[VERIMIP] Comparison of COSMO-TERRA and COSMO-CLM in weather mode for summer heat extremes

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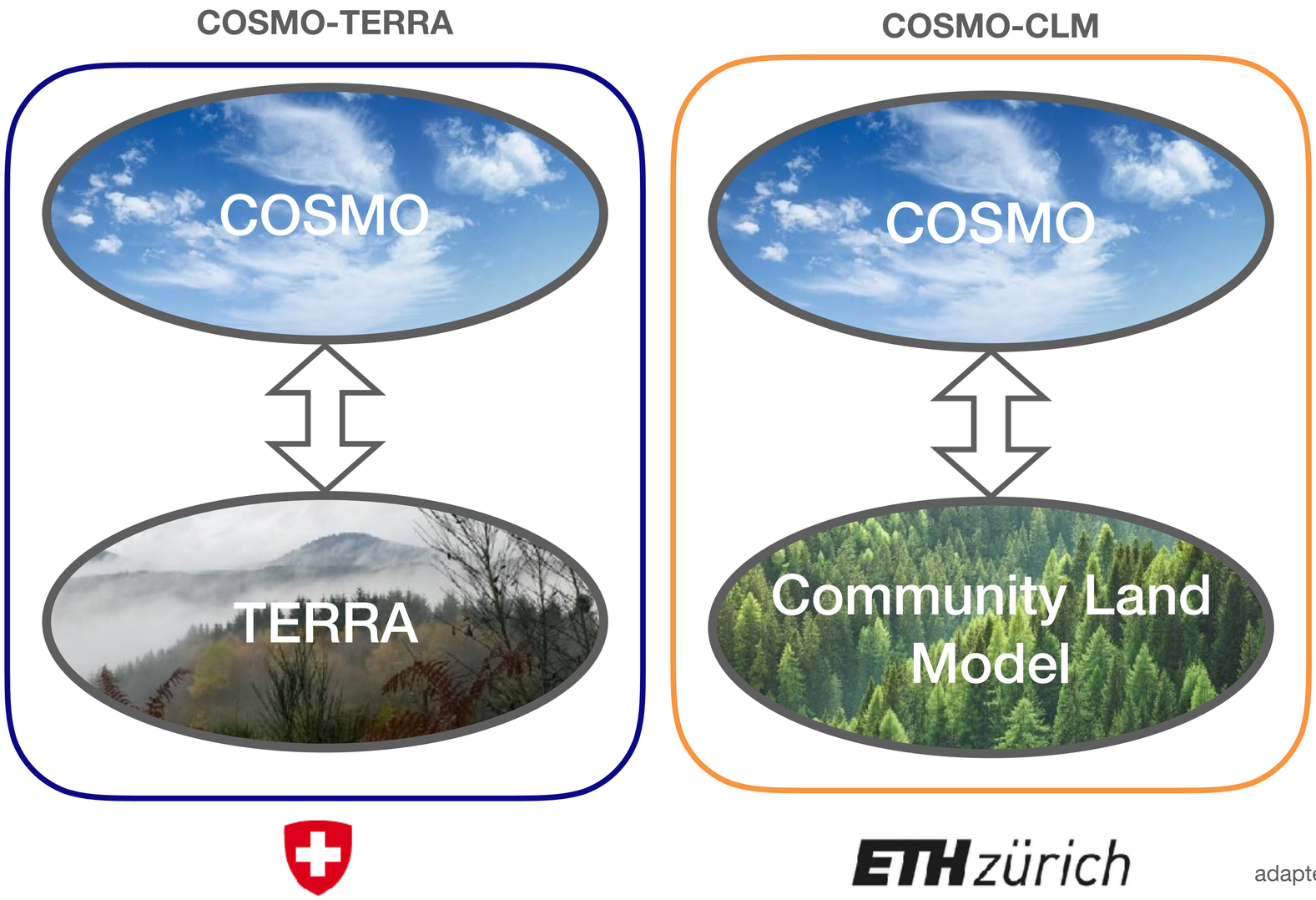
Framework



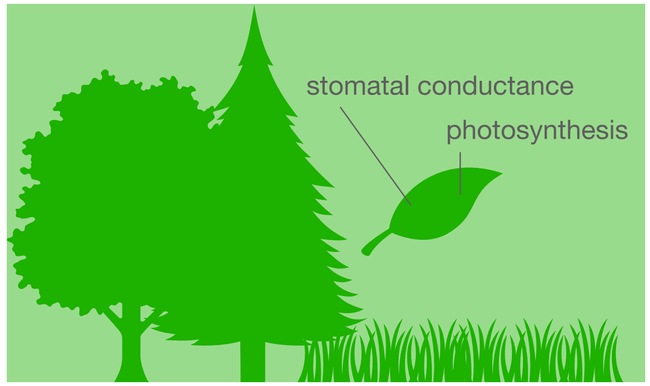
adapted from Edouard Davin

TERRA vs CLM

T_{2m} T_{2m}

empirical stomatal conductance

$T_{radiative}$



$T_{radiative\ (vegetation)}$

$T_{radiative\ (surface)}$

~ ‘2nd generation‘

~ ‘3rd generation‘

adapted from Vogel et al 2015

TERRA vs CLM

COSMO TERRA 5.0

COSMO TERRA 5.05 *standard* settings

COSMO TERRA 5.05 *advanced* settings

v5.05 DELAYED

COSMO CLM

Evaluation Datasets

model resolution: 6.6km, hourly

	EOBS	Satellite LST	GLEAM	WECANN	CERES	GHF estimate
type	**gridded meteorological stations**	**thermal infrared from EUMETSAT**	**model fed with satellite and ground observations**	**solar-induced fluorescence, machine learning**	**satellite observation**	**compound product**
time resolution	**daily 1950-2015**	**hourly 1991 - 2015**	**daily 1980-2016**	**monthly 2007-2015**	**daily 2000-2017**	**daily 2015**
spatial resolution	**0.1° × 0.1° Europe**	**5 × 5 km Europe & Africa**	**0.25° x 0.25° global**	**1° x 1° global**	**1° x 1° global**	**resp. resolution**
2m temperature [K]	daily 2m-temperature (min, max, mean) [K]					
ground temperature [K]		radiative ground temperature [K]				
SH [W m^{-2}]				daily sensible heat [Wm^{-2}] monthly average		
LH [W m^{-2}]			evapotranspiration [mm/day]	daily latent heat [Wm^{-2}], monthly average		
LW [W m^{-2}]					longwave radiation [Wm^{-2}]	
SW [W m^{-2}]					shortwave radiation [Wm^{-2}]	
Ground heat flux [W m^{-2}]						ground heat flux [Wm^{-2}]

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Ground heat flux [W m^{-2}]						ground heat flux [Wm^{-2}]

$$G_{obs,1} = LW_{net,CERES} + SW_{net,CERES} - H_{net,WECANN} - LE_{net,GLEAM}$$

$$G_{obs,2} = LW_{net,CERES} + SW_{net,CERES} - H_{net,WECANN} - LE_{net,WECANN}$$

Assessing LSM performance

Comparison	Evaluation	Benchmarking
Def: compare to other models	Def: compare to observations	Def: compare to benchmark
advantage: find where performance improvements are achieveable	advantage: compare to real measurements	advantage: a priori, non-relative, measure of information usage
challenges: making models more alike does not necessarily make them better	challenges: observations are not available / have gaps / have limitations / have uncertainties	challenges: finding a suitable benchmark

from Best et al 2015: The Plumbing of Land Surface Models: Benchmarking Model Performance

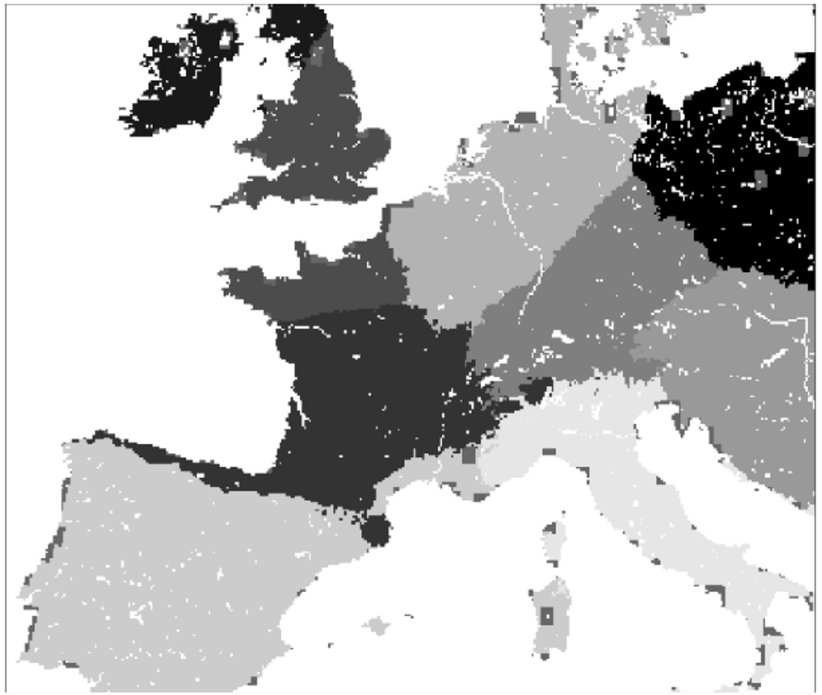
Benchmark experiment

(1) separate the domain in subdomains of similar points with kmeans algorithm

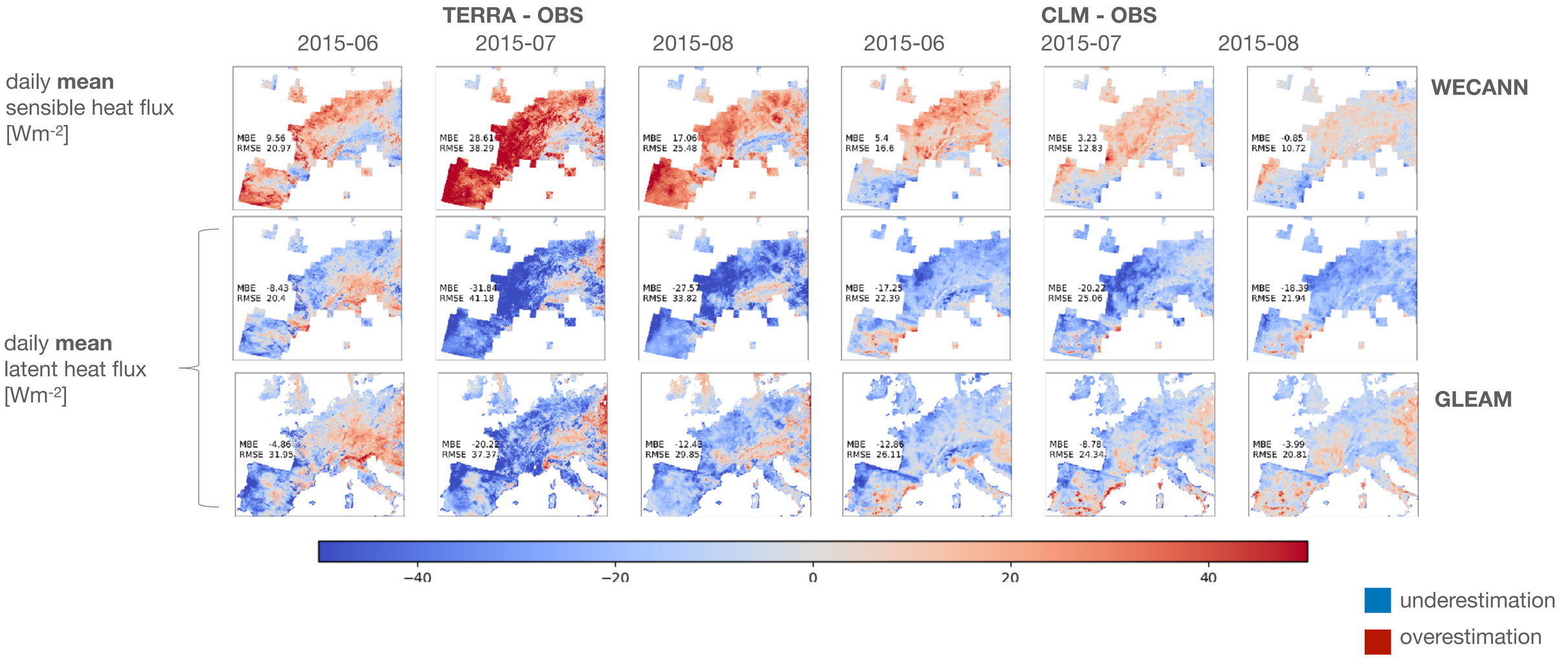
(2) train a ridge regression on each subdomain (year 2006)

$$f(SW_{COSMO}, PRECIP_{COSMO}) = w_1 SW_{COSMO} + w_2 PRECIP_{COSMO} + w_0 = LH_{GLEAM}$$

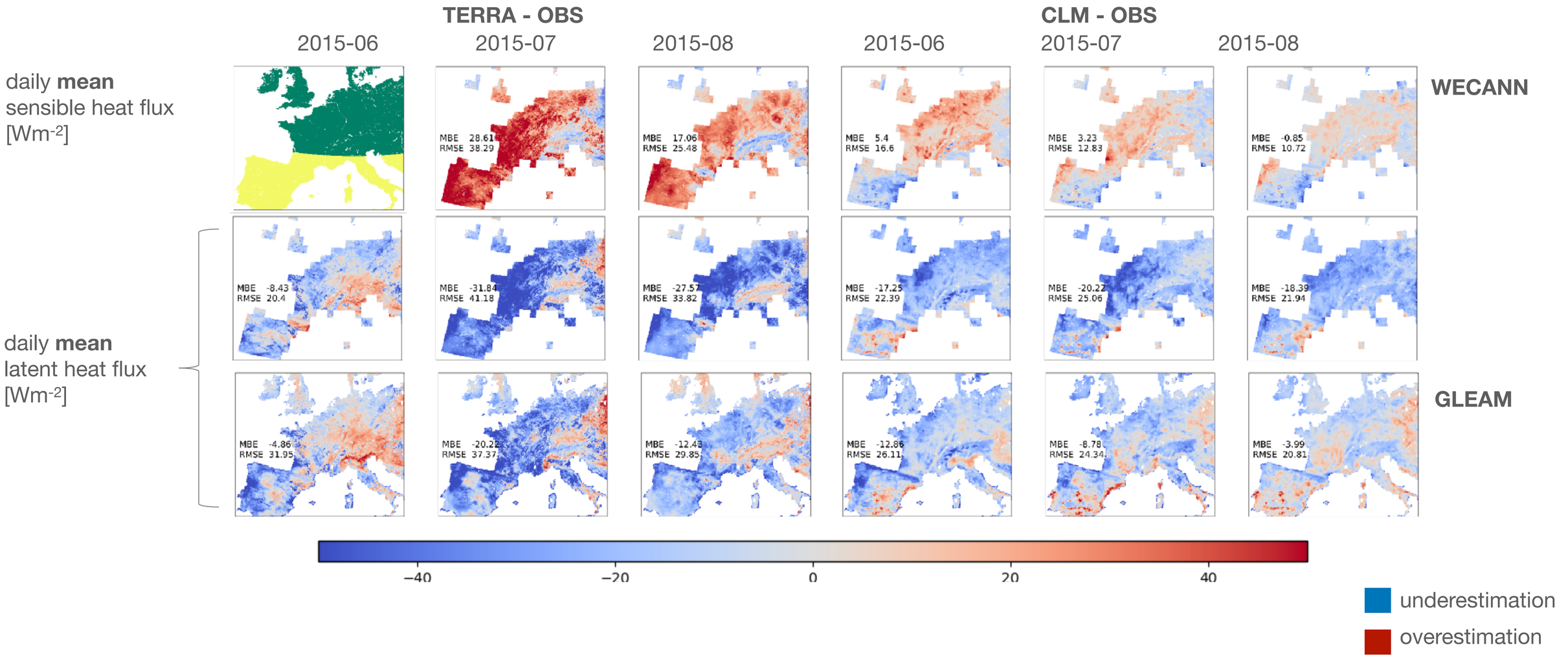
(3) estimate latent heat from regression for test data (years 2015, 2003)



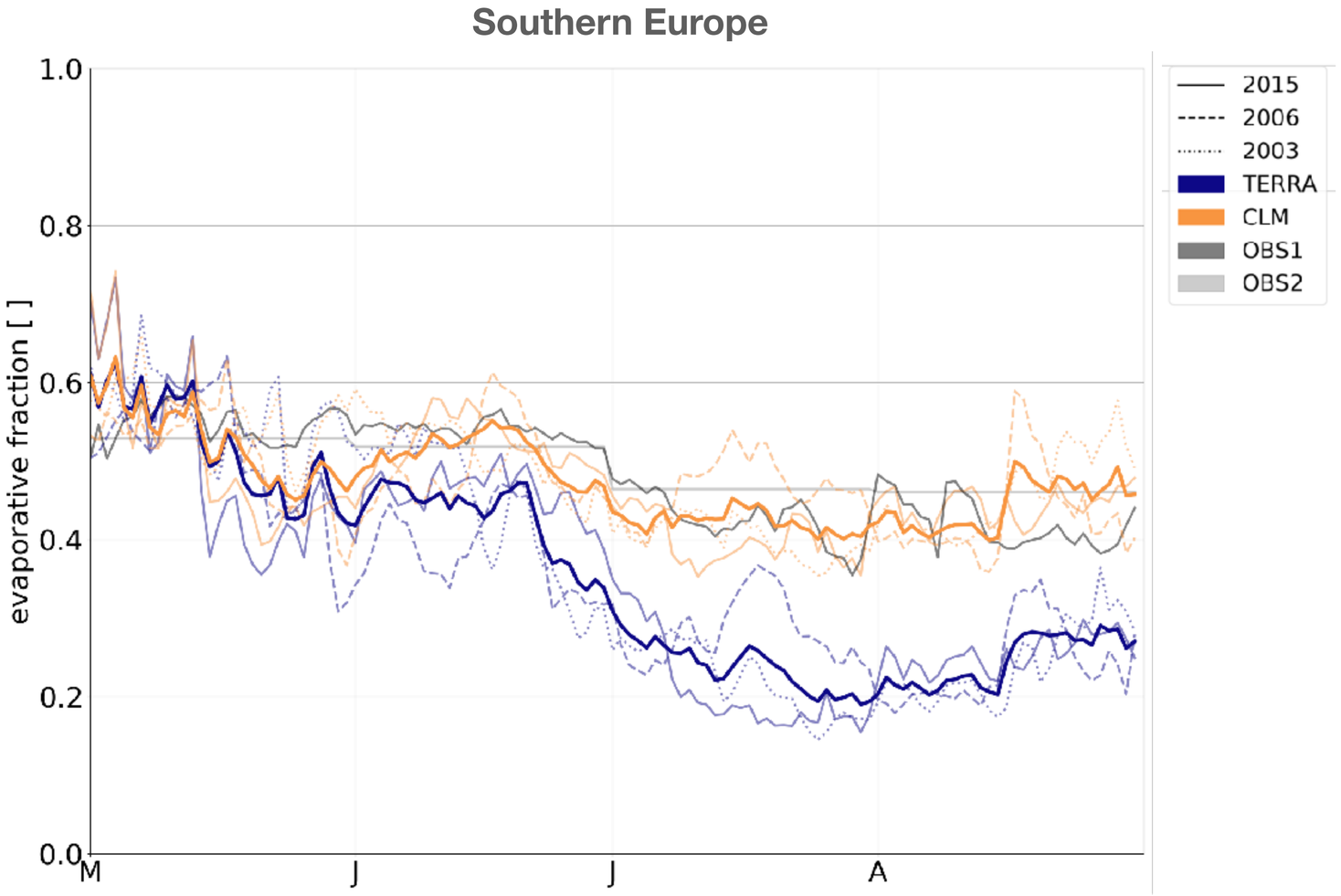
Evaluation of LH and SH



Evaluation of LH and SH

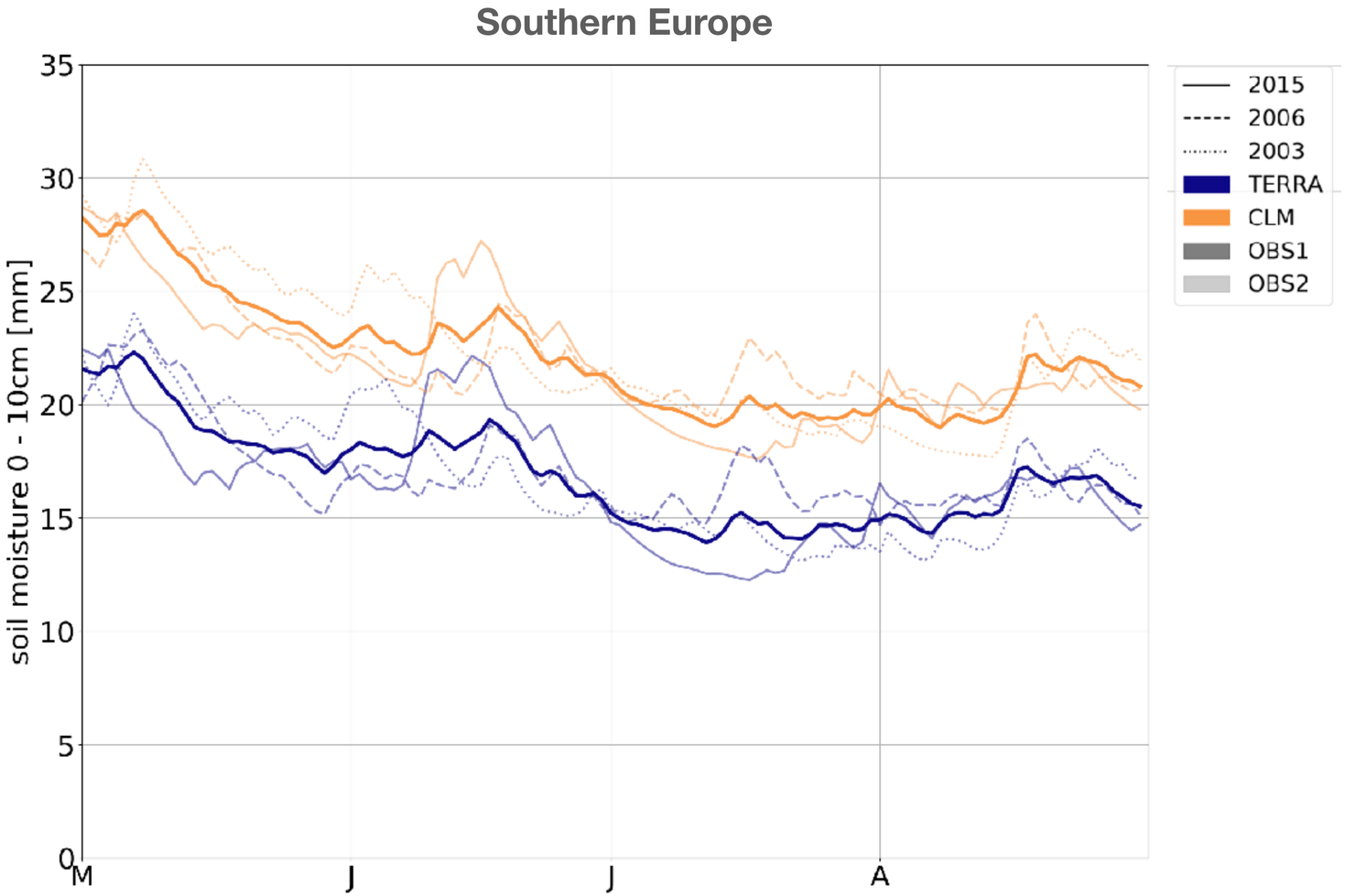


Evaporative fraction



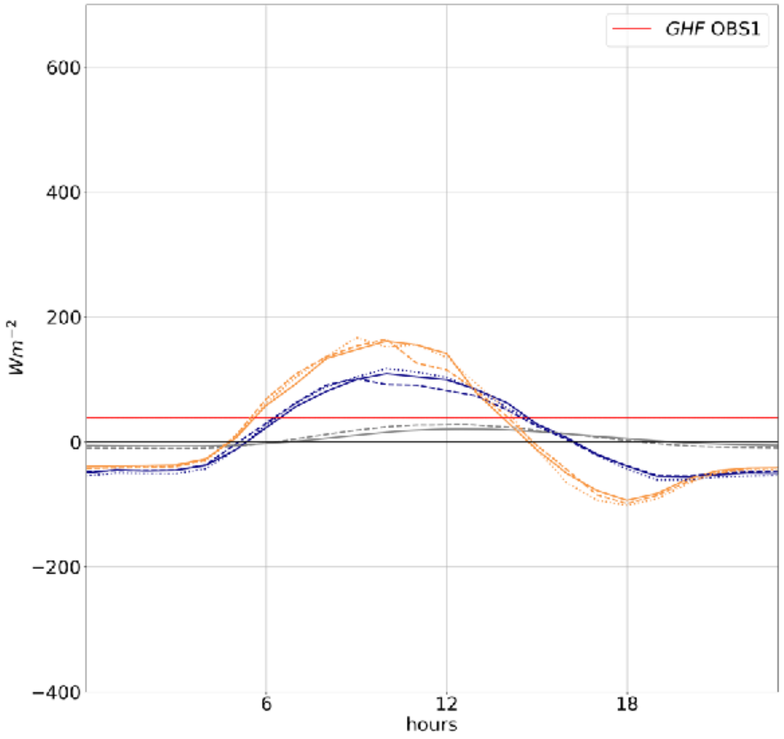
$$EF = \frac{LH}{LH + SH}$$

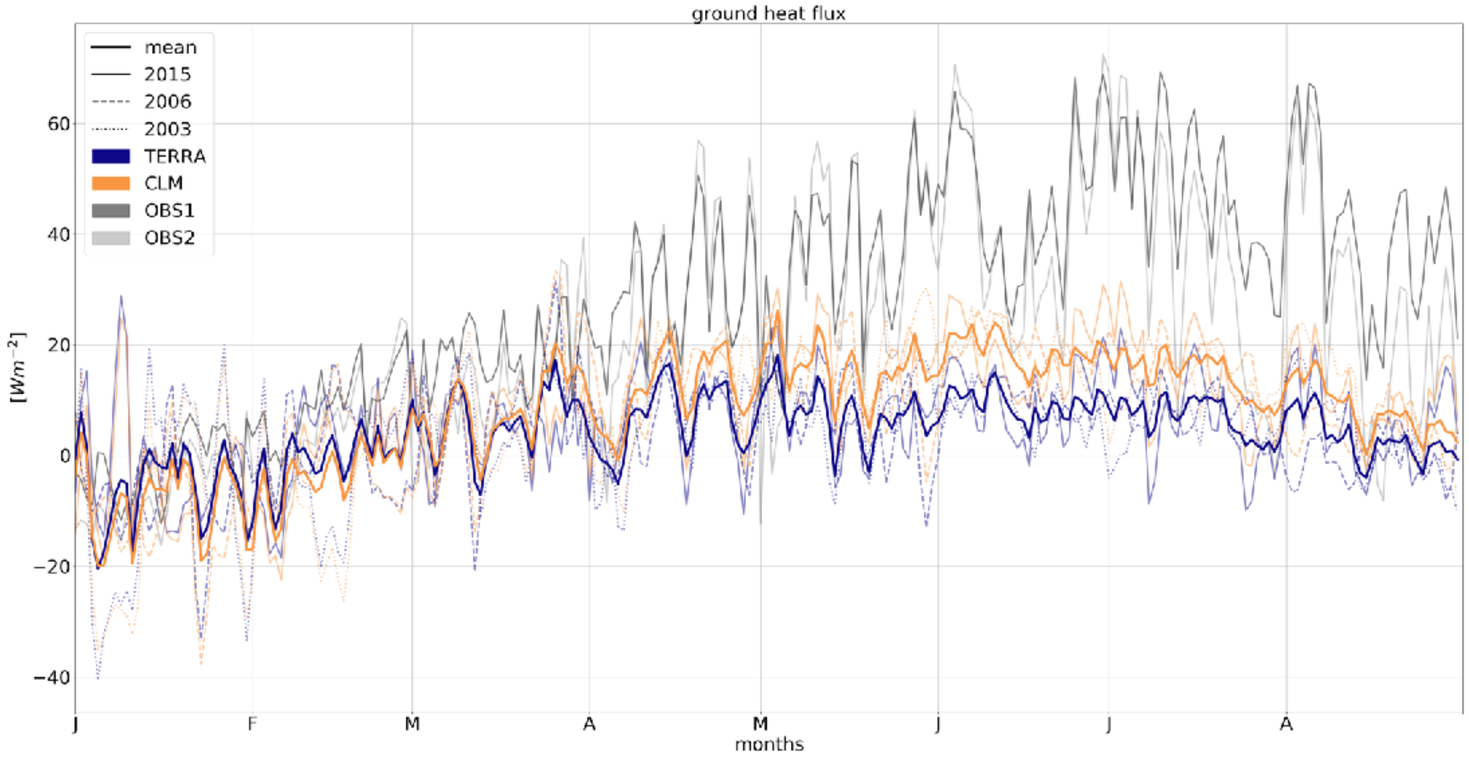
Soil moisture



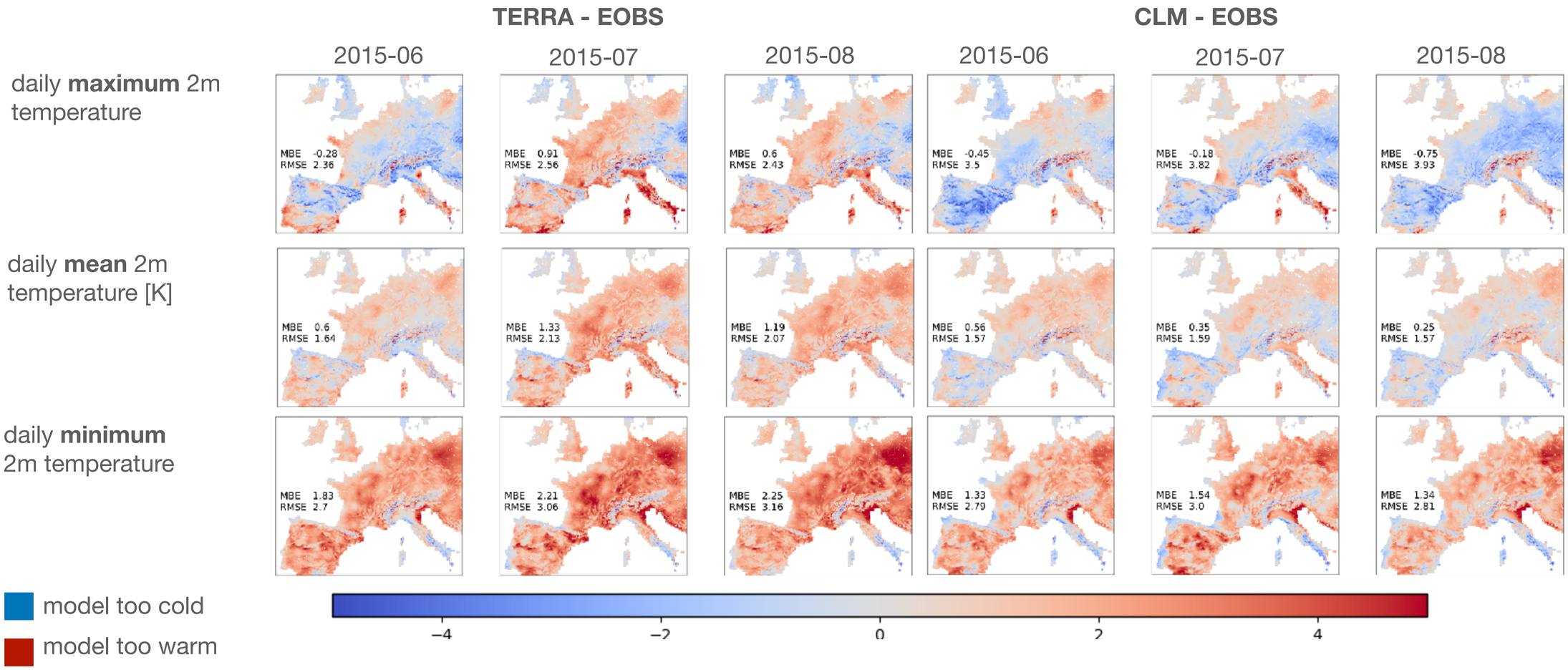
Ground heat flux

Southern Europe





Evaluation against EOBS

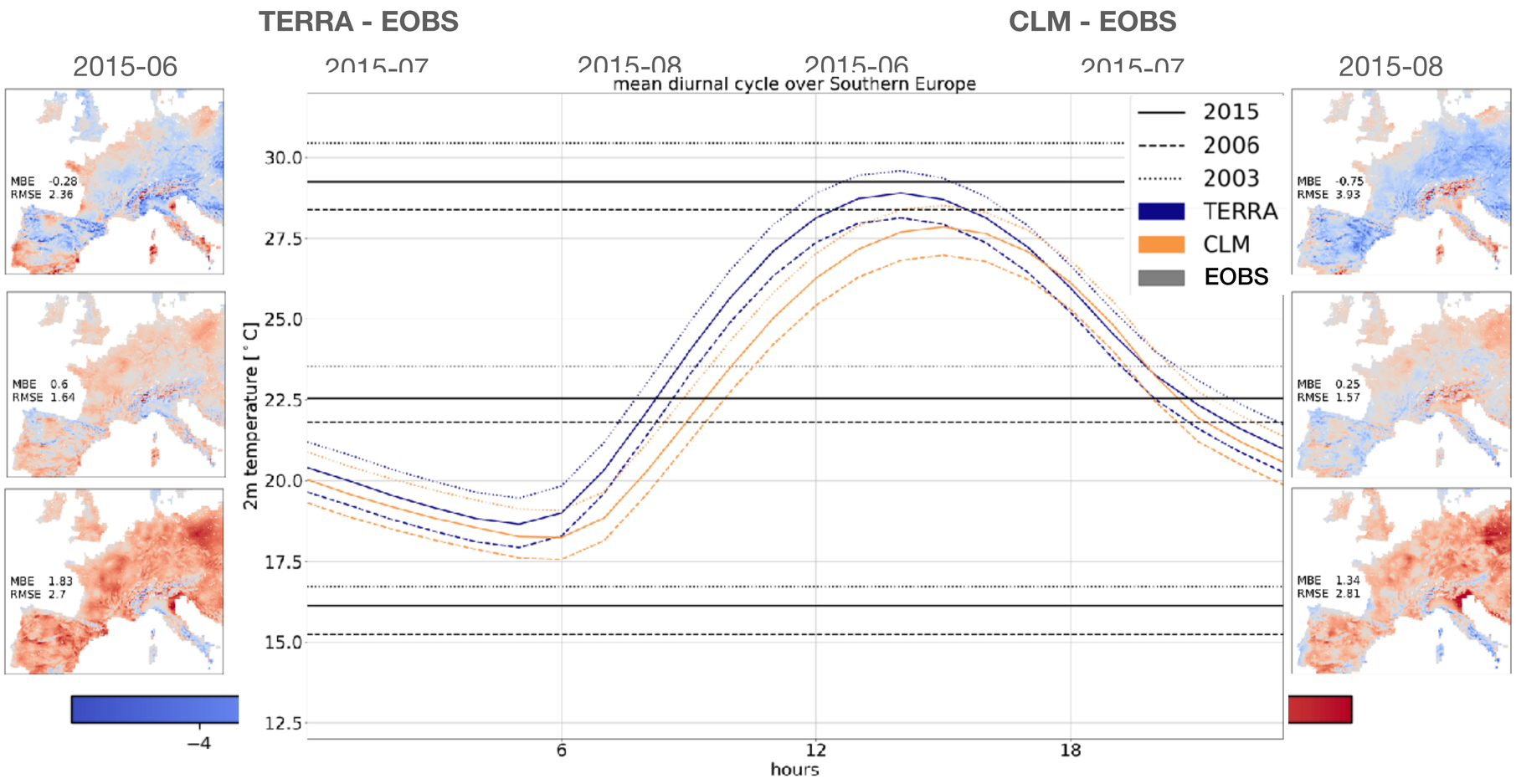


Evaluation against EOBS

daily **maximum** 2m temperature

daily **mean** 2m temperature [K]

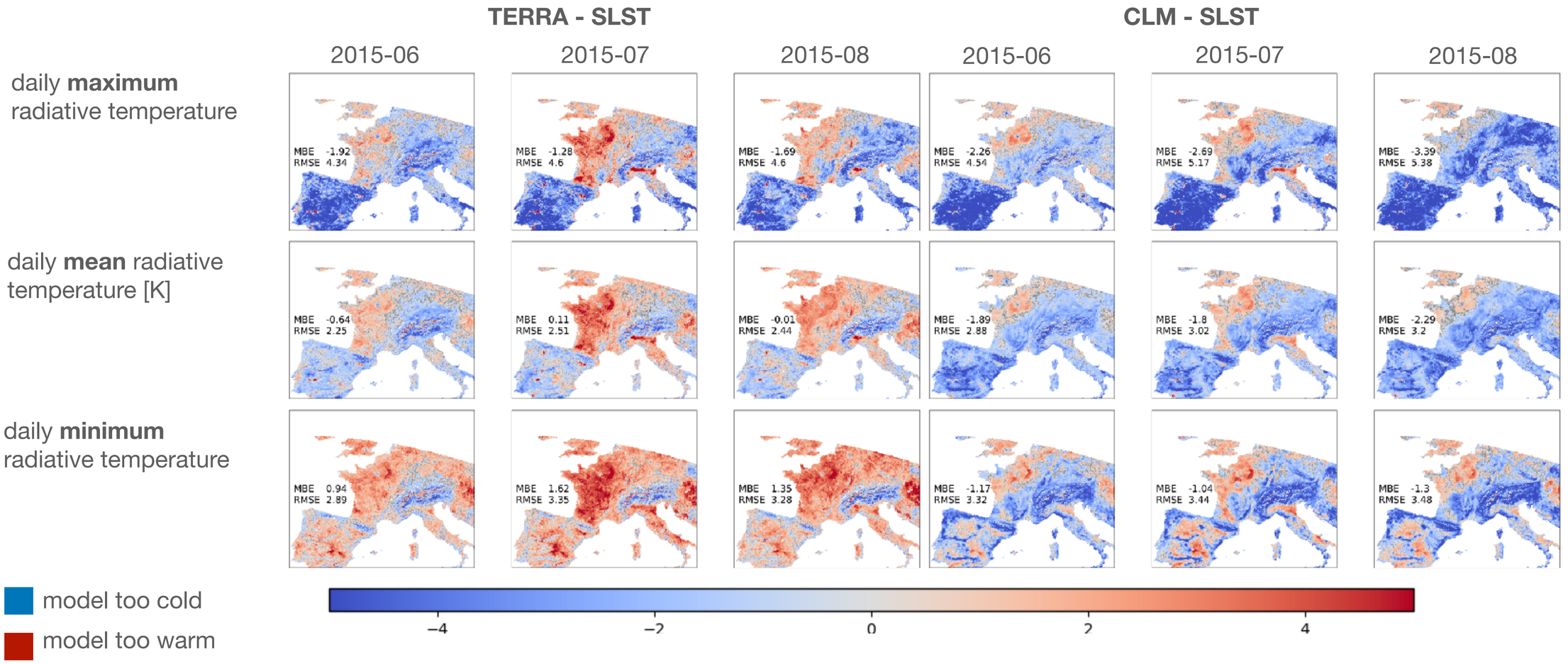
daily **minimum** 2m temperature



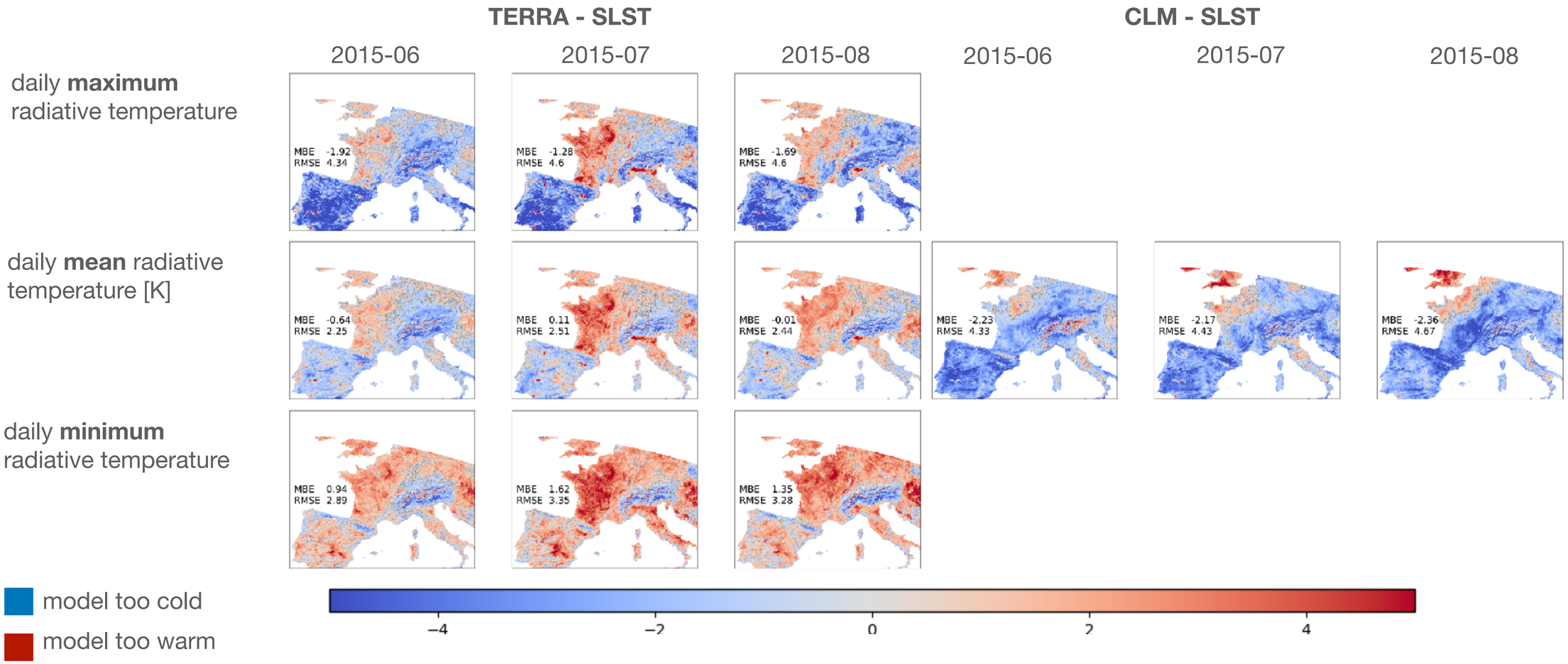
model too cold

model too warm

Evaluation against Satellite LST



Evaluation against Satellite LST



Evaluation against Satellite LST

daily **maximum** radiative temperature

daily **mean** radiative temperature [K]

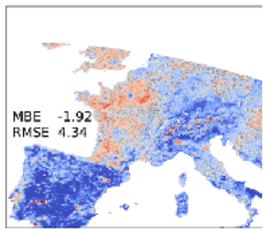
daily **minimum** radiative temperature

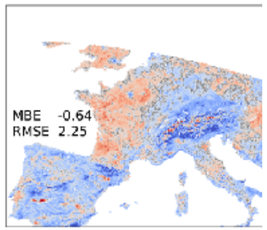
model too cold

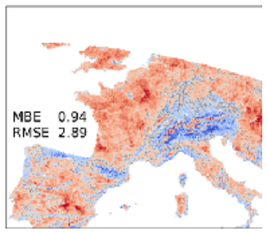
model too warm

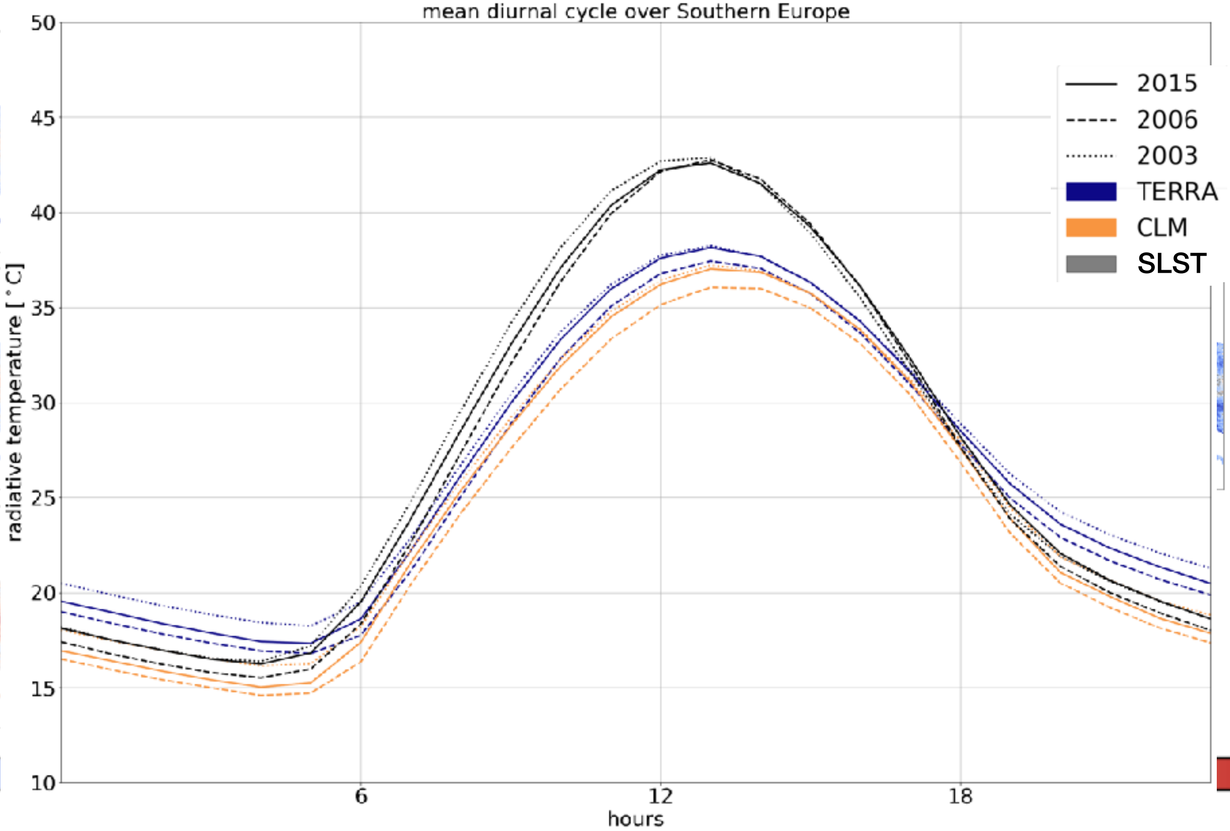
TERRA - SLST **CLM - SLST**

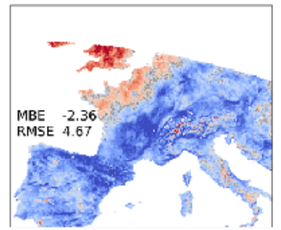
2015-06 2015-08



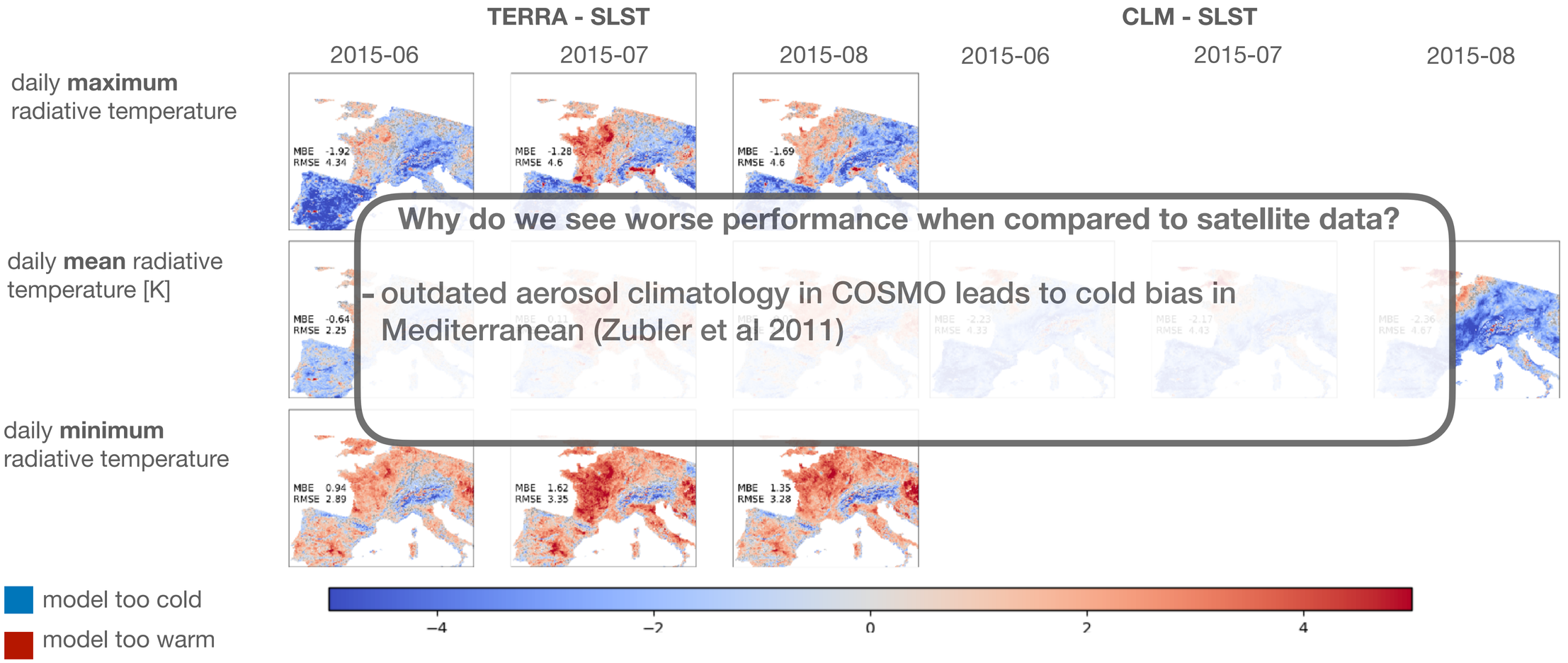








Evaluation against Satellite LST

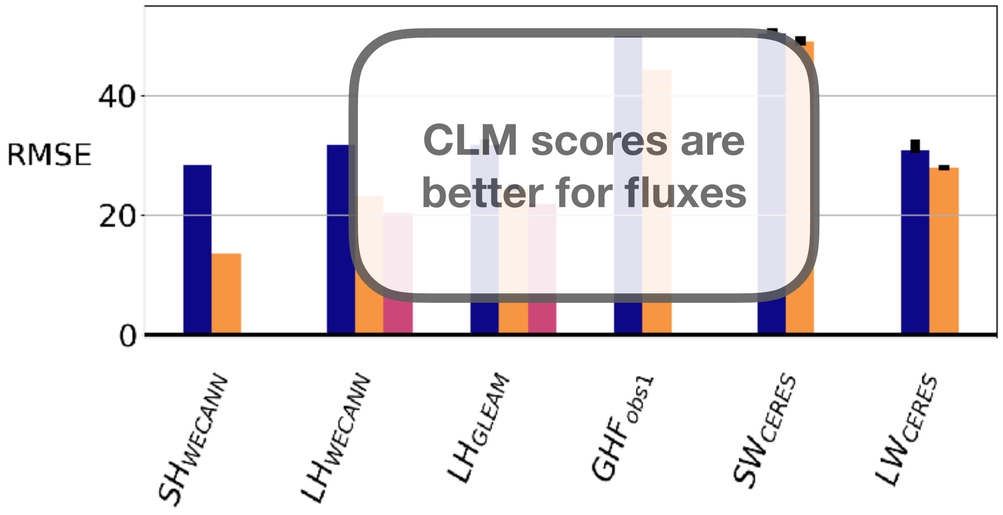


Why do we see worse performance when compared to satellite data?

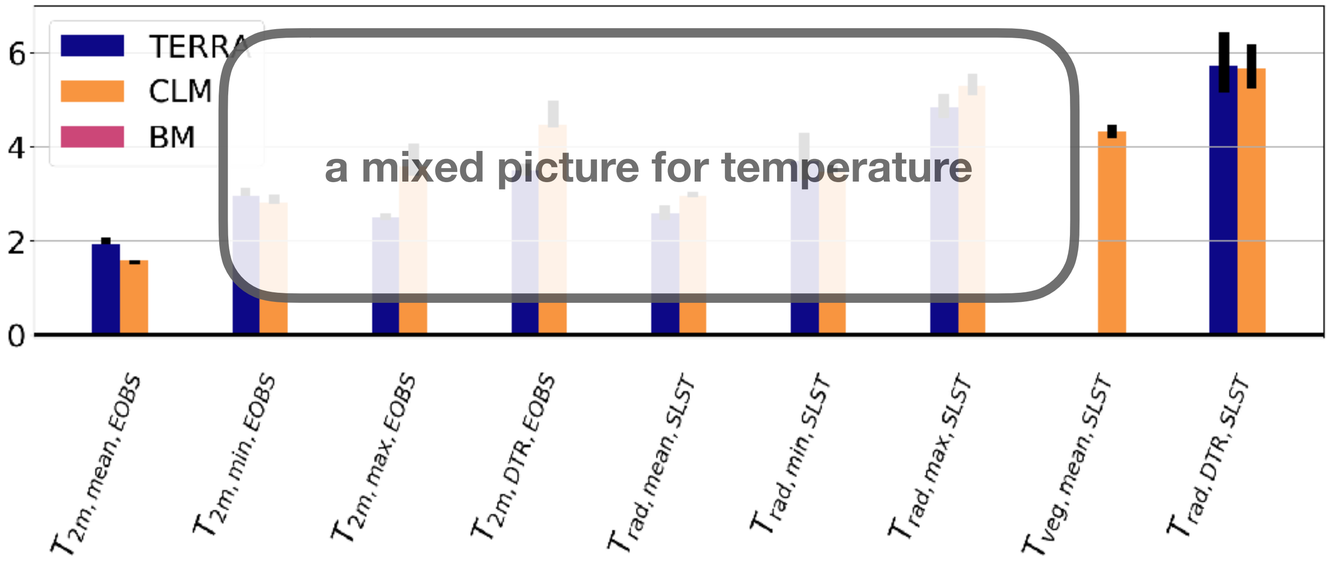
- outdated aerosol climatology in COSMO leads to cold bias in Mediterranean (Zubler et al 2011)

RMSE

JJA 2015 & 2003
(except WECANN)



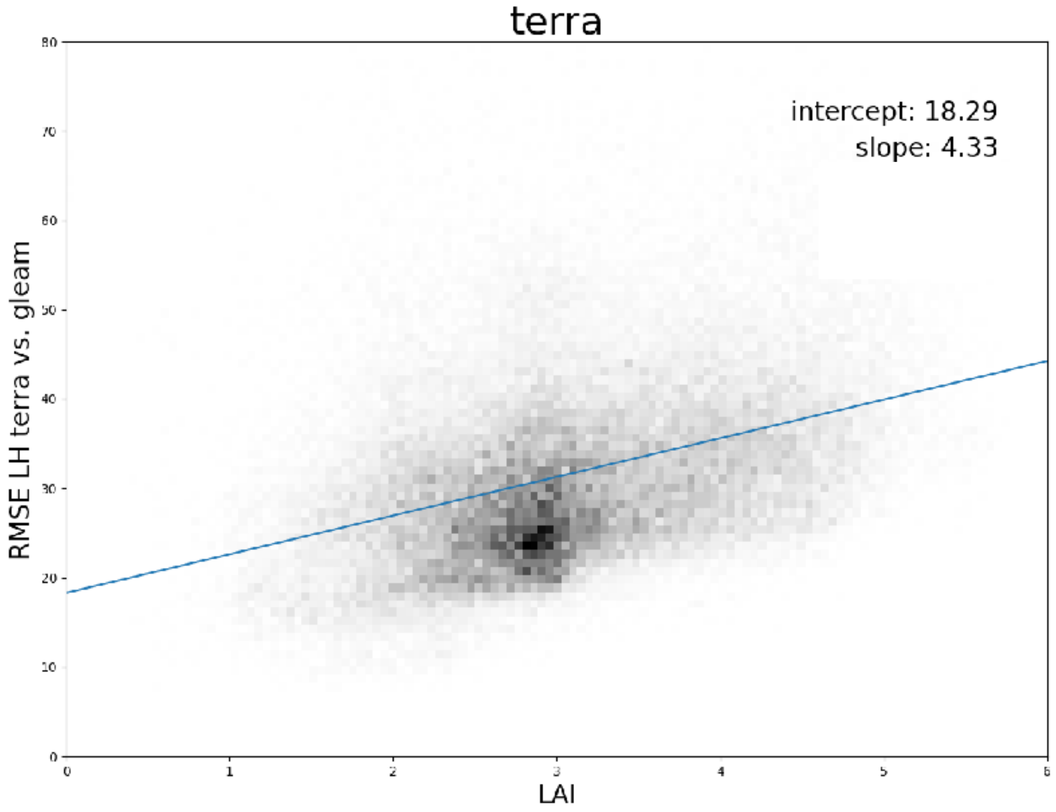
Fluxes

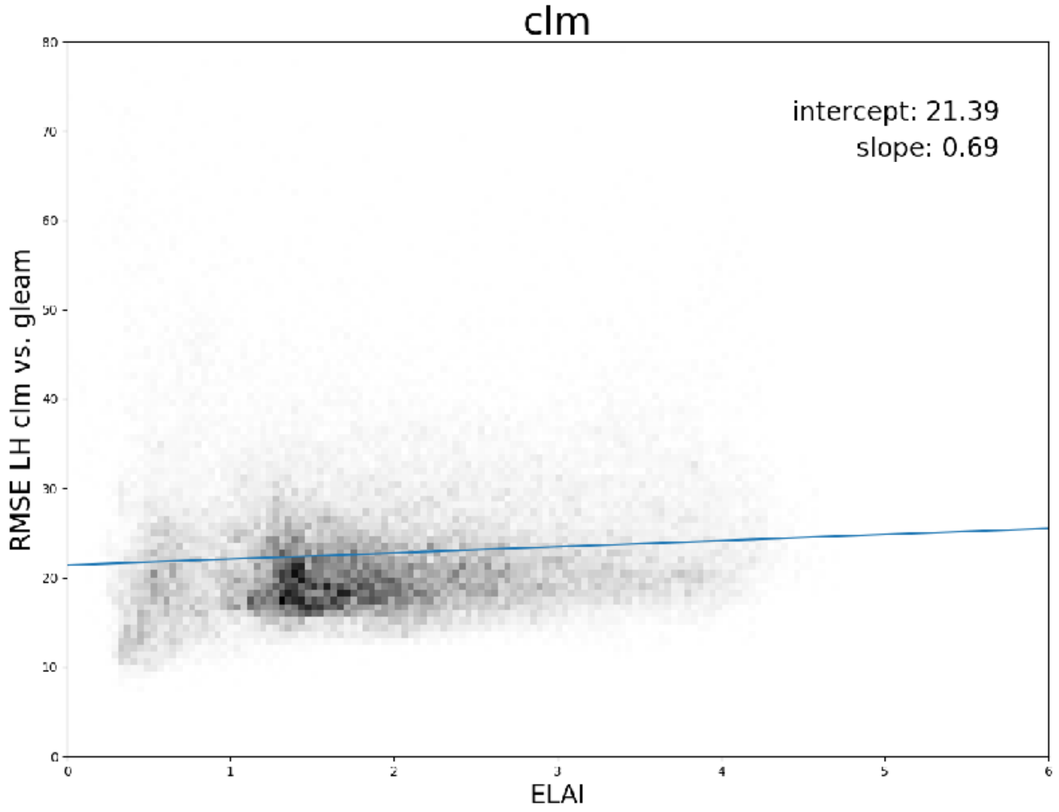


Temperatures

Error dependency on LAI

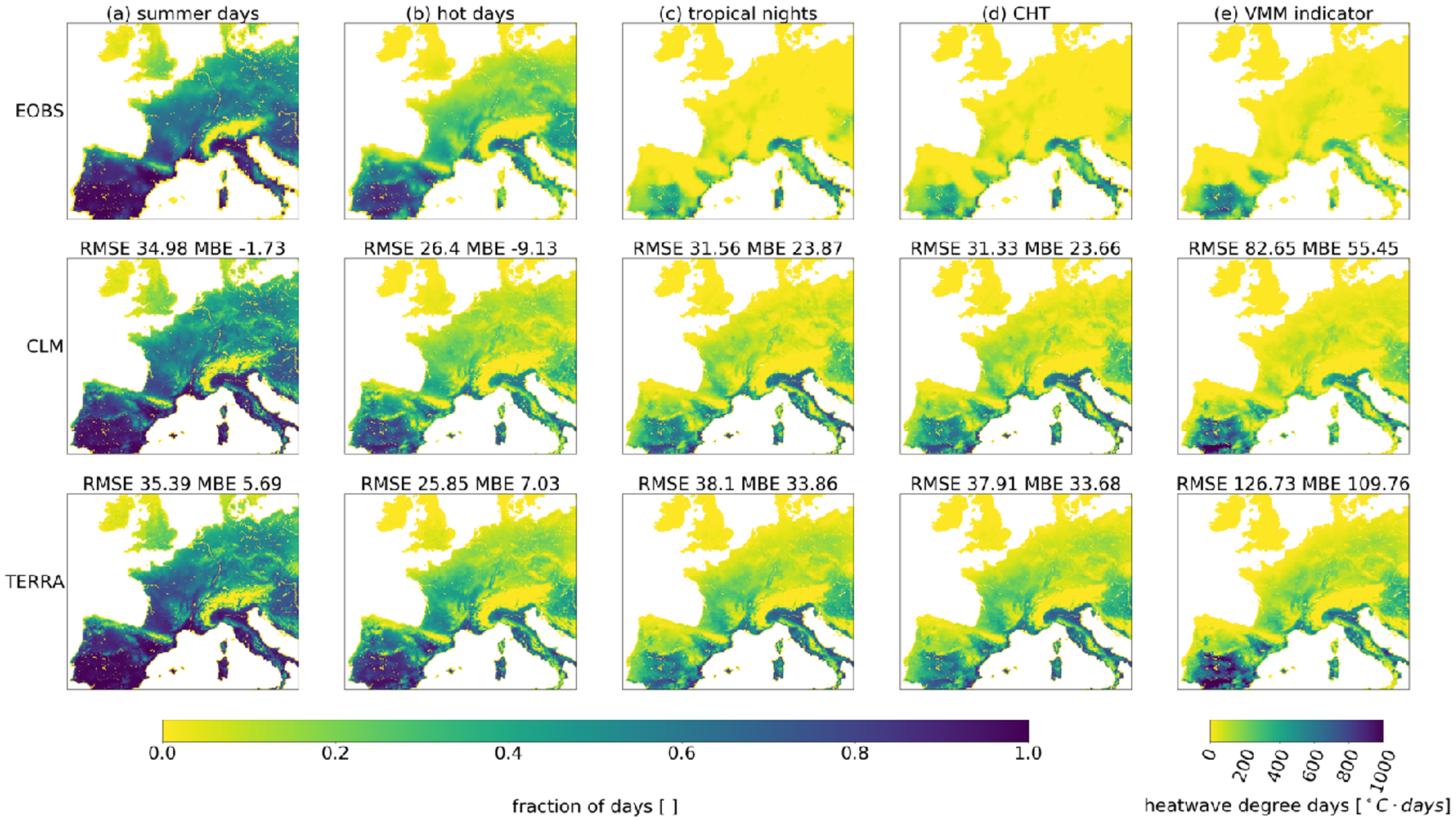
JJA 2015





the more vegetation in COSMO-TERRA, the worse it performs in terms of latent heat

Heat extremes



JJA all years

summerdays: Tmax > 25°C
hot days: Tmax >= 30 °C
tropical nights: Tmin > 20°C
CHT: hot day AND tropical night
Flanders Heat Index:
$\sum_i [(T_{min,i} - 18.2°C) + (T_{max,i} - 29.6°C)]h_i$

Conclusions

- overshooting sensible heat production in COSMO-TERRA, biases of similar sign but smaller in COSMO-CLM
- both models cannot beat benchmark experiment for latent heat estimation
- error in latent heat estimation in TERRA scales with vegetation density
- disagreement in findings of ground heat flux to JPS
- improved representation in fluxes in CLM did not translate into temperature
- comparing satellite-derived land surface temperature datasets with radiative temperature in models is challenging

Outlook

—> redo analysis with own tuning for CLM + new aerosol treatment

—> MCH standard verification still to come

—> waiting for COSMO-TERRA v5.05

References (Selection)

Davin, E. L., Maisonnave, E. and Seneviratne, S. I. (2016): Is land surface processes representation a possible weak link in current Regional Climate Models?, Environ Res Lett, 11:074027

Best, M. J., Abramowitz, G., Johnson, H. R. et al (2015): The Plumbing of Land Surface Models: Benchmarking Model Performance, Journal of Hydrometeorology, DOI: 10.1175/JHM-D-14-0158.1

Zubler, E. M., Lohmann, U., Lüthi, D., Schär, C. (2011): Intercomparison of aerosol climatologies for use in a regional climate model over Europe, Geophysical Research Letters, doi:10.1029/2011GL048081