# The Italian Air Force Met Service Operational NWP System

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The Italian Air Force Met Service short-range numerical weather 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 run operationally since June 2011.

The LETKF system makes use of a 40+1 member ensemble based on the COSMO model. The COSMO model is integrated on the European Mediterranean region 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 drifting radiosonde ascents (4D-RAOB), surface pressure observations from land and sea stations (SYNOP, SHIP, BUOY), manual and automatic aircraft observations, atmospheric motion vectors from MSG3-MET7, European wind profilers, METOP scatterometer winds, NOAA and METOP AMSUA/MHS and NPP ATMS radiances. Assimilation of GPS Zenith Total Delay and MODE-S aircraft data is under testing.

Temperature, wind and specific humidity on model levels and surface pressure are provided as analysis fields. The deterministic COSMO-ME runs four times a day (00/06/12/18 UTC) with a 72h forecast range and 7 km resolution initialized by the LETKF control state analysis and driven by ECMWF forecasts. The very high-resolution COSMO-IT model is integrated over the Italian region (2.8km resolution), using COSMO-ME fields as boundary conditions. COSMO-IT is initialized by nudging scheme four times a day (00/06/12/18 UTC) and it is integrated up to 30 h. A schematic view of the operational NWP system is given in Fig.1.

***LETKF Lateral Boundary Conditions Perturbation***

Implementation of a limited-area ensemble Kalman filter (EnKF) needs a suitable way to perturb lateral boundary conditions. The ensemble of lateral boundary conditions is obtained perturbing the 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 most recent 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 in the operational scheme, because the successful results with respect to other explored methods ("relaxation-to-prior perturbations" and "3-dimensional adaptive-temporally smoothed multiplicative inflation"). Because the RTPS is a purely multiplicative inflation method, a clear improvement is obtained when it is in combination with an additive inflation technique, designed in a way that it accounts for the flow dependency of the background covariance estimate.

The current operational implementation of the additive inflation uses the differences between ECMWF EPS ensemble forecasts valid at the analysis time 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 alternative 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 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) in COSMO model has been also implemented.

**The Italian Air Force Met Service Short Range Ensemble Prediction System: COSMO-ME EPS**

The atmospheric short-range ensemble prediction system (COSMO-ME EPS) based on the LETKF analysis and the COSMO model is running operationally since July 2013.

The relevant characteristics of the atmospheric COSMO-ME EPS are:

- Domain and resolution: COSMO model is integrated 40 times on the same domain of the LETKF system.
- IC and BC: initial conditions are derived from the LETKF system; lateral boundaries conditions are from the most recent IFS deterministic run perturbed using ECMWF-EPS.
- Model error: stochastics physics perturbation tendencies.
- Forecast range: 72 hours at 00/12 UTC.

**The Italian Air Force Met Service Operational Sea State Forecast System: NETTUNO**

The NETTUNO [5] 3' system is based on the ECMWF version of WAM model integrated over the whole Mediterranean basin which is driven by COSMO-ME forecast winds. It was developed in cooperation with the ISMAR-CNR institute of Venice.

Forecast fields (mean wave period and direction, significant wave height) are given two times a day (00/12 UTC) every 3 hrs up to 72 hrs. A high resolution (1') WAM model driven by COSMO-IT wind forecast and nested in the 3' NETTUNO is integrated over the Italian domain.

A short range sea state EPS based on the NETTUNO system and the COSMO-ME EPS has been tested and implemented in collaboration with ISMAR-CNR.

The sea state probabilistic forecast is obtained driving the WAM model with the hourly COSMO-ME EPS wind forecast members. The NETTUNO-EPS consists of 40+1 members, that are integrated at 00 UTC up to 48 hour forecast in the Mediterranean basin.

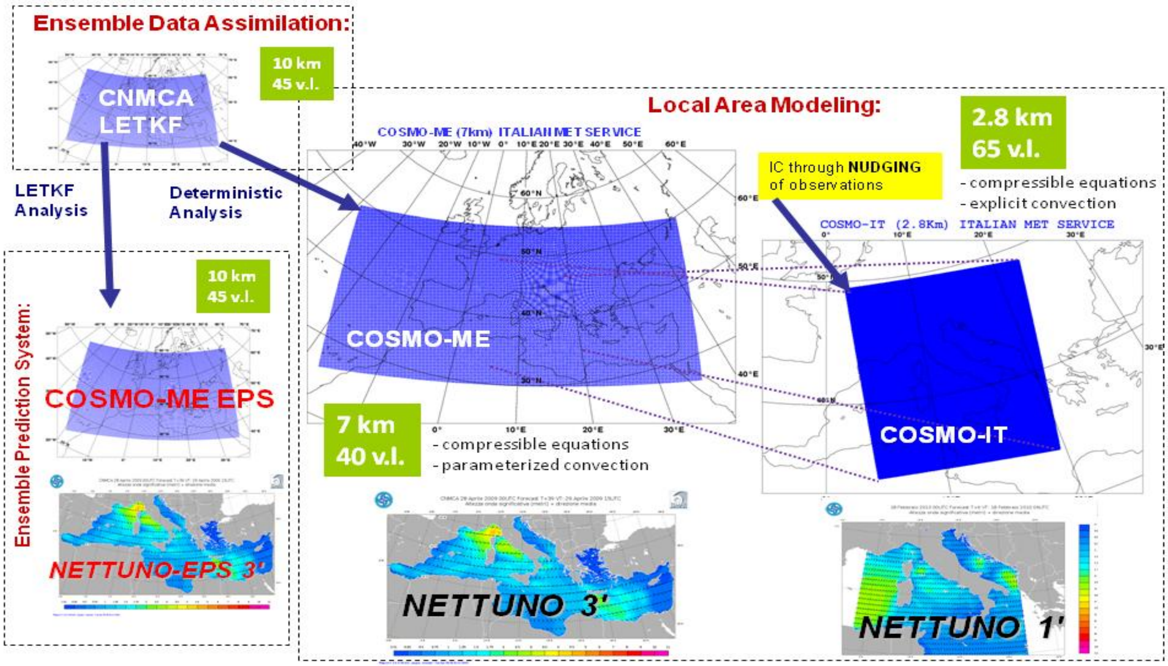


**Fig.1**: Schematic view of the operational Italian Air Force Met Service NWP system.

## References


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