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Impact of a projected future arctic sea ice reduction on the NAO and Rossby wave breaking

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Impact of a Projected Future Arctic Sea Ice Reduction on Extratropical Storminess and the NAO

Jürgen Bader and Ivar Seierstad

Bjerknes Centre for Climate Research, Bergen, Norway

ICTP, Trieste, November 20, 2008

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Outline

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Impact of a Projected Future Arctic Sea Ice Reduction on Extratropical Storminess and the NAO

Ivar Seierstad and Jürgen Bader, Climate Dynamics 2008

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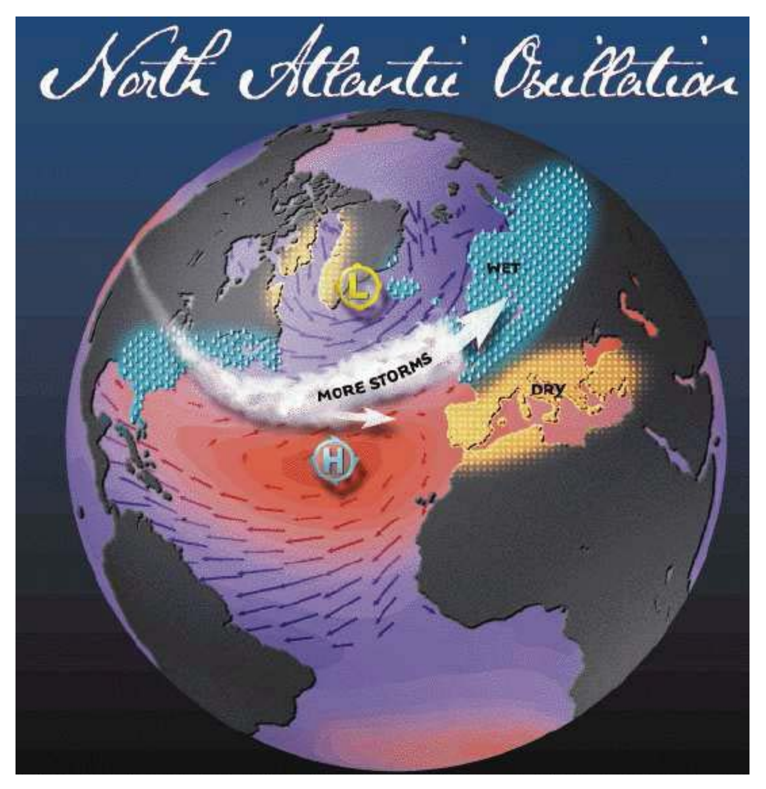
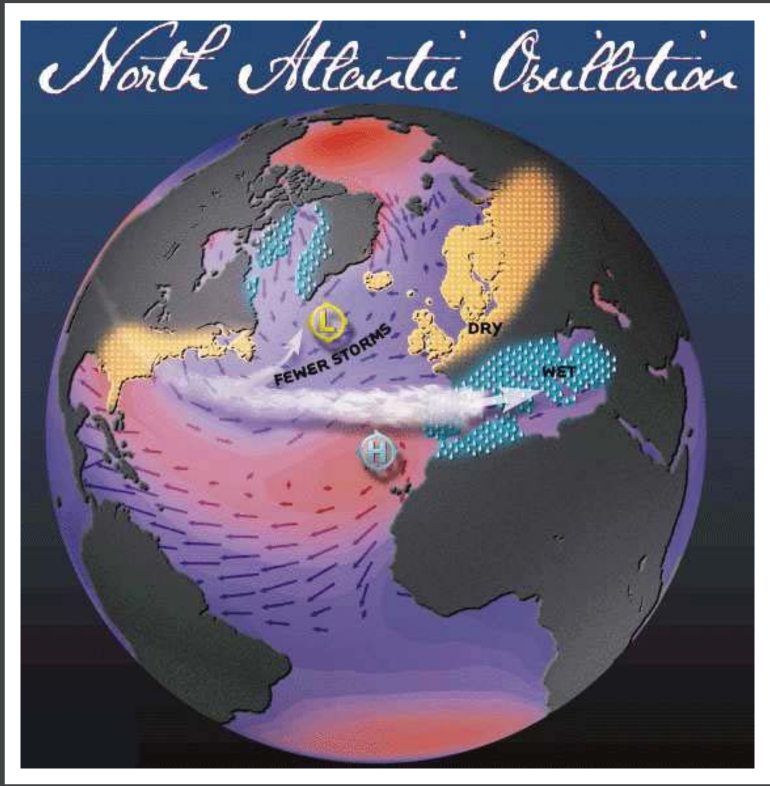
North Atlantic Oscillation (NAO)

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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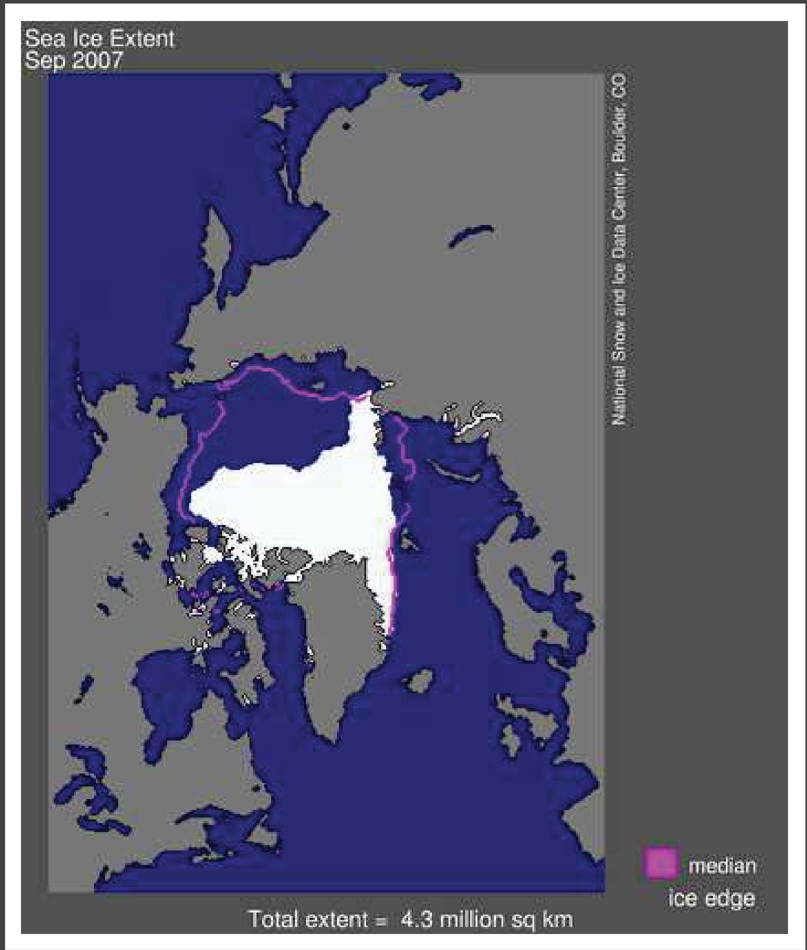
Observed Sea-ice Extent September 2007



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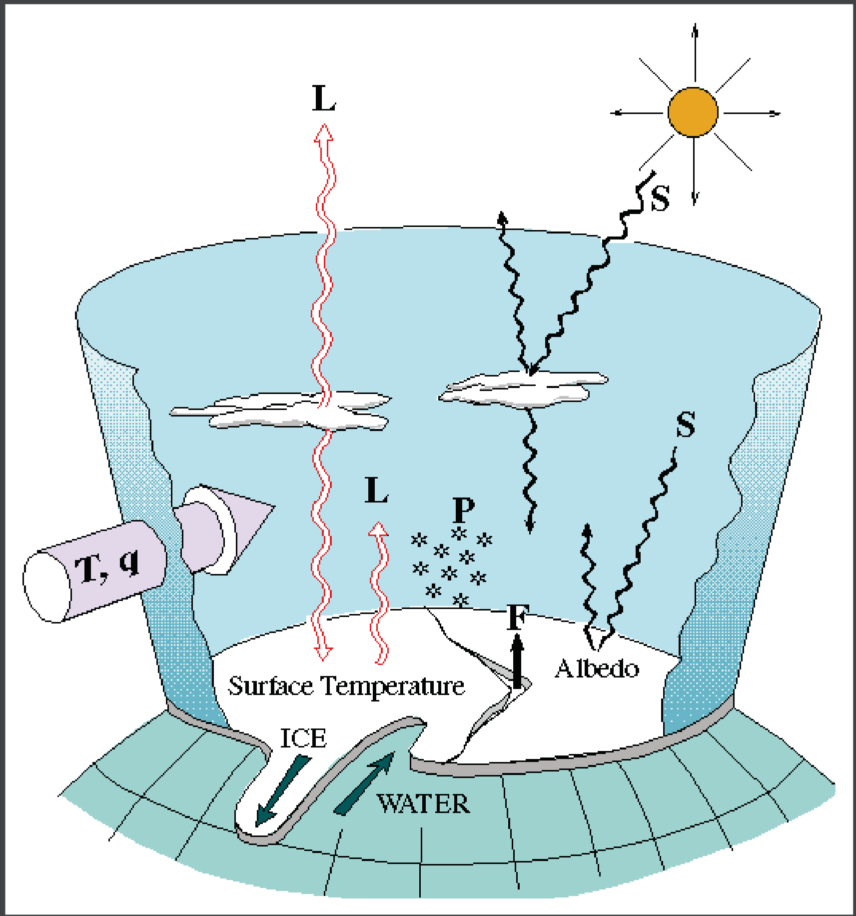
Sketch



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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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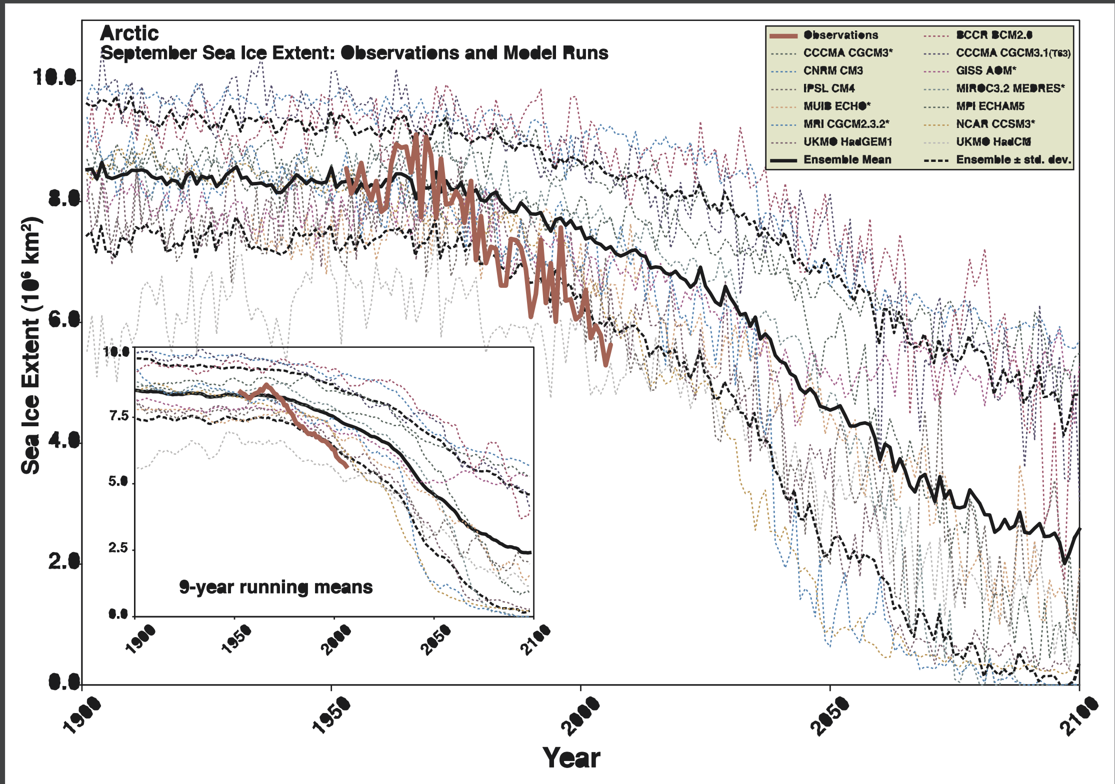
Observed and Simulated Sea ice Change



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

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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 were sea ice occurs; Future SSTs are used at these points

⇒ only changes in Arctic SIC and SSTs!

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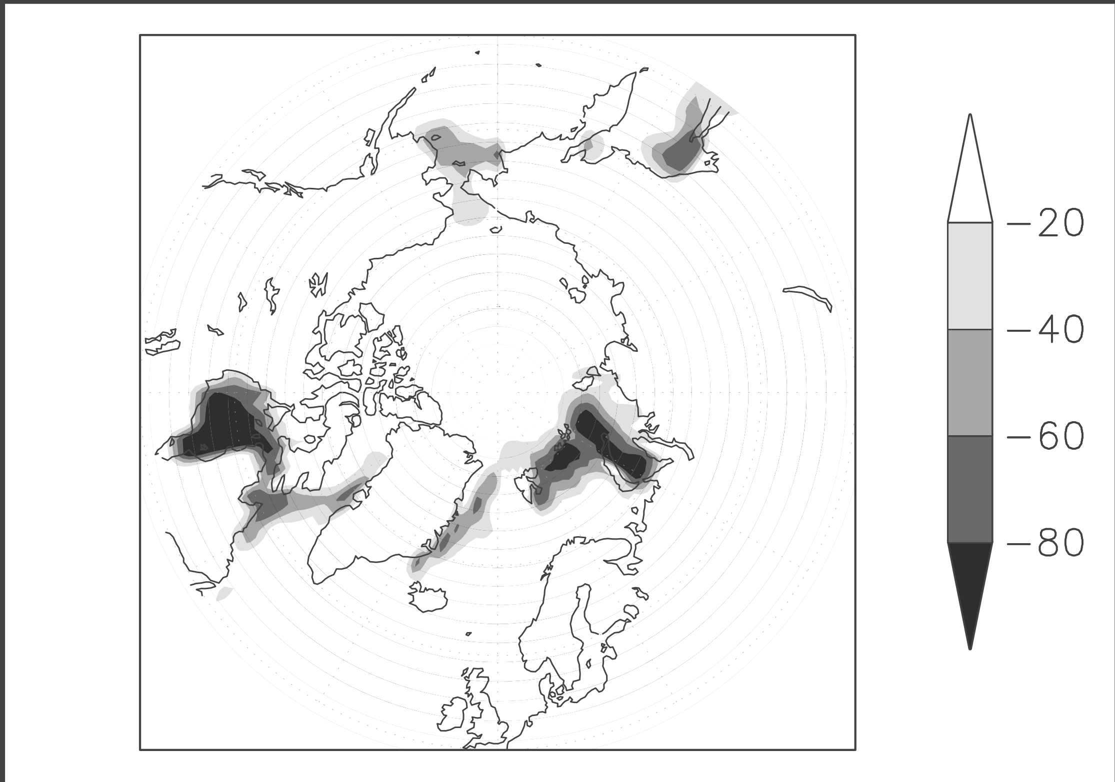
Sea-ice Reduction in January

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



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

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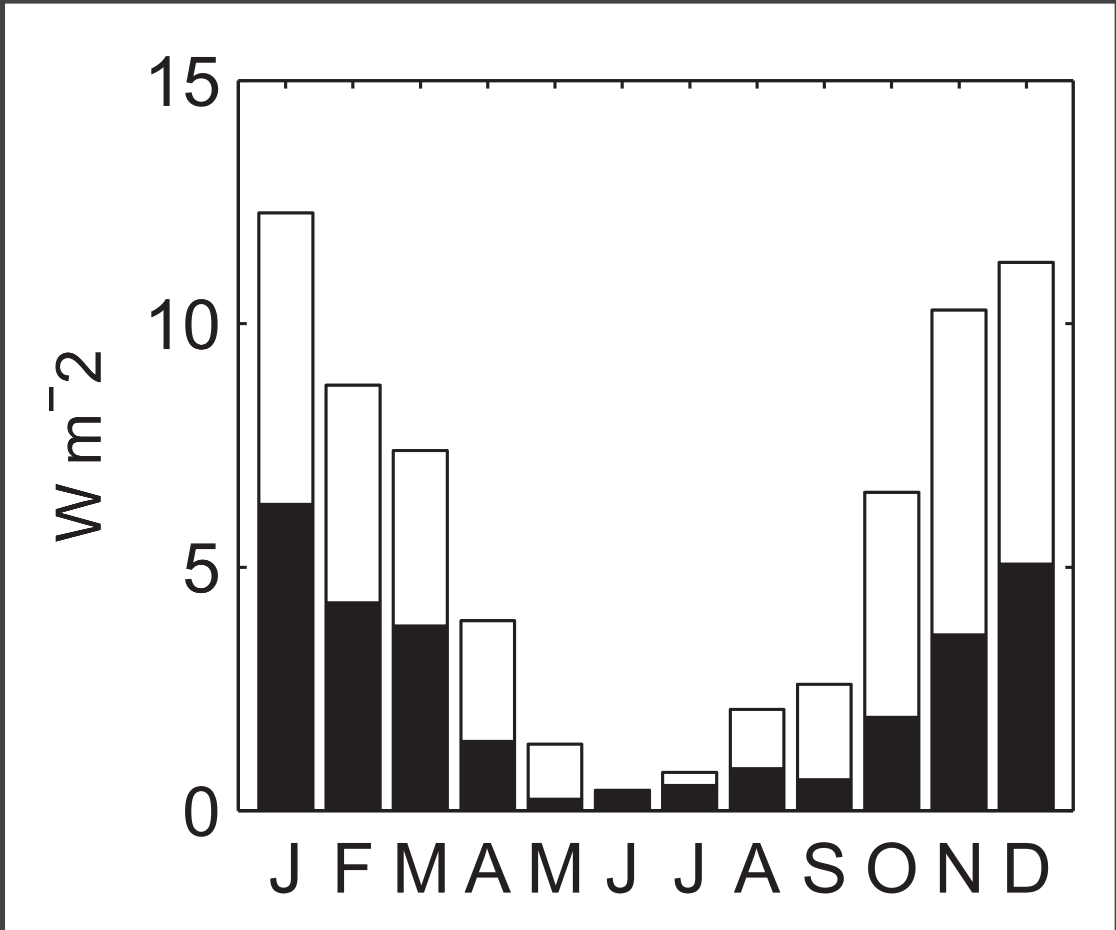
Latent and Sensible Heat-Flux Difference

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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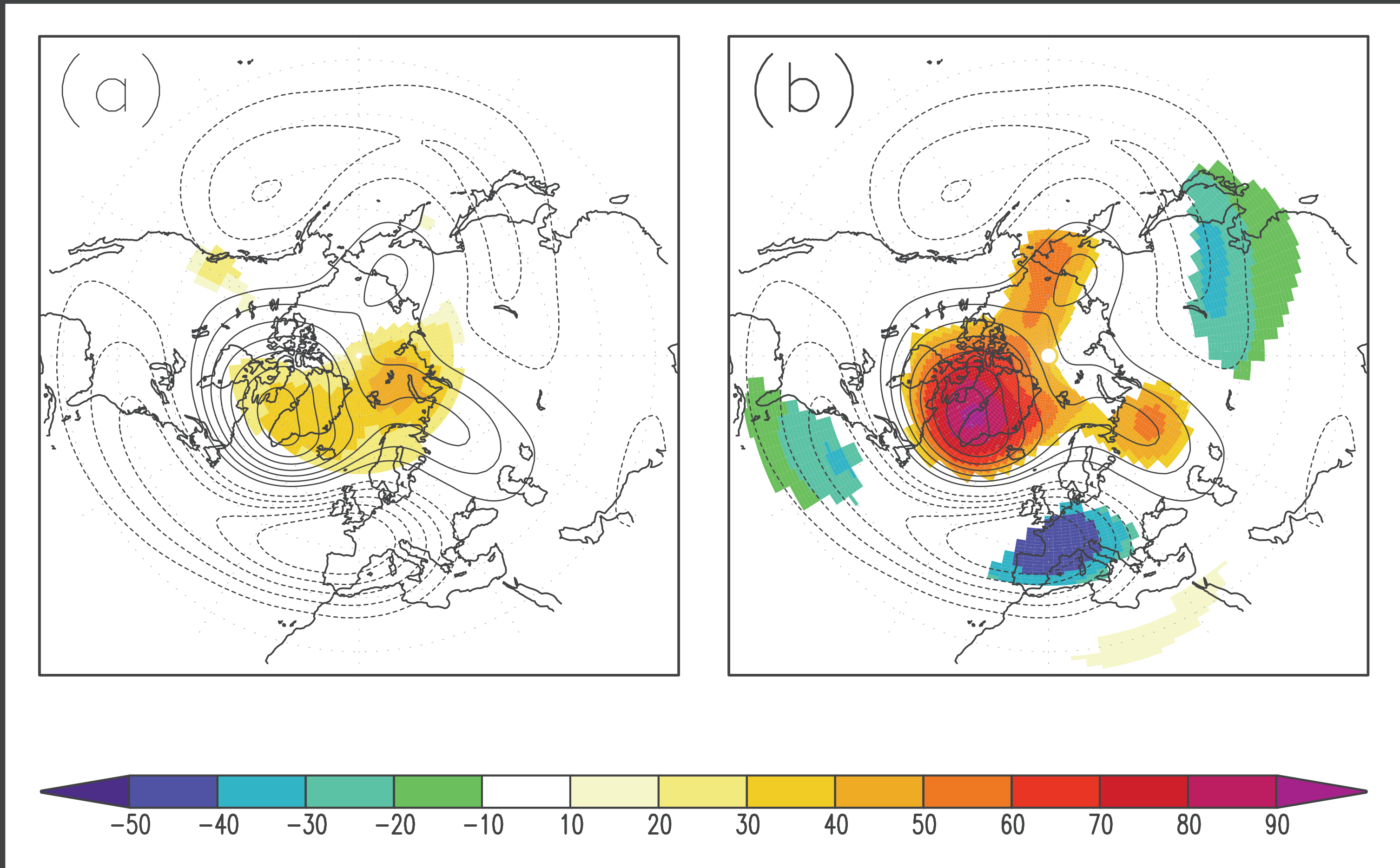
500 hPa Geopotential Height Response

[in gpm]

DJF March



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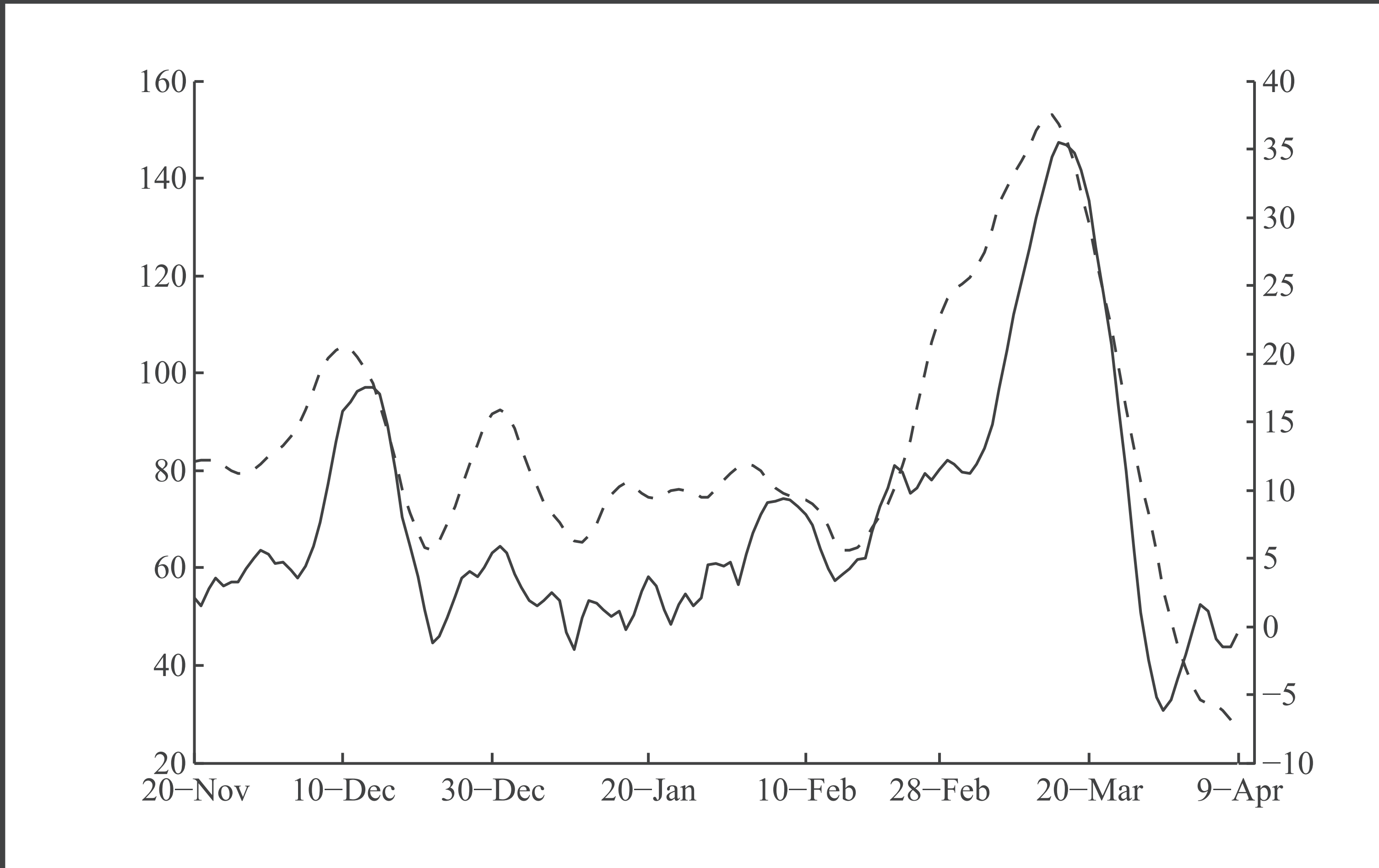
Reg. coeff. between 500hPa GPH Response and the NAO



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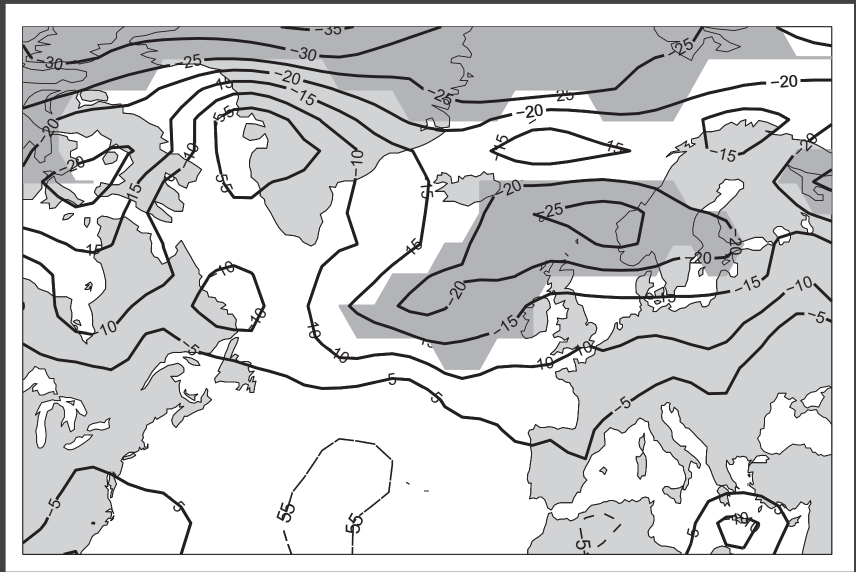
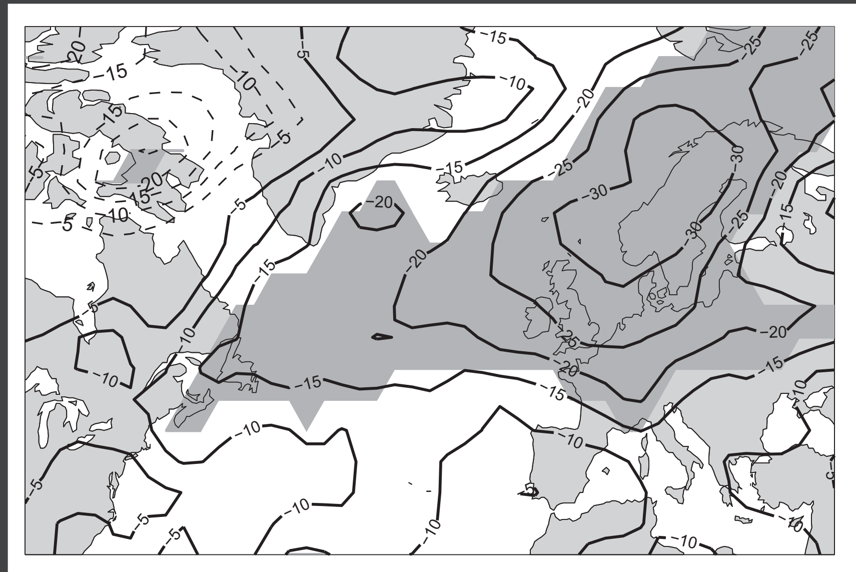
Storminess

Response in Eddy kinetic energy (2-8 day)

January



March



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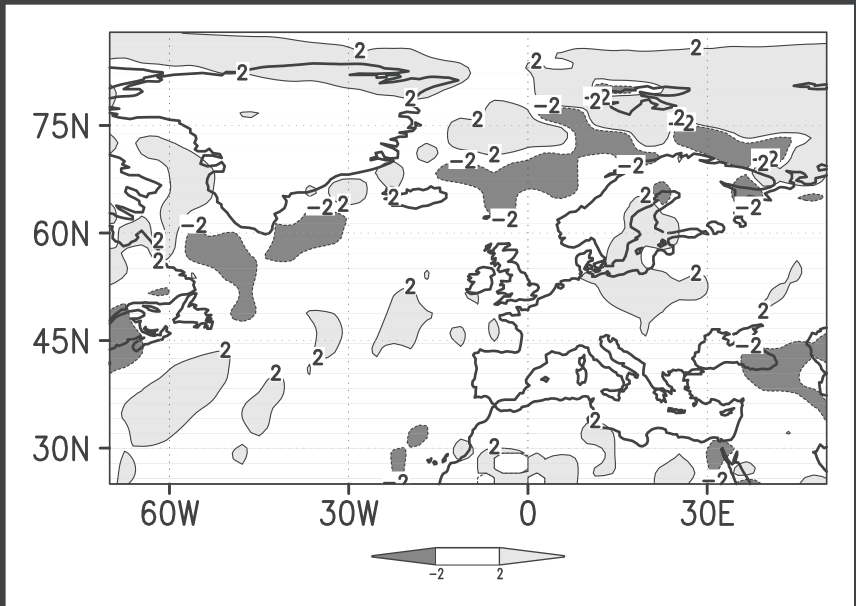
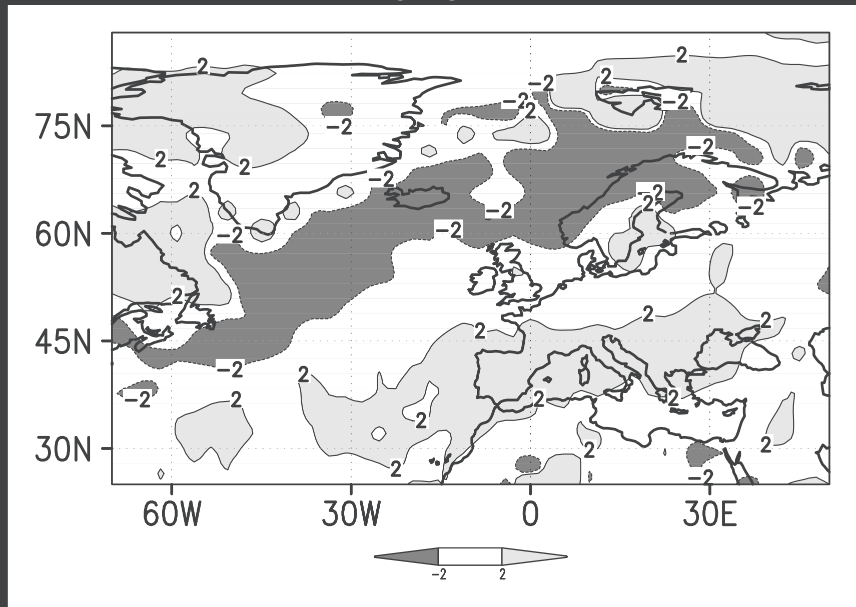
Precipitation Response

normalized

January



March



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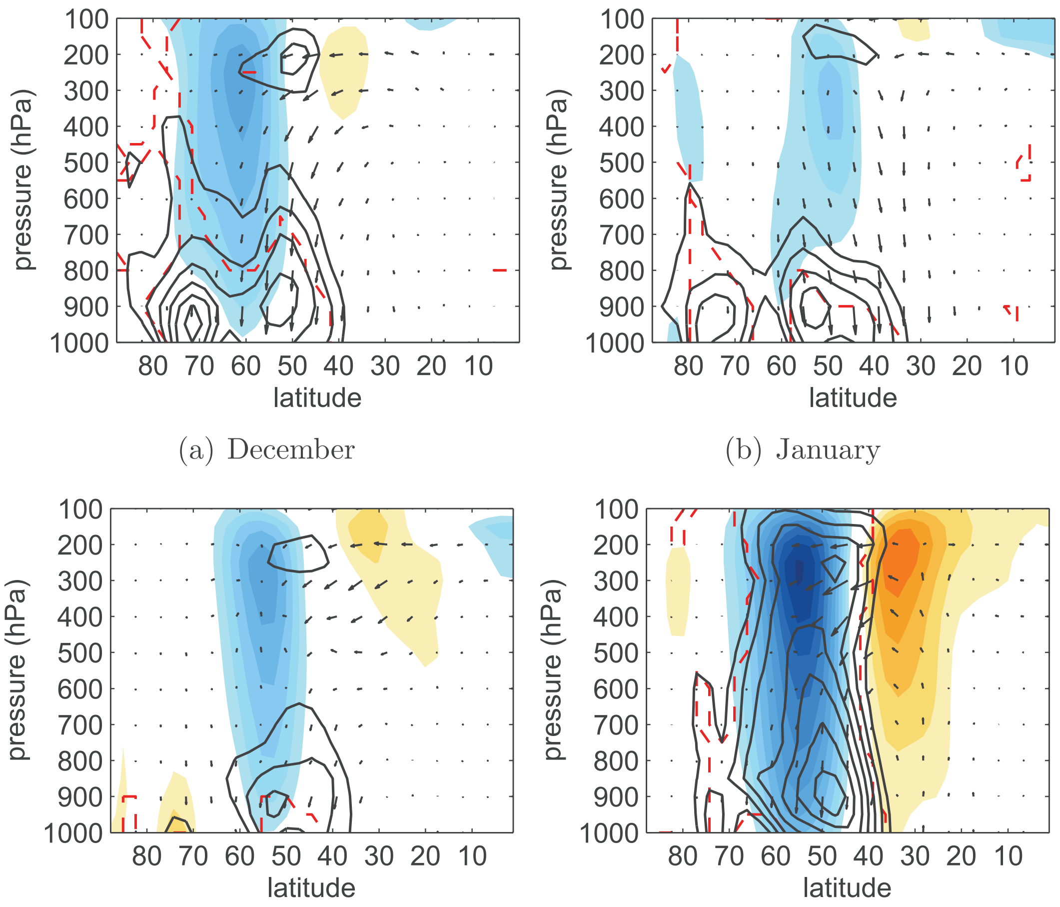
Response in: Zonal mean zonal wind, Storminess, EP-flux



(a) December (b) January

(c) February (d) March

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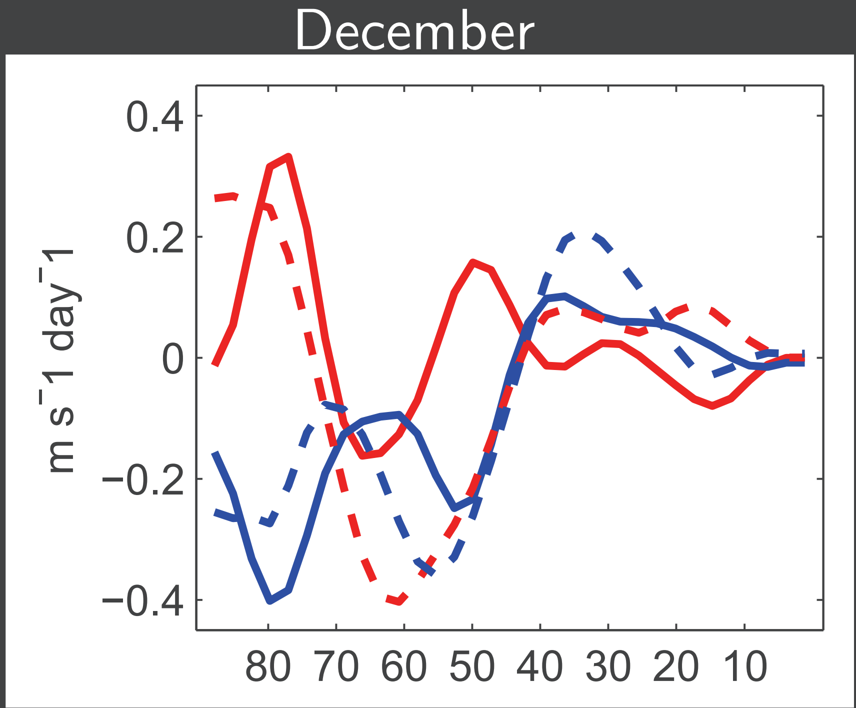
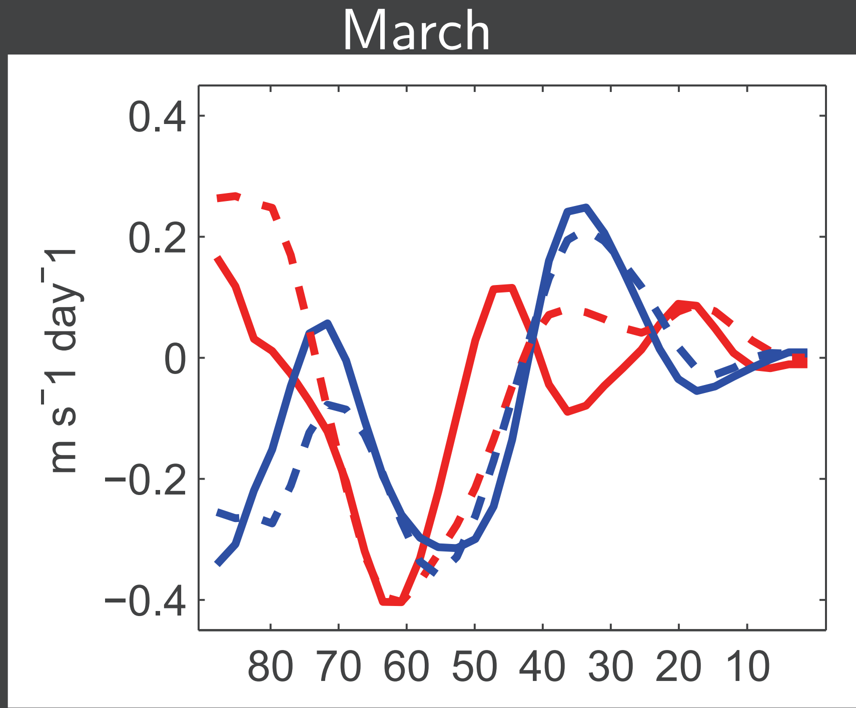
Forcing of the zonal mean zonal wind due to eddy momentum flux divergence

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

- removal of sea-ice reduces storminess locally but not much at midlatitudes in DJF
- large reduction in midlatitude storminess
- response strongly projects on the negative phase of the NAO
- consistent with a forcing from transient and quasi-stationary eddies associated with negative NAO events
- important large scale influence of sea-ice anomalies depend on their ability to trigger the negative phase of the NAO
- background state can result in qualitatively different atmospheric responses
- At this stage it is not clear why the NAO is much more sensitive in March.

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Thank you very much for your attention!

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