

PT SAINT: a brief project overview

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MeteoSwiss
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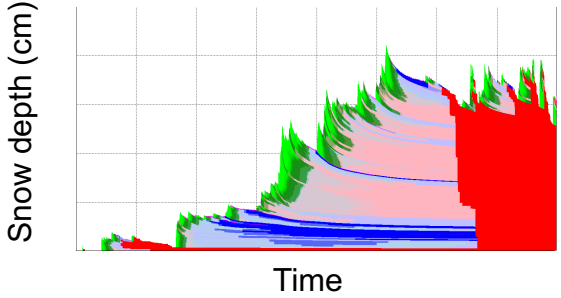
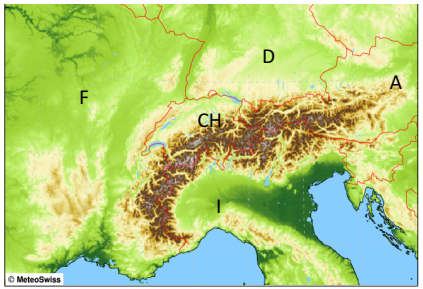
Project Goals – SAINT (University of Innsbruck)

- SAINT: **S**now cover **A**tmosphere **INT**eractions
- Originally proposed: Forcing/Coupling snow cover model SNOWPACK with the regional weather forecasting model COSMO (2km).
- Changed to: Implementation of new snow cover model (SCM) in COSMO-2 – at least a better snow surface temperature prediction.

SNOWPACK

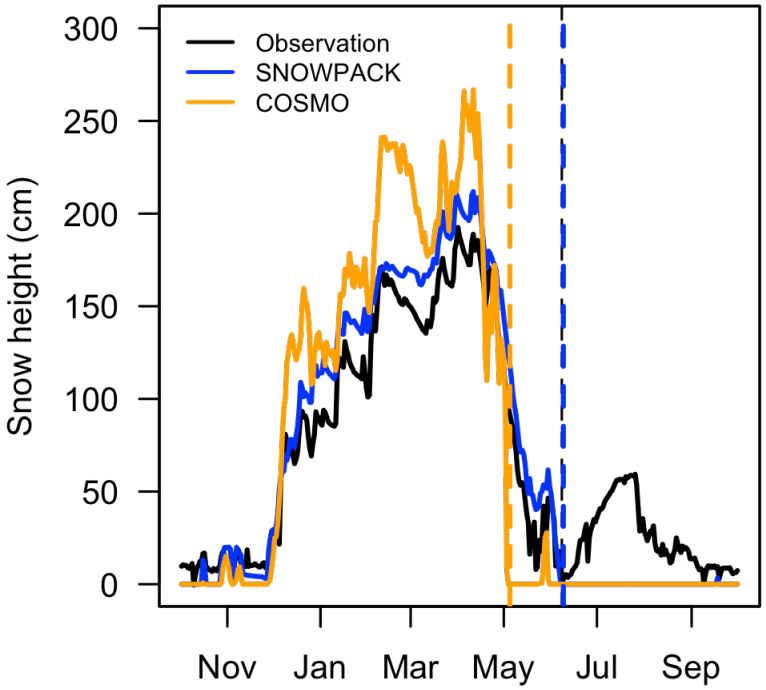


COSMO-2



Phase I: Snow height comparison – Local vs. regional

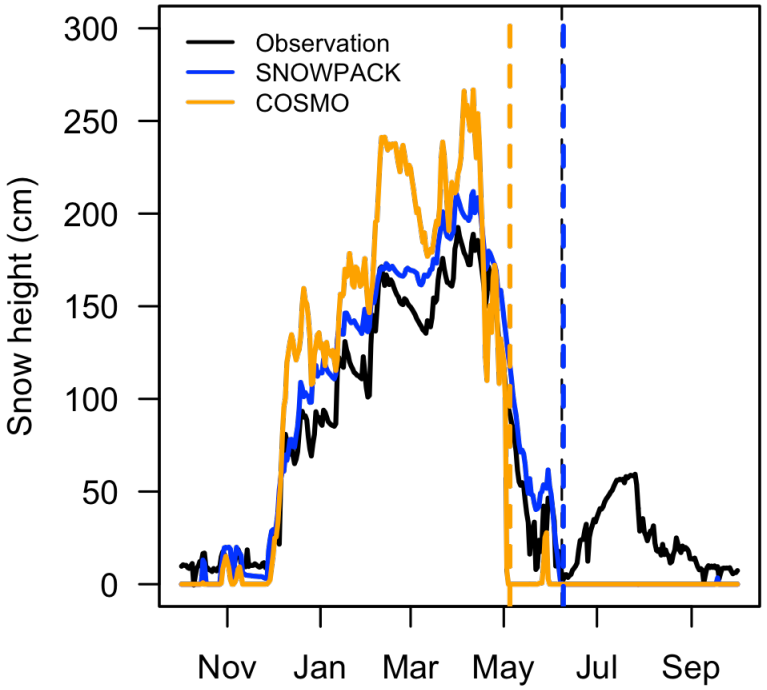
Weissfluhjoch



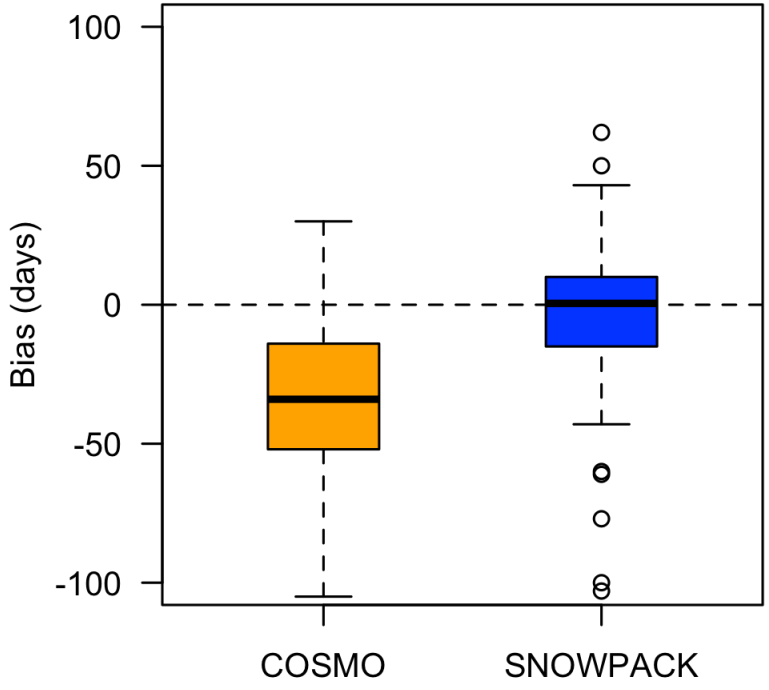
Intercantonal Measurement and Information System (IMIS)

Phase I: Snow height comparison – Local vs. regional

Weissfluhjoch

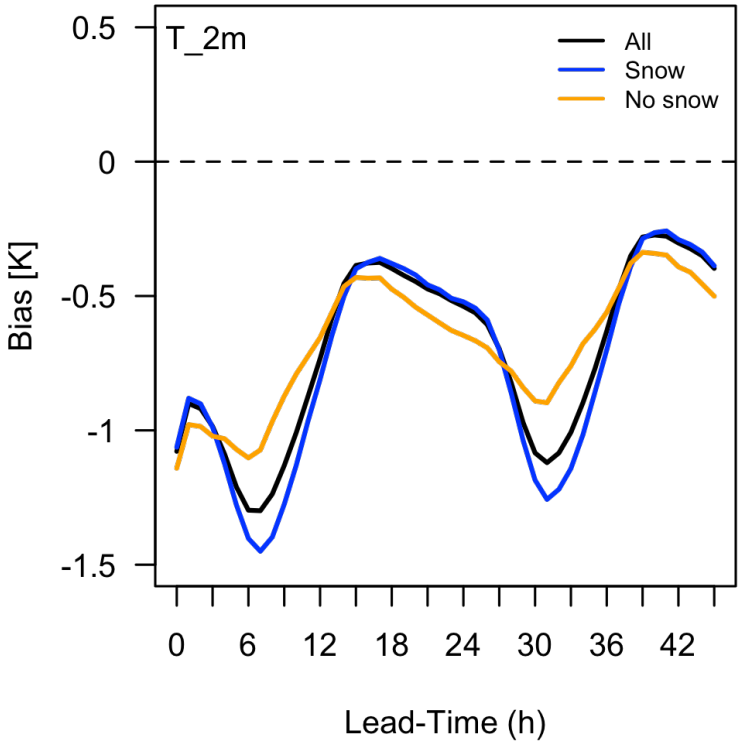


IMIS

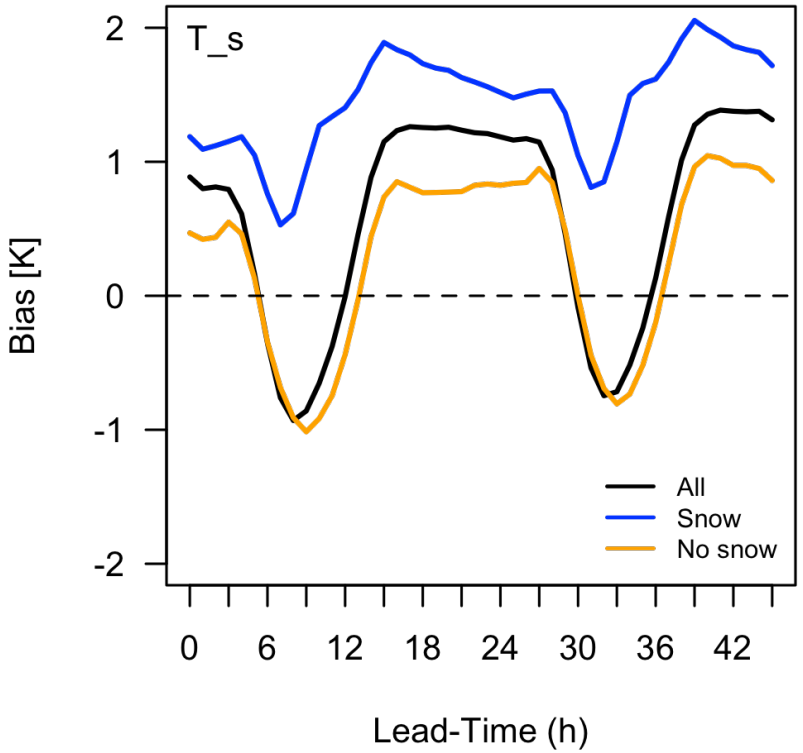


Phase I: Temperature Bias – Regional (IMIS) 2012-13

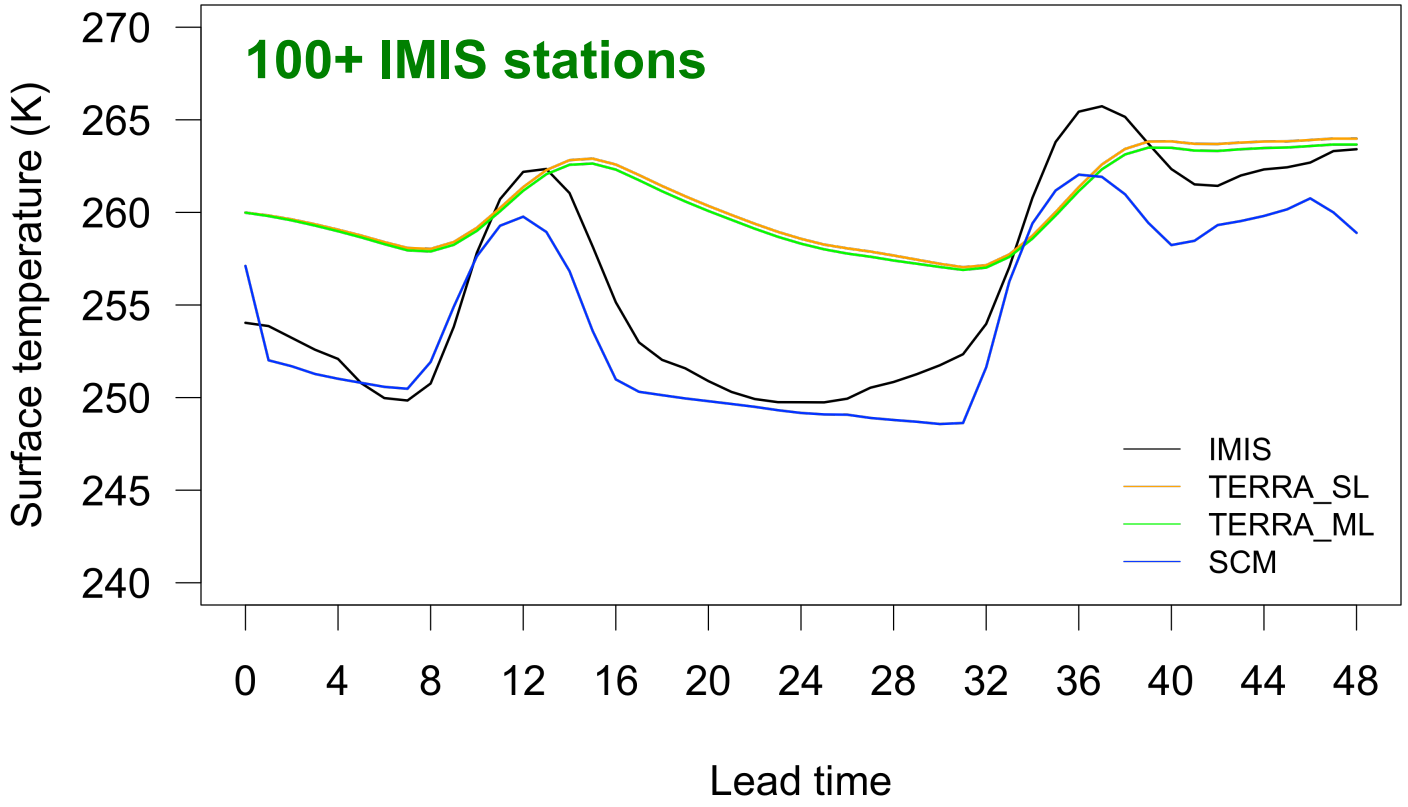
Air



Surface



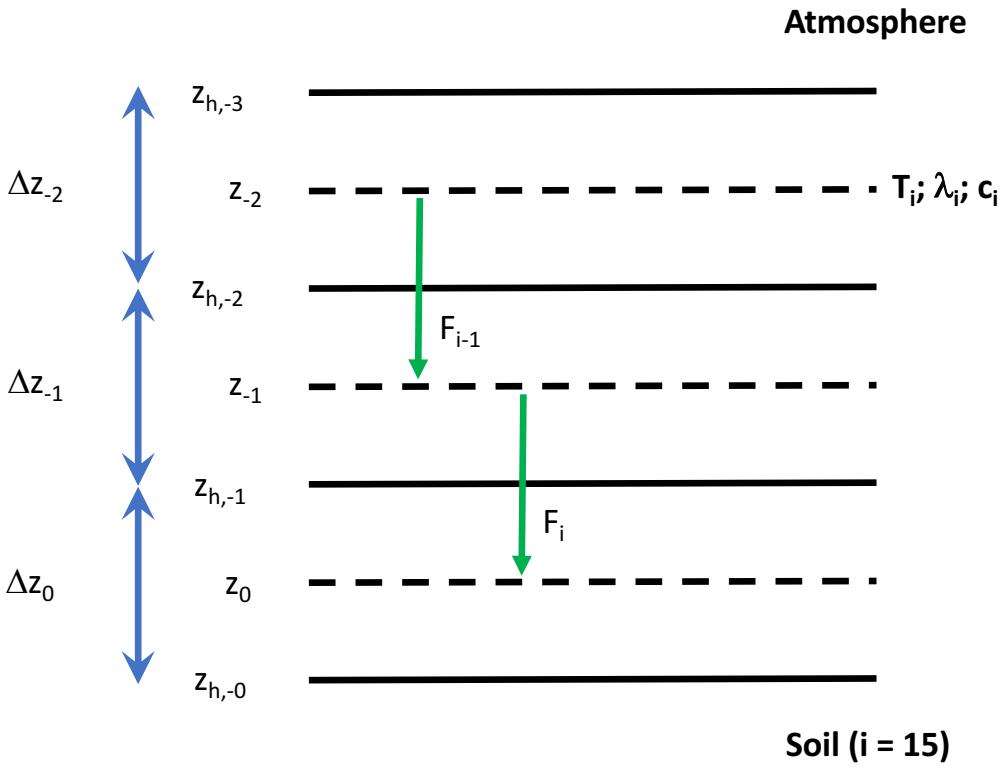
Phase I: Surface Temperature (SCM_{online}) – COSMO-2



Proposed COSMO Priority Task (PT) Project – SAINT

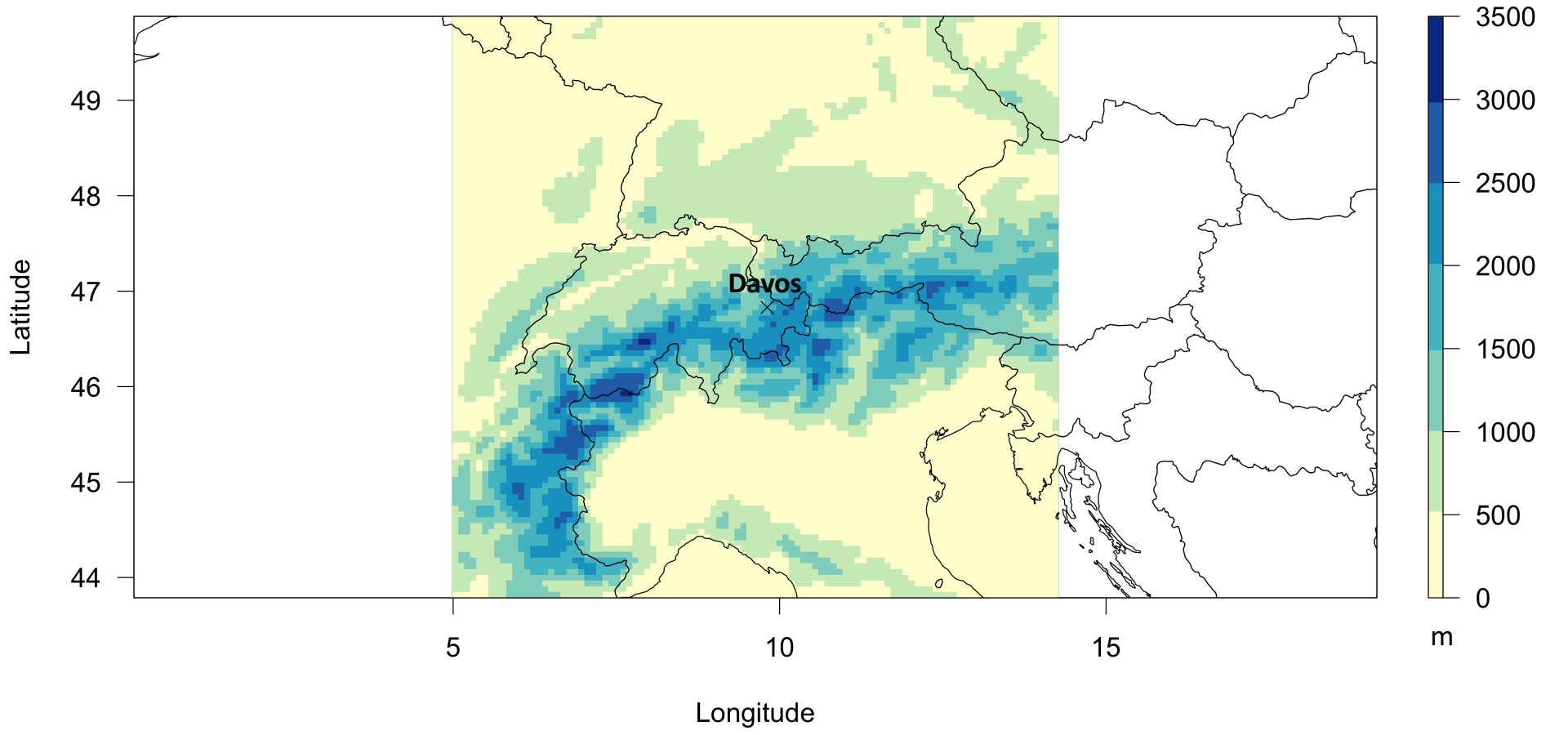
- **Phase I: validation of current multi-layer scheme – update as needed**
- **Phase II: implementation – adjustment of currently implemented parametrizations ; radiation (albedo), turbulence , tile approach …**
- **Phase III: validation of implementation especially diagnostic parameters (e.g. T_2m)**
- **Phase IV: documentation**
- **Duration: 2 years (50%), Start July 2017, End June 2019**

Phase I: CLM4.5 – snow cover scheme schematic (i = 3)

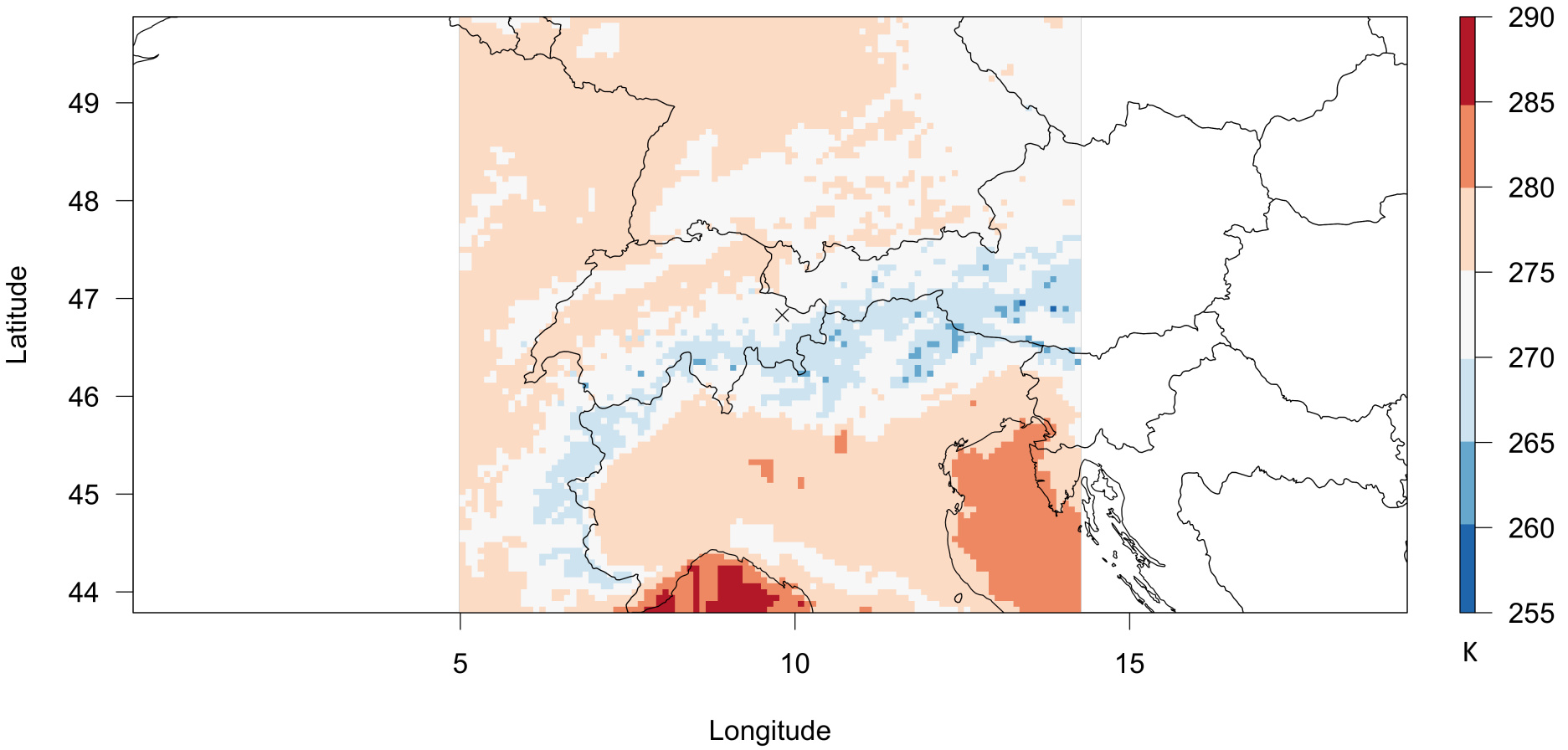


- Max. number of **5** snow layers depending on snow depth z_{sno}
- If $z_{sno} > 0.64$ m: $\Delta z_{-4} = 0.02$ m, $\Delta z_{-3} = 0.05$ m, $\Delta z_{-2} = 0.11$ m, $\Delta z_{-1} = 0.23$ m, $\Delta z_0 = z_{sno} - \Delta z_{-4,-3,-2,-1}$
- Temperature $\mathbf{T_i}$, thermal conductivity λ_i and volumetric heat capacity $\mathbf{c_i}$ defined at layer mid-points.
- Heat flux **F** between layer interfaces solved using Crank-Nicholson Method.

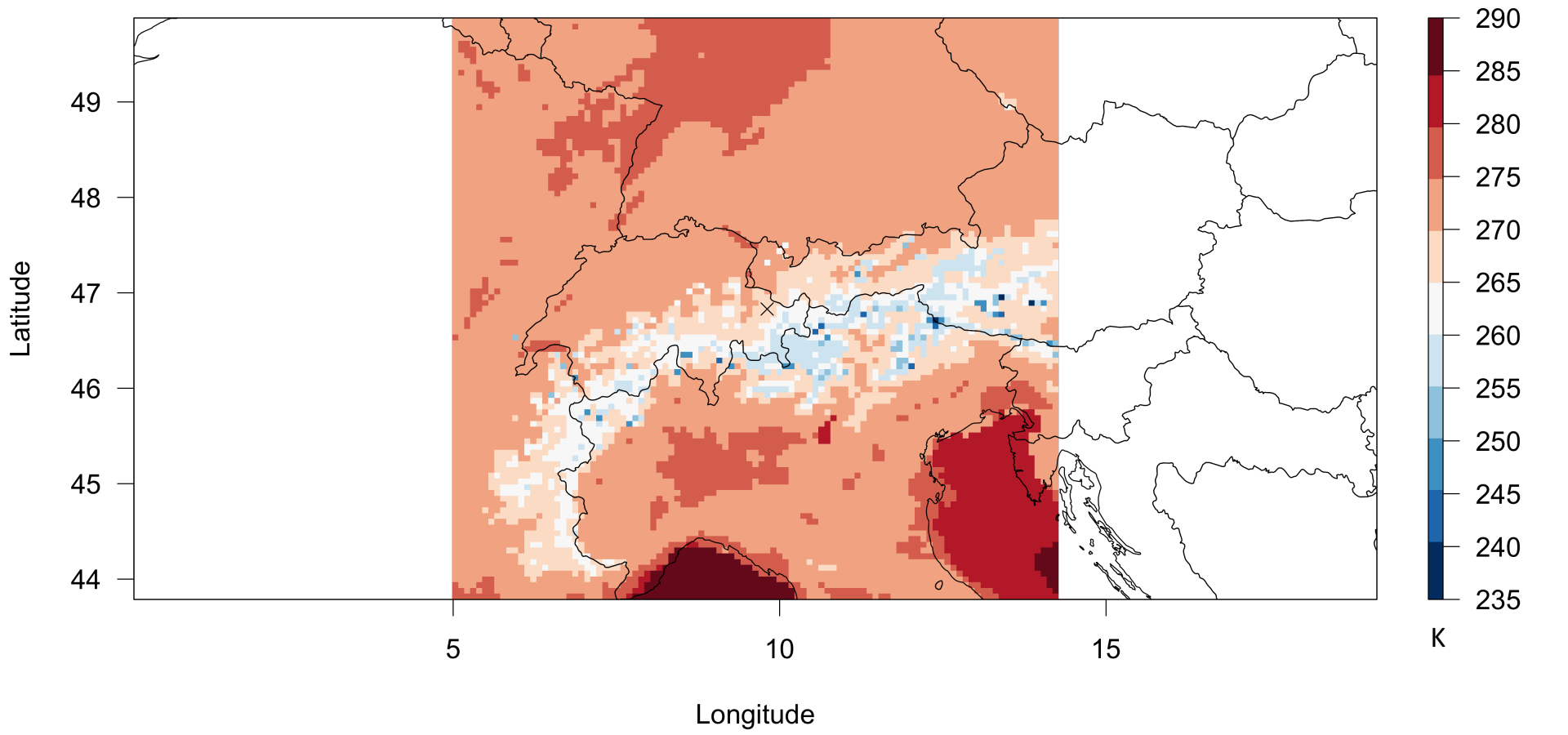
Phase II: COSMO(7km) Model Setup (HSURF)



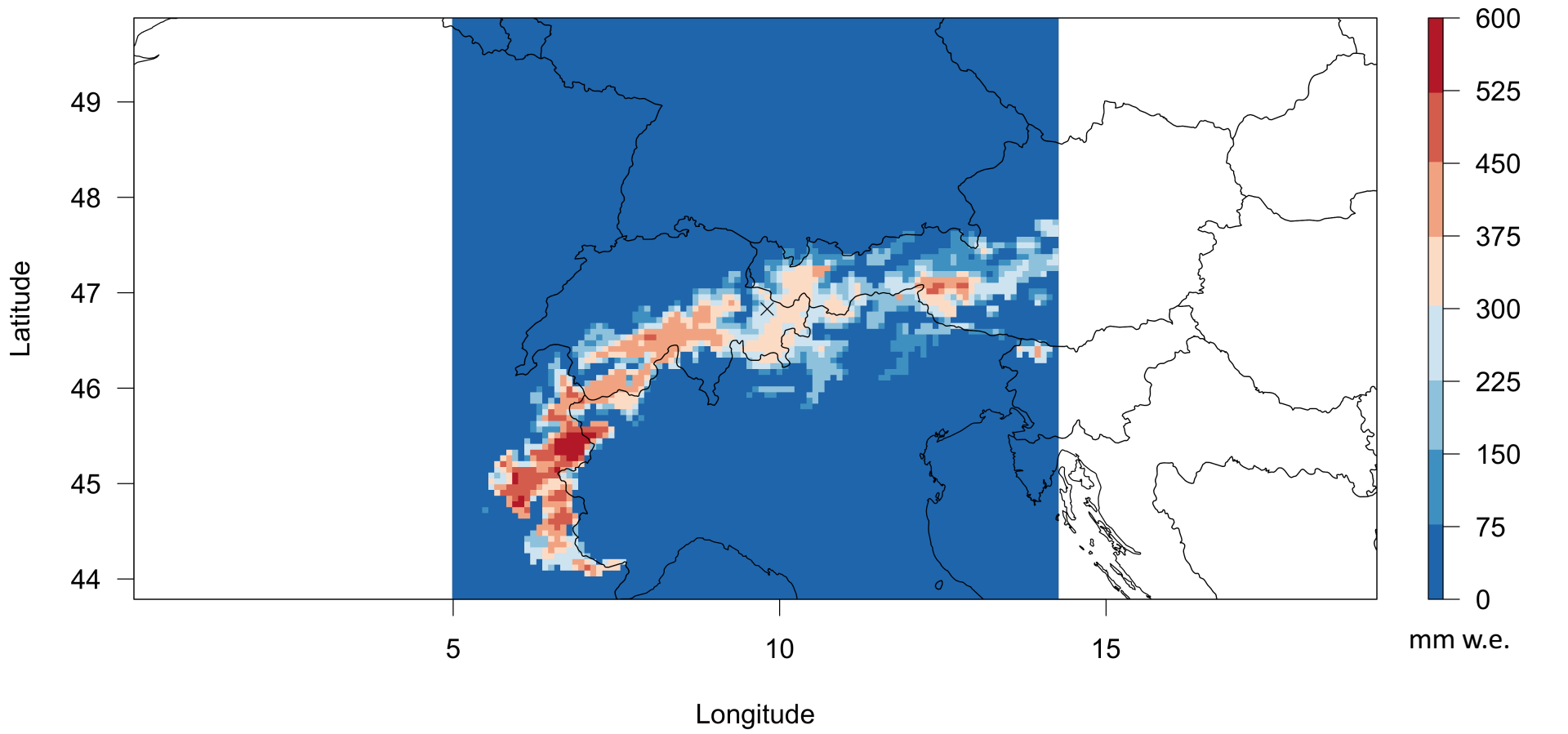
Phase II: COSMO(7km) Model Setup (T_2M)



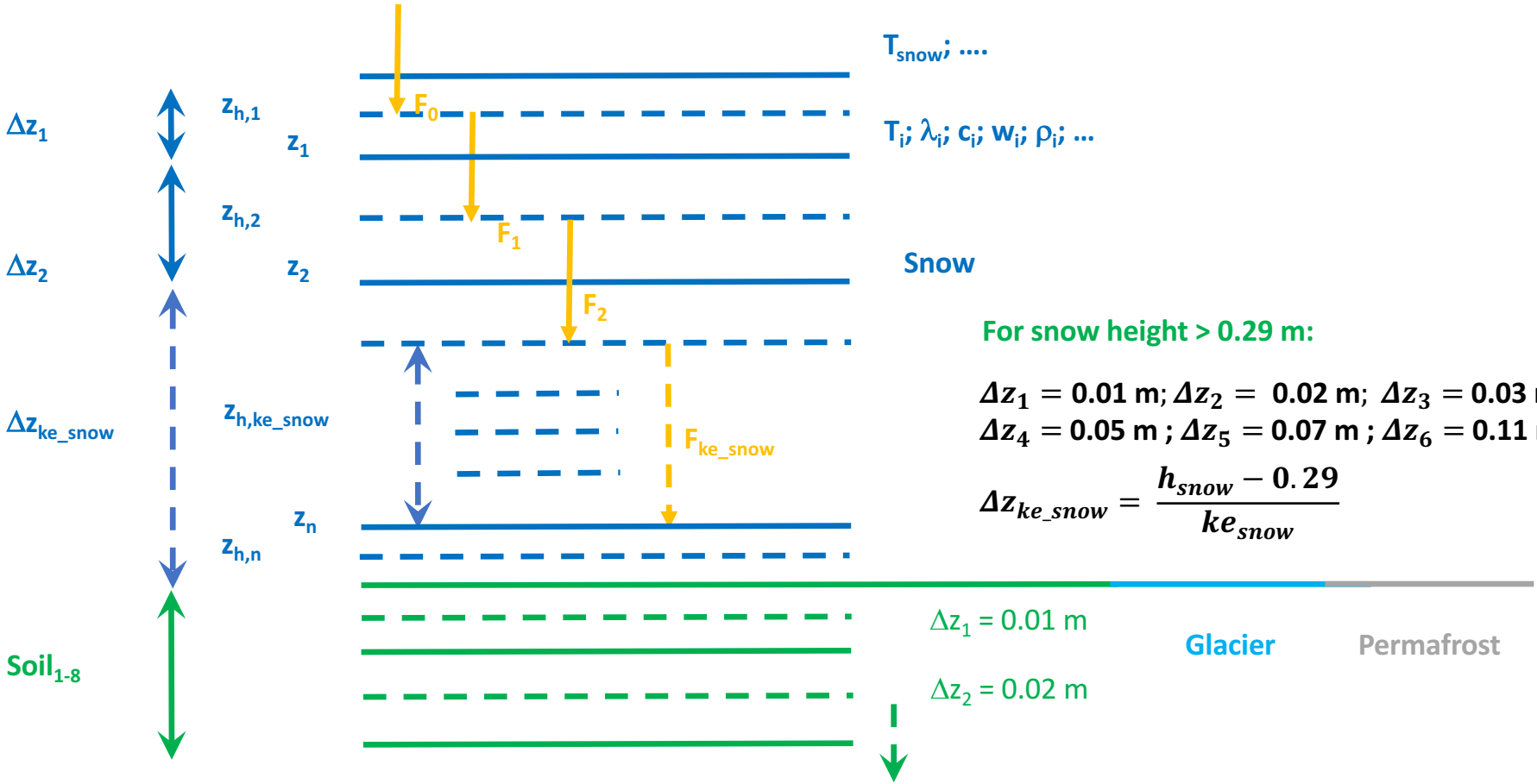
Phase II: COSMO(7km) Model Setup (T_SNOW)



Phase II: COSMO(7km) Model Setup (W_SNOW)



Phase II Snow cover scheme schematic (SCS) – SAINT

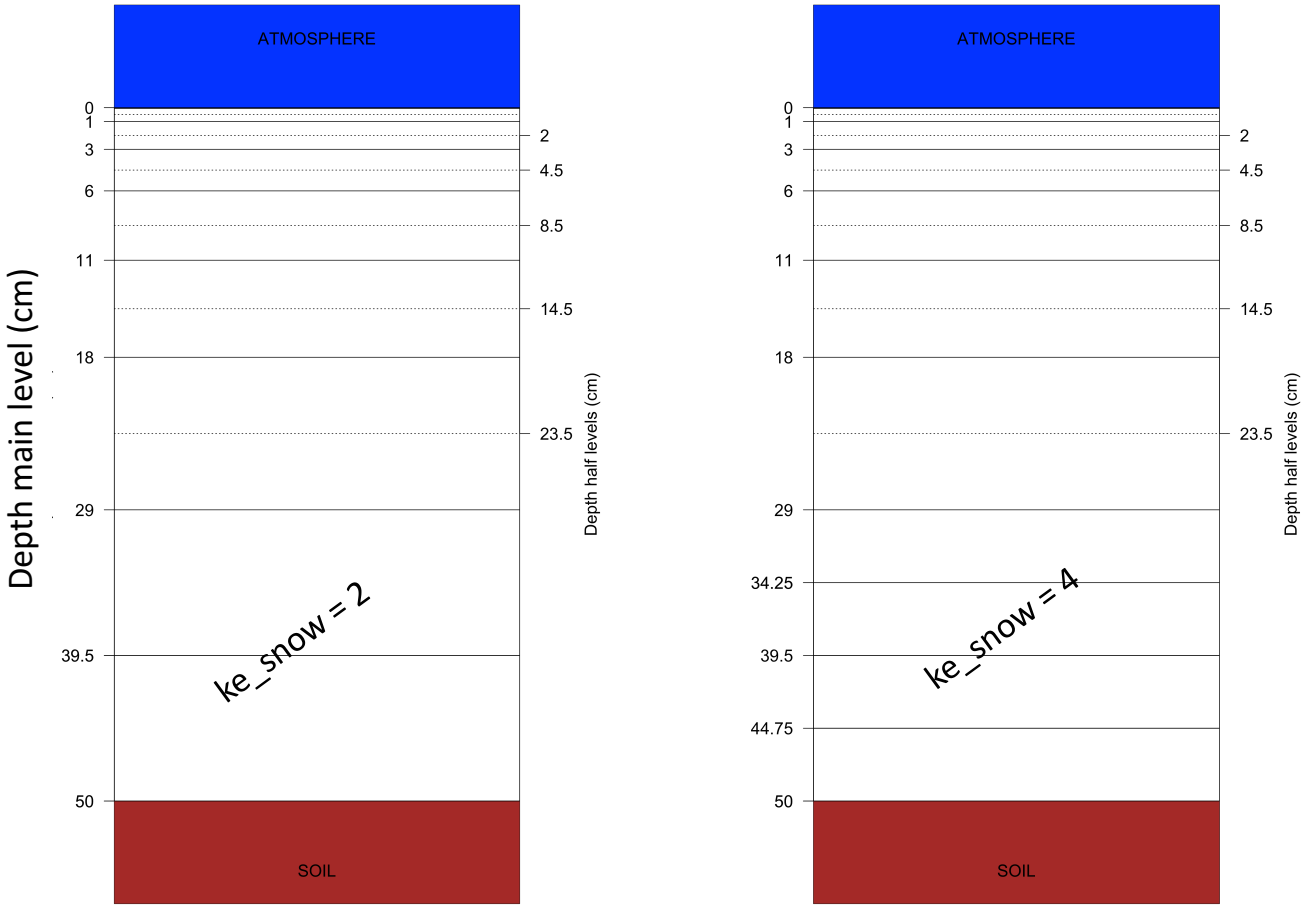


For snow height > 0.29 m:

$\Delta z_1 = 0.01$ m; $\Delta z_2 = 0.02$ m; $\Delta z_3 = 0.03$ m
$\Delta z_4 = 0.05$ m ; $\Delta z_5 = 0.07$ m ; $\Delta z_6 = 0.11$ m

$$\Delta z_{ke\_snow} = \frac{h_{snow} - 0.29}{ke_{snow}}$$

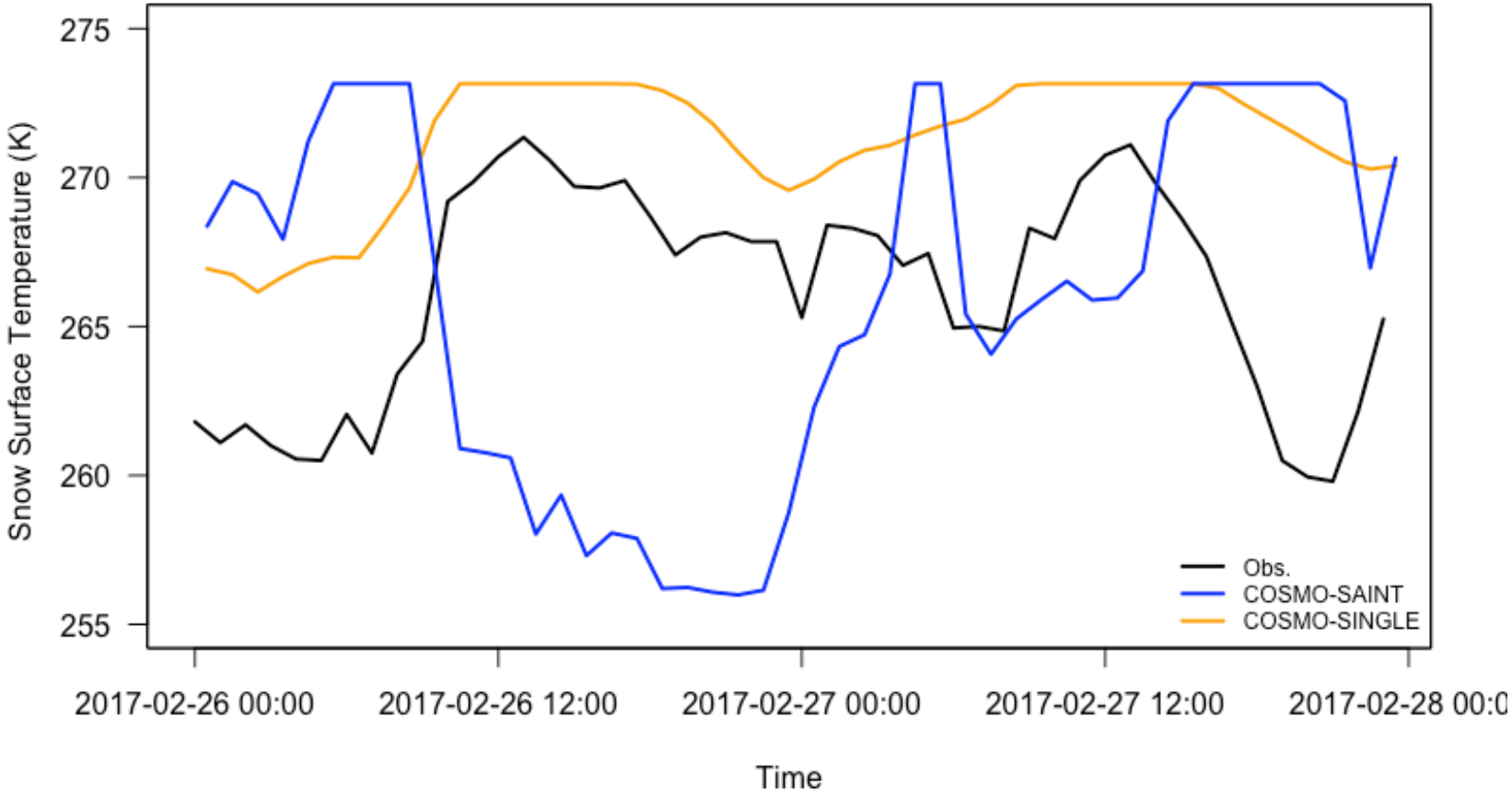
Phase II: Snow cover scheme schematic (SCS) – SAINT



Phase II: Proposed multi-layer snow cover scheme

- Code development based on COSMO version 5.04h including latest (?) developments by Matthias Raschendorfer.
- Call of a subroutine (*snow_on_soil*) in TERRA, which …
  - … uses a fixed number of snow layers (n_snow = 6) and an additional number of layers set by namelist (default ke_snow = 2)
  - … solves the heat equation for the whole column (snow + soil)
  - … calculates a snow specific atmospheric forcing (new albedo parameterization required).
  - … water transport (bucket) through snow column only (INTENT(OUT) > soil, runoff, storage(?))
  - … settling, absorption solar energy, dust on snow …
- Call of subroutine (snow_on_xxx) …

Phase II: Snow surface temperature comparison





Thanks!
Questions and/or comments?

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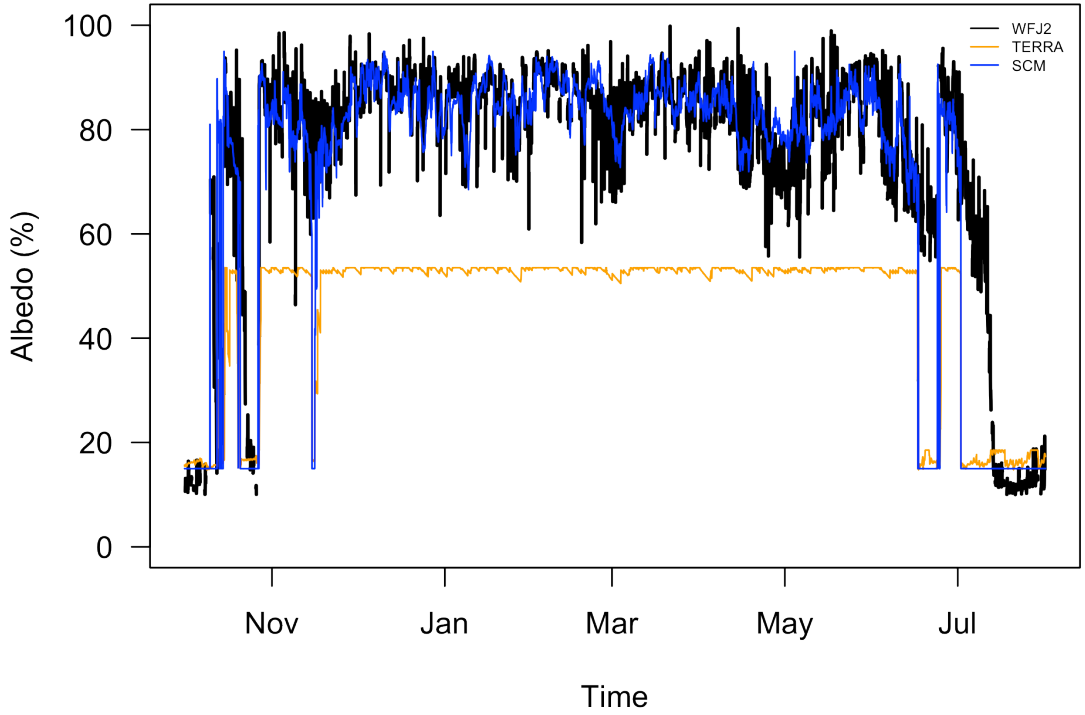
Open questions/issues (not in order) – SAINT

- How to handle impurities, e.g. **dust on snow**? Surface layer, i.e. albedo change only, vs. layer property?
- Sum of 'top' layers should be 'thick' enough to handle **absorption of solar radiation**. 'Prime number' thickness distribution $\Delta z_{1\text{-}5}$ = 1,2,3,5,7,11 cm = 29 cm OR fixed Δz_1 = Δz_2= 1 cm and 'log-thickness', i.e. increasing with depth of Δz_{ke_snow} layers.
- What about **snow on glaciers, permafrost and sea/lake-ice**?
- Water transport? Bucket vs. Richardson
- Snow in urban areas negligible? How does that work anyways?
- **Initialization of snow cover**, i.e. layer properties? Prior COSMO/ICON run vs. 'cold' start using e.g. SWE with constant density, dry snow, a linear temperature profile, i.e. **MCH snow analysis.**
- **Snow/Canopy interactions**, i.e. trees, shrubs etc.

Albedo model – SAINT

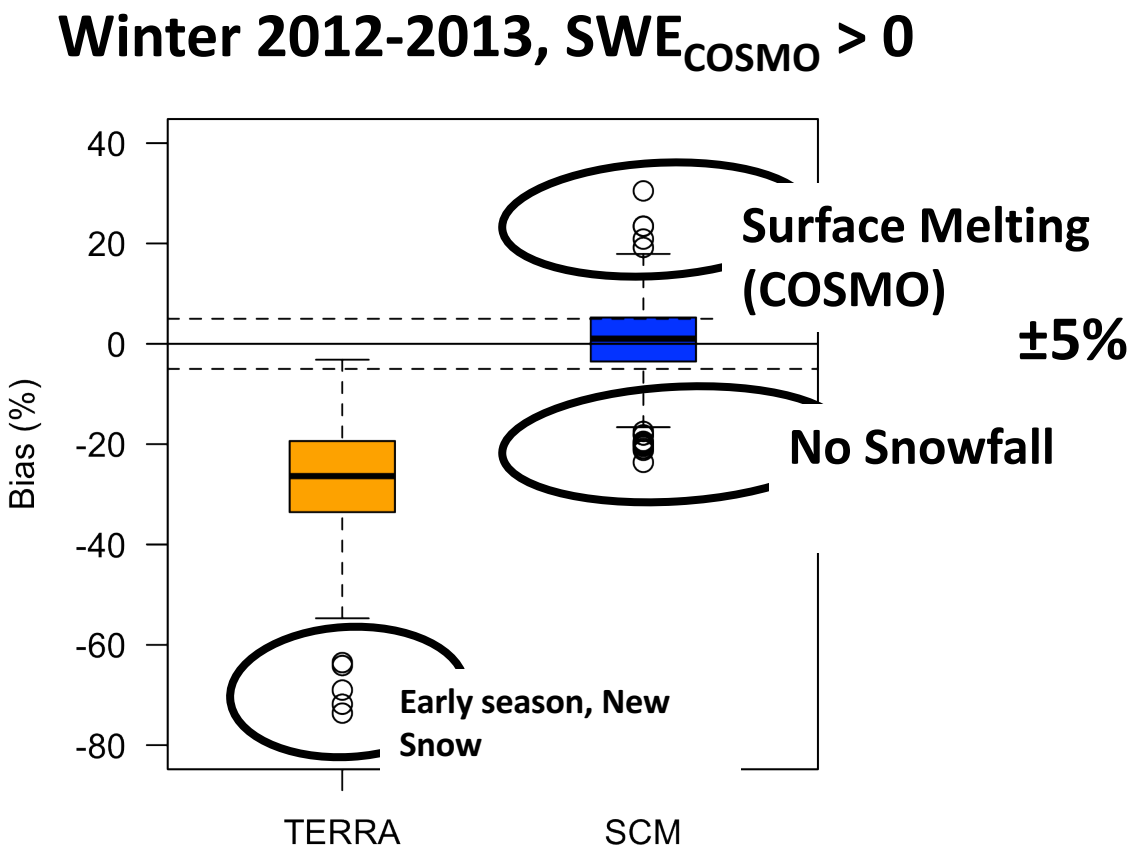
$$\alpha_{SCM} = a + b \times P_{rate} + c \times T_{SFC} - d \times T_{10m}$$



P_{rate} = Precipitation Rate
T_{SFC} = Snow Surface Temperature

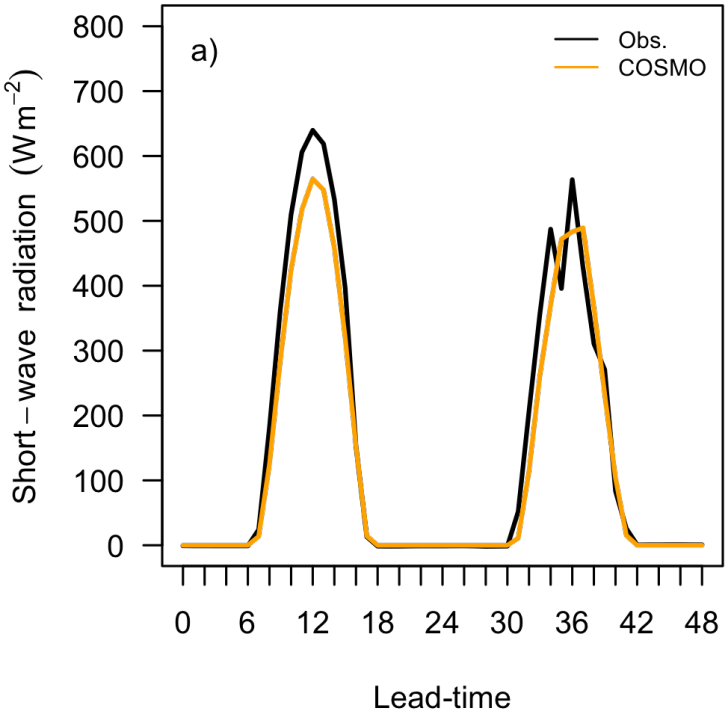
T_{10m} = Air Temperature 10 m

Albedo model – SAINT

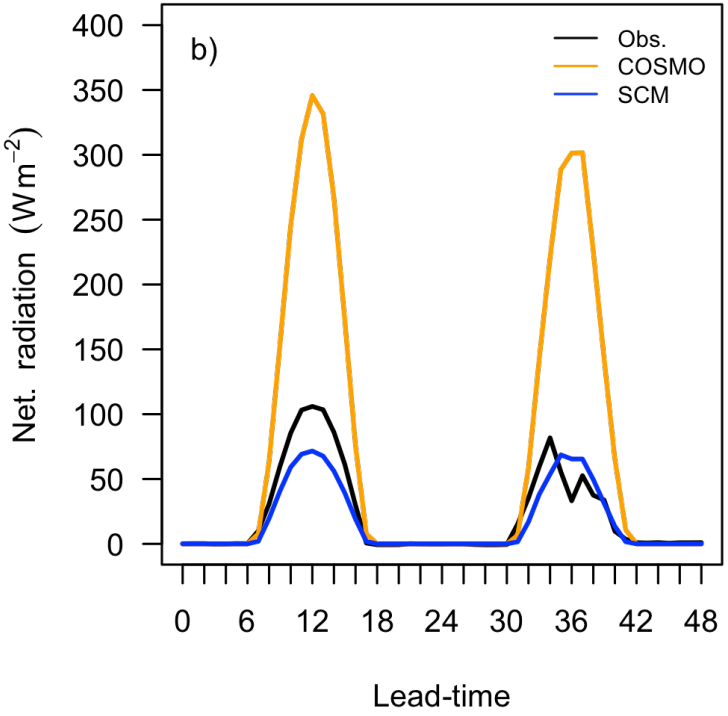


Short-wave radiation - COSMO-2 (WFJ)

Incoming



Net.



Diffuse radiation – COSMO-2 (WFJ)