Numerical modeling studies on the influence of the Arctic on the atmospheric large-scale circulation of the Northern mid-latitudes

**Question**

- What happens to the weather and climate of the Northern mid-latitudes if the sea ice and the Arctic atmosphere change faster than anticipated?
- Idealized model studies which only consider the influence of the Arctic and keep the influence of the mid-latitudes and tropics as small as possible

**Experiments**

- Atmosphere-only relaxation experiments (14 days)
- Idealized atmosphere-only experiments with reduced sea ice thickness (15 days, some 90 days)
- Idealized coupled experiments with initially reduced sea ice thickness (1 year)
- Idealized coupled experiments with modified albedo, lead closing parameter, longwave radiation (150 years)

**Atmosphere-only relaxation experiments**

Fig. 1: Forecast error reduction (%) through relaxation of prognostic variables north of 75°N in winter.

Within Northern mid-latitudes Northern Asia most affected – due to northerly component in mean westerly flow

**Idealized atmosphere-only experiments**

Fig. 3: Mean vertical temperature profiles for CTL (black contour lines), interval 4 °C, and differences (colour shading (K)) between ice-reduced (RED) and CTL

**Idealized short coupled experiments**

Fig. 4: Synoptic activity and Eady growth rate in CTL simulation and difference ice-reduced (RED) minus CTL

**Idealized long coupled experiments**

Fig. 5: Mean sea surface height response in the last 60 years of the 150 year-simulations

Spin-up of the Beaufort Gyre: less and/or thinner sea ice cover permit stronger momentum flux into the ocean

Pathway shift of mid-latitude surface currents: negative AO forces southward shift of Western Boundary Current Extensions, consequence: warmer and saltier North Atlantic current

**Conclusions**

- Reduced sea ice increases temperature mainly in Arctic boundary layer
- Strongest pathway from Arctic to Northern mid-latitudes: Barents Sea / Kara Sea area - Siberia
- Reduced westerly flow especially over Eurasian sector along with some cooling
- Less synoptic activity but stronger Eady growth rate in the Arctic (vertical stability increase not as relevant as vertical wind shear decrease)
- Southward atmospheric storm track shift
- Encouraging: results consistent between different methods and different time scales
- In long coupled simulations southward atmospheric storm track shift reflected in the ocean. Generally more active ocean circulation in Arctic and sub-Arctic.

**References**

- Semmler, T., Jung, T., Kasper, M.A., Serrar, S. (2017): Using NWP to assess the influence of the Arctic atmosphere on mid-latitude weather and climate. Submitted to Advances in Atmospheric Sciences