The atmospheric response to the forced removal of sea ice in a present-day climate simulation with EC-EARTH

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

Olivier Andry*, Richard Bintanja, Wilco Hazeleger

*Contact: olivier.andry@knmi.nl

Forcing

Setup

The no sea ice run (nSI) was performed with a non-coupled version of EC-EARTH. Both nSI run and control prescribe a fixed sea surface temperature (SST). Sea ice cover is set to 0 everywhere. Both the control and the nSI are intialized and run for 40 years.

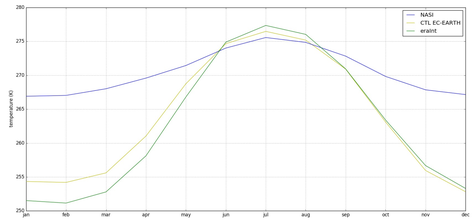

Figure 1: Near-surface atmospheric temperature seasonal cycle, averaged over 40 years. 1979-2015 mean for eraInt.

The total removal of sea ice results in a strong surface warming over the arctic ocean, mostly in winter.

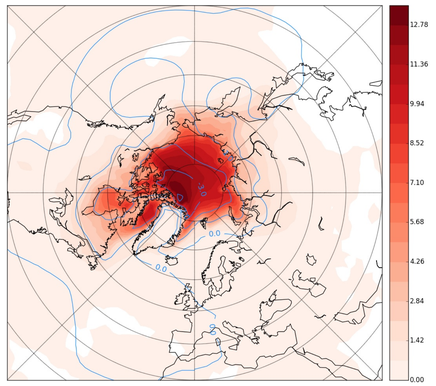

Figure 2: Near-surface atmospheric temperature anomaly pattern, contours show the sea level pressure anomaly pattern, averaged over 40 years.

Objectives

By applying a radical forcing we trigger a strong Arctic amplified warming. We look at alleged linkages:

- an increase in the occurrence of blocking events,
- a shift toward more negative phase of Arctic oscillation,
- an increase of baroclinic instability.

Main Conclusions

- **SI removal results in a strong surface warming, that stays near the Arctic surface, despite a relative instability of the model,**
- **there is hardly any impact on Arctic Oscillation, despite the strong forcing,**
- **changes in occurrence of blocking stay within the interannual variability.**

Limitations

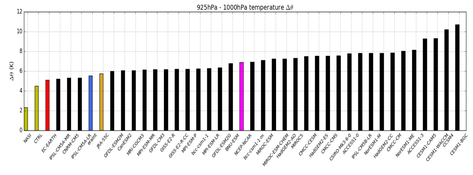

Figure 9: 925hPa - 1000hPa difference in Arctic mean potential temperature (north of $65^o N$). The nSI and the control runs are compared to reanalyses and CMIP5 models (1990-2005 average).

- Arctic near surface atmosphere is less stable in both control and nSI than any CMIP5 models or reanalyses.
- A missing possible linkage in those runs are stratospheric processes that are hardly represented by the model.
- These runs are not coupled.

Local Impacts

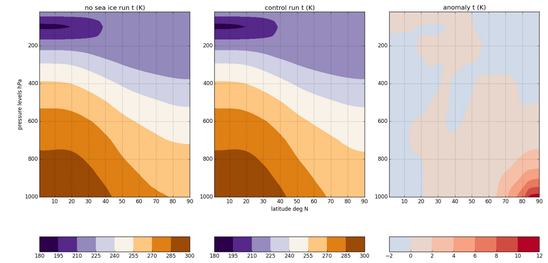

Figure 3: Zonal mean of atmospheric temperature for (left) nSI run, (middle) control run, (right) anomaly. 40 years average.

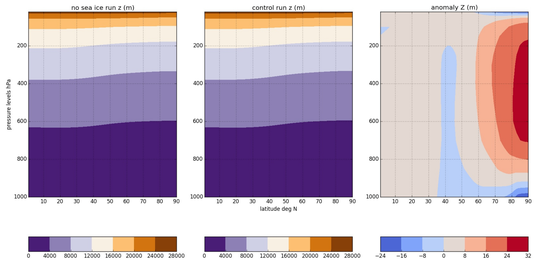

Figure 4: Zonal mean of geopotential height for (left) nSI run, (middle) control run, (right) anomaly. 40 years average.

The direct response is a strong surface temperature anomaly that does not propagate further than $65^o N$. Intense surface warming triggers a increase of geopotential height in the troposphere.

Remote Impacts

Arctic Oscillation (AO)

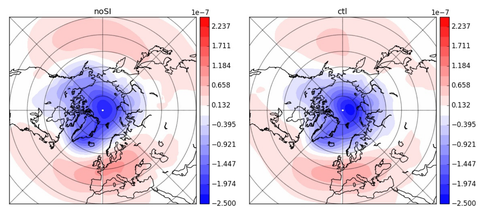

Figure 5: Pattern of the first EOF of the surface pressure field between $20^o N$ and $90^o N$, in winter (DJF). For the nSI run (left) and the control run (right).

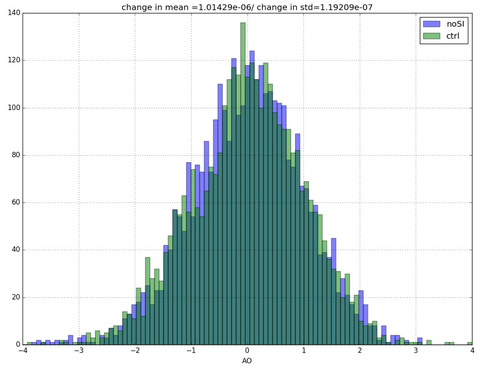

Figure 6: Distribution of the AO index in (blue) the nSI run and (green) control run. AO index is define as the principal component associated the first EOF of the surface pressure. For winter (DJF), from daily mean over 40 years.

Occurrence of blocking events

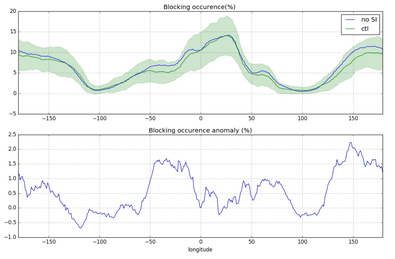

Figure 7: Blocking occurrence at $60^o N$ as a function of longitude. (blue) nSI run and (green) control run, green shading is the interannual variability, the lower figure show the anomaly.

Baroclinic instability

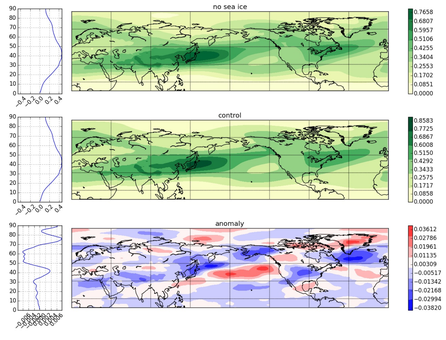

Figure 8: Maximum Eady growth rate at 500 hPa, for (top) nSI run, (middle) control run, (bottom) anomaly.