Real-time High-Resolution Thunderstorm Analyses and Forecasting Experiments Using OSCER Resources

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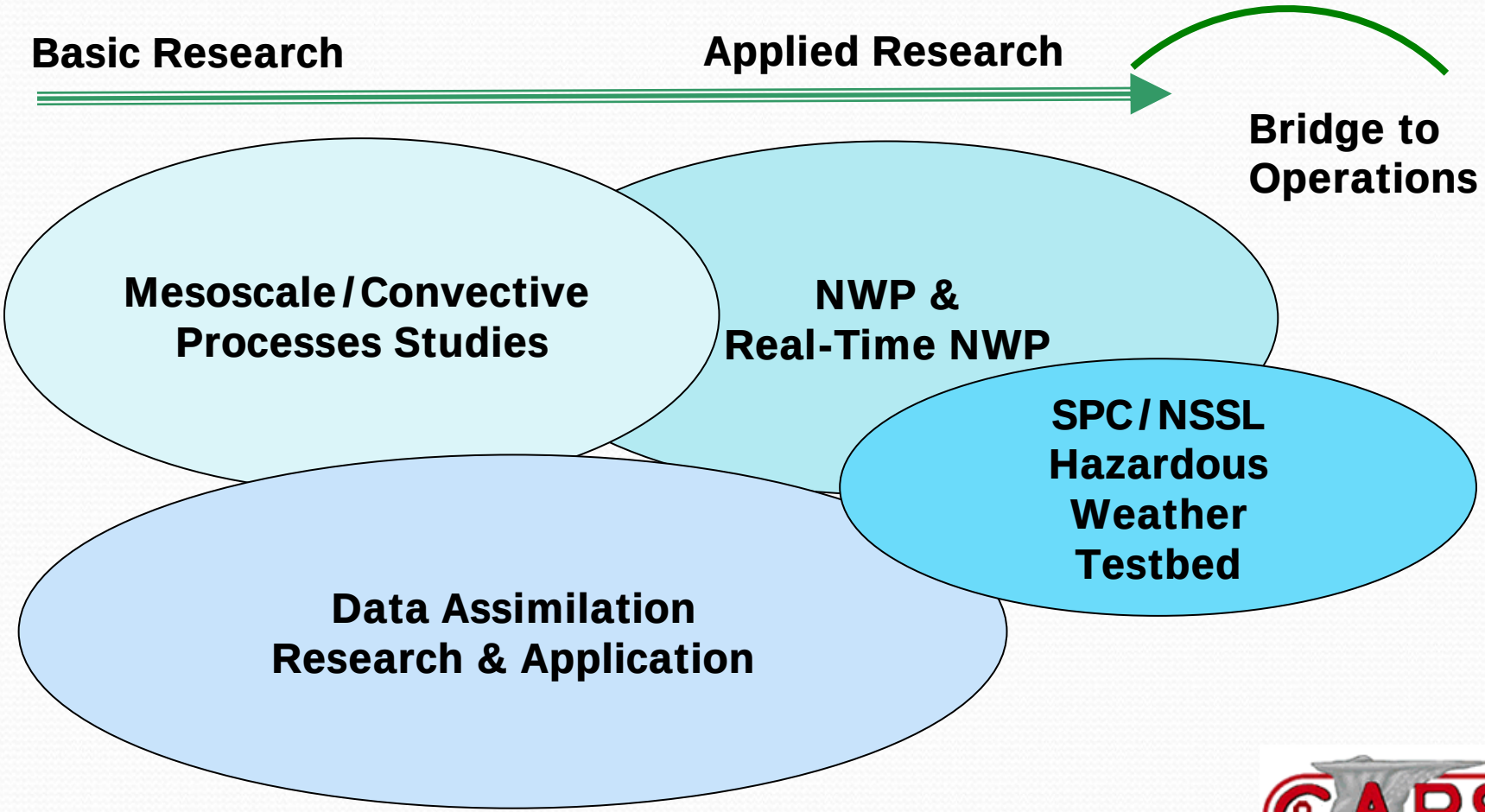
ARPS Simulated Tornado

About CAPS

- Research Center at the University of Oklahoma
- Storm-Scale Weather Analysis and Prediction
- Founded in 1989 as an NSF Science and Technology Center
- Now supported through individual research grants
  - NSF, NOAA, FAA, NASA, ONR, Private Industry grants

CAPS Research Areas



About CAPS – Computing

- **CAPS: Linux Workstations and Clusters**
  - **CAPS Ingest Cluster**
    - **Real-time Weather Data Ingest & Storage**
    - **Pre-processing of data for real-time experiments**
  - **Development Workstations & Servers**
    - **Code Development/Visualization/Local Storage**
- **OU Supercomputing Center for Education & Research - OSCER**
  - **Sooner ~4000 cores**
- **NSF TeraGrid**
  - **Really Big Iron Used for Large-scale Experiments**
  - **Ensemble Models run over 2/3 CONUS in Spring**
  - **Large Data Assimilation Experiments**

OU SUPERCOMPUTING CENTER for EDUCATION & RESEARCH
OSCER
UNIVERSITY OF OKLAHOMA

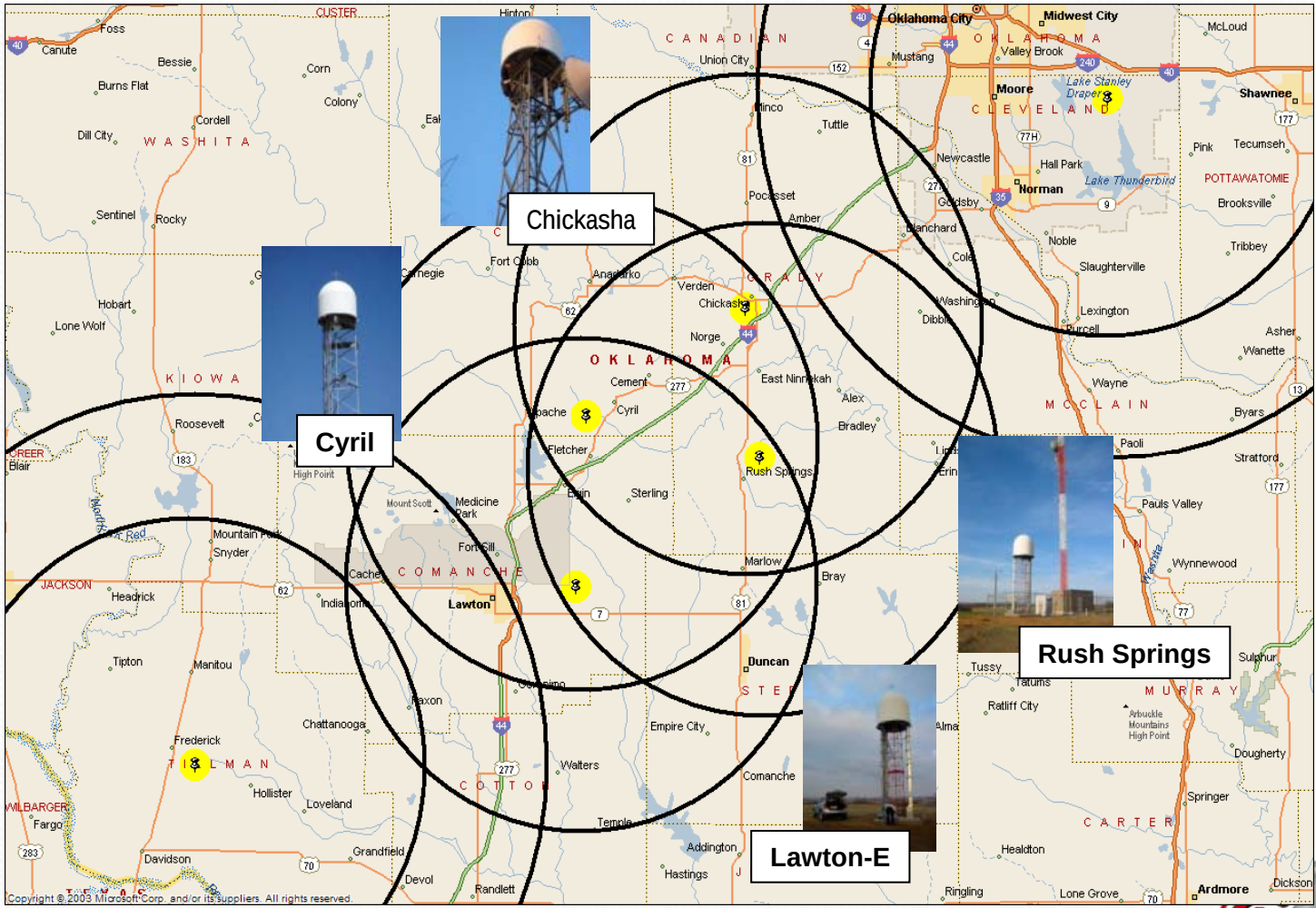
TeraGrid

CAPS

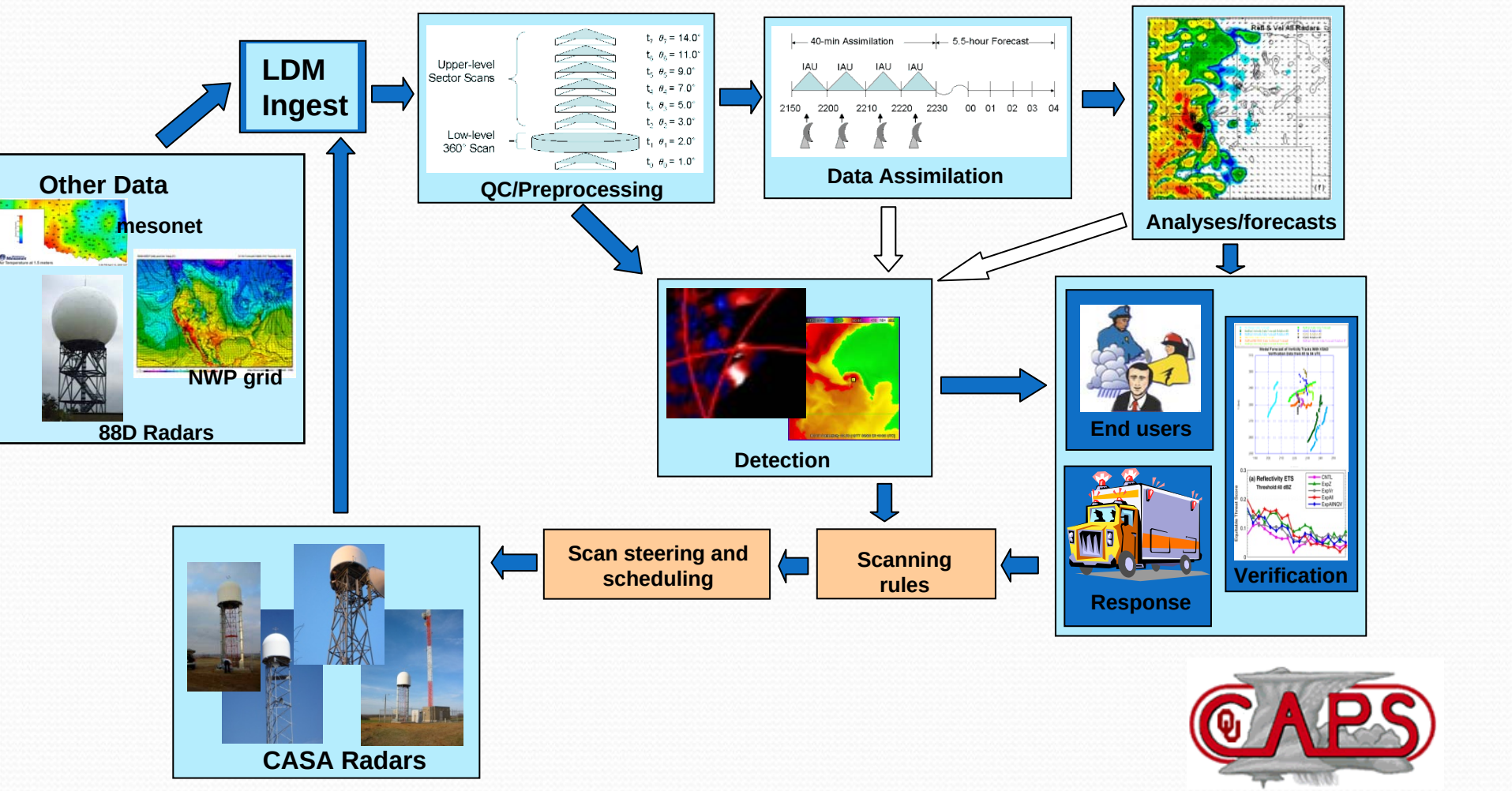
CAPS Research Using HPC OSCER & TeraGrid

- Storm-scale Process Studies
  - Storm Initiation (IHOP Project)
  - Tornadogenesis (Vortex & Vortex2 Projects)
  - Hurricane Intensity/Tracks
- Storm-scale Data Assimilation Research
  - Doppler Radar Wind and Reflectivity
  - Dual-Polarization Variables
  - Radar Refractivity → Low-level Humidity
- Linked Environments for Atmospheric Discovery (LEAD)
  - Democratization of NWP
- Real-Time Numerical Weather Prediction Experiments
  - Post-processing Ensemble of WRF & ARPS Forecasts
  - High Resolution Forecast

CASA Radar Network



Analysis and Prediction in Closed Loop System



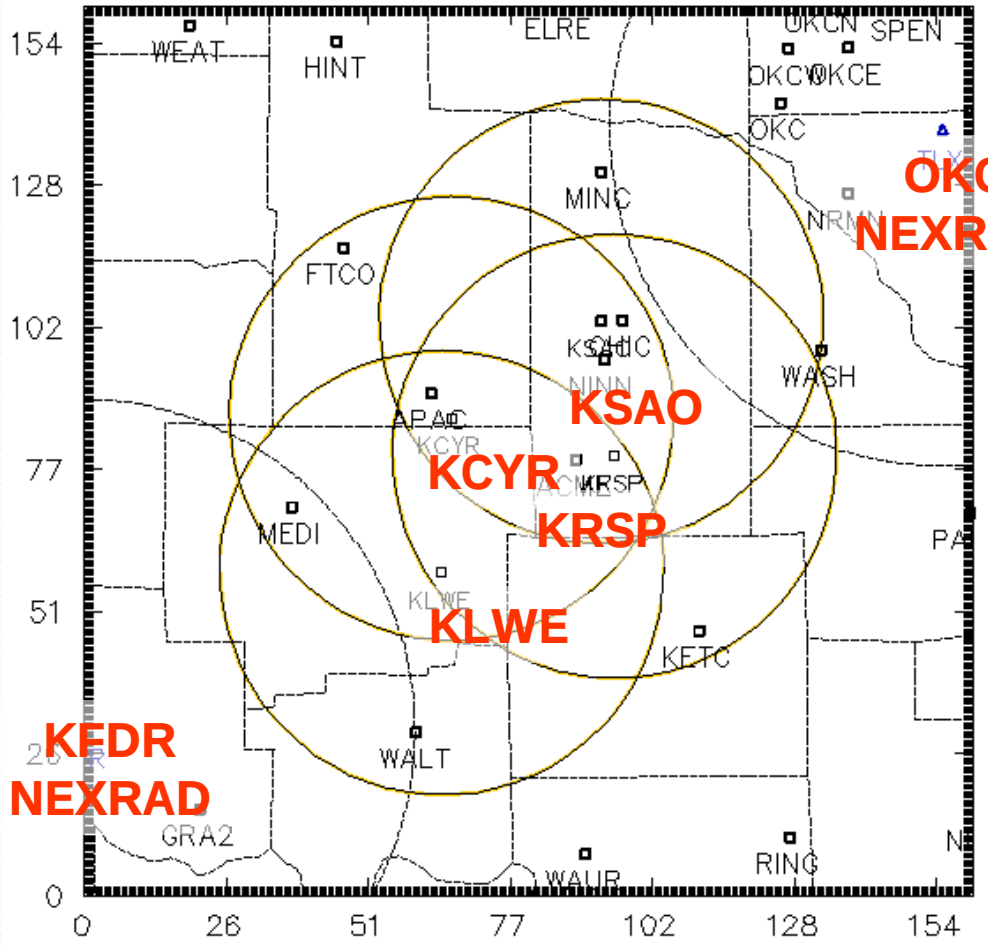
2009 CASA Analyses & Forecasts

- Real-time wind analyses every 5 minutes, provided to forecasters at HWT warning facility.
- Real-time forecasts up to 6-hours available within 30-90 minutes, assimilating CASA and all other data. Two forecasts can be run simultaneously.

Real-time Wind Vector Analysis

- Provide intuitive products that non-experts can understand and use – difficult to interpret raw radial velocity data
- Improve human-based detection and warning
- Show benefits of multi-sensor data analysis and temporal consistency through model assimilation
- Framework for modeling or automated extrapolation

2009 3DVAR Wind Analysis for HWT



IP1 radar coverage (40 km range)
NEXRAD (60 km range ring), OK Mesonet sites

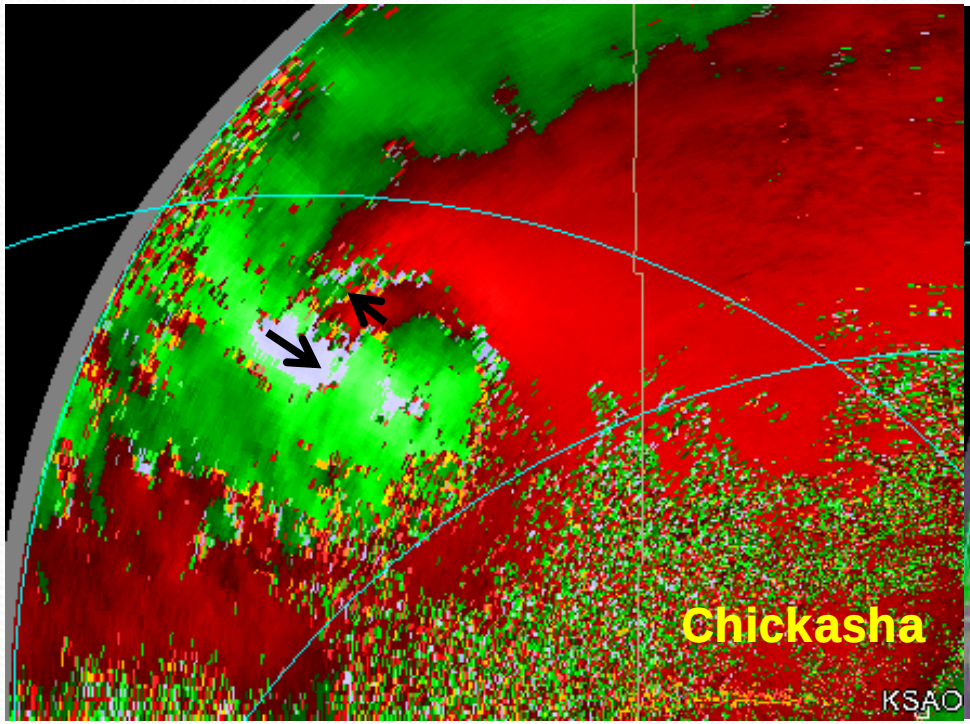
Using CASA, NEXRAD,
OK Mesonet, and NAM backgroun

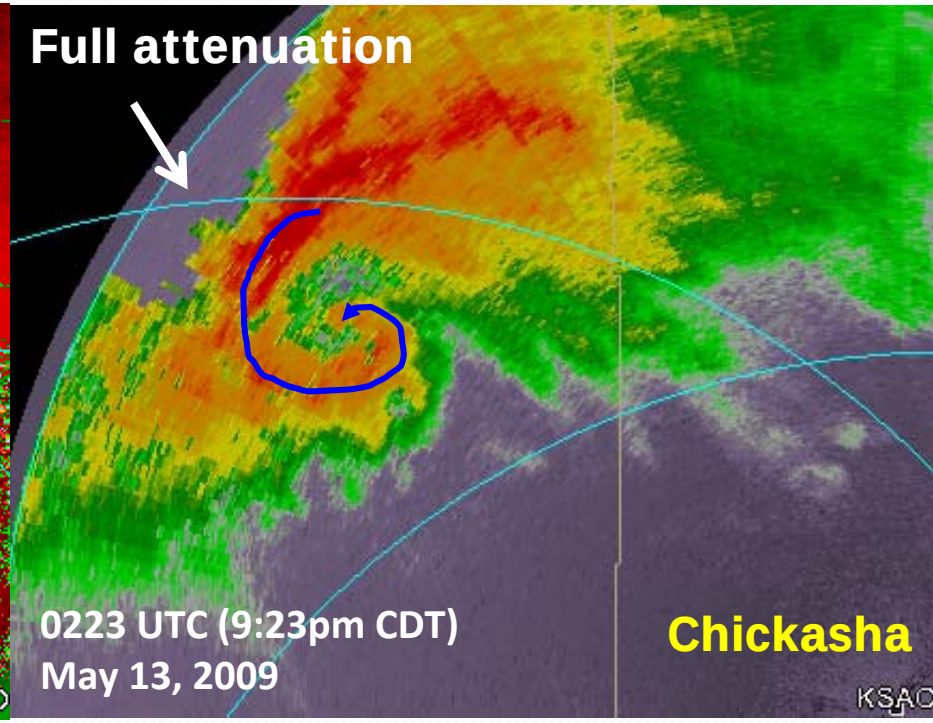
24/7, every 5 minutes
About 10 min delay

32 processors each task
100 total processors assigned

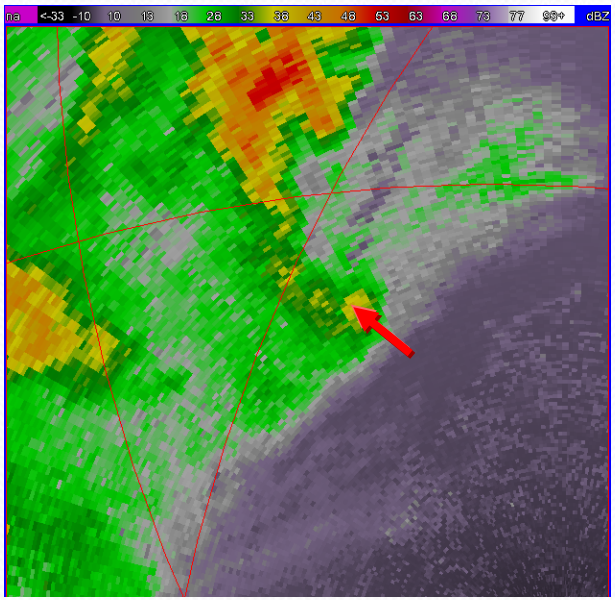
- **dx = 400 m, dz=400 for z<2km**
- **160 x 160 km**
- **10 levels up to 10 km AGL**
- **Integrated with display in HWT**
- **Graphical products also posted on the web in real-time**

May 14, 2009 (UTC) Anadarko Tornado Case

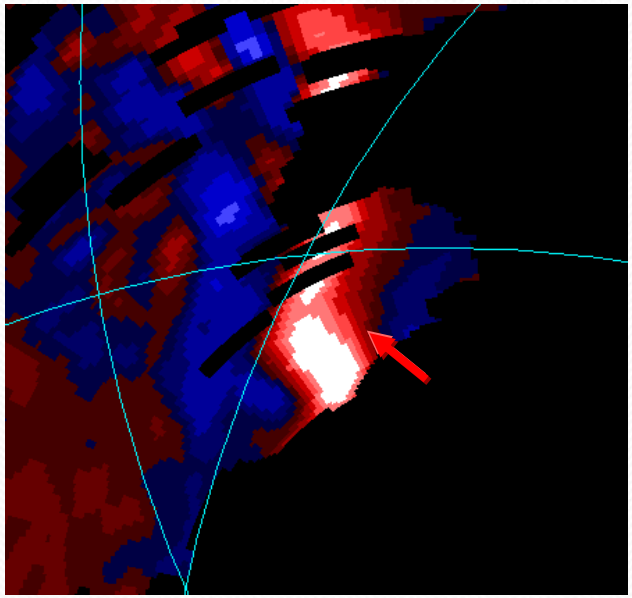




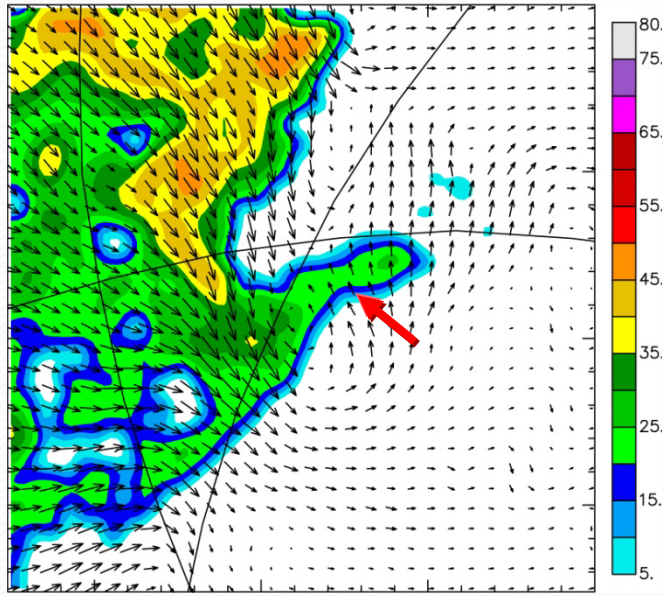
Analysis and Detection of Feb 10, 2009 Case of Low-level Vortex



Observed Reflectivity 4:10pm CDT 2/10/2009 (multi-radar merged)

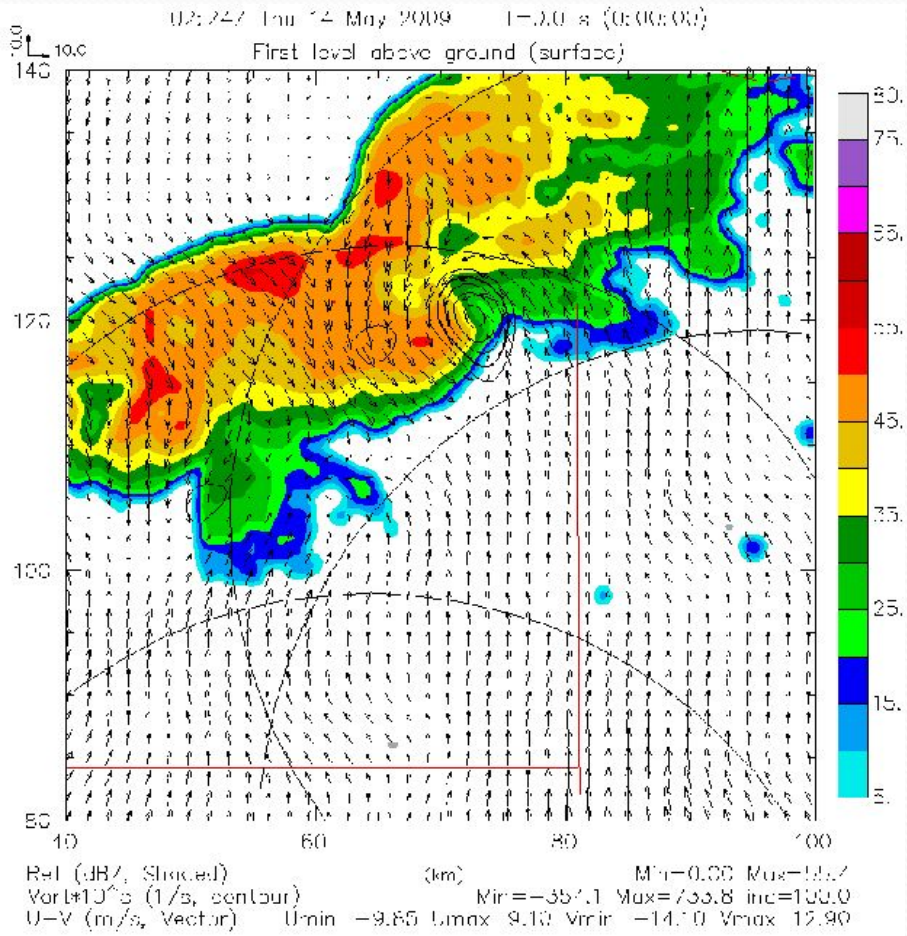


Velocity shear from WDSS-II Shear Algorithm



3DVAR analysis of low-level winds at 200-m resolution

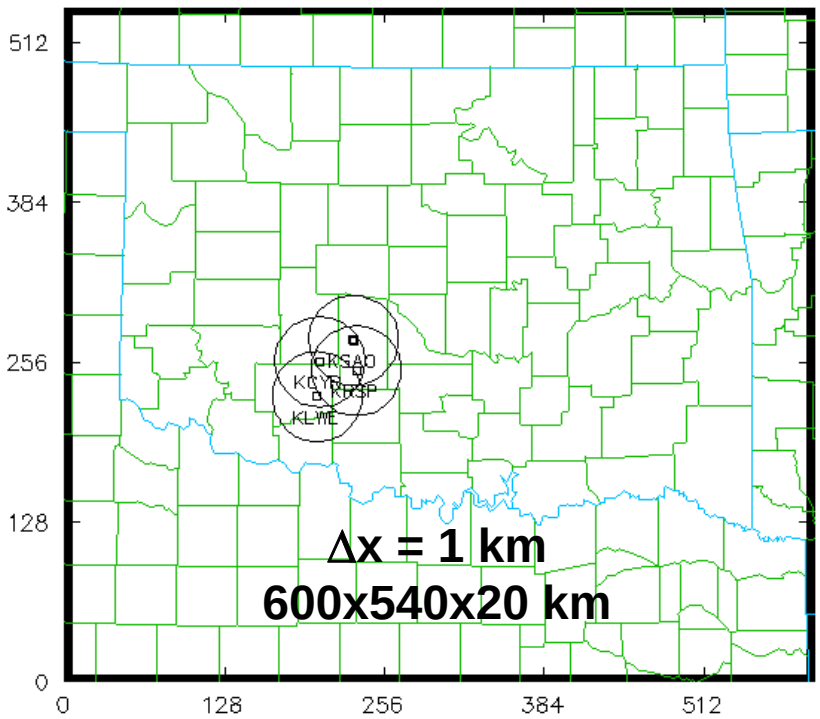
Analyses


First level above ground (surface)
140
120
100
80
40
60
80
100
45.
35.
25.
15.
5.
(km)
Vort*10^5 (1/s, contour)
U-V (m/s, Vector)

2009 CASA NWP Experiment

- Goals: Examine, in near real-time, the impact of IP1 data on convective storm forecast; provide forecast products to forecasters.
- Up to two simultaneous on-demand forecasts at 1-km resolution, assimilating CASA radar and other available observations.
- Using 800 processor cores each on OU OSCER supercomputer
- 6 h forecasts produced within 1.5 hours
- Forecast products available at http://www.caps.ou.edu/wx/casa as soon as they are produced.
- Data sent to HWT in realtime – did not get evaluated in realtime due to focus on wind analysis products - will be in the future.

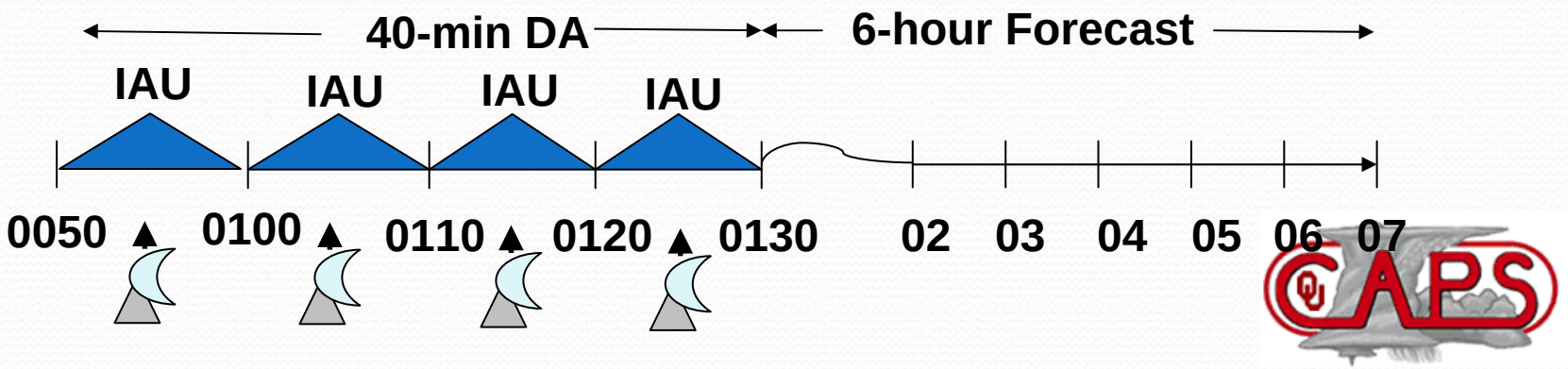
2009 Forecast Configuration



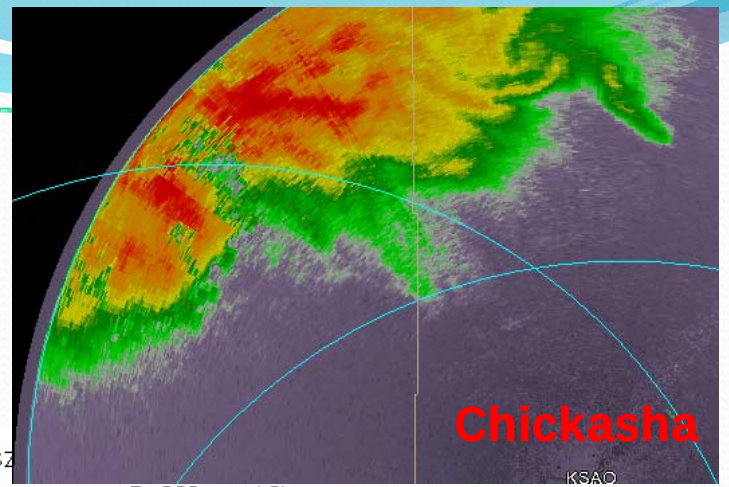
Using ARPS 3DVAR and the ARPS cloud analysis.

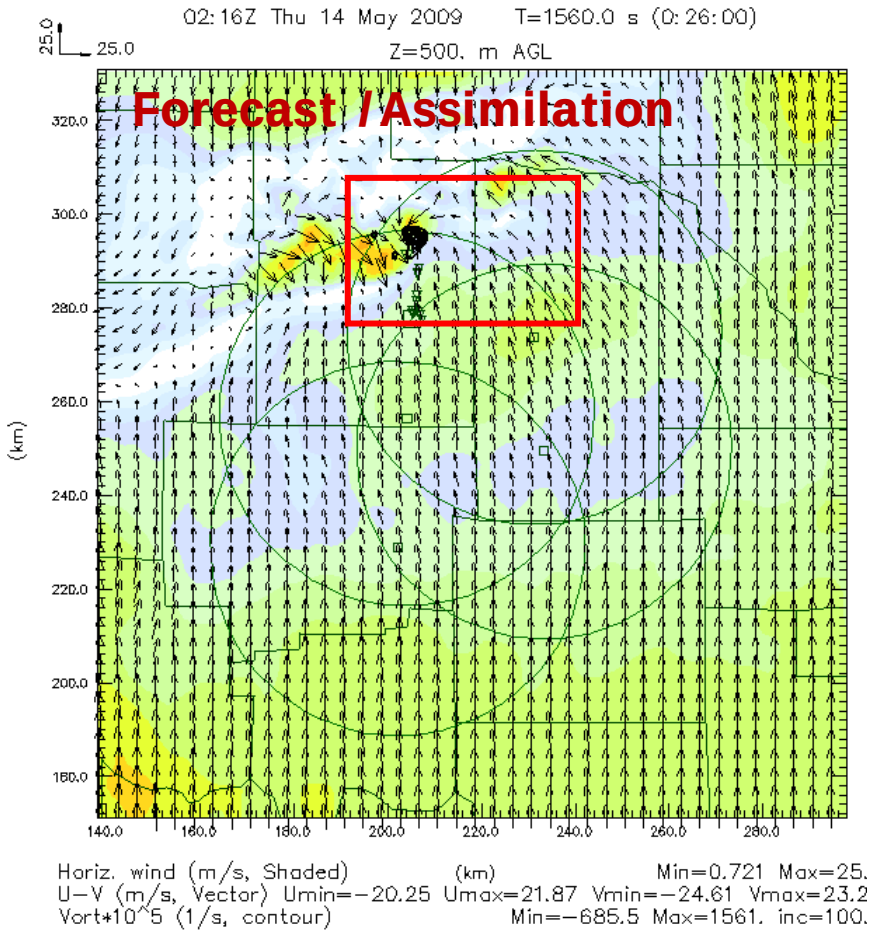
Incremental Analysis Updating applied to smoothly insert data and allow model adjustment

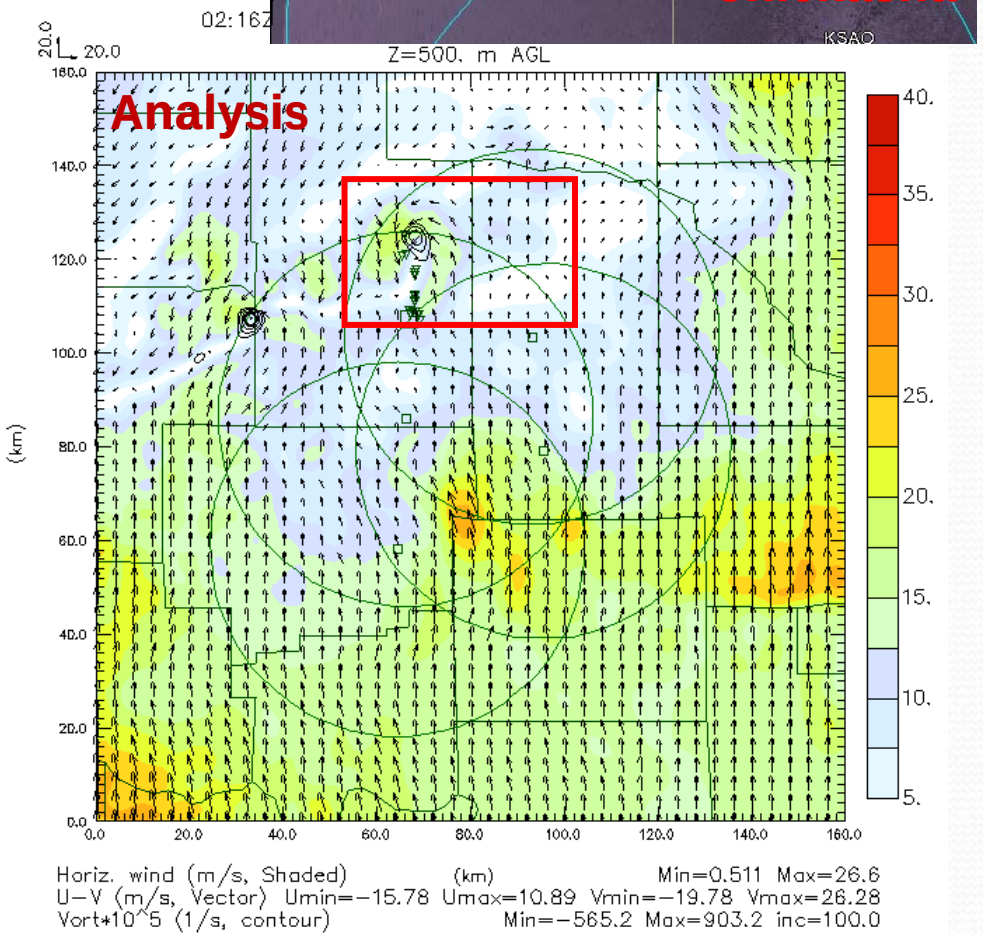
1.5 hours to complete each 6-h forecast



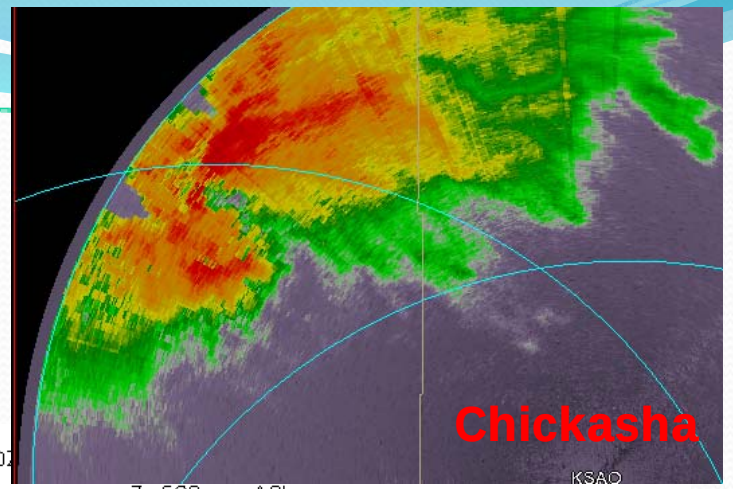
Assim. v.s. Analysis Wind Speed/Vectors at 500m AGL at 0216 UTC

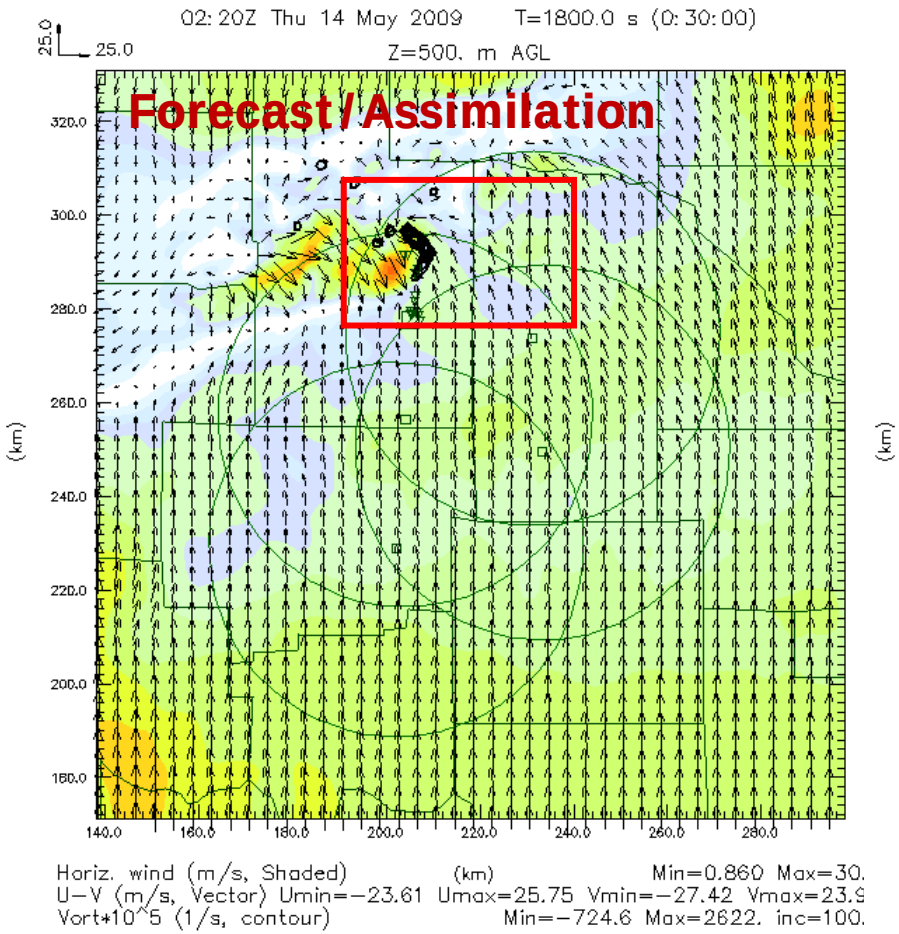


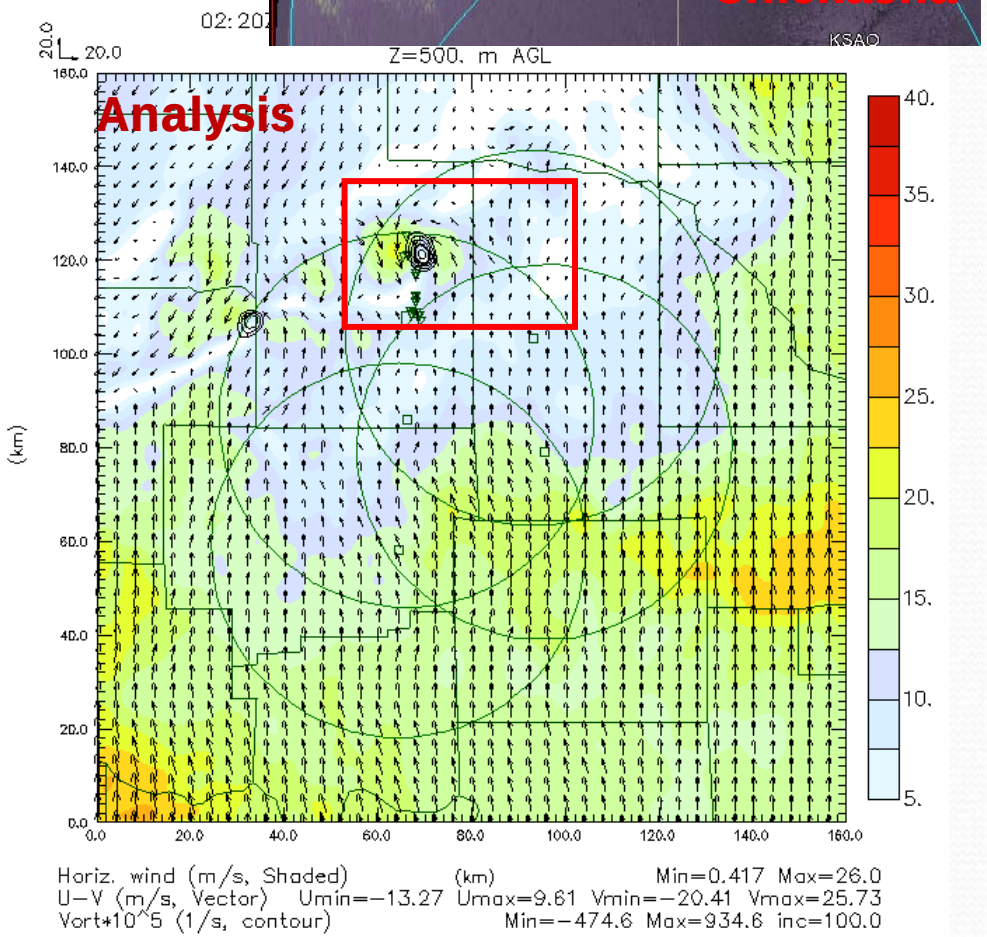


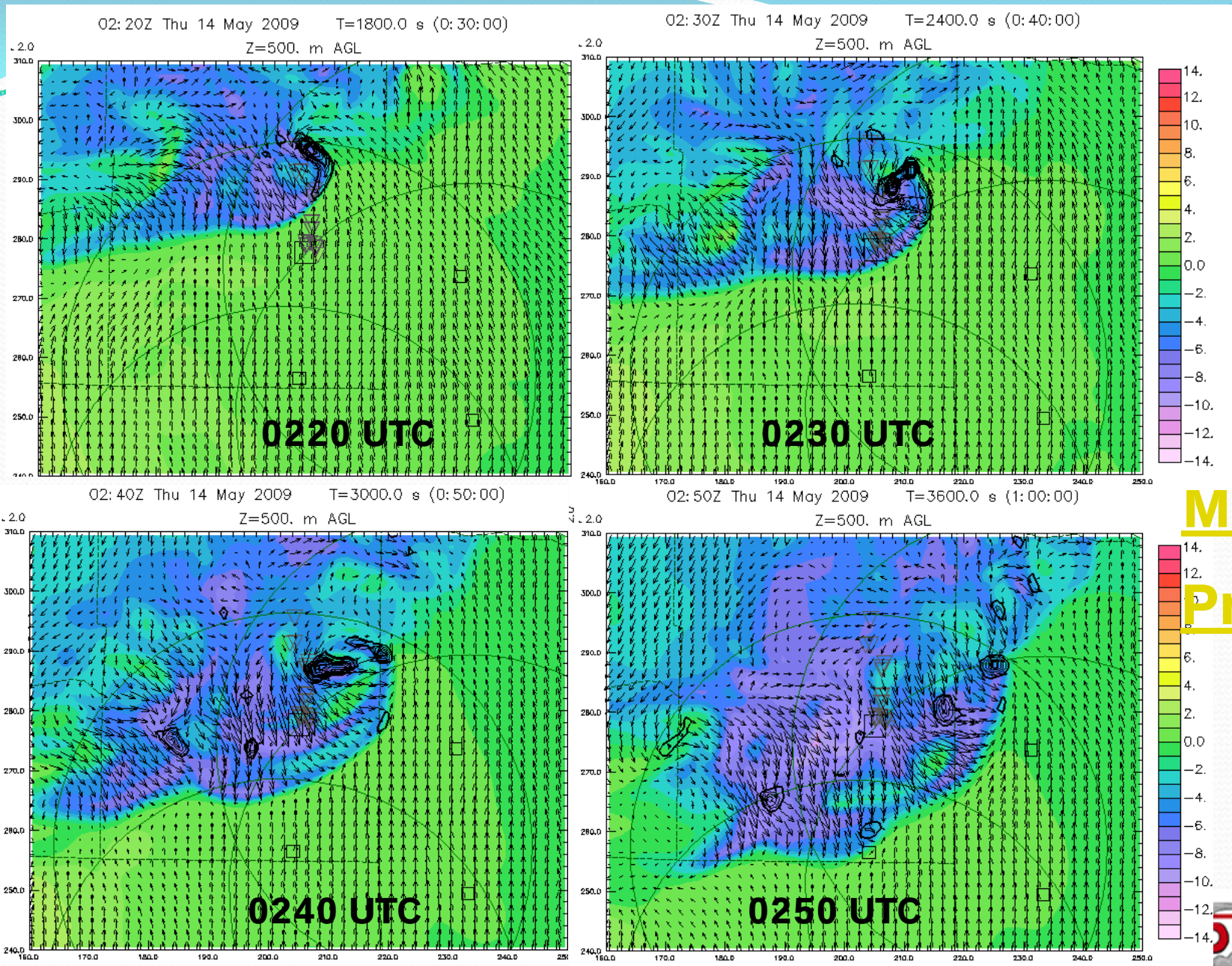


Assim. v.s. Analysis Wind Speed/Vectors at 500m AGL at 0220 UTC









Movie

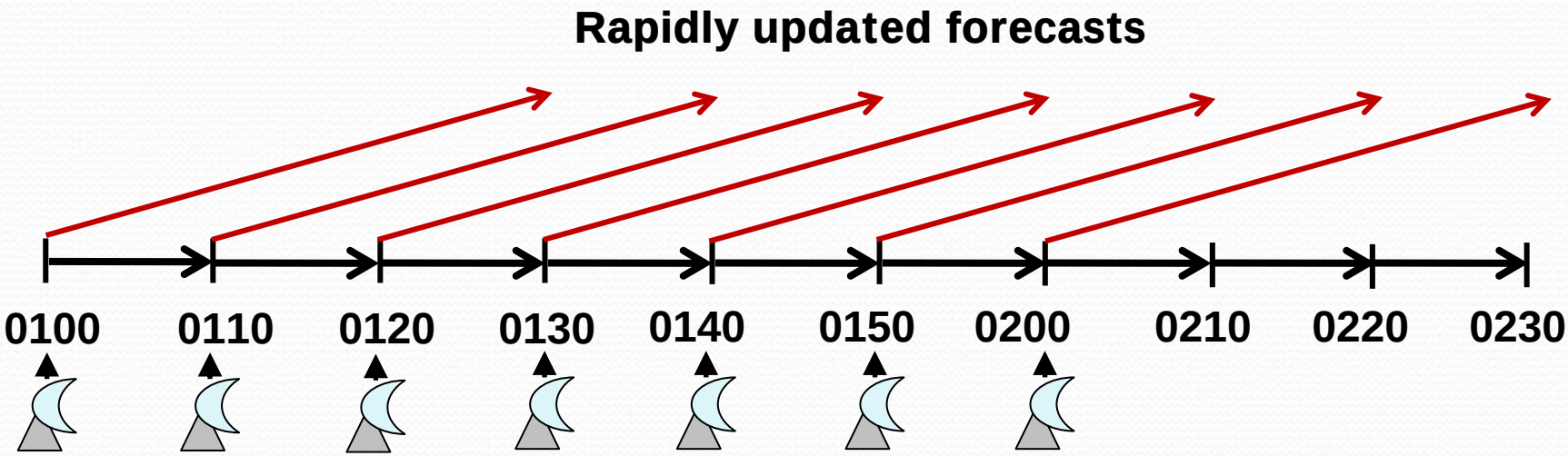
Pres

Forecast temperature perturbation + Vort. at z =500m AGL

2010 Plan

- 20 min reflectivity nowcasting every 1-2 minutes
- 3DVAR wind analyses every ~2 minutes,
- 30-minute NWP VSRFs every ~10 minutes.

Planned Forecast Configuration



Concluding Thoughts

- Wide range of weather research being pursued
- 3 Real-Time experiments run simultaneously each spring
- Generated 3d assimilated data sets for process studies – e.g. tornadogenesis
- Other Daily Weather Analyses & Forecasts provided 24/7/365
  http://www.caps.ou.edu/wx
  http://www.caps.ou.edu/ADAS.html
- OSCER is enabling useful scientific discovery in storm-scale analysis and prediction at CAPS!!

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