Priority Project T²RC² : Tuning the new radiation scheme

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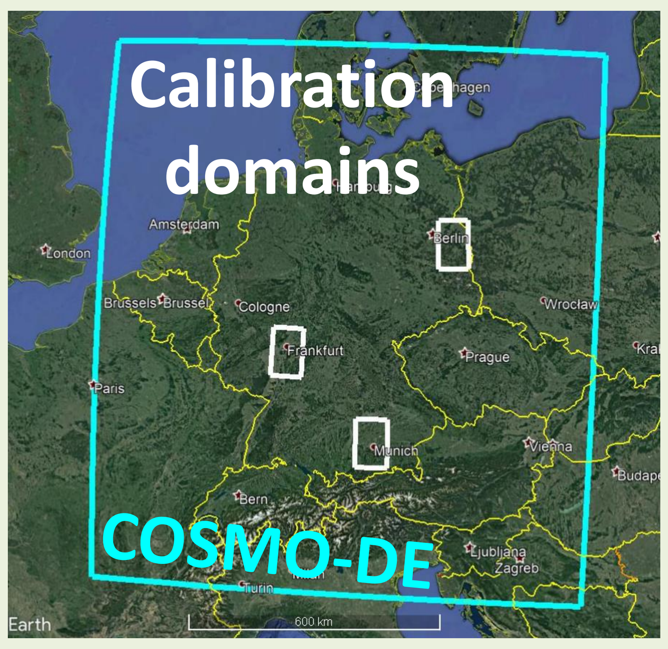
Abstract

Priority Project "Testing and Tuning of Revised Cloud Radiation Coupling" (T²RC²) aims at continuation of the development of the new cloud-radiation coupling scheme in the COSMO model (COSMO-cloudrad). The new scheme includes revised sub-grid scale clouds effect on radiation, detailed optical properties for liquid and frozen particles of different sizes, more accurate representation of aerosol effects on cloud microphysics, etc. From algorithmical point of view, the new scheme contains many cloud-radiation dependencies which contribution is described by about thirty parameters. Besides, different options are activated using ten logical switches. This makes the tuning of the scheme a difficult problem. The idealized COSMO framework was previously used to determine the parameters having particularly high influence on the radiative fluxes in the model (Khain et al., 2016). Here we utilize an "objective" parameters tuning (Voudouri et al., 2017; Khain et al., 2017) via comparison of real model forecasts against global radiation from CM-SAF satellite data (Müller et al., 2015). The experiments were performed for several month during 2016 over COSMO-DE domain. In this preliminary study we present parameters values of four subversions of COSMO-cloudrad, which optimize the global radiation over Offenbach, Lindenberg and Munich regions.

Calibration method



- *COSMO-DE 2.8km 5.1 four "cloudrad" versions, driven by ICON-EU analyses.*
- *For each version several continuous parameters are tuned - cyan in table*

Meta-Model

- *First, several parameters combinations are chosen according to specific design (Voudouri et al. 2017). For each combination, COSMO runs are performed for February, April, June and September 2016.*
- *For every hour at every grid point, the forecast of global radiation is then interpolated in parameters space using 2nd order polynomial (with interaction terms).*
- *These interpolations yield a "guess" for the global radiation for any chosen parameters combination (Meta-Model).*

Optimization

- *The parameters space is then sampled by large number of parameter combinations. For each combination the Meta-Model is verified against CM-SAF hourly global radiation at 5km resolution.*
- *The seek of the optimal parameters combination is performed by convergence algorithm (Khain et al. 2017).*
- *Finally the parameters combination which yields the optimal Meta-Model guess is defined.*

Calibrated versions

Key switches (yellow) | Tuned continuous parameters (cyan)

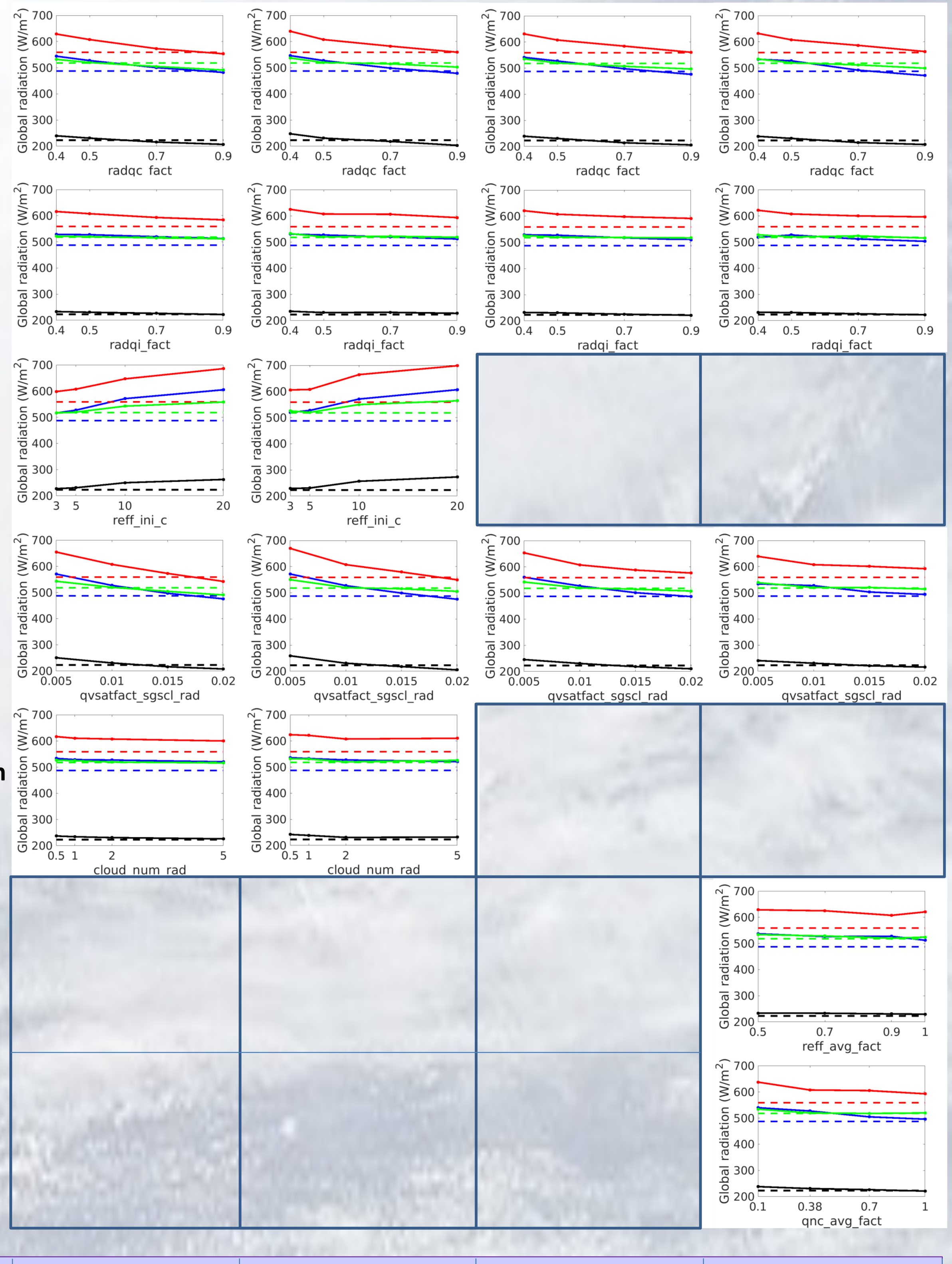
Parameter meaning	Parameter	Basic version	CAMS version	SK basic version	SK-SAM version
Tegen/CAMS CCN	itype_aerosol	2	4	2	2
Use Segal Khain parametrization for the droplets number concentration	icloud_num_type_rad	1	1	2	2
Use constant SGS droplets effective radius	luse_reff_ini_c_as_reffc_sgs	TRUE	TRUE	FALSE	FALSE
Use adiabatic profiles for droplets microphysics in convective SGS clouds	luse_qc_adiab_for_reffc_sgs	FALSE	FALSE	FALSE	TRUE
LWC reduction due to SGS variability	radqcfact [0.4 0.5 0.9]	X	X	X	X
IWC reduction due to SGS variability	radqifact [0.4 0.5 0.9]	X	X	X	X
SGS droplets effective radius	reff_ini_c [3 5 20]·10⁻⁶	X	X		
SGS LWC scale factor	qvsatfact_sgscl_rad [0.005 0.01 0.02]	X	X	X	X
Droplets number concentration for radiation	cloud_num_rad [0.5 2 5]·10⁸	X	X		
SGS droplets effective radius scale of adiabatic profile	reff_avg_fact [0.5 0.9 1]				X
SGS droplets concentration scale of adiabatic profile (clouds dilution)	qnc_avg_fact [0.1 0.38 1]				X

Global radiation sensitivity

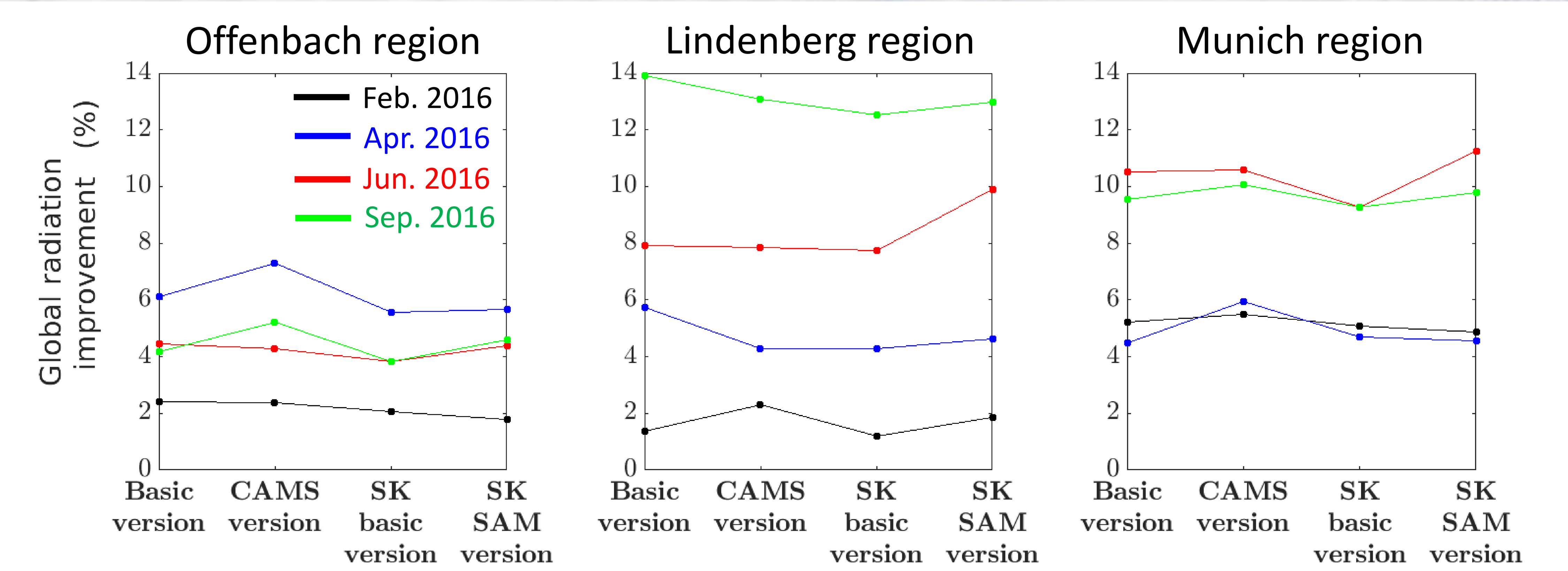
For every version and every parameter (X in table above) the averaged modeled (solid) global radiation for 12Z is plotted against the parameter value (keeping the other parameters default) and is compared to the averaged observed value (dashed).

- The global radiation is the lowest in February and the highest in June (obvious).
- Larger radqcfact (strongly) reduces the global radiation (increases GS and SGS LWC).
- radqifact has weaker effect (cloud ice).
- Larger reff_ini_c (strongly) increases the global radiation (larger droplets).
- Larger qvsatfact_sgscl_rad (strongly) reduces the global radiation (larger SGS LWC).
- Larger cloud_num_rad (slightly) reduces the global radiation (higher droplets concentration).
- reff_avg_fact has uncertain effect. Larger value increases the size of droplets in SGS cumulus (more transparent) but increases also their LWC (less transparent).
- Larger qnc_avg_fact (slightly) reduces the global radiation (lower dilution→ larger SGS LWC in cumulus). Significant in convective seasons (April and June).
- Note: CCN for SK and SK-SAM versions are climatological (Tegen). The effective radius retrieval in SK version and the adiabatic profiles in SK-SAM version are currently fed by constant CCN. The huge sensitivity to CCN is still missing and big improvement may be expected when prognostic CCN will be included.

Feb. 2016 | Apr. 2016 | Jun. 2016 | Sep. 2016



Calibration results



Parameter	Basic version	CAMS version	SK basic version	SK-SAM version
radqcfact	0.547 (34.5%) 0.55 (17%) 0.503 (4.1%) 0.571 (19.6%)	0.507 (13.3%) 0.555 (13%) 0.492 (1.8%) 0.532 (22.8%)	0.496 (5.4%) 0.573 (24.2%) 0.468 (9.4%) 0.495 (5.9%)	0.483 (8.4%) 0.613 (42.7%) 0.496 (3.2%) 0.495 (7.3%)
radqifact	0.509 (14%) 0.493 (6.2%) 0.491 (1.1%) 0.486 (8.2%)	0.476 (8.6%) 0.485 (4.9%) 0.508 (6.5%) 0.487 (1.4%)	0.711 (89.4%) 0.581 (77.3%) 0.497 (8%) 0.487 (5.6%)	0.481 (10.5%) 0.48 (6%) 0.503 (2.9%) 0.493 (9.5%)
reff_ini_c (·10⁻⁶)	5.85 (7%) 5.785 (1.2%) 5.87 (1.2%) 5.838 (8%)	5.965 (7.8%) 5.67 (3.3%) 5.461 (3.3%) 5.672 (4.9%)		
qvsatfact _sgscl_rad	0.012 (72.2%) 0.01 (50.7%) 0.014 (44.1%) 0.009 (26.2%)	0.014 (47.1%) 0.01 (25.1%) 0.012 (30%) 0.01 (36.4%)	0.011 (71.2%) 0.008 (22.5%) 0.017 (15.1%) 0.011 (76.6%)	0.012 (62.5%) 0.008 (16.2%) 0.01 (3.6%) 0.009 (26.3%)
cloud_num _rad (·10⁸)	1.216 (11.2%) 1.281 (1.3%) 1.331 (15%) 1.3 (6.7%)	1.673 (11.2%) 1.274 (2.5%) 1.288 (5.6%) 1.536 (12.8%)		
reff_avg _fact				0.933 (2.9%) 0.923 (1.2%) 0.94 (1%) 0.933 (3.4%)
qnc_avg _fact				0.513 (70.8%) 0.32 (4.9%) 0.898 (2.4%) 0.685 (52.4%)

Optimal parameters values for Feb, Apr, Jun and Sep 2016 averaged over the 3 regions. In parenthesis – uncertainty with respect to parameter range.

Conclusions

- Global radiation forecasts are optimized for 4 month during 2016 for 3 regions over Germany, separately. Optimization of several forecast fields over entire COSMO-DE domain and entire period to produce a single set of optimal parameters, is planned.
- The global radiation forecast improvement by various COSMO-cloudrad versions is similar. In summertime it reaches ~10%.
- "CAMS" version has little effect with respect to the "Basic version" because currently the prognostic CCN play role in the clear sky only.
- The "SK-SAM" version improves the "SK basic" in summertime due to larger role of SGS cumulus clouds over Germany.
- Larger improvement from SK parametrization is expected when prognostic CCN will be used for droplets activation (planned).

References

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