Global distribution of methane in the mid-troposphere as seen by IASI onboard three successive Metop platforms

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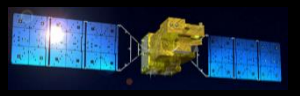
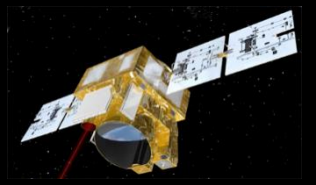
Passive SWIR
TROPOMI, GOSAT,…



Mostly land
Daytime
Total Column

SWIR

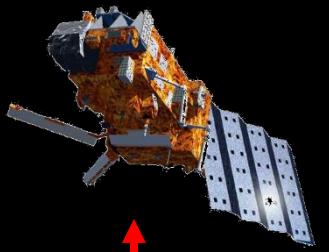
Active SWIR
Merlin



Land and sea
Day and Night
Total Column

SWIR

Passive TIR
AIRS, CrIS
IASI: since 2006
IASI-NG: 2025



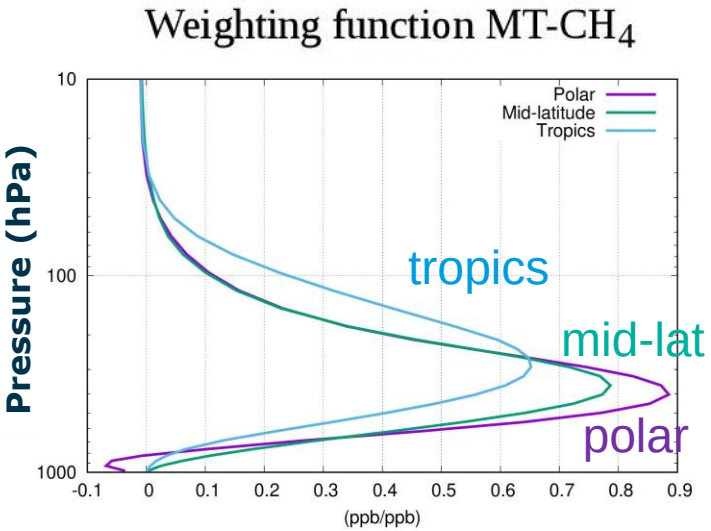
TIR

Land and sea
Day and night
Mid-tropospheric column

Retrieving methane with TIR observations

- **Main challenges:**
  - **IASI radiances** depend on **the temperature profile and greenhouse gas** concentrations with a GHG signal of the order of the IASI noise
- **Retrieval procedure (Crevoisier et al., 2009ab, 2013, 2018):**
  - **Non linear inference scheme** based on neural networks.
  - Based on the 4A RT code and the latest edition of the GEISA database.
  - Use of **IR (IASI) and MW (AMSU)** observations to decorrelate T from gas variations.

  → **We retrieve a mid-tropospheric column of methane (noted MT-CH4)**, **in clear sky only** (no clouds, no aerosols), **by day and night, over land and over sea**.
- **Application to the 3 IASI onboard Metop-A, B and C:**
  - The 3 IASI instruments lie within 0.1 K of each other for most part of the spectrum;
  - **The 3 IASIs onboard Metop-A, B and C can be considered as the same instrument**

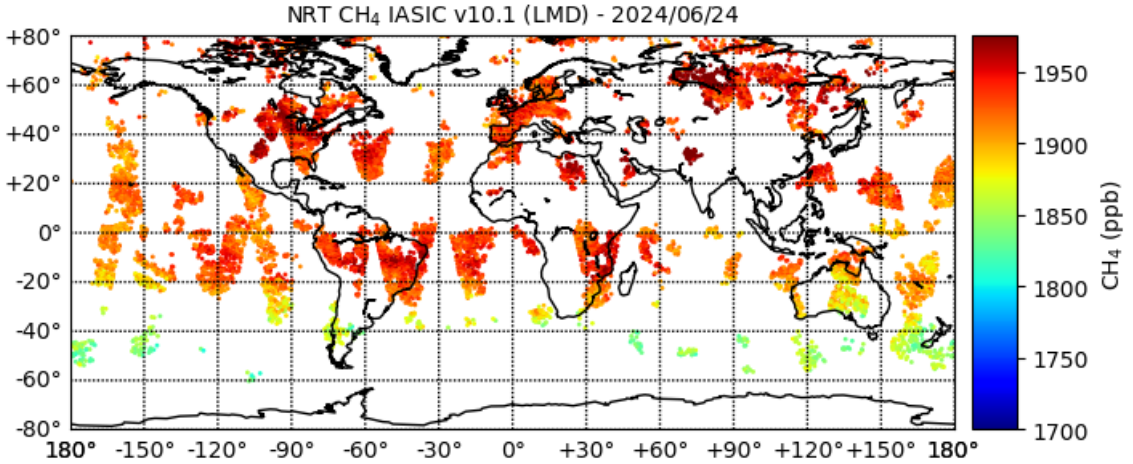


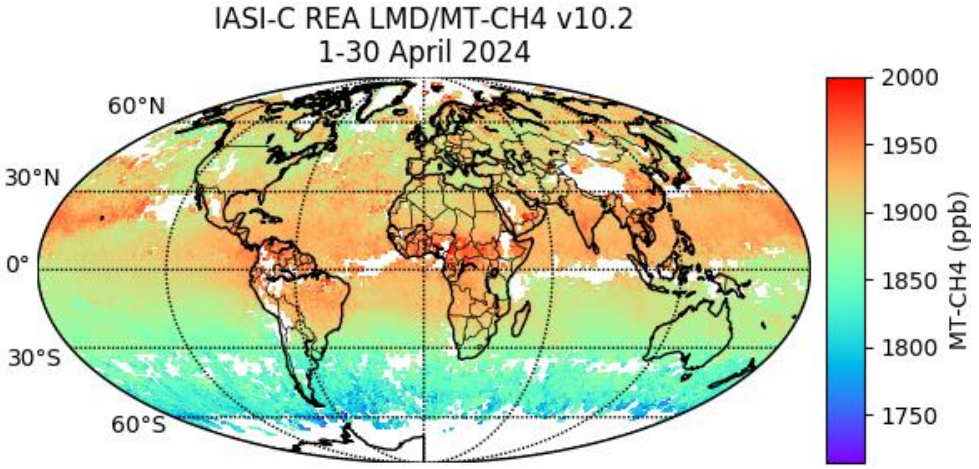
Assimilation of IASI MT-CH_4 v10 within C-IFS at ECMWF

2 kinds of operational products:

- **NRT v10.1:** Near-Real Time (D+1)
- **REA v10.2:** 3 months delay

Metop-A	Metop-B	Metop-C
2007/07 - 2021/10 15 years	2013/02 –2021/12 9 years	2019/05 – today 5 years





→NRT v10.1 data are delivered daily to Copernicus Atmospheric Service (CAMS) and assimilated within C-IFS alongside GOSAT XCH4 (Agustí-Panareda et al., 2023)

→ Positive impact of the assimilation of retrievals from one IASI.

→REA v10.2 data are delivered to Copernicus Climate Change Service (C3S, Buchwitz et al., 2018). Data can be accessed through the Data Store.

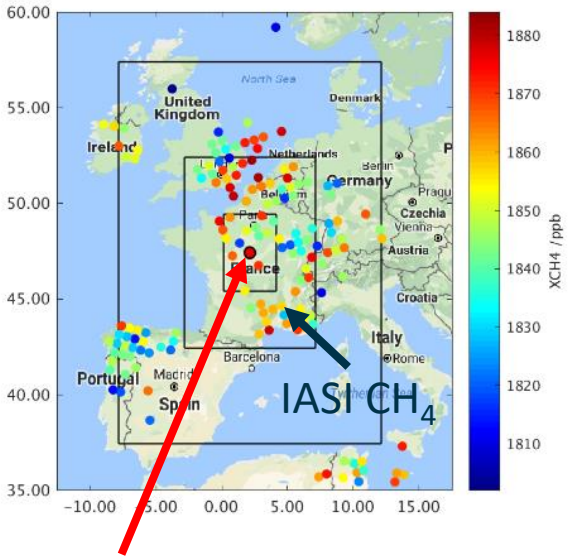
→Thanks to MethaneCAMP, IASI-B MT-CH4 has been extended above 60°N

→ New global version v13.

Validation

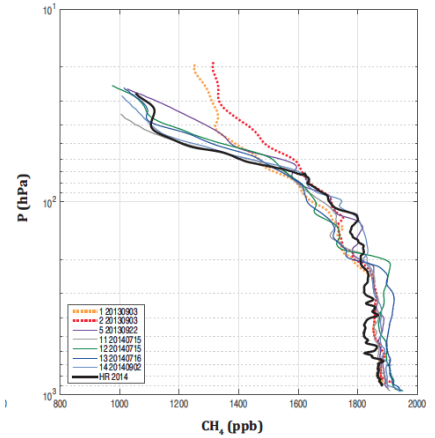
Over mid-latitudes:

- **A full validation of mid-tropospheric column required data covering the same part of the atmosphere (5-15 km).**
- **We use vertical profiles of atmospheric concentration of CH_4 given by AirCore collocated in time and space with IASI.**
- **AirCore data are taken from: the French AirCore program (https://aircore.aeris-data.fr)**



AirCore from Trainou

AirCore CH_4 Vertical profiles



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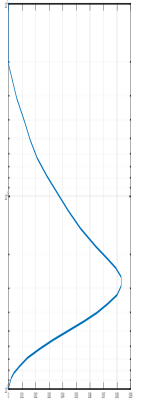
IASI CH_4 Weighting Function



→ 0.1 +/- 13 ppb for IASI-A (67 Aircores)

→ -2.9 +/- 17 ppb for IASI-B (64 Aircores)

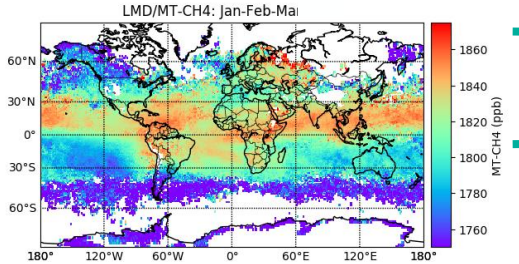
→ -1.1 +/- 17 ppb for IASI-C (89 Aircores)

- Comparison with AirCore validates the retrieval.
- Very good agreement between the 3 IASI instruments
- A std close to the theoretical one (12 ppb).

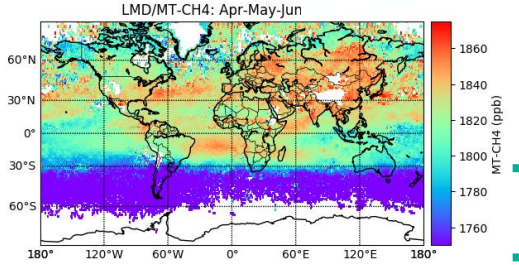
Over high latitudes:

- Only one colocalization (+/- 6h, 50 km) has been found between Aircore (Sodankylä, 2018/08/01) and IASI-B MT-CH4, yielding a **-0.43 ppb bias**

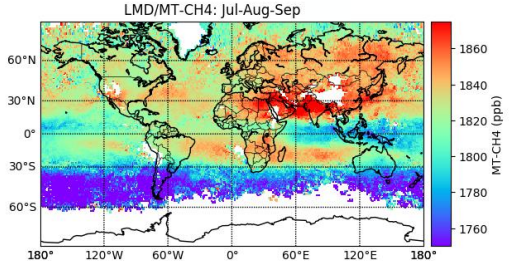
Global distribution of IASI MT-CH4



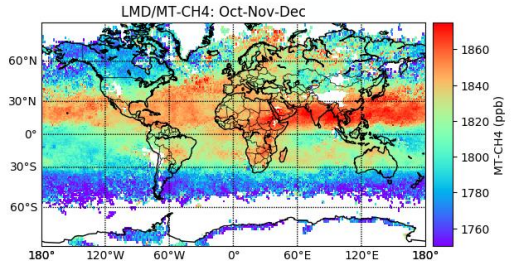
High values in northern hemisphere



Strong decrease in southern mid-latitudes



Strong emission of CH_4 by rice paddies in summer



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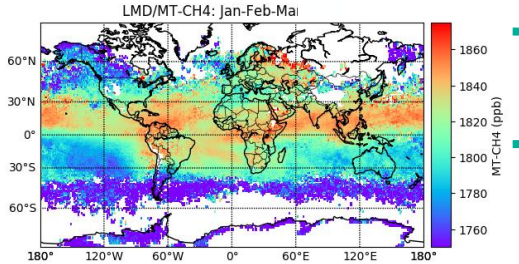

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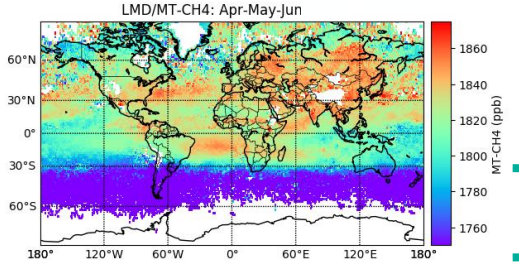

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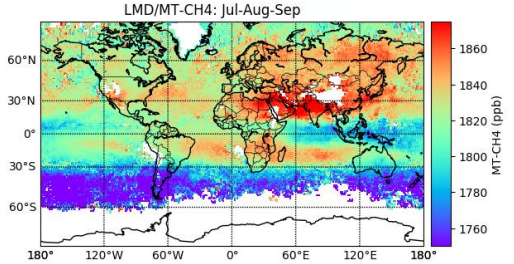

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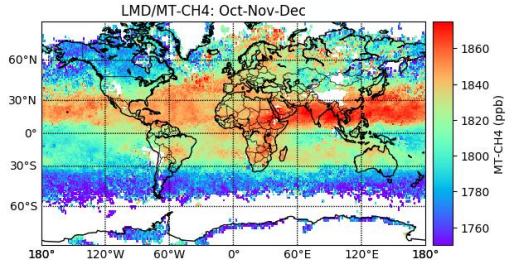
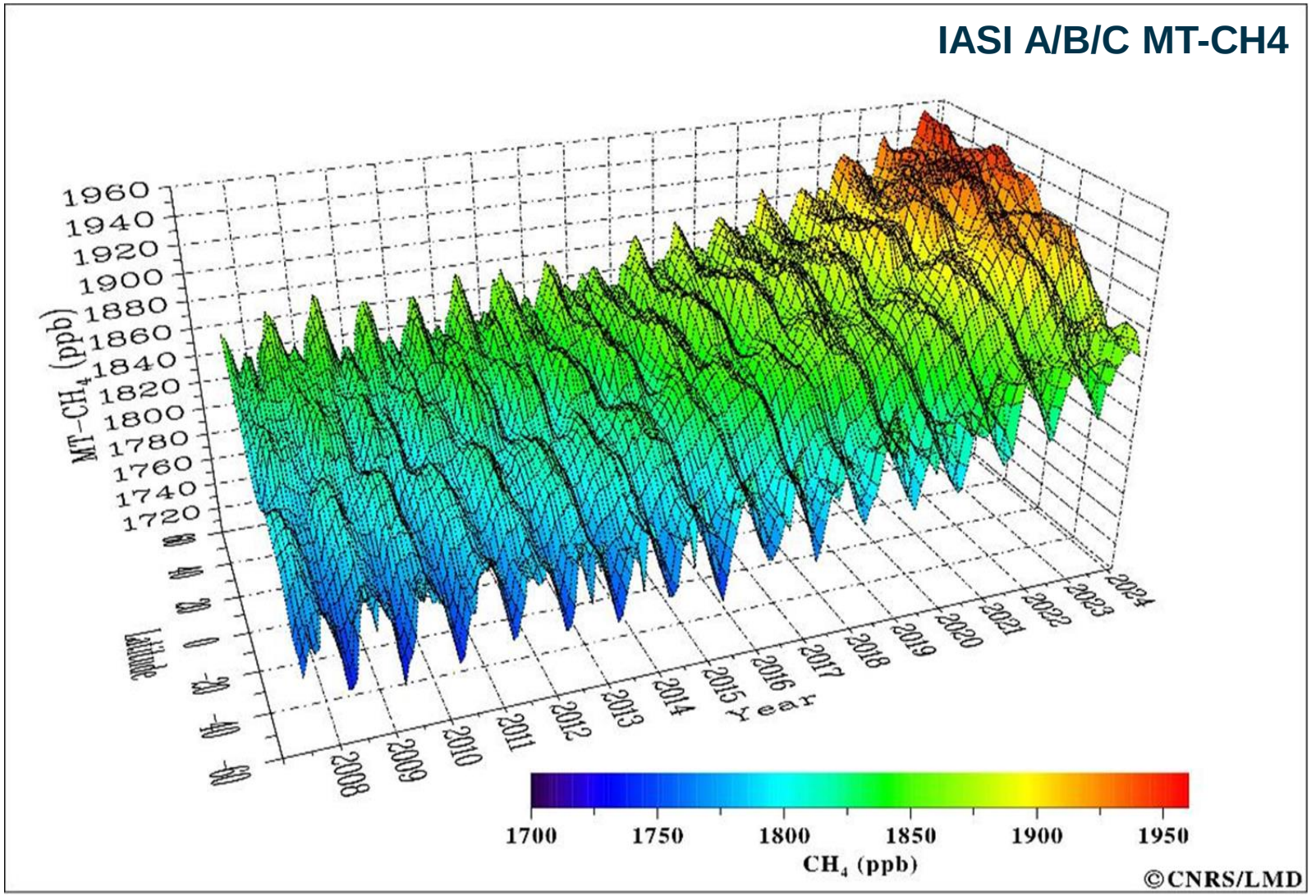
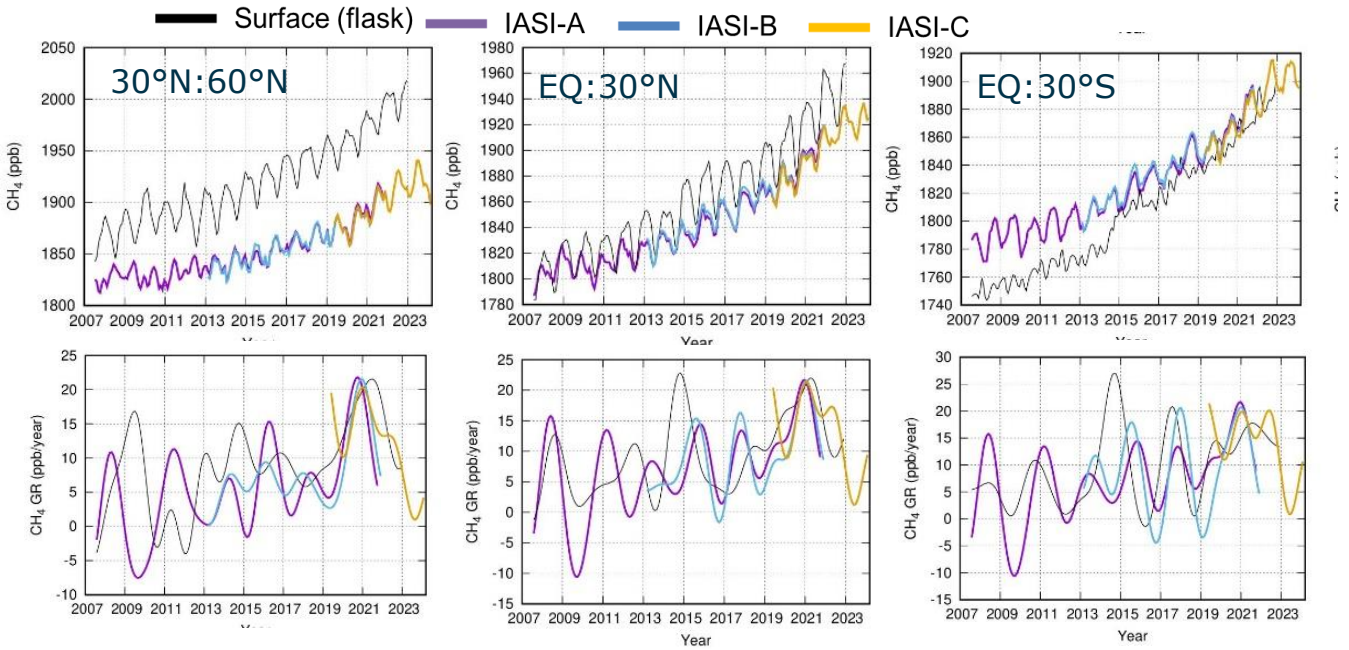
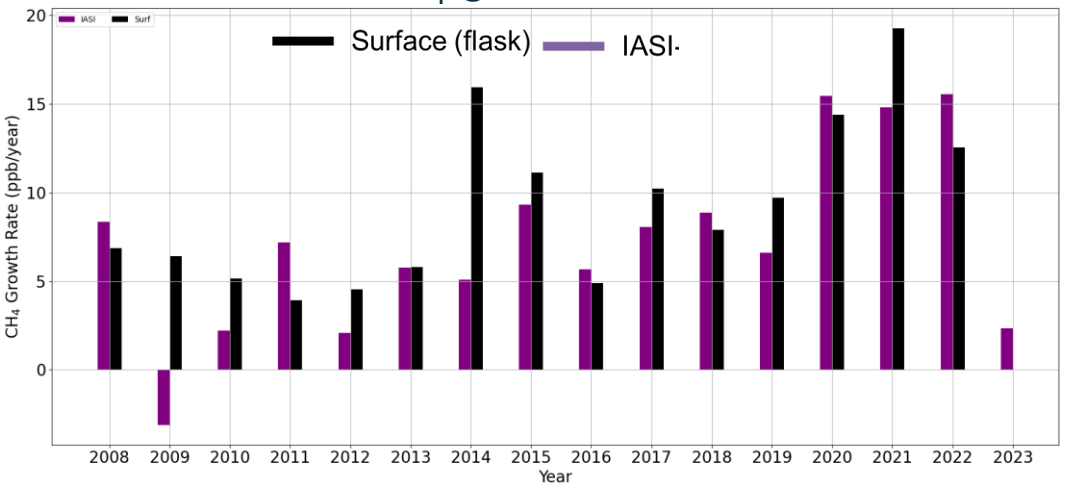




Global distribution of IASI MT-CH4

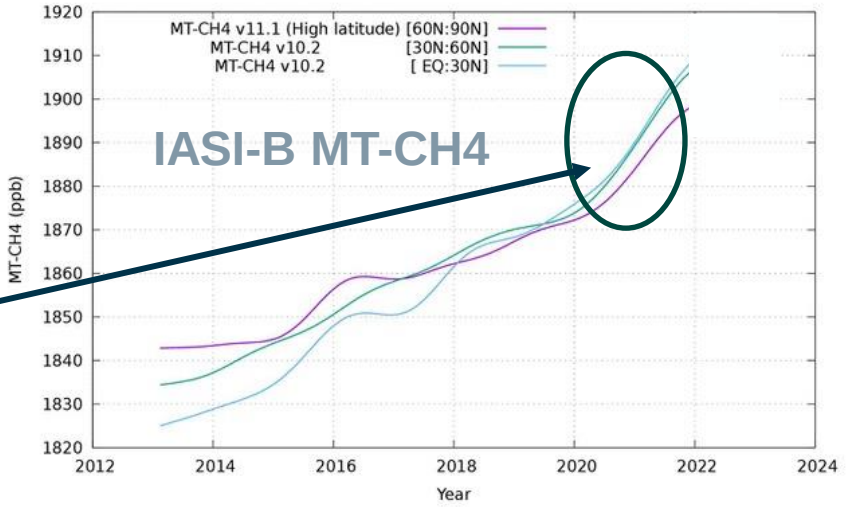


CH_4 growth rate



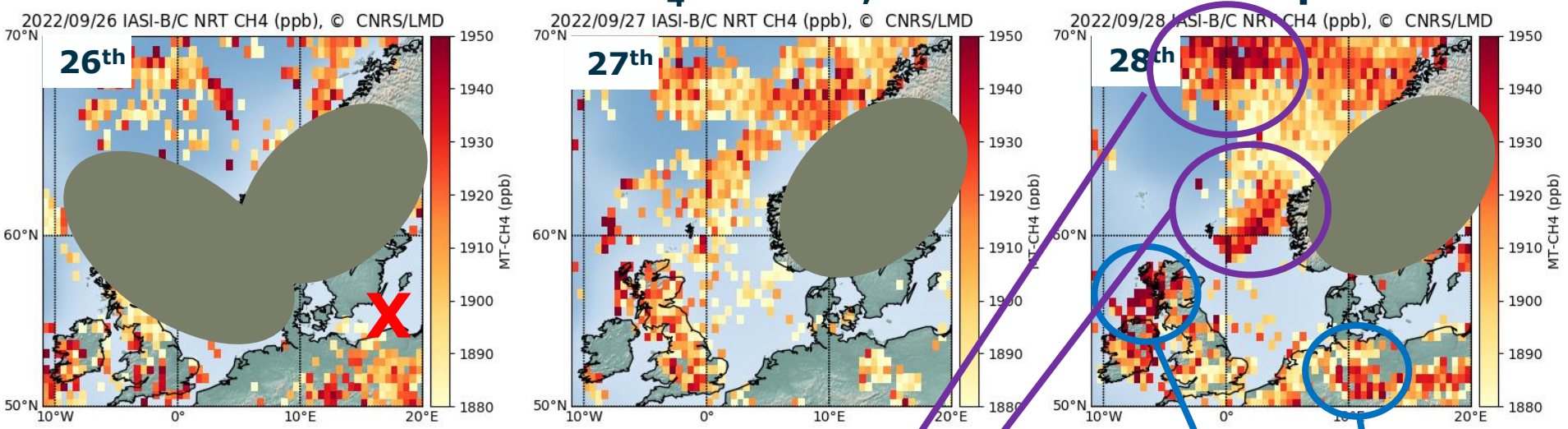
- **Before 2020, the growth rate was around 4-10 ppb/year while in 2021 the growth rate increased sharply to reach 15-20 ppb/year. It returned to around 5 ppb/year in 2023**

- **The strong increase in growth rate is not seen in high latitudes, implying that this increase is due to what is happening in the mid-latitudes and tropics**



Nord Stream leak on 27th September 2022

IASI-B + IASI-C MT-CH_4 for 26th, 27th and 28th of September

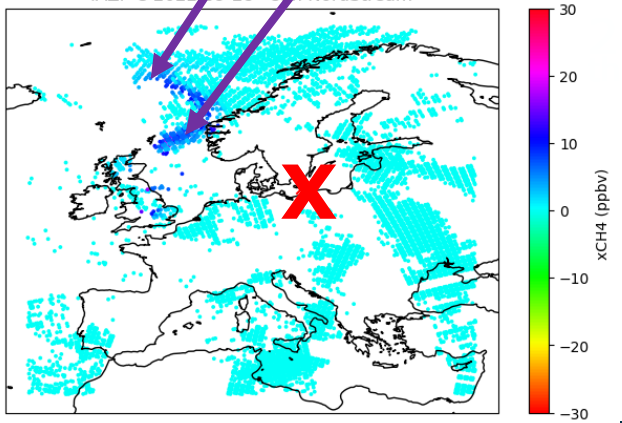


- **Lots of clouds…**
- 28th: 2 anomalies of ~30ppb West of Norway
- Good agreement in terms of location with simulations from WRF-CHEM:
  - A plume from NordStream
  - Signatures from anthropogenic emissions

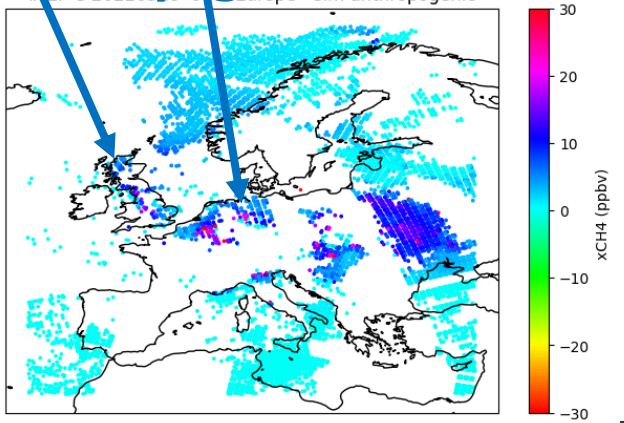
Estimation or emissions from NordStream in progress.

WRF-CHEM simulations for 28th (courtesy of I. Kamoun and A. Berchet, LSCE)

IASI MT-CH_4 from Nordstream emissions

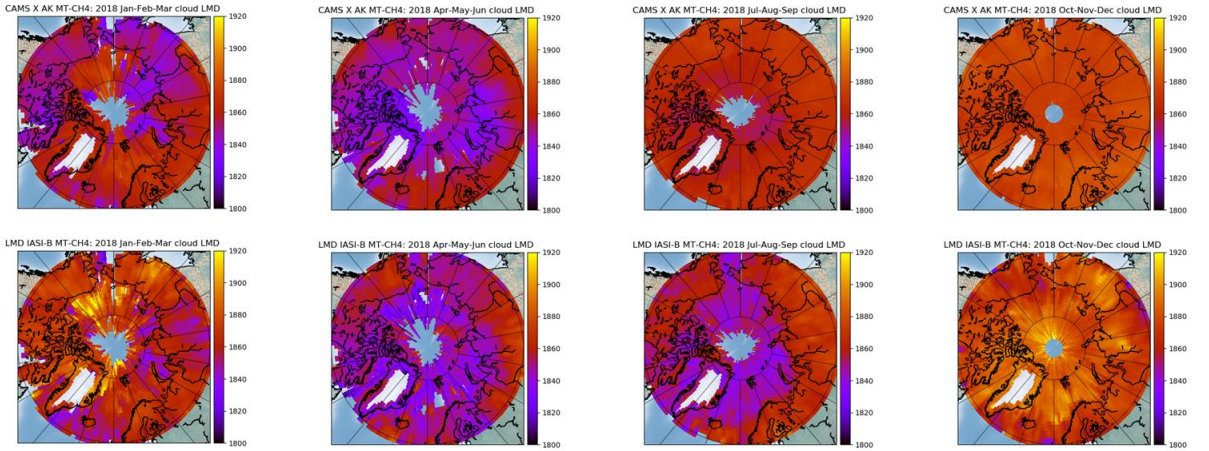


IASI MT-CH_4 from Anthropogenic emissions

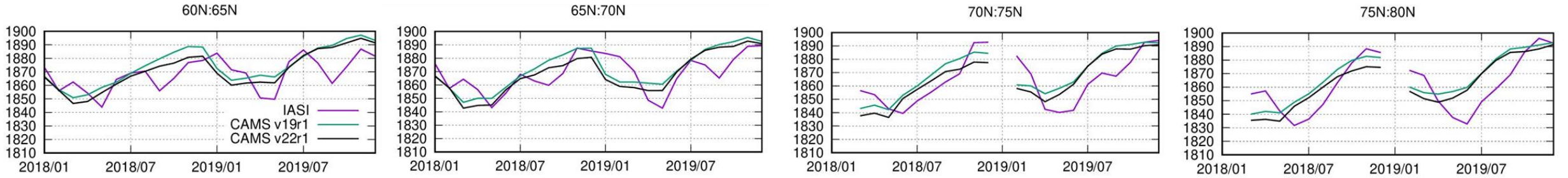


MethaneCAMP: special retrieval scheme over Arctic

CAMS 22r1 X AK →



IASI-B MT-CH4→



- IASI-B MT-CH_4 have been colocated with CH_4 profiles from CAMS v19r1 and CAMS v22r1 between 2018-2019
- Good agreement in terms of seasonality and trend. Slightly larger amplitude seen on IASI.
- One month shift at very high latitudes
- CAMS v22r1 is closer to IASI on average (a bias of 5-10 ppb between CAMS v19r1 and v22r1).

Conclusion

- Mid-tropospheric columns of CH_4 are available from 3 IASIs on board Metop-A/B/C.
- Using 2 IASI (A and B or B and C) allow having a full coverage of the globe in a single day.
- Comparison with co-located AirCore profiles of CH_4 show that both IASI agree with each other by less than 3 ppb and yield a precision of ~13-17 ppb for single retrieval from IASI.
- Since 2007, CH_4 weighted columns are delivered on 'near real time' (D-1) basis to the Copernicus Atmosphere Monitoring Service (CAMS) for assimilation. Comparison with TCCON stations and aircraft profiles highlight the positive impact of the assimilation of retrievals from one IASI.
- The exceptional radiometric and stability of IASI and its 23 year-program makes IASI well suited to monitor the evolution of greenhouse gases in the mid-troposphere.
- Data are available from the Copernicus Climate Change Service (C3S) data store.

… and 30 more years will come with IASI-NG !