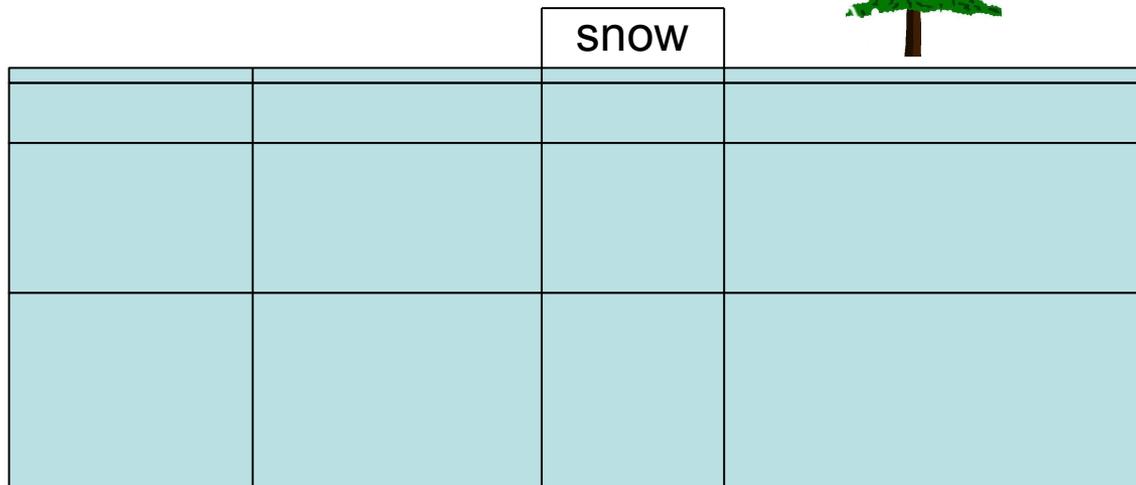# The surface scheme in HIRLAM

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.

snow

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 tempereatures, 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.
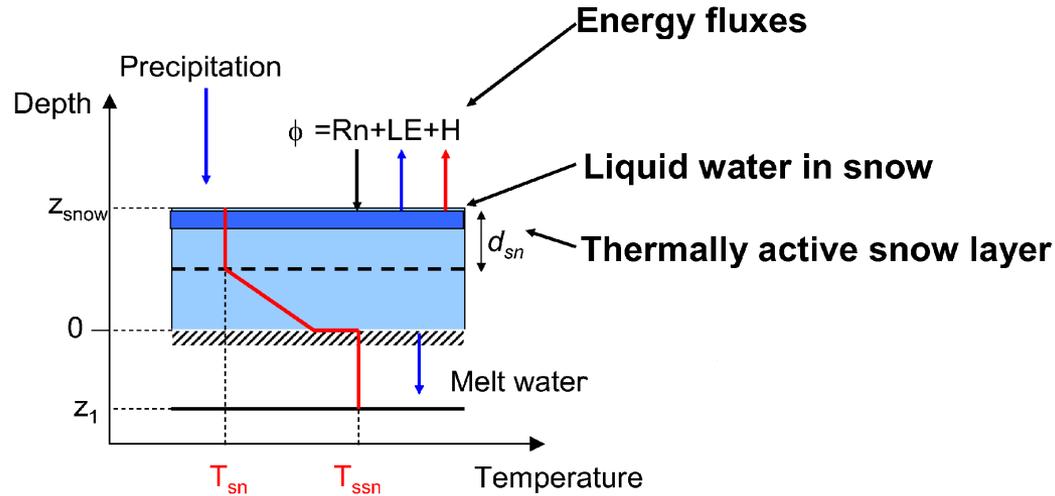
The snow fractions are simply estimated as:

$$frsn(x, y, t) = sn(x, y, t)/sncrit(x, y, t), \quad frsn \le 1$$

At present an ad hoc *sncrit* as a function of latitude and time of the year
Idea:

Estimate sncrit by also analysing the snow fraction (satellite ?)

Here we use only one layer of snow, the depth of which is Z_{snow} [m snow]. Only the upper part is thermally active in cases of deep snow:

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

$$c_{snow} = vhice * \rho_{sn}/\rho_{ice}$$

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

$$\alpha_{snow}^{-1} = 0.5\frac{Z_{snow}}{\lambda_{sn}} + 0.5\frac{Z_1}{\lambda_{soil}} \; ; \quad \lambda_{sn} = \lambda_{ice}\left(\frac{\rho_{sn}}{\rho_{ice}}\right)^{1.88}$$

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 ρ_{min} (=100kg/m3).
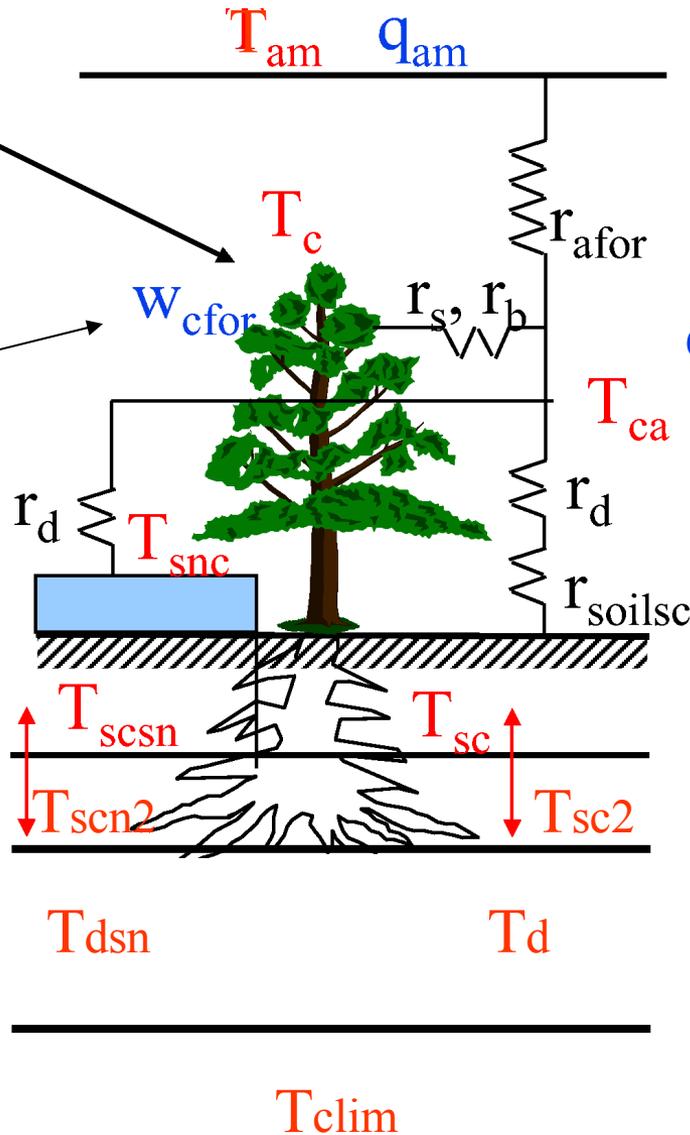
The amount of water which can be suspended in the snow, before
going to the soil, wsat, (fraction) is a function of the snow density:

wsat= $0.12 - 0.08 (\rho_{sn} - \rho_{min}) / (550 - \rho_{min})$

The forest tile

Low tree heat capacity

T_{am} q_{am}

T_c

w_{cfor}

Canopy water

r_s, r_b

r_{afor}

T_{ca}

q_{ca}

r_d

r_d

T_{snc}

r_{soilsc}

T_{scsn} T_{sc}

T_{scn2} T_{sc2}

T_{dsn} T_d

T_{clim}

$$H_{for} = \rho c_p \frac{T_{ca} - T_{am}}{r_{afor}} =$$

$$= H_c + frsn * H_{snc} + \left(1 - frsn\right) H_{sc}$$

Canopy air temperature and humidity

Calculations of r_b and r_d follows Chouhbury and Monteith, 1988

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

$$r_d \propto u_\star^{-1}$$

Radiation in the forest

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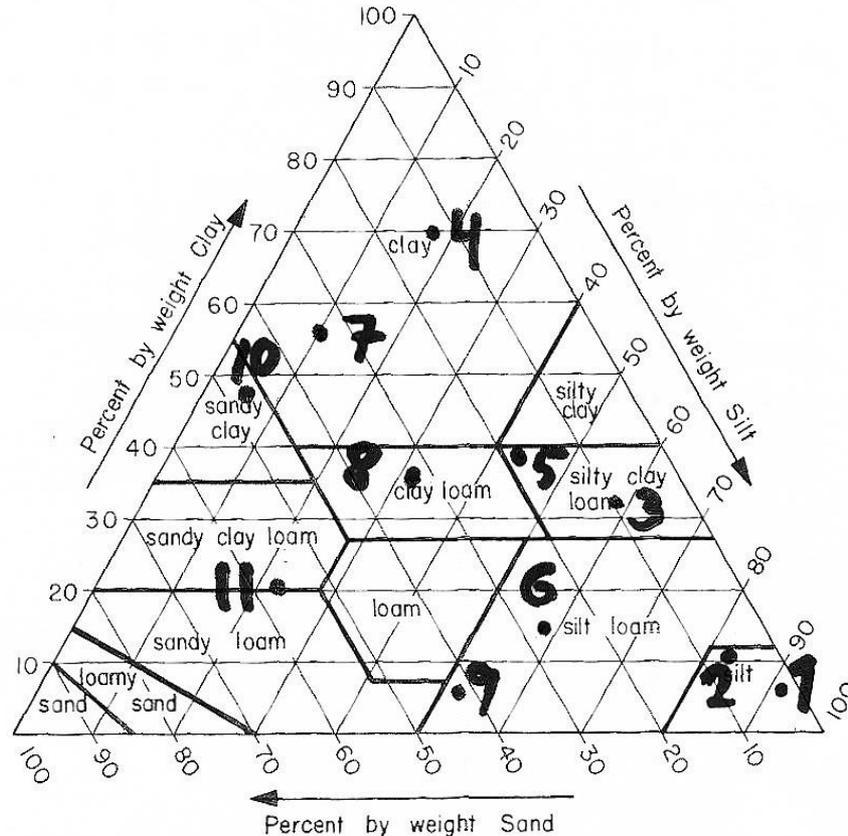
Dependent on the class, the porosity and amount of quartz is estimated, and the heat conductivity is calculated, taking into account the amount of soil water and the soil ice, at present estimated as a function of temperature (Viterbo). This parameterization follows Peters-Lidard et.al., 1998

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