Sensitivity with COSMO-1 over South Italy for CALMO-MAX

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PP CALMO-MAX
COSMO-GM St. Petersburg, 3 September 2018

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Introduction

The importance of accurate weather forecasts in the field of aviation is widely recognized.

CIRA is working on the definition of a new COSMO-LM configuration at very high resolution, running over a domain including the CIRA facilities, where several weather instruments are currently available.

CIRA is currently involved in the PT-AEVUS, PP-CALMO-MAX and PT-CIAO for the testing of this new configuration.

The days 5-6 November 2017 Italy was affected by a strong perturbation, which caused intense precipitation and related hazards.

The period **3 to 6 November 2017** has been selected as first test case in order to test the capabilities of this COSMO-LM very high resolution configuration (also considering different settings) and its capability in reproducing weather conditions during this period.

The domain considered

The domain is centered over Campania region in southern Italy. This area includes three airports, i.e. Capua (military airport “O. Salomone”), Naples (Capodichino civil airport), and Pratica di Mare (military airport “de Bernardi”).

Pratica di Mare

Naples

CIRA

Domain:**12.22° – 14.55°E; 40.63° - 41.88° N**

Rotated North Pole: **-166°; 41°**

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Model version and set-up

- Model versions:

  - int2lm_150611_2.02

  - cosmo_171215_5.04h

- RTTOV (Radiative Transfer model for TIROS Operational Vertical sounder) libraries Version 12 have been included.

- COSMO-LM resolution: **0.009° (about 1 km)**

- Computational domain**: 260 x 138 points; 60 vertical levels, time step 10 s.**

- Time period: From 1 October 2017 onward (running with a delay of 3 days for research purposes)

- Forcing data: ECMWF IFS (resolution of 0.075°)

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Model configuration

- Model configuration was provided by METEO-SWISS and ARPA Piemonte, with some adjustments (thanks to J. M. Bettems and M. Milelli).
- loldtur = .FALSE. : several internal turbulence switches are modified to reproduce the old ijk-scheme as close as possible. Testing the new COSMO-ICON physics (namely the modified prognostic TKE turbulence and the modified version of TERRA) at DWD was not yet successful.
- Deep convection explicitly resolved, while the shallow convection is parameterized using the Tiedtke scheme.
- Model configuration includes an optimized set of **TUNING** parameters (i.e. *rlam_heat tkhmin tur_len entr_sc c_soil, v0snow*) defined in the frame of PP CALMO (thanks to A. Vouduri, shown in the next slide).
- The effectiveness of this configuration was tested in 2017 at CIRA by means of a different set of tests, on a different domain (Piedmont region, including the city of Turin).

Reference configuration

Set of parameters used in the **operational** configuration

	DEF (default)	OPT1	OPT2
rlam_heat	1.0	0.74	1.24
tkhmin	0.4	0.176	0.233
tkmmin	0.4	0.4	0.233
tur_len	150	368.8	363.9
entr_sc	0.003	0.00014	0.000267
c_soil	1.0	0.663	0.492
v0snow	20	17.8	12.1
rat_sea	20.0	20.0	16.12903

Average T2m bias for the Piedmont test case: DEF: 0.68, OPT1: 0.36, OPT2: 0.43 °C

Parameters considered in CALMO-MAX

	Min.	Default	Max.
tkhmin	0.1	0.4	2
rlam_heat	0.1	1	2
v0snow	10	20	30
uc1	0	0.3	1
radfac	0.3	0.6	0.9
kexpdec	0	2	1
fac_rootdp	0.5	1	1.5

This is not the maximum value

parameters selected and related range of values

- uc1 is hard coded in data_constants.f90
- radfac is called now radqc_fact
- kexpdec is a number and is hard coded in sfc_terra.f90
- fac_rootdp is one of the parameters of the namelist EPSCTL

Sensitivity tests for CALMO-MAX

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Simple tests

TEST	Parameter
0	Default
1	tkhmin at minimum
2	tkhmin at maximum
3	rlam_heat at minimum
4	rlam_heat at maximum
5	v0snow at minimum
6	v0snow at maximum
7	uc1 at minimum
8	uc1 at maximum
9	radfac at minimum
10	radfac at maximum
11	fac_root_dp at minimum
12	fac_root_dp at maximum
13	kexpdec at 0.
14	kexpdec at 1.

Interaction tests

TEST	Parameter
15	rlam_heat (min) , uc1 (min)
16	rlam_heat (min), tkhmin (min)
17	uc1 (min), v0snow (max)
18	rlam_heat (min), v0snow (max)

The analysis of results shows that radfac, fac_root_dp and kexpdec produce very slight (or no) modifications, so they will be neglected.

The four interaction simulations were performed considering max (min) values of rlam_heat, uc1, tkhmin, v0snow.

T2m MEAN (°C) values over 3-6 November 2017

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T2m mean values

		DEF	TKHMIN		RLAM_HEAT		V0snow		UC1		RADFAC		FAC ROOTDP		KEXPDEC		INT1	INT2	INT3	INT4
	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
03-nov	14.6	15.8	15.7	16.3	15.8	15.8	15.8	15.8	15.3	15.9	15.8	15.8	15.8	15.8	15.8	15.8	15.3	16.4	15.3	15.8
04-nov	15.3	15.7	15.7	16.3	15.8	15.7	15.7	15.7	15.7	15.8	15.8	15.8	15.7	15.7	15.8	15.8	15.7	16.2	15.6	15.8
05-nov	15.9	16.5	16.4	16.8	16.5	16.5	16.5	16.5	16.3	16.6	16.5	16.5	16.5	16.5	16.5	16.5	16.3	16.8	16.3	16.5
06-nov	13.6	15.1	15.1	15.4	15.4	15.0	15.2	15.1	15.0	15.2	15.1	15.1	15.1	15.1	15.1	15.1	15.2	15.7	14.9	15.3

T2m average bias values

03-nov	14.6	1.2	1.1	1.7	1.2	1.2	1.2	1.2	**0.7**	1.3	1.2	1.2	1.2	1.2	1.2	1.2	**0.7**	1.8	**0.7**	1.2
04-nov	15.3	0.4	0.4	1.0	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.4	0.9	**0.3**	0.5
05-nov	15.9	0.6	0.5	0.9	0.6	0.6	0.6	0.6	**0.4**	0.7	0.6	0.6	0.6	0.6	0.6	0.6	**0.4**	0.9	**0.4**	0.6
06-nov	13.6	1.5	1.5	1.8	1.8	1.4	1.6	1.5	1.4	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.6	2.1	**1.3**	1.7

Observational values provided by the visibilimeter installed at CIRA:
The nearest grid point is considered. The first three hours of every day have been neglected.

uc1 at minimum (cosmo7) provides the best improvements, even in interactions simulations, combined with rlam_heat at minimum (cosmo15) and v0snow at maximum (cosmo17).

T2m max-min (°C) values over 3-6 November 2017

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Max daily T2m values

		DEF	TKHMIN		RLAM_HEAT		V0snow		UC1		RADFAC		FAC ROOTDP		KEXPDEC		INT1	INT2	INT3	INT4
	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
03-nov	**19.3**	19.5	19.4	19.8	19.8	19.5	19.5	19.5	19.9	19.4	19.5	19.5	19.5	19.5	19.5	19.5	20.0	19.9	20.0	19.8
04-nov	**24.0**	20.8	20.5	21.0	20.8	20.7	20.7	20.7	20.7	20.6	20.6	20.7	20.8	20.8	20.7	20.7	20.9	21.0	20.7	20.9
05-nov	**20.2**	19.5	19.5	19.6	19.5	19.5	19.5	19.5	19.7	19.4	19.5	19.5	19.5	19.5	19.5	19.5	19.8	19.6	19.7	19.5
06-nov	**18.2**	17.8	17.7	17.9	18.2	17.6	17.8	17.8	18.2	17.7	17.8	17.8	17.8	17.8	17.8	17.8	18.6	18.3	18.2	18.3

Max T2m average bias values

03-nov	**19.3**	0.2	**0.1**	0.5	0.5	0.2	0.2	0.2	0.6	**0.1**	0.2	0.2	0.2	0.2	0.2	0.2	0.7	0.6	0.7	0.5
04-nov	**24.0**	-3.2	-3.5	**-3.0**	-3.2	-3.3	-3.3	-3.3	-3.3	-3.4	-3.4	-3.3	-3.2	-3.2	-3.3	-3.3	-3.1	-3.0	-3.3	-3.1
05-nov	**20.2**	-0.7	-0.7	-0.6	-0.7	-0.7	-0.7	-0.7	-0.5	-0.8	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	**-0.4**	-0.6	-0.5	-0.7
06-nov	**18.2**	-0.4	-0.5	-0.3	**0.0**	-0.6	-0.4	-0.4	**0.0**	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	0.4	0.1	**0.0**	0.1

Min daily T2m values

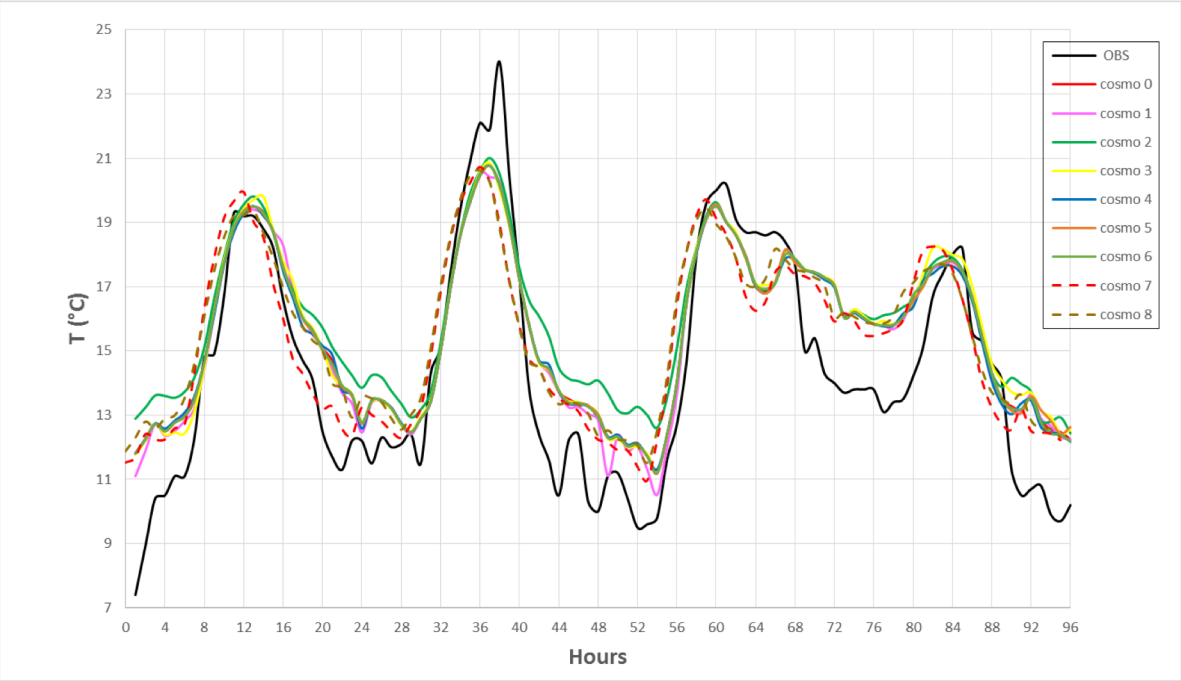
	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
03-nov	**10.5**	12.5	12.3	13.5	12.4	12.6	12.5	12.5	12.2	12.6	12.5	12.5	12.5	12.5	12.5	12.5	11.6	13.3	12.2	12.4
04-nov	**10.0**	12.4	12.4	12.9	12.5	12.4	12.4	12.4	12.3	12.5	12.4	12.4	12.4	12.4	12.5	12.5	12.3	12.9	12.3	12.5
05-nov	**9.5**	11.2	10.5	12.6	11.2	11.3	11.2	11.2	10.9	11.5	11.2	11.2	11.2	11.2	11.2	11.2	11.0	12.6	11.0	11.2
06-nov	**9.7**	12.2	12.2	12.4	12.4	12.2	12.4	12.2	12.2	12.3	12.2	12.2	12.2	12.2	12.2	12.3	12.3	12.7	12.0	12.4

Min T2m average bias values

03-nov	**10.5**	2.0	1.8	3.0	1.9	2.1	2.0	2.0	1.7	2.1	2.0	2.0	2.0	2.0	2.0	2.0	**1.1**	2.8	1.7	1.9
04-nov	**10.0**	2.4	2.4	2.9	2.5	2.4	2.4	2.4	**2.3**	2.5	2.4	2.4	2.4	2.4	2.5	2.5	**2.3**	2.9	**2.3**	2.5
05-nov	**9.5**	1.7	**1.0**	3.1	1.7	1.8	1.7	1.7	1.4	2.0	1.7	1.7	1.7	1.7	1.7	1.7	1.5	3.1	1.5	1.7
06-nov	**9.7**	2.5	2.5	2.7	2.7	2.5	2.7	2.5	2.5	2.6	2.5	2.5	2.5	2.5	2.5	2.6	2.6	3.0	**2.3**	2.7

tkhmin and uc1 at minimum provides a slight improvement for min T2m, while rlam_heat and uc1 at minimum provide an improvement for max T2m.

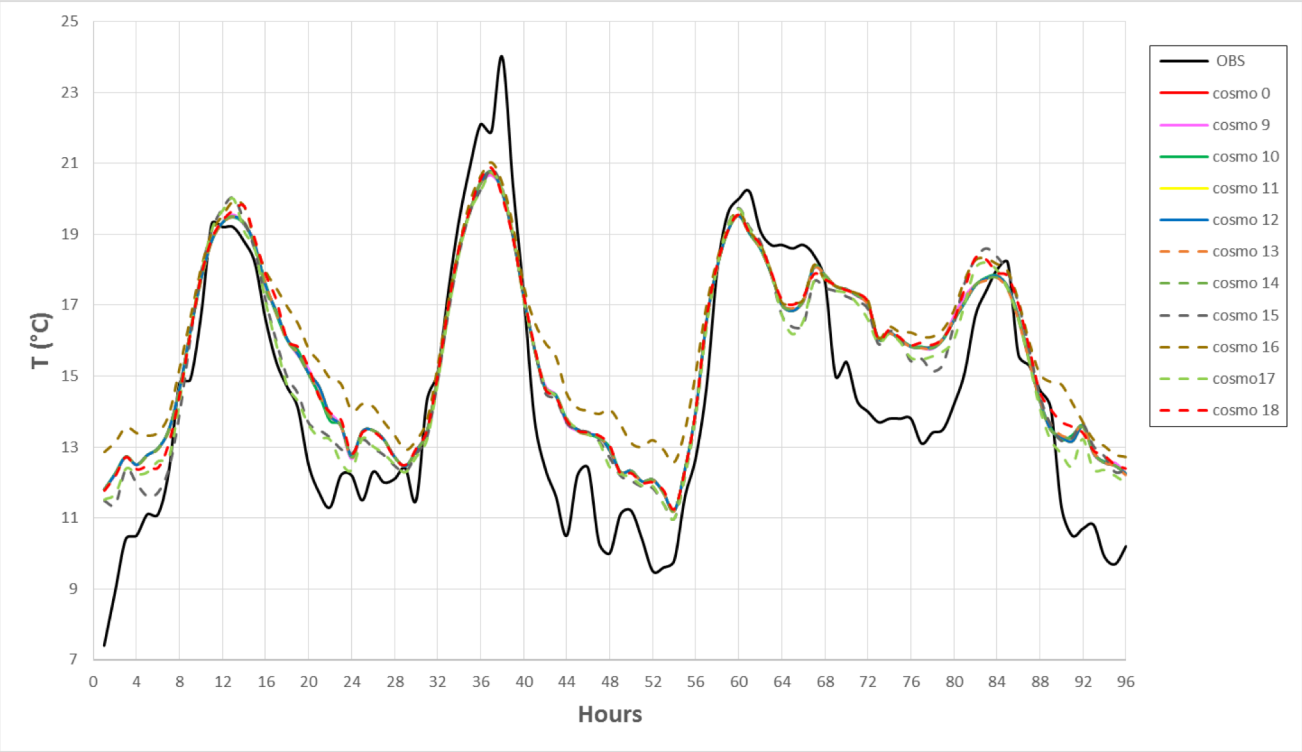
Time series of T2m (cosmo1 to cosmo8)



With the **default** configuration, mean and minimum daily temperatures are always overestimated, while the maximum daily temperature is underestimated.

- a reduction of THKMIN causes a general decrease of temperature, especially the minimum value.
- an increase of THKMIN causes a general increase of temperature, especially the minimum value.
- a reduction in RLAMHEAT causes a slight increase of temperature (mean, max, min).
- variations in V0snow do not modify the values of temperature with respect to default.
- a reduction in UC1 causes an increase of the maximum temperature and a reduction of the minimum.
- an increase in UC1 causes a slight reduction of the maximum temperature and a slight increase of the minimum.

Analysis of temperature (cosmo9 to cosmo18)



- changes in RADFAC, FAC_ROOT_DP KEXPDEC do not significantly change the temperature values.
- INT1 (RLAMHEAT min + UC1 min) provides an (improvement) increase of the maximum temperature, and a slight reduction of the minimum and mean (currently, this is the best configuration for temperature).

Precipitation (mm) values over 5-6 November 2017

Nearest grid point

		DEF	TKHMIN		RLAM_HEAT		V0snow		UC1		RADFAC		FAC ROOTDP		KEXPDEC		INT1	INT2	INT3	INT4
	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
05-nov	**33.15**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06-nov	**21.3**	0.2	0.2	1.4	3.7	0.0	0.8	1.4	0.3	0.3	0.6	0.2	0.2	0.2	0.2	0.2	2.9	5.4	1.5	2.2

Bias - Nearest point

05-nov	**33.15**	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2
06-nov	**21.3**	-21.1	-21.1	-20.0	-17.6	-21.3	-20.6	-19.9	-21.0	-21.0	-20.7	-21.1	-21.1	-21.1	-21.1	-21.1	-18.4	**-15.9**	-19.8	-19.1

Box 3x3

	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
05-nov	**33.15**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06-nov	**21.3**	0.2	0.4	1.1	3.5	0.0	0.6	1.6	0.4	0.5	0.7	0.3	0.2	0.2	0.3	0.3	2.5	6.1	1.4	2.3

Bias Box 3x3

05-nov	**33.15**	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2
06-nov	**21.3**	-21.1	-20.9	-20.2	-17.8	-21.3	-20.7	-19.7	-20.9	-20.8	-20.6	-21.0	-21.1	-21.1	-21.0	-21.0	-18.8	**-15.2**	-19.9	-19.0

Box 5x5

	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
05-nov	**33.15**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06-nov	**21.3**	0.4	0.7	1.1	2.6	0.1	0.5	1.3	0.4	0.5	0.7	0.3	0.4	0.4	0.4	0.3	2.1	5.9	1.1	2.5

Bias Box 5x5

05-nov	**33.15**	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2	-33.2
06-nov	**21.3**	-20.9	-20.6	-20.2	-18.7	-21.3	-20.8	-20.0	-20.9	-20.8	-20.6	-21.0	-20.9	-20.9	-20.9	-21.0	-19.2	**-15.4**	-20.2	-18.8

- On 3rd and 4th of November precipitation value is almost zero, and this null value is well reproduced by all the configurations.
- On 5th and 6th of November, strong precipitation are recorded, but they are largely underestimated by the default configuration

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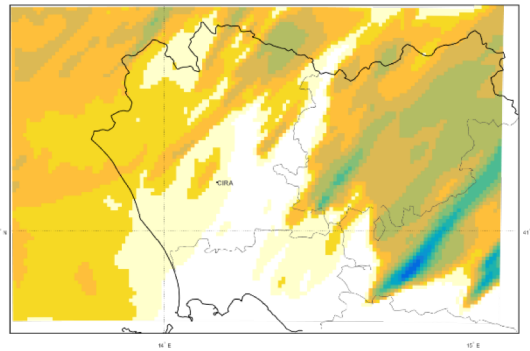
Analysis of precipitation

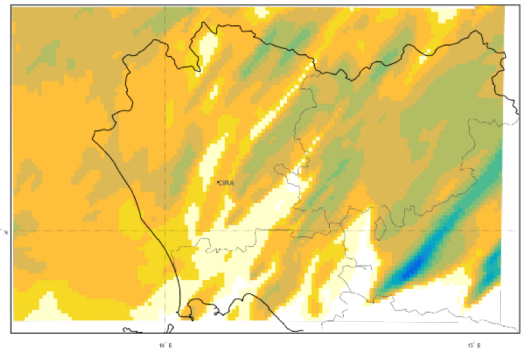
- an increase of tkhmin causes a slight increase of precipitation.
- a reduction in rlamheat increases the precipitation value.
- a reduction in v0snow increases the precipitation value.
- Variations in UC1, RADFAC, FAC_ROOT_DP, KEXPDEC do not cause variations.
- All the interaction simulations are able to slightly increase precipitation.
- Among these, INT2 (rlam_heat min + tkhmin min) appears to be the best configuration for precipitation.

Precipitation maps 6th November 2017

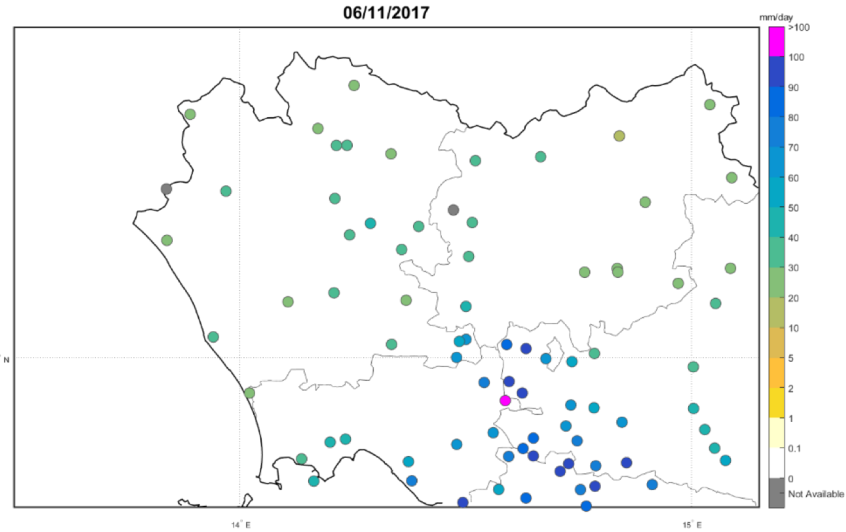
COSMO0

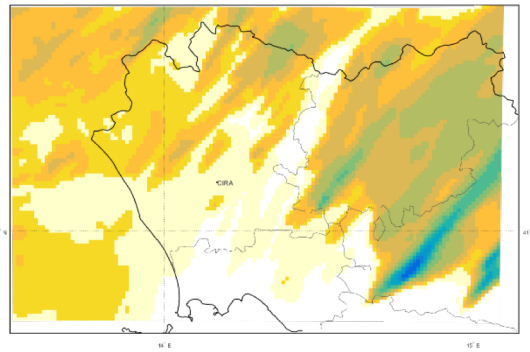


COSMO3 (RLAMHEAT min)

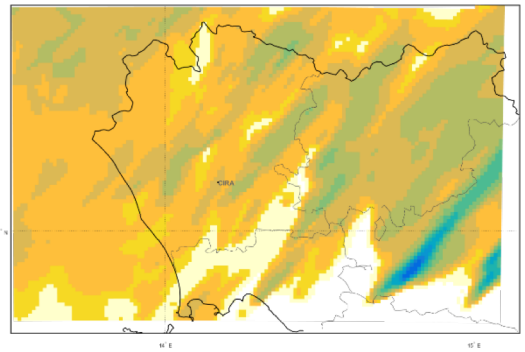


OBS (courtesy of ANCE Campania)





COSMO5 (v0snow min)



COSMO16 (INT2: rlam_heat min + tkhmin min)

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Preliminary conclusions

- Good improvement (0.5°C) in terms of temperature bias, but no significant improvement in terms of precipitation.
- The analysis of the results show that the parameters that have influence on this test case are: **tkhmin, rlam_heat, v0snow, uc1**.
- **radfac, kexpdec, fac_rootdp** have almost no impact on the solution, so the number of parameters could be reduced to 4.
- The minimum number of simulations required by MM is: $2N + 0.5N(N-1) + 1$ so in the present case ($N = 7$) it is 36 (too high).
- Assuming N=4, the minimum number of simulations is 15.
- Additional tests performed show that the vertical turbulence diffusion scheme (Prognostic TKE-based scheme, including effects from subgrid-scale condensation/evaporation) provides benefits in terms of precipitation. It needs an additional external parameter, i.e. the field SSO_STDH, which can be provided by running INT2LM with subgrid scale orography processes switched on and using ASTER as orographic data set. Anyway, this turbulence scheme is still under testing by DWD.

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Future work

- To perform an additional simulation 10 km → 5 km 1 km resolution.
- To perform additional interaction simulations if needed (suggestions by IMS are welcome).
- **To run the MM metamodel in order to define an optimal set of values for these key parameters, based on the output of these 18 simulations.**
- Hourly observational data provided by the CIRA weather station (single point) and daily data over several stations in Campania region provided by ANCE data (Associazione Nazionale Costruttori Edili)

THANKS !