




LENA PROJECT:
Permafrost degradation and water-air carbon cycle imbalance on the Siberian Arctic Land-Shelf-Atmosphere system with emphasis on the East Siberian Arctic Shelf

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…and >50 colleagues from the International Siberian Shelf Study (ISSS), SWE-RUS-US Arctic Ocean Investigation of Climate-Cryosphere-Carbon Interactions (SWERUS-C3) programs , and project of the Russian Government (14.Z50.31.0012), **Russian Scientific Foundation (grant no. 15-17-20032)**

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In general, carbon cycle imbalance in the Siberian Arctic land-shelf-atmosphere system is driven by rates of permafrost degradation and carbon pumping between Giant permafrost C-pools

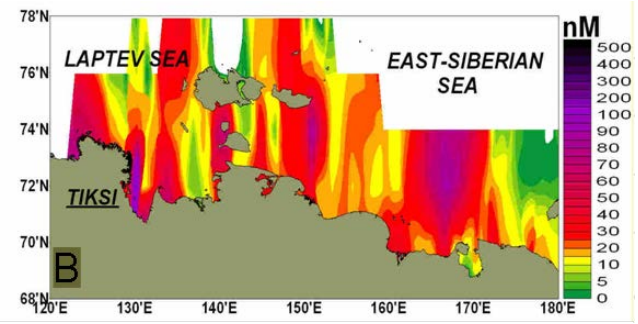
Tundra/taiga permafrost

- Pool size (0-3m): ~**1400 Pg-C**
- thaw/erosion-release of OC, CO_2 and CH_4
- Echoed in rivers (Arctic boundless C cycle)

Photo: P. Kuhry (PPP, 2009)

Subsea permafrost on Siberian shelf

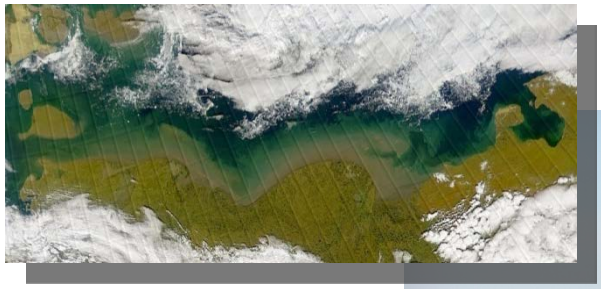
- Pool size: **~1000-1400 Pg-C (incl deep pools)**
- IPCC/ACIA: "permafrost lid" holds CH_4 in place
- but, elevated CH_4 levels in shallow bottom waters



Data: Shakhova et al. (Science, 2010)

Coastal Permafrost Complex / Yedoma

- Pool size: ~ **400 Pg-C**
- Pleistocene Ice Complex Deposit (ICD)
- thermal collapse, incr wave erosion
- thaw-release of OC and degr to CO_2



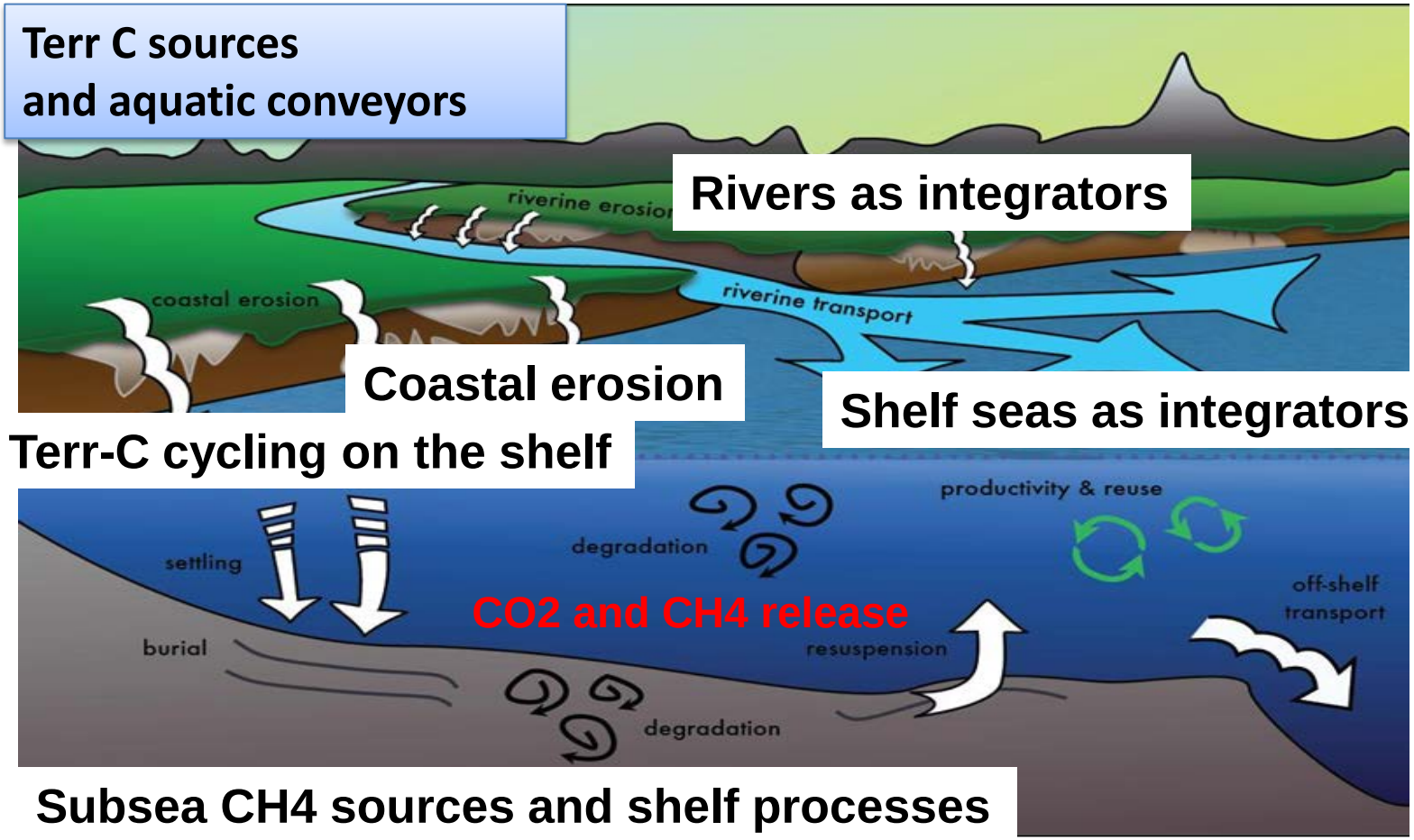
4000 km of East Siberian Arctic Coast

Photo: I. Semiletov

Atmospheric pool, for comparison
CO_2: 760 Pg and CH_4: 5 Pg

1 Pg = 1 billion ton

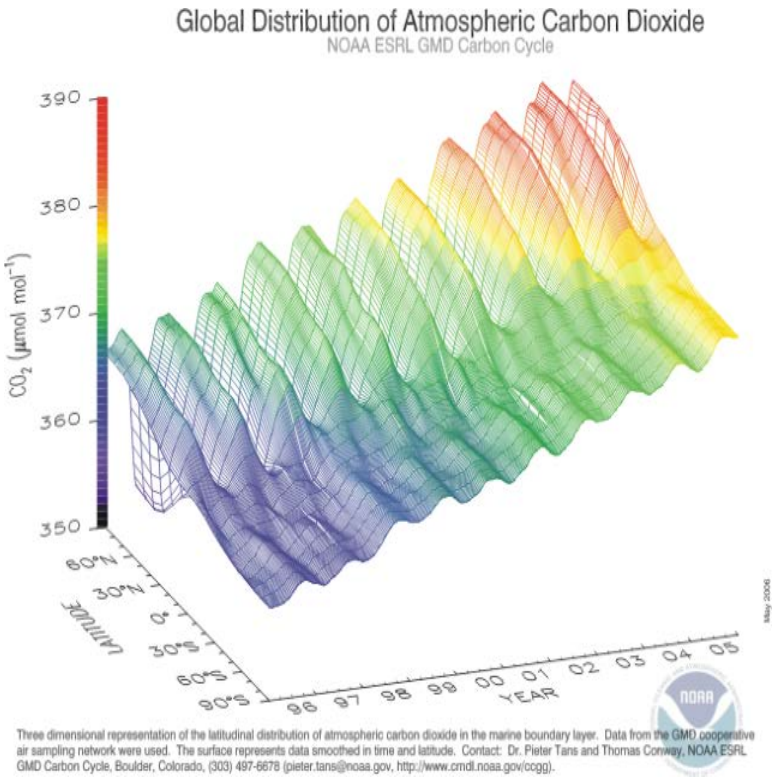
Terrestrial carbon sources and processing in the Siberian land-sea system

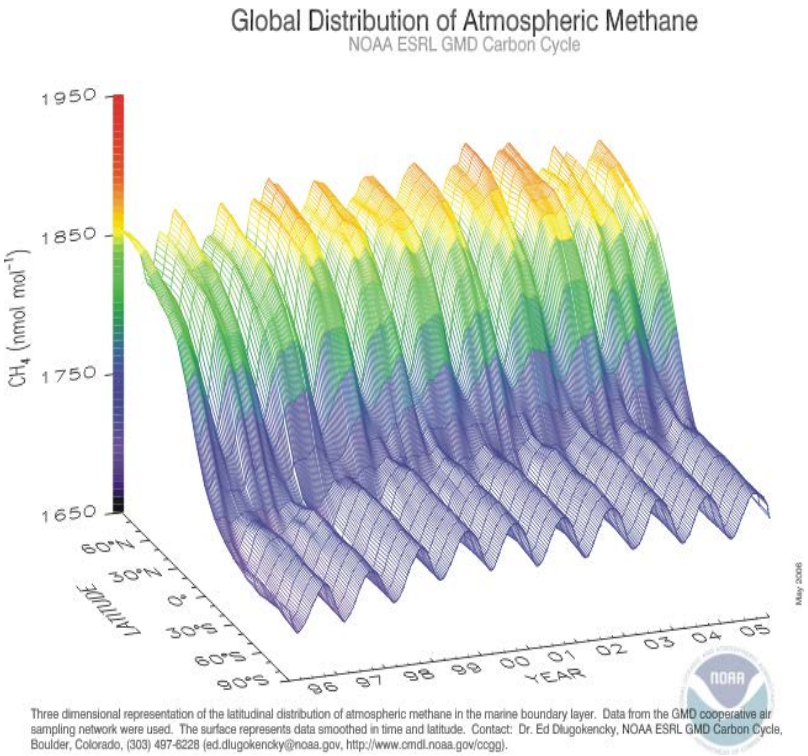


Imbalance in the carbon cycling in the Arctic land-shelf is resulted in:

1) extreme ocean acidification
2) CO_2 and CH_4 exchange at water-air interface

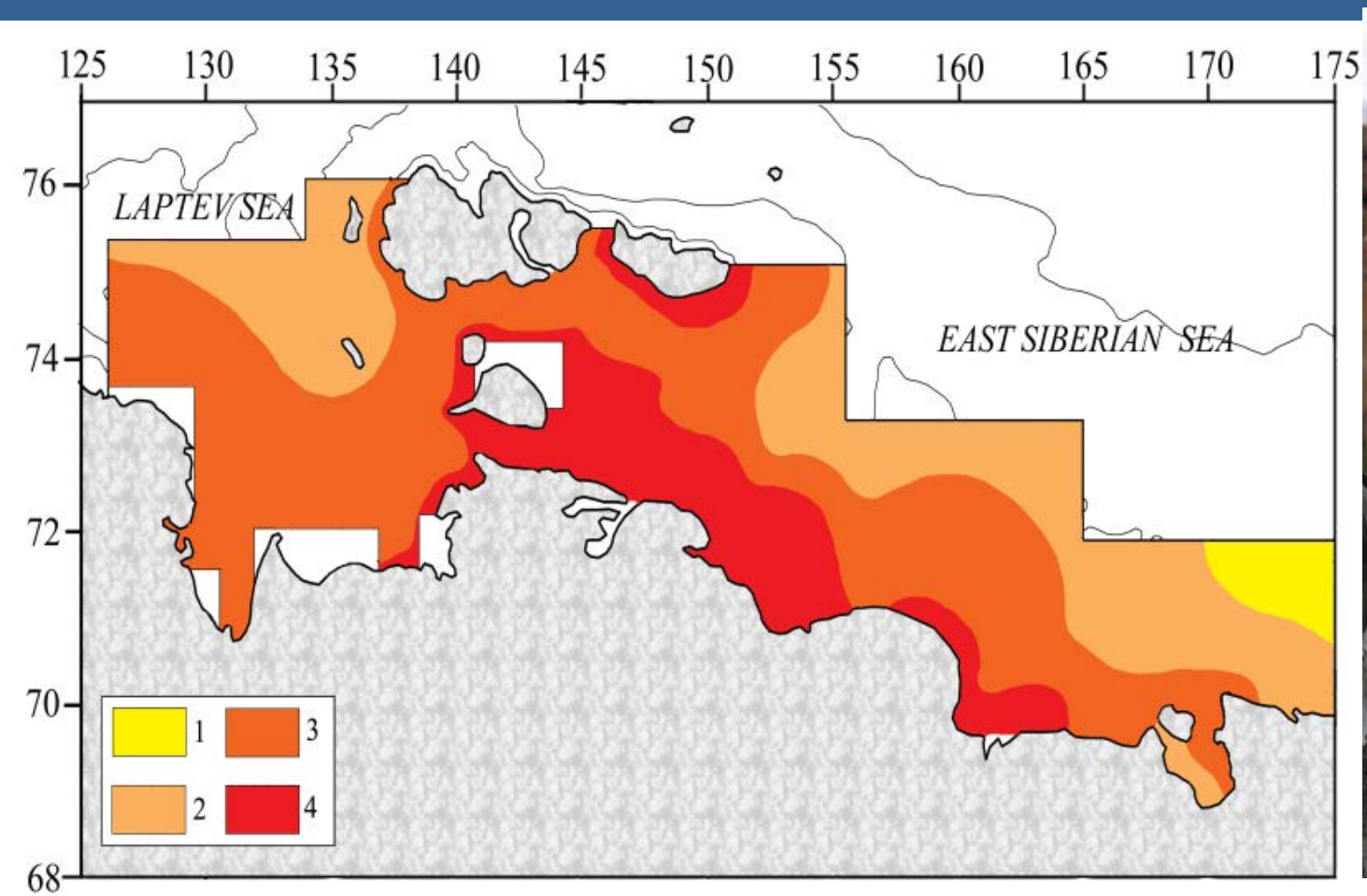
In climate time scale, planetary maximum of main greenhouses gases (GG), CO2 и CH4, is driven by permafrost (PF) thawing involving huge pools of carbon in the Arctic PF-related pools





Overarching Goal: **To understand the role of subsea PF degradation vs onshore PF degradation and their role in the carbon cyclingf imbalance**

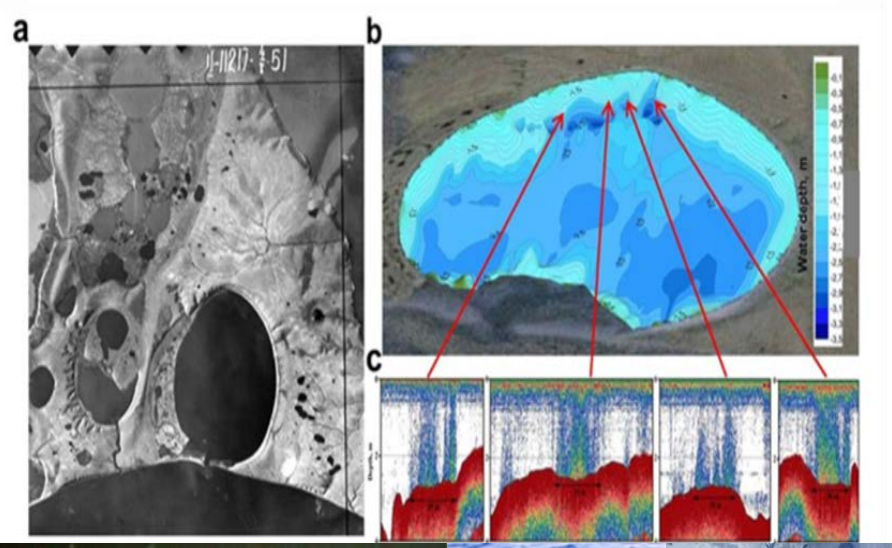
Key Results (1): Pleistocene ice-complex organic carbon (OC) dominates in surface sediment OC on the East Siberian Arctic Shelf - World's largest shelf

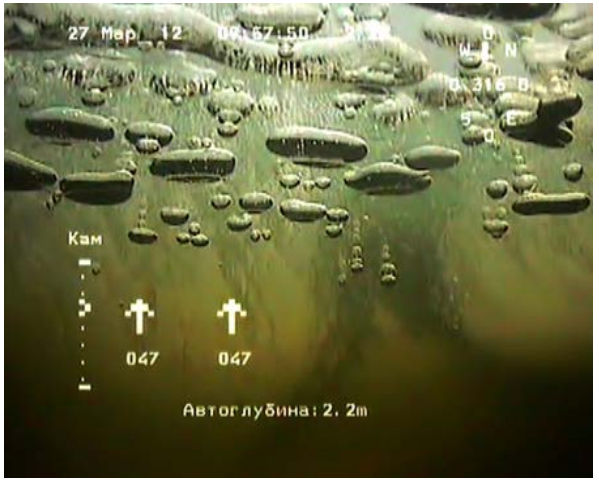


OC ccontribution of terrestrial organic carbon (CTOM, %)) in the surface ESAS sediments 1) <40%, 2) 40-69%, 3) 69-98%, 4) 98-100%

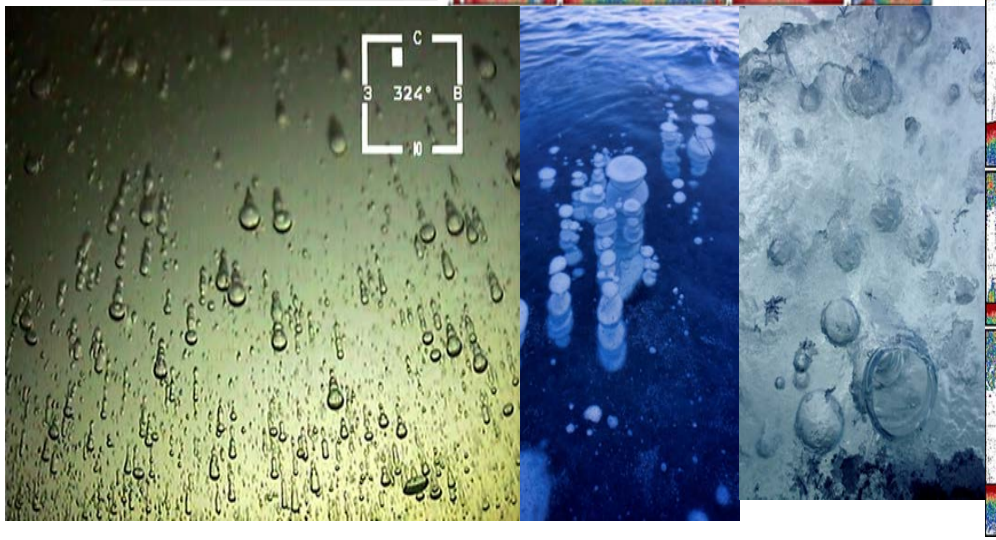
Key Results (2): Air-Sea Methane Imbalance:Bubble-induced fluxes is a predominant contributor to methane releases in the ESAS

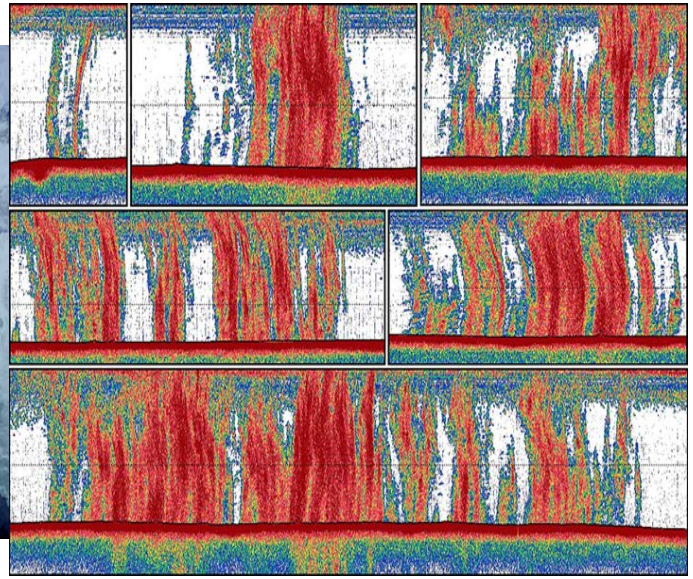
On the shallow shelf



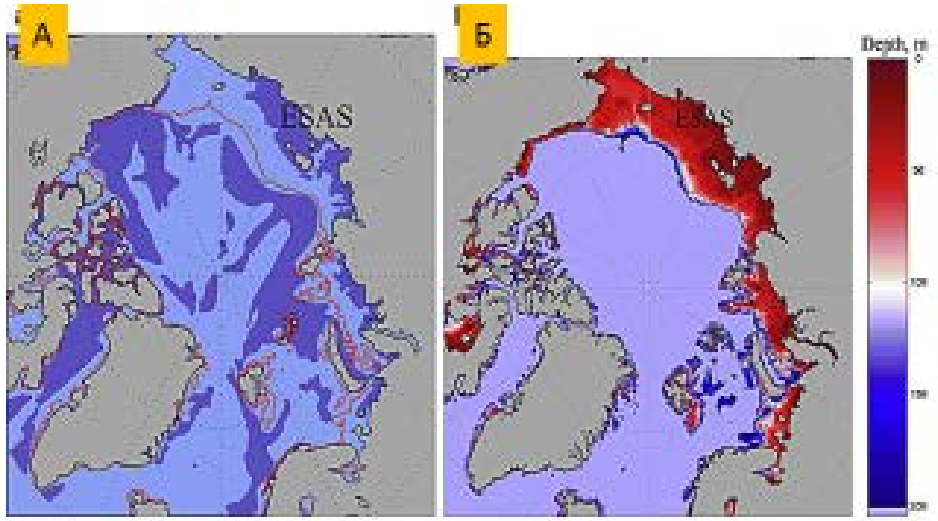


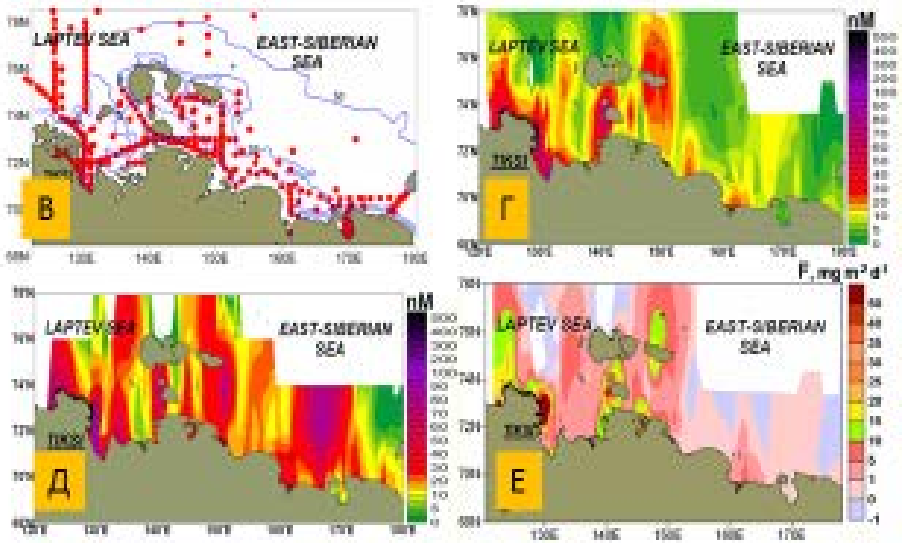
On the outer shelf

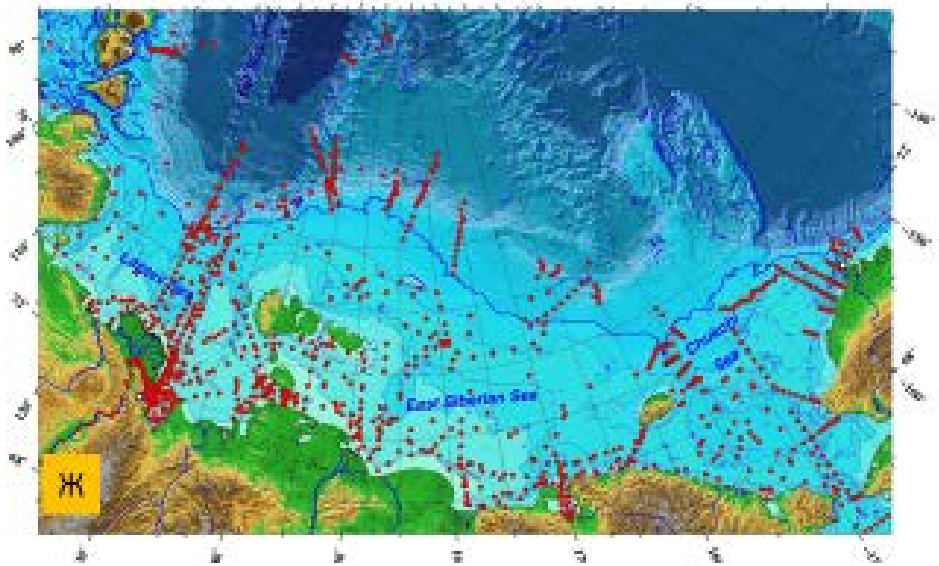


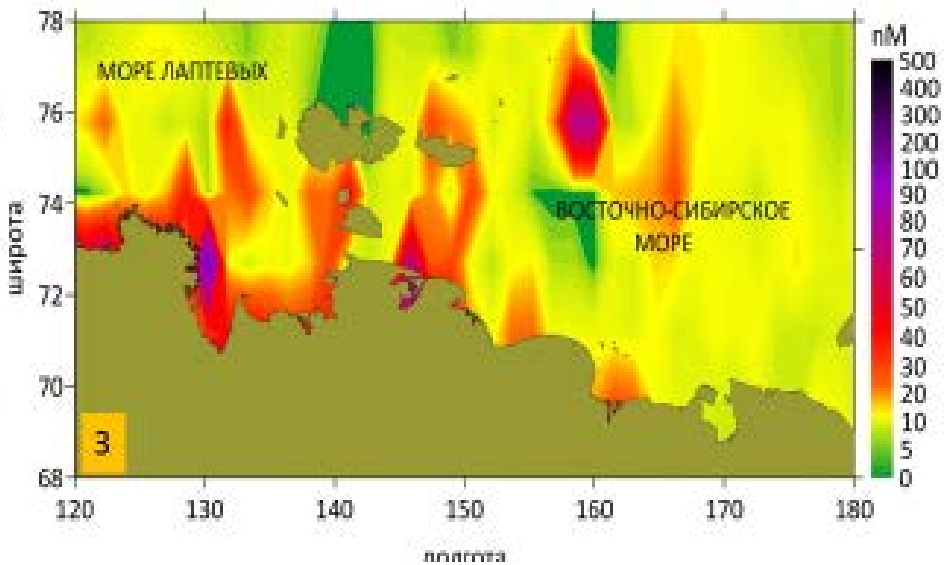


Key Results (3): Methane imbalance is increasing: over the last 8 yrs the ESAS area characterized by the surface dissolved CH4 content=20nM increased 8-10 times

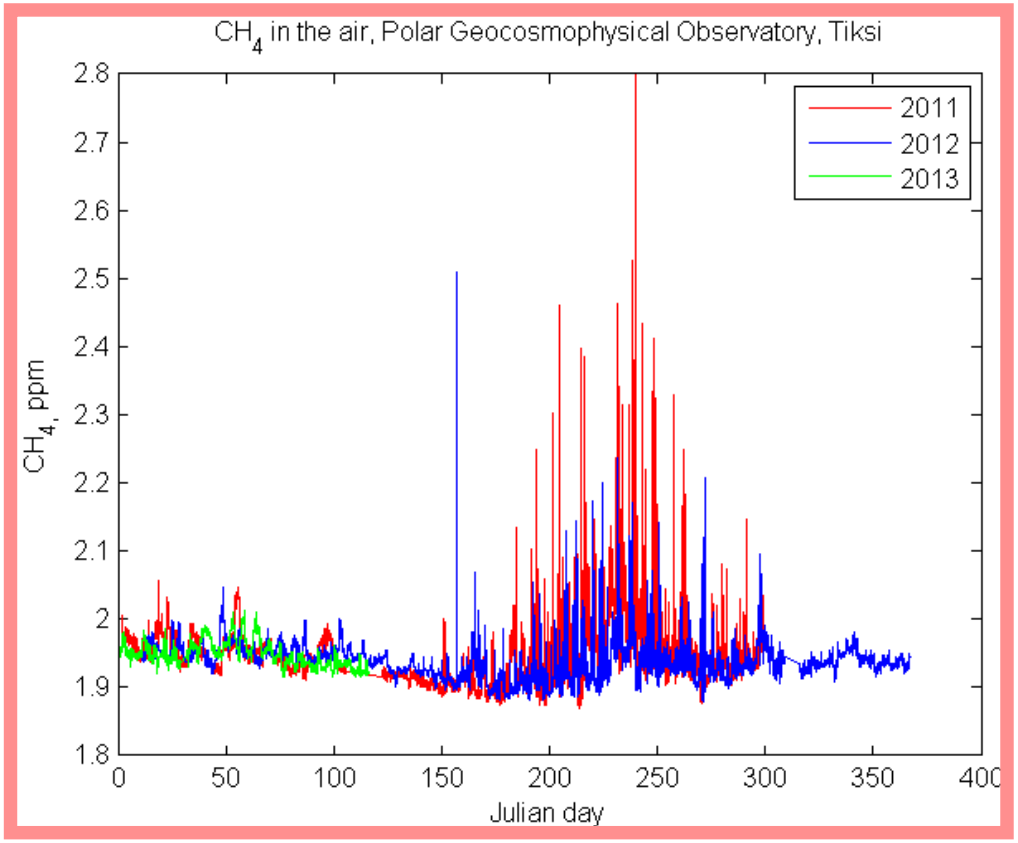








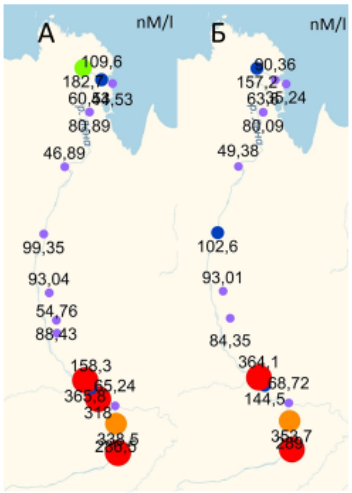
Key Results (4): Multiyear Air CH_4 monitoring on Polar Geocosmophysical Observatory, Tiksi, shows a significant imbalance in atmospheric CH4 cycling

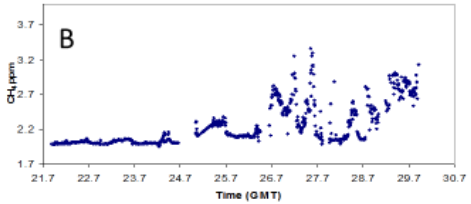


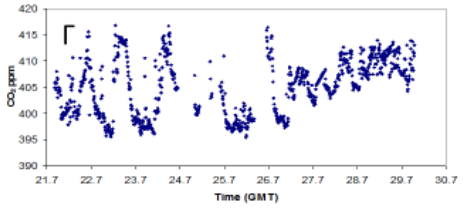
During summer period significant increase of air CH_4 variability from "local" background values of 1.9 ppm to anomalously high ~2.7 ppm was observed. Duration of those signals is ranged from hours to days. Background air CH_4 concentrations obtained during cold season are driven by the dominated southern winds, while

the summertime air CH_4 positive anomalies are associated with the northern winds (ESAS sources).

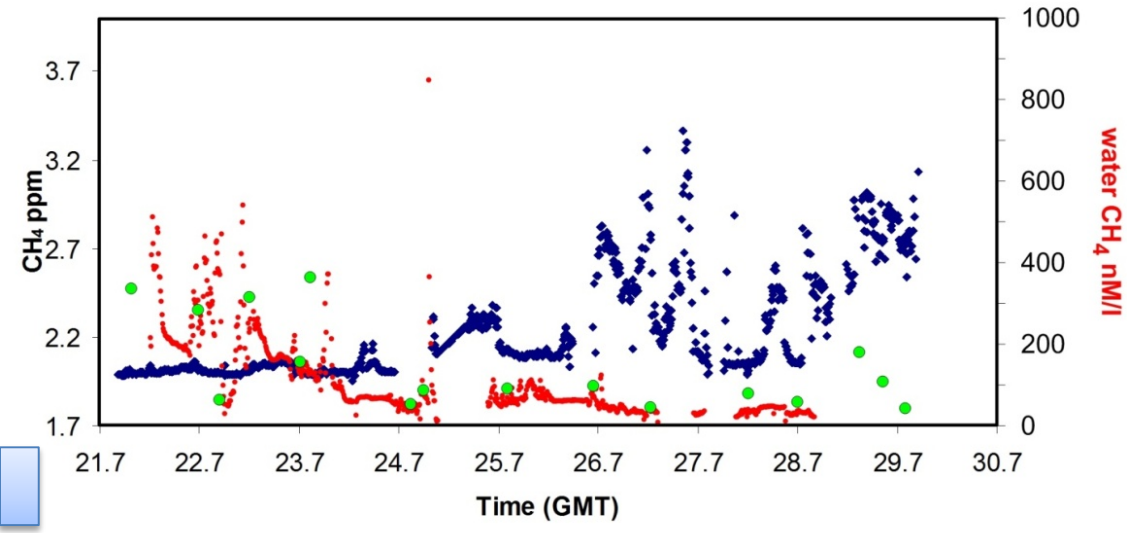
Key Results (5): New Lena River Survey (~1,500 km transect) -2018 shows that Siberian wetlands play the secondary role –after the ESAS in the regional atmospheric budget





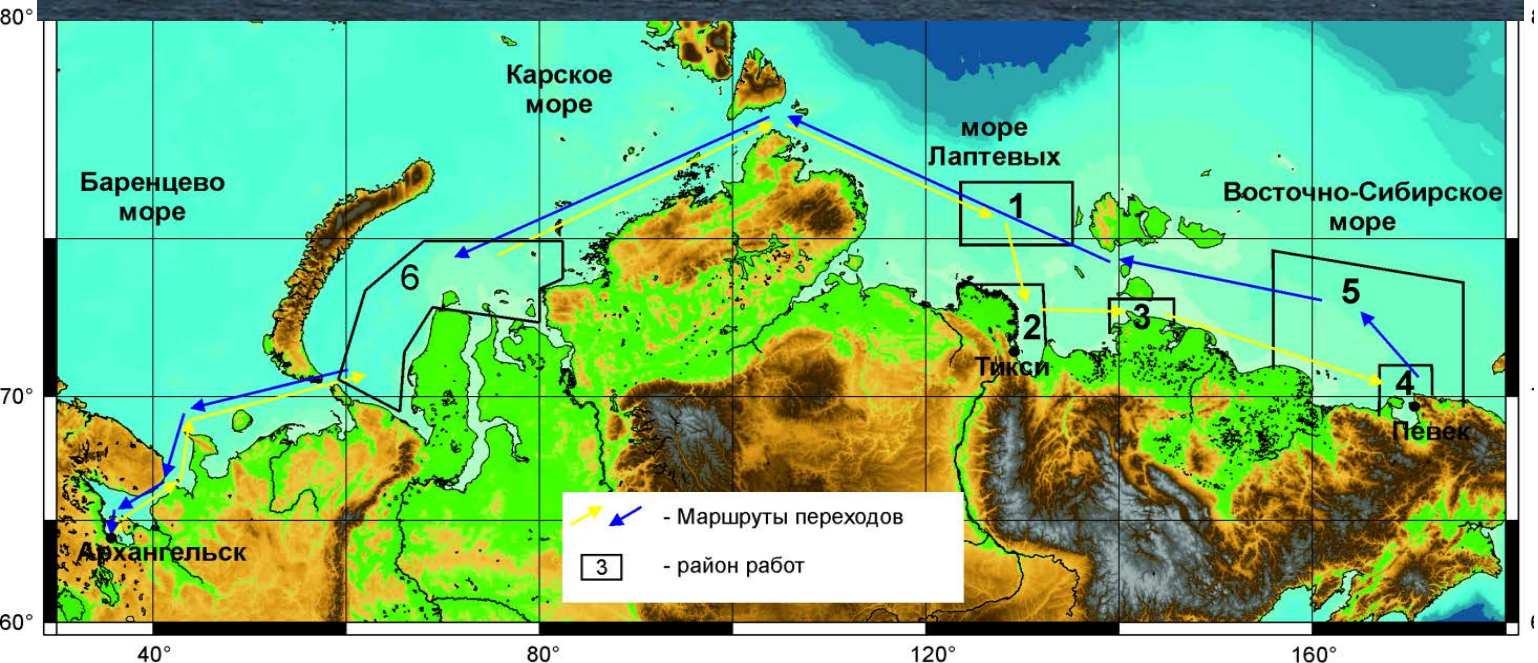


Dissolved CH4 concentrations (nM) are shown on panels А (surface water) and Б (bottom water). Air CH4 and CO2 concentrations are shown on panels В and Г, respectively



Downstream profiles of dissolved CH4 concentrations (red dots) and air CH4 (blue dots) along the ~1,500 km transect demonstrate the decreasing role of the Lena River in the dissolved CH4 export to the ESAS, while the northward increasing air CH4 concentrations (accompanied by northern winds) demonstrate the key role of the ESAS as source of atmospheric CH4

Cruise-2018 onboard the research vessel "Academician Keldish" (September-October) is aimed on complex biogeochemical, geophysical, and geological studies on mechanism of massive CH4 release from the ESAS




Thank you for your attention!