Introduction

Leads are stretches of open water within the pack ice of the Arctic Ocean formed by divergent and shearing motion of a fractured sea ice cover. Ridging compacts thin, weak ice into thick ice when the drift ice converges. By piling up blocks of thin ice space for leads is created within the ice pack so that open water areas occur once the floes part. These “windows” in the sea ice cover enable heat fluxes that are 1-2 orders of magnitude greater than the flux through the solid ice. How does this effect the climate mean state in the Arctic?

GFDD’s Climate Model CM 2.x

We conducted two experiments with a descendent of GFDD’s Coupled Global Circulation Model CM2.1 (Delworth et al., 2006; Grunwald et al., 2006), which consists of the

• AM2 atmosphere and LM 2 land models (2˚ × 2.5˚, 24 levels), Anderson et al. (2004),
• MOM4 ocean (1˚ grid, ~0.5˚ in Arctic, 50 levels), Griffies et al. (2005), and
• SIS sea ice model (same as ocean grid, 10 ice thickness categories), Winton (2000).

A control run without and another run with the ridging scheme implemented that is described in Lipscomb et al. (2007). Both simulations feature present day climate conditions (1990 GHG concentrations).

Ridging in CM2.x

The ridging scheme spurs lead formation by mechanically increasing ice thickness. Note, ridging itself only redistributes and thus conserves ice volume. Nevertheless, the long-term net effect is an increase in total Arctic sea ice volume:

Conclusions

The formation of leads is at the heart of many weather and climate relevant processes, such as the surface energy budget, sea ice growth and melt, and formation of low clouds. Leads enable an intensified exchange between atmosphere and ocean, such as heat flux increases by up to 30 W/m². Despite its central role sea ice deformation, i.e. ridge and lead formation, is rarely well described in many climate models nor are the parameters used in numerical ridging schemes well constrained by observations.

We show that the climate and sea ice mean state in the Arctic is altered by a state-of-the-art ridging scheme as follows:

1. sea ice concentration decreases by 5% on Arctic-wide average;
2. surface albedo decreases by more than 0.1 in some areas;
3. and low cloud fraction is increased by 2%.

Clouds reduce the radiative flux changes associated with ridging by 3 W/m² (6 W/m²) in winter (summer).

In summary this yields

A. an increased Arctic sea ice volume by 16% in winter and >20% in summer, and
B. generally warmer surface temperatures by about 2 °C with local maxima of up to 6 °C.

Therefore, climate models would benefit from intensified modeling and observational efforts of sea ice dynamics.

References


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