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Why the East-Siberian Arctic shelf should be considered as a new focal point for methane studies

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The importance of this huge pool of old carbon, stored within on-land permafrost in the Siberian region, has been repeatedly highlighted during the last decade. This importance is determined by the *gradual* mobilization of old carbon and its incorporation into the modern carbon cycle in the form of methane during permafrost thawing, creating a positive feedback to a global warming. At the same time, the "Siamese twin" role of Siberian on-land permafrost – relic off-shore permafrost, which presumably comprises the largest part of the East-Siberian Arctic shelf (ESAS) – has never been examined under a spot light. The purpose of this paper is to show that the ESAS represents an even more significant and incomparably more vulnerable carbon pool, which should be taken into consideration while assessing the global carbon cycle. The total value of the carbon pool stored in the ESAS is not less than 1,400 Gt of carbon which almost three times larger than carbon pool in the onshore Siberian ice-complex considered by many scientists as the most fragile part of the Arctic ecosystem.

Our recent studies conducted over the ESAS (2003-2007) showed widespread supersaturation of surface water with methane, reaching in some areas up to 10,000% above background level and implying that strong air-to-sea fluxes must occur at times. This supersaturation leads to a significant increase in atmospheric concentrations of methane above the sea surface of up to 8 ppm (for comparison, the latitude-specific monthly mean concentration is 1.85 ppm). Our first wintertime data (April 2007) showed extremely high concentrations of methane (up to 5.7 μmol l^{-1}) in the surface water beneath the sea ice. These values are commensurate with concentrations

measured during the winter time in thermokarst lakes in the Siberian Lowland; they represent the highest CH_4 concentrations ever observed in the Arctic Ocean, and are comparable to concentrations measured over decaying gas hydrate fields in the Sea of Okhotsk. In contrast to the widespread opinion, the temperature of the bottom waters measured within the study area in April 2007 ranged from -0.8˚C to 0˚C. The vertical distribution of dissolved methane (with a maximum just beneath the sea ice surface), as well as the size and number of CH_4 bubbles trapped within the sea ice strongly indicate ebullition as a mechanism of CH_4transfer to the water surface. Ebullition mechanism of methane transfer from the sediment into the upper layer of water column/atmosphere has been confirmed with recent finding of methane flare in the Laptev Sea mid-shelf. Accumulation of CH_4beneath the sea ice during the winter time can lead to a massive methane release upon ice breakup. Shallowness (about 70% of the East Siberian shelf is shallow than 40 m) allows methane to reach the atmosphere with almost no oxidation occurring first. Being a part of the continental margin and positioned within the fault zones, the ESAS provides favorable conditions for Earth degassing. Modern atmospheric methane burden would be increased *abruptly* a few times, if even a small part of the sub sea Arctic methane hydrates would be disturbed.