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Recent evolution of mid-tropospheric CH_4 in the tropics: 5 years from MetOp-A/IASI

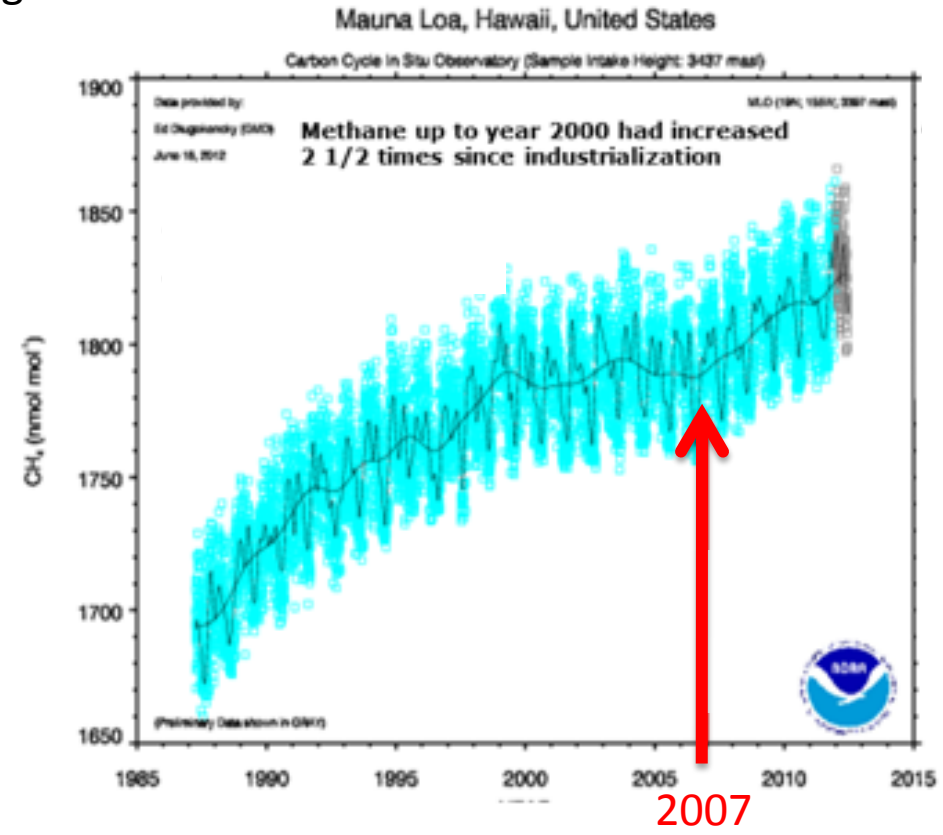
C. Crevoisier[1], R. Armante[1], T. Machida[2], Y. Sawa[3], H. Matsueda[3], T. Schuck[4],T. Thonat[1], L. Crépeau[1], N. A. Scott[1], and A. Chédin[1]

[1]LMD/CNRS, [2]NIES, [3]MRI, [4]MPI

http://ara.abct.lmd.polytechnique.fr

Why monitoring CH_4 from space?

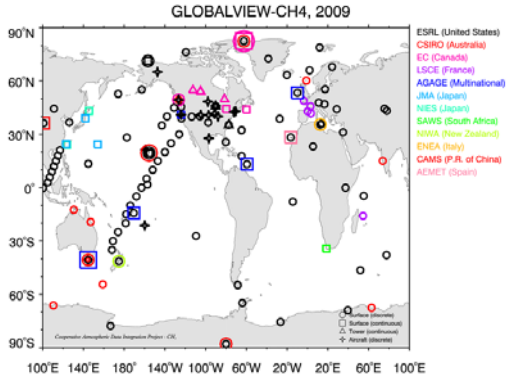
Methane is the third most important greenhouse gas in the atmosphere, after water vapor and CO_2, and is responsible for about 20% of the total radiative forcing by long-lived greenhouse gases.



CH_4 average concentration mostly reflects the balance between **emissions from the surface** (**wetland emissions**, **rice paddies**) and **destruction by OH** in the troposphere.

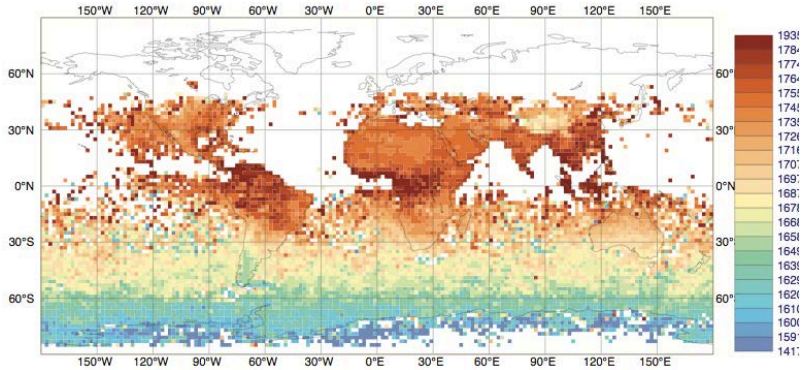
Observations of methane from the surface and from space

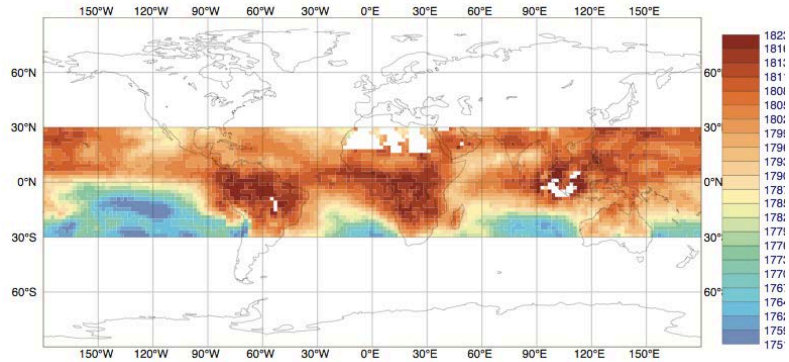
Surface stations

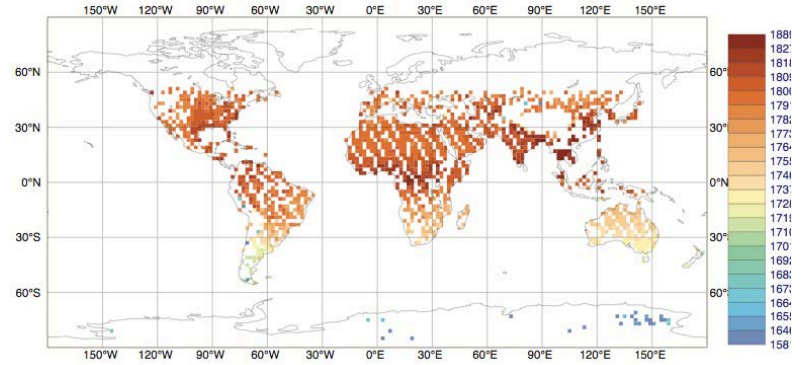


SCIAMACHY

2002-2012 | total column of CH_4
mostly over land, daytime







IASI

since July 2007| mid-tropo. column of CH_4
over land and sea, day and night

TANSO-FTS

since 2009| total column of CH_4
over land, daytime

+ IASI-B, -C, IASI-NG….

Retrieval of CH_4 from IASI

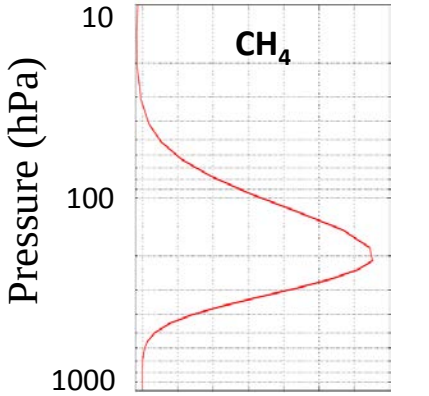
- Retrieval procedure (Crevoisier et al., 2009):
  - Use of IASI channels around 1305 cm^{-1}.
  - Non linear inference scheme based on neural networks (Chédin et al., 2003).
  - Based on the 4A RT code and the latest edition of the GEISA database.
  - Radiative biases are computed using the ARSA database.
  - CH_4 and T(p) are intimately correlated in the IR.

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

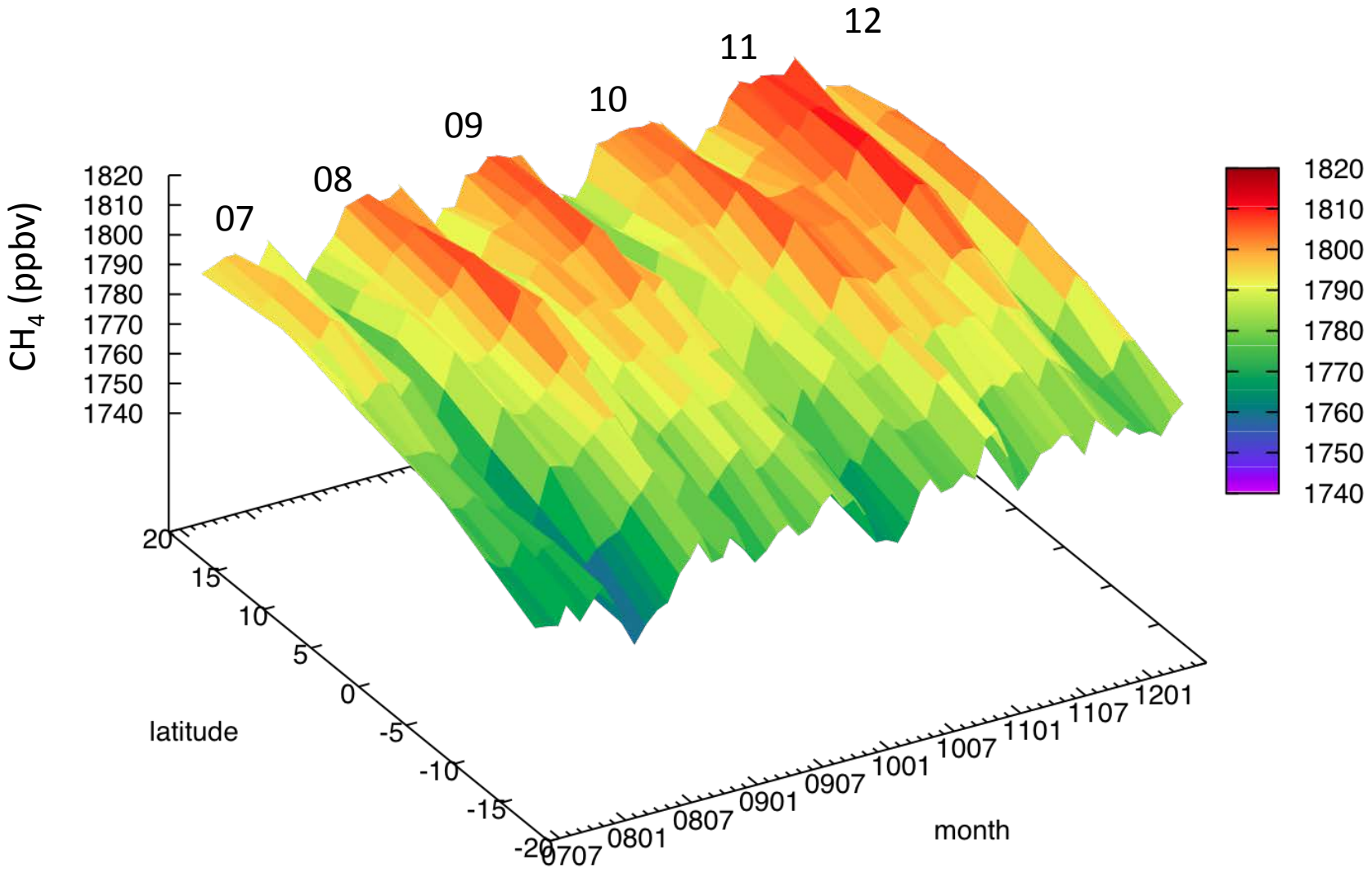
Weighting functions



We have now ~5.5 years (July 2007 – December 2012) of monthly averaged mid-tropospheric **CH_4** integrated content from **IASI**.

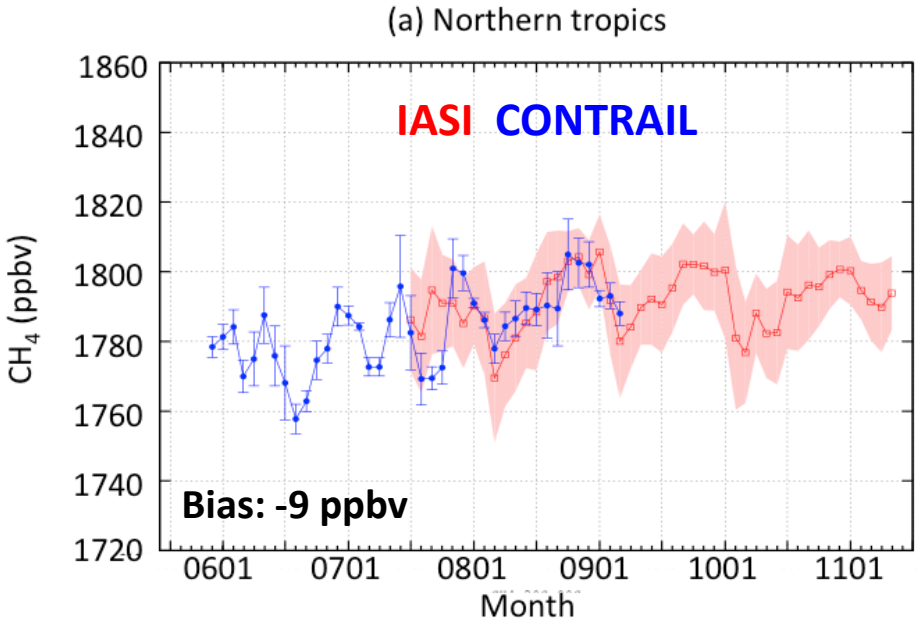
Mid-tropospheric CH_4 from IASI

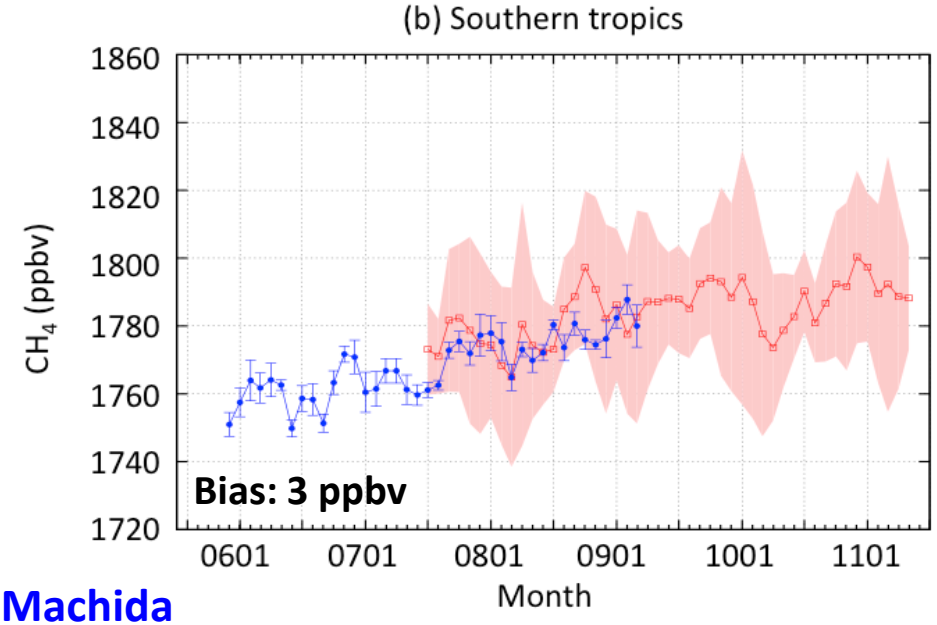
Zonally averaged tropical distribution of mid-tropospheric CH_4 as retrieved from IASI from July 2007 to June 2012



Crevoisier et al., ACPD, 2012

Comparison with CONTRAIL aircraft measurements



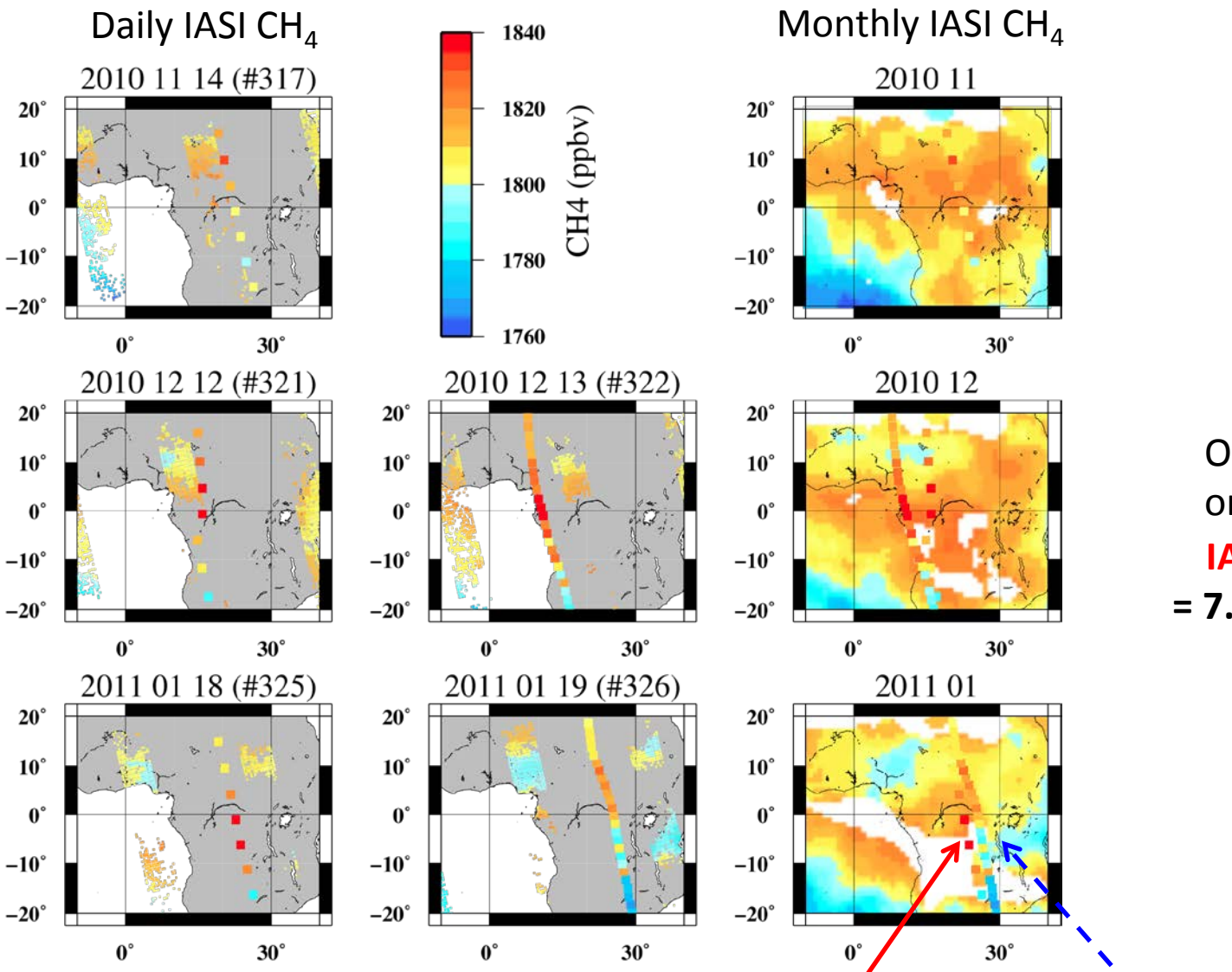


NB: IASI CH_4 ~6-16 km

aircraft CH_4 ~10 km

Collab. H. Matsueda, T. Machida

Comparison with CARIBIC aircraft measurements



Over 13 flights,
on a 4°x4° grid:

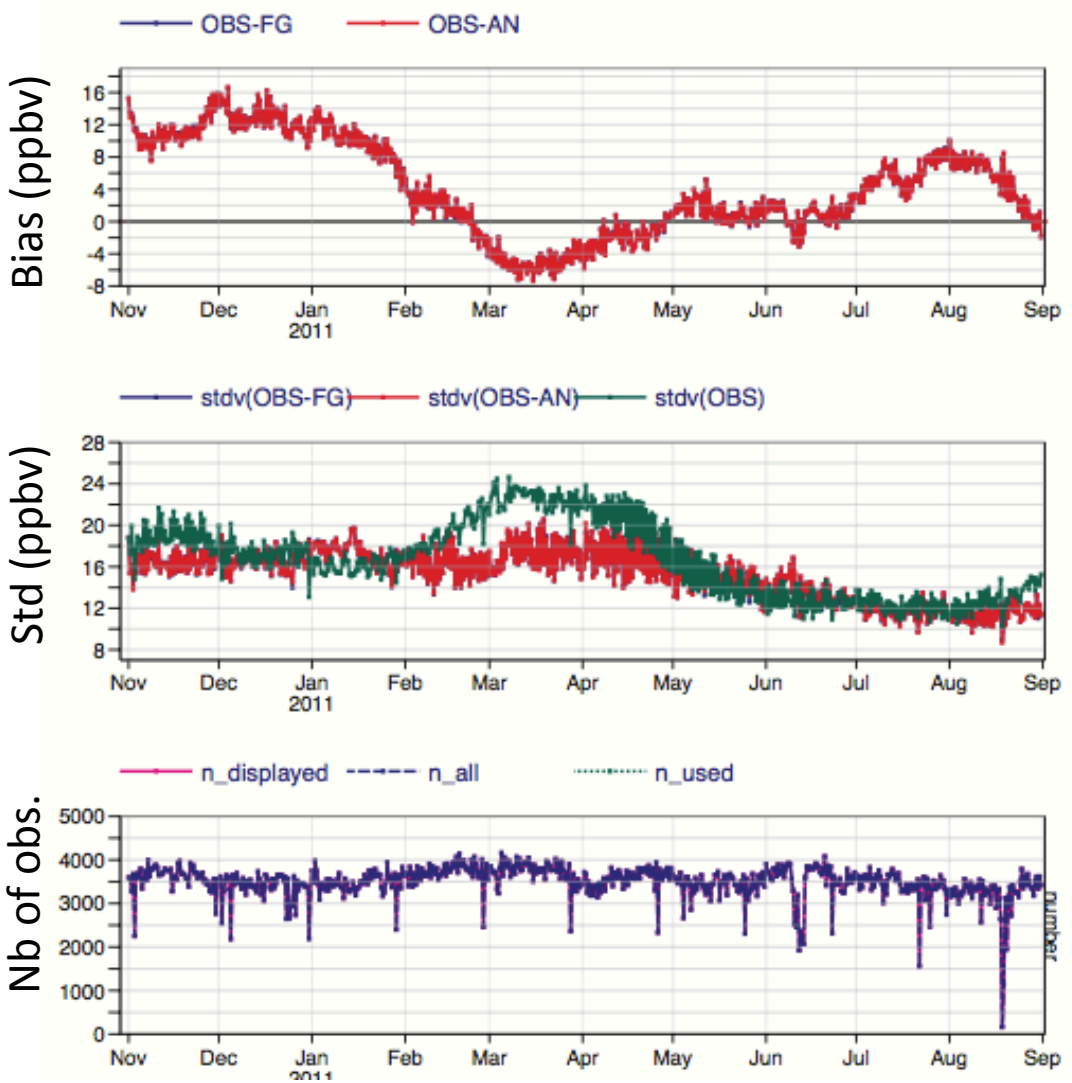
IASI – CARIBIC

= 7.2 ± 13.1 ppbv

Collab. T. Schuck

Monitoring of IASI CH_4 at ECMWF

- GOSAT CH_4 total column fields are now assimilated within the ECMWF IFS system.
- IASI CH_4 partial column are monitored by comparing them with the analysis.



Courtesy of
S. Massart

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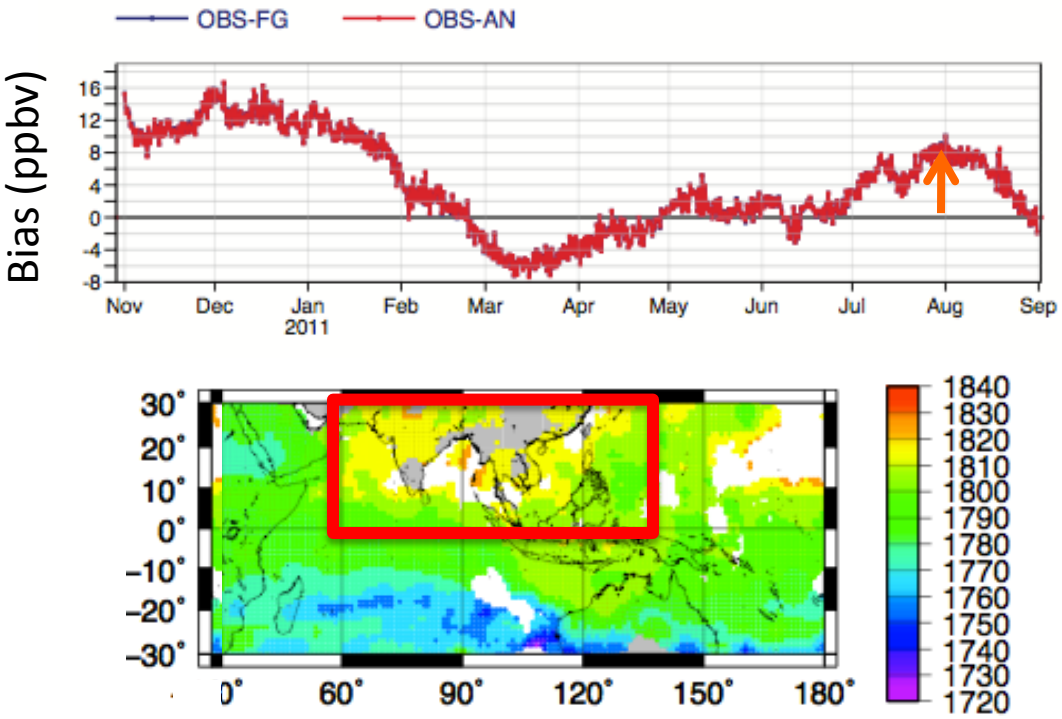

Rice emission in Asia

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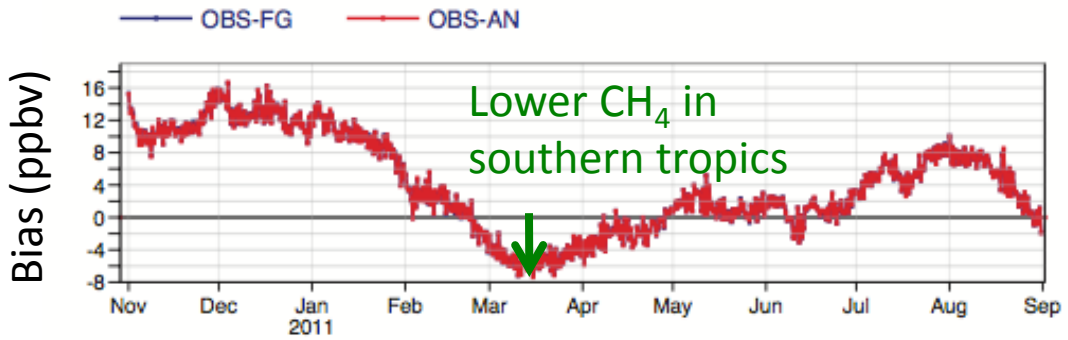
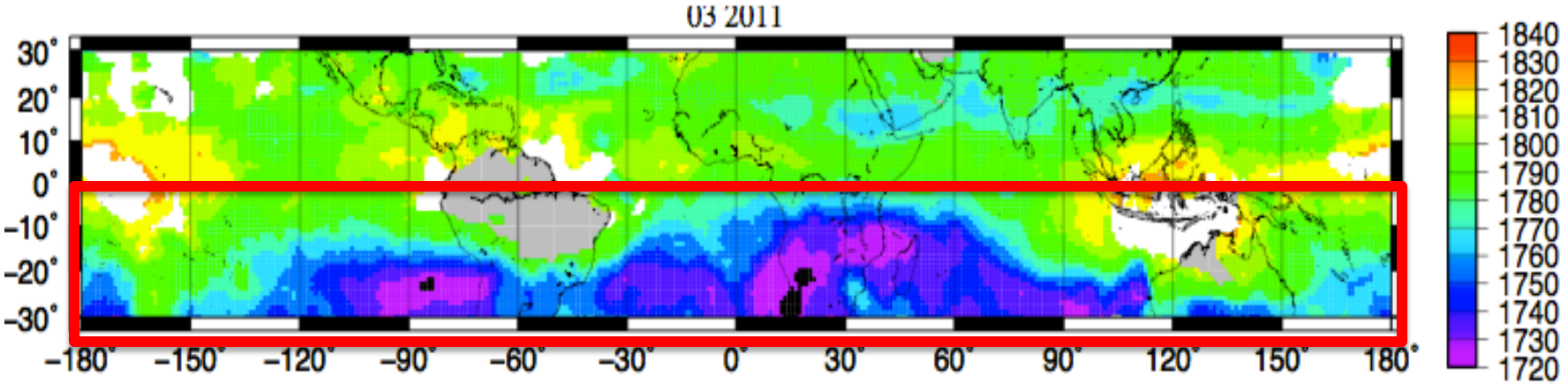
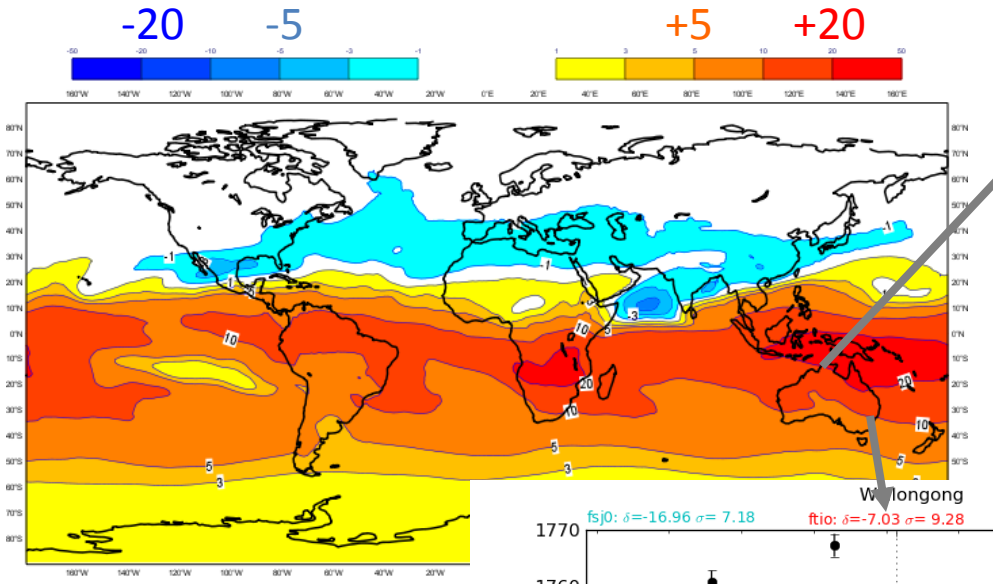


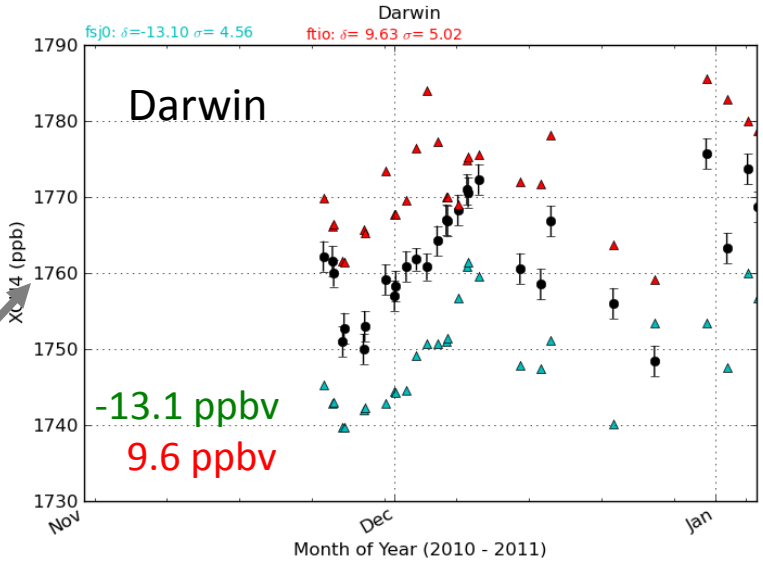


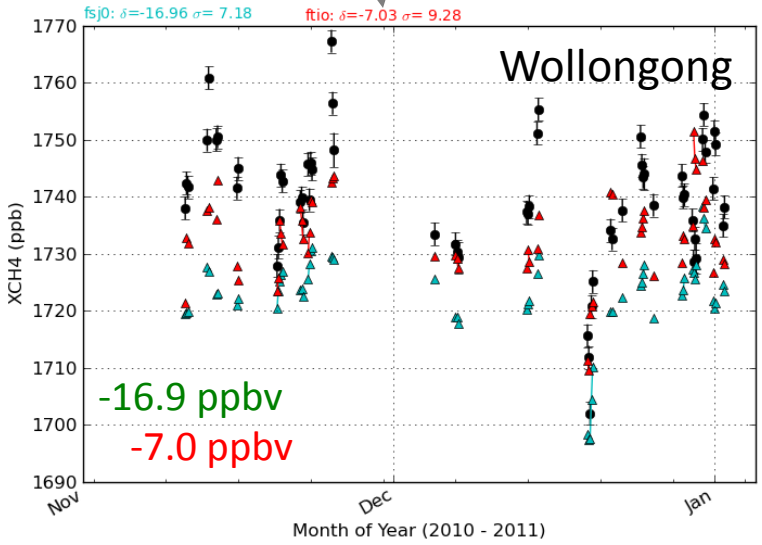
~~Monitoring~~ Assimilation of IASI CH_4 at ECMWF

- **Breaking news: IASI CH_4 fields are now being assimilated within IFS!**

Difference in CH_4 total column (Dec. 2011)
Anal. (IASI+GOSAT) – Anal. (GOSAT)







TCCON

IFS (GOSAT)

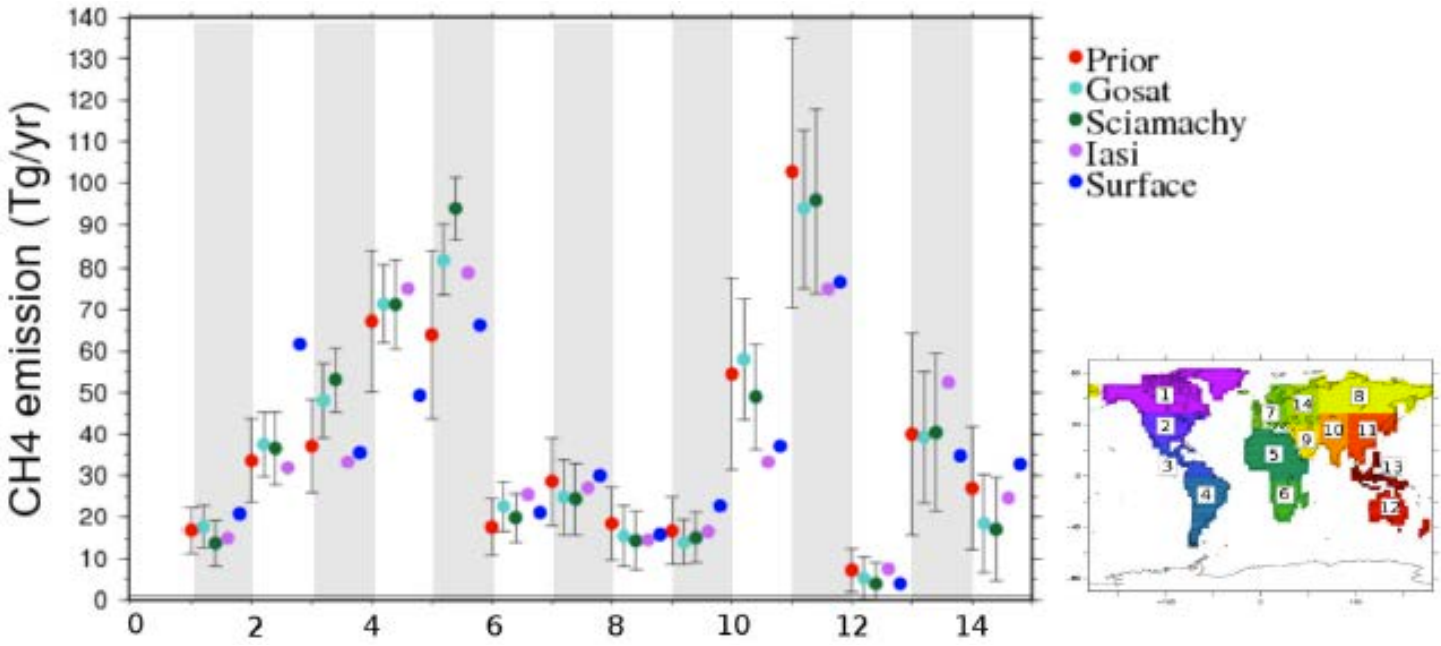
IFS (IASI+GOSAT)

Courtesy of S. Massart

Estimation of CH_4 surface emissions

IASI CH_4 is also used within a Bayesian inversion system in order to infer global and regional methane fluxes up to the grid-point weekly scale.

Regional emissions: August 2009-July 2010



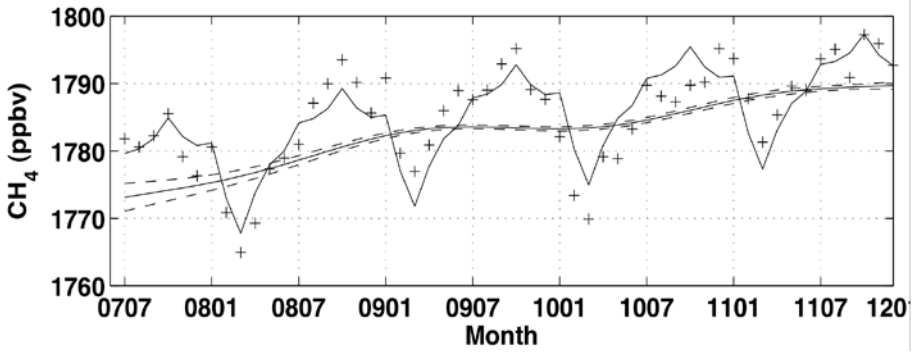
	Global emissions (Tg/yr)	Sigma (Tg/yr)
Prior	551	± 53
SURFACE	529	
IASI	531	
GOSAT Leicester	571	± 29
SCIAMACHY	573	± 26

- Decrease of global emissions for IASI and surface.
- Increase of global emissions for SCIAMACHY and GOSAT.

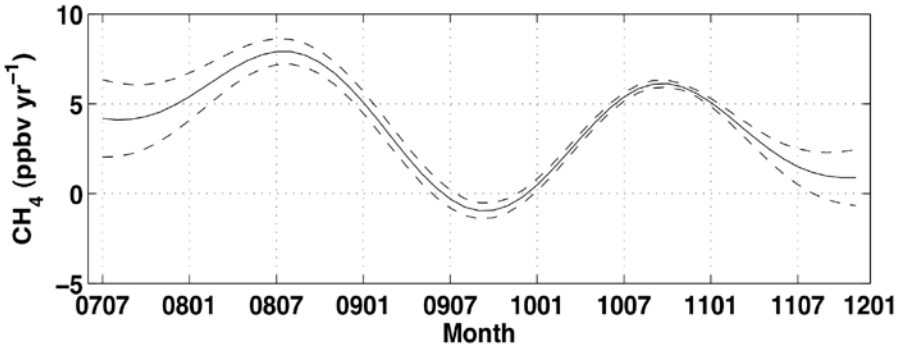
Courtesy of C. Cressot

Growth rate of mid-tropospheric CH_4 from IASI

Fit of IASI CH_4 (whole tropical band)



CH_4 instantaneous growth rate



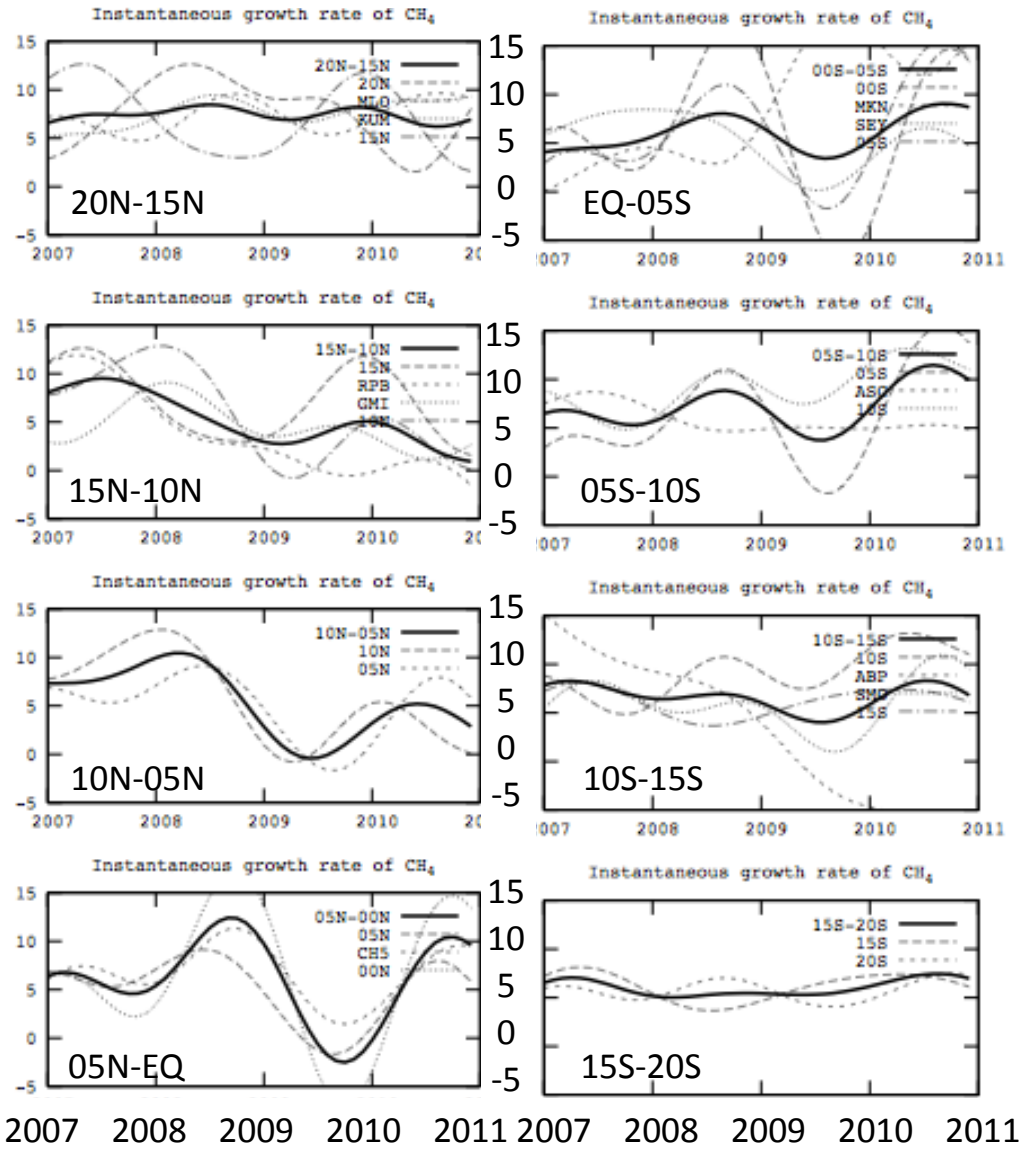
Procedure (following e.g. Dlugokencky et al., 1994):

- Fit: Polynomial trend + 4 harmonics / filering by low-pass filters.
- Deseasonalized long-term trend = polynomial trend + filtered residuals.
- Instantaneous growth rate = derivative of this function.

Crevoisier et al., ACPD, 2012

Growth rate of mid-tropospheric CH_4 from IASI

GR from NOAA surface network



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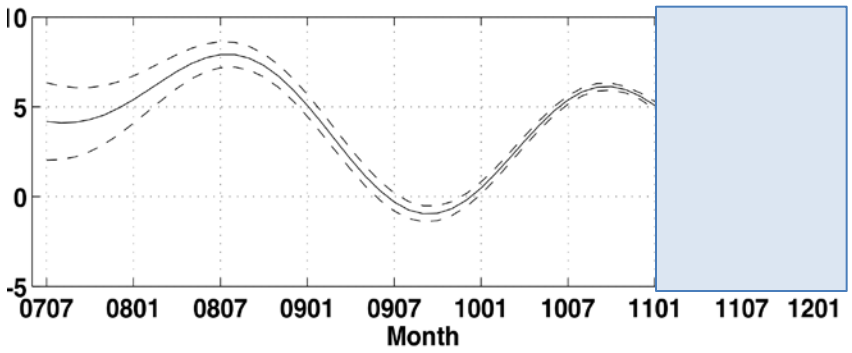

Very good agreement between IASI and surface tropical growth rate

IASI has the potential to follow methane trend on the long-term

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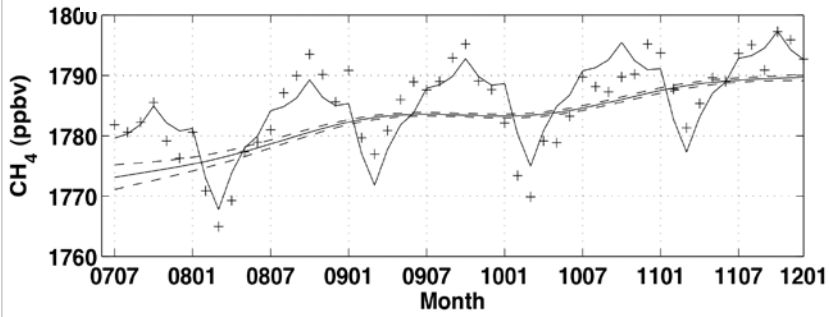


Annual increase (ppbv yr^{-1}) in CH_4

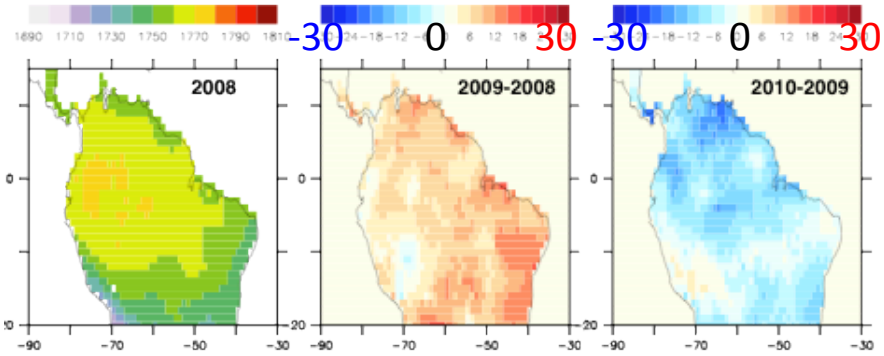
	IASI			Surface (Dlugokencky et al. 2009)	
Year	20N:20S	20N:EQ	EQ:20S	NH	SH
2007	9.5 ± 2.8	8.2 ± 1.8	10.7 ± 2.5	7.3 ± 1.3	9.2 ± 0.3
2008	6.9 ± 1.3	6.0 ± 1.2	7.9 ± 1.2	8.1 ± 1.6*	
2009	1.0 ± 0.8	-0.3 ± 0.5	2.3 ± 0.7		
2010	4.2 ± 0.9	3.6 ± 0.5	4.8 ± 0.8		
2011	2.2. ± 0.7	2.5 ± 0.7	1.8 ± 0.7		

- Trend of +10 ppb.yr^{-1} in 2007, which decreases throughout 2008-2009.

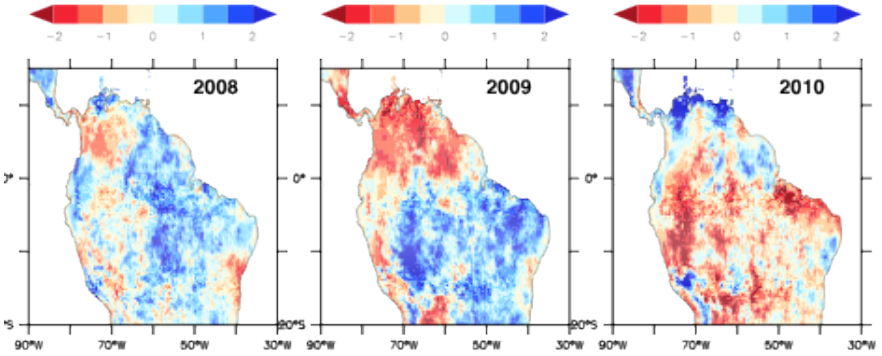
- The analysis of ECMWF precipitation fields reveals that precipitation has continuously decreased in wetland tropical regions over 2007-2009, the total rain fall in 2010 reaching a similar value to that of 2007.

Regional level: the Amazonian case

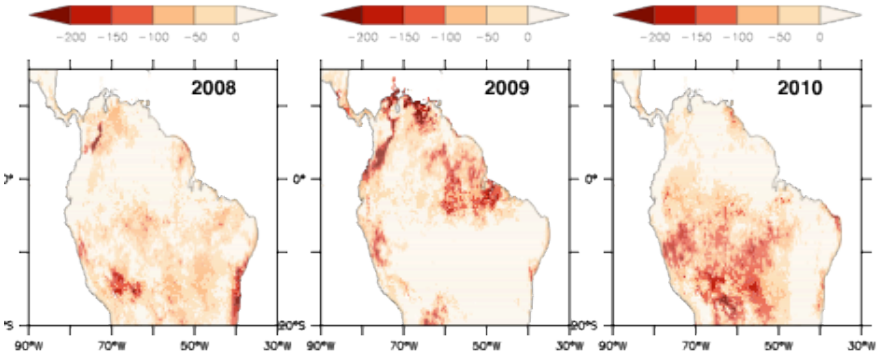
IASI CH_4 annual average (ppbv)



TRMM annual precipitation (mm)



Maximum water deficit

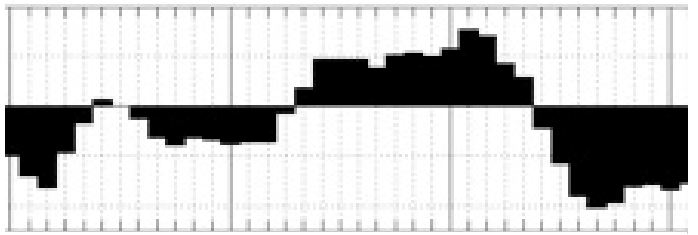


In 2010: severe drought in Amazonia

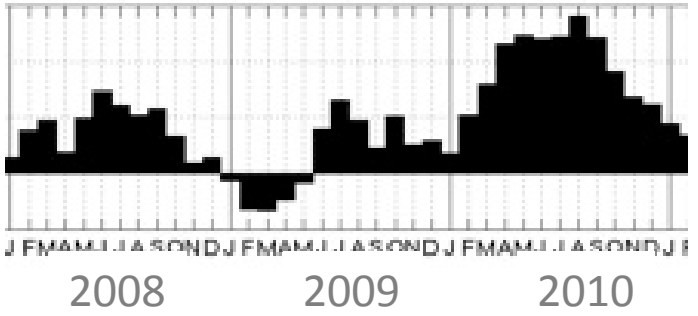
→ Decrease in wetland emission

Decrease of CH_4 of ~10ppbv detected by IASI.

Multivariate ENSO index



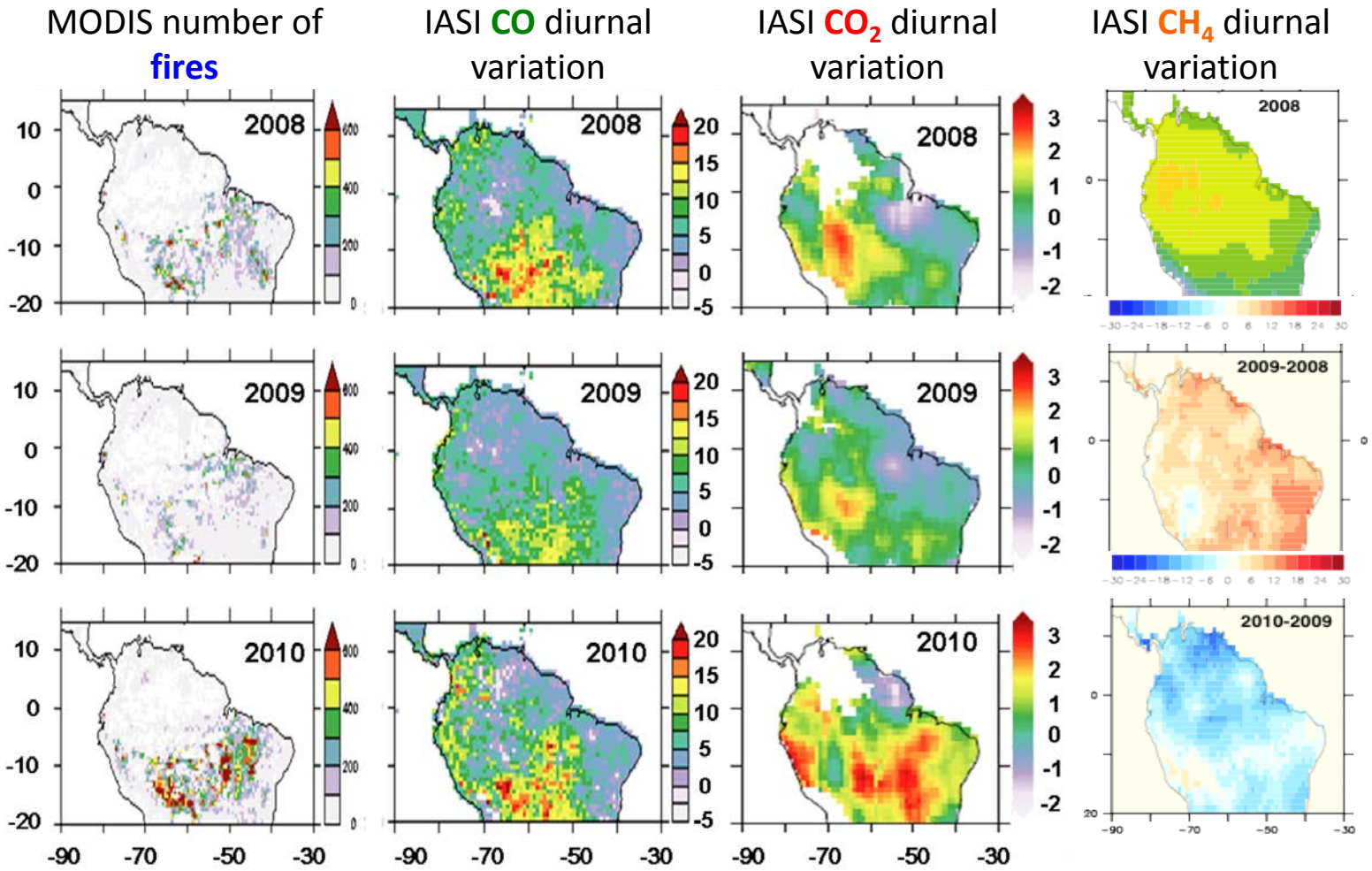
Atlantic Multidecadal Oscillation



Impact of climate variability on greenhouse gases

The 2010 very dry conditions also induced an increase in **fire**…

… well seen on **CO** and **CO_2** fields derived from IASI



IASI asset: simultaneous observation of CH_4, CO and CO_2.

Conclusion

- IASI can provide valuable information on methane cycle:

  - Long-term evolution (IASI-1, 2, 3 + IASI-NG)

    → IASI is part of the ESA CCI GHG (for both CH_4 and CO_2)

  - Information on surface emissions (even if we retrieve only CH_4 in the mid-troposphere).

    → Assimilation within the IFS system.

    → Added value to SWIR observations: both day and night, both land and sea

  - Link to climate factors, even at regional scale.

- The simultaneous retrieval of several gases is a clear asset to allow monitoring local to global events.

- Perspectives:

  - evaluation of the impact of GHG on radiative budget.

  - CH_4 at high latitudes ?

  - Synergy with lidar measurements (CNES/DLR Merlin mission).