© CNES/Photon/ill.Michel Regy, 2013

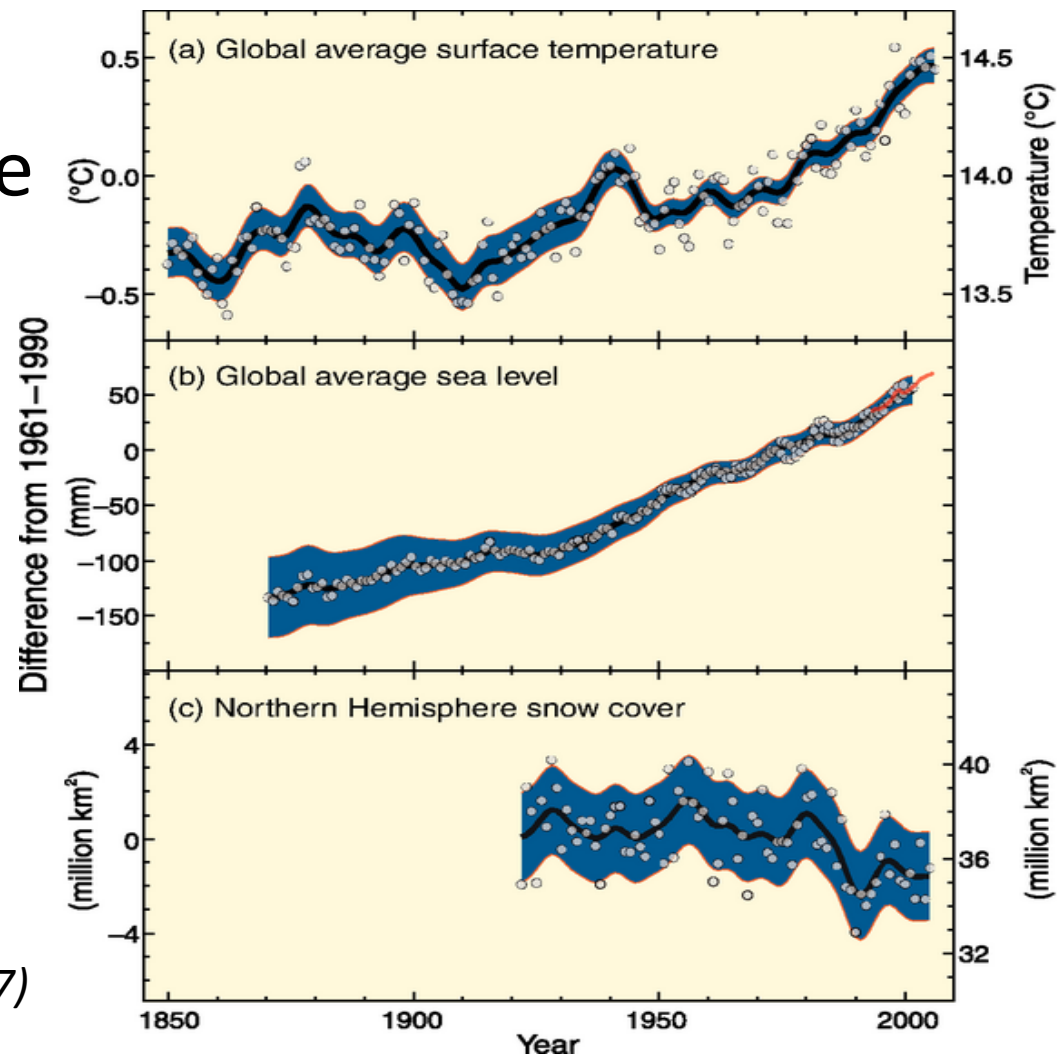# MEthane Remote sensing LIdar missioN
COPUOS, Vienna
12.-21. June 2013

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Climate Change

- Temperature Increase over the Earth

- Rising sea level

- Decreases in snow and ice extent

(IPCC report , 2007)

Climate protection measures require climate research.

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Scientific Background
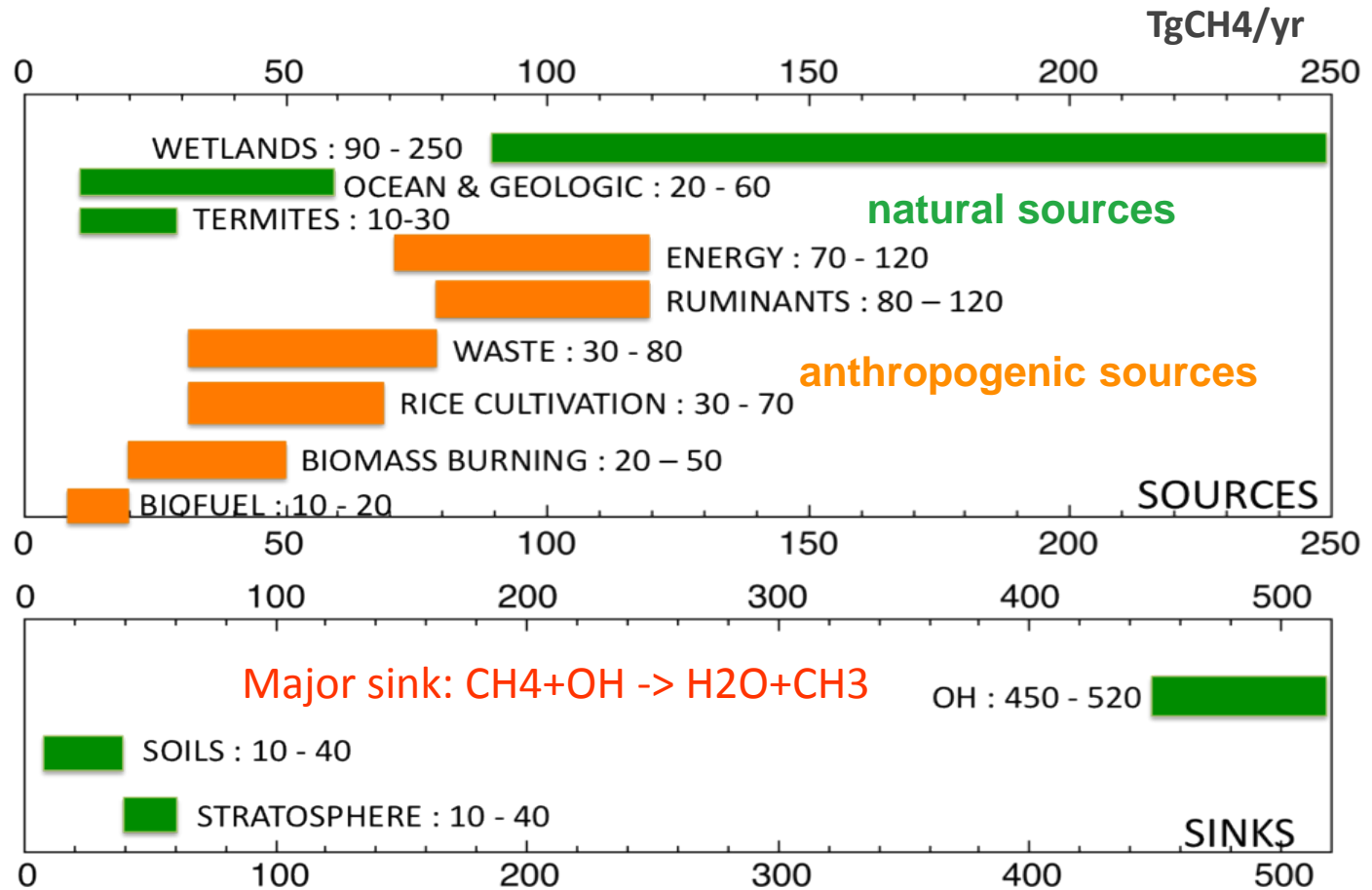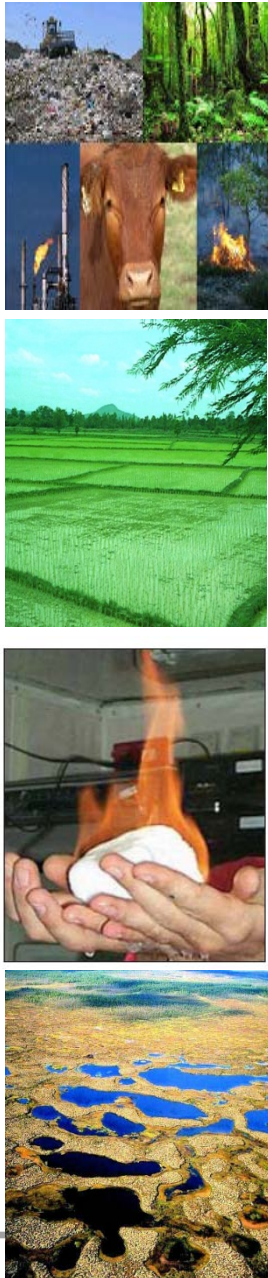
- CH_4 is second most abundant **anthropogenic greenhouse gas** with a **Global Warming Potential (GWP)** that is <u>25 times larger</u> than that of CO_2

- **Strongest change** in concentration due to **human activities** led to **doubling of its abundance** since pre-industrial times whilst CO_2 increased by 30%, "only"

- **Anthropogenic emissions** from gas leaks and incomplete combustions are **much more uncertain** than man-made emissions of CO_2

- The climate impact of the **reservoir of CH_4 in Arctic permafrost** is an important **unknown** in modelling **future climate**
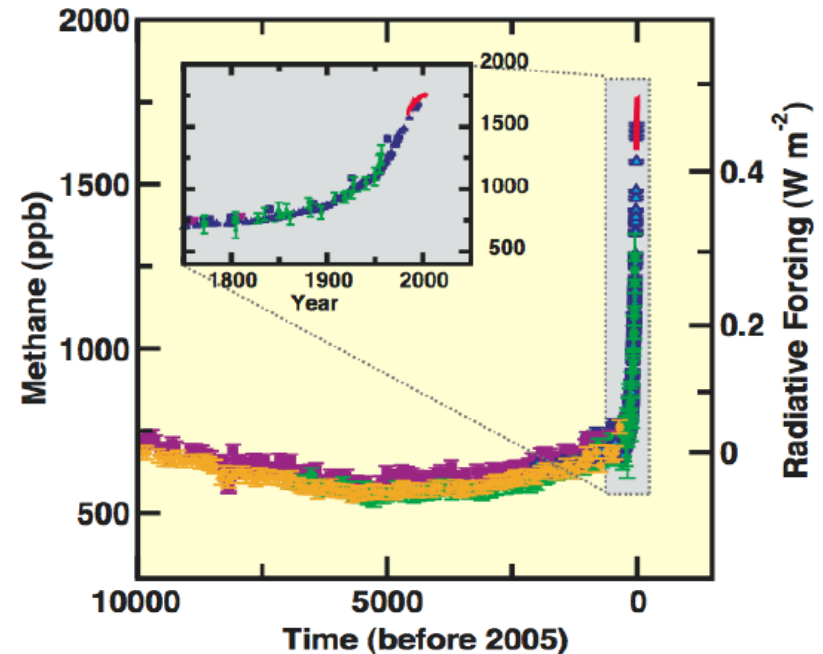
© IPCC, 2007

Atmospheric concentration of methane and corresponding radiative forcing over the last 10,000 years taken from ice core and atmospheric samples (red lines)

Sources & Sinks of methane

TgCH4/yr

WETLANDS : 90 - 250
OCEAN & GEOLOGIC : 20 - 60
TERMITES : 10-30

natural sources

ENERGY : 70 - 120
RUMINANTS : 80 – 120

WASTE : 30 - 80

anthropogenic sources

RICE CULTIVATION : 30 - 70

BIOMASS BURNING : 20 – 50

BIOFUEL : 10 - 20

SOURCES

Major sink: $CH_4 + OH \rightarrow H_2O + CH_3$

OH : 450 - 520

SOILS : 10 - 40

STRATOSPHERE : 10 - 40

SINKS

Methane is emitted by natural and anthropogenic sources.
Uncertain to a factor of 2 for individual sources (IPCC, 2007)

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MERLIN Mission
MEthane Remote Sensing LIdar MissioN

Political Background

Decision by **Sarkozy/Merkel** to develop and launch a joint Franco-German methane monitoring mission (**Franco-German Agenda 2020**, Feb. 2010).
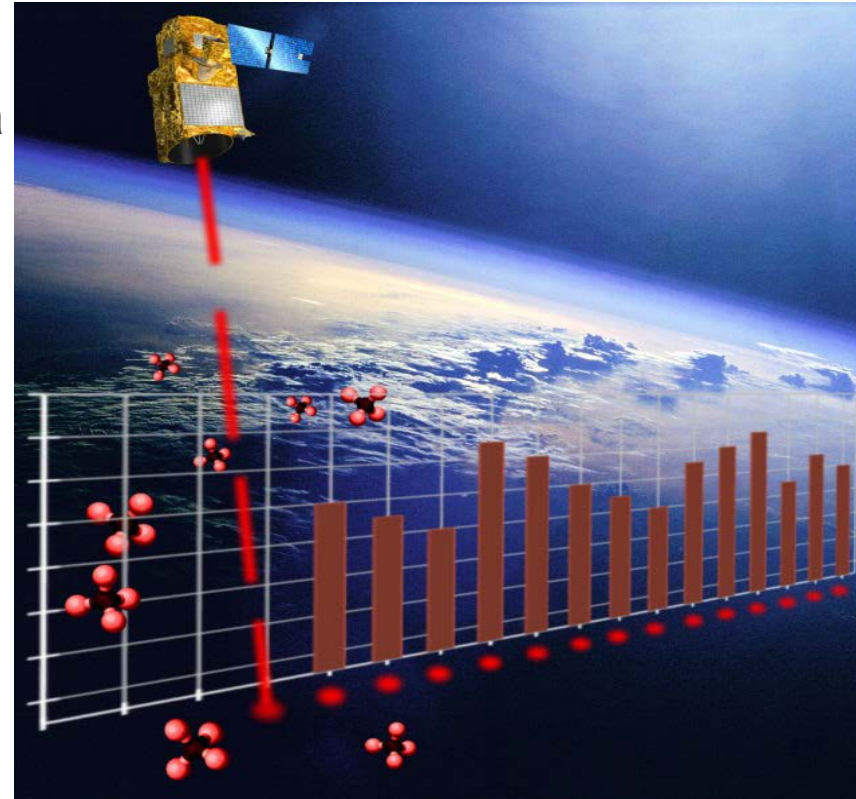
Mission Objectives
Primary

- High accurate space-borne measurements of **spatial** and **temporal variability** of **total atmospheric methane amount**

- *Inverse models* to achieve **methane fluxes** (emissions) & errors

Secondary (tentatively)

- Surface properties & Vegetation Contribution to cloud/aerosol data base

(Source: DLR)

MERLIN Facts

➢ <u>Low Earth orbit satellite for global methane column measurements</u>

➢ <u>Measurement principle</u>:

Integrated Path Differential Absorption (IPDA) LIDAR in the near IR using pulsed laser transmitter and range-gated receiver in nadir-viewing mode

    ✓ First space-borne system

➢ <u>Franco-German cooperation (CNES & DLR Space Administration)</u>:

    MYRIADE Evolutions platform, satellite operation, launch, F part of payload ground segment

    IPDA LIDAR system, G part of payload ground segment

➢ <u>Main data product</u>:

Column-weighted dry-air mixing ratios of methane, over satellite sub-track.

➢ <u>Satellite class</u>:

Small satellite (CNES MYRIADE Evolutions platform)

➢ <u>Launch date</u>: 2017 (3 years mission)
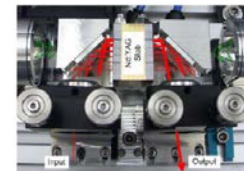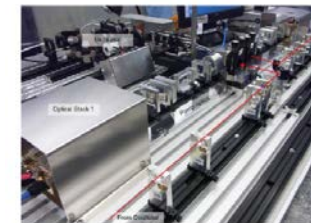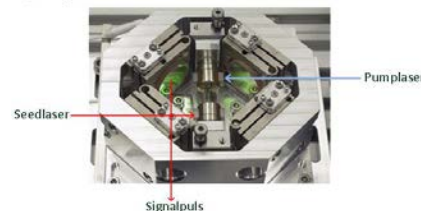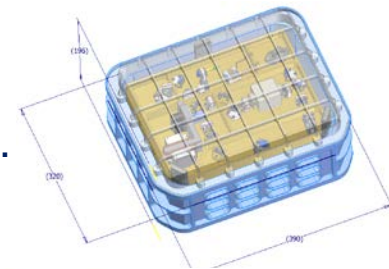
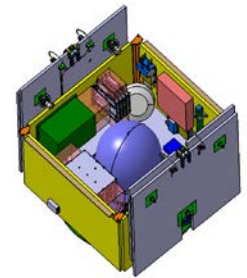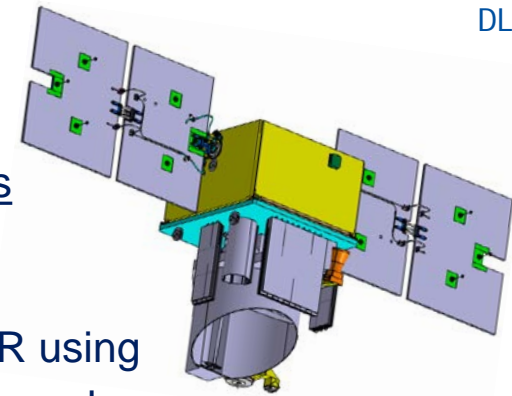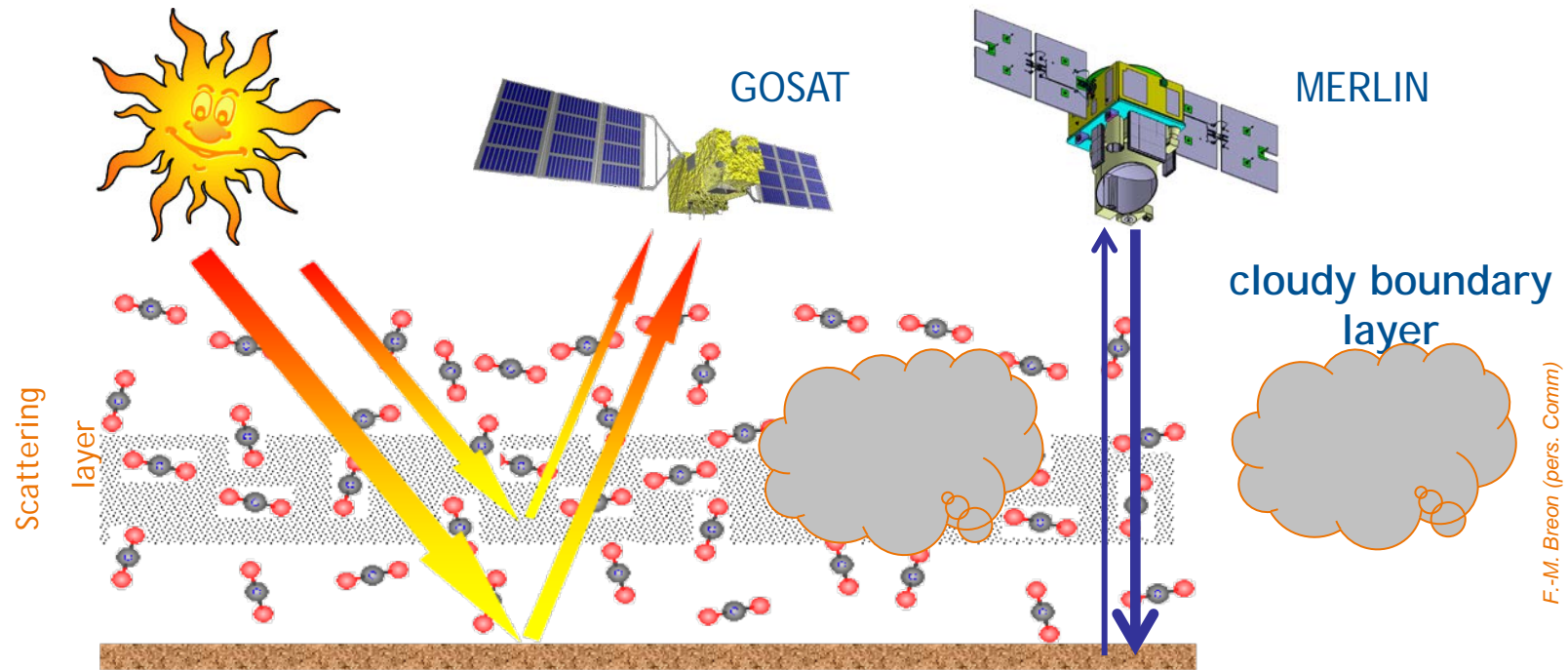➢ <u>Mission status</u>: Phase B

Figure 10: Laboratory setup amplifier with oscillator in the background (left), close-up of the slab with folding path (right)

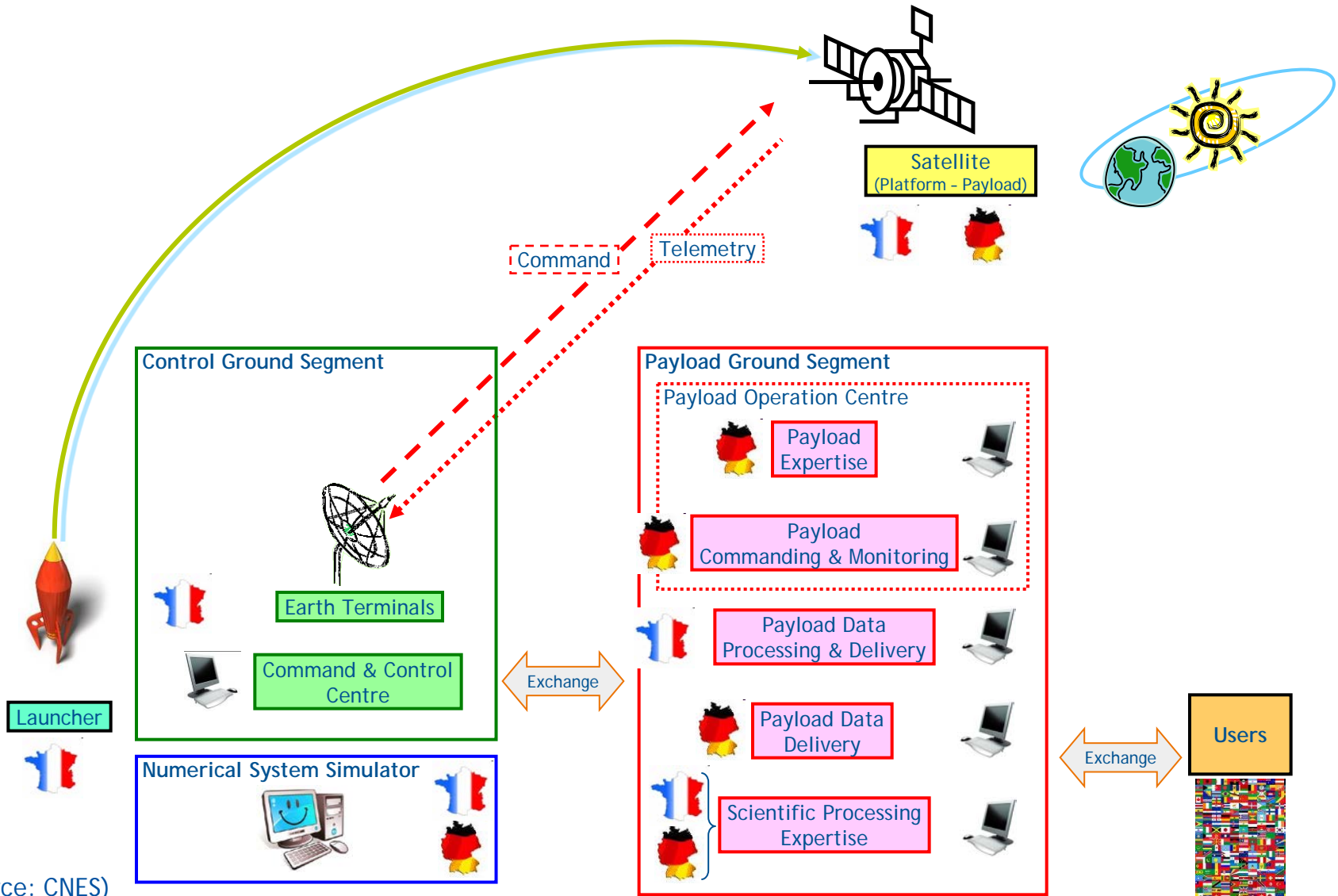# Why „active" Space-borne Measurements?

GOSAT

MERLIN

cloudy boundary layer

Scattering layer

F.-M. Breon (pers. Comm)

Active instruments much less sensitive to biases than passive instruments

- Allows **separation** between contributions **of surface and atmospheric scattering layers**

- allows to sound in **cloud holes** and through thin cirrus layers

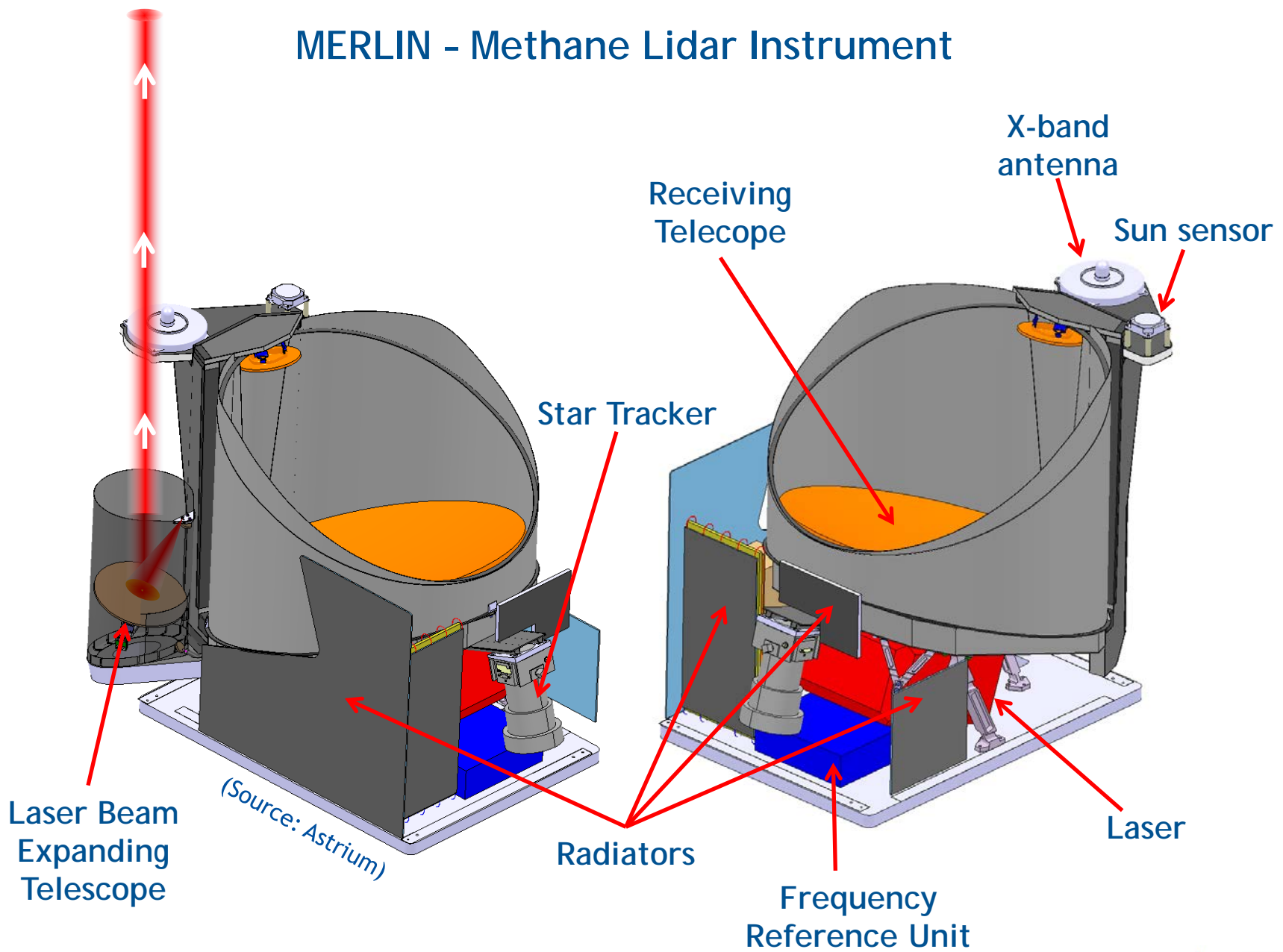- enables measurements at day and **night time** (high latitude coverage)

MERLIN System Architecture

Satellite
(Platform - Payload)

Command

Telemetry

Control Ground Segment

Earth Terminals

Command & Control Centre

Numerical System Simulator

Launcher

Exchange

Payload Ground Segment

Payload Operation Centre

Payload Expertise

Payload Commanding & Monitoring

Payload Data Processing & Delivery

Payload Data Delivery

Scientific Processing Expertise

Exchange

Users

(Source: CNES)

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MERLIN – Methane Lidar Instrument

(Source: Astrium)

Scientific Precision & Bias requirements on global Methane Mixing Ratio Measurements

MERLIN mission

	Threshold	Breakthrough	Target
Precision	36 ppb 2 %	18 ppb 1 %	8 ppb 0.5 %
Systematic error	3 ppb	2ppb	1 ppb
Horizontal sampling Accumulation	50 km	50 km	50 km
Objectives	Large wetland fluxes, inter-hemisphere gradients, seasonal and annual budgets on continental scale	Seasonal and annual budgets on country-scale resolves country-scale gradients	Highest Methane flux estimate quality (set by sampling error and model accuracy where any further measurement accuracy would not give better flux estimates) Kyoto protocol like monitoring

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MERLIN – Data Levels
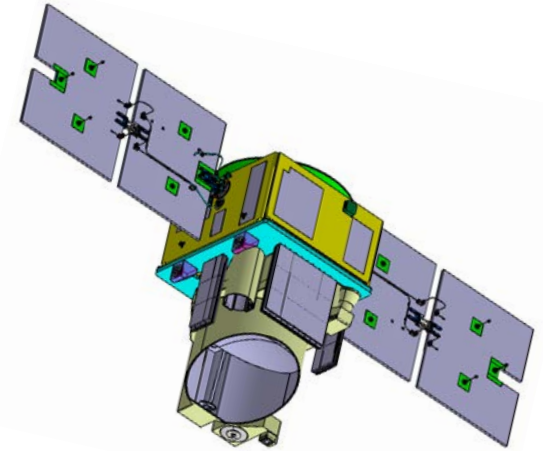
Official MERLIN data base:

Free access for scientific experts:
- L0 (Raw data)
- L1 (calibrated measurement intensities, Slant DAOD along the line of sight)

Free access for users:
- Atmospheric/geophysical data:
    - L2 (surface scattering elevation, DAOD, XCH4)
    - L3 (global methane maps)

Outside the official MERLIN data base:

- L4 (global Methane fluxes).
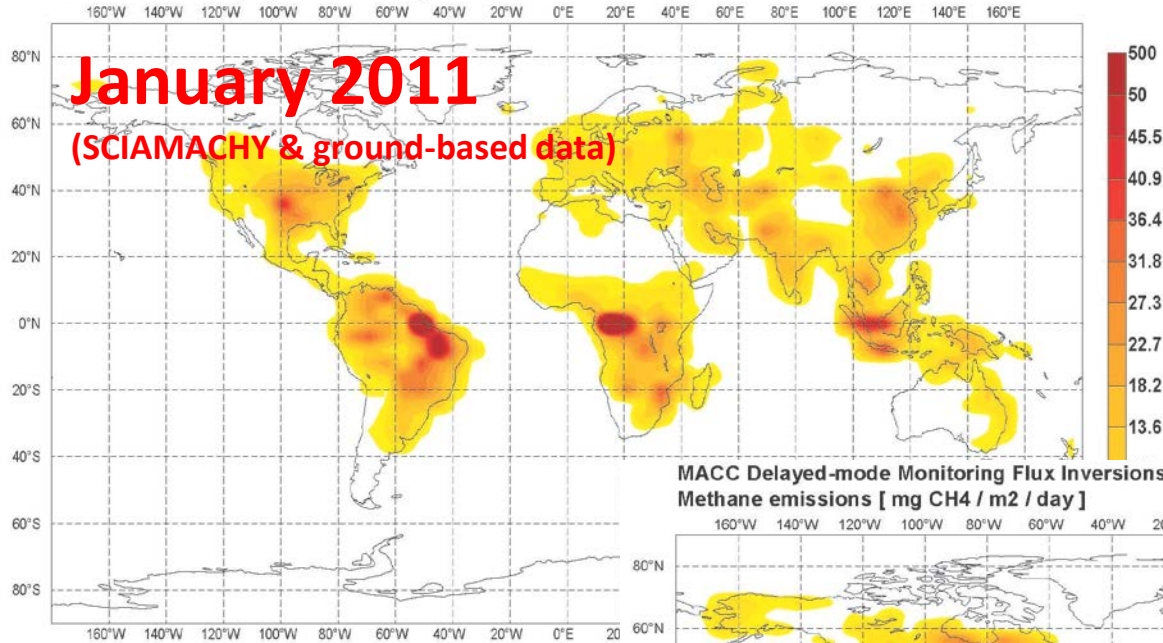- Value adding (i.e. canopy/cloud heights)

Evolution of atmospheric mixing ratio (in ppbv) in the tropical region (July 2007 to December 2010) .
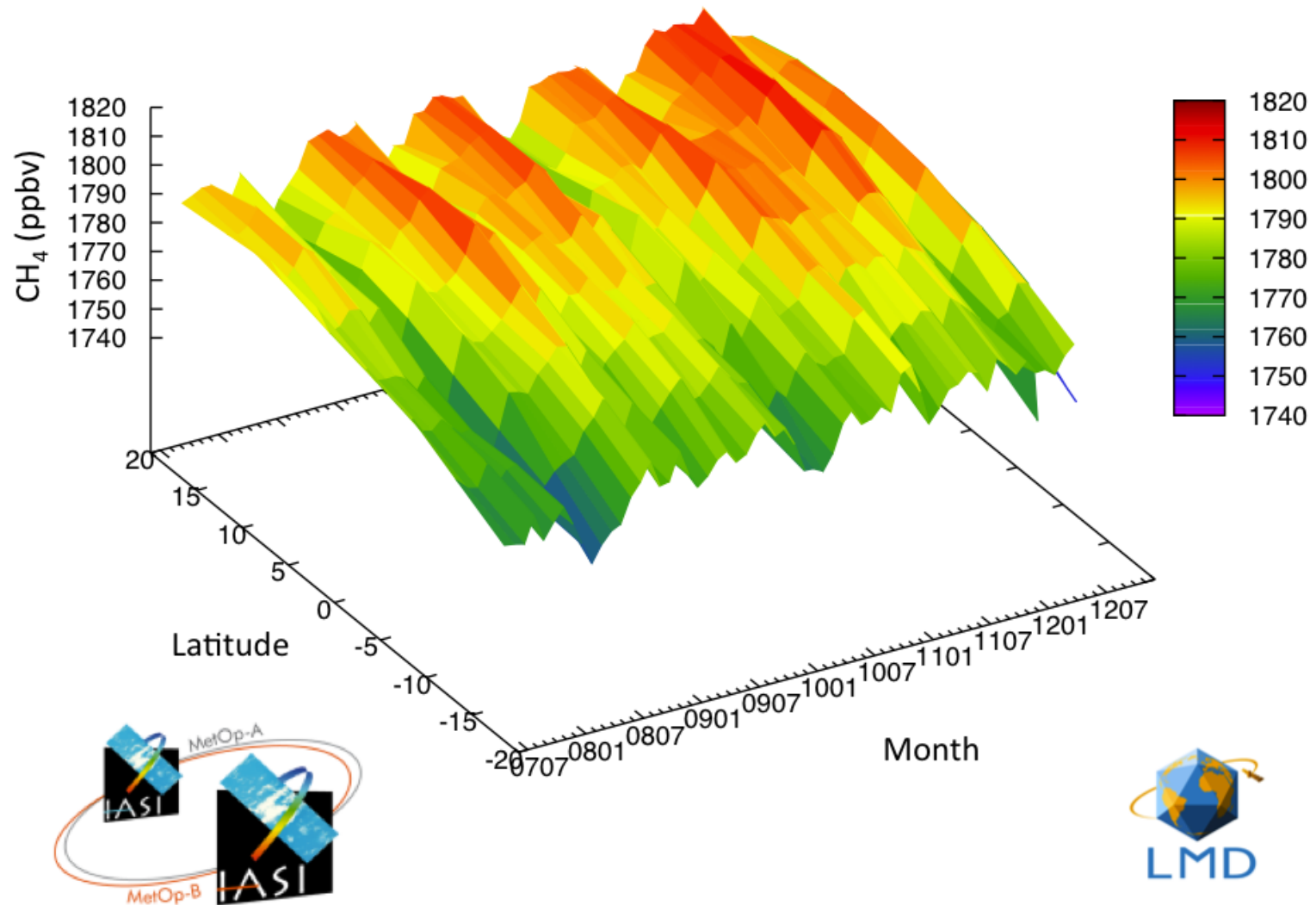
Level 4: Global Methane Flux

MACC Delayed-mode Monitoring Flux Inversions January 2011
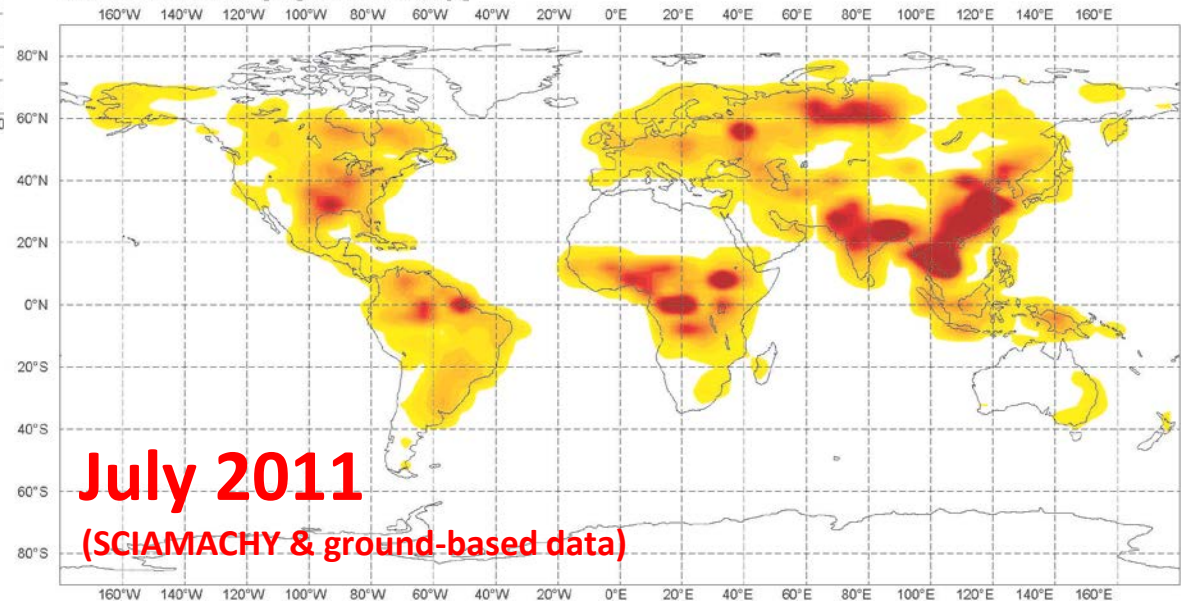Methane emissions [mg CH4 / m2 / day]

January 2011

(SCIAMACHY & ground-based data)

(Source: MACC-II project)

MACC Delayed-mode Monitoring Flux Inversions July 2011
Methane emissions [mg CH4 / m2 / day]
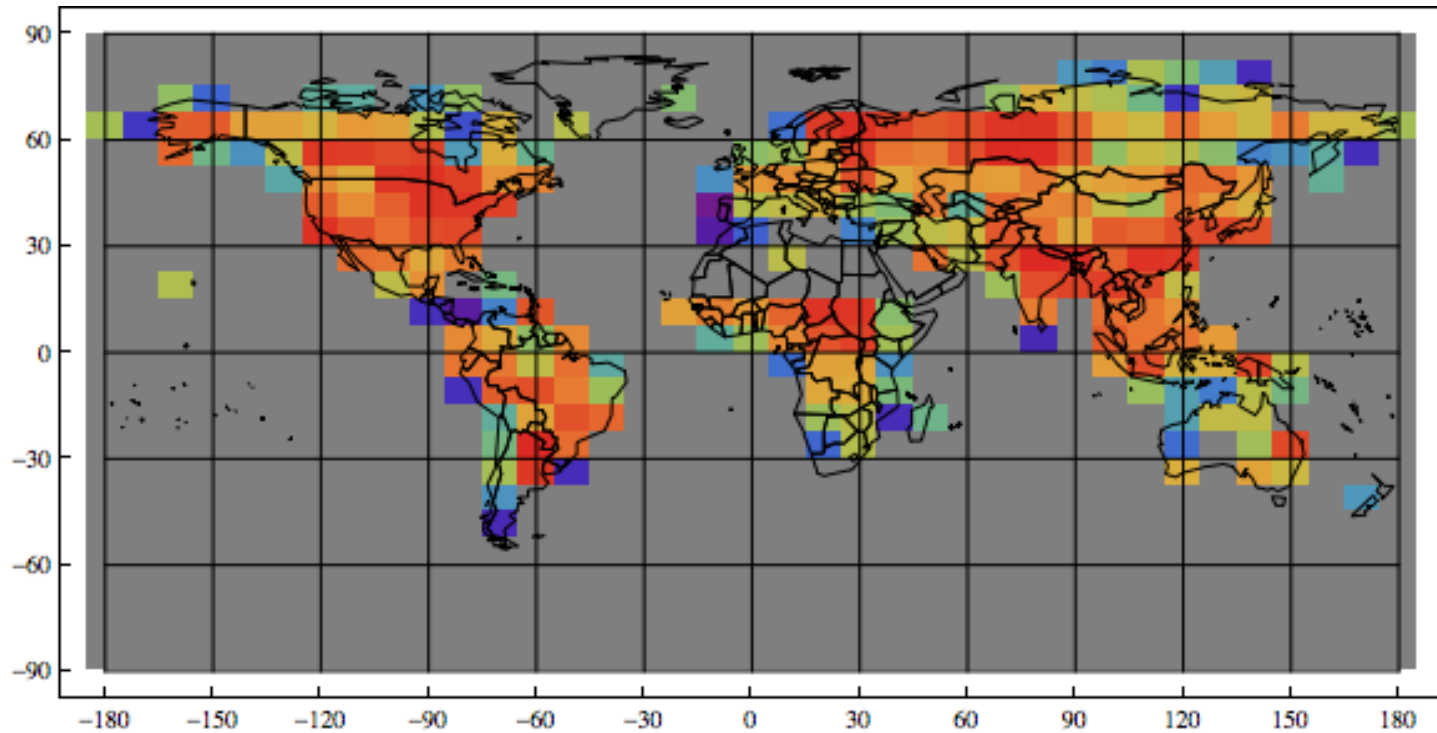
July 2011

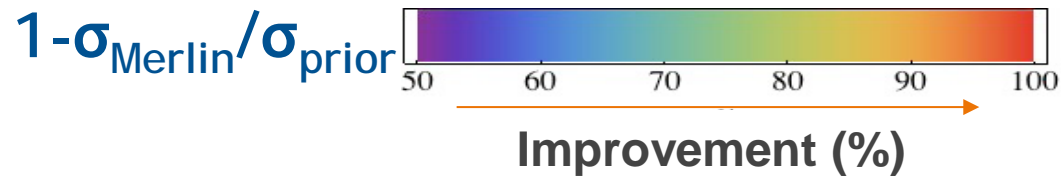**(SCIAMACHY & ground-based data)**

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Expected methane flux knowledge improvement by MERLIN data

M. Heimann, J. Marshall,
MPI-BGC, Jena;
C.Kiemle, DLR
Oberpfaffenhofen,
Germany

$$1-\sigma_{Merlin}/\sigma_{prior}$$

Improvement (%)

MERLIN → Substantial accuracy improvement with respect to the present knowledge of methane fluxes on regional scale

MERLIN

... to be launched in 2017

© CNES/Photon/ill. Michel Regy, 2013

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