Using the LEAD Portal for Customized Weather Forecasts on the TeraGrid

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Relocatable On-Demand Forecasts

Future Vision

• Numerical Weather Prediction (NWP) forecasts should *adapt* to the weather and user needs.

• Detailed NWP forecasts run in region of concern:
  – **Storm Prediction Center:** before issuing a severe thunderstorm or tornado watch
  – **Local Weather Forecaster:** anticipating local event
  – **Community Emergency Manager:** fire or disaster need

• Data mining of large-scale forecasts could identify areas of *expected risk* or *higher uncertainty* where additional forecasts would be most useful.
  – Higher resolution
  – Using more recent data
  – Using customized physics packages
LEAD

- Linked Environments for Atmospheric Discovery
- NSF Large Information Technology Research Project
- Goals
  - Democratization of high performance computing
  - Provide seamless integration of data access, analysis, and numerical weather forecasting models
  - Ease data exploration and mining
  - Support research and education
- Collaboration among Computer Scientists and Meteorologists
- 9 Research Partners
  - Univ of Oklahoma, Univ of Indiana, Univ of Illinois, Millersville Univ., Howard Univ., Univ of North Carolina, Univ of Alabama, Univ of Michigan, UNIDATA Program
WRF and TeraGrid

• WRF
  – Open source community Numerical Weather Prediction model.
  – Complex to install and implement on a workstation.
  – Even more difficult to set up on a supercomputer.
  – Further complexity to link to real-time or archived data.

• TeraGrid
  – NSF-sponsored supercomputing centers
  – Large facilities to handle BIG projects.

LEAD: Lets make it EASY to run WRF on TeraGrid!
LEAD Workflow

- Build experiment (Xbaya Workflow Builder/Monitor)
- Orchestrate components (BPEL Based with WSDL files)
- Pre-built workflows allow fast submit
ADAS & WRF
NWP Workflow

- Accept interactive user input
- Build terrain
- Build land surface features
- Find and access LEAD-10km gridded weather analysis including radar data
- Interpolate initial conditions
- Interpolate boundary conditions
- Build job script
- Obtain TeraGrid authorization token
- Transfer files to TeraGrid Supercomputing Center
  2007: Tungsten at NCSA
  2008: BigRed at Indiana University, NCSA as back-up
- Submit job to queue
- Transfer result files back using GLOBUS GRID-FTP
- Display and annotate files in user workspace
- Copy output files to OU for post-processing
- Optionally catalog results for sharing results, data mining.
Interactive Location Selection

<table>
<thead>
<tr>
<th>Region Type Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑ Regional 1000Km X 1000Km X 61 Domain with 30 Km Grid Spacing</td>
</tr>
<tr>
<td>☑ Regional 1000Km X 1000Km X 51 Domain with 5 Km Grid Spacing</td>
</tr>
<tr>
<td>☑ CONUS (552Km X 352Km X 51) Domain with 20 Km Grid Spacing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forecast Start Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dates and times in Greenwich Mean Time (GMT)</td>
</tr>
<tr>
<td>☑ Now (in other words, run a forecast using the most recent data available)</td>
</tr>
<tr>
<td>Please specify:</td>
</tr>
<tr>
<td>Start Date: 2008/01/16</td>
</tr>
<tr>
<td>Current Time: 2008/01/16 06:16Z</td>
</tr>
<tr>
<td>Start Hour: 02</td>
</tr>
</tbody>
</table>

| 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:
- Center Latitude: 32.3812
- Center Longitude: -108.8738
- Drag the balloon ( ) to move the region.

Embedded Google Map with atmospheric discovery data.
Storm Prediction Center

• NOAA/SPC produces
  – Severe Thunderstorm and Tornado Watches
  – Mesoscale weather discussions
  – 1-8 day outlooks for severe and hazardous weather

• Located in the National Weather Center at the Univ. of Oklahoma
SPC Spring Program in the Hazardous Weather Testbed

• Testing and calibration of new forecasting methods in a simulated operational setting

• Collaboration among
  – NOAA units
  – Universities
  – Private sector

• Testbed located between the NOAA Storm Prediction Center and Norman National Weather Service Forecast Office
2007 SPC Spring Experiment
LEAD On-Demand WRF

• High resolution forecast location of forecast based on morning data and severe weather outlook
• Weather Research and Forecasting (WRF) model
• ~1000x1000 km domain
• Start WRF using
  – Interpolation from operational NWP model (NAM) and/or
  – Interpolation from 10-km ADAS analysis
• Submit using LEAD web portal, selecting
  – Initial time
  – Domain center
2007-2008 Spring Experiments

- Observations
- Analysis and Data Assimilation
- Product generation, display, dissemination 20-30 min
- On-Demand Prediction Model <2-3 hrs
- Total Time required: < 4-5 hrs
- Forecaster discussions <1 hour

Linked Environments for Atmospheric Discovery
leadproject.org
Interactive Forecast Runs

Domain Centers

Spring 2007

Spring 2008

Linked Environments for Atmospheric Discovery

leadproject.org
**Results - Technology**

- Workflow service for *submitting* runs flawless and efficient
- Robustness of end-to-end system was *A Tale of Two Seasons*
  - 2007: Difficulties with robustness
  - 2008: Largely successful

**April 28-June 3 2008**

62 Forecasts Submitted

87% of end-to-end workflows successful
A Caveat

Flash Flooding at IU on June 4th

June 4-6th, 2008
Flooding at IU caused power and hardware problems bringing down Big Red and data capacitor
5 of 6 workflows lost in this period
Results – Sample Case 7-June-2007

- WRF ARW 1-km grid spacing
- 1000 x 1000 km domain
- Domain centered in SW Wisconsin
- Submitted two on-demand WRF runs
  1. Initialized with 3h forecast 12 UTC NAM
  2. Initialized with 15 UTC ADAS analysis
L\textit{inked} Environments for \textit{A}tmospheric \textit{D}iscovery leadproject.org

00 UTC 8-June-2007

Composite Refl

LEAD 9-h WRF (NAM)

NMM 24-h 4km WRF

LEAD 9-h WRF (ADAS)
From 2008: Forecasting Storm Initiation in Oklahoma

Forecast, 01-02 May 2008

Additional Cases
http://www.caps.ou.edu/wx/spc/
Computed Cloud

Linked Environments for Atmospheric Discovery
Results – NWP Forecasts

Subjective Scoring Scheme

<table>
<thead>
<tr>
<th>Parameter/Points</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
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<tr>
<td>Very Good</td>
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<td>Good</td>
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<tr>
<td>Fair</td>
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<tr>
<td>Poor</td>
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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 |

Preliminary Results

14 forecast cases evaluated to date

Mean Score Sum: 14.1 (2.8 avg element)
Mean LEAD ADAS: 14.8 (2.3 avg element)
Mean LEAD NAM: 13.0 (2.0 avg element)

Highest scores; direction of movement
Lowest scores: location of initiation
Future Plans

• Science
  – Complete subjective scoring of results for 2007 & 2008
  – Use 1-km NOAA Quantitative Precipitation gridded radar data (QP2) to objectively score forecasts

• Technology
  – Continue to work on improving robustness and repeatable turn-around time
  – Improve graphics for additional thunderstorm-specific diagnostic variables
  – Resume work with SPRUCE for urgent computing
LEAD on the Web

LEAD site
www.leadproject.org

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