Evaluation and improvement of climate simulations of sea ice

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At high latitudes, a significant part of the oceans is covered by sea ice that forms when seawater freezes. Sea ice is a major player in the global climate system. It is also a primary indicator of climate change, as it responds rapidly to variations in surface air temperatures and wind regimes.

Since years now, scientists have developed numerical models to assist them in better understanding the sea ice system. These models simulate the evolution of the main sea ice characteristics at high spatial resolution and temporal frequency, which makes them valuable tools to enlarge the picture given by incomplete observations. In addition, models are used for their predictive skills, from seasonal to centennial horizons. However, in spite of their increasing complexity, substantial uncertainties still persist in model reconstructions and predictions of Arctic and Antarctic sea ice.

In this doctoral thesis, we have developed the tools to properly identify the possible sources of these uncertainties. We have highlighted the important role of model physics and initial conditions for the climate simulations of Arctic sea ice. We have also implemented statistical methods to optimally constrain the models given measurements, a field of research known as data assimilation. In the framework of sea ice data assimilation, we have been able to propose a multi-decadal reconstruction of Antarctic sea ice thickness, which is not possible from observational data only.

Sea ice models become more comprehensive. At the same time, more and more observations are available to evaluate, constrain and improve them. To address the sensible questions about the future of sea ice and of climate in general, an optimal use of these two sources of information will be required. This thesis illustrates some steps to move forward in this direction.