Laboratoire d'Études du Rayonnement et de la Matière en Astrophysique et Atmosphères

CEOS : 13th meeting on the Atmospheric Composition Virtual Constellation

CNES-Paris, France, 28-30 June 2017

TCCON (Total Carbon Column Observing Network) for satellite GHG validation

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+ all PI's TCCON sites
+ OCO-2 validation team

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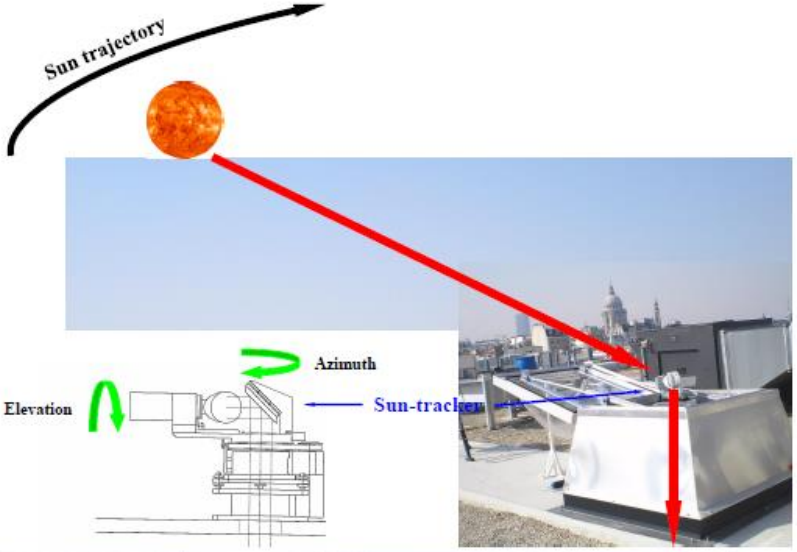
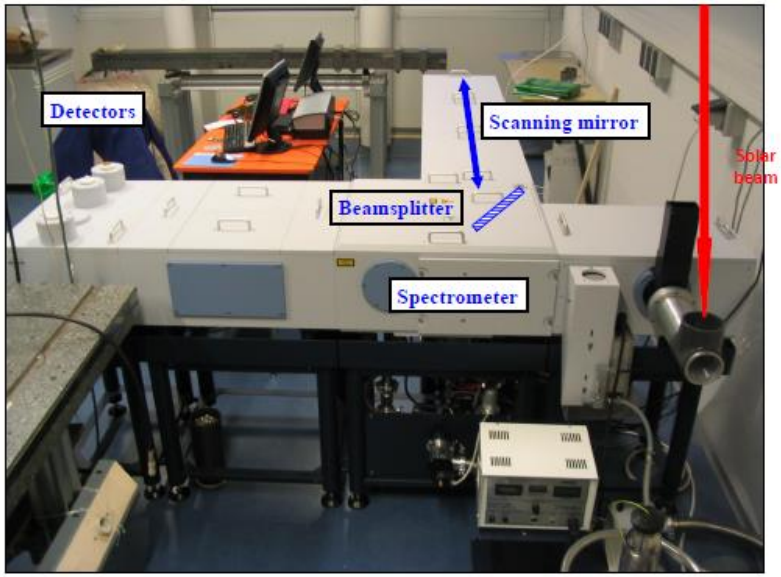
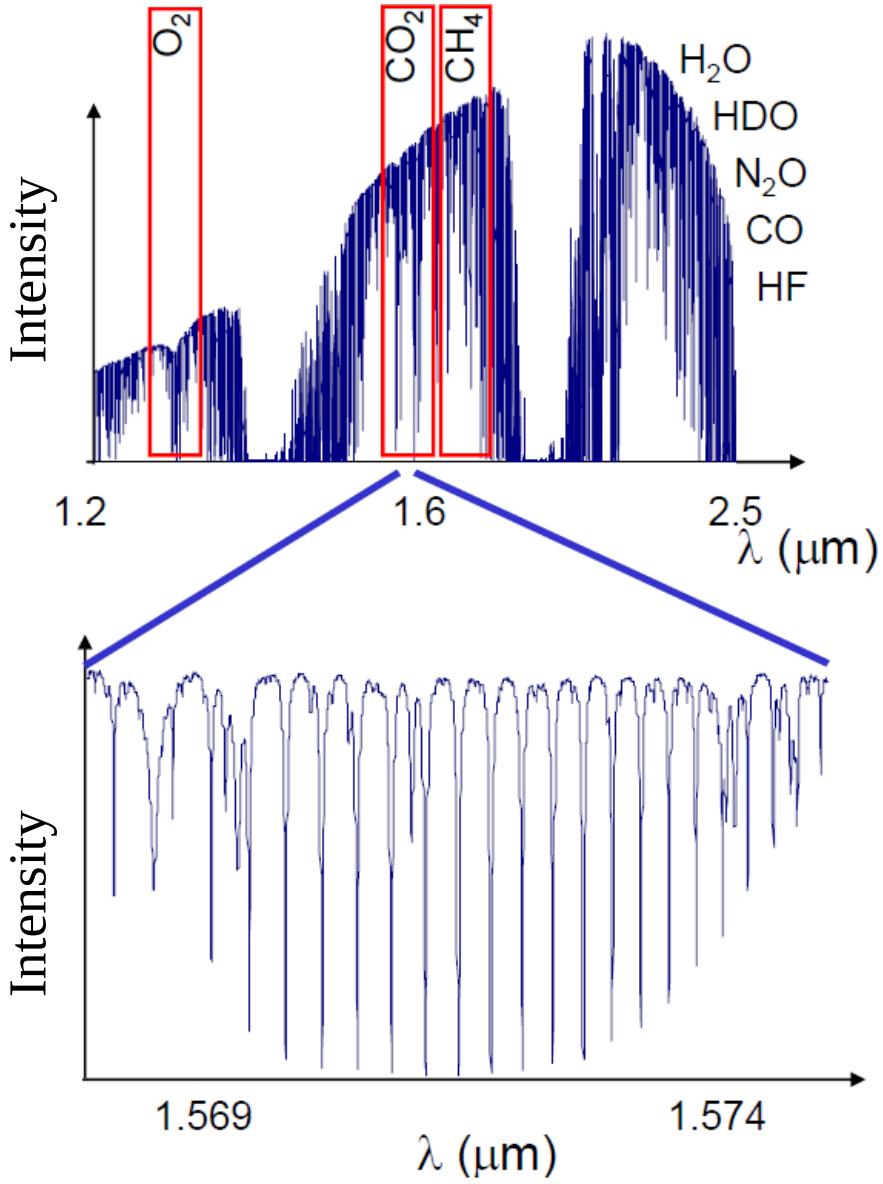
TCCON measurements

Solar absorption measurement using FTIR spectroscopy

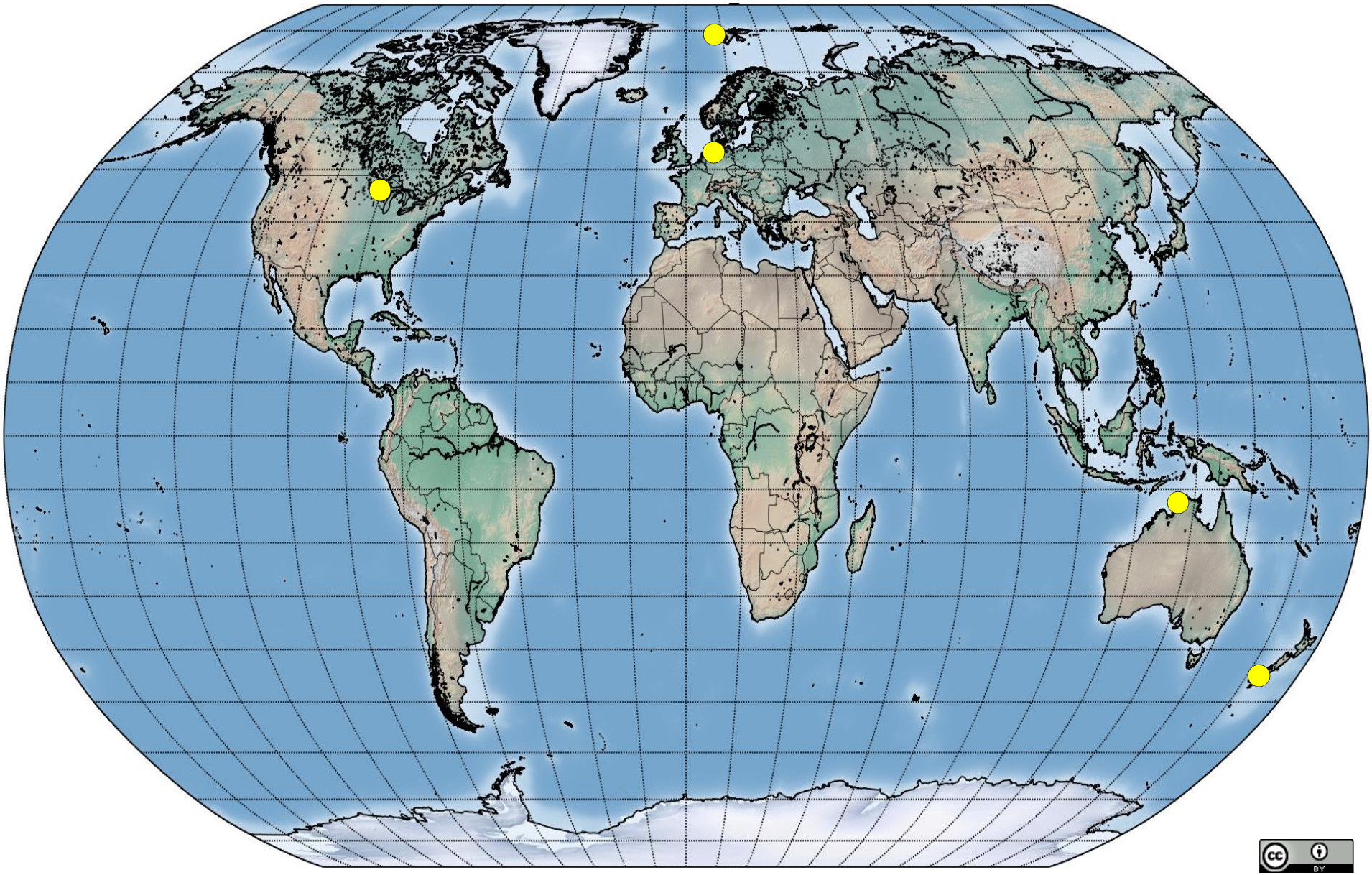






Dry-Air mole fractions of CO_2, CO, N_2O, CH_4, H_2O, HDO and HF

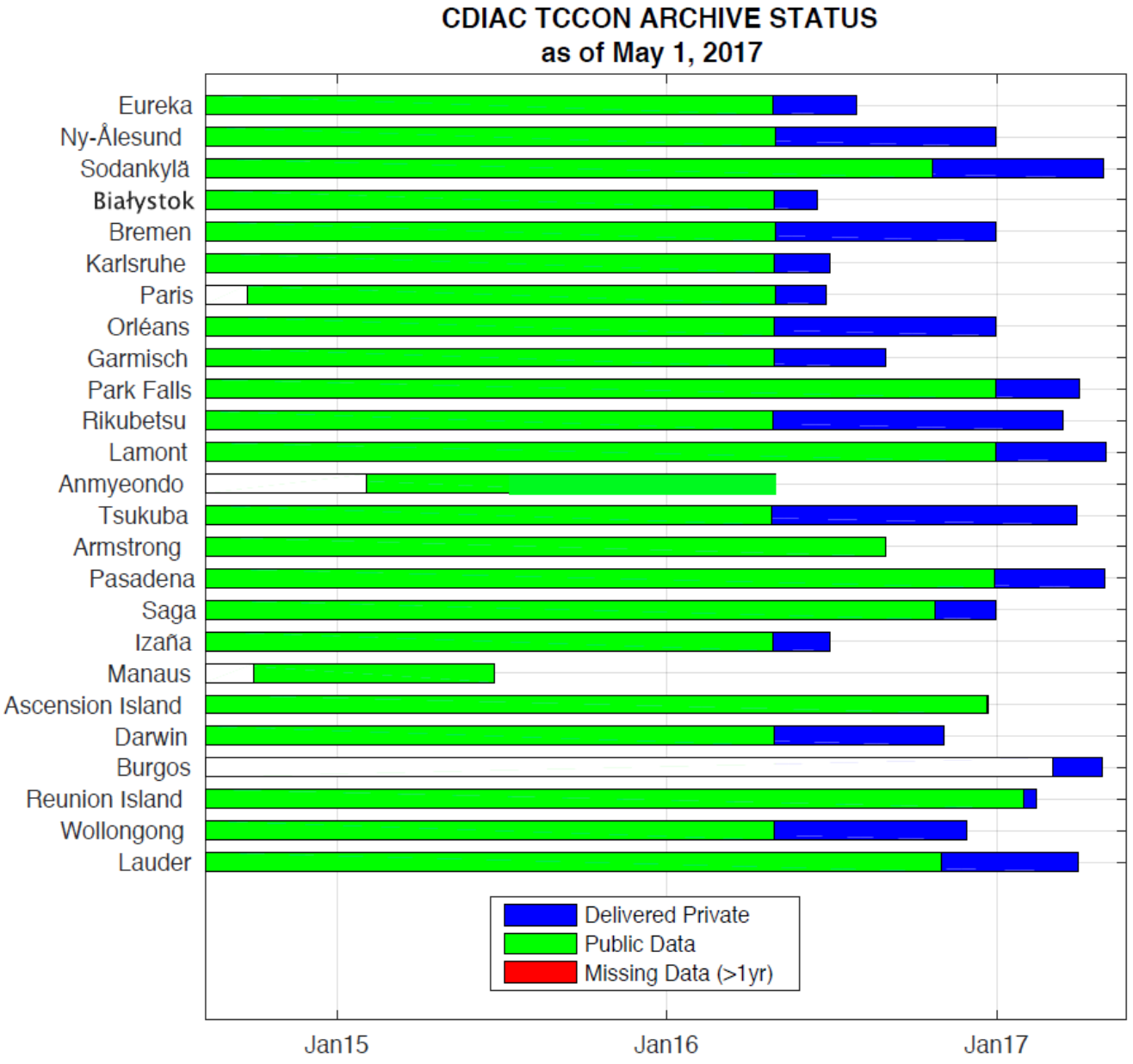
Total Carbon Column Observing Network (TCCON) 2005



Total Carbon Column Observing Network (TCCON) 2016

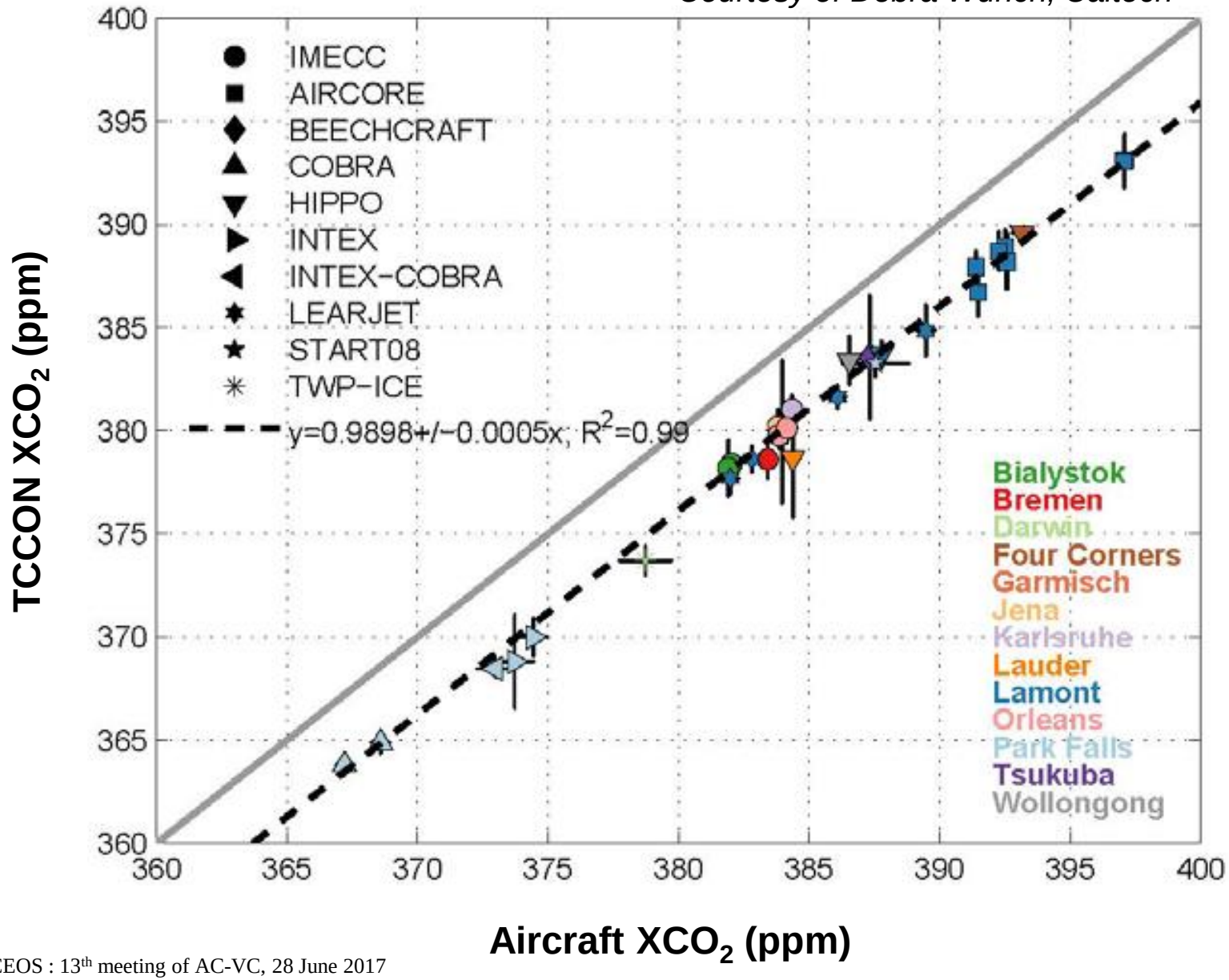
➔ Total Carbon Column Observing Network has grown enormously

TCCON data availability



Calibration of total column for XCO_2

Courtesy of Debra Wunch, Caltech



Relevance of TCCON for greenhouse gas measurements by satellites

SCIAMACHY

CO_2 and CH_4

Footprint 1800 km^2

GOSAT

CO_2 and CH_4

Footprint 87 km^2

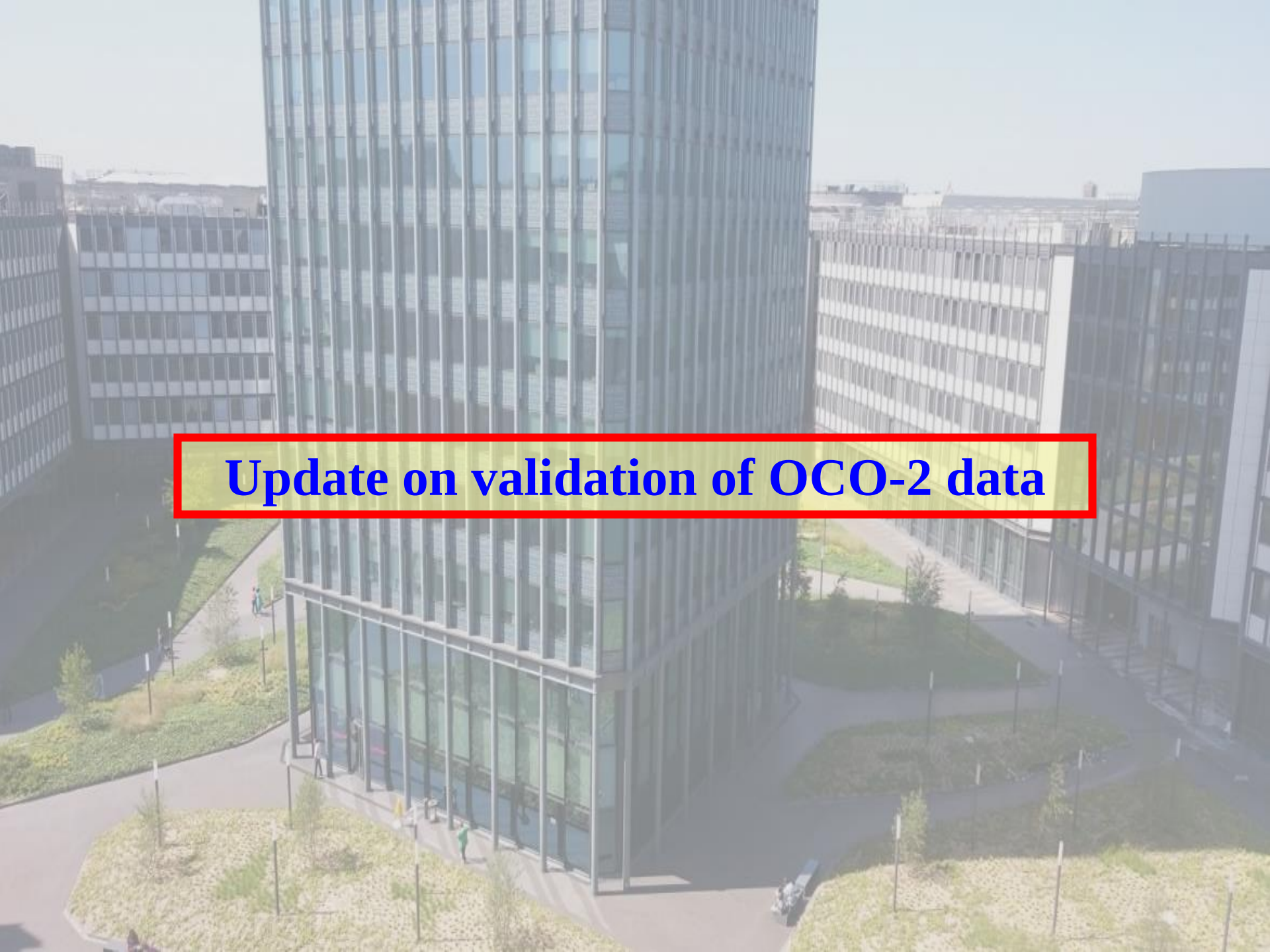
OCO-2

CO_2

Footprint ~3 km^2

TANSAT

- Validation of satellite data (spatial bias, temporal drift)
- Indirect calibration of satellite data versus *in situ* standard of the World Meteorological Organisation (WMO)

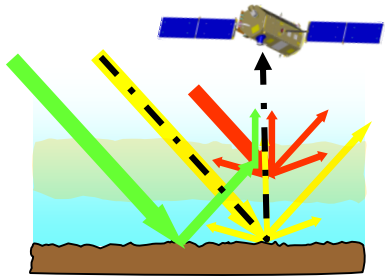


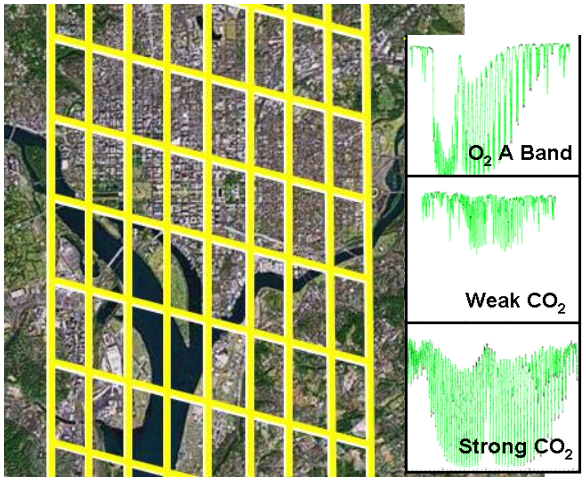
Update on validation of OCO-2 data

OCO-2 Has Three Observation Modes

Nadir Observations:

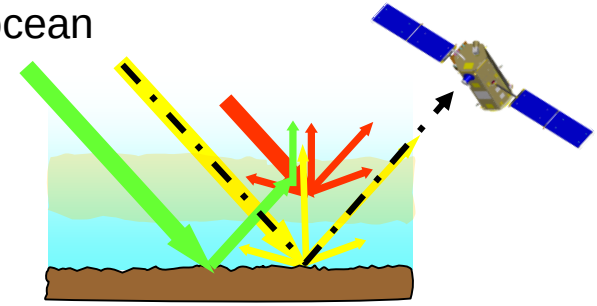
+ Small footprint (< 3 km^2)
– Low Signal/Noise over dark surfaces (ocean, ice)
– Yields data over land

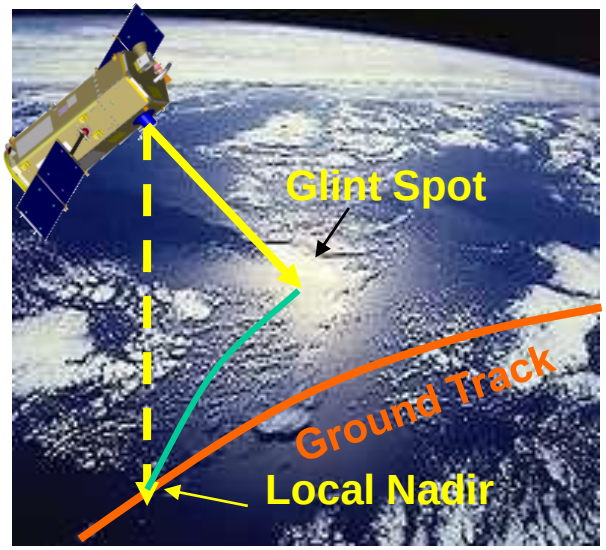




Glint Observations:

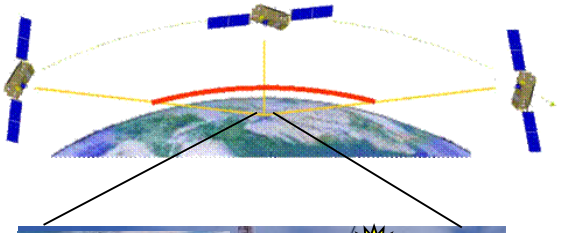
+ Improves Signal/Noise over oceans
– More cloud interference
– Provides data over land and ocean

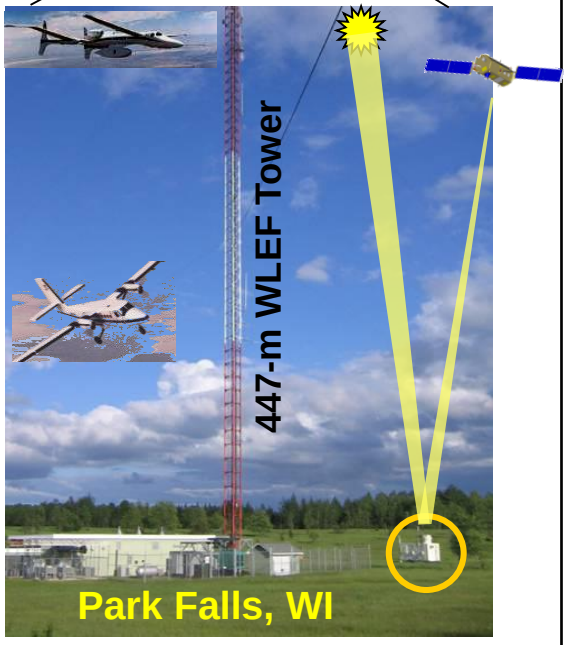




Target Observations:

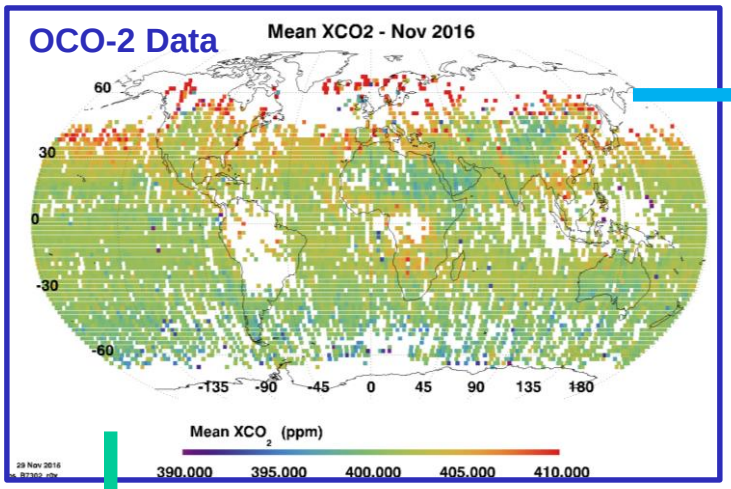
• Validation over ground based FTS sites, field campaigns, other targets

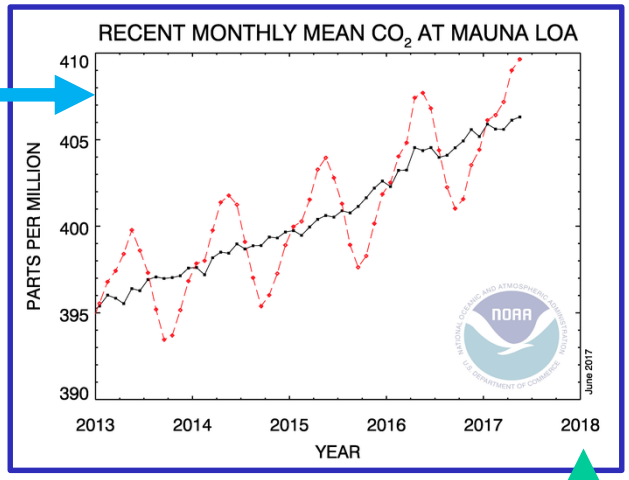


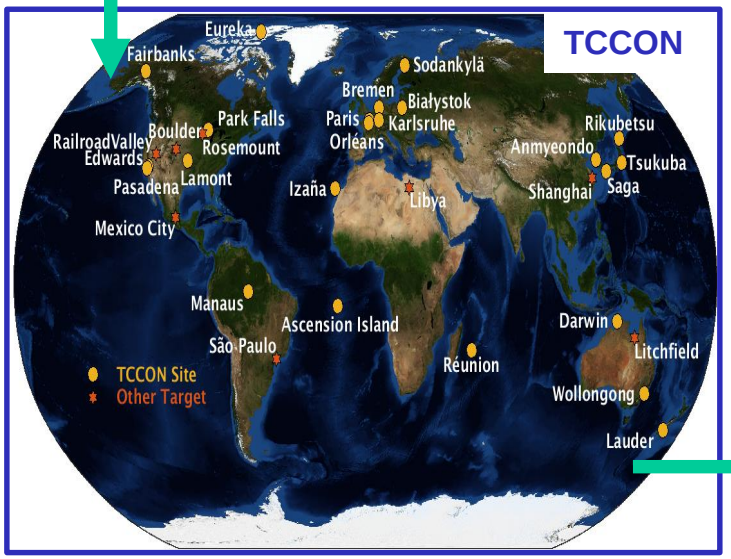


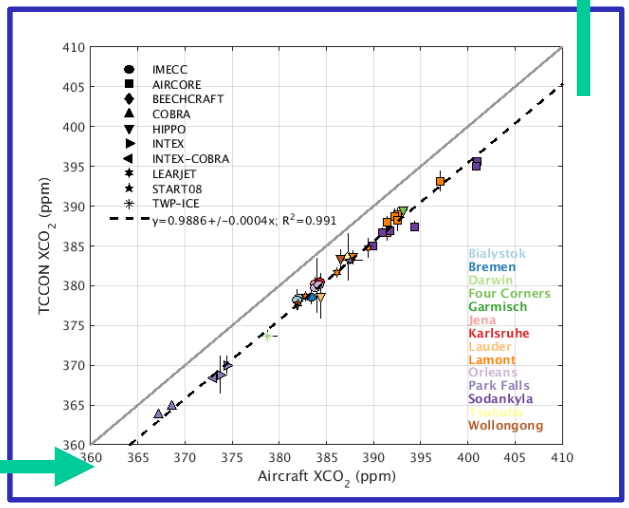
OCO-2 Validation Plan: Designed During Development for Original OCO

Jet Propulsion Laboratory
California Institute of Technology









TCCON vs Aircraft/Balloon Data

OCO-2 Validation Plan:

OCO-2 Column CO2 Observations are tied to the WMO surface measurements via comparisons to TCCON Data:

- OCO-2 data is compared to TCCON data for target, nadir and glint observations.
  - ➢ This is our key step
- TCCON measurements from all official sites have been compared to profile data from aircraft or balloons.
- The aircraft and balloon data utilize the WMO standard to tie to the TCCON data to the surface observations.

Target Observation Statistics

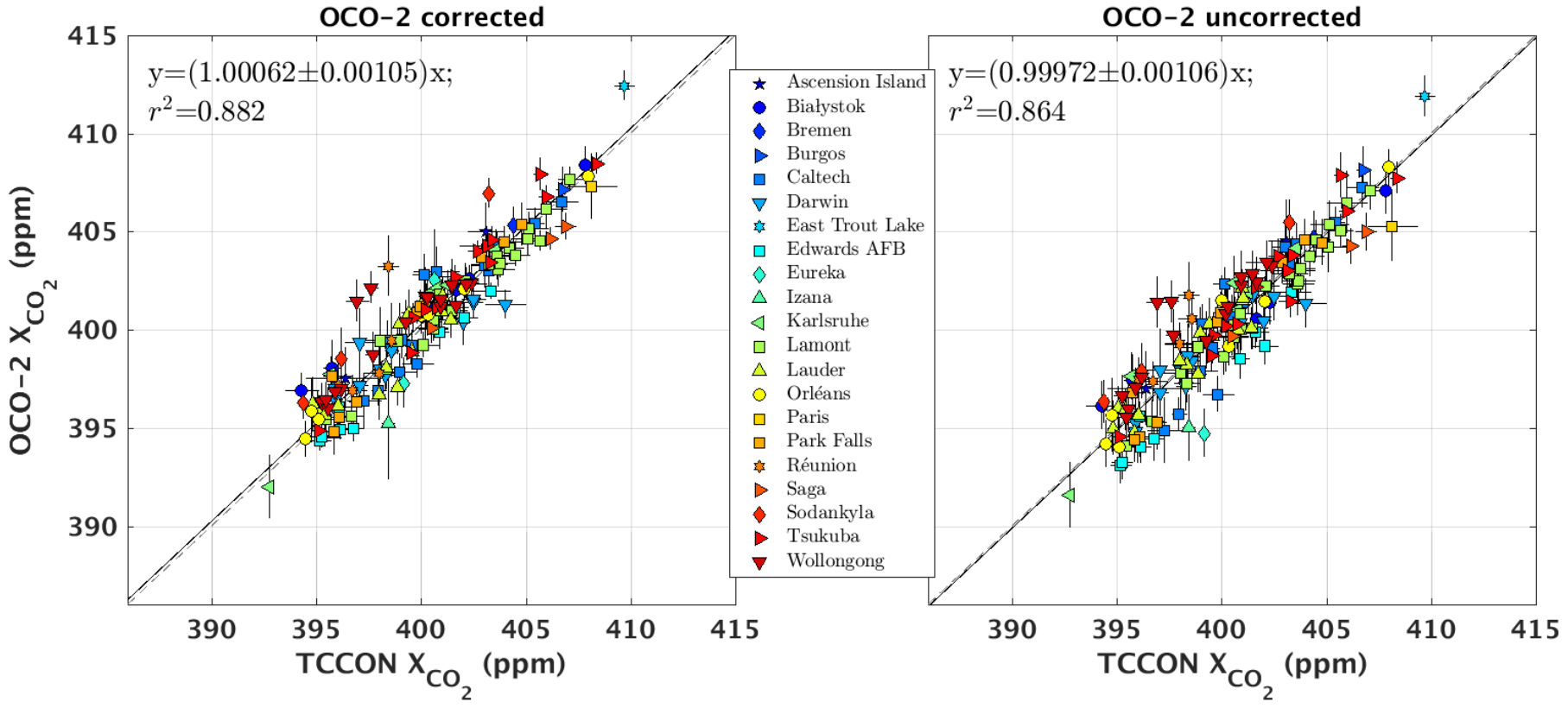
Jet Propulsion Laboratory
California Institute of Technology

Site	# Obs	June 2017	Last Obs	Site	# Obs	June 2017	Last Obs
Anmyeondo	4	0	2017-02-15 04:46:43	Litchfield	0	0	None
Ascension Island	10	0	2017-02-04 14:46:09	Manaus	4	N/A	2015-07-29 17:40:51
Bialystok	10	0	2017-03-30 11:08:35	Mexico City	3	0	2016-01-24 19:56:38
Boulder	0	0	None	Orleans	18	0	2017-04-20 13:04:09
Bremen	2	0	2016-03-17 12:10:17	Paris	3	0	2016-08-25 12:51:39
Burgos	1	0	2017-04-21 05:24:51	Park Falls	19	1	2017-06-06 18:55:59
Caltech	22	1	2017-06-23 21:14:38	Poker Flat/Fairbanks	14	2	2017-06-13 22:25:07
Darwin	18	0	2016-08-28 04:51:19	Railroad Valley	40	3	2017-06-25 21:05:28
Dryden (Armstrong)	17	0	2017-05-17 20:56:38	Reunion Island	23	0	2017-01-22 10:16:36
East Trout Lake	2	0	2017-05-11 20:00:03	Rikubetsu	2	0	2017-05-09 03:40:32
Eureka	4	N/A	2015-06-28 17:06:58	Rosemount	1	0	2016-07-01 19:19:56
Hyytiala	3	0	2017-05-05 10:46:10	Saga	5	1	2017-06-02 04:27:14
Izana	7	0	2017-05-08 14:25:18	Sao Paulo	1	N/A	2016-02-03 17:03:55
Karlsruhe	9	1	2017-06-13 12:27:22	Shanghai	3	N/A	2016-02-07 05:22:09
Lamont	34	0	2017-05-29 19:42:46	Sodankyla	11	1	2017-06-07 09:52:33
Lauder	21	0	2017-04-22 02:34:38	Tsukuba	17	1	2017-06-17 03:44:42
Libya	5	0	2017-02-20 11:38:42	Wollongong	23	0	2017-05-10 04:02:47

OCO-2/TCCON vs Target Data (Corrected, Uncorrected Side by Side)

Jet Propulsion Laboratory
California Institute of Technology

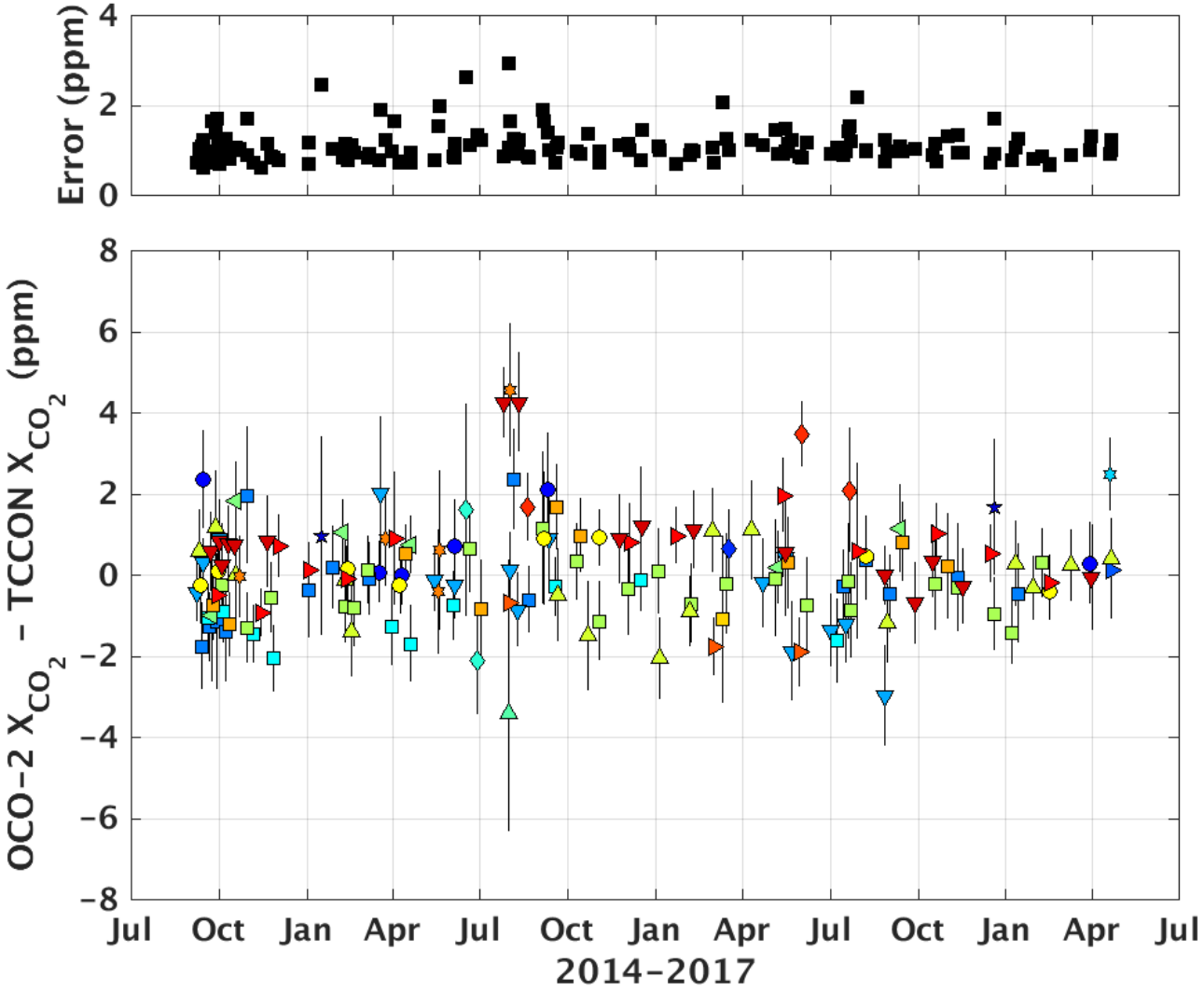
➔ 158 Target Observations vs TCCON



Bias correction applied ➔ Improved r^2

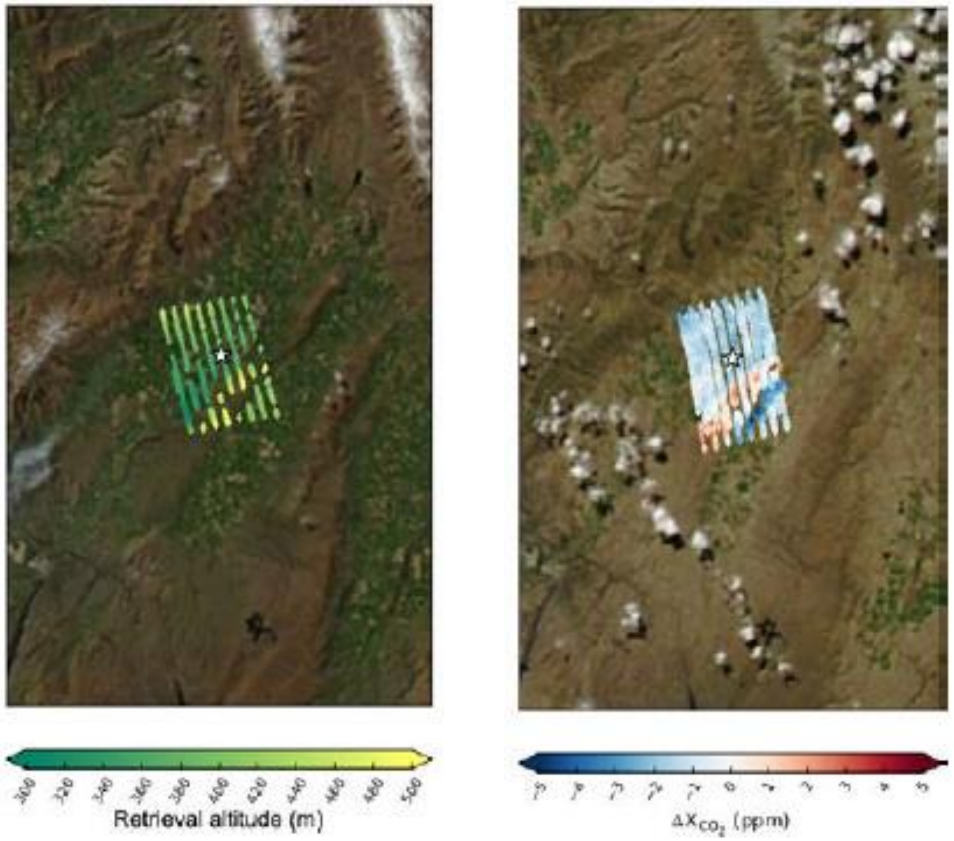
Figures extracted from Wunch *et al.*, AMT, 2017

OCO-2/TCCON – Time Series



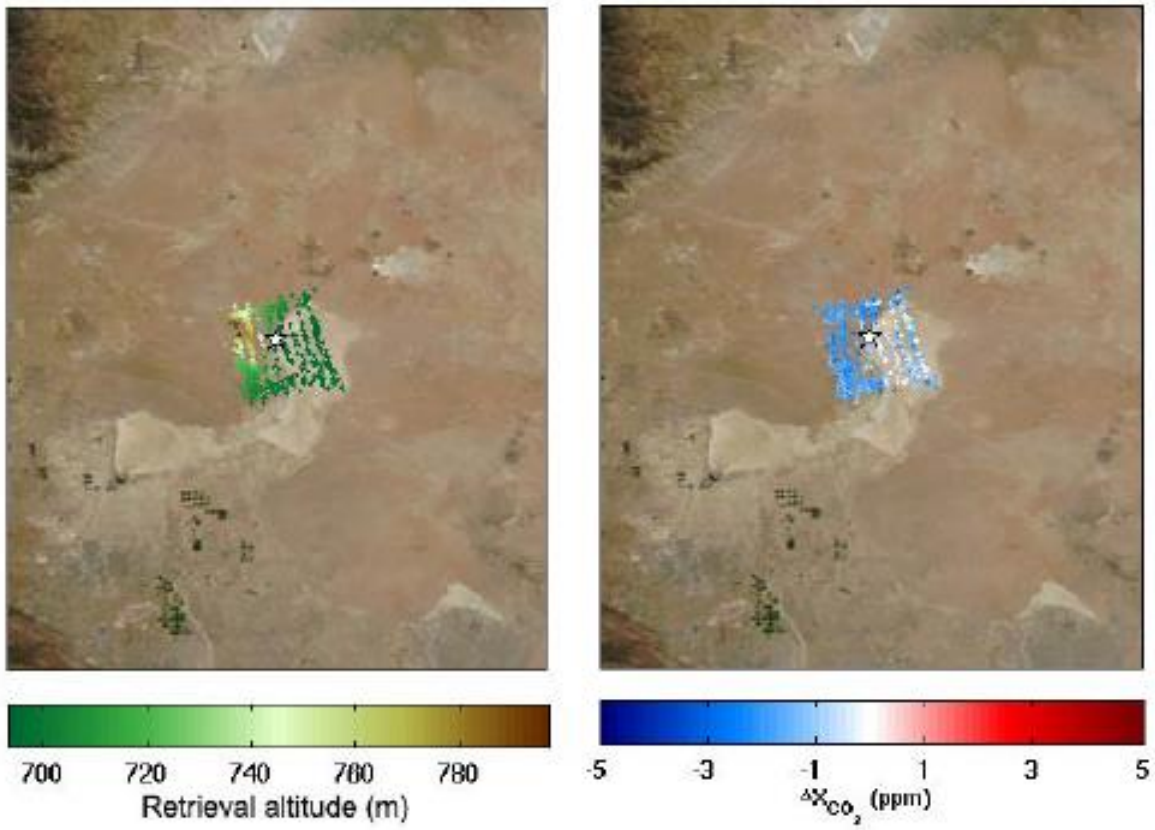
Matt Kiel/Coleen Roehl/Camille Viatte/Debra Wunch

Comparisons to TCCON: Geography Dependence



- Lauder, NZ target
- Background is MODIS image
- White star is location of the TCCON station
- Left panel: Elevation model
- Right panel: Difference between OCO-2 X_{CO2} and TCCON
- Bias due to altitude is apparent in the X_{CO2}
- Working to fix the effect in OCO-2 v08 retrievals

Comparisons to TCCON: Albedo Effect



- Target at Armstrong FRC/Edwards AFB
- Background is MODIS image
- White star is location of the TCCON station
- Left panel: Elevation model
- Right panel: Difference between OCO-2 X_{CO2} and TCCON
- Bright, desert scene with varying albedo
- Bias related to the surface brightness is apparent

New OCO-2 Target Locations

New as of March 2017:

- Hyytiala, Finland
- East Trout Lake, Canada
- Burgos, Philippines

Removed (for now?):

- Libya
- Mexico City
- Litchfield
- Looking at doing changes twice per year

Summary

➔ **TCCON data** has been found to be essential for the global GHG observation
⇒ calibration and validation of satellite retrievals
⇒ studying and improving models (atmospheric transport, biosphere)
⇒ test of spectroscopic parameters

➔ TCCON has advantage over space-based sensors
because the viewing geometry is much simpler (low aerosol impacts)

➔ TCCON disadvantaged over space-based sensors because of different instruments
⇒ Site-to-site bias exists
⇒ Working group formed during the last TCCON meeting @ Paris

➔ **Problems**
⇒ TCCON measurements are expensive (500 k€ to set-up a new site)
⇒ Operation (automation possible, but regular site visits are necessary)
⇒ Community expects data free of charge
⇒ No continuous funding

Thank you for your attention

2017 Annual Joint NDACC-IRWG & TCCON meeting hosted by the LERMA at the TCCON-Paris station

https://irwg-tccon-2017.sciencesconf.org/