Methane emission from the Arctic shelf?

AIRS v5 and IASI low troposphere data

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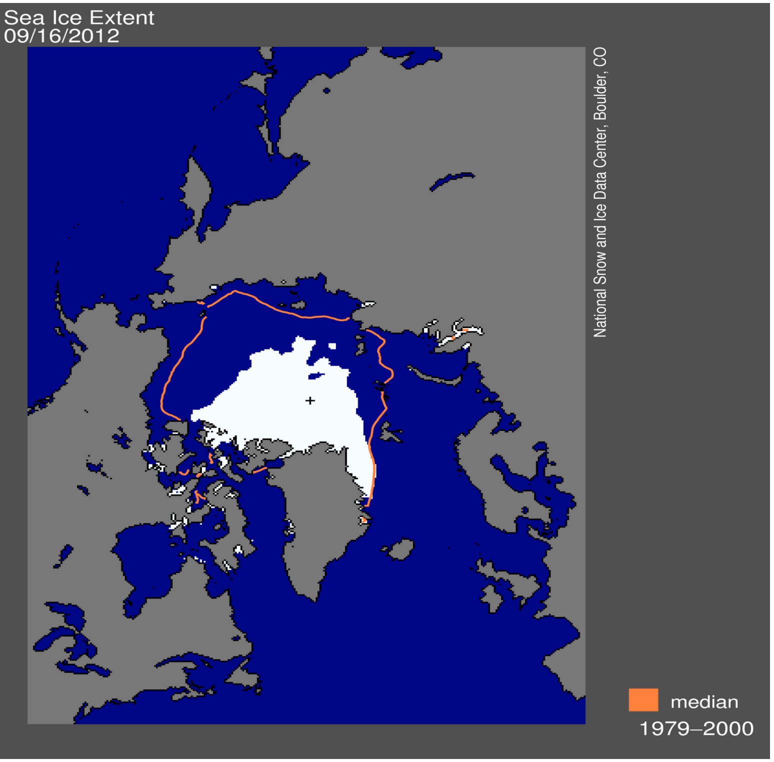
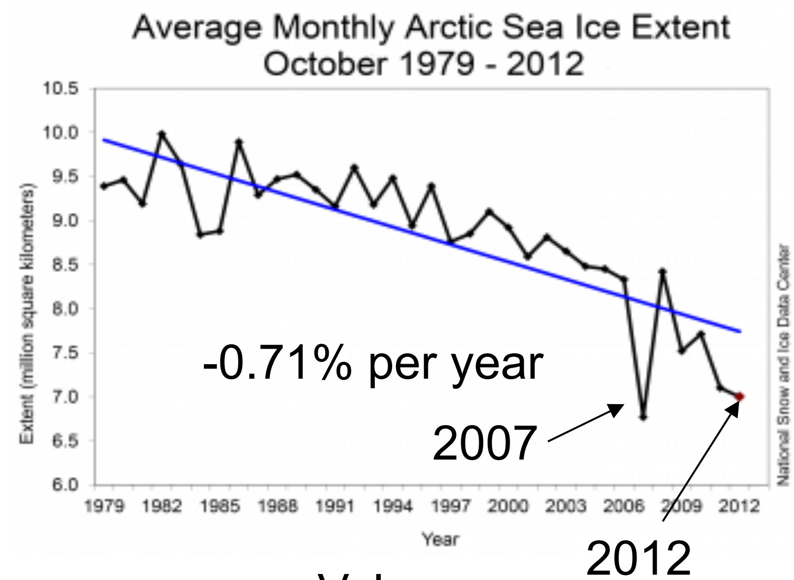
Background, motivation, goals.

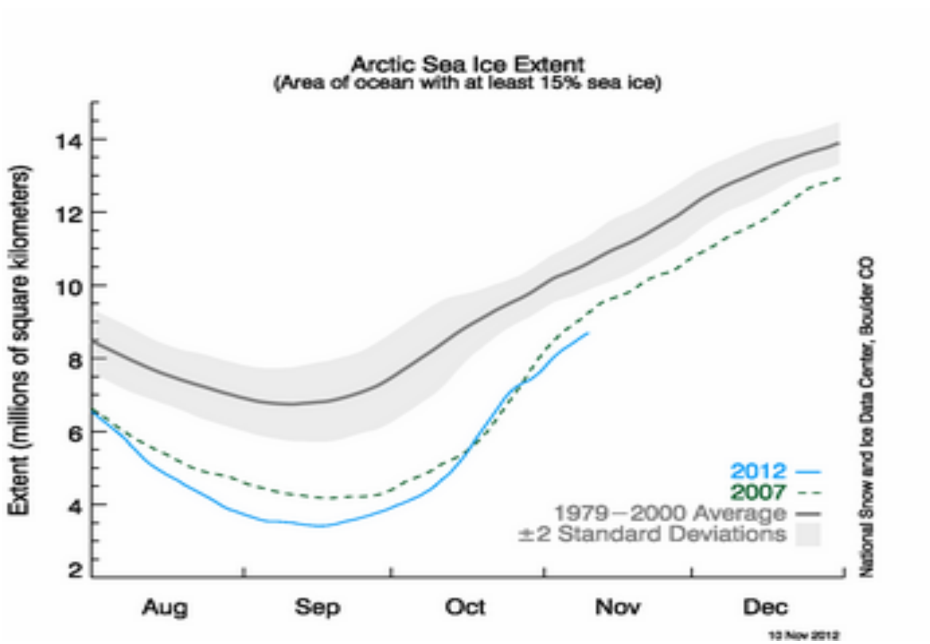
- Methane is **a stronger** (per molecule) **absorber** of IR radiation than CO_2: bands of CH_4 are less saturated than those of CO_2.
- Methane emission from natural sources (wetlands, permafrost, methane hydrates) are expected to increase with temperature, that makes the **positive feed-back** (self-supporting growth) possible. The question is **timescale** of this process: <u>chronic</u>, <u>catastrophic</u>, or something in between.

Arctic sea ice retreat

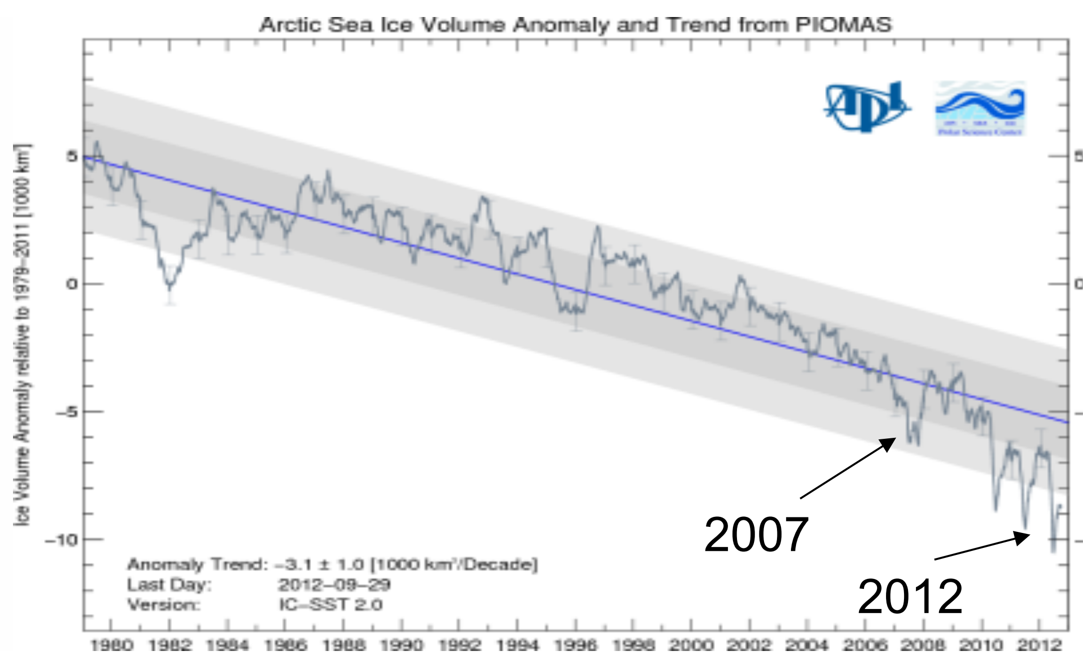




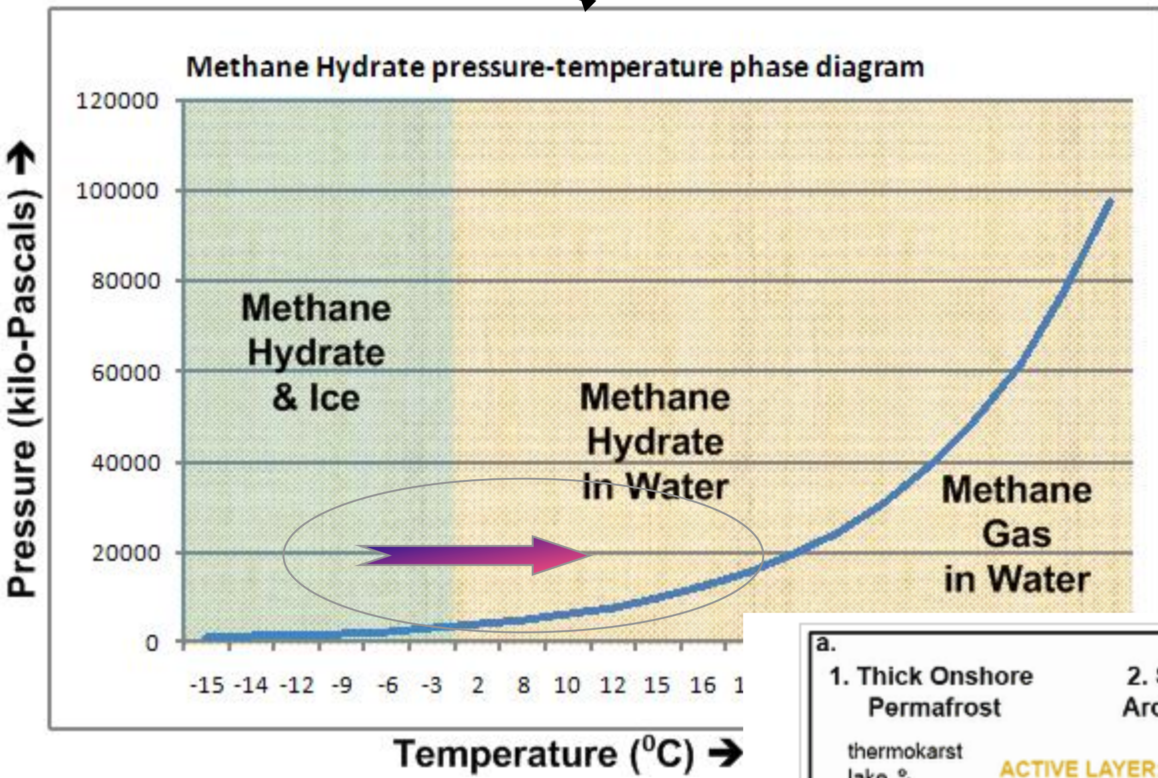
Extent

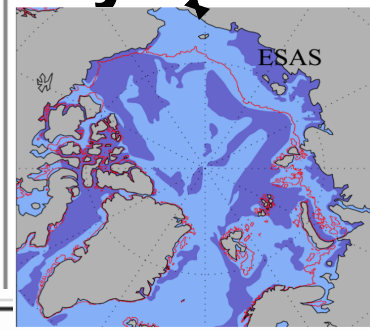


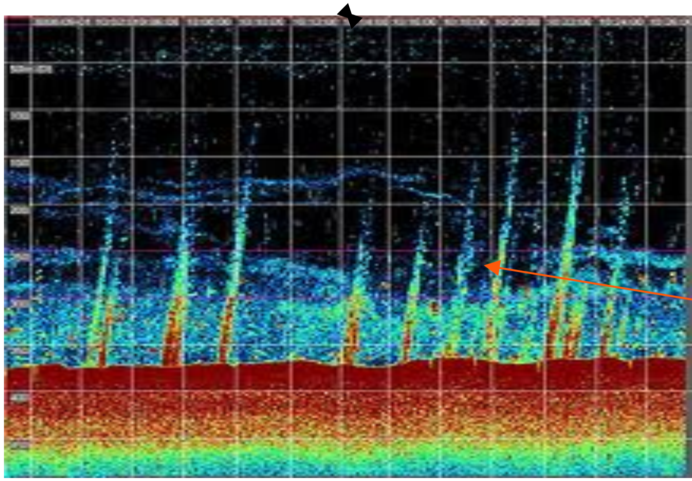
Volume



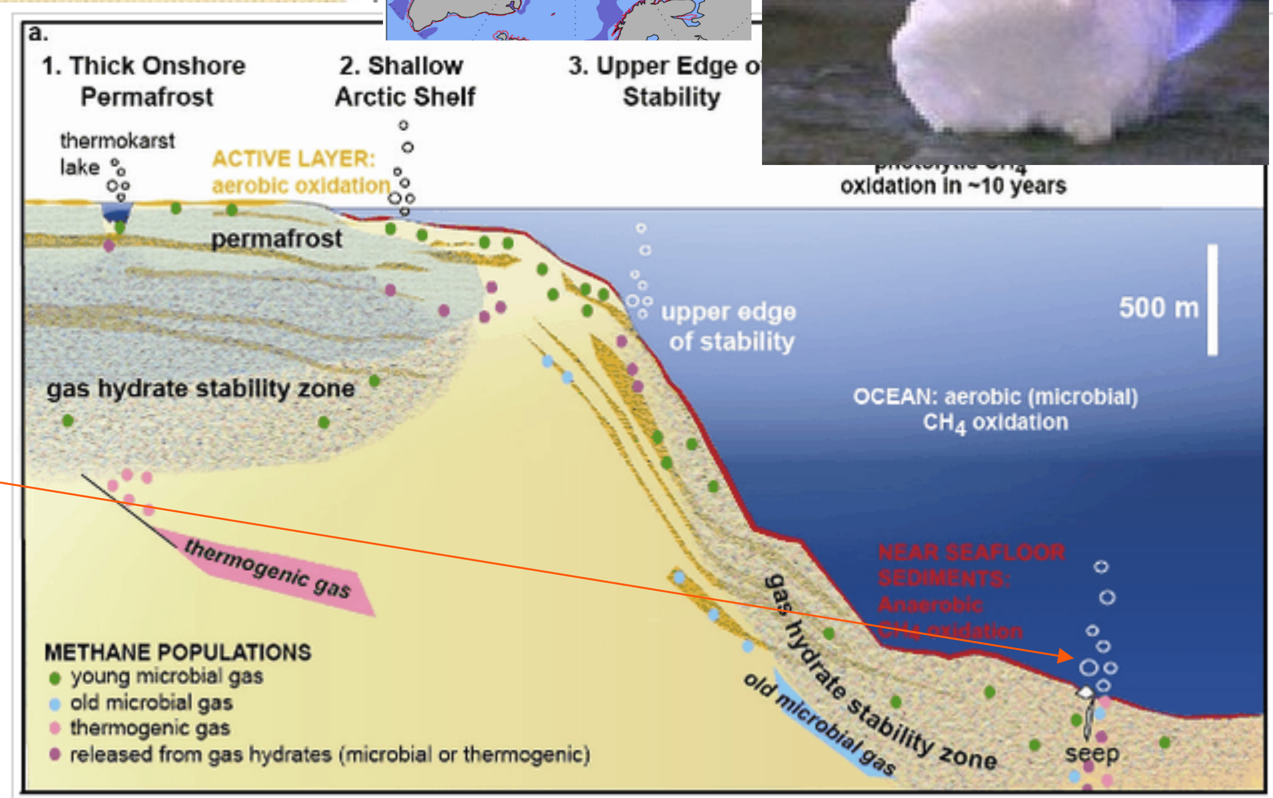
Methane sources in the Arctic: land permafrost and ocean hydrates







Sonar image of methane plumes rising from the Arctic Ocean floor (Image: National Oceanography Centre, Southampton)



Ruppel, Nature Knowledge, Hydrates/Climate, April 2011

Methane from the Arctic Ocean or from subArctic land? What is more important?

- Continental permafrost is impacted by the Arctic warming. Methane hydrates at the sea bed also should be melting.
- Emission from permafrost is supposed to be a **chronic** problem, i. e., methane should be increasing gradually. Emission from methane hydrates might be **abrupt or gradual**.
- Meanwhile, the amount of methane in the Arctic hydrates is estimated as **400 time more** than the global atmospheric CH4 burden!
- Monitoring of methane over the Arctic Ocean is necessary.

ROLE OF SATELLITES

- **Surface network** is insufficient in coverage
- **Satellite-borne instruments** have been on orbit since 2002 and just a careful analysis of available data should be performed (e. g, AIRS V5 → AIRS V6). Better spectral resolution → better sensitivity.
- **Near IR (e. g., SCIAMACHY) sensors** have problems in the Arctic: low sun and low reflectivity
- **Thermal IR instruments** on polar orbits: lots of data, but low sensitivity near the surface.

Thermal IR (TIR) averaging kernels

AK for IASI methane

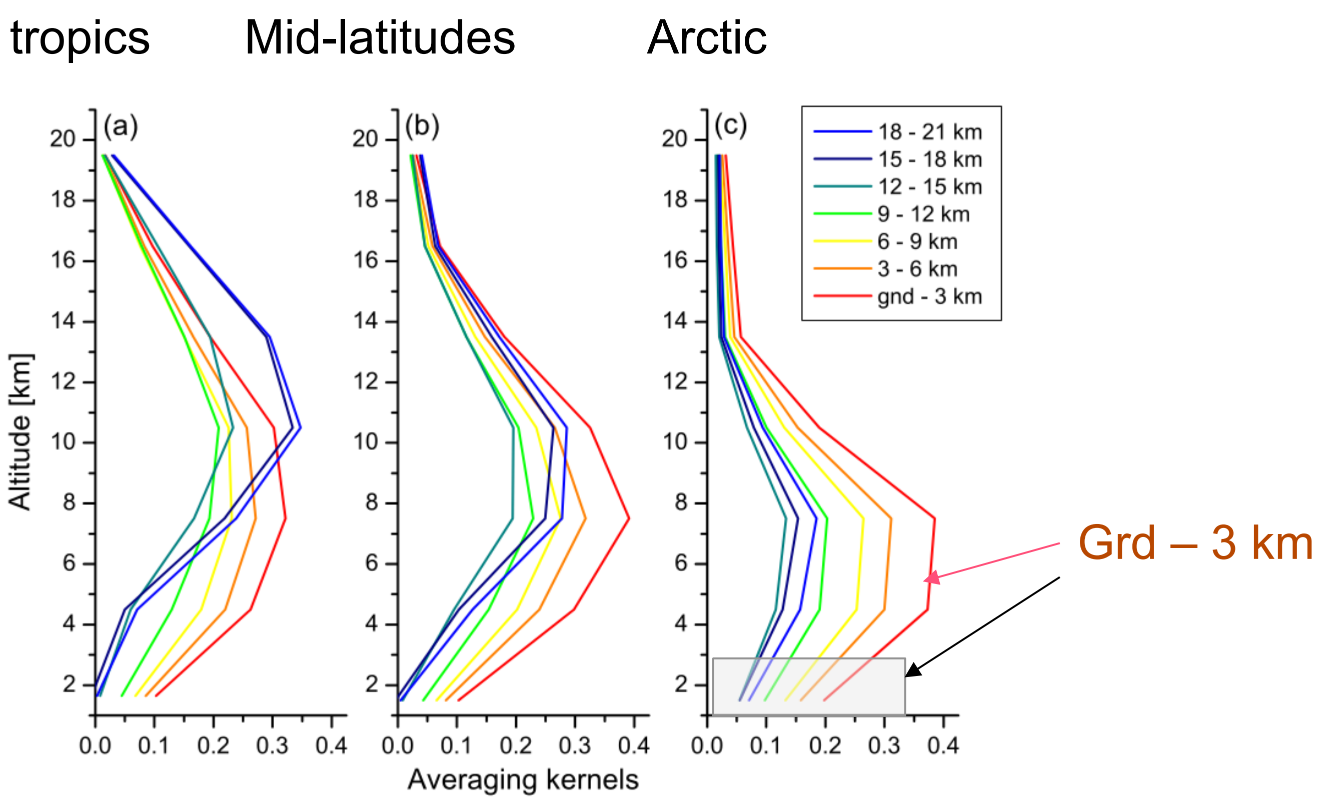


Fig. 5. Averaging kernels presented in mixing ratios unit for representative cases of **(a)** tropical, **(b)** midlatitude and **(c)** polar regions. The averaging kernels rows are plotted with respect to the middle of the retrieval layers.

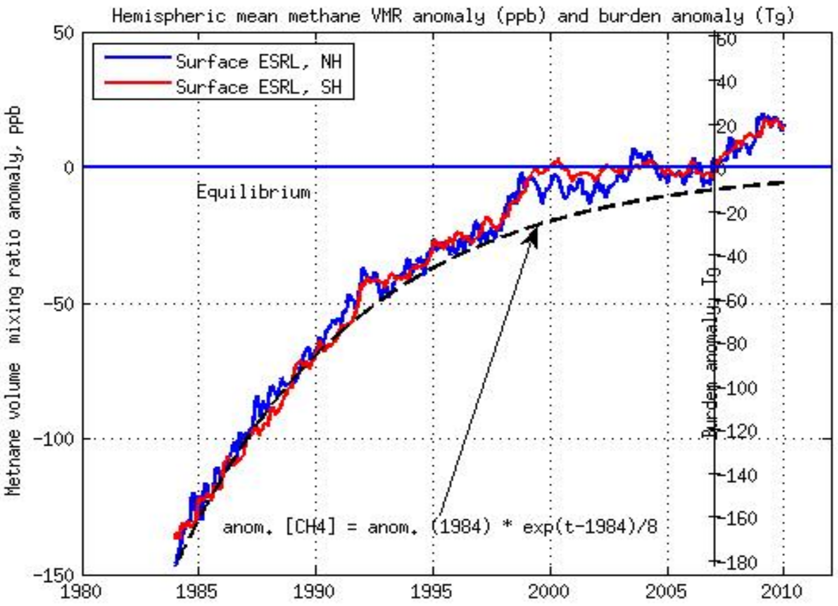
Razavi et al., ACP, 2010

The question is:

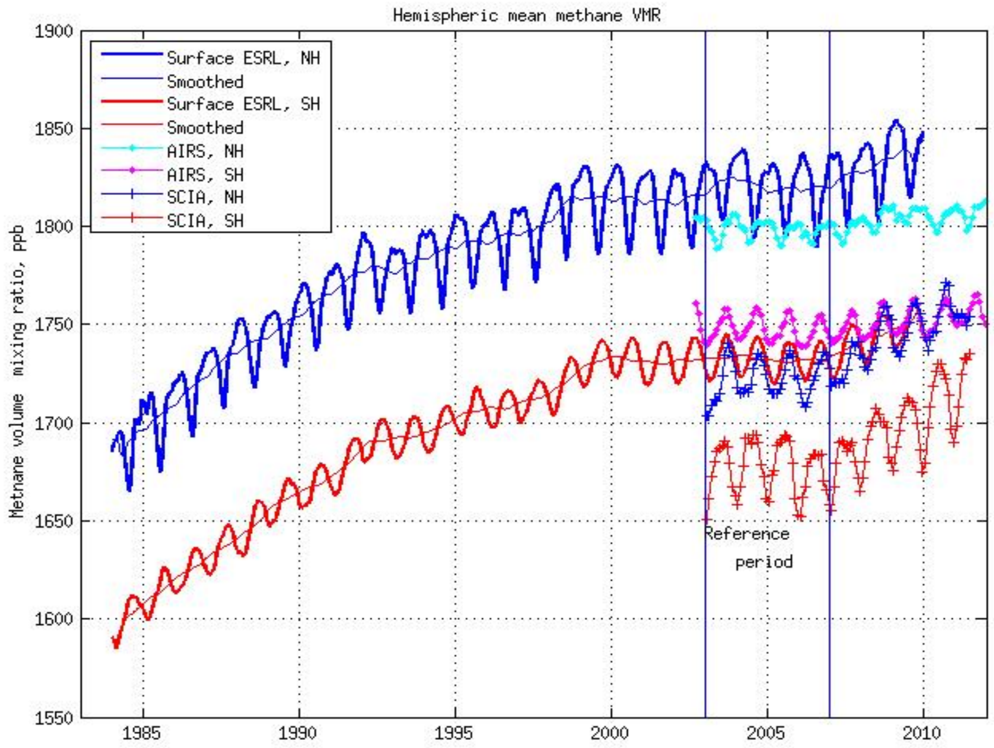
“Could the low troposphere methane data retrieved from TIR sensors serve as an indicator of methane over the Arctic Ocean?”

Global/hemispheric: satellite vs in-situ data

ESRL flask network



ESRL vs AIRS and SCIAMACHY

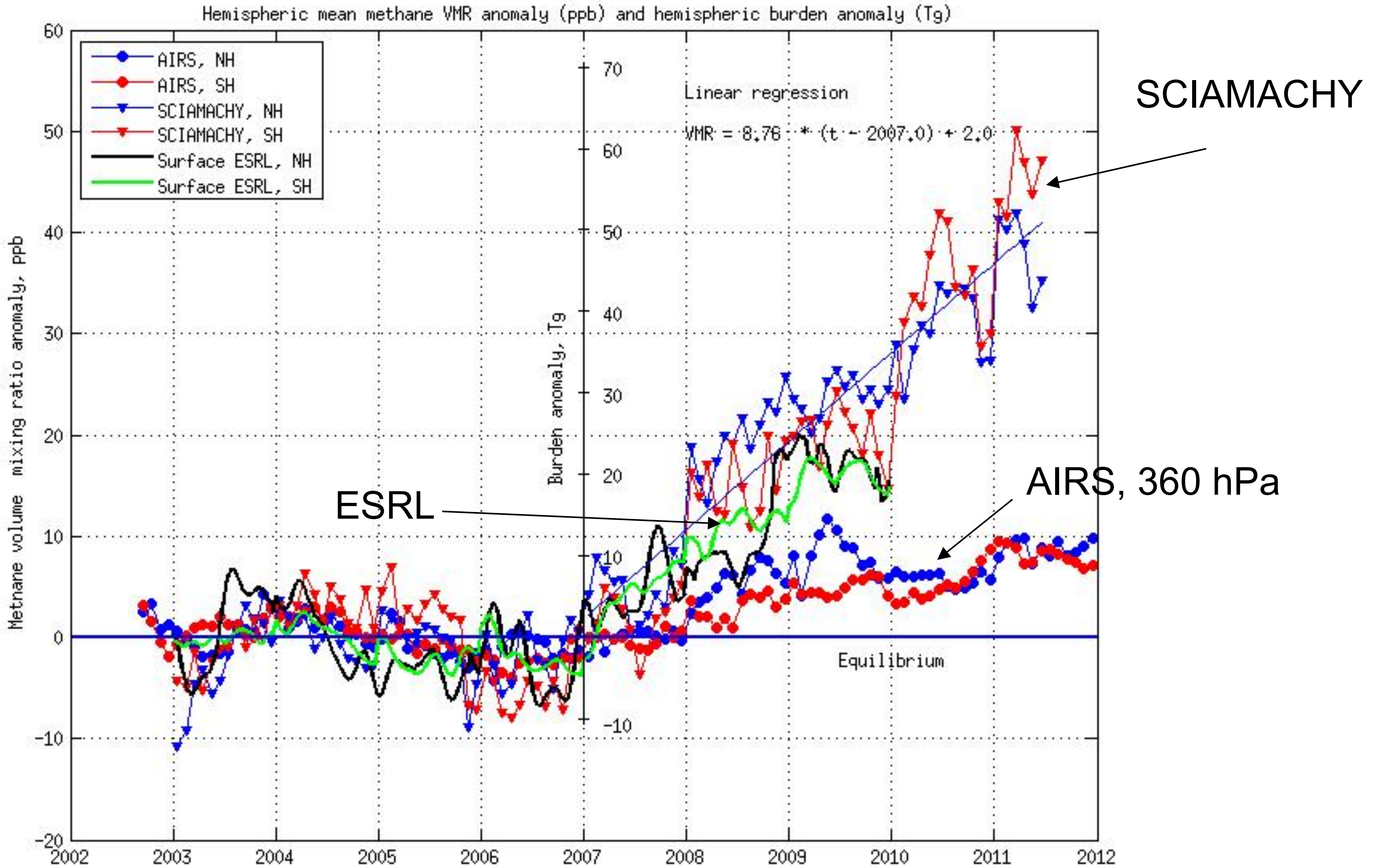


ESRL – **surface** network (just a few sites in the Arctic, and only on shore (GLOBALVIEW-CH4)

SCIAMACHY – Near IR (~ 1.8 µm), **tropospheric depth** (courtesy Christian Franckenberg, JPL), very few data in the Arctic/Antarctic

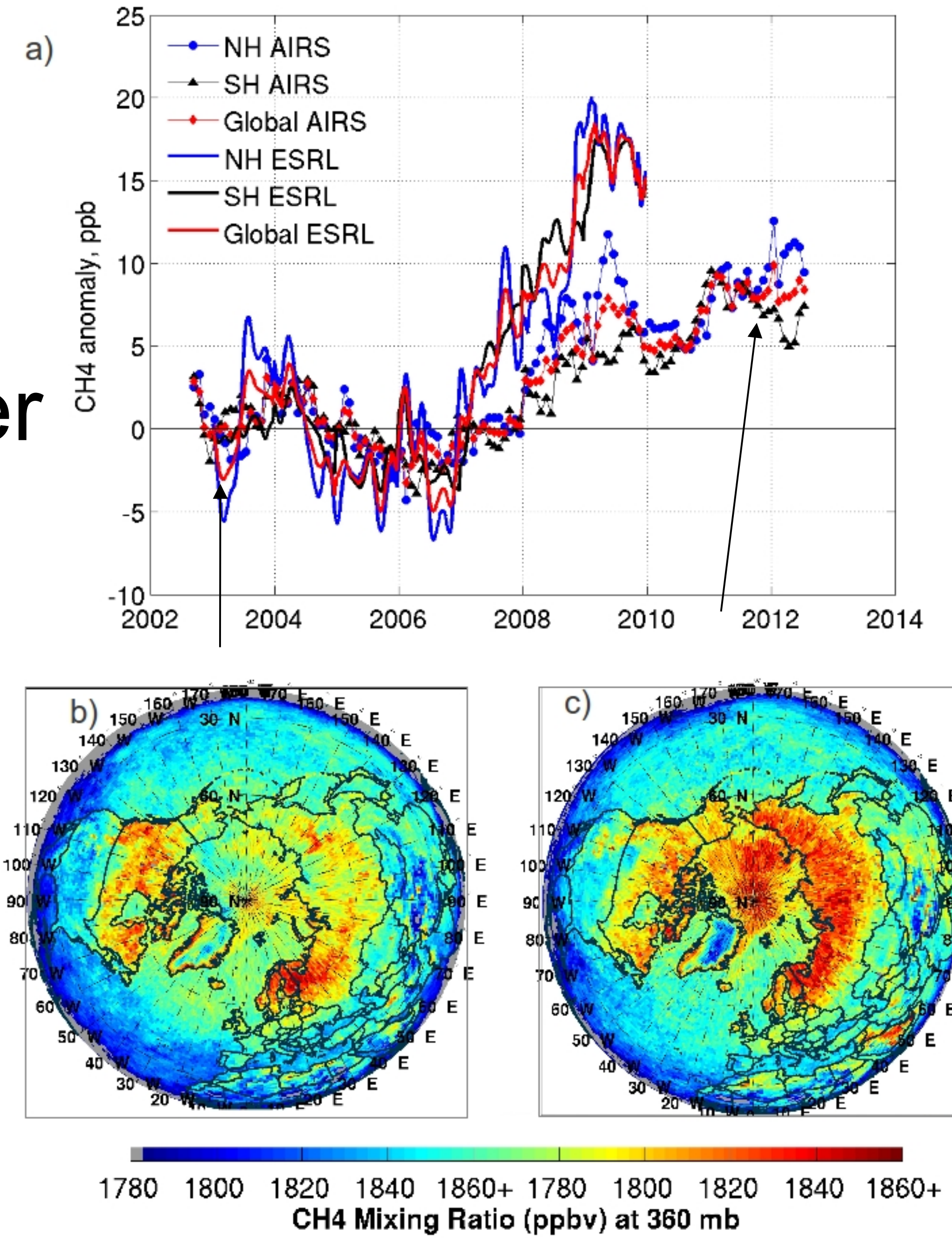
AIRS – TIR (~ 7.8 µm), **upper troposphere, including Arctic**

Anomalies (seasonal cycles subtracted), red – Southern hemisphere , blue – Northern hemisphere



SCIAMACHY: courtesy Ch. Franckenberg (JPL), ESRL – GLOBALVIEW_CH4-2009

AIRS CH4 v5 monthly anomalies, upper troposphere



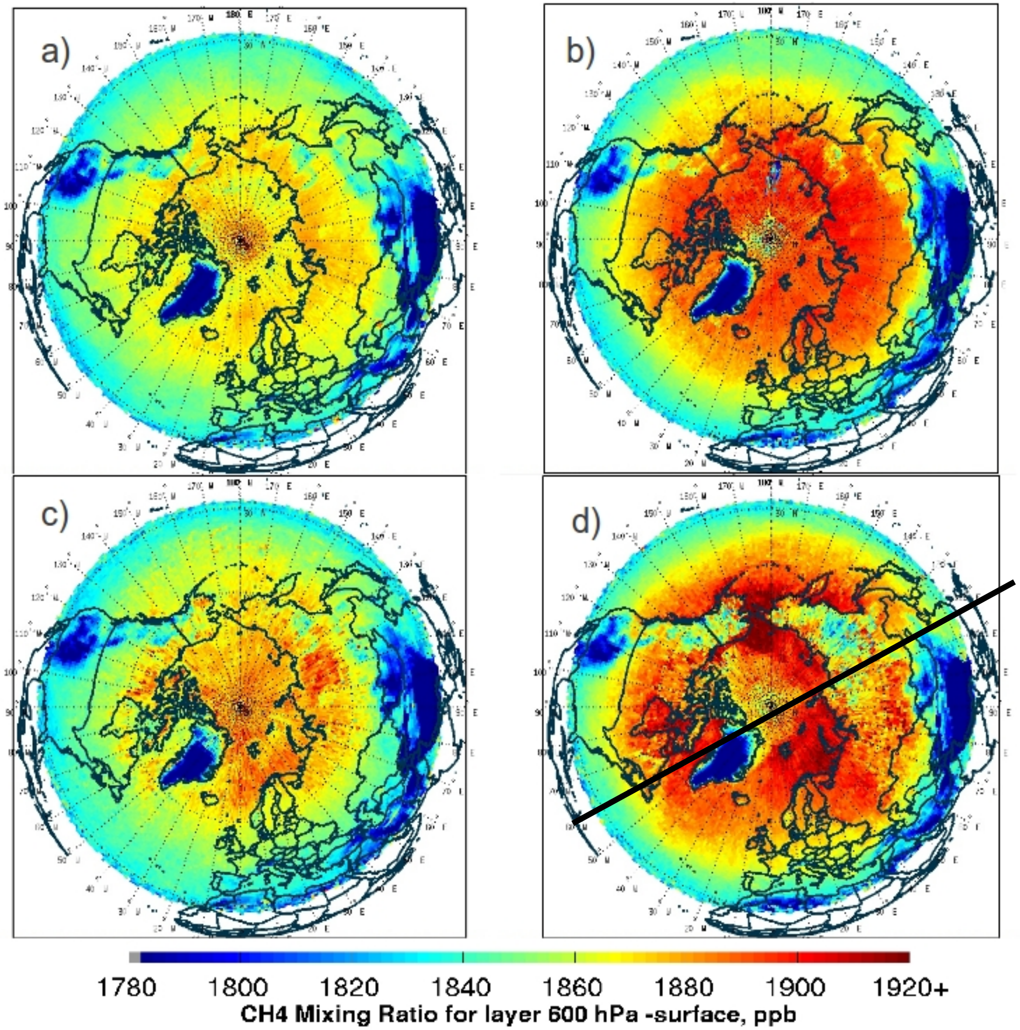
October 2002

October 2011

September, 2008

September, 2011

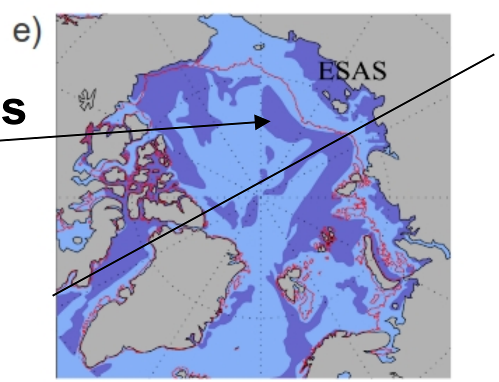
IASI CH4, low troposphere, mean below 600 hPa

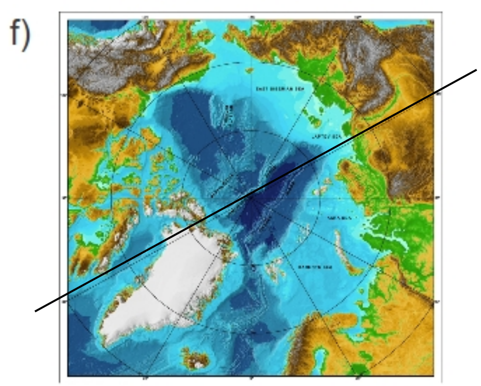


November, 2008

November, 2011

Locations of hydrates



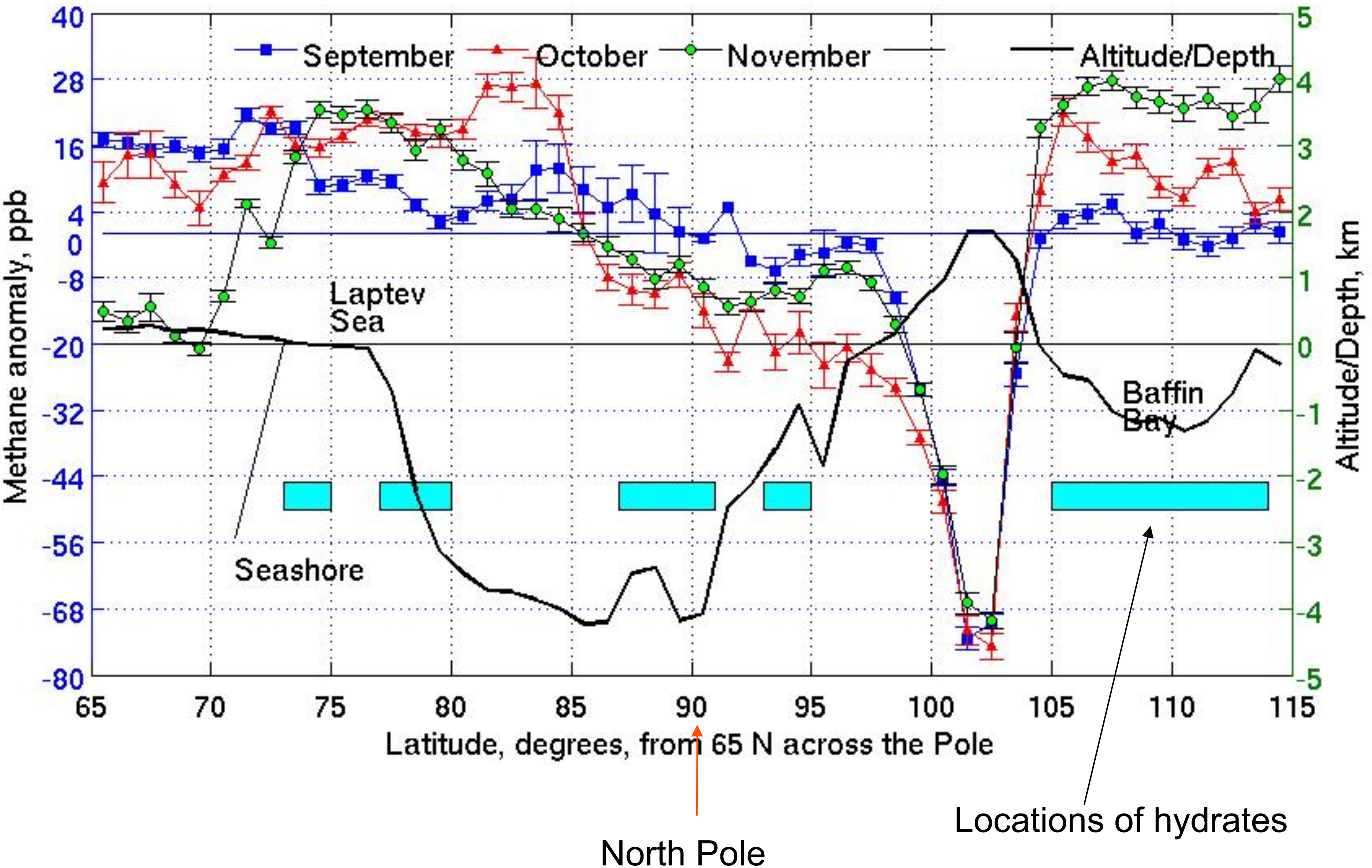


Cross-sections (next slide)

Batimetry

IASI CH4 anomalies , low troposphere

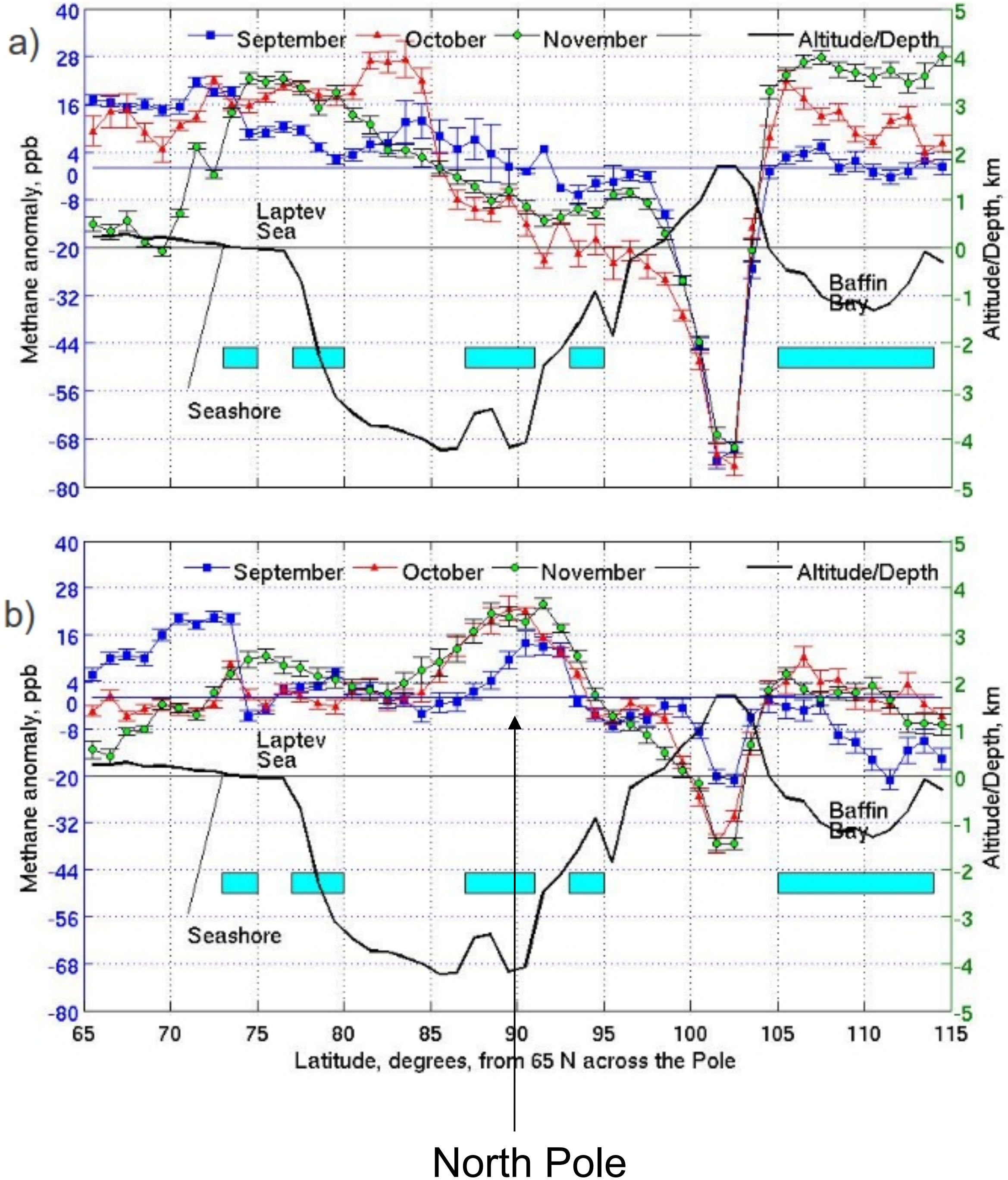
Cross-section, starting from Siberia via the Pole to N. America



Comparison of IASI (top) and AIRS (bottom) low tropospheric methane cross-sections

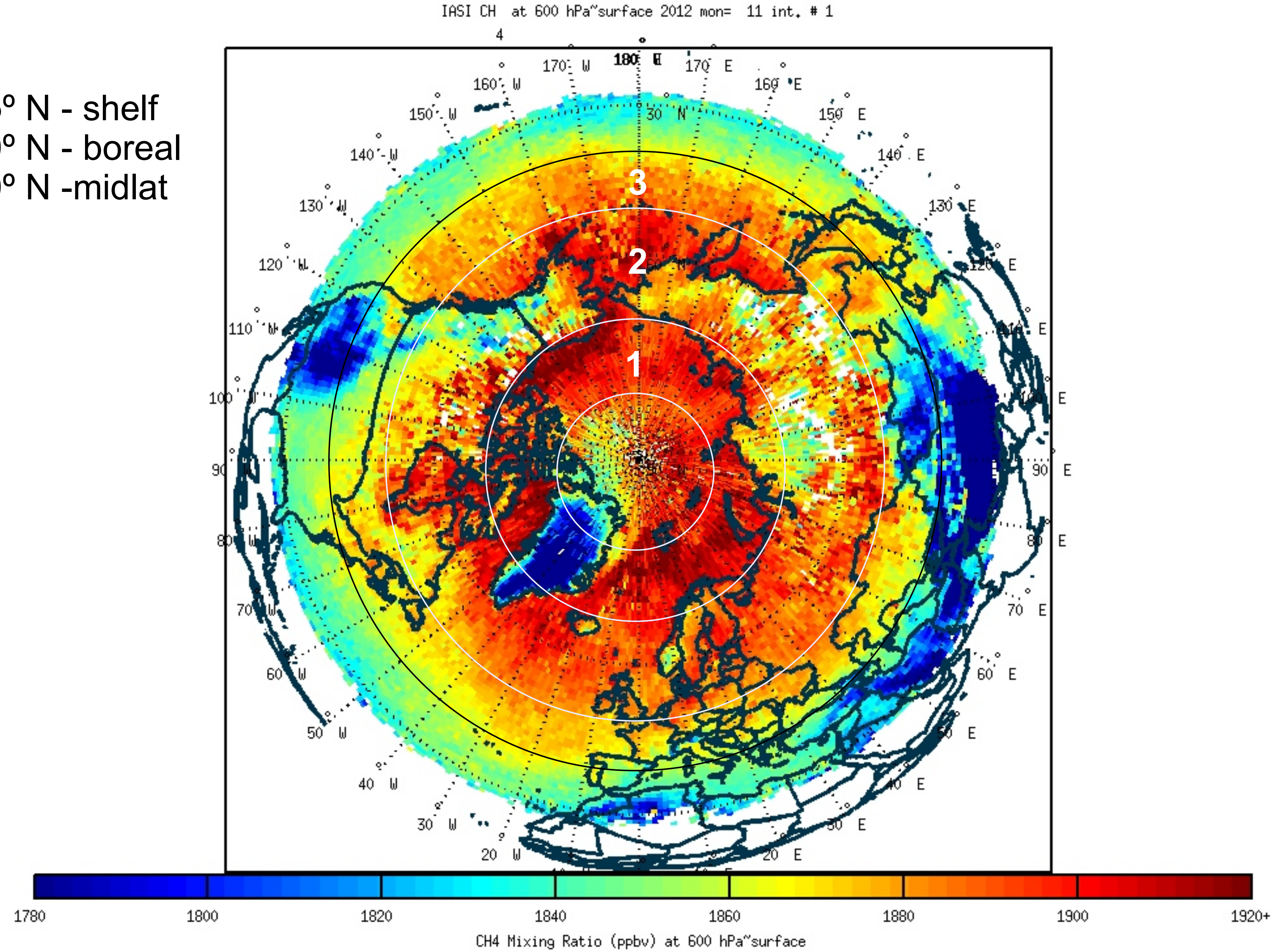
IASI, low troposphere

AIRS, low troposphere



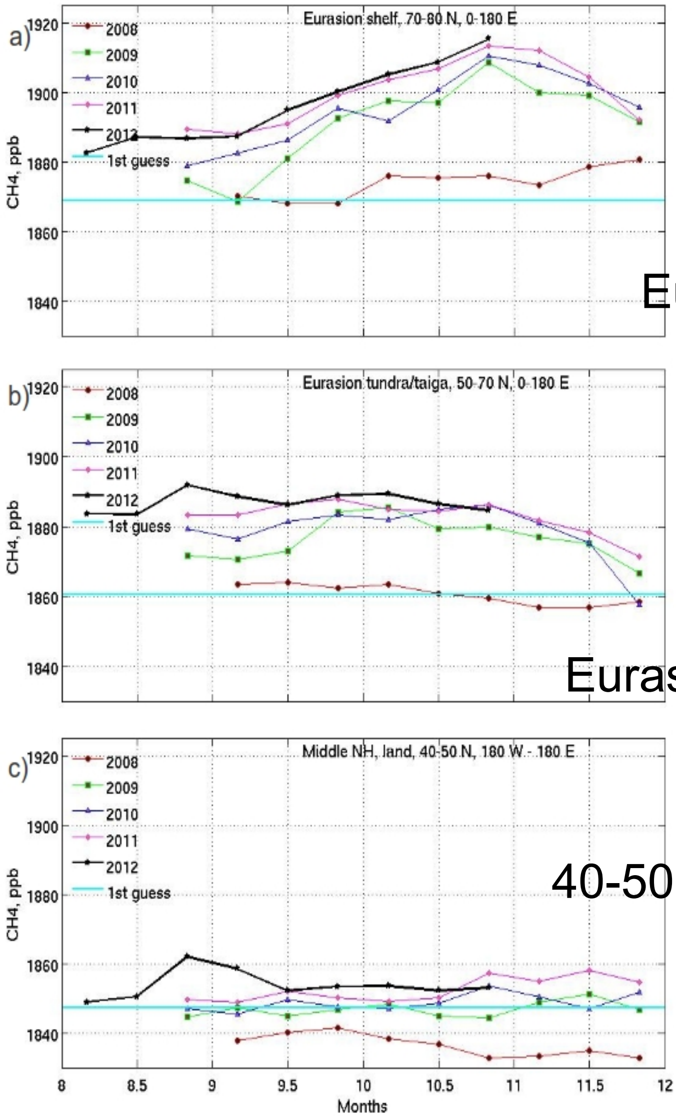
IASI mean CH4 in low troposphere for November 1 - 10, 2012 with boundaries of domains

1: 70º-85º N - shelf
2: 50º-70º N - boreal
3: 40º-50º N -midlat

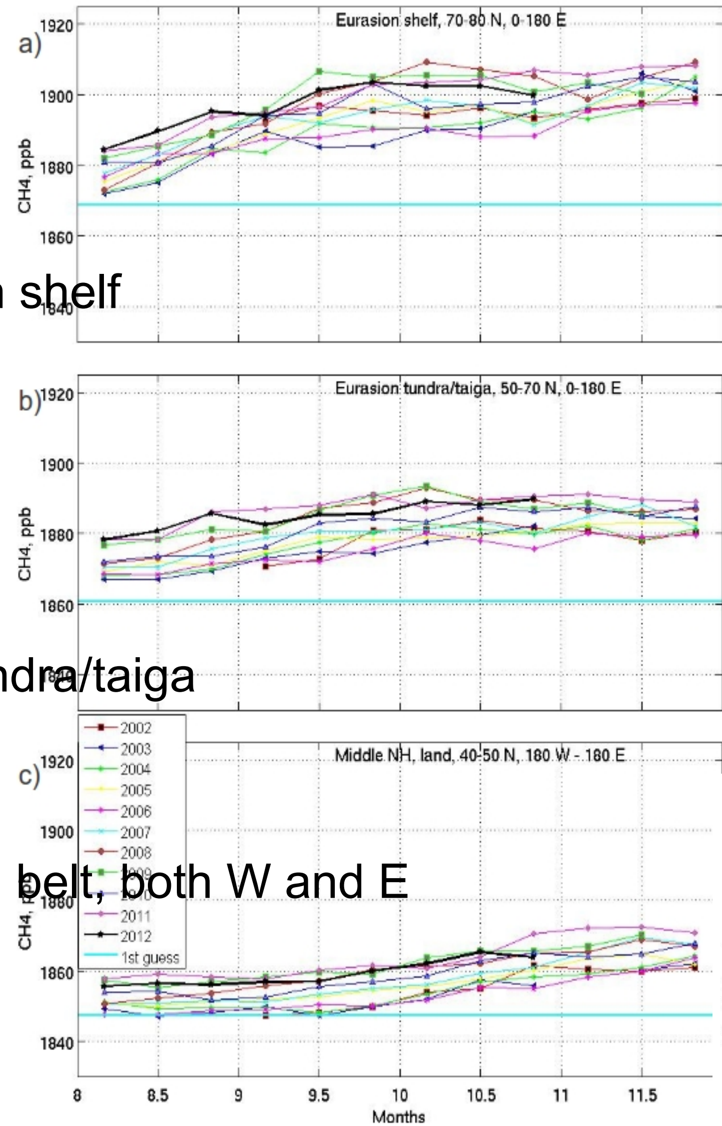


IASI and AIRS methane in the lower troposphere vs time for late summer – autumn

IASI low trop



AIRS low trop



Eurasian shelf

Eurasian tundra/taiga

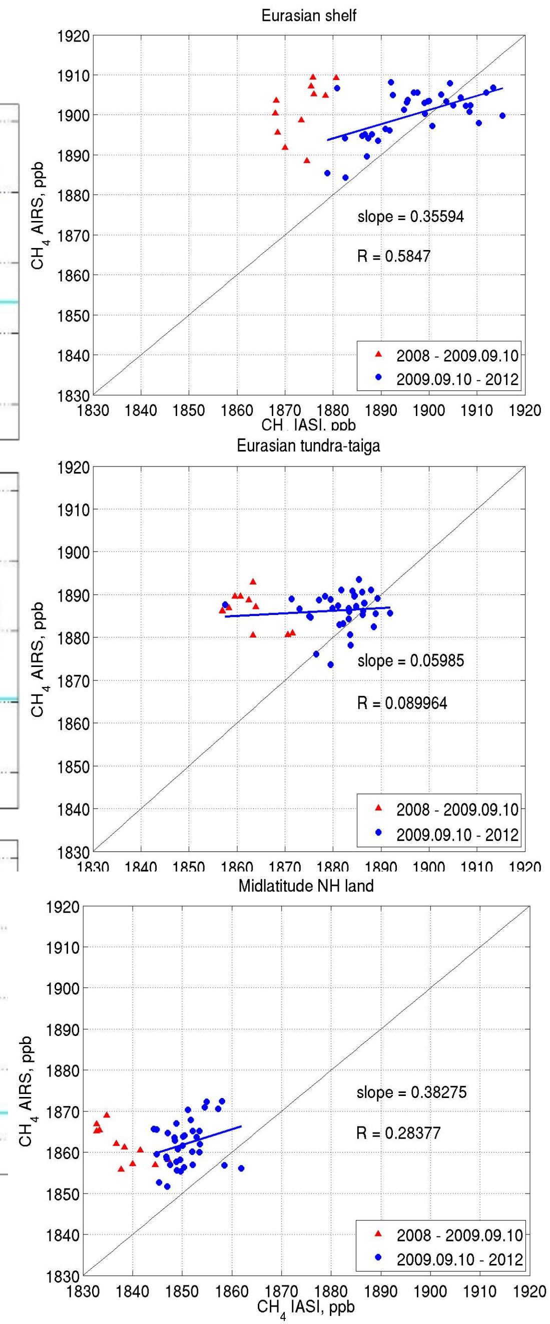
40-50 N land belt, both W and E

Aug.

Nov.

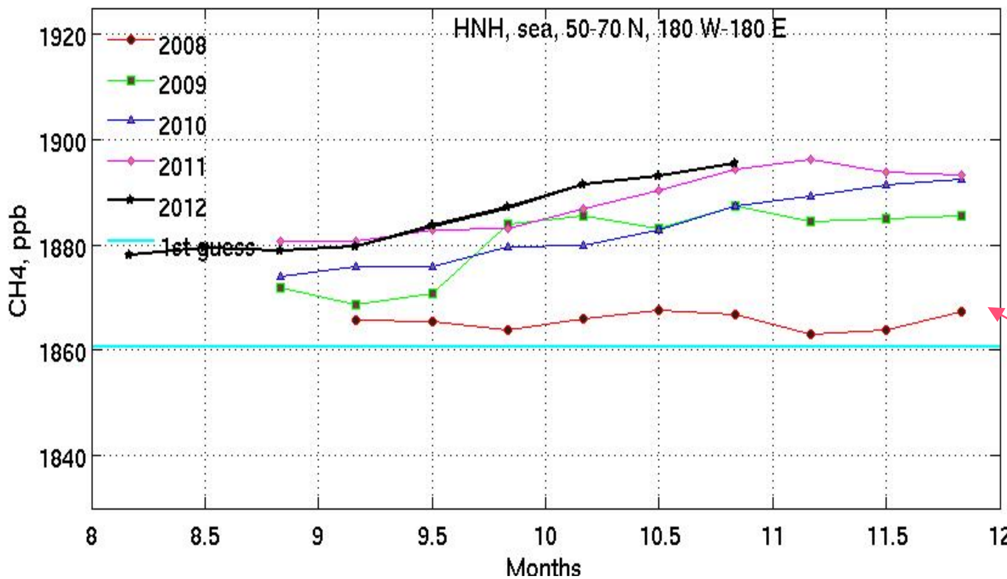
← Months →

AIRS vs IASI

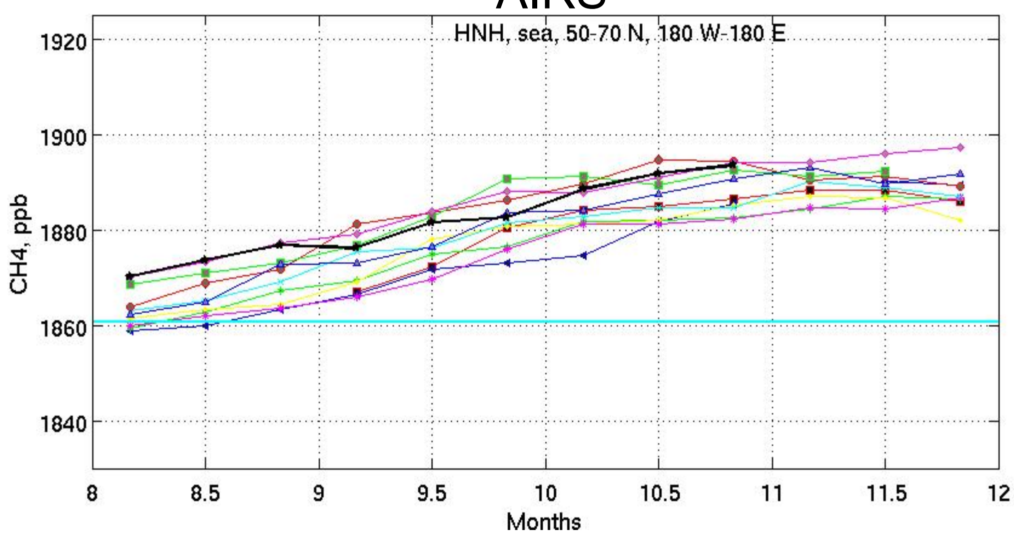


N Atlantic and N. Pacific oceans, 50° – 70° N

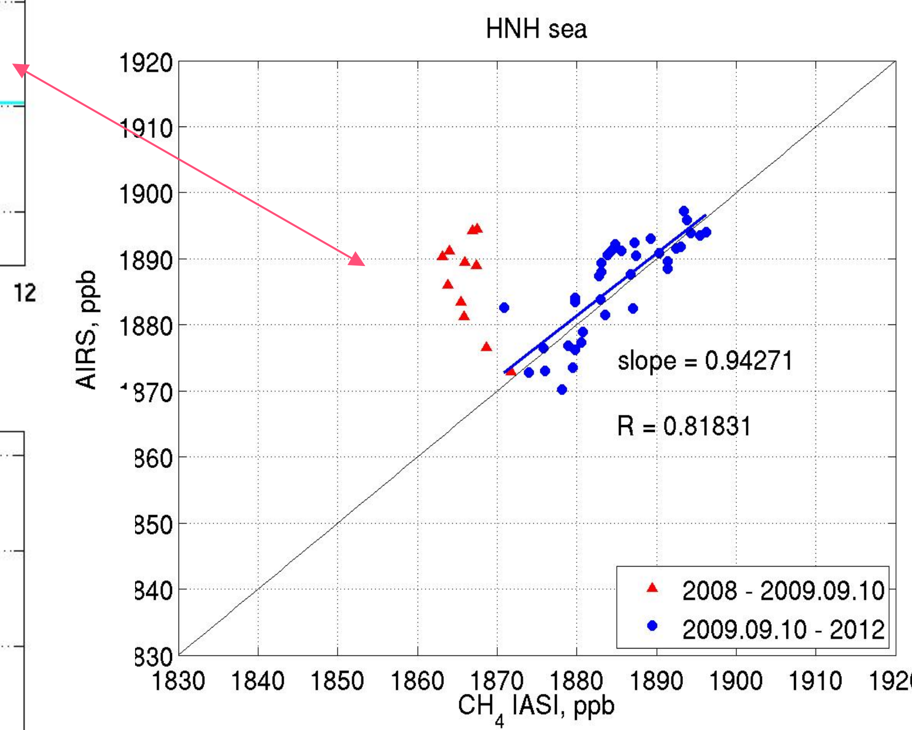
IASI



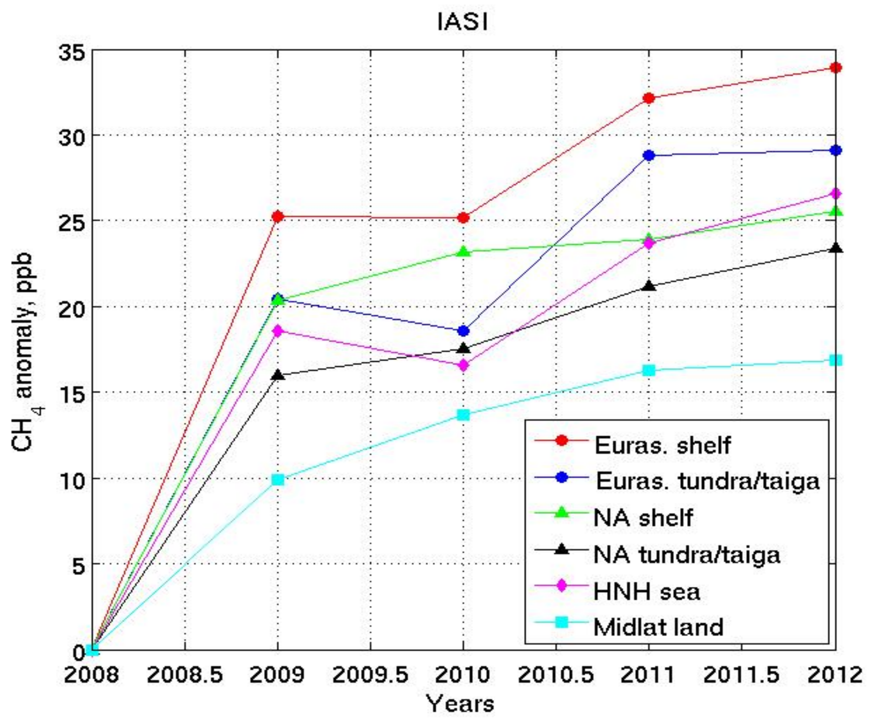
AIRS

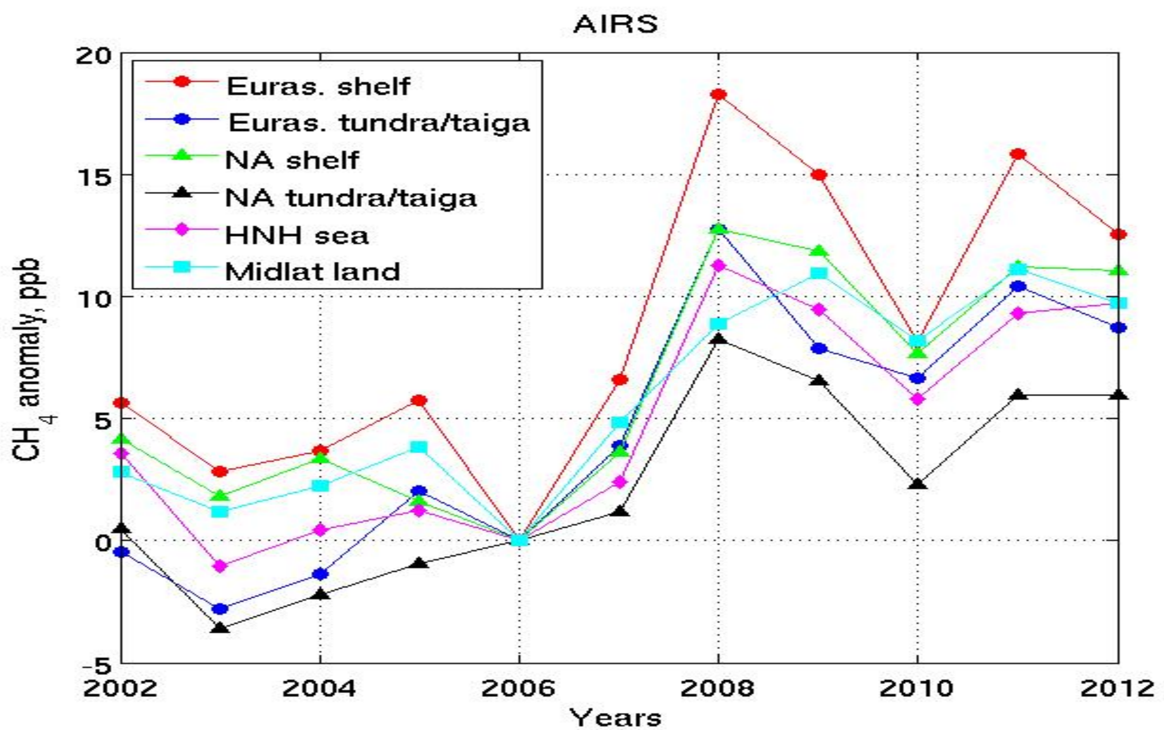


AIRS vs IASI



Low tropospheric mean October methane anomalies referenced to 2008 (IASI) and to 2006 (AIRS)





CONCLUSIONS

- IASI is more sensitive to the low troposphere than AIRS v5.
- IASI data can be used as qualitative indicator of the Arctic Ocean methane emission.
- Methane emission from the Arctic shelf has a maximum in September-early October.
- Current methane growth in the Arctic is **gradual**.
- Top-down emission estimates may be very uncertain (e. g., ± 100%)
- If a sudden venting (bubbling) of methane would happen due to hydrates destruction, IASI would be able to detect it.

What is recommended to do in the nearest future:

a) Reprocessing IASI, with inclusion of 2007, with a special attention to 2008 -2009.

b) Analysis of Japanese TANSO (TIR) low tropospheric methane data as obtained with a high spectral resolution.

c) Analysis of AIRS V6 low tropospheric data, as the only available satellite data since 2002.

d) Upper tropospheric data of all TIR sensors should be analyzed as well, to characterize global/hemispheric methane variations.