PT VAINT

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Relevance of PT VAINT

COSMO model

Current version of COSMO model:

- uses the Jarvis-Stewart stomatal resistance approach with the BATS parametrization
- the "one-big leaf" approach
- the phenology cycle based on a 6-year climatology and follows the same sinusoidal fitted curve between its max and min values

Current version of COSMO model:

- neglects any influence or feedback on the environmental conditions (no connection to the biogeochemical cycle via photosynthesis, no plant growth, etc…)
- applies in Jarvis approach the functions which are independent of each other
- does not consider the influence of atmospheric CO_2 concentration
- applies highly simplified dependencies, for which the leaf photosynthesis and CO_2 uptake cannot be calculated

PT VAINT

Task 1: Implementation of new photosynthesis/phenology scheme:

a) The canopy photosynthesis and stomatal regulation module (done)

b) The carbon allocation and plant growth module (testing)

c) The heterotrophic respiration and litter/soil carbon module (testing)

Task 2: Validation of implementation:

a) Validation of the new implementations from the SubTask 1a (done);

b) Validation of the new implementations from the SubTask 1b and 1c (in progress);

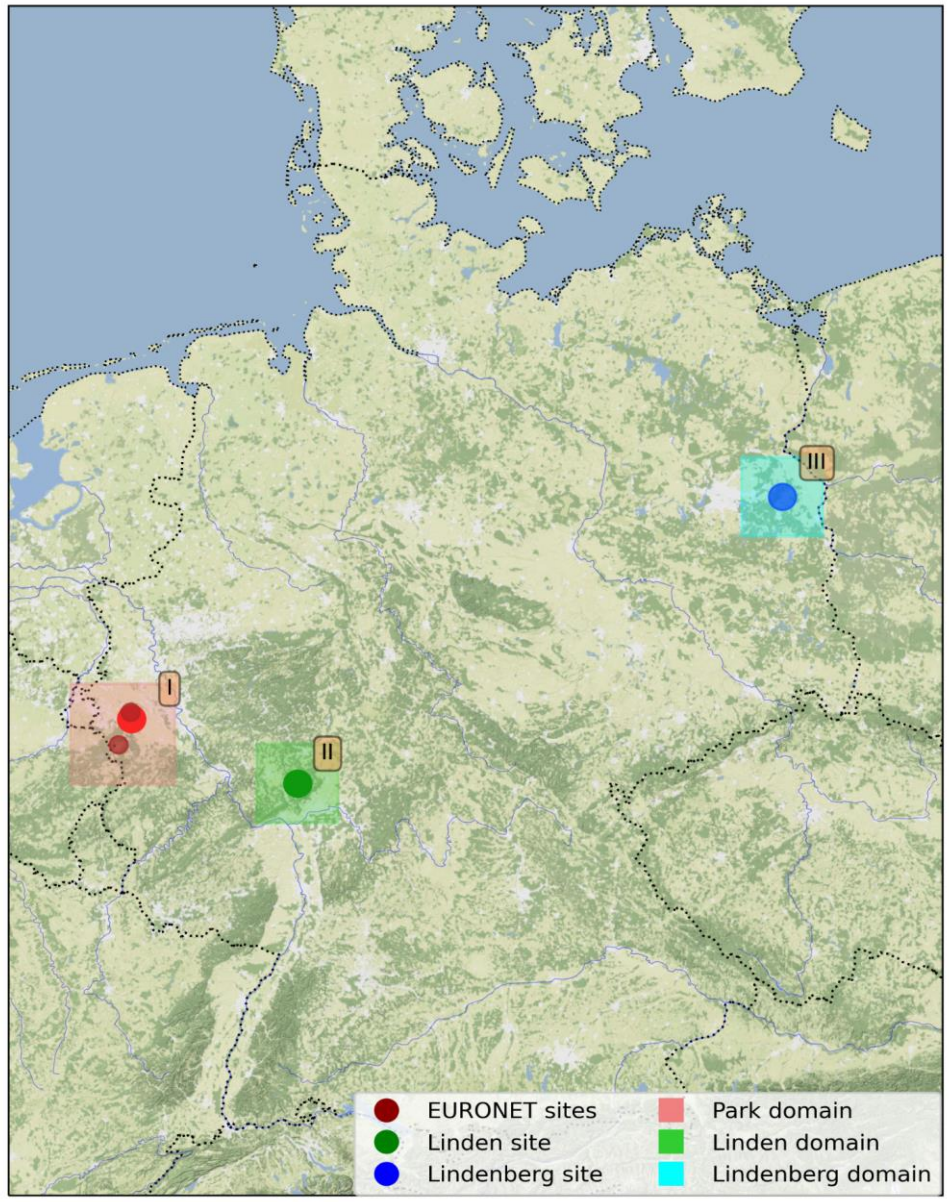
Task 3: Documentation:

a) The first version of the documentation + block schemes for CLM 3.5 and COSMO-CLM (done);

b) The first article (in progress)

More information about project: https://github.com/users/merajtoelle/projects/

Research domains



COSMO-CLM parameters:

- Time increment: 25 s
- Spatial resolution: 0.0275° ~ 3 km
- Grid size: 25 * 25
- Numbers of vertical layers: 50
- Numbers of soil layers: 9

Verification parameters:

- AEVAP, $ALHFL_{PL}$, $ALHFL_S$, $ASHFL_S$, QV_{2M}, QV_S, T_{2m}, T_S, T_{max}
- T_{min}, PS, $RELHUM_{2M}$, ZTRALEAV, ZVERBO, RSTOM

Data for comparisons:

- HYRAS, E-OBS, GLEAM datasets (T_{2m}, T_S, T_{max}, T_{min}, AEVAP, ZVERBO)
- EURONET, FLUXNET web-projects
- Linden and Lindenberg sites information (requests)

Experiments:	**Differences between experiments:**	**Research period:**
➢ CCLMref ***Terra-ML without changes***	The original code of COSMO-CLM based on v5.16 (stomatal resistance based on Jarvis approach, no leaf photosynthesis, one-big leaf approach)	from 1999 to 2017
➢ CCLMv3.5 ***Terra-ML + CLM 3.5***	The code of COSMO-CLM_v5.16 with the new implementations (stomatal resistance, leaf photosynthesis, two-big leaf approach) based on ***CLM 3.5 algorithms***	from 2010 to 2015
➢ CCLMv4.5 ***Terra-ML + CLM 4.5***	The code of COSMO-CLM_v5.16 with the new implementations (stomatal resistance, leaf photosynthesis, two-big leaf approach) based on ***CLM 4.5 algorithms***	from 2010 to 2015
➢ CCLMv4.5e ***Terra-ML + CLM 4.5 + changes in Terra-ML***	The code of COSMO-CLM_v5.16 with ***the CCLMv4.5 implementations*** + additional ***changes for dry leaf calculations*** (transpiration from dry leaves) based on CLM 4.5 algorithm	from 2010 to 2015

Differences in approach

COSMO-CLM v5.16 (original) **vs** *COSMO-CLM v5.16 (new updates)*

Algorithm for radiation:

- *"One-big-leaf" canopy*
- *"Two-big-leaf" canopy*

sunlit and shaded leaves

Algorithm for photosynthesis:

- *Not available*
- *Farquhar and Collatz models for C_3 and C_4 plants*

leaf photosynthesis is available

Algorithm for stomatal conductance:

- *Am empirical Jarvis-type approach*
- *A physical Ball-Berry approach*

coupling with photosynthesis and "two-big-leaf" canopy

Stomatal resistance (RSTOM)

TERRA_ML
(Jarvis approach – Jarvis et al., 1976)

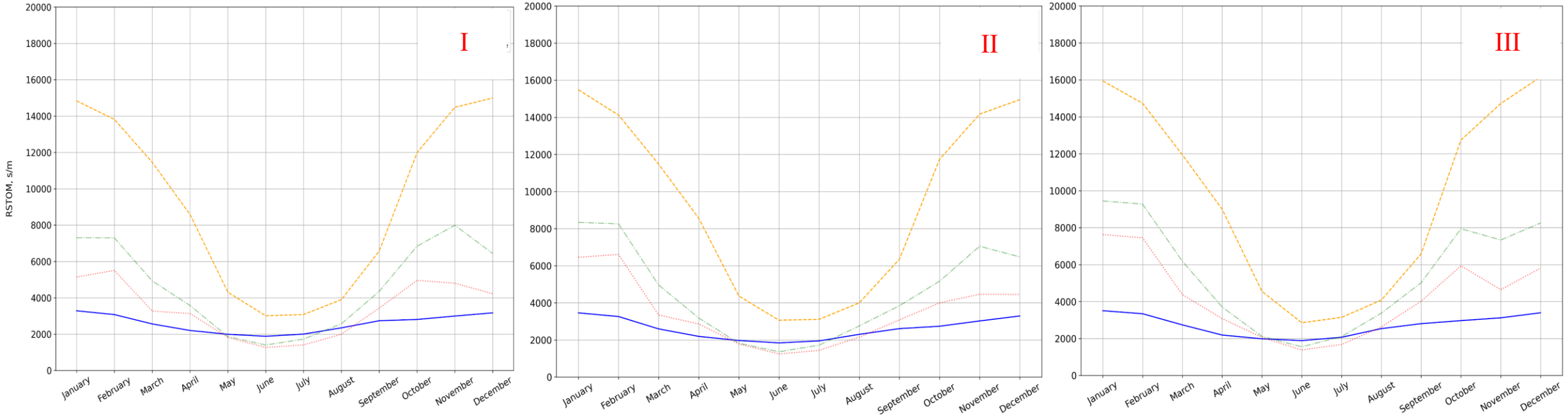
vs

TERRA_ML (updated)
(Ball-Berry approach – Collatz et al., 1991)

$$g_{st}^{can} = \frac{1}{r_{max}} + \left(\frac{1}{r_{min}} - \frac{1}{r_{max}}\right)[F_{rad}F_{wat}F_{tem}F_{hum}]$$

$$g_{st}^{can} = g_{st}^{sun}L^{sun} + g_{st}^{sha}L^{sha}$$

$$g_{st}^{sun,sha} = \frac{1}{r_s^{sun,sha}} = m\frac{A^{sun,sha}e_s}{c_s e_i}P_{atm} + bF_{wat}$$

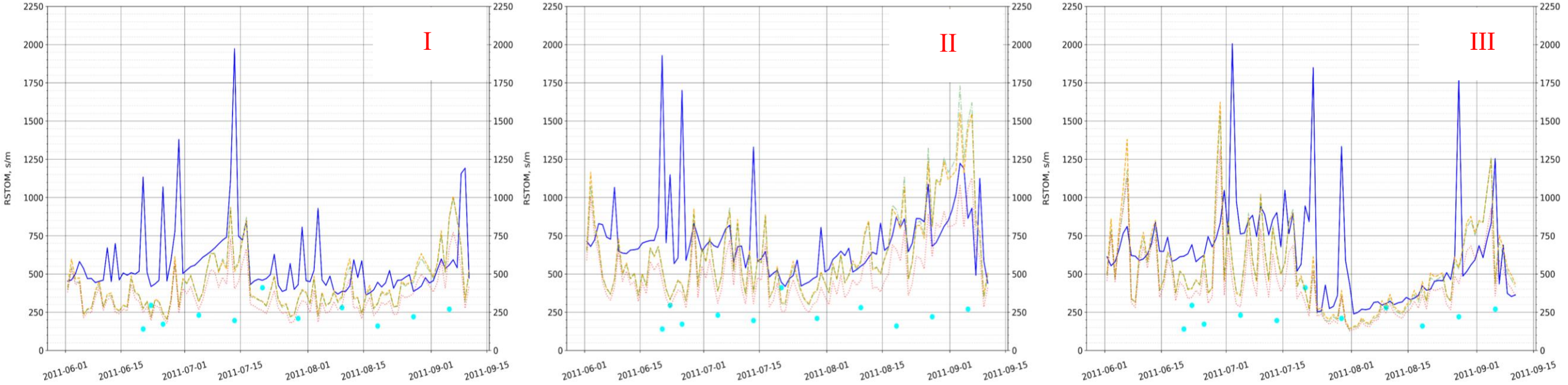


CCLMref — CCLMv3.5 — CCLMv4.5 ····· CCLMv4.5e

I – Parc, II – Linden, III – Lindenberg

Stomatal resistance (RSTOM)

Time period: from 01.06.2011 to 15.09.2011



CCLMref CCLMv3.5 CCLMv4.5 CCLMv4.5e IN-SITU data I – Parc, II – Linden, III – Lindenberg

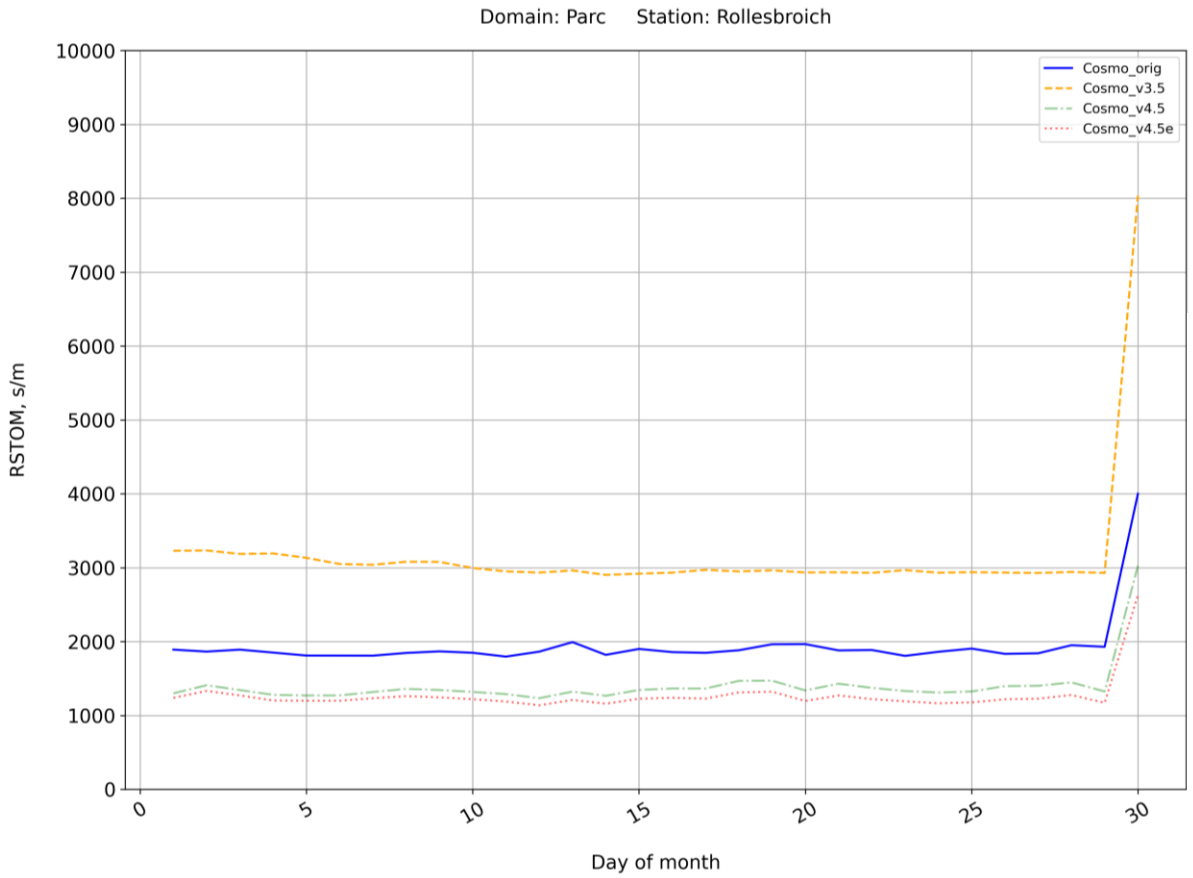
Statistical analysis of stomatal resistance data

	CCLMref	CCLMv3.5	CCLMv4.5	CCLMv4.5e
mean	713	384	384	314
std	495	183	183	133
mae	477	179	179	124
rmse	696	235	235	161
pcc	-0.426	0.103	0.103	0.08

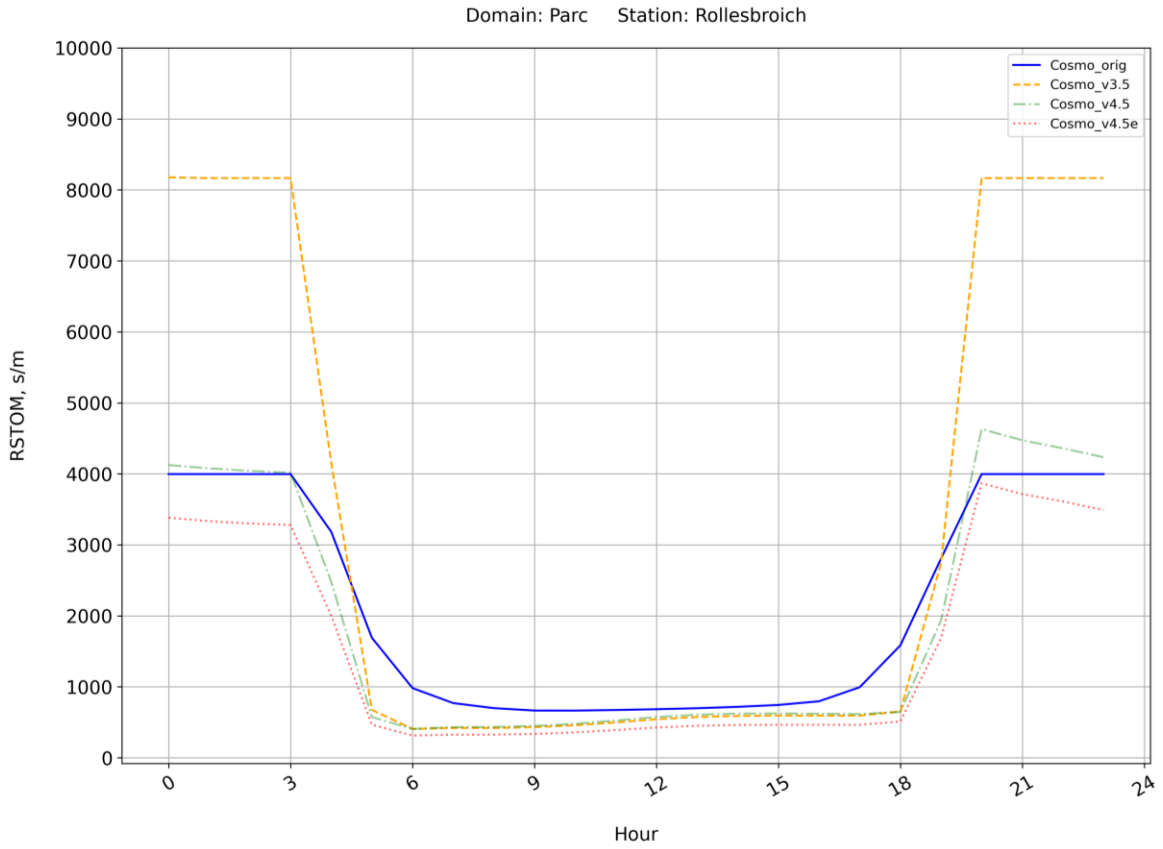
! The stomatal resistance data were measured in North America for C3 grass at 13:00 (PT)

Stomatal resistance (RSTOM)

Daily average values over 2010-2015 for June



Diurnal cycle over 2010-2015 from June to August



Model performance

At sites:

- Standard deviation (STD)
- Mean absolute error (MAE)
- Root mean square error (RMSE)
- Pearson correlation coefficient (PCC)

Grid points:

- Root mean square deviation (RMSD)
- Pearson correlation coefficient (PCC)
- Kling-Gupta Efficiency index (KGE)
- Distribution added value index (DAV)

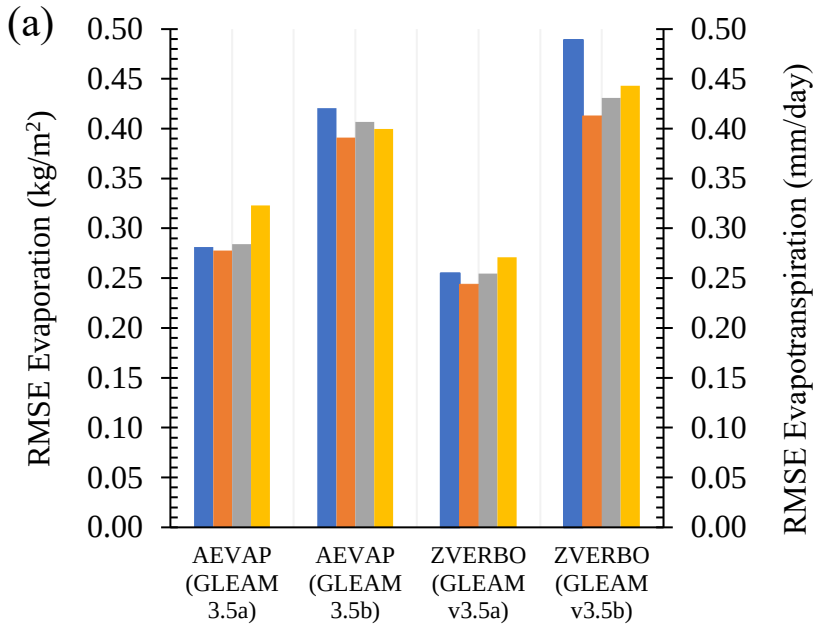
$$KGE = 1 - \sqrt{(\rho - 1)^2 + \left(\frac{\sigma_m}{\sigma_{obs}}\right)^2 + \left(\frac{\mu_m}{\mu_{obs}} - 1\right)^2}$$

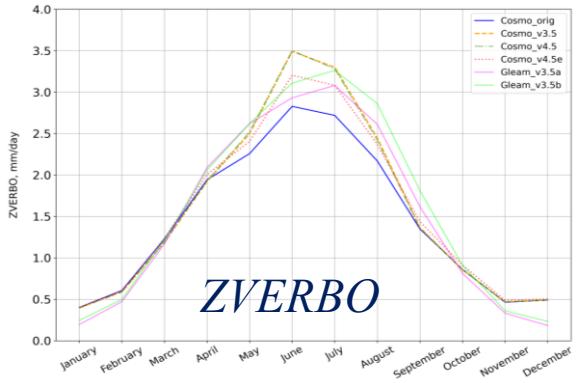
$$DAV = \frac{\sum_1^n \min(Z_{exp}, Z_{obs}) - \sum_1^n \min(Z_{ctr}, Z_{obs})}{\sum_1^n \min(Z_{ctr}, Z_{obs})}$$

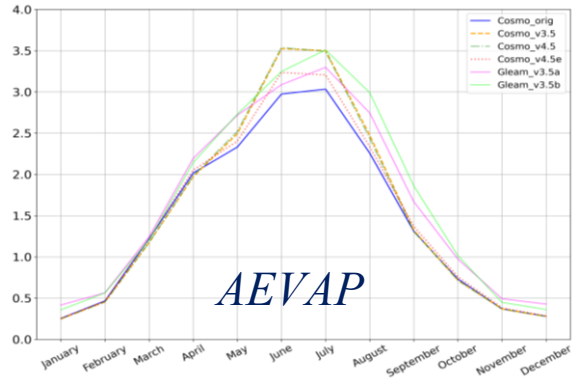
where: ρ is the Pearson correlation coefficient,
σ is standard deviation,
μ is the mean value,
Z is the frequency of values in a given bin for experiments, control run, and observations.

Total evapotranspiration (ZVERBO) and evaporation (AEVAP)

Stations (parc domain)







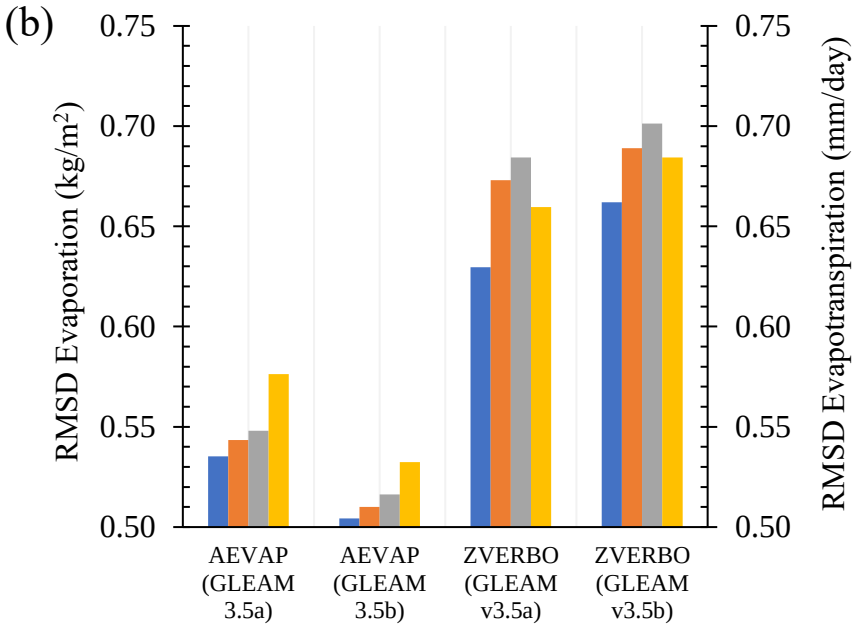
CCLMref

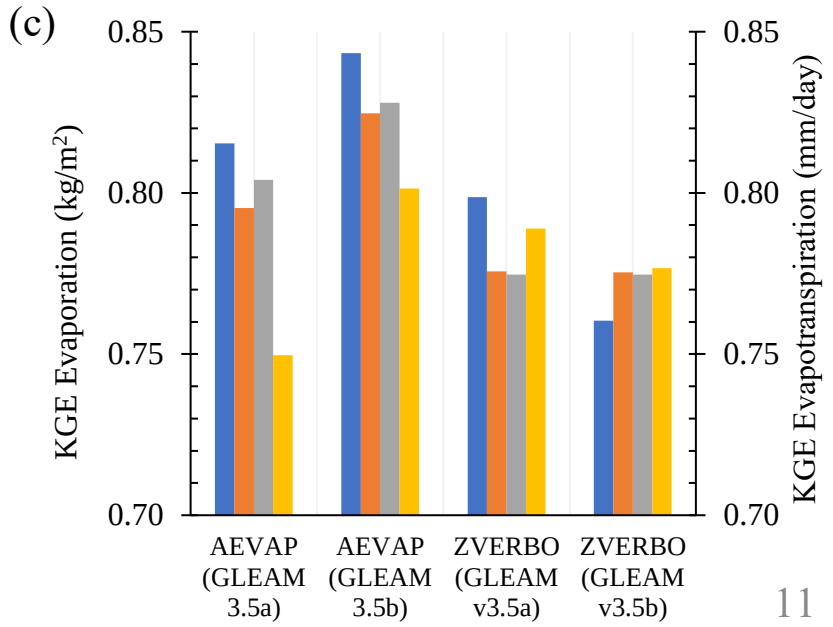
CCLMv3.5

CCLMv4.5

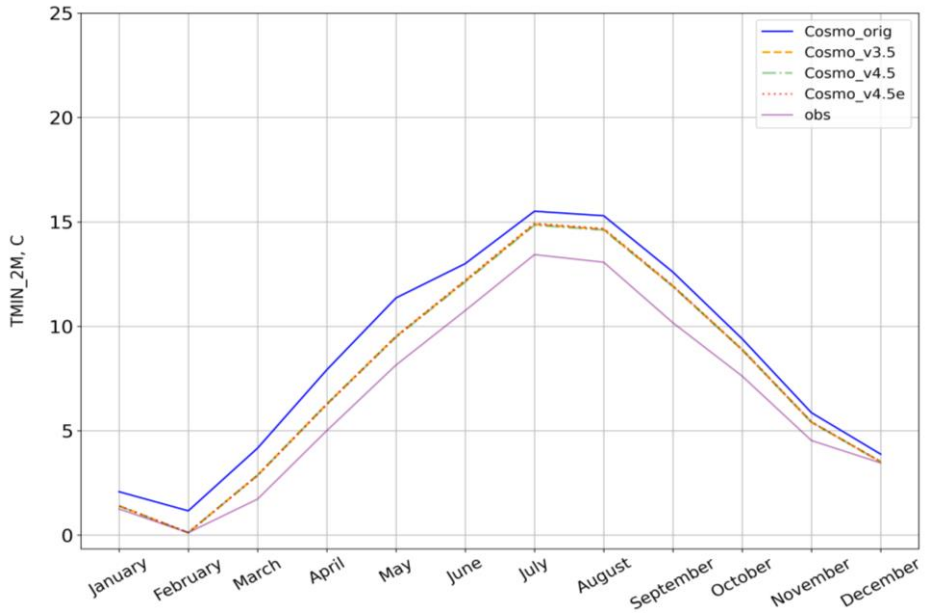
CCLMv4.5e

Grid points (parc domain)





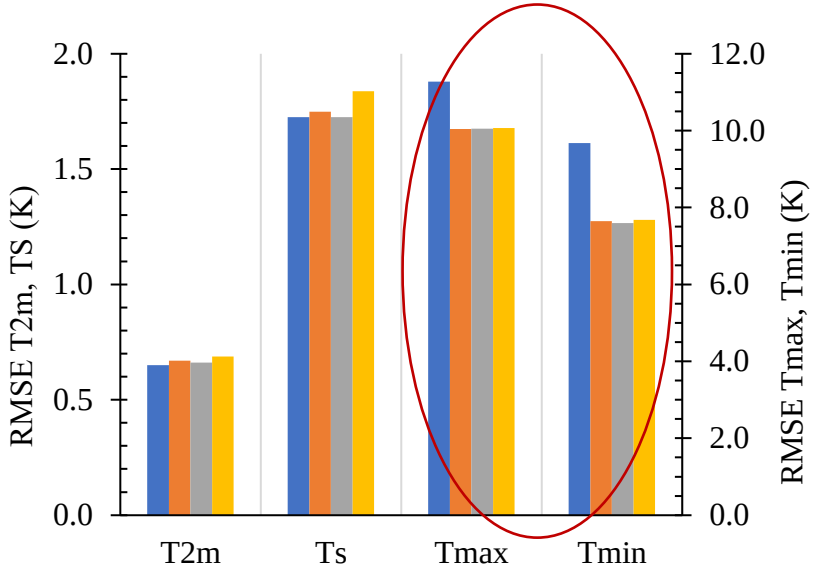
Surface (T_S), maximum (T_{max}) and minimum (T_{min})temperatures



CCLMref
CCLMv3.5
CCLMv4.5
CCLMv4.5e
IN-SITU data

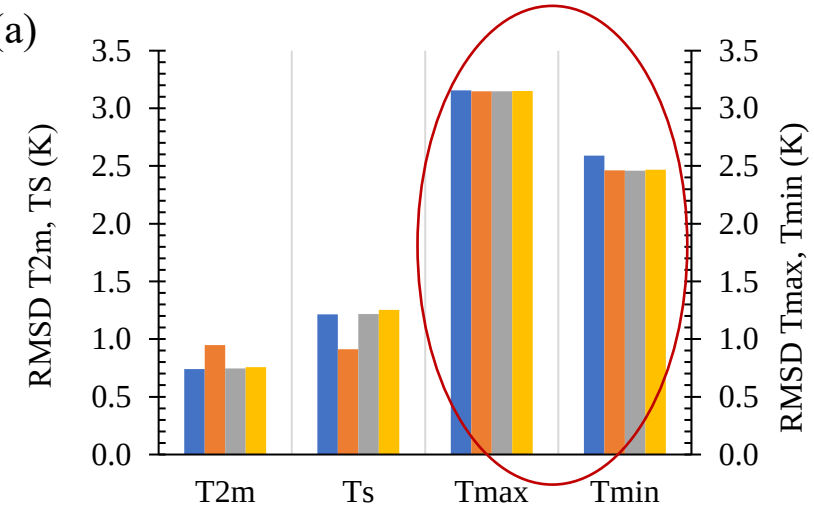
CCLMref
CCLMv3.5
CCLMv4.5
CCLMv4.5e

Stations (parc domain)

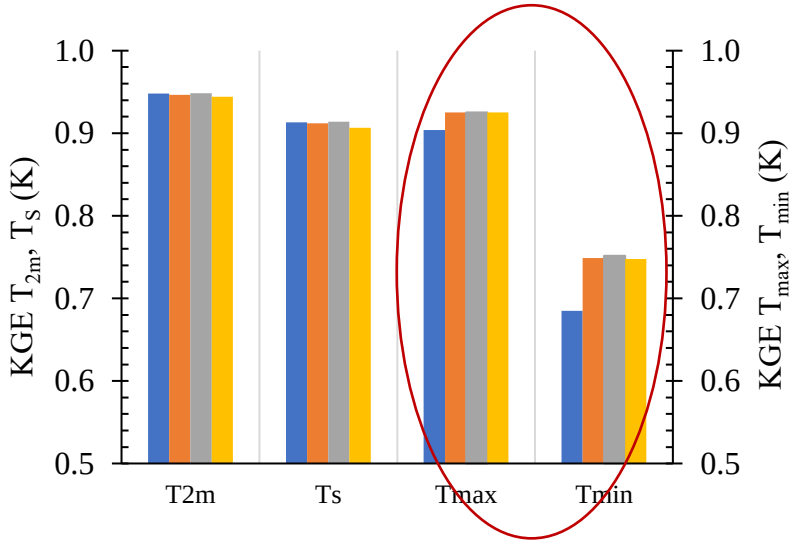


Grid points (parc domain)

(a)



(b)



Conclusions

The new versions (*CCLMv3.5, CCLMv4.5, CCLMv4.5e*):

- consider the difference of the physiological properties between sunlit and shaded leaves
- use the modern physically based approach for stomatal resistance.
- apply the prognostic environmental parameters for calculations of stomatal resistance, which are connected to each other by leaf photosynthesis.
- use stomatal resistance values, which are influenced by atmospheric CO_2 concentration
- allow to calculate the leaf photosynthesis and CO_2 uptake

Didn't change in (*CCLMv3.5, CCLMv4.5, CCLMv4.5e*):

- the phenological cycle of COSMO-CLM (yet), which is still based on a 6-year climatology and follows the same sinusoidal fitted curve between its maximum and minimum value each year neglecting any influence or feedback on the environmental conditions.

Our contacts:

GitHub page: https://github.com/users/merajtoelle/projects/1

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