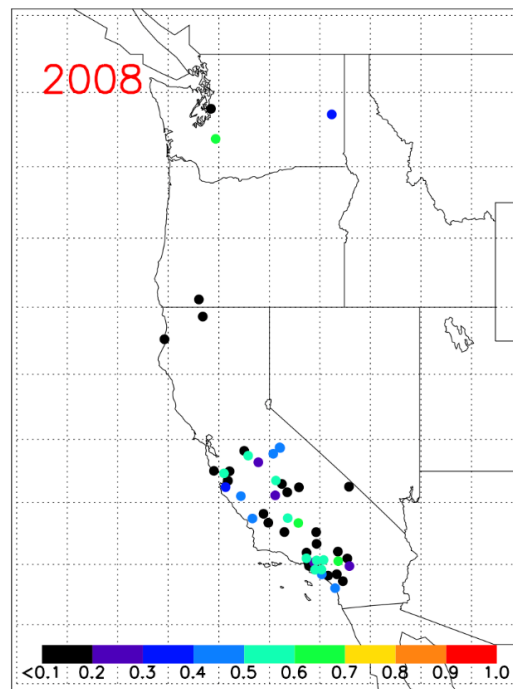
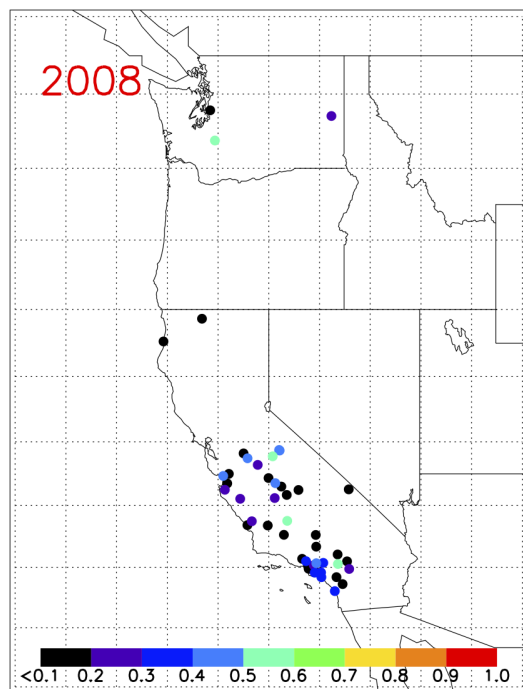


## Using Satellite Data to Aid Quantification and Attribution of Background Ozone Changes in the Western US

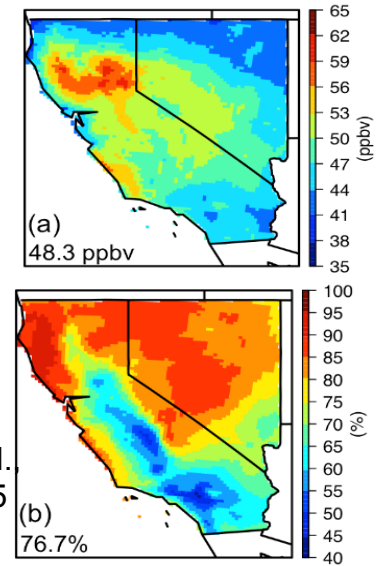
Jessica Neu, Greg Osterman, Kevin Bowman, Dejian Fu  
NASA Jet Propulsion Laboratory, California Institute of Technology



# Satellite Data in Background Ozone Studies

Satellite Measurements of ozone and  $\text{NO}_2$  have been successfully used with global and regional models to assess the processes that control background ozone

Background Ozone in Regional Model with Emissions Inversion and Assimilated Boundary Conditions

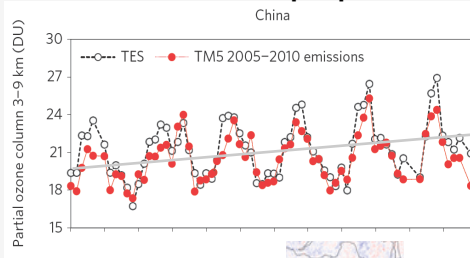


Huang et al.  
*JGR*, 2015

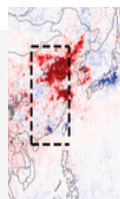
## Long-Range Transport and Stratosphere-Troposphere Exchange: Global Model with Emissions Inversion and Stratospheric Correction

MLS: Temporary increase in downward transport from the stratosphere partly due to 2009-2010 El Nino.

TES: 7% Increase in mid-tropospheric ozone

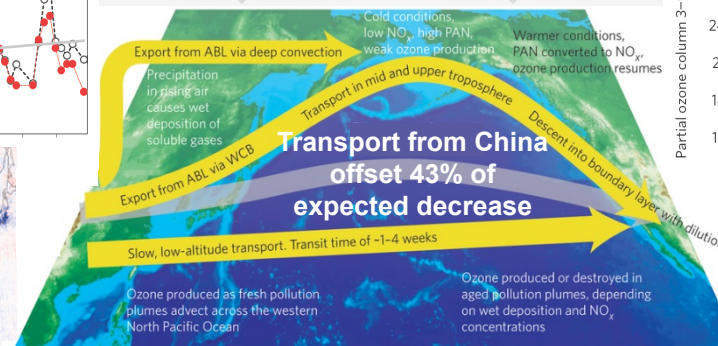


OMI: 21% increase in  $\text{NO}_x$  emissions.  
Explains 50% of the ozone increase.

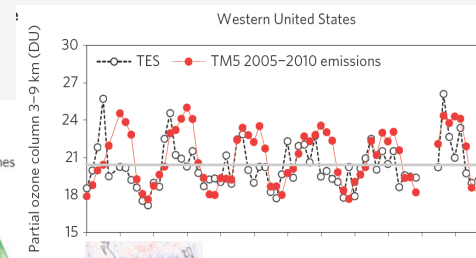


Explains 50% of the ozone increase

Offset 57% of expected ozone decrease



TES: No change in mid-tropospheric ozone

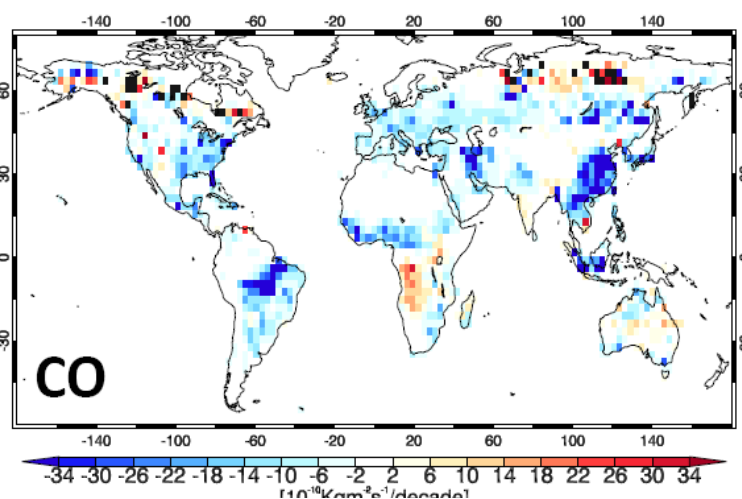
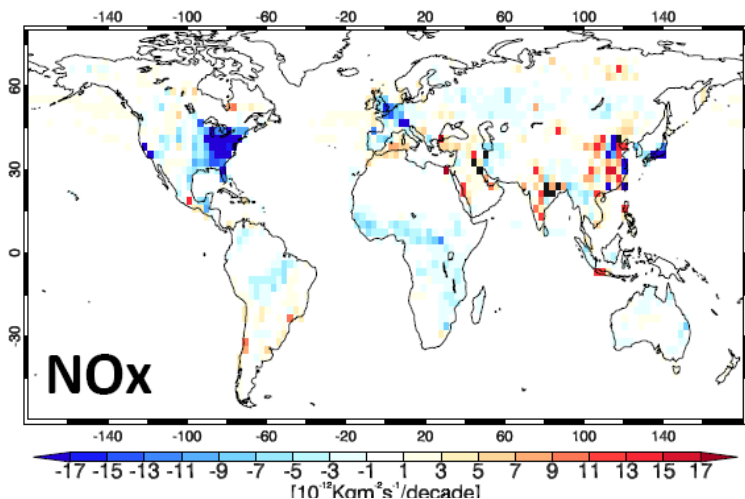


OMI: 21% decrease in  $\text{NO}_x$  emissions.  
Should have given a 2% decrease in ozone

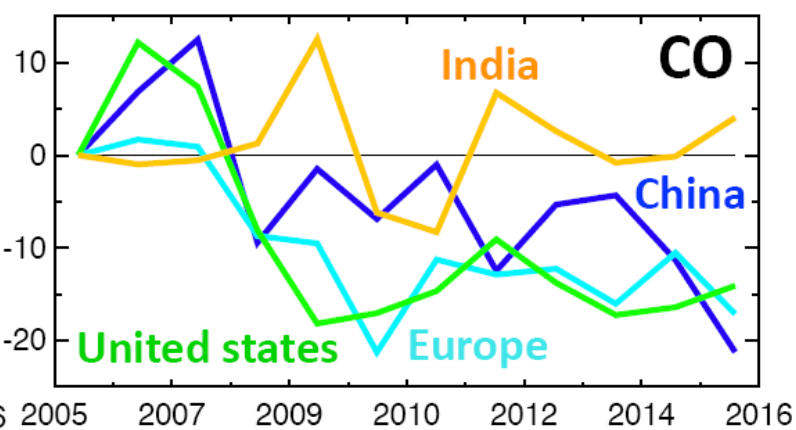
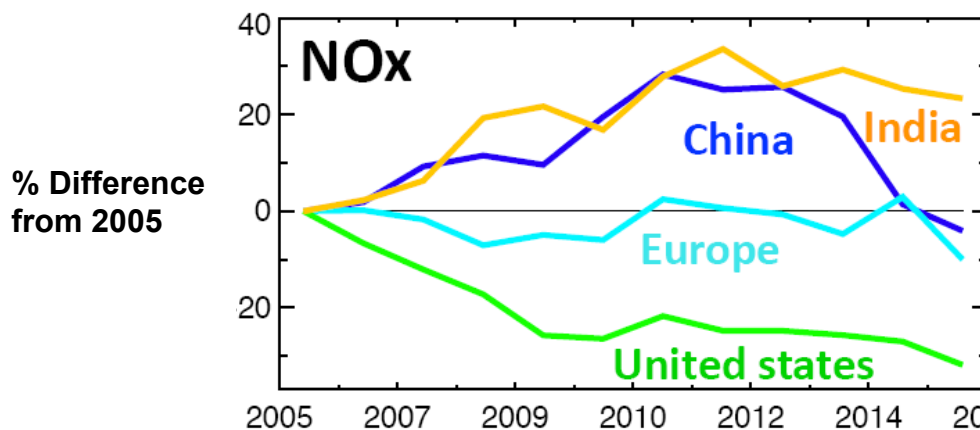
# Changes in Emissions During the Satellite Period

## 2005-2016 Changes in Emissions based on OMI NO<sub>2</sub> and MOPITT CO

2005-2016  
Trend



Figures courtesy  
of K. Miyazaki

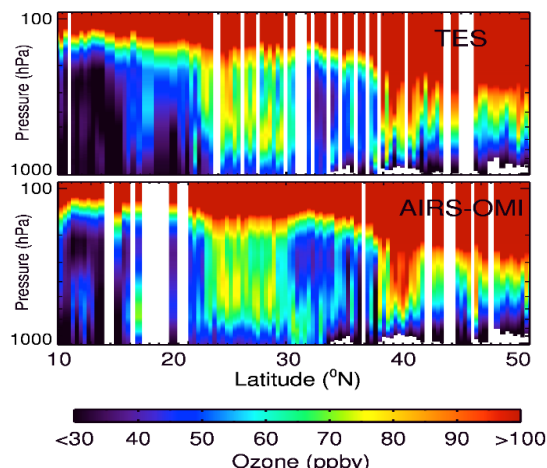


Complex, non-monotonic changes in emissions have occurred during the satellite period, particularly in Asia. What impact have these changes had on ozone in the Western US?

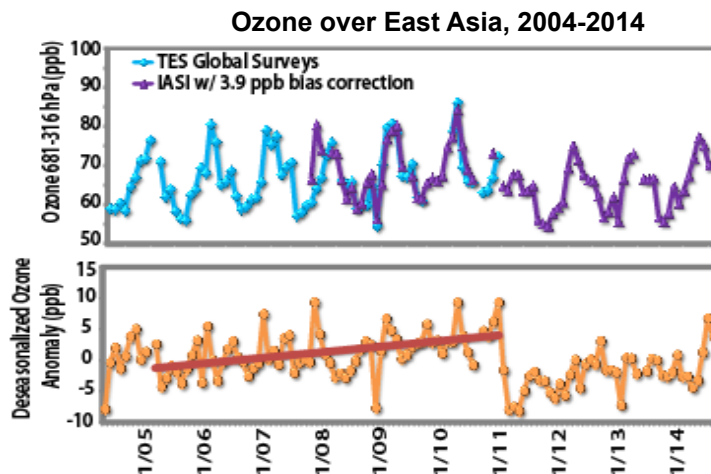


# HAQAST Partnership with CARB and SCAQMD

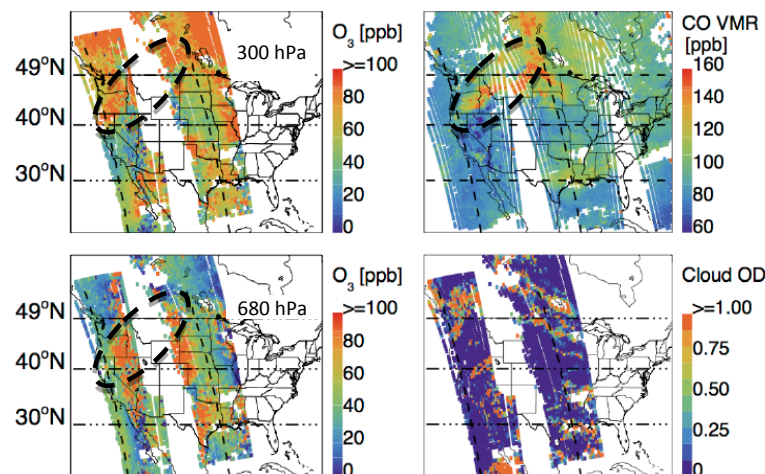
Analyze how background ozone has responded to changes in international emissions (particularly those from East Asia) as well as to natural variability in long-range transport and stratosphere-troposphere exchange over the past ~10 years.



Generate regional maps of tropospheric ozone profiles to aid in exceptional event analysis.



Use assimilated satellite measurements to generate ozone lateral and upper boundary conditions for regional models.



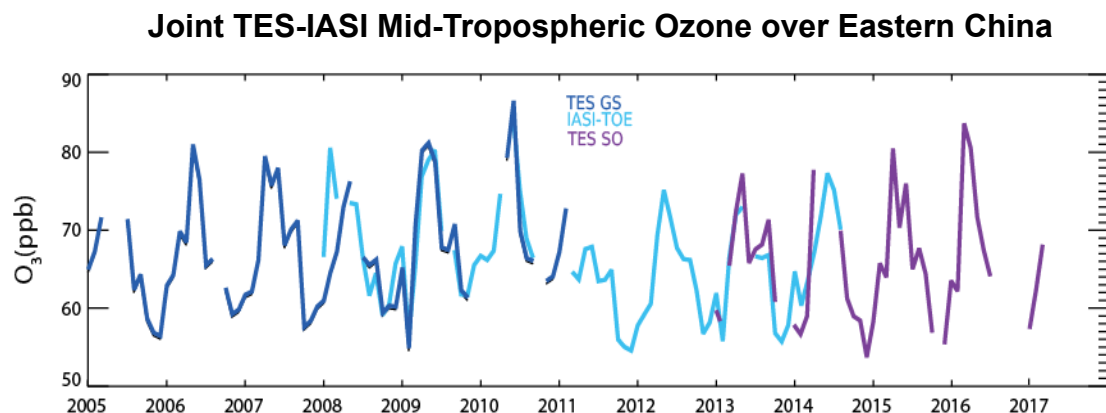
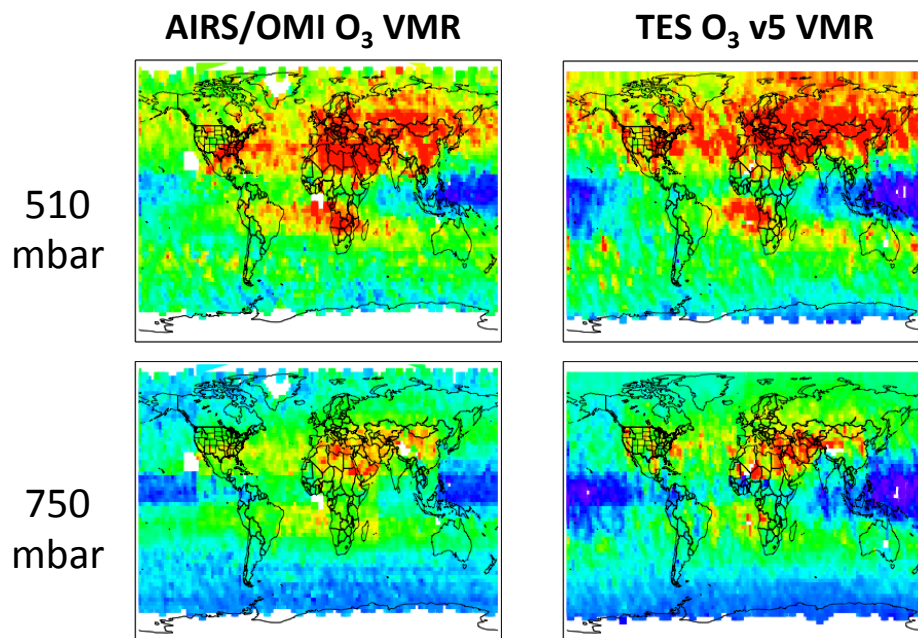


# New Satellite Records of Tropospheric Ozone

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

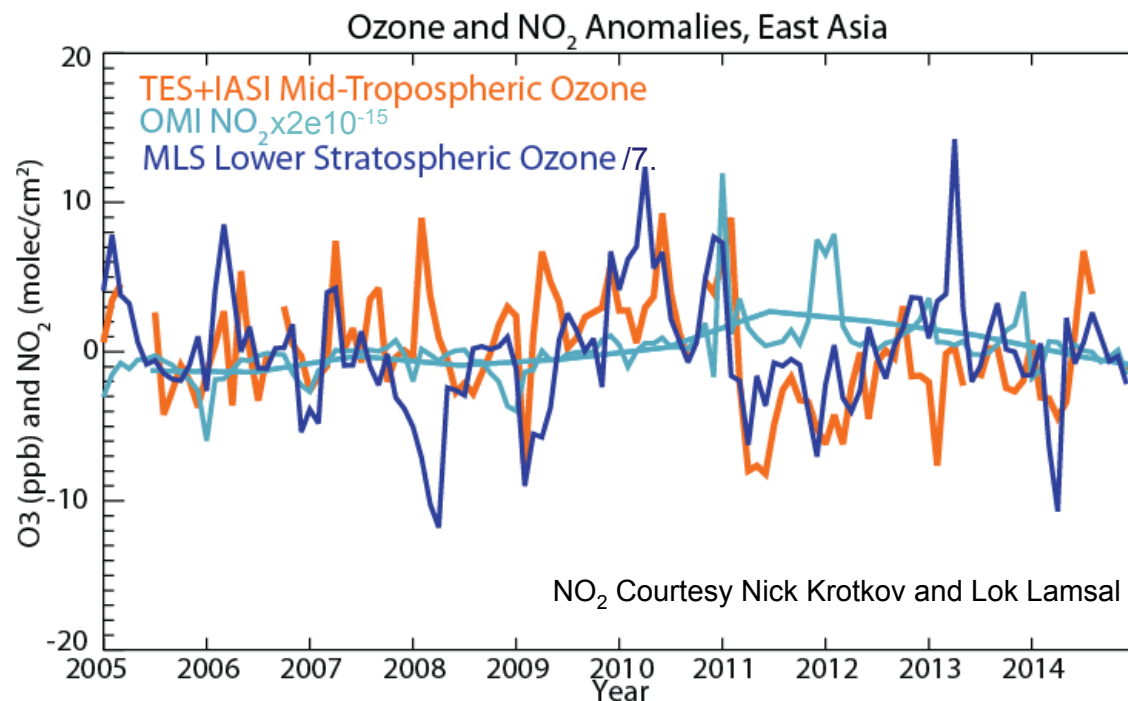
The JPL MUSES (Multi-SpEctra, Multi-SpEcies, Multi-Sensors Retrievals of Trace Gases) algorithm delivers both retrieved trace gas concentration profiles and observation operators.

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





# Assessing Changes in Background Ozone



The joint TES-IASI time series over East Asia shows a rapid drop in ozone in 2011 that appears to be of stratospheric origin, as well as an overall decline following peak values in 2010

# Assessing Changes in Background Ozone

## GEOS-Chem Simulations

$\text{NO}_x$  emissions based on OMI  $\text{NO}_2$  + Assimilation of stratospheric ozone from MLS

Evaluation against TES, IASI, AIRS/OMI and surface data

### 1. Baseline

- Mass balance emissions
- MLS assimilation

### 2. Global constant emissions

- Constant 2005 emissions globally
- MLS assimilation

### 3. China constant emissions

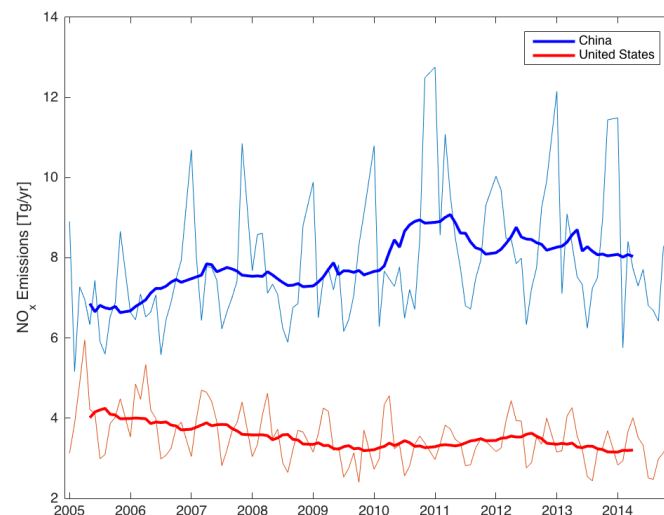
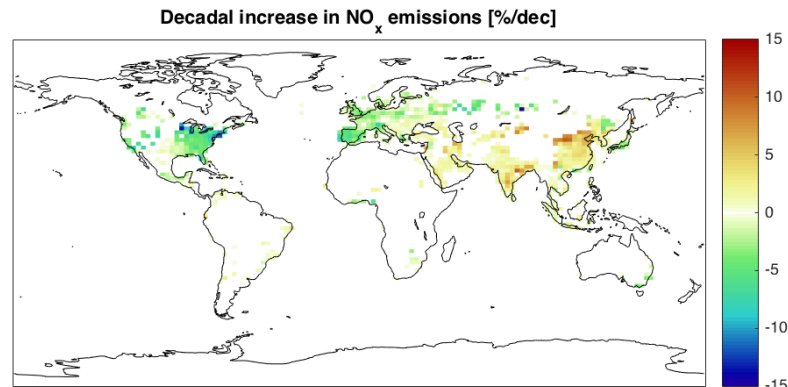
- Constant 2005 emissions over China
- MLS assimilation

### 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





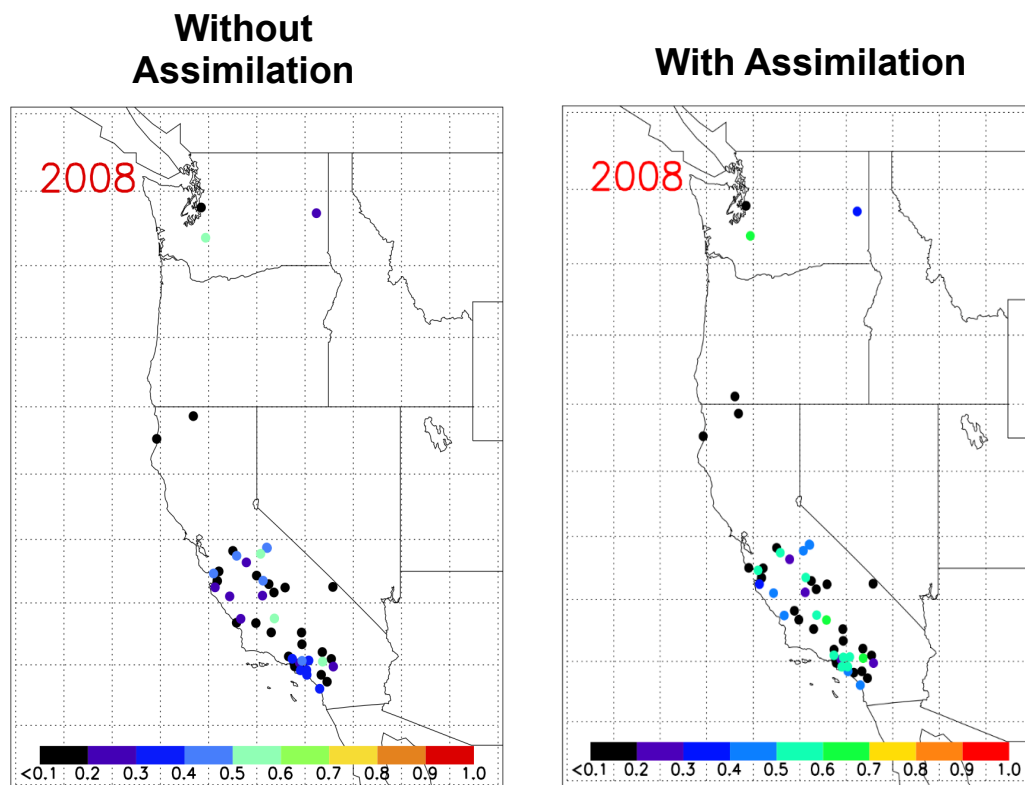
# Satellite-Assimilated Boundary Conditions

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 Tiger Team.

## Correlation Between Model and Surface Observations



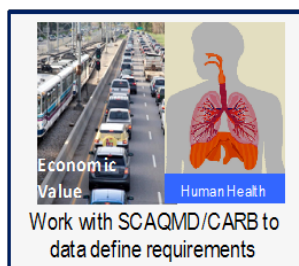
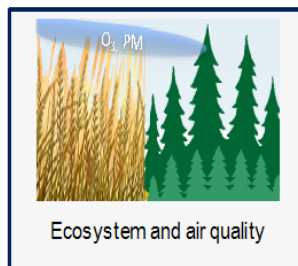
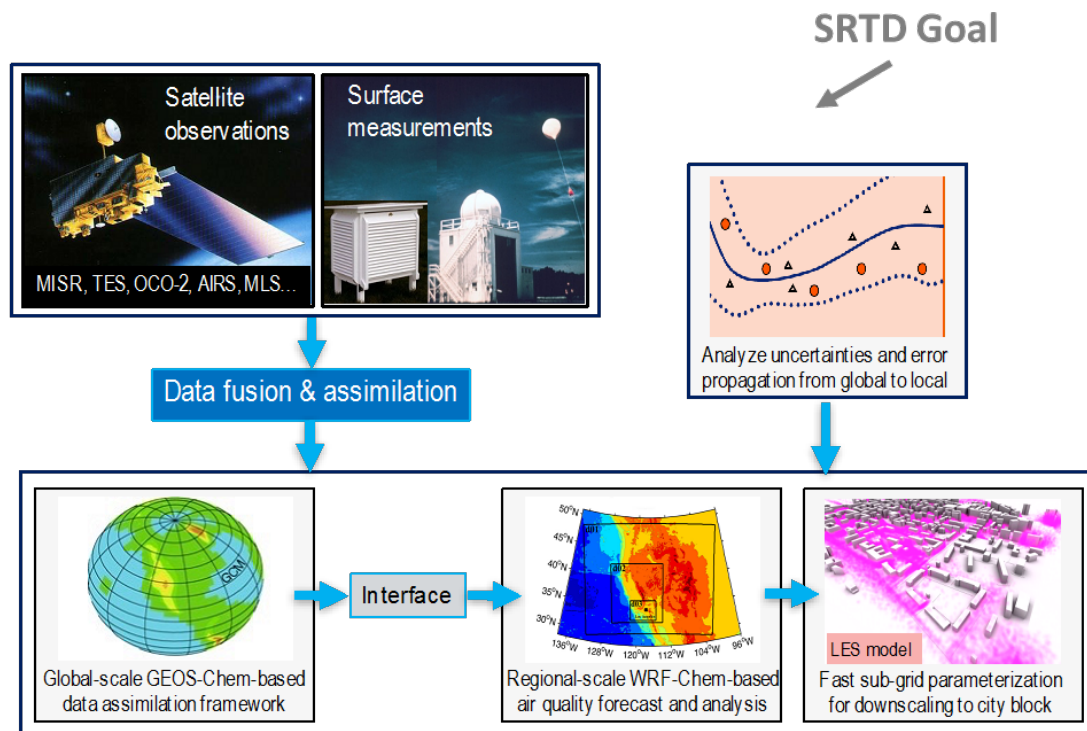




# JPL's New Strategic Research and Technology Development Air Quality Initiative

## Deliverable:

A unified modeling and data assimilation system for both ozone and aerosols for use in applications and in formulating missions for advancing air quality monitoring and forecasting as well as decision support



...

← Societal and JPL mission applications