A multi-year global synergetic satellite product of tropospheric CH4

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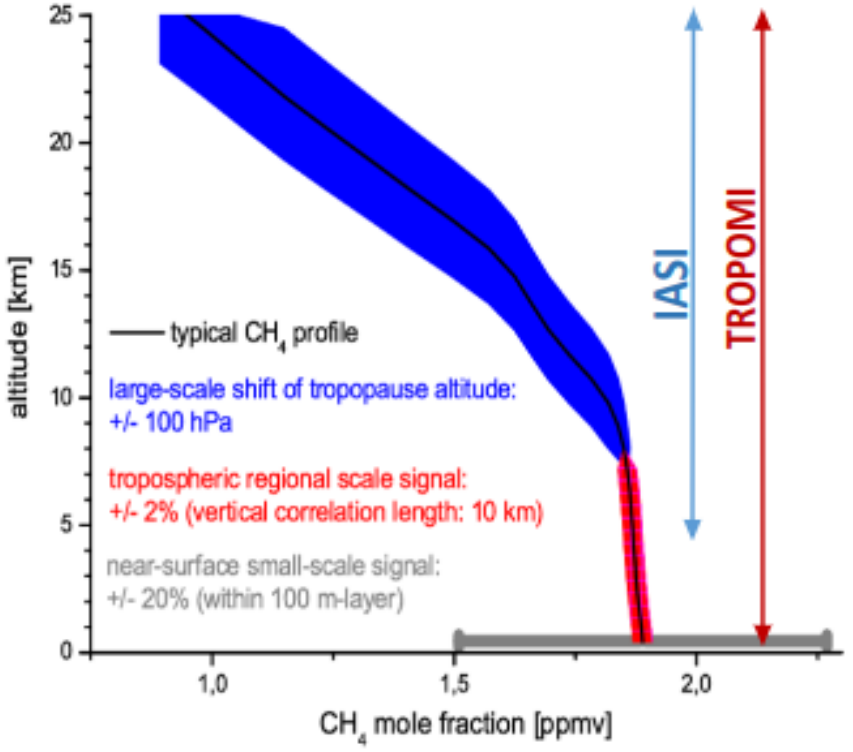
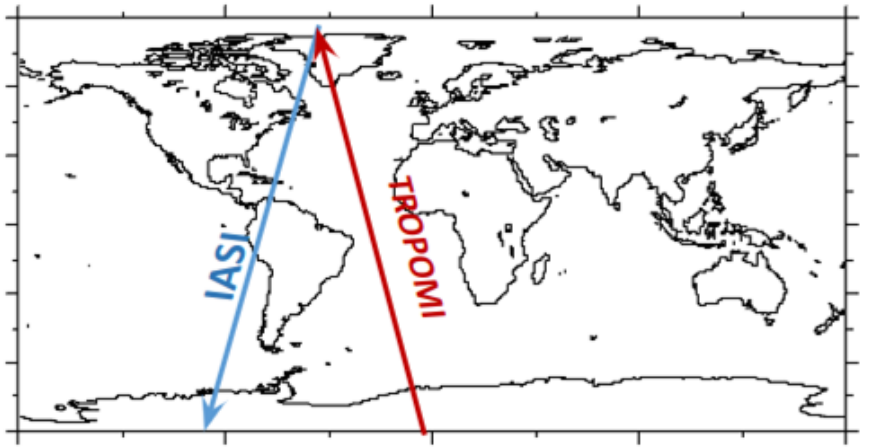
Scientific background

Methane data products in the lower troposphere with an improved vertical sensitivity can help for better understanding *anthropogenic emissions*.

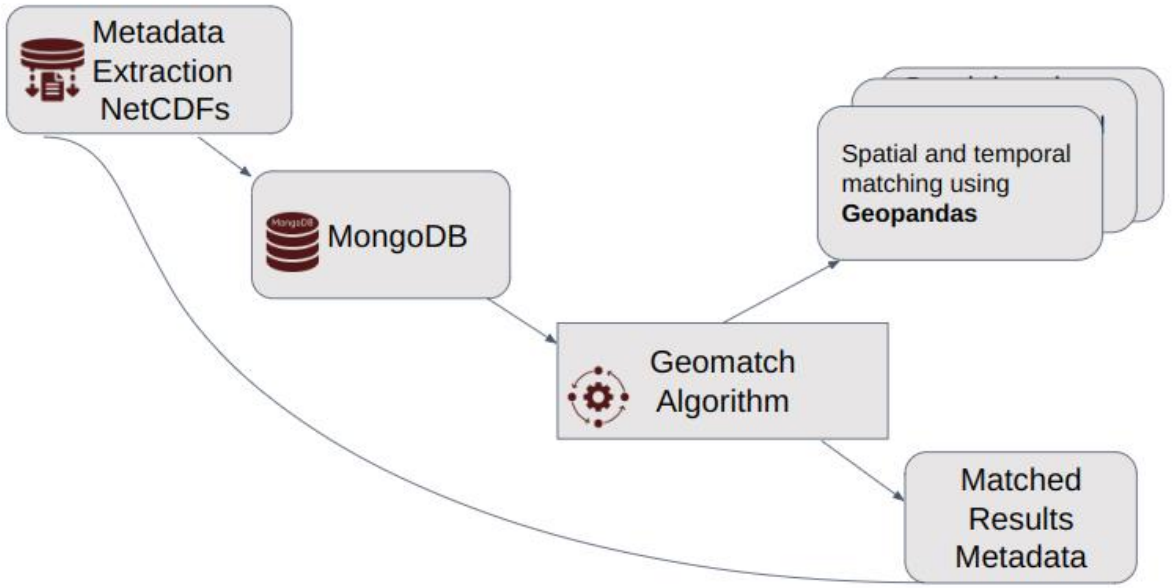


Combine IASI and TROPOMI to get surface near methane data



Problem: the sensors are on different satellites and orbits

Schematics

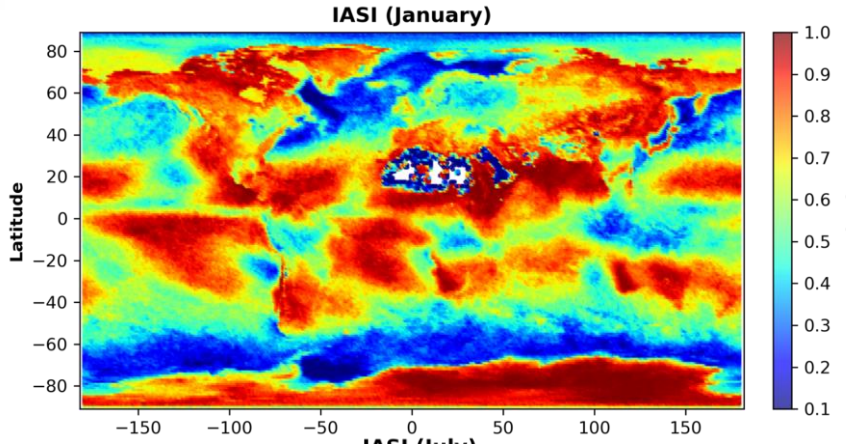


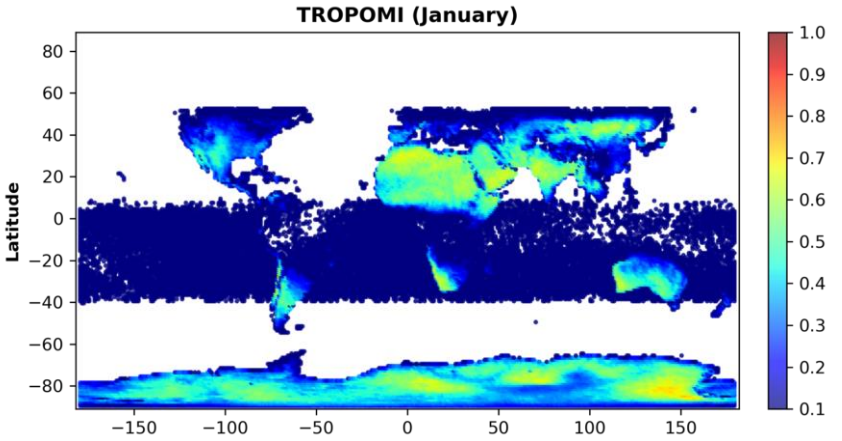
Kalman filter method:

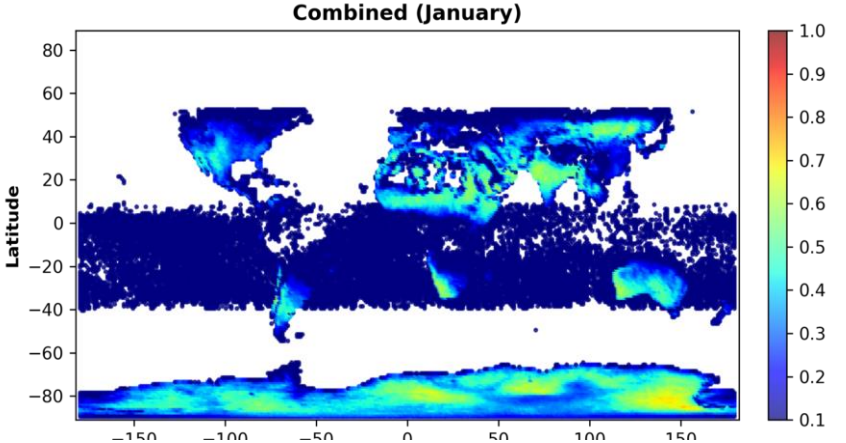
$$x^a = x^b + \mathbf{G}\left[y - \mathbf{H}x^b\right]$$
$$\mathbf{G} = \mathbf{S}^b\mathbf{H}^T\left[\mathbf{H}\mathbf{S}^b\mathbf{H}^T + \mathbf{S}_\varepsilon\right]^{-1}$$

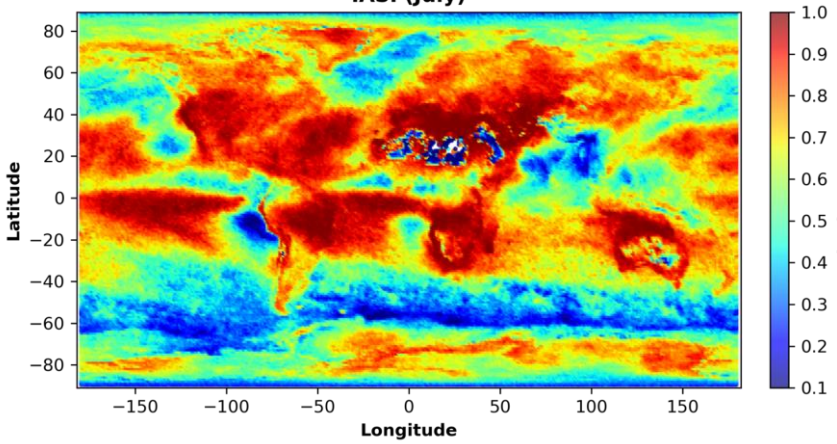
x^b, $\mathbf{S}^b$: IASI as background
y, $\mathbf{H}$, $\mathbf{S}_\varepsilon$: TROPOMI as obs.
x^a: Synergetic product

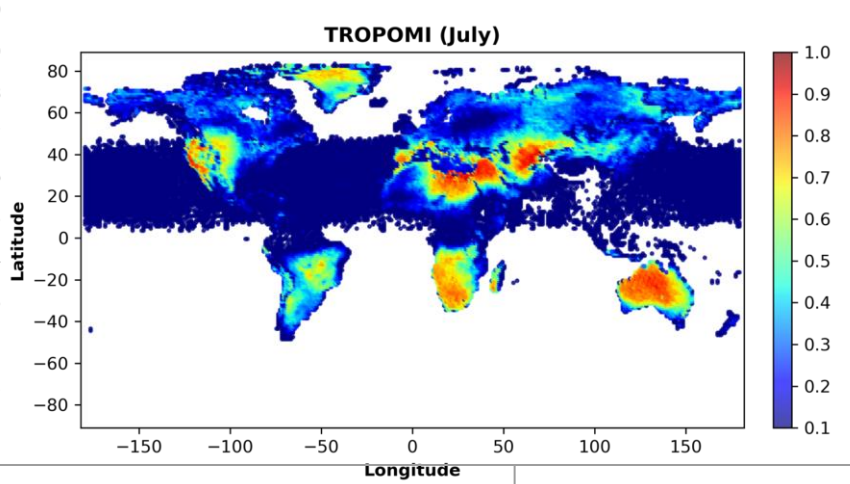
Data Statistics

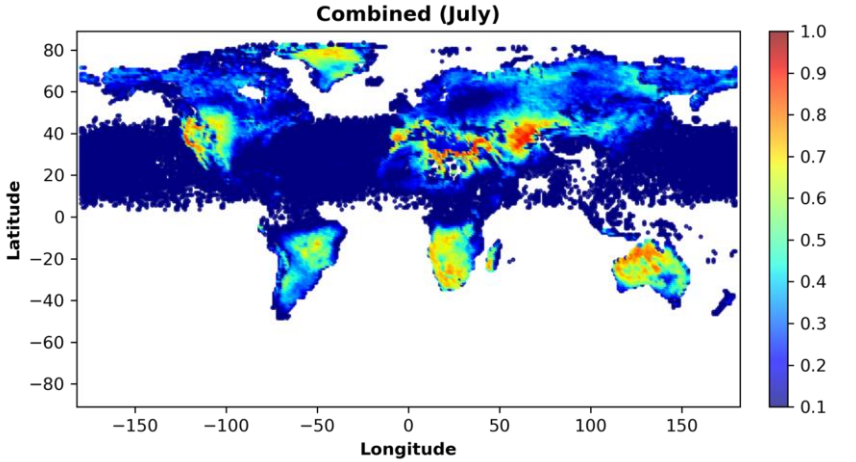






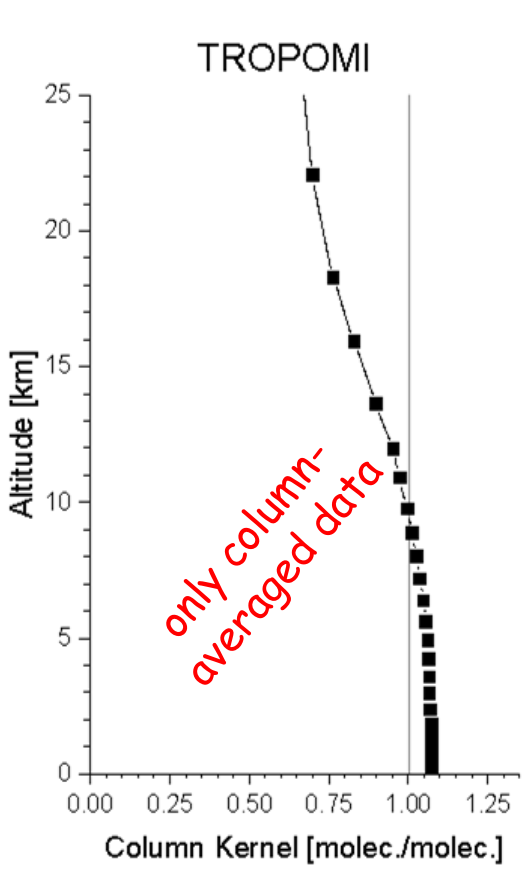


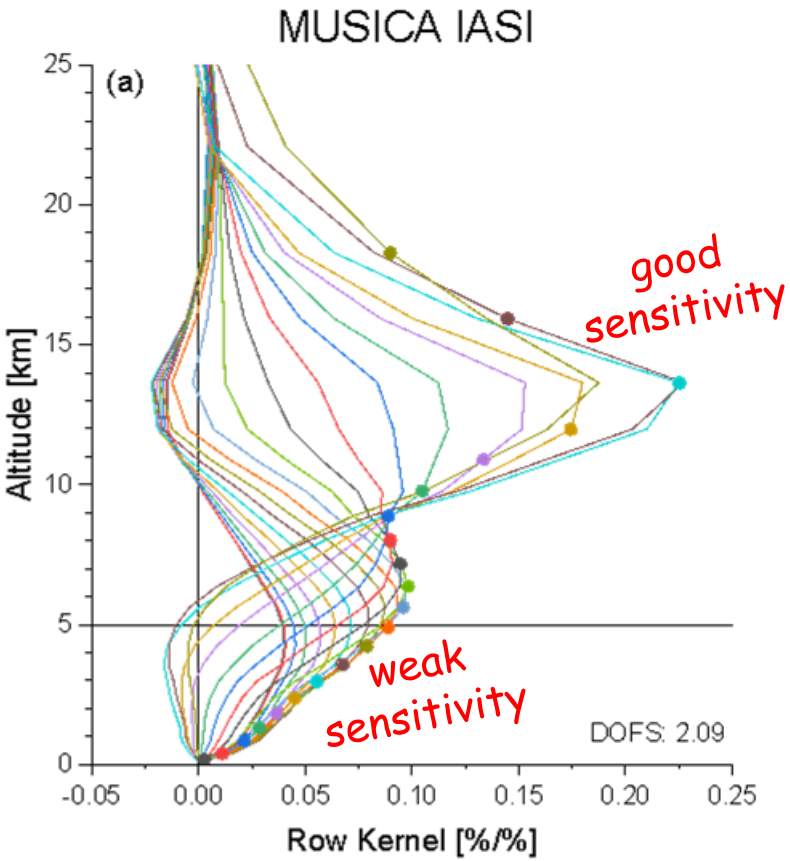


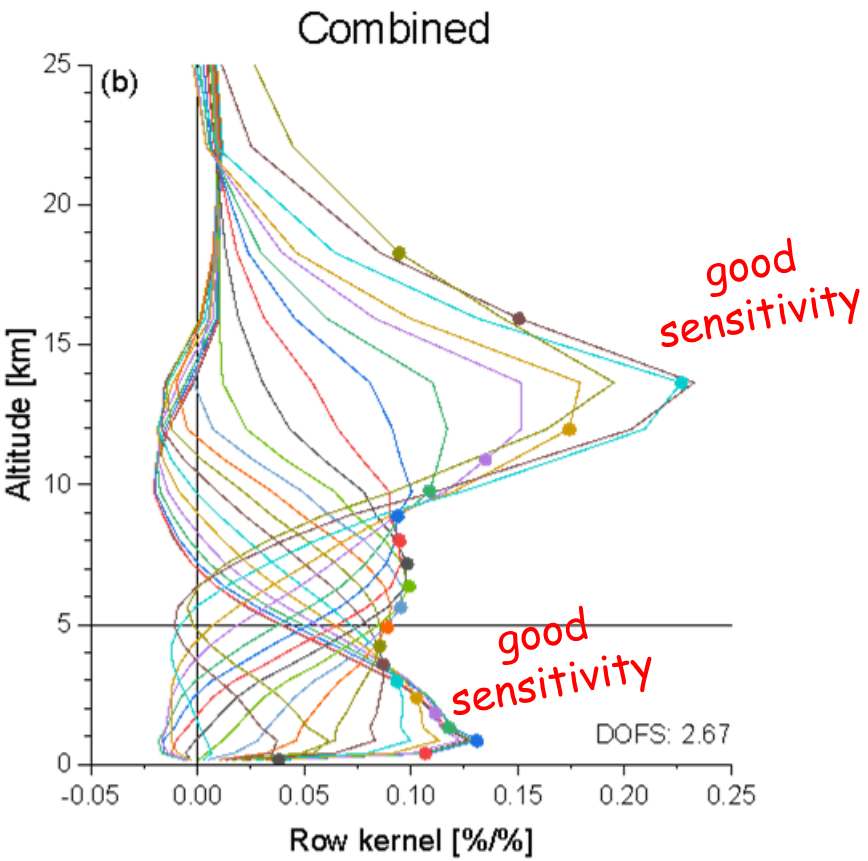


Month	IASI	TROPOMI	Combined
January (2018,2019,2020,and 2021)	73,260,469 (73 million)	39,608,020 (39 million)	29,656,080 (29 million)
July (2018,2019, and 2020)	53,595,654 (53 million)	31,621,447 (31 million)	17,689,901 (17 million)

Synergetic use of methane profile and total column data products: L2 product combination via a Kalman filter







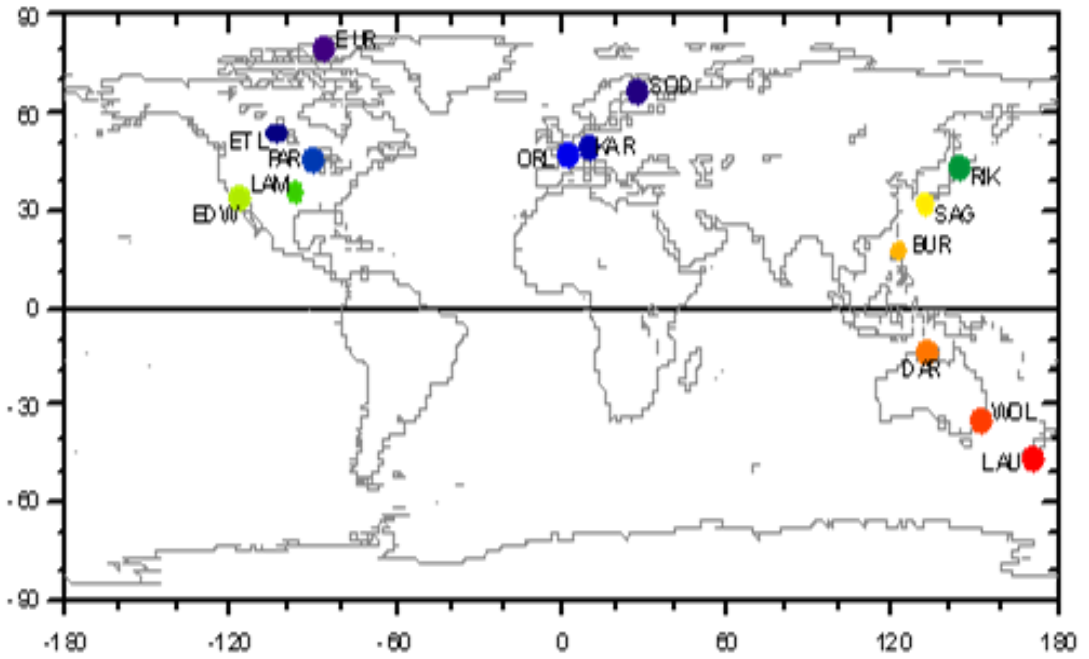
Validation

Reference data:

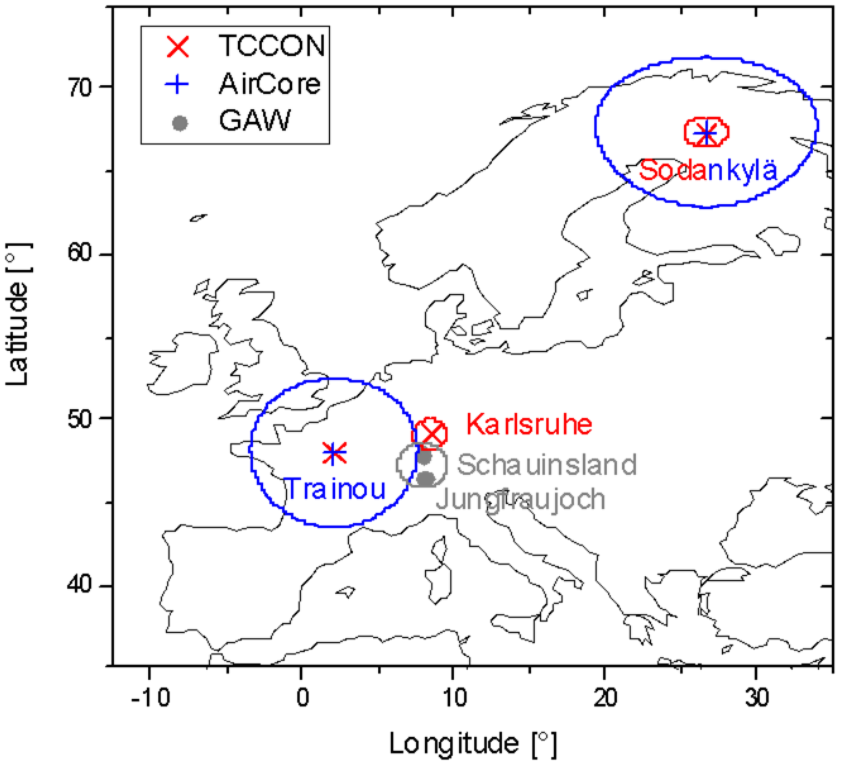
- Total Carbon Column Observing Network(TCCON)(14 stations),
- CH4 profile measurements made by 36 individual AirCore soundings,
- Tropospheric CH4 data derived from continuous ground-based in situ observations made at two nearby Global Atmospheric Watch (GAW) mountain stations

We are grateful to the colleagues for providing TCCON, AirCore and GAW data

Global TCCON stations

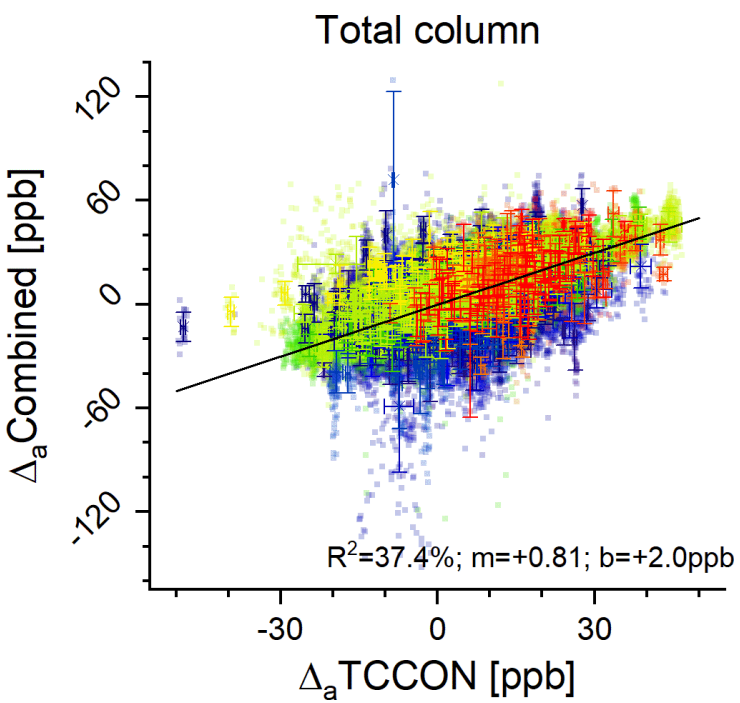


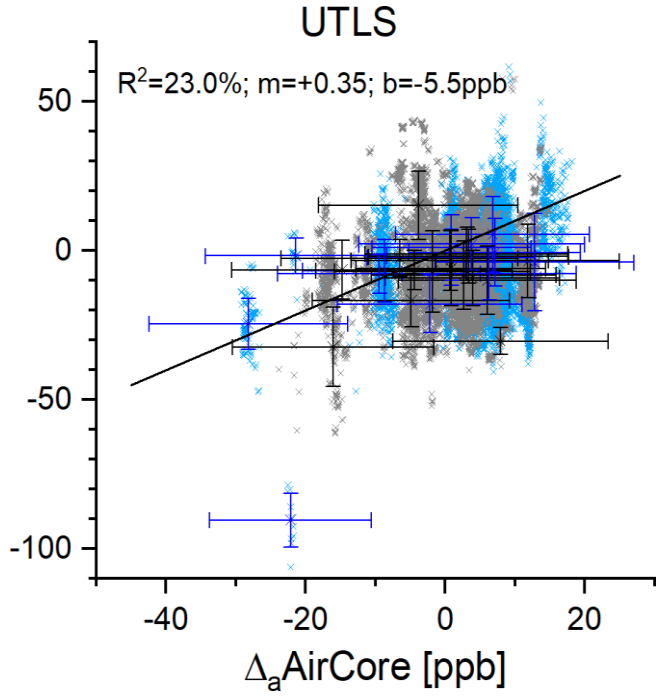
AirCore, GAW observations in Europe

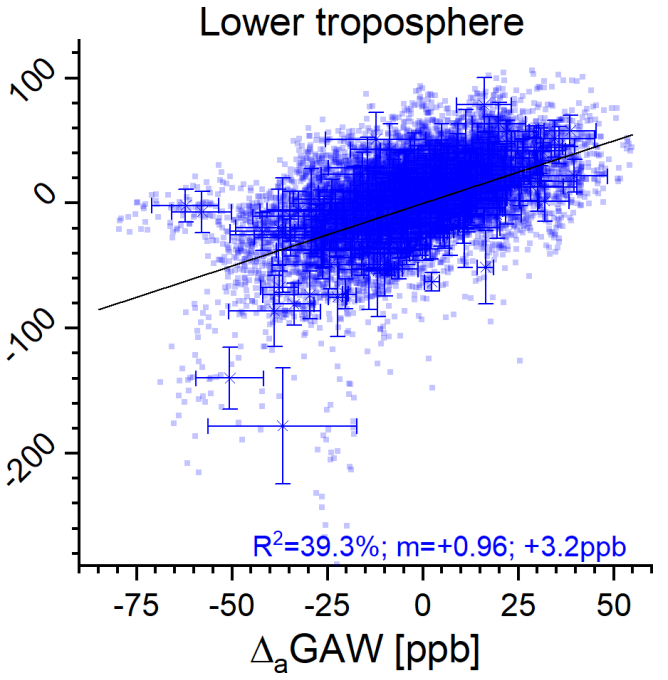


Validation and test study

Validating the information added to the a priori methane model (TM5), reference data TCCON, AirCore, and GAW:



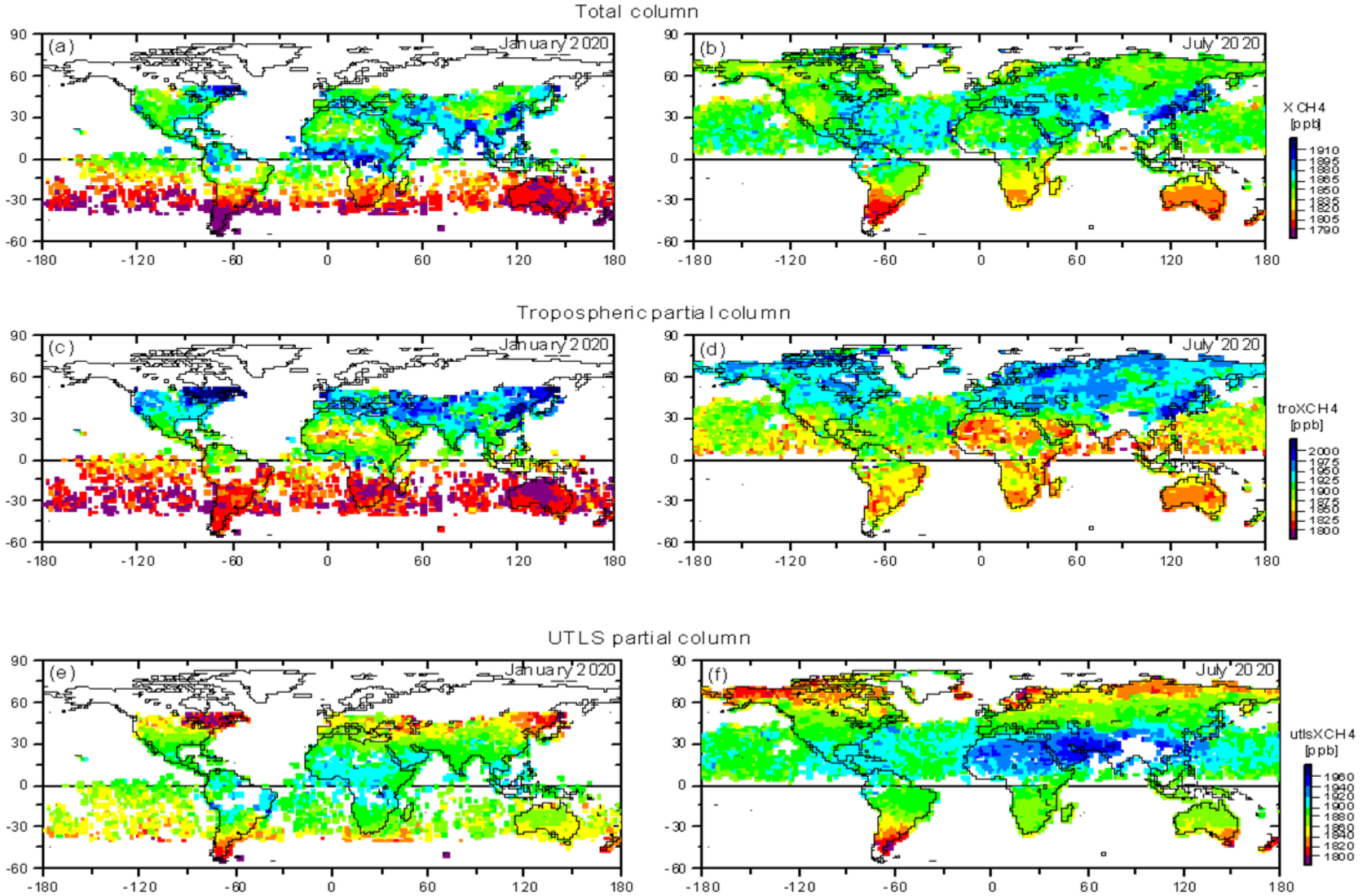




	TROPOMI	IASI	Combined
Total Column	0.38	0.14	0.37
UTLS	--	0.20	0.23
Lower Troposphere	--	0.20	0.39

The **combined product** is superior to the individual products. Additional information in **lower tropospheric data**.

Synergetic use of methane profile and total column data products: Validation and test study



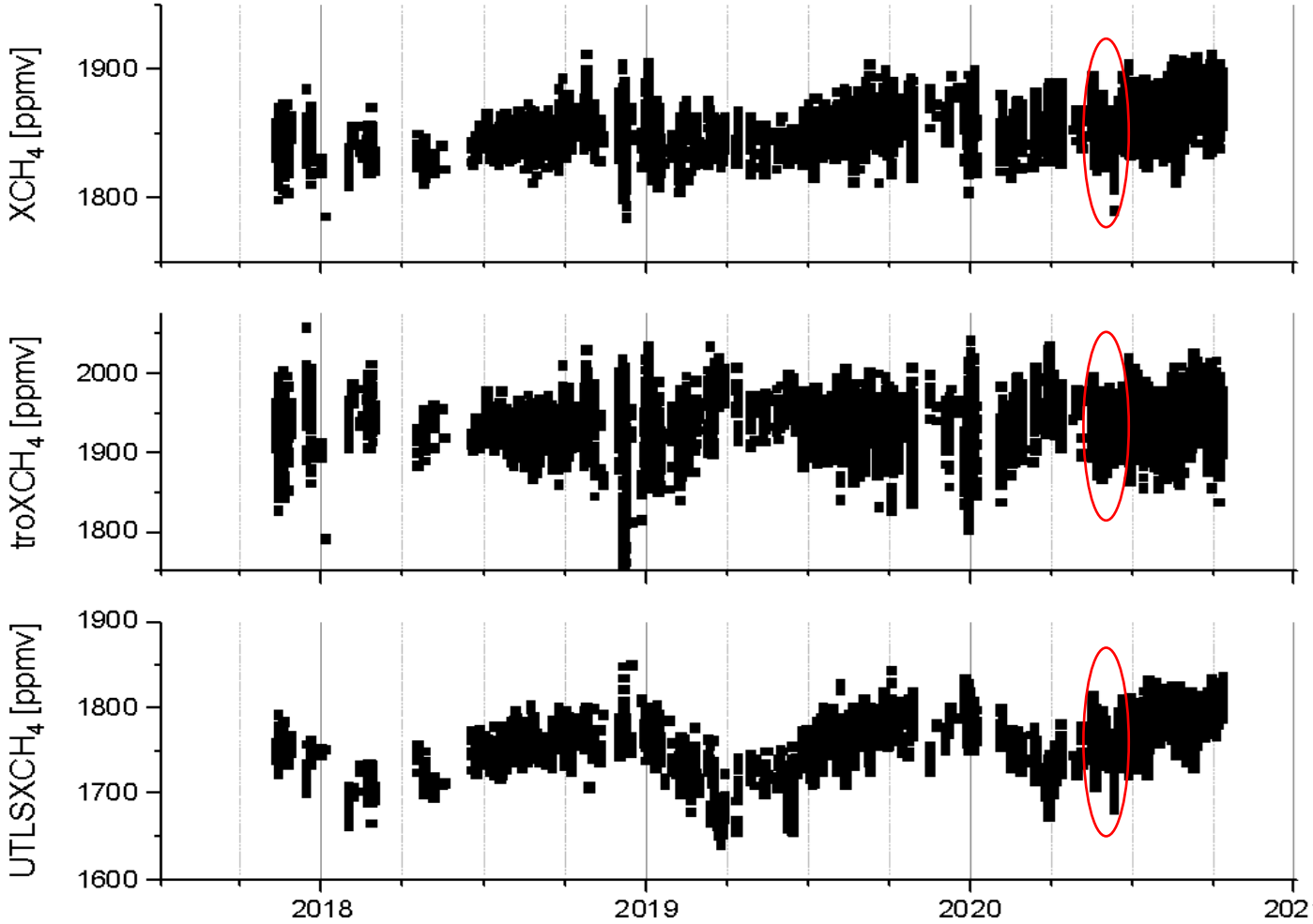
Total column

Surface – 6 km a.s.l.

Above 6 km a.s.l.

Validation and test study

Example, time series over Madrid, used in Tu et al. AMT 2022 (methane emissions of a waste disposal site)



Total column

Surface – 6 km a.s.l.

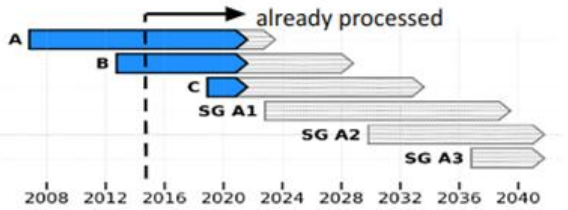
Above 6 km a.s.l.

Therefore, combined products are necessary to disentangle these signals.

Summary and Outlook

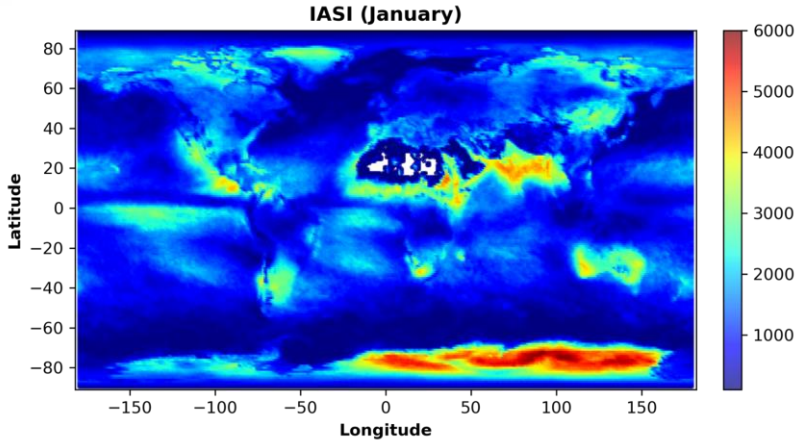
- A method to synergetically combine the IASI and TROPOMI data product by fully considering the individual data characteristics (uncertainties and sensitivities) of each sensors is presented.
- Synergetic combination of IASI and TROPOMI level 2 data provides a good global coverage and also an additional information in the lower troposphere that is not achievable by the individual products.
- IASI and TROPOMI successor instruments will be on the same satellite (Metop-SG) and will have many collocated observations for which the method can be applied.

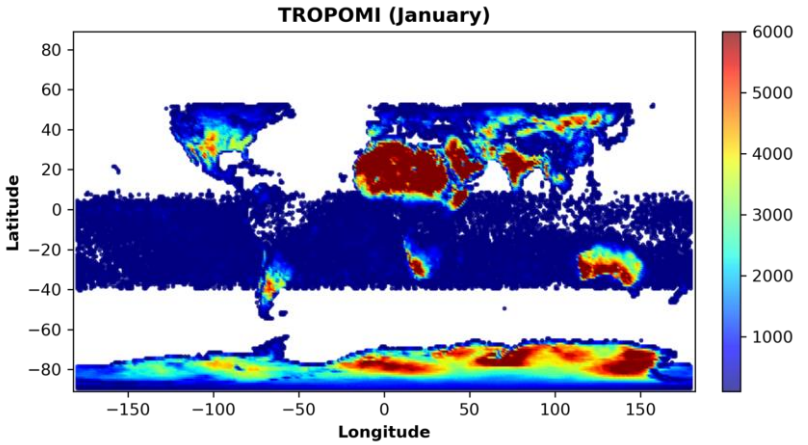
Operating IASI and upcoming IASI successor instruments

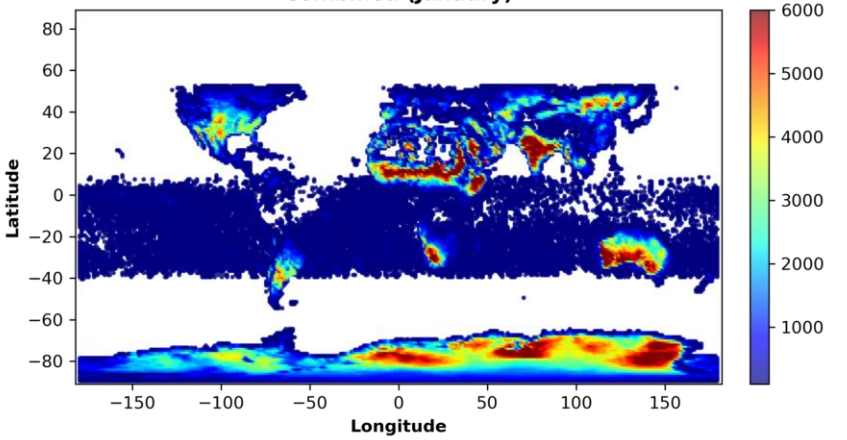


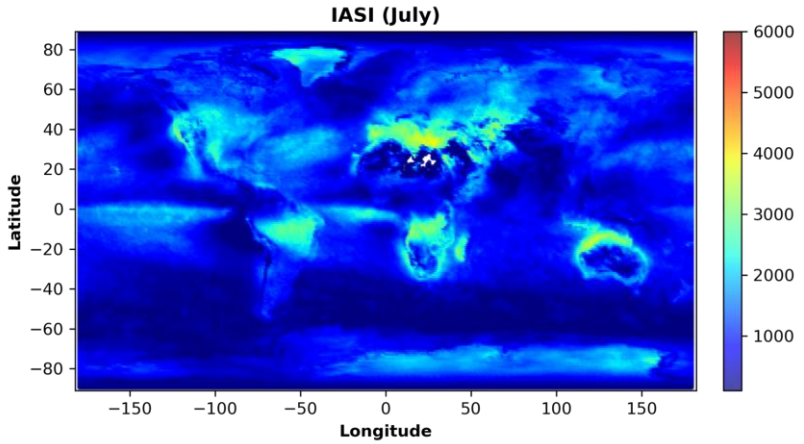
Any Question/ Query?

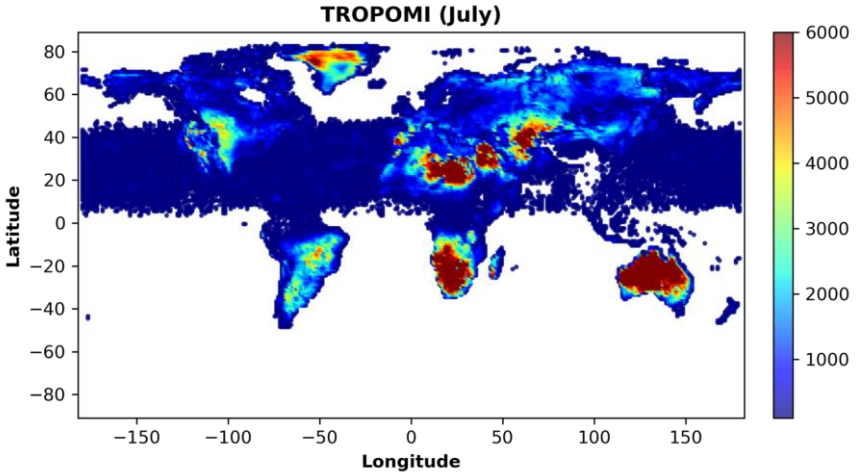
Data Count

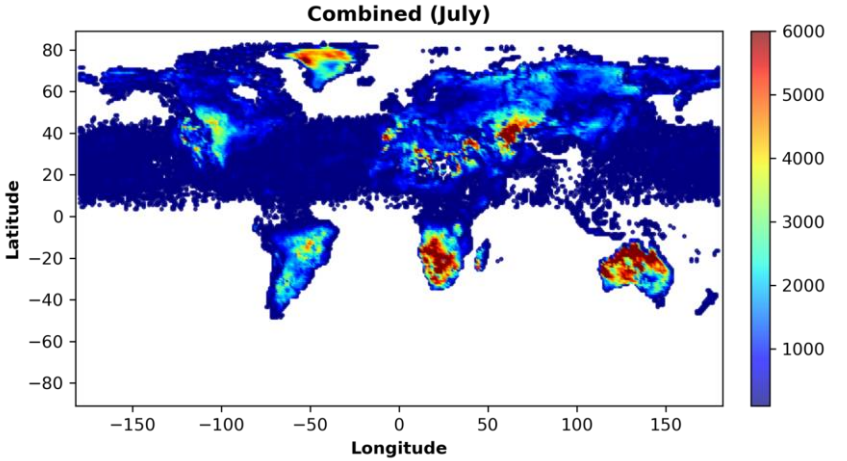

IASI (January)
Latitude
Longitude
6000
5000
4000
3000
2000
1000


TROPOMI (January)
Latitude
Longitude
6000
5000
4000
3000
2000
1000


Combined (January)
Latitude
Longitude
6000
5000
4000
3000
2000
1000


IASI (July)
Latitude
Longitude
6000
5000
4000
3000
2000
1000


TROPOMI (July)
Latitude
Longitude
6000
5000
4000
3000
2000
1000


Combined (July)
Latitude
Longitude
6000
5000
4000
3000
2000
1000

Data Statistics

	TROPOMI	IASI
Total obs	385,785,113 (386 million)	778,720,668 (779 million)
Total Combined obs	279,477,897 (279 million)	

Month	IASI	TROPOMI	Geomated
January (2018,2019,2020,and 2021)	73,260,469 (73 million)	39,608,020 (39 million)	29,656,080 (29 million)
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