Convective-scale Warn-on-Forecast:
The Severe Weather Forecast Improvements Project

Report on Project Activities

March 2011 through September 2011

The Warn-on-Forecast project has made very good progress during the six-month period from March – September 2011. Detailed progress reports on the five main areas of activity are shown below.

Data Quality Control. Several deliverables for 2011 have already been met. Quality controlled radar data from the Goodland, KS, and Pueblo, CO, radars have been completed for the 11 June 2009 VORTEX2 case, with nearly 4 hours of manually-corrected radar observations available from each radar. Quality controlled phased-array radar data from the 14 June 2011 microburst case over Norman, Oklahoma, have also been completed. Quality control of the 24 May 2011 phased-array radar observations of supercell thunderstorms is underway.

Software to enable conversion between WDSS-II netcdf and FORAY netcdf is complete and fully operational. The development and testing of Observation Processing and Wind Synthesis (OPAWS) software for preparing (basic quality control and objective analysis) radar data for assimilation is complete and the software is available through an online repository (http://code.google.com/p/opaws/).

Automated radar data quality control algorithms for reflectivity data, including the QCNN, CREM and AP-remove methods, have been implemented in WSSS-II. The 2D-Dealias method has been implemented for velocity data quality control and is presently being debugged. Testing of the initial quality-control daisy-chain combinations involving QCNN, AP-remove, CREM, 2D-Dealias and Eilts de-aliasing is underway.

Methods for sharing data with project partners are being explored, with Dropbox being one candidate solution.

Data Assimilation. Good progress is also being made in various data assimilation applications and experiments. The CAPS parallel EnKF system has been enhanced to include all conventional observations used by ADAS and ARPS 3DVAR, and the correctness of their assimilation on parallel platforms has been verified. The efficiency of the system has been further improved by careful load balancing. This EnKF system has been applied to the 10 May 2010 Oklahoma-Kansas tornado outbreak case over a mesoscale domain with a storm-scale nest to investigate the performance of the system for assimilating multi-scale observations. To include both the mesoscale and storm-scale features important on this day, storm-scale ensemble analyses at 4-km grid spacing are nested inside mesoscale ensemble analyses at 12-km grid spacing. Preliminary results show that the analyzed reflectivity exhibits a good fit with the observations in terms of shape, structure, and intensity, except where there is incomplete coverage of radar observations. While the analyzed reflectivity structures compare favorably with the observations in general, subsequent deterministic and ensemble forecasts produce only weak cells in central Oklahoma. Further testing is underway.

An Asynchronous Ensemble Square Root Filter (AEnSRF) algorithm initially implemented in an EnSRF code for the Advanced Research WRF (ARW) model has been implemented in the general EnKF framework of CAPS, and the algorithm further refined. The AEnSRF system also is being tested with the 10 May 2010

Oklahoma tornado case. Preliminary results show a clear advantage for the AEnSRF algorithm when analyzing radar data using 5-minute cycles. With the AEnSRF, elevation scans are grouped into 1-minute batches and are effectively analyzed at the time they were taken. Excellent flow structures are obtained for the tornadic supercell on that day using AEnSRF.

A prototype system for assimilating reflectivity data on the HRRR 3-km grid has been developed and tested for selected cases. Latent heating on the 3-km grid is applied during one hour of forward model integration, based on reflectivity data every 15 min, before a 15-hr HRRR forecast is produced. Testing of the prototype system is underway for the convectively active period of 11-19 August 2011. Extensive verification of forecasts initialized with and without 3-km radar-data assimilation is planned so that strengths and areas for improvement in the data-assimilation technique can be identified (see Fig. 1).

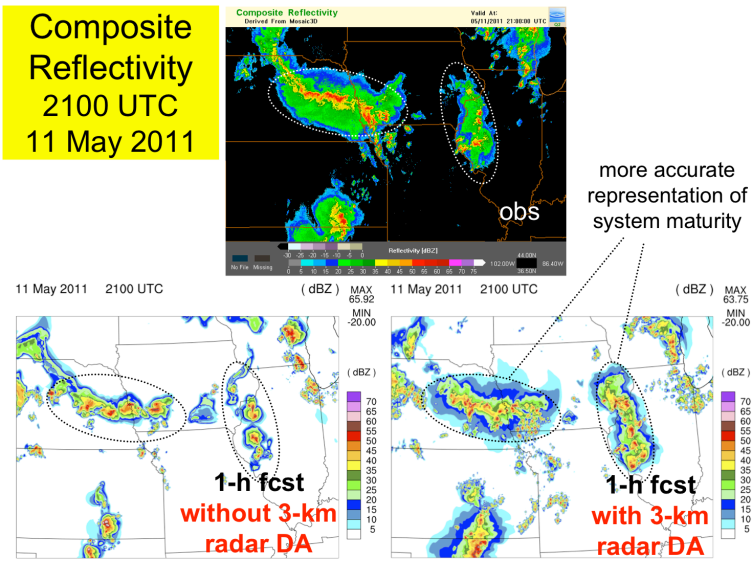

Figure 1. One-hour HRRR forecasts with radar data assimilation on the RR (13-km) grid (left) versus on the HRRR (3-km) grid (right) valid at 2100 UTC 11 May 2011 over the northern plains compared with observations (top).

The ensemble Kalman filter (EnKF) approach is being applied to tornadic supercell thunderstorms (8 May 2003 and 24 May 2011), a derecho-producing mesoscale convective system (4 June 2003), a flash flood (13 June 2011), and a damaging downburst (14 June 2011) event. Results indicate that the EnKF approach produces high-quality analyses, but the ensemble forecasts often dissipate the convection too quickly. These results are consistent with the results from the EnSRF and it is uncertain if initial condition or model error is the cause. Further testing is underway.

Progress has been slow in implementing a version of the Local Ensemble Transform Kalman Filter (LETKF) within the CAPS EnKF framework, due to other center needs, but it is expected that the LETKF will be functional by the end of the performance period. Satellite-derived profiles of temperature and dewpoint

temperature from the Atmospheric InfraRed Sounder (AIRS) instrument have been assimilated for two severe weather events, with results indicating that the satellite retrievals helped provide a more accurate depiction of the environment in which the thunderstorms developed.

Hazardous Weather Testbed. The 3DVAR real-time system was implemented for the spring Experimental Warning Program, with display and use by forecasters in AWIPS. Data were processed (and subsequently archived) for four floating domains, typically from 1700 UTC to 0200 UTC each day, from 17 April to 17 July 2011. The actual forecaster-based evaluation occurred during four weeks between 9 May and 10 June. Initial results suggest that the 3DVAR analyses provided additional information to forecasters regarding storm intensity beyond that available from the radar observations alone.

The OUN WRF hourly-updated forecasts became available in the Hazardous Weather Testbed as of May 2011. During the Spring Experiment in May and June, forecasters had access to OUN WRF forecast output (at 15-minute intervals), which included several experimental derived products. The OUN WRF was reconfigured this year to use the CAPS 3DVAR approach to initialize the model forecasts.

The ability of ensemble forecasts to predict convection initiation (CI) was evaluated by adding a CI desk to the HWT Spring Forecasting Experiment. In addition, the potential for a Storm-scale Ensemble of Opportunity (SSEO) to provide forecast guidance for severe weather was explored. Results suggest that the SSEO could be helpful in the near future before an operational storm-scale ensemble system is available. New visualization tools and approaches were tested and are being improved for next year. An exploratory analysis of simple graphics that convey basic forecast information to the general public is underway.

Capabilities. WRF, Unipost, and NCL have been configured to provide 15-min HRRR output, both for real-time and retrospective forecasts.

Social Science Research. Interviews of administrators at K12 schools were conducted and are being used to find out which sources of weather information are most useful schools and to evaluate the potential impacts of longer lead times for decision-making. Interview tapes have been transcribed and data analysis is underway. An annotated bibliography of social science hazard literature relevant to the concept of "lead-time" has been produced. This bibliography is part of the work with other warn-on-forecast partners to develop a unified plan for social science research and to collaborate on projects of mutual interest.

Survey questions to evaluate the efficacy of call-to-action statements in tornado warnings have been completed by over 1000 participants. Early results show that spotter reports are weightier than Doppler indicated; a sense of dread is most likely to induce shelter-seeking behavior; more information is needed, but not preferred during high stress events; emphasis in text (e.g., bold type or all caps) is preferred since it conveys urgency; a time range for the expected danger is preferred to a general expectation of danger until the warning expires; categorical risks are slightly preferred over percentages.

How first-order users, including emergency managers, broadcast meteorologists, and NWS forecasters, use SPC products also is being explored. A national survey for these groups is being considered.

Summary. The progress made during the first six months of 2011 for the WoF project is very good and on or ahead of schedule for most project areas. Many of the building blocks for the project, including manual quality-controlled data sets for testing and improved automated quality control procedures, are underway and already helping other project teams to make progress. The testing of real data cases, in both the Hazardous Weather Testbed and in post-event mode, has expanded. More cases are being studied with a greater variety of hazardous weather events. Social science research has expanded and is already providing information that will be beneficial not only to the project, but to NOAA as we seek to understand how warning information is used to make decisions.