Atmospheric impact of Arctic sea ice loss in a coupled ocean-atmosphere simulation

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SUPPLEMENTARY MATERIAL

Vertical structure in the ocean

In this supplementary material the vertical structure of the ocean for the model experiment described in Section 2 of the main document is considered. Here two periods are presented; April-May (AM) in Figure 1 and August-September in Figure 2. Figures 1 and 2 show zonal mean temperature and salinity for the Arctic (70N-90N), Atlantic (20N-70N) and Pacific (20N-70N). The left columns show the ensemble mean of the control run (CTRL); the ocean component of this model configuration is discussed and evaluated in detail in Megann et al. (2014) and within the coupled environment in Williams and Coauthors (2015). The right columns show the difference between the perturbation run (PERT) and CTRL.

Figure 1b shows that in AM there is a statistically significant positive temperature response in the North Atlantic between 50N and 70N over the top 100m of the ocean in PERT. This warming is related to sea ice melt in the Labrador Sea and Fram Strait where the ice has been thinned and melts away earlier in the season owing to its lower latitude compared with sea ice in the central Arctic. The ice-free ocean absorbs more shortwave radiation therefore warming the upper ocean. Similarly Figure 1d shows that in the Pacific there is an increase in temperature in the top 100m related to sea ice loss in the Sea of Okhotsk. Figures 1f and h show increases in salinity in the top 100m in the North Atlantic and in the Pacific at latitudes that correspond to the regions of sea ice melt in AM (i.e. the Labrador Sea, Fram Strait and Sea of Okhotsk). When sea ice melts there is a flux of freshwater from the ice to the ocean. The sea ice in PERT is thinner than in CTRL, therefore when the sea ice melts in PERT the ice to ocean freshwater flux is smaller than in CTRL. This leads to an increase in the salinity in PERT.

Figure 2b shows that in AS there is a more pronounced statistically significant positive temperature response in PERT in the top 100m of the North Atlantic extending northwards from 50N. In the central Arctic north of 70N the warming is in excess of 2K (in the zonal mean). The temperature increase in AS is greater than in AM as the ocean in the ice loss regions have been exposed to short-wave radiation over a longer period of time therefore allowing a greater accumulation of heat. Similarly Figure 2d shows a statistically significant warming of approximately 1K between 55N and 65N over the top 100m of the ocean at latitudes that correspond to the ice loss regions of the Sea of Okhotsk (50N-60N) and the Bering Sea (50N-65N). Figures 2f and h show an increase in salinity over the top 100m of the ocean north of 50N in the North Atlantic, across the Arctic basin and between 55N and 70N in the Pacific. The increase in salinity in the ice loss regions is again due the smaller ice to ocean freshwater flux in PERT where there is less sea ice in the initial conditions.

In AM and AS the most pronounced responses (largest in magnitude and statistically significant at the 95% level) are in the regions of sea ice loss and are confined to the mixed layer.

References


FIG. 1. April-May zonal mean temperature and salinity as a function of depth (0-1500m) for the Arctic (70N-90N), Atlantic (20N-70N) and Pacific (20N-70N) sectors. The left column shows the ensemble mean temperature and salinity from the model control run (CTRL) and the right column shows the difference between the perturbation run (PERT) and CTRL.
Fig. 2. As in Figure 1 but for August-September