CALMO-MAX @ CIRA:
Sensitivity with COSMO-1 over South Italy

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Status of activities

- No new simulations with respect to those presented at COSMO GM 2018 in St. Petersburg.
- A deeper analysis has been performed using new observational data.
- Preparation of the manuscript:

  E. Bucchignani, A. Voudouri, P. Mercogliano, A sensitivity analysis with COSMO-LM at 1 km resolution over South-Italy,
  submitted to *Atmosperich Research* (under review)

- Previous submission to *Advances in Meteorology* was rejected, because a single observational station (for validation of temperature and precipitation) was considered. Now a wide number of stations has been taken into account.

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

- 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°)

- Observational data:

  - CIRA ground station
  - Daily precipitation data from 76 stations spread over Campania region, **provided by (Italian Civil Protection)** (NEW)
  - Daily temperature and precipitation data for selected stations located in the **Lazio region provided by the SCIA system** (NEW)

- Test : intense events of precipitation during 5th-6° November 2017

Sensitivity tests for CALMO-MAX

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Simple tests

TEST	Parameter
C0	Default
C1	tkhmin at minimum
C2	tkhmin at maximum
C3	rlam_heat at minimum
C4	rlam_heat at maximum
C5	v0snow at minimum
C6	v0snow at maximum
C7	uc1 at minimum
C8	uc1 at maximum
C9	radfac at minimum
C10	radfac at maximum
C11	fac_root_dp at minimum
C12	fac_root_dp at maximum
C13	kexpdec at 0.
C14	kexpdec at 1.

Interaction tests

TEST	Parameter
C15	rlam_heat (min) , uc1 (min)
C16	rlam_heat (min), tkhmin (min)
C17	uc1 (min), v0snow (max)
C18	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 have been neglected.

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

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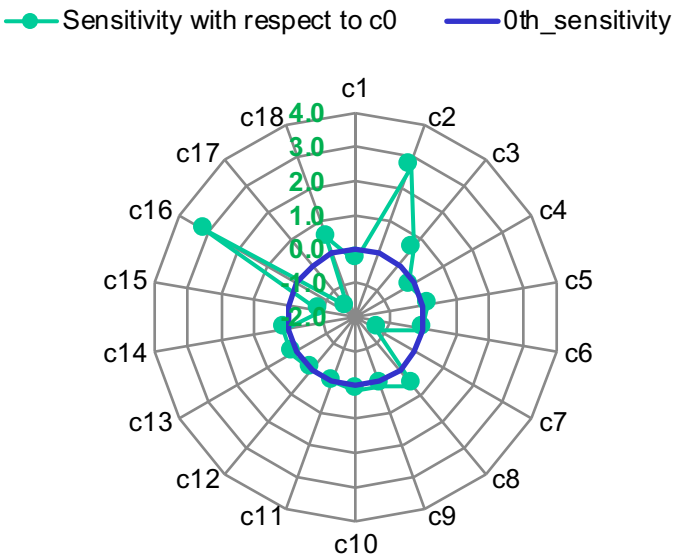
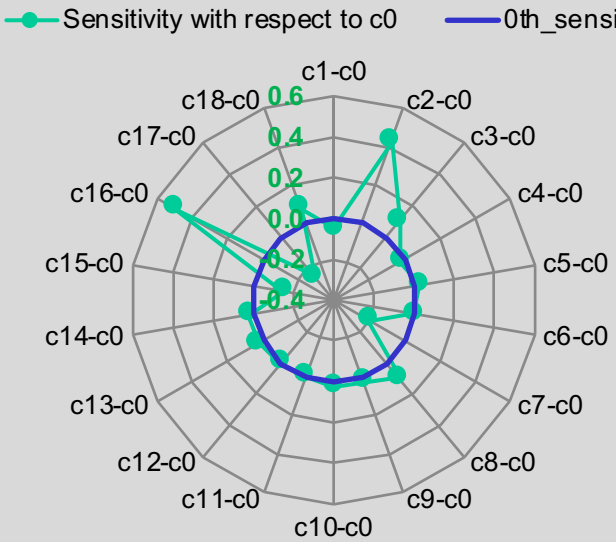
Daily T2m (°C) sensitivity at CIRA site (averaged on the entire event)

From 3rd to 6th November



Spider graph obtained considering percentage differences with respect to c0.



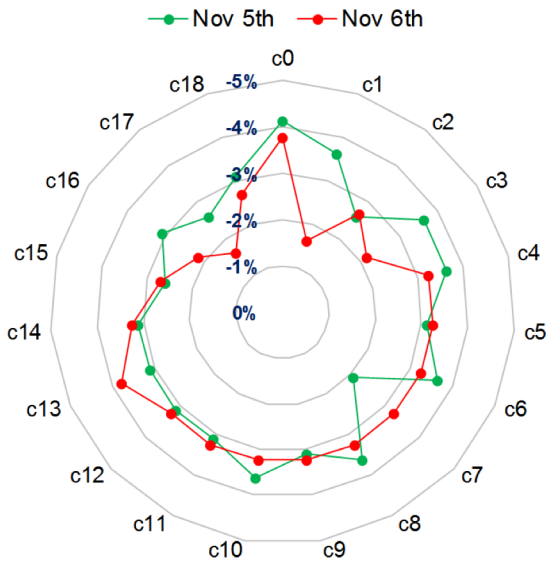
Spider graph obtained considering absolute differences with respect to c0.

C2 (**tkhmin at maximum)** and c16 (**rlam_heat (min), tkhmin (min)** show the highest sensitivity

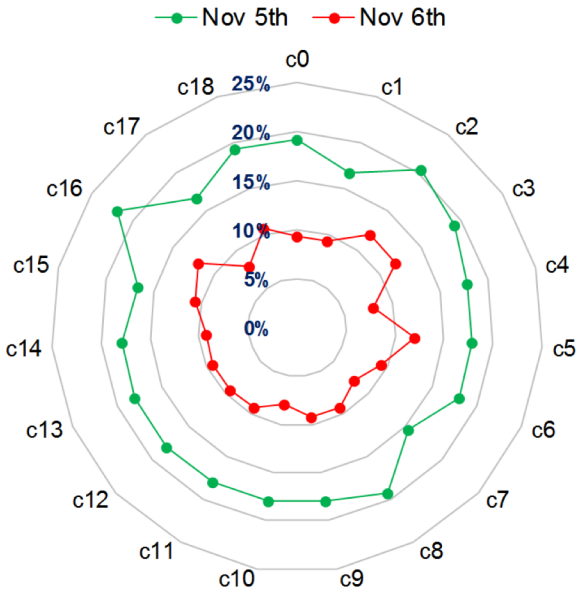
Thanks to Euripides Avgoustoglou for making the spider graphs.

T2m SCIA (°C) values over 5-6 November 2017

Daily maximum (left) and minimum (right) T2m values (°C) averaged over the six SCIA stations (Arpino, S. Elia Fiumerapido, S. Giorgio a Liri, Formia, Frosinone and Alvito) for two days. The nearest grid point is considered. The first three hours of every day have been neglected.



T2m maximum values

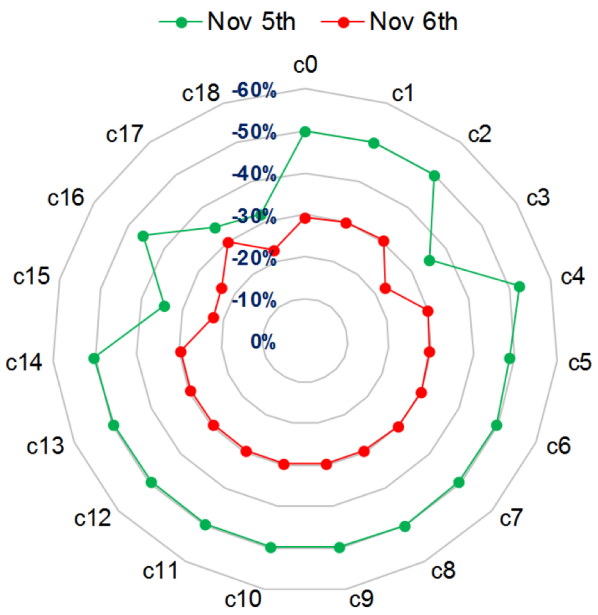


T2m minimum values

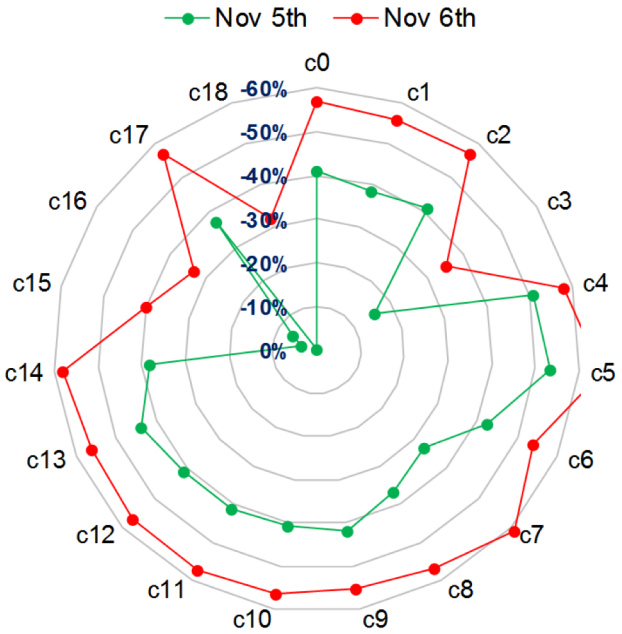
The maximum values are underestimated by c0, but improvements are achieved with several configurations, in particular with c17 for 5th and with c1 and c17 for 6th November.
Minimum values are overestimated by c0. Slight improvements are achieved with c7 and c17.

Precipitation (mm) values over 5-6 November 2017

Daily precipitation values (mm) averaged over the network of ANCE stations (left) and SCIA stations (right)



ANCE network of stations



SCIA network of stations

c0 underestimates the observed value and that improvements are recorded with the configurations c3, c15, c16 and c18. These are all characterized by **rlam_heat** at minimum.

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Main findings of analysis of sensitivity for temperature

- A reduction of tkhmin causes a decrease of minimum and mean T2m. Stratification is made more stable, leading to decrease of night air temperature. On the other side, its increase causes a general increase of temperature, especially the minimum value (up to 1.5°C). In fact, an increase of tkhmin implies that the turbulent kinetic energy is maintained in stable conditions, eliminating strong inversions.

- A reduction in rlamheat causes a slight increase of T2m, while its increase does not modify the values of temperature with respect to C0. Generally, an increase of rlam_heat will increase the heat fluxes upward from the warm surface, leading to a larger heating of the lower atmosphere.
- Variations in v0snow do not have relevant effects on T2m.
- A reduction in uc1 causes an increase of the maximum temperature and a reduction of the minimum, while an increase causes a slight reduction of the maximum temperature and a slight increase of the minimum.
- Variations in radqc_fact, fac_root_dp and kexpdec produce very slight (or null) modifications of T2m values.

Analysis of sensitivity for precipitation

- A reduction of tkhmin does not cause variations, while its increase causes a growth of precipitation, since it increases the small convective cloudiness.
- A reduction in rlam_heat causes the largest increase of precipitation, while its increase causes a reduction. In fact, the reduction of this parameter causes an increase of instability, leading to more precipitation.
- A reduction in v0snow does not modify the values of precipitation, while its increase causes a modest increase of precipitation.
- Variations in uc1, radqc_fact, fac_root_dp and kexpdec produce very slight or null modifications.
- Interaction simulations including rlam_heat at minimum are able to increase precipitation, in particular when combined with v0snow at maximum.

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Conclusions

- In the considered sensitivity test some parameters showed a strong impact and they could be a standalone source of further investigation.
- 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 optimal configuration for temperature is characterized by the minimum value of uc1 (the parameter controlling the vertical variation of critical relative humidity for sub-grid cloud formation), even better when combined with the minimum value of (rlam_heat) the factor for laminar resistance for heat.
- This configuration allows a good improvement in terms of temperature bias (up to 0.5°C) over this complex orographic area.
- Improvements for precipitation can be achieved by setting the rlam_heat at its minimum value. An increase in the value of v0snow (factor for vertical velocity of snow) also provides a positive effect on precipitation.

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Future work

- 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 (based on the sensitivity results), the minimum number of simulations is **15**.
- **Do you think Is it necessary to perform additional interaction simulations?**
- **Considering the availability of IMS data are ready for running the MM metamodel (waiting feedback from IMS) in order to define an optimal set of values for these key parameters, based on the output of these 18 simulations.**

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T2m SCIA (°C) values over 5-6 November 2017

Daily maximum T2m values (°C) averaged over the six SCIA stations (Arpino, S. Elia Fiumerapido, S. Giorgio a Liri, Formia, Frosinone and Alvito) for two days, for observational and model data (all configurations). The nearest grid point is considered. The first three hours of every day have been neglected.

	OBS	c0	c1	c2	c3	c4	c5	c6	c7	c8
Nov 5th	19.3	18.5	18.6	18.8	18.6	18.6	18.7	18.6	18.9	18.6
Nov 6th	18.5	17.8	18.2	18.0	18.1	17.9	17.9	17.9	17.9	17.9

	OBS	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18
Nov 5th	19.3	18.7	18.6	18.7	18.7	18.7	18.7	18.8	18.7	18.8	18.7
Nov 6th	18.5	17.9	17.9	17.9	17.9	17.8	17.9	18.0	18.1	18.2	18.0

Daily minimum T2m values (°C) averaged over the six SCIA stations for observational and model data (all configurations).

	OBS	c0	c1	c2	c3	c4	c5	c6	c7	c8
Nov 5th	7.8	9.3	9.1	9.4	9.3	9.2	9.2	9.2	9.0	9.3
Nov 6th	7.5	8.2	8.2	8.4	8.4	8.1	8.4	8.2	8.1	8.2

	OBS	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18
Nov 5th	7.8	9.2	9.2	9.2	9.2	9.2	9.2	9.1	9.5	9.1	9.3
Nov 6th	7.5	8.2	8.1	8.2	8.2	8.2	8.2	8.3	8.4	8.1	8.3

The maximum values are underestimated by c0, but improvements are achieved with several configurations, in particular with c17 for 5th and with c1 and c17 for 6th November.
Minimum values are overestimated by c0. Slight improvements are achieved with c7 and c17.

Precipitation (mm) values over 5-6 November 2017

	OBS	c0	c1	c2	c3	c4	c5	c6	c7	c8
Nov 5th	26.1	13.1	13.1	13	16.9	12.4	13.4	13.1	13.2	13.0
Nov 6th	51.1	36.0	35.8	35.5	39.4	35.8	35.9	35.8	35.8	35.9

	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18
Nov 5th	13.1	13.1	13.1	13.1	13.1	13.0	17.1	14.1	17.1	17.8
Nov 6th	35.9	36.0	35.9	35.9	35.9	35.9	39.6	39.1	35.8	39.5

Daily precipitation values (mm) averaged over the network of ANCE stations, for observational and model data (all configur.).

	OBS	c0	c1	c2	c3	c4	c5	c6	c7	c8
Nov 5th	34.7	20.4	21.4	20.5	29.3	17.0	16.2	20.0	23.2	21.9
Nov 6th	21.9	9.4	9.7	9.4	14.2	9.2	7.6	10.1	8.5	9.5

	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18
Nov 5th	20.1	20.6	20.4	20.4	19.5	21.4	33.5	32.5	21.7	34.6
Nov 6th	9.8	9.5	9.4	9.4	9.6	9.2	13.1	14.6	9.4	14.9

Daily precipitation values (mm) averaged over the six SCIA stations, for observational and model data (all configurations).

c0 underestimates the observed value and that improvements are recorded with the configurations c3, c15, c16 and c18. These are all characterized by **rlam_heat** at minimum.