TCCON4S5P

First Validation Results of the Sentinel-5P Methane Using Global TCCON and NDACC-IRWG Data

Validation team: Mahesh Kumar Sha*, Bavo Langerock, M. De Mazière, Minqiang Zhou, Yang Yang, D. G. Feist, R. Sussmann, F. Hase, M. Schneider, T. Blumenstock, J. Notholt, T. Warneke, C. Petri, R. Kivi, Y. Té, P. O. Wennberg, D. Wunch, L. Iraci, K. Strong, D. W. T. Griffith, N.M. Deutscher, V. Velazco, I. Morino, H. Ohyama, O. Uchino, K. Shiomi, T. Y. Goo, D. F. Pollard, Pucai Wang, T. Borsdorff, H. Hu, O. Hasekamp, J. Landgraf, C. Roehl, M. Kiel, G. Toon, TCCON team & NDACC-IRWG team

* mahesh.sha@aeronomie.be

ROYAL BELGIAN INSTITUTE FOR SPACE AERONOMY

Sentinel-5 Precursor

Sentinel-5 Precursor (S-5 P) is the first of the ESA atmospheric composition of Sentinels contributing to the European Commission Copernicus Programme to improve our understanding of the planet and the environment.
S-5 P has been successfully launched on 13th October 2017. Near-polar sun-synchronous orbit at an altitude of 824 km with an ascending node equatorial crossing at 13:30. Orbit cycle is 16 days (14 orbits per day, 227 orbits per cycle). Mission duration is 7 years.

TROPOsheric Monitoring Instrument (TROPOMI) onboard S-5 P is a grating spectrometer covering 8 bands (UV – short-wave IR), common telescope for UVN and SWIR, pushbroom configuration and wide swath (108° → 2600 km on surface). The primary products measured are Ozone, NO_2, CO, CH_2O, CH_4, SO_2, Aerosol, Clouds and UV-Index. The application of the data measured will be on ozone layer monitoring, climate monitoring, air quality monitoring and forecast, volcanic plume detection and UV index forecast.

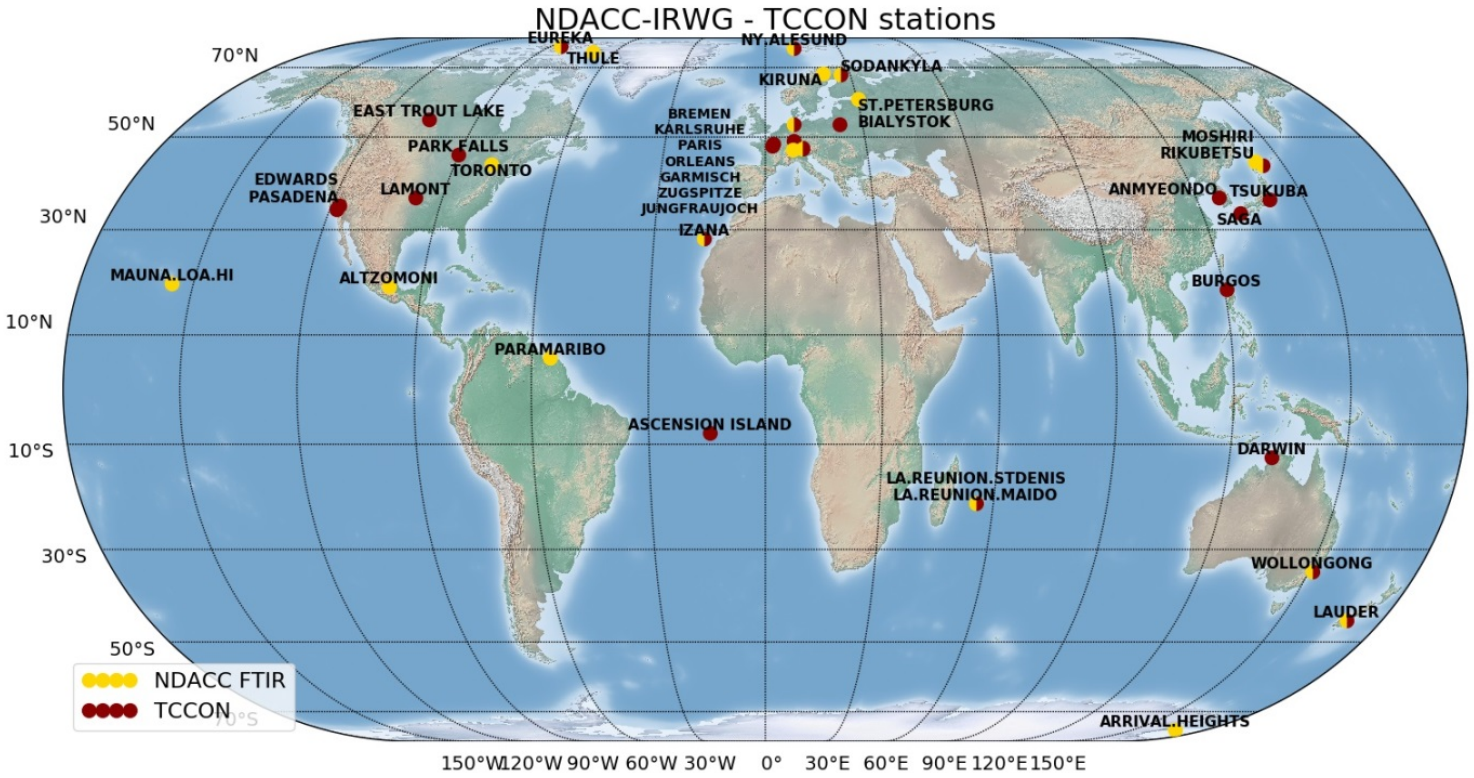
TROPOMI uses the absorption information from the Oxygen-A Band (757–774 nm) and the SWIR spectral channel (2305–2385 nm) to retrieve the CH_4 global abundance in the Earth's atmosphere. CH_4 products has a spatial sampling of 7x7 km2.

Table 1 – Sentinel-5P TROPOMI mandatory atmospheric composition data products addressed by this project

Parameter	Data Product	Vertical resolution	Systematic Uncertainty Requirement	Random Uncertainty Requirement
CH_4	Total CH_4	Total column	1.5%	1%

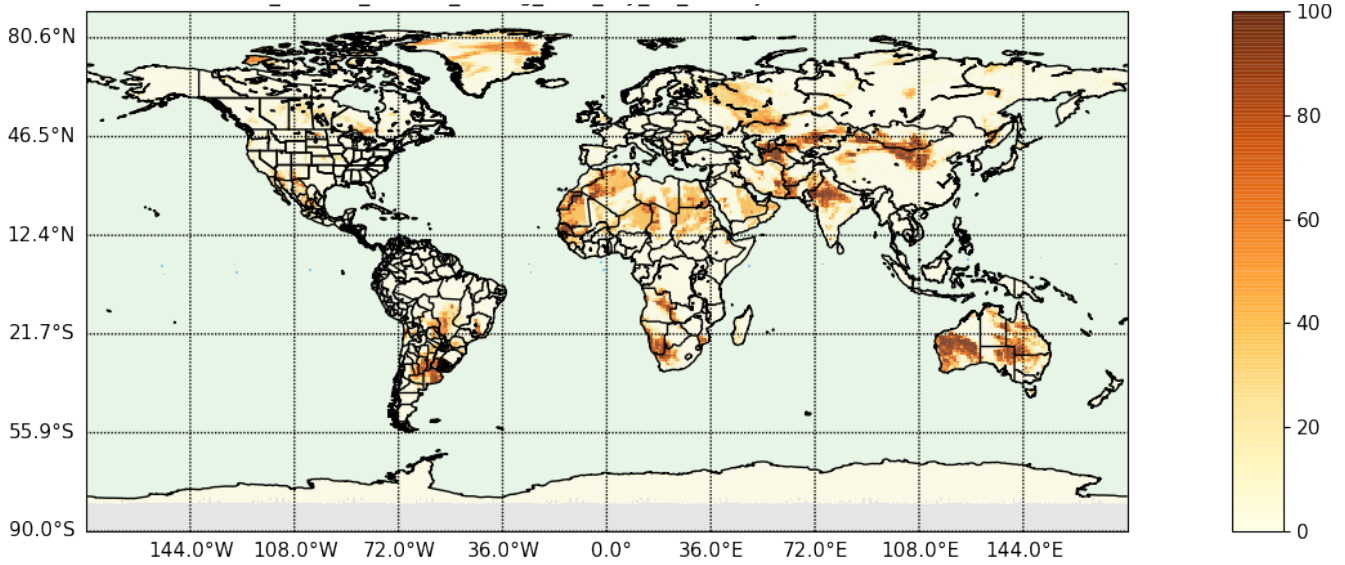
Groundbased networks used for the validation study

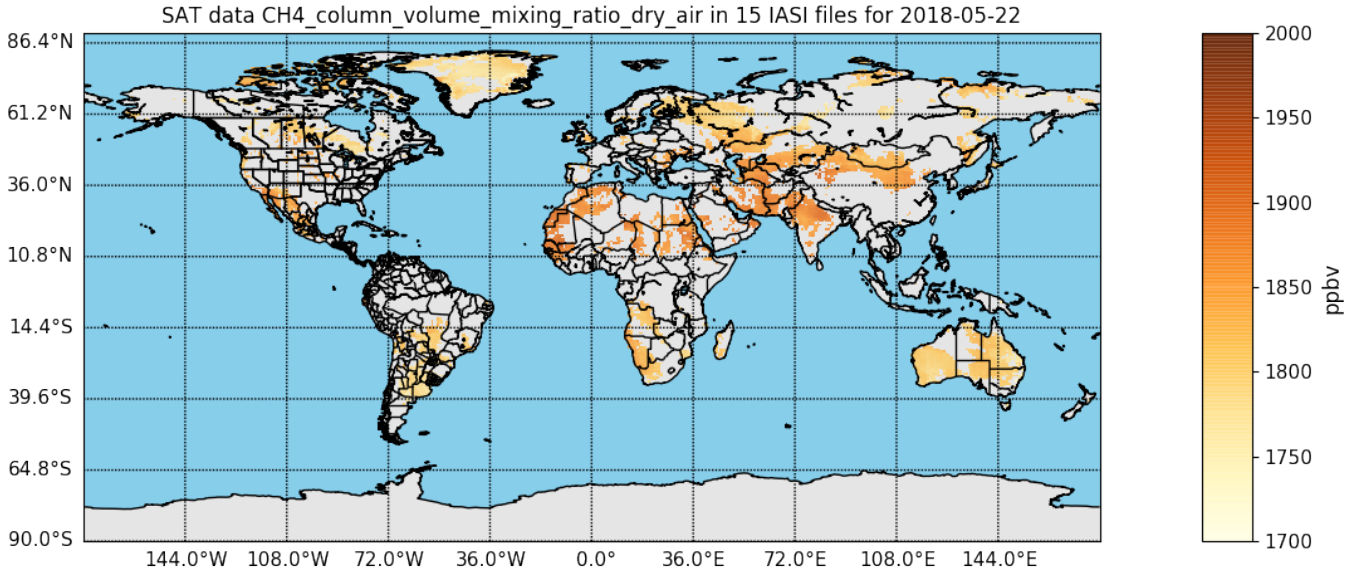
- The Total Carbon Column Observing Network (TCCON)
  - 22 stations in the northern hemisphere and 5 stations in the southern hemisphere
  - High accuracy / precision (0.2% / 0.5% for CH4 and 2% / 1% for CO)
- The infrared Working group (IRWG) of the NDACC
  - 10 stations in the northern hemisphere and 4 stations in the southern hemisphere
  - Accuracy / precision (3% / 1.5% for CH4 and 3% / 1% for CO)



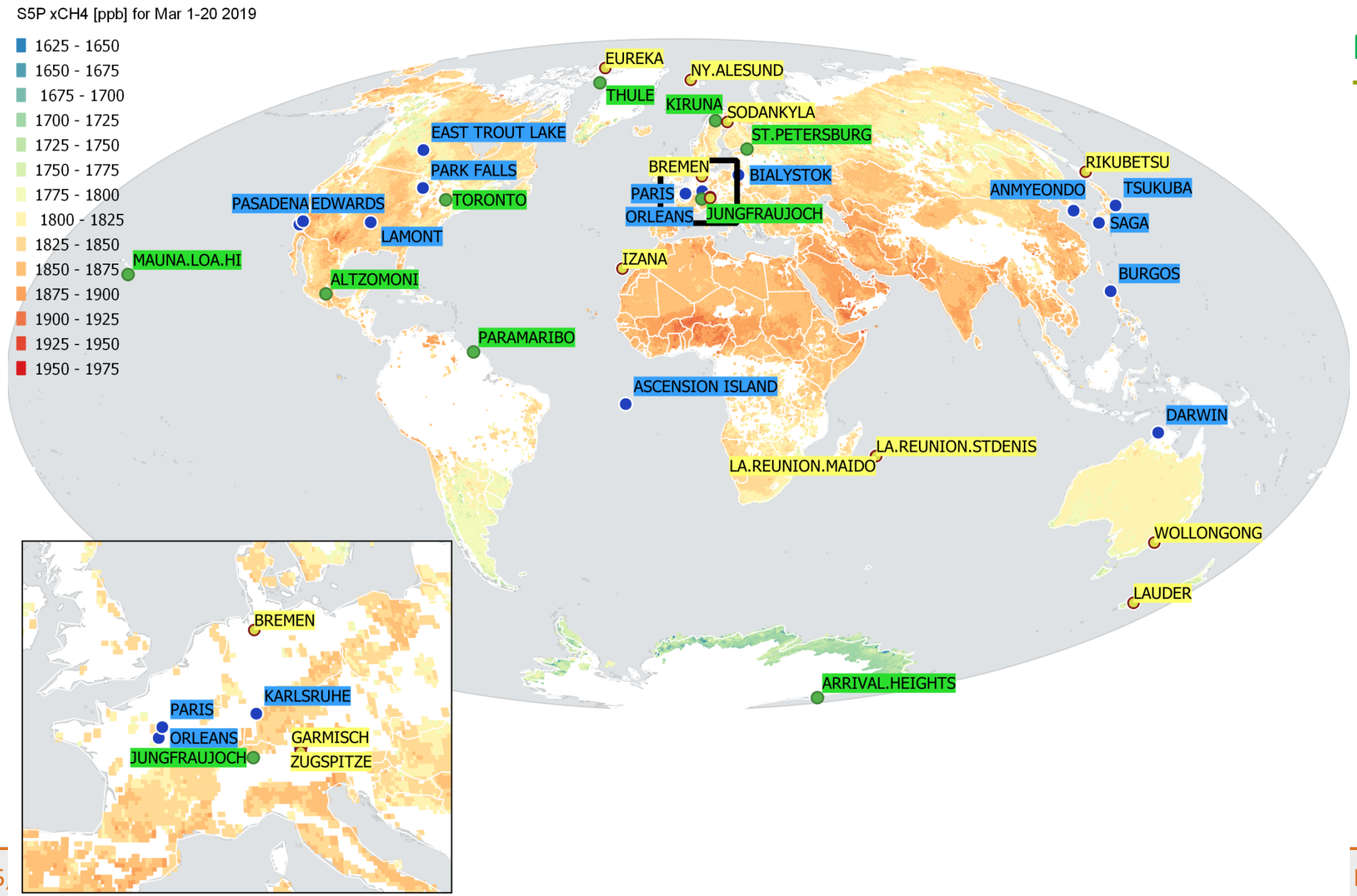
TROPOMI global plot for Methane (CH_4)

S-5P CH_4 QA values: strict filtering
➔ **no island stations** for validation





S-5P xCH_4 global plot – mean of 1-20 March 2019



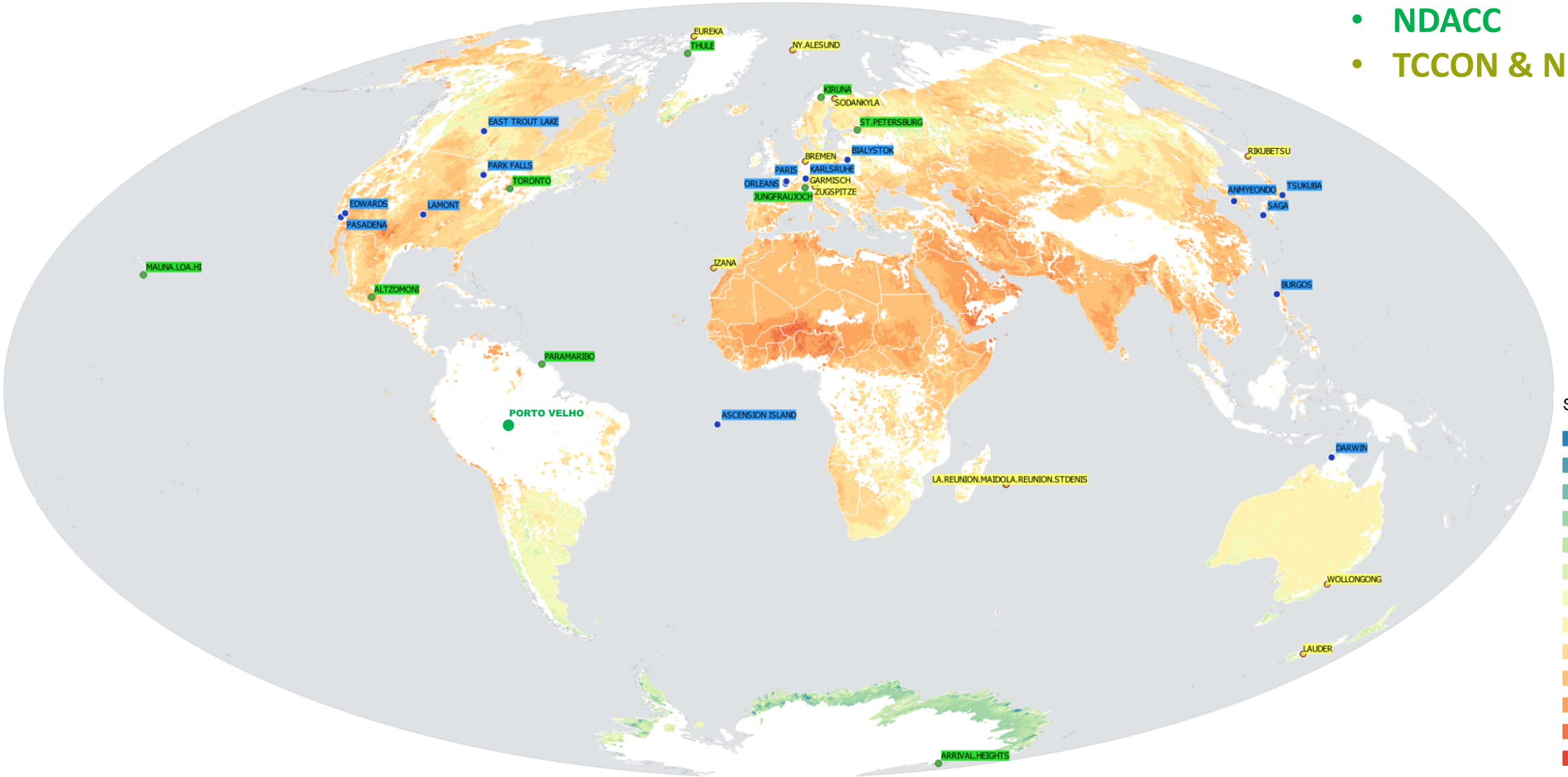
TCCON

NDACC

TCCON & NDACC

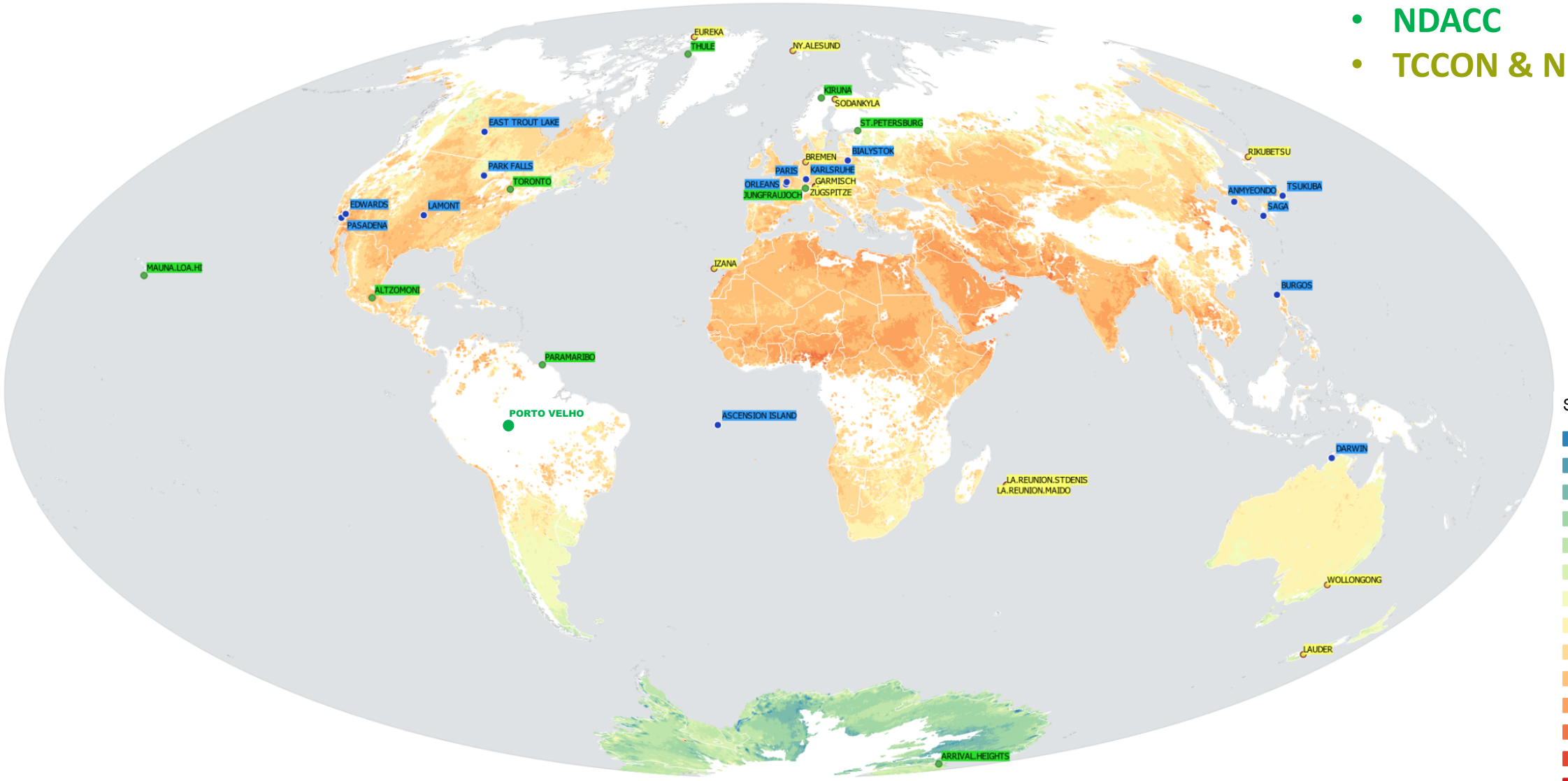
S-5P xCH_4 global plot – mean of 1-20 March 2019

- TCCON
- NDACC
- TCCON & NDACC



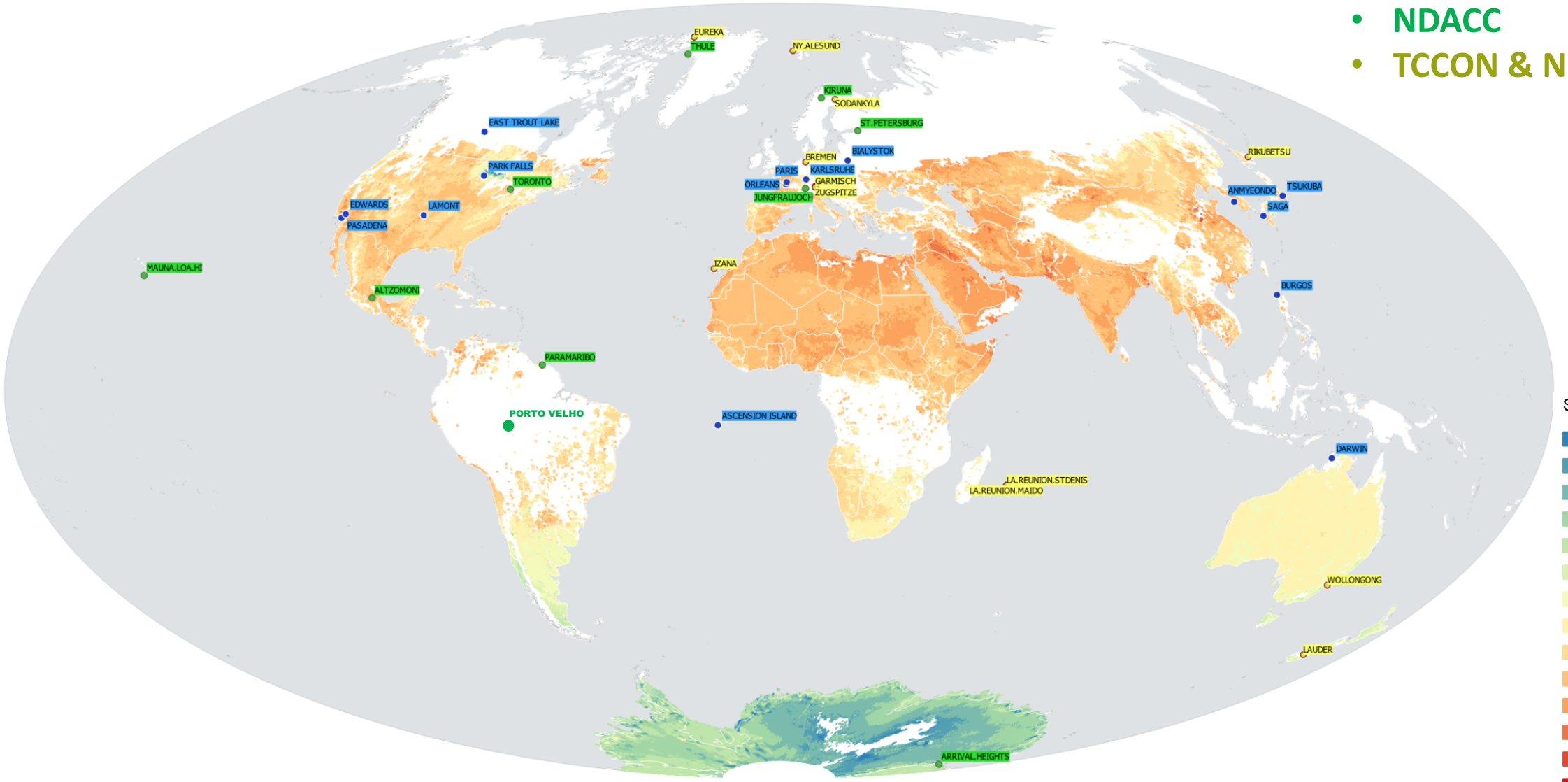
S-5P xCH_4 global plot – mean of 1-28 February 2019

- TCCON
- NDACC
- TCCON & NDACC



S-5P xCH_4 global plot – mean of 1-31 January 2019

- TCCON
- NDACC
- TCCON & NDACC



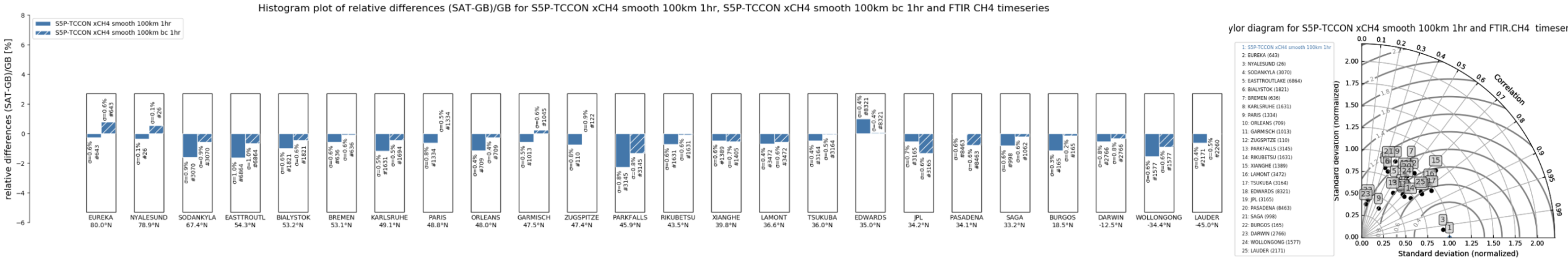
Coincidence criteria for validation study

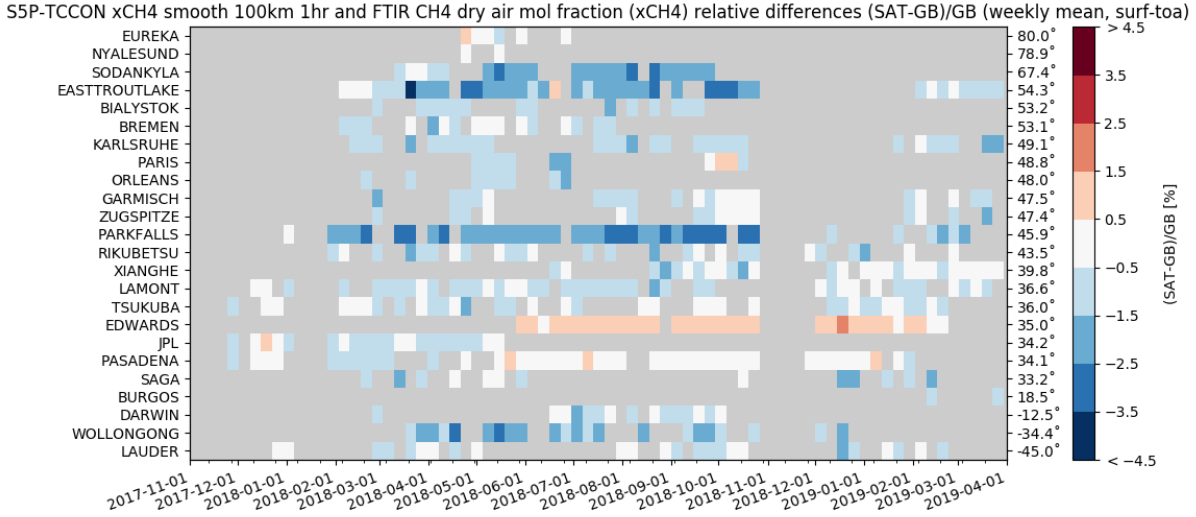
- Period of study started with the first available data (17 November 2017 till 1 April 2019)
- TCCON data provided by 27 stations (fast data delivery and standard data) ➔ **Many Thanks!**
- NDACC data provided by 14 stations (rapid data delivery – CAMS27 contract cams27.aeronomie.be) ➔ **Many Thanks!**
- S-5P data from the Copernicus data hub and Mission Performance Centre (MPC) provided by the Payload Data Ground Segment (PDGS) at DLR

  S-5P CH_4 version 01.02.02 and 01.03.00 (RPRO & OFFL)
- Coincidence criteria for CH_4: Time delta = 1h (TCCON) & 6h, 3h & 1h (NDACC); Geo-distance delta = 50 km and 100 km radius, qa_value>0.5. Normal XCH_4 product and bias-corrected XCH_4 product. From the coincident and filtered satellite measurements an average of all pixels is taken for each TCCON and NDACC measurements
- S-5P CH_4 priori is used as common prior (Rodgers, 2003), altitude correction is done for each satellite pixel to the ground-based station height

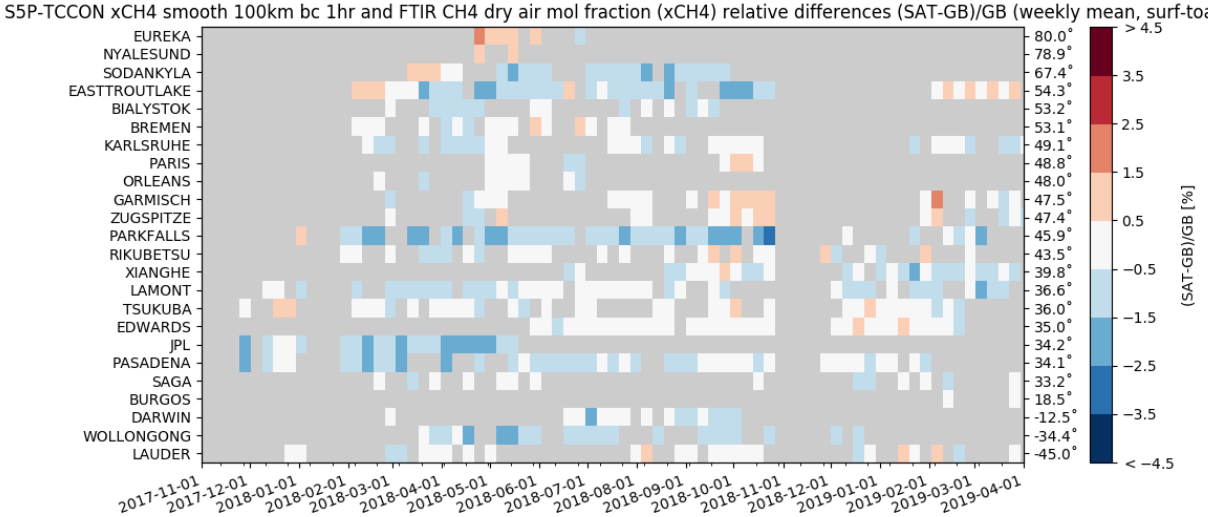
- Validation using NDACC CH_4 data are part of the **VDAF** study (mpc-vdaf.tropomi.eu)

S-5P validation results – XCH_4





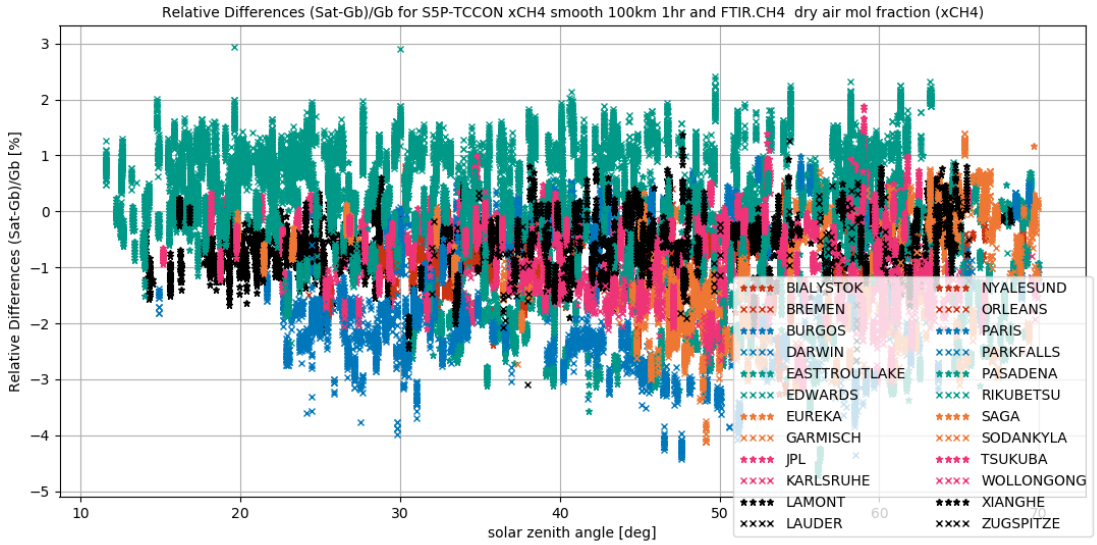
S-5P Standard product

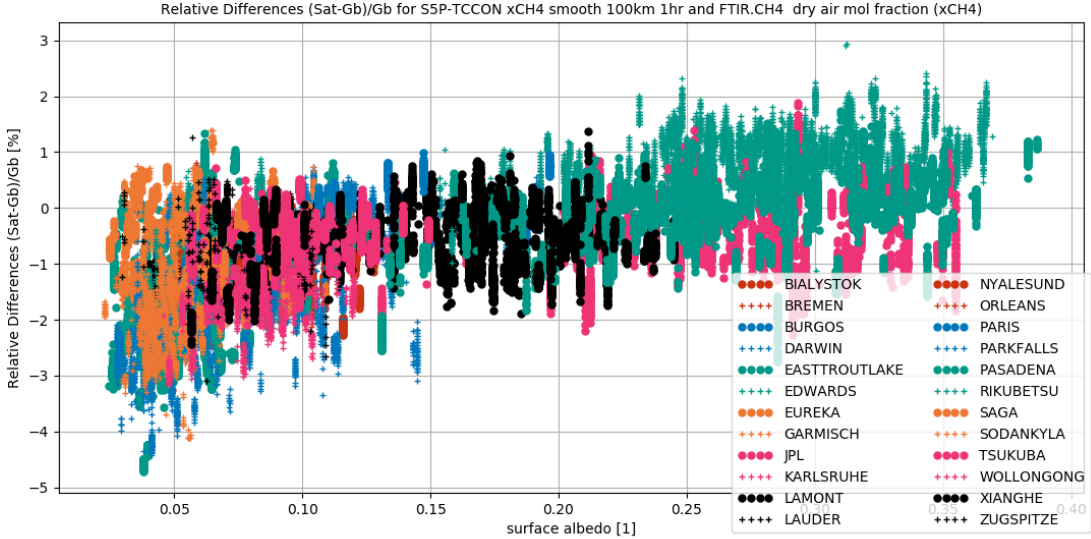


S-5P Bias corrected product

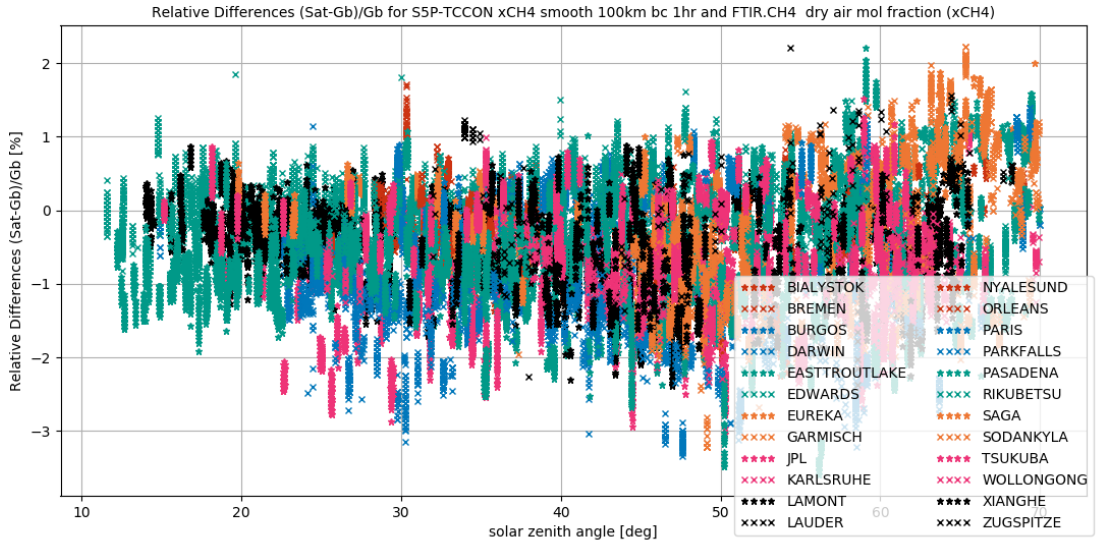
S-5P validation results – XCH_4

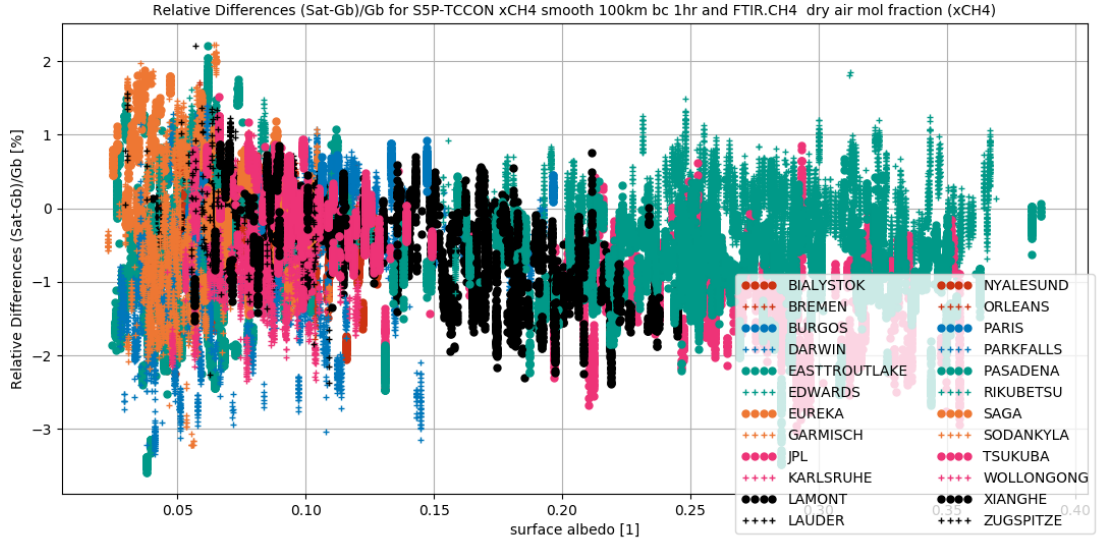
S-5P Standard product



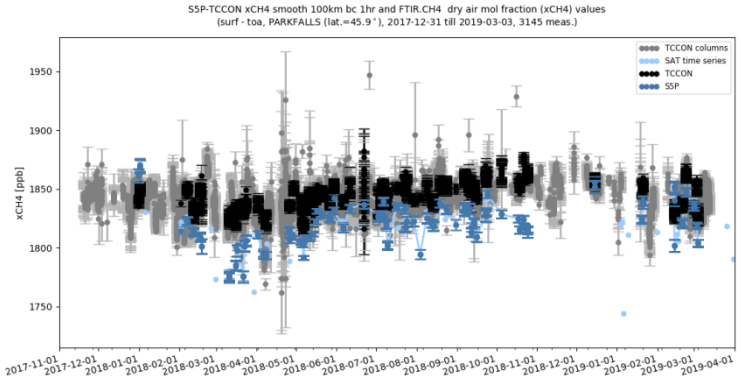


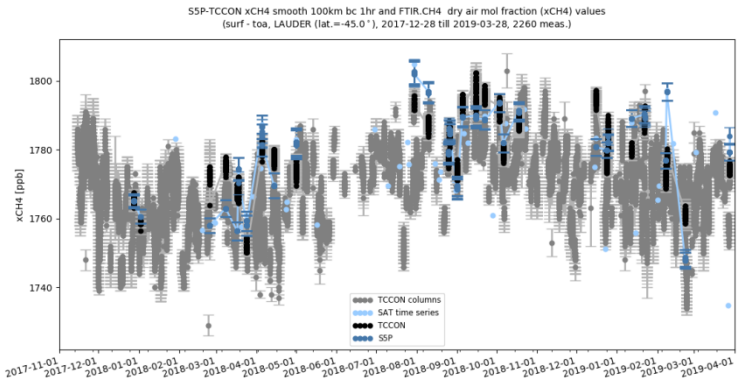
S-5P Bias corrected product



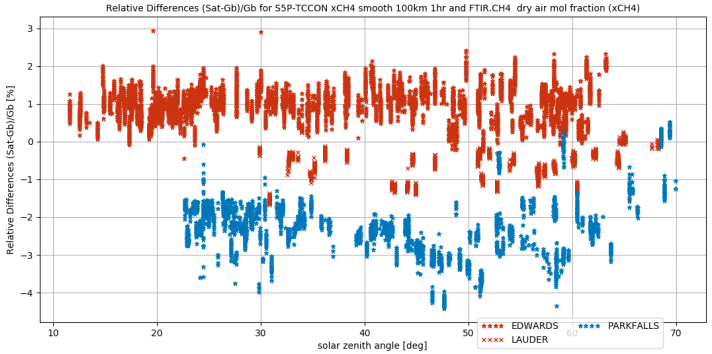


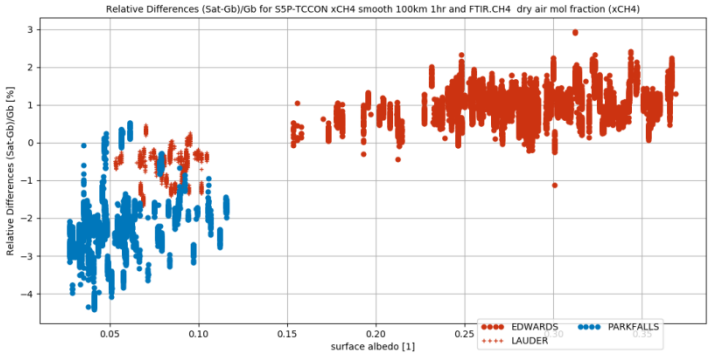
S-5P validation results – XCH_4



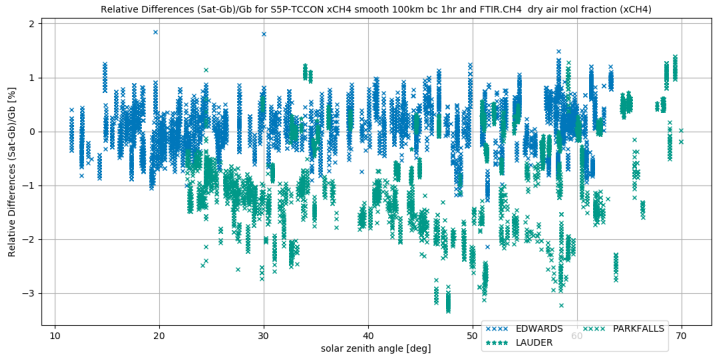


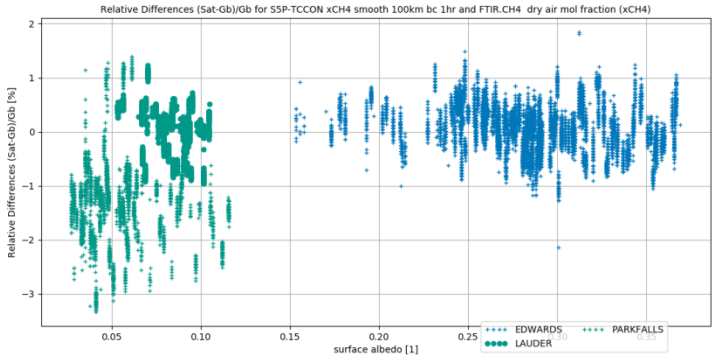
S-5P Standard product





S-5P Bias corrected product





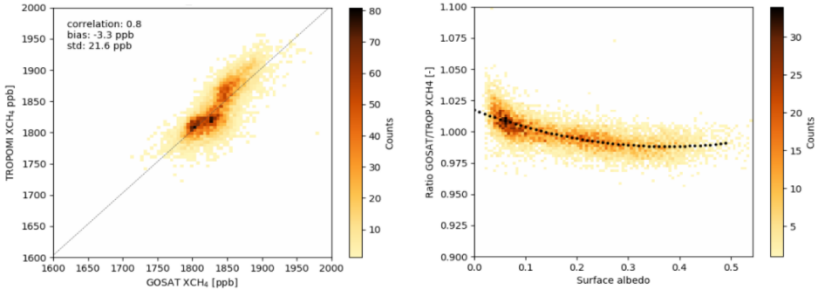
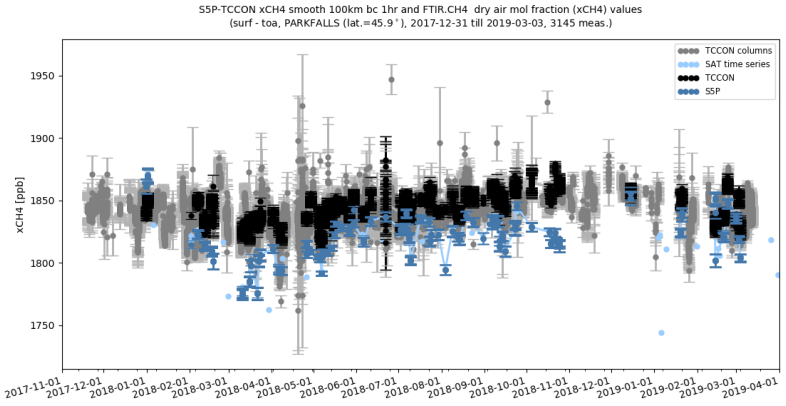
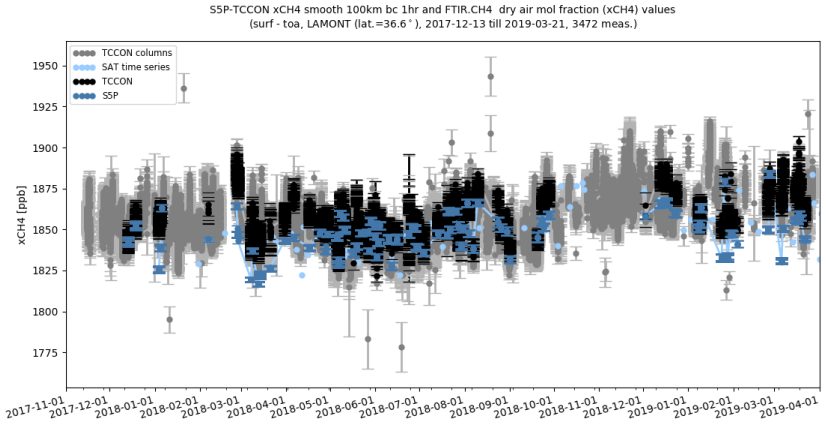


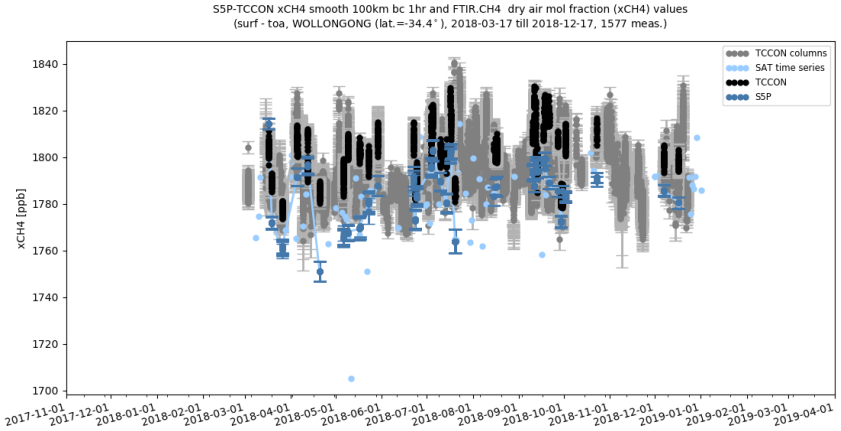
Figure 5: Left panel: correlation plot of TROPOMI and GOSAT CH_4 measurements. Right panel: ratio of GOSAT and TROPOMI CH_4 as a function of surface albedo. The black dashed line represents the second order polynomial fit from which the correction coefficients in Eq. 54 have been derived.

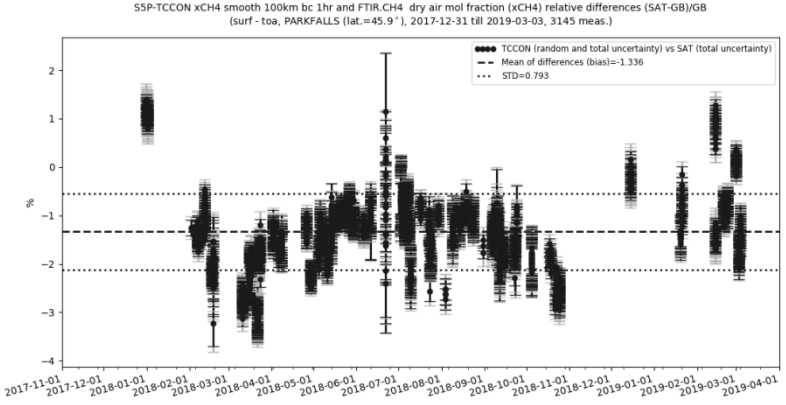
Reference: ATBD for Sentinel-5 Precursor Methane Retrieval

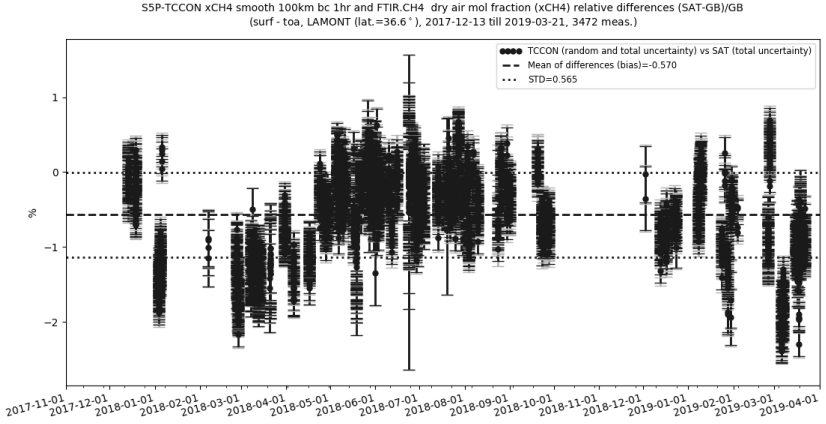
S-5P validation results – XCH_4

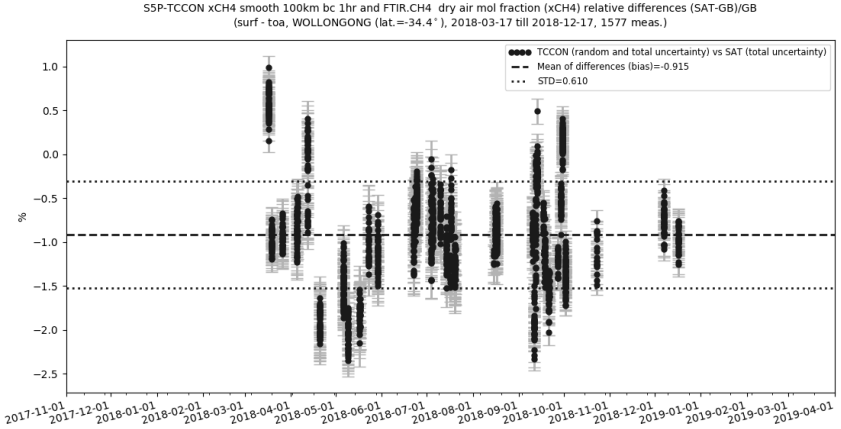












Parkfalls

Lamont

Wollongong

S-5P validation results – XCH_4

site	#	Std	correlation	mean relbias (%)	relbias std(%)	lat
EUREKA	643	0.8	0.75	0.77	0.57	80.0
NYALESUND	26	1.0	0.99	0.56	0.06	78.9
SODANKYLA	3070	0.8	0.32	-0.58	0.92	67.4
EASTTROUTLAKE	6864	0.8	0.51	-0.68	0.98	54.3
BIALYSTOK	1821	0.7	0.46	-0.46	0.56	53.2
BREMEN	636	0.9	0.53	-0.10	0.61	53.1
KARLSRUHE	1694	0.7	0.58	-0.47	0.54	49.1
PARIS	1334	0.6	0.53	0.01	0.51	48.8
ORLEANS	709	0.7	0.67	-0.27	0.36	48.0
GARMISCH	1045	0.7	0.65	0.25	0.56	47.5
ZUGSPITZE	122	0.9	0.43	0.01	0.90	47.4
PARKFALLS	3145	0.6	0.61	-1.34	0.79	45.9
RIKUBETSU	1631	0.7	0.79	-0.09	0.60	43.5
XIANGHE	1405	0.9	0.76	-0.56	0.68	39.8
LAMONT	3472	1.1	0.64	-0.57	0.57	36.6
TSUKUBA	3164	0.9	0.82	-0.06	0.47	36.0
EDWARDS	8321	0.8	0.83	0.06	0.42	35.0
JPL	3165	1.1	0.33	-1.35	0.64	34.2
PASADENA	8463	0.9	0.66	-0.79	0.56	34.1
SAGA	1062	1.0	0.41	-0.20	0.57	33.2
BURGOS	165	0.5	0.16	-0.16	0.22	18.5
DARWIN	2766	0.4	-0.01	-0.33	0.76	-12.5
WOLLONGONG	1577	0.9	0.63	-0.91	0.61	-34.4
LAUDER	2260	0.8	0.78	-0.03	0.46	-45.0
Mean	--	0.8	0.58	-0.30	0.58	

Conclusions

- First validation study covering all TCCON and several NDACC stations
- Good coincidences for many sites but also very few coincidences for some sites
- Validation of TROPOMI XCH4 with TCCON XCH_4:
  - Bias corrected product shows better result; high negative bias for some stations are due to the way the albedo correction is currently done; bias in the high latitude sites due to the profile difference of CH_4; SZA dependence seen for the stations
  - Mean bias of -0.3% ± 0.51% (24 stations; median bias of -0.235%)
    ➔ **systematic uncertainty (1.5%) compliant with mission requirement**
  - Standard deviation for all sites < 1%
    ➔ **random uncertainty (1%) compliant with mission requirement**
  - Correlation coefficient is ~ 0.6 (median)
- Overall recommendation: **the CH_4 product was recommended for release** to the public along with the product readme file. The product covering all seasons with one year of measurements is compliant with the mission requirements.

Notes

Acknowledgements: Sentinel-5 Precursor is a European Space Agency (ESA) mission on behalf of the European Commission (EC). The TROPOMI payload is a joint development by ESA and the Netherlands Space Office (NSO). The Sentinel-5 Precursor ground-segment development has been funded by ESA with national contributions from The Netherlands, Germany, and Belgium.

This TCCON4S5P validation work has been funded by the Belgian national agency (BELSPO) through the TROVA project, and the TCCON data have been funded by the individual national agencies of each partner.

The NDACC-IRWG data have been funded by the individual national agencies of each partner.

The VDAF validation work has been funded by ESA and BELSPO / BIRA-IASB.

Thank you for your attention!