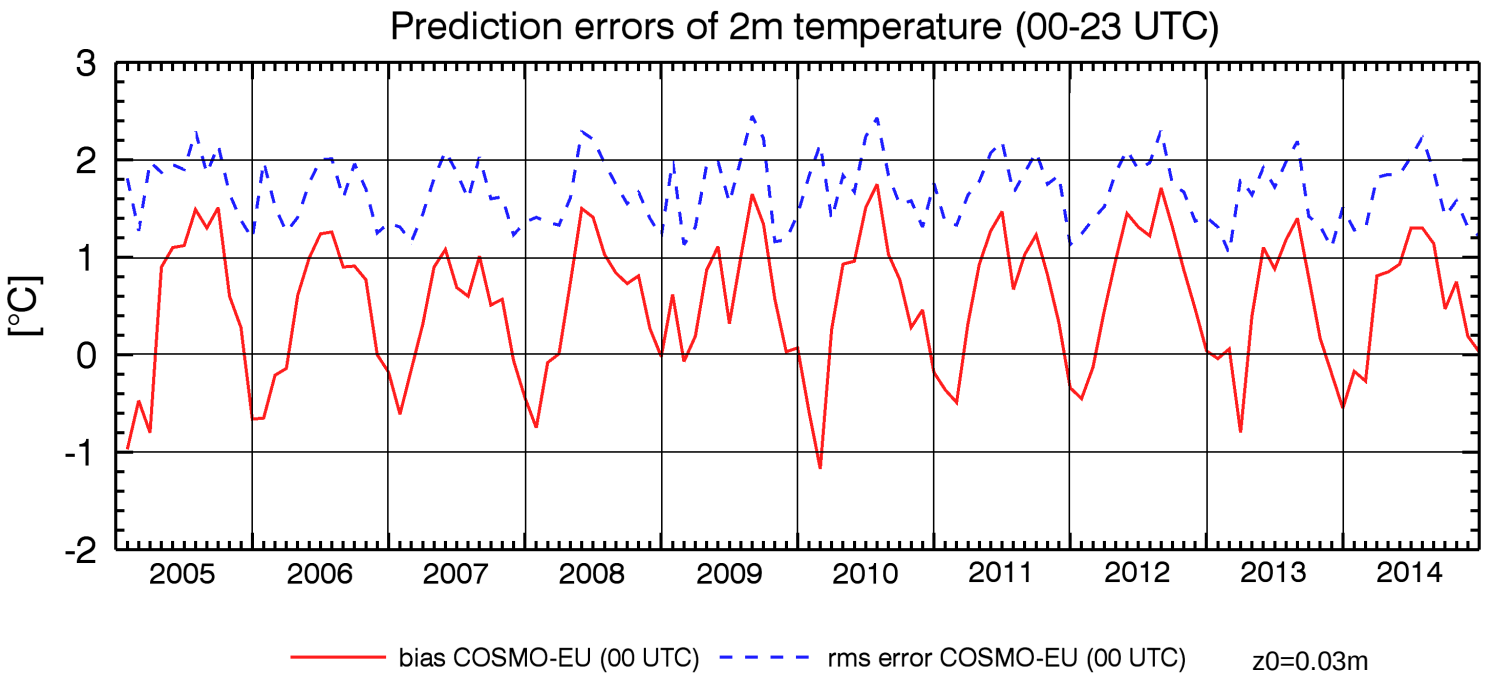
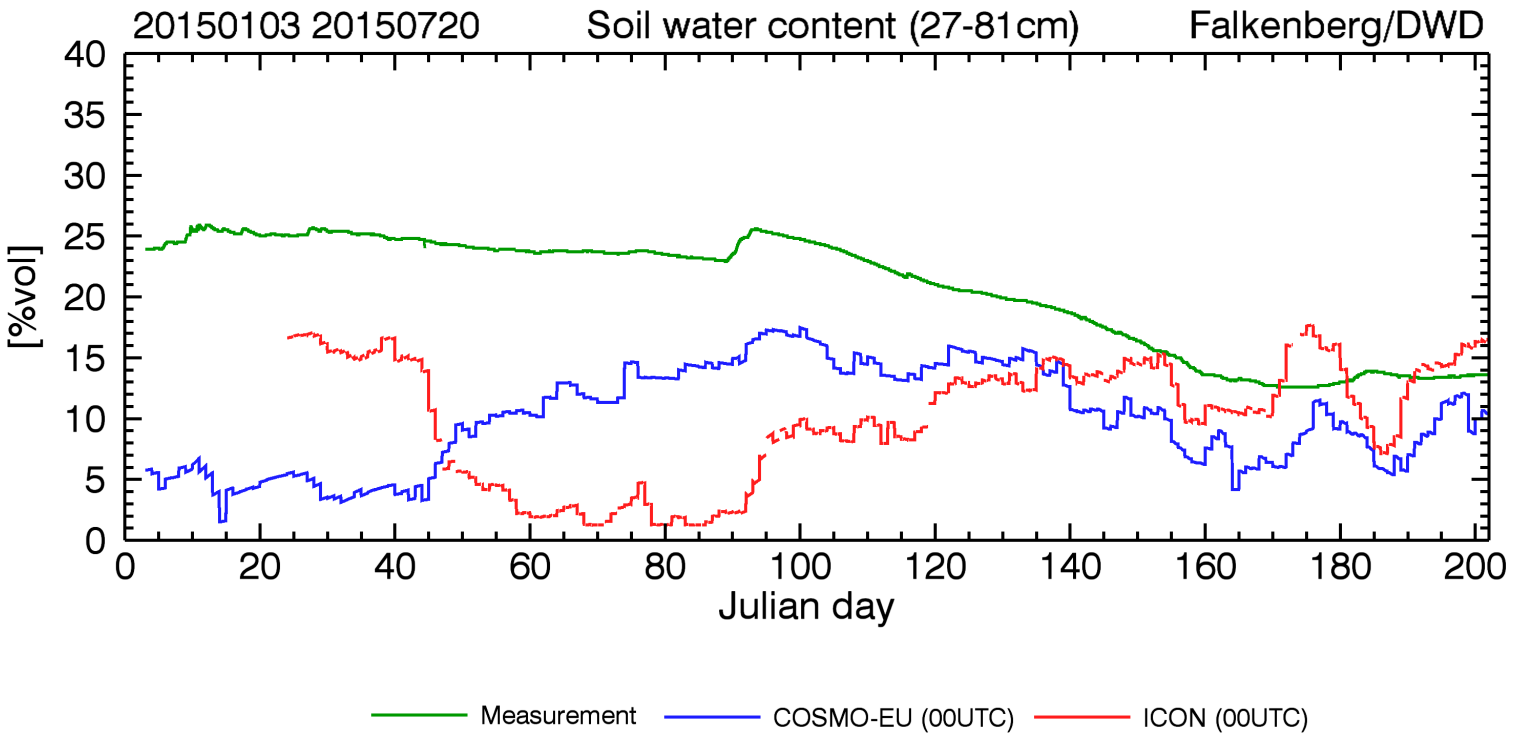
Model studies on the insulating effect of vegetation on soil temperatures at the Falkenberg site

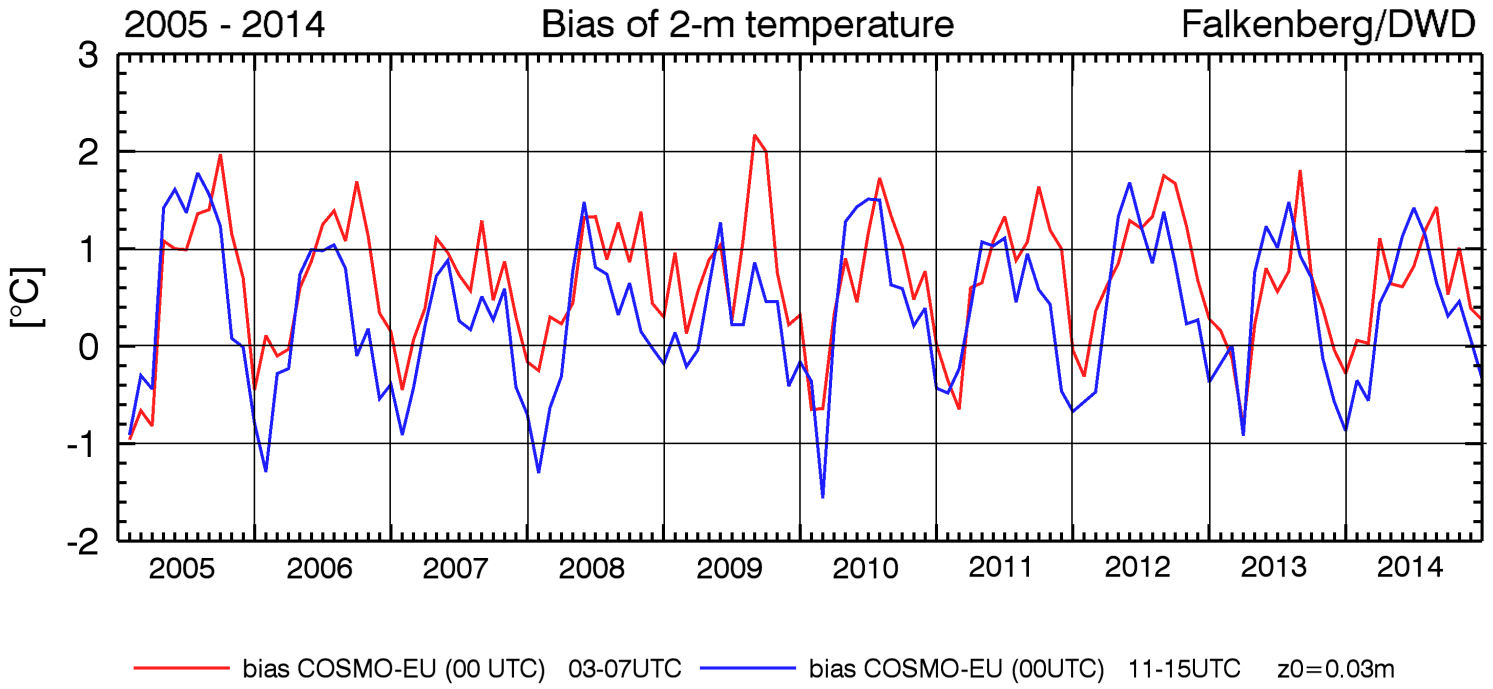
G. Vogel, P. Shrestha, M. Breil, J.-P. Schulz and N. Laube



- COSMO-EU: warm bias summer, cold bias winter
- Rms error shows seasonal cycle



January-May 2015: COSMO-EU and ICON too dry because Soil Moisture Analysis (SMA) tries to correct for cold bias



Daily minimum temperatures show higher warm bias than daily maximum temperatures

Motivation

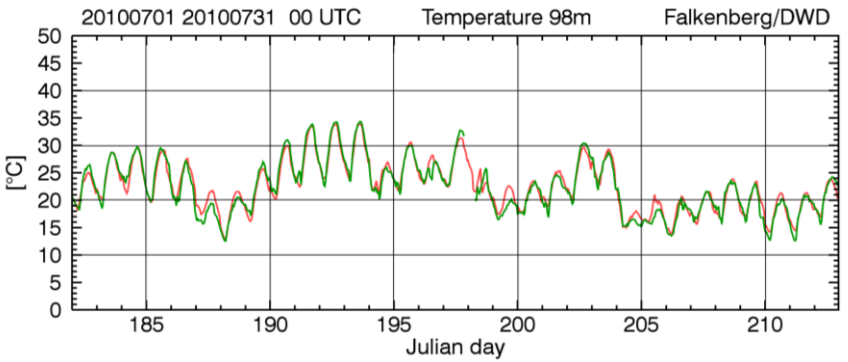
- High importance of 2-m temperature for many decisions in daily life
- Long-lasting systematic temperature biases in annual cycle in all DWD forecast models
- Due to its role for the energy and water budget a more realistic soil moisture simulation is needed.
- Reducing systematic model errors would avoid artifical soil moisture adjustment.

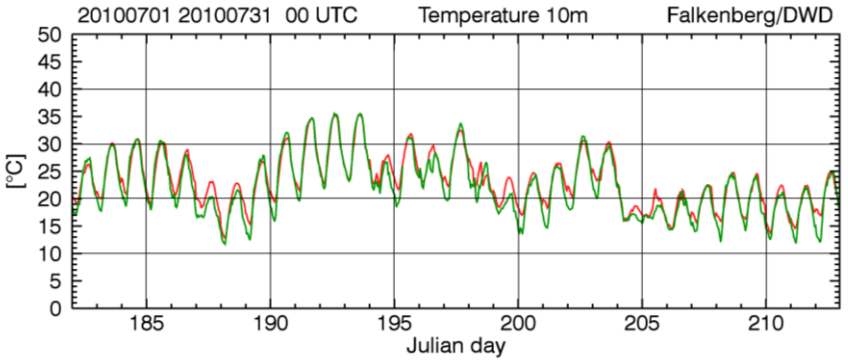
July 2010

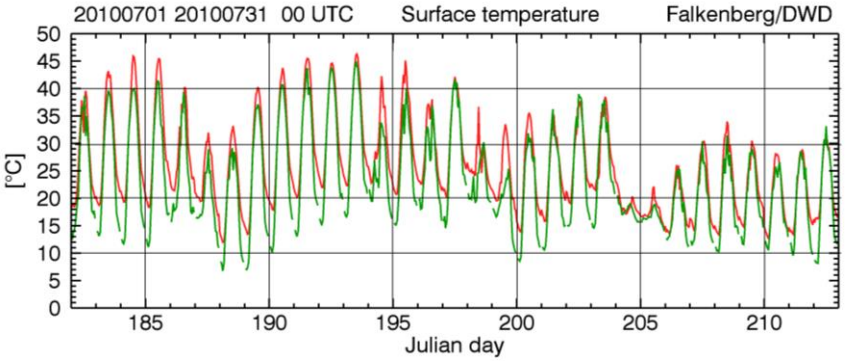
Warm bias

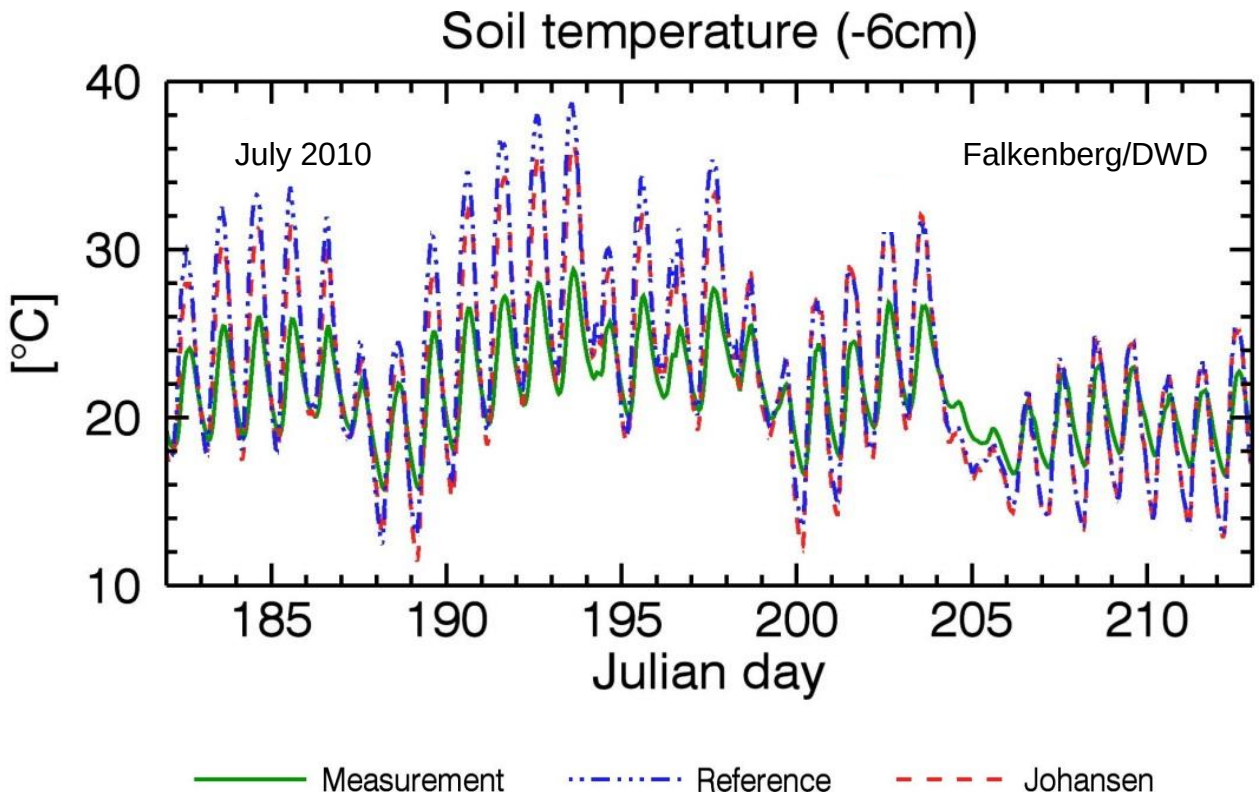
Measurement

COSMO-EU



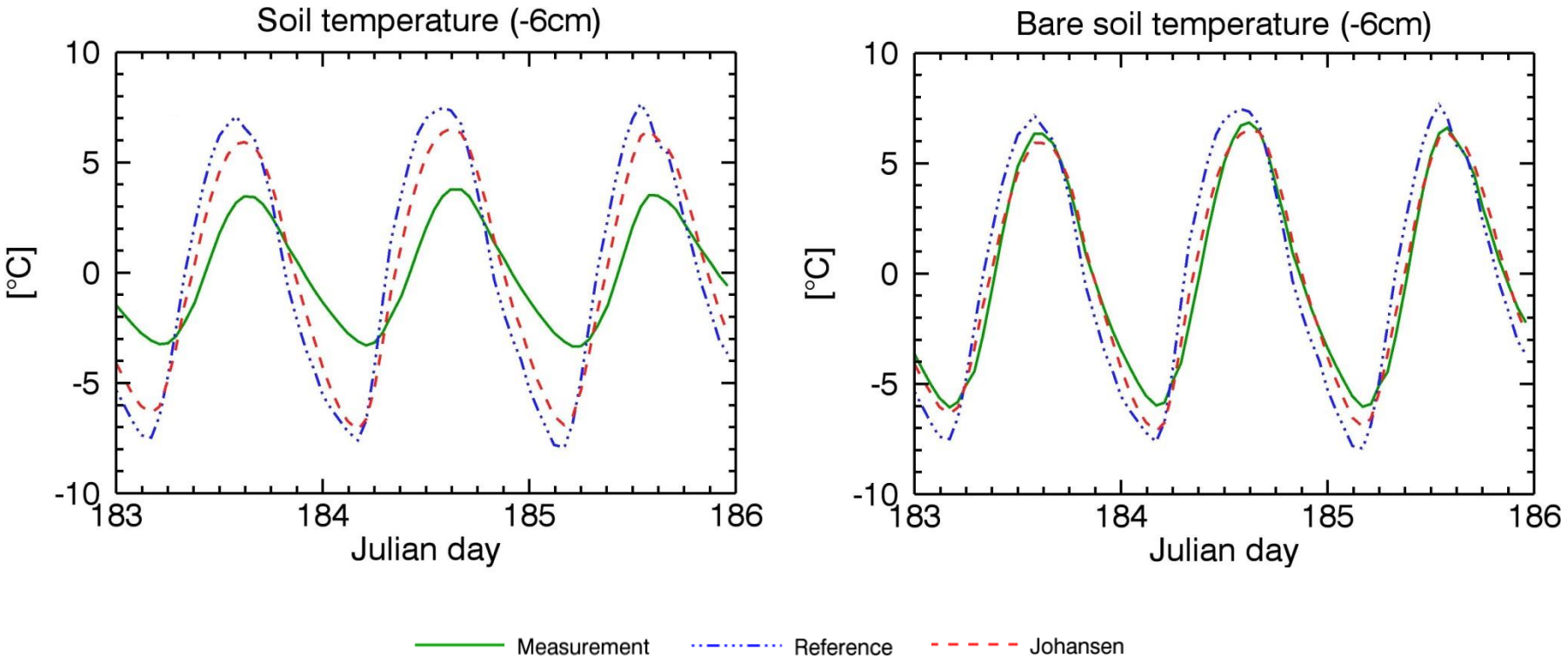




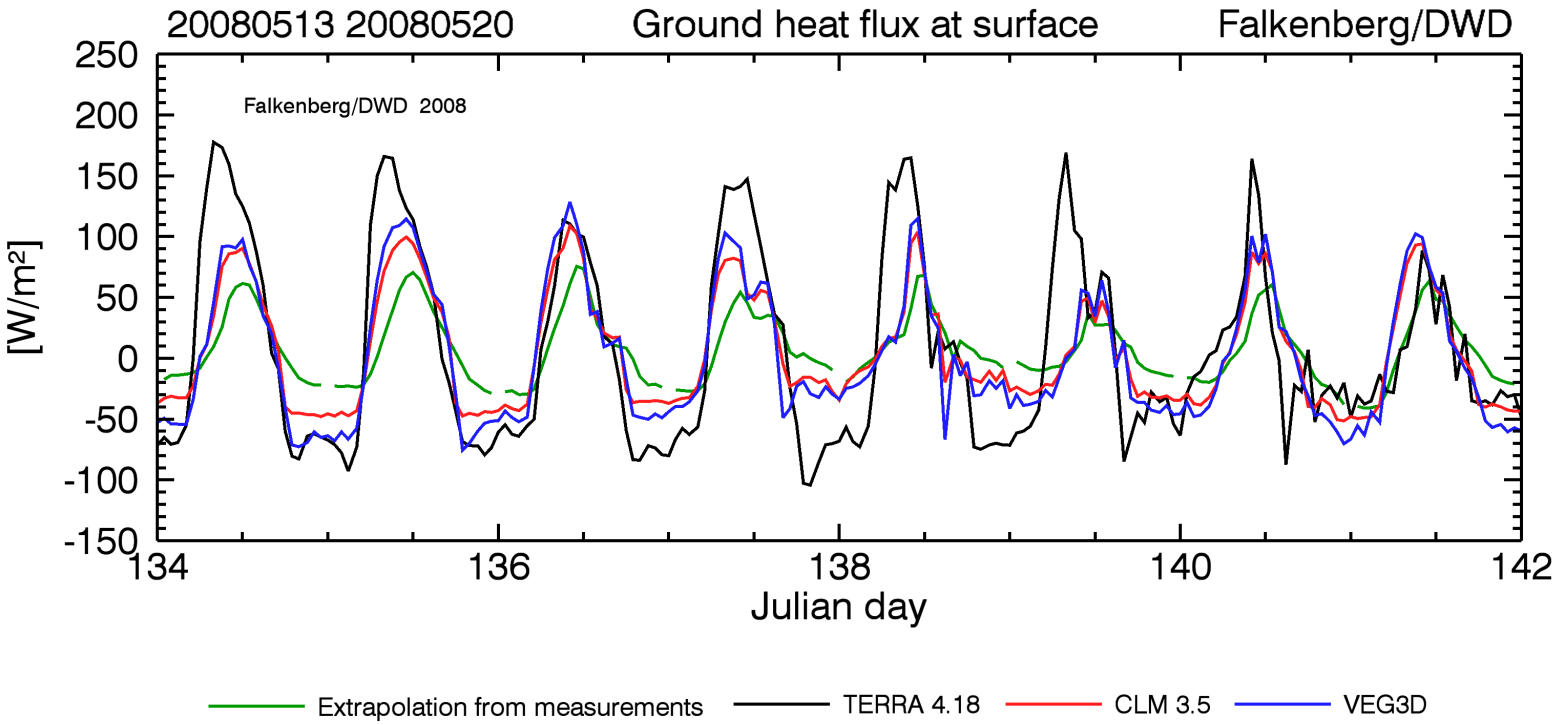


Reference: soil thermal conductivity kept constant
Johansen: soil moisture-dependent approach, therefore more realistic

Falkenberg/DWD 02-04 July 2010

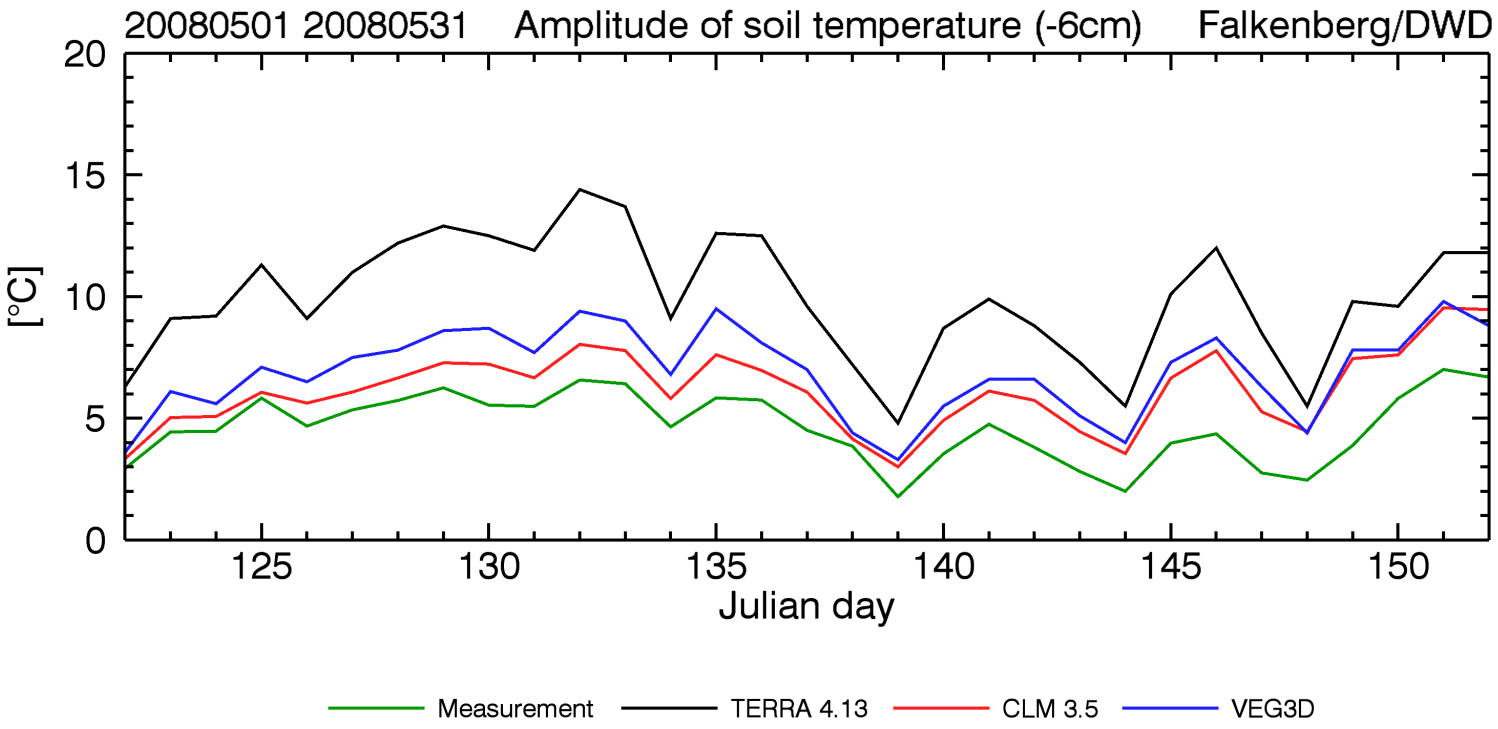


Schulz, J.-P. et al.: Evaluation of the ground heat flux simulated by a multi-layer land surface scheme using high-quality observations at grass land and bare soil (in revision at Met. Z.)

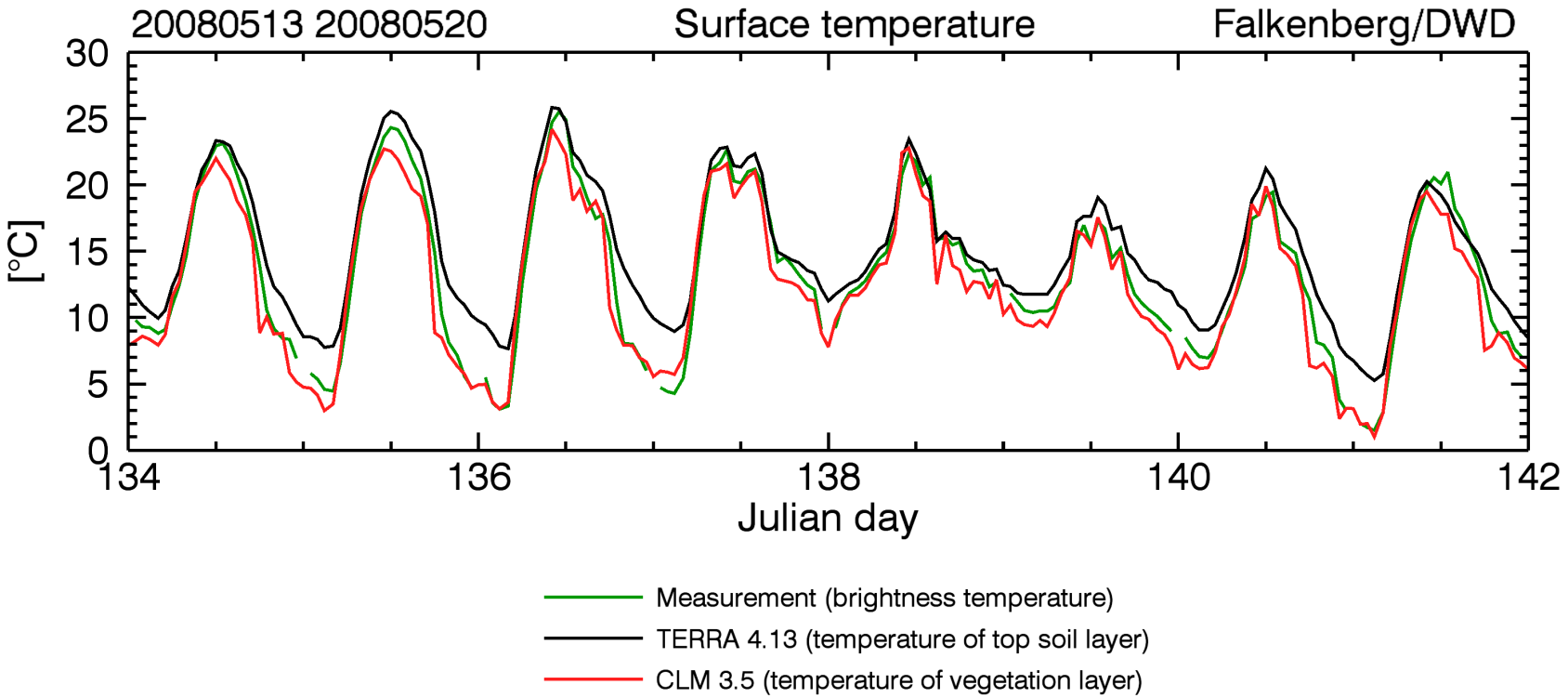


- Shading by vegetation directly affects ground heat flux.
- The land surface schemes CLM and VEG3D include a shading formulation, this significantly improves the simulated ground heat flux.

Extrapolation made by Becker (2014)



Diurnal temperature range substantially improved in CLM and VEG3D compared to TERRA



Vogel, G. et al.: Modelluntersuchungen zum Einfluss der Abschattung der Solarstrahlung durch die Vegetation auf die Erdbodentemperaturen in Falkenberg – Deutscher Wetterdienst, MOL-RAO Aktuell 3/2015, Lindenberg 2 pp. (available from: www.dwd.de/mol)

Findings of the summer case:

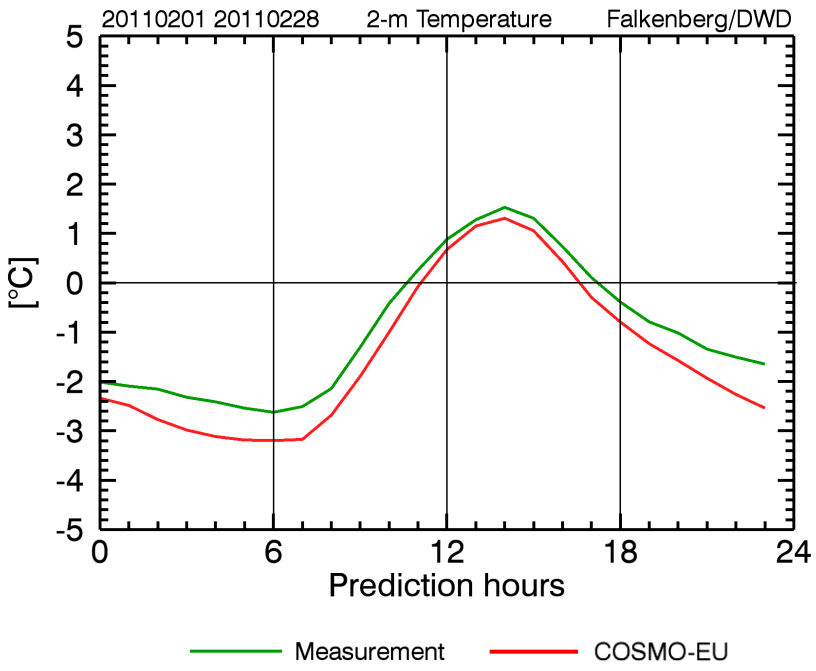
- The overestimation of the diurnal amplitudes of soil temperature in TERRA during summer is mainly caused by the neglected shading of the solar radiation due to the vegetation cover.

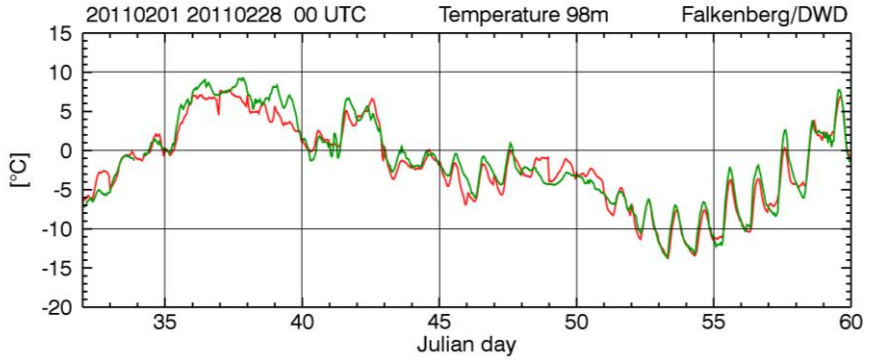
- The advanced vegetation scheme of CLM provides fairly accurate surface temperatures during morning and at noon-time.

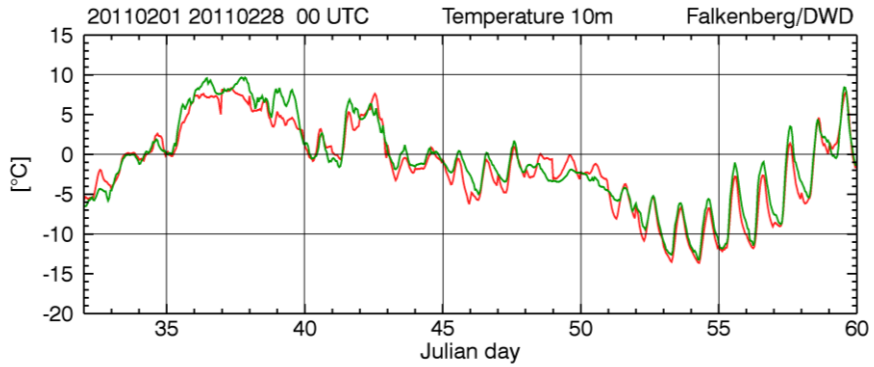
- A moisture-dependent thermal conductivity becomes relevant when the current soil moisture strongly deviates from its soil-type specific mean value.

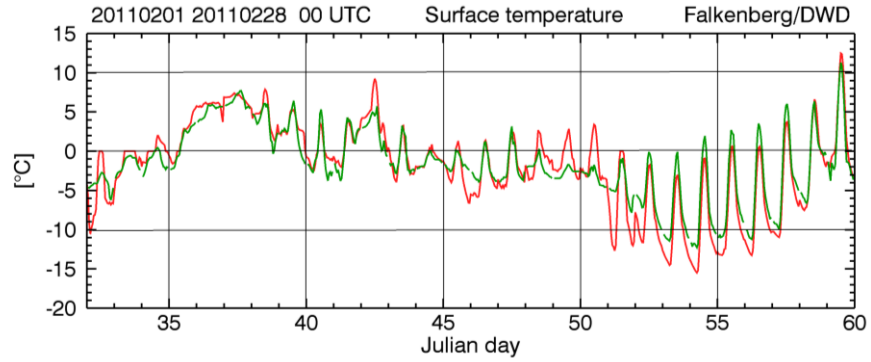
Cold bias

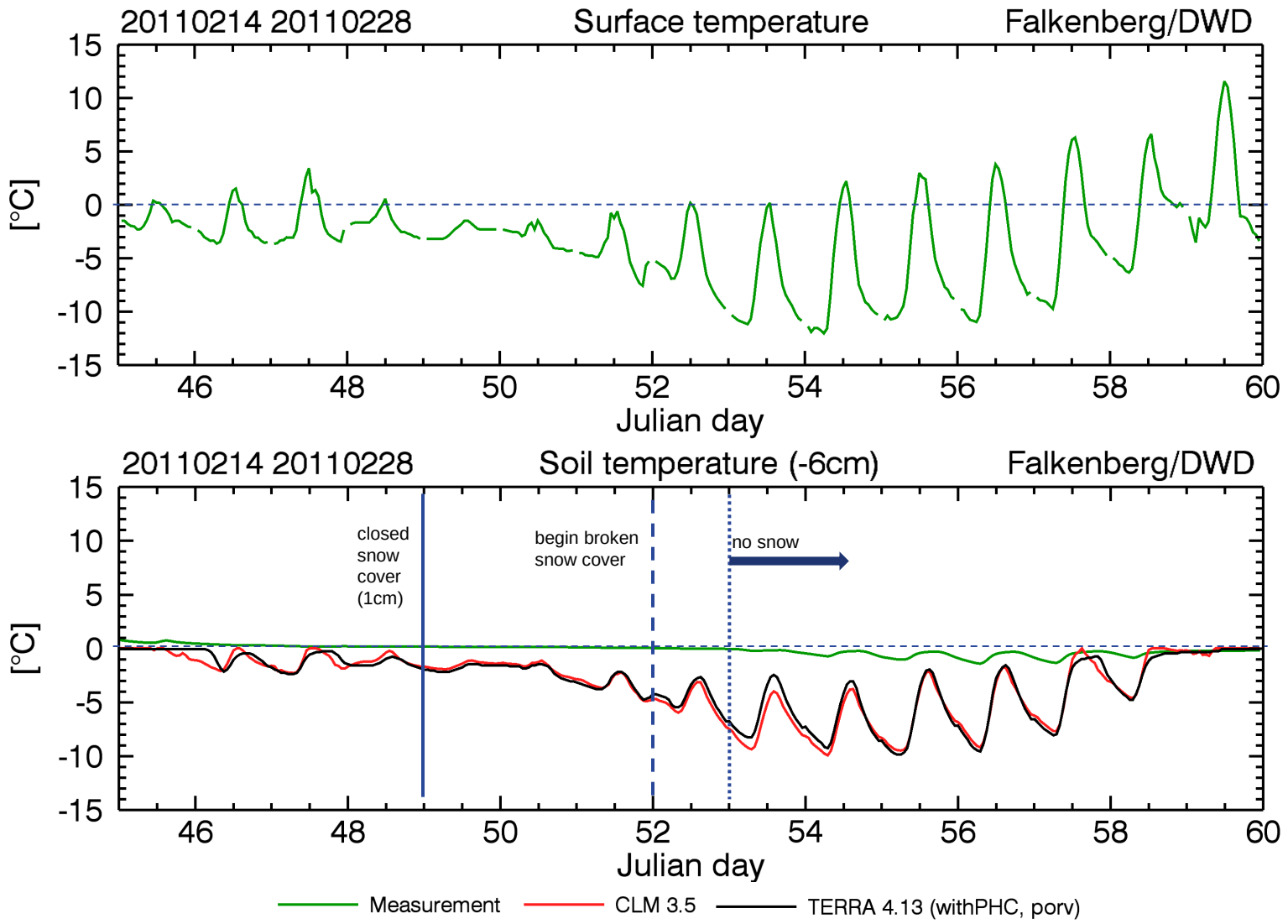
Snow-free cold period (end of February 2011)

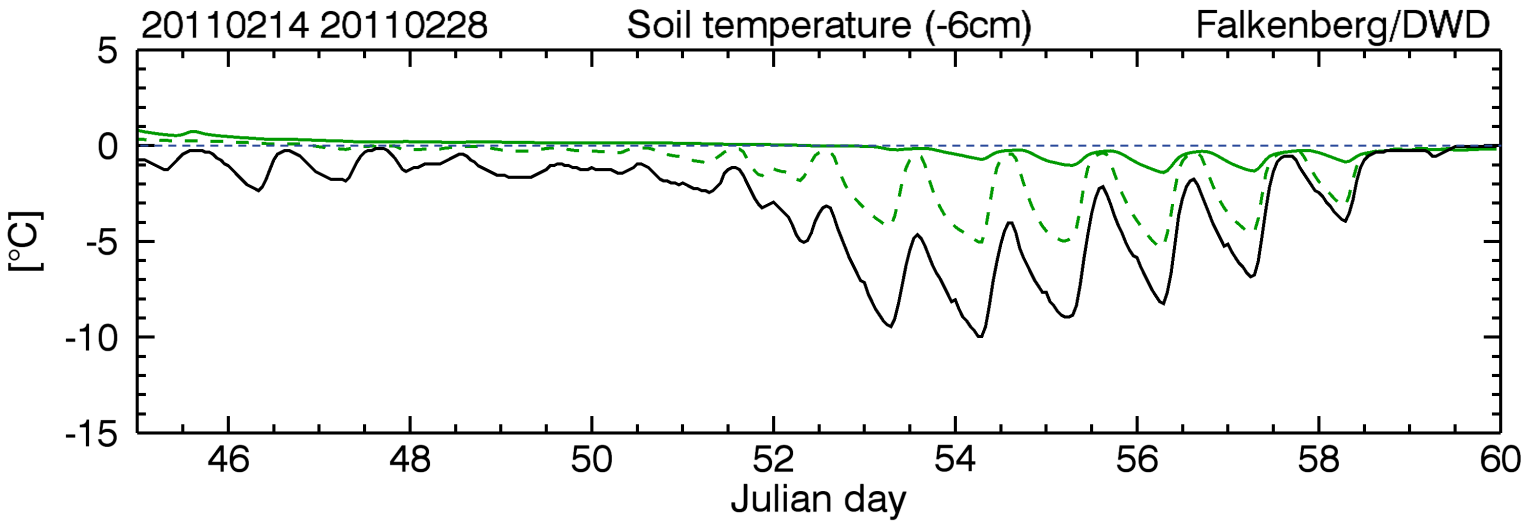


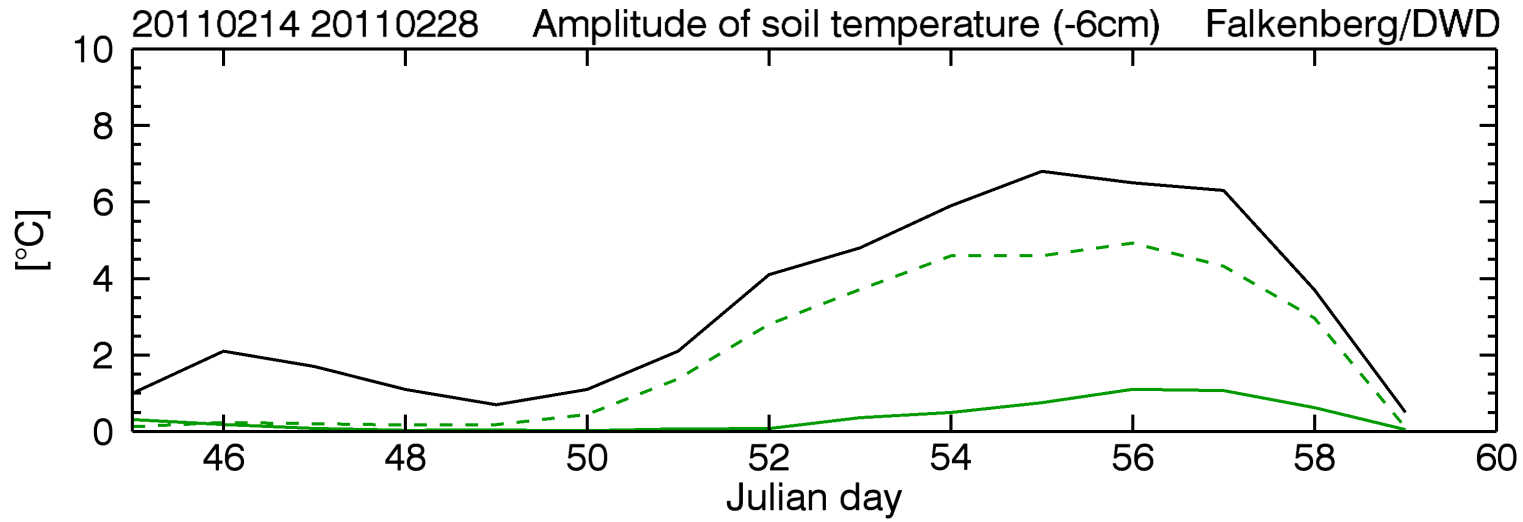


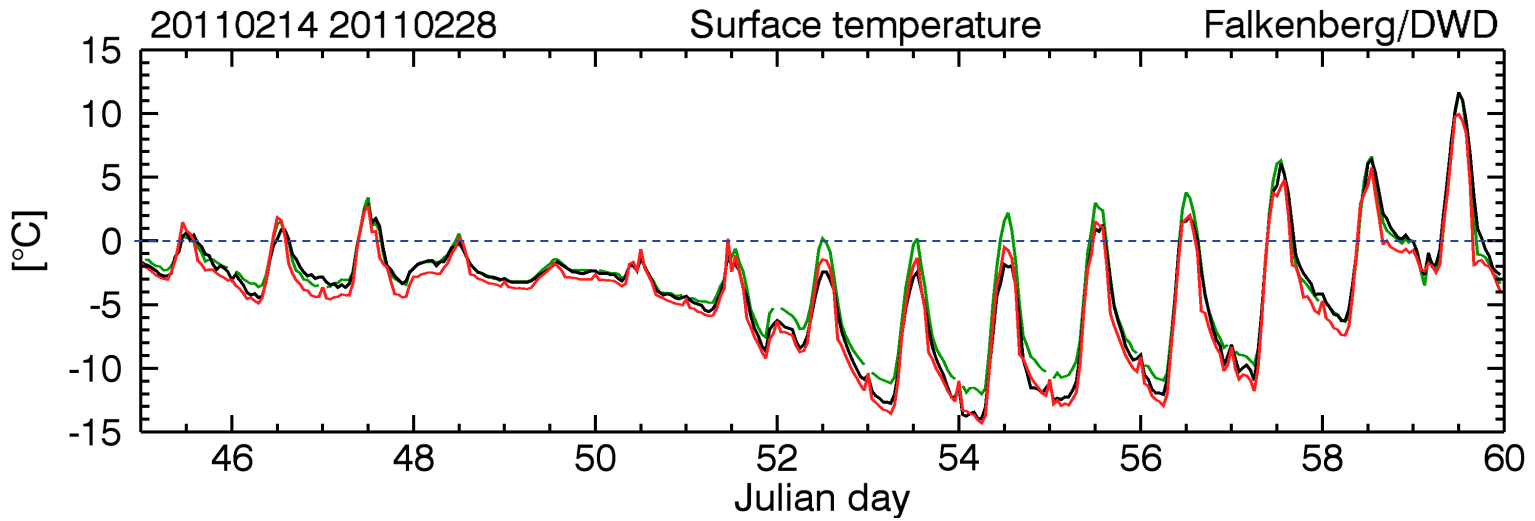


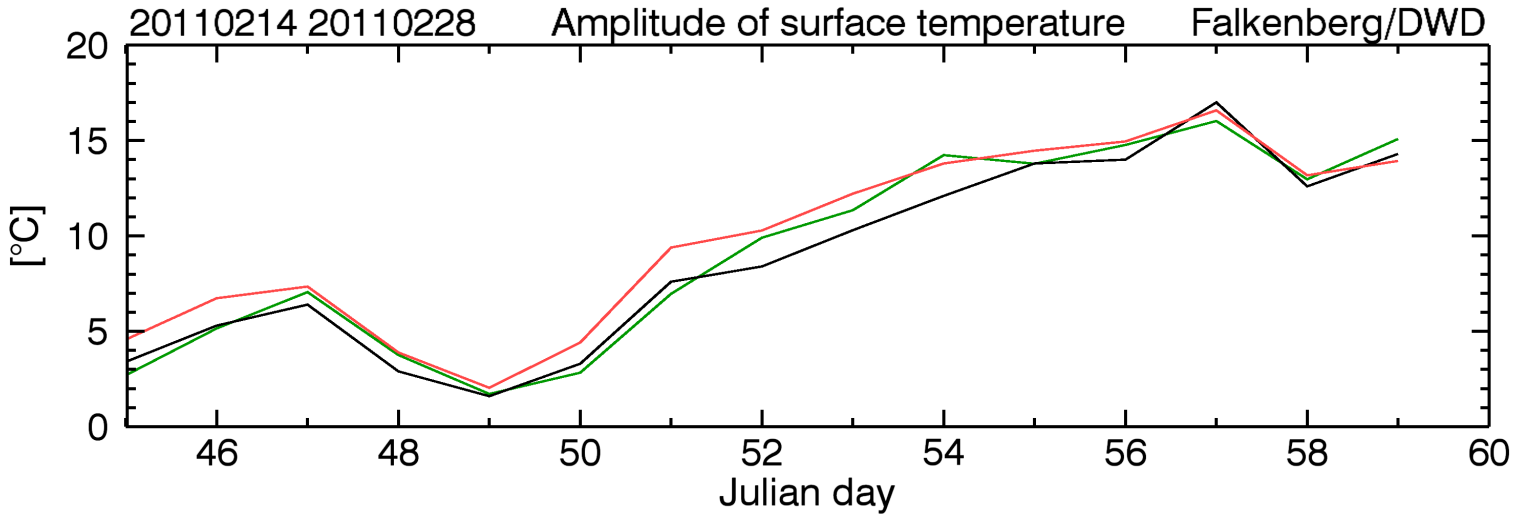



20110214 20110228
Surface temperature
Falkenberg/DWD
[°C]
15
10
5
0
-5
-10
-15
46
48
50
52
54
56
58
60
Julian day
20110214 20110228
Soil temperature (-6cm)
Falkenberg/DWD
closed snow cover (1cm)
begin broken snow cover
no snow
[°C]
Julian day
Measurement
CLM 3.5
TERRA 4.13 (withPHC, porv)


20110214 20110228
Soil temperature (-6cm)
Falkenberg/DWD
[°C]
5
0
-5
-10
-15
46
48
50
52
54
56
58
60
Julian day


20110214 20110228
Amplitude of soil temperature (-6cm)
Falkenberg/DWD
[°C]
10
8
6
4
2
0
46
48
50
52
54
56
58
60
Julian day
Measurement (grass cover)
Measurement (bare soil)
TERRA 4.13 (bare soil)





Measurement (brightness temperature) TERRA 4.13 (temperature of top soil layer) CLM3.5 (temperature of vegetation layer)

Findings of the winter case:

- In winter, a vegetation layer prevents strong cooling of the soil, as found in the measurements at Falkenberg.

- Amplitudes of soil temperatures under bare soil indicate that the heat conduction process in TERRA works well. Reasons for negative offset of the simulated soil temperatures are still unknown.

- Due to the lower thermal inertia of the canopy layer the CLM can better match the noon-time surface temperatures than TERRA. Both, TERRA and CLM are too cold during morning.

Conclusions

- A canopy layer effectively dampens the diurnal amplitudes of soil temperature under both summer and winter conditions, as found in the measurements at Falkenberg.
- A canopy layer including its own temperature also makes the heat input from the surface into the atmosphere more realistic in the diurnal and annual cycles.
- In TERRA, an explicit vegetation layer is not implemented. Consequently, the diurnal temperature amplitude is overestimated in the soil and underestimated at surface.
- In CLM, the shading of solar radiation by vegetation during summer is well captured. In contrast, a representation of the insulation effect during winter was expected but is missing.


Thank you for your attention!