SAO long-term satellite data records of HCHO, CHOCHO and water vapor: synergies with the GEMS and TEMPO missions

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TEMPO

Talk outline

Smithsonian NASA

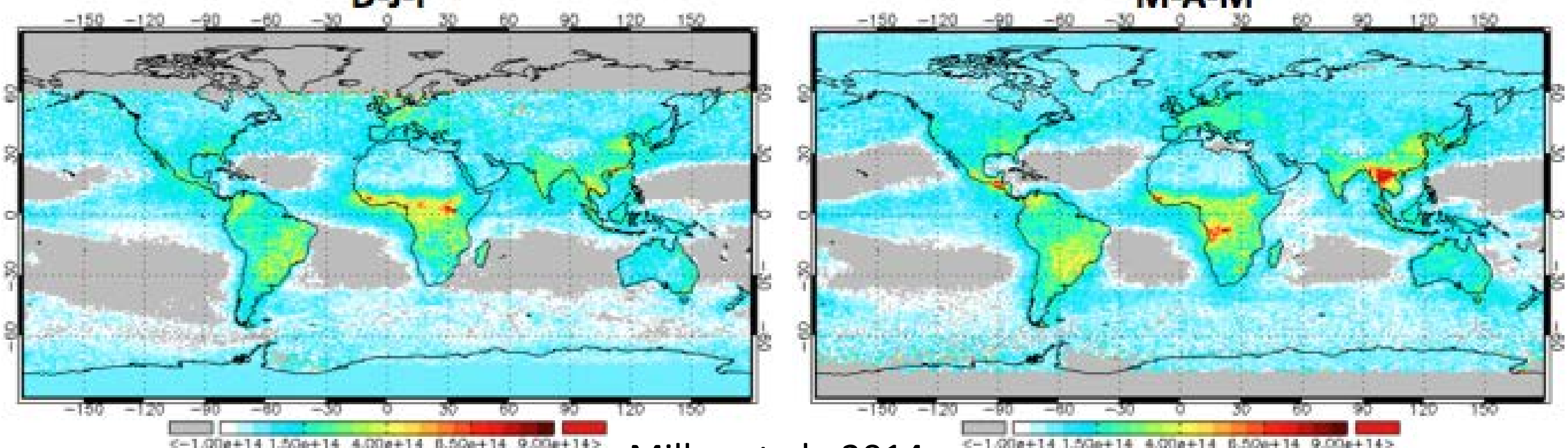
- SAO heritage: 20 years of HCHO, CHOCHO and H_2O retrievals
- The need for harmonization
- MEaSUREs project for HCHO, CHOCHO and H_2O
  - Homogenized retrievals
  - Instrument stability/inter-calibration
  - AMF calculations
  - Gridded products
  - Validation
- Conclusions

SAO heritage: 20 years of HCHO, CHOCHO and H_2O retrievals

MOLECULE	SENSOR	PUBLICATIONS
HCHO	GOME, OMI, OMPS	(Chance et al. 2000, Kurosu et al., 2004, Gonzalez Abad et al., 2015, 2016)
CHOCHO	OMI	(Miller et al., 2014)
H_2O	OMI	(Wang et al., 2014, 2016)

Starting with the design of GOME and SCIAMACHY the SAO group has made essential contributions to algorithm developments for trace gas retrievals using UV-VIS backscattered solar radiation

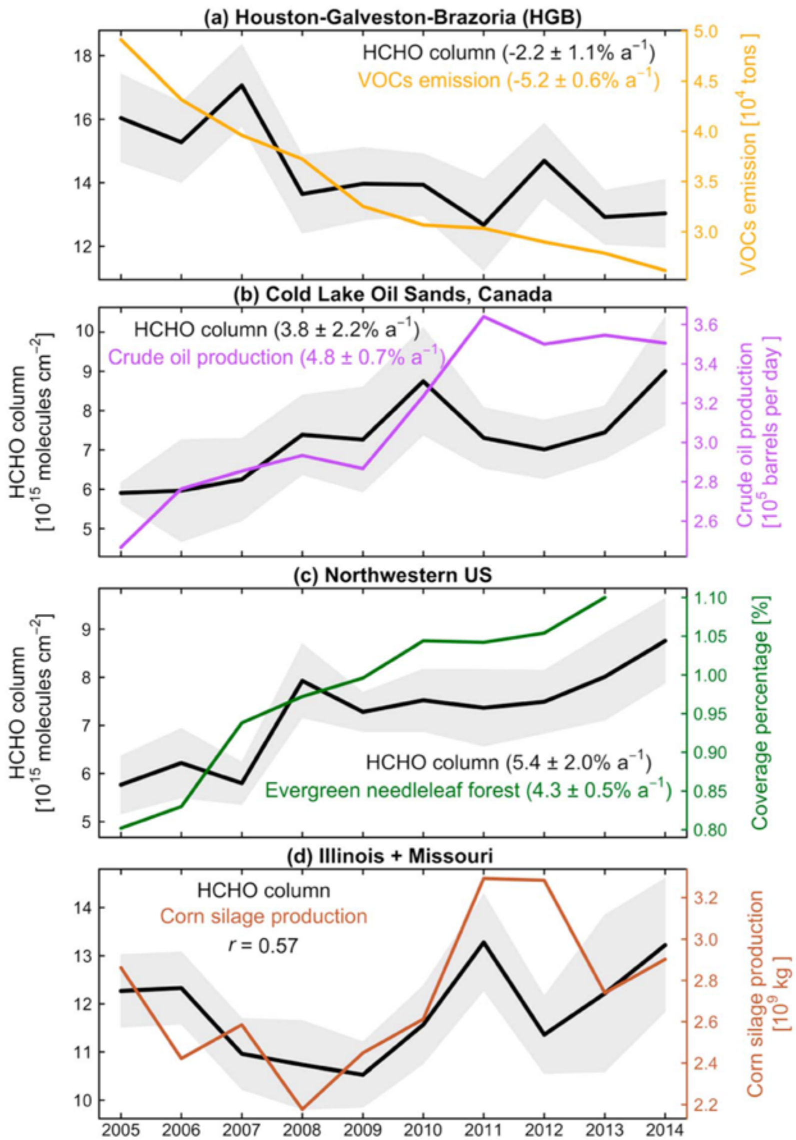
OMI CHOCHO retrievals



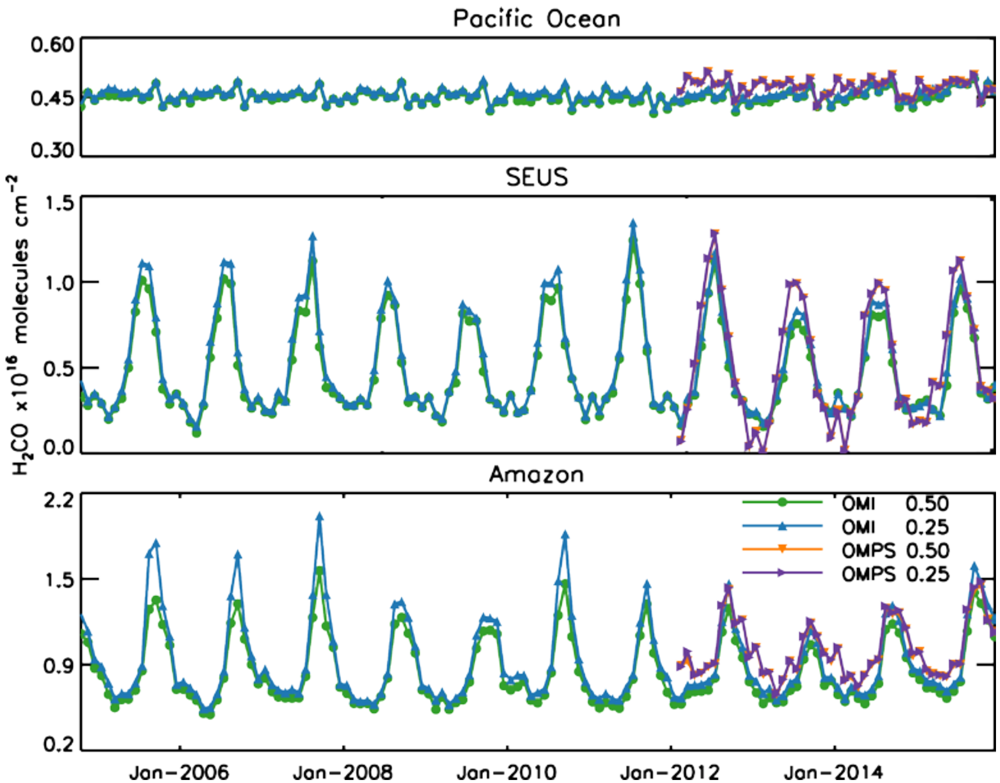
Miller et al., 2014

TEMPO

The need for harmonization



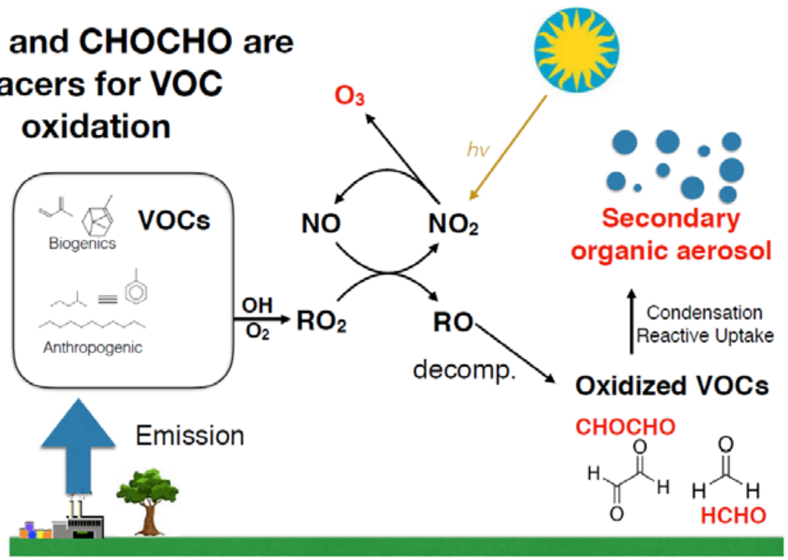
Zhu et al., 2017



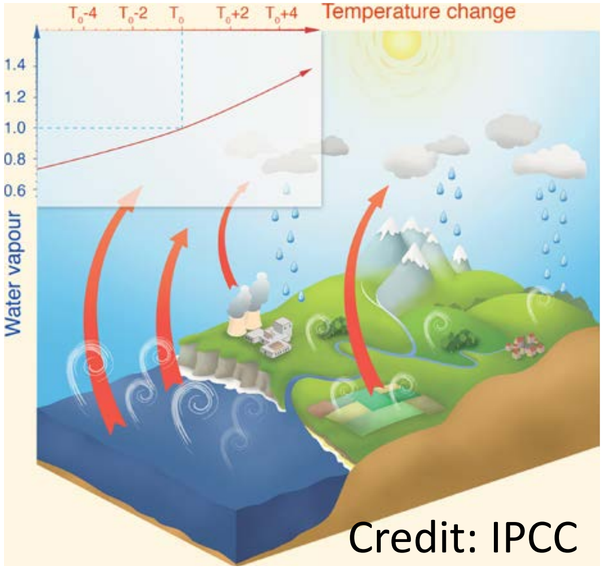
- The long-term stability of OMI has allowed the development of trend analysis of NO_2 and HCHO
- Fusion of data series from different sensors will increase the capabilities to perform multi-decadal trend analysis

MEaSUREs project for HCHO, CHOCHO and H_2O

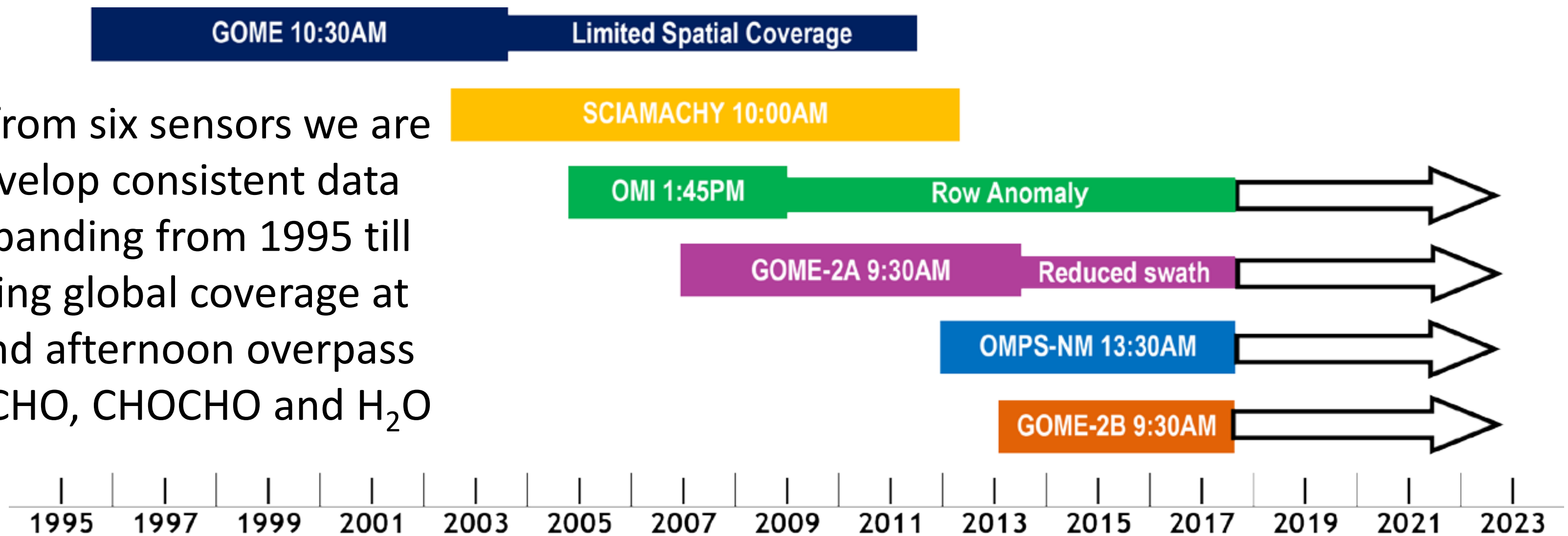
HCHO and CHOCHO are tracers for VOC oxidation



- The oxidation of VOCs plays an important role in air quality and climate
- H_2O is an ECV, with impacts on the climate system



Using data from six sensors we are able to develop consistent data records expanding from 1995 till 2023 offering global coverage at morning and afternoon overpass times for HCHO, CHOCHO and H_2O



TEMPO

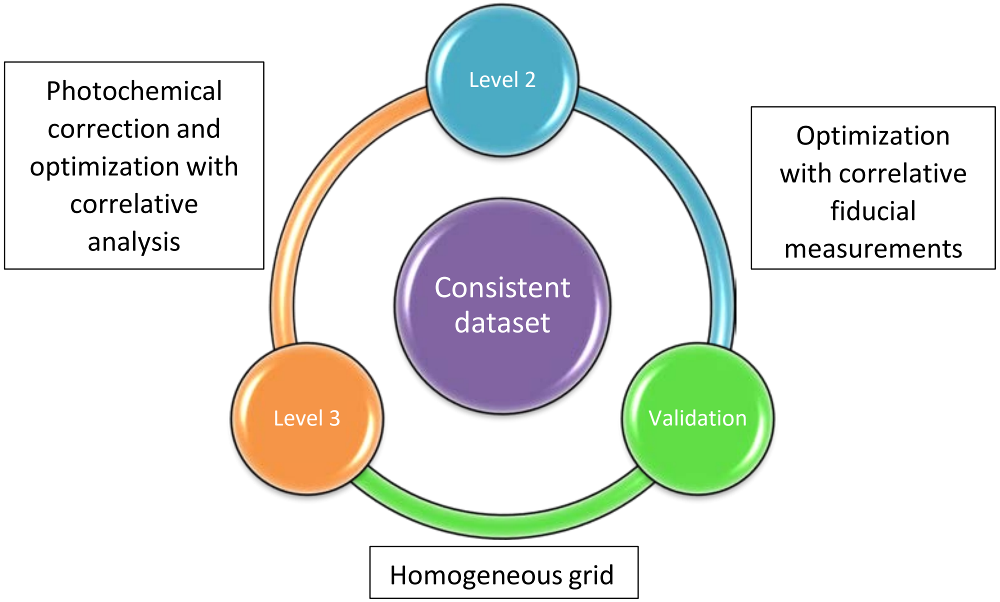
MEaSUREs project for HCHO, CHOCHO and H_2O

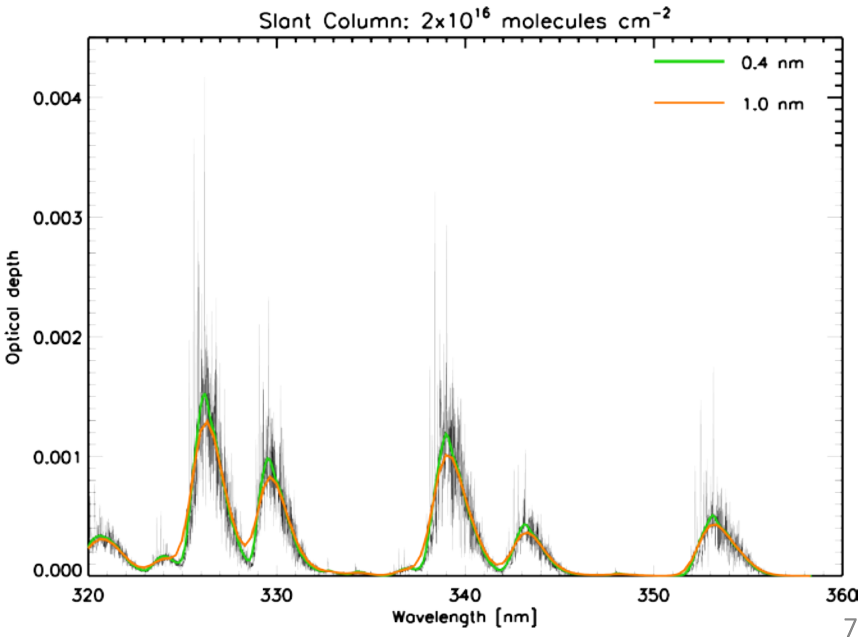
ID	Task	Start	Finish	2018–2023 (Q3 2018 – Q4 2023)
1	**Produce ESDRs from July 1995 to July 2023**	07/01/18	06/30/23	
2	Level 1b interface	07/01/18	06/30/19	Consistent retrieval interface
3	Ouput data definition	07/01/18	09/30/19	Standarized ouput
4	Collect correlative data	10/01/18	06/30/19	
5	Develop gridding tool	01/01/19	06/30/19	
6	Develop consistent stand-alone AMF tool	04/01/19	03/31/20	
7	Develop stand-alone instrument characterization tool	07/01/19	03/31/20	
8	Derive consistently improved solar irradiances	10/01/19	03/31/20	
9	**Develop consistent ESDRs from OMI, GOME2 and OMPS-NM**	04/01/20	12/31/21	v1 delivered
10	Instruments characterization	04/01/20	12/31/20	
11	Optimize retrieval for multi-sensor consistency	04/01/20	12/31/21	
12	Extensive verification, validation and improvement	04/01/20	12/31/21	
13	**Develop consistent ESDRs from GOME, and SCIAMACHY**	01/01/22	03/31/23	v2 delivered
14	Instruments characterization	01/01/22	06/30/22	
15	Optimize retrieval for multi-sensor consistency	01/01/22	03/31/23	
16	Extensive verification, validation and improvement	01/01/22	03/31/23	
17	Evaluate available new version l1b data	01/01/23	06/30/23	
18	**Reprocess with latest l1b data until July 2023**	01/01/23	06/30/23	
19	**Final Processed Data**	03/01/23	06/30/23	
20	**Documentation**	01/01/19	06/30/23	
21	Output data specification	01/01/19	12/31/19	
22	Write ATBDs of ESDRs	10/01/19	12/31/20	ATBDs delivered
23	L2 and L3 data description	07/01/21	03/31/23	
24	**Final L2 and L3 data description**	01/01/23	06/30/23	
25	**Final documentation delivery**	04/01/23	06/30/23	
26	**Web site development**	10/01/18	06/30/19	
27	Web site maintenance	04/01/19	06/30/23	
28	**Public server set up**	07/01/19	12/31/19	
29	Public server maintenance	10/01/19	06/30/23	
30	**Attend ESDSWGs & scientific meetings**	07/01/18	06/30/23	

The temporal overlap between the this MEaSUREs project, TEMPO and GEMS missions offers a great opportunity for synergies between them to test algorithms, validation schemas and consistent dataset formats

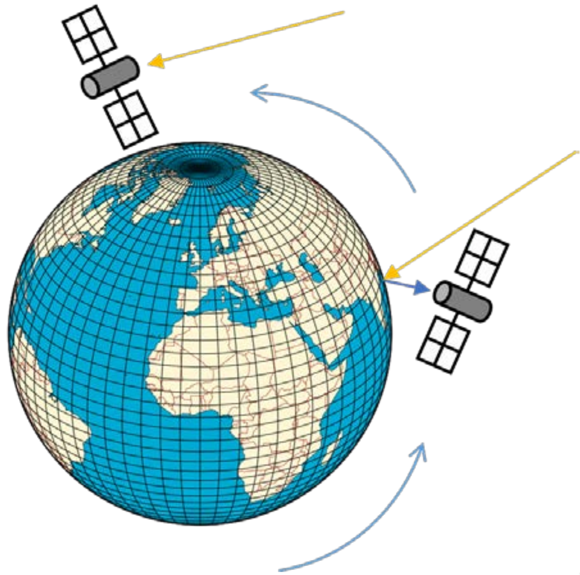
Homogenized retrievals

- Base code for all algorithms will be shared with TEMPO
- Level 2 and level 3 files will be standardized across MEaSUREs products and TEMPO
- Improved algorithm traceability chains and error characterization incorporating experiences from past projects such as QA4ECV (Boersma et al., 2018)
- Retrieval setting optimization due to instrument differences will have two phases:
  - 1st will optimize retrievals with overlapping validation data (OMI, GOME-2A/B and OMPS)
  - 2nd will use correlative analysis to optimize the retrievals settings for earlier instruments (GOME, SCIAMACHY)

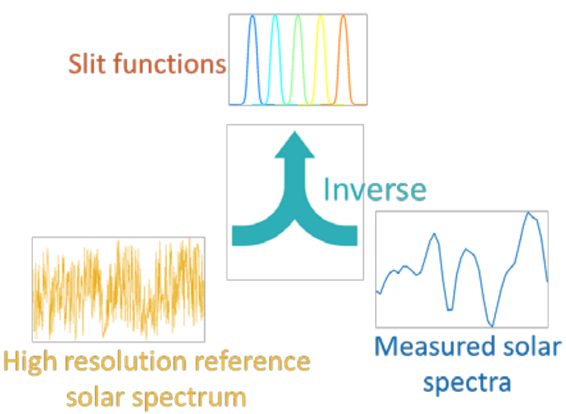




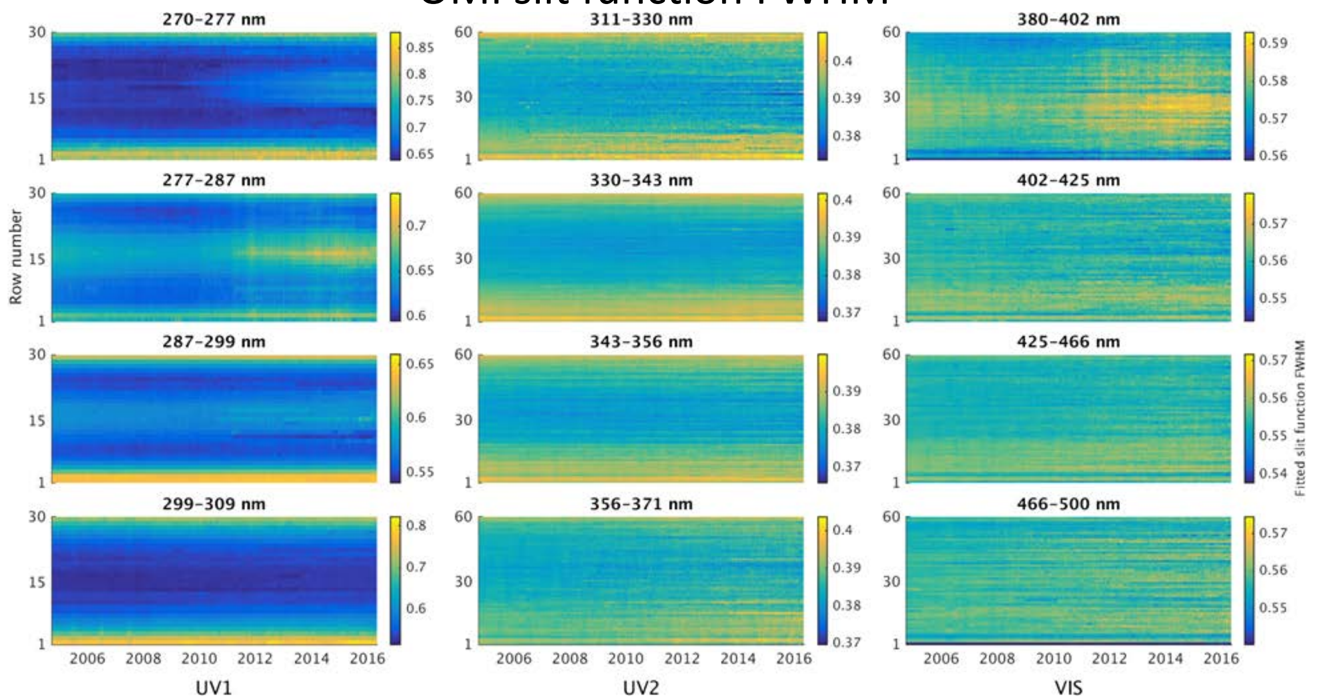
Instrument stability / inter-calibration



- Characterization of drifts in instrument performance over time is crucial to construct long-term trends and seasonal cycles.
- Calibration will be achieved via correlation with high resolution solar spectra (Sun et al., 2017) as demonstrated with OMI.



OMI slit function FWHM

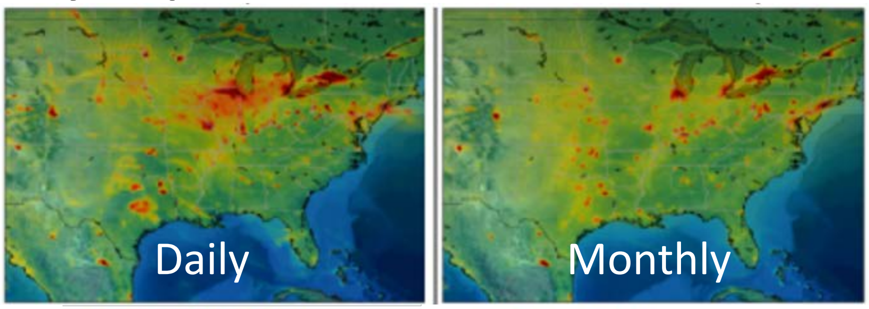


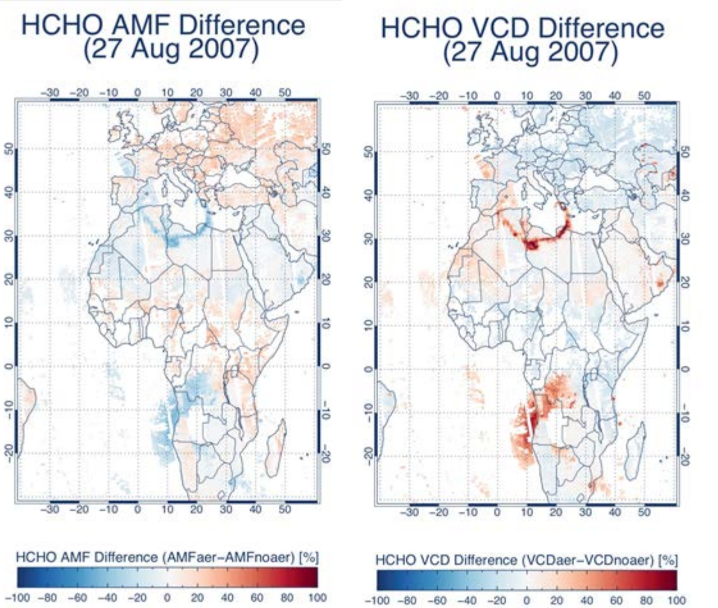
Sun et al., 2017

AMF calculation

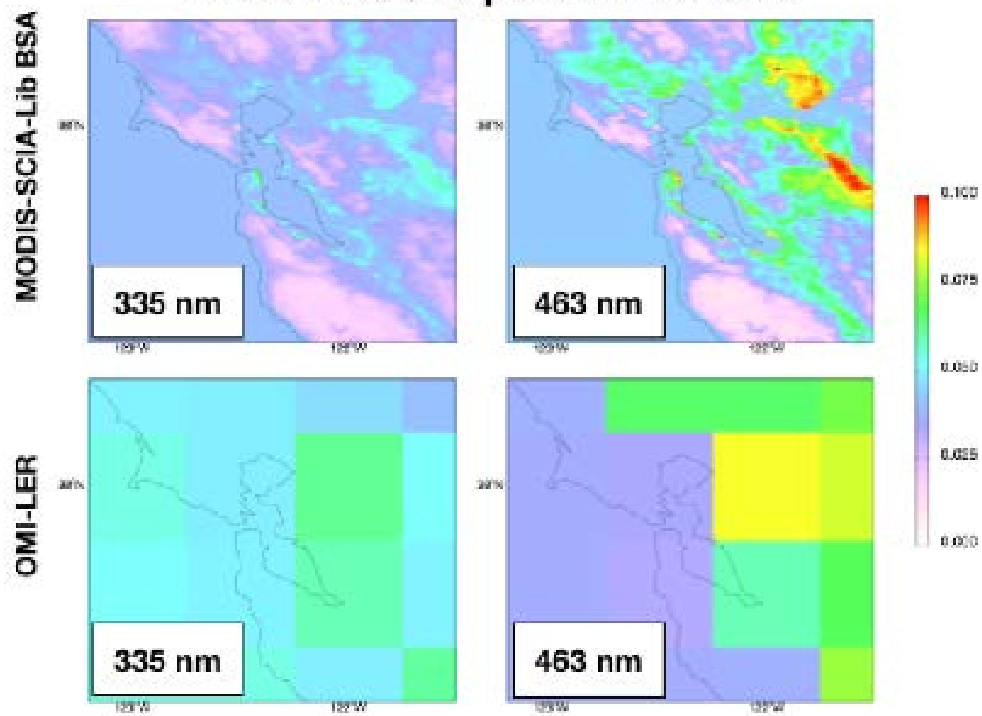
- Air Mass Factor calculations are the main source of error in current retrievals.
- Compute AMFs with online radiative transfer calculations and upgraded datasets.
- Improved error characterization (surface reflectance, clouds, aerosols and profile shape)

Daily shape factors GEOS-Chem and MERRA2





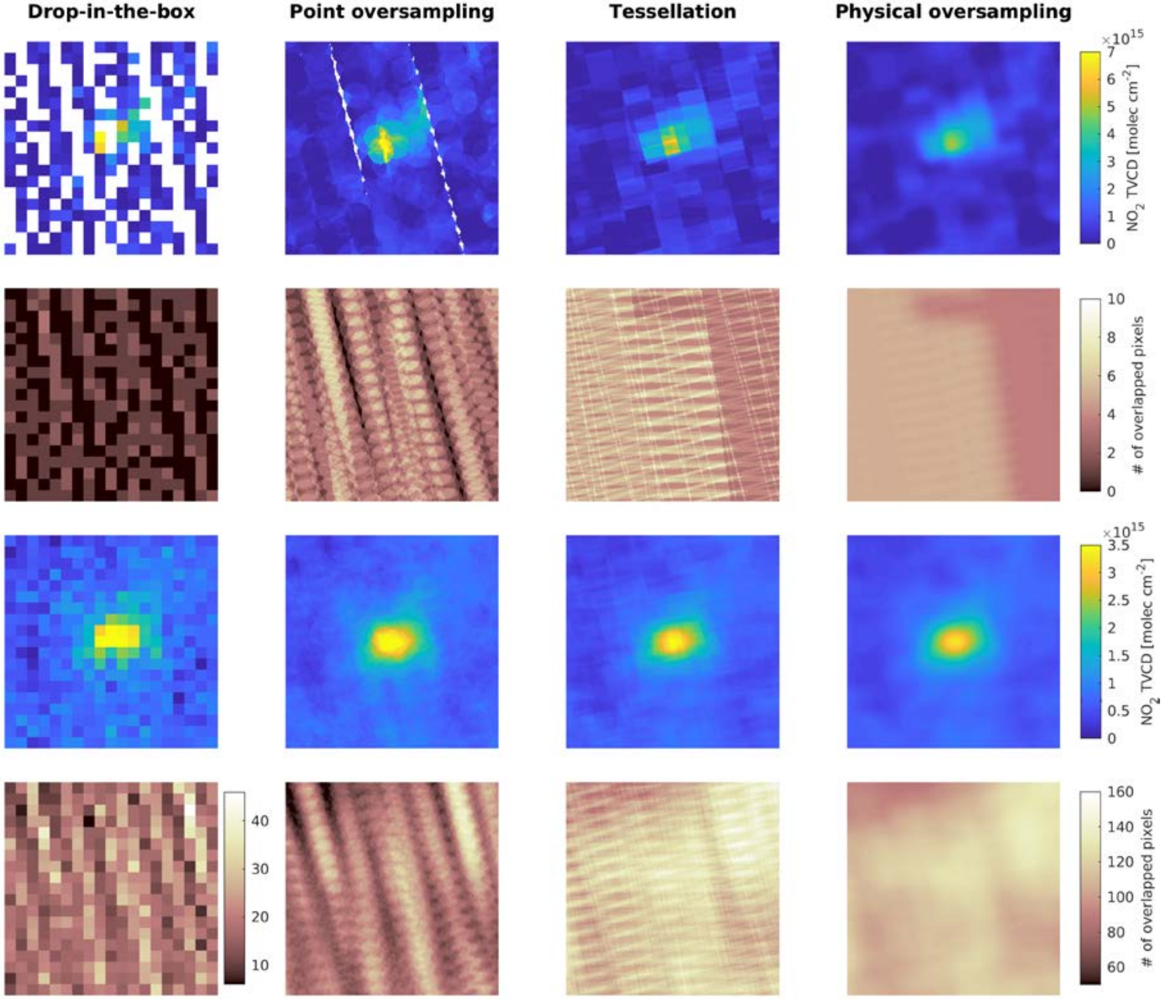
Reflectance comparison with OMI



AMF algorithm will use BRDF climatology that combines information from MODIS, SCIAMACHY, and USGS datasets

Gridding algorithm

- We will produce level 3 products based on a new physics-based gridding approach that properly accounts for instrument footprint (Sun et al., 2018)
- Goals:
  - Mitigate effect of noise levels in HCHO and CHOCHO products
  - Facilitate intercomparisons between instruments with different spatial and temporal resolution
  - Trend analysis



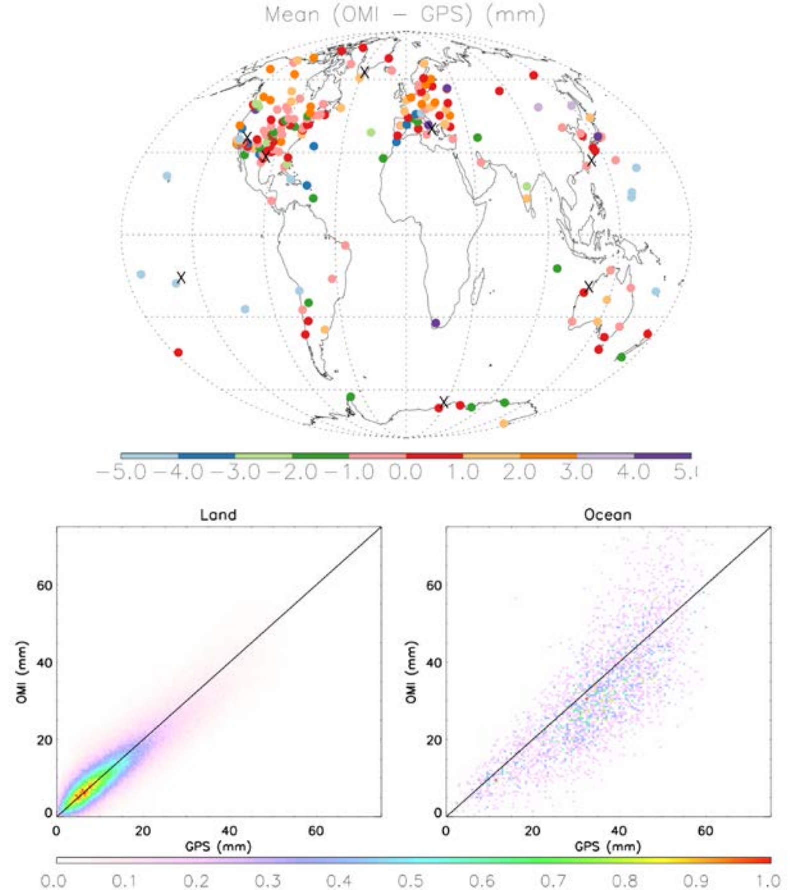
Sun et al., 2018

Validation

- Validation studies are a key component of our strategy to derive consistent and accurate products.
- We will use a mix of ground-based and in-situ (aircraft and sondes) measurements.
- HCHO will also include column observations from NDACC (FTIR-VIS-UV) and Pandonia networks

Product	Correlative data set	Period covered	Geographic coverage
HCHO, CHOCHO & H_2O	MILAGRO[1,2]	Mar. 2006	Mexico City
	DISCOVER-AQ[1,2]	Jul. 2011, Sep. 2013, Feb. 2013, Jul. – Aug. 2014	Maryland, Texas, California, Colorado
	SENEX[1]	Summer 2013	Southeast US
	SEAC[4]RS[1,2]	Aug. – Sep. 2013	Southeast US
	CONTRAST[1,2]	Jan. – Feb. 2014	West Pacific
	KORUS-AQ[1]	May. – Jun. 2016	Korea
H_2O	NCAR GPS[3]	1995 – present	Global
	AERONET[3]	1993 – present	Global
	RSS microwave[4]	1987 – present	Global
	GRUAN[5]	2009 - present	Global

1. Aircraft campaign; 2. HCHO and H_2O only; 3. Ground-based remote sensing; 4. Satellite remote sensing; 5. Radiosonde



Wang et al., 2016

Conclusions

- We are developing long-term intercalibrated HCHO, CHOCHO and H_2O products from 6 sensors
- By design this project is a robust and rigorous testbed of TEMPO trace gas algorithms
- Validation studies will provide global baseline datasets to link TEMPO, GEMS and Sentinel 5 as well as inform best practices for their validation
- Coordinated development of algorithms with TEMPO will simplify testing and implementation of upgrades to TEMPO algorithms

Thanks for your attention

Questions?

We will like to thank NASA for their support throughout ACMAP Aura, TASNPP and MEaSUREs grants.
We will also like to thank the TEMPO and OMI Science teams.