6th IASI Conference
Nancy, 02-06 December 2024

Last evolutions of the mid-troposphere column of methane as seen by IASI onboard three successive Metop platforms

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Summary

1. Retrievals of mid-tropospheric column of methane from IASI and AMSU observations

2. An analysis of methane growth rate

3. Extension over high latitude

4. Study the possibility to replace AMSU channels by IASI L2 Temperature

5. Conclusions

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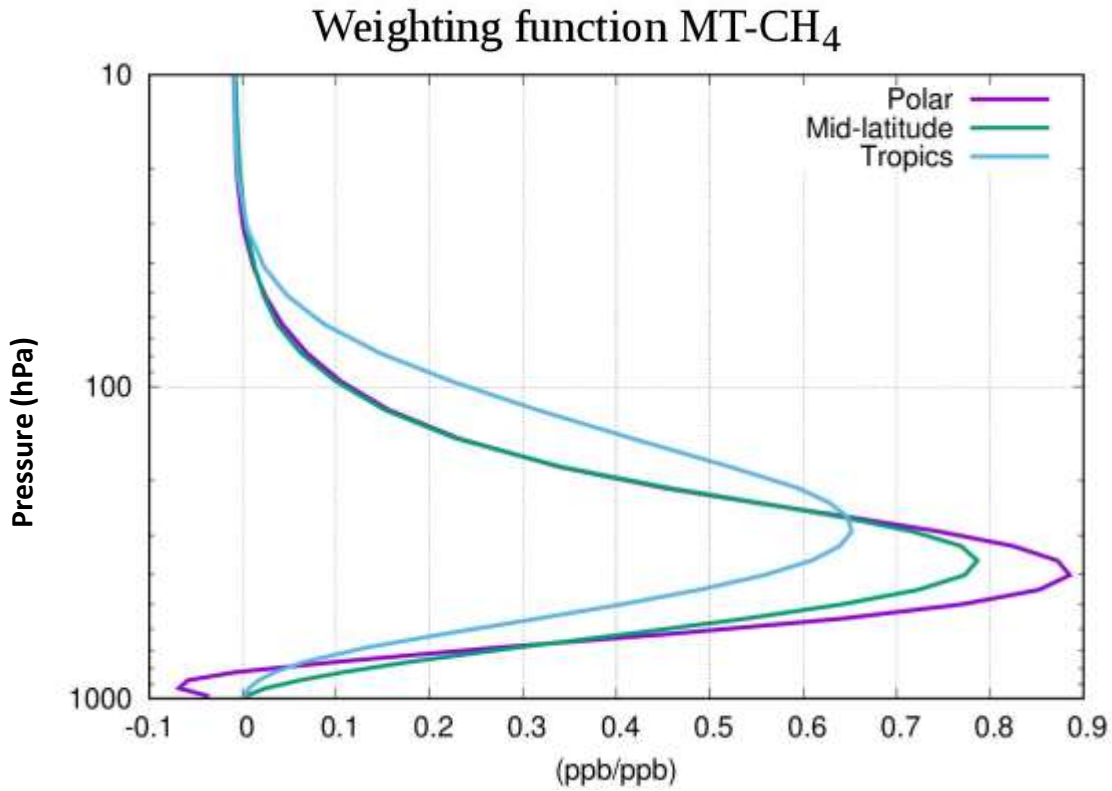
MT-CH4 retrievals from IASI

- **Main challenges:**
  - IASI radiances depend on the temperature profile and greenhouse gas concentrations whose typical seasonal variations are of the order of the IASI noise

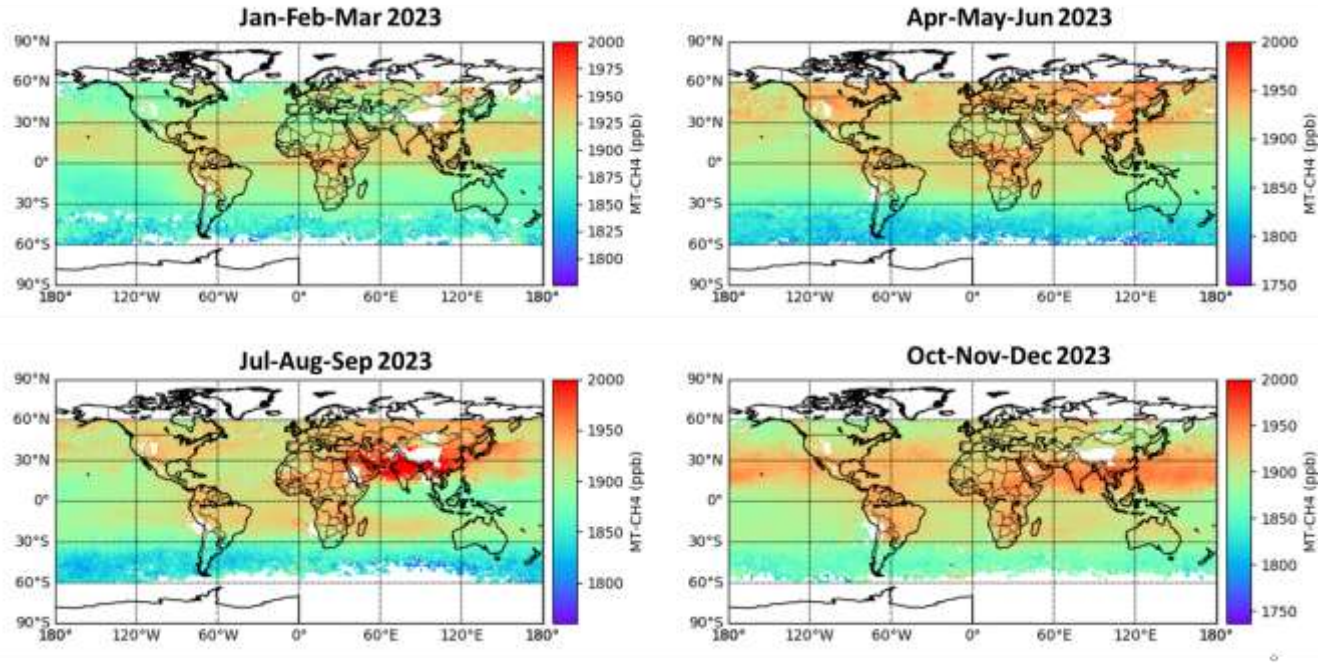
- **Retrieval procedure** (Crevoisier et al., 2009ab, 2013, 2018):
  - **Non linear inference scheme** based on neural networks.
  - Based on the 4A RT code and the latest edition of the GEISA database.
  - **Systematic radiative biases** between simulations and observations are computed using the **ARSA database**.
  - Use of **IR (IASI) and MW (AMSU)** observations to decorrelate Temperature from CH_4 variations : **channels for CH_4 @7.7µm + AMSU channels**



→ **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.**

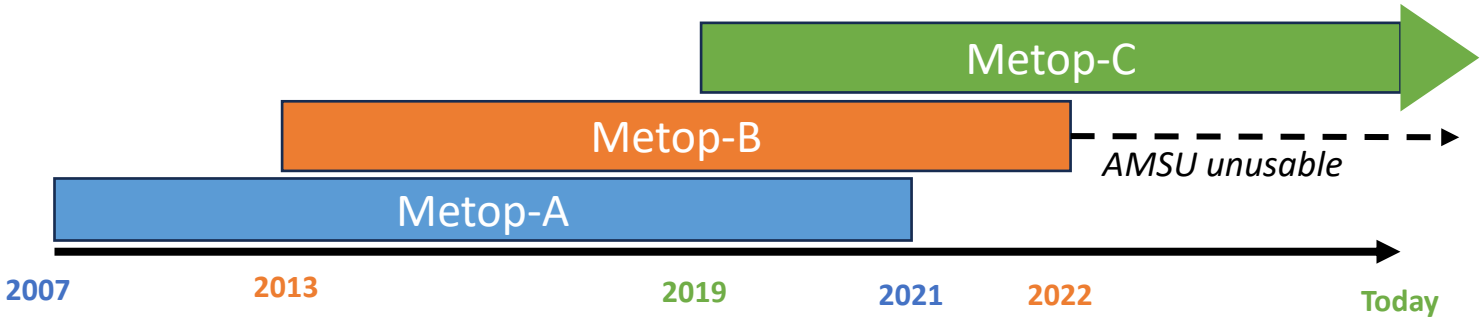
IASI sensitivities to GHG

- **Application to the 3 IASI onboard Metop-A, B and C:**



	MT-CH4 : IASI		
Metop	**A-B**	**B-C**	**A-C**
Mean (ppb)	0.6	-0.7	-2.4
Std(ppb)	10.5	10.4	9.1

**computed using 1°X1° monthly grid boxes over the common periods*



Theorical precisions:

- **< 12-15 ppb Tropics**
- **< 15-20 ppb over mid-latitudes**

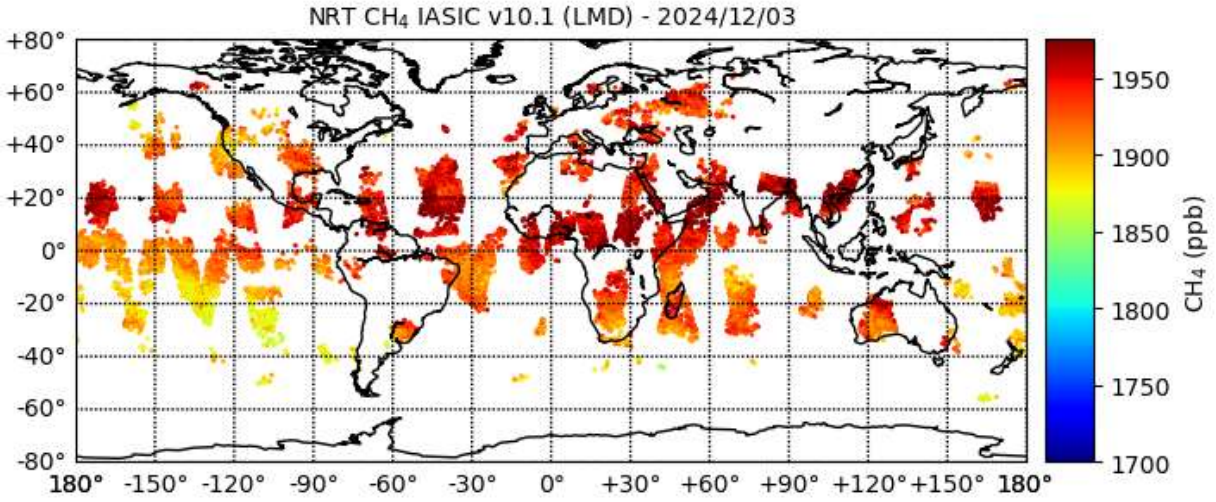
The 3 IASIs onboard Metop-A, B and C can be considered as the same instrument

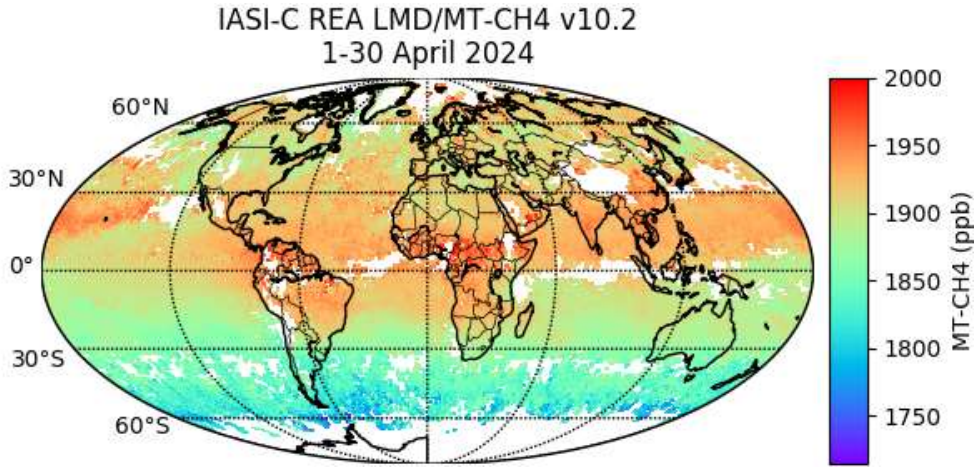
(The 3 IASI instruments lie within 0.1 K of each other for most part of the spectrum)

Assimilation of IASI MT-CH4 v10.1 within C-IFS at ECMWF

2 kinds of operational products:

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





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

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

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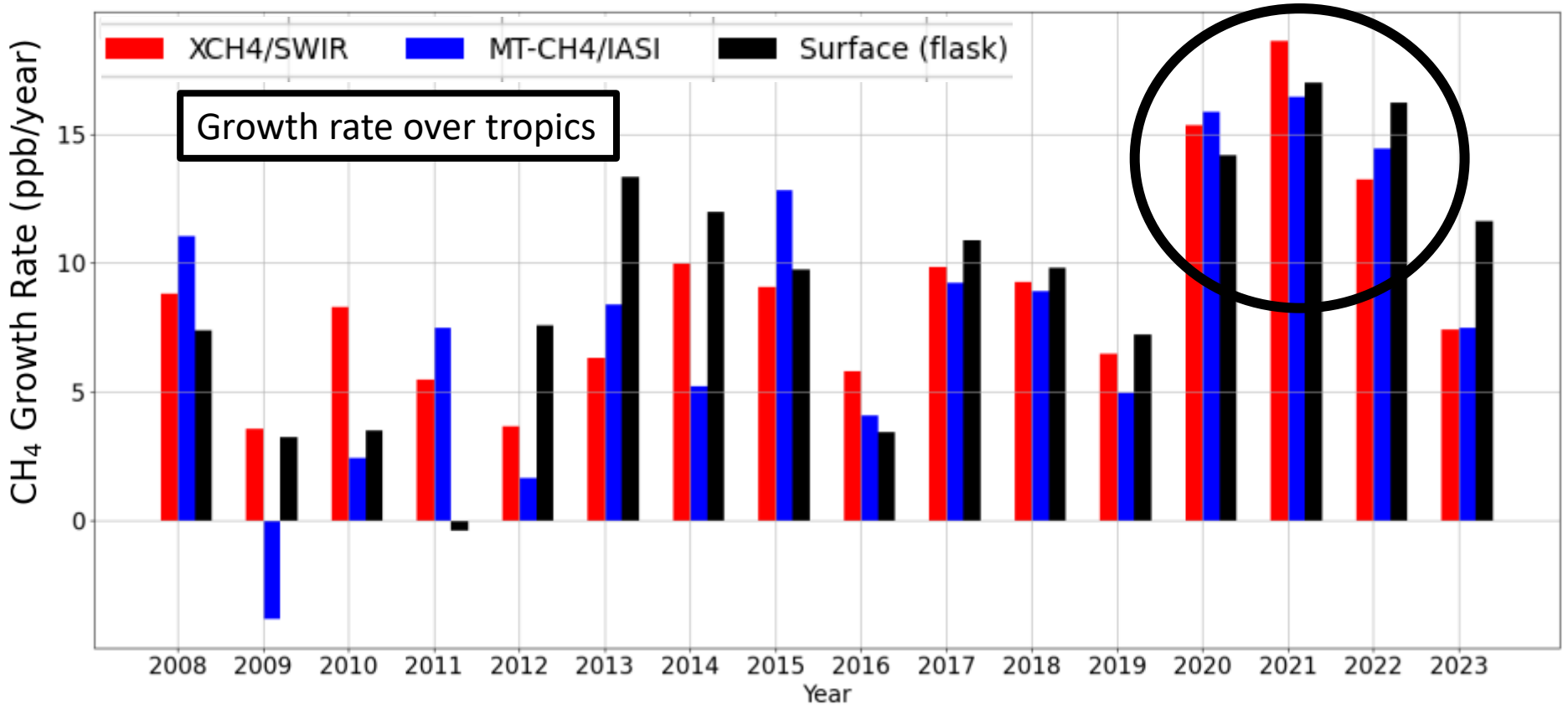
Growth rate over Tropics

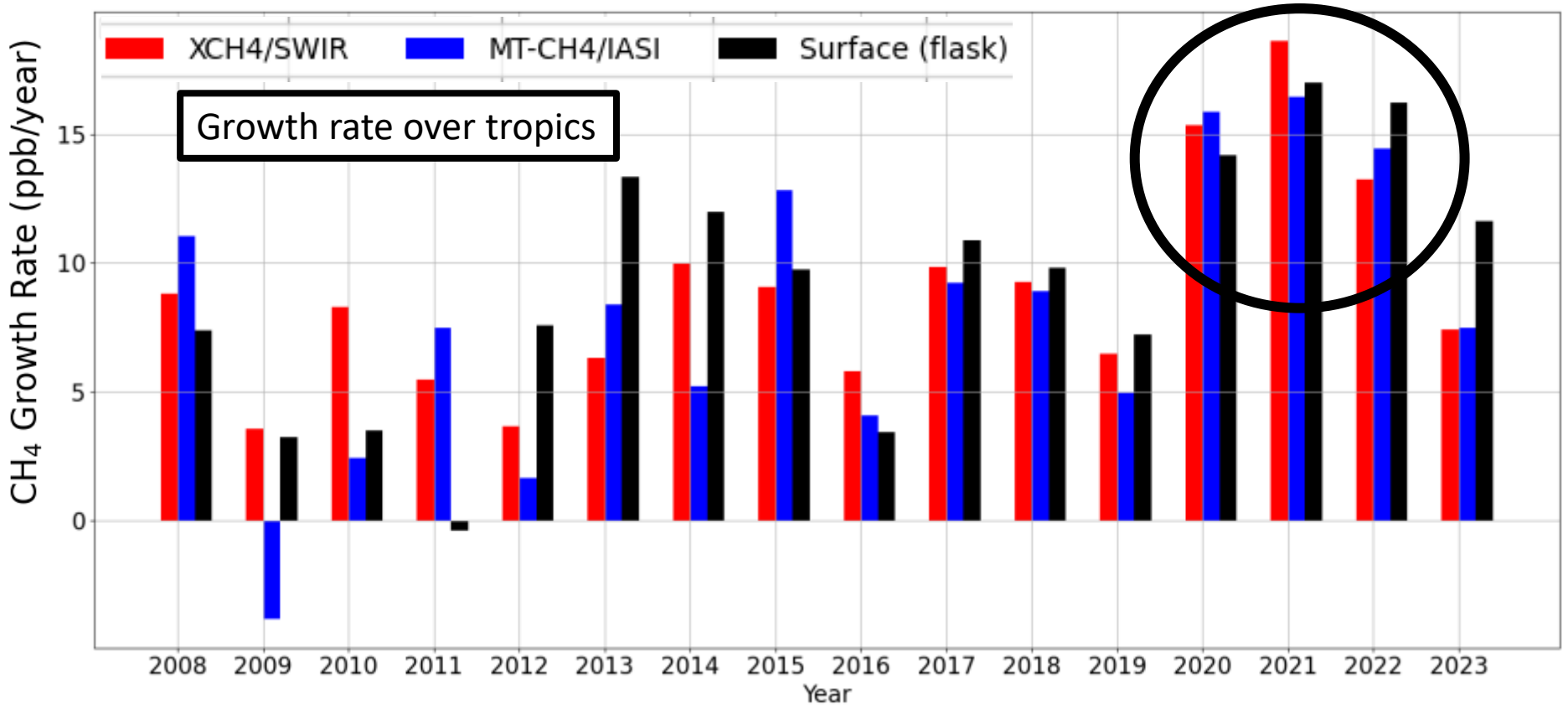


- **XCH4:** Total columns (**mostly over land and day**)
- **MT-CH4:** mid-tropospheric columns (**over land/sea, night/day**)
- **Surface:** at surface and not cover all the globe surface

- ***XCH_4***: *Total column of CH_4 from SWIR missions (SCIAMACHY/ENVISAT, TANSO-FTS/GOSAT and TANSO-FTS-2/GOSAT-2, source: https://cds.climate.copernicus.eu/datasets/satellite-methane?tab=overview)*
- ***Surface (flask)***: *Surface stations (source: NOAA, https://gml.noaa.gov/data/data.php)*

- **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 7 ppb/year in 2023**

Growth rate over Tropics



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- **During the lockdown (2020-2022) :** *(Peng S. and al., Nature, 2022)*

NOx emissions ↘ → Radical HO ↘ → CH_4 destruction ↘

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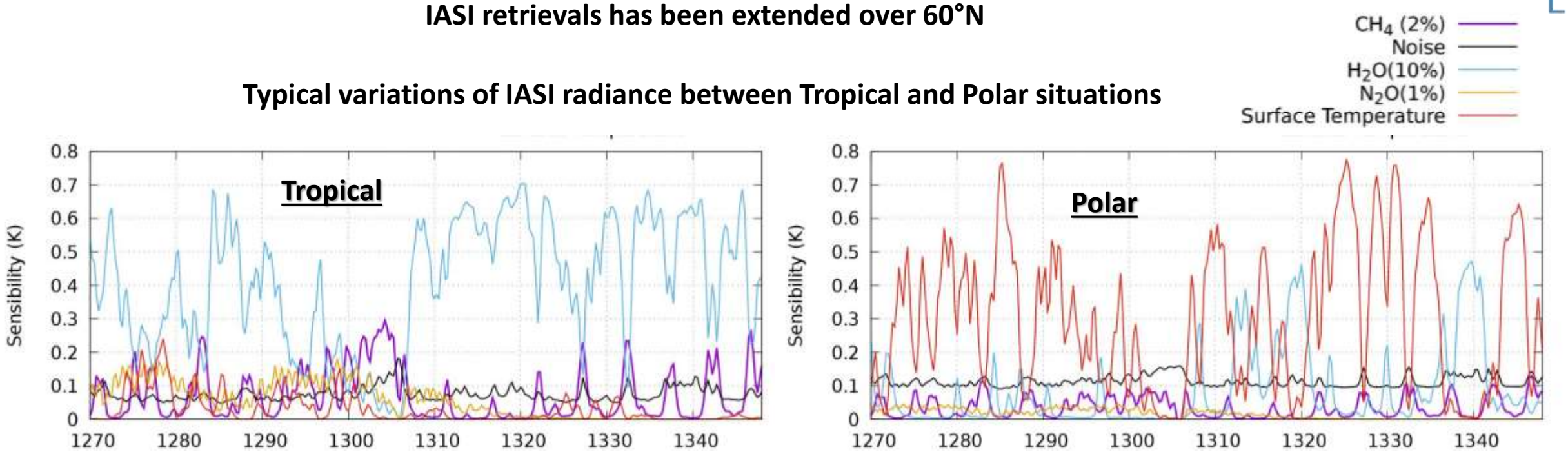
MethaneCAMP: special retrieval scheme over Arctic

IASI retrievals has been extended over 60°N

Typical variations of IASI radiance between Tropical and Polar situations



- **A new retrieval scheme has been developed and validated for Polar situations:**

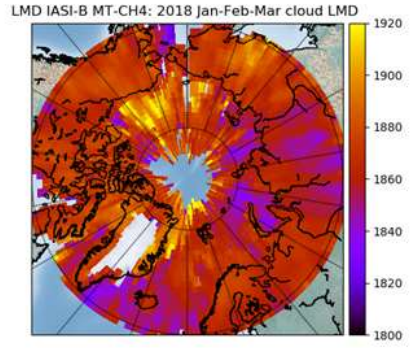
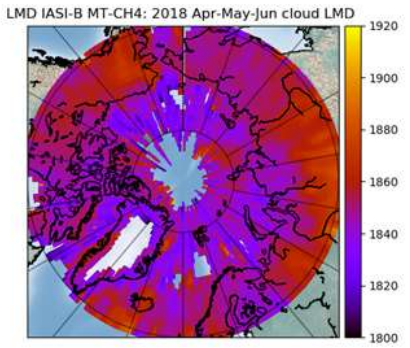
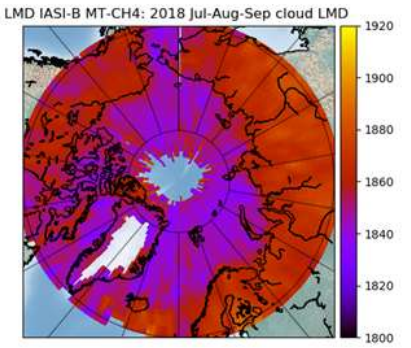
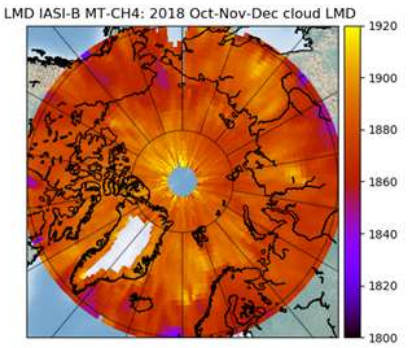
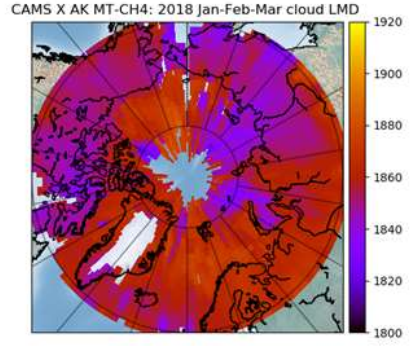
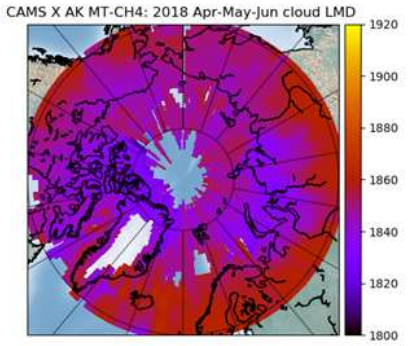
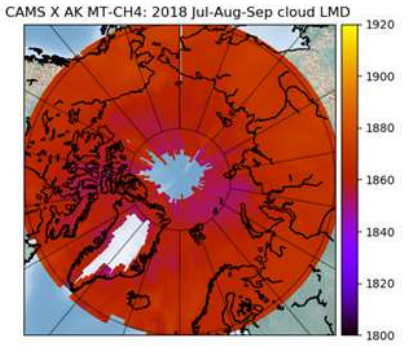
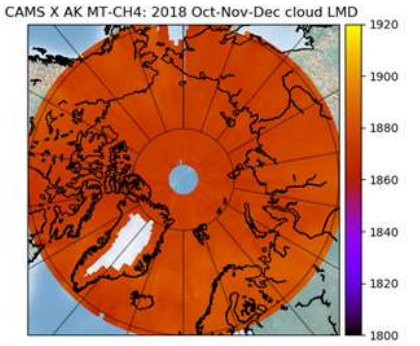
- **A new selection of IASI channels** specifically for polar situations;
  → To take into account the sensitivities to **surface properties:** we now include IASI windows channel;
  → To **reduce the noise**, we use moving **averages over 5 IASI successive channels.**

- A **specific training** database has been computed;

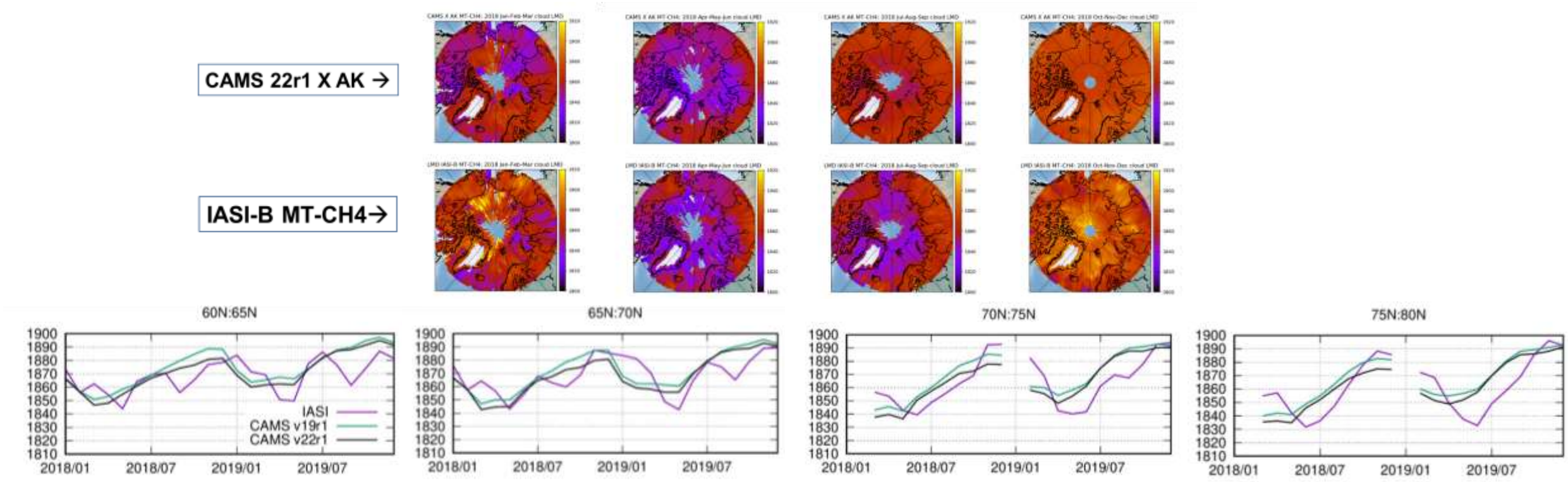
→ Expected precision: 15-20 ppb

MethaneCAMP: special retrieval scheme over Arctic

IASI MT-CH4 retrievals over Arctic

	Jan-Feb-Mar 2018	Apr-May-Jun 2018	Jul-Aug-Sep 2018	Oct-Nov-Dec 2018
IASI-B MT-CH4→				
CAMS 22r1 X AK →				

MethaneCAMP: special retrieval scheme over Arctic



- **Good agreement** in terms of seasonality and trend. Slightly larger amplitude seen on IASI.
- **One month shift at very high latitudes between IASI and CAMS → interinsting point !**
- CAMS v22r1 is closer to IASI on average (a bias of 5-10 ppb between CAMS v19r1 and v22r1).

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

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AMSU onboard Metop Platforms

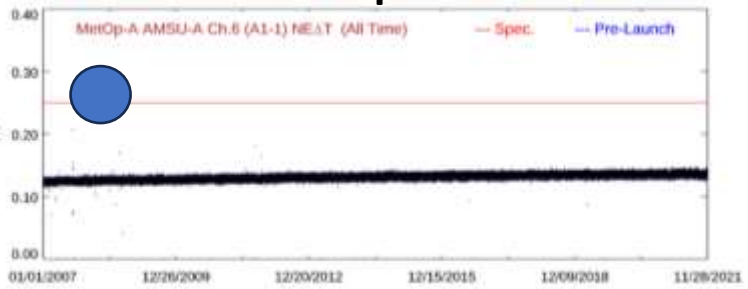
usable

unusable

degraded

Metop A

AMSU 6

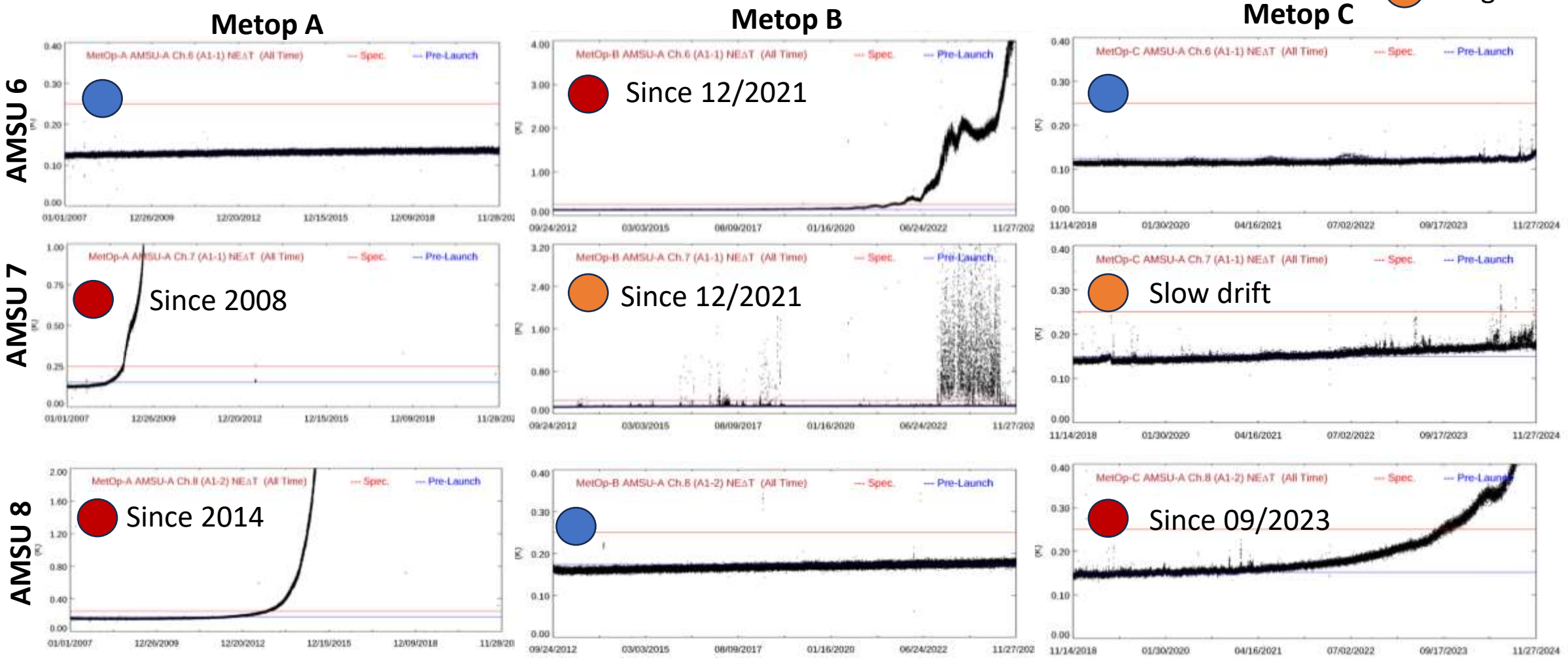


Evolution of AMSU channel noise (NEΔT) over the years (https://www.star.nesdis.noaa.gov/icvs/)

AMSU onboard Metop Platforms

Since 12/2021, due to the degradation of AMSU channels onboard Metop platforms**, it's impossible to use the same selection of AMSU channels for each Metop platform**

usable
unusable
degraded



Evolution of AMSU channel noise (NEΔT) over the years (https://www.star.nesdis.noaa.gov/icvs/)

AMSU onboard Metop Platforms

- **Possible solution in study:**

  → **Replace AMSU channels** (sensitive to the temperature in the mid/up troposphere) by a selection of temperatures provided by **L2 IASI temperature** profiles (**IASI Climate Data Record T &Q Release 1.1**)

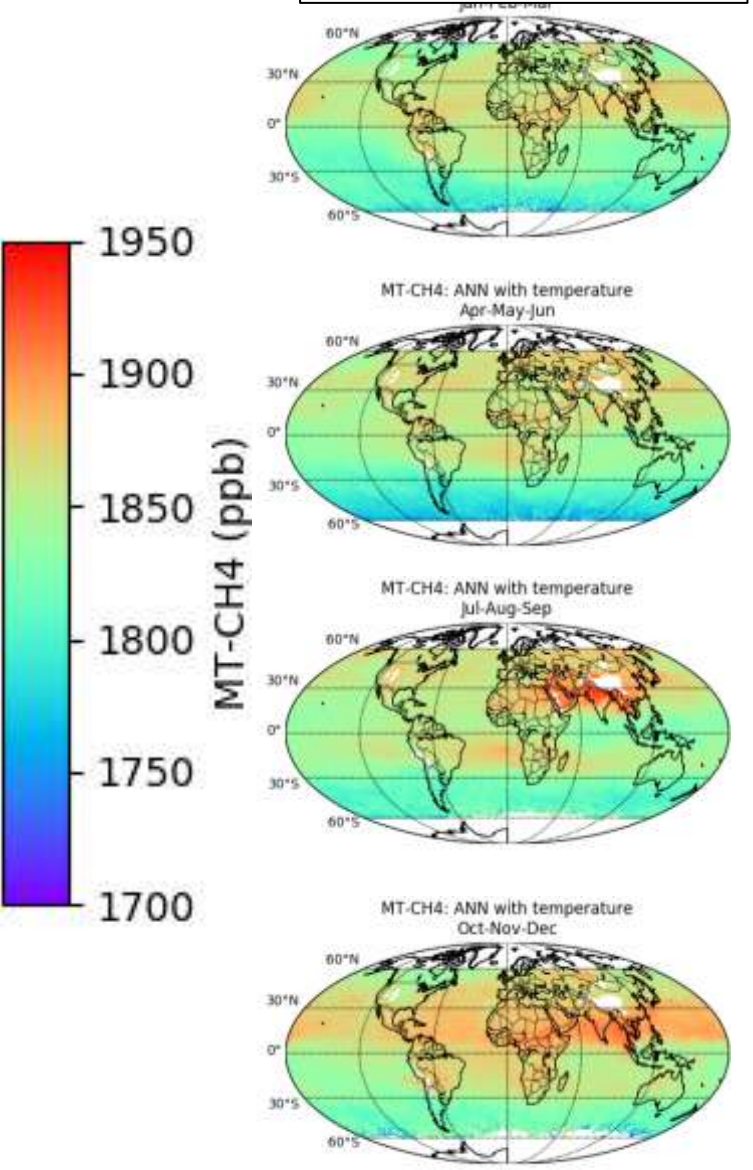
- A **new retrieval scheme** has been developed using **the same IASI channel selection** presented before but the **AMSU channels are replaced by a selection of IASI L2 temperature** values in the troposphere (**noted ANN AMSU-free**);

- Over the training database:

	Using AMSU channels	Using IASI L2 T
Over tropics	< 15 ppb	< 12 ppb
Over mid-latitudes	< 20 ppb	< 20 ppb

Replace AMSU channels by IASI L2 T

Seasonal maps of MT-CH4 using IASI L2 T



Jan-Feb-Mar

Apr-May-Jun

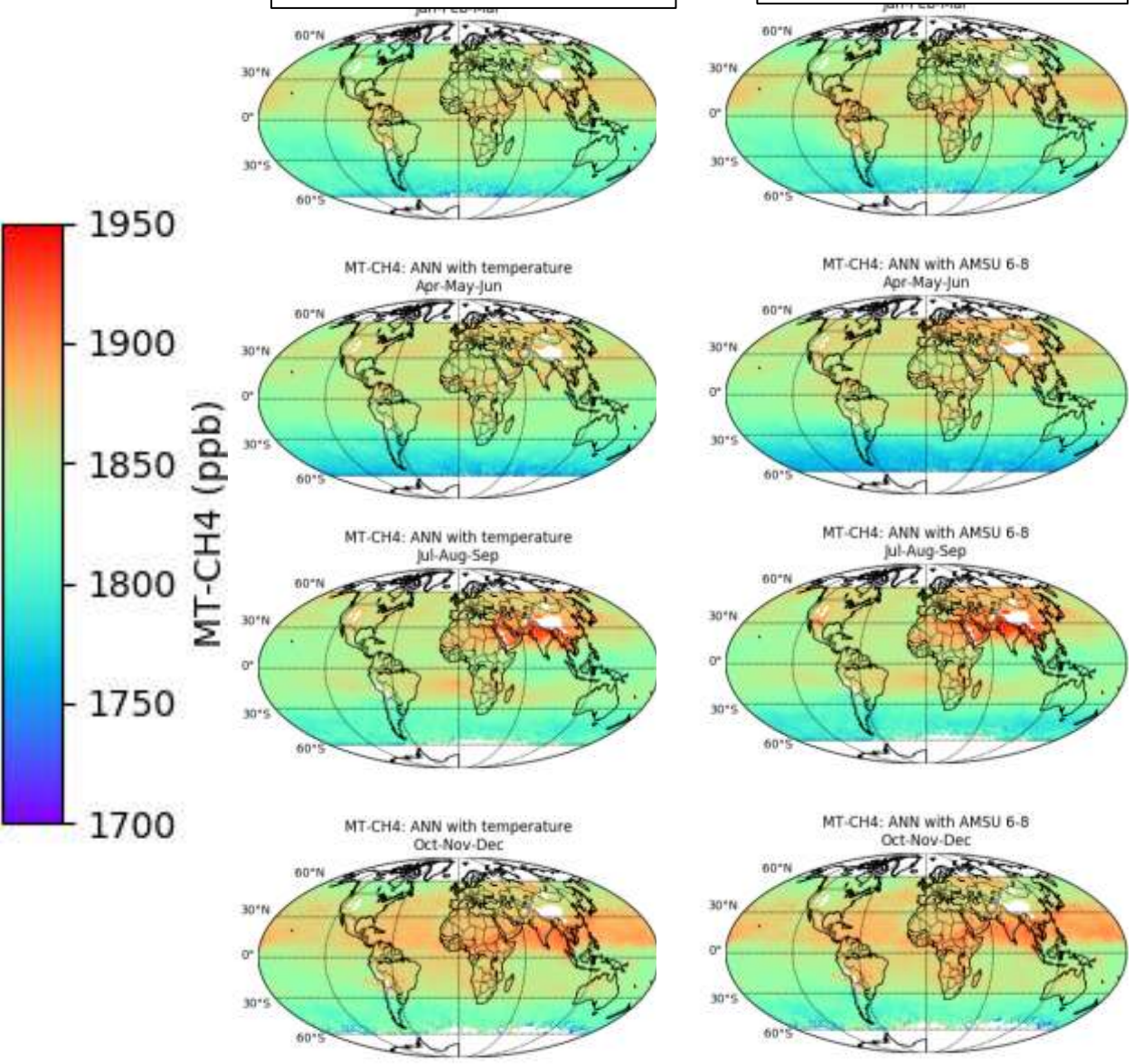
Jul-Aug-Sep

Oct-Nov-Dec

Replace AMSU channels by IASI L2 T

Seasonal maps of MT-CH4 using IASI L2 T

Seasonal maps of MT-CH4 using AMSU



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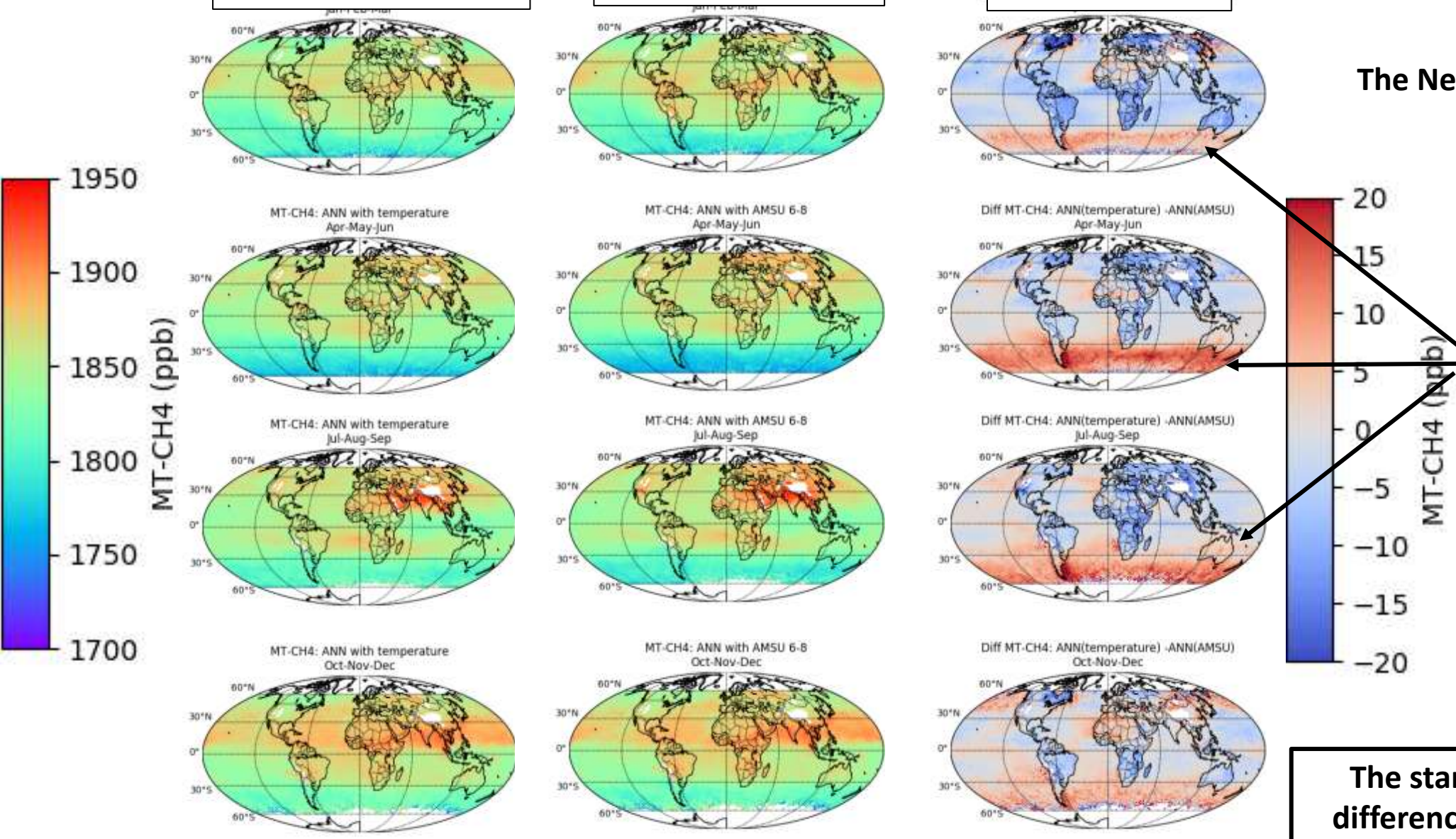
Replace AMSU channels by IASI L2 T

Seasonal maps of MT-CH4 using IASI L2 T

Seasonal maps of MT-CH4 using AMSU

Difference IASI L2 T - AMSU



The Negative biases over land

positive difference over southern mid-latitude

The standard deviations of differences are below 10 ppb

Conclusions

- We have now around 17 years MT-CH4 from IASI observations and available in the AERIS website and C3S data store;
- MT-CH4 has been extended over 60°N during the MethaneCAMP project;
- AMSU (used to provide information of temperature profil with IASI) are unstable onboard the Metop platforms
  - Since 12/2021, due to the degradation of AMSU channels onboard Metop platforms, it's impossible to use the same selection of AMSU channels for each Metop platform;
  - The possibility to replace AMSU by a selection of levels of IASI L2 temperature profils is in study
    → The first results seem encouraging, even if there are still points to improve.

Funding acknowledgment: CNES, EUMETSAT, EU/Copernicus, ESA

Thank your for your attention