A multi-year global synergetic IASI-TROPOMI satellite product of tropospheric CH4

***Kanwal Shahzadi*[1,2], *Matthias Schneider*[1], *Nga Ying Lo*[1], *Jörg Mayer*[2], *Frank Hase*[1], *Peter Braesicke*[1], *Tobias Borsdorff*[3] *and Mari Martinez Velarte*[3]**

1- Karlsruhe Institute of Technology, Institute of Meteorology and climate Research – Atmospheric Trace Gases and Remote Sensing.

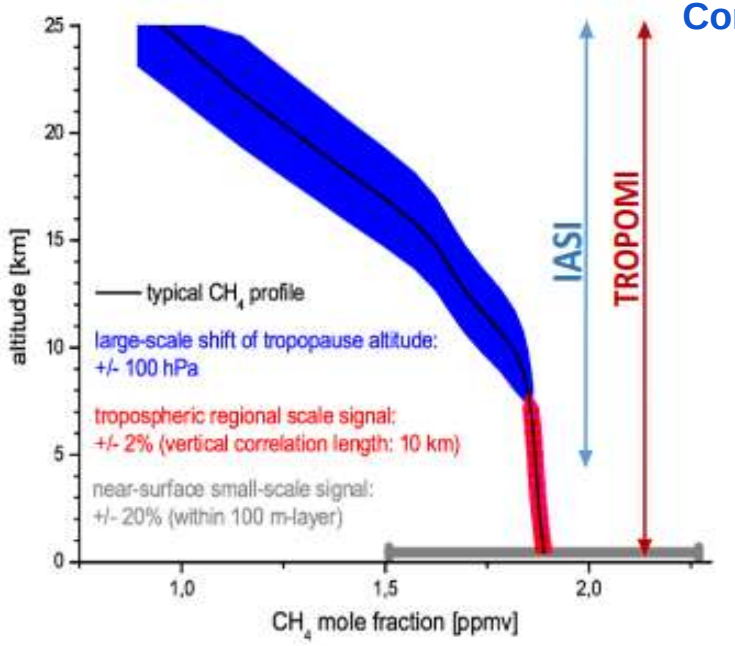
2- Karlsruhe Institute of Technology, Scientific Computing Center.

3- SRON Netherlands Institute for Space Research, Leiden, the Netherlands.

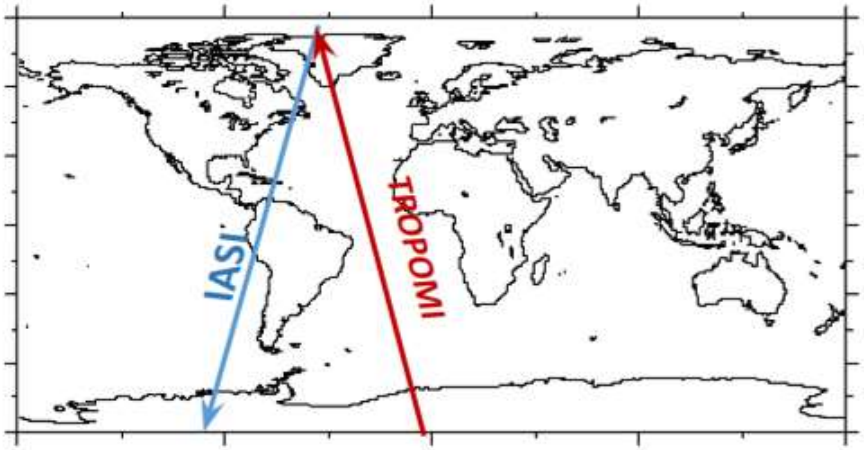
Karlsruher Institut für Technologie

Scientific background

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

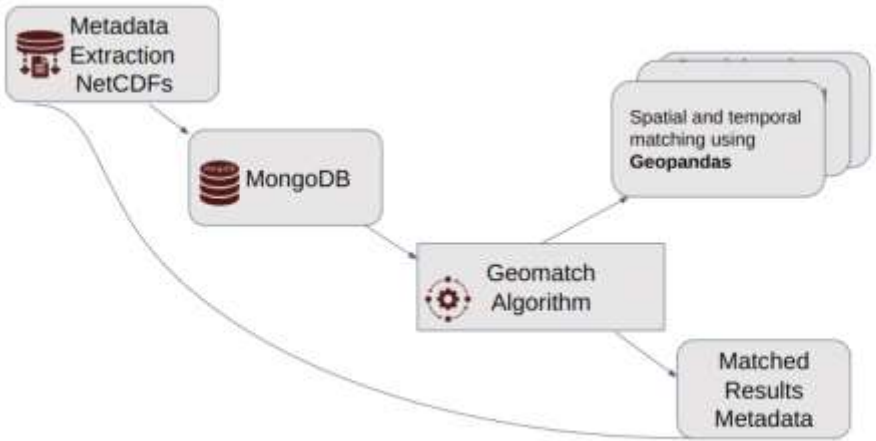


Combine IASI and TROPOMI to get surface near methane data



Problem: the sensors are on different satellites and orbits

Schematics



Kalman filter method:

$$x^a = x^b + \mathbf{G}\left[y - \mathbf{H}x^b\right]$$

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

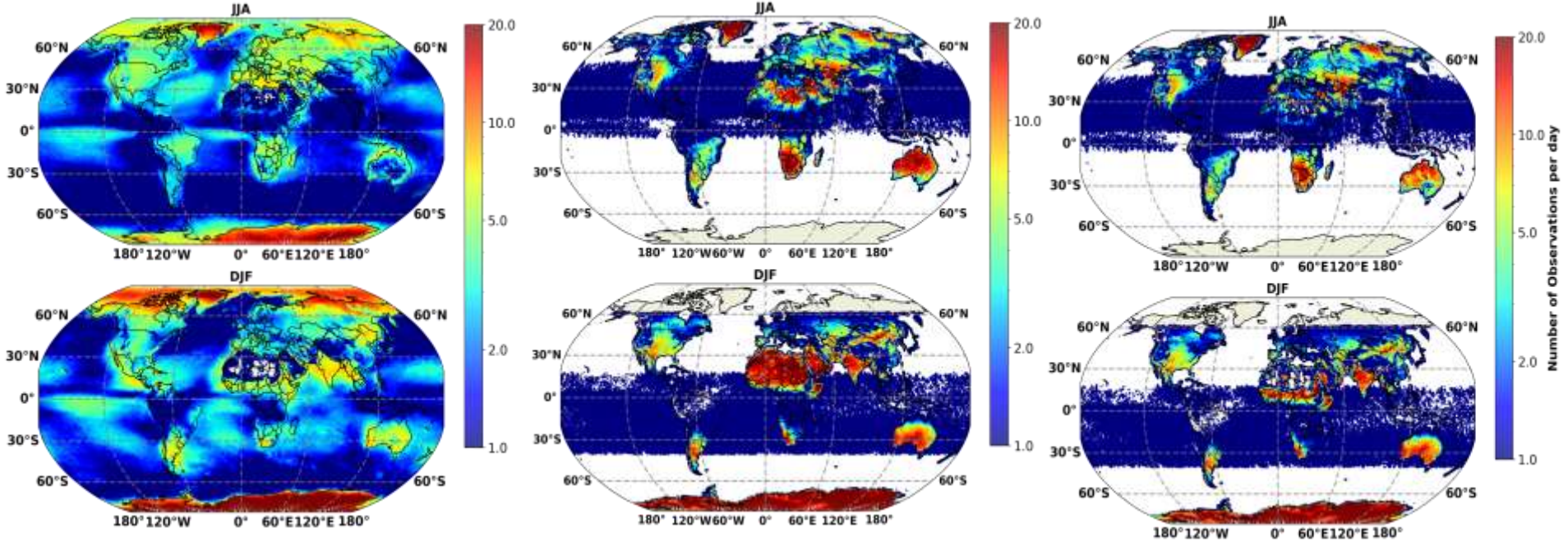
x^b, $\mathbf{S}^b$: IASI as background

y, $\mathbf{H}$, $\mathbf{S}_\varepsilon$: TROPOMI as obs.

x^a: Synergetic product

Data statistics

Average number of observations per day in 100x100km



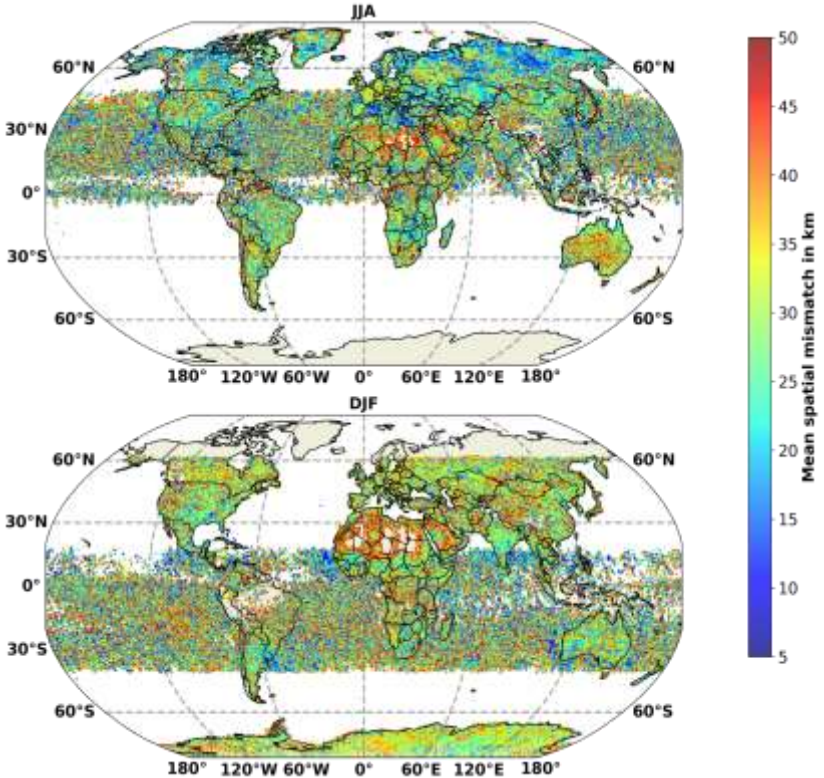
IASI **TROPOMI** **Combined**

Time duration: 2018- July 2021

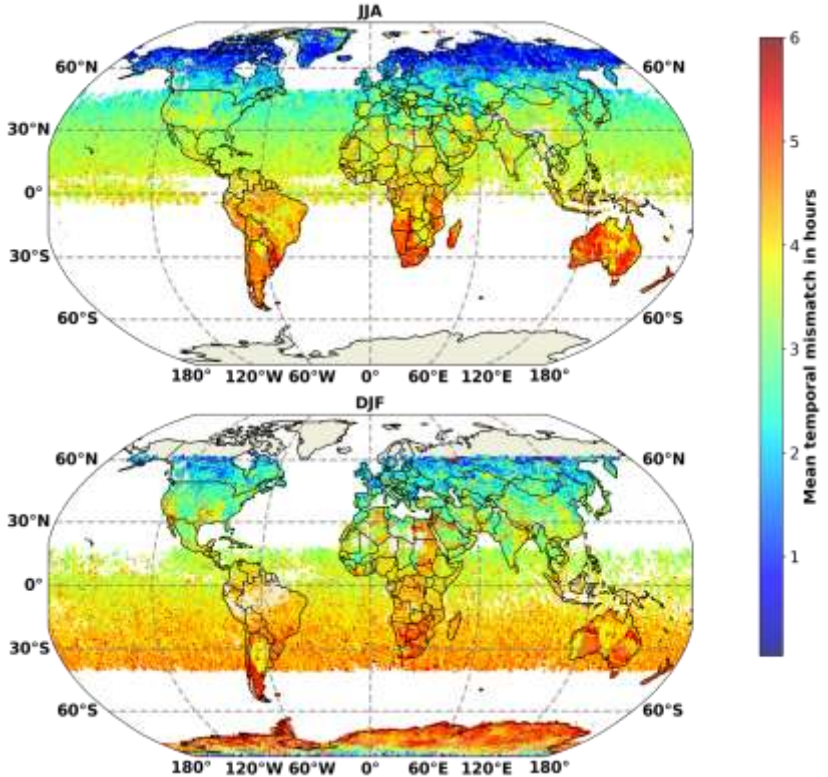
JJA: June, July, August
DJF: December, January,February

Karlsruher Institut für Technologie

Mean spatial and temporal mismatches



Spatial



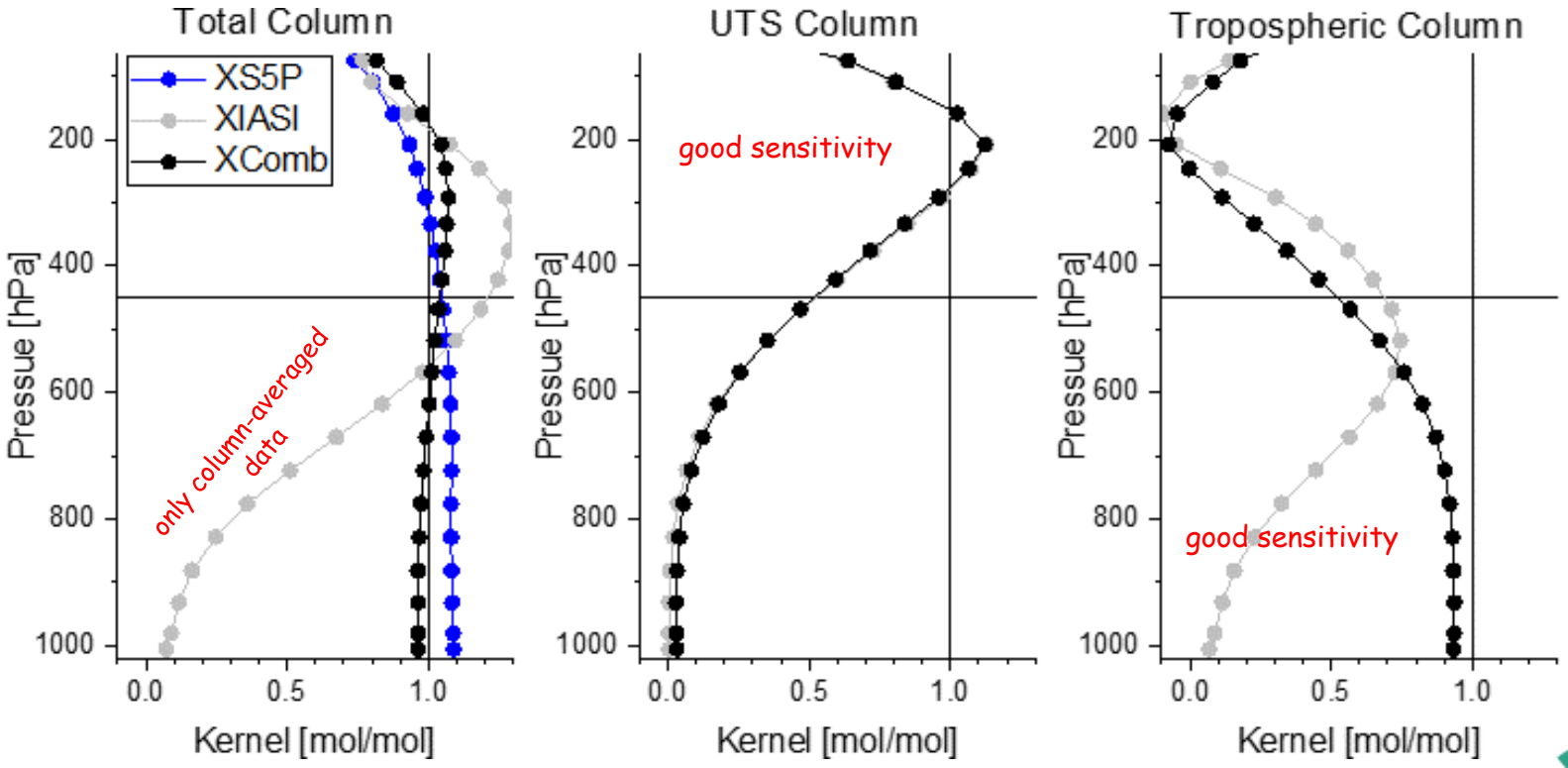
Temporal

JJA: June, July, August
DJF: December, January,February

Spatial radius: 50km
Temporal radius: 6hrs

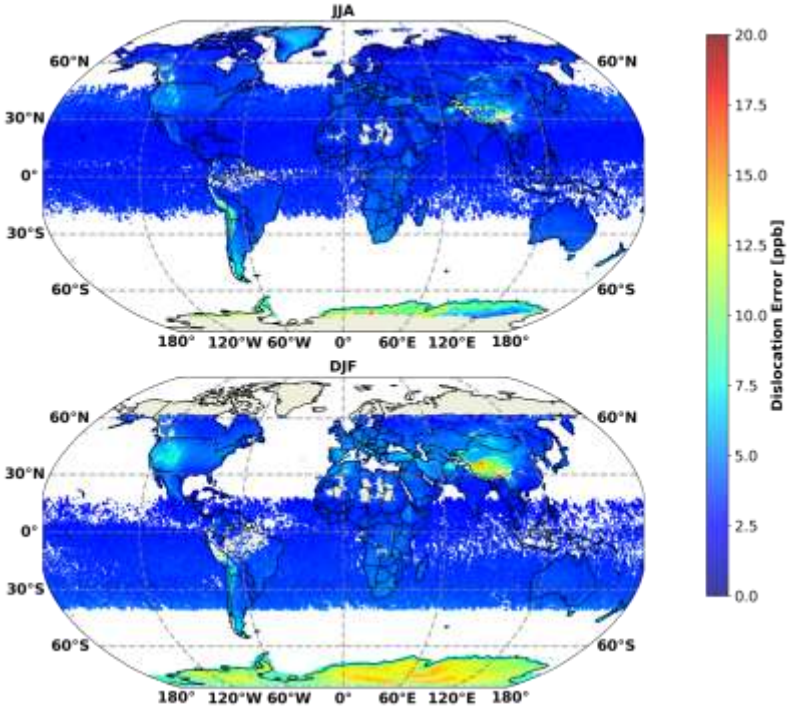
Karlsruher Institut für Technologie

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

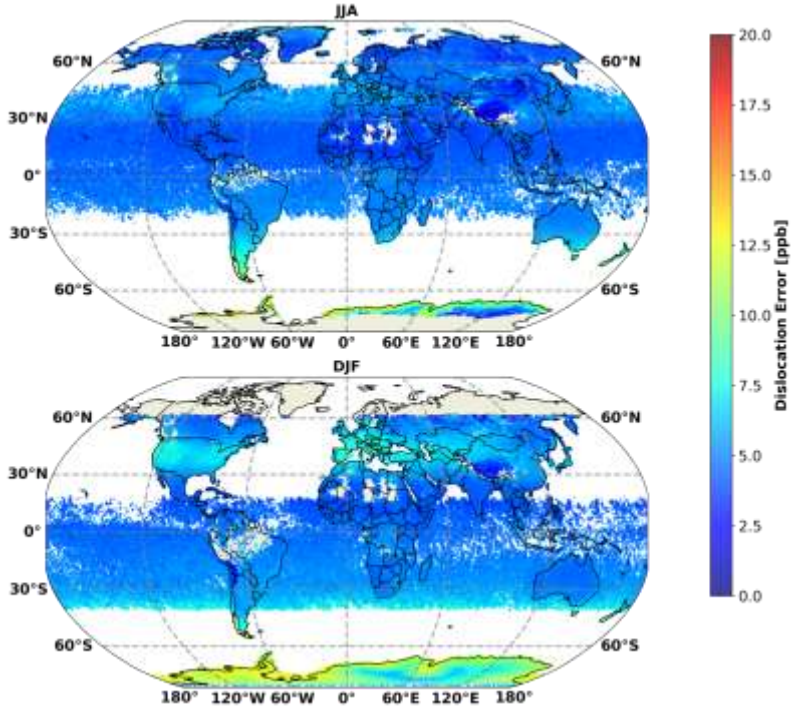


Karlsruher Institut für Technologie

Uncertainties: Dislocation Error (Combined Product)



Tropospheric Column

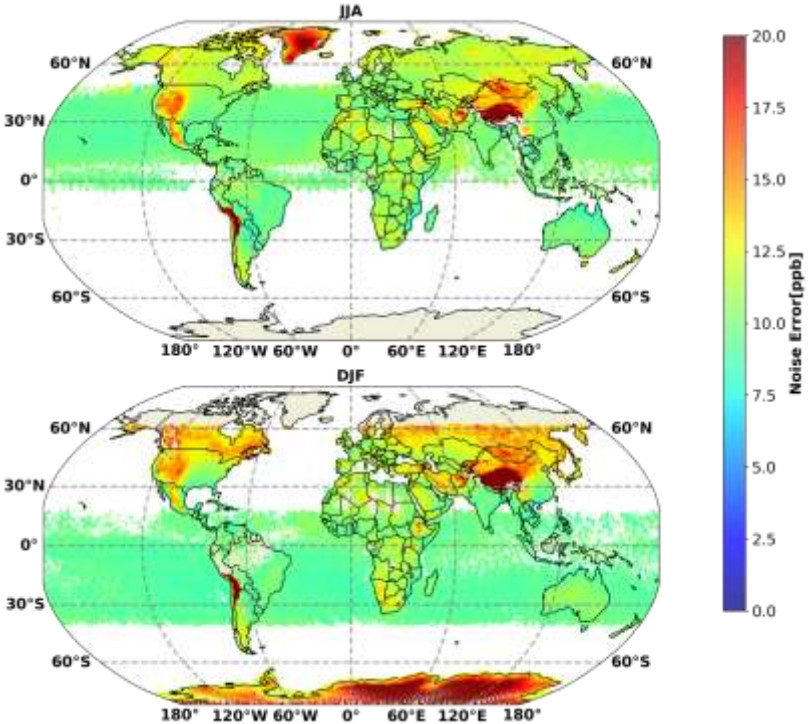


Upper Troposphere and Stratosphere

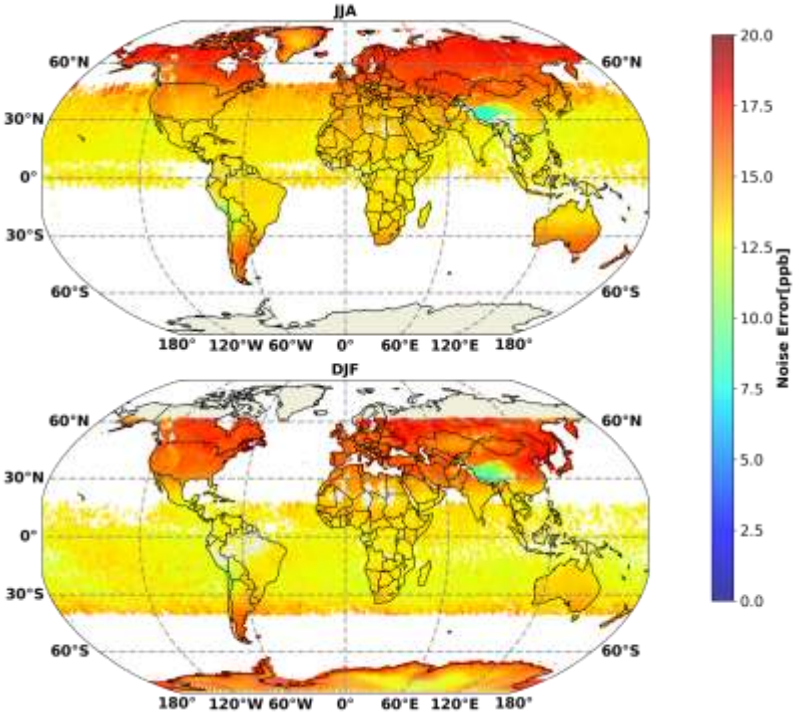
JJA: June, July, August
DJF: December, January,February

Karlsruher Institut für Technologie

Uncertainties:Noise Error (Combined Product)



Tropospheric Column



Upper Troposphere and Stratosphere

JJA: June, July, August
DJF: December, January,February

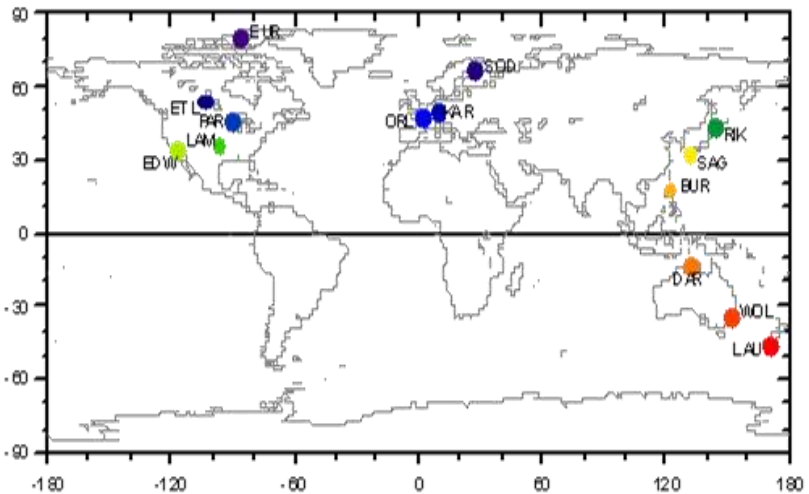
Karlsruher Institut für Technologie

Validation

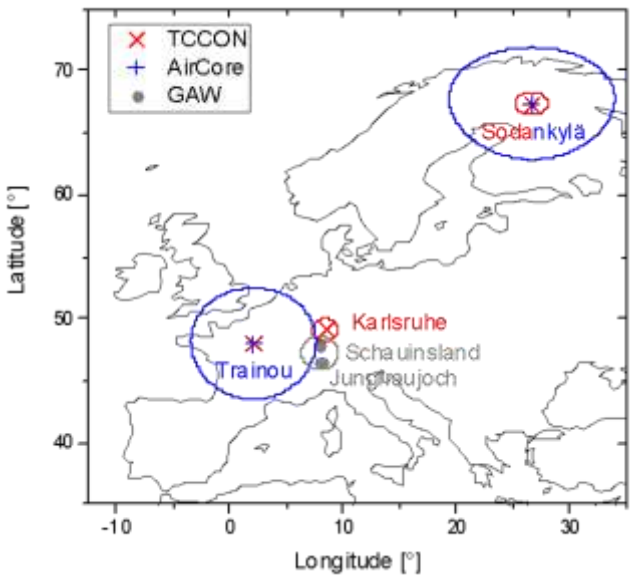
Reference data:

- 14 Total Carbon Column Observing Network (TCCON) 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

Global TCCON stations



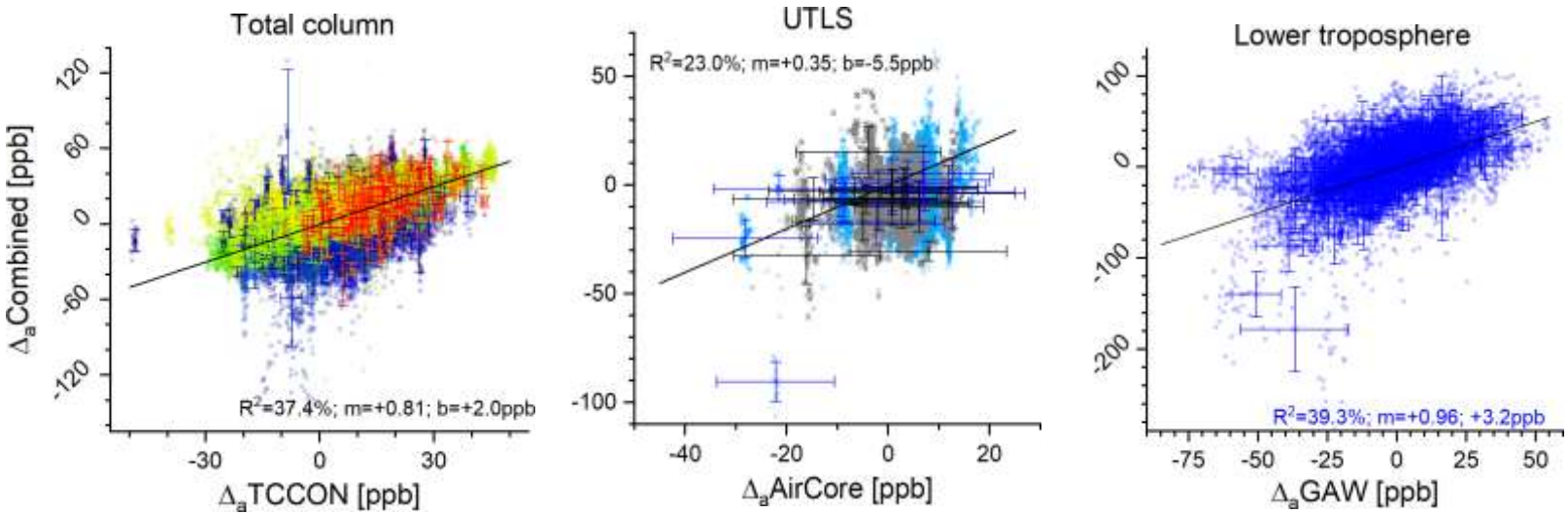
AirCore, GAW observations in Europe



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

Validation and test study

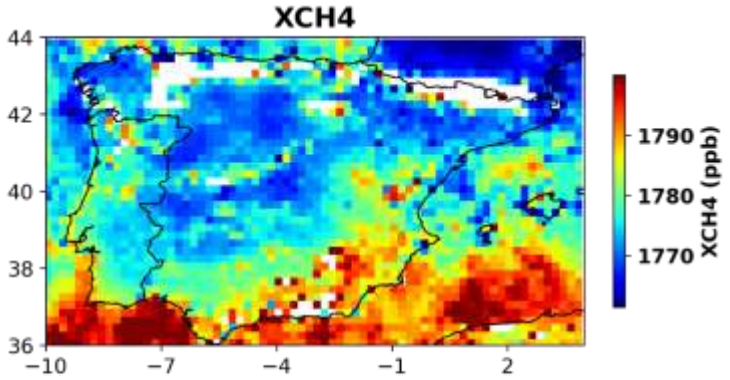
Validating the correction of the apriori methane model ($\Delta_a = x_{retrival} - x_{apriori}$), reference data TCCON, AirCore, and GAW

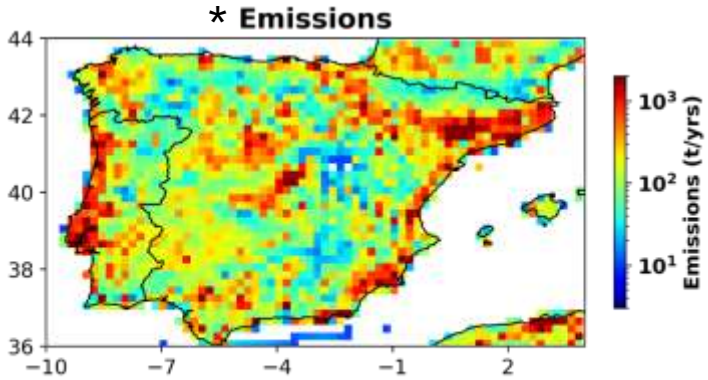


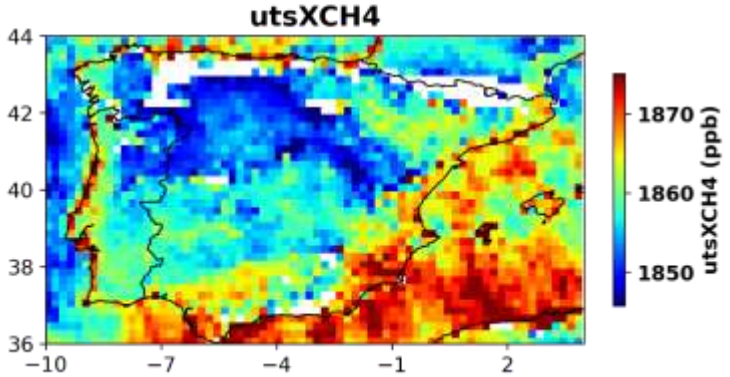
	TROPOMI	IASI	Combined
Total Column	0.38	0.14	0.37
UTS	--	0.20	0.23
Lower Troposphere	--	0.20	0.39

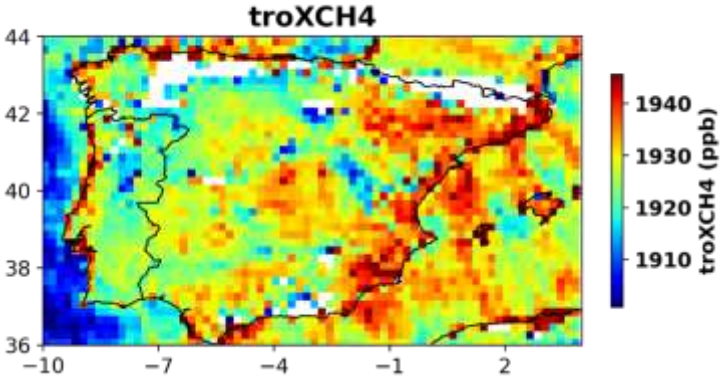
The **combined product** is superior to the individual products. Additional information in **lower tropospheric data**.

Synergetic Combined IASI-TROPOMI product vs Emissions









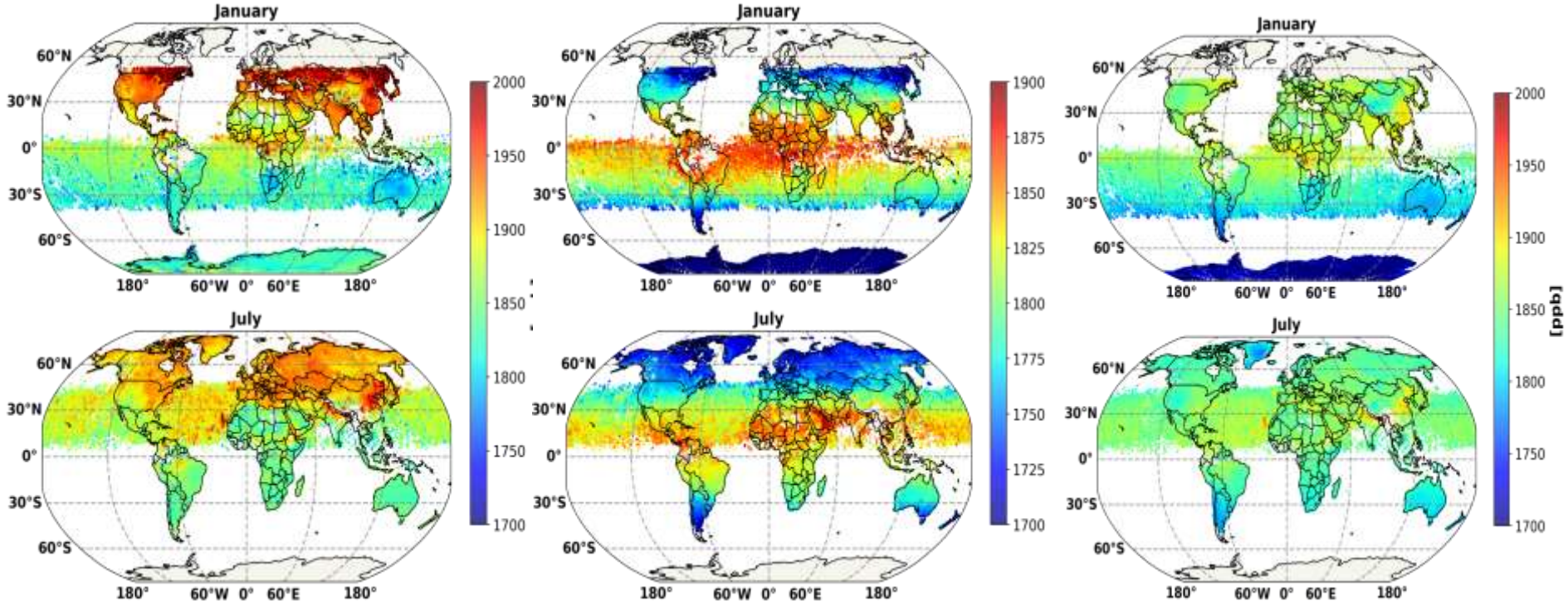
* EDGAR (Emissions Database for Global Atmospheric Research)

Karlsruher Institut für Technologie

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.
- Working with level 2 data (already processed data) makes the method computationally very efficient and flexible (different products, tropospheric definition).
- IASI-NG, where 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.

Mean monthly CH4 Combined Product



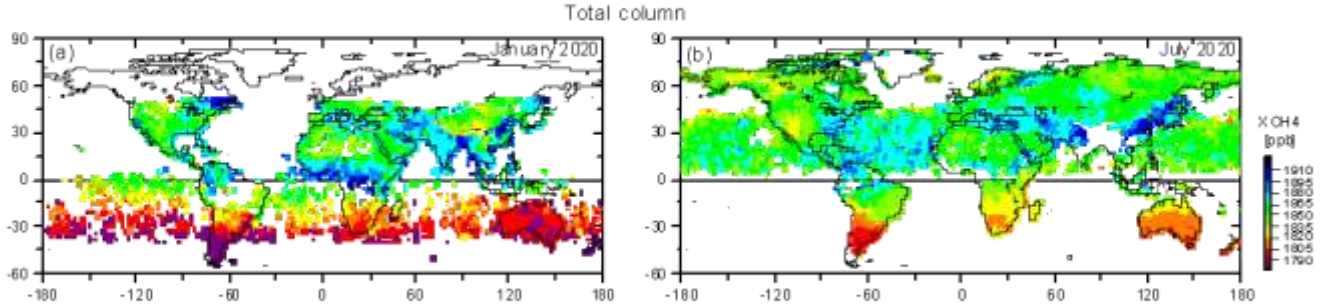
Tropospheric Column

Upper Troposphere and Stratosphere

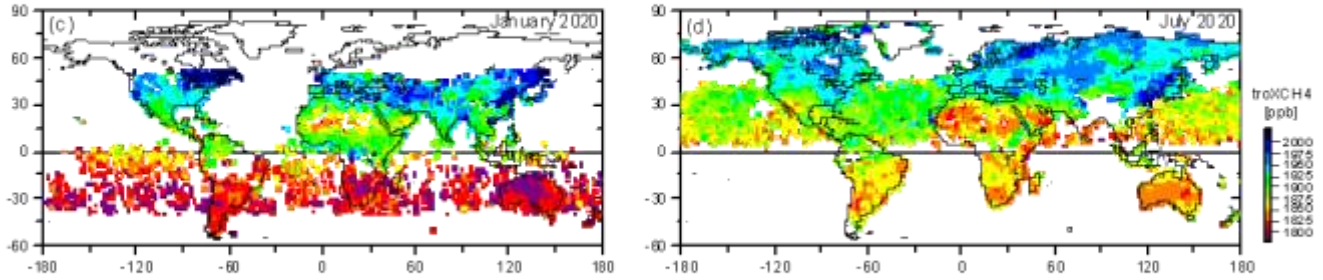
Total Column

January and July 2020 1°x1° monthly mean “MUSICA IASI/RemoTeC TROPOMI fused methane data set

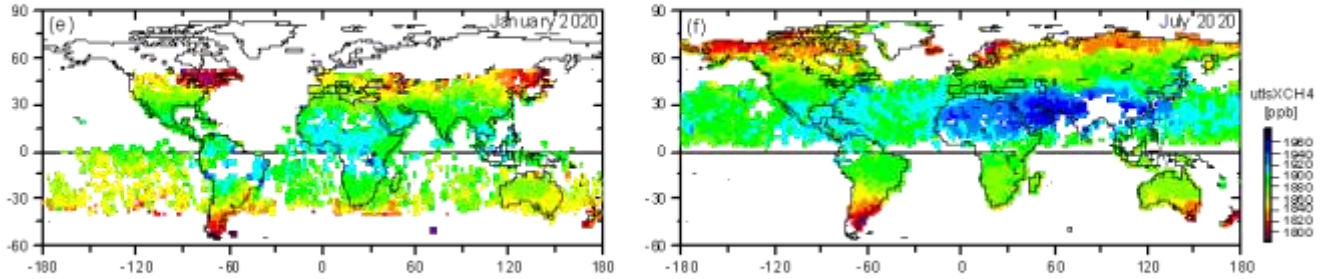
variable: <xch4>

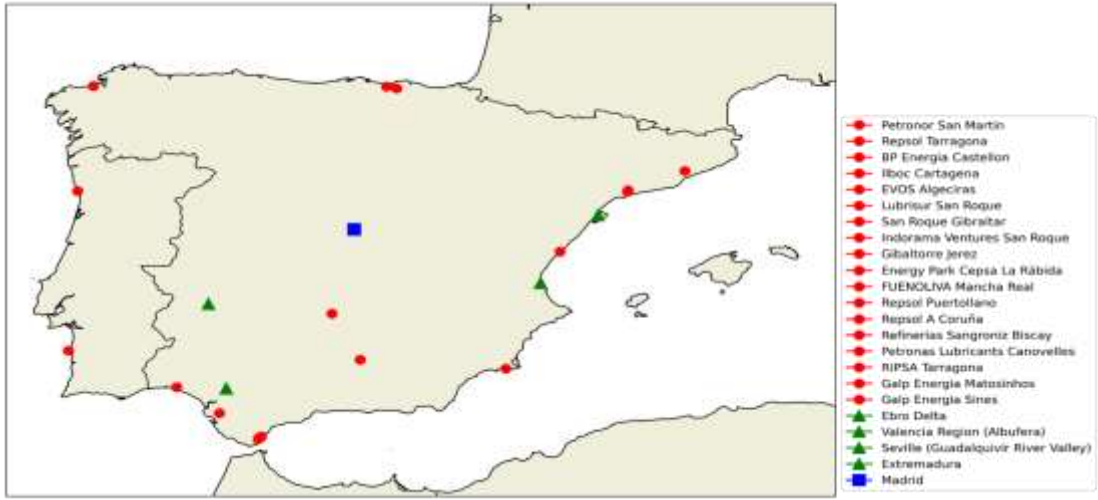


variable: <troxch4>



variable: <utsxch4>




Petronor San Martin
Repsol Tarragona
BP Energia Castellon
Iboc Cartagena
EVOS Algeciras
Lubrisur San Roque
San Roque Gibraltar
Indorama Ventures San Roque
Gibaltorre Jerez
Energy Park Cepsa La Rábida
FUENOLIVA Mancha Real
Repsol Puertollano
Repsol A Coruña
Refinerias Sangroniz Biscay
Petronas Lubricants Canovelles
RIPSA Tarragona
Galp Energia Matosinhos
Galp Energia Sines
Ebro Delta
Valencia Region (Albufera)
Seville (Guadalquivir River Valley)
Extremadura
Madrid