Soil and Surface Activities in the COSMO Consortium

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with contributions from
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- developments for soil module ICON-TERRA

  → (2-m) temperature biases (underestimation of diurnal cycle)
  - soil heat conduction
  - vegetation shading

- phenology model (external parameters)

COSMO to be replaced by ICON-regional (by 2020, in development)

→ common ICON-COSMO physics

→ surface module: **ICON-TERRA** replaces COSMO-TERRA by end of 2015

→ TERRA further developed in ICON,

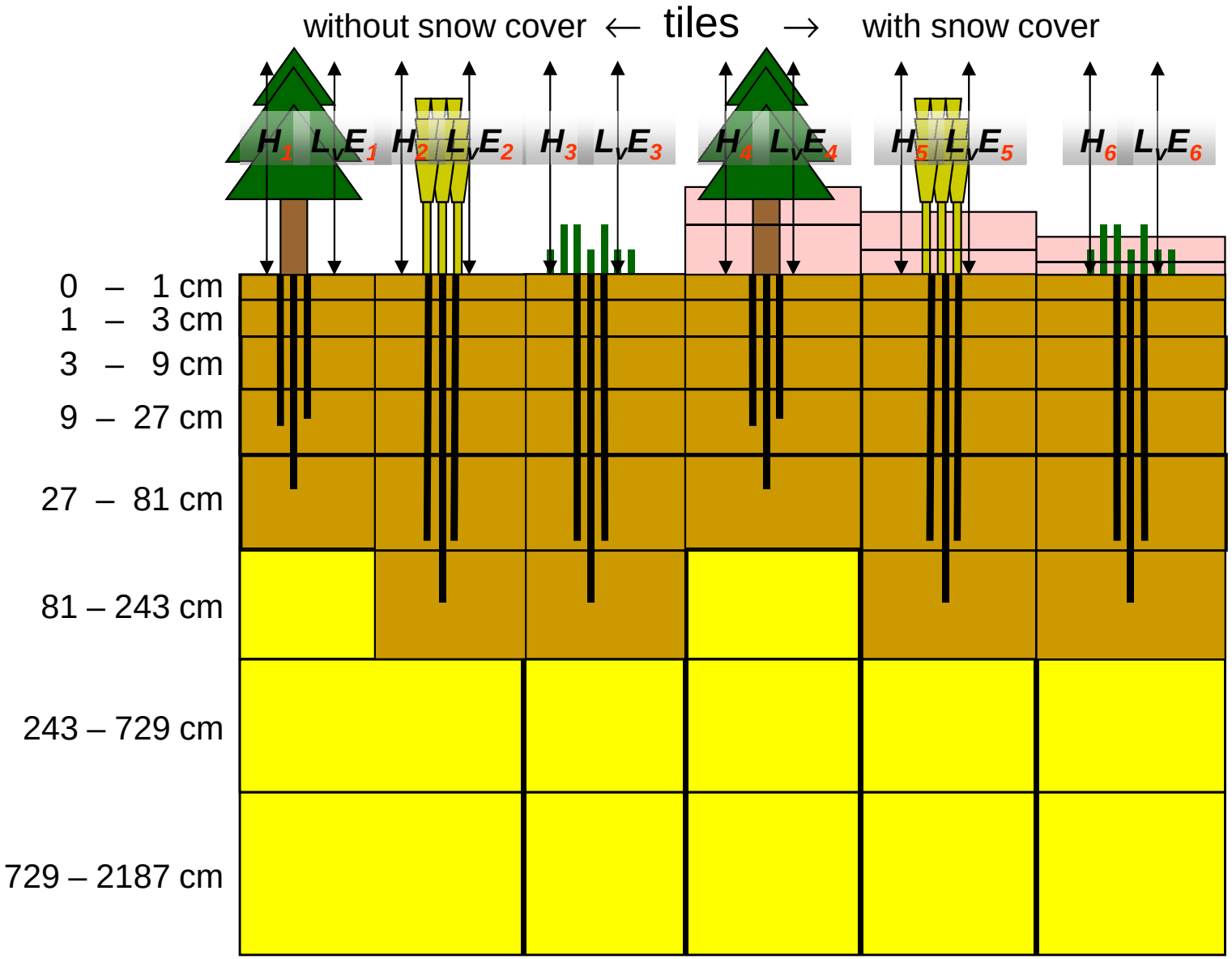
except:

- (simple) **urban** parameterization (to represent
  urban 'heat buffering' + paved surfaces; anthropogenic heat emissions;
  target: final implementation mid 2016
- **mire**: ready at RHM; open: definition of mire locations, technical review

ICON-TERRA status:

- **tile** approach implemented (but with interface only in ICON, not in COSMO)
- **multi-layer snow** model implemented (still technical issue with GRIB 2)
- improved **snow cover diagnostics**
- advanced look-up table for land-use parameters (LAI, plant cover, root depth)
- **exponential root** density profile
- improved **soil heat conduction:**
  - **soil moisture dependent** soil heat conductivity (Johanssen)
  - effect of **organic components** on hydraulic + thermal processes within root zone
    (approach as in JULES land-surface model) → vertically inhomogeneous soil

ICON-TERRA developments: organic component



organic component:

smaller heat conductivity (and heat capacity) than other parts of soil

→ **increases insulation** of soil

ICON-TERRA outlook:

- (ICON only: **tile** approach in variational **soil moisture analysis**)
- (longer-term:) **snow analysis** for multi-layer snow
- **physiographic data** (SRNWP collaboration for comparison / improvement)
- within ~ 1 year:
  - consideration of ambient humidity in plant **stomatal resistance**
  - resolved **roughness layer for canopy** (vegetation shading)

ICON-TERRA developments: model temperature bias

→ *Gerd Vogel, Jan-Peter Schulz*

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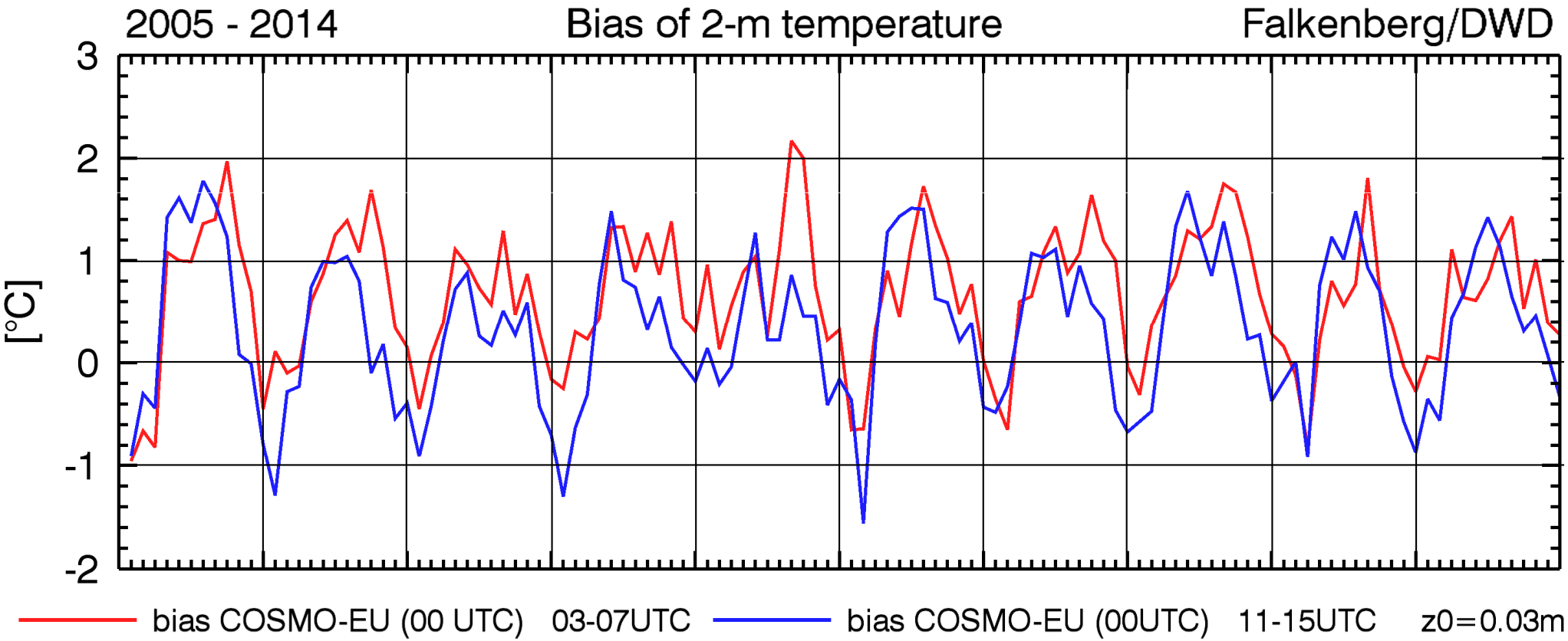

- ✓ warm bias in summer
- ✓ higher warm bias at T_{min} than T_{max} , i.e. too small diurnal cycle

ICON-TERRA developments: model temperature bias

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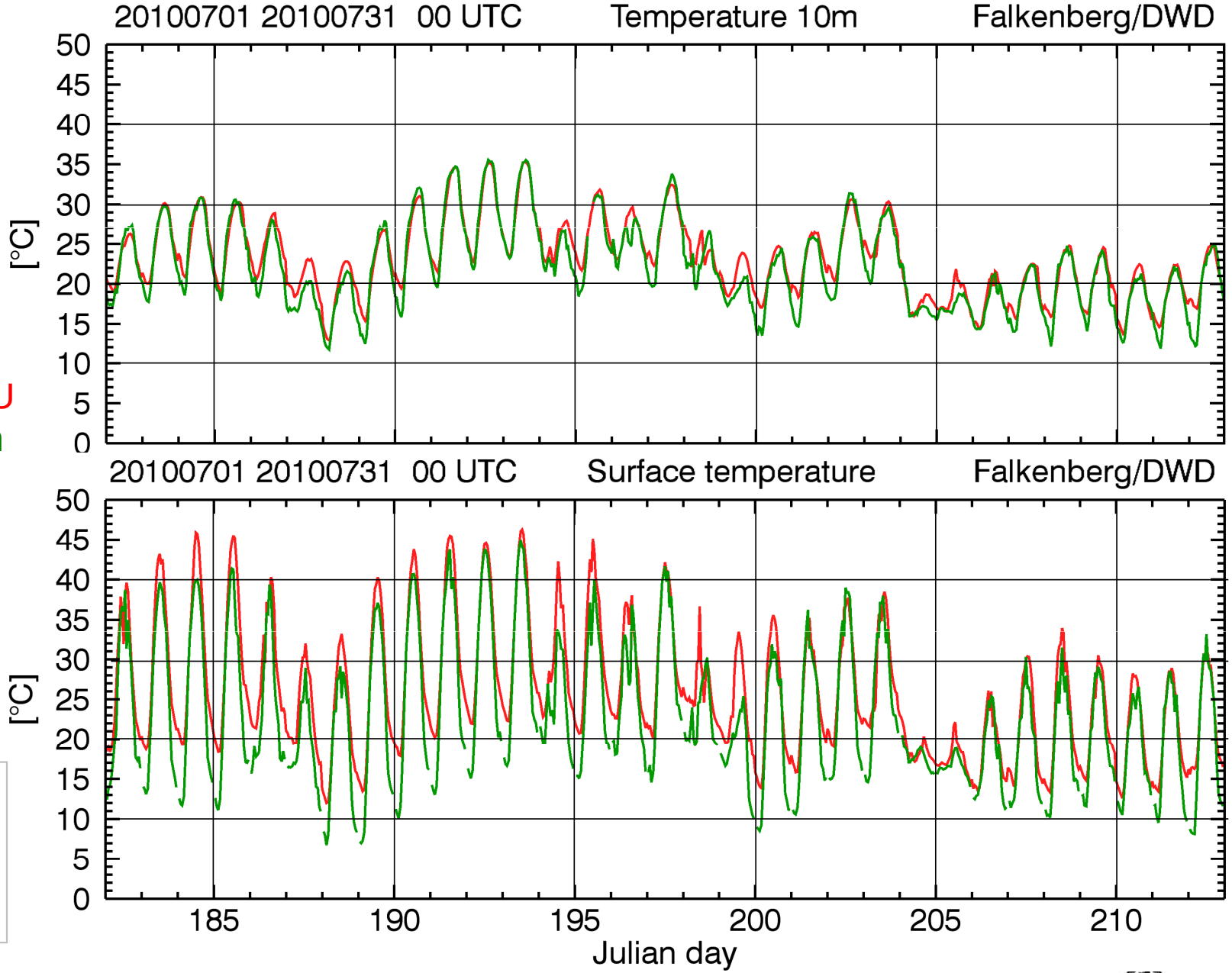
temperature 10 m above surface

COSMO-EU

observation

surface temperature



✓ bias comes from surface / soil, not from atmosphere

ICON-TERRA developments: model temperature bias

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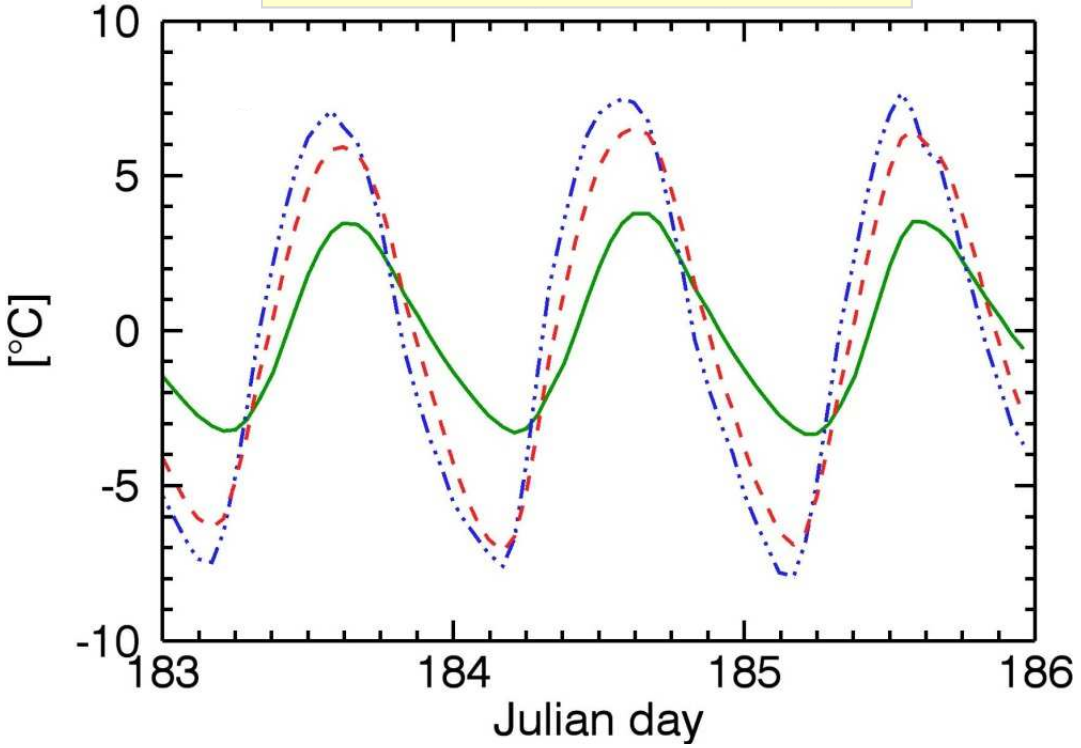
Offline TERRA: Falkenberg 2 – 4 July 2010

soil temperature (-6 cm)



- ✓ too much sensible heat at surface (from solar radiation) transported downwards to soil layers beneath
- → too large diurnal cycle within soil,
- → too small diurnal cycle at surface / +2m
- ✓ 'Johanssen' increases insulation of soil, decreases bias in diurnal cycle (slightly!)
- ✓ (similar effect by organic soil component)

observation (grass)
reference (soil heat conductivity: constant)
Jonanssen (soil heat conductivity: soil moisture dependent, reduced in dry soil)

ICON-TERRA developments: model temperature bias / vegetation shading

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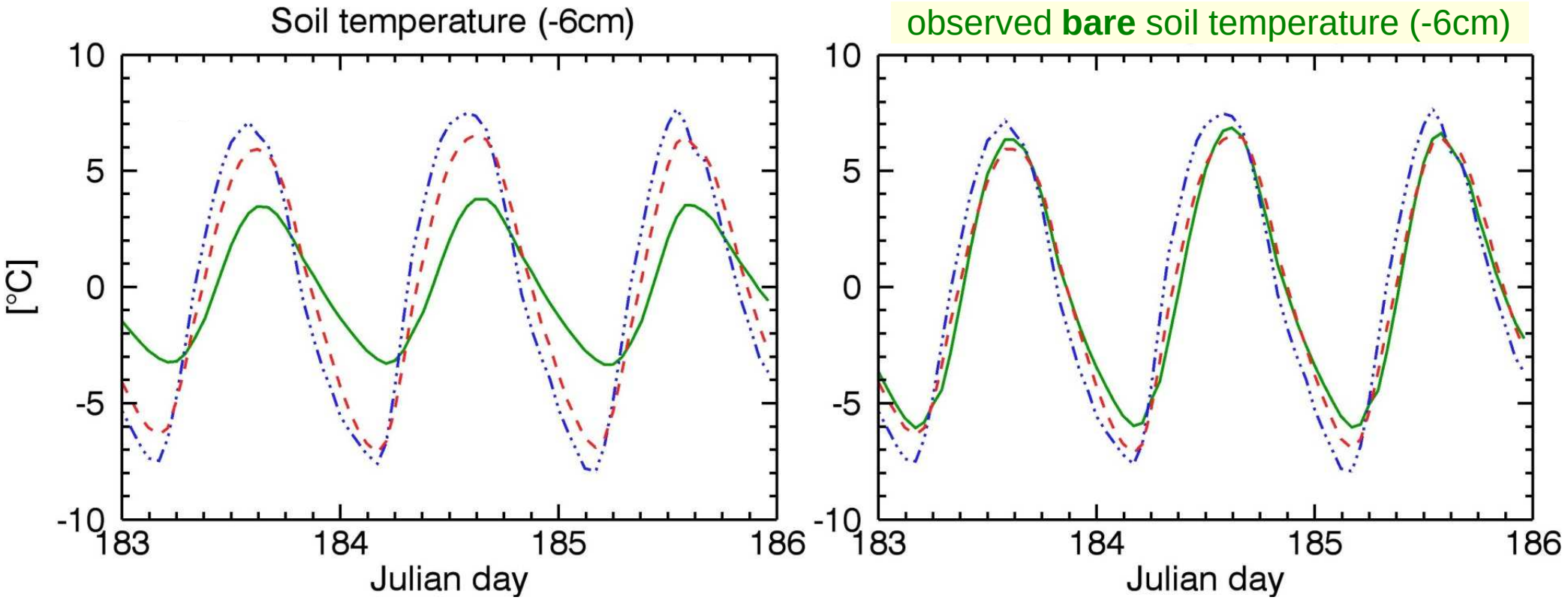
Offline TERRA: Falkenberg 2 – 4 July 2010

observation
reference
Jonanssen

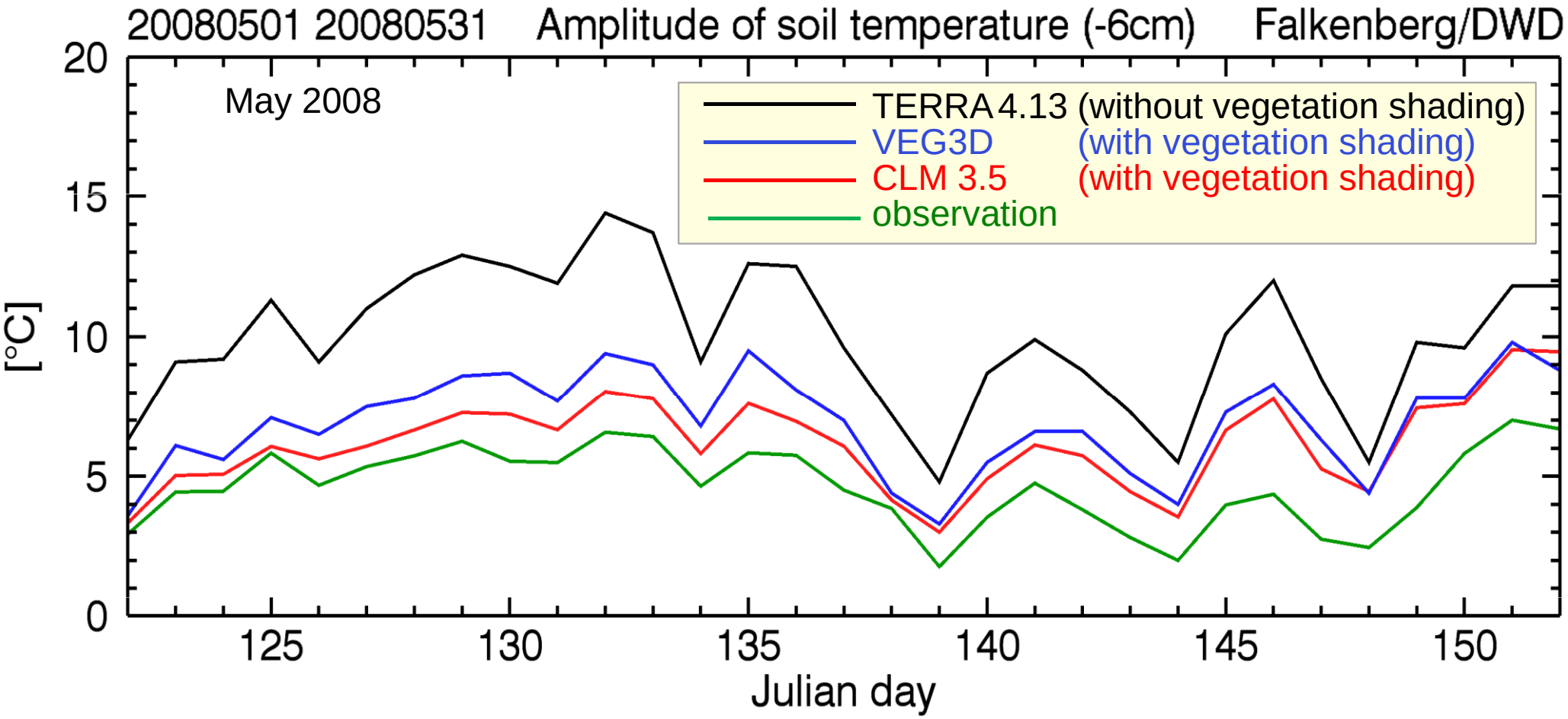


✓ good agreement of TERRA soil moisture with observed **bare** soil temperature

→ heat conduction process works well (with Johanssen; also in found in winter)

→ overestimation of diurnal amplitude of soil temperature in TERRA during summer mainly caused by the neglected **shading** of solar radiation due to **vegetation**)

ICON-TERRA developments: model temperature bias / vegetation shading



✓ with vegetation shading:
amplitude of diurnal cycle of *soil* temperature much better (smaller)

ICON-TERRA developments: model temperature bias / vegetation shading

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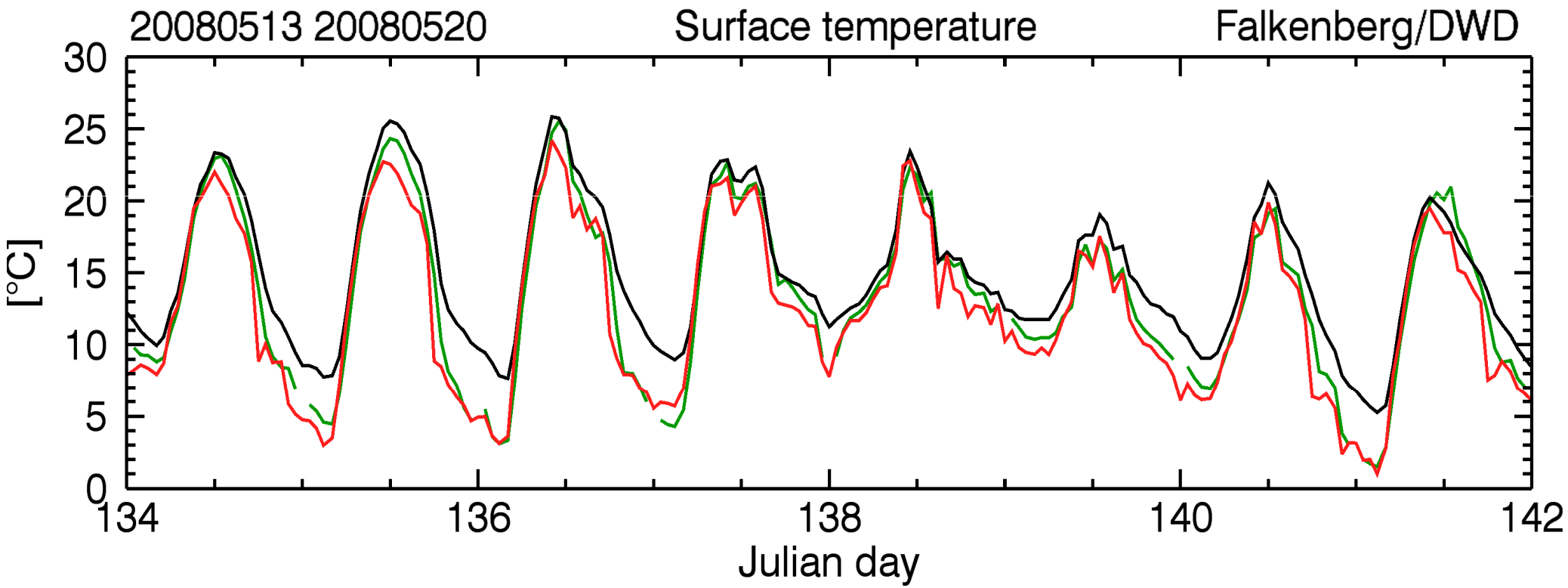

TERRA 4.13 (temperature of top soil layer / without vegetation shading)
CLM 3.5 (temperature of vegetation cover / with vegetation shading)
observation (brightness temperature)

✓ with vegetation shading:
amplitude of diurnal cycle of *surface* temperature much better (larger)

→ (work will start soon to) implement vegetation shading (in ICON-TERRA)

ICON-TERRA developments: phenology model

→ *Reto Stöckli, Jan-Peter Schulz, Gerd Vogel*

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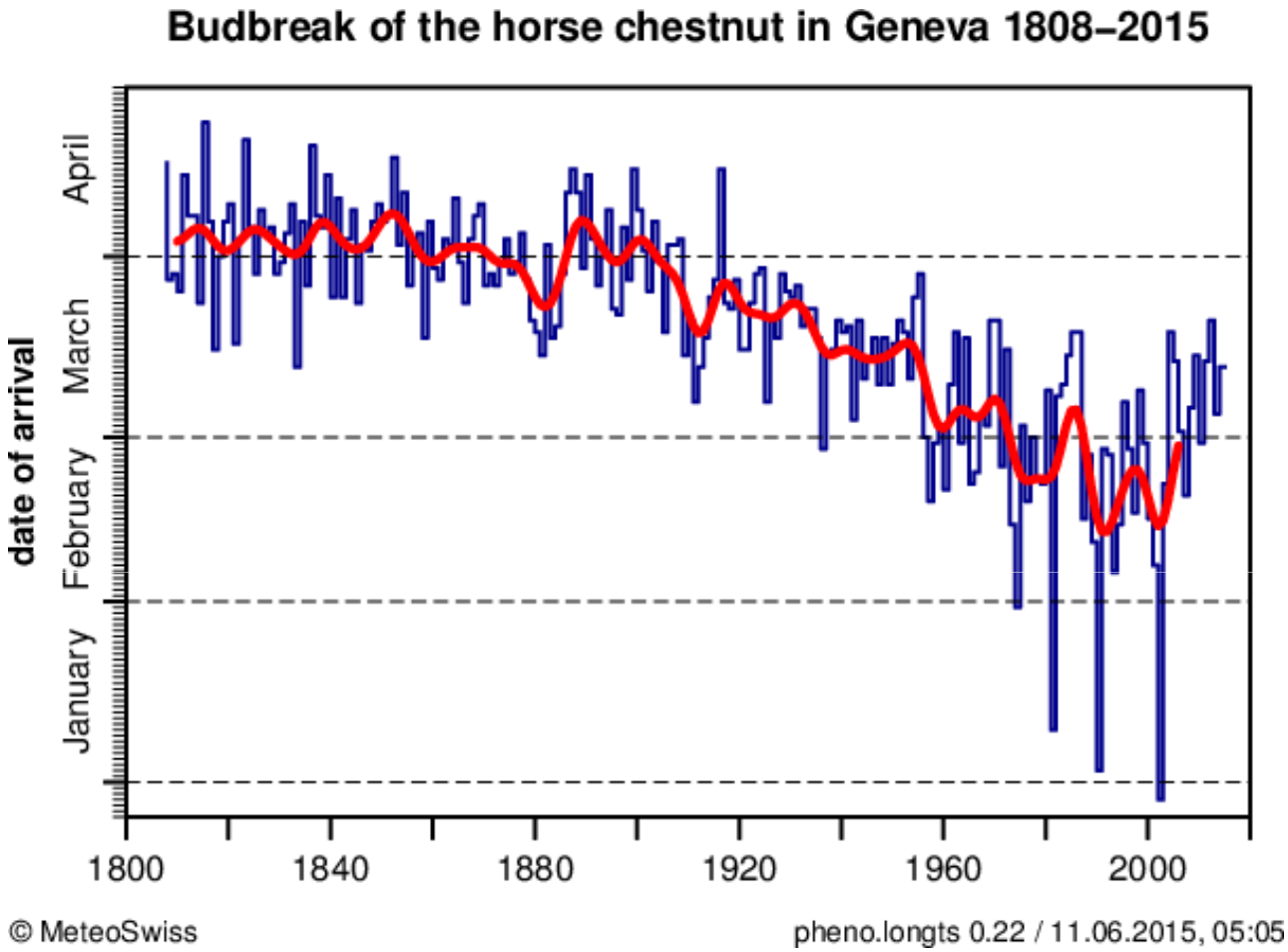
Aim: Implement a **phenology** model to capture the **inter-annual variability** and decadal trends of the vegetation cycle



inter-annual variability + decadal trends are important!

Vegetation state depends on

- temperature history since start of year
- day length
- water availability
- ~~NPP (net primary productivity)~~

→ **phenology model** calibrated with MODIS data (Stöckli, MeteoSwiss; ref. Knorr et al., Polcher et al.) implemented in offline TERRA

ICON-TERRA developments: phenology model

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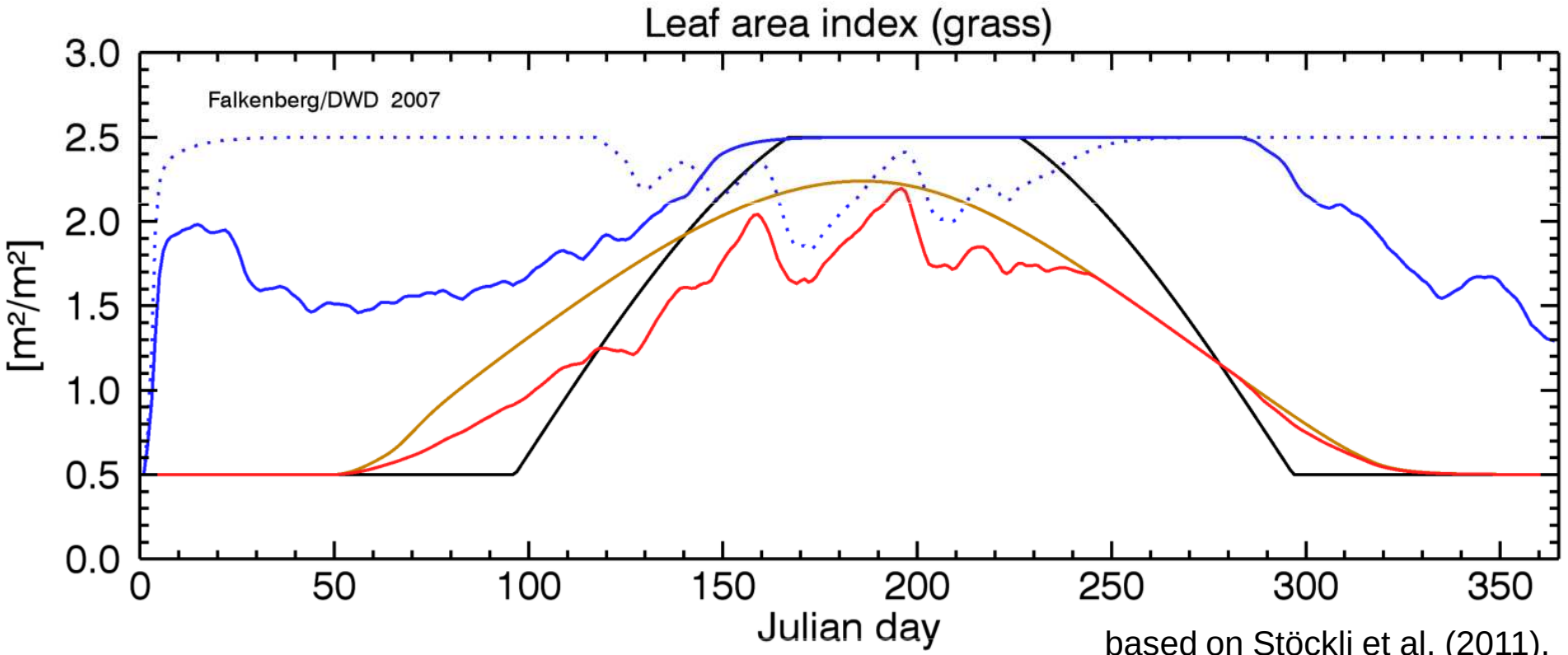
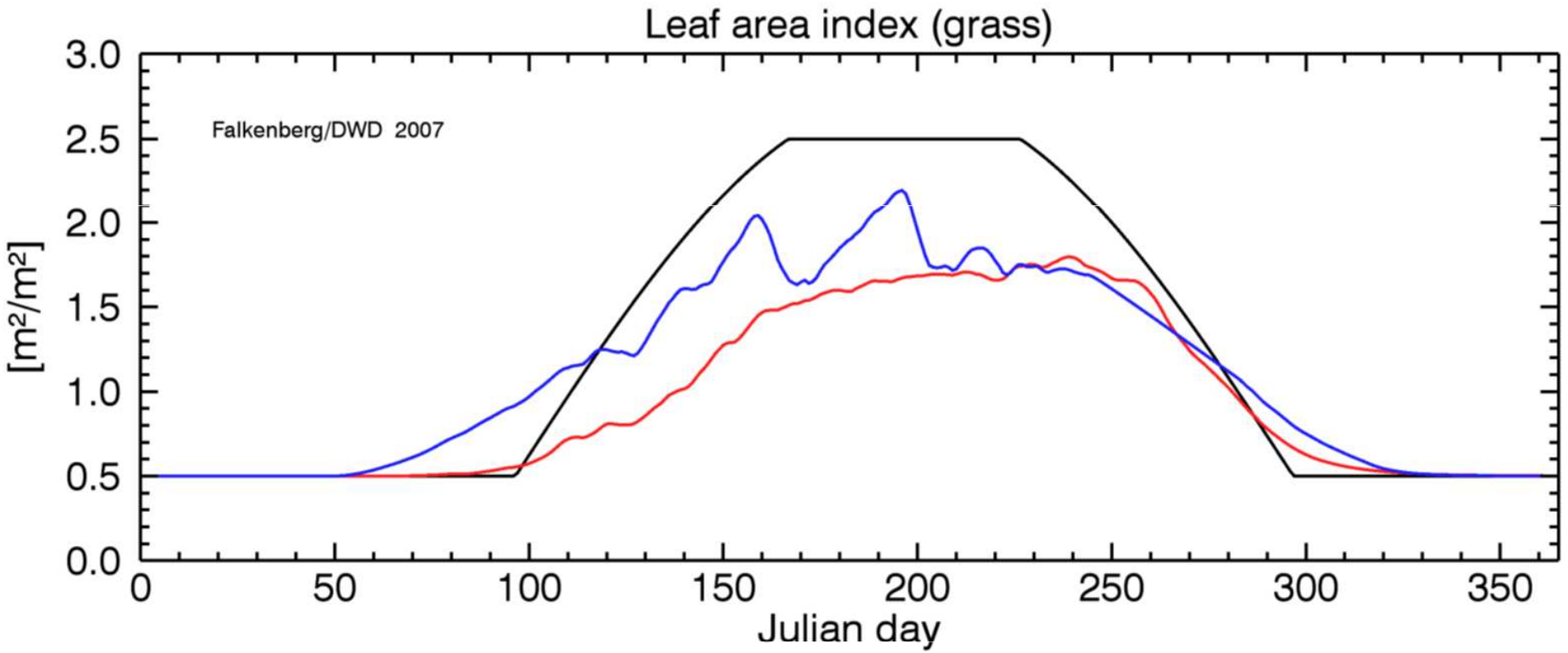


based on Stöckli et al. (2011),
C3-grass (nordic, LAI adapted)

stress factors limiting LAI:

- current param. (sinus: TERRA)
- temperature (history)
- length of day
- vapour pressure deficit
- all stress factors

ICON-TERRA developments: phenology model



all stress factors limiting LAI:

current param. (sinus: TERRA)

C3-grass (nordic)

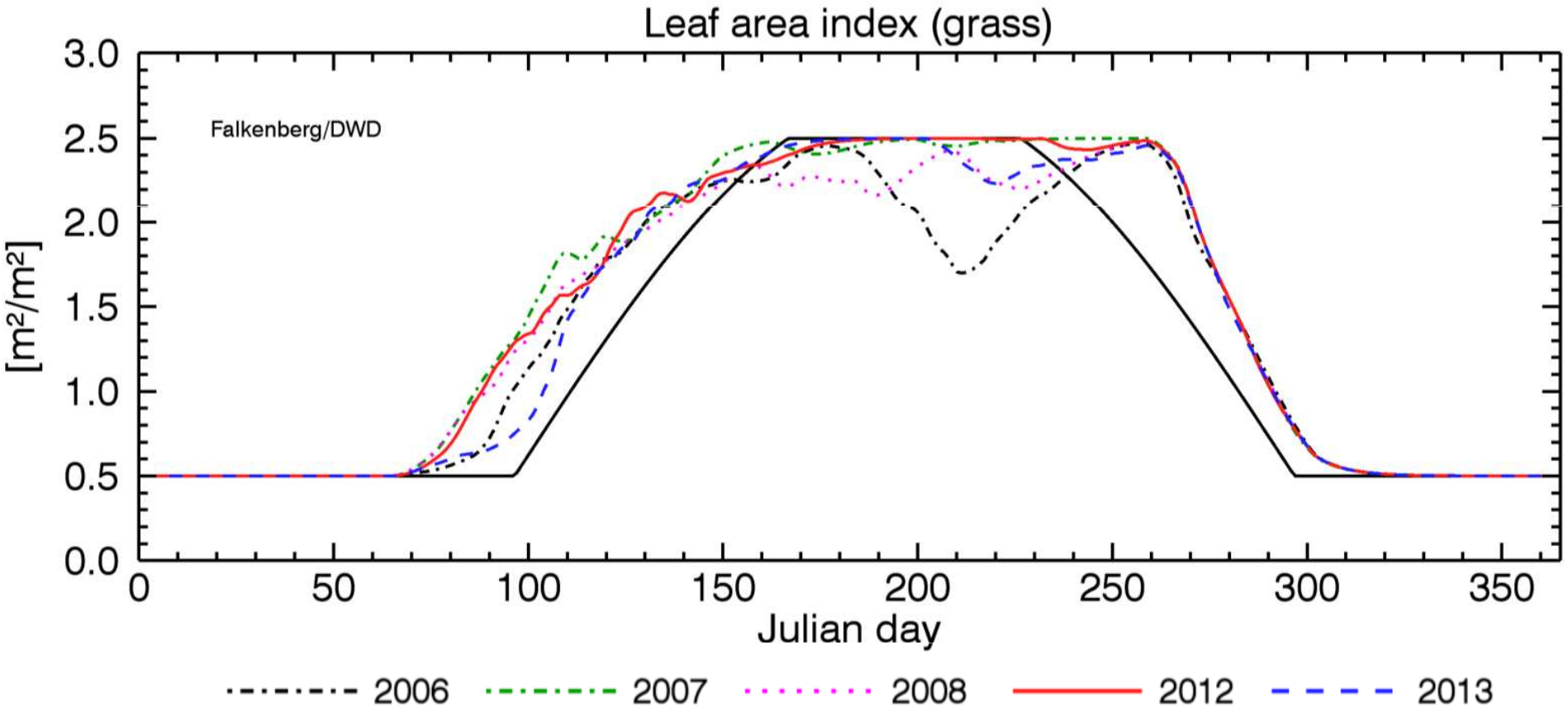
C4-grass (African savannah)

some stress factors are too strong:

- ✓ C3-grass: length of day
- ✓ C4-grass: min. temperature

→ combine stress factors for C3, C4 to match Falkenberg grass

ICON-TERRA developments: phenology model



C3 grass tuned for Falkenberg:
stress functions:
T_{min} C3; day length C4; vapour pressure deficit min. 7, max. C4

ICON-TERRA developments: phenology model

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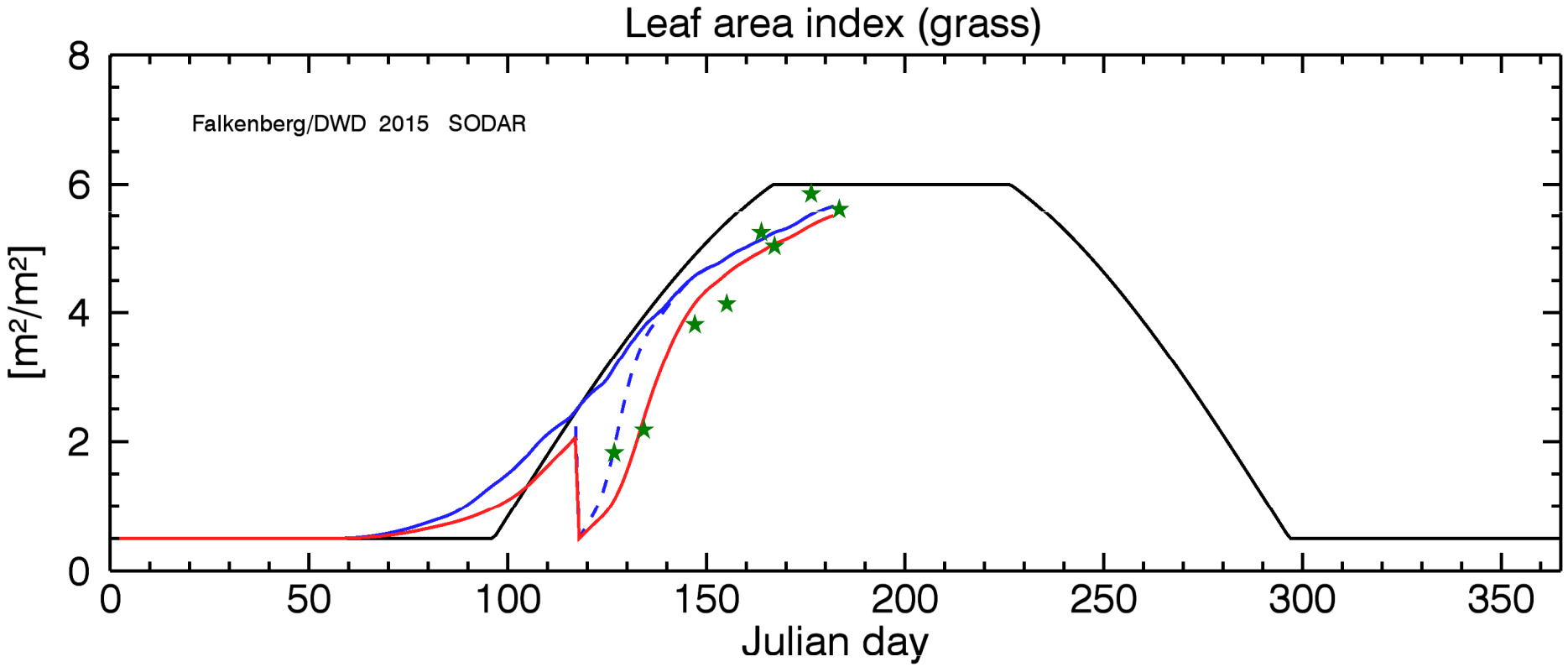

★ observations 2015 ! (cold in April)

current parameterization (sinus: TERRA)

Tmin C3, day l. C3+C4, vapour p.d. 7/C4, C3-grass, LAI_max=6

Tmin C3, day l. C3+C4, vapour p.d. 7/C4, C3-grass, LAI_max=6, **with mowning**

Tmin C3, day l. C3+C4, vapour p.d. 7/C4, C3-grass, LAI_max=5, **with mowning, growth rate *0.5**

ICON-TERRA developments: phenology model

status:

- current TERRA cannot account for the inter-annual variability of phenology
- the approach by Stöckli et al. (2008, 2011) was implemented
  (stress functions of temperature, length of day, water availability; combining concepts of threshold values (Polcher 1994) , of growth + decay rates (Knorr et al. 2010))
- testing at 3 different sites:
  with some tuning, the site specific behaviour can be well described.

next steps:

- inclusion of the full 35 plant functional types (mapping to TERRA land use types)
- implementation into 3-D coupled model code

ICON-TERRA developments: