Jet Propulsion Laboratory
California Institute of Technology

Updated tropospheric chemistry reanalysis and emission estimates using long-term sounder composition records

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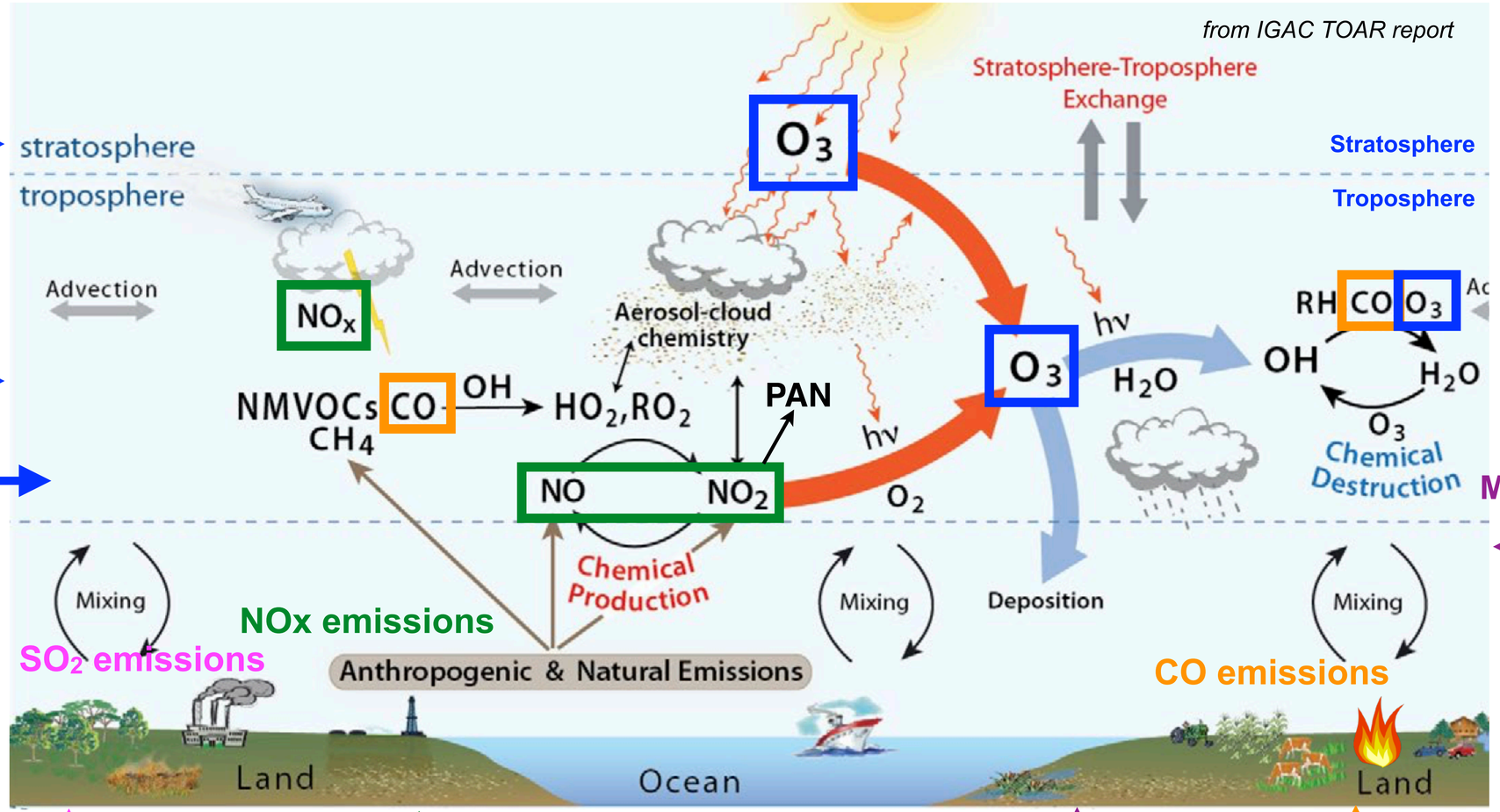
Multi-constituent multi-satellite chemical data assimilation



MLS (O_3,HNO_3)

TES

AIRS/OMI (O_3)

Monitoring

CrIS (O_3,PAN)

Assimilation

OMI (SO_2)

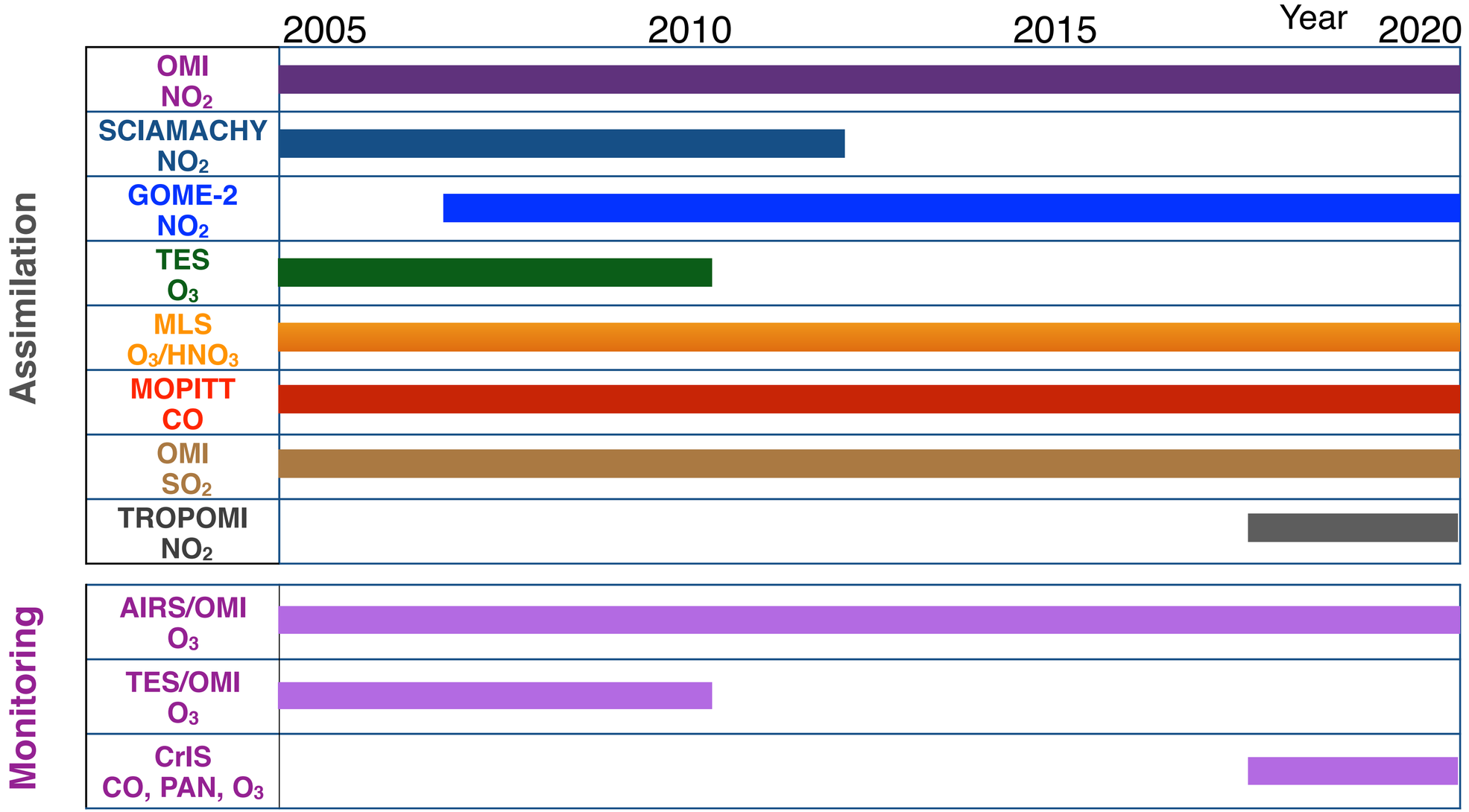
OMI, SCIAMACHY, GOME-2, TROPOMI (NO_2)

Monitoring

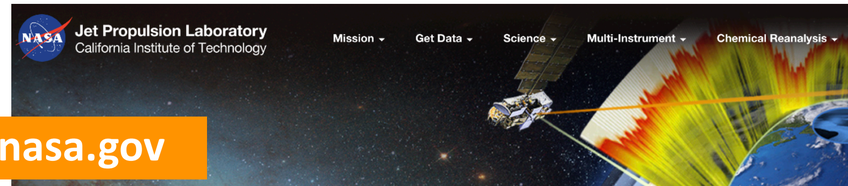
CrIS (CO)

MOPITT (CO)

Decadal tropospheric chemistry reanalysis: TCR-2



Miyazaki et al., 2020a

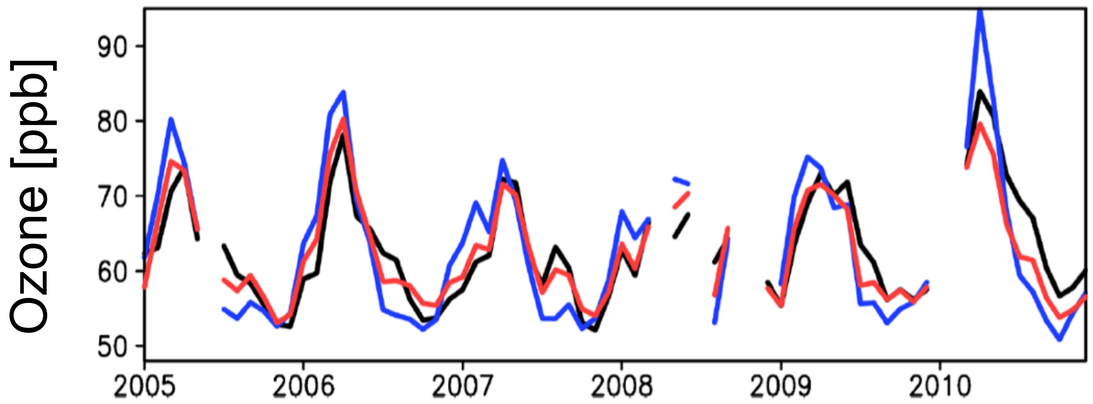


https://tes.jpl.nasa.gov

Free tropospheric and surface ozone validation

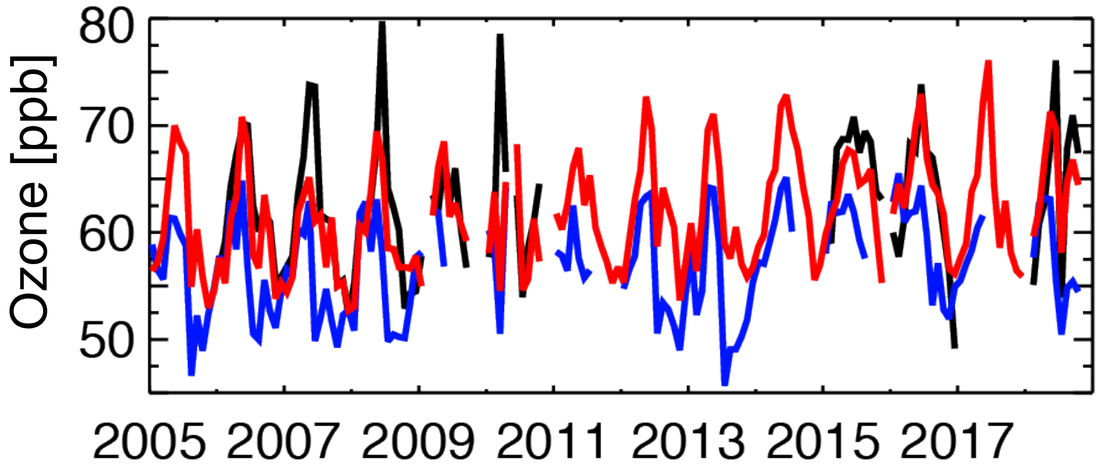
700-300 hPa: against TES (China)

AIRS/OMI
Model
Reanalysis
(w/o TES)



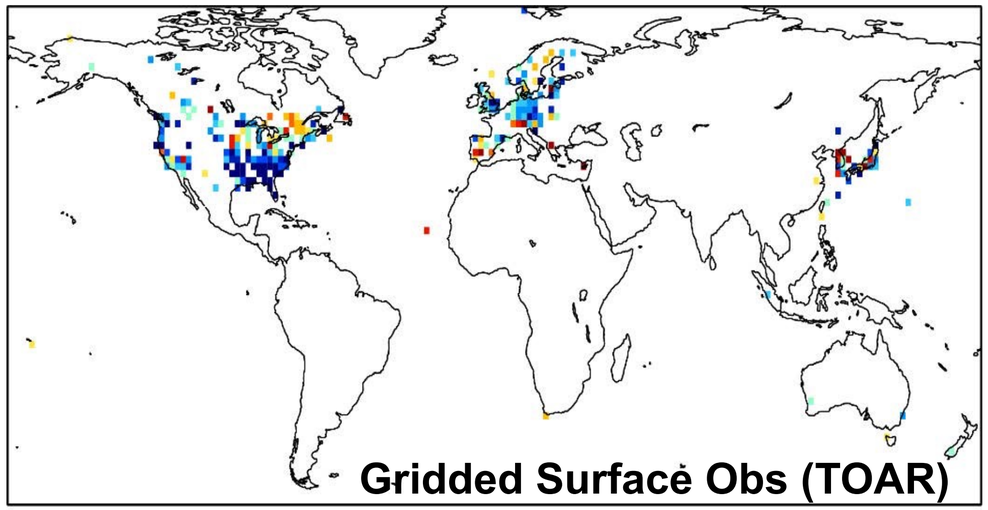
700-500 hPa: against AIRS/OMI (China)

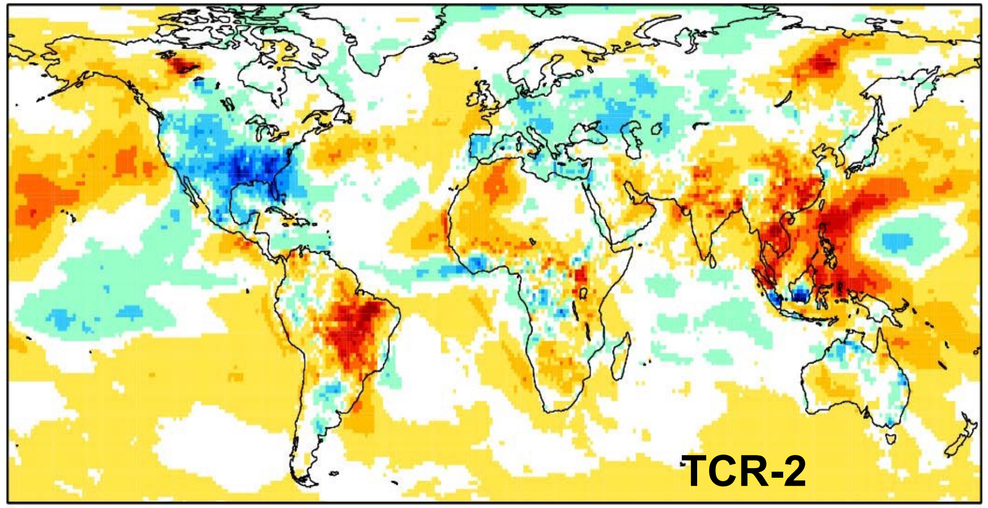
AIRS/OMI
Model
Reanalysis



TES/OMI multispectral ozone products have also been used to infer surface ozone (Colombi et al., in prep.)

Surface ozone changes: 2005-2014

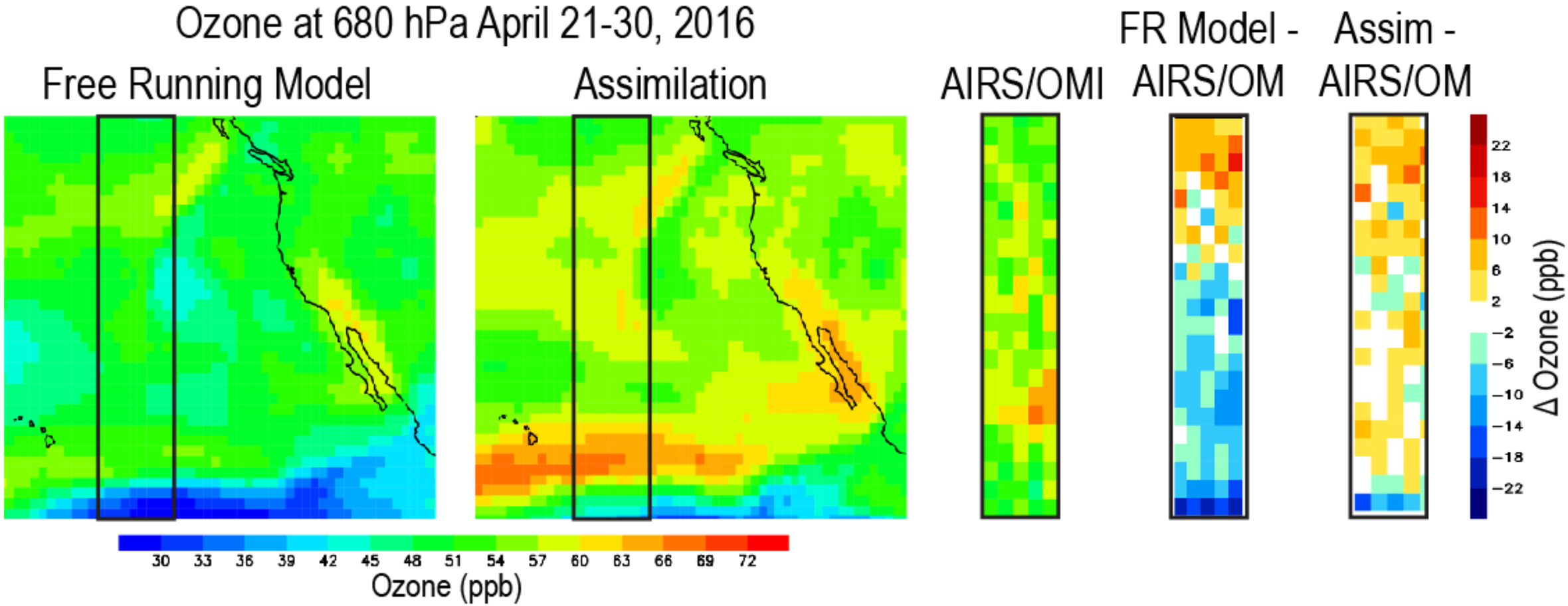




ΔO_3 (ppb)

Regional model boundary conditions: Evaluation using AIRS/OMI

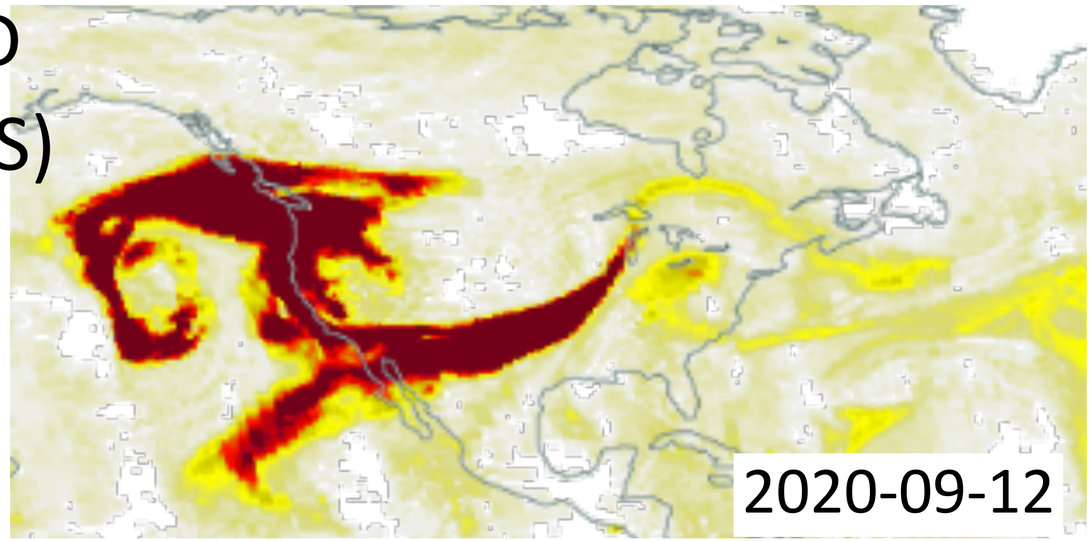
NASA HAQAST



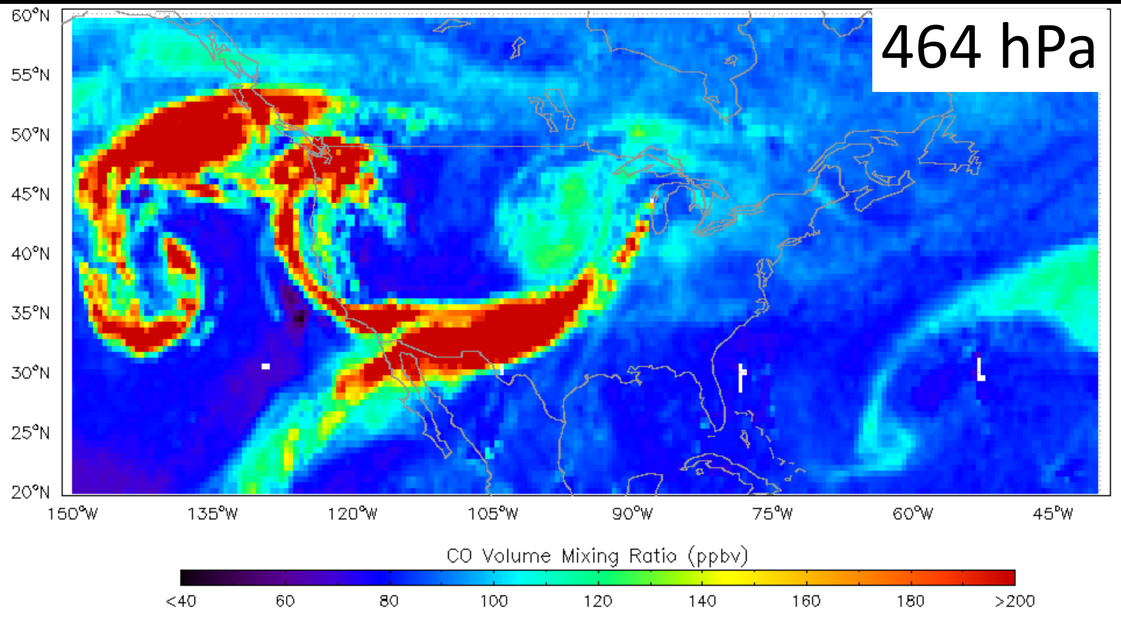
- The assimilation improves the representation of plume transport across the Pacific relative to AIRS/OMI
- Further improvements may be seen with assimilation of AIRS/OMI O_3.

CrIS composition data: 2020 California wildfires

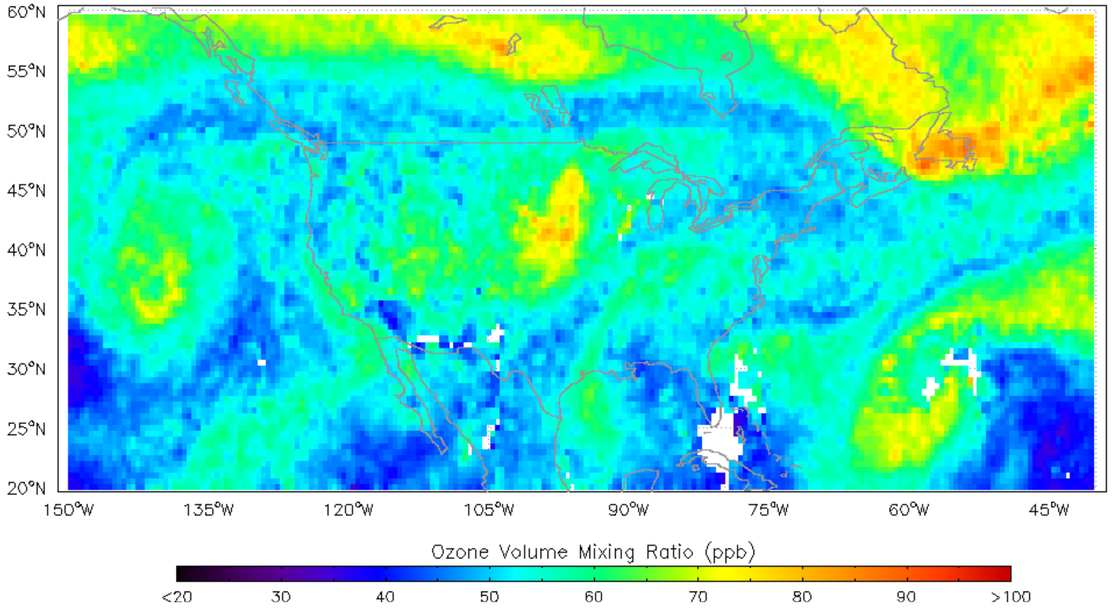
AOD (VIIRS)



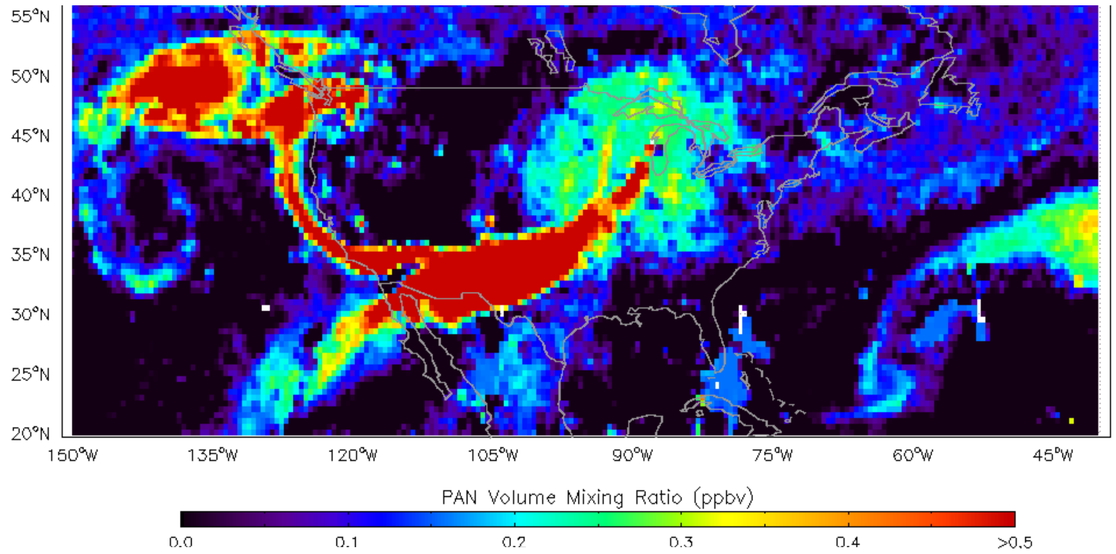
CO



O3



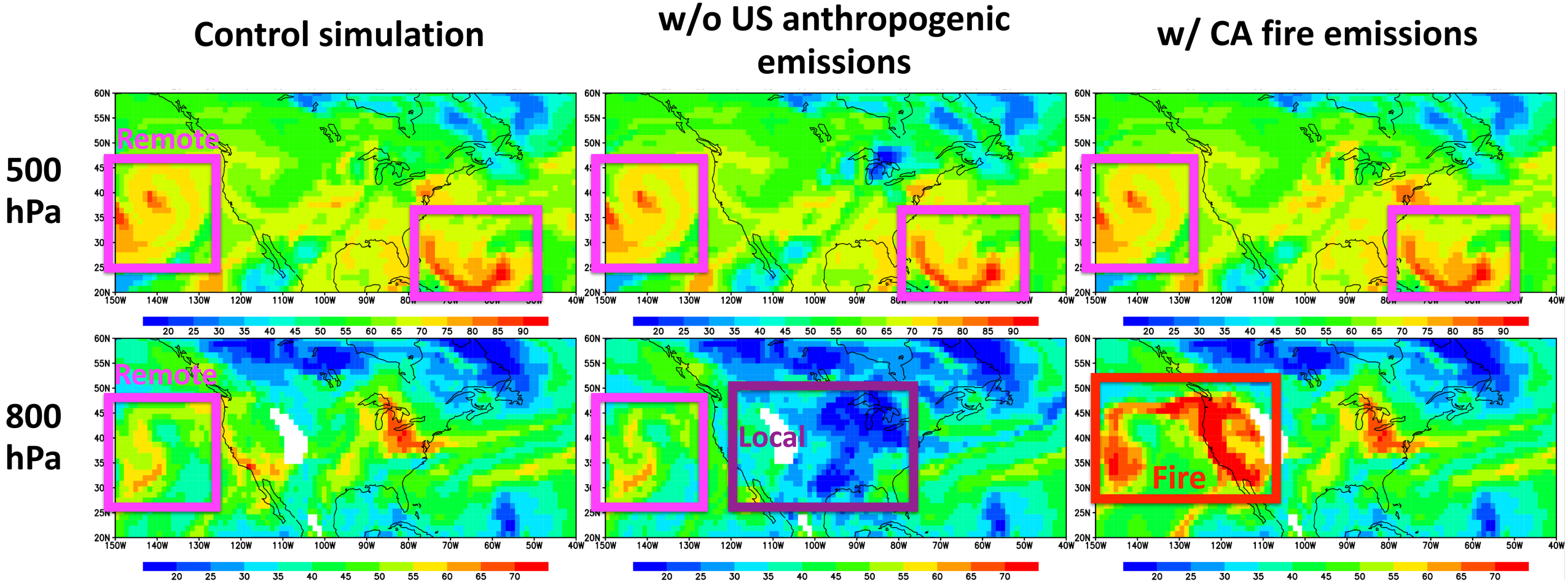
PAN



CrIS single-footprint retrievals from MUSES developed under JPL TROPESS

CrIS provides detail spatial maps of complicated chemical responses linked to wildfires

CrIS composition data: 2020 California wildfires

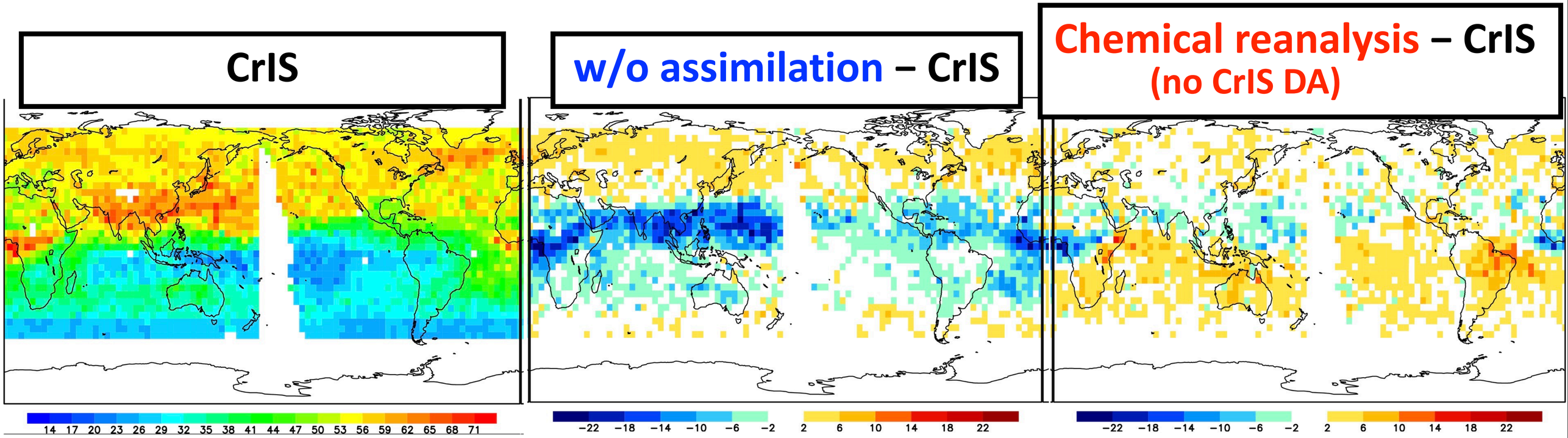


Ozone, 2020-09-12

- The model simulations demonstrate the relative importance of different processes.
- Assimilating CrIS data would comprehend understanding of more detailed processes (e.g., emissions)

CrIS composition data: COVID environmental impacts

700 hPa ozone, June 2020



How does CrIS data inform us the COVID-19 impacts on tropospheric composition?

CrIS composition data: COVID environmental impacts

Environmental policy to reduce human health risk from air pollution

Human activity

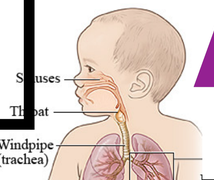
Human activity and technology

Air pollutant emissions (NOx etc)

Complex chemical mechanisms

Air pollution level (Ozone, PM2.5)

Human health



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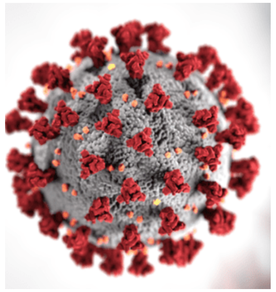
Implications for effective policy making

COVID-19 natural experiment



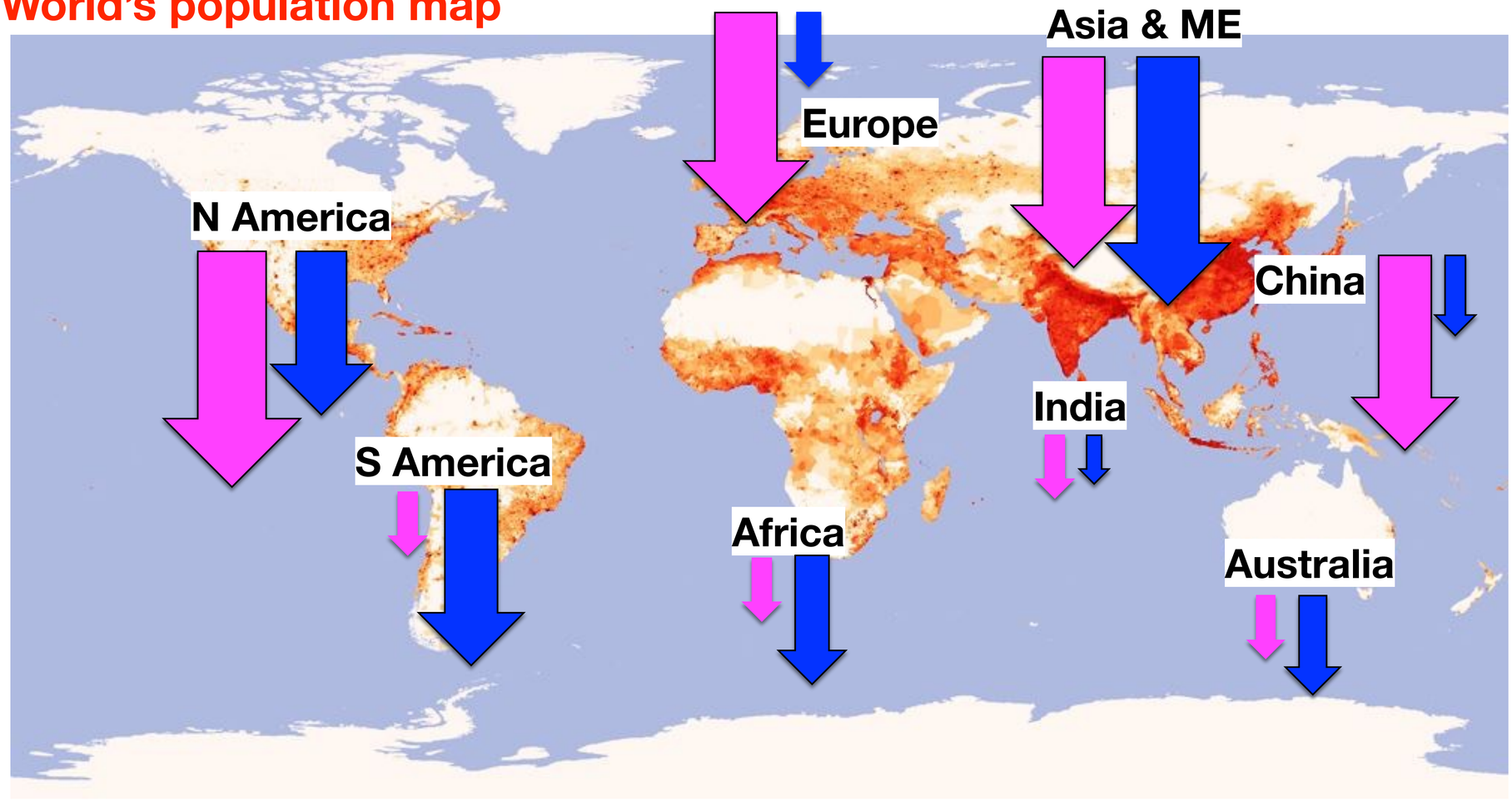
Answer!! (observables)

Can be inferred

Global emission changes and their impacts on ozone

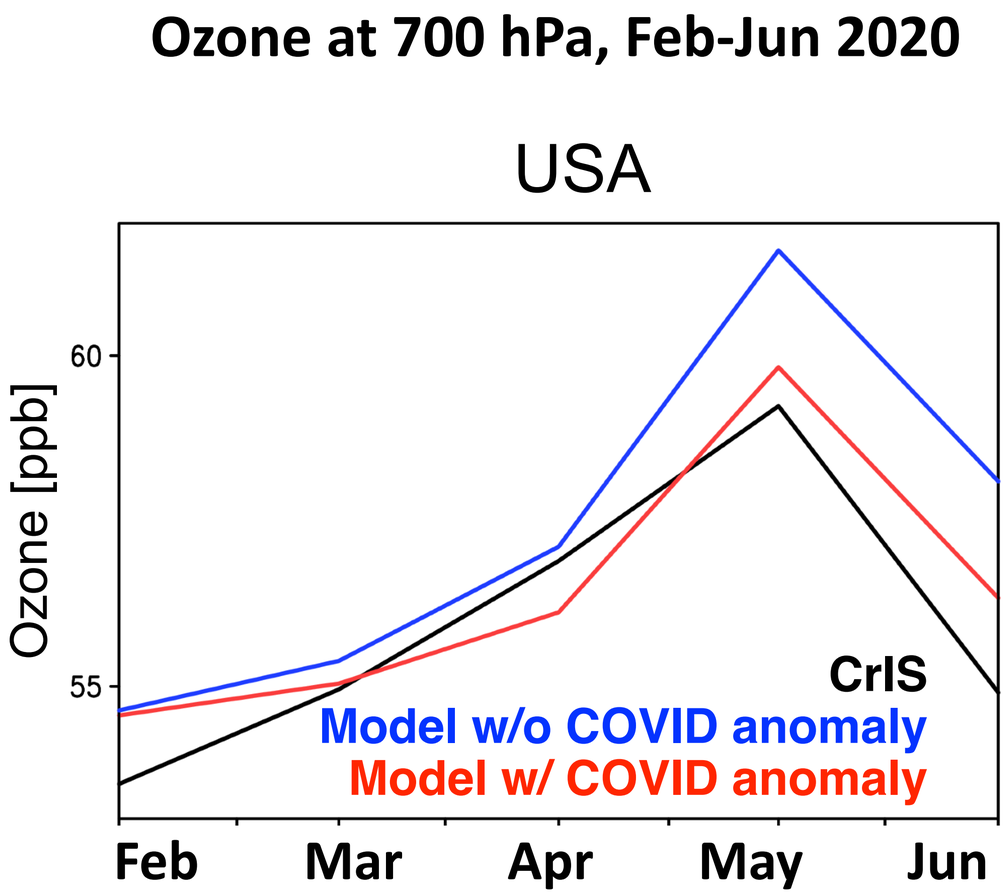
Changes in NOx emissions → Changes in global ozone

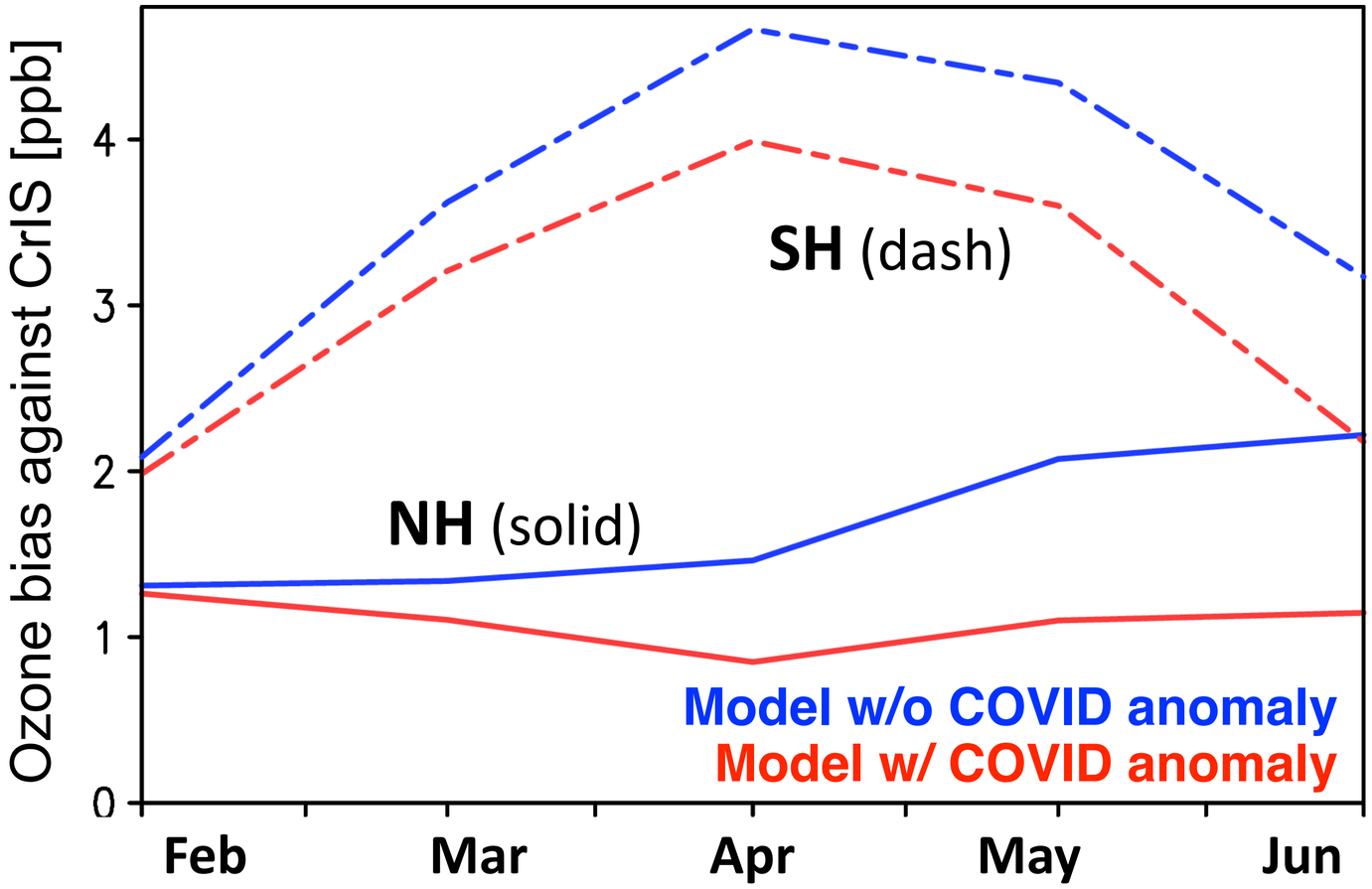
World's population map



The ozone response strongly depends on the region and timing of lockdown

CrIS composition data: COVID environmental impacts





- Demonstrate the substantial influences of the COVID pandemic on FT ozone
- CrIS provides important information to calibrate these changes for the global troposphere.

Summary

- A 16 year tropospheric chemistry reanalysis has been conducted using multi-constituent multi-sensor satellite data assimilation, in order to provide comprehensive information on long-term and short-term (e.g., COVID-19) atmospheric composition variability associated with changes in human and natural activities.

- New LEO and GEO measurements and multi-spectral retrievals of composition from JPL TROPESS, including CrIS and AIRS/OMI, provide much-improved spatial and temporal resolution and coverage. They should lead to greater usefulness of satellite measurements for air quality applications.

Q1. What overarching science questions would you like to address with long-term sounder composition records, given what you know about their quality and uncertainty?

A. Decadal/multi-year (e.g., ENSO) variations in atmospheric compositions, e.g., related to human activity (combined with CO2), lightning, inter-continental and inter-hemispheric long-range transport of air pollutants (O3, CO) and its precursors (e.g, PAN), STE, wildfires, ozone chemistry regime (VOC/NOx), nitrogen deposition (e.g., HNO3). Chemistry-climate model simulation evaluation. Improving regional air quality forecast/reanalysis

Q2. What should be the highest priorities when developing new trace gas products for air quality / climate monitoring?

A. Consistent long-term records, simultaneous retrievals of multiple key chemical species, high spatial sampling around key urban areas

Summary

Q3. What are the highest priorities in terms of composition data products / data fields / information from sounder retrievals, from the perspective of chemical data assimilation? Here you can even highlight current shortcomings, difficulties in using/ accessing the products, lack of available tools etc.

A. Effective QC (maximized data use with no very bad data!). Estimates of vertical sensitivity and error covariances. Optional: error correlation information for neighbor pixels (needed for making super observations).

Q4. Given that the LEO sounders (IASI, IASI-NG, CrIS) will continue to be in orbit till ~2040s, what, in your mind, are the key observational gaps?

A. Near-surface measurements (e.g., HIMAP or higher spectral resolution in the IR+UV column measurements). TIR geostationary measurements over the US.