Use of Sea Surface Temperature (SST) obtained from the MFS system as boundary condition for the COSMO model: impact on forecast precipitation

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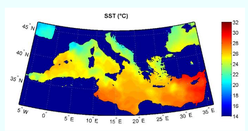
Abstract

The operational configuration of COSMO model at CNMCA (COSMO-ME) uses the OSTIA Sea Surface Temperature (SST) analysis, as a boundary condition, that it is kept constant over the entire forecast period.
In this work, the weak coupling between the MFS (Mediterranean Forecasting System) oceanic system and the COSMO atmospheric model was investigated. SST forecast fields, provided by MFS at 3 hours interval, are used as boundary conditions in the COSMO model integration. The study focused on the impact of the coupling on COSMO forecast precipitation, in particular the cumulated precipitation in 24 hours for the 1st, 2nd and 3rd forecast day.
The forecast precipitation for operational and experimental runs are compared with the observational data recorded in the period from August 2013 to March 2014 by rain gauges located on the Italian territory. The use of SST forecasts determines a clear improvement in the precipitation forecast over land and coast stations for the period September-October-November 2013 especially for high thresholds.

Operational and experimental setups

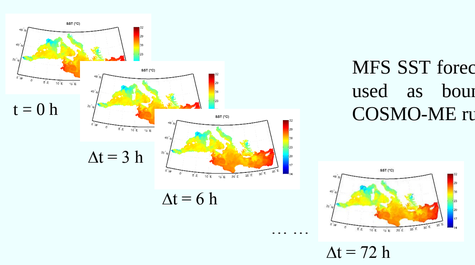
In the operational COSMO-ME configuration, the OSTIA SST analysis is kept constant during the model integration. For this study, COSMO model was run with the option of using SST forecast fields provided by the MFS (Mediterranean Forecasting System) every 3 hours. The MFS oceanic model, managed by INGV of Bologna, provides forecasts of ocean parameters as SST, salinity, currents and others up to 240 hours (http://medforecast.bo.ingv.it and www.myocean.eu).

OPERATIONAL



OSTIA SST analysis is kept constant during the COSMO model integration.

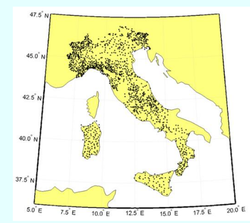
EXPERIMENTAL



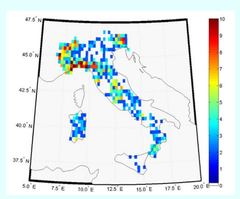
MFS SST forecast fields updated every 3 h are used as boundary conditions during the COSMO-ME run.

Rain gauges data

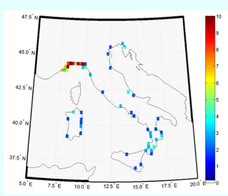
The forecast precipitation by COSMO model, in two different setups (operational and experimental), is compared with the data collected by the rain gauges network on the national territory. The network consists of more than 1500 rain gauges and distributed as in the Figure on right.
The distribution and density are fairly uniform and rain gauges data by Apulia Region are missing. In the present study, the rain gauges dataset covers the period from August 2013 to March 2014 and was provided by the Civil Protection Department.
In order to make the comparison between forecast and measured precipitation, the domain is divided into boxes of 0.25 deg. The number of rain gauges within each box is considered (see figures below): it's an important parameter for the characterization of the comparison. A higher density of rain gauges ensures a more realistic measured precipitation.



Distribution of the rain gauges on Italian territory (by Civil Protection Department).



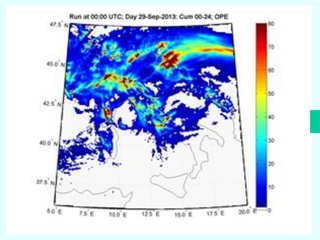
Number of rain gauges in each box for the all territory.



Number of rain gauges in each box for the coastal area only.

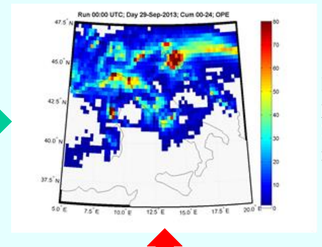
Comparison method

The resolution of the COSMO model, in the COSMO-ME configuration, is 0.0625 deg (about 7 kilometers). In order to make the comparison with the rain gauges data, the forecast precipitation is upscaled to a resolution of 0.25 deg. Each new box contains 16 resolution cells (see figures on the right).
Within each box, no one, one or more rain gauges can be present; the cumulated precipitation associated with the box is the simple arithmetic average of the precipitation recorded by rain gauges within the same box (see figures on the right). For the comparison, only the boxes that contain at least 2 rain gauges are considered.
The agreement between forecast and measured precipitation is evaluated by using the dichotomous indices: Probability Of Detection (POD), False Alarm Ratio (FAR) and Critical Success Index (CSI). These indices are calculated by comparing the daily accumulation predicted by the model with the accumulation recorded by rain gauges; the indices are calculated separately for the operational (OPE) and experimental (EXP) runs. The difference between the two different sets of calculated indices provides information on the improvement or worsening of forecasts by using SST fields obtained from MFS. The comparison is performed separately for the 1st, 2nd and 3rd day of forecasts.



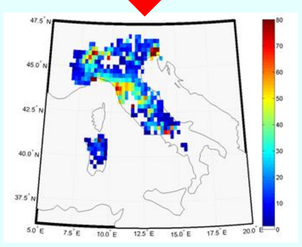
Example of cumulated precipitation forecast in 24 hours at the original resolution (0.0625 deg).

Upscaling



Example of cumulated precipitation forecast in 24 hours at upscaled resolution (0.25 deg).

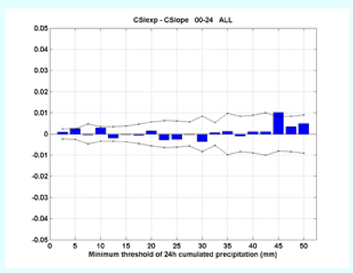
Comparison



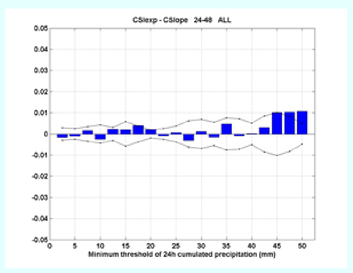
Example of cumulated precipitation in 24 hours recorded by rain gauges upscaled at 0.25 deg resolution.

Results

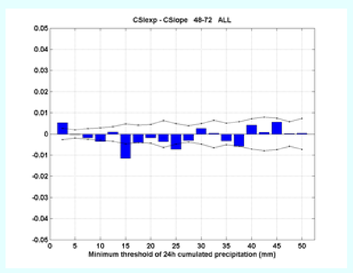
The differences between the two series of dichotomous indices PODexp - PODope, FARexp - FARope and CSIexp - CSIope are reported as function of the minimum cumulated precipitation. Moreover, the intervals of significance, calculated by using boostrapping technique, are also reported (black solid lines in figures).



CSIexp – CSIope (1° day)



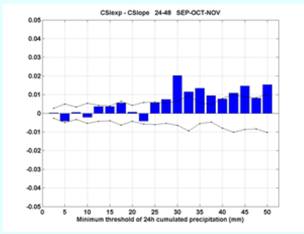
CSIexp – CSIope (2° day)



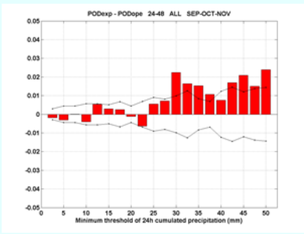
CSIexp – CSIope (3° day)

The use of SST fields obtained from the MFS system determines, in the overall period (August 2013 - March 2014), a slight improvement for the 1st and 2nd day of forecast, for the highest values of the threshold. For the 3rd day, on the contrary, you may notice a slight deterioration. In general, the variations of indices are substantially contained in the significance intervals; therefore, it's not possible to clearly appreciate improvements or deteriorations for the EXP experimental series.
The available dataset is also subdivided on a monthly basis and the accumulation registered by all rain gauges for the 2nd day of forecast is taken into account (not reported here). A clear improvement is appreciable for September, October and November 2013, while there is a clear deterioration for March 2014.

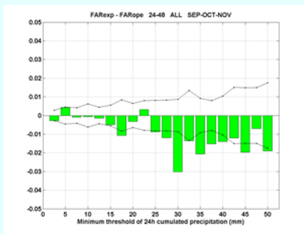
So, considering the period September-October-November 2013, the forecast precipitation in the EXP series is clearly closer to the observations, both on the coast and on all territory (see figures below).



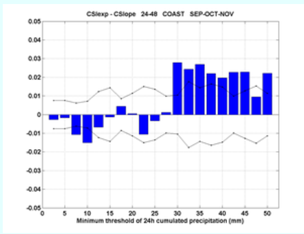
CSIexp – CSIope (all rain gauges)



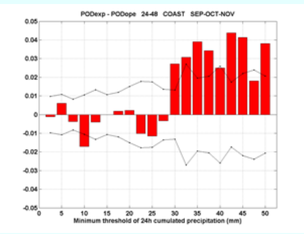
PODexp – PODope (all rain gauges)



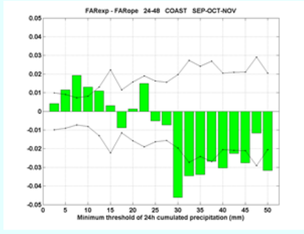
FARexp – FARope (all rain gauges)



CSIexp – CSIope (coastal rain gauges)



PODexp – PODope (coastal rain gauges)



FARexp – FARope (coastal rain gauges)

The results obtained are consistent with those expected: the use of the SST fields provided by MFS determines an improvement, in terms of forecast precipitation, in the autumn months. In fact, in this period the sea is more dynamic and has a greater impact on meteorological events and in particular on more intense cases.

Acknowledgements

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