Paper review

mainly refer to

Improvements to the assimilation of Doppler radial winds for convection-permitting forecasts of a heavy rain event

Lippi, D. E., J. R. Carley, and D. T. Kleist

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2020.03.17

Other reference:

Janjić, T., and Coauthors, 2018: On the representation error in data assimilation. *Quart. J. Roy. Meteor. Soc.*, **144**, 1257–1278

Outline

- **Introduction and background**
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  - *Forecast sensitivity to background error covariance length scales*
- **Summary and conclusions**

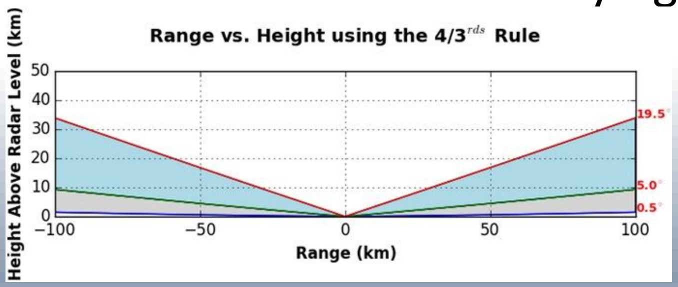
Introduction and background

- NCEP ... ympics in Atlan ... ds were assim ... cale Forecast Syste ...

- Including vertical velocity
- Refinement of super-observation

→reduce representation error

- Radi ... e historically been ignored for assimilation in operations because data coverage reduces rapidly as the elevation angle increase.
- NCEP's radial wind observation operator did not account for vertical motion which necessitated the restriction of a maximum allowable elevation angle in order to exclude observations with high scan elevation angles from contaminating the analysis, as the contribution from vertical motions would potentially become nonnegligible at such angles.
- Reducing the errors that arise from the disparity between observation and model resolution: super-observations (smoothing of the information content and underlying variance in the observation field)

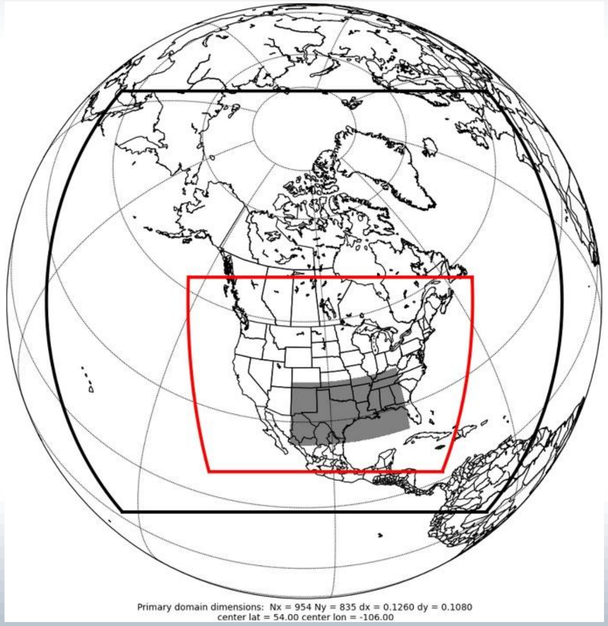


Methods

Model and data assimilation configuration

- The NAMv4 runs hourly data assimilation cycles and was reconfigured to issue 36-h forecast four times per day at 0000, 0600, 1200, and 1800 UTC over the 12-km parent and 3-km CONUS domains and 18-h forecasts at each intermediate hour (e.g., 0100, 0200, 0300, 0400, and 0500 UTC etc.) over the 3-km CONUS nest.

Domain	Grid space	Radiation (LW/SW)	Microphysics	Turbulence	Surface layer	Land surface	Gravity wave drag	Cumulus
Parent	12 km	RRTMG (Mlawer et al. 1997; Iacono et al. 2008)	Ferrier–Aligo (Aligo et al. 2018)	MYJ (Janjić 2001)	MYJ (Janjić 2001)	Noah (Ek et al. 2003)	On (Alpert 2004)	BMJ (Janjić 1994)
CONUSnest	3 km	RRTMG (Mlawer et al. 1997; Iacono et al. 2008)	Ferrier–Aligo (Aligo et al. 2018)	MYJ (Janjić 2001)	MYJ (Janjić 2001)	Noah (Ek et al. 2003)	None	None



Methods

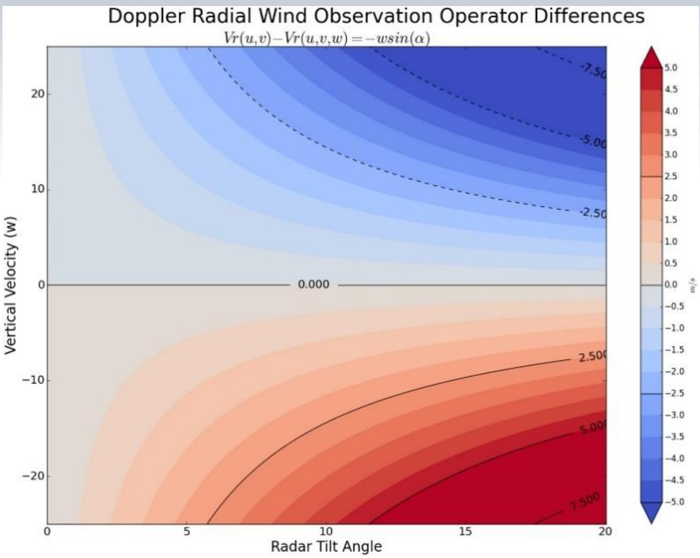
Extending the radial wind operator for vertical velocity

1) The radial wind observation operator

$$V_r(\theta,\alpha) = u\cos(\theta)\cos(\alpha) + v\sin(\theta)\cos(\alpha) + \boldsymbol{w\sin(\alpha)}$$

θ: azimuth angle

α: elevation angle

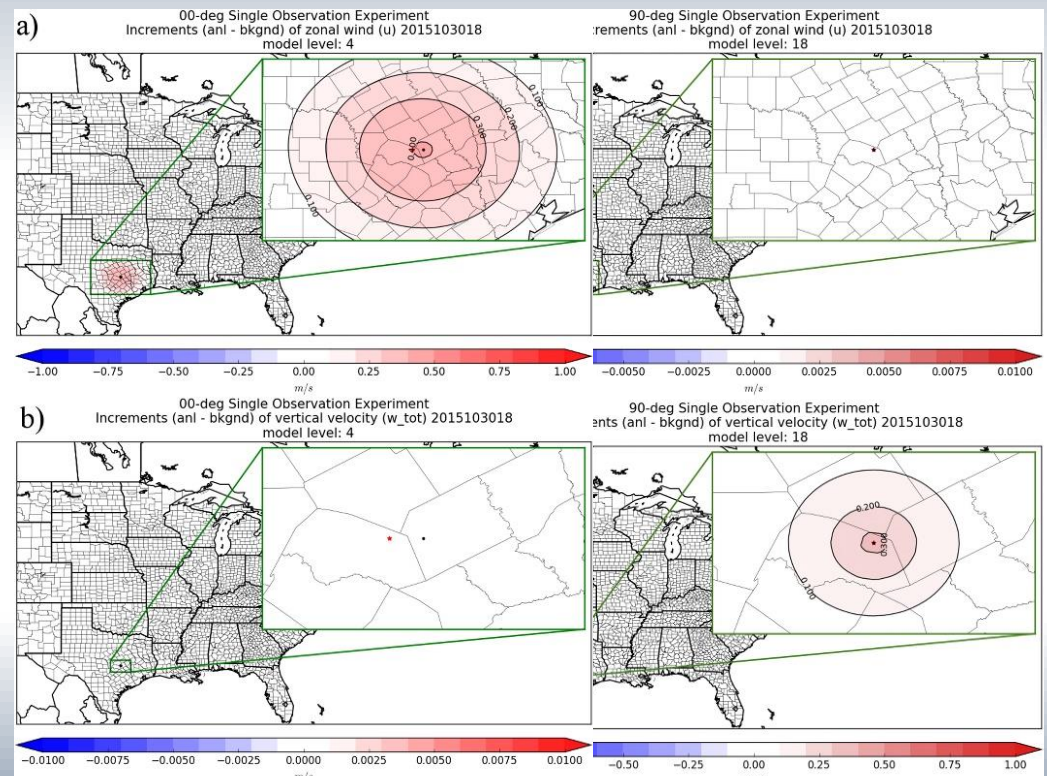


Reduces representativeness error (Janjić et al. 2018)

2) Vertical velocity analysis control variable

Nonhydrostatic Multiscale Model on the B-grid (NMMB; Janjić and Gall 2012), diagnoses vertical velocity via the nonhydrostatic continuity equation.

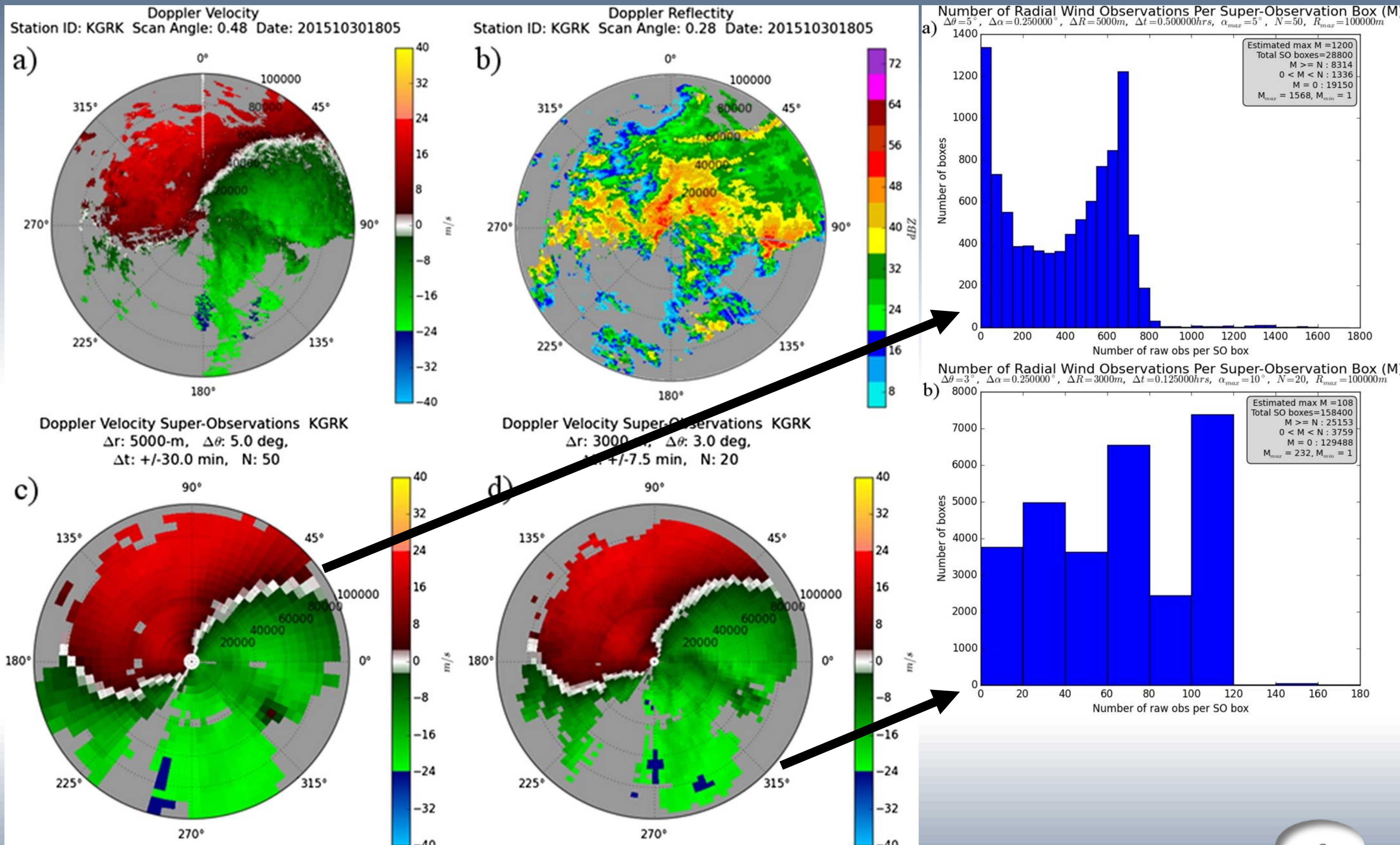
3) Single observation tests



Methods

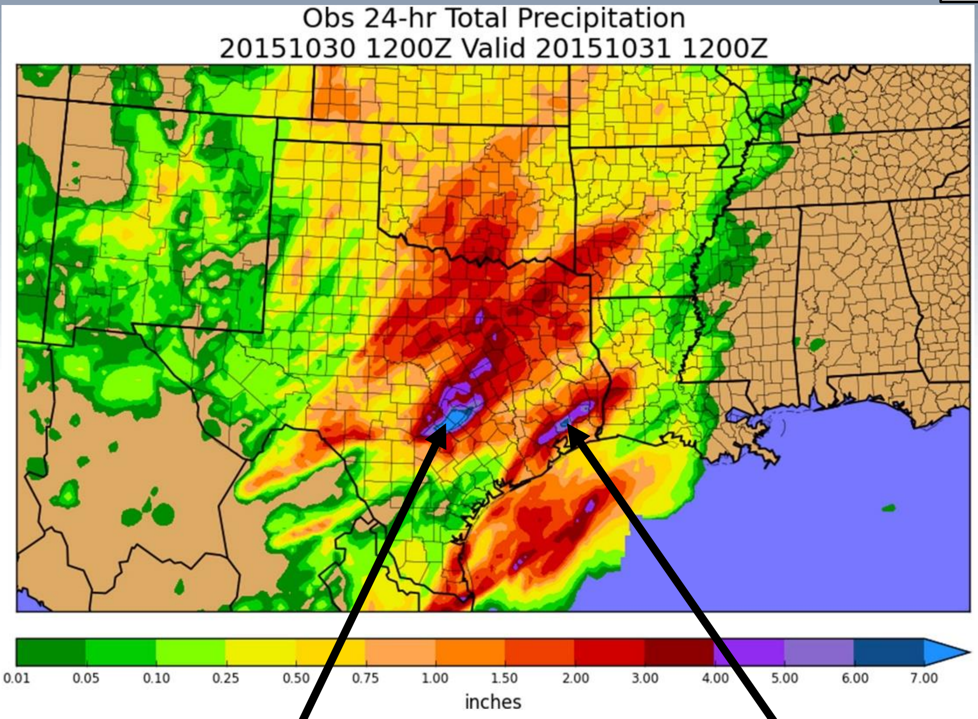
Configuration	Azimuth range (°) $\Delta\theta$	Elevation angle range (°) $\Delta\varepsilon$	Radial range (m) Δr	One-half time range (h) Δt	Max elevation angle (°) ε_{max}	Min No. of samples N
Default	5	0.25	5000	±0.500	5	50
Experimental	3	0.25	3000	±0.125	10	10

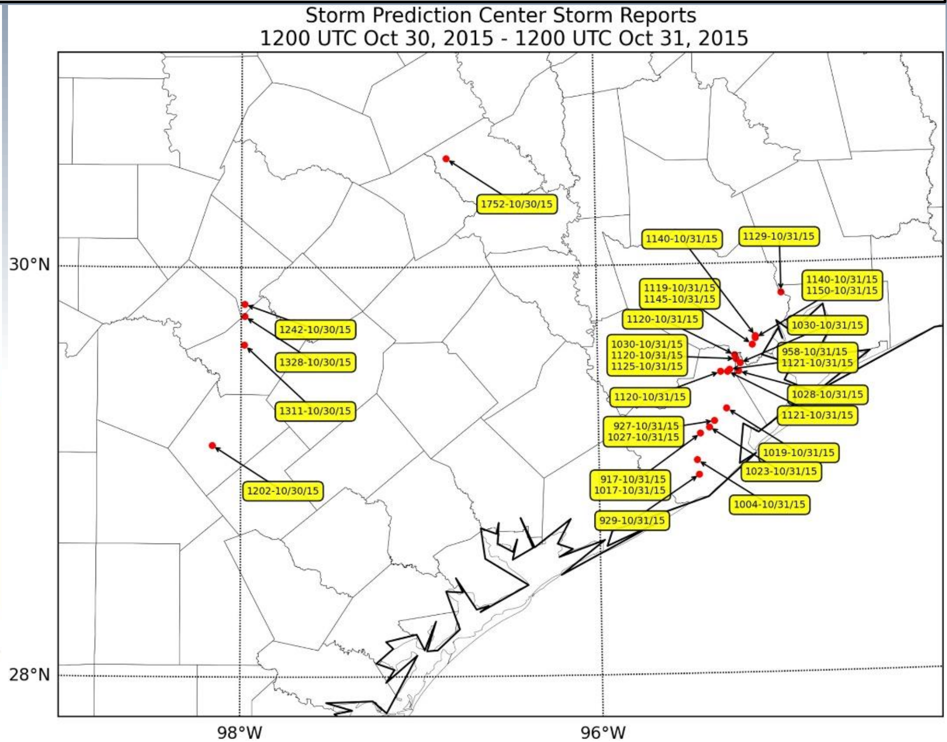
Creating super-observations of radial wind data



Case study overview

Tornado reports from the Storm Prediction Center (1200 UTC 30 Oct–1200 UTC 31 Oct 2015)





Between Austin and San Antonio

Houston

Experimental design

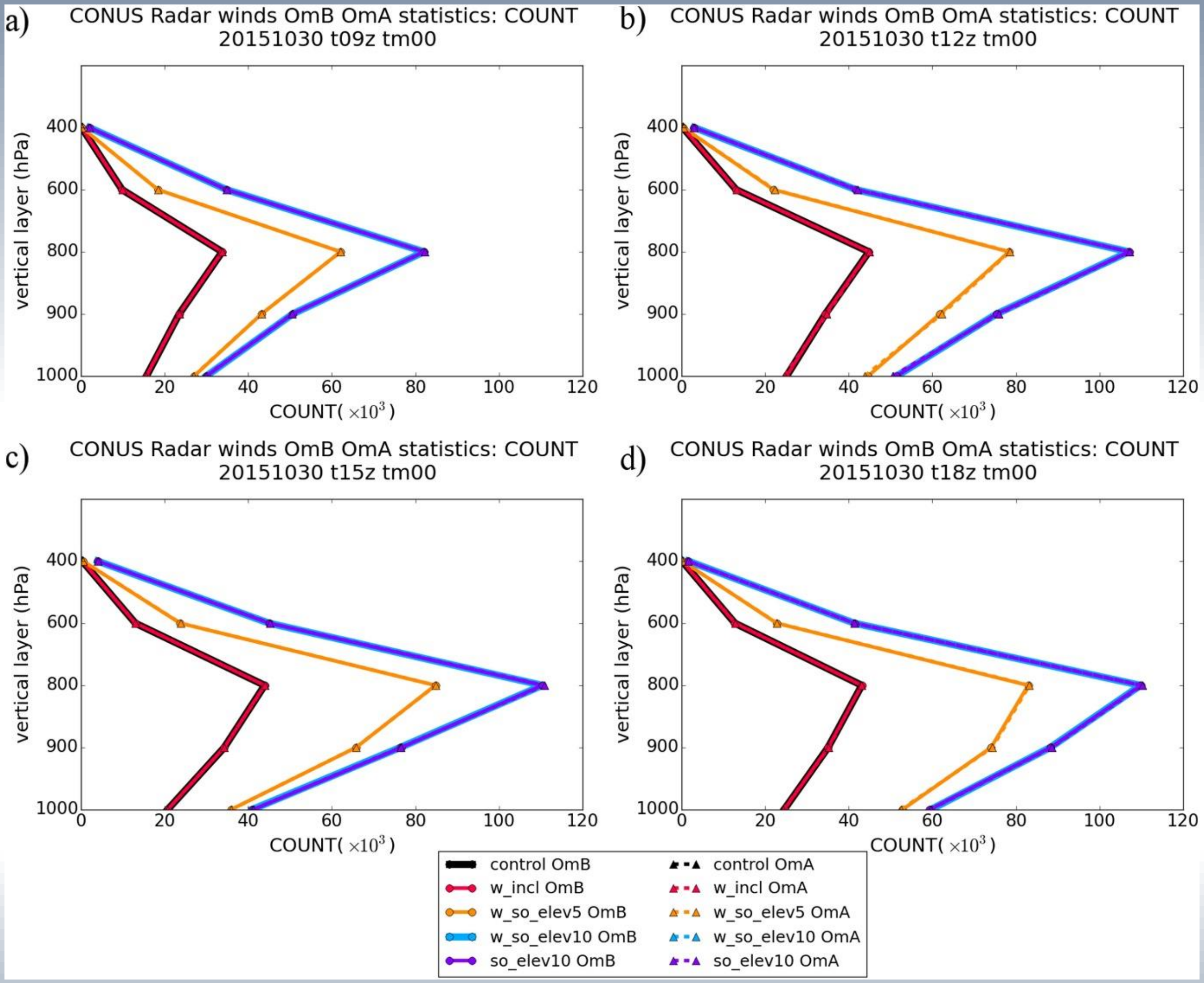
- Control
- w_incl
- w_so_elev5
- w_so_elev10
- so_elev10

		Azimuth range (°)	Elevation angle range (°)	Radial range (m)	One-half time range (h)	Min No. of samples	Max elevation angle (°)
Exp	w	$\Delta\theta$	$\Delta\varepsilon$	Δr	Δt	N	ε_{max}
control	No	5	0.25	5000	±0.500	50	5
w_incl	Yes	5	0.25	5000	±0.500	50	5
w_so_elev5	Yes	3	0.25	3000	±0.125	20	5
w_so_elev10	Yes	3	0.25	3000	±0.125	20	10
so_elev10	No	3	0.25	3000	±0.125	20	10

Data assimilation

Fit-to-observations

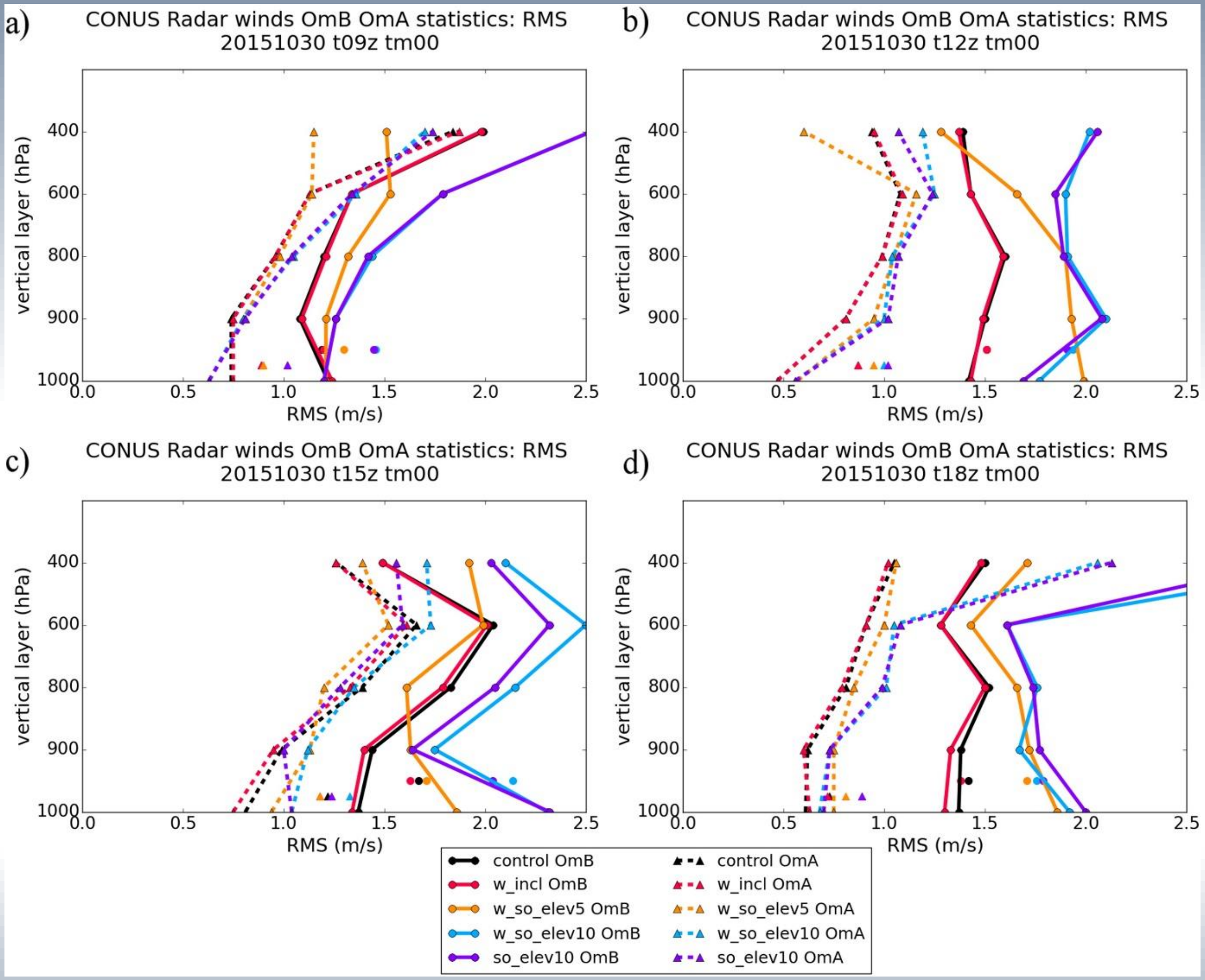
Data counts



Data assimilation

Fit-to-observations

Root mean square

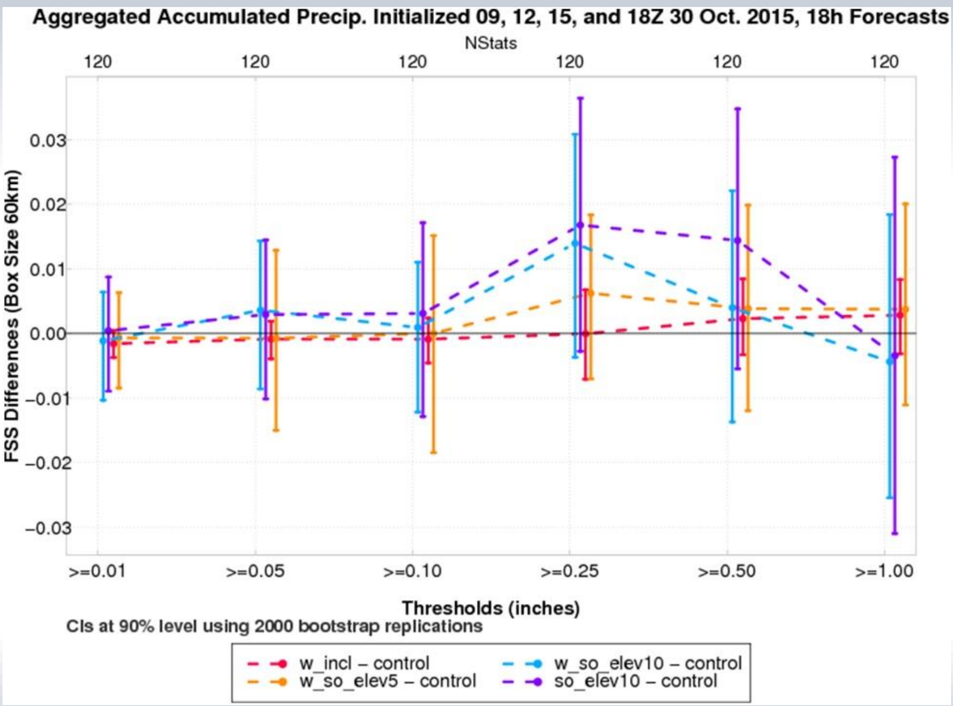


Verification

FSS and FBIAS

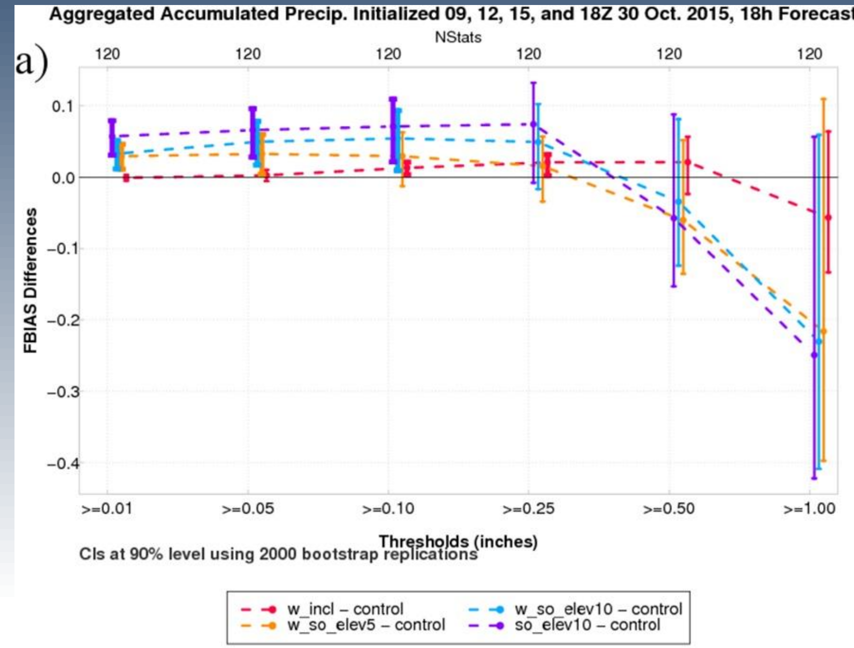
Fractions skill score

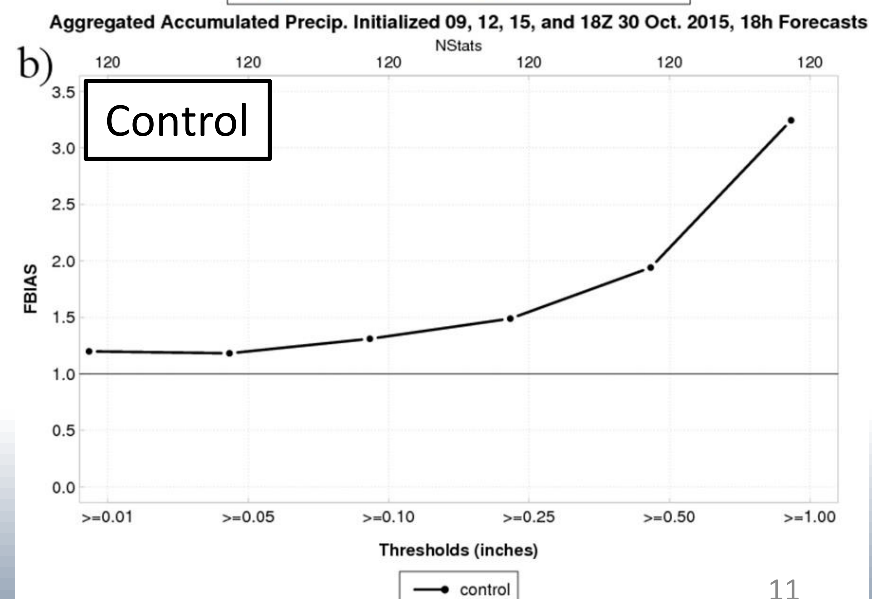
$$FSS = 1 - \frac{\frac{1}{N}\sum_N (P_f - P_o)^2}{\frac{1}{N}\left(\sum_N P_f^2 + \sum_N P_o^2\right)}$$



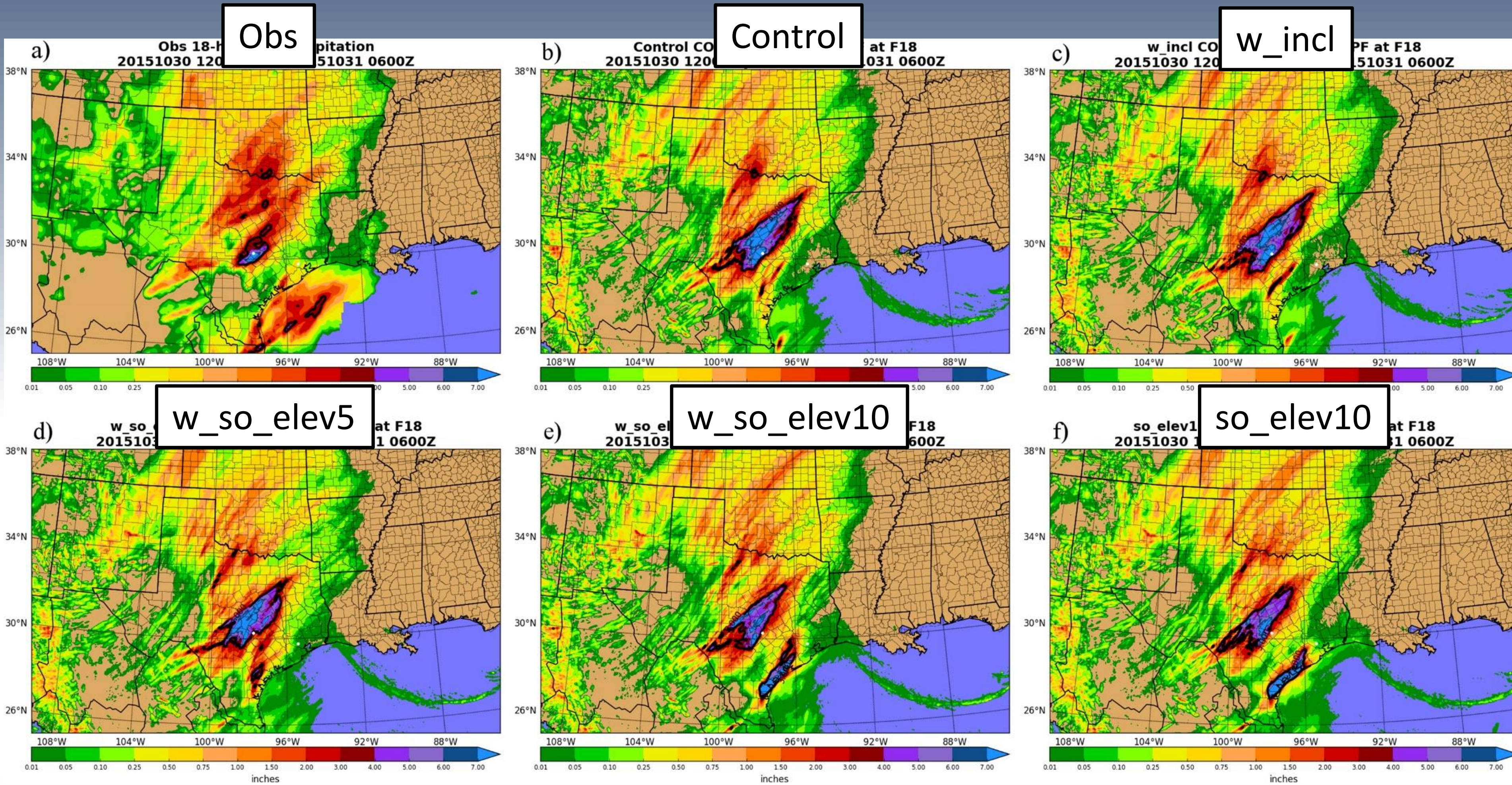
bias

$$FBIAS = \frac{hits + false\ alarms}{hits + misses}$$





Forecast assessment



Summary and conclusions

- The RMS scores showed a neutral impact on the analysis for including vertical velocity in the observation operator.
- The elev10 experiments showed slight improvements in the FSS at the 0.25 and 0.50 in. thresholds and in FBIAS at the 0.50 and 1.00 in. thresholds.
- The strongest sensitivity was to the super-observation parameters where those experiments mostly demonstrated some (slight) improvement relative to the control.
- It is suggested that Convective-scale model forecasts are sensitive to the methods and settings for assimilating radial winds.

Thanks