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Use of the LEAD Portal for On-Demand Severe Weather Prediction

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ABSTRACT

The Linked Environments for Atmospheric Discovery (LEAD) Portal was used in real time for on-demand forecasting of severe weather during the 2007 Hazardous Weather Testbed (HWT) Spring Experiment. The LEAD portal is web-based and uses service oriented architecture to allow users to access and analyze meteorological data and to prepare, submit, and monitor numerical forecasts and then archive, analyze, and verify forecast data. Two 9-hour Weather Research and Forecasting model (WRF) forecasts, initialized at 15 UTC over relocatable regional domains, were submitted once a day during a portion of the two month HWT experiment. The forecast domains were centered on areas of elevated risk for severe weather occurrence as determined by a LEAD Project meteorologist using information supplied from Mesoscale Discussions issued by the NOAA/Storm Prediction Center and/or daily HWT weather briefings. The initial conditions for the two forecasts were either interpolated from the LEAD ARPS Data Analysis System (ADAS) 10-km horizontal grid spacing CONUS 1500 UTC analysis or from the 3-hour North American Model (NAM) 1200 UTC forecast. The lateral boundary conditions were extracted from the 1200 UTC NAM forecasts using the ARPS EXT2ARPS software package. Due to resource limitations, the WRF forecast data were not available in time for comparison with other model guidance prior to afternoon convective activity, but the forecast data such as temperature, dew point temperature, winds and precipitation were available for comparison with observations and other model forecasts in near-real time. This test validated the use of the LEAD Portal for on-demand forecasting of severe weather. Preliminary assessments of forecast skill and recommendations for future on-demand testing are presented.

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1. INTRODUCTION

This work examines the use of a web portal known as the Linked Environments for Atmospheric Discovery (LEAD) for the creation, management and verification of on-demand thunderstorm predictions made during the 2007 Hazardous Weather Testbed (HWT) spring prediction experiment. The HWT 2007 experiment was a collaboration among university faculty and students, government scientists, and NOAA and private forecasters to further our understanding and use of storm-scale numerical weather prediction in weather forecasting . LEAD scientists and Portal developers were in a unique position to work with HWT participants to expose this technology to real time forecasters, students, and researchers.

There are three primary goals of the 2007 LEAD On-demand experiment: 1) to test and report on the LEAD Portal capabilities in a real time forecasting environment providing on-demand forecast information to severe weather forecasters, 2) to identify additional user needs for future enhancements and development of the LEAD Portal, and 3) to identify other services or resource needs to support the portal services. It is important to highlight that this work is experimental from two perspectives: 1) the portal software, including the automated use of grid computing resources, is under development and 2) the use of a real time convective-scale numerical prediction system in the operational forecast process is relatively new. This paper will provide a summary of the operational and logistical aspects of the forecast process on the verification of the numerical predictions.

As numerical modeling capabilities expand and additional remote sensing networks are deployed, there is an increasing need to manage the expanding volume of data available for use in meteorology research and education and to simplify the complicated process of using that data in weather prediction. This improvement can be referred to as the democratization of weather prediction and analysis. Several educational and research institution across the US have expended considerable resources training students, researchers, and support personnel in the development and use of research and real time weather prediction systems. These systems are often composed of several meteorological applications, including analysis, forecasting, verification, and web page components. Since there are no freely available simplified software systems capable of providing an easy to create, use and maintainable forecast and analysis system, most users must write thousands of lines of code that scripts the processing of data, staging and execution of the analysis and forecast applications (i.e. ADAS, ARPS, WRF etc) on supercomputers as well as providing verification and output graphics. One such system ARPSCNTL, (Droegemeier 1995, Carpenter et al. 1999, 2001, 2004), created and supported at the University of Oklahoma (Xue 2007), is comprised of 50,000 lines of PeRL and operates 24 hours a day (see http://www.caps.ou.edu/wx/p). ARPSCNTL manages the ingoing data and prepares, submits and monitors the forecasts and generates graphics output for web pages and verification. This complex system has been in use and continual refinement for over 12 years and requires regular maintenance and development. ARPSCNTL was used during the 2007 HWT in a separate project to provide 33-hr thunderstorm ensemble predictions over the CONUS (Xue, 2007 and Xue et al. 2008).

LEAD is a five year large ITR project funded by the National Science Foundation and is charged with developing an easy-to-use web-based interface designed for meteorology students, researchers and educators to advance advancing scientific discovery in mesoscale meteorology (Droegemeier et al. 2005, Gannon et al. 2007a, 2007b, 2007c). The LEAD project has two primary goals: to democratize the use of complex weather predictions systems and to enhance our understanding, prediction, and to dynamically interact with mesoscale weather phenomenon. One deliverable of the project is the LEAD Portal, a web-based system that uses service oriented

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Corresponding Author's Address: Keith Brewster, CAPS/Univ of Oklahoma, 120 David L. Boren Blvd, Suite 2500, Norman OK, 73072 architecture (Gannon, 2007d) to provide users with the ability to prepare, conduct, monitor, and verify WRF forecasts as well as explore and analyze data, including NEXRAD radar data. Baltzer et al. (2007) applied the LEAD portal in an UNIDATA workshop as a tool to help workshop participants build, submit and view WRF model forecasts. Many applications and use cases exist within meteorology for the portal including supporting undergraduate education (Clark and Yalda, 2006, Clark et al., 2007).

2. FORECAST PREPARATION

The daily forecasts were prepared by a LEAD scientist interacting with SPC/HWT forecasters and participants. The tools used were the LEAD portal and a supercomputer accessed over the Web. The LEAD scientists were Dr's Dan Weber and Keith Brewster, who interacted directly with the SPC forecasters and HWT participants to obtain the daily model domain location recommendations. The 9-hr WRF forecasts consisted of 1000 km x 1000 km regions placed in an area of elevated risk of severe weather occurrence during the 1500-0000UTC forecast period. The on-demand forecasting process is depicted in Figure 1, and illustrates the forecaster's interaction with the weather to create a customized forecast process not possible within the current real-time NWP scheme.

The forecast creation process involves several steps. Once the forecast region was identified, the forecast/workflow building and submission process was completed via the LEAD Portal (http://www.leadproject.org). A workflow consists of a series of applications that are linked together via data input and output and executed in series or parallel, as applications allow. A simple WRF forecast workflow includes interactive selection of the forecast domain, the preparation of the forecast initial and lateral boundary conditions, preparation of the terrain and land surface files, and specification of other necessary forecast input parameters. In addition, post-processing applications such as WRF-POST and ARPSPLT are available for inclusion in the WRF forecast workflow (Gannon et al. 2007b).

The workflows were submitted to the computing resources at the National Center for Supercomputing Applications (NCSA). For this project the Tungsten machine was used. Due to the load on that machine, including other 2007 HWT computing resource needs, the workflow often waited for several hours in queues to run, before 80 Tungsten processors were available to be allocated to the workflow. The plan for the 2008 LEAD-HWT effort includes securing more resources for the forecaster-initiated on-demand forecasts, allowing for more real time use and evaluation of the forecast data.

The entire process, from login to workflow submission, required less than 5 minutes to complete and represents a huge savings in terms of manpower when compared to other real time forecast scripting systems that requires significant development overhead and maintenance. The portal contains capabilities to process several different types of meteorological data including support for NetCDF version 3.5, surface observations, radar data and satellite data. In addition, workflows perform the necessary data movements to satisfy the forecast requirements, including moving large amounts of data within the portal and to and from supercomputing centers. For more information on the data subsystems of the LEAD portal see Plale (2004) and Plale et al. (2005a and 2005b).

Figures 2 and 3 contain screen-shots of the forecast generation steps, including login and experiment creation, domain selection and experiment summary display. The current LEAD portal has a modest workflow library available for users becoming familiar with the workflow environment. Users can also build WRF workflows using the workflow composer, but during this experiment the workflow library was used in conjunction with the domain selector.

The on-demand forecasts were initialized using the 15UTC LEAD ADAS analysis or 3-hr NAM forecast initialized at 1200UTC with a horizontal grid spacing of 2-km. The ADAS analysis included radar data and other observations to update the 3-hour NAM forecast from the 12UTC initial time. The background filed for the ADAS analysis was the 3-hr NAM forecast. One advantage to this on-demand forecast system configuration is the potential rapid turnaround for a convective scale forecast using NAM forecasts updated with mid-morning observations. The period selected, from 1500 UTC to 0000 UTC overlaps with part of the 2007 HWT forecast and verification period for the larger-scale 2 and 4-km grid spacing numerical forecasts. The LEAD on-demand forecasts began in the first week of May and continued until June 8^{th}. Figure 4 contains a graphical representation of the forecast region center location for each forecast during the experiment, including failed workflows with filled symbols representing completed forecasts. An attempt was made to submit NAM and ADAS initialized forecasts with the same center location via graphical means, but the graphical means at which the domain location is determined allowed for small differences in grid location, on the order of several kilometers. A more precise determination of the model grid center information is possible if the users manually enters the domain center information into the settings box in the domain selector (Fig. 3a).

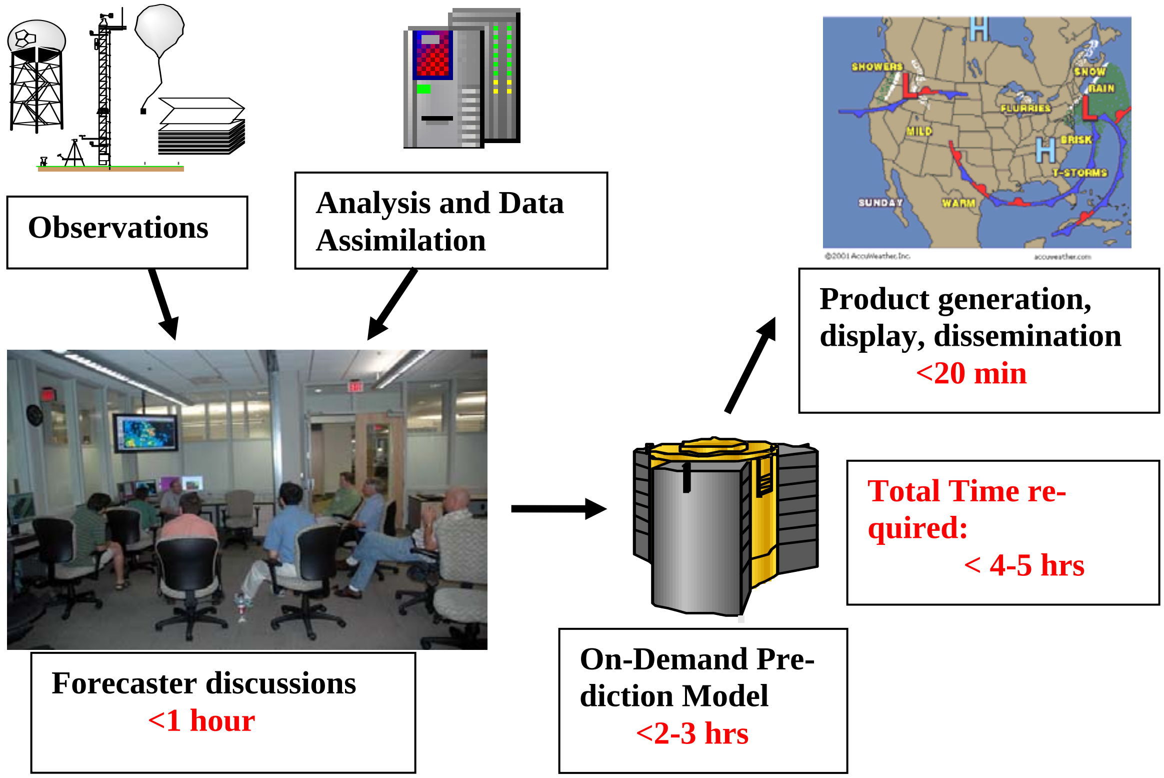
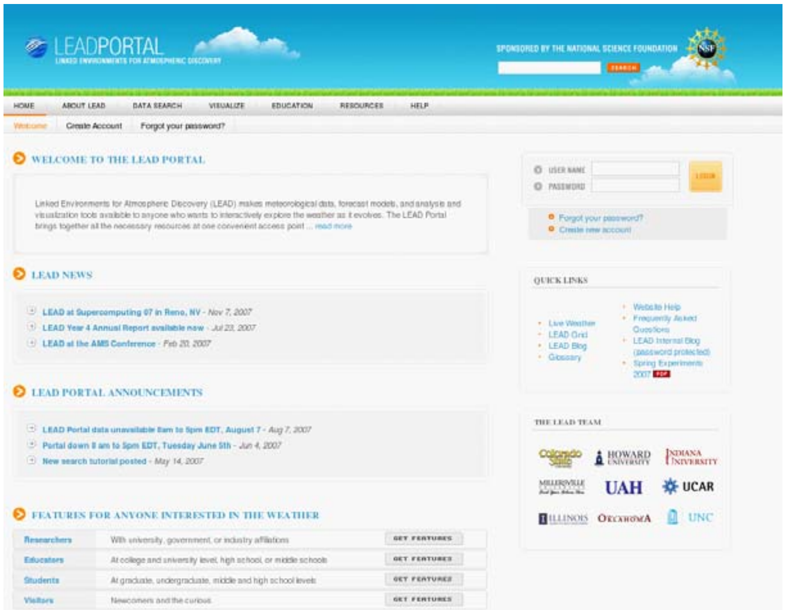


Fig. 1. Depiction of the on-demand forecast process, including the collection and analysis of data, forecaster discussions, creating and completing the on-demand WRF forecast. Total required time is a function of computing resources and represents approximately 80 dedicated processors for 4-5 hrs for the 9-hr forecast. Forecast times can be reduced to <2-3hr if 160 or more processors were used.

(a)



WELCOME TO THE LEAD PORTAL

Linked Environments for Atmospheric Discovery (LEAD) makes meteorological data, forecast models, and analysis and visualization tools available to anyone who wants to interactively explore the weather as it evolves. The LEAD Portal brings together all the necessary resources at one convenient access point ... read more

LEAD NEWS

- LEAD at Supercomputing 07 in Reno, NV - Nov 7, 2007
- LEAD Year 4 Annual Report available now - Jul 23, 2007
- LEAD at the AMS Conference - Feb 20, 2007

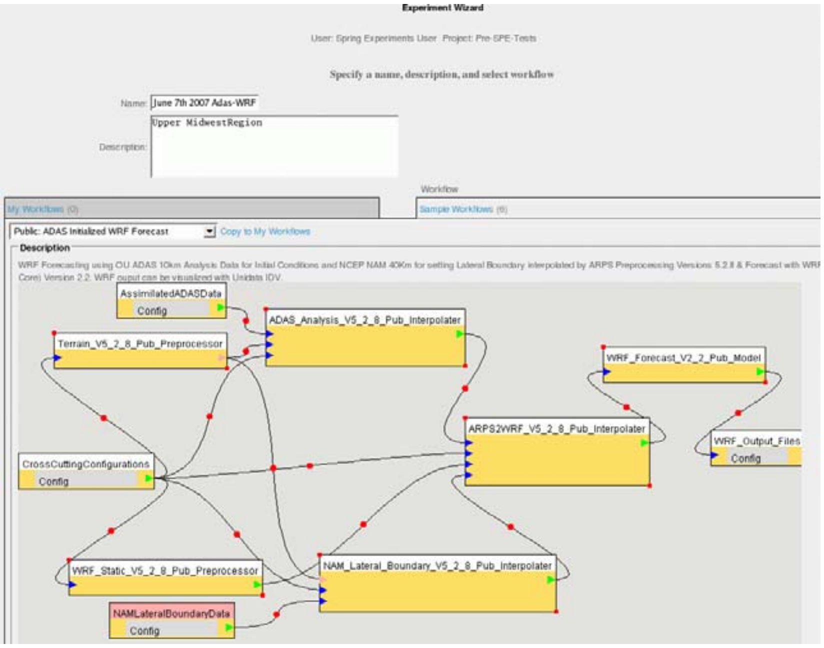
LEAD PORTAL ANNOUNCEMENTS

- LEAD Portal data unavailable 8am to 5pm EDT, August 7 - Aug 7, 2007
- Portal down 8 am to 5pm EDT, Tuesday June 5th - Jun 4, 2007
- New search tutorial posted - May 14, 2007

FEATURES FOR ANYONE INTERESTED IN THE WEATHER

Researchers	With university, government, or industry affiliations	GET FEATURES
Educators	At college and university level, high school, or middle schools	GET FEATURES
Students	At graduate, undergraduate, middle and high school levels	GET FEATURES
Visitors	Newcomers and the curious	GET FEATURES

(b)



User: Spring Experiments User Project: Pre-SPE-Tests

Specify a name, description, and select workflow

Name: June 7th 2007 Adas-WRF

Description: Upper MidwestRegion

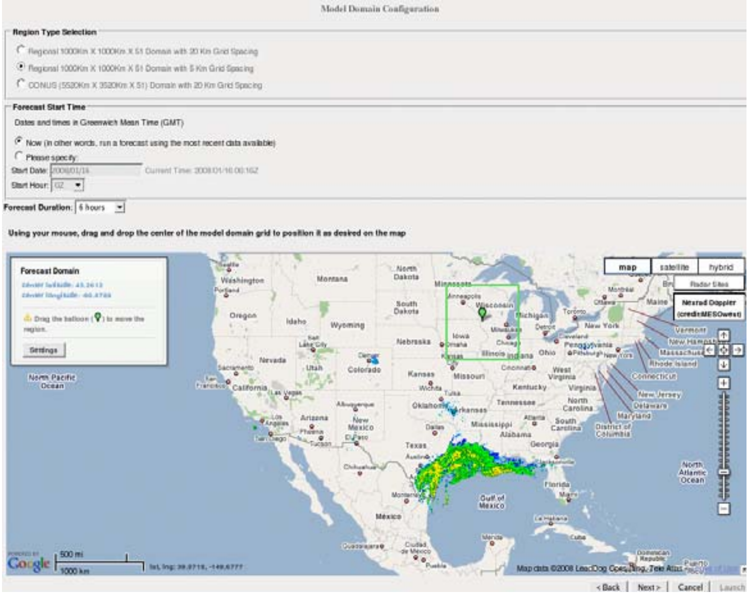
Public: ADAS Initialized WRF Forecast

Description

WRF Forecasting using OU ADAS 10km Analysis Data for Initial Conditions and NCEP NAM 40Km for setting Lateral Boundary interpolated by ARPS Preprocessing Versions 5.2.8 & Forecast with WRF Core) Version 2.2. WRF ouput can be visualized with Unidata IDV.

Fig. 2. Screenshots of two of the 7 LEAD Portal workflow steps needed to launch a WRF 2km work-flow similar to that performed during the 2007 HWT-LEAD on-demand forecast exercise. a) login home page, b) experiment builder page.

(a)



Model Domain Configuration

Region Type Selection

○ Regional 1000Km X 1000Km X 51 Domain with 20 Km Grid Spacing
● Regional 1000Km X 1000Km X 51 Domain with 5 Km Grid Spacing
○ CONUS (5520Km X 3520Km X 51) Domain with 20 Km Grid Spacing

Forecast Start Time

Dates and times in Greenwich Mean Time (GMT)

● Now (in other words, run a forecast using the most recent data available)
○ Please specify:
Start Date: 2008/01/16 Current Time: 2008/01/16 00:16Z
Start Hour: 0Z

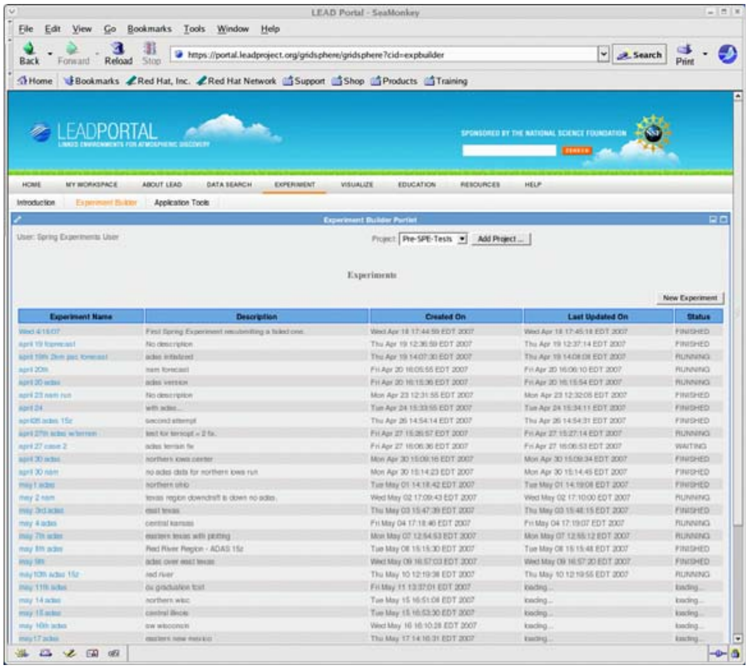
Forecast Duration: 6 hours

Using your mouse, drag and drop the center of the model domain grid to position it as desired on the map

Forecast Domain

Drag the balloon ( ) to move the region.

(b)



https://portal.leadproject.org/gridsphere/gridsphere?cid=expbuilder

User: Spring Experiments User

Project: Pre-SPE-Tests

Experiments

Experiment Name	Description	Created On	Last Updated On	Status
Wed 4/18/07	First Spring Experiment resubmitting a failed one.	Wed Apr 18 17:44:59 EDT 2007	Wed Apr 18 17:45:18 EDT 2007	FINISHED
april 19 forecast	No description	Thu Apr 19 12:36:59 EDT 2007	Thu Apr 19 12:37:14 EDT 2007	FINISHED
april 19th 2km pac forecast	adas initialized	Thu Apr 19 14:07:30 EDT 2007	Thu Apr 19 14:08:08 EDT 2007	RUNNING
april 20th	nam forecast	Fri Apr 20 16:05:55 EDT 2007	Fri Apr 20 16:06:10 EDT 2007	RUNNING
april 20 adas	adas version	Fri Apr 20 16:15:36 EDT 2007	Fri Apr 20 16:15:54 EDT 2007	RUNNING
april 23 nam run	No description	Mon Apr 23 12:31:55 EDT 2007	Mon Apr 23 12:32:05 EDT 2007	FINISHED
april 24	with adas...	Tue Apr 24 15:33:55 EDT 2007	Tue Apr 24 15:34:11 EDT 2007	FINISHED
april26 adas 15z	second attempt	Thu Apr 26 14:54:14 EDT 2007	Thu Apr 26 14:54:31 EDT 2007	FINISHED
april 27th adas w/terrain	test for terrain = 2 fix.	Fri Apr 27 15:26:57 EDT 2007	Fri Apr 27 15:27:14 EDT 2007	RUNNING
april 27 case 2	adas terrain fix	Fri Apr 27 16:06:36 EDT 2007	Fri Apr 27 16:06:53 EDT 2007	WAITING
april 30 adas	northern iowa center	Mon Apr 30 15:09:16 EDT 2007	Mon Apr 30 15:09:34 EDT 2007	FINISHED
april 30 nam	no adas data for northern iowa run	Mon Apr 30 15:14:23 EDT 2007	Mon Apr 30 15:14:45 EDT 2007	FINISHED
may1 adas	northern ohio	Tue May 01 14:18:42 EDT 2007	Tue May 01 14:19:08 EDT 2007	FINISHED
may 2 nam	texas region downdraft is down no adas.	Wed May 02 17:09:43 EDT 2007	Wed May 02 17:10:00 EDT 2007	RUNNING
may 3rd adas	east texas	Thu May 03 15:47:39 EDT 2007	Thu May 03 15:48:15 EDT 2007	FINISHED
may 4 adas	central kansas	Fri May 04 17:18:46 EDT 2007	Fri May 04 17:19:07 EDT 2007	RUNNING
may 7th adas	eastern texas with plotting	Mon May 07 12:54:53 EDT 2007	Mon May 07 12:55:12 EDT 2007	RUNNING
may 8th adas	Red River Region - ADAS 15z	Tue May 08 15:15:30 EDT 2007	Tue May 08 15:15:48 EDT 2007	FINISHED
may 9th	adas over east texas	Wed May 09 16:57:03 EDT 2007	Wed May 09 16:57:20 EDT 2007	FINISHED
may10th adas 15z	red river	Thu May 10 12:19:38 EDT 2007	Thu May 10 12:19:55 EDT 2007	RUNNING
may 11th adas	ou graduation test	Fri May 11 13:37:01 EDT 2007	loading...	loading...
may 14 adas	northern wisc	Tue May 15 16:51:08 EDT 2007	loading...	loading...
may 15 adas	central illinois	Tue May 15 16:53:30 EDT 2007	loading...	loading...
may 16th adas	sw wisconsin	Wed May 16 16:10:28 EDT 2007	loading...	loading...
may17 adas	eastern new mexico	Thu May 17 14:16:31 EDT 2007	loading...	loading...

Fig 3. As in Fig 2, (a) domain selection page, and (b) the experiment summary page.for a project.

3. FORECAST EVALUATION

Verification from within a real time workflow is a difficult task simply due to the fact that the verification data are not available until after the forecast time has been reached. At present, LEAD is developing verification applications for the portal to compare surface data and rainfall observations to the gridded forecast data. As a result, we will present only subjective verification results for two of the cases during the spring experiment, while continuing to work on the objective verification.

Note that a significant portion of the workflows, approximately 60% or 40 of the 65 cases, encountered software and/or hardware problems. The failure points in the workflow system consisted of compute nodes failures at the supercomputing site (NCSA Tungsten) during an unusually unstable period in the aging Linux Cluster. In addition, the computing resources were limited for this effort as most of the HWT resources were focused on the large scale 2-km and 4-km ensemble simulations, requiring approximately 65 times more computing resources than the LEAD On-demand forecasts (approximately 7600 CPU hours). Additionally, the workflows encountered file data transfer failures (GridFTP), due to Grid FTP implementation and configuration problems on file servers, job submission (WS GRAM) and control and LEAD cyberinfrastructure errors to which solutions have been obtained in collaboration with TeraGrid systems engineers. Some of the forecast failures were due to unusually heavy loads on the supercomputer head nodes and long queue wait times in which the LEAD workflow submission wait time was exceeded. The LEAD portal continues to be evaluated and improved as the LEAD Portal and TeraGrid resources mature.

Thunderstorm prediction verification is an active area of research and both objective and subjective verification processes contain flaws and merits. The verification of the LEAD 2007 HWT WRF on-demand deterministic forecasts is presented using subjective verification methods. It has been shown that the use of traditional objective quantitative precipitation (QPF) verification methods for storm-scale forecasting is problematic in that small errors in the position of strong storms can lead to large errors in RMS, threat scores and other point-wise statistics and not reveal some of the other potential values of a storm-scale forecast such as revealing the mode and severity of convection (e.g., Baldwin and Kain, 2006, Davis et al 2006a, Davis et al. 2006b).

We choose to perform a subject analysis of two convectively active days, June 5th and 7th, 2007 because these forecasts produced model output at 15 minute intervals throughout the 9 hour forecast, while earlier forecasts during the experiment period generated output at 1 hour intervals. A more complete verification analysis of all of the on-demand forecasts will be presented at the oral presentation.

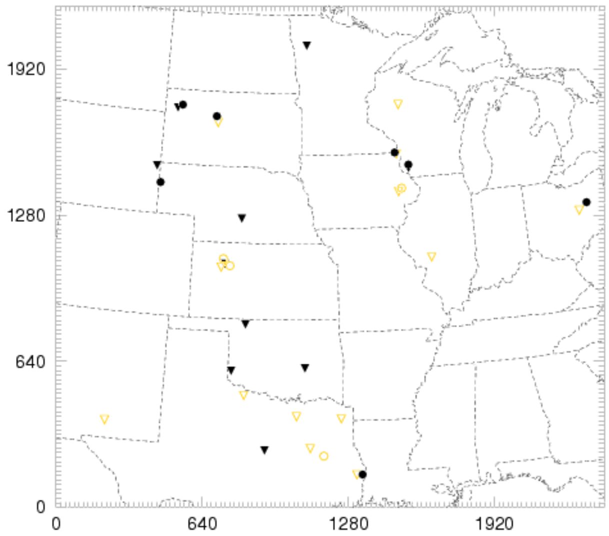


Fig. 4. Symbols represening the center latitude and longitudes locations of the forecast regions initialized at 15 UTC using the 3-hr NAM forecast (circles) and the 15 UTC ADAS analysis (triangles) forecasts. Solid and unfilled symbols indicate completed and failed forecasts, respectively. Failed forecasts were due to supercomputer hardware and software failures, excessive batch job waits >12 hours, or missing input data.

3.1 Subjective Criterion

Several subjective scoring parameters were used to grade the WRF forecasts. These include the time of initial significant thunderstorm development, the speed and direction of storm movement, the location and intensity in terms of maximum estimated radar reflectivity, and the convective mode. Table 1 contains the scoring guidelines used in this study. These criteria were selected for use in comparing the NAM and ADAS initialized simulations with the observations and the HWT large scale 2 and 4km WRF forecasts started the night before the LEAD on-demand forecasts. Model generated composite reflectivity is compare to composite reflectivity from the HWT model output and to the composite observed reflectivity.

Table 1. Subjective scoring matrix description. Higher numbers (points) represent better skill and are focused on grading thunderstorm characteristics, such as time of initiation, location, movement, intensity (dBZ) and convective mode.

Parameter/Points	4	3	2	1	0
Initiation Timing (hr)	< 1	1-2	2-3	3-4	>4
Location (km)	< 30	30-60	60-90	90-120	>120
Speed Error (km/hr)	< 9	9-18	18-27	27-36	>36
Direction Error (+/- Degrees)	<5	5-15	15-25	25-35	>35
Reflectivity Intensity (max dBZ)	< 5	5-10	10-15	15-20	>20
Mode Accuracy (% matching coverage)	>75	60-75	40-60	25-40	<25

3.2 June 7th, 2007 Case Study

The June 7th case was selected due to numerous severe weather reports in the upper midwest and contained isolated supercells as well as convection organized in a line.

Comparison of the 20 UTC radar images for the HWT 2 and 4km forecasts and the LEAD on-demand shows distinct differences among the various forecasts (Figs 5-8). The difference among the forecasts is the use of the previous days 21Z SSEF data for the ARW2 and ARW4, the resolution and initial condition for the ARW3, and 15 UTC data and resolution for the LEAD-ADAS run.

At this time the NMM-4, LEAD NAM and NSSL-4 show convection that is weaker than the observed both in terms of coverage and intensity over SE Iowa and western Wisconsin. Note that the observed areas feature a line of individual supercellular storms from which several severe weather reports were received. This bias is also present at a later time (00 UTC).

The LEAD-ADAS and ARW2 forecasts were superior to the others in terms of intensity, location, and orientation of the storm over southeastern Iowa. However, over Wisconsin the LEAD-ADAS forecasts over-predicted the aerial coverage of convection.

At 00 UTC the aerial coverage of observed convection decreased slightly but the intensity remained. There were some differences among the forecasts, that were of a similar nature to those found at 20 UTC,

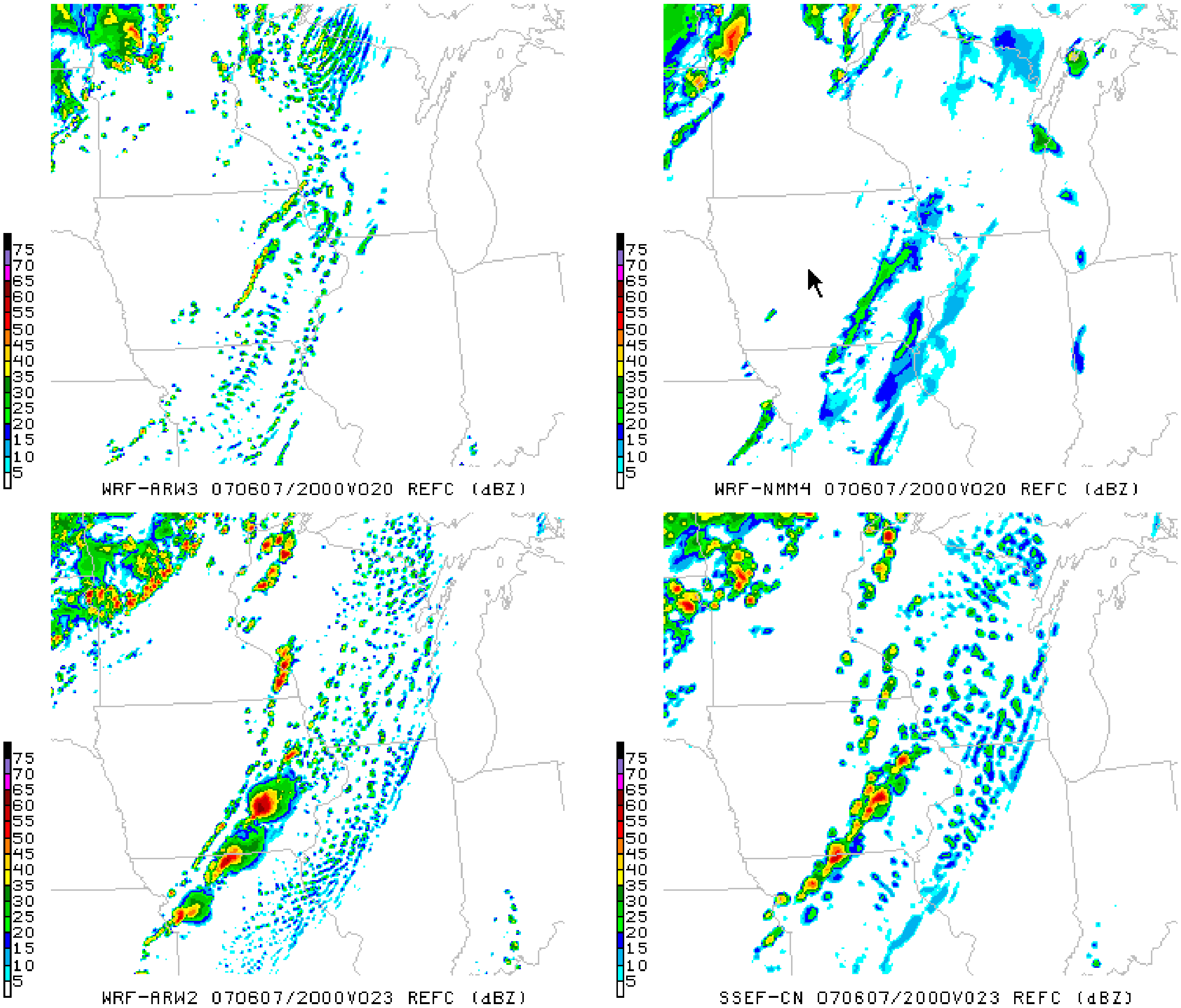


Fig 5. Comparison of four forecasts of radar composite valid at 20 UTC 07 June 2007: a) 3-km WRF ARW initialized at 00 UTC, b) 4-km WRF NMM initialized at 00 UTC, c) CAPS 2-km WRF initialized at 21 UTC 06 June 2007, 4-km WRF ARW SREF Control forecast initialized at 00 UTC. Compare to the additional forecasts and verification radar in Fig 6.

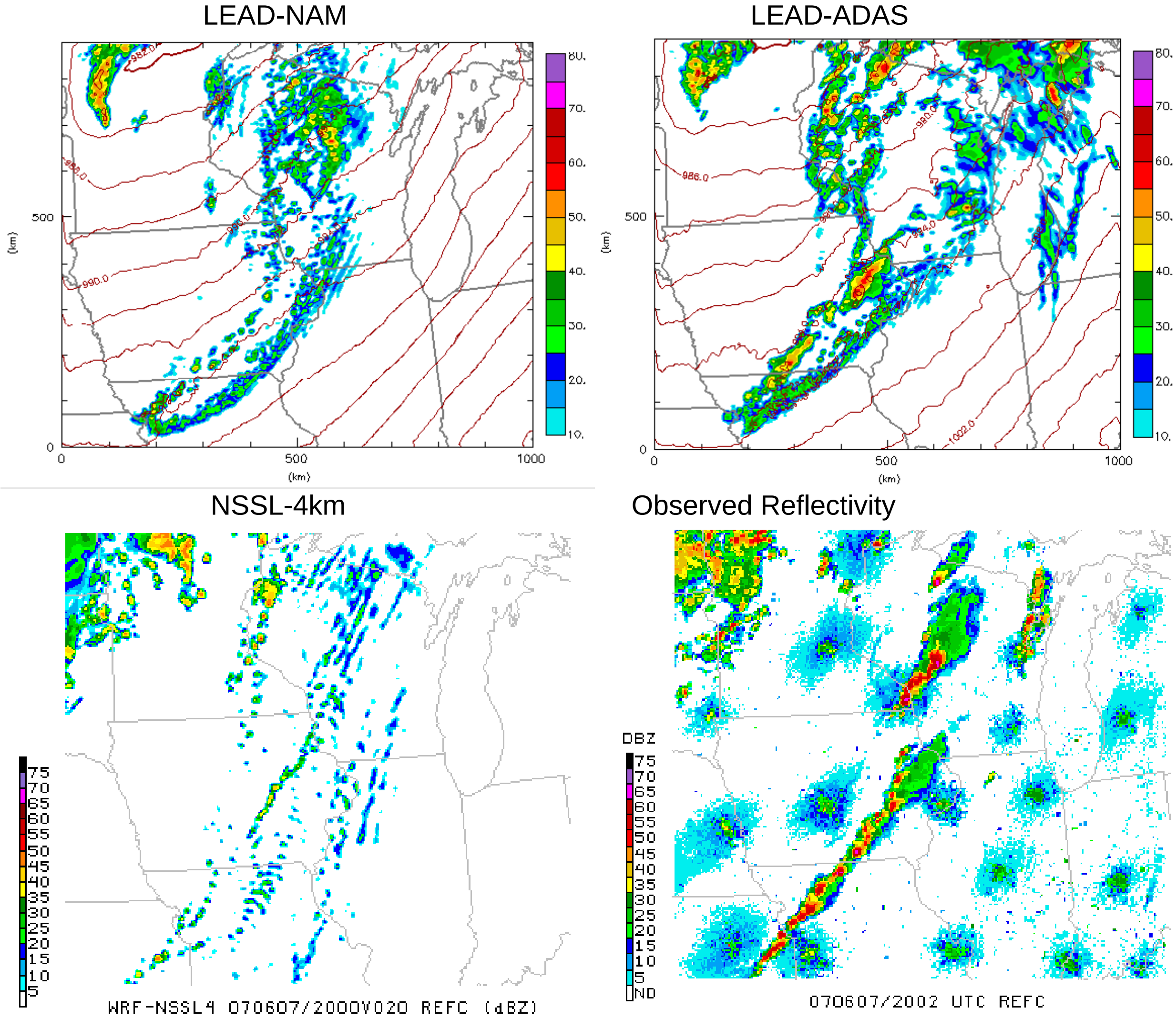


Fig 6. Comparison of three forecasts of radar composite valid at 20 UTC 07 June 2007: a) LEAD 2-km WRF initialized from the 3h forecast of the 1200 UTC NAM, b) LEAD 2-km WRF initialized from the 15 UTC ADAS analysis, c) NSSL 4-km WRF initialized at 00 UTC, d) Observed radar composite at 2002 UTC.

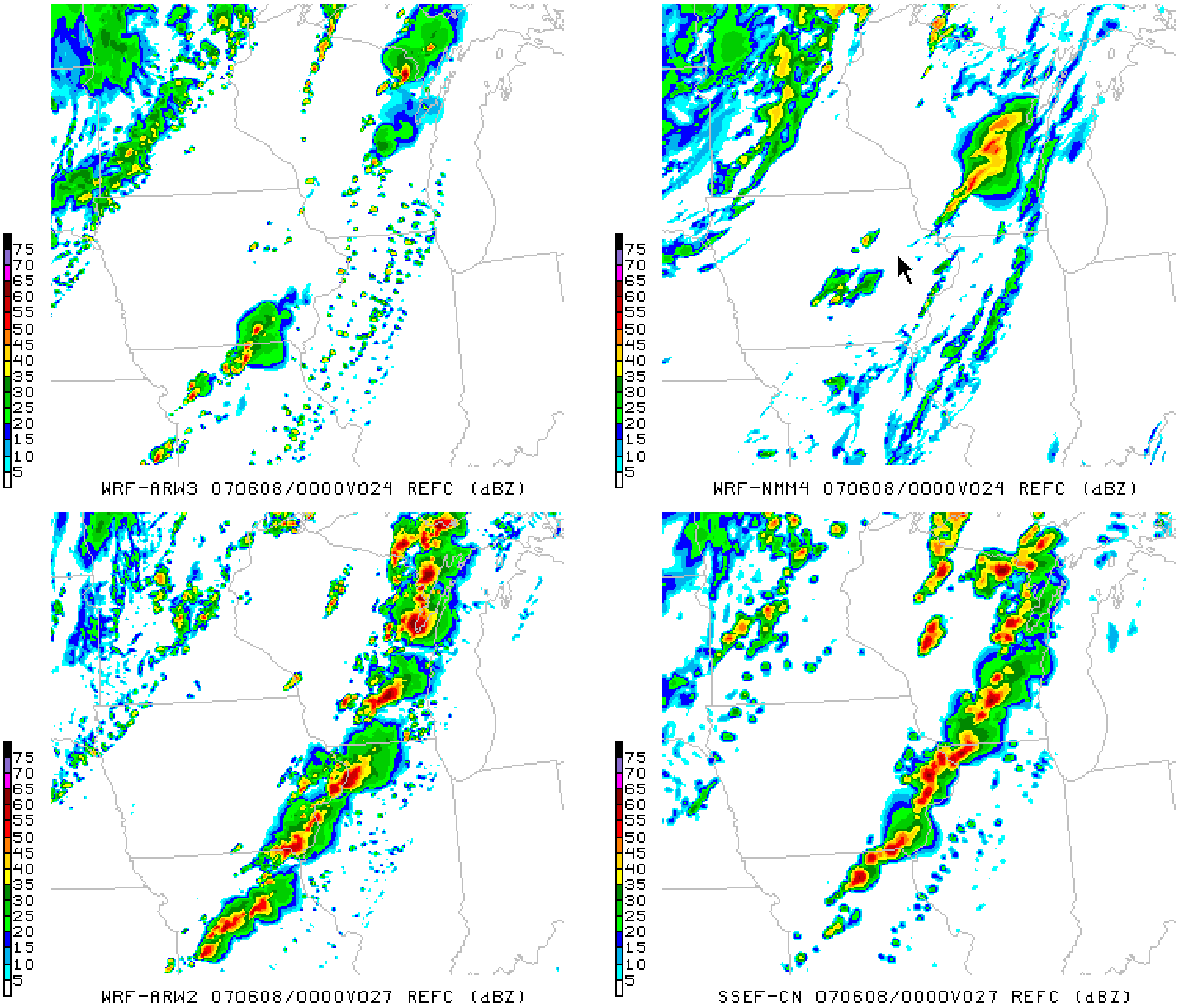


Fig 7. Comparison of four forecasts of radar composite valid at 00 UTC 08 June 2007: a) 3-km WRF ARW initialized at 00 UTC, b) 4-km WRF NMM initialized at 00 UTC, c) CAPS 2-km WRF initialized at 21 UTC 06 June 2007, 4-km WRF ARW SREF Control forecast initialized at 00 UTC. Compare to the additional forecasts and verification radar in Fig 8.

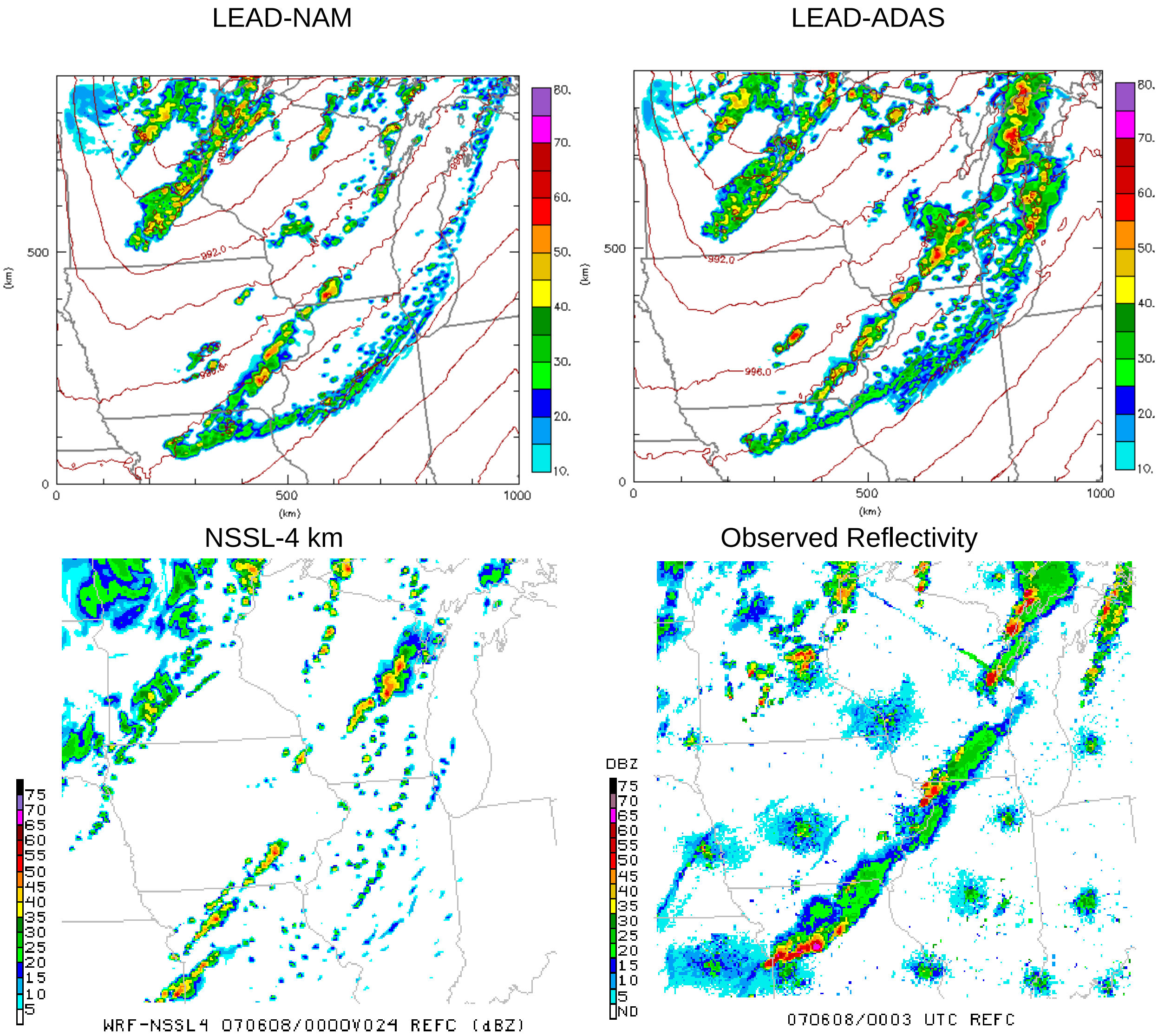


Fig 8. Comparison of three forecasts of radar composite valid at 00 UTC 08 June 2007: a) LEAD 2-km WRF initialized from the 3h forecast of the 1200 UTC NAM, b) LEAD 2-km WRF initialized from the 15 UTC ADAS analysis, c) NSSL 4-km WRF initialized at 00 UTC, d) Observed radar composite at 2002 UTC.

Table 2. Subjective scores for LEAD On-Demand WRF forecasts.

Date (2007) mm/dd	ADAS or NAM	Grid Center lat,lon (Degrees)	Timing	Location	Speed	Direction	Intensity	Mode	Sum
06/05	ADAS	42.87, -104.23	2	2	3	4	1	3	15
06/05	NAM	42.22, -103.97	1	1	3	3	1	3	12
06/07	ADAS	42.87, -90.70	3	3	2	4	3	2	17
06/07	NAM	43.00, -90.70	2	2	1	4	2	2	13

Considering a comparison of just the two LEAD forecasts, the ADAS run does a better job handling the main line of convection during the period as the NAM-intiialized run is a little slow in initiating convection on that line in Iowa and produces less intense convection. However, the ADAS-initialized run produces some spurious convection early in the run that started in NE Iowa and quickly moved northeast – the remains of that can be seen in the Upper Pennisula of Michigan at 20 UTC (Fig 6b). It is possible that the ADAS analysis resulted in the net convective inhibition being too weak in those areas for this case. At 00 UTC both LEAD forecasts had a weak secondary boundary to the southeast of the main line running from near Chicago, across northern Illinois into northern Missouri. In the case of ADAS it appears that this is convection on an outflow boundary from the main line, while in the NAM-initialized run it seemed to have developed on its own as a weak line.

The subjective verification (Table 2) used data from the model forecasts during the period from 18-22 UTC. In general, both forecasts predicted the direction of the resultant convection very well, indicating that the steering flow was similar between both initial conditions, likely because surface only data are available at 15 UTC. Differences between mode types are also small and are related to environmental conditions. Location of the convection is more sensitive to stability and convective inhibition, in which the ADAS analysis could produce a considerably different outcome. This is evident, since the ADAS initialized run created spurious convection soon after initialization time, pointing to a domain-wide modification of the atmospheric stability. The speed was estimated using a 18-22 UTC window and following convection that initiated in NE Iowa and moved to the NE. Both forecasts handled the speed of this convection well, with minor difference between them.

4. DISCUSSION AND FUTURE PLANS

LEAD was successful in building and deploying a web-based portal from which one can seamlessly and quickly submit and manage on-demand high resolution numerical forecasts for severe weather. Some early technical difficulty with the data flow and queing to the supercomputer centers have been addressed and we are confident now in the robustness of the system for future use.

The system generate forecasts that were unique compared to the other high resolution forecasts being run for the Spring HWT operations, and we expect them to be valuable members of high-resolution ensembles used for severe weather forecast guidance.

All of the LEAD-generated forecasts will be verified objectively against quantitative precipitation estimates and subjectively using the criteria described here.

Planning is underway to decide the extent that LEAD on-demand thunderstorm prediction will be integrated into the spring 2008 HWT operations. The LEAD Project continues to develop the portal with the inclusion of new applications and workflow capabilities. For the real-time aspect to have a more direct role as real-time guidance in the upcoming forecast experiment, additional computing resources must be dedicated to this effort.

For a similar scale exercise in which two WRF forecasts are conducted daily in an on-demand fashion, we estimate that approximately 400-500 compute processors are needed for up to 2 hours. This would provide a forecast turnaround on the order of 2 hours, allowing the review of the output for use in the updated early afternoon discussion. Given the exposure from the 2007 experiment, SPC forecasters and HWT participants could build and submit the on-demand forecasts soon after the LEAD 15 UTC ADAS analysis product is available.

5. ACKNOWLEDGMENTS

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