Project SAINT: Experience with TERRA_ML:

Sascha Bellaire

Offenbach, 10.03.2017

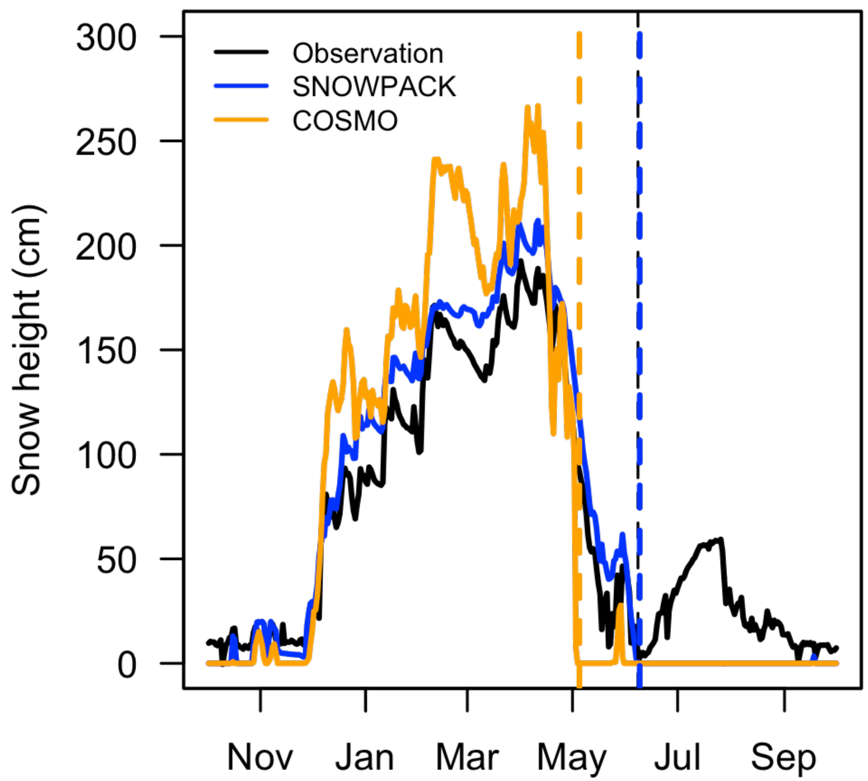
WSL Institute for Snow and Avalanche Research SLF

Project SAINT: Goals

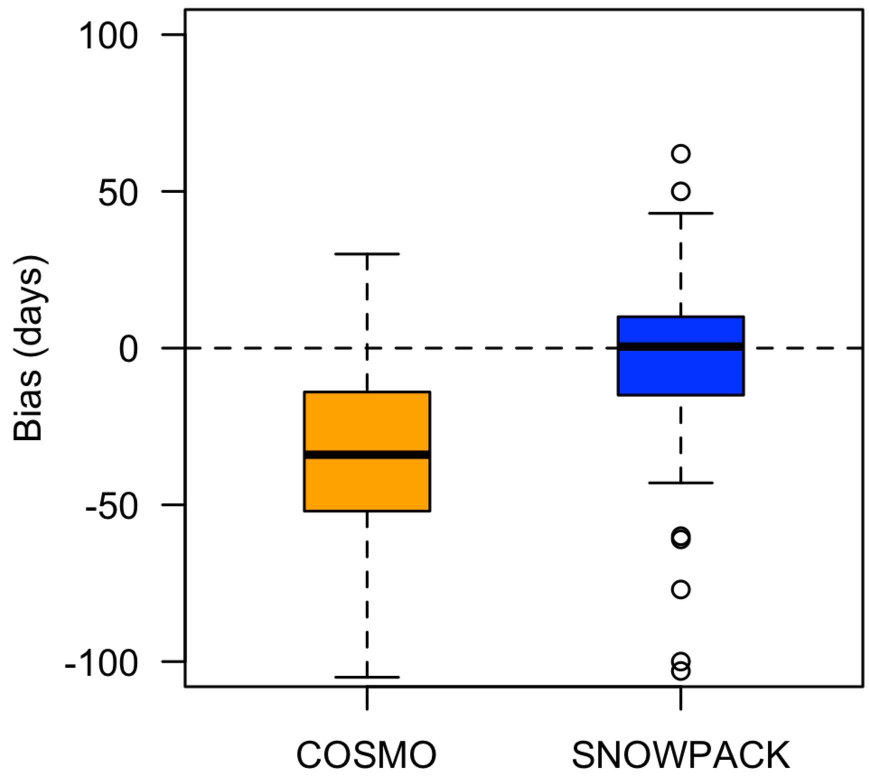
Project SAINT: Goals

Project SAINT: Snow height comparison

Weissfluhjoch

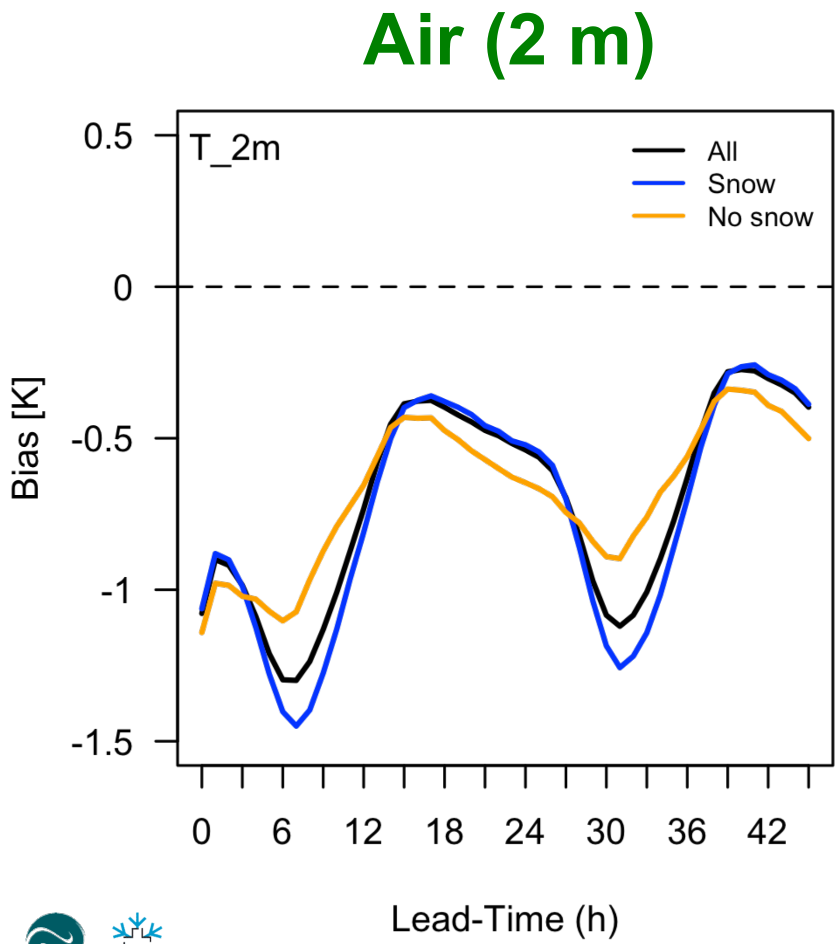


IMIS



WSL Institute for Snow and Avalanche Research SLF

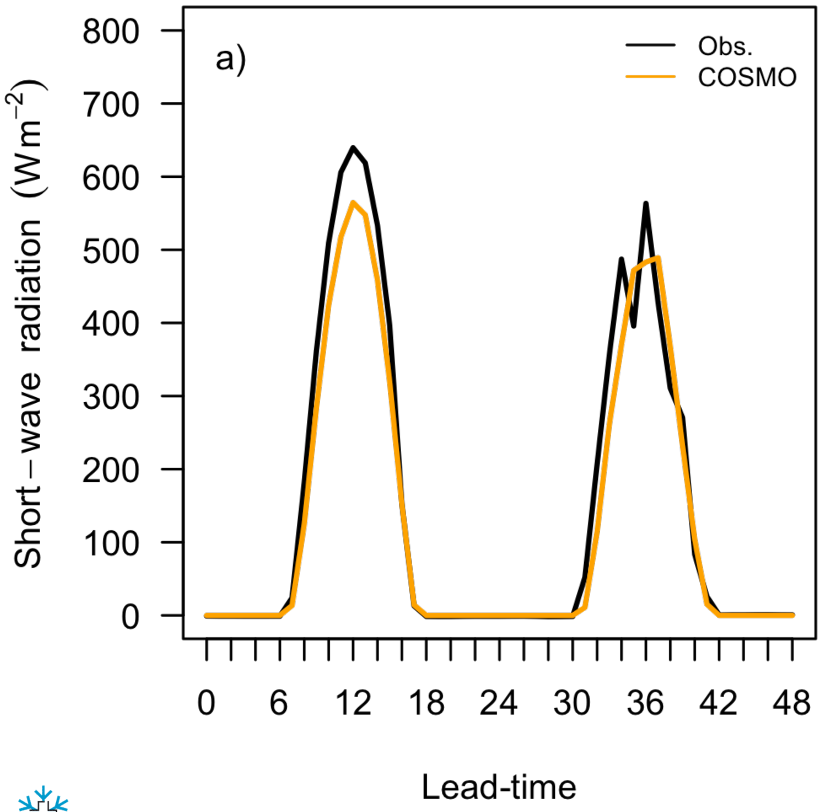
Project SAINT: Air Temperature Bias (IMIS)



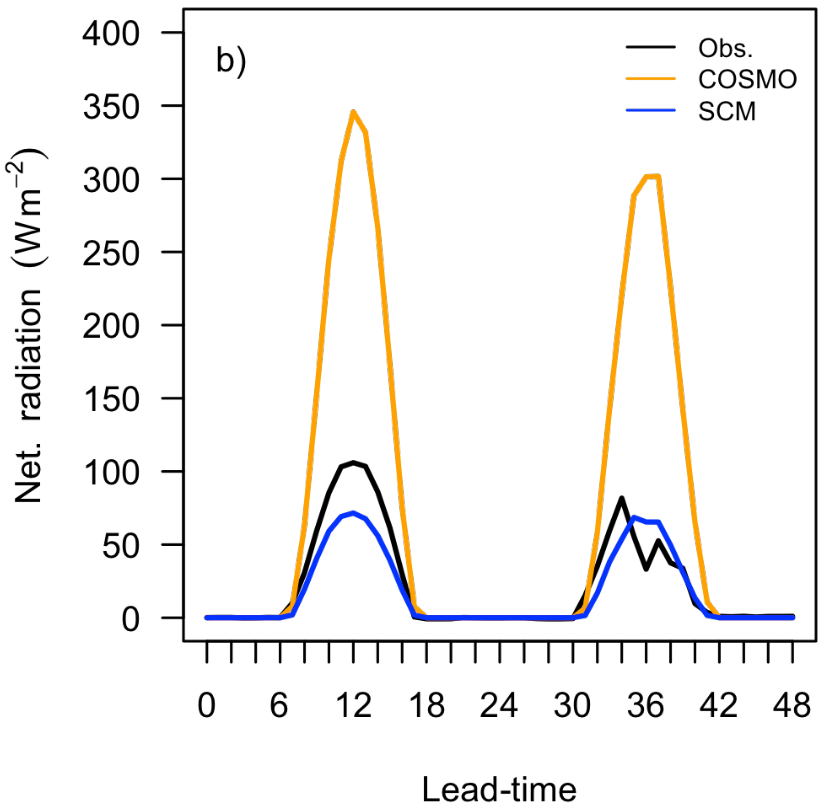
- 100+ IMIS stations
- Sep. 2012 – Oct. 2013
- Operational (MeteoSwiss) 03 UTC run

Project SAINT: Short-wave radiation (WFJ)

Incoming

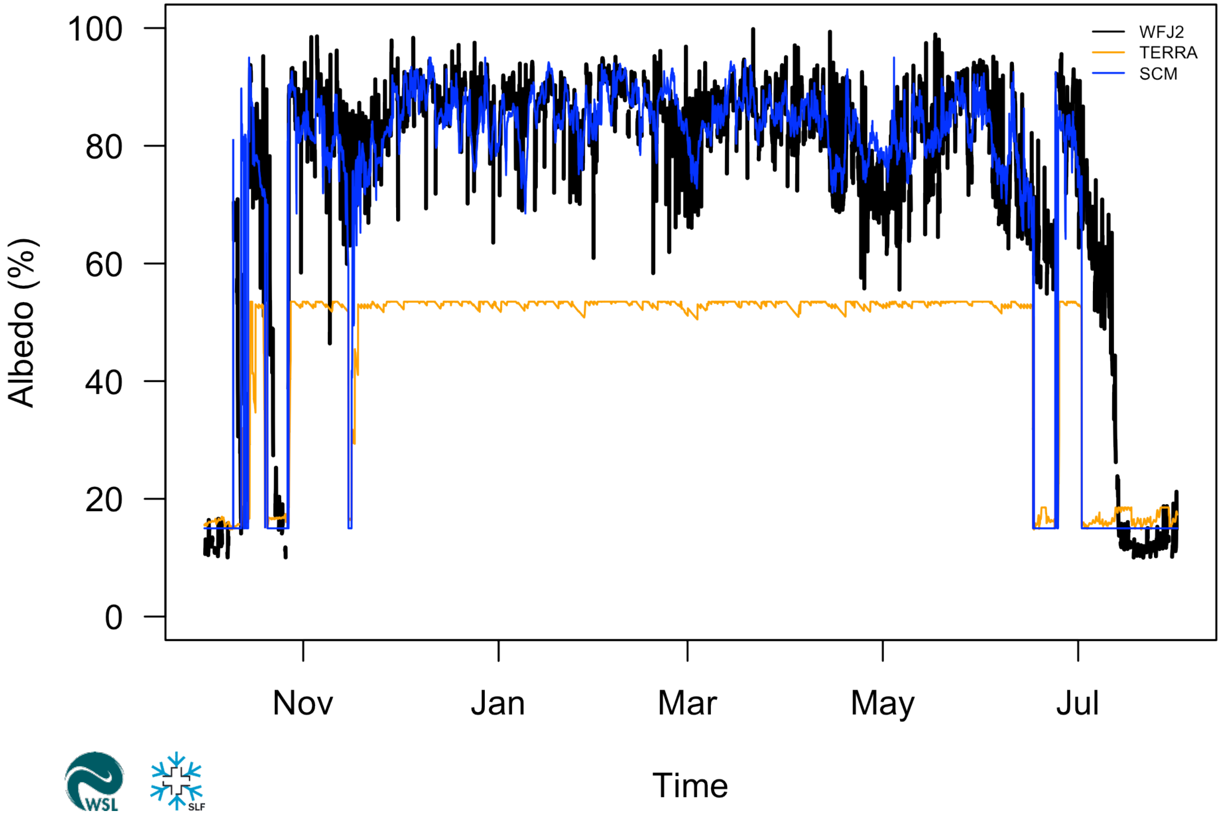


Net.



Project SAINT: Albedo model (WFJ)

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



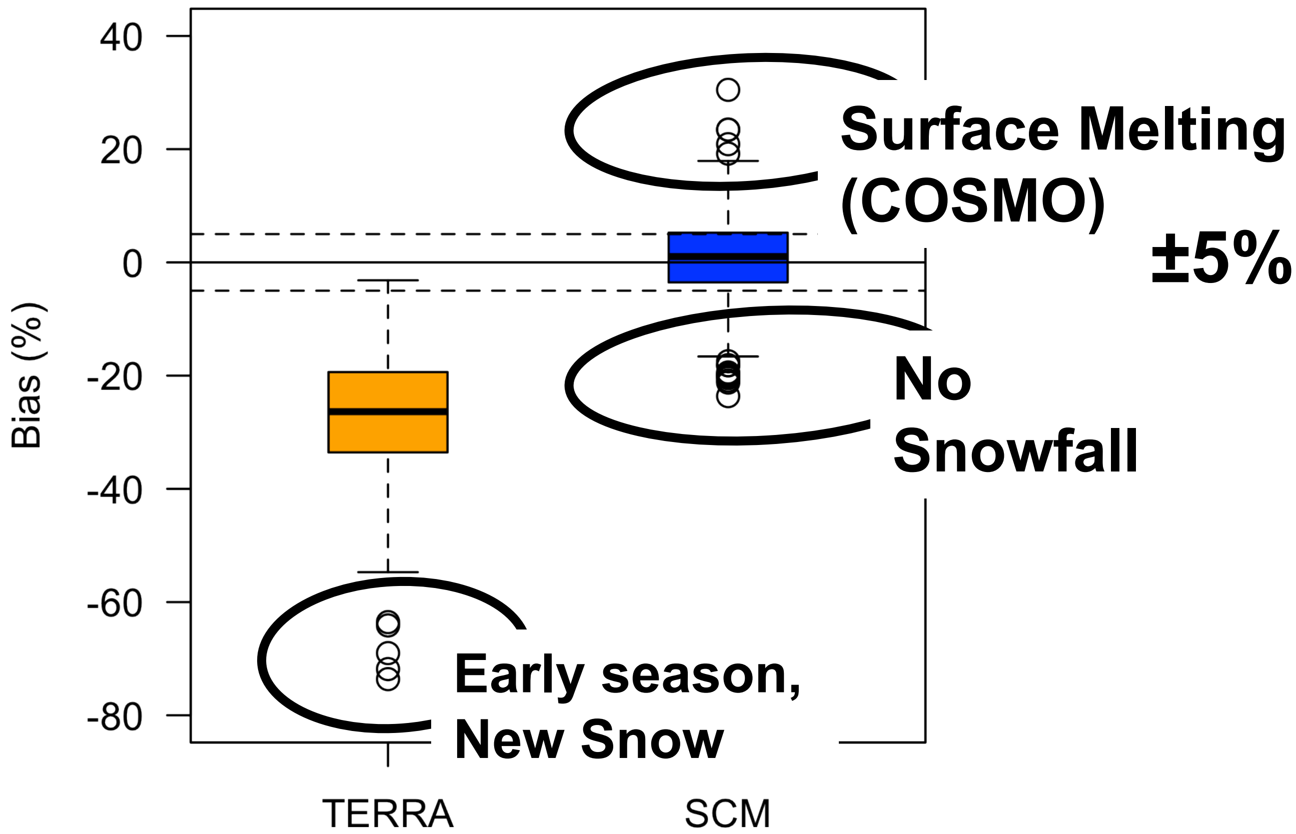
P_{rate} = Precipitation Rate

T_{SFC} = Snow Surface Temperature

T_{10m} = Air Temperature 10 m

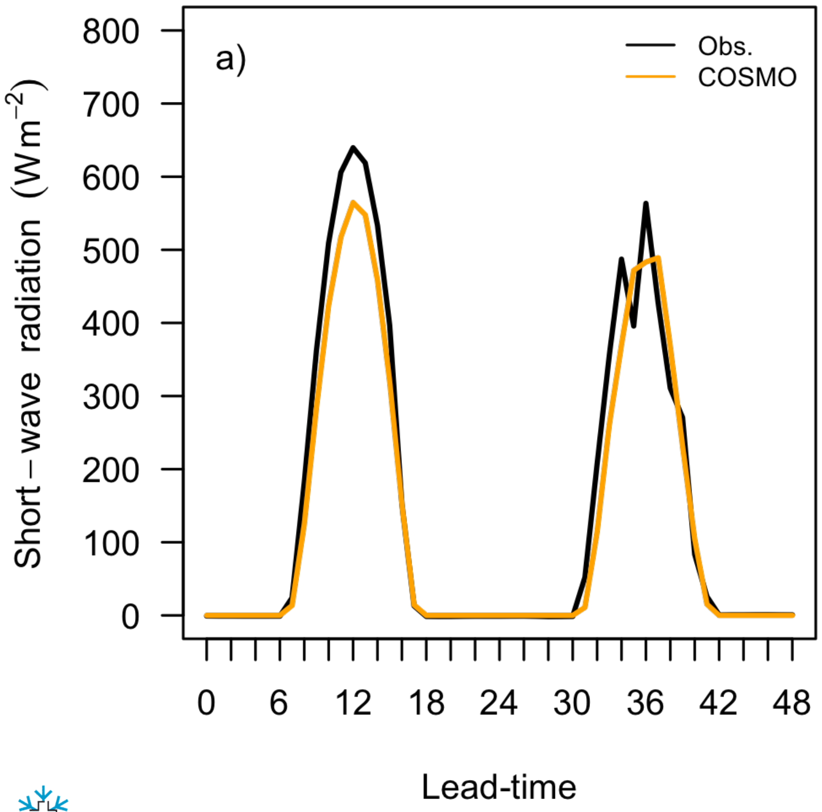
Project SAINT: Albedo model (WFJ)

Winter 2012-2013, $SWE_{COSMO} > 0$

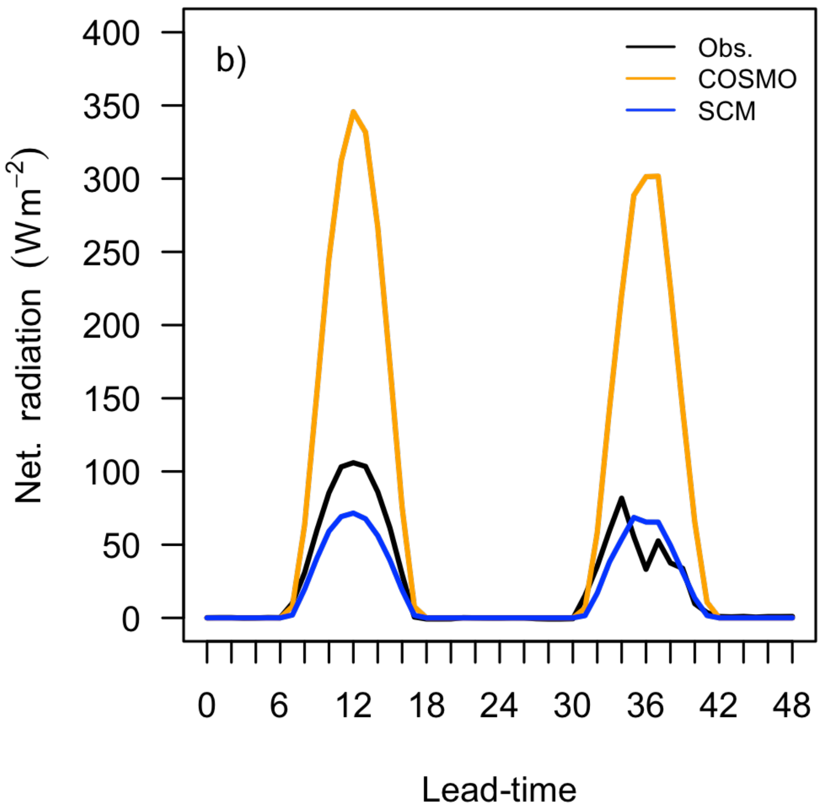


Project SAINT: Short-wave radiation (WFJ)

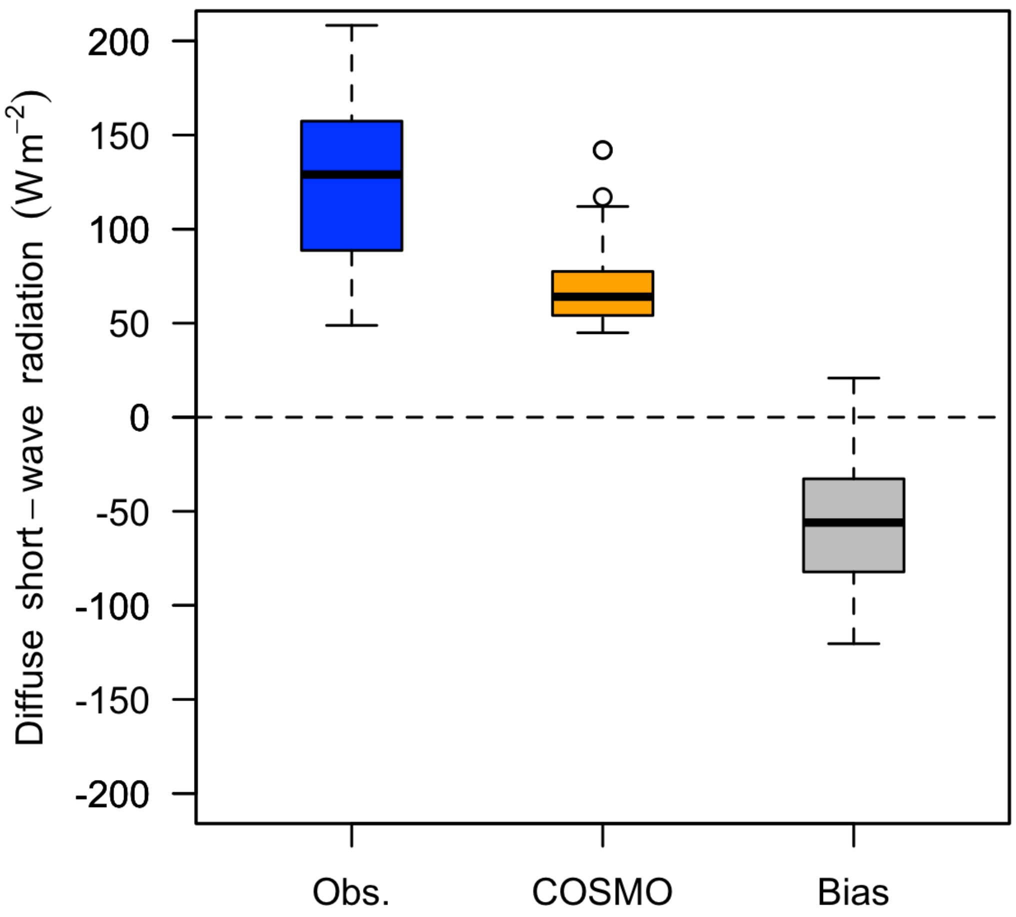
Incoming



Net.



Project SAINT: Diffuse radiation (WFJ)



Project SAINT: Surface Energy Balance

Radiation (Net.):

$$Q_S^* = SW_{IN} - SW_{OUT}$$

$$Q_L^* = LW_{IN} - LW_{OUT}$$

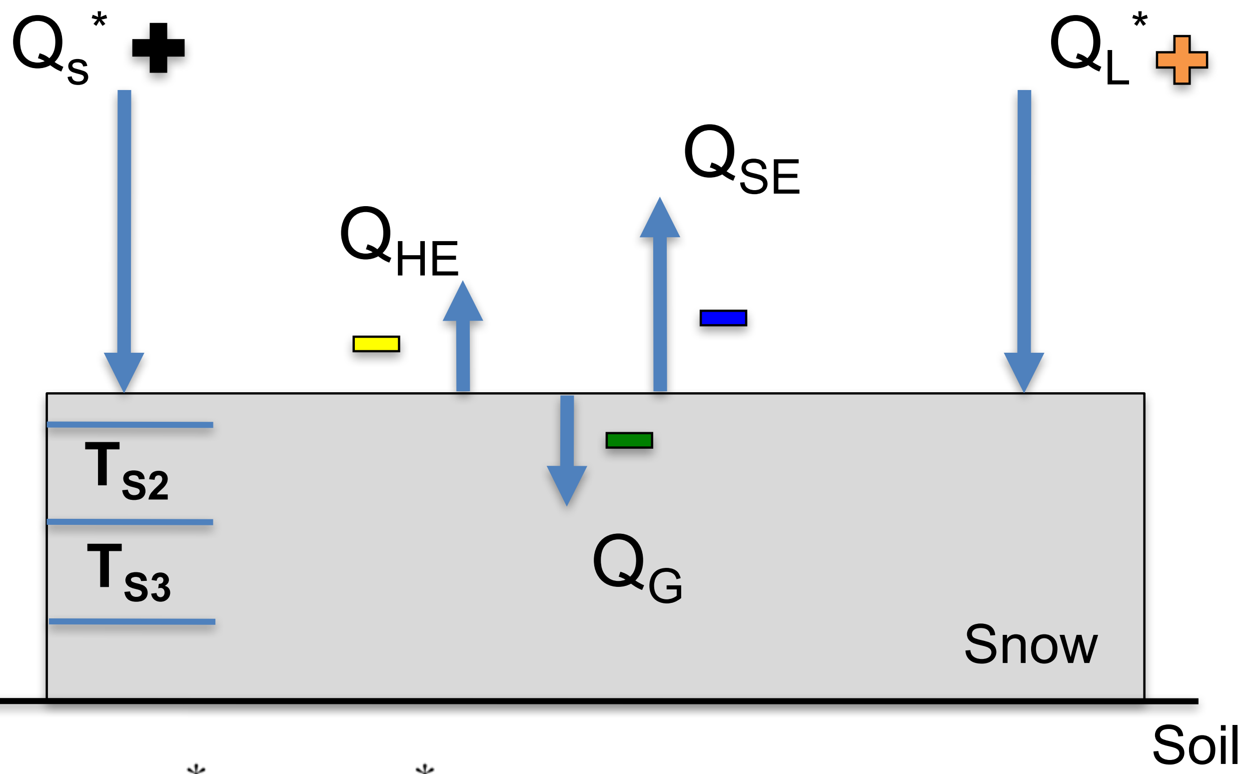
Turbulent Fluxes:

$$Q_{HE} = C_1 \times \left(q_{top} - q_{bot}\right)$$

$$Q_{SE} = C_2 \times \left(T_{top} - T_{bot}\right)$$

Ground Heat Fluxes:

$$Q_G = -C_3 \times \left(T_{S3} - T_{S2}\right)$$



Energy Balance:

$$Q_S^* = -Q_L^* - Q_{HE} - Q_{SE} + Q_G$$

$$Q_S^* + Q_L^* + Q_{HE} + Q_{SE} - Q_G = 0$$

Project SAINT: Solving Heat Equation

One dimensional heat-equation:

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2} \qquad 0 \le x \le L, \quad t \ge 0$$

$$\alpha = \frac{\lambda}{\rho c_p}$$

Forward Time, Centered Space:

$$T_i^{m+1} = rT_{i+1}^m + (1 - 2r)T_i^m + rT_{i-1}^m$$

$$r = \frac{\alpha \Delta t}{\Delta x^2}$$

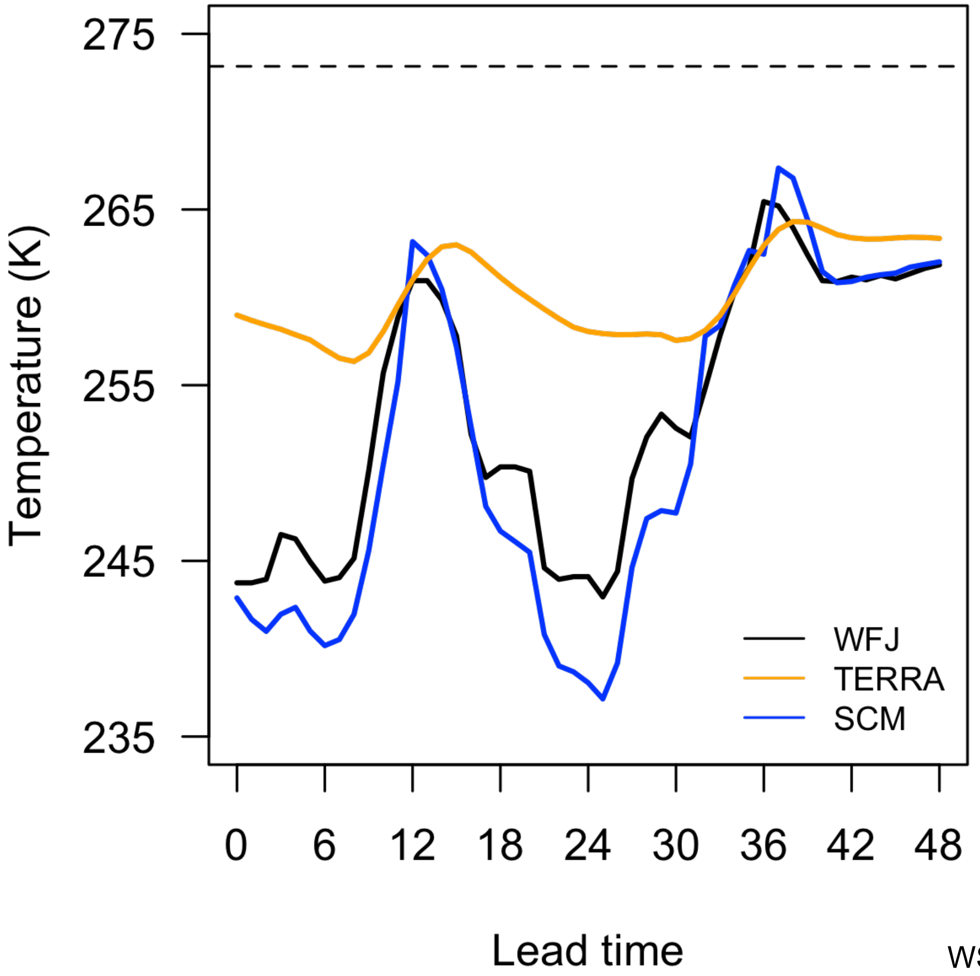
Thermal conductivity

$$\lambda = 2.0 \times 10^{-2} + \left(2.5 \times 10^{-6} \times \rho^2\right)$$

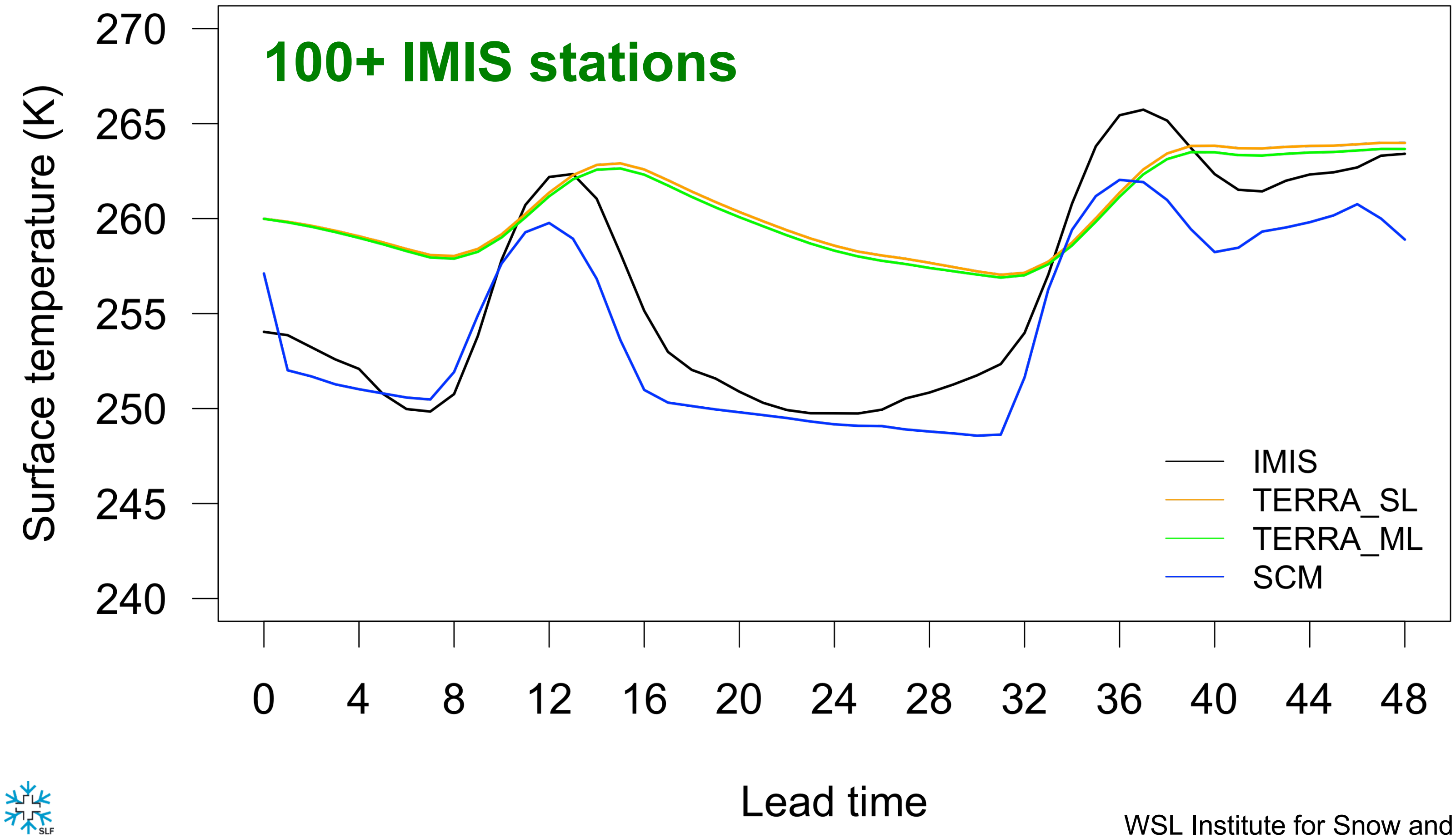
layer index = i *density ρ*

time index = m *Specific heat of ice; c_p = 2105 J kg^{-1} K^{-1}*

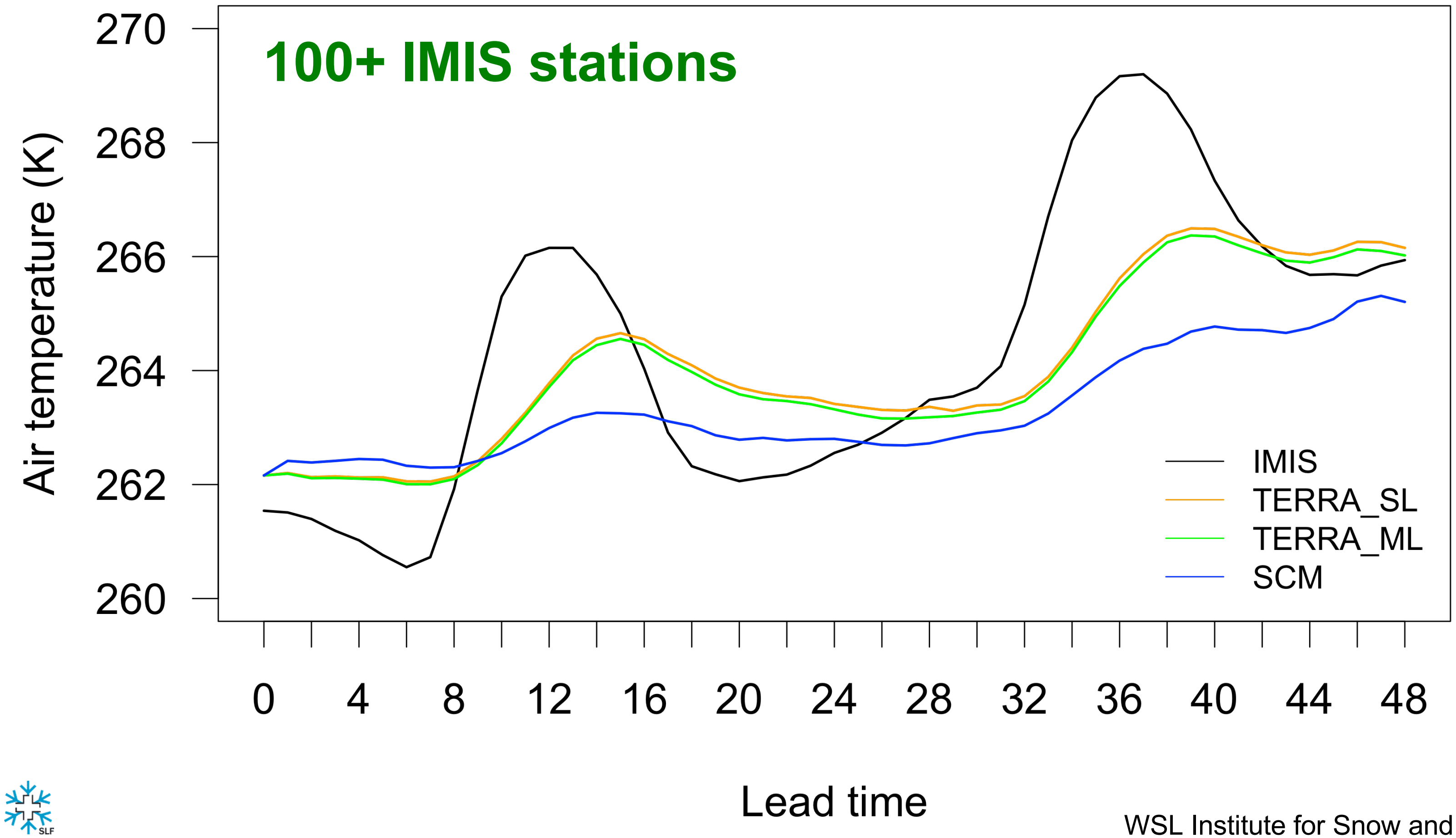
Project SAINT: Surface Temperature (WFJ-SCM$_{offline}$)



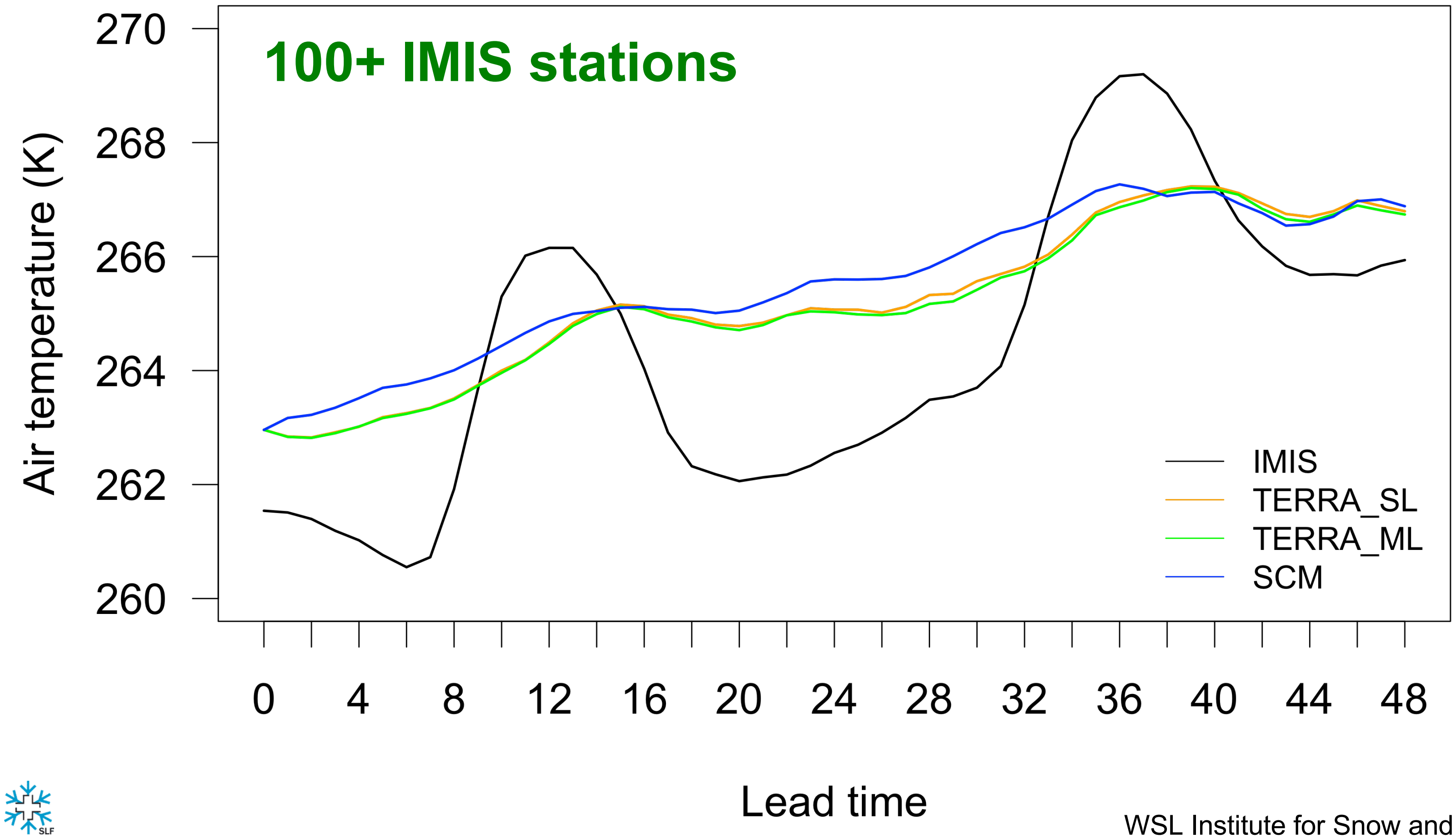
Project SAINT: Surface Temperature (SCM_{online})



Project SAINT: 2 m air temperature (SCM_{online})



Project SAINT: 10 m air temperature (SCM_{online})



Future Work: ‘Minimum’ ToDo’s

Near surface processes:

- Turbulence (stability corrections, CH_{min} …)
- Radiation (diffuse radiation, sub-grid scale parameterizations …)
- 2 m diagnostics
- Weighted temperature approach (snow covered vs. non snow covered areas)
- Snow redistribution
- ...

Snow cover model:

- Phase changes (melt-refreeze
- Water transport
- Settling (densification)
- New snow density
- Absorption (solar radiation)
- …

Thoughts, comments?

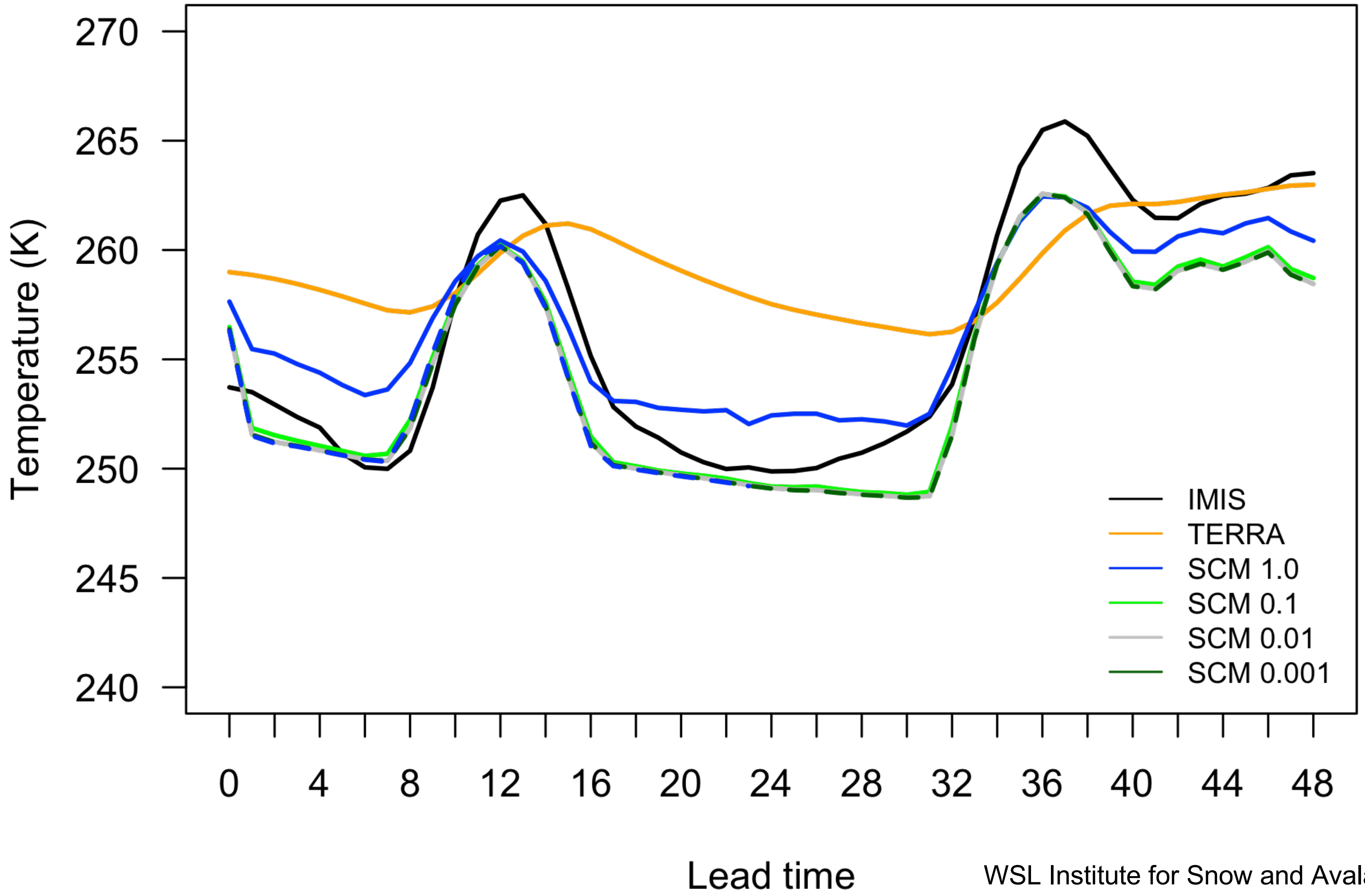
Sascha Bellaire

Offenbach, 10.03.2017

Discussion points:

- Is an improved snow cover scheme needed?
- What needs to be improved from an operational point of view?
- On which scale is a snow cover scheme required? Local, regional, global?
- Snow cover scheme for ICON?
- …

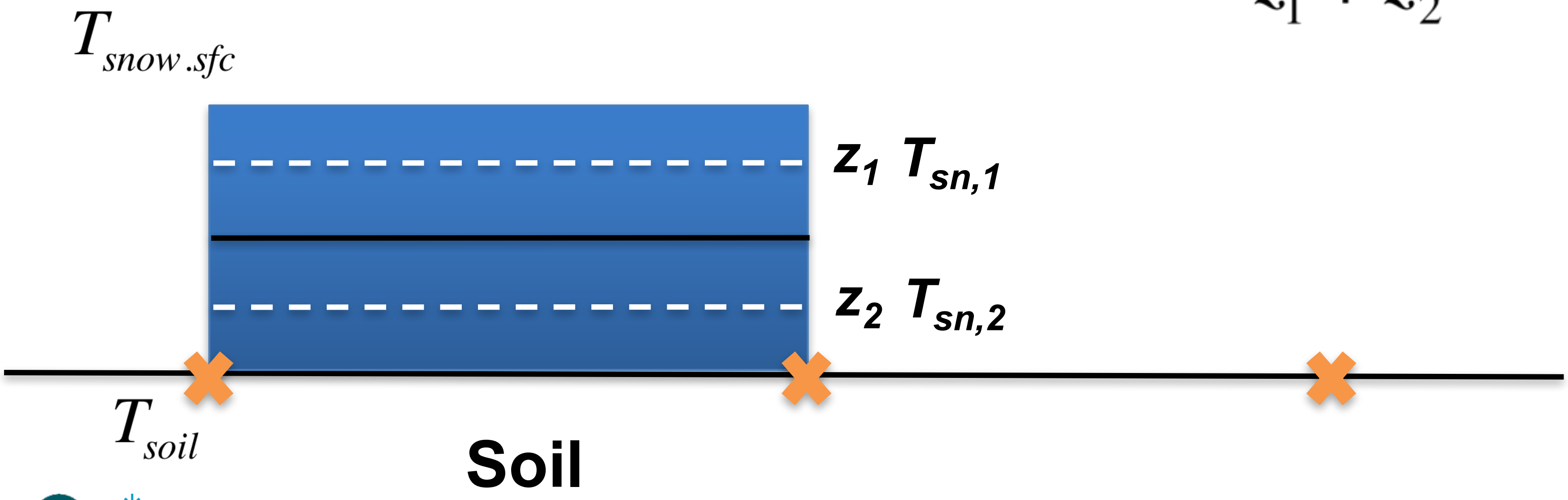
Project SAINT: Surface Temperature (SCM_{online})



Project SAINT: TERRA_ML

Snow surface temperature by linear extrapolation:

$$T_{snow,sfc} = \frac{T_1 \cdot (2z_1 + z_2) - T_2 \cdot z_2}{z_1 + z_2}$$



Project SAINT: TERRA_ML

Snow Temperature T_{sn}

$$\rho_{sn}\frac{\partial T_{sn}}{\partial t} = \frac{\partial}{\partial z}\lambda_{sn}\frac{\partial T_{sn}}{\partial z} + L_f(F - M) - \frac{\partial R}{\partial z}$$

Liquid Water W_{liq}

$$\frac{\partial W_{liq}}{\partial t} = M - F - \frac{\partial q}{\partial z}$$

Total Water (SWE) W_{tot}

$$\frac{\partial W_{tot}}{\partial t} = -\frac{\partial q}{\partial z}$$

Snow density ρ_{sn}

$$\frac{\partial \rho_{sn}}{\partial t} = \frac{\rho_{sn}}{W_{tot}}\left(-\frac{\partial q}{\partial z}\left(1 - \frac{\rho_{sn}}{\rho_w}\right) + \rho_{sn}\frac{\rho_w - \rho_i}{\rho_w \rho_i}(M - F)\right) + \sigma(t)$$