The use of COSMO model in the CNMCA Operational LETKF System: First Results

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Outline

- The CNMCA Ensemble Data Assimilation System (LETKF)
- Comparison HRM-COSMO LETKF:
  - COSMO model settings
  - Observation increment statistics
  - COSMO-ME objective verification
- Conclusions and future developments

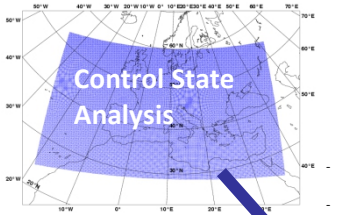
CNMCA LETKF Implementation

- 40+1 member ensemble at 0.09° (~10Km) grid spacing (HRM model), 40 hybrid p-sigma vertical levels (top at 10 hPa)
- 6-hourly assimilation cycle run and (T,u,v,qv,ps) as a set of control variables
- Observations: RAOB, SYNOP, SHIP, BUOY, AIREP, AMDAR, ACAR, AMV (MSG, MET7), WindPROF, SCAT(METOP), AMSU-A (METOP,NOAA) radiances (very soon)
- Localization: horizontally with 800 Km circular local patches; verticallly to layers whose depth increases from 0.2 scale heights at the lowest model levels to 2. scale heights at the model top (obs weight smoothly decay with a pseudo-gaussian function)
- Adaptive selection radius using a fixed number of effective observations (sum of obs weights)
- Inflaction: multiplicative (relaxation to prior spread), additive (NMC), BC (IFS EPS), SST
- Daily blending of the mean upper level analysis with the IFS analysis to compensate the limited satellite data usage

CNMCA NWP SYSTEM since 1 June 11

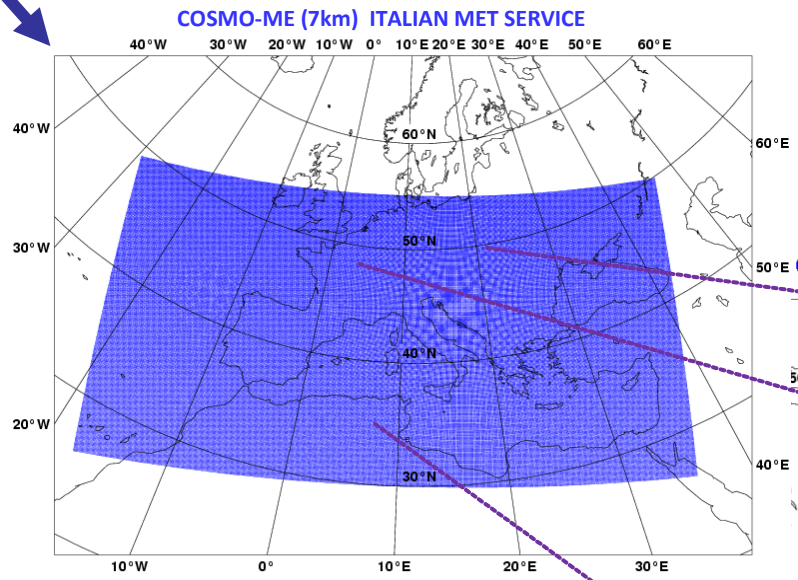
Ensemble Data Assimilation:

LETKF analysis ensemble (40+1 members) every 6h
using TEMP, PILOT, SYNOP, SHIP, BUOY, Wind Profiler, AMDAR-ACAR-AIREP, MSG/MET7 AMV, METOP scatt. winds, NOAA/METOP AMSUA radiances (very soon)
+ Land SAF snow mask, IFS SST analysis once a day



10 km
40 v.l.

HRM hydrostatic model
parameterized convection

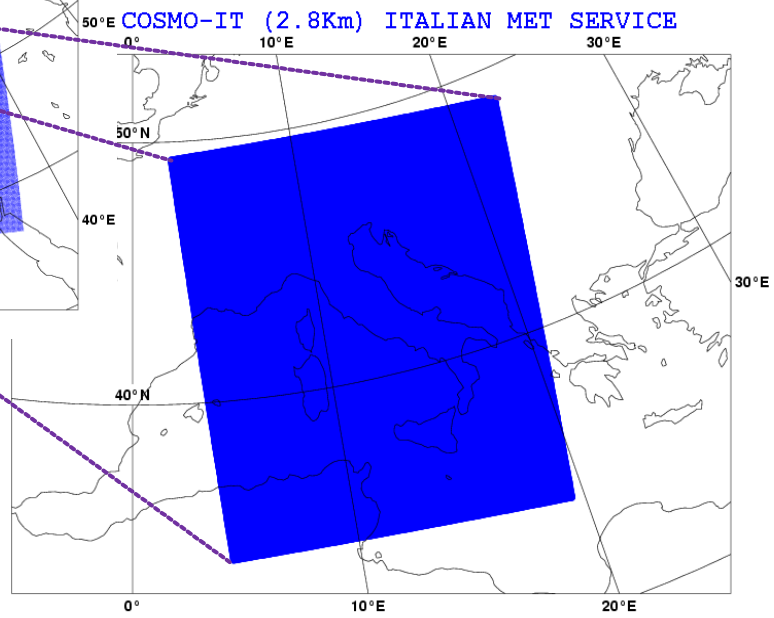


7 km
40 v.l.

compressible equations
parameterized convection

2.8 km
50 v.l.

compressible equations
explicit convection



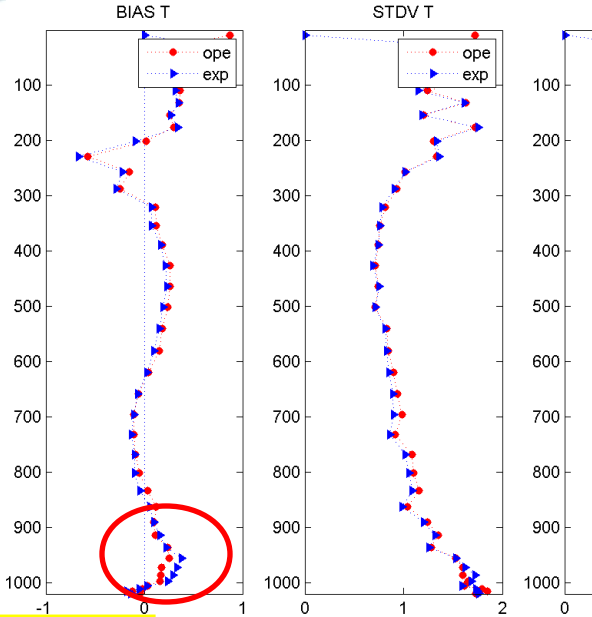
Local Area Modelling:
COSMO

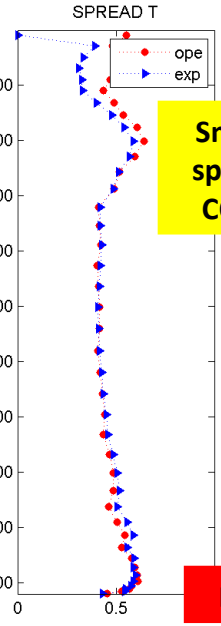
COSMO model in CNMCA-LETKF

- HRM hydrostatic model is subtituted by COSMO non-hydrostatic model in CNMCA LETKF system taking into account of that:
  - The model top is raised from 21.5km (43hPa) to 26km (18hPa) using 45 vertical levels to reduce the influence of the sponge layer (upper levels Rayleigh damping zone)
  - Initial pressure perturbation fields are derived using the hydrostatic balance equation
- The CNMCA-LETKF system using COSMO model is experimental running since February 2012 with basicly the same settings of the operational one
- Observation increment statistics (obs-BG) is continously monitored and deterministic forecasts from this system are objectively verified against conventional observations

HRM vs COSMO LETKF

TEMPERATURE

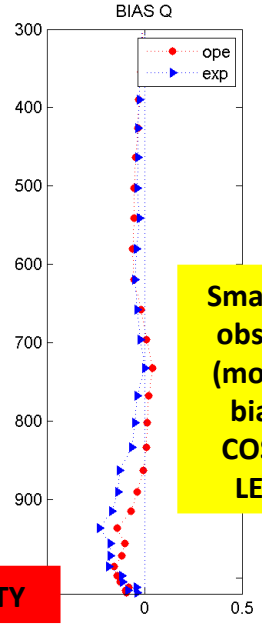


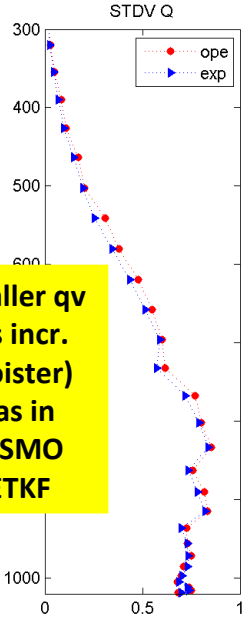


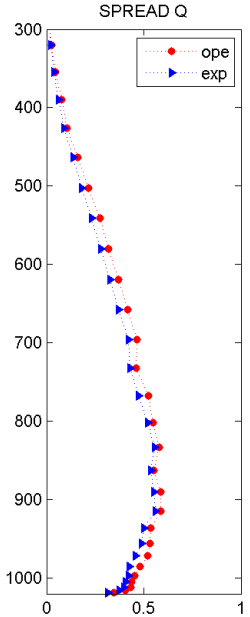
Smaller T spread in COSMO

Larger T obs incr. (colder) bias in COSMO LETKF

SPEC. HUMIDITY

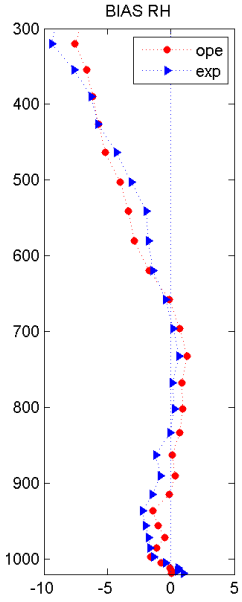


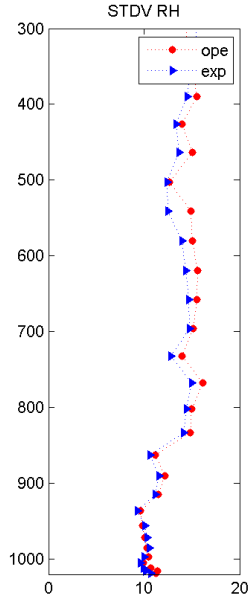


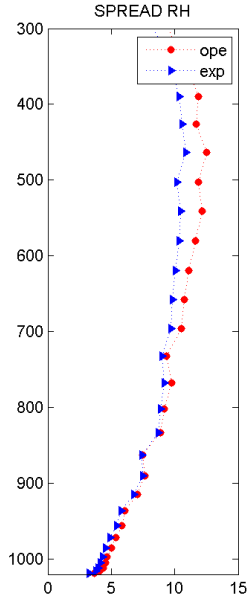


Smaller qv obs incr. (moister) bias in COSMO LETKF

REL. HUMIDITY



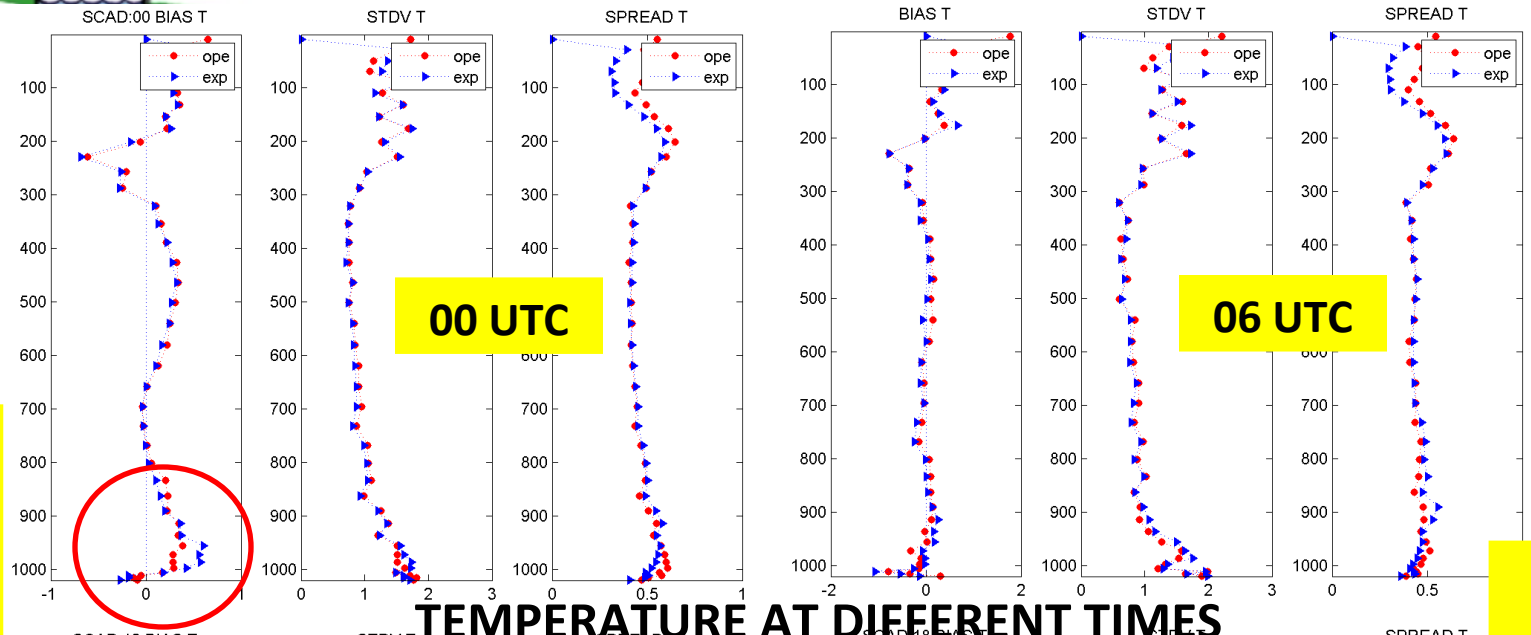




RAOB obs increment statistics (obs -BG ensemble mean) on 40 levels from 28 apr 2012 to 01 jun 2012 (00 06 12 18 UTC)

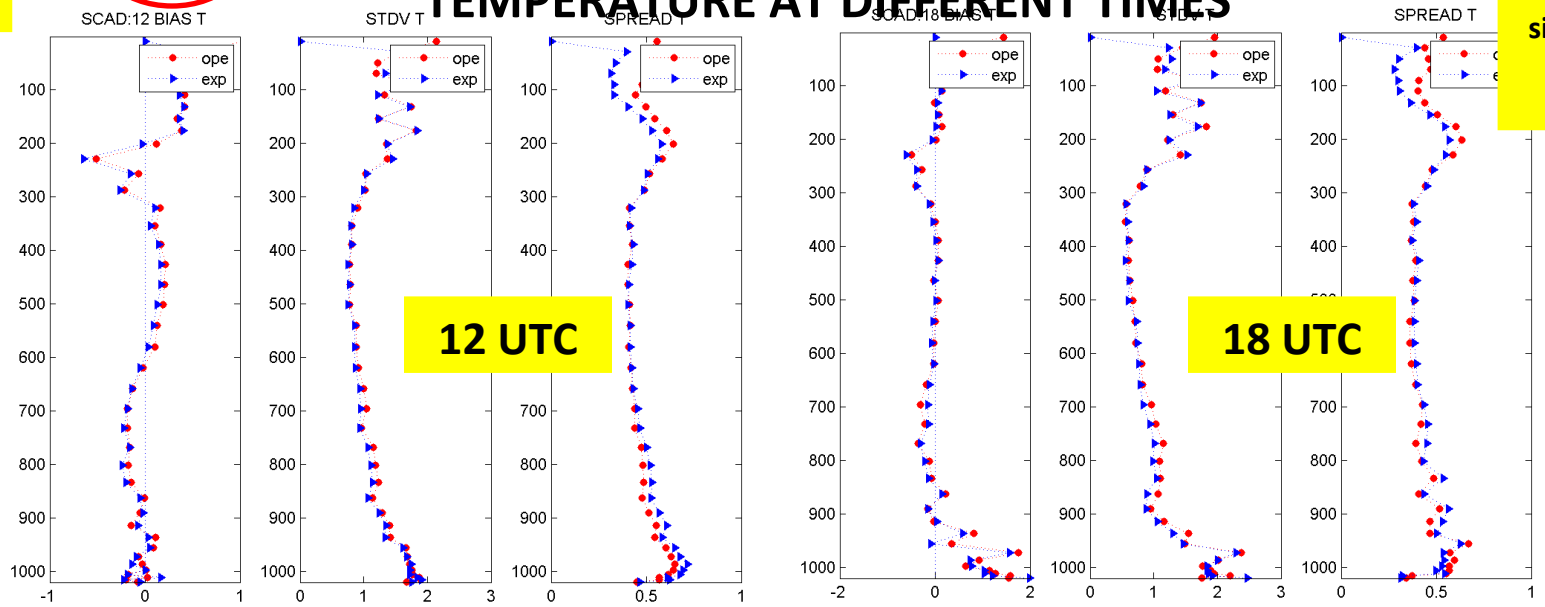
HRM vs COSMO LETKF: 00UTC

RAOB obs increment statistics on 40 p-levels from 28 apr 2012 to 01 jun 2012



Larger T obs incr. (colder) bias in COSMO LETKF

TEMPERATURE AT DIFFERENT TIMES



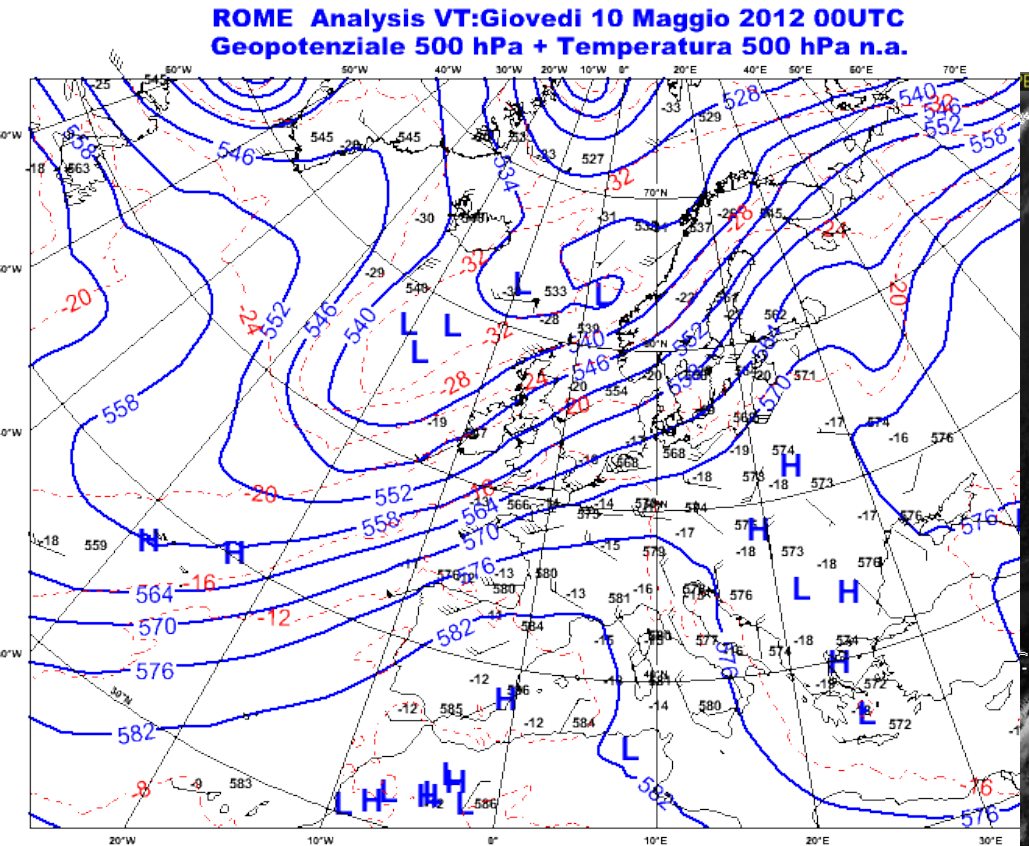
Small sample size at 06 and 18 UTC

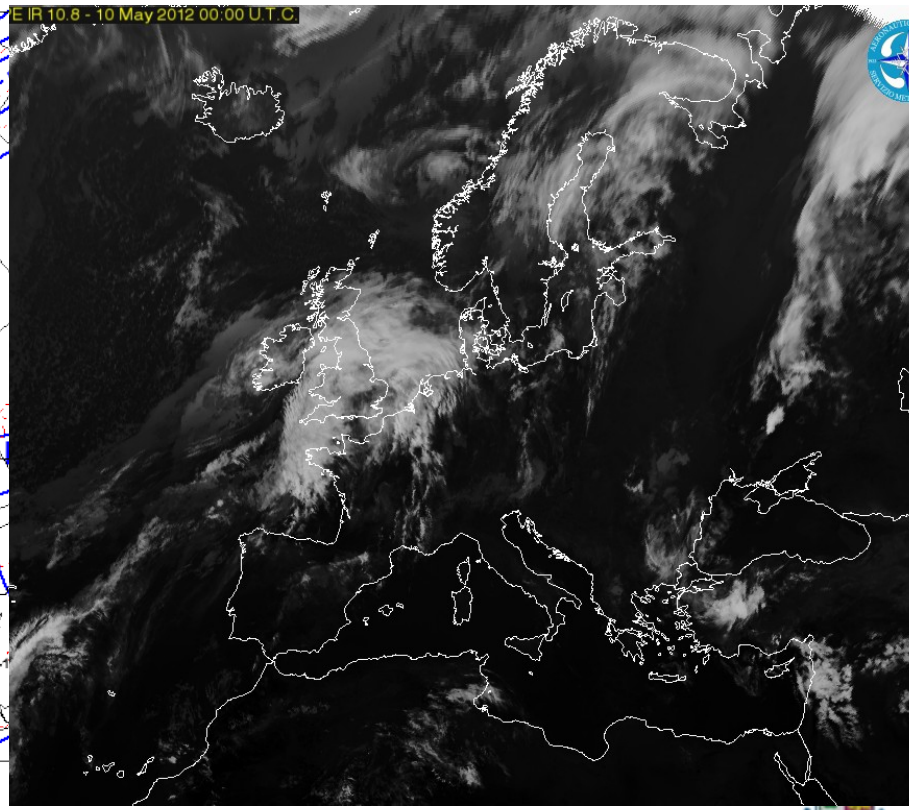
COSMO LETKF: 00UTC

Nocturnal Colder Bias in COSMO Background Ensemble Mean

10-11 May 2012 CASE STUDY

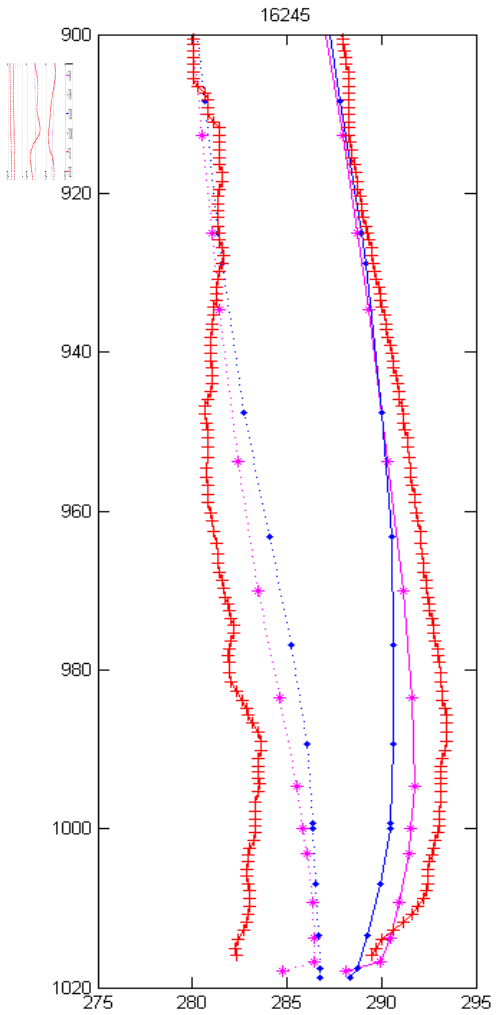
Upper level ridge over SW Europe → Subsidence → Stable condition



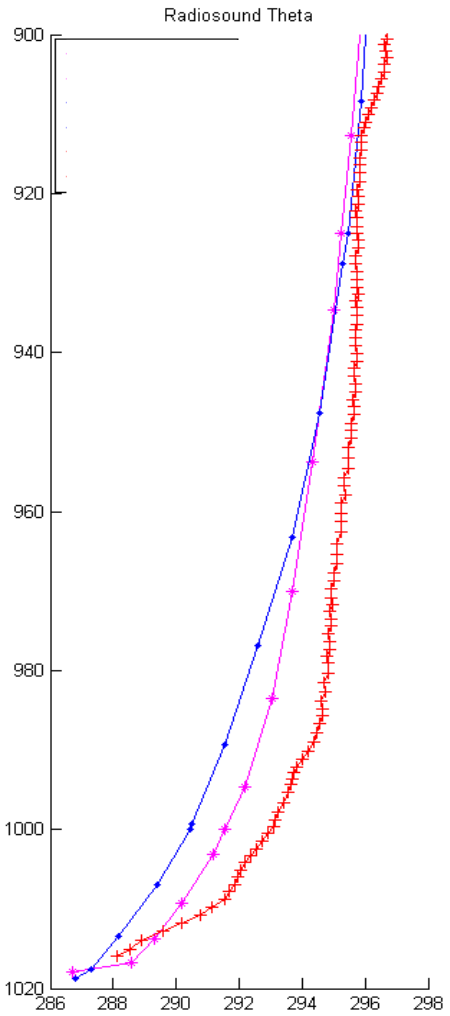


HRM vs COSMO LETKF: 00UTC

PRATICA DI MARE RAOB 20120510 00UTC HRM VS COSMO



Td T



Theta

The strong cooling thermal inversion is not well represented using COSMO model. HRM makes a better job!

COSMO LETKF: 00UTC

Sensitivity to the turbulence scheme

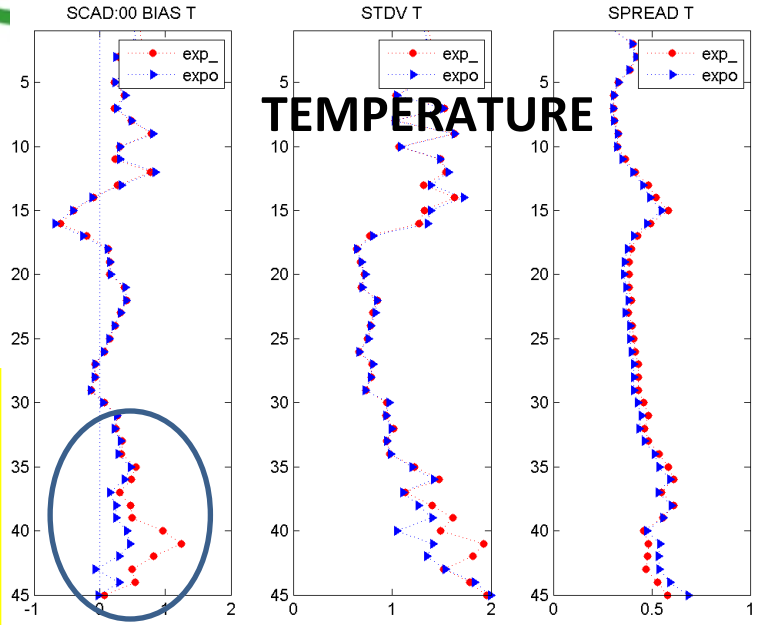
10-11 May 2012 CASE STUDY

RAOB obs increment statistics on 45 COSMO model levels at 00UTC

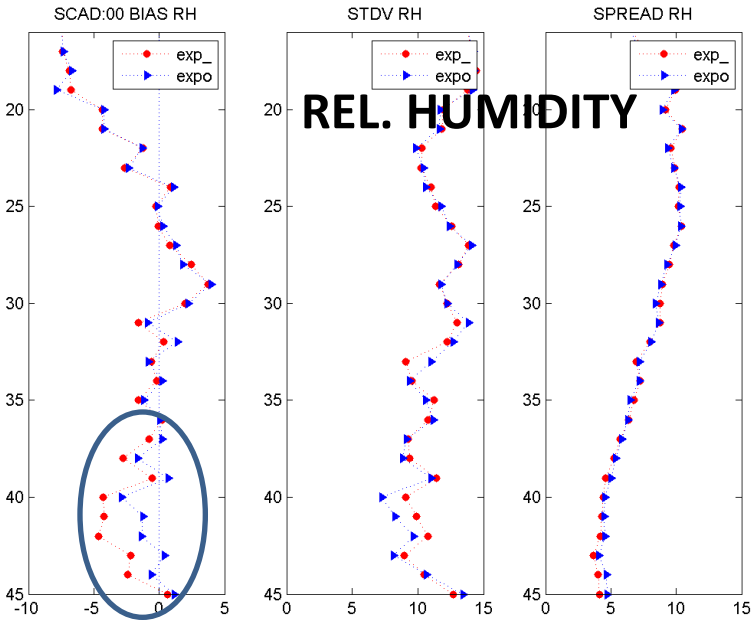
OLD (DIAG. TKE) VS OPE (PROG. TKE) TURBULENCE SCHEME

Larger T obs incr. (colder) bias using the oper. turbulence scheme

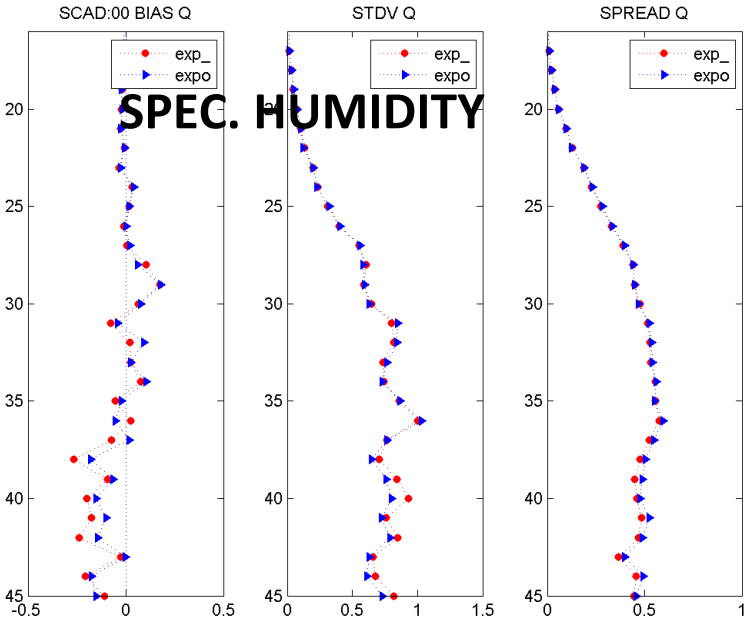
TEMPERATURE



REL. HUMIDITY



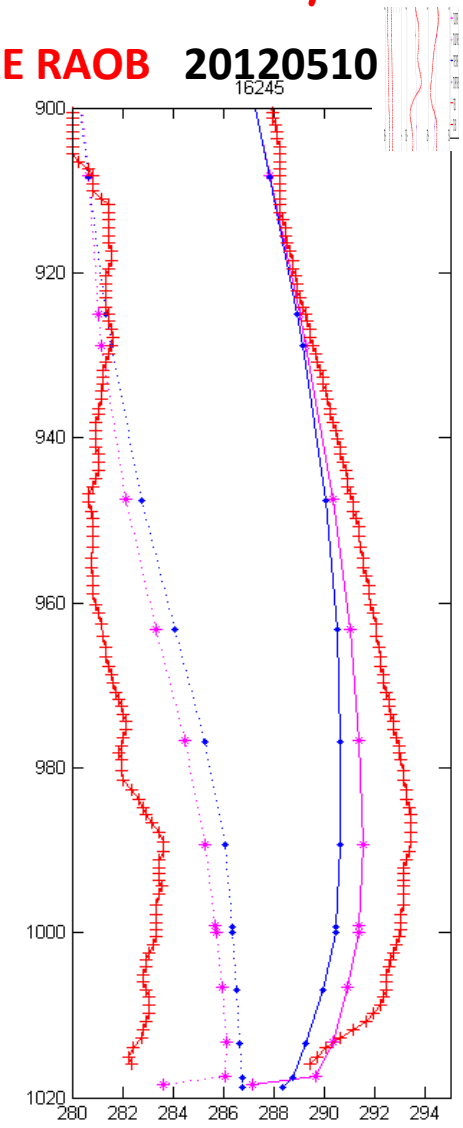
SPEC. HUMIDITY

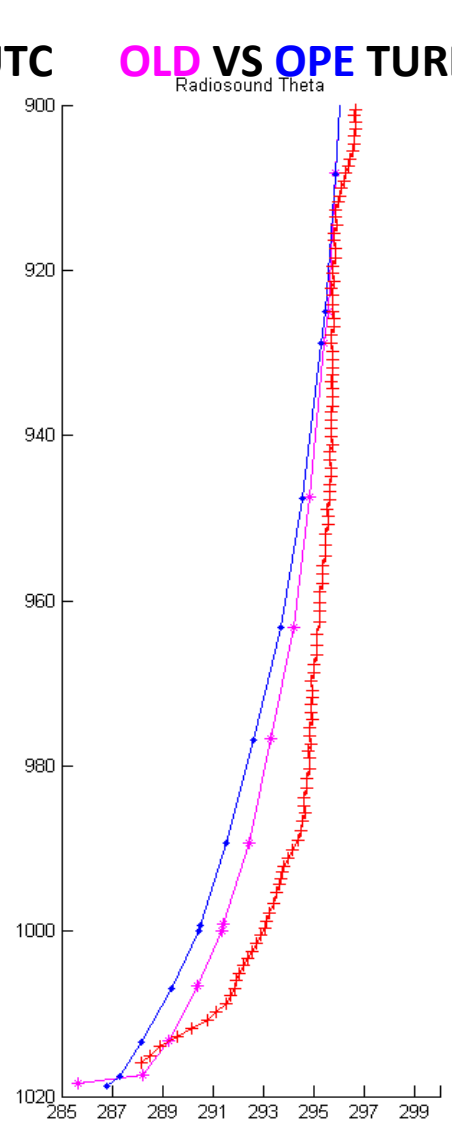


COSMO LETKF: 00UTC

Sensitivity to the turbulence scheme

PRATICA DI MARE RAOB 20120510 00UTC OLD VS OPE TURBULENCE SCHEME

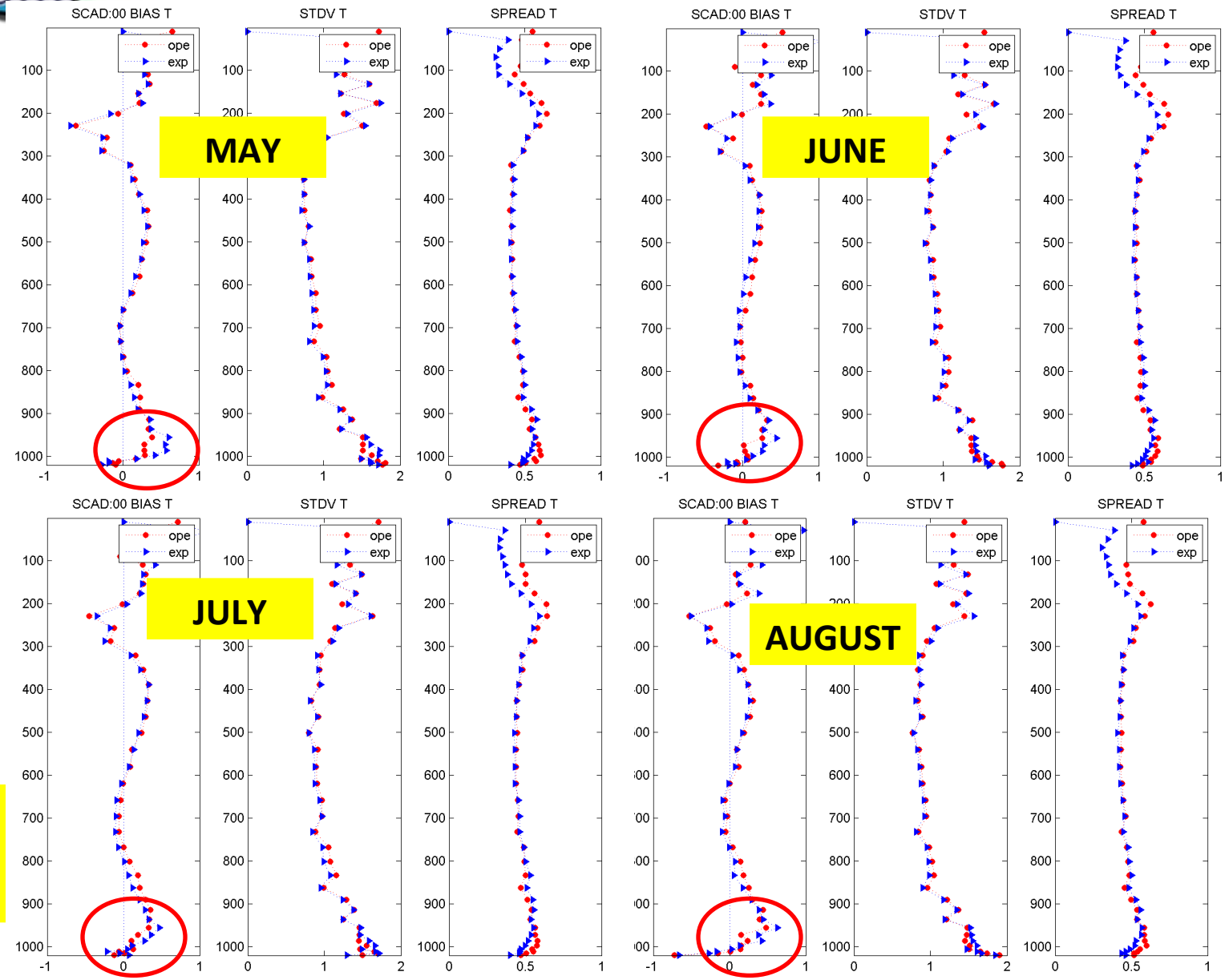




The strong cooling thermal inversion is not well represented in COSMO using the prognostic TKE (ope) turbulence scheme. COSMO with the diagnostic TKE (old) scheme makes a slightly better job.

HRM vs COSMO LETKF: 00 UTC

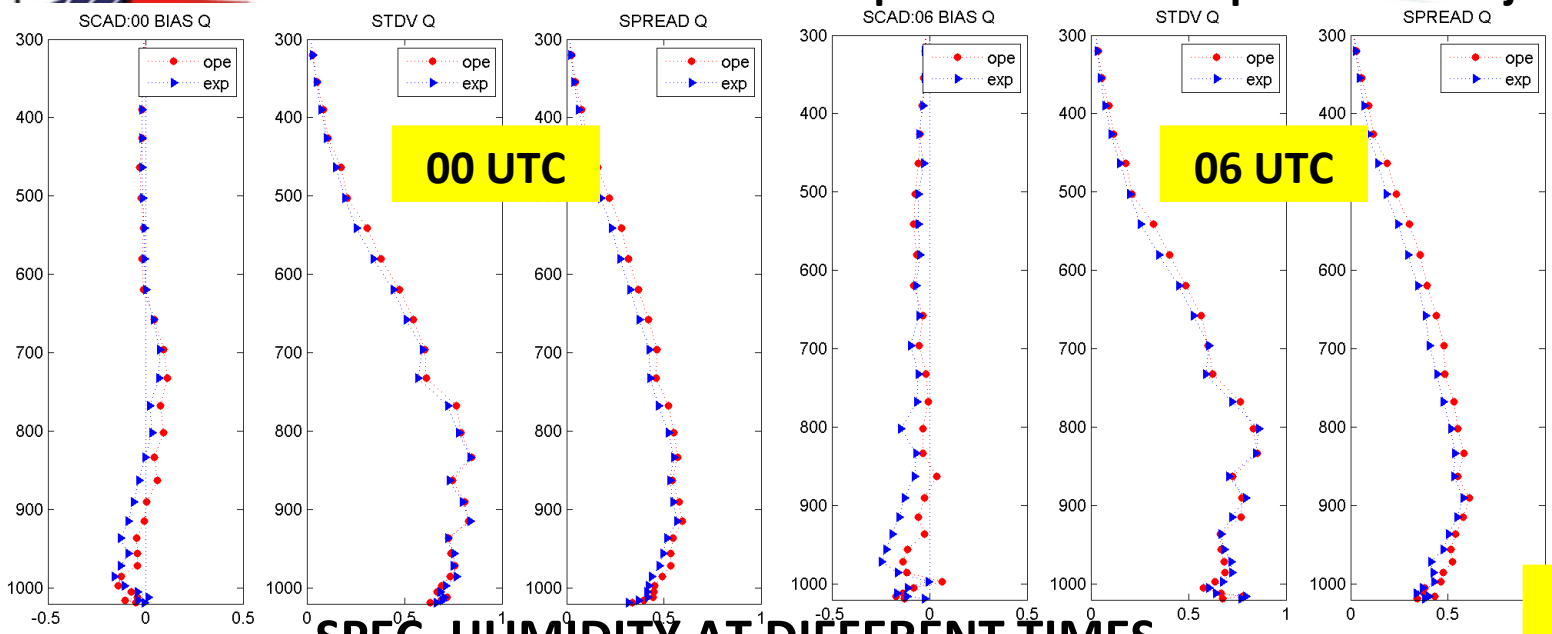
TEMPERATURE *MONTHLY STATISTICS*



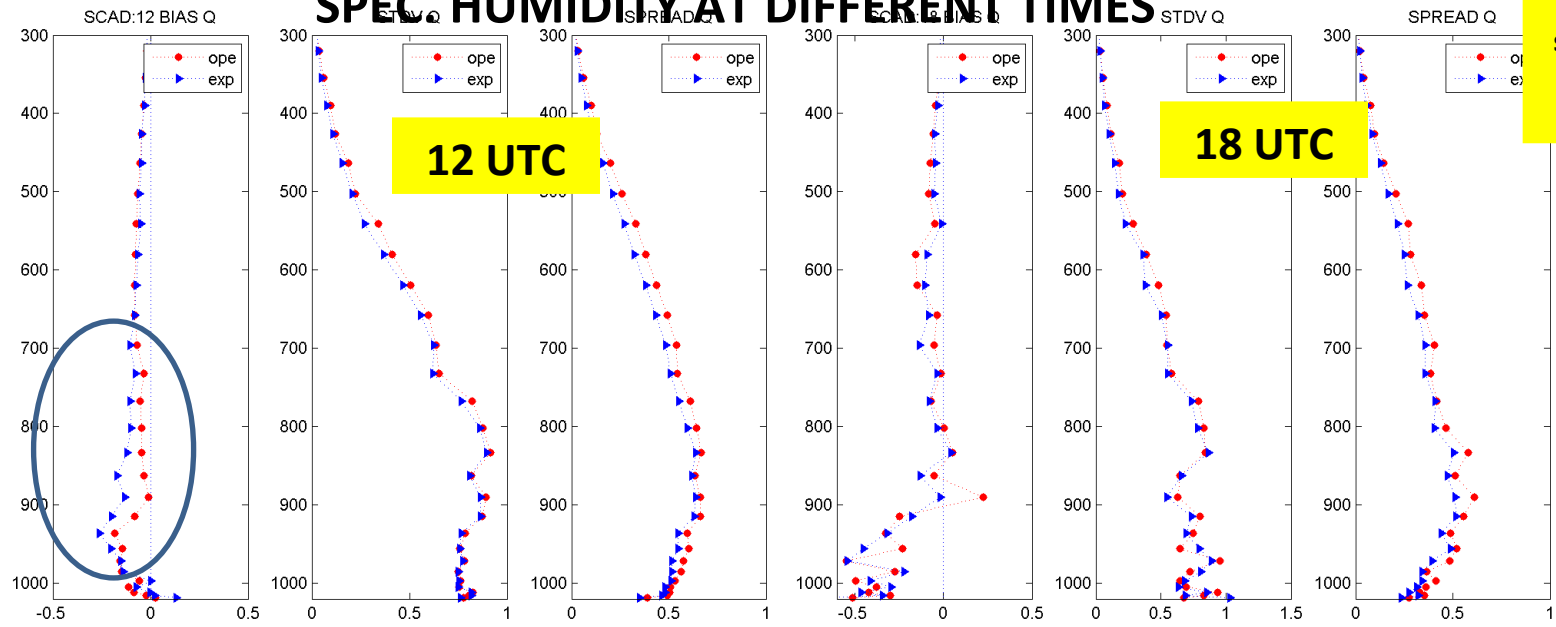
The problem disappears in the summer months.

HRM vs COSMO LETKF

RAOB obs increment statistics on 40 p-levels from 28 apr 2012 to 01 jun 2012



SPEC. HUMIDITY AT DIFFERENT TIMES

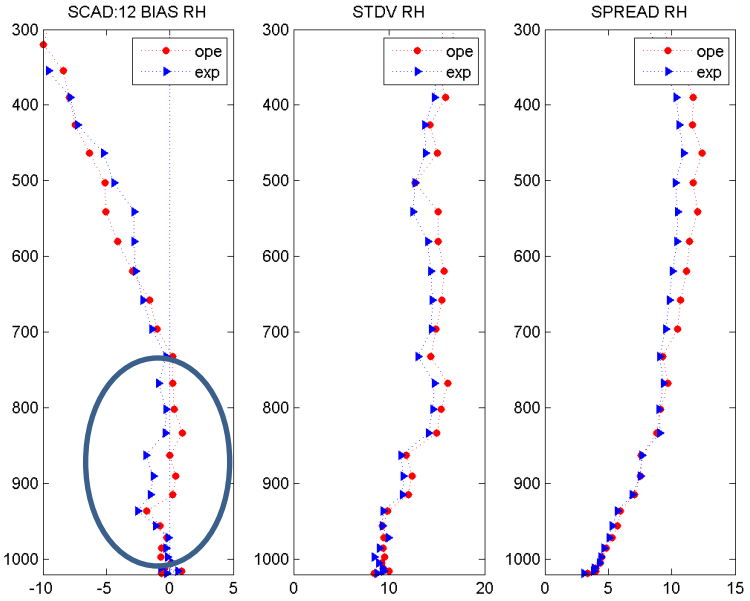


Small sample size at 06 and 18 UTC

Smaller qv obs incr. (moister) bias in COSMO LETKF

HRM vs COSMO LETKF: 12 UTC

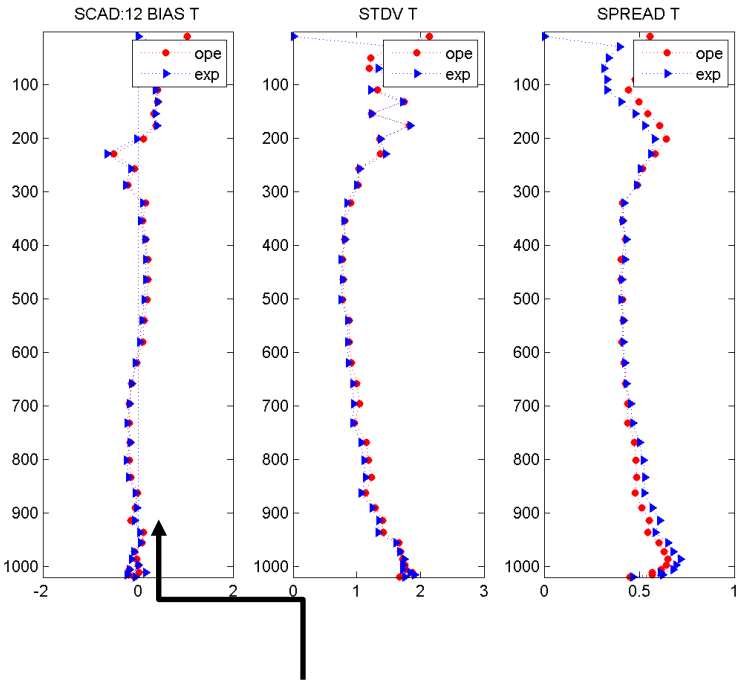
REL. HUMIDITY



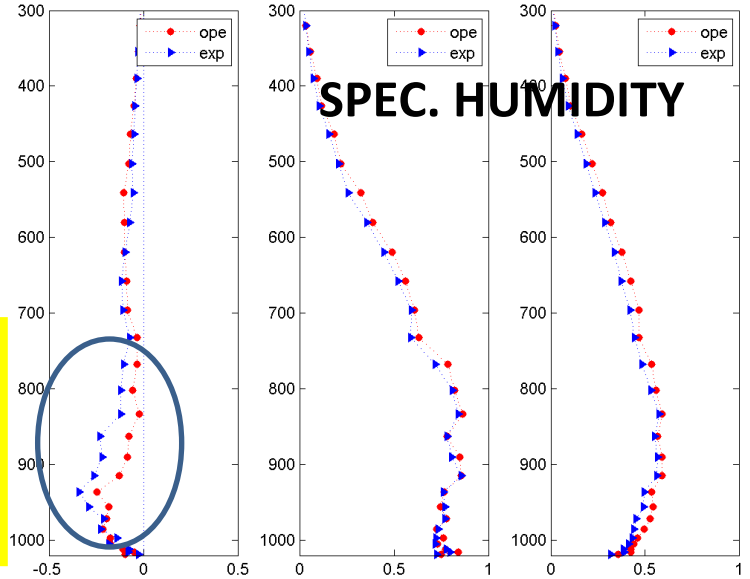
RAOB obs increment statistics on 40 p-levels from 28 apr 2012 to 01 jun 2012 at 12UTC

Smaller RH obs incr. (moister) bias in COSMO LETKF

TEMPERATURE



SPEC. HUMIDITY



Smaller qv obs incr. (moister) bias in COSMO LETKF

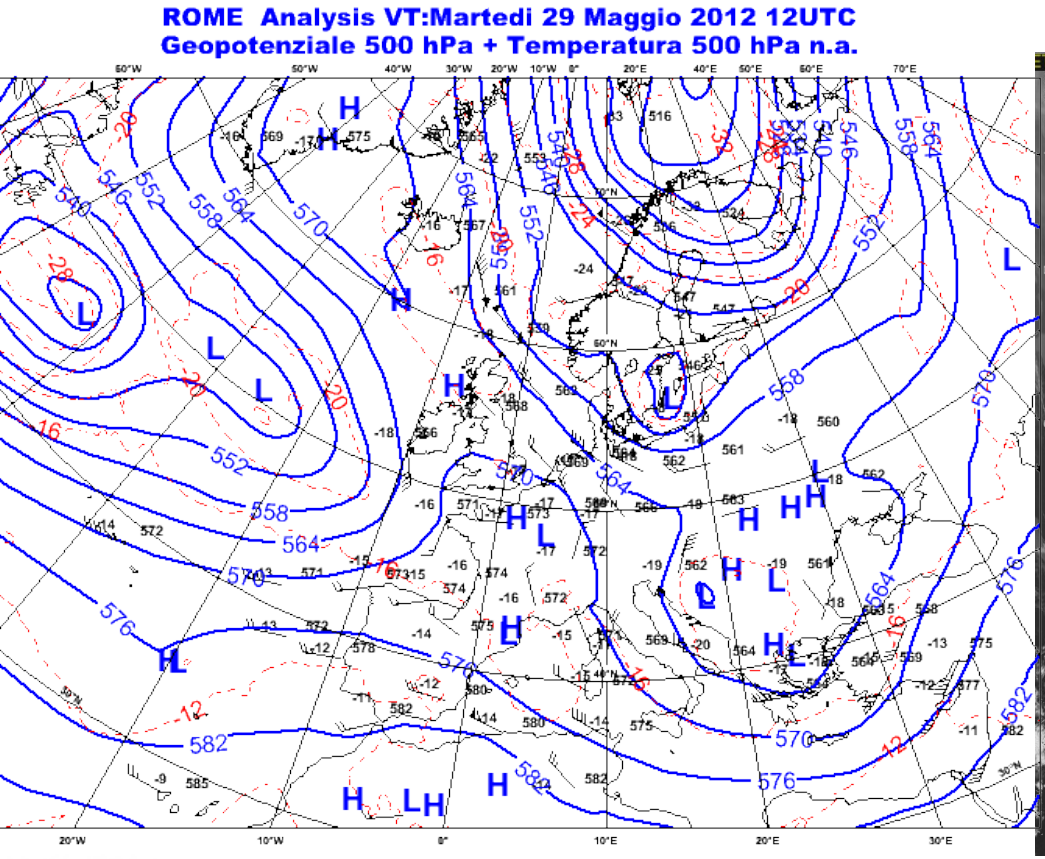
NO TEMPERATURE OBS INCR. BIAS

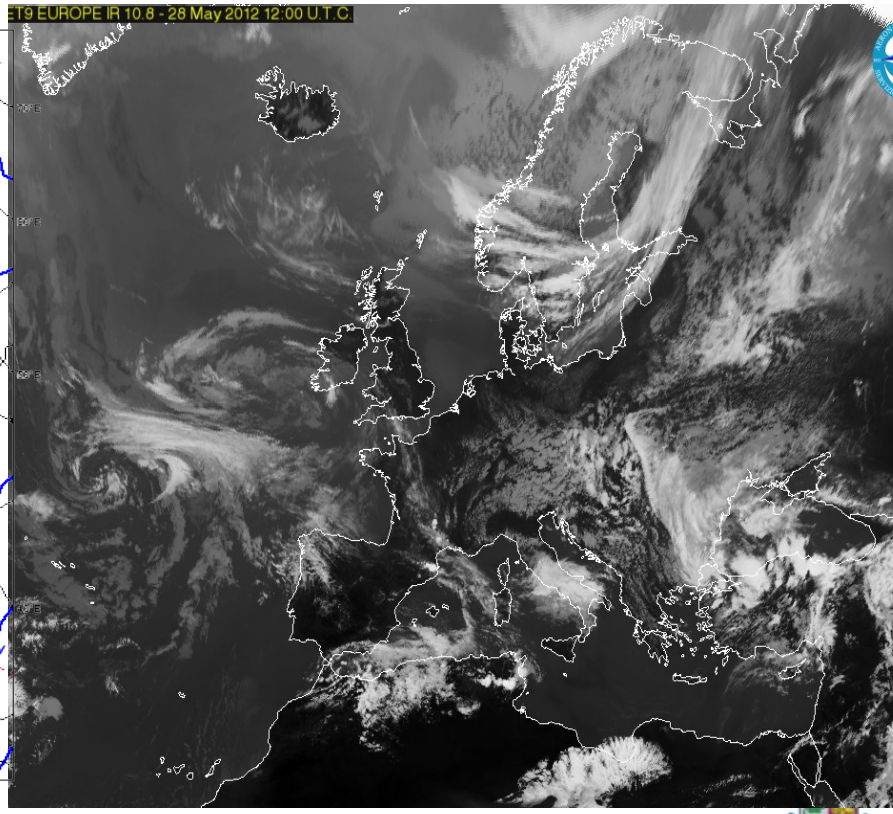
COSMO LETKF: 12 UTC

Diurnal Moister Bias in COSMO Background Ensemble Mean

28-29 May 2012 CASE STUDY

Weak cyclonic circulation over SE Europe





COSMO LETKF: 12 UTC

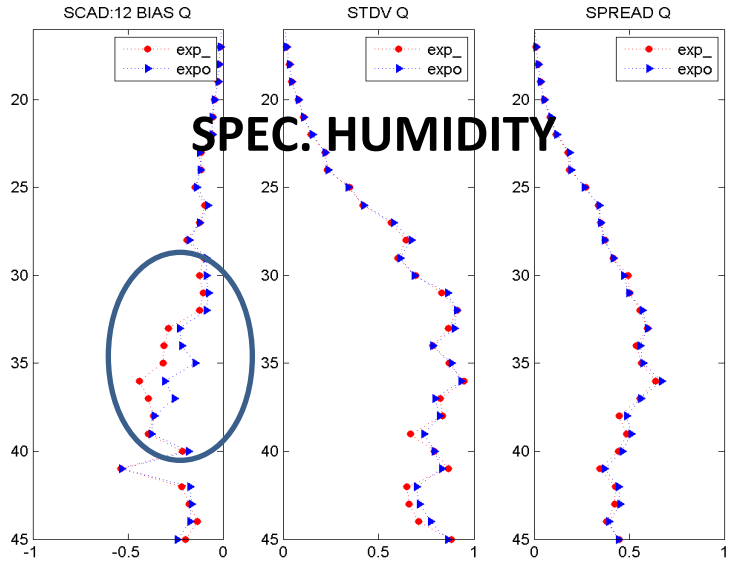
Sensitivity to the turbulence scheme

28-29 May 2012 CASE STUDY

RAOB obs increment statistics on 45 COSMO model levels at 12 UTC

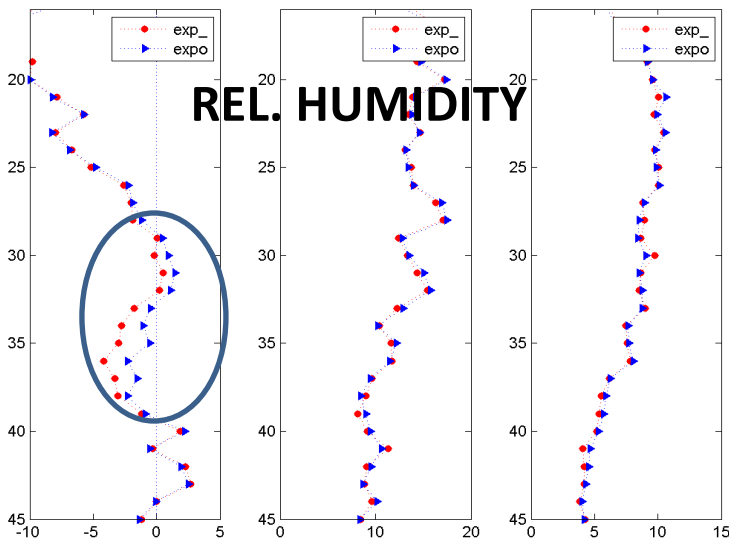
OLD (DIAG. TKE) VS OPE (PROG. TKE) TURBULENCE SCHEME

SPEC. HUMIDITY



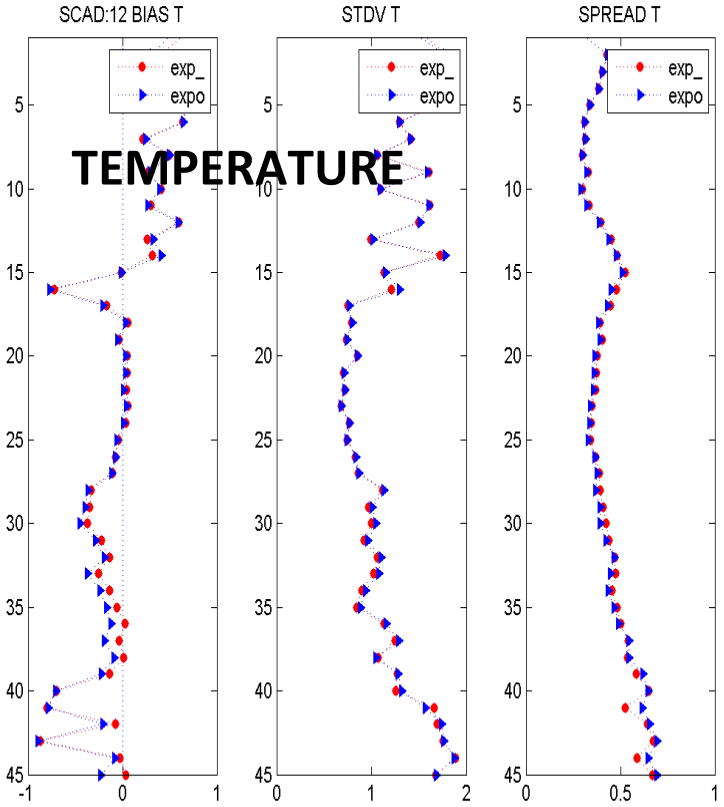
Smaller qv obs incr. (moister) bias using the oper. turbulence scheme

REL. HUMIDITY



Smaller RH obs incr. (moister) bias using the oper. turbulence scheme

TEMPERATURE



COSMO LETKF: 12 UTC

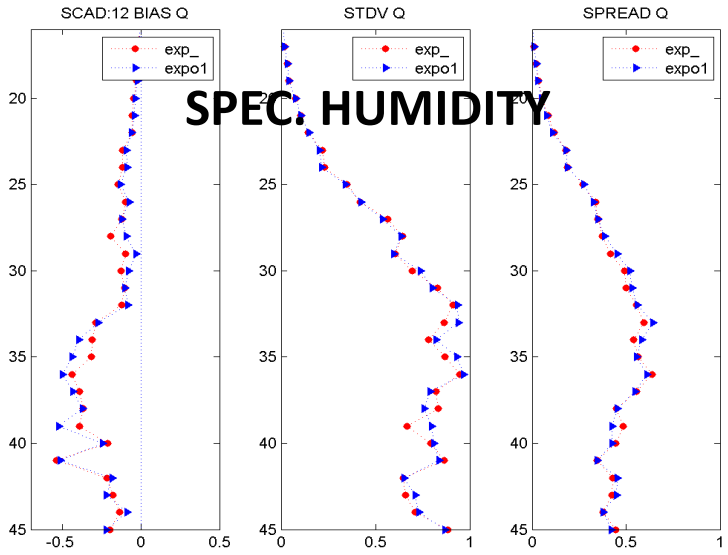
Sensitivity to the convection scheme

28-29 May 2012 CASE STUDY

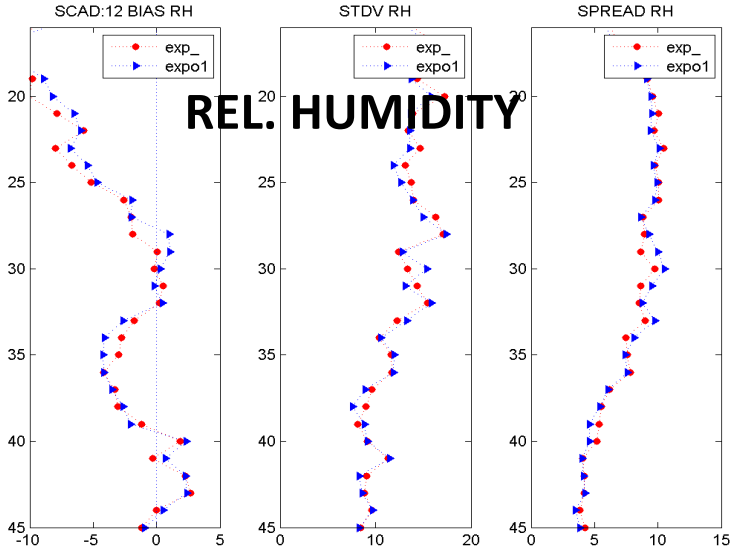
RAOB obs increment statistics on 45 COSMO model levels at 12 UTC

EXP (KAIN-FRITSCH) VS OPE (TIEDTKE) CONVECTION SCHEME

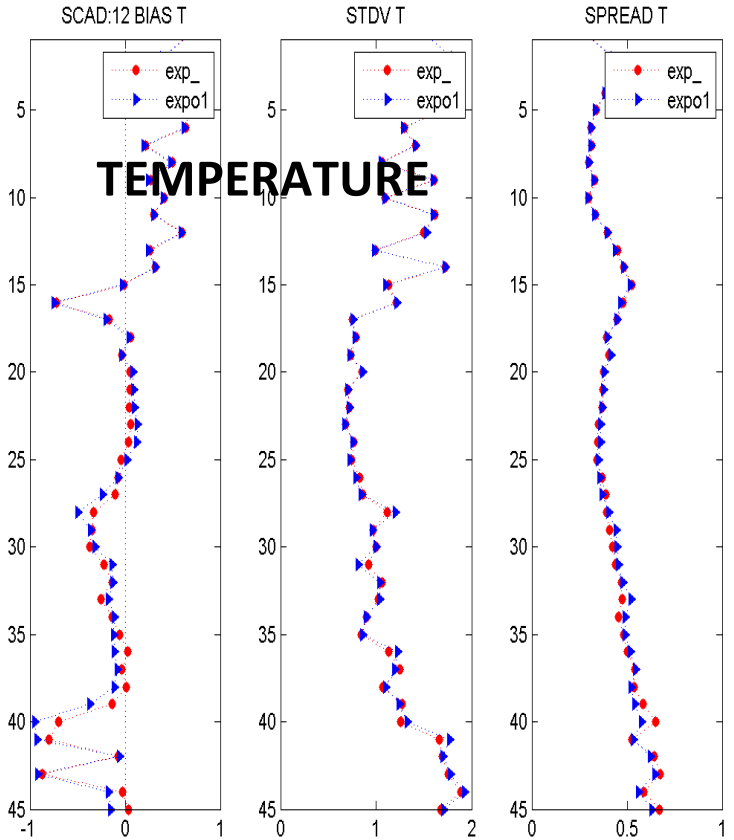
SPEC. HUMIDITY



REL. HUMIDITY



TEMPERATURE

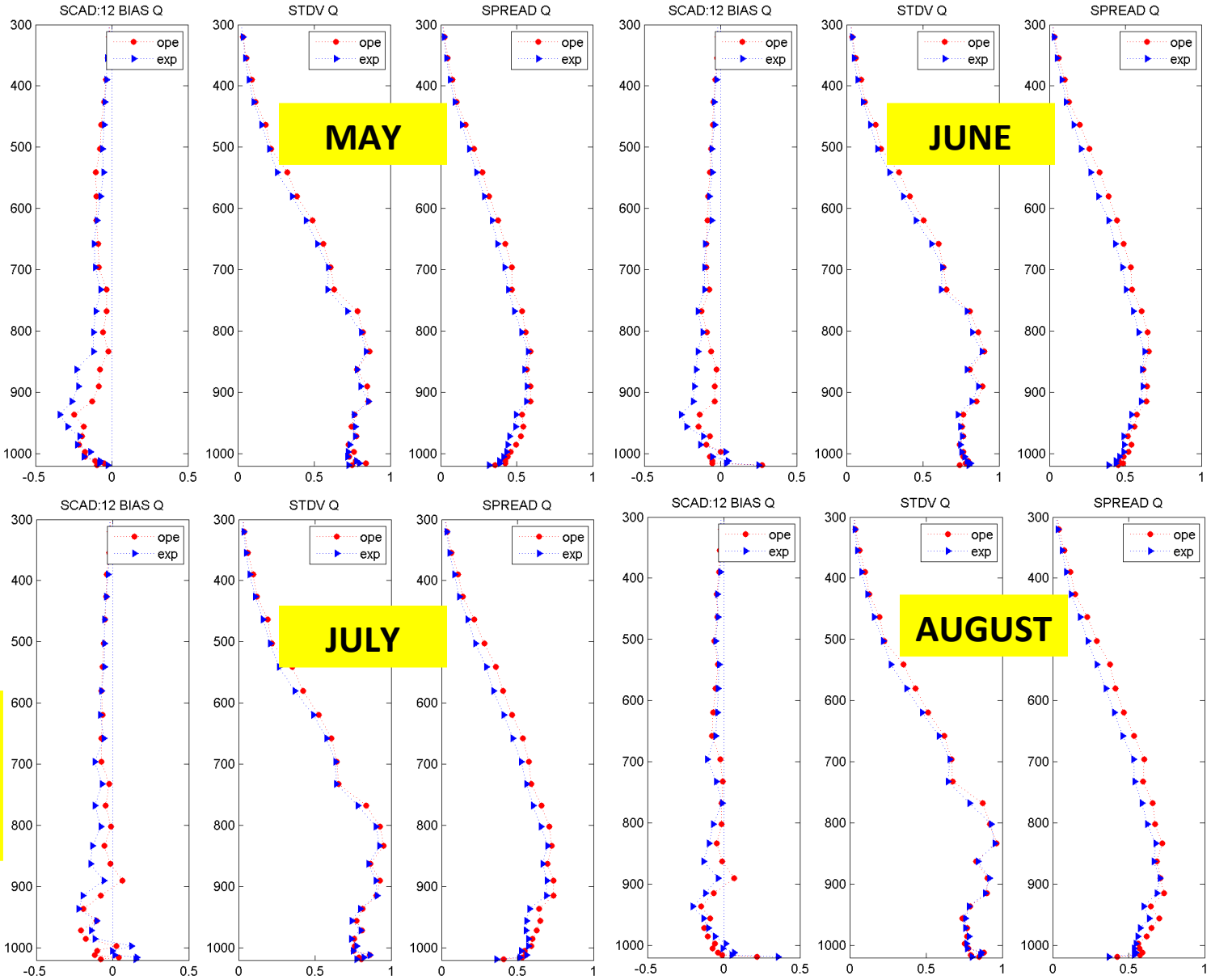


Smaller qv obs incr. (moister) bias using the exp KF convection scheme.

The use of Kain-Fritsch scheme deteriorates the BG ensemble mean

HRM vs COSMO LETKF: 12 UTC

SPEC. HUMIDITY *MONTHLY STATISTICS*



The problem is present in the period under examination.

Summary of Results

From observation increment statistics :

Nocturnal larger negative temperature bias near the surface in COSMO-LETKF background ensemble mean

- COSMO-LETKF with TKE prognostic turbulence scheme tends to produce less intense cooling thermal inversion than the HRM-LETKF (even if it does not well reproduce the observed situation).

Is the prognostic TKE scheme too diffusive ?

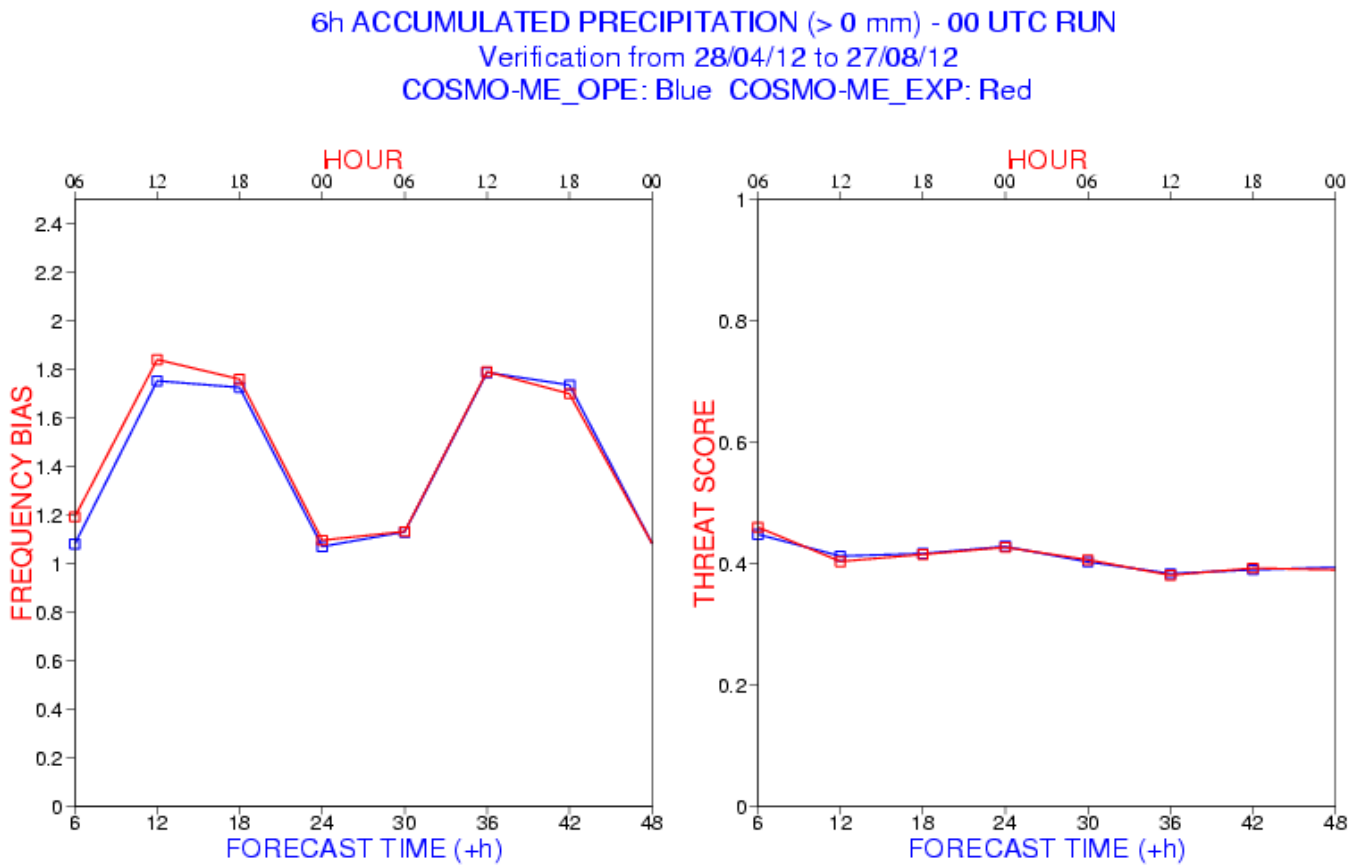
- The use of the old turbulence scheme slightly improves the performance of COSMO-LETKF background ensemble mean near the surface

Diurnal larger positive humidity bias in the middle-lower troposphere using COSMO model

- COSMO-LETKF with TKE prognostic turbulence scheme tends to moisten the troposphere more than the HRM-LETKF.
- The use of the old turbulence scheme seems to have a very small positive impact
- The use of the Kain-Fritch convection scheme does not improve the performance of COSMO-LETKF background ensemble mean

HRM vs COSMO LETKF: 00 UTC

COSMO-ME objective verification against SYNOP



Very slight precipitation over-estimation using COSMO-LETKF

Conclusions

- CNMCA has planned to substitute HRM with COSMO model in its ensemble data assimilation (LETKF) system, which is used operationally to initialize the deterministic COSMO-ME model
- COSMO-LETKF and HRM-LETKF performances were compared for spring-summer 2012
- Observation increment statistics shows two well-known deficiencies. COSMO model is too humid and the prognostic TKE turbulence scheme is not able to reproduce correctly the strong cooling inversion in spring.
- Objective verification of COSMO-ME forecasts from both LETKF systems shows no significant differences, except for a very slight precipitation over-estimation using COSMO-LETKF

Future Developments

- Comparison of COSMO and HRM-LETKF in fall-winter period
- Assimilation of AMSU-B/MHS and IASI retrievals
- Use of KENDA and contribution to its improvement

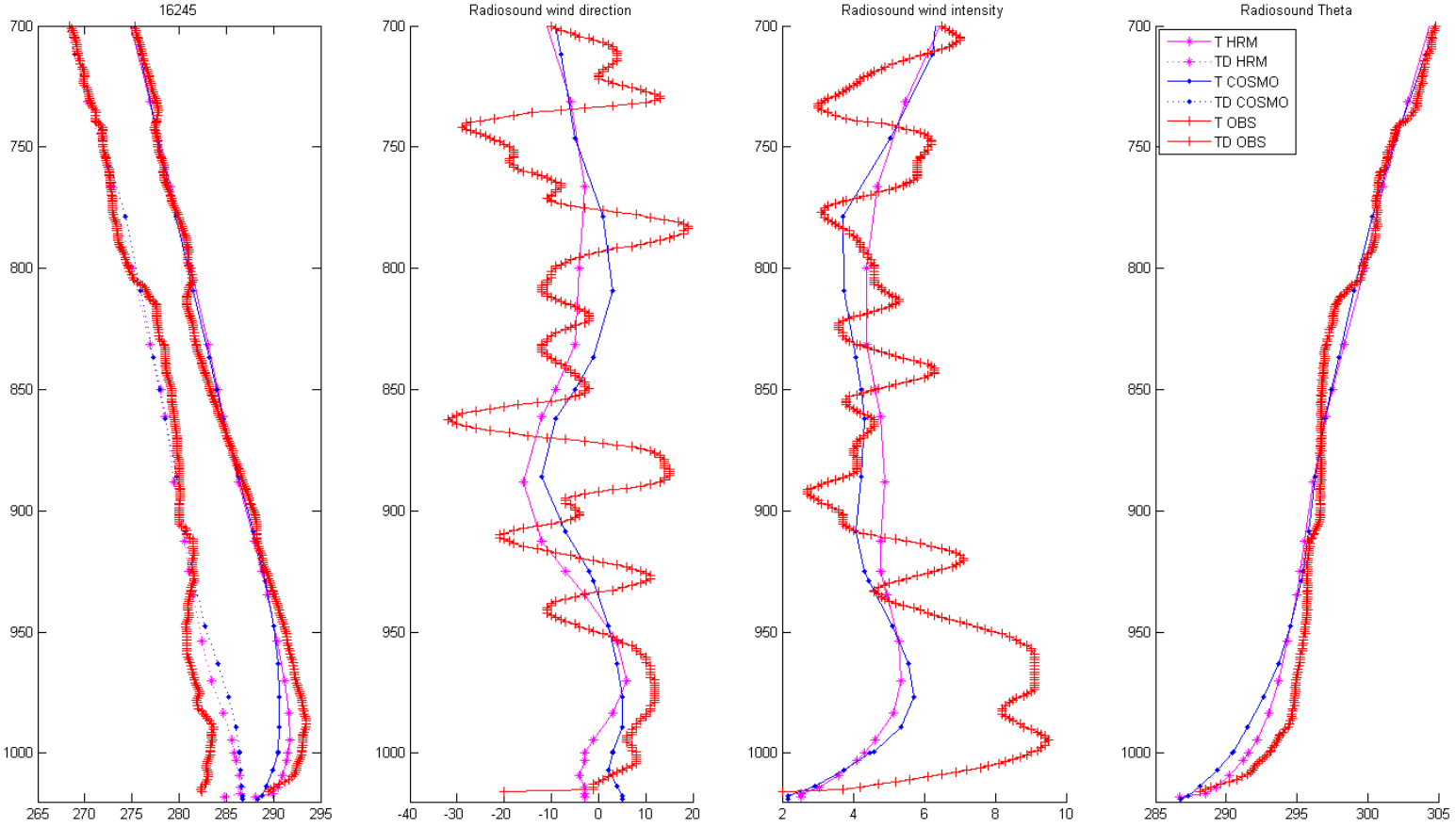
- Tests with shorter assimilation window
- Further tuning of model error representation (tuning of cov. localization, self-evolved additive noise, bias correction, etc.)
- Implement a Short-Range EPS based on LETKF

Thanks for your attention!

HRM vs COSMO LETKF: 00UTC

2/8 cloud coverage

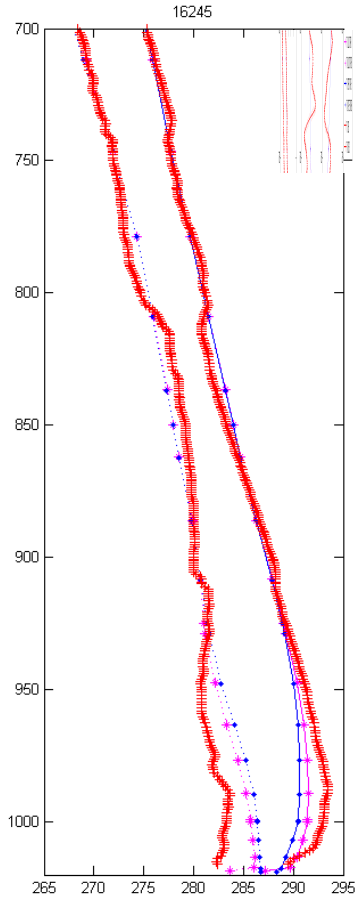
PRATICA DI MARE RAOB 20120510 00UTC HRM VS COSMO



COSMO LETKF: 00UTC

Sensitivity to the turbulence scheme

PRATICA DI MARE RAOB 20120510 00UTC OLD VS OPE TURBULENCE SCHEME



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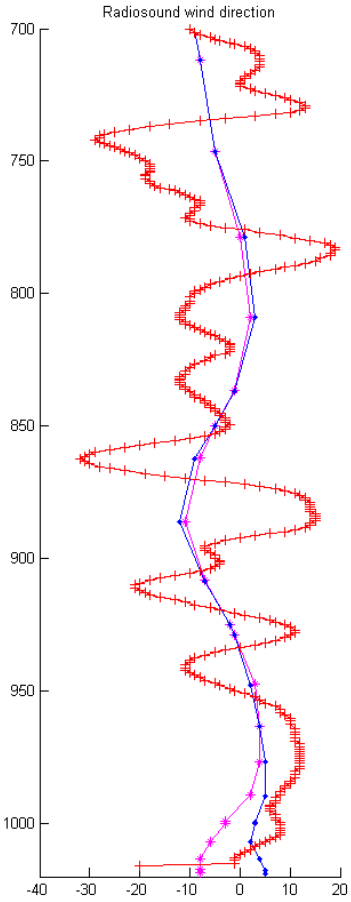
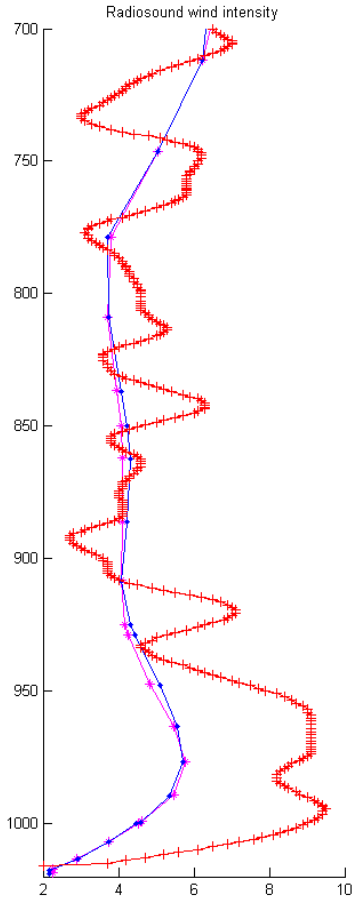


Dir



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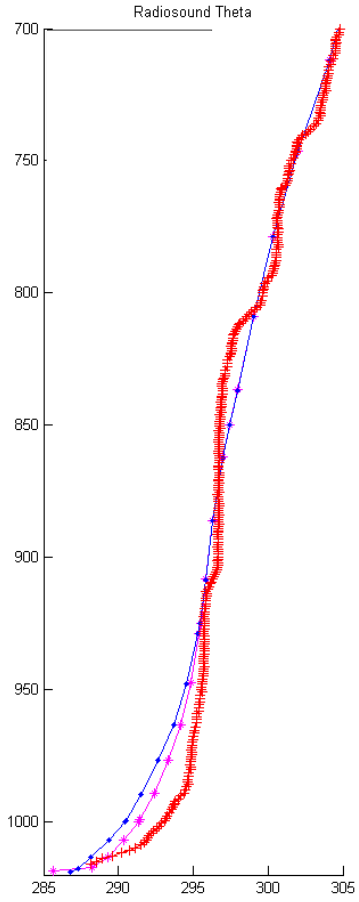
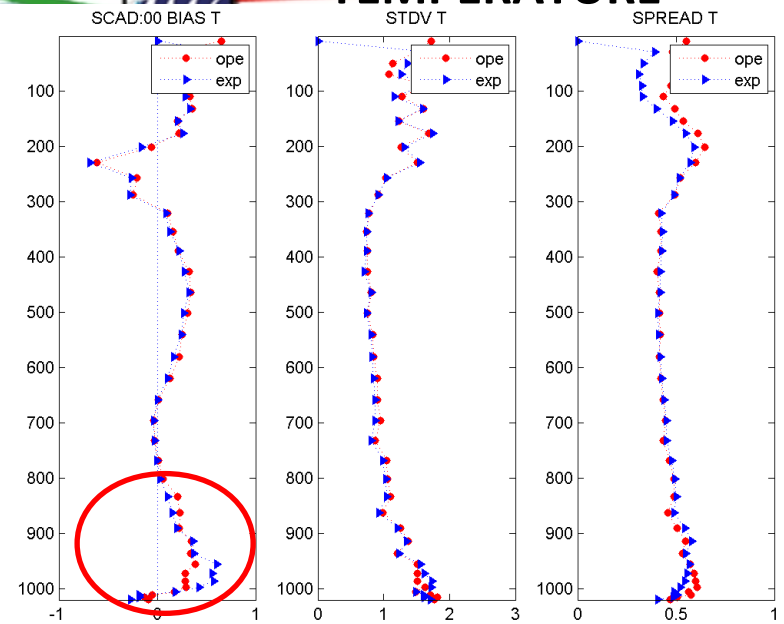


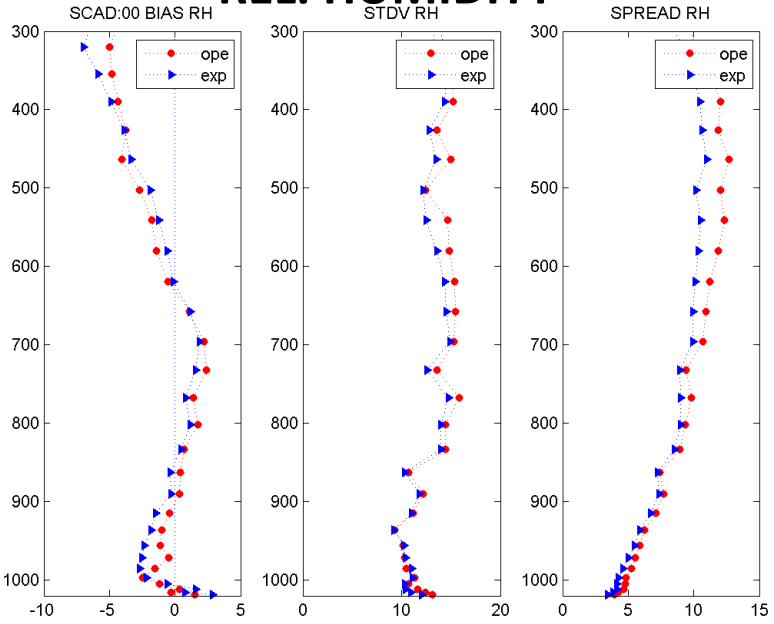
Theta

HRM vs COSMO LETKF: 00UTC

TEMPERATURE

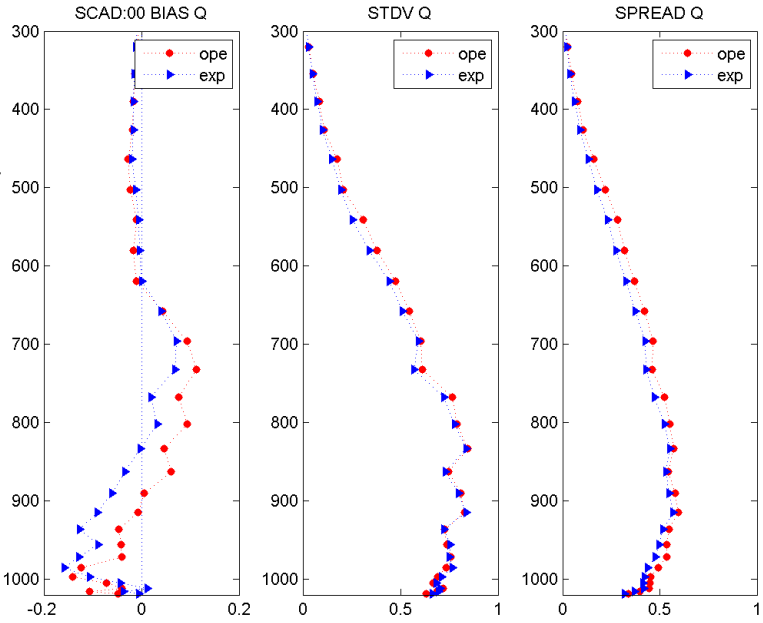


REL. HUMIDITY



Larger T obs incr. (colder) bias in COSMO LETKF

SPEC. HUMIDITY



RAOB obs increment statistics on 40 p-levels from 28 apr 2012 to 01 jun 2012 at 00UTC