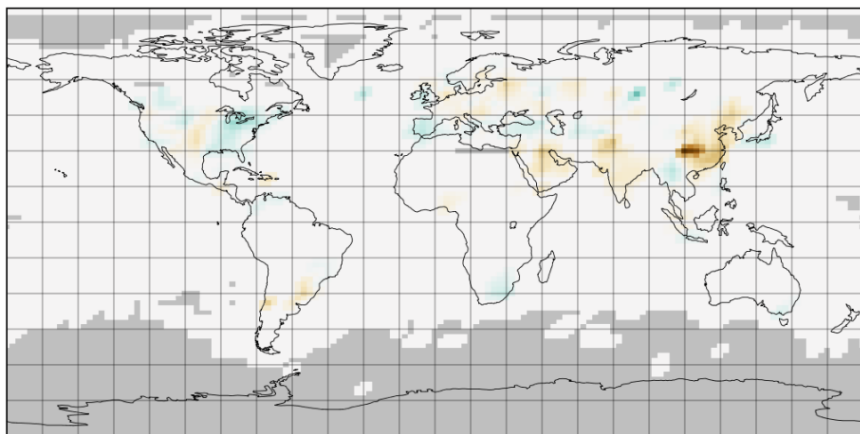


Update: Using Satellite Data to Aid Quantification and Attribution of Background Ozone Changes in the Western US

Jessica Neu, Greg Osterman, Thomas Kurosu, Kevin Bowman, Dejian Fu
NASA Jet Propulsion Laboratory, California Institute of Technology

Fractional filtered difference in surface NO_x emissions from mass balance (2011 – 2005) May

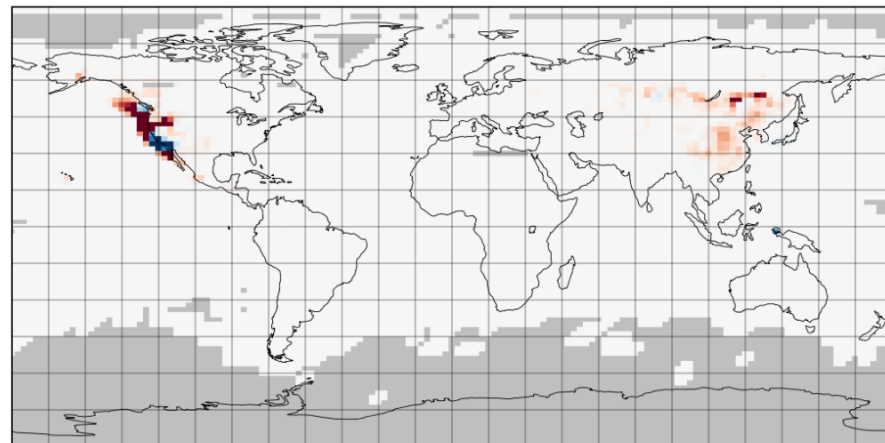


Fractional filtered difference in surface NO_x emissions from mass balance (2011 – 2005) May (unitless)

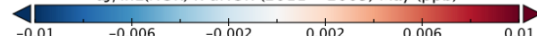


Data Min = -0.7, Max = 1.3, Mean = 0.0

$dj/\ln E(\text{NO}_x) \times d\text{NO}_x$ (2011 – 2005) May



$dj/\ln E(\text{NO}_x) \times d\text{NO}_x$ (2011 – 2005) May (ppb)



Data Min = -0.03, Max = 0.2, Mean = 0.0002



Satellite-Assimilated Boundary Conditions

SCAQMD has requested boundary conditions for their SIP model for 2008, 2012, and 2015

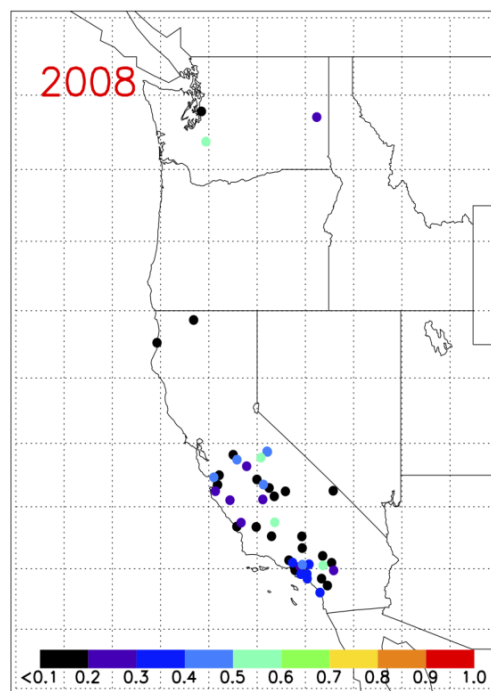
We are providing BCs from GEOS-Chem with assimilation of tropospheric and stratospheric ozone profiles as part of our baseline funding

Technical documentation of this work and SCAQMD's implementation of the BCs in their model is being done through the SIPs Tiger Team. Dissemination of BCs to other AQ managers such as BAAQMD is also funded through the TT.

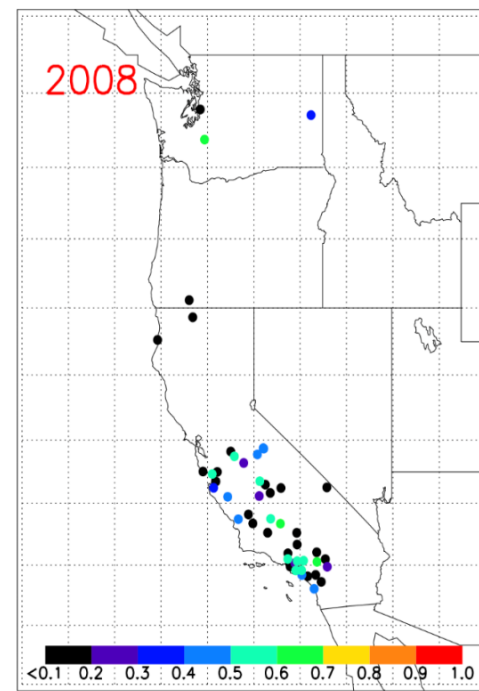
Evaluation complete
2008 BCs available early Aug

Correlation Between Model and Surface Observations

Without Assimilation



With Assimilation



- ✓ Assimilations improves comparisons to surface monitors for years 2005-2010 (2008 shown)
- ✓ Improved tropospheric values in comparison to AIRS-OMI (not shown)
- Running assimilation for all years: 2005 - 2015



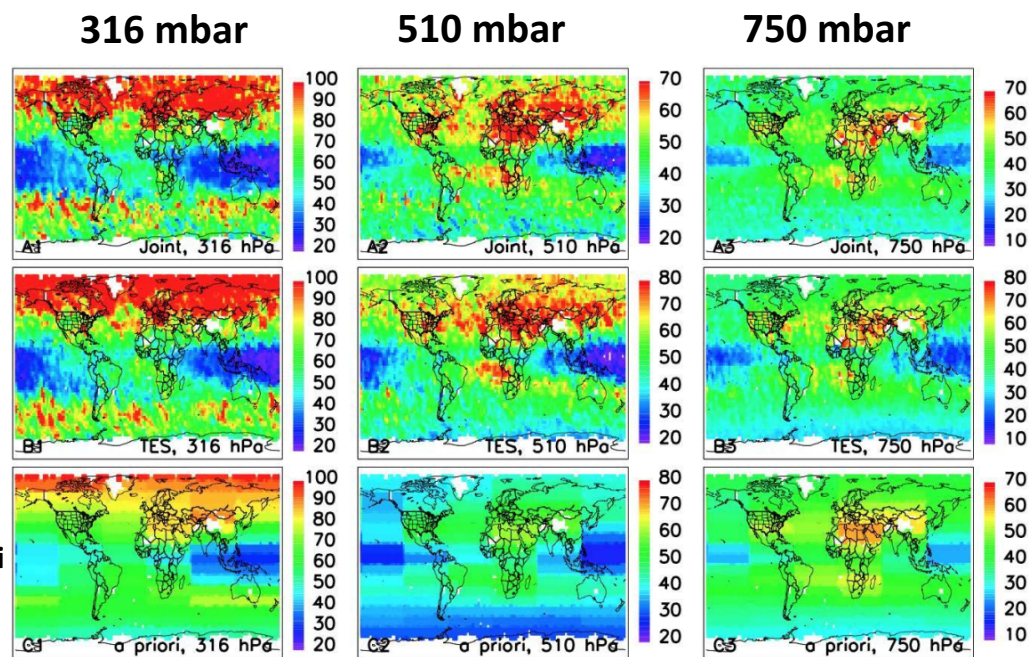
New Satellite Records of Tropospheric Ozone

Assessing trends in tropospheric ozone and assimilation of ozone measurements into models requires well-characterized retrievals with quantified errors.

The JPL MUSES (MULTi-SpEctra, MULTi-SpECies, Multi-SENSors Retrievals of Trace Gases) algorithm delivers both retrieved trace gas concentration profiles and observation operators.

MUSES is based on TES retrieval algorithm and provides a consistent set of sensitivity metrics and error estimates.

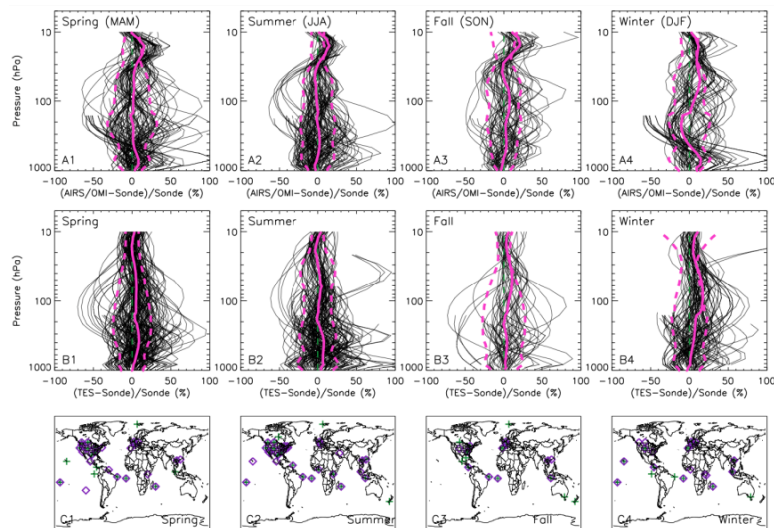
AIRS-OMI processing underway for the Aura time period



AIRS-OMI validation paper has been submitted

Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2018-138>
 Manuscript under review for journal Atmos. Meas. Tech.
 Discussion started: 16 May 2018
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Atmospheric
Measurement
Techniques
Discussions
EGU



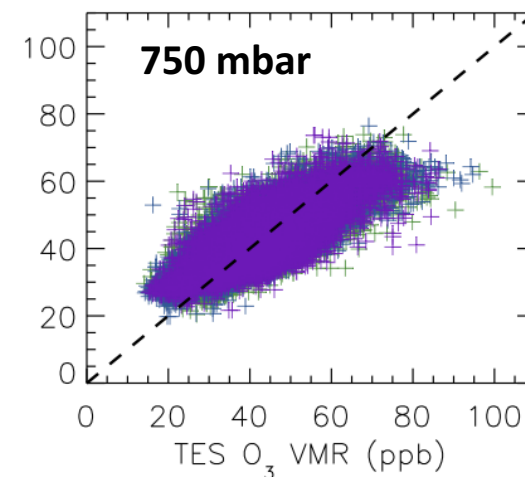
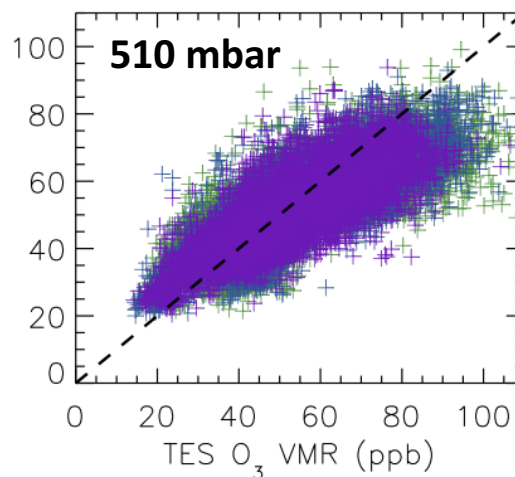
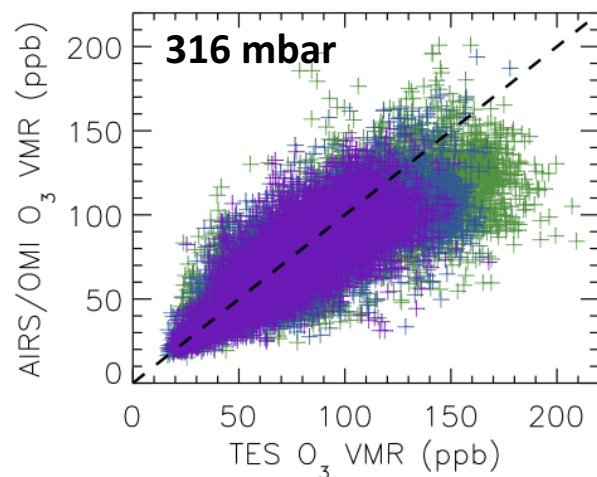
Retrievals of Tropospheric Ozone Profiles from the Synergistic Observation of AIRS and OMI: Methodology and Validation

Dejian Fu¹, Susan S. Kulawik², Kazuyuki Miyazaki³, Kevin W. Bowman⁴, John R. Worden¹, Annmarie Eldering¹, Nathaniel J. Livesey¹, Joao Teixeira¹, Fredrick W. Irion¹, Robert L. Herman¹, Gregory B. Osterman¹, Xiong Liu⁴, Pieter F. Levelt^{5,6}, Anne M. Thompson⁷, Ming Luo¹

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Abstract. The Tropospheric Emission Spectrometer (TES) on the A-Train Aura satellite was designed to profile tropospheric ozone and its precursors, taking measurements from 2004 to 2018. Starting in 2008, TES global sampling of tropospheric ozone was gradually reduced in latitude with global coverage stopping in 2011. To extend the record of TES, this work presents a multispectral approach that will provide O_3 data products with vertical resolution and measurement uncertainty similar to TES by combining the single-footprint thermal infrared (TIR) hyperspectral radiances from the Aqua Atmospheric Infrared Sounder (AIRS) instrument and the ultraviolet (UV) channels from the Aura Ozone Monitoring Instrument (OMI). The joint AIRS+OMI O_3 retrievals are processed through the Multi-SpEctra, Multi-SpEcies, Multi-Sensors (MUSES) retrieval algorithm. Comparisons of colocated joint AIRS+OMI and TES to ozonesonde measurements show that both systems have similar errors, with mean and standard deviation of the differences well within the estimated measurement uncertainty. AIRS+OMI and TES have slightly different biases (within 5 parts per billion) versus the sondes. Both AIRS and OMI have wide swath widths (~1,650 km for AIRS; ~2,600 km for OMI) across satellite ground tracks. Consequently, the joint AIRS+OMI measurements have the potential to maintain TES vertical sensitivity while increasing coverage by two orders of magnitude, thus providing an unprecedented new dataset to quantify the evolution of tropospheric ozone.





Assessing Changes in Background Ozone

Satellite measurements of NO_2 and CO indicate that ozone precursor emissions have undergone rapid changes over the past decade, particularly in China. How have these changes impacted background ozone concentrations in the US?

GEOS-Chem Model Simulations:

1. Baseline

- Mass balance emissions
- MLS assimilation

2. Global constant emissions

- Constant 2005 emissions globally
- MLS assimilation

3. China constant emissions

- Constant 2005 emissions over China
- MLS assimilation

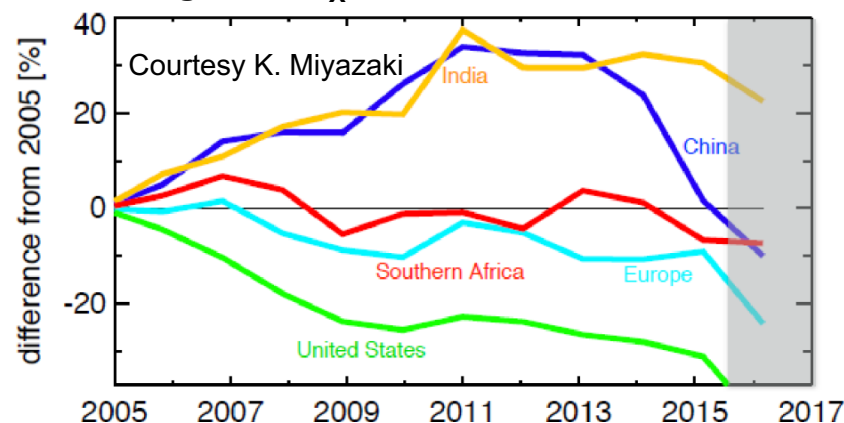
4. China extrapolated emissions

- Mass balance emissions + extrapolated trend over China
- MLS assimilation

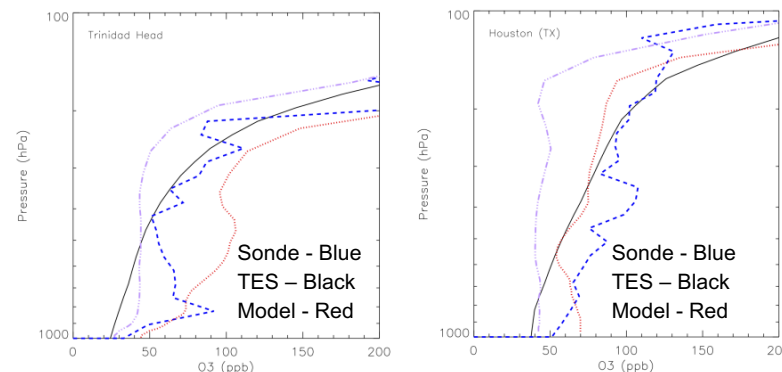
5. Constant stratosphere

- Mass balance emissions
- Repeated 2005 meteorology and 2005 MLS assimilation

Relative Change in NO_x Emissions based on OMI NO_2



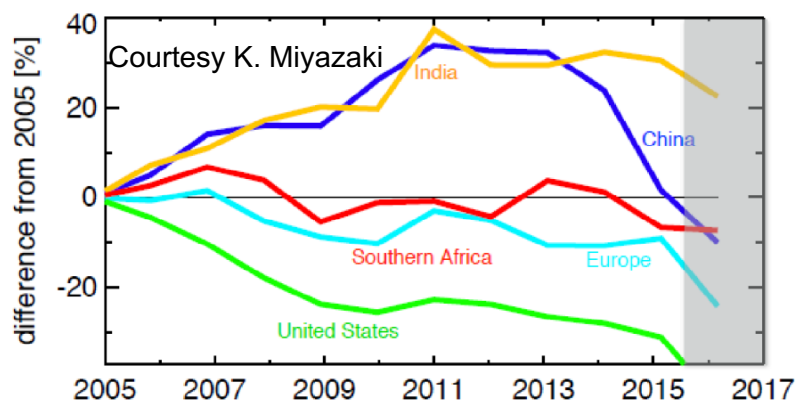
Evaluation of Baseline Simulation for 2006



Evaluation complete
Baseline simulation expected by end of Aug

Adjoint Analysis: Isolating the Impact of Emissions

Relative Change in NO_x Emissions based on OMI NO_2

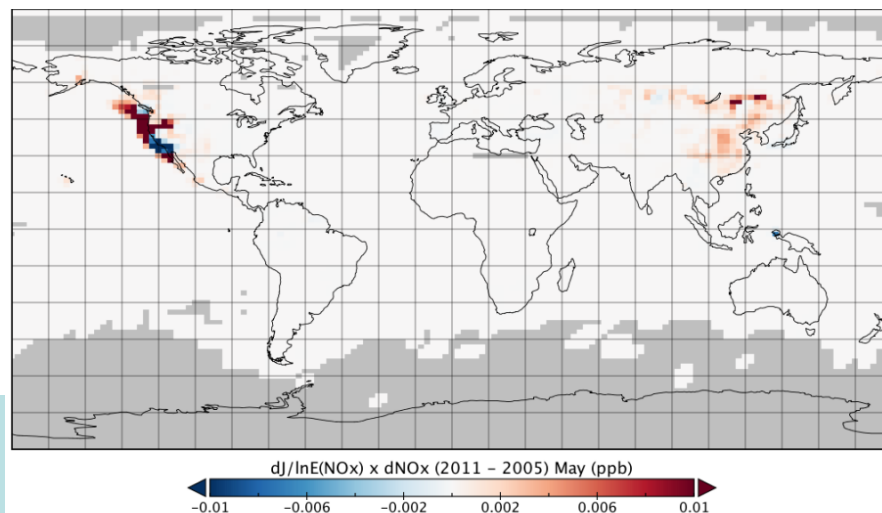


The GEOS-Chem adjoint is being used to determine the impact of NO_x emissions changes on surface O_3 in EPA Region 9

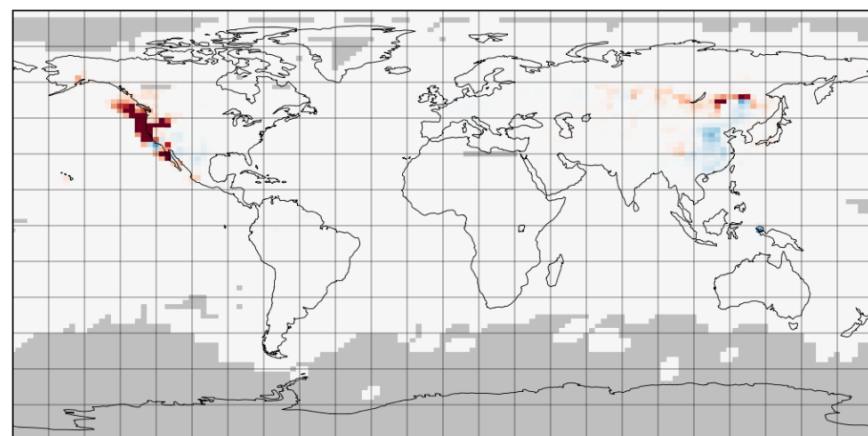
Sensitivities are calculated for a single month (May 2006) and convolved with emissions changes from 2005-2011 and 2011-2015.

EPA Region 9 is sensitive to local and East Asian emissions. The decrease in East Asian emissions from 2011-2015 is reflected in Western US O_3 ; changes in transport are not accounted for here.

$dJ/\ln E(\text{NO}_x) \times d\text{NO}_x$ (2011-2005); J=EPA 9 Sfc O_3



$dJ/\ln E(\text{NO}_x) \times d\text{NO}_x$ (2011-2005); J=EPA 9 Sfc O_3



Preliminary Analysis Complete
Next: Evaluation of Temporal Changes in Sensitivity

Using Satellite Data to Aid Quantification and Attribution of Background Ozone Changes in the Western US

- ◆ Analyze how background ozone has responded to changes in international emissions, transport, and stratosphere-troposphere exchange
 - Adjoint sensitivity analysis and forward model simulations constrained by satellite data are underway
 - Validation of AIRS/OMI a critical step for providing long-term record of tropospheric O₃
- ◆ Use assimilated satellite measurements to generate ozone lateral and upper boundary conditions for regional models.
 - Evaluation of 2008 assimilation against surface O₃ and ozonesondes complete
 - Generating model boundary conditions for 2008, working with SCAQMD
 - AIRS/OMI processing underway for 2012 and 2015 boundary conditions
- ◆ Generate regional maps of tropospheric ozone profiles to aid in exceptional event analysis.
 - AIRS/OMI capability available, but no requests from stakeholders thus far

Tiger Team: Supporting the Use of Satellite Data in State Implementation Plans (SIPs)

- ◆ Produce technical documentation describing the provision of BCs and their implementation in CMAQ by SCAQMD
 - Once 2008 BCs are complete, will work with SCAMQD to ensure proper implementation in CMAQ and document the process
 - Documentation to be reviewed by SIPs TT participants
- ◆ Provide additional BCs to BAAQMD and other agencies as requested
 - Requested time periods and domains have been noted and AIRS/OMI processing schedule has been prioritized as required.