Use of Radiances in the CNMCA Operational Ensemble Data Assimilation System

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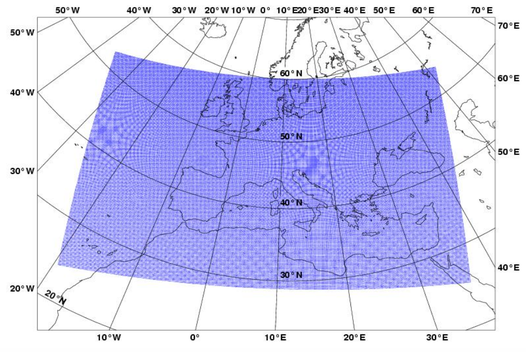
CNMCA Implementation (*Bonavita, Torrisi and Marcucci, Q.J.R.M.S., 2008, 2010)*

- ***OPERATIONAL SINCE 1 JUNE 2011***
- ***LETKF Formulation*** *(Hunt et al,2007)*

Analysis Ensemble Mean	$\overline{\mathrm{x}}^{\mathrm{a}} = \overline{\mathrm{x}}^{\mathrm{b}} + X^{b}\overline{w}^{a}$	$\overline{\mathrm{w}}^{\mathrm{a}} = \widetilde{P}^{a} Y^{bT} R^{-1}(y - H(x^{b}))$	$\widetilde{\mathrm{P}}^{\mathrm{a}} = \left[(m-1)I + Y^{bT} R^{-1} Y^{b}\right]^{-1}$
Analysis Ensemble Perturb.	$\mathrm{X}^{\mathrm{a}} = X^{b} W^{a}$	$\mathrm{W}^{\mathrm{a}} = \left[(m-1)\widetilde{P}^{a}\right]$	$\mathrm{Y}^{\mathrm{b}} = \left[(H(x_1^b) - \overline{H(x^b)}),\ldots,(H(x_m^b) - \overline{H(x^b)})\right]$

- 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 (ERS2, METOP), AMSUA radiances (since April 2012)



Model and sampling errors are taken into account using:

- State Dependent Multiplicative Inflaction according to Whitaker et al (2010)

an. pert. $\mathbf{x}'_{\mathrm{a}} = \mathbf{x}'_{\mathrm{a}} \sqrt{\alpha \frac{\sigma_{\mathrm{b}}^2 - \sigma_{\mathrm{a}}^2}{\sigma_{\mathrm{a}}^2} + 1}$ α = 0.95, σ^2 = variance

- Climatological Additive Noise

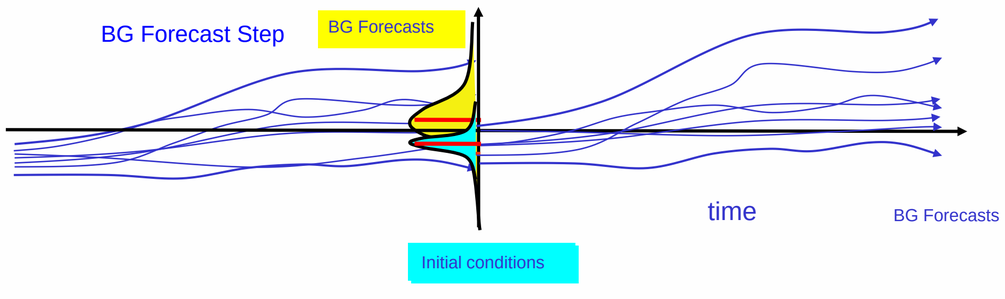
an. memb. $\mathbf{x}_i^a \leftarrow \mathbf{x}_i^a + \alpha \mathbf{x}_i^n, \quad \alpha \mathbf{x}_i^n \sim N(0, \mathbf{Q})$ α Scale factor

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

- Lateral Boundary Condition Perturbation using EPS
- Climatological Perturbed SST

Long Deterministic Run from LETKF

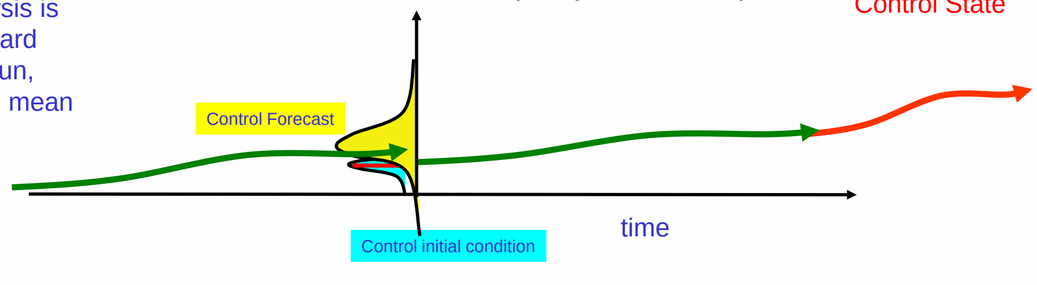
Analysis Step $\overline{\mathrm{x}}^{\mathrm{a}} = \overline{\mathrm{x}}^{\mathrm{b}} + K\,(y - H(\overline{x}^{b}))$



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

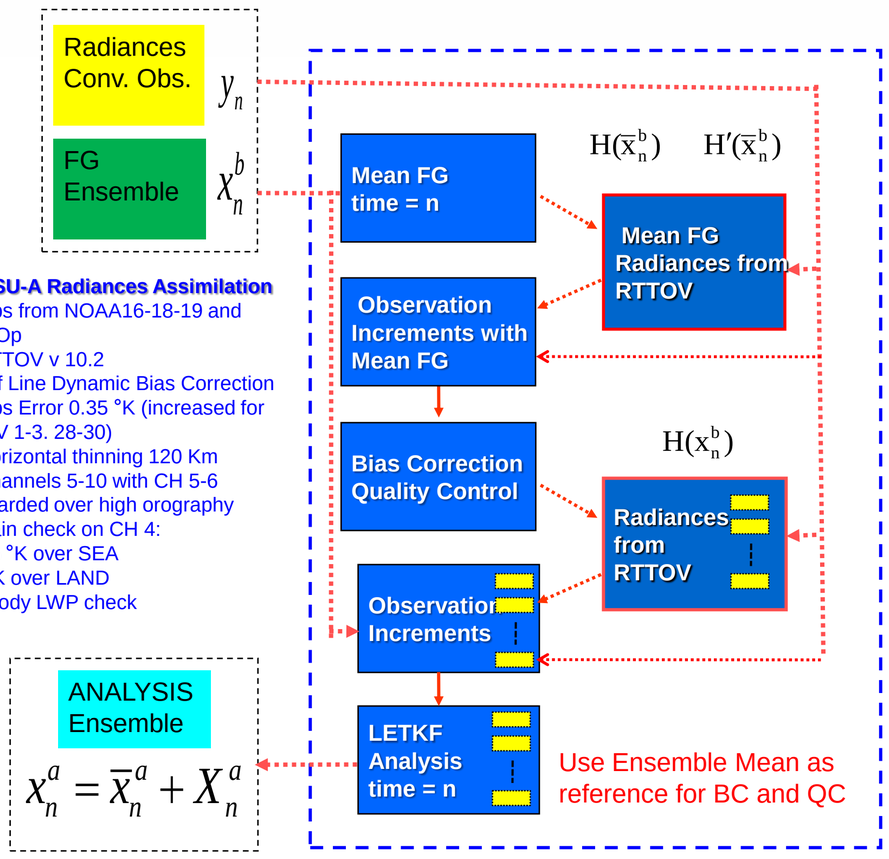
$x_c^a = x_c^b + K\,(y - H(x_c))$

Deterministic Long Run from Control State



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

Radiances Assimilation Scheme



AMSU-A Radiances Assimilation

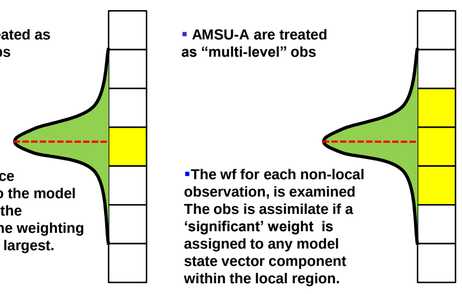
- Obs from NOAA16-18-19 and MetOp
- RTTOV v 10.2
- Off Line Dynamic Bias Correction
- Obs Error 0.35 °K (increased for IFOV 1-3. 28-30)
- Horizontal thinning 120 Km
- Channels 5-10 with CH 5-6 discarded over high orography
- Rain check on CH 4: 1.5 °K over SEA, 1°K over LAND
- Grody LWP check

MAXIMUM-BASED SELECTION METHOD

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

CUTOFF-BASED SELECTION METHOD

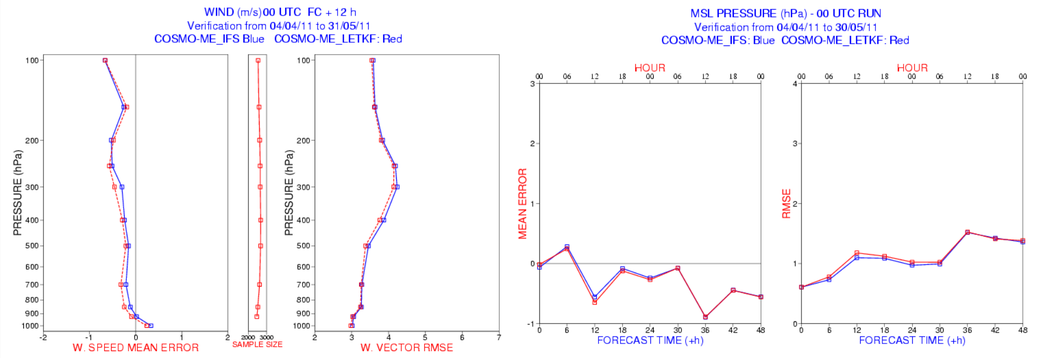
- AMSU-A are treated as "multi-level" obs
- The wf for each non-local observation, is examined The obs is assimilate if a 'significant' weight is assigned to any model state vector component within the local region.



Use also the wf shape as vertical covariance localization function

LETKF vs IFS 4D-VAR Analysis

April – May 2011: All European stations



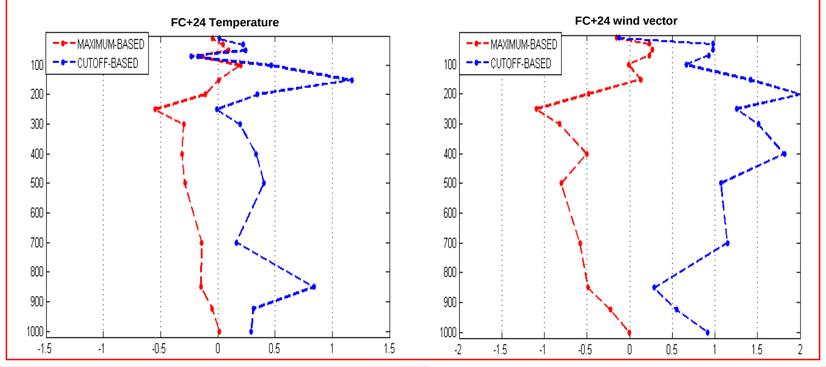
- COSMO-ME is initialized by LETKF ensemble mean and by IFS 4D-Var
- LETKF gives verication results similar to IFS 4D-Var analysis
- As far as we know, CNMCA is the first meteorological centre, which uses operationally a pure ensemble data assimilation (LETKF) to initialize a deterministic NWP model (COSMO-ME)

EXPERIMENTS DESCRIPTION:

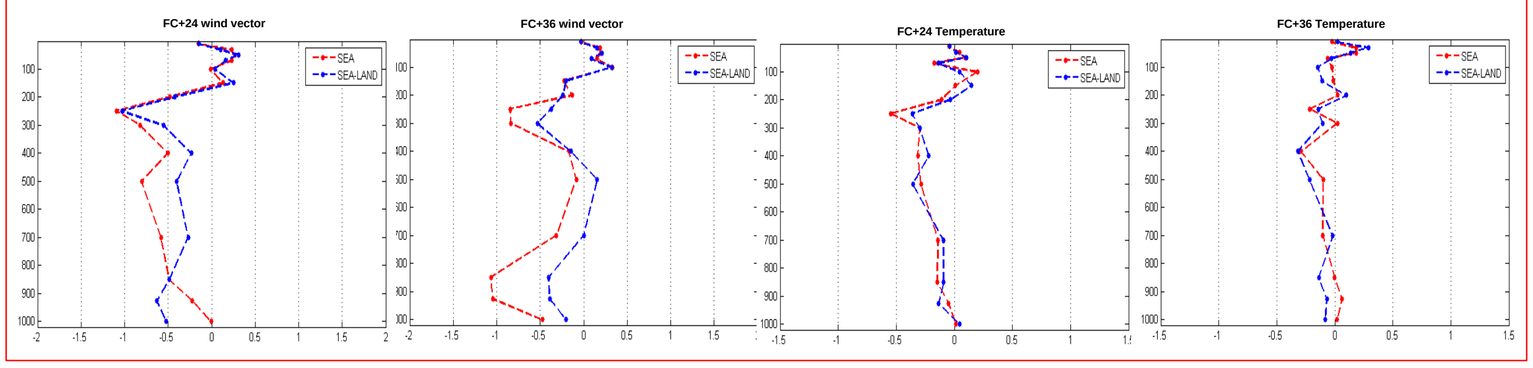
- ❖ Control run without AMSU-A assimilation
- ❖ Run with AMSU-A assimilated over SEA (MAXIMUM-BASED Method)
- ❖ Run with AMSU-A assimilated over SEA and LAND (MAXIMUM-BASED Method)
- ❖ Run with AMSU-A assimilated over SEA (CUTOFF-BASED Method)

The vertical profiles of the relative rmse with respect to control run are shown

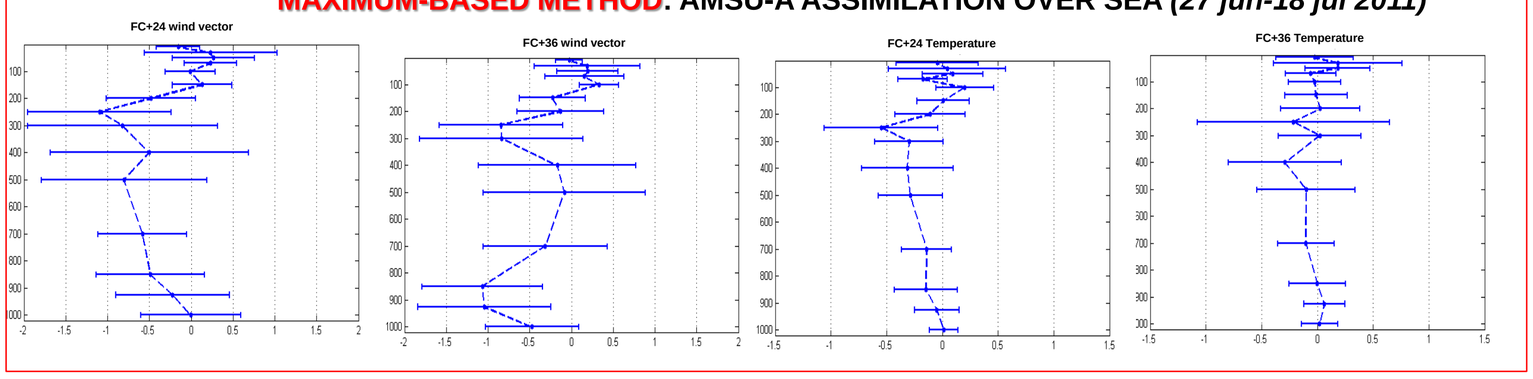
MAXIMUM-BASED vs CUTOFF BASED METHOD



MAXIMUM-BASED METHOD: SEA VS SEA-LAND AMSU-A ASSIMILATION ***(27 jun-18 jul 2011)***



MAXIMUM-BASED METHOD: AMSU-A ASSIMILATION OVER SEA ***(27 jun-18 jul 2011)***



FUTURE DEVELOPMENTS :

- **Assimilation of AMSU-B/MHS and IASI retrievals will be investigated soon.**
- **Balancing and non-linearities are issues to address**
- **Tests with COSMO model and shorter assimilation window**
- **Further tuning of model error representation (tuning of cov. localization, evolved additive noise, bias correction, etc.)**
- **Implement a Short-Range EPS based on LETKF**