Overview of the present HIRLAM surface assimilation

Mainly taken from:

Analysis of surface variables and parameterization of surface processes in HIRLAM. Part I: Approach and verification by parallel runs

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Surface assimilation in HIRLAM is carried out for:

- Water surface temperature
- (Sea ice fraction)
- Snow depth
- 2 meter temperature and relative humidity, only to be used as input to soil temperature and soil moisture
- Soil temperature
- Soil water content

Basic assimilation techniques

- **The 2-dimensional spatial interpolation is based on successive corrections (Cressman type) or statistical interpolation with a box data selection (Lorenc). The software originates from the SMHI MESAN and was adapted to HIRLAM by Navascues.**
- **The sequential soil assimilation is based on Mahfouf (1991), Bouttier (1993) and Giard and Bazile (2000). It was implemented in HIRLAM by Auoso and Navascues.**

Water temperature and sea ice fraction analysis (1)

- The background field is the previous analysis with a weak relaxation toward climatology (to ensure a correct seasonal evolution and to avoid accumulation of noise).
- Gridpoints and observation stations are classified (Inland, Near coast, Coast, Lake and Open sea).
- Successive corrections analysis with weights depending on distance and a scaling factor related to the classification of gridpoints and observation points.
- Pseudo observations from the ECMWF (NCEP) water temperature analysis
- Fraction of sea is diagnosed from the water temperature analysis

Successive correction weights related to land/lake/sea anisotropy

$$W_{ik} = w(r_{ik}) f(class_i, class_k)$$

obs.class	grid point class				
	inland	near coast	coast	lake	open sea
inland	1.	0.5	0.0	1.	0.0
near coast	0.5	1.	0.5	0.5	0.3
coast	0.0	0.5	1.0	0.0	0.9
lake	1.	0.5	0.0	1.	0.0
open sea	0.0	0.3	0.9	0.0	1.0

Water temperature and sea ice fraction analysis (2)

- **Various input data sets of SST and sea ice fraction are utilized by the different HIRLAM groups, for example OSI SAF data (DMI and met.no) ac and special data from the Baltic Sea (FMI and SMHI)**
- **A new statistical interpolation scheme is being developed (Homleid and de Vries).**
- **SMHI is developing SST and sea ice fraction analysis for a coupled atmospheric, ocean and sea ice model system over the Arctic (HIRLAM + HIROMB in EU DAMOCLES).**

Analysis of snow depth

- **The background snow mass field is obtained by fractional averaging from the different surface tiles, relaxed toward climatology and converted to snow depth. The conversion takes snow aging and snow melting into account.**
- **Statistical interpolation is applied with a structure function based on a second order autoregressive. (SOAR) function.**
- **Only land surface observations are utilized. A station-by-station bias correction is applied.**

Analysis of 2 meter temperature and relative humidity (1)

Careful estimation of the background field:

- **Moving of the atmospheric profiles to the elevation of the stations**
- **Fractional averaging of the surface fields over the surface tiles**
- **Re-calculation of the surface temperature (to keep the potential temperature lapse rate in the surface layer)**
- **Diagnosis of 2 meter temperature and relative humidity following Geleyn (1988)**

Background deviation check

Analysis of 2 meter temperature and relative humidity (2)

2-dimensional statistical interpolation OI:

- Box data selection
- OI QC following Lorenc/ECMWF
- Autocorrelation model based on horizontal and vertical distances
- Analysis boxes are wider than QC boxes

Analysis of soil temperatures

Surface temperature Ts and mean layer soil temperature Td are analyzed for each surface tile separately following Giard and Bazile (2000)

$$\Delta T_d = \Delta T_{2m}/(2\pi)$$
$$\Delta T_s = \Delta T_{2m}$$

Complications with the new surface (snow) scheme:

- **Most surface stations are in low vegetation areas, while forest dominates grid-points in the Nordic area**
- **How to diagnose 2 meter temperature from snow and canopy temperatures**

Analysis of soil water content

The assimilation of soil water content follows Giard and Bazile (2000) with an adaptation to surface tiles by Ayuso:

$$\Delta w_s = \alpha_s^T \Delta T_{2m} + \alpha_s^H \Delta H_{2m}$$
$$\Delta w_d = \alpha_d^T \Delta T_{2m} + \alpha_d^H \Delta H_{2m}$$

Surface assimilation issues from the HIRLAM perspective – (1) short term

- Adapt to new surface parameterization scheme (snow and canopy temperatures, multi-layer soil)
- Tune the soil assimilation (ideas from the talk by Bouyssel)
- Introduce SST and sea ice analysis based on OI + new input data (OSI SAF + NAR?)

(all within the HIRLAM code framework)

Surface assimilation issues from the HIRLAM perspective – (2) medium term

We urgently (2008) need a surface assimilation for HARMONIE (HIRLAM version of ALADIN):

- **We would prefer a joint development with the ALADIN group!**
- **We are prepared to contribute to assimilation of "Nordic" variables – snow, SST, ice and lakes**
- **Which spatial interpolation tool? CANARI? SPAN(MESAN)? (Move surface physics from the interpolation tool to SURFEX)**
- **Soil assimilation technique (OI, dynamical OI, SEKF…, within or outside SURFEX)?**
- **Improve consistency of upper air and surface assimilation (2 meter observations + surface temperature control variable in upper air analysis?)**

Surface assimilation issues from the HIRLAM perspective – (3) long term

- Spatial interpolation by variational techniques with wavelets as basis functions (anisotropy and in-homogeneity)?
- More advanced soil assimilation algorithms?
- Use of ensembles?
- Keep surface and upper-air assimilations in separate modules but coupled via an assimilation solver?
- Soil assimilation within 4D-Var outer loops?
- Use of satellite data