Impact of decreasing sea ice cover and warming Arctic surface temperature on the Northern mid-latitude climate – comparison of coupled with uncoupled EC-Earth simulations

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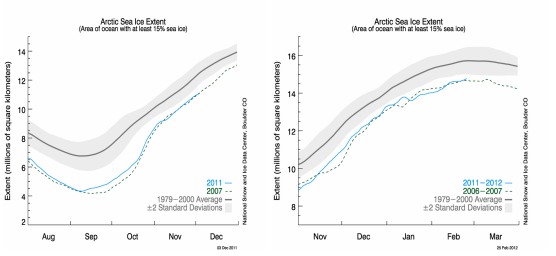
Motivation

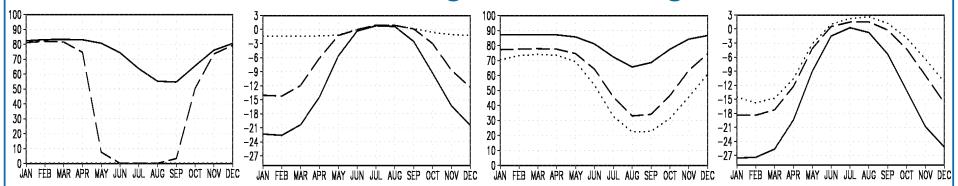
Arctic sea ice declining faster than predicted by climate models – what is the sole influence of declining Arctic sea ice on the Northern mid-latitudes climate as opposed to multiple influences in coupled simulations?



Methods

Idealized sensitivity experiments	Coupled model experiments
T255L62 (79 km)	T159L62 (125 km)
One with reduced sea ice concentration (SIC) plus increased sea ice surface temperature (SIST) (referred to as **IR**): SIST ≤ Tfreeze – 10 ºC → SIST = SIST + 10 ºC, SIC = SIC SIST > Tfreeze – 10 ºC → SST = Max(Tfreeze,SIST), SIC = 0 One with ice-free Arctic throughout the year (referred to as **IF**)	physical processes in ocean and ice considered, therefore ice thickness and extent reduction through dynamics / thermodynamics 1850-2005: observed greenhouse gas and aerosol concentrations (**hist**) 2006-2100: two different emissions scenarios for greenhouse gases and aerosols: RCP **4.5**, RCP **8.5** (radiative forcing in 2100 compared to 1850: 4.5 and 8.5 W/m2)
atmosphere-only	atmosphere-ocean-sea-ice
SST unchanged	SST changed

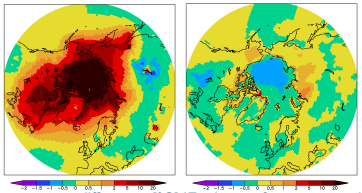
Surface forcing / surface changes



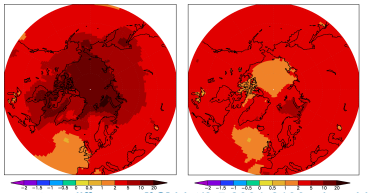
Prescribed sea ice concentration [%] and surface temperature [°C] averaged over Arctic sea grid points north of 70 °N as climatological monthly means from 1960 to 2000. Solid line: reference experiment, dashed line: IR, dotted line: IF.

Simulated sea ice concentration [%] and surface temperature [°C] averaged over Arctic sea grid points north of 70 °N as climatological monthly means. Solid line: hist 1851-1950, dashed line: hist/4.5 2001-2100, dotted line: hist/8.5 2001-2100.

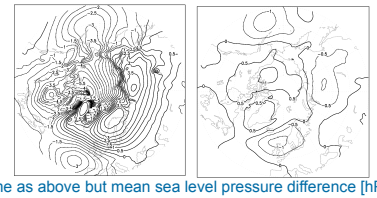
Results



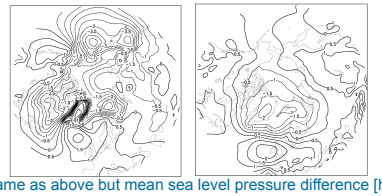
2 m temperature difference [°C] IF minus reference over the Arctic and the Northern mid-latitudes as climatological seasonal means for (left) winter and (right) summer 1960-2000



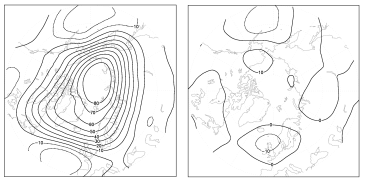
2 m temperature difference [°C] hist/8.5 2001-2100 minus hist 1851-1950 over the Arctic and the Northern mid-latitudes as climatological seasonal means for (left) winter and (right) summer



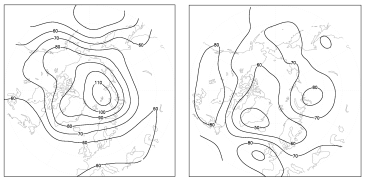
Same as above but mean sea level pressure difference [hPa]



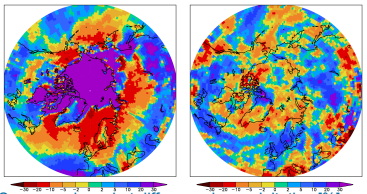
Same as above but mean sea level pressure difference [hPa]



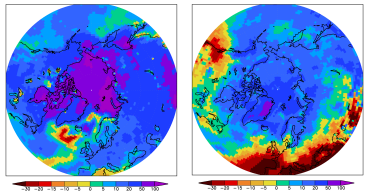
Same as above but difference in 500 hPa geopotential [m]



Same as above but difference in 500 hPa geopotential [m]



Same as above but difference in precipitation [%]



Same as above but difference in precipitation [%]

Summary and conclusions

- Idealized studies exaggerate the contrast between Arctic and mid-latitude warming
- Similar between idealized and coupled experiments is the baroclinic response in the Central Arctic in winter while areas of barotropic responses differ. In summer circulation responses differ and are weak compared to winter.
- Precipitation response in winter qualitatively similar but in coupled experiment overlaid by effect of general warming; in summer noisy response in idealized experiment (40 years for precipitation responses too short!)
- Cloud response different between idealized and coupled experiments. Clouds very uncertain but hugely important for radiation balance and speed of Arctic sea ice melting!

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