Workshop Polar Climate Change: Driving Processes, Extreme Events, and Global Linkages
Nanjing, China, 23rd and 24th of October, 2017

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Large ensembles of uncoupled and coupled model experiments on the influence of Arctic sea ice decline on mid-latitude weather and climate

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

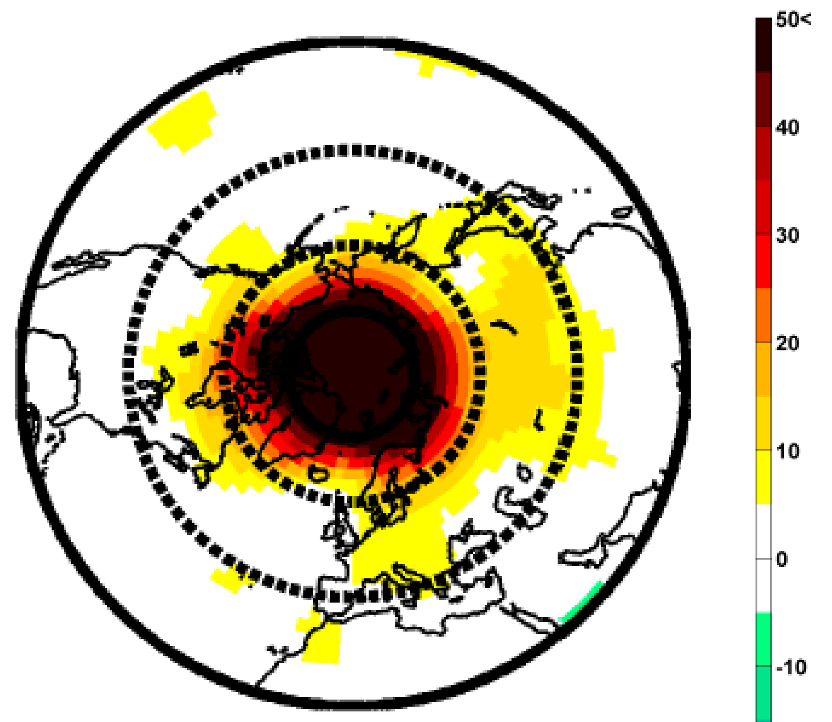


Fig. 1: Forecast error reduction (%) through relaxation of prognostic variables north of 75°N in winter
Within Northern mid-latitudes Northern Asia most affected – due to northerly component in mean westerly flow

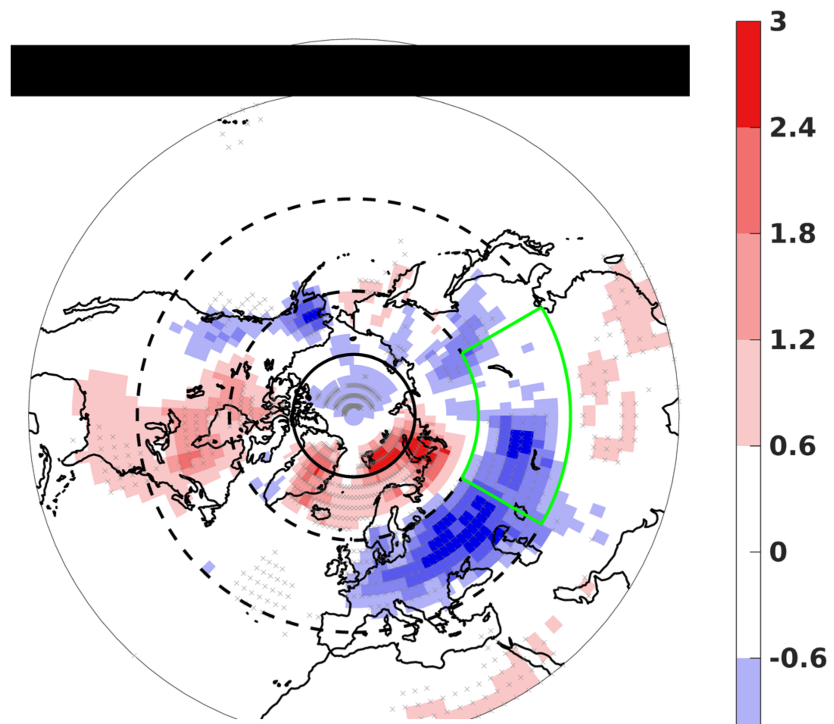
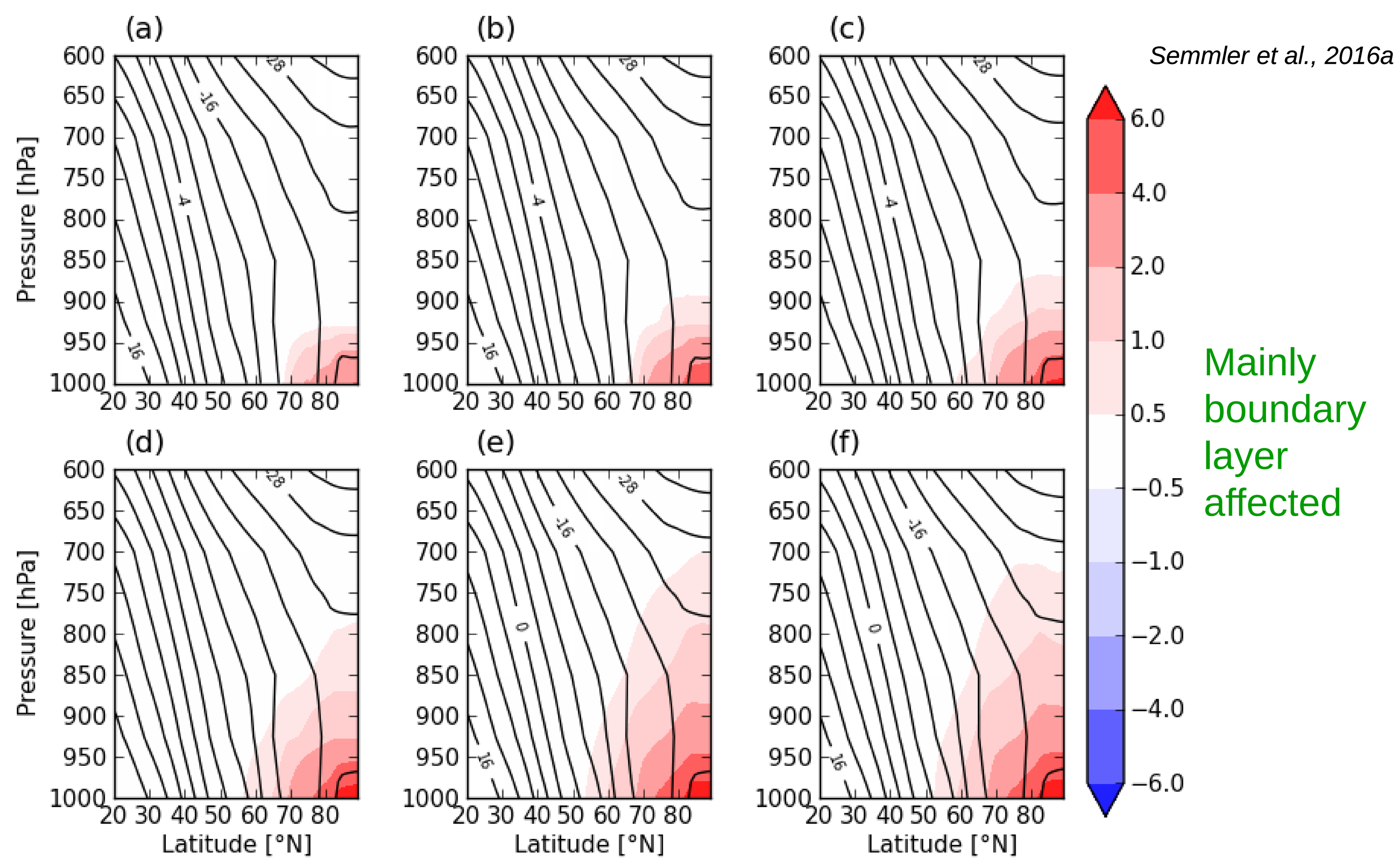


Fig. 2: 2 m temperature anomaly (K) in cases of strongly improved forecasts in Northern Asia winter
Link to European cold winters
Semmler et al., 2017, AAS
Jung et al., 2014, GRL

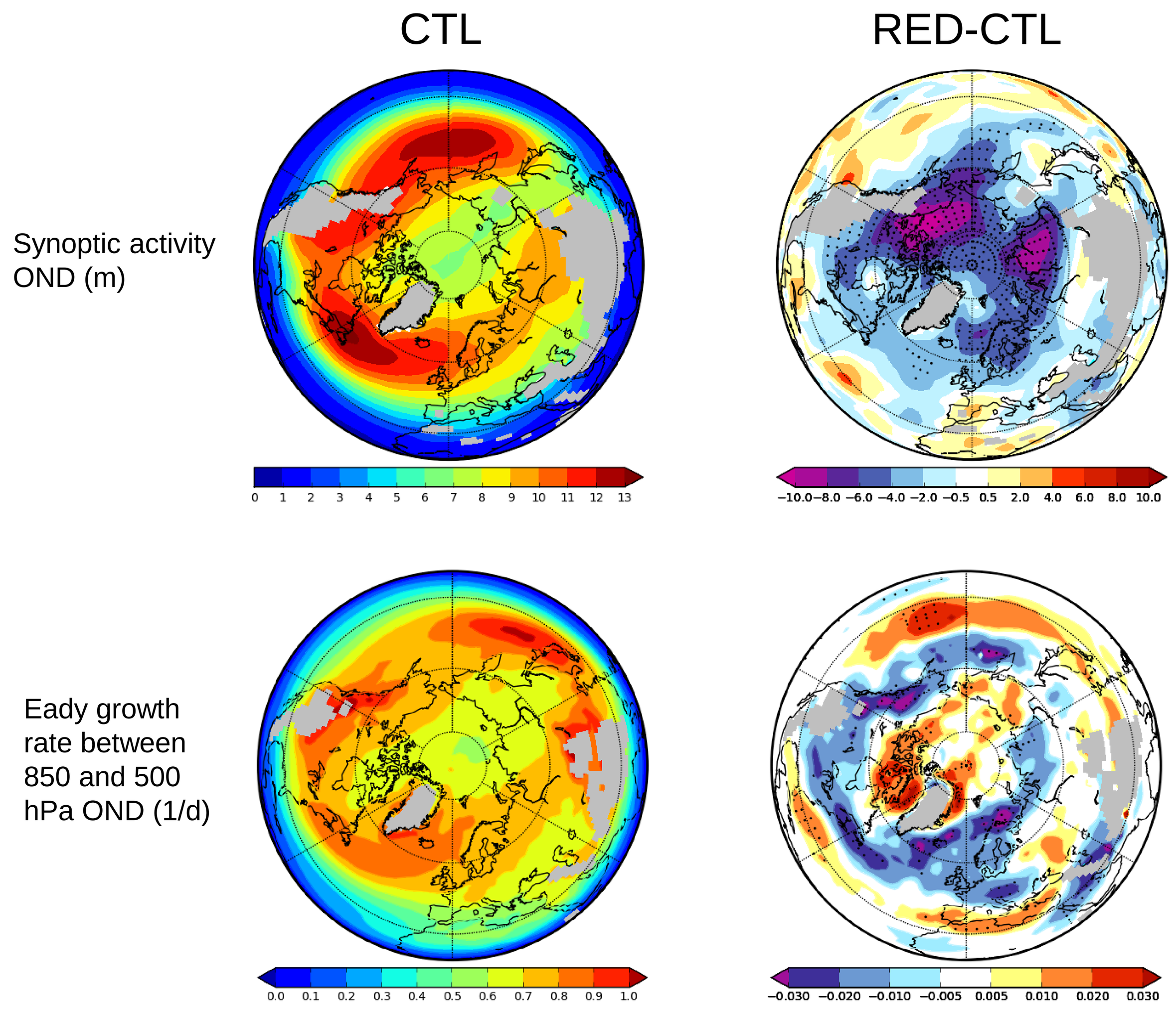
Idealized atmosphere-only experiments



Mainly boundary layer affected

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



Semmler et al., 2016b

Less synoptic activity but stronger Eady growth rate in Arctic, southward shift of storm track

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

Idealized long coupled exeriments

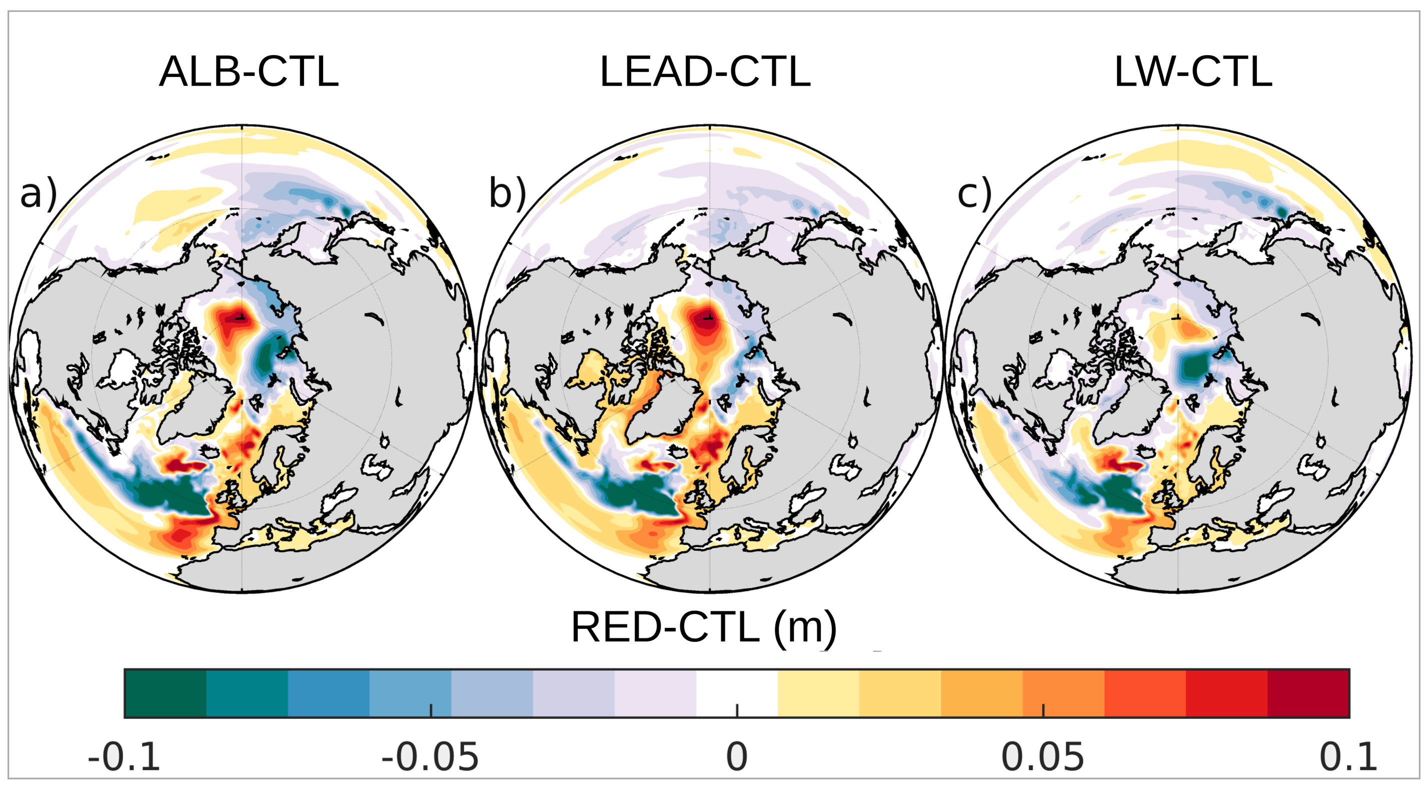


Fig. 5: Mean sea surface height response in the last 60 years of the 150 year-simulations

Campos et al., 2017, in prep.

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:
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- **Campos, C., Semmler, T., Jung, T. (2017):** The response of Northern hemisphere oceans to the Arctic sea ice decline. *In preparation.*

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