BALTEX

Baltic Sea Experiment

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

Minutes of

8th Meeting of the BALTEX Science Steering Group

at
Stockholm University
in Stockholm, Sweden
8 to 10 December 1998

edited by
Rüdiger Brandt

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

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Summary of Major Action Items

1. Prof. Raschke and Dr. Van Lammeren are asked to organise a workshop on clouds and radiation

2. Prof. Dera offers to organise a planning meeting in Sopot to coordinate and plan ship time for the *BRIDGE* period.

3. SMHI and the Rossby Center are asked to organise a workshop to interest people in an intercomparison project.

Introduction

The 8th meeting of the BALTEX Science Steering Group (SSG) was hosted by the Department of Meteorology at Stockholm University in Stockholm, Sweden. The meeting opened on Tuesday, 8 December, at 2 p.m. and closed at 1 p.m. on Thursday, 10 December 1999. A scientific symposium on „Field experiments in the frame of BALTEX" was held as part of the SSG meeting during the afternoon hours of 8 December. The agenda of the meeting including the symposium's speakers list is given in Appendix 1 of these minutes. See Appendix 2 for a list of this meeting's participants.

1 Opening

Prof. Peter Lundberg from the Meteorological Institute at Stockholm University (SU) opened the SSG meeting and expressed his cordial welcome to the meeting participants. He gave a brief historic review of the history of his institute which was founded by Rossby.

In his response the Vice-Chairman of the BALTEX SSG, Prof. Erhard Raschke, thanked Prof. Lundgren and his team at SU for hosting the SSG meeting in Stockholm. Prof. Raschke stressed that the institute at SU is a very famous one and that it has already hosted a number of meetings in the frame of BALTEX and EUCREX.

2 Symposium

Following earlier practice the SSG meeting continued with a scientific symposium, which was dedicated to the field experiments in the frame of BALTEX. See Appendix 1 for the agenda of this symposium and Appendix 3 for abstracts of the presentations given at the symposium.

The chairman of the symposium, Prof. Hilding Sundqvist, closed the symposium at 6.30 p.m.

3 Report of the BALTEX SSG Chairman

After approving the minutes of the 6th and the 7th SSG meetings and the checking of the action items of these meetings Prof. Bengtsson pointed out that the Interim Memorandum of Understanding for the conduction of BRIDGE has been very successful.

The chairman reported upon a talk he had at the CLIVAR implementation meeting with Prof. Chahine and Prof. Graßl. During that talk they expressed their satisfaction with the work which has been done so far within BALTEX. BALTEX is in a very good shape and it even by-passed the other Continental Scale Experiments (CSE).

Prof. Bengtsson stressed that the main point of this SSG meeting is the conduction and implementation of BRIDGE. The discussion on that should include the contents of BRIDGE, possibilities of funding (national and international), etc.. The time schedule has to be reviewed and a bottom line information which is needed has to be defined.

4 Report of the BALTEX Secretariat

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

4.1 Second Study Conference on BALTEX

Dr. Isemer reported that the conference was very successful. 182 participants gave 140 presentations (12 invited papers, 1 evening lecture, 127 conference contributions). Prof. Raschke reported that 30 papers were send in for publishing in a special issue of the Contributions to Atmospheric Physics. About 15 of these are planned to be published.

Dr. Isemer pointed out that 40.000 ECU funding were available for the conference. 46 participants were supported to take part in the conference.

The SSG again thanked the secretariat for the very good organisation of the conference.

4.2 BALTEX Data Centers

Progress made at the BALTEX Data Centres was briefly summarised by Dr. Isemer. The BALTEX Meteorological Data Center (BMDC) is operationally working. So far there have been 24 data requests, 10 requests during the last year. At the BALTEX Hydrological Data Center (BHDC) a change in the personal staff has caused some delay. So far there have been 1 or 2 data requests.

4.3 New BALTEX leaflet

Dr. Isemer presented the draft of a new BALTEX information leaflet. The SSG members were asked to send in their comments on that draft before X-mas 1998.

4.4 Further items

Dr. Isemer reported that a BALTEX Publication library is now online on the web. The library now needs input from all participating scientists.

Prof. Raschke informed the group that there is some money available to support scientists to work for a limited time period at the secretariat in Geesthacht. The secretariat was asked to announce that on the BALTEX home page.

4.5 Change in staff at the secretariat

Dr. Isemer informed the SSG that he will leave the secretariat at February 1st. He stressed that the reason for this is that GKSS offered a permanent position to him. In future times he will work on EU - funding possibilities for all scientists at GKSS. He thanked the SSG and all BALTEX participants for the very good co-operation during his work at the secretariat. He pointed out that it was a very interesting time and that the decision to leave the secretariat was very hard to make.

On behalf of the SSG and all BALTEX participants Prof. Bengtsson expressed his gratitude for Dr. Isemers engagement for BALTEX. He expressed his hope that the connection between BALTEX and Dr. Isemer will stay somehow in future.

5 Report of BALTEX Working Groups

5.1 Working Group Process Studies (WGP)

The chairman of the WGP, Prof. Eberhard Ruprecht, mentioned that the WGP organised the first field experiments. Now small workshops should be organised. The first workshop was held during the last conference on Rügen. At the beginning of 1999 a meeting with the modelling group within BALTEX should be held to discuss the needs of the modelers and possible contributions to that from the WGP.

Prof. Ruprecht stressed that in future cloud and radiation issues must be more emphasised.
Action: Prof. Raschke and Dr. Andre van Lammeren are asked to organise such a workshop.

Prof. Jouko Launiainen pointed out that efforts need to be done to measure the heat budget over the partially ice covered Baltic Sea. There is a need for a representative designed experiment.

5.2 Working Group Numerical Experimentation (WGN)

Dr. Nils Gustafsson reported that since the last meeting of the WGN in 1997 no other meeting has taken place. In spite of that a lot of modelling activities were carried out in different groups. The HIRLAM group has a close co-operation with the Baltic States (education workshops, work station transfer into these countries, model transfer).

Prof. Bengtsson suggested contacts to the Golizyn group in Moscow.

Prof. Källen reported that the SWECLIM group concentrates on climate modelling and anthropogenic effects. The group is setting up a 3D-model.

Prof. Anders Omstedt suggested a meeting of the WGN with the WGP with respect to air - sea interaction.

Prof. Bengtsson stressed that one aim of BALTEX is to deliver tools (coupled models and data assimilation tools) to the services at the end of BALTEX.

Dr. Skouratovich mentioned close links to the service in Moscow.

The SSG encourages closer links between WGN and WGP. A Workshop on critical issues like P - E, clouds, coupled modelling, etc. should be held.

5.3 Working Group Radar (WGR)

Jarmo Koistinnen reported that the BRDC is expected to run operationally from April 1st, 1999 onwards. More details are given in the minutes of the 3rd meeting of the WGR in appendix 4.

6. Report of the BALTEX Network co-ordinators

6.1 Coupled Modelling of the Baltic Sea

In his review Prof. Wolfgang Krauß, the chairman of this network, pointed out that the oceanographic data assimilation, transport through the Danish Straits and the development of a coupled ice-ocean model has already been done for three winters (1986, 1988, 1993). A ten years run including the BRIDGE period is planned. A run of a coupled atmosphere-ocean model (without sea ice) has been carried out.

Future items are as follows:

- implementation of sea ice
- 1993/94, 1995/96 model periods
- simulation of a longer period and water/energy budget calculations
- 10 years run.

Prof. Ann-Sophie Smedman pointed out the importance of the continuation of wave model runs. The WAM model is operational at SMHI, two other wave models are operational at FMI.

Prof. Bengtsson suggested that for the BRIDGE period two coupled Baltic Sea / Ice systems should be run. One at the IfM in Kiel, another model should be set up in the

HIRLAM/SWECLIM environment. Prof. Källen mentioned that the SWECLIM group can not commit to that for BRIDGE at present.

Prof. Laursen pointed out that a 3D - ocean model is not necessary for short range weather forecast, but a wave model has to be coupled because of the momentum exchange.

6.2 New Baltic II

Prof. Lennart Bengtsson reported that the UKMO left the group and that the KNMI is a new member of the New Baltic community.

On a planning meeting in de Bilt in November 1998 four subareas have been defined:

- better use of satellite observations; integrate GPS data (extended network)
- two independent data assimilation systems for BRIDGE: 1. DWD (including soil moisture), 2. HIRLAM group (including lakes)
- simulate climate aspect of the heat and water balance of the Baltic Sea (MPI Hamburg), T106 10 years run, forced with reanalysis data
- short time integrations (overprediction of precipitation, severe problems concerning clouds).

Prof. Bengtsson pointed out that NEW BALTIC II is central for the national services and that co-operations between hydrologists and meteorologists are in particular promising.

7 Report on NOPEX

Dr. Sven-Erik Gryning stated that NOPEX/WINTEX are long term continuous studies. WINTEX/NOPEX is dealing with

- local scale studies
- regional scale studies
- remote sensing aspects.

Within this project a data base SINOP exists. In that data base standard climate data, subproject data and data from external organisations are collected. Sven-Erik Gryning stressed that in a co-operation with BALTEX NOPEX should not be seen as a data delivery body. With respect to a co-operation with the two Experiments an important issue is the harmonisation of the database and an agreement on the data policy. It was pointed out that the NOPEX SSG sees a co-operation with BALTEX as an advantage.

8 Status and Preparation of BRIDGE

8.1 BRIDGE Task Force

Dr. Mikko Alestalo gave a short review on the work of the task force. He suggested to name persons for each item. He stated that more information is needed to know better what is realised with respect to the IMoU.

8.2 Atmospheric part

Dr. Nils Gustafsson reviewed the two 4DDA systems.

The DWD 4DDA is non-hydrostatic. It has got 7km resolution on an extended REMO grid. The assimilation is based on nudging and it includes latent heat nudging. They also use a variational soil moisture assimilation scheme. The hole system is tested in pre-operational mode. The HIRLAM 4DDA make use of the ECMWF computer, has got 20km resolution in the area from Greenland to the Ural.

During the Enhanced Observation Periods (EOP's) during BRIDGE additional radiosounds should be launched from Gotland. SMHI is willing to do that during the whole BRIDGE period. Dr. Mikko Alestalo tries to manage additional soundings on the Aland islands. The SSG suggested that additional soundings from ships/RV should be put into GTS.

8.3 Oceanographic part

Prof. Anders Omstedt reported that there was an ocean meeting at SMHI in Norrköping on November 15/16. The minutes of that meeting are in appendix 5.

Prof. Dera offers to organise a planning meeting in Sopot to coordinate and plan ship time for the BRIDGE period.

8.4 Hydrological part

Prof. Sten Bergström reported that there is a growing interest of Norwegian and Finnish hydrologists to join BALTEX.

SMHI and the Rossby Center are asked to organise a workshop to interest people in an intercomparison project.

9 Discussion on the Implementation of *BRIDGE*

A comprehensive and constructive discussion on the implementation strategy for *BRIDGE* led to decisions and recommended actions concerning preparations for *BRIDGE* which are summarised as follows:

9.1 New Time Plan

BRIDGE will be conducted in the period from **October 1999 to January 2002**. Modelling and observational activities during *BRIDGE* will be divided into

1) **a continuous base-line observational program** (comparable to the PIDCAP level) during the entire 28 months period, and

2) **specific enhanced observational programs** confined to limited periods of a few months duration. The latter will include the following periods:

- October 1999
- January/February 2000
- August/September 2000
- January 2001
- April/May 2001
- January 2002.

9.2 5th EU framework program

On February 22/23 there is a planning meeting at the GKSS Research Center. At this meeting the strategy how to apply for funds within the 5th EU framework program should be discussed and detailed.

10 Next SSG Meetings

The SSG concluded to convene for its 9th meeting on May 19-21, 1999 at the FMI in Helsinki. In connection with that meeting there should be a hydrological workshop (1 day).

11 Closing of the Meeting

The Chairman closed the SSG meeting at 1 p.m. on Thursday, 10 December 1998. He thanked all participants for engaged and constructive discussions. The participants of the meeting appreciated the excellent conduction of both the symposium and the SSG meeting at SU and expressed their thanks to Prof. Peter Lundgren and his team.

12 List of Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
BAHC	Biospheric Aspects of the Hydrological Cycle, IGBP subprogram
BALINEX	BALTEX Land Surface Experiment at Lindenberg
BALTEX	Baltic Sea Experiment
BALTRAD	BALTEX Radar Network
BASIS	Baltic Air-Sea-Ice Study
BASYS	Baltic Sea and Sea-Ice Modelling
BfG	Bundesanstalt für Gewässerkunde, Koblenz, Germany
BHDC	BALTEX Hydrological Data Centre
BMBF	Bundesministerium für Forschung und Technologie, Bonn, Germany
BMDC	BALTEX Meteorological Data Centre
BODC	BALTEX Oceanographic Data Centre
BRIDGE	The Main BALTEX Experiment, planned for 1999-2001
BSMO	Baltic Sea circulation model
CCM	Continuous Climate Monitoring
CEOP	Central Enhanced Observing Period
CFE	Concentrated Field Effort
CSE	Continental Scale Experiment
CT	Conductivity - Temperature
CTD	Conductivity - Temperature - Depth
DFG	Deutsche Forschungsgemeinschaft, Germany
DIAMIX	Diapycnal Mixing in the stratified ocean; Field experiment in BALTEX
DM	Deutschlandmodell, operational NWP model of DWD
DMI	Danish Meteorological Institute, Copenhagen, Denmark
DWD	Deutscher Wetterdienst, Offenbach / Germany
EC	Executive Committee
ECHAM	European Climate Model - Hamburg version
ECMWF	European Centre for Medium Range Weather Forecast, Reading / UK
EGS	European Geophysical Society
EM	Europamodell, operational NWP model of DWD
EMHI	Estonian Meteorological and Hydrological Institute, Tallinn / Estonia
ESA	European Space Agency, Darmstadt / Germany
EU	European Union
FIMR	Finnish Institute of Marine Research, Helsinki / Finland
FMI	Finnish Meteorological Institute, Helsinki / Finland
GAME	GEWEX Asian Monsoon Experiment
GCIP	GEWEX Continental Scale International Project
GEWEX	Global Energy and Water Cycle Experiment
GHP	GEWEX Hydrology Panel
GKSS	GKSS Research Centre, Geesthacht / Germany
GPCP	Global Precipitation Data Centre

Acronyms and Abbreviations (continued)

GRDC	Global Runoff Data Centre
GTS	Global Telecommunication System
HBV	Swedish Conceptual Hydrological Model for Runoff Simulation
HIRLAM	High Resolution Limited Area Model
HTM	Horizontal Transport Model
ICSU	International Council of Scientific Unions
IfMK	Institut für Meereskunde Kiel, Germany
IHPAS	Institute of Marine Sciences, University of Szczecin, Szczecin, Poland
IMGW	Institute for Meteorology and Water Management, Polish Hydromet Service
INTAS	International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union
IOPAS	Institute for Oceanology, Polish Academy of Sciences, Sopot, Poland
IOW	Institute for Baltic Sea Research Warnemünde, Warnemünde, Germany
KNMI	Royal Netherlands Meteorological Institute, De Bilt / The Netherlands
LBA	LAMBADA-BATTERISTA Experiment for Amazonia
IGBP	International Geosphere Biosphere Program
LHMA	Latvian Hydrometeorological Agency, Riga, Latvia
LIM	Leipzig Institute for Meteorology
LINEX	Lindenberg Experiment
LITFASS	Lindenberg Inhomogeneous Terrain Fluxes between Atmosphere and Surface - a DWD long-term Study 1995 - 2000
MAGS	Mackenzie River GEWEX Study
MAST	Marine Action in Science and Technology
MPI	Max-Planck Institute
MPIfM	Max-Planck-Institute for Meteorology, Hamburg, Germany
NASDA	National Space Development Agency of Japan
NCAR	National Centre for Atmospheric Research
NCEP	National Centres for Environmental Prediction
NEWBALTIC	EU project for BALTEX: Full-scale studies on the energy and water cycle of the Baltic Sea catchment region
NOPEX	Nordic Pilot Experiment
NWAHMS	North-West Administration of the Russian Federal Service for Hydrometeorology and Environmental Monitoring, St.Petersburg, Russia
NWP	Numerical Weather Prediction
PEP	Pilot Study of Evaporation and Precipitation in BALTEX
PIDCAP	Pilot Study for Intensive Data Collection and Analysis of Precipitation
PILPS	Project for Intercomparison of Land Surface Parameterization Schemes
REMO	Regional Model

Acronyms and Abbreviations (continued)

RS	Rawinsonde
RSHI	Russian State Hydrological Institute, St. Petersburg, Russia
SEWAB	Surface Energy and Water Balance Model
SMHI	Swedish Meteorological and Hydrological Institute, Norrköping/Sweden
SSG	Science Steering Group
SVAT	Surface-Vegetation-Atmosphere-Transfer
TRMM	Tropical Rainfall Measuring Mission
UKMO	United Kingdom Met Office
UNEP	United Environmental Programme
UV	Ultraviolett
WCRP	World Climate Research Program
WGNE	BALTEX Working Group on Numerical Experimentation
WGP	BALTEX Working Group on Process Studies
WGR	BALTEX Working Group on Radar
WINTEX	Winter Experiment in NOPEX
WMO	World Meteorological Organization

Appendix 1

8th BALTEX SSG Meeting

at Stockholm University (SU)
Stockholm, Sweden
8 - 10 December 1998

Agenda

Tuesday, 8 December 1998

14.00	1	**Opening, Welcome** Peter Lundberg, Hilding Sundqvist, Ehrhard Raschke
14.15	2	**Symposium** Field experiments in the frame of BALTEX (see separate agenda)
18.30		**Closing of the symposium**

Wednesday, 9 December 1998

9.00	3	**Opening of the SSG meeting** Report of the BALTEX SSG chairman L. Bengtsson
	4	**Report of the BALTEX Secretariat** H.-J. Isemer
	5	**Report of BALTEX Working Group chairmen** E. Ruprecht: WG Process Studies N. Gustafsson: WG Numerical Experimentation J. Koistinen: WG Radar
	6	**Report of BALTEX Network co-ordinators** L. Bengtsson, W. Krauß Reports on the field experiments are included in the symposium presentations.
	7	**Report on NOPEX** S.-E. Gryning
12.30		**LUNCH**

Wednesday, 9 December 1998 (continued)

14.00	**8**	**Status and preparation of *BRIDGE***
		The following topics will in particular be discussed, status reports are expected to be given by the individuals mentioned.
	8.1	**Overall status** (M. Alestalo)
	8.2	**Atmospheric part** (N. Gustafsson, M. Alestalo)
	8.3	**Hydrologic part** (S. Bergström)
	8.4	**Oceanographic part** (A. Omstedt)
	8.5	**Satellite data** (E. Raschke)
	8.6	**Radar and GPS** (J. Koistinen)
	8.7	**Field Experiments** (E. Ruprecht, S.-E. Gryning)
	8.8	**Funding aspects** (L. Bengtsson, E. Raschke)
	8.9	**Implementation meeting** (L. Bengtsson)
18.00		**Closing of Wednesday's session**

Thursday, 10 December 1998

9.00	**8**	**Status and preparation of *BRIDGE* (continued)**
12.00	**9**	**Further items**
	10	**Next SSG meeting**
12.30	**11**	**Closing of the meeting**

Explanatory Agenda

The central topic to be discussed at the upcoming 8th BALTEX SSG meeting will be the status and preparation of *BRIDGE*, the main observational and modelling period in BALTEX. Reports and items on the SSG meeting agenda should therefore concentrate on *BRIDGE* and *BRIDGE*-related matters. The possible co-ordination between NOPEX/WINTEX and *BRIDGE*, including issues related to joint funding applications, will be an important topic in this context. Relation and interactions of *BRIDGE* with the NOPEX activities near Uppsala and at Sodankyla will be discussed.

The SSG will have to prepare for an implementation meeting for *BRIDGE* to be held in early 1999 with expected participation of Weather Services, research institutes and universities which have so far signed the memorandum for the conduct of *BRIDGE*. The SSG members are expected to play an active role in the preparation of this meeting and *BRIDGE* in general.

Hans-Jörg Isemer
International BALTEX Secretariat
on behalf of the SSG chairman, Professor Lennart Bengtsson
4 November 1998

8th BALTEX Science Steering Group Meeting
at Stockholm University, Stockholm, Sweden
8 to 10 December 1998

Symposium on:

Field Experiments in the frame of BALTEX

The symposium will be held in the Manne-Siegbahn Institute at the University Campus.

Tuesday, 8 December 1998

14.00 **Opening and Welcome**
Peter Lundberg, Hilding Sundqvist, Ehrhard Raschke

Chair: ***Hilding Sundqvist, Stockholm University***

14.15 **Transport measurements from direct observations of motionally induced voltages**
Peter Sigray, Stockholm University, Stockholm, Sweden

14.40 **DIAMIX: 'Diapycnal Mixing Experiment in the Baltic Sea'**
Anders Stigebrandt, Gothenburg University, Gothenburg, Sweden

15.05 **Numerical modelling of the Baltic at MISU**
Kristofer Döös, Stockholm University, Stockholm, Sweden

15.30 **BASIS: 'Baltic Air-Sea-Ice Study'**
Jouko Launiainen, Finnish Institute of Marine Research FIMR, Helsinki Finland

15.55 **Break**

Chair: *N.N.*

16.25 **PEP: 'Pilot Study of Evaporation and Precipitation in BALTEX'**
Ann Sofi Smedman, Uppsala University, Uppsala, Sweden

16.50 **LITFASS: 'Lindenberg Inhomogeneous Terrain - Fluxes between Atmosphere and Surface: a Long-term Study'**
Frank Beyrich, German Weather Service DWD, Lindenberg Observatory, Germany

Field Experiments in the frame of BALTEX
(continued)

Tuesday, 8 December 1998

17.15 **Planned KNMI contributions to LITFASS and BALTEX**
Andre van Lammeren, The Netherland's Weather Service KNMI, De Bilt, The Netherlands

17.40 **The Wilga catchment experiment - Research results**
Ewa Bogdanowicz, Institute of Meteorology and Water Management IMWM, Warsaw, Poland

18.05 **NOPEX/WINTEX**
Sven-Erik Gryning, Risö National Laboratory,Roskilde, Denmark

18.30 **Closing of the Symposium**

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Appendix 2

Participants at 8th BALTEX SSG meeting , 8 – 10 December 1998, Stockholm, Sweden

Mikka Alestalo	FMI, Helsinki, Finland
Lennard Bengtsson	MPIfM, Hamburg, Germany
Sten Bergström	SMHI, Nörrköping, Sweden
Frank Beyrich (for Prof. Müller)	DWD, Lindenberg, Germany
Rüdiger Brandt	GKSS, Geesthacht, Germany
Jerzy Dera	IOPAS, Sopot, Poland
Sven-Erik Gryning	Risoe, Roskilde, Denmark
Nils Gustafsson	SMHI, Nörrköping, Sweden
Hans-Jörg Isemer	GKSS, Geesthacht, Germany
Erland Källén	MISU, Stockholm, Sweden
Peeter Karing	EMHI, Tallinn, Estonia
Jarmo Koistinen	FMI, Helsinki, Finland
Piotr Kowalczak	IMGU, Poznan, Poland
Wolfgang Krauß	IfM, University Kiel, Germany
Jouko Launiainen	FIMR, Helsinki, Finland
Leif Laursen	DMI, Copenhagen, Denmark
Angela Lehmann	DWD, Offenbach/Main, Germany
Anders Omsted	SMHI, Nörrköping, Denmark
Ehrhard Raschke	GKSS, Geesthacht, Germany
Dan Rosbjerg	ISVA, Lyngby, Denmark
Eberhard Ruprecht	IfM, University Kiel, Germany
Ivan M. Skuratovich	CHB, Minsk, Belarus
Ann-Sofi Smedman	MIUU, Uppsala, Sweden
Hilding Sundquist	MISU, Stockholm, Sweden
André van Lammeren	KNMI, AE de Bilt, Netherlands
Valery S. Vuglinsky	RSHI, St. Petersburg, Russia

Transport measurement from direct observation of motionally induced voltages

Peter Sigray[1], Peter Lundberg[1] Tim Fristedt[1] and Lennart Crona[2]
[1]Meteorological Institution/Physical Oceanography, Stockholm University, Stockholm, Sweden
[2]Defence Research Establishment, Stockholm, Sweden

Foreword: A seminar was hold at the symposium on: Field Experiments in the Frame of BALTEX the 8:th of December 1998. The seminar is summarised in this paper.

Abstract: Two main field trials have been performed in order to investigate the method of measuring motionally induced voltage (MIV) in shallow water environments. The first measurement, was carried out in the channel of Björnsund. A narrow channel with a rectangular cross-section. The water mass was well mixed and the flow was constant throughout the whole cross-section. An excellent agreement between flux measured with a current meter and the method of induced voltage was obtained. The second measurement was performed in the Sound at Öretvisten where a stratified flow was found. The barotropic flow in the Sound was measured with the MIV method despite the fact that both the layer's velocity and thickness were changing during the measurement.

INTRODUCTION

In 1832 Faraday claimed that electromagnetic induction created electrical fields in the oceans. Since then, measurements of induced voltages have been shown to be a useful tool for monitoring volume transport fluctuation. Prior experimental investigations of induced electrical fields have repeatedly focused on large-scale ocean currents. The efforts of monitoring small-scale rapidly-changing flows have been somewhat neglected. Nevertheless, since eutrophication and pollution of fjords, bays and estuarine environments have increased during the last decades, a better understanding of coastal areas is needed.

The method of MIV has an advantage compared to ordinary velocity measuring sensors in that it is possible to continuously monitor the total flow through a strait with an arbitrary sampling frequency. Since the recording equipment is located on shore it will not be limited by battery life or data dumping. In contrast to the ADCP (Acoustic Doppler Current Profiler), the deployed electrodes are easy to handle from a small boat and are relatively inexpensive. Compared to point sensors, which have to be placed in the free stream, the electrodes placed on the bottom are in principal unaffected by shipping trade and navigation. For studies where water transport in narrow straits are of interest the motionally induced voltage technique could be a suitable tool and a valuable complement to point sensor and ADCP measurements.

2. THE METHOD

Superimposing a geomagnetic field B upon an oceanic velocity field $v = (u,v,w)$ will, according to Faraday's law of induction, give rise to an electrical field $E=\bar{v}x\bar{B}$. The finite electrical conductivity σ of seawater will allow an electrical current through the fluid. Following Ohm's law the current density vector J at each point in the fluid is equal to the sum of the voltages times the conductivity. By introducing the potential, $E=-\nabla\Phi$, this relationship assumes the following form:

$$\nabla\Phi = \bar{B} \times \bar{v} - \frac{\bar{J}}{\sigma} . \qquad (1)$$

This equation is based on the assumption of a quasi-steady B-field, which is justified on the grounds that the fluctuations of the earth's magnetic field are much smaller than the stationary components. By integrating the cross-channel component vertically from a depth $z = -H_s$ (where nonconducting bedrock is encountered) to the free surface at $z = 0$, the following expression is obtained:

$$\int_{-H_s}^{0} \sigma\frac{d\Phi}{dx}dz = \int_{-H_s}^{0} \left(\sigma\left(B_z v - B_y u\right) - J_x\right)dz . \qquad (2)$$

This equation can be further simplified by noting that the water motion primarily is aligned with the channel ($v >> u,w$), and that the vertical component of the earth's magnetic field is much larger than the horizontal components ($B_z >> B_x$, B_y). Hence the product $B_y u$ will be small, and consequently $J_x >> J_y$, J_z. The vertical integral of J_x, viz. the "average" of the main electrical circuit, must be equal to zero since the bottom is nonconducting. This scaling will also cause the horizontal gradient of the scalar field Φ to be constant with depth, and hence the following equation is obtained:

$$\frac{\partial\Phi}{\partial x} = B_z v^* ; v^* = \int_{-H}^{0} \sigma v dz / \int_{-H_z}^{0} \sigma dz . \qquad (3)$$

Where H is the channel depth and v^* is the conductivity-weighted vertical average of the velocity. From this expression it is recognised that for non-stratified homogeneous flow in a channel with a horizontal nonconducting bottom, σ plays no rôle for the induced cross-channel potential difference, $d\Phi$. It can be shown from (1) that the directly observable quantity U in volts, is related to the total volume flow Q in m^3/s as

$$U=\delta\Phi=\frac{B_Z Q}{H} \quad . \qquad (4)$$

3.1. THE CHANNEL OF BJÖRNSUND

The channel of Björnsund is an artificial narrow channel of about 250 m length constituting the northern passage between the Havstensfjord and the Skagerakk via the Malö Strömmar. The channel also separates the island of Orust and the mainland. The channel is 45 m wide and has a depth of approximately 9 m. The cross section is approximated to be of a rectangular shape giving a cross sectional area of 405 m^2. The flow in the channel is characterised by a strong tidal signal composed mainly of M_2 tide. The strong tide together with the geometry of the channel give rise to very high current velocities (often up to 2 m/s) as well as to a homogeneous water mass passing through the channel. The water mass passing through the channel may be regarded as well mixed causing both temperature and salinity to be constant during the measurement.

3.2. THE CHANNEL OF BJÖRNSUND: MEASUREMENT

The current was measured with a Gyttre SD-6000 current meter programmed to sample at an interval of 5 minutes. It was placed 2 m from the bottom, approximately midway in the channel in order to detect the free stream velocity. The Gyttre current meter has a current velocity accuracy of 0.5 cm/s and the direction can be determined within ±2°.

Two pairs of Ag/AgCl were deployed in the channel during neap. The distance between the two pairs were approximately 50 meters. The distance between the sensors and the acquisition system were 100 to 150 meters. There was no need for preamplifiers, since the induced signal strength was of the order of 1 mV. The signal from each electrode was connected to the acquisition system with an unshielded copper cable. The electrode signals were directly connected to a high impedance multimeter. All channels were recorded simultaneously with a frequency of 0.2 Hz and a delay between each channel of 0.015 s. Data was transferred to a PC and displayed in real time. The raw induced voltage signal and the measured velocity are shown in Fig. 1. The M_2 tide as well as higher harmonics are clearly observed.

A LSF between the transport and the voltage was performed. The result is shown in the scatter plot in Fig. 2 showing an r^2 value of 0.98. The linear model with the 95 % confidence limits can be summarised as follows :

$$Q = \left(\frac{h}{B_Z}\right) \cdot U + m$$

$$\left(\frac{h}{B_Z}\right) = 204229 \pm 5463 \left[\frac{m^3}{Vs}\right]$$

$$m = -131 \pm 5.7 \left[\frac{m^3}{s}\right]$$

Where m is the offset difference between the electrodes expressed as a volume transport. The results from the LSF are in accordance with a perfectly working model.

4.4. THE CHANNEL OF BJÖRNSUND: CONCLUSIONS

The motionally induced voltage in a narrow channel of rectangular shape has been measured. The measured signal is composed of two strongly dominating components the M_2 (12.42 h) and the M_4 tide (6.21 h). All in accordance with shallow water tidal phenomena. Comparing data measured

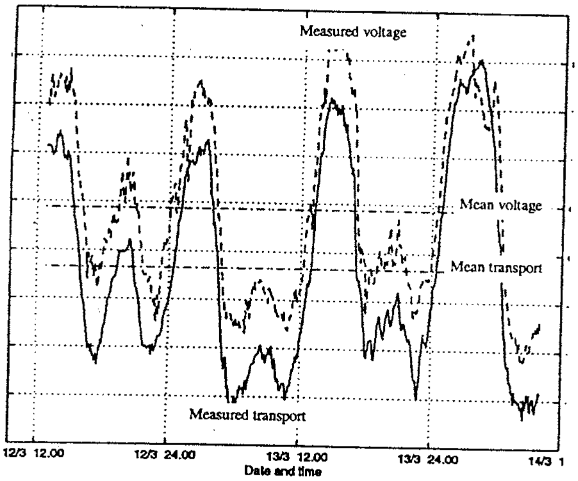

Fig. 1. The dashed line shows the data of the measured voltage and the full line the velocity measured by the current meter. The agreement is good.

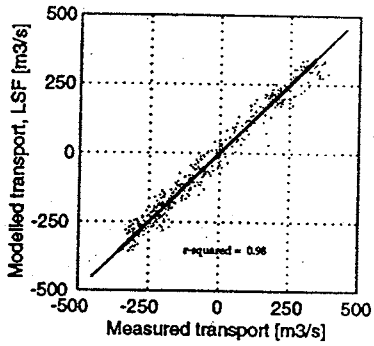

Fig. 2. Scatter plot of data. A good agreement is achieved between the measured velocity and the MIV method signal.

with the current meter with that from the MIV method a very good agreement is achieved.

As a final remark, it has been shown that the Ag/AgCl electrode works well in coastal environment where background noise is usually high. Furthermore, it is possible to measure modest transports, often encountered in shallow waters. The fit between flow calculated from current-meter and induced voltage data is better than 3 %. The small disagreement is mainly limited by uncertainties in the cross-section and by lack of detailed knowledge of the flow.

5.1 THE SOUND

The results from the channel of Björnsund show that the method of MIV is applicable to shallow water environments. However, the Sound and the channel of Björnsund are of course not fully comparable. First, the flow in the Sound is not as well experimentally controllable as is the case of Björnsund. Secondly, a stratified water volume is found in the Sound, especially in the region around Helsingborg and Helsingör. In order to investigate the MIV method's robustness, regarding stratified flows, a field trial was performed in this region. Data were recorded between May 8:th and May 13:th 1996. The measurement was carried through at Öretvisten between Helsingborg (Sweden) and Helsingør (Denmark), in the northern part of the Sound, in that a multilayer flow situation would be ensured. The location is a sill, dividing the Sound (in which a salt wedge often is found) from the Kattegat. The upper layer of the salt wedge is continuously mixed along the salt wedge, and when entering the Kattegat the upper layer salinity is increased to around 20 psu. Despite this increase, the Kattegat is often found to be strongly stratified, since the Kattegat bottom water has a salinity between 32-34 psu. Two Gyttre SD-2000 current meters located at the pilot buoys M_3 and M_4, were used to measure the velocity of the dynamically more active upper layer at Öretvisten. In addition to this current data, a time series of the depth velocity profile was acoustically measured at Drogden.

5.2 THE SOUND: MIV AND STRATIFIED FLOWS

The technique of MIV has been shown to work in open ocean conditions, where the signals measured reflects the horizontal and vertical average of the velocity field situated between two far distanced electrodes, i.e. the horizontally averaged barotropic transport perpendicular to the axis connecting the electrodes. In the light of (1) together with the fact that the conductivity is the inverse resistance ($\sigma = \rho^{-1}$), it is tempting to adopt a somewhat more intuitively physical approach. The system can be compared to an electrical circuit scheme, where the water layers correspond to electromotoric forces (EMFs) with an electric potential of $H_z vL$ (L is the distance between the electrodes). Each EMF also possess a inner resistance R, which can be associated to the resistivity (or conductivity) through $R = \rho W A^{-1} = W(\sigma A)^{-1}$, where W is the width of the Sound. Solving for the measured voltage $\Delta V = E_i - R_i i_i$, the following expression is found

$$\Delta V = \frac{E_1 R_2 + E_2 R_1}{R_1 + R_2 + \frac{R_1 R_2}{R_b}} . \qquad (6)$$

Where the upper layer is denoted *1*, the lower *2* and the bottom *b*.

A fundamental assumption leading to expression (6) is that the water volume can be described as a 3-layer system. Thus, unknowns are conductivities and EMF (velocities) of the layers. To fully solve expression (6) all 5 unknown parameters have to measured simultaneously to determine one of the 6 parameters. Experimentally these requirements are seldom fulfilled. Instead useful approximations have to be introduced into (6) which makes an interpretation of a single MIV sensor signal possible. The following three assumptions are made for the Öretvisten region: First it is assumed that the shortening through the bottom is negligible. This assumption is supported by bottom sediment measurement showing a wedge of bedrock structure at Öretvisten, which effectively insulates the sea bottom. Second, the velocity of the lower layer is low, hence, it is set to zero in (6). The last assumption that is made is concerning the upper and lower layer thickness. Comparing the measured current at the pilot buoy with the MIV signal, see Fig. 4, it is clear that the upper layer velocity was unchanged during the measurement despite the fact that the total flow was decreasing, as indicated by the MIV signal. The only satisfying explanation that can be given is that the thickness of the upper layer was decreasing. By making use of the pilot buoy and the MIV it would be possible to extract the change of the thickness of the upper layer. However, as pointed out earlier, an estimate of the barotropic flow is desired solely from a single MIV sensor. Hence, the ratio h_1/h_2 is set to 1. This assumption can be regarded as somewhat arbitrary, but it will later be shown that the MIV technique is rather robust and the influence of this choice is weak.

Expression (6) can now be written as:

$$v_1 = \frac{\Delta V}{H_z L}(1 + \gamma\kappa). \qquad (7)$$

Here, γ is the ratio between the conductivities in the lower and the upper layer, while κ is the ratio between the thickness of the lower and upper layer.

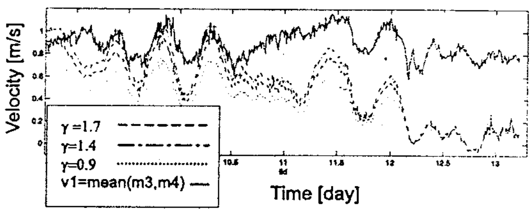

Fig. 3. The measured average velocity between the M_3 and M_4 buoys is shown as a full line. The γ tuned MIV signals are plotted as broken lines. The γ parameter is tuned between 0.9 and 1.7. The abscissa covers the five days of measuring.

γ can approximately be set to 1.6, κ is set to 1, i.e. h_1 • h_2. The result is shown in Fig. 3, from which it is apparent that the current meter located in the upper layer and the "MIV sensor" are not measuring the same property of the flow. It is also obvious that by tuning the MIV signal (by changing the κ and γ parameters) it is not possible to decrease the discrepancy between the signals. These evidences indicate that the "MIV velocity" should be interpreted as a "barotropic velocity" rather than a true velocity. Consequently, a comparison between the pilot buoy velocities and the MIV signal is not relevant to make.

As a final test on these statements a comparison was made with an ADCP measurement performed at Drogden. It has to borne in mind that the two measurements are separated with a distance of 55 km. A direct comparison is difficult to make. The two signals are shown in Fig. 4. The agreement is good. The weakening trend is clearly observable in both signals. The discrepancy in the beginning is due to the first-time-baptism of the electrodes.

5.3 THE SOUND: CONCLUSIONS

The electrical potential on the bottom of Öretvisten (in the northern part of the Sound, between Sweden and Denmark) was measured during 5 days. Simultaneous measurements of the local current velocity in the upper layer and the total flow at Drogden could be associated to the voltage signal. The slow trends in voltage signal is seen to reflect total volume flow, while the more rapid fluctuations are due to local phenomena. However, the most important aspect shown herein, is the robustness of the MIV technique for measuring the total volume flow. It has been shown that, despite a strong stratification and a multilayered flow, the voltage signal mirrors the total transport. A simple fit between the measured voltage and the transport would then be sufficient in order to accomplish a monitoring of the transport in the Sound.

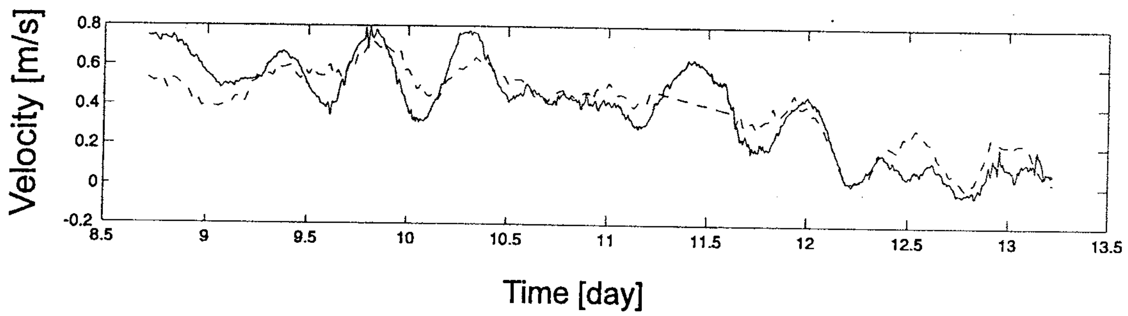

Fig. 4. The measured signal at Drogden plotted together with the measured signal from the Sound. A good agreement is achieved. The MIV velocity is plotted wit a full line and the measured velocity at Drogden with a broken line.

PEP in BALTEX

1.Introduction and overview of the project structure and goals

PEP in BALTEX is a preparatory experiment to the BALTEX Mean Experiment, BRIDGE, and aims at developing reliable methods for determination of evaporation and precipitation over the Baltic Sea. The starting date of the project was 1 November, 1997, and the work is scheduled to be completed within a three year period. The following groups are participating in the project:

Department of Meteorology, Uppsala University, *MIUU* (now: Department of Earth Sciences, Meteorology), Uppsala, Sweden, Coordinator

Risö National Laboratory, Denmark, *Risö*, Contractor

Max-Planck-Institut, Hamburg, Germany, *MPI*, Contractor

Finnish Meteorological Institute, Helsinki, Finland, *FMI*, Contractor

Swedish Meteorological and Hydrological Institute, Norrköping, Sweden, *SMHI*, Contractor

Institut für Meerskunde, Kiel University, Kiel, Germany, *IfM*, Contractor.

2. Work performed within the project during its first year

For obvious reasons the work during the first year of PEP has to a large extent been concerned with establishing the measurements that will constitute the Continuous Measurement Programme and with the Concentrated Field Effort. Measurements were thus performed at the sites Zingst, siuated on the German Baltic Sea coast; Christiansö; Östergarnsholm and Kopparnäs, Figure 1. But concurrently, work has also began in several of the other research areas of the project, as outlined below.

2.1. The continuous measurements of evaporation

Photographs of the four measuring sites are shown in Figure 2. These sites are all equipped with instrumentation for continuous measurement of the water vapor flux with the eddy correlation technique at a height of about 10 m above mean sea level. The exposure of the sites to wind directions with long undisturbed over water fetch varies, however considerably, and there is also additional instrumentation at most of the sites. Some of these site-specific features are outlined below for each of the sites.

The southernmost site is *Zingst*, which is situated at the German coast, cf. Figure 1 and 2a, and operated by MPL. It is instrumented with a sonic anemometer of the METEK type plus a LICOR closed path system for measuring humidity fluctuations. At the site there is also a micro-rain radar. About 30 km north of the measuring station there is a wave buoy. The site is open to winds coming from the sector 290° - 70°, over north. The site is a sand beach, with gently sloping bottom. It means that a certain coastal influence is likely to to be felt at this site even in cases with winds coming from the sea. This is clearly illustrated in Figure 3, which shows examples of measurements from Zingst from the beginning of October. From the three upper graphs distinct diurnal trends can be seen in the curves for temperature, sensible heat flux and latent heat flux respectively. These graphs should be compared with corresponding graphs from the Christiansö site, Figure 4. Although Figure 3 and 4 are not from exactly the same time period, they are close enough in time - Figure 4 starts a week after the end of Figure 3 - for a general comparison of diurnal trends. In fact, no such trends are discernable in the figure from Christiansö, see further discussion below. Thus, in conclusion, it is likely that the Zingst site is representative of a coastal zone characteristic for beaches with gently sloping bottom.

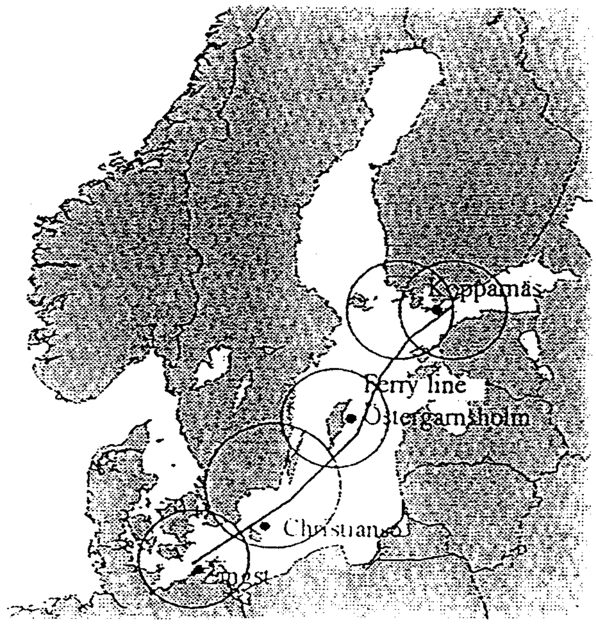

Figure 1. Map of the Baltic Sea and surrounding land areas, showing the 4 sites of the continuous measurements programmes: Zingst, Christiansö, Östergarnsholm and Kopparnäs. Also indicated, in a schematic way, is the extension of ferry boat routes between Germany and Finland (cf. Figure 6, which shows actual routes).

The *Christiansö* site, Figure 1 and 2b, is operated by Risö. A 10 m high mast has been erected on a very small island near the main island Christiansö. The mast is instrumented with a SOLENT sonic anemometer and an Ophir open path instrument for measuring humidity fluctuations. At the site there is also a micro-rain radar. The site is exposed to winds coming from the approximate sector 120° - 300° over south. The sea floor outside the island drops

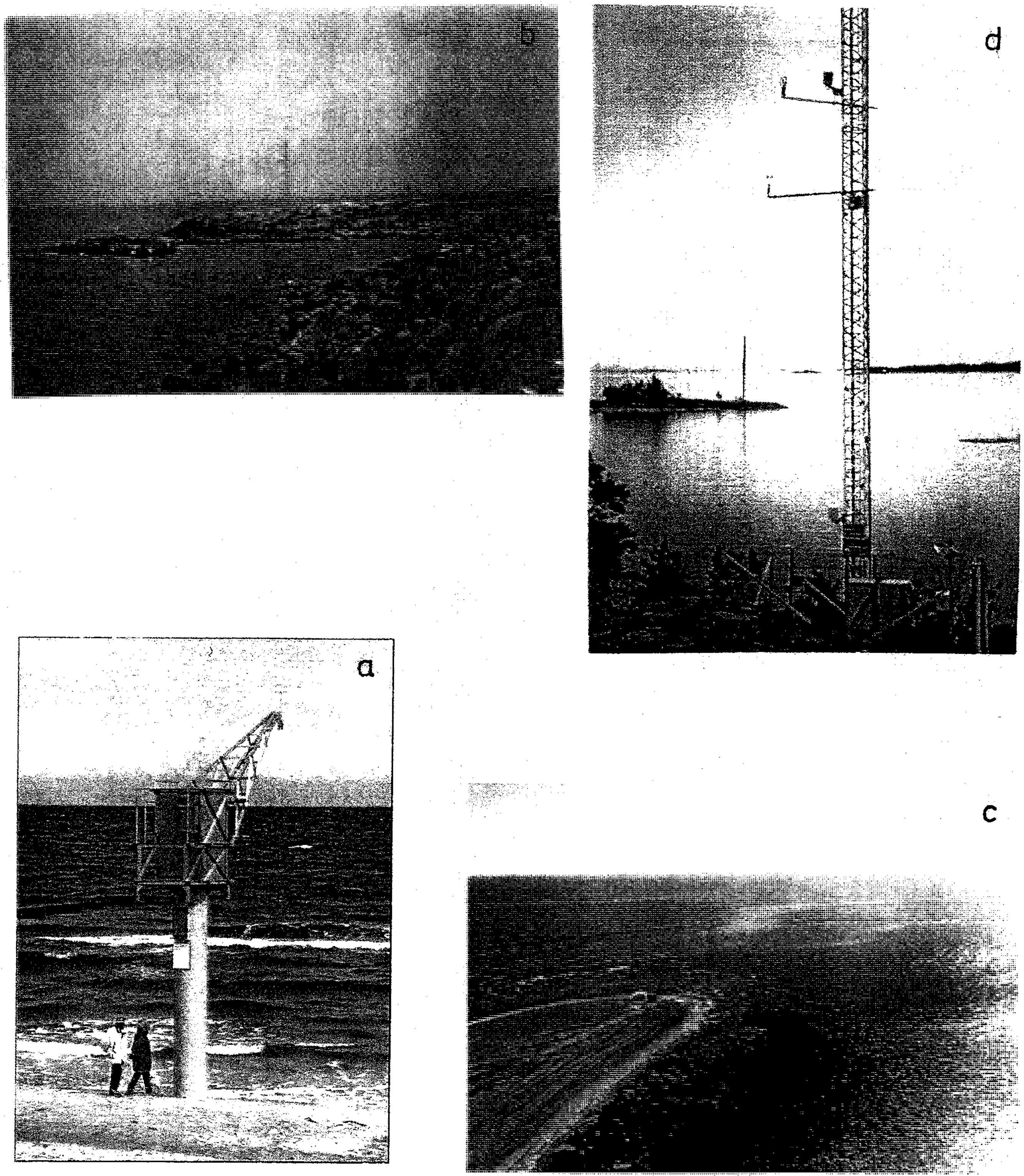

Figure 2. Photographs from the 4 sites for continuous measurements of evaporation and precipitation: a. Zingst, b. Christiansö; c. Östergarnsholm and d. Kopparnäs.

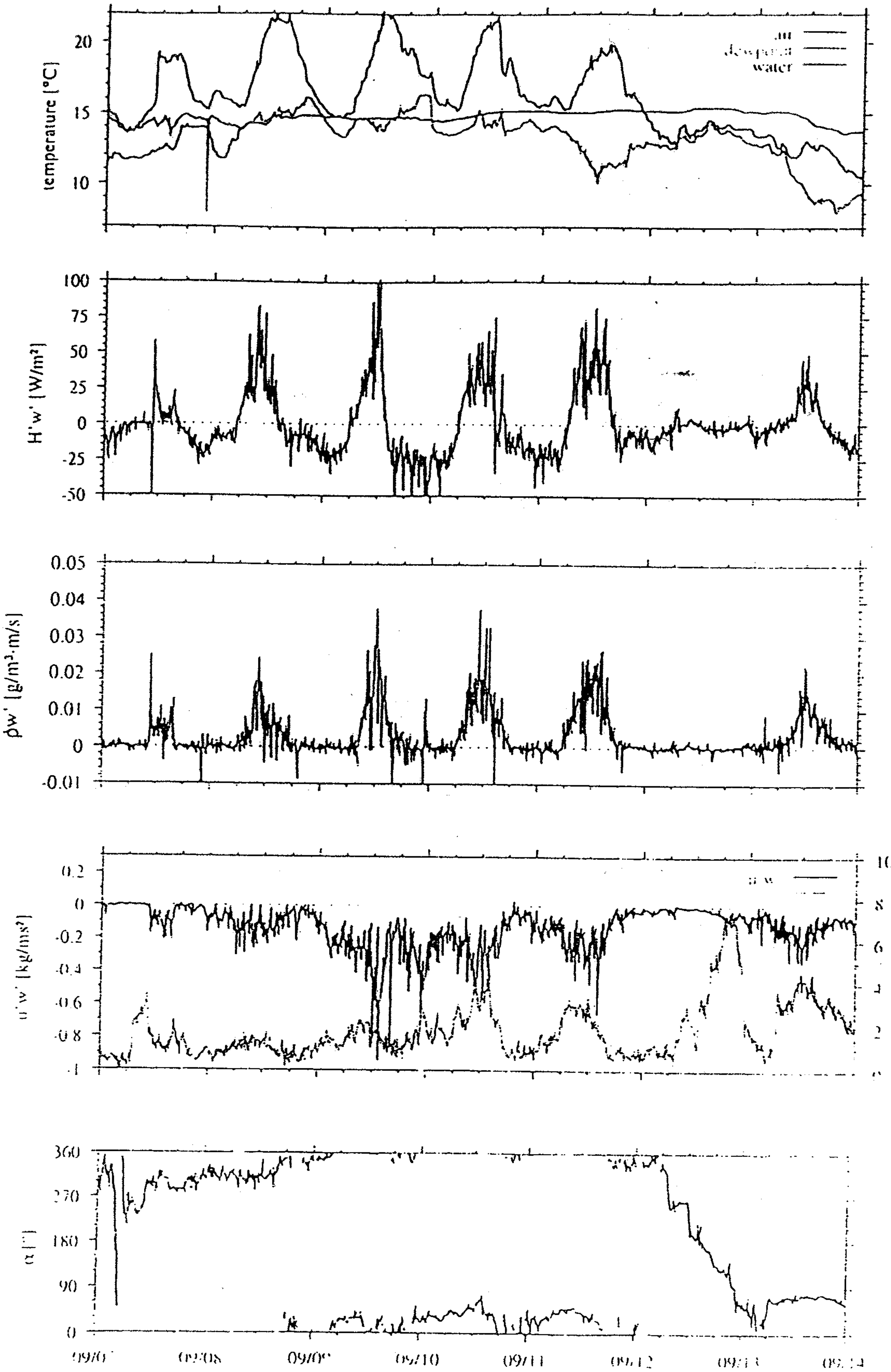

Figure 3. Example of measurements from Zingst, for the time period 7 - 14 September, 1998. Legend, in order from top of the figure: temperature (air, dewpoint and water); sensible heat flux; water vapor flux (evaporation); kinematic momentum flux and wind direction respectively. Wind directions from outside the grey band are from the sea.

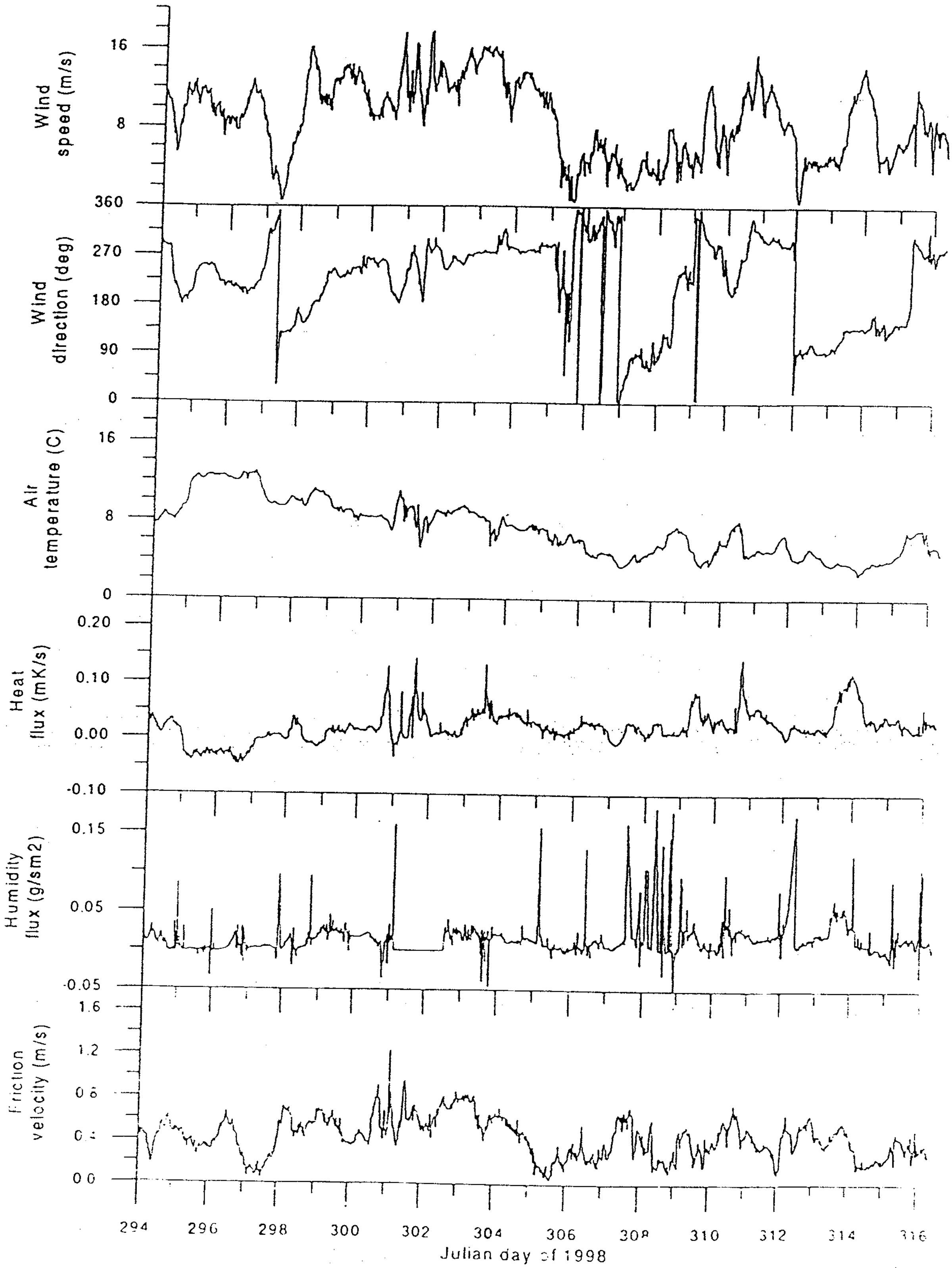

Figure 4. Measurements from the Christiansö site for the period 21 October to 11 November, 1998.

rapidly to relatively great depths, so that the measurements from the undisturbed sector are likely to represent open sea conditions fairly well. Figure 4 shows an overview of the result of the measurements at this site during the Concentrated Field Effort, 21 October - 11 November, 1998.

The *Östergarnsholm* site, Figure 1 and 2c, is operated by MIUU. In addition to the humidity flux measurements at 9 m, performed with the aid of a SOLENT sonic anemometer and a LICOR, there is a lot of additional measurements at this site (financed by other sources than EU PEP in BALTEX). Thus, there is a 30 m high tower, instrumented with sonic anemometers at three levels and, in addition, slow response ('profile') sensors of temperature and of wind speed and direction at 5 levels plus sensors for global radiation and atmospheric pressure. There is also an IfM 'ship rain gauge' installed at the site, which records precipitation on a continuous basis. Side by side with this instrument there is a micro-rain radar. About 4 km southeast of the site there is a 3D wave-rider buoy. The site is exposed to open water fetch for the approximate sector from 60° over south to 220°. The sea floor outside the peninsula where the tower is situated drops rapidly to depths in excess of 20 m. Thus for most conditions, the site is likely to give results that are fairly representative for open sea conditions. Nevertheless, a special study is under way (financed from other source than PEP) to investigate systematically how the incident wave field is influenced during different conditions, with the possible implications this may have with respect to the measured fluxes.

The *Kopparnäs* site, Figure 1 and 2d, which is operated by FMI, contains several instrumented masts, but for the PEP project flux measurements are performed on a mast situated on a small island, Gåsören, seen to the left in Figure 2d. The humidity flux is measured continuously with a combination of a SOLENT anemometer and a special humidity sensor with about 1 Hz response time. The site is open to winds from a southerly sector, but there are some minor islands upwind as can be seen from the photograph, Figure 2d.

The continuous measurements started on schedule 1 May, 1998 at all four stations and have run with only minor breaks at Zingst, Christiansö and Kopparnäs. The eddy correlation measurements at 9 m at Östergarnsholm were plagued by numerous problems, so that direct flux measurements were only obtained during about 30 percent of the time. Later in the project when a reliable bulk formulation for computing evaporation has been derived, accurate data can be calculated for the remaining 70 percent of this time period as well. Since the start of the CFE (12 October, 1998) the water vapor flux measurements at Östergarnsholm are, however, operational.

The micro rain radar measurements are also part of the continuous measurements. Figure 5 shows an example of a rain event as depicted by one of the micro-rain radars. Particularly interesting is the course of events in the later part, where it is seen that only a minor part of the heavy rain occurring at 500 m (the dotted line) actually reaches the ground. The occurrence of this kind of feature is crucial in the interpretation of the composite radar images.

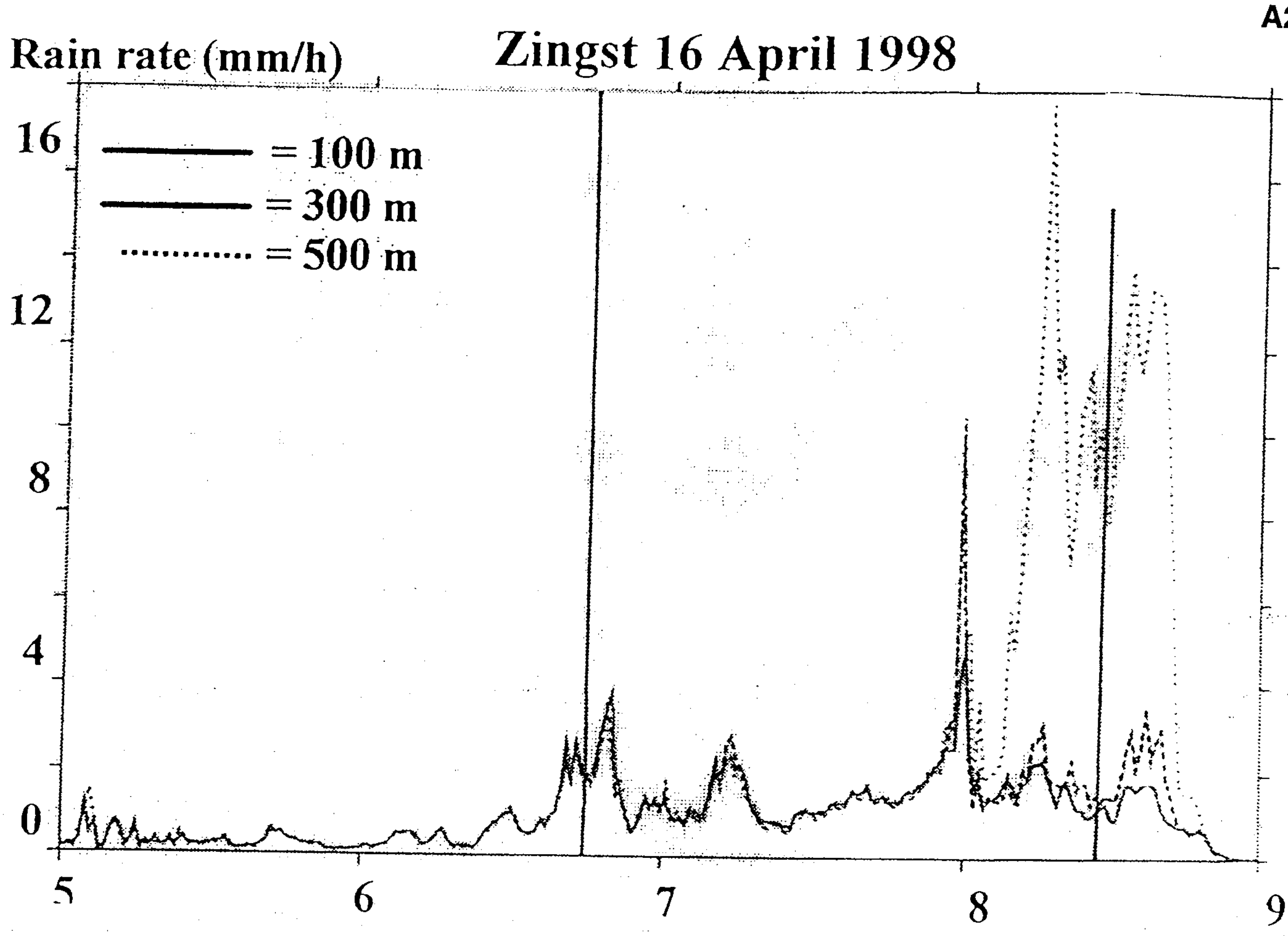

Figure 5. Example of a micro rain radar recording from Zingst, showing rain intensity as a function of time and height.

Ferry boat measurements of precipitation are also occurring on a continuous basis as planned. Figure 6 shows the routes traversed and also a comparison of measured precipitation against precipitation simulated with the German Weather Forecast model for one particular month, May, 1998.

2.2 The Concentrated Field Effort.

A Concentrated Field Effort was launched during the time period 12.10.98 to 12.11.98. From a meteorological point of view, the CFE period was characterized by strong cyclonic activity, with many high wind periods, reaching near to full storm (25 m s^{-1}) and many precipitation periods. The latter was very good for the distrometer rain measurements on board the RV Heincke. These measurements are very accurate and are thus expected to be extremely useful for validation of the composite weather radar pictures.

The high winds that occurred especially during the first half of the CFE hampered the execution of radio soundings at Christiansö and Östergarnsholm. Nevertheless, at Östergarnsholm there were carried out radio soundings on 34 occasions and pilot balloon wind measure-

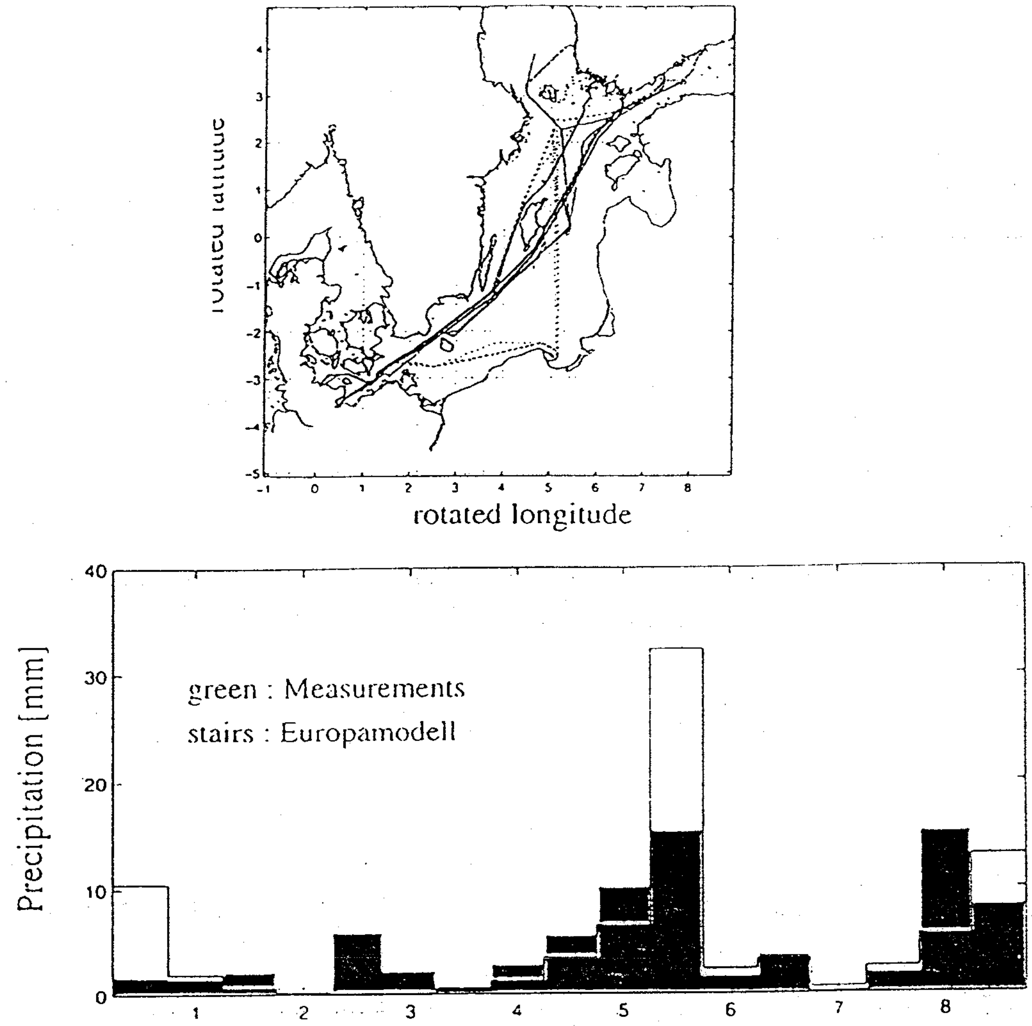

Figure 6. The map shows cruises of ferries measuring precipitation for May, 1998 (dotted lines) and of RV Heincke (full lines) during the Concentrated Field Effort 29 September - 5 November, 1998. The lower figure shows measured precipitation on all ferries as a function of the rotated longitude of the European Model of the Deutscher Wetterdienst in May, 1998. The predicted precipitation of this model is shown for comparison.

ments on 35 occasions (3 balloons each time); additional radio soundings were carried out 4 times per day by SMHI at Visby, which is situated on the western side of Gotland, some 50 km from Östergarnsholm (other financing than EU PEP). At Christiansö radiosoundings were carried out every day at 12 noon (except for during a couple of days with extremely strong winds); in addition, during two days soundings were performed with 3 hour intervals. Also at Kopparnäs, daily radiosoundings were performed during the CFE.

The MPI group made a very substantial effort during the CFE. They operated their combined installation of a Differential Absorption Lidar (DIAL), a laser celiometer and an UHF RADAR/RASS throughout the CFE at a well exposed coastal site on Gotland, situated only about 7 km from the Östergarnsholm site. A recently developed coherent low power Doppler lidar to measure the vertical wind with very high resolution was operated for the first time side by side with the RADAR/RASS. The quick views of the data during the campaign are very promising as far as quality and continuity of the measurements are concerned. The measurements will provide vertical profiles of water vapor flux, sensible heat flux and momentum flux as well as boundary layer height. These results will be subject to detailed comparisons with corresponding simultaneous data from Östergarnsholm and from RV Heincke, during the time periods of several days that the ship took measurements just outside Östergarnsholm.

2.3 Other work carried out during the first year

All work reported below must be regarded as first steps on work that will continue throughout the three year project period.

Work has been done by a PhD student, Anna Rutgersson, at SMHI under joint supervision from and co-operation with MIUU and SMHI to validate the performance of the Swedish weather prediction model HIRLAM concerning surface fluxes of water vapor, sensible heat and momentum over the Baltic Sea against measurements from Östergarnsholm. Figure 7 shows typical results. For the month of March, 1998 it gives, Figure 7a, the sensible heat flux, and Figure 7b, the latent heat flux (evaporation expressed in energy units). The crosses are measured values from Östergarnsholm, the full curve with dots the operational HIRLAM results and the remaining curves are results obtained with two alternative parameterizations for the bulk exchange coefficients and from simulation with the oceanographic model PROBE, the circles. It is notable that the present HIRLAM model version generally overestimates both evaporation and sensible heat flux. It is also gratifying that the PROBE model, which will be used in later in the project for estimation of the evaporation over the entire Baltic Sea for a 12 month period, gives such good agreement with the measurements.

SMHI have worked on implementing a new scheme which will transform weather radar data from a polar co-ordinate system to a cartesian system. Also considerations have been given to calibrate radar output against a known radar radiation source, the sun. The results so far are promising, pointing at sizable systematic calibration differences between radars in the network which will be used within the PEP project.

Using the Mesoscale Analysis System (MESAN) and multi-source data from the BALTEX PIDCAP period (August - October, 1995), SMHI have derived monthly accumulated precipitation fields. MESAN is designed to provide an overall best-estimate of accumulated precipitation, using a rigorous quality control scheme and optimal interpolation. Output fields have a resolution of 0.1°.

Presentations of the project at conferences

1. BALTEX-meeting organized by the Royal Swedish Accademy of Sciences, Stockholm,

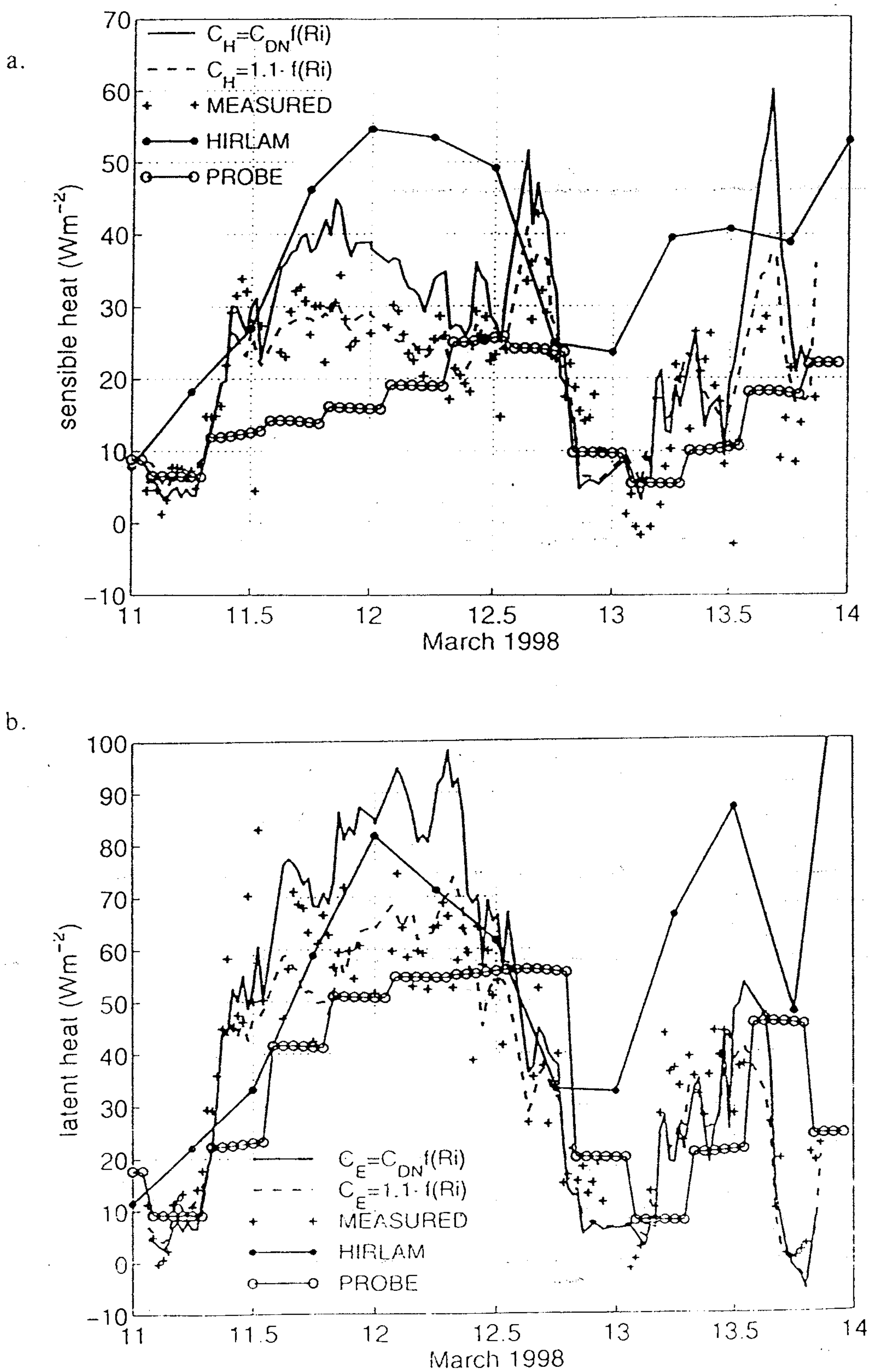

Figure 7. Comparison of estimates of sensible heat flux, Figure 7a and evaporation (expressed as 'latent heat flux' in energy units), Figure 7b for March, 1998 for the Östergarnsholm area. Legend: crosses, measurements from Österegarnsholm; full curve with black dots, HIRLAM simulations; curve with circles, simulation with the SMHI oceanographic model PROBE; other curves, alternative formulations for calculating the fluxes from bulk formulations, according to legend in the figures.

Sweden, 13 November, 1997.

2. Second Study Conference on BALTEX, Rügen, Germany, 25 - 29 May, 1998.

3. Conference organized by EU for presentation of projects funded within the Environment and Climate Research Programme, Wien, Austria, 19 - 23 October, 1998, Ref. Smedman et al., 1998.

4. Workshop on evaporation of the Baltic Sea, Rügen, 29 May, 1998.

PEP Webb site

PEP in BALTEX is presented at the following Webb site: http://cirrus.met.uu.se.

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The LITFASS Project of DWD: Status and Suggested Contribution to BRIDGE

F. Beyrich
Meteorologisches Observatorium Lindenberg, Deutscher Wetterdienst,
D-15864 Lindenberg, Germany
email: fbeyrich@dwd.d400.de

Introduction

The German Weather Service (DWD) currently runs a research project (LITFASS = 'Lindenberg Inhomogeneous Terrain - Fluxes between Atmosphere and Surface: a Long-term Study') in order to develop and to test a strategy for the determination of the area-averaged turbulent fluxes of heat, momentum, and water vapour over a heterogeneous landscape. The fluxes shall be representative for a horizontal scale of about 10 km (while the typical patch scale is between 10^2 to 10^3 m) corresponding to the size of a grid cell in the present operational numerical weather prediction model of the DWD.

LITFASS consists of three components:

- the development of a non-hydrostatic micro-• -scale model with a grid-size of 100 m (the LITFASS Local Model - LLM)
- experimental investigations of land surface - atmosphere exchange processes and boundary layer structure within a 20 km x 20 km area around the Meteorological Observatory Lindenberg (MOL)
- operation of a data base (LITFASS data base) as an interface between measurement and modeling activities

LITFASS is closely related to the BALTEX program since

- the scientific goals of LITFASS meet some of the BALTEX objectives, in particular concerning
  - the atmosphere - land surface coupling (long-term monitoring and process studies),
  - the formulation of high-resolution atmospheric models, and
  - the development of scale aggregation schemes for treating small-scale non-homogeneity in the surface characteristics,
- the topography around Lindenberg is typical for large regions of northern Central Europe and hence for a major part of the southern BALTEX area

The LITFASS Measurement and Monitoring Concept

The LITFASS experimental strategy comprises several levels of observation and measurements which are characterised in Table 1. This strategy has been first tested during the four-weeks LITFASS-98 experiment which took place in the Lindenberg area in May / June, 1998. This experiment could be considered as a prototype of a Cloud / Precipitation / Air - Land Surface Interaction Experiment of the BALTEX Initial Implementation Plan. It has been realized through a close cooperation between DWD and other institutions, namely GKSS Geesthacht, KNMI De Bilt, MPI for Meteorology Hamburg, DLR Oberpfaffenhofen, PIK Potsdam and groups from the universities of Bayreuth, Braunschweig, Dresden, Hannover, Heidelberg, Kiel, and Wageningen. Special emphasis was put on the determination of turbulent fluxes using different direct and indirect techniques. A summary of the methods employed is given in Table 2 demonstrating that six magnitudes of spatial sampling scales are covered by the different measurement systems.

Table 1 – The LITFASS measurement and monitoring strategy

Level	Observation Regime	Parameters	Spatial Coverage
0	once during LITFASS	orography landuse soil types	whole LITFASS area with 100 m * 100 m resolution
1	once per year	landuse agriculture	major part of LITFASS area
2	every 2 weeks (weekly during special periods)	soil parameters (T_S, q_S) vegetation parameters (h, LAI)	20 - 30 typical test areas
3	continuously	Lindenberg Column registr. rain gauges registr. water gauges energy budget stations	MOL 15 sites 7 sites 6 sites (in preparation)
4	during field experiments	turbulent fluxes - eddy correlation - remote sensing / aircraft	 - selected sites - spatially integrating

Table 2 – Flux measurements during the LITFASS-98 experiment

Sampling scale covered by the different flux measurement systems	
eddy correlation measurements (sonics)	10^{-1} m
remote sensing systems (wind profiler, lidar, sodar)	10^1 .. 10^2 m
small-aperture scintillometer	10^2 m
large-aperture scintillometer	10^3 m
Helipod, DO-128	10^4 m
Falcon	10^5 m

Status of LITFASS

LITFASS had been originally planned as a five-year project covering the period from June, 1995, to June, 2000. In order to account for some delay in the implementation of LITFASS but also to be in phase with the schedule of BALTEX – BRIDGE, a prolongation of the project runtime has been envisaged up to the year 2001. Deviding the LITFASS project into two phases, a planning and preparation stage and an implementation stage, the project is currently situated at the transition from phase 1 to phase 2. The key activities of these phases are listed in Table 3.

Table 3 - Status of the LITFASS project at the transition between the two main phases

Phase 1 - Planning and Preparation	Phase 2 – Implementation
◆ detailed elaboration of the project workpackages ◆ creation of the infrastructure (ABL field site, measurement systems, data base concept ◆ physio-geographical description of the LITFASS area (orography, landuse, soil) ◆ test of measurement strategy (field experiments LINEX-96/97, LITFASS-98) ◆ development of the first LLM version	◆ (quasi-operational) monitoring regime of the LITFASS measurement program ◆ field experiments for model validation and process studies ◆ test and physical extension of the LLM ◆ (quasi-operational) LLM simulation in delayed mode ◆ data analysis and interpretation ◆ final goal: development of new parameterizations

Perspectives and Suggested Contribution to BRIDGE

The LITFASS monitoring program will be operational during BRIDGE (October 1999 to December 2001). This program is designed to provide a comprehensive dataset on land – atmosphere interaction processes and boundary layer structure including basic hydrological data over a roughly two year period.

Since similar monitoring activities are carried out in two other regions of the BALTEX area, namely in Central Sweden (Marsta – Norunda) and in Northern Finland (Sodankylä), a close cooperation between LITFASS and the corresponding programs in Scandinavia and Finland is suggested in order to achieve some harmonization of the measurement program, data analysis strategies, data formats and quality control procedures. This is aimed to provide comparable datasets from the three regions to the modelling community. It would then allow a detailed analysis of the temporal and spatial variability of the components of the energy and water cycle at different latitudes over the BALTEX area with special emphasis on energy partitioning between latent and sensible heat fluxes, and the modelling of air-land interaction for different climatic regions / types of landscape structure in the BALTEX region.

In addition, DWD offers to host at the Meteorological Observatory in Lindenberg and in the LITFASS area a Cloud / Precipitation / Air – Land Surface Interaction Experiment during the period of the Main BALTEX Experiment, BRIDGE, in 2000.

Contributions of KNMI to BALTEX/BRIDGE

André van Lammeren, Arnout Feijt, Joop Konings and Erik van Meijgaard
Royal Netherlands Meteorological Institute
P.O. Box 201, 3730 AE De Bilt
The Netherlands

1. Introduction

Clouds play an important role in our climate. They play an important role in the hydrological cycle. Clouds modify the earth-radiation budget. Thin cirrus clouds have a warming effect while low clouds have a distinct cooling effect (Ramanathan et al., 1989). Clouds dominate the vertical transport of energy, momentum and trace gasses in the free troposphere. Despite their importance, clouds are represented only rudimentary in climate as well as weather forecast models. It appears that the model representation of clouds in climate models has a major impact on model predictions for climate change. Cess et al. (1989) showed that cloud feedback is a major source of uncertainty in model responses to climate forcing.

To narrow down the uncertainty, reliable data sets on clouds are needed. There have been many intensive observational campaigns which provide data for these studies (ASTEX, FIRE, EUCREX, etc.). During these campaigns a set of ground based instruments, satellites and in-situ aircraft data are combined. Several cases are studied and model output is compared with the outcome of the campaigns. Parameterizations are tested and developed further on these cases. However the number of cases which are used are often very limited. This is due to the limited time span of the campaigns and the enormous efforts, which are needed to analyze the data in sufficient detail. On the other side of the "observational spectrum" are the traditional synoptical cloud observations. There are long time records available but they contain too little information to be used for the evaluation of model output. So, long time series of objective cloud observations could contribute to the evaluation of models with respect to clouds and cloud-radiation interactions.

When comparing model output with cloud observations the spatial sampling is a problem. A single point observation is only representative for a limited area which is often smaller then the model resolution. The natural cloud variability, in space and time, complicates the direct comparison of observations from a single point with model output. This problem is less prominent for satellite observations. Here, often the time sampling is a problem.

From the above considerations it was concluded that a network of ground based stations combined with the satellite data would provide an important data set for cloud studies. Starting from this concept the Cloud Detection System (CDS) was installed and operated for a two year period (1995/1996). In this paper the CDS is described and the potential of the system is illustrated by some examples in section 2. In section 3 the future work on clouds is described in the context of BALTEX/BRIDGE. In section 4 some concluding remarks are made.

2. The Cloud Detection System (CDS)

The 10 network stations are located in a 120*120km^2 area in the Netherlands (Fig. 1). Each station consists of a Lidar ceilometer, a narrowband IR radiometer and a pyranometer to measure global shortwave (SW) radiation. In this section only a brief description of the CDS is given. More detailed information can be found in Van lammeren et al. (1998).

More extensive measurements are performed at the meteorological tower at Cabauw, which is located near the center of the area. Up to 200m the mean vertical profiles are measured of temperature, humidity, visibility and wind speed and direction. Measured radiation budget components are: longwave down- and upwelling radiation and shortwave global, diffuse and reflected radiation. Also a video-camera (color S-VHS system) is installed, which takes an image of the sky each 3.2s. The recordings are an invaluable aid in interpreting the other measurements. This infrastructure provides the data for the study of cloud-radiation interaction.

Other available tools for interpretation of the measurements are data on the actual atmospheric conditions and radiative transfer models. The HIgh Resolution Limited Area Model (HIRLAM), operational at KNMI, provides information on temperature and humidity profiles, and wind speed and direction on a 50km scale. The 6-hourly rawinsonde data from de Bilt, close to the center of the TEBEX area, are available. Radiative transfer calculations are performed using Modtran for longwave and the KNMI Doubling Adding model (DAK) for shortwave radiation.

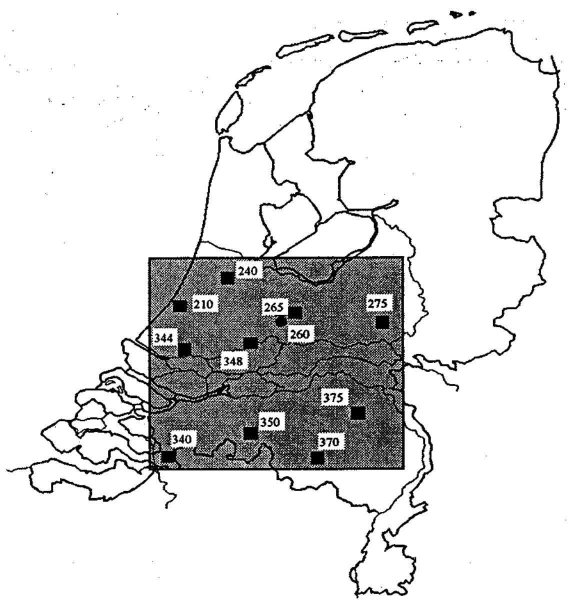

Figure 1 The CDS-area with the locations of the 10 ground based CDS-stations.

The AVHRR Processing scheme Over cLouds, Land and Ocean (APOLLO) is used for detection of cloud contamination and fully cloudy pixels from AVHRR measurements (Saunders and Kriebel, 1988). Cloud properties which are retrieved using APOLLO extensions are: cloud cover fraction, cloud top temperature, reflectivity, optical thickness, ir- emissivity and ice-detection.
An algorithm inspired on the ISCCP-cloud detection scheme is developed to analyse the Meteosat measurements.

HIRLAM-analysis data are used to calculate better threshold values to identify cloud free areas.The cloud detection system is used to retrieve the following cloud characteristics: total cloud cover, cloud top temperature, cloud base height, cloud base temperature, reflectivity and optical thickness. More important than the mean cloud properties are the variability of these properties in time and space.

As an illustration of the potential of the CDS one example of a comparison of model output with observations is presented. The Regional Atmospheric Climate Model, RACMO (Christensen et al., 1992), combines the dynamics of the HIRLAM model with the physics package of the ECHAM4-GCM. The CDS-data are used for evaluation of the RACMO output. To make a direct comparison of observations and model-data possible, the observed temperatures of the cloud layers are plotted as a function of time. One example is shown in figure 2. For January 3 - 7, the cloud base temperatures from the IR-radiometer are plotted as boxes with a variable width. The atmosphere above a cloud is shielded for the IR-radiometer. So, if there are multiple cloud layers, the lowest cloud layer shields the higher cloud layers. This shielding is represented by the width of the box. A thin box indicates that this section of the atmosphere is strongly shielded by lower clouds.
The gray value of the box refers to the cloud cover in this layer (black is overcast). The observed cloud cover profiles are derived for every 10 minute period. The spatial averaging over the entire network and temporal averaging to obtain hourly data is done straightforwardly keeping track of the shielding. The boxes at temperatures below -50°C indicate the clear sky fraction. The atmospheric correction causes this layer to be spread out over several temperature bins.
From the Meteosat data the lowest apparent brightness temperatures (with 5% significance) are used to estimate the cloud top temperatures (stars). The contour line is the 75% cloud cover contour from the RACMO model which was run in the forecast mode (+6 until +30) (Van Meygaard et al., 1998).
The Meteosat results were not available for January 3. The disappearing of the clouds between 13:00 and 15:00 UTC is clearly visible. The model cloud disappears a few hours too early. January 4 was clear for the whole day.
For January 5, 1995 there is a good agreement between observations and model. The clouds, which correspond to a frontal zone, are reasonably well represented by the model. The cloud top temperatures before15:00 UTC indicate the presence of high semi-transparent clouds. The good agreement continues until the end of January 6. Then the model clouds disappear. For the whole daytime period of January 7 the model predicts a clear sky while there is a stratus field present over the CDS-area. The mid altitude cloud with cloud base at -20°C and cloud top at -40°C, which shows up in the model output between 17:00 and 23:00 UTC is also observed by Meteosat.
From these examples it is clear that the CDS data base is a valuable data set for model evaluation. In a very straightforward and reliable manner it is possible to obtain objective information about the performance of a cloud parameterization over longer time periods.

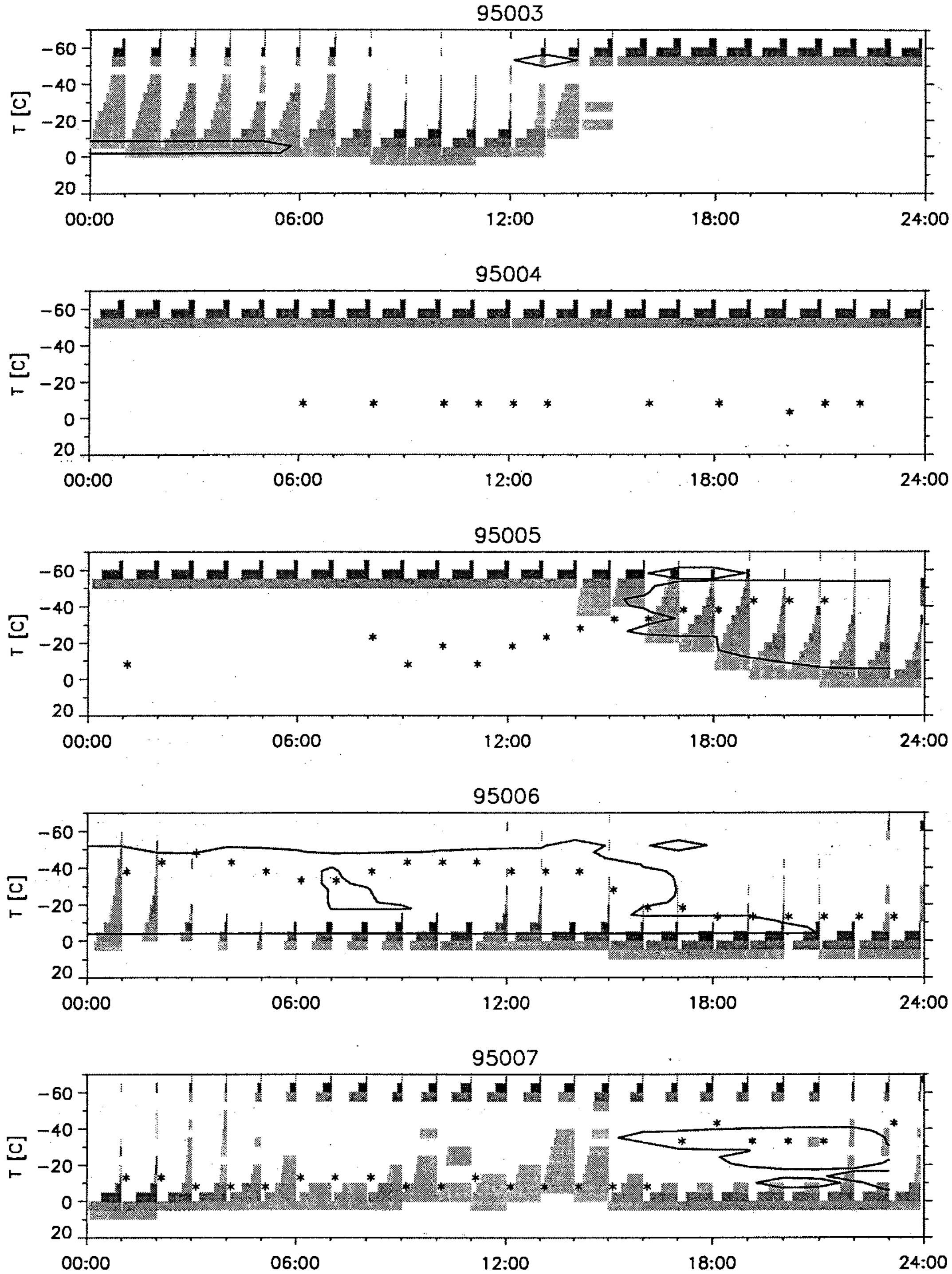

Figure 2 Comparison of the CDS observations with RACMO model data for January 3-7, 1995 (from top to bottom). The cloud base temperatures from the IR-radiometer are plotted as boxes with variable width and color (see text for explanation). The estimated cloud top temperatures are derived from the Meteosat data (stars). The contour line is the 75% cloud cover contour from the RACMO model which was run in the forecast mode (+6 - +30).

The additional data in the CDS database may help to identify the atmospheric processes in the parameterization, which need to be improved. More detailed examples of model output comparison with CDS data are presented in Van Meygaard et al. (1998). In this study model runs with different parameterizations are used.

3. Contributions to BALTEX/BRIDGE

In 1999 an operational Cloud Detection System will become available within the Netherlands. A minimum of twelve stations (max. 21) distributed over the whole country will be operated continuously. The instruments will be very similar to the earlier network. The detection range of the lidar ceilometers will be extended to 40,000 ft. This data will be available for the whole BRIDGE period (BRIDGE, 1997).

Together with the Department of Meteorology from the University of Bonn the initiative is taken to study the possibility of a European Cloud Observing Network. This concentrates on the liquid water content of clouds. A network of microwave radiometers within the BALTEX modeling area (which includes the Netherlands) will provide accurate local information on the LWC. Retrieval algorithms for satellite observations from operational meteorological satellites will be used to give LWC fields for the whole BALTEX modeling area. It is expected that the combination of ground based microwave radiometers and satellite data will provide an accurate and high resolution data set. The network is planned to operate during the first two IOP's. For the IOP in April/May 2001, an extensive cloud campaign is planned: the BALTEX BRIDGE Cloud campaign (BBC).

The BBC campaign is planned to combine the operational KNMI cloud detection system, the central site in Cabauw and in-situ aircraft observations. Shortly before the actual campaign a micro wave radiometer intercomparison will take place at Cabauw. After the intercomparison the micro wave radiometers are planned to be distributed over the CDS stations. An aircraft with in-situ cloud observations will fly over the combined CDS and microwave radiometer network. At the central Cabauw site an extensive set of ground based remote sensing instruments will be installed including several lidars, radars, IR-radiometers, wind profiler and RASS system etc..

Finally, the CDS concept is widely applicable. On many places within the BALTEX area similar instrumentation is already in operation. It is suggested to investigate the applicability of the BALTEX CDS. Which would mean that a major effort has to be put in the organizational aspects of the network.

4. Concluding Remarks

In this paper the concept of the Cloud Detection System has been presented. From the results of our two year long time series an example was shown which illustrates the power of such a detection system. Based on similar results, KNMI decided to make the CDS fully operational. This new CDS will be a valuable contribution to the BRIDGE experiment. Other initiatives are taken to better characterize the cloud fields over the BALTEX area. There are plans to combine LWP derived from a network of microwave radiometers with satellite retrieved LWP. For the IOP in April/May 2001 the BALTEX BRIDGE Cloud campaign (BBC) is planned.

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HEAT FLUX AT A NORTHERN SITE IN A SPARSE BOREAL FOREST DURING WINTER CONDITIONS

Sven-Erik Gryning and Ekaterina Batchvarova
Risø National Laboratory
DK-4000 Roskilde, Denmark

INTRODUCTION

As a part of the EU financed WINTEX project, measurements of atmospheric turbulence were carried out at Sodankylä in Northern Finland in March 1997. The purpose was to study the feasibility of applying sonic anemometers for turbulence measurements, as well as performance of other meteorological instruments, during harsh winter conditions, and to investigate the heat flux in and above a sparse boreal forest typical for the Northern hemisphere.

SITE AND INSTRUMENTATION

The Sodankylä Meteorological Observatory (67° 29' N, 26° 39' E), is located in a sparse forest of typically 6-8 meter tall pine trees. The area is typical for the subarctic Northern Finland with coniferous forests and large open mires dominating the landscape. During the experimental period, March 12 to 24, 1997 the ground was covered with snow and the trees most of the time bare without snow cover. Day and night were approximately equally long. The instrumentation of the site was rather comprehensive. Turbulence was measured by the use of sonic anemometers in and above the sparse forest, mounted on a mast at heights of 2, 6, 12 and 18 meters. The global radiation was routinely measured by the Finnish Meteorological Institute at a height of 16 meters, well above the forest. Profiles of atmospheric properties were measured by radiosondes released regularly every 3 hours during the entire experimental period. As a part of the STAAARTE initiative air-plane measurements were performed on two occasions during the experiment. In addition to the routine meteorological observations snow properties were measured.

In this study we will concentrate on the turbulence measurements. The wind fluctuations and temperature fluctuations were measured with a sonic anemometer (Solent Research 3D ultrasonic anemometers). The measurements are based on the principle of direct transit time of a sound pulse between two points on the instrument. The temperature fluctuations are determined by using the dependence of the sound velocity on the air temperature. Measurements of humidity fluctuations were performed with an OPHIR optical hygrometer (measuring height 18m), but these measurements are not discussed here.

SOME DATA EVALUATION

It is a very characteristic feature in the turbulence measurements that a pronounced gradient in the heat flux and temperature can be observed between the lowest level of measurements inside the forest and the measurements above the forest.

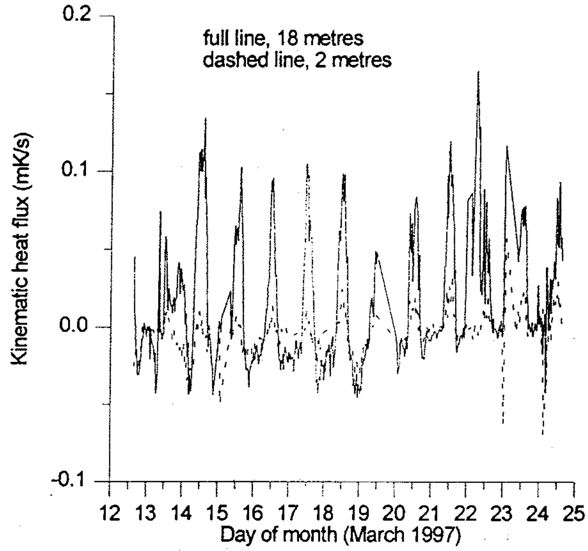

Figure 1. Sensible kinematic heat flux at two heights as function of time. The kinematic heat flux (mKs^{-1}) can be converted to Wm^{-2} by multiplication of 1300 (Wm^{-2}/mKs^{-1}).

Figure 1 shows the kinematic heat flux at two meters and 18 meters height, representing the conditions near the forest floor and well above the forest. The amplitude of the diurnal variation of the heat flux is pronounced larger for the measurements at 18 meters compared to the measurements at 2 meters. It is clearly seen that during daytime, the heat flux above the forest is noticeable larger than near the forest floor. During night-time the heat flux above the forest is smaller than inside the forest.

The temperature at 2 and 18 meters is shown at Figure 2. The amplitude of the temperature at 2 meters is larger than at 12 metres. It is a characteristic feature during daytime that the temperature inside is larger than outside the forest, which is characteristic for an unstable atmosphere and associated generally with positive heat flux. During night the temperature increases with height, typical for a stable atmosphere.

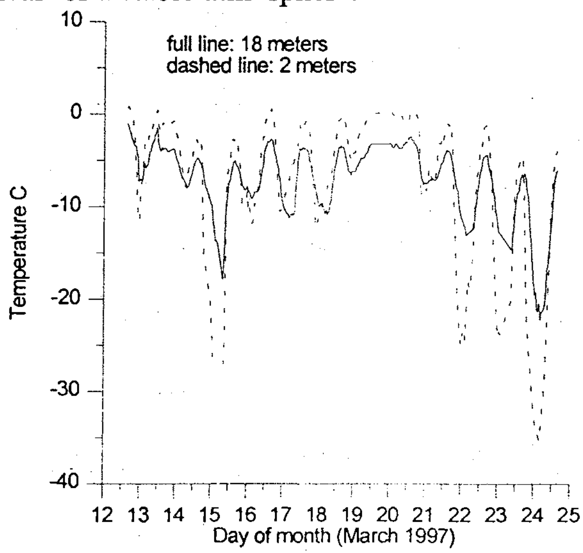

Figure 2. Temperature at two heights as function of time.

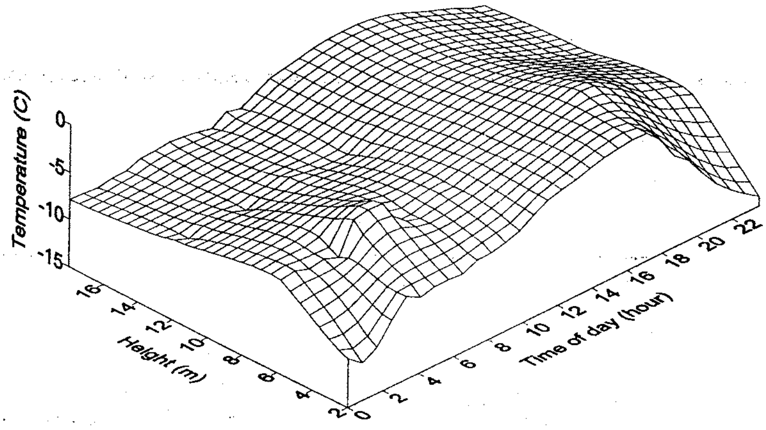

Figure 3. Average temperature as function of height and time of day, interpolated from measurements at 2, 6, 12 and 18 meters height.

In order to further illustrate the daily variability of the sensible heat flux and temperature in and above the sparse forest, the diurnal variation of the average heat flux and temperature for the experimental period was calculated. Figure 3 shows the daily interpolated variation of the average temperature for the period 13 to 23 March, based on half hourly temperature measurements. Near the ground (inside the sparse forest) the temperature has its minimum approximately an hour past midnight, then it increases slowly reaching a maximum at 4 PM, when the temperature starts to fall rapidly. Above the forest (18 meters) the minimum

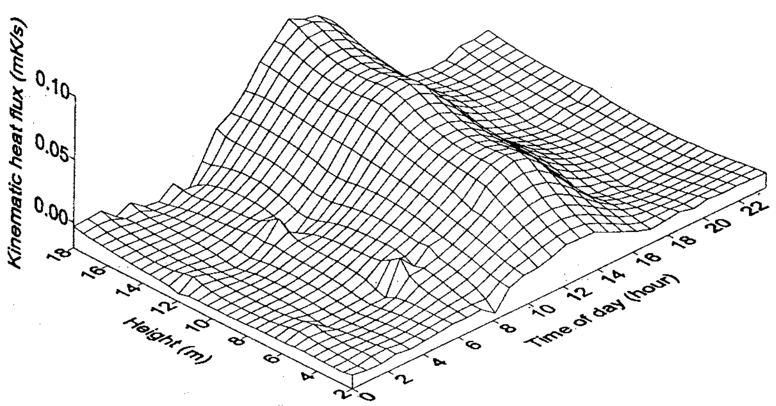

Figure 4. Average sensible heat flux as function of height and time of day, interpolated from measurements at 2, 6, 12 and 18 meters height.

temperature during the night is larger (warmer) and the maximum temperature during the day is smaller than inside the forest. Thus the temperature amplitude inside the forest is larger than above the forest. It is also characterises that generally the tempareturestratification inside the forest is stable and it is neutral or unstable above the forest.

The sensible heat flux, plotted in the same way, is shown in Figure 4. It is seen that the heat flux is negative (downward directed) during the night. The diurnal variation is larger above the forest than inside. It is also characteristic that the heat flux during daytime increases as function of height between the forest floor and the top of the forest, reaching a maximum value at noon of 100 Wm^{-2} above the forest, being only 15 Wm^{-2} near the forest floor

DISCUSSION

The meteorological conditions with rather long days, a snow covered ground surface and bare pine or spruce trees is rather typical for the Northern boreal forest during the last part of the winter, but hardly characteristic for the whole winter period. The measurements shows that the forest has a pronounced effect on the local meteorology. The forest induced convective heat flux is comparable to heat fluxes found in middle Europe, and is able to form a convective mixing layer that reaches a depth of typically 500 meters in the late afternoon. The convection is caused by warming of the trees by solar radiation. The trees are bare (not snow covered) with low albedo and thus an efficient absorber of short-wave radiation. The forest floor is covered with snow which reflects short wave radiation. The upward directed heat flux above the forest originates mainly from the warming of the trees, while the heat flux from the forest floor remains small.

At this time of the year, the abundant frozen lakes and mires in the area are still covered by snow. The micrometeorological conditions over lake and mires, small or negligible heat fluxes during daytime, differs considerable from forest conditions. Therefore from a point of view of convection the Northern boreal landscape is very inhomogeneous, with relative large heat fluxes over the forest and negligible fluxes over the snow covered lakes and mires during daytime. Another way of expressing this is that the albedo is very variable over the Northern boreal landscape during this part of the year. The variability of the albedo during other parts of the year is not studied here.

The measurements shows that is reasonable to use sonic anemometers during the winter conditions for measurements of heat flux. A few cases of rime on then sensorheads of the sonic anemometers were noticed, but this was rather uncommon due to the generally dry inland air. In a coastal environment this might pose a much bigger problem. When rime is present the measurements become highly unrealistic. These cases can easily be detected and the measurements removed.

Minutes of the 3rd meeting of the BALTEX Working Group on Radar

German Weather Service, Meteorological Observatory Hohenpeissenberg
17-18 November, 1998

1. **Welcome**: The participants were welcomed by the Chairman, Jarmo Koistinen (FMI). Participating were: Rüdiger Brandt (BALTEX Secretariat GKSS), Chris Collier (University of Salford), the Chairman, Daniel Michelson (SMHI), Johann Riedl (DWD, MOHp), and Klaus-Jürgen Schreiber (DWD, Offenbach).

   It was highly appreciated that the BALTEX Secretariat could provide traveling funds for Chris, who didn't get it from the University. However, according to him, the negative attitude of the University has returned to the favorable position for BALTEX work.

2. **Apologies**: Tage Andersson (SMHI), Zdzislaw Dziewit (IMWM), and Vladimir Zhukov (RC RSA), were unable to attend.

   Membership: Jan Svensson has left the WGR. It would be beneficial for the work of WGR to have a representative from each BALTEX country providing data to the BRDC.
   Action: Jarmo will contact the Baltic States, DMI and DNMI whether they are willing to send a representative to the WGR.

3. The **Agenda** was adopted (see Attachment 1).

4. The **Minutes** from the previous meeting at DMI, 23-24 February, were accepted. The WGR´s work was well received at the 7th BALTEX SSG Meeting in Copenhagen, 3-4 March.

   In the COST-75 Final Seminar at Locarno several BALTRAD-related papers were presented. According to Chris, the proceedings from the COST-75 Final Seminar have been sent to the publisher.

   In the 2nd BALTEX Study Conference at Rügen papers related to BALTRAD were presented and a review of the BALTRAD plan and products was given by Jarmo (however, he had no time to provide the paper).

5. **BRDC**. The procedure for receiving data from the BALTEX Radar Data Centre (BRDC) is to first become a registered BALTEX Data User with the Secretariat at GKSS. This entitles the User to receive data from any of the Data Centres. Yet

each Data Centre will require a specific license. Forms for becoming a registered BALTEX Data User are available at the BALTEX Secretariat's website: http://w3.gkss.de/baltex/baltex_home.html

All hardware which will be used by the BRDC are already purchased and are up and running. Daniel's ambition is to have the BRDC established and running by April 1, 1999.

6. **BRIDGE Radar Data**.

Interim Memorandum of Understanding (IMoU)

DMI, DWD, EMHI, FMI, IMWM and SMHI have signed the BRIDGE IMoU in which they agree to provide the radar products to BRDC continuously during the BRIDGE period (1 Oct. 1999 - 31 Dec. 2001).

Radar network and national radar data

SMHI (Sweden):

Data collection applying RAVE has been implemented for research purposes so that original high resolution polar volumes are consistently received and archived from all 11 radars. This facilitates better resolution (especially vertically), use of better interpolation algorithms and more efficient clutter cancellation algorithms compared to the Ericsson EWIS data used in operational NORDRAD.

FMI (Finland)

FMI will replace their last MRL5 at Rovaniemi either in 1999 or 2000. The new system will be located at Luosto, a fjell top 60 km NE from the present location. The radar will act as part of the operational network. It will also be used as a testbed for the development of advanced radar techniques including a klystron transmitter with programmable pulse phase-modulation and pulse length.

DMI (Denmark)

No information exist of the possible plans to install new systems. There has been preliminary plan to shift the Kastrup radar on the island Bornholm and to replace the Kastrup radar with a new one, whose location would be more inland.

DNMI (Norway)

An expansion of their one radar "network" has been started. The first addition is scheduled for the summer of 1999 at Mandal. Although the Norwegian network does not expand significantly the radar coverage over the Baltic Sea catchment area in normal network conditions, its role can be regionally very important in cases of missing Swedish data. In spite of several contacts by Jarmo and Daniel, DNMI has not responded to the request whether they will sign the IMoU. A suitable compromise in case of no signing would be a separate permission to use the Norwegian data in BRDC - it will be transmitted to SMHI in any case as a part of operational NORDRAD exchange.

Action: Jarmo and Daniel will contact DNMI again to establish the rules to use their radar data in BRIDGE.

DWD (Germany)

DWD will install a new radar at Dresden in the spring of 1999 which can be added to the three North German radars used during BRIDGE. The DWD could provide data from all other radars in addition to the principle four already targeted for BRIDGE, either individually or as composites. This could be valuable for covering BALTEX model areas, which are larger than the catchment area itself. BRDC will start with the first three and add more if or when feasible.

IMWM (Poland)

The Institute has received a considerable loan from the World Bank, which will be used (among other developments) to realize an ambitious plan for establishing a radar network which would cover the country and hence larger part of the BALTEX region. The realization would consist of the replacement of the present MRL5 at Legionowo with a modern Doppler system, updating the existing Katowice radar telecommunications and software, installing the existing Doppler radar (which has been years in factory packages) and purchasing five new systems - altogether 8 radar systems in near future. The sites for the new systems are already known.

EMHI (Estonia)

EMHI has purchased recently one Doppler radar hardware. Software and signal processor are still missing due to lack of money. Siting is not yet determined, although it has been pointed out the best location in terms of fitting in existing networks is in the southwest. However, 24-hourly security and maintenance may implicate a site close to Tallinn, which is only 80 km from the FMI Vantaa radar, thus not optimally enhancing the BALTEX radar coverage.

LHA(Latvia)

LHA has not yet purchased a radar but there is great interest and funding from the customers seems to be available, which could lead to quick action. A radar delegation from FMI will visit LHA in January 1999. The optimal siting of Latvian and Estonian radars is strongly interactive, i.e. the first siting decision in either of the countries should be taken into account in the second site selection.

RCRSA/RSHI(Russia)

There should be several digitized MRL5 radars in operational use in St. Petersburg area as was recently explained to a visiting FMI representative in a cooperation project related to road weather services. However, no detailed information exist presently of the practical possibilities to collect this data in near real time and to transmit it to the BRDC. The plans to establish a data line between FMI and St. Petersburg have not proceeded. FMI has send some test data to an agreed address but the data disappeared into "a black hole". The reasons for slow process are at least the bad economical situation in Russia together with the hard competition between several meteorological research and weather service institutes in St. Petersburg area.

Action: It would be of great help if Vladimir could clarify the state of Russian radars and availability of their data and its transmission possibilities e.g. in BUFR format.

BALTRAD Products

A discussion took place concerning the general acceptance of the four BALTRAD products, agreed in the previous WGR meeting (product details will follow in Sections 7-9 below) and listed in the following:

- Single radar PseudoCAPPI, nominally 500 m ASL, of the radar reflectivity factor (acronym dBZ). Produced nationally at each radar and transmitted to the BRDC.
- The whole BALTRAD coverage composite of dBZ at 500 m PseudoCAPPI (acronym dBZC). Produced at BRDC.
- Three hourly accumulated precipitation (acronym RR), in units mm liquid rain, derived from integrated dBZC and gauge observations. Produced at BRDC.
- Single radar vertical wind profile (sounding) derived from Doppler measurements (acronym WP). Produced at each radar if possible and transmitted to the BRDC.

The spatial resolution (i.e. pixel size) of horizontal BALTRAD products will be 2 x 2 km^2.This is believed to be high enough even for urban hydrological applications.

Temporal resolution in instantaneous products (dBZ, dBZC and WP) will be 15 minutes and in RR products 3 hours, fitting to the synoptic observation times.

The accumulation period of the precipitation product was originally chosen to be 3 hours. The reasons for that were mainly the following:

1. Three hours fit to the synoptic observation period of the prevailing weather, temperature and humidity.
2. Sampling differences between radar and surface measurements of precipitation decrease when the integration period gets longer as instantaneous radar samples of dBZ are taken only every 15 minutes in BALTRAD. Some gauge-radar comparisons suggest that in convective cases comparisons based on hourly or shorter accumulation periods may exhibit nothing but noise.
3. The temporal resolution of a NWP model output is typically 3 hours.
4. It was felt that in cases of rapidly moving weather systems accumulation periods of 6 h or 12 h would not any more give good information of the location of the system.

Action: All WGR members should contact their national modeling community, both meteorology and hydrology, to get their views if 3-hourly radar accumulations are most suitable for model validation or other purposes. It should be noted that e.g. in case of hourly precipitation fields the amount of data (model and radar) would increase by a factor of 3.

Raw polar volume data will not be available as standard BALTRAD products; they will however, be available on a case by case basis from individual institutes who archive such volumes.

<u>BALTRAD file formats</u>

In principle BALTRAD data handling should be based on existing and well tested file formats, such as NORDRAD and BUFR. However, there are several reasons why the existing formats don't cover all BALTRAD requirements:

1. Accuracy of data values is not high enough.
2. Quality information is missing.
3. Bitmaps describing pixel level quality or other overlay parameters are missing.

4. The product is not available (e.g. accumulated precipitation).
5. Compression methods are not effective.

These reasons lead to the agreement that **BRDC radar data will be archived using a specific BALTRAD file format**, which is well documented, see Daniel's paper Michelson, D., The BALTRAD File Format, Version1.0. As can been seen from the document, the format is quite simple consisting of a header (variable-length ASCII-text lines) followed by the data section. The BRDC will make the RAVE software available to all institutes who contribute radar data to the BRDC or who are WGR members. It is written in the platform-independent freeware Python programming language and in ANSI-C.

Action: All WGR members should confirm that the header contents of each BALTRAD product contain sufficient information of all national measurement parameters, calibration settings, adjustment and correction factors as well as methods of calculation and selectable constants applied, so that the final end user has no hesitation of the product contents and of the applied methods behind it.

Note that the **BRDC can provide on-line products and data exchange to individual Institutes in BUFR and in BALTRAD format**, whichever is the most convenient way for the Institute (see BALTRAD data exchange)..

BALTRAD data exchange

A common hope was expressed that the procedures to use BRDC data, described in item 5 above, should cover all necessary administration.

The national BRDC input products dBZ and WP will be transmitted to BRDC using as far as possible the existing operational formats and routines e.g. NORDRAD-DECNET, BUFR-GTS and BUFR-ETR. ETR is the network in which data exchange between the ECMWF and its member states is operated.

Action: All WGR members using ETR in the operational BRIDGE data exchange should check that the formal procedure required from ECMWF to get the permission to use ETR has been done. If not, the actions described in Daniel's e-mails (see Attachment 2) should be started immediately.

In near future the ECMWF will establish a new EQUANT (provider) RMDCN (combined GTS+ECMWF) network. Lines between member states and the ECMWF will be upgraded to 96 kbps bandwidth. The line speed between member states and EQUANT will be 128 kbps (32 kbps is reserved for GTS traffic). Due to considerable savings in line costs the NORDRAD traffic (64 kbps) will also be transferred to this RMDCN network (hence. the bandwidth between EQUANT and each NORDRAD country will be 192 kbps). The time scale for this is such that first tests will be performed in spring 1999 and the whole EQUANT traffic of GTS+ECMWF+NORDRAD should be operational at the end of 1999. The transmission change from the present routines to the new ones will be overlapping so that no problems for BALTRAD data exchange should appear. All BALTRAD countries (not necessarily the Institutes) have already now existing access points to EQUANT.

A six-hour cutoff time was agreed for data to be provided to the BRDC. These data will be provided continuously. National solutions for BRDC input routines is not yet established at each BALTRAD contributor, but the following routines seem probable at present:

- dBZ

  DNMI, FMI and SMHI (later hopefully EMHI and LHA) will provide their operational NORDRAD products.

  DMI sends already now the Danish products to SMHI using BUFR-ETR. It was agreed in the meeting that DWD will use the same solution (unfortunately DWD is able to provide only 4-bit resolution).

  Daniel is presently in dialogue with IMWM to work out if/how data can be exchanged. A possibility would be for Poland to transmit data to Graz, as Poland anyway sends there dBZ data as part of the operational CERAD (Central European Radar Network). ZAMG (Austria) is connected to the ETR. A second choice would be a direct ftp with SMHI. Much depends on the actions and their speed, which IMWM will realize with the World Bank loan.

  Action: Daniel should confirm with DMI that they will send BALTRAD data from <u>all</u> radars. He should also continue the dialogue with IMWM to find a solution.

- WP

  The most probable solution will be a simplified BUFR-coded wind profile which is presently introduced to NORDRAD exchange (not yet distributed from all radars) and can be exhanged in ETR. It should be noted that a BUFR version which fulfills BALTRAD requirements (e.g. quality information) doesn't exist at present. Therefore Jarmo made a proposal in the GORN meeting in Warsaw last October to enhance the BUFR code for Doppler radar wind soundings (see Attachment 3). The proposal was unanimously accepted. Jarmo will provide the limits of the quantities in the proposal to Jean-Louis Maridet (Meteo France) and to Jan Kracmar (CHMI) who will provide the respective BUFR descriptors. Finally Konrad Köck (Univ. Graz) will make the respective change to the latest version of the available BUFR code. It was estimated that these changes could be ready early next spring.

  Action: Jarmo should act so that the BUFR enhancement would be available as soon as possible.

The BRDC will output three products, WP, dBZC and RR. They will be distributed in two ways:

- The Institutes which provide BRDC input data will receive output products after 24 hours when the commercial value of them has vanished. The same network and format solutions will be used as during the input process. Note that BRDC will provide the format conversions from BALTRAD to BUFR and to NORDRAD. Due to various quality and resolution problems it seems now that RR will be provided only in the BALTRAD format. Synop times will be avoided, as will distributions of ECMWF model data. BALTRAD data will be distributed once per day; products will be transferred individually, i.e. no huge packages will be created. Checks on whether the data is successfully transferred from the BRDC will be created. The BRDC will not be obliged to retransmit products.
- All BRDC output products will be collected on CD-ROMs, available for official BALTEX Data Users. The BRDC software (RAVE-Radar Analysis and

Visualization Environment) will possibly be included on one of the CD-ROMs. The time spacing between CD-ROMs is to be determined, as will the delay from product generation to availability on CD-ROM. The BALTEX Secretariat, the WCRP and others could be asked to contribute towards the costs of reproducing the CD-ROMs.

Action: Daniel should agree with the ECMWF which time period is the most suitable for the distribution of BRDC output products.

Implementation of improved algorithms can be done during the course of BRIDGE but there will be no explicit re-runs using these improvements. Hence, the methods used by the BRDC should be documented in the file headers.

7. BALTRAD algorithms for the reflectivity product (dBZC).

Radars which miss the six-hour cutoff will not be included in the dBZC or RR composites. CAPPI levels should be given in meters above sea level. A 500 m Pseudo-CAPPI, or closest thing to it, is the level we want.

Calibration of radar systems

The meeting agreed that no common BALTRAD calibration routines will be required. However, each Institute will make their best to achieve a high level in their operational calibrations. A close cooperation between the contributing Institutes is recommended. Tools to provide it are developed in the existing NORDRAD Quality Assurance (QA) cooperation.

NORDRAD has done quite a bit of work on homogenizing the network, especially in discovering programming errors which account for around 6-9 dB of the difference between Ericsson and Gematronik systems (King, 1998). Still, random differences up to 3-4 dB between individual NORDRAD radars appear, which can neither be explained nor corrected well at present. Possible progress can be achieved through continuous monitoring of overlapping areas between radars. A monitoring program has been recently implemented by a specific NORDRAD project. The application programs, i.e. how to use the monitoring information in real time radar pair adjustments, will be developed in the NORDRAD QA project which will be launched in 1999. This project contains also a detailed documentation of the NORDRAD radars and their calibrations as well as a Workshop which will be held at FMI in March,1999. FMI has confirmed that at least one participant from DWD is welcome to the Workshop.

The NORDRAD field experiment, carried on in the winter 1997/98 using metallic spheres, proved that an absolute transmitter-receiver calibration requires tremendous work and resources when only the existing signal sampling and processing tools are available (see Koistinen et al., 1998). The calibration of the receiver chain seemed to be much easier and more practical by using the sun or by using a reference feed horn. Both of these methods will be tested and developed during the NORDRAD QA and in the Workshop. Tage Andersson should provide us with information on his experience how sun calibration could be implemented. Ideally we would want NORDRAD calibration work to include all BALTRAD radars. There is currently no common BALTEX framework for conducting field experiments or use of monitoring software yet this is highly recommended. RAVE will contain the ability to compare overlapping areas when compositing. The algorithms found in NORDRAD QA could be implemented in RAVE to cover the radar pair comparisons for all BALTRAD radars.

Action: DMI should be involved more closely to the BALTRAD calibration actions. Especially, Jarmo should ask Søren what is the status and experience of the transportable C-band radiometer, planned to be operational for sun calibrations in 1998. Jarmo should follow the NORDRAD QA project and implement with Daniel applicable radar network adjustments into the dBZC product.

Clutter cancellation

All existing Doppler radars with recently updated Sigmet or Gematronik clutter filters will provide clutter-free data in almost all cases of ground clutter. The filters, especially FFT, remove or affect only very small fraction of real weather data (typically less than 1 % of the echo coverage). The problems remain severe in the rest of the BALTRAD radars (roughly estimating 10 % of all yearly measurements contain areas of strong clutter due to anaprop):

- DWD Hamburg and Berlin are EEC non-Doppler radars which use statistical clutter filters in the intensity channel. Although the statistical filter is clearly worse than a good Doppler filter, it provides better clutter elimination than clutter mapping. Hamburg could be a Doppler system if these components are activated.
- FMI Rovaniemi radar applies only clutter mapping, which is not effective enough. The data quality will be much improved when the system is replaced with the new radar at Luosto.
- SMHI, DMI and DNMI Ericsson systems are not able to provide Doppler filtering in the intensity (dBZ) measurements to the range of 240 km but only in the Doppler measurements up to 120 km. A radar operator can switch on or off clutter elimination based on the mapping method. There are cases when the mapping seems to be switched on during widespread precipitation (thus producing a hole into the precipitating area). In cases of no rain the mapping algorithm is not able to eliminate some very strong permanent clutter. Daniel presented a new algorithm for transforming polar volume data to cartesian grids which uses 3-D interpolation and a cylindrical search volume. This method should be implemented in RAVE and evaluated as it could help remove clutter and anaprop more efficient than the present methods. The clutter elimination methods Tage and Daniel have developed in the EU projects DARTH and PEP already show quite convincing ability in selected cases to eliminate strong anaprop without strong side effects on the real weather signals (see Andersson et al., 1998). Daniel will also study a RAVE approach in which the Doppler mode filtered data up to 120 km could be combined with the intensity mode data between 120 km and 240 km.

Actions: Daniel should test and implement a working ground clutter (including anaprop) elimination algorithm for all Ericsson systems in RAVE prior to the start of BRIDGE. It should be clarified which kind of clutter eliminations are used or should be added to the DMI and DNMI radar data. It should be clarified how to monitor and control the on/off switching of the mapping method in all Ericsson systems. Johann should start actions to activate the Hamburg radar Doppler properties into operational use.

In spite of the various BALTRAD clutter rejection techniques, anomalous sea clutter and ship clutter may remain locally significant problems e.g. in Gotland and Korpo radars. Luckily they seem to occur in relatively rare occasions. Manual editing of products could be useful and efficient in such cases but the WGR found that no software and manpower exist to check each radar product manually. Satellite data will not be used in creating BALTRAD products. Nor will NWP.

As major use of BALTRAD accumulated precipitation product (RR) will take place outside the radar community, among people not experienced to interprete radar images, it was agreed that the products should exhibit as little clutter as possible. It is better even to eliminate some weak precipitation (as many clutter filters do) than to leave fragments of intensive clutter. A "bad" example is the PIDCAP radar data, which exhibits strong permanent clutter patterns (in addition to the 5 dB overall bias) around each Ericsson radar. Each data provider should make the best to minimize clutter in the input products WP and dBZ as the generation of dBZC will most probably not contain additional clutter rejection phases.

Attenuation

- Gaseous attenuation is implemented in all radar softwares and should not cause any problems. Anyway it should be checked that the value of 0.016 dB/km (two-way) is actually programmed in the signal processor of each C-band system.
- Partial or total beam blocking varies from site to site. For example FMI has very few problems with beam blockage as radar sites have been chosen carefully so that antenna horizons are almost free of obstacles above the elevation angle of 0.2 degrees. DWD has no special treatment for partial or total beam blockage but their dBZ products will contain data from higher elevations than the lowest ones in cases of blocked sectors. Blocked beams, if narrow, could also be interpolated. SMHI does nothing yet but has serious problems at many sites(e.g. at Norrköping radar).The Met. Office corrects a partially blocked beam up to 60% blockage. Otherwise the beam is considered completely blocked and is rejected. This strategy was derived many years ago and could perhaps be improved. A working solution in BALTRAD could be integration of PPIs of widespread precipitation over weeks or months followed by calculation of the average dBZ deviation at each azimuth angle from the overall dBZ average. Accordingly to the British algorithm, partially blocked sectors could be corrected by the azimuthal dBZ deviation. Totally blocked sectors could be interpolated from the neighboring azimuths and/or replaced by data from an overlapping radar. **Action**: Daniel should integrate longer periods of widespread dBZ fields over western parts of the NORDRAD network to see how strong the blocked sectors are quantitatively. The most convenient correction algorithms should be implemented either into the dBZ production or into the dBZC production.
- Attenuation due to rain is operationally switched on continuously in all Ericsson systems. Rain is assumed year-round but the correction can be switched off. The

starting point of the correction can be delayed in range in order to avoid erroneous application in strong clutter close to the radar. The existing attenuation correction accumulation is capped at 4.8 dB for a full ray. Obviously the correction leads to better precipitation measurements in warm airmass summer precipitation. In solid precipitation (which is present in longer ranges of the dBZ product almost during the whole year) the applied algorithm leads in principle to overestimation. However, as vertical reflectivity profile correction is not applied at present (see below), the liquid attenuation correction will compensate part of the long range underestimation, most prominent in shallow winter precipitation. The FMI and DWD systems don't contain any attenuation corrections due to precipitation. SIGMET Inc. has promised to add a correction algorithm (a four parameter model has been discussed) into the IRIS software.

Action: The rain attenuation correction applied continuously in solid precipitation in all Ericsson systems should be changed to a snow attenuation correction during cold seasons. The need for this is most important immediately when simultaneous reflectivity profile correction will be implemented, see below. Otherwise the two corrections together will lead to physically unjustified results. Sigmet Inc. should update the IRIS software with a precipitation attenuation correction as soon as possible. The easiest way to achieve homogeneous BALTRAD attenuation treatment in the incoming dBZ is to switch off all precipitation attenuation corrections until all radar systems are equipped with equivalent tools to make the correction in real time.

<u>Vertical reflectivity profile correction</u>

In absolute units the vertical reflectivity profile is on average the largest and most frequently occurring factor in the BALTEX area, which introduces significant sampling differences between gauge and radar measurements of precipitation. The effect is most prominent in cold season precipitation at longer ranges. A scan strategy incorporating 10-15 elevations provides the ability to implement more accurate correction methods than strategies with only a few angles. This is being recognized at many institutes today. Embedded convection may ruin many routines which use averaged profiles containing the bright band. Smyth and Illingworth (1998) suggest a way of remedying this. Problems are also apparent in cases with widespread upper level precipitation (virga or Altostratus), which never reaches the ground (Koistinen and Saltikoff, 1998). In spite of these problems it has been convincingly showed that even a correction based on average profiles will help much (Joss and Lee; 1995).

At present the BALTRAD Institutes have no practical experience of profile corrections although FMI will implement a correction scheme for test use in December 1998. As this issue is vitally important from the point of the quality of the dBZ, dBZC and RR products, a common but simple algorithm should be implemented. A solution could be the one applied in the UK (Kitchen et al. 1994). There the height of the 0 degree isotherm is regarded as very reliable quantity from the NWP models. Together with a simple statistical reflectivity profile model it could be used to help correct for bright band and partial beam overshooting effects without jeopardizing the radar data's independence from NWP.

Action: Daniel and Jarmo will introduce a method which operates on the composite as an entity, incorporating topography and HIRLAM information of the 0 degree isotherm height. The outcome should be tested during the BRIDGE pilot period.

Compositing:

Use of a high-resolution topographical database at BRDC could improve the analysis and treatment of beam blockage and be of use in compositing. The compositing algorithm would select the pixel from the radar located closest to the ground. This was adopted. The dBZ data from DWD (so called PL products) already contain maximum values in vertical, which can overestimate precipitation in some cases. This must be documented in BALTRAD product descriptions.

Action: Daniel should check if the topographical database produces sufficiently good radar horizons compared to the known horizons, measured at the site or viewed from the long period accumulated precipitation fields. It should be checked how the existing NORDRAD compositing has created the horizons.

Implementation plan:

All actions mentioned above, except the beam blocking correction, should be implemented by April 1, 1999.

8. BALTRAD algorithms for optimal accumulated precipitation fields (RR)

A maximum of three consecutive missing dBZ values will be the threshold used when accumulating composite images. If the data gap is longer, the radar in question will be omitted from the RR composite (in areas which cannot be replaced by data from the neighboring radars).

Use of HIRLAM will be avoided in deriving the precipitation field outside the radar coverage.

The following issues are in the time order of applying them.

Thresholding dBZC and RR

The motivation for thresholding is that we are creating a precipitation product. Weak echoes are generated by e.g. insects giving ugly "rain" echoes during warm and sunny anticyclones. Extremely weak precipitation echoes are insignificant from the point of precipitation amounts. A climatological, monthly varying, threshold should be implemented, based on the average 850 hPa temperature. It can be considered later to implement a real time algorithm based on the actual 850 hPa temperature field from a NWP model (HIRLAM). Midsummer threshold will be +7 dBZ and midwinter threshold -2 dBZ. The thresholds will be applied only to the BALTRAD RR composites during the Z-R conversion (see below) as they are being integrated to the gauge-radar product. The dBZC composites themselves will not be thresholded as clear air echoes contain lot of meteorological information (see e.g. Andersson, 1998).

After thresholding the individual dBZC fields the integrated 3-hourly precipitation field RR will be thresholded once more: all pixels with less precipitation than 0.1 mm will be thresholded.

A maximum threshold, applicable in identifying hail, should be treated with caution. With a single polarization radar there is no absolute way to distinguish between hail and rain. A new header parameter should be added which is basically a histogram of the dBZ values contained in the RR composite. Thus every RR user can easily monitor the possibility and frequency of hail in each RR product and, if needed, to search the respective locations from the respective dBZC products.
Action: Daniel and Jarmo will produce the details of the header parameter and monthly threshold values.

Z-R relationship

The water phase at ground level must be determined. Temperature analysis (MESAN) should be very useful in giving 2m temperatures and relative humidity (without NWP), combined with FMI's statistical function (Koistinen and Saltikoff, 1998). Inclusion of 850-1000 hPa thickness from HIRLAM would possibly improve the 2 m phase analysis in areas of sparse ground observations. Present weather codes in synop observations could be interpolated if the analysis takes into account the local ground topography.
Action: Jarmo will provide the FMI lookup table for the phase and Daniel will implement the use of MESAN analyses of T(2m) and RH(2m).

It was decided that we will use A=200, b=1.5 for rain and A=400, b=2.0 for snow (see Koistinen 1997). **Action**: Jarmo will derive the continuous function between these two based on the 2 m phase analysis.

Orographic enhancement:

A correction scheme should be implemented by multiplying the 3-hourly radar accumulation field with a correction factor available in MESAN. The correction is based on HIRLAM low level winds. The correction should be done before the gauge adjustment. Over major part of the BALTRAD composite area the orographic enhancement of precipitation is small.
Action: Daniel should implement the MESAN scheme and test in cases how reliable it is.

Flow distortion error

Before gauge adjustment we should in principle correct all errors in gauge measurements. Usually they are small but in cases of snowfall the flow distortion error can introduce a significant bias in operational gauge networks (which don't contain fences and wind shields). An underestimation of 30-70% is common in the frequently occurring windy conditions. It can be estimated and corrected using the WMO Jokioinen comparison study (Førland et al., 1996). Knowledge of the gauge type, snowfall intensity and actual wind speed at the height of 2m is required before the

flow distortion correction scheme can be applied. It should not be applied to optical gauges.
Action: Daniel should study if MESAN can provide a correction factor field either independent of NWP using ground observations only, or together with the HIRLAM wind field (optimal solution).

Rain gauge adjustment

MESAN used at SMHI was presented and it was agreed that it is unsuitable for creating an observation-only based analysis. MESAN will produce too much smoothed fields as it uses optimal interpolation based on climatological autocorrelation functions.

Two gauge-radar adjustment methods were advocated: Koistinen and Puhakka (1981), and Rosenfeld's (1995) technique based on probability matching of radar and gauge measurements. The former may be more robust and better adapted to BALTRAD purposes as the probability distributions required for the latter are so far unknown in the BALTEX region and climate. Yet it would be valuable to conduct research on deriving probability density functions which are valid for the weather types found in the BALTEX region. It was agreed the K&P method would be implemented at the BRDC. The general gauge-radar relationship would be derived every 12 (or 24) hours and used every 3 hours. The adjustment will use only those gauge observations, which are available in real time. Ship gauges will not be used. All climatological gauge data, which is received later, will be used for validation purposes of the RR products. There is no principal difficulty to perform the gauge adjustment once more, i.e. integrating the RR field with all later gauge data, available at the BMDC.

The importance of quality control was emphasized. The K&P method assumes a priori that all gauge observations which pass the QC are accurately correct values. MESAN's QC of individual gauges (observational error) could be used with the Koistinen and Puhakka method, which includes a QC part. Additionally we will assume a threshold for gauge values (0.5 mm) in order to include them in the comparison with radar. This assumes that radar contains no clutter. Radar estimates at gauge sites should be thresholded at 0.1 mm for the 12-hour accumulation. Values under these thresholds will not be used in the gauge-radar comparison and in the analysis of the adjustment field.
Action: Jarmo and Daniel should implement the K&P method into BRDC by April 1, 1999.

Some additional ideas concerning gauge-radar adjustment appeared: Could SYNOP present weather combined with gauge measurements fill in areas void of radar data? Satellite data could be useful in filling in additional gaps, but significant research must be conducted before methods can be implemented in BALTRAD's context. Could the previous month's accumulated precip be used as a reference with which to quality control the current situation?

Implementation plan

As much as possible will be implemented by April 1, 1999.

9. BALTRAD Wind soundings (WP)

The BRDC will receive and distribute profiles from the contributing institutes. The wind direction and velocity parameters, along with associated variance quantities, are given the highest priority. Methods which increase the unambiguous velocity range are recommended. The BRDC will try to compile the soundings into a daily time-height plot for each radar. These will be browsable on the web as gif images, at least 24 hours after the measurements are made. The use of WP in NWP models will be enhanced by the new COST-717 action and related research (see Rinne, 1998).

Radial wind velocity polar volumes will not be collected at the BRDC but may be available on request from individual institutes.

10. BALTRAD and related radar activities

The work in WGR will be highly relevant for COST 717. Some of the WGR members will be members of 717, although it is too early to say exactly who. Chris, Jarmo and Daniel are preliminarily involved in defining a possible application to Framework V, coordinates by Pier Paolo Alberoni at SMR/ARPA, Bologna.

11. Forthcoming meetings

Next WGR meeting will be preliminarily 17-18 February, 1999, either in Warsaw or St. Petersburg, with Copenhagen as a backup.
Action: Jarmo will contact Zdzislaw and Vladimir and organize.

8th SSG meeting will be in Stockholm, 8-10 December, 1998. WGR activities will be presented by Jarmo there.

The BRIDGE Implementation meeting has not been determined yet. Daniel might be the appropriate representative there.

Abstracts for the EGS conference should be received by 15th December. It seems that none of us is able to participate the meeting.

EUMETNET OPERA will meet in Vienna in April-May, 1999.

AMS 29th Conference on Radar Meteorology will be in Montreal, 12-16 July. Abstract deadline is January 4th. A paper should definitely be produced on international networking for this event.
Action: Daniel will write an abstract and the paper will be authored by the whole WGR.

13. The meeting was closed.

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Appendix 5

Version: Bridge-o1.doc
Date: 1998-11-04
By: Anders Omstedt

Minutes of

The BALTEX/BRIDGE Ocean program Planning meeting

at

SMHI, Norrköping, Sweden
15-16 October, 1998

1. Introduction

On the behalf of the BALTEX SSG (7th BALTEX SSG meeting 26 May 1998) Prof. Anders Omstedt, SMHI was asked to take steps for the planning and the co-ordination of the oceanographic measuring program during the BRIDGE period. Based upon contacts with the oceanographic community it was decided to have a joint workshop at SMHI during 15-16 October 1998. All ocean partners as listed in the Interim Memorandum of Understanding (IMOU), as well as those involved in the ocean measurements within the HELCOM program were invited, Attachment 1. Of the invited people 14 participants joint the workshop, Attachment 2.

2. Meeting

During the morning on 15 October three presentations were given. Prof. Anders Omstedt outlined the scientific aims for the BALTEX and particularly the BRIDGE program. Mr. Hans Dahlin reviewed earlier experiments in the Baltic Sea and pointed out the need for good calibrations of the CTD data. Dr. Hans-Jörg Isemer presented the recent developments in BALTEX/BRIDGE and the positive response that the IMOU has received.

The afternoon on 15 October the different institutes reviewed their plans for the BRIDGE period. Also some main oceanographic issues were discussed. These issues were summarised with recommendations for actions during the next day.

3. BRIDGE Ocean actions

3.1 Introduction

BRIDGE will be the main intensive observational and modelling period within the framework of BALTEX. It is planned during the period October 1999 to December 2001. The major purpose is to provide observational and model-based data for detailed analysis of water and energy cycle budgets and processes in the whole Baltic Sea drainage basin. Activities during BRIDGE are generally divided into:

- Base-line observational and modelling programmes which will deliver continuous observational and model data during the entire 27 months period.
- Specific enhanced observational and modelling programmes confined to limited periods (EOP) of typically a few weeks or months.

In the oceanographic part of BRIDGE we distinguish between the following main activities:

- EOPs with hydrographic surveys of the whole Baltic Sea and Kattegat.
- EOPs with special field activities.
- Base-line observations related to the in- and outflows through the Baltic entrance areas.
- Base-line observations related to sea levels, sea surface temperatures and ice.
- Data quality controls, storing, archiving, availability and exchange.

Based upon the discussions during the planning meeting the following recommendations and suggestions for actions were given. The aim was to take these actions before the next BALTEX SSG meeting in December 1998.

3.2 Enhanced observational periods with hydrographic surveys of the whole Baltic Sea and Kattegat.

For the initialisation and verification of numerical models and for heat and water balance studies the whole Baltic Sea and Kattegat area needs to be covered about 4 times during the BRIDGE experiment. These surveys need to be co-ordinated with the HELCOM programs as well as with the BRIDGE enhanced observational periods. The measuring activities should therefore be co-ordinated around one week during the following periods: October 1999, Jan/Feb. 2000, Aug./Sept. 2000, April/May 2001.

The measurements should be based upon CTD data with a horizontal resolution of less then 10 nautical miles depending on events and areas. Added to the CTD data the meteorological data and ADCP data are welcome.

Recommendations: The hydrographic surveys should be co-ordinated with the HELCOM program and the active research vessels should be asked to enhance their measurements during these periods. The meeting asked Mr Björn Sjöberg to take the lead and plan and co-ordinate these activities.

3.3 Enhanced observational periods with special field efforts.

The planned special field efforts during the BRIDGE period includes the following parts:

- DIAMIX
- PEP in BALTEX
- BALTEX-BASIS
- Transport of dense deep water on the way from the Arkona Basin to the Gotland Basin.

The first three experimental studies are presently running and co-ordinated by Prof. Anders Stigebrandt, Prof. Ann-Sofi Smedman and Prof. Jouko Launiainen, respectively. They will be partly running during the BRIDGE experiment and are important parts of BRIDGE.

The ventilation of the deeper parts of the Baltic Sea is through dense bottom currents that entering the Baltic Sea through the Danish Sounds. The transports of dense bottom water from the Arkona Basin into the Gotland Basin show many complicated features as mesoscale eddies, dense bottom pools, internal waves and vertical mixing. These processes are of main interest for our understanding and for the modelling of the Baltic Sea. Research done so far by Institute of Oceanology, Sopot, Poland, in the Stolpe Channel with the Research Vessel Oceania, show many of these dynamic features and will be continued during the BRIDGE period. Additional ship activities during the EOP periods should be co-ordinated with the measurements by R/V Oceania.

At the R/V Oceania also measurements of solar radiation fluxes and irradiance attenuation coefficients will be measured. Optical measurements should also be taken from other regions in the Baltic Sea, as from for example from the Gulf of Bothnia.

Recommendations: The experimental studies of the inflow dynamics from the Arkona to the Gotland Basin should be planned and co-ordinated with R/V Oceania as the hub in the experiment. The meeting asked Prof. Jan Piechura to take the lead and plan and co-ordinate these activities. Also to contact another research vessel from which the polish oceanographers could perform optical measurements during the BRIDGE experiment.

3.4 Base-line observations related to the in- and outflows through the Baltic entrance areas.

To close the BALTEX water and heat cycles information about the in– and outflows of water, heat and salt through the Baltic Sea entrance area are of main importance. Measurements (sea level data, currents, temperature and salt) are needed for the whole period and actions are needed for the planning and co-ordination. The measurements through the Sound could be organised by SMHI together with SU (Stockholm University, Prof. Peter Lundberg) and DHI. For similar measurements through The Great Belt and the Little Belt, contacts needs to be taken with other IMOU partners as well as with the Royal Danish Administration of Navigation and Hydrography.

Recommendations: For the planning and co-ordination of the measurements through the Sound, Dr. Bertil Håkansson was asked to take the lead. Mr Hans Dahlin was asked to contact the Royal Danish Administration of Navigation and Hydrography and ask them to join the IMOU, making data available during the BRIDGE period.

3.5 Base-line observations related to the sea level, sea surface temperatures and ice

The modelling community during the BRIDGE period needs data sets of sea levels, sea surface temperatures and ice. These data sets need to be stored in a common database at the BALTEX Oceanographic Data Centre (BODC). Some aspects about the different parameters are listed below;

For sea level data:

- We should aim for hourly values for as many stations as possible
- We should make an inventory of stations in the Baltic Sea/Kattegat region with at least hourly time resolution by improving and updating the inventory made for the BOOS initiative within the EuroGOOS framework.
- Find a common reference level and a common datum for all stations.
- For each station give the Benchmarks and controls during the BRIDGE period.
- At the BODC store sea level data with two values at each time: the local height system and the common reference level.

For SST and ice:

- Find out who will carry out the gridding of SST and ice maps.
- Find out which institute that can deliver gridded and point data to BODC.

- Find out SST-sources from for example buoys and try to get air temperatures at the same time.
- Improve ice observations with particularly ice thickness observations from ice breakers and land fast stations.

Recommendations: Mr Barry Broman was asked to support the BODC with an inventory on sea level stations and make, together with Mr Pekka Alenius, a suggestion for a common storage form and common reference level. Mr Hans Dahlin was asked to contact BSH asking them to join the IMOU and making data available during the BRIDGE period. Mr Hans Dahlin was also asked to make an inventory of available operational buoy stations that could be included during the BRIDGE period and co-ordinate this information with the BODC.

3.6 Data quality controls, storing, archiving, availability and exchange

The success of the oceanographic part during BRIDGE will highly be due to the how well the data can be collected, stored and made available for the BALTEX users. We concluded that all data collected during the BRIDGE period should be collected at one data centre (BODC). This will require clear instructions to those that deliver data. The same model for data users as has been developed at the Hydrological and Meteorological Data Centres (BHDC and BMDC, respectively) should be followed. Data delivery and data quality guidelines should be prepared. The BODC should only compile the data and no data analysis is expected. Data quality control remains the responsibility of the data originators and data should be exchanged in a rather basic form, allowing data exchange through for example FTP with ordinary ASCII-files.
Meteorological data from RV cruises needs probably to be stored both at BODC and BMDC. This should be discussed between the two data centres.

The CTD data should be delivered with a 0.1 dbar vertical resolution and preferable as pressure, temperature and salinity.

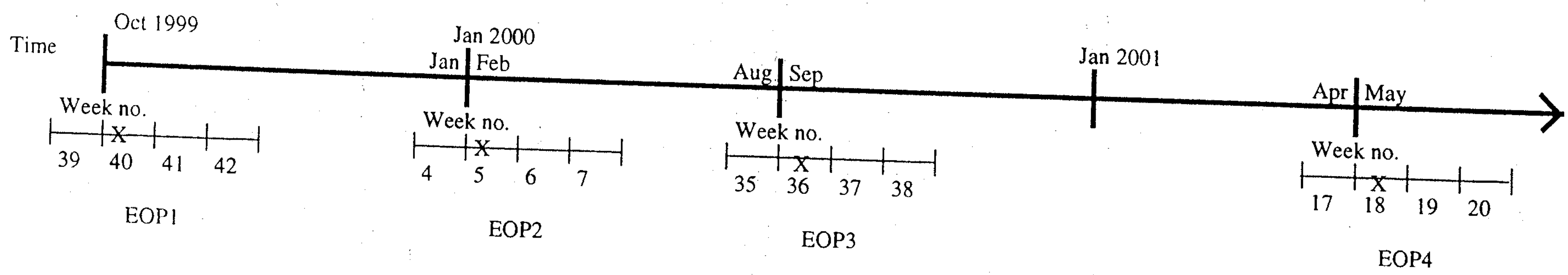
With all oceanographic data we mean:
- Base-line measurements of sea level data with 1 hour time step
- CTD data with 0.1 dbar vertical resolution (about 10 cm), together with meteorological data from research vessels.
- Gridded SST and ice data
- Base-line measurements of currents, temperature and salinity for the entrance areas with calculated volume flow of in- and out flows through the Sound, the Great Belt and the Little Belt.

Recommendations: Mr Pekka Alenius was asked to prepare two guidelines together with Mr Björn Sjöberg. The first guideline should clearly state how the data originators should deliver data to BODC. The second guideline should outline how the data originators should control the CTD data quality. Mr Pekka Alenius was asked to estimate the working load for the BODC during BRIDGE and give a plan to the next BALTEX SSG meeting (December 1998) on how the BODC should work during BRIDGE experiment.

3.7 Time plan and involved institutes and research vessels

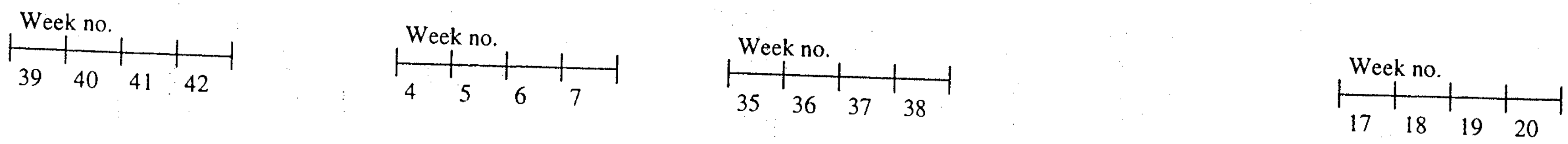
An important part of the ocean program is to co-ordinate the hydrographic measurements during the BRIDGE period. Below the planned time period is outlined with enhanced observation periods (EOP) given. All institutes involved in BRIDGE need to be informed and asked on which period they could join the hydrographic surveys. Mr Björn Sjöberg and Prof. Anders Omstedt were asked to contact all possible institutes as soon as possible and co-ordinate at least the October 1999 enhanced observational period.

The BALTEX/BRIDGE Ocean program



Institute/Research vessel:____

Most convenient week?



Gunni Ærtebjerg
National Environment Research Institute
Dep. of Marine Ecology and Microbiology
Fredriksborgvej 399
DK-4000 Roskilde, DENMARK

Hannu Grönvall
Finnish Institute of Marine Research
P.O. Box 33
FIN-00931 Helsinki, FINLAND

Eugeniusz Andrulewicz
Sea Fisheries Institute
Department of Oceanography
Kollataja 1
pl-81 332 Gdynia, POLAND

Lars Hernroth
Institute of Marine Research
P.O.Box 4
SE-453 21 Lysekil, SWEDEN

Erik Buch
The Royal Danish Administration
of Navigation and Hydrography
Overgaden o. Vandet 62 B
DK-1023 Copenhagen K, DENMARK

Pentti Kangas
Finnish Environment Agency
Kesäkatu 6, P.O.Box 140
FIN-00251 Helsinki, FINLAND

Juozas Dubra
Center of Marine Research
Taikos Pr. 26
LIT-5802 Klaipeda, LITHUANIA

Dieter Kohnke
Bundesamt für Seeschiffahrt und Hydrographie
GOOS-Sekretariat
Postfach 30 12 20
D-20305 Hamburg, GERMANY

Jüri Elken
Estonian Marine Institute
Department of Marine Physics
aldiski Road 1
EE-0001 Tallinn, ESTONIA

Wlodzimierz Krzyminski
Institute of Meteorology and Water Management
- Gdynia Marine Branch -
Waszyngtona 42
PL-81 342 Gdynia, POLAND

Sverker Evans
Swedish Environm. Prot. Agency
Research Department
Smidesvägen 5
SE-171 85 Solna, SWEDEN

Juha-Markku Leppänen
Finnish Institute of Marine Research
P.O. Box 33
FIN-00931 Helsinki, FINLAND

Juliusz Gajewski
Maritime Institute
Dlugi Targ 41/42
PL-80 830 Gdansk, POLAND

Pentti Mälkki
Finnish Institute of Marine Research
P.O. Box 33
FIN-00931 Helsinki, FINLAND

Jouko Launianen
Finnish Institute of Marine Research
P.O. Box 33
FIN-00931 Helsinki, FINLAND

Juha Sarkkula
National Board of Waters
and the Environment Hydrological Office
P.O.Box 436
FIN-00101 Helsinki, FINLAND

Pekka Alenius
Finnish Institute of Marine Research
P.O. Box 33
FIN-00931 Helsinki, FINLAND

Björn Sjöberg
SMHI
Nya Varvet 31
SE-426 71 Västra Frölunda, SWEDEN

Wolfgang Matthäus
Institut für Ostseeforschung Warnemünde
an der Universität Rostock
Seestrasse 15, Postfach 301161
D-18112 Rostock, GERMANY

Aivars Yurkovskis
Marine Monitoring Centre
Institute of Aquatic Ecology
8 Daugarivas str.
LV-1007 Riga, LATVIA

Arne Nielsen
The Royal Danish Administration
of Navigation and Hydrography
Overgaden o. Vandet 62 B
DK-1023 Copenhagen K, DENMARK

Bernard Wisniewski
Institute of Marine Sciences
University of Szczecin
ul. W[1]ska 13
PL-71 415 Szczecin, POLAND

Palle Bo Nielsen
The Royal Danish Administration
of Navigation and Hydrography
Overgaden o. Vandet 62B
DK-1023 Copenhagen K, DENMARK

Halina Kowaleska-Kalkowska
Insitute of Marine Sciences
University of Szczecin
ul. W[1]ska 13
PL-71 415 Szczecin, POLAND

Manfred Rolke
Bundesamt für Seeschiffahrt und Hydrographie
Postfach 30 12 20
D-20305 Hamburg, GERMANY

Anders Stigebrandt
Department of Oceanographic
Geovetarcentrum
Guldhedsgatan 5 A
SE-413 81 Göteborg, Sweden

Jan Piechura
Institute of Oceanology
Polish Academy of Sciences
Powstancow Warszawy 55
PL-81 712 Sopot, POLAND

Gösta Walin
Department of Oceanographic
Geovetarcentrum
Guldhedsgatan 5A
SE-413 81 Göteborg, Sweden

Mikko Alestalo
Finnish Meteorological Institute
Meteorological Research
P.O.Box 503, Vuorikatu 24
FIN-00101 Helsinki, FINLAND

Hans-Ulrich Lass
Institut für Ostseeforschung Warnemünde
Seestrasse 15
D-18119 Rostock-Warnemünde, GERMANY

Sten Bergström
SMHI
SE-601 76 Norrköping, SWEDEN

Hans-Jörg Isemer
GKSS Forschungszentrum Geesthacht GmbH
International BALTEX-Secretariat
Postfach 1160
D-21494 Geesthacht, GERMANY

Andreas Lehmann
Institut für Meereskunde and der Universität Kiel
Düsternbrooker Weg 20
D-24105 Kiel, GERMANY

Lennart Bengtsson
Max-Planck-Institut für Meteorologie
Bundesstrasse 55
D-20146 Hamburg, GERMANY

Bertil Håkansson
SMHI
SE-601 76 Norrköping, SWEDEN

Jerzy Dera
Institut of Oceanology PAS
Pol. Academy of Sciences
Powstancow Warszawy 55
PL-81712 Sopot, POLAND

Barry Broman
SMHI
SE-601 76 Norrköping, SWEDEN

Wolfgang Krauss
Institut für Meereskunde an der Universität Kiel
Düsternbrooker Weg 20
D-24105 Kiel, GERMANY

Peter Lundberg
Stockholm Marine Research Centre
Stockholm University
SE-106 91 Stockholm, SWEDEN

Lars Axell
SMHI
SE-601 76 Norrköping, SWEDEN

SMHI

1998-10-19

The BALTEX/BRIDGE Ocean program
Planning meeting 15 - 16 October,1998

List of participants

Pekka Alenius
Finnish Institute of Marine Research
P.O. Box 33
FIN-00931 Helsinki, FINLAND

Rüdiger Brandt
GKSS Forschungszentrum Geesthacht
GmbH
International BALTEX-Secretariat
Postfach 1160
D-21494 Geesthacht, GERMANY

Barry Broman
SMHI
SE-601 76 Norrköping, SWEDEN

Hans Dahlin
SMHI
SE-601 76 Norrköping, SWEDEN

Jüri Elken
Estonian Marine Institute
Department of Marine Physics
Paldiski Road 1
EE-0001 Tallinn, ESTONIA

Juliusz Gajewski
Maritime Institute
Dlugi Targ 41/42
PL-80 830 Gdansk, POLAND

Bertil Håkansson
SMHI
SE-601 76 Norrköping, SWEDEN

Hans-Jörg Isemer
GKSS Forschungszentrum Geesthacht
GmbH
International BALTEX-Secretariat
Postfach 1160
D-21494 Geesthacht, GERMANY

Andreas Lehmann
Institut für Meereskunde and der
Universität Kiel
Düsternbrooker Weg 20
D-24105 Kiel, GERMANY

Peter Lundberg
Stockholm Marine Research Centre
Stockholm University
SE-106 91 Stockholm, SWEDEN

Anders Omstedt
SMHI
SE-601 76 Norrköping, SWEDEN

Jan Piechura
Institute of Oceanology PAS
Powstancow Warszawy 55
PL-81 712 Sopot, POLAND

Anna Rozwadowska
Institute of Oceanology PAS
Powstancow Warszawy 55
PL-81 712 Sopot, POLAND

Björn Sjöberg
SMHI
Nya Varvet 31
SE-426 71 Västra Frölunda, SWEDEN

Appendix 6

BALTEX Oceanographic Data Center: BALTEX ODC

Status report, December 1998

Pekka Alenius
Finnish Institute of Marine Research
P.O.Box 33, FIN-00931 Helsinki
tel: 358-9-613 94 439
fax: 358-9-612 94 494
e-mail: alenius@fimr.fi

Object

The Finnish Institute of Marine Research (FIMR) has offered to act as the Oceanographic Data Center (BALTEX-ODC, the previous acronym BODC is the official acronym of British Oceanographic Data Center and cannot be used within BALTEX) for the BALTEX international research project. The BALTEX-ODC acts as a service center for all BALTEX participants in oceanographic data questions.

The BALTEX-ODC is mainly a meta-data center providing links to the data originators around the Baltic Sea. The BALTEX-ODC can act as a real data center for BALTEX/BRIDGE Ocean Program.

This status report describes the situation in December 1998. It includes the response to the recommendations of the planning meeting "The BALTEX/BRIDGE Ocean Program" held in Norrköping 15-16 October 1998.

Data types

The major oceanographic data types that have been discussed in relation to BALTEX/BRIDGE are:

1. sea level data with 1 hour time steps
2. CTD data with 0.1 db vertical resolution together with meteorological data from research vessels
3. Gridded SST and ice data
4. Base-line measurements of currents, temperature and salinity for the entrance areas with calculated volume flow of in- and outflows through the Sound, the Great Belt and the Little Belt.

Information on these types of data should be included into the BALTEX-ODC according to the discussions in Norrköping.

Time periods of data

Previous definition of the important periods of data was: BALTEX key periods are 1986-1987, 1992-1993 and 1995. Other important periods are the BALTEX oceanographic experiments, BASIS and DIAMIX in 1997 and 1998.

The present opinion of the planning meeting was that the BALTEX-ODC should at least concentrate to the BRIDGE period.

Meta data information

Meta data contains the contact addresses and persons of data originators as well as information on their data holdings and availability of data. Such a list should include the oceanographic institutions around the Baltic Sea and the international oceanographic organizations where data is available on certain conditions. This meta-data will be put available in internet. The FIMR has a WWW server where a home page for BALTEX-ODC is under construction. That home page will be linked to the BALTEX secretariat home page right after it has been made public.

Physical data storage

Those data types mentioned previously in this report should be stored physically into the BALTEX-ODC. However, no real data sets has so far been collected to BALTEX-ODC. The construction of the gridded data is done in different institutions, not by the BALTEX-ODC.

The data collected by different institutions should be stored in a unified format in the data center to make the use of the data easy. The FIMR has facilities to produce e.g. CD-ROM's on limited amounts.

The data delivery should be done either by file transfer via FTP or by disk media (either diskettes or CD-ROMs).

Activities so far

The home pages of the BALTEX-ODC are still under construction.

The planning meeting in Norrköping recommended that Mr. Pekka Alenius should prepare two guidelines together with Mr. Björn Sjöberg from SMHI. The first should clearly state how the data originators should deliver data to BALTEX-ODC. The second guideline should outline how the data originators should control the data quality.

The BALTEX-ODC has received from the BALTEX secretariat a list of sea level stations around the Baltic Sea reported by the participating countries.

The planning meeting suggested Mr. Barry Broman from SMHI and Mr. P. Alenius to make a suggestion for a common storage form and common reference level for the sea level data. This work has not yet been done, but Mr. P. Alenius has had some discussions with Finnish Geodetic Institute on the problems of the common reference level.

Mr. P. Alenius visited the BALTEX Hydrological Data Center in Norrköping in 16 October 1998. The basic working structures seem to be quite similar in both data centers. A data base following some of the ideas of the Hydrological Data Center is now under construction in BALTEX-ODC. In addition to the meta-data and data, also a data base for authorized data users is under contruction.

Mr. P. Alenius visited SMHI laboratory in Gothenburg in 30. October 1998 and discussed with Mr. B. Sjöber and Mr. Jan Szaron on the data formatting and data delivery problems. The ideas for the guidelines are clarifying and short guidelines will be written in early 1999. It seems most appropriate to stick in the data delivery to common ASCII-files with certain key-words identifying the different parameters. The BALTEX-ODC will ask different institutes to send sample data sets in the beginning of 1999 to test the data delivery.

The FIMR has the technical facilities to organize and fulfill the BALTEX-ODC tasks. The man power resources available for the task will be decided by the FIMR in very near future.

Appendix 7

Review of the Workshop on Evaporation of the Baltic Sea

The workshop was held at Rügen
during the 2nd Study Conference on BALTEX
on Friday, May 29, 1998, 8.30-11.00 h

Participants: see list (Annex 1)

After a short opening by the chairman, E. Ruprecht (opening remarks see Annex 2), 5 authors gave an overview on their work concerning evaporation of the Baltic Sea:

K. Bumke (Annex 3)
H.-J. Isemer (Annex 4)
A. Omstedt (Annex 5)
A. Rutgersson (Annex 6)
E. Heise (Annex 7)

Each talk was interrupted and followed by heavy discussions. Thus, participants could successfully exchange their thoughts and ideas.
The participants agreed on the two main problems.

1. Observations
2. Parameterizations

1. In order to estimate evaporation of the whole Baltic Sea sufficient and reliable observations of different parameters are needed as SST, wind, humidity etc. There exist, however, particular problems, as

a) correct measurements of SST e.g. to catch the highly time-variable upwelling regions,
b) consider coastal effects, in particular for the wind fields,
c) parameter sampling to include diurnal variability, or small-scale changes,
d) systematic errors due to ship effects.

2. Bulk-parameterization is the most often used method to estimate evaporation:
a) there is still a discussion about the bulk coefficients and their dependency on wind speed and stability,
b) the effect of surface waves on the vertical fluxes are not yet fully explored, in addition the observation of wave age, which is the required parameter, is not an easy task.

An additional question was raised whether other parameterizations or methods should be used for the estimation of evaporation, e.g. budget method, inclusion of numerical models.

The participants agreed that the ongoing and planned field experiments of BALTEX as PEP, BASIS, Östergarnsholm, can contribute a lot to solve many of the open questions. Therefore large support should be given to these experiments.

A very fruitful discussion finished the workshop. All participants agreed that this was a useful meeting and that similar workshops should be organized.

WG on Process Studies

Workshop on Evaporation of the Baltic Sea, May, 29, 1998

PARTICIPANTS:

Dr. Karl Bumke	Institut für Meereskunde Düsternbrooker Weg 20 24105 Kiel, Germany email: kbumke@ifm.uni-kiel.de
Prof. Dr. Lutz Hasse	Institut für Meereskunde Düsternbrooker Weg 20 24105 Kiel, Germany email: lhasse@ifm.uni-kiel.de
Dr. Erdmann Heise	Deutscher Wetterdienst Postfach 10 04 65 63004 Offenbach email: eheise@dwd.d400.de
Dr. Hans-Jörg Isemer	BALTEX-Sekretariat GKSS Forschungszentrum Max-Planck-Strasse 21502 Geesthacht, Germany email: isemer@gkss.de
Dr. Ralf Lindau	Institut für Meereskunde Düsternbrooker Weg 20 24105 Kiel, Germany email: rlindau@ifm.uni-kiel.de
Mikael Magnussen	Dep. of Earth Sciences, Meteorology Uppsala University Box 516 75120 Uppsala, Sweden email: mikael.magnusson@met.uu.se
Prof. Dr. Anders Omstedt	Swedish Meteorological and Hydrological Institute (SMHI) 60176 Norrköping, Sweden email: aomstedt@smhi.se
Dr. Burkhardt Rockel	GKSS Forschungszentrum Max-Planck-Strasse 21502 Geesthacht, Germany email: rockel@gkss.de
Prof. Dr. E. Ruprecht (Chairman)	Institut für Meereskunde Düsternbrooker Weg 20 24105 Kiel, Germany email: eruprecht@ifm.uni-kiel.de
Anna Rutgersson	Dept. of Earth Sciences, Meteorology Swedish Meteorological and Hydrological Institute (SMHI) 60176 Norrköping, Sweden email: arutgers@smhi.se
Prof. Dr. Ann-Sofi Smedmann	Dept. of Earth Sciences, Meteorology Uppsala University Box 516 75120 Uppsala, Sweden email: annsofi@big.met.uu.se

International BALTEX Secretariat Publication Series

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

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

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

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

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

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

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

No. 8 : *Hydrological, Oceanic and Atmospheric Experience from BALTEX.* Extended Abstracts of the XXII EGS Assembly, Vienna, Austria, April 21-25, 1997. Editors: M. Alestalo and H.-J. Isemer. August 1997, 172 pages.

No. 9 : The Main BALTEX Experiment 1999-2001 – ***BRIDGE.*** Strategic Plan. October 1997, 78 pages.

No. 10: Minutes of Fifth Meeting of the BALTEX Science Steering Group at Latvian Hydrometeorological Agency in Riga, Latvia, April 14-16, 1997. January 1998.

No. 11: Second Study Conference on BALTEX, Juliusruh, Island of Rügen, Germany, 25-29 May 1998. Conference Proceedings. Editors: E. Raschke and H.-J. Isemer. May 1998, 251 pages.

International BALTEX Secretariat Publication Series (continued)

No. 12: Minutes of 7th Meeting of the BALTEX Science Steering Group at Hotel Aquamaris in Juliusruh, Island of RÜGEN, Germany, 26 May 1998. November 1998.

No. 13: Minutes of 6th Meeting of the BALTEX Science Steering Group at Danish Meteorological Institute in Copenhagen, Denmark, 2 to 4 March 1998. January 1999.

No. 14: BALTEX – BASIS Data Report 1998. Editor: Jouko Launiainen March 1999, 96 pages.

No. 15: Minutes of 8th Meeting of the Science Steering Group at Stockholm University in Stockholm, Sweden, 8 to 10 December 1998. May 1999.

Copies are available upon request at the International BALTEX Secretariat.