CH4

# A Close-up of the Methane Global Budget

MPI-Biogeochemistry
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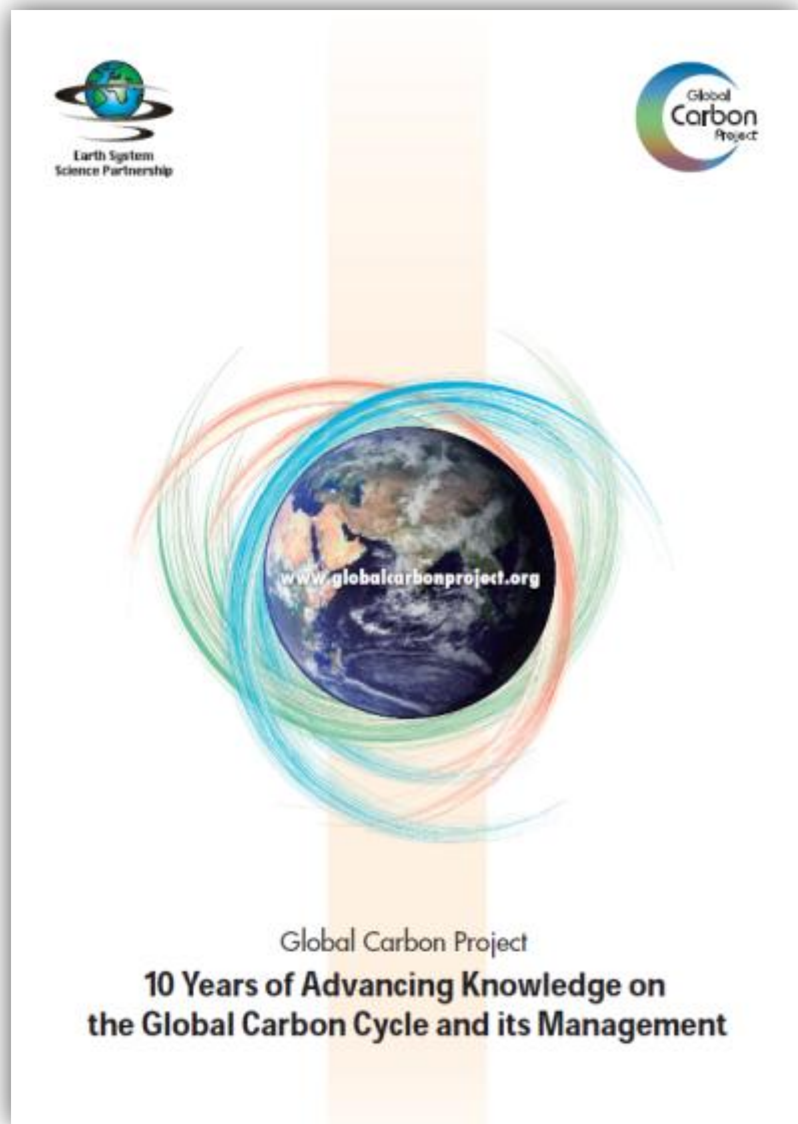
# Global Carbon Project (GCP): Objectives

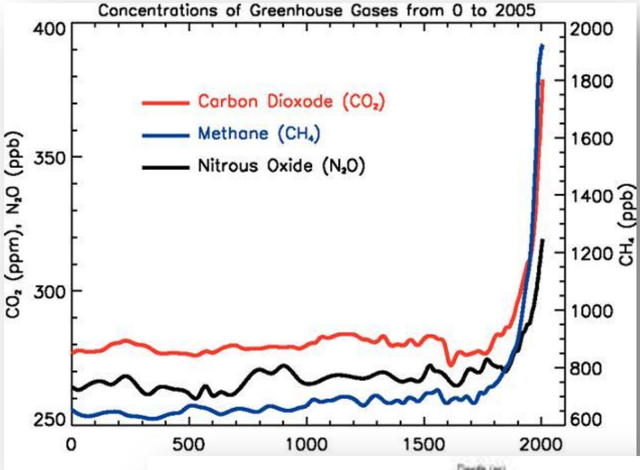



To develop comprehensive, policy-relevant understanding of the global carbon cycle, encompassing its natural and human dimensions and their interactions.

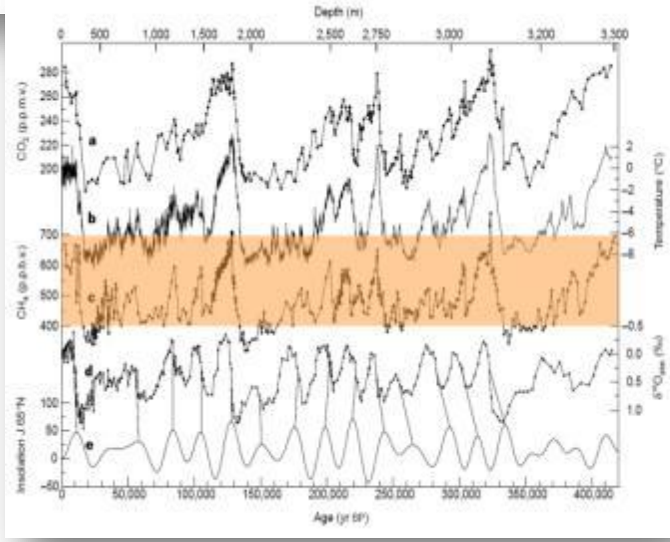
- Annual update of the global $CO_2$ budget
- New: Annual update of the global $CH_4$ budget

# Why Methane?

- $CH_4$ – one of the most important radiatively active trace gases
- 0.5 W $m^{-2}$ direct RF
- Important for tropospheric chemistry
- Wide range of sources with high uncertainties
- Rapid rise in atmospheric concentrations since start of records in 1978 (0.8-2% $y^{-1}$)
- High variability in atmospheric growth rate
- Target for emissions reductions due to short life time

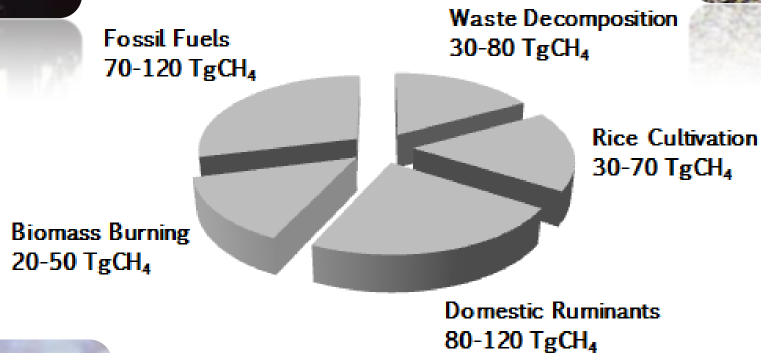



IPCC 2007

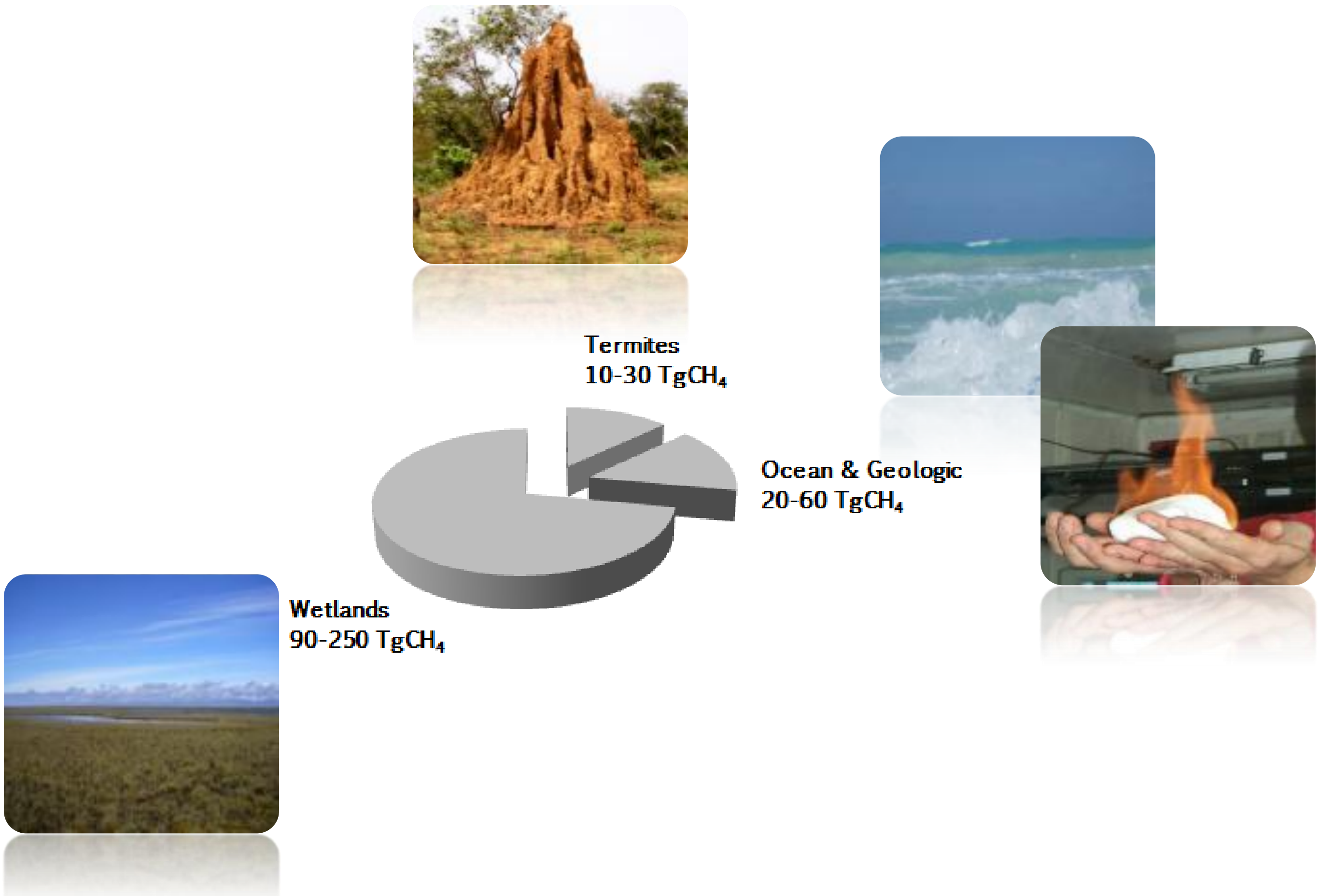


After Petit et al., 1999

# Anthropogenic $CH_4$ Sources



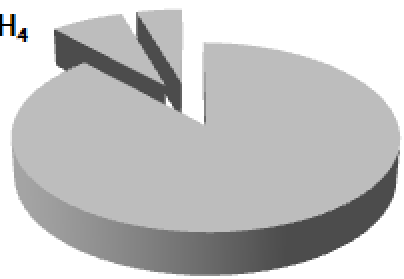

# Natural $CH_4$ Sources



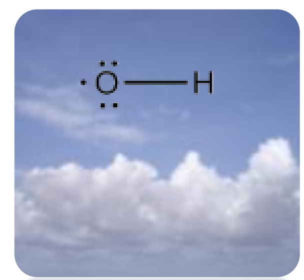
# $CH_4$ Sinks

Stratosphere
20-60 $TgCH_4$

Soils
10-40 $TgCH_4$



Tropospheric OH
450-520 $TgCH_4$



# GCP Global Methane Budget

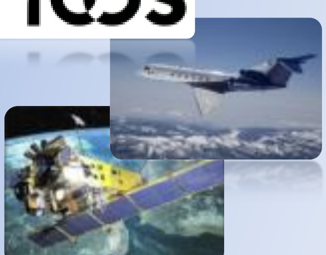
- Regular update of the $CH_4$ global budget, annually or bi-annually – similar to global $CO_2$ budget
- Synthesis of existing data, bottom-up and top-down
- Contributions from
  - Observational networks (NOAA, CSIRO, LSCE, AGAGE)
  - Inventories (EDGAR, GEIA, GFED)
  - Inverse modeling groups, chemical transport models (OH)
  - Process-based models for wetland and fire
- Budget release in a high-profile paper each year

## Atmospheric Observations

Ground-based data from observation networks.

Airborne observations.

Satellite data.



## Emission Inventories

Number of livestock, area of rice cultivation (FAO, EDGAR).

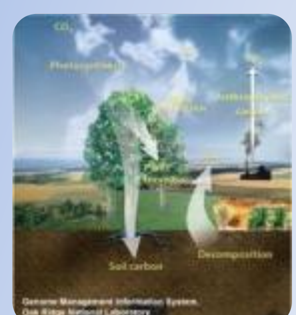
Fossil fuel $CH_4$ emissions (EDGAR).

Fire emissions (GFED/GEIA).

## Biogeochemistry Models

Ensemble of different wetland models, e.g. LPJ-Why-Me, ORCHIDEE, …

Top-down model to calculate annual flooded area.



## Inverse Models

Ensemble of different atmospheric inversion models.

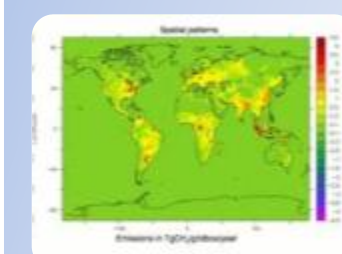
Groups from the TransCom project.

So far:

Bousquet et al.

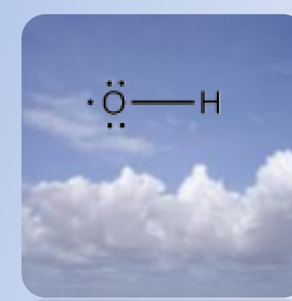
Bruhwiler et al.

Houweling et al.

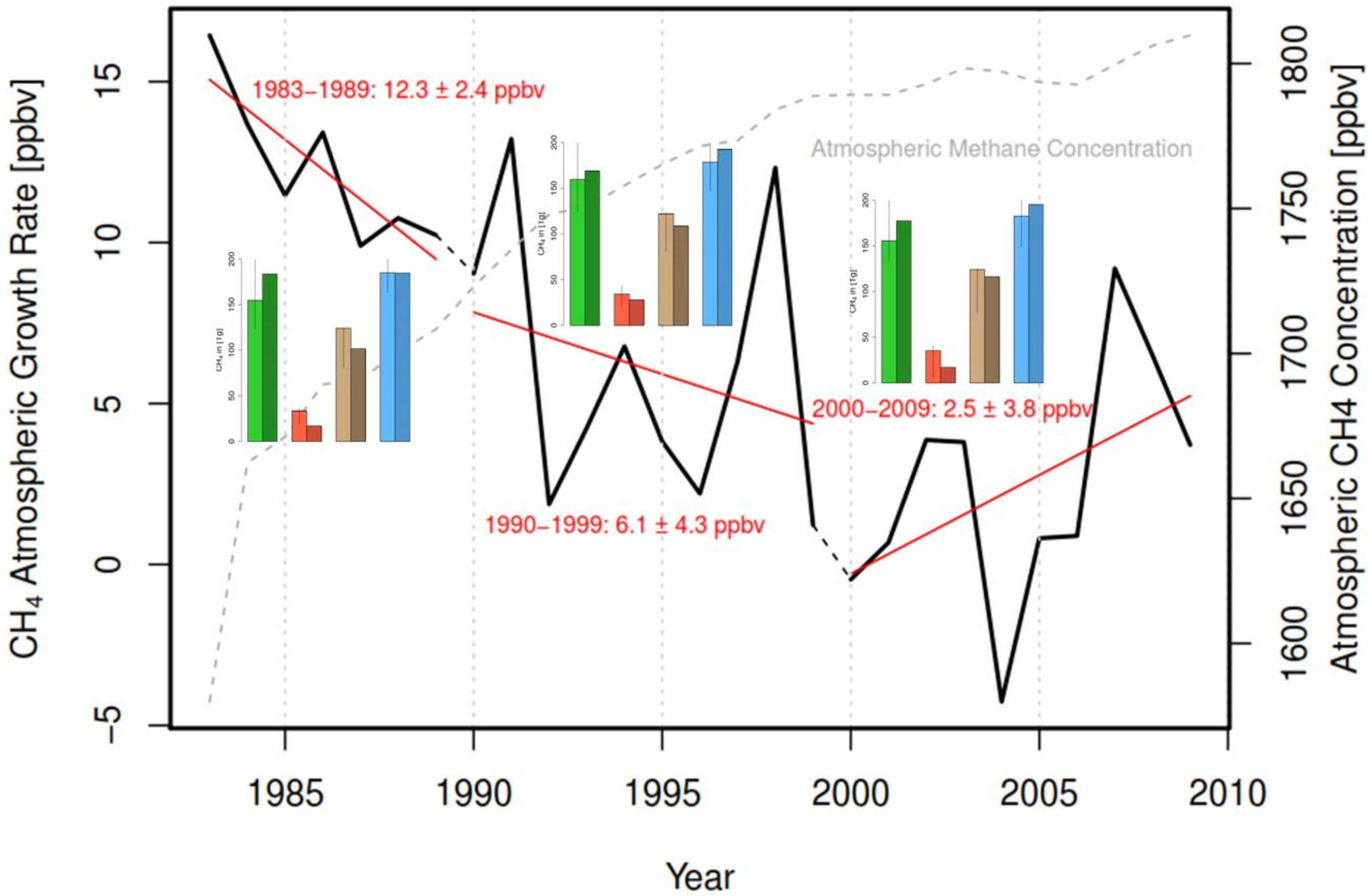


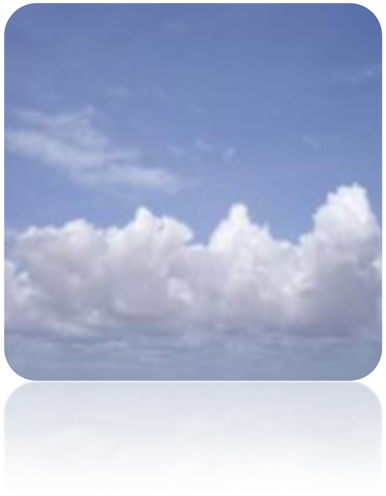
## OH Sink

Long-term trends of the OH sink, not year-to-year variability.



# $CH_4$ Atmospheric Growth Rate, 1983-2009

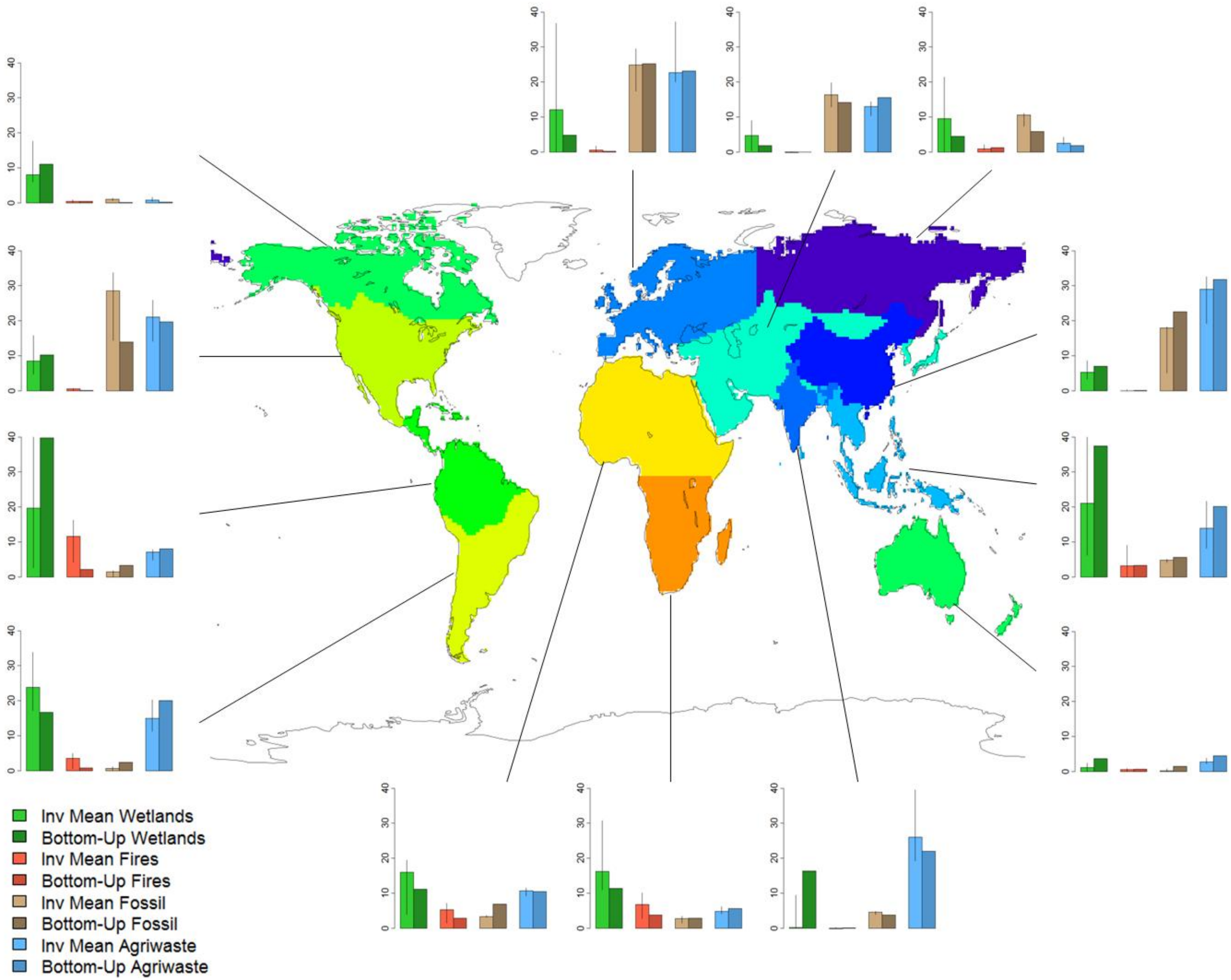


Data from NOAA, CSIRO, LSCE atmospheric networks. Inversion results from Bousquet et al. (2011), Bruhwiler et al. (in prep.) and Houweling et al. (in prep.)

LSCE
Global Carbon Project

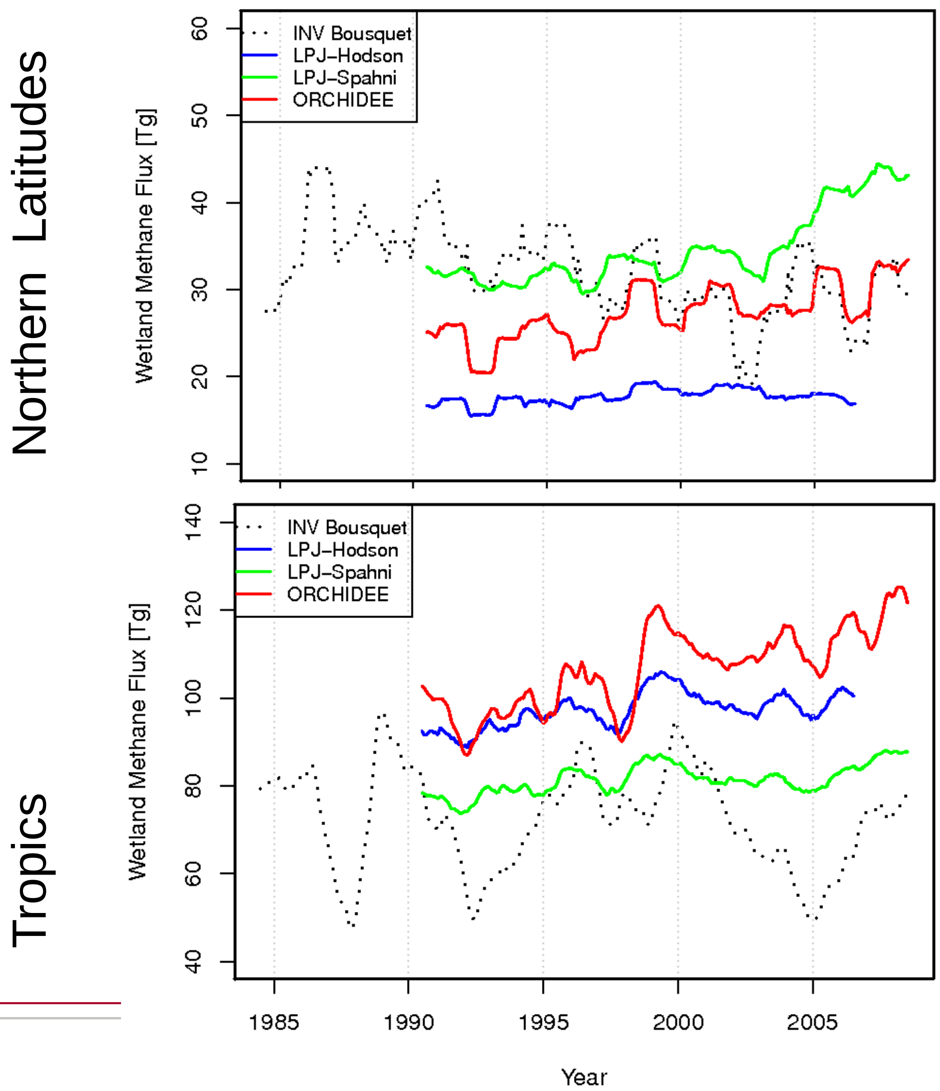
# Regional $CH_4$ Budgets, 2000-2008




**Contributors:**

ORCHIDEE (Ringeval et. al., 2010)
LPJ-WHy-Me (Spahni et al., 2011)
LPJ Methane (Hodson et al., 2011)
GFEDv3 (van der Werf et al. 2010)
RETRO
EDGAR (European Comission, 2009)
Bousquet et al., 2011
Bruhwiler et al. (in prep.)
Houweling et al. (in prep.)

# Wetland $CH_4$ Emissions, 1984-2008

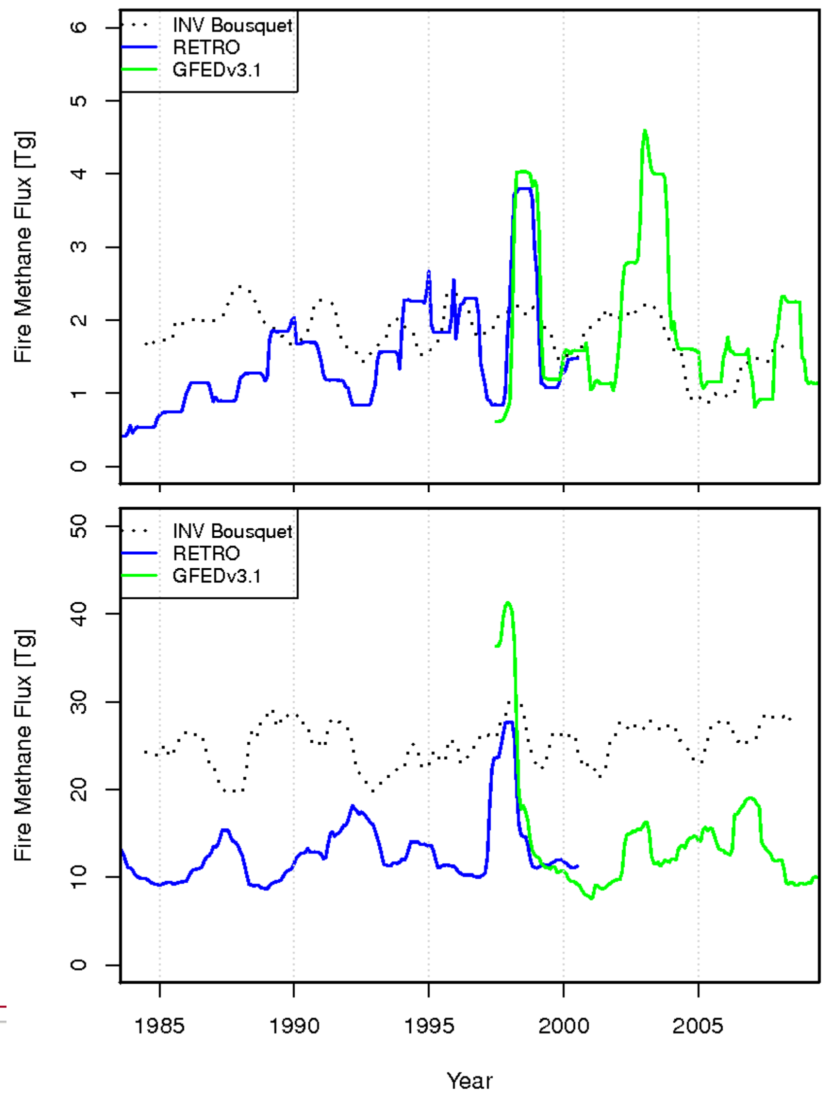



Increase 2005-2009 due to precipitation forcing (increase in tropical land precipitation)

# Fire $CH_4$ Emissions, 1984-2008

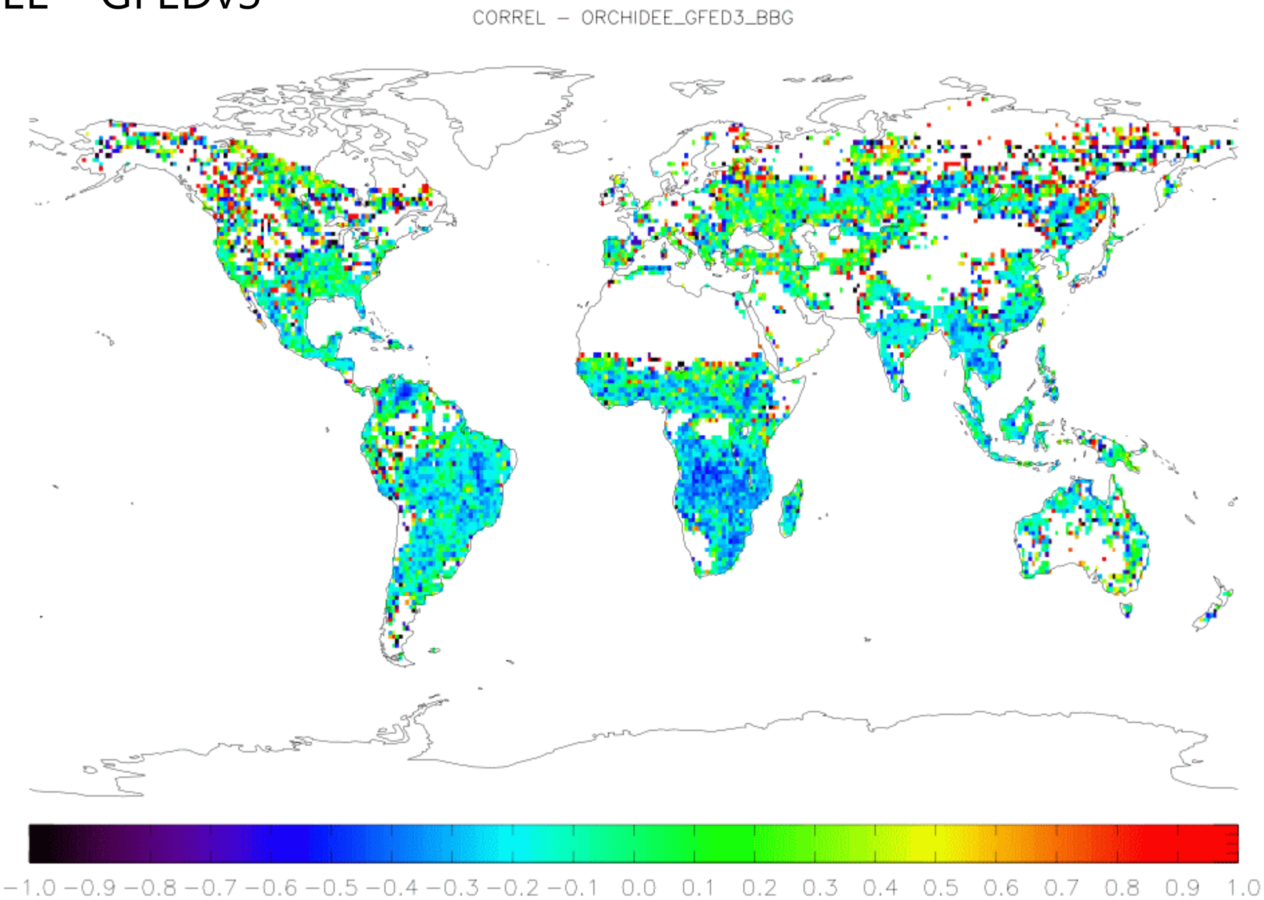
Northern Latitudes

Tropics



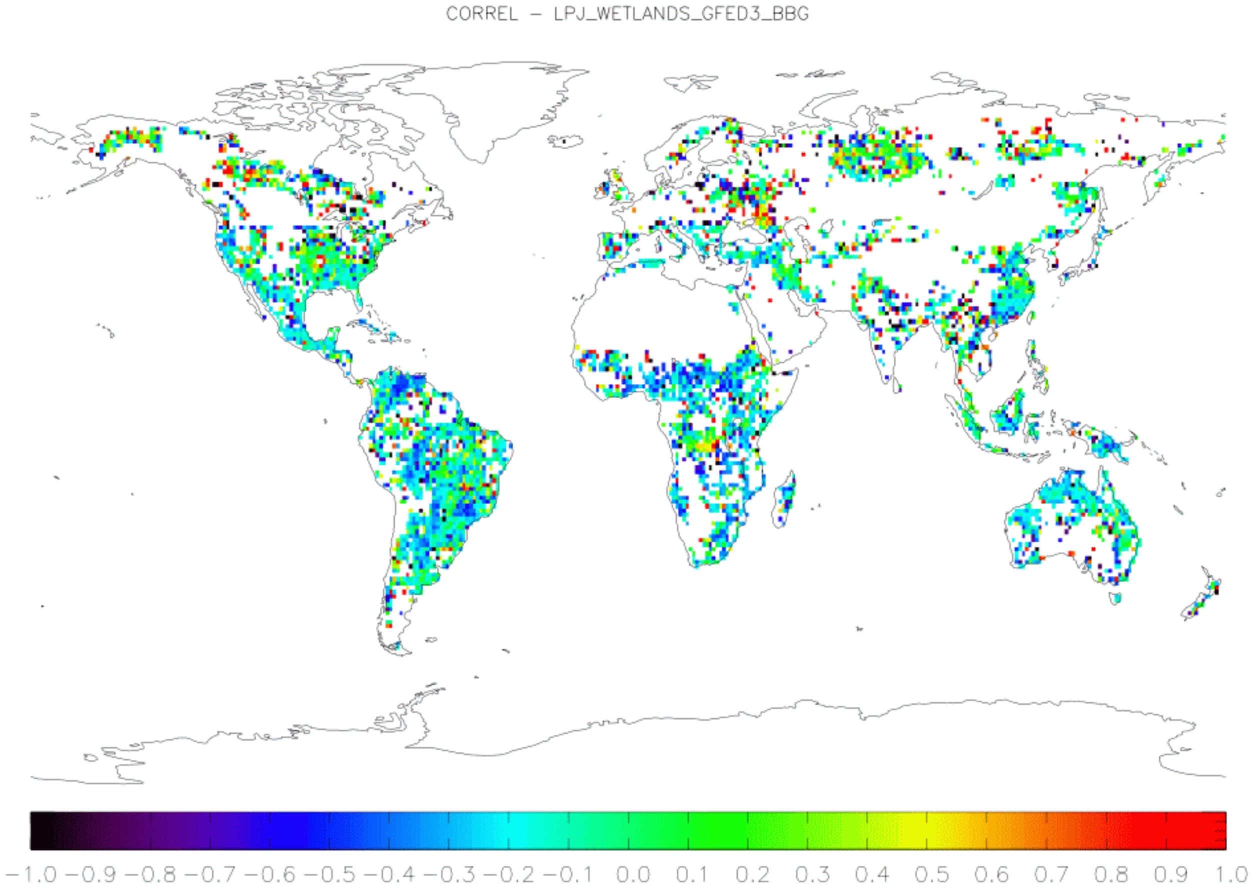

# Correlation between wetland and fire flux

- ORCHIDEE – GFEDv3



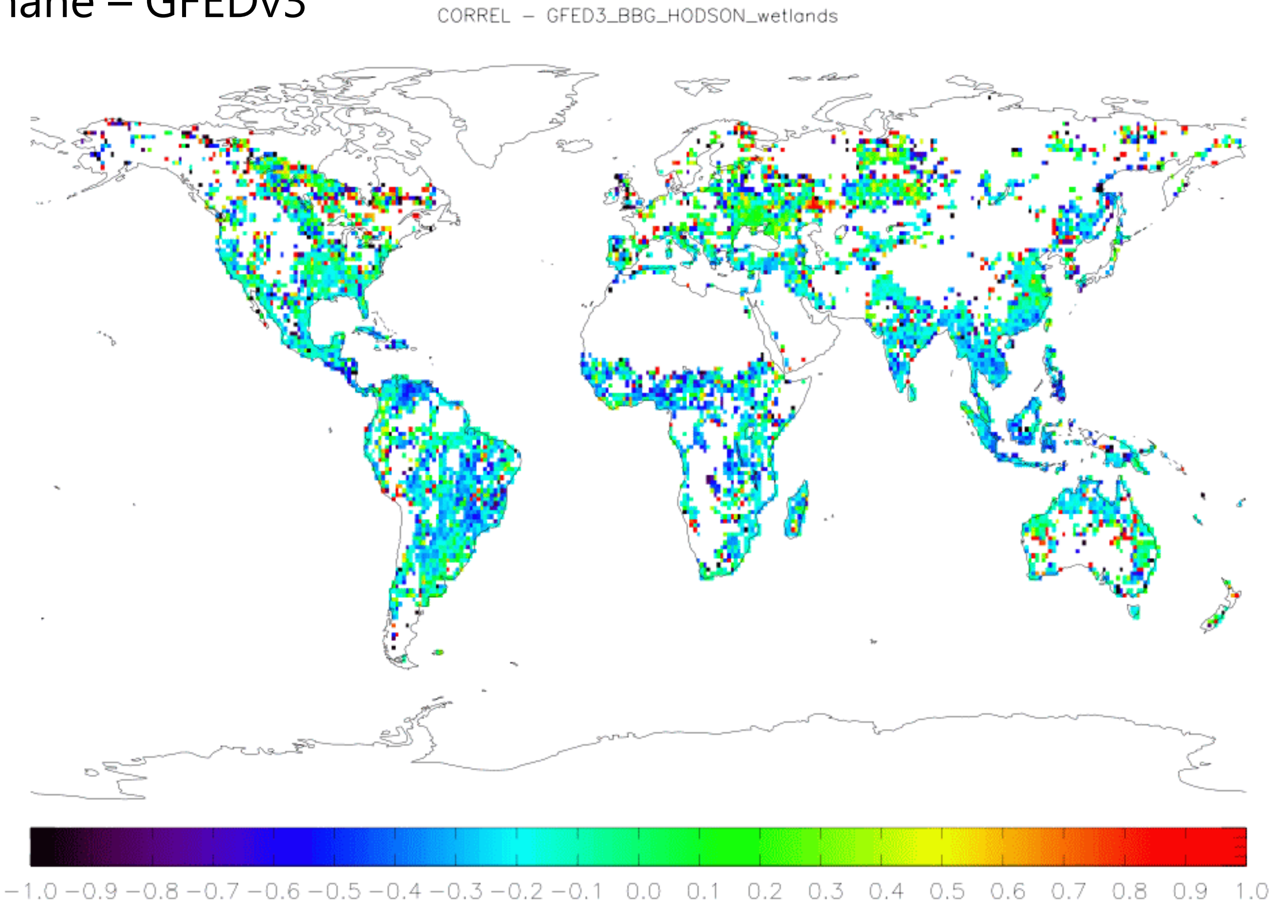
# Correlation between wetland and fire flux

- LPJ-WHy-Me – GFEDv3

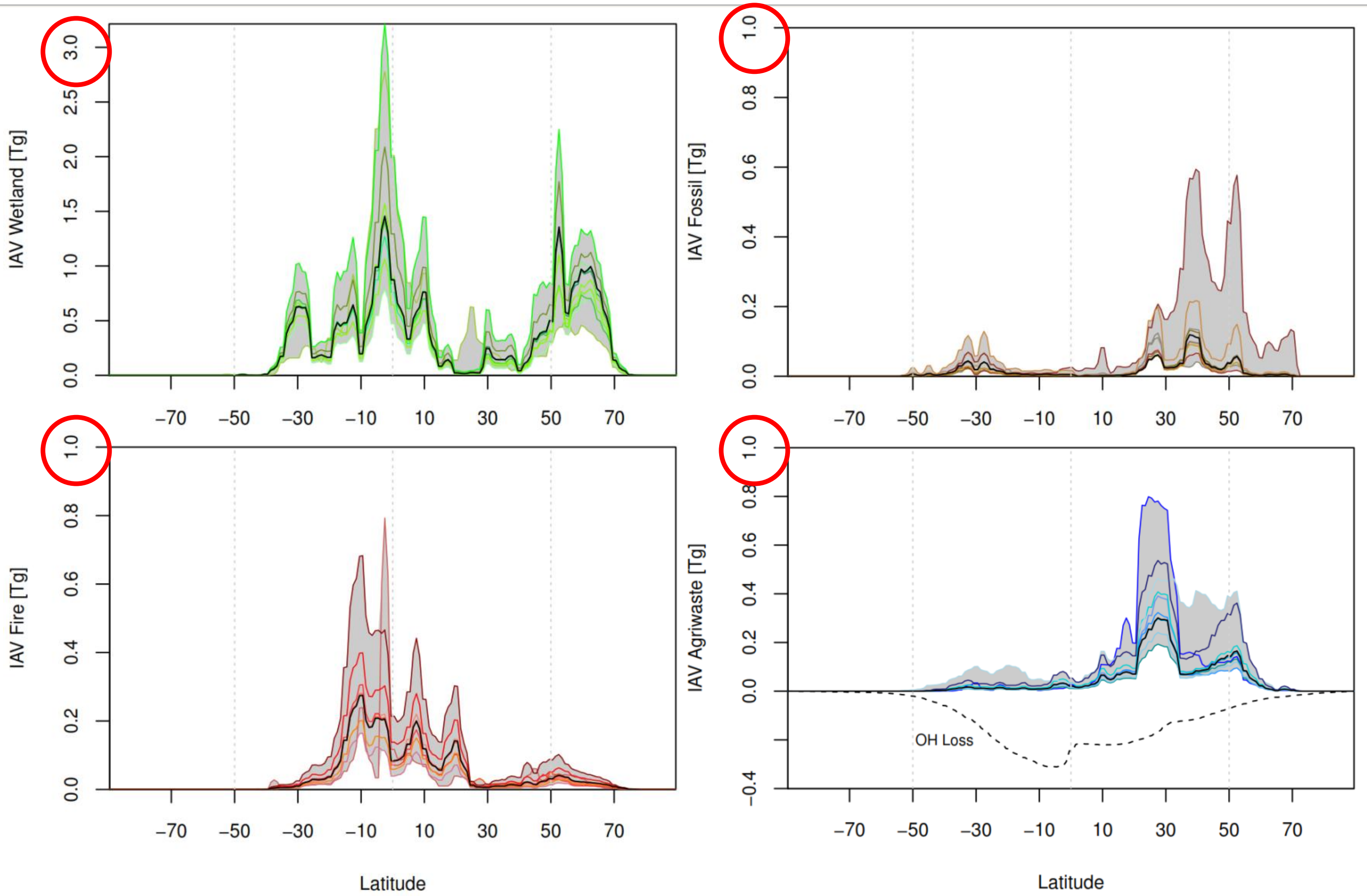


# Correlation between wetland and fire flux

- ↘ LPJ Methane – GFEDv3



# Interannual Variability



# Inversion Results - Totals

| | 1984-1989 | 1990-1999 | 2000-2008 |
|---|---|---|---|
| Average Atmospheric Concentration | 1671.8±43.5 | 1759.8±20.9 | 1796.9±6.9 |
| Average Atmospheric Growth Rate | 12.5±2.2 | 7.6±3.4 | 4.8±2.2 |
| Total Sources | 537.7 | 535.9<br>533.0 | 537.8<br>533.2<br>540.5<br>517.7 |
| Total Anthropogenic Sources | 337.3 | 333.4 | 336.2<br>354.0<br>319.9 |
| Total Natural Sources | 200.3 | 202.5 | 201.6<br>186.5<br>197.8 |
| Total Sinks | | | -525.0 |

Data from NOAA, CSIRO, and LSCE atmospheric networks

Bousquet et al. 2011

PYVAR-SAC Inversion (Pison et al. 2009)

Houweling et al. (in prep.)

Bruhwiler et al. (in prep.)

# Inversion Results – By Category

| | 1984-1989 | 1990-1999 | 2000-2008 |
|---|---|---|---|
| Wetlands | 163.7 | 165.3 | 163.2<br>164.0<br>184.0 |
| Biomass Burning | 32.2 | 33.5 | 34.7<br>25.0<br>13.8 |
| Fossil Fuel | 118.2 | 117.7 | 117.4<br>122.0<br>78.2 |
| Agriculture/Waste | 187.0 | 182.2 | 184.1<br>207.0<br>241.8 |

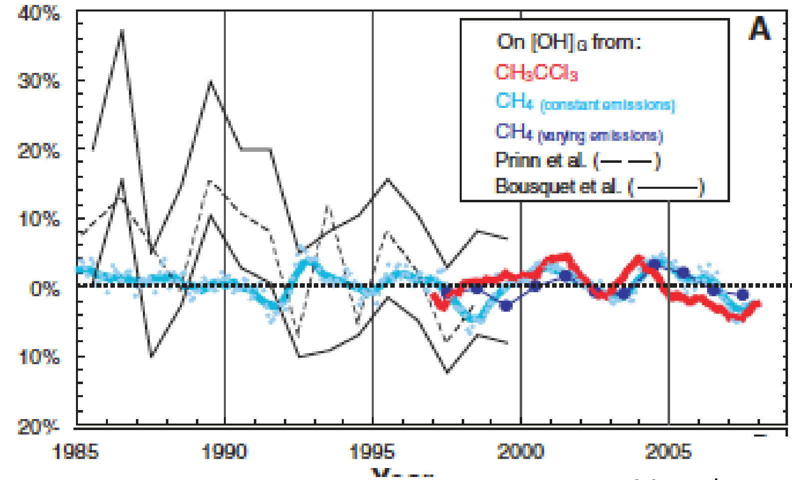
Bousquet et al. 2011

Houweling et al. (in prep.)

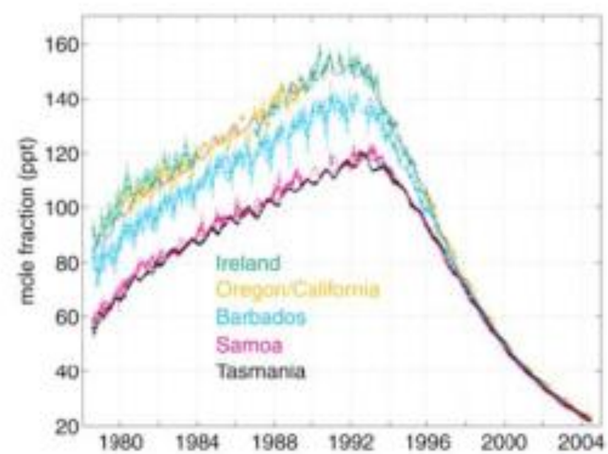
Bruhwiler et al. (in prep.)

# OH Sink

- Optimized using Methyl Chloroform proxy
- Small variations inferred for 2000-2009 (<5%) by recent Montzka paper
- Small variations also inferred by atmospheric chemistry models
- Large variations (5-10%) inferred for 1980-2000 by Prinn et al. (2005) and Bousquet et al. (2005)
- Convergence for the 2000s?




Montzka et al., 2011




Prinn et al., 2005

# Conclusions

- First attempt at a regular update of the $CH_4$ global budget within GCP
- Elements of the budget have been identified, initial data gathering has started and will continue
- Data analysis and synthesis of top-down and bottom-up approaches
- First budget release planned for end of this year, together with $CO_2$ budget

# Thank you.

**List of contributors (so far):**
↘ Sander Houweling, Lori Bruhwiler, Bruno Ringeval, Elke Hodson, Ben Poulter, Renato Spahni, Guido van der Werf

**Your contribution**

↘ You want to contribute your ideas, data, model results to this GCP activity?
↘ Please contact Stefanie Kirschke (stefanie.kirschke@lsce.ipsl.fr)

↘ **Planet Under Pressure 2012:** Methane in the Climate System – The Basic Science and Reduction, Adaptation and Mitigation Strategies
Abstract deadline: September 16, 2011