LATE REQUEST FOR A SPECIAL PROJECT 2019–2021

MEMBER STATE:	Italy
Principal Investigator[1]:	Massimo Milelli
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Other researchers:	Valeria Garbero (Arpa Piemonte)
Project Title:	Analysis of the Urban Heat Island over Torino with COSMO model at 1km

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ITURB	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2019	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for the years: (To make changes to an existing project please submit an amended version of the original form.)		**2019**	**2020**	**2021**
High Performance Computing Facility	(SBU)	900000	900000	
Accumulated data storage (total archive volume)[2]	(GB)	600	1200	

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 modelling of urban environment has gained much attention in the last years; in fact, multiple parametrisations for the land use type have been developed. In COSMO model, cities are represented by natural land surfaces with an increased surface roughness length and a reduced vegetation cover (modification of soil and vegetation parameters of the TERRA model). However, in this representation, urban areas are still treated as water-permeable soil with aerodynamic, radiative and thermal parameters similar to the surrounding natural land. Therefore, this basic representation could not reliably capture the urban physics and associated urban-climatic effects including urban heat islands. For this reason, further developments of the parametrisation of the urban land have been carried out. In particular, the TERRA-URB bulk parametrisation scheme with a prescribed anthropogenic heat flux has been used in this work. The simple bulk-model TERRA-URB includes the effects of buildings on the air flow without resolving the energy budgets of the buildings themselves, but using the externally calculated anthropogenic heat flux. This approach allows representing effects of multiple cities on the atmosphere without requiring additional data on the building structure. The use of the previously estimated anthropogenic heat flux, modified thermal and radiative parameters and a modified surface-layer transfer scheme, provides the urban heat island with the correct diurnal phase. The magnitude of this flux can potentially be revised to fit the mean measured signal. TERRA-URB uses a pre-calculated anthropogenic heat flux which accounts for country-specific data of energy consumption, calculated on the base of the population density and the latitude dependent diurnal and seasonal distribution. Due to this simple representation of the urban land as a bulk, TERRA-URB is computationally inexpensive. The latest version of TERRA-URB implements the Semi-empirical Urban canopy parametrisation (SURY). It translates urban-canopy parameters (containing 3D information) into bulk parameters. TERRA-URB takes additional surface parameter input fields: ISA (Impervious Surface Area) and AHF (Annual-mean anthropogenic Heat Flux).

In the Cosmo Consortium a Priority Task has been created, in order to study this thematic. It will start in September 2019 and finish at the end of 2020. Since there will be a harmonization of development of the COSMO and ICON (ICOsahedral Nonhydrostatic) models in the time horizon of 2020 and further development of the COSMO model will be reduced during 2019, it is necessary to introduce the new parametrisation in ICON.

The main goals of the PT are the following:

- test of TERRA-URB in different configurations (analysis, forecast, domain, physical schemes);
- calibration of the tuning parameters;
- analysis of the external parameters (update, improvement);
- test of the IFS skin temperature formulation (Viterbo & Beljaars, 1995) that was adapted and implemented in TERRA;
- test of a new formulation of the bare soil evaporation, based on the resistance method, which was developed and implemented in TERRA, the soil module of COSMO model;
- implementation of the scheme in the ICON model for NWP applications.

Technical characteristics of the 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.

Since the very beginning of the code development, the software have 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 XC40 clusters, NEC SX8, INTEL/AMD Linux clusters.

Computer resources

Although the runs will be deterministic (no use of the EPS is foreseen), the enhanced horizontal resolution (1 km) will require a relatively large number of Billing Units (hereafter BUs) and of storage capacity, 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. Eventually, depending on the results, the set-ups of the system could be partly modified and it might be possible to have other simulations.

References

Milelli, M., Bucchignani, E., Mercogliano, P., Garbero, V., 2017: Preliminary activity with COSMO-1 over Torino including TERRA-URB parametrisation. COSMO Newsletter 17, 4-14

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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

Wouters, H., Demuzere M., Ridder K. D. and van Lipzig N. P., 2015: The impact of impervious water-storage parametrization on urban climate modelling. Urban Climate, 11, 24-50

Viterbo, P., Beljaars, 1995: An improved land-surface parametrisation scheme in the ECMWF model and its validation. J. of Climate, 8, 11, 2716-2748