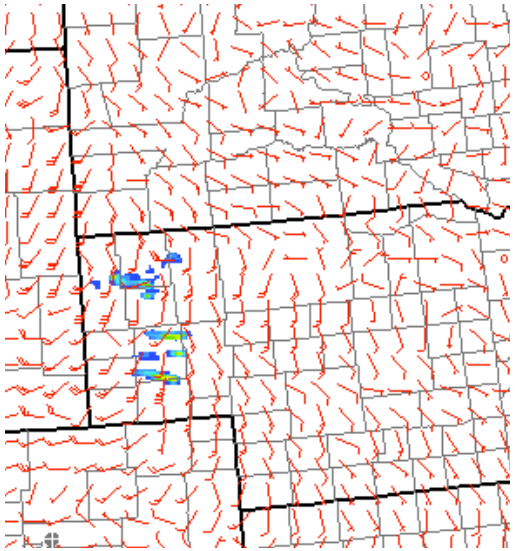
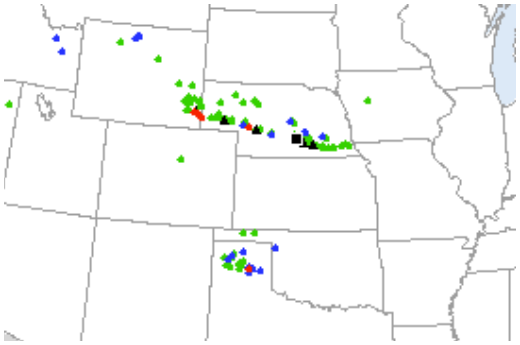
Demonstration of radar-data assimilation and prediction for Front Range convection

Glen Romine, David Dowell, Chris Snyder

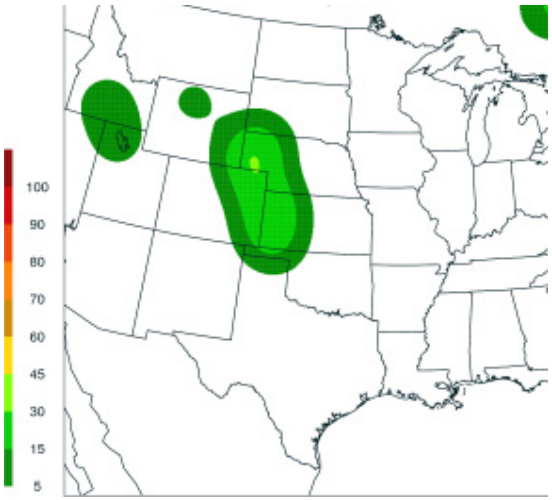
1 HR Max UH



Storm Reports



Spatial smoother 24 HR UH density

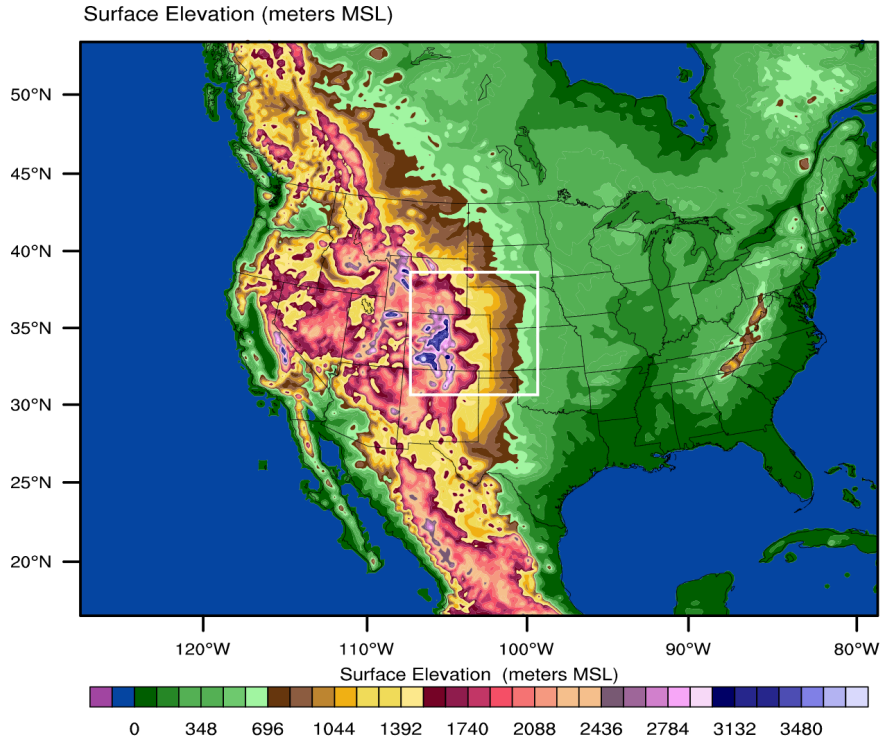


4th EnKF Workshop - 09 Apr 2010

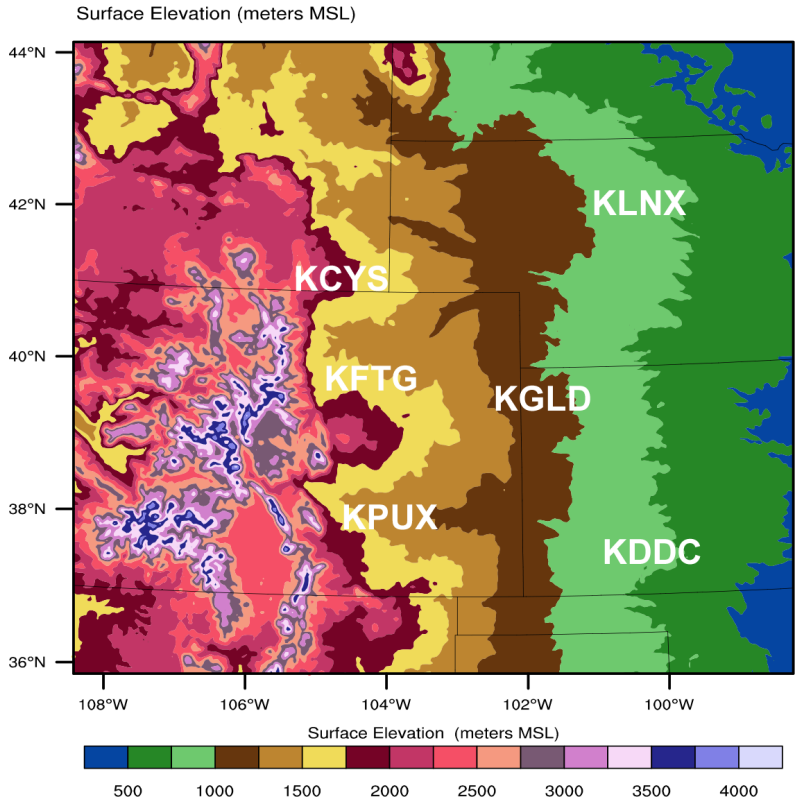
Project Overview

Ensemble-based data assimilation and prediction

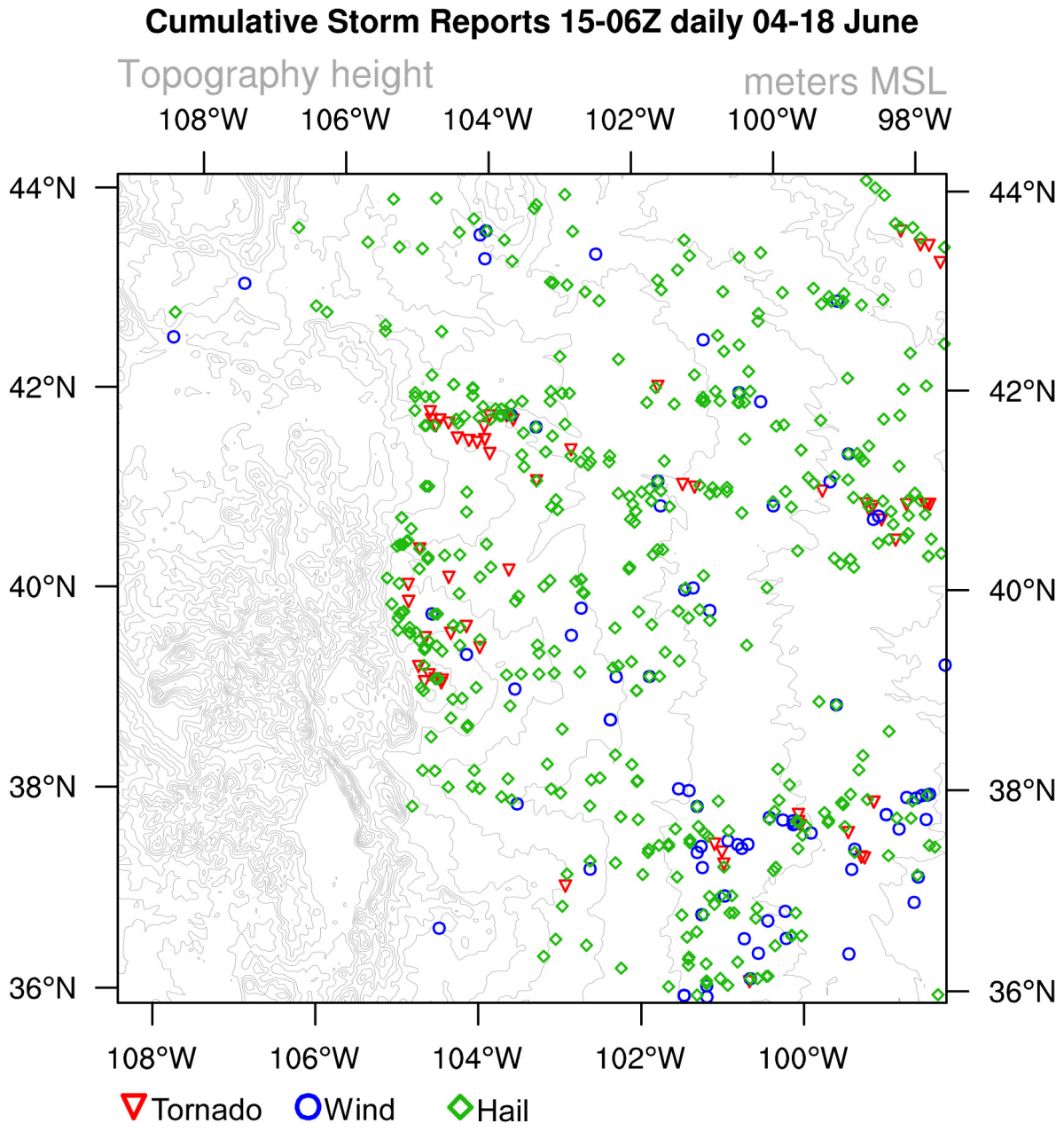
- Test drive for Data Assimilation Research Testbed (DART) system
- Mesoscale DA on CONUS domain
- Storm-scale DA on Front Range → High Plains domain 4-17 June 2009
  - Overlaps the most interesting time/region of VORTEX2 domain in 2009
  - Complex terrain a focus of STEP program (our funding source)
- Probabilistic analyses and 6 hr forecasts from 50-member ensembles



15 km mesoscale, 3 km storm-scale



Chugwater and Denver Tornado Alleys



Significant spatial relationship between storm report locations and terrain features:

Cheyenne Ridge
Palmer Divide
Raton Mesa

Preparations

DART enhancements (~v.4320):

- Improved observation processing (especially MADIS stream)
- Additive noise for radar obs, low reflectivity observations, utilizing model state defined fall velocity in radial velocity forward operator
- Enhanced radar operators for ingesting fall velocity and reflectivity from the microphysics

WRF model (v3.1.1) enhancements:

- Thompson microphysics (v3.2) with reflectivity and fall velocity diagnostics
- Inline NSSL severe weather diagnostics (e.g. every time step max updraft helicity, reflectivity, surface winds, updraft, downdraft)
- Cavallo RRTM patch (corrects lw radiation problems at model top)
- HRRR-like model configuration

Datasets:

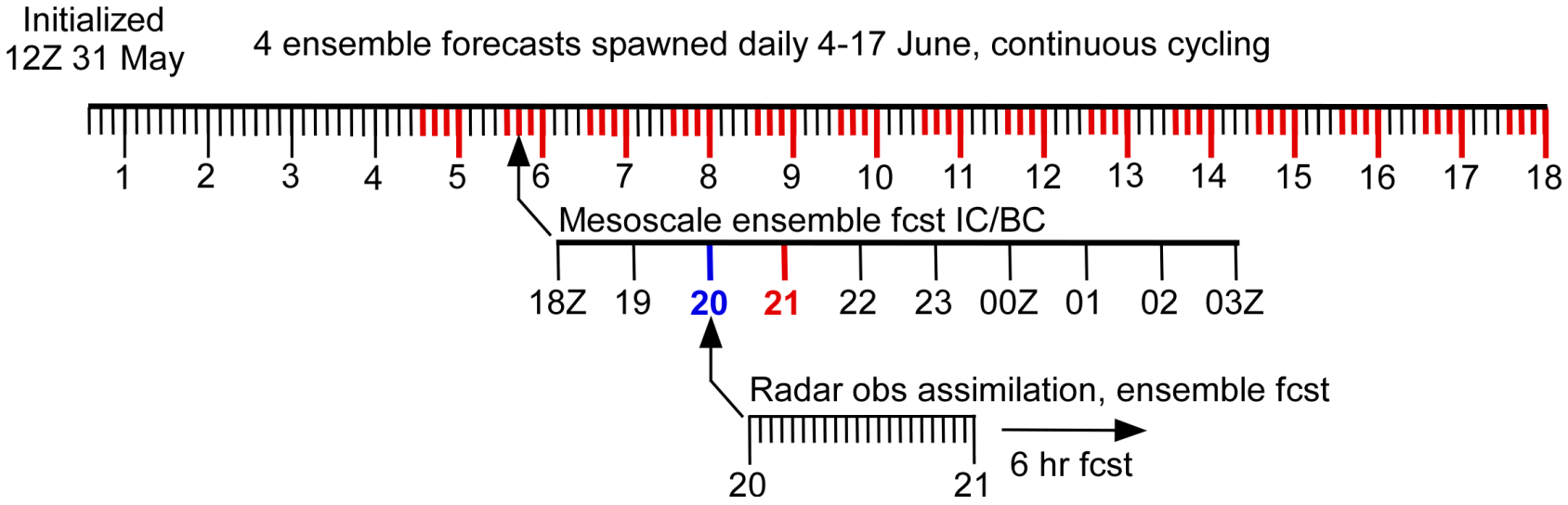
- Standard "mesoscale" observations: radiosonde, surface, aircraft, satellite track cloud winds, buoy
- WSR-88D velocity and reflectivity: KFTG, KCYS, KPUX, KDDC, KGLD, KLNX
- MADIS, NCEP reanalysis, HDSS

Radar processing:

- Using objective analysis tools built by David Dowell
- Accommodating super-res, simple clutter filter, improved mapping for meshing observations from multiple radars

System Configuration

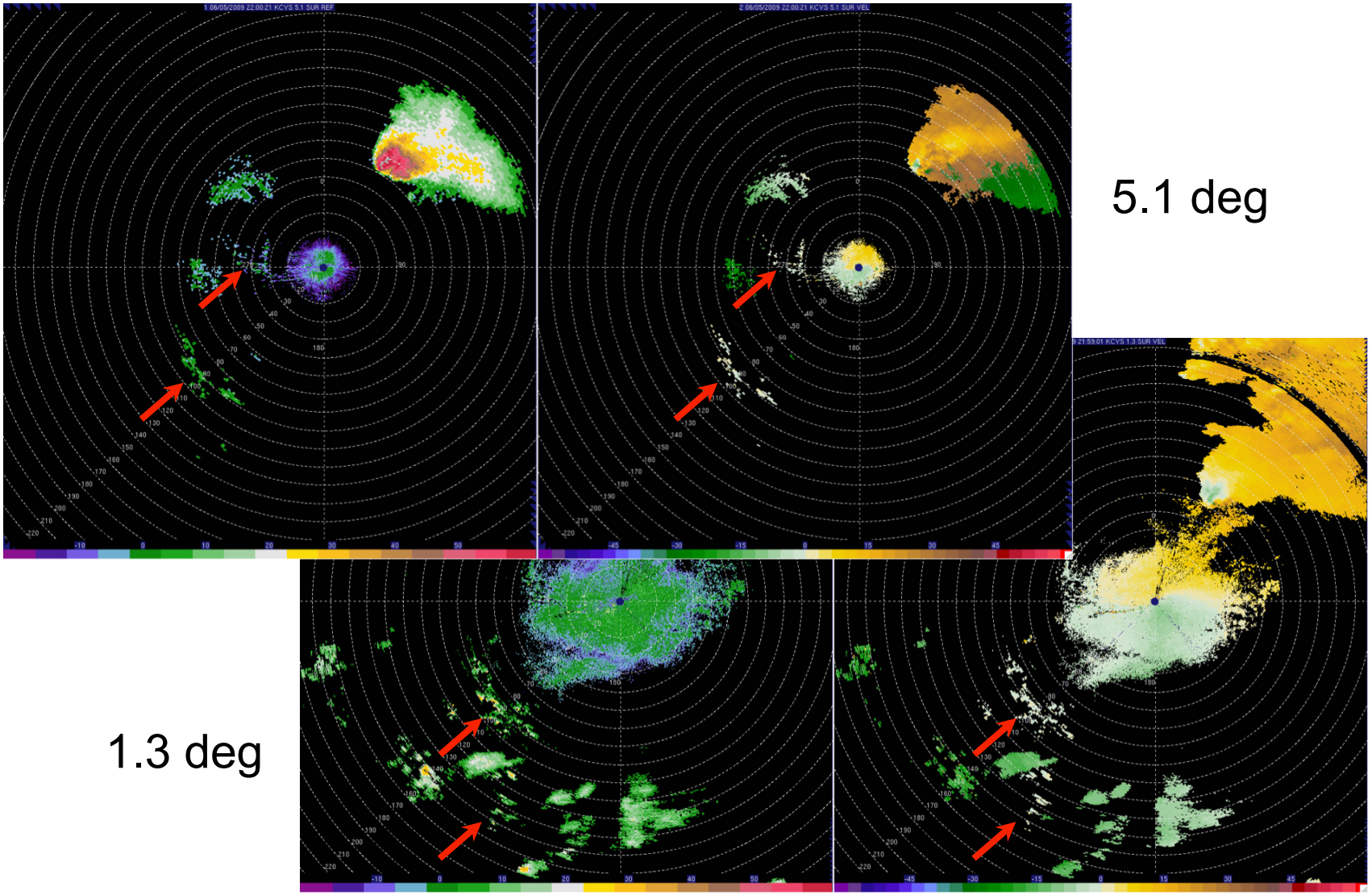
- DART
  - 50 members, EAKF, adaptive prior inflation & localization (AL)
  - localization ~320/4 [km] H/V halfwidth, AL - 1600 obs
  - Continuous cycling (3-hourly) on mesoscale
  - Configuration adapted from Ryan Torn's RTA system
- WRF
  - ESRL's HRRR-like configuration
  - Physics: KF, Thompson, Noah, Dudhia, RRTM, MYJ
  - Grids 369x297 / 301x301 x51



Ground Clutter: Mountains

Reflectivity

Velocity



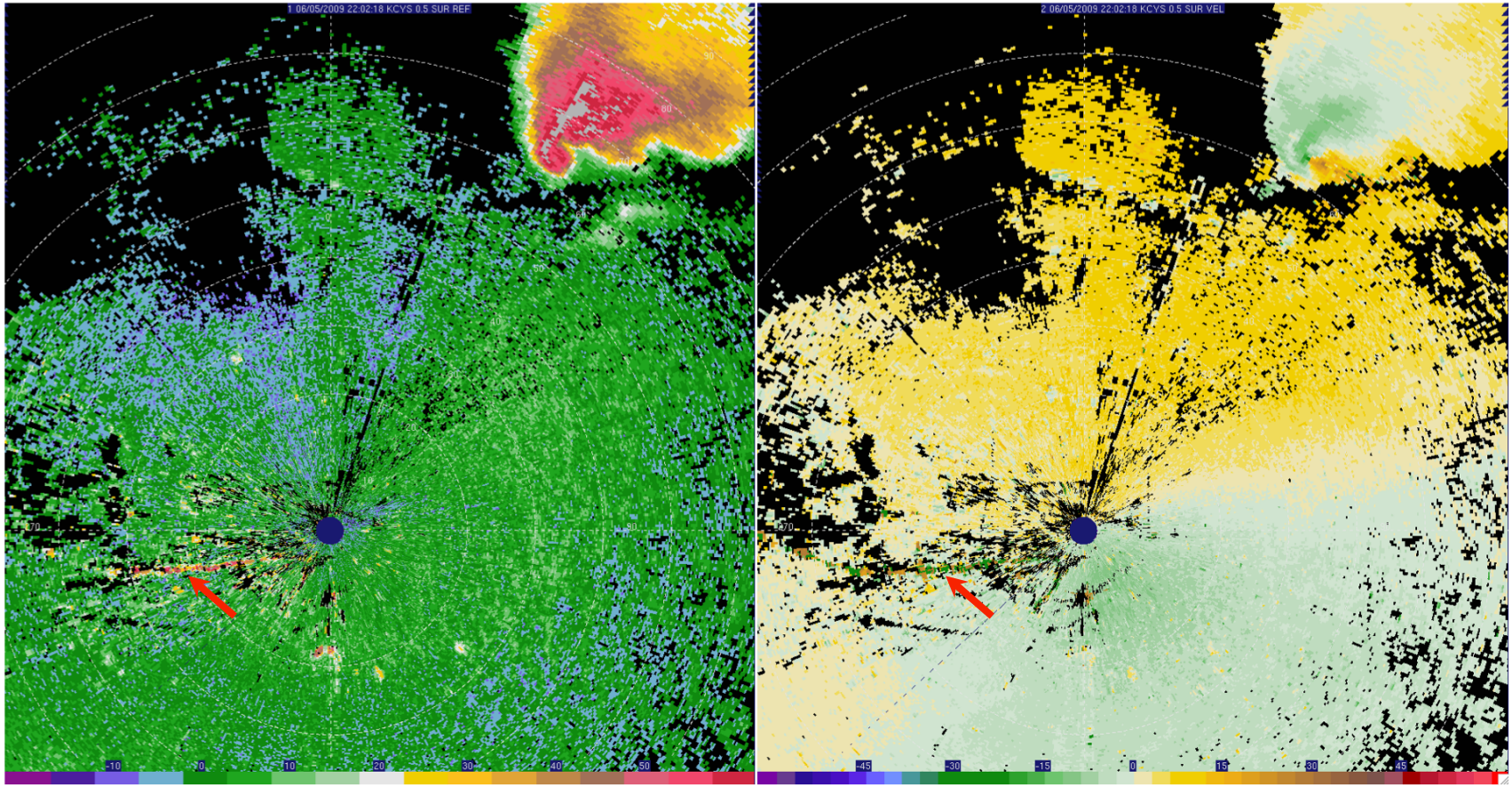
5.1 deg

1.3 deg

Ground Clutter: Highways

Reflectivity

Velocity

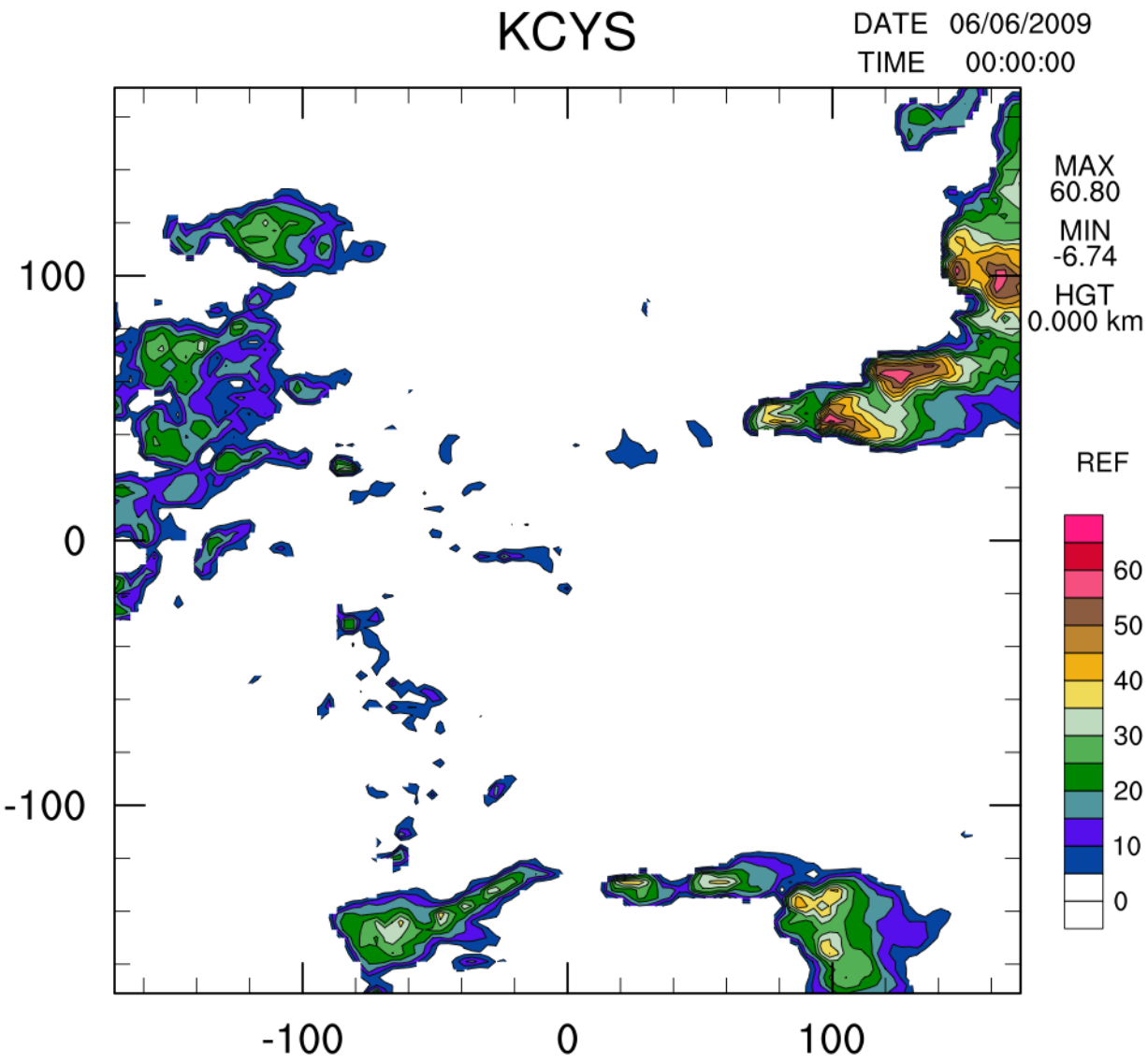


Ground-Clutter Removal: Two Approaches

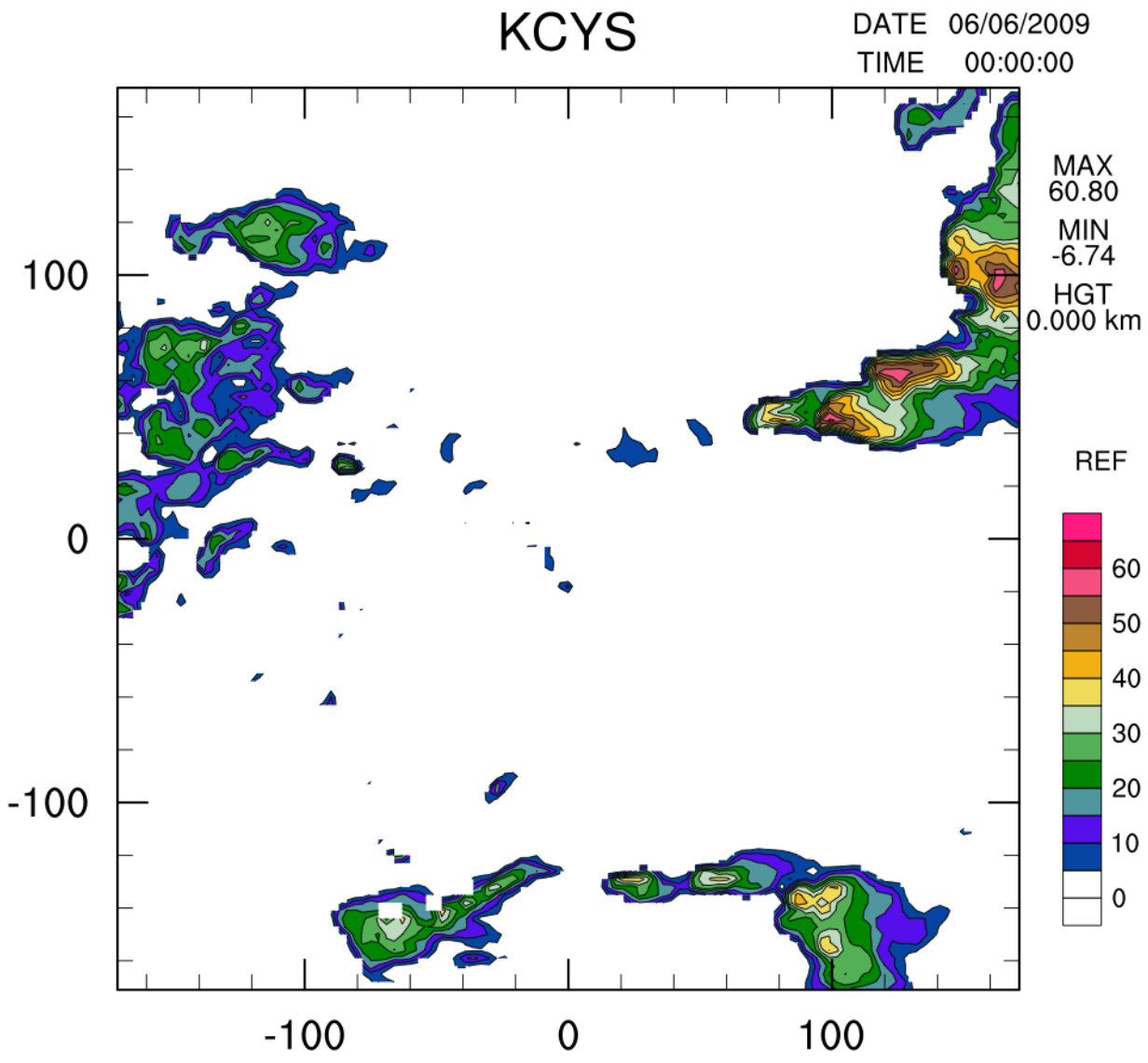
- Steiner and Smith (2002)

- Clutter mask identified from multi-day radar-data statistics
  - Statistics for each elevation angle
  - Highways
    - high Z_{dB} ob availability
    - low std. dev. of Z_{dB}
    - high std. dev. of V_r
  - Other ground clutter
    - high Z_{dB} ob availability
    - low std. dev. of Z_{dB}
    - low std. dev. of V_r
    - V_r near 0

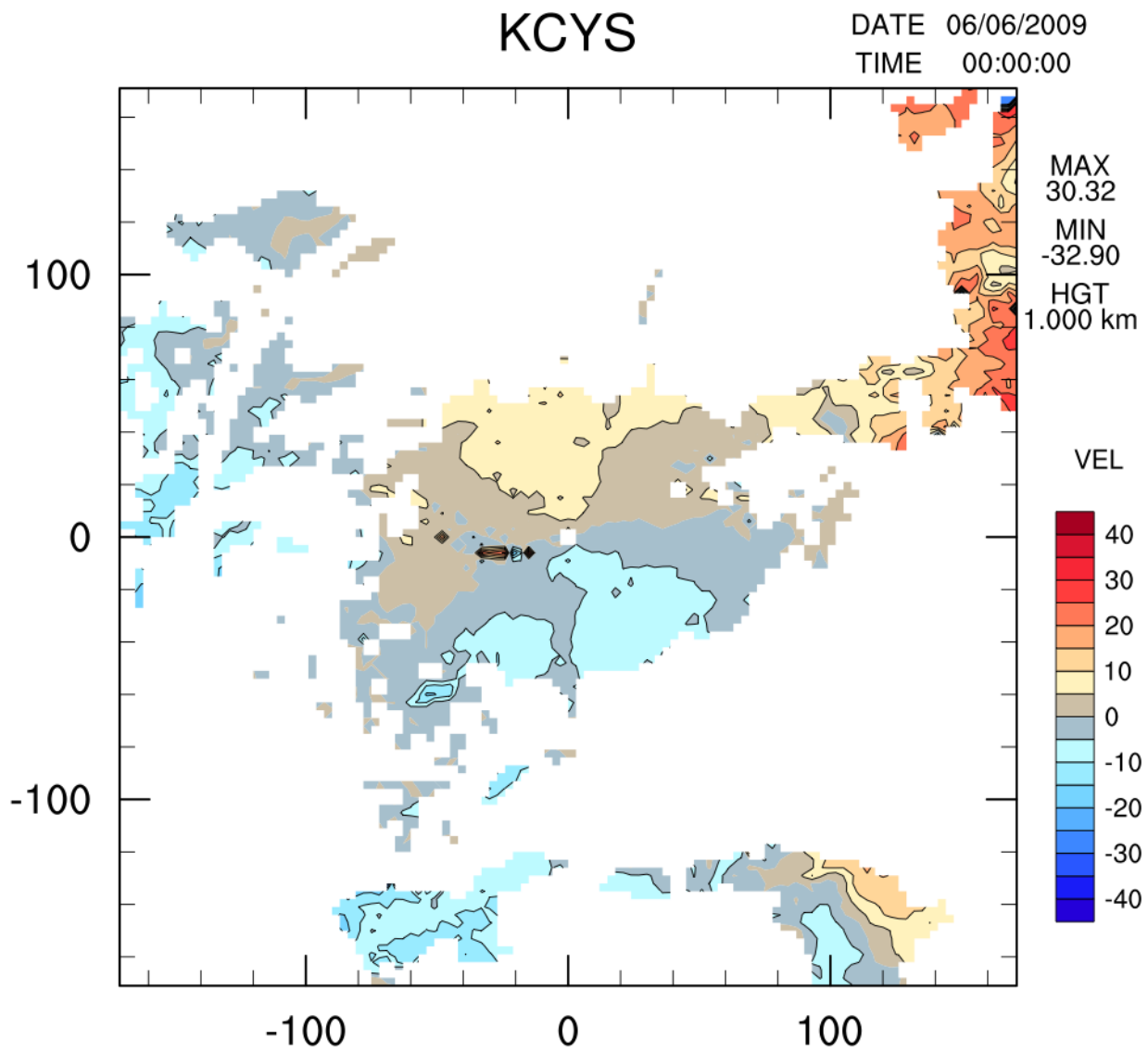
Ground-Clutter Removal: Reflectivity



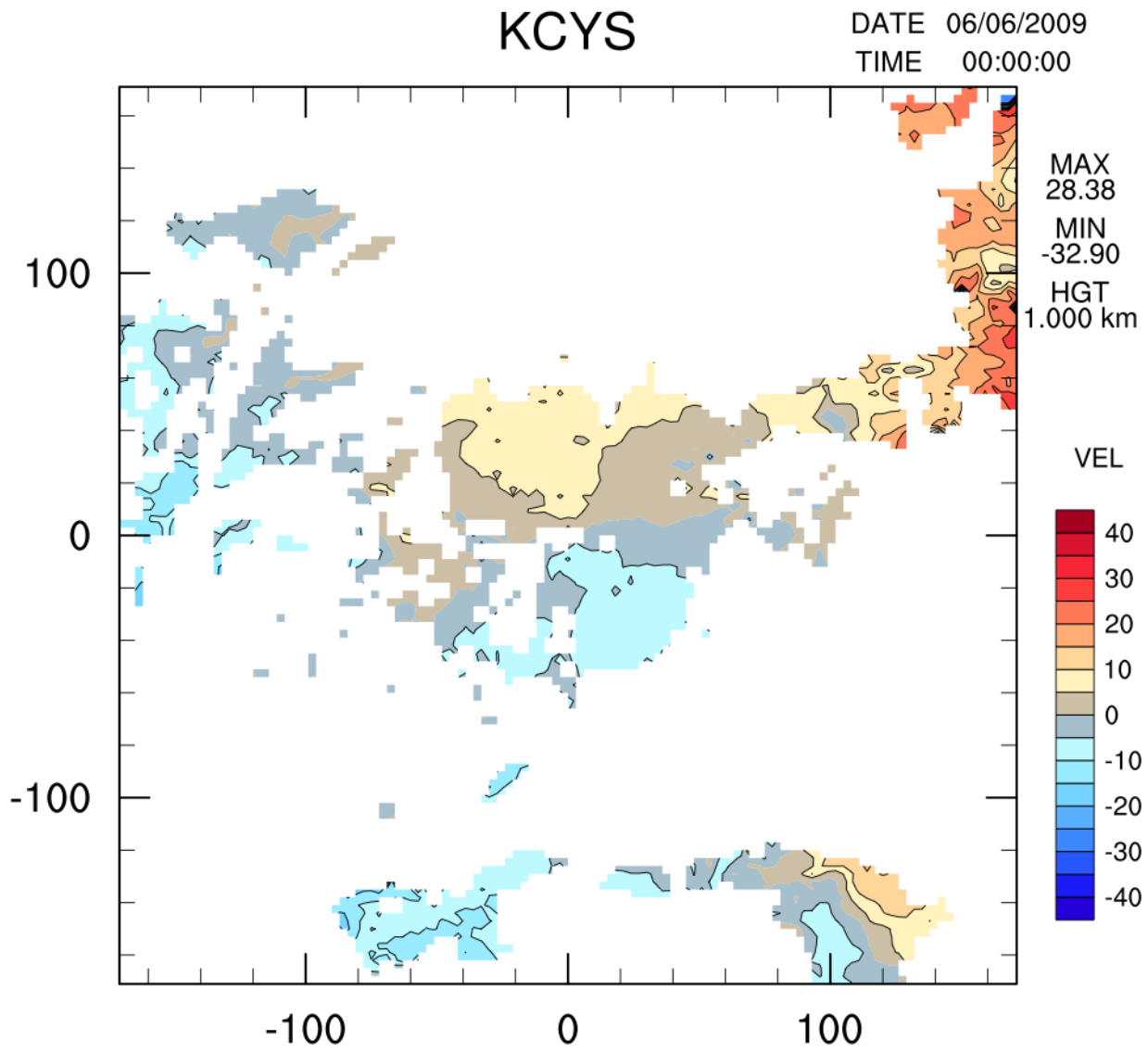
Ground-Clutter Removal: Reflectivity



Ground-Clutter Removal: Velocity

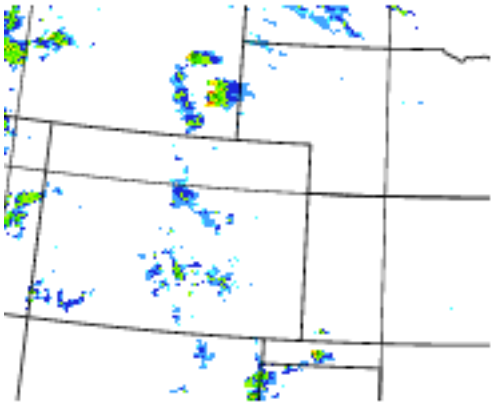


Ground-Clutter Removal: Velocity



Preliminary test case event 20090605 – radar evolution

2100



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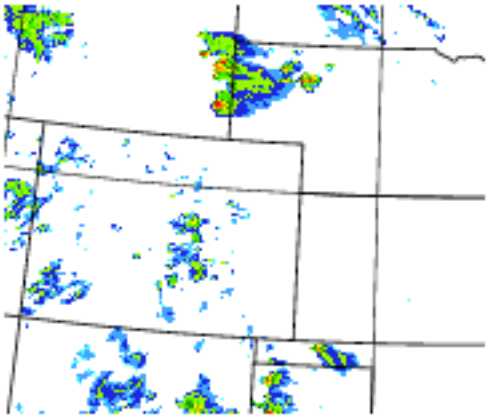

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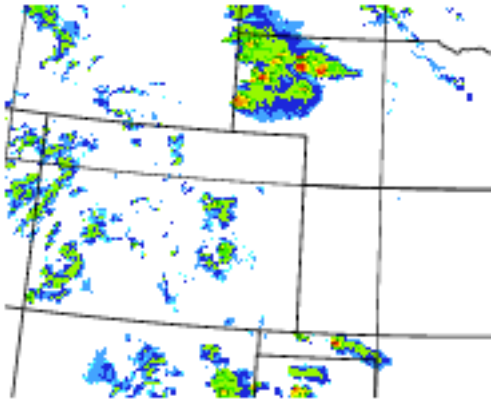

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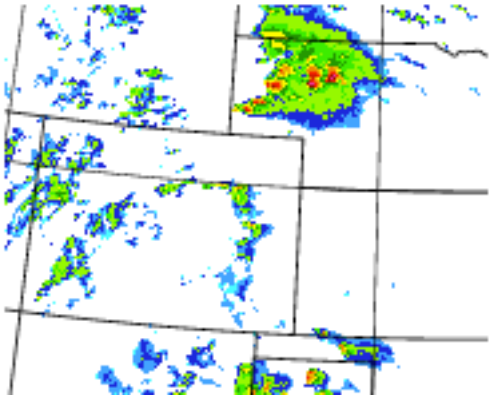

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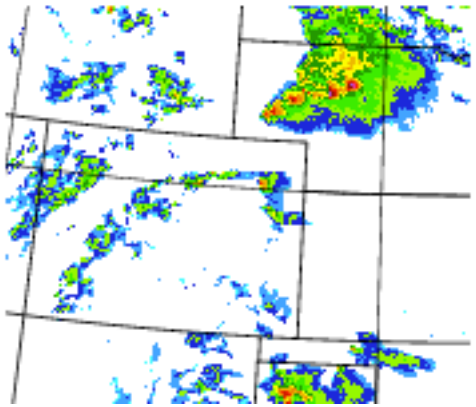

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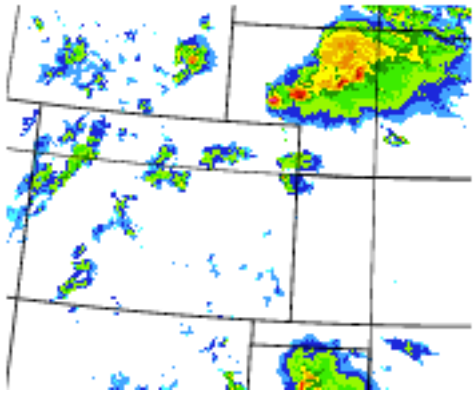
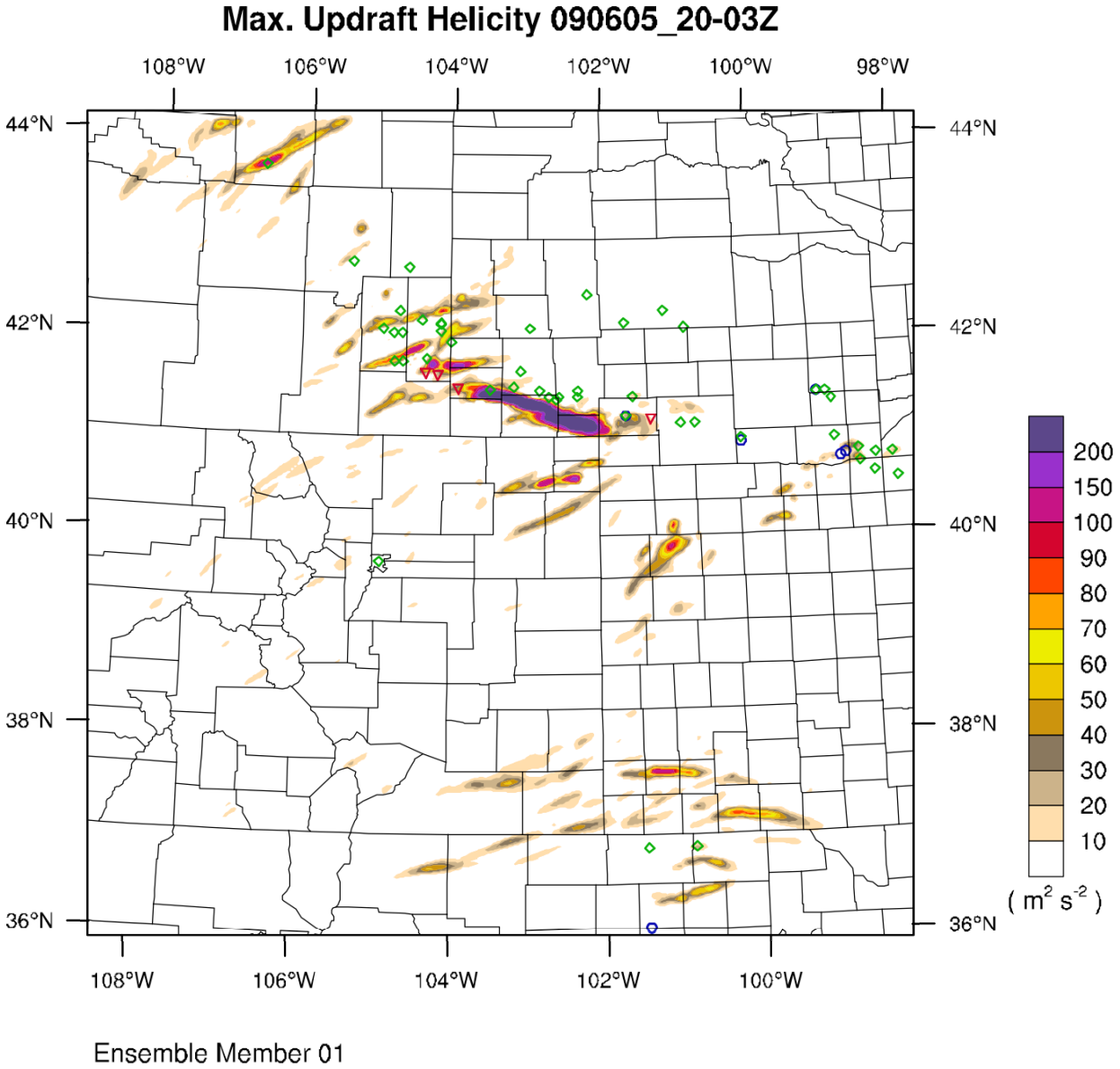
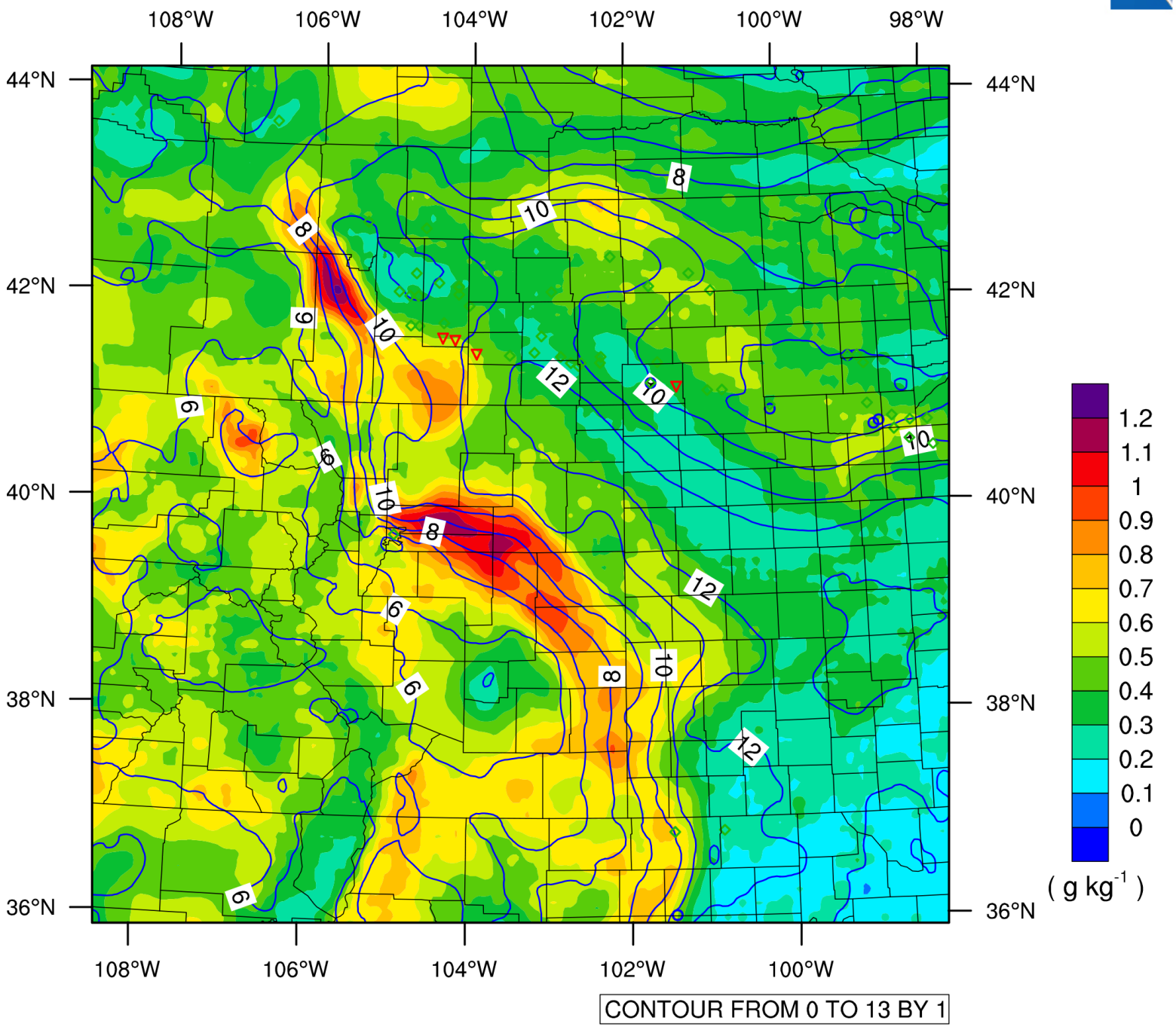


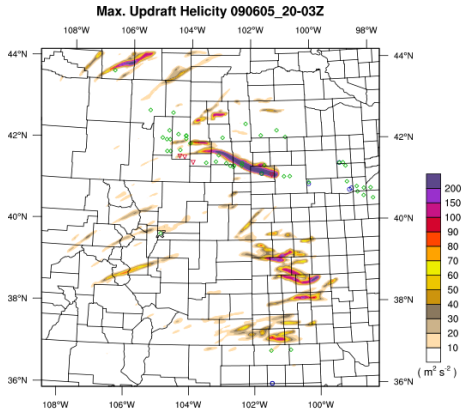
Preliminary results from 'control' storm-scale ensemble forecast



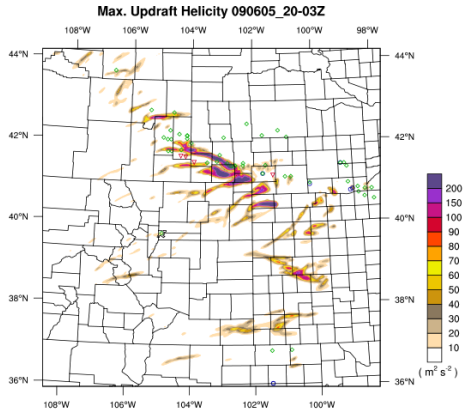
Updraft helicity swath ~= rotating storm tracks

Ens Spread in Q2 (g/kg) 2009-06-05_21:00:00

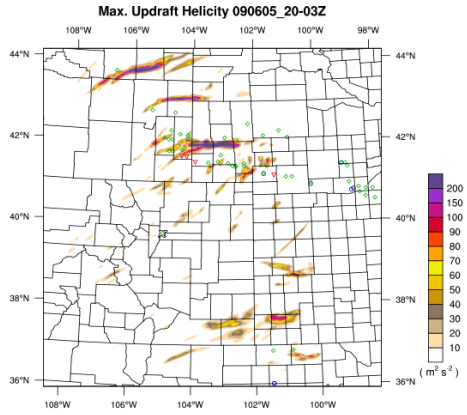




Ensemble Member 02



Ensemble Member 04



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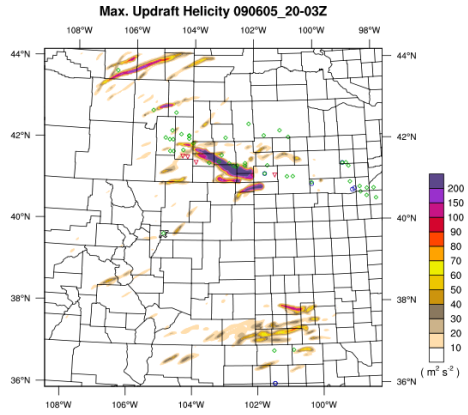
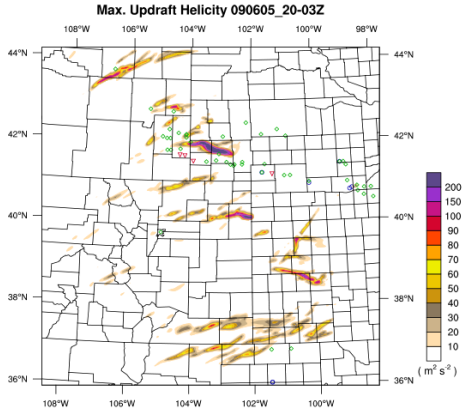


Ensemble Member 08



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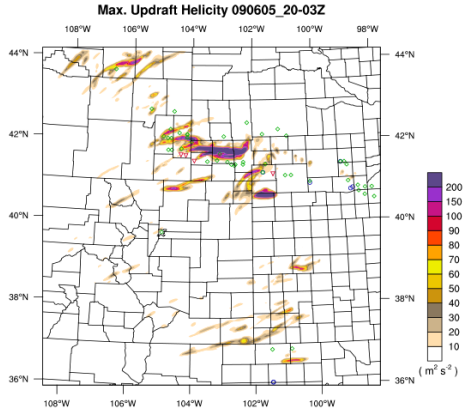
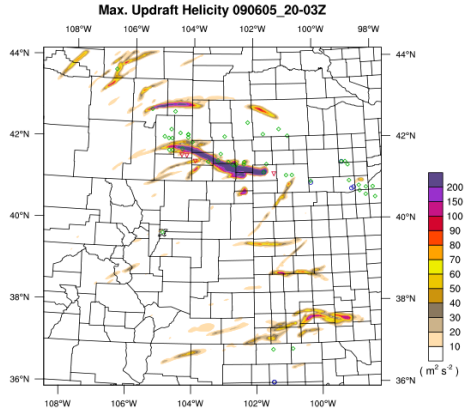
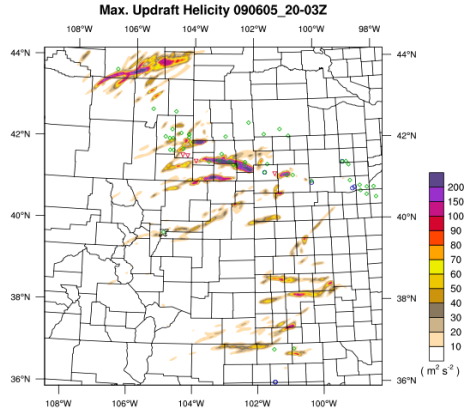


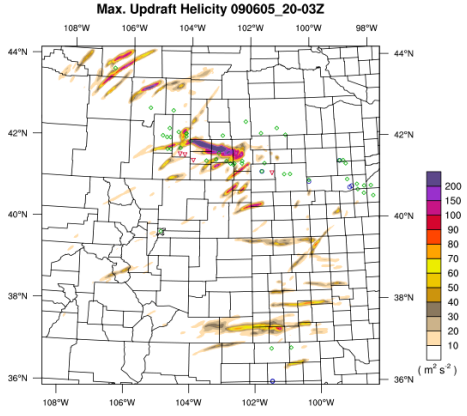
Ensemble Member 12



Ensemble Member 14



Ensemble Member 16



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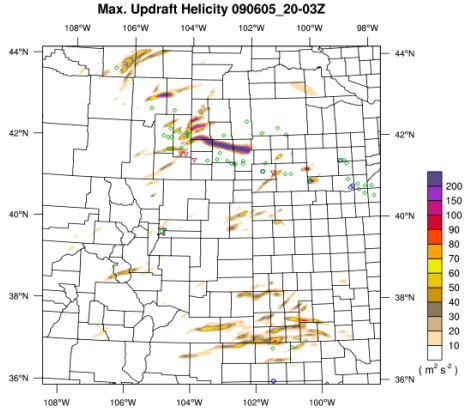
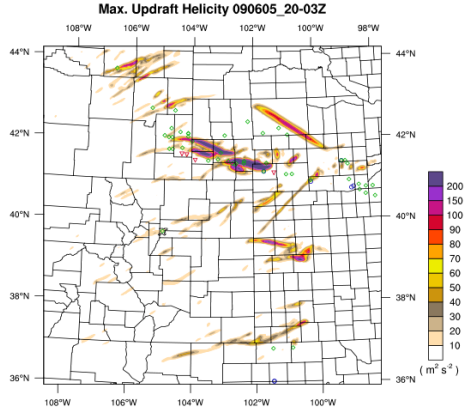
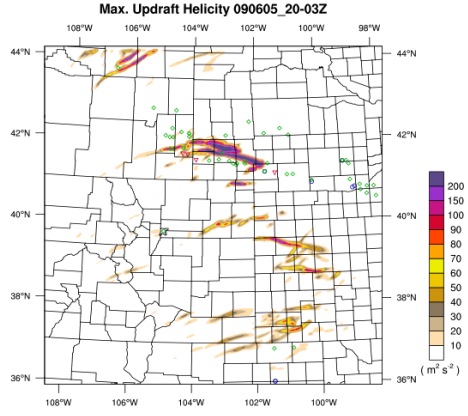


Ensemble Member 20

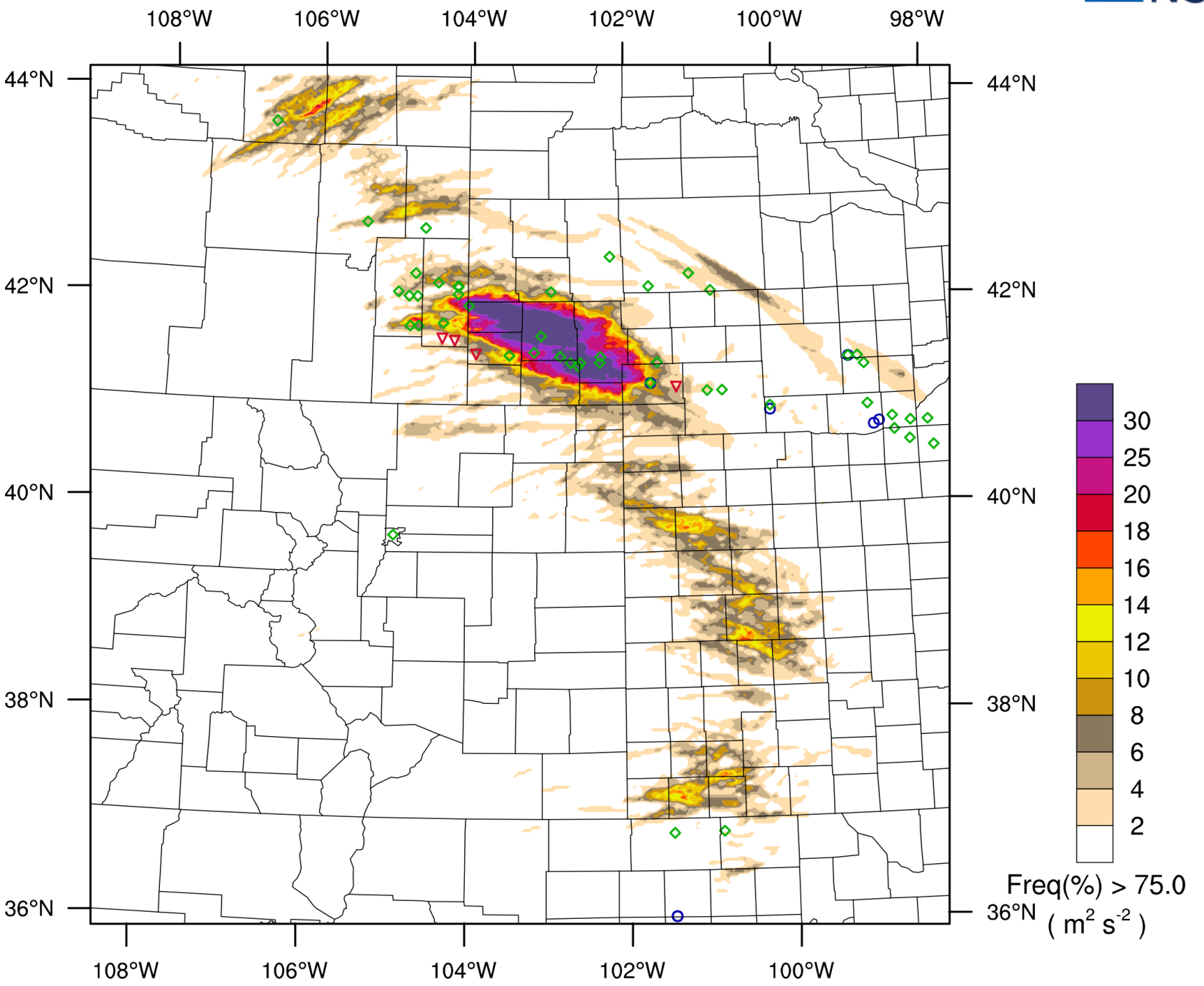


Ensemble Member 21



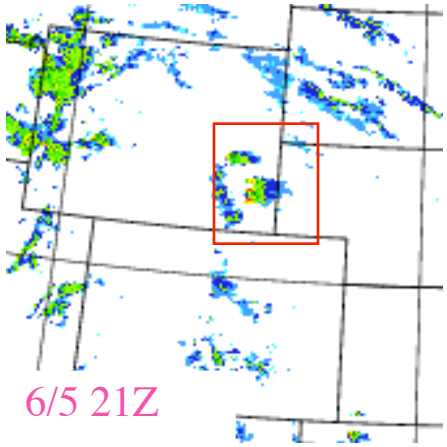
Ensemble Member 22

Max. Updraft Helicity 090605_20-03Z

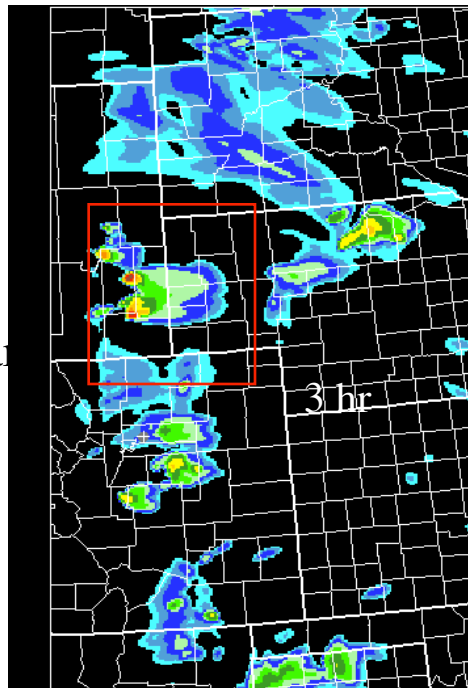


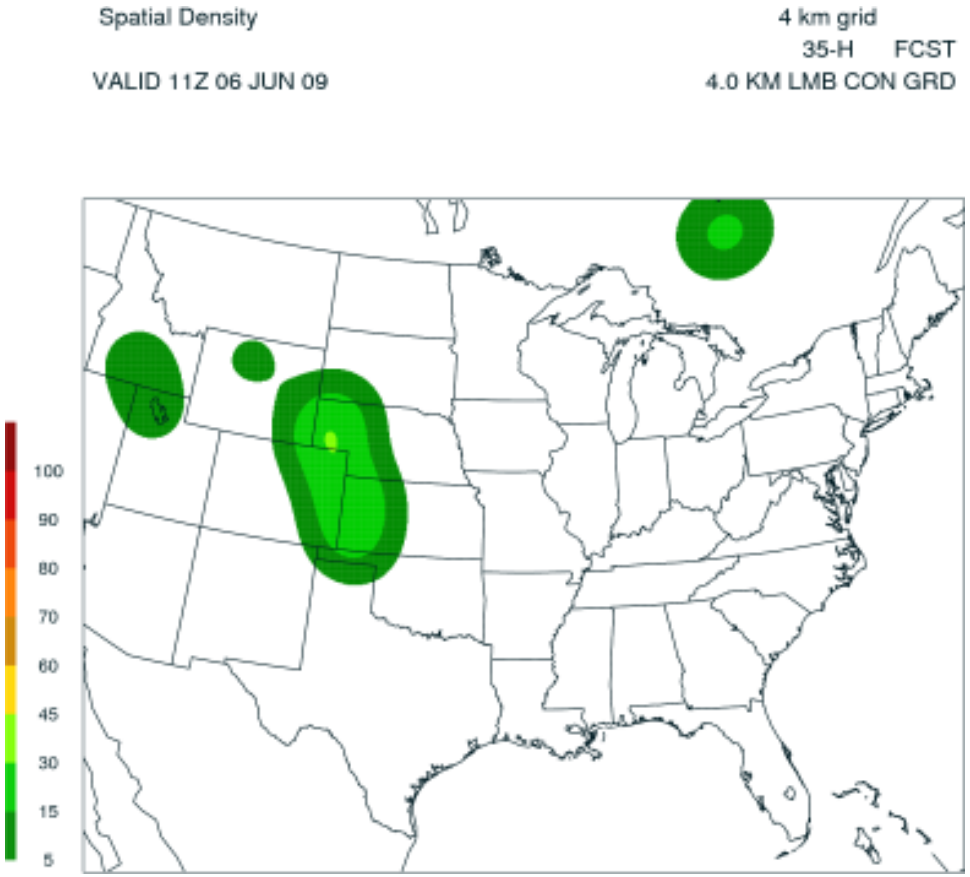
HRRR and NSSL WRF forecast verification

Composite Radar



HRRR Sim. Radar





Very preliminary impressions

- Continuously cycled mesoscale background is providing an adequate convective scale IC/BC
- Good range of convective environments encapsulating the observed event in 0-4 hrs
- Excess convection (anticipated from HRRR real time performance)
- Slow spinup in control (expect improvement with radar data assimilation)

Objectives moving forward

- Demonstrate consisntent short-range forecast guidance exceeding that from HRRR (best deterministic guidance, different IC)
- Smooth transition from analysis to ensemble forecast (probabilistic nowcast to convective forecast)
  - Clean spin up/down
  - e.g. fit to radial velocity observations 0-30 minutes
- Develop novel probabilistic guidance (potential application to severe weather watches)
  - November workshop
  - Focused collaboration with NOAA ESRL and NSSL