

# Atmospheric response to recent summer Arctic Ice Anomalies

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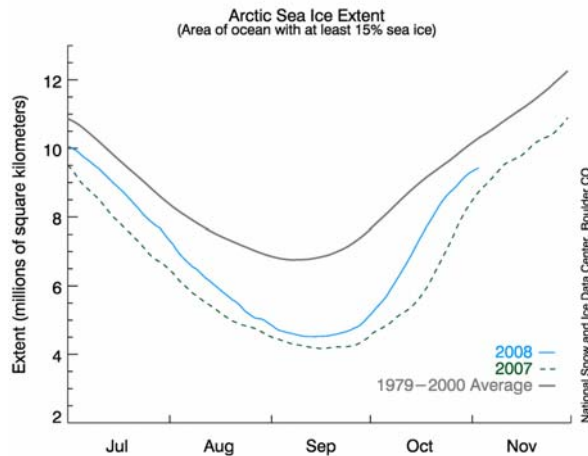
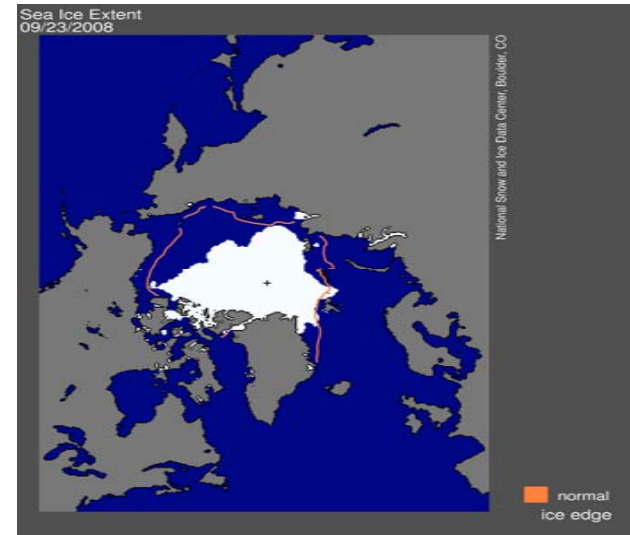
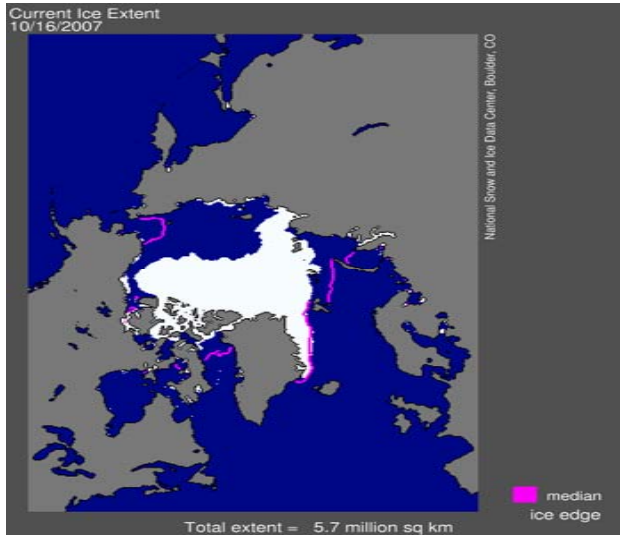
**Laura Ferranti**

**Franco Molteni**

# OUTLINE

1. Motivation and experimental setup
2. Atmospheric response to 2007 & 2008 ice anomaly
  - Heat fluxes Observed anomalies
  - Circulation response
  - Attribution?
3. Coupled versus Uncoupled Response.
  1. Role of mid-latitude SST
4. Linearity of the atmospheric response
  1. Ice anomaly under different background SST

# Arctic Sea-Ice



- The last 2 summers have seen unprecedented anomalies in the Arctic ice extension
- Did the large ice anomalies impact the atmospheric circulation?

Images from the National Snow and Ice Data Center: [http://www.nsidc.org/sotc/sea\\_ice.html](http://www.nsidc.org/sotc/sea_ice.html)

## Implications for seasonal /decadal forecasting:

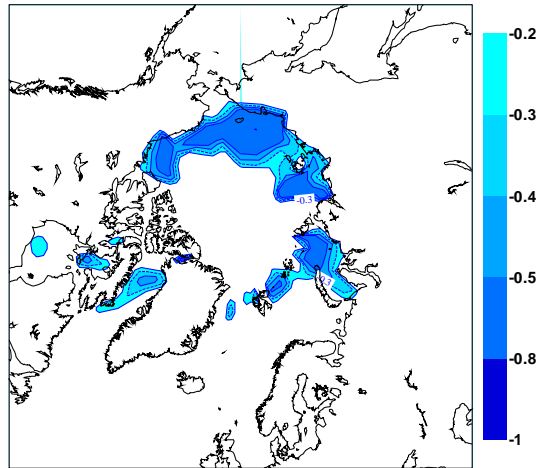
- Design of seasonal forecast systems: treatment of the ice. Currently many SF forecasting systems ignore the effect of sea ice, which is prescribed from climatological values.
- Attribution: Were the unusual cold/wet summers in 2007/8 over Western Europe related to the ice?
- How strong is the ice forcing and how linear is the atmospheric response?
- In a warming scenario with Arctic ice melting, can we anticipate the future summers? Or do we need coupled GCMS?

# Experimental Setup

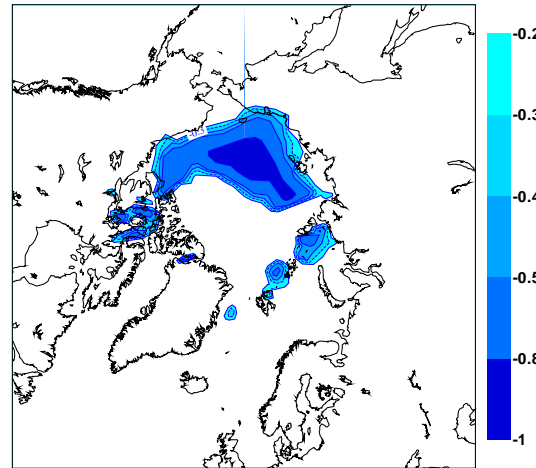
- Atmospheric Only Experiments (Uncoupled)
  - Forced by Observed SST and prescribed ice concentration.
  - Same atmospheric model as used for seasonal forecast (IFS-Cy31r1, T159, 62 levels)
- Sensitivity experiments: OBS\_ICE – CLIM\_ICE
  - Observed ice concentration: OBS\_ICE
  - Climatological ice concentration: CLIM\_ICE
- 2 Sets of Experiments: 2007 and 2008
  - Experiments start in May: 5 months (May to September)
  - 40 ensemble members each.
  - Response for July-August

# Ice Concentration: Obs\_Ice – Clim\_ice

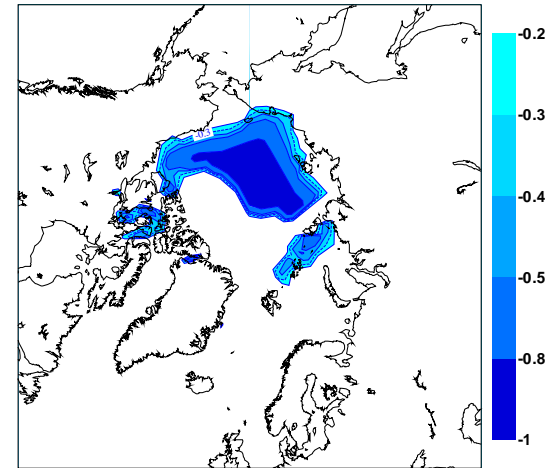
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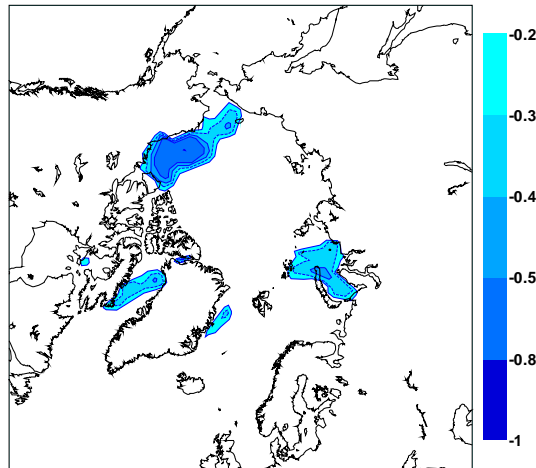
**AUG 2007**



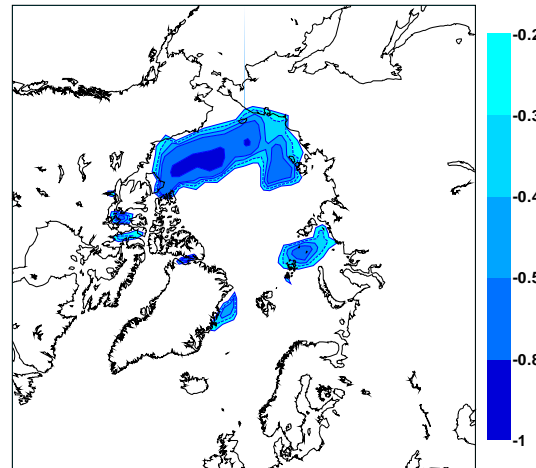
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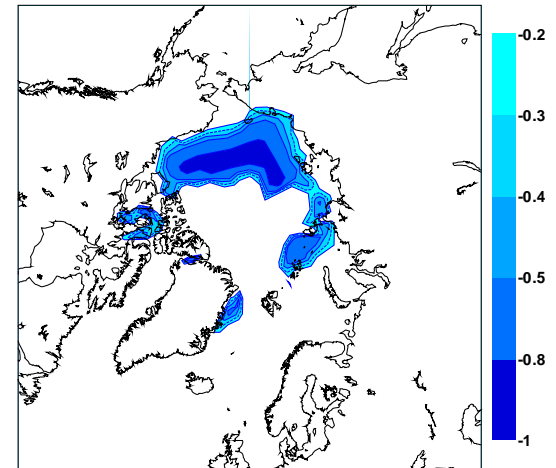
**JUL 2008**



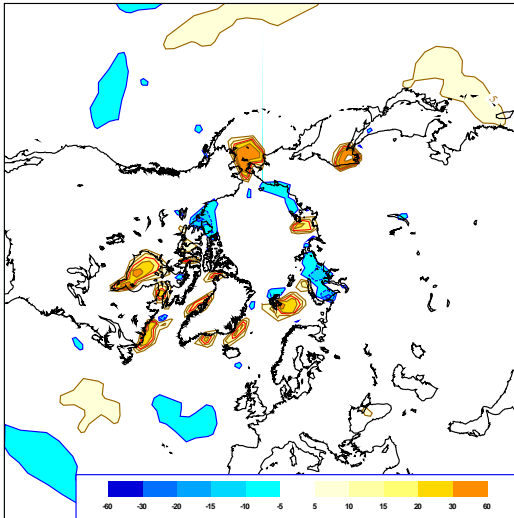
**AUG 2008**



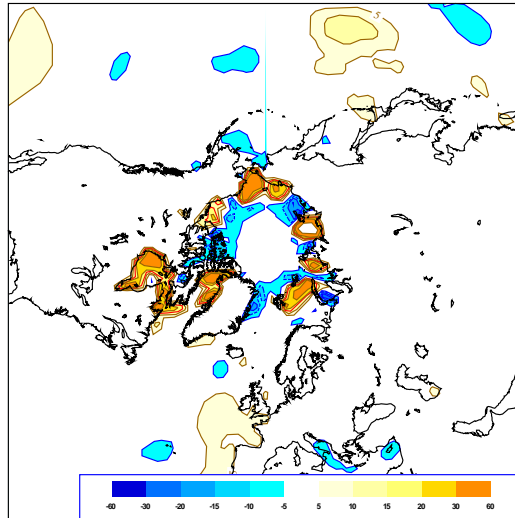
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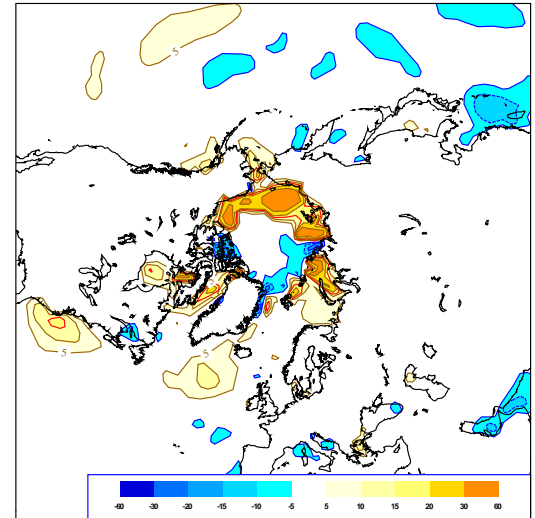
MAY



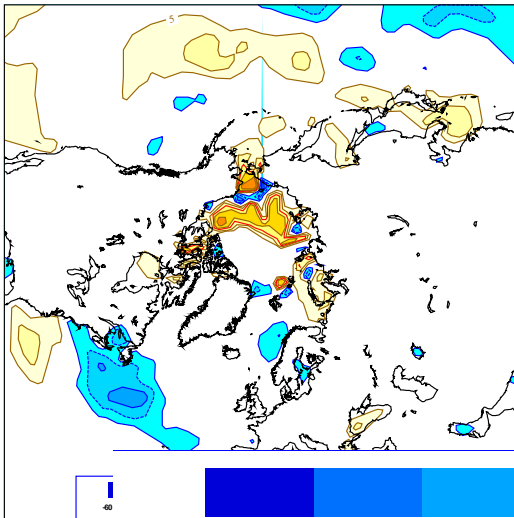
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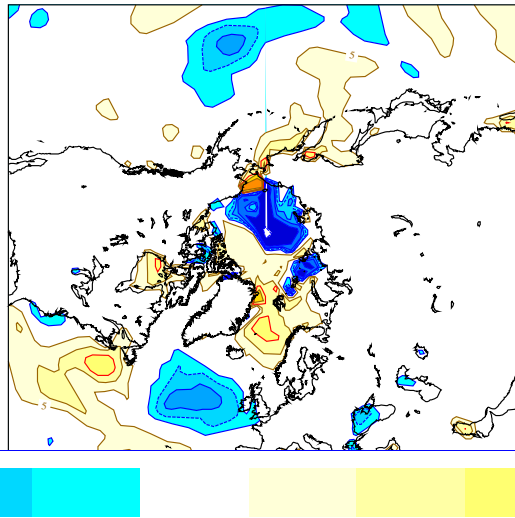
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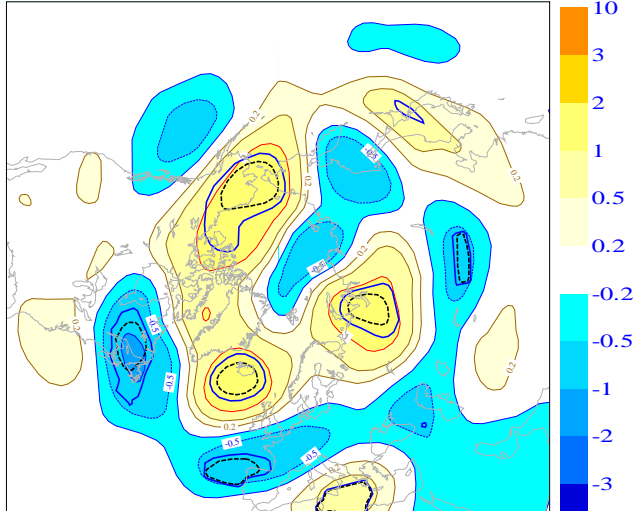
Obs\_Ice – Clim\_Ice  
Total Heat Flux  
May-to-September 2007



# Impact on Z500

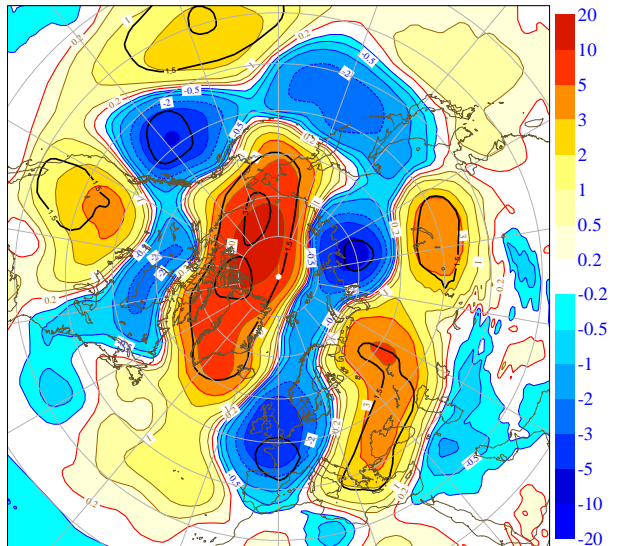
2007

Z500 JA 2007: Obs-Clim Ice



Atmos model  
(uncoupled)

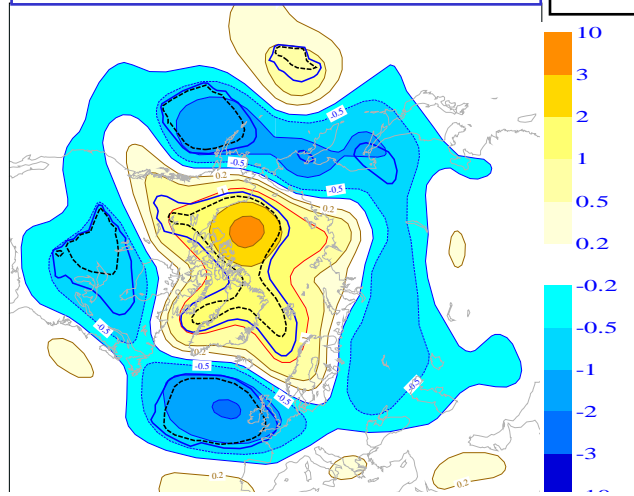
Z500 anomalies JA 2007 (1979-2001)



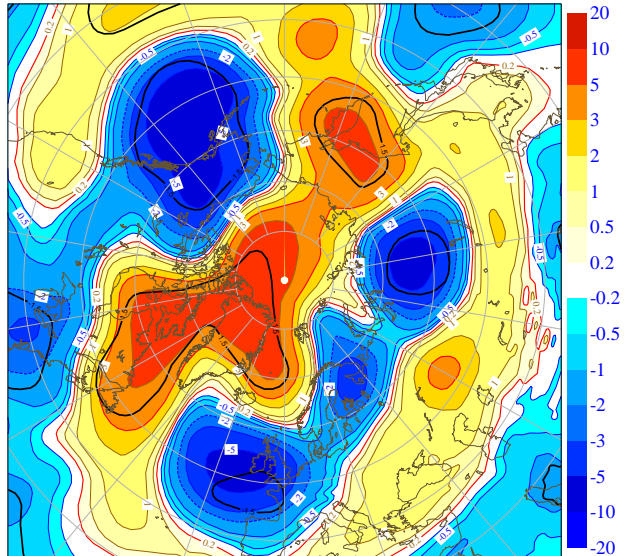
Observed  
Anomalies

2008

Z500 JA 2008: Obs-Clim Ice



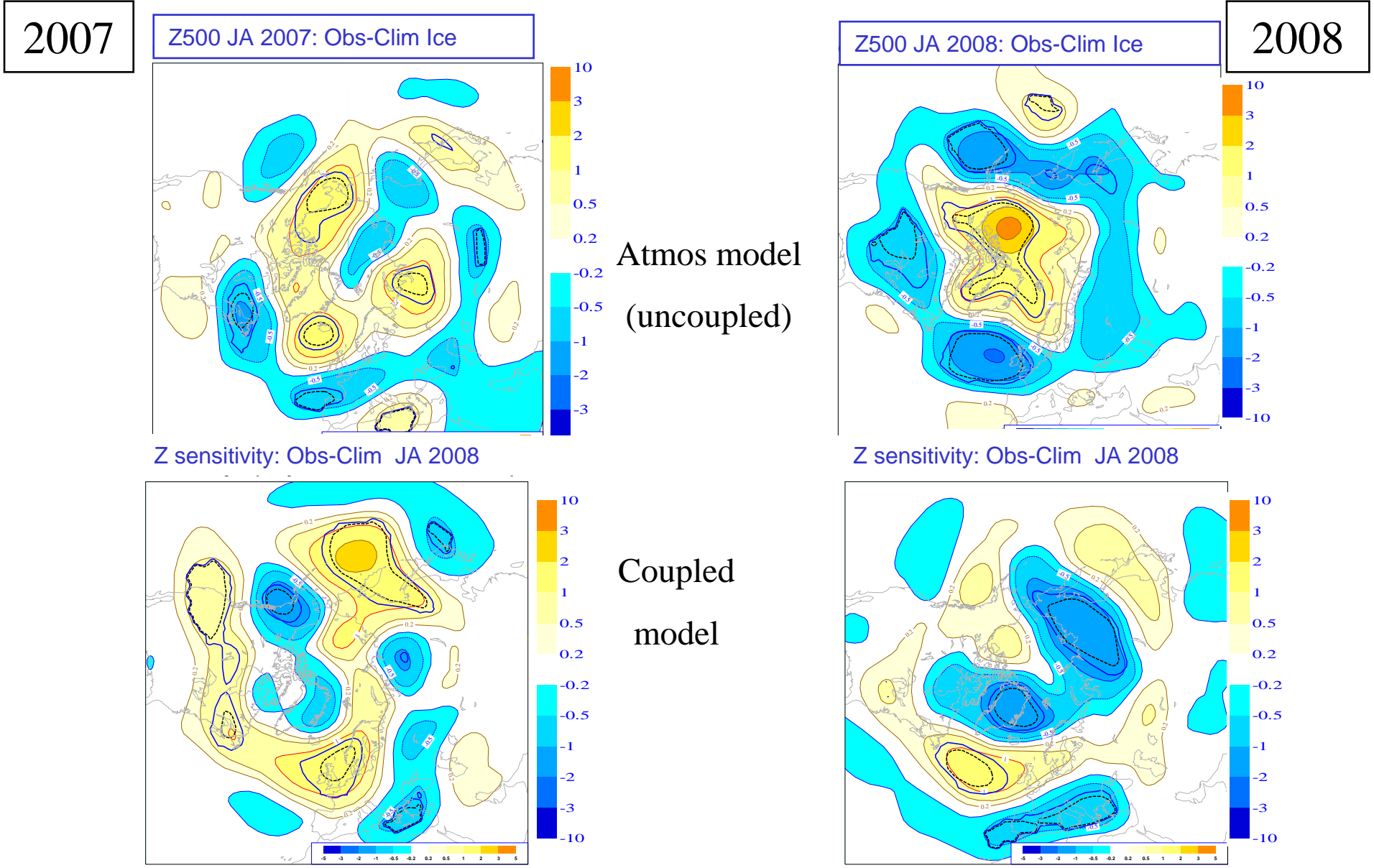
Z 500 anomalies JA 2008 (1979-2001)



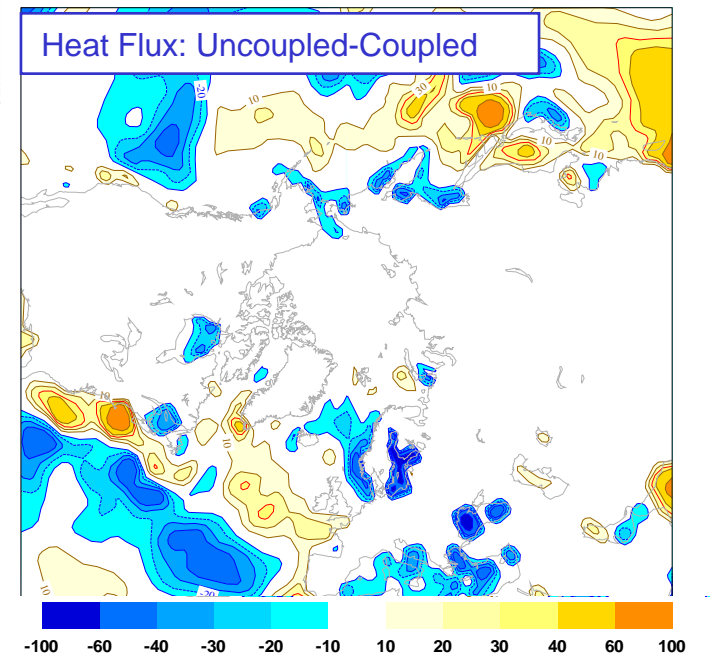
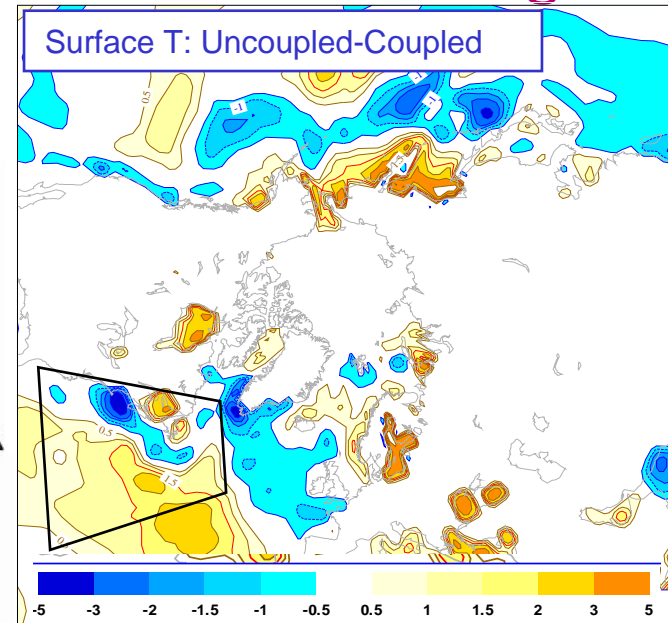
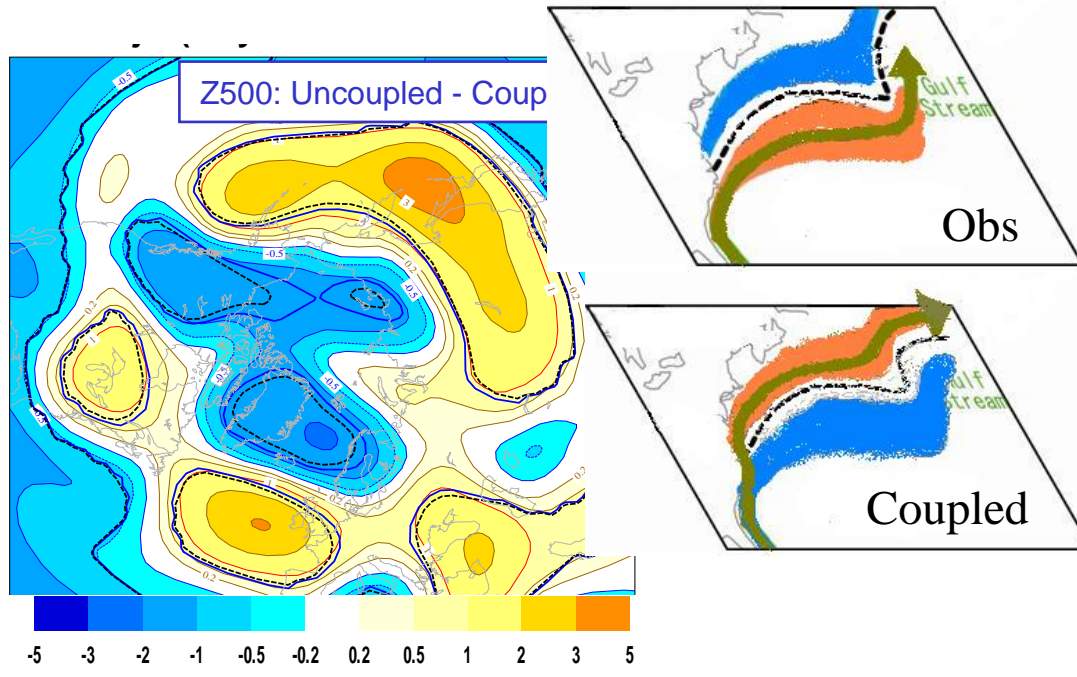


## 2. Coupled/Uncoupled/Partial Coupling

# But how is the response in coupled mode?



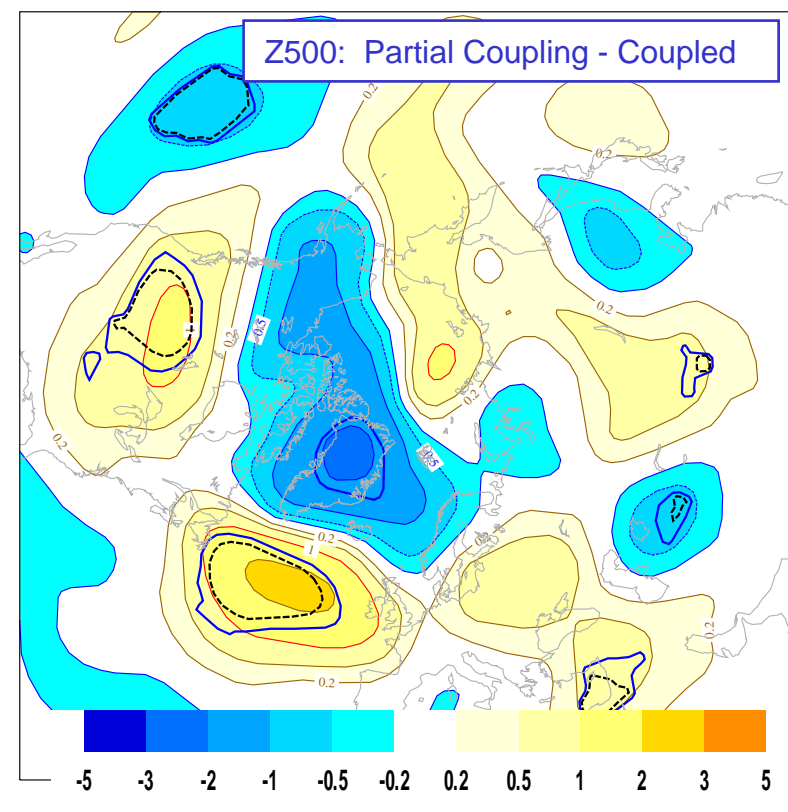
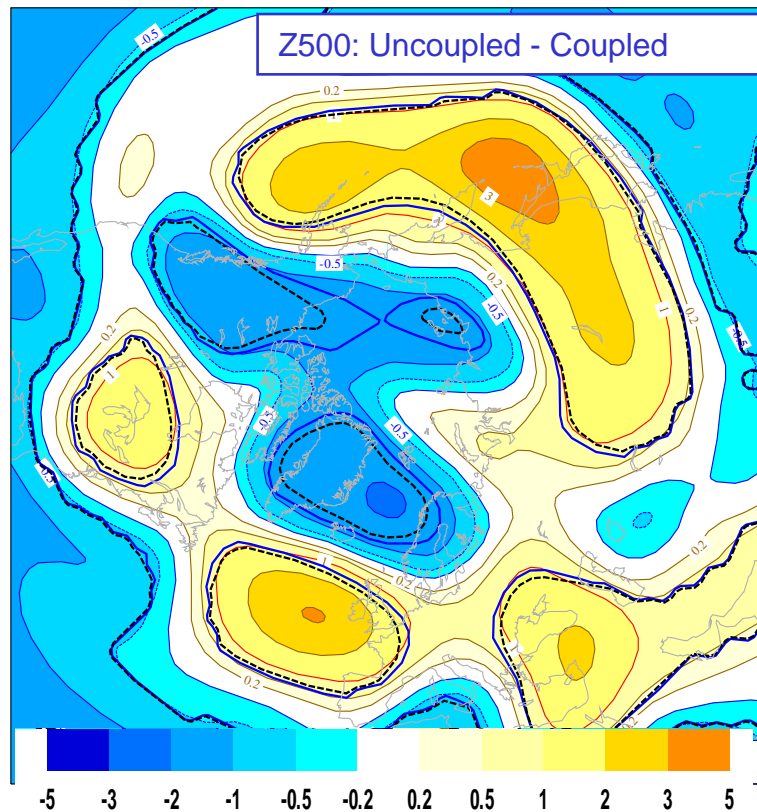
# Differences in circulation and surface forcing Uncoupled - Coupled (2008)



- Large Surface Temperature differences in the Western Boundary Currents, consistent with the inability of the models to represent sharp meridional SST fronts and the separation of the Gulf Stream
- Large associated heat flux (latent 60-100W/m<sup>2</sup>)
- Partial Coupling experiment: May-Sept 2008

# Impact of N-W Atlantic SST in the Atmosphere

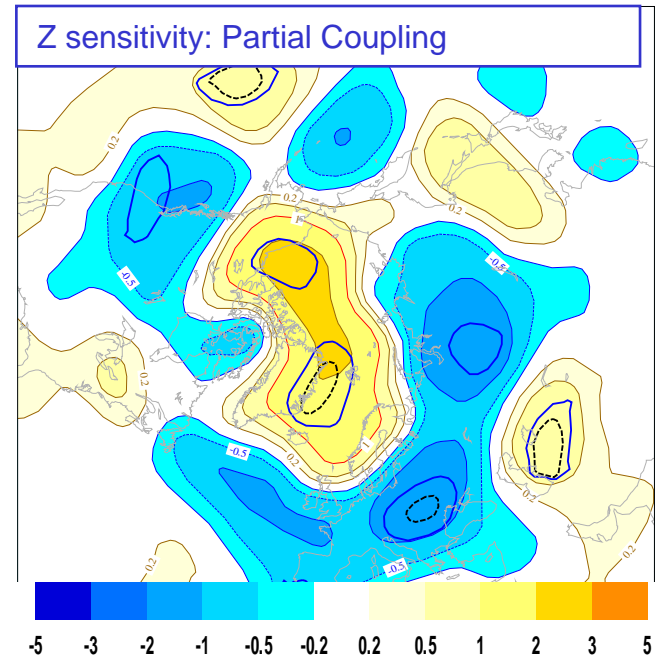
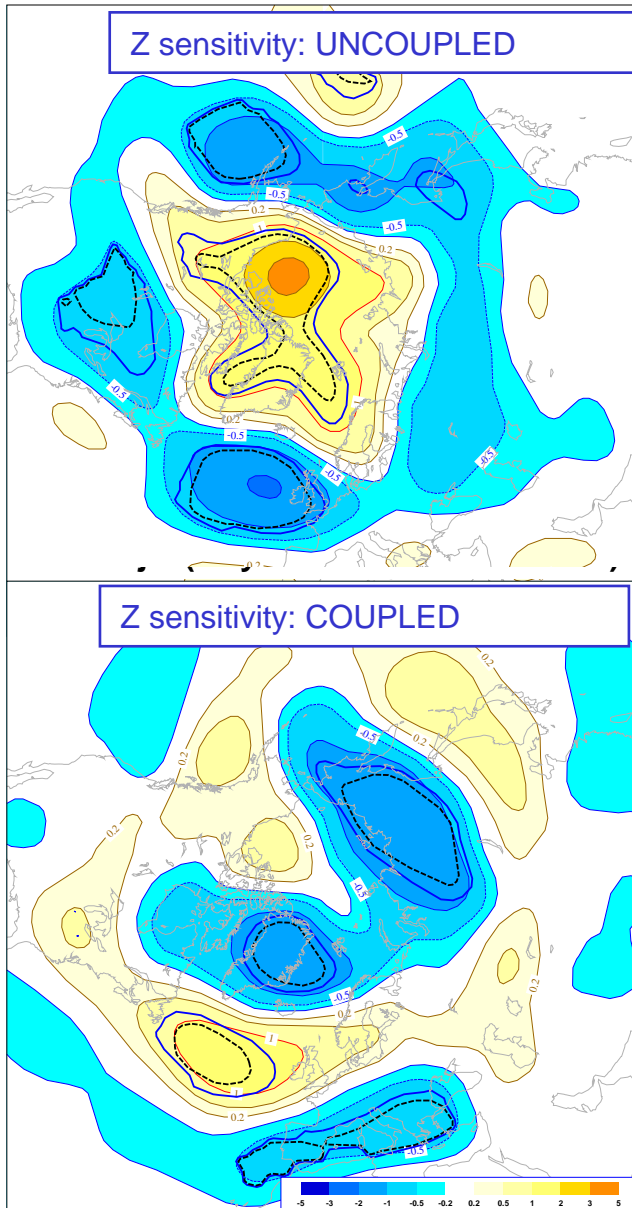
## 1) Impact on mean circulation



- The Atmosphere responds strongly to the SST in the North West Atlantic
- Correcting the SST in the North-West Atlantic can correct large part of the mean error in the atmospheric circulation over North Atlantic Sector

# Impact of N-W Atlantic SST in the Atmosphere

## 2) Impact on the response to the Arctic Ice anomaly



Correcting the N-W Atlantic SST changes the response of the atmosphere to the given ice anomaly!!

Does it apply to more cases?

## Tantalizing results... More questions

- **Which specific aspects of the SST in the North-West Atlantic are important?**
  - Is the mean state?
  - Is the anomaly (2008 had strong SST anomalies in NW Atlantic)?

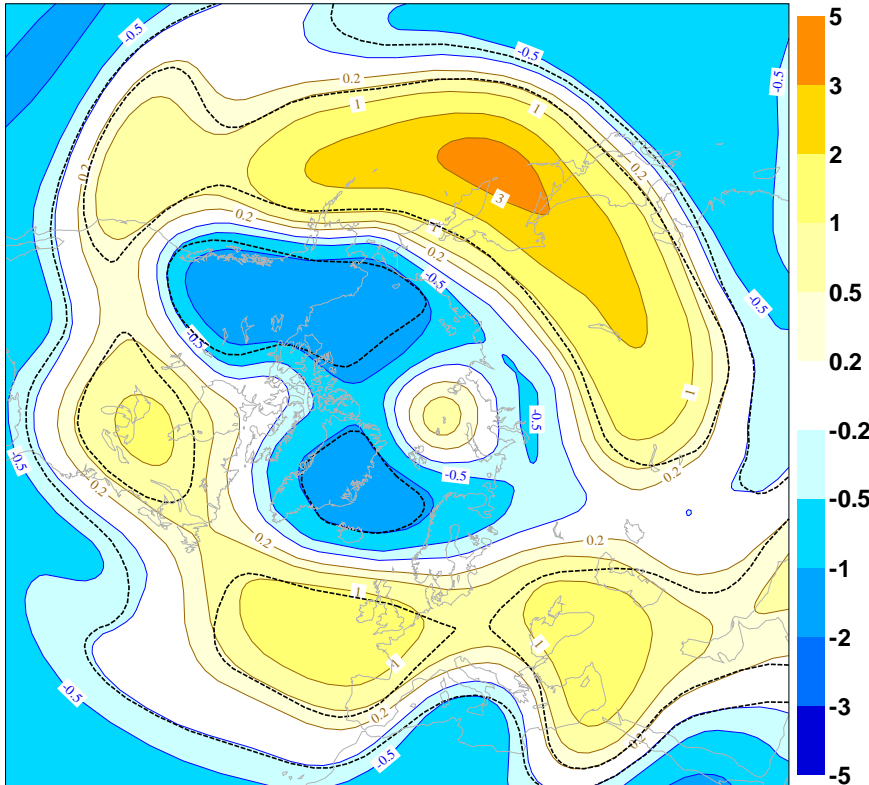
### *Ongoing experiments*

- **The previous experiment was for 2008. Do the conclusions hold for other years?**
  - Additional set of experiments for 2007 (next)
  - Ongoing experiments for other dates
  - Testing the impact of anomaly versus mean/state on going.

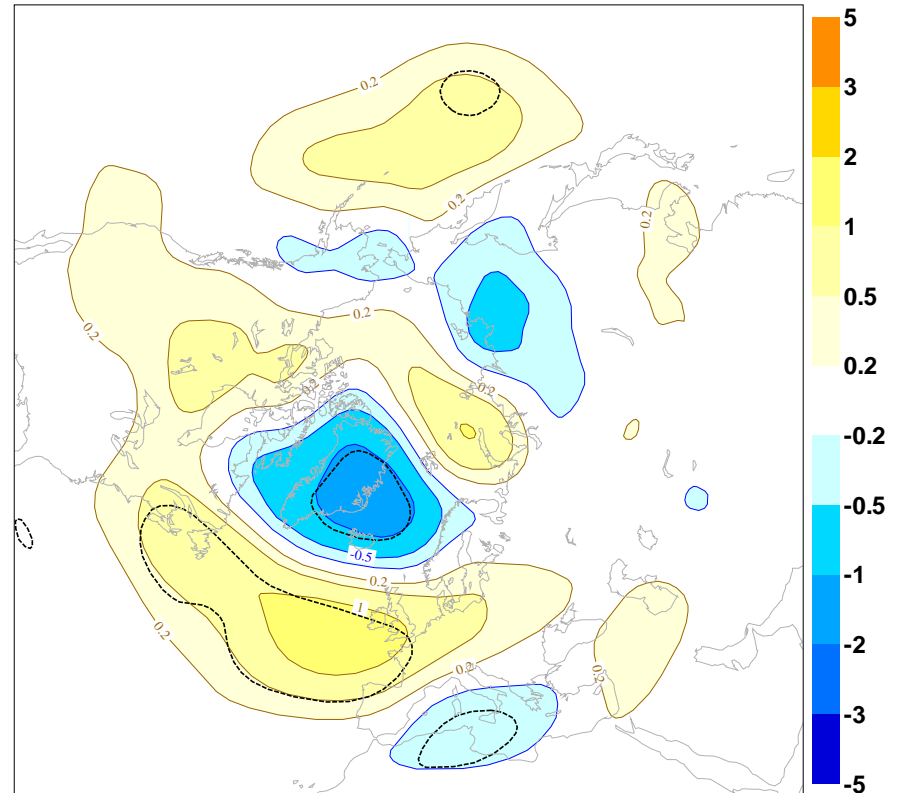
*Implications for climate predictions: flux correction or high resolution ocean models?*

# Impact of NW Atlantic on Mean State (2007 + 2008)

**uncoupled-coupled: Z500(JA)**



**partial-coupled: Z500(JA)**



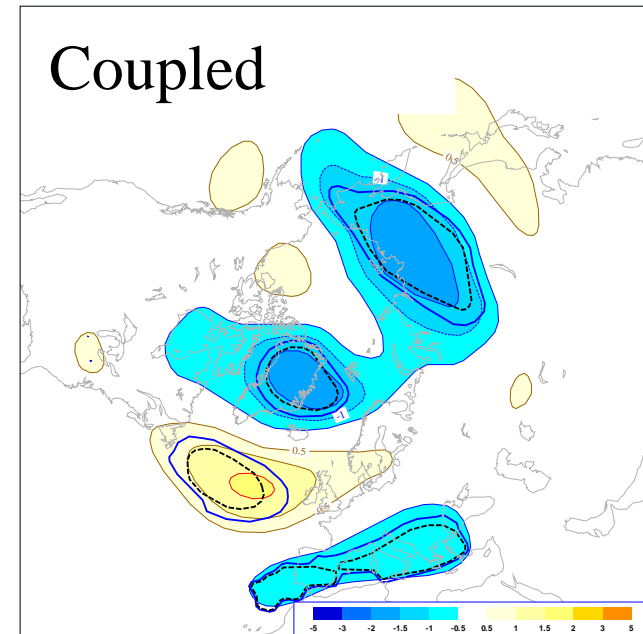
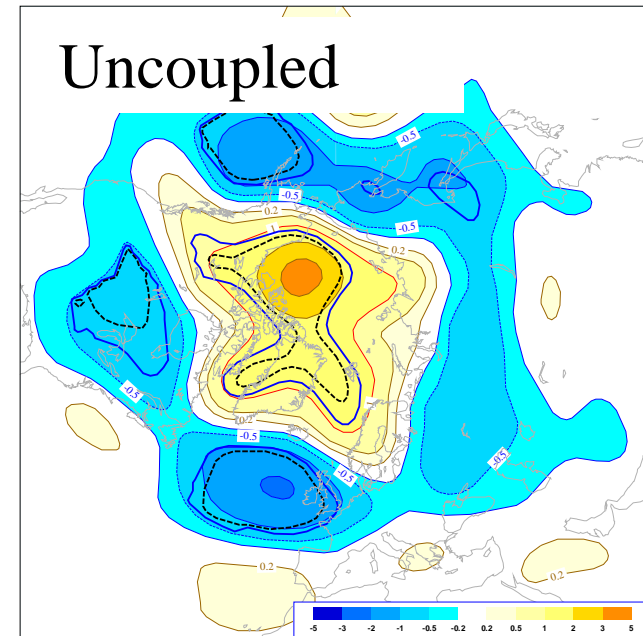
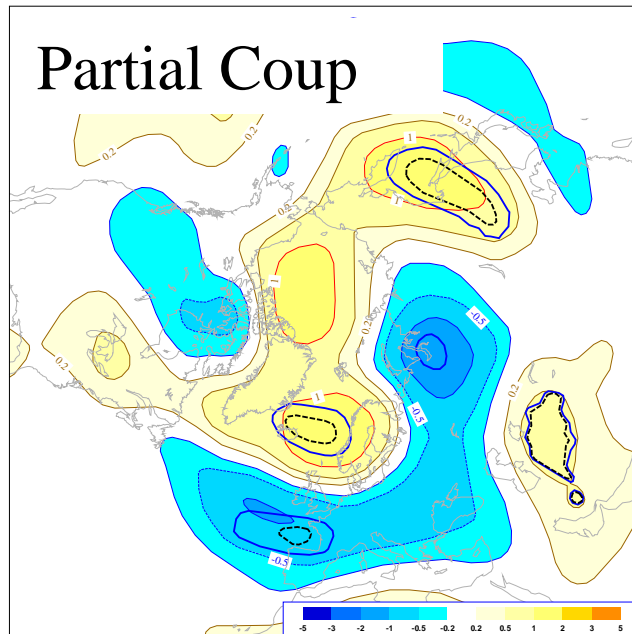
The impact on the mean state seems robust.

The differences between coupled and uncoupled for 2007/2008 is similar to the 1987-2006 climatology (not shown)

# Impact of coupling on the sensitivity (2<sup>nd</sup> order)

## Impact Partial Coupling 2008:

The NW Atlantic SST determines the atmospheric response to the Arctic ice anomaly

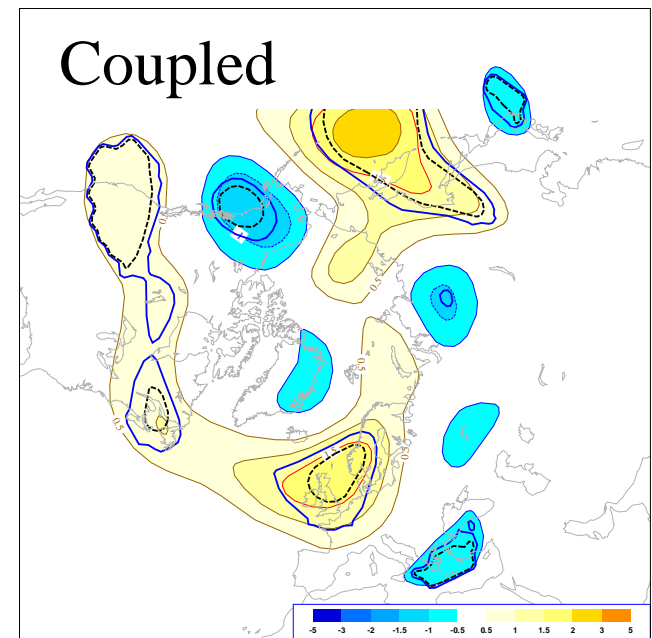
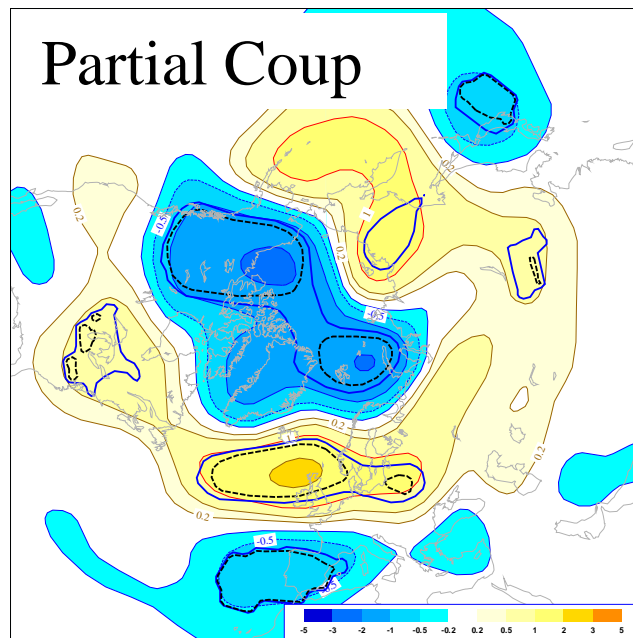
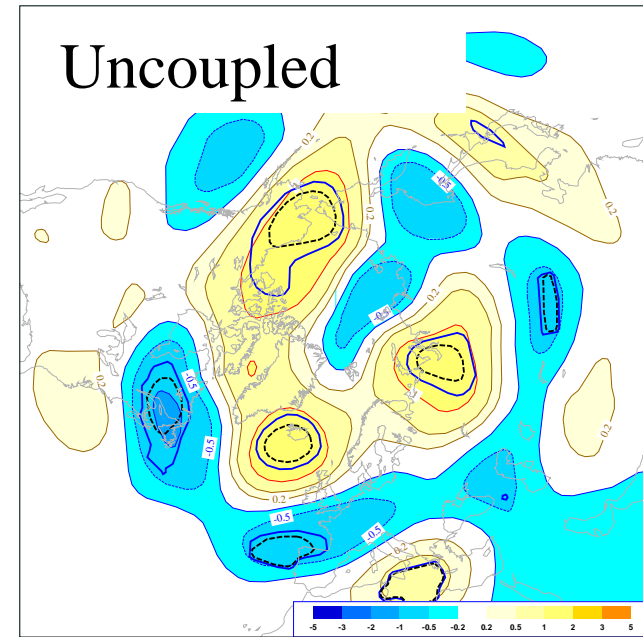




# Impact of coupling on the sensitivity (2<sup>nd</sup> order)

## Impact Partial Coupling 2007:

The NW Atlantic SST **impacts but does not determine** the atmospheric response to the Arctic ice anomaly



### 3. How strong is the impact of the ice?

- Results so far indicate that atmospheric response is non linear, and depends on the atmospheric mean state and SST.
- How does it compare with the inter-annual SST forcing?
- Additional set of experiments:

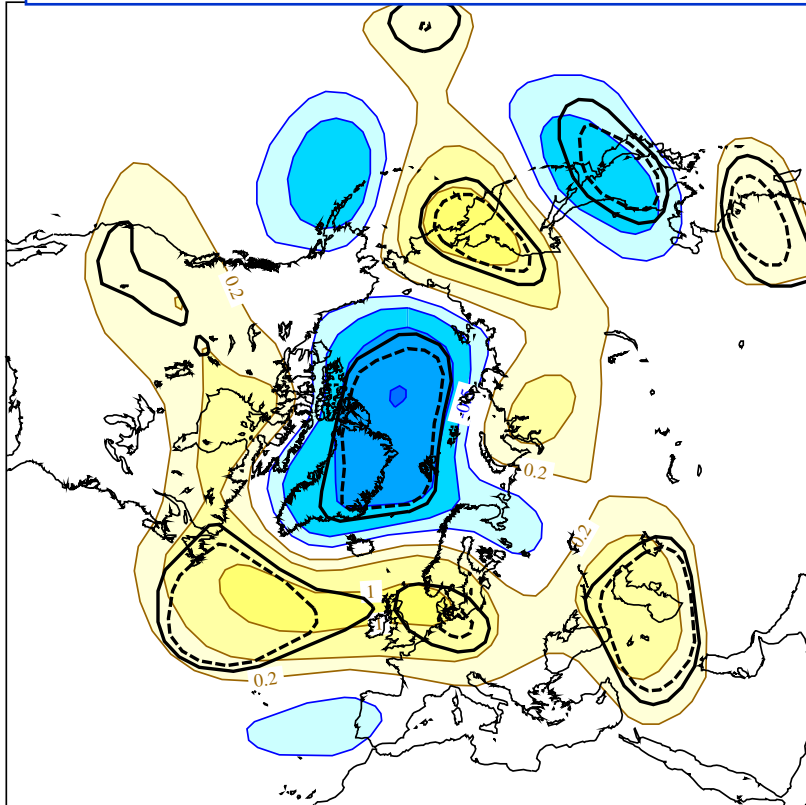
2007 ice anomaly using SST from 1987-2006

20 years x 5 ens members = 100 ens members

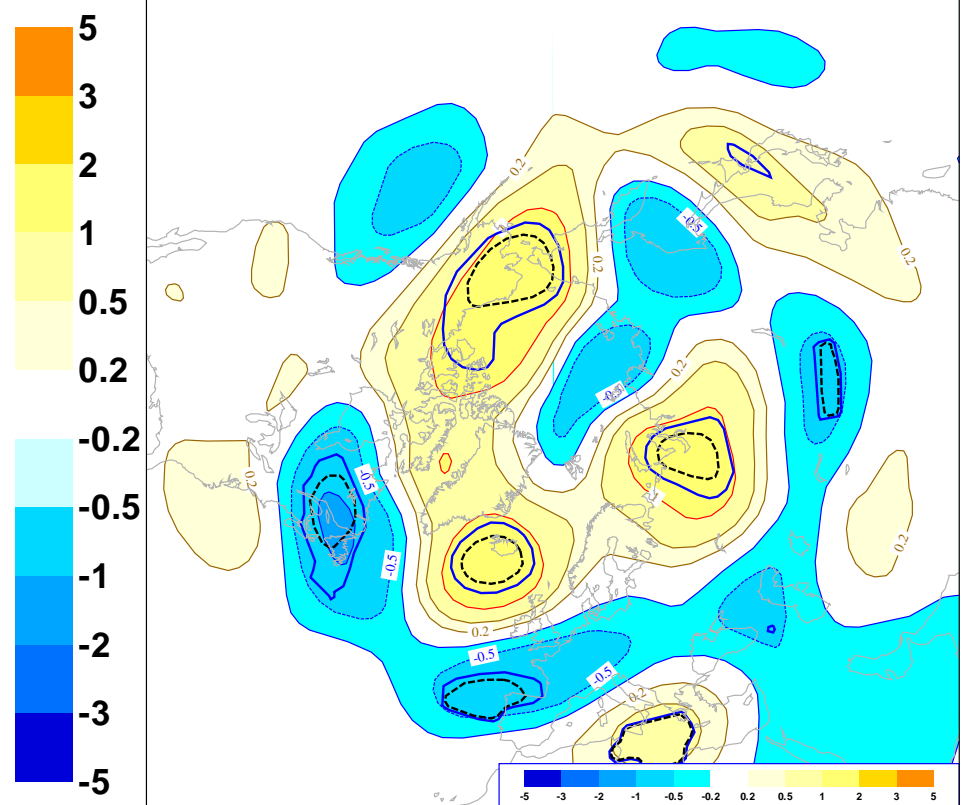
**2007\_Ice – Clim\_Ice**

# Sensitivity to 2007 ice anomaly: 1987-2006

**Z500: 2007 ice – Clim ice**  
(1987-2006 SST)



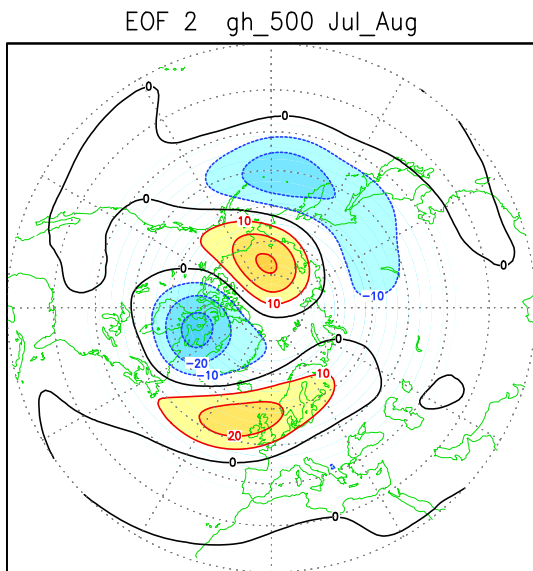
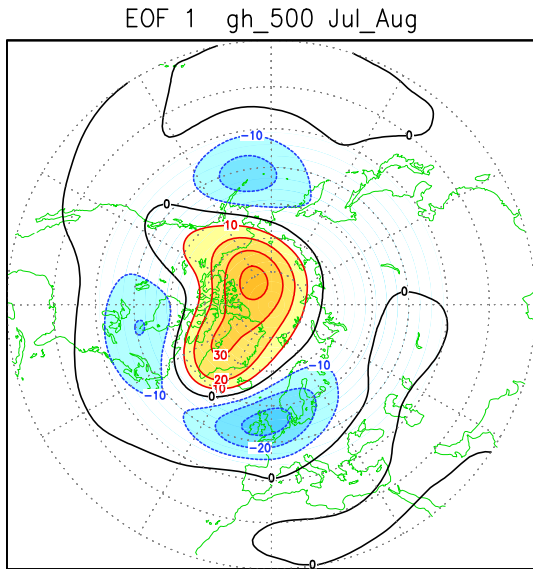
**Z500: 2007 ice – Clim ice**  
(2007 SST)



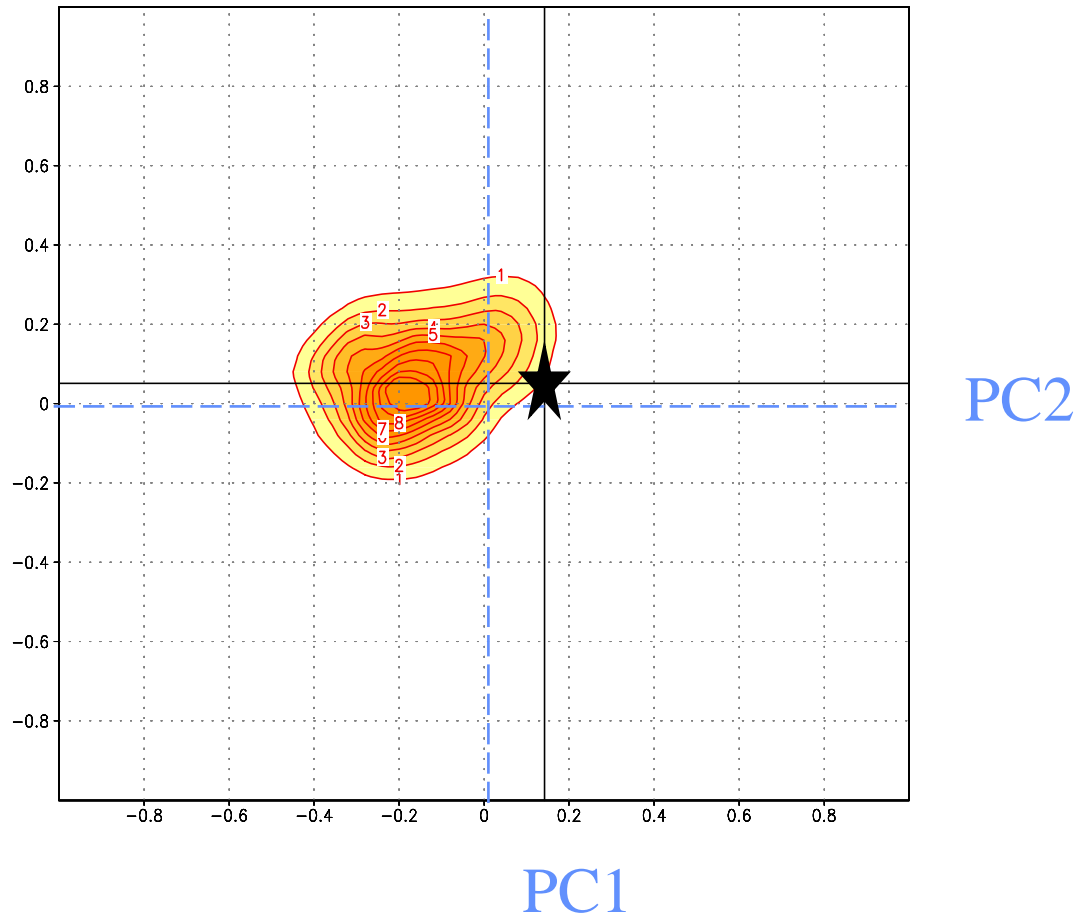
Response is very sensitive to underlying SST.... More statistics needed

★ Response with 2007 SST

PDF of the sub ensembles with non 2007 SST



PDF of PC1–PC2 response (20-yr SST)



SST can significantly change the response of the atmosphere to the ice anomaly

# Summary

- Recent Arctic ice anomalies (summer 2007/8 ) had a significant impact on the atmospheric circulation over the North-Atlantic sector.
  - The response projects into the summer AO
- The response of the atmosphere is non linear, and it is highly conditioned by the underlying SST.
  - Implications for the experimental design and ensemble generation.
- During summer the atmosphere responds strongly to the North-West Atlantic SSTs
  - The NWA SST determines the mean circulation over the North Atlantic sector.
  - The NWA SST conditions the response to the prescribed ice anomalies (changing the polarity of the AO response).
- Serious implications for seasonal/decadal/climate predictions.