Evaluation of the global radiation simulated by the operational ICON model over Central Europe

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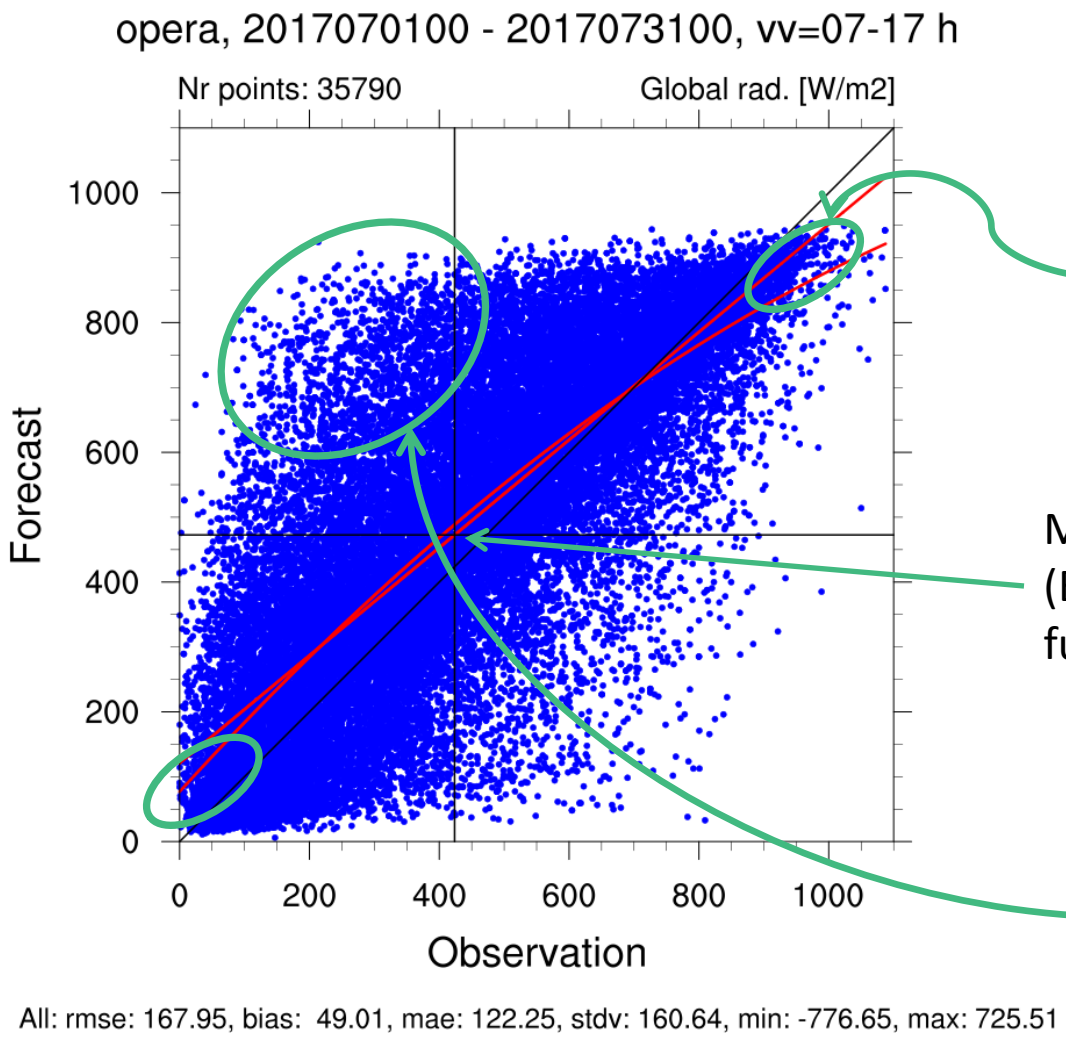
201707, 07-17h, Global radiation

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Andrea Steiner, DWD

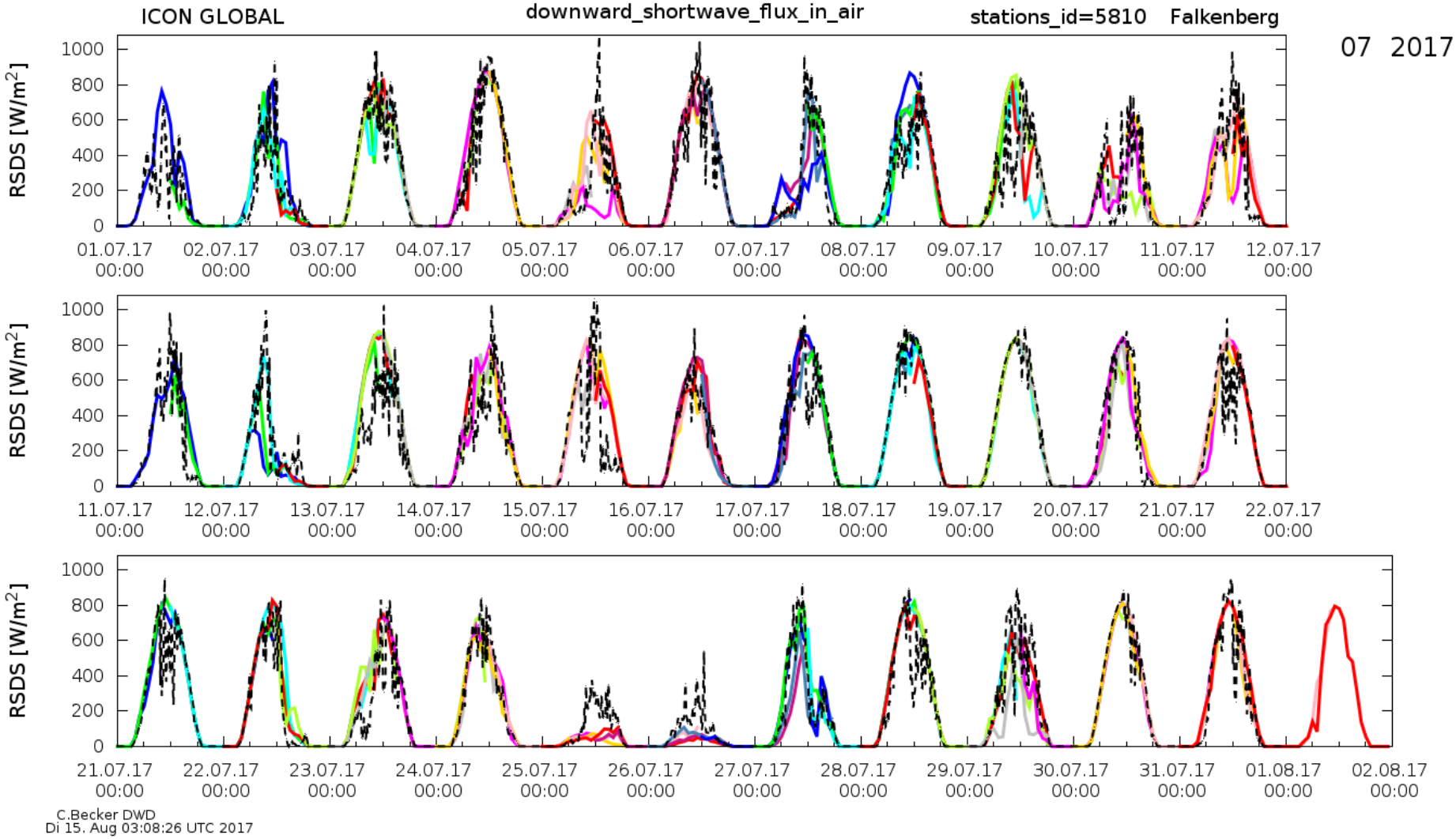


➔ During day

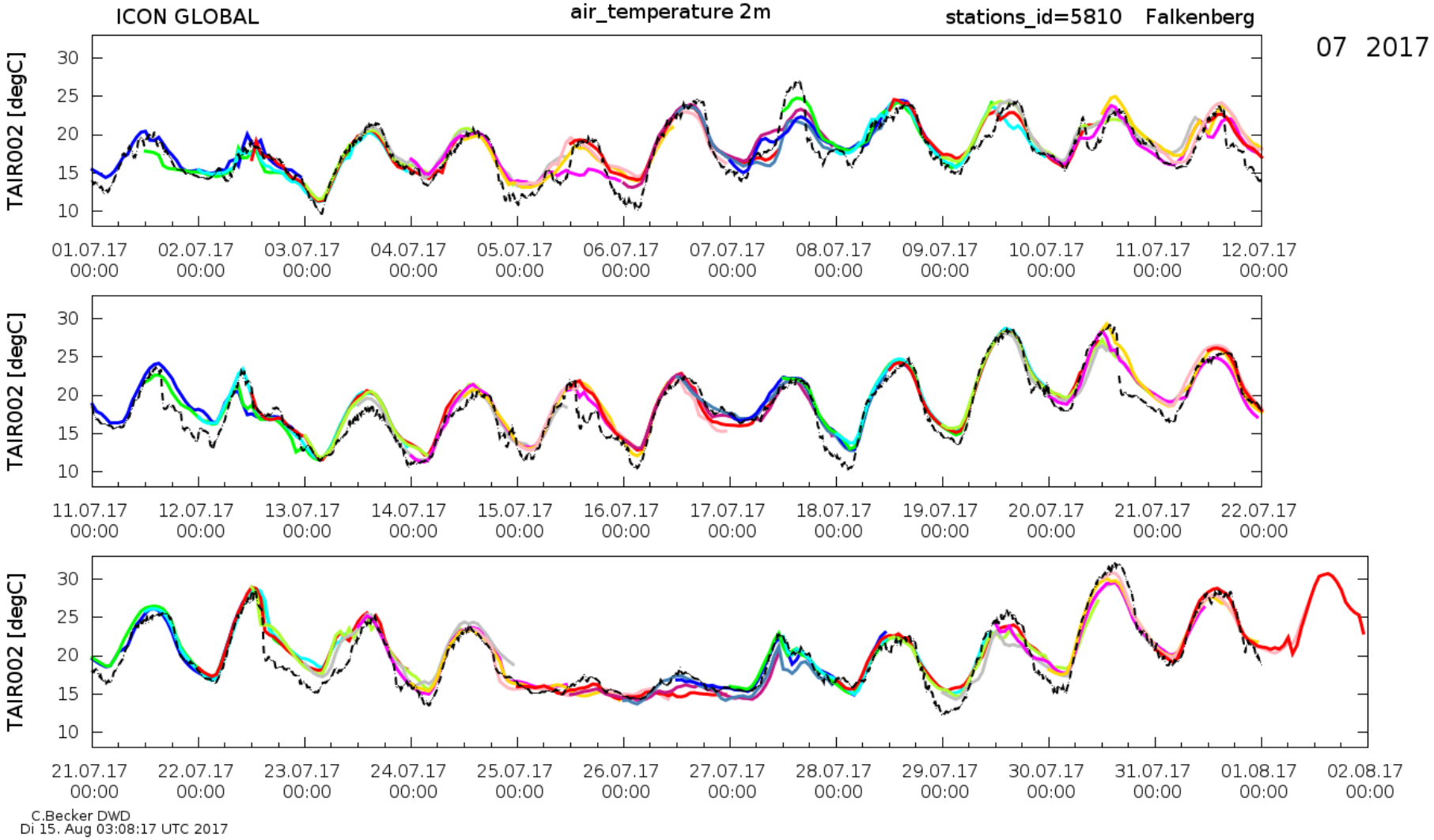
High radiation values underestimated (optically too thick aerosols/cirrus/atmosphere?).
Low radiation values overestimated (missing clouds?).

Mean bias of almost 50 W/m^2 in July (Evaluation for only Lindenberg but a full year yields: 20 W/m^2).

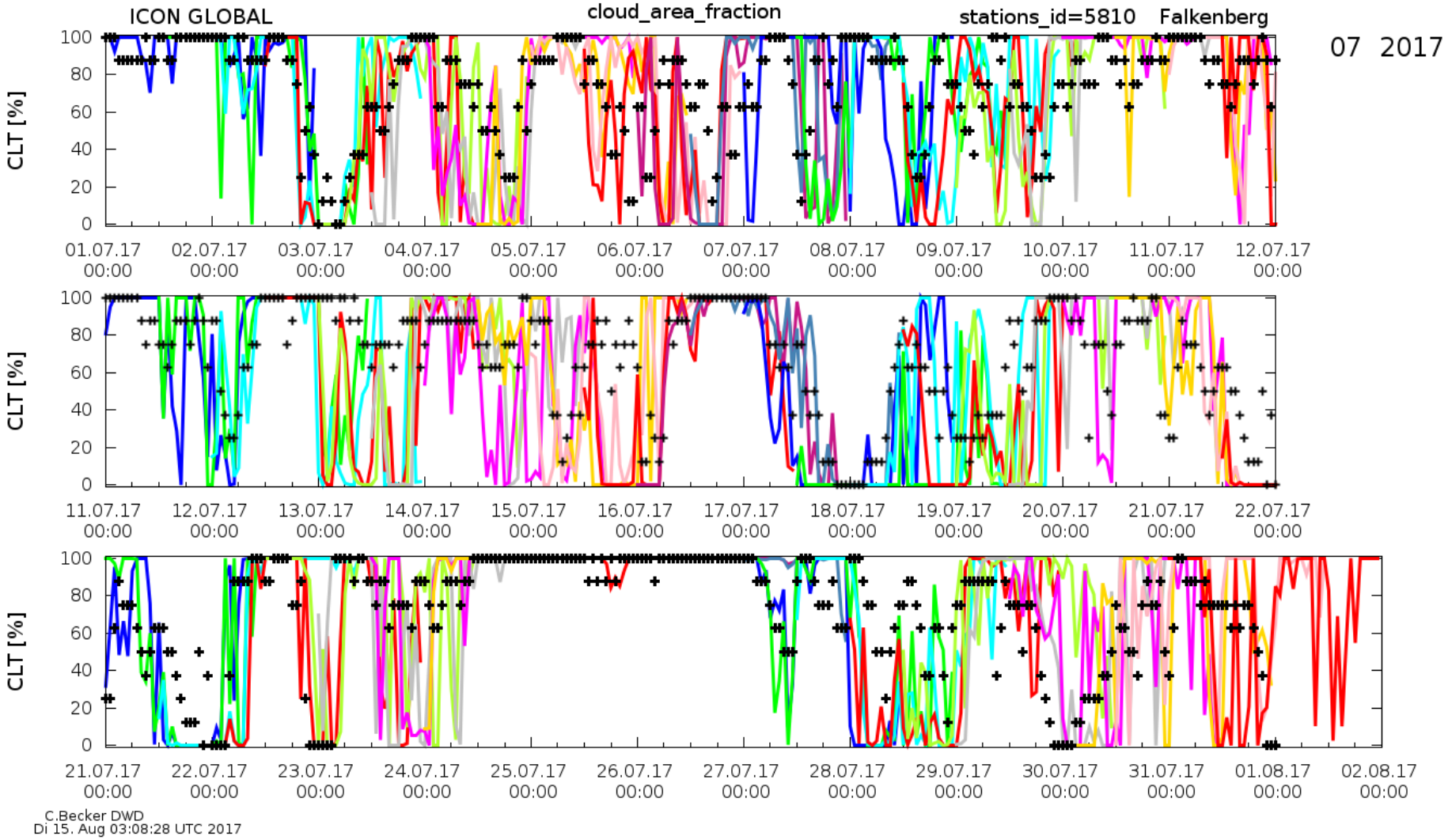
Overestimation of the radiation:
Optically too thin clouds?
Or too few clouds?



Downward shortwave radiation at surface: For clear sky (19 & 30 Jul.) good (or slightly underestimated), for partly cloudy conditions (13 & 14 Jul.) overestimated.



2-m temperature: For clear sky (19 & 30 Jul.) diurnal amplitude underestimated, for partly cloudy conditions (13 & 14 Jul.) diurnal amplitude (often) overestimated.


ICON GLOBAL
cloud_area_fraction
stations_id=5810 Falkenberg
07 2017
CLT [%]
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02.07.17 00:00
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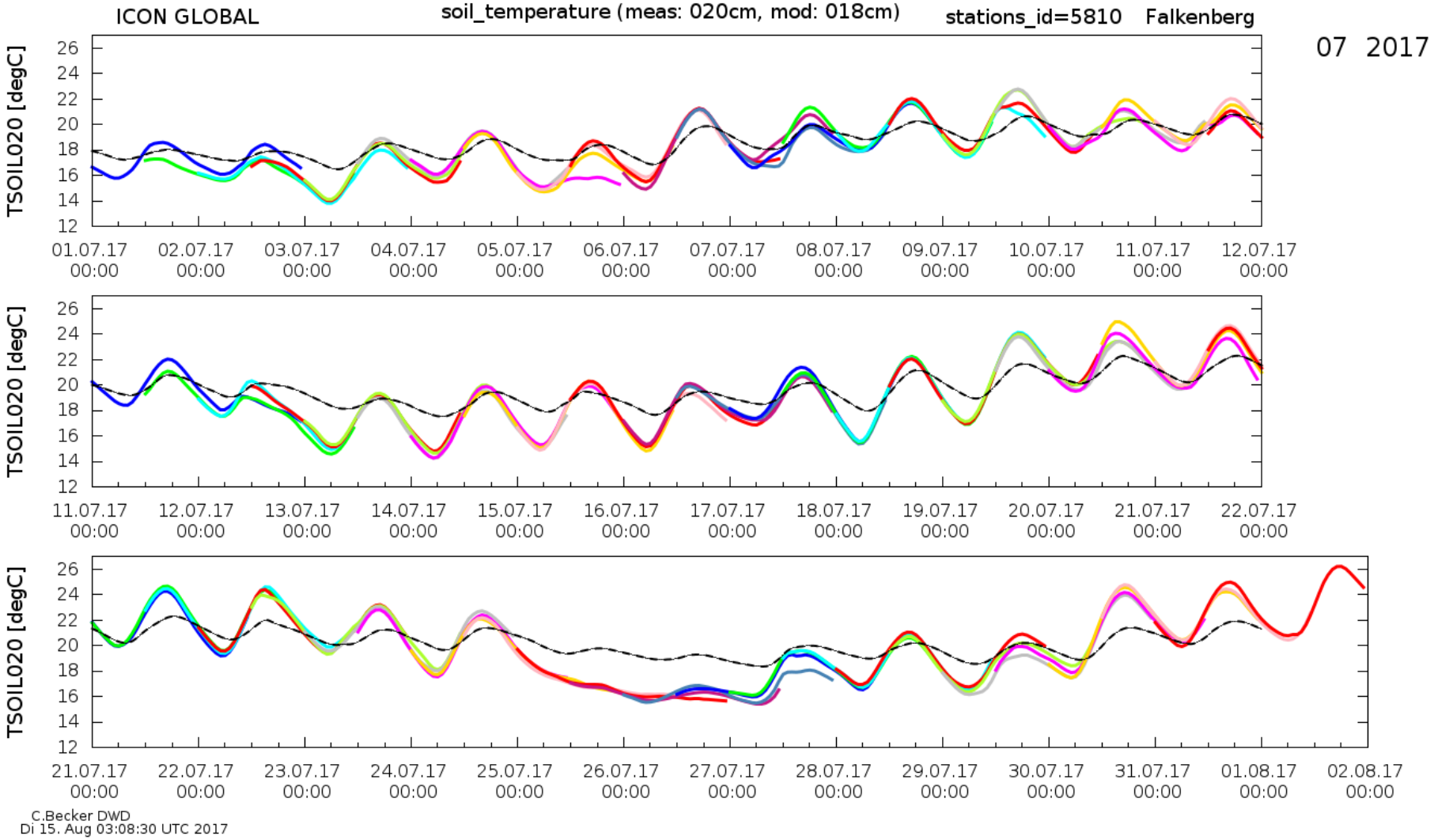
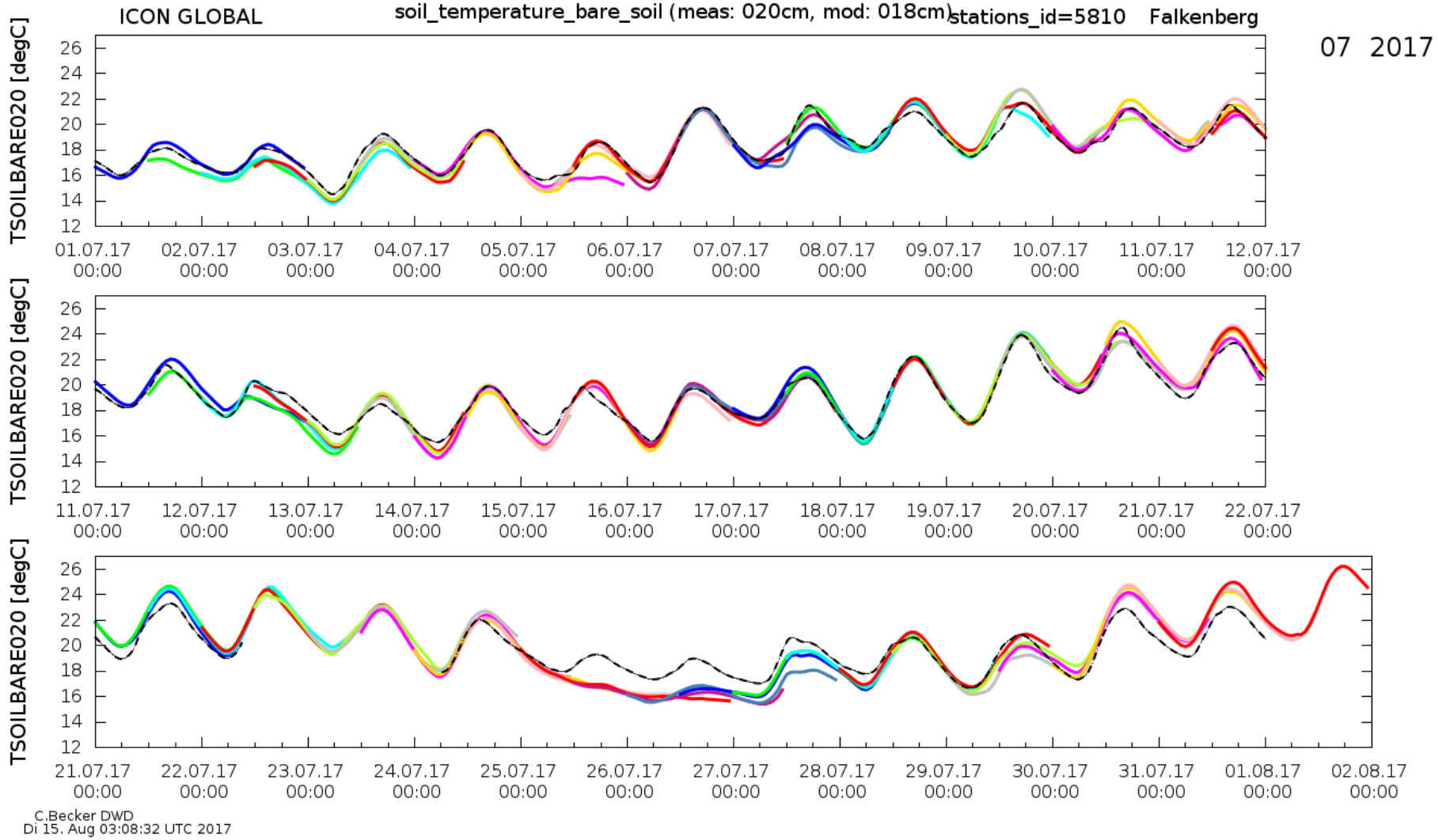
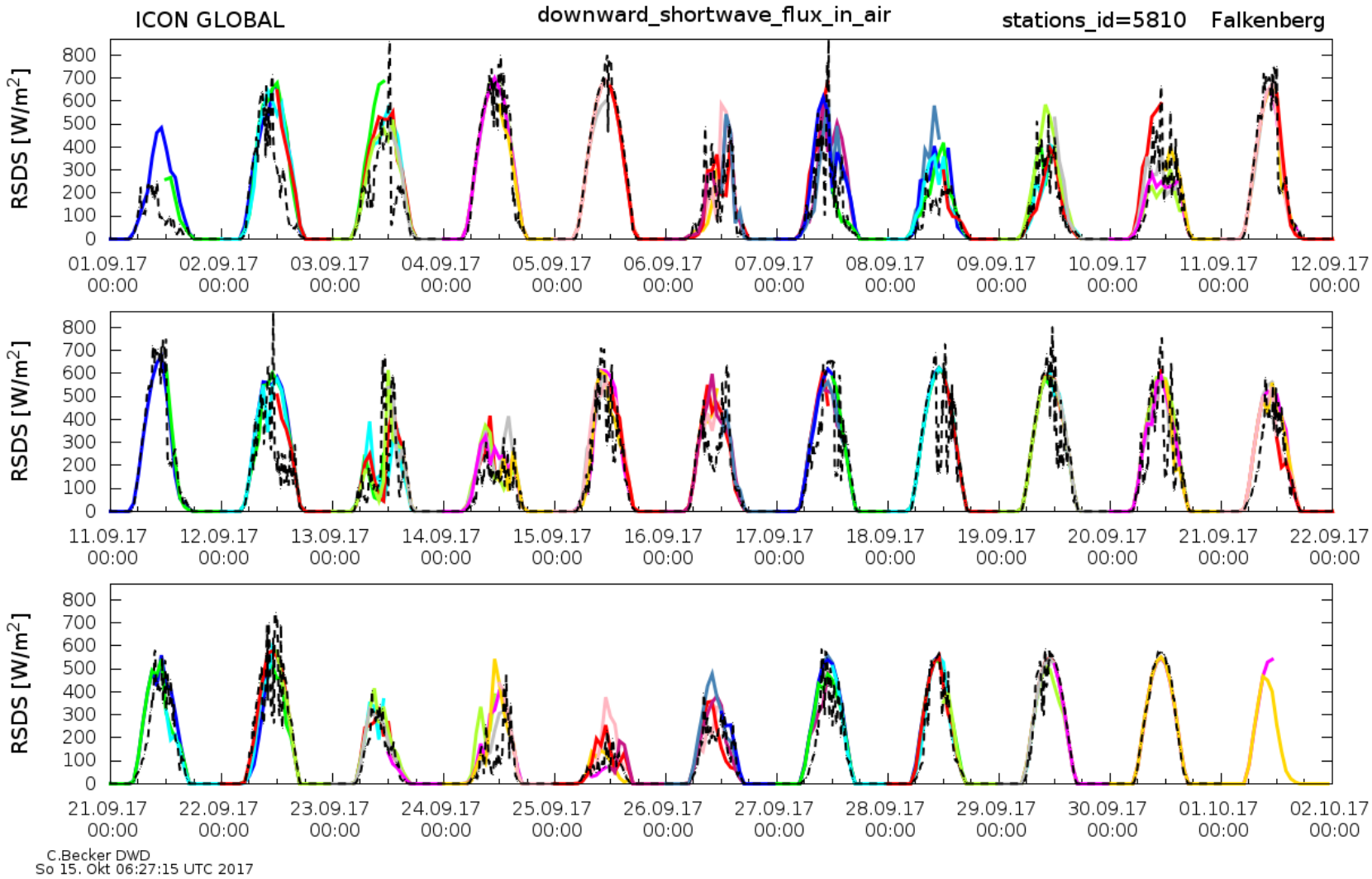
C.Becker DWD
Di 15. Aug 03:08:28 UTC 2017



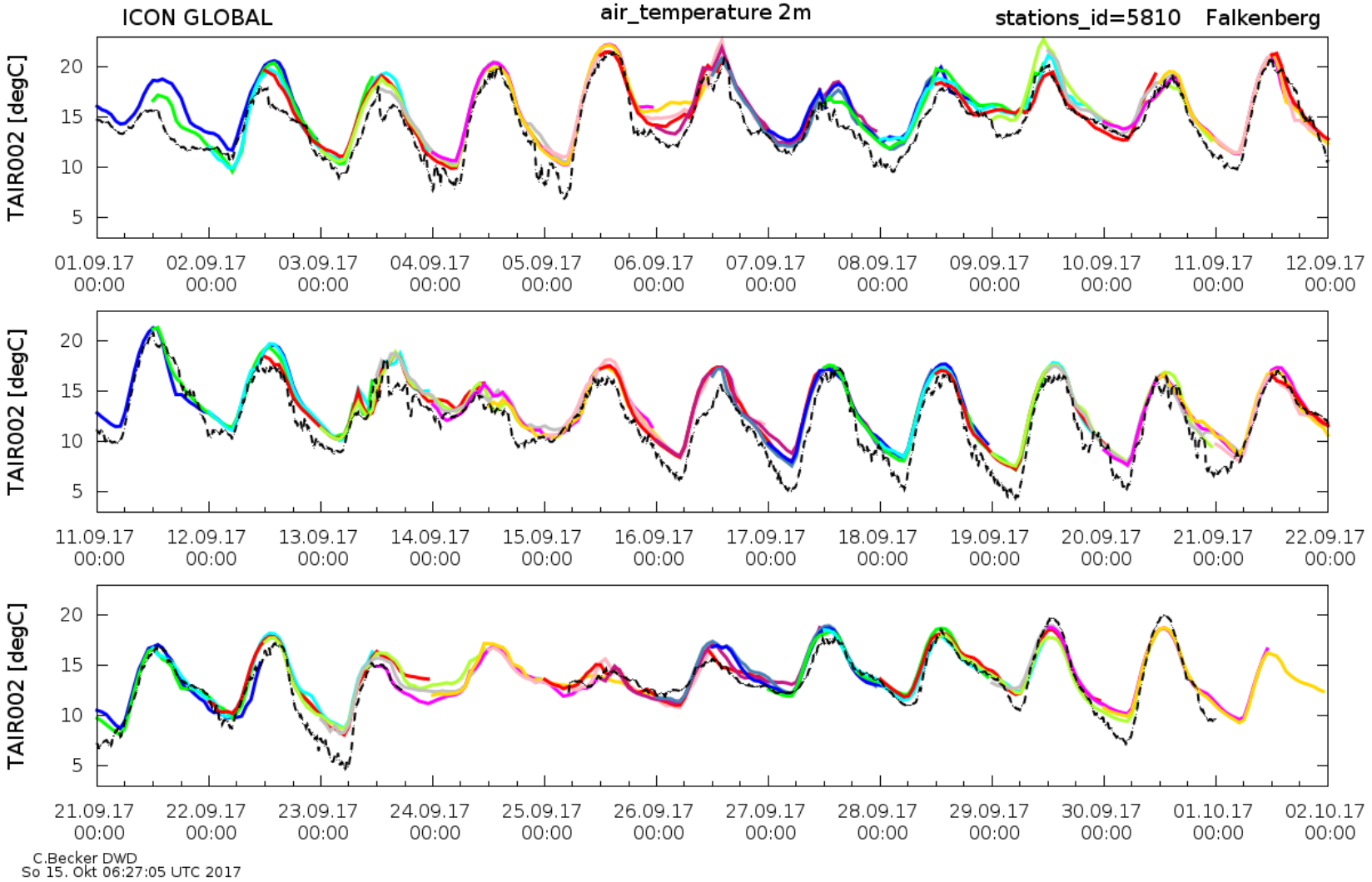
Amplitudes of the diurnal cycles of the simulated soil temperatures under grass are systematically overestimated.



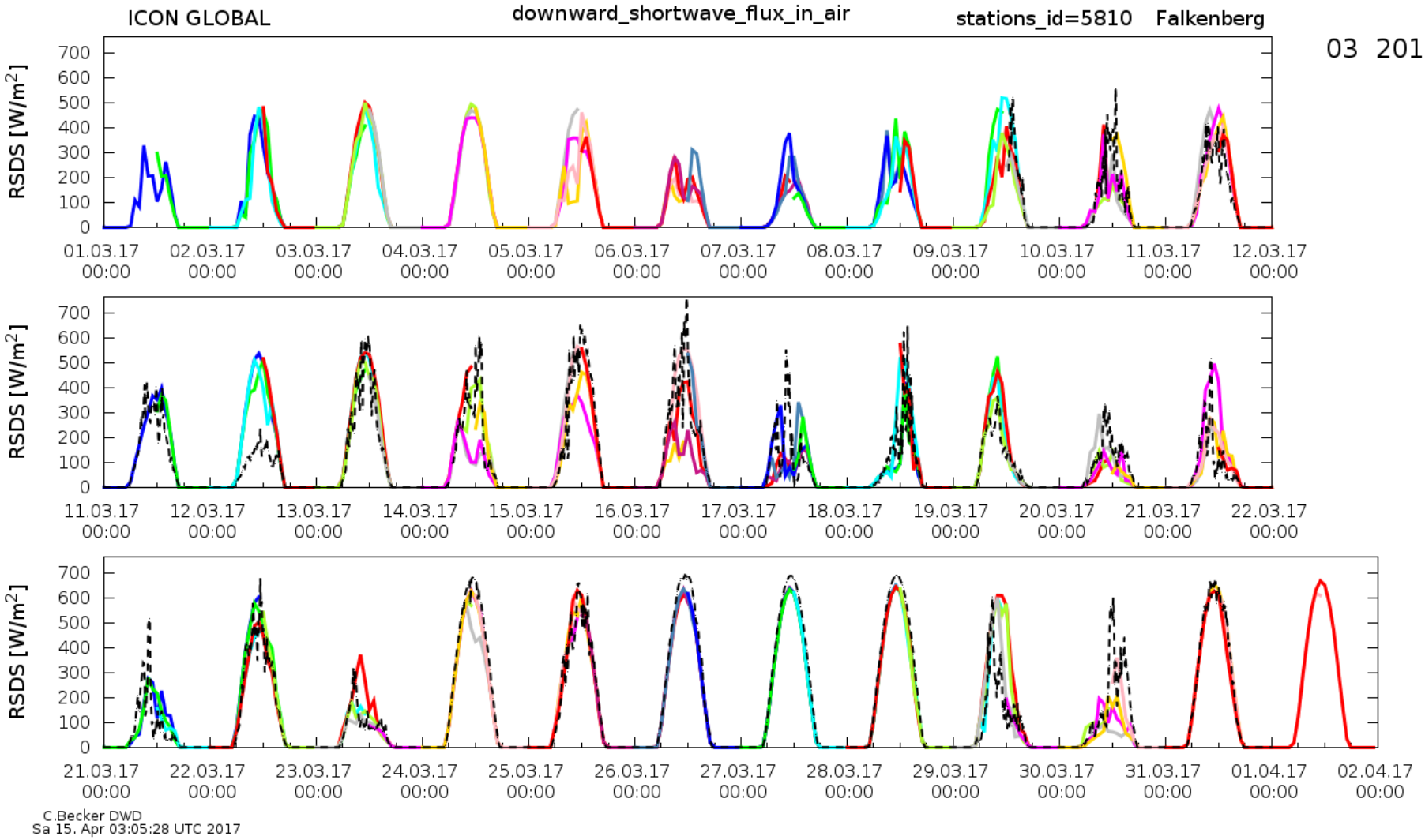
Amplitudes of the diurnal cycles of the soil temperatures under bare soil are simulated very well.



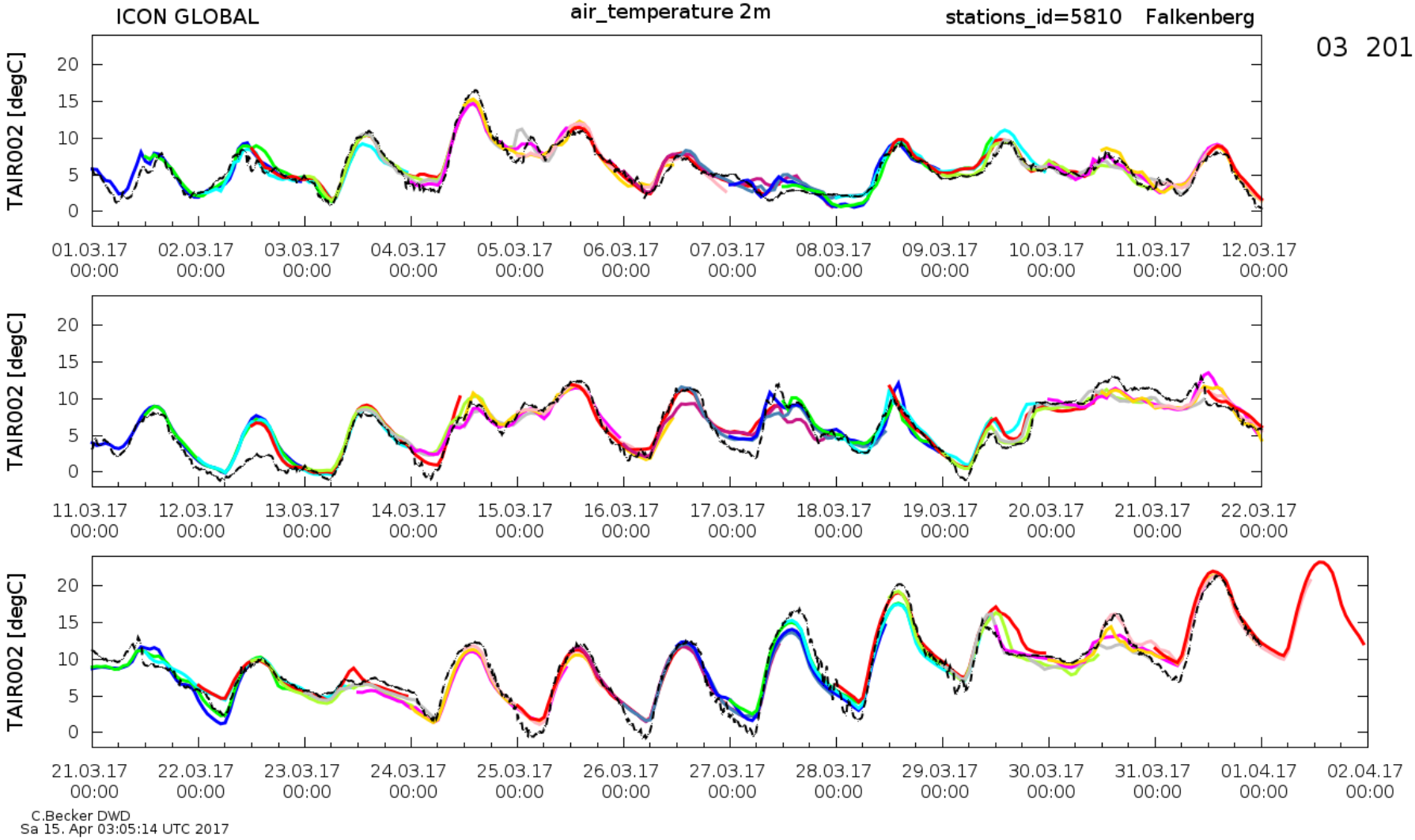
Downward shortwave radiation at surface: For clear sky (30 Sep.) good (or slightly underestimated), for partly cloudy conditions (1 & 2 Sep.) overestimated.



2-m temperature: For clear sky (30 Sep.) diurnal amplitude underestimated, for partly cloudy conditions (1 & 2 Sep.) diurnal amplitude (often) overestimated.



Downward shortwave radiation at surface: For clear sky (31 Mar.) good (or slightly underestimated), for partly cloudy conditions (12 Mar.) overestimated.



2-m temperature: For clear sky (31 Mar.) diurnal amplitude underestimated, for partly cloudy conditions (12 Mar.) diurnal amplitude (often) overestimated.

Surface temperature in TERRA

(Doms et al. 2011)

$$C_s \frac{\partial T_s}{\partial t} = R_{SW} + R_{LW} + LE + H + G$$

T_s : surface temperature
C_s, t : heat capacity per unit area, time
R_{SW}, R_{LW} : net shortwave radiation flux, net longwave radiation flux
LE, H, G : latent heat flux, sensible heat flux, ground heat flux

Skin temperature in IFS

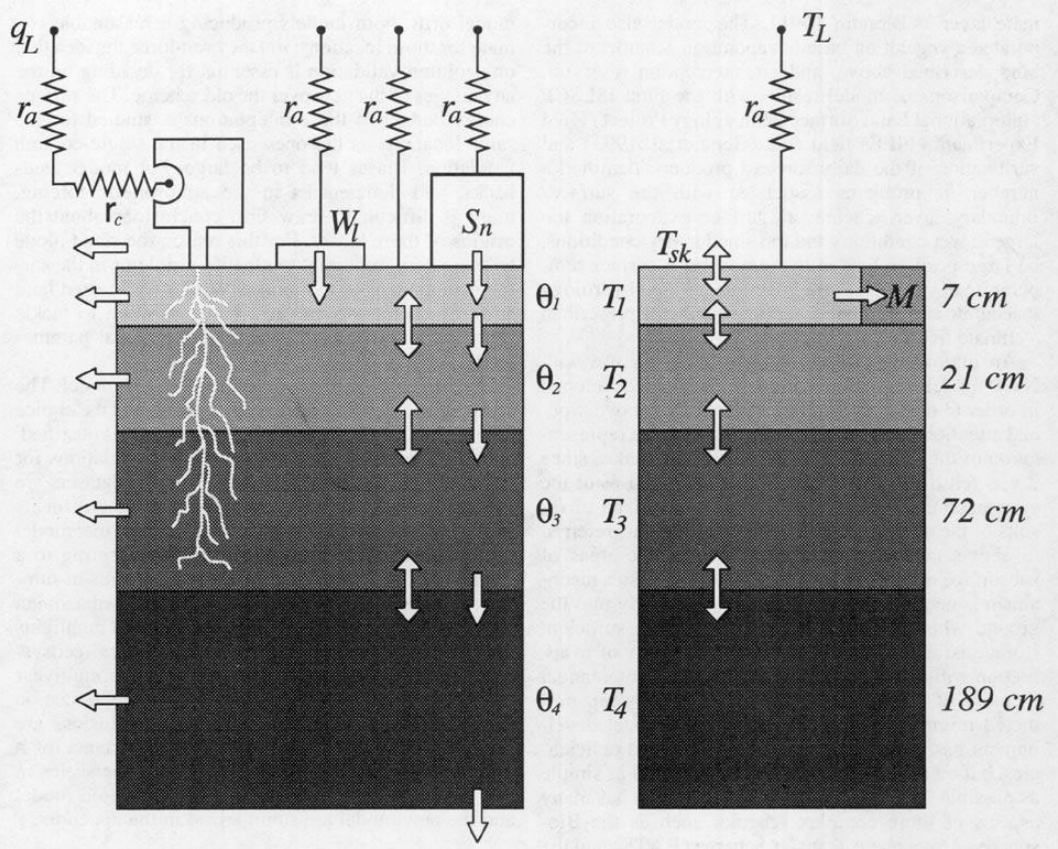
(Viterbo and Beljaars 1995)

$$\Lambda_{sk}(T_{sk} - T_s) = R_{SW} + R_{LW} + LE + H$$

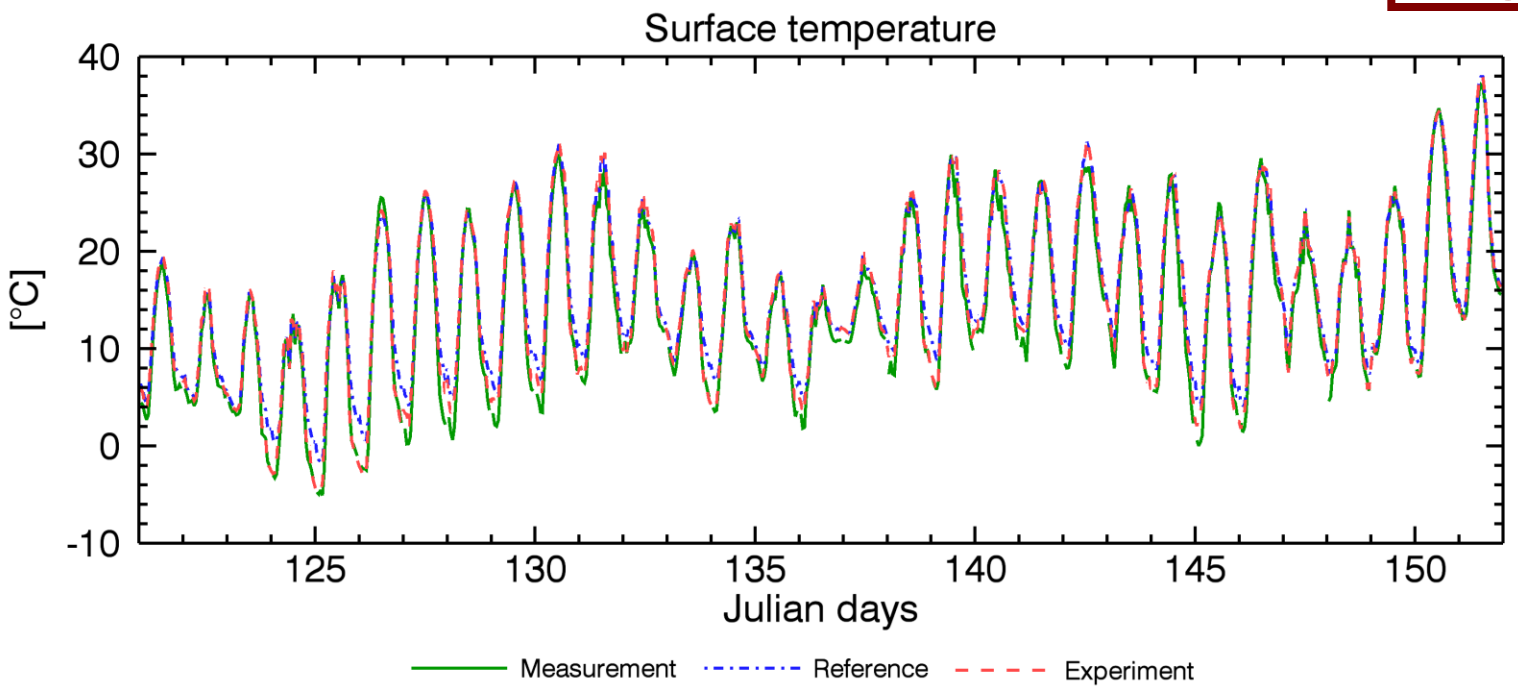
T_{sk}, T_s : skin temperature, surface temperature
Λ_{sk} : skin layer conductivity
R_{SW}, R_{LW} : net shortwave radiation flux, net longwave radiation flux
LE, H : latent heat flux, sensible heat flux

Skin temperature in IFS

(Viterbo and Beljaars 1995)

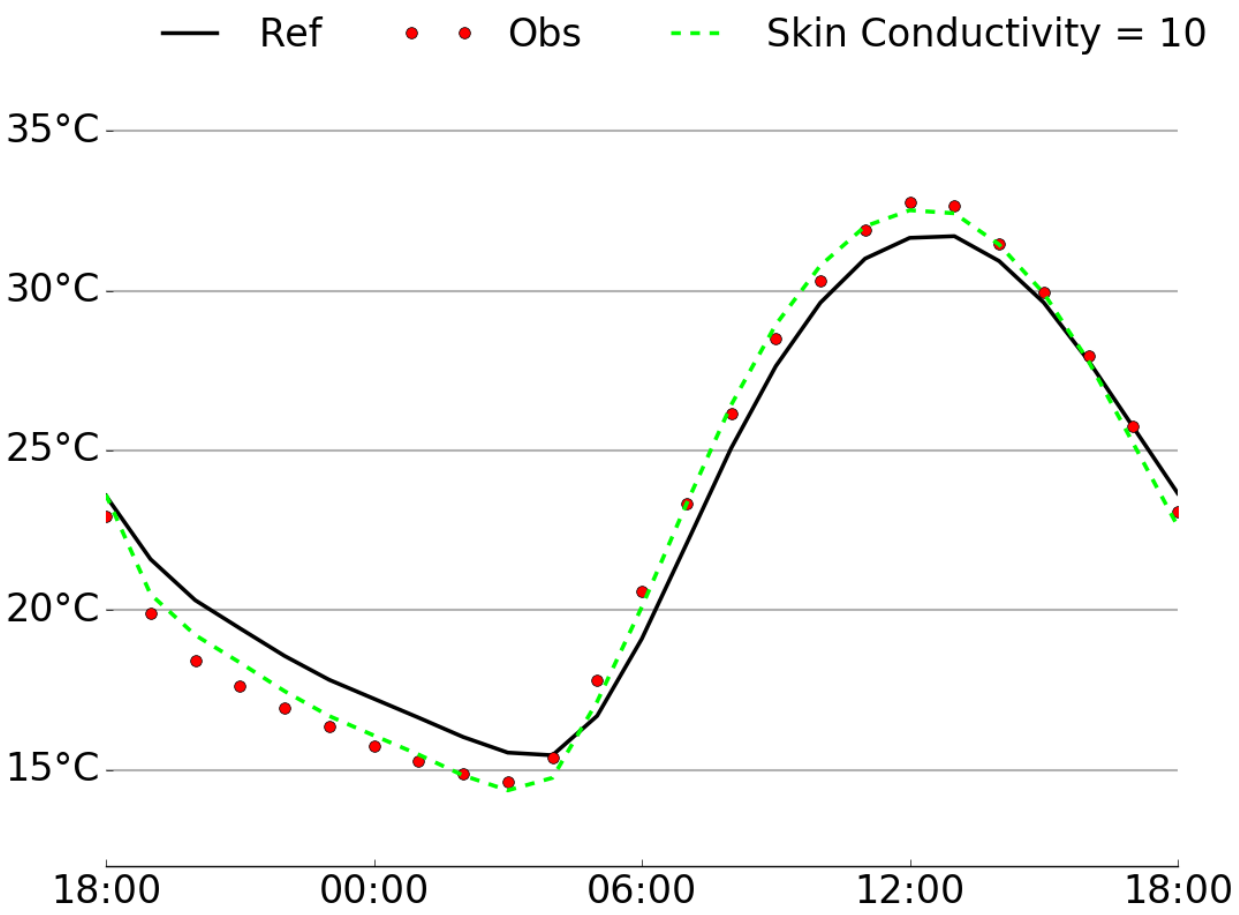


May 2011



Amplitude of the diurnal cycle of the surface temperature in TERRA is systematically underestimated (clear nocturnal warm bias), with the skin temperature formulation it is substantially increased and much closer to the measurements

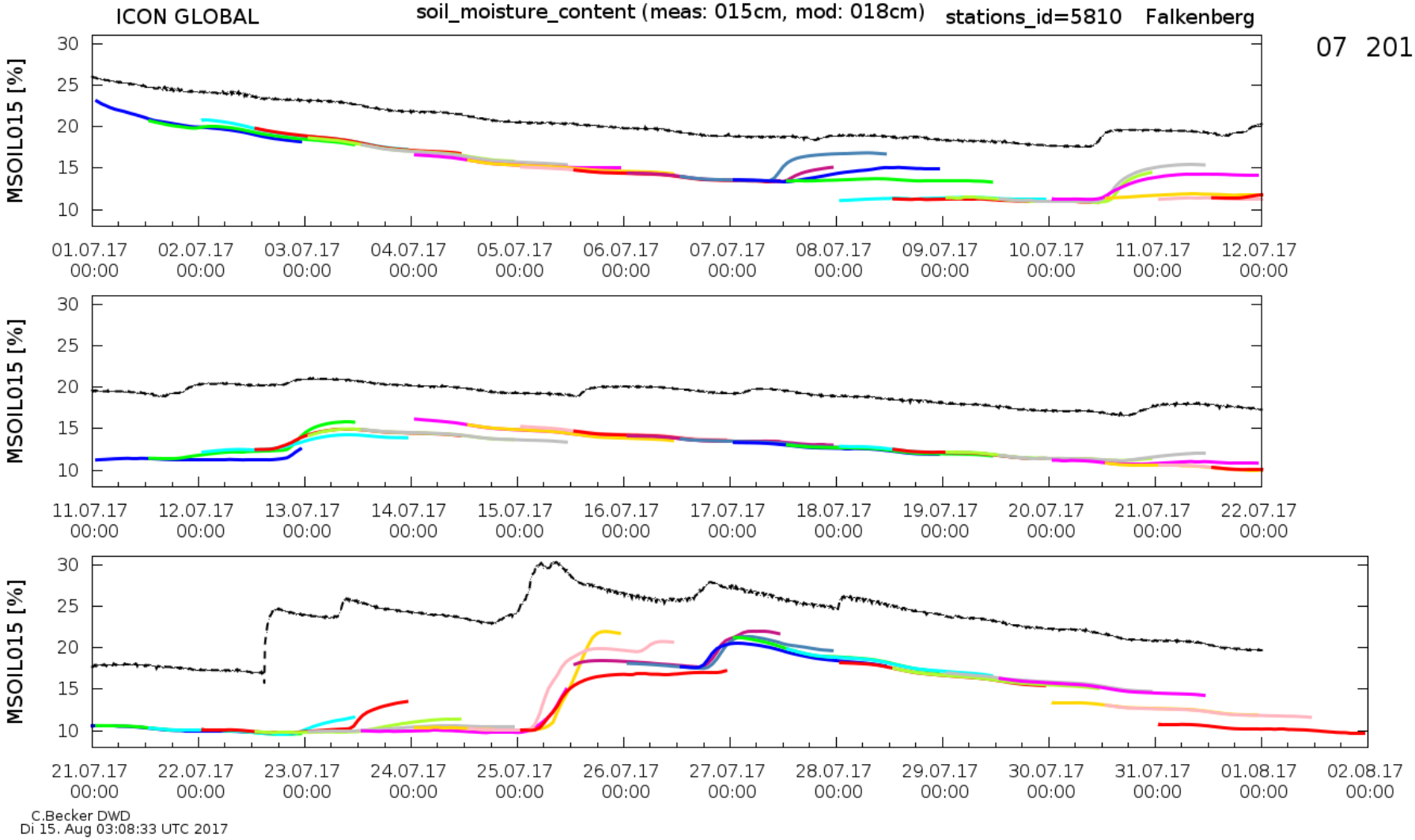
COSMO-DE: 1 - 2 July 2015



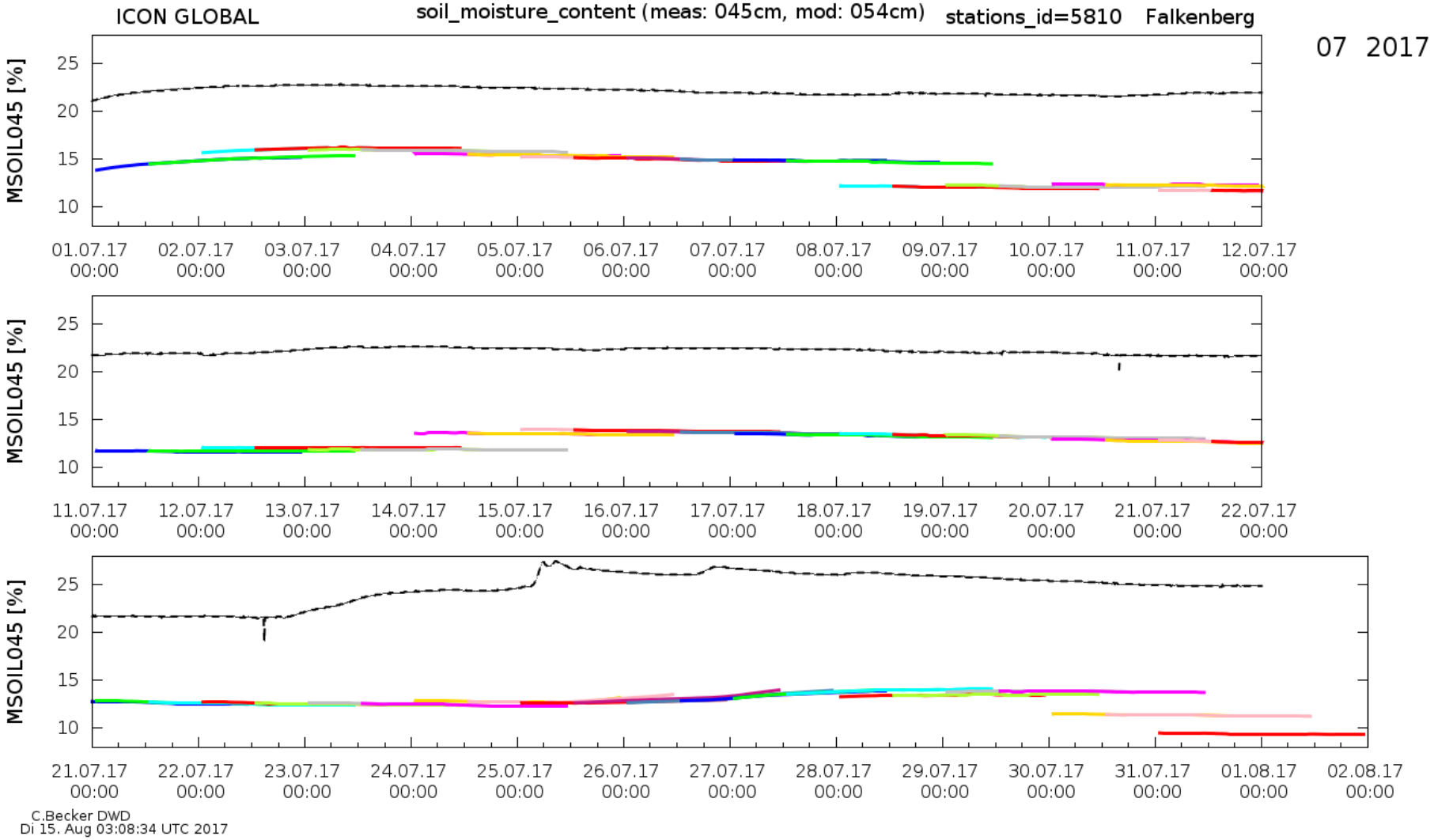
- Obs: Meteosat, cloud free pixels in satellite and model
- Black line: TERRA surface temperature (COSMO-DE)
- Green line: IFS skin temperature

Christine Sgoff, HErZ Frankfurt

Amplitude of the diurnal cycle of the surface temperature in TERRA is systematically underestimated, with the skin temperature formulation it is substantially increased and much closer to the measurements



The soil water content is substantially underestimated. Unphysical increments due to the soil moisture analysis are visible.



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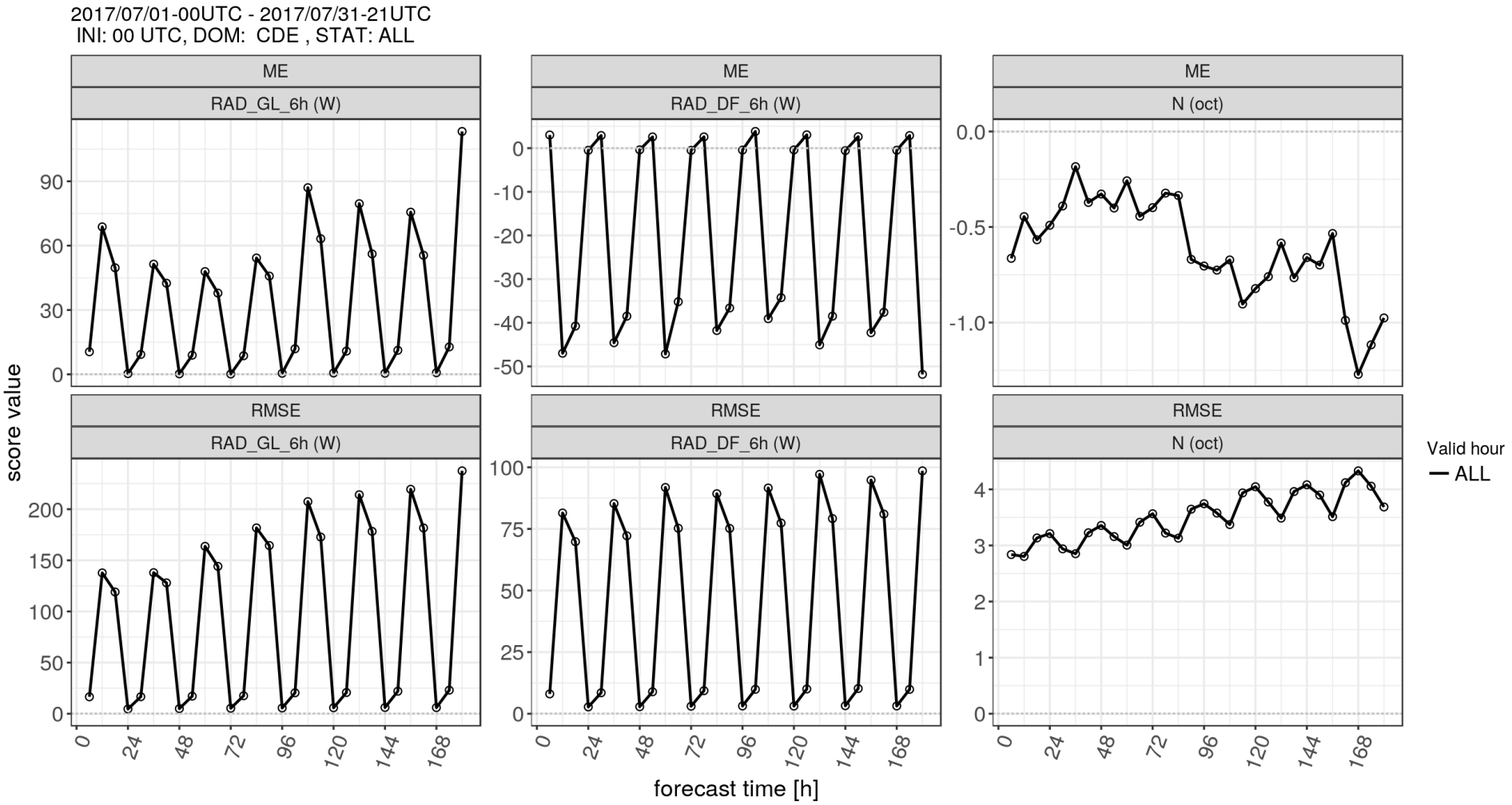
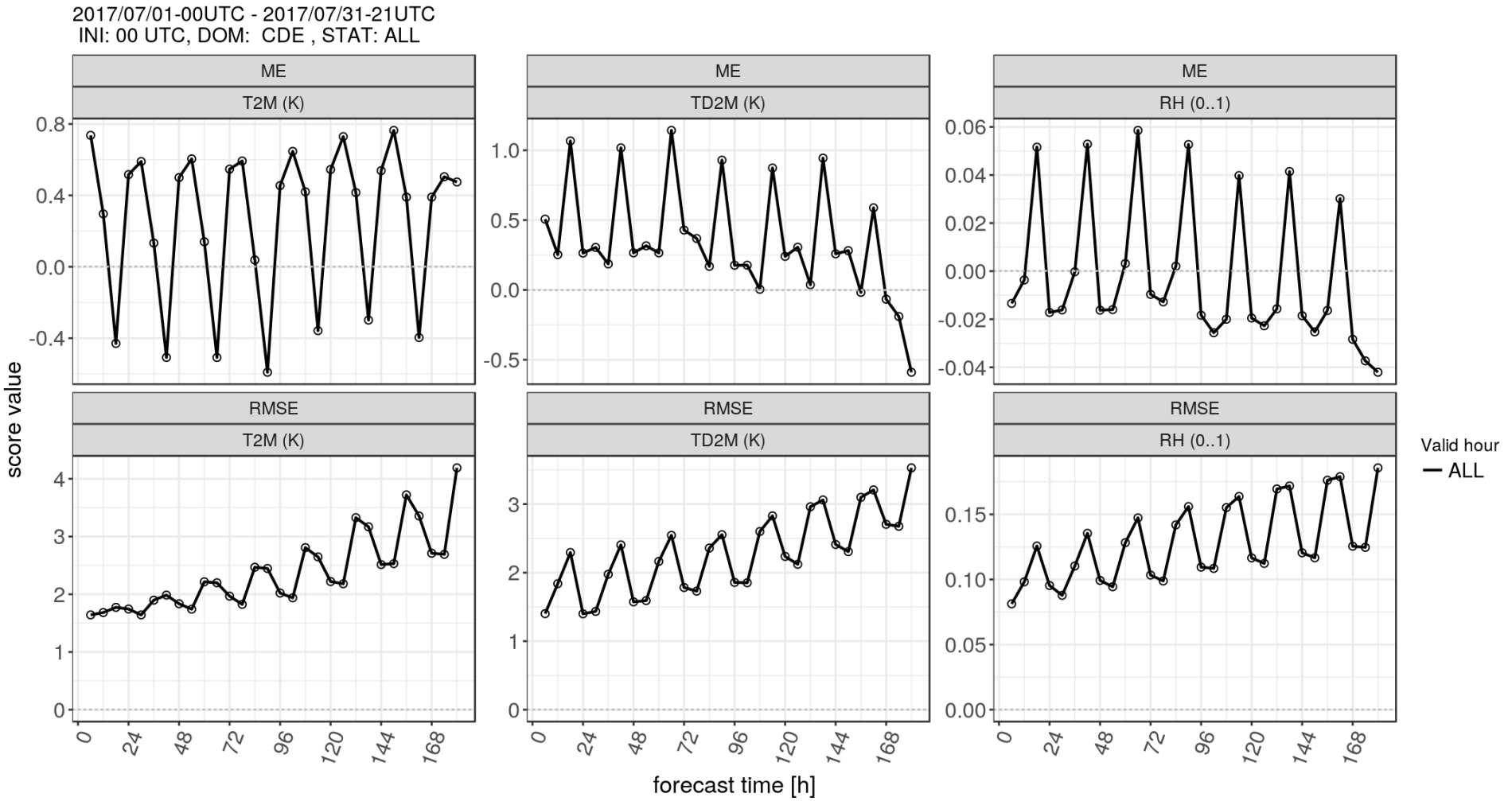
ICON: Central Europe, July 2017, 00 UTC



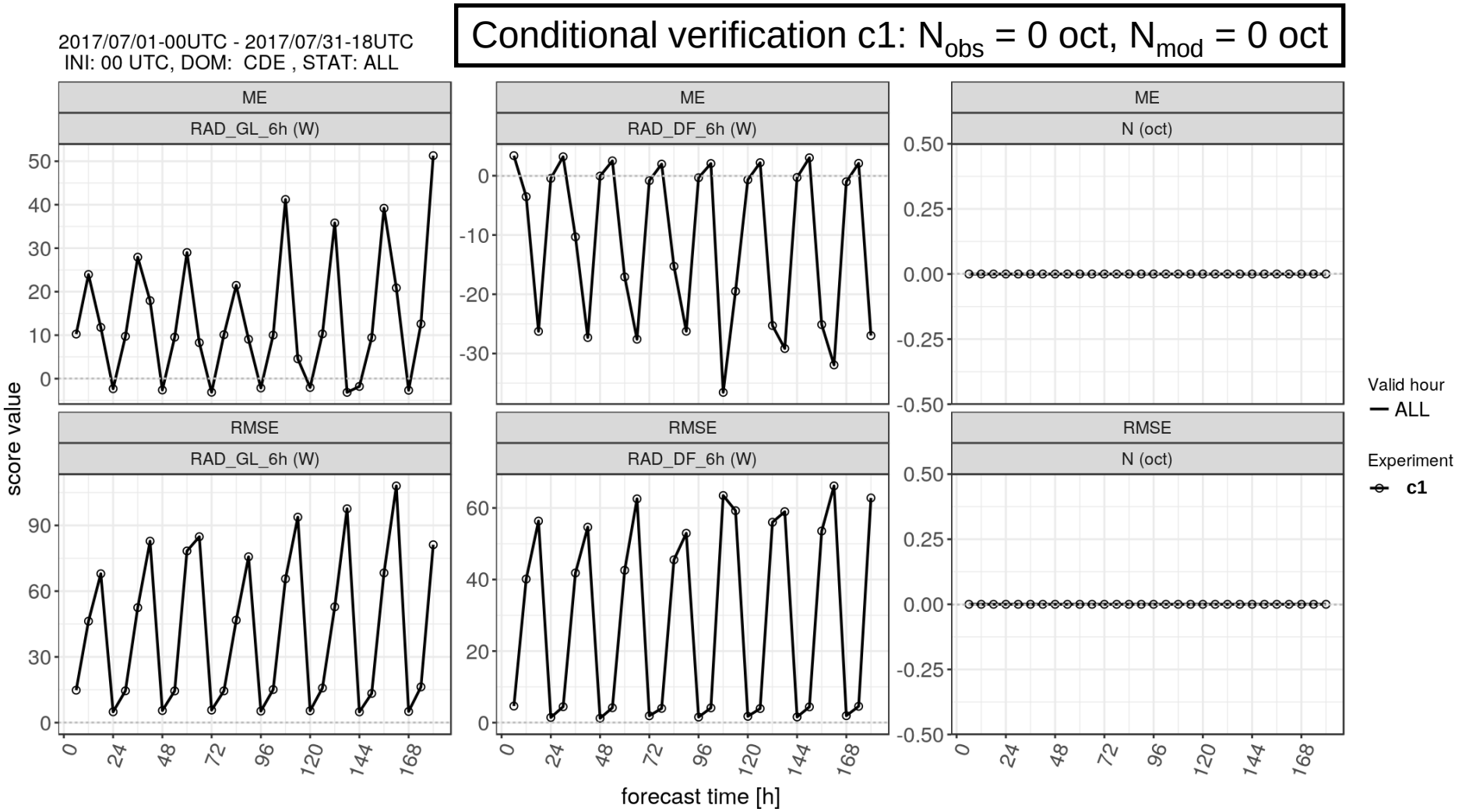
During daytime global radiation overestimated (about 60 W/m^2), diffuse radiation underestimated (40-50 W/m^2). Total cloud cover underestimated (0.5-1 oct).

ICON: Central Europe, July 2017, 00 UTC



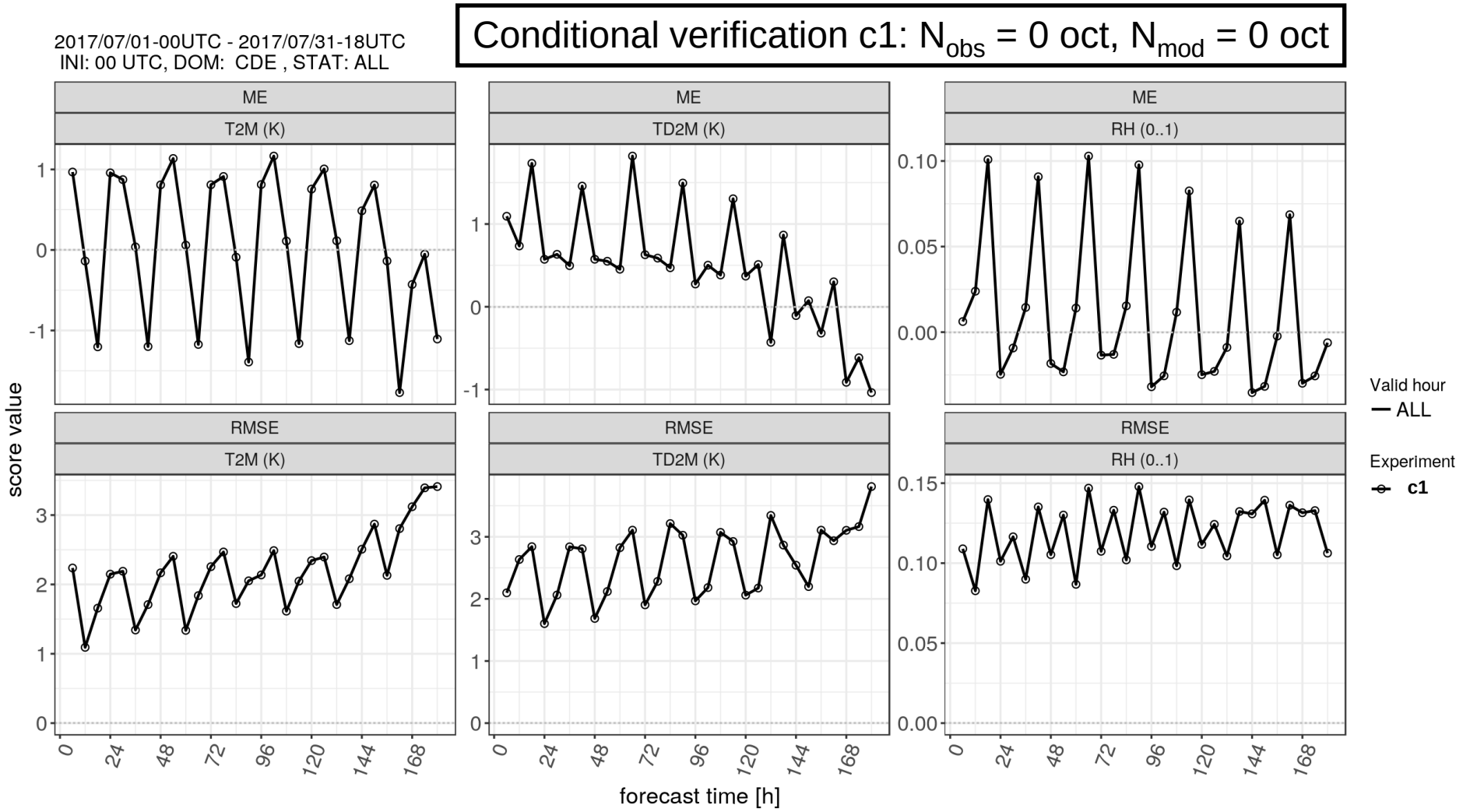
Surface warm bias at night (about 0.6 K) and reduced also at noon, and strange cold and moist bias at 18 UTC. Problem in transpiration?

ICON: Central Europe, July 2017, 00 UTC



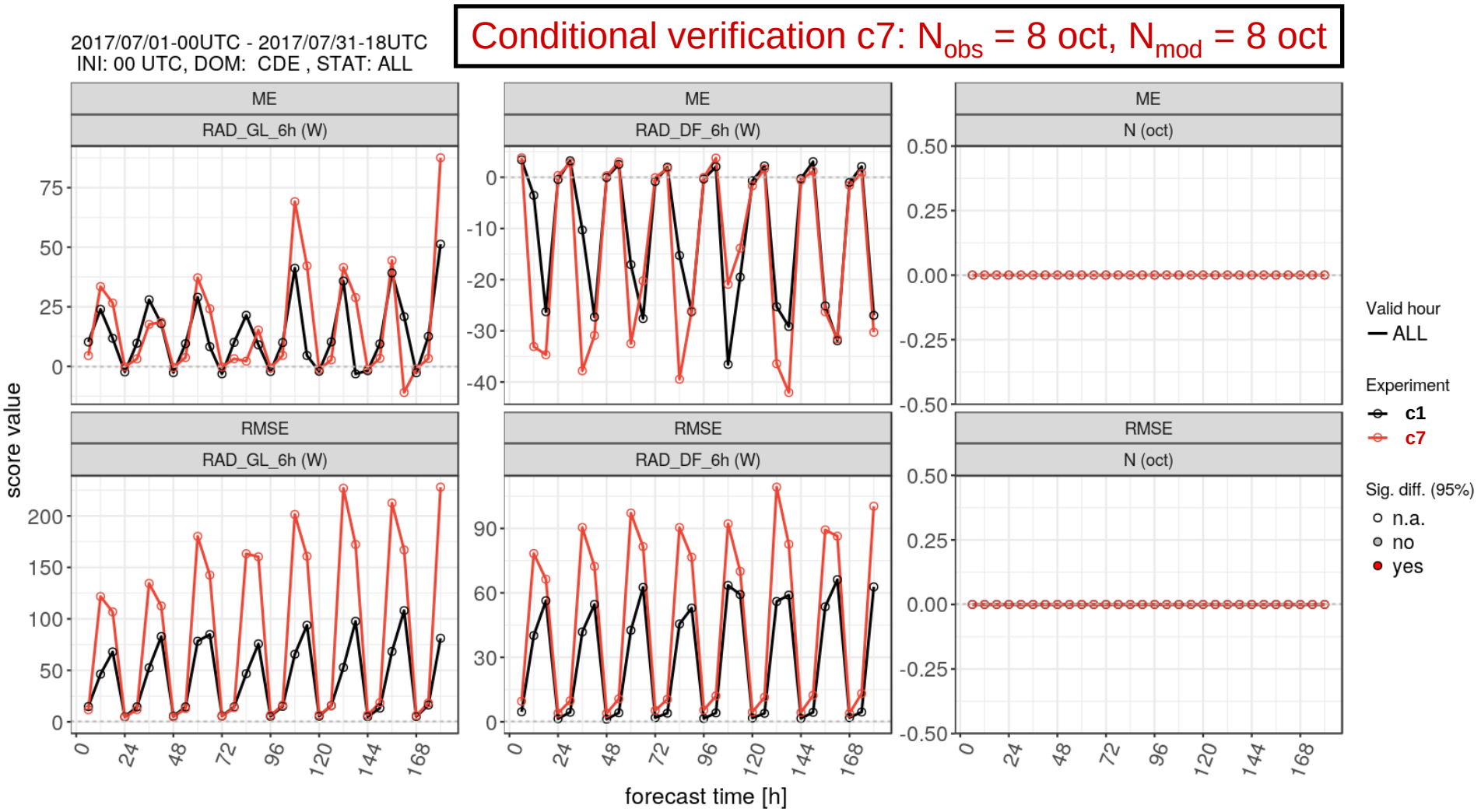
Conditional verification for clear sky (obs. and mod.): During day global radiation overestimated (about 30 W/m^2), diffuse radiation underestimated (20-30 W/m^2).

ICON: Central Europe, July 2017, 00 UTC



Conditional verification for clear sky (obs. and mod.): Surface warm bias at night (about 1 K), and strange cold and moist bias at 18 UTC. Problem in transpiration?

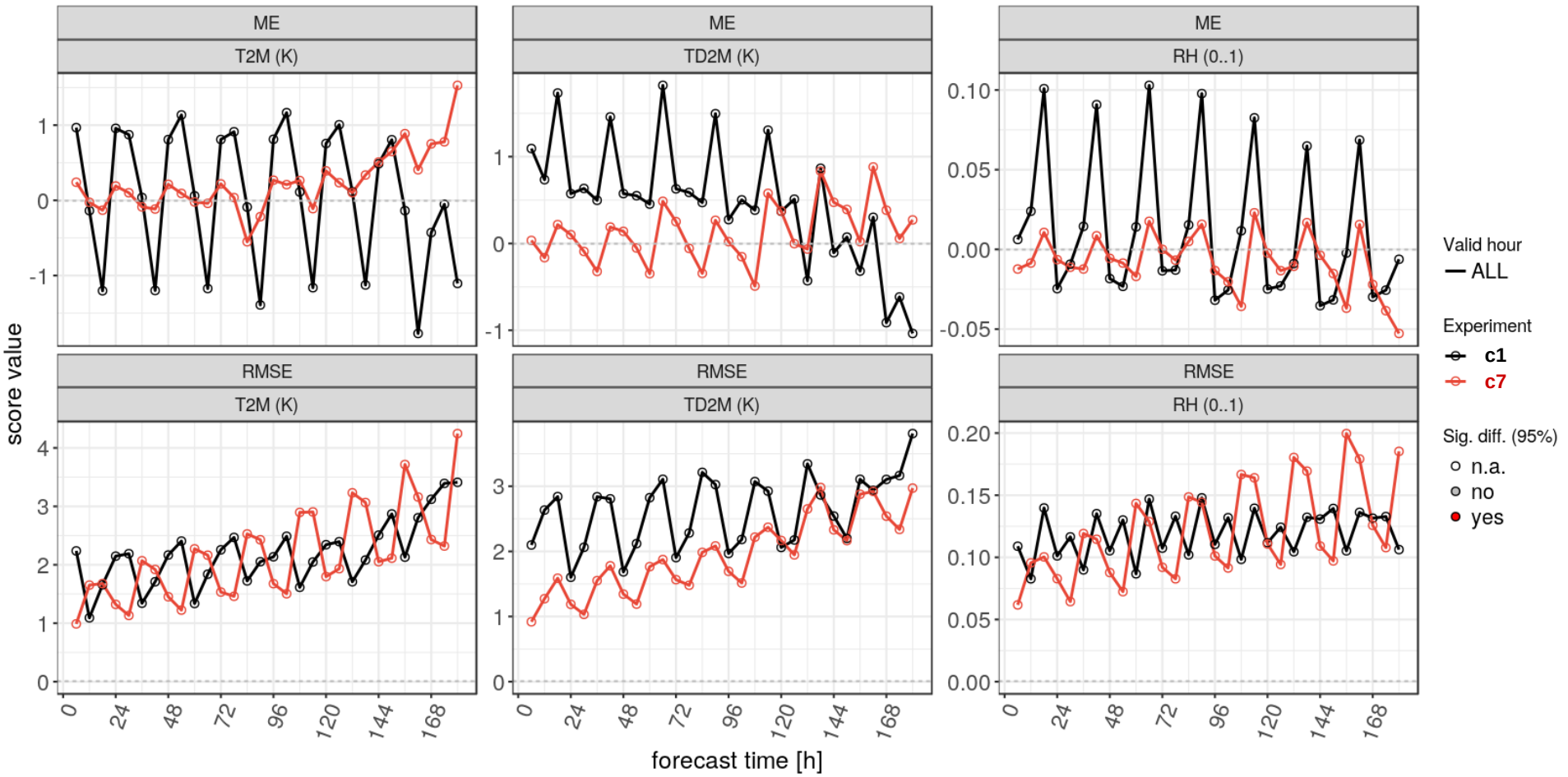
ICON: Central Europe, July 2017, 00 UTC



Conditional verification for overcast sky (obs. and mod.): Bias of global radiation comparable to clear sky, RMSE much larger.

ICON: Central Europe, July 2017, 00 UTC

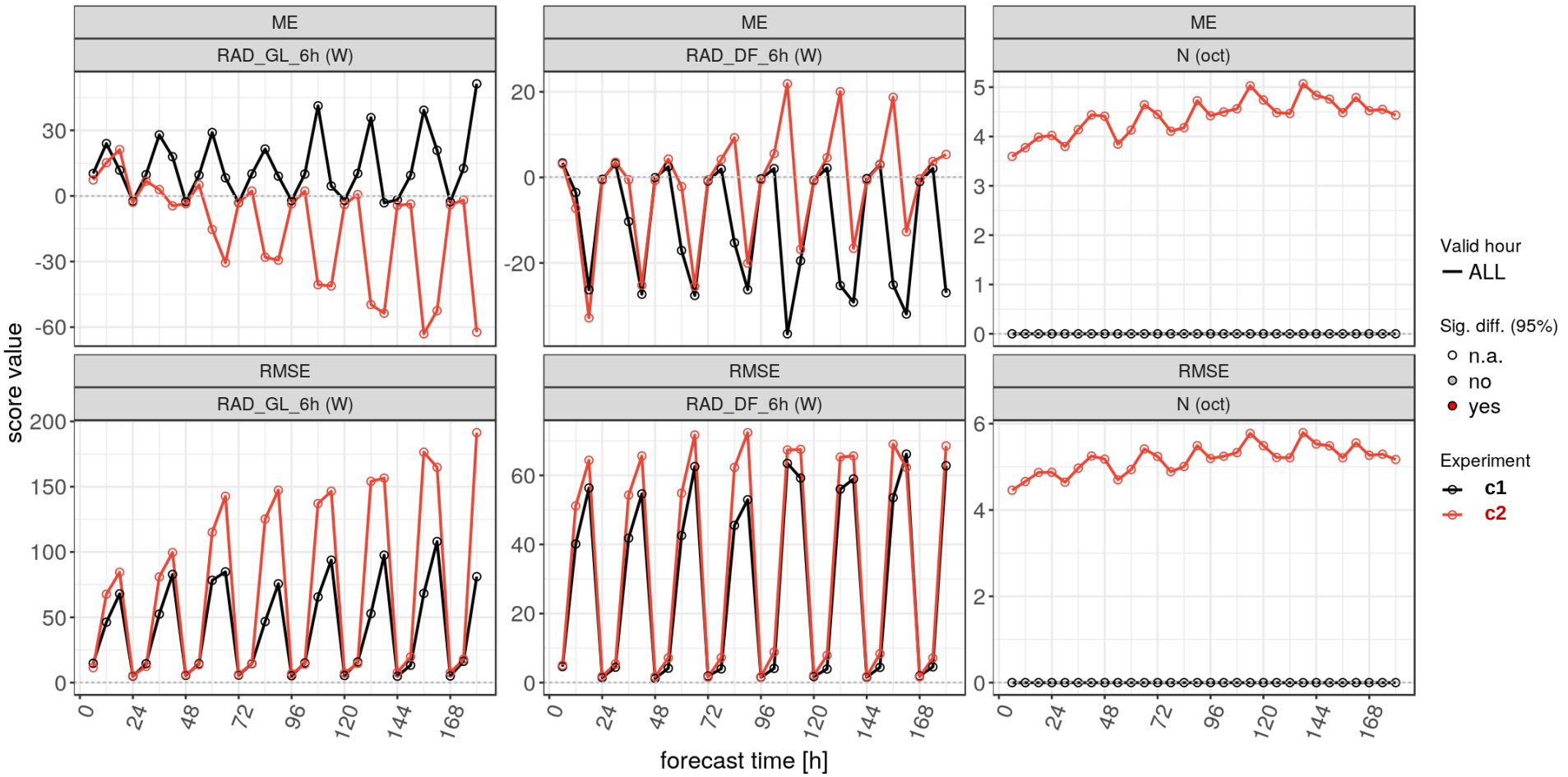
Conditional verification c7: N_{obs} = 8 oct, N_{mod} = 8 oct



Conditional verification for overcast sky (obs. and mod.): Temperature biases in the afternoon and at night very much reduced.

ICON: Central Europe, July 2017, 00 UTC

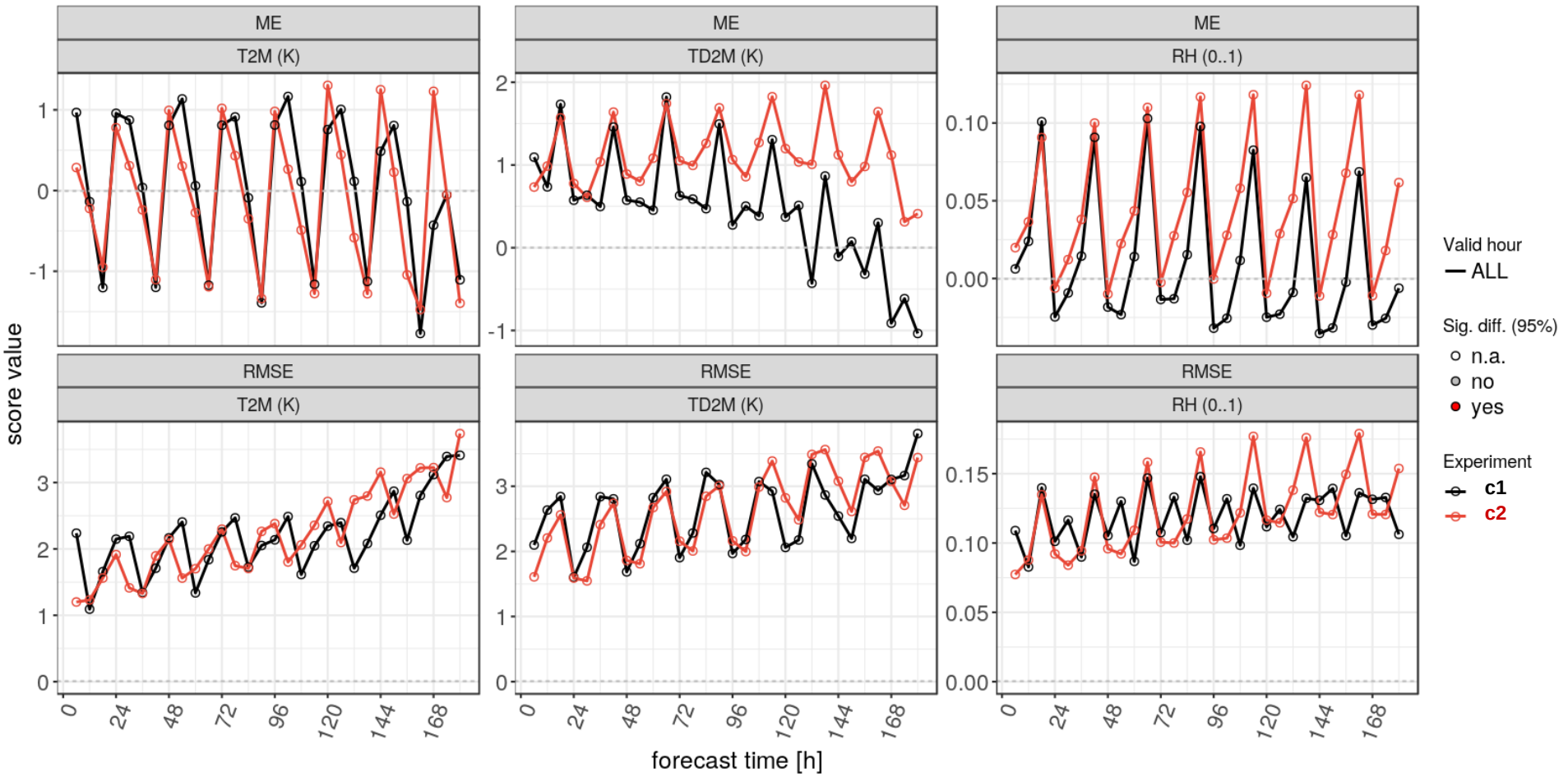
Conditional verification c2: N_{obs} = 0 oct, N_{mod} > 0 oct



Conditional verification c2: Total cloud cover highly overestimated, bias of global radiation becomes negative.

ICON: Central Europe, July 2017, 00 UTC

Conditional verification c2: N_{obs} = 0 oct, N_{mod} > 0 oct



Conditional verification c2: Biases of temperature and rel. humidity comparable to clear sky. Biases have little dependence on radiative forcing, created by local effect.

Conclusions

- The global radiation in ICON is systematically overestimated over Central Europe (on average).
- When the global radiation is realistically simulated, e.g. in some clear-sky cases at Falkenberg, then the amplitude of the diurnal cycle of the simulated 2-m temperature is systematically underestimated, in particular the nights are too warm.
  => Canopy or skin temperature formulation is needed.
- When the global radiation is overestimated, e.g. in many cases of partial cloud cover at Falkenberg, also the amplitude of the diurnal cycle of the simulated 2-m temperature is systematically overestimated, in particular the days are too warm.
  => Positive radiation bias causes positive temperature bias.
- The ICON conditional verifications confirm the overestimation of global radiation. But the behaviour of the surface temperature can not be explained by this. It appears to be governed by local effects, e.g. due to the transfer scheme.