Evaluation of CH_4 standard AIRS and IASI retrievals for the Arctic and recent findings

Leonid Yurganov, UMBC/JCET
Ira Leifer, Bubbleology Res. Internat.
Shawn Xiong, NOAA
Gennady Chepurin, UMCP

NASA Sounder Science Team Meeting
10/01/2014, Marriott Greenbelt, MD

Supported by NASA grant: "***Long-term Satellite Data Fusion Observations of Arctic Ice Cover and Methane as a Climate Change Feedback***", **PI Ira Leifer**

Outline

Methane (CH4) is a product of NASA (AIRS, V6) and NOAA (IASI-1), it is publicly available on line:

AIRS v6, Level 2 and Level 3:
http://disc.sci.gsfc.nasa.gov/datareleases/aqua-airs-version-6

IASI Level 2, now is a part of NUCAPS:
http://www.nsof.class.noaa.gov/saa/products/search?sub_id=0&datatype_family=IASI&submit.x=23&submit.y=7

The data for lower 0-4km of the troposphere are analyzed.

Retrieval algorithms for both data sets are similar and global validation demonstrated a reasonable accuracy (***X. Xiong et al., 2010, 2013***). However, the Arctic Ocean is a specific area that needs a special consideration. Standard Quality Control is insufficient for the Arctic, especially for the lower tropospheric data **over ice**.

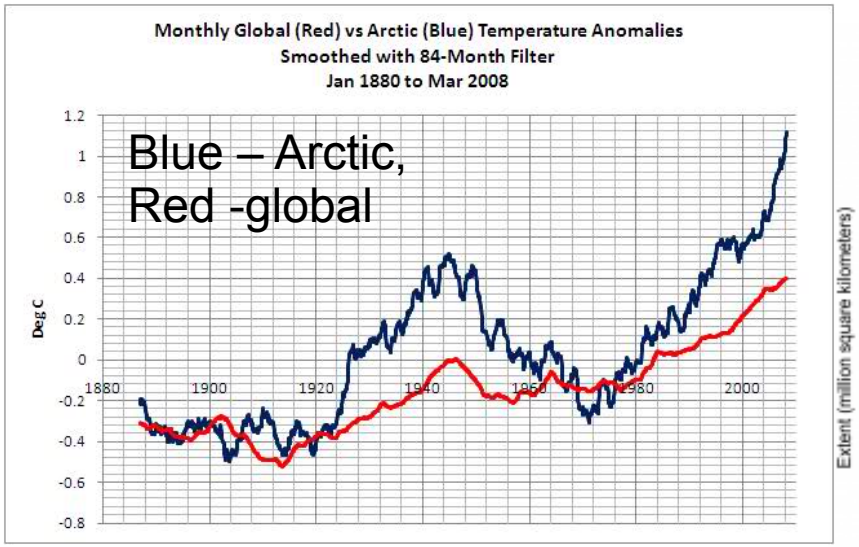
It will be shown that methane data over **open water** are accurate enough and do not contradict to a hypotheses of emissions from **methane hydrates.**

Background and motivation.

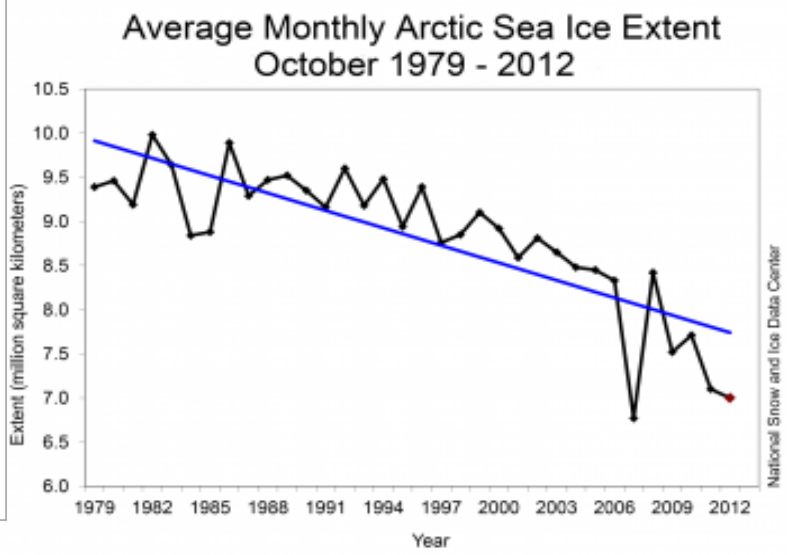
The Radiative Forcing of methane is ~ **23-100 times higher** than that of CO2.

Arctic warming is twice as faster than the rest of the World, mostly in winter time.

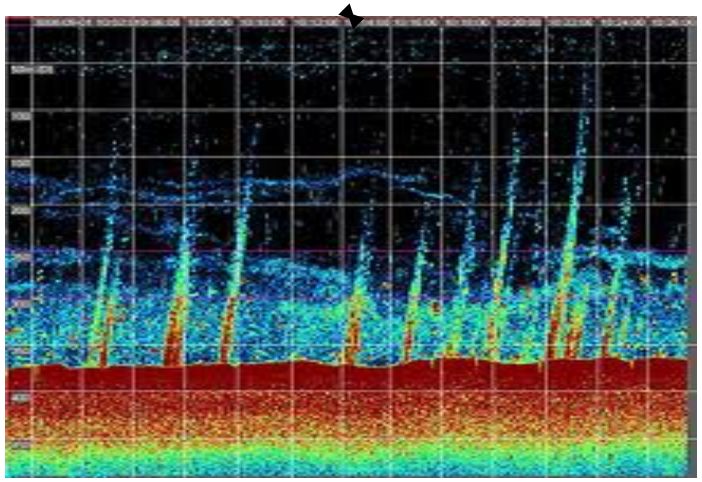
Temperature



Sea Ice Extent

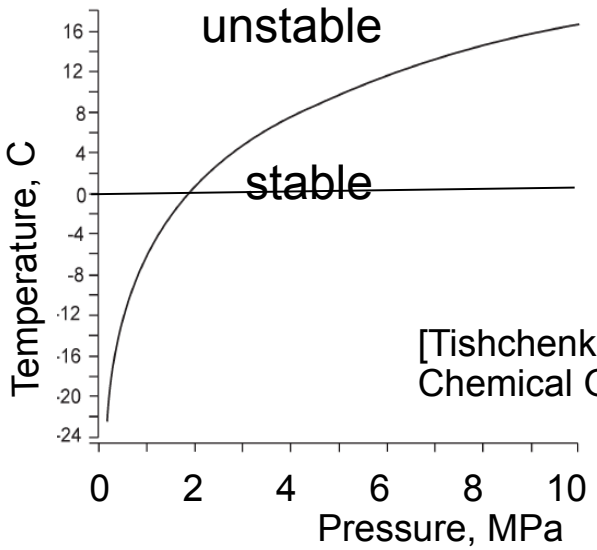


Methane hydrates

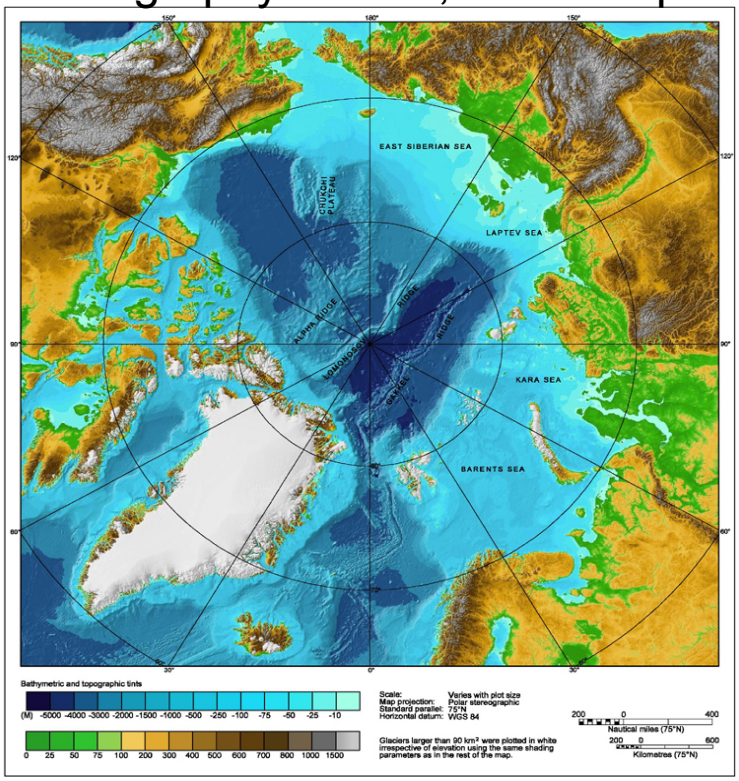


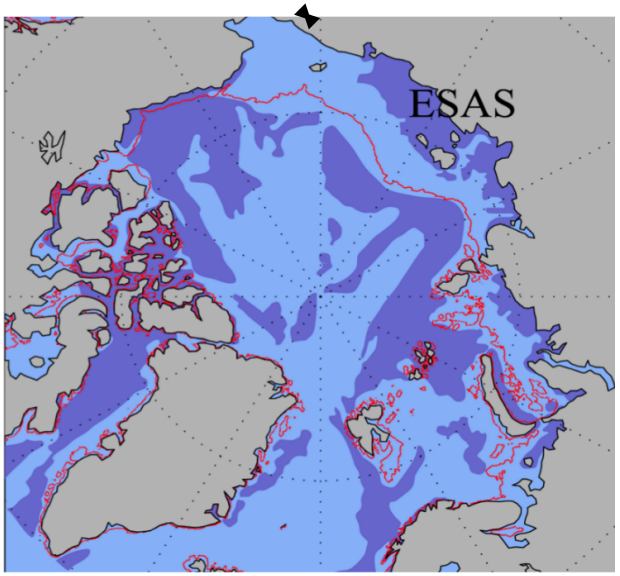
Sonar image of methane plumes rising from the Arctic Ocean floor near Svalbard (Image: National Oceanography Centre, Southampton)

Phase Diagram of methane hydrates



[Tishchenko P., et al., Chemical Geology. 2005].



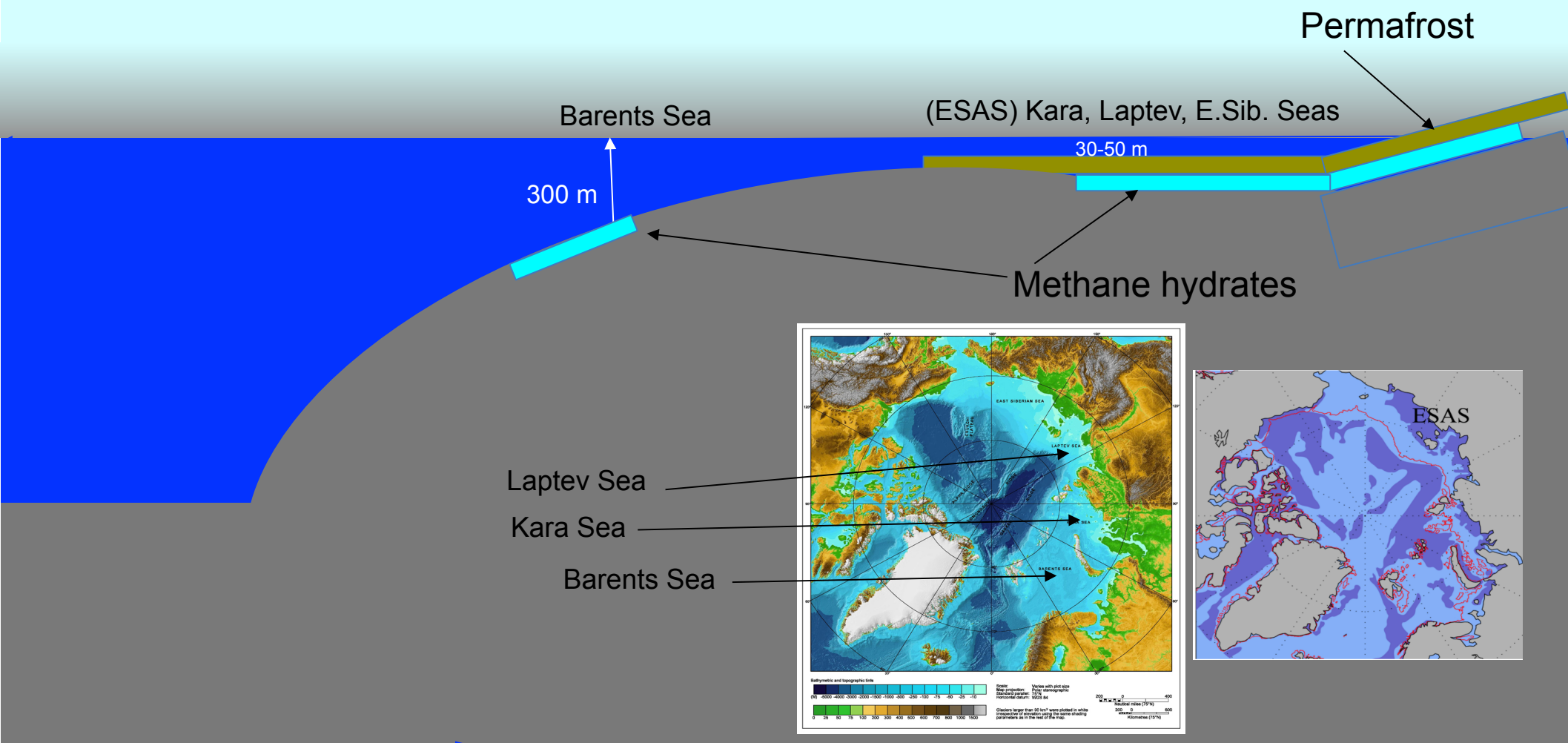


Methane hydrates are predicted along the slopes of the shelf

[Soloviev et al., 1987]

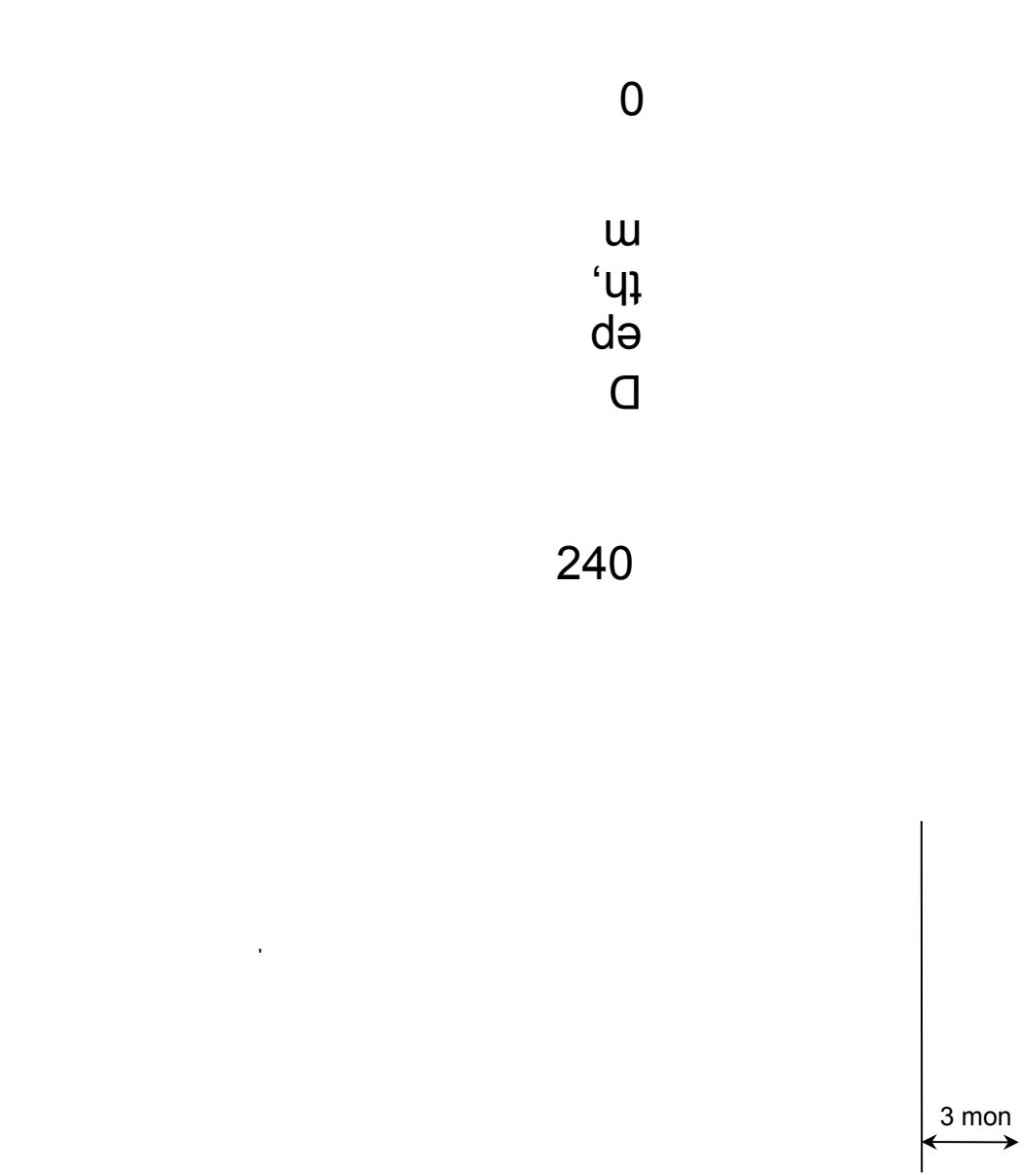
A simplified scheme of predicted methane hydrates in the Arctic

Methane hydrates may be stable either under the 300 m of seawater, or under the layer of permafrost



Seawater temperature climatology for 1950-2012 from the surface to the depth of 250 m, Barents Sea: note a delay in the bottom layer

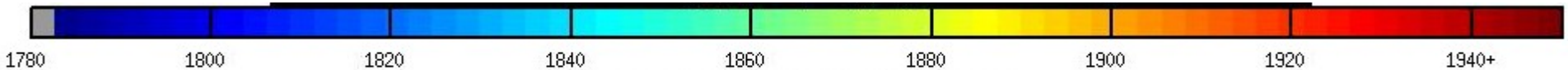
Seasonal maximum of SST is in **August**, near the sea floor (~250 m), in **November**



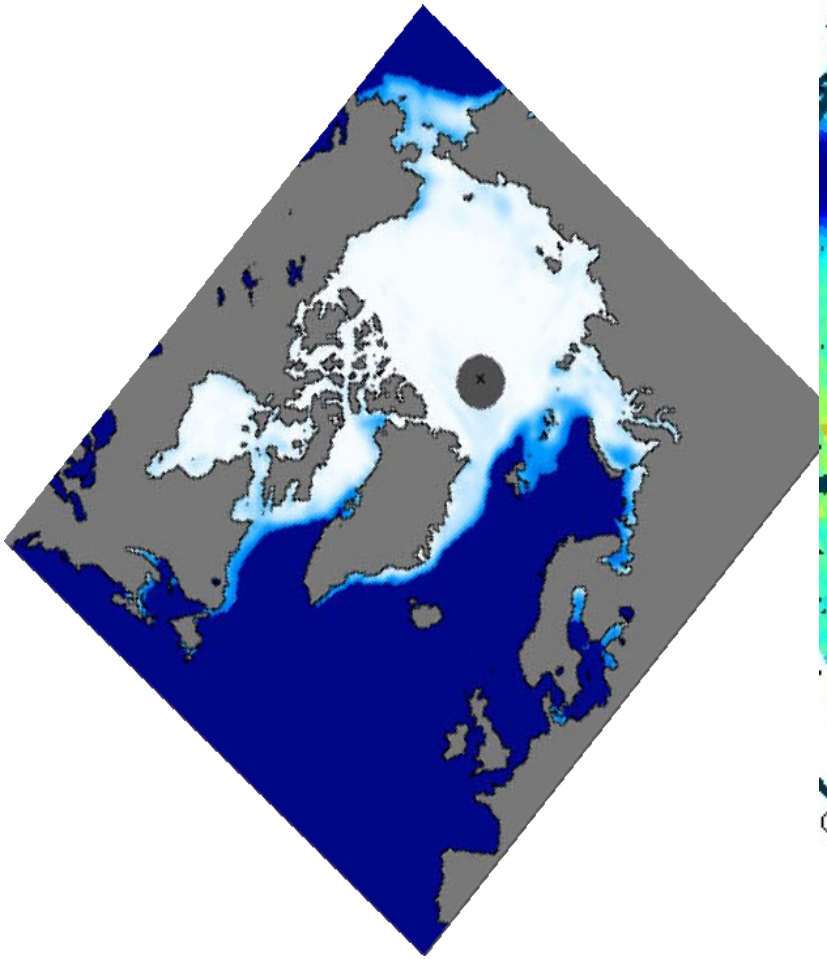
The CH4 maps based on standard data need a careful analysis and estimation of errors. In particular, look at a huge difference between ice-free and ice covered ocean. Is it a real difference or an artifact?

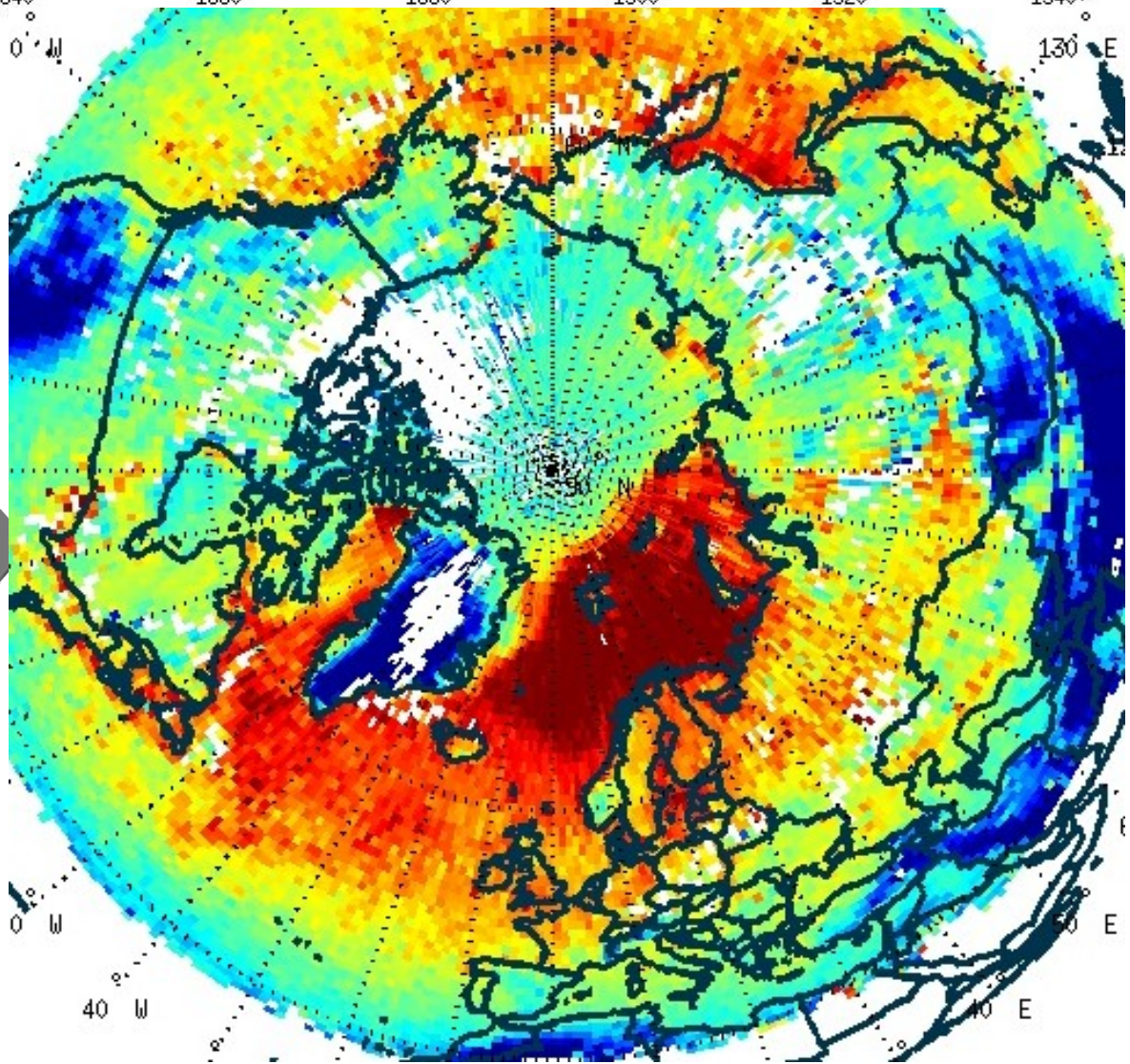
January 2013

IASI L3 methane (0-4 km)



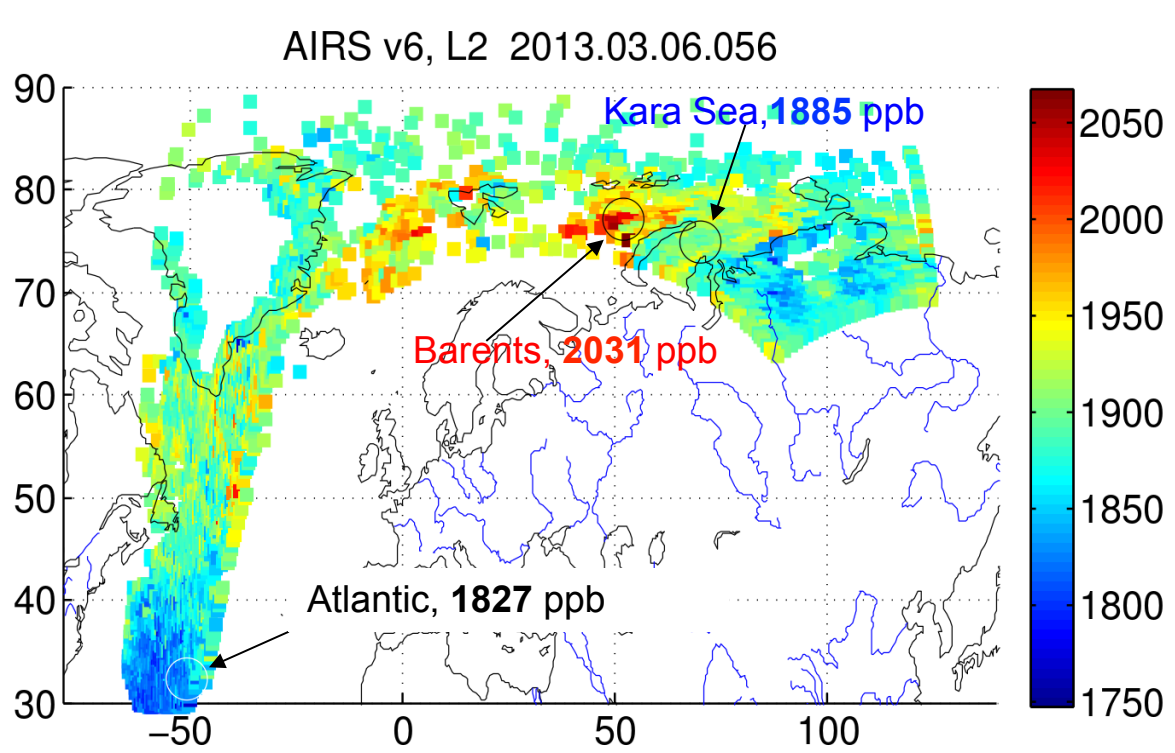
Ice map (NASA)



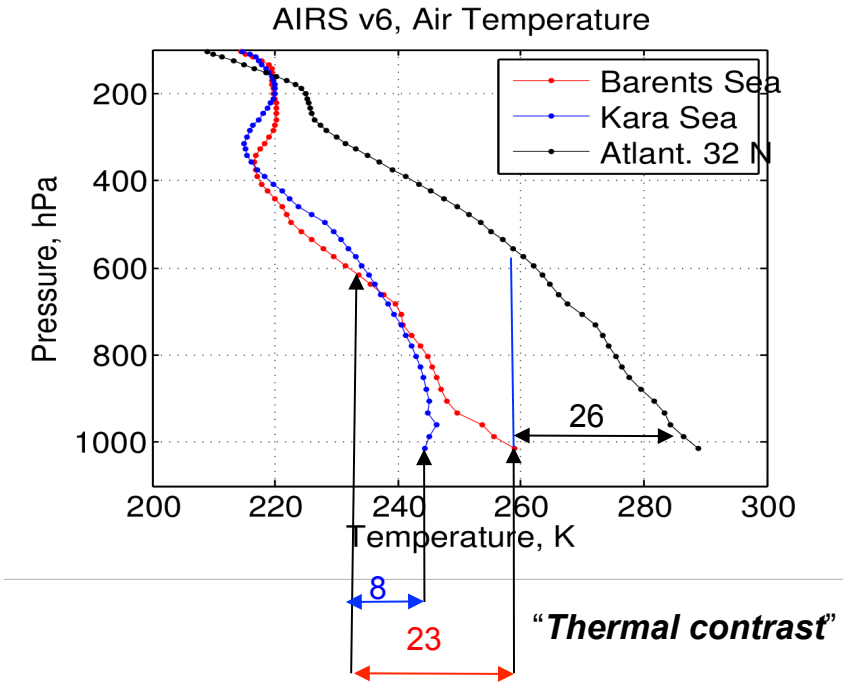


Case study

Here is a part of one AIRS orbit in March (Barents is open water, Kara is ice-covered).



As a rule, there are several orbits over every site of the Arctic Ocean per day



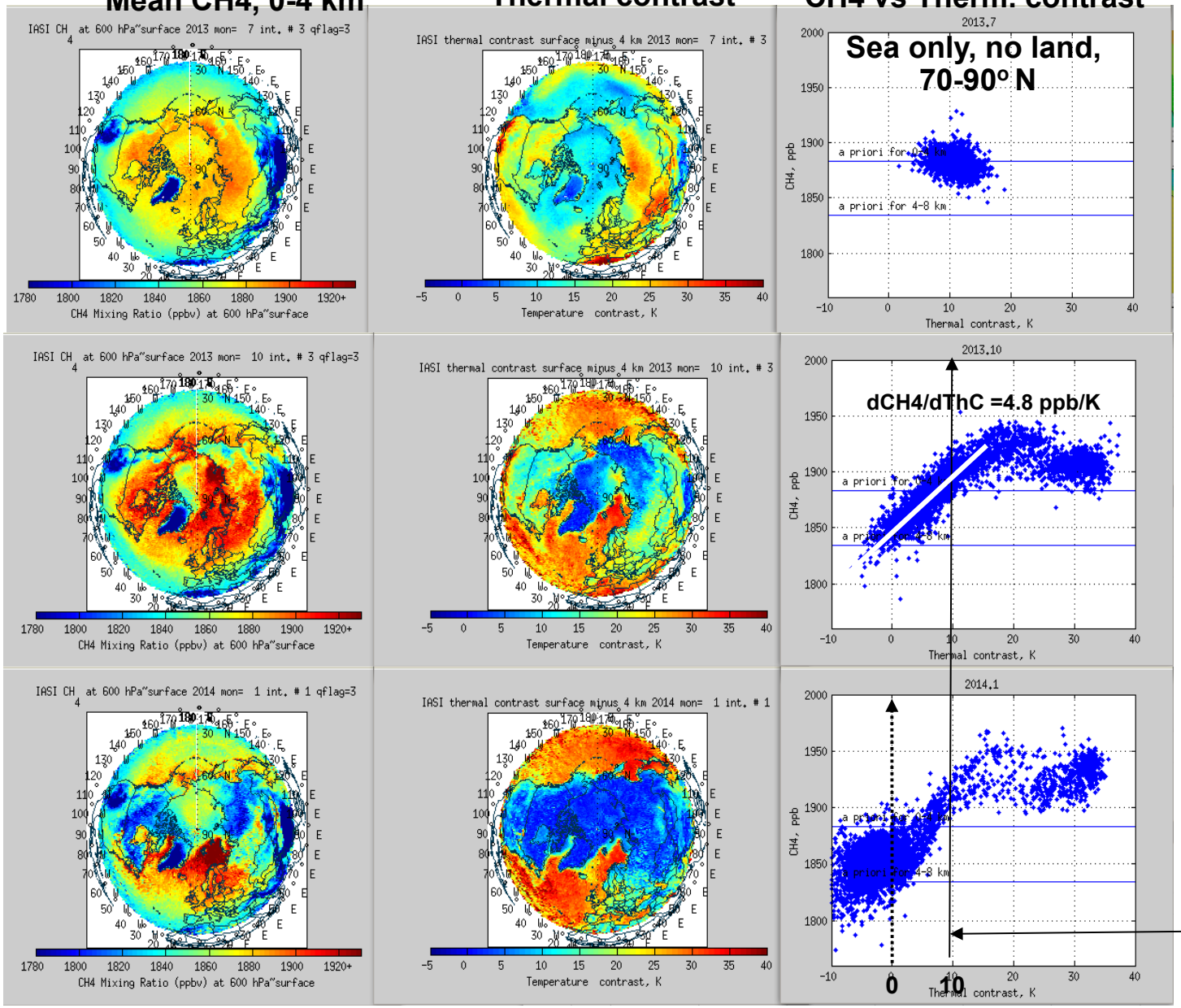
Aver. Kernels for bottom layer

Averaging kernels strongly depend on the thermal contrast. Over the Barents Sea retrievals for the bottom layer has a sensitivity that is 8 times higher, than over the Kara Sea. *Thermal contrast* (ThC) is defined here as a difference between SST and the air temperature at 4 km.

Kara Sea Atlant. Barents

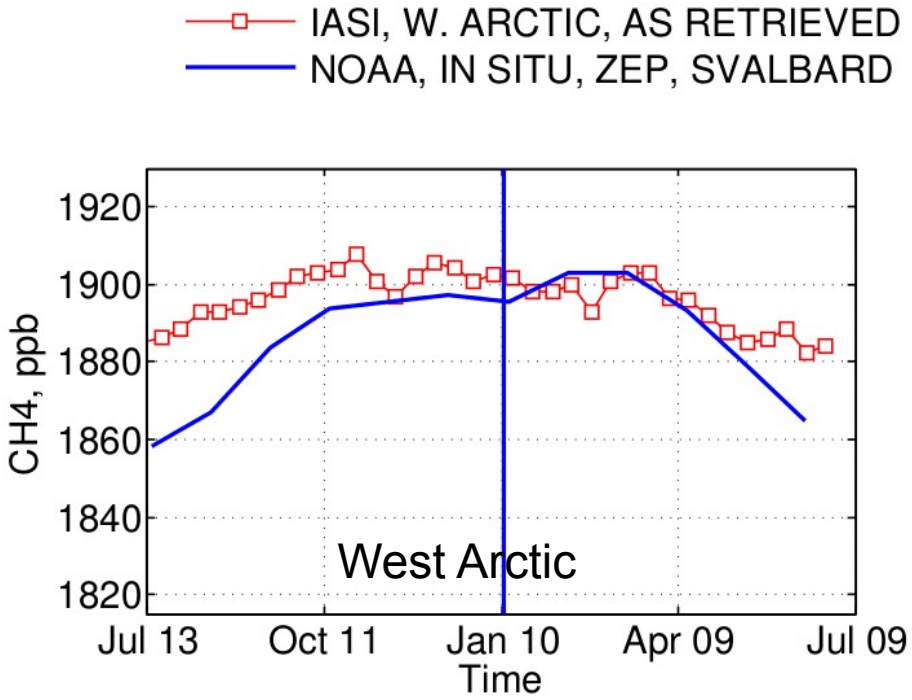
Here is IASI methane concentration *versus* the thermal contrast (ThC) over the Arctic Ocean .

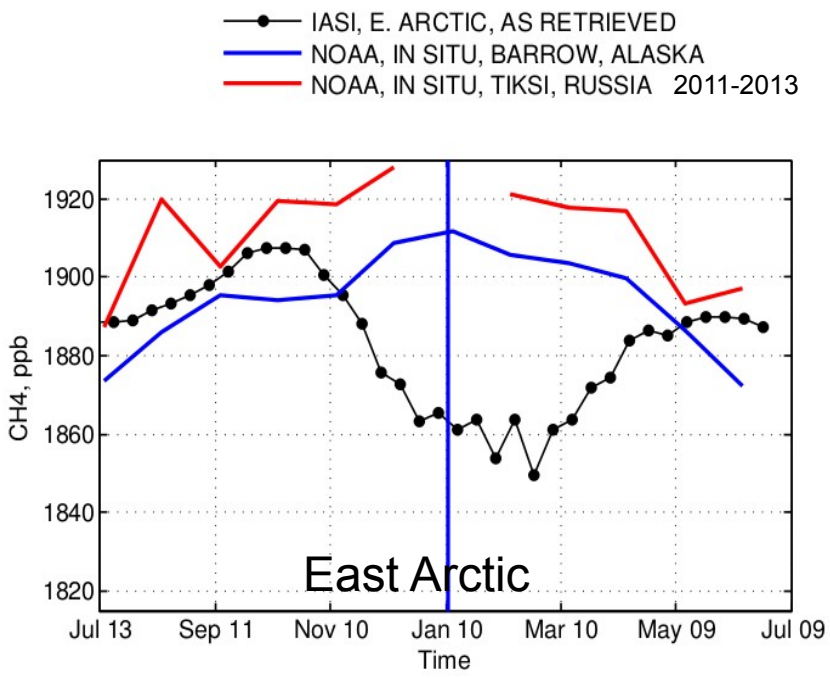
Mean CH4, 0-4 km | **Thermal contrast** | **CH4 vs Therm. contrast**



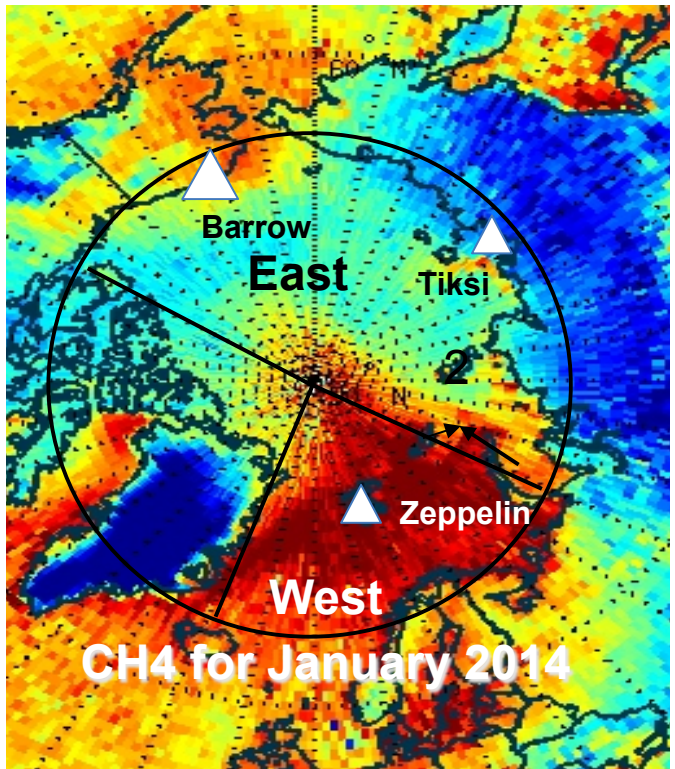
Satellite CH4 below 10 K of ThC is underestimated with a slope of 4.8 ppb of CH4 per 1 K of ThC. A good news is an apparent independence on the thermal contrast for ThC > 10 K.

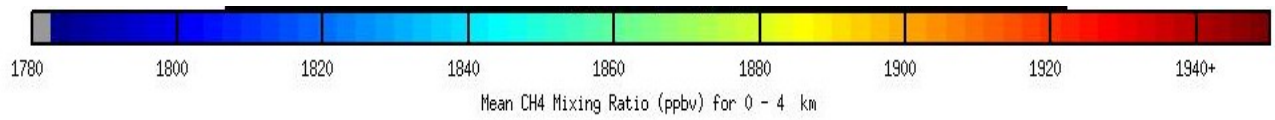
Seasonal cycles of CH4 averaged over 2009-2013 for IASI (0-4 km mean) and surface in situ



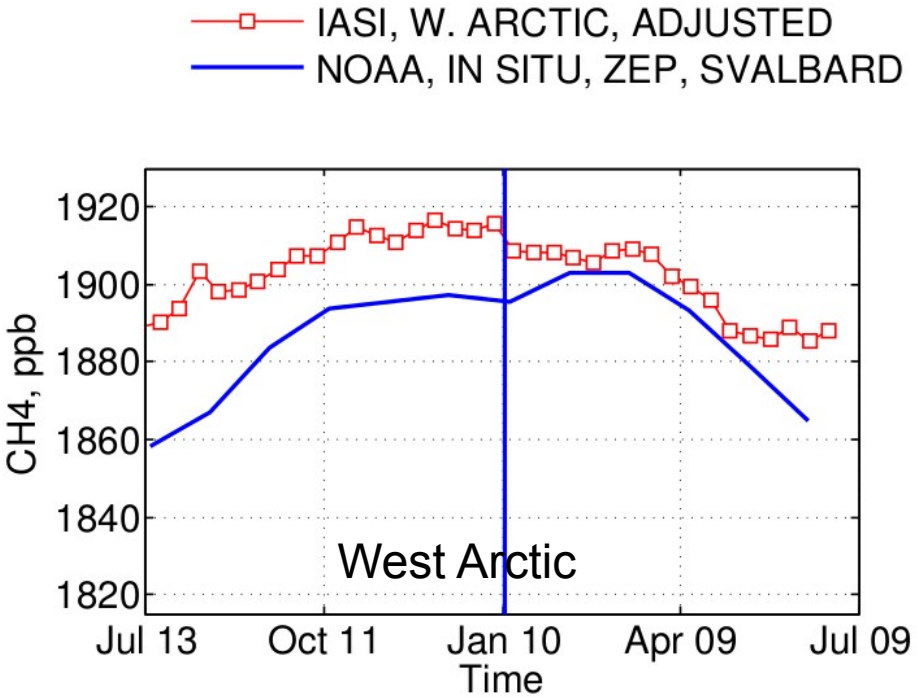


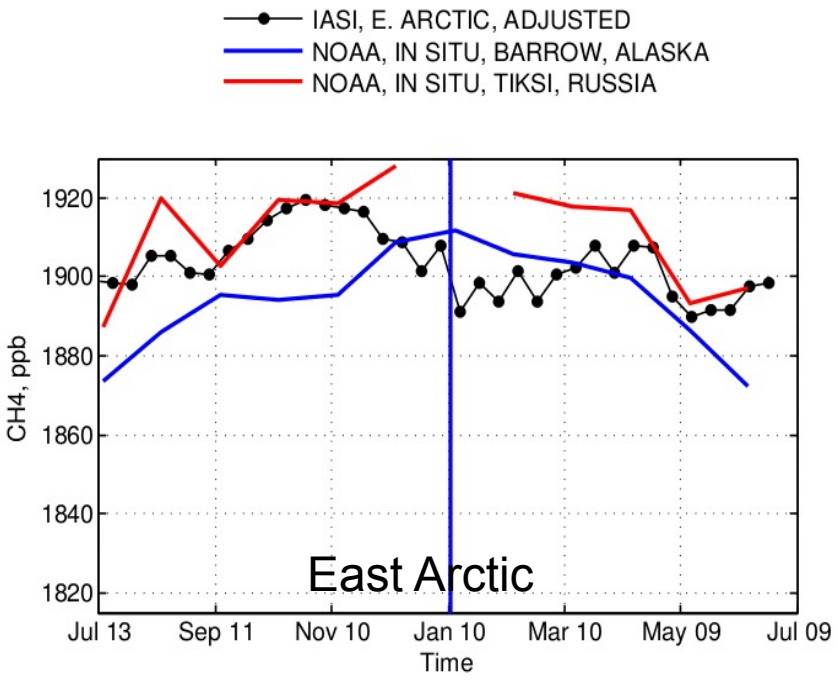
IASI data as retrieved by standard processing with standard Quality Control.





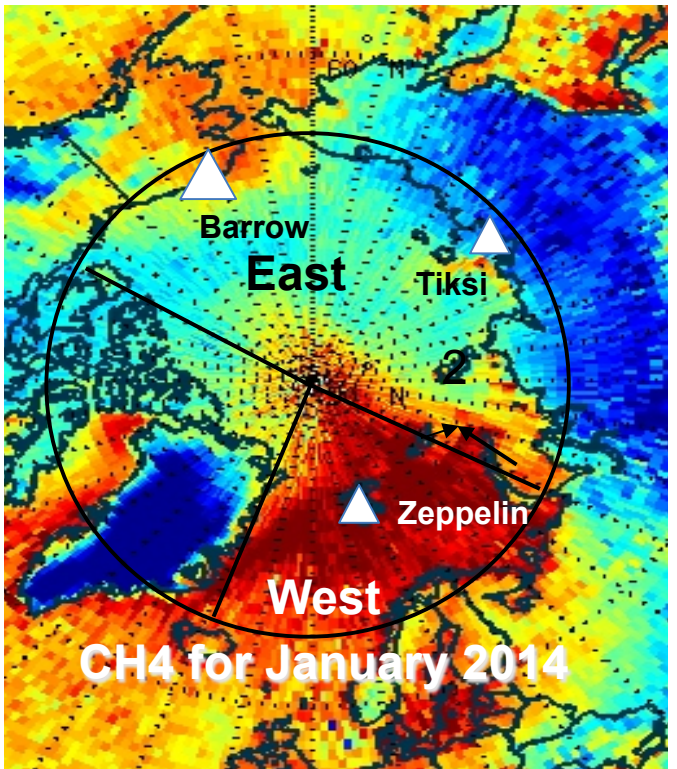
Seasonal cycles of CH4 averaged over 2009-2013 for IASI (0-4 km mean) and surface in situ





IASI data adjusted using the 4.8 ppb per K empirical dependence.

CH4 data over the ice-covered East Arctic are unreliable, at least for the lower 0-4 km. Adjustment applied to them improves a disagreement, but could not be recommended as a remedy: low sensitivity still exists. CH4 for ThC<10 K at the next slides have been masked as unreliable.



Retrieved mean November CH4 for 2009 - 2013 for ThC>10 K: AIRS and IASI

1º x 1º

0.5º x 0.5º

AIRS

IASI

300-500 m of
seawater depth
(presumed location
of methane hydrates)

Retrieved mean December CH4 for 2009 - 2013 for ThC>10 K: AIRS and IASI

1º x 1º

0.5º x 0.5º

AIRS

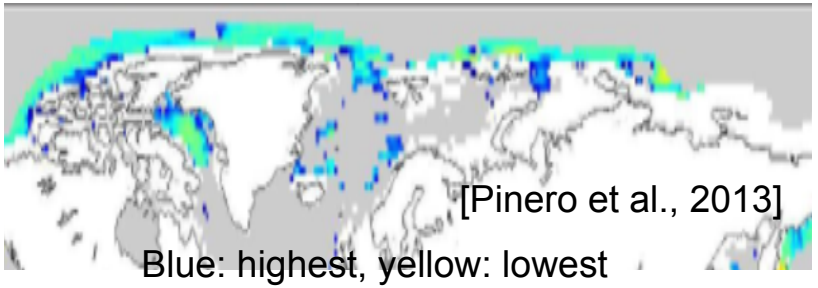
IASI

Baffin Bay

Barents Sea

300-500 m

Model locations of methane hydrates



[Pinero et al., 2013]

Blue: highest, yellow: lowest

IASI CH4 data averaged over the entire Arctic Ocean (ThC>10 K) to the North from 70 N (blue) as well as for two areas of interest: Baffin Bay and Barents Sea.

Baffin Bay with averaging for areas with different seawater depths.

IASI

, Kara Sea

IASI

Conclusions

Evaluation of AIRS and IASI. **Analysis of standard AIRS and IASI CH4 retrievals for 0-4 km layer makes sense over open seawater. Such data over sea ice and/or for low Thermal Contrast are unreliable.**

A check up of IASI data for consistency is on the list.

Methane over the Arctic ocean. **Satellite data on Methane in the West Arctic do not contradict to a hypothesis of existing and growing with years emission from methane hydrates.**

A simplified scheme of albedo and methane feed-backs

(albedo is active in summer, methane is active in autumn-spring)