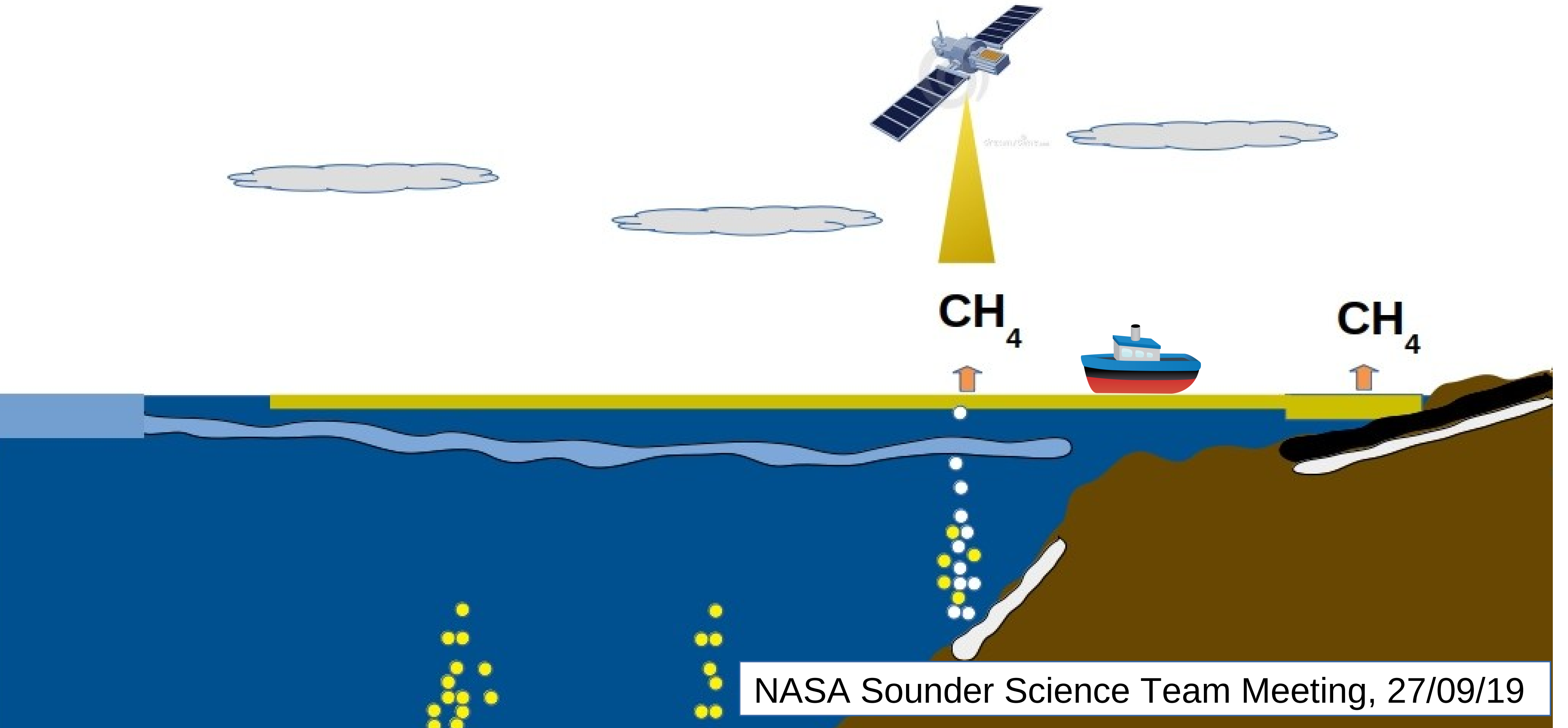
Enhanced Arctic Low Tropospheric methane correlates with increased mixing of seawater

Leonid Yurganov, University of Maryland Baltimore County (Ret), MD, USA
Frank Muller-Karger, University of South Florida, FL, USA
Ira Leifer, Bubbleology Research Int., CA, USA



NASA Sounder Science Team Meeting, 27/09/19

Outline

1. Methane (CH_4) is a greenhouse gas

2. Arctic is warming

3. CH_4 sources may grow

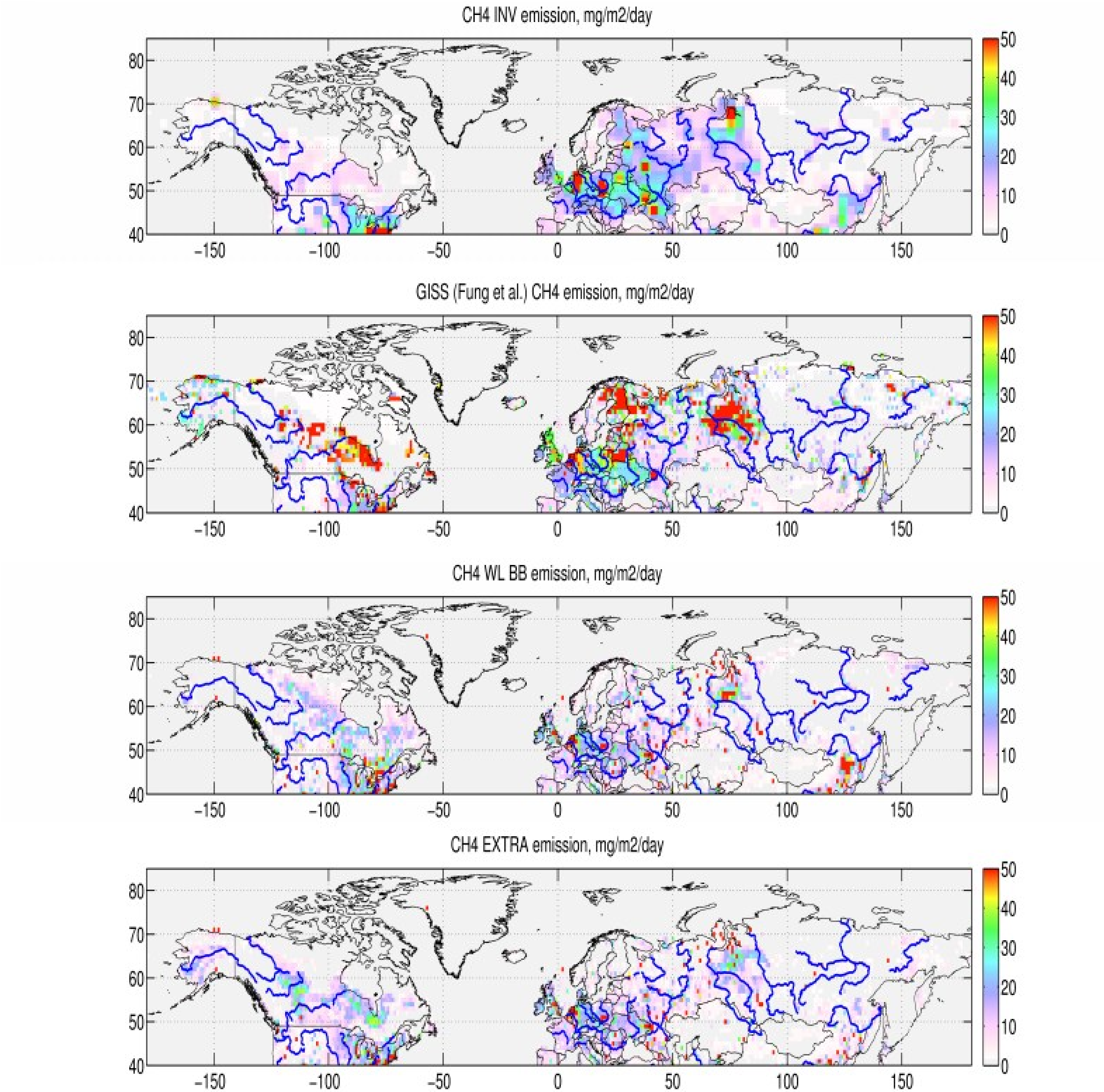
4. SWIR (NIR) sounders, like TROPOMI, need Sun light and have low S/N over water and ice. They are inefficient in the Arctic.

5. TIR sounders (AIRS, IASI, etc) data are available 24/7 and year-round BUT require warm surfaces (water or land).

6. We use AIRS v6 L3 (IR only) and NUCAPS IASI from the CLASS site.

Currently emission from the Arctic seas in models and budgets is counted as ZERO!

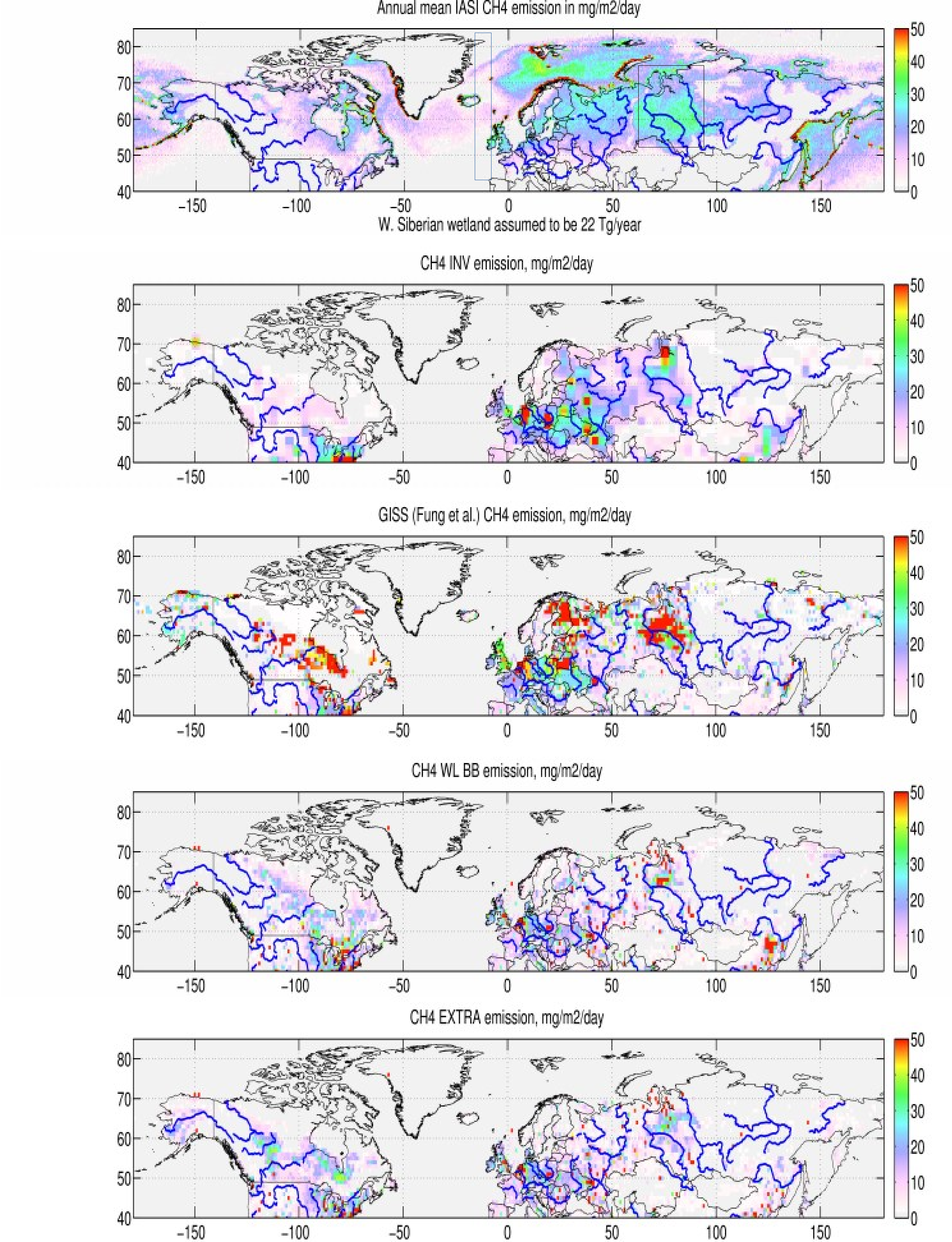
Example CH_4 emissions from currently available models and inventories



IASI and CH4_INV are top-down, others are bottom-up. More information see
http://transcom.project.asu.edu/pdf/transcom/T4.methane.protocol_v7.pdf

Preliminary estimate of CH_4 flux from IASI data (2010-2014)

West Siberia lowland (WSL) was assumed to emit 22 Tg/yr. WSL CH4 anomaly referenced to N. Atlantic was used to scale the map in flux units: mg/m^2/day

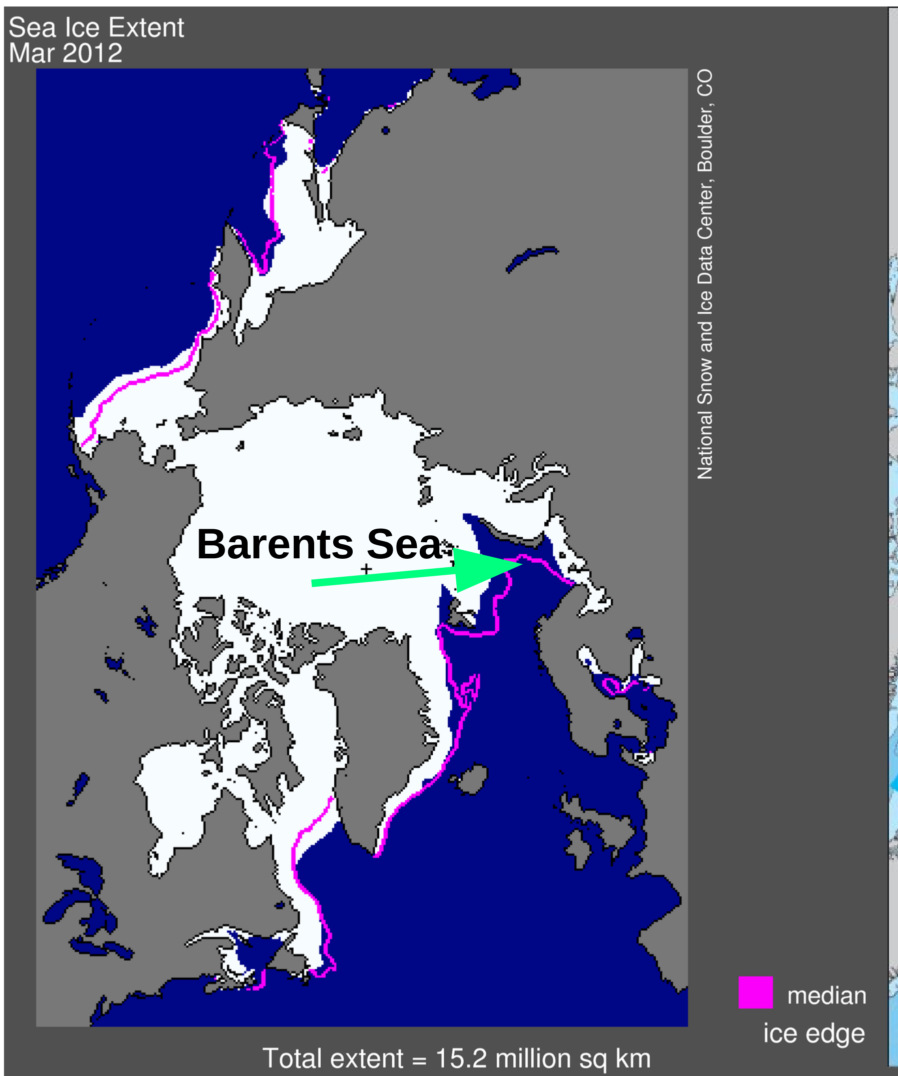


CH_4 emissions from various models and inventories

IASI and CH4_INV are top-down, others are bottom-up. More information see http://transcom.project.asu.edu/pdf/transcom/T4.methane.protocol_v7.pdf

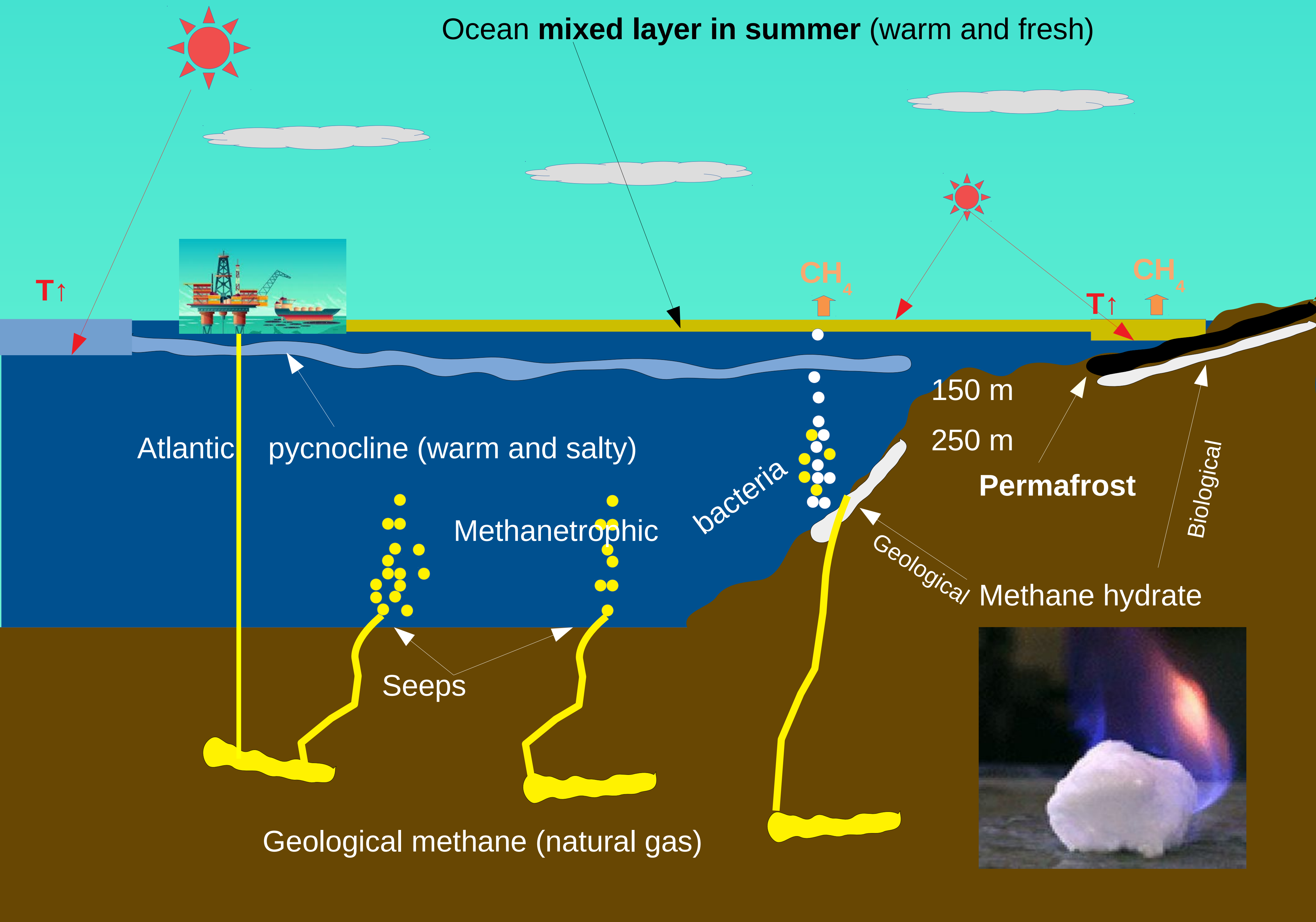
The Barents and Kara seas are of interest due to the following:
1) they are known for **oil/gas fields**;
Also
2) Barents is impacted by **heat flux** from the warm Atlantic currents
3) and it is **free of ice year-round** that makes measurements from satellites easier (warm surface).

Sea ice in March 2012



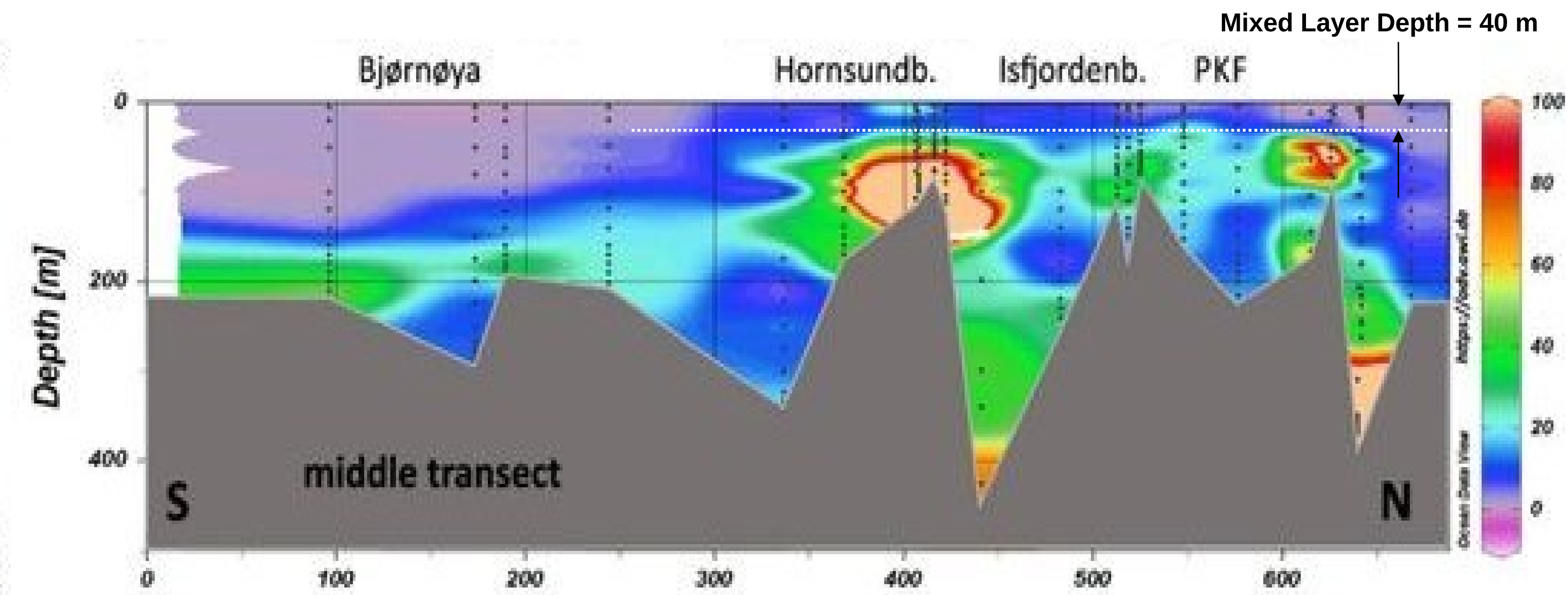
Path of warm Atlantic water

Methane sources and ocean stratification in the Arctic seas



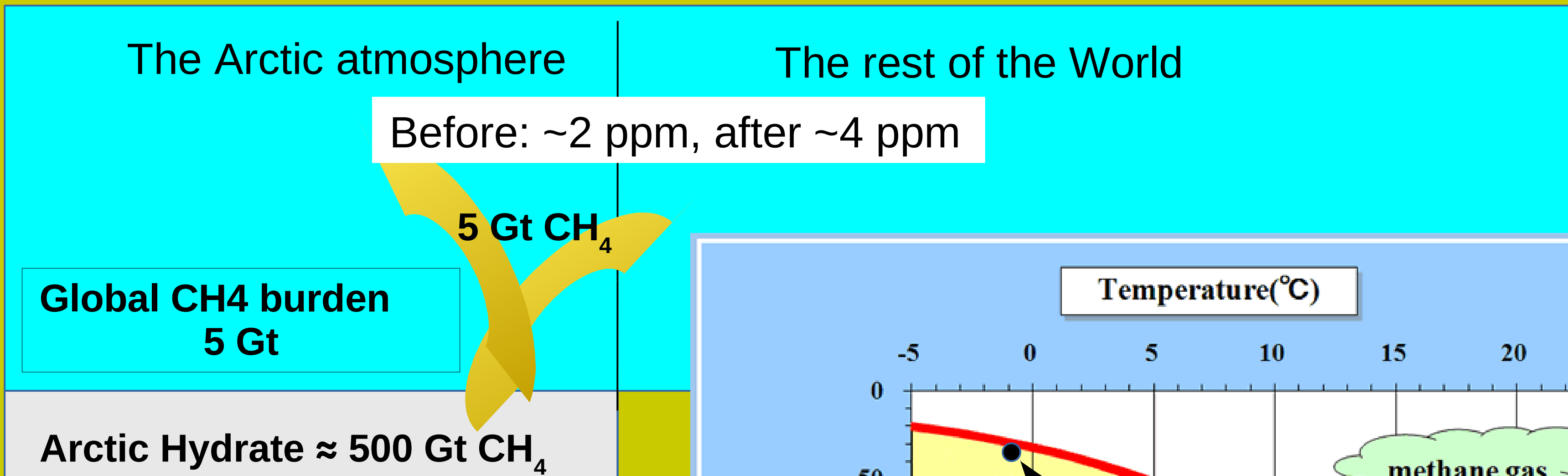
“Widespread methane seepage along the continental margin off Svalbard - from Bjørnøya to Kongsfjorden” by Mau et al. (2016)

August-September, 2015. Anomalies of of dissolved methane concentrations in nM: note a very shallow Mixed Layer.

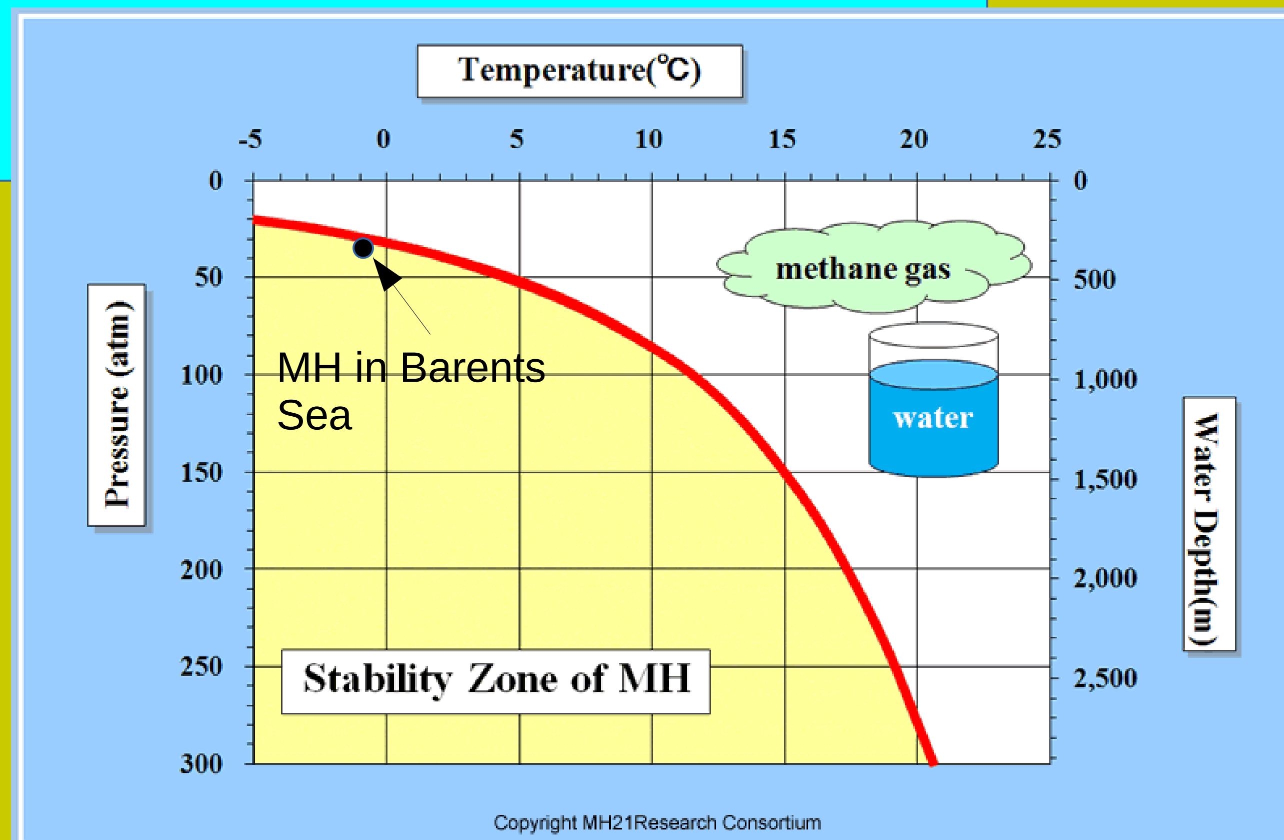


In summer flux is really close to zero. Satellites are able to measure methane both in summer and in winter.

Climatic effect of Arctic methane (“Methane hydrate gun hypotheses”)



Emission of only 1% of methane locked as hydrate in the Arctic seabed would result in doubling its global concentration.



A few degrees increase of temp-re would dissociate MH

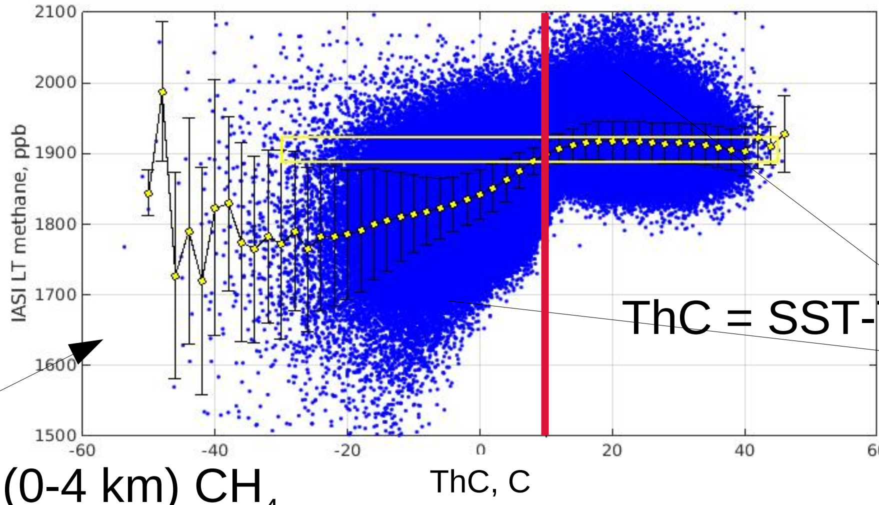
According to the so-called “Methane Hydrate Gun hypotheses” [J. Kenneth et al, 2003], methane emitted from hydrates may cause abrupt global warming, much faster than now predicted.

Unreliable data for cold surfaces should be screened out. ThC is better than DOF.

Nov.-Dec. 2009-2012, sea only.

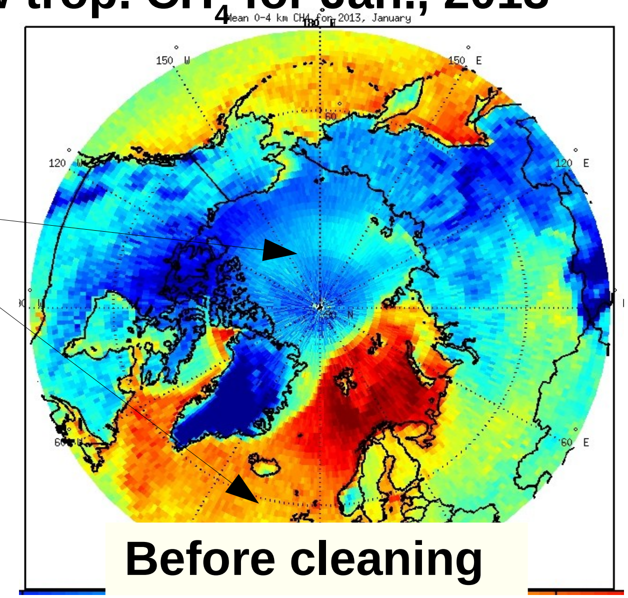
Thermal Contrast (ThC) – Air temperre at 4 km altitude must be 10° C lower than surface temperature

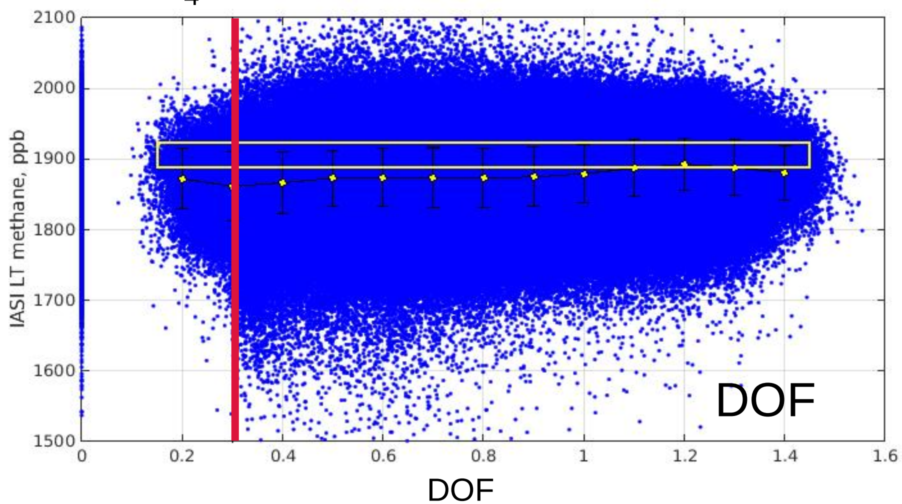
Low trop. CH_4 for Jan., 2013

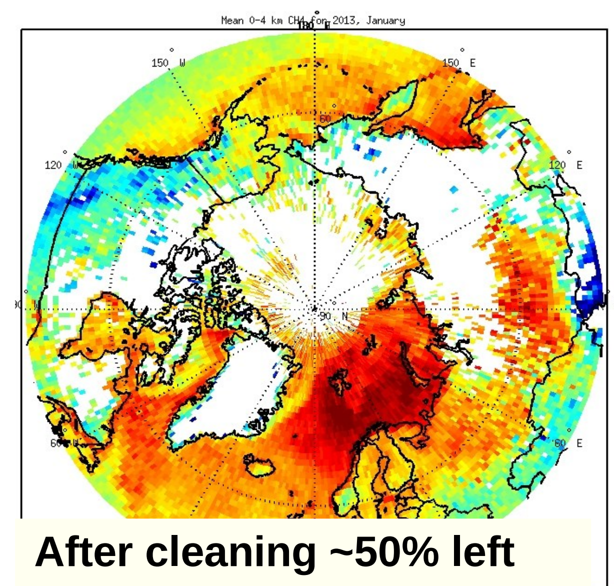


ThC = SST-T(600)

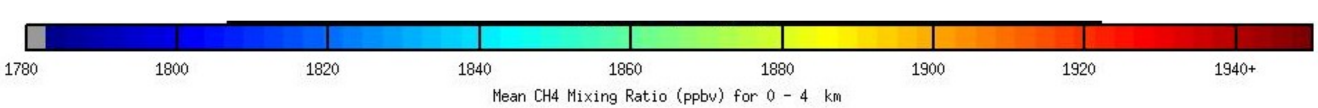
IASI, LT (0-4 km) CH_4







Degree of Freedom (DOF) – a parameter characterizing information content, must be more than **0.3** (**criterion for AIRS v6 Level 3**)

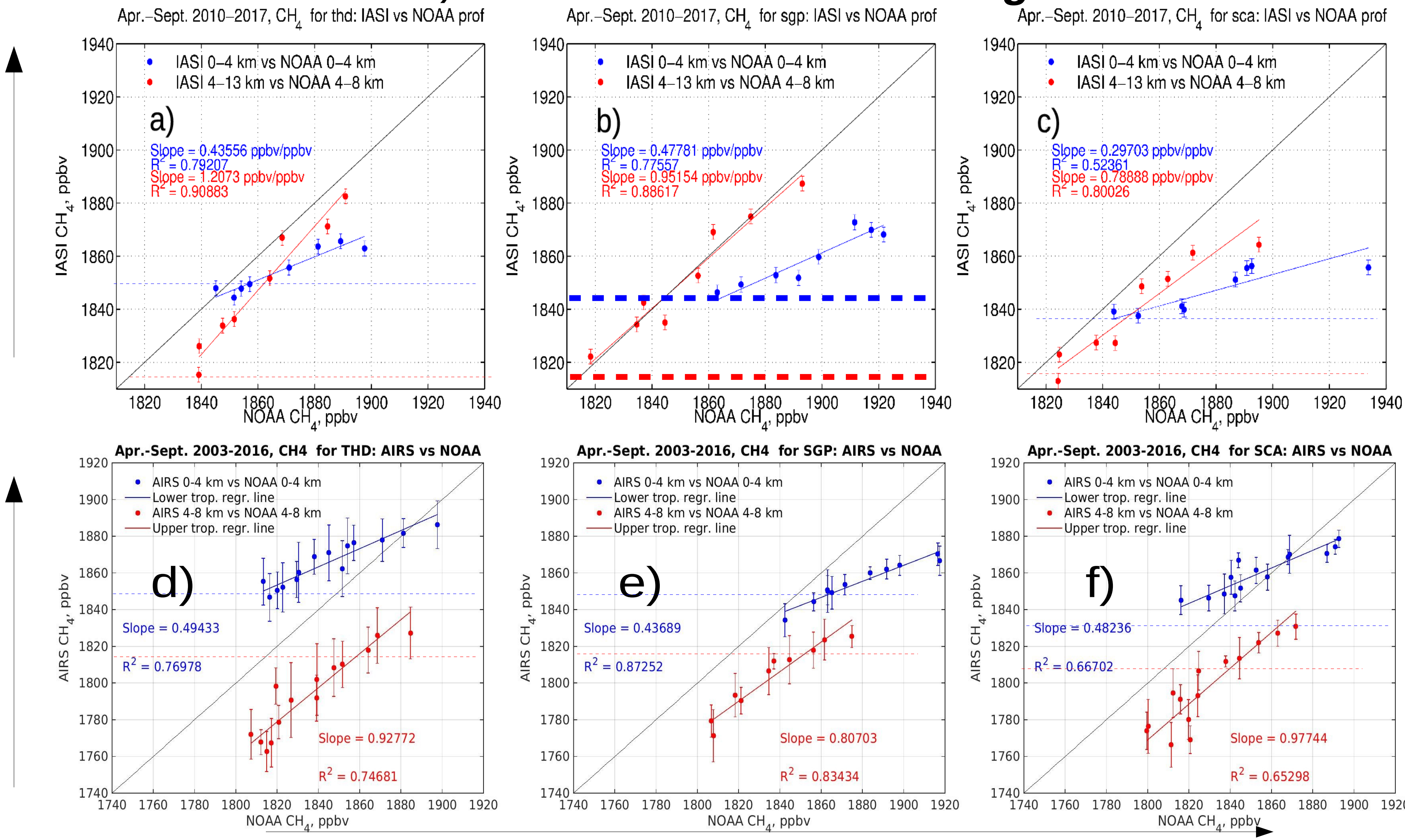


Validation of IASI and AIRS using profiles of CH_4 measured from a NOAA aircraft, summer months including 2018

IASI

Dotted lines
A priori
(S=0)

AIRS



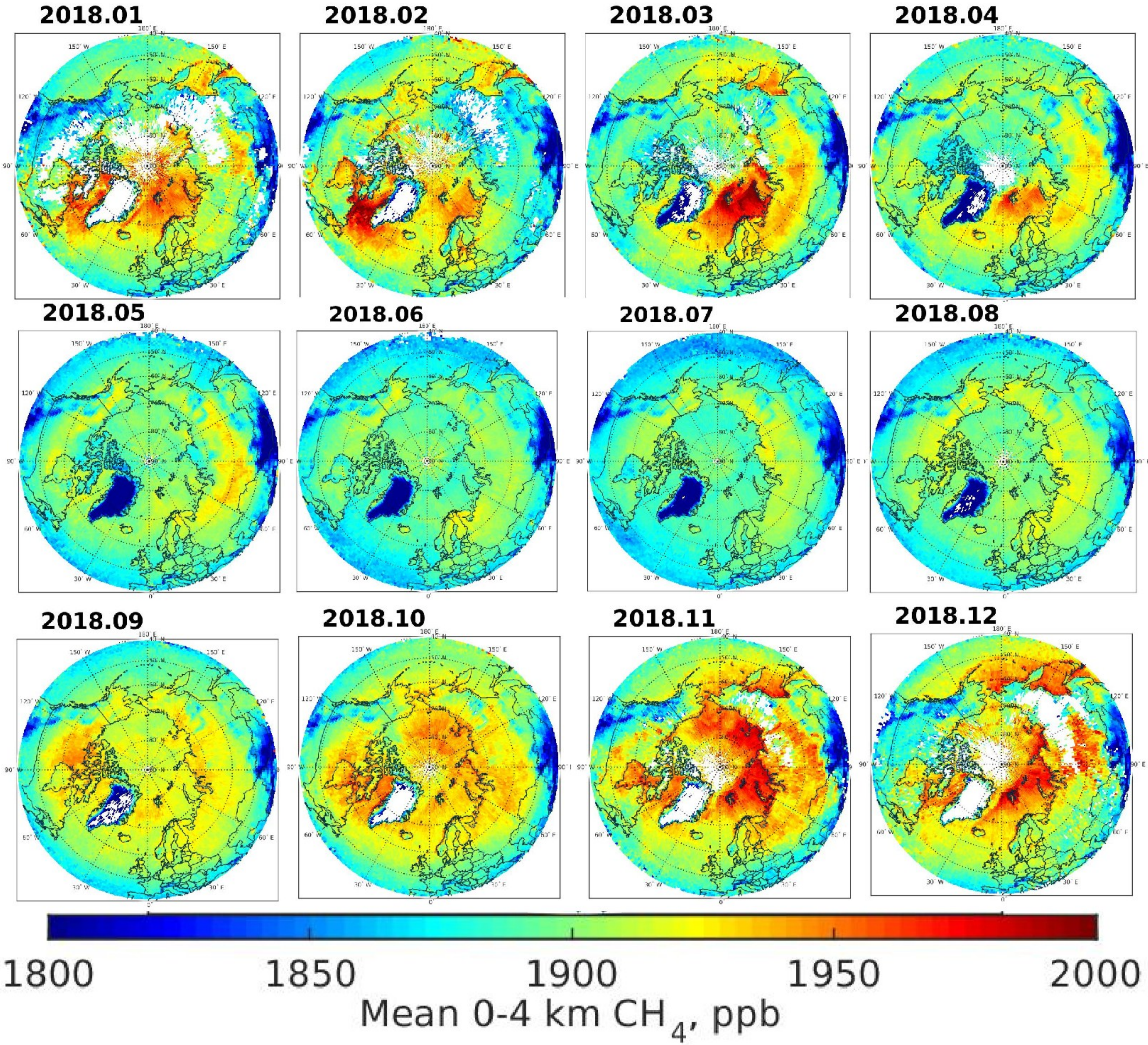
Averaged NOAA/ESRL aircraft profiles (courtesy Colm Sweeney)

Blue: lower troposphere LT (0-4 km), red: mid-upper troposphere MUT (4-8 km)

Slopes in LT ~ 0.5, slopes in MUT ~1.0. Dotted a priori lines correspond to zero sensitivity
LT is more useful to study emissions.

Monthly mean 0-4 km CH_4 in ppb retrieved from IASI data, 2013

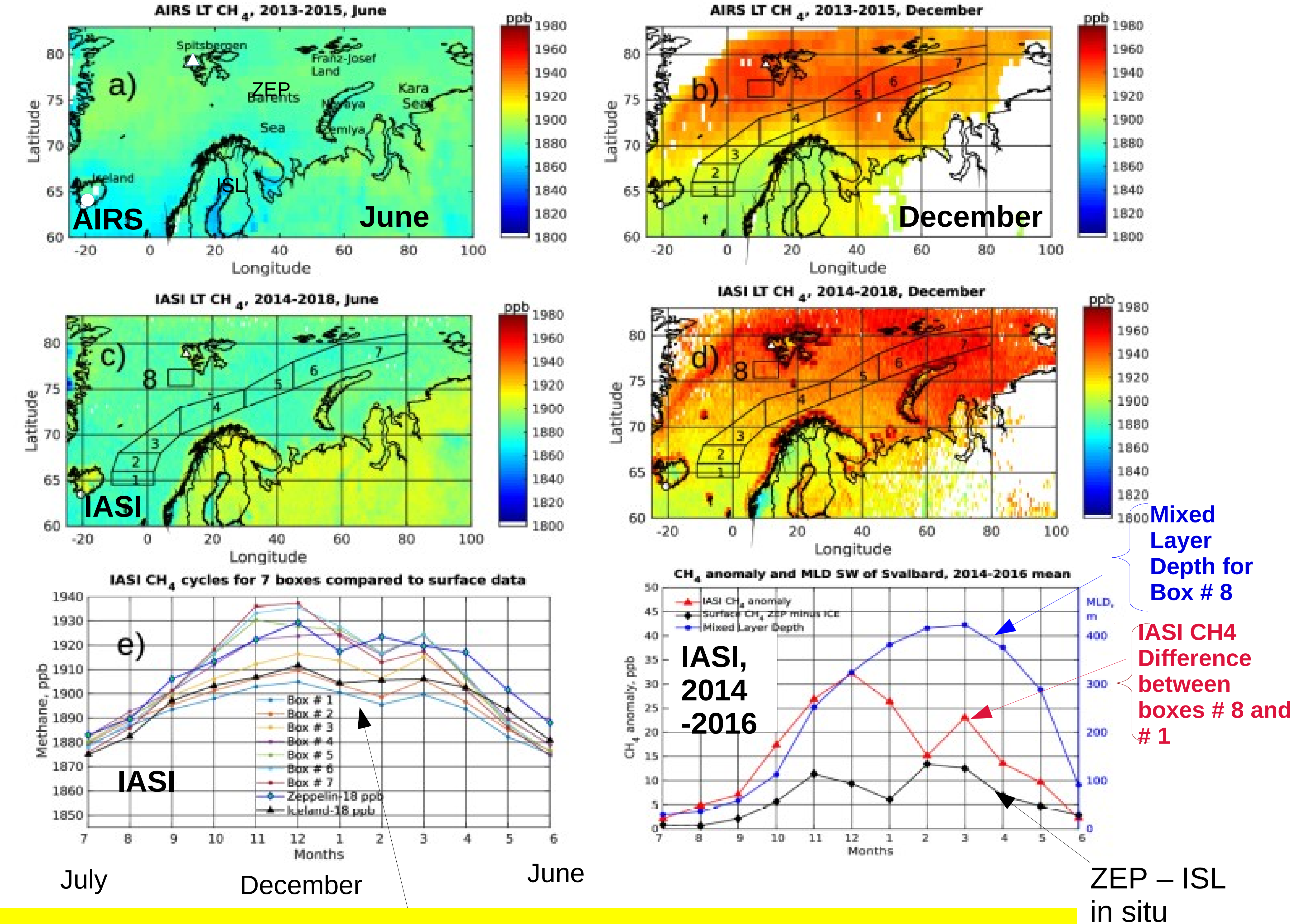
(White is for data with Thermal Contrast <10º C, i.e., for cold surfaces)



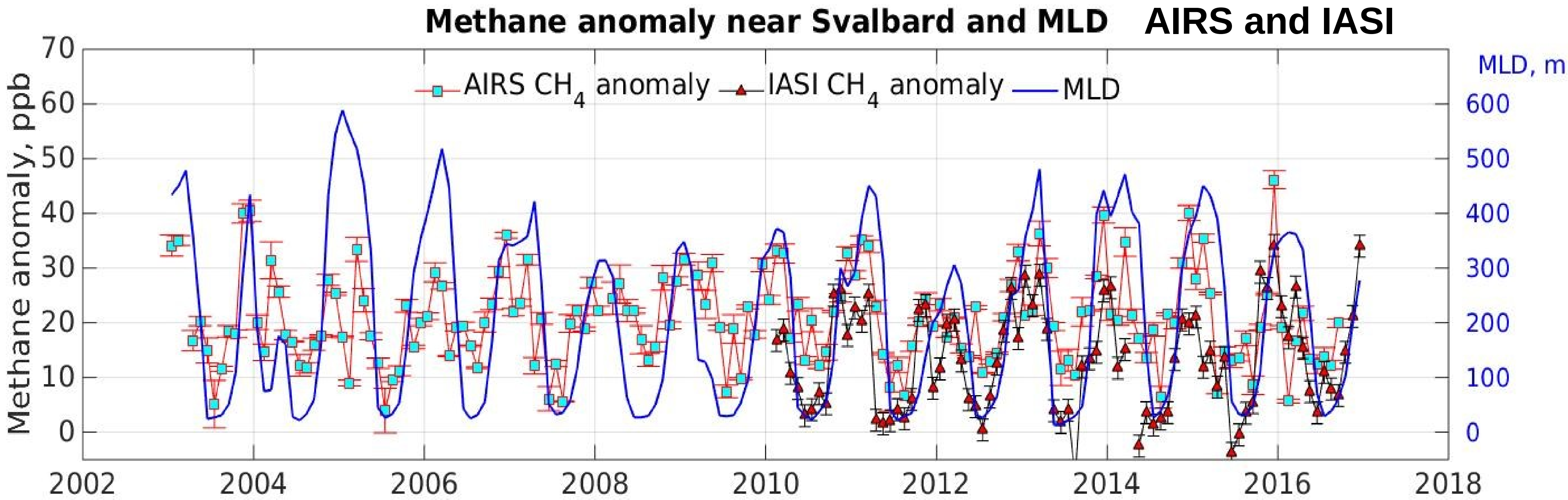
Anomalies between January and April

Homogeneous field of methane between May and August

Anomalies between October and December



IASI CH_4 monthly Concentrations for 7 boxes from Iceland to Kara Sea

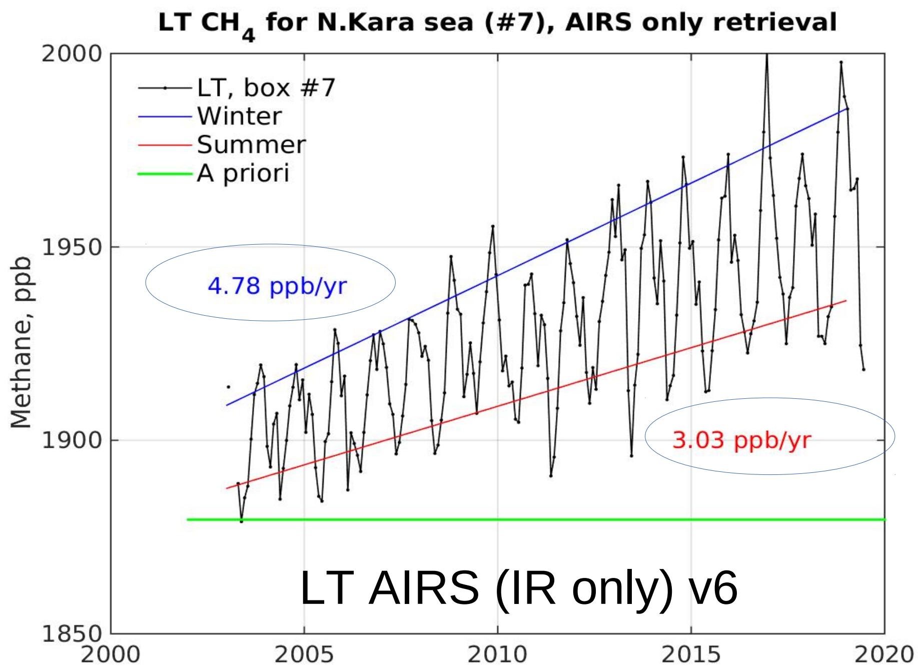


Blue line is Mixed Layer Depth, calculated for the Box #8 from a global ocean circulation model ECCO-2.

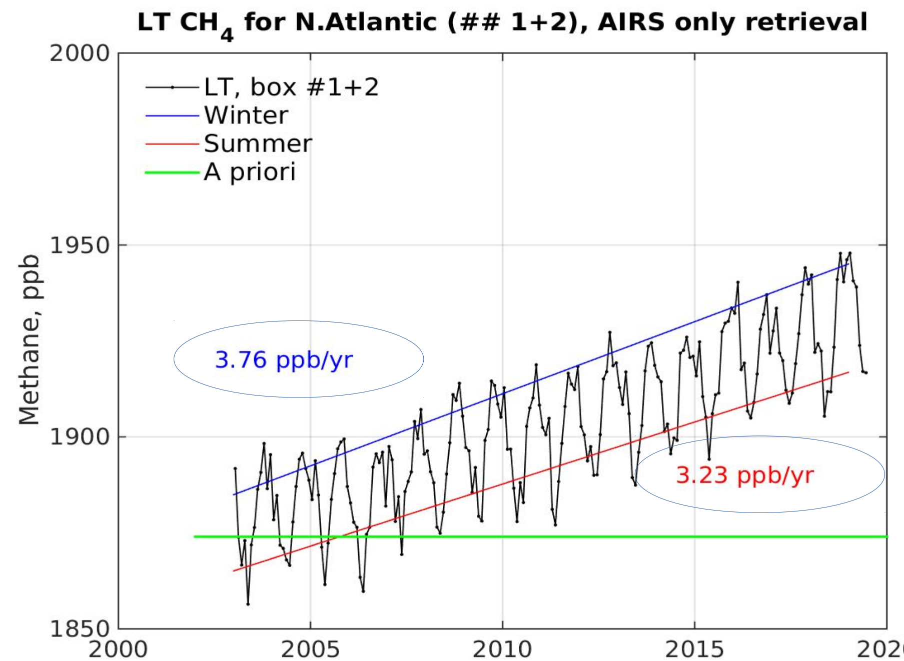
"Methane LT anomaly" is a difference in concentration between for Box #8 (near Svalbard) and combined boxes #1 and #2 (near Iceland). The higher mixing, the higher methane.

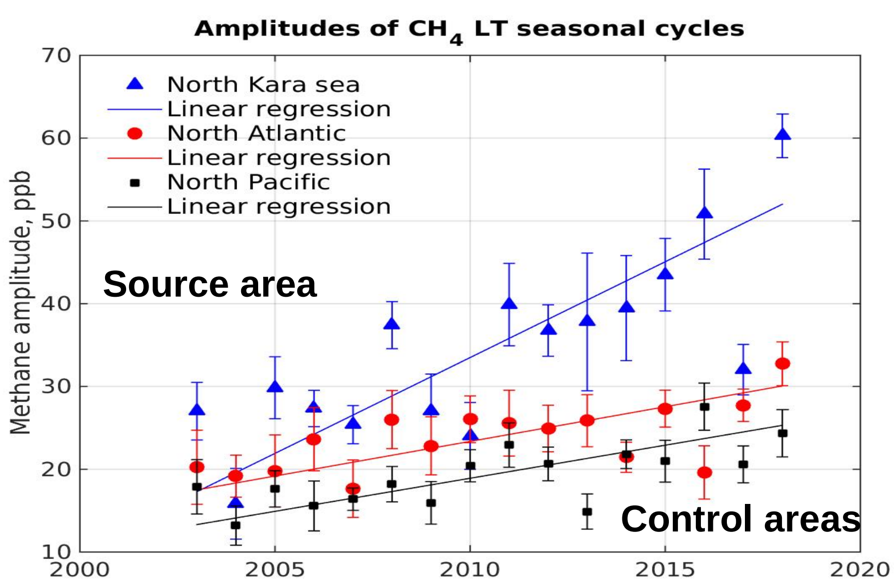
Is there a positive trend in emission? If there is, the amplitude of SC should grow.

Source area



Control area near Iceland





Winter CH_4 over Kara grows faster than near Iceland. Summer concentration trends at 2 sites are similar.

The amplitude of the Kara seasonal cycle grows with years and doubled from 2003 to 2018.

This may be a result of a positive trend of emission from the seabed.

Conclusions (1)

1. AIRS v6 and IASI NUCAPS v1 indicate a significant methane anomaly over the Arctic Ocean in a period between November and April. This coincides with a period of good mixing of the water column.

2. The amplitude of CH_4 seasonal cycle over Barents and Kara seas is growing with years. This may evidence a growing methane flux from the seabed.

Conclusions (2): Suggestions what to do next for the Arctic methane.

A global universal retrieval technique (like NUCAPS or CLIMCAPS) may be not sufficiently accurate for the Arctic specifics. A modified existing code may be re-performed for the Arctic. Several input parameters may be introduced from various independent sources (MERRA-2, MW, MODIS, etc):

1. Ice cover (concentration, thickness, types, emissivity, etc.)
2. Humidity and temperature profiles, SST.
3. Also single-FOV retrievals should be realized.
4. Further efforts to improve retrievals for the Lower troposphere.

This program should be oriented on a climatic influence of methane as a greenhouse gas. Other parameters (gases, aerosols, H2O, T) specifically for Arctic may be retrieved with a better accuracy.

Include AIRS and IASI methane data into inverse models