



Climate change and extratropical storms

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Extratropical cyclones: extreme winds and rainfall



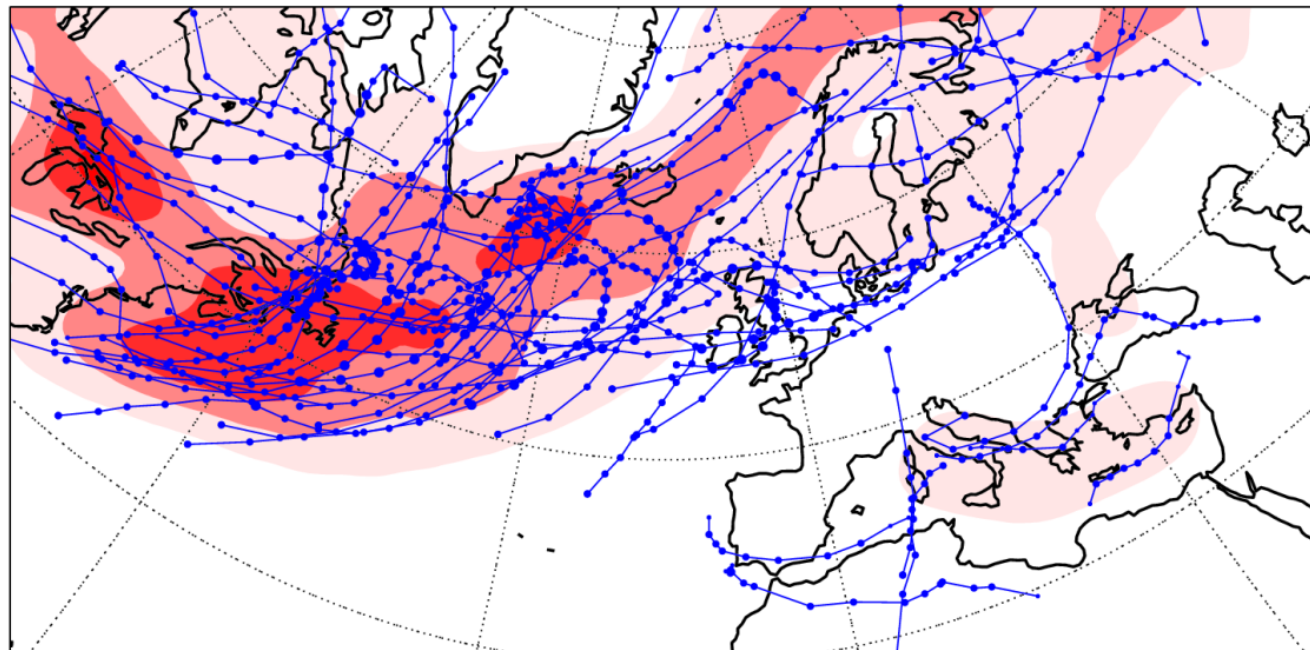
Jan 2017 Windstorm Egon: €212M losses



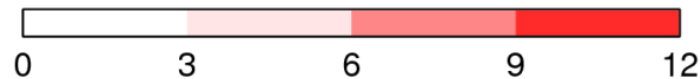
July 2007 Tewkesbury flood: €3B loss

How will climate change affect extratropical cyclones?

Observed Cyclones Tracks

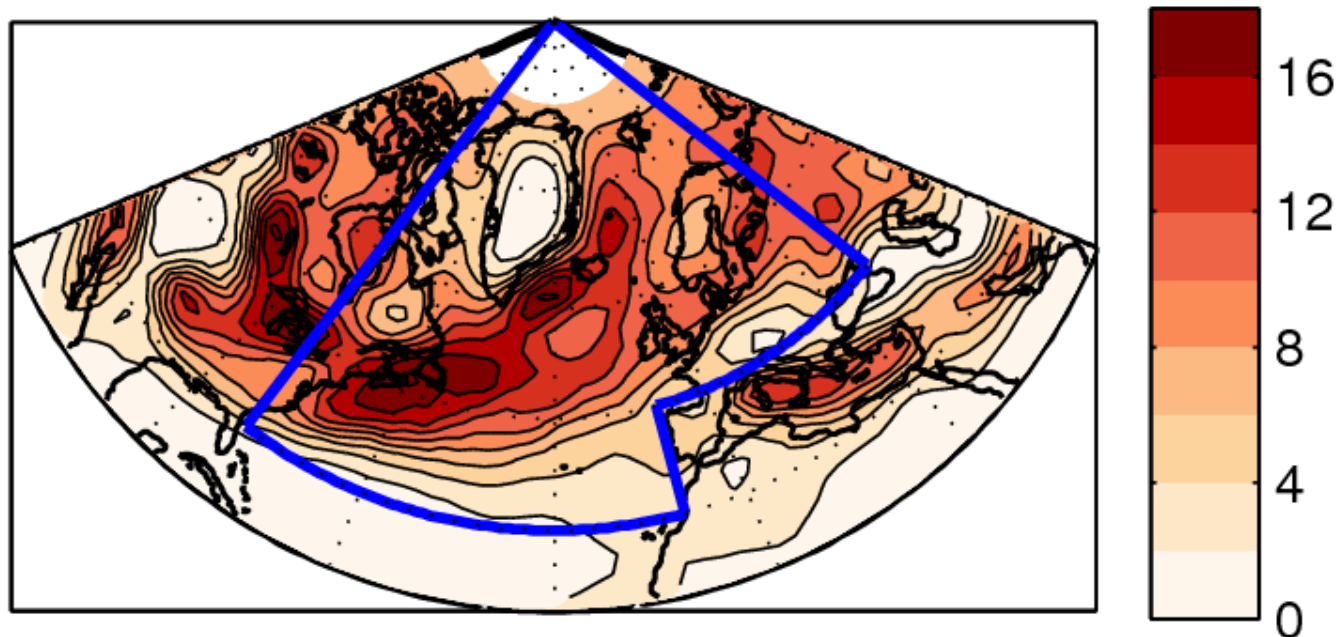


Track Density (tracks per month) from Climatology



Cyclone tracks for 1979-1980 using 6-hourly
850hPa vorticity for Hodges (1995) algorithm

djf track density



DJF ERA-Interim wintertime cyclone track
density (1990-2009)
(Tracks per month in a 5° radius)

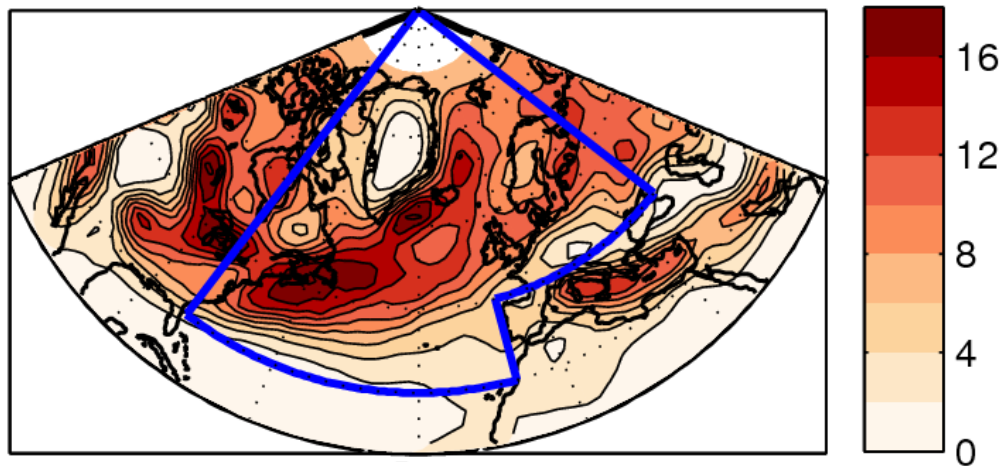


How well do climate models represent extratropical cyclones?

How are extratropical cyclones projected to change in climate models?

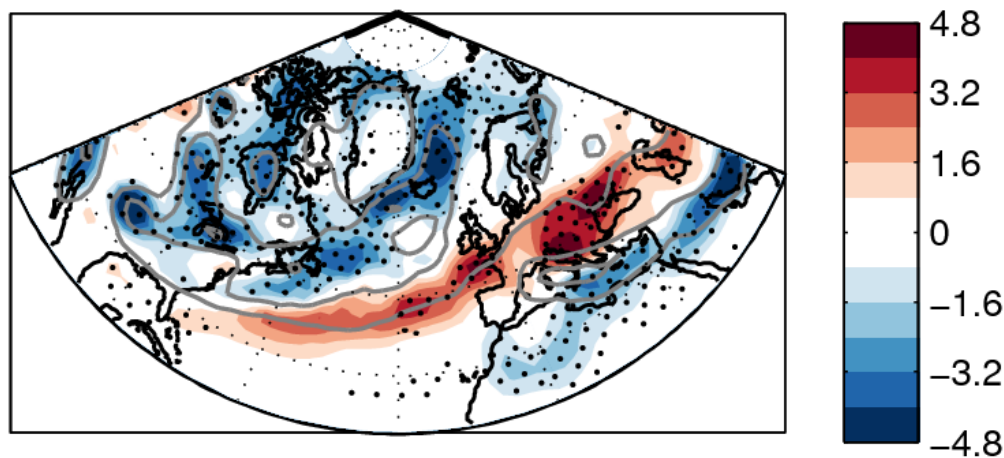
Compare the results from 22 climate models from the Fifth Coupled Model Intercomparison Project (CMIP5)

djf track density



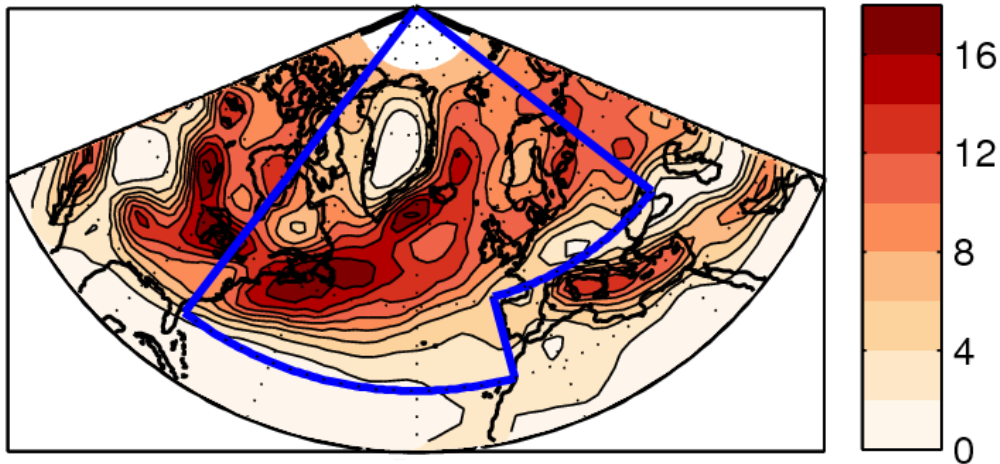
DJF ERA-Interim wintertime
cyclone track density (1990-2009)
(Tracks per month in a 5° radius)

djf track density



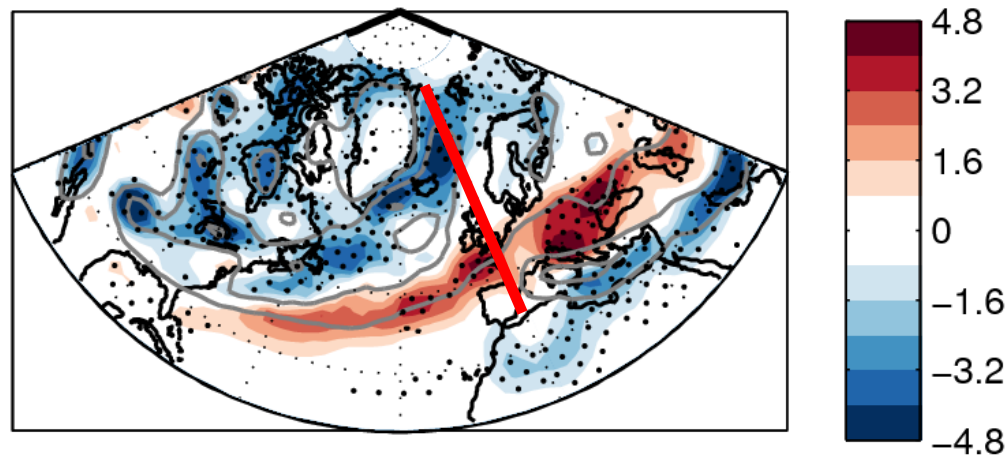
DJF CMIP5 historical model
mean biases against ERA-
Interim from 22 CMIP5 models

djf track density



DJF ERA-Interim wintertime
cyclone track density (1990-2009)
(Tracks per month in a 5° radius)

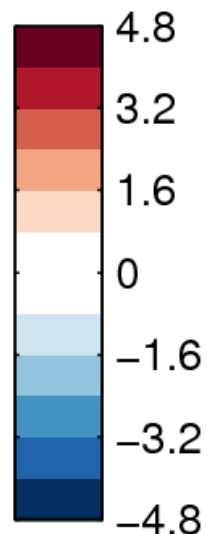
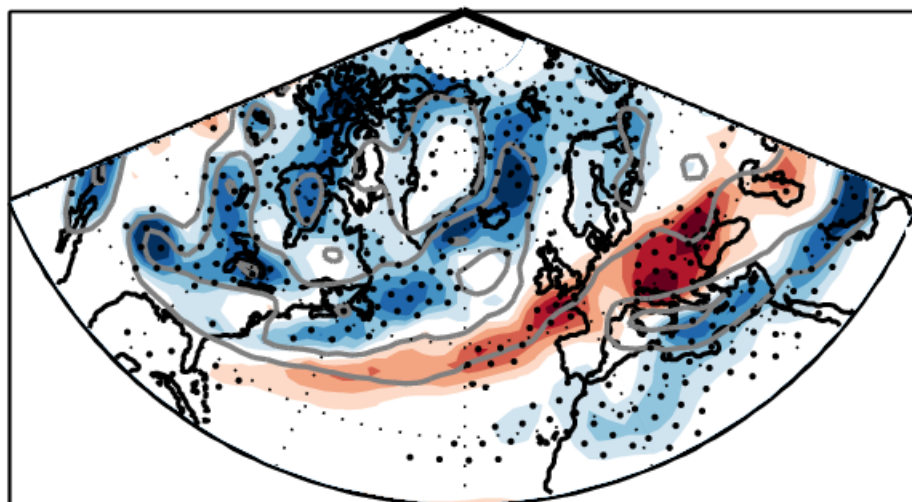
djf track density



DJF CMIP5 historical model
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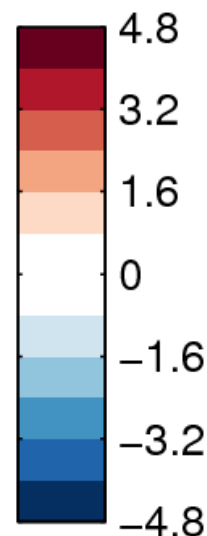
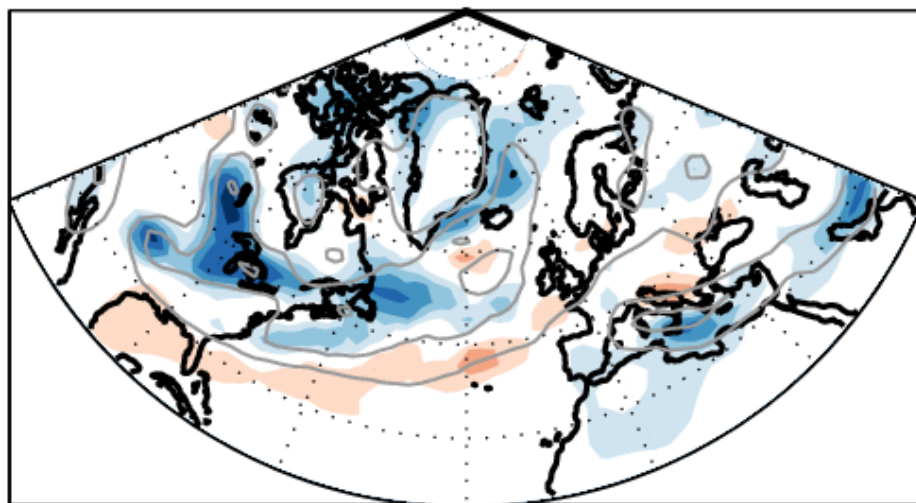
The latitude of the North
Atlantic storm track agreed
with ERA-Interim in 4 models

djf track density



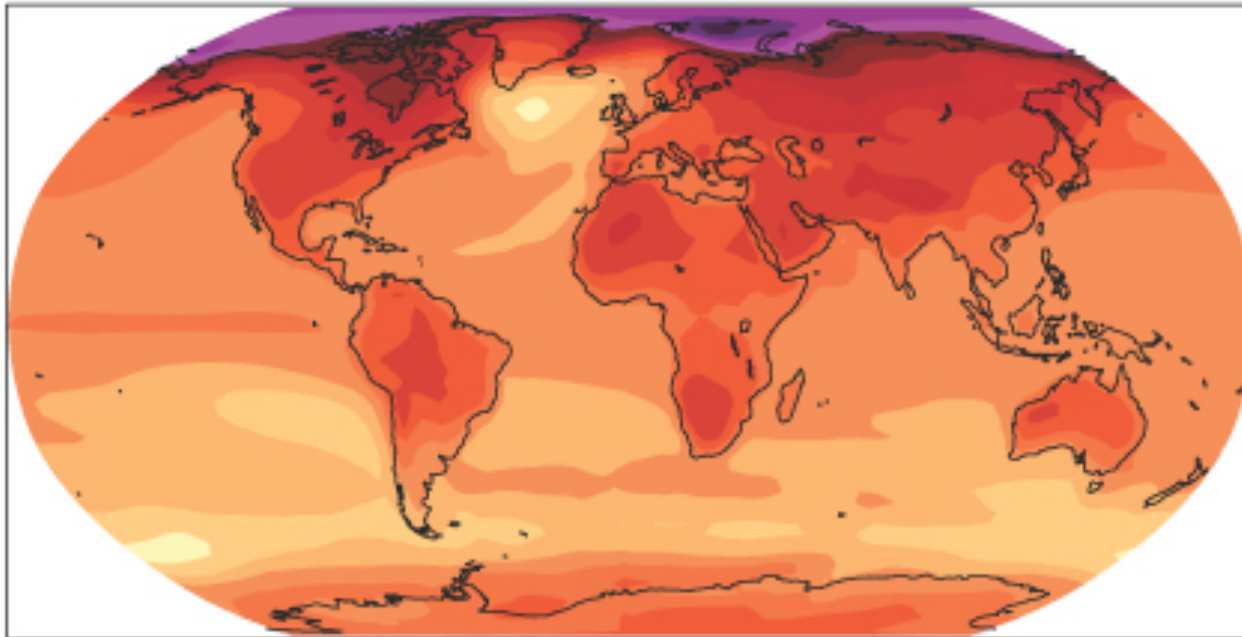
DJF CMIP5 present day model biases
against ERA-Interim: Cyclone Track
density

tden Small errors



DJF CMIP5 present day model biases
against ERA-Interim for 4 models with
smallest biases

A1B: 2080-2099

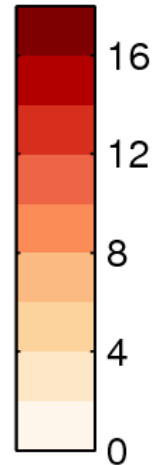
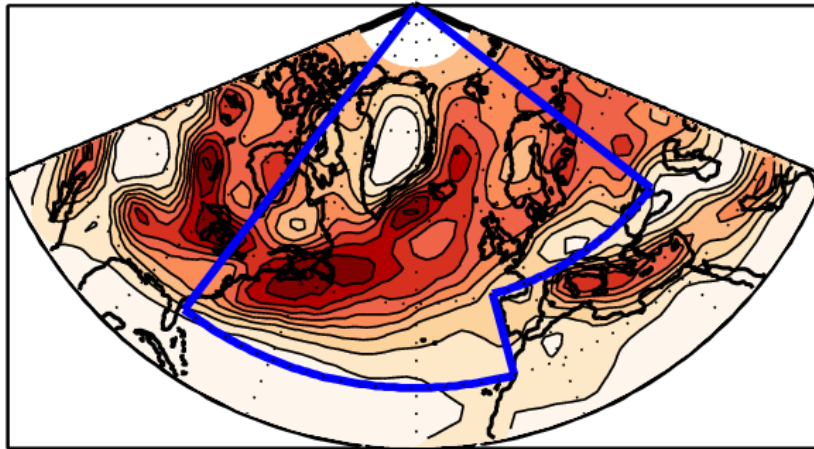


CMIP3 mean surface temperature differences for 2080-2099 minus 1980-1999 (IPCC AR4, 2007)

Reduced Equator to Pole temperature difference –
less extratropical cyclones

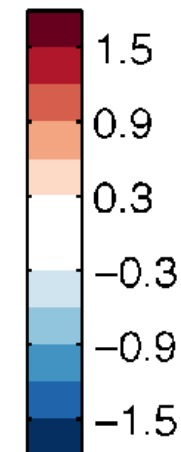
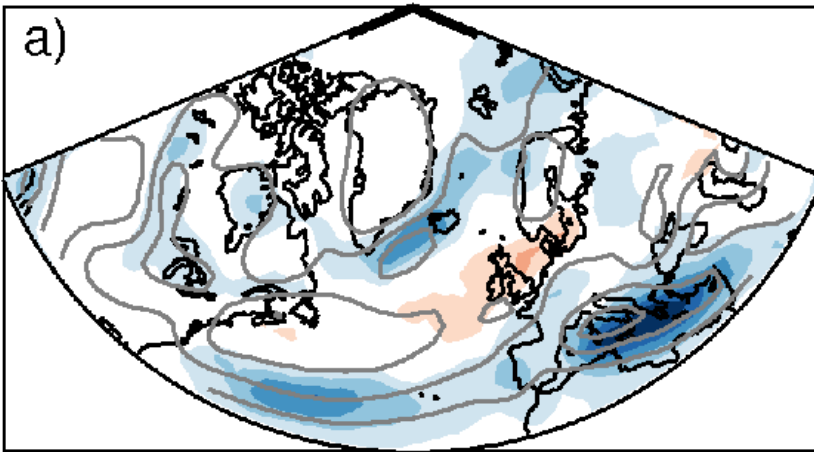
Mitigated warming in the North Atlantic Ocean

djf track density



ERA-Interim wintertime cyclone track density (1990-2009)

track density

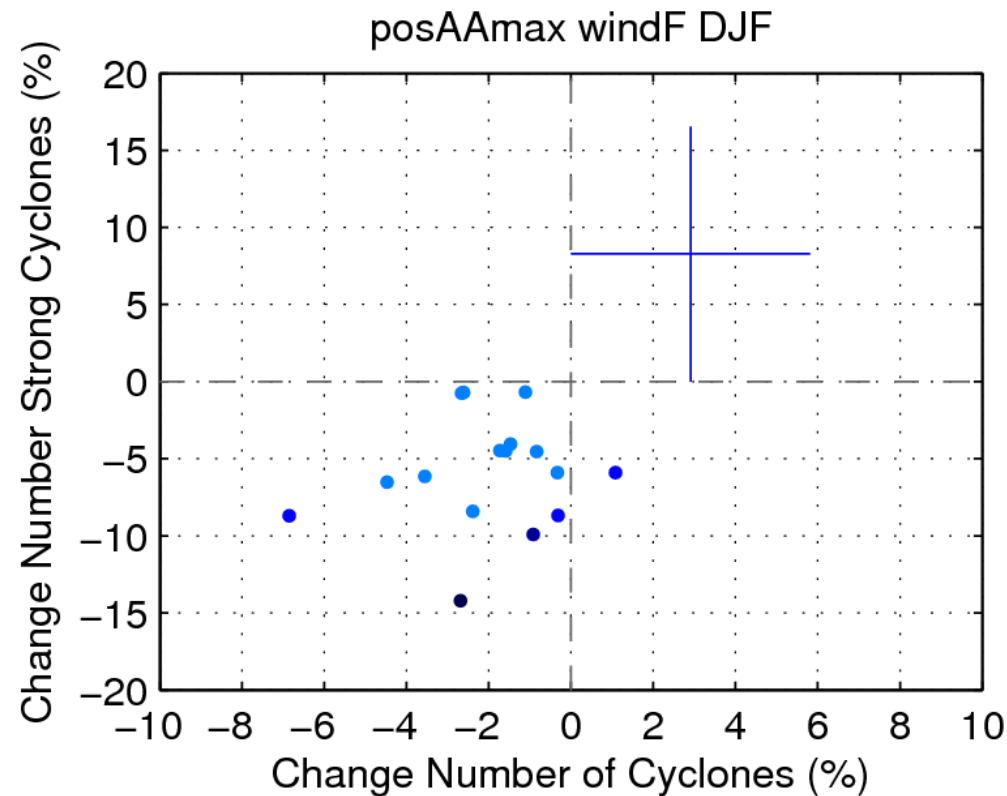


CMIP5 cyclone track density: RCP4.5
Scenario (2070-2100) minus
Historical (1980-2005)

Fewer Scandinavian and
Mediterranean cyclones



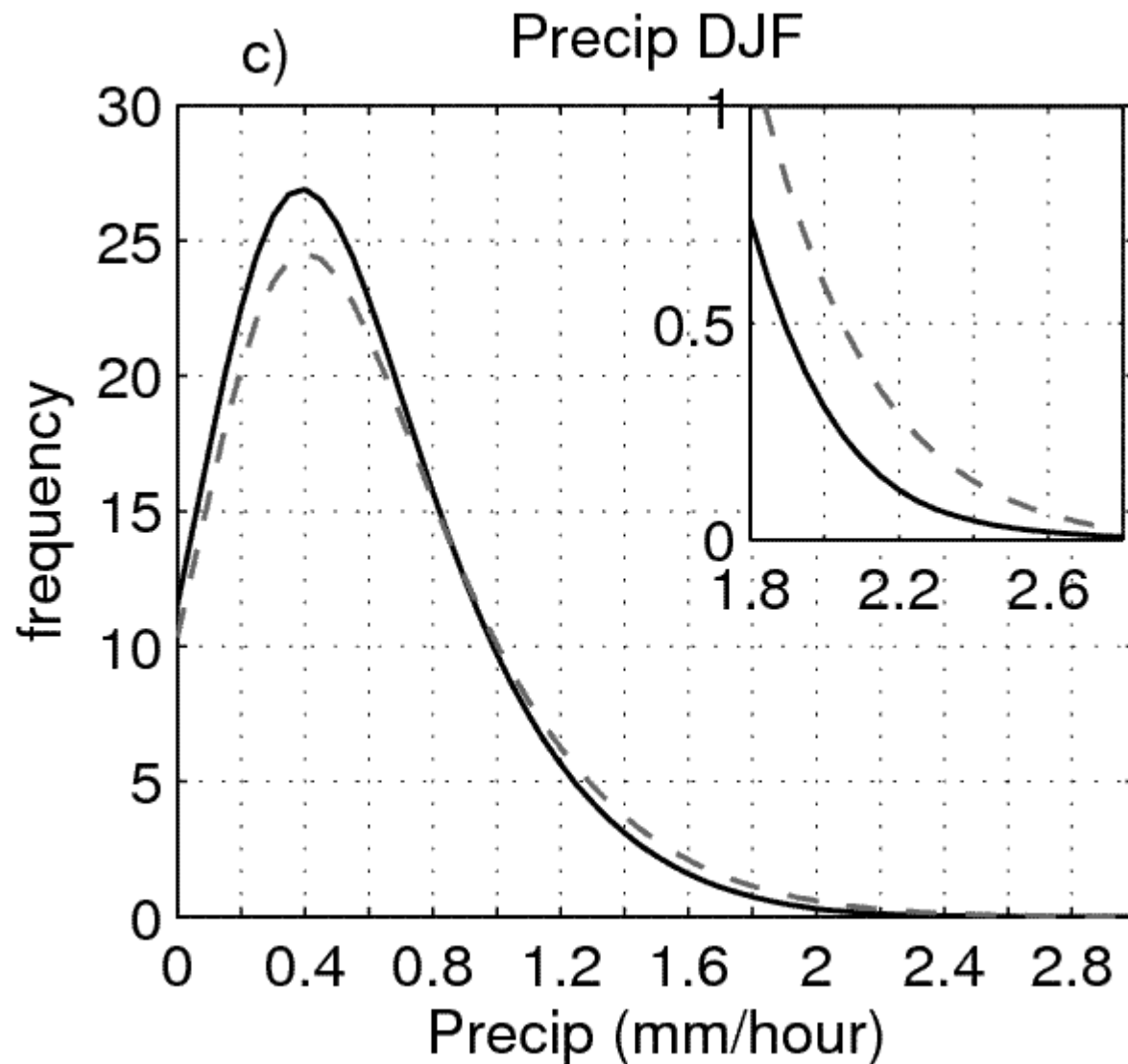
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NATURAL ENVIRONMENT RESEARCH COUNCIL



CMIP5 RCP4.5 North Atlantic DJF and JJA Change in Total Cyclone Number (2070-2100 minus 2005-1980) versus Change in Number of Strong Cyclones

Zappa *et al.* 2013b, *J. Climate*.

Increase in heavy precipitation



Increases in strongly
precipitating North Atlantic
cyclones

26% increase in number of
North Atlantic cyclone with
90th percentile present-day
precipitation rates
(18% increase for Europe)

1975-2005

2070-2100



Jan 2007 Windstorm Kyrill: €6B loss

- Fewer Mediterranean and Scandinavian cyclones, slight increase in cyclones over NW Europe
- North Atlantic cyclones don't become more intense, however there is an increase in heavily precipitating cyclones

- Some CMIP5 climate models have substantial biases, with higher resolution models tending to have smaller biases
- Large spread in CMIP5 projections associated with uncertainty in Arctic sea ice projections and (to a lesser extent ocean circulation)

- Improving climate model projections critical for informing climate adaptation and to provide trustworthy Climate Services e.g. for insurance (C3S WISC project), energy and forestry sectors

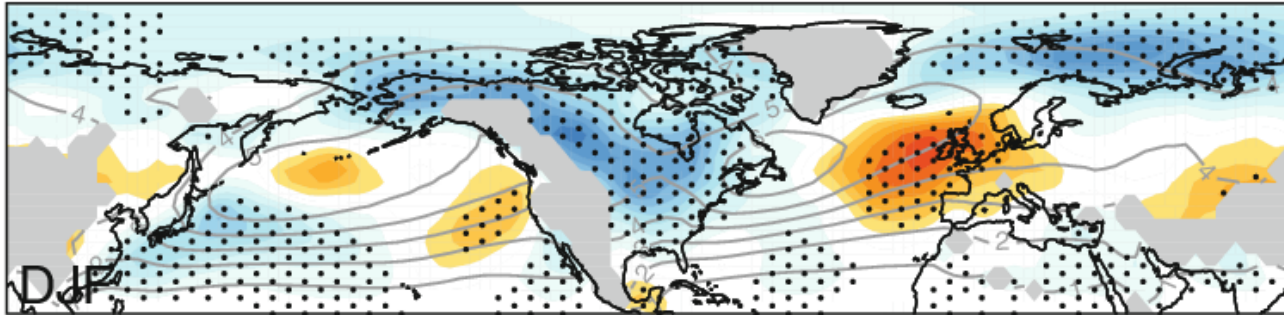


Storm Gudrun, Jan 2005
200 million trees felled

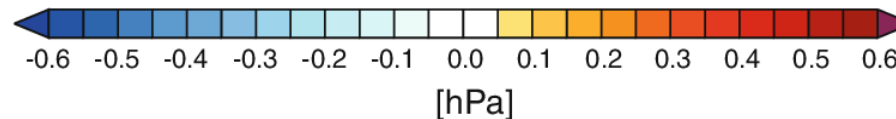
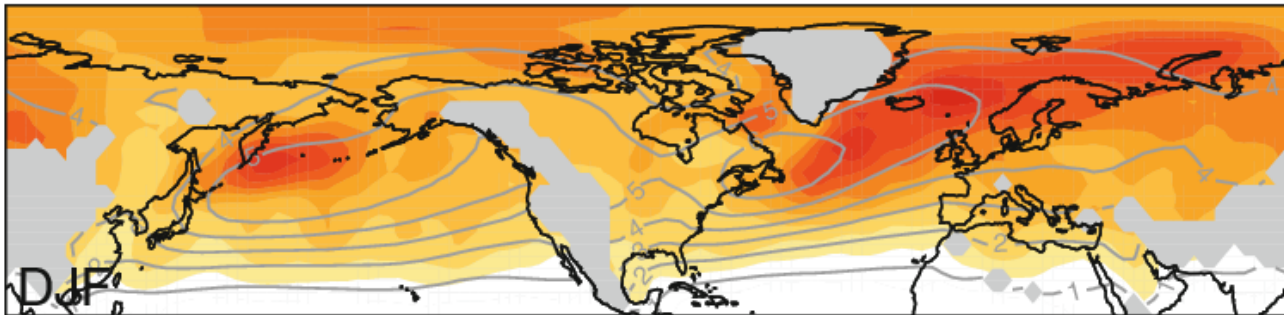
- Requires sustained investment to improve climate models and narrow uncertainty in projections e.g. H2020 PRIMavera, APPLICATE and Blue Action projects

Why is the spread between climate projections so large?

DJF CMIP5 Storm Track response



DJF CMIP5 inter-model spread

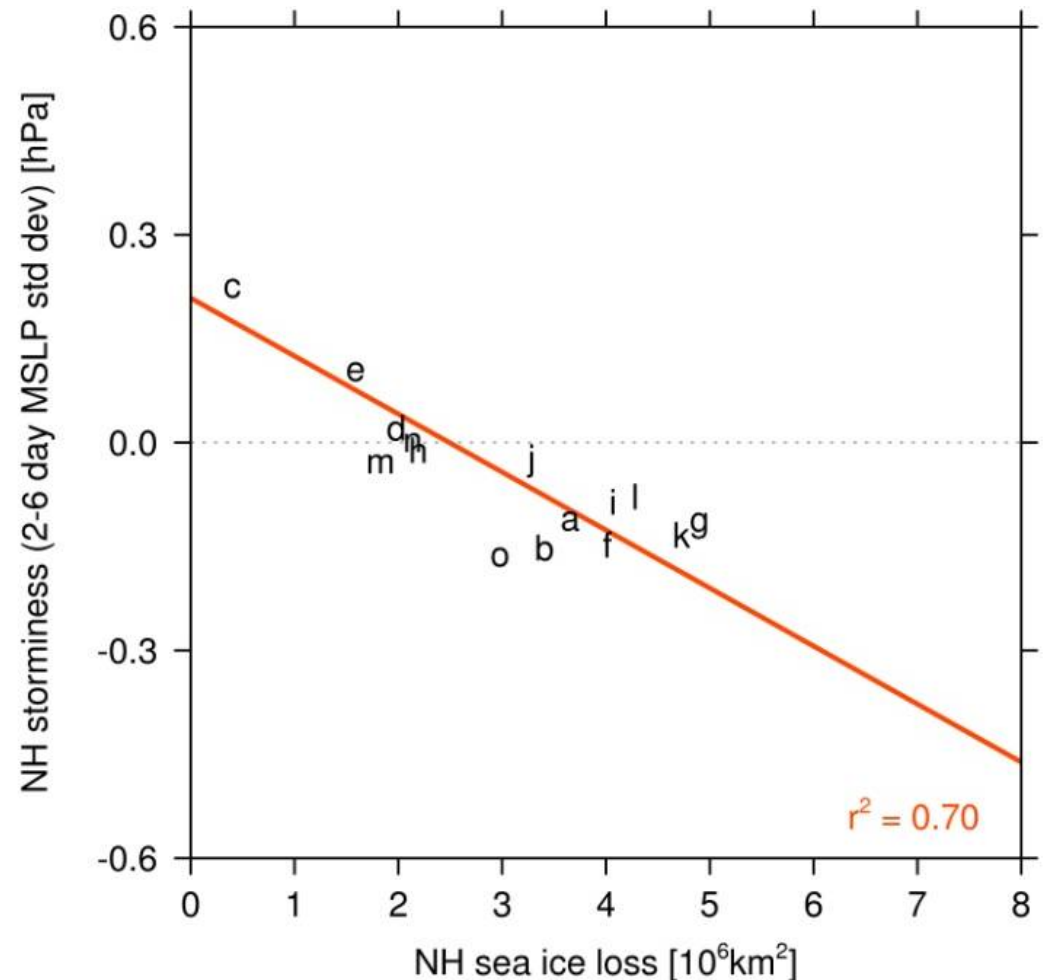


Upper) DJF CMIP5 multi-model mean storm track response (RCP4.5 2080-2100 minus HIST 1985-2005) as standard deviation of the 2-6 bandpass filtered mean sea level pressure. Lower) DJF CMIP5 inter-model standard deviation of storm track responses

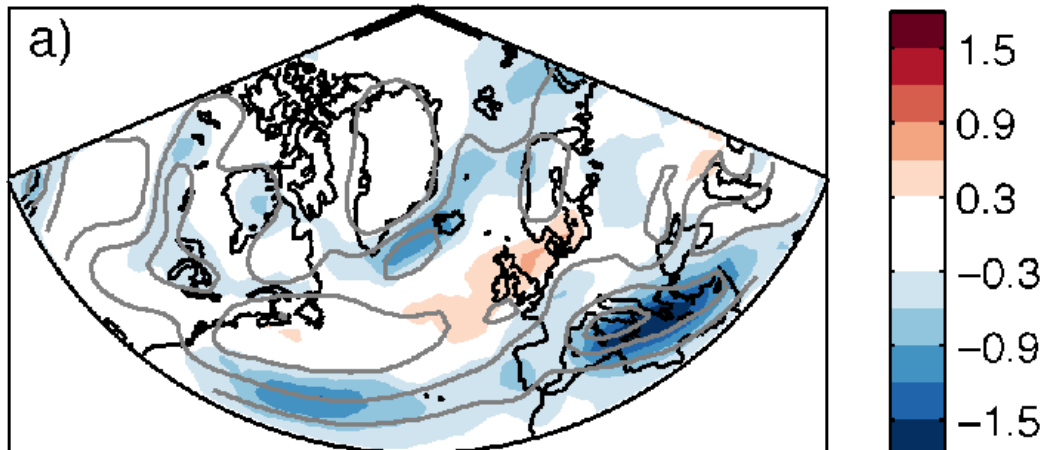
Harvey et al. (2012), *GRL*

- Decline of Arctic sea ice and Arctic amplification leads to weakening of equator-to-pole temperature and storminess (Harvey et al. 2014)

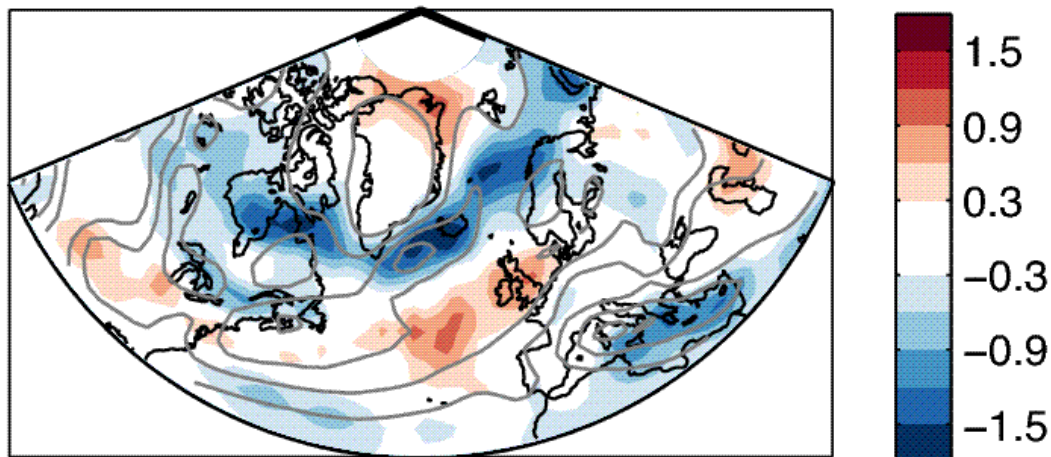
Spread in NH storm track responses associated with changes in equator-to-pole temperature difference, which is itself mostly governed by the spread of CMIP5 climate change response in the Arctic



track density



CMIP5 cyclone track density: RCP4.5
Scenario (2070-2100) minus
Historical (1980-2005)



CMIP5 cyclone track density: RCP4.5
Scenario (2070-2100) minus
Historical (1980-2005) for the Small
Biases climate models