# Towards solving missing ice problem: the essential importance of rigorous model data comparison

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The last glacial (Marine Oxygen Isotope Stage (MIS) 4-2) was marked by recurring periods of rapidly varying climate instability resulting from periodic discharges of massive icebergs into the North Atlantic that shed their load of scoured bedrock rubble to deep-water sediments, in discrete layers, as they melted. Peaks of ice rafted debris corresponded with intense cold periods in Greenland, that are attributed to the disruption of the North Atlantic thermohaline circulation. It is a key to understand the sizes of global ice sheets during the MIS 3 and 2, since the timing is also an important period for understanding human migration and megafauna extinctions.

Recently, the size of the northern hemisphere ice sheets located both on the North American continent and northern Europe during the MIS 3 and 2, was questioned arguing that the Global Mean Sea Level (GMSL) was smaller, hence the so called Missing Ice Problem was solved (Gowan et al., 2021). To reconstruct past sea levels, for estimating changes in global ice volume, it is necessary to obtain evidence from biofacies that rely on *in situ* fossil material and that grew at specific, shallow-water depths close to oceans shorelines during their life span. At such sites, a time series is also necessary for estimating the exact timing of the lowest sea level by identifying geological sequences and the dating has to be made on the *in situ* fossil organisms themselves (Yokoyama et al., 2022).

In this presentation, we aim to discuss GMSL MIS 3 and MIS 2 by both reviewing previously published studies (Yokoyama et al., 2018; Ishiwa et al., 2019) together with newly available data from far-field sites (Webster et al., 2023).

[References: Gowan et al., 2021 *Nature Comm.* 12, 1190; Ishiwa et al., 2019 *Sci Rep*, 9, 6449; Webster et al., 2023 *IAS spec pub.*; Yokoyama et al., 2018 *Nature*, 406, 713-716; Yokoyama et al., 2022 *Nature Comm.* 13 6261]

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