COSMO General Meeting 2013

Sibiu, 2 – 5 September 2013

First results of simulations with COSMO-1_ITA and comparison of results with COSMO configurations at different resolutions

M. P. Manzi[1], P. Mercogliano[1,2], M. Milelli[3]

[1] Impact on soil and Coast Division, EuroMediterranean Centre for Climate Change (CMCC),I-81043 Capua (CE), Italy

[2] Meteo System & Instrumentation Laboratory, Italian Aerospace Research Center (CIRA), I- 81043 Capua (CE), Italy

[3] ARPA Piemonte, I-10135 Torino, Italy

Outlook

- Aim of the work
- Description of the test cases
- Features of the simulations
- Performances evaluation using :
  - satellite data
  - radiosounding data
- Conclusions

Aim of the work

In the framework of the MeteoSwiss project COSMO-NExT, a development of the COSMO configuration at 1.1 km, deterministic, is under development (named COSMO-1).

COSMO-1 is a new set-up of the COSMO model developed in order to:

- increase the resolution in space and time
- update the present frequency of the operative COSMO configurations

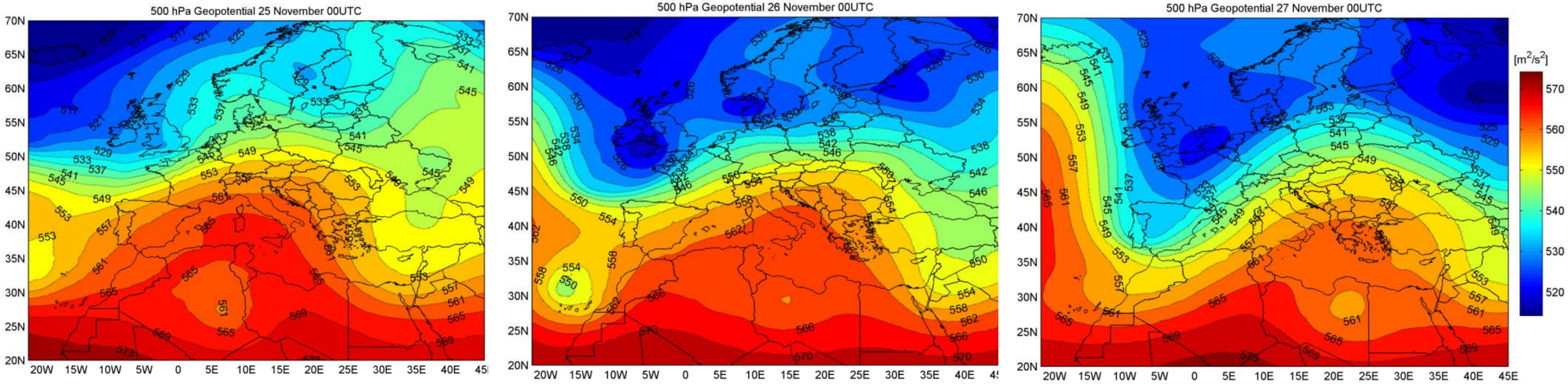
COSMO-1 is also in testing phase at CIRA, in collaboration with MeteoSwiss and Arpa Piemonte.

The first step of this testing phase concerned the installation and running of the code (COSMO version 4.26) on the CMCC supercomputer (NEC SX 8R) installed at CIRA.

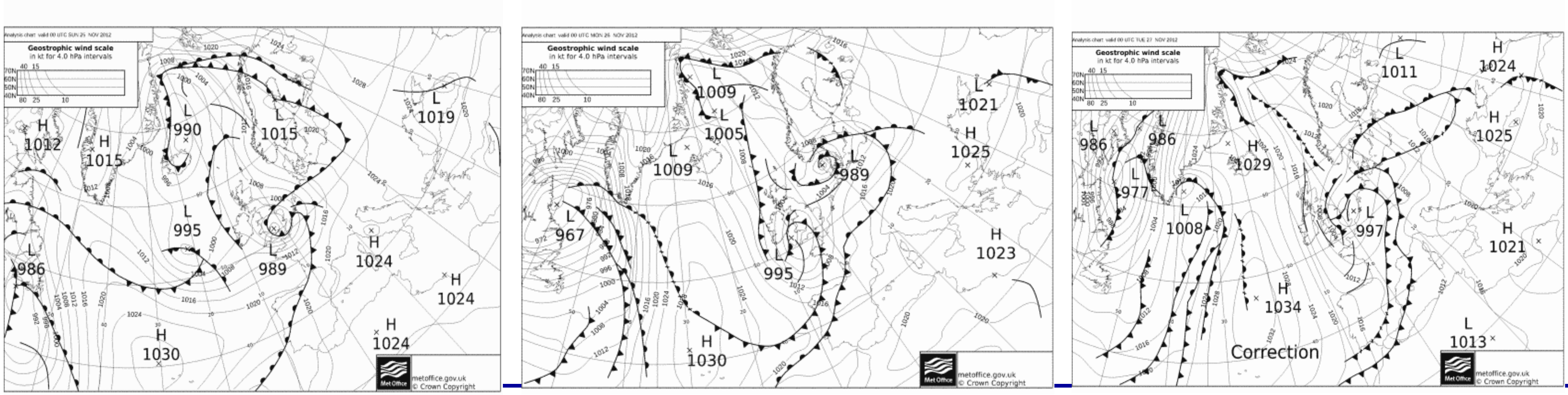
The second step concerned the running of simulation of the COSMO-1 over the Italian domain (named COSMO-1_ITA) for a 6 days period and the evaluation of the performances with different type of observations.

The last step concerns an optimization of the previous simulations in terms of configuration parameters choice, for example time step and domains.

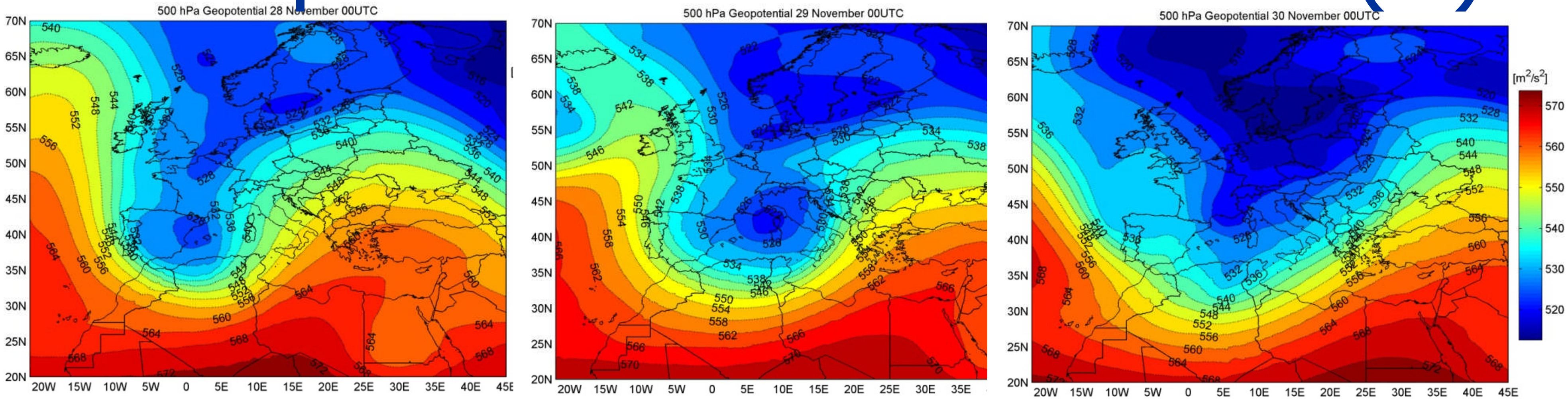
Description of the test cases (1)



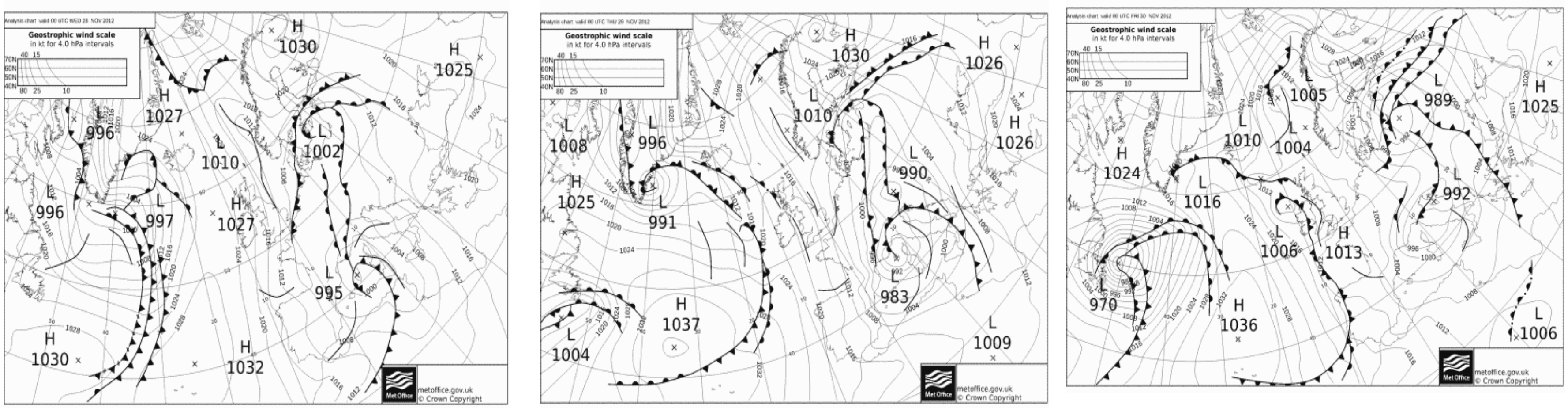
From the 25th to the 27th of November 2012, the Mediterranean area was interested by a high pressure ridge. During the 26th of November there was a gradual collapse of the Mediterranean anticyclonic area pushed towards Eastern Europe by an Atlantic perturbation. The precipitation over the southern Italy started the 27th of November



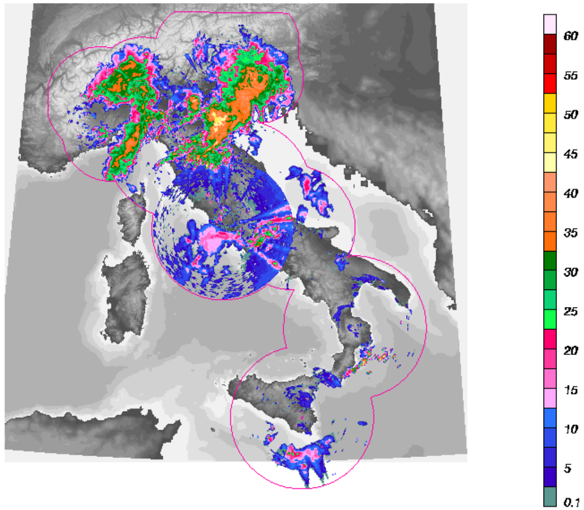
Description of the test cases (2)



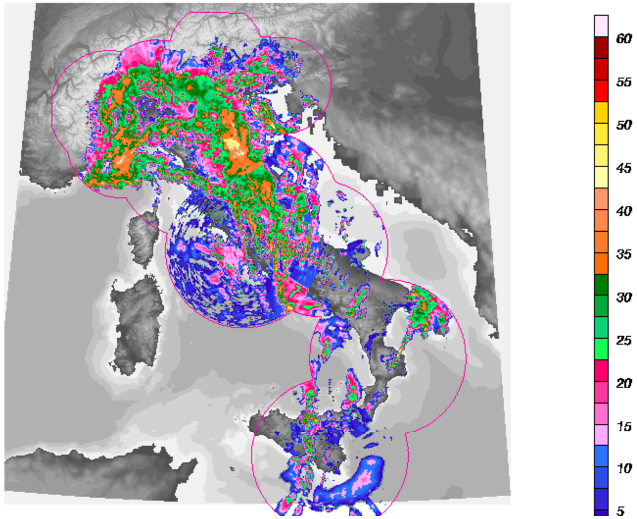
From the afternoon of the 27th to the 30th of November 2012 Italy was interested by an intense southern moist flow due to a low pressure system centred over the western Mediterranean Sea. This synoptic pattern caused an intense thunderstorm activity with widespread precipitations over the peninsula.



Description of the test cases (3)

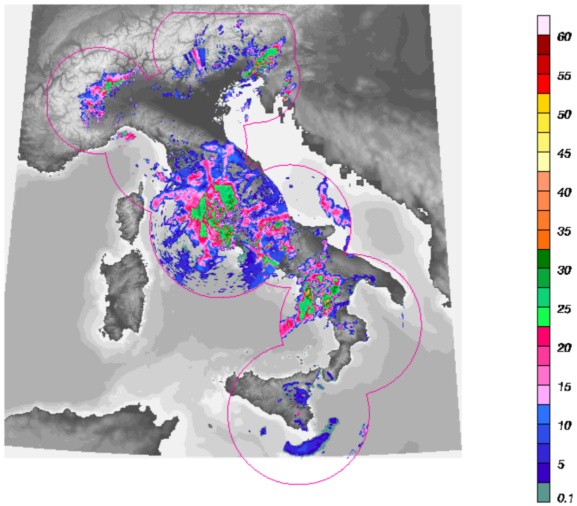


27/11/2012
19 UTC

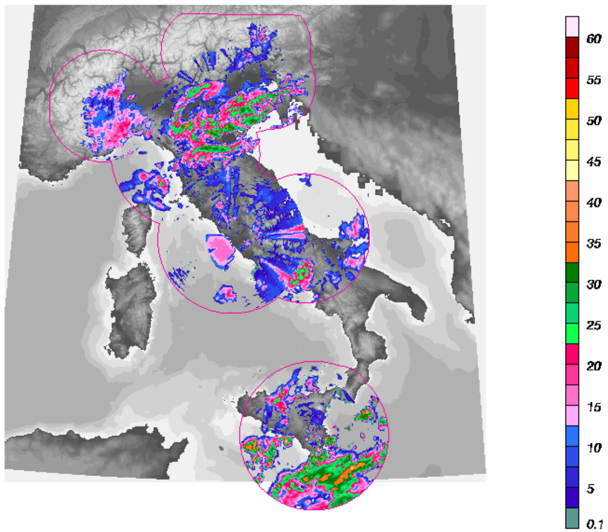


28/11/2012
12 UTC

Maps of reflectivity @ 2000 m of altitude (CAPPI) from national radar mosaic (provided by Italian Civil Protection).



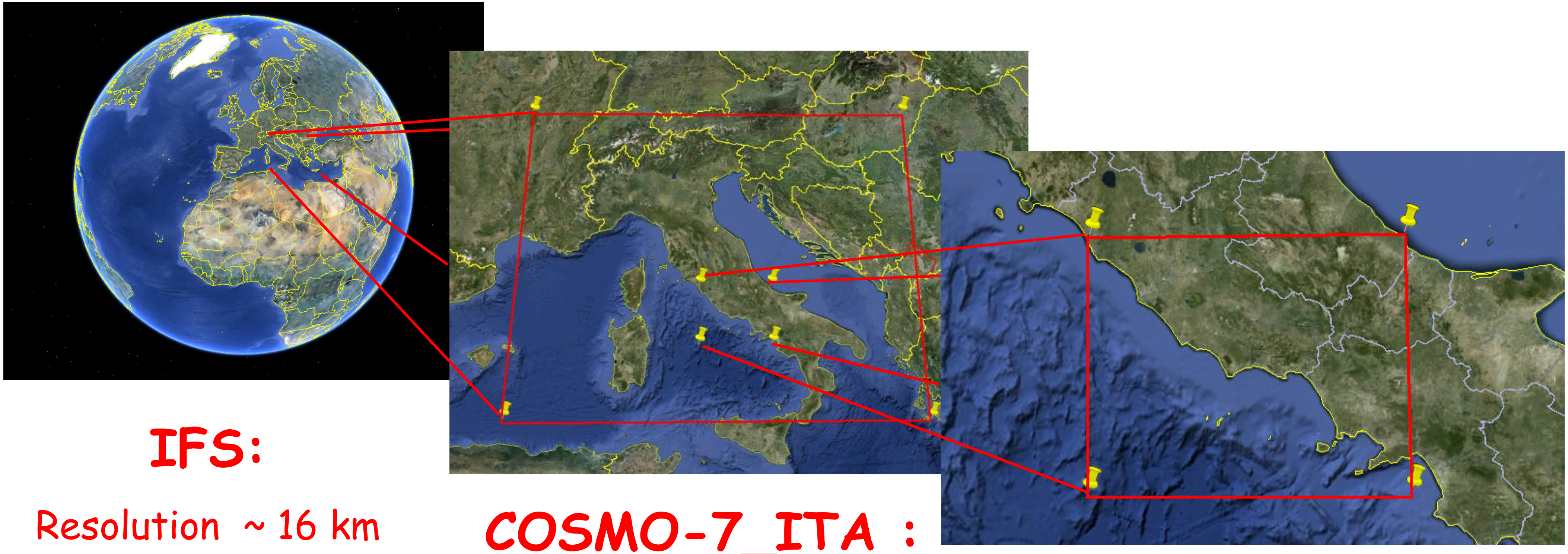
29/11/2012
09:30 UTC



30/11/2012
10:00 UTC

Pictures from : http://www.arpa.emr.it/cms3/documenti/_cerca_doc/meteo/radar/rapporti/rapporto_meteo_20121127-1202.pdf

Features of simulations (1)



IFS:

Resolution ~ 16 km

COSMO-7_ITA :

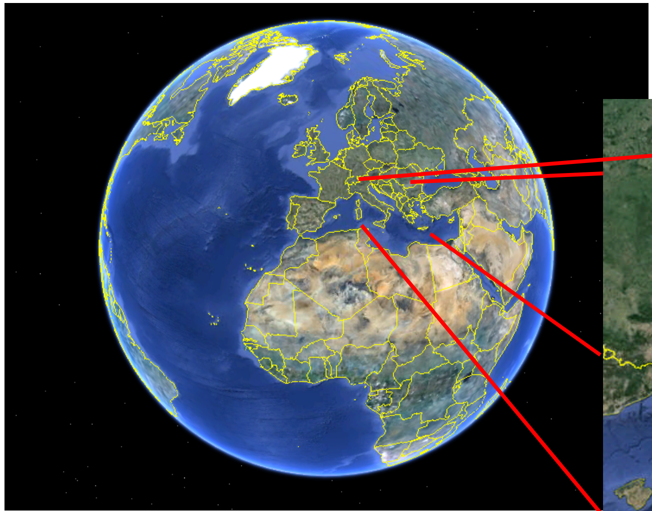
Resolution ~ 7 km

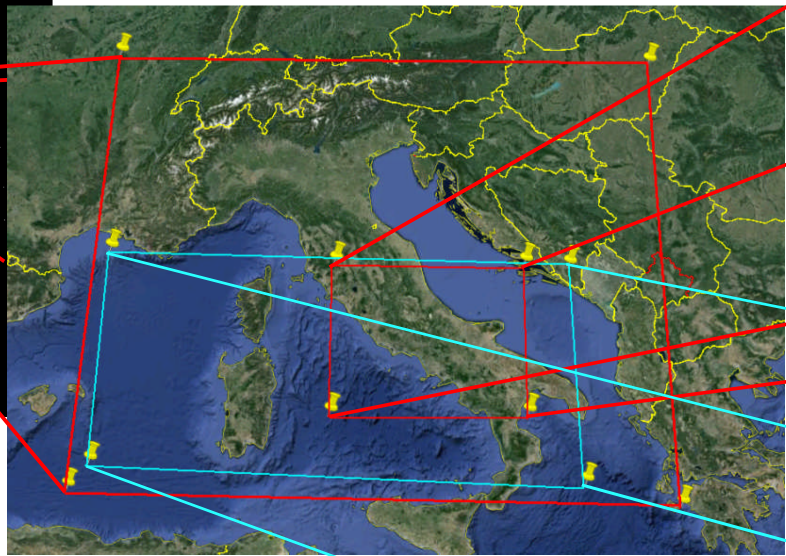
COSMO-1_ITA :

Resolution ~ 1 km

Features of simulations (2)

COSMO-1_ITA*: Resolution ~ 1 km





IFS:

Resolution ~ 16 km

COSMO-7_ITA:

Resolution ~ 7 km

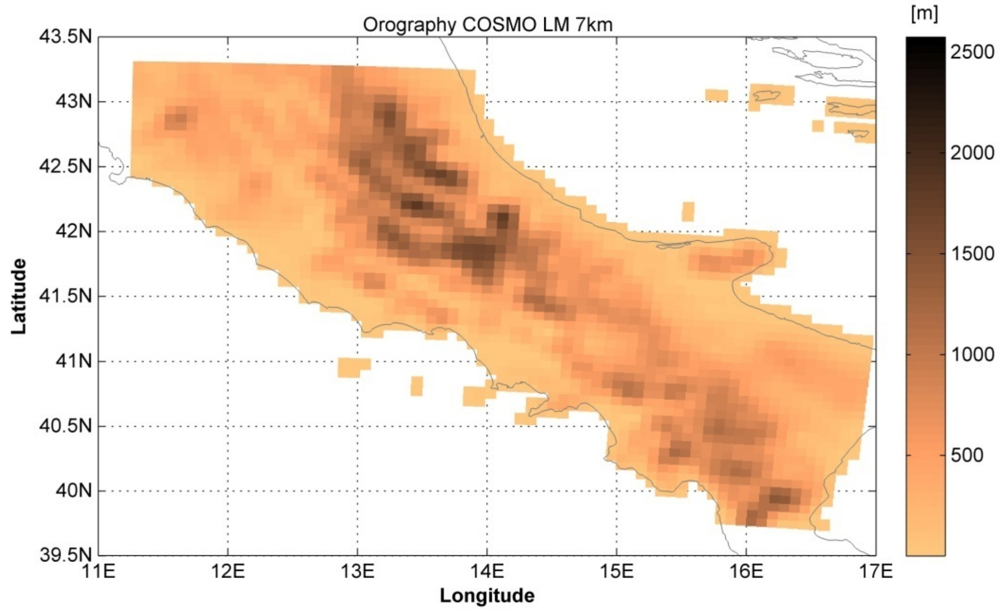
COSMO-2.8_ITA: Resolution ~ 3 km

* New configuration

Features of simulations: COSMO 7 km

Initial and boundary condition from ECMWF (about 16 km)

Grid characteristic	ie_tot=240, je_tot=160, ke_tot=40
Time step	dt = 40.0
Interval between two consecutive boundary data	hincbound=3.0
Soil processes	lsoil=.true., lmulti_layer=.true.,
Subgrid-scale convection	lconv=.true. , itype conv=0, (Tiedtke scheme)
Switch for nudging	lnudge =.TRUE.,
Format of output files	yform_write='ncdf',



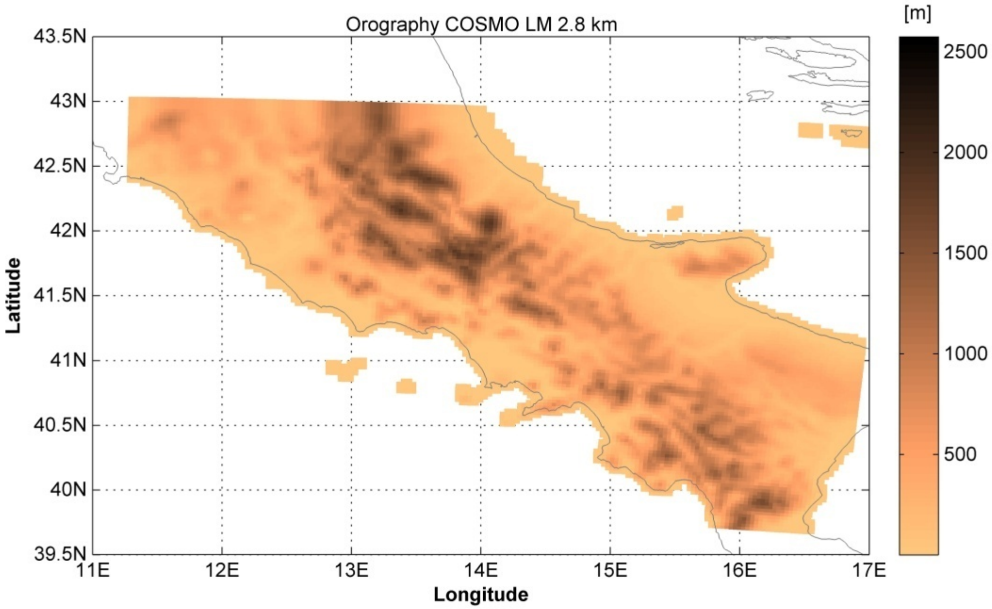
Parameters for the satellite images

```
&SATCTL
  itype_rttov=9,
  num_sensors=1,
  sat_input_01='MSG',     2,'SEVIRI',8, .TRUE., .TRUE., .TRUE., .TRUE.,
  nchan_input_01=1,2,3,4,5,6,7,8,
  lcon_clw=.TRUE,
```

Features of simulations: COSMO 2.8 km

Initial and boundary condition from COSMO-7_ITA (about 7 km)

Grid characteristic	ie_tot=400, je_tot=175, ke_tot=60
Time step	dt = 20.0
Interval between two consecutive boundary data	hincbound=1.0
Soil processes	lsoil=.true., lmulti_layer=.true.,
Subgrid-scale convection	lconv=.true. , itype conv=3, (Shallow convection based on Tiedtke scheme)
Switch for nudging	lnudge =.FALSE.,
Format of output files	yform_write='ncdf',



Parameters for the satellite images

```
&SATCTL
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  num_sensors=1,
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  nchan_input_01=1,2,3,4,5,6,7,8,
  lcon_clw=.TRUE,
```
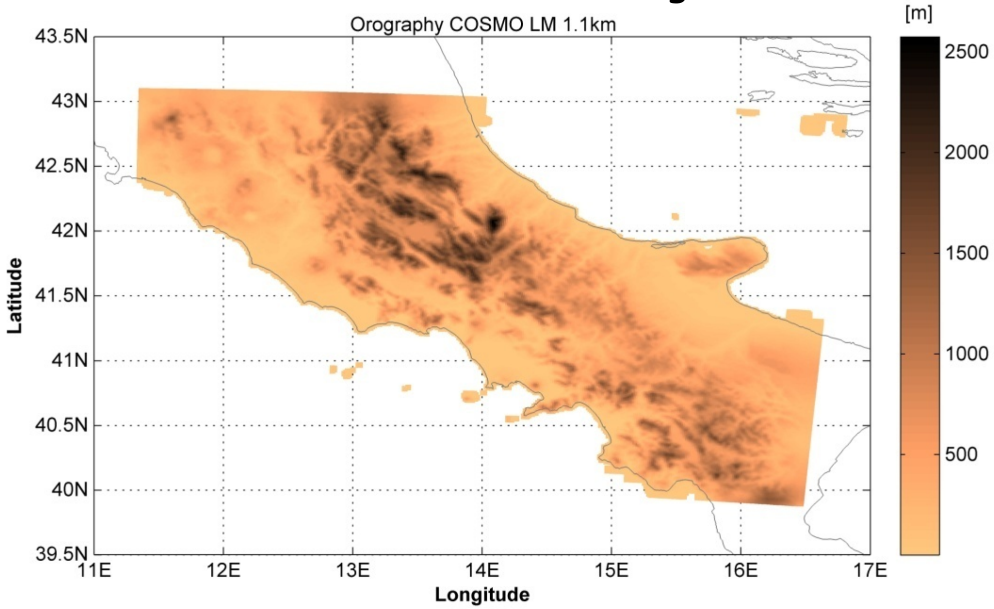

Features of simulations:COSMO 1.1 km* (1)

* New configuration

Initial and boundary condition from COSMO-7_ITA (about 7 km)

Grid characteristic	ie_tot=400, je_tot=300, ke_tot=60
Time step	dt = 5.0
Interval between two consecutive boundary data	hincbound=1.0
Soil processes	lsoil=.true., lmulti_layer=.true.,
Subgrid-scale convection	lconv=.true. , itype conv=3, (Shallow convection based on Tiedtke scheme)
Switch for nudging	lnudge =.false.,
Format of output files	yform_write='ncdf',



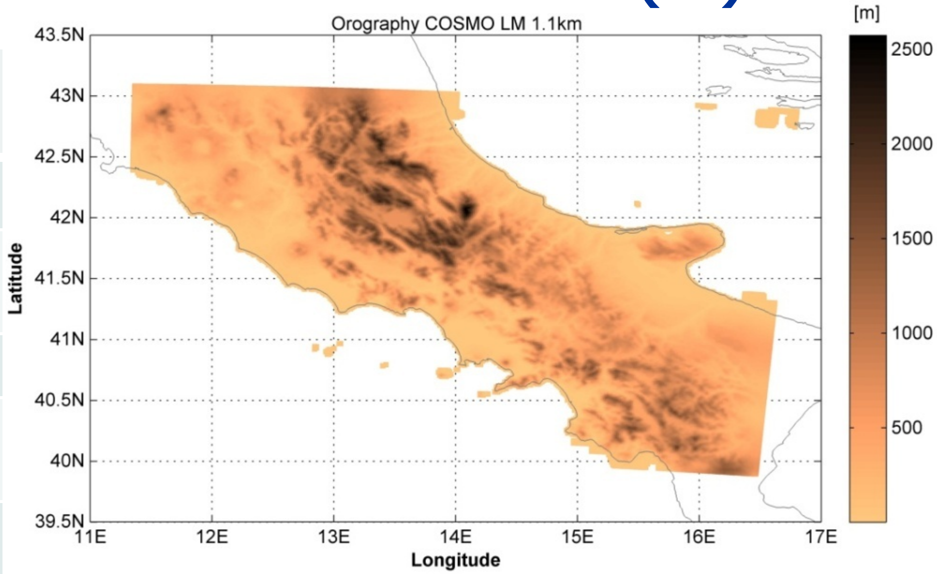
Parameters for the satellite images

```
&SATCTL
  itype_rttov=9,
  num_sensors=1,
  sat_input_01='MSG',    2,'SEVIRI',8, .TRUE., .TRUE., .TRUE., .TRUE.,
  nchan_input_01=1,2,3,4,5,6,7,8,
  lcon_clw=.TRUE,
```

Features of simulations: COSMO 1.1 km (2)

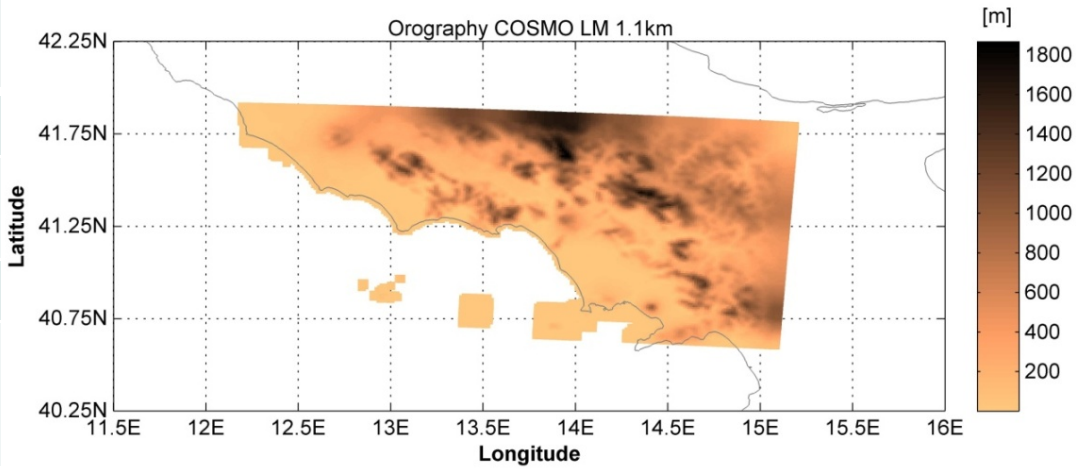
New configuration

Grid characteristic	ie_tot=400, je_tot=300, ke_tot=60
Time step (s)	dt = 5.0 (also dt=8 have been tested)
Coefficient for divergence damping	xkd=0.1
Fast wave solver	Itype_fast_waves=2
Bottom boundary condition	itype_bbc_w=114 (linear extrapolation of u and v to the ground)
Runge Kutta advection scheme	iadv_order=5

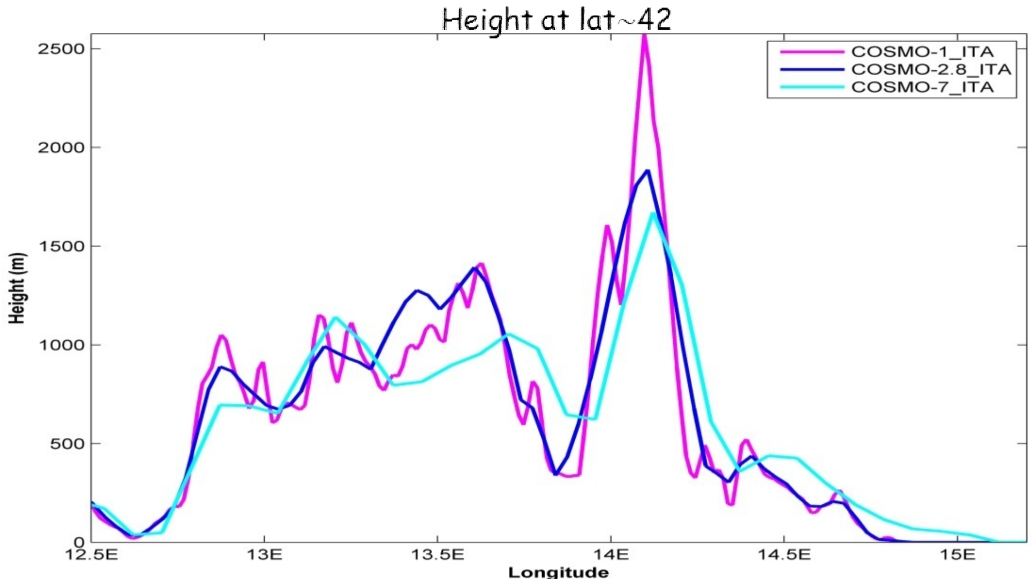


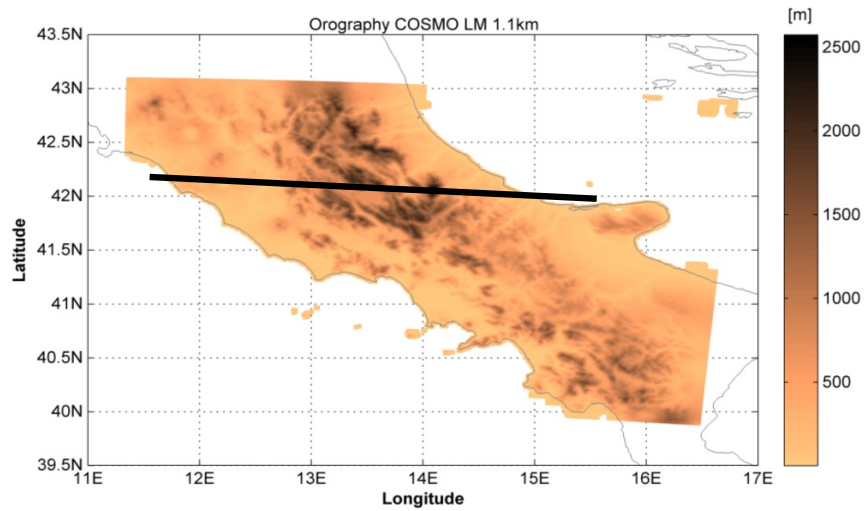
Old configuration

Grid characteristic	ie_tot=225, je_tot=120, ke_tot=60
Time step (s)	dt = 5.0
Coefficient for divergence damping	xkd=0.01
Fast wave solver	Itype_fast_waves=2
Bottom boundary condition	itype_bbc_w=4 (quadratic extrapolation of u and v to the ground)
Runge Kutta advection scheme	iadv_order=5



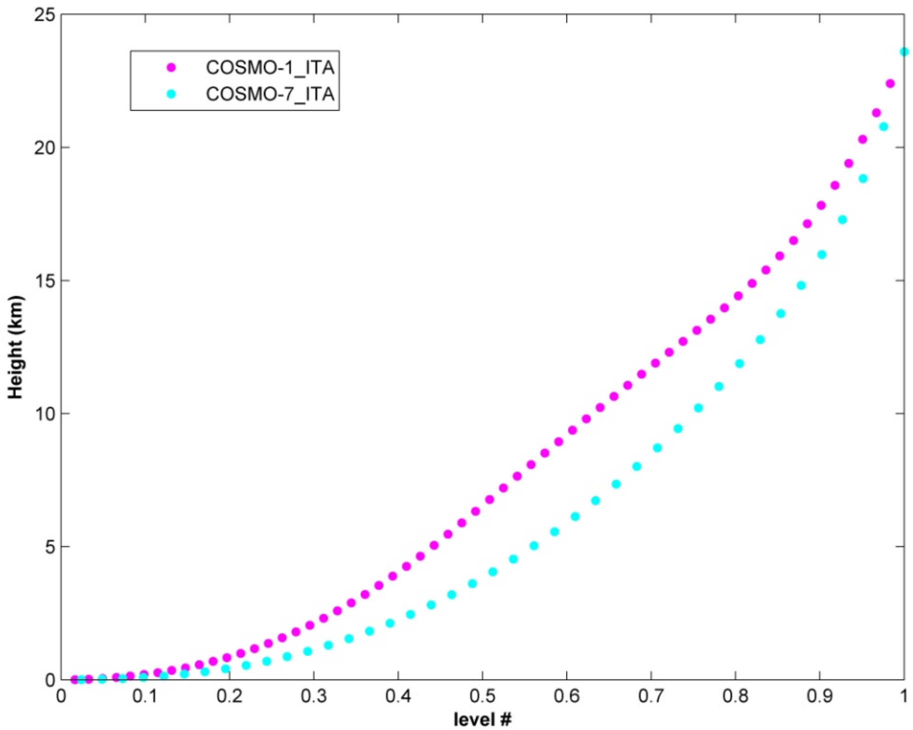
Features of simulations: Orography





Treatment of orography and filtering (int2lm *7km – 1km* and int2lm *7km – 2.8km*)	
Type of low pass filter and number of sequential applications of filter	lfilter_oro=.true., ilow_pass_oro=4, numfilt_oro=1,
Parameter for filtering and order of the orography filtering	eps_filter=0.1, norder_filter=5,
Extra smoothing of steep orography	ilow_pass_xso=6, (type of low pass filter) lxso_first=.FALSE., (extra smoothing of orography first) numfilt_xso=6, (number of sequential applications of filter) rxso_mask=300.0, (mask for xso)

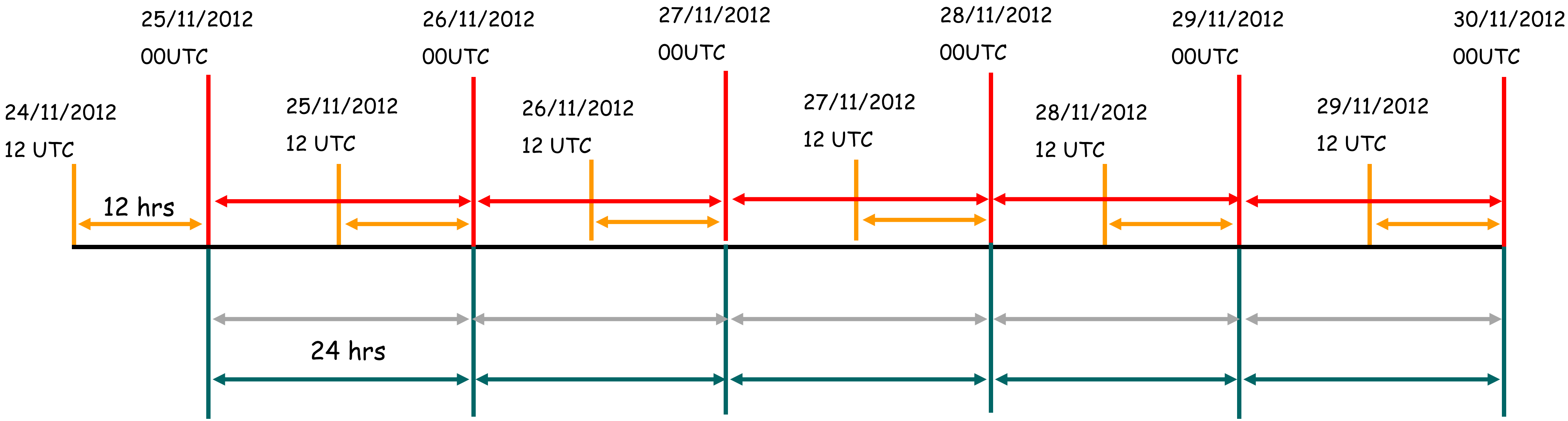
Features of simulations: Vertical grid



No further investigation has been carried out in this work about the number of the vertical levels to be used in COSMO-1_ITA, since previous studies (done by Milelli) show that the model behavior substantially doesn't change, changing the number of vertical levels (60 vs. 100).

Performed runs

COSMO-1_ITA
COSMO-2.8_ITA
COSMO-7_ITA 00 UTC
COSMO-7_ITA 12 UTC

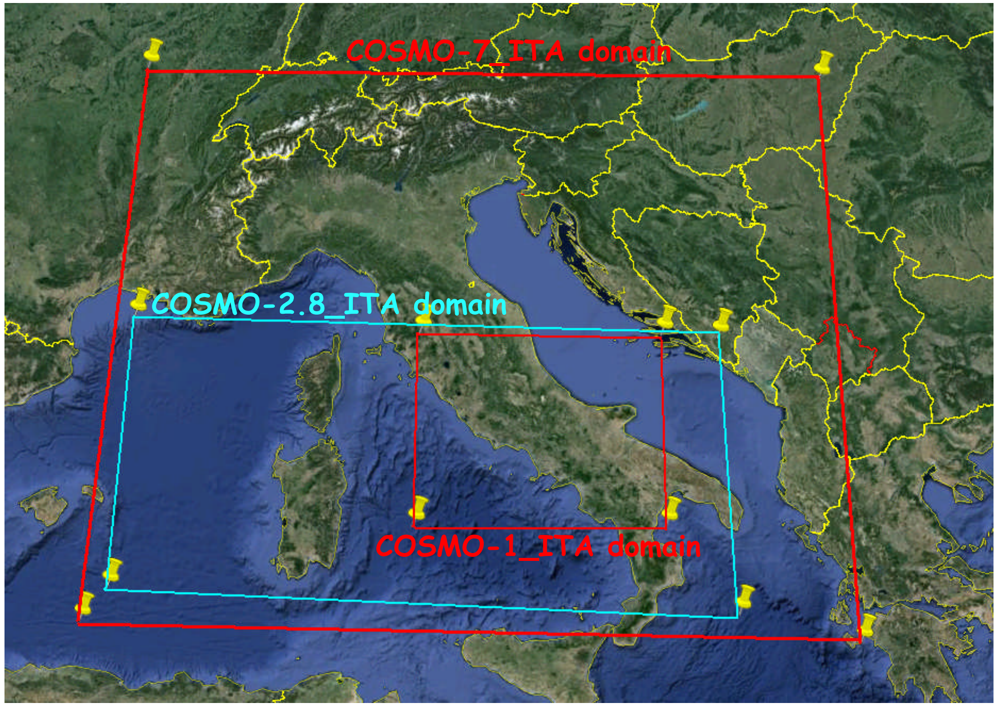


- COSMO-7_ITA 12 UTC: COSMO 7km – initial time 12 UTC_ Forecast range 12 hours. Nudging is performed for each hour.
- COSMO-7_ITA 00 UTC: COSMO 7km – initial time 00 UTC_ Forecast range 24 hours. Nudging is performed for each hour.
- COSMO-1_ITA is initialized by COSMO-7 00UTC with a forecast range of 24 hours. No nundging. Upgrade of b.c. each 1 hour.
- COSMO-2.8_ITA is initialized by COSMO-7 00UTC with a forecast range of 24 hours. No nundging. Upgrade of b.c. each 1 hour.

Computational costs:

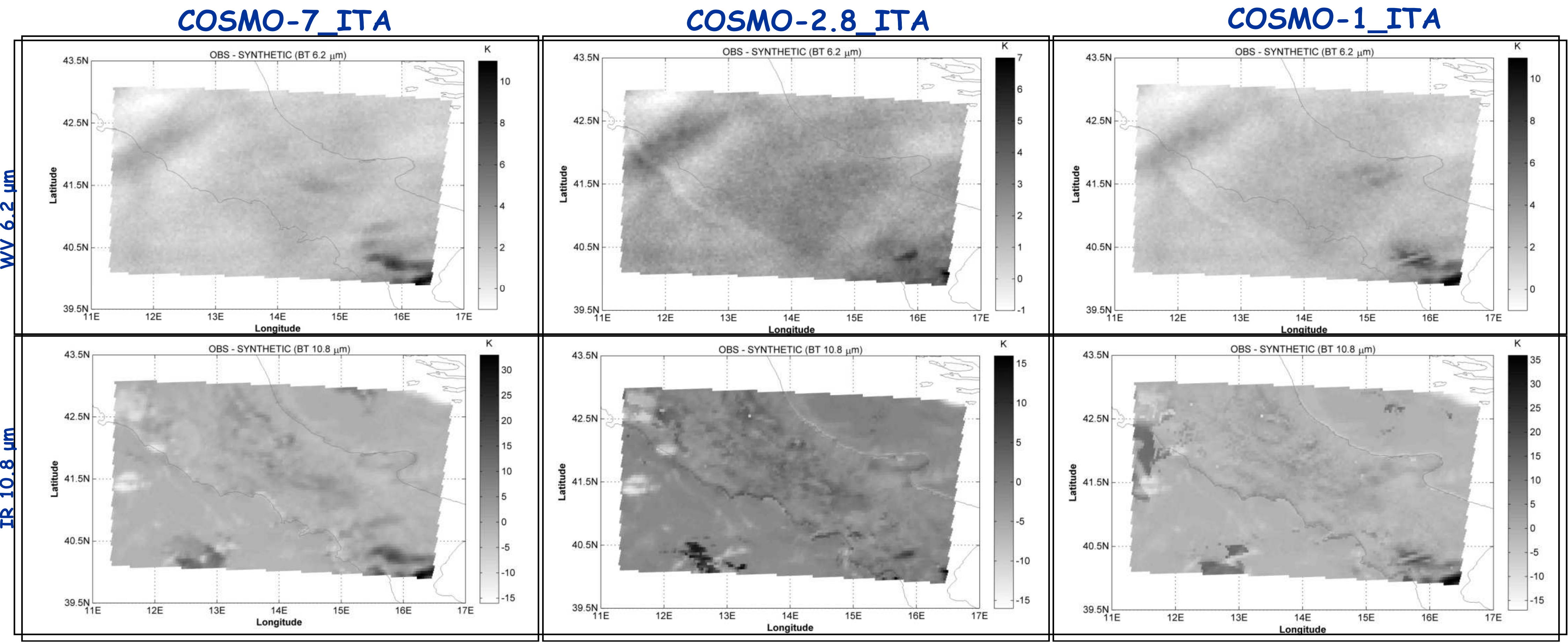
Resolution	ie x je	dt	Processors	Elapsed Time
7 km	240 x 160	40	2	50 min
2.8 km	400 x 175	20	2	165 min
1.1 km	400 x 300	5	8	370 min

- Elapsed Time refers to 10 hours forecast
- The domain of COSMO-2.8_ITA simulations has a higher number of grid points and the elapsed time is more than 3 times that of COSMO-7_ITA simulations, using the same number of processors.
- The domain of COSMO-1_ITA simulations has a higher number of grid points and the elapsed time is more than 7 times that of COSMO-7_ITA simulation, even if has been used a higher number of processors.



Performances evaluation with satellite (1)

Simulation of 26/11/2012 forecast hour 04UTC



WV 6.2 µm ⟷ Water Vapour

IR 10.8 µm ⟷ Cloud Temperature

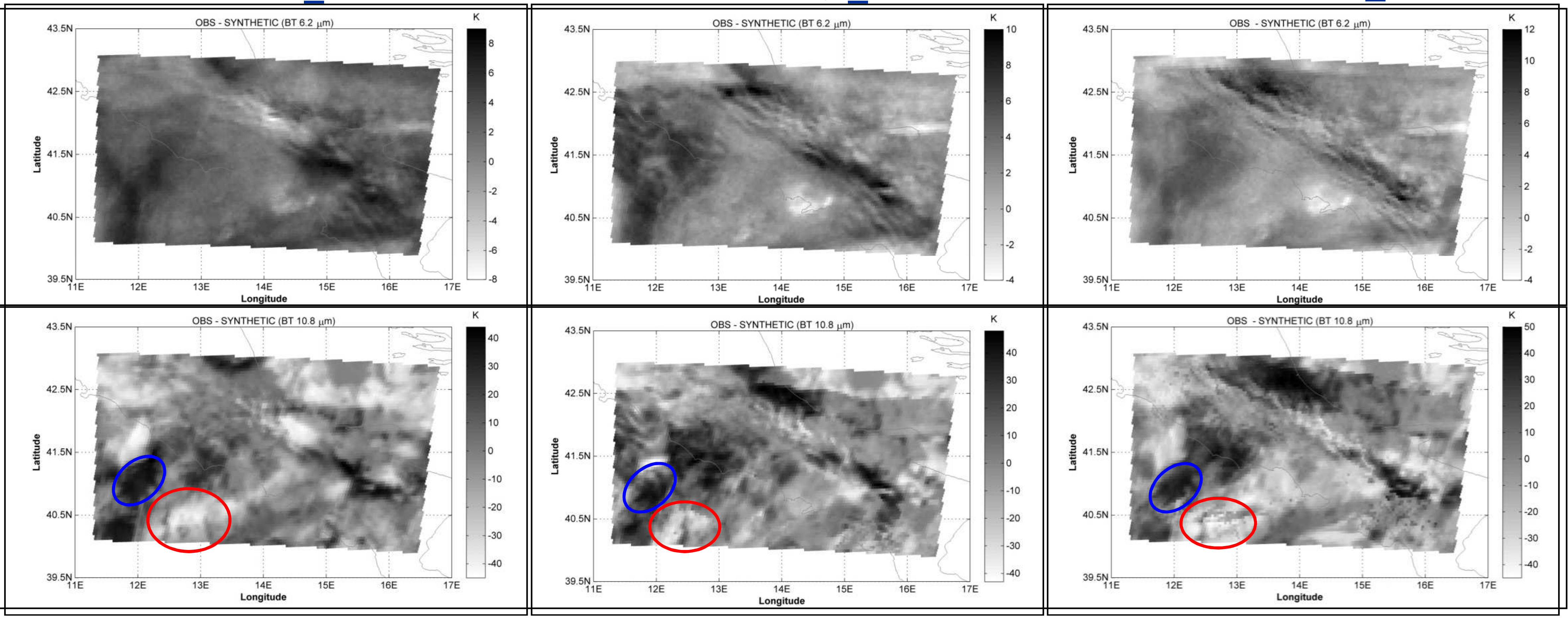
Performances evaluation with satellite (2)

Simulation of 30/11/2012 forecast hour 13UTC

COSMO-7_ITA | **COSMO-2.8_ITA** | **COSMO-1_ITA**

WV 6.2 µm

IR 10.8 µm

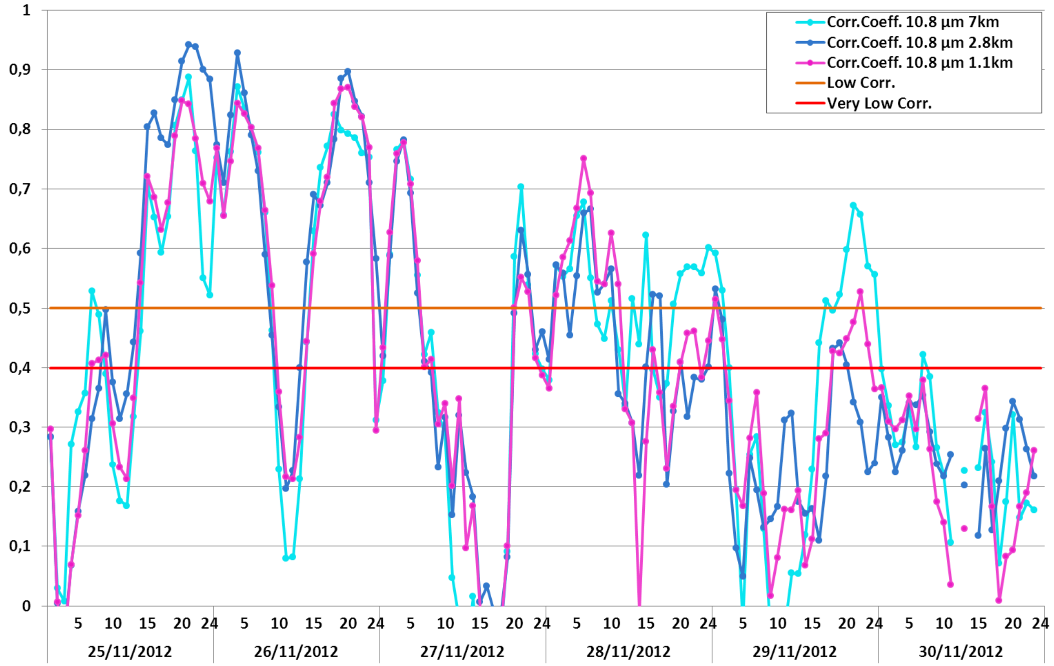


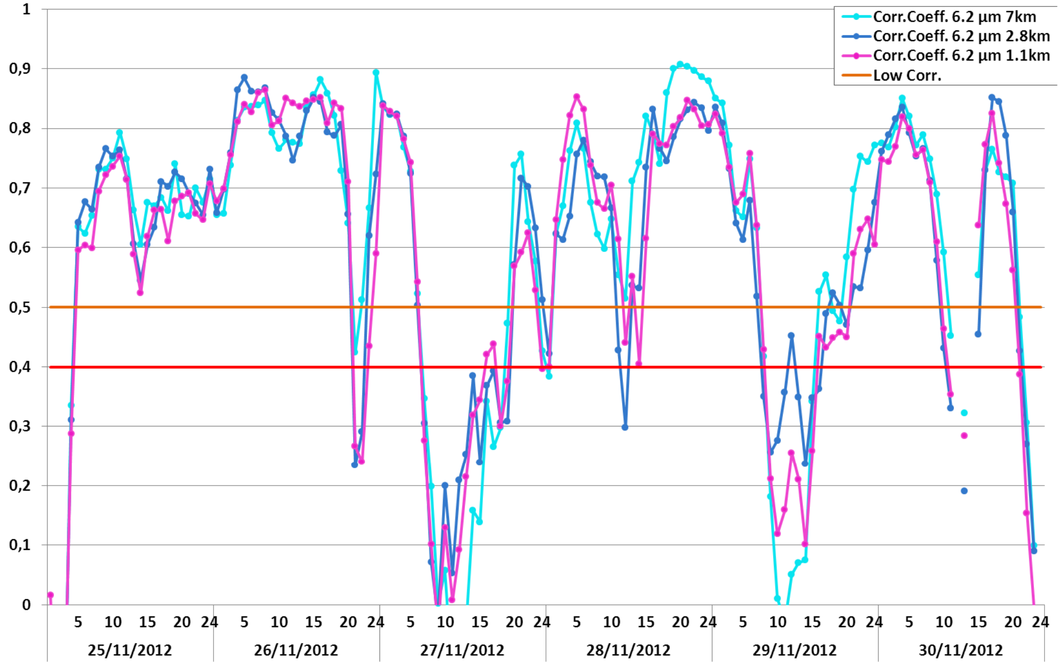
WV 6.2 µm ⟷ Water Vapour

IR 10.8 µm ⟷ Cloud Temperature

Performances evaluation with satellite (3)

Correlation coefficients (B.K.Reichert, C.Träger-Chatterjee, J.Asmus 2005)





Mean Corr.Coeff. 10.8 µm

	25	26	27	28	29	30
7km	0,46	0,62	0,32	0,51	0,32	0,25
2.8km	0,52	0,67	0,36	0,44	0,25	0,26
1.1km	0,46	0,64	0,36	0,45	0,29	0,22

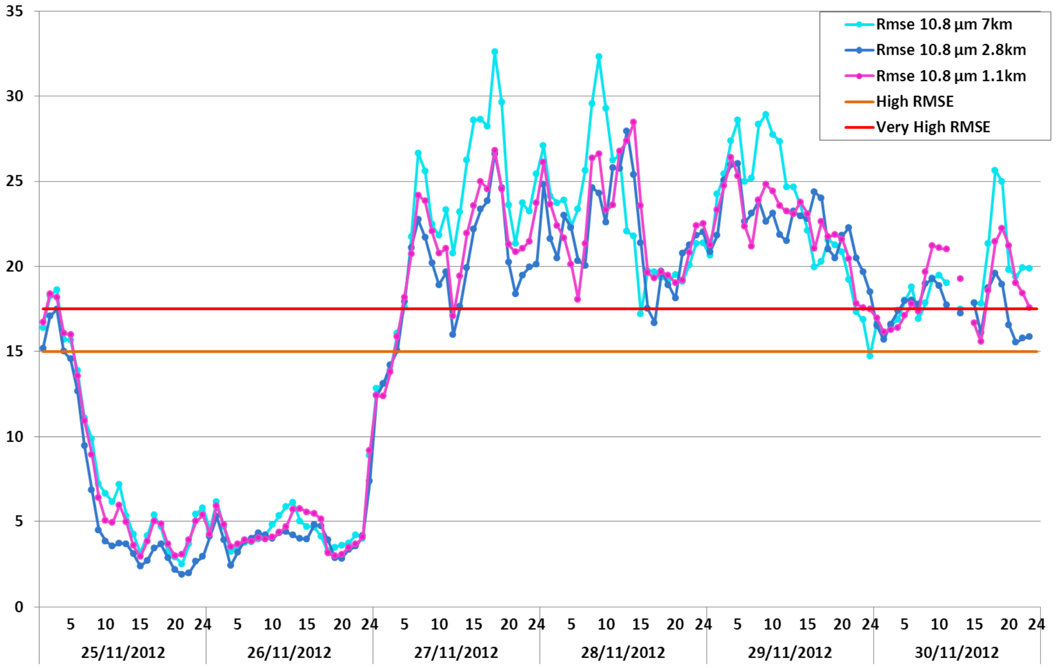
Mean Corr.Coeff. 6.2 µm

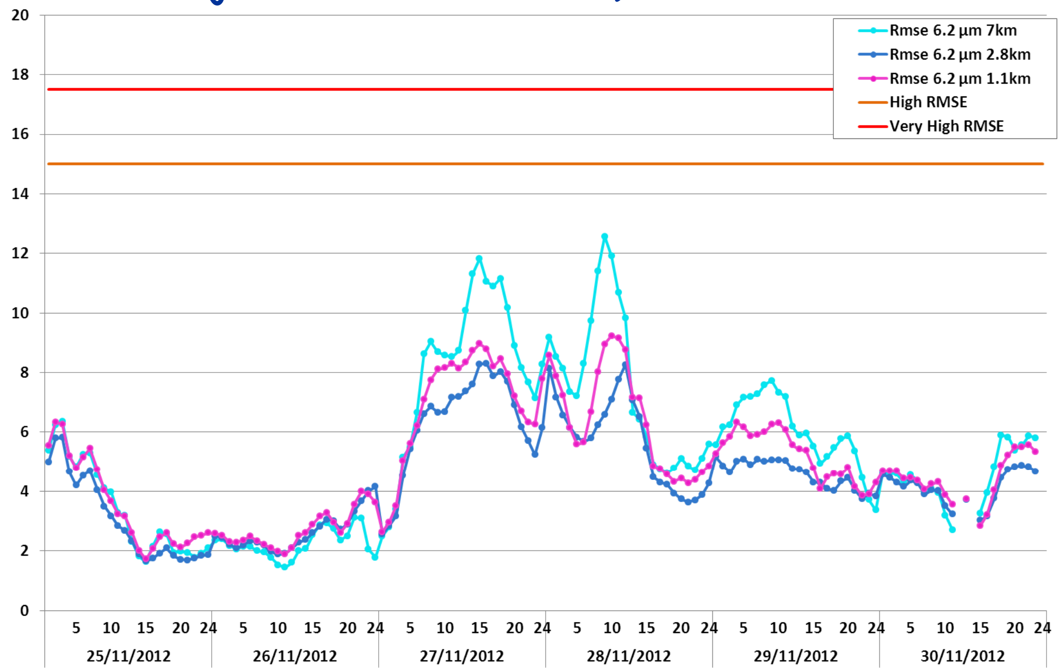
	25	26	27	28	29	30
7km	0,56	0,76	0,40	0,74	0,49	0,64
2.8km	0,56	0,74	0,45	0,69	0,51	0,61
1.1km	0,54	0,74	0,43	0,71	0,48	0,60

- The simulations at different resolution show almost the same pattern except for simulations of 28th/29th
- General good agreement with observations for periods without clouds for both channels
- Lower agreement for cloudy periods, especially for IR 10.8 µm channel

Performances evaluation with satellite (4)

Rmse (B.K.Reichert, C.Träger-Chatterjee, J.Asmus 2005)





Mean Rmse 10.8 µm

	25	26	27	28	29	30
7km	8,21	4,56	22,93	23,11	23,16	19,02
2.8km	6,56	4,07	19,56	21,96	22,51	17,48
1.1km	7,92	4,50	20,69	22,56	22,36	18,62

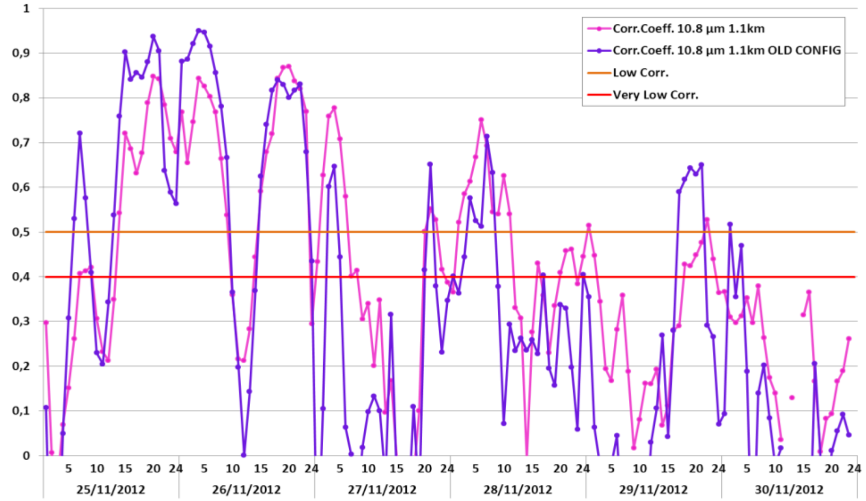
Mean Rmse 6.2 µm

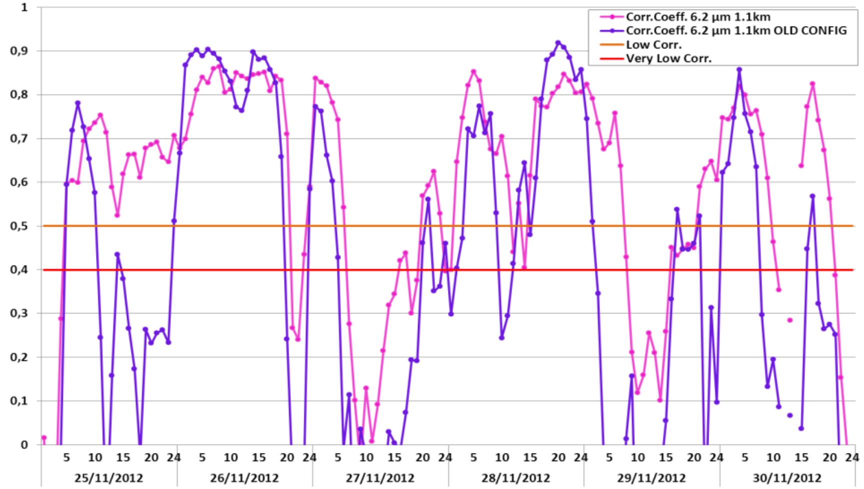
	25	26	27	28	29	30
7km	3,43	2,24	8,12	7,43	6,01	4,57
2.8km	3,05	2,63	6,30	5,69	4,59	4,14
1.1km	3,55	2,71	6,97	6,40	5,24	4,44

- The three simulations show almost the same pattern
- General low error for periods without clouds for both channels
- Higher error for cloudy periods for IR 10.8 µm channel
- Almost no error for WV 6.2 µm channel for the entire period

Performances evaluation with satellite (5)

OLD VS NEW CONFIGURATION



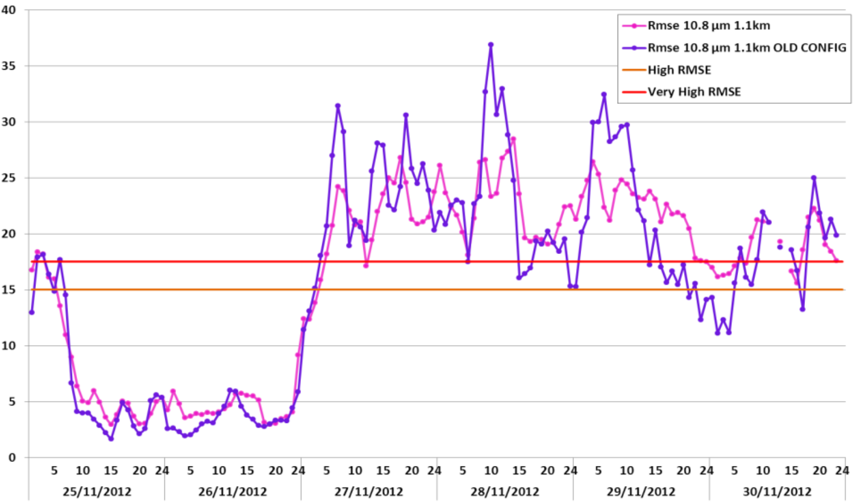


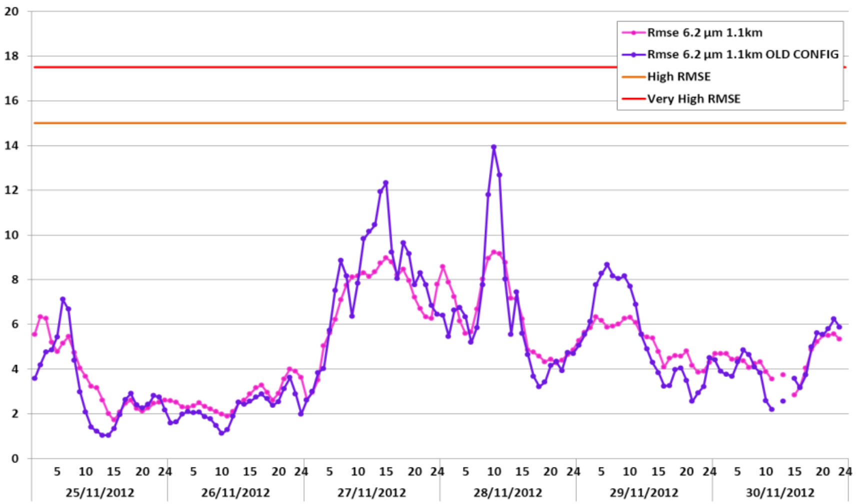
Mean Corr.Coeff. 10.8 µm

	25	26	27	28	29	30
new	0,46	0,64	0,36	0,45	0,29	0,22
old	0,50	0,68	0,15	0,34	0,17	0,08

Mean Corr.Coeff. 6.2 µm

	25	26	27	28	29	30
new	0,54	0,74	0,43	0,71	0,48	0,60
old	0,27	0,68	0,22	0,65	0,15	0,35





Mean Rmse 10.8 µm

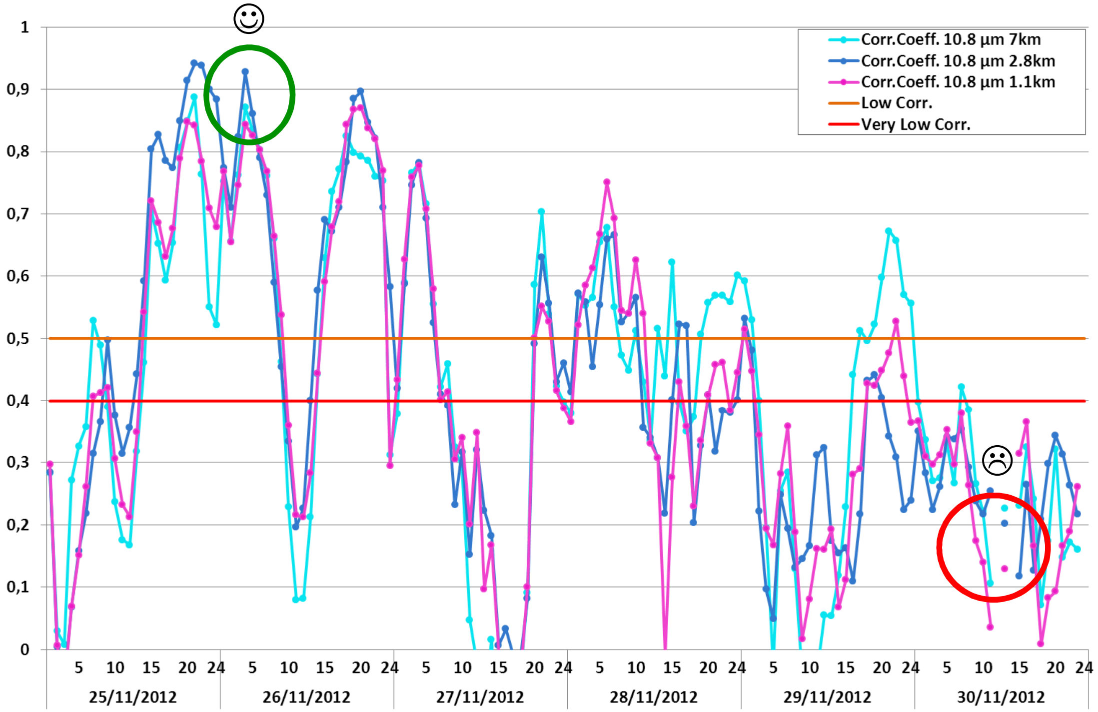
	25	26	27	28	29	30
new	7,92	4,50	20,69	22,56	22,36	18,62
old	7,38	3,50	22,82	22,57	21,25	17,65

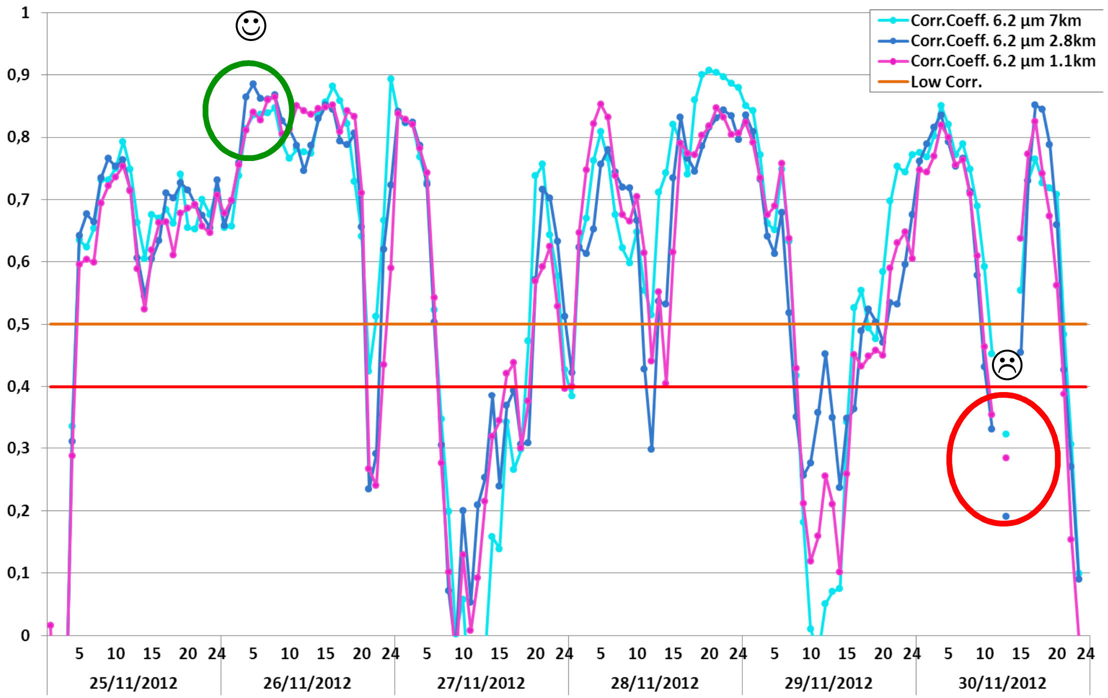
Mean Rmse 6.2 µm

	25	26	27	28	29	30
new	3,55	2,71	6,97	6,40	5,24	4,44
old	3,10	2,22	7,74	6,34	5,43	4,26

Performances evaluation with satellite (3)

Correlation coefficients

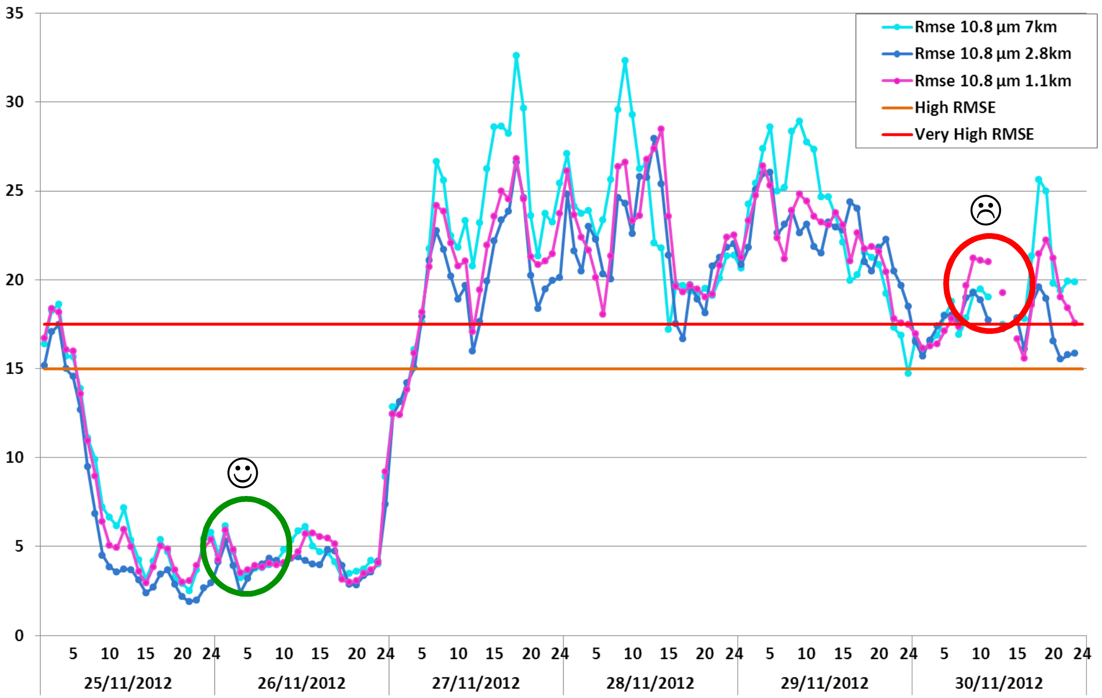


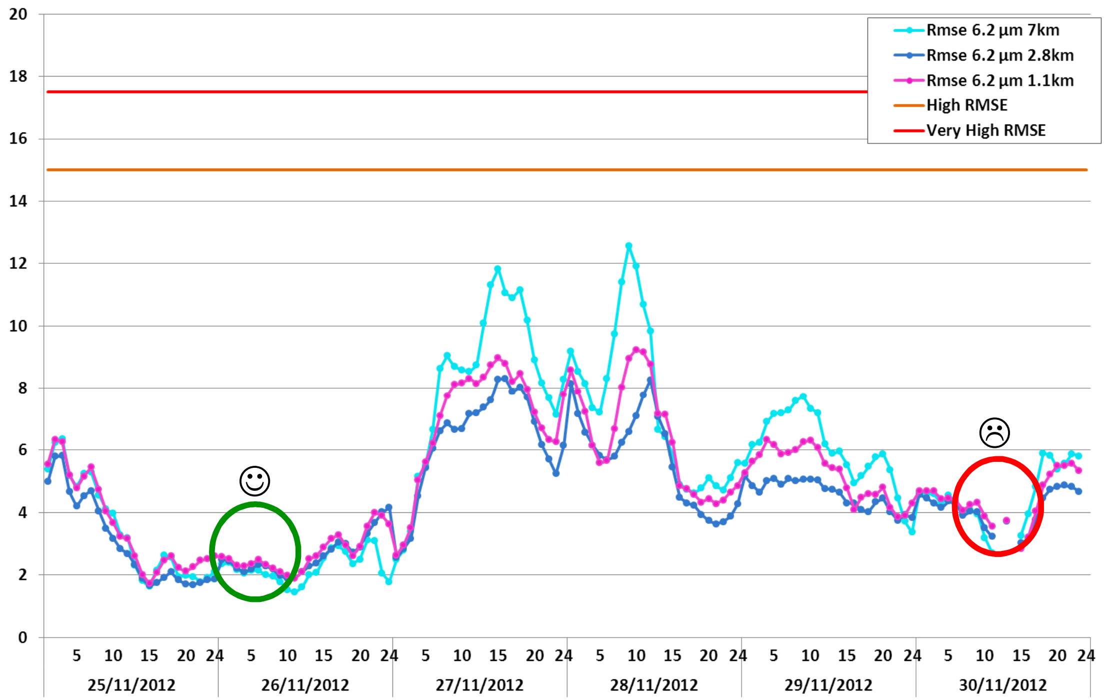


- The simulations at different resolution show almost the same pattern except for simulations of 28th/29th
- General good agreement with observations for periods without clouds for both channels
- Lower agreement for cloudy periods, especially for IR 10.8 µm channel

Performances evaluation with satellite (4)

RMSE





- The three simulations show almost the same pattern
- General low error for periods without clouds for both channels
- Higher error for cloudy periods for IR 10.8 µm channel
- Almost no error for WV 6.2 µm channel for the entire period

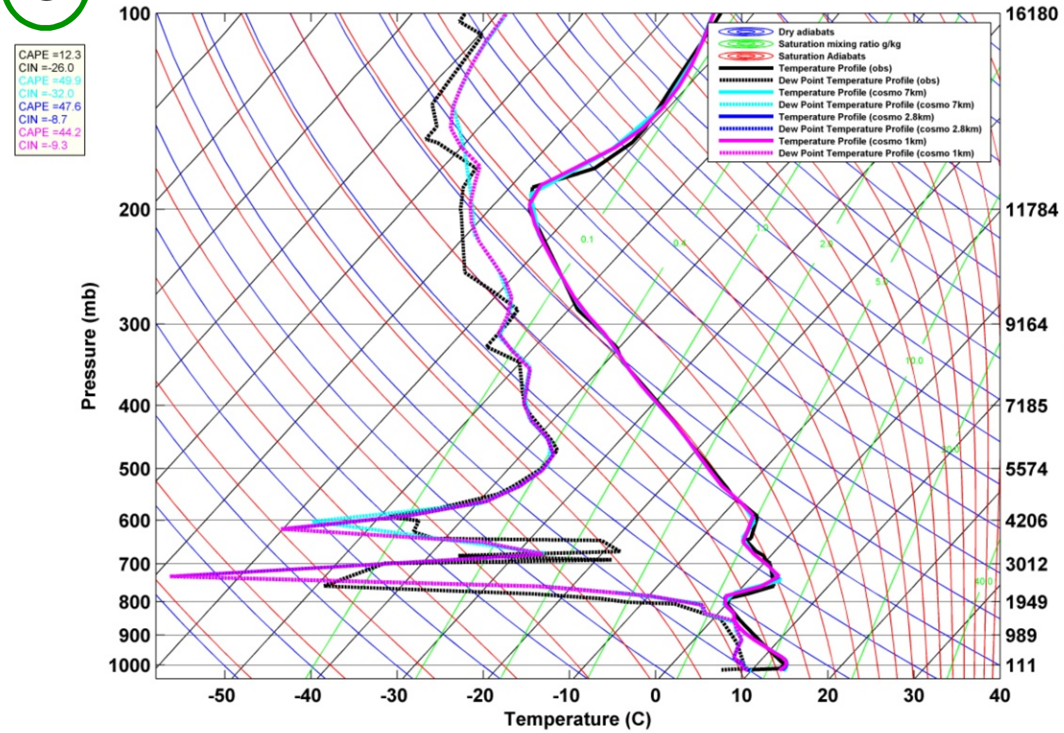
Performances evaluation with radiosounding (1)

- Soundings taken from Pratica di mare every 00 UTC and 12 UTC
- Station latitude: 41.65
- Station longitude: 12.43
- Station elevation: 32.0
- COSMO Soundings realized for the nearest grid point

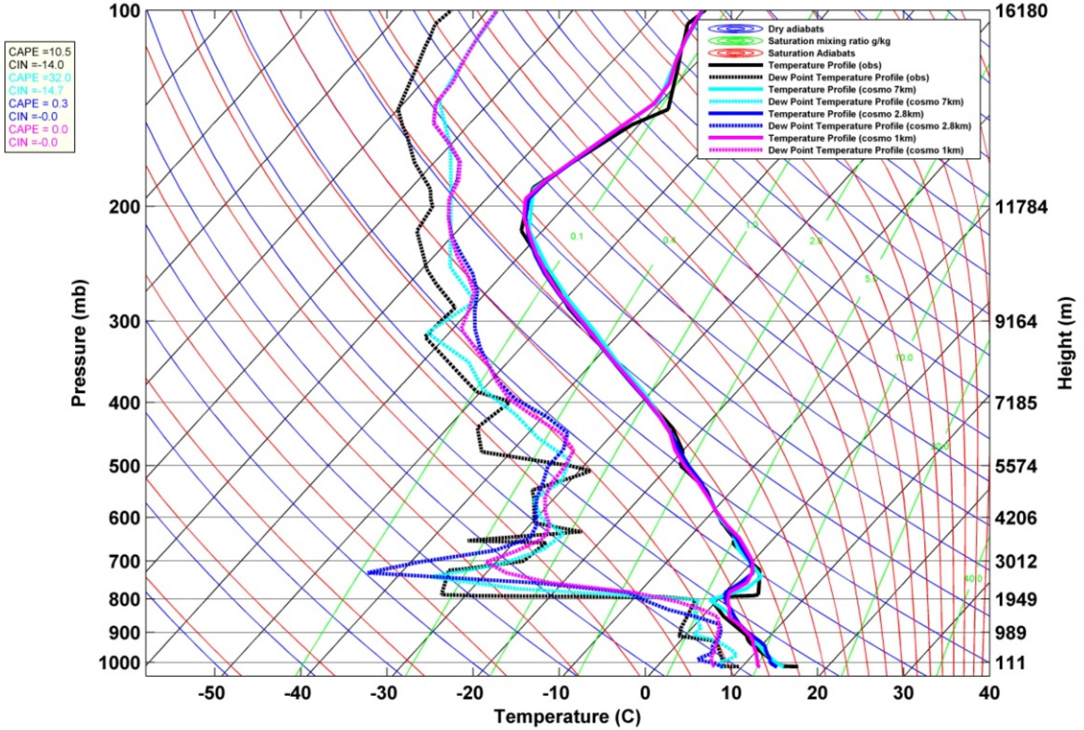
Performances evaluation with radiosounding (2)

☺

26/11/2012 00UTC (ANALYSIS)



26/11/2012 12UTC

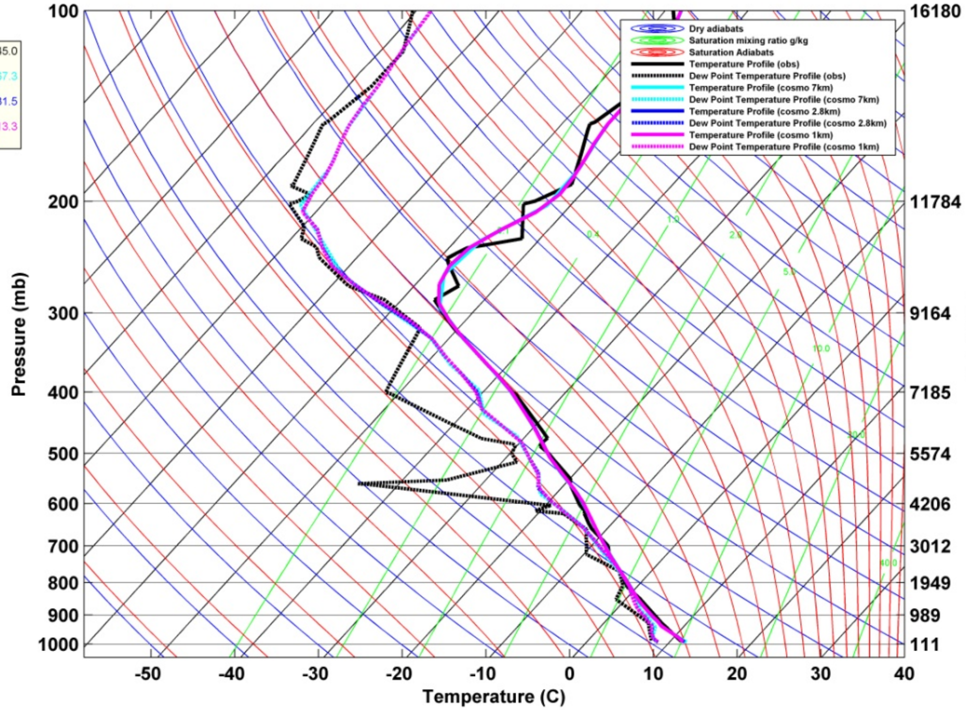


- COSMO-7_ITA, COSMO-2.8_ITA and COSMO-1_ITA show almost the same pattern
- General good agreement with the pattern of the observation sounding

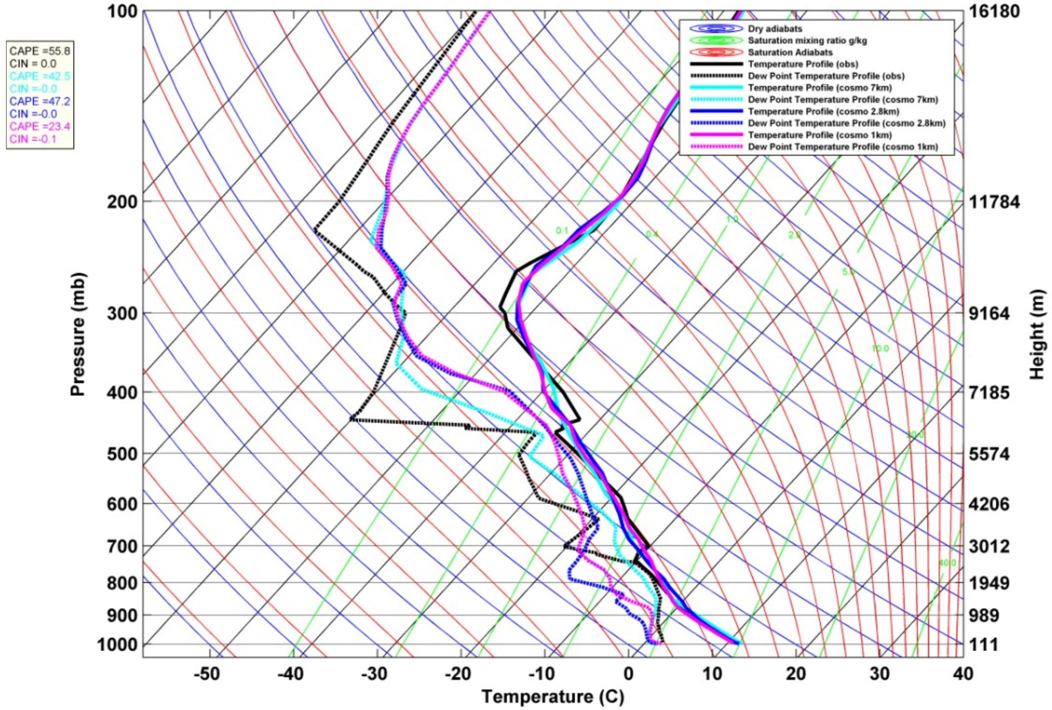
Performances evaluation with radiosounding (3)

☹

30/11/2012 00UTC (ANALYSIS)

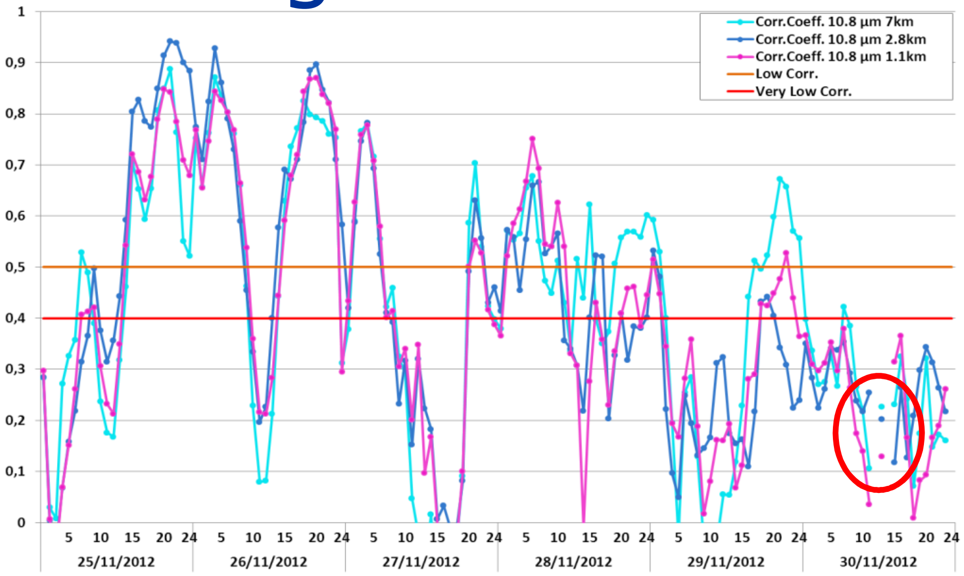


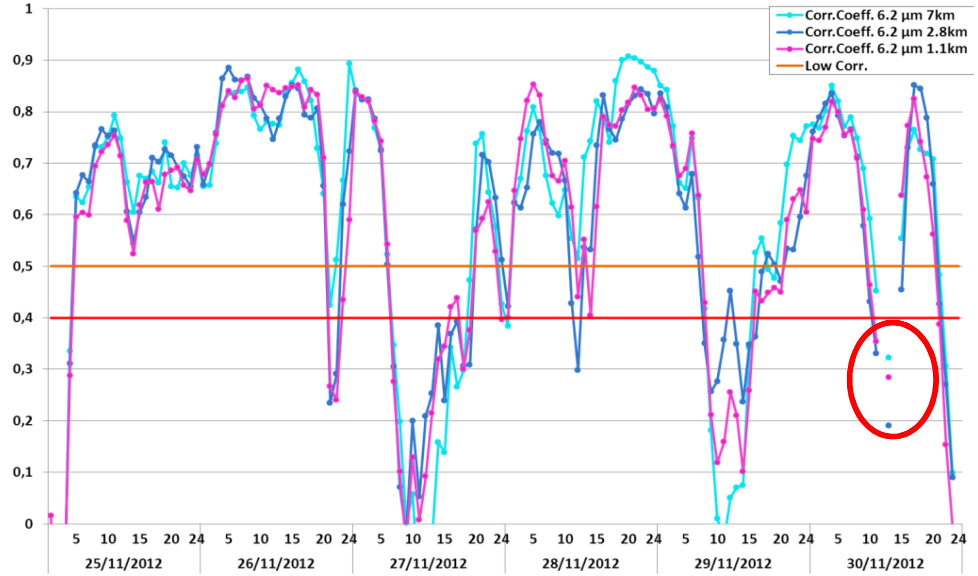
30/11/2012 12UTC

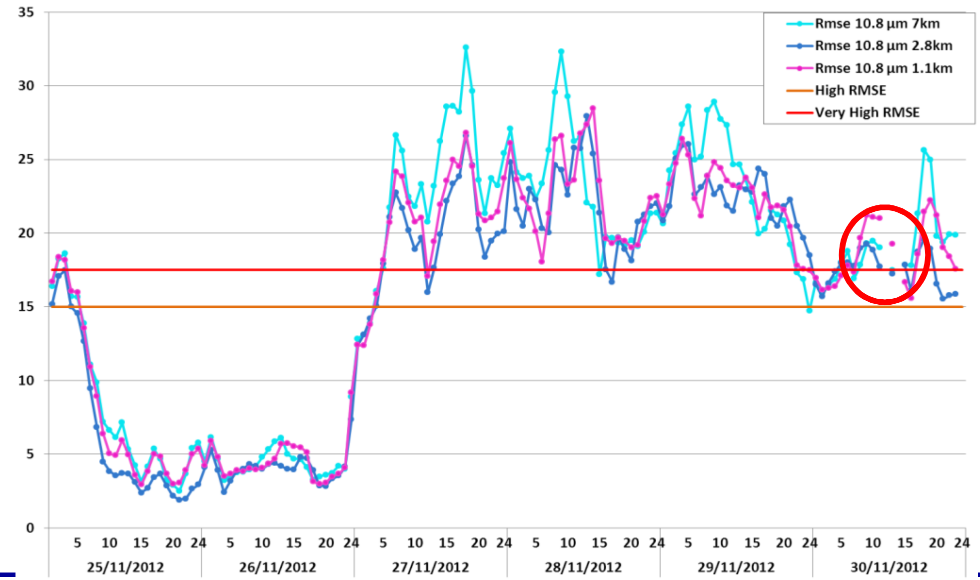


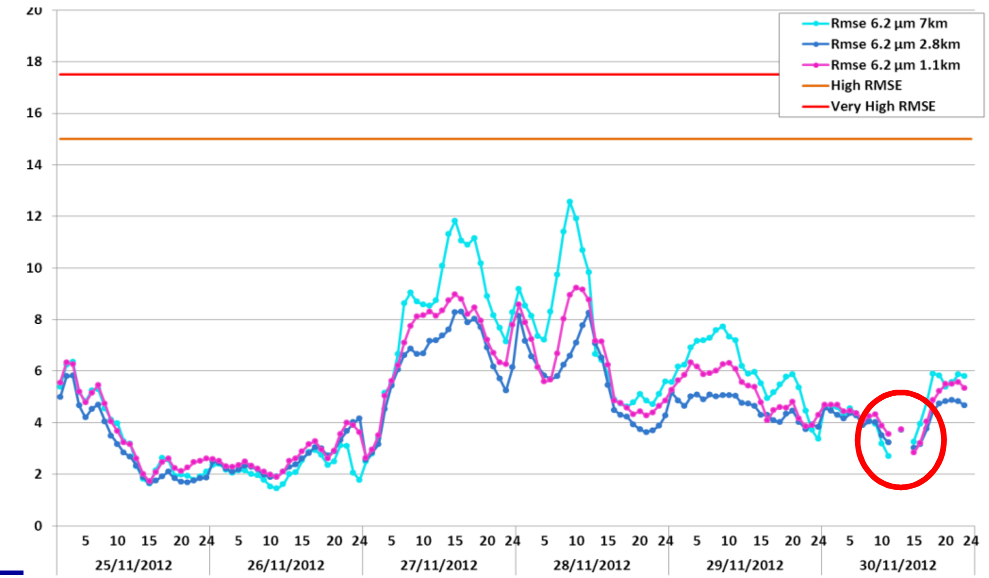
- COSMO-1_ITA and COSMO-2.8_ITA show almost the same pattern, different from that of COSMO-7_ITA
- There's a lower agreement with the pattern of the observed sounding:
  - the analysis differs for lower levels (900-700 hPa) and for middle levels (600-350 hPa)
  - the 12UTC simulations show a pattern quite different from the observations. The 7km simulation exhibits a different behaviour compared with the others two configuration.

…coming back to satellite verification…





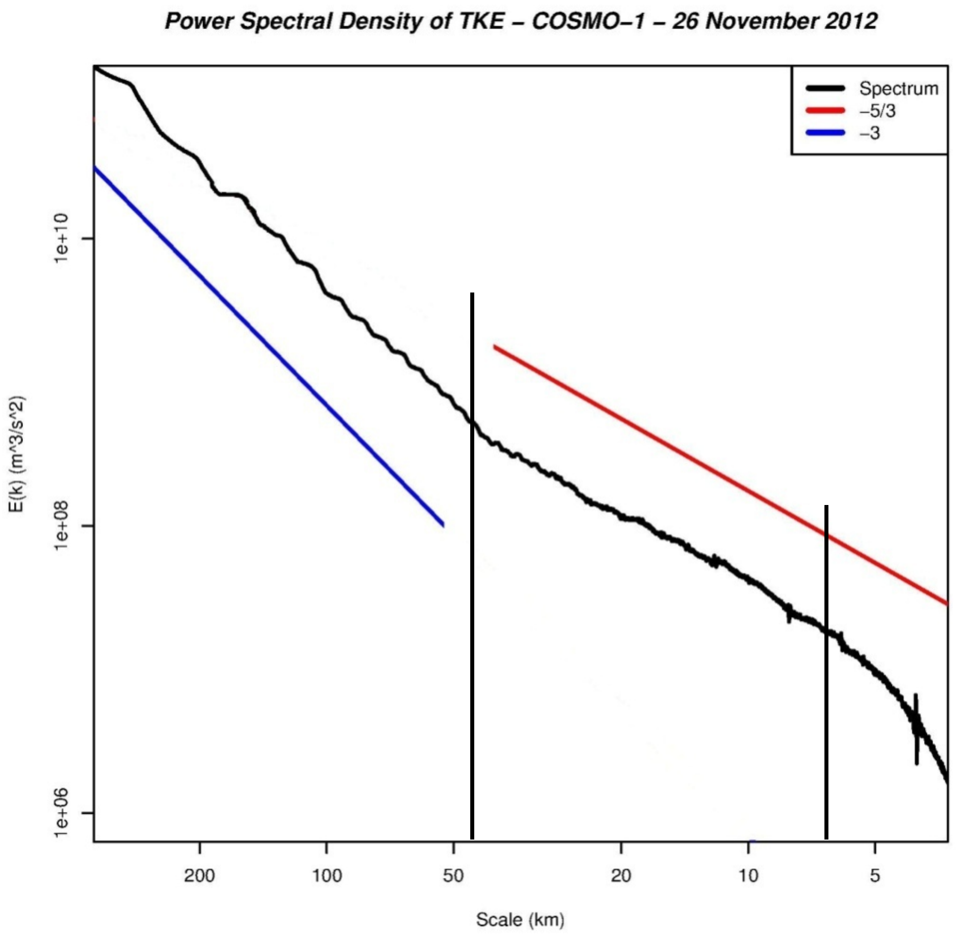


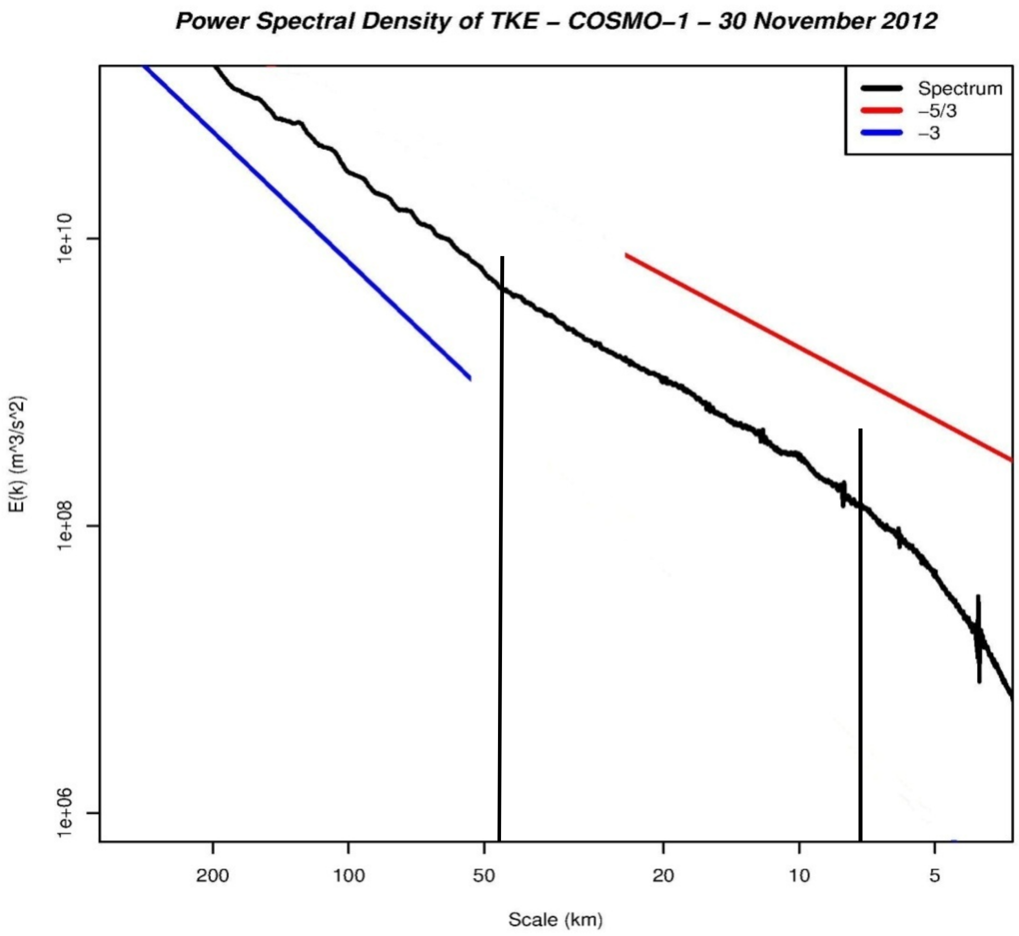


Kinetic energy spectra (1)

- Spectral decomposition obtained with 2D-DCT (Denis *et al.* 2002, MWR)
- Using U and V (averaged together) at 200 hPa, 250 hPa, 300 hPa, 400 hPa, 500 hPa, 600 hPa, 700 hPa
- Daily average (+24h with 1h output)
- Only 26 and 30 November shown but results confirmed for the other days
- Agreement with experimental spectra by Skamarock, MWR 2004
- Transition from -3 to -5/3 around 50 km
- Loss of information between 10-5 km (effective resolution of the model)

Kinetic energy spectra (2)





Conclusions

- The aim of the work was the evaluation of the performances of COSMO-1 model over the Italian domain with different kinds of observations, suitable for the high resolution of the model, and with different configurations of COSMO (different resolutions: 7 km and 2.8 km)

- The behaviour of COSMO-7_ITA, COSMO-2.8_ITA and COSMO-1_ITA is quite the same for almost every variable analyzed in the validation, even if, for the cloudy days analyzed, the three simulations have worst performances. Further investigations will be done.

- The analysis of kinetic energy spectra shows a good agreement with experimental spectra by Skamarock. The loss of information is between 10-5 km

- Next steps include performing of other test cases (in order to include the study of other meteorological situations).

Thanks for your attention!