Tropical and high latitude forcing of the NAO

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Themes and motivation of the workshop

- …large-scale atmospheric circulation over the North Atlantic Arctic sector is impacted by SST variations in the North Atlantic and over the tropics, but also by arctic sea ice and Eurasian snow cover. Controversy exists, however, on the relative importance of these various factors …

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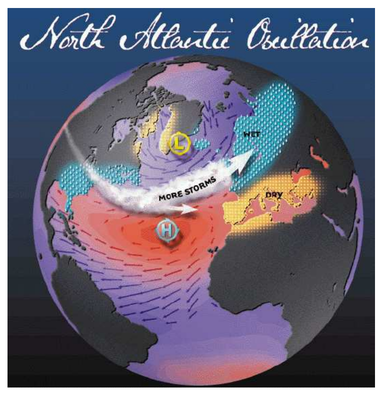
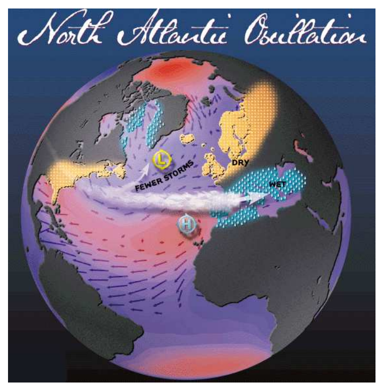
North Atlantic Oscillation (NAO)

positive NAO



negative NAO



NAO is the dominant mode of winter climate variability in the North Atlantic region. The NAO is a large scale seesaw in atmospheric mass between the subtropical high and the polar low.

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North Atlantic SST forcing of the NAO

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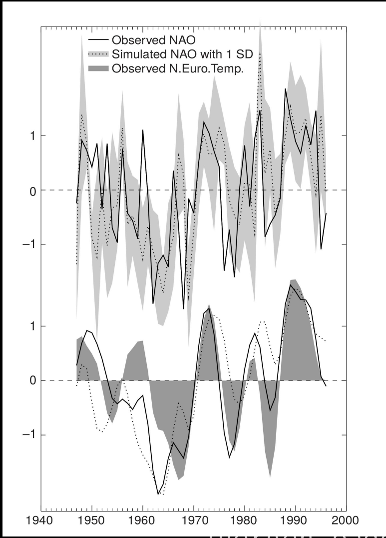
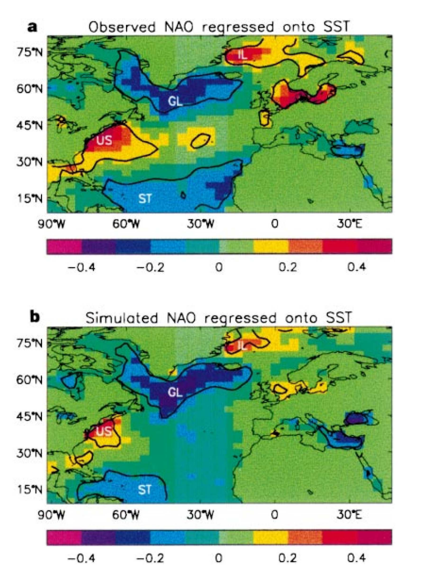
Oceanic forcing of the NAO



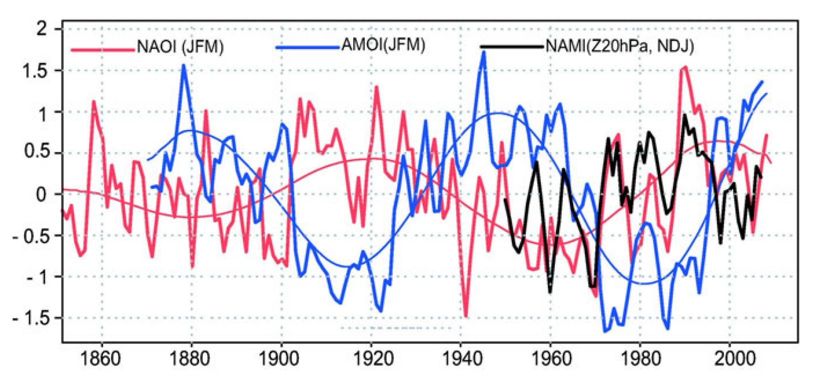
Rodwell, Rowell, and Folland; Nature 1999

North Atlantic Tripole pattern



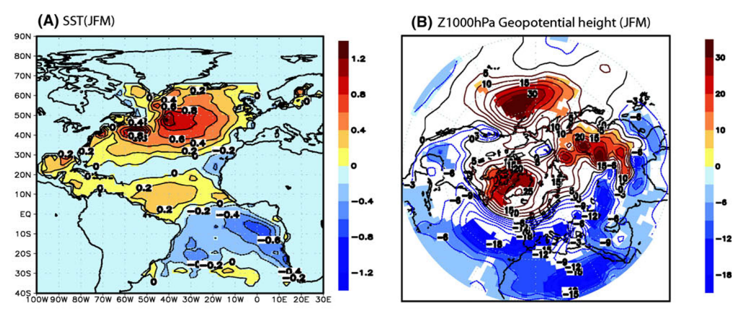
Rodwell, Rowell, and Folland; Nature 1999

Out-of-phase relationship between observed AMO and NAO



Omrani, Keenlyside, Bader and Manzini; Climate Dynamics 2014

Out-of-phase relationship between observed AMO and NAO



Omrani, Keenlyside, Bader and Manzini; Climate Dynamics 2014

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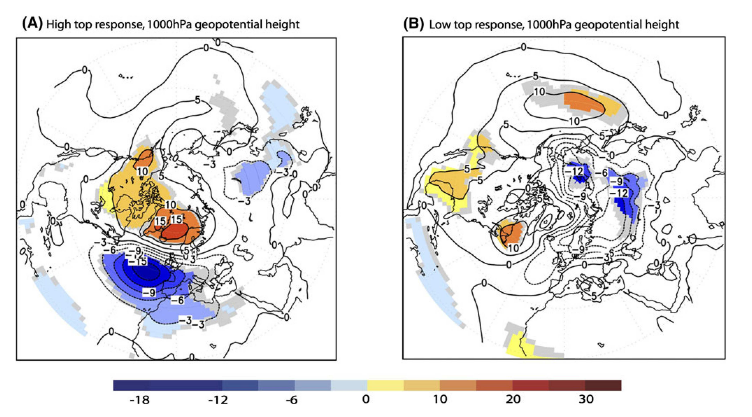
Stratosphere important for AMO impact on NAO



Omrani, Keenlyside, Bader and Manzini; Climate Dynamics 2014

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Tropical SST forcing of the NAO

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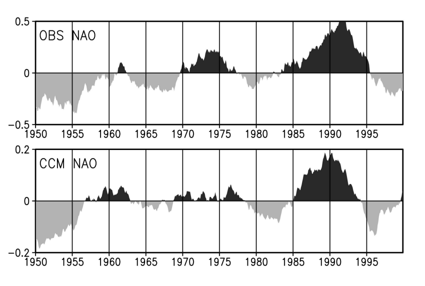
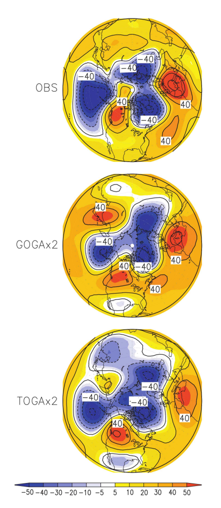
Tropical Origin of recent NAO trend



Hoerling, Hurrell, and Xu;
Science 2001

Tropical warming origin of recent NAO trend



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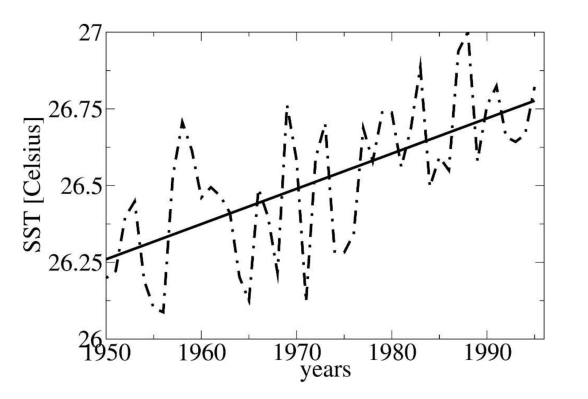
Indian Ocean warming



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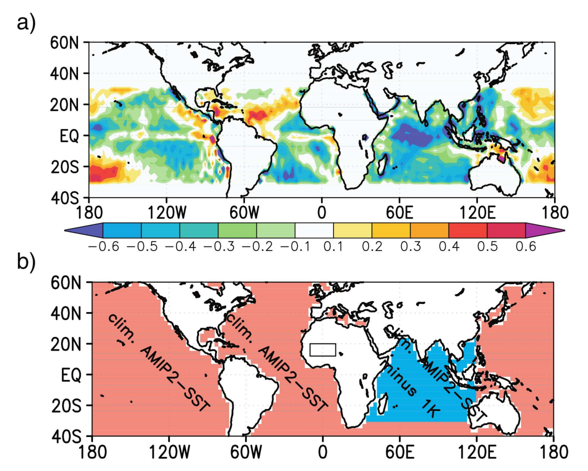
Indian Ocean warming



Bader and Latif 2003

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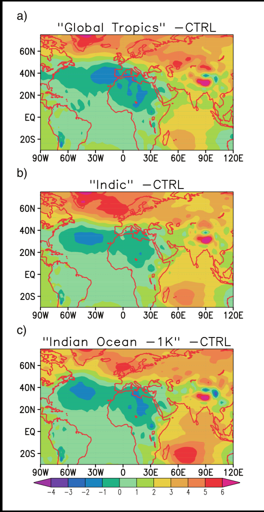
Indian Ocean warming forces recent NAO trend



Bader and Latif 2003

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Arctic sea-ice forcing of the NAO

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Scientific Objectives

Impact of a projected future Arctic Sea Ice Reduction on the North Atlantic Strom Track and the NAO

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Sea Ice Experiments with ECHAM5

- AGCM ECHAM5
- Resolution: T42 ($2.8^\circ \times 2.8^\circ$) horizontal; 19 vertical levels
- Two experiments are performed:
  - A *"present-day"*-integration is forced by the current observed (1981-1999)
  - A *"future"* by a projected (2081-2099) seasonal cycle of Arctic sea ice

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Sea Ice Experiments with ECHAM5 II

more details:

- "present day" integration: SST and SIC are based on the HadISST 1.1 dataset; The computed seasonal cycle covers the period 1981-1999
- "future" integration: SIC is based on the ECHAM5/MPI-OM IPCC SRESA1B scenario output; seasonal SIC-cycle is computed from three ensemble members (2080-2099) SSTs have been replaced at grid point where sea ice has changed; Future SSTs are used at these points

$\Rightarrow$ only changes in Arctic SIC and SSTs!

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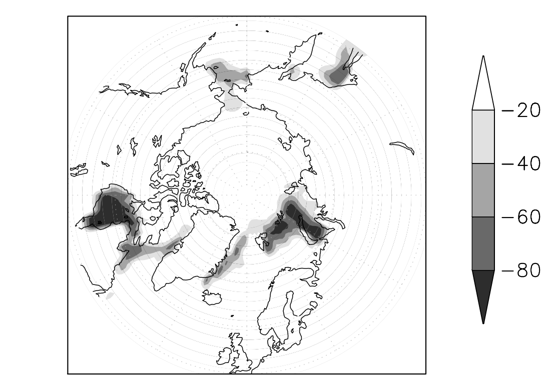
Sea-ice Reduction in January

"Future-" minus "Present-day-" Integration [in %]



Except over Hudson Bay, spatial pattern consistent throughout the winter season

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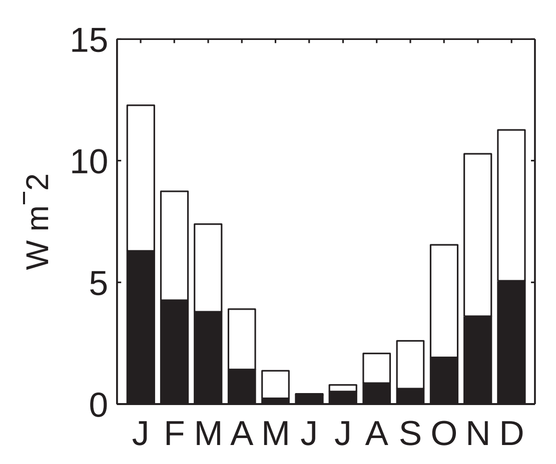
Latent and Sensible Heat-Flux Difference

averaged over ocean points between 55°N and 85°N [in Wm^{-2}]



largest response in heat-forcing in the winter season

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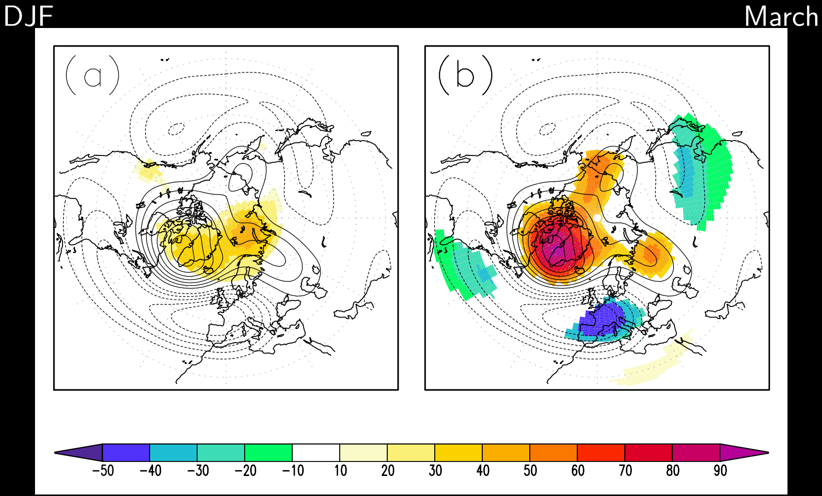
500 hPa Geopotential Height Response

[in gpm]



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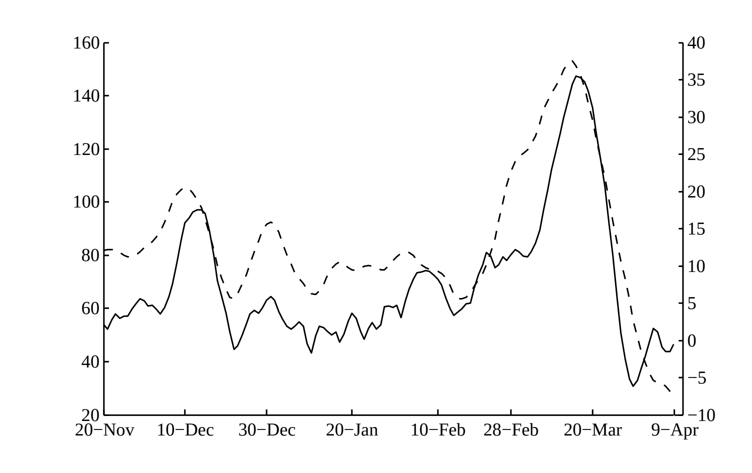
Reg. coeff. between 500hPa GPH Response and the NAO



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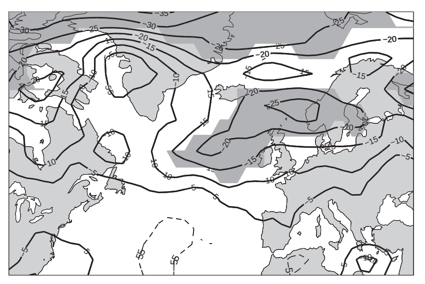
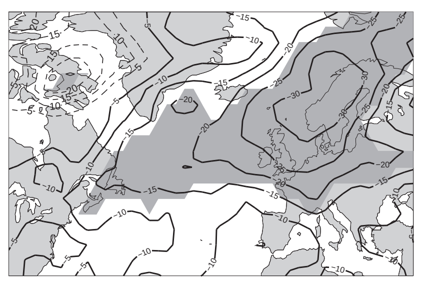
Storminess

Response in Eddy kinetic energy (2-8 day)

January



March



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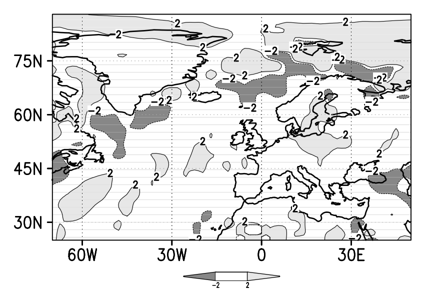
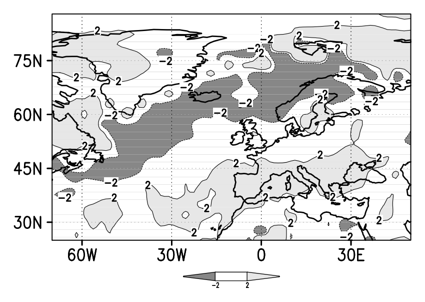
Precipitation Response

normalized

January



March



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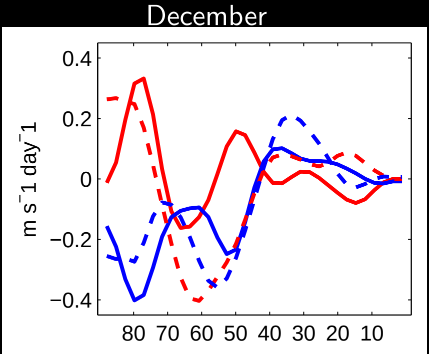
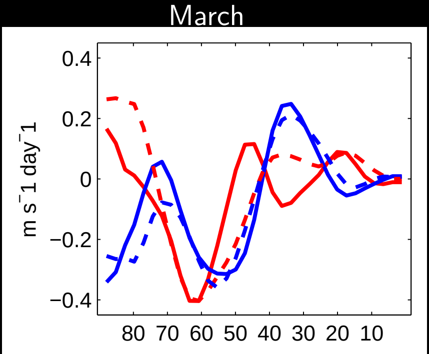
Forcing of the zonal mean zonal wind due to eddy momentum flux divergence

vertically averaged 700-100 hPa





- dashed lines: Response in eddy momentum flux divergence for a negative NAO-composite
- solid lines: Response in eddy momentum flux divergence

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Summary and Conclusions

- north Atlantic Ocean warming induces a negative NAO-phase
- stratosphere resolving AGCMs might be better for SST-sensitivity studies
- tropical ocean warming seems to induce a positive NAO-phase
- Arctic sea-ice reduction (Arctic warming) triggers a negative NAO
- $\rightarrow$ there seem to be competing mechanisms
- $\rightarrow$ What are the individual contributions from the different forcing regions?

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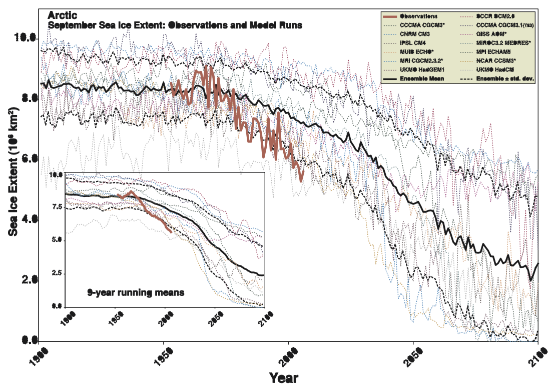
Observed and Simulated Sea ice Change



Stroeve et al. 2007, GRL: Observed Sea Ice Change faster than simulated

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Thank you very much for your attention!

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