A Severe Weather QuickOSSE Examining the Impact of Super Constellations of GPS Radio Occultation Satellites

aer Atmospheric and Environmental Research

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INTRODUCTION

GPS Radio Occultation (GPS RO) has proven a valuable addition to the global climate observing system since the launch of the COSMIC constellation in 2006.

- Demonstrated improvements in global weather forecast skill
- Valuable unbiased, remotely-sensed observations

In our study, we measure the impact of vastly increased profiles on mesoscale weather analysis and forecasting.

- Moving from ~1,800 profiles/day to 250K & 2.5M/day

METHOD

The QuickOSSE is our experiment framework. (Atlas 2015)

- One case study to get a first look at impact.
- Using a 24-member ensemble in WRF-DART. (Anderson 2001/Chen 2009)
- Non-local excess phase observation forward operator.

Observing System Simulation Experiment (OSSE) components, in order:

1. Nature Run – "truth" in the OSSE framework
2. Simulate observations by sampling the Nature Run
3. Perform experiments with combinations of simulated obs
4. Verify experiments against "truth", i.e., the Nature Run

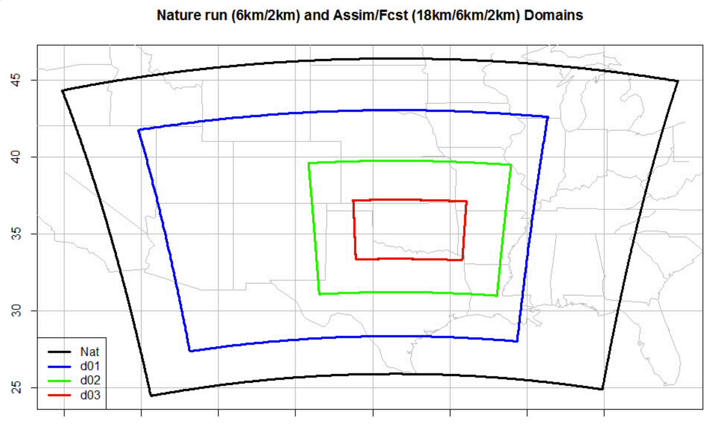

Figure 1. Arrangement of WRF domains and nests used for this study. The 6 km and nested 2 km domains (black and red, respectively) are used to generate the Nature Run. The blue 18 km grid is used for Assimilation experiments, while nested 6 km and 2 km resolution domains are used for the experiment forecasts.

Case Study Selection:

- May 31/June 1, 2013 – Oklahoma City "El Reno" tornado
- F4 tornado and urban flash flooding
- Hourly cycling data assimilation 1200 – 1800 UTC
- Launch forecasts at 1400, 1600 and 1800 UTC

Experiment Design:

- Control – conventional GTS data
- C250K – Control + GPS RO from a 250,000/day constellation
- C2.5M – Control + GPS RO from a 2.5 million/day constellation

SIMULATED GPS RO OBSERVATIONS

GPS RO excess phase observations were simulated by repurposing COSMIC mission data to the time period and size of future constellations of interest, then sampling from the Nature Run using.

- Viewing azimuths are randomized; valid times reassigned.

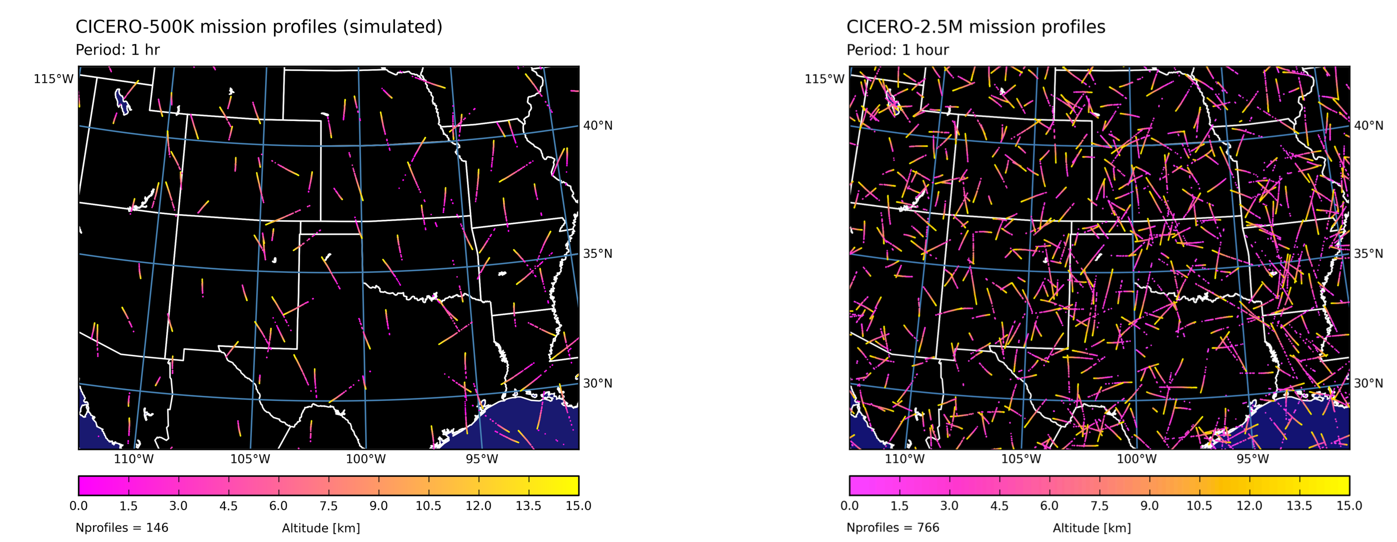

Figure 2. Examples of 1-hour spatial sampling of simulated GPS-RO constellations that generate 500,000 global profiles/day (left) and 2.5 million global profiles/day (right).

RESULTS

Analysis impacts:

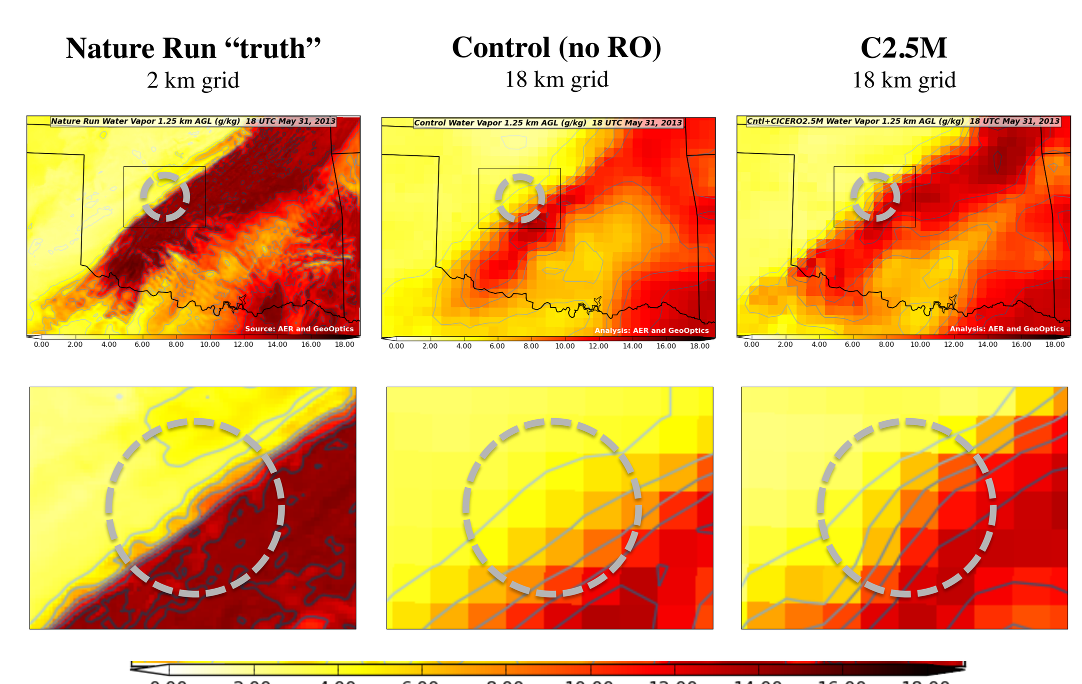

Figure 3. Water vapor mixing ratio (g/kg) from the Nature Run and Control & C2.5M assimilation experiments, 1.25 km above ground level, valid 1800 UTC May 31, 2013.

Forecast impacts:

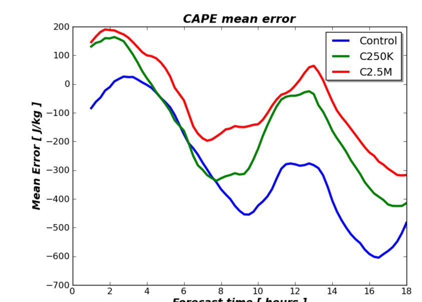

Figure 4. CAPE mean forecast error as a function of forecast time for Control (blue, no GNSS RO) and two experiments using GNSS RO observations, C250K (green, 250K global profiles/day) and C2.5M (red, 2.5M global profiles/day). These statistics are domain-average differences, every 15 minutes during the forecast period, comparing 2 km Nature Run fields ("truth") directly with the 2 km experimental treatment forecasts valid at the same time.

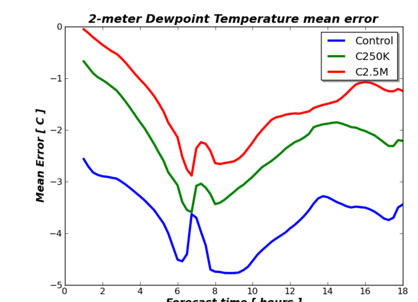

Figure 5. Same as Fig.4, but for 2-meter dewpoint temperature.

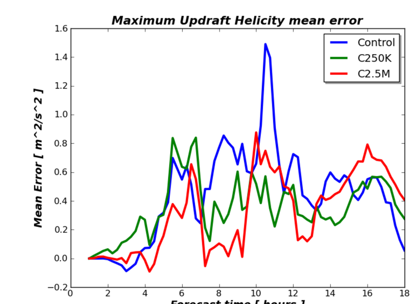

Figure 6. Same as Fig.4, but for maximum updraft helicity.

CONCLUSIONS

Given that very large GPS RO constellations provide dense temporal and spatial sampling of the troposphere, we observe the following in our study:

- mesoscale structures in the lower troposphere can be resolved with higher fidelity than conventional obs
- regional analysis impacts persist for many hours into the forecast for both surface-sensible and vertically integrated quantities, resulting in improved forecasts

Although GPS-RO observations only provide a measure of path-integrated quantities, we find that small-scale horizontal moisture gradients can be observed and established via mesoscale data assimilation using a non-local obs operator.

FUTURE DIRECTIONS...

This is a single case study – these findings may not apply in other regions and/or synoptic situations.

➔ explore a wide range of regional case studies, globally.

There does not appear to be an upper limit/asymptote of the impact at the mesoscale, even with 2.5 million global profiles/day.

➔ explore the impact of larger constellations. Is there an inflection point?

Use this WRF-DART OSSE framework to evaluate the sensitivity to a range of forward GPS-RO operators.

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