

# Impacts of missing initial condition scales on supercell forecasts: Implications for convective-scale data assimilation

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# Motivation: Warn-on-Forecast

- Paradigm shift in short-term forecasting of convective hazards: **NWP plays major role**
  - tornadoes, heavy rain, damaging wind/hail, etc.
- Convection-allowing ensemble DA & forecasts
  - Probabilistic guidance
  - EnKF or VAR-EnKF hybrid
- Conventional + radar + satellite data

# Ensemble IC resolution limits

- Real-time ensemble DA on  $< 3$ -km grids is currently impractical for many centers
- Longer-term problem: atmospheric state is generally unobserved at scales  $< 1$  km
- Can initially unknown scales be accurately recovered during cycled DA or free forecasts?

# Explore with supercell simulations

- Idealized case (ELRENO): thermal bubble, homogeneous, no radiation/surface physics
- Full-physics cases (6 May 2015, 19 May 2013): 3-km EnKF member downscaled to ~300-m



Isolated supercell

Isolated supercell

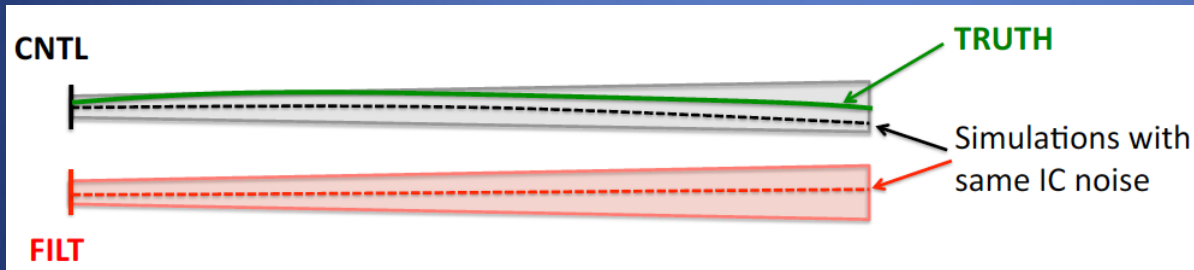
Discrete supercells → MCS

# Basic Approach

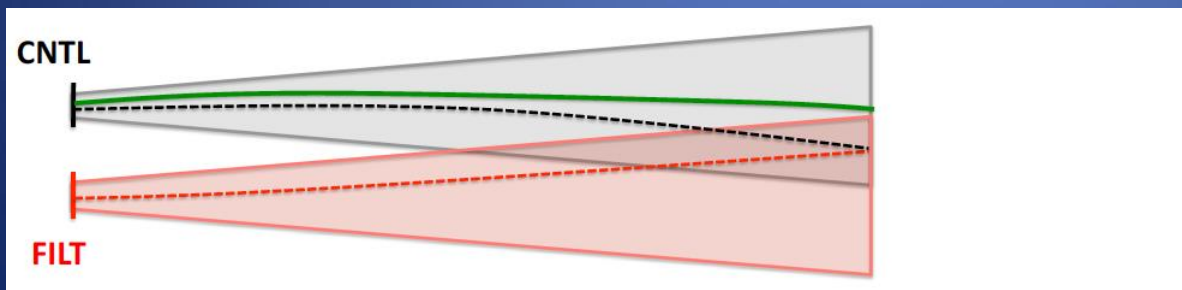
- Take TRUTH simulation at time of mature supercell and generate coarsened IC's
- Compare simulations initialized from filtered IC's to TRUTH
- **Cutoff wavelength** = 2, 4, 8, or 16 km
- For TRUTH and each cutoff, generate **ensemble** of 9 sims, each with different white noise realization

# Why an ensemble framework?

- If storm evolution is very sensitive to IC, then IC resolution impact could vary wildly between two nearly identical storms (or moment to moment in the same storm), making it impossible to use a single pair of sims to *generalize* the effect of IC resolution error

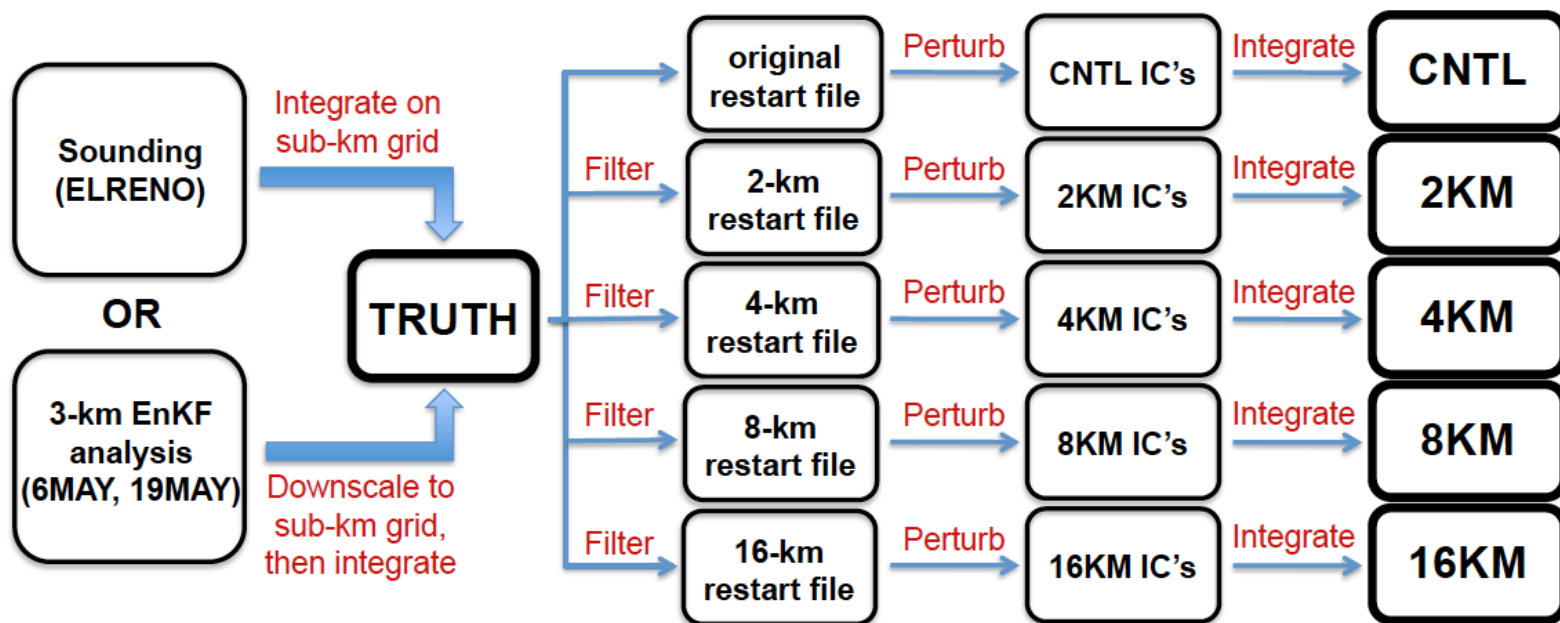


IC resolution error  $\gg$  IC perturbation error  $\rightarrow$  deterministic framework is sufficient



IC resolution error  $\approx$  IC perturbation error  $\rightarrow$  need ensemble framework!

# Schematic of methodology



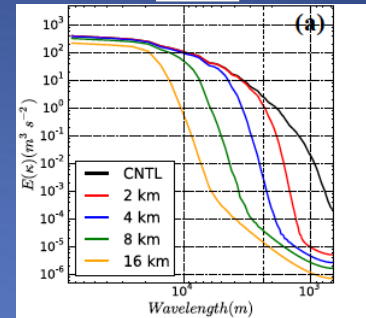
# Energy spectra (ELRENO $w$ )

- Energy spectra rapidly recover during first 10 min of integration
  - similar results for other cases & variables
- *Error* energy spectra suggest IC resolution is “forgotten” after 1 hour in ELRENO

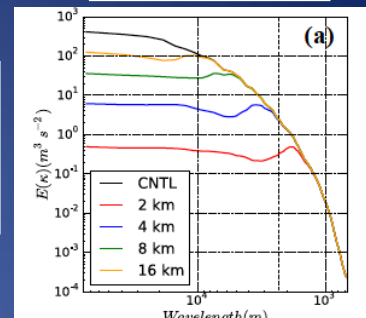
$w$

$w$  error

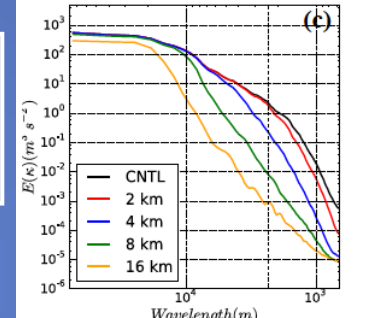
0 min



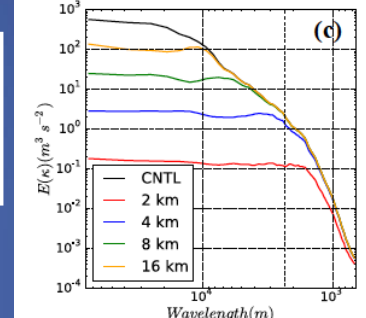
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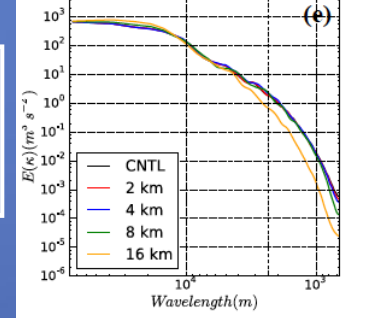
1 min



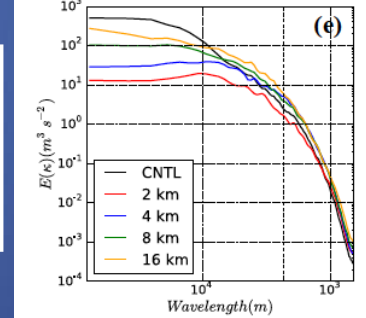
1 min



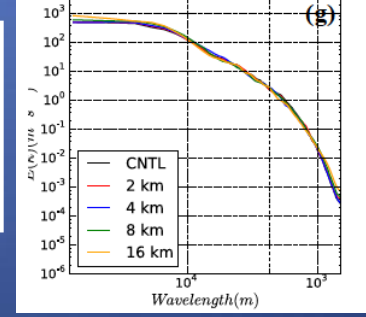
5 min



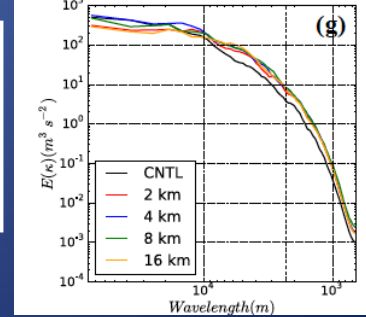
10 min



10 min



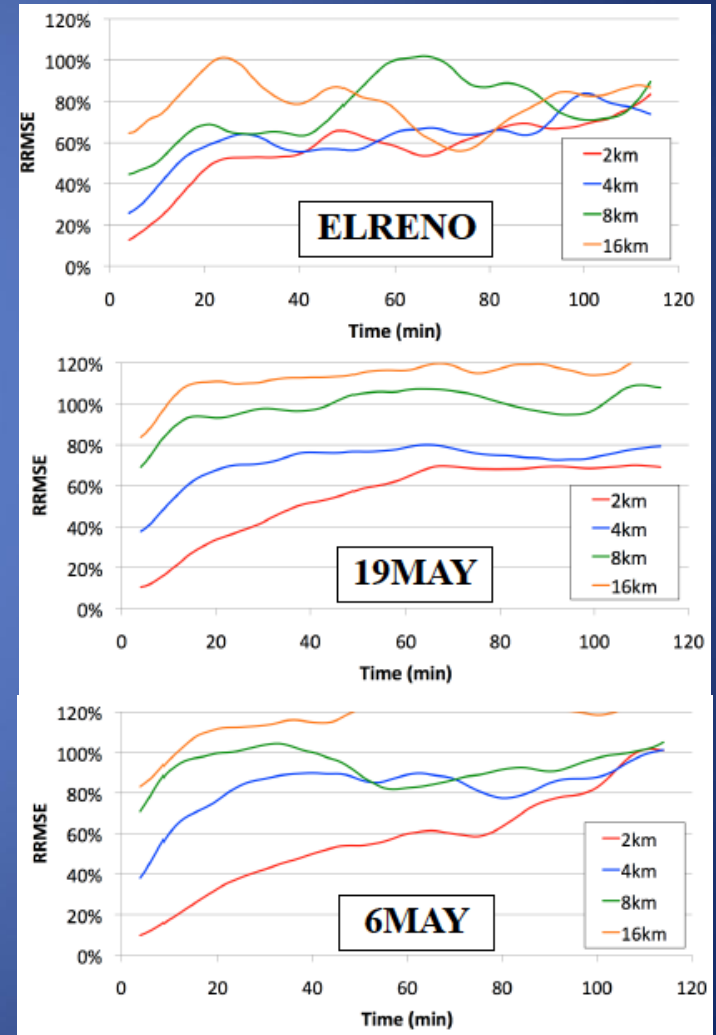
60 min





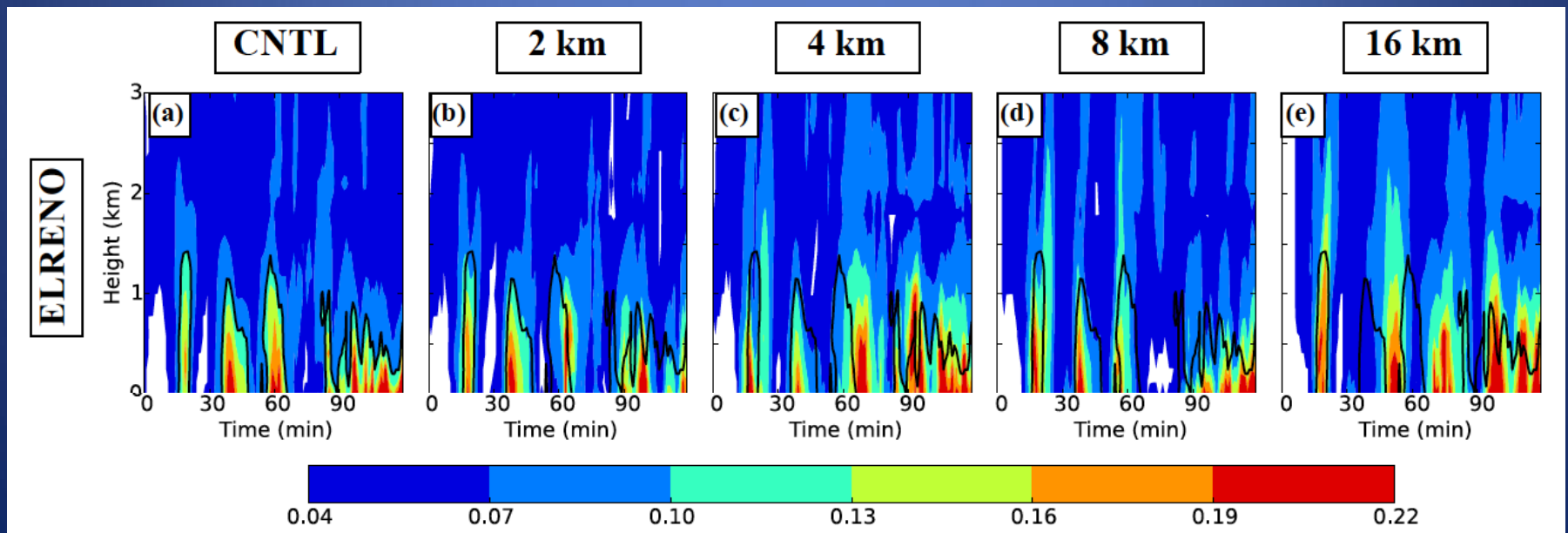
# RRMSE w

- $RRMSE = RMSE/RMS * 100 \%$
- 6MAY, 19MAY errors remain correlated with IC resolution longer than ELRENO
- 100 % RRMSE does NOT mean loss of predictability!
  - Subjective evaluation makes this clear



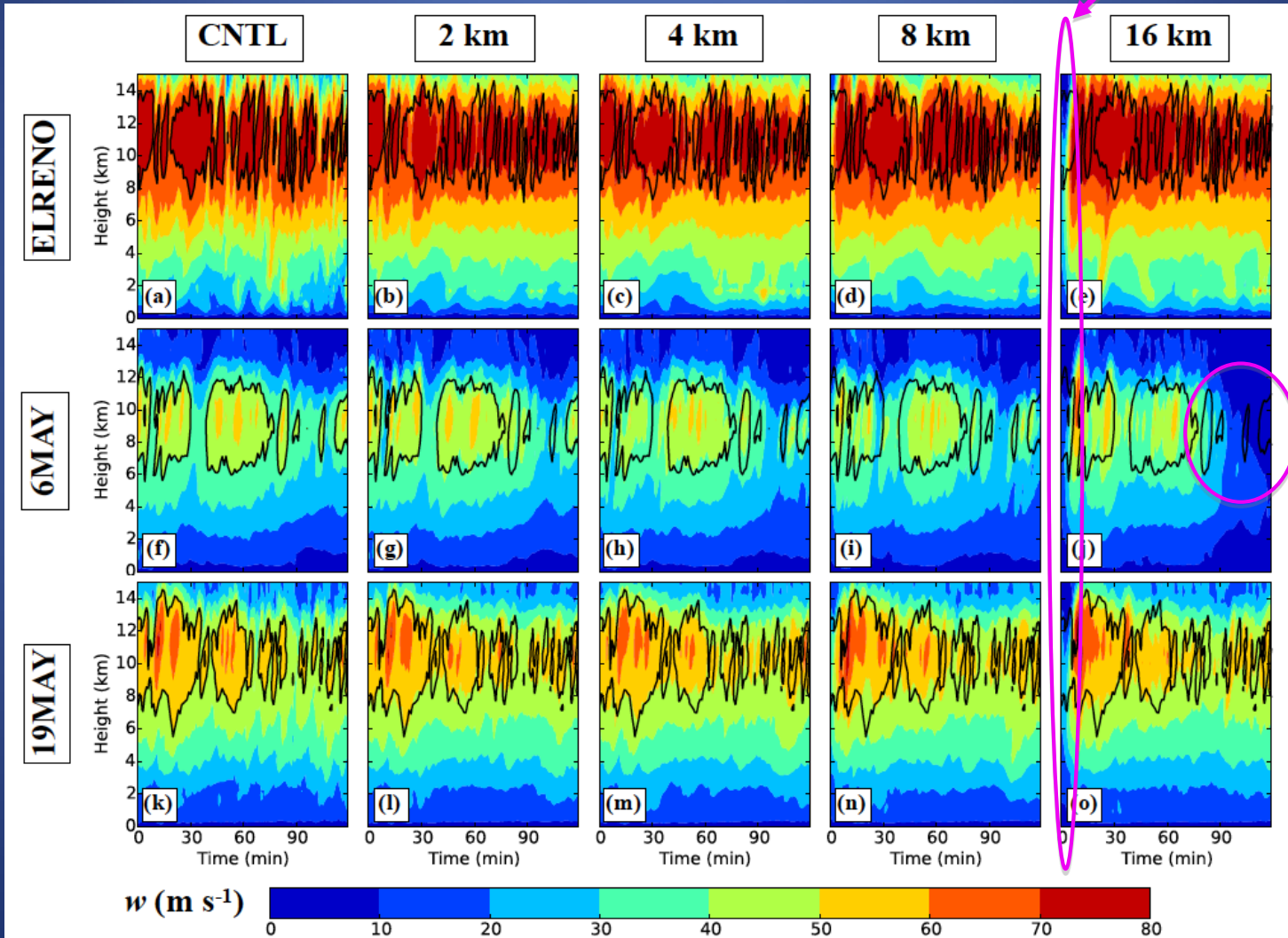
# ELRENO $\zeta_{max}$

- First hour: general degradation as IC resolution decreased
- Second hour: no relationship to IC resolution
- Consistent with energy spectra

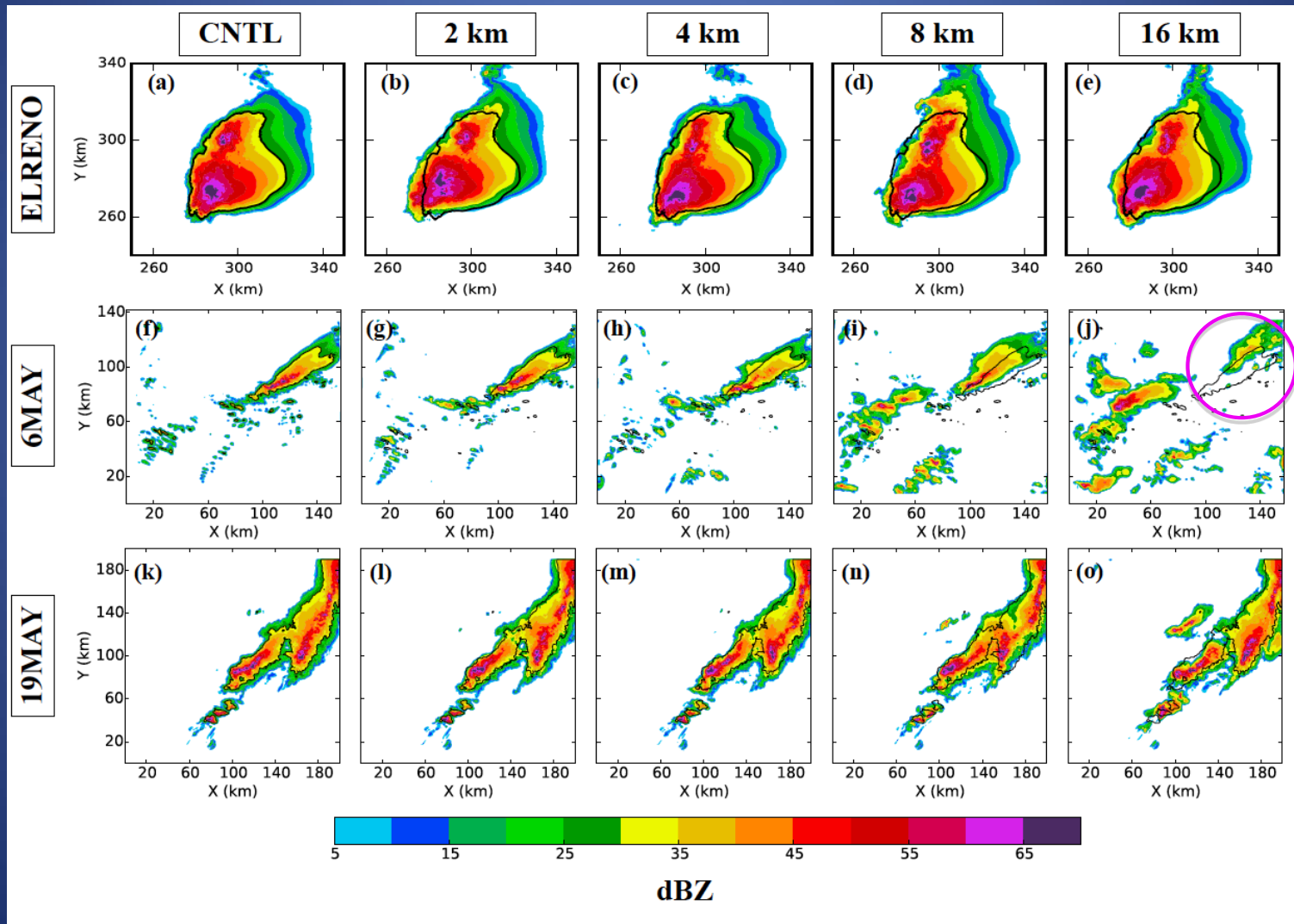


# $w_{max}$ (for all $x, y$ )

“spin-up”

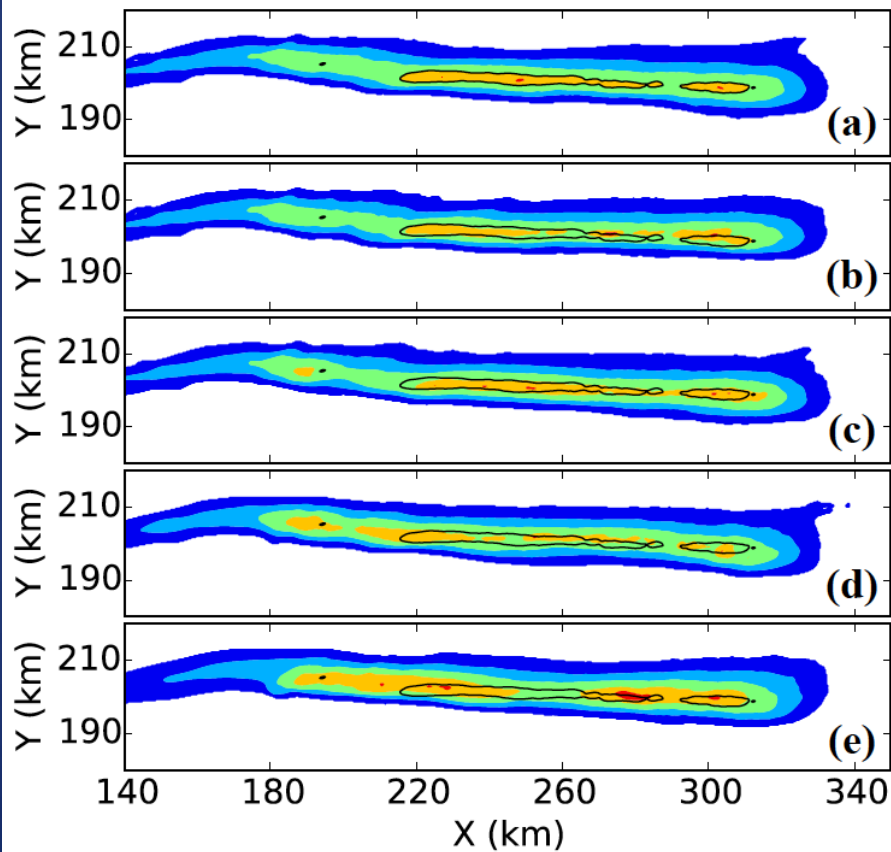


# dBZ ( $z=2$ km) after 2 h

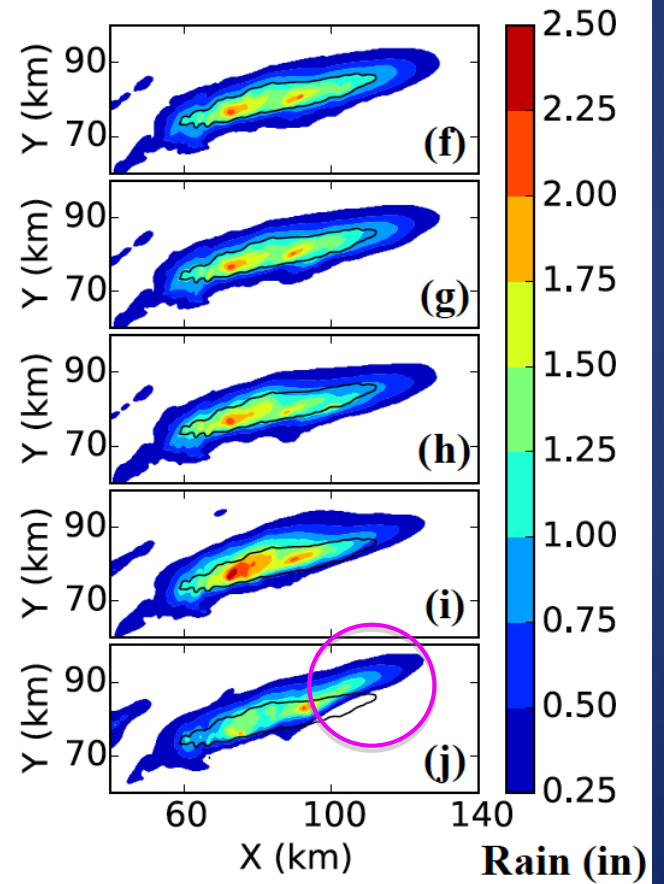


# 2-h rainfall

**ELRENO**



**6MAY**



# Conclusions

- Missing IC scales mostly regenerated by 5 min
- After that, **storm evolution qualitatively insensitive to lack of IC scales < 10 km!**
  - **EXCEPTION: timing of low-level rotation**
- Homogeneous simulations may underestimate impact of IC resolution errors
  - Lack of far-field errors that would otherwise propagate into convective regions and grow rapidly

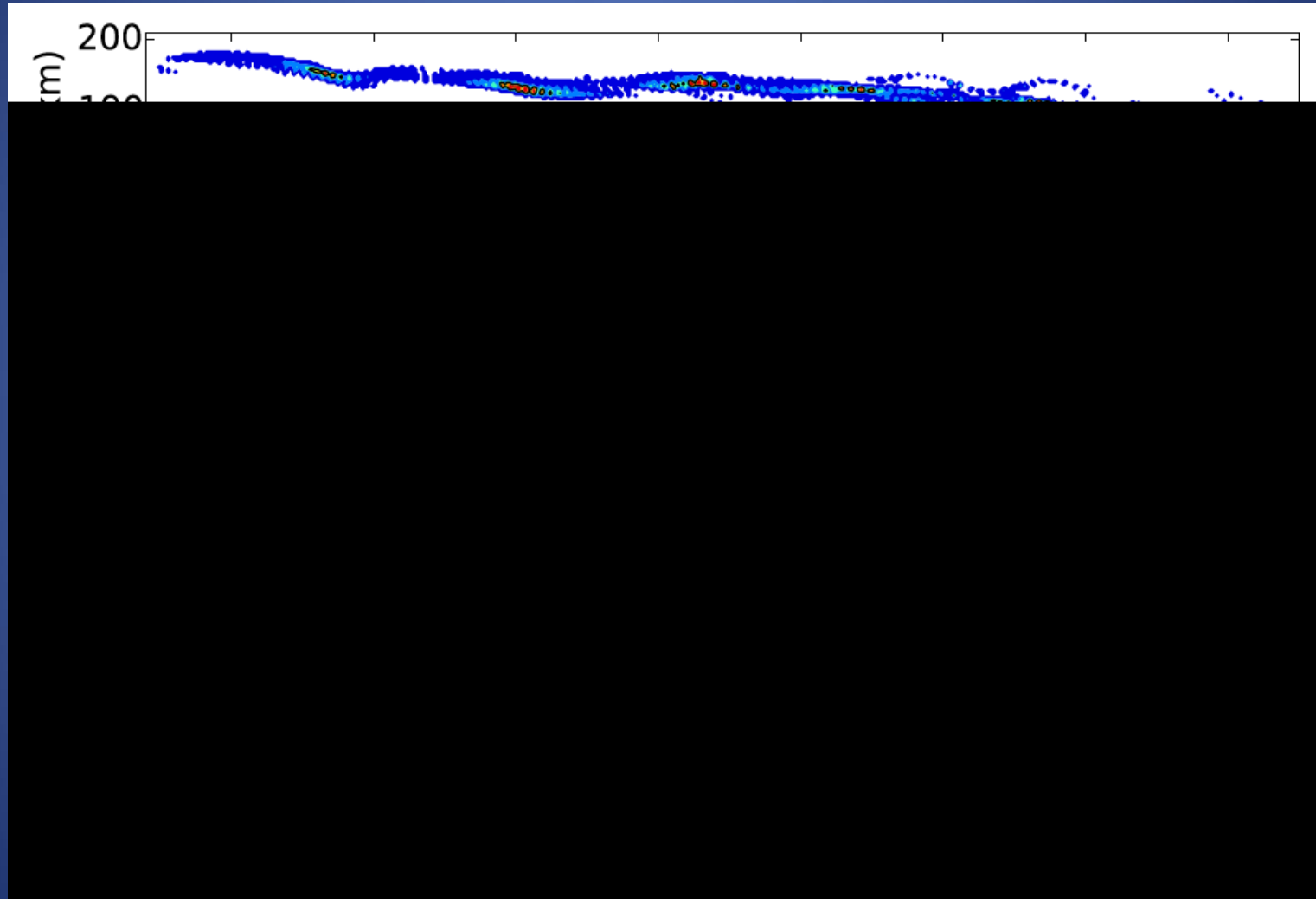
# Implications for storm-scale DA

- Decreasing analysis grid spacing below 3 km won't substantially improve supercell DA
- Those computing resources can be better used (e.g., finer forecast grid, larger ensemble)
- Option 1: Perform coarse (e.g., 3-km) DA, then downscale to finer forecast grid (e.g., 1 km)
- Option 2: Mixed-resolution DA
- Supercell DA will benefit more from new observations of large-scale storm environment than from denser radar observations

# Extra Slides



# ELRENO $\zeta_{max}$ (for all $t, z$ )



# $w_{max}$ (for all $t, z$ )

ELRENO

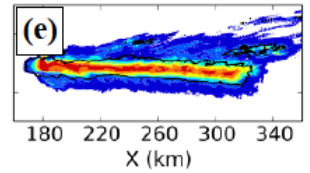
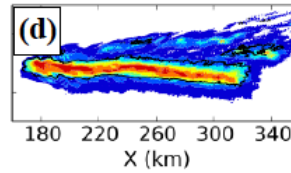
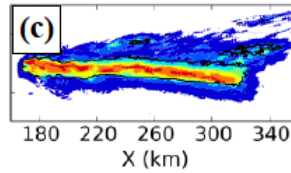
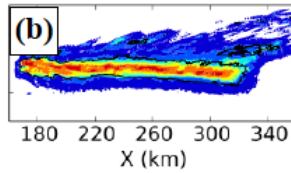
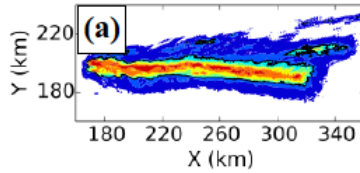
CNTL

2 km

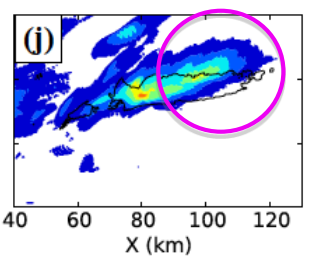
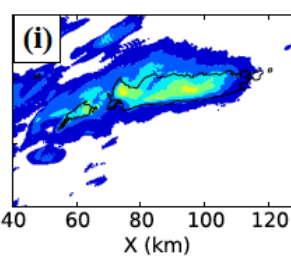
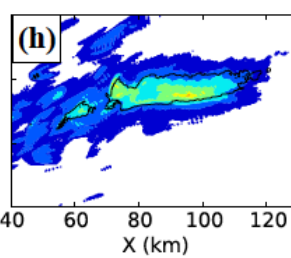
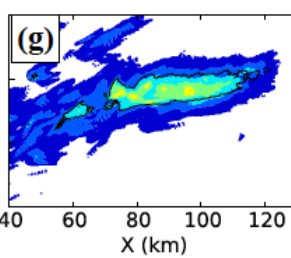
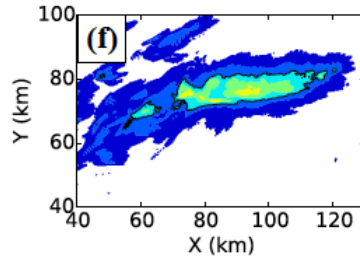
4 km

8 km

16 km



6MAY



19MAY

