HYDROMETEOROLOGY

The network for hydrological watch comprises:

* Hydrological Division of the LBHM: the work is planned and monitored from here.
* 3 hydrological sub-divisions in Kaunas, Panevėžys and Šilutė that are responsible and take care of:
* 84 gauging stations (74 on rivers and 10 on lakes).

All stations are manned. In the nearest years to come, we still do not plan to open any automatic station, though financing permitting, we hope to open 3-4 new hydrological stations in the period of 1994-96. That means, that there is tendency in Lithuania to retain the same scope of hydrological network.

Observations in all gauging stations are usually carried out twice a day at 06 and 18 GMT and then transmitted by teletype or telephone to the Hydrometeorological Centre at the headquarters of the LBHM once a day. The main programme is observed:

* measurements of water level are carried out in 81 GS,
* water level is recorded by a water-level recorder in 25 GS,
* water temperature is measured in 81 GS,
* water discharge is computed in 71 GS,
* the data are transmitted once a day from 29 GS,
* sediment discharge is measured only in 3 GS on the largest Lithuanian rivers, the Nemunas and Neris. The main reason for this is a comparatively small sediment discharge (approximately 50 g/m3),
* meteorological observations are performed in 49 GS.

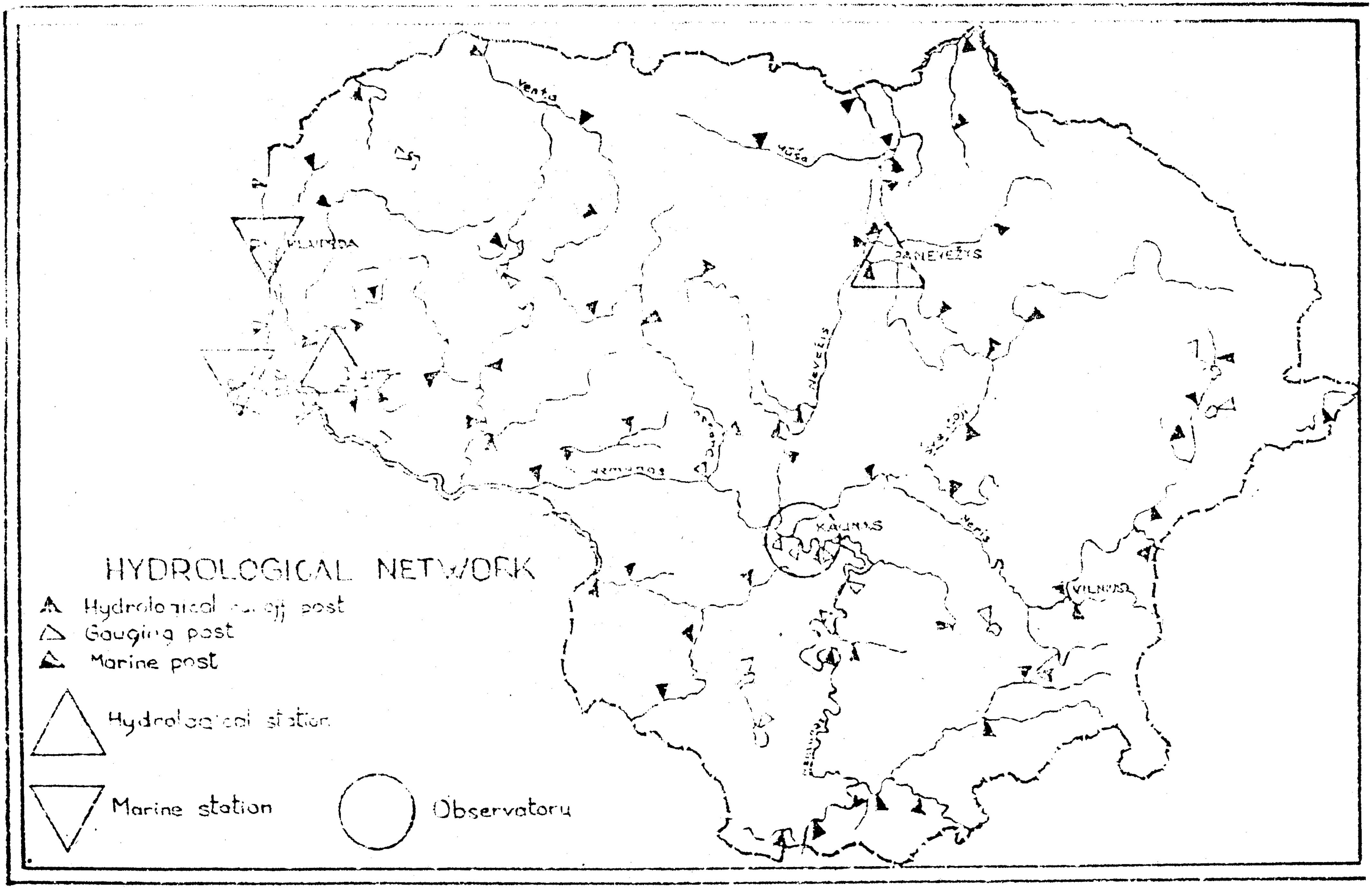
Precipitation and snow depth are measured by the precipitation gauge, water content in the snow is calculated, while other meteorological phenomena like thunderstorms, fogs, snow storms, hail, glaze are observed visually and registrated at the gauging stations as well.

On the lakes and rivers there 400 storage works. The largest of them are: Kauno Marios reservoir (63,5 square km), Elektrėnai Lake storage near the Elektrėnai PS (11 square km). About 20 storage works in Lithuania have the average area of 2-3 square km. The rest of them are small reservoirs, covering the area of less than 1 square km.

Three additional GS are established in B.Ančia Hydro Power Station, Kaunas Hydro Power Station, Kavarskas Pumping-station, where run-off is calculated against the electricity output.

Groundwater is observed by the Lithuanian Geological Survey. There are several wells, equipped by geologists in our hydrological and gauging stations, but they do not cover the whole territory of the state and do not provide a full picture of groundwater in Lithuania.

All the hydrological, meteorological and agrometeorological data are stored only in manuscripts, no computerised data base is available yet.



HYDROLOGICAL NETWORK
Hydrological post
Gauging post
Marine post
Hydrological station
Marine station
Observatory
Venta
Mūša
Nevėžis
Neris
Nemunas
KLAIPĖDA
PANEVĖŽYS
KAUNAS
VILNIUS

OBSERVATIONS IN GAUGING STATIONS
on Lithuanian rivers in 1993

Item No.	River/ Canal	Gauging Station	Water Level	Water-level Recor-der	Water Temp-era-ture	Dis-charge /Run-off	Opera -tional data trans-mis-sion	Meteo-rological Obser-vations	Sedim -ent run-off	Annual series
1	2	3	4	5	6	7	8	9	10	11
1	Svyla	Guntauninkai	+		+	+		+		32
2	Nemunėlis	Tabokinė	+		+	+	+	+		50
3	Agluona	Dirvonaliai	+		+	+				35
4	Mūša	Miciūnai	+		+	+		+		49
5	Mūša	Ūstukiai	+		+	+				37
6	Lėvuo	Kupiškis	+		+	+	+	+		51
7	Lėvuo	Bernatoniai	+		+	+				27
8	Lėvuo	Pasvalys	+		+	+	+	+		64
9	Istras	Talačkoniai	+		+	+				17
10	Tatula	Trečionys	+		+	+				27
11	Yslikis	Kyburiai	+		+	+		+		24
12	Venta	Papilė	+		+	+	+	+		47
13	Venta	Leckava	+		+	+	+	+		12
14	Aunuva	Aunuvėnai	+	+	+	+		+		21
15	Rešketa	Gudeliai	+		+	+		+		49
16	Bartuva	Skuodas	+		+	+	+	+		49
17	Akmena	Kretinga	+		+	+				1
18	Nemunas	Druskininkai	+		+	+	+	+		117
19	Nemunas	Nemajūnai	+		+	+	+	+	+	73
20	Nemunas	Kauno HPS				+				35
21	Nemunas	Kaunas	+		+		+			117
22	Nemunas	Kaunas (Lampėdžiai)	+		+		+			64
23	Nemunas	Seredžius	+		+		+	+		117
24	Nemunas	Smalininkai	+	+	+	+	+	+	+	183
25	Nemunas, Rusnės atšaka	Lazdėnai	+		+					14
26	Nemunas, Atmatos atšaka	Rusnė	+	+	+	+	+	+		184
27	Baltoji Ančia	B.Ančia HPS				+				30
28	Merkys	Žagarinė	+		+	+		+		43
29	Merkys	Puvočiai	+	+	+	+	+	+		50
30	Šalčia	Valkininkai	+		+	+	+	+		22
31	Ūla	Zervynos	+	+	+	+	+	+		35
32	Skroblus	Dubininkas	+		+	+	+	+		18
33	Verknė	Verbyliškės	+	+	+	+	+	+		55
34	Strėva	Semeliškės	+	+	+	+		+		33
35	Neris	Buivydžiai	+	+	+	+	+	+		28
36	Neris	Vilnius	+		+	+	+			117
37	Neris	Jonava	+		+	+	+	+	+	117
38	Žeimena	Kaltanėnai	+	+	+	+				34
39	Žeimena	Pabradė	+		+	+	+	+		55
40	Būka	Vaišnoriškė	+		+	+		+		19

1	2	3	4	5	6	7	8	9	10	11
41	Peršokšna	Januliškis	+	+	+	+		+		12
42	Vilnia	Vilnius	+		+	+				68
43	Merkys-Vokė canal	Žagarinė	+		+	+				43
44	Šventoji	Anykščiai	+	+	+	+				67
45	Šventoji	Ukmergė	+	+	+	+	+			70
46	Širvinta	Liukonys	+	+	+	+				24
47	Nevėžis	Panevėžys	+	+	+	+	+			15
48	Nevėžis	Dasiūnai	+	+	+	+	+	+		34
49	Šventoji-Nevėžis canal	Dauginčiai				+				30
50	Juosta	Jackagalys	+		+	+		+		18
51	Sanžilė canal	Bernatoniai	+		+	+				27
52	Smilga	Pasmilgys	+		+	+		+		21
53	Šušvė	Šiaulėnai	+		+	+	+	+		31
54	Šušvė	Josvainiai	+	+	+	+				57
55	Dubysa	Lyduvėnai	+	+	+	+		+		61
56	Dubysa	Padubysys	+	+	+	+		+		65
57	Kražantė	Pluskiai	+		+	+				24
58	Mituva	Žindaičiai	+	+	+	+		+		30
59	Alsa	Paalsys	+		+	+				38
60	Šešupė	Kalvarija	+		+	+	+	+		63
61	Šešupė	Marijampolė	+	+	+	+	+			69
62	Šešupė	Kudirkos Naumiestis	+		+	+				20
63	Pilvė	Papilvis	+	+	+	+				16
64	Milupė	Stoškai	+	+	+	+				38
65	Jūra	Pajūris	+	+	+	+	+	+		55
66	Jūra	Tauragė	+	+	+	+	+			69
67	Akmena	Paakmenis	+	+	+	+		+		45
68	Šešuvis	Skirgailai	+		+	+				56
69	Šyša	Jonaičiai	+		+	+				35
70	Šustis	Jonaičiai	+		+	+				35
71	Minija	Kartena	+		+	+	+	+		70
72	Minija	Lankupiai	+		+	+	+			15
73	Veiviržas	Mikužiai	+	+	+	+		+		50
74	Upita	Eidukai	+		+	+				14
		Total:	71	25	72	71	29	42	3	

OBSERVATIONS in HYDROLOGICAL STATIONS
on Lithuanian lakes in 1993

Item No.	Lake/ Storage work	Station	Water level	Water-level record-er	Water temp-erature	Dis-charge/Run-off	Oper-ational data trans-mission	Meteo-rologic-al obser-vations	Water temp-erature in vertical sound-ing	Annual series
1	2	3	4	5	6	7	8	9	10	11
75	Kauno marios Storage Work	Birštonas	+		+		+	+		34
76	Kauno marios Storage Work	Darsūniškis	+		+		+	+	+	34
77	Kauno marios Storage Work	Kaunas HPS	+							34
78	Žeimenys	Kaltanėnai	+		+					34
79	Tauragnas	Tauragnai	+		+			+	+	39
80	Totoriškių Lake	Trakai	+		+		+	+		42
81	Dusia	Meteliai	+		+			+	+	54
82	Žuvintas	Rezervation	+		+			+		34
83	Plateliu Lake	Plateliai	+		+			+	+	32
84	Lūkstas	Varniai	+		+			+	+	36
		Total:	**10**	-	**9**	-	**3**	**8**	**5**	

Appendix 12

First draft

POLISH CONTRIBUTION TO THE BALTEX SCIENTIFIC PLAN
(proposed research topics)

I. METEOROLOGY

1.1. Meso-scale 3D atmospheric model aimed on simulation of mass and energy transport over Poland
- * Institute of Meteorology and Water Management, Warsaw

1.2. Coupled hydrologic/atmospheric model of the Polish part of the Baltic coast
- * Institute of Meteorology and Water Management, Gdynia, Warsaw

1.3. Water balance in the lower atmosphere over the southern part of the Baltex region
- * Institute of Metetorology and Water Management, Warsaw

1.4. Impact of global and net radiation on hydrologic processes in the Baltex region
- * Institute of Geophysics, Warsaw
- * Institute of Meteorology and Water Management, Warsaw

1.5. Multifractal analyzes of precipitation fields over Poland
- * Institute of Meteorology and Water Management, Warsaw

1.6. Interrelations between atmospheric circulation over Europe and climatic anomalies in Poland
- * Institute of Geophysics, Warsaw
- * Institute of Meteorology and Water Management, Warsaw

1.7. Meso-scale climate scenarios: Central Europe
- * Institute of Geophysics, Warsaw

II. HYDROLOGY

2.1. Conceptualization of land surface processes (and hydrologic models) for the territory of Poland
- * Institute of Geophysics, Warsaw
- * Institute of Hydroengineering, Gdańsk
- * Warsaw University, Institute of Physical Geography
- * Warsaw Technical University, Institute of Environmental Engineering
- * Agricultural University in Wroclaw, Hydrology Department

2.2. Impact of climatic and land surface characteristics on water balance in Poland
   * Institute of Geophysics, Warsaw
   * Warsaw University, Institute of Physical Geography

2.3. Statistical analyzes of long-term series of hydrologic observations for the Southern part of the Baltex region
   * Institute of Geophysics, Warsaw

2.4. Methodology of water balance assessment of the mountainous part of the Vistula basin
   * Technical University in Kraków, Institute of Hydrotechnics and Water Management

2.5. Hydrologic processes in the lower part of the Odra (oder) river basin
   * Technical University in Szczecin, Institute of Hydrotechnics

III. OCEANOLOGY

3.1. Solar radiation processes over the Baltic Sea under various weather conditions
   * Institute of Oceanology, Sopot
   * Istitute of Meteorology and Water Management, Gdynia

3.2. Impact of sea level variations on dynamic of water exchange between Baltic and the North Sea
   * Institute of Oceanology, Sopot

3.3. Investigation of mass and energy fluxes between the Baltic Sea and the atmosphere: theory and experimental studies
   * Institute of Oceanology, Sopot
   * Institute of Hydroengineering, Gdańsk

3.4. Dynamics and physical properties of the Baltic waters
   * Institute of Oceanology, Sopot

3.5. Ice processes in the Southern Baltic
   * Institute of Hydroengineering, Gdańsk

Appendix 13

BALTEX Working Group on Numerical Experimentation

Report of first meeting in Kiel, January 10-11, 1994

Submitted by J. Willebrand, Kiel, Germany

1. INTRODUCTION

The first meeting of the BALTEX WG on Numerical Experimentation started at 10:00 h on Monday, January 10. The chairman welcomed all group members and a number of guests (participants are listed in the appendix). On invitation of the chairman, Dr.L.Bengtsson introduced the objectives of BALTEX as a regional contribution to GEWEX, and explained the role of this group which has been formed on recommendation of the BALTEX Scientific Steering Committee. The purpose of this meeting was that the group should determine its work program to address the tasks that had been defined by the steering committee. The agenda which is given in the appendix was adopted.

2. PRESENT STATUS OF BALTEX NUMERICAL MODELLING ACTIVITIES

2.1 ATMOSPHERIC MODELS

N.Gustafsson discussed the present situation of atmospheric models suitable for experimentation within the framework of BALTEX. Different models are developed and utilized operationally by the weather services in the countries participating in the BALTEX and also by some research institutions. The HIRLAM model, developed in a common research project among the weather services in the Nordic countries, Netherlands and Ireland, the Europa-Model (EM) and the Deutschland-Model (DM) developed by the German weather service and the HIRHAM model operated at the Max-Planck-Institute for Meteorology are such models suitable for BALTEX.

The calculation of fluxes from the inhomogeneous land- and sea surfaces of the Baltic Sea area, the simulation of the associated mesoscale dynamical effects of these fluxes in the form of secondary circulation systems (e.g. land- and sea breezes) as well as a proper simulation of other small scale intensive weather phenomena put strong constraints on the spatial resolutions of the atmospheric model to be applied for data assimilation and simulation studies during the BALTEX. The convective snow bands formed during cold air outbrakes over the open water surfaces of the Baltic Sea, with the events during the winter months of 1987 as an extreme case, and the intensive mesoscale baroclinic development on 14 January, 1993 in the southern part of the Baltic Sea are examples of such phenomena. Simulations studies have indicated that grid resolutions of the order of 10 - 20 km are required for a proper simulation.

Calculation of fluxes through the inhomogeneous lower atmospheric boundary in the Baltic Sea area makes it necessary to introduce oceanographical and hydrological models that are coupled to the atmospheric models. Some progress has already been achieved in this area, one example is the ice drift model that has been coupled to the data assimilation of the operational HIRLAM model of SMHI.

The BALTEX objectives necessitates refinements of the physical parameterization schemes of the atmospheric models to be applied. Sub-grid scale averaging of the fluxes from the inhomogeneous lower boundary, vertical turbulent transport mechanisms as well as condensation and precipitation are examples of important areas for improvements of parameterization schemes. Several optional parameterization formulations exist. It is necessary to carry out intercomparison studies and to develop a physical understanding of why these different schemes sometimes lead to significantly different results.

B. Rockel informed the group on the activities at GKSS research center. Basis for the modelling efforts is the Deutschland-Modell (DM) which has been installed at the German Climate Research Centre (DKRZ) at Hamburg. During the next six months the region of the DM will be extended to cover the whole BALTEX region. The main problem in building this first version of the BALTEX model (BM) is the sampling of the needed surface fields (orography, roughness, length, land coverage, soil type, vegetation cover, leaf area index, root depth) on the 18 x 18 kM grid. The BM will be driven by 1 hourly boundary conditions provided by the Europa-Modell (EM) of the German Weather Service. The BM is intended to be a research model rather than an operational model. Simulations with the BM (30h forecasts) for studies of the energy and water cycle over the BALTEX area will be done for certain chosen months.
As part of a cooperative effort, a common REgional MOdel (REMO) will be developed at DKRZ. It will allow the exchange of physics packages from different institutions.

2.2 HYDROLOGICAL MODELS

S.Bergstroem discussed the situation of hydrological modelling which has a long tradition in the Nordic countries. Both conceptual and more physically based models are available. The most advanced model is the SHE-model available at the Danish Hydraulic Institute while the HBV-model from SMHI in Sweden is the most widely used conceptual model within the Nordic countries. Other models are also available.

Experience so far shows rather convincing that the size of the Baltic Basin should not be a problem for the hydrological models which hence can provide excellent tools for verification of the atmospheric models. It will also be useful to compare the intermediate output form these two types of models and to make the corresponding intercomparison with field data.

There is a need to develop the hydrological models further to reduce the remaining empirism and decrease the need for model calibration. Areas of particular interest are snow processes, evapotranspiration and evaporation from lakes and all aspects of areal variability of the hydrological processes. A specific factor which has to be considered in large scale hydrological modelling is the human impact on river run-off, in particular the effects of river regulation for power production.

Dr. J.C.Refsgaard added supplementary information on the distributed, phyically based models drawing on DHI's experience with their SHE model.
After 15 years of development, this model is now fully ready for operational use. DHI has experience with applications ranging from 1 ha to 5,000 km2. It is feasible to utilize the model for the entire Baltic region using a coarse grid of e.g. 10 x 10 km2.
While for purposes confined to pure run-off prediction lumped conceptual models (like e.g. HBV) provide just as good results as the more advanced models, the main advantages of the distributed models lie in their capability to provide more physically correct descriptions of the individual hydrological processes at different spatial scales. The distributed models are also very well suited for coupling with meteorological models and for utilization of remote sensing data.

Dr. Nawalany pointed out during the discussion of hydrological models that the direct inflow of groundwater into the Baltic Sea which is not included in simple models could be potentially significant and would deserve closer investigation.

2.3 BALTIC SEA MODELLING

The status of oceanographic modelling was described by Dr.W.Krauss. The presently most ambitious effort is a high-resolution Baltic Sea circulation model which is run at IfM Kiel. The model is based on the GFDL-code with a free surface, and allows to study the response to wind forcing as well as thermal forcing and freshwater fluxes through the surface or from rivers. The resolution is 5km, and vertically 6 m in the upper layers. Modelling of the exchange between Kattegat and the Baltic Sea will require nested models of resolution 1-2 km.

While high-resolution 3-dimensional models are necessary to simulate currents and stratification in the Baltic, simpler and/or coarser models can still be useful for limited purposes. In particular, models with low vertical resolution (as e.g. the model operated at BSH) and also 2-d barotropic models can be rather useful for predicting wind-driven sea level variations which constitute the main forcing for the flow through belt and sound. For long-term integrations over several decades, 2-d (x-z) models can also be helpful as they may allow, through systematic parameter variations, to optimize poorly known mixing parameters. The results from these simpler models can be used to optimize the parametrization in high-resolution models.

3. COUPLED MODELS

The development of coupled models was discussed by Dr. Bengtsson. The land, the sea and the atmosphere constitute a physical system with strong couplings. For the proper simulation and forecasting of this system, coupled hydrological, oceanographic and meteorological models must be utilized. To obtain the full benefit of coupled models, it is required that the coupling between the different models is two-way, except for the coupling between land surface and Baltic Sea which is only one-way. In general circulation models as well as recent operational limited area models, e.g. the HIRLAM and the DWD and Europa-Modell, a coupling exists only between the land and the atmosphere. In HIRHAM an advanced land-surface scheme allows a comprehensive exchange of water, heat and momentum between the land

surface and the atmosphere. Problems are to find a more realistic determination of vegetation, soil and percolation and run-off properties representative for areas from 50 - 50 000 km2 and to express precipitation and energy fluxes in terms of such areas and their properties. Dynamical changes in land surface conditions caused by the atmosphere will concentrate on a realistic representation of snow and vegetation (changes in leaf area index).

Ocean-atmosphere coupling has often used the so-called flux correction technique whereby systematic errors of the atmospheric and ocean model, respectively, are empirically corrected based on their performance of each subsystem versus a prescribed observed data set or a climatology. It appears however that the new generation of coupled models has now reached a level of sophistication where this does not longer appear necessary.

Coupled ocean/atmosphere models are presently not available for the Baltic Sea. Here a coupling of the primitive equation model (GFDL-model with a free surface) presently run at IFM Kiel and an atmospheric model, either the EUROPA-Modell of DWD or HIRHAM, seems now feasible. Furthermore a sea-ice model for the Baltic is crucial for a better simulation of the thermal exchange with the atmosphere.

4. STATUS OF DATA ASSIMILATION SYSTEMS

W.Wergen discussed modern data assimilation systems for atmospheric models which combine the information from the actual observations with prior knowledge. The latter is mainly derived from the time history of the observations which is transported forward in time by the for ecast model. A typical, 6-hourly intermittent, 4-dimensional data assimilation scheme consists of an analysis (A), an initialisation (I), and a forecast step (V). The 6-hour forecast serves as a first guess for the analysis. In areas where it deviates from the observations, it is corrected by statistical methods. In the initialisation step, the mass and wind fields are mutually adjusted. The subsequent 6-hour forecast serves as first guess for the next analysis and so on. During this process, the model is adapted to the evolution of the real atmosphere as reported by the incoming observations.

At DWD, 3 separate data assimilation streams are maintained for the Global-Model 1 (GM), the Europa-Modell (EM) and the Deutschland-Modell (DM). The EM has a resolution of 50, the DM of 14 km. Both models have 20 levels in the vertical with 8 levels below 850 hPa. Similar models are also run in the HIRLAM community. Apart from the traditional fields such as wind components, temperature, and humidity in the free atmosphere these model s can provide a wealth of additional information.
This includes the surface fluxes momentum, sensible and latent heat, and of many other quantities relevant to the BALTEX objectives.

It is straightforward to calculate budgets for various areas from these fields. A calculation by E. Heise indicates that in the annual mean the precipitation is almost compensated by evaporation over the Baltic. The calculated water budgets results are however model-dependent and are e.g. different for GM and EM.

The analysed as well as the initialised fields are archived in full model resolution at most operational centers. The time resolution is usually 6 hours. Analysed fields and the observations are stored indefinitely, forecasts are kept only for a limited time. Apart from the hight resolution models run in the HIRLAM-comunity and at DWD, ECWMF is currently in the process of re-analysing the period from 1979 to 1993. Despite their lower resolution, these data might be of interest for longer time studies. The topic of data assimilation in ocean models was discussed by O. Brink-Kjaer. The activities have been focussed on the assimilation of wind and sealevel data with barotropic ocean models. An operational system including the

North Sea, the danish straits and the Baltic is operationally run by DMI/DHI. The development of assimilation schemes for 3-d models which so far has been precluded by extremely high computing demands appears however feasible during the period of BALTEX.

5. KEY SCIENTIFIC ISSUES FOR MODELLING

There was agreement among the group members that the modelling effort within BALTEX should be directed to the development and verification of models for the system atmosphere-land surface-Baltic Sea which will form the basis for environmental models in this region.

The following key scientific issues were identified:

a) Determination of the water budget of the Baltic region on time scales from weeks to decades

This will require an accurate estimation of precipitation, evapotranspiration and all other air-sea fluxes, river runoff and the transport of water and salt through belt and sound. It also requires an understanding of the dynamics of inflow events into the Baltic Sea, and of the thermohaline circulation and mixing processes which determine the long-term distribution of water masses in the Baltic Sea.

b) Interaction between synoptic scale and mesoscale processes in the atmosphere

The forcing on the atmosphere from the inhomogenous land and water surfaces of the Baltic Sea area generates mesoscale secondary circulation systems, land- and sea-breezes, as well as significant modifications of synoptic scale circulations. These mesoscale phenomena strongly influence the geographical distribution of e.g. precipitation and need to be further investigated by means of model simulations and observational campaigns.

c) Thermal coupling between Baltic sea and atmosphere

The net air-sea energy exchange can reach locally up to 1,000 W/m2 during extreme weather situations. It is hence a potentially important forcing mechanism for both systems. In particular, the role of sea ice for the thermal exchange needs to be investigated.

d) The role of land surface variability on the hydrological cycle

The land surface shows great variability with different vegetation and land use. Therefore the energy and water balance is highly variable. The understanding of this sub-grid variability and its representation in atmospheric and hydrological models is an area of great importance.

e) The role of lakes for hydrological and energy cycle

The Baltic basin is characterized by its large number of lakes. Their contribution to the water and energy balance is very important but not fully understood. Of particular interest is the evaporation from a mosaic of land and lakes and the energy balance related to ice formation anf break up on lakes.

f) Snow in the hydrological cycle

Snow is a significant component of the hydrological cycle in the BALTEX region. There is a need to better understanding of the energy balance and better models for snow accumulation and melting. The areal distribution of processes related to snow are of particular interest.

6. DATA SETS FOR MODELLING

The following data sets are considered as fundamental for the planned modelling activities:

1) Data from operational systems

i) Atmospheric surface data, in particular surface wind stress, sea surface temperature, precipitation, and the complete set of thermal and hydrological fluxes. These data will be available from the operational atmospheric models;

ii) Run-off data (to be obtained through SMHI);

iii) Tide gage data (there appears to be a problem with data from some eastern countries which should be brought to the BALTEX steering group);

iv) Precipitation from networks (in delayed mode)

v) Sea-ice coverage and possibly thickness (available from SMHI and FMRI, also from BSH in form of maps)

2) Crucial observational problems

There was consensus that the availability of continuous measurements of the flow through belt and sound (including its baroclinic component) has the highest priority for model development and calibration. In addition, combined hydrographic sections and current measurements across sills and straits in the western Baltic, e.g. Darss-Gedser or Bornholm-Sweden are necessary to determine the circulation.

The group noted that the present network of radiosonde stations in the Baltic region is the minimum necessary for the high-resolution atmospheric models, and recommended that it should not be reduced during the BALTEX period.

Non-operational data from various modelling projects were briefly discussed. There was agreement that model results should generally be freely available to the community.

7. SUGGESTED PROJECTS

After an intense discussion, a number of possible projects were identified which will address the key scientific issues and appear to be feasible for implementation during the BALTEX period:

a) Water and energy budgets over the BALTEX region from atmospheric models

Atmospheric models provide all the terms of the water and energy budgets. They are available both from the analyses in the data assimilation and from short-range forecasts. These terms are calculated routinely for the Europa-Model of the Deutsche Wetterdienst for the entire BALTEX area as well as separately for all sea and land points inside that area. It is recommended that similar calculations be performed operationally in the HIRLAM model using identical algorithms.

Interested institutions: GKSS, DWD, SMHI, DMI
Implementation period: 1994-96 ??

b) Baltic Sea response to atmospheric and hydrological forcing

The response of the Baltic Sea to atmospheric forces and river run-off should be modeled for the periods 1992/93 and 1986/87. One of the main goals of this analysis will be to determine the net in- and outflow through the Danish Straits

and to compute the annual variations of the water and fresh water volume of the Baltic. Groups at different institutes are encouraged to develop and use different types of models and intercompare the results. Model outputs should be made available to other institutes for validation.

Interested institutions: IFM, DHI/DMI, SMHI
Implementation period: 1994-96

c) Development of a sea-ice module for the Baltic Sea model

An extension of the circulation models to incorporate the effect of sea ice will be required. In particular, besides thermodynamic fluxes the dynamics of ice motion need to be simulated. There exist several independent models which are suitable for coupling with the GFDL circulation model.

Interested institutions: IFM, Inst. of Geophysics Helsinki, SMHI
Implementation period: 1995-97

d) Thermohaline circulation and long-term variability of the Baltic Sea

To understand the mean thermohaline circulation and water mass distribution as a consequence of highly variable forcing, integrations over 10-15 years should be performed with a Baltic Sea model. The atmospheric forcing fields will be provided by the reanalysis project at the ECMWF, monthly river run-off data by SHMI. Besides the high-resolution GFDL-model, simpler models to investigate different parametrizations will also be used.

Interested institutions: IFM, DHI/DMI, SMHI
Implementation period: 1996-2000

e) Intercomparison of atmospheric models

An intercomparison of atmospheric fields describing the hydrological and energy cycles should be performed with different high-resolution models, particularly HIRLAM, BM and ECMWF models. Relevant fields include clouds (cloud cover, liquid water and ice content), precipitation (rain, snow), evapotranspiration, heat fluxes (sensible, latent) as well as radiative fluxes, separately for land and sea areas. The institutes running the models have to establish a convenient and standardized format for the intercomparison. In a first step atmospheric fields for 1992/93 of the 50 km resolution versions of HIRLAM, EM and ECMWF should be compared. In the future the period of the BALTEX field experiment where more dense coverage of measured data concerning the energy and water cycle will be suitable.

Interested institutions: GKSS, SMHI, DMI
Implementation period: 1995-96

f) Mesoscale Meteorological Reanalysis

Two periods with interesting atmospheric and oceanographic phenomena, October 86 - Dec. 87 and Oct. 92 - Dec. 93, have been identified as intensive data periods for BALTEX. Mesoscale meteorological analysis fields, produced by a modern data assimilation system, are required for these periods over the Baltic Sea area. These data will e.g. be used for the forcing of oceanographic models. Proper lower boundary conditions, e.g. sea ice and sea-surface temperatures, should be used during the production of these data assimilations. The data for the 92 - 93 period has already been produced operationally by the DWD EM data assimilation. It is recommended that one of the participating institutes from the HIRLAM community, e.g. the SMHI, will carry out the data assimilation for at least the January 87 period.

Interested institutions: DWD, SMHI, DMI
Implementation period: 1994-96

g) Full Hydrological Model for the Baltic Area

A conceptual model is to be established as soon as possible on the basis of existing data. The objective is to simulate total daily run-off for the entire basin on a subcatchment basis. As secondary outputs soil moisture conditions and snow accumulation will be calculated for all main subcatchments. The model simulations will be carried out for at least a 10 year's period. This project will provide a first rough overview of the land phase of the water balance for the Baltic area.

Interested institutions: SMHI, DHI
Implementation period: 1994-96

h) Use of Hydrological Models and Observations to validate the Hydrological Components of the Meteorological Models

Firstly, the output from the meteorological models (precipitation, snow, evaporation, soil moisture and temperature) will be compared to corresponding output from hydrological models. Secondly, the output from the meteorological models will be used as input to hydrological models and the simulated river run-off will be compared with observed run-off data. These studies will be carried out on two levels: (a) On the entire Baltic area using the conceptual model established under project (g). (b) Detailed studies on selected river basins using distributed, physically based models established under project (i).

Interested institutions: SMHI, DHI
Implementation period: 1995 - 2000

i) Development and Intercomparison of Hydrological Models for selected River

Basins

Three large river basins will be identified as the basis for detailed studies. The river basins could e.g. be Torneaelven, Wistula and Dangava. Distributed and physically based models will be established with special emphasis on snow accumulation and melt, evapotranspiration, lake evaporation and interaction between surface waters and groundwater. Intercamparison will be carried out between the distributed, physically based models and the conceptual model established under project (g). Attention will be given to the spatial variation of hydrological processes and to the coupling to atmospheric models. Remote sensing techniques will be applied such as radar and satellites e.g. for assessing soil moisture/evaporation and lake temperature. Remote sensing data will be incorporated in the hydrological models by use of data assimilation techniques.

Interested institutions: SMHI, DHI
Implementation period: 1995 - 2000

j) Coupled air-sea-land model

It is intented to couple an atmospheric model, either the EUROPA-Modell of DWD or HIRHAM, with a Baltic Sea primitive equation model (GFDL-model with a free surface) and a hydrological model (possibly the HBV-model). The experiments will be performed for the periods 1992/93 and if possible also for 1986/87.

Interested institutions: MPI, IFM, GKSS, SMHI, DMI
Implementation period: 1997-2000

8. NEXT MEETING

There was agreement that the areas of coupled models and of data assimilations systems need more study. It was suggested to have a workshop on these issues, with participation from all groups and individuals working in this field. A possibility would be to organise a specific modelling session at the BALTEX conference planned for summer 1995. The matter will be decided by correspondence among group members, after consultation with the steering committee.

The meeting was closed at 13:30h on January 11.

BALTEX Working Group on Numerical Experimentation

Modified meeting report, to be used in parts for implementation plan

Submitted by J. Willebrand, Kiel, Germany

6. DATA SETS FOR MODELLING

The following data sets are considered as fundamental for the planned modelling activities:

1) Data from operational systems

i) Atmospheric surface data, in particular surface wind stress, sea surface temperature, precipitation, and the complete set of thermal and hydrological fluxes. These data will be available from the operational atmospheric models;

ii) Run-off data (to be obtained through SMHI);

iii) Tide gage data (there appears to be a problem with data from some eastern countries which should be brought to the BALTEX steering group);

iv) Precipitation from networks (in delayed mode)

v) Sea-ice coverage and possibly thickness (available from SMHI and FMRI, also from BSH in form of maps)

vi) Satellite data, in particular cloud and radiation measurements, sea surface temperature, altimetric sea surface height and sea state

2) Crucial observational problems

There was consensus that the availability of continuous measurements of the flow through belt and sound (including its baroclinic component) has the highest priority for model development and calibration. In addition, combined hydrographic sections and current measurements across sills and straits in the western Baltic, e.g. Darss-Gedser or Bornholm-Sweden are necessary to determine the circulation.

The group noted that the present network of radiosonde stations in the Baltic region is the minimum necessary for the high-resolution atmospheric models, and recommended that it should not be reduced during the BALTEX period.

Non-operational data from various modelling projects were briefly discussed. There was agreement that model results should generally be freely available to the community.

7. SUGGESTED PROJECTS

The number of projects has been identified which will address the key scientific issues and appear to be feasible for implementation during the BALTEX period:

a) Water and energy budgets over the BALTEX region from atmospheric models

Atmospheric models provide all the terms of the water and energy budgets. They are available both from the analyses in the data assimilation and from short-range forecasts. These terms are calculated routinely for the Europa-Model of the Deutsche
Wetterdienst for the entire BALTEX area as well as separately for all sea and land points inside that area. It is recommended that similar calculations be performed operationally in the HIRLAM model using identical algorithms, so that the dependence of the water balance on resolution and parametrization can be assessed

Interested institutions: GKSS, DWD, SMHI, DMI, MPI
Implementation period: 1994-96

b) Baltic Sea response to atmospheric and hydrological forcing

The response of the Baltic Sea to atmospheric forces and river run-off should be modeled for the periods 1992/93 and 1986/87. One of the main goals of this analysis will be to determine the net in- and outflow through the Danish Straits and to compute the annual variations of the water and fresh water volume of the Baltic. Groups at different institutes are encouraged to develop and use different types of models and intercompare the results. In particular, models capable of assimilating oceanographic observations need to be developed. Model outputs ~~should be made available to other institutes~~ for validation.

Interested institutions: IFM, DHI/DMI, SMHI
Implementation period: 1994-96

c) Development of a sea-ice module for the Baltic Sea model

An extension of the circulation models to incorporate the effect of sea ice will be required. In particular, besides thermodynamic fluxes the dynamics of ice motion need to be simulated. Several variants of the sea ice model developed by Hibler (19**) are suitable for coupling with the GFDL circulation model, however the parametrization needs to be adjusted to Baltic Sea conditions.

Interested institutions: IFM, Inst. of Geophysics Helsinki, SMHI
Implementation period: 1995-97

d) Thermohaline circulation and long-term variability of the Baltic Sea

To understand the mean thermohaline circulation and water mass distribution as a consequence of highly variable forcing, integrations over 10-15 years should be performed with a Baltic Sea model. The atmospheric forcing fields will be provided by the reanalysis project at the ECMWF, monthly river run-off data by SHMI.
Besides the high-resolution GFDL-model, simpler models to investigate different parametrizations will also be used.

Interested institutions: IFM, DHI/DMI, SMHI
Implementation period: 1996-2000

e) Intercomparison of atmospheric models

An intercomparison of atmospheric fields describing the hydrological and energy cycles should be performed with different high-resolution models, particularly HIRLAM, BM and ECMWF models. Relevant fields include clouds (cloud cover, liquid water and ice content), precipitation (rain, snow), evapotranspiration, heat fluxes (sensible, latent) as well as radiative fluxes, separately for land and sea areas. The institutes running the models have to establish a convenient and standardized format for the intercomparison. In a first step (94/95) atmospheric fields for 1992/93 of the 50 km resolution versions of HIRLAM, EM and ECMWF should be compared.

During the period of the BALTEX field experiment (97/98) a more dense coverage of measured data concerning the energy and water cycle will be available. For this period an intercomparison for the high resolution models is planned.

Interested institutions: GKSS, SMHI, DMI, MPI
Implementation period: 1994-2000

f) Mesoscale Meteorological Reanalysis

Two periods with interesting atmospheric and oceanographic phenomena, Oct. 86 - Dec. 87 and Oct. 92 - Dec. 93, have been identified as intensive data periods for BALTEX. Mesoscale meteorological analysis fields, produced by a modern data assimilation system, are required for these periods over the Baltic Sea area. These data will e.g. be used for the forcing of oceanographic models. Proper lower boundary conditions, e.g. sea ice and sea-surface temperatures, should be used during the production of these data assimilations. The data for the 92 - 93 period has already been produced operationally by the DWD EM data assimilation. It is recommended that one of the participating institutes from the HIRLAM community, e.g. the SMHI, will carry out the data assimilation for at least the January 87 period. At MPI the use of the T106 model (31 levels) is planned.

Interested institutions: DWD, SMHI, DMI, MPI
Implementation period: 1994-96

g) Full Hydrological Model for the Baltic Area

A conceptual model is to be established as soon as possible on the basis of existing data. The objective is to simulate total daily run-off for the entire basin on a subcatchment basis. As secondary outputs soil moisture conditions and snow accumulation will be calculated for all main subcatchments. The model simulations will be carried out for at least a 10 year's period. This project will provide a first rough overview of the land phase of the water balance for the Baltic area.

Interested institutions: SMHI, DHI
Implementation period: 1994-96

h) Use of Hydrological Models and Observations to validate the Hydrological Components of the Meteorological Models

Firstly, the output from the meteorological models (precipitation, snow, evaporation, soil moisture and temperature) will be compared to corresponding output from hydrological models. Secondly, the output from the meteorological models will be used as input to hydrological models and the simulated river run-off will be compared with observed run-off data. These studies will be carried out on two levels: (a) On the entire Baltic area using the conceptual model established under project (g). (b) Detailed studies on selected river basins using distributed, physically based models established under project (i).

Interested institutions: SMHI, DHI
Implementation period: 1995 - 2000

i) Development and Intercomparison of Hydrological Models for selected River

Basins

Three large river basins will be identified as the basis for detailed studies. The river basins could e.g. be Torneaelven, Wistula and Dangava. Distributed and physically based models will be established with special emphasis on snow accumulation and melt, evapotranspiration, lake evaporation and interaction between surface waters and groundwater. Intercamparison will be carried out between the distributed, physically based models and the conceptual model established under project (g). Attention will be given to the spatial variation of hydrological processes and to the coupling to atmospheric models. Remote sensing techniques will be applied such as radar and satellites e.g. for assessing soil moisture/evaporation and lake temperature. Remote sensing data will be incorporated in the hydrological models by use of data assimilation techniques.

Interested institutions: SMHI, DHI
Implementation period: 1995 - 2000

j) Coupled air-sea-land model

It is intented to couple an atmospheric model, either the EUROPA-Modell of DWD or HIRHAM, with a Baltic Sea primitive equation model (GFDL-model with a free surface) and a hydrological model (possibly the HBV-model). The experiments will be performed for the periods 1992/93 and if possible also for 1986/87.

Interested institutions: MPI, IFM, GKSS, SMHI, DMI
Implementation period: 1997-2000

BALTEX modelling deliverables

The modelling effort within BALTEX is directed to the development and verification of models which describe all relevant components of the energy and water cycle in BALTEX region. The models must be suitable to describe the physical state of the system atmosphere-land surface-Baltic Sea, including its variability on time scales from weeks to decades, on spatial scales ranging from 10-20 km to basin size. They must also allow to study the response of the system to natural or anthropogenic changes of the global climate, and will form the basis for environmental models in the region.

Specifically, models must be capable to address the following scientific issues:

The following list needs to be expanded

- Water budget of the Baltic region
  This requires an accurate modeling of precipitation, evapotranspiration and all other air-sea fluxes, river runoff and the transport of water and salt through belt and sound. It also requires an understanding of the dynamics of inflow events into the Baltic Sea, and of the thermohaline circulation and mixing processes which determine the long-term distribution of water masses in the Baltic Sea.

- Interaction of mesoscale with synoptic scale processes
  Boundary layer forcing on the atmosphere from inhomogenous land and water surfaces generates mesoscale secondary circulation systems, land- and sea-breezes, as well as significant modifications of synoptic scale circulations.
  These mesoscale phenomena particularly influence the geographical distribution of precipitation.

- Thermal coupling between Baltic Sea and atmosphere
  The net air-sea energy exchange can reach locally up to 1,000 W/m2 during extreme weather situations, and is a potentially important forcing mechanism for both systems. In particular, the role of sea ice for the thermal exchange needs to be investigated.

- Land surface variability
  The land surface shows great variability with different vegetation and land use. Therefore, the energy and water balance is highly variable. The understanding of this sub-grid variability and its representation in atmospheric and hydrological models is an area of great importance. The contribution of lakes to the water and energy balance is very important but not fully understood. Of particular interest is the evaporation from a mosaic of land and lakes and the energy balance related to ice formation and break up on lakes.

- Snow in the hydrological cycle
  Snow is a significant component of the hydrological cycle in the BALTEX region. There is a need to better understanding of the energy balance and better models for snow accumulation and melting. The areal distribution of processes related to snow are of particular interest.

It is obvious that no single model can serve all purposes in anoptimal way. The BALTEX approach is to develop a hierarchy of models which includes various models for the three subsystems atmosphere, land surface and Baltic Sea as well as fully coupled models. It is expected that the following principal models
models will be developed and validated during BALTEX:

1) An atmospheric general circulation model for the BALTEX region, with a resolution of 18 km. The model will be based on existing models (e.g. HIRLAM, DM) and allow to estimate all components of the atmospheric energy and water cycles, including a parametrization of the land surface (soil type, vegetation cover, leaf area index, root depth). It will be driven by hourly boundary conditions from larger-scale models (e.g.EM DWD).

2) HIRHAM ****** input from atm. modeler needed

3) A full hydrological model for the Baltic region which will be based on existing data. This will allow to simulate total daily run-off for the entire basin on a subcatchment basis, and to calculate soil moisture conditions and snow accumulation for all main subcatchments.

4) A distributed and physically based model with special emphasis on snow accumulation and melt, evapotranspiration, lake evaporation and interaction between surface waters and groundwater which will be applied to several large river basins (e.g. Torneaelven, Wistula and Dangava). Attention will be on the spatial variation of hydrological processes and on the coupling to atmospheric models.

5) A 3-d circulation model for water and salt transport in the Baltic Sea, with a resolution of max. 5 km which will allow to study the response of the Baltic Sea to atmospheric forces and river run-off, and to determine the net in- and outflow through the Danish Straits. The model will include dynamics and thermodynamics of sea ice in order to correctly represent the energy and freshwater exchange with the atmosphere. The model must contain a provision to allow combination with oceanographic observations (sea leavel, temperature/salinity, currents), most likely via the adjoint model.

6) A number of models for the Baltic Sea circulation which may have lower resolution, reduced complexity, or cover a smaller region compared with 5) but are more economic and therefore allow e.g. long-term integrations, or e.g. high-resolution for limited areas (e.g. Danish Straits).

7) A fully interactively coupled model, build from the elements in 1), 3) and 5) possibly with reduced resolution.

List of presently available models

a) Atmospheric models: * * * input from N. Gustafsson

b) Hydrological models: * * * input from S. Bergstroem

c) Ocenographic models

DHI Horsholm, Denmark:
2-d barotropic PE-model, nested C-grid;
region: North Sea and Baltic Sea;
resolution: 10 nm North Sea, 3 nm Belt Sea, 1 nm Danish Belts;

forcing: meteorological parameters from ECMWF and HIRLAM;
prognostic in operational use;
no coupling with ice model
(Vested et al., 1992).

3-d baroclinic model (SHE), C-grid;
region: Sound;
resolution: horizontal 100m, vertical: ?;
forcing: wind, sea level;
prognostic;
no coupling with ice model.

FIMR Helsinki, Finland:
2.5-d baroclinic model,
vertical T/S-structure based on self-similarity;
region: Gulf of Finland;
resolution: 2.5 nm, 2 layers;
forcing: wind
2-d ice model
(Tamsalu & Myrberg, 1993, Leppaeranta, 1981)

BSH Hamburg, Germany:
3-d baroclinic PE-model, nested C-grid;
region: North Sea and Baltic Sea;
resolution: 1 nm German Bight, western Baltic (nearshore area),
5 nm offshore area, 10 nm North Sea and Baltic, vertical 10 levels;
forcing: metorological parameters from EM (Europa Modell, DWD), river runoff;
prognostic in operational use;
no coupling with ice model.

IfM Kiel, Germany:
2-d barotropic PE-model, C-grid;
region: North Sea and Baltic Sea;
resolution: 6 nm;
forcing: meteorological parameters from EM, river runoff;
assimilation of hydrographic parameters with adjoint methods,
no coupling with ice model.

3-d baroclinic PE-model, B-grid;
region: Kattegat, Belt Sea, western Baltic;
resolution: 2 nm, 32 levels;
forcing: meteorological parameters from EM, river runoff,

prognostic;
no coupling with ice model;
under development:
coupling with coarse-resolution model at open boundaries;

3-d baroclinic PE-model, B-grid;
region: Skagerrak, Kattegat, Belt Sea and Baltic Sea;
resolution: 2.7 nm, 21 levels;
forcing: meteorological parameters from EM, surface flux boundary conditions for temperature and salinity, river runoff,
initial fields: realistic 3-d distribution of temperature and salinity;
prognostic;
coupling with ice model under development
(Lehmann, 1992; 1994).

IfO Warnemuende, Germany:
3-d baroclinic PE-model, B-grid;
region: Skagerrak, Kattegat, Belt Sea and western Baltic;
resolution: 1 nm, 28 levels;
forcing: wind;
prognostic;
no coupling with ice model;

SMHI Norrkoeping, Sweden:
Box model (PROBE-Baltic) region: Baltic Sea;
resolution: 13-19 sub-basins;
forcing: meteorological parameters from ECMWF and HIRLAM;
prognostic, forecast of temperature;
coupling with ice model and HIRLAM under development
(Omstedt, 1990).

2-d barotropic PE-model;
region: Baltic Sea;
resolution: 10 nm;
forcing: meteorological parameters from HIRLAM;
prognostic;
coupling with ice model
(Zhang & Wu, 1990; Leppaeranta, 1981; Omstedt et al. 1994)

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Appendix 15

Proposal for the implementation plan

Process Studies

Submitted by E. Ruprecht, Kiel, Germany

The BALTEX area has a very complex structure: The Baltic Sea in the centre with its small opening, the Danish Straits, to exchange water with the world oceans, its different basins seperated by high sills and its large river inflows, is surrounded by flat land, forests, lakes, mountain regions. This complex structure causes a large number of inhomogeneities, e.g. land/sea, sea/ice, land/lake, fresh/salt water, which affect atmospheric and oceanic circulations and are the cause of meso-scale processes. In order to investigate the hydrological cycle of the BALTEX area, the large-scale circulation, its modification by the complex physiography of this region and meso- and small scale processes which develop because of the complex structure have to be understood. The interesting processes can be divided into four groups:

1. Processes at horizontal inhomogeneities as
a) coasts
b) sea/ice margin and leads
c) lake/land
d) land types.

2. Exchange processes
a) in the atmospheric boundary layers over land and sea,
b) in the marine mixed layer,
c) in the regions of water exchange between the various subbasins and between North Sea and Baltic Sea,
d) in the regions of fresh water input (river mouth).

3. Hydrological processes
a) cloud and precipitation processes over sea compared to those over land
b) precipitation at mountains
c) snow accumulation and melting
d) soil water dynamics.

4. Extreme events and modifications
a) deep depressions
b) modification of frontal systems passing the Baltic Sea region
c) cold air outbreaks from the continent
d) water exchange through the Danish Straits
e) severe/mild winters causing highly different sea-ice conditions.

The different processes of these four groups are of course not independent from each other. It is just their interaction which is responsible for changes in the atmospheric and oceanic circulations and for modification of the hydrological cycle of the BALTEX region.

Horizontal inhomogeneities affect the atmospheric boundary and marine mixed layer and by this means influence evaporation. If the effect is strong enough, a secondary circulation can develop causing the generation of clouds and even precipitation. Typical phenomena are the land-sea breeze circulation with clear sky areas off the coast and clouds over land, or heavy snow fall when cold air outbreaks from the continent hit the Swedish coasts after warmed up and moistened by the open Baltic Sea.

Most of these processes are not yet correctly simulated in the available models. Fine-scale models (horizontal resolution smaller than 1 km) have to be operated. Such models must be non-hydrostatic and have to be made nestable into larger-scale models or large-scale analyses. This is true for both atmospheric and oceanic models. In addition special field experiments have to be carried out to validate the model results.

Numerical models of the atmosphere very often have difficulties to correctly simulate clouds and precipitation processes. Since the latter are an essential component of the hydrological cycle, strong emphasis should be put on the validation of these numerical results. Special field experiments must be planned in particularly over the Baltic Sea to measure rainfall and cloud properties as coverage, top height, water content etc., by in-situ and remote sensing methods.

The phenomena described as Rextreme eventsS can hardly be investigated by field experiments because they are not only extreme but also not very frequent. Since they can cause large changes of the hydrological cycle e.g. by heavy rainfall or large amount of snow, and since they can get the atmospheric and oceanic state which in course affects the hydrological cycle e.g. intrusion of salt water through the Danish Straits or large ice coverage during extreme winters, special methods are needed to study these phenomena. It can be done by:
- a special observational network,
- numerical model experiments.

A dense network must be set up at synoptic and radiosonde stations including launches from ships, in particularly the latter are urgently needed. The results of the direct observations are the basis for the analysis and diagnosis of the extreme events. They are also necessary to validate the results of the numerical models, to examine how well these models are able to simulate these regional and local affected phenomena.

The major inflow of highly saline water through the Danish Straits is one of the oceanic extreme events. It is connected with a certain atmospheric wind and pressure field. Large amount of salt and oxygen is imported into the Baltic Sea by these events which plays a crucial role for the salt budget and the biological life in the Baltic Sea. The network for hydrographic measurements in the Danish Straits has to be expanded and the results of the numerical models must be analysed to understand whether these events are correctly simulated. In the view of the above discussions three main field experiments are proposed:

1) Cloud and Precipitation Experiment (CAPE)

2a) Front-Modification Experiment (FROMEX)
2b) Land Inhomogeneities Experiment (LINEX)

Because clouds and precipitation processes are so essential for the hydrological cycle, CAPE has first priority. A field comparison is proposed to be carried out in the centre of the Baltic Sea to verify parameters of the numerical models. The size of the experimental area should correspond to the grid size of the models.

Besides model verification the field campaign aims to assess and validate those methods which are applied to measure or estimate precipitation, cloud water and evaporation over the sea. These methods are in particular remote sensing methods as from satellites, RADARs or shipborne. In order to cover different synoptic situations with different cloud systems two field campaings are proposed: winter season (1996/97) and summer season (1997). In order to investigate the modifications of frontal systems moving over the BALTEX region, the operational network has to be completed by special measurement as for example radiosonde launches from ships, wind profilers at the coasts and the application of satellite observations in different spectral ranges. For these studies emphasis should be put on the installation of RADARs in particular at the western side of the BALTEX area i.e. Denmark, Northern Germany, and Southern Sweden.

Complementary to the field experiment over the sea a similar experiment is proposed over land to study the processes at homogeneities as land/lakes and flat land/forest. The experiment layout will be similar to this over the sea.

The two campaigns FROMEX and LINEX will not be carried out before 1997. With the data from already existing observation networks and the results of the numerical models diagnostic studies are proposed to be performed before the realization of the field experiments. All these studies should concentrate on such processes which affect the hydrological budget. That is an important point because it gives the general goal BALTEX is aimed at.

In the BALTEX area there exists a number of experiments already ongoing or planned which are related to BALTEX and the results of which can contribute to the aims of BALTEX. These experiments are:

a) NOPEX
(Northern Hemisphere Land-Surface Climate Processes Experiment):
A HAPEX-type study in North Europe, the experimental site is near Uppsala, Sweden, it is planned to investigate those processes which are the effects of inhomogeneities at land (land type, land/lake); it has a strong hydrology component.

b) Studies connected to the bridge construction in the Danish Straits (Great Belt link and Oeresund Link): hydrographic and current measurements, which are needed to quantify the water exchange between Baltic and North Sea.

c) Finnish Winter Experiment: an experiment carried out during March 1994 in theGulf of Bothnia, it is related to study processes at the sea/ice and air/ice boundaries.

d) Swedisch Utklippan Experiment: an experiment planned by the University of Uppsala at the island of Utklippan to investigate processes within the atmospheric boundary layer at the sea.

e) Lindenberg observational site: It is a base station of the German Weather Service located SE of Berlin, Germany, continuous atmospheric measurements are already carried out, it is planned to use also wind profilers, other remote sensing instruments and equipment to measure turbulent fluxes; it can be used as calibration station.

f) Finnish Summer Experiment: planned for 1994/95 in the Gulf of Finland to study water exchange between the Gulf of Finland and the Baltic Sea and perform observations for verification of HIRLAM.

g) GOBEX (Gotland Basin Experiment): an experiment planned during summerautumn 1995 to study the saltwater intrusions into the Baltic Sea and their effects on the Gotland Basin.

Strong efforts should be taken to use the observations of the already ongoing experiments for BALTEX relevant research and to try to influence the plans of future experiments in the direction of the BALTEX goals.

DMI

Appendix 16

MINUTES
of
BALTEX Working Group on Data Management and Data Studies
held at Danish Meteorological Institute in Copenhagen, January 17-18, 1994.

Participants:

P. Alenius	Finnish Institute of Marine Research
E. Heise	Deutscher Wetterdienst, Zentralamt, Abteilung F.
J. Neisser	Deutscher Wetterdienst, Meteorological Observatory Lindenberg
W. Krzymiński	Institute of Meteorology and Water Manage, Wroclaw
K.-G. Karlsson	Swedish Meteorological and Hydrological Institute
H. Woick	EUMETSAT
L. Laursen	Danish Meteorological Institute

Agenda.

1. Welcome
2. Introduction to BALTEX (Dr. Raschke)
3. Status of routine networks
4. Status of existing archives
5. Technical aspects of data exchange
6. Data-policy
7. Discussion of relevant diagnostic studies
8. Preparation of a report
9. Other matters

1. and 2.
The meeting was opened by Leif Laursen and in the absence of E. Raschke he gave a short review of the history and organization of the international BALTEX programme.

The meeting was hampered by the fact that Dr. Raschke as well as Dr. Reitenbach and Dr. Korkutis was unable to attend the meeting. Furthermore some time was spent on discussing the somewhat frustrating fact, that support is given to BALTEX activities in Sweden and Germany only.

The meeting was organized as follows:
1) A short presentation of the participants and their institutes interests / background
2) Presentations by the participants.
3) A discussion of the points on the agenda.

In the series of short presentations the following main points are mention

Woick reported about METEOSAT TRANSITIONAL PROGRAMME in the years to come. He mentioned in particular the development of the Meteosat Archive and Retrieval Facility(MARF). In this presentation several modern techniques for data handling was described. It seems appropriate to aim at using several of these within BALTEX.

Karlsson described in some detail the different areas of research in connection with BALTEX which has been initiated at SMHI. Furthermore he presented a list of data available at SMHI at the moment and some of the new sets to be considered such as radar and satellite data. In particular the offer from SMHI to serve as a data centre for hydrology was stressed.

Alenius presented some information on the different archives containing oceanographic data and some of the problems involved with access to these data. He also mentioned the experience with some of the previous coordinated oceanographic efforts in the Baltic Sea.

Neisser distributed a rather impressive list of modern equipment suitable to make different kind of meteorological measurements. These instruments available at a few sites may be most suitable as reference for satellite and radar measurements covering bigger areas.

Heise gave an overview of the status of the existing meteorological network and description of available data at most national weather services. He informed the group that for the time being DWD could not confirm to host the meteorological data centre for BALTEX. The decision will be made in 1994. Furthermore Heise showed an example of the waterbalance of the BALTEX region obtained by using DWD's Europemodel.

Krzymiński described several different sources of oceanographic and hydrological data in Poland. Many of these data are hard to access as they are stored on different old media and some of them are not even on digital form at present. Further it was noted that an incentive for the polish colleagues to make these data available is missing at the moment.

All of the above mentioned presentation included some aspects concerning the possibility to utilize data from the different sources. Laursen strongly recommended that the difficult question on data-policy was forwarded to the BALTEX steering committee or at least postponed to a later meeting.

Written contributions from Reitenbach and Korkutis was briefly mentioned by Laursen.

It was also noticed that the rather demanding tasks assigned to this working group might have been a little more careful described in the terms of reference put up by the steering committee and that some guidelines or expectations from the other groups would have been helpful.

The group discussed whether it should restrict itself to only work with data and data related issues or actively encourage diagnostic studies. The majority of the group found it naturally to be involved at some level in different diagnostic studies although this may create some overlap with other working groups.

Brink-Kjær visited the meeting and gave a number of comment on the meeting in Working Group of Numerical Modelling which took place in the preceding week in Kiel.

3. and 4.
It was realized that the character of existing networks and archives was rather different for the three disciplines meteorology / oceanography / hydrology. Thus it was found appropriate to separate the work into three branches

DMI

SMHI	Karlsson	Hydrology
DWD	Heise	Meteorology
FIMR	Alenius	Oceanography

It was decided to establish a comprehensive inventory of existing data with special emphasis on data from the so called test years 1987, 1992 and 1993 (see page 20 in the implementation plan).

Parts of the Polish contribution to such an inventory has been submitted to Dr. Raschke in 1993.

It was advised that the coordination of the inventory should stay with the chairman whereas the actual collection of information should be carried out by the three "branches".

A questionnaire should be sent to all organizations likely to hold relevant data. This questionnaire contains the following questions:

Name of organization

Point of contact

List of data contained: *parameters*
geophysical area/location
time period
frequency
quality

Storage medium

Technical detail about access

Data policy (restrictions, prices etc.)

These questionnaires should be sent with clear reference to the BALTEX programme.

5.
There was general agreement that the major centres normally use standards already agreed in other framework.

The storage media should preferably be limited to rather few such as exabyte tapes and optical discs.

The connection to computer networks is important for the participant.

6.
This issue was left to later.

7.
A number of possible data studies / diagnostic studies was mentioned, especially by the participants from SMHI and from DWD such as cloud climatology and precipitations estimated from satellite data.

8.
The preparation of a report suitable to be available before the meeting in the BALTEX steering committee in May was discussed and it was agreed that the contributions from SMHI, DWD, FIMR on the inventory should be completed with contributions.

Neisser:	Remarks on need for reference stations and non synoptic data with emphasis on further meteorological field campaigns.
Woick:	Remote sensing and data at EUMETSAT and ESA.
Karlsson:	Remote sensing issues, a swedish view. Comments on the use of remote sensed data.
Krzymiński	Inventory.

9.
Other matters.
The lack of a high resolution physiographic database was discussed. The important issue has been touched upon many times and may need serious considerations at high level.

The meeting was closed at 15^{00} on the 18th January.

Appendix 17

DATA SETS FOR MODELLING

1) **Boundary Conditions, topography, soil, vegetation etc.**

   10 km horizontal resolution
   include measure of inhomogenity
   fine tuning by Isemer and Gustafsson

2) **Data from observational Systems**
   (validation, assimilation)

   - atmospheric surface data ~ every 3h
   - run-off ~ daily
   - tide gauge, problem in some countries
   - precipitation from networks (delayed mode)
   - sea-ice (coverage, thickness) ~ two times per week
   - satellite (cloud/radiation, SST, altimeters)

3) **Crucial observations**

   - past observations (surface temperature, wind)
   - inflow / outflow
   - hydrographic sections
   - radiosonde network

4) **Historical data**

   Periods for especially 2) and 3)

   - 1986/87 (modelling efforts by SMHI, HIRLAM community)
   - 1992/93 (modelling efforts by DWD)
   - further BALTEX intense observational periods

Appendix 18

Two Types of Experiments

1. Field campaigns
   studying meso-/small-scale processes

2. Intensive observation periods
   studying extreme events and modification of synoptic-scale systems

<u>Aims</u>

- understand the processes
- validate results of numerical models
- improve parametrizations
- verify remote sensing methods

Proposed Experiments

1. Cloud and Precipitation Experiments
   a) over the sea
   b) over the land (with a strong hydrological component)

2. Atmosphere-ice-ocean Experiment

3. Baltic Sea vertical advection / micing Experiment
   (utilizing chemical tracers, current and hydrographic measurements)

4. Frontal Modification Experiment

5. Coastal Experiment

Appendix 19

A mesoscale meteorological reanalysis of January 1987 for BALTEX

Data period: 15 December 1986 - 15 February 1987

Geographical area: 146 x 142 horizontal points with 22 km grid resolution in a rotated latitude/longitude geometry (approximately 10W - 45E, 48N - 75N). 24 (possibly 32) vertical hybrid levels.

Assimilating models:

- HIRLAM Level 2 with Eulerian advection and 4th order horizontal diffusion, including the Sundqvist condensation/precipitation scheme and the Savijarvi/Sass radiation scheme.
- The SMHI sea ice forecast model.

Input data:

- TEMP, PILOT, SYNOP, SHIP and AIREP observations.
- NMC Washington SST analyses over the Atlantic
- SST and sea ice coverage data from the SMHI Marine Forecasting Office
- Lateral boundary data from ECMWF analyses
- An improved HIRLAM physiography data set

Analysis schemes:

- HIRLAM (ECMWF) 3-dimensional multivariate OI analysis of the mass-, wind and humidity fields
- HIRLAM surface analysis of snow depths, ice coverage and SST

Output data:

- Complete set of model level fields including cloud variables, complete set of surface fields and surface fluxes at + 00h, +03h and +6h
- Post processed fields at pressure levels 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70 and 50 hPa.

Institution: SMHI

Time schedule: Preparations during 1 July - 30 October 1994.

Production during 1 November 1994 - 31 January 1995.

Appendix 20

Deutscher Wetterdienst
Zentralamt
Frankfurter Strasse 135
63067 Offenbach am Main

Statement for BSSG - Meeting, Geesthacht, May, 16 - 18, 1994

German Activities at DWD relevant for BALTEX

Within the framework of GEWEX, the German National Meteorological Service, Deutscher Wetterdienst (DWD) has established the Global Precipitation Climatology Centre (GPCC) which is preparing a global gridded data set for a period of 10 years of monthly precipitation data for global climate modelling. Further DWD has agreed to serve as regional data centre within Region VI of WMO for World Weather Records. At present data for the period 1981 - 1990 are requested from all member countries.
Within the Commission for Marine Meteorology (CMM) of WMO, DWD has offered to establish a global data centre for ship observations last year. This data centre will be located at the Seewetteramt, a regional office of DWD in Hamburg .
Subsets of the archivied data might be of interest for BALTEX and could assumebly be used within research projects.

With respect to BALTEX the DWD is presently preparing the establishment of the meteorological data centre (BALTEX-MDC).
Dr. Angela Lehmann will take the responsibility for the Centre. She will be assisted by a scientist funded for 3 years by the Federal Ministry of Research and Technology. The contract will start in June 1994.

Further support will be considered during the process of reorganization of the DWD and will hopefully be available by the end of 1995.

In preparation of data collection for the MDC a first questionnaire was distributed to get an overview on the availibility of observations and data sets in the region. The letter was addressed to the National Meteorological Services. The Science Steering Group will be informed on the results as early as possible. It is planned to start the operational storage of data disseminated via GTS in early 1995.

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