The impact of different initial and boundary conditions on air quality operational chains: an application on the Italian domain

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Introduction

This work presents comparison among three operational modeling chains for air quality forecasts in the national territory: kAIROS, FORAIR-IT, and CHIMBO, implemented respectively by Arpae/SNPA, ENEA, and CNR-ISAC. In particular, the experiment concerns quantitative comparisons between numerical simulations and observations aimed at evaluating differences attributable to the use of different initial and boundary conditions (IBC) for air quality forecasts over Italy. The aim of this study is an assessment of using CAMS European air quality forecasts as boundary conditions with the aim of eliminating one computational domain (the European one) and improving modeling performance.

Materials and method

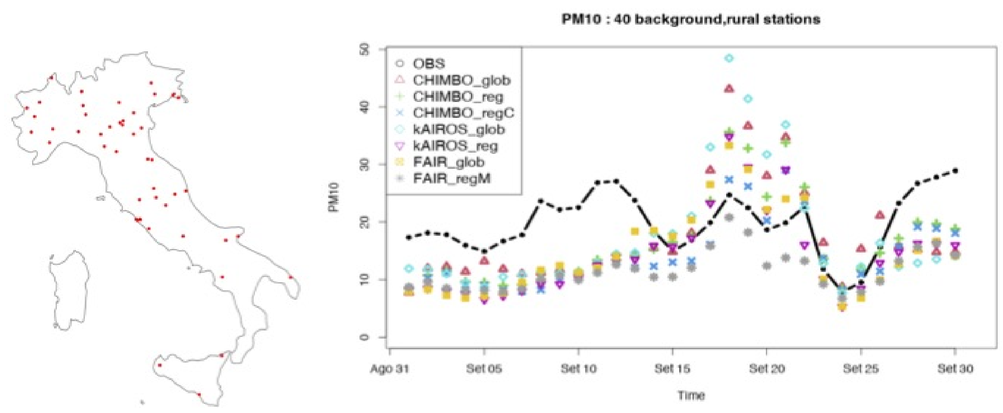
Currently, pollutant concentration forecasts in the atmosphere at a national scale are generated using a two-domain nesting (European and Italian) approach and using the air quality model implemented by ECMWF (European Centre of Medium-Range Weather Forecast) on a global scale (i.e., CAMS global) as initial and boundary conditions, with a spatial resolution of about 40 km. A significant improvement could result from replacing the IBC, transitioning from the global model to the regional one (i.e., CAMS regional), which has a spatial resolution of about 10 km. This new configuration would offer advantages of different kinds: From a purely computational perspective, it would (i) avoid the use of the nesting configuration, no longer needing to generate simulations on the European domain; (ii) since regional products result from an ensemble of state-of-the-art European models, a better performance is expected compared to that obtained from the current chains. In this work we present the models verification performed by using the measured made available by EEA (www.eea.europa.eu). Given the horizontal resolution of the models, which spans between 10 and 4 km, the rural background measurement stations are taken into account for a proper use of spatial representativeness of the observations. The comparison has been carried out for PM_{10} (Figure 1 and 2), O_3 (Figure 3) and NO_2 (Figure 4) by calculating the key model evaluation statistics (i.e. Pearson correlation coefficient, Normalized Mean Bias, Root Mean Square Error) as well as the Taylor diagram and Correlation matrix (Carslaw, D. C., Ropkins, K. (2012). openair — An R package for air quality data analysis. Environmental Modelling Software, 27-28, 52-61).

Conclusions

Despite being a preliminary assessment based on a single month period (September 2023), all model chains initialized with the CAMS regional fields show better performance compared to the current version. In particular, it has emerged that the CHIMBO and kAIROS chains derive greater benefit from it compared to FORAIR in terms of improvement in temporal correlation and estimation of mean concentration values of PM_{10}, O_3 and NO_2. In addition, the correlation Plots show that each chain improves his scores with CAMS regional in respect with CAMS global.

Comparison for Particulate Matter (PM_{10})

Figure 1: Left panel shows the stations location, right panel depicts the time-serie of mean values calculated over 40 background rural measurements stations of PM_{10} concentrations as observed (black dashed line) and calculated by different modeling chains inizialized with global and regional CAMS models (see legend).



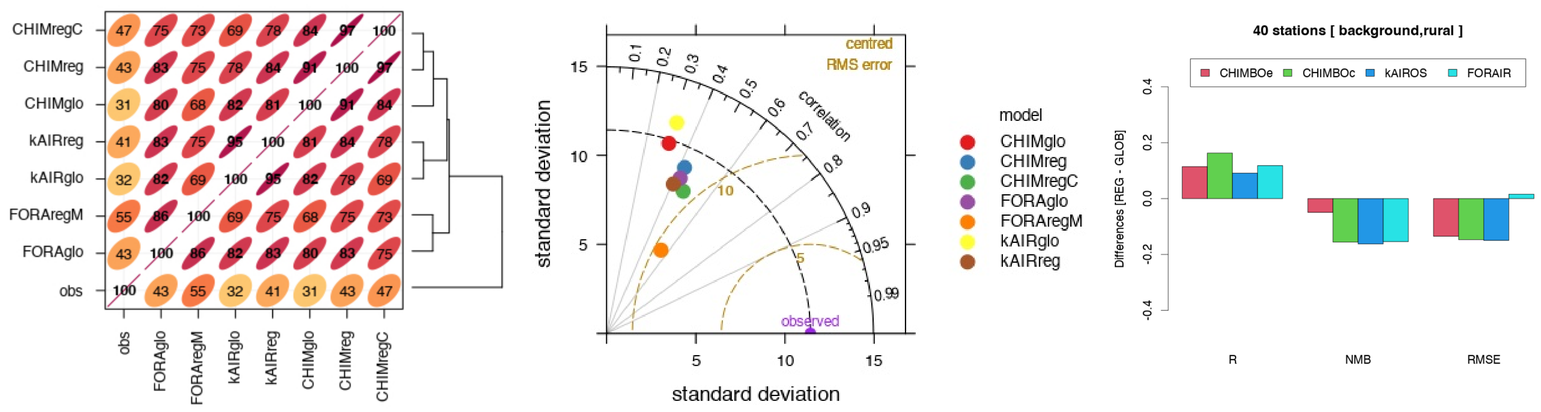


Figure 2: Correlation Plot (left), Taylor diagram (center), differences for R, NMB and RMSE (right).

Comparison for Ozone (O_3)

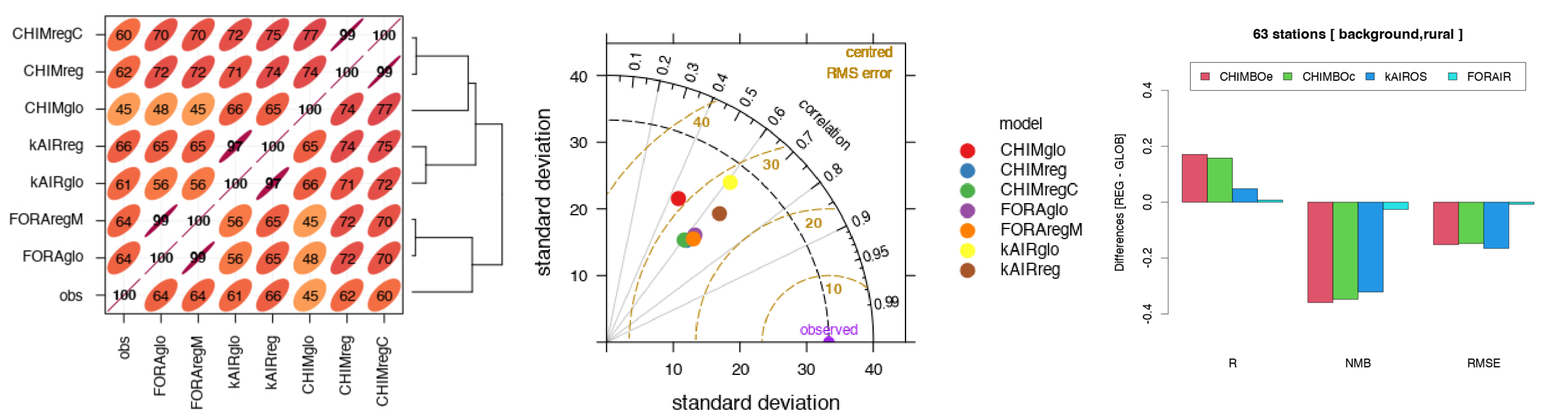


Figure 3: Correlation Plot (left), Taylor diagram (center), differences for R, NMB and RMSE (right).

Comparison for nitrogen dioxide (NO_2)

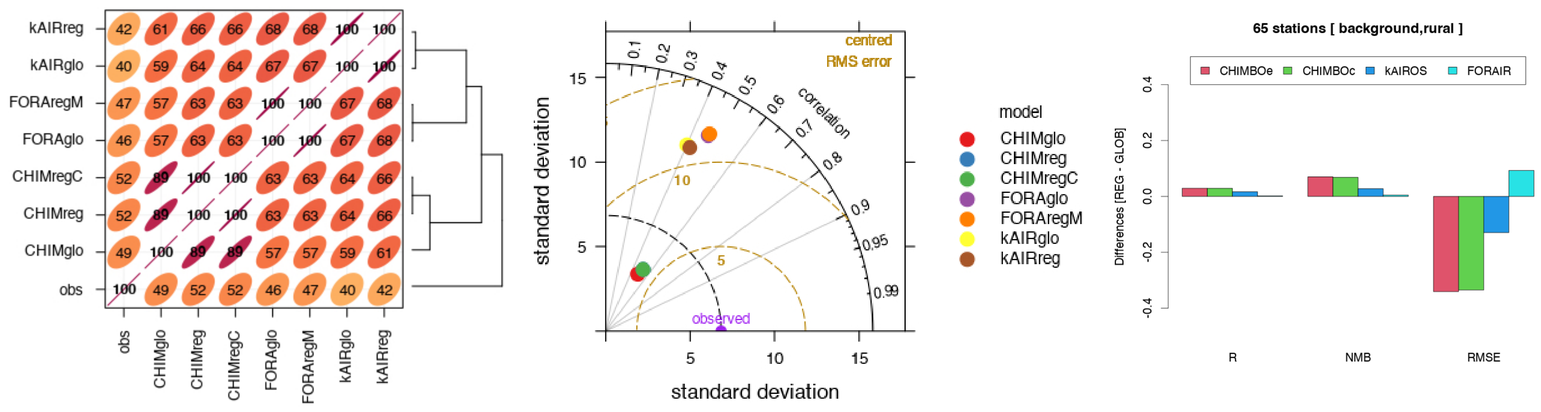


Figure 4: Correlation Plot (left), Taylor diagram (center), differences for R, NMB and RMSE (right).

Acknowledgements

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