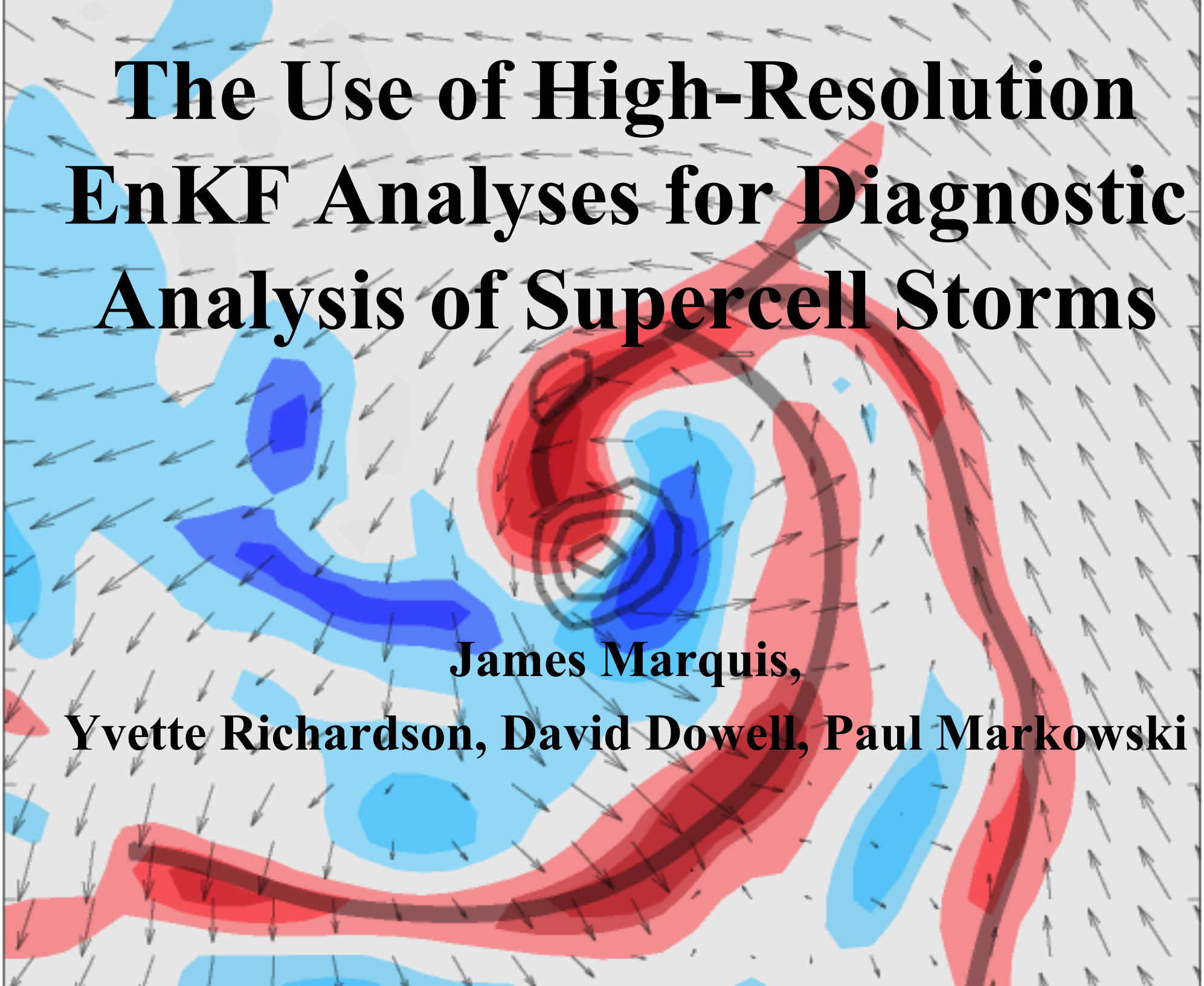
The Use of High-Resolution EnKF Analyses for Diagnostic Analysis of Supercell Storms



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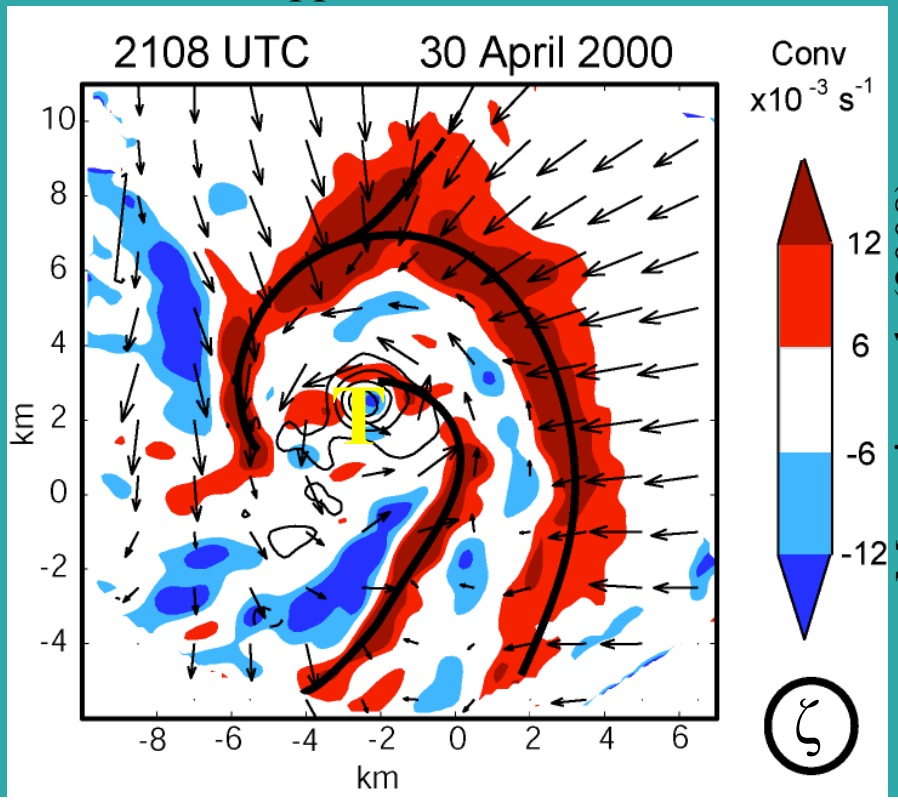
Introduction

- Prior research uses Doppler on wheels (DOW) data to analyze tornadic supercell storms.
  - interested in: gust fronts, trajectory analysis, $d\zeta/dt$, 3D vorticity fields, temperature fields (if available), etc.

Dual-Doppler $z = 300\ m$



Marquis et al. (2008)

Introduction

- DOW dual-Doppler synthesis limitations:
  - Small spatial & temporal coverage;
  - often only single-Doppler data available (usually with better spatial/temporal coverage)
- Assimilate DOW velocities into WRF using EnKF to increase spatial and temporal coverage of data
  - Can sequence of posterior analyses accurately capture the evolution of the storm?

EnKF implementation

- Model: WRF-ARW,
  - $\Delta x,y = 500$ m, $125\text{m} < \Delta z < 2\text{km}$, $\Delta t = 1$ s,
  - grid dim ~200 x 200 x 40 (top = 20 km),
  - LFO microphysics (*Gilmore et al. 2004*),
  - open lateral boundary conditions,
  - no surface fluxes, no radiation.

  – Homogeneous environment: Proximity sounding (when available), RUC

EnKF implementation

- DA:
  - DART with EAKF option,
  - 50 members,
  - Gaspari-Cohn localization (6 km),
  - ensemble:
    - random warm bubbles
    - random noise added to hodographs,
  - Perturbations added to θ, q_v, u, v every 5 min

(Dowell and Wicker 2009)

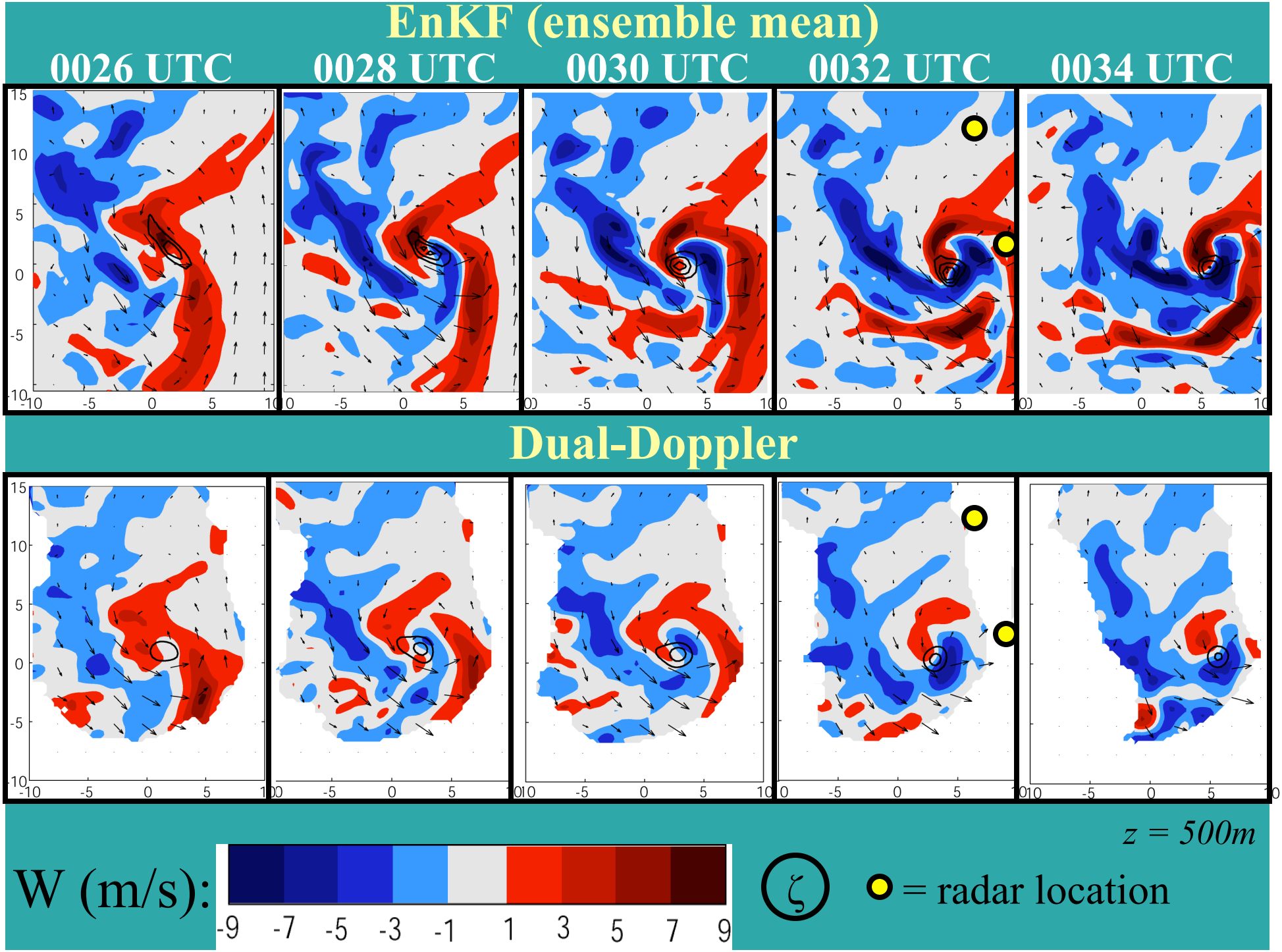
EnKF implementation

- Data assimilated:

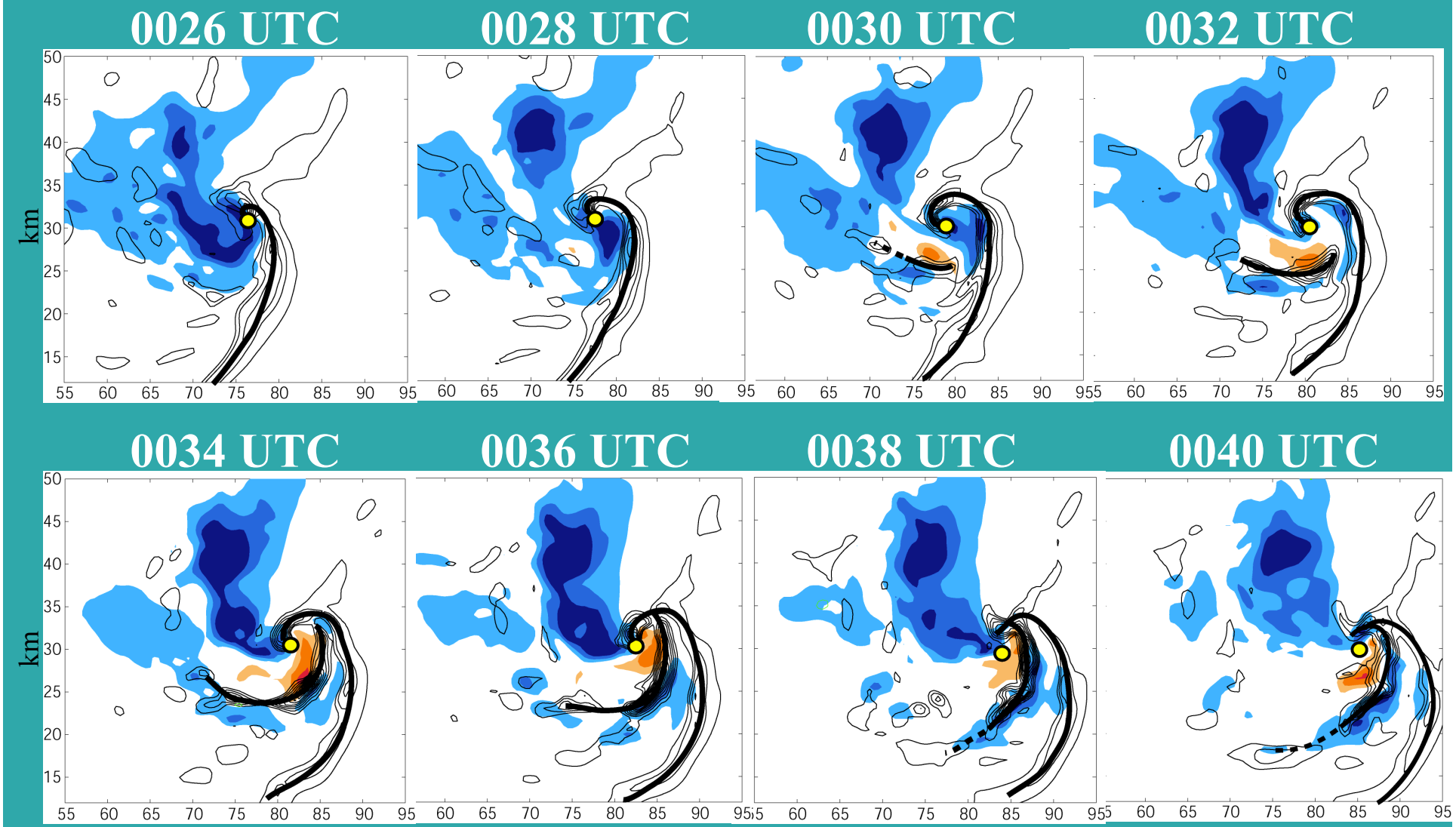
  - single-Doppler radial velocities every 2 min,

  - objectively analyzed to 1 km grid,

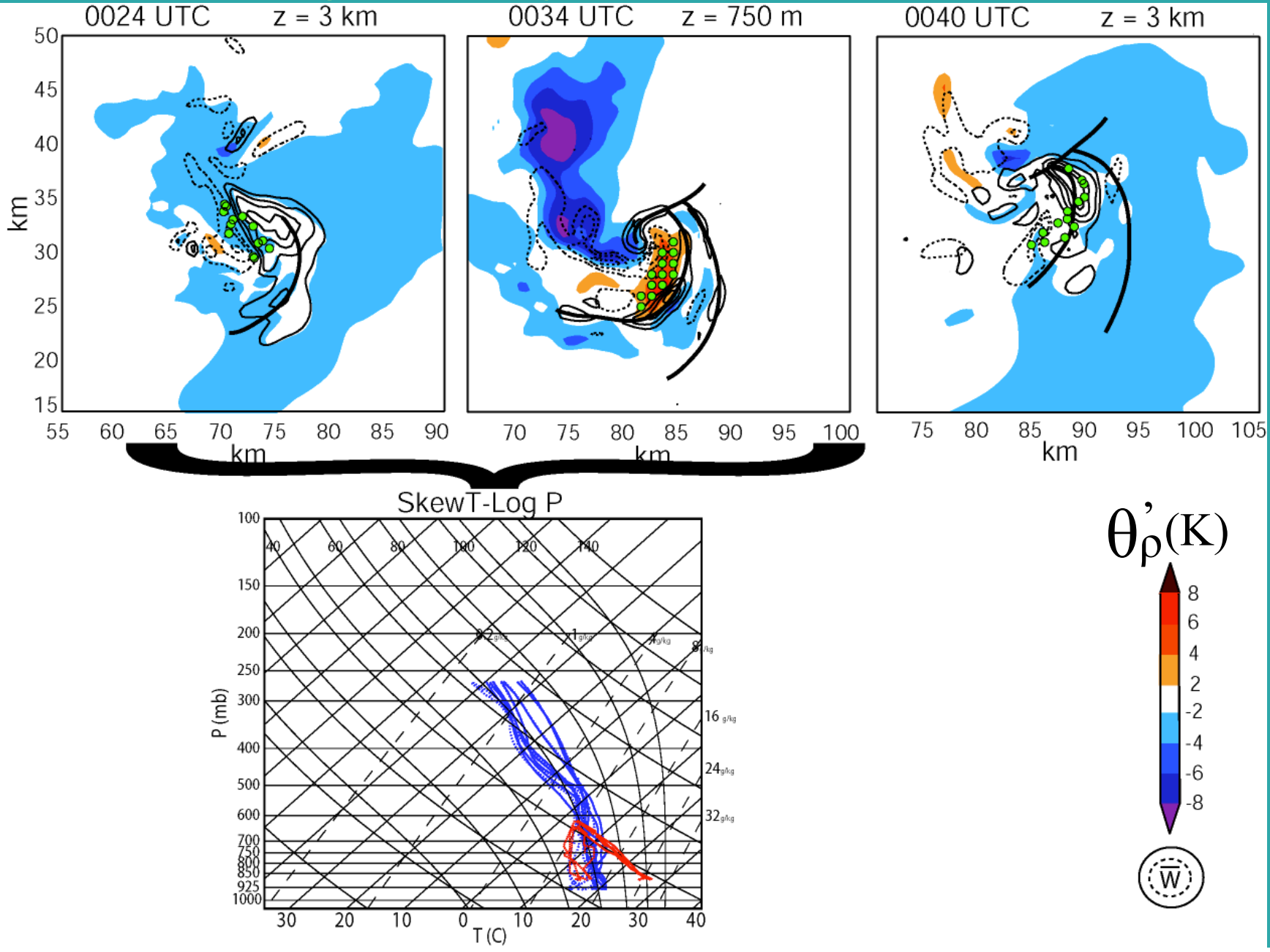
  - only one radar assimilated at a time,


EnKF (ensemble mean)
0026 UTC
0028 UTC
0030 UTC
0032 UTC
0034 UTC
Dual-Doppler
z = 500m
W (m/s):
-9 -7 -5 -3 -1 1 3 5 7 9
ζ
= radar location

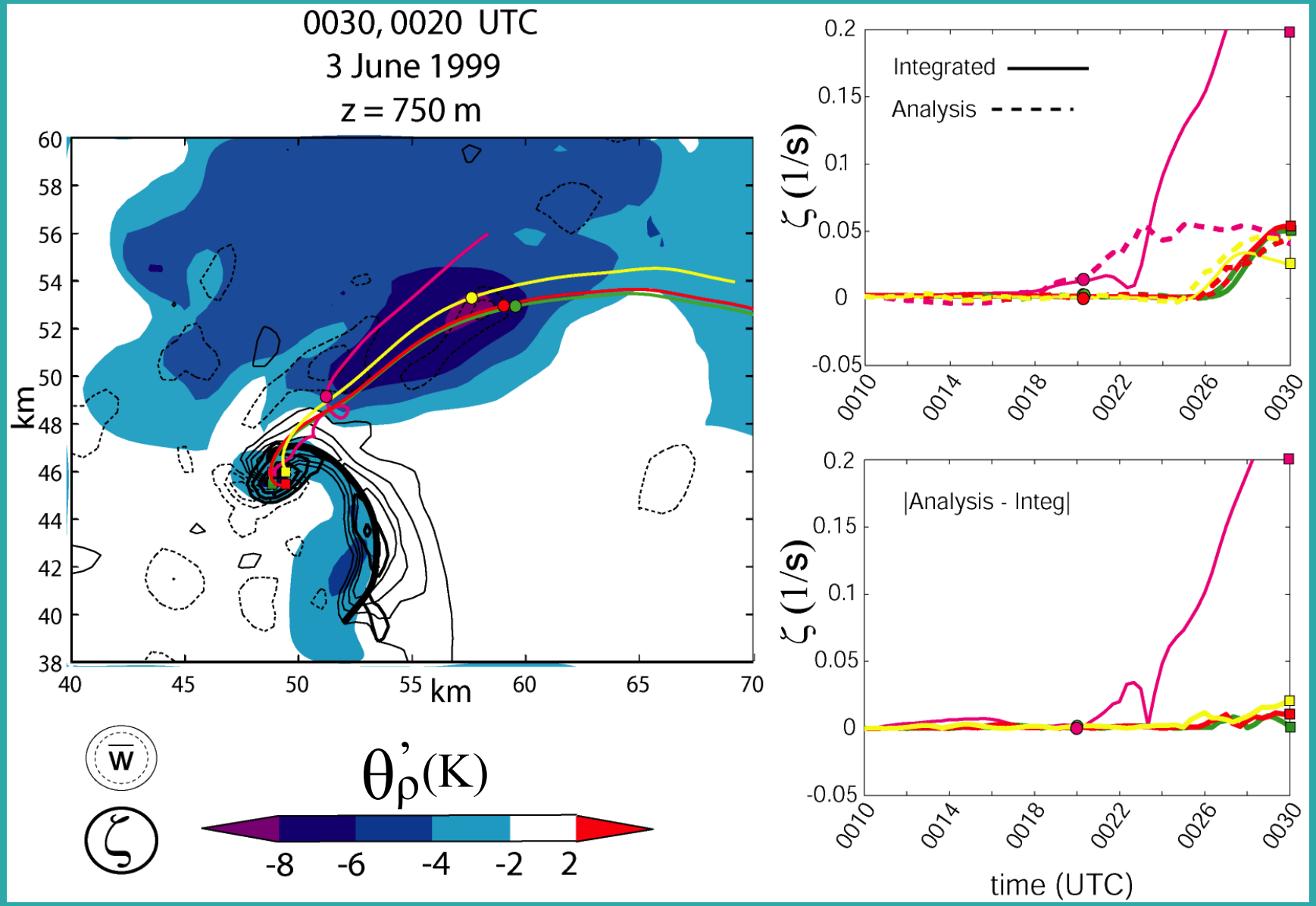
Thermodynamics (ens. mean)



Trajectory example 1



Trajectory example 2



Retrieved pressure

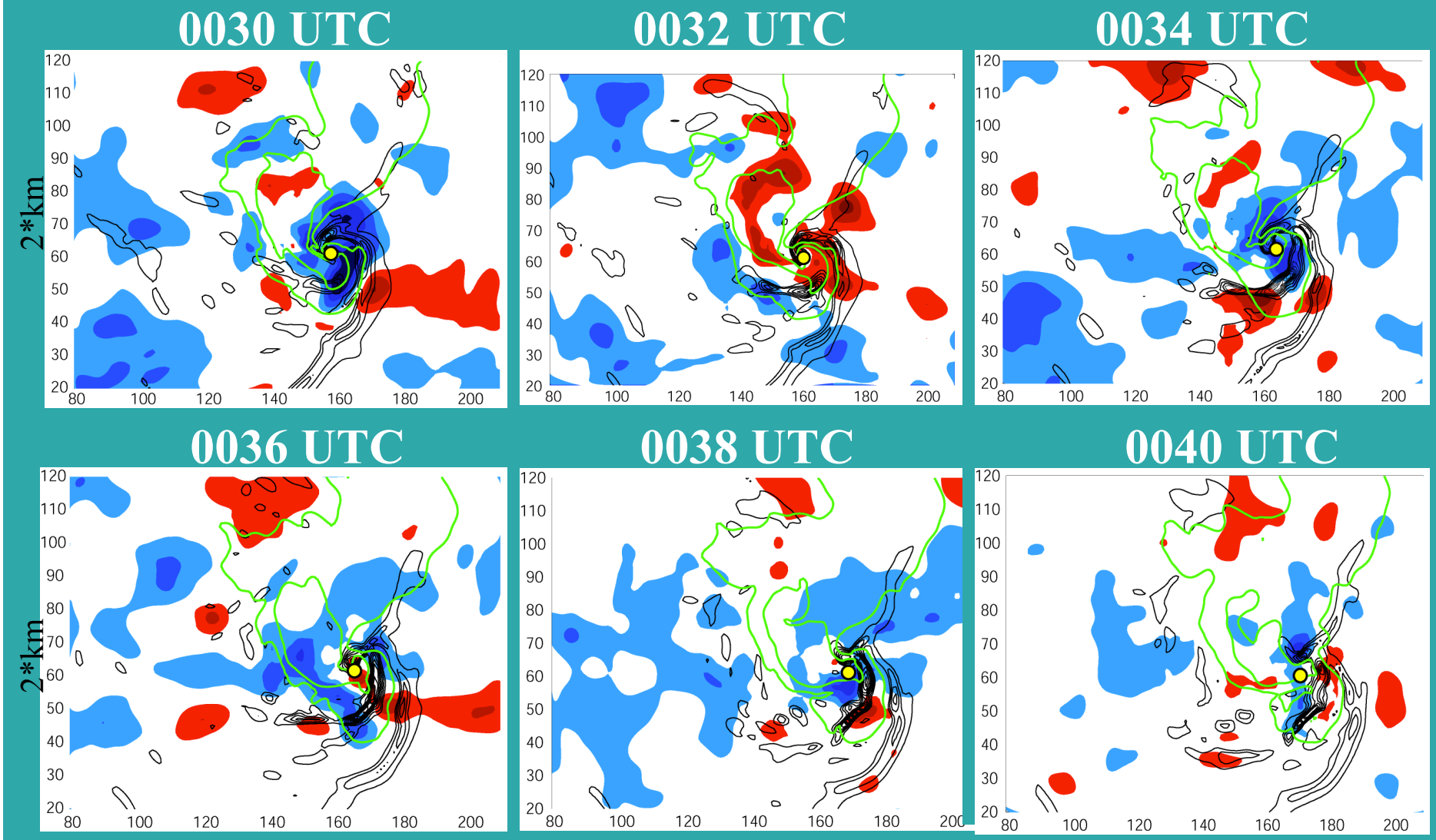
- Want pressure for:

$$\frac{dw}{dt} = -\frac{1}{\rho}\underbrace{\left(\frac{\partial p'_b}{\partial z} + \frac{\partial p'_d}{\partial z}\right)}_{\text{Relevant to supercells}} + B + \ldots$$

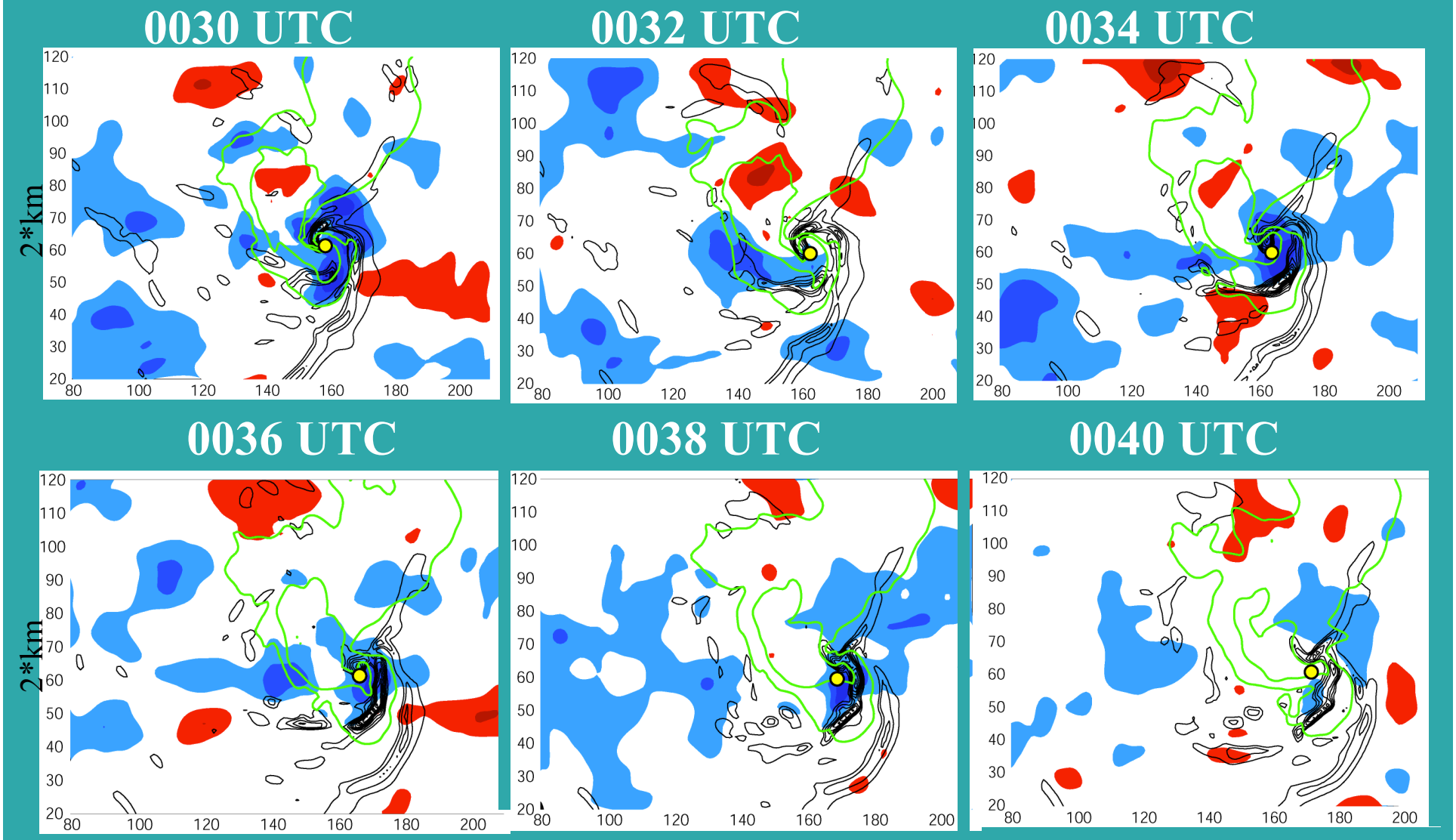
WRF diagnostic pressure:

$$p = p_o\left(\frac{R_d\theta_m}{p_o\alpha_d}\right)^{\gamma}$$

Retrieved pressure (posterior)



Retrieved pressure (prior)



Pressure questions

- Pressure 'shocked' during update of u,v,w, θ, q_v, etc.
  - Then recovering during model integration?
  - Why do other model fields appear realistic after model advance?

- Diagnostic pressure calculation affected by product of independently updated model variables?

$$p = p_o \left(\frac{R_d \theta_m}{p_o \alpha_d} \right)^{\gamma}$$

$f(\theta, q_v)$

$f(\Phi,\mu)$

Conclusions

- EnKF and dual-Doppler kinematic fields are similar
- Trajectories for parcel positions seem reasonable
  -integrating forcings along paths a bit sketchy?
- Pressure fields: ?????

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  - DART code writers,
  - CISL facilities & support staff,
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  - DOW crew
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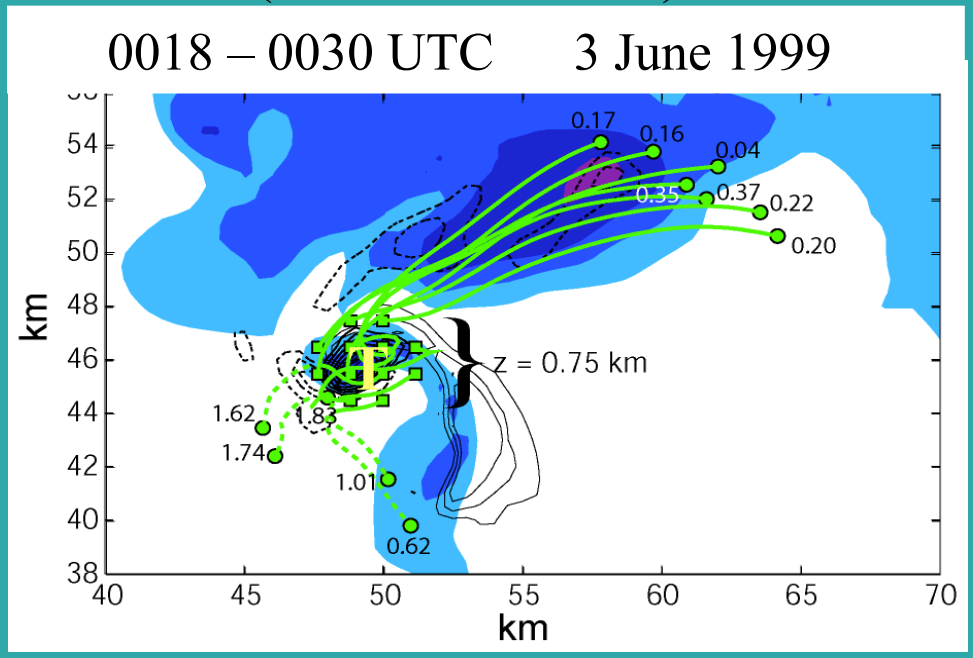
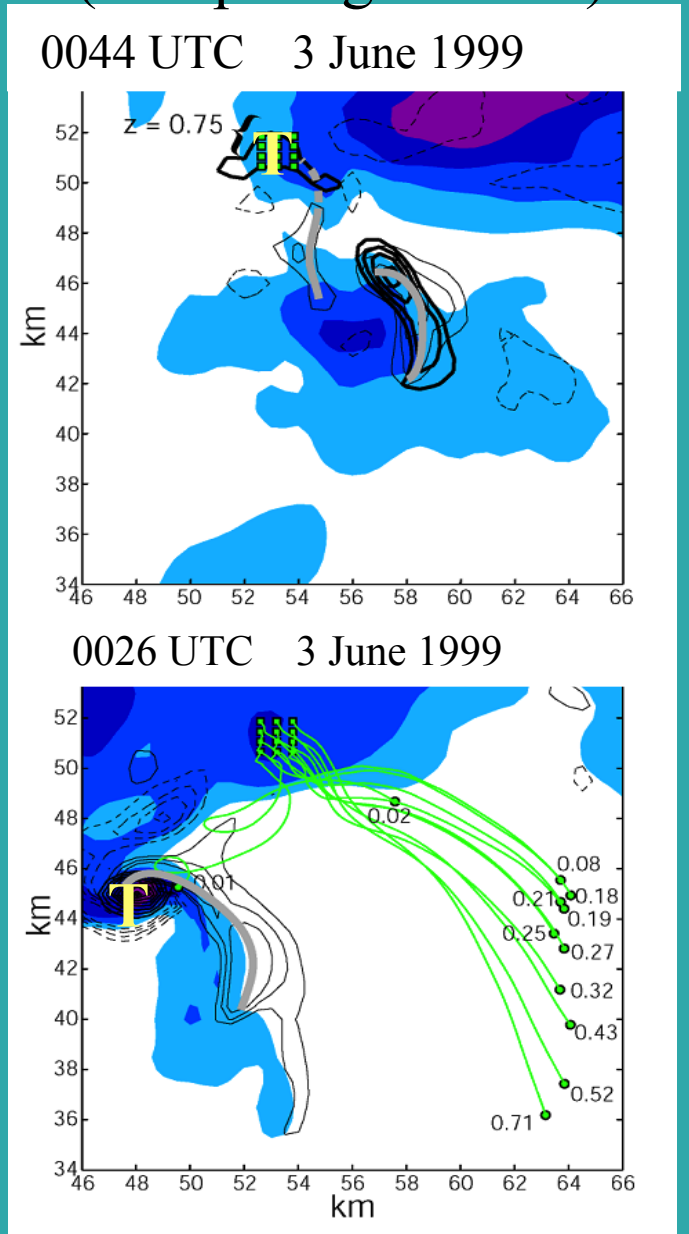
Trajectory example 2

(mature tornado)



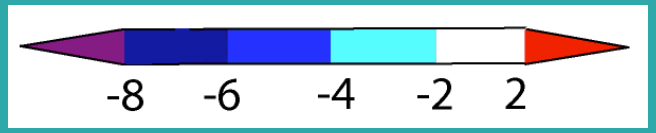
(storm-relative)

(dissipating tornado)



(ground-relative)

θ_ρ'(K)



z = 750 m