# Report

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# Surface Data Assimilation Meeting on Nordic aspects

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## 1.Introduction

The aim of the meeting was to bring HIRLAM staff working with surface data assimilation and surface modelling together to discuss and make plans for improving HARMONIE data assimilation and modelling, with focus on Nordic aspects. An additional purpose of the meeting was to bring experiences from the HIRLAM system into the HARMONIE surface data assimilation and modelling system. The meeting started with approximately one day of presentations, accompanied by lively discussions. This part served as an introduction to the various surface parts of the HARMONIE system and methodologies and ideas of various potential enhancements of it. Then half a day was devoted to separate working group discussions. Finally, during the last day the outcome of the individual working group sessions were presented and discussed in a common summary discussion.

## 2.Presentations and General Status of HARMONIE surface data assimilation

In the presentations recent progress, present status and future plans related to surface modelling and data assimilation were presented. The following presentations were made and provided an important background for the rest of the meeting:

- Introduction (Magnus Lindskog)
- Overview HARMONIE and its use of SURFEX (Trygve Aspelien)
- HARMONIE surface data assimilation (Mariken Homleid)
- SMHI experiences of HARMONIE surface data assimilation (Karl-Ivar Ivarsson)
- Flake and its use in HIRLAM and in SURFEX (Ekaterina Kourzeneva)
- HIRLAM winter 2011 10 m wind speeds over sea ice (Sami Niemelä)
- Lake analysis and peaceful co-existence in HIRLAM (Laura Rontu )
- Snow analysis in HIRLAM and ideas for improvements (Kalle Eerola and Suleiman Mostamandy)

The presentations are available at the following HIRLAM wiki page:

https://hirlam.org/trac/attachment/wiki/HarmonieWorkingWeek/SURFACEDA201103 /

The presentations are also available at the following NETFAM web page:

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

From the presentations and discussions in direct relation to them it was clear that HARMONIE surface data assimilation and modelling developments have during the last years to a large extent been concerned with technical work needed for adopting the components of the HARMONIE system to the externalised SURFEX surface module. There are still some technical issues that needs to be solved on a short time-scale. A number of improvements of the current system, needed for improved modelling of Nordic aspects were identified. These include improved handling of ice, snow and lakes in data assimilation and modelling. Details regarding these proposed enhancements are presented in the next section, presenting working groups outcome.

The present HARMONIE default data assimilation system is based on a horizontal spatialisation tool (CANARI) to horizontally distribute screen level data. This spatialisation is followed by an adjustment of soil properties based on the spatialised screen level data. This is presently done with a vertical adjustment based on optimal interpolation (OIMAIN). Work with defining the main specifications of an improved spatialisation tool and initial developments towards such a tool is carried out within the EURO4M project, in which both Météo-France and the SMHI is involved. The EURO4M project has a time scale of 4 years and major CANARI development should be coordinated with EURO4M work. In addition there is ongoing developments to replace the vertical optimal interpolation methodology (Maria Diez, AEMET). This method is very promising and will most likely have a positive impact on quality Nordic winter conditions data assimilation and forecast quality Nordic winter conditions. In future more resources should be directed towards replacing OIMAIN with EKF. Data assimilation developments done for handling of lakes, ice, SST etc. should be done in routines that can be called both from OI_MAIN and EKF.

Despite the importance of ongoing and planned enhancements of the HARMONIE surface data assimilation and modelling it should at the same time not be forgotten that, after some more technical adjustments, that an evaluation of the functionality of the present system and its performance is needed.

## 3.Working groups

The participants were split into two working groups. The idea was to have both researchers with data assimilation and modelling experiences in each group. Since several people expressed an interest to participate in both of the groups it was decided to after the individual working group sessions have a rather extensive common summary discussion.

The instructions to both of the working groups were to propose enhancements aiming at an improved description of Nordic winter conditions in the HARMONIE system. Including enhanced utilisation of present observations, introduction of new types of observations and enhanced assimilation and modelling methodologies (proposed developments, estimated of time needed for development and developers)

Working group 1 focused on **Snow** and consisted of Kalle, Suleiman, Stefan, Magnus, Trygve.

Working group 2 focused on **Lakes and sea** and consisted of Ekaterina, Patrick, Mariken, Laura, Bin, Karl-Ivar.

## 4.Outcome of Summary Discussion and Actions

### *4.1. Snow*

*Modelling*

In SURFEX there are currently four different snow modelling options: EBA, D95, 3-L and CRO. The current default scheme in HARMONIE is D95. A disadvantage of D95 is that it does not include a prognostic snow temperature, which is felt important for Nordic winter conditions. One should therefore aim for introducing the 3-L snow model. Ideally it should be combined with a soil heat conduction model, but it should also be checked how 3-L works together with the force-restore soil scheme. In addition the functionality of 3-L together with the multi-layer canopy scheme needs to be investigated. On a longer time scale the best surface model option for HARMONIE is MEB (Multiple Energy Balance), which Stefan, Patrick and Aaron Boone are currently developing. MEB will conceptually not work together with the multi-layer canopy scheme over forest tiles. The possibility to apply the multi-layer canopy scheme over non-forest tiles will be investigated. The first step is to utilize MEB only over forest tiles.

*Data assimilation and use of observations*

The snow data assimilation in HARMONIE is currently not properly working when the SURFEX surface scheme is applied. The reason is that the snow-fields in the upper-air FA file is not syncronised with the snow field in the SURFEX LFI file. The CANARI surface data assimilation utilises the snow field from the FA-file as first guess, but this is different from the one in the LFI-file. In cold start the snow field in the LFI-file looks very patchy even after several days of assimilation. The reason for this should be checked. The initial FA snow cover is taken from the boundary file.

At the moment the GlobSnow satellite based snow observations are tested in the HIRLAM environment (Span) by Suleiman. The plan is to also introduce GlobSnow observations into the HARMONIE CANARI based surface data assimilation system. Technically this means that the GlobSnow observations should be introduced into ODB (probably like SYNOP observations, but some subtype so that they can be recognized and distinguished from SYNOPs). GlobSnow experiments with HIRLAM will continue to gather experience of the quality, problems and how to use them (Suleiman with help from Kalle and others). Things to be studied include whether snow water equivalent (SWE) or snow thickness should be used, conversions between SWE and snow thickness, the areal representation of snow in the satellite pixels and in the first guess respectively. In addition Globsnow observation error correlations and biases and procedures for handling these needs to be considered.

When going to 3-L or other snow model we need to consider how to distribute the snow in the vertical and for different tiles. As a first step this can probably be done rather empirically but at the longer term one should consider more advanced methods for

distribution (like EKF). Finnish MeteoroIogical Institute is addressing such future approaches within the COSDAS project, aiming at combine remotely sensed SWE mesurements and snow model predictions to produce optimal analyses of SWE using data assimilation.

***Action 1**: Trygve and Mariken to make the syncronisation of FA and LFI with the snow fields in HARMONIE SURFEX properly working (either by importing Météo-France fixes or by own developments) (May, 2011).*
***Action 2**: Trygve and Mariken to investigate reason for patchy initial snow states and possibility to take the initial snow field from the boundary file (June, 2011).*
***Action 3**: Stefan and Patrick to check with Aron Boone about possibility to run 3-L, together with force-restore soil scheme and Canopy multilayer scheme or other recommended settings together with 3-L. (May, 2011).*
***Action 4**: Trygve and Mariken to make initial test with 3-L within HARMONIE SURFEX with recommended settings for 3-L (September, 2011).*
***Action 6**: Trygve, Mariken, Karl-Ivar and Magnus to study the functionality and performance of the surface scheme and its handling of snow and assess the impact of the OI analysis within SURFEX in general.(December, 2011).*
***Action 7**: Patrick and Stefan to design MEB to examine the possibility to combine it with* the multi-layer canopy scheme over non-forest tiles (June, 2012).
***Action 8**: Suleiman and Kalle to exploit the characteristics of Globsnow data within the HIRLAM framework (December, 2011).*
***Action 9**: Kalle and Mariken to introduce GlobSnow observations into the HARMONIE CANARI surface analysis system with a first basic, non-tuned version of the assimilation configuration (December, 2011).*
***Action 10**: Kalle, Suleiman and Mariken to optimize settings and procedures in HARMONIE CANARI surface data assimilation for handling of GlobSnow data (December, 2012).*

### *4.2 Lakes and Sea*

*Modelling*

It is of importance for HARMONIE forecasts in Nordic conditions to improve the handling of lakes. A first step should be to include a proper lake modelling in HARMONIE, utilizing Flake. At a later stage one should combine the HARMONIE Flake modelling with lake data assimilation, based on experiences gained from HIRLAM and SURFEX off-line. At present there are problems with Flake cold start data. An improvement of the Flake climatology is of interest for the entire NWP community. Ekaterina has done Flake developments during her stay at Meteo-France. These are included in SURFEX version 6.1 or 7. Additional developments are however needed to make Flake properly running in HARMONIE, using Lambert projection and other projections different from regular lat-lon. A proposed approach is to apply a PDF-based “aggregation method” for determining lake characteristics for a particular projection. It should be general enough to handle different available projections. The developments should preferably be based on SURFEX version 6.1 or 7, which is expected to be available in the HARMONIE 37t1 branch in summer.

There is yet no sea ice fraction in SURFEX. Some SURFEX routines diagnose sea ice from SST colder than -2 C. At the moment, where it is sea ice, surface temperature is

taken from the boundary model. A first step of improvement would be to include a representation of ice in SURFEX. The next step would be to include a modelling of ice. The modelling will be performed by introducing the HIGHTSI ice model to SURFEX. HIGHTSI is a one-dimensional snow/ice model. Horizontal ice transport/dynamics is not represented but there are ideas about ocean flux in HIGHTSI, for example by utilising climatology. At a later stage plans for data assimilation of ice will be planned.

Initial new developments regarding lake and ice modelling can be carried out within SURFEX off-line, but keeping in mind that the goal is to introduce the developments into the HARMONIE system. Computing times required by Flake and HIGHTSI will be addressed.

*Data assimilation and use of observations*

Today there is no data assimilation of Sea Surface Temperature (SST). The present methodology is to interpolate the ECMWF analysis onto the HARMONIE grid. The quality of the interpolated SST field is at present considered satisfactorily. As mentioned in previous section there is presently not an ice variable present in SURFEX and hence no ice analysis applied. A next step for future developments of ice analysis will be to start an inventory of available observations, global as well as local. In addition the availability of local SST products will be subject to an inventory. A proper web-forum will be set up for such an inventory. Provided a SURFEX sea ice tile has been introduced in SURFEX, ECMWF ice (O&SI SAF) interpolated to the HARMONIE grid is easily introduced when needed. .Furthermore the potential of ice and SST products the HIROMB model for HARMONIE data assimilation will be investigated. HIROMB is an ocean model including prognostic ice and data assimilation of SST.

It is presently not clear what is the best procedure for combining Lake surface temperature and ice observations with the Flake model. One should first address Lake surface temperature observations and later on ice observations (in-situ as well as remote sensing observations). A first step could be to compile a discussion paper on various possible approaches for updating the Flake prognostic variables from assimilation of lake surface temperature observations, for example by development of Flake B matrix and EKF approaches. In addition to this vertical distribution of lake surface temperature observations one needs to think of horizontal spread of observational observations, considering lake depth.

***Action 11****: Ekatharina to solve problems with Flake cold start data (within HIRLAM framework and beneficial also for HARMONIE) (June, 2011).*
***Action 12****: Ekatharina to properly run Flake within SURFEX off-line and SURFEX within HARMONIE for all available projections or at least Lambert. (December, 2011).*
***Action 13****:* Tido, Laura and Bin to include a representation of ice in SURFEX *(*December, 2011*).*
***Action 14****:* Tido, Laura and Bin to include HIGHTSI into HARMONIE SURFEX (December, 2012*).*
***Action 15****: Ekatharina to* Tido, Laura and Bin to include a representation of ice in SURFEX *(*December, 2011*).*

***Action 16**: Ekatharina to include Lake Surface Temperature (LST) and Lake ice data assimilation for Flake in HARMONIE (*December, 2012*).*
***Action 17**: Magnus to consult to include LST and ice data assimilation for Flake in HARMONIE (*December, 2012*).*
***Action 18**: Magnus to together with Xiahoua organise web-forum for SST and ice data inventory (June, 2011).*
***Action 19**: All meeting participants to contribute to SST and ice data inventory (December, 2011)*
***Action 20**: Karl-Ivar to Stefan to investigate* the potential of ice and SST products the HIROMB model for HARMONIE data assimilation (June, 2012*).*

### *4.3 EKF*

EKF might be tested both for snow and lake analysis in addition to soil analysis. The aim is to finalize the implementation EKF in HARMONIE within December 2011.

## 5. Presentation of outcome from surface meeting at ASM

Mariken Homleid will include material from the surface data assimilation meeting on Nordic aspects in her presentation at the ALADIN/HIRLAM All Staff Meeting in Norrköping.

## 6. Upcoming surface meetings

The opinion of the meeting participants was that it was very useful for discussions and planning in the present meeting to have attendance from both modellers and data assimilation researchers. However it was felt that the next couple of meetings should be in the form of smaller working weeks or scientific visits. Within the current year it is felt too early to organise a surface meeting on coordinated impact studies.