Task 4.3
Enhancement of observational data sets by data assimilation and analysis

T. Kaminski[2], L. Axell[5], K. Christensen[3], J. Debenard[3], R. Gerdes[1], R. Giering[2], P. E. Isachsen[3], P. Kallberg[5], M. Karcher[1,4], F. Kauker[1,4], H. Schyberg[3], A. K. Sperrevik[3], F. T. Tveter[3], and M. Vossbeck[2]

[1]Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, [2]FastOpt, Hamburg, Germany, [3]Norwegian Meteorological Institute, Blindern
[4]O.A.Sys. – Ocean Atmosphere Systems, Hamburg, Germany, [5]Swedish Meteorological and Hydrological Institute, Norrköping

A set of data assimilation systems around regional NWP and ocean-sea ice climate models using different data assimilation techniques are being prepared for production of atmospheric, oceanic and sea ice fields that combine information from models and observations, including those collected in WPs 1, 2, and 3. The individual activities benefit from development of models or assimilation methods in WP4.1 and WP4.2.

Partner	Model	Assimilation Method	Assimilation window	Total Period
SMHI	HIRLAM/HIROMB	3D-Var (later 4D-Var)/OI	6 h for the atmosphere	12-36 mon planned
met.no	HIRLAM NWP model	3D-Var (optionally 4D-Var later)	6 h; Forecasts up to 48 h	Probably 1 to 3 mon
met.no	ROMS	nudging (later 3D-Var)	12-20 h	operational from Spring 2010
AWI/FastOpt/OASys	NAOSIM	4D-Var	2 years	2006-2008

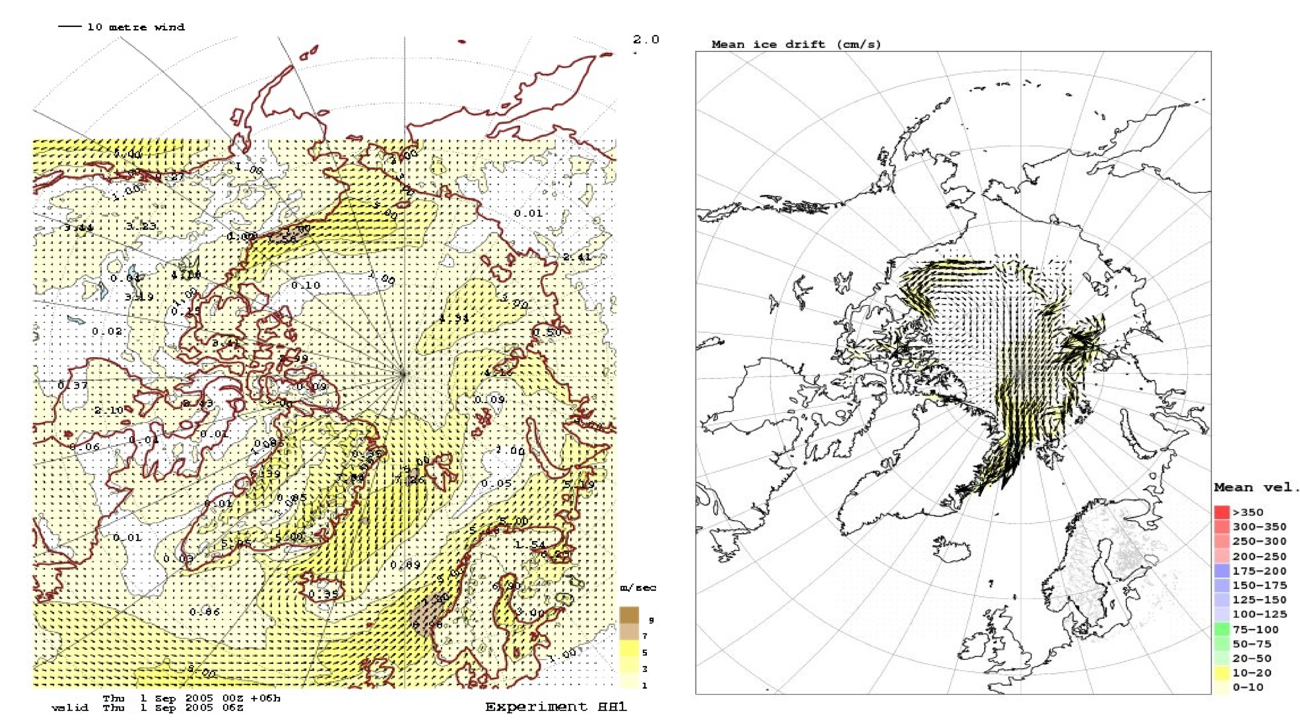
SMHI:

Model:

* HIRLAM and HIROMB set up on identical, rotated grids, South Pole at 4S, 0E
* Coupling time step: 6 hours (two-way)
* Horizontal resolution: 0.2 degrees = 22 km (306x306 grid points)
* Vertical resolution: 40 vertical hybrid levels in HIRLAM, 208 vertical z levels in HIROMB
* Open boundaries: ECMWF analyses for HIRLAM, World Ocean Atlas 2005 for HIROMB

Main Achievements: A two-way coupled atmosphere-ice-ocean system has been set up, which does not need a separate coupler. The first version of a long coupled reanalysis has been completed, covering January 2005 to February 2006 (14 months). A second, improved version of the reanalysis has been started, with greatly enhanced observational data bases (ocean and atmosphere).

Figure: September 2005 mean (left) wind vector and (right) ice drift vector from the coupled reanalysis. A clockwise-rotating gyre is found in the Canada Basin, which is known as the Beaufort Gyre. Also, the dominant outflow of ice through the Fram Strait is evident.



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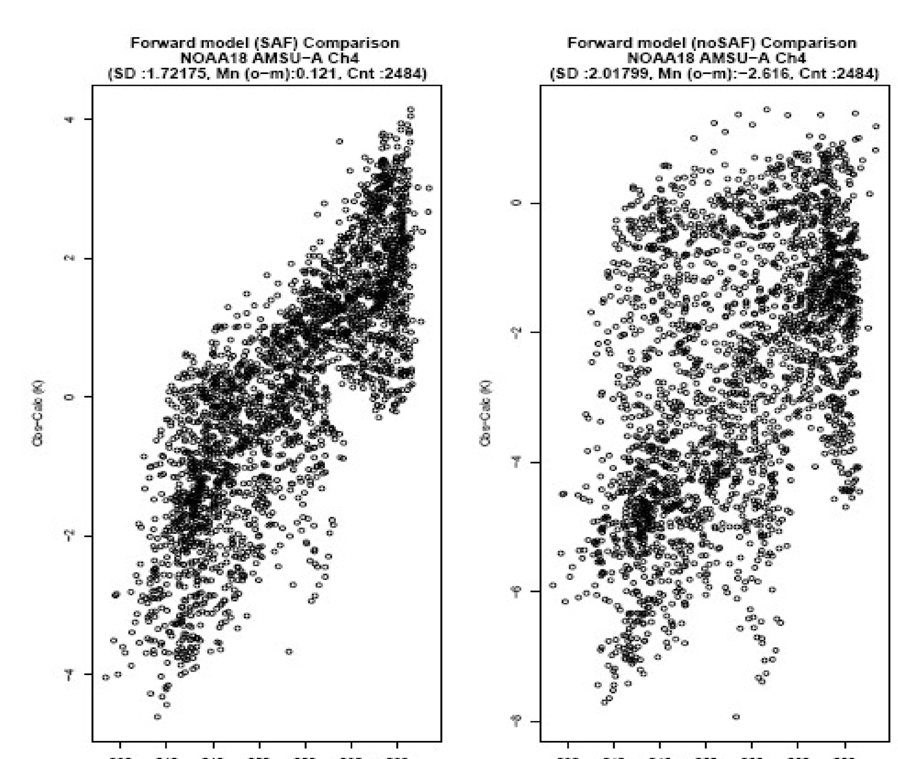
Model: The international programme HIRLAM, HIgh Resolution Limited Area Model, is a cooperation of 9 European meteorological institutes, which maintains and develops the HIRLAM regional Numerical Weather Prediction model. The operational Norwegian implementation of the HIRLAM model is used for these studies at met.no, and it covers Europe, the North Atlantic and a large part of the Arctic with 12 km horizontal resolution.

Main Achievements: Main efforts so far has been on improving modeling of satellite microwave radiances for lower tropospheric temperature sounding over sea ice. If we can improve the description of the sea ice surface contribution to the signals, it becomes easier for the assimilation scheme to extract information on the temperature profiles in the lower part of the troposphere. As there are few radiosondes in the Arctic, these satellite observations are a main source of atmospheric profile information for Numerical Weather Prediction (NWP) and reanalysis in the Arctic.The next step is to show the impact of the improved surface description in a data assimilation experiment using AMSU-A satellite sounding observations in the Arctic in the HIRLAM regional NWP model assimilation system. Eventually it is expected that the method will be implemeted in operational regional NWP and reanalysis systems.

Figure: AMSU-A ch 4 is a lower tropospheric temperature sounding channel with a strong contribution from the surface. The figures show differences between simulated and observed brightness temperatures over sea ice as a function of surface temperature in the HIRLAM model. Right panel: Simulations using radiative tranfer model RTTOV-8 with constant sea ice emissivity Left panel: With SSM/I based multiyear sea ice chart as emissivity predictor The reduced scatter in the left panel shows that the multiyear sea ice estimate helps in determining the sea ice emissivity. The trend with respect to surface temperature can be modelled with a linear relation. This trend is related to fact that the efficient emitting layer is below the surface, and the temperature increases with the distance below the surface, with a steeper increase at low temperatures.



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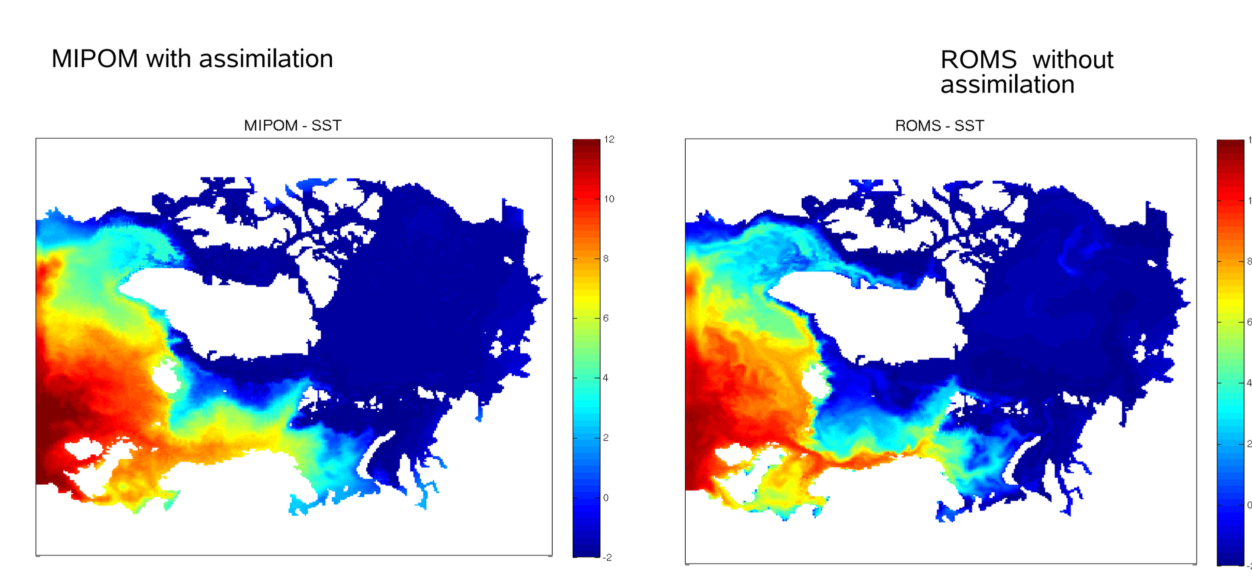
Model: The ocean and sea ice model MIPOM/MI-IM will shortly be replaced by ROMS (Regional Ocean Model System) for all forecast domains used at met.no. ROMS contains an adjoint model and has strong support for data assimilation, in particular using variational methods. A full-rank, multivariate method (3DVar) for data assimilation is under development. During the transition period the nudging algorithm for remotely sensed SST and sea ice is migrated from MIPOM/MI-IM to ROMS.

Main Achievements: The ocean model ROMS has been configured for operational use at met.no. In addition a successive correction method for assimilating in-situ data (ARGO buoys and ice-tethered profilers) has been developed and is currently tested in the so-called "Arctic-20km" model domain that covers the Nordic Seas and the Arctic. The model has also been tested at higher resolution and it shows superior results for water mass conservation, maintenance of strong ocean fronts, and statistics for the velocity field compared with the old MIPOM based system.

The Figures show sea surface temperature for 2008-12-31 as modelled by both the old operational model MIPOM and the new model ROMS in the Arctic-20km domain. It is clearly seen that ROMS is capable of handling sharp fronts that in MIPOM are smeared out due to a combination of modelled and numerical diffusion. It should be noted that the MIPOM system here uses a simple SST and ice concentration assimilation scheme based on nudging while no assimilation is used in the present ROMS simulation.



AWI/FastOpt/OASys

Model: NAOSIM consists of an ocean model derived from GFLD's MOM2 and a dynamic-thermodynamic sea-ice model with a viscous-plastic rheology. The model domain encloses the North Atlantic north of about 50N and the Arctic ocean. In the setup used here the model has a 0.5 x 0.5 degree horizontal resolution, twenty vertical layers, and uses a time step of 30 minutes.

Main Achievements: Production of a set of analysed fields (ocean: T, S, u, v; ice: thickness and area) over the period from 07/2006 to 06/2008 that are consistent with the model and as close as possible to the following set of observations: Daily ice concentration from the EUMETSAT Ocean & Sea Ice Satellite Application Facility based on multi-sensor SSM/I analysis, hydrography (T,S) from the ITP programme based at WHOI, ARGO floats from CORIOLIS, and long term SSS from the PHC atlas. Experience in handling the variational assimilation system that optimises simultaneously initial and boundary conditions as well as process parameters in the ocean and sea-ice component models.

Figure: Right hand panels: Monthly mean sea ice thickness [m] for July, August, and September 2007 without (upper right) and with (lower right) assimilation. Left hand panel: Remotely sensed sea ice concentration [%] in September 2007 from SSM/I SSMIS EASE-grid provided by NSIDC.