# Severe Weather Simulation Experiment (QuickOSSE) Using Super Constellations of GNSS Radio Occultation Satellites

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# GNSS Radio Occultation (RO)

GOES-16 image courtesy NOAA/NASA.

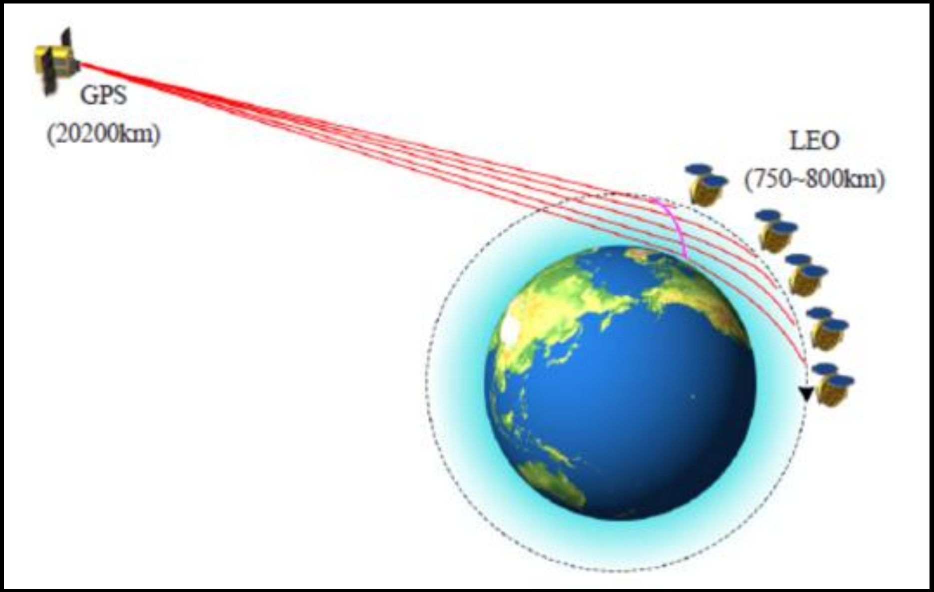



Fig. 1 A schematic illustration of a GNSS RO event, shown are ray paths (red), a vertical profile of perigee points (purple), LEO orbit (black dashed) and the atmospheric layer (shaded in cyan).

*Graphic courtesy http://dj.daracenter.org/c/gps/principle/*

GNSS Radio Occultations have improved global numerical weather prediction over the last 10 years.

--- NCEP, ECMWF, CMC

--- stable observations; SI traceable

--- unbiased observations

# Central question:

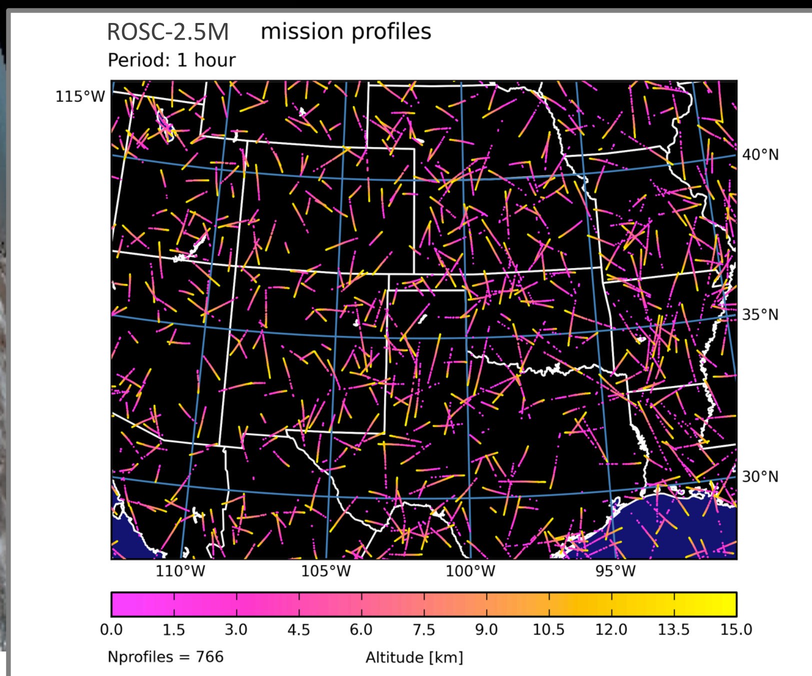
Given the current suite of operational GNSS RO receivers in orbit (i.e., 4,000 – 8,000 global profiles/day),

what could the impact of 1-3 orders of magnitude ***more*** profiles from GNSS RO constellations be on severe weather forecasting?

That is, examine the potential of 250,000 – 2,500,000 global GNSS-RO profiles/day.

# Severe Weather Impact Study – Simulated Observations

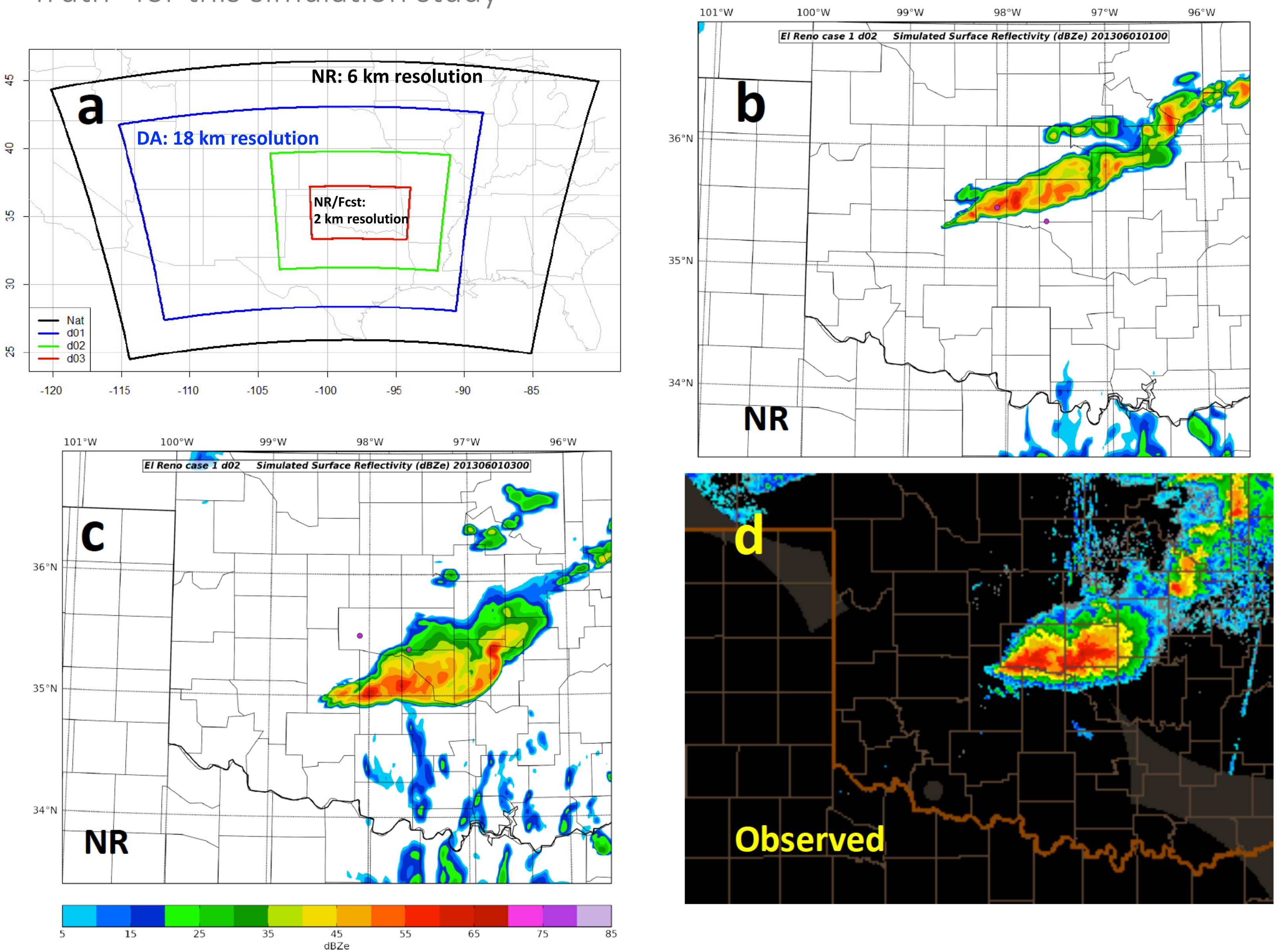
- **The problem**: severe wx forecasting needs improvement; increased data density should help
- **The approach**: OSSE that adds GNSS-RO data to NWP and examine effects on severe wx forecast
  - simulate GPS-RO observations for a variety of constellations; 250 K – 2.5 M profiles/day globally
  - WRF/DART ensemble data assimilation, $N_{ens} = 24$; hourly DA cycling for 7 cycles, pre-storm
  - verify forecasts against Nature Run (i.e., “true”) updraft helicity and 2-meter sensible weather
- **The payoff**: quantify expected forecast improvements as a function of GNSS-RO data density; looking for inflection points




← Approximate GNSS-RO sampling over study domain for **1 hour**
– 2.5M global profiles/day
– approx. 1,200 microsats
– RO Super Constellation (ROSC)

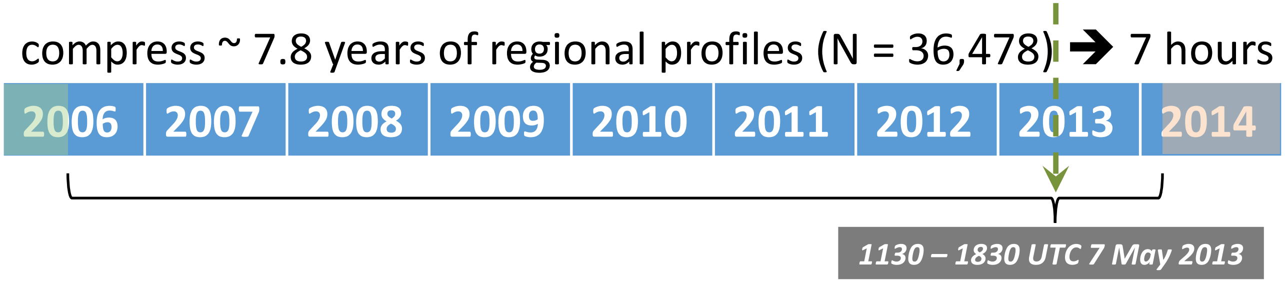
# Nature Run (NR) for OSSE study

"Truth" for this simulation study



# Conversion of COSMIC RO profiles to simulated ROSC profiles

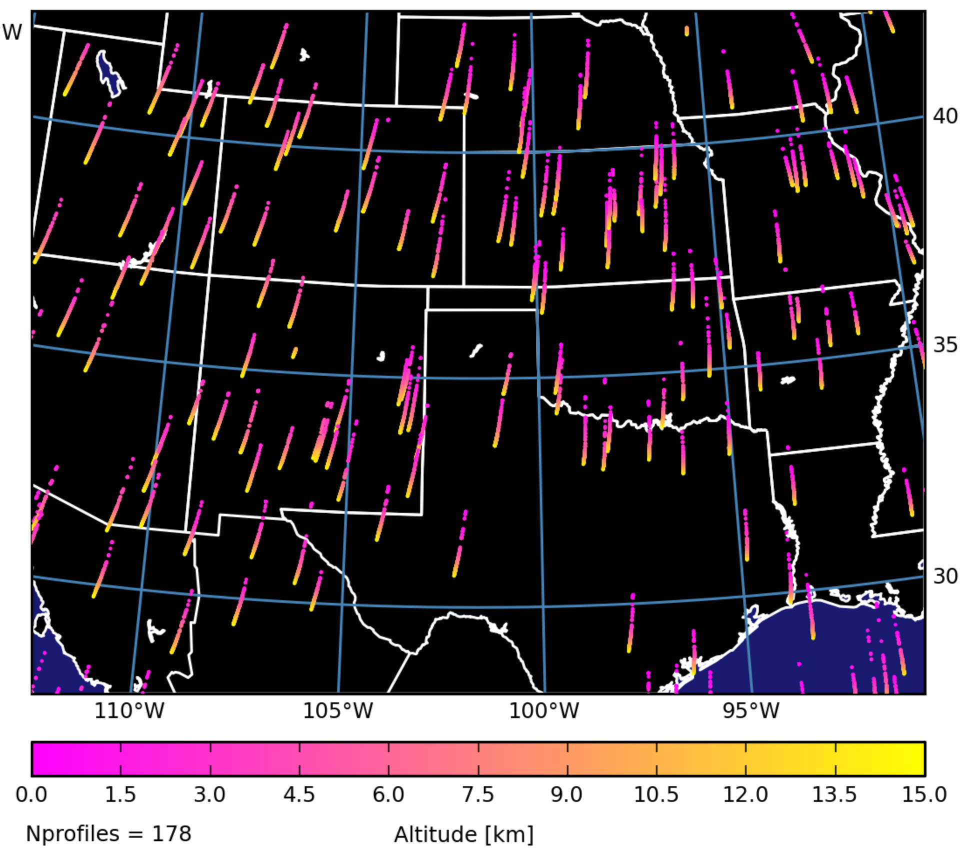
**Time:** compress ~ 7.8 years of regional profiles (N = 36,478) ➔ 7 hours




**Space:** rotate profiles/azimuths from COSMIC (preferred) orientations ➔ random

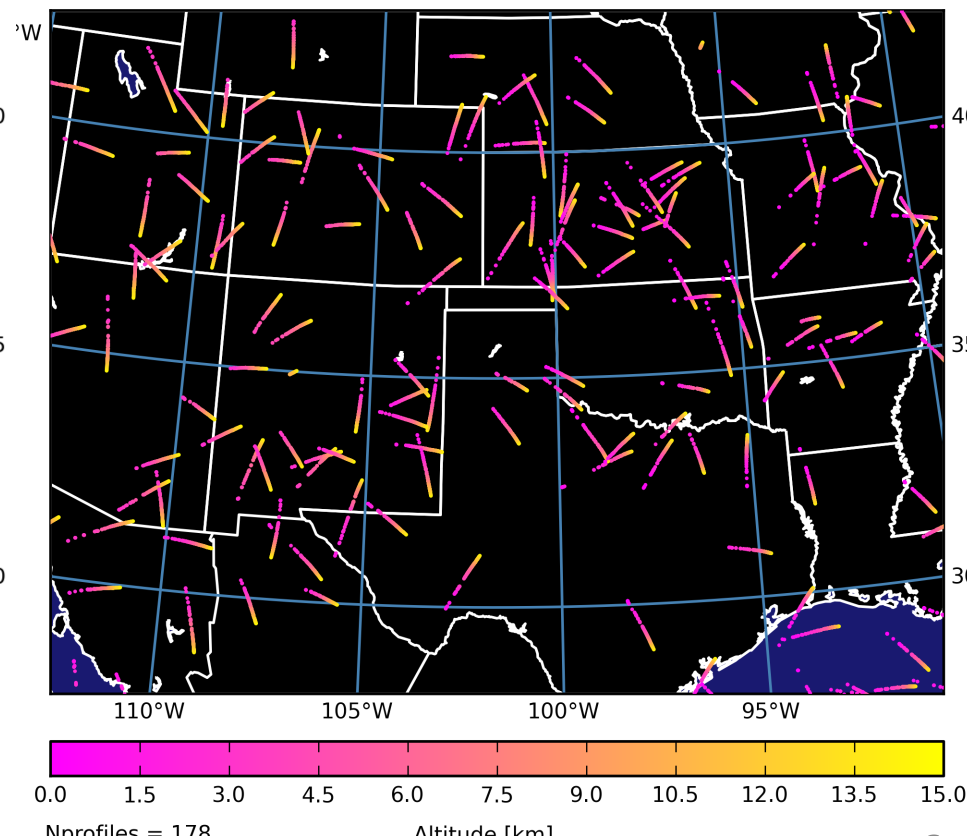
COSMIC/G22 profiles, rising occultations

Period: 7.8 yrs (May 20, 2006 - Feb 27, 2014)



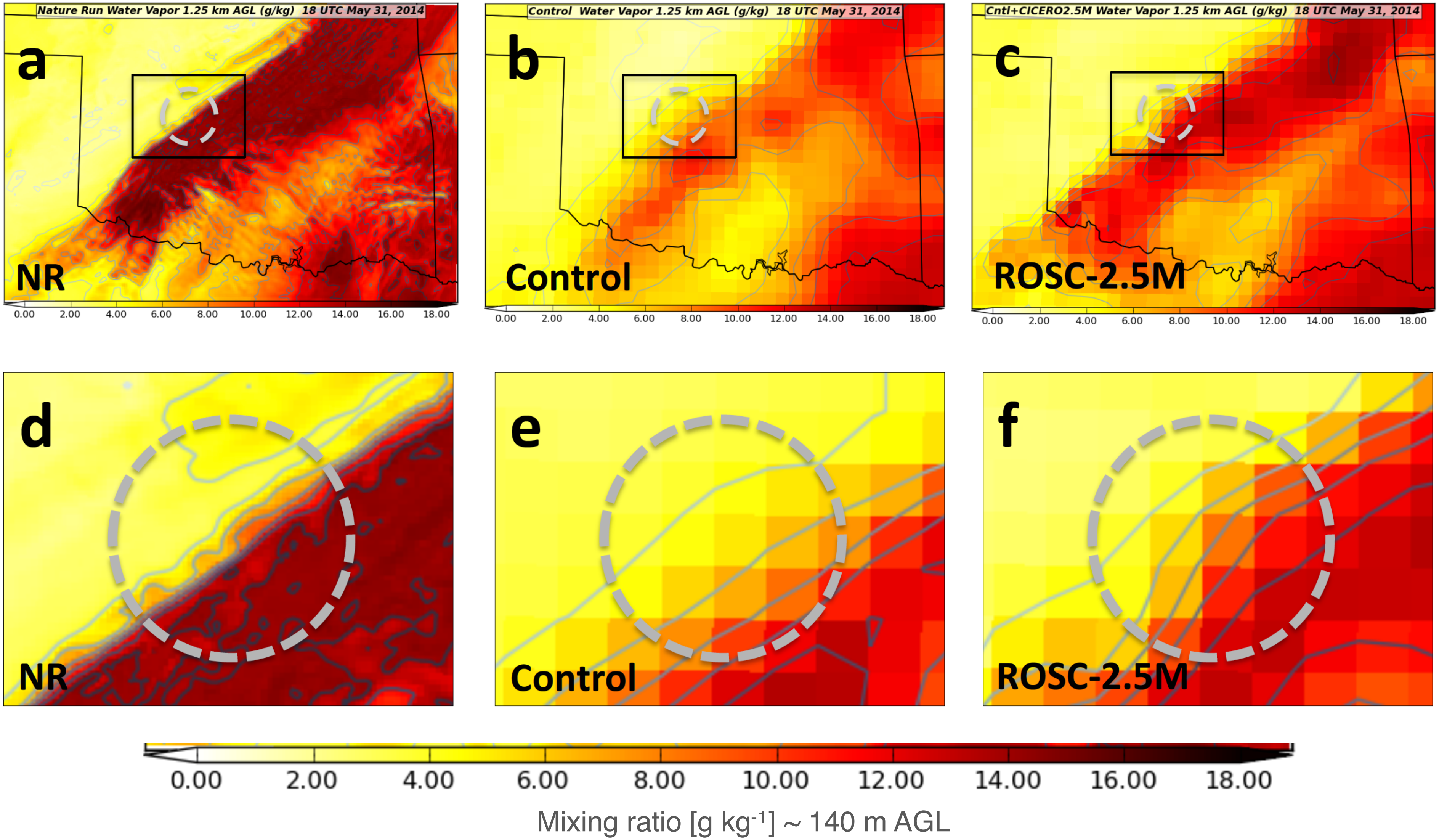

ROSC/G22 profiles, rising occultations

Period: 7 hrs (May 31, 2013, 1130 - 1830 UTC)



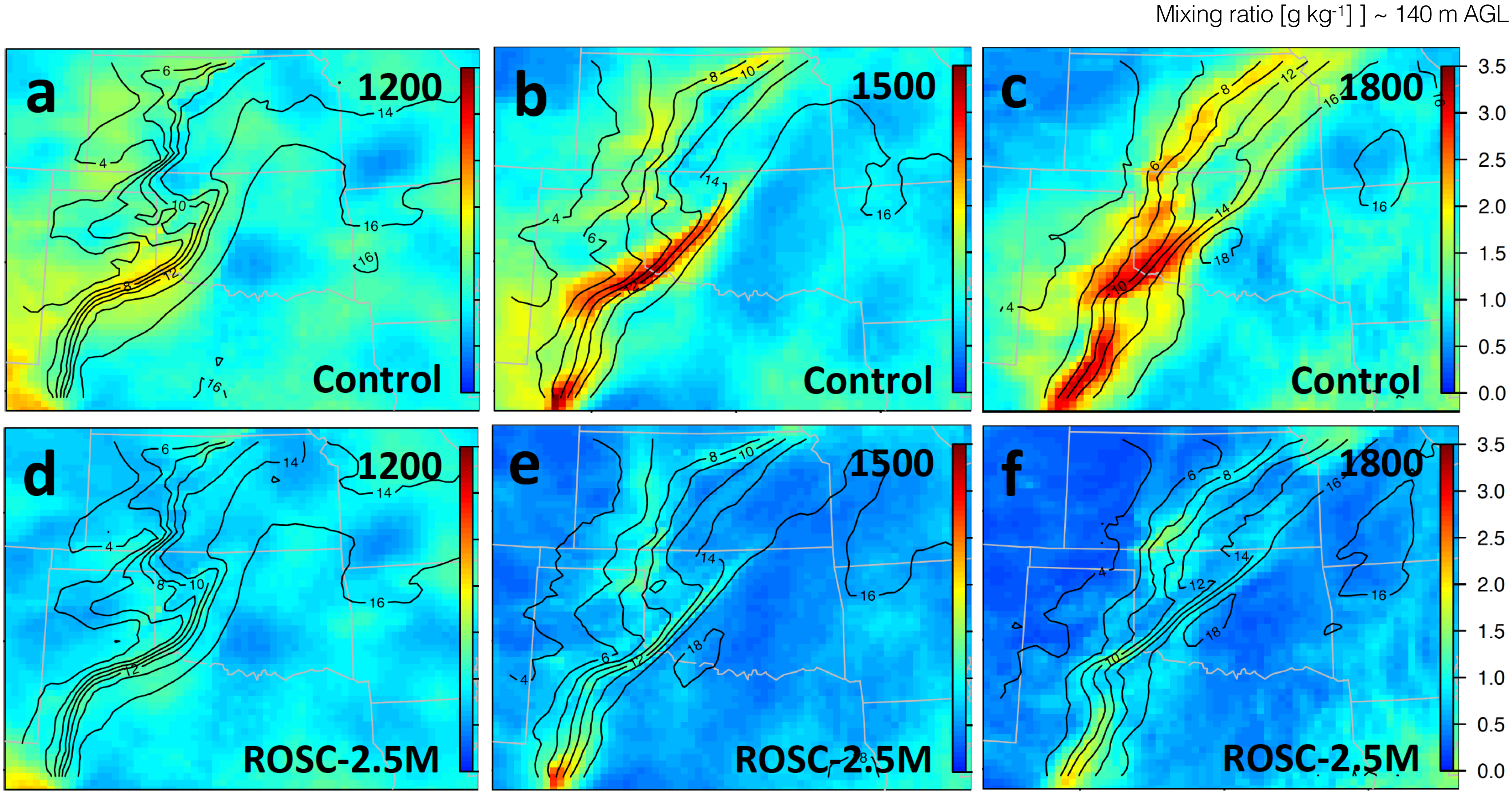
# Pre-storm EnKF analyses of low-level water vapor

2 km grid Nature Run and 18 km grid OSSE experiments after 7, hourly DA cycles



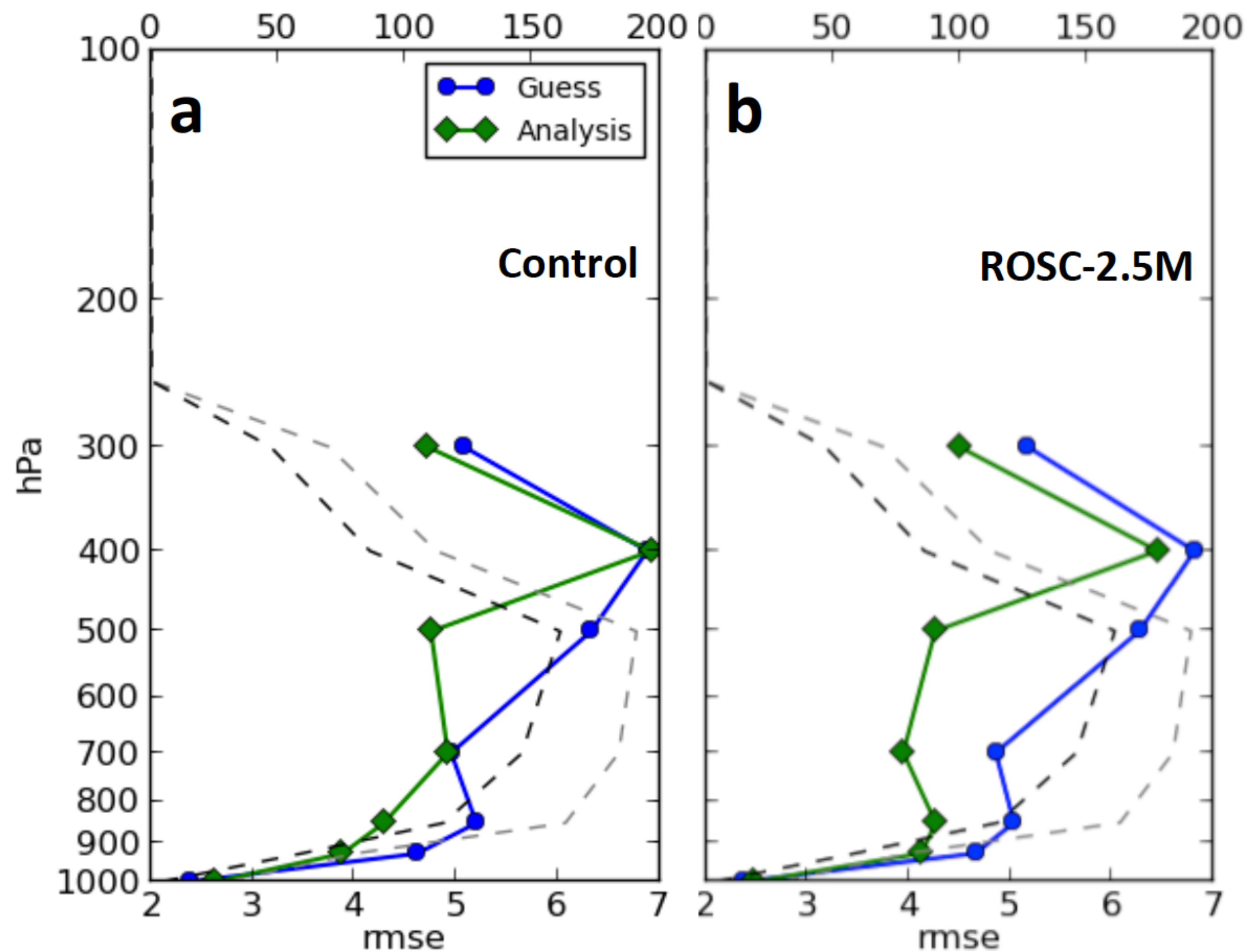
# Pre-storm EnKF analyses of low-level water vapor

Time series of ensemble mean (contours) & uncertainty (colored field)

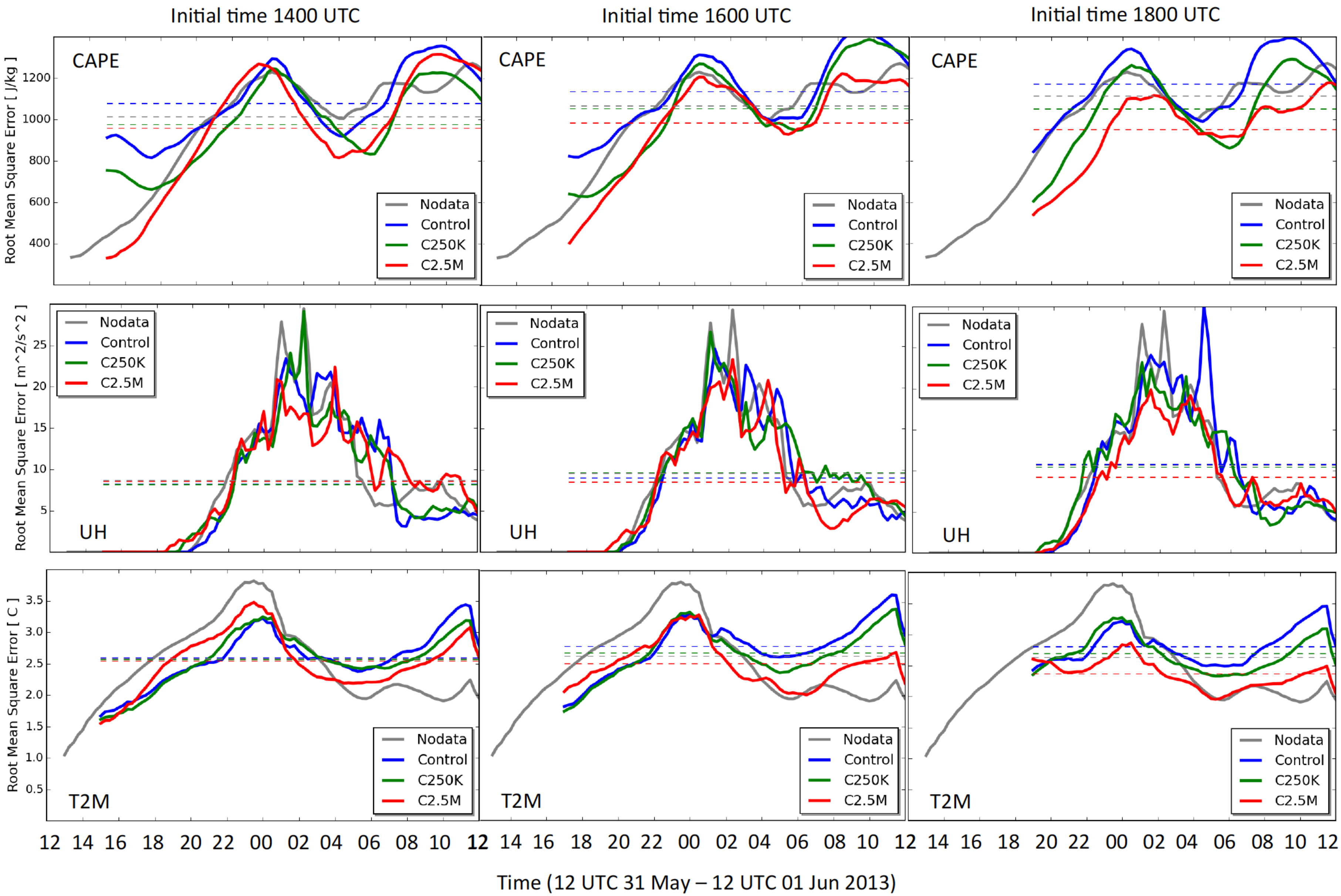


# RMS dewpoint error of backgrounds & analyses

Compared to all simulated radiosondes



# RMS Errors of OSSE forecasts



# Summary and Conclusions

- A QuickOSSE to explore the potential impact of very large GNSS RO constellations is complete.
- Focus is on severe weather impacts.
- First mesoscale, severe weather application/evaluation of RO data.
- Very positive results for tropospheric moisture analysis.
- Forecast results for this one case are overall positive.
  - Results are not general; sample is too small.
- Hope to extend this work to evaluate impacts on a diverse set of cases.
- *Monthly Weather Review* article in press (February):

S. M. Leidner, T. Nehrkorn, J. M. Henders, M.Mountain and T. P. Yunck. 2017: A severe weather quick observing system simulation experiment (QuickOSSE) of global navigation satellite system (GNSS) radio occultation (RO) super constellations. *Mon. Weather Rev.,* accepted.

# Thank you.

## Questions?