Impacts of regional sea ice loss – a global response

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1. Polar-Amplification MIP of CMIP6 (PAMIP) Experiment Design

AIM: . To improve understanding of the range of model responses to reduced Arctic sea ice and possible mechanisms, using multi-model global climate model simulations.

- Atmospheric-only simulations forced with present day sea ice concentrations (SIC) versus future regional SIC.
- Sea surface temperature forcing consistent for all experiments (present day).
- Members initialized from single start date April 1st 2000 (historical run).
- Large ensemble (100 members) needed to distinguish a robust response from background variability.
- We use 150, plus 150 with opposite phase of QBO (HadGEM3 Met Office Model).

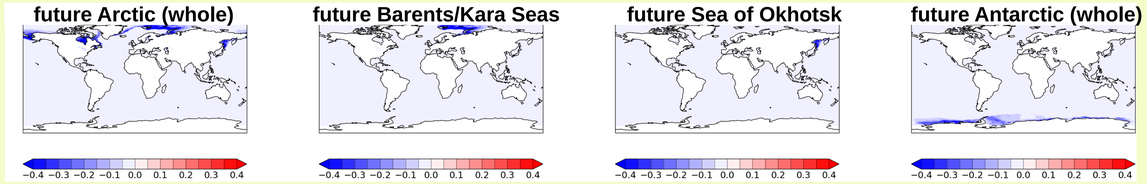

Figure 1: The sea ice forcing. Winter SIC for future (different regions) minus present day experiments.

2. Mid-Latitude Winter Response in Met Office Model

- Weakening of tropospheric winds towards North pole, strengthening towards jet core
- Pan-Arctic: Weakening of stratospheric winds
- Sea of Okhotsk: Tropospheric wind response but not stratosphere

Opposite hemisphere response – or just noise?

- Symmetric weakening of winds on equatorward side of jet in both hemispheres ?
- Significant Antarctic response for u-wind and pressure for BKSeas experiment ?

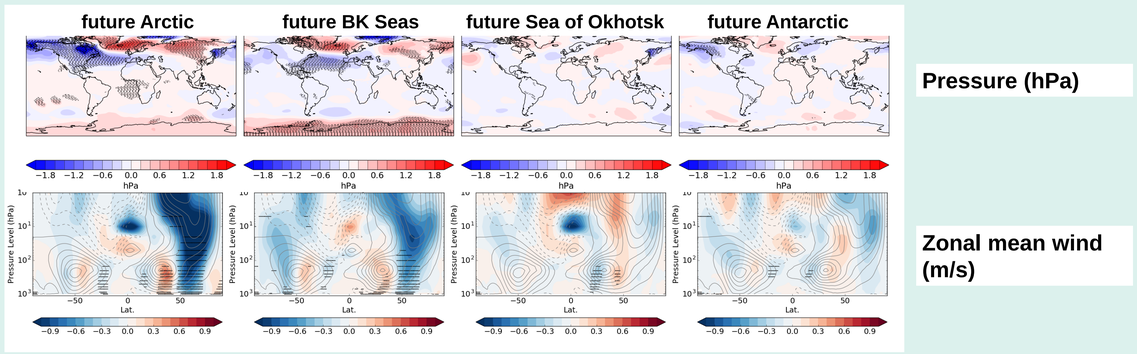

Figure 2a: Response to reduced sea ice, future minus present day experiments (stippling significant differences at 95% level relative to variability of 300 members, present day wind shown as contours at 5m/s intervals, negative dashed).

North Atlantic Oscillation (NAO)

- Significant Negative NAO response for pan-Arctic and Barents/Kara Seas experiments

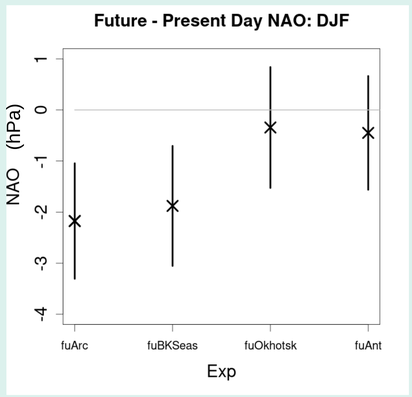

Figure 2b: Response to reduced sea ice for NAO index with 95% range from t-test (pressure difference Azores – Iceland in hPa).

3. Role of QBO in Met Office Model

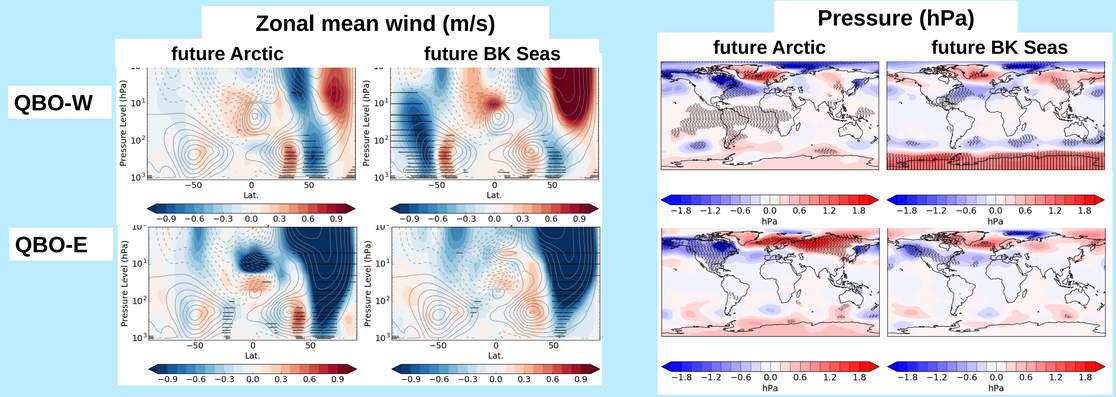

Figure 3: Response to reduced sea ice for alternative QBO phase, winter QBO-Westerly (+) or QBO-Easterly (-): future minus present day (as Fig 1 but 150 members).

Stratosphere: Weakening of winds throughout Arctic for QBO-E, no significant response for QBO-W

- Relates to increased upward wave activity as in Labe et al, (2019)

Troposphere: fuArc → Neg. NAO response for QBO-W; more extensive for QBO-E, less like NAO

Opposite hemisphere response? BK Seas → Significant Antarctic response in u-wind & pressure for QBO-W but not QBO-E ?

- May relate to QBO-W shifting zero-wind line into southern hemisphere (O'Sullivan and Salby,1990) ?

4. Conclusions

- Response to reduced Arctic Sea Ice in Met Office model adds further evidence of
  - an equatorward shift of the tropospheric jet
  - a shift towards negative phase of North Atlantic Oscillation
- Response to reduced Arctic Sea Ice is somewhat dominated by Barents/Kara Seas
- Stratospheric response is much stronger for QBO-E experiments
- Multi-model analysis planned to further understand mechanisms of response

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Labe et al, 2019, GRL, The Effect of QBO Phase on the Atmospheric Response to Projected Arctic Sea Ice Loss in Early Winter
O'Sullivan and Salby, 1990, J. Atmos. Sci, Coupling of the Quasi-biennial Oscillation and the Extratropical Circulation in the Stratosphere through Planetary Wave Transport.
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