

SNAPSHOTS on HIRLAM work on SURFACE DATA ASSIMILATION and MODELLING

Laura Rontu

FMI, Meteorological Research, International HIRLAM-B programme,
Physical parametrisations

With contributions by

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Mariken Homleid, Ekaterina Kurzeneva,

Suleiman Mostamandy, Jouni Pulliainen, Patrick Samuelsson



**SRNWP Expert Group on Surface
ECMWF the 5th of September 2011**



In this presentation

From HIRLAM to HARMONIE

Snow and vegetation

Lakes

Sea surface

Orography

Soil & Urban



**SRNWP Expert Group on Surface
ECMWF the 5th of September 2011**



HIRLAM-B programme and HARMONIE

**HIRLAM as operational limited area
MODEL: 1985 – 2015**

International HIRLAM PROGRAMME

HIRLAM 1 – 6 1985-2005

HIRLAM-A 2006-2010

HIRLAM-B 2011-2015

... HIRLAM-Z ...

HIRLAM-B programme and HARMONIE

HIRLAM – ALADIN Research for Meso-scale Operational NWP In Europe
- HARMONIE cooperation 2005 -

HARMONIE as pre-operational local
NWP model system

based on ALADIN-AROME from
Meteo France

used and developed within
HIRLAM consortium since 2005

**HIRLAM-B programme focuses in the
operational kilometer-scale NWP
development, application and
maintenance in the HARMONIE
framework**

**How to transfer experience from the
HIRLAM model to HARMONIE?**

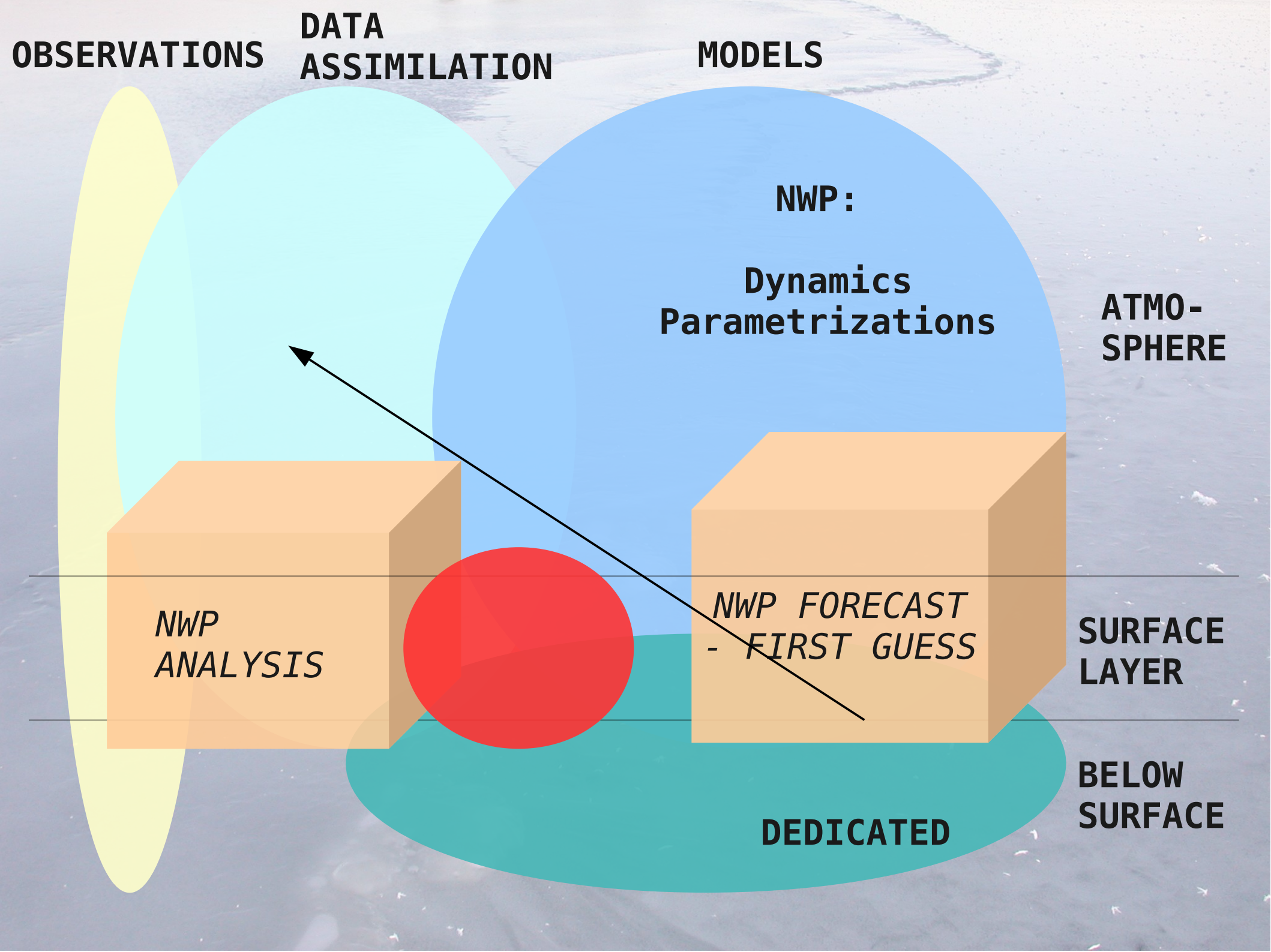
**Convergence between the plans of
ALADIN and HIRLAM programmes**

HIRLAM APPROACH on SURFACE

Focus on Northern aspects

**Integration of surface data assimilation,
surface description and
prognostic parametrisations
for the operational NWP application**

Work within SURFEX framework



OBSERVATIONS

**DATA
ASSIMILATION**

MODELS

**ATMO-
SPHERE**

**NWP:
Dynamics
Parametrizations**

*NWP
ANALYSIS*

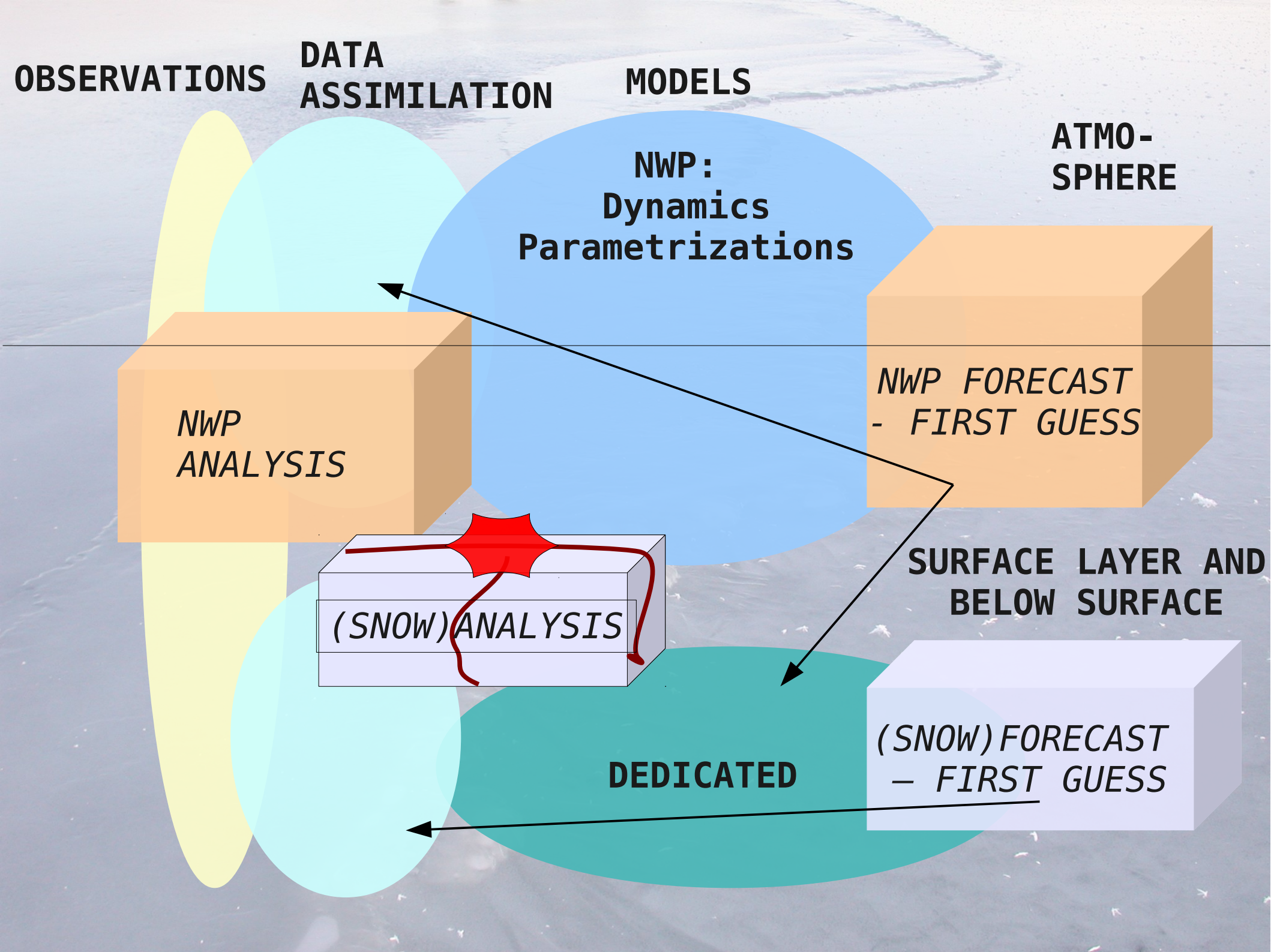
*NWP FORECAST
- FIRST GUESS*

(SNOW) ANALYSIS

**SURFACE LAYER AND
BELOW SURFACE**

DEDICATED

*(SNOW) FORECAST
- FIRST GUESS*



SNOW AND VEGETATION

A photograph of a winter landscape. The foreground is a snow-covered field with some small mounds. In the middle ground, there is a dense forest of evergreen trees, many of which are heavily covered in snow, giving them a white, frosted appearance. The background shows a clear blue sky and distant, hazy hills or mountains.

From HIRLAM "newsnow"
to HARMONIE MEB

Snow data assimilation

IN SEARCH OF SOLUTIONS FOR THE HIRLAM SURFACE TEMPERATURE PROBLEMS

Laura Rontu, Finnish Meteorological Institute

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ASM09

poster/LR:

Newsnow has solved, from the point of view of a synoptic forecaster

- Nordic temperature problem (snow insulates ground heat flux)

- Spring humidity problem (realistic treatment of melting snow)

- Ice (glacier) heat flux problem (better estimate of heat transfer in ice)

The role of surface data assimilation where is snow and ice?

Problems

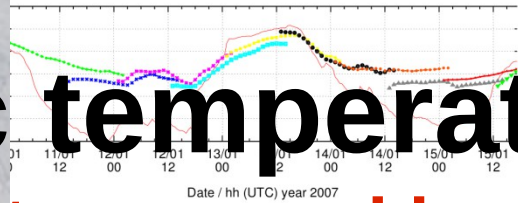
Studies

Discussions

WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM NORDIC WINTER TEMPERATURE PROBLEM

Well-known Nordic winter temperature problem is related to cold surface cases. Most of the NWP models have problems in treating these situations. Symptoms of the problem in HIRLAM include

Screen-level temperature is too low, especially at night. Difference between lowest model level and surface/screen level is too large. In case studies, not so clearly in standard verification scores



Screen level temperature in Sodankylä 11-15 January 2007. Thin line: observations; Reference HIRLAM forecasts (v.7.1beta, spring 2007), starting every 12 UTC

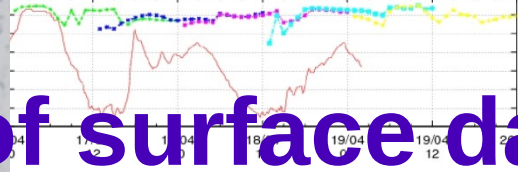
Figure 1: an example of observed and forecasted temperatures in January 2007 in Sodankylä (Finland). Observations (thin line) and reference HIRLAM forecasts (coloured lines) are compared with forecasts by two versions of HIRLAM: "newsnow" (Sanja et al., 2006) surface parametrization

SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM NORDIC SPRING HUMIDITY PROBLEM

Spring humidity problem has been detected when sun is already shining but day and snow starts melting, but during night the screen-level temperature well below zero, most typically in April in Sodankylä. Perhaps it exists also moist surface without snow. The symptoms of this problem in HIRLAM

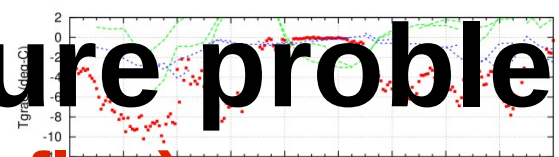
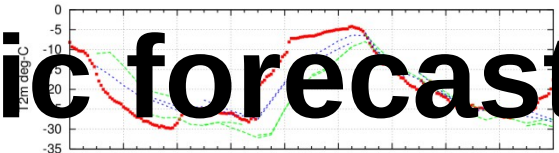
are: constant 0% relative screen-level relative humidity, systematically large latent heat flux and very small sensible heat flux

that underestimated daytime surface energy balance (sum of surface layer and advection fluxes), which may lead to lower than observed daytime temperature

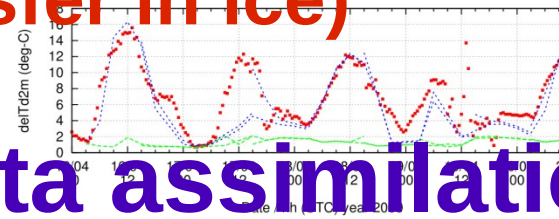
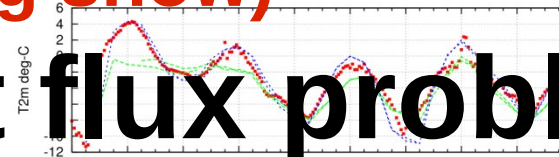


humidity in Sodankylä 17-18 April 2009. Thin line: observed, colour reference HIRLAM forecasts (operational RCR v. 7.2.1)

Figure 2: an example of observed and forecasted relative humidity in Sodankylä in April 2009. Observations (thin line) during the same time are compared with forecasts by two versions of HIRLAM: "newsnow" (v. newsnow) and the reference v. 7.3beta1.



Screen level temperature (upper figure) and $T_s - T_{nlev}$ (lower) in Sodankylä 11-15 January 2007. Red dots: observed, lines - newsnow HIRLAM forecasts: blue - v. 7.3beta1 newsnow, April 2009, green - v. 7.3beta1



Screen level temperature (upper figure) and dew point deficit $T_{2m} - T_{d2m}$ (lower) in Sodankylä 11-15 January 2007. Red dots: observed, lines - newsnow HIRLAM forecasts: blue - v. 7.3beta1 newsnow, April 2009, green - v. 7.3beta1

Now the screen-level temperature is realistic, presumably most probably because the insulating effect of snow cover is properly handled by the "newsnow" surface parametrizations. However, there is still almost no gradient between the lowest model level and the near-surface temperature. This means that the lowest model level temperature is too cold. This feature seems to be typical for the simulations of the shallow arctic boundary layer. Possible reasons to be studied further:

- surface layer turbulent flux formulations and related diagnostics of screen-level temperature over different surface types
- vertical resolution close to the surface
- formulations related to the long-wave radiation
- humidity and cloud formation in these conditions

CONCLUSION
The "newsnow" parametrizations seem to solve the "Nordic temperature problem" from the practical point of view, i.e. the predicted screen level temperature is realistic. However, deeper questions of modelling the shallow arctic boundary layer remain.

Most of the NWP models have some problems in treating these spring situations, but the reference HIRLAM seems to behave worst of all, as is regularly seen at the mast verification page <http://fminwp.fmi.fi>.

Figure 3: HIRLAM v.3beta1 shows the same unrealistic features as the operational RCR. In "newsnow", the screen-level temperature and dew point deficit are now mostly realistic. The sensible heat flux is larger, and latent heat flux smaller, both clearly closer to the observations than in the reference simulation (not shown). The afternoon 17th of April is an exception: too moist and with unrealistically large latent heat flux also in "newsnow".

CONCLUSION
Based on comparisons during three weeks of April 2009, it can be concluded that "newsnow" parametrizations basically solve the spring humidity problem. Also the vertical profiles show clearly improved humidity forecast. However, in individual cases the old problem shows up, indicating that the subtle surface layer energy and moisture balance is difficult to simulate and sensitive to small changes in any of the near-surface meteorological parameters, snow cover and (low level) cloudiness. Again, the role of surface data assimilation may be important in these cases.

Implementation of multi-energy balance (MEB) into SURFEX

Patrick Samuelsson
SMHI

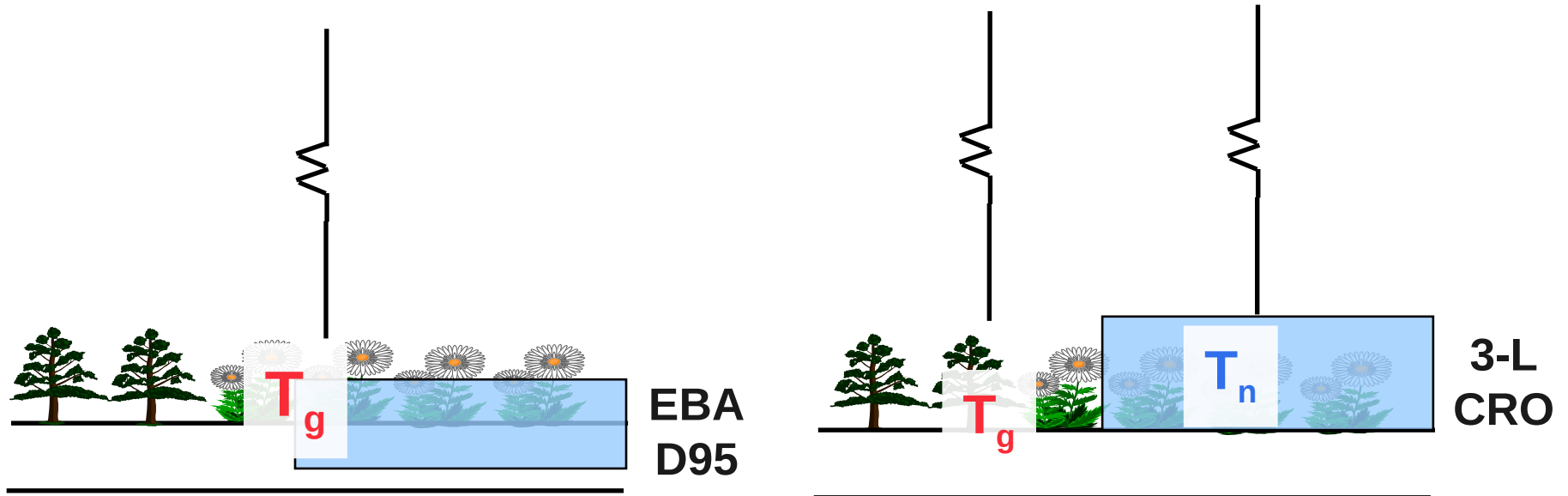
Stefan Gollvik

Aaron Boone
Meteo France

Christophe Canac



Current SURFEX 6.1 ISBA



No explicit canopy vegetation energy balance (temperature)!



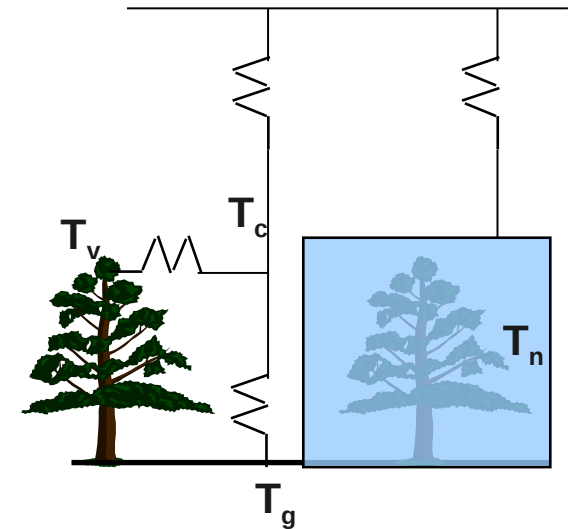
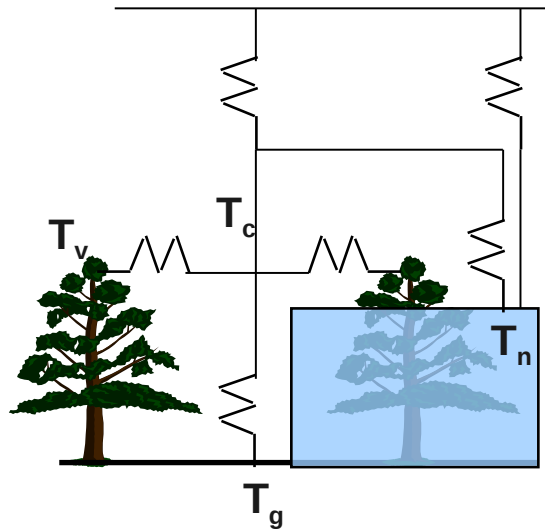
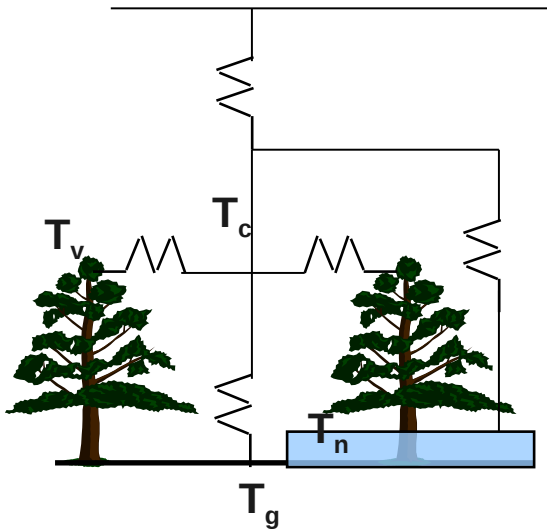
We want to model this!

Multi-Energy Balance (MEB)

Snow well below the canopy

Snow partly buries the canopy

Snow buries the canopy



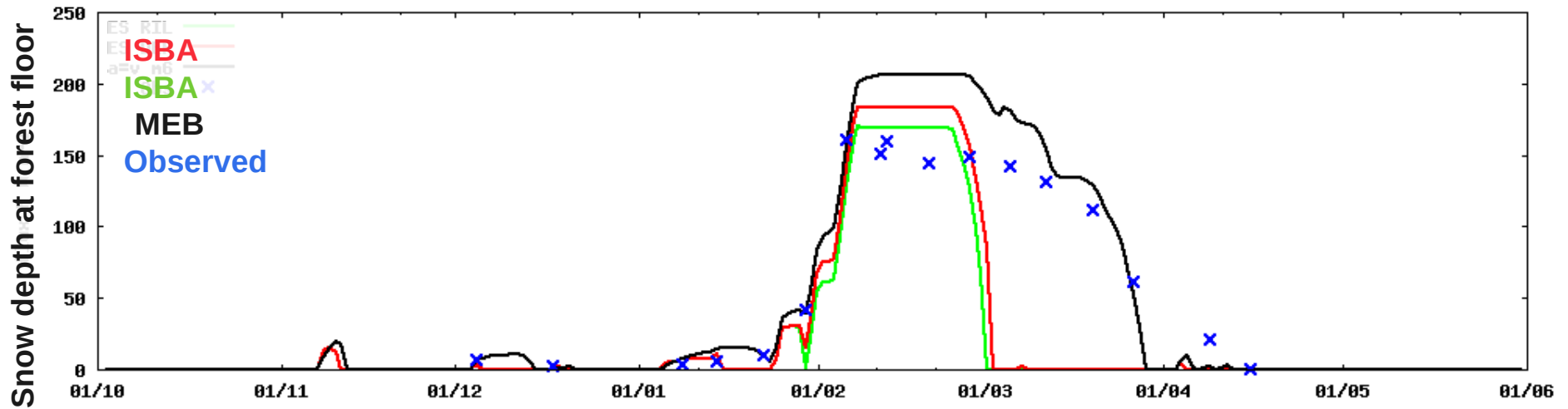
MEB is designed to work with

- snow schemes 3-L and CRO (requires separate snow energy balance)
- soil schemes 2-L & 3-L (force restore) and DIF (diffusion)

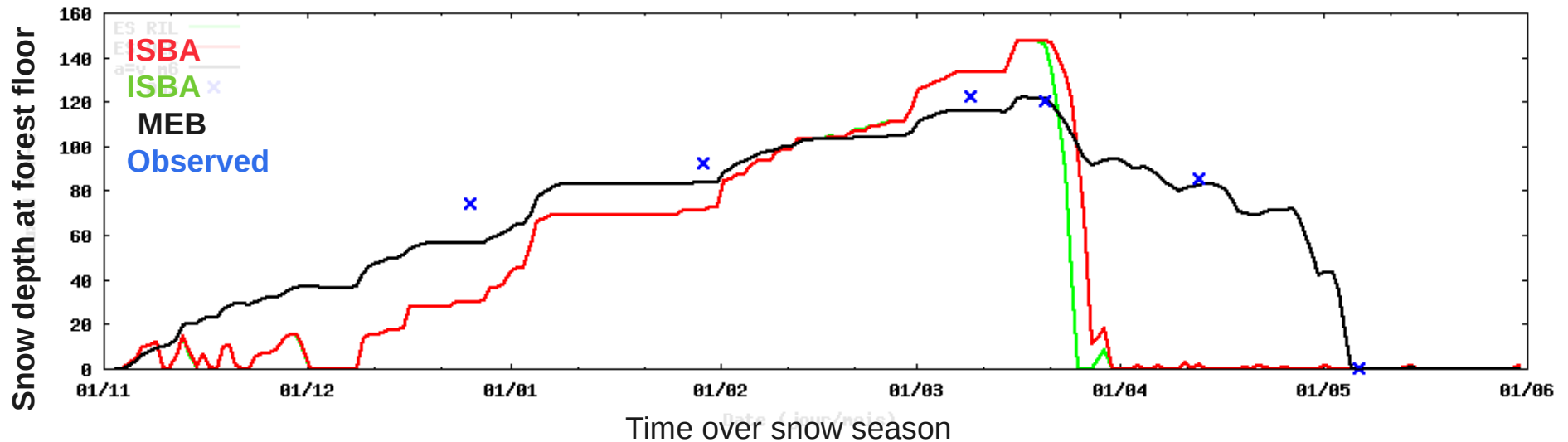
Evaluation of MEB

Two SnowMIP2 forest sites where snow interception matters

Alptal (Switzerland), 1185 masl, trees: 25 m, LAI 4.2



Fraser (US Rockies), 2820 masl, trees: 27 m, LAI 5

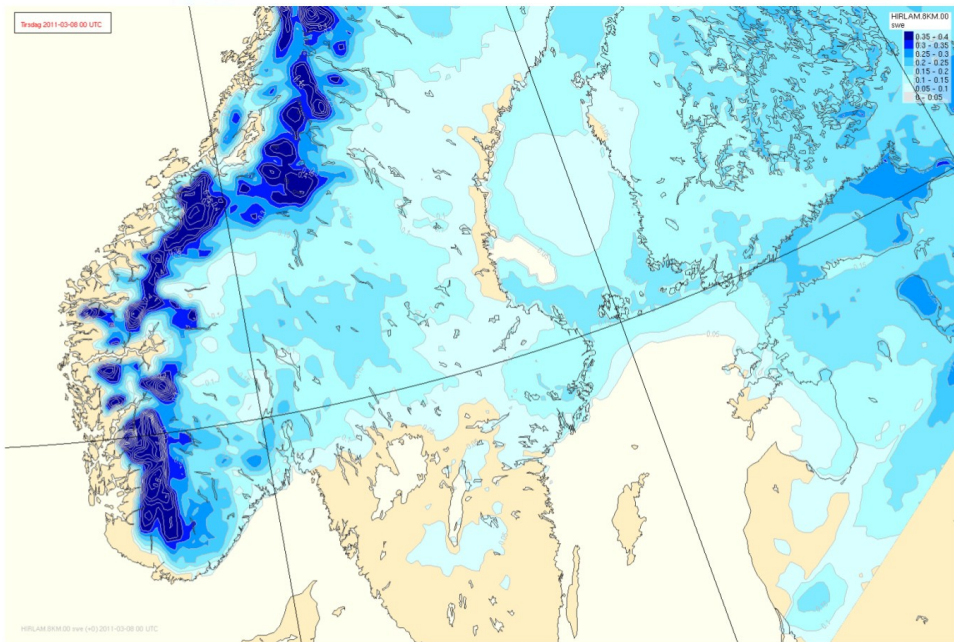


By Mariken Homleid, 2011

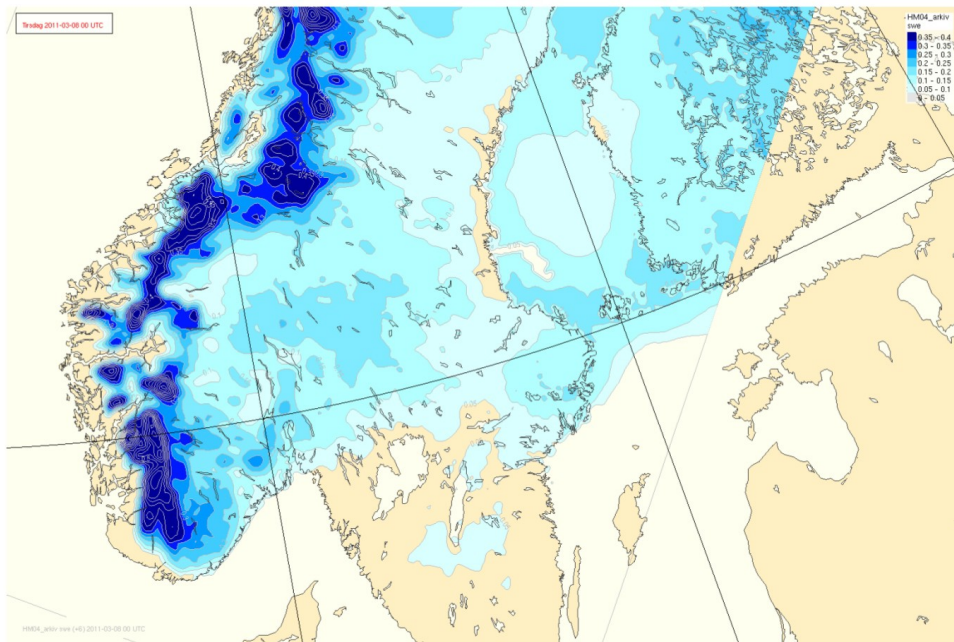


Status of snow analysis in HARMONIE

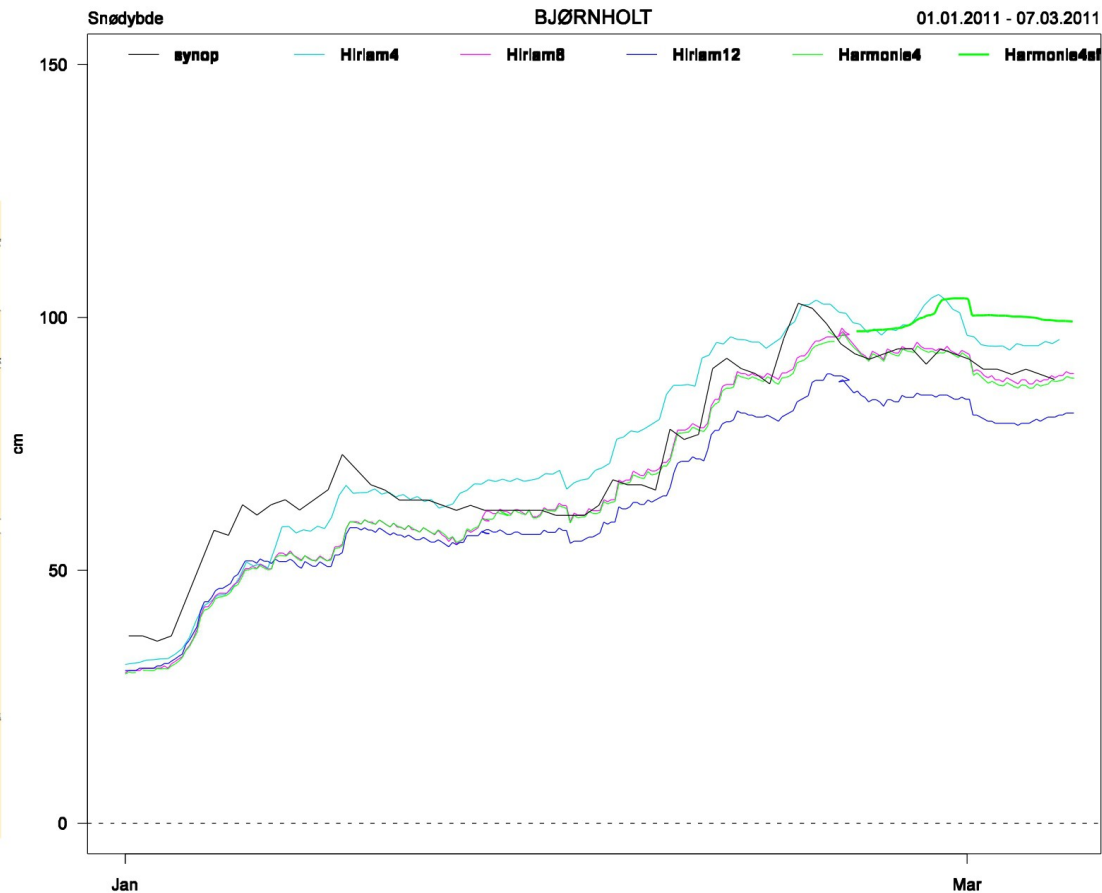
- in analogy with HIRLAM's snow analysis
- in HARMONIE at met.no since 18 February 2010
- HARMONIE and HIRLAM are very close
- good results at stations with representative observations, e.g. Bjørnholt:



Hirlam8 snow water equivalent 8 March 2011

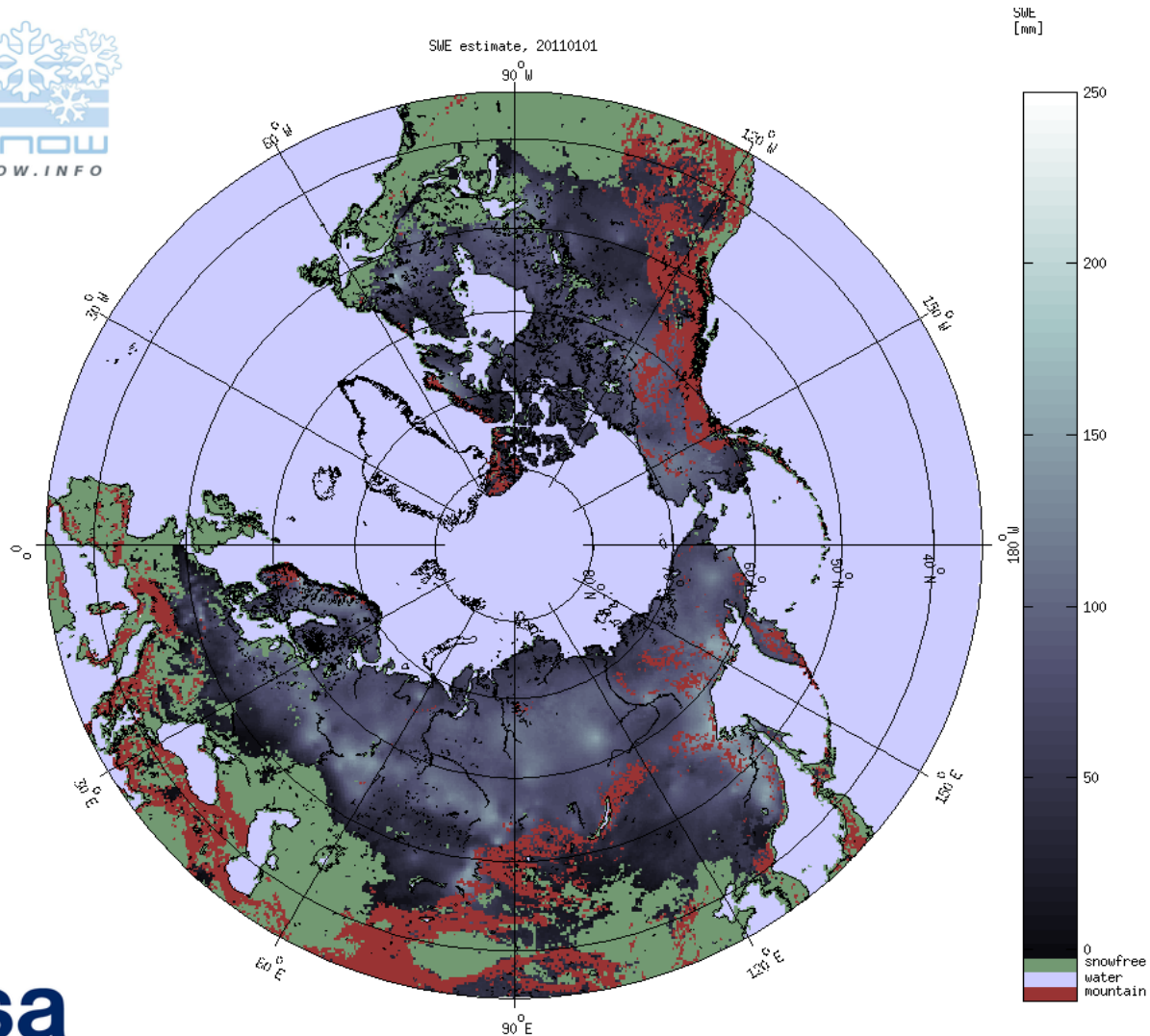


Harmonie4 snow water equivalent 8 March 2011



Globsnow

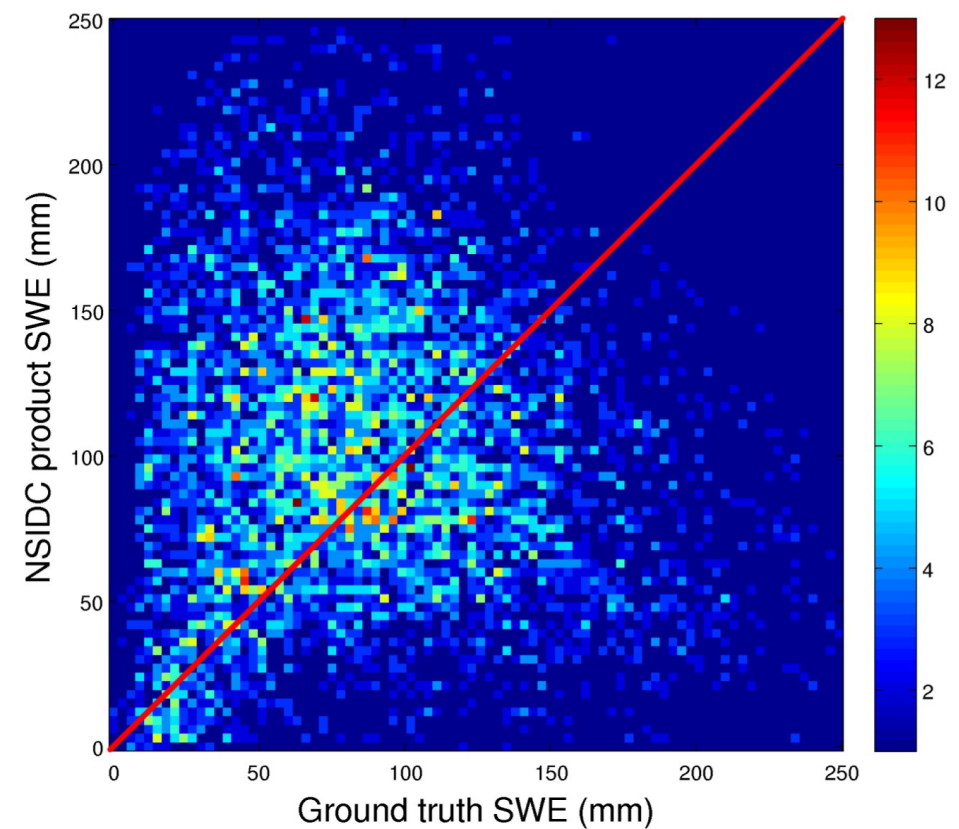
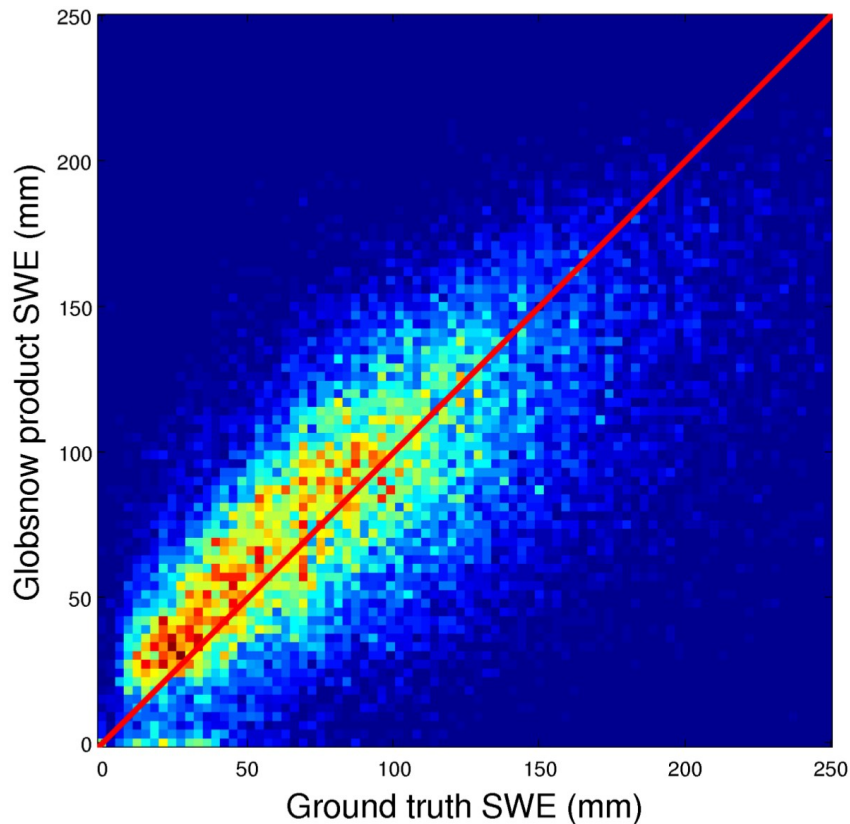
www.globsnow.info



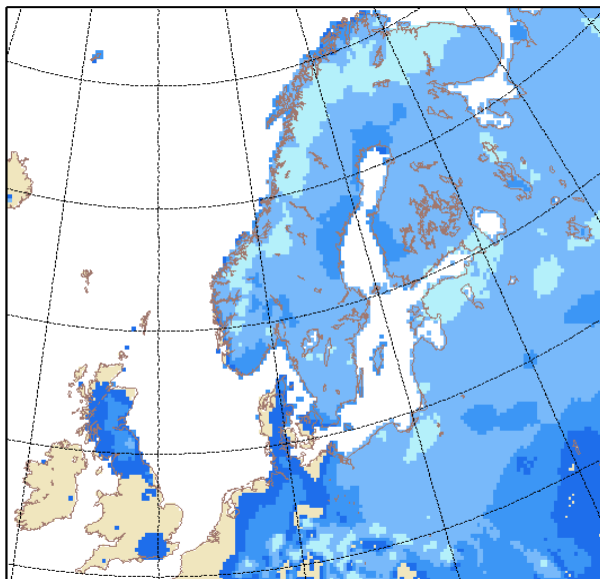


SWE retrieval accuracy (I)

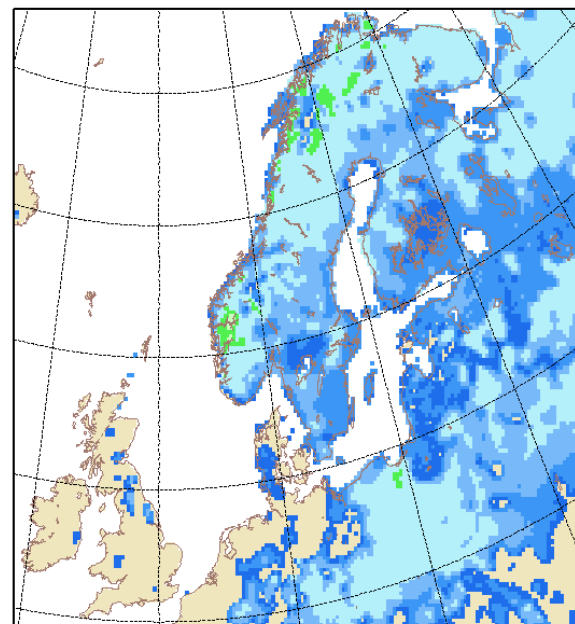
- **Density scatterplot**
- **Ground truth data is INTAS SCCONE SWE path data**



P: SNOW_73_ref AUTUMN 2010, +00H, Snow depth (meters)
 initial: 00Z15DEC2010 valid: 00Z15DEC2010

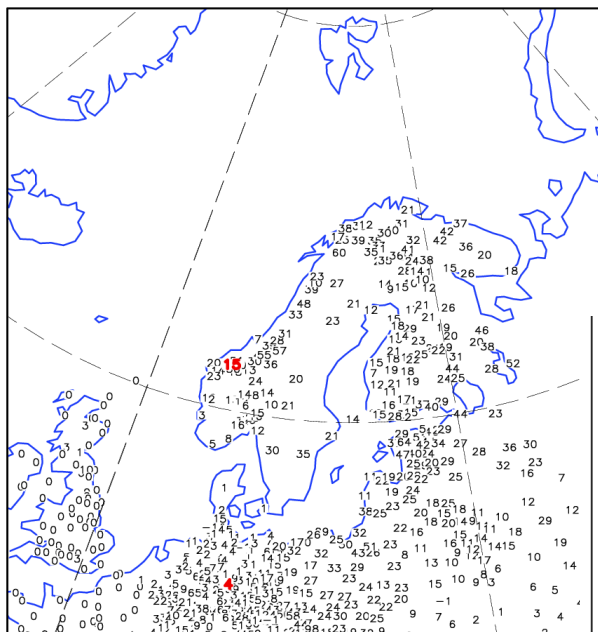


EXP: AWSG, +00H, Snow depth (meters)
 initial: 00Z15DEC2010 valid: 00Z15DEC2010

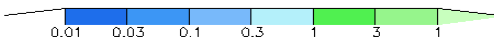
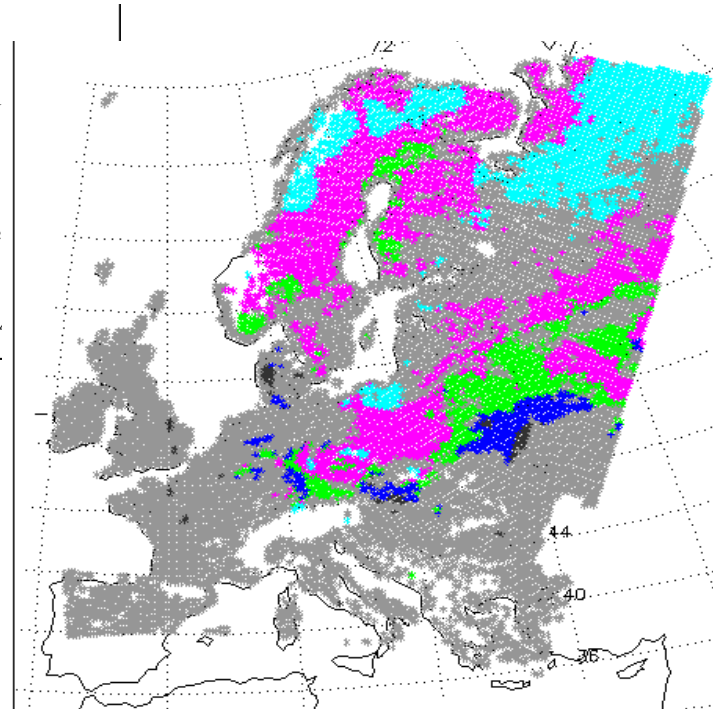
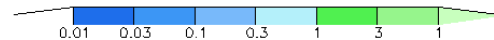
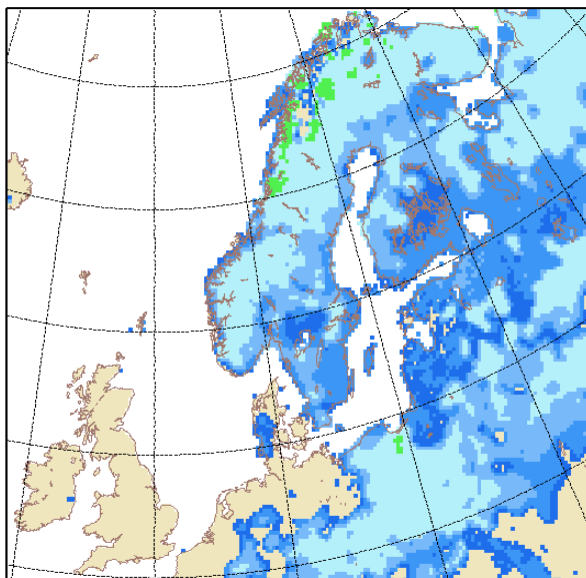


HIRLAM + Globsnow 15 December 2010

ref: snow obs. data at 20101215 06

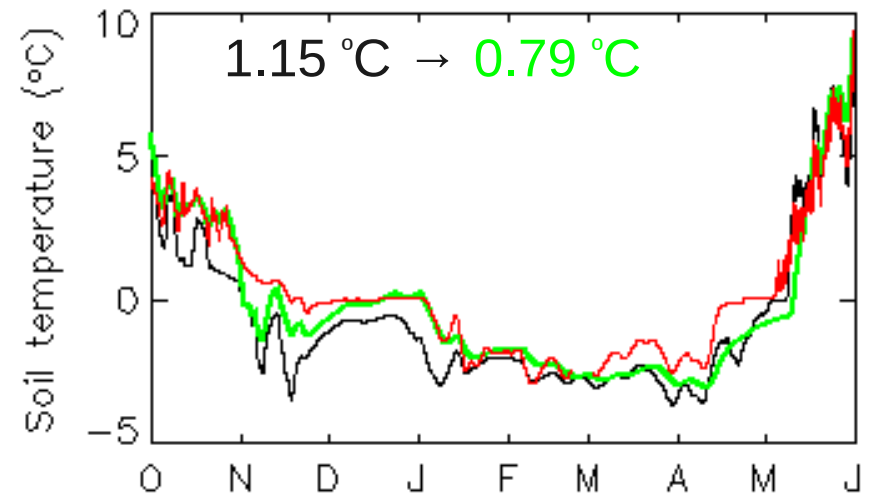
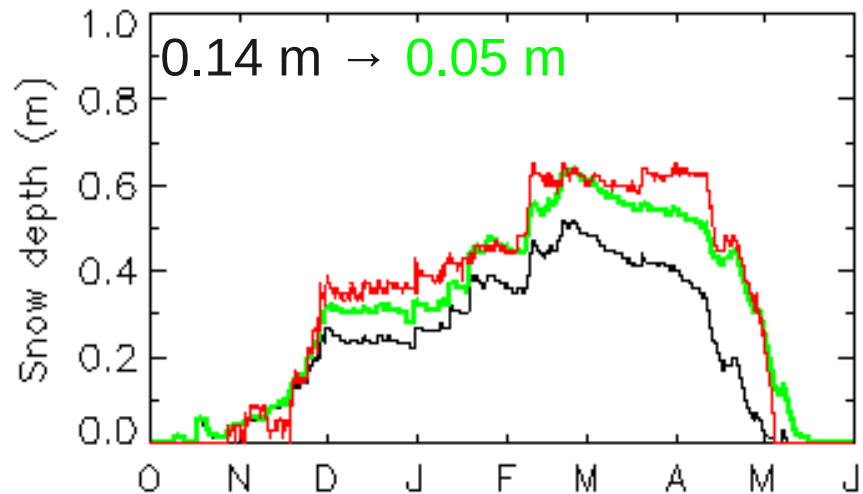
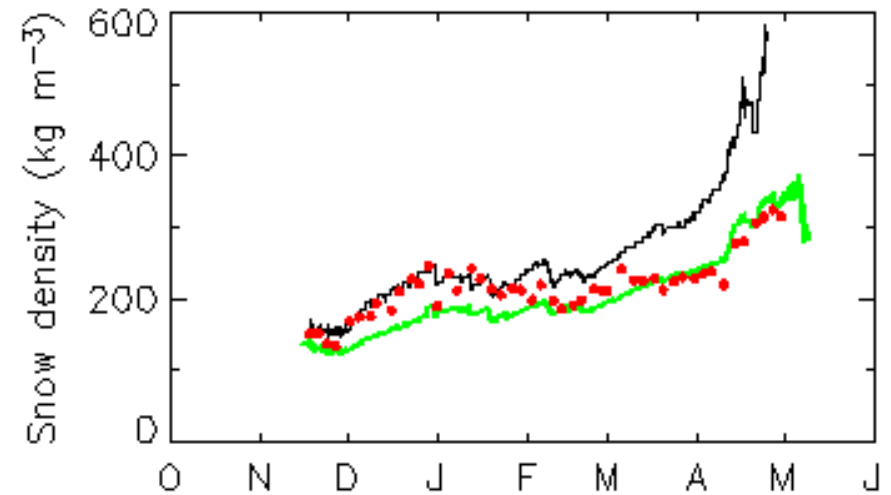
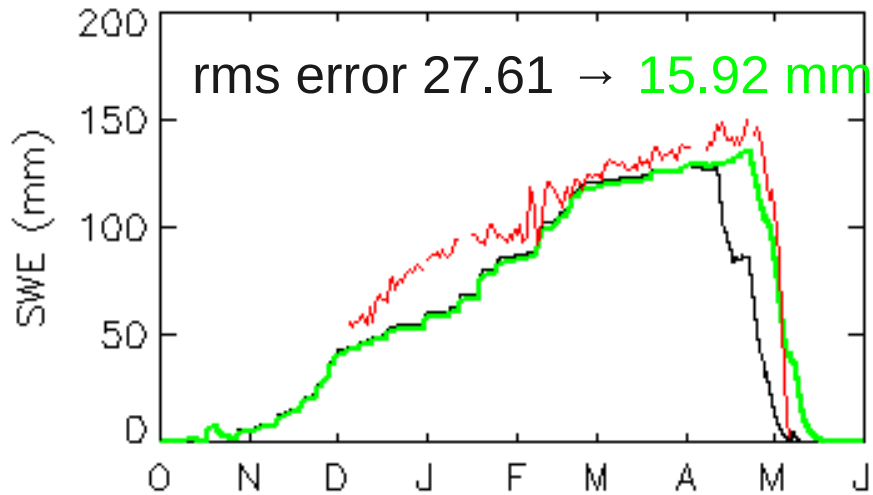


EXP: AWGO, +00H, Snow depth (meters)
 initial: 00Z15DEC2010 valid: 00Z15DEC2010



By Suleiman Mostamandy

Sodankylä 2008-2009: CoSDAS snow model + data assimilation





SNAPS

Snow, Ice and Avalanche Applications



**Northern
Periphery
Programme**

2007–2013



HARMONIE CONTRIBUTION TO SNAPS

How to provide useful information for avalanche forecasters and model by using HARMONIE with SURFEX

- **Atmospheric conditions:**
near surface wind, temperature, humidity, radiation, precipitation
- Kilometre-scale **snow maps** over complex orography
from SYNOP and satellite input
- **Advanced snow properties** like
snow depth, density, water content, layers
- **High-resolution orography** available in HARMONIE

- run HARMONIE experiments
over Iceland and Northern Scandinavia and verify
- improve snow data assimilation
- define and validate snow variables

LAKES

A satellite-style map of the Great Lakes basin in North America. The lakes are shown in dark green and blue, surrounded by brown and grey land. A small blue circle is positioned on the western shore of Lake Michigan, indicating a specific location of interest.

**Lake depth and climatology
data**

Lake modelling – Flake

Lake data assimilation

A rectangular inset map in the bottom right corner, overlaid on the satellite image. It shows a grid of colored pixels, primarily yellow and blue, representing a spatial distribution of data or model results. Dashed black lines indicate a coordinate grid.

**STATUS OF
FLAKE IN
OPERATIONAL
HIRLAM AND
IN SURFEX**

**Depth and
fraction of
lakes**

**Cold start
climate data**

**Data
assimilation**

Prognostic model

HIRLAM

Implemented
in climate
generation

Implemented
in climate
generation

Peaceful
coexistence
LST, ice

Integrated to ISBA +
all over HIRLAM
switchable

SURFEX

Stand-alone
only

Stand-alone
only

Not
implemented

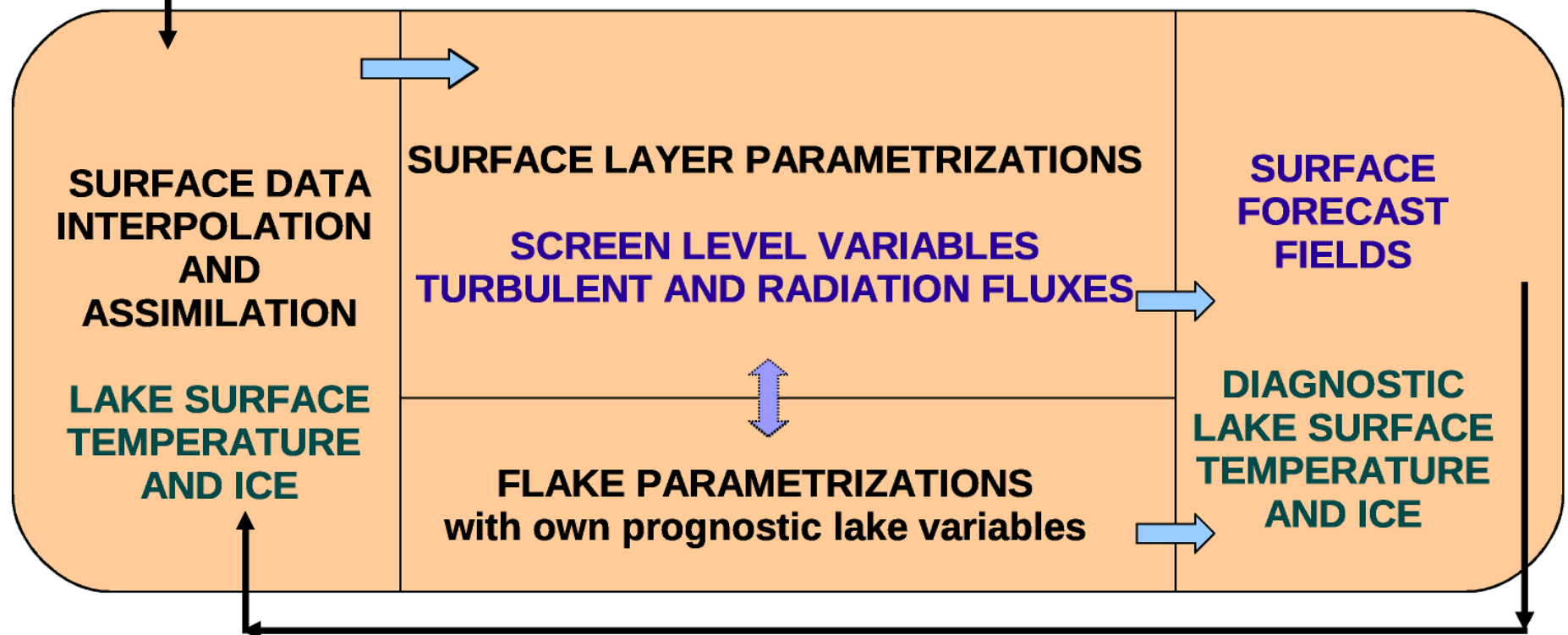
Module for water tile

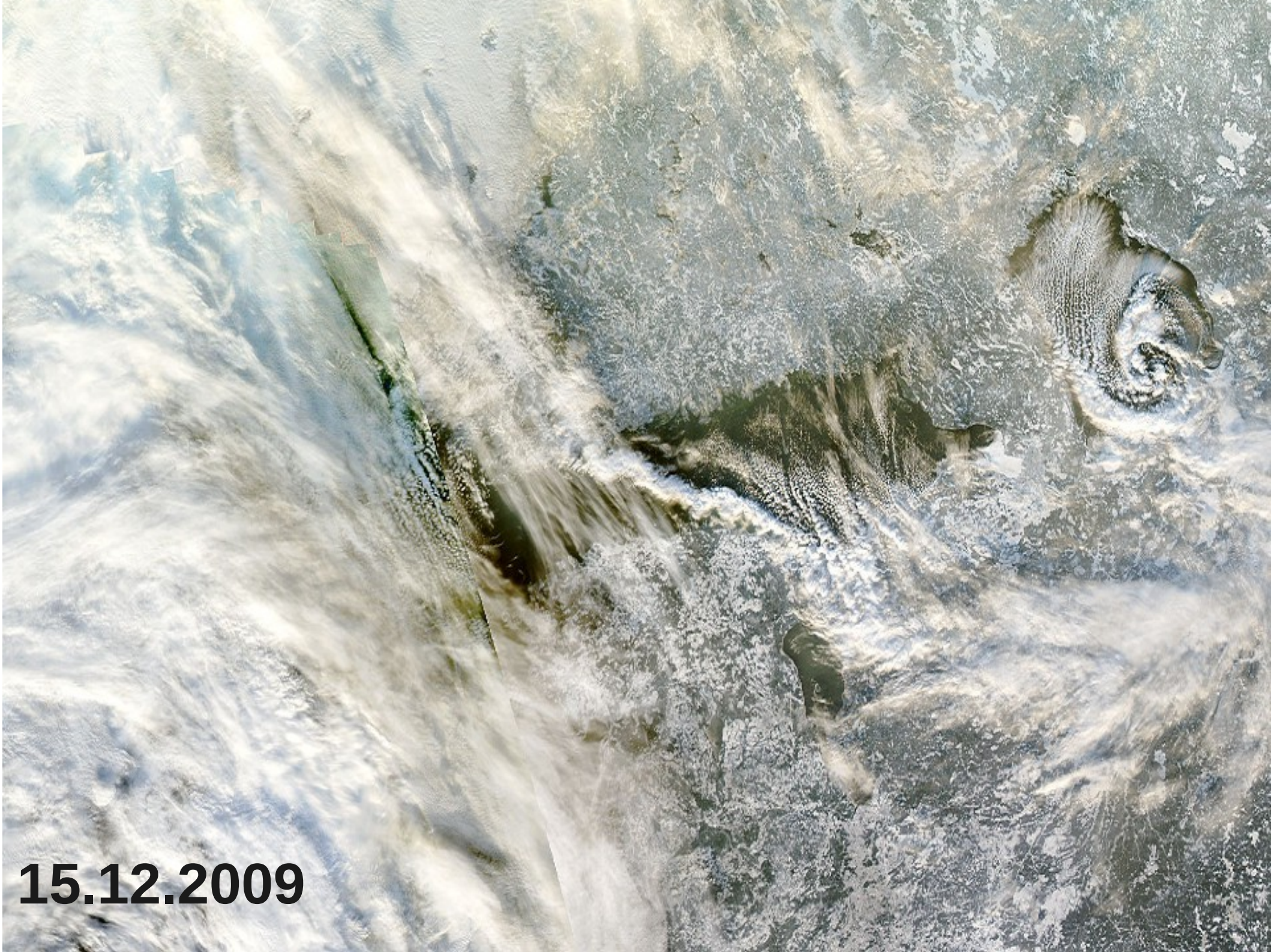
PEACEFUL COEXISTENCE OF SURFACE DATA ASSIMILATION AND FLAKE

INPUT (OBSERVATIONS)

- ECMWF analysis = climate!
 - Finlake climate data
 - Baltic sea observations
 - Local lake observations

- FLake provides background for the LST analysis
- FLake prognostic lake variables are not influenced by the data assimilation
- During the forecast, the HIRLAM surface layer parametrizations see the assimilated SST and ice/water fraction and evolving lowest model level variables
- FLake parametrizations know the evolving atmospheric fluxes at each time step





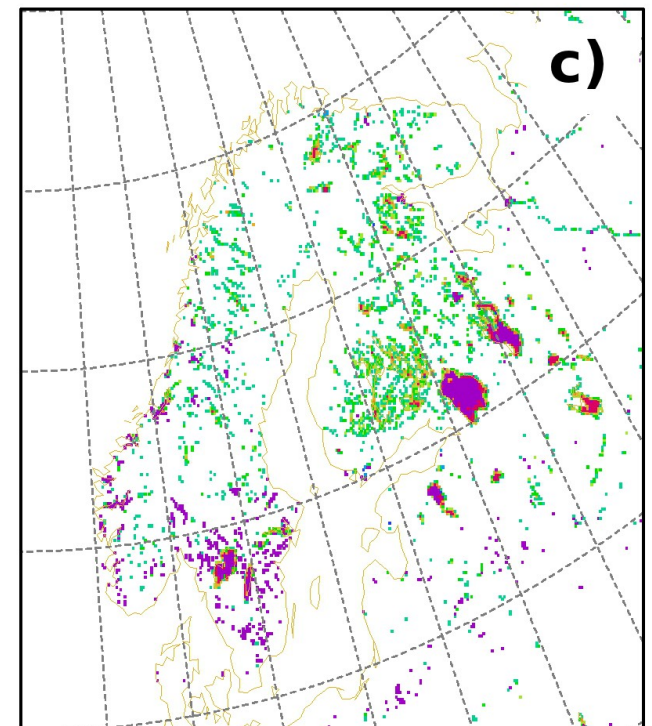
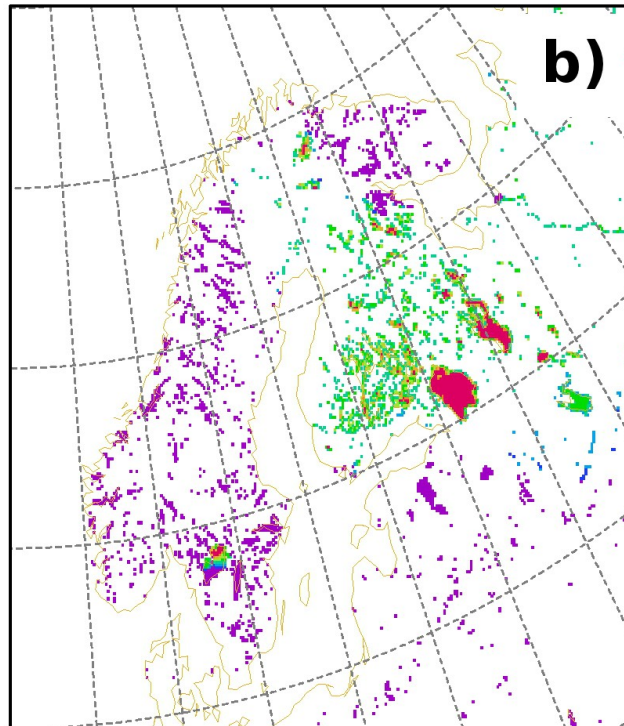
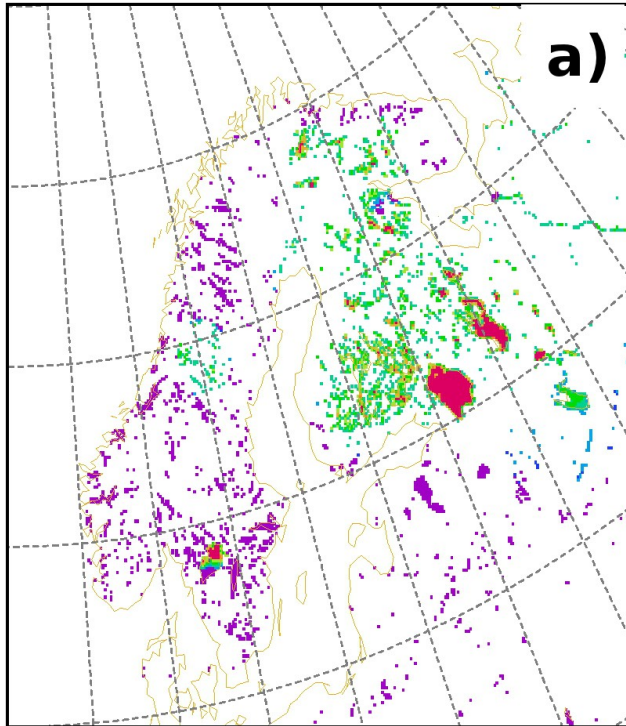
15.12.2009

Fraction of ice over lakes

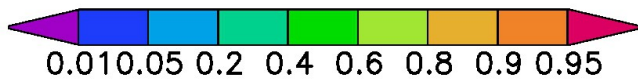
Climatological

Analysed

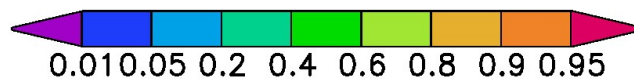
FLake



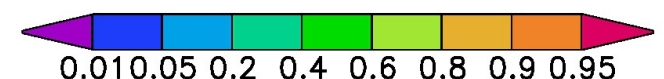
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min=0 max=1 mean=0.324822



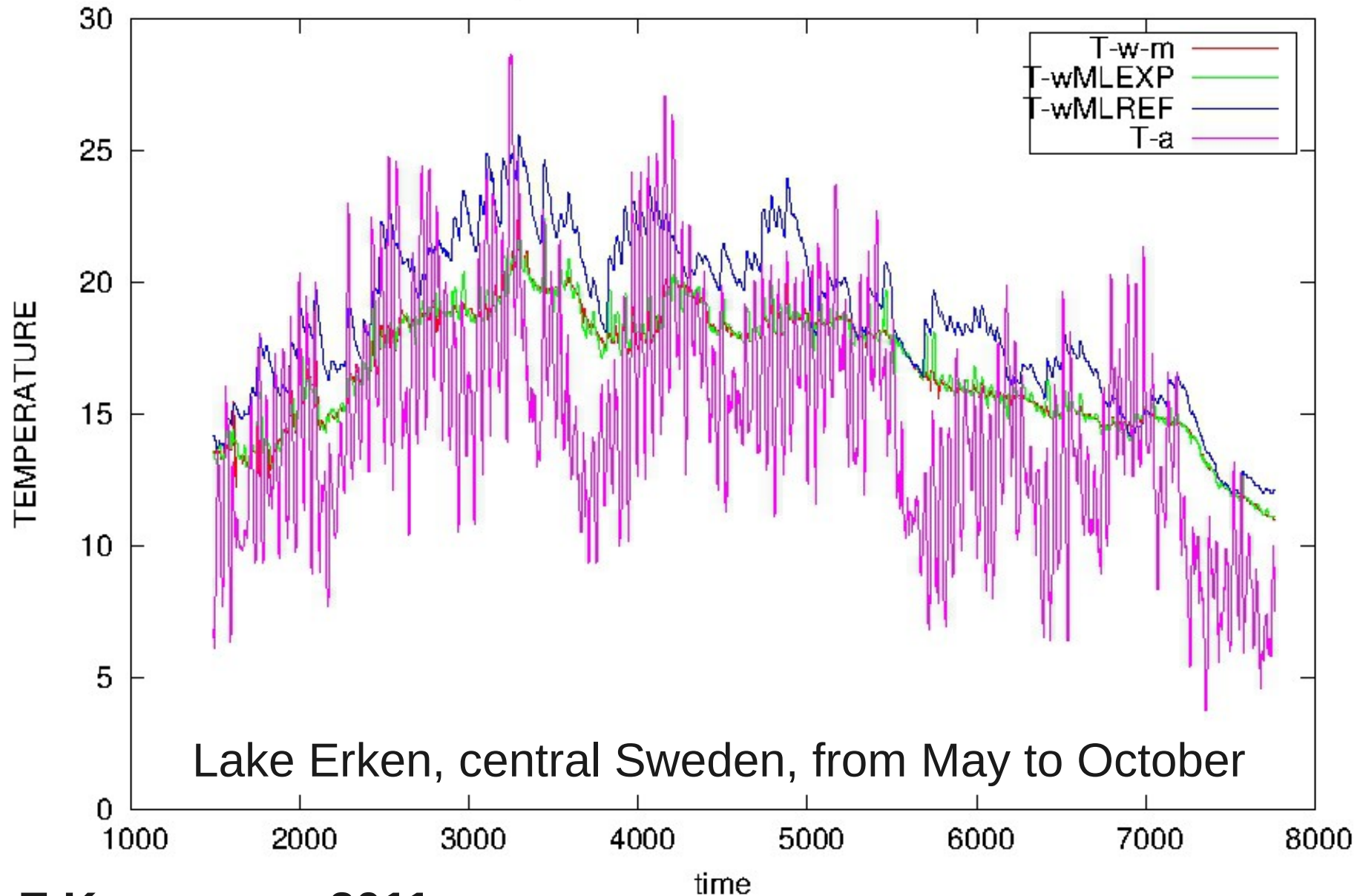
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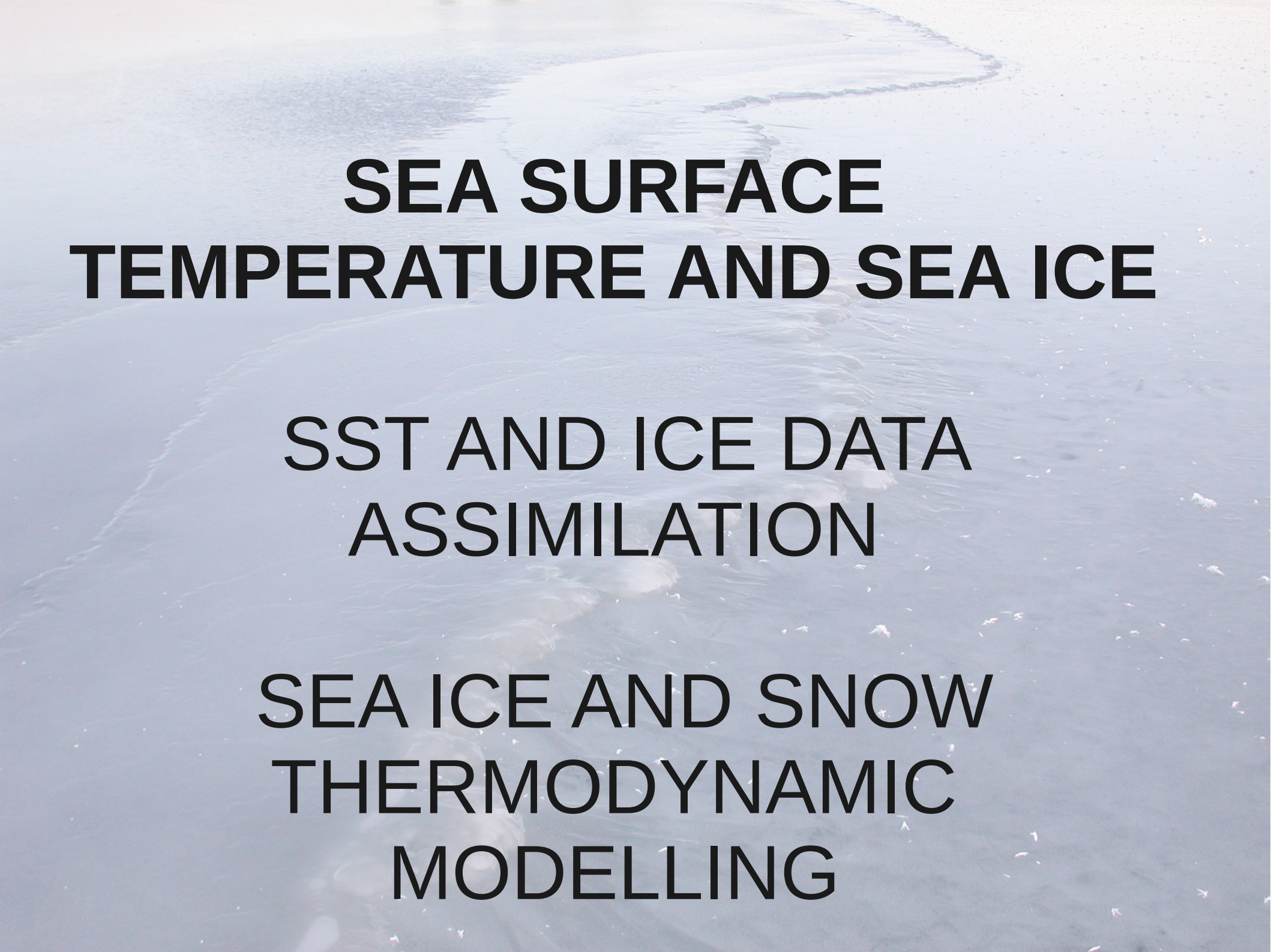
15.12.2009

A FIRST ATTEMPT TO ASSIMILATE LAKE SURFACE TEMPERATURE FOR FLAKE

Temperatures - measured and simulated



Lake Erken, central Sweden, from May to October

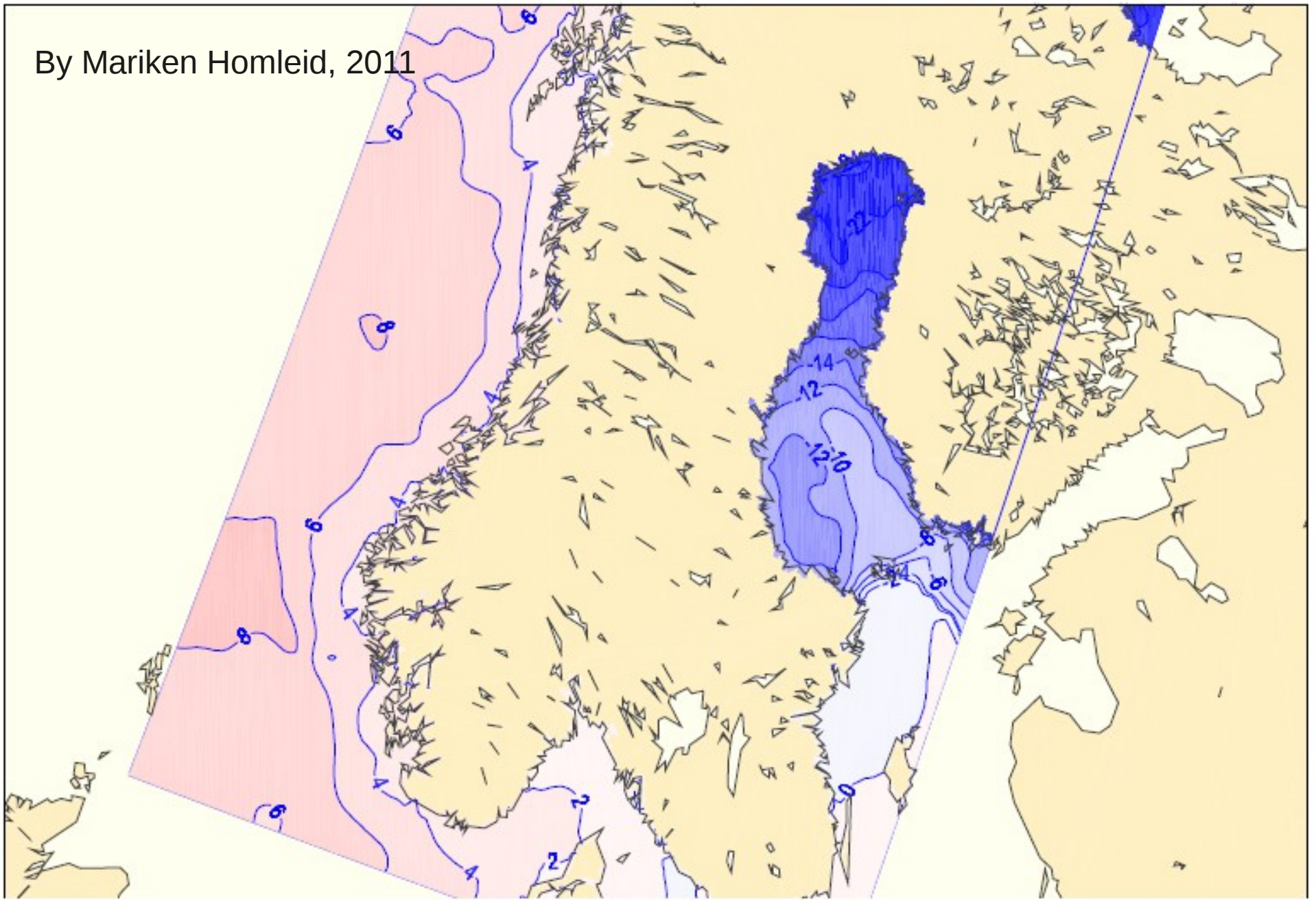
An aerial photograph of a large, irregularly shaped sea ice floe floating in the ocean. The ice is a pale, milky blue color, contrasting with the darker blue of the surrounding water. The floe has a rough, textured surface with some smaller ice fragments and snow patches. The water around the floe shows some ripples and small waves.

SEA SURFACE TEMPERATURE AND SEA ICE

SST AND ICE DATA ASSIMILATION

SEA ICE AND SNOW THERMODYNAMIC MODELLING

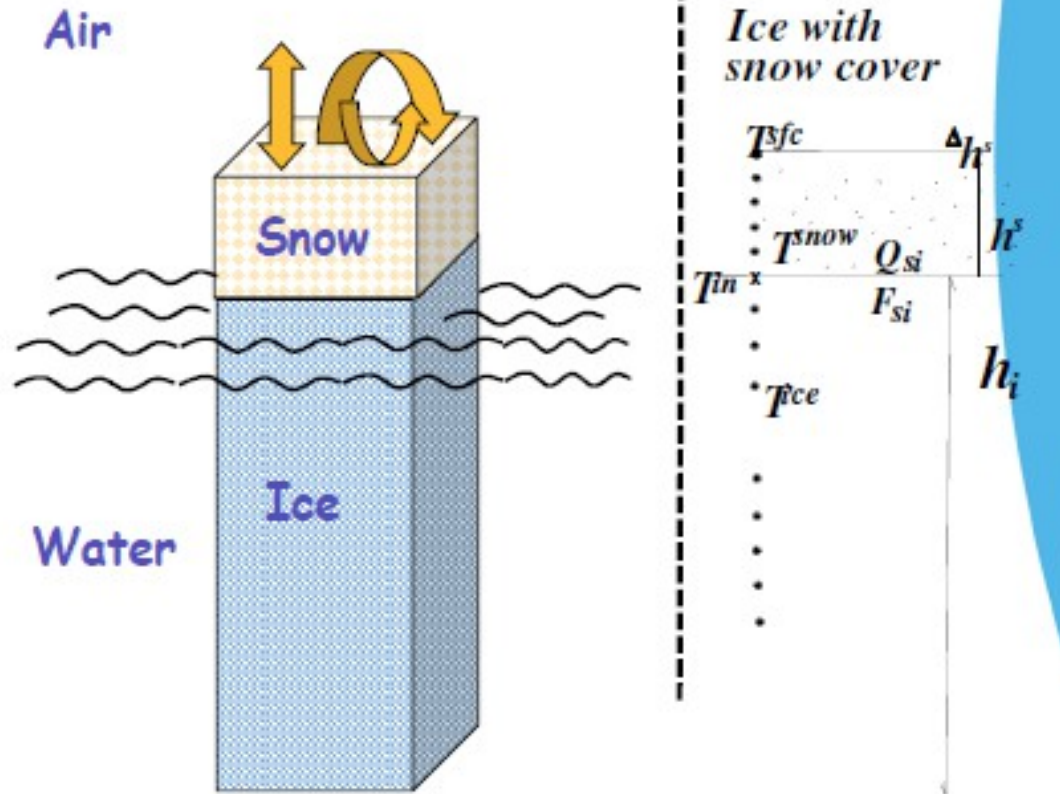
By Mariken Homleid, 2011



Example of OSTIA SST from ECMWF boundaries optimally interpolated to HARMONIE. If $SST < 271.2$ K, ice can be diagnosed



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE



HIGHTSI

HIGH RESOLUTION
THERMODYNAMIC ICE
AND SNOW MODEL

by Bin Cheng et al.,
FMI 1998 -

Implementation to
SURFEX prognostic
model and coupling to
SST/sea ice analysis,
started recently

HIGHTSI: One dimensional snow/ice model

HIGHTSI Documentation found best via

<http://www.atm.helsinki.fi/~jaraisan/numlab2011/NumLab11.html>

OROGRAPHY

**Parametrisation of orographic
radiation effects**

**Consistent usage of digital
elevation data in NWP**

Parametrization of orographic effects on surface radiation in HIRLAM

By A. V. SENKOVA¹, L. RONTU^{2,*} and H. SAVIJÄRVI³, ¹*Russian State Hydrometeorological University, St. Petersburg, Russia;* ²*Finnish Meteorological Institute, Helsinki, Finland;* ³*University of Helsinki, Helsinki, Finland*

(Manuscript received 15 September 2006; in final form 19 February 2007)

ABSTRACT

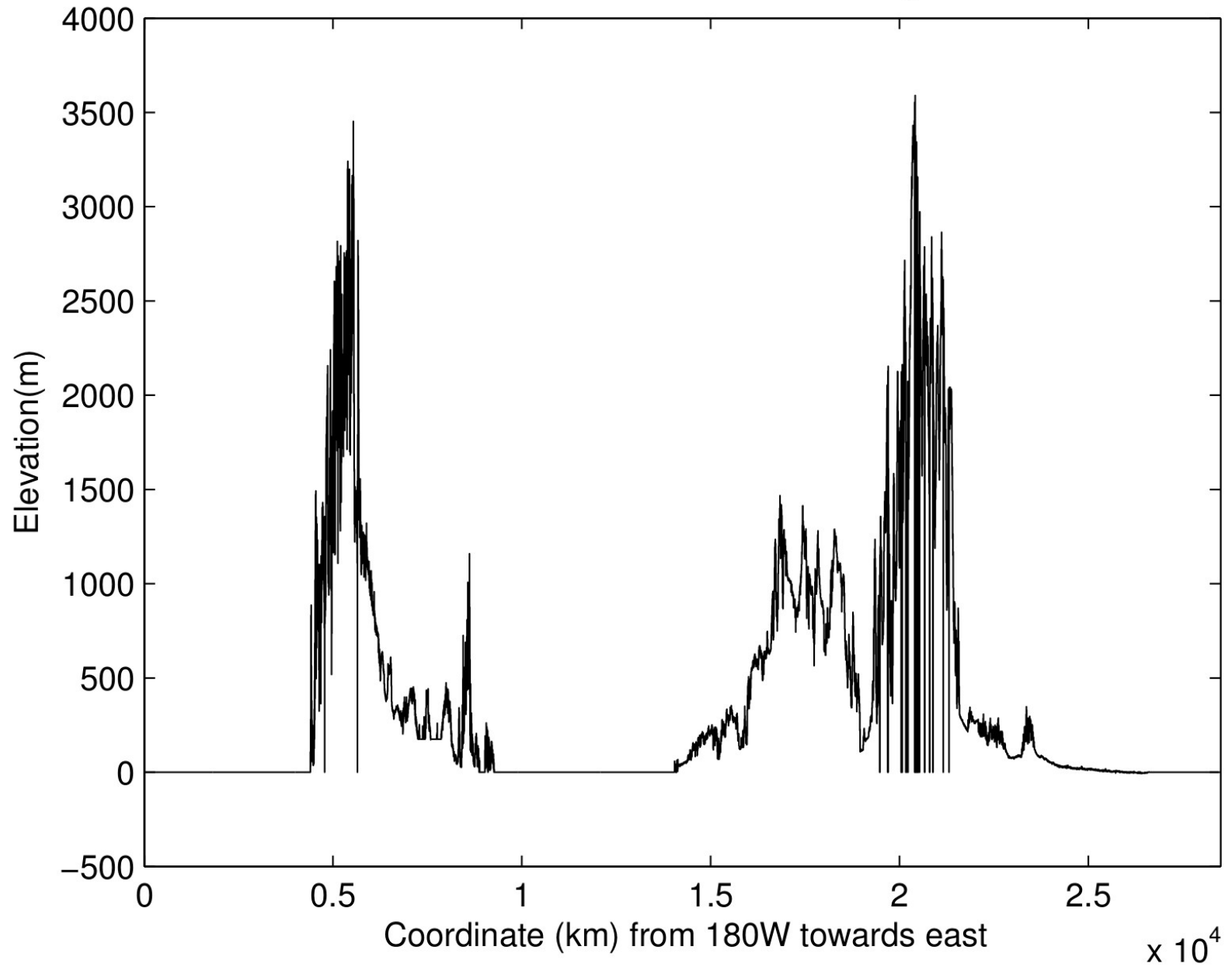
A parametrization scheme for orographic effects on surface radiation was introduced in the High Resolution Limited Area Model. One-kilometre resolution digital elevation data were used to derive the needed orographic parameters. The scheme is applicable within a model setup of any resolution, but is shown to significantly affect the local near-surface temperatures only when the horizontal resolution is less than a few kilometres. Then, typical maximum local differences due to the new parametrizations are 50–100 W m⁻² in the net radiation fluxes and 1°–3° in the screen-level temperature. Interactions between clouds and radiation were detected both in the single-column and three-dimensional sensitivity experiments.

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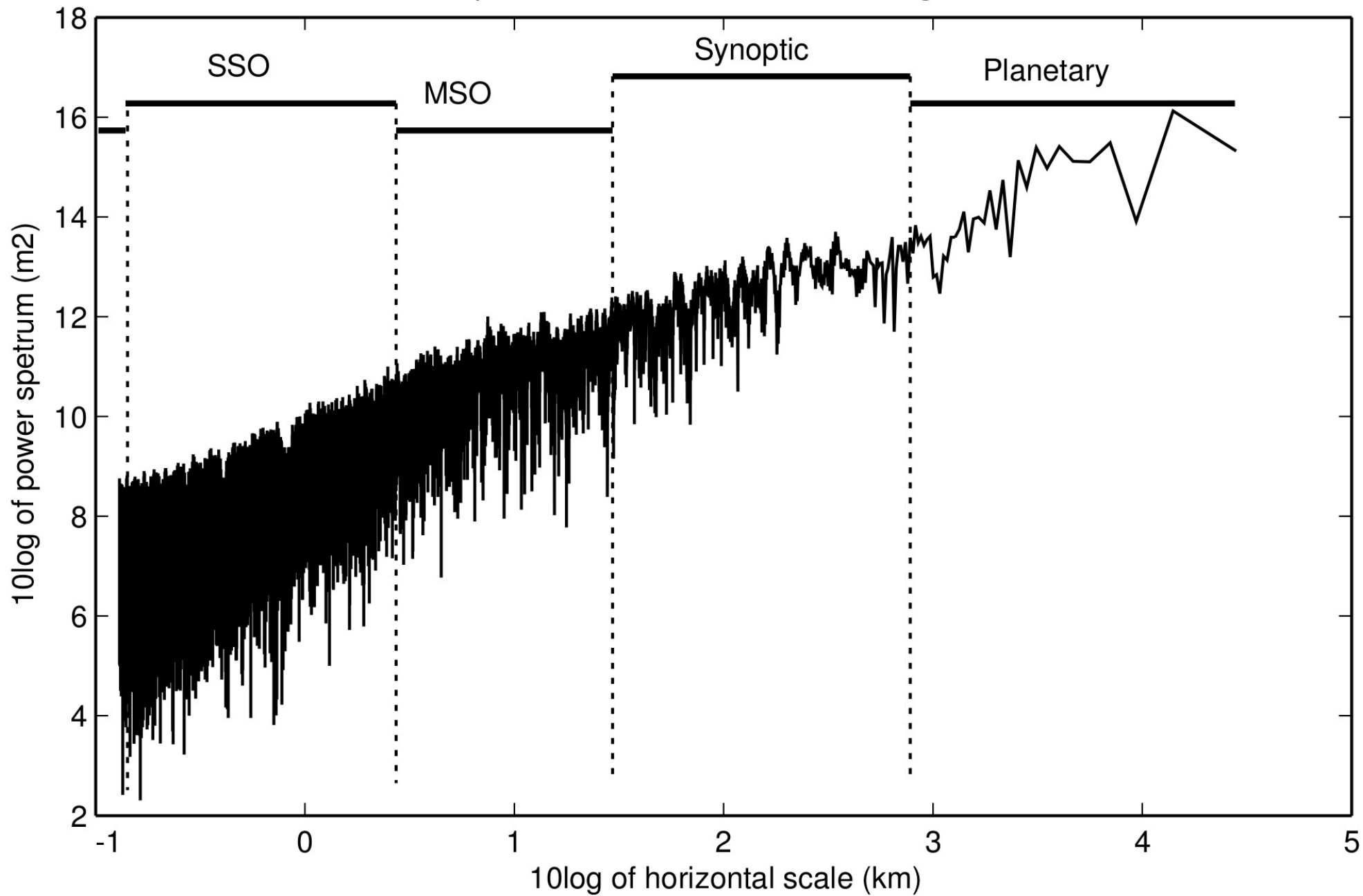
ORORAD TO ENTER PREOPERATIONAL PHASE WITHIN HIRLAM 7.4
(available in HIRLAM since 2007, to be suggested also to SURFEX)



Surface elevation 180W–180E along 45N



Spectrum of surface elevation along 45N



OROGRAPHIC PLAN

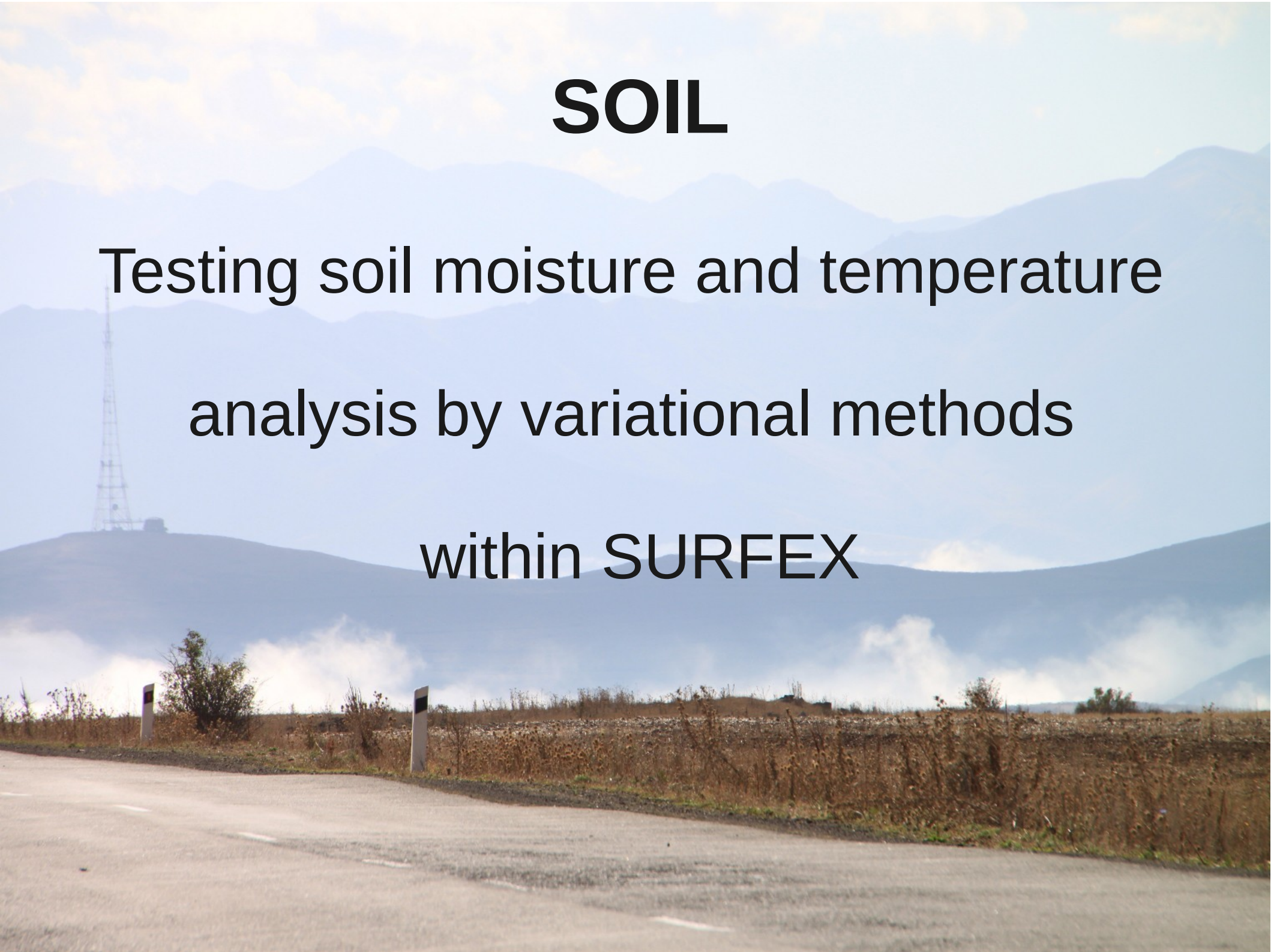
Take the most detailed global digital elevation data (ASTER?)

Do (spectral) filtering to separate scales for derivation of variables for

- **Model dynamics**
- **Orographic buoyancy wave parametrisations**
- **Smallest scale orographic effects on momentum fluxes**
- **Orographic radiation parametrisations**

SOIL

Testing soil moisture and temperature
analysis by variational methods
within SURFEX



URBAN

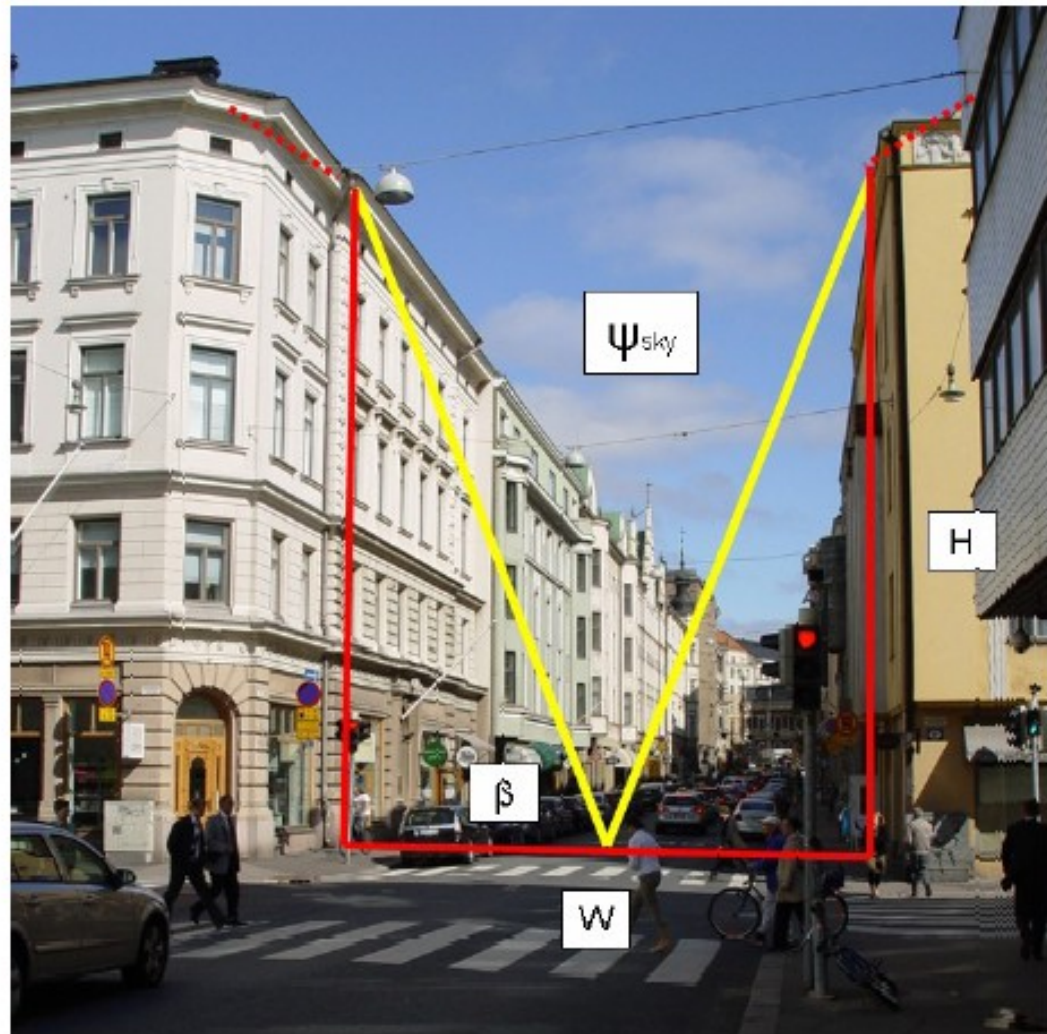
High resolution town descriptions



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Central Helsinki in a nutshell

- On the coast, 60.2 N, 25.9 E
- Minor orographic variations
- Population: 600 000, 1 M in Helsinki metropolitan area
- Fairly closed streets
- Building height 20-30 m
- Mostly built in the early 20th century
- brick, concrete, steel frame
- street surfaces mostly asphalt and granite setts
- Photo: Uudenmaankatu, Achim Drebs





EUROPEAN REANALYSIS AND OBSERVATIONS FOR MONITORING

Tracking changes in European climate

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Specifically, the objectives of EURO4M are to:

- Generate datasets consisting of time series of observations and reanalyses of past observational data;
- Produce innovative and integrated high-quality data products for research and practical applications;
- Out reach to the user community, stakeholders, policy-makers and the general public with data products and climate services;
- Evolve into a future GMES service on climate change monitoring that is fully complimentary and supportive of the existing core services.



HARMONIE surface data assimilation

Mariken Homleid

August 24, 2011

<http://netfam.fmi.fi/sfcda11/>

<http://hirlam.org>

Gollvik & Samuelsson



THANK YOU!