Atmospheric and Environmental Research

A GNSS Radio Occultation Simulation Study Examining Impacts on Severe Convective Weather Analysis and Prediction

Mark Leidner[1], Thomas Nehrkorn[1], John Henderson[1], Marikate Mountain[1] and Tom Yunck[2]

1- Atmospheric and Environmental Research, a Verisk Analytics Company
2 - GeoOptics, Inc.
(presented by Gottfried Kirchengast/WEGC on behalf of Mark Leidner)

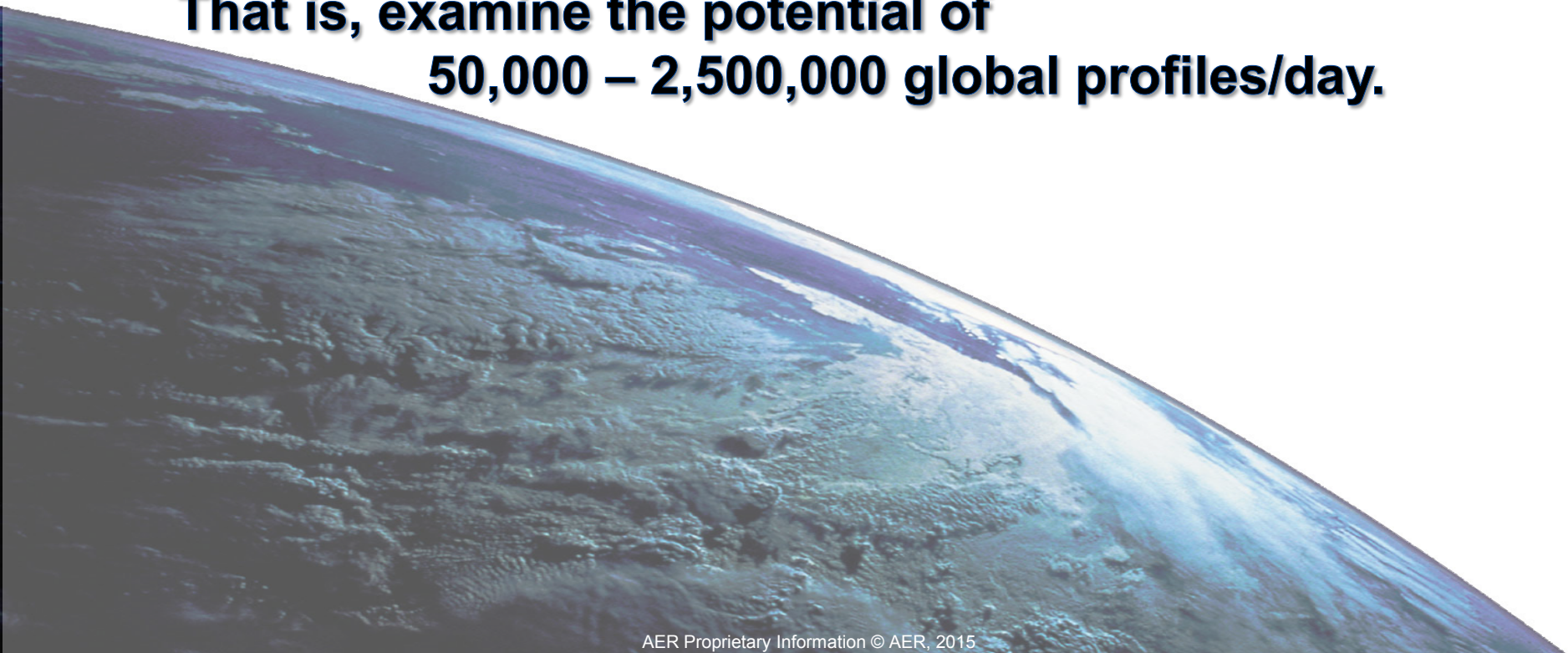
Central question:

Atmospheric and Environmental Research

Given the current and projected sampling of COSMIC & COSMIC-2 (i.e., about 2,000 and 5,000/10,000 global profiles/day)**,**

what would the impact of 1-3 orders of magnitude more profiles from a GNSS RO constellation be on severe weather forecasting?

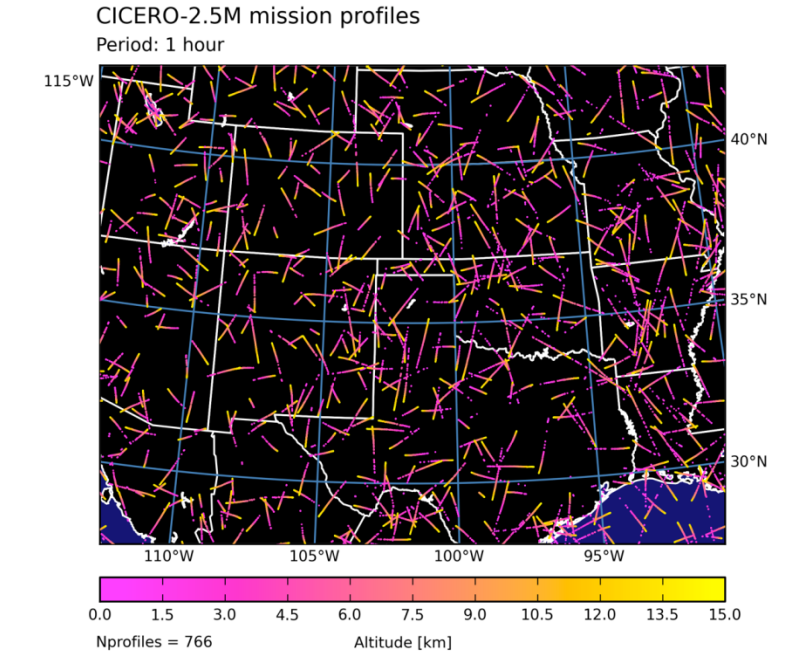
That is, examine the potential of 50,000 – 2,500,000 global profiles/day.



Severe Weather Impact Study: Radio Occultation

Atmospheric and Environmental Research

- The problem: severe wx forecasting needs improvement; more data density should help
- The approach: OSSE that adds GNSS-RO data to NWP and examine effect on severe wx forecast
  - WRF/DART ensemble data assimilation
  - verify against Nature Run (i.e., "true") 2-meter sensible weather and updraft helicity
  - simulated GNSS-RO observations for a variety of constellations; 60 K – 2.5 M profiles/day globally
- The payoff: quantify expected forecast improvements as a function of GNSS-RO data density

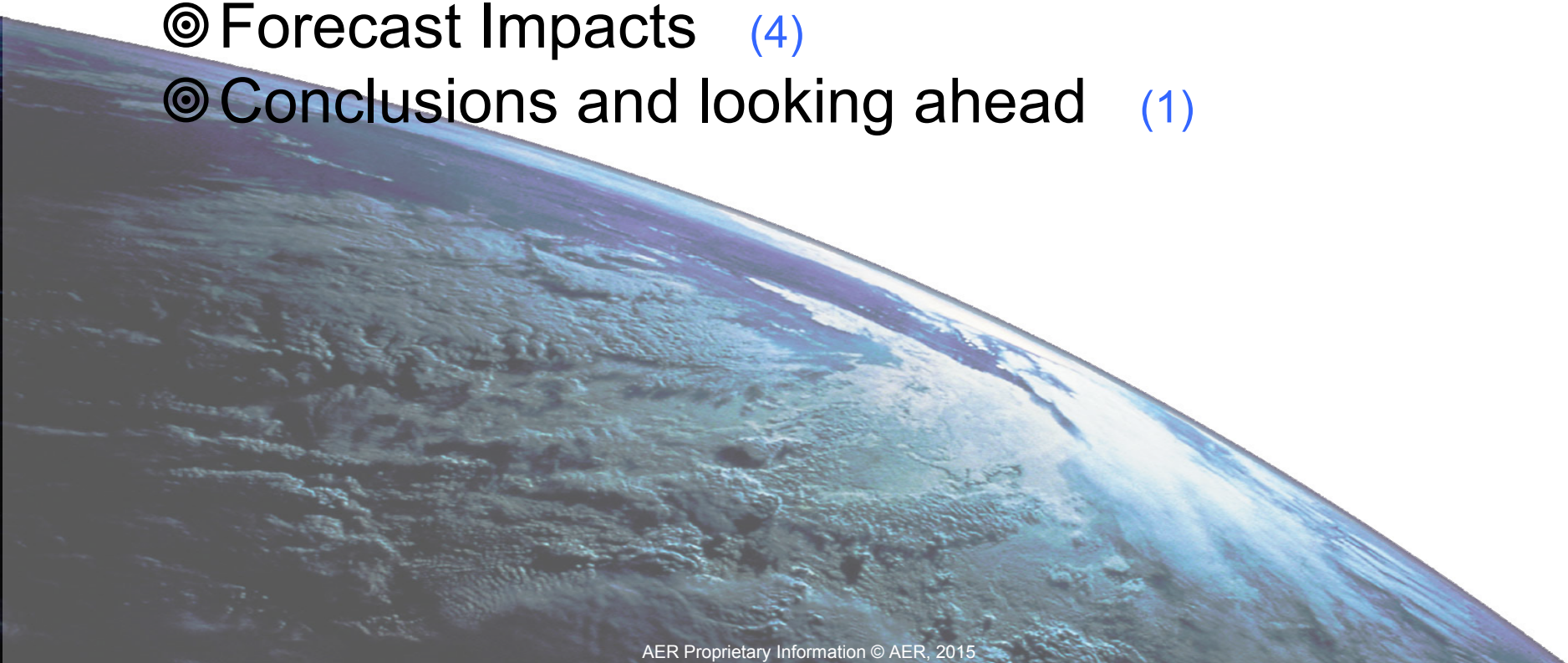


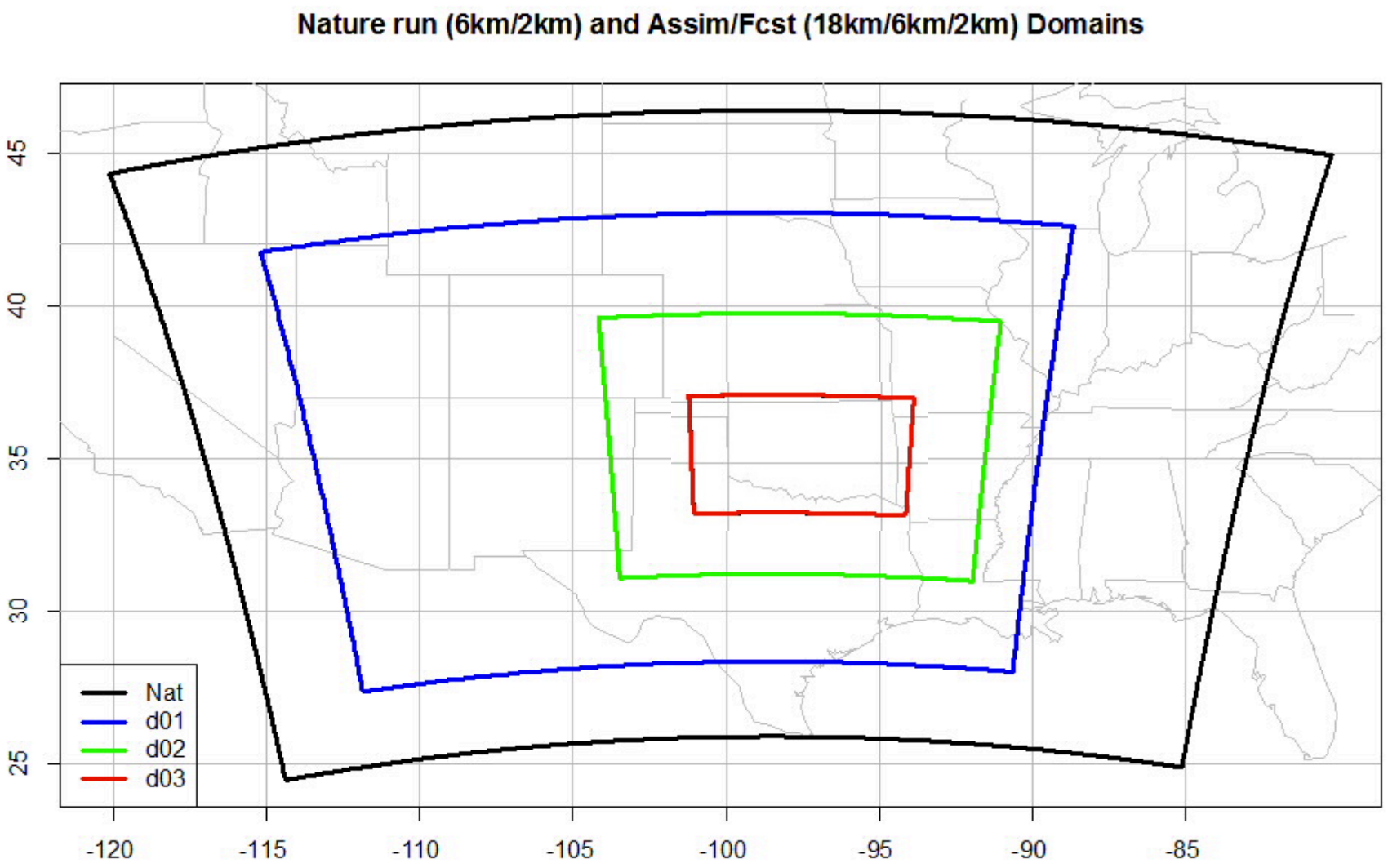
←Approximate GNSS-RO sampling over study domain for ***1 hour***, assuming

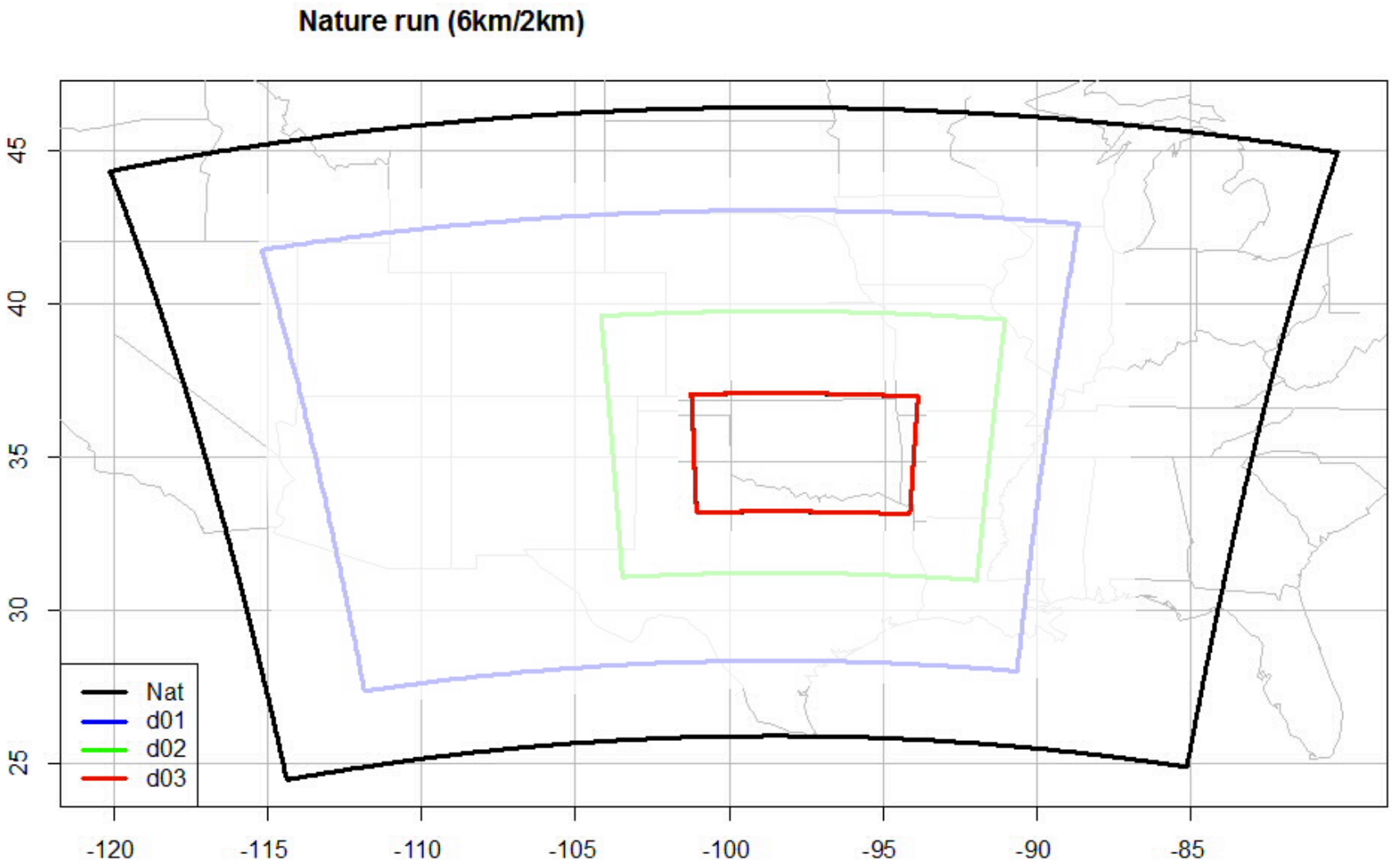
- a future constellation that could produce up to 2.5M global profiles/ day, e.g., approx. 1,200 microsats.

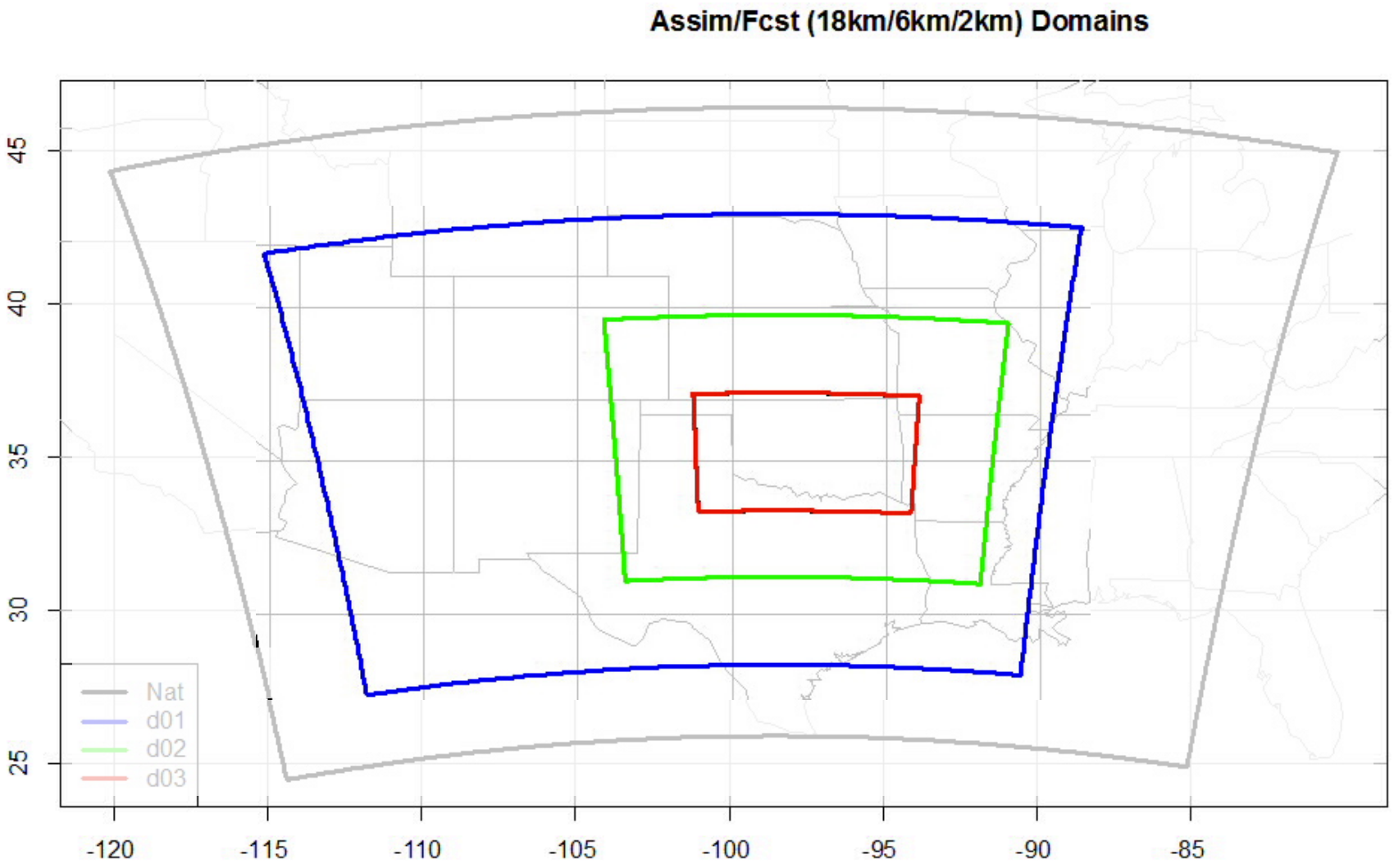
Outline

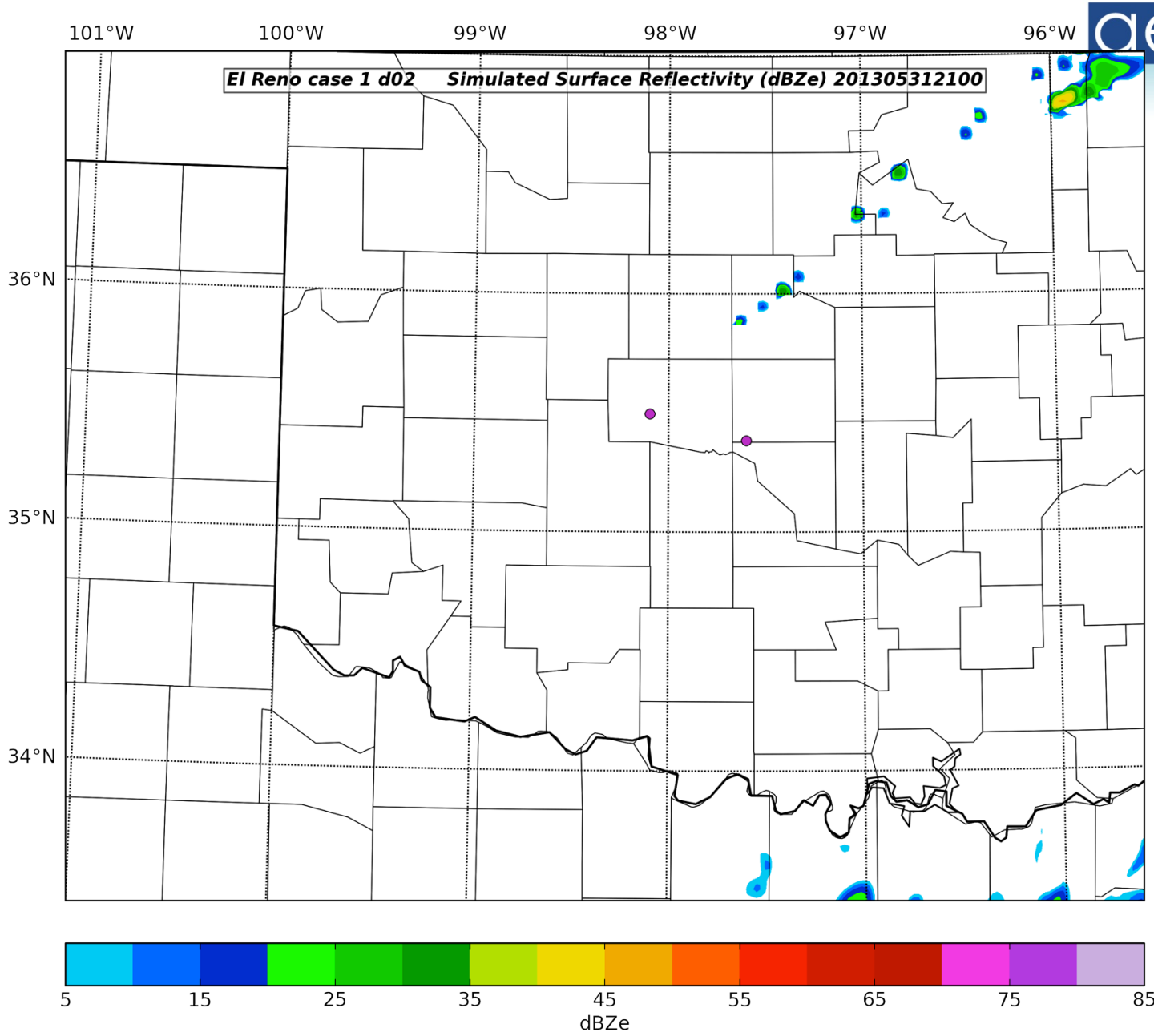
- Severe Weather OSSE (8)
- Simulated CICERO data (**C**ommunity **I**nitiative for **C**ontinuing **E**arth **R**adio **O**ccultation) (4)
- Vertical thinning of GNSS RO data (2)
- Analysis Impacts on water vapor (4)
- Forecast Impacts (4)
- Conclusions and looking ahead (1)




Nature run (6km/2km) and Assim/Fcst (18km/6km/2km) Domains
45
40
35
30
25
-120
-115
-110
-105
-100
-95
-90
-85
Nat
d01
d02
d03


Nature run (6km/2km)
45
40
35
30
25
-120
-115
-110
-105
-100
-95
-90
-85
Nat
d01
d02
d03


Assim/Fcst (18km/6km/2km) Domains
45
40
35
30
25
-120
-115
-110
-105
-100
-95
-90
-85
Nat
d01
d02
d03

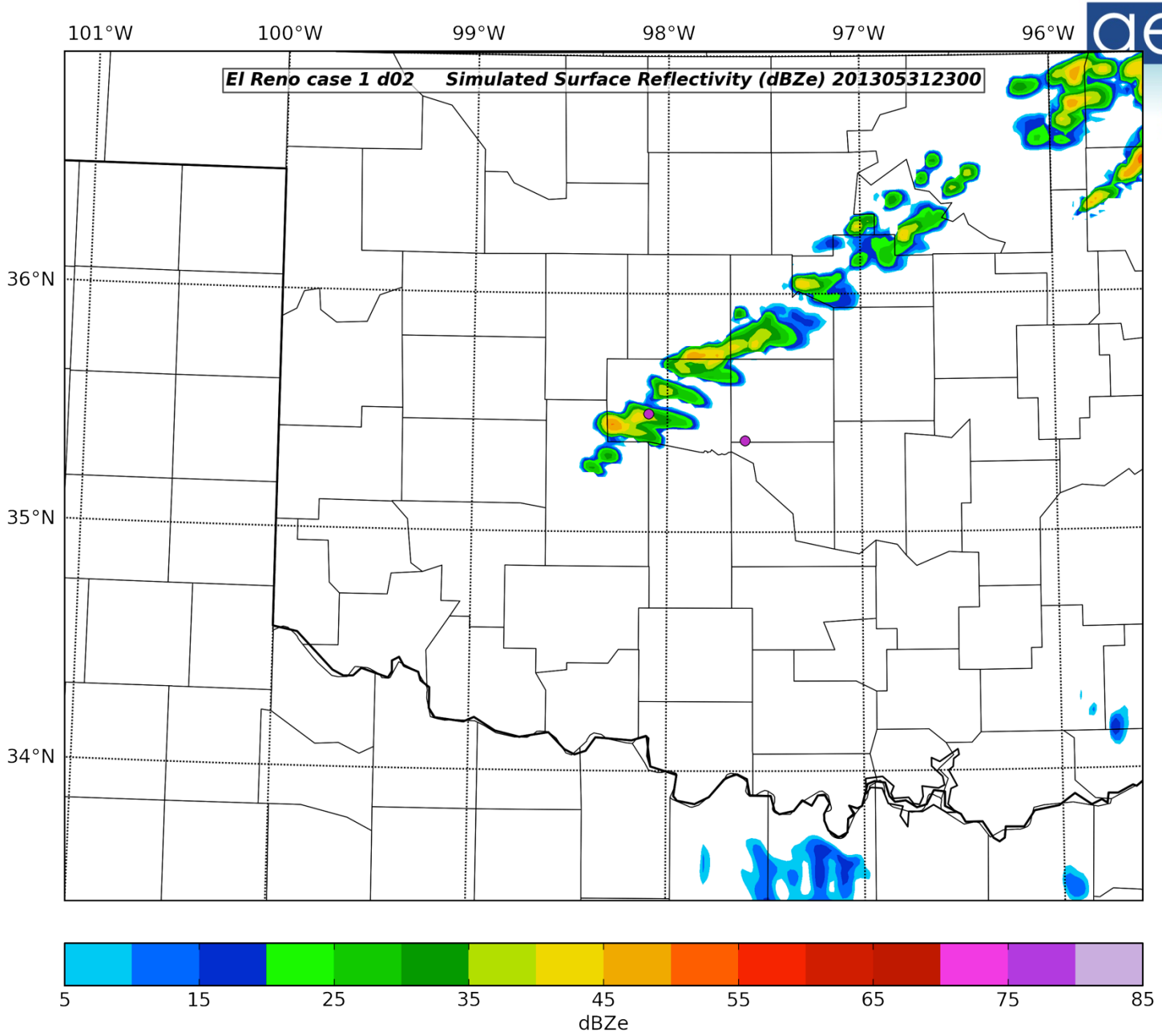


aer
Atmospheric and Environmental Research

WRF Simulated Radar Reflectivity

Nature Run

21Z May 31

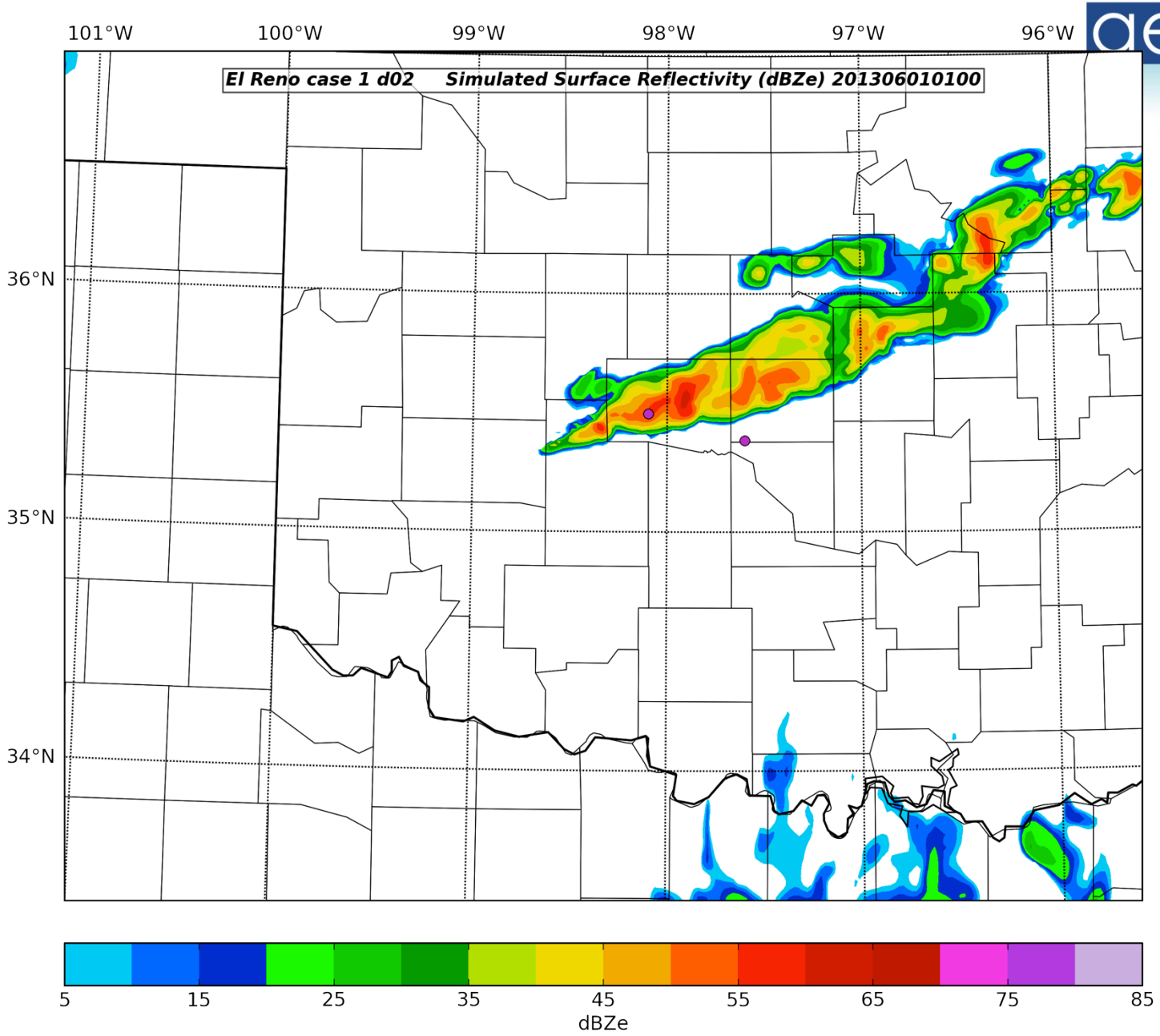


aer
Atmospheric and Environmental Research

WRF Simulated Radar Reflectivity

Nature Run

23Z May 31



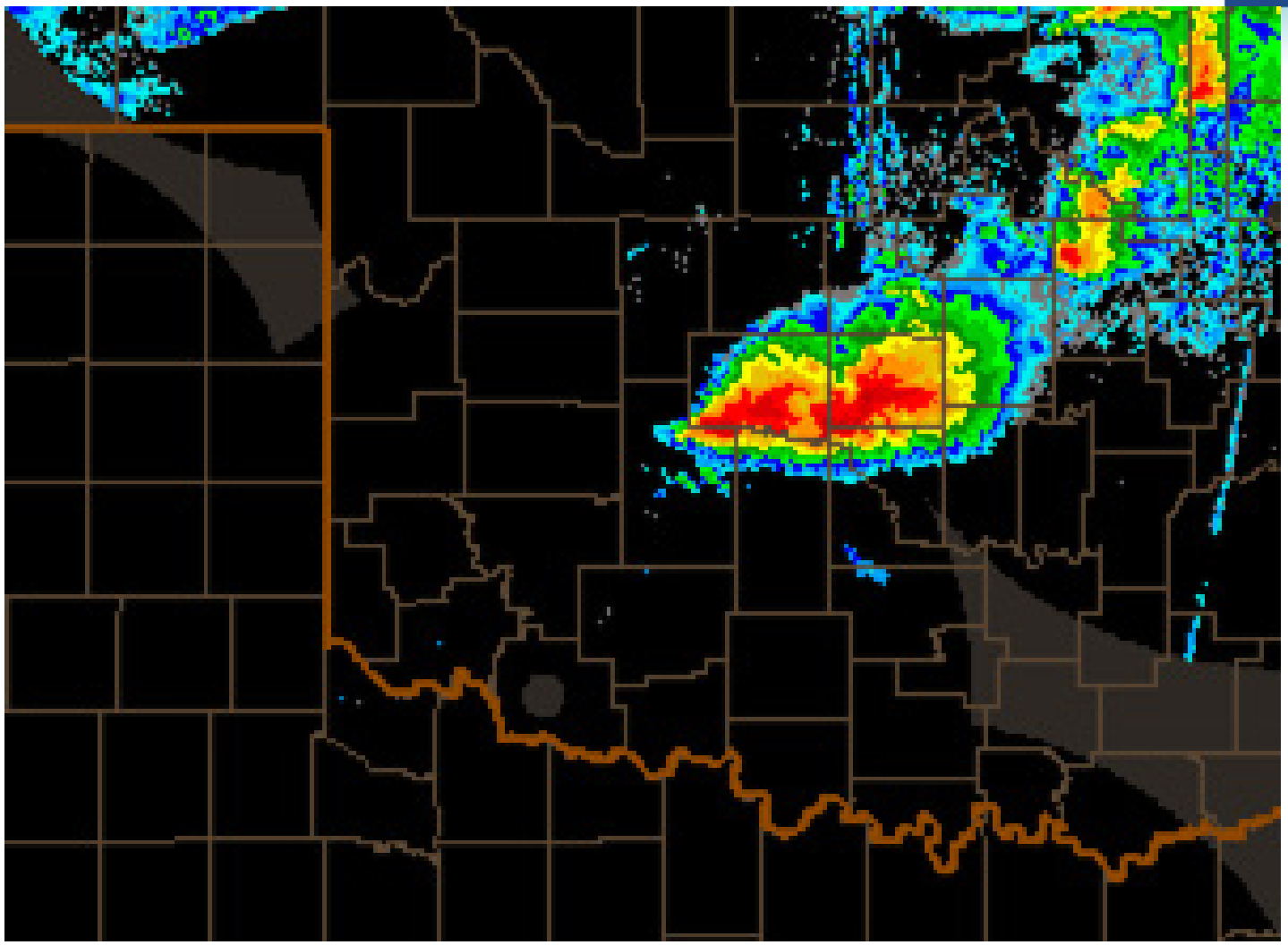
aer

Atmospheric and Environmental Research

WRF Simulated Radar Reflectivity

Nature Run

01Z June 1

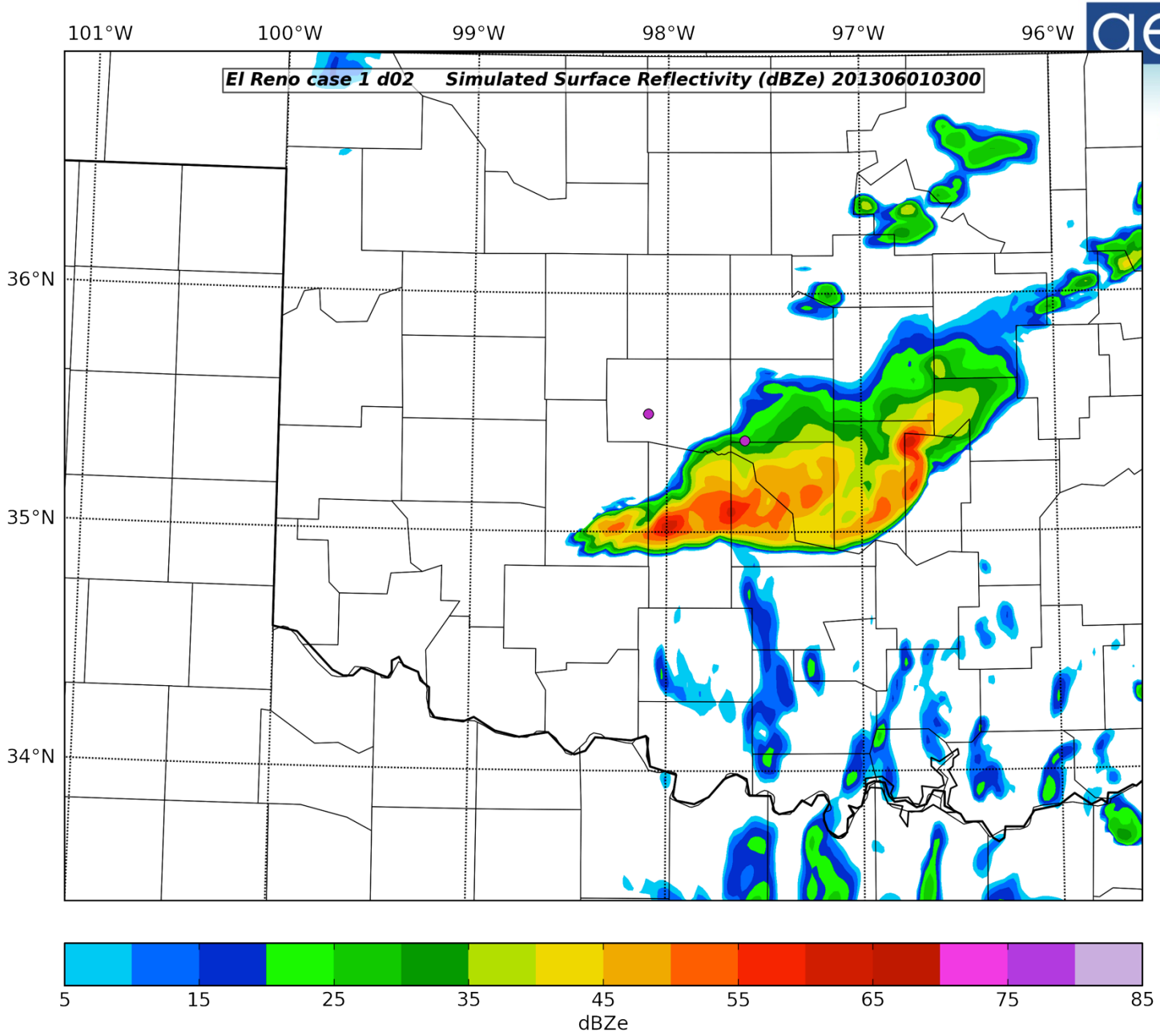


aer

Atmospheric and Environmental Research

Observed Radar Reflectivity

01Z June 1



aer

Atmospheric and Environmental Research

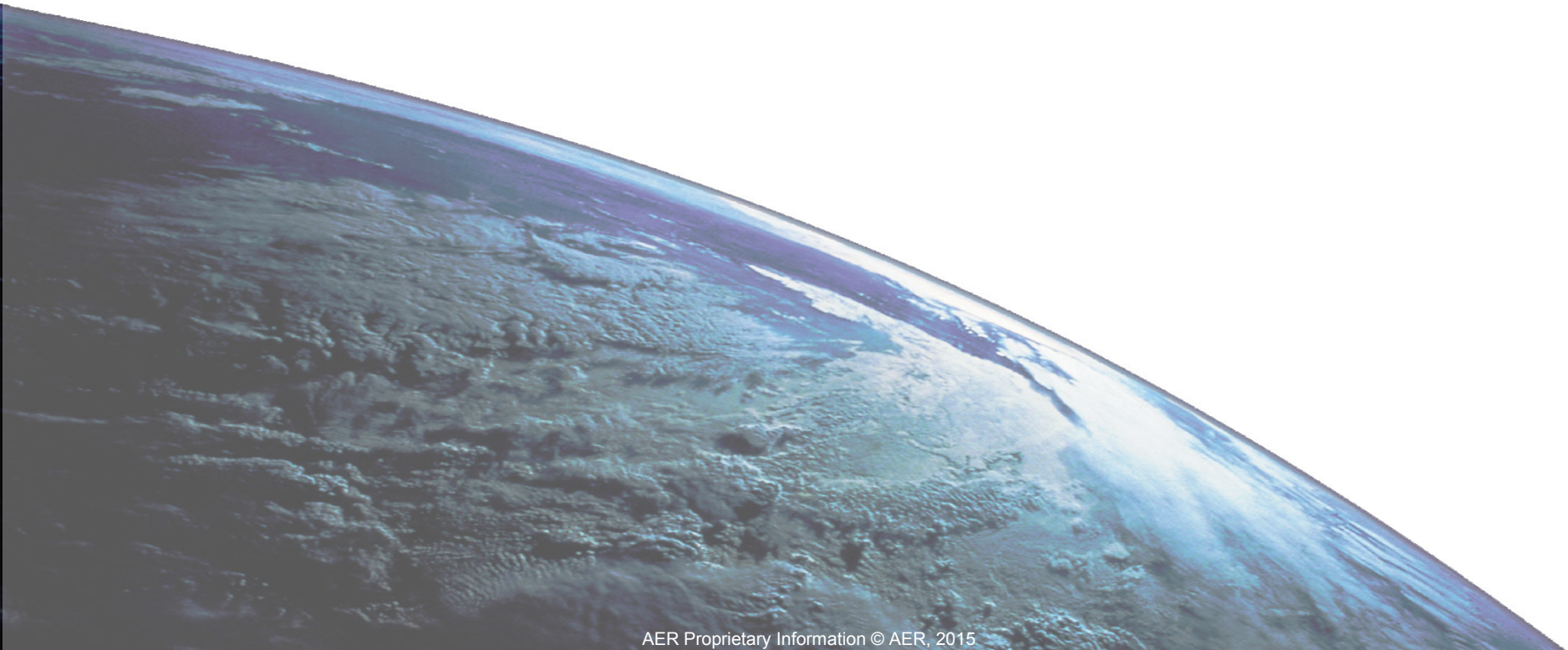
WRF Simulated Radar Reflectivity

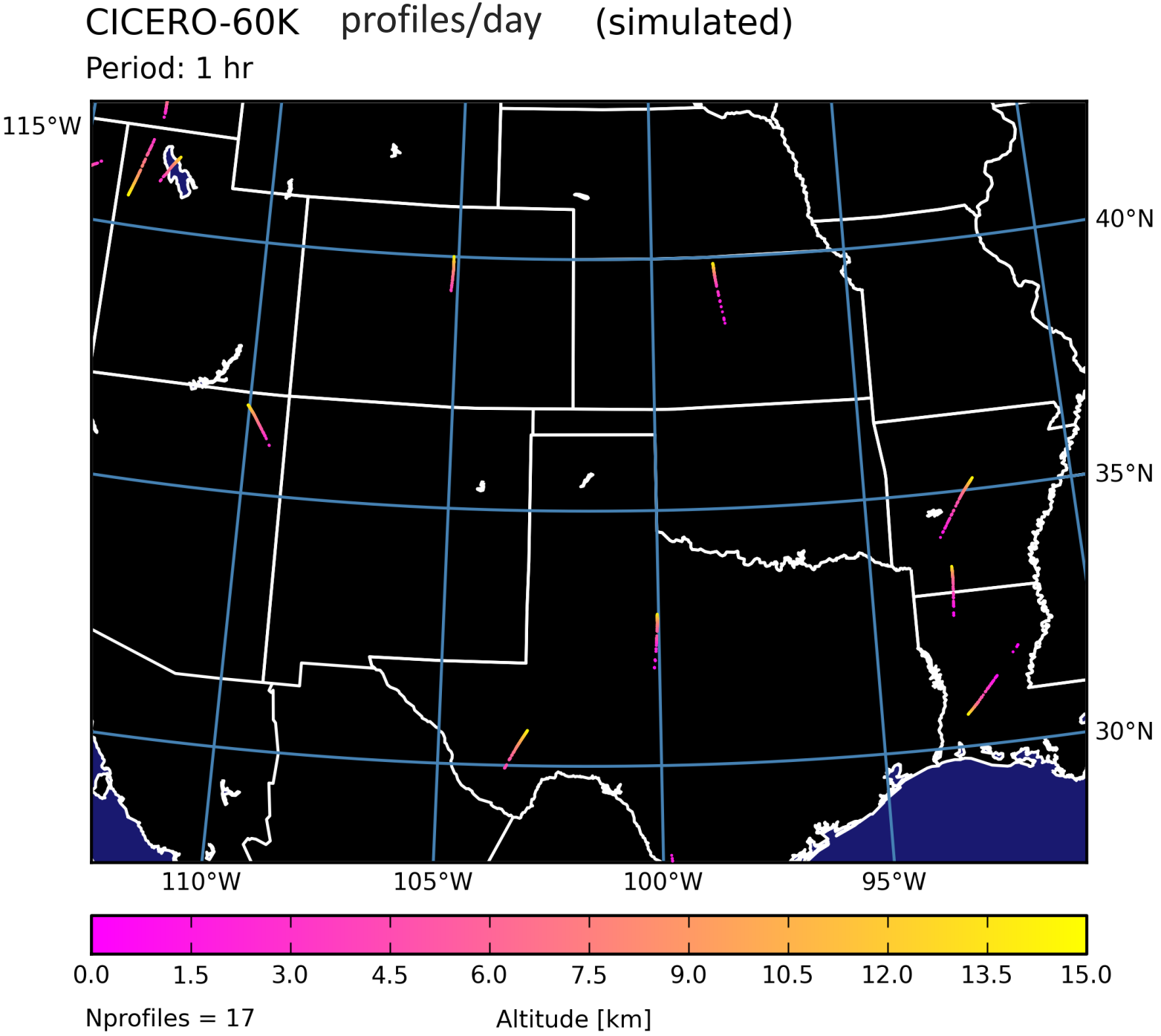
03Z June 1

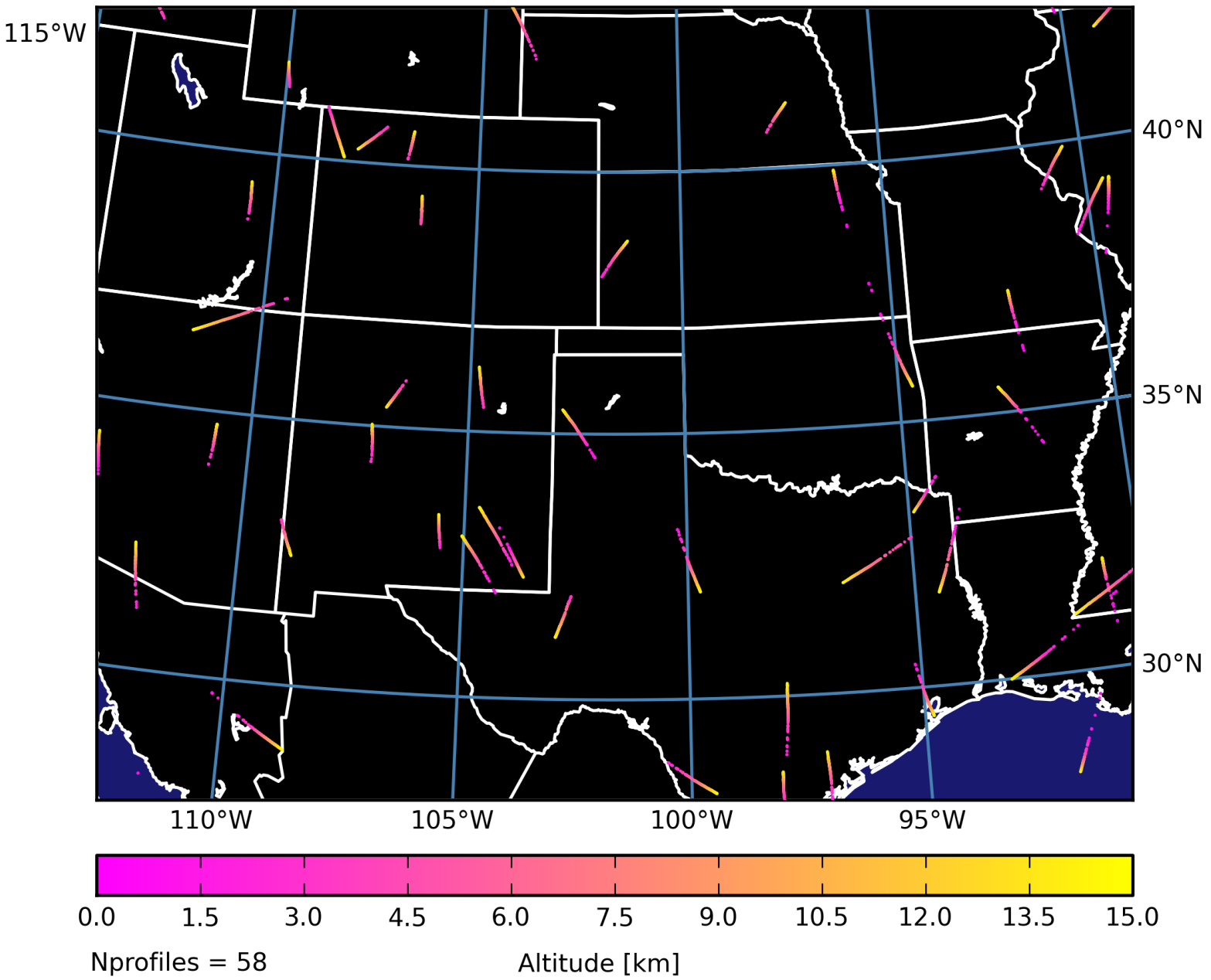
Simulating CICERO data (1/4)

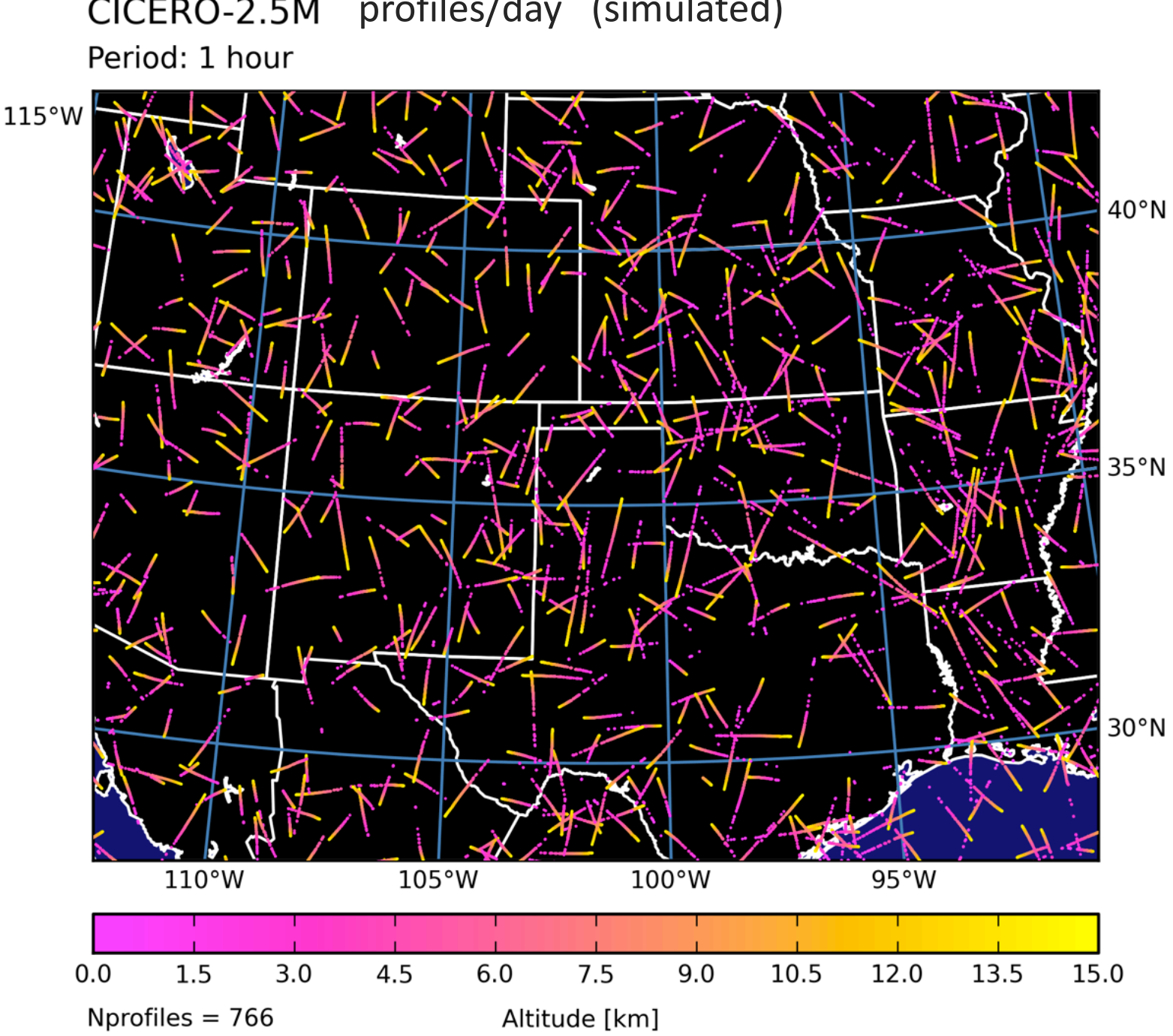
Atmospheric and Environmental Research

- transformation of real COSMIC -> simulated CICERO constellations

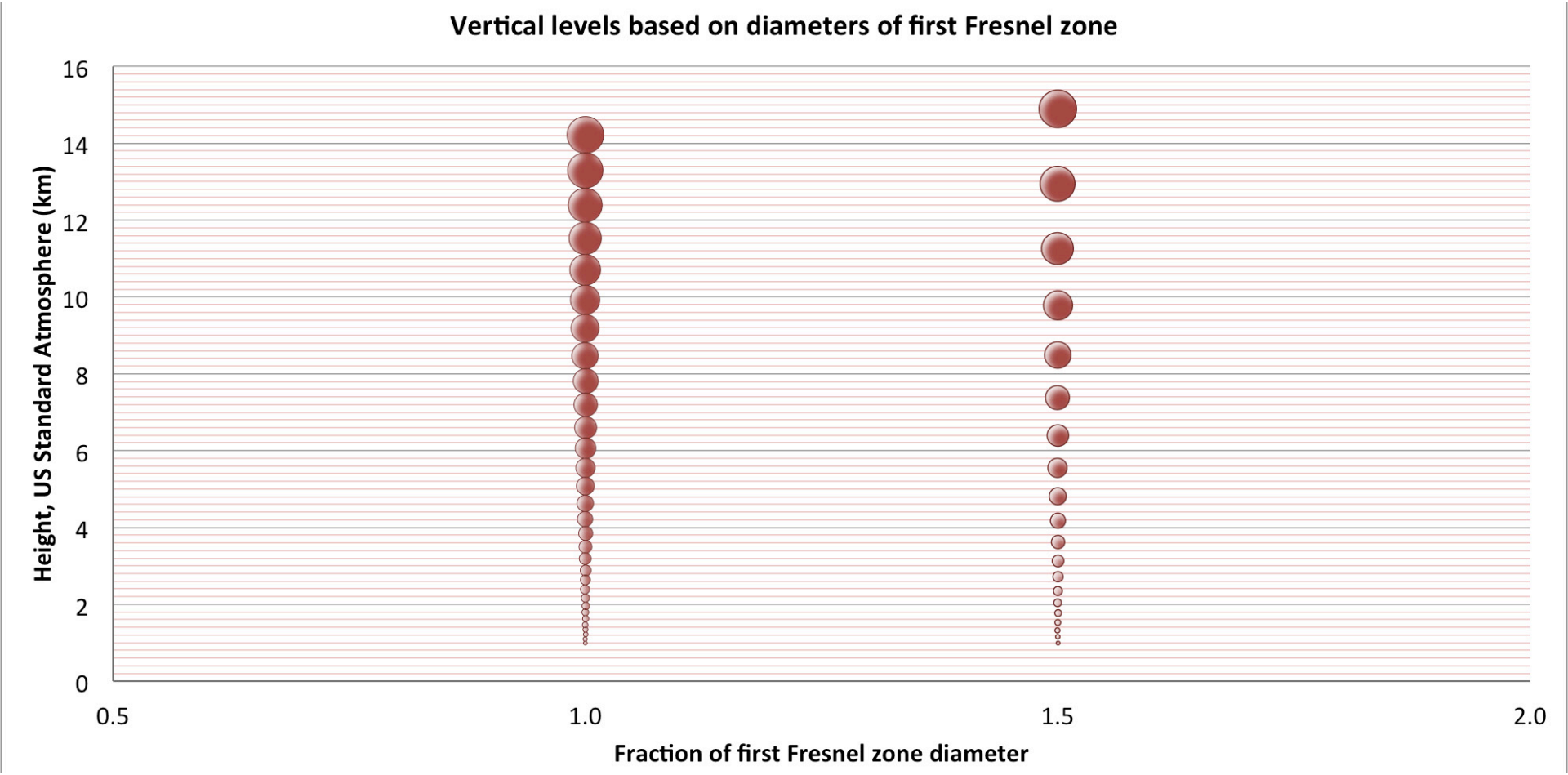



CICERO-60K profiles/day (simulated)
Period: 1 hr
115°W
40°N
35°N
30°N
110°W
105°W
100°W
95°W
0.0
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
13.5
15.0
Nprofiles = 17
Altitude [km]


CICERO-200K profiles/day (simulated)
Period: 1 hr
115°W
40°N
35°N
30°N
110°W
105°W
100°W
95°W
0.0
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
13.5
15.0
Nprofiles = 58
Altitude [km]

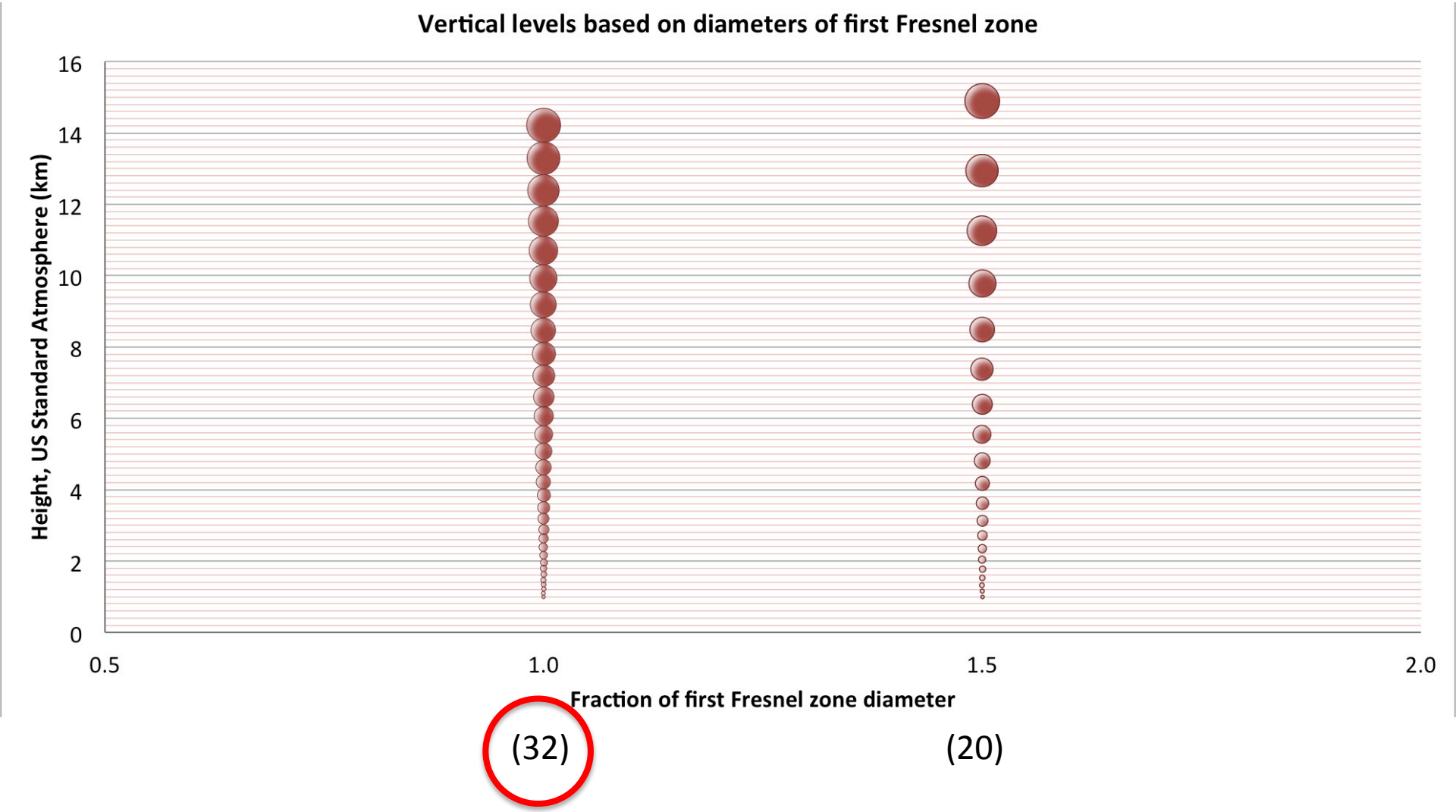

CICERO-2.5M profiles/day (simulated)
Period: 1 hour
115°W
40°N
35°N
30°N
110°W
105°W
100°W
95°W
0.0
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
13.5
15.0
Nprofiles = 766
Altitude [km]

Vertical thinning



(32) (20)

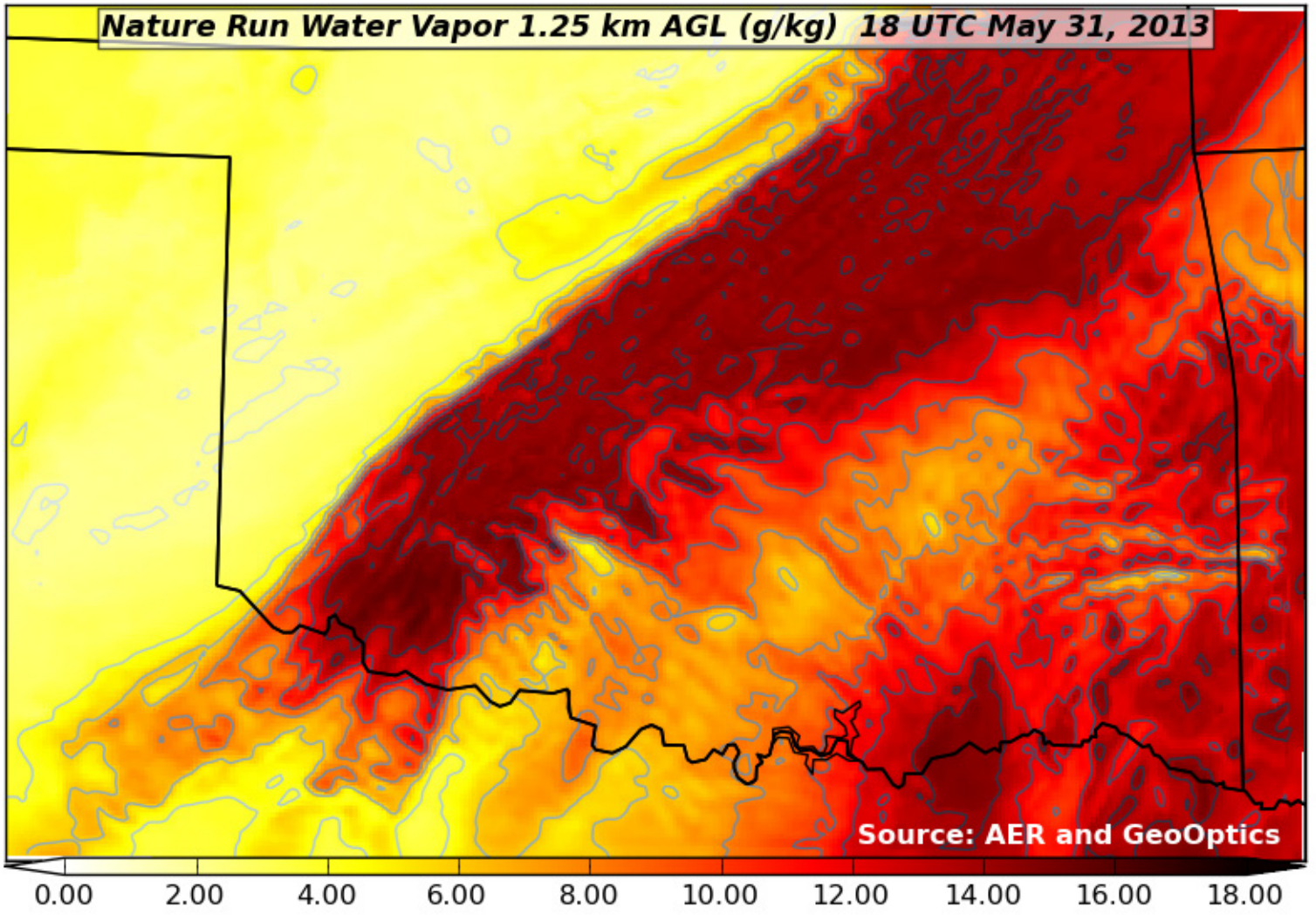
Vertical thinning



(32)

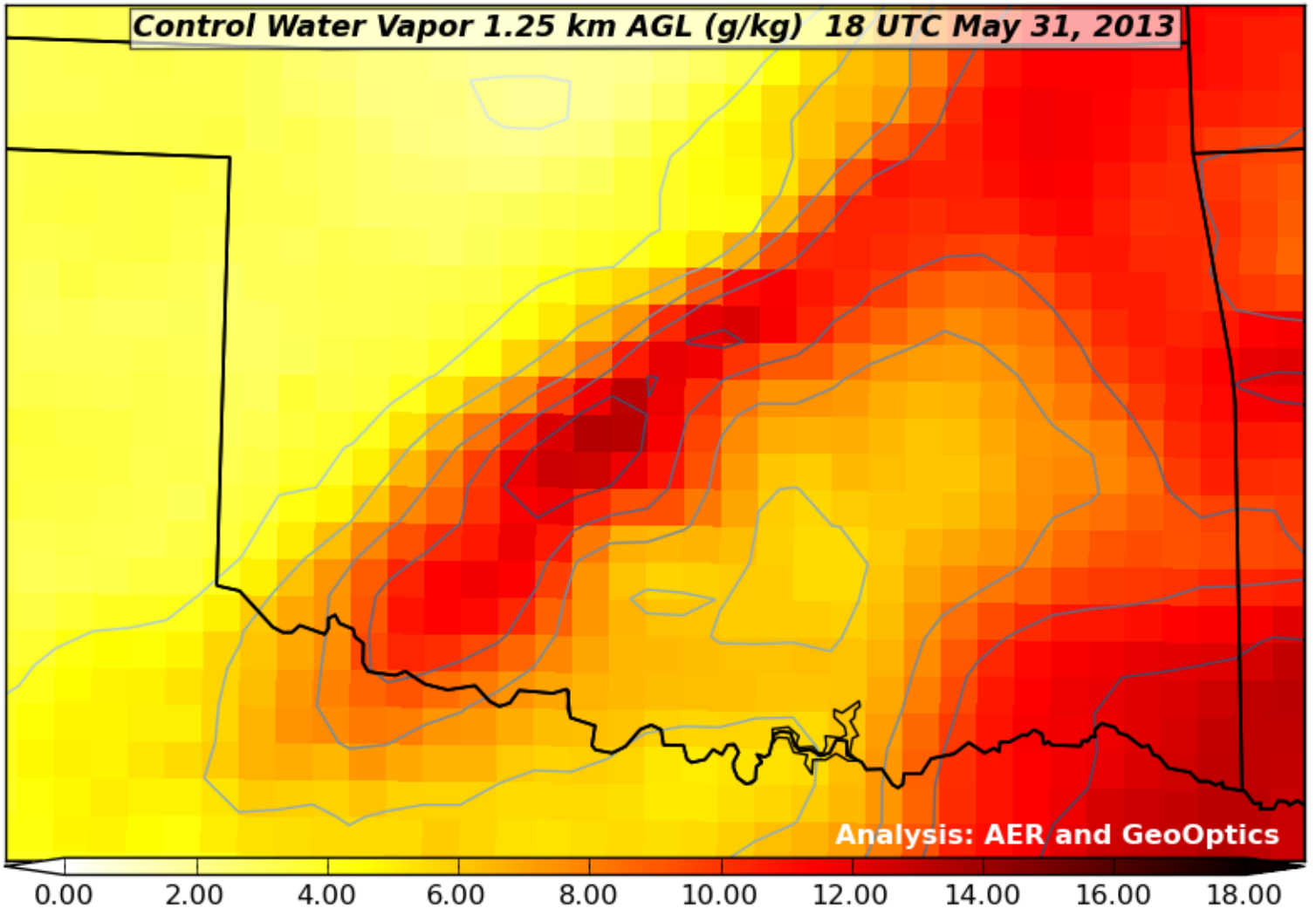
(20)

Analysis Impacts on water vapor (1/4)



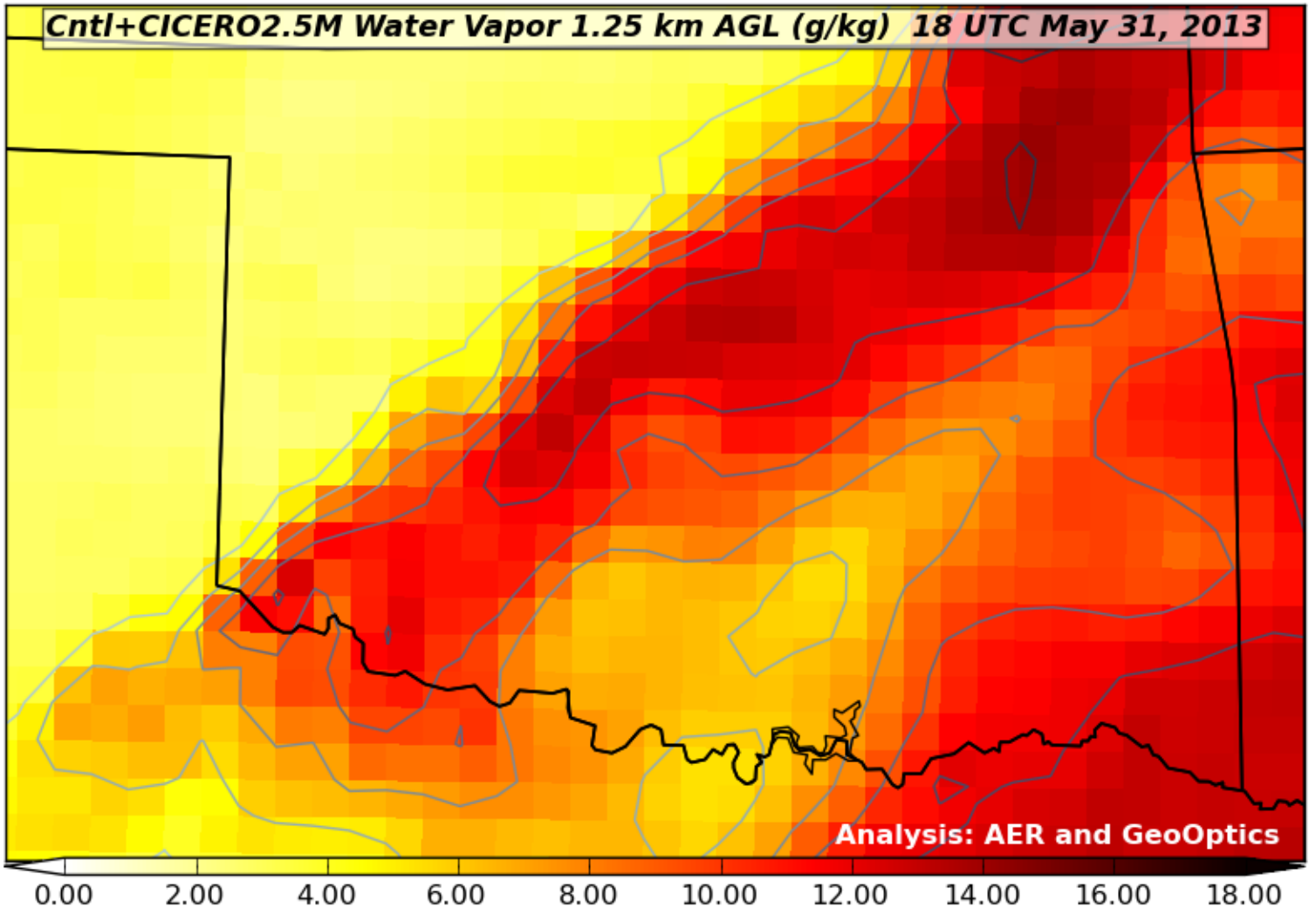
Note: Nature Run grid has a horizontal resolution of 2 km.

Analysis Impacts on water vapor (2/4)



Note: OSSE data assimilation grid has a horizontal resolution of 18 km.

Analysis Impacts on water vapor (3/4)



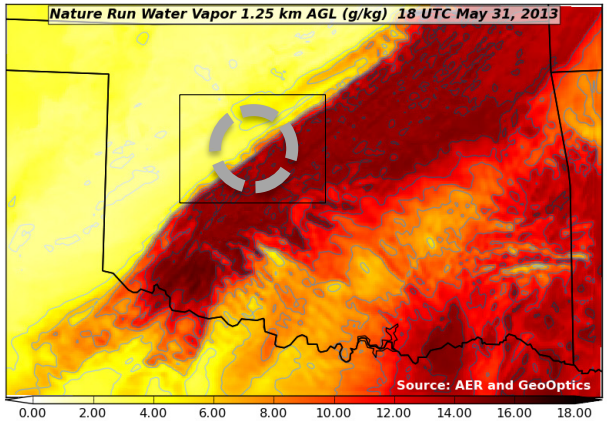
Note: OSSE data assimilation grid has a horizontal resolution of 18 km.

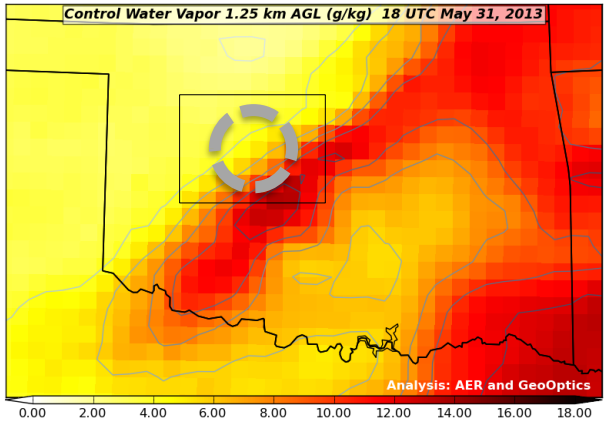
Analysis Impacts on water vapor (4/4)

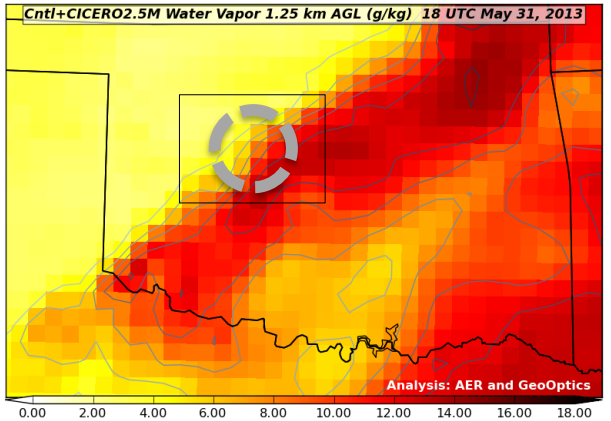
Nature Run "truth"

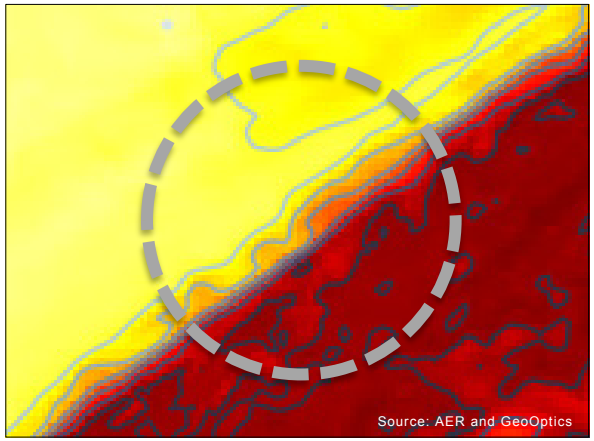
Control (no RO)

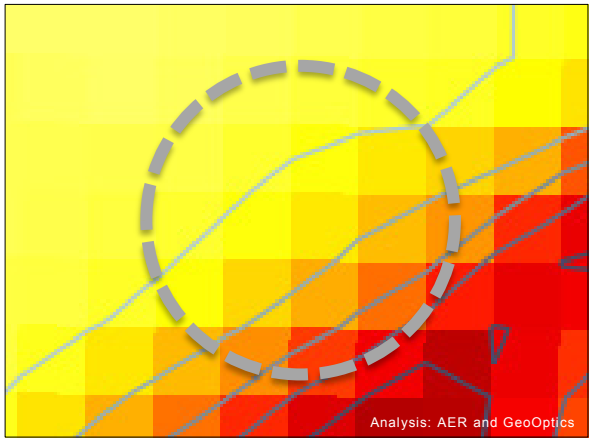
Control + GNSS-RO

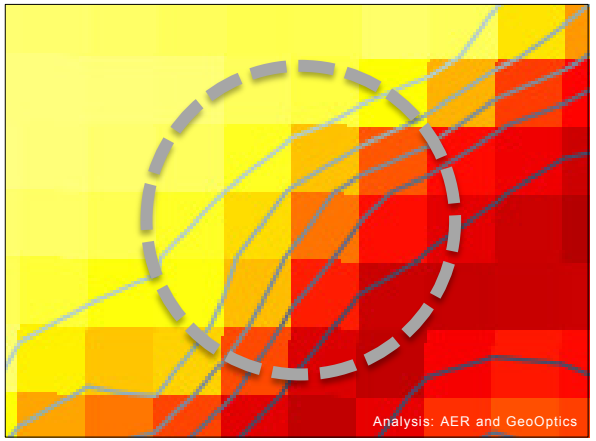


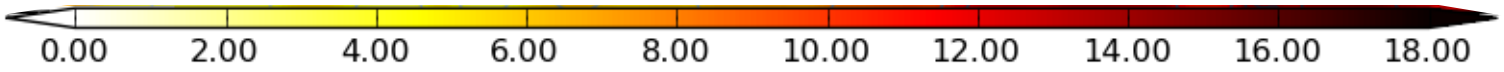






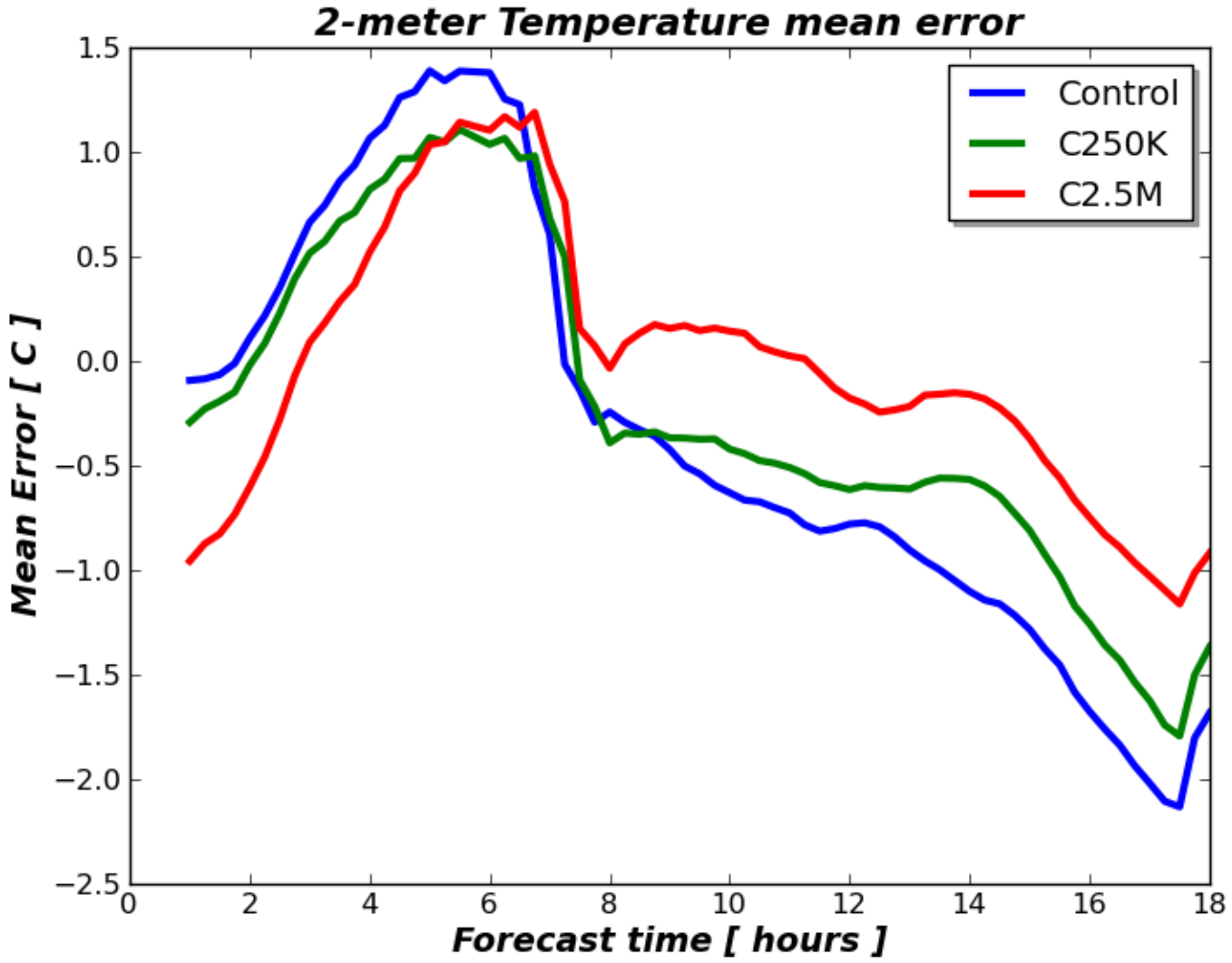






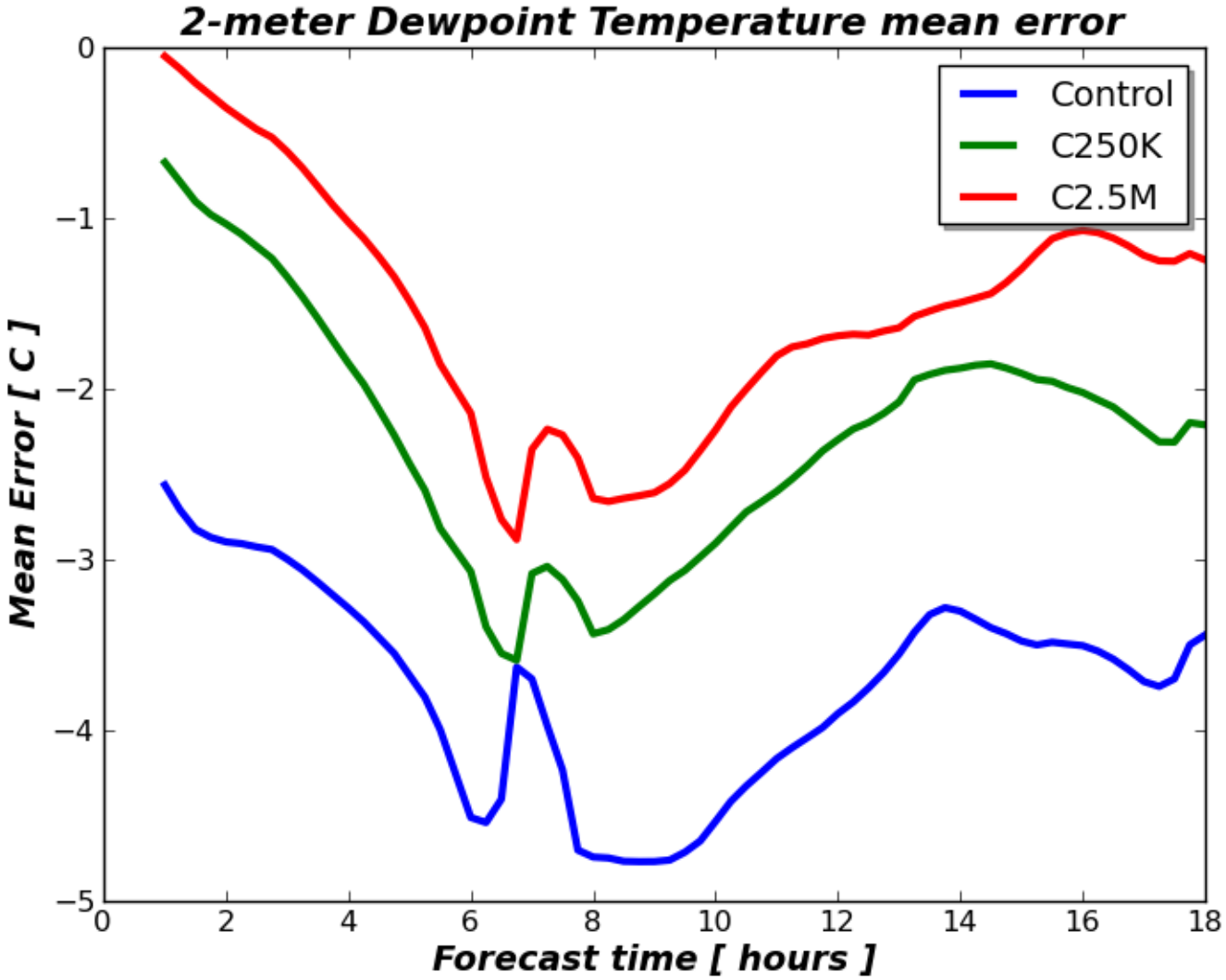
Forecast Impacts (1/4)

Surface Sensible Weather



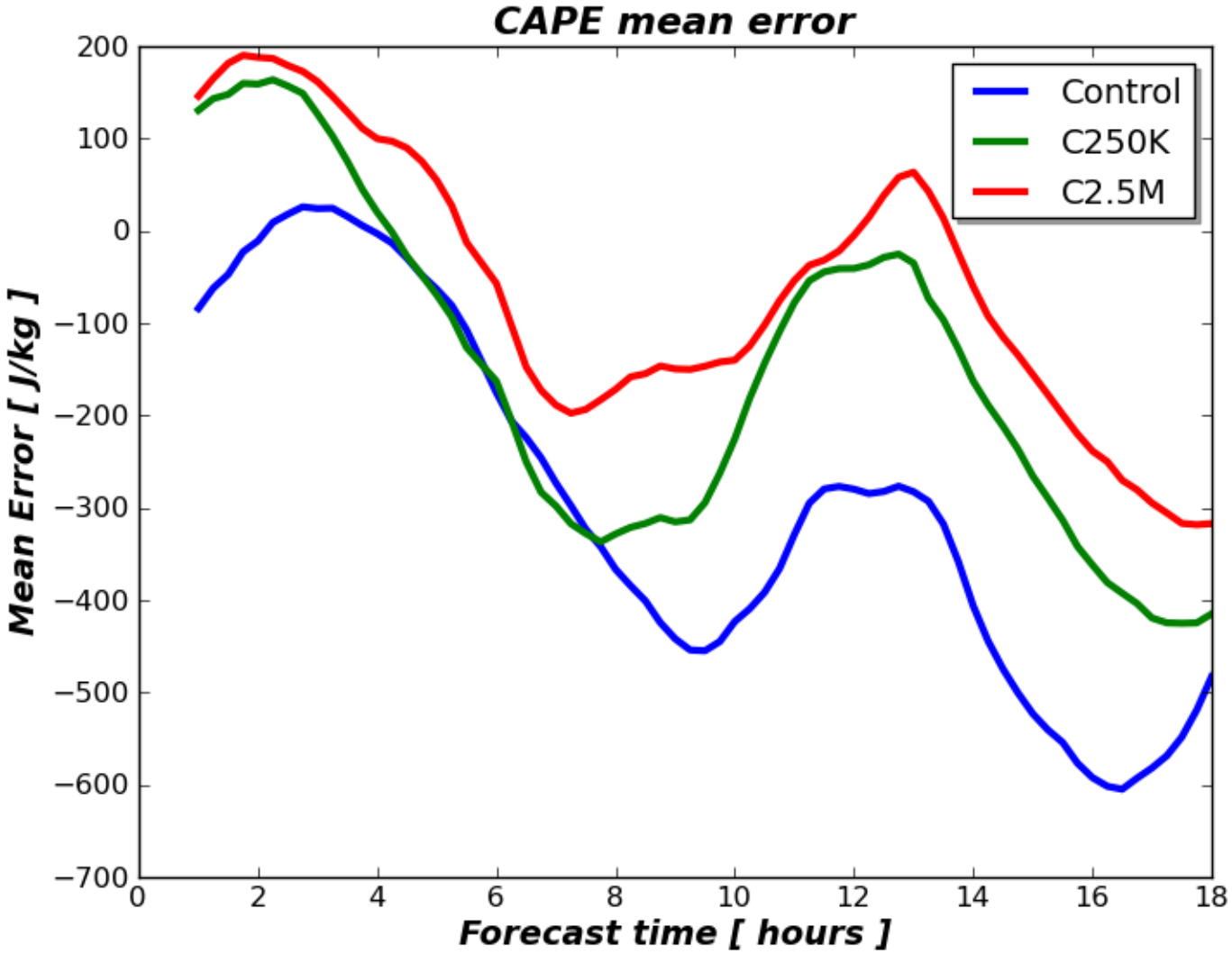
Forecast Impacts (2/4)

Surface Sensible Weather



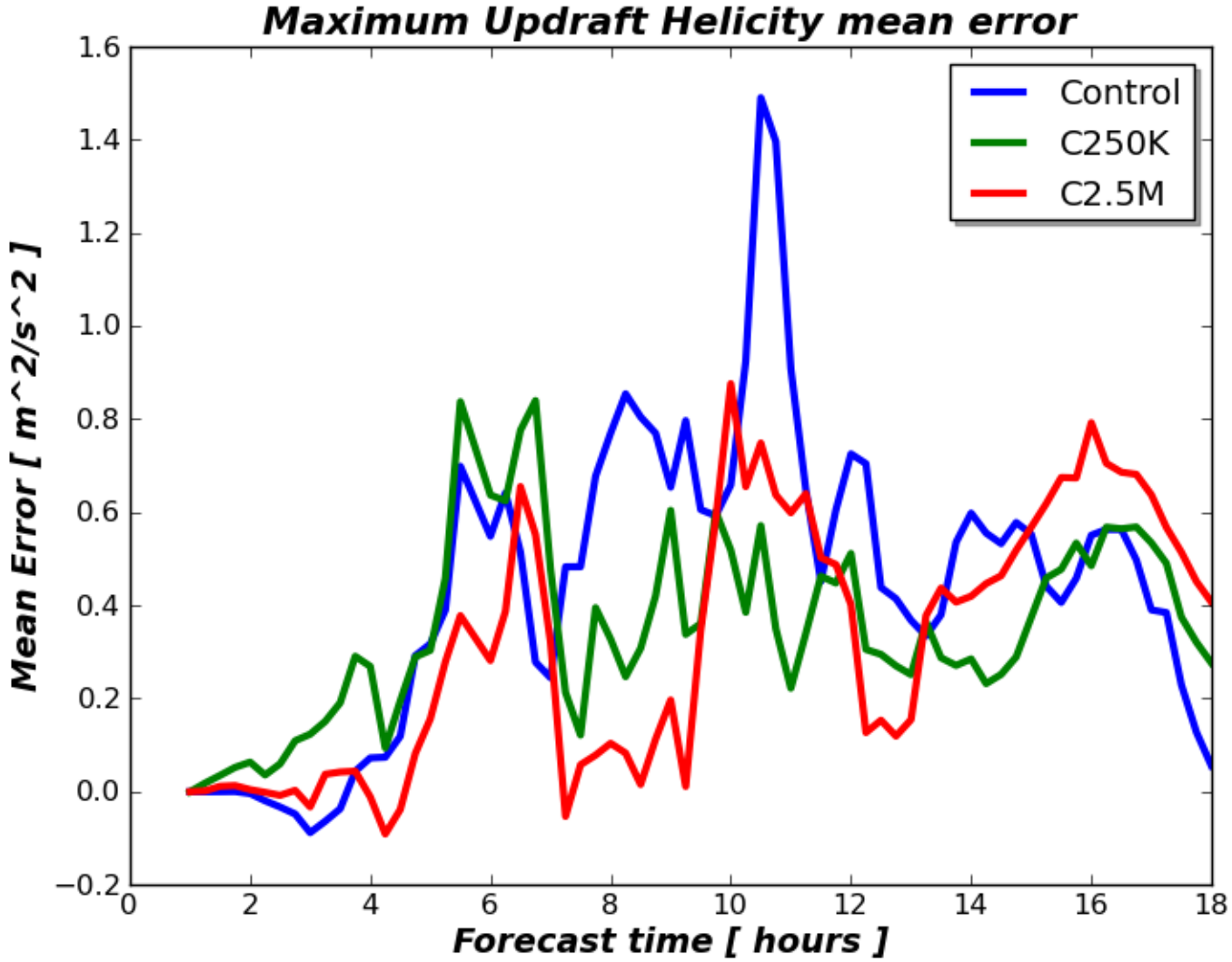
Forecast Impacts (3/4)

Vertically Integrated Quantity



Forecast Impacts (4/4)

Vertically Integrated Quantities



Conclusions and looking ahead

- An OSSE to explore the impact of very large GNSS RO constellations is nearly done.
- 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.
- Currently finishing a broad validation across many variables.
- Currently writing a journal article for publication shortly.
- Hope to extend this work to evaluate impacts on a diverse set of cases.

Thank you for your attention!