1st Periodic Report

IOMASA

Contract Number EVK-CT-2002-00067

Reporting Period:

Project Month 1–12,

1 November, 2002 – 31 October, 2003

Sections 1 – 4

Coordinator: Klaus Künzi, Georg Heygster

http://www.uni-bremen.de/~pharos/iomasa

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Participants Information

N°	Institution/ Organization	Street name/ number	Post Code	Town/City, Country		Title	Family Name	First Name	Telephone N°	Fax N°	E-mail
1	IUP, UB	Otto-Hahn-Allee 1	28359	Bremen	DE	Prof.	Künzi	Klaus	+49-421-218-3909	+49-421-2184555	kunzi@uni-bremen.de
2	IUP, UB	Otto-Hahn-Allee 1	28359	Bremen	DE	Dr.	Heygster	Georg	+49-421-218-3910	+49-421-218-4555	heygster@uni-bremen.de
3	IUP, UB	Otto-Hahn-Allee 1	28359	Bremen	DE	Dr.	Melsheimer	Christian	+49-421-218-2584	+49-421-218-4555	melsheimer@uni-bremen.de
4	Ørsted*DTU, DTU		2800	Lyngby	DK	Dr.	Toudal Pedersen	Leif	+45-4525-3791	+45-4593-1634	ltp@oersted.dtu.dk
5	Ørsted*DTU, DTU		2800	Lyngby	DK		Saldo	Roberto	+45-4525-3790	+45-4593-1634	rs@oersted.dtu.dk
6	DMI	Lyngbyvej 100	2100	København Ø	DK	Dr.	Gill	Rashpal S.	+45-3915-7500	+45-3915-7300	rsg@dmi.dk
7	DMI	Lyngbyvej 100	2100	København Ø	DK	Dr.	Andersen	Søren	+45-3915-7346	+45-3915-7300	san@dmi.dk
8	DMI	Lyngbyvej 100	2100	København Ø	DK		Bøvith	Thomas	+45-3915-7500	+45-3915-7300	thb@dmi.dk
9	met.no	P.O. Box 43, Blindern	0313	Oslo	NO	Dr.	Schyberg	Harald	+47 22 96 33 28	+47 22 96 30 50	h.schyberg@met.no
10	met.no	P.O. Box 43, Blindern	0313	Oslo	NO	Dr.	Breivik	Lars-Anders	+47 22 96 33 33	+47 22 96 30 50	l.a.breivik@met.no
11	met.no	P.O. Box 43, Blindern	0313	Oslo	NO		Tveter	Frank Thomas	+47 22 96 33 57	+47 22 96 30 50	f.t.tveter@met.no
12	SMHI		60176	Norrköping	SE	Dr.	Landelius	Tomas	+46 11 495 81 80	+46 11 495 80 01	Tomas.Landelius@smhi.se
13	SMHI		60176	Norrköping	SE	Dr.	Gustafsson	Nils	+46 11 495 81 80	+46 11 495 80 01	Nils.Gustafsson@smhi.se
14	SMHI		60176	Norrköping	SE		Dahlgren	Per	+46 11 495 81 80	+46 11 495 80 01	Per.Dahlgren@smhi.se
15	SMHI		60176	Norrköping	SE	Dr.	Perov	Veniamin	+46 11 495 84 53	+46 11 495 80 01	venjamin.perov@smhi.se

IUP: Institut für Umweltphysik; UB: University of Bremen; DTU: Technical University of Denmark; DMI: Danish Meteorological Institute, met.no: The Norwegian Meteorological Institute; SMHI: Swedish Meteorological and Hydrological Institute

SECTION 1

Management and Resource Usage Summary

1.1 Objectives of the reporting period

The first half of the reporting period coincides with phase 1 of the project, focused on preparation activities: Providing Day 0 algorithms and models to the partners, inventorying the data and making them available, preparing the numerical weather prediction (NWP) activities, organising and coordinating the activities of the partners. The second half of the reporting period is the beginning of phase 2 of the project, the development phase, ending in March 2005 (project month 28).

1.2 Scientific/Technical progress made in different work packages according to the planned time schedule

Until the end of the reporting period (project month 12), all work packages have been on schedule: Work package 1.1, 2.1, 3.1., 4.1, and 5.1 have been successfully completed at the end of project month 6, and the subsequent work packages 1.2, 2.2, 3.2, and 4.2 are on schedule so far. Table 1.1 gives an overview of the situation. The triple vertical line marks the end of the reporting period.
Table 1.2 shows a comparison between planned and used manpower and financial resources.

1.2.1 Partner 1: IUP

WP 1.1 Day 0 algorithms for the retrieval of total water vapour (TWV) and cloud liquid water (CLW) from SSM/T2 and SSM/I data, respectively, have been provided to the partners. AMSU-A, AMSU-B data of the investigation period (2001–2002) have been made available to the partners. Global radiosonde data 1996–2002 from radiosonde stations have been provided by DMI; in addition, high-resolution radiosonde data from cruises of the research vessel "Polarstern" (AWI, Alfred Wegener Institute, Bremerhaven, Germany) are available at IUP (see also Report for IOMASA Deliverable 1.1). A survey of recent literature on total water vapour retrieval and surface emissivity was done and provided to the partners. An IOMASA member web site (password-protected) has been set-up for easy access to information and internal documents among the partners (http://www.uni-bremen.de/~pharos/iomasa-member)

WP 1.2 Reading and integration routines for radiosonde profiles (global, Polarstern) have been written. The procedure to calibrate the TWV retrieval algorithm with radiosonde data has been almost completely re-implemented and is now adapted to AMSU-B data. The work to transfer the retrieval procedure for

Table 1.1: **IOMASA Project Planning and Time Table.** The triple vertical line marks the end of the reporting period.

Project Month	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35
Meeting months	⇓ 1		⇓ 6			⇓ 12			⇓ 18					⇓ 28		⇓ 32		⇓ 36
Management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Part 1: Remote sensing of atmospheric parameters (Partner 1)																		
1.1: Data and day 0 algorithms	■	■	■															
1.2: Atmospheric algorithms				■	■	■	■	■	■	■	■	■	■	■				
1.3: Produce retrieved fields															■	■		
1.4: Validation																	■	■
Part 2: Improving numerical weather prediction models (Partners 4,5)																		
2.1: Prepare NWP activities	■	■	■															
2.2: Improve Arctic high-res. NWP				■	■	■	■	■	■	■	■	■	■	■				
2.3: Prepare real time assimilation															■	■		
2.4: NWP Production and validation																	■	■
Part 3: Empirical model for emissivity and backscatter of sea ice (Partner 2)																		
3.1: Prepare sea ice modelling	■	■	■															
3.2: Sea ice forward models				■	■	■	■	■	■	■								
3.3: Influence of snow											■	■	■	■	■	■		
3.4: Validate sea ice forward models																	■	■
Part 4: Sea ice concentration retrieval (Partner 3)																		
4.1: Prepare sea ice retrieval	■	■	■															
4.2: Sea ice retrieval algorithm				■	■	■	■	■	■	■	■	■	■	■				
4.3: Produce sea ice fields															■	■		
4.4: Validate sea ice algorithm																	■	■
Part 5: Real time processing and user interface (Partner 2)																		
5.1: Define interfaces and formats	■	■	■															
5.2: —																		
5.3: Setup of production and interface															■			
5.4: Validate production and interface																	■	■

cloud liquid water path from the SSM/I sensor to the recently launched AMSR-E (aboard Aqua satellite) has been started. Preliminary results are encouraging. The work on determining the sea ice emissivity at temperature sounding frequencies has been initiated. Appropriate satellite data and data handling programs have been provided.

1.2.2 Partner 2: DTU

WP 3.1 An on-line database of 25 years of SMMR and SSM/I data has been established.

WP 3.2 Forward models relating relevant geophysical parameters for the atmosphere, ocean and sea ice to measured brightness temperatures have been implemented for the SSM/I instrument and the new AMSR microwave radiometer. An on-line database of AMSR swath data is being established.

WP 5.1 Some data exchange formats have been defined. Note that on Progress Meeting 2 it was agreed that “instead of exchanging data, we shall rather exchange algorithms” (see section 6.1.2 of Minutes of

Table 1.2: Comparison between planned and used manpower and financial resources by Work Packages (WP) and partners

WP	**Partner**	**Person-Months**		**Financial Resources [€]**	
		planned	**used**	**planned**	**used**
0	IUP	1	1	4,896	4,872
1.1	IUP	6	7	29,378+7,818[a]	34,107+8,115[a]
1.2	IUP	10	9.5	48,963+8,500[b]	46,288+8,620[b]
2.1.	met.no	4	4	51,000[c]	50,020[c]
	SMHI	1	1	10,291[d]	9,661[d]
2.2	met.no	5.7	5	70,969[e]	61,443[e]
	SMHI	9	6.6[f]	76,623[g]	58,843[g]
3.1	DTU	7	7	32,754	32,754
3.2	DTU	6	6	25,694	25,694
4.1	DMI	6	6	30,000+7,558[h]	21,738+7,937[h]
	met.no	2	2	24,000	24,067
4.2	DMI	6	6	30,000+6,400[i]	21,738 + 2,134[i]
	met.no	3	2	36,000	24,067
5.1	IUP	1	1	4,896+3,700[j]	4,872+745[j]
	DTU	3	3	12,869	12,869
	DMI	1	1	5,000	
	met.no	1	1	12,000	12,034
	SMHI	0[k]	0	0	0

[a] durable equipment
[b] travel subsistence
[c] incl. travel to Kick-off Meeting
[d] incl. travel to Progress Meeting 1
[e] incl. travel to Progress Meeting 1
[f] see explanation in section 1.4
[g] incl. travel to Kick-off Meeting
[h] durable equipment
[i] travel subsistence, cosumables and others
[j] consumables
[k] see explanation in section 1.4

Progress Meeting 2, Annex A.3) A near real time data distribution system has been set up at DTU to present IOMASA results to interested parties. The server can be accessed through the IOMASA web portal at DTU: http://www.seaice.dk/iomasa

1.2.3 Partner 3: DMI

WP 4.1 Two years of QuikSCAT and SSM/I data have been collected and a validation strategy has been devised. Day 0 models and algorithms have been defined (see "IOMASA Phase1 report for Part 4 (sea ice concentration)", Report for IOMASA Deliverable 4.1).

WP 4.2 A study of melt-induced snow metamorphosis phenomena and their effect on sea ice concentration retrieval has been concluded (see also DMI Technical Report 03-13 by R. Tonboe, S. Andersen and L. Toudal, about detection and influence of warm air events: "Anomalous Winter Sea Ice Backscatter and Brightness Temperatures"). Preparations for deriving ice concentration from SAR scenes is in a near final state. Backscatter and emissivity models have been obtained and will provide the basis for algorithm development.

WP 5.1 Data exchange formats have been defined.

1.2.4 Partner 4: met.no

WP 2.1 For providing NWP fields to the other project partners, a system for extracting data from the NWP model HIRLAM (High Resolution Limited Area Model) was set up. This system contains code and a script to extract a set of quantities of particular interest from the full model fields stored at the Norwegian Meteorological Institute. With this system the following fields will be available:

- Total cloud liquid water
- Total column water vapour
- 2 m temperature
- 10 m wind
- Accumulated 6 hours precipitation

These data can be provided for four times a day, i.e., every 6 hours. The data are stored in gridded binary (GRIB) format, and the format of the data is documented in the Report for IOMASA Deliverable 2.1.1.

WP 2.2 A near-real-time data stream for providing co-located AMSU measurements and interpolated HIRLAM profiles and surface data has been set up.

WP 4.1 Methods for atmospheric correction of SSM/I data for sea ice retrieval and methods for sea ice retrieval from QuikSCAT data have been reviewed.

WP 4.2 A system for providing co-located ice retrievals from an ice processing chain taking SSM/I data as input, is being set up. A method for using multi-pass correlations as a part of sea ice retrieval from satellites has been derived.

WP 5.1 met.no has contributed to the specification of definitions of formats and software for the provision of NWP model fields.

1.2.5 Partner 5: SMHI

WP 2.1 The data streams for the direct measurements of the AMSU-B radiances, redistributed by EUMETSAT, as well as the OSI SAF (Satellite Application Facility on Ocean and Sea Ice) ice concentration measurements are now up and running.

WP 2.2 The HIRLAM variational data assimilation (HIRVDA) system has been extended to include an outer loop in the minimisation process. Making intermediate re-linearisations in an outer loop allows the minimisation to find solutions also for observations with a non-linear relationship to the NWP state vector. This is known to be the case for AMSU-B radiances and model humidity.
The surface analysis in HIRLAM has been extended to produce and assimilate pseudo observations of ice fraction on the HIRLAM scale (e.g., 22 km) based on the OSI SAF data stream that was set up in WP 2.1.

There is a close collaboration with the HIRLAM project concerning the development of a new surface package based on surface tiles. This work includes an improved snow formulation which is of interest to IOMASA because of its relationship to surface emissivity and skin temperature.
A new flux formulation has been developed that can deal well with a stably stratified atmospheric surface layer. Tests show significant influence of the new parameterisation in winter time at northern latitudes.
Ongoing work is concentrated on implementing a new humidity variable in the NWP model with normally distributed error statistics and on extending the NWP model state vector with surface skin temperatures as well as surface emissivities for the AMSU-A and -B frequencies. The former is an important assumption in the data assimilation system and the latter should relax the requirement on good estimates of skin temperature and emissivity to a decent first guess.

1.3 Milestones and deliverables obtained

See Table 1.3 and Table 1.4.

Table 1.3: Overview of Deliverables Obtained. All dates are in project months.

Deliverable	**Date**	
	planned	**actual**
1.1	6	6
2.1.1	6	6
2.1.2	6	6
3.1.1	6	6
3.1.2	12	12
4.1	6	6
5.1	12	12

Table 1.4: Overview of Milestones Reached. DL denotes "Deliverable"; all dates are in project months.

Milestone	**Date**	
	planned	**actual**
DL 1.1	6	6
DL 2.1.1	6	6
DL 3.1.1	6	6
DL 3.1.2	12	12
DL 4.1	6	6
DL 5.1	12	12

1.4 Deviations from the work plan or/and time schedule and their impact on the project

1.4.1 SMHI

There are errors in the work plan concerning the amount of time SMHI is supposed to work in different work packages. The contract preparation forms say that SMHI should work 30 person-months but if the person-months in the Description of Work are summed up the result is 39. We propose that the work plan is updated in the following way (person-months from Description of Work in parentheses):

	Work package	Person-months
WP 2.1	Prepare NWP activities	01 (04)
WP 2.2	Improve Arctic NWP	23 (22)
WP 2.3	Real-time assimilation	02 (04)
WP 2.4	Validation of impact	02 (04)
WP 5.1	Define IO formats	00 (01)
WP 5.3	Distribution system	01 (02)
WP 5.4	Demonstration data	01 (02)
	Total:	30 (39)

In the following the planned figures for the person-months of each work package are based on the new values in this table.

SMHI, WP 2.1 The reason for the discrepancy between the originally planned 4 person-months and the proposed and used 1 person-month was that our IOMASA work has benefitted from results in other SMHI projects. We then asked for our remaining 3 person-months from WP 2.1 to be transferred to WP 2.2.

SMHI, WP 2.2 Competition for resources at SMHI only allowed the IOMASA project to spend 6.7 of the planned 9 person-months on WP 2.2 during the first project year. The intention is still to have spent the planned 23 person-months on this work package when it will be finished by project month 29.

SMHI, WP 5.1 In the Description of Work, SMHI was supposed to work 1 person-month in this work package but this time is proposed to be removed in order to make the total number of person-month meet what SMHI has committed to in the contract. This is no problem since on Progress Meeting 2 it was agreed that emphasis is on exchanging algorithms rather than data, reducing the amount of work in WP 5.1.

1.5 Co-ordination of the information between partners, communication activities

IOMASA project meetings

Kick-off meeting, 4-5 November, 2002, IUP, Bremen, Germany: project partners

Progress Meeting 1, 24-25 April, 2003, DMI, Copenhagen, Denmark: project partners and User Advisory Group (UAG)

Progress Meeting 2, 30-31 October, 2003, SMHI, Norrköping, Sweden: project partners

Conferences/Workshops attended

3rd EuroGOOS conference, 3-6 December, 2002, Athens, Greece: G. Heygster (IUP) presented an overview of IOMASA: “IOMASA – Integrated Observation and Modeling of Arctic Sea ice and Atmosphere”

HIRLAM Workshop, 9-12 February, 2003, Copenhagen: T. Landelius, N. Gustafsson (SMHI); assimilation of AMSU data was discussed among other things.

EGS-AGU-EUG Joint Assembly, 6-11 April, 2003, Nice, France: V. Perov presented his work on surface heat flux modelling under the title “Application of a new spectral theory of turbulence to a stably stratified atmospheric boundary layer”.

13th International TOVS Study Conference (ITSC-XIII), 29 October - 4 November, 2003, Montréal, Canada: P. Dahlgren presented a poster entitled “Ongoing and planned activities in the usage of ATOVS AMSU A/B in the HIRLAM 3DVAR system at SMHI”.

Co-operation with other projects/networks

SMHI: Cooperation with the HIRLAM project concerning the work on implementing outer loops in the data assimilation and on an improved snow formulation, with the EU project CLOUDMAP2 concerning the use of a new humidity variable in the assimilation process, and with the national SWECLIM project concerning surface heat flux modelling.

SMHI: AMSU-A and AMSU-B data received at SMHI via the EARS service (Eumetsat ATOVS Retransmission Service)

SMHI: Ice concentration estimates are provided by the OSI SAF.

1.6 Difficulties encountered at management and co-ordination level and proposed/applied solutions

At Progress Meeting 2, all Partners voiced their concern that for coordinating and discussing the ongoing development phase activities, the time between Progress Meeting 2 (project month 12) and Mid-term Review (originally scheduled at the end of project month 22) is too long. All Partners agreed on holding the Mid-term Review 4 months earlier, i.e. at the end of project month 18 (early May, 2004)

SECTION 2

Executive Publishable Summary

Contract n°	EVK-CT-2002-00067	Reporting period:	Nov. 2002 – Oct. 2003
Title	IOMASA – Integrated Observation and Modeling of Arctic Sea ice and Atmosphere		

Objectives: The overall objective of IOMASA is to improve our knowledge about the Arctic atmosphere and ocean by using satellite information which is continuously available, but currently not exploited. This progress will be achieved through an integrated approach involving

1. Remote sensing of atmospheric parameters temperature, humidity and cloud liquid water over sea and land ice,
2. Improved remote sensing of sea ice with more accurate and higher resolved ice concentrations (percentage of ice covered sea surface), and
3. Improving numerical atmospheric models by assimilating the results of the points 1 and 2.

The first half of the reporting period coincides with phase 1 of the project, focused on preparation activities: Providing Day 0 algorithms and models to the partners, inventorying the data and making them available, preparing the numerical weather prediction (NWP) activities, organising and coordinating the activities of the partners. The second half of the reporting period is the beginning of phase 2 of the project, the development phase, ending in March 2005 (project month 28). It is devoted to developing and improving algorithms.

Scientific achievements: The following data are now available to all project partners: SMMR and SSM/I (25 years), AMSU-A and -B (since 2000), QuikSCAT (2001-2002), global radiosonde data (1996-2002), relevant HIRLAM numerical weather prediction fields like total cloud liquid water or 2 m temperature. Data streams for the direct measurements of AMSU-B radiances, redistributed by EUMETSAT, as well as for the OSI SAF (Satellite Application Facility on Ocean and Sea Ice) ice concentration measurements have been set up. A near-real-time data stream for providing co-located AMSU measurements and interpolated HIRLAM profiles and surface data has been set up. The assimilation system for HIRLAM has been extended and prepared for the assimilation of humidity and temperature information from AMSU data. In addition, a near real time data distribution system has been set up at DTU to present IOMASA results to interested parties (http://www.seaice.dk/iomasa). A new heat flux scheme is being implemented in HIRLAM. Development of the sea ice emissivity model and of the algorithms to retrieve total water vapour, cloud liquid water, temperature profile, and sea ice concentration from the remote sensing data is progressing.

Socio-economic relevance and policy implications: If brought to operational application the results should improve operational weather forecasts in Northern Europe, helping to improve the living conditions in Northern Europe and especially human off-shore activities in the Arctic region, such as navigation, fisheries, tourism, and exploitation of marine mineral resources. In addition, reliable forecasts are the first step in risk management and disaster control whether in the marine environment, the atmosphere or on land. It is important in making decisions on capital expenditure regarding investments in industry and infrastructure. The assimilation of AMSU-B data will also enhance value of data of meteorological European satellites because sensors similar to AMSU-B are planned on future METOP satellites. The new surface heat flux scheme should lead to improved weather forecasts for Northern Europe and especially of clouds in the Arctic.

Keywords: Numerical Weather Prediction, Arctic, Remote Sensing Data, Microwave Sounding, Assimilation, Sea Ice Concentration, Surface Emissivity, Total Water Vapour, Cloud Liquid Water

Publications (cumulative list)

Peer-Reviewed Articles:

Authors	Date	Title	Journal	Reference
S. Sukoriansky, V. Perov, B. Galperin	2003	Application of a new spectral theory of turbulence to a stably stratified atmospheric boundary layer	Geophysical Research Abstracts	Vol. 5, 07037, 2003

Non-refereed Literature:

Authors / Editors	Date	Title	Event	Reference	Type[1]
G. Heygster, S. Andersen, N. Gustafsson, K. Kunzi, T. Landelius, H. Schyberg, L. Toudal	Dec 2002	IOMASA – Integrated Observation and Modeling of Arctic Sea ice and Atmosphere	3rd EuroGOOS conference	Proceedings of the 3rd EuroGOOS conference, Athens, 3-6 Dec. 2002	paper
P. Dahlgren	Nov 2003	Ongoing and planned activities in the usage of ATOVS AMSU A/B in the HIRLAM 3DVAR system at SMHI	ITSC XIII	Proceedings of ITSC XIII, Montreal, Canada, Nov. 2003	paper
R. Tonboe, S. Andersen, L. Toudal	2003	Anomalous winter sea ice backscatter and brightness temperatures		DMI Techn. Rep. 03-13, 62 pp.	techn. report
D. Hofman-Bang	2003	Microwave remote sensing of sea ice	Master Thesis		thesis

Articles submitted to peer-reviewed journals:

Authors	Date	Title	Submitted to
S. Sukoriansky, V. Perov, B. Galperin	2003	A spectral closure model for turbulent flows with stable stratification - Theory and a test case of atmospheric SBL over ice	Boundary Layer Meteorology
N. Selbach, T.J. Hewison, G. Heygster	2003	Emissivity of sea ice at 89 GHz, 157 GHz and 183 GHz in the Arctic winter	IEEE Trans. Geosci. Remote Sens.

Planning of future publications:

Author(s)	Date	Title	Target	Type
R. Tonboe, S. Andersen, L. Toudal	2003	Anomalous winter sea ice backscatter and brightness temperatures	Remote Sens. of Envir.	paper
T. Bøvith, S. Andersen, L. Kaleschke	2004	Sea ice concentration from Single polarised SAR data using Second-Order Grey level Statistics and Learning Vector Quantisation	DMI	techn. report
D. Hofman-Bang, L. Toudal Pedersen	2003	Retrieval of geophysical parameters from AMSR data	DTU	report
G. Hong, J. Miao, G. Heygster, K. Künzi	2004	Simultaneous retrieval of cloud liquid water and precipitable water vapour over open ocean and sea ice using AMSR-E data	IEEE Trans. Geosci. Remote Sens.	paper

SECTION 3

Detailed Report by Work Package

3.1 Work Package 1.1 (IUP)

3.1.1 Objectives

Provide sensor data of historic investigation period and day 0 algorithms for atmospheric remote sensing.

3.1.2 Methodology and scientific achievements

[This section is covered by parts of the Report for IOMASA Deliverable 1.1.]

3.1.3 Discussion and conclusion

This work package has been successfully completed. It is documented in the Report for IOMASA Deliverable 1.1.

3.2 Work Package 1.2 (IUP)

3.2.1 Objectives

Development of algorithms for retrieval of atmospheric parameters.

3.2.2 Methodology and scientific achievements

Reading and integration routines for radiosonde profiles (global TEMP, and Polarstern) have been written; they are needed for the development of all three algorithms (retrieval of total water vapour, cloud liquid water, surface emissivities). The activities in this work package have so far concentrated on the total water vapour, as the adapted algorithm is planned to be completed by project month 20.

Total water vapour (TWV)

The procedure that calibrates the TWV retrieval algorithm has been almost completely re-implemented. It is now adapted to AMSU-B data and uses the radiative transfer model ARTS (Atmospheric Radiative Transfer System), a modular, customizable program that has been (and still is) developed at IUP (Atmospheric Sounding Group). It uses the Rosenkranz absorption model (continuum and lines) for H_2O, O_2, N_2 (but can also use all other standard absorption models). The procedure does the following steps

1.
   - Use radiosonde profiles, integrate TWV from them
   - Simulate AMSU-B brightness temperatures T_1, T_2, T_3, T_4, T_5 (where the numbers denote the following frequencies: 89.0, 150.0, 183.3±1, 183.3±3, 183.3±7) for a range of ground emissivities ϵ_s for each radiosonde profile
2. Select three channels i, j, k
3. Linear fit of ΔT_{ij} vs. ΔT_{jk} for each radiosonde profile (many different emissivities)
4. Find focal point $(\overline{b_{jk}}, \overline{b_{ij}})$ as point of least square distance from all fitted lines
5. Linear fit of $TWV \sec\theta$ vs. $\ln\eta_c = \ln\left(\frac{\Delta T_{ij} - \overline{b_{ij}}}{\Delta T_{jk} - \overline{b_{jk}}}\right)$ yields the required calibration constants C_0, C_1 for the retrieval algorithm:

$$TWV \sec\theta = C_0 + C_1 \ln\eta_c$$

By selecting different frequency triples (i, j, k) and different subsets of radiosonde profiles, the algorithm can be adapted to different ranges of TWV:

- Low TWV (< 1.5 kg/m^2): $(i, j, k) = (3, 4, 5)$
- Medium TWV (1.5 kg/m^2 $< TWV <$6 kg/m^2): $(i, j, k) = (2, 3, 4)$
- High TWV (> 6 kg/m^2): $(i, j, k) = (1, 2, 3)$, but the accuracy has to be assessed since the surface emissivities at channel 1 (89 GHz) deviates appreciably from the surface emissivity at channels 3, 4, and 5.

Cloud liquid water (CLW)

The Advanced Microwave Scanning Radiometer for EOS (AMSR-E), launched on May 4, 2002 aboard NASA's Earth Observing System (EOS) Aqua satellite. This new instrument measures the Earth's radiation in two orthogonally polarised channels at 6 frequencies extending from 6.925 to 89.0 GHz. A physical method to simultaneously retrieve the cloud liquid water path (CLW) and total water vapour (TWV) is proposed here by using the polarisation differences. Comparisons are made between AMSR-E retrievals of CLW and TWV and those obtained using other methods over open ocean. TWV compares well with the results from a linear regression algorithm, especially for TWV below 40 kg/m^2. However, for CLW, a large bias exists between our retrieved results and the results from the regression algorithm of Wentz. The difference becomes larger when CLW exceeds 1 kg/m^2. TWV and CLW within a cloud system over sea ice are also calculated, and the results are as expected.

Surface emissivities at temperature sounding frequencies

The work on determining the sea ice emissivity at temperature sounding frequencies has been initiated. Appropriate radiosonde data from RV Polarstern have been provided, also the corresponding satellite data. A program was developed to extract satellite data (AMSU-A and -B) at the time and date of a given radiosonde from the raw satellite data which are organised by complete orbits. All satellite data within given limits, e.g., ±100 km and ±3 h from the radiosonde rise can now be easily extracted.

3.2.3 Socio-economic relevance and policy implication

The development of the total water vapour and cloud liquid water retrieval algorithm is is economically attractive because it aims at better exploitation of existing data; no new sensors need to be developed and brought to space.

3.2.4 Discussion and conclusion

The work package is in good progress and first results (TWV algorithm) are expected soon.

3.2.5 Plan and objectives for the next period

The algorithm development and adaptation is going to be continued. First retrieved TWV fields are expected at the beginning of 2004. However, it is planned to further improve the calibration of the TWV algorithm by, e.g., distinguishing climatological sub-regions.

3.3 Work Package 2.1 (SMHI, met.no)

3.3.1 Objectives

Prepare NWP activities.

3.3.2 Methodology and scientific achievements

[This section is covered by parts of the Report for IOMASA Deliverable 2.1.1.]

3.3.3 Discussion and conclusion

This work package has been successfully completed, it is documented in the Report for IOMASA Deliverable 2.1.1. Data from NOAA-17 was planned to be included in the processing line but unfortunately the scan motor has broken down and no AMSU-A data is available. Since the assimilation of AMSU-B depends on co-located temperature measurements, provided by AMSU-A, this means that also AMSU-B data from NOAA-17 will be useless in this project.
The current implementation for OSI SAF data is computationally expensive and could be coded in a more efficient way. Ice information diagnosed from ECMWF SST (sea surface temperature) should be analysed in the same way but with higher observation error.

3.4 Work Package 2.2 (SMHI, met.no)

3.4.1 Objectives

Improve high-resolution Arctic NWP

3.4.2 Methodology and scientific achievements

A near-real-time data stream for providing co-located AMSU measurements and interpolated HIRLAM profiles and surface data has been set up. This is a preparation for improving assimilation of AMSU-A microwave sounder data over ice, and statistics from these co-location files will be used as a basis for experimentation with surface emissivity schemes and quality control methods.

Humidity

Following the recommendation from UAG member Steven English (The Met Office) we focus on assimilation of raw radiances instead of TWV products. The former are more probable to have Gaussian statistics and this is a requirement for a successful assimilation.

A test system has been set up that presents monitoring statistics of AMSU-A from NOAA-15 and -16. The output from this system will be made available to the public through the NWP SAF monitoring pages.

The HIRLAM variational data assimilation (HIRVDA) system has been extended to include an outer loop in the minimisation process. Making intermediate re-linearisations in an outer loop allows the minimisation to find solutions also for observations with a non-linear relationship to the NWP state vector. This is known to be the case for AMSU-B radiances and model humidity.

Software for running the radiative transfer model RTTOV-7 with co-located AMSU-A and HIRLAM data has been provided to SMHI by met.no. In return SMHI will add an IO-interface for GRIB files and a procedure for co-location of AMSU-B data.

Work has begun on introducing the surface emissivity and the surface skin temperature into the control vector during the minimisation in the data assimilation procedure. The idea is that only a decent first guess of these parameters should be necessary. Recent results from IUP show that emissivities for the AMSU-A and -B channels are strongly correlated[1]. This can be used to constrain the control vector that otherwise would have to be extended with some 10 extra variables. LTU works at providing AMSU-B emissivities based on OSI SAF estimates of ice concentration and ice type.

Surface heat flux

The conventional Monin-Obukhov (MO) similarity theory has been extended to the stably stratified atmospheric surface layer. New correction functions to the neutral drag were introduced depending, besides the bulk Richardson number, on one more stability parameter involving the Brunt-Väisälä frequency in the free atmosphere and on roughness lengths for wind and temperature (humidity). Results show close agreement between potential temperature and wind profiles in 1D HIRLAM and LES (large eddy simulation) models. Tests show significant influence of the new parameterisation in winter time at northern latitudes.

3.4.3 Socio-economic relevance and policy implication

If brought to operational application, the results should increase prosperity and strengthen security in Northern Europe by boosting operational weather forecasts, helping to improve the living conditions in Northern Europe and especially human off-shore activities in the Arctic region, such as navigation, fisheries, tourism, and exploitation of marine mineral resources.

Greater confidence in short and medium term weather predictions which benefits the entire population of this region, and also the environment through improved risk management possibilities and better disaster control. Reliable forecasts are the first step in risk management and disaster control whether in the marine environment, the atmosphere or on land, and for all economic activities and developments. It is important in making decisions on capital expenditure regarding investments in industry and infrastructure.

The assimilation of AMSU-B should lead to improved weather forecasts for Northern Europe - especially for precipitation. It will also enhance value of data of meteorological European satellites because sensors similar to AMSU-B are planned on future METOP satellites.

The new surface heat flux scheme should lead to improved weather forecasts for Northern Europe and especially of clouds in the Arctic.

[1] N. Selbach, T.J. Hewison, G. Heygster, Emissivity of sea ice at 89 GHz, 157 GHz and 183 GHz in the Arctic winter, paper submitted to *IEEE Trans. Geosci. Remote Sens.*, 2003

3.4.4 Discussion and conclusion

Even if assimilation of TWV products is not a priority at this time it would still be interesting to compare the result from assimilating raw radiances with that of assimilating TWV. Code for assimilation of TWV in HIRLAM is already available and this option could also be used as a fall-back strategy in case severe problems occur with the raw radiance approach.

3.4.5 Plan and objectives for the next period

Humidity

Contact has been made with UAG member Stephen English at the Met Office and Per Dahlgren is going there as a visiting scientist working with AMSU-B over ice during some of the spring 2004.
A lesson from the work on AMSU-B at the Met Office is that quality control is very important for AMSU-B with respect to cloud liquid water and cloud ice. Time will be spent to develop a cloud detection scheme for AMSU-A over ice and land (in collaboration with met.no) and for AMSU-B over all surfaces. The stand-alone RTTOV model will be used for the initial experiments. Also other sources providing cloud masks will be investigated such as the NWP SAF.
In order to model AMSU-B, estimates of surface skin temperature and emissivities are needed. While waiting for estimates from DTU, the model sensitivity with respect to these variables will be investigated. Before feeding the AMSU-B measurements into the assimilation system they must be free of bias. This is a requirement for the minimisation to work properly. No new results are probably necessary. Instead the same scheme which is used for bias correction of AMSU-A could be implemented.
The work on including the surface skin temperature and emissivity in the control vector will continue. This work will also consider the sensitivity of the minimisation with respect to the first guess of the surface parameters. The new results from IUP[2] regarding the correlation between emissivities at different AMSU-A and -B frequencies will be exploited by constraining the solution with these relationships.

Surface heat flux

The new flux formulation will be implemented in HIRLAM. Three test runs are planned to be carried out using one month of data:

1. Reference
2. Reference + new snow scheme
3. Reference + new snow scheme + new flux

After this the ice surface parameterisation will be extended to treat snow on ice. A decent estimate of the skin temperature for ice surface with and without snow is needed for modelling AMSU radiances.
An additional test will then be run with the ice scheme:

4. Reference + new snow scheme + new flux + new ice scheme

3.5 Work Package 3.1 (DTU)

3.5.1 Objectives

Prepare sea ice modelling activities.

[2] N. Selbach, T.J. Hewison, G. Heygster, Emissivity of sea ice at 89 GHz, 157 GHz and 183 GHz in the Arctic winter, paper submitted to *IEEE Trans. Geosci. Remote Sens.*, 2003

3.5.2 Methodology and scientific achievements

An on-line database of 25 years of daily SMMR and SSM/I brightness temperatures from the Northern hemisphere has been established at DTU, and exchanged with partner DMI. The database is being used for time series analysis to study the temporal variations of sea ice signatures (see also DMI Technical Report 03-13 by R. Tonboe, S. Andersen and L. Toudal, about detection and influence of warm air events: "Anomalous Winter Sea Ice Backscatter and Brightness Temperatures").

3.5.3 Discussion and conclusion

This work package has been successfully completed.

3.6 Work Package 3.2 (DTU)

3.6.1 Objectives

Construction of sea ice forward model.

3.6.2 Methodology and scientific achievements

Radiative transfer theory provides the relationship between the observed brightness temperatures T_B (K) and some geophysical parameters. A model describing this relationship is known as a forward model, and here an ocean/atmosphere forward model described by *Wentz* [2000][3] has been used as the starting point. The model describes the connection between four geophysical parameters (wind, water vapour, liquid water and sea surface temperature) and the brightness temperatures measured by the AMSR. The model described by *Wentz* [2000] is only valid for water surfaces, so the model has to be expanded to take ice-covered surfaces in to account.

Inclusion of ice in the Forward Model In the model by *Wentz* [2000], the upwelling brightness temperature at the top of the atmosphere - the brightness temperature measured by the AMSR satellite - is written in equation (10) as:

$$T_{B\uparrow} = T_{BU} + \tau \left[ET_S + T_{B\Omega}\right]$$

where T_{BU} is the contribution of the upwelling atmospheric emission, τ is the total transmittance from the surface to the top of the atmosphere, E is the Earth surface emissivity and $T_{B\Omega}$ is the surface scattering integral.
A change in the surface content from open water to ice only has an influence on the following parts of the model: ET_s (the brightness temperature close to the sea surface) and $T_{B\Omega}$.
In order to be able to include ice in the model for the brightness temperature close to the sea surface, one has to consider the difference between the emissivity of an open water sea surface and an ice-covered sea surface.
The brightness temperature, $T_{B,ice}$, at the ice surface can be written as:

$$T_{B,ice} = T_{P,ice} E_{ice}$$

where $T_{P,ice}$ is the physical temperature of the ice surface and E_{ice} is the emissivity of the ice surface. The emissivity of an ice-covered surface depends on the type of ice cover, the polarisation and the frequency.

[3]Wentz, F., T. Meissner, Algorithm Theoretical Basis Document, version 2: AMSR Ocean Algorithm, *RSS Tech. Proposal 121599A-1*, Nov. 2000; http://www.seaice.dk/iomasa/documents/Wentz_AMSR_Ocean_Algorithm_Version_2.pdf

The preliminary sea ice emissivities used to calculate the brightness temperatures of the different channels of the AMSR are given in Table 3.1.

Table 3.1: Emissivities at AMSR frequencies for the First Year (FY) and Multi Year (MY) ice used in the forward model.

	Frequency	6 GHz	10 GHz	18 GHz	23 GHz	37 GHz
FY	Vertical	0.9204	0.9127	0.9373	0.9409	0.9347
	Horizontal	0.7502	0.7738	0.8314	0.8490	0.8600
MY	Vertical	0.9692	0.9284	0.8843	0.8554	0.7813
	Horizontal	0.8651	0.8356	0.7917	0.7792	0.7248

Now, the brightness temperature close to a surface mixed of open water, first-year (FY) and multi-year (MY) ice can be written as:

$$T_{B,S} = ET_S = C_{ow}T_{B,ow} + C_{FY}T_{B,FY} + C_{MY}T_{B,MY}$$

where C_{ow}, C_{FY} and C_{MY} and are the concentrations (= surface fractions) of open water, FY and MY year sea ice, respectively, and $T_{B,ow}$, $T_{B,FY}$ and $T_{B,MY}$ are the respective brightness temperatures of the three different surface types.
The surface scattering integral is given in *Wentz* [2000], equation (61) as:

$$T_{B\Omega} = [(1 + \Omega)(1 - \tau)(T_D - T_C) + T_C]\, R$$

In this equation it is only the sea-surface reflectivity, R, which is influenced by the ice. An effective reflectivity for a mixed surface can be written as:

$$R_{eff,mix} = 1 - E_{eff,mix} = 1 - (C_{ow}E_{ow} + C_{FY}E_{FY} + C_{MY}E_{MY})$$

where C_{ow}, C_{FY} and C_{MY} are the concentrations of the three surface types and E_{ow}, E_{FY} and E_{MY} are the emissivities of the surface types.
The last thing one has to take in to consideration when including ice in the model is that the forward model described by *Wentz* [2000] has a surface temperature included. This temperature has to take the temperature of the ice into account and therefore the surface temperature used in the ice model has to be calculated by:

$$T_{S,mix} = C_{ow}T_{P,ow} + C_{ice}T_{P,ice}$$

where C_{ow} and C_{ice} are the concentrations of open water and sea ice, respectively, and $T_{P,ow}$ and $T_{P,ice}$ are the respective physical surface temperatures. This mixed surface temperature only has to be used in the part of the model concerning the atmosphere, not in the parts concerning the dielectric constant of sea-water and the wind-roughened sea surface.

3.6.3 Discussion and conclusion

The work package is in good progress.

3.6.4 Plan and objectives for the next period

The development activities will be continued.

3.7 Work Package 4.1 (DMI, met.no)

3.7.1 Objectives

Prepare activities on sea ice concentration retrieval.

3.7.2 Methodology and scientific achievements

The following data will be provided:

1. SSM/I swath and QuikSCAT data of 2 year investigation period from archive of Partner 3,
2. Collection of suitable SAR data and ice analyses from the archives of Partner 3,
3. Additional collection and analysis of SAR data obtained from relevant areas.
4. Day 0 models and algorithms:
   - Microwave radiative transfer models,
   - K_u-band wind model function,
   - Sea ice concentration algorithms from SSM/I,
   - Ice type algorithms from QuikSCAT,
   - Synergistic SSM/I-QuikSCAT ice concentration algorithm.

The work package is completed and has been documented in the report "IOMASA Phase1 report for Part4 (sea ice concentration)".

3.7.3 Socio-economic relevance and policy implication

The planned acquisitions of SAR data rely largely on ESA ENVISAT ASAR data and thereby provides an excellent opportunity to showcase the use of this data for detailed analysis of the sea icem, thus strengthening the European position in space.

3.7.4 Discussion and conclusion

The work package has been successfully completed and is documented in a report entitled "IOMASA Phase1 report for Part4 (sea ice concentration)". This report includes the "IOMASA sea ice validation plan", which outlines the planned validation of the IOMASA sea ice concentration product and contains a detailed plan of SAR data acquisitions.

3.8 Work Package 4.2 (DMI. met.no)

3.8.1 Objectives

Construction of algorithm for ice concentration retrieval.

3.8.2 Methodology and scientific achievements

Ice concentration retrieval algorithms using SSM/I are well-known and have been used for the last 20 years. Work in recent years has concentrated on the optimisation of tie-points, which are fundamental for sea ice concentration retrievals, as well as correction for the atmospheric influence. Current SSM/I based algorithms are capable of retrieving sea ice concentration with an accuracy of only 5-10%, which results in corresponding inaccuracies in ocean/atmosphere fluxes. These fluxes vary dramatically with the addition of even small areas of open water in the form of leads and polynias within the consolidated ice cover. This in turn affects the performance of NWP models with regards to, e.g., humidity, winds and temperature estimates. Thus it is crucial that the sea ice cover is represented correctly. The primary objective in this work package will thus be to improve the ice concentration retrieval in regions infested with the above-mentioned leads and polynias. This will be carried out by way of

1. improved accounting for the atmospheric contribution to the satellite-measured radiances and back-scatter values,
2. improved knowledge of the ice surface type enabling more accurate specification of reference radiative properties, also known as tie-points, that span the scale of ice concentrations. This will be obtained mainly from work package 3 in combination with synergies between QuikSCAT and SSM/I.

The sea ice concentration algorithm developed is envisaged to take into account relevant parameters describing the radiative transfer in the atmosphere and at the ice/ocean surface. In connection with the development of the EUMETSAT Satellite Application Facility (SAF) on Ocean and Sea Ice, correction methods for SSM/I brightness temperatures based on NWP model output have been applied with good results and are being used operationally. More specifically, using NWP model estimates of surface wind and integrated water vapour content, it has proved possible to reduce the standard deviation of the SSM/I-derived sea ice concentration estimates by 5-15%, while reducing the bias to max. 2%. This method will be adopted and possibly improved, e.g., by a more accurate specification of surface emissivity in the radiative transfer calculations.

The important sea ice information obtained from QuikSCAT is the differentiation of various ice surface types. However, a major problem for ice retrieval from scatterometer is the influence of the surface wind not least in mixtures of sea ice and open water. It is planned to use the knowledge gained from atmospheric correction of SSM/I data to improve the reliability of ice type retrievals by correcting them for the influence of winds as obtained from an NWP model and current K_u-band wind model functions. Subsequently emissivity and backscatter models developed in Part 3 will be combined with sea ice type information using state-of-the-art synergistic data combination techniques to further improve the sea ice concentration estimates.

So far this work package has dealt with the response of the sea ice to intrusions of warm air. It has been shown that this process affects a large area every year and hampers use of some sea ice concentration algorithms. This work has been documented in a scientific report [*Tonboe et al.*, 2003][4] and will be further described in a paper to be submitted end of 2003/early 2004. Additionally a large effort has been allocated to prepare for the detailed analysis of SAR scenes by way of a semi-automatic scheme. A draft report is available which will be completed early 2004 (see list on p. 14). Good results have been obtained and the method will be carried into operational use at the Greenland Ice Service to assist in generating an independent, high-resolution ice concentration data set.

3.8.3 Socio-economic relevance and policy implication

Better knowledge of sea ice properties allows improved weather forecasting in Arctic areas. This in turn benefits directly key activities in the region such as shipping and fisheries.

3.8.4 Discussion and conclusion

The work package is in good progress and first results have already emerged. One publication has already been completed and two more are in queue.

[4] R. Tonboe, S. Andersen and L. Toudal, Anomalous Winter Sea Ice Backscatter and Brightness Temperatures, *DMI Technical Report 03-13*, 2003

3.8.5 Plan and objectives for the next period

The work package continues throughout the next period. The strategy is to further identify processes that affect the accuracy of ice concentration retrieval over sea ice covered areas and to determine their fingerprint in terms of active and passive microwave radiative properties. This will be carried out by detailed analysis of the data sets collected during work package 4.1 and in close cooperation with Part 3. A prototype production chain will be set up based on the current OSI SAF production chain and improvements will be implemented in this chain to facilitate the use in NWP models.

3.9 Work Package 5.1 (DTU, DMI, IUP, met.no)

3.9.1 Objectives

Prepare real time processing and user interface.

3.9.2 Methodology and scientific achievements

Data exchange formats Data exchange formats for the most relevant data types have been preliminarily defined as binary GRIB format for gridded data and plain ASCII format for more simple data.

Near real time data distribution to end-users A near real time data distribution system has been set up at DTU to present IOMASA results to interested parties. The server can be accessed through the IOMASA web portal at DTU: http://www.seaice.dk/iomasa The two figures below show the layout of the system, and examples of retrievals of cloud liquid water (Figure 3.1) and total atmospheric water vapour (Figure 3.2).

3.9.3 Discussion and conclusion

This work package has been successfully completed. The data distribution system can be accessed at http://www.seaice.dk/iomasa

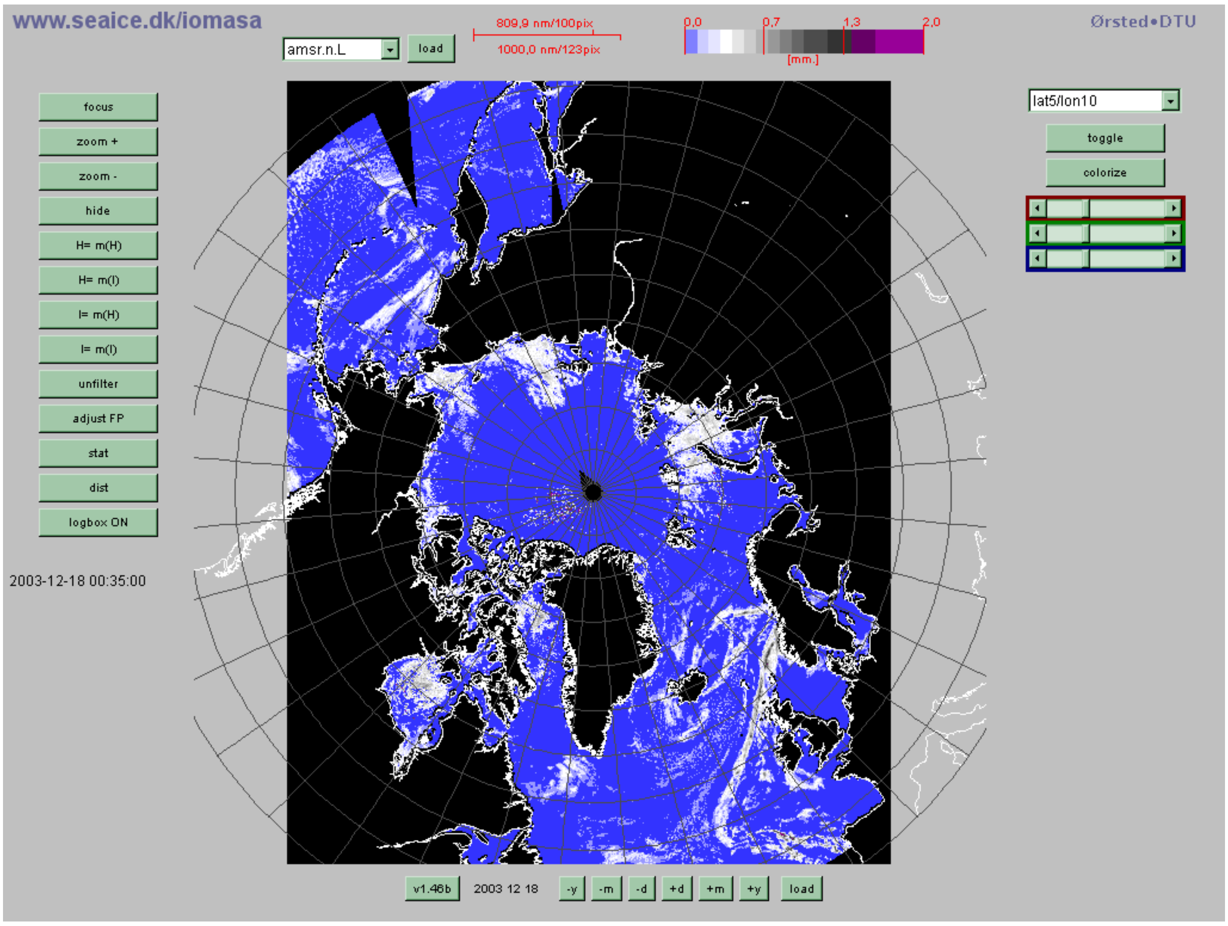

Figure 3.1: Retrieval of cloud liquid water from AMSR data using forward model from work package 3.2. AMSR data from National Snow and Ice Data Center, December 18, 2003.

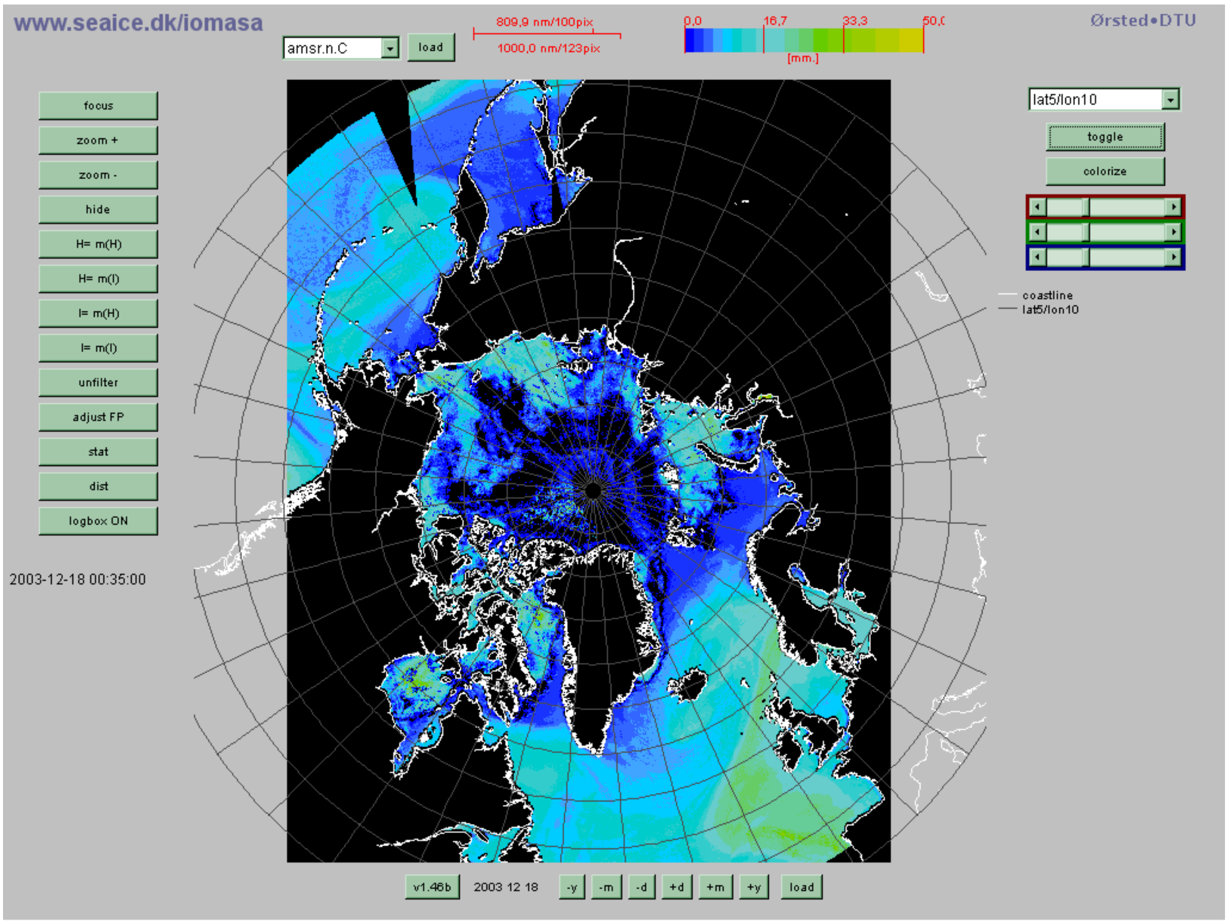

Figure 3.2: Retrieval of atmospheric water vapour from AMSR data using forward model from work package 3.2. AMSR data from National Snow and Ice Data Center, December 18, 2003.

SECTION 4

Technological Implementation Plan (Cumulative)

[See eTIP on http://www.cordis.lu/fp5/tip.htm (EVK3-CT-2002-00067)]

ANNEX A

Meeting reports

A.1 Kick-off Meeting, 4–5 November, 2002 , IUP, Bremen

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Kick-off Meeting of the project IOMASA,
held November 4-5, 2002
at Institute of Environmental Physics (IUP), University of Bremen.

Participants:
IUP:
Dr. Georg Heygster
Hong Gang
Lars Kaleschke
Prof. Klaus Künzi
Dr. Christian Melsheimer
Dr. Junggang Miao
Prof. Justus Notholt
Nathalie Selbach

DTU-DCRS (Danish Centre for Remote Sensing, Technical University of Denmark):
Dr. Leif Toudal

DMI (Danish Meteorological Institute):
Søren Andersen

met.no [DNMI] (The Norwegian Meteorological Institute):
Dr. Harald Schyberg

SMHI (Swedish Meteorological and Hydrological Institute):
Dr. Nils Gustafsson
Dr. Tomas Landelius

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AGENDA
========
Introductory items
        Welcome addresses by coordinating Partner and EU
        Tour-the-table for presentation of attendees
        Short reminder of the origin of the initiative

Project Overview:
        Summary and Innovation
        Project logic graphic
        Project Structure: 5 Parts and 4 Phases
```

```
        Work breakdown and Deliverables, see table, ~ 1/WP

Presentation of the five Project Parts by the respective
steering committee members, each presentation covering:
        - state of the art and partner's experience relevant to IOMASA
        - progress since submission of proposal
        - partner's aspiration with regard to IOMASA
        - short description of the project part,
        - detailed plan for Phase 1 (WP X.1), including state of
          planned deliverables

        Part 1 (IUP):
        Remote sensing of atmospheric parameters:
                       - Total Water Vapour (TWV)
                       - Cloud Liquid Water (CLW)
                       - Surface emissivity at T-sounder frequencies
        Part 2 (met.no, SMHI):
        Improving numerical weather prediction models
                       - TWV assimilation
                       - Temperature Sounding
                       - Surface Flux
        Part 3 (DTU):
        Empirical models for emissivity and
                       backscatter of sea ice:
                       - Forward model
                       - Snow
                       - AMSR (together with IUP)
        Part 4 (DMI + met.no):
        Sea ice concentration retrieval
        Part 5 (DTU + DMI):
        Demonstration of real time processing and user interface.

Review of Phase 1: Are we ready to envisage Phase 1, especially Part 5?
        Internal communication may be required

Action items for KOM: Decide on
        - Period of offline investigation: 2 years, probably
          1999 and 2000
        - Region of investigation: most parts of the Arctic
          as covered by the operational model of met.no
        - Geographic projection grid of all data

Social objectives and technical implementation plan
        Success of project measured in 2 dimensions:
                - publications in reviewed journals
                - transfer of scientific progress to applications
        TIP background, European paradox, role of TIP
        3 social objectives: improve
                (1) weather forecast
                (2) ice charts
                (3) heat flux estimation
        annual versions of TIP required, eTIP

User advisory group
        purpose: dialogue with end users in the a.m. fields
        will attend PM1, MR, FP
        potential members:
                - ECMWF (1) (name?)
                - HIRLAM initiative (1) (name?)
```

```
                - EUM SAF NWP (1) (name?)
                - ice service of met.no (2) (name?)
                - ice service of DMI    (2) (name?)
                - Missing: representatives for (3) (name?)
        other potential members?

Contribution to EU OF Cluster
        Purpose, participation in workshops, also by other partners
        3rd EuroGOOS Conference, Athens, 3-6 Dec (Presentation)
        Bruxelles meeting 'European Research 2002' (Poster)

Questions and answers with the EC

Project management:
        Report duties, table of reports
        Next meetings: Fix places and dates

Any other business

End of formal part, optional scientific discussions

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1.1 Welcome Address (K. Künzi).
===============================
1.2 Introductory round.
========================
1.3 Origin of the Initiative (G. Heygster)
==========================================
 - Several previous projects on remote sensing of polar regions at
 IUP, e.g.:
 PELICON (1996-98), SEA LION (1998-2000) -- both in cooperation with
 DTU.
- Combine remote sensing of polar atmosphere and remote sensing of sea
 ice and apply it to numerical weather prediction (NWP);
 IOMASA initiative was actually spawned at a meeting at DMI in July 2001
 with participation of DTU, IUP and DMI.


1.4 Overview of IOMASA (G. Heygster)
====================================
- 5 parts, 4 phases, schedule.

2. Presentations about the 5 Project Parts:
===========================================
2.1 Part 1: Remote Sensing of Atmospheric Parameters (G. Heygster)
==================================================================
- Part 1 done by IUP
- Problem: Sparse data over Arctic region, standard algorithms to
  derive atmospheric parameters from remote sensing data do not work over ice
- Total water vapour (TWV) over ice: New algorithm developed at IUP, derive TWV
  from ratios of channel differences of SSM/T2 (-> J. Miao et al. 2001)
- works up to TWV of 6kg/m^2 (using 150 and 183 GHz channels)
- could get to higher values if 89 GHz channel used, but more
  contribution from surface with unknown emissivity
- surface emissivities have been measured during SEPOR/POLEX campaign in March
  2001 (-> N. Selbach)
- Cloud signature (related to cloud liquid water, CLW) over ice: New
```

```
  algorithm developed at IUP, uses polarisation channel differences and
  ratios ("R-factor") of SSM/I (J. Miao et al. 2000).
- Cloud signature: linear combination of water vapour and small contribution
  of CLW
- Possible improvements: Use AMSR instead of SSM/I (more channels,
  higher spatial resolution)
- Temperature profile retrieval (from SSM/T1) could possibly be improved by
  surface emissivity information from SSM/I (sea ice) and OLS (surface
  temperature) and sea ice emissivity knowledge.
Questions/Comments:
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(T. Landelius): Wouldn't information on the sea ice emissivity also
   be useful for AMSU-B humidity sounding?
(J. Miao): We only do TWV, not water vapour profiles, but yes.
   But maybe SSM/I frequencies too far off AMSU-B frequencies?



2.2 Part 2: Improving NWP Models (N. Gustafsson, H. Schyberg)
==============================================================
- Part 2 done by met.no and SMHI
  [state of the art NWP:
   * models are more sensitive to dynamic fields (motion, temperature)
       than to static ones; therefore, water vapour until now not yet
       assimilated
   * 3D variational assimilation (3D-Var) or 4D-Var (ECMWF, Japan)
    or
   * Continuous assimilation (nudging) (DWD)
    or
   * flow-dependent assimilation (ensemble Kalman filter) (Canada)
    for
   assimilation of satellite and other data]
- NWP at met.no and SMHI: HIRLAM (3D-Var operational, 4D-Var soon)
- assimilation of data from AMSU-A, ground-based GPS, MODIS TWV
- ATOVS data from NOAA-15,16,17
- ATOVS data source:
  * NOAA/NESDIS (BUFR format), too much time delay: up to 6 hours
  * via own receiving station (HRPT format), quick, but not global
  * EUMETSAT retransmission (http://www.eumetsat.de/en/dps/atovs.html),
    starting Nov.2002, covers North Atlantic and Arctic (to be extended further)
- RTTOV-7 model for simulation of ATOVS radiances
- surface emissivity needed
- Surface flux parameterisation used by met.no and SMHI in HIRLAM:
  ISBA (Interactions between Soil-Biosphere-Atmosphere)
  * different soil and vegetation types
  * snow model
  * "tiles": various surface types within one grid square
  * (up to) 5 tiles: bare soil (various types), low vegetation (various types),
    forest (various types), water, ice; in addition: possible snow cover
  * assimilation of soil surface temperature and soil moisture
  * improved turbulence scheme
Questions/Comments:
-------------------
(N. Gustafsson/H. Schyberg):
- Consider using SAF sea-ice product for HIRLAM/ISBA.
- Extraction of 2-year data set done by met.no; EUMETSAT AMSU
  retransmission: set up data flow in about 6 months.
(all):
- Some discussions on "incest problems" that will probably be
```

of relevance to us. In particular, using ice analyses from the day before eliminates model error correlations. Also a point on bias correction of satellite data, which ECMWF only performs close to ground based stations; HIRLAM will probably follow that approach.

2.3 Part 3: Empirical Model f. Emissivity and Backscatter of Sea Ice (L.Toudal)

- Part 3 done by DTU-DCRS
- Importance of ice signatures ("Is the signature due to ice concentration or due to ice surface type?")
- QuikSCAT: HH-VV-ratio clearly shows ice edge
- backscatter: higher for multiyear (MY) ice (less saline => more penetration => more scatt. by inhomogeneities)
- emissivity: higher for first-year (FY) ice
- example QuikSCAT time series of backscatter, 2002:
    * stable in winter
    * highly variable in summer, caused by variable surface properties: wet snow, surface melting
    * in July, MY ice not visible because backscatter reduced dramatically (wet snow/ surface melting)
- example SSM/I time series of ice emissivity, 1996-97:
    * stable in winter, but with slow variations, espec.: increase towards end of winter that causes retrieval of erroneously high ice concentrations (>100%); due to surface characteristics like wet snow cover
    * highly variable in summer
    * over permanently open water: variable all year, but more so in summer
- models:
    * MWMOD: Surface (sea ice and ocean water) emissivity and atmospheric radiative transfer
    * backscatter model implemented at DMI
    * validation with satellite observations (temporal/spatial variability)
- theoretical consideration of the retrieval accuracy obtainable depending on the channels included;
  although assumption of uncorrelated channels may not hold there was a rather remarkable improvement through the inclusion of low frequency channels available on AMSR.

Questions/Comments: -

2.4 Part 4: Sea Ice Concentration Retrieval (S. Andersen)

- Part 4 done by DMI
- Ice charting at DMI since 1959 (Greenland area)
- 500 SAR scenes per year (Radarsat)
- SAR image texture classification
- thin ice detection: ratio (SSM/I pol.ratio) / (SeaWinds pol.ratio)
- joint experience DMI/met.no (SAF HL[high latitudes] centre), passive microwave:
    * tie points improved, monthly tie points determined
    * atmospheric correction: includes wind and TWV
    * tested a number of ice concentration algorithms (sensitivity to CLW)
    * investigated sea ice emissivity
    * multisensor products (ice edge, ice type)
    * multisensor product based on Bayesian approach (ERS Scat, SSM/I)
    * operational Atlantic sea ice products (from scat., AVHRR, passive

```
    microwave)
- Goals within IOMASA:
  * better accounting for snow/ice properties (from Part 3)
  * improved use of multiple sensors
  * use of better atmospheric fields over ice (from Part 1)
  * improved use of high-resolution sensors (but trade-off with more
    noise)
  * validation/calibration
Questions/Comments:
-------------------
(G. Heygster): Use AMSR instead of SSM/I, or is there too much time
   lag between AMSR and the other SSM sensors?

(S. Andersen): The concept of IOMASA is centered around the
   requirements of numerical weather prediction; the operational
   constraints within IOMASA require the use of SSMI (AMSR will be
   considered but it is unlikely that data will be available with
   sufficient timeliness within the coming years to be useful in NWP
   model applications).
(L. Toudal): One hour might be o.K.; more than that would be a
   problem for CLW (rapid changes) but still o.k. for sea ice (slower
   changes).
(G. Heygster): ARTIST algorithm (-> L. Kaleschke) has been
   preliminarily modified to use AMSR (instead of SSM/I), results seem to
   be considerably better (resolution).
(L. Kaleschke): How to validate ice algorithms that are based on SAR
   images?
(L. Toudal): Difficult. But to validate/test the low-concentration
   performance, a garantueed ice-free area could be chosen
(S. Andersen): High concentration conditions must be
considered and the best available and most general information is
presently SAR data (low concentration tests have been done several times
and algorithm performance under such conditions is well documented).
(J. Miao): Maybe use R-factor thresholds determined from
algorithm sensitivities to CLW.


2.5 Part 5: Demonstration of Real Time Processing & User Interface (L. Toudal)
==============================================================================
- Part 5 done by DTU-DCRS

- a user interface was developed in the EU-funded project IWICOS
  (Integrated Weather, Sea Ice and Ocean Service System), and earlier
  projects like IMSI (Integrated use of new microwave satellite data for
  improved sea ice observation, ca. 1996-1999)
- IWICOS: Information system for user of sea ice information:
  * via Internet
  * satellite imagery: SSM/I, QuikSCAT, AMSU, AVHRR
  * ocean data: bathymetry, waves
  * weather data: wind
  * geography data:  coastlines, grids
  * ice data: charts, concentration contours (isolines)
- the IWICOS interface is a Java applet
- covers potentially ice-affected areas of N and S hemisphere
- static data (coast lines etc.) are installed locally
- dynamic data, for users on ships, received via satellite (Inmarsat)
- the IWICOS interface can be used in IOMASA for dissemination of data
  to the public user community and for data exchange between project partners
- http://www.dcrs.dtu.dk/sea-ice
```

```
- but: not suitable for internal raw data exchange
- we have to find a way for raw data exchange, maybe simple ftp
  server?
- "data broker" server system that was used for raw data in IWICOS (developed
  by a Finnish company) is nice, but bulky and difficult to maintain,
  therefore not advisable for IOMASA
Questions/Comments:
-------------------
(L. Toudal) We can reuse the IWICOS infrastructure (IWICOS funding ends
   Dec. 2002).
(G. Heygster): Will IWICOS java browser run for the next 3 years?
(L. Toudal): Yes. It may even be renamed the IOMASA browser.




3. Review of Phase 1
=====================
Ready to start Phase 1.

4. Action Items:
================
4.1 Two-year Offline Investigation Period and Area
================================================
- What (which data) from whom:
  * AMSU-A,B: 2000-2002 at IUP (level 1B, level 1C can be generated
    easily)
  * Radiosonde, synopt. data: DMI has access to archive
  * SSM/I: DMI has archive. Restrict to 1 out of 3 sensors (else too
    much data)? BUFR format - DMI has reading software.
  * QuikSCAT: at DMI
  * SAR: ENVISAT preferable over Radarsat because of
    multipolarisation (or global monitoring mode instead of multipolarisation?)
  * NWP: met.no/SMHI can supply 20km resolution from Jan. 2003
    (just switching from 40 km to 20 km now)

- Where (which area):
  * Overlap region of met.no and SMHI NWP area

- When (which time period):
  * NWP data: 2003-2004 (since better resolution (20km) NWP starts Nov.2002)
  * remote sensing data: 2001-2002, then 2003-2004

- Which Grid:
  HIRLAM of met.no and SMHI uses rotated lat-lon grid (equator runs through
  forecast area). SMHI provides a conversion routine to (and from)
  conventional lat-lon grid.

4.2 Algorithms
==============
- IUP provides Fortran code for TWV algorithm to SMHI and DMI


5. User Advisory Group (UAG)
============================
- potential members of the UAG to contact [by whom]:
 (a) weather forecast:
  * ECMWF: Jean Noël Thépaut [T. Landelius / N. Gustafsson]
```

```
           or Erik Andersson (also in SAF)
  * UK Met. O. (NWP SAF): Steve English [G. Heygster]
  * HIRLAM: Heikki Järvinen (FMI)  [T. Landelius]
 (b) ice charts, heat flux:
  * SMHI climate modelling: Markku Rummikainen [T. Landelius]
                            Ralf Döscher?
  * DMI ice service: K. Hansen [S. Andersen will ask colleagues]
  * met.no ice service: Helge Tangen [H. Schyberg]
 (c) heat flux modeling:
  * ?? [T. Landelius will look for people]

6. Social Objectives
====================
6.1 Publications
================
- measure for the success of the project
- joint publications or publications by one partner

6.2 Technology Implementation Plan (TIP) (C. Melsheimer)
==========================================================
- promote and facilitate exploitation of R&D results in FP5 projects
- contractual obligation
- standardized set of datasheets to be filled in and submitted as
  draft TIP after one and two years, final TIP to be submitted at the
  end of the project.
- online (electronic) form - "eTIP"
- main sections of TIP are about  results of the project; several
  standard categories of results:
  * usable outside the project
  * usable in follow-on projects
  * only usable within the project
- most important: identify possible results of IOMASA. Starting point:
  list of deliverables in the DOW (Description of work), but also
  other things
- main work done by project coordinator (eTIP account registration,
  filling in project details etc.)
- project partners responsible for details on results related to their
  specific part
- C. Melsheimer will supply the partners with relevant information
  (selected from two big web sites dealing with the TIP:
   www.hyperion.ie/TIPWebsites.htm and etip.cordis.lu/)
- everyone should think about possible results so that we can come up
  with a draft list of results before the next meeting (in
  about 6 months, see below)
- TIP will be on the agenda of the next meeting.

7. EU OF (operational [ocean] forecasting) Cluster
==========================================
- Meeting of EU OF Cluster and 3rd EuroGOOS conference in Athens, 3-6 Dec,
  2002 (http://www.eurogoos2002.gr/): G. Heygster will represent IOMASA there.
  Contributions needed:
  * about 1 page of text (based on the DOW)  and one graphic from each
    partner, within two weeks.
  * there will be proceedings (reviewed), deadline around January

- Meeting "European Research", Nov 11-13, Bruxelles
  (http://europa.eu.int/comm/research/conferences/2002/index_en.html):
  We could only have presented a brochure, for which it is too early.
```

```
8. Project Management
=====================
8.1 Reports
===========

8.2. Meetings
=============
- Kick-off Meeting (KOM)
- 4 Progress Meetings (PM)
- one Midterm Review (MR)
- one Final Presentation (FP)

Month   Type   Date     Place        Details
-----------------------------------------------------------------------
1       KOM    11/2002  Bremen
6       PM1     4/2003  København    at DMI, Thu/Fr 10-11 Apr. 2003 (tentatively)
12      PM2    10/2003  Norrköping?
22      MR      8/2004  Oslo?
28      PM3     2/2005  TBD
32      PM4     6/2005  TBD
36      FP     10/2005  TBD

9. Any Other Business
=====================
- IOMASA Logo: G. Heygster has drafted a first version, will circulate
  it later. Ideas welcome

- IOMASA web site: public area (already set up:
  www.iup.physik.uni-bremen.de/iuppage/psa/2001/14iomasa.html) and
  member area (for project partners) will be set up within the next 6 months.

- The Contract (EVK3-CT-2002-00067) has been received by University of
  Bremen, copies have been handed out to all project partners

- University of Bremen administration needs account information
  from the partners in order to forward the advance received from the EU
  to the partners.

- University of Bremen needs an administrative point of contact for
  each partner


Appendix: List of All Action Items
==================================
No.  Who                         What
--------------------------------------------------------------------------
1    all                          identify possible "results" (in the
                                    sense of the Techn. Impl. Plan)
2    all (except IUP)             tell IUP account information for
                                    forwarding of the project money
                                    by University of Bremen(bank
                                    account no., bank, reason for payment)
3    all (except IUP) tell IUP their administrative point
                                    of contact

4    IUP                          provide AMSU-A,B data 2001-2002
5    IUP                          provide Fortran code of TVW algorithm
                                    to SMHI and DMI
6    IUP                          set up member area of IOMASA web site
```

```
7    IUP (C. Melsheimer)       send all partners relevant information
                                 on TIP
8    IUP (G. Heygster)         contact Steve English about UAG

9    DMI                provide  radiosonde and synopt. data 2001-2002
10   DMI                       provide SSM/I data 2001-2001 (which
                                 satellite? Communication needed on that.
11   DMI (S. Andersen)         contact colleagues (ice service) about UAG

12   met.no/SMHI               collect NWP data 2003-2004

13   met.no (H. Schyberg)      contact Helge Tangen about UAG

14   SMHI                      provide conversion routine from HIRLAM grid
                                 to conventional lat-lon grid and back
15   SMHI (T. Landelius)       contact Jean Noël Thépaut (or Erik Andersson),
                                 Heikki Järvinen, Markku Rummikainen (Ralf
                                 Döscher?) about UAG
16   SMHI (T. Landelius)       look for people for UAG that are interested in
                                 heat flux modeling


Acronyms/Abbreviations
=================================
AMSU - Advanced Microwave Sounding Unit (part of ATOVS)
ATOVS - Advanced TIROS Operational Vertical Sounder
CLW -  cloud liquid water
(Euro)GOOS - (European group to support the) Global Ocean Observing System
FY  - first-year
MY  - multiyear
NWP -  numerical weather prediction
OLS -  Operational Linescan System, Vis/IR sensor of DMSP
SAF -  Satellite Application Facility
TBD -  to be defined
TIP -  Technology Implementation Plan
TWV -  total water vapour
UAG -  User Advisory Group
```

Minutes taken by
Christian Melsheimer
University of Bremen
Institute of Environmental Physics
PO Box 330440
28334 Bremen,Germany
Tel.: +49-(0)421-218-3041
Fax: +49-(0)421-218-4555
e-mail: melsheimer@uni-bremen.de
http://www.sat.uni-bremen.de/

Some additions and corrections by N. Selbach, L. Kaleschke,
G. Heygster and S. Andersen.

A.2 Progress Meeting 1, 24–25 April, 2003, DMI, København

```
*============================================*
| Minutes of the IOMASA Progress Meeting 1,  |
| 24-25 April, 2003                          |
| held at DMI, Copenhagen, Denmark           |
*============================================*

Start of meeting: 24 April, 9:30
End of meeting:   25 April, 14:00

Participants:
-------------
IUP:
Georg Heygster                    GH
Christian Melsheimer    CM
Jungang Miao    JM

DTU-DCRS:
Leif Toudal Pedersen    LT
Roberto Saldo    RS

DMI:
Søren Andersen    SA
Rasmus Tonboe    RT

met.no:
Harald Schyberg    HS
Frank Thomas Tveter    FT

SMHI:
Per Dahlgren    PD
Tomas Landelius    TL

UAG:
Stephen English (UK Met. Office)  SE
Carl Fortelius (FMI)    CF
Keld Q. Hansen (DMI)    KH
Markku Rummukainen (SMHI)    MR
Helge Tangen (met.no)    HT


1. Introductory items:
=======================
Welcome address.
Introductory round.
History of IOMASA initiative.

2. User Advisory Group (UAG):
=============================
Rationale for the formation of the UAG
 - purpose: dialogue with end users in the below-mentioned fields
 - introduction of UAG members and their specific fields

3. Project Overview for the UAG members:
========================================
    - Summary and Innovation
    - Project logic graphic
    - Project Structure: 5 Parts and 4 Phases
```

- Work breakdown and Deliverables, see table, 1/WP

4. Presentation of the five Project Parts for the UAG :
==

4.1 Part 1, IUP: Remote sensing of atmospheric parameters

(G. Heygster):

- Total water vapour (TWV) from SSM/T2, AMSU-B:
   * J. Miao' algorithm (using ratios of brightness temperature differences of 3 frequencies).
   * Example image: comparison of TWV over Antarctica; ECMWF data vs. data retrieved by the algorithms above.

C
C M. Rummukainen: What determines the TWV distribution seen over Antarctica
C G. Heygster/J. Miao: Mainly the orography, but details and changes are
C caused by local weather patterns that might be missed by the sparse
C observing stations.
C M. Rummukainen: It would be interesting to see a time series of these
C TWV images (retrieved from SSM/T2 data).
C

 * Transfer the algorithm to AMSU-B data and arctic conditions (needs redetermining parameters of the algorithm using radiosonde data)

 * Problems of the algorithm: The emissivity of the ground (water, ice), this is the subject of N. Selbach's PhD thesis (SEPOR/POLEX data).

- Cloud liquid water (CLW) over ice from SSM/I
  * Ratio of polarisation differences of 2 frequencies.

- Temperature sounding, reduce error caused by ground (sea, ice) emissivity:
- include info on ice concentration/type

- feed this info into the assimilation scheme, since the AMSU-A radiances rather than the temperature retrieved from them are fed into the assimilation scheme.

C
C M. Rummukainen: How sensitive is the CLW algorithm to the lowest clouds
C (important in the arctic)
C G. Heygster/J. Miao: Not known very well yet, would need validation with
C data (i.e. CLW profile measurements)
C M. Rummukainen: Consider SHEBA data or modeling based on SHEBA experiment
C as to vertical structure.
C C. Fortelius: Effect of ice clouds?
C J. Miao: In general, the scattering by ice clouds is not very
C important at those SSM/I frequencies (for CLW) and those AMSU-B
C frequencies (for TWV) that are used here; except for strong
C convective clouds.
C But occasionally, retrieval did not work within arctic because of ice
C clouds.
C L.T. Pedersen: Can you detect where the retrieval is bad
C (because C of ice clouds)?
C J. Miao: Not yet, for this, we would need more validation
C

```
4.2  Part 2, met.no/SMHI: Improving Numerical Weather Prediction
-----------------------------------------------------------------
(H. Schyberg):

Goal: Improve use of sounding data over Arctic.
SMHI: AMSU-B, humidity
met.no: AMSU-A, temperature

- better surface emissivity modeling using ice info (now: just
  assuming constant emissivity, i.e. constant ice cover)

- setup HIRLAM 3D-VAR for this; conduct impact studies

Approach: Start with simple approach, later: use better emissivity models
  (from other Project Part)

- quality control: cloud contamination

   * temperature and humidity channels can be contaminated by CLW (CLW is
     not a HIRLAM variable)
   * develop strategy to handle that.

C
C  S. English: Implemented variable ice coverage at Met Office, but
C    effective quality control (CLW,cloud ice) is also required.
C

(T. Landelius):
Humidity Assimilation (AMSU-B):

- Sensitivity of T_b to TWV depends on humidity and temperature => need
  colocated temperature information
- Arctic is dry => peak of weighting functions at low altitude
  ("surface shines through") => need surface emissivity

Surface heat flux modeling:

- Ice cover reduced heat flux by 2 orders of magnitude
- HIRLAM uses 100% ice cover within ice edge
- new surface scheme with different tiles (i.e., different surface
  types within one grid square, e.g. ice and open water)
- ice information from within IOMASA



4.3 Part 3, DTU-DCRS: Empir.models for emissivity and backscatter of sea ice:
-----------------------------------------------------------------------------
(L.T. Pedersen)

SSM/I ice concentration algorithm (Comiso bootstrap algorithm) for
emissivity information for other IOMASA Parts

Problem in ice concentration retrieval:
  - Time series of area with 100% ice cover year-round: Algorithm yields
    > 100% in summer
  - Time series of area with ice cover of 0% (summer) to 100%
    (winter): Algorithm yields >100% in late winter (wet snow cover)
  - Time series permanently ice-free area: Some variation, between
    -20% and +20%, more variation in summer (!)
```

```
Reason for that problem:
 - poorly known ice emissivity, ocean emissivity (wind influence) and
   atmospheric humidity

Data from several campaigns (e.g. DTU/Convection campaign, 17 & 20 Mar
2001: AWI VIS scanner, TUDRAD 16/34 GHz, [...??]): Areas covered by 100%
young ice (frazil ice) yield 50% ice concentration using both Comiso
Bootstrap and NASA Team algorithms


Prelim. Study AMSU-B 150 GHz and 89 GHz shows distinct signature
caused by ice type (surface properties)

AMSR: Like SSM/I, but some more low-frequency channels: explore that

Microwave models:
 - Radiometry: Empirical model (from time series analysis); MWMOD
 - Scatterometry: Empirical model (from time series analysis);
   R. Tonboe's backscatter model


4.4 Part 4, DMI/met.no: Sea ice concentration retrieval
----------------------------------------------------------------------
(S. Andersen):

- SAF HL (high latitudes) center (DMI, met.no)
- Tight connection to Part 3
- State-of-the-art:
   * operationally: (1) NASA Team, Bootstrap (weather-filtered, static
     tie points); (2) SAF products (weather-corrected, monthly tie points)
   * Advances at 85 GHz (more experimental state)
      - ASI (L. Kaleschke)
      - SEALION (S. Kern)
- Poorly known ice/snow contributions affects ice concentration retrieval,
- SSM/I ice type not reliable (=> use scatterometer data ...)
- Little reference data over sea ice => difficult to assess performance


Goals:
Overall: Improve description of leads/polynias in daily/hemispheric
analyses

Further:
- Better accounting for sea ice/snow properties
- Improve use of multiple sensors for concentration retrieval
- Improve use of atmospheric fields
- Improve use of high resolution channels
- extensive assessment/validation

Expertise:
- DMI/met.no ice charting service:  about 500 SAR images/year
  (classification, texture)
- Thin ice detection scheme: (SSM/I-PR)/(Seawinds-PR) (R. Tonboe)
- Backscatter model (snow cover/thickness, snow LWC (wet snow), snow
  grain size etc.) (R. Tonboe)
- Tie points
   * weather correction
   * sensitivity of the various algorithms to CLW
```

```
   * Bayesian multi-sensor (scatterometer & radiometer, e.g., QuikSCAT
     & SSM/I)

C
C   G. Heygster: As to ice edge plot (1%, 10%, 20%, 50%) just shown: NASA Team
C     algorithm smears out even ideally sharp ice edge to about 70 km (because
C     of the low resolution). Are the isolines in the plot just the
C     smeared-out edge? But then, how can it be that there are the 1% to 50%
C     isolines within only a few km?
C   S. Andersen/R. Tonboe: This is an artefact caused by the land mask.
C

4.5  Part 5, DTU/DMI: Demonstration of real time processing and user interface
------------------------------------------------------------------------------
(L.T. Pedersen):

IWICOS
- demonstrate near real-time service running for an extended period of
  time
- takes into account limited bandwidth of many users
- for standard web browsers, JAVA
- free
- there is an offline archive, accessible to, e.g., all IOMASA
  partners

IWICOS has regular users, about 100-200 hits/day, about 100-200
users/month,
 from about the following domains:
  research institutions, ice services, fishery, shipping companies,
  oil companies


- suitable for data distribution to end-users in CONVECTION, IOMASA, GreenICE

- also suitable for storing historic data for within IOMASA

C
C   M. Rummukainen: Atmospheric Model developers would need quality
C     information in addition to data, and not just image data
C   G. Heygster/S. Andersen: We should discuss distribution for IOMASA
C     end users (like M. Rummukainen:); IWICOS as is (image data) might
C     not be suitable.
C   H. Tangen: How much maintenance does IWICOS need?
C   R. Saldo: Very little, mainly archiving to DVD; about one day per month
C


5.  Review of Phase 1: Results of Phase 1 of each Partner:
==========================================================

5.1  Part 1: WP 1.1: Sensor data and day 0 algorithms:
------------------------------------------------------
(C. Melsheimer):
Data inventory:
- Radiosonde: Global radiosonde station data available at IUP and DMI
  (preliminary quality check: only few profiles from Siberia o.K.);
  in addition, radiosonde data taken during research cruises of RV
  Polarstern are available from Alfred-Wegener Institute
- AMSU-A,B, level 1B: Years 2000-2002 are available at IUP (about 200 GB
```

```
  of data); scripts exist to convert to Level 1C
- SSM/I, F-14: Available at DMI, years 2001-2002
- QuikSCAT Data: Available at DMI
- Further details in IOMASA web site member area

C
C   M. Rummukainen: The polar ozone campaigns also have radiosonde data,
C     and also water vapour measurements; DMI people know details
C   S. English: Include information on the exact data source and format
C     (e.g., for radiosonde, TEMP, GTS, whatever); also document changes
C     in calibration (e.g. there was a change in calibration of F-14)
C

IOMASA member web site
- Password-protected (i.e. non-public web site accessible to IOMASA partners)
- Makes available information relevant for all project partners, e.g.
    * E-mail addresses
    * Meeting schedule, agenda, minutes
    * Reports
    * Documents: Proposal, DoW
    * List (and possibly links to PDF files) of relevant Literature
    * Publications and Presentations from IOMASA (with links to files)
    * Algorithms developed and used within IOMASA
    * Data inventory and information how to access/get the data
- URL:
    http://www.iup.physik.uni-bremen.de/iuppage/psa/2001/iomasa-member
    or click on Member Area on the public IOMASA page on IUP web site
    http://www.iup.physik.uni-bremen.de/iuppage/psa/2001/14iomasa.html
- New virtual web server at University of Bremen operational soon: easier URL

C
C   L.T. Pedersen: Copyright problem with putting links to PDF files
C     of published papers (even own ones, depending on the journal;
C     even more so papers by other authors).
C     Maybe don’t link them, since most of use can get online version
C     from our libraries.
C     For own papers, maybe put a preliminary version (internal report)
C     on the web site.
C

(G. Heygster):
- Sea ice emissivity
  Literature: not much on emissivity at AMSU-A temperature-sounding
  frequencies except Miao’s algorithm
  => we take that (Miao’s) algorithm

- Further relevant literature:
   * Liu & Curry 2003: "Arctic ’Hot Spots’ at 37 and 85 GHz"
     - Anomalies  up to 30K (15K) at 85 GHz (37 GHz)
     - Most important factors contributing
       * CLW        ~ 10K
       * T_s        ~ 10K
       * Open Leads ~  2K  (?)

   * Voss et al. 2003:  "Ice types from SSM/I & QuikSCAT"
      - NTA: MY ice concentration increases in summer
      - one contribution: transitional melting / wet precipitation

   * Jossberger/Mognard, 1999: "Snow depth over land"
```

```
      - in spite of title, relevant for us (over ice)
      - snow metamorphism (driven by temperature gradient in snow)
      - Temperature gradient index (TGI): temporal average
        of (T_ground - T_air)/snowdepth
      - TGI estimate from T_b(19H)-T_b(37H) => estimate snow depth


C
C   H. Schyberg: Use Miao’s algorithm together with NWP profiles instead of
C     radiosonde
C   S. English: Work by Weng (will send information later)
C

(J. Miao):
Validation of TWV retrieval from AMSU-B with TWV from GPS

- Cooperation of IUP, GKSS, TU Dresden
- Use GPS from Antarctica coastal stations (giving ground-based
  humidity measurements),
  and some over the continent using CHAMP satellite (occultation measurements)
- Result: agreement, but error increases toward high TWV (algorithm
  saturation)
- Exception: for 1 station (the northernmost and relatively warmest  one, near
  the tip of the Antarctic peninsula) there is not much correlation.



5.2  Part 2 (met.no,SMHI): WP 2.1: Prepare NWP activities
----------------------------------------------------------
(H. Schyberg):

Delivery of NWP fields for other project parts
- Code/scripts to extract 2003-2004 HIRLAM20 data is implemented
- 4 fields: Total CLW, TWV, 2m temperature, 10 m wind, 4 times daily (00,
  06, 12, 18 UTC)
- Area: Europe and Arctic except areas north of Bering Strait (East
  Siberian Sea, Chukchi Sea)
- 1 daily GRIB file containing the 4 fields (1 vector, 3 scalar),
  about 6 MB
- GRIB: free and open documentation and software available on the WWW
- grid is rotated spherical with mesh-width 0.2 degree.

- How to disseminate to IOMASA partners?
- Probably generated monthly.

C
C   M. Rummukainen: Only these 4 fields? How about, e.g. precipitation?
C     Generally, one recognises more parameters to be of importance later.
C   L.T. Pedersen: Precipitation, (accumulated over 6 hours)
C   H. Schyberg: We’ll see if it can be added too, but this would need
C     6-hour forecast data instead of analysis data.
C   C. Fortelius: But there is a spin-up effect.
C   C. Fortelius: Beware of boundary effect in HIRLAM (depending on
C     the forecast period, this may affect a zone up to about 20 grid
C     points)
C

Set-up of operational data stream for assimilation (H. Schyberg)
-----------------------------------------------------------------
```

- Will set up experimental OSI SAF chain for production of additional ice products for IOMASA (MY ice fraction is not operational):

	Input ->	Output
Operational:	SSM/I	Total ice concentration (and more) (HDF, GRIB + quicklooks)
Experimental:	QuikSCAT, AVHRR	MY ice fraction (new for IOMASA), later: Better emissivity information

- Develop interface subroutine to import SAF ice data at AMSU footprints

- Implement processing chain for near-real-time production of collocation files with AMSU-A level 1c, HIRLAM data and SAF sea ice data (for statistics, experimentation and assimilation):
  * AMSU-A 1c data from both own (met.no) receiving station and EUMETSAT ATOVS Retransmission Service (EARS)
  * EARS: 3 receiving stations (Tromsø, Greenland, Canary Isl.), availability within 30 min (?)
  * Reception facilities installed and AMSU-A level 1c files received at met.no
  * Work with interfacing ongoing (in parallel with change of operating system at met.no): cross-platform ASCII transfer, BUFR coding,production of colocation files etc.

C
C S. English: EARS 1c data might have calibration changes, why not
C start with EARS AMSU-A 1a and produce 1c yourself.
C G. Heygster: AMSU-B?
C H. Schyberg: Done by SMHI.
C

Data stream (P. Dahlgren):

- EARS will start running in about 1 week.

WORKING:
-local AMSU-A 1c -> BUFR_hirlam -> HIRLAM
TO DO:
- AMSU-B 1c -> BUFR_hirlam -> HIRLAM
OR ?
- EARS AMSU-A/B 1c -> BUFR_ears -> HIRLAM
When EARS is running, the local antenna will no longer be used.

(T. Landelius):
Setup of operational data stream (ice concentration) for experimental data stream
- Test data from OSI SAF
- Use 10 km OSI-SAF data to create super-observations on the HIRLAM scale (ca 10-40 km depending on configuration). The super-observations of ice concentration are then fed into the HIRLAM surface analysis scheme and assimilated using successive corrections.
- The SST and the fraction of water are modified based on the outcome of the ice analysis in order to get consistent information.

5.3 Part 3 (DTU): WP 3.1: Prepare sea ice modeling activities

```
--------------------------------------------------------------
(L.T. Pedersen):

Day 0 model of emissivity:
empirical - analysis of time series (20 years of SSM/I); now also
MWMOD

- DTU has SSM/I global data since August 2002, stored on DVD
- Data from own airborne field campaign CONVECTION (Greenland
  Sea Convection Mechanisms And Their Implications)
- Requested snow data from NSIDC

C
C   S. English: Alaska Ice Center might also have relevant data, S. English
C     will give L.T. Pedersen the contact information
C

April or May 2004: DTU campaign GreenICE (together with Scottish
Marine Institute, AWI -- C. Haas's induction measurement of ice
thickness from helicopter-- and others):
10 day drifting camp on sea ice north of Greenland; won't carry a radiometer,
but other measurements will be done)




5.4  Part 4 (DMI): WP 4.1: Prepare sea ice concentration retrieval
-------------------------------------------------------------------
(S. Andersen):

Preparation and day 0 tools
----------------------------
- Radiative transfer models: MWMOD, ARTS
- Ku band wind model function NSCAT2
- Sea ice concentration algorithms:
   * NASA, NASA2, Bootstrap, Norsex, Calval, Bristol,
   * Svendsen near 90 GHz, ASI, SEALION
- Scatterometer ice type detection schemes
   * SAF revised ice type scheme
   * thin ice detection scheme
- Synergistic ice concentration algorithm
   * Grandell 1999
   * Day 0.5 (presentation by R. Tonboe later)
- SSM/I / QuikSCAT Data:
   F-14 swath data 2001-2002 (43 GB)
   (?rather use F-13 because of calibration changes in F-14? see
    earlier comment by S. English, section 5.1)
   Seawinds (QuikSCAT) global 2001-2002  (63 GB)
- Validation strategy (5 main areas: once/month; 1 additional area:
  once/(2 months)), relying on SAR scenes from the following sources:
  * AO (Announcement of Opportunity) data (free) ASAR,
     - 170 scenes (Assist)
     - 311
     - 1270 (Cryosat)
   * 29 kEUR in IOMASA to purchase scenes (contingency, dual pol.)
   * ice service scenes

Example images for ice information from Radarsat scene:
 - neural network approach
```

- fuzzy logic classification

(H. Schyberg):
Example image: Bayesian ice type classification from QuikSCAT data:
- supervised, with OSI SAF ice type classes
- closed MY ice clearly over-estimated (extending far south especially along coasts,

Anomalous winter sea ice SAR and scatterometer sigma_0 and radiometer T_b
----
(R. Tonboe):

- caused by temporary melts
=>increase of: snow grain size, surface roughness; formation of ice crusts and layers in snow

- after melt: FY ice mimics MY ice
- ice concentration retrieval affected during and after melt.
- melt occurs frequently near the ice edge in winter
- sigma_0 and emissivity changes are long-lived (> 3 months)
- Example: temporary melt at Baffin Bay, Dec. 2001:
   * FY ice: sigma_0 increases to MY ice value and stays
   * sigma_0 pol. ratio drops during melt
   * SSM/I PR goes up
   * SSM/I GR first goes up slightly, then goes down
   * NASA Team ice concentration drops from 100% to 75% and stays there
- microwave signature modeling:
   * sigma_0 at C, Ku band: RT model (Tonboe)
   * emissivity at SSM/I frequencies: MWMOD

- Conclusion:
   * temporary melt changes snow grain size, roughness, forms ice layers in snow
   * Bootstrap and 85 GHz algorithms least sensitive to emissivity changes
   * detection of temporary melts with GR, sigma_0, HIRLAM
   * IOMASA report before 2004
   * paper to Remote Sensing of Environment before 2004

5.5 Part 5 (DTU-DCRS): WP 5.1: Preparation of Real time processing
----
and user interface

(L.T. Pedersen):

- tool is there and running (see earlier presentation)
- exact definition of IOMASA products needed

6. Review of Phase 1: Are we ready to start Phase 2?
==
Yes.
Exception: SMHI as to AMSU-B: slightly behind schedule, not ready yet, but within a few weeks.

```
7. Feedback from UAG
=====================
K. Hansen: IOMASA is a very ambitious scientific project; overall objective:
  new products and improved input to weather models -  in this case the end
  users are operational weather centers.
  Problems  challenges:
  - Need for UAG, role of UAG not clear; specific end user(s) not clear.
  - How to bring science to operation?
  - Quantify need for IOMASA,
  - Quantify expected output and long term goals for IOMASA
  - Quantify near real time operational products
  - Relations to SAF? GMES? Other?
 Focusing at the DMI operational users needs, a number of secondary products
 may be a result of IOMASA, i.e.:
   - sea ice edge (user defined, 0%, 1%, 10%...)
   - realistic representation of ice concentration near ice edge
   - ice types / thickness
   - ice surface roughness
   - surface winds
   - precipitation over water (visibility)

S. English: Operational continuity is important for NWP centres, and
  therefore a fully supported operational product will be preferred to a
  product with limited lifetime.

S. Andersen: Note: IOMASA = Development project, i.e. no guarantee to deliver
  things that are better

H. Schyberg/G. Heygster: Of course, we can not oblige SAF to take our product

H. Tangen: SAF is asked to seek partners to help improve their work, but be
  careful about quality.  What are the end products (not clear)?  There are
  other sea ice activities running in parallel (e.g. ICEMON and Northern
  View, both in GMES) -- need to communicate/coordinate

S. Andersen: It is quite well defined and straightforward how an improved sea
  ice product will be implemented in OSI SAF

H. Tangen: e.g., ICEMON is the opposite strategy compared to IOMASA:
  1st phase (20 months): no research & development, but
  state-of-the-art products. Only then: R&D

M. Rummukainen: Climate is not a focus of IOMASA (so why should
  I participate) --
  -- but: Availability of new data is relevant for regional climate
  modeling.
  - for example melt episodes: how often do they occur?
  - for IOMASA data to be used for climate modeling: need quality flags,
    numerical data (not images)
  - Swedish ice breaker campaigns might be interesting for IOMASA
  - GLIMPSE project: talk to Klaus Detloff (AWI)

G. Heygster: How to get SHEBA data?
M. Rummukainen: Contact Colin Jones at Rossby-Centre (SMHI).

L.T. Pedersen: Does that mean that, e.g., CLW fields, together with error bars
  and quality flags, are of interest for you?
M. Rummukainen: Yes
```

C. Fortelius: There is no CLW in HIRLAM, just TCW condensate (ice + water).
- Boundary problems: TCW near boundary unreliable
- As to assimilation experiments: validation with case studies and forecast verification statistics
- suggest also to look at analysis increments (i.e., the impact of putting new information like humidity fields into model) and look at the physics that causes the analysis increment.
- work with reference HIRLAM, not your national HIRLAM version. This would enhance your impact: If changes ad improvements are done and tested with reference HIRLAM, then chances are good that this is taken over by the national HIRLAM versions (but not vice versa!).

S. English: As to your 3 experiments (1. ice data -> better heat flux; 2. assimilation of AMSU-A; 3. Assimilation of AMSU-B): how are you going to do that? Do you have the resources? It might be difficult to achieve the -- to me, rather ambitious -- goals if IOMASA.
You need to run the model for a period of several weeks for each experiment

Changes should be tested individually and together where interactions are considered likely (e.g. improved sea ice and improved sea ice emissivity model for ATOVS assimilation).

H. Schyberg: Maybe we won't succeed to check all combinations

S. English: Assimilate AMSU-B radiances instead of TWV product. Preferable since you want to assimilate the variable that has as Gaussian an error statistics as possible (which is rather radiances than quantities retrieved from them - TWV is related non-linearly to radiances). Gaussian error statistics is an assumption behind the assimilation.

Is your main goal science (you mentioned publications as a major outcome) or operational application (as stated in DoW).

- UAG members are asked to submit their comments given here in some written form.

8. Action Items for PM1:

8.1 List of Deliverables:

- Going through list of deliverables from Description of Work (DoW) and discussing which are the main deliverables that are greater interest outside IOMASA, either for the general public (P), or just the weather/ice services (S);
  this is also relevant for the IOMASA brochure (see 10.1)

No.	Deliverable title	Date	Nature	for:
Part 1: Remote sensing of atmospheric parameters (Partner 1)				
1.1	Baseline data and algorithms for atmospheric remote sensing	6	Re,Da,Me	P
1.2.1	Retrieval algorithm for TWV from AMSU-B data	20	Re,Da,Me	P

1.2.2	Retrieval algorithm for cloud signature from SSM/I-B data	29	Re,Da,Me	P
1.2.3	Retrieval algorithm for surface emissivity at AMSU-A frequencies	29	Re,Da,Me	P
(1.3.1	Fields of TWV of investigation period	32	Da)	
(1.3.2	Fields of cloud signature of investigation period	32	Da)	
1.3.3	Operational processing chain for cloud signature	32	Re,Da	P
(1.4	Validation report for TWV and cloud signature	36	Re)	
Part 2: Improving numerical weather prediction models (Partners 4,5)				
(2.1.1	Report on setup of operational data stream	6	Re)	
2.1.2	2 data years of NWP fields: Wind, TWV,liquid water path, and surface temperature	6	Da	S
2.2.1	Report and programme code on humidity assimilation into NWP	20	Re,Me	P
2.2.2	Report and programme code on temperature assimilation into NWP	29	Re,Me	P
2.2.3	Report and programme code on interface implementation (sea ice)	29	Re,Me	S+P
2.3	Report on real time assimilation system for TWV and improved temperature assimilation	32	Re,Da	P
2.4	Validation report on assimilation impact	36	Re	P
Part 3: Empirical model for emissivity and backscatter of sea ice (Partner 2)				
3.1.1	Offline data and day 0 algorithms for Part 3	6	Re,Da,Me	P
(3.1.2	HIRLAM data of project year 1	12	Da)	
3.2.1	Report and programme code for emissivity and backscatter model of sea ice	22	Re,Me	P
3.2.2	Report on improvement potential with sensors AMSR(-E)	22	Re	P
3.3	Report and programme code for influence of snow	32	Re,Da	P
(3.4	Validation report for sea ice model	36	Re)	
Part 4: Sea ice concentration retrieval (Partner 3)				
4.1	Data sets and day 0 algorithms for sea ice retrieval	6	Re,Da	P
4.2	Report and programme for retrieval of sea ice concentration	29	Re,Me	P
4.3	Sea ice concentration data set of investigation period	32	Da	P
4.4	Validation report for sea ice retrieval	36	Re	P
Part 5: Real time processing and user interface (Partner 2)				
(5.1	Data formats and software interfaces for real time production	12	Re)	
(5.3	Real time production and distribution system	32	Re,Da)	
5.4	Demonstration report and data	36	Re,Da	P

Nature: Re = Report, Da = Data, Me = Method

C

```
C   L.T. Pedersen: Copyright issues with, e.g., Radarsat images
C

8.2 Results in the sense of TIP:
----------------------------
- Draft of TIP must be ready latest after one year, i.e. November 2003
- main task: identify results, such as:
  algorithms, models, data sets (in all about 5 to 10 results)
  1) TWV, CLW retrieval algorithms
  2) Assimilation scheme, heat flux

- Each IOMASA partner to submit about 2 results from his project part
  to coordinator within about 1 month
- C. Melsheimer)to send example TIP (project on detection of
  hydrocarbon in water) to all partners.

8.3  Input for Management Progress Report (due end of May):
-----------------------------------------------------------
- State that you are on schedule, and if not, why so
- State person-months used
- submit by mid-May to coordinator
- L.T. Pedersen sends an example to all


9. Project Management:
======================
9.1  Reports that come with the Phase 1 deliverables:
------------------------------------------------------
- please send ASAP to coordinator who will produce a common cover page
  and forward everything to EU.


9.2 Next meetings:
------------------
(UAG only expected to attend MTR in Aug 2004 and FP in November 2005)
PM2: Oct 30/31 at SMHI, Norrköping  (not finalised yet, finalise date
     by end of May, get feedback on date when circulating minutes).

MTR: Aug 26/27, 2004, met.no, Oslo (tentatively)

10. Additional topics
=====================

10.1  IOMASA brochure (C. Melsheimer)
-------------------------------------
- brochure to present/introduce IOMASA to scientists and forecast people
- request for comments.
=> first comments:
- it is not clear if things refer to
   * end user products
   * end user software
   * better scientific knowledge
- more emphasis on deliverables (see 8.1, discussion about list of deliv.)
- which contact person for what deliverable/domain
- brochure should be printed once only (not updates; too expensive)

10.2  AMSR (G. Heygster)
--------------------------
- G. Heygster is  PI for AMSR sea ice
```

```
- 3 problems with AMSR:
    * hot load has uneven temperature distribution;
    * cold load: mirror too small for antenna beam
    * radio frequency interferences (at 6 GHz H and V) over
      industrialized areas
- CLW from AMSR: first results


11. Any other business:
========================
- link to IOMASA IWICOS from IOMASA page
- add e-mail addresses of UAG to IOMASA member page (how safe is a
  password-protected web page with respect to address-collectors for
  spam?), or make a distribution list.
- presentation files of this meeting to C. Melsheimer



---------
GLOSSARY/ACRONYMS:
------------------
ASI            ARTIST sea ice algorithm
CHAMP          CHAllenging Minisatellite Payload (GFZ Potsdam/DLR)
CLW            cloud liquid water
DMI            Danish Meteorological Institute
DTU-DCRS       Technical Univ. of Denmark, Danish Center for Remote Sensing
GKSS           GKSS Research Center (near Hamburg, Germany)
GLIMPSE        Global implications of Arctic climate processes and
               feedbacks (http://www.awi-bremerhaven.de/www-pot/atmo/glimpse/)
GMES           Global Monitoring for Environment and Security
GreenICE       Greenland Arctic Shelf Ice and Climate Experiment
               (http://www.dmi.dk/f+u/ocean/GreenICE.htm)
Icemon         operational ice monitoring for marine operations and climate
               change (http://www.nersc.no/ICEMON/)
IUP            Institut für Umweltphysik (Environm. Physics), Univ. Bremen
IWICOS         Integrated Weather, Sea Ice and Ocean Service System
LWC            liquid water content
met.no         Norwegian Meteorological Institute
NSIDC          National Snow and Ice Data Center
OSI SAF        Satellite Application Facility (SAF) on Ocean and Sea Ice
SEPOR/POLEX    Surface Emissivities in POLar Regions - POLar EXperiment
SHEBA          Surface HEat Budget of the Arctic ocean
               (http://sheba.apl.washington.edu/)
SMHI           Swedish Meteorological and Hydrological Institute
TCW            total cloud water
TWV            total (column) water vapour

Minutes prepared by
   Christian Melsheimer
```

A.3 Progress Meeting 2, 30–31 October, 2003, SMHI, Norrköping

Minutes of the IOMASA Progress Meeting 2,
30-31 October, 2003
held at SMHI, Norrköping, Sweden

Start of meeting: 30 October, 13:00
End of meeting: 31 October, 12:00

Participants:

IUP:
Georg Heygster GH
Christian Melsheimer CM

DTU-DCRS:
Leif Toudal Pedersen LTP
Roberto Saldo RS

DMI:
Søren Andersen SA
Thomas Bøvith TB

met.no:
Harald Schyberg HS
Frank Thomas Tveter FT

SMHI:
Nils Gustafsson NG
Tomas Landelius TL

1. Introductory items:

* Welcome address.
* Introductory round.
* Overview of project schedule: We are amidst Phase 2, i.e., algorithm development.

2. Progress of Phase 2: Status and Results of Phase 2 of each Partner:

2.1 Part 1 (IUP): WP 2.1: Atmospheric remote sensing algorithms

(C. Melsheimer):

Total water vapour (TWV) from AMSU-B:

* J. Miao' algorithm (using ratios of brightness temperature differences of 3 frequencies).

Freq. [GHz]:	89	150	183.31+/-7	183.31+/-3	183.31+/-1
channel no.:	1	2	3	4	5

Channel 1, 2: Window channels,
Channel 3,4,5: around water vapour line.

* Using radiosonde data to get the constants C0, C1 for the algorithm
  TWV * sec(theta) = C0 + C1 * log [(Ti-Tj)/(Tj-Tk)],
* Use different channel combinations (i,j,k = 3,4,5, or 2,3,4) depending on saturation of channel 5
* C0, C1 depends weakly on the temperature and water vapour profile

```
    of the atmosphere, therefore:
  * Use different sets of C0,C1 for different seasons and regions
  * Assumption of surface emissivity independent of frequency is o.k.
    for channels 3,4,5, but not for 2,3,4 => higher error.
  * Educated guess of emissivity, using, e.g., ice type information,
    could help improve accuracy.
  * Related work: N. Selbachs PhD thesis: emissivity at 157GHz and
    183GHz is quite well correlated, emissivity at 89GHz and 183GHz
    less well correlated.

//
//    LTP: If partitioning into regions is done, the region
//       borders have to be treated carefully (discontinuities)
//    NG: Why not use temperature profile from satellite
//       (AMSU-A) to decide which bias to use?
//    LTP: As to emissivities - some info on them is available...
//    NG: We use emissivity as a control variable, therefore
//       knowledge about the correlations between emissivities at different
//       frequencies can be very useful.
//    NG: When do you have TWV fields - we want to see the difference
//       between assimilating AMSU-B radiances and assimilating TWV (from
//       AMSU-B); we’ll be ready for assimilating AMSU-B radiances in about
//       half a year.
//    CM: Depending on how well the algorithm is calibrated,
//       first fields can be ready by end of this year.
//

   (G. Heygster):

    Cloud liquid water (CLW) over ice from SSM/I

  * CLW influence radiative fluxes, sea ice balance,sea ice retrieval,
    its parameterization critical to climate models.
  * Problem: high and varying surface signal, low thermal contrast
  * Solution: Use R-factor, calculated from horizontal and vertical
    polarisation brightness temperatures (T_h, T_v) at two frequencies
    f1, f2, from SSM/I:
    R(f1,f2)=log[(T_v(f1)-T_h(f1))/(T_v(f2)-T_h(f2)], i.e. logarithm
    of ratio of polarisation differences
  * R(1,2) = R(surface) + B*(CLW + A*TWV) + R(dry air); B is related
    to the frequency difference of the liquid water absorption
    coefficient (k(f1)-k(f2)), A is the ratio of the frequency
    difference for liquid water and water vapour absorption
    coefficients
  * Choose suitable frequency pair to make B large and A small in
    order to retrieve CLW, e.g. (18GHz,23GHz) and (23GHz,36GHz)
  * Surface contribution R(surface) investigated using clear-sky
    (CLW=0) cases
  * AMSR(-E) data:
       + can be used instead of SSM/I; higher resolution
       + additional channels at 6GHz and 10GHz can yield information
         on surface contribution

//
//    NG: Can you retrieve total water, CLW + PWV?
//    GH/HS: Difficult to retrieve them simultaneously
//       since they have very different radiative behaviour.
//    Cloud ice is an error source because of scattering.
//    HS: Can CLW be retrieved using other sensors?
```

```
//    GH: Yes, e.g. Polder; needs sunlight.
//    HS: Can we also get AMSR data in near real time
//    LTP: Yes, possible (within about 4-6 hours)
//    GH: We use AMSR for daily sea ice maps (Gunnar Spreen, Lars Kaleschke),
//       sometimes, AMSR data are there faster than SSM/I
//

  2.2 Part 2 (met.no/SMHI): WP 2.2 Improve Arctic high-resolution NWP

   (H. Schyberg):

    NWP assimilation activities:

   SMHI: AMSU-B, humidity

   met.no: AMSU-A, temperature
     * NWP fields for use by project partners
          + code/script to extract 2 years (2003-2004) NWP data
            implemented
          + deliverable report 2.2.1 sent
     * extracts from HIRLAM 20 of 6hr forecast:
          + total CLW
          + CWV
          + 2 m temperature
          + 10 m wind speed
          + precipitation last 6 hrs (NEW)
     * 4 analyses daily (0h, 6h, 12h, 18h)
     * Data format etc. documented in Deliverable Report 2.2.1

//
//    NG: Precipitation 0-6hrs dangerous, in first hour (0h-1h), values
//       might be erroneous
//    LTP: Use  2h-6h instead of 0h-6h?
//    NG: Yes, for example, but difficult to achieve. One possibility
//       is to use, e.g., 6h-12h.
//

    Setup of operational data stream for assimilation

     * done: EARS (Eumetsat ATOVS Retransmission Service)
          + observations received within 30 min
          + reception facility installed, AMSU-A 1c
          + interface developed
     * AMSU-A collocation chain:

     EARS + HIRLAM20 + OSI SAF
    --------------------------
    = Tb’s, RTTOV simulated Tb’s, profiles, ice data


    WP 2.2

     * Experimental OSI SAF chain for production of additional ice
       products for IOMASA under development:
                 Input   ->         Output
  Operational:   SSM/I         Total ice concentration (and more)
                             (HDF, GRIB + quicklooks)
  Experimental:  QuikSCAT,     MY ice fraction (new for IOMASA),
                 AVHRR         later: Better emissivity information
```

```
     * Subroutine to import SAF ice data at AMSU footprint
     * will be basis for producing statistics for AMSU observations vs.
       forward-modelled (RTTOV) observations from HIRLAM fields
     * statistics will aid in developing emissivity formulation for
       AMSU-A channels
     * will aid in quality control formulation (problem: deep [= thick]
       water clouds)

   (T. Landelius):

    Humidity Assimilation (AMSU-B):

     * done:
          + outer minimization loop
     * ongoing:
          + new humidity variable (rel. humidity)
          + skin temperature and emissivity as control variable
     * planned:
          + visit at UK MetOffice (Per Dahlgren)
          + emissivity, first guess
          + AMSU-B cloud mask
          + bias correction scheme (between radiative transfer model and
            observation)
          + AMSU-B into HIRVDA (= HIRLAM variational data assimilation)

    Surface heat flux modeling:

     * done:
          + HIRLAM snow scheme
          + Flux formulation for stable conditions
     * ongoing:
          + Flux implementations
     * planned:
          + validation of new flux and snow
          + HIRLAM ice scheme
          + validation of new ice

//
//    GH: There are activities on snow depth with AMSR, and snow/ice
//       interface temperature
//    TL/GH Priorities: which of the planned items first?
//    LTP: In winter, snow/ice interface temperature from radiometer
//       (AMSR), since snow quite transparent then
//       <- snow depth from HIRLAM?
//       -> snow surface temperature
//    TL: Emissivity at AMSU (A,B) channels?
//    LTP: OSI-SAF: ice concentration & ice type => we => emiss. at AMSU
//       freq.
//    HS: ...or directly from SSM/I (no detour via ice concentration/type)
//    GH: Emissivity. important, needed by many => we need to coordinate that
//          (DTU group is working on that)
//    LTP: Most crucial: AMSU-A channels; AMSU-B channels less influenced
//    SA: In the end, all improvements should be put into one model
//    HS/NG: That is the plan, and then we can assess the overall impact
//       of IOMASA
//    NG: This can take very long ...
//    CM/GH: ...follow-on projects? Discuss that later (e.g., next meeting)
//    GH: The CARE project should be made more aware of importance of
//       surface for NWP
```

```
//

  2.3 Part 3 (DTU): WP 3.2: Construction of sea ice emissivity forward model:

   (L.T. Pedersen):
     * IOMASA Interactive Ice Browser on DTU web site:
       [1]http://www.seaice.dk/iomasa
     * AMSR-E data:
          + ice products:
               o 89 GHz algorithm
               o bootstrap algorithm
               o combined algorithm (similar to ARTIST algorithm)
          + a number of regular users
     * Advanced (experimental) statistical retrieval: SST, WS (wind
       speed), WV(z), CLW(z), T_air(z), T_ice, C (ice conc.), epsilon(f)
       (emissivity)
          + Statistical retrieval:
               o measured radiance T_a = F(p), p=(SST, WS, WV...)
               o linearise radiative transfer equation: T_a = M p
                    # Wentz's water emissivity model
                    # Empirical ice emissivity model for AMSR channels
//
//    LTP/GH: Problems with calibration of AMSR data (used to calibrate
//       ice emissivity model.
//    GH: There are two different calibrations (a Japanese one and
//       one from F. Wentz), they are expected to converge; more info
//       on that in March 2004.
//
               o retrieval of p using optimal estimation method (OEM),
                 as, e.g. described in LTP's PhD thesis.
     * example TWV, CLW, wind, SST retrieval from North Atlantic (Sep 26,
       2003, 4:30 UTC):
          + looks reasonable; note: even SST under clouds, because of the
            use of microwaves
          + small problem: low SST values at left edge
//
//    GH: possible explanation: SST mainly from 6 GHz channel (least
//       sensitive to atmosphere /  most sensitive to SST), has widest
//       opening angle => sees part of e.g., spacecraft
//    HS: Ice surface temperature?
//    LTP: Does not work yet, but this can be sorted out.
//    SA: Area north-east of Greenland looks strange also in TWV
//    LTP: Yes, that's an area of 30%-60% ice concentration
//       => different channels (having different footprints) see different
//       things => trouble
//
     * Comparison SST 27 Oct 2003: DTU AMSR statistical retrieval vs.
       OSI-SAF SST (based on IR):
          + correlation (scatter plot) looks good
          + problem at coast because algorithm does not understand land
            => just a question of a good land mask
     * Comparison SST 27 Oct 2003: DTU AMSR statistical retrieval vs.
       Wentz's AMSR algorithm:
          + correlation good except one area with very poor result
//
//    LTP: DTU algorithm is related to Wentz's
//    SA: There is an alternative algorithm from Japan, completely
//       independent of Wentz's
//
```

```
     * Wind estimate:
         + high CLW causes errors
     * Comparison Wind 27 Oct 2003: DTU AMSR statistical retrieval vs.
       Wentz's
         + maybe calibration problem/discrepancies
     * Comparison TWV [27 Oct 2003?]: DTU AMSR statistical retrieval vs.
       Wentz's:
         + good correlation
         + standard deviation of WV over ice higher (interesting to
           compare this with IUP WV activities)
//
//    GH: You could compare with GPS-WV and Polder WV
//    NG: We are also assimilating ground-based GPS-WV estimates
//
     * CLW:
         + Comparison with AVHRR cloud image looks reasonable
     * Comparison Ice concentration: DTU AMSR statistical retrieval vs.
       Bootstrap algorithm
         + ice edge reasonable
     * maybe include emissivity (10 channels) in statistical retrieval
       (needs a priori emissivity info)
     * MY ice: enhanced at (SSM/I) ice edge (footprint size problem:
       different channels see different areas)
         ______________________________________________________________

     * AMSR retrieval of all that was done to check the forward model
       (emissivity, radiative transfer)
     * the retrieved data would need proper validation

//
//    LTP: we should make comparison with IUP's CLW, TWV
//    GH: Advantage of Wentz's ocean emissivity model over MWMOD?
//    LTP: Wentz's model orders of magnitude more computationally
//       efficient because it is tuned to SSM/I and AMSR frequencies.
//    GH: AMSR: There is a correction for land contamination.
//

  2.4 Part 4 (DMI): WP 4.2: Construction of algorithm for sea ice concentration
  retrieval:

   (S. Andersen):
     * Objectives: scatterometer, radiometer, NWP, validation data => (1)
       atmosphere, (2) surface effects, (3) improved C_T (total ice
       conc.) algorithm, (4) validation
     * (1) Atmosphere data:
         + Scatterometer, Radiometer, NWP =>(evaluate)=> WV, wind speed,
           LWC, temperature
         + awaiting input from partners 1 and 2
         + choose best source
     * (2) Surface effects:
         + which ones are important?
              o time series of scatterometer & SSM/I data
              o time series of concentration algorithms (near 90 GHz,
                NASA TEAM, NASA TEAM 2, bootstrap)
         + develop detection scheme
         + correct/flag data
         + example: Melt Events:
              o melt and refreeze affects ice concentration (IC)
                retrievals
```

```
              o detectable in time series of NASA TEAM (NT) alg.
                retrievals over FY and MY ice
              o does not affect all algorithms equally (bootstrap almost
                immune)
          + Melt events have typical signatures in time series of T,
            GR(19-37) , PR(19), Tb(19), Tb(37)-Tb(89), sigma0, APR
            (active pol. ratio from scatterometer), bootst. IC, NT IC,
            near90 IC [for plots of these signatures see PDF file of
            presentation]; different signatures for FY and MY ice
          + e.g., NT IC decreases during melt event and stays low
            afterwards
          + the melt signatures of the various quantities help discover
            synergies
//
//    GH: Stefan Voss (PhD thesis about sea ice, IUP, 2002) did not
//       observe reduced FY NT IC after melt events.
//    SA: Surprising because we have definitely observed that.
//    GH/SA: Not clear why the findings are so different...
//
     * (3) Algorithm development:
          + Scatterometer => surface; Radiometer => ice conc.; NWP =>
            history => improved ice concentration retrieval
          + focus on surface effects (atmospheric correction may use
            existing techniques)
          + Initial phase: data sets online
          + Near future:
              o identify
                   # problematic conditions
                   # algorithm differences
                   # active/passive "fingerprints"
              o feedback to part 2 (surface properties)
              o correlation between orbits (met.no)
//
//    HS: Ocean: No correlation between 2 orbits
//          Ice: Some correlation
//          This might help algorithms
//
              o Tuning of Seawinds statistics (met.no), see PM1
//
//    HS: Not ideal yet
//
              o Coinciding interests with EuroClim project
     * (4) SAR classification (T. Bøvith):
          + Code from Lars Kaleschke (IUP),
              o streamlined/optimized
              o adapted to operational use
              o parallelised
              o interface to ice analyst’s workstation
          + Idea: provide tool to ice analyst to delineate ice in great
            detail
          + Ice Analyst Interface
              o view/select features
              o select/manipulate training areas
              o review classification results
              o mask untrusted areas
          + Draft report available
              o 5 representative scenes:
                   # worst recognition accuracy: 80%
                   # typically > 90%
```

```
                   # some features are consistently helpful
//
//    LTP/RS: Problems with ENVISAT AO data: ordered data not recorded,
//       wrong scene on CD (DVD? tape?), ...
//
              o SAR features (9 different texture measures):
                   # homogeneity measures: angular 2nd moment (ASM),
                     entropy (ENT)
                   # smoothness measures: contrast (CON), dissimilarity
                     (DIS), homogeneity (HOM), inverse difference moment
                     (INV)
                   # others: correlation (COR), mean (MU)
              o using too many features makes the result worse
              o consistently useful: COM, ASM, ENT, Lee
              o occasionally useful: INV, COR, HOM, DIS, MU (˜Lee)
//
//    GH: How can too many features reduce the accuracy? Is it
//       "overlearning" (too specific training)?
//    SA/TB: No, rather: some features are not very well correlated with
//       what we want to see => they introduce noise
//    RS: How do you know the "consistently useful features" are just the
//       ones that work best?
//    SA: Our results are based on 5 scenes of different physical
//       setting. So we can not say that choosing only the
//       "consistently useful features" will give the best results,
//       the "occasionally useful" features should be checked as
//       well.
//


     * Examples for classification:
       (a) Turbulent sea limit (E Greenland, Scoresby sound area):
          + turbulent (=wind-roughened) water and ice are
            indistinguishable
          + overestimation of turbulent water area => training areas in
            very turbulent area to be omitted; user must know the
            limitations of the data
//
//    RS: Can you tell if a simple approach (thresholding) works as well?
//    SA: Why not, but quite likely it won’t work well. Several of the
//      features are certainly best described by a combination of
//      texture  and amplitude. How non-linear this is, we do not know
//      for sure.
//
       (b) Turbulent sea limit (Baffin bay, Disko Island area, 16-26 Dec
       2001):
          + Melt and refreeze
          + series of 3 RADARSAT scenes
//
//    CM: Water between ice dark?
//    SA: Typically yes, but theta-dependent.
//       SSM/I IC show the typical melt problems, but SAR always shows
//       contrast. This has to do with the radar wavelength. It can be
//       shown that C-band is largely immune to the larger snow grains,
//       whereas Ku band will be affected. Present SAR’s operate in C-band.
//
     * Plans:
          + Test dependence of result on ice expert
          + training by ice analysts
```

```
          + compare method to 2001 Odden and 2003 Polarstern
          + initiate routine processing
          + Test Gamma and PMR features
          + Coincident RADARSAT/ENVISAT data

//
//    SA: Do we try to make microphysical description of ice on which
//       algorithm is based? or rather go on with empirical algorithm
//    LTP: A physical algorithm is nice, but we should have a fallback
//        option
//    GH: Now we have 2 totally different ice algorithms:
//       DTU’s statistical (OEM) retrieval, and DMI’s.
//       Should one of them be the "standard" one in IOMASA?
//    SA: Ice service should not rely on just one algorithm (e.g., switch
//       to bootstrap during melt events)
//    LTP: We should continue with both approaches; OEM does not always
//       work fine.
//    HS: And it’s 2 different sensors: AMSR and SSM/I
//    LTP: Yes, but OEM algorithm with SSM/I works almost as fine as with
//       AMSR; however, SST retrieval works much better with AMSR.
//       Also consider: there are 3 SSM/I’s but only 1 AMSR (used to be 2
//       until recently...)
//

  2.5 Part 5 (DTU-DCRS): WP 5.1 Real time processing and user interface: Define
  interfaces and formats:

   => see section 2.3 above

3. Review of Phase 2:

   All tasks are on schedule

4. Inter-task communication/coordination

  who:                 what                              to whom                    when
                                                                                    from end
  IUP:      TWV fields                           DMI,DTU,SMHI                       of 2003
            CLW fields                           met.no
            CLW algo. (R-fact.)                  met.no, DMI,DTU
            temp. retr. algo.                    met.no
            emiss. correlations
                                                 all
            (SEPOR/POLEX)
                                                 all (to website if o.K.
            Nathalie’s PhD thesis
                                                 with Nathalie)
  DTU:    L.T. Pedersen’s PhD thesis             all
          HIRLAM data extraction
  met.no:                                        all
          (startup now)
          ice emissivity forward model,
  DTU:                                           DMI
          snow emissivity model
          AMSR data (ftp)                        DMI
  DMI: report on melting events                  all
          experimental ice products              all
          SAF ice conc.                          all: http://saf.met.no
  DTU: AMSU emissivities                         all
```

	OEM retrieval (prelim. report)	all	end of 2003
IUP:	List of arctic RS stations (so they can select satellite passes)	DTU	
DMI:	Synop data 1996-2003	IUP	
IUP:	LaTeX template of Report	all: website	

DTU-IUP: compare CLW fields (from OEM and AMSU) for some example situations; IUP sends specification of example (cloud systems across ice edge) to DTU.

Note: Best way to exchange algorithms and reports is the IOMASA member web site

5. Project management

5.1. Report duties

(C. Melsheimer)

* Periodic report after each project year (year one ends now), due within 2 months(compiled and sent to EC by coordinator)
* Input to coordinator by November 20 (LaTeX, ASCII, RTF, (DOC))
* Kind of input needed:
    + for Section 1 (Management Report):
        o planned/used manpower (person-months) and funds; by WP
        o scientific/technical progress
        o milestones/deliverables obtained
        o deviations from work plan
        o meetings, conferences, cooperations with other projects
    + for Section 2 (Executive Summary about main results achieved, to be made public by EC (1 to 2 pages)):
        o publications by project partners from the last 12 months
        o publications in queue
        o 2 hard copies of each publication
    + for Section 3 (Detailed scientific/technical progress, per WP, max. 4 pages per WP):
        o Objectives
        o Methodology and scientific achievements related to WP including contribution from partners
        o Socio-economic relevance and policy implication
        o Discussion and conclusion
        o Plan and objectives for the next 12 months

5.2. Next meetings

All project members agreed to shift Midterm Review (MTR) from end of month 22 to end of month 18, i.e. May 2004:

* MTR: Monday 10 May - Tuesday 11 May, 2004 at met.no, Oslo, Norway
* PM3: Feb/Mar 2005 at DTU, Copenhagen, Denmark

6. Action items for PM2

6.1.1 Deliverables 3.1.2: HIRLAM data year 1

o.K. (see section 4., Inter-task communication)

6.1.2 Deliverable 5.1: formats/interfaces for real time production instead of exchanging data, we shall rather exchange algorithms

6.2. Input for first Periodic Report

see above, section 5.1 (input to coordinator due on Nov 20)

7. Additional topics

IOMASA brochure

* not complete yet, should be done this year.
* 3 nice images needed:
    1. Ice concentration
    2. Atmospheric field (TWV or CLW or so)
    3. Ice Browser screenshot
* comments etc. till 20 November

8. Any other business

IOMASA web pages

* IOMASA web pages, now hosted by IUP, have recently often been unreachable (construction works, moving of servers to new building etc.)
* we should consider moving them to DTU web server that is maintained by Roberto Saldo

Presentations at this meeting

All participants of this meeting are to send electronic copies of their presentations to the coordinator, preferably in PDF format.

DMI report on melting events

put link to online version of report (on DMI website) to IOMASA member web site

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GLOSSARY/ACRONYMS:

ASI	ARTIST sea ice algorithm
CLW	cloud liquid water
CWV	column water vapour (= TWV = PWV)
DMI	Danish Meteorological Institute
DTU-DCRS	Technical Univ. of Denmark, Danish Center for Remote Sensing
EuroClim	European climate change [?] (http://euroclim.nr.no)
FY	first-year (ice)
IC	ice concentration
IR	infra-red
IUP	Institut für Umweltphysik (Environm. Physics), Univ. Bremen
LWC	liquid water content
met.no	Norwegian Meteorological Institute
MY	multi-year (ice)
NSIDC	National Snow and Ice Data Center
NT	NASA TEAM (algorithm for sea ice concentration retrieval)
NWP	numerical weather prediction
OEM	optimal estimation method
OSI	SAF Satellite Application Facility (SAF) on Ocean and Sea Ice

```
PWV          precipitable water vapour (= TWV = CWV)
SEPOR/POLEX Surface Emissivities in POLar Regions - POLar EXperiment
SMHI         Swedish Meteorological and Hydrological Institute
SST          sea surface temperature
T            temperature
Tb           brightness temperature
TCW          total cloud water
TWV          total water vapour (= CWV = PWV)
WV           water vapour
```

Minutes prepared by Christian Melsheimer

Abbreviations/Acronyms

AMSR	Advanced Microwave Scanning Radiometer; on satellite ADEOS-2 (Midori)
AMSR-E	Advanced Microwave Scanning Radiometer for EOS; on satellite Aqua
AMSU	Advanced Microwave Sounding Unit; on NOAA satellites
CLW	cloud liquid water
DMI	Danish Meteorological Institute
DMSP	Defence Meteorological Satellite Program
DTU-DCRS	Technical University of Denmark
ECMWF	European Centre for Medium-Range Weather Forecast
FY	first-year (ice)
GRIB	gridded binary (format)
HIRLAM	High Resolution Limited Area Model
IUP	Institut für Umweltphysik (Institute of Environmental Physics)
LES	large eddy simulation
met.no	The Norwegian Meteorological Institute
MY	multi-year (ice)
NWP	numerical weather prediction
NWP SAF	Satellite Application Facility (SAF) on Numerical Weather Prediction
OSI SAF	Satellite Application Facility (SAF) on Ocean and Sea Ice
SAR	synthetic aperture radar
SMHI	Swedish Meteorological and Hydrological Institute
SSM/I	Special Sensor Microwave/Imager on DMSP satellites
SSM/T	Special Sensor Microwave/Temperature sounder
TWV	total water vapour
UAG	User Advisory Group
DTU	Technical University of Denmark
DMI	Danish Meteorological Institute
UB	University of Bremen