Exploration of Targeted Profiler and Radiosonde Observations for Improving Severe Storm Forecasting

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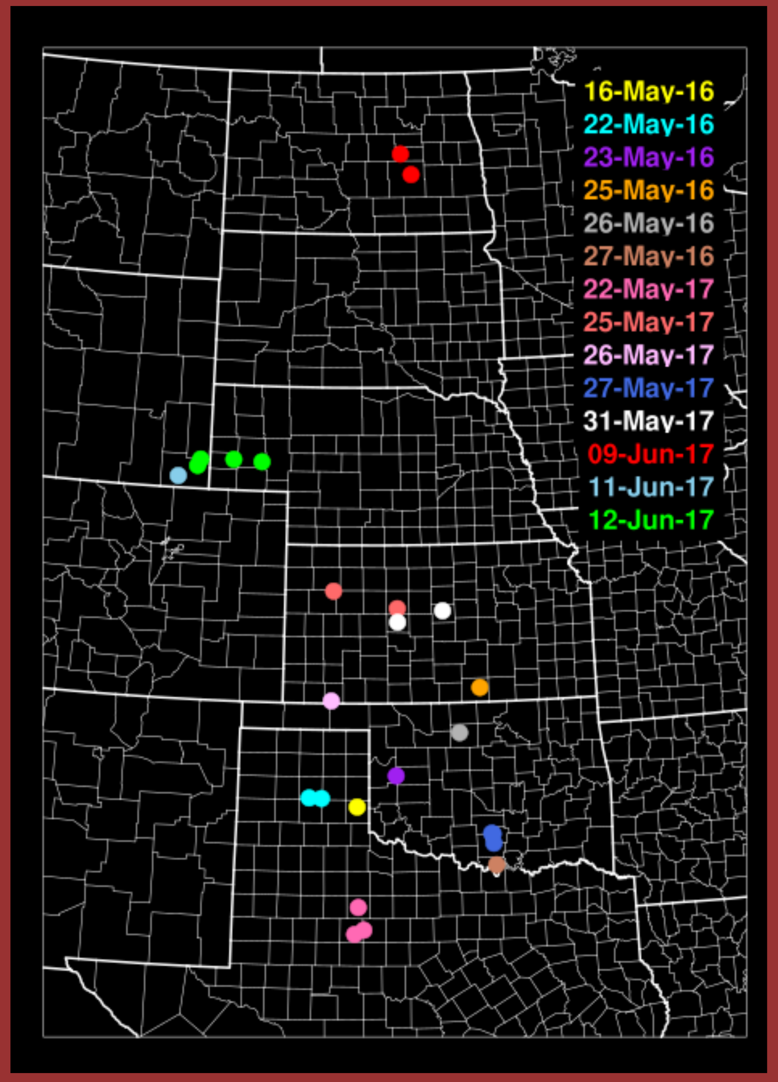
The NRC and instrumentation workshops have recommended that ground-based remote-sensing (profiling) systems be developed for monitoring rapid changes in the local severe convective environment.

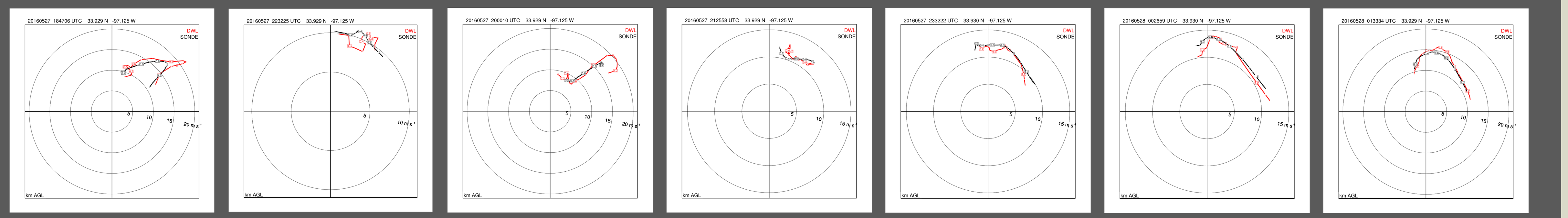
To examine the utility of remotely-sensed profiles of t, q_v, u, v, w in the lower atmosphere for both qualitative use in severe weather forecasting and quantitative use in data assimilation, the University of Oklahoma and NSSL have developed two **Collaborative Lower Atmosphere Mobile Profiling Systems (CLAMPS)** each with a

- Atmospheric Emitted Radiance Interferometer (AERI)
- Doppler wind lidar (DWL)
- Microwave Radiometer (MWR)
- Vaisala RS-41 Radiosonde System

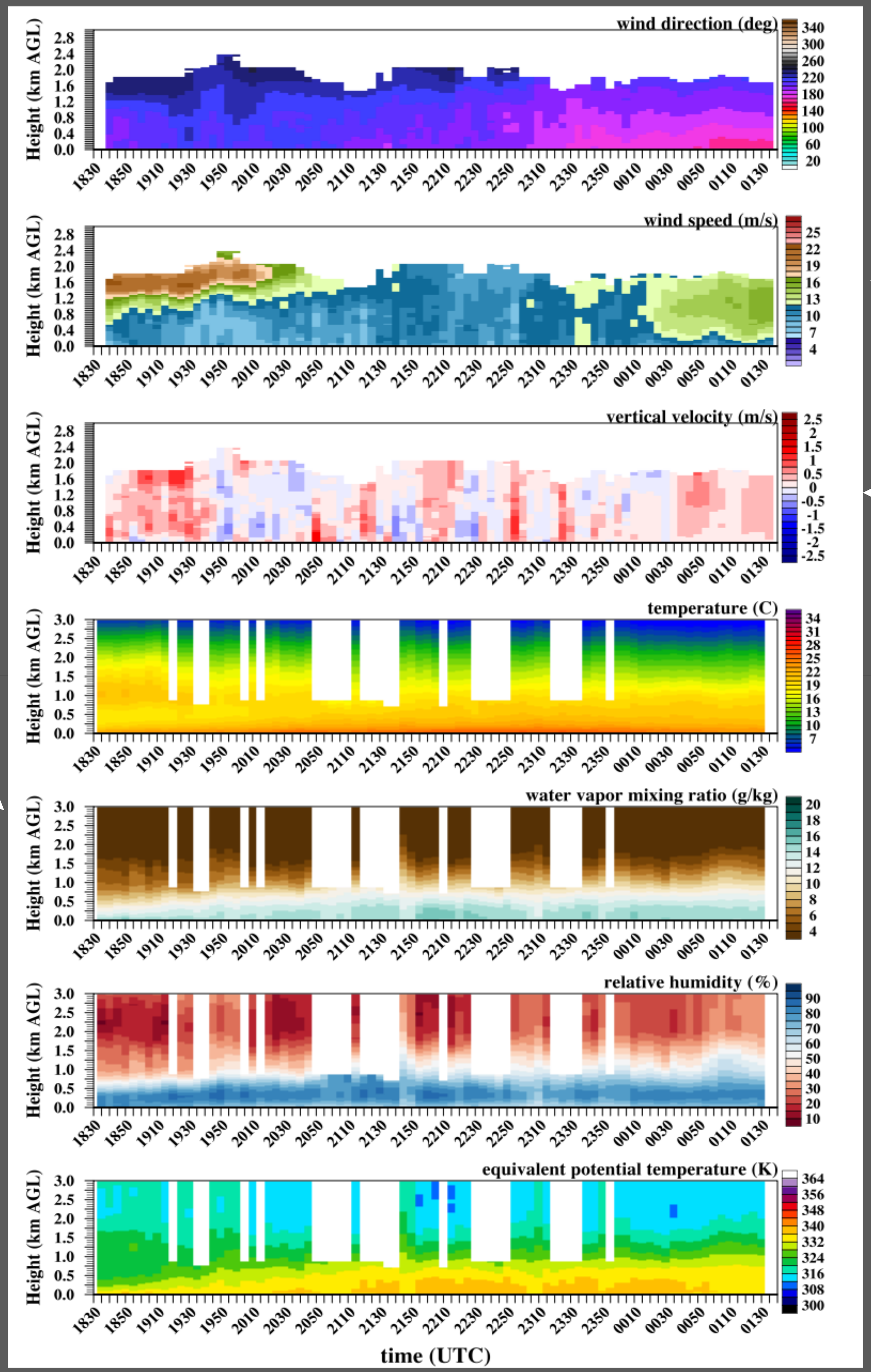


Locations of 24 NSSL CLAMPS-2 deployments in pre-convective and near-storm environments over 14 days in 2016 and 2017.

May 27, 2016



DWL Velocity Azimuth Display (VAD) wind profiles (VWPs) compare well with collocated radiosondes and provide much greater vertical resolution in the lower atmosphere than profiles from 404 MHz wind profilers and WSR-88D VWPs.



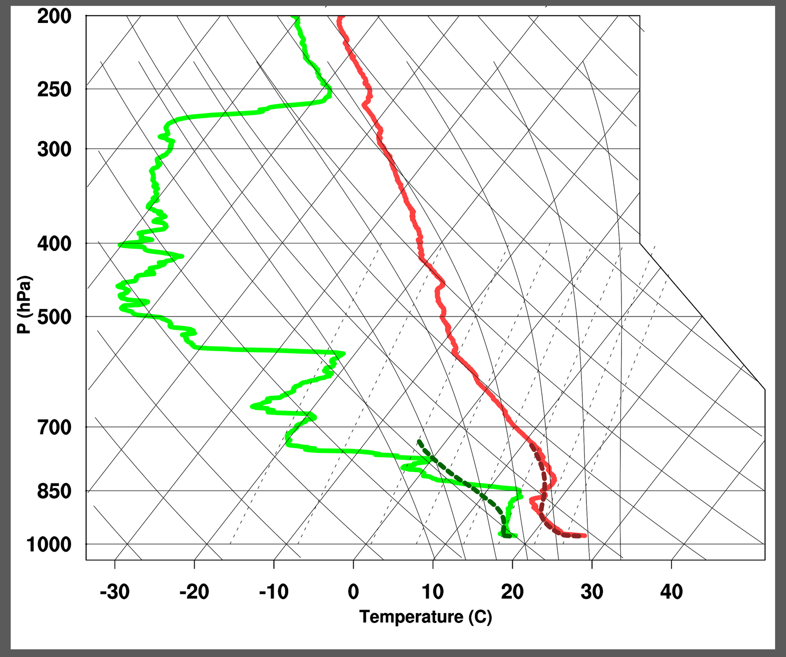
Filtered time/height plots of DWL and AERI retrievals from 1830 UTC 27 May to 0140 UTC 28 May.

DWL VWPs can observe rapid changes in the wind profile in the lowest 1 – 2 km, a layer that is vitally important for diagnosing the potential for severe weather and tornadoes.

DWLs can also provide information on mesoscale vertical motion.

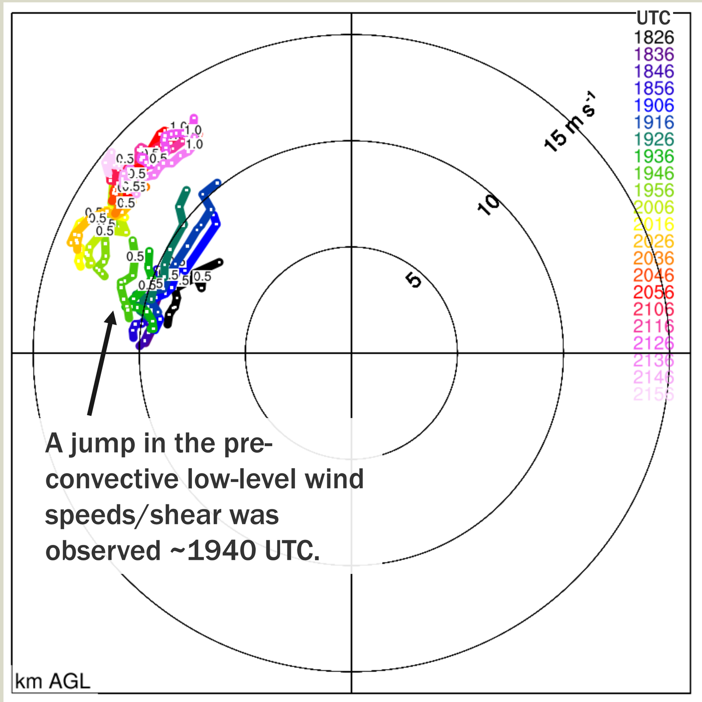
The AERI can retrieve profiles of t and q_v every few minutes…

…but for qualitative use in severe weather forecasting, the AERI profiles are often too smooth and can miss important vertical details as seen in comparisons to radiosondes.

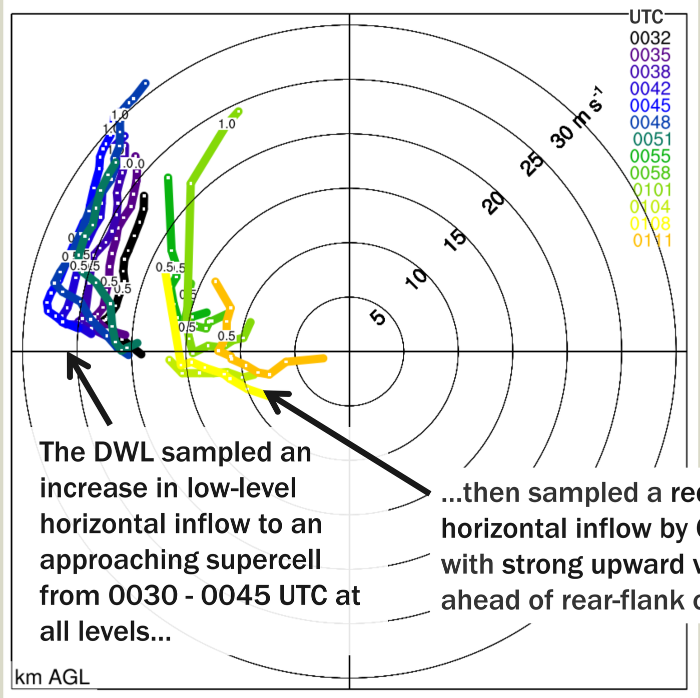


AERI (dashed) and radiosonde (solid) observations of temperature and dewpoint valid 2000 UTC 27 May 2016.

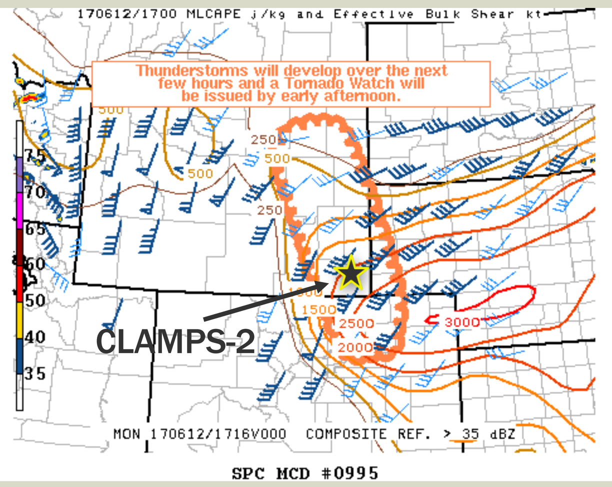
June 12, 2017

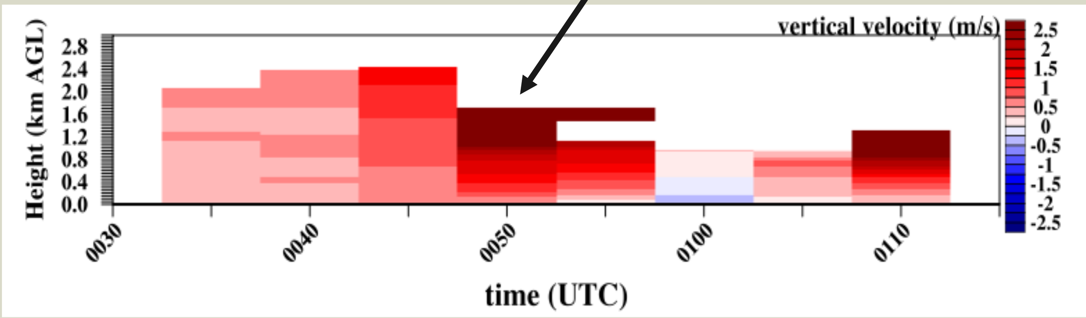


Filtered DWL VWPs obtained at the location shown below from 1826 UTC to 2155 UTC 12 June 2017.



Lightly-filtered DWL VWPs obtained in the near-field inflow to the supercell pictured above-right from 0032 UTC to 0111 UTC 13 June 2017.





Data assimilation experiments

HYPOTHESIS: Despite AERI's low vertical resolution, the high frequency of the retrievals, and the high temporal and high vertical resolution DWL VWPs, will reduce initial condition errors and improve short-term (0-9 h) NWP model forecasts of convection.

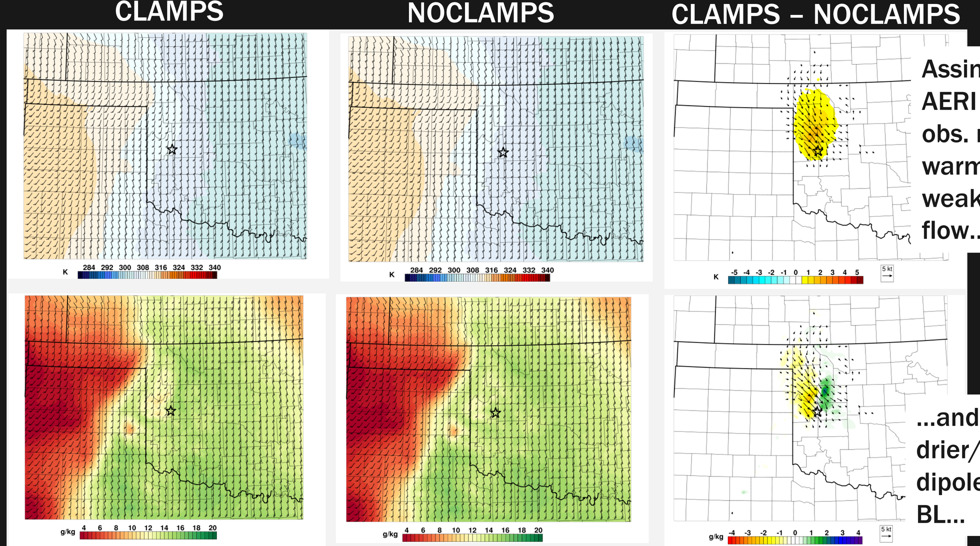
EXPERIMENTS: Assimilate AERI retrievals of t, q_v and DWL u, v into an 80-member EnKF-based mesoscale (15-km) analysis and convection-allowing (3-km) forecast system (emulating the NCAR ensemble; Schwartz et al. 2015) and compare the forecasts to experiments that deny the retrievals.

OBSERVATION TARGETING: Ensemble Sensitivity Analysis (ESA; Torn et al. 2008) was used in real time to guide CLAMPS-2 to sensitive locations in the pre-convective environment.

Example of two DA experiments for the May 23, 2016 case:

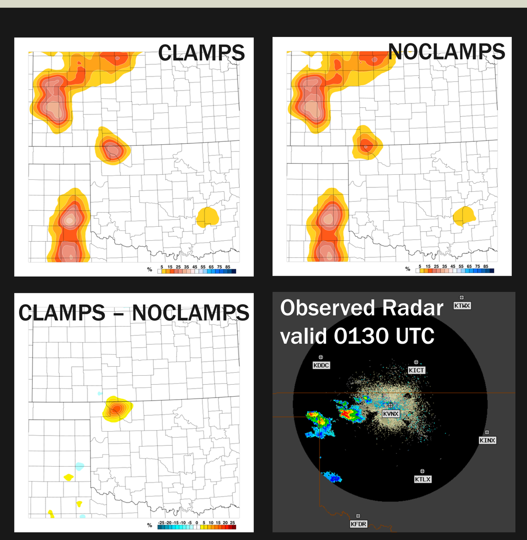
CLAMPS: Assimilation of conventional obs. (incl. radar) plus AERI t, qv and DWL u, v every 15 min from 18 – 23 UTC.

NOCLAMPS: Assimilation of conventional obs. (incl. radar) only.



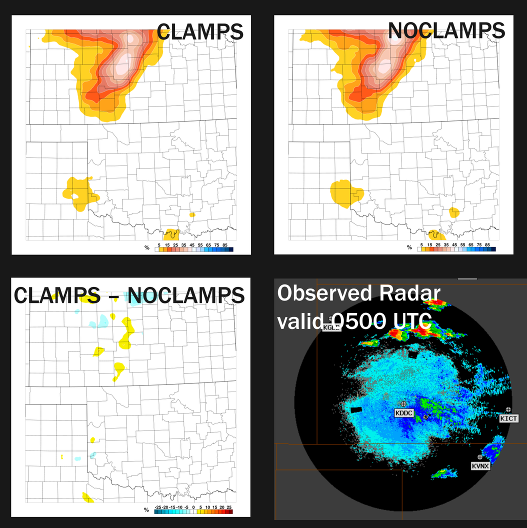
Ensemble mean fields valid 2300 UTC, the final analysis time. The star indicates CLAMPS-2's location.

…which, at 2.5 h into the forecasts, leads to higher confidence in the occurrence of the tornadic supercell in NW OK.



Percentage of CLAMPS and NOCLAMPS forecasts (2.5 h) with simulated refl. > 35 dBZ within ~25 km of a point valid at 0130 UTC, and their difference (bottom left). Observed 0.5° reflectivity from KVNX at 0130 UTC (bottom right).

But significant impacts are gone by 6 h into the forecasts.



As above but for 6 h forecasts valid 0500 UTC and observed reflectivity from KDDC.

Objective verification will soon be performed over 12 cases to determine the robustness of these positive AERI/DWL impacts in the first few hours.

Schwartz, C.S., G.S. Romine, R.A. Sobash, K.R. Fossell, and M.L. Weisman, 2015: NCAR's Experimental Real-Time Convection-Allowing Ensemble Prediction System. *Wea. Forecasting,* **30**, 1645–1654.
Torn, R.D. and G.J. Hakim, 2008: Ensemble-Based Sensitivity Analysis. *Mon. Wea. Rev.,* **136**, 663–677.