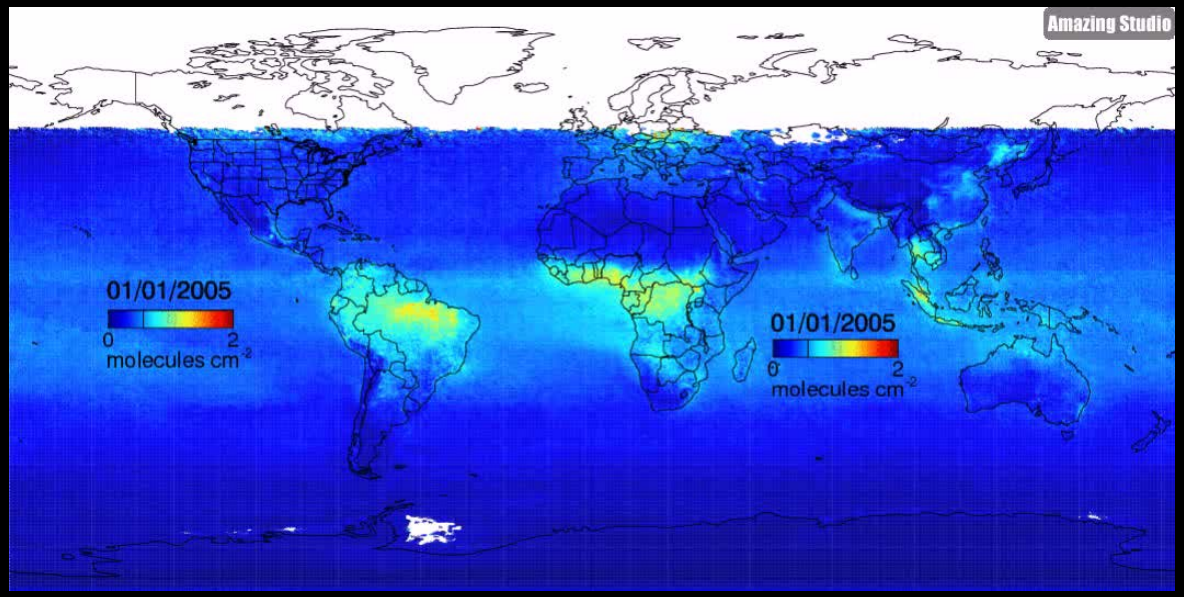
Smithsonian Astrophysical Observatory OMPS Nadir Mapper formaldehyde retrievals



Gonzalo González Abad, Kelly Chance and Xiong Liu

STAR JPSS 4th Annual Science Team Meeting

17th August 2017

Outline

- Formaldehyde in the atmosphere
- Smithsonian Astrophysical Observatory OMPS formaldehyde retrieval:
  - Spectral fitting
  - Air mass factor correction
  - Reference sector correction
- Intercomparison between SAO OMI and OMPS formaldehyde retrievals
- Towards a long-term data record
- Next steps

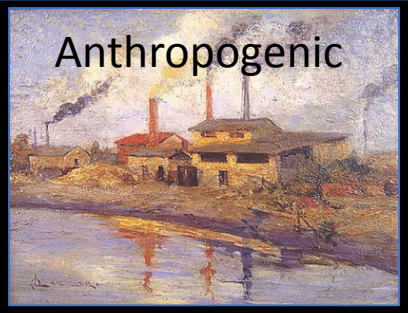
Formaldehyde in the atmosphere:
Formation of tropospheric ozone, organic aerosols, and tropospheric oxidation capacity

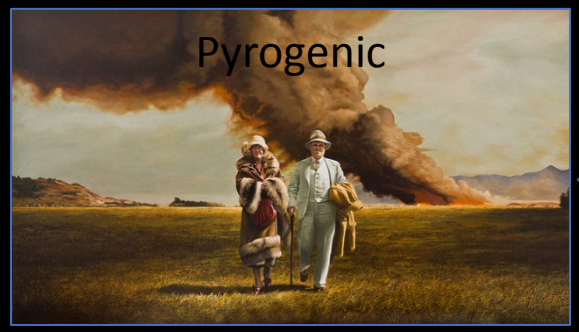
Tropospheric chemistry

Air quality

Climate

Formaldehyde in the atmosphere: sources and sinks





CH_4

Oxidation

NMVOCs

HCHO

OH radical

Photolysis

H_2O; HCO

H; H_2; CO; HCO

Formaldehyde in the atmosphere: satellite observations

Short tropospheric lifetime
→ NMVOCs proxy

Biogenic Emissions

Pyrogenic Emissions

Anthropogenic Emissions

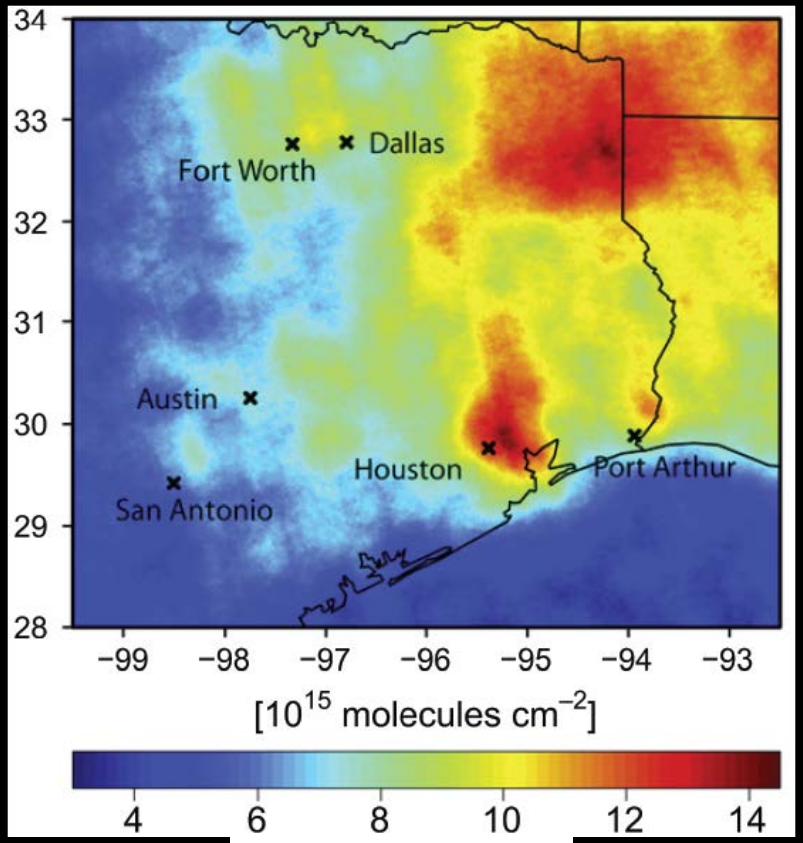
Aerosol formation

Ozone pollution and sensitivity

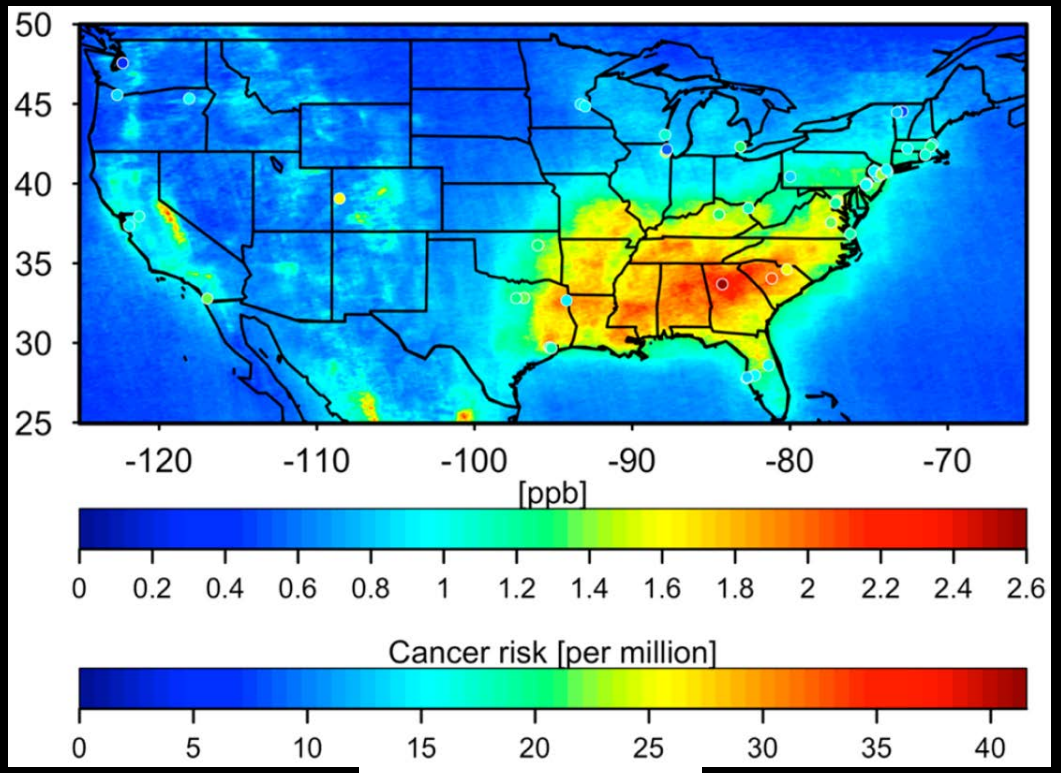
Health studies

Long term trends

Formaldehyde in the atmosphere: satellite observations



Zhu et al., 2014



Zhu et al., 2017

Smithsonian Astrophysical Observatory formaldehyde retrieval

(González Abad et al., AMT, 2016, doi:10.5194/amt-9-2797-2016)

1

Spectral fitting (ΔSCD)

2

Air mass factor correction (ΔVCD)

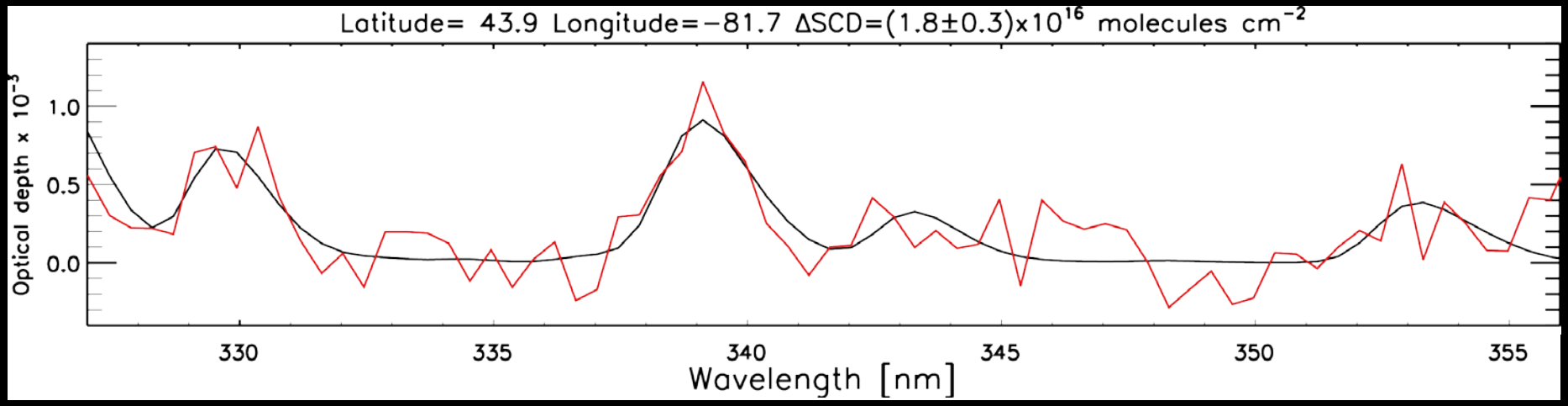
3

Reference sector correction (VCD)

Smithsonian Astrophysical Observatory formaldehyde retrieval

Direct spectral fit of radiances

$$I = \left[(aI_o + \sum_i \alpha_i X_i) e^{-\sum_j \alpha_j X_j} + \sum_k \alpha_k X_k\right] ScalPoly + BasePoly$$



Smithsonian Astrophysical Observatory formaldehyde retrieval

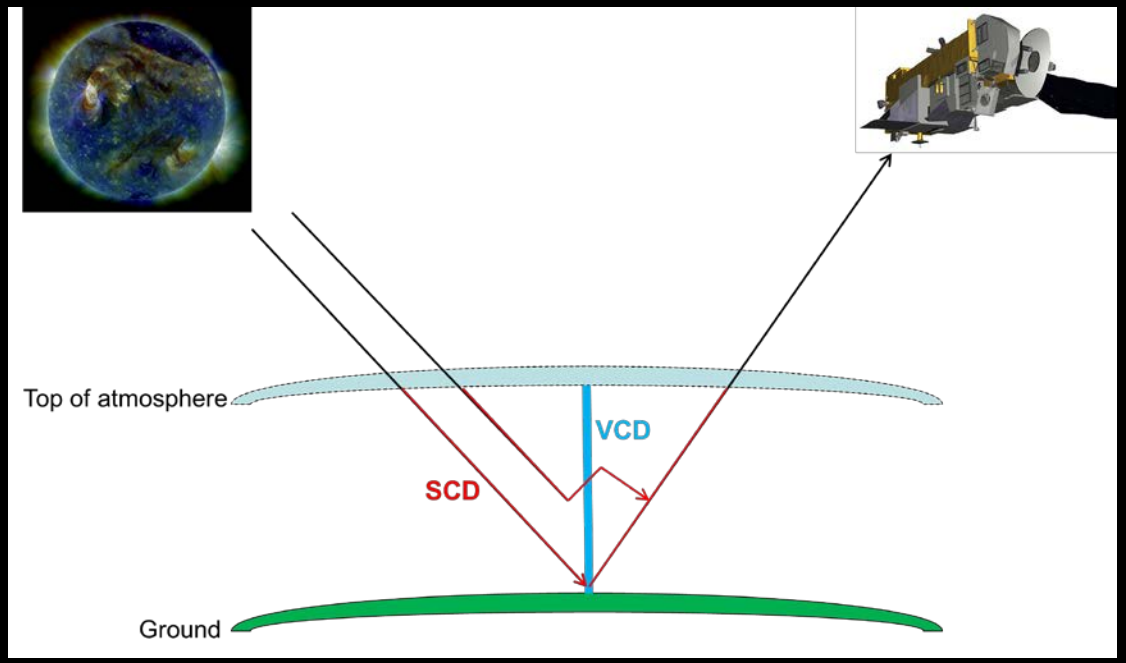
Direct spectral fit of radiances

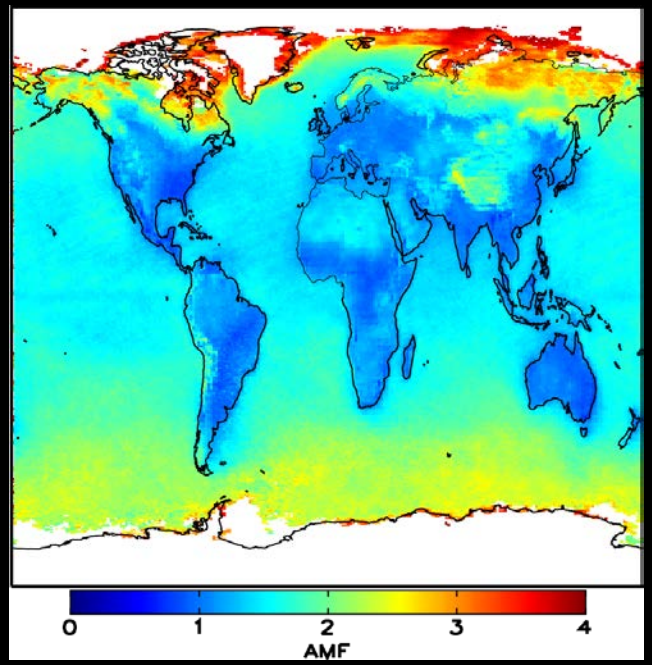
Fitting window	327.7 nm - 356.0 nm
Radiance reference spectrum	Computed online over the remote Pacific ocean between 30° N and 30° S
Baseline polynomial	3rd order
Scaling polynomial	3rd order
Instrument slit function	Pre flight measurements
Solar reference spectrum	Chance and Kurucz (2010)
H_2CO cross-sections	Chance and Orphal (2011), 300 K
O_3 cross-sections	Malicet et al. (1995), 228 K & 295 K
NO_2 cross-sections	Vandaele et al. (1998), 220 K
BrO cross-sections	Wilmouth et al. (1999), 228 K
O_2-O_2 collision complex cross-sections	Thalman and Volkamer (2013), 293 K
Molecular Ring cross sections	Chance and Spurr (1997)
Undersampling correction	Computed online (Chance et al., 2005)

Smithsonian Astrophysical Observatory formaldehyde retrieval

Air mass factor correction

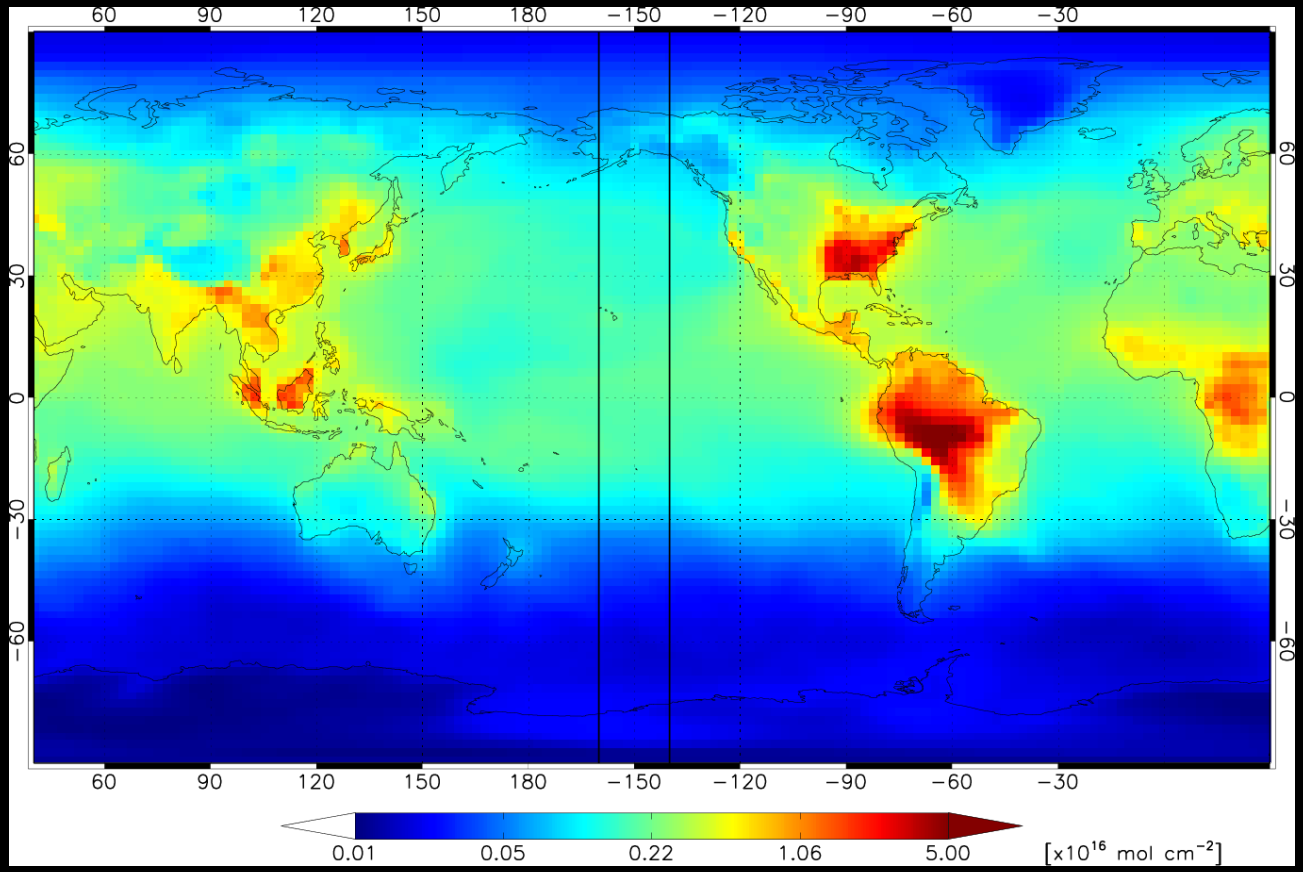
$$\Delta VCD = \frac{\Delta SCD}{AMF}$$





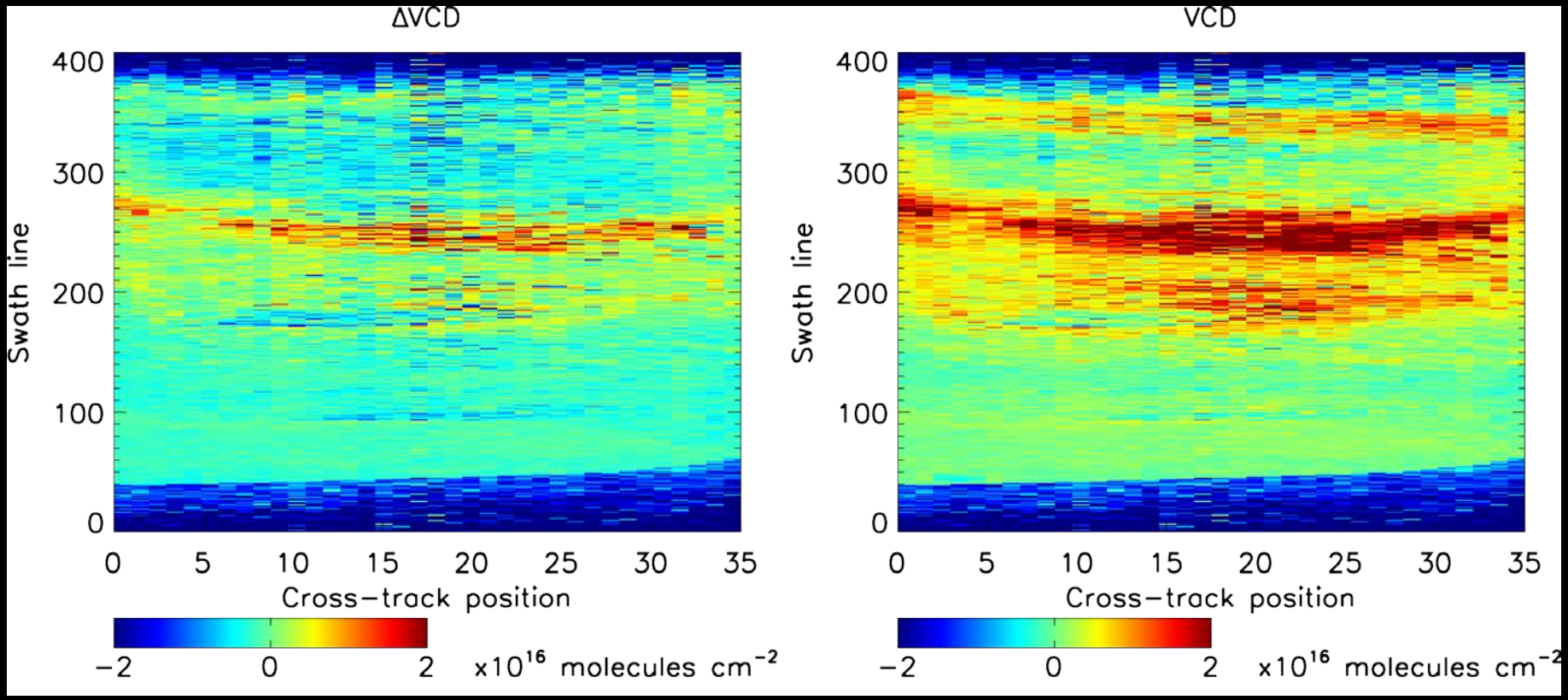
Smithsonian Astrophysical Observatory formaldehyde retrieval

Pacific Ocean Reference Sector Correction



Smithsonian Astrophysical Observatory formaldehyde retrieval

Pacific Ocean Reference Sector Correction



Intercomparison between SAO OMI and OMPS formaldehyde retrieval

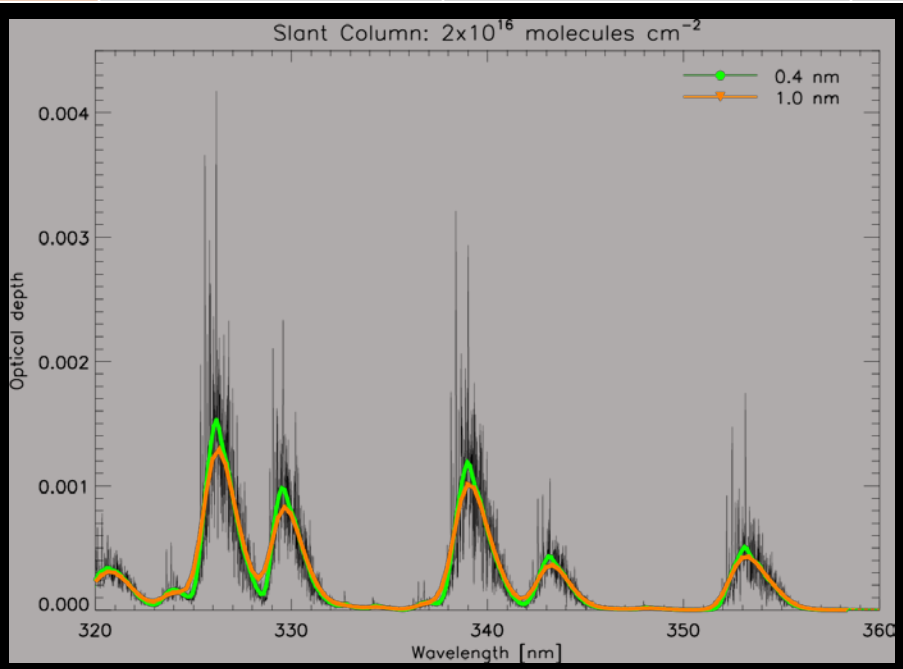
	Spectral Resolution [nm]	Spectral Coverage [nm]	Nadir Spatial Resolution [km^2]	Swath Size [km]	Overpass local time
OMPS	1.00	300-380	50 x 50	2800	13:30
OMI	0.42 (UV-2)	270-500	13 x 24	2600	13:42

Major differences between SAO OMPS and OMI formaldehyde retrievals

SAO retrieval	Fitting window [nm]	Surface Reflectance	Cloud parameters (cloud fraction and cloud pressure)
OMPS	327.7 – 356.0	TOMS climatology	Rotational Raman (Vasilkov et al., 2014)
OMI	328.5 – 356.5	OMI 5 year climatology (Kleipool et al., 2008)	O_2-O_2 absorption (Stammes et al., 2008)

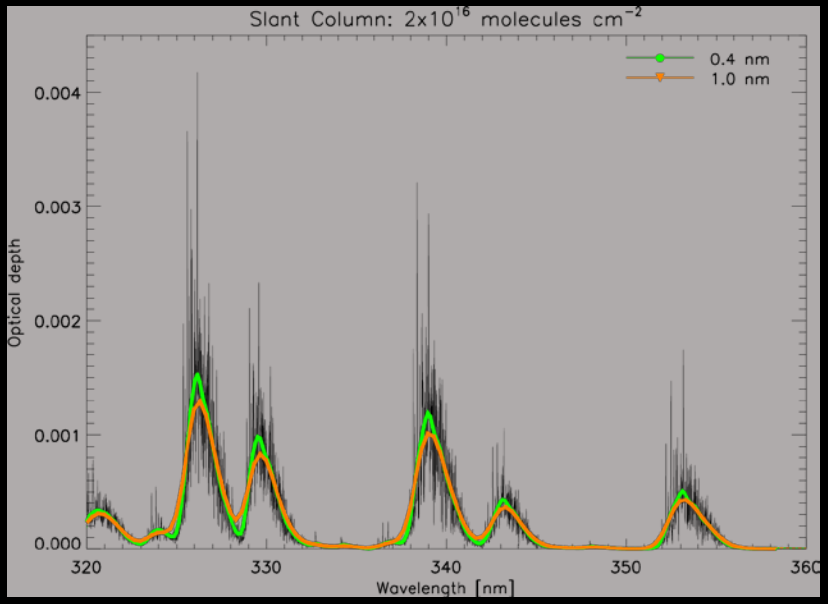
Intercomparison between SAO OMI and OMPS formaldehyde retrieval

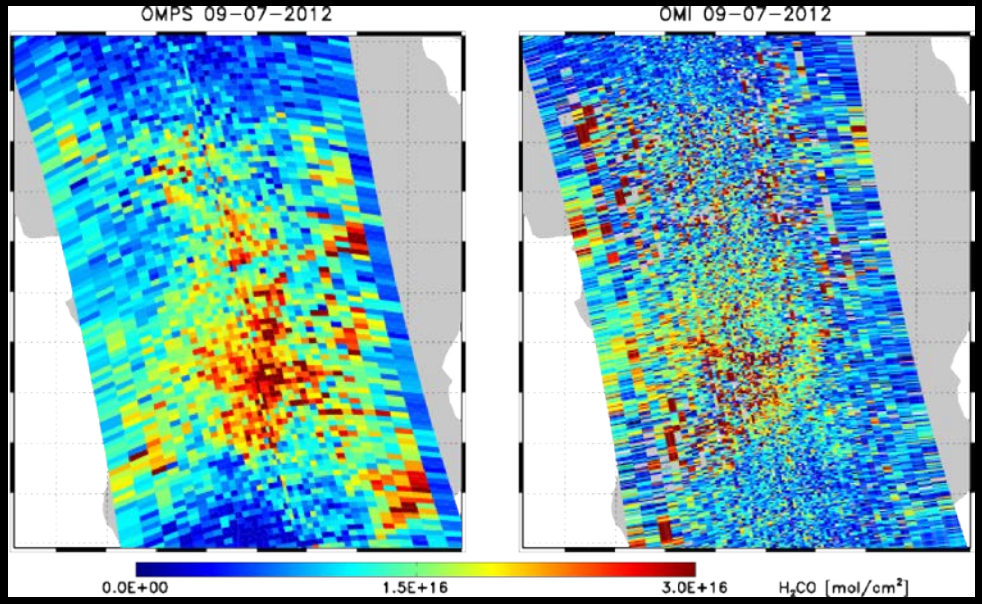
	Spectral Resolution [nm]	Spectral Coverage [nm]	Nadir Spatial Resolution [km^2]	Swath Size [km]	Overpass local time
OMPS	1.00	300-380	50 x 50	2800	13:30
OMI	0.42 (UV-2)	270-500	13 x 24	2600	13:42



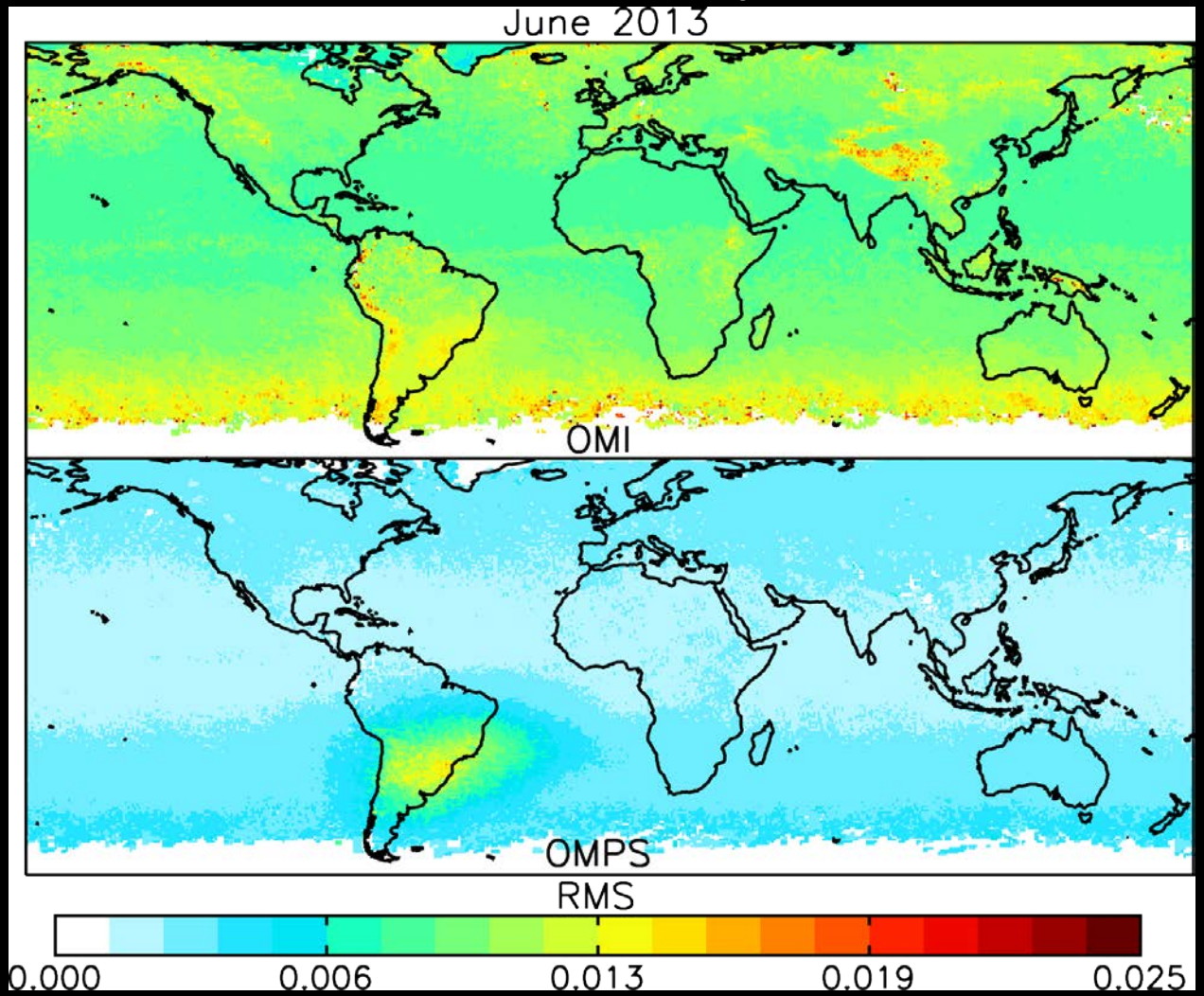
Intercomparison between SAO OMI and OMPS formaldehyde retrieval

	Spectral Resolution [nm]	Spectral Coverage [nm]	Nadir Spatial Resolution [km^2]	Swath Size [km]	Overpass local time
OMPS	1.00	300-380	50 x 50	2800	13:30
OMI	0.42 (UV-2)	270-500	13 x 24	2600	13:42

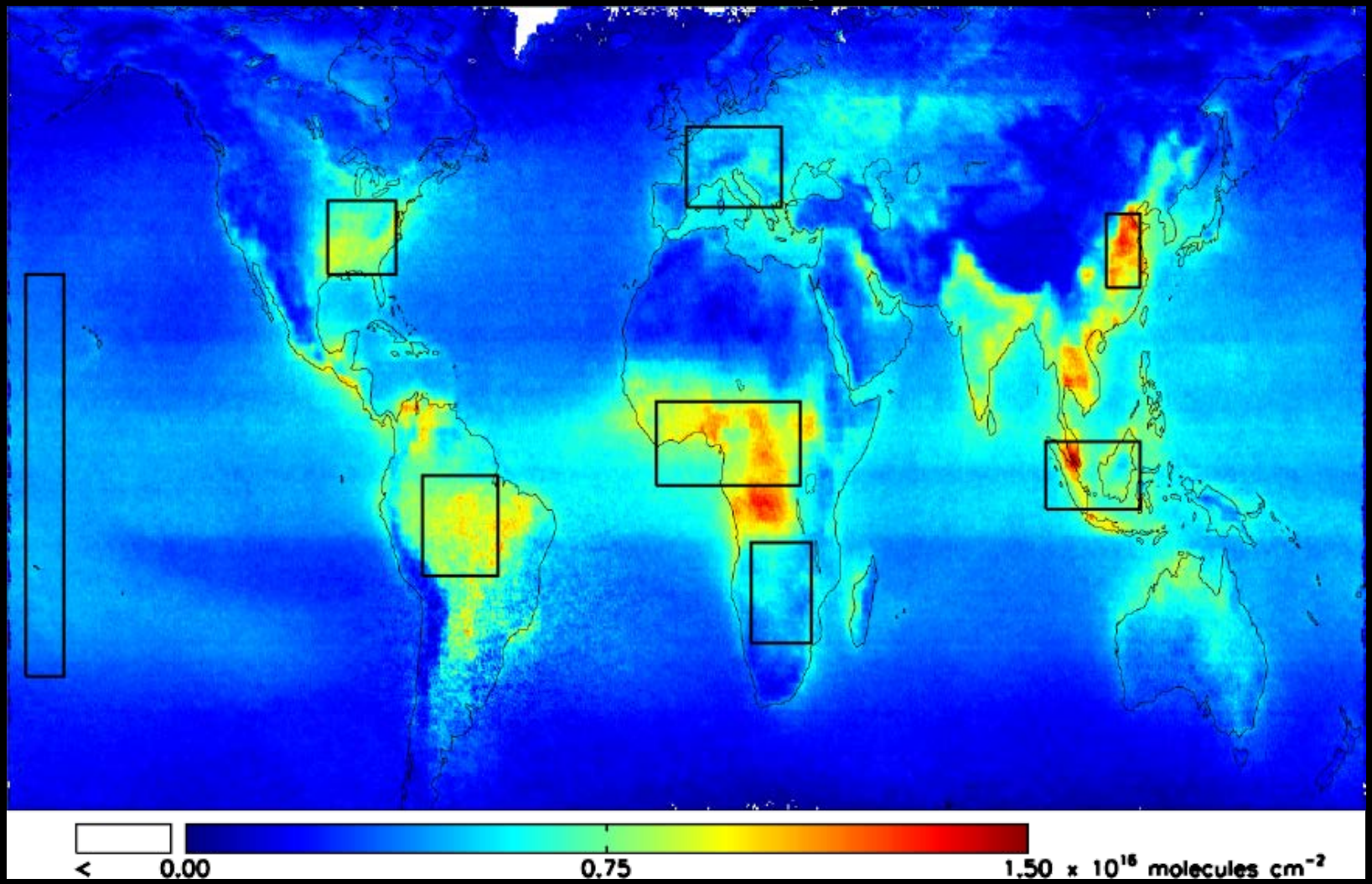




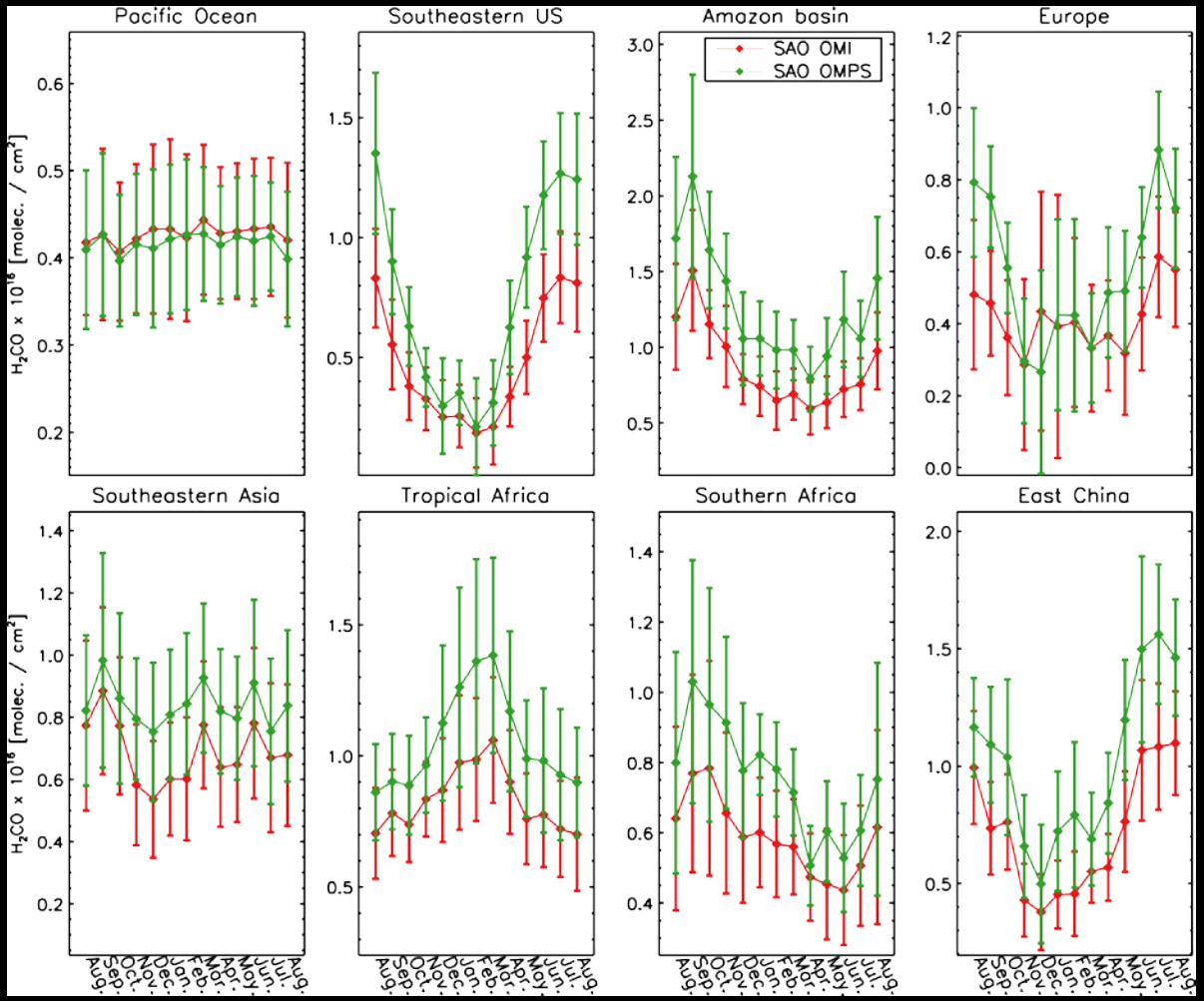
Intercomparison between SAO OMI and OMPS formaldehyde retrieval



Intercomparison between SAO OMI and OMPS formaldehyde retrieval



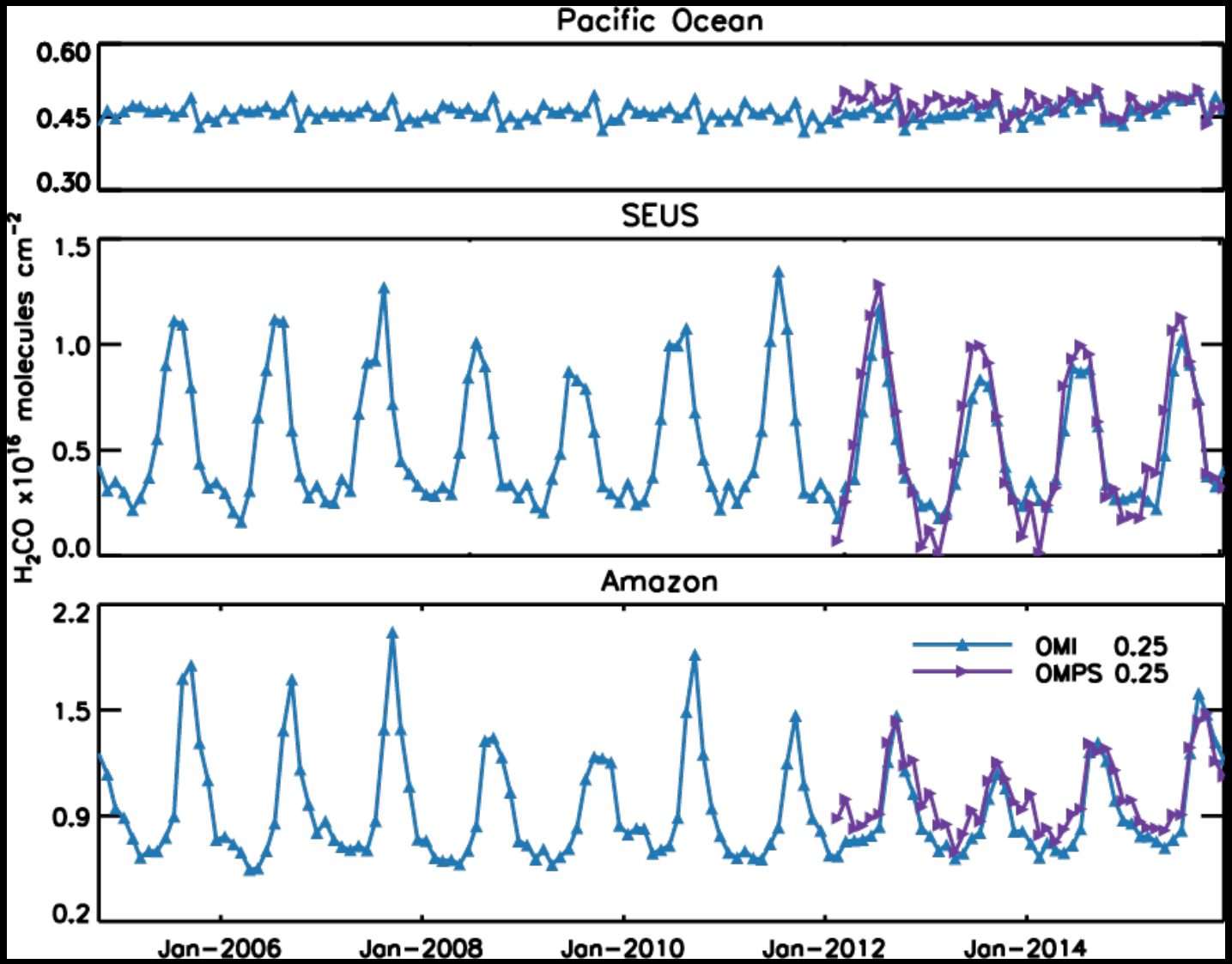
Intercomparison between SAO OMI and OMPS formaldehyde retrieval



Region	Correlation
Pacific Ocean	0.71
SEUS	0.99
Amazon	0.99
Europe	0.77
SE Asia	0.86
Tropical Africa	0.97
Southern Africa	0.95
East China	0.96

For these eight regions OMPS retrievals are biased high with respect to OMI retrievals 23%.

Towards a long-term data record



Future work

- Reprocess whole data record with new L1B radiances, upgraded calibration and AMF calculation.
- Perform validation studies following Zhu et al., 2016 methodology (GEOS-Chem as intercomparison platform)
- Set up SAO public web page for data distribution

Campaign	Time Period	Location	Agency
TORERO	Jan. – Feb. 2012	Eastern Tropical Pacific	NCAR
DISCOVER-AQ	Jan. – Feb. 2013	California	NASA
NOMADSS	Jun. – Jul. 2013	Southeast U.S.	NCAR
SENEX	Summer 2013	Southeast U.S.	NOAA
DISCOVER-AQ	Aug. – Sep. 2013	Texas	NASA
SEAC^{4}RS	Aug. – Sep. 2013	Southeast U.S.	NOAA
CONTRAST	Jan. – Feb. 2014	Western Tropical Pacific	NCAR
FRAPPÉ	Jul. – Aug. 2014	Colorado	NCAR
DISCOVER-AQ	Jul. – Aug. 2014	Colorado	NASA
WINTER	Jan. – Mar. 2015	Mid-Atlantic U.S.	NOAA
SONGNEX	Mar. - May 2015	Western U.S.	NOAA
KORUS-AQ	May – Jun. 2016	South Korea	NASA

Thanks for your attention

This study was supported by NASA Atmospheric Composition Program/Aura Science Team (NNX11AE58G) and internal Smithsonian Institution funds from the Consortium for Unlocking the Mysteries of the Universe