Project: **1543**

Project title: **Internal gravity waves and mixing in the warming Arctic**

Principal investigator: **Prof. Dr. Friederike Pollmann**

Report period: **2025-11-01 to 2026-10-31**

The Artemics group members joined on 01/01/2026 (postdoctoral researcher) and, due to delays in the hiring procedure and visa processing, on 04/15/2026 (PhD student). Much of the research work and computing demands have hence been shifted the second half of the allocation period and in particular much of the PhD student's modeling work planned for 2026 will be performed in the last quarter (after the report period). This report will therefore focus on the work performed by the postdoctoral researcher on modeling tidal effects in the Arctic Ocean with FESOM2.

How does FESOM2 perform in modeling Arctic tides?

The overarching goal is to diagnose the internal wave generation from tide-topography interaction in simulations with the ocean model FESOM2 forced by the lunisolar tidal potential. An evaluation in the Arctic Ocean had not been attempted before, so we began by comparing tidal amplitudes, phases and currents against observations. Fig. 1 shows that FESOM2 reliably models the M2-tidal amplitudes in the Arctic Ocean. Most of the outliers are located in small inlets and sounds, where the model's land mask differs notably from reality owing to resolution limitations. Fig. 1b also highlights that the observations' availability leads to a near-shore bias of the evaluation. The performance for the other tidal constituents is comparable (not shown).

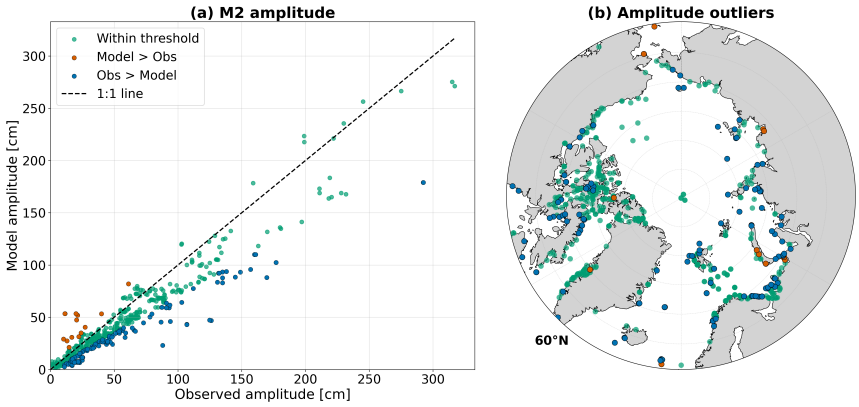


Fig. 1: M2-tide amplitude comparison between observed (Hart-Davis et al., 2024) and modeled output (a) and geographic location of these comparison points (b). Colors denote model over- (red) and underestimation (blue) by more than 30%. Credit: Dr. Ekaterina Bagaeva.

What is the impact of including tidal forcing in Arctic Ocean modeling in FESOM2?

Fig. 2 demonstrates how tidal forcing modifies the modeled Arctic hydrography. The model output is compared against observations (Unified Database for Arctic and Subarctic Hydrography, Behrendt et al., 2017) in different sectors of the Arctic. In all the six sectors tested (Fig. 2 shows a selection), the addition of tidal forcing moves the model mean temperature closer to the observed one, which is in many regions a significant improvement within the uncertainty of the observations. Temperature and salinity determine the stratification, which is a key parameter for internal wave generation, propagation and dissipation.

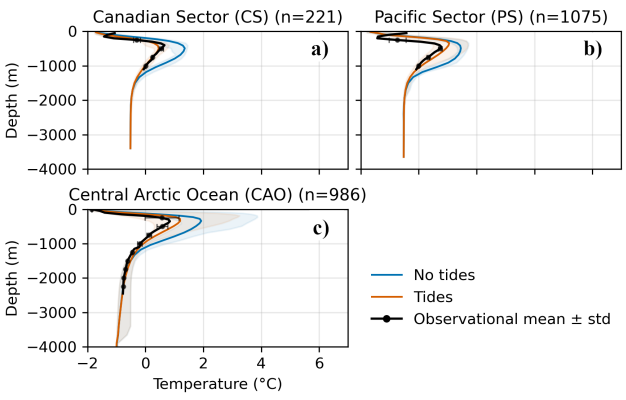


Fig. 2: Modeled and observed mean temperature profiles in three select Arctic regions. Black error bars represent the spread in observed values, blue and orange shading that of the model output with tides. Credit: Dr. Ekaterina Bagaeva.

What is the influence of embedded sea ice formulation?

The results shown above were obtained for the default sea ice formulation in FESOM2 (levitating). The more realistic expression is embedded sea ice, where sea ice and ocean share the same grid (Scholz et al., 2022). This was not yet tested in the Arctic Ocean. A preliminary attempt is shown in Fig. 3, which demonstrates how the choice of sea ice configuration influences upper ocean hydrography and sea ice characteristics. A robust assessment of tidal effects on sea ice as planned in Artemics thus requires a dedicated investigation of how the sea ice configuration impacts modeled sea ice and internal wave controls like stratification. This is proposed for the upcoming allocation period.

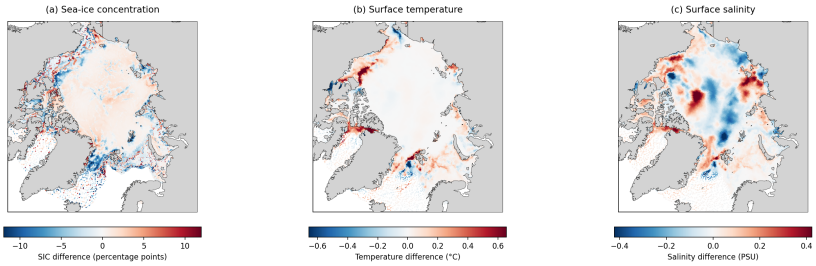


Fig. 3: Preliminary analysis of differences of embedded minus floating sea ice experiments (1998 annual mean, with tidal forcing, model still drifting). Credit: Dr. Ekaterina Bagaeva

Internal tide generation in FESOM2

Since the differences between the more realistic embedded sea ice configuration and the default one in FESOM2 need to be resolved before a reliable internal tide generation estimate for the Arctic Ocean can be computed, we so far focused on a back-of-the-envelope estimate given by the scaling relation of Jayne and St. Laurent (2001). This links the barotropic-to-baroclinic energy flux to the bottom buoyancy frequency, the tidal current velocity, a representative topographic wavenumber and height and the ocean's background density. The outcome is shown in Fig. 4, identifying the steep continental slopes as one generation hot spot.

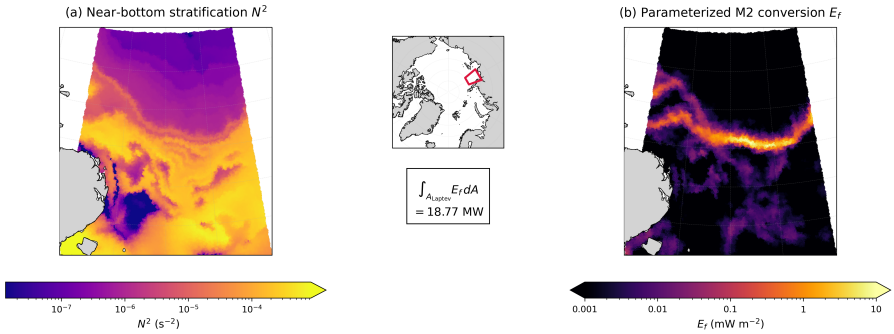


Fig. 4: Near-bottom stratification and estimated internal tide generation in a Laptev Sea test region covering the shelf, steep continental slope and the deeper basin. Credit: Dr. Ekaterina Bagaeva

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