Geophysical Research Abstracts
Vol. 21, EGU2019-13537-1, 2019
EGU General Assembly 2019

North Atlantic Ocean Circulation around Greenland in CESM 2.0

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The Community Earth System Model (CESM) version 2.0 was launched in June 2018 – improving both the physical parameterizations and numerical methods in the CESM components (e.g. ocean, atmosphere, ice). However, we do not know yet what is the performance of the ocean component in this new CESM version for oceanic waters around Greenland. Greenland is a key place to study due to its high sensitivity to the climate change. The Greenland Ice Sheet is losing mass by, approximately, 35 Gt/yr, which 30% is due to the ice discharge. The highest rates of ice discharge are observed at tidewater glaciers.

Thus, in this presentation we evaluate CESM 2.0 in simulating the ocean circulation in the Greenland vicinity, both in terms of present-day simulation and sensitivity to anthropogenic greenhouse forcing, with the ultimate goal of assessing the sensitivity of the Greenland ice sheet mass budget to future changes in the ocean conditions. For this purpose, we analyze results from simulations under three different scenarios with static and/or interactive Greenland ice sheets: i) pre-industrial (PI) control - no anthropogenic effect, ii) one-percent CO_2 concentration (1pct CO_2), where the concentration of CO_2 increases one percent per time step until reaches four times the PI atmospheric CO_2 level (1140 ppm) and iii) four times PI CO_2 levels (abrupt 4xCO_2). Thus, we can evaluate the response of the ocean in stable, intermediate and extreme scenarios. Three sites (each close to three main Greenland outlet glaciers: Helheim, Kangerlussuaq and Jakobshavn Isbrae) are chosen to evaluate the water masses signature. These tidewater glaciers have been shown to be sensitive to ocean forcing change, with increased discharge to the ocean and major contribution to sea level rise in the last decade (van den Broeke et al., 2016). A longer transect from Greenland to Iceland is also presented to evaluate the North Atlantic Meridional Overturning Circulation (NAMOC). Preliminary results show that in the 1pct CO_2 scenario the Atlantic Meridional Overturning Circulation (AMOC) index decreases 0.087 Sv/yr and 0.16 Sv/yr for the 4xCO_2 scenario. In the latter, the signature of the NAMOC is so weak that suggests a shutting down of the NAMOC. The modeled southern hemisphere part of the AMOC (SAMOC) is enhanced in the 4xCO_2 scenario.

The main water masses identified around Greenland in the pre-industrial simulation are the Polar Water at the surface, Atlantic Water subsurface/intermediate water and Deep water in the vicinity of the Helheim and Kangerlussuaq; and a fresh surface water and Labrador Intermediate Water around Jakobshavn glacier. In the 1pct CO_2 and 4xCO_2 scenarios was observed an increase, in the Atlantic Water temperature (about 150 m depth), by approximately 2.5 and 8.5^{o}C, respectively and a deepening of approximately 350 m of the thermocline in the average of the last 30 years of each simulation.