Laboratoire de Glaciologie et Géophysique de l'Environnement

Soutenance de thèse

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Ice-ocean interactions in the context of future ice-sheet/ocean coupled models

Abstract:

The next generation of climate models will include an ice-sheet model in order to improve the ice sheet mass balance projections by accounting for the ice dynamics and ice-oceans interactions. On the one hand, the Southern Ocean (SO) is indeed driving the acceleration of the Antarctic outlet glaciers via an increase in the basal melting of the ice shelves. On the other hand, the increasing ice discharge from Antarctic Ice Sheet (AIS) contributes to the current sea level rise and is likely to become the largest cryospheric contributor to sea level rise by the end of the current century. In addition, the related freshening may have significant implications on future sea-ice cover and on bottom water formation. However, it is not clear yet how the ocean and ice-sheet components of future coupled systems will account for the ice-ocean interactions, which are both causes and consequences of the AIS mass imbalance. Here in this work, different aspects of the standalone ocean and ice-sheet components have been investigated. A first step of this thesis has been focused in the representation of the glacial freshwater uxes in current ocean models. Based on recent glaciological estimates, the ice shelf basal melting fluxes have been spatially distributed in an ORCA025 grid, and the calving rates have been applied into an improved version of the NEMO-ICB iceberg model. This preliminary study has been used to produce a monthly iceberg meltwater climatology, to be used to force current ocean models. This work shows the importance of representing the iceberg meltwater fluxes when modeling sea ice, which can be inexpensively achieve by using our climatology. The improvements in the representation of the glacial freshwater fluxes have been considered in the study of the ocean model response to the Antarctic mass imbalance. This study considers a realistic perturbation in the glacial freshwater forcing as close as possible as it will be represented in future ice-sheet/ocean models. According to our results, up to 50% of the recent Antarctic sea ice volume changes might be caused by the observed decadal AIS mass imbalance rate. Glacial freshwater forcing appears to be crucial to correctly represent the ice-ocean interactions and projecting sea ice cover of future coupled

systems. However, the estimation of the glacial freshwater input in future climate models will be strongly dependent upon the capacity of ice-sheet models to reproduce the grounding line migrations of marine ice sheet glaciers. Current ice-sheet models present large uncertainties related to different parametrizations. In the context of the future climate models, we have studied the sensitivity of ocean-driven grounding line retreats to the application of two different friction laws and two different englacial stress approximations. The model responses almost indistinctively to either the SSA or the SSA* englacial stress approximations. However, differences in the contribution of the glacier to the sea level rise can be up to 50% depending on the friction law considered. The more physically constrained Schoof friction law is significantly more reactive to the ocean perturbations than Weertman law and should be considered in future coupled systems. This work underlines that uncertainties related to the ice sheet model estimates of grounding line migrations may not only contribute to uncertainties in sea level projections, but also the sea ice cover through the ice-ocean interaction in future ocean models.This conclusion suggests the need for improving the representation of both the ice shelf basal melting and the glacier interaction with the bedrock, in order to improve the climate projections of future climate models, in which the spatial and seasonal distribution of the glacial freshwater fluxes may play an important role in setting the sea ice cover.