4th IASI Conference
Juan-les-Pins, 11-15 April 2016

Spatio-temporal variability of 3 anthropogenic greenhouse gases (CO_2, CH_4 and N_2O) in the mid-troposphere as seen from IASI onboard Metop-A and Metop-B

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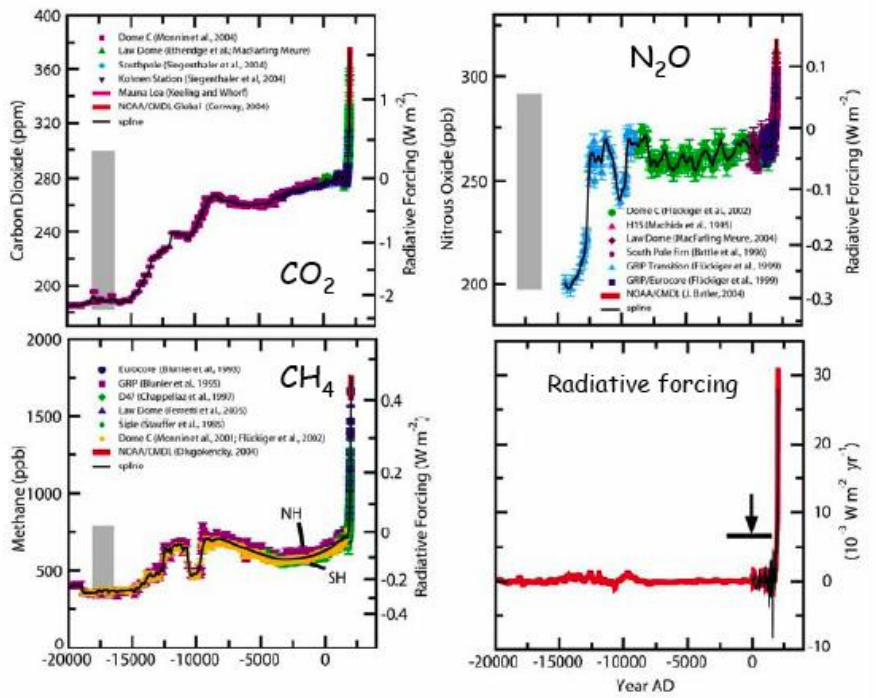
Why monitoring GHG from space?

Increase since pre-industrial era:

+31%

x 2.5



IPCC, 2007

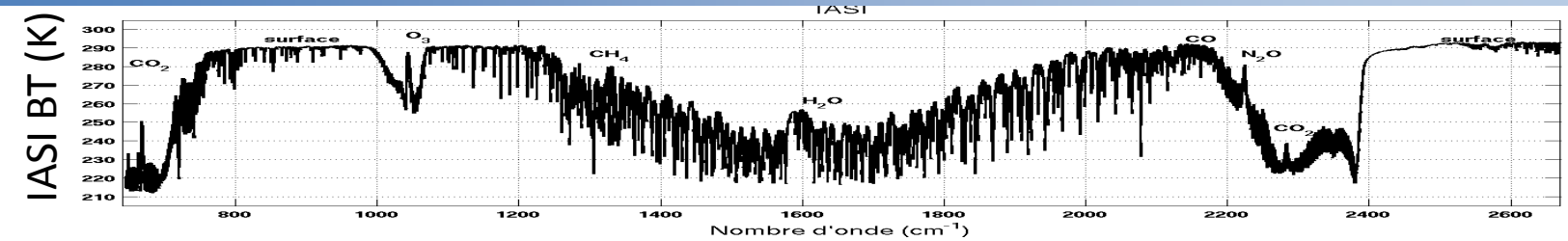
+18%

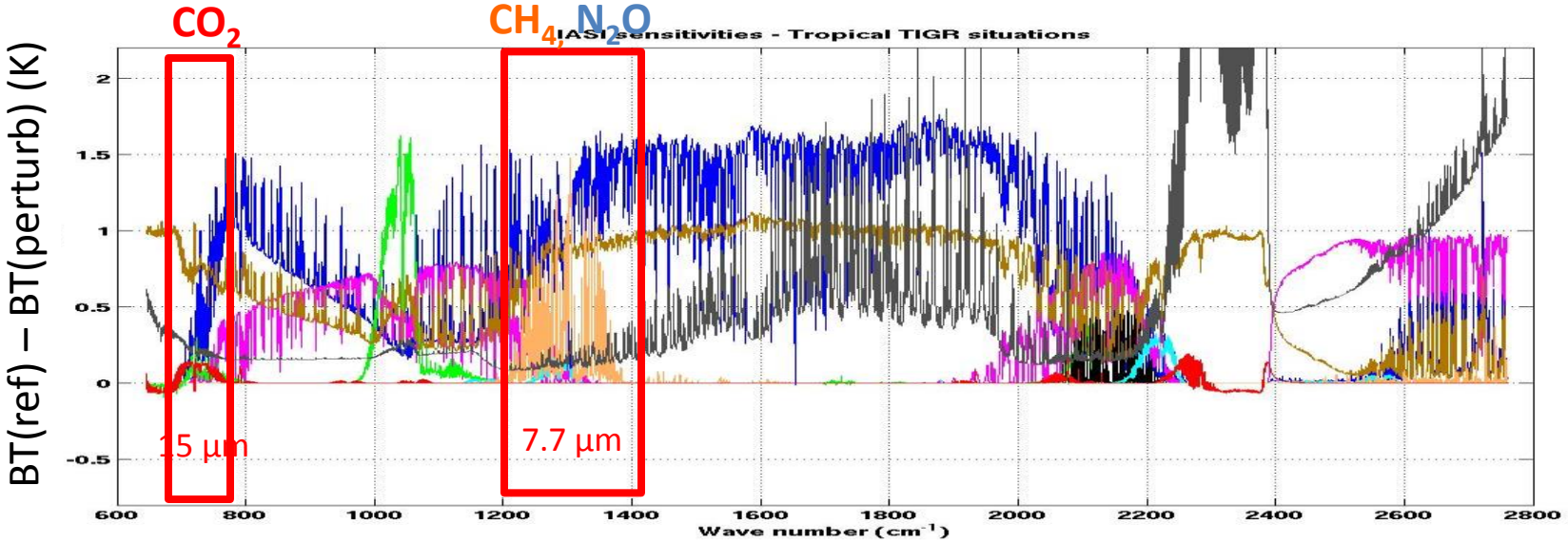
IPCC, 2007

GHG average concentrations mostly reflect the balance between their **sources** **and** **sinks.**

	Sources	Sinks	SWIR sat. Obs.
CO_2	Fossil fuel, fire, respiration	Vegetation, ocean	OCO-2, GOSAT, *MicroCarb*
CH_4	Wetland, rice paddies, fire	Destruction by OH	GOSAT, *S5P, S5, Merlin*
N_2O	Agriculture, watse	Photolysis and oxidation	-

IASI sensitivities to GHG





T (1K) H_2O (20%) CO_2 (1%) O_3 (10%) N_2O (2%) CO (10%) CH_4 (10%) Tsurf (1 K)

Scott and Chédin, 1981
www.noveltis.fr/4AOP/

Chédin et al, 1985
ara.abct.lmd.polytechnique.fr

Jacquinet-Husson et al, 2011
ether.ipsl.jussieu.fr

The very small seasonal variability of these gases compared to their background values, combined to the strong dependence of IR radiances to atmospheric temperature and the simultaneous sensitivity of the channels to several gases, makes their retrieval challenging.

IASI sensitivities to GHG

- Retrieval procedure (Crevoisier et al., 2009ab, 2013):

-Non linear inference scheme based on neural networks (Chédin et al., 2003).

-Based on the 4A RT code and the latest edition of the GEISA database.

-Systematic radiative biases between RT simulations and IASI observations are computed using the ARSA database.

-gas and T(p) are intimately correlated in the IR.

→ Use of IR (IASI) and MW (AMSU) observations to decorrelate T from gas variations.

89 channels for CO_2 (@15µm) and 24 channels for CH_4 (@7.7µm)

+ AMSU 6 and 8

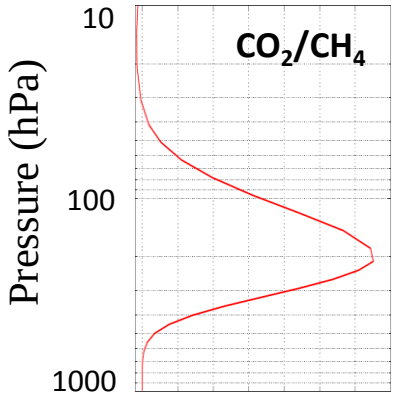
-The decorrelation between T/gas is easier to do in the tropics.

⇒ better precision in the tropical region.

- We retrieve a mid-tropospheric content:

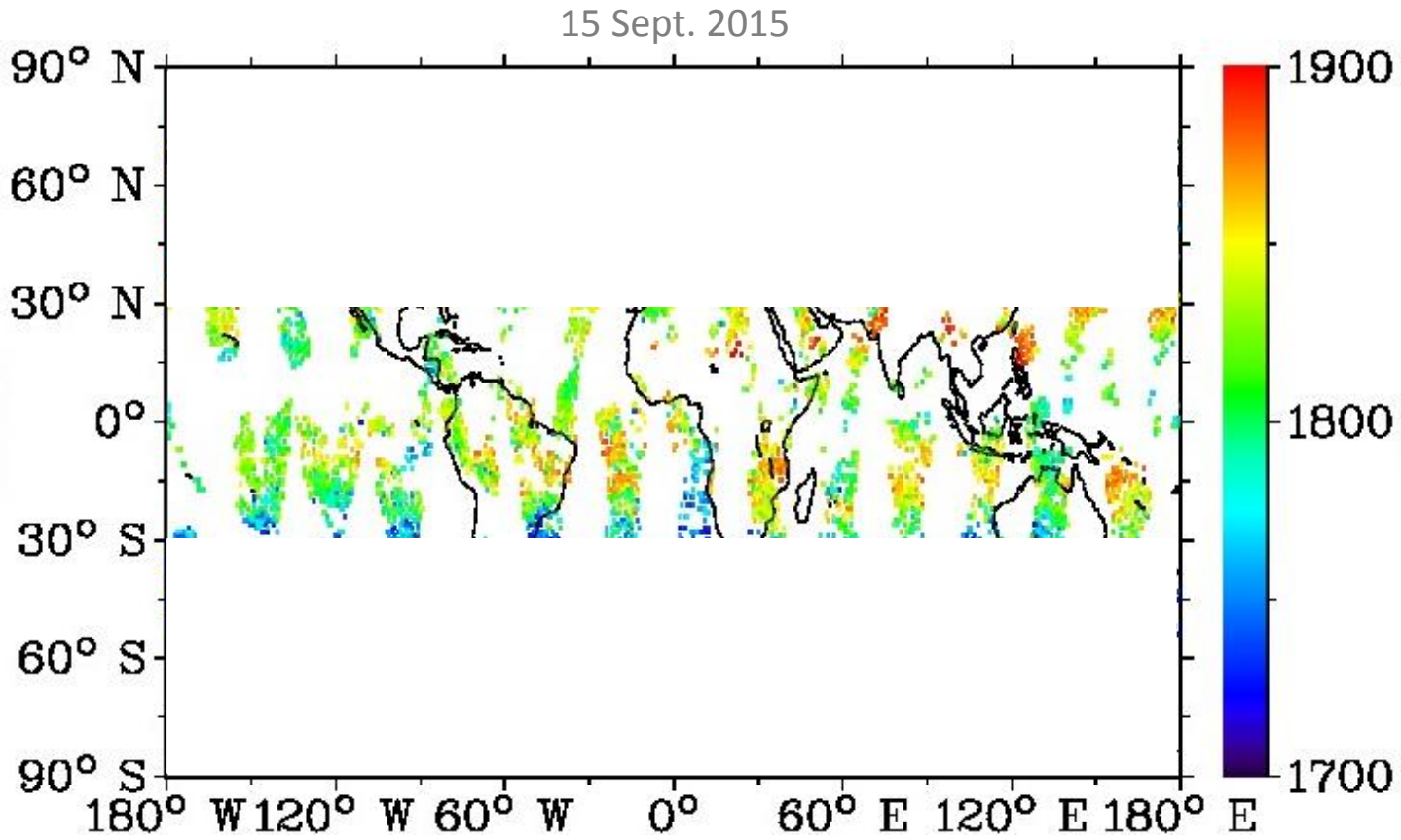
- clear sky only (no clouds, no aerosols)
- by day and night
- over land and over sea

Typical vertical sensitivity



Mid-tropospheric CH_4

At IASI 3rd conference back in 2013: retrieval restricted to the tropics, from Metop-A



Mid-tropospheric CH_4

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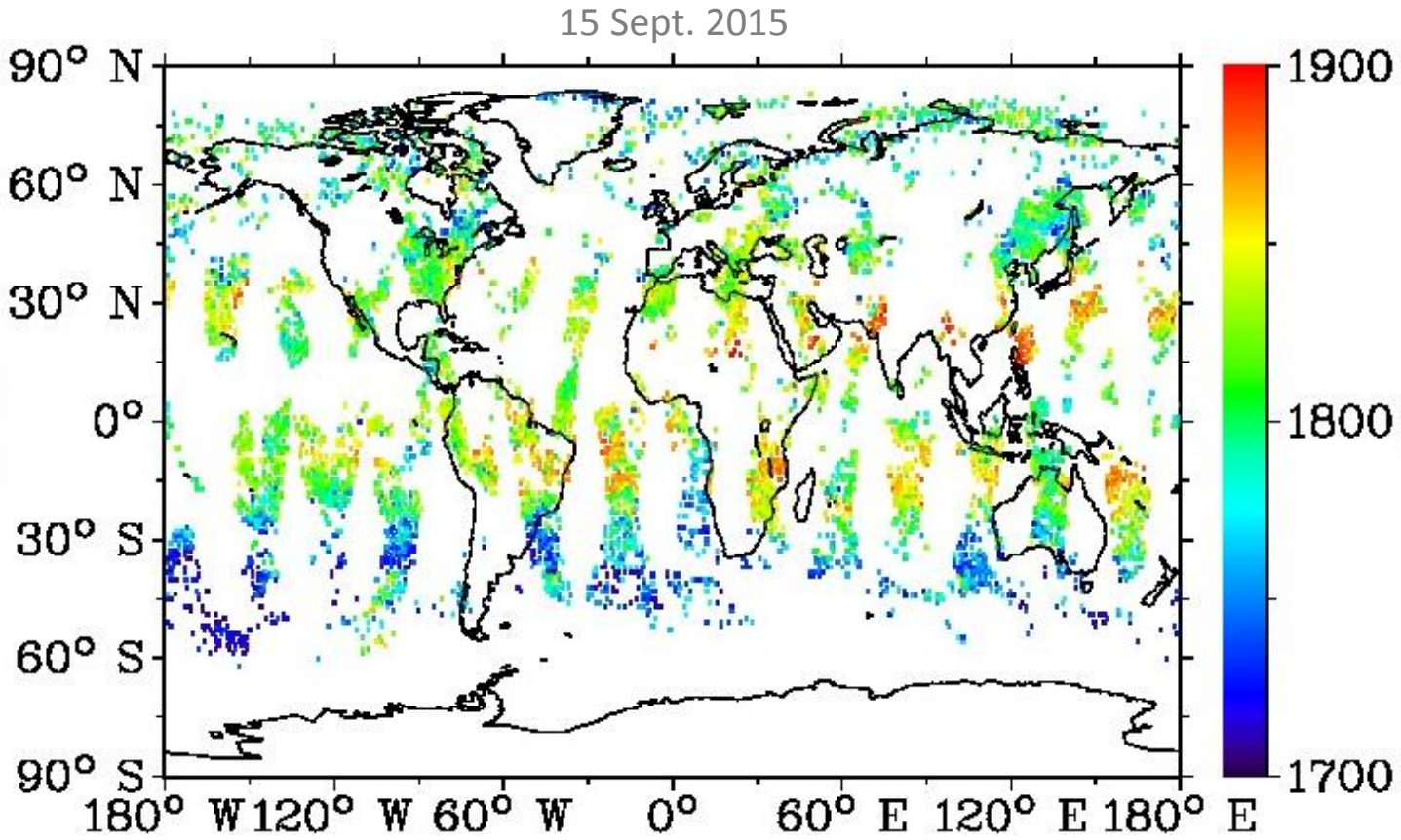
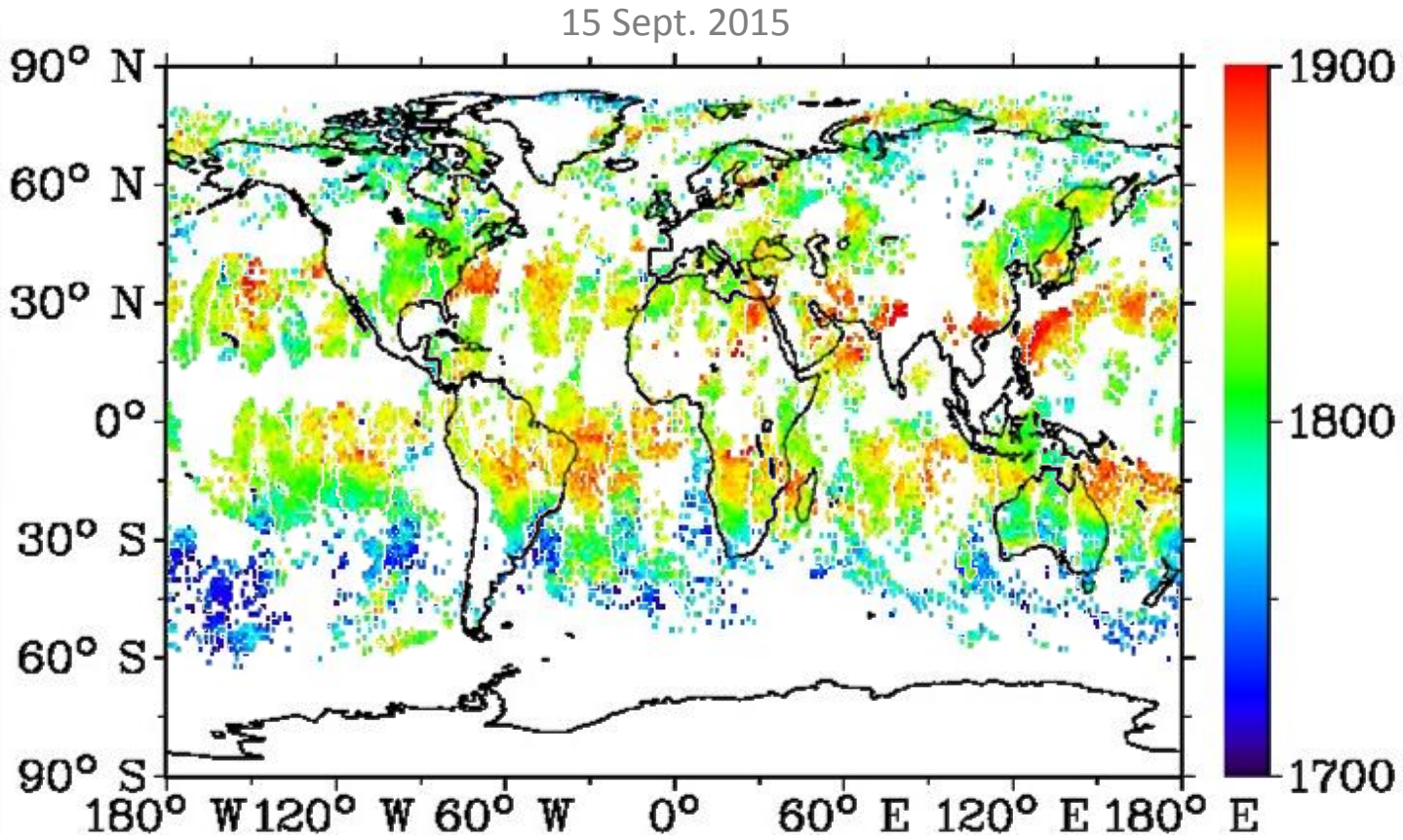
Since then: extension to extra-tropical regions for CH_4



Mid-tropospheric CH_4

At IASI 3rd conference back in 2013: retrieval restricted to the tropics, from Metop-A

Since then: extension to extra-tropical regions for CH_4
extension to Metop-B for both CH_4 and CO_2

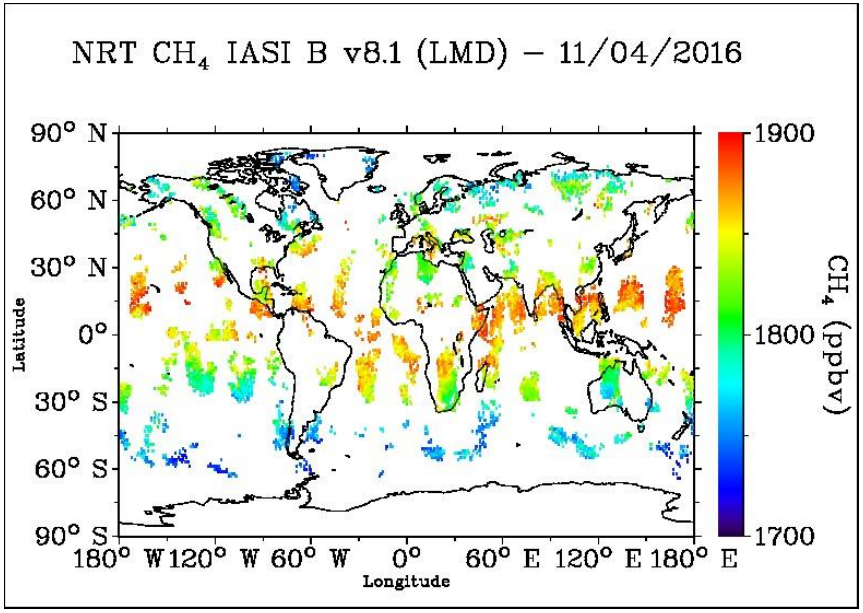


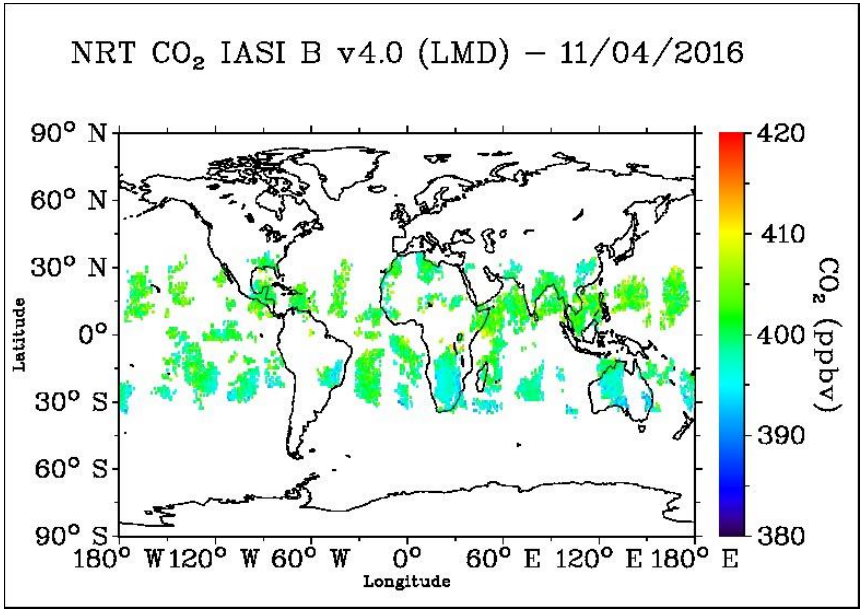
Metop-A + Metop-B provide full coverage in one day.

Mid-tropospheric CH_4

At IASI 3rd conference back in 2013: retrieval restricted to the tropics, from Metop-A

Since then: extension to global coverage for CH_4
extension to Metop-B for both CH_4 and CO_2
near-real time delivery (D+1) for both CH_4 and CO_2





→NRT data daily delivered to Copernicus Atmospheric Service for assimilation at ECMWF

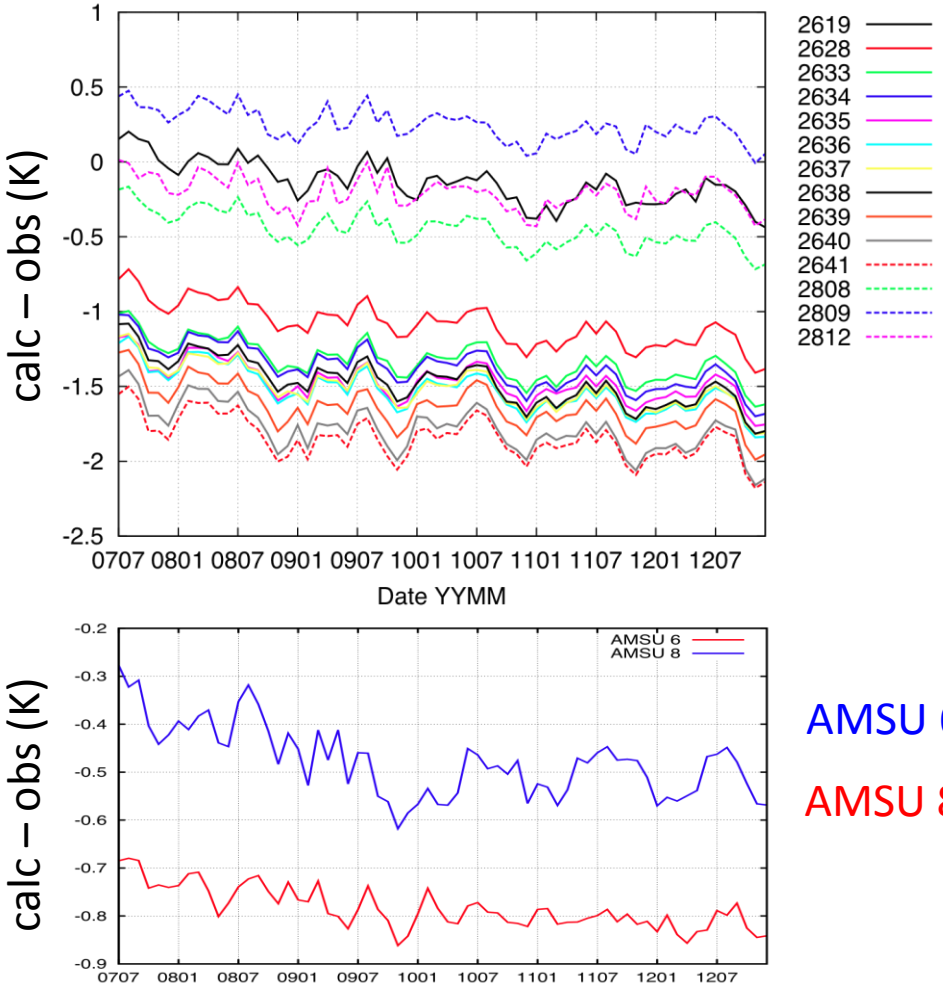
→ See S. Massart's talk later today

→Contribution to ESA-Climate Change Initiative-GHG (CO_2 and CH_4)

Retrieval scheme

A very important step: radiative monitoring of the instruments through computation of "calc-obs" residuals using co-located simulations (ARSA+4A) and IASI observations.

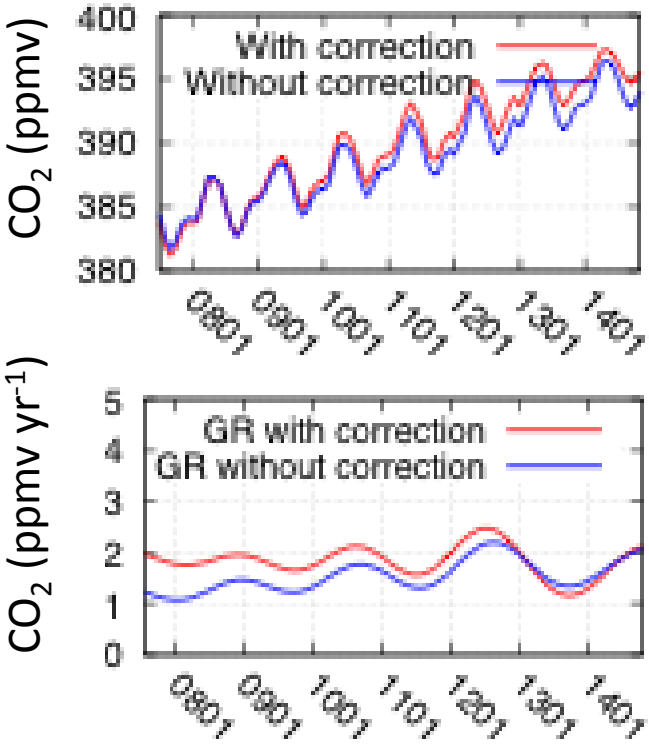
Monthly evolution



AMSU 6

AMSU 8

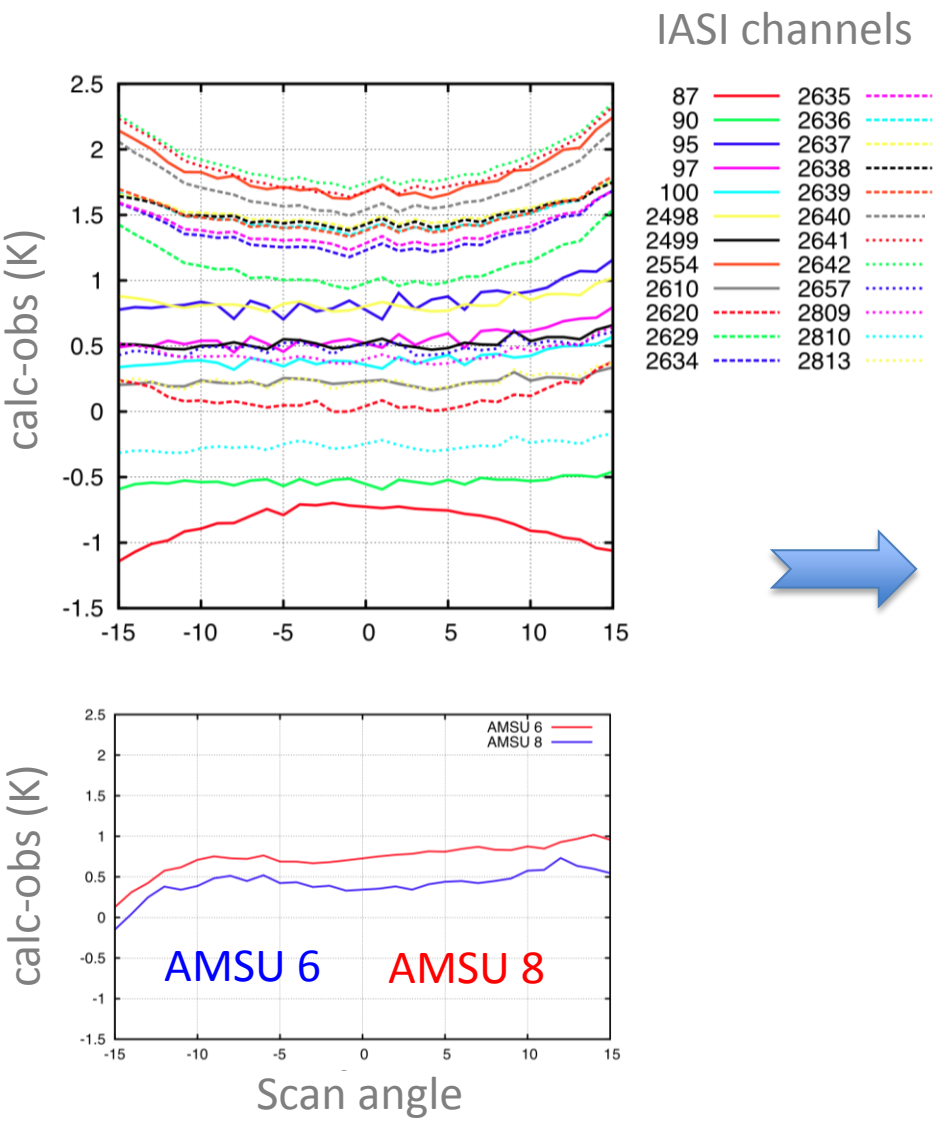
Impact on retrieved CO_2

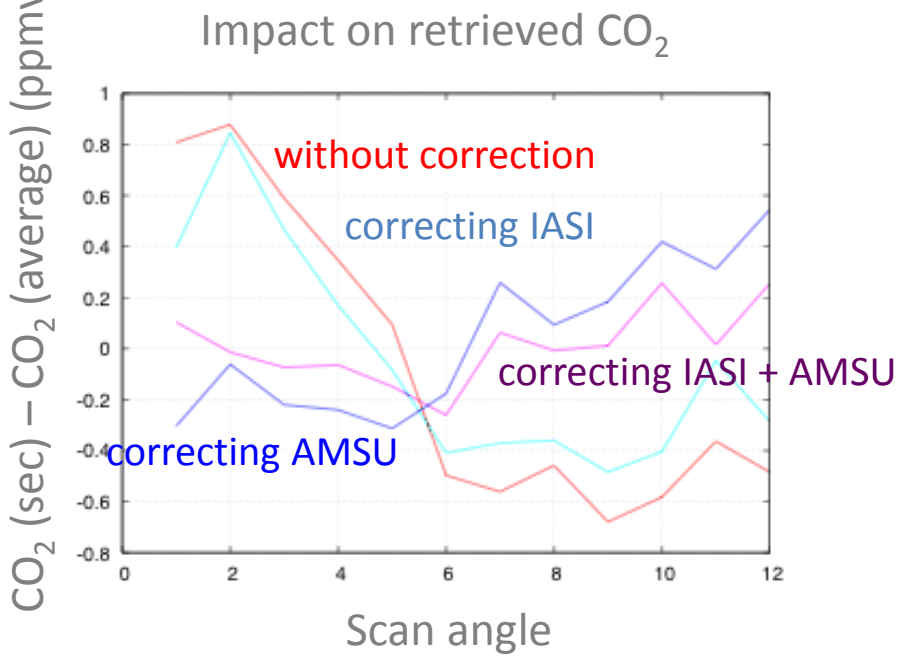


see N. A. Scott's poster #81

Retrieval scheme

Characterization of radiative behavior according to scan angle

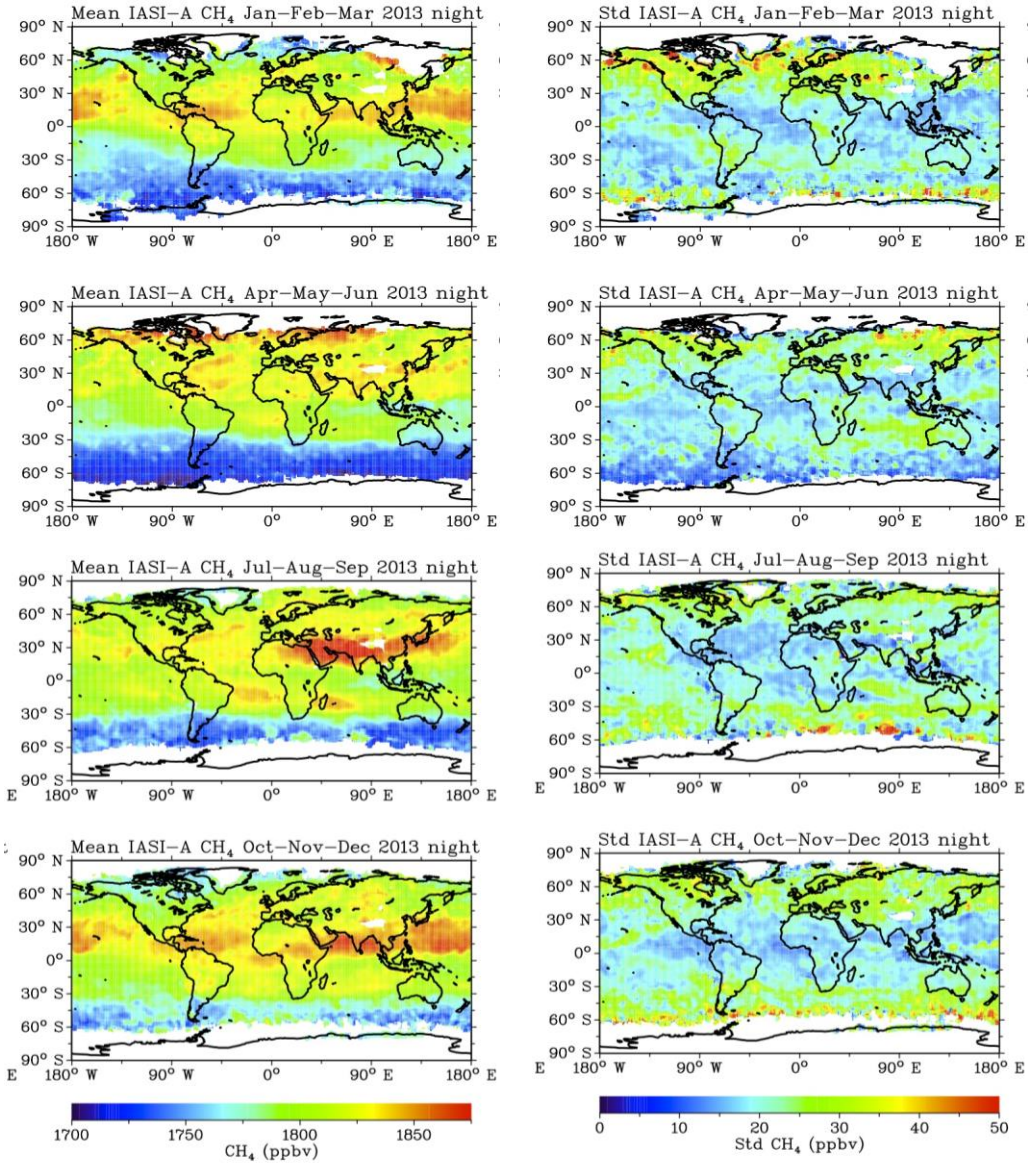




Mid-tropospheric CH_4

8 years from IASI/Metop-A (July 2007-June 2015)

Seasonal Average | **Standard deviation**



- Retrieval accuracy ~12 ppbv

- Lower std in the tropics.
→Better precision.

- Usually lower std in the southern than in the northern hemisphere.
→ Lower variability of CH_4.

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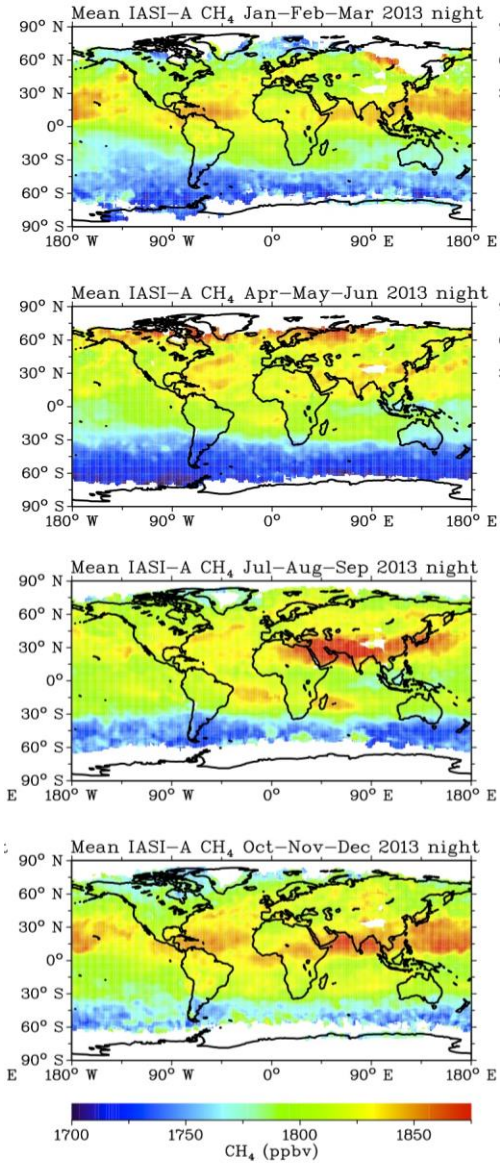
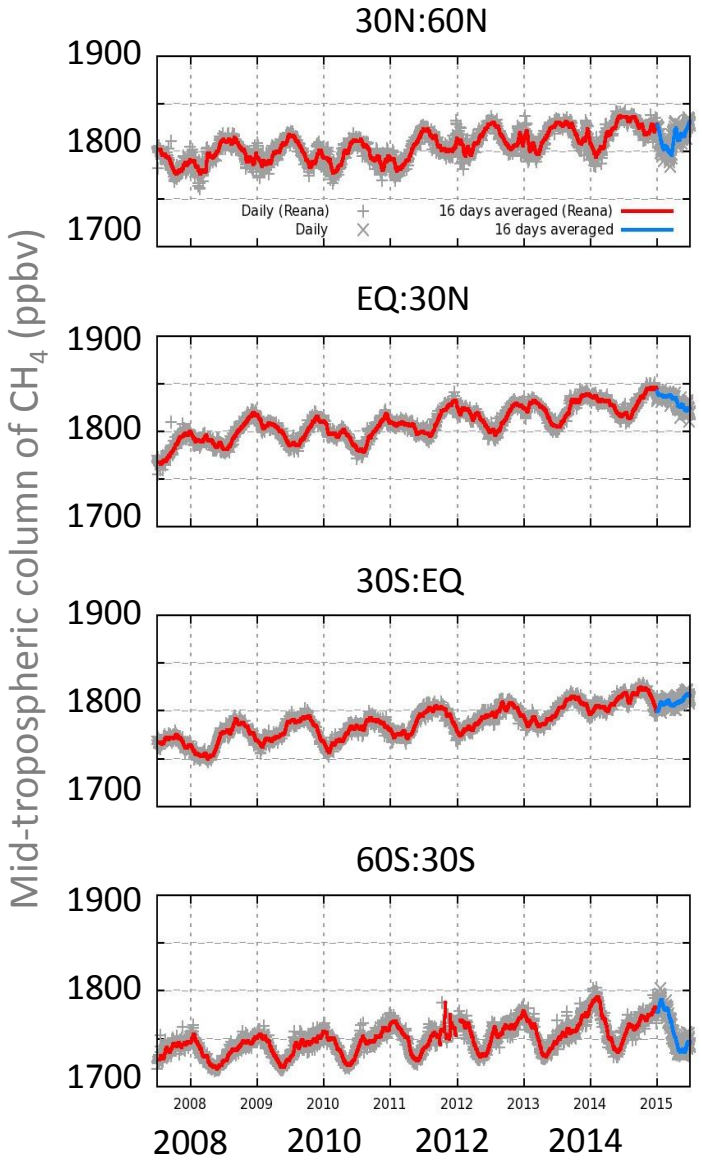
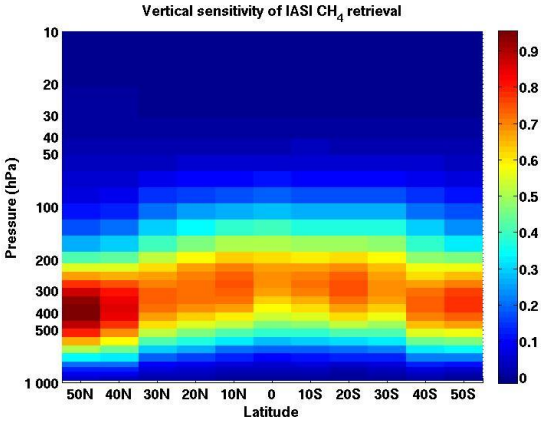
Mid-tropospheric CH_4

8 years from IASI/Metop-A (July 2007-June 2015)

Seasonal Average







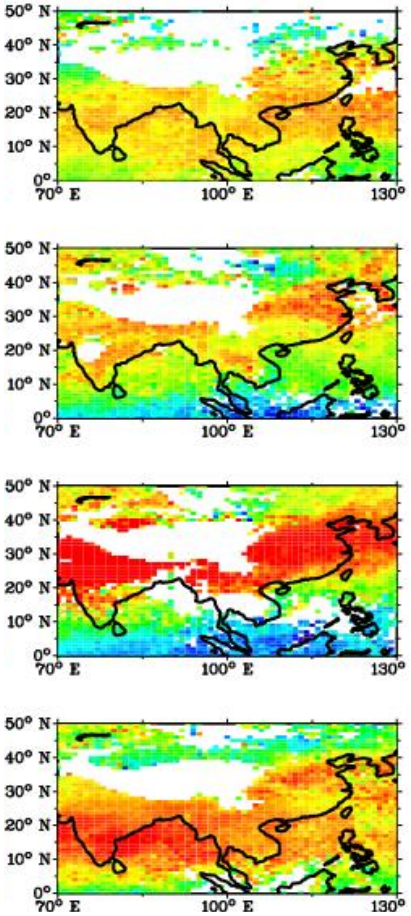
- In the tropics: max @ 250 hPa (~11 km) while tropopause @ 16 km.
- In the mid-lat: max @ 400 hPa (~7 km) while tropopause @ 8 km.

Mid-tropospheric CH_4

Analysis of retrieved fields

- Strong emission of CH_4 by rice paddies in summer
- Rapid uplift to the mid-troposphere due to monsoon convection.
- Then Southward transport towards Indonesia.

Asia

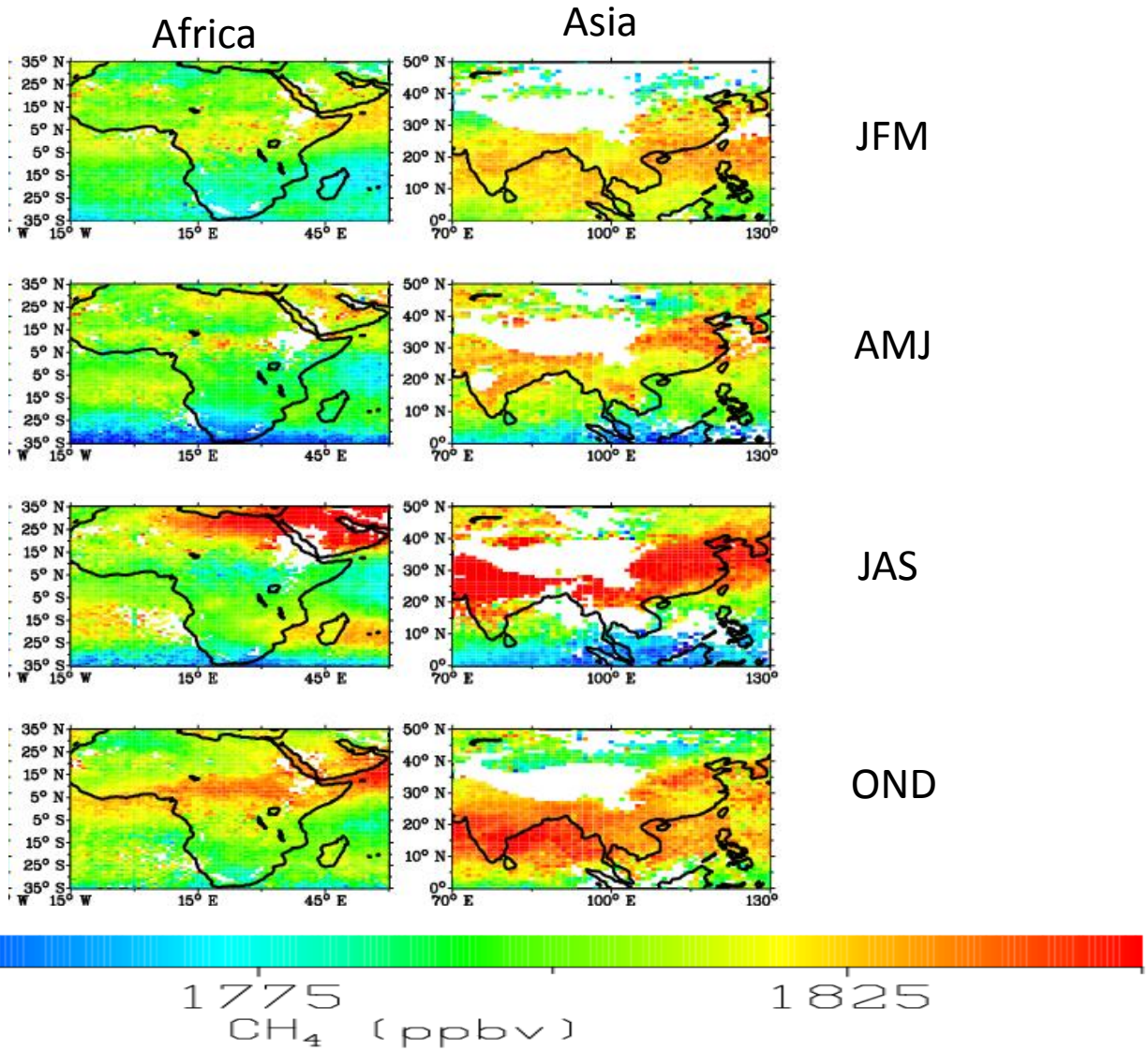


Mid-tropospheric CH_4

Analysis of retrieved fields

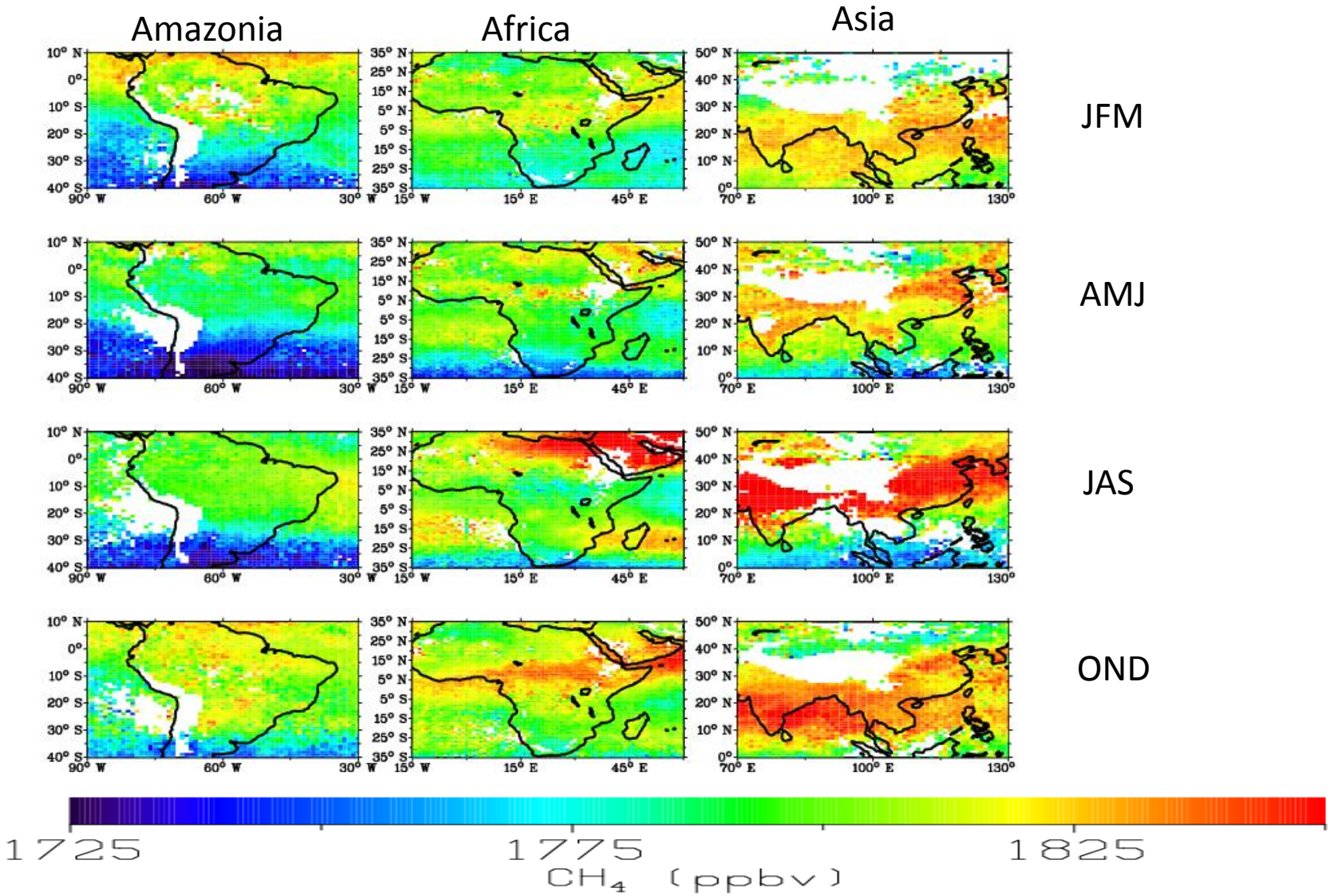
- Summer : transport of emissions from Asia Westwards.

- Fall/winter : wetland emissions (tropical forest).



Mid-tropospheric CH_4

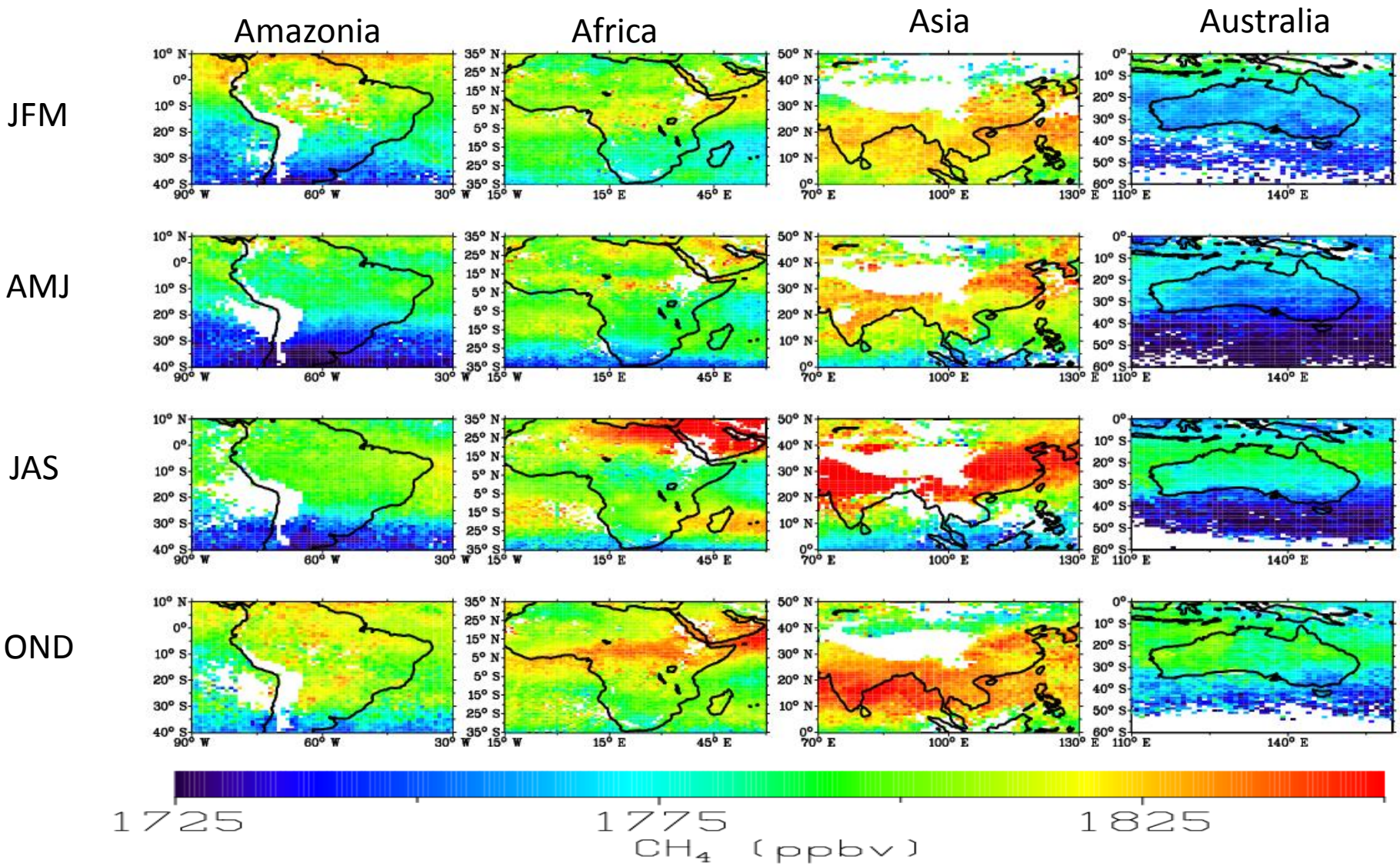
Analysis of retrieved fields



winter : wetland emissions in Amazonia.

Mid-tropospheric CH_4

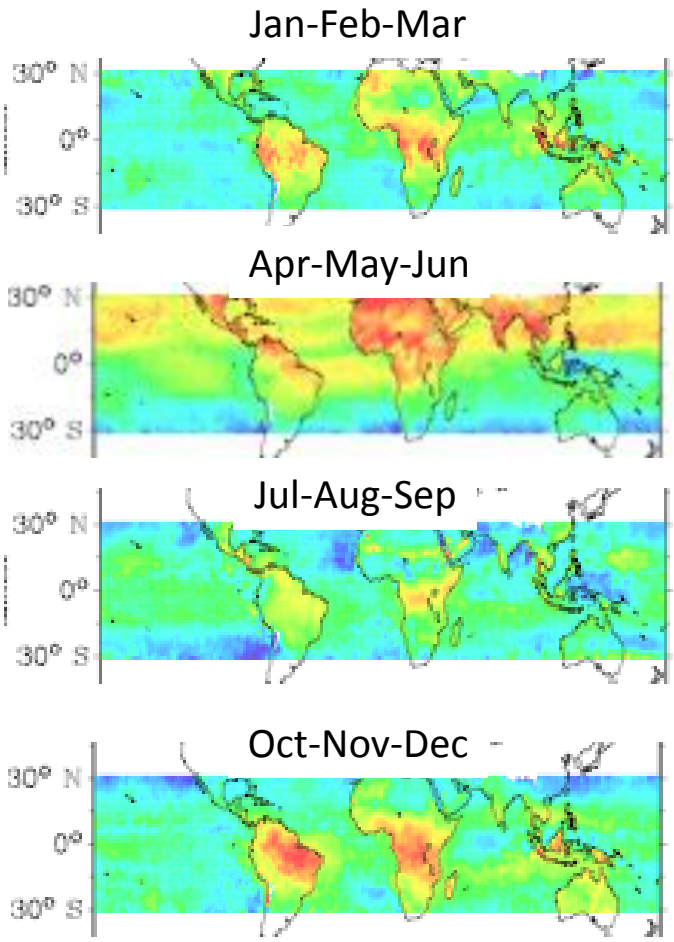
Analysis of retrieved fields

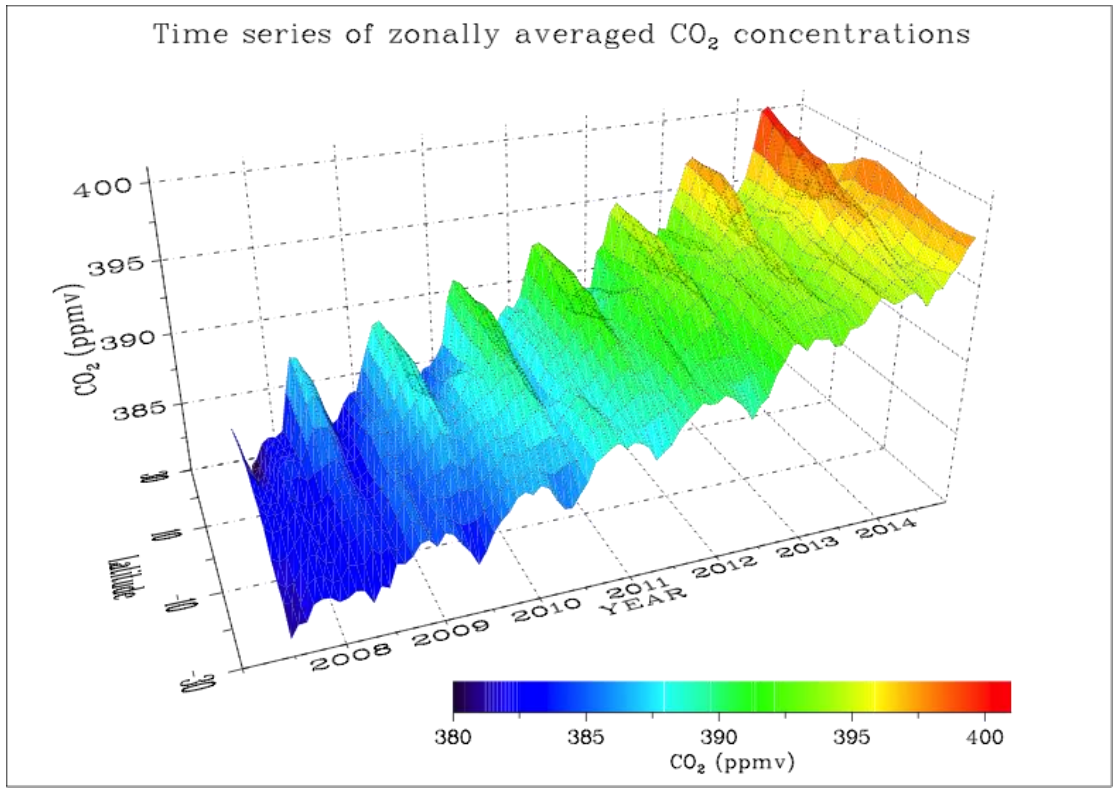


Although sensitive to the mid-troposphere, IASI does provide information of surface fluxes

Mid-tropospheric CO_2

8 years of mid-tropospheric CO_2 from IASI/Metop-A (July 2007-June 2015)





Annual trend: 2.1 ppm yr^{-1}

- Biomass burnings emission.
- Strong seasonal variationsand inter hemispheric gradient.

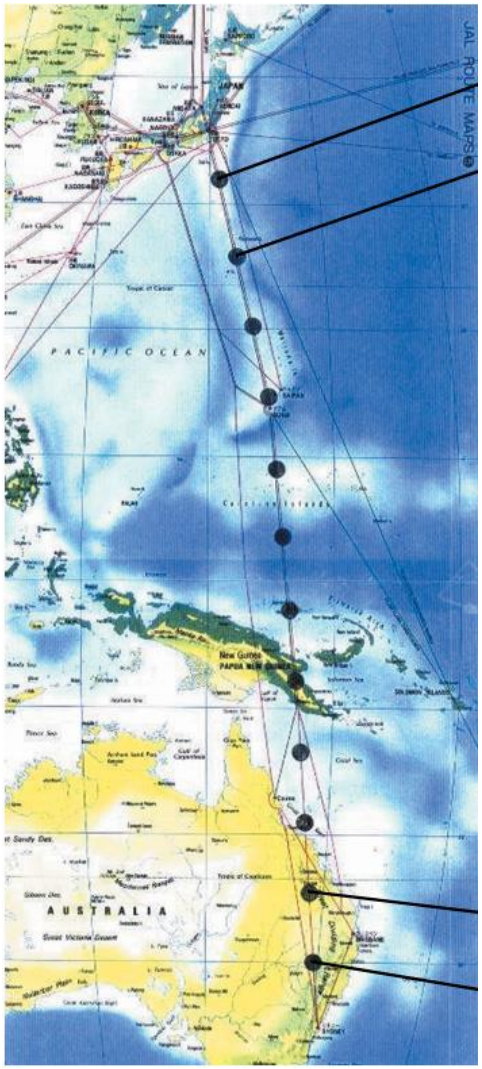
Validation with aircraft measurements: CONTRAIL (1/4)

CONTRAIL Comprehensive Observation Network for TRace gases by AIrLiner

Comprehensive Observation Network for TRace gases by AIrLiner

JAL commercial flights from 2006 to 2009
at an altitude of 10-12 km.

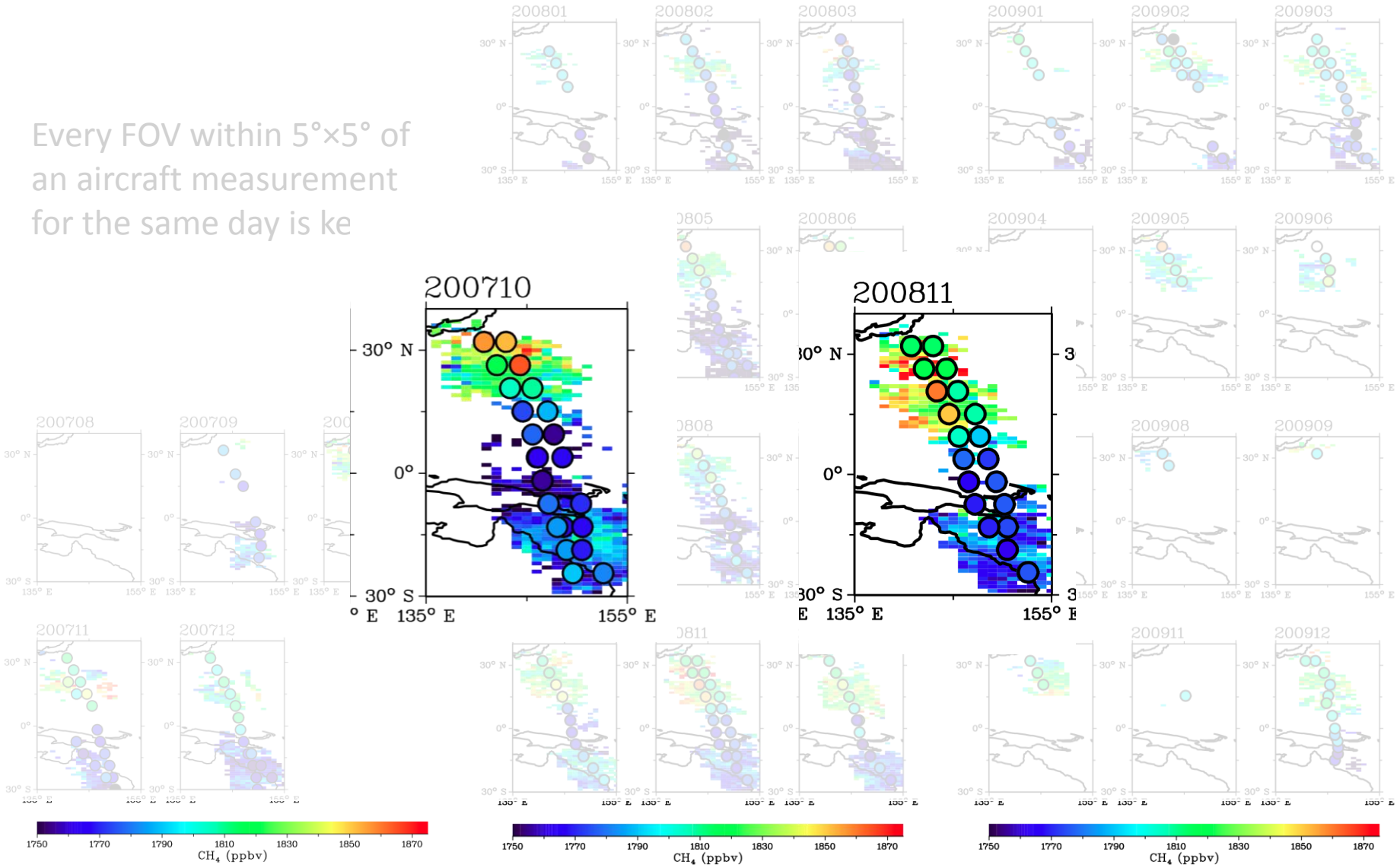
http://www.cger.nies.go.jp/contrail/index.html



Validation with aircraft measurements: CONTRAIL (2/4)

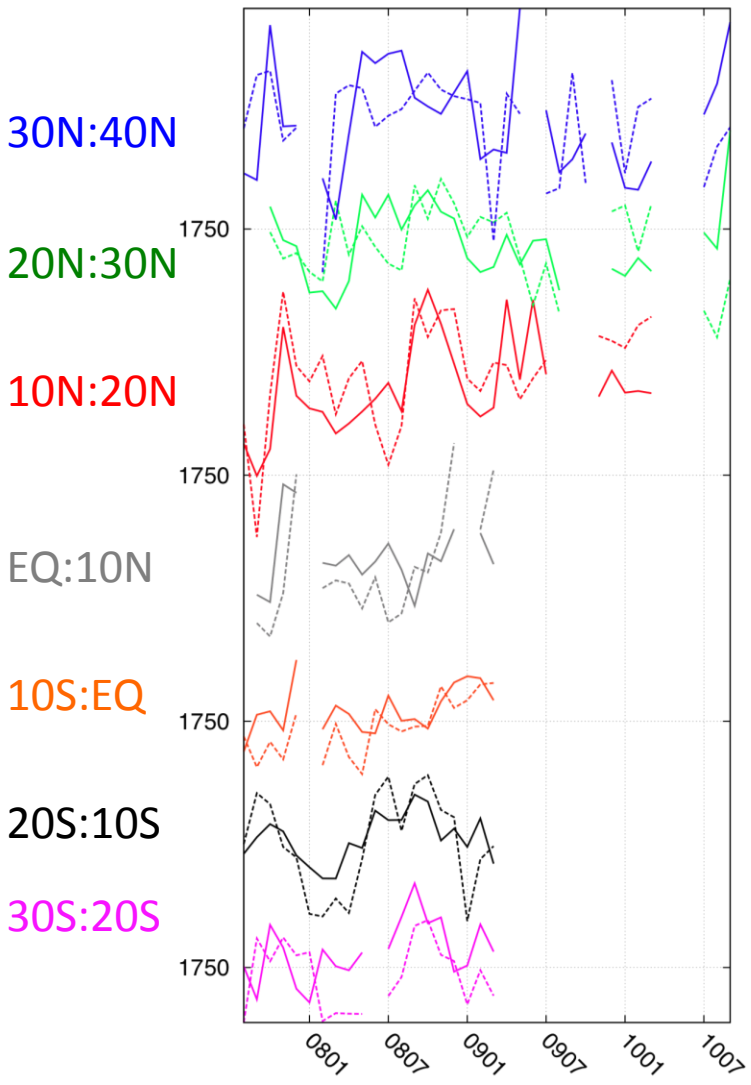
Mid-tropospheric CH_4

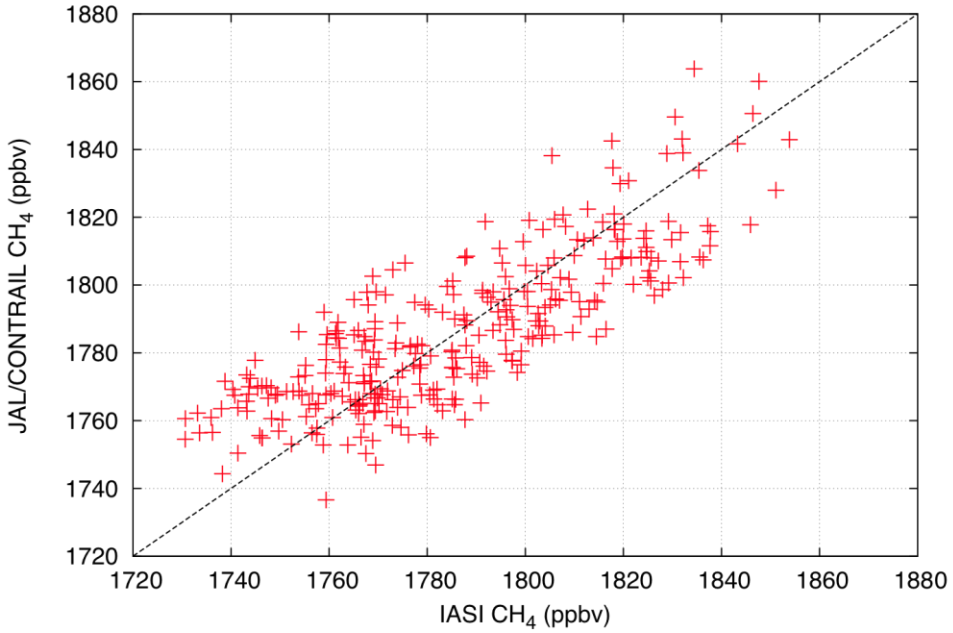
Every FOV within 5°×5° of an aircraft measurement for the same day is ke



Validation with aircraft measurements: CONTRAIL (3/4)

Mid-tropospheric CH_4





IASI CH_4 – CONTRAIL CH_4
=
-0.89 ± 16.13 ppbv (R = 0.81)
(over 311 pairs)

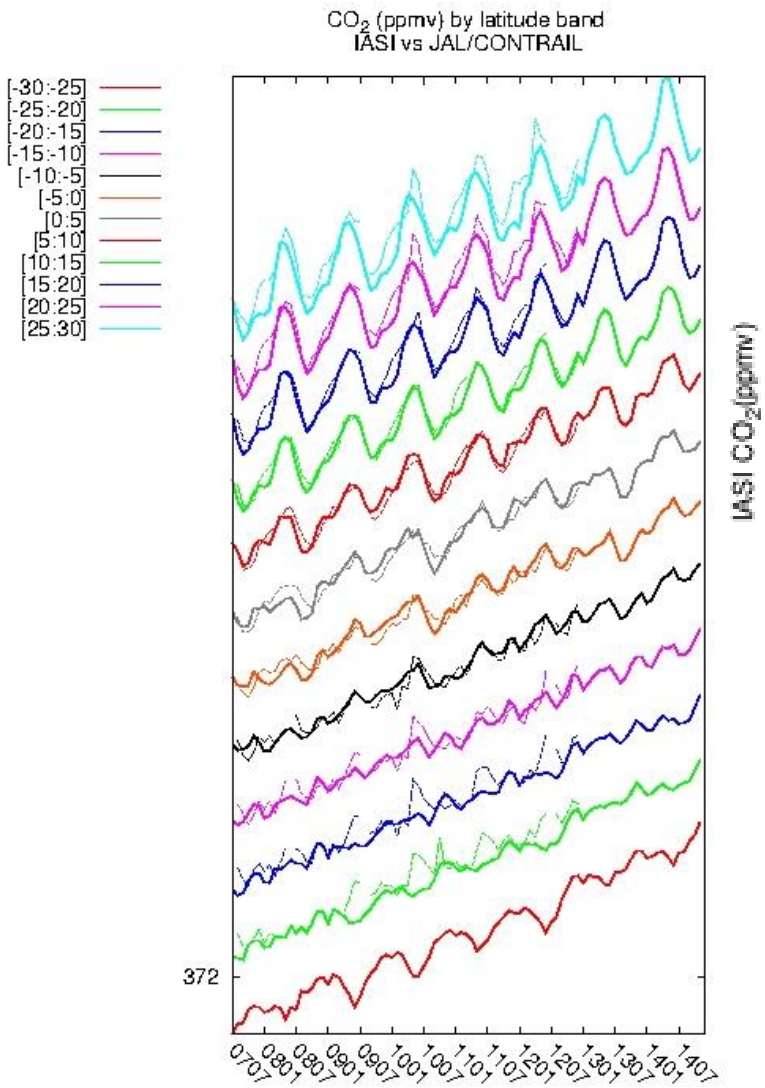
But need of full profile measurements for proper validation.

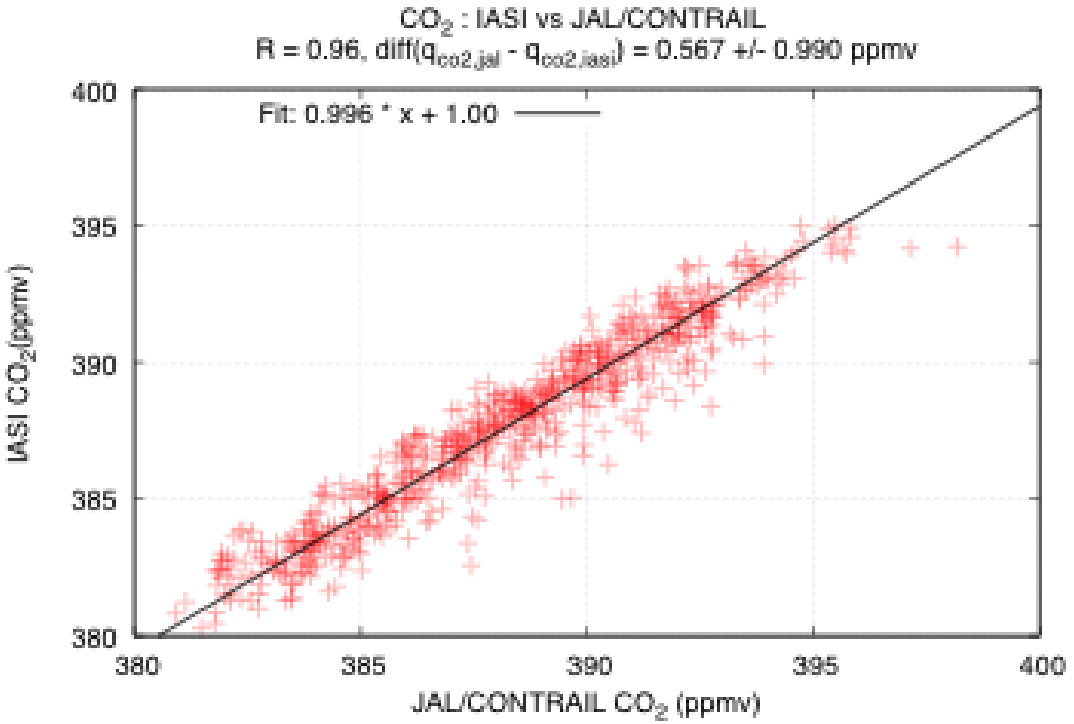
→ **see Membrive's talk (Thursday, 14:20) on L2 validation with aircraft and balloon instruments**

Validation with aircraft measurements: CONTRAIL (4/4)

Mid-tropospheric CO_2

Excellent stability between IASI/Metop-A and IASI/Metop-B…



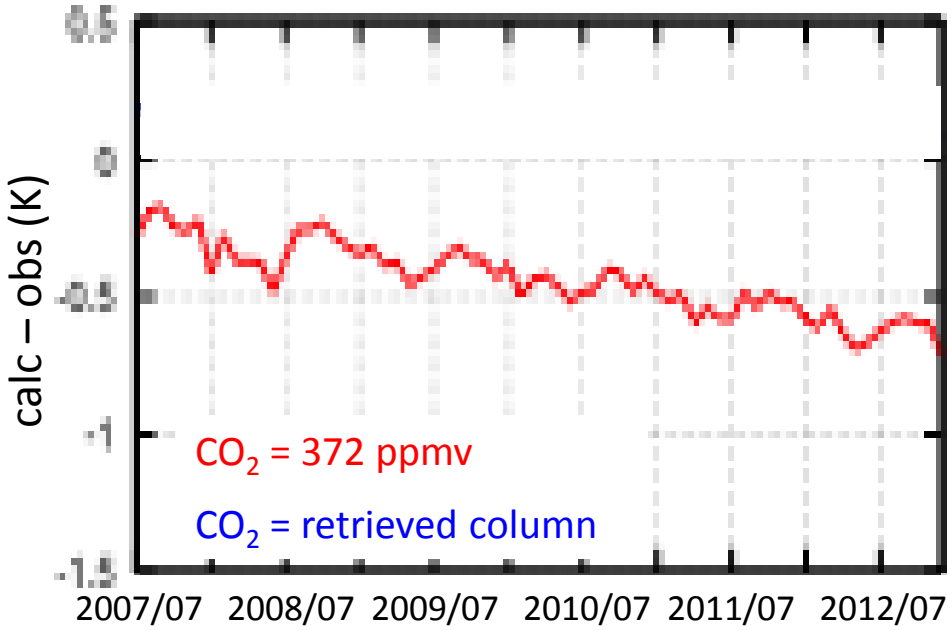


IASI CO_2 – CONTRAIL CO_2
=
0.57 ± 0.99 ppmv (R = 0.96)
(over 311 pairs)

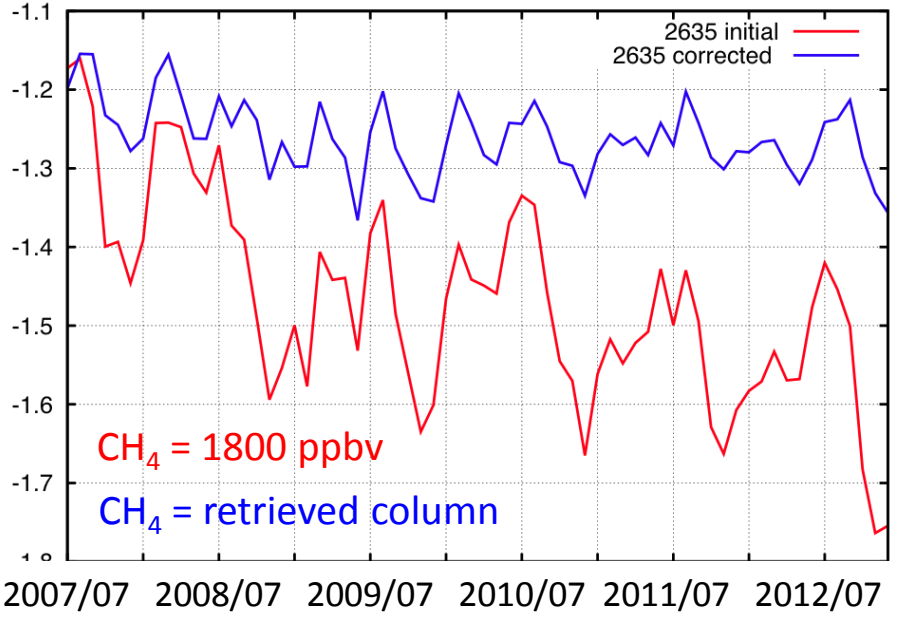
Validation through radiative transfer simulations

- Use of fixed or retrieved CO_2/CH_4 mid-tropospheric columns as inputs to RT 4A simulations on ARSA radiosounding database.
- Comparison with IASI co-located observations.

IASI channel @699.5 cm^{-1}



IASI channel @1303.75 cm^{-1}



Using the retrieved column cancels the CO_2/CH_4 signature in the calc – obs difference (residuals of ~0.1K).

→ see Armante's talk (Thursday, 13:20) on L2 validation through RT simulations

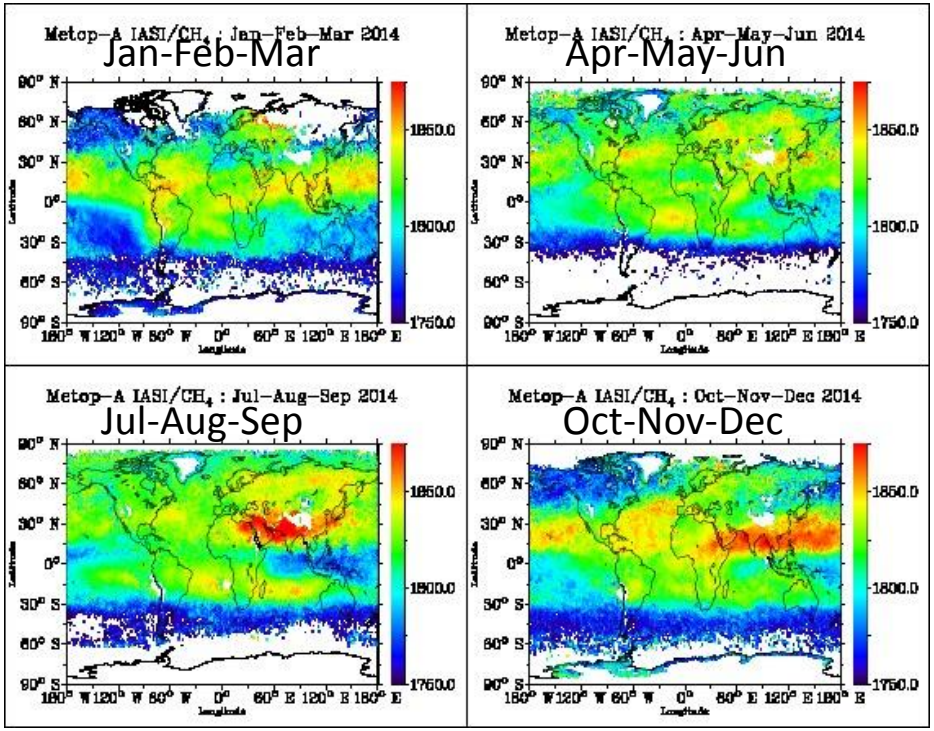
Mid-tropospheric CH_4: From Metop-A to Metop-B

2 year of CH_4 mid-tropospheric column from Metop-B

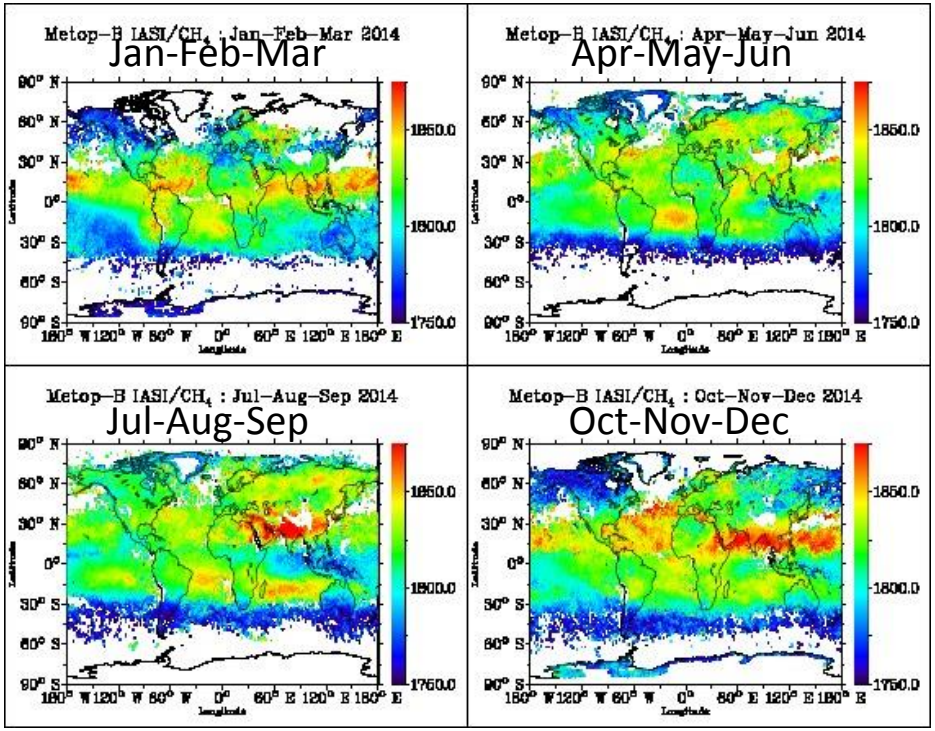
- The inference scheme has been adapted to IASI/AMSU onboard Metop-B and 2 years have been processed (Feb. 2013-Jan. 2014).
- Same networks.
- Systematic radiative biases computed for each platform.

Seasonal maps of mid-tropospheric CH_4 column for 2014

Metop-A



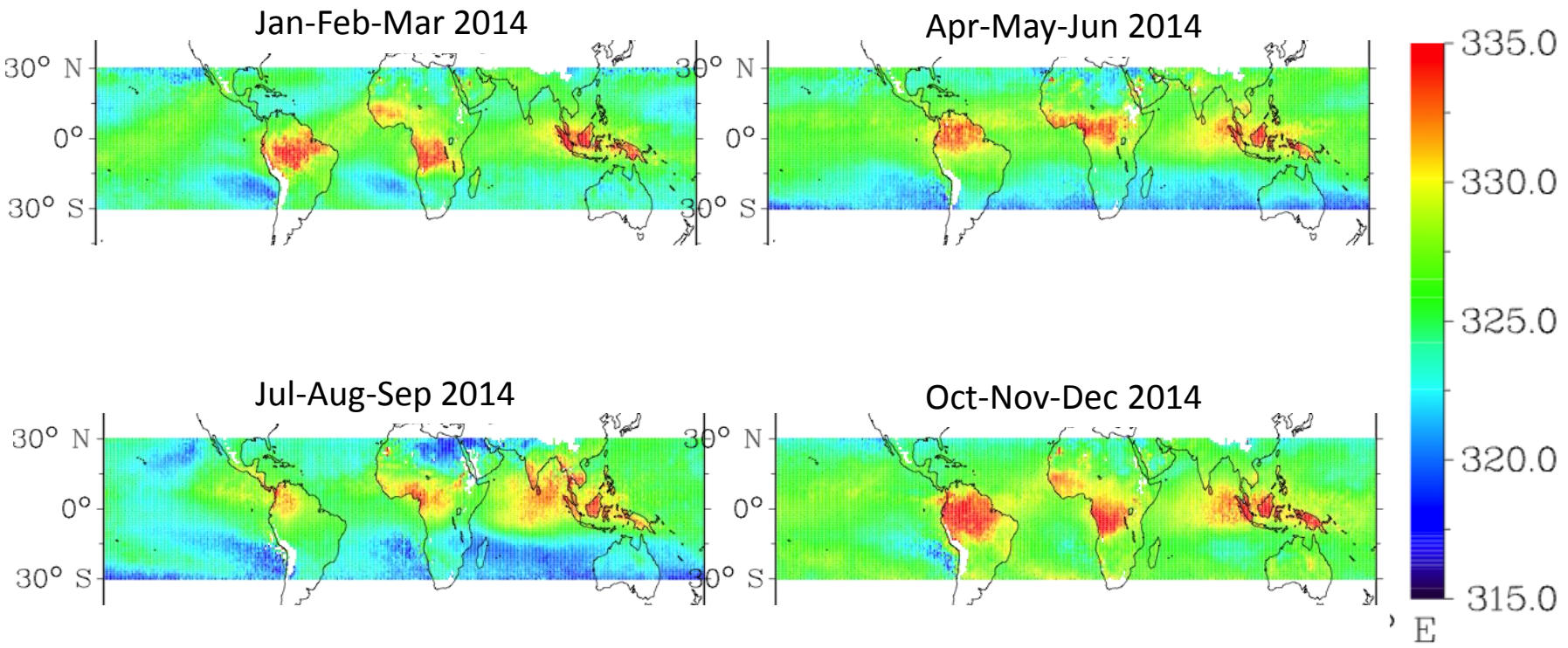
Metop-B



Mid-tropospheric N_2O

Preliminary results: simultaneous retrieval of CH_4 and N_2O

Seasonal mid-tropospheric N_2O (ppb) column from IASI/Metop-A



- Based on 7.7µm CH_4 channels' sensitivity to N_2O.
- Networks trained to retrieve simultaneously CH_4 and N_2O.

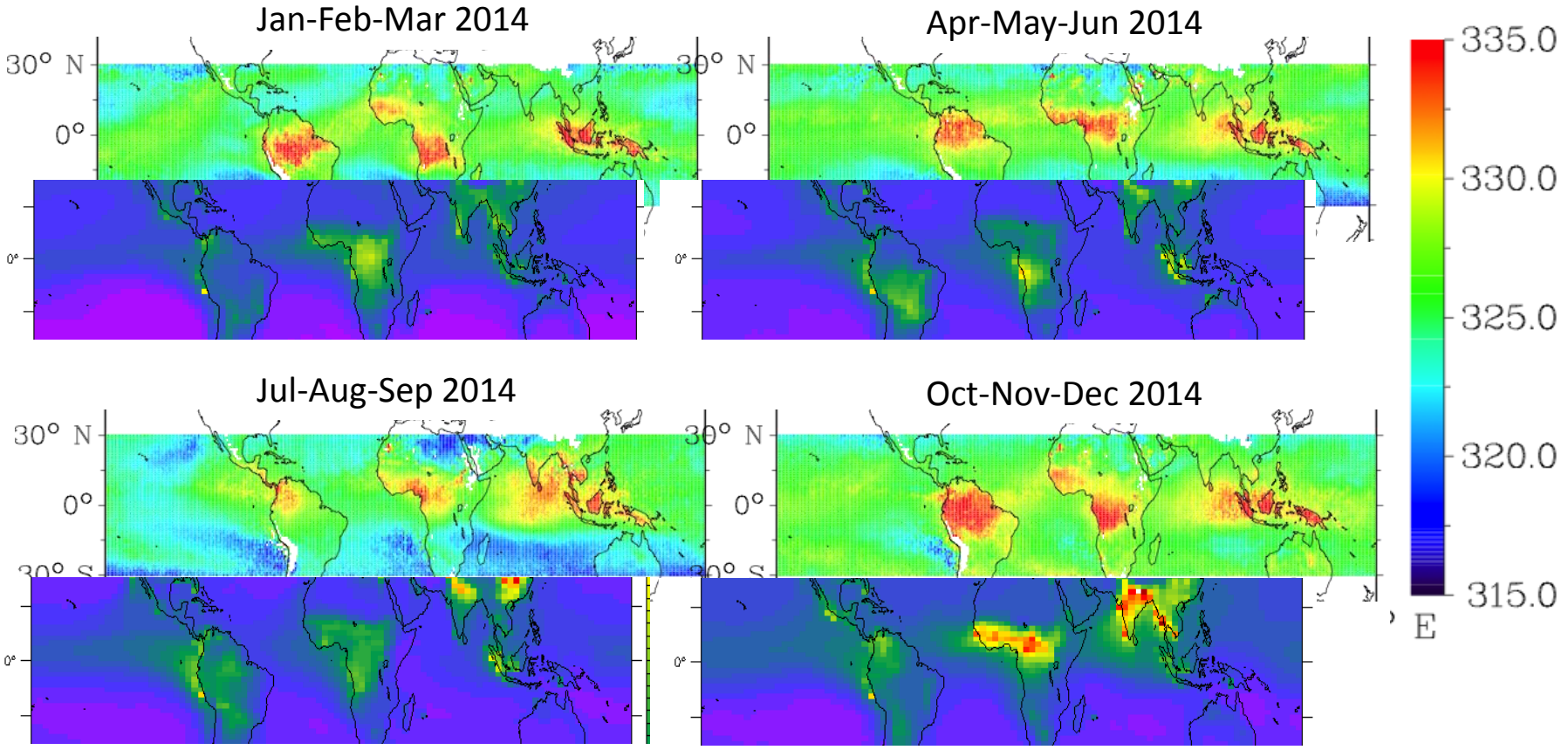
→ CH_4 fields not affected while delivering N_2O fields.

Mid-tropospheric N_2O

Preliminary results: simultaneous retrieval of CH_4 and N_2O

Seasonal mid-tropospheric N_2O (ppb) column from IASI/Metop-A

… and comparison with state-of-the-art LMDz4 atmospheric transport model



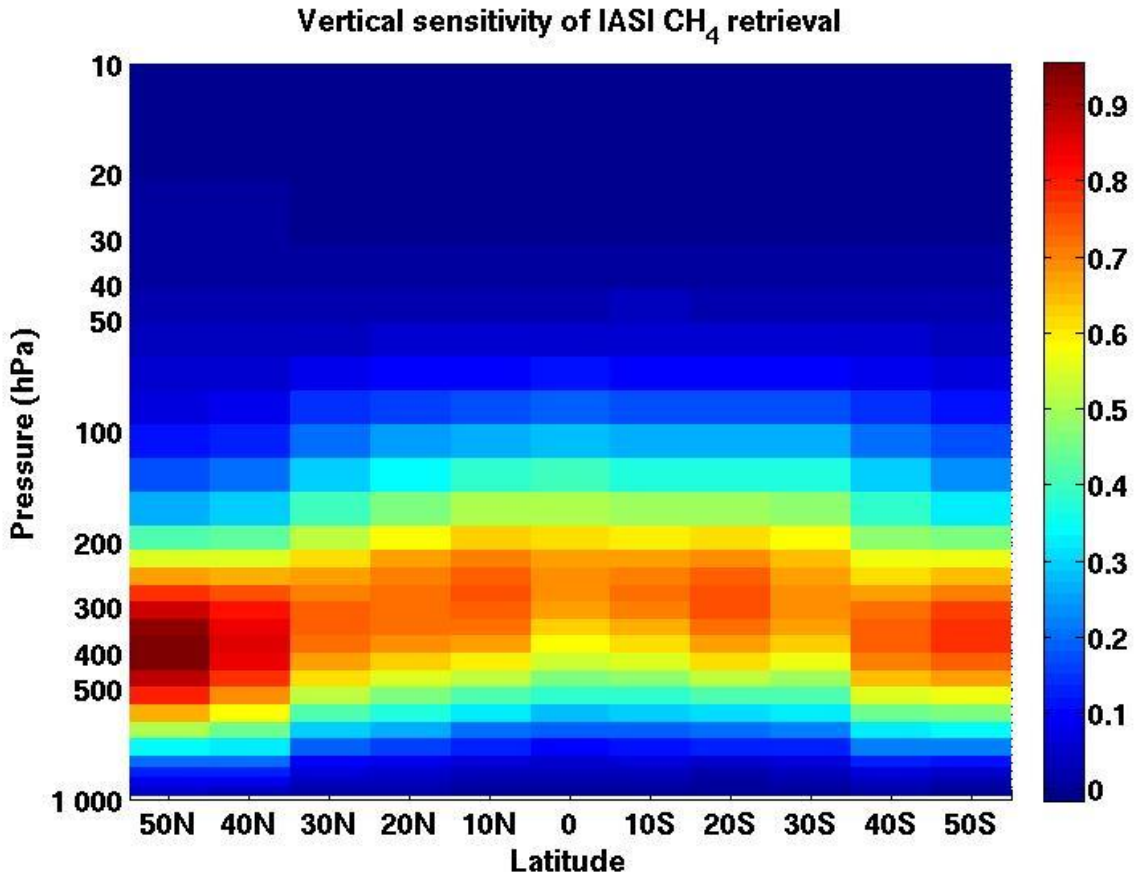
(R. Thompson, comm. pers.)

Summary

Gas	CO_2	CH_4	N_2O
Spatial	30N:30S	70N:70S	30N:30S
Temporal	NRT (D+1)	NRT (D+1)	Preliminary
Metop-A	2007-2015	2007-2015	2014
Metop-B	2013-now	2013-now	-
Users	CAMS, ESA-CCI-GHG	CAMS, ESA-CCI-GHG, Surface fluxes	-

Main issue: loss of both AMSU 7 and 8 channels on Metop-A…
→Need to rely on AMSU 6 only: OK for CH_4, not for CO_2
→Update and reprocessing needed.

Mid-tropospheric CH_4

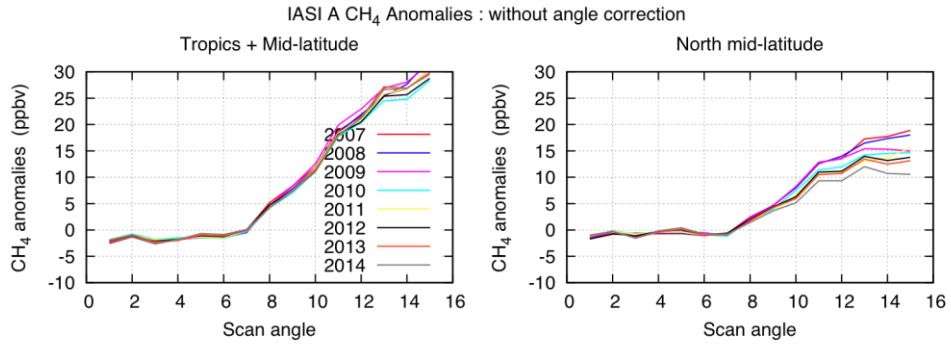


- In the tropics: max @ 250 hPa (~11 km) while tropopause @ 16 km.
- In the mid-lat: max @ 400 hPa (~7 km) while tropopause @ 8 km.

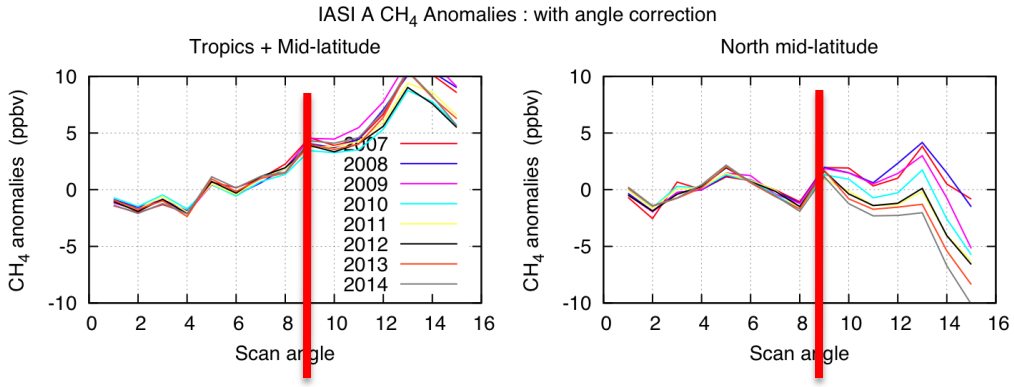
Mid-tropospheric CO_2

Impact of the scan angle

CH_4 anomalies as a function of scan angle



Without correction of scan-angle dependency of radiative biases



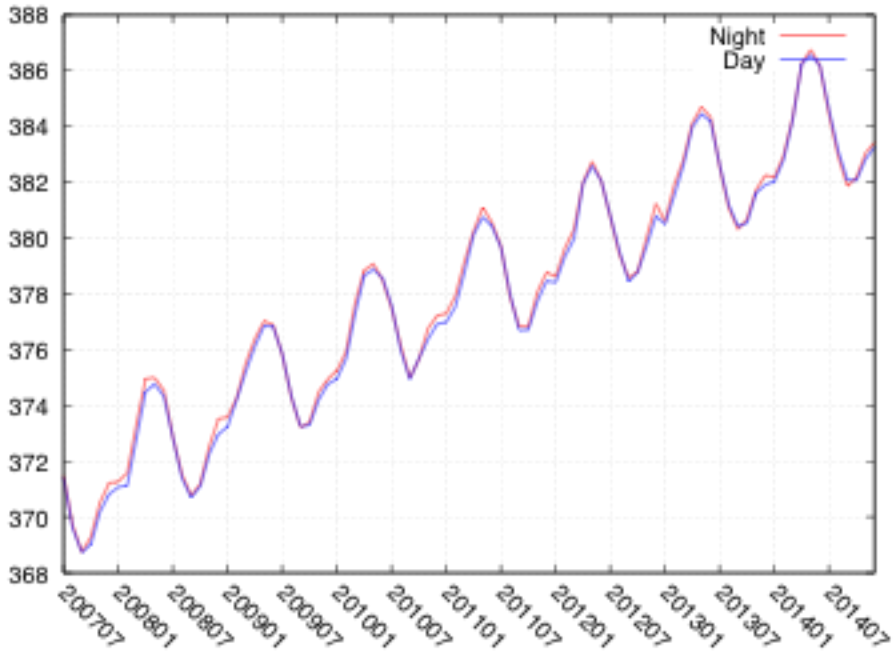
With correction of scan-angle dependency of radiative biases

Retrievals limited to scan angle 9

Mid-tropospheric CO_2

A few validations

Excellent stability between IASI/Metop-A and IASI/Metop-B…



Mid-tropospheric CO_2

A few validations

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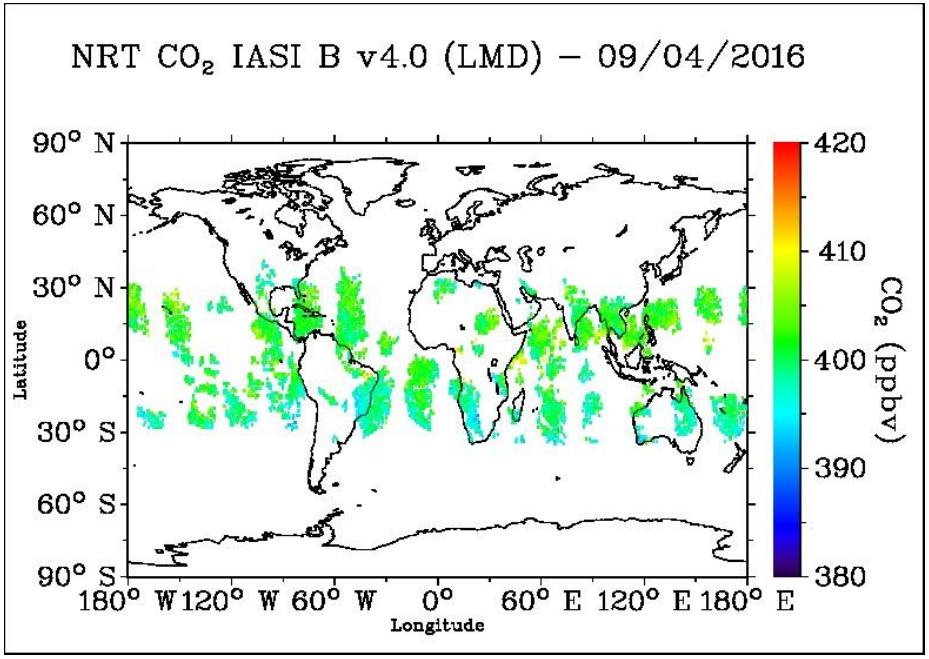
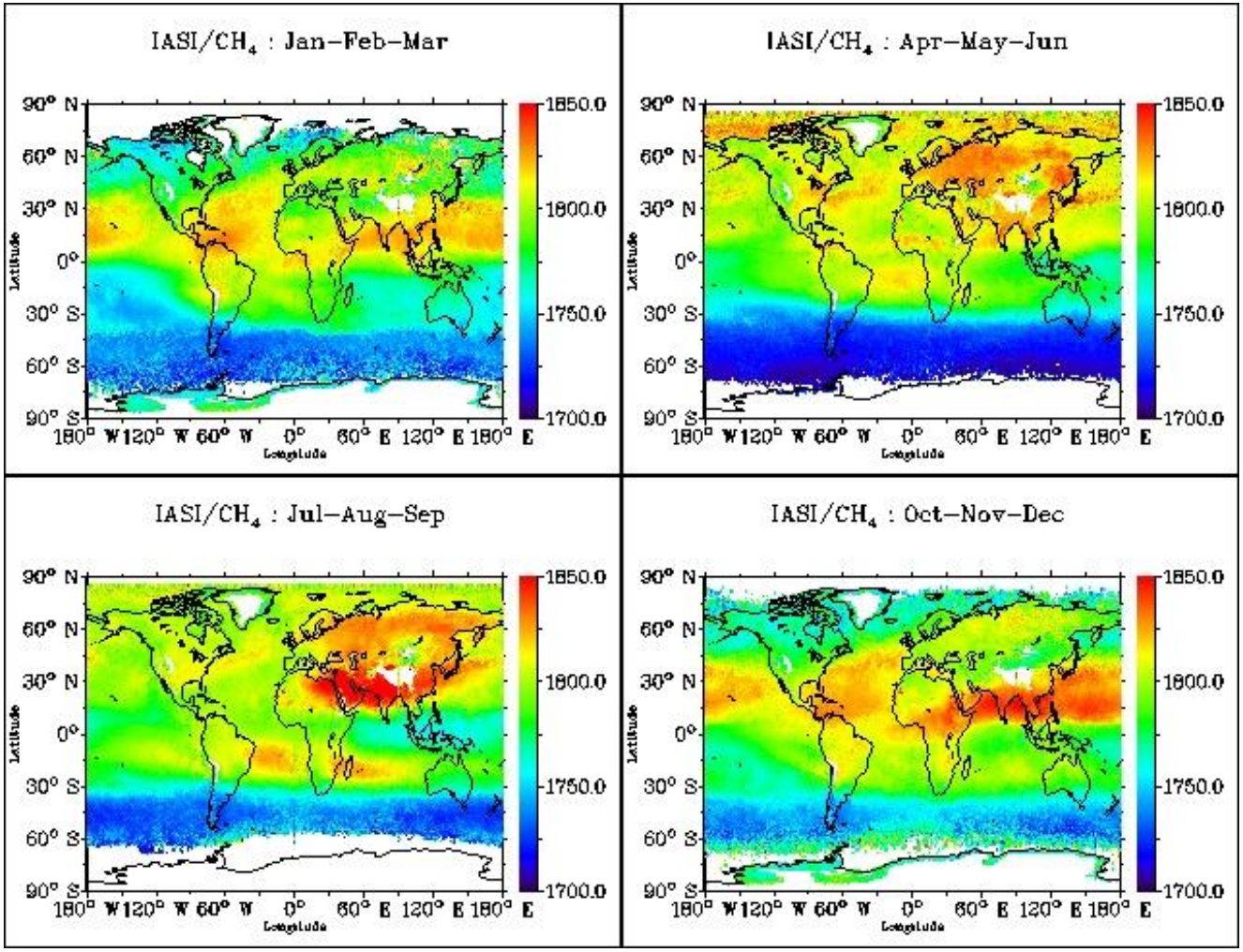


3. Retrieval of mid-tropospheric column of CH_4 from Metop-A

8 years of CH_4 from Metop-A

Seasonal maps of IASI CH_4 – Average over July 2007-June 2015



Mid-tropospheric CO_2

A few validations

Excellent stability between IASI/Metop-A and IASI/Metop-B…