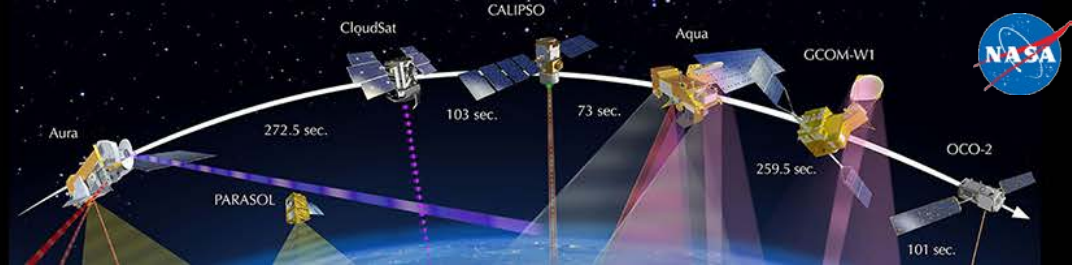
A-Train Symposium 2017

19-21 April 2017 Pasadena, California



Synergistic Observations from OCO-2 and Other A-Train Sensors

David Crisp and Annmarie Eldering

(Jet Propulsion Laboratory, California Institute of Technology)
for the OCO-2 Science Team

April 19, 2017

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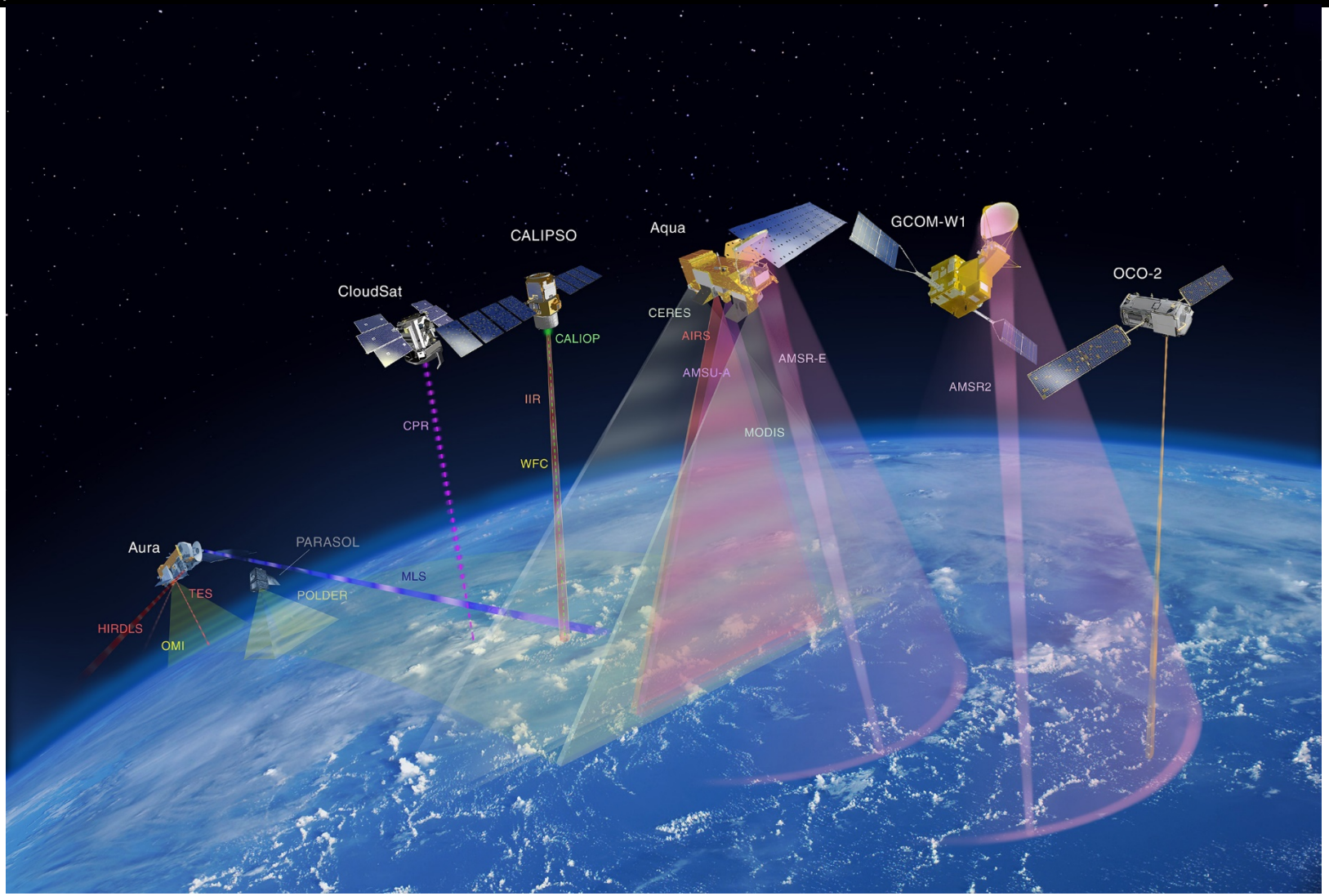
Government sponsorship acknowledged

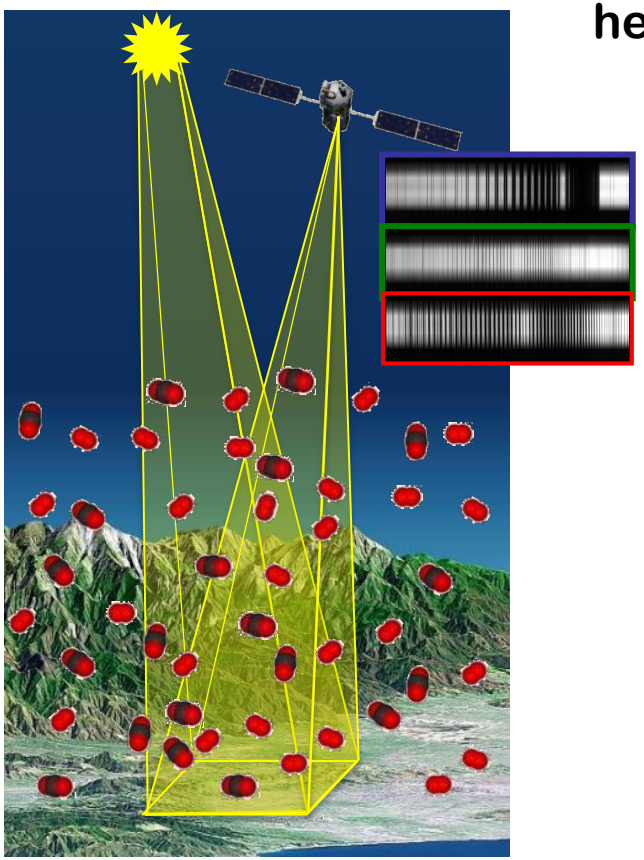
Orbiting Carbon Observatory-2 (OCO-2)



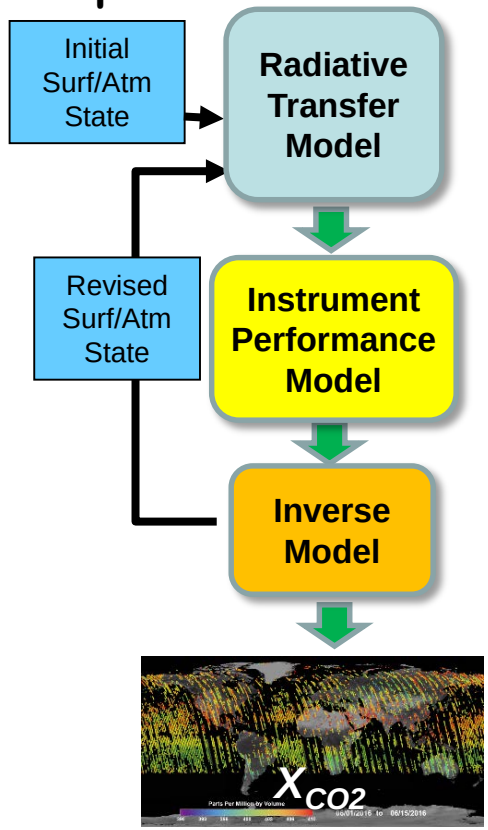
OCO-2 was inserted at the head of A-Train on 3 August 2014

Measuring CO_2 from Space

- **Record** spectra of CO_2 and O_2 absorption in reflected sunlight

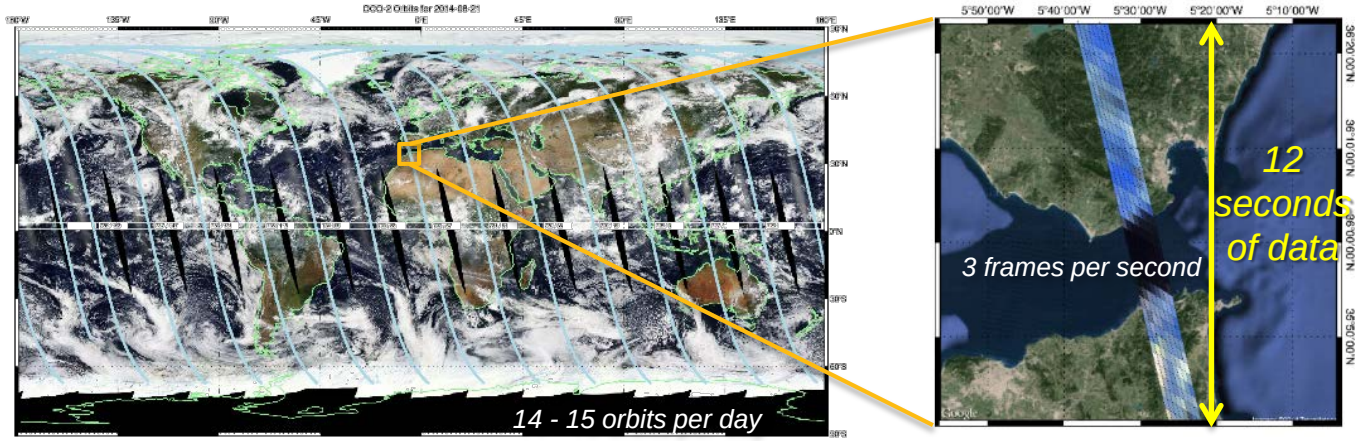


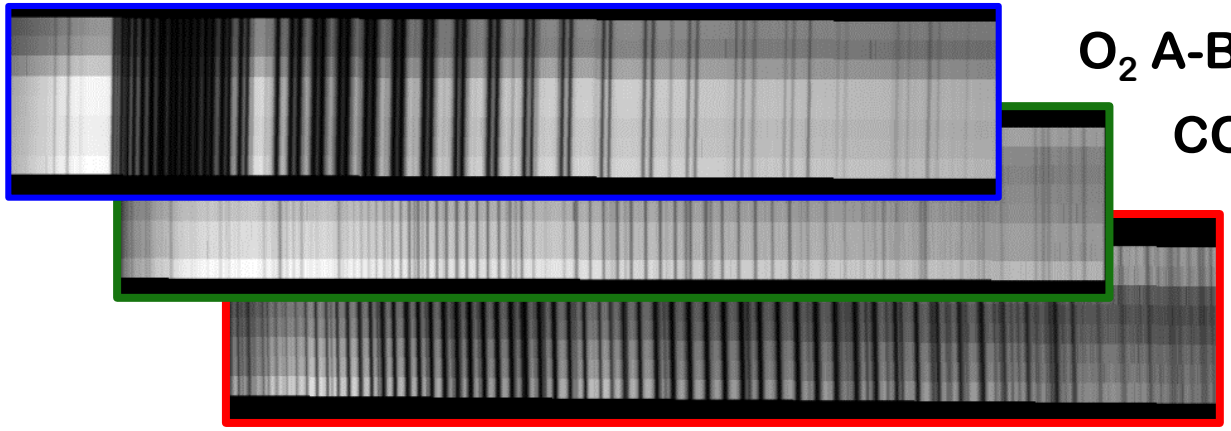
Retrieve variations in the column averaged CO_2 dry air mole fraction, X_{CO2} over the sunlit hemisphere



Validate measurements to ensure X_{CO2} accuracy of 1 ppm (0.25%)

OCO-2 Sampling Approach





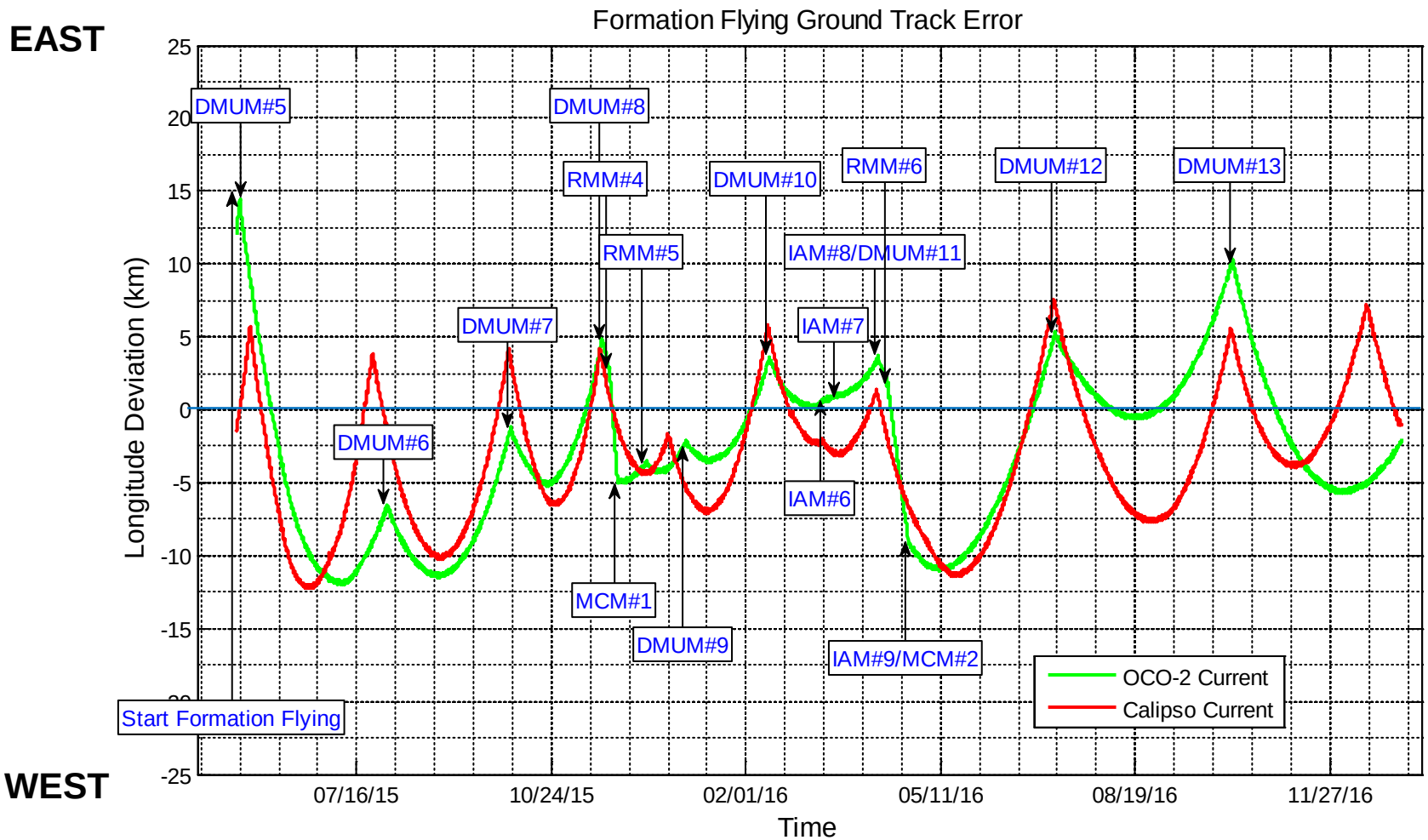
O_2 A-Band

CO_2 1.61 μm Band

CO_2 2.06 μm Band

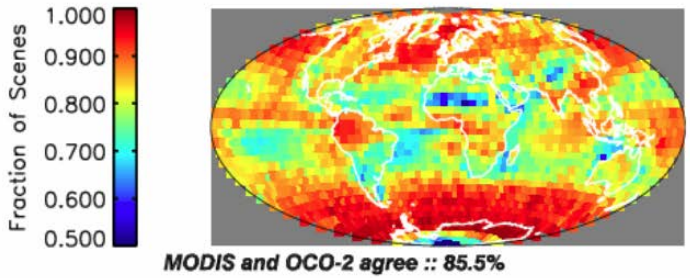
The OCO-2 instrument collects 24 soundings each second as it flies over the sunlit hemisphere of the Earth, yielding almost 1 million soundings each day

Formation Flying: OCO-2, CALIPSO, and CloudSat

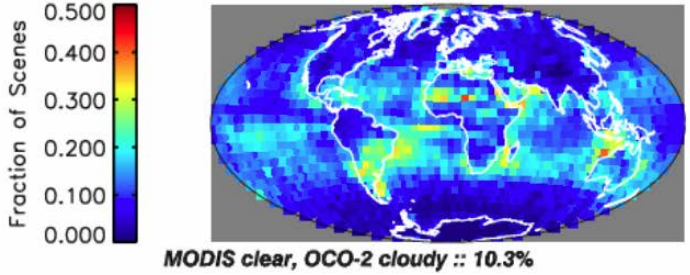


The OCO-2 Navigation Team maintains the OCO-2 orbit track so that the CALIPSO and CloudSat footprints usually fall within the OCO-2 nadir swath.

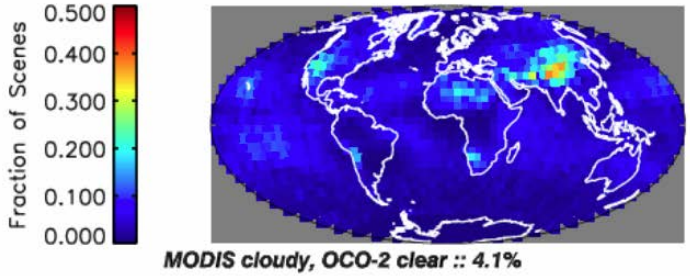
Cloud Screening: OCO-2 + MODIS



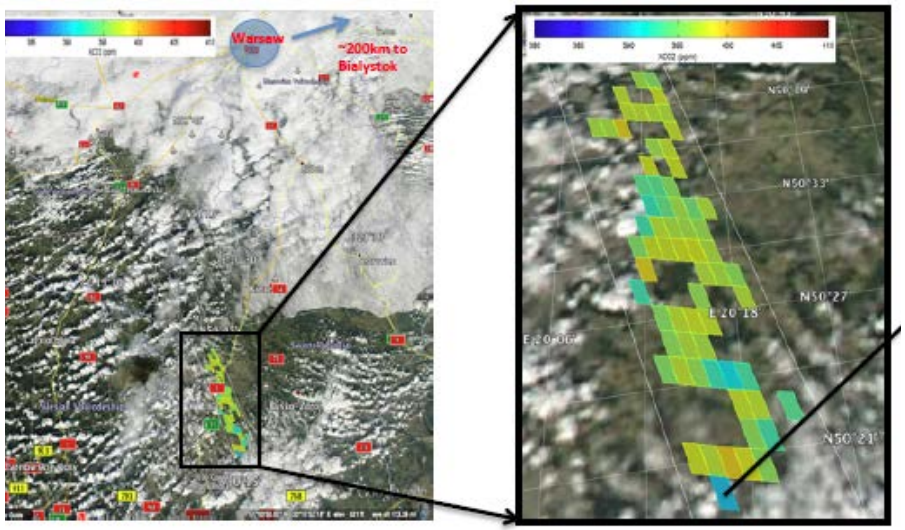
AGREE
85%



MODIS CLEAR
OCO-2 CLOUD
10%



MODIS CLOUD
OCO-2 CLEAR
5%



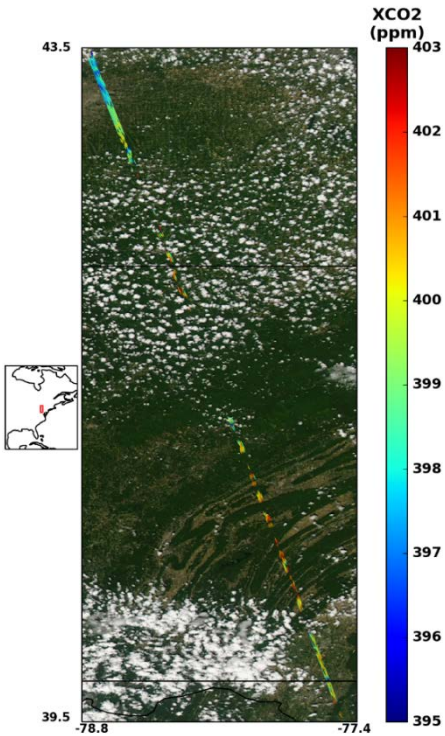
Occasionally, low clouds are missed, and contribute to anomalously low X_{CO2} estimates.

Generally, the agreement between OCO-2 and MODIS is very good (better than 85% agreement).

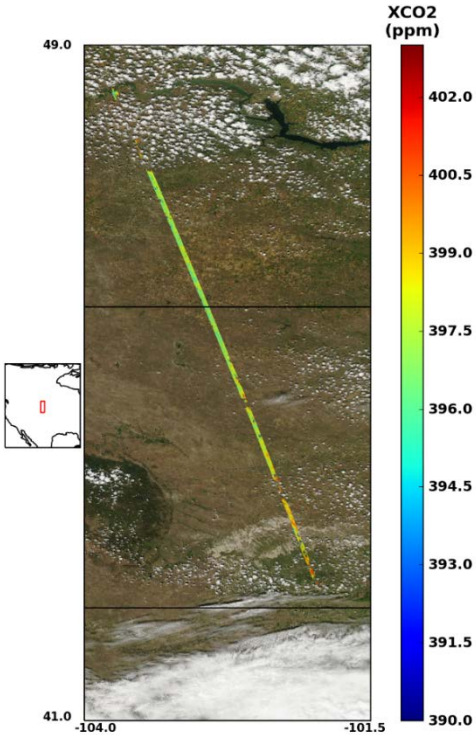
Tommy Taylor et al. AMT 2016

Partially Cloudy Scenes: OCO-2 + MODIS

Assessing performance of cloud screening in partially cloud fields over North America



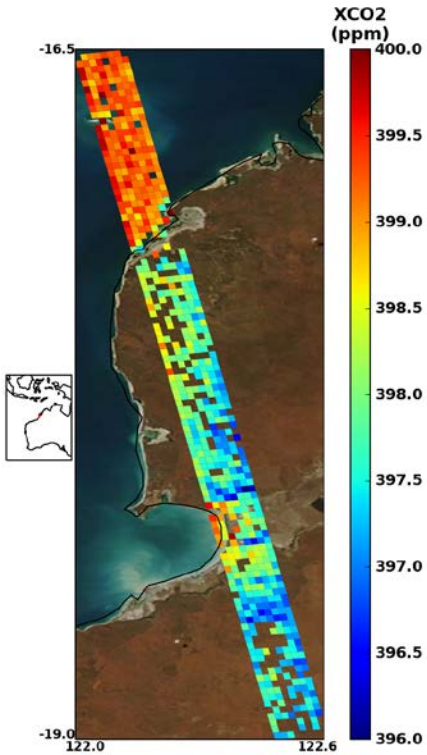
27 July, 2016:
Mid-Atlantic
Orbit 11016, Nadir

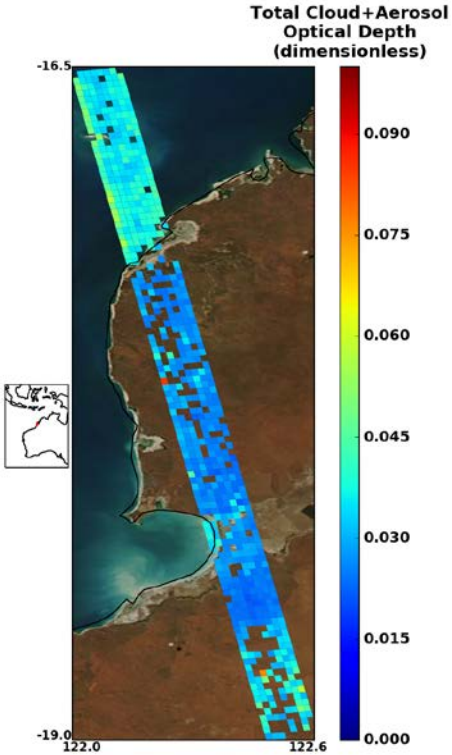


5 August, 2016:
Mid-West
Orbit 11148, Nadir

Chris O'Dell and Emily Bell

Identifying sources of bias in land-nadir transitions over northwest Australia

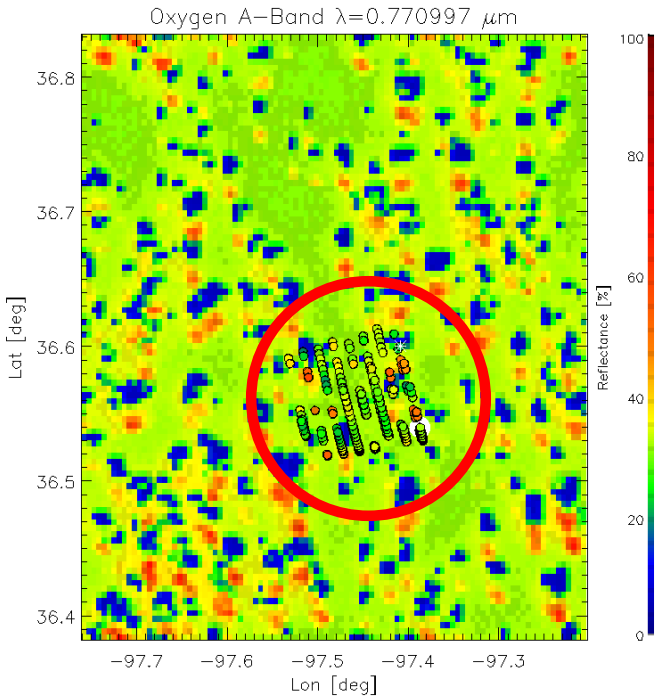




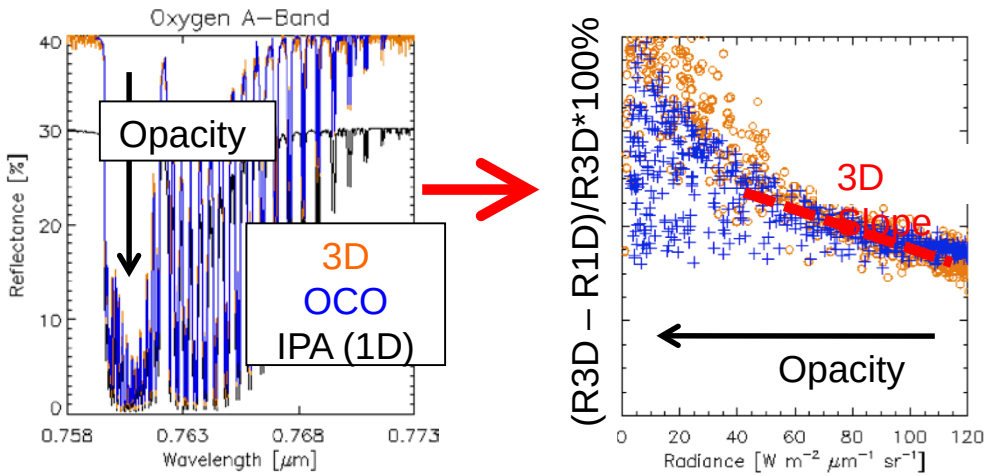
MODIS observations used to validate cloud optical depth retrievals in a clear regions.

Tommy Taylor and Rob Nelson

3D Cloud Effects: Mechanism, Detection and Mitigation : OCO-2 + MODIS



Normalized 3D "Spectral" Residual

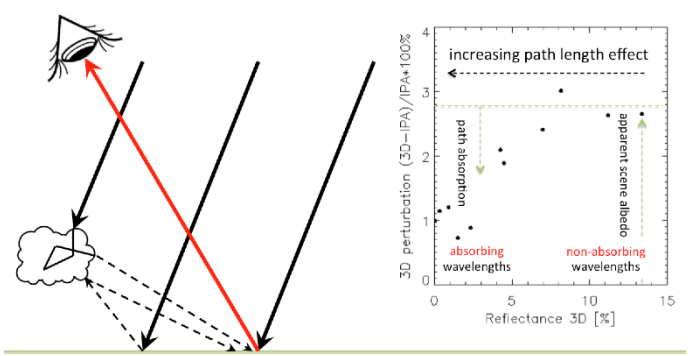


It may be possible to detect 3D cloud effects based on the residual's radiance dependence.

Mitigation may be possible by including 3D slope in state vector, *avoiding* operational 3D calculations.

<u>OCO-2 3D Radiance Simulator</u> based on MCARaTS RT code (H. Iwabuchi, Japan)

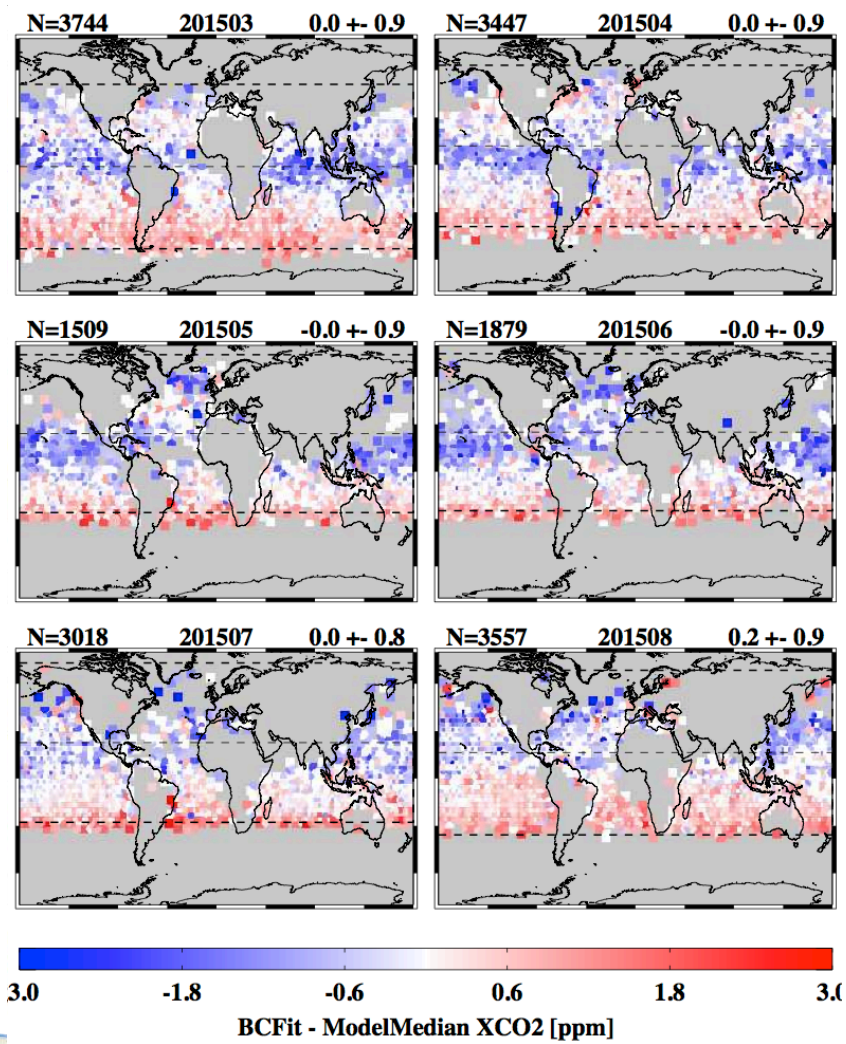
→ Studied mechanism of 3D effects
Pixel-by-pixel OCO-2/model validation possible.



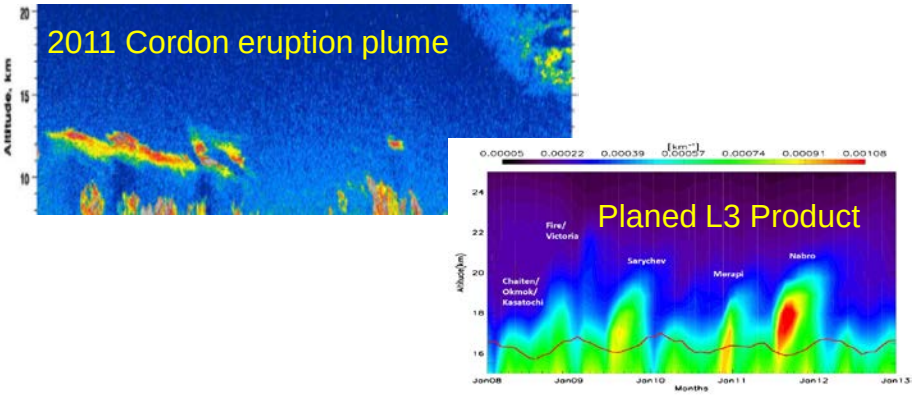
Schmidt et al., 2017 (in preparation)

Coming Attractions: Using CALIPSO Aerosol Profiles

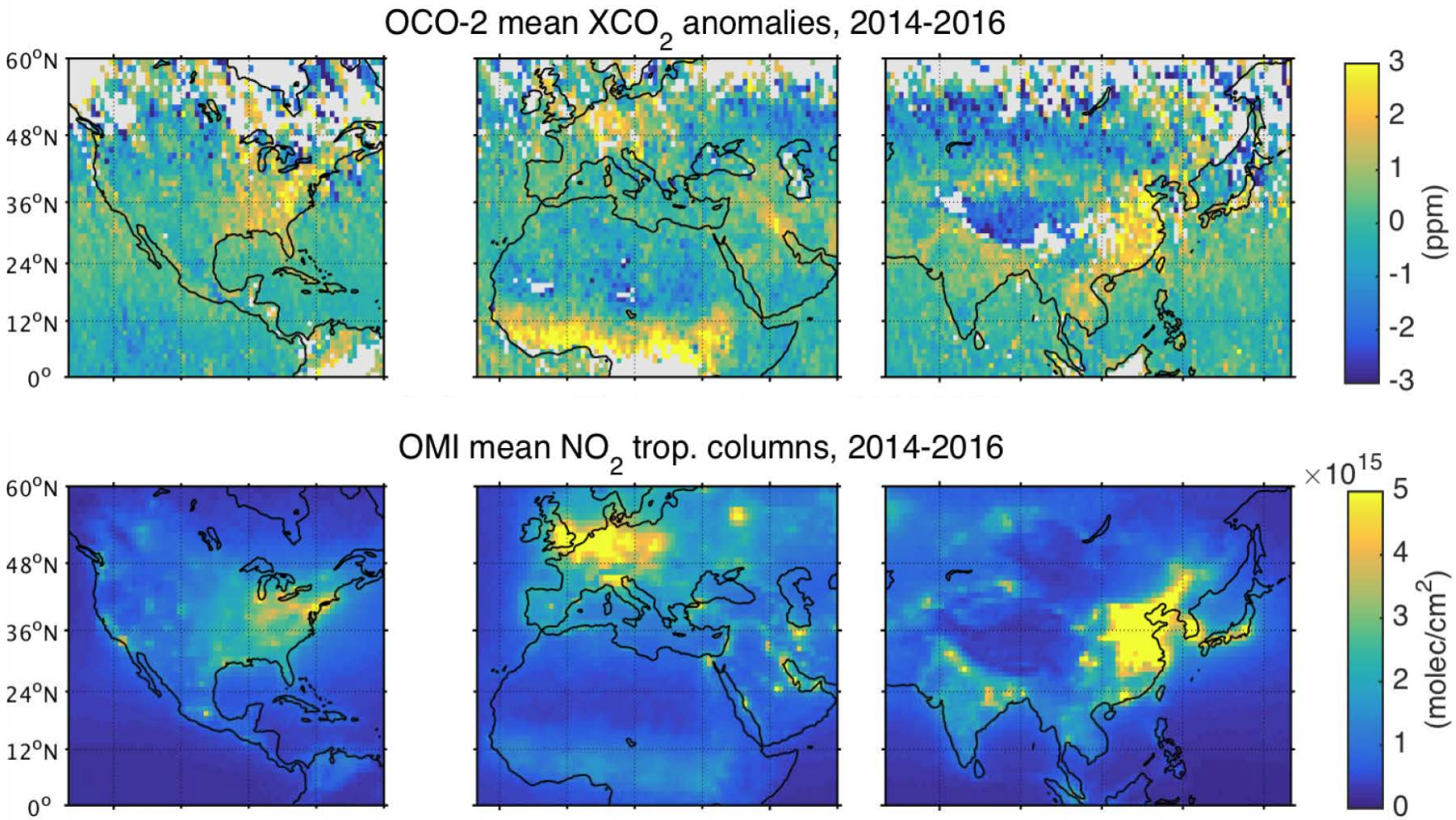
With Strat Aerosols



- Optically-thin stratospheric aerosol layers can introduce biases in the OCO-2 X_{CO2} products
  - The largest effects are seen at high latitudes over the ocean
  - Volcanic activity and fires that enhance stratospheric aerosols can introduce large errors
- CALIPSO CALIOP data can be used as a prior for stratospheric aerosols



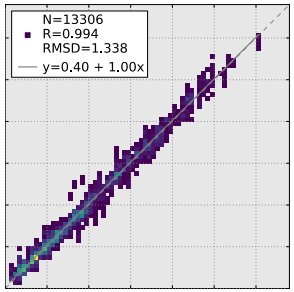
Anthropogenic Emissions: OCO-2+OMI

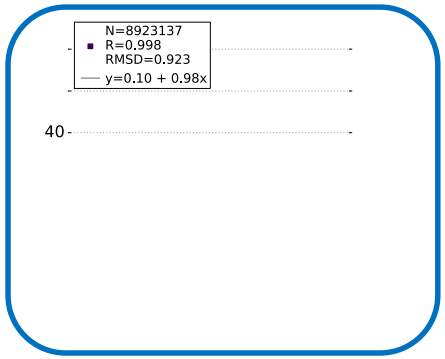


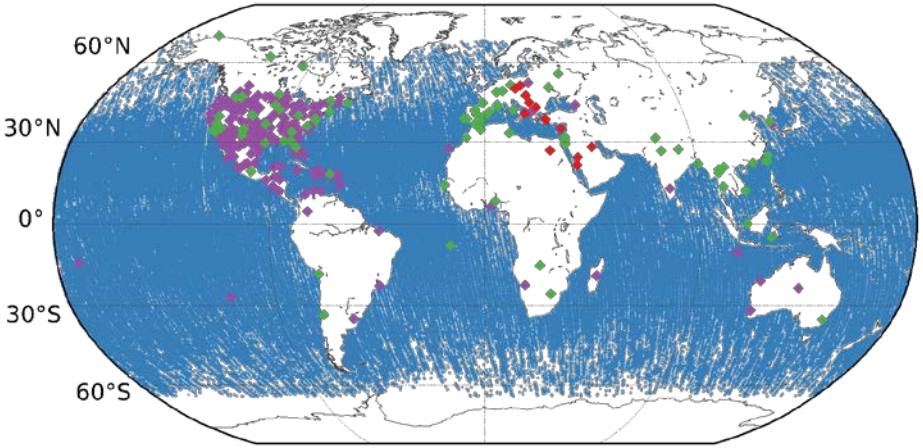
Janne Hakkarainen et al. GRL (2016)

OCO-2 Total Column Water Vapor vs GCOM-W1 AMSR2

- Accurate knowledge of the distribution of water vapor in Earth's atmosphere is of critical importance to both weather and climate studies.
- OCO-2 acquires space-based measurements of the two most important greenhouse gases, water vapor and carbon dioxide.
- Total column water vapor (TCWV) information is routinely retrieved from the OCO-2 near-infrared. spectra.





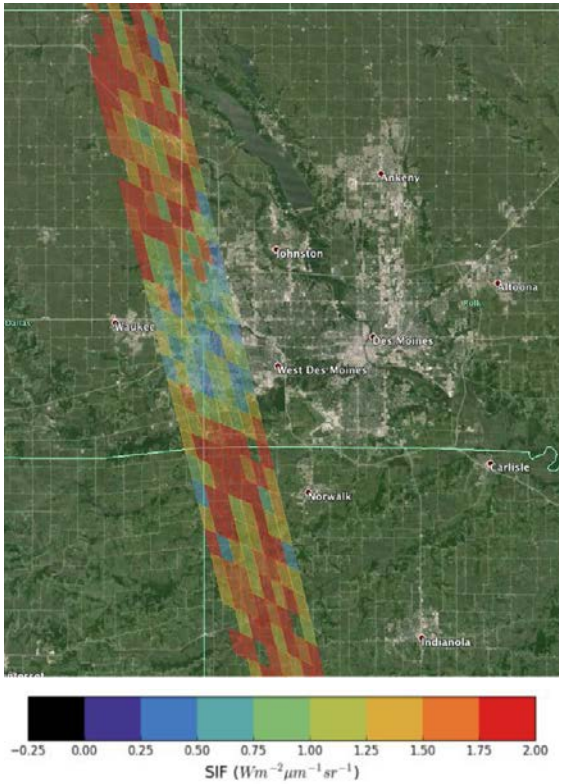


Location of SuomiNet sites (purple), AERONET sites (green), IGRA sites (red), and AMSR2 grid cells (blue) that have a valid OCO-2 measurement co-located in time and space (Sep 6, 2014-Feb 10, 2016).

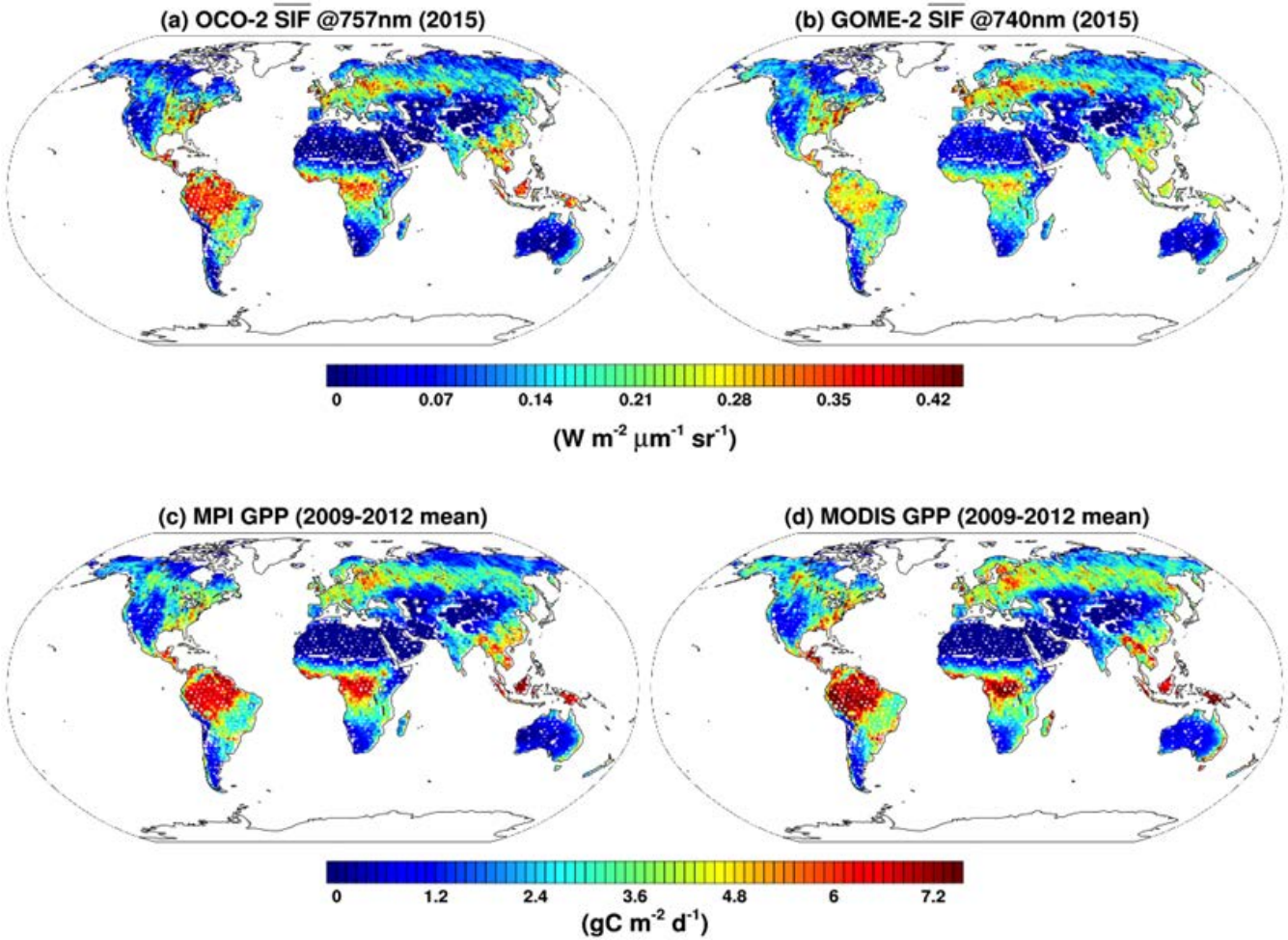
- Comparisons to multiple validation sources show that OCO-2 delivers TCWV measurements with unprecedented precision, accuracy, and spatial resolution (< 3 km^2).
- OCO-2 TCWV measurements may be useful in improving numerical weather reanalysis products.

Robert R. Nelson et al. GRL 2016

OCO-2 Solar Induced Chlorophyll Fluorescence (SIF) vs MODIS GPP



OCO-2 SIF over Des Moines, Idaho



Ying Sun et al. (submitted 2017)

Other Synergistic A-Train Products

- Junjie Liu, Kevin Bowman, Dave Schimel, Nick Parazoo, Anthony Bloom, Meemong Lee, Kevin Gurney, Dimitris Menemenlis. American biosphere carbon flux inter-annual variability: from satellite CO_2, phenology, to eddy covariance observations
- Nicholas C. Parazoo. Using A-Train observations to examine resilience and vulnerability of Arctic and boreal ecosystems to climate change
- Aronne Merrelli, Ralf Bennartz, Chris O'Dell. Combining CALIOP and OCO2 for improved XCO2 retrieval
- Ray Nassar, Tomohiro Oda, Debra Wunch, Dylan B.A. Jones. Quantifying Large Anthropogenic CO_2 Sources from OCO-2
- Annmarie Eldering, David Crisp, Michael Gunson. An Update on the OCO-2 Mission Status
- Thomas P. Kurosu, Florian M. Schwandner, David C. Pieri, Justin P. Linick. Too kink to be square? mapping satellite polygon footprints to regular grids by tessellation