The CNMCA Operational LETKF Data Assimilation System

CNMCA - Italian National Met. Center, Rome - Italy

Lucio Torrisi & Francesca Marcucci

CNMCA - EnKF DA (*Bonavita, Torrisi and Marcucci, Q.J.R.M.S.,2008,2010*)

- ***OPERATIONAL SINCE 1 JUNE 2011*** to initialize the 7km COSMO-ME model

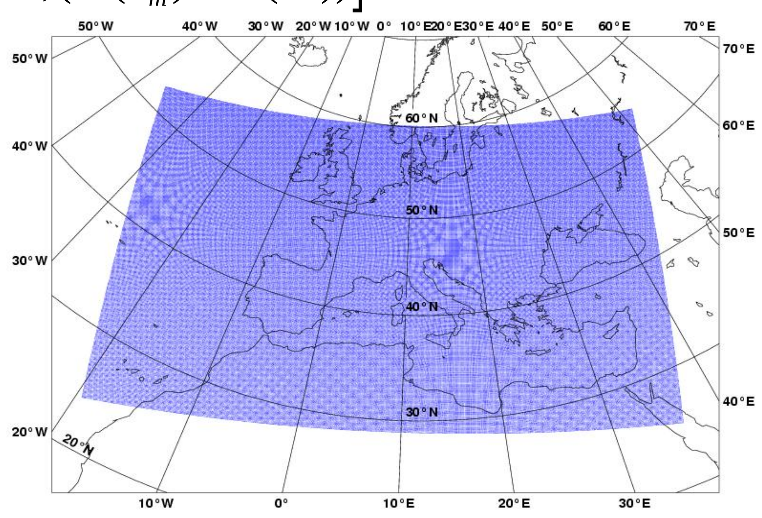
  CNMCA is the first meteorological centre which uses operationally a pure EnKF DA to initialize a deterministic NWP model

- ***LETKF Formulation*** *(Hunt et al,2007)*

Analysis Ensemble Mean: $\bar{x}^a = \bar{x}^b + X^b \bar{w}^a$ $\quad \bar{w}^a = \tilde{P}^a Y^{bT} R^{-1}(y - H(x^b))$ $\quad \tilde{P}^a = \left[(m-1)I + Y^{bT} R^{-1} Y^b\right]^{-1}$

Analysis Ensemble Perturb.: $X^a = X^b W^a$ $\quad W^a = \left[(m-1)\tilde{P}^a\right]$ $\quad Y^b = \left[(H(x_1^b) - \overline{H(x^b)}),....,(H(x_m^b) - \overline{H(x^b)})\right]$

- 6-hourly assimilation cycle
- 40 ensemble members + control run with 0.09° (~10Km) grid spacing (HRM model), 40 hybrid p-sigma vertical levels (top at 10 hPa)
- (T,u,v,qv,ps) set of control variables
- Observations: RAOB, SYNOP, SHIP, BUOY, AIREP, AMDAR, ACAR, AMV (MSG), WindPROF, SCATwinds (METOP), AMSUA radiances (soon)



Model and sampling errors are taken into account using:

- "Relaxation-to-Prior Spread" Multiplicative Inflaction according to Whitaker et al (2010)

an. pert. $x'_a = x'_a \sqrt{\alpha \frac{\sigma_b^2 - \sigma_a^2}{\sigma_a^2} + 1}$ $\quad \alpha = 0.95$, σ^2 = variance

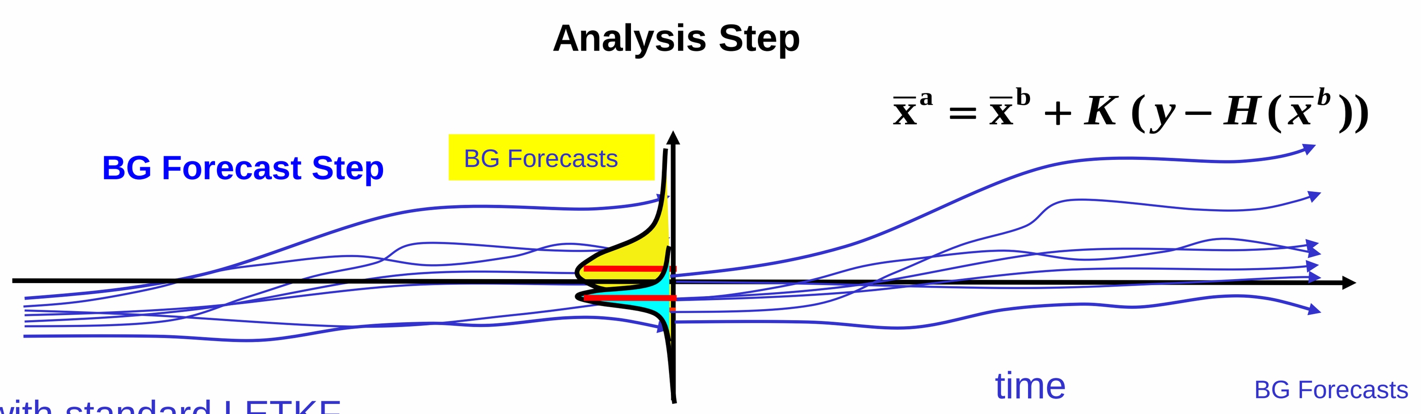
- Climatological Additive Noise

an. memb. $\mathbf{x}_i^a \leftarrow \mathbf{x}_i^a + \alpha \mathbf{x}_i^n, \quad \alpha \mathbf{x}_i^n \sim N(0, \mathbf{Q})$ $\quad \alpha$ Scale factor

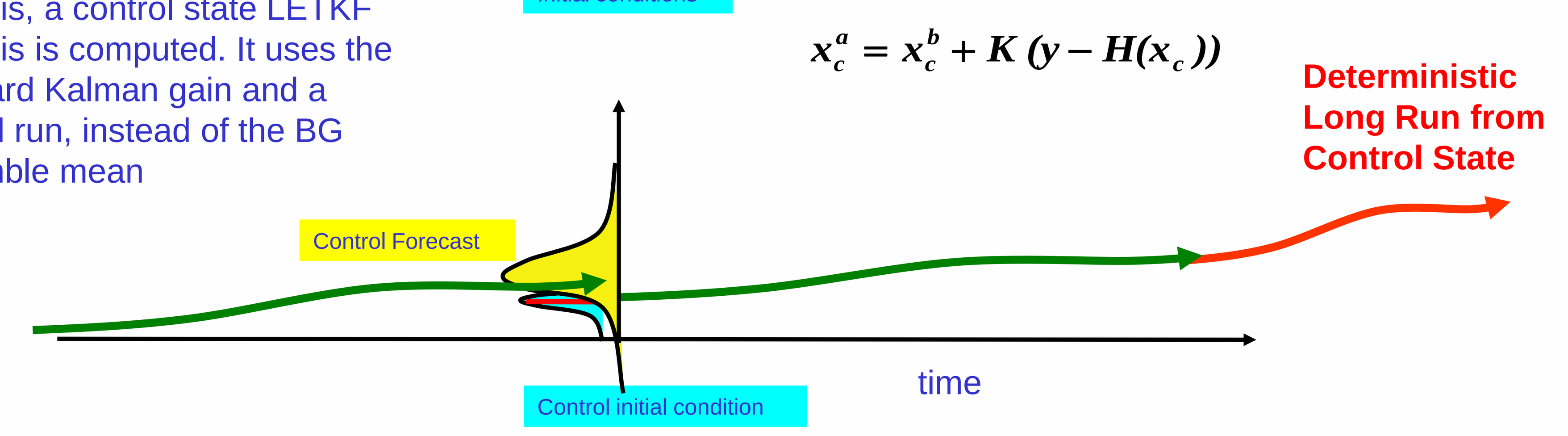
$\mathbf{x}_i^n$ randomly selected, 48-24h forecast differences

- Lateral Boundary Condition Perturbation using EPS
- Climatological Perturbed SST
- Adaptive selection radius using a fixed number of effective observations (sum of obs weights)

Long Deterministic Run from LETKF



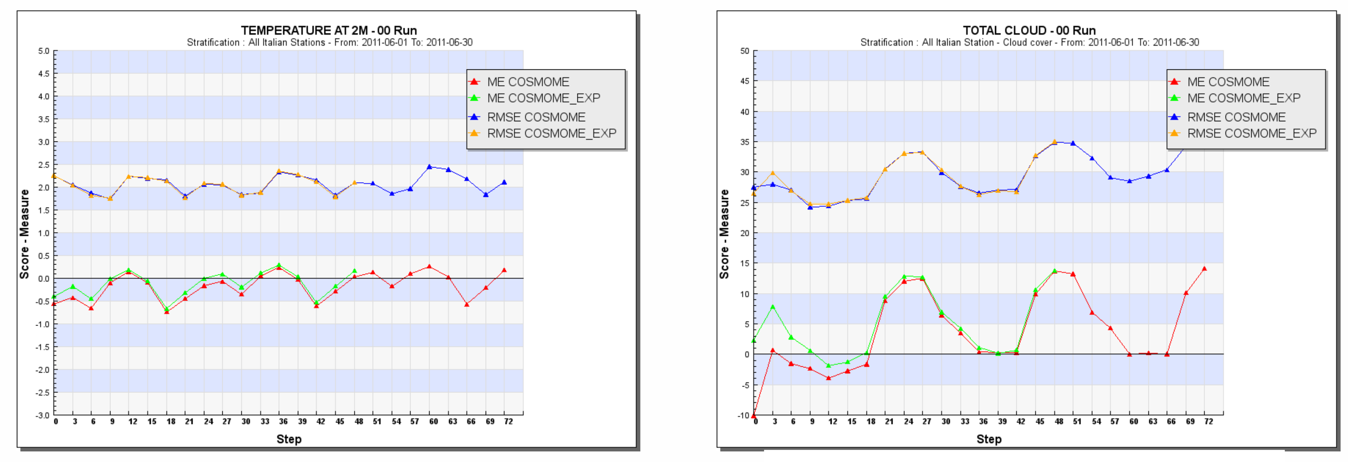
Along with standard LETKF analysis, a control state LETKF analysis is computed. It uses the standard Kalman gain and a control run, instead of the BG ensemble mean

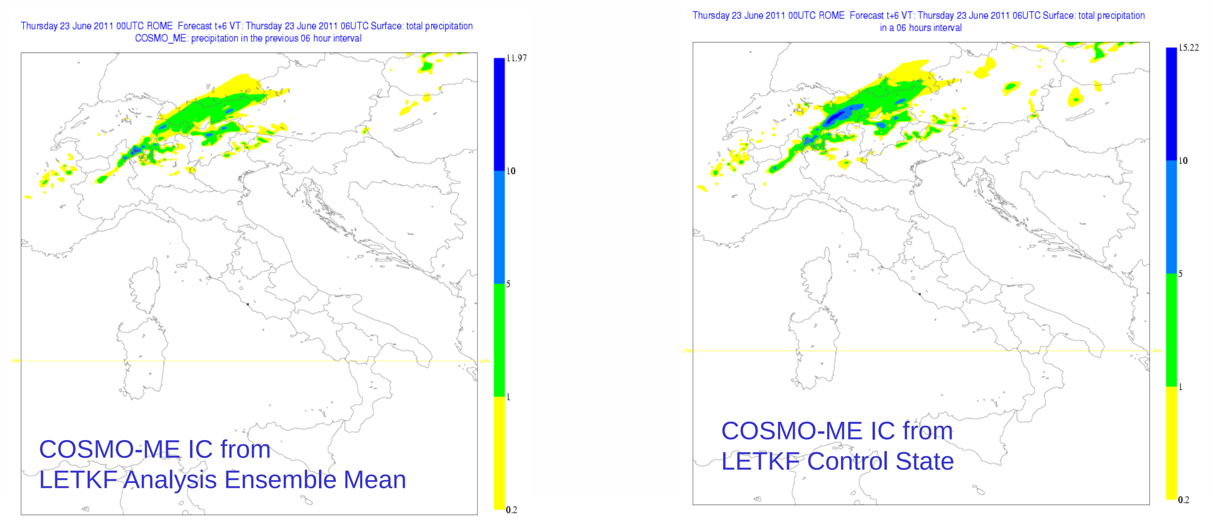


CONTROL vs MEAN STATE

June 2011: All Italian Stations

COSMOME_EXP = from LETKF Control State

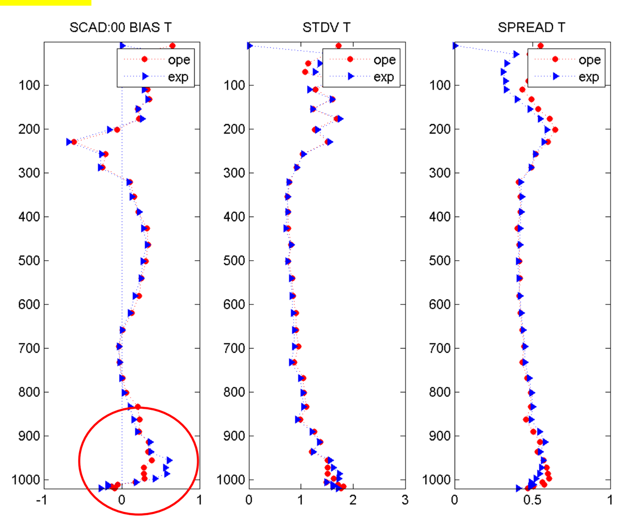




The use of a control state improves the first forecast hours with respect to the mean state (small scales filtered out)

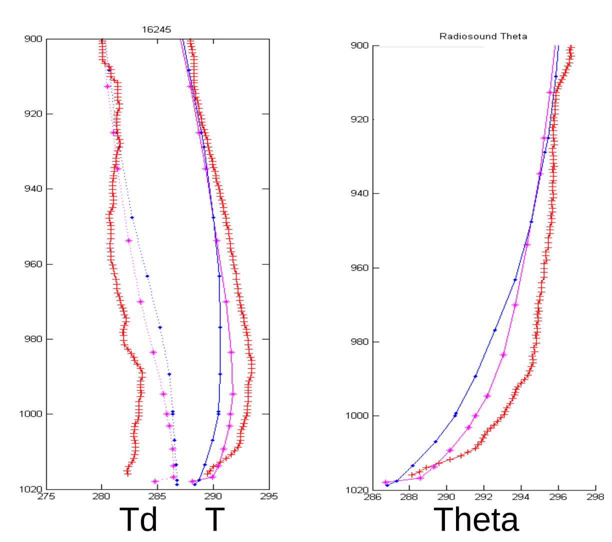
COSMO vs HRM prognostic model in LETKF

00 UTC 28 apr – 01 jun 2012: RAOB



Larger T obs incr. (colder) bias in COSMO LETKF. The problem disappears in the summer months (not shown)

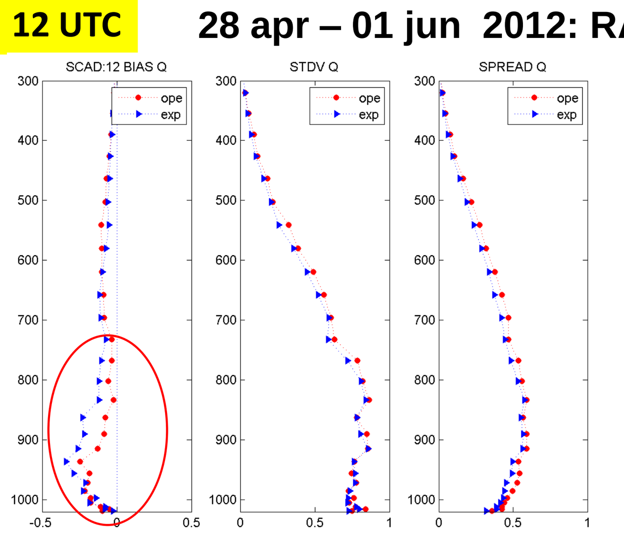
CASE STUDY : 20120510 00UTC



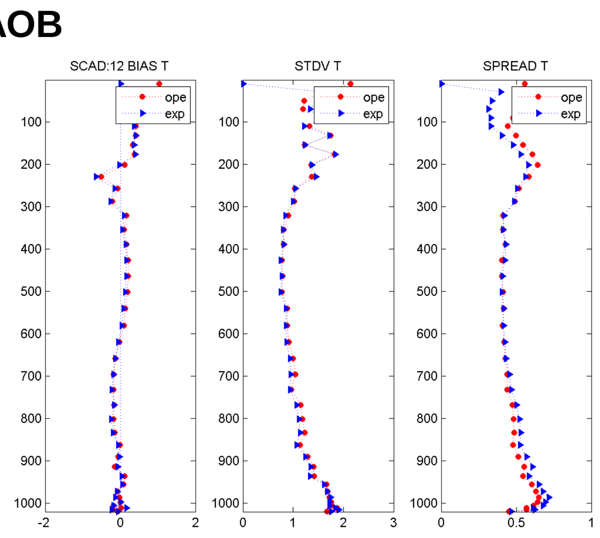
PRATICA DI MARE RAOB HRM VS COSMO

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

12 UTC 28 apr – 01 jun 2012: RAOB



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



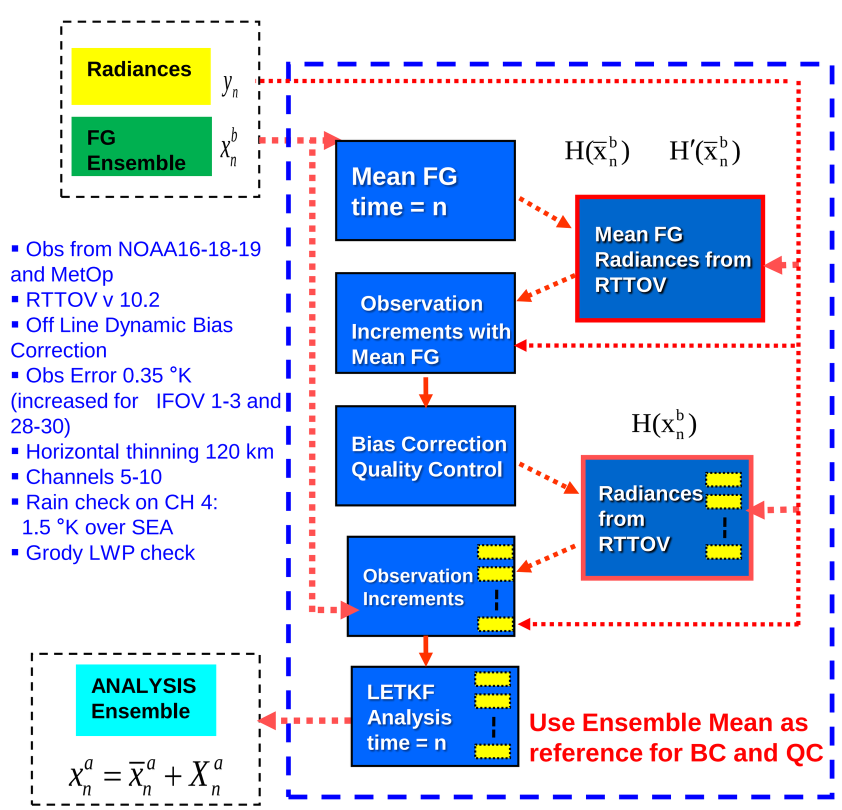
No temperature obs.incr. bias

- **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 that COSMO model is moister in the BL and it 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 (not shown)

FUTURE DEVELOPMENTS :

- **Further tests using COSMO model in fall-winter season**
- **Further tuning of model error representation (tuning of cov. localization, stochastics physics, bias correction, etc.)**
- **Assimilation of AMSU-B/MHS and IASI retrievals**
- **Implement a Short-Range EPS based on LETKF**
- **Use of KENDA code**

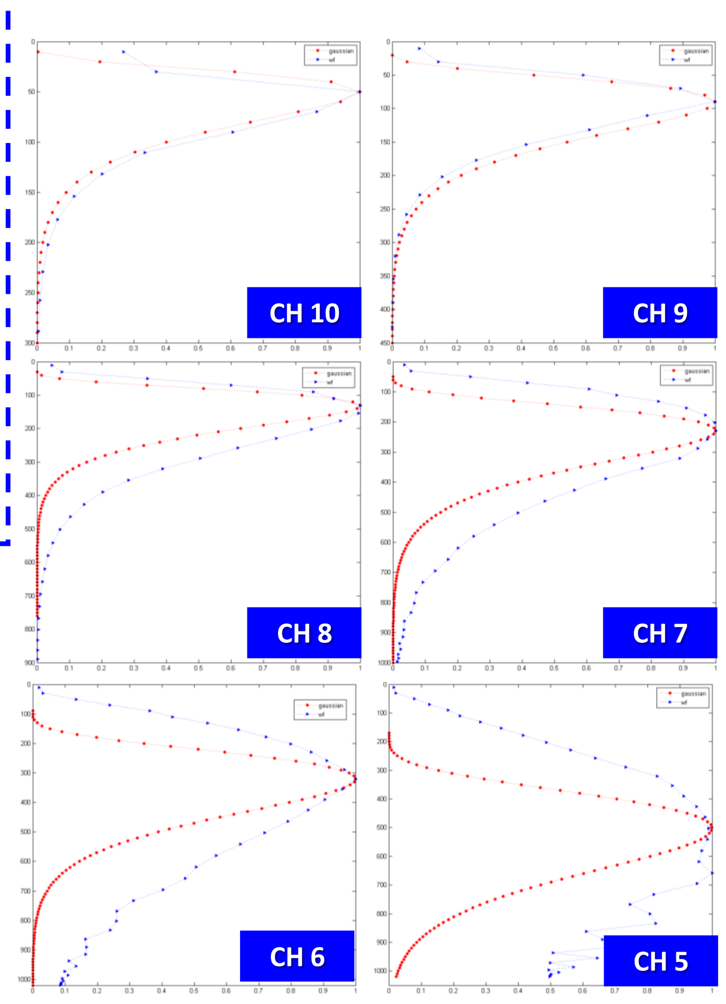
AMSU-A ASSIMILATION



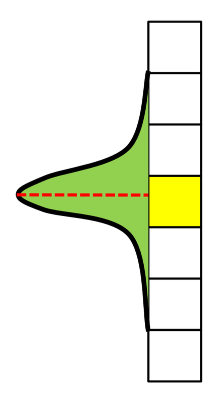
- Obs from NOAA16-18-19 and MetOp
- RTTOV v 10.2
- Off Line Dynamic Bias Correction
- Obs Error 0.35 °K (increased for IFOV 1-3 and 28-30)
- Horizontal thinning 120 km
- Channels 5-10
- Rain check on CH 4: 1.5 °K over SEA
- Grody LWP check

WEIGHTING FUNCTION vs STANDARD LOCALIZATION

WF ensemble mean averaged over the period 27 jun -18 jul 2011 and the standard vertical localization function (gaussian) are shown



MAXIMUM-BASED METHOD



- AMSU-A are treated as "single-level" obs
- Assign radiance to the model level for which the magnitude of the weighting function (WF) is largest.

- Radiances are vertically localised using WF ensemble mean or the standard gaussian function
- Looking at AMSU-A obs incr statistics (27 jun-18 jul 2011), the use of WF to localize radiances gives a small positive impact at lower channels (CH=5,6) where the WF is wider than the standard loc. function (gaussian)
- The AMSU-A assimilation over sea gives a small positive impact (not shown), further investigation on vertical localization are ongoing