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Influence of ocean - sea ice - atmosphere feedbacks in Antarctica

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The Ross Sea sector is a major place of dense water formation. A significant amount of dense water is formed in polynyas and results from air - sea ice - ocean interactions. However, the representation of physical processes specific to polar regions is generally poor within climate models.

Our aim is to quantify the effects of physical feedbacks, in particular those in which sea ice is involved. We choose limited area modeling in order to use parametrizations specific to polar regions at a relatively high resolution (40 km). Physical feedbacks are involved in air - sea ice - ocean interactions, and some atmospheric regional models have therefore been coupled to a sea ice model or a 1-layer ocean model. However, none of these models have been coupled to a 3-dimensional ocean model in Antarctica, although this is needed to represent dense water formation. We therefore describe and evaluate the new coupled atmosphere - sea ice - ocean regional model TANGO (Jourdain et al., 2010). This is a coupling of the regional atmospheric model MAR (Gallée et al., 2005) and the ocean - sea ice model NEMO (Madec et al., 2008). This study is motivated by previous studies that have emphasized the improvement of ocean - sea ice simulations (using the model NEMO) when it is forced by the atmospheric regional model MAR (Mathiot et al., 2008, 2010).

Stand alone atmosphere or ocean - sea ice experiments are performed to evaluate the skills of MAR and NEMO in the Ross Sea sector, Antarctica. A methodology is described to isolate physical feedbacks as captured by TANGO. Our methodology provides an estimation of the effects of physical feedbacks. It is shown that they significantly affect the sea ice properties, the atmospheric boundary layer, and the first 700$\sim$m of the ocean, even after a few months of model-integration. The dense water formation in polynyas is affected by coupling, although the turbulent heat flux parametrization has a larger impact. Finally, TANGO is evaluated using observations of sea ice temperature, area, and thickness, and data from automatic weather stations.