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Use of satellite precipitation estimates in short term precipitation forecasting via elastic registration

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Assimilation of satellite precipitation estimates into cloud resolving models is a challenging problem for which even the most general methodologies such as the variational analysis and the ensemble Kalman filter may not be effective. This is because precipitation processes are strongly nonlinear and intermittent, which makes the estimation of model state variables as a function of precipitation observations challenging in many instances. For example, in the case of variational data assimilation, if the model forecasts no precipitation while precipitation is observed, no sensitivity of model forecasted precipitation to model state variables may be derived from the adjoint model and the minimization procedure might get trapped into a local minimum without making effective use of the precipitation observations. Similarly, in the case of ensemble methodology, if all members of the ensemble forecast no precipitation while precipitation exists, no update would be performed because no relationship between precipitation and state variables is found in the ensemble space. Therefore, ad-hoc procedures for inserting, removing, and displacing precipitation features are still needed to augment the most general assimilation methodologies. In this study, we investigate a procedure for correcting phase (location) precipitation errors. The procedure is based on the automatic identification of the elastic deformation of the model grid that maps the forecasted precipitation into the precipitation estimates derived from satellite observations. The elastic deformation field is derived as the solution of the elastodynamic equation that minimizes the difference between the observed precipitation and the elastically transformed model precipitation. The model state variables are updated through the application of the deformation transform. Although this procedure can affect the model balance, it is expected to perform satisfactorily in situations where the areas of model and observed precipitation exhibit good similarity. The methodology is applied to a flash flood producing storm that occurred in North-Eastern Italy in August 2003. An evaluation based on satellite and ground radar observations is performed. Results indicate the procedure's effectiveness.