COSMO Priority Project: Testing and Tuning of Revised Cloud Radiation Coupling $T^2(RC)^2$: Extension

Version 2.0, 08.05.2019

Project duration: 09.2019 – 03.2020

Project leader: Harel Muskatel

Summary

This is an half year extension of the **T**esting and **T**uning of **R**evised **C**loud **R**adiation **C**oupling – $T^2(RC)^2$ priority project. The tasks mentioned in this document are based on un-finished sub-tasks from the previous phases of the project.

In the previous phases of the project new parametrizations for water droplets (Hu and Stamnes, 1992) and ice particles (Fu, 2007) were implemented as well as new optical properties for these species that were calculated based on state of the art data and adapted to COSMO spectral bands. Sensitivity analysis for choosing the most sensitive tuning parameters were performed and the new cloud-radiation scheme was systematically calibrated. The new cloud droplets and ice particles optical properties were also implemented in the ICON RRTM scheme and tested over DWD domain. In this project we also introduced the CAMS-ECMWF prognostic aerosols which is now effective both in the radiation scheme and also in the cloud and ice nucleation schemes of COSMO. Additionally, the Kinne aerosol climatology (macV2-2013) was implemented as well as the ICON-ART prognostic dust. An alternative radiative solver based on the Monte-Carlo Spectral Integration technique was realized and new approaches for Sub-grid Scale (SGS) clouds parametrizations were examined. All of these new features are already a part of the latest code version and will be available on the next COSMO release.

In this last extension we wish to finish verifications of the latest modifications and to provide the final report and documentations for the COSMO community.

Motivation

Radiation is the main source of the Earth's energy, and it is strongly coupled to other elements of NWP models especially the heating and cooling rates. On the other hand, precise line by line calculation of extinction of radiation in the atmosphere due to different scatterers and absorbers is computationally costly. Wise parameterizations of the cloud hydrometeors and aerosols optical properties and also a smart computational algorithm are key aspects of a fast and accurate operational radiation transfer model. Aerosols have two impacts on radiation: direct by absorbing and scattering radiation, and indirect by influence on cloud microphysical properties as the droplet concentration and effective radius. In this last phase of the project we want to test the impact of both effects on the radiative fluxes and cloud thickness and cloud cover against measurements.

Actions proposed

1. Testing ICON-ART prognostic dust in COSMO radiation scheme (Task 8)
2. Testing CAMS prognostic aerosols in COSMO microphysical scheme (Task 9)
3. Testing cloud cover schemes in the new cloud-rad scheme against observations (Task 10)
4. Project's summary and documentations (Task 12)

Description of individual tasks

Task L: Project leadership

Estimated resources: 0.05 FTE

Task 8: Implementation and testing of ICON-ART prognostic aerosols in COSMO radiation scheme

ICON-ART is a global ICON NWP model coupled with the ART modules developed at KIT which deals with aerosols and reactive gases in the atmosphere. In previous phase we coupled ICON-ART dust prognostic field which is run semi-operational with COSMO radiation scheme. Preliminary tests were performed and now we wish to further test this version of COSMO radiation scheme.

Therefore we propose the following subtasks:

8.3 Comparative testing of the model output against observational data (T2m, global radiation) using ICON-ART dust input to the radiation scheme. The model performance will be tested compared with Tegen climatology and CAMS prognostic aerosols options. The runs will be performed in ECMWF computers.

In addition, comparisons will be performed to evaluate radiative effects of COSMO-ART dust compared with CAMS, and different aerosol climatology data (Tegen and Macv2) against experimental datasets for clear/cloudy sky conditions. Additional testing of the new cloud scheme will be made against large statistics in cloudy conditions over the whole 2018 versus observations at the Lindenberg Observatory and Meteorological Observatory of Moscow State University for the evaluation of uncertainties of the new cloud-radiative scheme.

Deliverables:

(03.2020, Harel Muskatel 0.1, Alon Shtivelman 0.1, A. Poliukhov 0.1, N. Chubarova 0.05, G. Rivin 0.05) Case studies, documentation of effects

Estimated resources: 0.4 FTE

Task 9: Implementation and testing of CAMS prognostic aerosols in COSMO microphysical scheme

CAMS-ECMWF aerosol model includes prognostic variables for the mass of sea salt, dust, organic matter, black carbon and sulfate aerosols. Implementation of these fields into the radiation model of COSMO has been completed and tested. In the second phase of the project these aerosols were also used for cloud formation using the Segal and Khain cloud nucleation scheme. Preliminary test cases were performed and analyzed but we wish to have a statistical examination of this indirect effect on clouds and rain compared with the default fixed aerosols and cloud droplets number concentrations. Therefore we propose the following subtasks:

9.3 Testing the new aerosols-microphysical scheme against measurements in COSMO-IMS domain. Since May 2019 the new scheme is the running test version in IMS and can be compared with the operational setup. Both versions are based on latest COSMO version and run twice a day. We will examine the impact on T2m, global radiation, rain and more.

In addition testing of the new cloud scheme will be made against large statistics in cloudy conditions over the whole 2018 versus observations at the Lindenberg Observatory and Meteorological Observatory of Moscow State University for the evaluation of uncertainties of the new cloud-radiative scheme.

Deliverables:

(03.2020, 0.2 FTE, Harel Muskatel 0.1, Pavel Khain 0.1, Chubarova 0.05, Shatunova 0.05, Khlestova 0.05) Case studies, documentation of effects

Estimated resources: 0.35 FTEs

Task 10: SAM LES utilization for parameterization of sub-grid scale shallow cumulus cloud cover

In this task we plan to analyse the possibility to improve the parameterization of the cloud cover of shallow cumulus. In the default COSMO version, the total cloud cover (CLC) depends on two parts. The sub-grid scale cloud cover (CLC_SGS) is a function of a mixed-phase generalized relative humidity RH_g and of other parameters, and the so-called convective cloud cover (CLC_CON) is assumed to be proportional to shallow cumulus cloud depth (TOP_CON-BAS_CON). Other two alternative schemes are available: an alternative scheme based also on RH_g and a statistical scheme. The three approaches were not yet comprehensively tested.

Therefore we propose the following subtasks:

10.3 Testing the sub-grid scale CLC parameterization schemes against satellite measurements such as CALIPSO.

Deliverables:

(03.2020, Pavel Khain 0.2) SGS cloud cover schemes verifications against ground base and satellite observations

Estimated resources: 0.2 FTE

Task 12: Documentation and Summary

12.1 writing $T^2(RC)^2$ final technical report and updating COSMO user's guide. Writing a journal paper on the new ice optical properties parametrization.

Deliverables:

(03.2020, Harel Muskatel 0.1, Pavel Khain 0.05) writing $T^2(RC)^2$ final technical report and updating COSMO user's guide.

Estimated resources: 0.15 FTE

Risks - N/A

Task	Contributing scientist(s)	FTE-years	FTE per person	Start	Deliverables	Date of delivery	Preceding tasks
8.3	Harel Muskatel (IMS) Alon Shtivelman (IMS) Natalia Chubaroba (RHM) Alexei Poliukhov (RHM) Gdaly Rivin (RHM	0.4	H-0.1 A-0.1 N-0.1 P-0.05 G-0.05	01.09.2019	Results from case studies and documentation of the effects	28.02.2020	8.1,8.2
9.3	Harel Muskatel (IMS) Pavel Khain (IMS) Natlia Chubarova (RHM) Marina Shatunova (RHM) Julia Khlestova (RHM)	0.35	H-0.1 P-0.1 N-0.05 M-0.05 J-0.05	01.09.2019	Results from case studies and documentation of the effects	28.02.2020	9.1,9.2
10.3	Pavel Khain (IMS)	0.2	P-0.2	01.09.2019	SGS cloud cover schemes verified against satellite observations	28.02.2020	10.1, 10.2
12.1	Harel Muskatel (IMS)	0.15	H-0.1 P-0.05	01.09.2019	Documentations	28.02.2020	

Task	Contributing scientist(s)	FTE-years	FTE per person	Start	Deliverables	Date of delivery	Preceding tasks
	Pavel Khain (IMS)						
L	Harel Muskatel (IMS)	0.05	H-0.05	01.09.2019	Project leadership	28.02.2020	
All		**1.15**		01.09.2019		28.02.2020	

Estimated resources needed for COSMO-year 2019-2020:

Alon Shtivelman 0.1 FTE

Pavel Khain 0.35 FTE

Harel Muskatel 0.35 FTE

Natalia Chubarova 0.15 FTE

Gdaly Rivin 0.05 FTE

Alexey Poliukhov 0.05 FTE

Marina Shatunova 0.05 FTE

Julia Khlestova 0.05 FTE

Total: 1.15 FTE