Single-Doppler EnKF assimilation of high-resolution data from the 29 May 2004 OKC supercell: Comparisons with dual-Doppler analyses.

Lou Wicker

NOAA/National Severe Storms Lab, Norman OK

With lots of help from:

Dr. Michael Biggerstaff, Daniel Betten,
Dr. Ted Mansell, Dr. Conrad Ziegler

May 29, 2004 west of Geary OK

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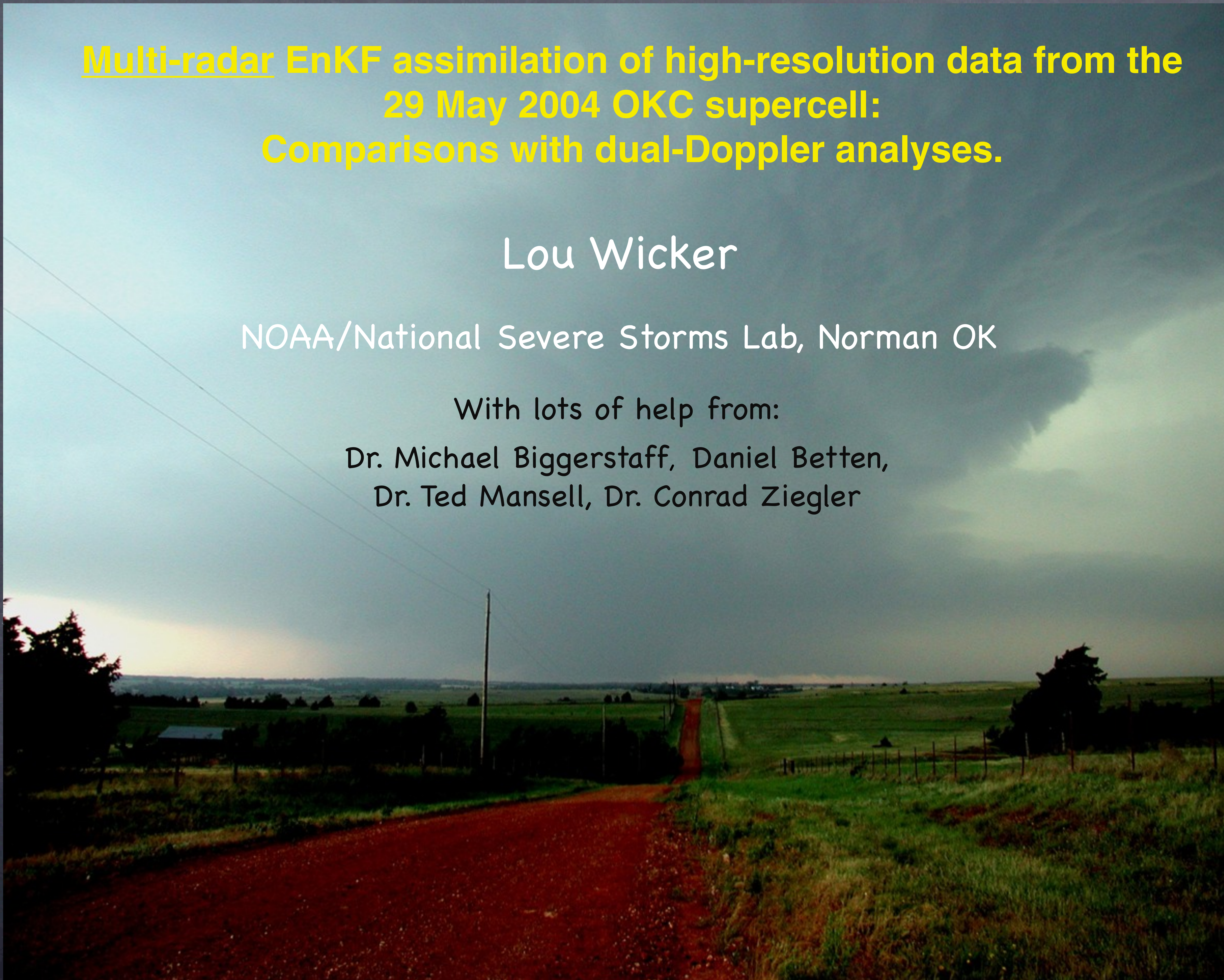


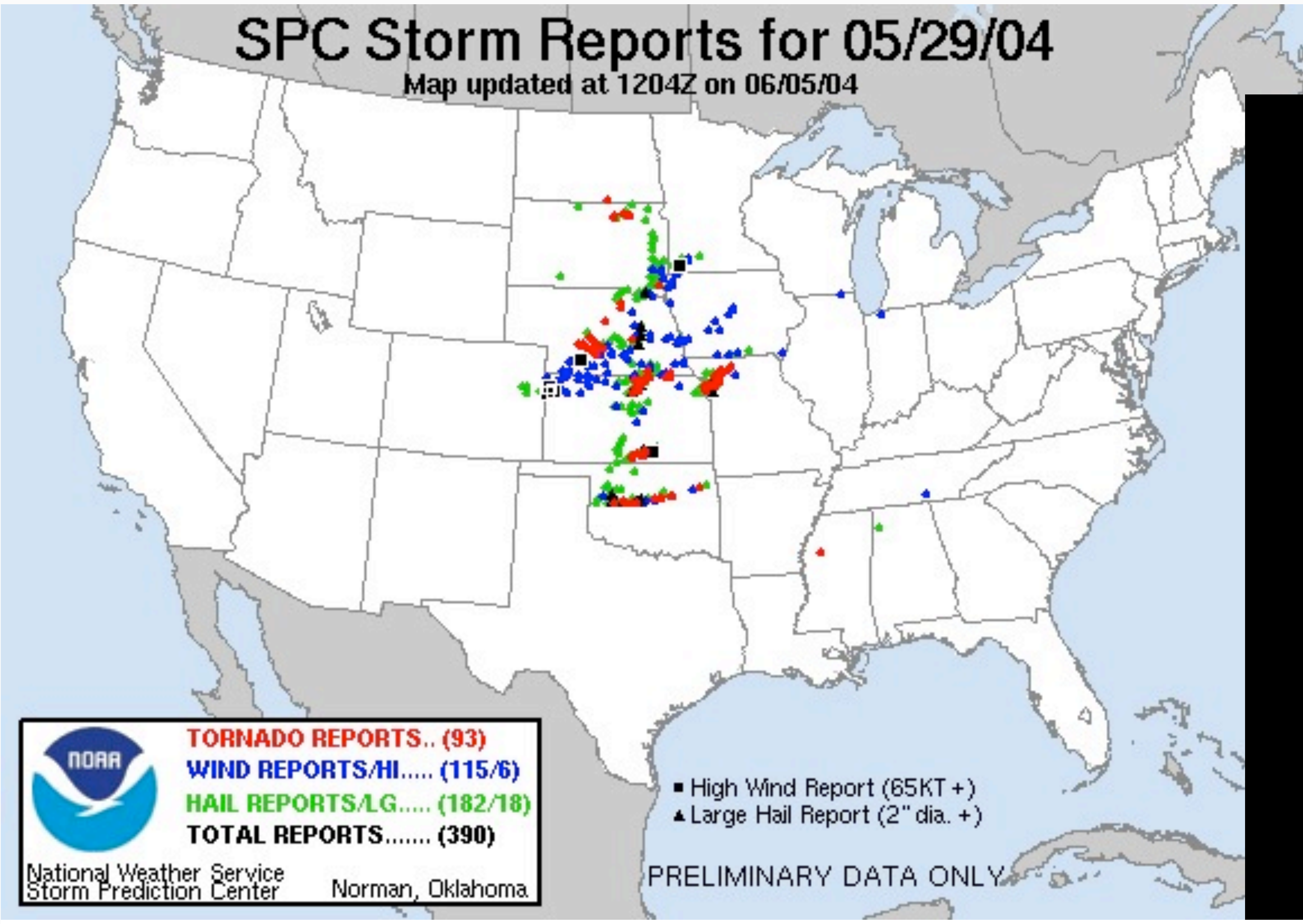
May 29, 2004 west of Geary OK

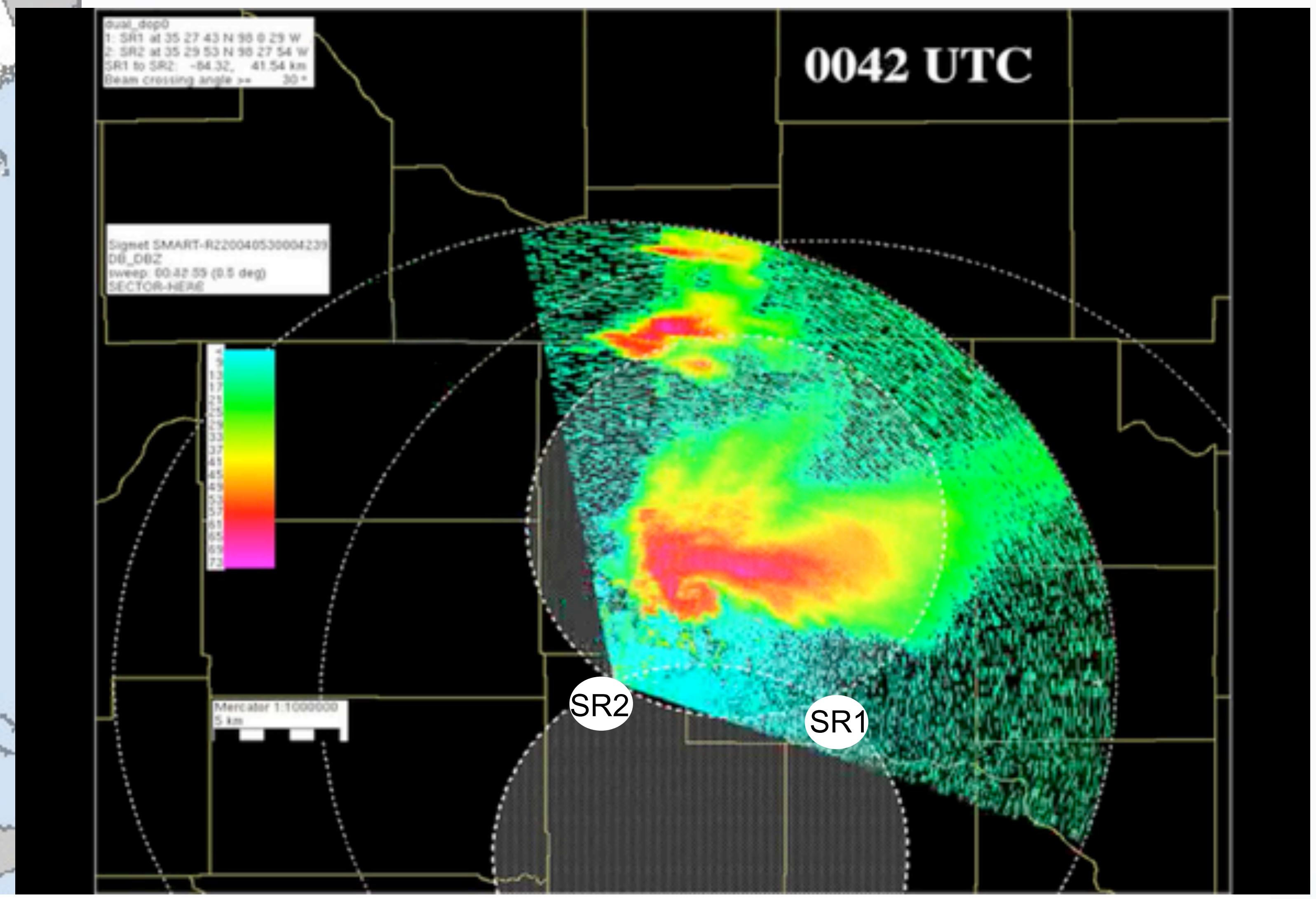

WORK IN
PROGRESS

Storm-scale Analysis: Challenge of Radar Data

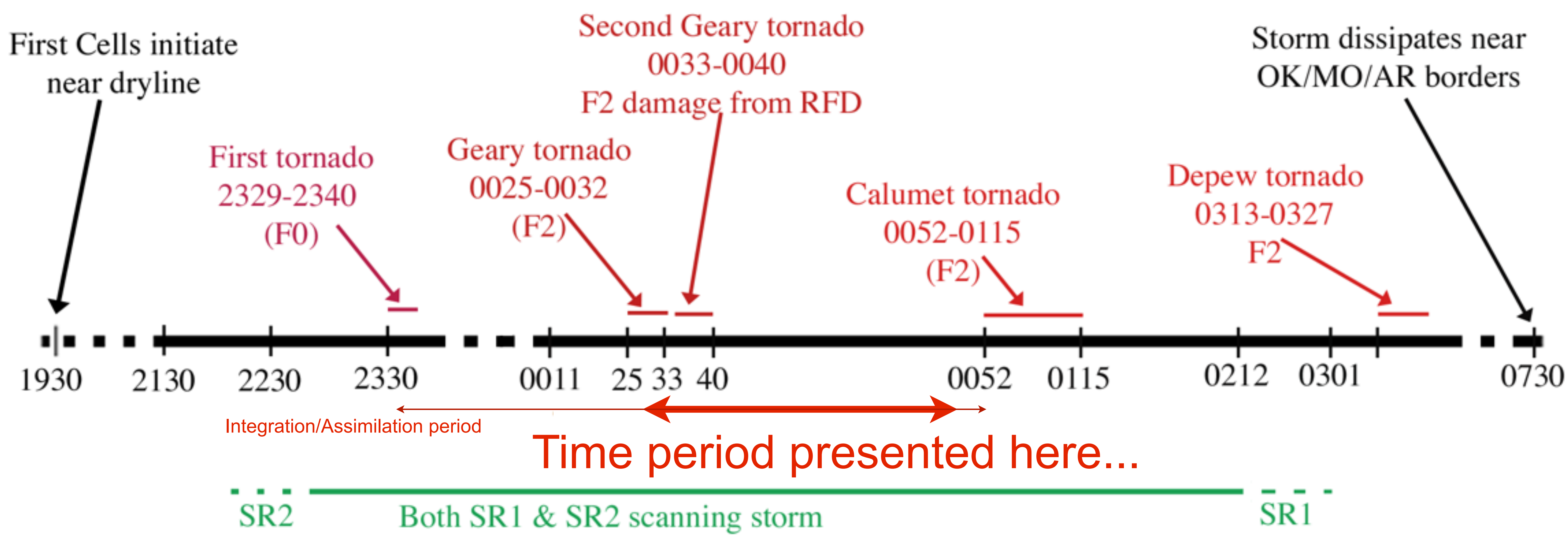
- Retrieval of full kinematic and thermodynamic state from 2 (or 4/5) types of observations
  - here: radial velocity and reflectivity
- Background state uncertainties
  - mesoscale environment
- Model errors are significant
- Observation errors not well understood
- **How to verify what you get?**

Storm Events

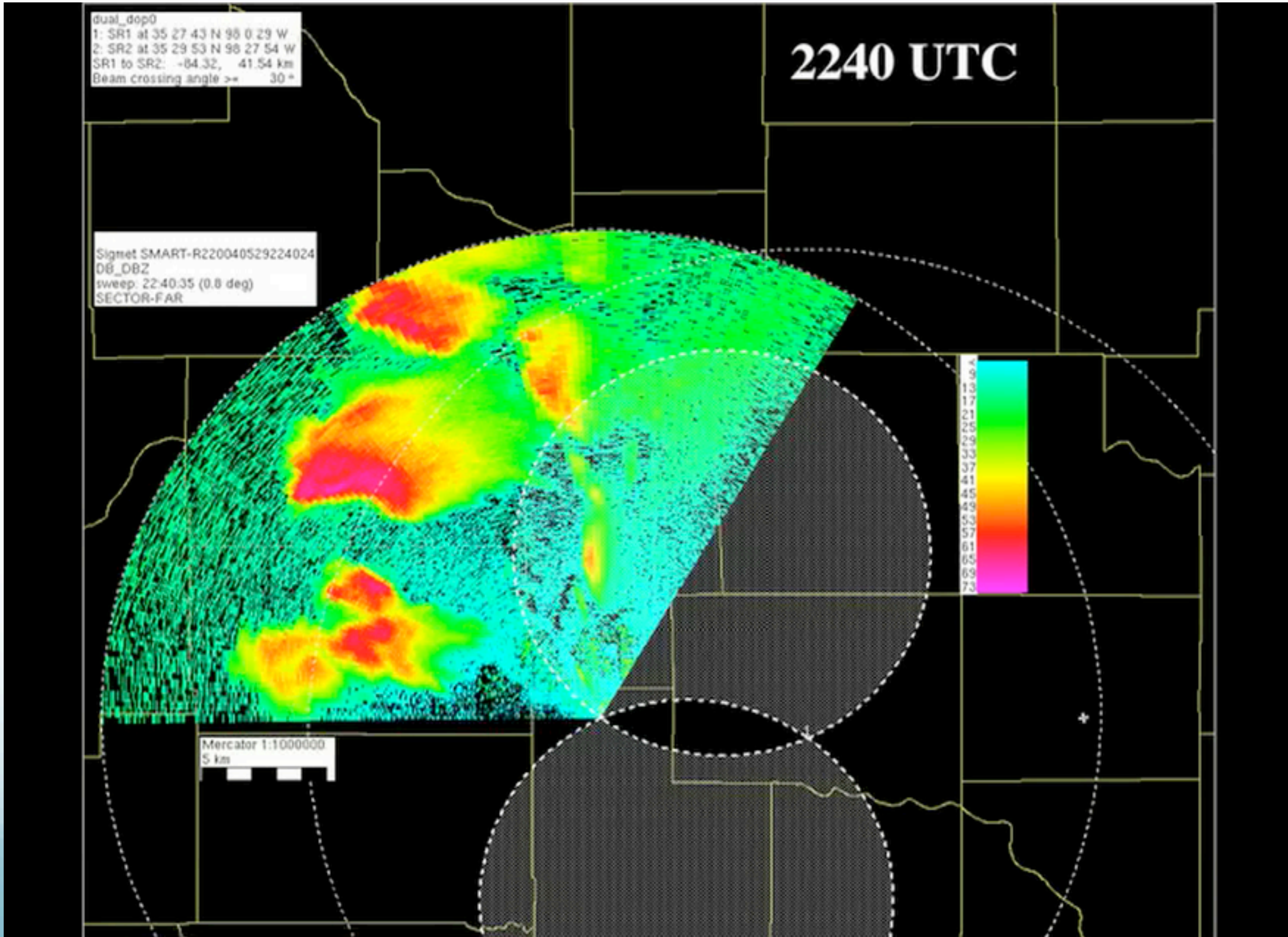




Timing of events during 29 May 2004 Supercell storm



Low-Level Radar Evolution



NCOMMAS Model Parameters

- 1 km horizontal grid (140 x 120 km domain)
- 200 m vertical resolution near ground (Z(top)=22 km)
- Physics
  - no surface physics, no radiation
  - TKE
- IC & BC
  - single homogeneous sounding
  - no Coriolis, open boundaries
- Microphysics:
  - **Mansell ZVD-HV: 4 class ice, 2 moment, density of graupel and hail predicted**

EnKF Parameters

- Square root filter of Whitaker and Hamill
- Maintain ensemble spread via additive noise no inflation used
  - Add perturbations in regions where model reflectivity too low
  - Add noise where reflectivity is > 30 dBZ every 4 min.
    - 1 m/s to U & V, and W
    - 0.5 K to Theta, Td
  - Modified Caya algorithm (normalizes perturbations)
  - ensemble tends to be underspread.....
- 30 members (probably need > 45)
- Initial winds in soundings have 2 m/s noise added
- Radial velocity and reflectivity were used to update all model variables except TKE and pressure.

Experiments

- Radar data are thinned to a 2 km super-ob grid.
  - Volume every 3 minutes with 18 tilts.
  - SR2 Vr and dBZ used in all experiments (west radar)
  - SR1 Vr only after 0010 UTC (east radar)
- Warm bubble “cook” from 2330 - 2345
- Radar assimilation
  - 0045 - 0000 (lots of data from SR2)
  - 0000 - 0010 (little data)
  - 0010 - 0115 (lots of data from both radars)
- Storm structure is poor at 0010.
- Treat 2330-0010 as spin-up period.

Dual-Doppler Analysis

(Betten and Biggerstaff, 2009 ECCS)

- Generated on a 750/500 m (dx/dz) grid
- Vr gridded via Cressman analysis with a radius increasing with range from radars
- Reflectivity analysis is max value at point
- NCAR software used for retrieval of Cartesian winds
- O'Brien method used for correcting divergence errors
- For this case (at least) - W values strongly impacted by filtering
- Choose to examine things at low elevation angles.

Kinematic Questions....

- How well does a single Doppler EnKF compare with a dual-Doppler analysis?
- Does adding a second radar improve the analysis?
- Does adding a second radar which is scanning only at low-levels improve the analysis (VORTEX2 question....)
- ~Qualitative comparisons here today...
  - look not only a W, but U/V wind fields

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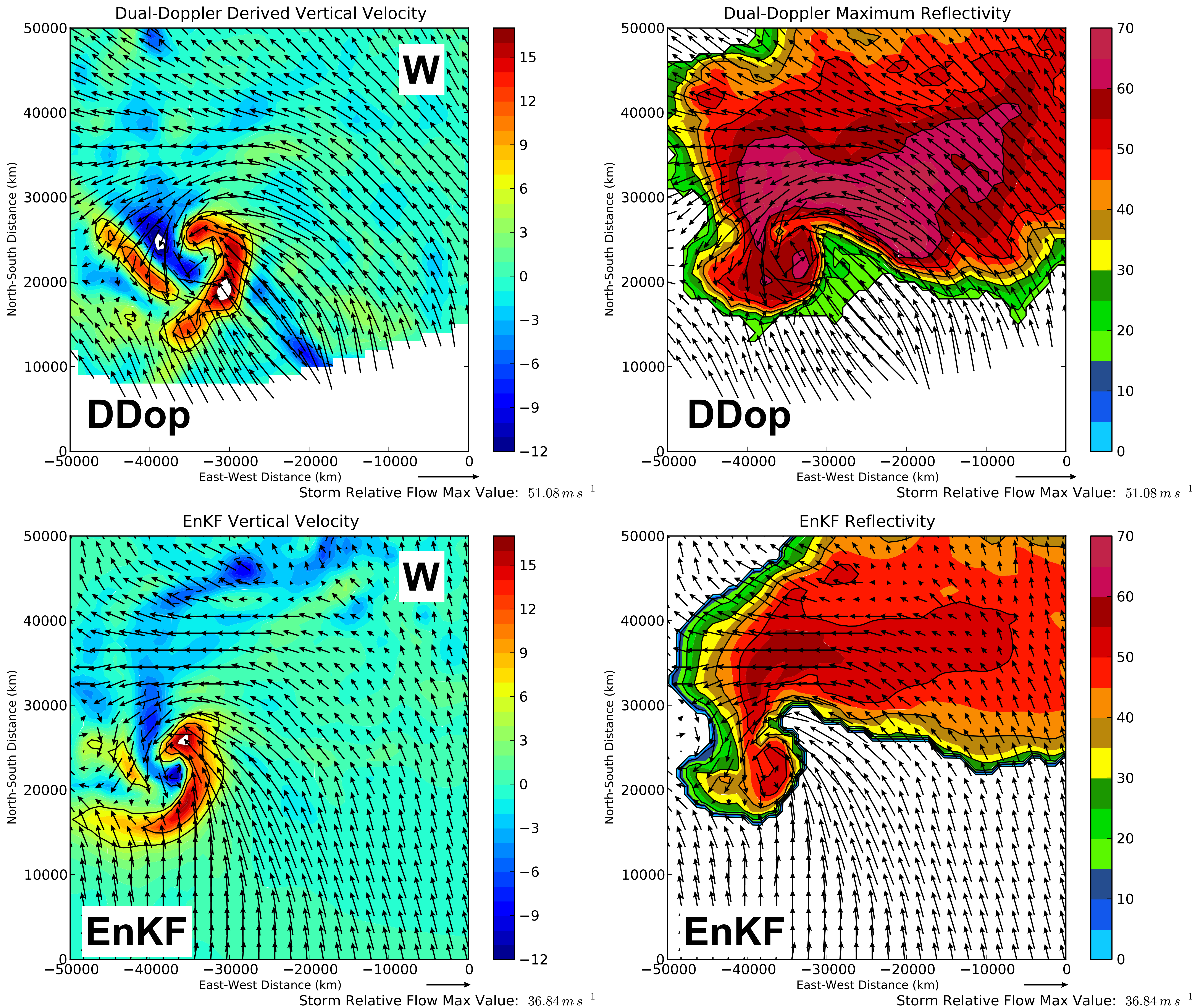
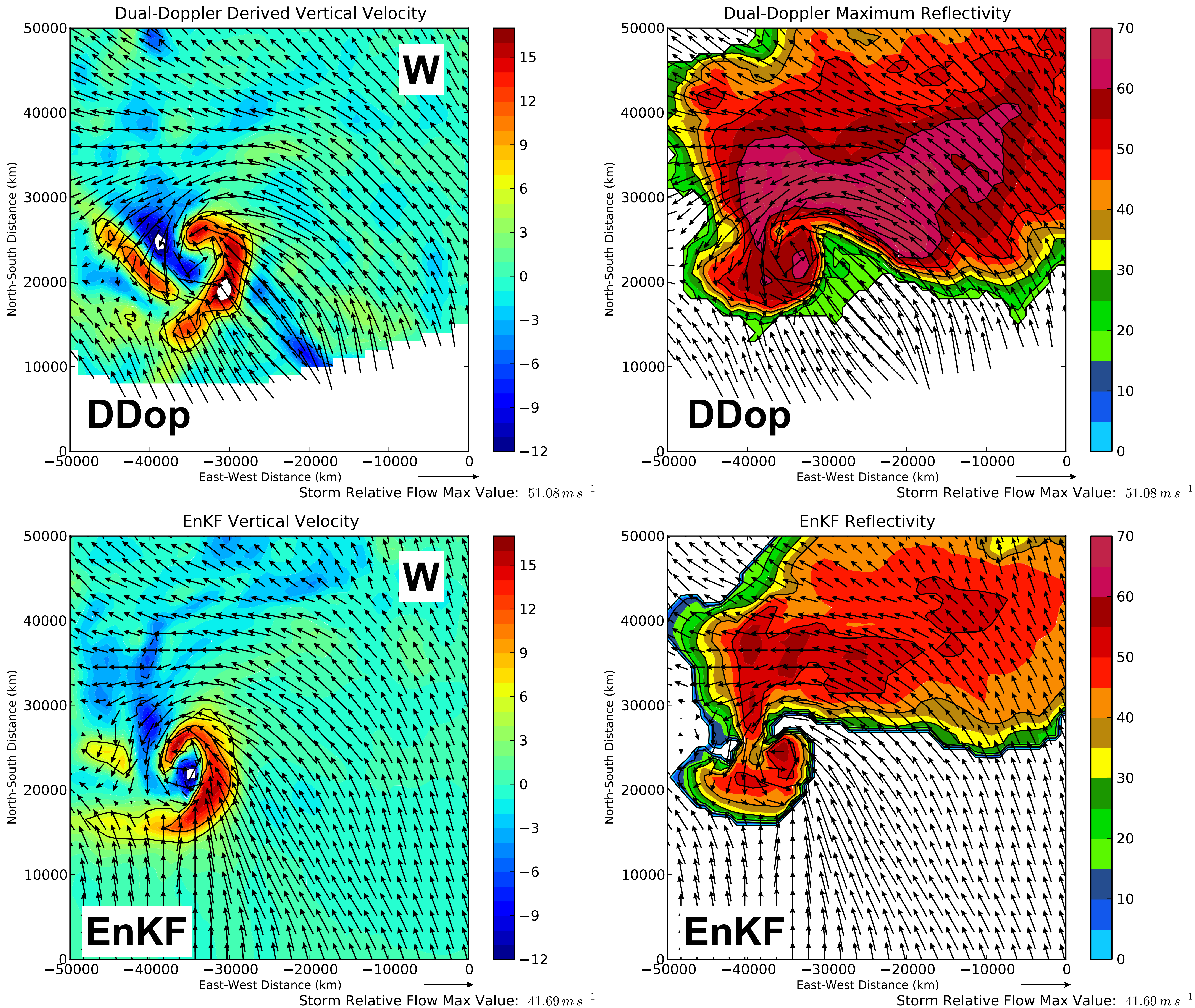
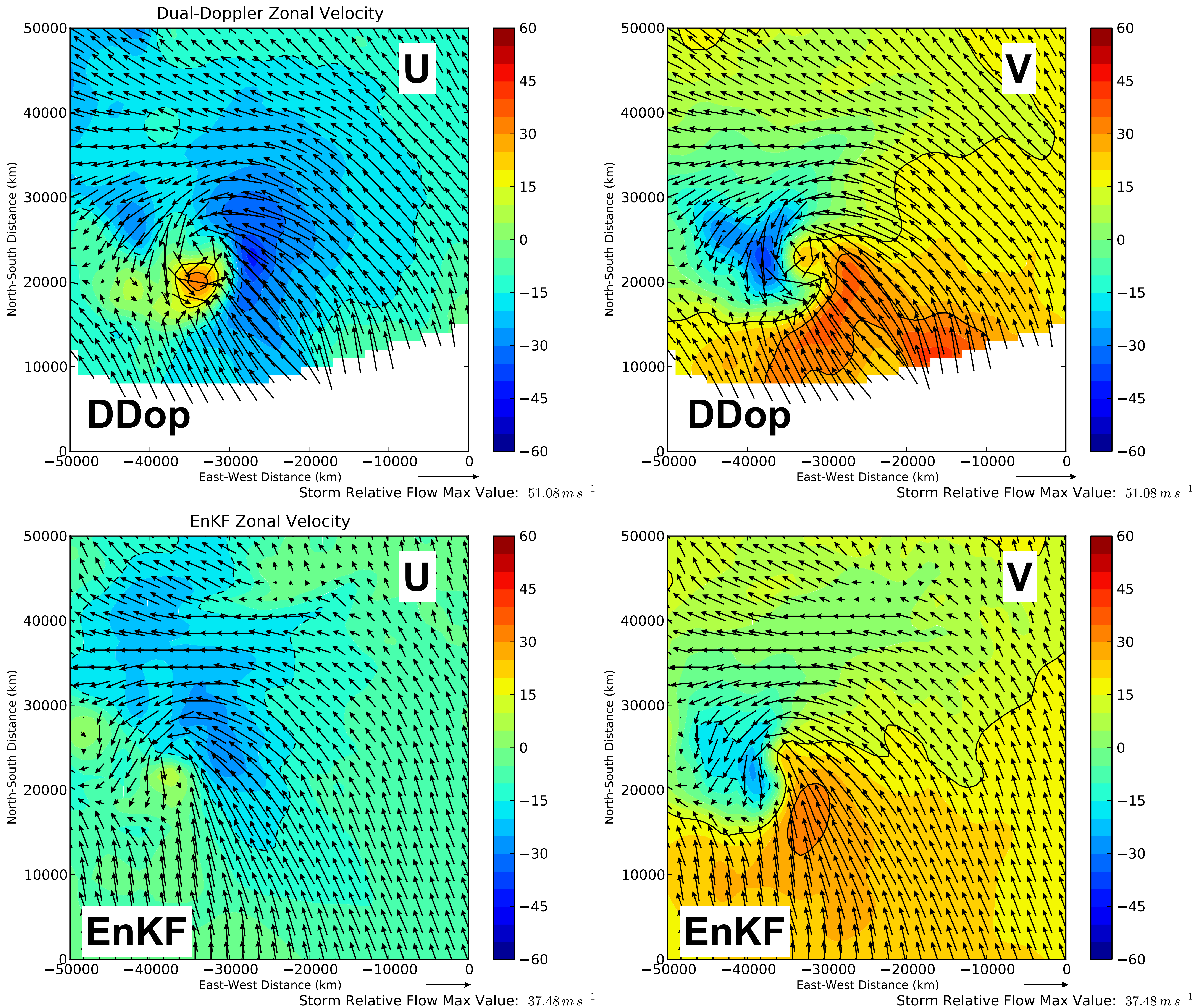
0027 UTC 1 km W **1 radar** (8 EnKF cycles)



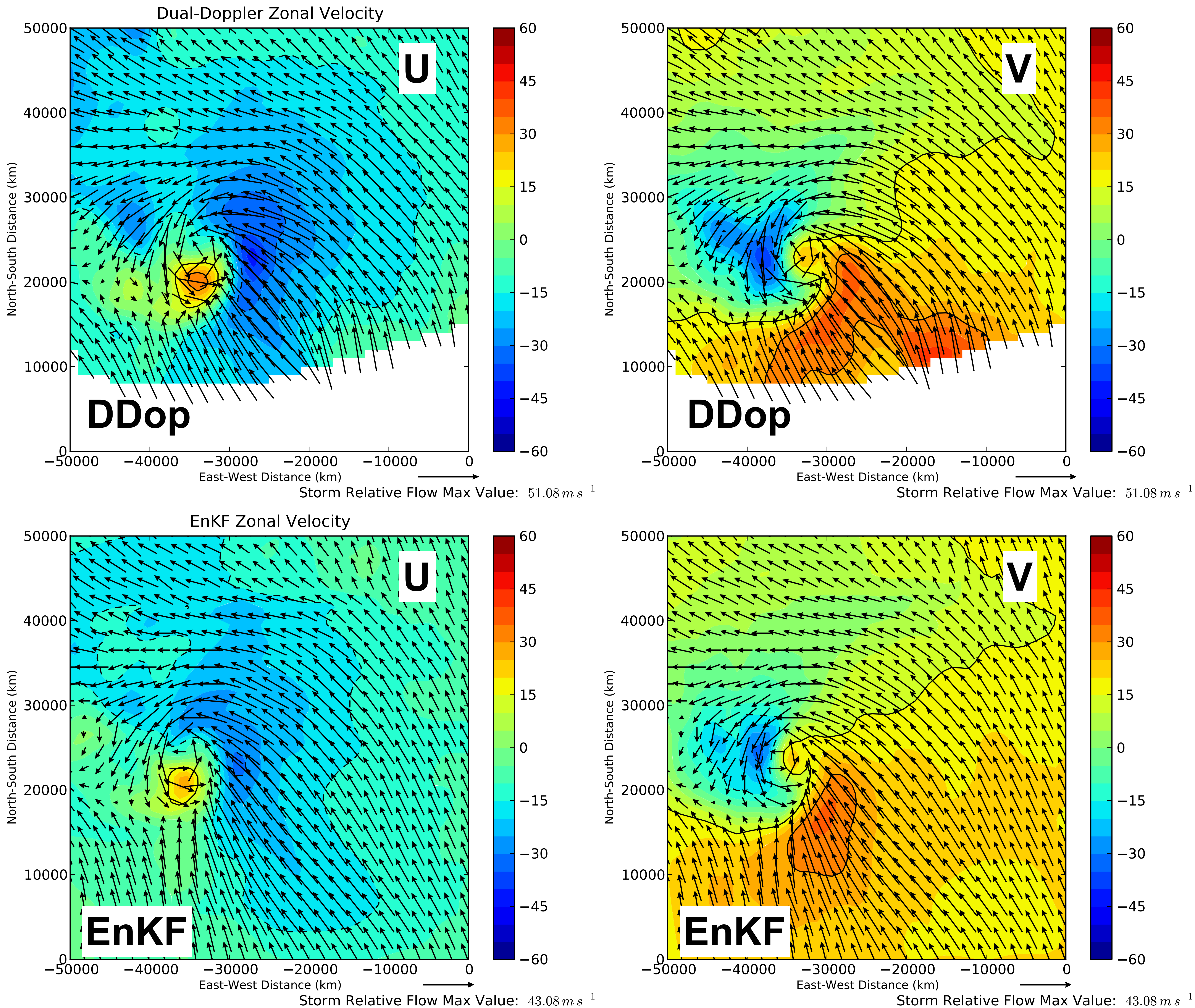
0027 UTC 1 km W **2 radars** (8 EnKF cycles)



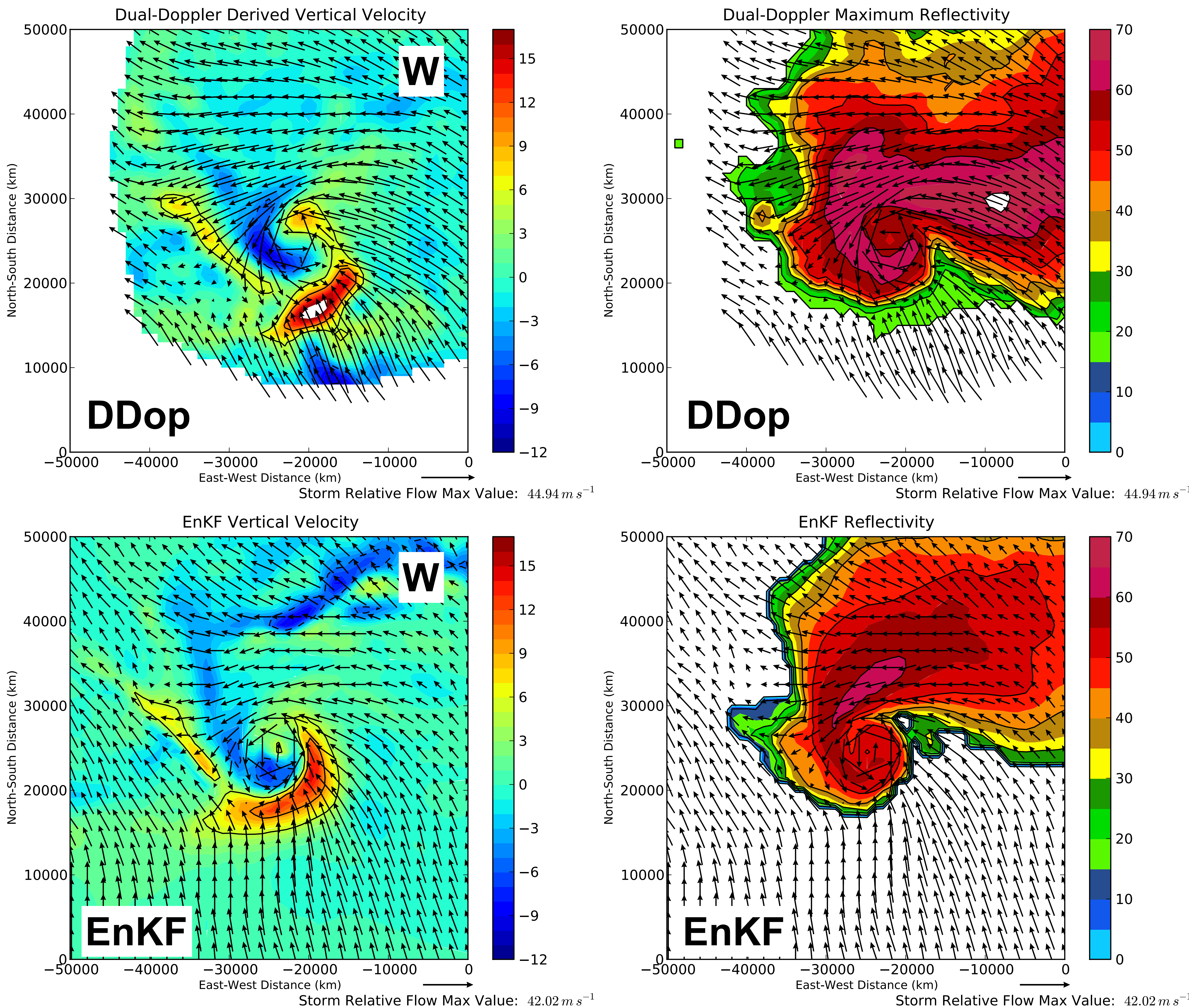
0027 UTC 1 km U & V 1 radar (8 EnKF cycles)



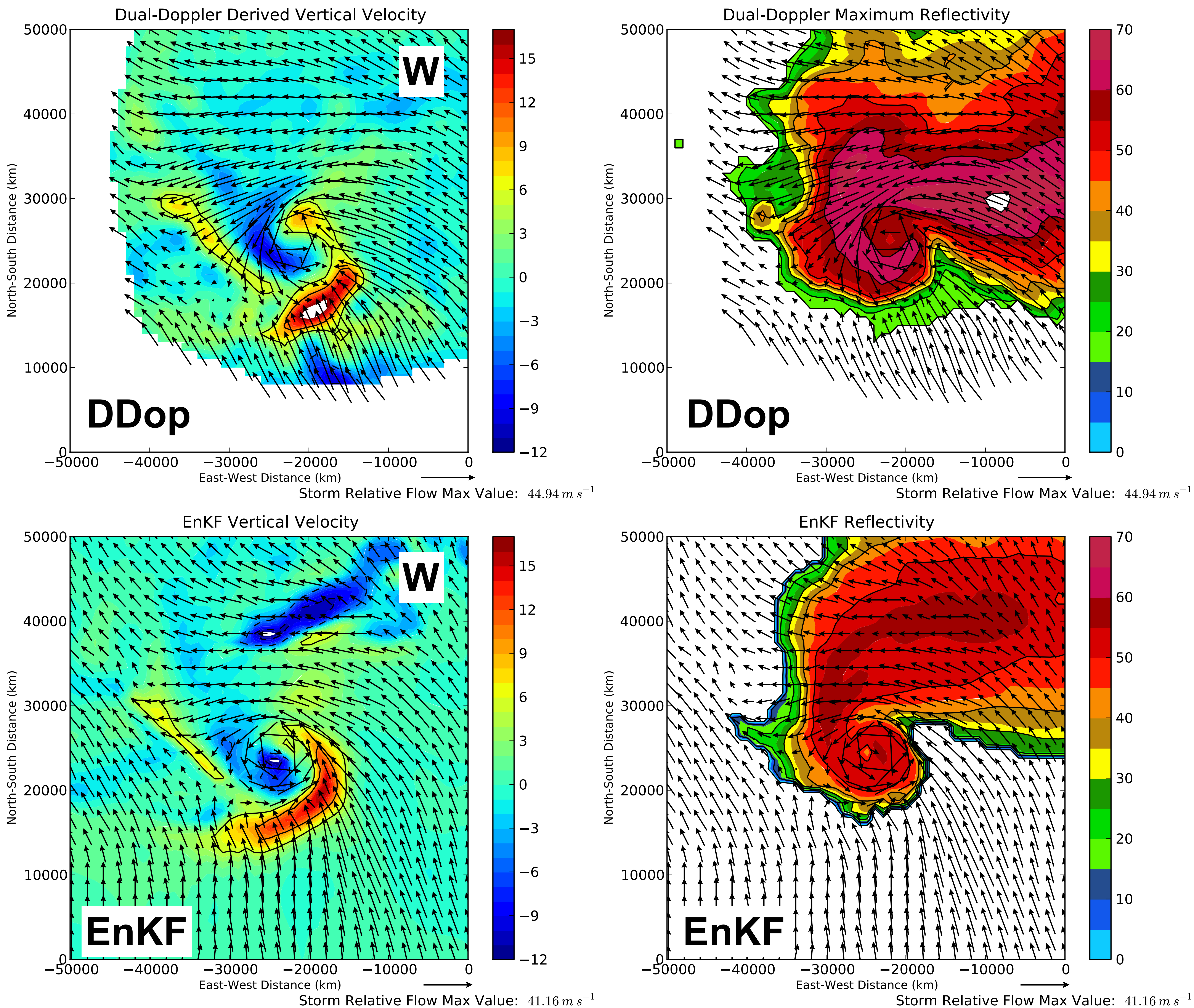
0027 UTC 1 km U & V 2 radars (8 EnKF cycles)



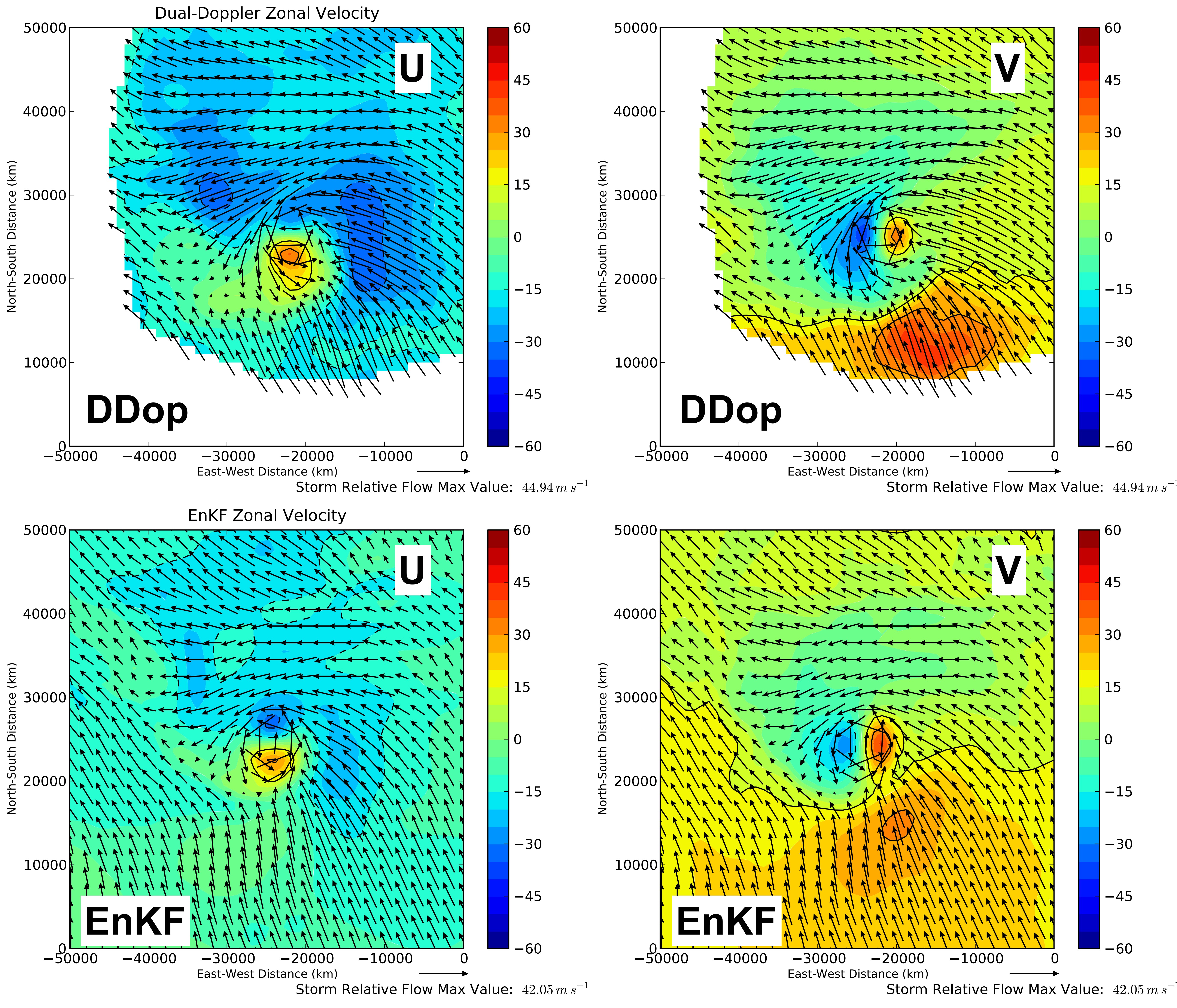
0045 UTC 1 km W 1 radar (8 EnKF cycles)



0045 UTC 1 km W 2 radars (8 EnKF cycles)

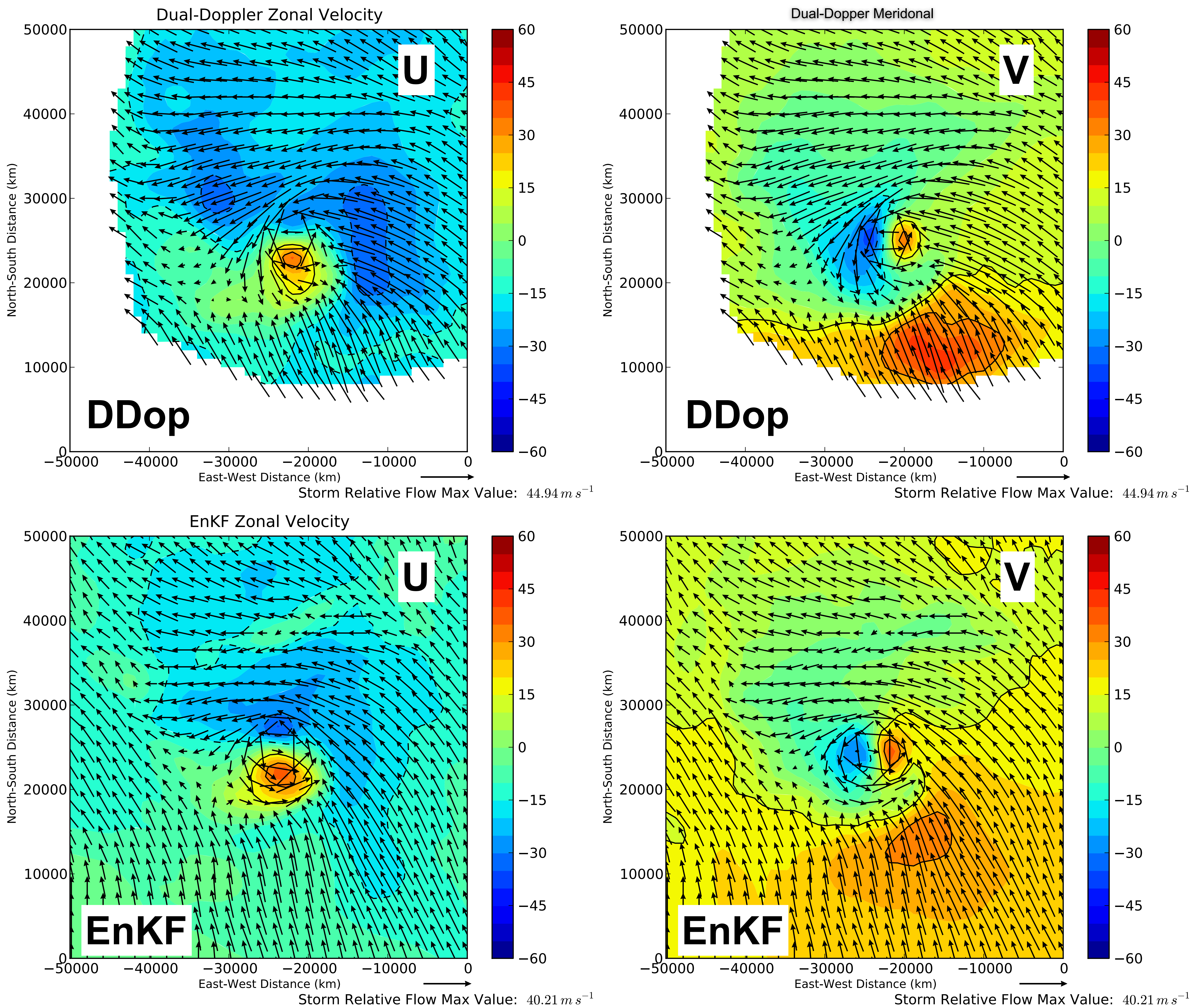


0045 UTC 1 km U & V 1 radar (17 EnKF cycles)



0045 UTC 1 km U & V

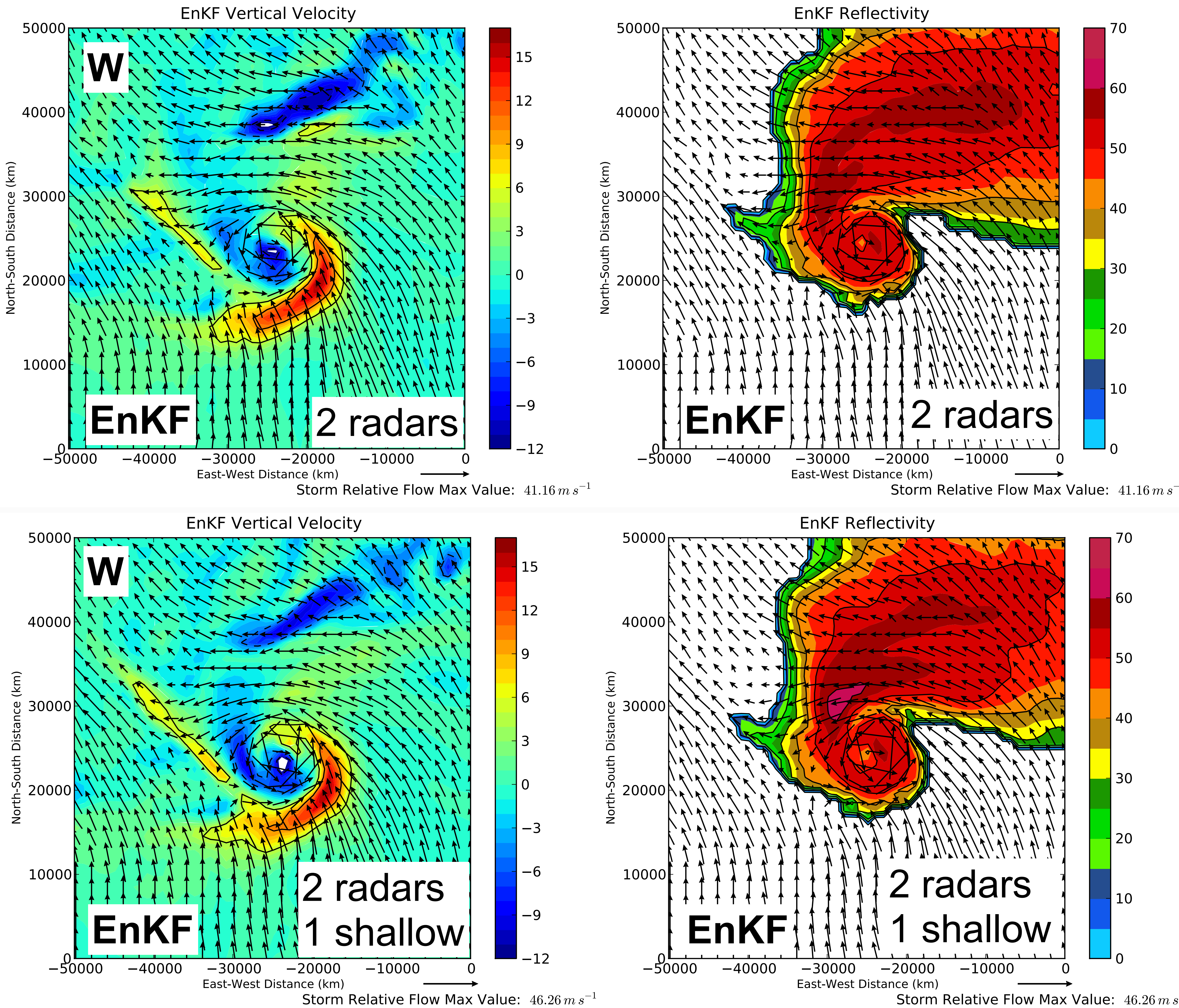
2 radars
(17 EnKF cycles)



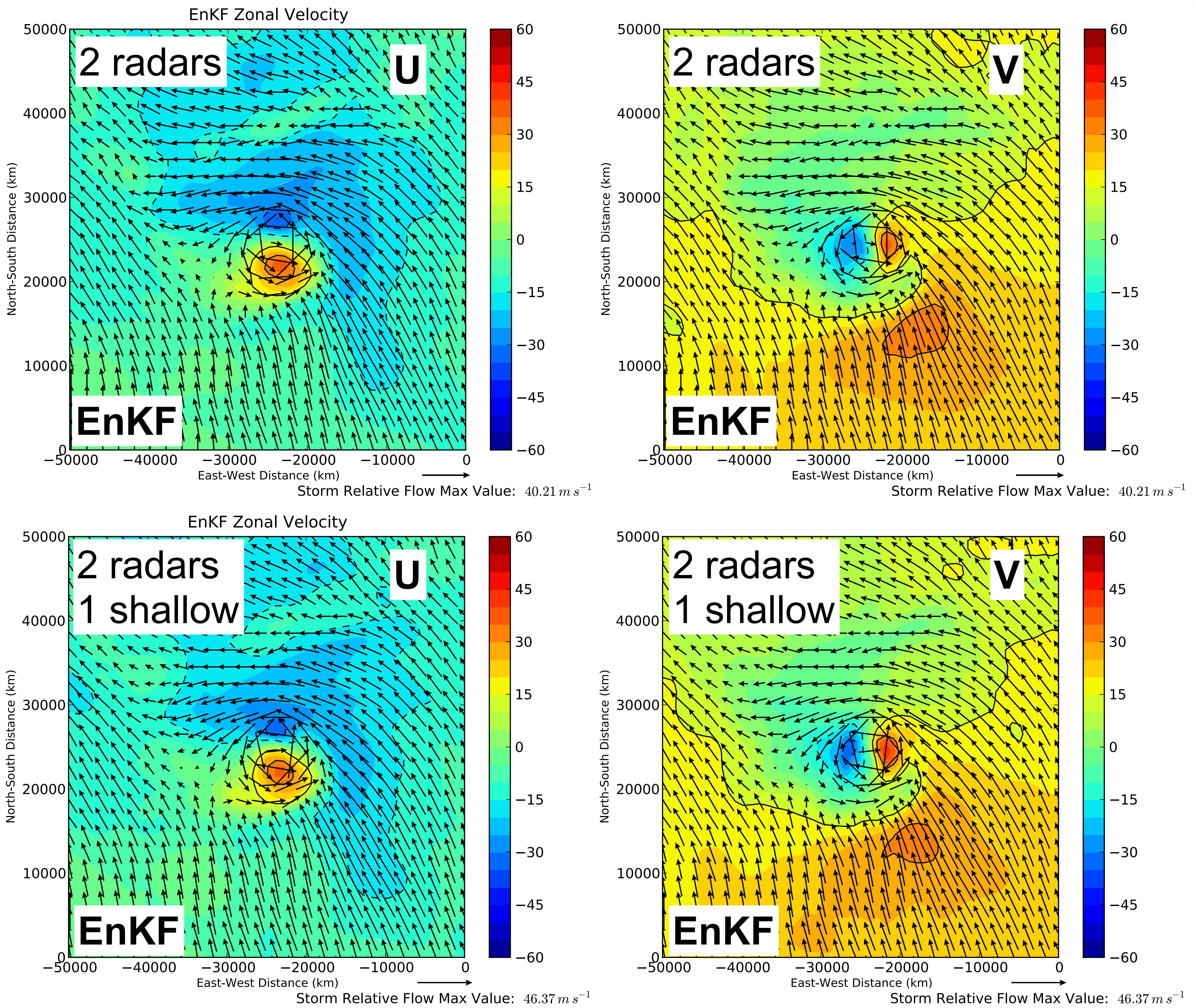
Kinematic Questions....

- How well does a single Doppler EnKF compare with a dual-Doppler analysis?
- Does adding a second radar improve the analysis?
- **Does adding a second radar which is scanning only at low-levels (z < 4 km) still improve the analysis? (question related to field programs...)**
- Qualitative comparisons here today...
  - look not only a W, but U/V wind fields

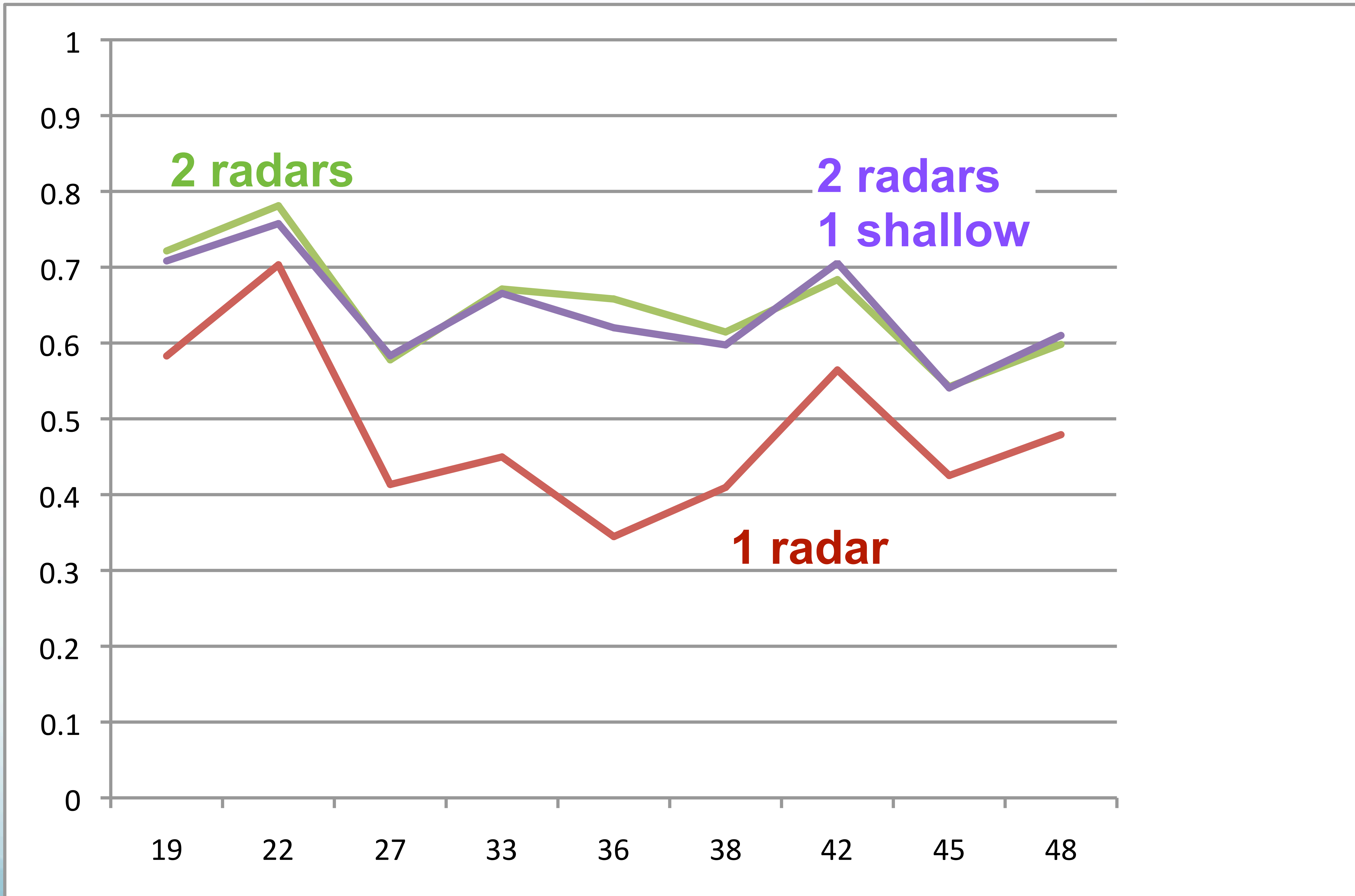
0045 UTC 1 km W (17 EnKF cycles)



0045 UTC 1 km U & V 2 radars (17 EnKF cycles)

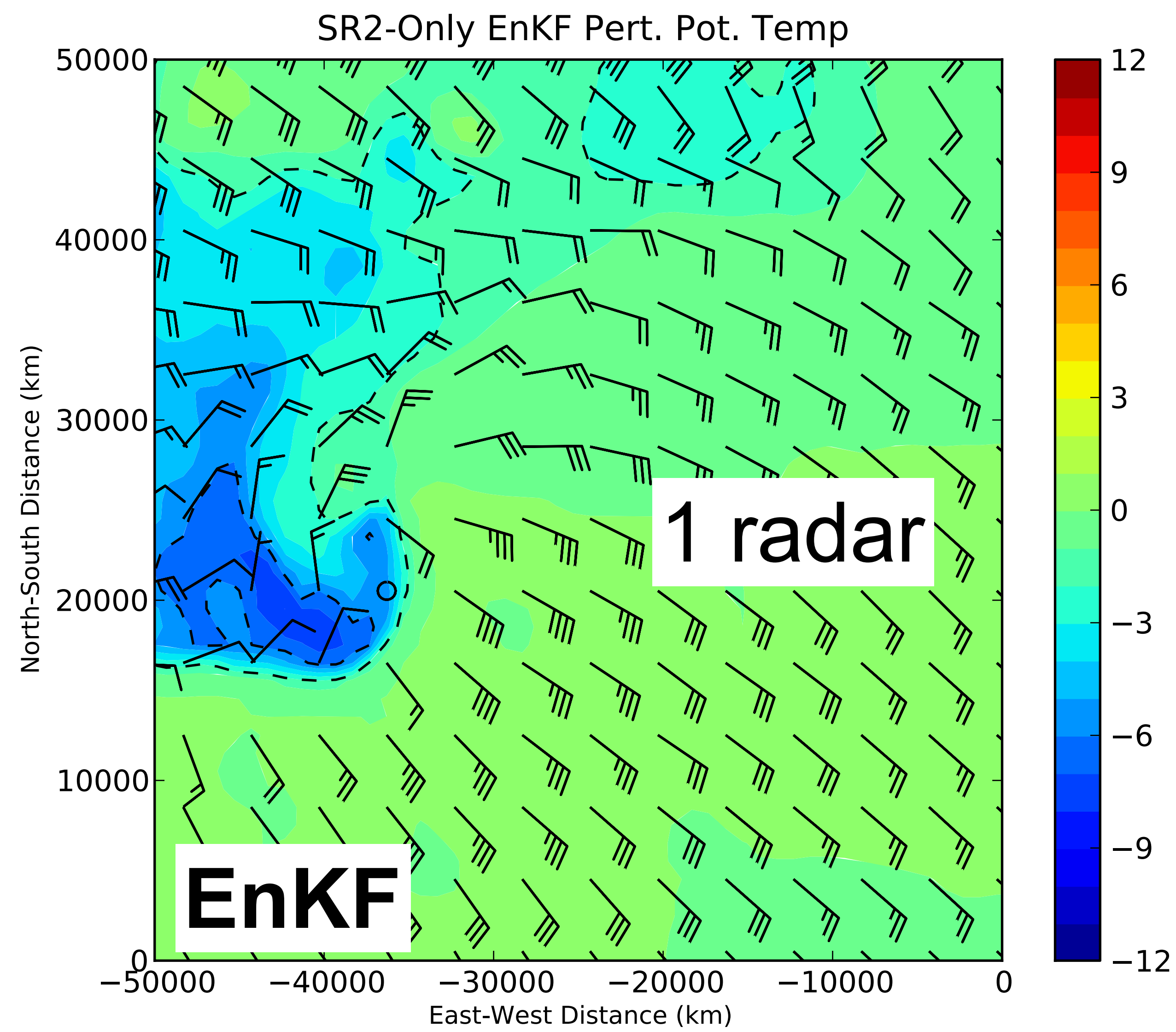


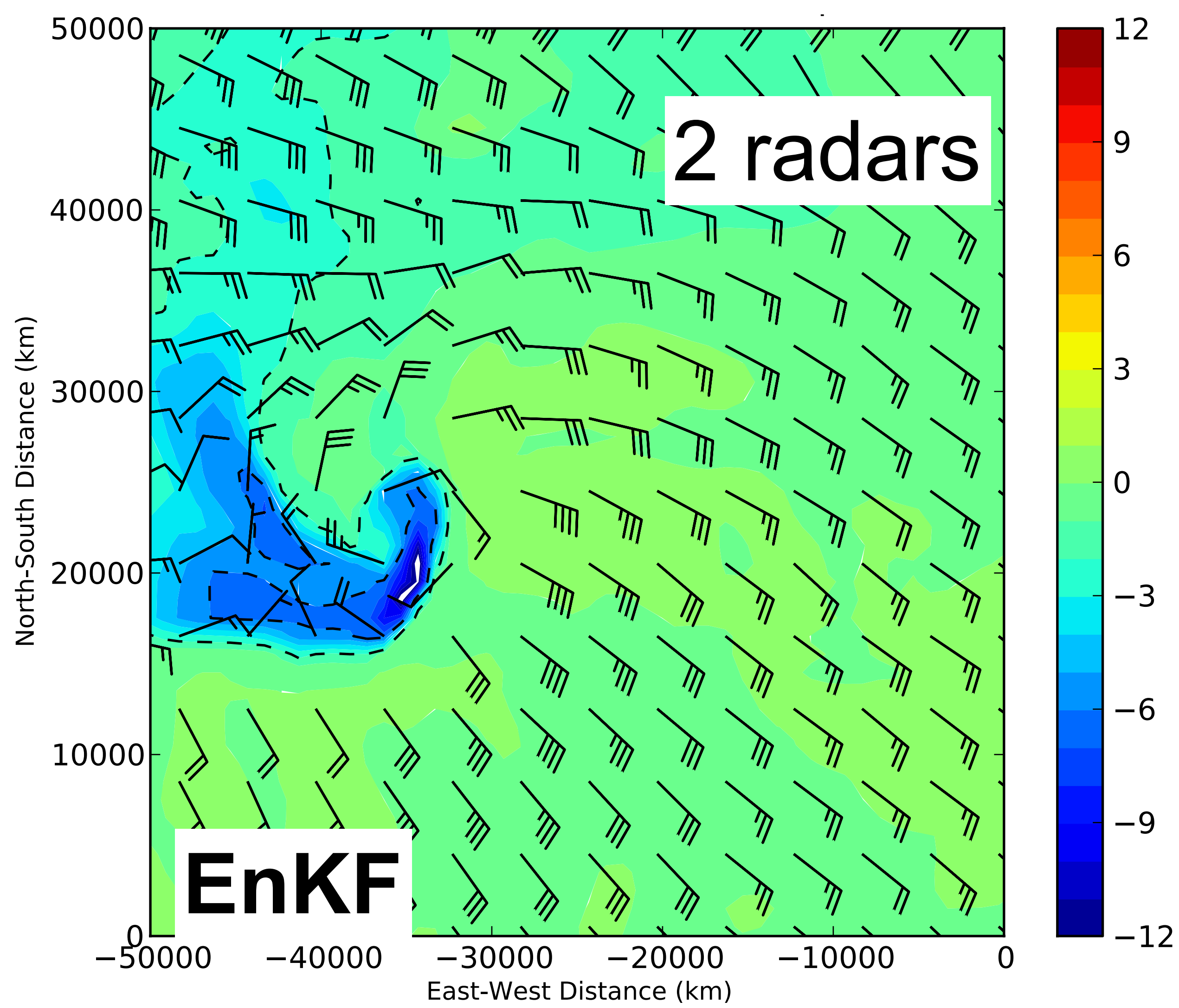
W-Correlations with Dual-Doppler W
z = 1 km

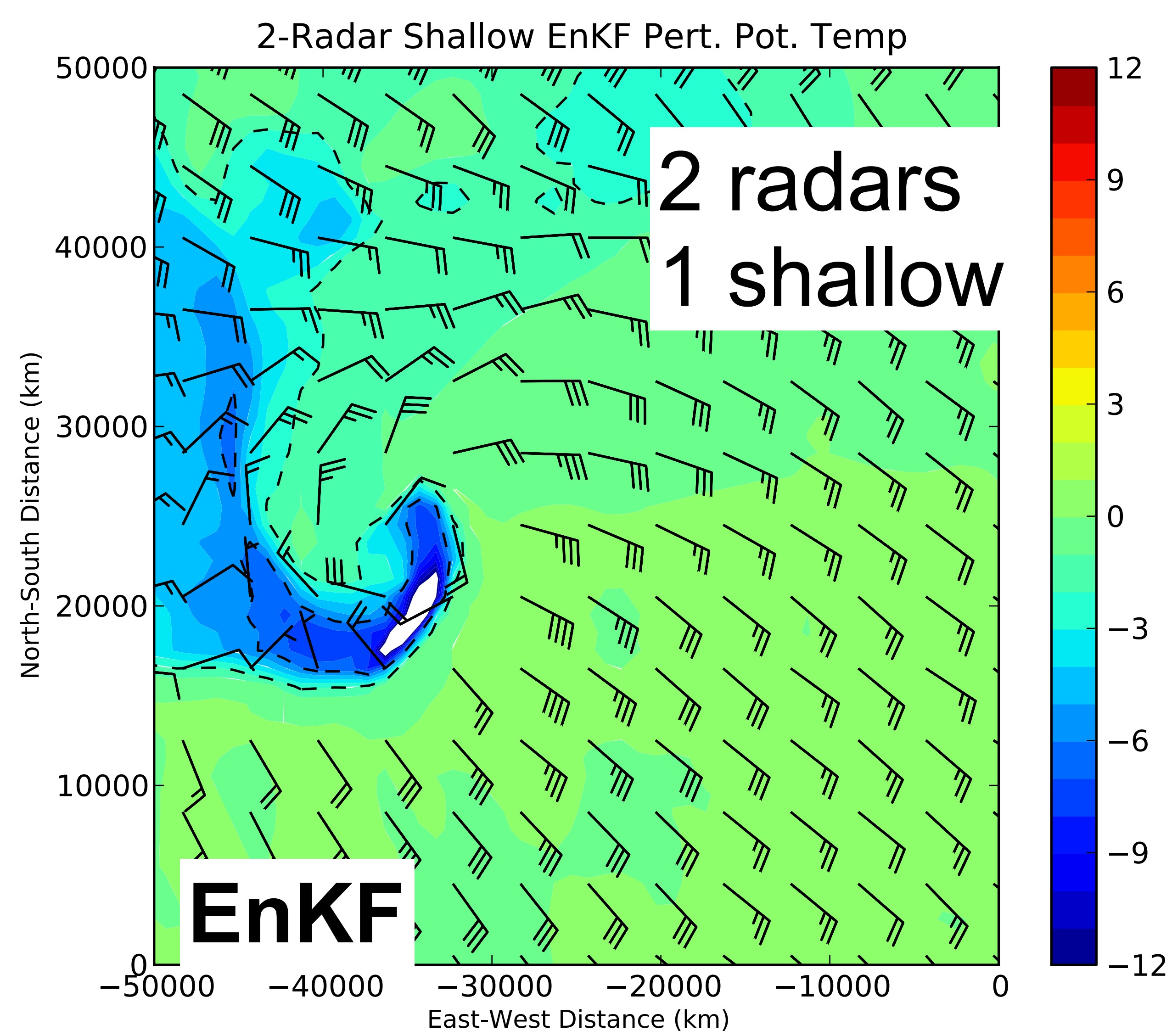


UTC Minutes after 00Z

0027 UTC Pert Surface Temp (8 EnKF cycles)







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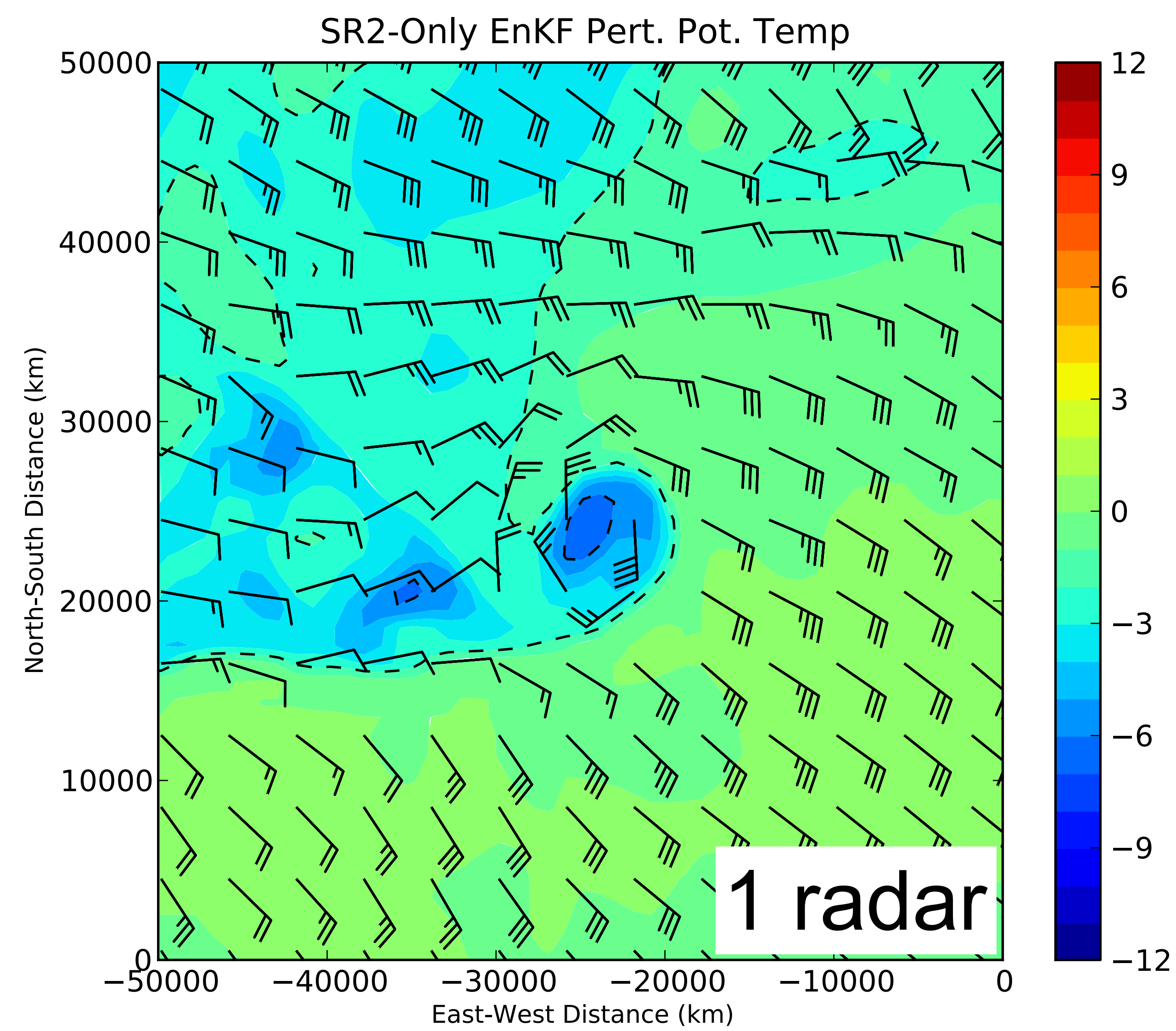

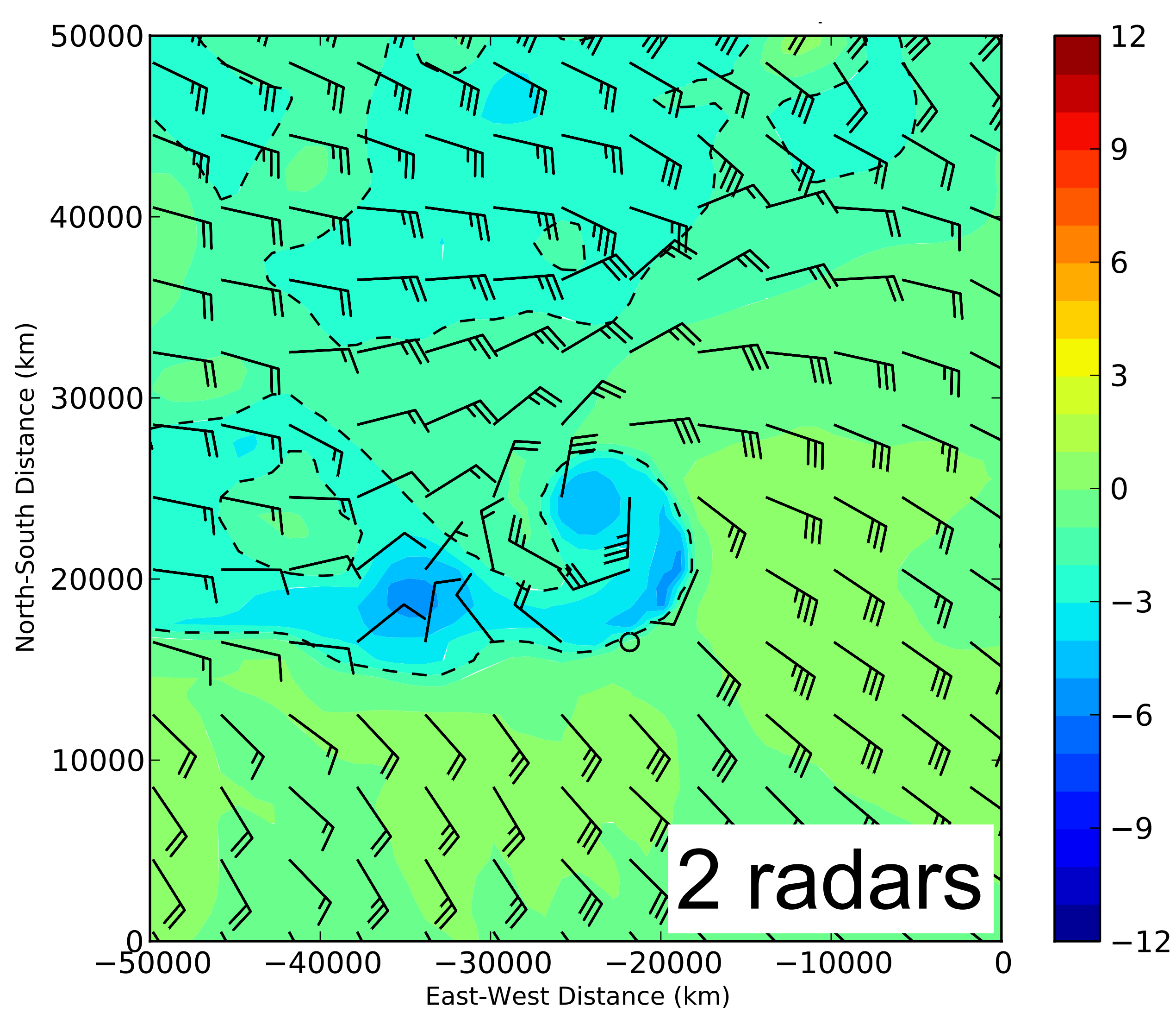

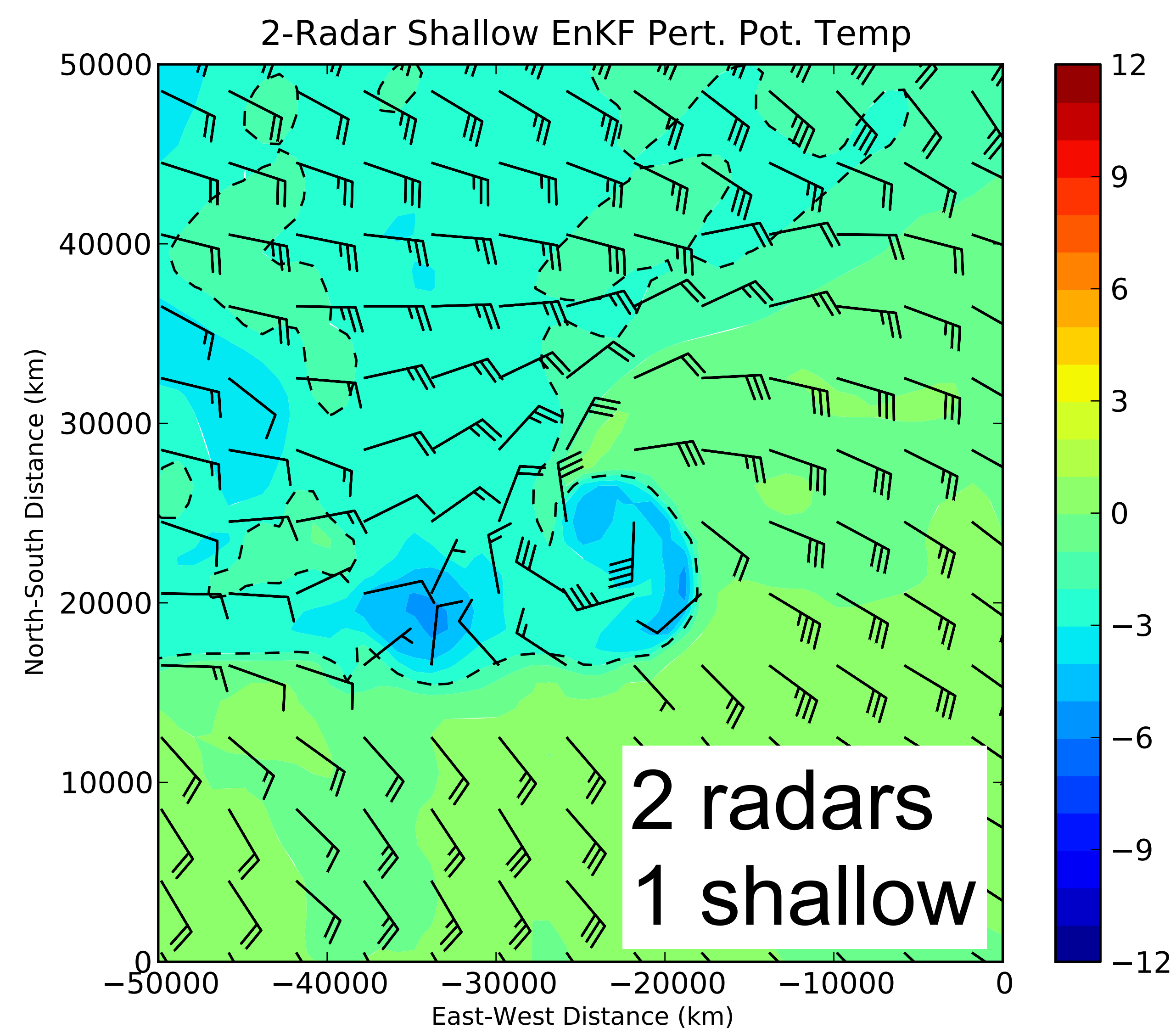

Preliminary Conclusions

- Much to be learned from this data set - many more data sets of this quality needed to examine problem (VORTEX2-2010?)
- Analyses from a single radar - is it good enough?
- Multiple radar analysis clearly closer to dual-Doppler
- Can have radars scanning in different ways (deep versus shallow) [fast versus slow?]
- Sequentially using multiple radars works (not shown).
- EnKF using Mansel ZVD microphysics appears to generate most physically realistic solution wrt reflectivity errors and surface temperatures (not shown).
- In situ thermodynamic data is critically needed to resolve analysis differences between various microphysical schemes

Future Work

- Compare DD, EnKF, and 3DVAR kinematic analyses and quantify uncertainties in all three analyses
- More detailed studies of the thermodynamic differences between experiments.
- Use the ensemble as background for other platforms analyses?
- Downscaling the ensemble analyses and using EnKF to re-analyze the surface, DoW, K-band radar as an offline DA procedure