GEO-CAPE OSSE activities and the CEOS AQ constellation

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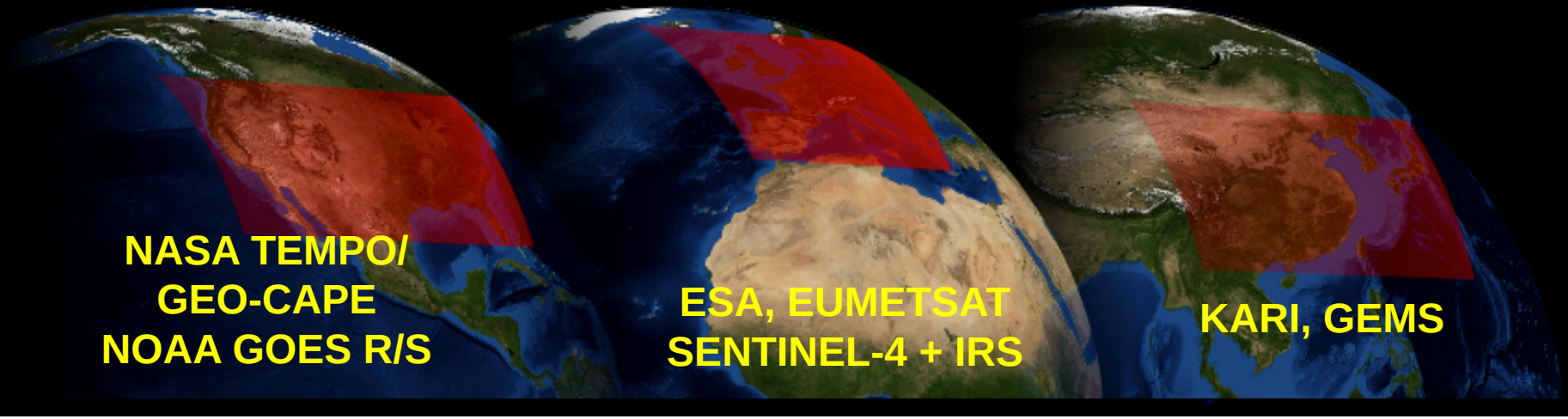
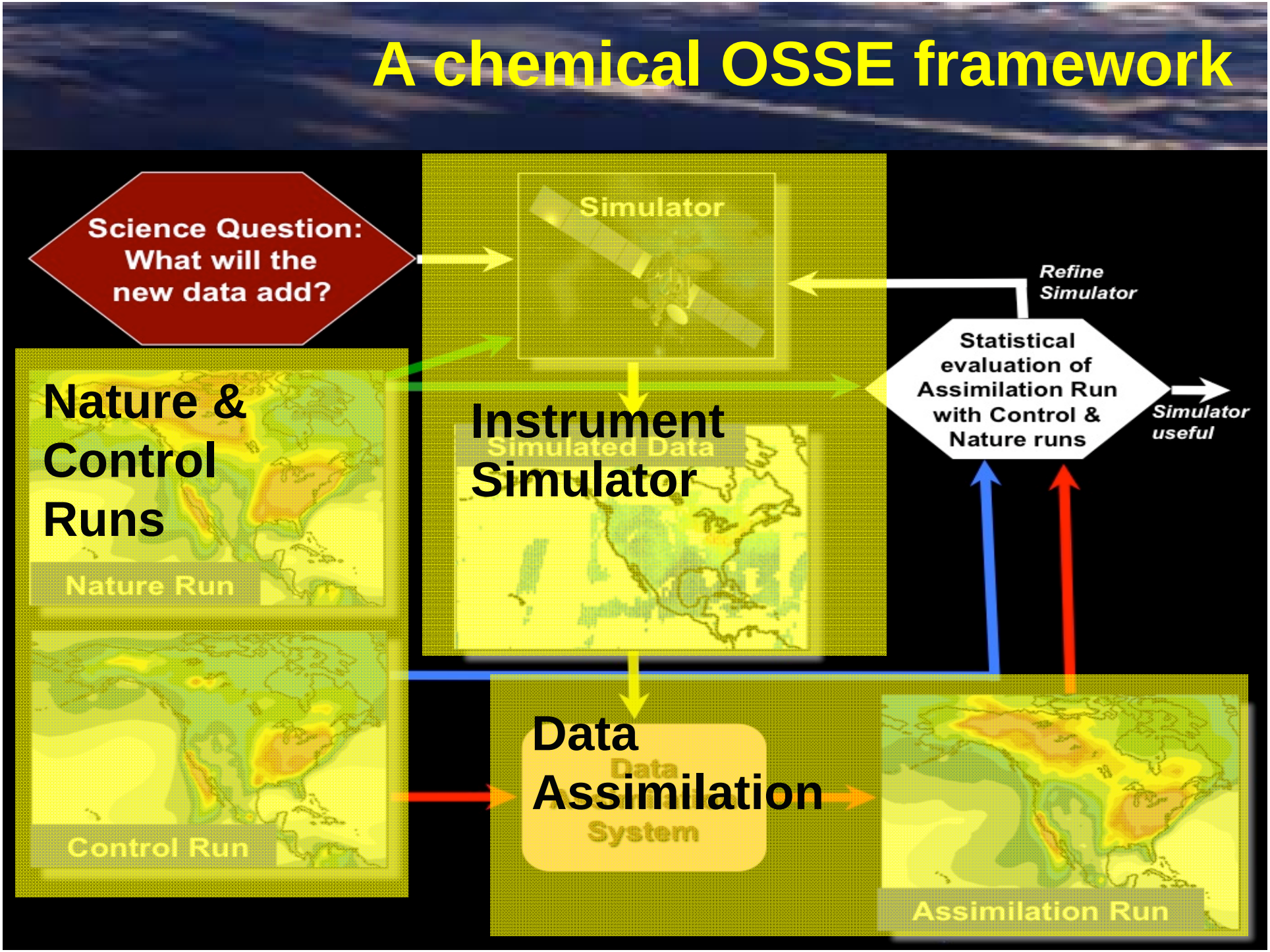
OSSEs & the GEO constellation

- The CEOS Atmospheric Composition Constellation activity identified joint OSSEs as a way to promote collaboration between the planned and proposed geostationary Earth orbit (GEO) missions from NASA GEO-CAPE/TEMPO, ESA Sentinel 4 & KARI GEMS
- OSSEs are extensively used by the NWP community to develop and optimize contemporary meteorological satellite instruments; now increasingly used in other fields of earth observation
- OSSEs assess the ***impact of hypothetical observations on a model analysis/forecast/inversion*** and provide a means to generalize on the conclusions of limited case-studies



A chemical OSSE framework



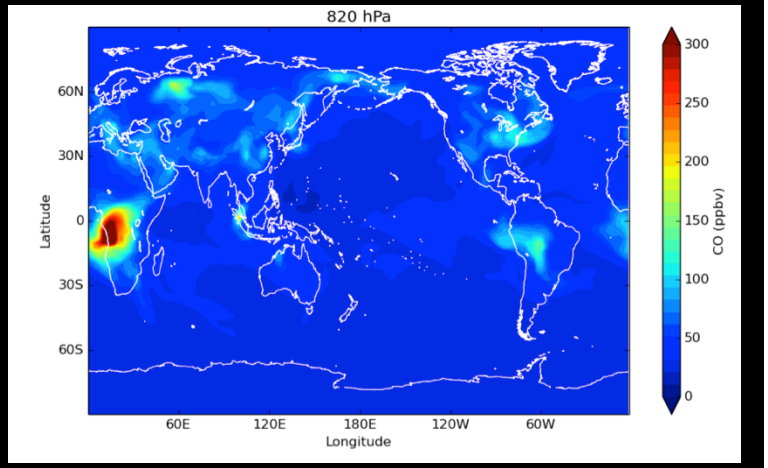
OSSE goal

An OSSE to demonstrate value of a GEO constellation: *What is the impact of the constellation observations for improving analysis and forecast of pollutant distributions?*

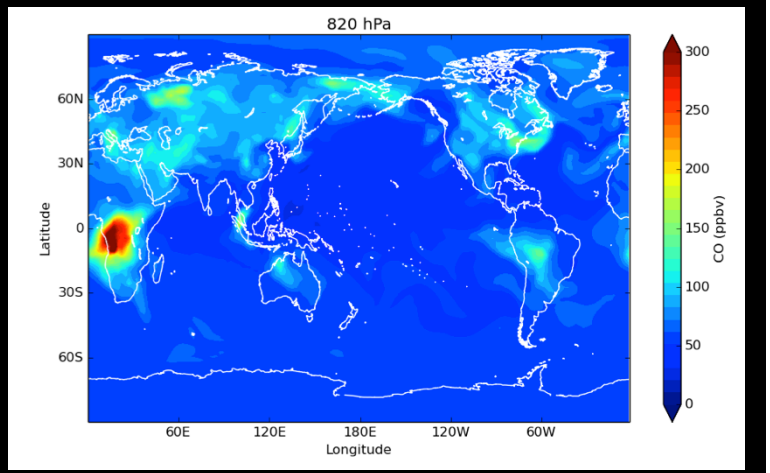
First experiments: Build on experience assimilating Terra/MOPITT multispectral tropospheric CO observations that have sensitivity to the lower troposphere, and imagine similar capability for all the members of the GEO constellation

Such capability proposed for GEO-CAPE over the USA with EV CHRONOS to fly concurrently with TEMPO; Europe currently plans column CO measurements from IRS accompanying Sentinel 4; currently no CO plans for the Korean platform to accompany GEMS

Control run: Met Only assimilated

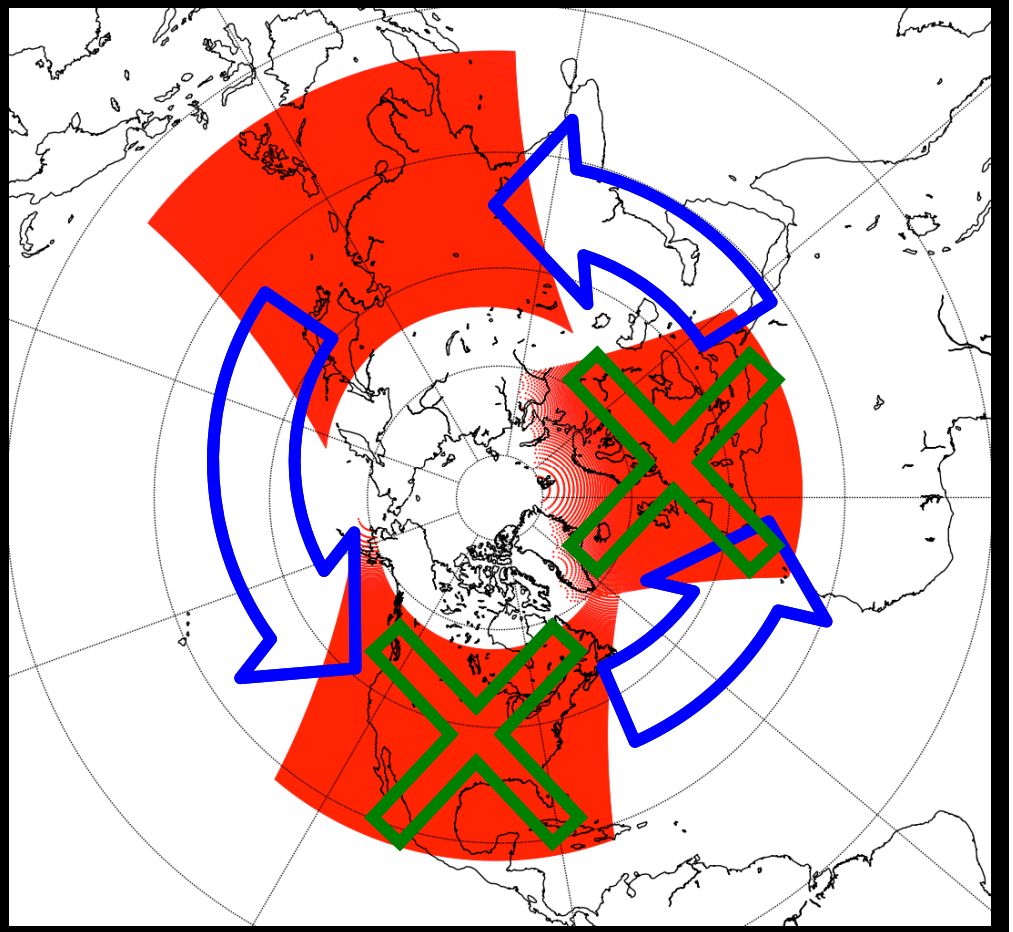


Assimilation run: Met + MOPITT



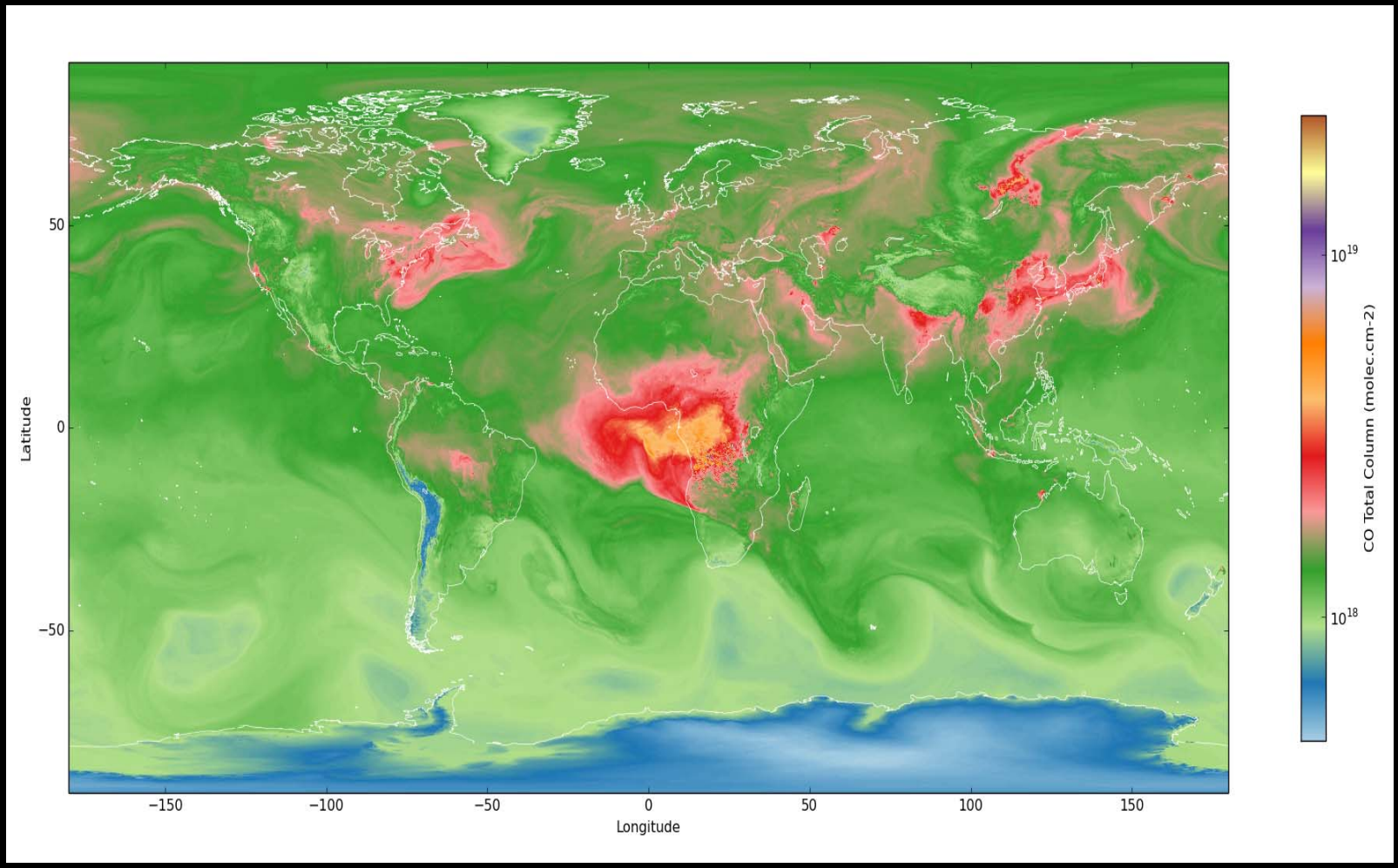
Experimental setup

- **Nature Run (NR):** GEOS-5 0.5^{o} Global Mesoscale Simulation for summer 2006
- **Instrument Simulator:** Computationally efficient regression algorithm based on MOPITT multispectral observations (Worden et al., 2010)
- **Control Run (CR):** CESM CAM-Chem at 1^{o} resolution
- **Assimilation Run (AS):** DART EAKF



- Assess the ability to observe impact of emissions over each region
- Look at importance of long range transport from one region to next
- Investigate the value of the measurements from each mission individually and together

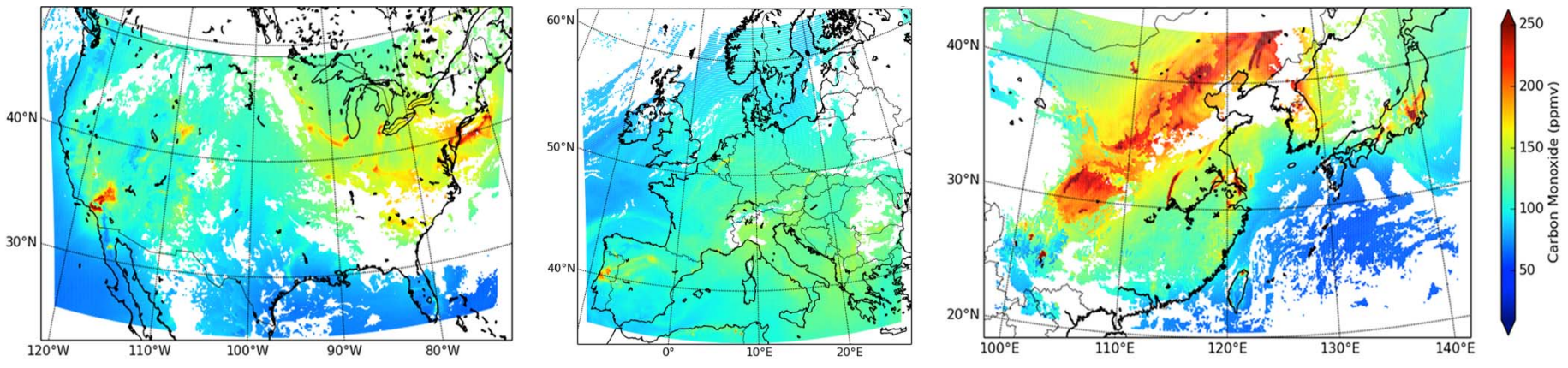
The Nature Run (NR)



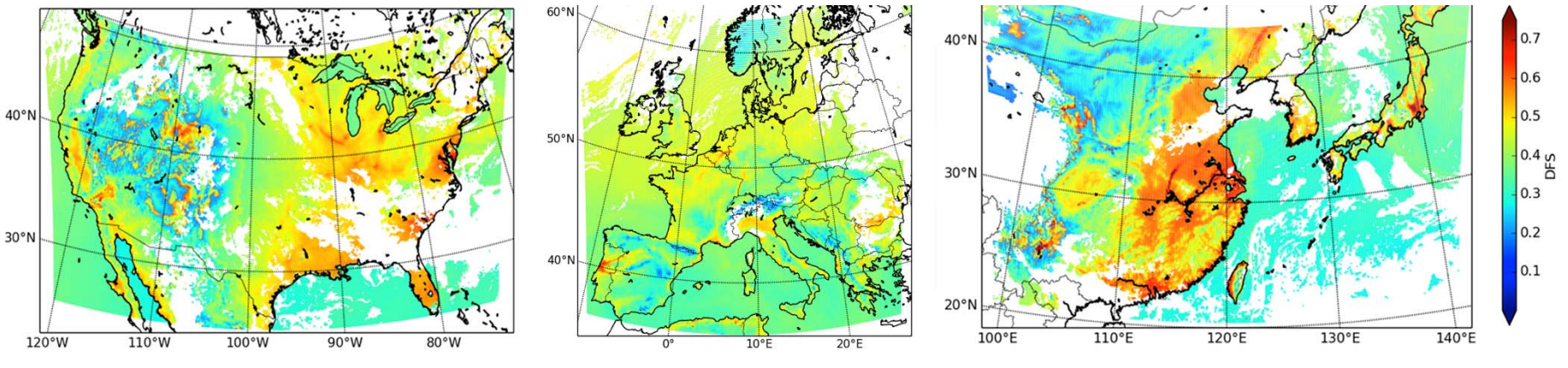
Global Mesoscale Simulation: GMAO GEOS-5 7-km high resolution CO total column 15 July 2006

Courtesy Arlindo Da Silva, NASA GSFC

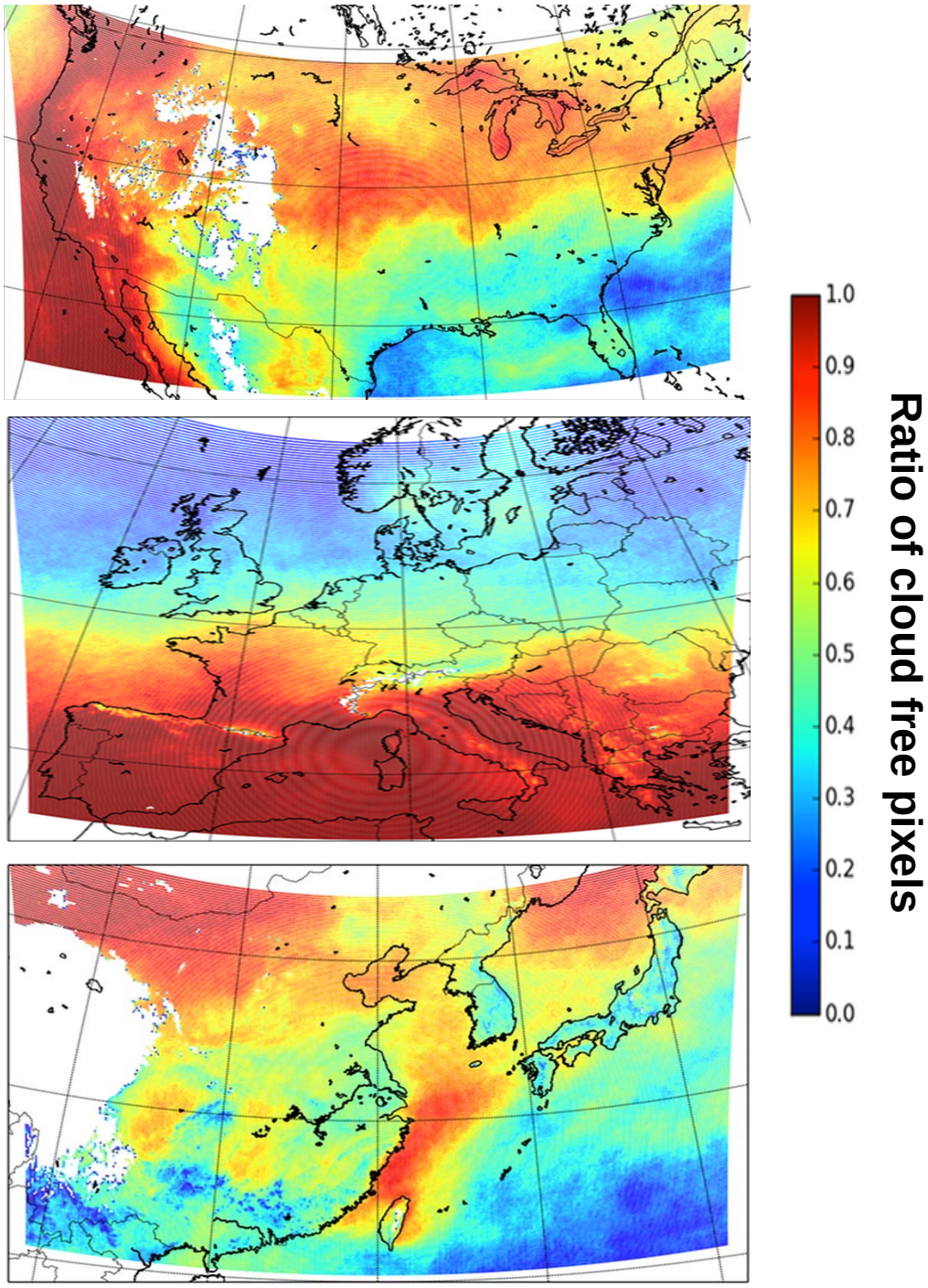
Observation simulator: Near-surface CO concentration accounting for scene-dependent measurement sensitivity



Scene-dependent retrieval near-surface information content – large differences between regions



15 July 2006, 3pm local time

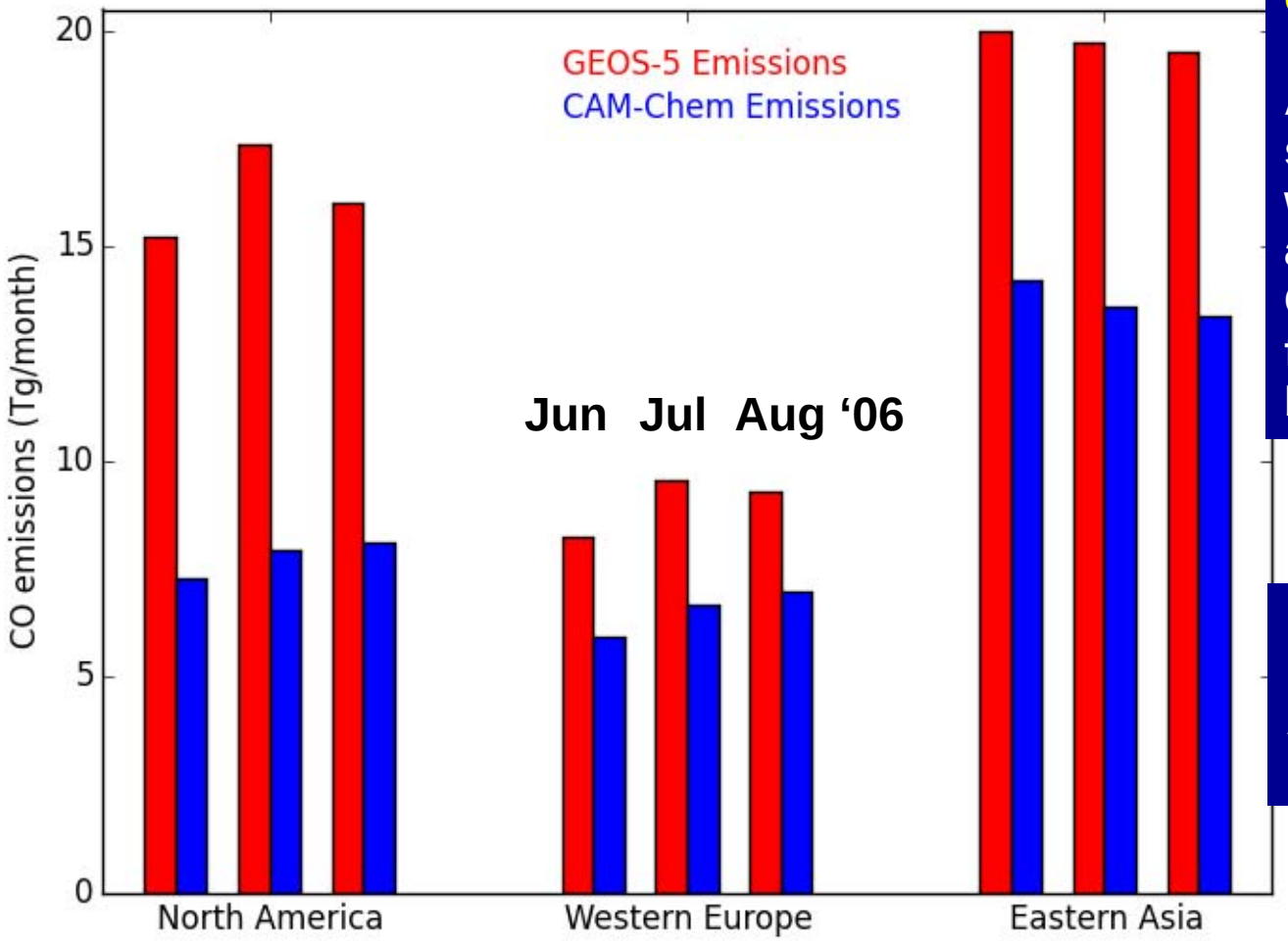


Simulated cloud coverage

Cloud coverage varies according to region with large differences affecting effective temporal coverage

July 2006 cloud coverage ratio

CO anthropogenic emissions budget



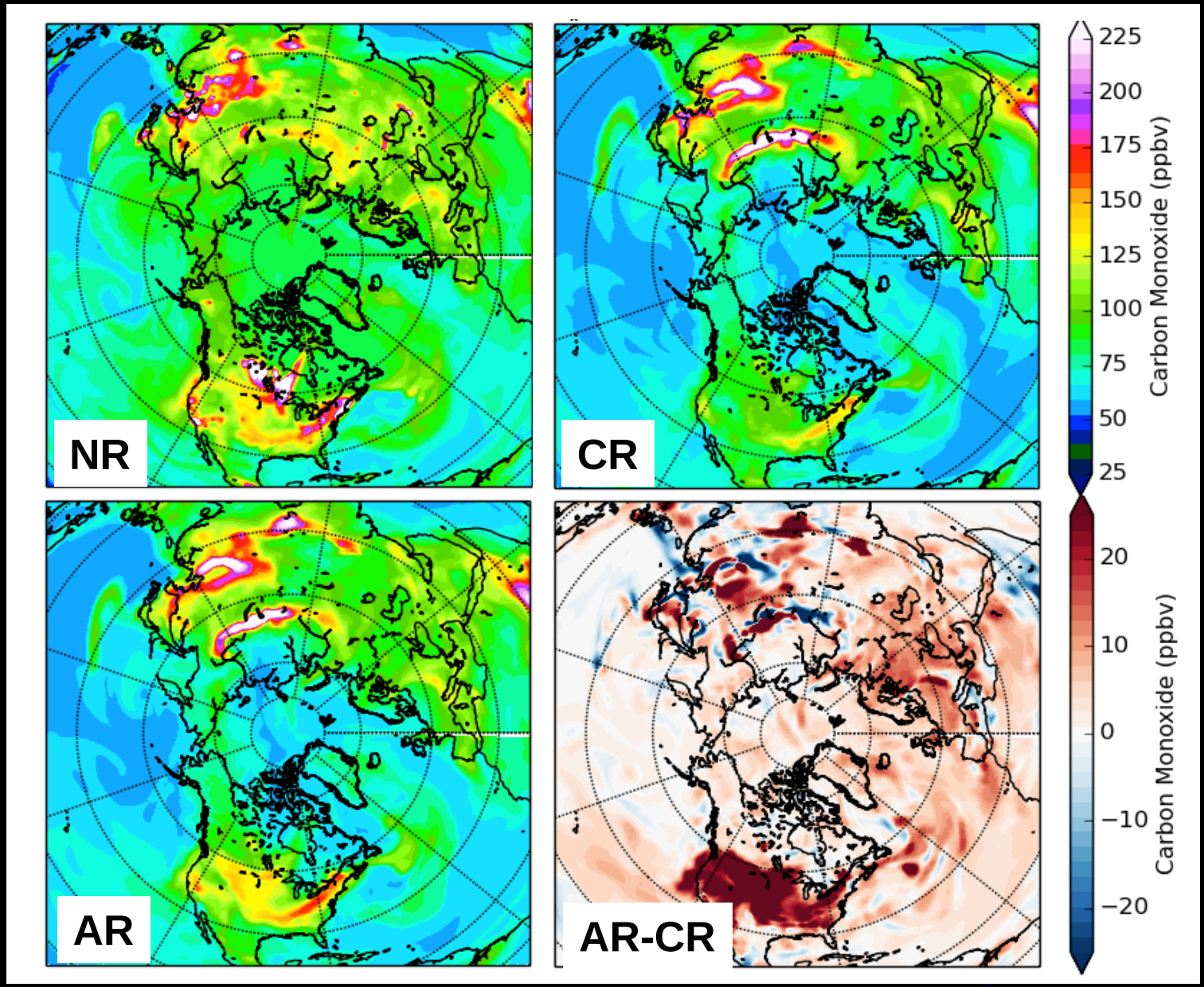
GMAO GEOS-5 NR

Anth: merge of several inventories with EDGAR (2000) as a base (EPA/NEI, CAC, BRAVO, EMEP); fires: QFED v2.2; biog: MEGAN

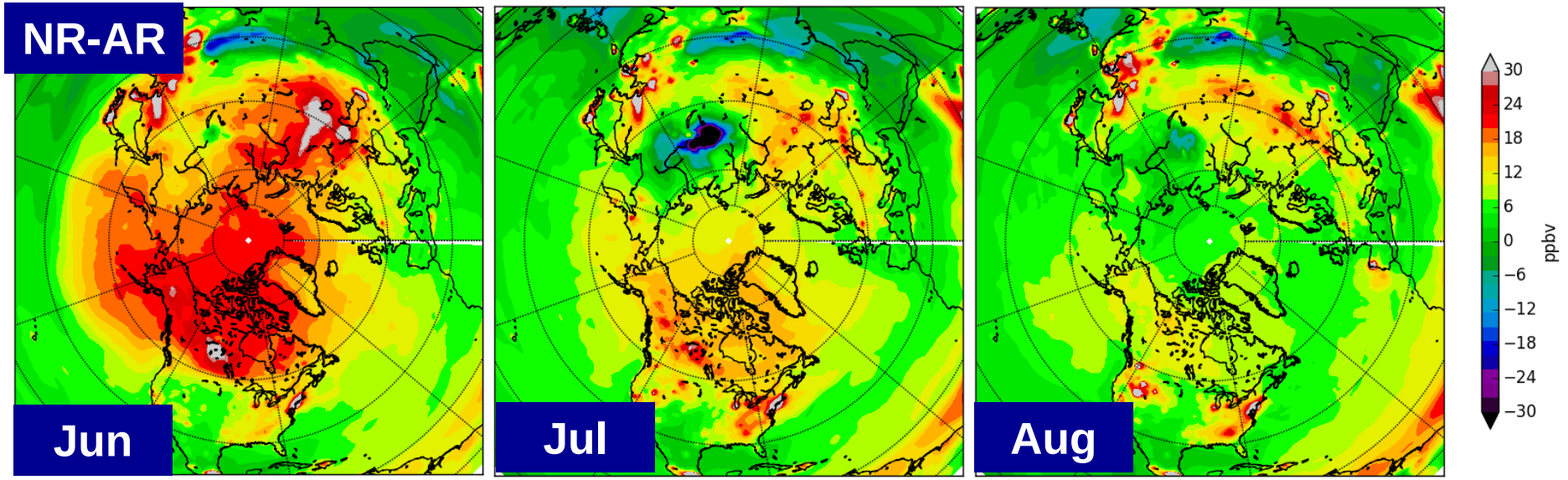
NCAR CAM-Chem CR

Anth/fires: MACCity; biog: MEGAN

The OSSE result for the difference between the Assimilation Run (AS) and Control Run (CR) for June 26, 2006, for CO concentration after the assimilation of Simulated Candidate Observations from GEO over Europe, Asia and USA



DA impact relative to nature run (NR): Assimilating all 3 GEOs
Monthly 200 – 1000 hPa average

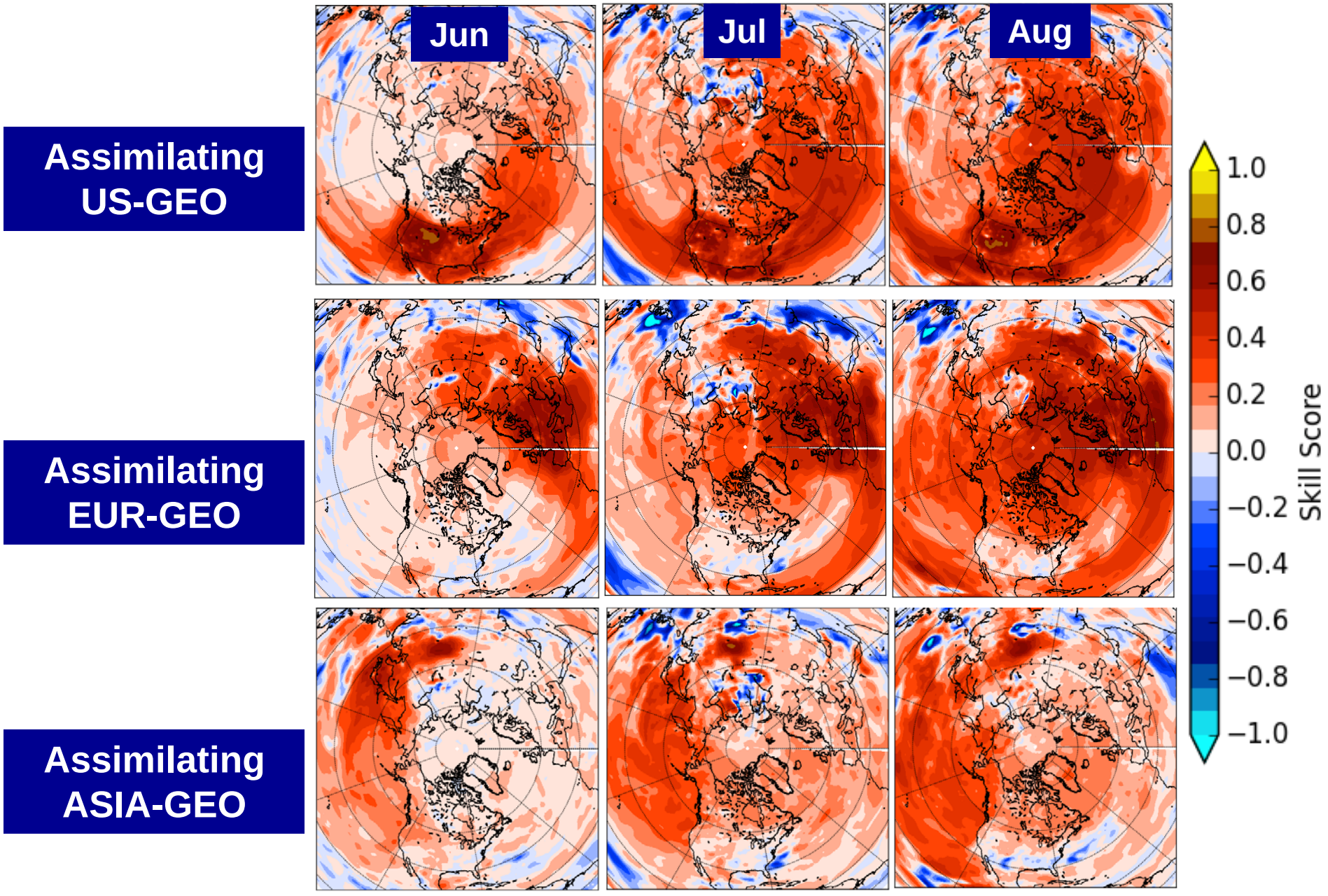


Next look at Skill Score

= 1 – MSE(AR-NR) / MSE(CR-NR)

SS > 0 improved simulation
SS < 0 degraded simulation
SS = 1 perfect simulation

DA impact relative to nature run: Assimilating individual GEOs
Monthly 200 – 1000 hPa average



First OSSE results

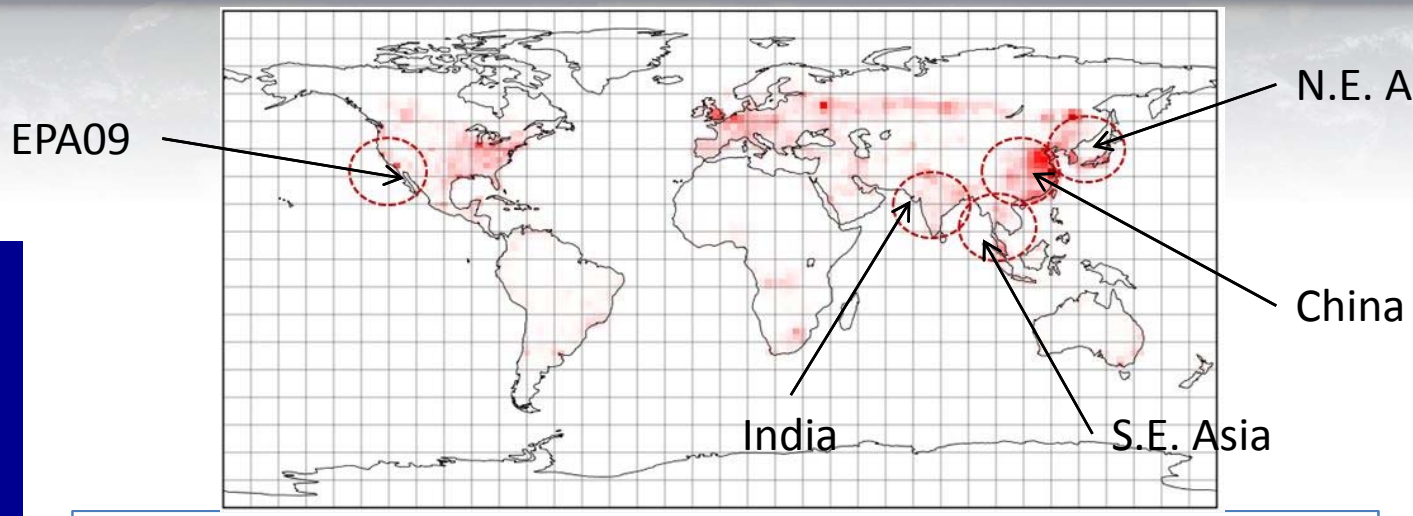
- Assimilation of the GEO constellation provides a strong constrain over anthropogenic source locations
- Global constraint of CO is also strong in remote regions due to long range transport of assimilation increments
- Impacts are reduced over Asia due to increased cloud coverage limiting the number of clear observations
- Experiments are being extended with a winter case study when the CO lifetime is longer, and emissions and cloud coverage also change

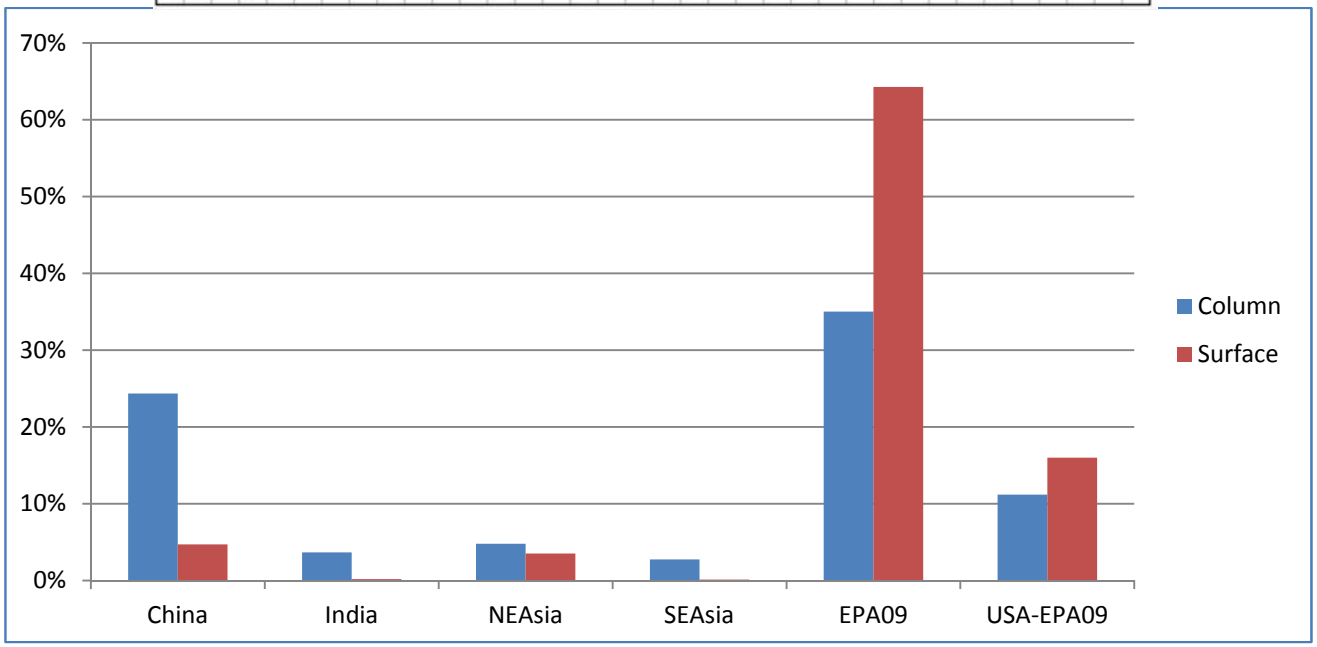
Next steps

- Expand the experiments to consider AOD, tropospheric ozone and chemical correlations

Regional Distribution of the EPA09 Ozone Sensitivity

- **Over 35% of mean surface ozone in EPA09 comes from emissions outside EPA09**
- **Chinese emissions contribute to mean column ozone @ 70% of local emissions**

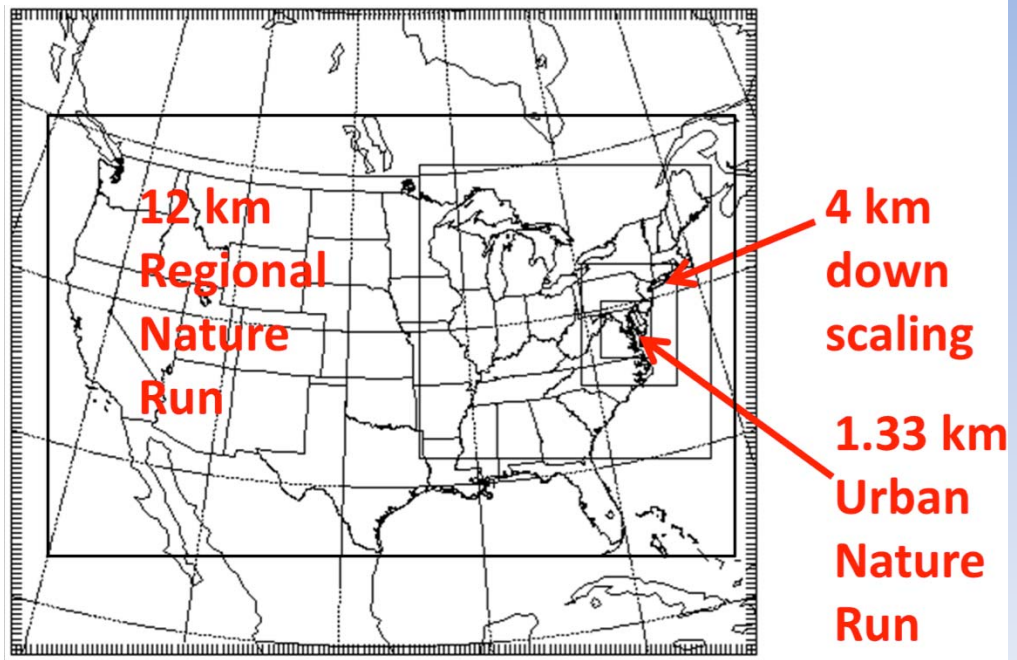




GEOCAPE Atmosphere Regional/Urban OSSE

Task	Participants	Institute
1. Urban Nature Run**	K. Pickering/C. Loughner	NASA/GSFC
2. Regional Nature Run*/DA*	B. Pierce/A. Lenzen/T. Schaack	NOAA/CIMSS
3. Forward RT Modeling*	K. Bowman/V. Natraj/T. Kurosu	JPL
4. AK Regression*	D. Edwards/H. Worden	NCAR
5. Multi-Spectral Retrieval*	L. Iraci/S. Kulawik	NASA/BAERI
6. Nature Run Verification*	M. Newchurch/L. Wang	UAH

* Completed in FY13 * Completed in FY14 * In preparation



Extends previous GEOCAPE OSSE studies by:

- Utilizing independent modeling systems for generation of the Nature atmosphere and conducting the assimilation impact experiments
- Accounting for realistic atmospheric variability, which requires evaluation of the nature runs with respect to observations.
- Inclusion of realistic variability in the synthetic radiances, which requires incorporation of realistic surface UV and visible reflectivities, and IR emissivities.
- Inclusion of realistic sensitivities, which requires generation of averaging kernels (AK) for each retrieval for use in assimilation studies

Thank You!

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