$T^2(RC)^2$ - status report March 2019

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Tasks:

1.1 Final set of tuning parameters– **done**. PK used the idealized framework to perform a sensitivity analysis to rate ~30 tuning parameters of the new radiation scheme for six types of clouds. He presented the results in the 2016 CUS.

Case studies - **done**. UB and HM performed more than 30 case studies using the new cloud-radiation scheme

1.2 Re-write the new radiation related portions of the code adapted to GPU architecture – **done**.

1.3 Automatic parameter tuning performed (CALMO method) **done** – long periods runs in COSMO-DE domain using the new radiation scheme performed on ECMWF computers using 30M BU from DWD. Analysing using CALMO methodology is ongoing some of the results was presented in ICCARUS 2018 (PK). Tuning 4 COSMO-cloudrad subversions ("basic", "CAMS", "Segal-Khain", "Segal-Khain+ shallow Cu parametrization". The tuning focused on improving the global radiation (comparing with stations and CM-SAF) and was performed over Germany during 4 month period at 2016. The results yielded improvement of the global radiation & RMSE of several percent together with the optimal parameter sets for each of the subversions.

2.1 Analysis and understanding of current SGSC parameterization Testing and adaption of the alternative SGSC parameterization in the turbulence scheme– **done**. UB implemented a new calculation of SGS effective radius based on number concentration and SGS QC.

2.2 & 2.3 Analysis HUCM idealized 2D & 3D SAM (bin microphysics) **done**. PK simulated different clouds types using these tools including Cu clouds. He developed new parametrization for SGS clouds effective radius and LWC.

3.1 Implementation of CAMS aerosols into COSMO –**done**. The optical properties were adapted from ECMWF to COSMO 8-band radiation scheme. INT2LM and COSMO codes were revised to digest the 5-species

(divided to 11 tracers) of aerosols mixing ratios taken from MACC (UB, HM).

3.2 CAMS- Case studies and documentation of the effects **done** - HM performed 30 case studies under different weather situations, some with dust storms. The results - model performance as well as radiation scheme performance were compared to the climatology aerosols available in COSMO (Tanre and Tegen). Was presented on CUS-2017. A test version of COSMO-CAMS is running since June2017 in the IMS (so far with success).

4.1 Experiments for comparison of quality and efficiency of SP and DP radiation **done**. The new perturbation module was successfully implemented at IMS. Few ideas for DP reduction for the code were tested and compared. Final decision and recommendation will be presented on GM-2017 (PK, HM, IC, OF, XL).

4.2 Experiments evaluated and recommendations for official COSMO code **done**.

5.1 Experiments conducted and effects documented of temporal resolution of radiation scheme– **done**. COSMO 7-km & 2.8km experiments in partial CLC and high WS conditions performed using different temporal resolutions of radiation call-time. The T2M, CLC, fluxes RMSE were compared and localized biases were checked. The CPU cost as function of temporal resolutions was obtained. Recommendations for operational COSMO were given (AS, HM).

5.2 Implementation MCSI method in test version of COSMO – **done** (UB, HM).

5.3 Testing the MCSI method – case studies and documentation of the effects –**done** (HM). The MCSI scheme were tested against control COSMO benchmark schemes and against based ground measurements in Israel domain. Both CPU runtime and model performance were tested.

6.1 The implementation of Kinne MAC-v2 aerosol climatology in the model **done** (MS, AP, NC, GR, UB).

6.2 The results of inter-comparisons of different aerosol COSMO simulations with the accurate experimental measurements in clear sky conditions **done**. Clear sky studies comparisons of COSMO model with both Tanre and Tegen climatologies performed against observational data from Moscow State University Meteorological Observatory (MSU MO) Russia and the Falkenberg/Lindenberg sites. Comparison of Kinne and Tegen climatolgies against AERONET observations was performed also (NC, AP, MS, GR).

6.3 The results of inter--comparisons of different aerosol COSMO simulations with the accurate off-line model simulations in clear sky conditions **done** COSMO model with both Tanre and Tegen climatologies performance under clear sky conditions were tested against the accurate RT CLIRAD(FC05)-SW model and benchmark Monte-Carlo model**.** (NC, AP, MS, GR).

6.4 The results of inter-comparison of different aerosol COSMO simulations with the accurate experimental measurements in cloudy conditions (NC, AP, MS, GR) **ongoing**. Assessment of absolute and relative deviations between real measurements and forecasted values (radiation parameters, integral water vapor and cloud water content) is partly done for the Lindenberg observatory. Evaluation period is March October 2016.

New experiments with the new cloud-radiation scheme and different parameters over Moscow (2018 period) (MS,NC,GR).

The radiative and temperature effects of aerosol over two Israel sites were evaluated. The inter-comparison between model and measured radiative data has been implemented for clear sky conditions.

6.5 The assessment of the accuracy of implementation of new aerosol climatology to radiation fields and several meteorological parameters (NC, AP, MS, GR) **done**.

6.6 The assessment of the deviations between the forecasted and observed meteorological parameters due to new cloud and different aerosol inputs (NC, AP, MS, GR) **ongoing** extended in phase 2 as part of tasks 6.3 & 6.4. Assessments of precipitation forecast with new cloud and different aerosol inputs were made using observations from field campaign in Pyeongchang area (MS, GR).

7.1 Implementation of Fu's ice particles optical properties in ICON-RRTM scheme – **done** (SG, HM)

7.2 Implementation of Hu & Stamnes water droplets optical properties in ICON-RRTM scheme – **done** (SG, UB)

7.3 Case studies and documentations of the effects using ICON-LAM- **ongoing**. Preliminary sensitivity tests performed on ICON (MK, SG) on global scale. The parameters which have particularly high influence on the radiative fluxes in the model underwent massive tuning via comparison of model forecasts against 20 radiation observations stations. These sensitivity experiments were performed for Feb/Apr/Jun/Sep during 2016 over COSMO-DE domain using ECMWF computers (PK).

8.1 Implementation of ICON-ART aerosols in COSMO radiation scheme: Adaptation of INT2LM code to allow the time and space interpolation of ICON-ART aerosols fields onto COSMO grid – **done** (DR, HM).

8.2 Implementation of ICON-ART aerosols in COSMO radiation scheme– **done** (DR, HM). A few tests of urban aerosol studies using COSMO-ART over Moscow and Moscow suburbs for spring 2018 have been fulfilled which maybe useful for the future prognostic aerosol ICON-ART implementation.

8.3 Case studies and documentations of the effects- **ongoing**. Clear skies test cases performed against ground base aerosol and radiative observations in in Israel and over the pristine area in Russia at the Arctic Tiksi observatory. The results were compared to other COSMO versions and benchmark CLIRAD model (AP,DR, NC, HM).

9.1 Implementation of CAMS prognostic aerosols in the water droplets nucleation scheme of Segal & Khain (2006) to define cloud number concentration of both COSMO's microphysical scheme as well as for the radiation scheme. **Done** (HM).

9.2 Implementation of CAMS prognostic aerosols in COSMO's ice nucleation schemes in the 2-mom scheme. **Done** (HM).

9.3 Case studies and documentations of the effects. **Ongoing.** A few-days case study performed comparing a number of model schemes using combinations of the mentioned implementations. The model's T_2m, rain, LWC, cloud cover and more, showed large sensitivities to the different schemes. A test version of COSMO using the implementations mentioned in 9.1 is running in the IMS since 18.12.2018 (HM).

10.1 Check Boeing parametrization components using SAM LES simulations with BOMEX setup. **Ongoing**. Verification of the COSMO shallow convection LWC against the proposed parametrization (related to the adiabatic LWC profile). This verification can be performed in real COSMO run or in idealized COSMO run for BOMEX conditions. **Done** (PK).

10.2 New shallow convection shutdown scheme development. Reviewing the shallow cumulus parametrization of COSMO, and suggesting to correctly merge it with the radiation scheme. Assuming good agreement with the new LWC parametrization, we can use the COSMO shallow convection LWC profile to obtain the Reff for the radiation scheme (for Cu). Similar analysis can be performed in ICON. **Done** (PK).

10.3 SGS cloud cover schemes verifications against ground base and satellite observations including fish-eye camera verification and testing radiation response. **Not started yet**.

11.1 Updating the COSMO latest version with (RC)2 and T2(RC)2 developments – **ongoing**. Most of the code was transfer to 5.5 branch (on CSCS git). COSMO test runs on both Idealized and real cases, showing logical behaviour were performed (PK, UB, SG). Implementation of Macv2 in Cosmo version 5.05 (AP,NC).