Assimilating satellite-derived land surface temperature: Model Equivalent

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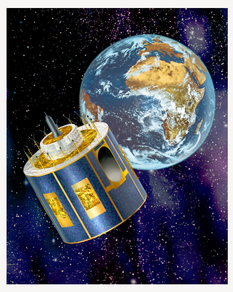
Motivation

- Improve simulation of coupled land-atmosphere system; important, as complex interactions between land and atmosphere strongly influence near-surface weather and climate
- Land surface temperature (T_{skin}) is important component of surface energy balance; accurate simulation can improve simulation of soil temperature, latent and sensible heat flux
- Design observing system simulation experiment to assimilate T_{skin} derived from satellites (obtained from LANDSAF derived from SEVIRI)



Main findings to be expected:

(1) Learn about coupling processes and deficiencies in current system by evaluating information provided by data assimilation system

(2) Estimate soil/surface parameters based on T_{skin} assimilation. What can be learned from estimated parameters?

(3) Effect of improved initial state of T_{skin} and improved parameters on the atmospheric boundary layer.

T_{skin} Model Equivalent

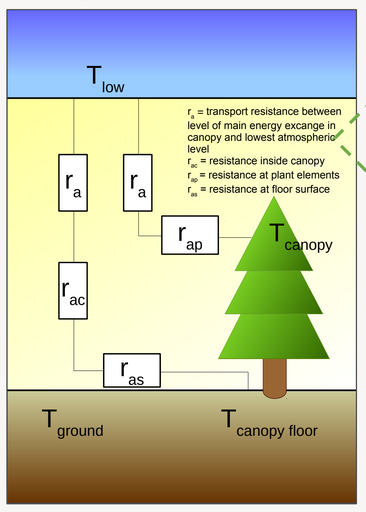
Preliminary goal: identify a good model T_{skin} equivalent to be used in assimilation process. Currently vegetation temperature is not considered in the COSMO model, but there are two different possible implementations (Canopy Scheme and Skin Conductivity Scheme):

Canopy Scheme [1] :

- Resistance approach from AMBETI-model
- Prognostic equation for canopy surface temperature from a land-surface scheme of the Rossby Centre regional atmospheric climate model

Skin Conductivity Scheme [2]:

- Based on the representation of skin temperature in the ECMWF land surface model (H-TESSEL)
- Skin represents vegetation layer and top layer of the bare soil (no snow)



Main equations:

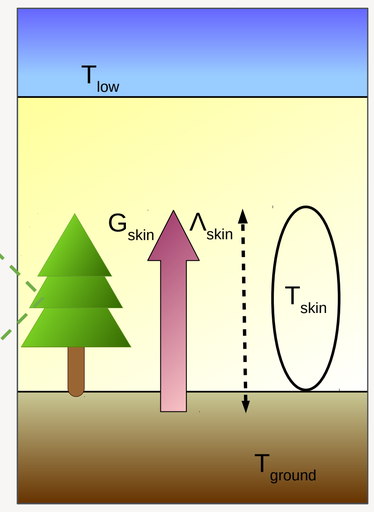
$$\frac{\partial T_{canp}}{\partial t} = \frac{1}{C_{canp}}\left(R_{canp} + H_{canp} + L_{canp}\right)$$

$$T_{skin} = SVF \cdot T_{ground} + (1 - SVF) \cdot T_{canp}$$

$$G_{skin} = \Lambda_{skin}\left(T_{skin} - T_{ground}\right)$$

$$\Lambda_{skin} = 10\,\frac{W}{Km^2}$$

SVF = sky-view-fraction
Λ_{skin} = skin conductivity
G_{skin} = skin layer heat flux



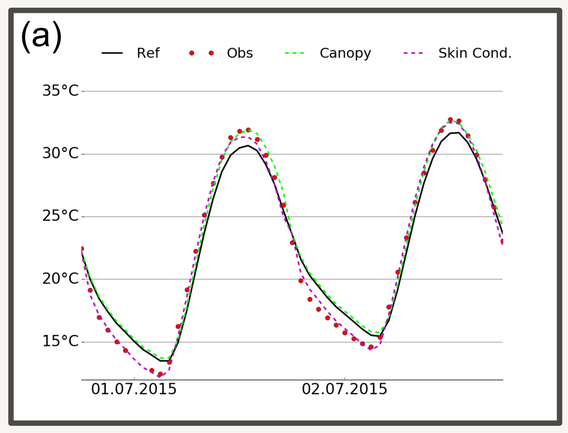
Comparison of T_{skin} Model Equivalents

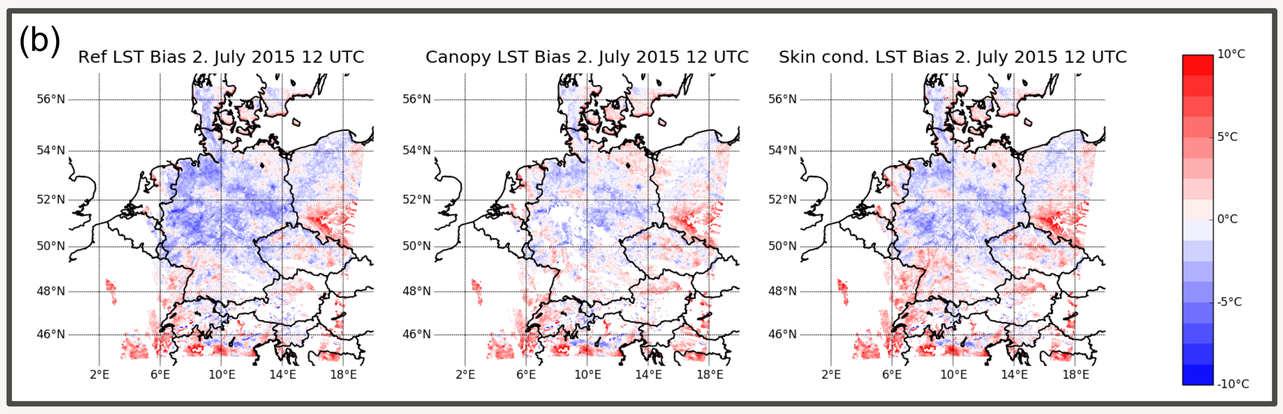
(a) Diurnal cycle of mean T_{skin} over COSMO-DE domain:

- Diurnal amplitude too small in reference
- Daytime maximum improved for both new schemes
- Night minimum improved for skin conductivity scheme

(b) Bias of T_{skin} over the COSMO-DE domain (02.07.2015 12 UTC):

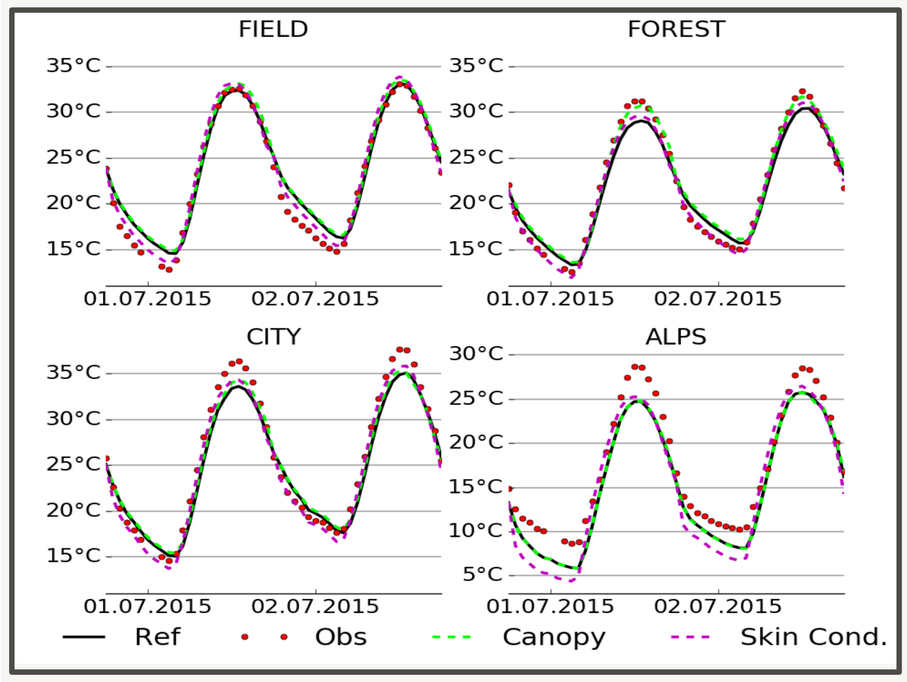
- Smaller cold bias for both new schemes
- Canopy scheme leads to clouds at areas where in the other cases no clouds are observed or modelled

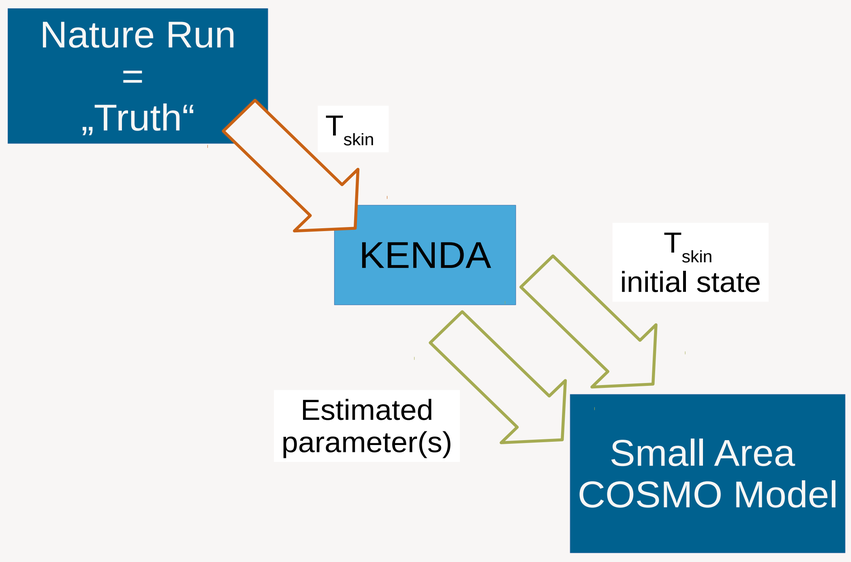




Land Use Effects

- Different land use types represent diurnal cycle with varying degrees of success
- Larger biases for city and Alps





Assimilation Experiments

- The effects of assimilation of T_{skin} and the parameter estimation will be assessed with **idealized cases**.
- **Data assimilation** based on a local ensemble transform Kalman filter (LETKF) technical realised by KENDA (Kilometre-Scale Ensemble Data Assimilation [3])
- Combine data assimilation with **parameter estimation** through state vector augmentation in EnKF
  → **possible candidate is the skin conductivity**
- Data assimilation and parameter estimation will be tested with **real cases** to gain improved understanding of physical processes and observations in a structured framework (Observational data from the LANDSAF **surface temperature product derived from SEVIRI**)

References

[1] Helmert, J., Zängl, G., Machulskaya, E., Pondkule, M., Reinert, D., Vogel, G., and Ritter, B. (2016). TERRA and EXTPAR, Recent developments at DWD. Presentation.

[2] Schulz, J.-P. and G. Vogel, 2017: An improved representation of the land surface temperature including the effects of vegetation in the COSMO model. Geophysical Research Abstracts, 19, EGU2017-7896.

[3] Schraff, C., Reich, H., Rhodin, A., Schomburg, A., Stephan, K., Periáñez, A., Potthast, R. (2015): Kilometre-Scale Ensemble Data Assimilation for the COSMO Model (KENDA). Q.J.R. Meteorol. Soc.

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