<u>LATE</u> REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Italy

Principal Investigator[1]: Massimo Milelli (mcy)

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Francesca Bassani, Polytechnic of Turin

Project Title:

Implementation and test of a urban parameterization module in ICON Model

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP**ITMIL2	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2021	
Would you accept support for 1 year only, if necessary?	YES ☐	NO X

Computer resources required for the years: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	X	900000	900000
Accumulated data storage (total archive volume)[2]	(GB)	X	200	400

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

[2] If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages).

Following submission by the relevant Member State the Special Project requests the evaluation will be based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

All accepted project requests will be published on the ECMWF website.

Motivation and work plan

The main topic of this SP is the transfer of the achievements of the previous SPITMIL2, with respect to the urban surface parameterisation TERRA_URB (Wouters et al., 2016, TU from now on) and its external parameters from the COSMO atmospheric model to the ICON(-LAM) model. The project will also include extensive experiments with the new package and further developments and applications of TU within ICON(-LAM).

The up-to-date version of TU will be firstly used in COSMO Model in order to test new urban external parameter datasets and then to evaluate the optimal configuration of urban external parameters to import in ICON Model. In particular the use of Local Climate Zones (LCZ, see Stewart and Oke, 2012 and Demuzere et al., 2019), as a proxy for urban canopy parameters, is envisaged. Different case studies will be selected over the area of Turin, taking into account previous findings about the observed Urban Heat Island (UHI) effects (Milelli, 2016), in summer and in autumn/winter, for a 2-weeks period in order to have more robust statistics and to permit a soil adjustment, in agreement with previous studies (Bucchignani et al., 2019 and Garbero et al., 2020). As soon as the latest release of TU will be finalized in the most recent ICON version, simulations will be conducted with ICON for the same case studies as COSMO and the evaluation of the urban scheme will be performed for both models. The energetic balance at the surface will help in understanding the impact of the different components of the external parameters such as Building Fraction (BF), Building Height (H), Canyon geometry (Height/Width ratio or H2W). The runs will be performed in analysis mode firstly, but then also in forecast mode.

The model evaluation and verification will be performed using a dense network of surface stations (to evaluate UHI), radiometers (to evaluate the PBL modifications over the city), satellite data (to evaluate the surface UHI or SUHI). ERA5-Land reanalyses will be used as well.

The working plan is the following:

1. Definition of new test cases over the Greater Turin Area
2. COSMO model simulations with TU
3. COSMO model simulations with TU and LCZ
4. ICON model simulations with TU to be compared with 2)
5. ICON model simulations with TU and LCZ to be compared with 4)

6. Extensive verification of the simulations using all available observations

Technical characteristics of the numerical codes

In the framework of this special project, the following F90 codes will be used:

- INT2LM, an interpolation program which performs the interpolation from coarse grid model data to COSMO initial and/or boundary data. The following coarse grid models are possible(at the moment): ICON (the global German model), IFS (the global ECMWF spectral model), GFS (global US model), UM (UK Met Office Unified Model) and COSMO (when the COSMO model is nested into itself);

- COSMO, the non-hydrostatic limited-area atmospheric prediction model. This code has been designed for both operational forecasts and various scientific applications on the meso-beta (from 5 to 50 km) and meso-gamma (from 500 m to 1 km) scale. COSMO model is based on the primitive thermo-hydrodynamical equations describing compressible flow in a moist atmosphere. The model equations are formulated in rotated geographical coordinates and a generalized terrain following height coordinate. A variety of physical processes are taken into account by parametrisation schemes;

- ICON, which combines the non-hydrostatic dynamical core, with the parametrisation package originating from the ECHAM6 atmosphere model. The physics is adapted for the vertical coordinate system and time stepping scheme of the ICON dynamical core. ICON has an icosahedral grid which provides a nearly homogeneous coverage of the globe. This avoids the so-called pole problem related to the convergence of meridians in lat-lon grids, which poses severe challenges to a computationally efficient implementation. In the current operational version, the global ICON grid has 2,949,120 triangles, corresponding to an average area of 173 km^2 and thus to an effective mesh size of about 13 km. All scalar prognostic model variables (e.g. temperature, density, moisture quantities) are located in the circumcenter of the triangles, whereas the edge-normal wind components are located in the edge midpoints.

Since the very beginning of the code development, the software has been parallelised using the MPI library for message passing on distributed memory machines. It has to be underlined that these codes are portable and can run on any parallel machine providing MPI. At the moment, they are implemented for both operational and research use on several platforms, including Cray XC40clusters, NEC SX8, INTEL/AMD Linux clusters.

Computer resources

This work will consider deterministic runs only (no use of the EPS is foreseen). The simulations will be performed at very high horizontal resolution (1 km for COSMO, about 1-3 km for ICON), so they will require a relatively large number of Billing Units (hereafter BUs), also in consideration of the different set-ups and models that will be tested. Therefore an overall cost of about 900000 BUs per year is envisaged. Depending on the results, the set-up of the system could be partly modified and it might be possible to have other simulations. Moreover we expect some debug work, at least in the first year.

References

Wouters, H., Demuzere, M., Blahak, U., Fortuniak, K., Maiheu, B., Camps, J., Tielemans, D. and van Lipzig, N. P. M., 2016: The efficient urban canopy dependency parametrization (SURY) v1.0 for atmospheric modelling: description and application with the COSMO-CLM model for a Belgian summer. Geosci. Model Dev., 9, 3027-3054

Stewart, I. D. and Oke, T. R., 2012: Local Climate Zones for urban temperature studies, Bull. Amer. Meteor. Soc., 93, 1879-1900. DOI: 10.1175/BAMS-D-11-00019.1

Demuzere, M., B. Bechtel, A. Middel and G. Mills, 2019: Mapping Europe into local climate zones, Plos One, 14, e0214474. DOI: 10.1371/journal.pone.0214474

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Bucchignani, E., P. Mercogliano, V. Garbero, M. Milelli, M. Varentsov, I. Rozinkina, G. Rivin, D. Blinov, A. Kirsanov, H. Wouters, J.-P. Schulz and U. Schättler, 2019: Analysis and evaluation of TERRA_URB scheme: PT AEVUS Final Report, COSMO Technical Report, 40 (http://www.cosmo-model.org/content/model/documentation/techReports/docs/techReport40.pdf)

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