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Optimizing next-generation operational observation networks for the short-term forecast of Mediterranean high-impact weather

L. Garcies Artigues and V. Homar Santaner
Universitat de les Illes Balears, Departament de Física, Palma de Mallorca, Spain (victor.homar@uib.es, +34 971 173426)

Weather forecasting authorities are perceiving increasing pressure from the public to extend and improve the quality of short-range predictions while reducing costs and increasing the overall forecasting efficiency. The European community is strongly committed to attain this increased efficiency by focusing on the observational component of the weather forecasting process. One important research commitment is oriented to optimize the integrated observing system networks to achieve better representations of the atmosphere and eventually more accurate forecasts. In this context, sensitivity analysis techniques aim at identifying causal atmospheric structures that have a relevant effect on a particular aspect of interest, such as strong winds or heavy rains. Indeed, information derived from such sensitivity analysis should be the guiding basis for decision makers to focus on areas where an increased observational effort would significantly improve the quality and value of short-range numerical weather predictions across the region. Although several sensitivity calculation techniques exist that aim at computing the relevant areas for a particular weather event -such as those used in real-time targeting campaigns- permanent redesigns of the observational strategies require climatological sensitivity information. However, no consensus exists on how climatological sensitivity information should be derived or even verified in a relevant and useful way.

The aim of this work is twofold, on the one side, the essential results from 3 sensitivity climatologies (an adjoint-based and two different ensemble-based) for the short-range prediction of Mediterranean intense cyclones are presented. On the other hand, a verification testbed to evaluate and compare the skill of each climatological sensitivity estimate is developed. The verification of these climatologies is essential to ensure the reliability of the sensitivity products and ultimately provide robust guidance to policy-makers on plans to redefine routine observational strategies. We propose the use of Observing System Simulation Experiments to quantify the reliability of the available adjoint and ensemble sensitivity climatologies. In particular, verification experiments with the NCAR Advanced Research WRF ARW model are conducted for the 25 most intense Mediterranean cyclones of the ERA-40 database to test the ability of each method in identifying areas where perturbations in the initial conditions derived from the sensitivity fields lead to a greater impact on the forecast of the intense cyclone. For the sake of calibration of the verification results, the performance of the sensitivity climatologies is tested against a reference sensitivity proxy consisting of the judgement of an experienced severe weather meteorologist who was asked to indicate the region where a perturbation in the initial conditions would have the largest impact on the forecasted cyclone's depth.

Our results reveal the significantly superior skill of the human and adjoint sensitivity fields against both climatological ensemble sensitivity methods. Also, an optimized ensemble sensitivity climatology based on an ad hoc classification of Mediterranean intense cyclones show a moderate advantage over the previous ensemble sensitivity version.