Model evaluation of COSMO-LM at 1 km resolution COSMO-1 over South Italy

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Introduction

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

Forecasting supporting pilot and air traffic controllers during the different flight phases is a top priority in different research projects in which CIRA is currently involved.

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:

PT_AEVUS: testing the TERRA-URB scheme

PP_CALMO-MAX: definition of an optimized configuration

PT_CIAO: testing of the Bechtold convection scheme.

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_170901_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°)

Model configuration

- Orography: GLOBE; Landuse: GLOBCOVER; Soil: DSMW; Albedo: MODIS dry sat
- Model configuration was provided by METEO-SWISS and ARPA Piemonte, with some adjustments.
- 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. Voudouri).
- loldtur = .TRUE. (old ijk-version of the turbulence and the soil model)
- *Preliminary tests with the vertical turbulence diffusion scheme (Prognostic TKE-based scheme, including effects from subgrid-scale condensation/evaporation) were also performed. This scheme 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.*

Model configuration and sensitivity

	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

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

Further tests are currently in progress.

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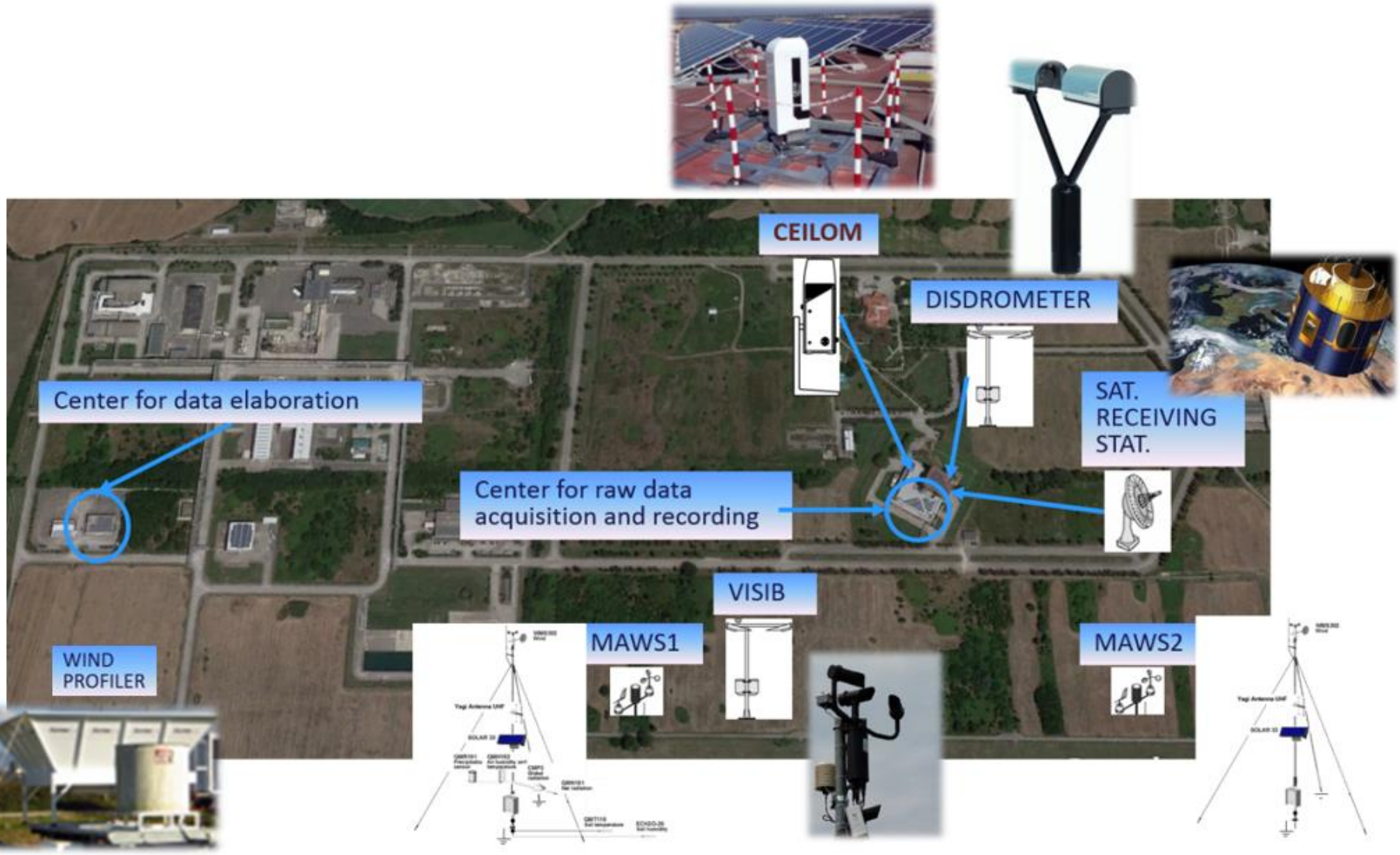
Model evaluation

Model evaluation is performed in a daily basis at CIRA by using a combination of in situ observation and satellite products, specifically:

- Data provided by the **ground station** installed at CIRA, for different surface parameters, such as temperature, precipitation, humidity, radiation.
- Data provided by the **visibilimeter** (in terms of horizontal visibility), the **ceilometer** (in terms of the CEILING and HPBL variables), the **disdrometer** (in order to characterize the microphysics of precipitation) installed at CIRA.
- Data provided by **radio soundings** performed at 12-hours frequency at Pratica di Mare airport, in terms of temperature and wind vertical profiles (up to 16000 m), CAPE and CIN indicators.
- Data provided by the **wind profiler** of ARPA (Regional Agency for Environmental Protection) Campania, installed at CIRA, in terms of wind (intensity and direction) and vertical wind shear, up to 6000 m altitude (in steps of 50 m), every 30 minutes.
- Satellite **EUMETSAT** MSG-2 data available at CIRA, over seven SEVIRI channels at 3 km resolution, in terms of cloud cover and brightness temperature.

Location of Meteo instrumentation at CIRA



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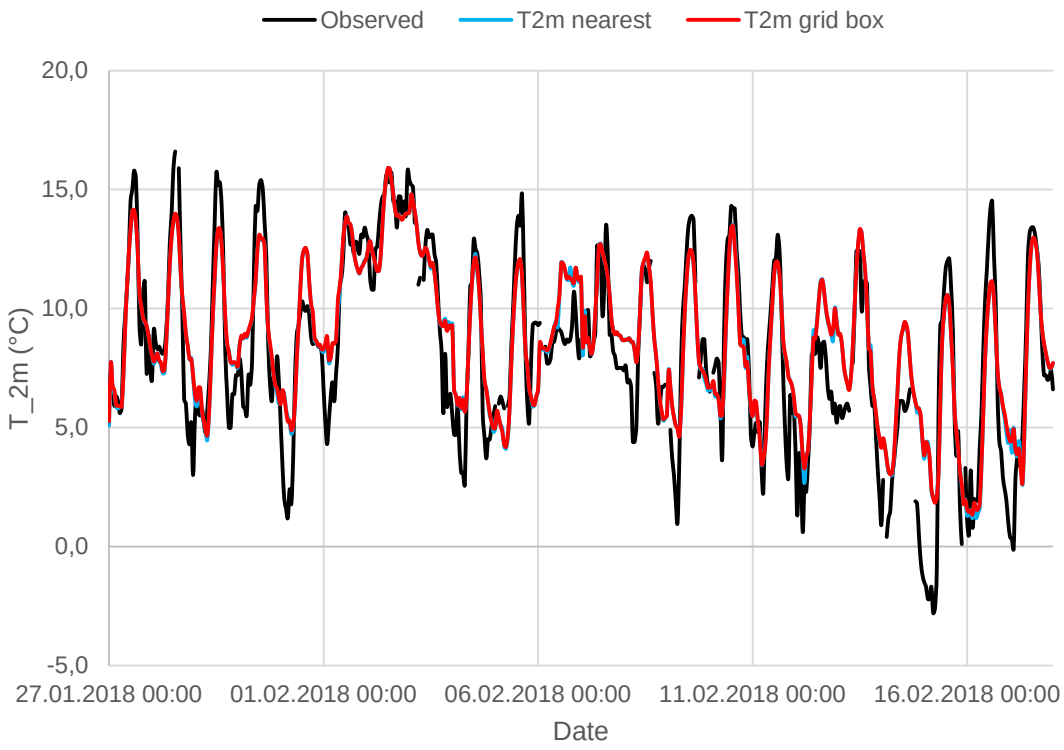
Routine for model evaluation

A set of standard MATLAB routines, able to evaluate the performances of the COSMO-LM model in terms of key parameters and related error information (bias, rmse…), has been developed at CIRA.

More specifically:

- Standard variables (e.g. T2m, TOT_PREC) are evaluated considering both the nearest grid point value and a 3x3 points box value.
- The brightness temperature (evaluated through the RTTOV libraries for several channels) is compared with MSG-2 SEVIRI data. Maps of bias are provided, remapping COSMO values over the satellite grid.
- Wind values provided by COSMO-LM are extracted considering the nearest grid point to the wind profiler location. For each vertical level, the related value is compared to the nearest wind profiler vertical step (50 m step, up to 6000 m).
- The COSMO variable HPBL is compared to the Mixing Layer Height evaluated using a MATLAB routine, starting from backscattering profiles of the ceilometer.

T2m (°C) at CIRA over the period 27/01 to 17/02 2018



	OBS	Nearest point	Grid box
Average	9.4	8.6	8.7
Max	16.6	15.9	15.9
Min	-2.8	1.2	1.3
Av. Bias	-	0.5	0.5
Max Bias +	-	6.6	6.4
Max Bias -	-	-3.5	-3.5

- No significant differences between “grid box” and “nearest point” values.
- Minimum temperature always overestimated.
- Maximum temperature in some cases well reproduced, but generally underestimated
- Good performances in terms of average bias.

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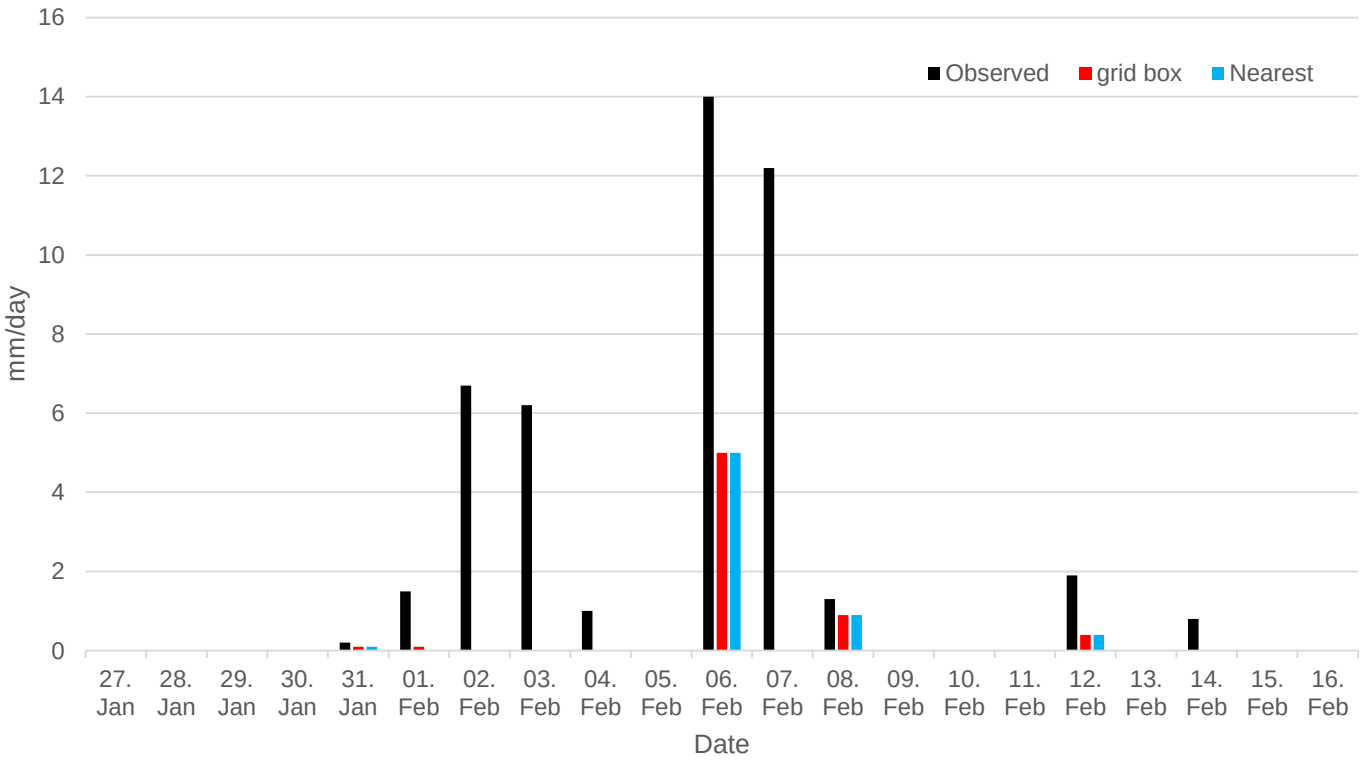
Total precipitation (mm) at CIRA over the period 27/01 to 17/02 2018



- No significant differences among “grid box” and “nearest point” values.
- Precipitation always underestimated.

Evaluation against Wind profiler data

The **January 30th** has been analysed as representative of a day with **low** winds values

On **February 2nd**, Capua was affected by **medium** winds, larger that 5 m/s (low risk)

On **February 6th**, Capua was affected by **strong** winds, larger that 10 m/s (medium risk)

	Average obs. velocity	Model bias	Max obs. velocity	Model bias	Correlation
Jan 30th	**1.9**	-0.2	**4.5**	1.2	0.3
Feb 2nd	**7.2**	0.06	**10.5**	-3.8	0.8
Feb 6th	**9.0**	-0.7	**15.0**	2.1	0.6

Wind values (m/s) recorded at 150 m height.

- Good capabilities of COSMO-LM in reproducing daily average wind values
- Large biases over the peak values
- Quite good correlation between model and observation.

Hourly vertical wind speed bias profiles and wind direction bias.

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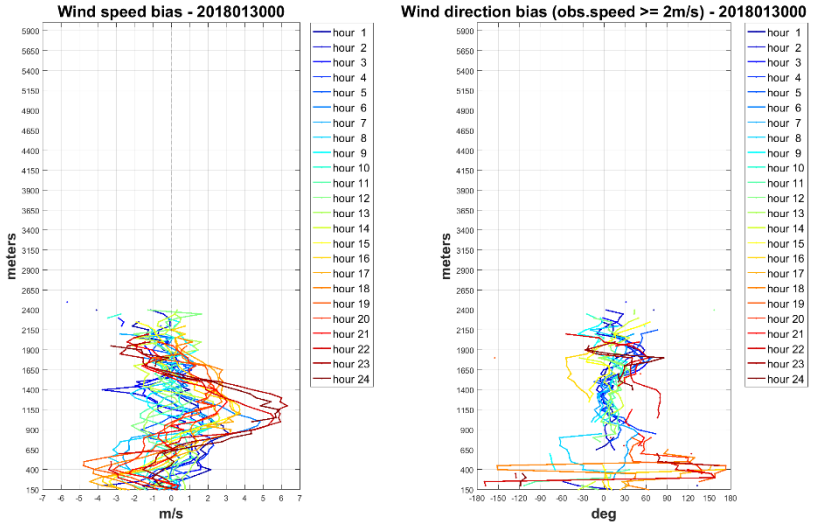
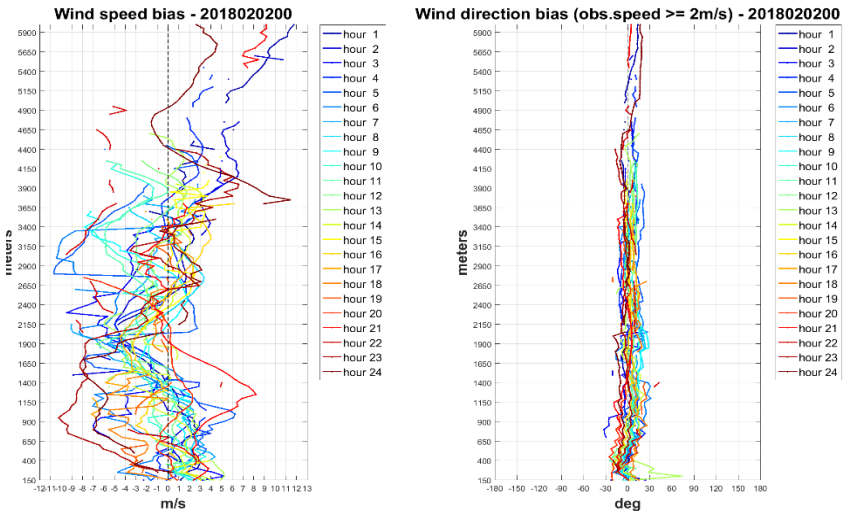
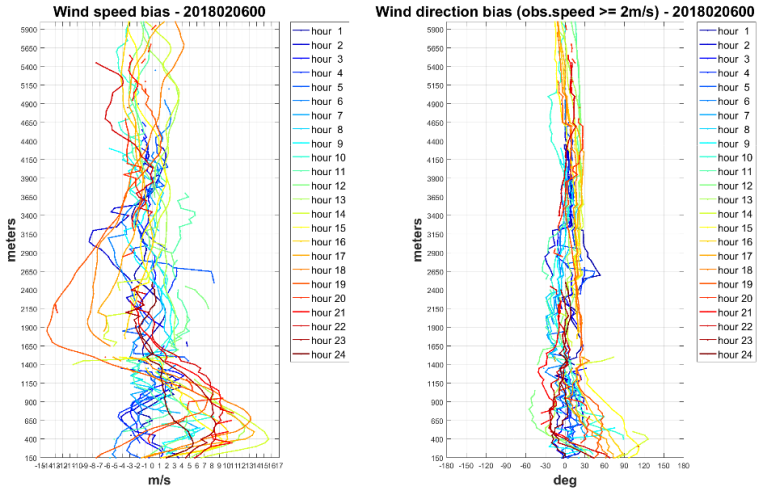
January 30th



February 2nd



February6th



- An average good behaviour is recorded
- Bias compensation effects.

Evaluation against Radiosounding at Pratica di Mare

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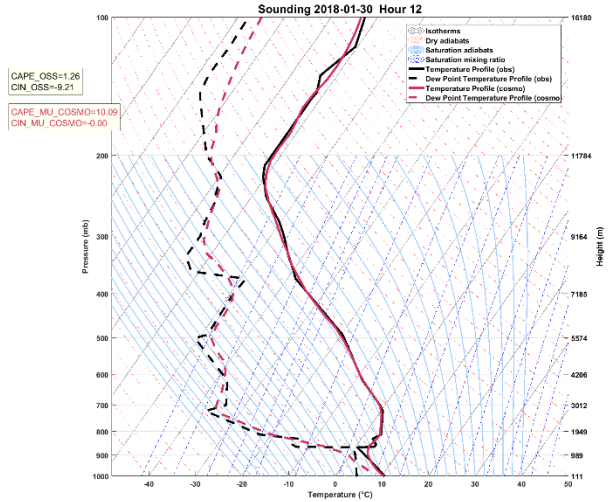
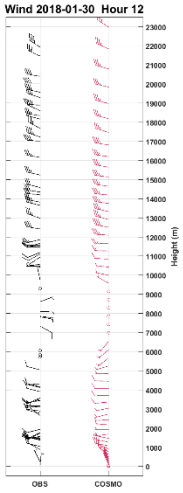
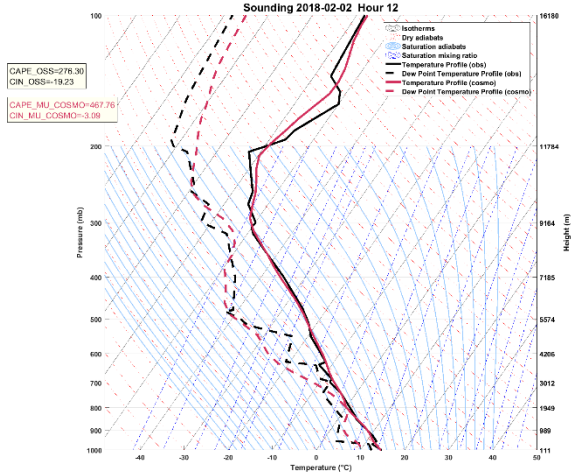
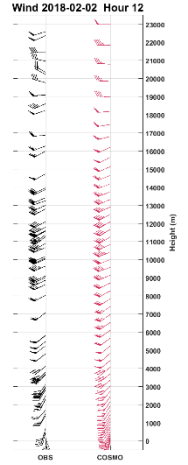
January 30th h 12



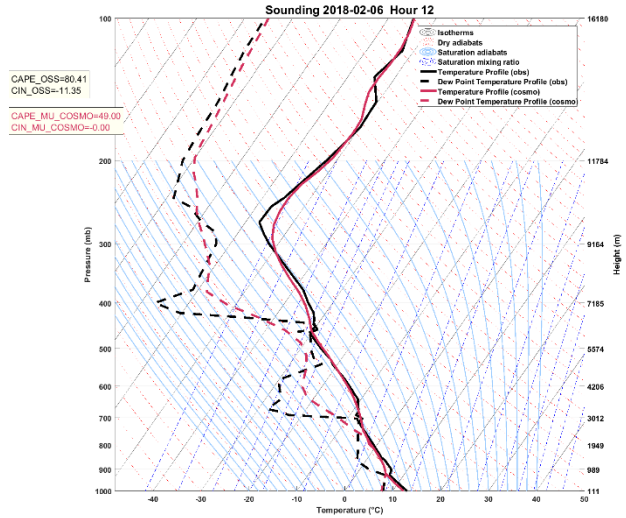


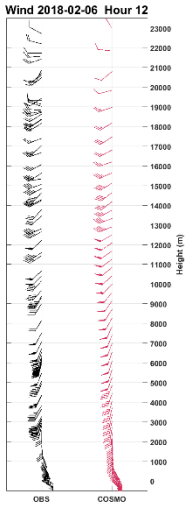
February 2nd h 12





February 6th h 12





- Very good agreement between model and observed temperature .
- Dew-point temperature profiles are generally captured by the model, with the exception of singular points
- CAPE values generally overestimated by the model
- CIN values generally underestimated by the model
- Wind profiles generally qualitatively well reproduced.

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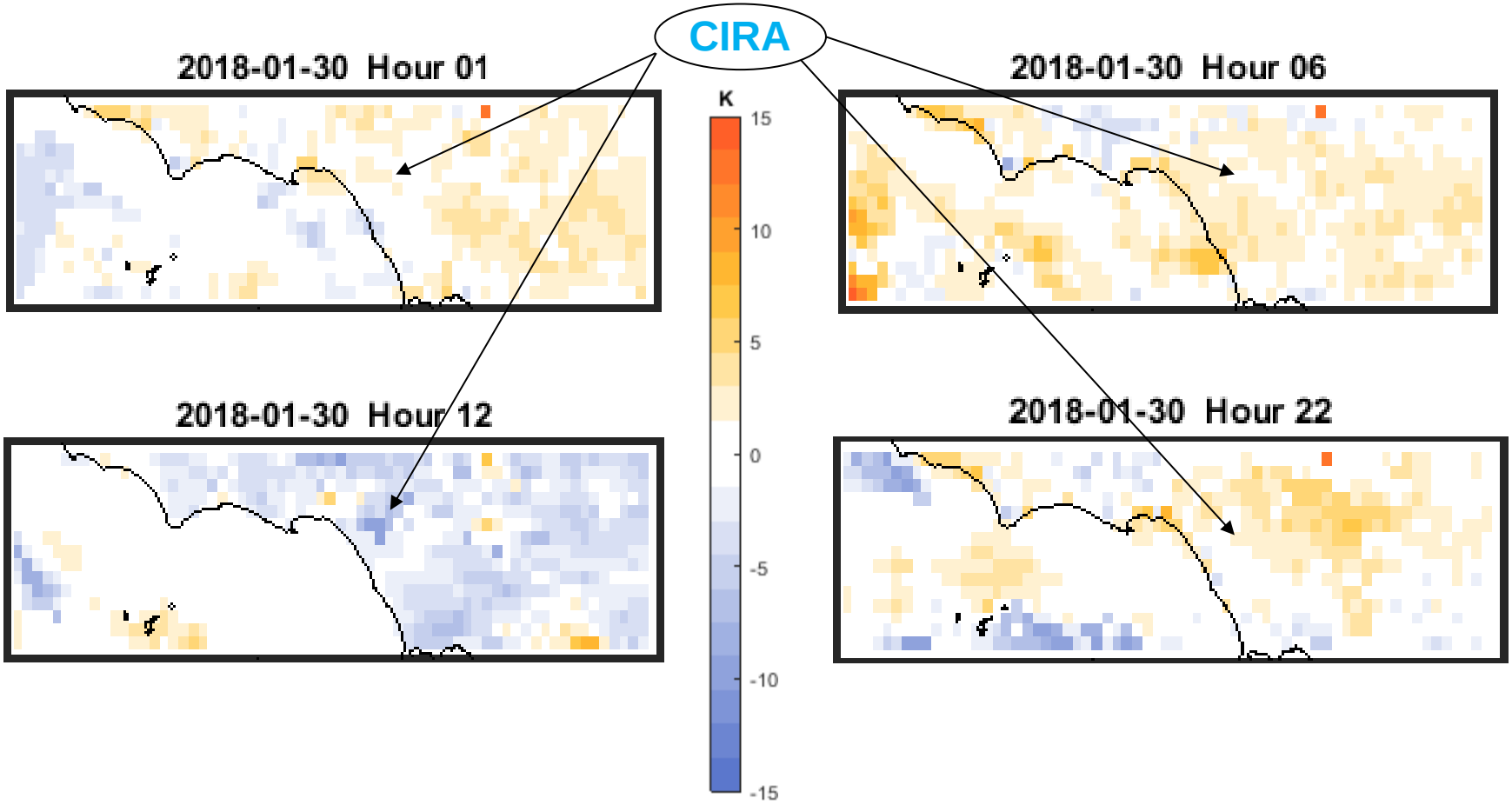
Evaluation against Radiosounding

	Temperature		Dew Point Temp		CAPE	CIN
	Bias	**Rmse**	**Bias**	**Rmse**	**Bias**	**Bias**
30 Jan h00	-0.05	0.7	1.24	3.7	0	0
30 Jan h12	0.14	0.8	1.1	3.0	9.2	8.8
2 Feb h 00	0.95	2.3	1.15	4.2	-11.7	-129
2 Feb h 12	0.01	1.5	0.78	3.6	16.1	191.4
6 Feb h 12	-0.1	0.9	3.39	6.1	0	0
6 Feb h 24	-0.09	0.9	1.4	4.9	11.3	31.4

Some numerical values related to the validation against Radiosounding.

Bias maps of the brightness temperature IR108



Hourly maps of the **bias** (model minus observation) of the **brightness temperature** for the January 30th 2018, related to the IR108 channel.

Large biases are generally recorded (additional investigation on the use and calibration of RTTOV library is required) .

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Average bias [K] of the brightness temperature

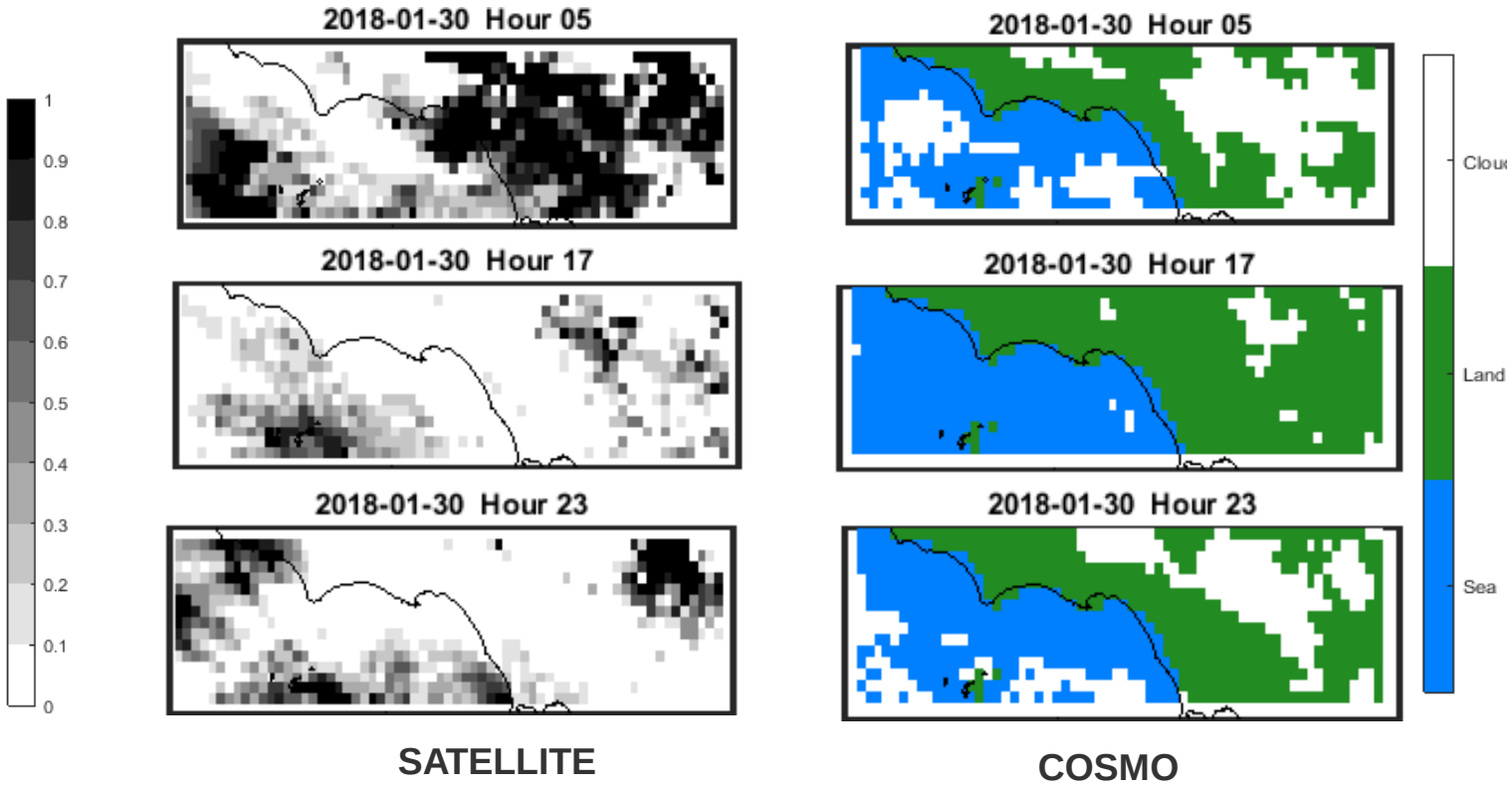
	30 Jan	2 Feb	6 Feb
IR108	-0.2	11.1	5.9
IR039	-0.7	4.6	-3.2
IR120	0.1	11.5	5.1

This table shows the average bias [K] (model minus observation) of the brightness temperature over the three days considered, related to 3 (out of 7) SEVIRI channels considered.

Hourly values have been averaged over the whole domain and over the each day considered.

Very large biases in some cases.

Maps of the Cloud Cover



Hourly maps of the cloud cover, provided by the satellite and by COSMO-LM

Cloud cover qualitatively well reproduced by COSMO-LM

Cloud ceiling height (above MSL) and HPBL

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Evaluation against Ceilometer data.

	Time	OBS	Model nearest	Model box
Jan 30th	2:00 am	**629**	635	726
Jan 30th	3:00 am	**Clean**	635	758
Jan 30th	12:00	**Clean**	Clean	15983

CEILING (m)

	Time	OBS	Model nearest	Model box
Jan 30th	8.00 am	**570**	172	171
Feb 2nd	8.00 am	**795**	794	796

HPBL (m)

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Conclusions

- COSMO-LM shows a quite good capability in reproducing the variables analyzed.
- Non negligible bias are still recorded in some cases.
- Precipitation is underestimated, large biases concerning satellite data.
- Good agreement with radiosounding at Pratica di Mare.
- Model configuration still needs improvements.

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Future work

Execution of sensitivity tests in the frame of PP CALMO MAX and PT CIAO.

Implementation of TERRA-URB scheme.

Analysis of additional parameters for evaluation, and specifically:

- Elrodd – Knapp parameter vs Clear Air Turbulence.
- Visibility
- Quantitative analysis of cloud cover.

Satellite data evaluation, according with the methodology presented in:

- M.P. Manzi, P. Mercogliano, M. Milelli, First results of simulations with COSMO-1_ITA and comparison of results with COSMO configurations at different resolutions, COSMO Newsletter No. 14, 2014

THANKS !