Off-line constraints on NEI2011 NOx emissions using CMAQ/GSI/OMI Tropospheric NO2 Data Assimilation

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Aura Chemical Reanalysis in support Air Quality Applications

July 2011 CMAQ NOx emissions sensitivity studies

In support of the Lake Michigan Air Directors Consortium (LADCO) State Implementation Plan (SIP) modeling we are conducting July 2011 CMAQ simulations to investigate:

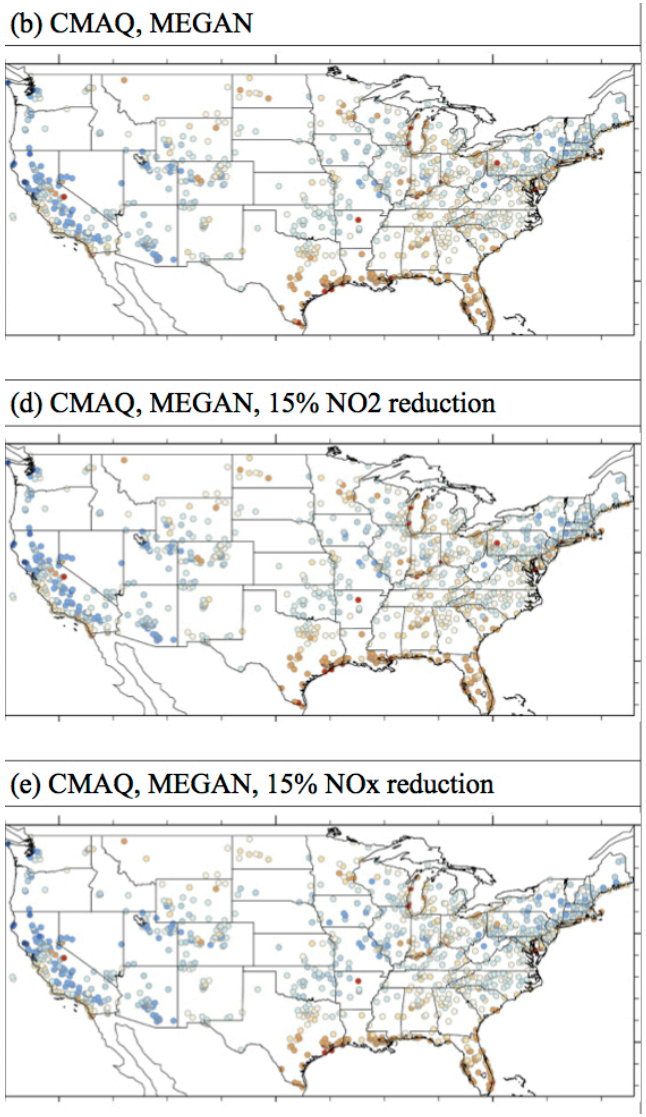
- how model bias in ozone precursors (NO2 and HCHO as proxies for total NOx and VOCs) is sensitive to model processes and emissions inputs

- how simulated ozone is sensitive to changes in precursors, via changing model processes and inputs

The CMAQ NOx emission sensitivity studies, along with CMAQ/GSI OMI NO2 Data Assimilation (DA), are used to adjust NEI 2011 NOx emission inventories

July 2011 CMAQ NOx emissions sensitivity studies: Ozone Response

July 2011 MDA8 ozone



Eastern US	RMSE	Mean Error	Mean Fractional Error	Mean Bias	Mean Fractional Bias	r^2
CMAQ, MEGAN	6.56	5.8	15.9	2.06	4.11	0.15
CMAQ, MEGAN, 15% NO_2 reduction	6.52	5.77	15.87	1.97	3.89	0.15
CMAQ, MEGAN, 15% NO_X reduction	6.08	5.49	15.38	1.2	1.94	0.14

Western US	RMSE	Mean Error	Mean Fractional Error	Mean Bias	Mean Fractional Bias	r^2
CMAQ, MEGAN	4.96	4.08	11.69	-2.77	-7.89	0.6
CMAQ, MEGAN, 15% NO_2 reduction	4.99	4.09	11.73	-2.83	-8.05	0.6
CMAQ, MEGAN, 15% NO_X reduction	5.25	4.18	12.06	-3.34	-9.53	0.6

July 2011 CMAQ NOx emissions sensitivity studies: Ozone Response

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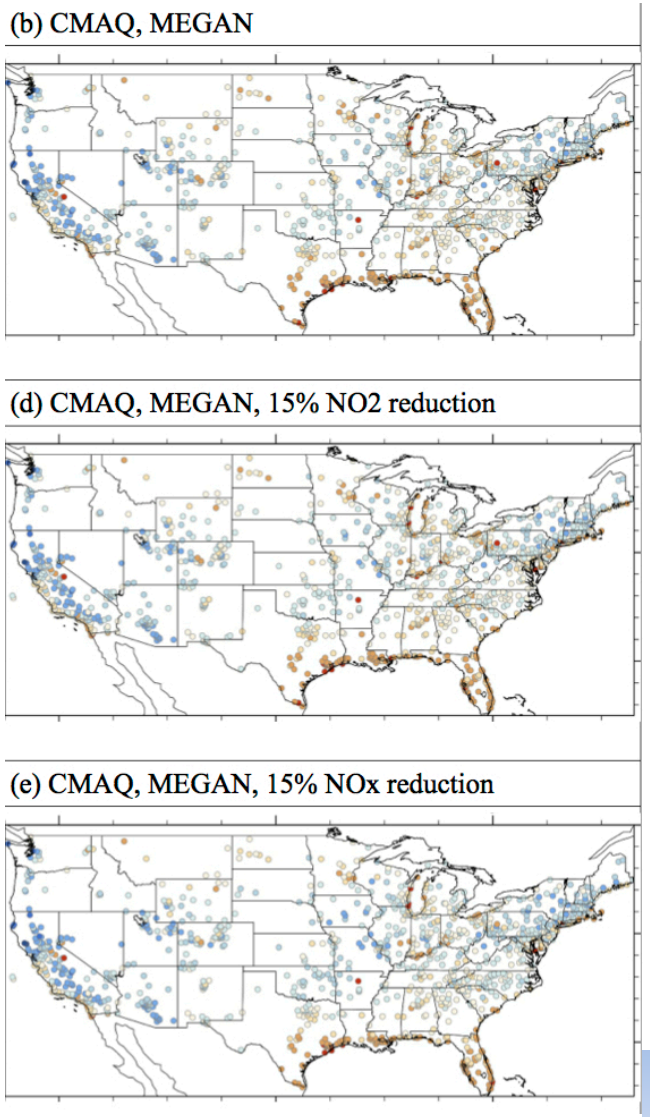

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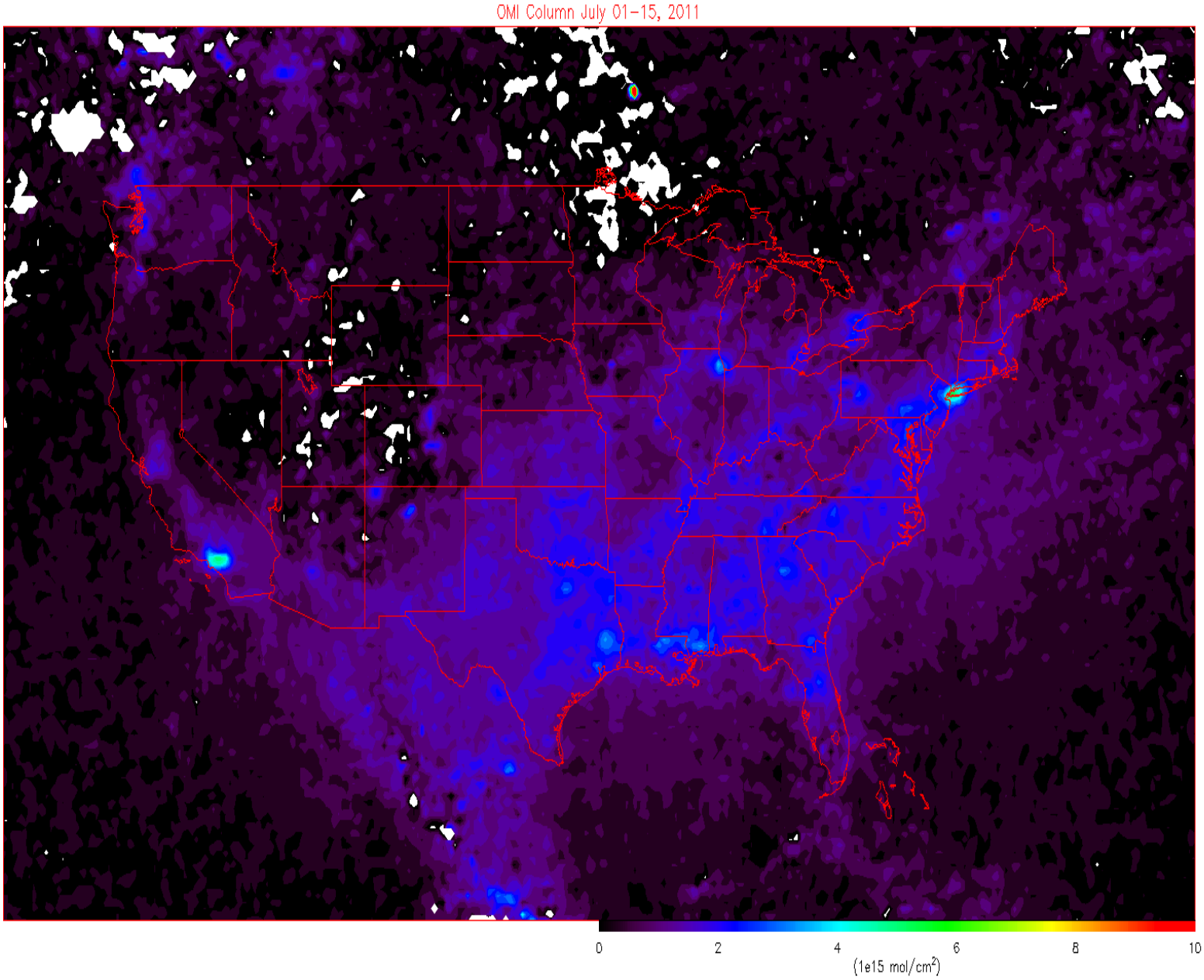
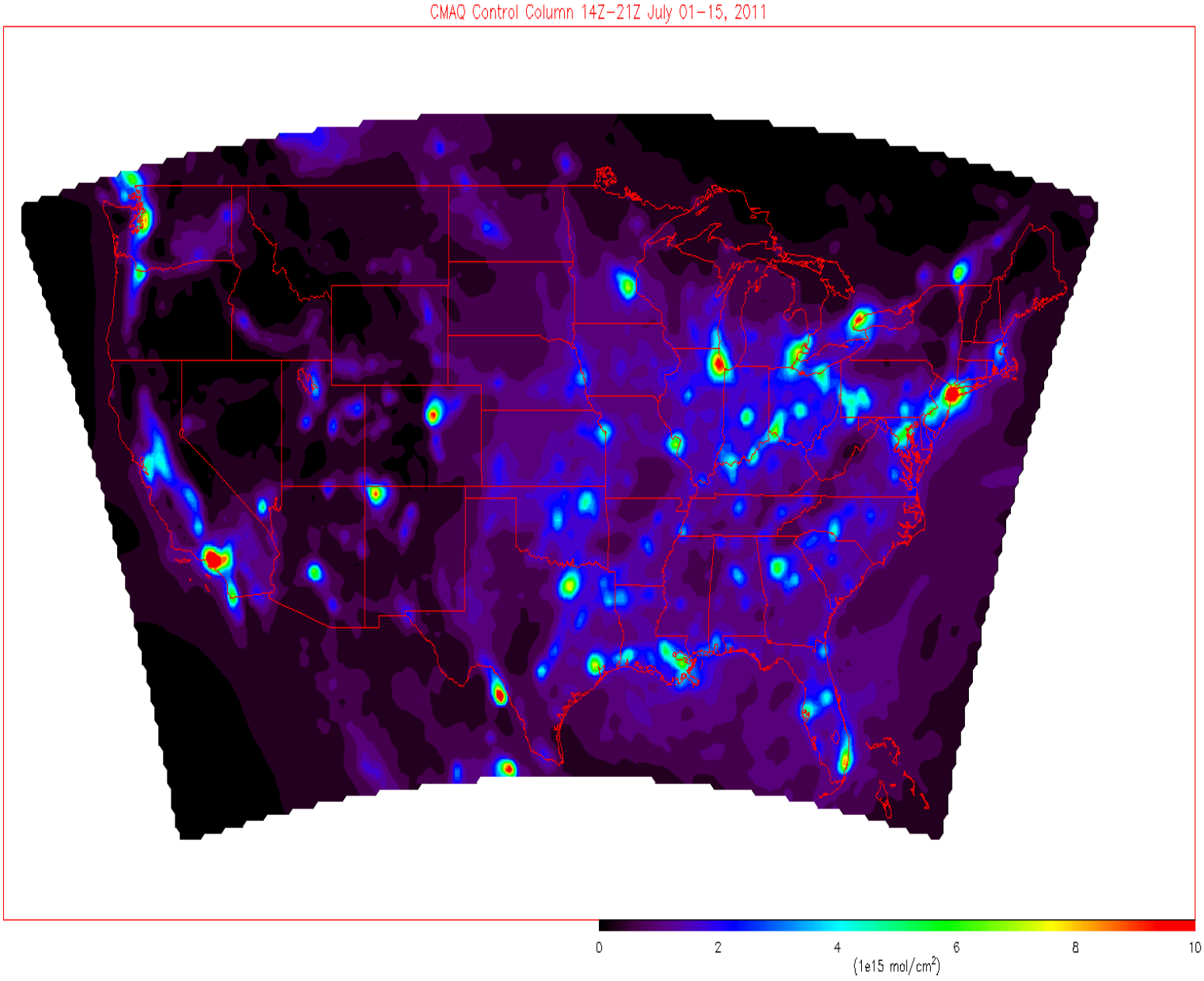
Uniform 15% NOx reductions improves agreement between CMAQ and observed July 2011 MDA8 ozone in the Eastern US but worsens the agreement in the Western US

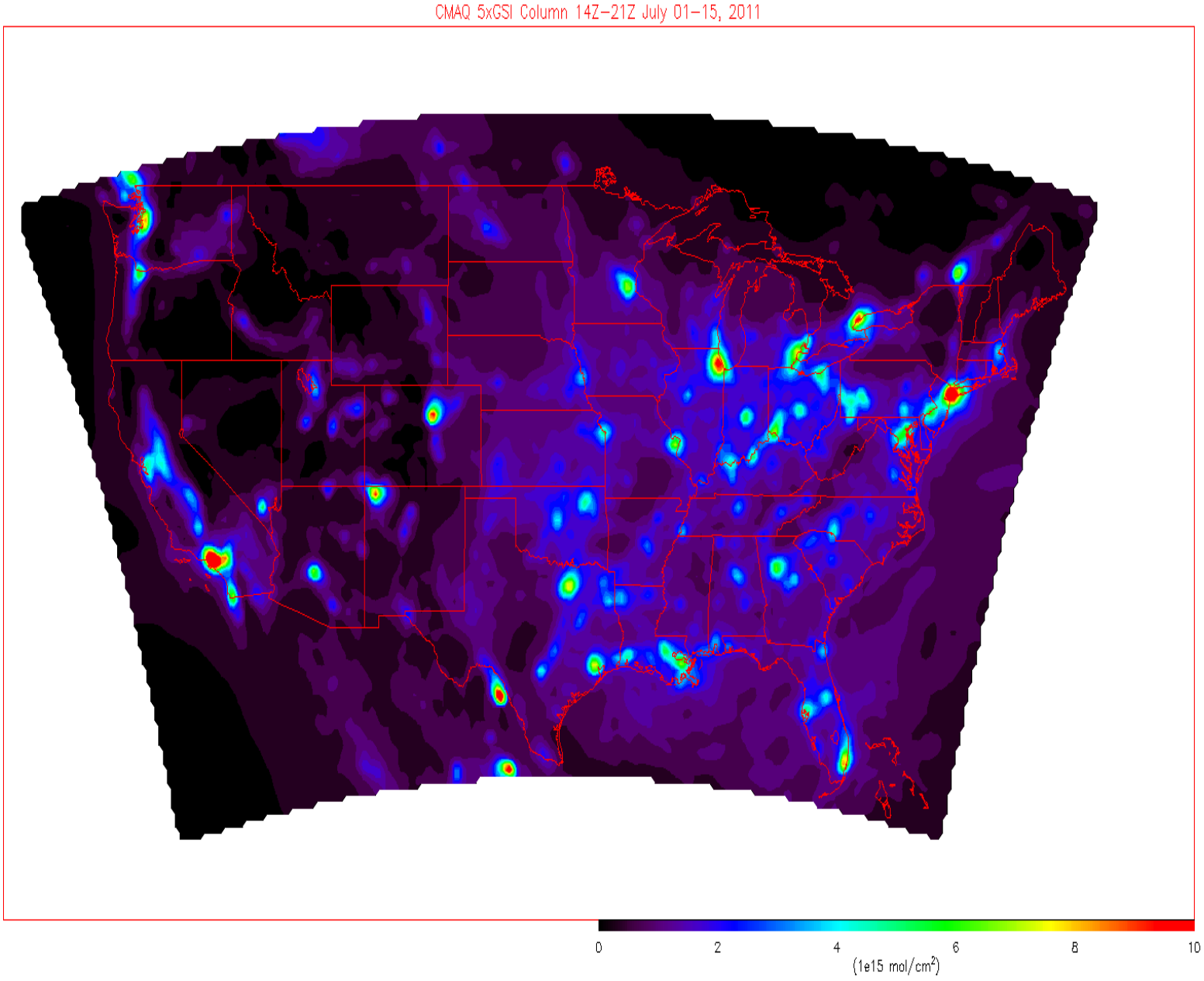
OMI Tropospheric NO2 Column July 1-15, 2011



CMAQ Control Tropospheric NO2 Column July 1-15, 2011



CMAQ GSI/OMI DA Tropospheric NO2 Column July 1-15, 2011



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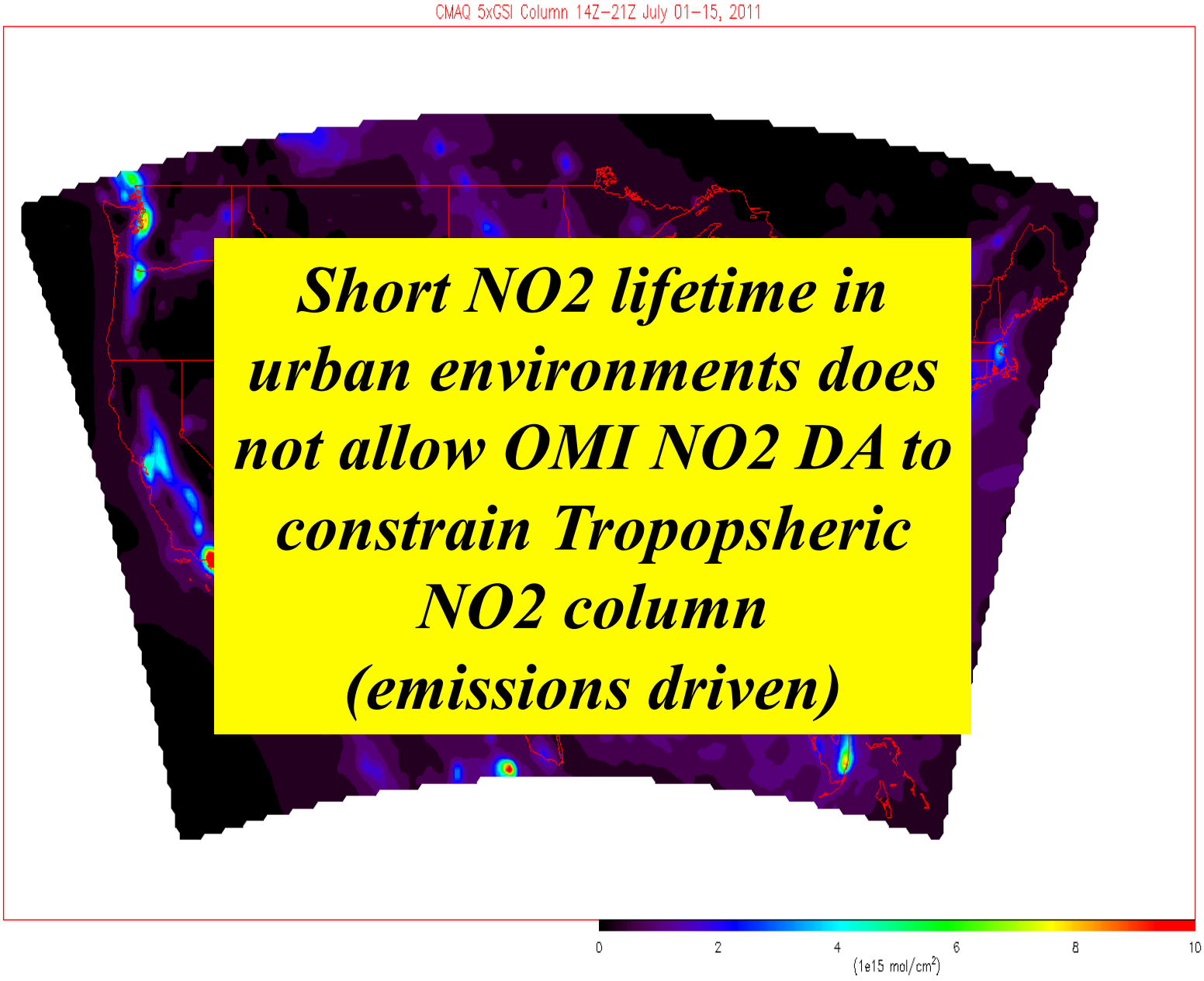
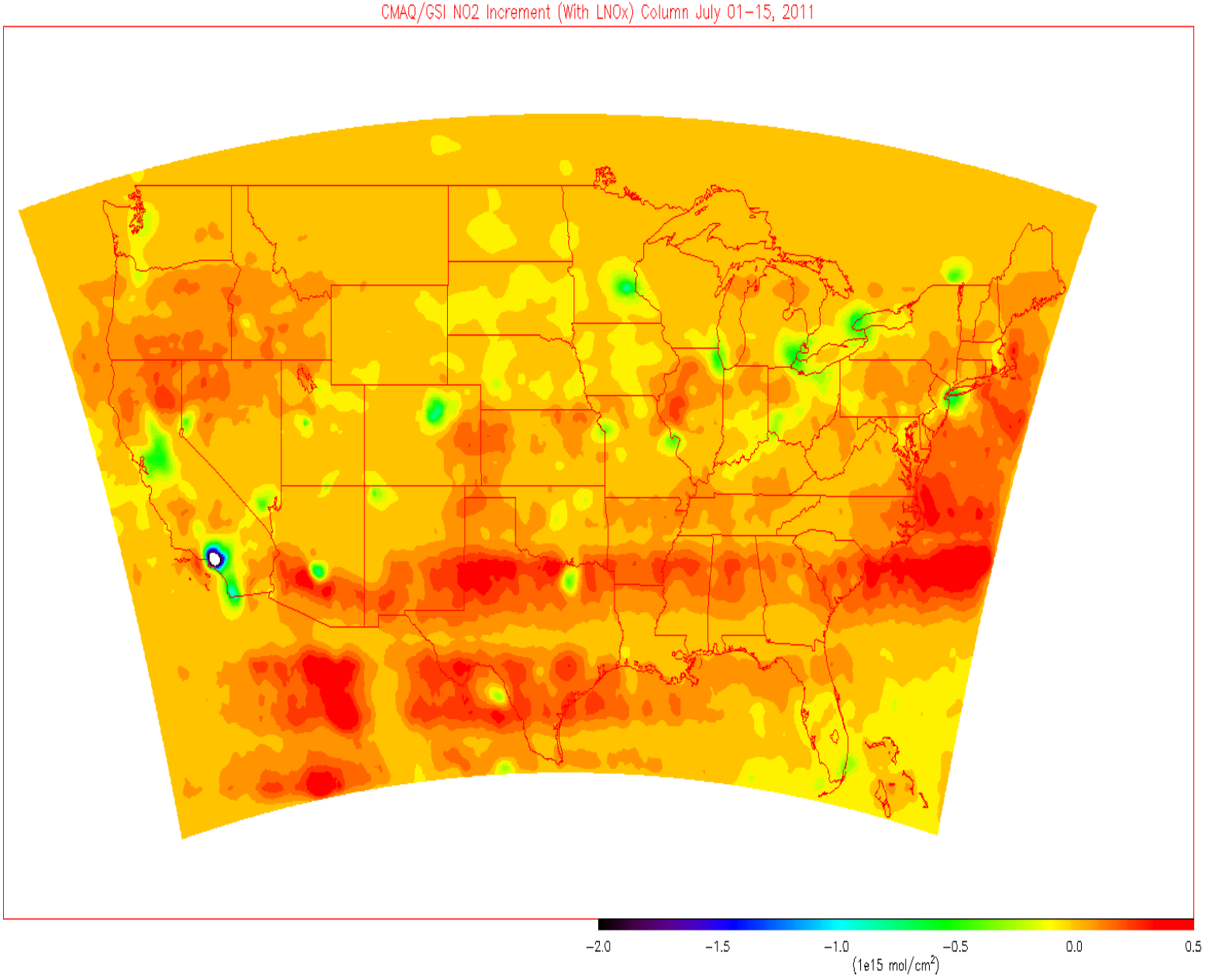


CMAQ GSI/OMI DA NO2 Column *Increment* July 1-15, 2011



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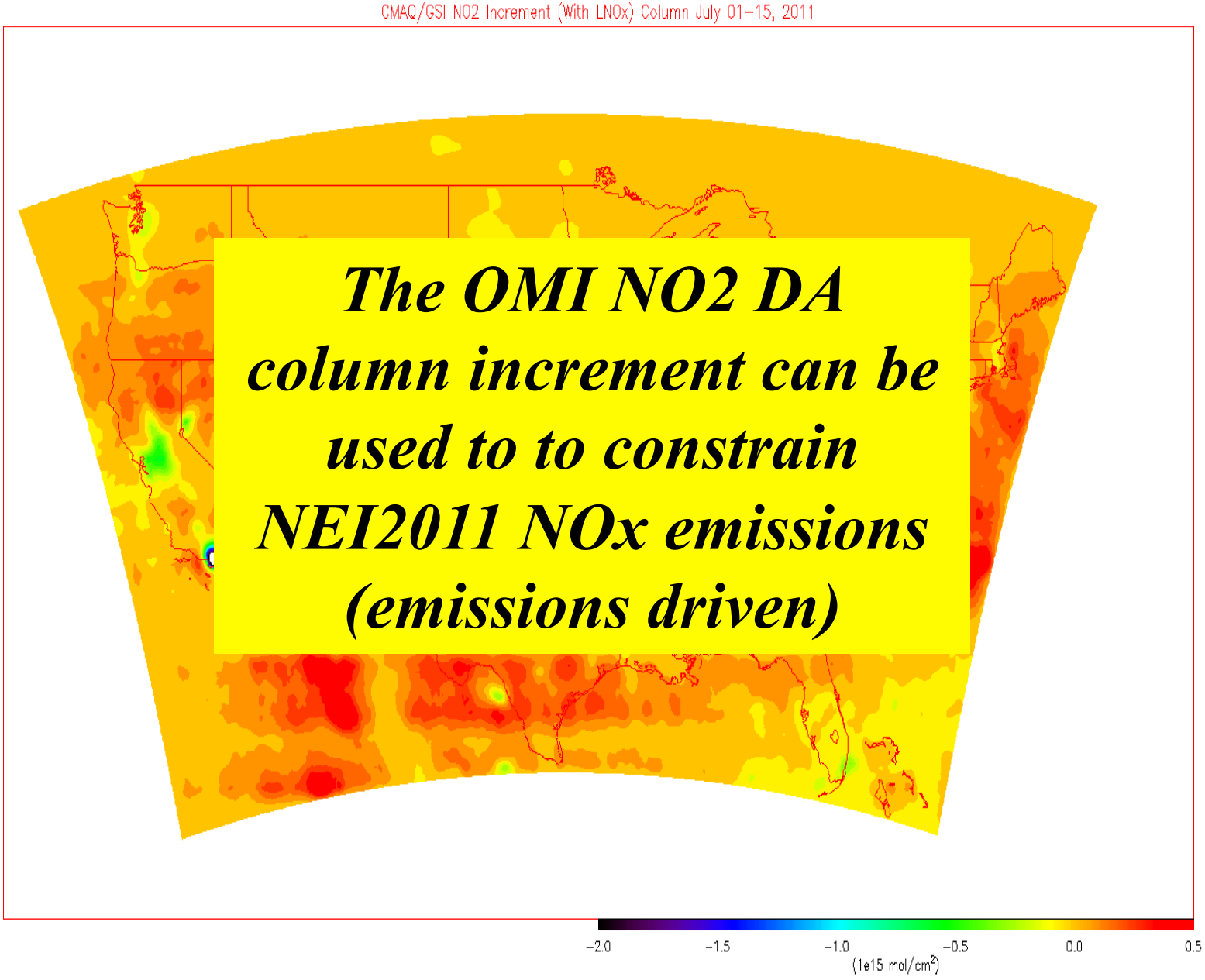
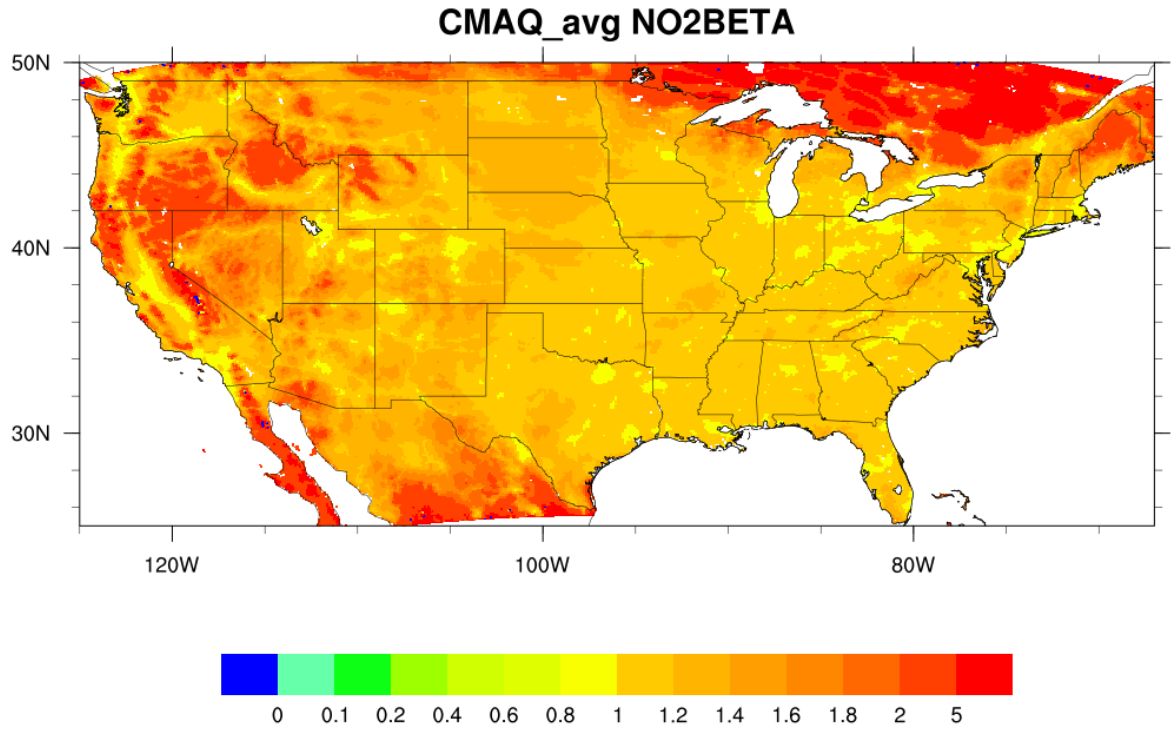


Adjusting NEI 2011 Area Sources using Mean GSI OMI NO2 Analysis Increment



Monthly mean ***NO2 Jacobians*** (β=normalized delta-Emissions/normalized delta-NO2) are computed from a 2011 CMAQ 15% NOx emission perturbation experiment following (Lamsal, et al, 2011)

$$\frac{\Delta E}{E} = \boxed{\beta} \times \frac{\Delta \Omega}{\Omega}.$$

Monthly mean tropospheric ***NO2 Analysis Increments*** are computed from the 2011 CMAQ/GSI OMI NO2 assimilation (used to define normalized delta-NO2)

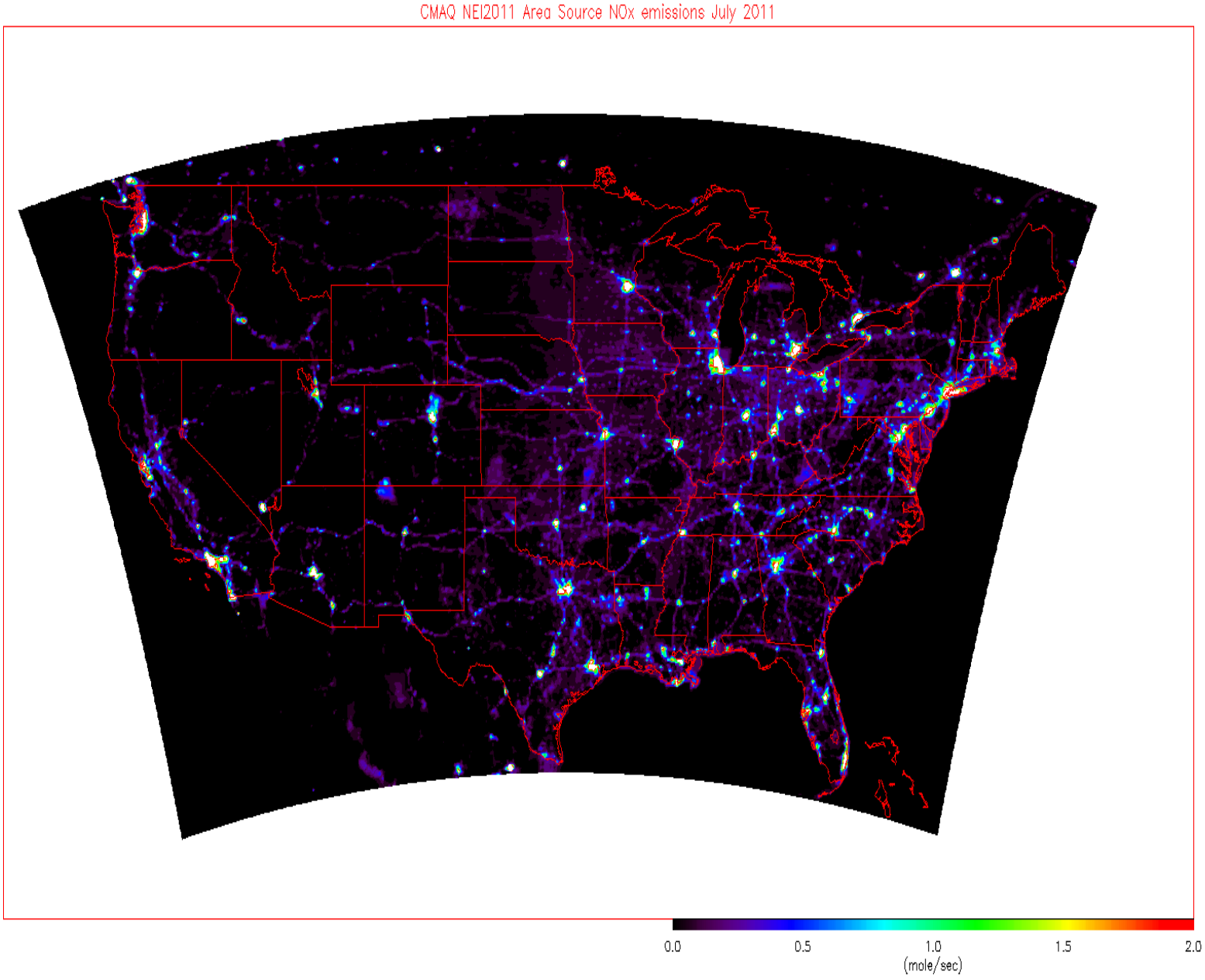
$$\frac{\Delta E}{E} = \beta \times \boxed{\frac{\Delta \Omega}{\Omega}}.$$

delta-NO2 from OMI NO2 DA and Jacobian (β) from NO2 emissions perturbation experiment are used to ***adjust NEI 2011 NO2 emissions***

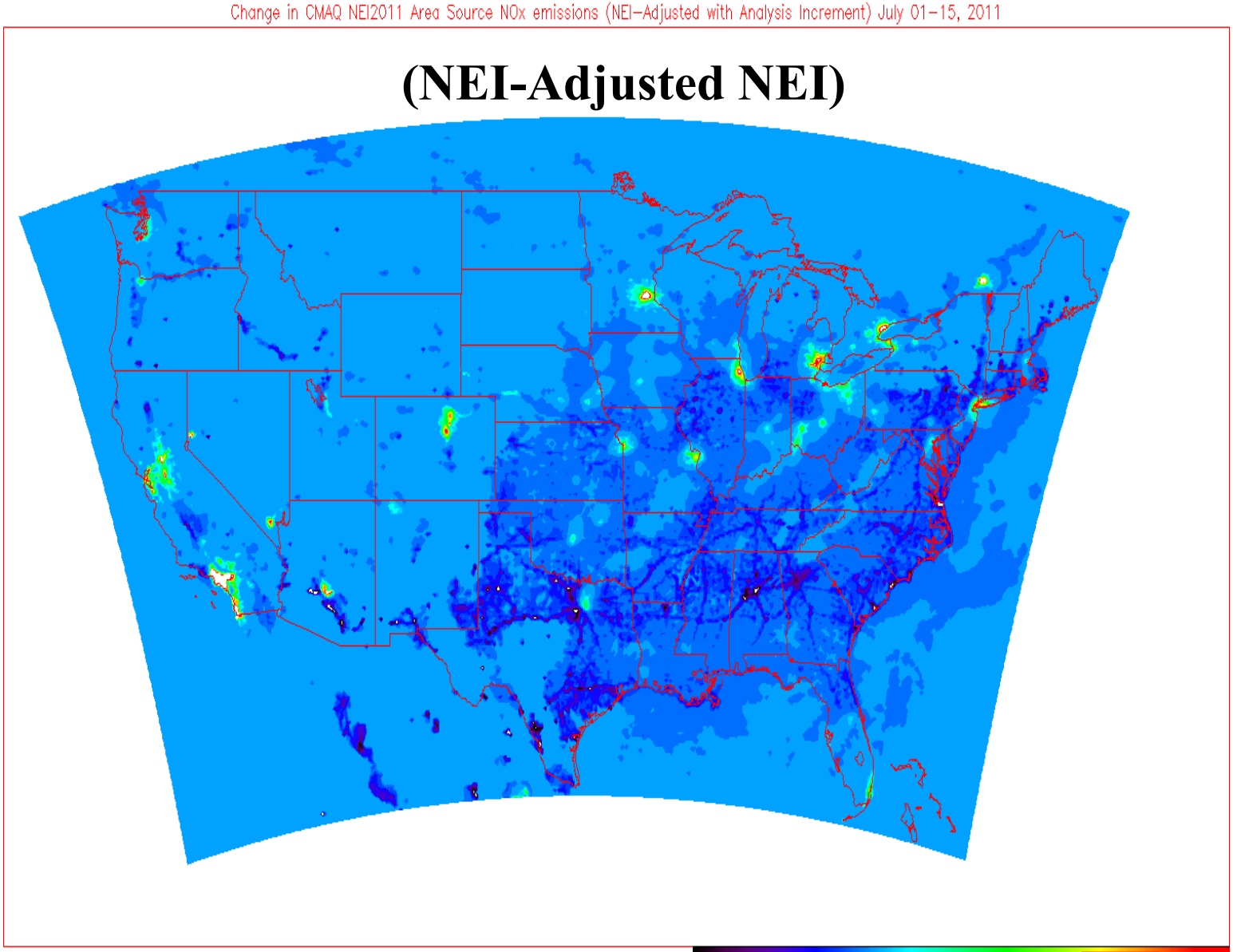
$$\boxed{\frac{\Delta E}{E}} = \beta \times \frac{\Delta \Omega}{\Omega}.$$

Lamsal, L. N., et al. (2011), Application of satellite observations for timely updates to global anthropogenic NOx emission inventories, Geophys. Res. Lett., 38, L05810, doi:10.1029/2010GL046476.

NEI 2011 Area Source NOx emissions July 1-15, 2011



Change in NEI 2011 Area Source NOx emissions July 1-15, 2011



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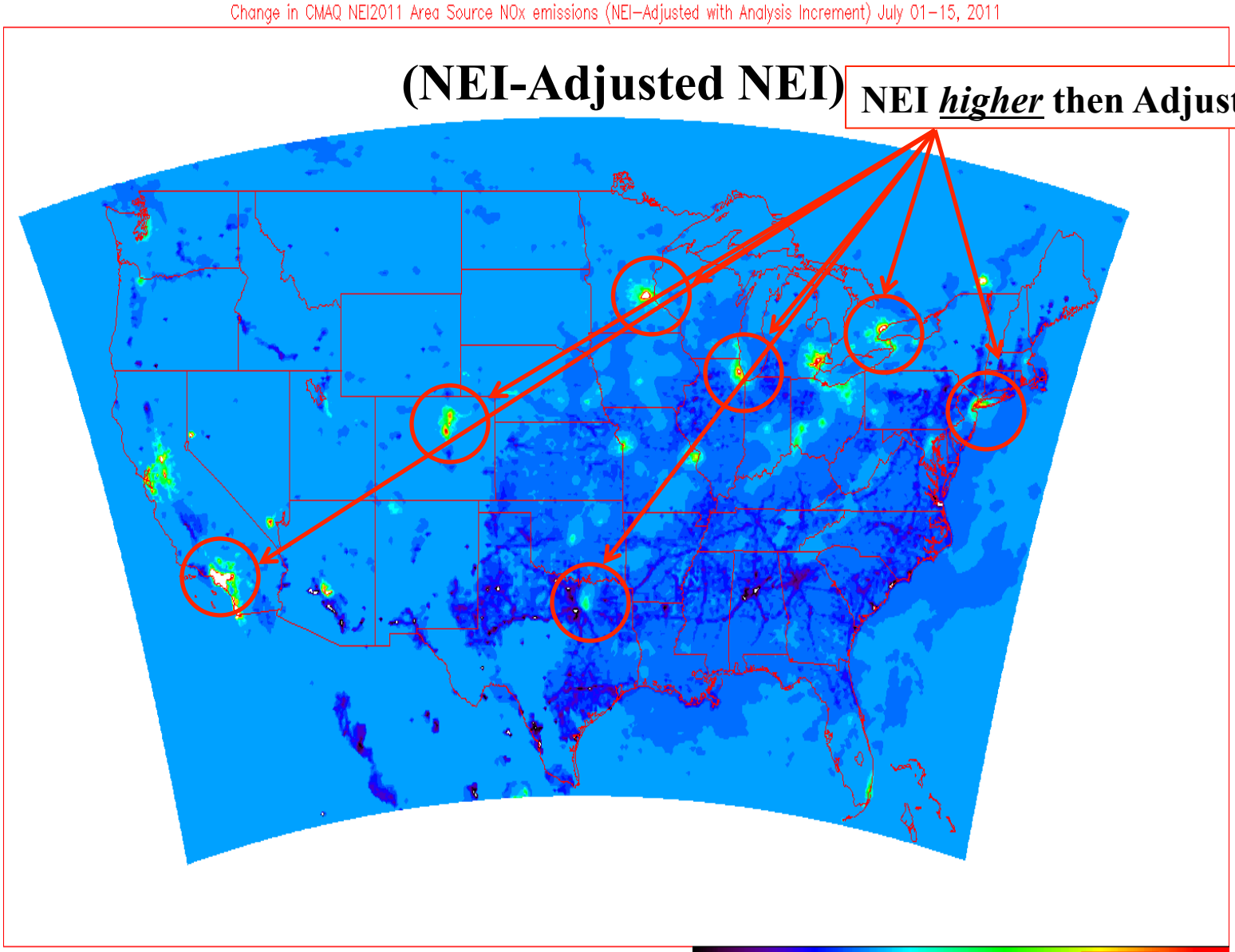

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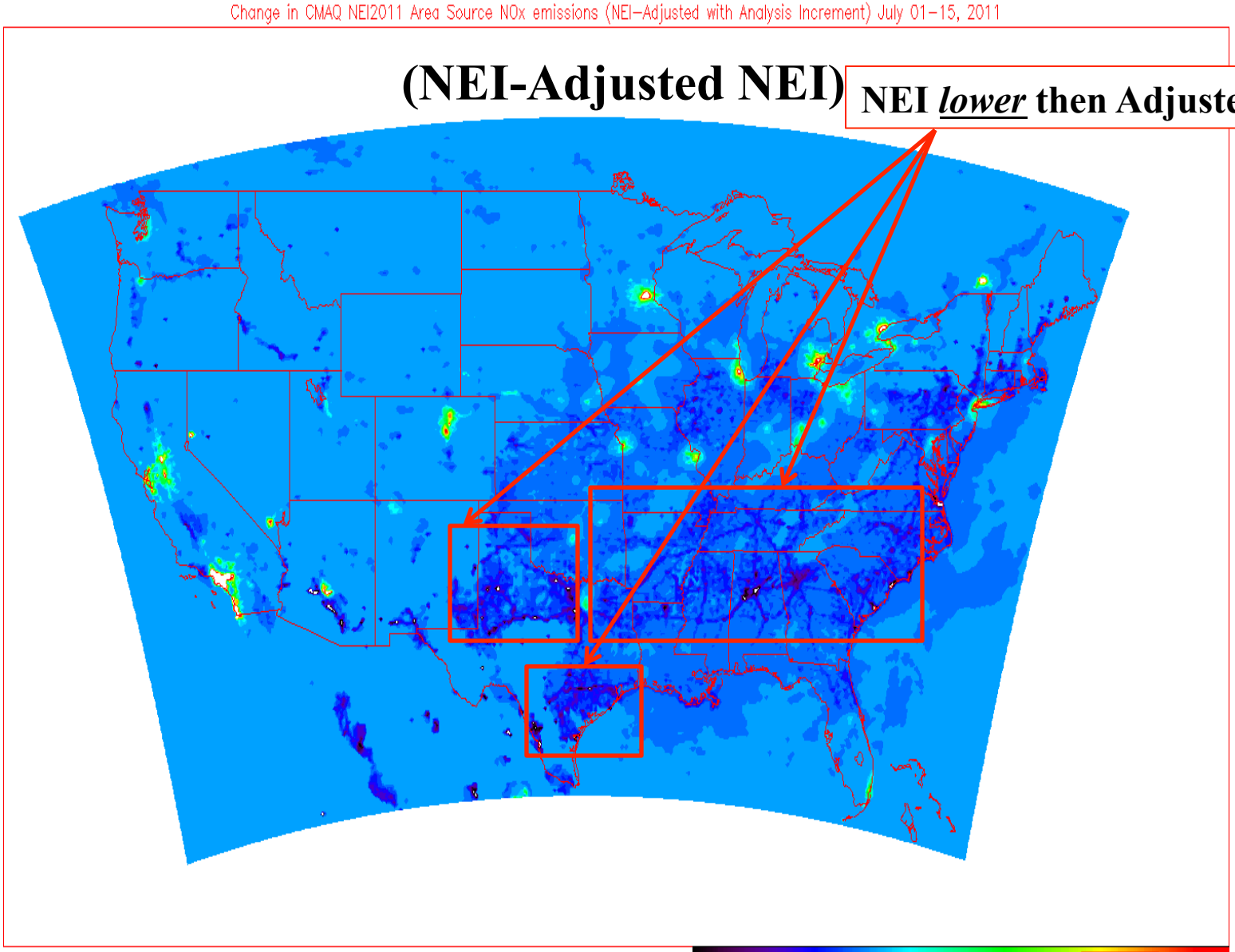

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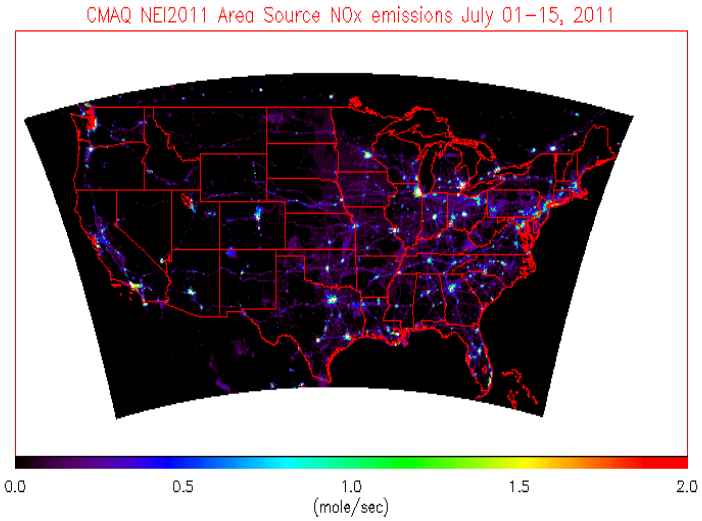
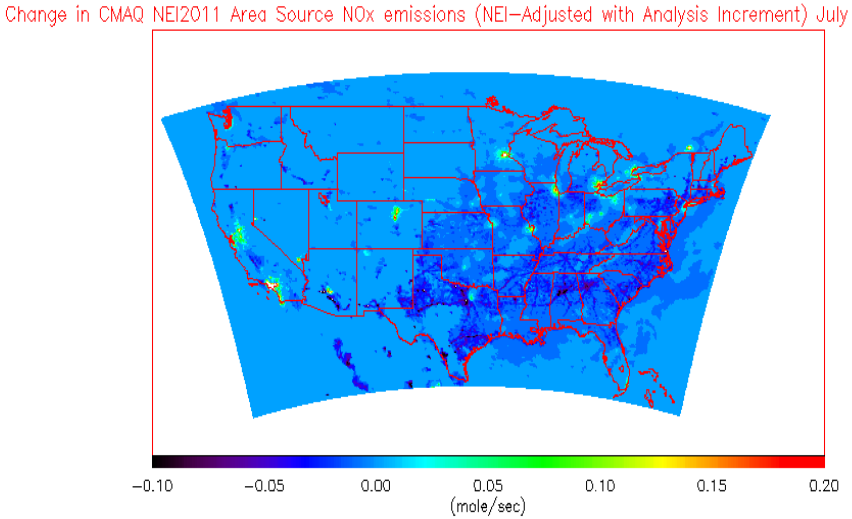
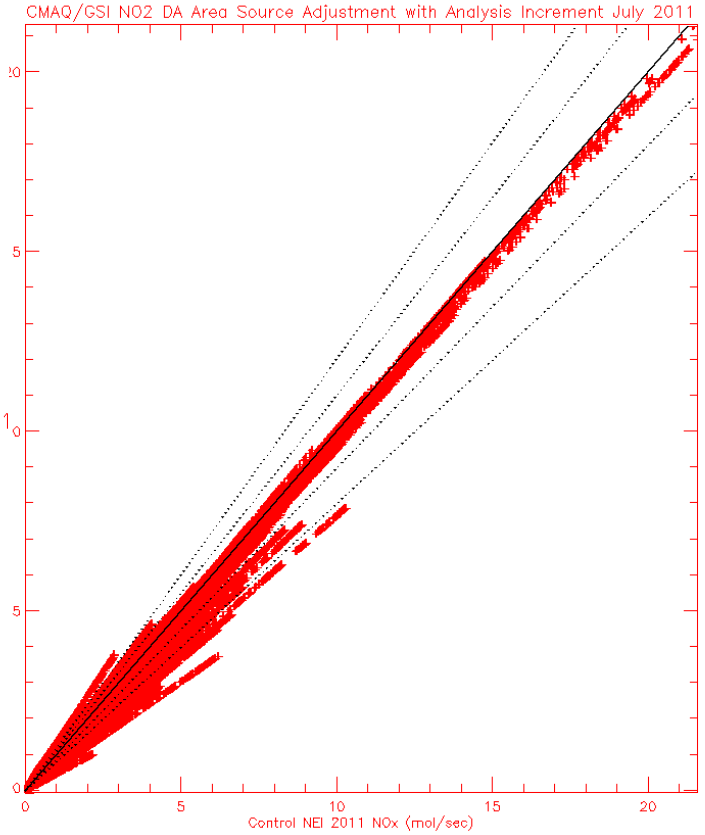
Area Source NOx Emissions Adjustment







delta-NO2 from OMI NO2 DA and Jacobian (β) from NO2 emissions perturbation experiment are used to adjust NEI 2011 NO2 emissions

$$\frac{\Delta E}{E} = \beta \times \frac{\Delta \Omega}{\Omega}.$$

HAQAST Partnerships

- NWS National Air Quality Forecast Capability (NAQFC)
- EPA/CDC Bayesian Space-time Downscaling Fusion Model
- Others ?

Deliverables (sustainability)

- NWS/EPA CMAQ/GSI OMI NO2 DA capability
- OMI NO2 Bufr files

Next Steps

1) Assimilate OMI NO2 slant column instead of tropospheric NO2 column (air mass factor artifact in analysis increment)
2) Assimilate OMI BEHR NO2 slant
3) Assimilate GeoTASO (TEMPO airborne simulator) NO2 column during Lake Michigan Ozone Study (LMOS 2017)
4) Assimilate TropOMI NO2 column (improved spatial resolution)
5) Assimilate TEMPO NO2 column (improved spatial/temporal resolution)