COSMO Priority Task: TERRA Nova

Version 8.5, 13/03/2017

Task Leader: Yiftach Ziv (IMS)

Goal

Testing the new version of the soil module - TERRA

Motivation

The soil model TERRA in ICON was improved, in particular to be applicable for a global model with global scale and large time steps. Furthermore, a number of adaptions and modifications in the physical parameterizations have been implemented, which are not yet available in COSMO / TERRA.

Among various bug fixes, fixes for stability issues and technical updates, the main modifications introduced by the unified physics are (a) resistance-based bare soil evaporation scheme, (b) modified activation of interception storage scheme, (c) revised formulation of dependency of heat conductivity on soil moisture, (d) revised algorithm for soil ice melting/freezing for better numerical stability, (e) slight modifications to the single-layer snow model, (f) modification of some parameters such as: reduced soil heat capacity in the presence of roots, fix evaporation limiter at wilting point, discard reduced infiltration of convective precipitation, fix for transfer coefficient limiter over glacier points, etc.

The unified physics approach leads to the usage of the ICON version of TERRA in COSMO, which could mean a different model behavior compared to the former COSMO version. Although a positive impact of the new soil model is expected, there is a strong demand for documenting the performance of this new version, on three typical climatological regions of interest for COSMO: Western Europe, Eastern Mediterranean and North-Western Russia. To support a future physical interpretation of the observed differences, the verification of the simulations should not be limited to a standard verification, but should also bring some insights in the surface layer and in the soil processes.

This PT will be synchronized with an M.Sc. thesis, proposed by the group of Prof. Sonia Seneviratne at ETHZ, aiming at comparing COSMO coupled with the community land model (so called COSMO/CLM) with COSMO coupled with TERRA. This will provide an additional control point and also support a better understanding of the strength and the limitations of the latest release of the TERRA module.

Description of Individual Sub-Tasks

Task0: Securing computational resources for execution of simulations

In order to collect enough statistics, the various simulations will require a significant amount of computational resources. Except for the runs on the North-Western Russia, which will be conducted with local computing resources at RHM, the experiments will be computed on the ECMWF HPC platform with billing units provided by MeteoSwiss (IMS is an ECMWF *associated* member and do not have resources of their own).

Currently 6 million billing units are already allocated at ECMWF for this project. A very preliminary estimation of about 10 million billing units for the basic scope of the project has been made (and 18 million billing units for the full scope of the project), which will be revised once the reference configuration has been computed (configuration 1, see task 1). If necessary, an update of the project requirements will be made, and additional billing units will be provided by MeteoSwiss.

Deliverables:

(1) COSMO environment set up in ECMWF computational centre, enabling runs of the task
(2) Securing enough billing units for execution of the PT.

Task1: Compare various TERRA versions over various domains

Subtask 1.1: Defining and executing the simulations.

In order to document the performances of the new TERRA, three versions of COSMO will be run as part of the PT, while an additional version of COSMO/CLM will be run by ETHZ as part of the M.Sc.

All 4 versions will rely on the same COSMO-POMPA 5.0 (for full GPU support, required for the MSc), with different soil modules: (1) TERRA of v5.00; (2) TERRA of v5.05 with recommended (conservative) configuration; (3) TERRA of v5.05 with advanced configuration (according to DWD experts); (4) community land model.

Each simulation will be implemented as hindcast (i.e. no data assimilation), initialized with COSMO analysis, with ICON analysis, or with IFS analysis if the former is not available. Three hourly boundary conditions will be obtained from analysis (00Z,12Z) and forecast (00Z/12Z +03,+06,+09). In order to account for changing conditions of SST, PLCOV, LAI, etc., these quantities will be updated every 24 hours at 00UTC, using the hosting model analysis for SST and INT2LM output for the other fields. Note in particular that the soil model will be allowed to run free in all simulations.

The 3 versions in the scope of this PT (COSMO/CLM excluded), will be run over 3 regions: Western Europe, Eastern Mediterranean and North-Western Russia, at two different resolutions: ~6.5 km and ~2.5

km. An additional ~1 km resolution is optional and depends on both computing and human resources. In addition, the COSMO/CLM configuration will be run only at ~6.5 km.

A focus of this PT is to accumulate enough statistics to have a good documentation of the history of the soil and land surface. Each simulation will be initialized in winter, when the soil is inactive, and will extend for 3 to 8 months to account for snow melting processes and behavior during summer. Each simulation will be preceded by at least 2 months spin up time. The chosen periods depends on the target region. They are:

- For the Western Europe region: JJA 2003, MAMJJA 2015. (JJA 2006 as an addition option).
- For the Eastern Mediterranean region: MAMJJA 2016.
- For the North-Western Russia region: AMJJAS 2010, JFAMJJAS 2016
- More details are available in appendix A.

Subtask 1.2: Verification of the simulations and documentation of the main differences.

Results from the various runs will be compared to observations from several sources in order to document the performance of each configuration, for each domain and for each period. Besides the standard verification providing general model scores, some more soil and surface oriented scores will also be computed. The following observations will be used:

Variables	Near surface, Upper Air*	Fluxes LW, SW, LH, SH	Fluxes LW, SW, LH, SH	Land Surface Temperature	(optional) Soil T(z),W(z)
Source	SYNOP / TEMP	FLUXNET	FLUXNET	CM SAF	SwissSMEX
Type	Site Specific	Gridded	Site Specific	Gridded	Site Specific
W. Europe	yes	yes	yes	yes	yes
E. Mediterranean	yes	no	yes	yes	no
NW Russia	yes	no	yes	no	no

* The choice of the tools to use for the standard verification is still being evaluated. One possibility is to use the VERSUS software installed at ECMWF and at RHM; another option would be to use the tools used by MeteoSwiss at CSCS (movero & Rfdbk), transferring the necessary files from ECMWF or RHM to CSCS.

Deliverables:

(1) A set of simulations based on the reference COSMO/TERRA 5.00, and the associated observation listed in the previous table, available for further studies.

(2) Documenting the differences between the three versions of TERRA and standard near surface measurements in terms of RMSE, MBE and other scores used, for instance, by MCH "Movero" (standard verification).

(3) Documenting the differences in land surface temperature between the three versions of TERRA and CM-SAF data base, according to CM-SAF validation methods (Anke et al. 2016).

(4) Documenting the various fluxes differences and diurnal deviations between the three versions of TERRA.

(5) Optional – preliminary analysis of reasons for differences between versions arising from deliverable (1).

Advising and collaborations

- J.M. Bettems (MeteoSwiss, WG3b).
- J. Helmert (DWD) and J.P. Schultz (DWD) – TERRA experts.
- E. Davin (ETHZ) - observation and CLM expert.

Outlook of Future Steps

Gain understanding of which schemes in which version works best.

Skills of Participating Scientists

Scientific skills:

- Understanding soil physics

Programming skills:

- Fortran 90.
- Matlab, Python

Task	Contributing Scientist(s)	FTE-Years	Start	Deliverables	Date of Delivery
0	Y. Ziv (IMS) A. Shtivelman (IMS)	0.08 0.07	9.2016	COSMO environment set up in ECMWF computational centre, enabling test runs of the task - COMPLETED	2.2017
1	Y. Ziv (IMS) I. Rozinikina (RHM) M.Nikitin (RHM) Y. Levi (IMS) J.M Bettems (MCH) J. Helmert (DWD) J. P. Schultz (DWD)	0.4 0.05 0.15 0.01 0.02 0.02 0.02	1.2017	(1) A set of simulations based on the reference COSMO/TERRA 5.00, and the associated observation listed in the previous table, available for further studies. (2) Documenting the differences between the three versions of TERRA and standard near surface measurements in terms of RMSE, MBE and other scores used, for instance, by MCH "Movero" (standard verification). (3) Documenting the differences in land surface temperature between the three versions of TERRA and CM-SAF data base, according to CM-SAF validation methods (Anke et al. 2016). (4) Documenting the various fluxes differences and diurnal deviations between the three versions of TERRA.	12.2017

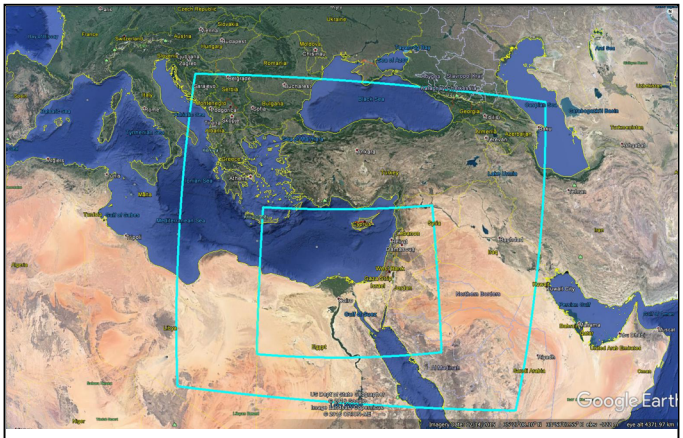
Total of 0.82 FTEs

Bibliography

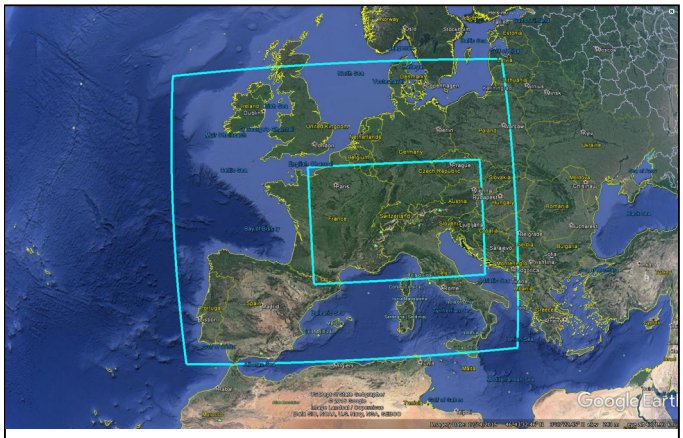
- COSMO Documentation.
- Community Land Model: see http://www.cgd.ucar.edu/tss/clm/
- D. T. Anke, B. Jedrzej, G Frank, T. Isabel, 2016, *Validation Report- Meteosat Land Surface Temperature- Edition 1*, EUMETSAT Satellite Application Facility on Climate Monitoring (CM-SAF), DOI: 10.5676/EUM_SAF_CM/LST_METEOSAT/V001.

Appendix A – domains properties

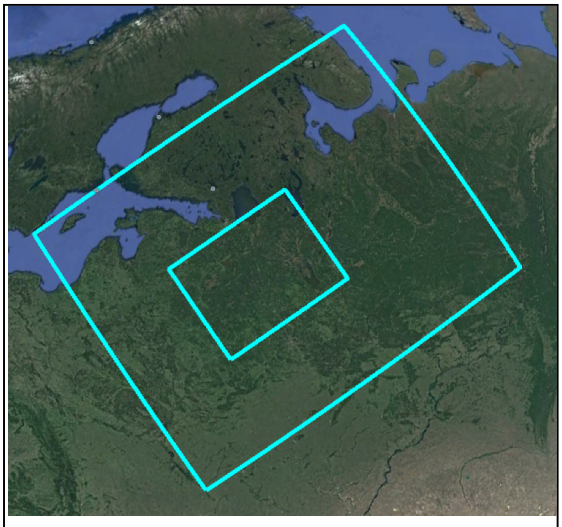
Name	Res.	pollon	pollat	polgam	startlon	startlat	dlon	dlat	ie_tot	je_tot
MED	7	-156	52	0	-5	-15	0.0625	0.0625	401	353
MED	2	-180	90	0	25	26	0.025	0.025	561	401
MED	*1*	*-180*	*90*	*0*	*25*	*26*	*0.011*	*0.011*	*1121*	*801*
EU	7	-170	43	0	-16.32	-9.78	0.06	0.06	393	338
EU	2	-170	43	0	-6.82	-4.42	0.02	0.02	582	390
RUS	7	-90	25	0	-33	-1	0.06	0.06	280	220
RUS	2	-90	25	0	-29	3	0.02	0.02	300	230



Mediterranean 6.5km & 2.5 km



European 6.5km & 2.5 km



Northern Forest 6.5km & 2.2 km