2011 Aviation Weather Testbed Summer Experiment
Final Report Summary
June 27 – July 22, 2011

Overview

The Aviation Weather Center located in Kansas City, Missouri hosted its first annual Aviation Weather Testbed (AWT) Summer Experiment from 27 June through 22 July 2011. There were approximately 40 participants from 15 different organizations during the two-week experiment. As part of the AWC mission, activities within the AWT help support the research-to-operations process, improving the safety of flight with respect to weather prediction, and providing weather prediction support that enhances National Airspace (NAS) traffic flow management. The AWT Summer Experiment tested and evaluated a variety of numerical data, including deterministic and ensemble models, as guidance for forecasting convection in and around the "Golden Triangle" (Atlanta-Chicago-New York), which is a high air traffic area in the United States. Several scientific goals and questions were driving factors of the experiment. With high resolution models being a major component of the experiment, a key question pointed to the ability of these high resolution models to provide insight into weather-induced NAS impacts. Participants of the experiment addressed the concept of value added from probabilistic data over deterministic data and explored the capability of the experimental datasets to help focus on specific threat regions. Furthermore, experiment participants evaluated various ways of communicating and visualizing NAS impacts through unique displays.

Experiment Design

Each morning participants formed teams in order to collaborate on the analysis of the day's weather and its potential impact in and around the Golden Triangle, answer survey questions, and develop forecast graphics. The day's activities began with a hand analysis of weather maps and then proceeded to an examination of satellite (including GOES-R proxy products) and observational data and various model guidance. Teams worked through several survey forms that contained questions regarding the utility of the experimental datasets and weather impacts on the NAS. The teams collaborated to produce two daily forecasts graphics that outlined the impact of convection to the Golden Triangle. The first graphic, the "Aviation Weather Impact Graphic", highlighted convection features that would impact the golden triangle from 1800 UTC to 0000 UTC. The second forecast graphic, an exceedance probability graphic, highlighted areas where there were a 30% and 60% probability of composite reflectivity greater than 40 dBZ and echo tops greater than 37,000 feet for the same time period. Teams answered survey questions related to the justification of the graphics and gave a stand-up briefing on their forecasts. Following the briefing, teams used the North American Ensemble Forecast System (NAEFS) global ensemble to determine potential weather impacts to the NAS in the 2-7 day time frame and answered survey questions related to long-range air traffic impact forecasting. Lastly, teams evaluated the previous day's forecast by analyzing the two forecast graphics that were created the day before.

Experimental and Operational Model Guidance

Several institutions contributed new and existing data sets that were tested during the experiment, and each were used to create the aforementioned forecast graphics. High resolution ensemble and deterministic numerical weather prediction models were tested for their ability to correctly resolve the timing, location, morphology, mode, and porosity of convection. The deterministic 3 km High Resolution Rapid Refresh (HRRR; Benjamin 2009) and the Consolidated Storm Prediction for Aviation (Wolfson 2008), along with a 4 km twelve member Air Force Weather Agency ensemble model and NCEP's Short-Range Ensemble Forecast (SREF) system were used in combination with derived air traffic impact forecasts from NCAR to determine the forecast graphics. In addition, the GOES-R program supplied the "Nearcast" forecasts (Petersen 2008), a short-term forecast of convective initiation derived from satellite and RUC model data.

a. Ensemble Data

DOD/Air Force Weather Agency provided the cornerstone of the experiment in way of a 4 km WRF-ARW core-based ensemble. The ensemble was comprised of 12 members with initial conditions from downscaled deterministic runs of UM, GFS, GEM, and NOGAPS. Physics diversity was created by applying various combinations of land surface, PBL, cumulus, and microphysics. The forecasts were initialized at 1800 UTC based on 1200 UTC global inputs with forecasts out to 36 hours. The domain of the ensemble spanned the eastern two-thirds CONUS. Various fields were made available, but emphasis was placed on probabilistic forecasts of echo tops greater than or equal to 25,000 feet and composite radar reflectivity of 40 dBZ or greater.

EMC's Short-Range Ensemble Forecasts (SREF) were also utilized in the forecast process as a supplemental dataset. The ensemble had a horizontal resolution of 32-35 km and spanned the North American domain. It was updated four times daily (0300, 0900, 1500, and 2100 UTC) with hourly forecasts out to 39 hours and three-hourly forecasts out to 87 hours. This multi-model ensemble had Eta, RSM, WRF-NMM, and WRF-ARW members with NAM and GFS providing the initial and boundary conditions. The post-processed ensemble was comprised of 21 members plus a 3-hour time-lagged WRF-NAM. Calibrated fields were mined from the ensemble as guidance for probabilistic forecasts of thunderstorm occurrence and probabilistic forecasts of thunderstorm coverage and intensity. Additionally, these calibrated fields were combined with historical aircraft position data to produce aviation convective guidance. These fields include probabilistic thunderstorm impact at specific flight levels.

b. Derived Airspace Capacity Reduction

NCAR contributed a derived "air traffic impact potential" forecast. These forecasts were probabilistic capacity reduction forecasts derived from a time-lagged ensemble of CoSPA forecasts and from the 4 km AFWA ensemble. The ensemble-predicted storm intensity and echo tops were combined and translated into a Weather Avoidance Field (Steiner et al 2010). Using Metron's Mincut Approach, the airspace capacity reduction was determined in the north-south and east-west orientations at flight levels 20,000 feet, 30,000 feet, and 40,000 feet. These forecasts provided a first-look at the potential reductions in airspace capacity and were used as an initial evaluation of the current day's weather scenario.

NOAA/ESRL/NCAR/MIT/LL Consolidated Storm Predication – First Guess Polygons also provided guidance for storm prediction in and around the Golden Triangle. Probabilistic forecasts were derived from time-lagged ensemble of the CoSPA forecasts and used to produce the First-Guess Polygons. The polygons highlighted the coverage, confidence, and echo top heights of storms. The polygons were generated every 15 minutes out to 8 hours in hourly increments.

c. GOES-R

The University of Wisconsin/CIMSS provided Lagrangian "Nearcast" model forecasts of precipitable water and derived theta-e fields over various vertical layers. These projections of moisture and temperature retrievals were provided out to 9 hours at hourly timestamps. These forecasts supplied information on moisture availability min middle and upper layers of the troposphere, low-level moisture gradients and boundaries, and areas of convective instability. Forecasts were used to help predict convective initiation and evolution.

d. Convection-Allowing Deterministic Model Data

For near storm-scale guidance, GSD's experimental 3 km High Resolution Rapid Refresh (HRRR) model was exploited. This convection-allowing model was initialized from the 13 km Rapid Refresh and used a configuration of the WRF-ARW. Additionally, model included hourly assimilation of all observations available including 3-D radar and lightning data. Hourly forecasts were run out to 15 hours and spanned the full CONUS domain.

The NOAA/MDL Localized Aviation MOS Product (LAMP) Convection Probability and Potential forecasts were also utilized to make the convection/impact forecasts. The LAMP Convection Probability forecasts were based on GFS inputs and current observations. Convection was defined as the yes/no occurrence of reflectivity greater than or equal to 40 dBZ and/or one more cloud to ground light strikes within 20 km of a grid box and within a 2 hour time period. Convection potential forecasts were generated from the probabilities through the application of objectively-derived threshold exceedance probabilities. These forecasts can be viewed as forecast bias, which is the average ratio of predicted areal coverage of convection versus actual areal coverage. During the summer experiment, Convection Potential thresholds were set at: less than 35% corresponded to no potential, between 35% and 55 % corresponded to low potential, 56% to 70% corresponded to medium potential, and greater than 70% corresponded to high potential of convection.

Lastly, the North American Ensemble Forecast System (NAEFS) was used to produce a Day 2-7 categorical forecast of convection impacts. NAEFS is a joint effort between USA, Canada, and Mexico and is a combination of global ensemble forecasts from NCEP and Environment Canada, which includes 40 different models. The models have varying initial conditions and model physics and is updated every 12 hours based on 1200 UTC and 0000 UTC observations.

Results

As a direct result of the experiment, the hourly SREF and 3 km HRRR were deployed into AWC operations. Additionally, subjective findings resulted from the various surveys designed to answer the scientific questions that set the foundation of the experiment. The survey element of the experiment was separated into various components: Traffic Impact, Model Comparison and Forecast Development, Convection Initiation and Model Trends, and Extended Forecast Using NAEFS.

a. Traffic Impact

The traffic Impact survey instructed the participants to use the NCAR derived airspace capacity reduction potential data and the aviation convective guidance from hourly SREF output to initially examine the potential for convective weather impact to the air traffic flow in the

Golden Triangle from 1800 UTC through 0000 UTC. Participants examined the East-West and North-South capacity reduction fields at the 75% and 50% thresholds for flight levels 20,000 ft, 30,000 ft, and 40,000 ft. Details in the survey responses indicated that participants were able to use this derived data to isolate specific regions where the capacity would be reduced due to convective hazards. Participants were then instructed to use the SREF aviation convective guidance to isolate regions impacted by convective weather. These SREF fields were generated by combining meteorological data with gridded historical aircraft information to highlight where convection could potentially most impact the NAS. Survey results showed that general agreement of where the NAS would be impacted by convection existed among the NCAR Capacity Reduction and SREF data. With the SREF data being hourly, this aviation convective guidance could be used to refine the timing of highest potential impact.

b. Model Comparison and Forecast Development

The forecast teams were asked to view current observation data including radar, satellite, surface, and upper air observations and discuss ongoing convection in terms of organization, areal coverage, and impact to the NAS, specifying affected jet routes. Participants were then instructed to compare and contrast the various model data in terms of the value of higher-resolution model over the lower-resolution models for forecast guidance of traffic flow impact. Survey results indicated that high resolution model data did a better job depicting convective mode and evolution and boundary interactions. At times, the high-resolution convective allowing models were able to depict isolated cells and porosity of convection. Additionally, high-resolution data picked up on timing and location of storm initiation and decay.

Participants were then asked to comment on the value added from the 4 km AFWA ensemble compared to the other models. A general consensus was that the 4 km ensemble added value to the forecast process in that more information was provided on storm structure (e.g., cellular nature) and transition properties of the initial on-going convection. The ensemble was able to define isolated, higher intensity convection within the broad convective field. However, it was documented that it can be difficult to ascertain small-scale features based probabilistic information alone

c. Convection Initiation and Model Trends

After the forecast graphics production the forecast teams were directed to evaluate the current weather scenario and convective trends, specifically convective initiation. They were asked how the varying models were handling convective initiation and morphology. Consensus was that the higher resolution models tended to better indicate convective initiation than the coarser resolution models.

The Nearcast data was used as guidance for forecasting convection initiation. The vertical theta-e difference product was primarily used to identify regions that were expected to become convectively unstable. Participants noted that the Nearcast dataset highlighted areas of instability except in regions that were contaminated by cloud cover and was a good indicator of initial growth and areal coverage of convection.

d. Extended Forecast

Forecasters were asked to come up with a categorical long term, days 2-7 aviation impact potential from convection using web-based imagery of NAEFS data. They were to determine whether air traffic delays from 1800 UTC through 0000 UTC would be considered low, average, or elevated. These risk categories were defined as follows: average delays are around 1500, low would be considered 650 delays, and elevated would be 2300 or greater delays. Teams were to examine the instability fields and derive a categorical forecast. Out of the various fields available, forecasters tended to use the probability of lightning within 20 km of a grid point to determine that impact to the NAS. Some of the forecasters related the overall coverage to the potential. Other fields such as joint probability of shear and instability were not focused on due to the propensity towards lower probabilities.

Future Work

The Aviation Weather Center will host its second annual summer experiment June 4-15, 2012. The experiment will create, test, and refine the next generation national aviation weather forecast: The Aviation Weather Statement. Working in teams, participants from our government, academic, and private partners will gather together in the AWT to collaboratively develop this new forecast product, and evaluate emerging weather data sets to be used as new tools in the forecast process, with a focus on high-impact atmospheric convection.