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Case studies of 4D-Var assimilation of potential vorticity observations derived from image processing

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Short-range forecasts errors occurring in numerical weather prediction are often diagnosed by forecasters as being displacement errors: forecast locations of meteorological structures are displaced from their observations, and this displacement can be evaluated through inspection of satellite images. However, current representation of background error are based on Gaussian assumptions, and linear or weakly non-linear data assimilation schemes are used to correct errors. This hypothesis is more and more critical as resolution increases and as the meteorological situation evolves more and more non-linearly.

Therefore, high resolution forecasts models of strongly non-linear processes, such as thunderstorms or tropical cyclones, need a different, more realistic initialization. Some methods have been developed to identify and correct the position and amplitude of storm-scale thunderstorms and of tropical cyclones, including bogussing practices and variational assimilation of simulated observations.

Despite the growing number of radiance data being assimilated, global models sometimes fail to predict mid-latitude cyclogenesis, even if the upper or lower level precursors are visible in the images from geostationary satellites. Different operational procedures, often based on potential vorticity inversion, have been developed to exploit the link between water vapour images and the initial state of the upper level of the troposphere. Our goal is to build observations of potential vorticity that correct the displacement and amplitude error of the dry intrusions using a image satellite processing technique.

An algorithm developed for the identification and tracking of dry intrusions in water

vapour imageries is used to define potential vorticity pseudo-observations in the upper troposphere. A simple object-based methodology produces observations that are built to locally correct the amplitude and displacement errors as diagnosed from the comparison of the trajectories in the image processing tool. An approximate form of Ertel potential vorticity operator is used to incorporate the pseudo-observations inside a 4D-var assimilation scheme. It is applied to real cases of cyclogenesis forecasts and within an operational data assimilation scheme, the high resolution (20 km over Europe) global model ARPEGE. Experiments on several cases studies highlight the ability of the algorithm to correct locally the tropopause and to partially improve the forecasts of the cyclogenesis. Advantages and drawbacks of this procedure are finally discussed.