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Real-time ozone forecasts over Eastern North America during the summer of 2004: An assessment of several models and their ensemble

S. McKeen (1,2), J. Wilczak (3), G. Grell (4,2), S. Peckham (4,2), M. Pagowski (4,5)

(1) Aeronomy Laboratory, National Oceanic and Atmospheric Administration, Boulder, Colorado, USA (Stuart.A.McKeen@noaa.gov) / Fax: 303-497-5373 / Phone: 303-497-5622), (2) Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado, USA, (3) Environmental Technology Laboratory, National Oceanic and Atmospheric Administration, Boulder, Colorado, USA, (4) Forecast Systems Laboratory, National Oceanic and Atmospheric Administration, Boulder, Colorado, USA, (5) Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, Colorado, U.S.A.

As part of the ICARTT/NEAQS field study (International Consortium for Atmospheric Research on Transport and Transformation/New England Air Quality Study) conducted over New England during the summer of 2004, five operational and research institutions contributed their real-time air quality forecast model (AQFM) results to a central facility (the National Oceanic and Atmospheric Administration [NOAA] Aeronomy Laboratory). The NOAA Forecast Systems Lab WRF/Chem version 1 model (Weather Research and Forecast model/Chemistry version) is one forecast. The Meteorological Services of Canada provided results from both their CHRONOS (Canadian Hemispheric and Regional Ozone and NOx System) and AURAMS (A Unified Regional Air-quality Modeling System) models. Also included are O_3 forecasts from the NWS/NCEP (National Weather Service/ National Center for Environmental Prediction) CMAQ/ETA (Community Multi-scale Air Quality Model/ETA) model. The Baron AMS (Baron Advanced Meteorological System, Inc.) Corporation provided three AQ forecasts at two horizontal resolutions with results from the 45 and 15 km resolution models considered here. Forecasts from the University of Iowa 12 km horizontal resolution STEM-2K3 (Sulfur Transport and Emissions Model - 2003) AQ model complete the ensemble of seven real-time forecasts.

The AQFM results and corresponding observations, as collected in real-time, of upper air and surface O_3, winds, temperature and water vapor at 15 locations over Eastern North America can be found at the NOAA Environmental Technology Lab (ETL) Internet web-address: http://www.etl.noaa.gov/programs/2004/neaqs/verification/. Also on this web address are the first ever, real-time ensemble forecasts of surface O_3, as well as real-time bias-corrected O_3 forecasts. This presentation focuses on the detailed statistical evaluation of these AQFM O_3 forecasts using observations collected during July and August of 2004 through the U.S. EPA sponsored AIRNow network (Aerometric Information Retrieval Now). The region of model overlap within the analysis includes roughly 340 monitoring stations throughout the Eastern U.S. and Southern Canada. The O_3 ensemble, determined with equal weighting of the seven forecasts, is also evaluated in terms of standard statistical measures, threshold statistics and variance analysis. The ensemble is found to have significantly more temporal correlation to the observed daily maximum 1-hour average and maximum 8-hour average concentrations than any individual model. However, root-mean-square errors (RMSE) and skill scores show the usefulness of the uncorrected ensemble is limited by positive O_3 biases in five of the seven AQFMs. The ensemble and AQFM statistical measures are re-evaluated using two simple bias correction algorithms for forecasts at each monitor location; subtraction of the mean bias, and a multiplicative ratio adjustment. The impact these two bias correction techniques have on RMSE, threshold statistics, and temporal variance is presented. For the threshold statistics a preferred bias correction technique is found to be model dependent and related to whether the model over-predicts or under-predicts observed temporal O_3 variance. All statistical measures of the ensemble forecast, and particularly the bias corrected ensemble forecast, are found to be insensitive to the results of any particular model. The results of this study provide direct and practical recommendations for improving real-time O_3 forecasts when using an equal-weighted ensemble.