Development of ocean and non-breaking wave coupled Model (FESOM-Wave) and applications to modern and paleo oceans

G. Lohmann, S.Z. Wang, X. Gong, P. Scholz, D. Barbi and D. Sidorenko*, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany*

In Short

- Coupling MASNUM non-breaking surface wave model to FESOM ocean model
- Role of surface wave physics in improving the modern ocean reconstruction
- Modelling diagnose of the ocean surface wave based on interglacial and glacial oceans
- Ocean surface wave development and its impact on a climate warmer than the nowsdays

Non-breaking wave is an irreplaceable physics that alters the climate system by changing upper ocean mixture, vertical oceanic heat exchange and sea surface roughness [1]. Previous studies have demonstrated that involvement of wave physics into ocean models leads to results in better agreement with observations. In particular, compared to limited improvement by surface breaking wave for top few meters of the ocean [2] [3], modelling work coupled with non-breaking wave have presented a better reconstcution of ocean temperaures in the upper a few hundred meters and also seasonal variability of the mixed layer depths [4] [5]. However, most up-to-date ocean models, as well as Earth System models, have not included wave physics into their model processes.

In this project, we aim to construct an ocean and non-breaking wave coupled model FESOM-Wave by coupling AWI Finite-Element Sea-Ice ocean model (FESOM)[6] [7] to MASNUM surface non-breaking wave Model [8]. We will apply the newly developed FESOM-Wave model to simulate surface ocean wave propagation and the corresponding ocean circulation at various glacial and interglacial climates of the past. For the first time, this will provide systematic diagnose of the surface-wave impact on the ocean at warmer and colder climates relative to the nowadays and also indications for the roles of surface wave in global warming.

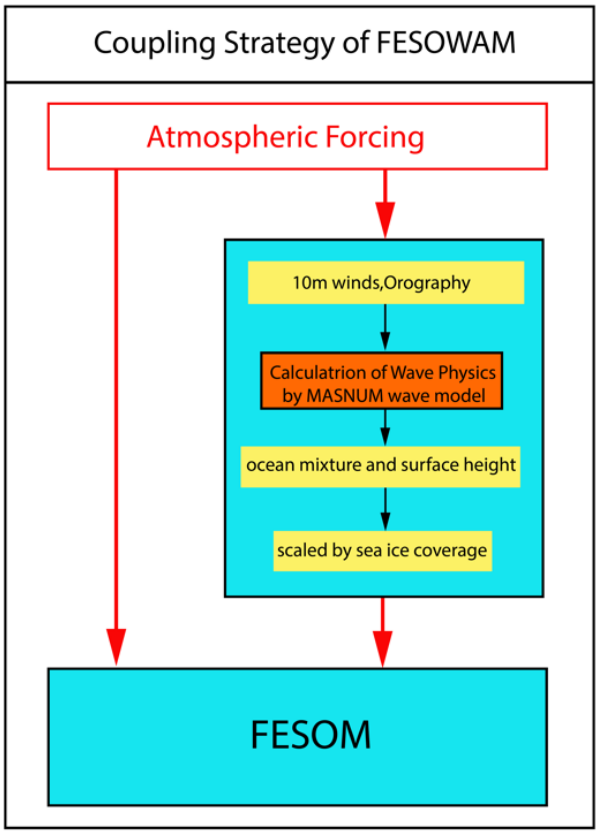

Figure 1: *Coupling strategy in developing FESOM-Wave in this project.*

We plan to finish two modelling tasks: (1) Coupling the suface wave model to FESOM (Fig.1). (2) Using FESOM-Wave model to simulate ocean wave development and its impact on the modern and also colder (Last Glacial Maximum) or warmer (Mid Holocence, Early Holocene and Last Interglacial) oceans relative to the Present. Our versions of FESOM and the MASNUM wave model have been already used in publications for various scientific purposes. Moreover, our preliminary results using offline-coupled approach with FESOM and the wave model have shown significant improvement in simulating the modern ocean (fig.2). So far, both FESOM and wave model have been successfully complied on HLRN. Thus, we are able to start the FESOM-Wave incorporation work as soon as we get the permission of computational resources.

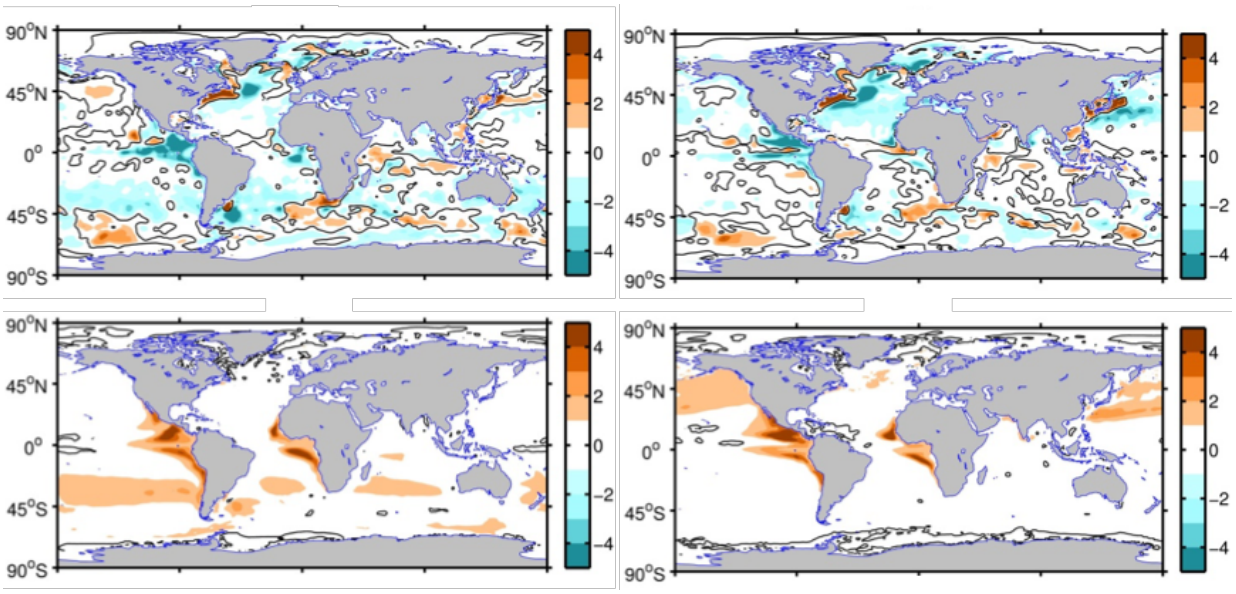

Figure 2: *Improvement of simulating 50m ocean temperatures (Units: degree) by offline coupling FESOM to MASNUM wave model, with the left and right columns for the February and August results, respectively. The upper panel shows the bias in simulating sea surface temperatures using the FESOM standalone model compared to the WOA dataset. The lower panel exhibits anomalies of the offline wave-ocean coupled model compared to FESOM standalone results. Indeed, the opposite colors in the lower panel compared to the upper row suggest an improvement of the modelled oceans in the FESOM-O-wave simulation.*

Our project is investigated under the guidance of the "Joint Declaration between the State Oceanic Administration of the Peoples Republic of China and the Federal Ministry of Education and Research of the Federal Republic of Germany concerning Sino-German Collaboration on Marine and Polar Research (2013-2020)". In addition, the FESOM-Wave coupling work also provides a case solution to improve vertical ocean mixture physics in the AWI Climate Model. Thus, it is aligned with AWI internal collaborations between the Climate Dynamics Group and the Paleoclimate Dynamics Group.

More Information

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