# Assimilation of GOES-R GLM Flash Extent Density and Radar Data using GSI EnKF and Hybrid En3DVar: Impacts with MCS and Supercell Storm Cases

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## Review of GLM DA progresses at CAPS (OU):

1. Developed flash extent density data assimilation (FED DA) capabilities within GSI EnKF and tested with an MCS case (Kong et al. 2020a, MWR). Included FED data preprocessor, FED obs operators.
2. Developed FED DA capabilities based on GSI hybrid En3DVar, including adjoint of operator. Compared FED DA using GSI EnKF, 3DVar and hybrid En3DVar for a supercell case (Kong et al. 2020b, MWR, under review). Pure En3DVar performed best, 3DVar worst. FED operator tuned.
3. Developed new FED obs operators based on fitting FED observations and model forecast priors. Results reported briefly at last GLM meeting. Manuscript under preparation. Also tested with different (Thompson and NSSL) microphysics.
4. **Assimilating FED data with and without radar observations (today's talk).**

**Goal:** Examine the impacts of GLM data with and without radar data.

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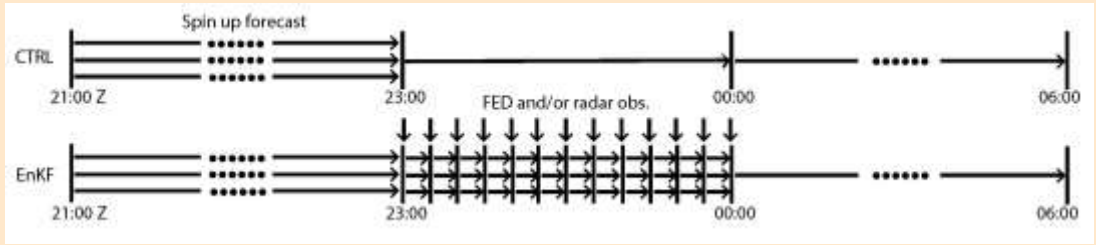
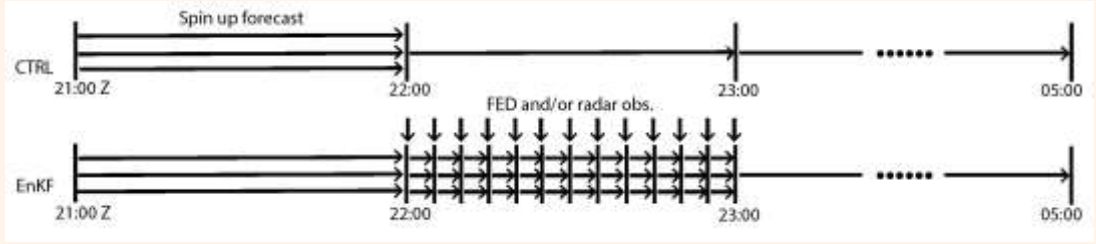
## Storm cases

1. MCS case (Jul 12, 2018, Kong et al. 2020a)




2. Supercell case (May 1, 2018, Kong et al. 2020b)

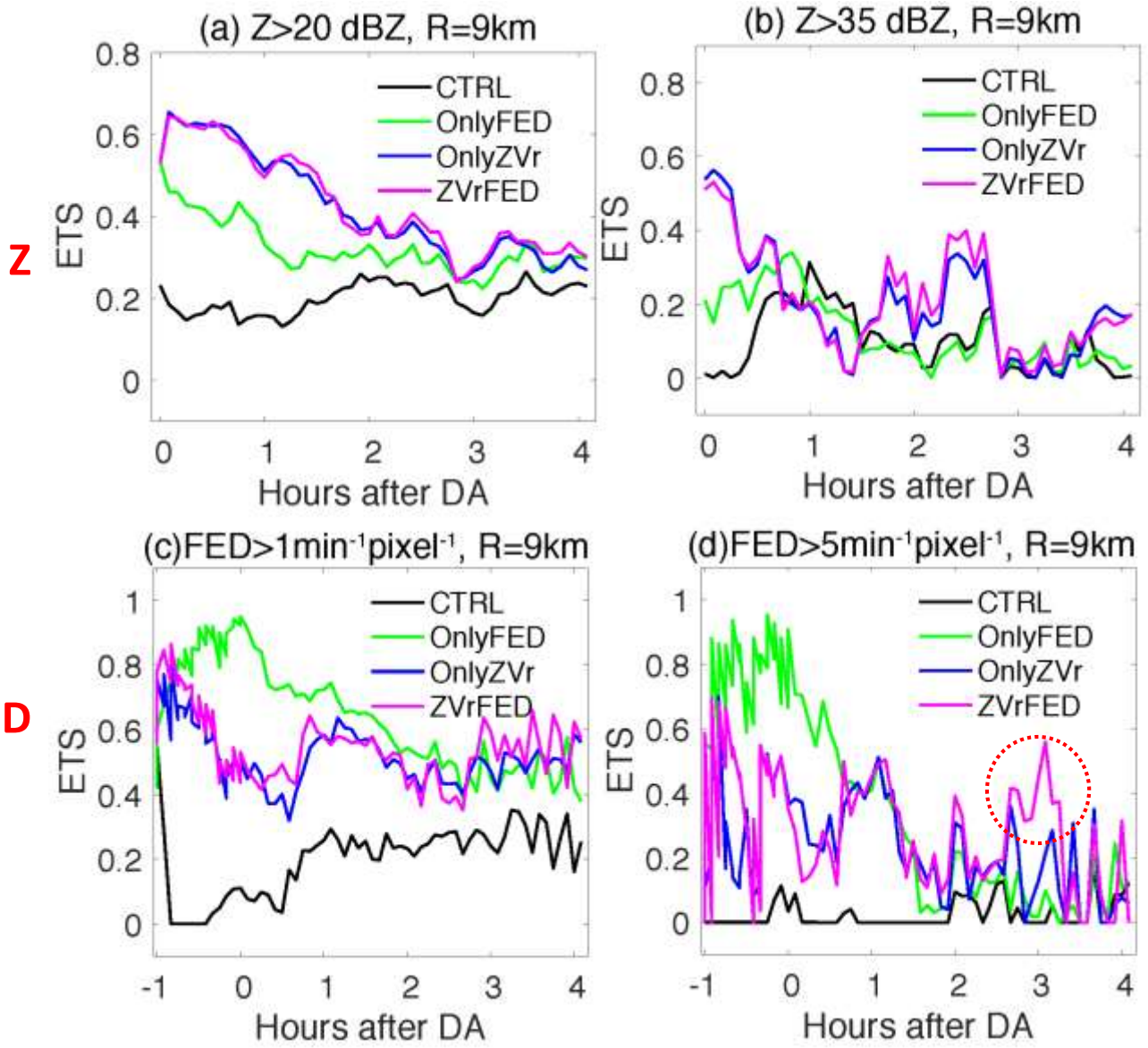



## Experiment setup

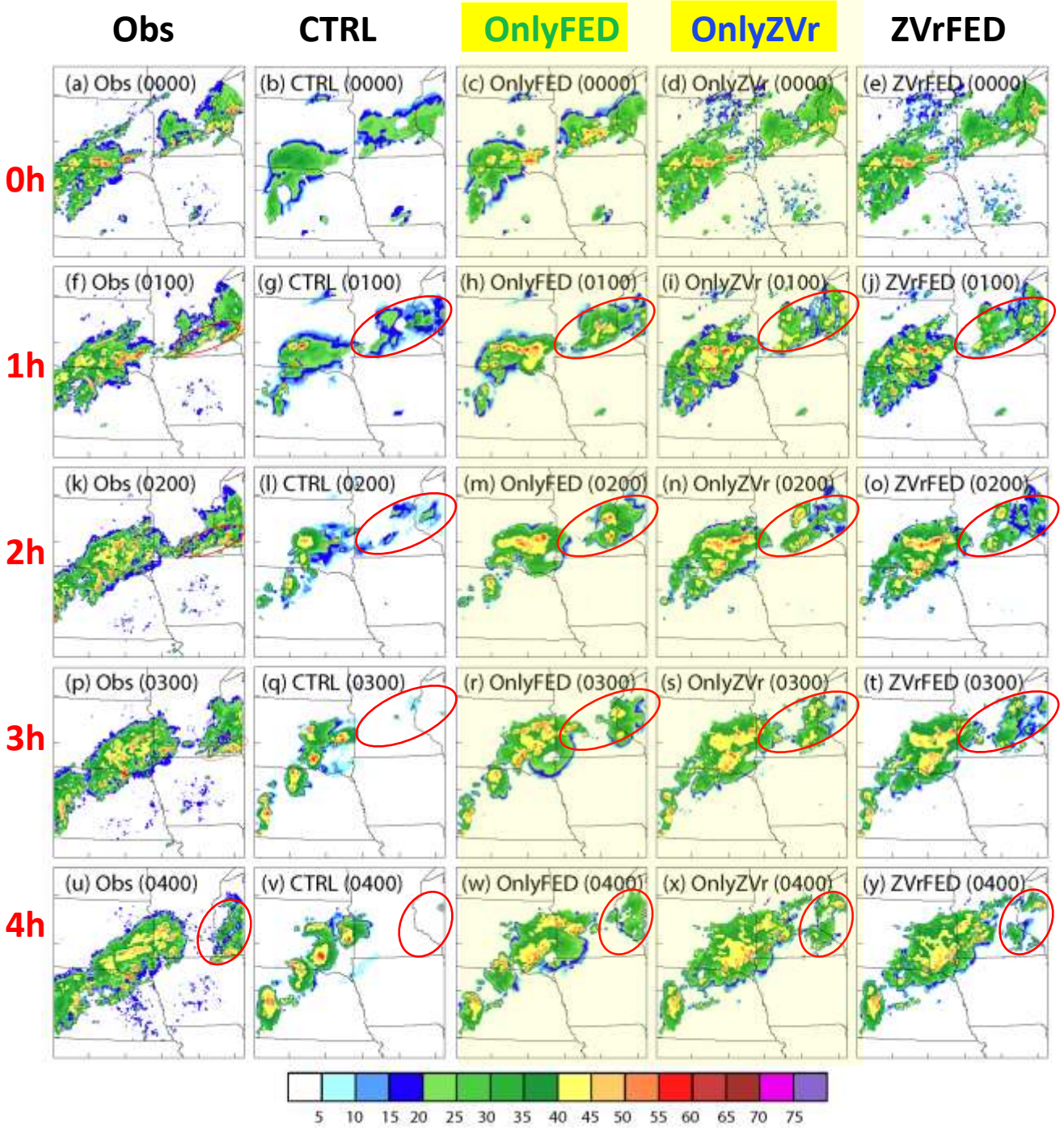
- 2-h (1-h) spinup ensemble forecasts for the MCS (supercell) case from 3 h NCEP NAM forecast + SREF perturbations.
- Assimilate FED and/or radar obs. using EnKF every 5 min for 1 hour. 6-h forecast from ensemble mean analysis.
- WRF model, dx=3 km (1km) for MCS (supercell) case, 53 levels.
- 40 member ensemble, 2 sfc, 3 PBL and Thompson MP.
- Using graupel-mass-based FED operator (Kong et al. 2020a. b).
- For localization purpose, FED assumed at 6.5 km height. 15 km cutoff radius in horizontal, 4 in $-\log(P/P_{ref})$ (~32 km on average, effectively two dimensional).
- Observation error: 0.5 $min^{-1}pixel^{-1}$ (small obs. error is used to increase influence of weak observations)
- Relaxation to 95% of prior spread (RTPS) adaptive covariance inflation

| Experiment name | Descriptions |
|---|---|
| **CTRL** | Does **not** assimilate any data |
| **OnlyFED** | **Only** assimilate FED observation |
| **OnlyZVr** | **Only** assimilate radar (Z+Vr) observation |
| **ZvrFED** | Assimilate **both** radar and FED observations |

# The 0-4 h forecast ETS for the MCS case




- For 0-4h reflectivity forecasts, all DA experiments give obviously higher ETS than CTRL. ETSs from ZvrFED and OnlyZVr are similar and are higher than that of OnlyFED.
- When both radar and FED data are assimilated (ZVrFED), the additional positive impacts of FED are small but still present in terms of the FED forecast after 2.5 h.




# 0-4 h Z forecasts

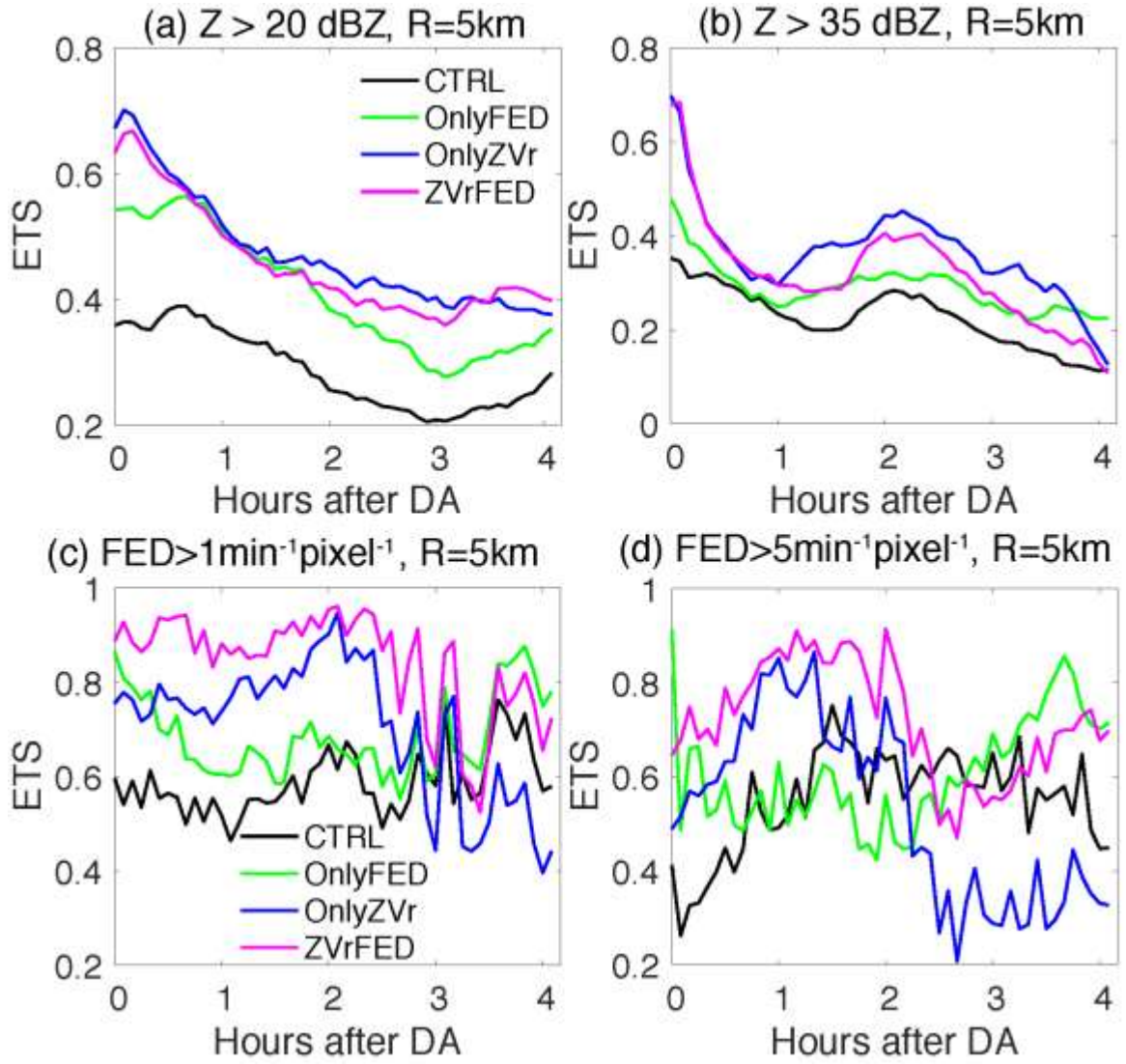
OnlyFED and OnlyZVr produces comparable results;

This is very encouraging considering the much lower data volume and the lower horizontal resolution of FED data compared to radar.

# The 0-4 h ETS for supercell case

Z

FED



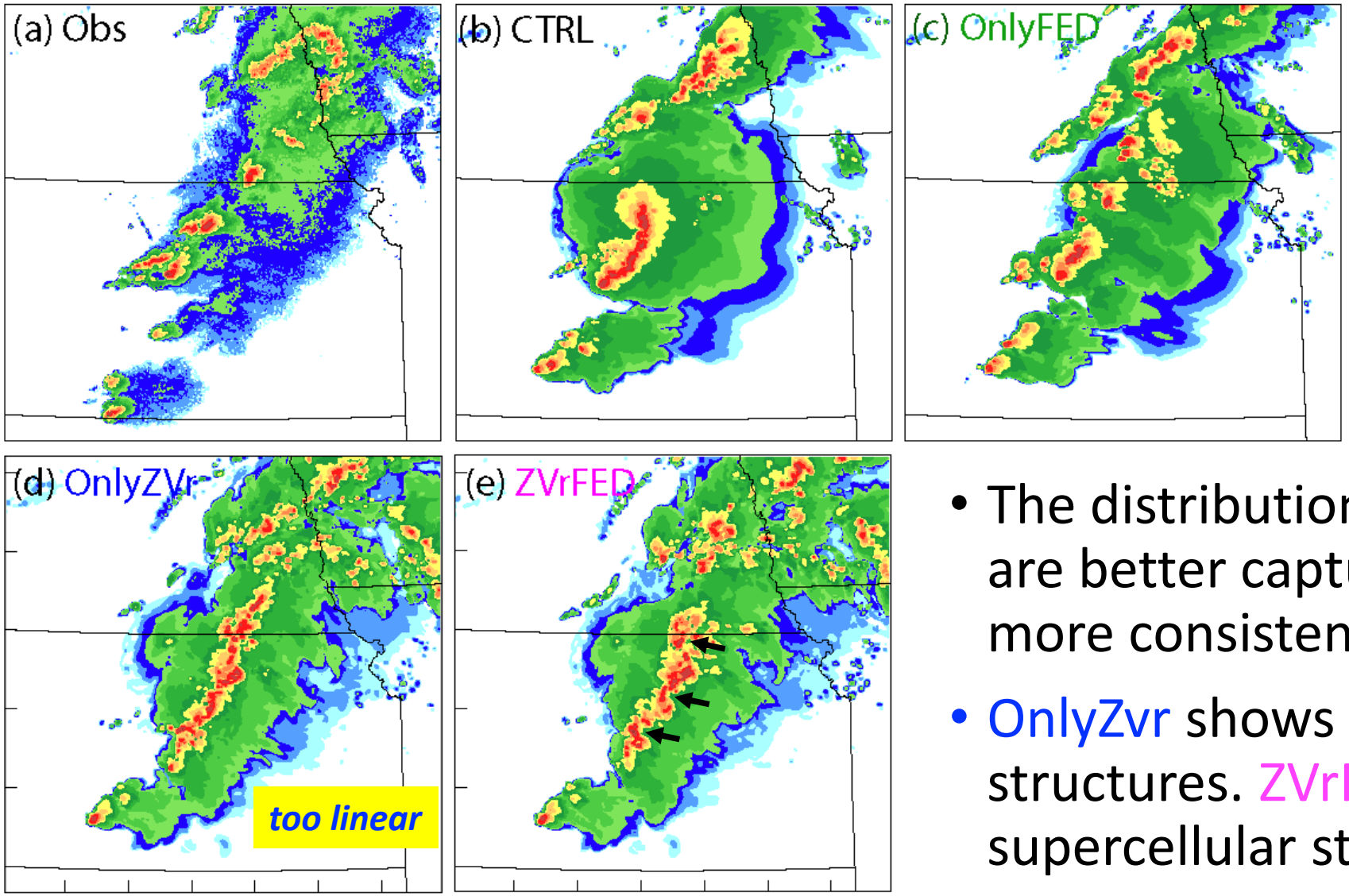

For 0-4h reflectivity forecasts, all DA experiments give obviously higher ETSs than CTRL.

ETSs from ZvrFED and OnlyZVr are similar and are better than OnlyFED.

For 0-4 h FED forecasts, ZVrFED produces higher ETSs than other experiments.

OnlyFED produces ETSs worse than CNTL for high threshold at some hours.

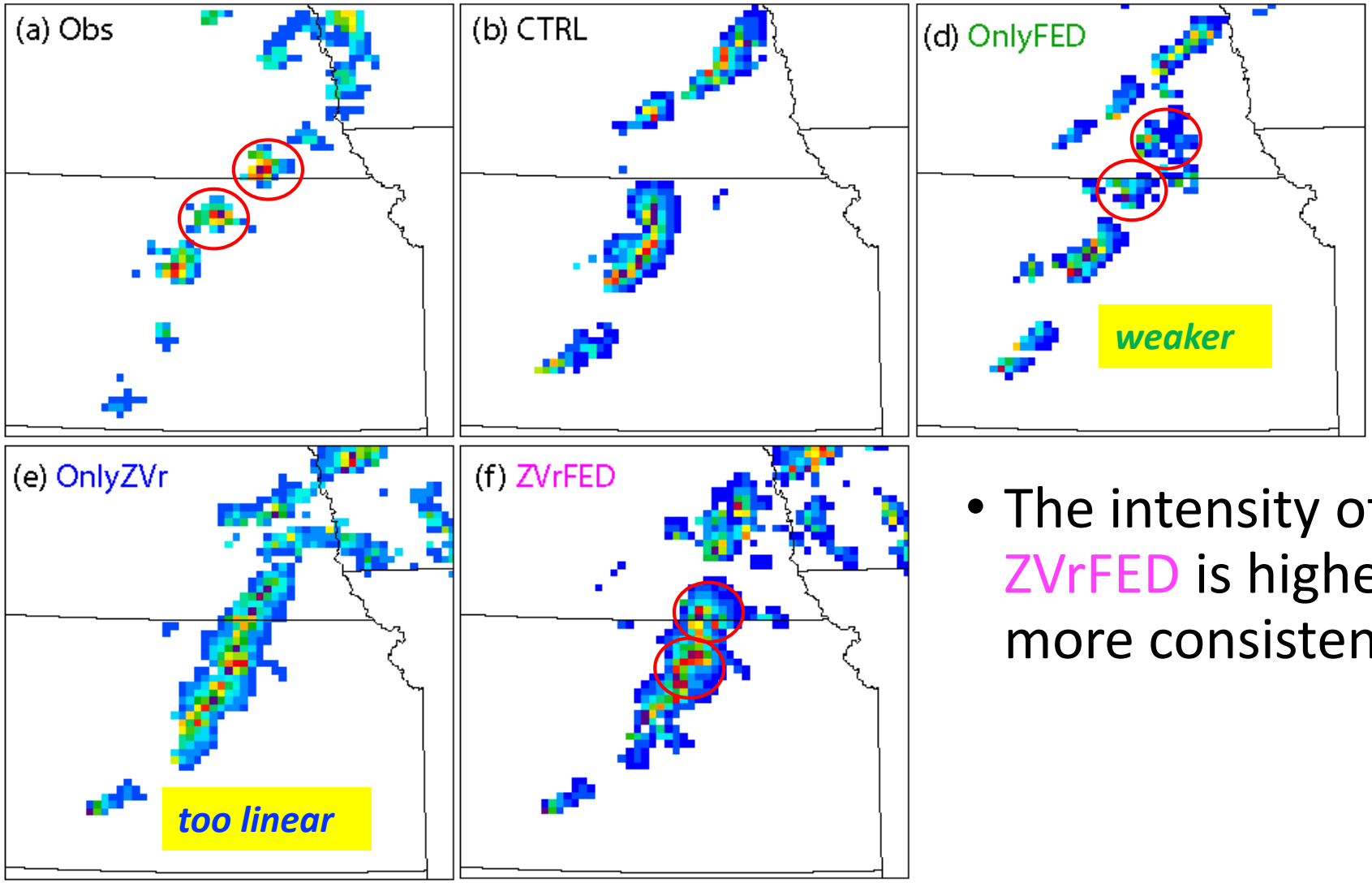
# The 1-h Z forecasts for supercell case




- The storms in CTRL develop a bow-echo structure instead of discrete super-cellular structures.

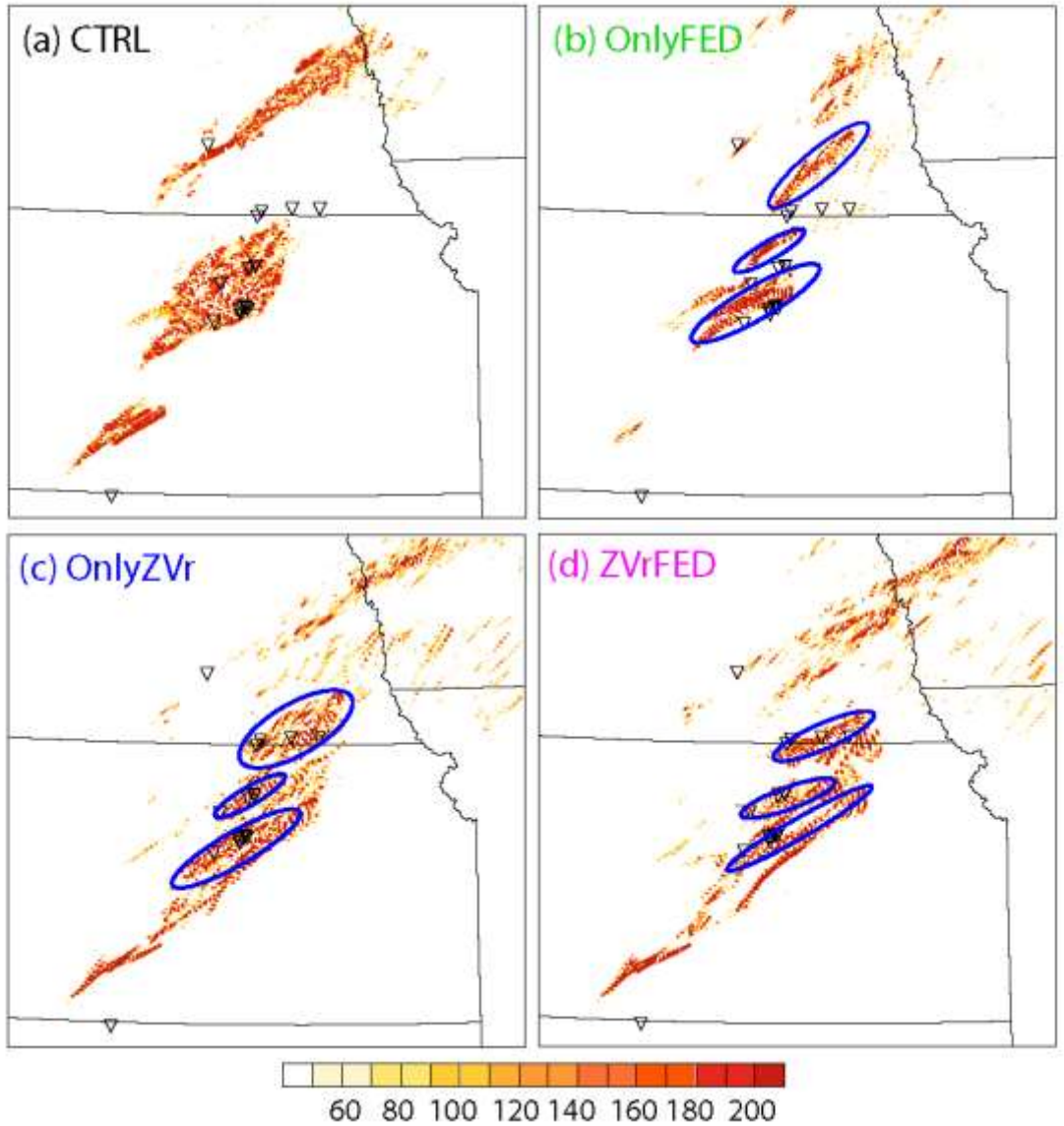
- The distributions of discrete storm cells are better captured in OnlyFED and are more consistent with observations.
- OnlyZvr shows too linear reflectivity structures. ZVrFED shows best supercellular structures.

# The 1-h FED forecasts for supercell case




- The intensity of the FED forecasts from ZVrFED is higher than the others and more consistent with the obs.

# The 0-2 h Forecasts of Updraft Helicity (UH)




- All the DA experiments produce more accurate UH swaths than CTRL.
- The UH swaths from ZVrFED match the tornado reports slightly better than OnlyZVr and both are better than OnlyFED.

# Conclusions

1. Overall, FED DA with GSI EnKF produces generally comparable results as radar DA.
2. When radar data are assimilated together with FED observations, the additional positive impacts of FED DA are relatively small but still present.

## Ongoing work:

- Assimilating FED observations coupled with different MP (e.g., Thompson, NSSL) schemes, using consistently fitted FED observation operators.

## References:


1. Kong, R., M. Xue, A. O. Fierro, Y. Jung, C. Cliu, E. R. Mansell, and D. R. MacGorman, 2020a: Assimilation of GOES-16 Geostationary Lightning Mapper Flash Extent Density Data in GSI EnKF for the Analysis and Short Term Forecast of a Mesoscale Convective System. *Mon. Wea. Rev.*, **148**, 2111-2133.
2. Kong, R., M. Xue, C. Liu, A. O. Fierro, E. R. Mansell, and D. R. MacGorman, 2020b: Assimilation of GOES-R Geostationary Lightning Mapper Flash Extent Density data in GSI 3DVar, EnKF, and Hybrid En3DVar for the Analysis and Short-Term Forecast of a Supercell Storm Case. *Mon. Wea. Rev.,* under review.

# Questions?