Winter-time methane over the Arctic seas: AIRS, IASI, and CrIS data.

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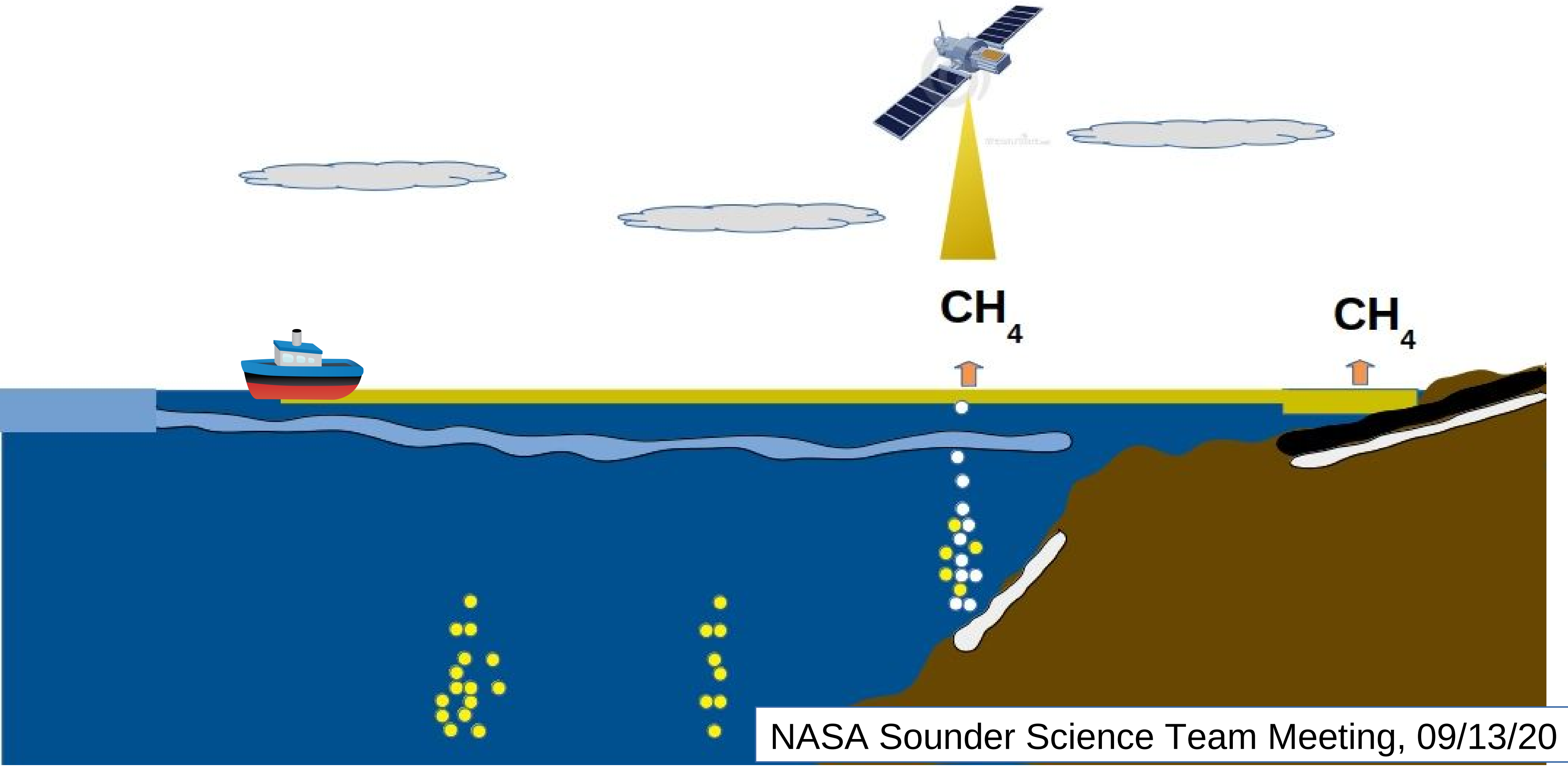
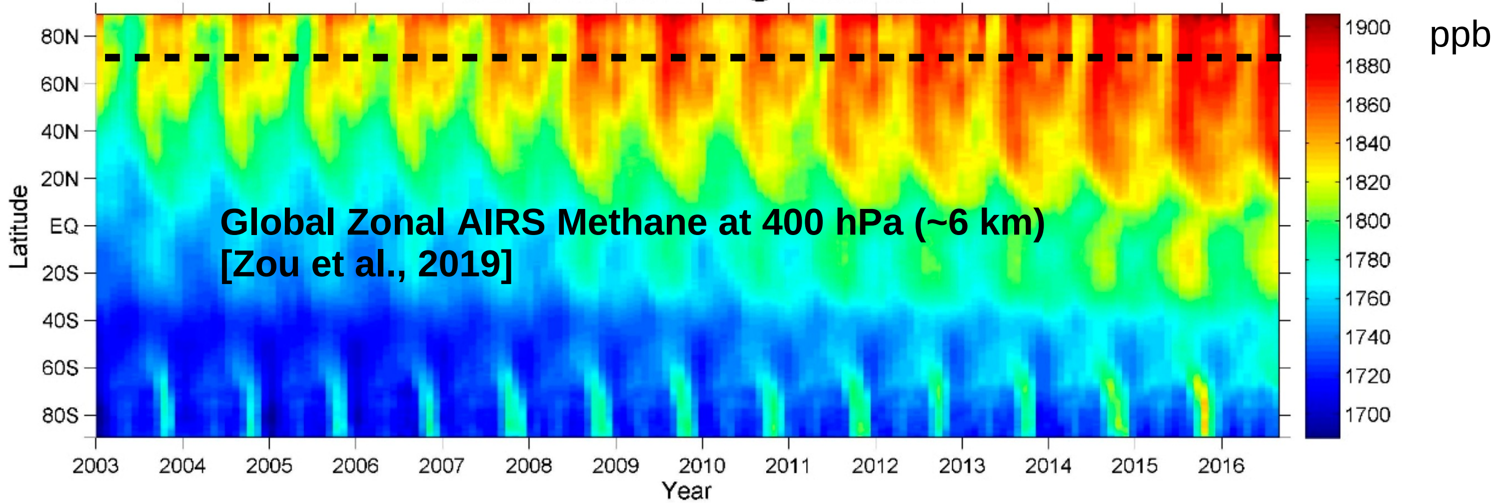


NASA Sounder Science Team Meeting, 09/13/20



Outline

● We focus here on the Arctic Barents-Kara seas area and use publicly available data:

1) AIRS v6 L3 (IR only) from DAAC, 2002-2020
2) IASI NUCAPS L2 from the CLASS NOAA site, 2010-2020
3) CrIS SNPP CLIMCAPS L2 from DAAC, 2015-2020

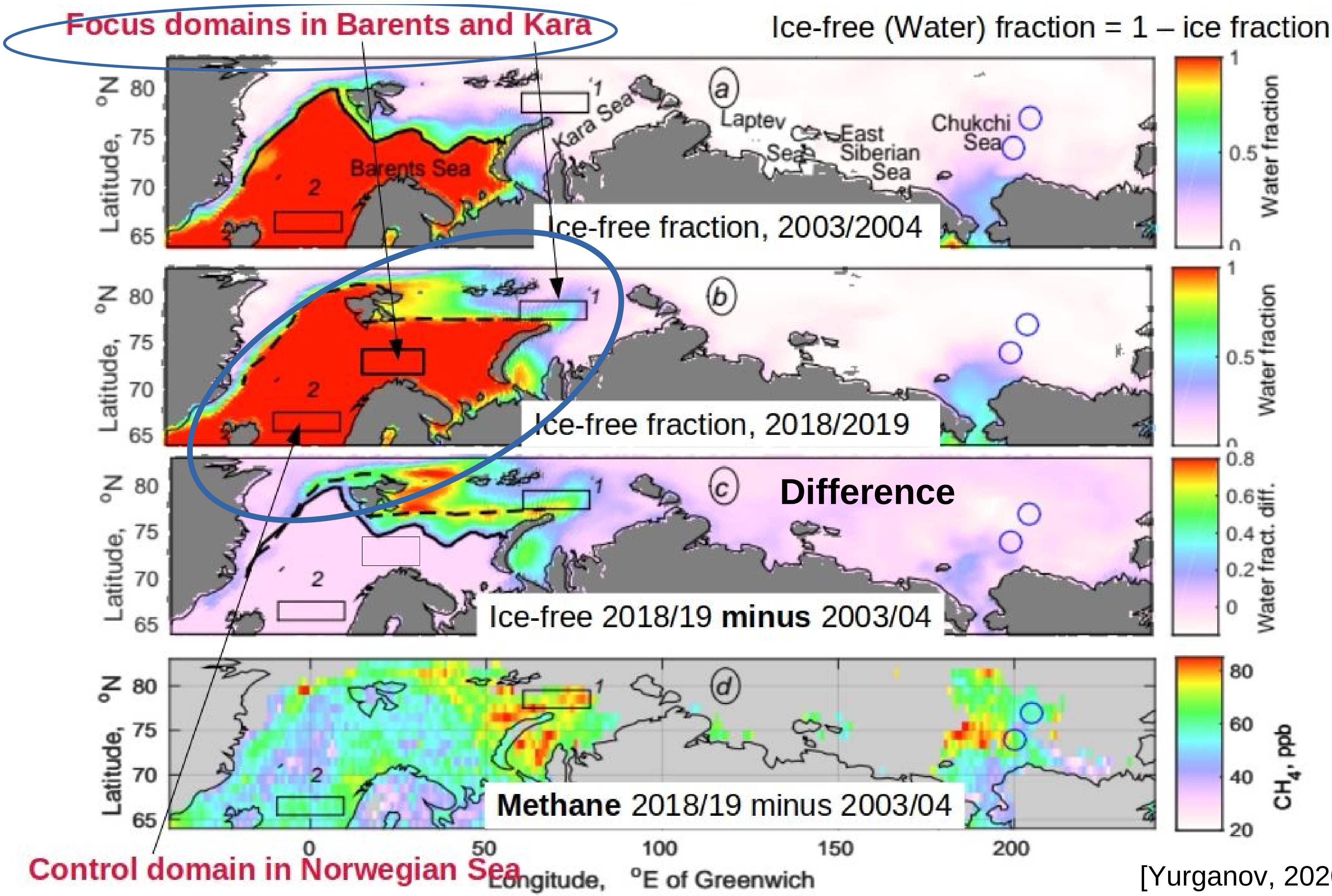
● This report is based on 3 papers: in the *Global Biogeochemical Cycles (* under review) now, *and* publications of 2019 and 2020.

● SWIR (NIR) remote sensing sounders, like TROPOMI, are inefficient in the Arctic. In the same time, direct measurements are sparce.

● Data for TIR sounders (AIRS, IASI, etc) are available and unique. BUT they require high temperature contrast. Winter data over thick sea ice and frozen land have been filtered out.

Introduction 1. Geography. Arctic sea ice fraction in early winter: November – December - January.

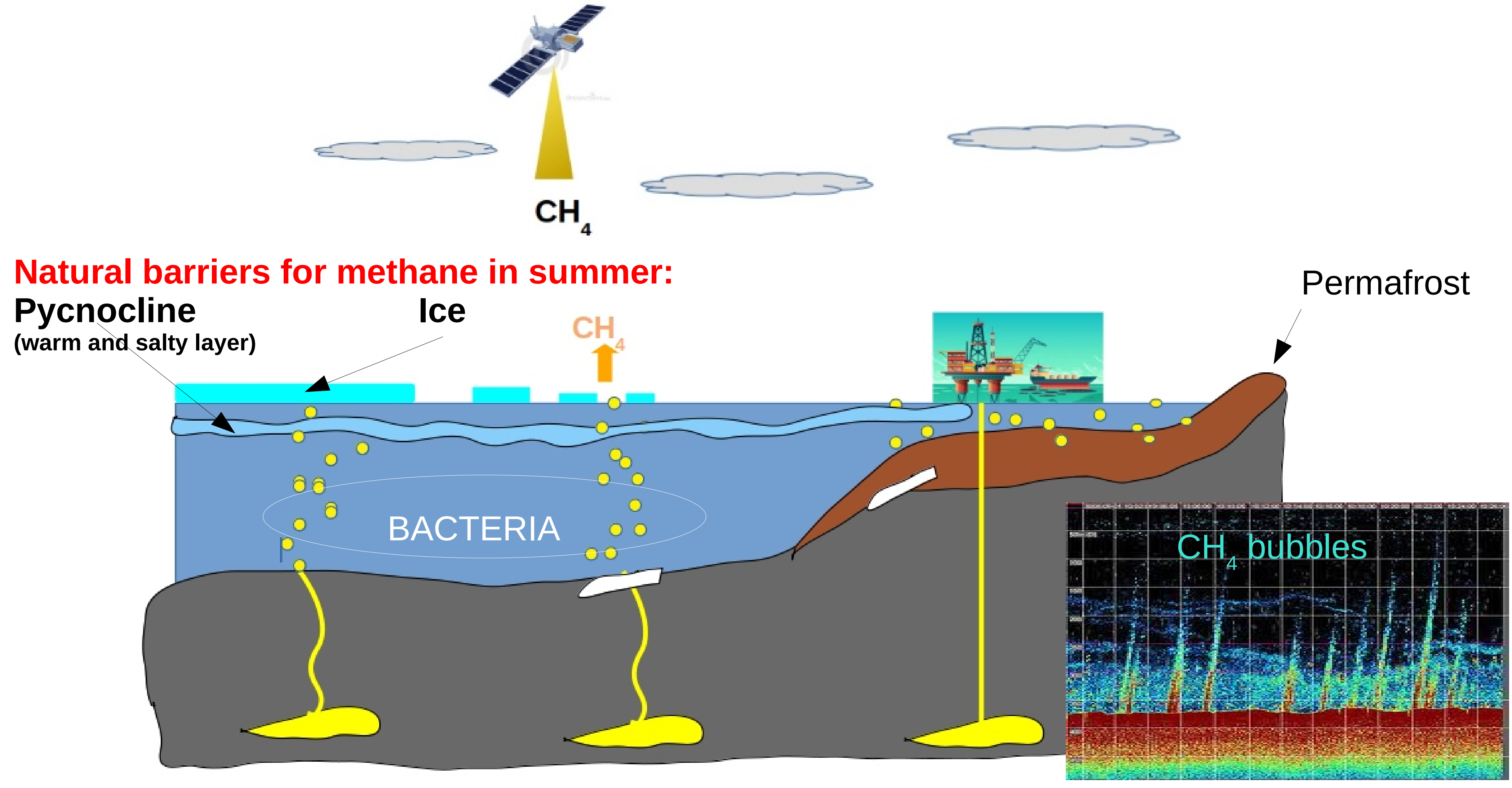
Maps of ice-free fraction of the surface (1- ice concentration) for beginning and end of AIRS period



[Yurganov, 2020]

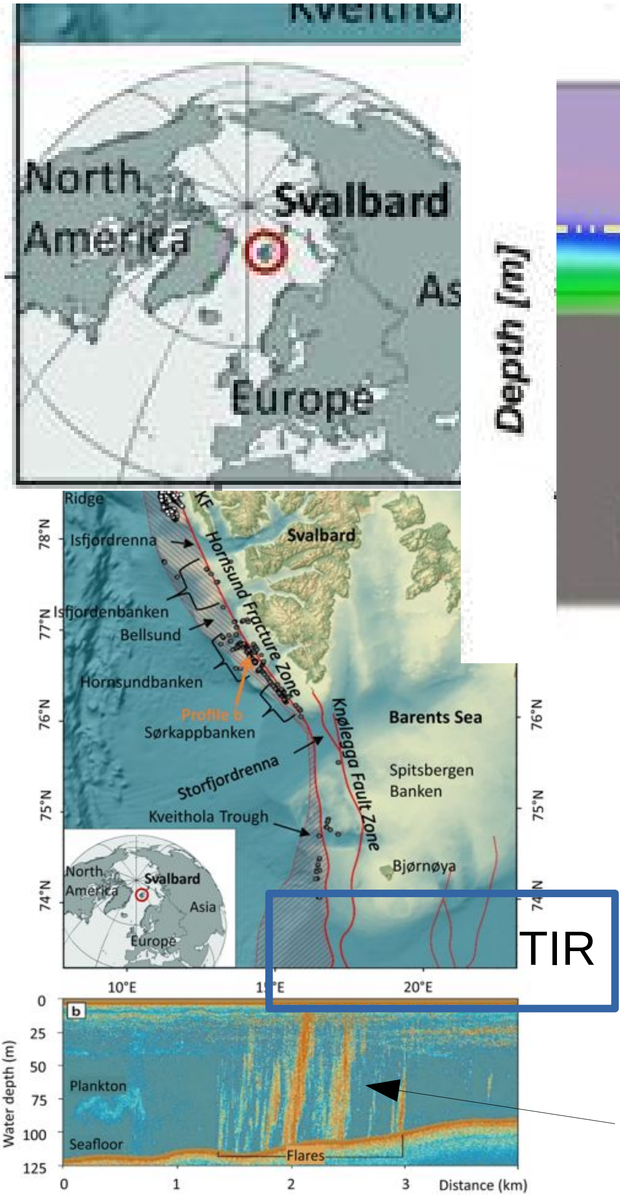
Introduction 2. Arctic marine methane: sources and transport.

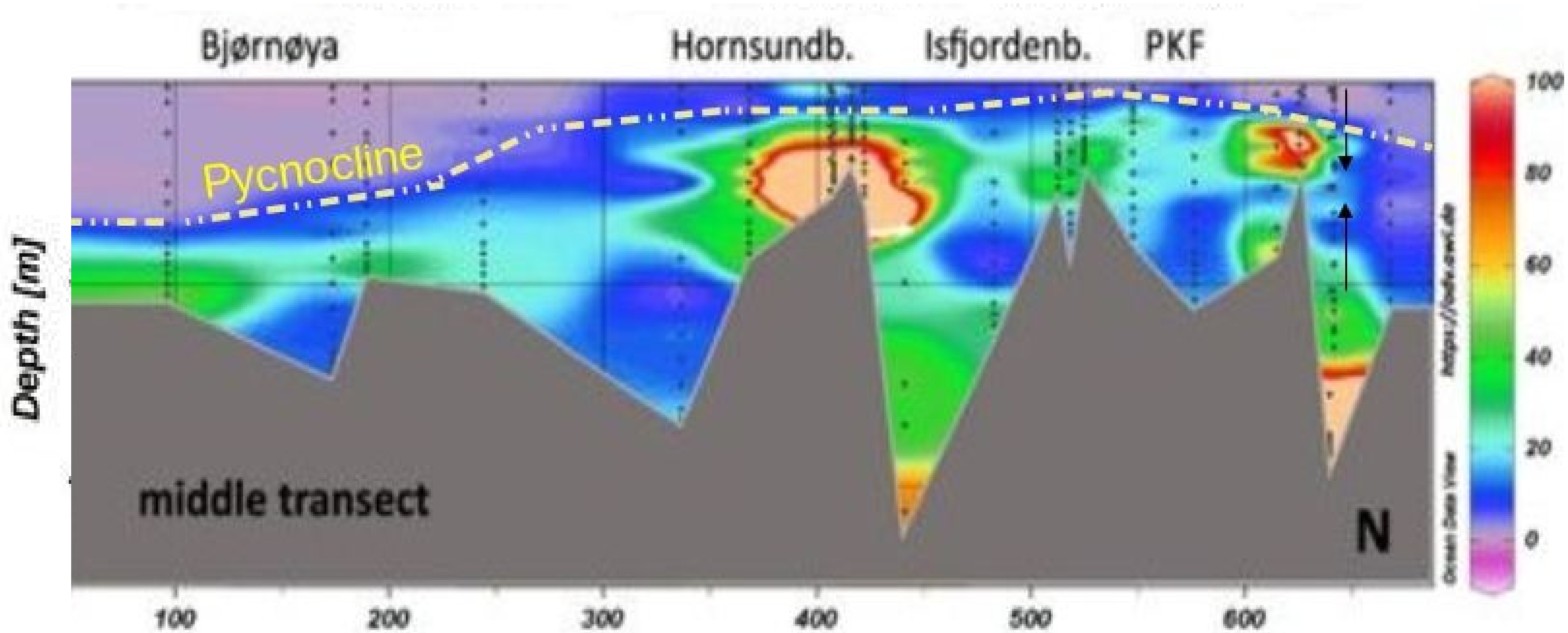
Methane is emitted from the seabed and rapidly dissolves in water. Two barriers on the way to air: pycnocline in summer and ice in winter. Methanotrophic bacteria consume dissolved methane.



Introduction 3. Available direct samplings of dissolved methane in summer

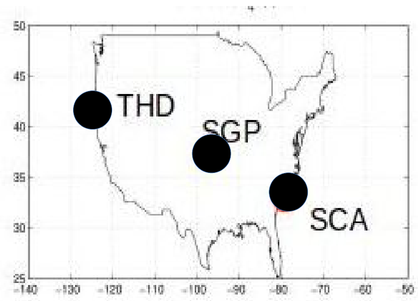
Mau et al., (2017) measured CH4 near Svalbard in August-September, 2015. Anomalies of of dissolved methane concentrations in nM





In summer the pycnocline prevents CH4 entering sea surface.

Plumes of bubbles

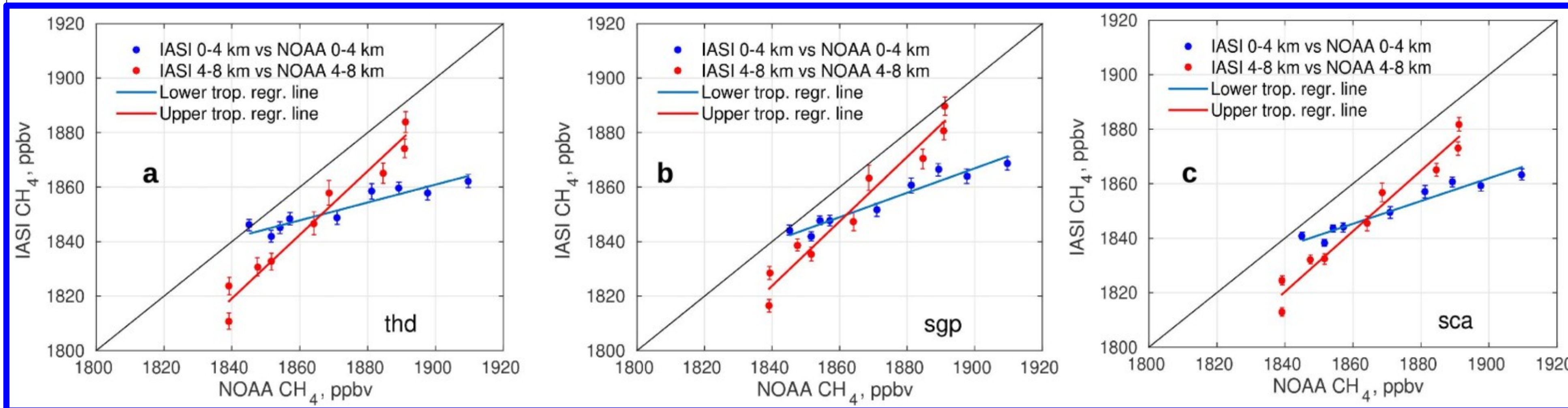


Validation of IASI and AIRS vs NOAA flights at three sites

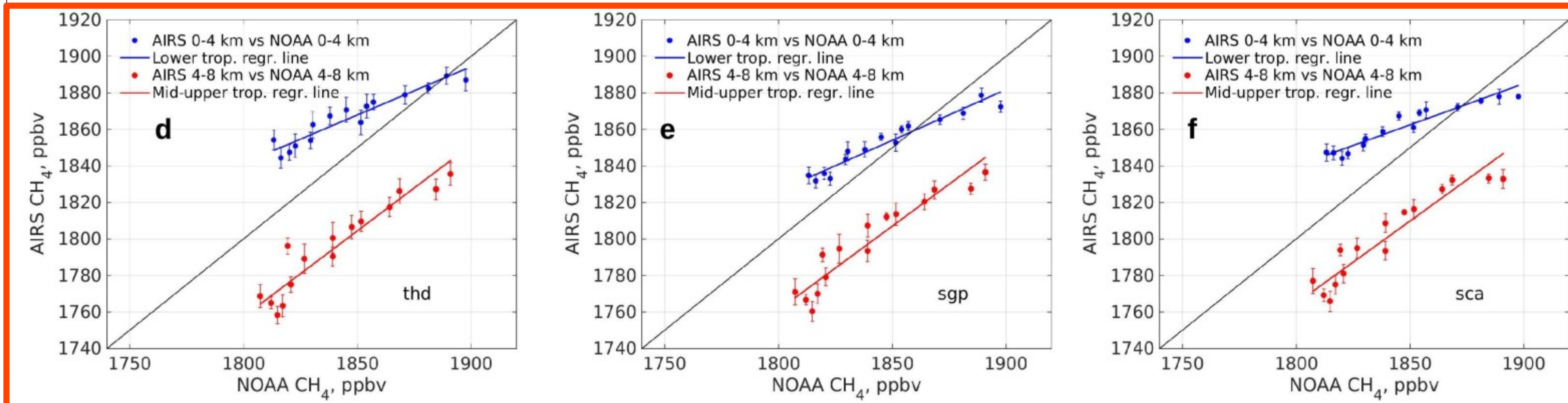
RED is for mid-upper troposphere >4 km; **slopes ~ 1.0**

BLUE is for lower troposphere <4 km; **slopes 0.4 – 0.5**

[Yurganov et al., 2019]



IASI

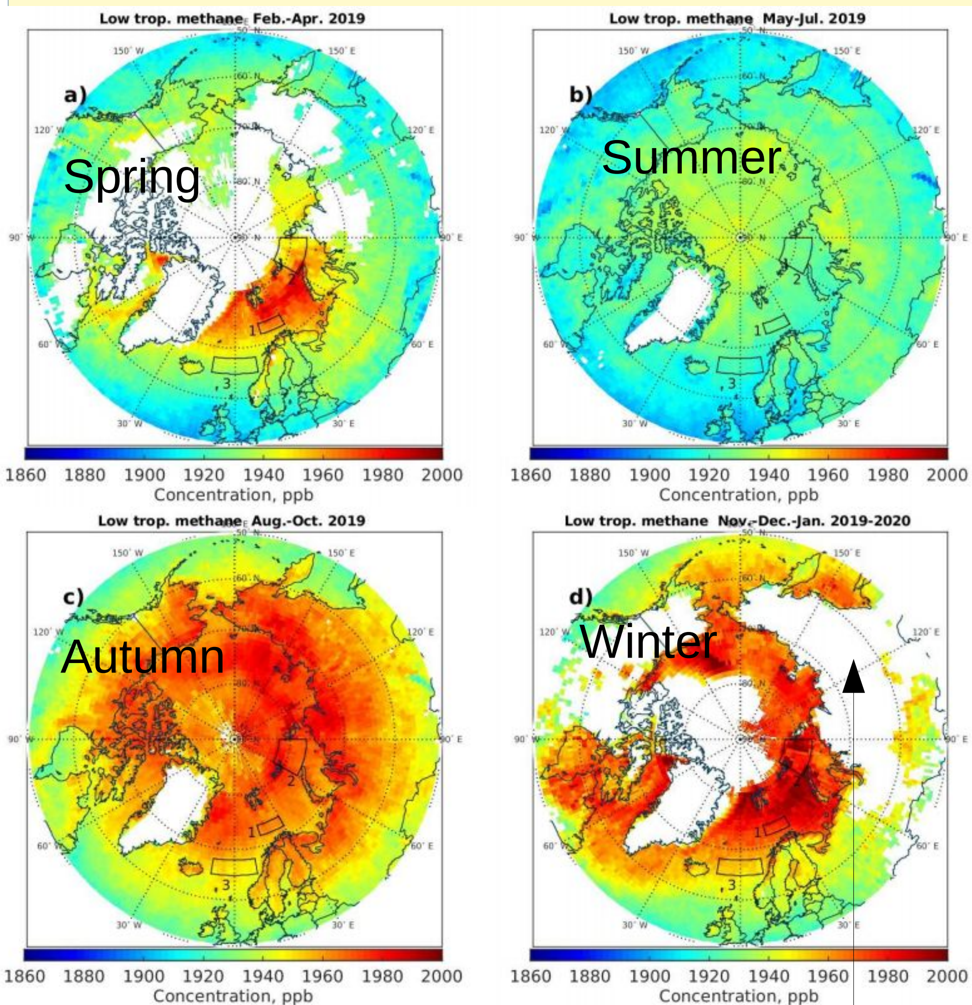


AIRS

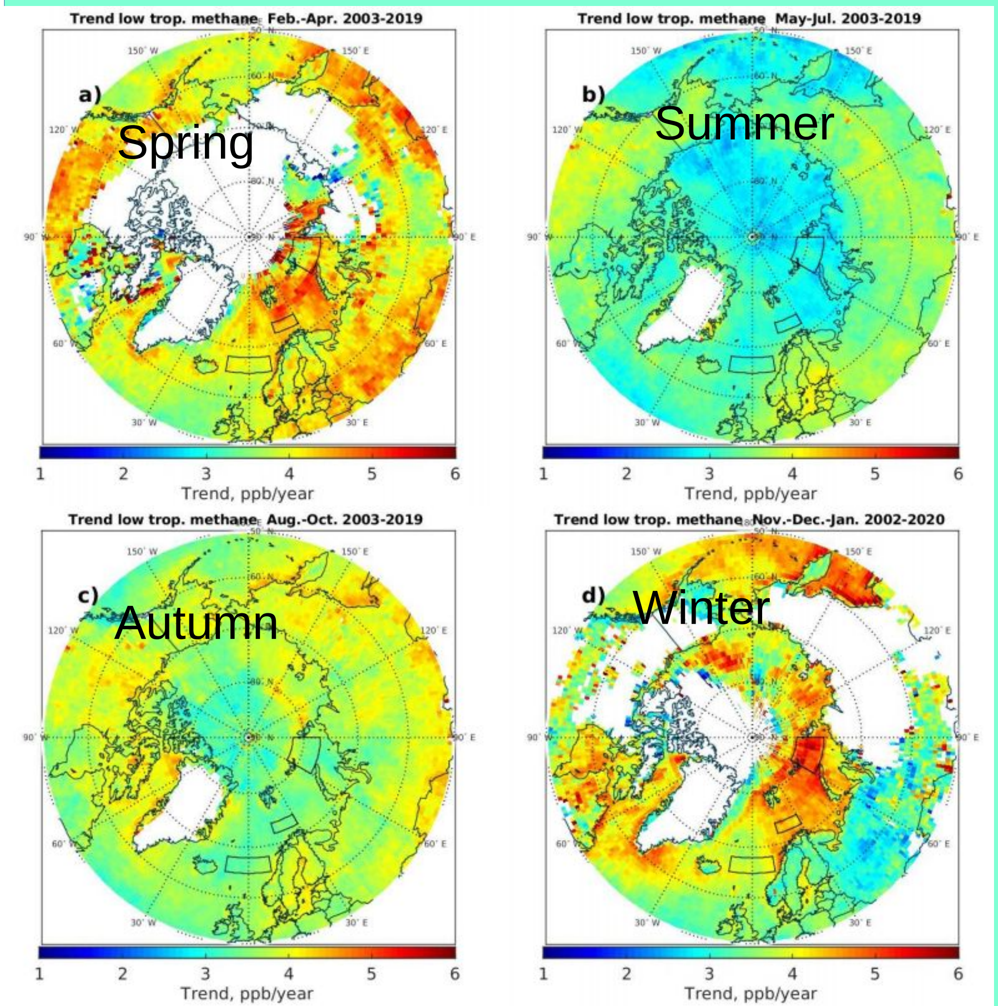
Slope = sensitivity: response of retrieval to a unit change in real concentration. Retrieved changes in CH_4 for 0-4 km are underestimated. Data for 4-8 km are closer to reality. Bias is of secondary importance in terms of anomalies.

AIRS CH_4 0-4 km for four seasons

Concentrations after February, 2019



Trends after 2002



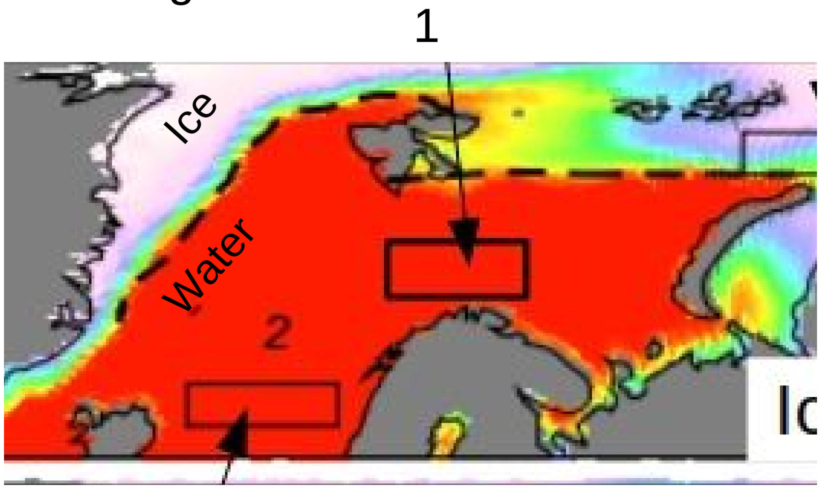
White – filtered out data for cold surfaces

Spring: Feb. - Apr.
Summer: May – July
Autumn: Aug. - Oct.
Winter: Nov. - Dec. - Jan.

[Yurganov et al., *GBC*, 2020]

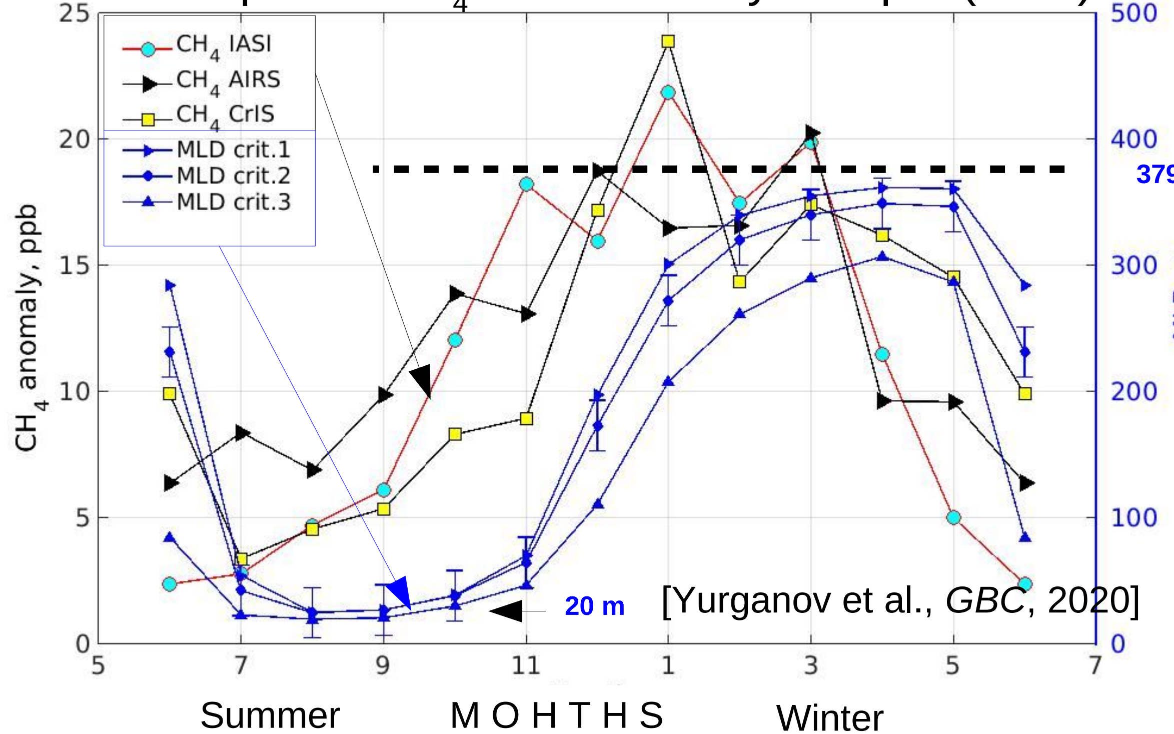
Methane over Barents Sea, retrieved from 3 sounders and averaged for 2015-2018

CH4 anomaly = box 1 – box 2
averaged over 2015-2018

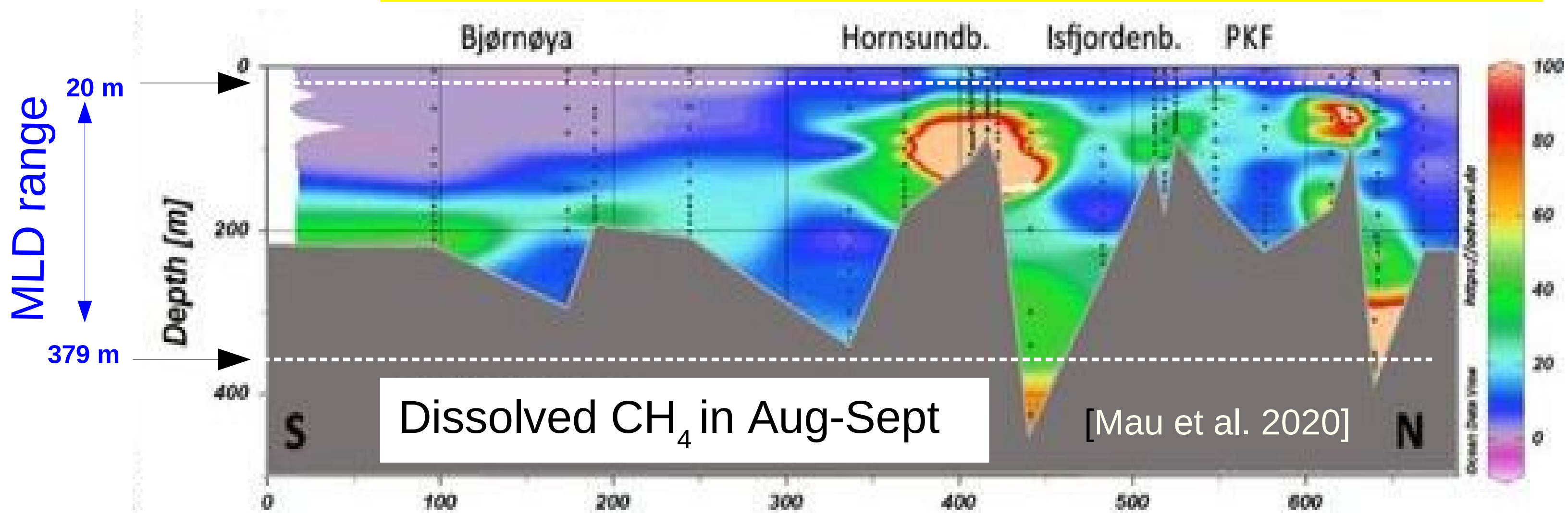


Mixed layer depth (MLD) characterizes seawater mixing and varies between 20 m and 270 m

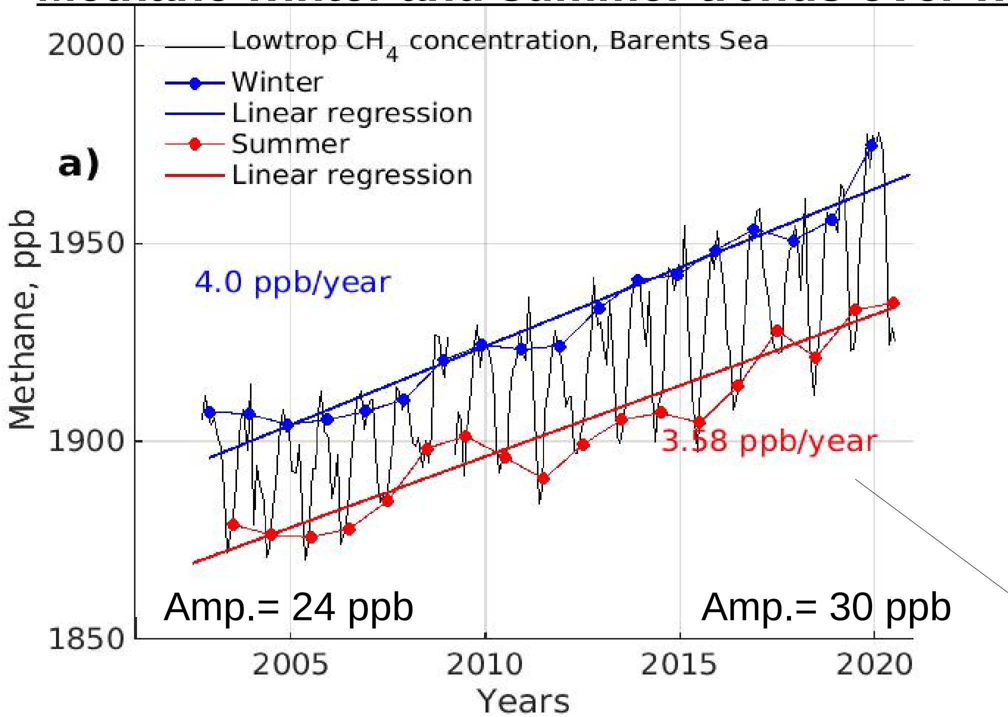
Atmospheric CH_4 and Mixed layer depth (MLD)

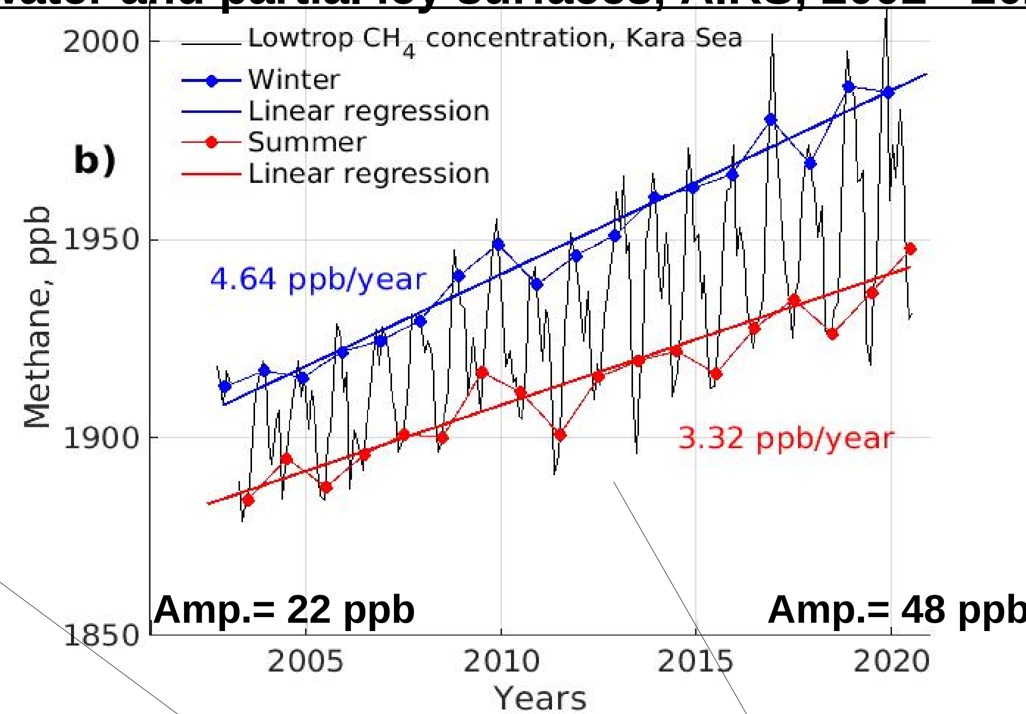


CH_4 anomaly and MLD both maximize in winter



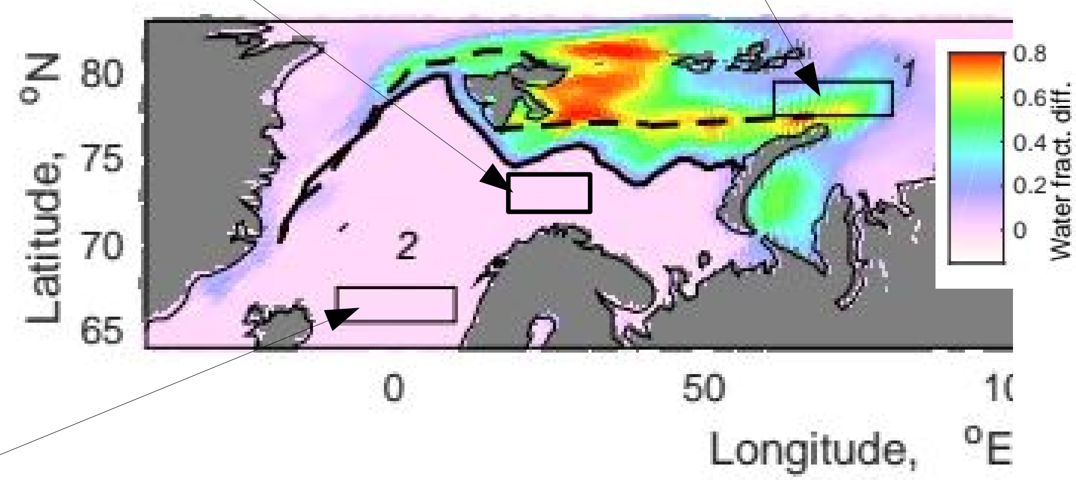
Methane winter and summer trends over water and partial icy surfaces, AIRS, 2002 - 2020

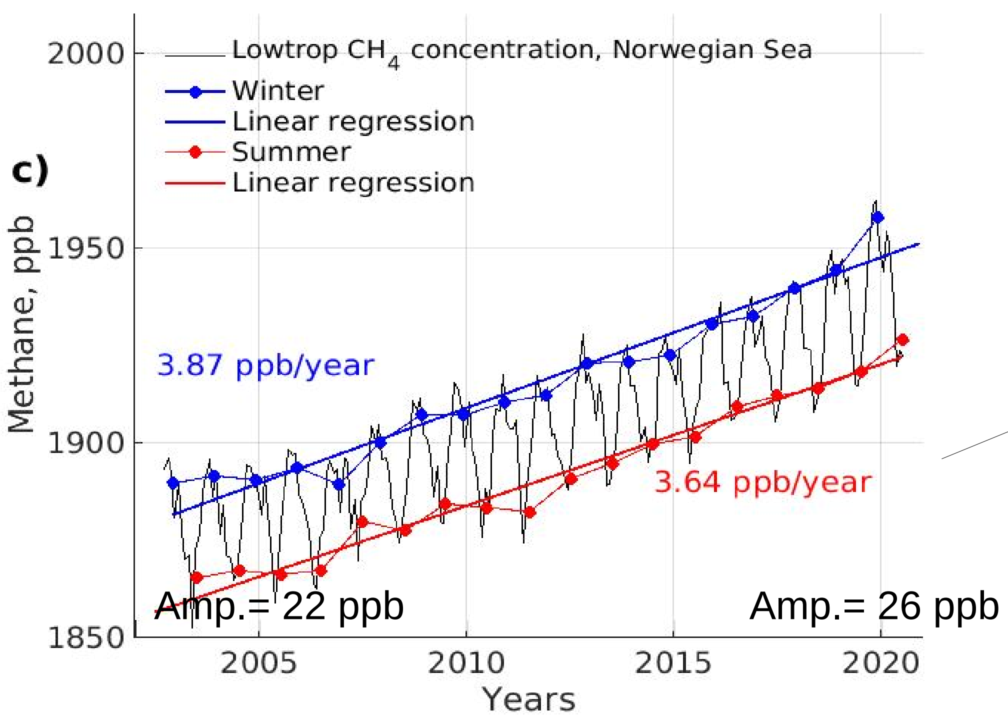




[Yurganov, 2020]

Open water increase for 17 years





Amplitude over open sea increased ~ 20% (statistically insignificant increase)
Amplitude over partially ice-covered Kara sea ~doubled (statistically significant)

Conclusions

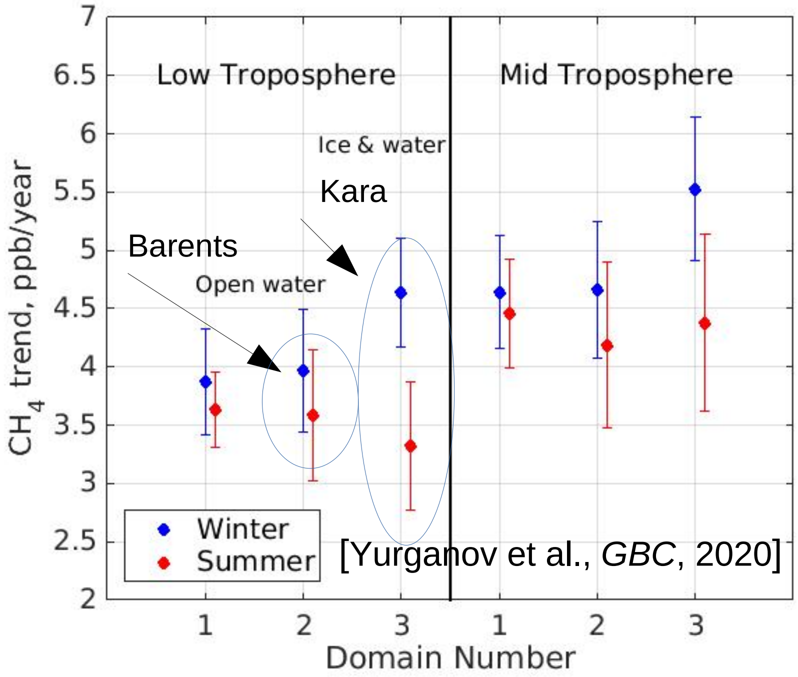
1. The November breakdown of the pycnocline opens pathway for CH_4 transport from the sea floor to air **in winter**.

2. **Winter Barents** CH_4 grows with years with almost the same rate as in **summer**. We assume that during last 17 years the wintertime **flux did not increased much.**

3. Another pattern was observed over **Kara sea.** Fast winter growth of CH4 was observed. This may be explained by a decay of ice cover in this area.

4. The results may have important implications for the Arctic methane if the observed now decline in ice would be spread onto the rest of Arctic ocean.

CH_4 seasonal **trends** over ice-free and partially covered seas: 1 – Norwegian Sea, 2 – Barents Sea, 3 – Kara Sea



Kara methane vs ice-free surface