The CNMCA (Italian National Meteorological Center) Operational LETKF Data Assimilation System

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The CNMCA short-range prediction system is based on the Ensemble Kalman Filter (EnKF) approach [1,2] for the data assimilation component and the COSMO regional model (www.cosmo-model.org) for the prognostic one. In particular the Local Ensemble Transform Kalman Filter (LETKF [3]) scheme has been implemented at CNMCA, because it is easy to implement, intrinsically parallel and more efficient and flexible for nonlocal observations.
The operational implementation of the LETKF algorithm at CNMCA makes use of a 40+1 member ensemble based on the COSMO model. The COSMO model is integrated on the European Mediterranean region (COSMO-ME) at 10 km horizontal resolution on 45 model levels. A 6 hourly intermittent analysis cycle is implemented, making use of the observations available in a 6-h window centred at the analysis time. The observational dataset operationally ingested comprises 4D radiosonde ascents (RAOB), surface pressure observations from land and sea stations (SYNOP, SHIP, BUOY), manual and automatic aircraft observations, atmospheric motion vectors from Meteosat, European wind profilers, scatterometer winds from METOP/OceanSat2 and AMSU-A/MHS radiances from METOP and NOAA satellites. The CNMCA-LETKF data assimilation system is used to initialize the COSMO-ME model at the resolution of 0.0625° (about 7 km). A schematic view of the operational NWP system is given in Fig.1.

Lateral Boundary Conditions Perturbation

Implementation of a limited-area ensemble Kalman filter (EnKF) needs a suitable way to perturb lateral boundary conditions. Usually a proper ensemble of boundary conditions can be provided by an EnKF on a larger domain (Global Ensemble Value method) or can be obtained by perturbation around a deterministic estimate using assumed spatial and temporal covariance relationships. We choose to follow an hybrid solution: the ensemble of boundary conditions is obtained perturbing the most recent available IFS deterministic forecast making use of the ECMWF-EPS. The 40 EPS members are randomly chosen and the perturbation of each one with respect to their mean is added to the IFS deterministic forecast.
The Sea Surface Temperature (SST) is also climatologically perturbed using the differences of the IFS SST analysis from the ECMWF operational archive.

Model and sampling error treatment

A multiplicative and additive covariance inflation has introduced to ameliorate sampling errors due to small ensemble size and also to account for model errors in assimilating real observations.
The method proposed in [4], the so called “relaxation-to-prior spread” (RTPS), has been tested and implemented, because the successful results with respect to the “3-dimensional adaptive-temporally smoothed multiplicative inflation” [5]. A clear improvement has been obtained when the RTPS was used in combination with an additive inflation technique.
In the first version of the CNMCA-LETKF system, based on HRM model, a climatological additive noise were implemented. Climatological additive inflaction has the technical disadvantage to require an “enough” long period of 36/48h forecasts (it needs to re-run the model or to interpolate old runs to the new resolution), for these reasons an alternative method based on ECMWF-EPS forecast has been chosen, when we moved to COSMO model. The difference between EPS ensemble forecasts valid at the analysis time is computed and interpolated on the COSMO grid. The mean difference is then removed to yield a set of perturbations that are globally scaled and used as additive noise.
Recently, an adaptive flow-dependent additive inflaction has been implemented and

experimentally tested. The perturbations are derived by a suitable scaling of the “zero-mean” differences of lagged CNMCA-LETKF ensemble forecasts giving a self-evolving and flow-dependent additive noise. A small positive impact has been found at second day forecast, probably because this additive error has a component that projects onto the growing forecast structures. The use of SPPT (Stochastic Physics Perturbation Tendencies) scheme is also under testing.

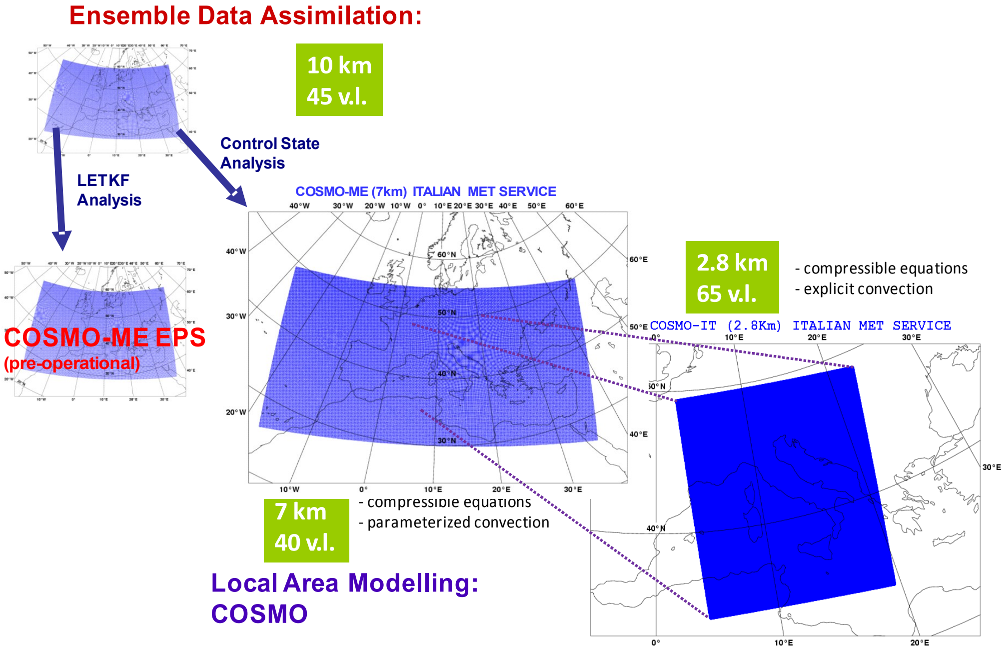

Fig.1: Schematic view of the operational CNMCA-NWP system.

References

[1] Bonavita M, Torrisi L, Marcucci F. 2008. The ensemble Kalman filter in an operational regional NWP system: Preliminary results with real observations. *Q. J. R. Meteorol. Soc.* 134, 1733-1744.

[2] Bonavita M, Torrisi L, Marcucci F. 2010. Ensemble data assimilation with the CNMCA regional forecasting system. *Q. J. R. Meteorol. Soc.* 136, 132-145.

[3] Hunt, B. R., E. Kostelich, I. Szunyogh. “Efficient data assimilation for spatiotemporal chaos: a local ensemble transform Kalman filter”, *Physica D*, 230, 112-126, 2007

[4] Whitaker, J. S., T. M. Hamill ” Evaluating Methods to Account for System Errors in Ensemble Data Assimilation”. *Mon. Wea. Rev.*, 140, 3078–3089, 2012

[5] Li, H., E. Kalnay, and T. Miyoshi, 2009: Simultaneous estimation of covariance inflation and observation errors within ensemble Kalman filter. *Q. J. R. Meteor. Soc.,* **135**, 523-533.