Geophysical Research Abstracts, Vol. 8, 01582, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01582

Ensemble sensitivities, their relationship to adjoint sensitivities, and their use in targeted observations

B. Ancell, G.J. Hakim, C.M. Mass

Department of Atmospheric Science, University of Washington, U.S.A.

(bancell@atmos.washington.edu / 206-685-2183)

This study defines a new type of sensitivity, referred to as ensemble sensitivity, which is obtained by linearly regressing some scalar response function of the forecast state onto the intial conditions. The mathematical relationship is first demonstrated between adjoint-based sensitivities, which describe how arbitrary perturbations would evolve linearly to change some forecast response function, and the ensemble sensitivities, which describe how perturbations spread by the statistics defined by the ensembles themselves would linearly change the same forecast response function. Ensemble and adjoint-based sensitivities of a response function representing the 24-hr forecast of sea-level pressure at a single point in Western Washington state are then compared with respect to temperature and geopotential height during a typical wintertime flow situation off the northwest coast of North America. Both adjoint and ensemble sensitivity fields are calculated with a set of 90 analyses from an ensemble Kalman filter (EnKF) system interpolated to the PSU/NCAR MM5 version 3 model from the WRF model. Calculations were performed on a model grid with 45-km horizontal resolution and 33 vertical sigma levels. It was found that adjoint and ensemble sensitivities are very different in terms of location, scale, and magnitude. Adjoint sensitivities are mesoscale lower-tropospheric structures which tilt strongly upshear, whereas ensemble sensitivities are synoptic-scale, exist throughout the troposphere, and are associated with significant weather features at initial time. It is demonstrated how ensemble sensitivities can be dynamically interpreted by considering how the associated statistically-spread perturbation projects onto the adjoint sensitivity field.

Adjoint and ensemble sensitivities are also examined for their usefulness with targeted observation strategies, which is a major subject of investigation in the upcoming

THORPEX field program. Although adjoint sensitivities reveal locations of largest growth, it is shown that weighting the ensemble sensitivity values by a term involving the observation and background variances reveals the optimum locations for targeting observations to reduce variance of the response function the most in the EnKF system. It is also demonstrated how the variance reduction due to observations given the simultaneous assimilation of other observation can be readily calculated. The observations which provide the largest response function variance reduction are shown to be in regions away from both the maximum in ensemble and adjoint sensitivity.