The surface scheme in HIRLAM

The concept is a fully tiled scheme, where there is no coupling between the tiles, and the influence from other tiles comes only from the atmosphere.

Separate soil profiles for each tile, no ”skin-temperature”, but instead is the thickness of the first layer only 1 cm. The reason for keeping separate soil temps is that there could be very different behaviour under snow, and also that fluxes influencing the soil is very different inside and outside the forest.
Components in the HIRLAN surface scheme

• Totally 7 tiles: sea, ice, open land, low veg., forest, open land snow, forest snow
• For all land tiles: 3 prognostic temperatures, soil depths of 1, 7.2 and 43.2 cm. Heat conduction dependent on soil type, soil water and (parameterized) soil ice. Climatological forcing below third layer.
• The forest tile has a common (prognostic) canopy temperature and separate temperatures for the snow free and snow covered forest floor.
• Two separate snow covers with separate evolutions of temperature, snow amount, liquid water, density and albedo
• Sea ice has 2 layers, the deepest 92 cm for oceans and 42 cm in the Baltic. Heat flux at the bottom, from the water.
• At present no lake model, work is going on here.
The snow tiles

The surface analysis, SPAN (Navasques et.al.) is performing an OI analysis of snow depth. The first guess is relaxed towards climatology. Using the first guess snow density, the snow depth is transformed to the model variable, snow water equivalent. The analysis increment (for the open land snow) is also added to the ice tile and the forest tile multiplied with an ad hoc factor of 1 and 0.5 respectively.

The snow fractions are simply estimated as:

\[ frsn(x, y, t) = sn(x, y, t)/sncrit(x, y, t), \quad frsn \leq 1 \]

At present an ad hoc \textit{sncrit} as a function of latitude and time of the year

Idea:

Estimate \textit{sncrit} by also analysing the snow fraction (satellite ?)
Here we use only one layer of snow, the depth of which is \( Z_{\text{snow}} \) [m snow]. Only the upper part is thermally active in cases of deep snow:

\[
\frac{dT_{\text{sn}}}{dt} = \frac{1}{c_{\text{snow}} \cdot MIN(Z_{\text{snow}}, d_{\text{sn}})} \left[ \Phi - \alpha_{\text{snow}}(T_{\text{sn}} - T_{\text{ssn}}) \right]
\]

\[c_{\text{snow}} = v_{\text{hice}} \cdot \rho_{\text{sn}} / \rho_{\text{ice}}\]

Here the coefficient \( \alpha_{\text{snow}} \) (formulation from ERA 40) is parameterizing a "fictive" profile through the snow, since the isolation is a function of the snowdepth:

\[
\alpha_{\text{snow}}^{-1} = 0.5 \frac{Z_{\text{snow}}}{\lambda_{\text{sn}}} + 0.5 \frac{Z_{1}}{\lambda_{\text{soil}}} ; \quad \lambda_{\text{sn}} = \lambda_{\text{ice}} \left( \frac{\rho_{\text{sn}}}{\rho_{\text{ice}}} \right)^{1.88}
\]
Snow density calculations

The snow density is thus influencing the heat capacity of the thermally active layer.

The snow density is calculated by a weighted value of three components:

- "dry" snow
- water in the snow
- ice due to frozen water in the snow, and rain freezing on cold snow (at present not stored as a separate variable)

The dry snow is, in turn, composed of old snow, with gradually increasing density (Douville et al., 1995), and newly fallen snow with density $\rho_{\text{min}} (=100\text{kg/m}^3)$.

The amount of water which can be suspended in the snow, before going to the soil, $w_{\text{sat}}$, (fraction) is a function of the snow density:

$$w_{\text{sat}} = 0.12 - 0.08 \left( \frac{\rho_{\text{sn}} - \rho_{\text{min}}}{550 - \rho_{\text{min}}} \right)$$
Low tree heat capacity

Canopy water

Canopy air temperature and humidity

Calculations of \( r_b \) and \( r_d \) follows Chouhbury and Monteith, 1988

\[
r_b \propto LAI^{-1} u_\star^{-1/2}
\]

\[
r_d \propto u_\star^{-1}
\]
We define a “view factor” $\text{viewfs}$, defined as how much of the incoming SW radiation is passing the canopy and reaching the forest floor. This parameter is a function of LAI, solar angle and total cloudcover. The corresponding factor for long wave radiation, $\text{viewfl}$, is only a function of LAI.

Then we calculate the radiation as usual between soil and atmosphere, but also between the canopy and the forest floor, both for snow covered and snow free parts, separately.
Heat conduction in the soil.

Dependent on the fractions of clay, silt and sand the soil is classified in 11 classes:

Dependent on the class, the porosity and amount of quartz is estimated, and the heat conductivity is calculated, taking into account the amount of soil water and the soil ice, at present estimated as a function of temperature (Viterbo). This parameterization follows Peters-Lidard et.al., 1998.
HIRLAM surface plans

• Tuning of the surface scheme, in connection with the other physical parameterizations.

• Start the work of externalization

• Compare this scheme with SURFEX

• Start work of interaction between the surface analysis and 4D-var

• Improve the changes of surface temperatures in Span, to better fit the T2m-analysis (idea from Balsamo ?)

• Work is under way, to implement Flake in HIRLAM

• Add snow on sea ice, and urban area (Aladin)
Some points about the T2m-values in surface parameterizations

• The estimation of T2m from surface temperature and model profile

• The values of T2m for different tiles, with respect to verification and analysis