EMS Annual Meeting Abstracts
Vol. 13, EMS2016-352, 2016
16th EMS / 11th ECAC

Techniques for Sensitivity Analysis of Spatial Features in Forecasts: The Stochastic Kinetic Energy Backscatter Scheme

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Stochastic Kinetic Energy Backscatter Schemes (SKEBS) are introduced in Numerical Weather Prediction (NWP) models to represent uncertainties related to unresolved subgrid-scale processes, with the goal of improving the reliability of probabilistic forecasts. These schemes are formulated using a set of parameters that must be determined using physical knowledge and/or for obtaining a desired outcome (e.g., increasing ensemble spread). In order to fully assess the effect of these parameters on forecasts, the NWP model must be run at different values of the parameters, which is impractical as NWP models are computationally intensive. Here, methods of experimental design from statistics (e.g., Latin-square designs and 2k fractional designs are employed to reduce the necessary number of runs, and fixed-effects and random-effects models are employed to model the sensitivities. Focus is placed on four factors and their effect on spatial features of forecasts, as simulated by the SKEBS-enabled Weather Research and Forecasting. The four factors include two physically motivated SKEBS parameters (determining amplitude of perturbations applied to streamfunction and potential temperature tendencies), a purely stochastic element (a seed used in generating random perturbations), and a factor reflecting daily variability. A method for identifying coherent features (i.e. objects) within forecast fields is developed, and the effects of the four factors on object features (e.g., number, size, and intensity) are assessed. It is found that SKEBS does not have an appreciable effect on any of the examined object features. However, it appears that the overall spatial structure of the forecasts is affected by the four factors. Further details of this complex relationship between forecasts and the four factors are presented.