

The CNMCA Operational LETKF Data Assimilation System: Recent Results and Developments

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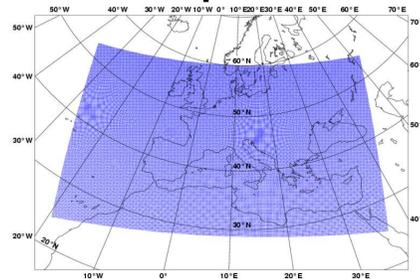


CNMCA - EnKF DA (Bonavita, Torrisi and Marcucci, Q.J.R.M.S., 2008, 2010)

- 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)

$$\begin{aligned} \text{Analysis Ensemble Mean } \bar{x}^a &= \bar{x}^b + X^b W^a \bar{w}^a = \tilde{P}^a Y^b T R^{-1} (y - H(\bar{x}^b)) & \tilde{P}^a &= [(m-1)I + Y^b T R^{-1} Y^b]^{-1} \\ \text{Analysis Ensemble Perturb. } X^a &= X^b W^a & W^a &= [(m-1)\tilde{P}^a] & Y^b &= [H(x_1^b) - \bar{H}(x^b), \dots, H(x_m^b) - \bar{H}(x^b)] \end{aligned}$$

- 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 (since June 2012)



Model and sampling errors are taken into account using:

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

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

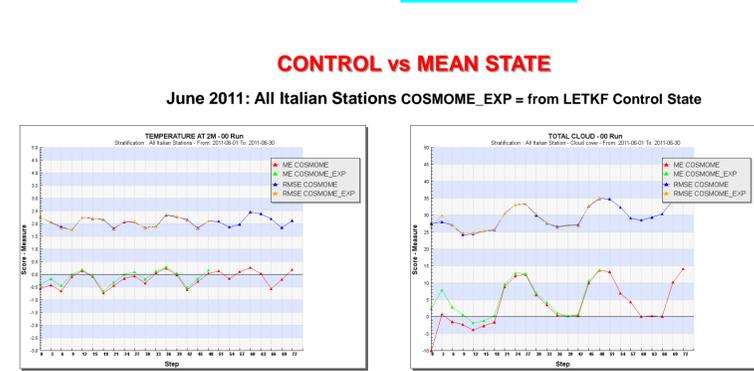
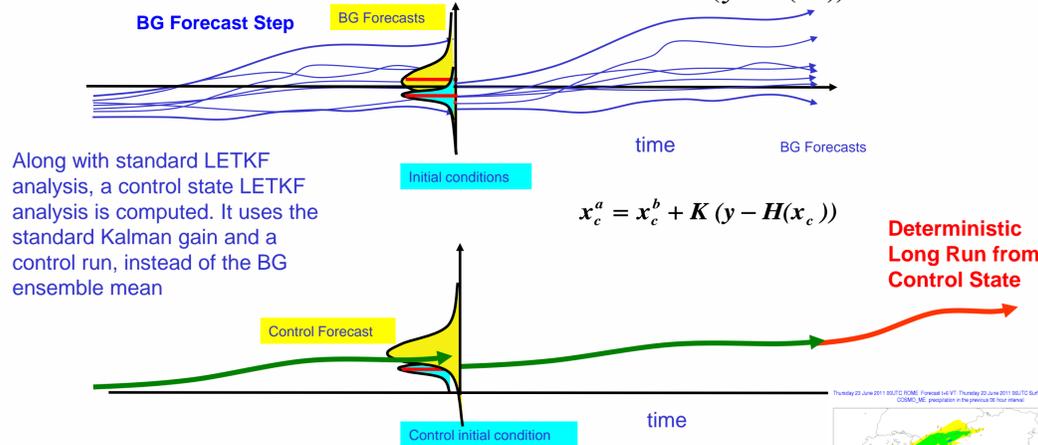
- Climatological Additive Noise
- an. memb. $x_i^a \leftarrow x_i^a + \alpha x_i^n$, $\alpha x_i^n \sim N(0, Q)$ α Scale factor
- x_i^n randomly selected, 48-24h forecast differences
- Lateral Boundary Condition Perturbation using EPS
- Climatological Perturbed SST

Long Deterministic Run from LETKF

Analysis Step

$$\bar{x}^a = \bar{x}^b + K (y - H(\bar{x}^b))$$

$$x_c^a = x_c^b + K (y - H(x_c^b))$$



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

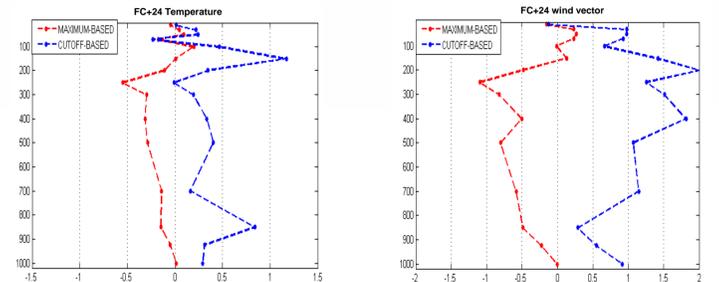
AMSU-A ASSIMILATION

MAXIMUM-BASED METHOD (Fertig et al. 2007)

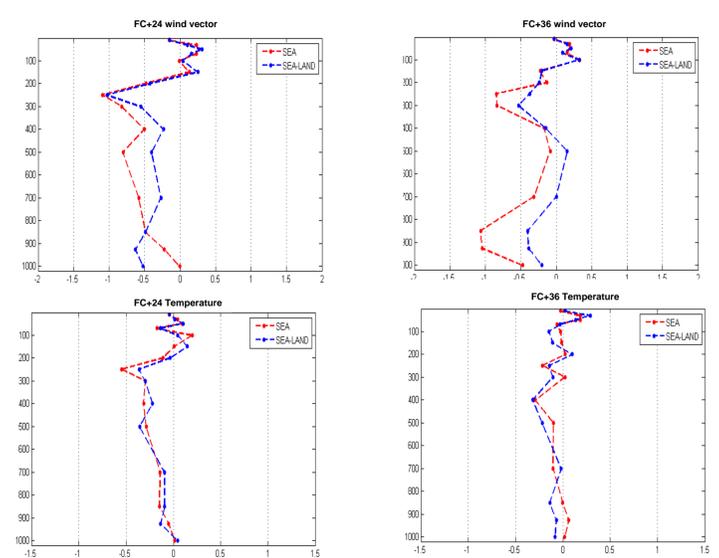
- AMSU-A are treated as "single-level" obs
- AMSU-A are treated as "multi-level" obs
- Assign radiance observations to the model level for which the magnitude of the weighting function (wf) is largest.
- The wf for each non-local observation, is examined. The obs is assimilated if a 'significant' weight is assigned to any model state vector component within the local region.
- Use also the wf shape as vertical covariance localization function
- 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, 28-30)
- Horizontal thinning 120 Km
- Channels 5-10 with CH 5-6 discarded over high orography
- Rain check on CH 4: 1.5 °K over SEA, 1°K over LAND
- Grody LWP check

The vertical profiles of the relative rmse with respect to control run (without AMSU-A assimilation) are shown

MAXIMUM-BASED vs CUTOFF BASED METHOD

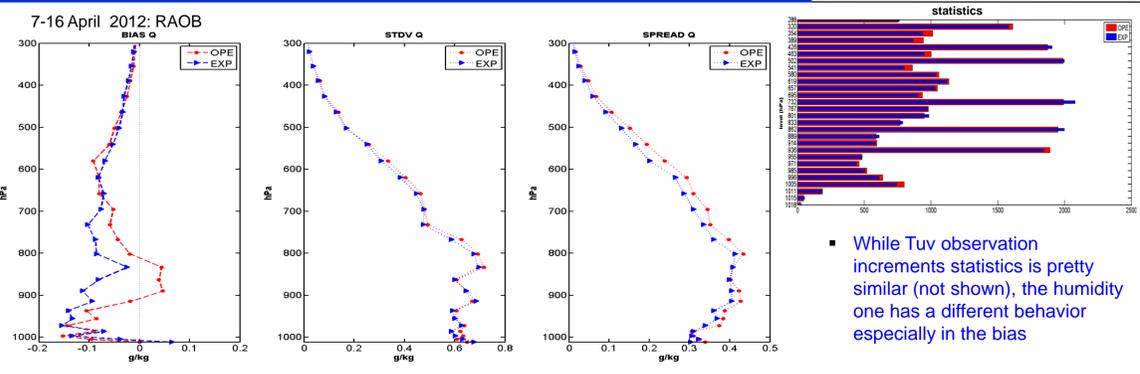


MAXIMUM-BASED METHOD: SEA VS SEA-LAND AMSU-A ASSIMILATION (27 Jun-18 Jul 2011)

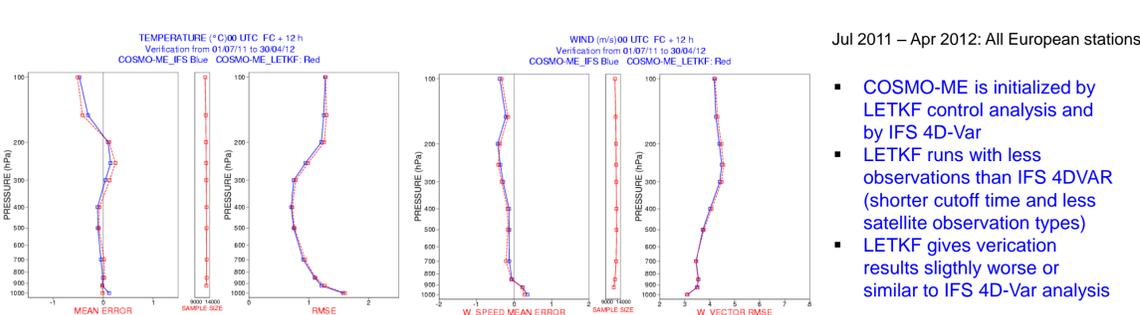


AMSU-A assimilation (over sea) gives a clear positive impact using the Maximum-based method

COSMO vs HRM prognostic model in LETKF



LETKF vs IFS 4D-VAR Analysis



FUTURE DEVELOPMENTS :

- Further tests using COSMO model to take into account the low-level humidity bias
- Further tuning of model error representation (tuning of cov. localization, stochastic physics, bias correction, etc.)
- Assimilation of AMSU-B/MHS and IASI retrievals will be investigated soon
- Balancing and non-linearities are issues to address
- Implement a Short-Range EPS based on LETKF