

## ***Interactive comment on “Coastal dynamics and submarine permafrost in shallow water of the central Laptev Sea, East Siberia” by P. P. Overduin et al.***

### **Anonymous Referee #1**

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Thank you for preparing this manuscript. It is an interesting paper to read as it involves multiple assumptions and conclusions.

The key question authors try to answer is as follows. What is the rate of ice-bonded permafrost degradation, when the permafrost got submerged by the ocean? Therefore, the authors try to estimate a location of the upper boundary of the ice-bonded permafrost (IBP) at two moments of time. Conveniently, the first measurement of IBP surface was done by drilling in 1983. Consequently, the authors try to estimate the IBP surface location in 2011, using geoelectrical surveys (no drilling this time).

One of the primary assumptions is concerned about "How to define the surface of

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IBP using the recovered resistivity values?" Note that the latter are not measured, but estimated from the electrical currents. Nevertheless, after citing some literature, the authors declare that "IBP depth was defined at values of 15  $\Omega\text{m}$  and higher" (Page 3749, Line 9). This conclusion was based on a similar study by Overduin et al., (2012) in Alaskan Beaufort Sea, as cited. The difference between this study and the Overduin et al., (2012) work is that in 2012 Overduin et al. drilled into the sediments recovered ground material samples, measured their resistivity-temperature dependence, etc. Unfortunately, nothing similar is performed for the Laptev Sea sediments. Moreover, in the 2012 paper, Overduin mentions that "previous work by Overduin et al. [2008] suggests that the transition from ice-free to ice-bonded sediment may not be sharp but occur over tens of meters, depending on the sediment temperature and pore water salinity". In the present manuscript (Page 3749, Line 3), the authors also state that "Kang and Lee (2015) show an increase in electrical resistivity on freezing for silt-sand mixtures with 40% saturation from around 5  $100\Omega\text{m}$  to over 300  $\text{k}\Omega\text{m}$ . For 100% saturated mixtures with saline pore water, the resistivities can be expected to be around 4 to 10 times lower (Kang and Lee, 2015)." Therefore, it seems to the reviewer that the threshold value of 15  $\Omega\text{m}$  used to define the IBP depth is picked up rather arbitrary. It would be great to learn more further justification of 15  $\Omega\text{m}$ ! How would the final results change if the threshold value is different, e.g. range between 10 and 100  $\Omega\text{m}$ ?

Another primary assumption is concerned about timing of the flooding for boreholes 304 and 305. On page 3755, Line 18, the authors state that "the time of submergence at any point along the geoelectric profiles can be calculated based on the assumption that past erosion rates are similar to the long term mean rates observed over the past sixty years." As a result, the authors suppose that the borehole 305 is flooded almost 250 years ago. This is a very strong hypothesis, which may lead to some erroneous results, since it involves extrapolation into the past for 250 years based on 60 years of measurements (4 times longer than the period of observations). On the other hand, it is possible to assume that it could have been a different erosion pattern the Muostakh Island. The spit, connecting the island to the Bykovsky Peninsula, could have eroded

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across its entire shoreline, not from the tip as the authors assume. Hence, the boreholes 304 and 305 could have been flooded much later, and hence the permafrost degradation rates could be estimated much differently.

Unfortunately, no subsea permafrost drilling to validate the geoelectrically estimated location of the IBP surface was performed. Without the actual validation, there are always speculations about the location of the IBP surface. No right or wrong,.. nobody can give a definite answer without drilling and validating the geoelectrical survey. Anyways, in the present form of this manuscript, the reviewer do not see an in-depth analysis of all uncertainties and how the uncertainties influence the estimated rate of the IBP degradation.

It would be also great to put this study into the perspective of other submarine permafrost profiles displayed by M. N. Grigoriev in presentations, e.g. "The permafrost evolution of the shelf-coastal zone in the Eastern Russian Arctic", 2010, see the attached.

Specific comments: 1) P 3748, L 25: Regarding the "modelled water-layer resistivity value": What is the modeled value for the water? How does it correspond to the observation by the CTD datalogger? It looks like the observed resistivity value changes a lot. 2) What are the uncertainties in the estimated resistivity values? Please incorporate them into the analysis. On page 3754, Line 24: How were the error bars computed? 3) In figure 4, how do you derive the electrical resistivity for the boreholes? Is it based on formula (1)? 4) Figure 5 might be omitted or better tied to the analysis.

Interactive comment on The Cryosphere Discuss., 9, 3741, 2015.

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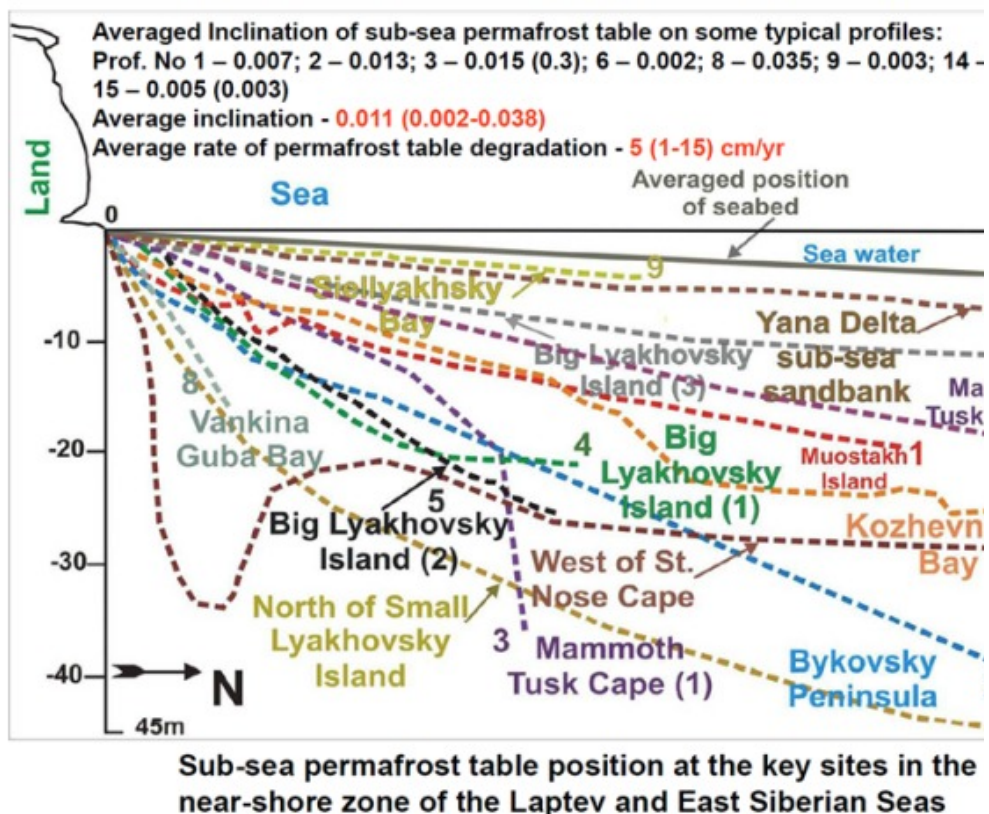


Fig. 1.

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