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WRF simulations of a flash flood event in central Italy: a comparison between variational data assimilation methods

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Nowadays, the assimilation of huge amount of data, acquired in situ or by remote sensing, is a determining factor in the estimation of initial conditions, with consequent impact on the weather forecasts accuracy. This study aims to provide a comparison between three dimensional and four dimensional variational data assimilation systems (3D-Var and 4D-Var) of the Weather Research and Forecasting (WRF) model in a complex topography region. Radar data and conventional observations, provided by the Global Telecommunication System (GTS), are assimilated into the WRF model to simulate a flash flood event in central Italy.

The case study, occurred during the intensive observation period IOP4 (14 September 2012) as part of the HYdrological cycle in the Mediterranean EXperiment (HyMeX), is characterized by a persistent and deep low pressure system over the Tyrrhenian Sea, associated with high convective activity. The heavy precipitations, daily rainfall amount exceeded 150 mm, produced flash floods and several river outflows along the eastern coast of central Italy.

In order to evaluate/compare the performance of 3D-Var and 4D-Var methods in terms of quantitative precipitation forecasts (QPF), several simulations, assimilating radar measurements and conventional observations, are carried out. The rainfall forecast and the precipitation measured by the rain gauges are compared with two different approaches: traditional and object-based. The first approach matches gridded model data to point-based observations through three statistical indicators: probability of detection, false alarm rate and critical success index. The second one identifies the forecast and observed areas of precipitation as objects and compare them considering certain attributes, such as size, centroid displacement and intersection area.

The assimilation of conventional observations with 4D-Var system improves the localization of precipitation patterns respect to 3D-Var and consequently the QPF. In addition, the use of radar reflectivity and radial velocity in 4D-Var experiments, enhances the estimate of rainfall peaks, as corroborated by statistical scores.