PT AEVUS I and II

Analysis and Evaluation of TERRA-URB scheme

Task Leader: CIRA

COSMO GM 2019

Rome, 11th September 2019

h 09:10 - 09:35

Paola Mercogliano

PT_AEVUS Introduction

Title: Testing the implementation of the TERRA-URB scheme

Institutions:

- CIRA - Italian Aerospace Research Center
- RHM – HydroMet Center of Russia
- ARPA Piemonte - Italy

Researchers: P. Mercogliano (CIRA), E. Bucchignani (CIRA), E. Oberto (ARPA Piemonte), I. Rozinkina (RHM), D. Blinov (RHM), H. Wouters (KU Leuven), V. Garbero (ARPA Piemonte), G. Rivin (RHM), M. Varentsov (RHM), A. Kirsanov (RHM).

Advising and collaborations:
J.M. Bettems (MeteoSwiss), U. Schattler (DWD), M. Milelli (ARPA Piemonte), P. Khain (IMS), J.P. Schulz (DWD), KU Leuven – (KU – Leuven)

PT_AEVUS Motivations

- The increase of built surfaces can contribute to modify local atmosphere variables patterns (e.g. Urban Heat Islands (UHIs) effect).

- COSMO model, even at high resolution, is not able to cope with this effect (Milelli, 2016) without specific parameterization. Adopting urban parameterizations in high resolution configurations is crucial to better forecast temperature, moisture and precipitation especially in urban area.

- Modelling of urban environments has gained much attention in the last years, as multiple parameterizations considering this urban dynamics became available also in COSMO model.

- PT focus on TERRA_URB bulk parameterisation scheme. The latest version of TU implements the semi-empirical urban canopy parametrisation (SURY). Urban canopy parameters (except ISA and AHF) are specified as fixed field parameters (hard-coded constants) in the current version.

PT AEVUS goal

- TERRA_URB (the details can be found in Wouters et al. (2015, 2016)). is computationally fast and is recommended for studies with spatial and temporal scales where the interactions between the urban canyon air and the atmosphere do not need to be resolved in detail.

- The aim of this PT is an evaluation and a deep verification of the performances of the code including TU using more case studies, in order to decide if (and how) to improve the calibration of the namelist parameters, or the parameterisation itself.

- **It is expected to have a stable, efficient and reliable urban scheme in the official COSMO model code, with well tested and documented impact of the scheme.**

A brief story of PT AEVUS (1)

Official start of the task: September 2017

In January 2018 the **COSMO version 5.04g_urb1** has been released and several bugs have been detected.

In April 2018, a SubTask0 has been established in the proposal to give evidence of the debugging activities to be performed. In particular an array of runs has been performed (modifying the model configuration by varying some keys parameters). **Afterwards, the debugging of the beta model version including TERRA-URB was successfully achieved.**

In June 2018, **COSMO version 5.05 (including TERRA-URB)** has been officially released. During the last year, several versions have been released (5.05_urb2, 5.05_urb3, 5.05_urb4) to fix some bugs and a new version of INT2LM (2.05a) has been released too.

In December 2018 Jan- Peter Schulz has been designed as code owner to clearly identify a focal point for debugging activity

A brief story of PT AEVUS (2)

An unphysical heating of rural area in the COSMO 5.05urb1/2/3, switching on the TERRA_URB, leads to the unphysical heating even in case of complete absence of urban areas (ISA=0 and AHF=0). The problem was eliminated in 5.05urb4 release (thanks to U. Schaettler).

Currently **COSMO 5.05_urb4** provides satisfactory results for a specific configuration using itype_canopy = 1 (concerning the type of canopy parameterization with respect to surface energy balance).

An incorrect behavior of skin-layer temperature formulation (itype_canopy = 2) leads to the decreasing the air temperature diurnal range instead of its expected increasing. The problem was eliminated after fixing a code bug (thanks to M. Varentsov).

Preliminary tests have reported the high sensitivity of the urban climate simulations to the skin temperature formulation (itype_canopy = 2).

Additionally preliminary test shows have been performed using the new ICON physics.

PT_AEVUS is officially closed on August 201

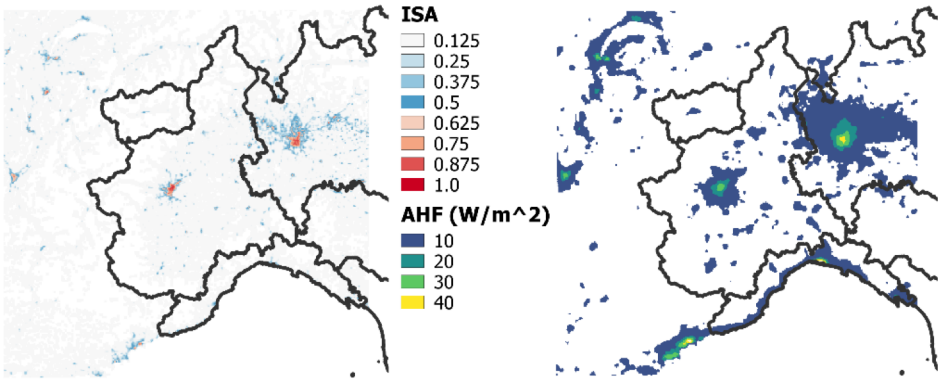
Running COSMO with TERRA_URB

COSMO run by activating or not the urban scheme TERRA_URB

Parameter	CTRL	URB
lterra_urb	F	T
ntiles	0	2
itype_ahf		1
itype_kbmo_uf		1
itype_eisa		2

Required urban canopy parameters provided by EXTPAR describing urban morphology and thermal properties

✓ urban area fraction (impervious surface fraction ISA)
✓ annual-mean anthropogenic heat flux (AHF)

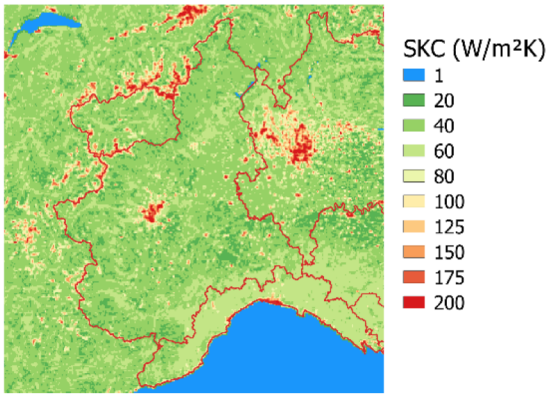


and using the canopy scheme or the skin conductivity scheme to calculate the surface temperature

Parameter	C1	C2
itype_canopy	1	2
calamurb		1000
cimpl		120

Required parameter provided by EXTPAR

✓ skin conductivity field (SKC)

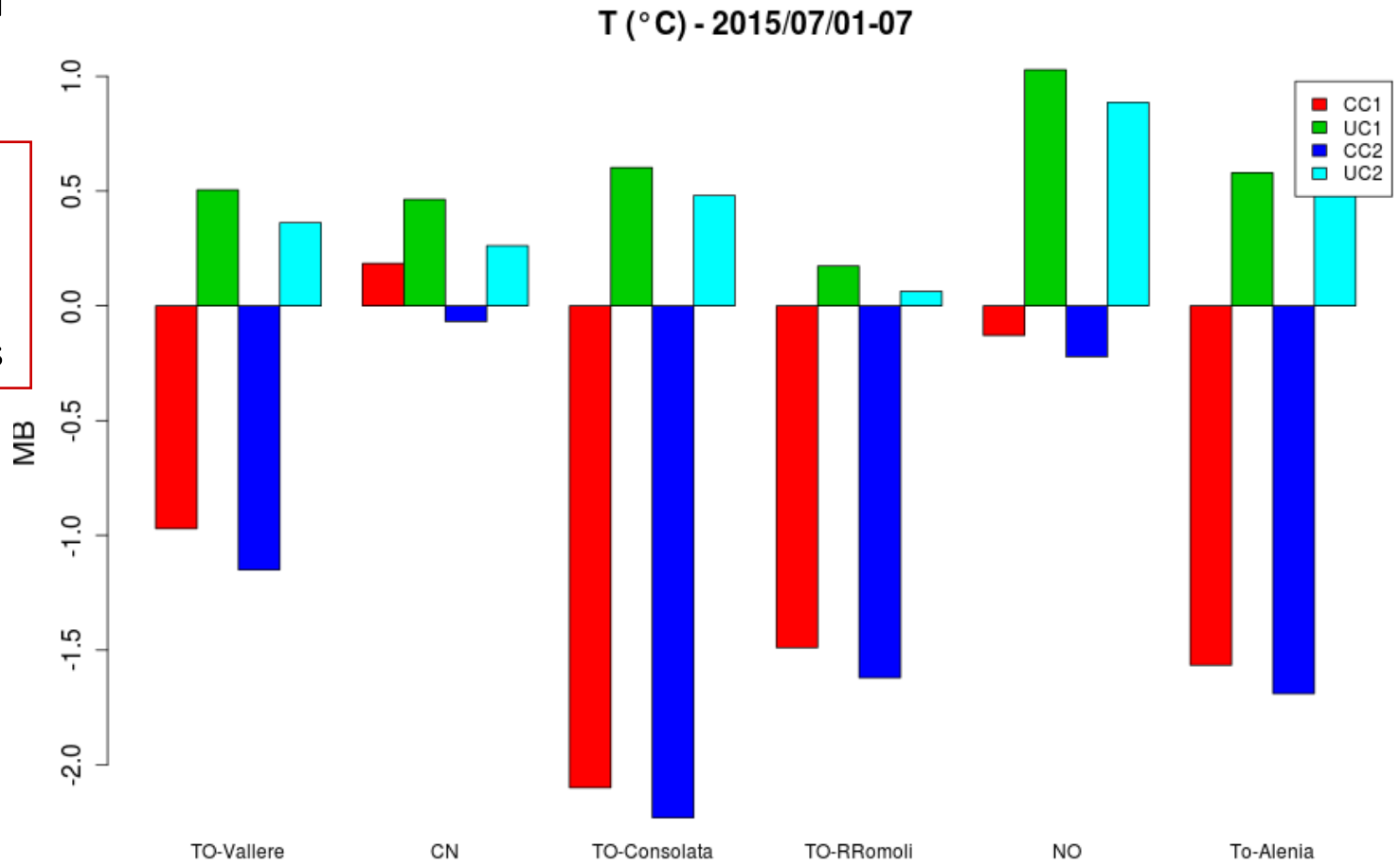


Main results achieved

CC1: lterra_urb=F and itype_canopy=1
UC1: lterra_urb=T and itype_canopy=1
CC2: lterra_urb=F and itype_canopy=2
UC2: lterra_urb=T and itype_canopy=2

URB configuration significantly improves the 2m temperature forecast in major urban area even if it overheats too much

2m temperature in Turin and close urban areas Cuneo and Novara



Main results achieved

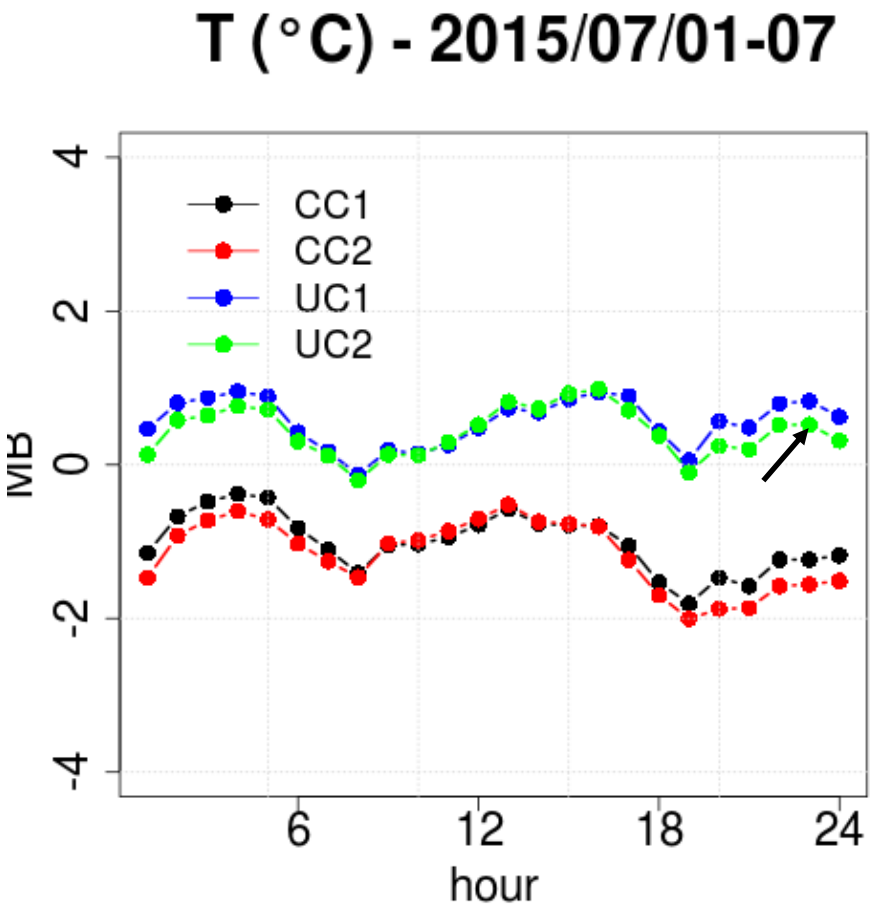
CC1: lterra_urb=F and itype_canopy=1
UC1: lterra_urb=T and itype_canopy=1
CC2: lterra_urb=F and itype_canopy=2
UC2: lterra_urb=T and itype_canopy=2

The different configurations have been evaluated using 4 urban stations in Turin

URB configuration significantly improves the 2m temperature forecast in urban area even if it overheats too much

C1 seems to have performance similar to C2 in urban areas

2m temperature over 4 urban stations



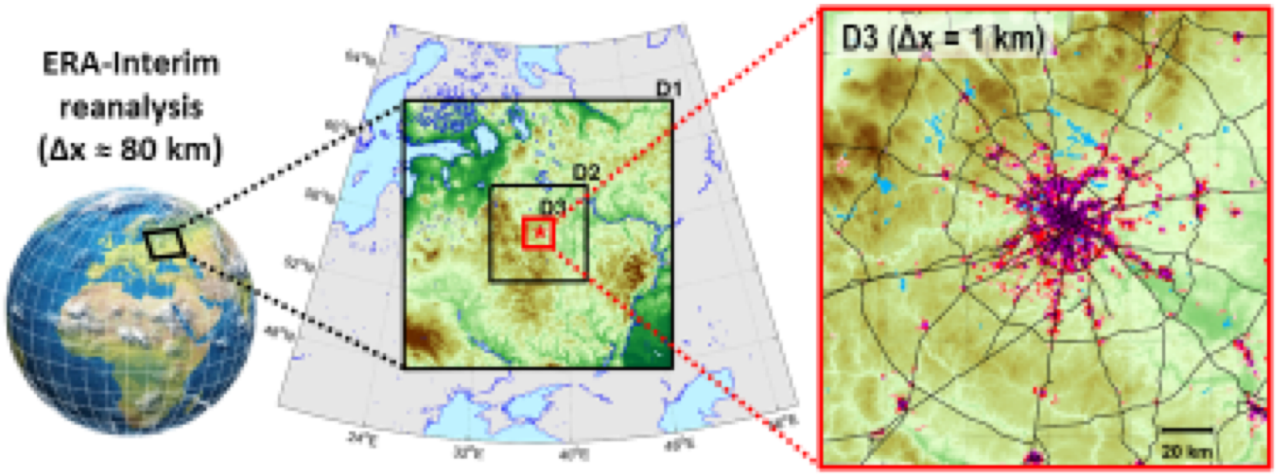
Main results achieved

RHM contribution to AEVUS PT

Overview of the modelling framework for Moscow megacity

The testing of the new COSMO versions including TERRA_URB (5.05g_urb1, …urb4) was performed using the same modeling framework as was used in the previous studies for Moscow with older climate version COSMO 5.0_clm9_urb), described in (Varentsov et al., 2018):

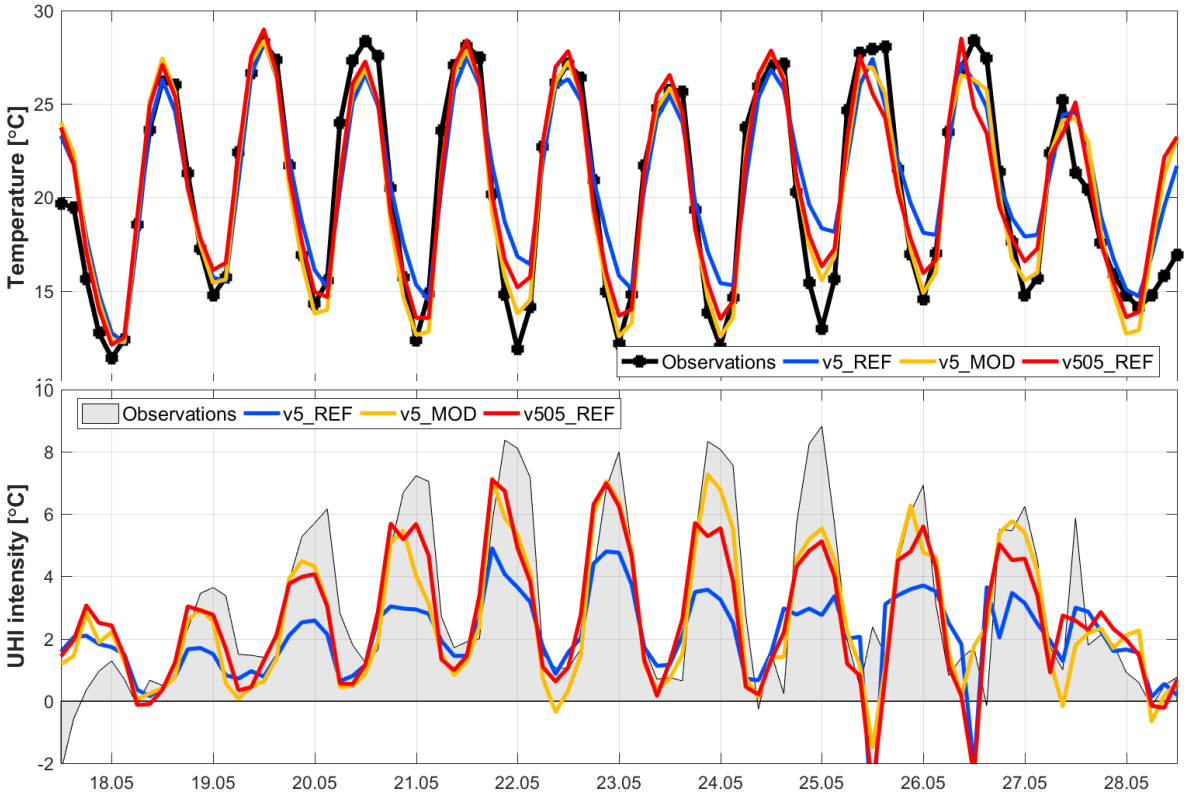
- Downscaling of the ERA-Interim reanalysis in continuous simulations for selected case studies (10-15 days) using three nested domains
- TERRA_URB is used for the finest domain D3 with 1-km horizontal grid step
- Urban canopy parameters (FR_PAVED/ISA & AHF) are additionally clarified using OpenStreetMap data according to the original GIS-based technology (Samsonov et al., 2015)
- Simulations at supercomputers Lomonosov-2 of Moscow State University and Cray-XC40 of RHM



Model verification for a summer case (17-28 May 2014)

	v5_REF	v5_MOD	v505_REF*
Model version	5.0_clm9		5.05urb4

Mean rural temperature (averaged over 9 stations)



UHI intensity for city center

- Reference climate configuration (blue)
- Optimized climate configuration (yellow) with itype_canopy=2
- New meteo configuration including COSMO-ICON physics, with itype_canopy=2 (red)

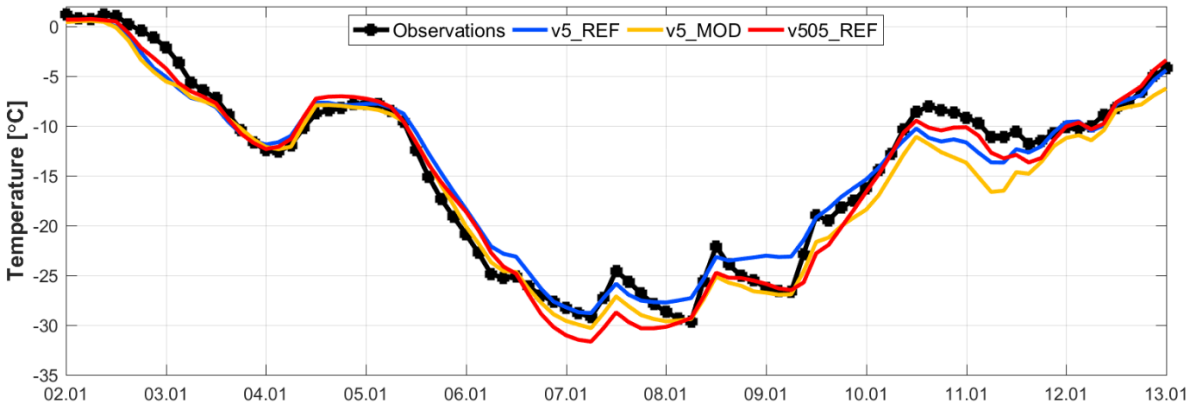
- Results with the new version 5.05urb are consistent with reference

- Even without accurate tuning, 5.05urb shows good results wrt (v5_MOD)

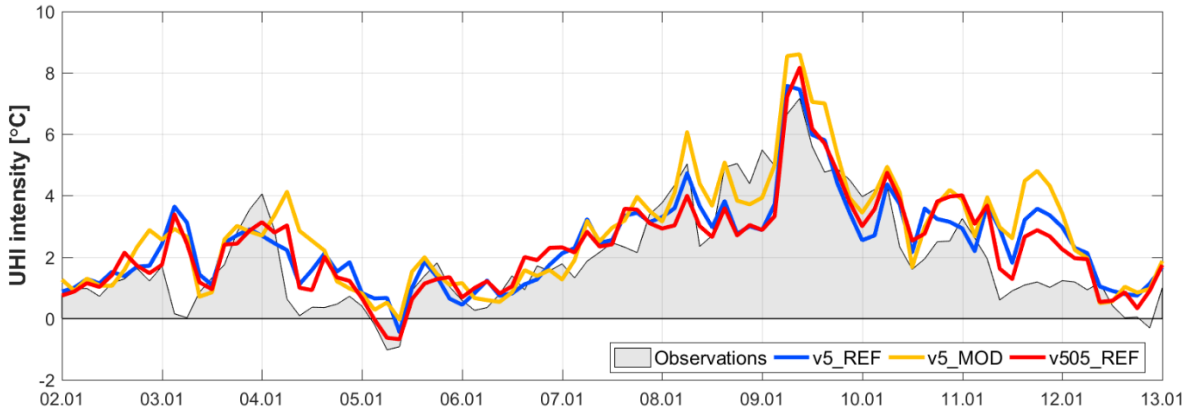
- Itype canopy 2 leads to a lower temperature in rural areas
- further increase in the UHI intensity wrt reference

Model verification for a winter case with extreme frosts (1-15 Jan 2017)

Mean rural temperature (averaged over 9 stations)



UHI intensity for city center



- Itype canopy 2 leads to a lower temperature in rural areas
- further increase in the UHI intensity wrt reference less evident

	v5_REF	v5_MOD	v505_REF*
Model version	5.0_clm9		5.05urb4

- **Reference climate configuration (blue)**

- **Optimized climate configuration (yellow) with itype_canopy=2**

- **New meteo configuration including COSMO-ICON physics, with itype_canopy=2 (red)**

- Results with the new version 5.05urb are consistent with reference

- Even without accurate tuning, 5.05urb shows good results wrt (v5_MOD)

Open issues at end of PT_AEVUS

Several issues are still open and needs to be addressed:

- The use of hard-coded values for the urban canopy parameters is a significant weakness point. It is necessary to implement the possibility to define urban canopy parameters as 2D EXPAR fields; Different possibilities to produce the required datasets of 2D external parameters will be investigated.

- Even the basic urban canopy parameters currently available in EXTPAR, ISA fraction and AHF, need to be improved. Further dataset needs to be investigated.

- A better calibration of parameters is still needed (especially concerning INPUT_PHY and TUNING)

- Increase number of test cases using skin temperature formulation (itype_canopy =2)

- Investigate the usage of different forcing (ECMWF IFS or ERA-Interim) data forcing also in view of the transition process from COSMO to ICON

- Preparation for the TERRA-URB implementation into ICON model

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Introduction to PT AEVUS2

During the PT AEVUS meeting at ICCARUS 2019, the possibility of a new PT AEVUS 2 follow-up was discussed, and all the participants agree on it.

A PT proposal has been submitted:

- Task Leader: CIRA
- Duration, start/end data. (October 2019- October 2020)
- COSMO Participants: CIRA, Arpa Piemonte, DWD, RHM
- External partners: Flemish Institute for Technological Research (VITO), Ruhr University of Bochum, Polytechnic of Torino.
- FTE: 1.1 Year.

This PT should be considered as a second part of the work started in PT AEVUS, aiming at address the mentioned issues still open after PT_AEVUS

Consolidate the implementation of the TERRA_URB scheme in the COSMO model, draft a new PT or PP aiming at transferring these developments into the ICON model.

Thanks for your attention