# Review of existing modeling studies on Arctic-midlatitudes linkages

*Yannick Peings and Gudrun Magnusdottir*

**Outline**

- Robust results, agreement across different studies

- Uncertain results that need to be reconciled or reproduced

- Suggestions for direction and coordination in future modeling studies

*Thanks to Clara Deser, James Screen and Timo Vihma for their contributions !*

## Different types of numerical experiments that have been performed in the literature

- **AGCM perturbation experiments with repeating sea ice forcing**, from observations or projections, hemispheric or regional
(e.g., Alexander et al. 2004, Balsameda et al. 2010, Bhatt et al. 2008, Blüthgen et al. 2012, Cassano et al. 2013, Deser et al. 2010, Grassi et al. 2013, Honda et al. 1999, 2009, Kim et al. 2014, Kumar et al. 2007, Liptak and Strong 2014, Liu et al. 2012, Magnusdottir et al. 2004, Mori et al. 2014, Peings and Magnusdottir 2014, Pethoukov and Semenov 2010, Screen 2013, Screen et al. 2015a-b, Seierstad and Bader 2009, Semenov and Latif 2015, Strey et al. 2010, Sun et al. 2014, Sun et al. 2015)

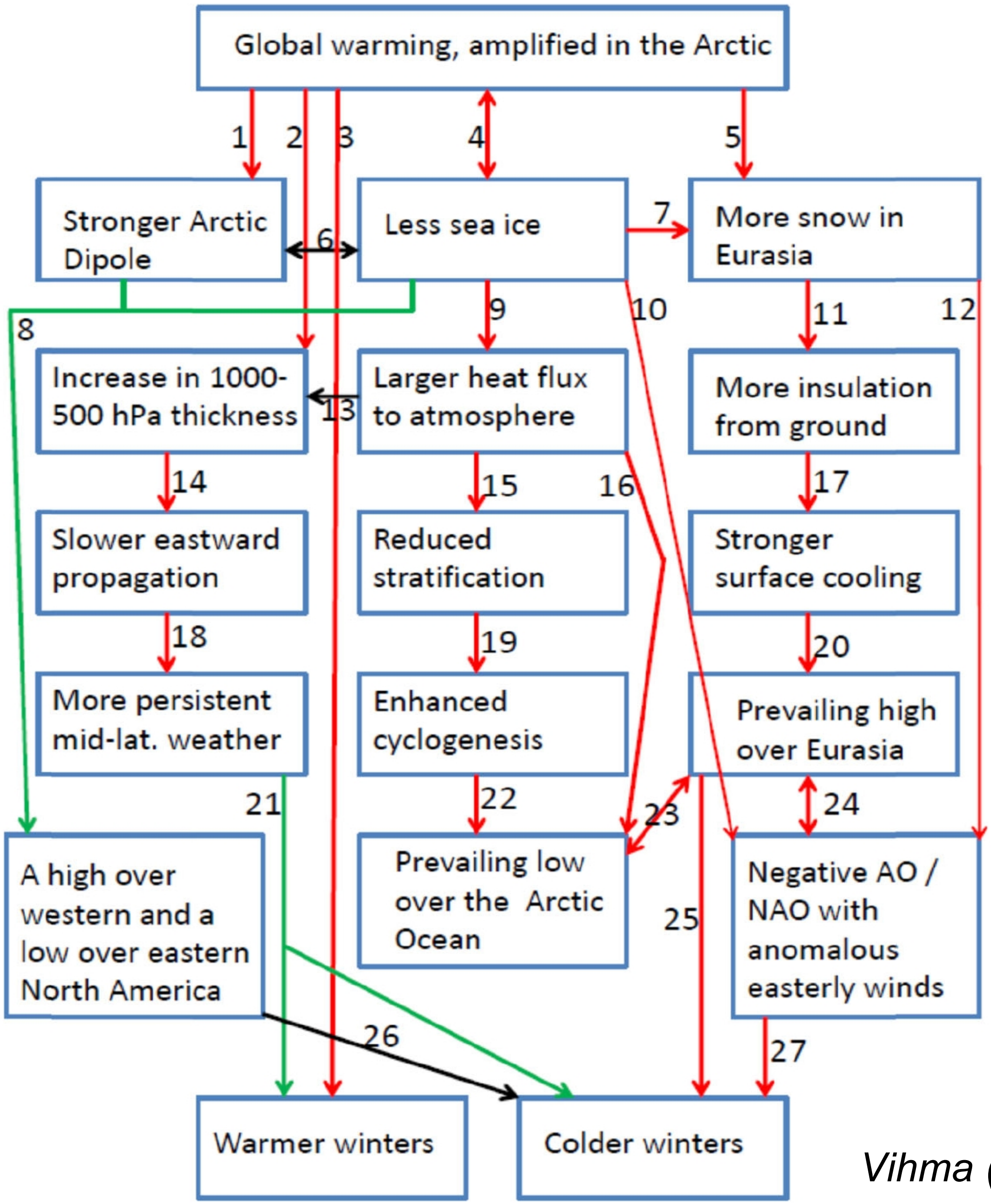
- **AMIP-type experiments** with prescribed chronology of SIC and/or SST anomalies
(e.g., Kug et al. 2015, Perlwitz et al. 2015, Screen et al. 2013, 2014, Singarayer et al. 2005, Wu et al. 2015)

- **Coupled ocean-atmosphere** experiments
(e.g., Deser et al. 2015, Orsolini et al. 2012, Rinke et al. 2013)

- **Simplified GCMs** idealized experiments
(e.g., Butler et al. 2010, Hassanzadeh et al. 2014)

# *Arctic Working Group Telecon – October 1st, 2015*

Many processes are involved …
(Vihma 2014, Cohen et al. 2014)




*Vihma (2014)*

**"Higher-confidence" results (good agreement between numerical studies)**

1) Local response to sea ice loss and causes for Arctic Amplification (AA)

2) Late winter negative NAO/NAM response to <u>projected (large)</u> Arctic sea ice loss

3) Teleconnection between Barents-Kara Seas and Siberia

**“Higher-confidence” results (good agreement between numerical studies)**

**1) Local response to sea ice loss and causes for Arctic Amplification (AA)**

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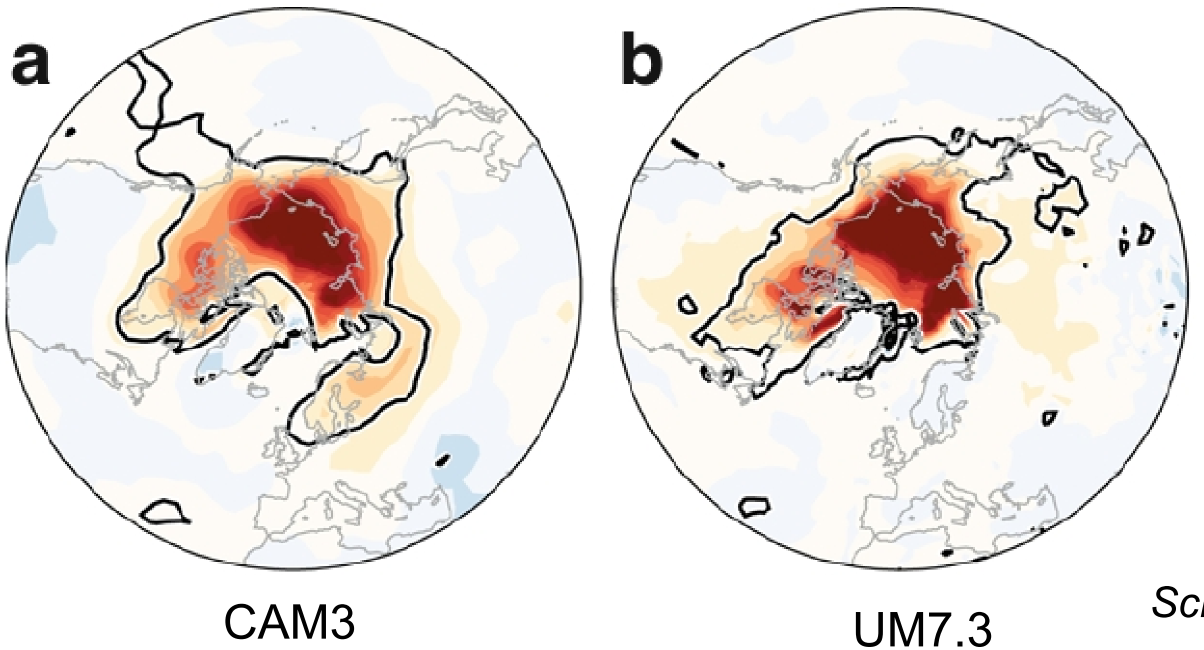
## 1) Local response to sea ice loss and causes for Arctic Amplification

*Response of autumn (SON) surface temperature to observed sea ice loss*




*Screen et al. (2014)*

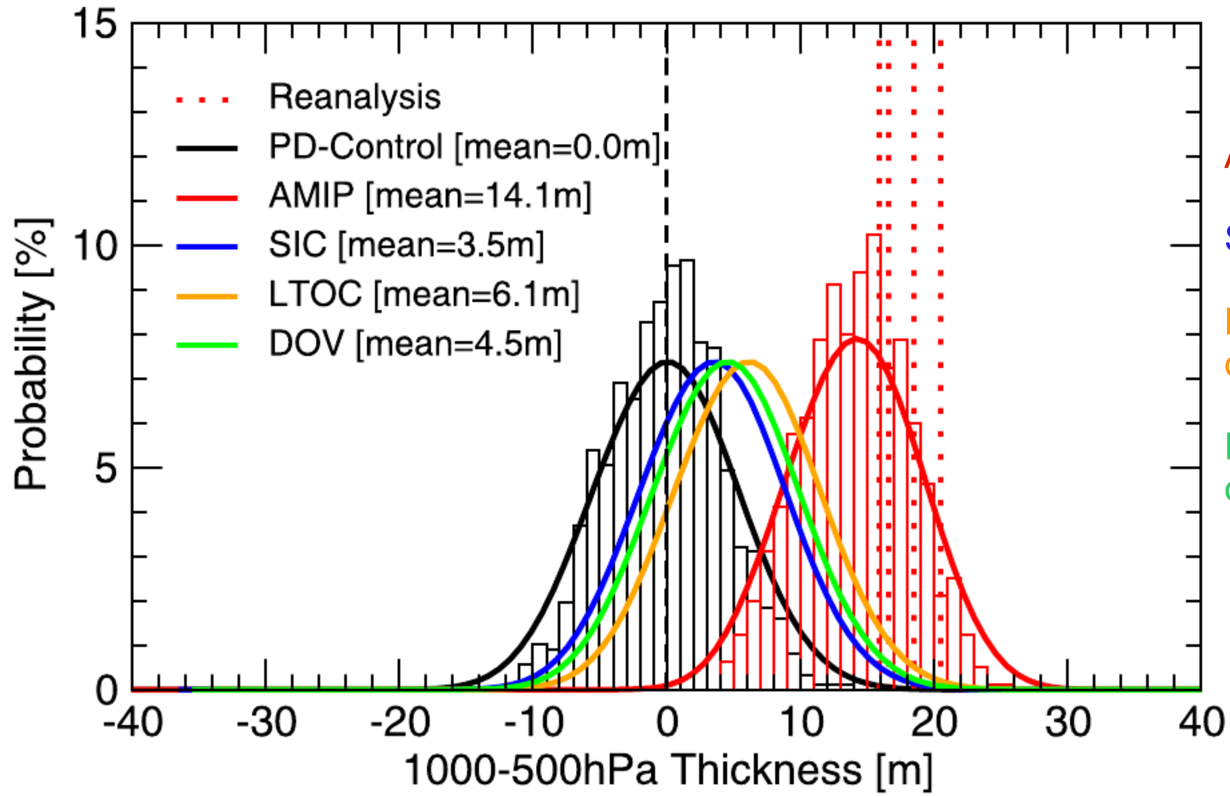
**Increase in surface temperature (decrease of the surface temperature inversion)**

**Increase in cloud cover, moisture, precipitation**

**Warming and increase in thickness of the lower troposphere**

## 1) Local response to sea ice loss and causes for Arctic Amplification

*Role of SIC vs decadal ocean variability and internal variability*




AMIP : SST + sea ice

SIC : sea ice only

LTOC : long-term oceanic trend

DOV : decadal oceanic variability

*Perlwitz et al. (2015)*

**Sea ice loss is not the only contributor to AA**

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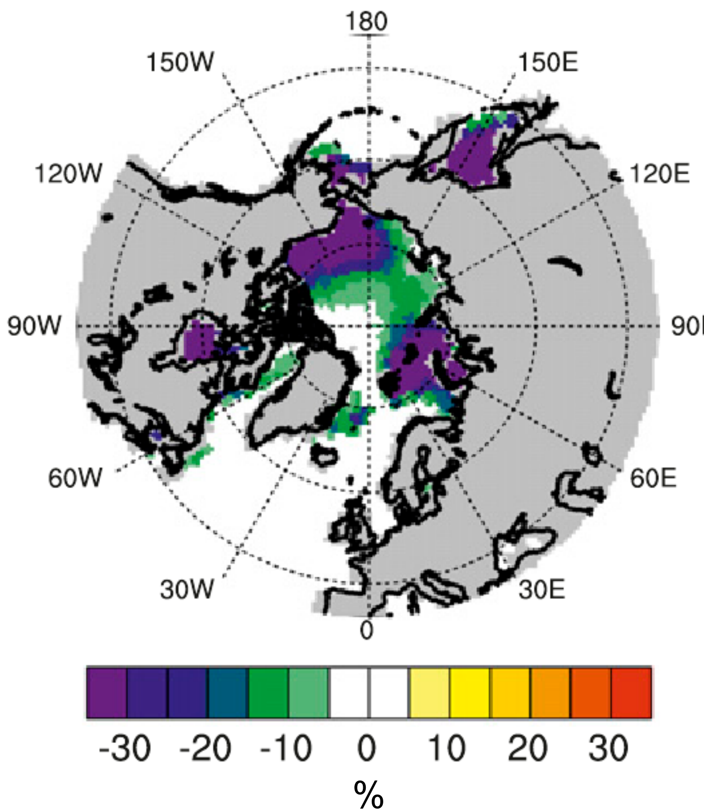
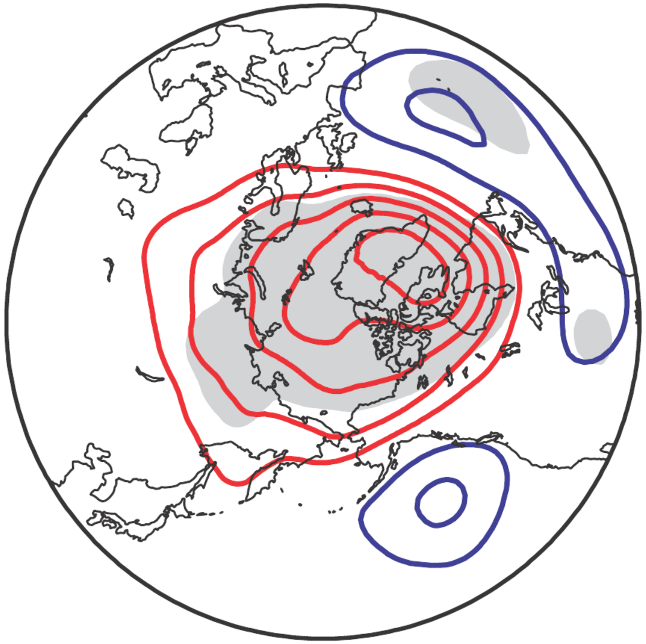
## 2) Late winter negative NAO/NAM response to projected large Arctic sea ice loss

*Exemple of sea ice forcing in winter*
*(Peings and Magnusdottir 2014)*




*Z500 response in Jan-Feb (Deser et al. 2010)*



NAO- pattern (equatorial jet shift)

*Supported by, e. g., Deser et al. 2010, Peings and Magnusdottir 2014, Seierstad and Bader 2009*

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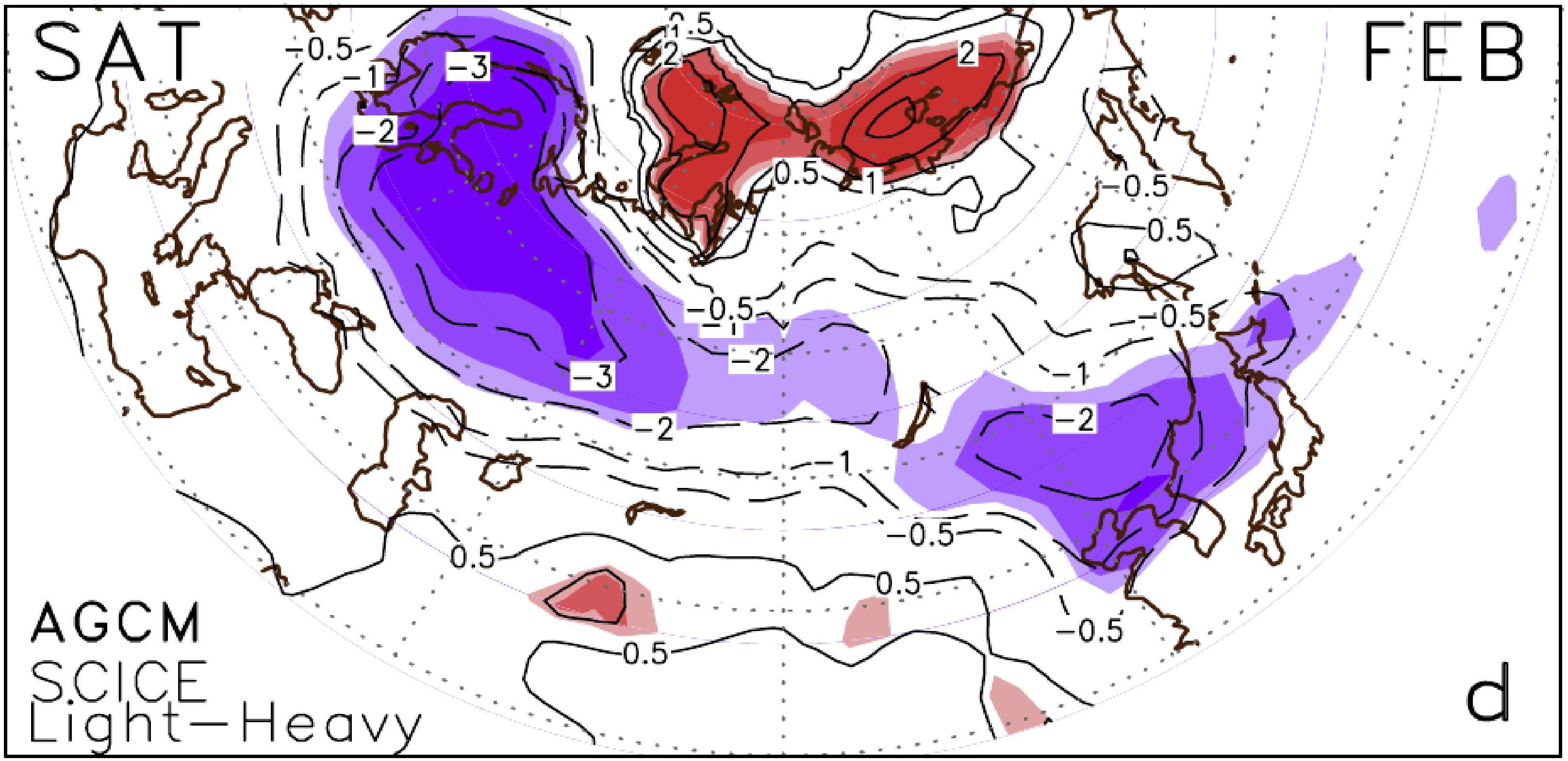
**3) Teleconnection between Barents-Kara Seas and Siberia**

## 3) Teleconnection between Barents-Kara Seas and Siberia

*Response of February air surface temperature to Barents-Kara sea ice anomalies*




*Honda et al. 2009*

**Less sea ice, warming in the Barents-Kara Seas induce a cooling over Siberia/central Asia**

*Supported by, e.g., Kim et al. 2014, Kug et al. 2015, Liu et al. 2012, Mori et al. 2014, Pethoukov and Semenov 2010*

**"Lower-confidence" results : conflicting findings or based on a single study**

1) Remote dynamical response to AA (e.g., signal vs internal atmospheric variability; role of the stratosphere; role of ocean dynamics)

2) Competing influence of regional sea ice anomalies

3) Response in terms of cold winter extremes over Europe and North America

4) Competition between the response to Arctic Amplification and other factors (global warming, oceanic decadal oscillations, etc ...)

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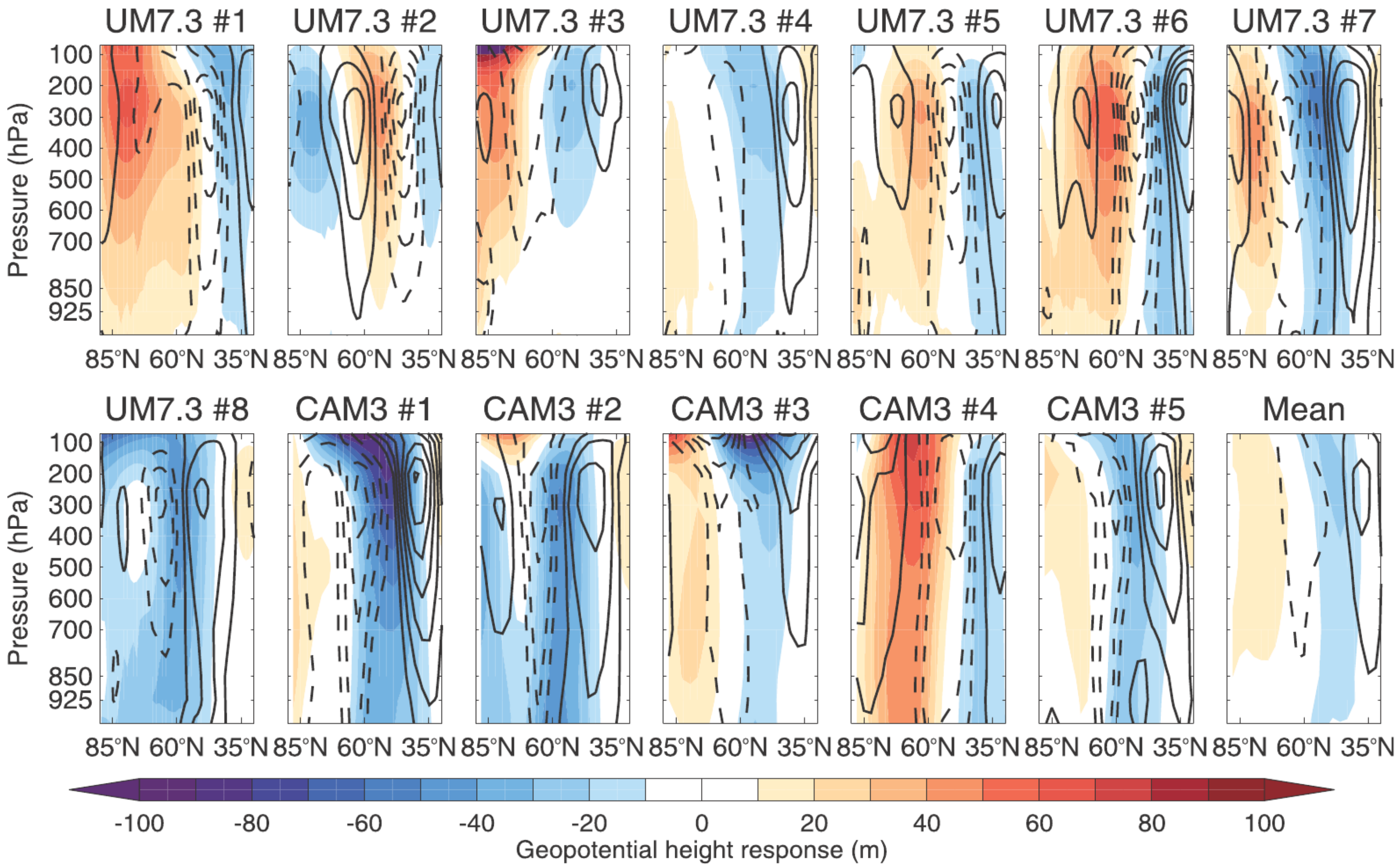
## 1) Remote dynamical response (signal vs noise, model uncertainties ?)

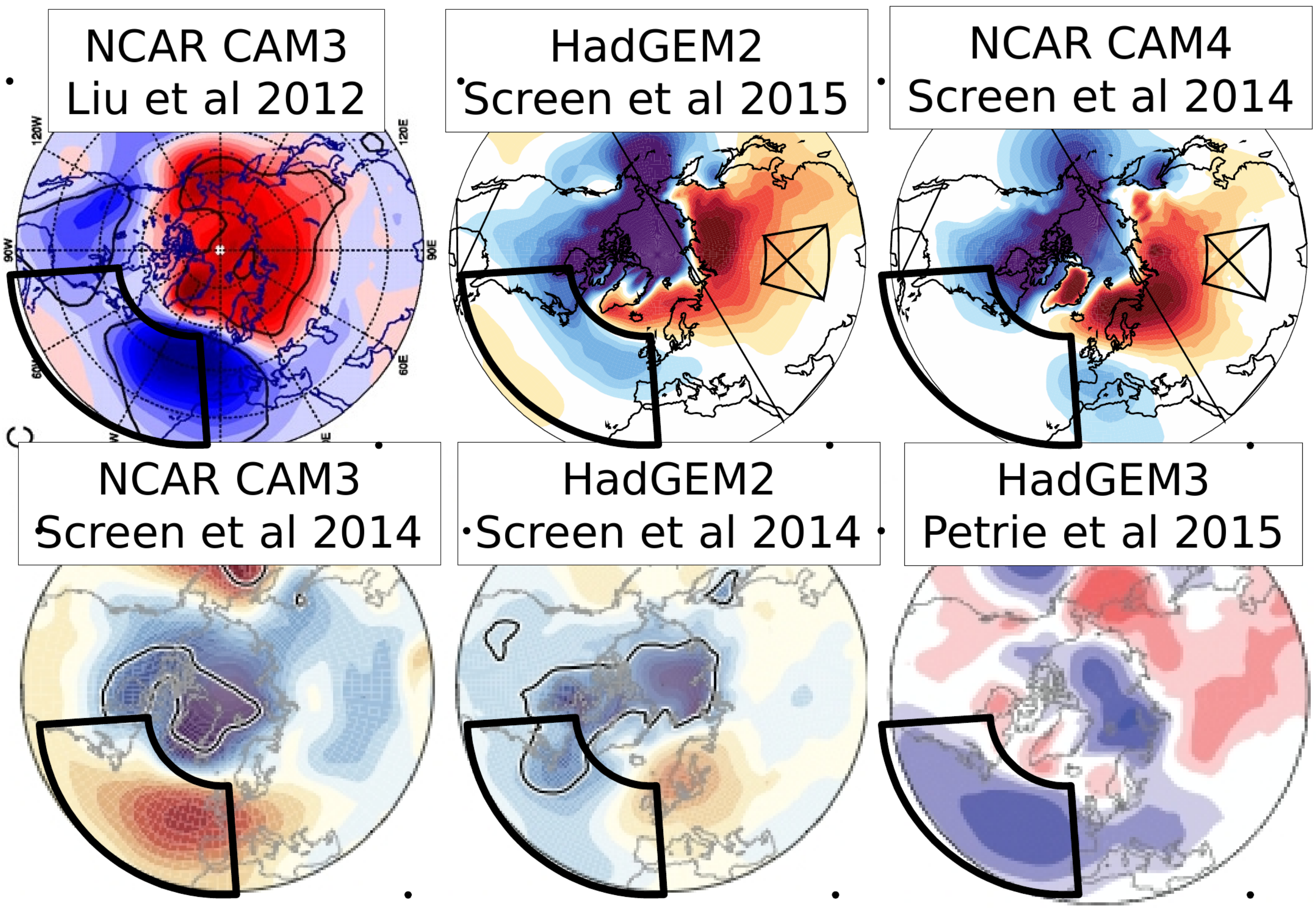
*Illustration of inter-model and inter-member spread in the atmospheric response*




*Screen et al. (2013)*

## 1) Remote dynamical response (signal vs noise, model uncertainties ?)

*Diversity in the response of winter SLP*



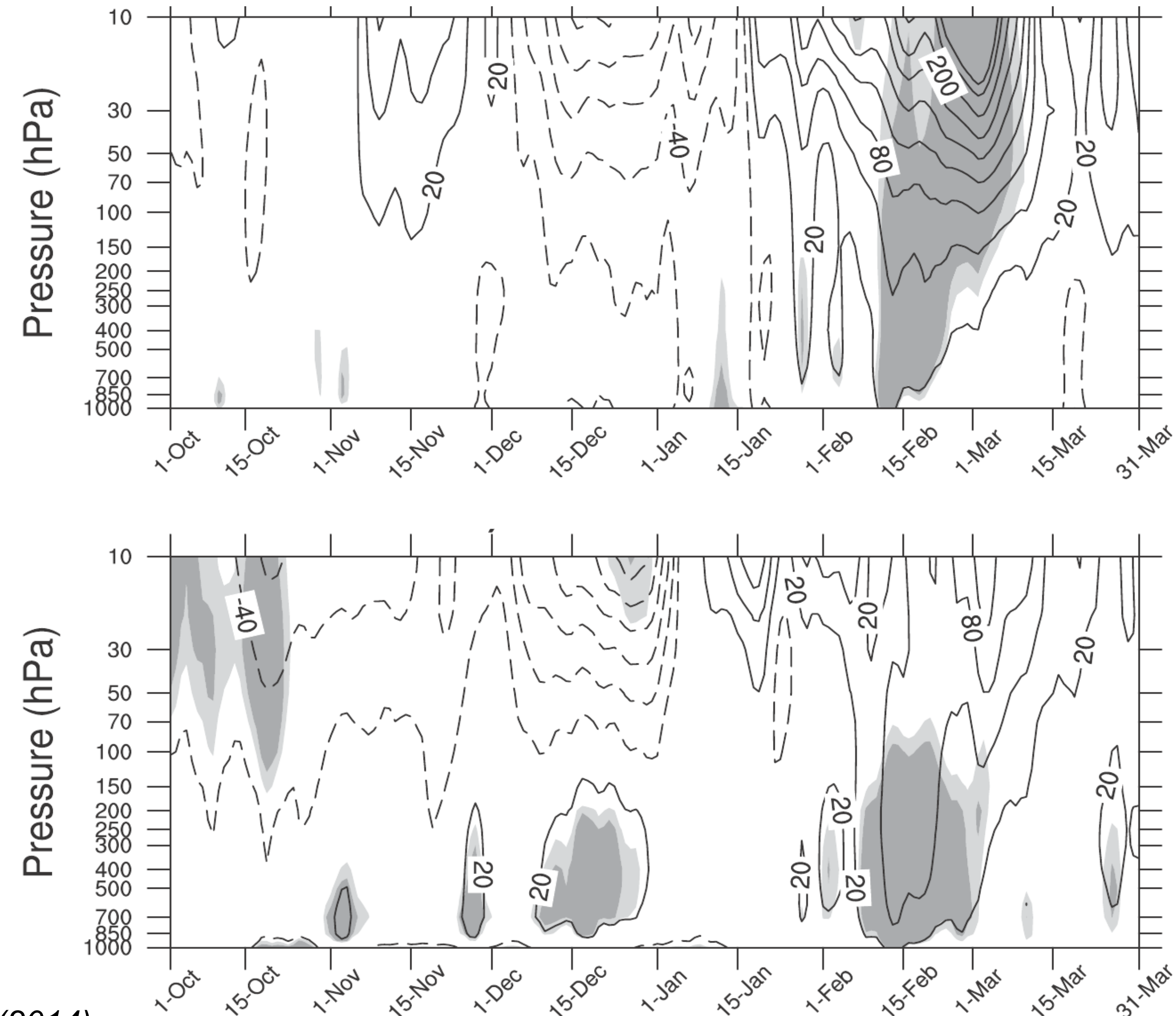

*Thanks to J. Screen*

## 1) Remote dynamical response (role of the stratosphere ?)

*Response of the polar cap geopotential (NAM anomalies) as a function of pressure and time*

**Recent sea ice anomalies (2007-2012)**

**Projected sea ice anomalies (RCP8.5 2080-2099)**



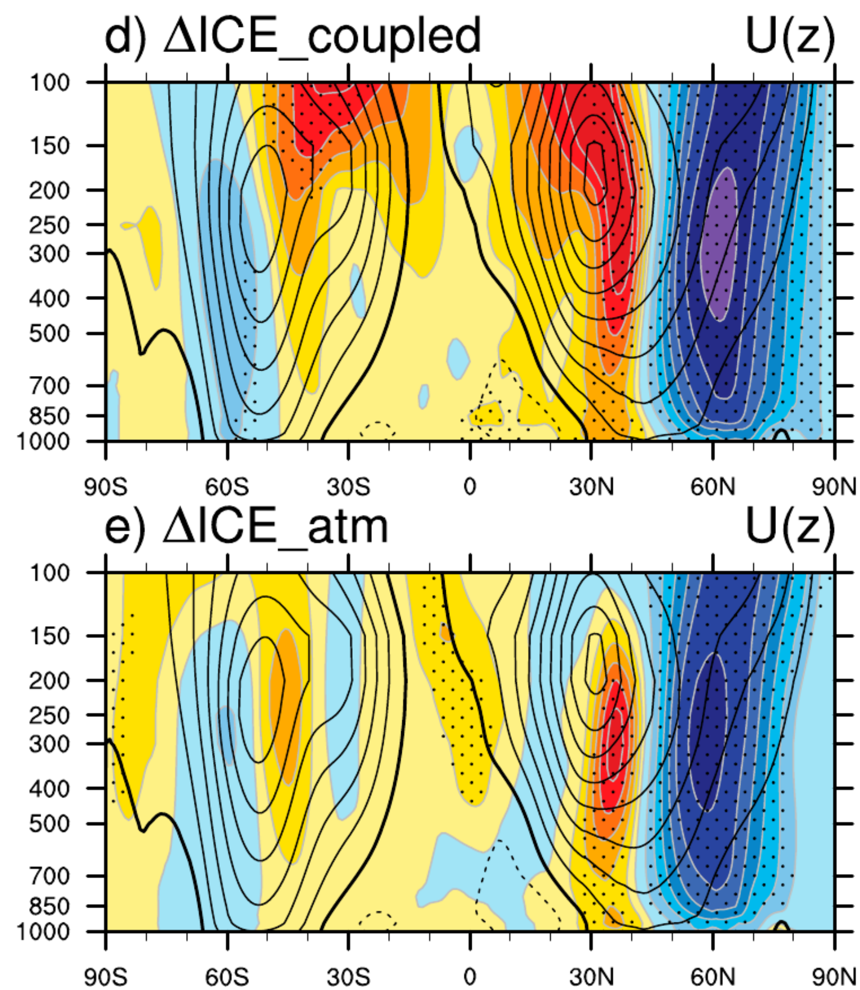

*Peings and Magnusdottir (2014)*

## 1) Remote dynamical response (role of ocean dynamics ?)

*Response of the DJF zonal wind to RCP8.5 sea ice loss*

**Response in OAGCM**

**Response in AGCM**




*Deser et al. (2015)*

**Using an interactive ocean reinforces the NH response and induces SH anomalies**

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**2) Competing influence of regional sea ice anomalies**

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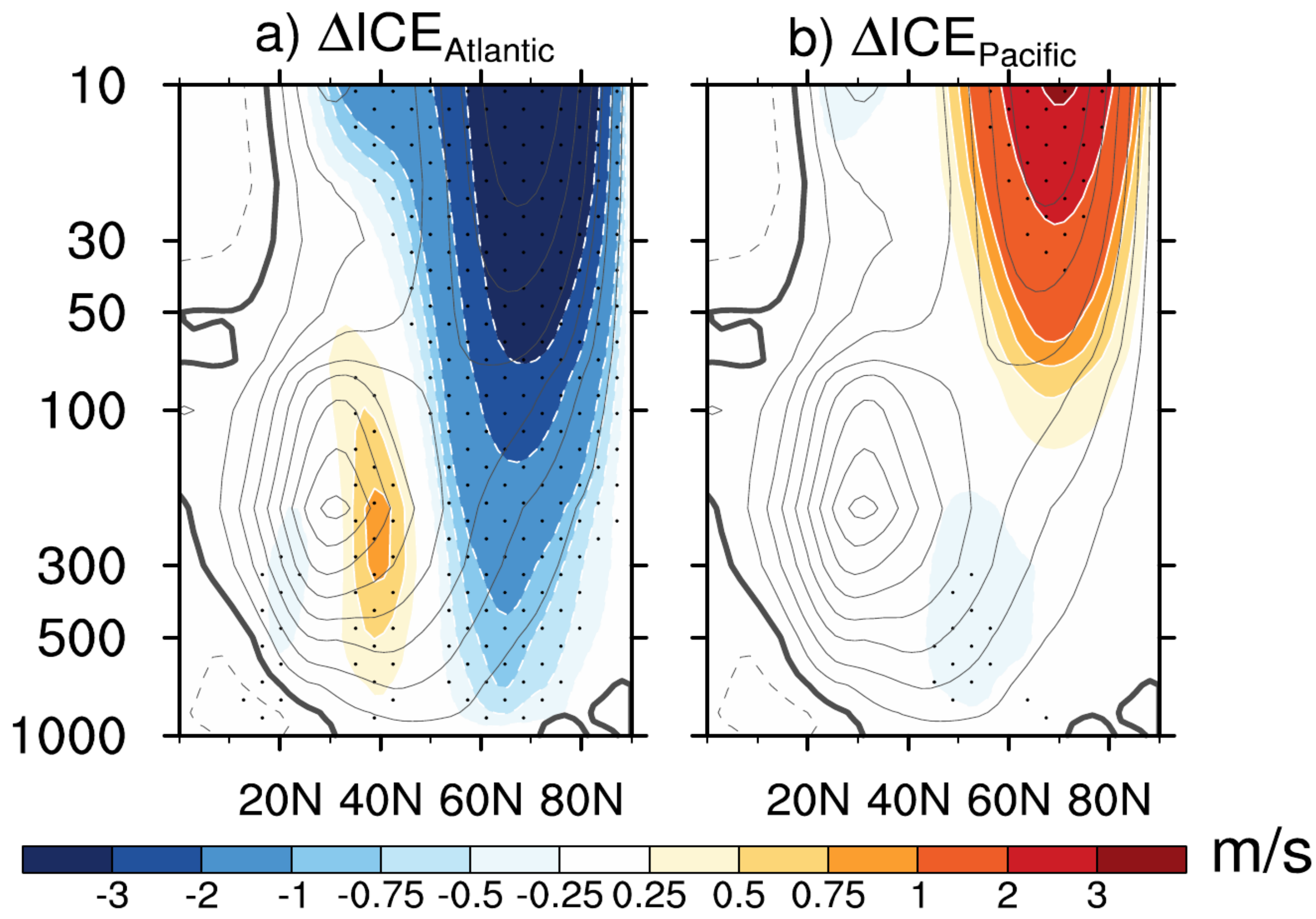
## 2) Competing influence of regional sea ice anomalies

*Response of the zonal wind : opposite effect of Atlantic vs Pacific RCP8.5 sea ice anomalies*




*Sun et al. 2015*

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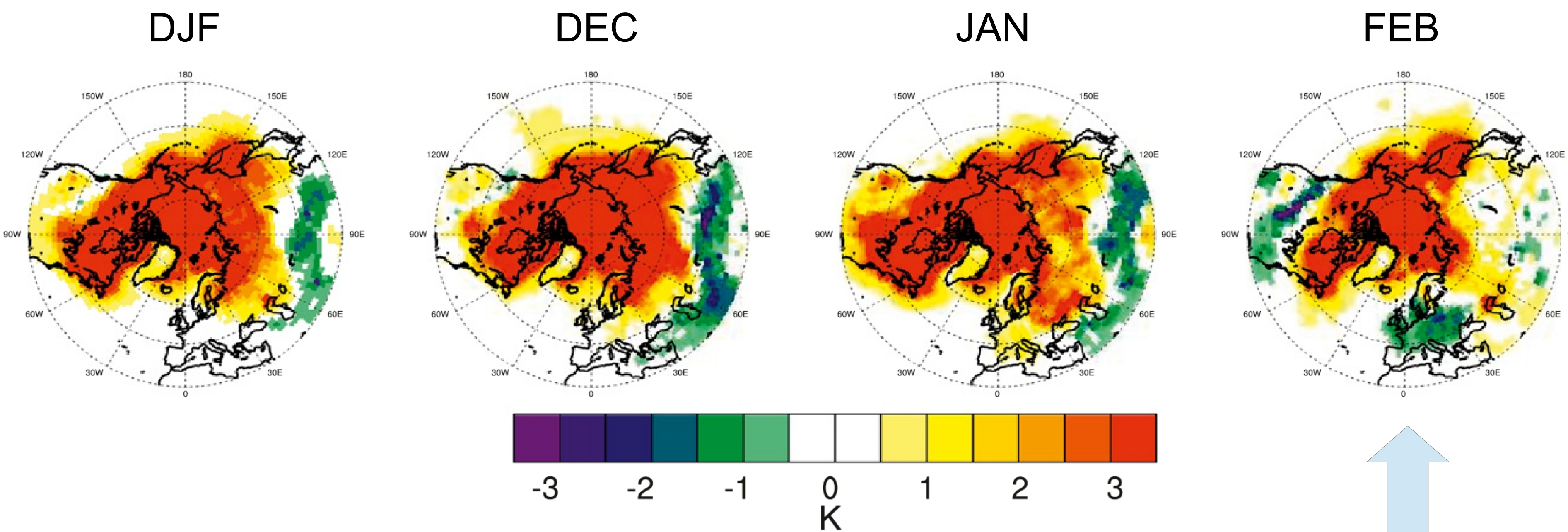
**3) Response in terms of cold winter extremes over Europe and North America**

4) Competition between the response to Arctic Amplification and other factors (global warming, oceanic decadal oscillations, etc ...)

## 3) Response in terms of wintertime cold extremes over Europe and North America

*Response of cold extreme temperature (10th percentile) to projected RCP8.5 2080-2099 sea ice anomalies in CAM5*




*Peings and Magnusdottir 2014*

**Larger NAO/NAM-response in February**

**Response in terms of cold extremes over Europe/North America is less clear than over Asia as it is more dependent on the large-scale dynamical response (NAO/NAM)**

**“Lower-confidence” results : conflicting findings or based on a single study**

1) Remote dynamical response to AA (e.g., signal vs internal atmospheric variability; role of the stratosphere; role of ocean dynamics)

2) Competing influence of regional sea ice anomalies

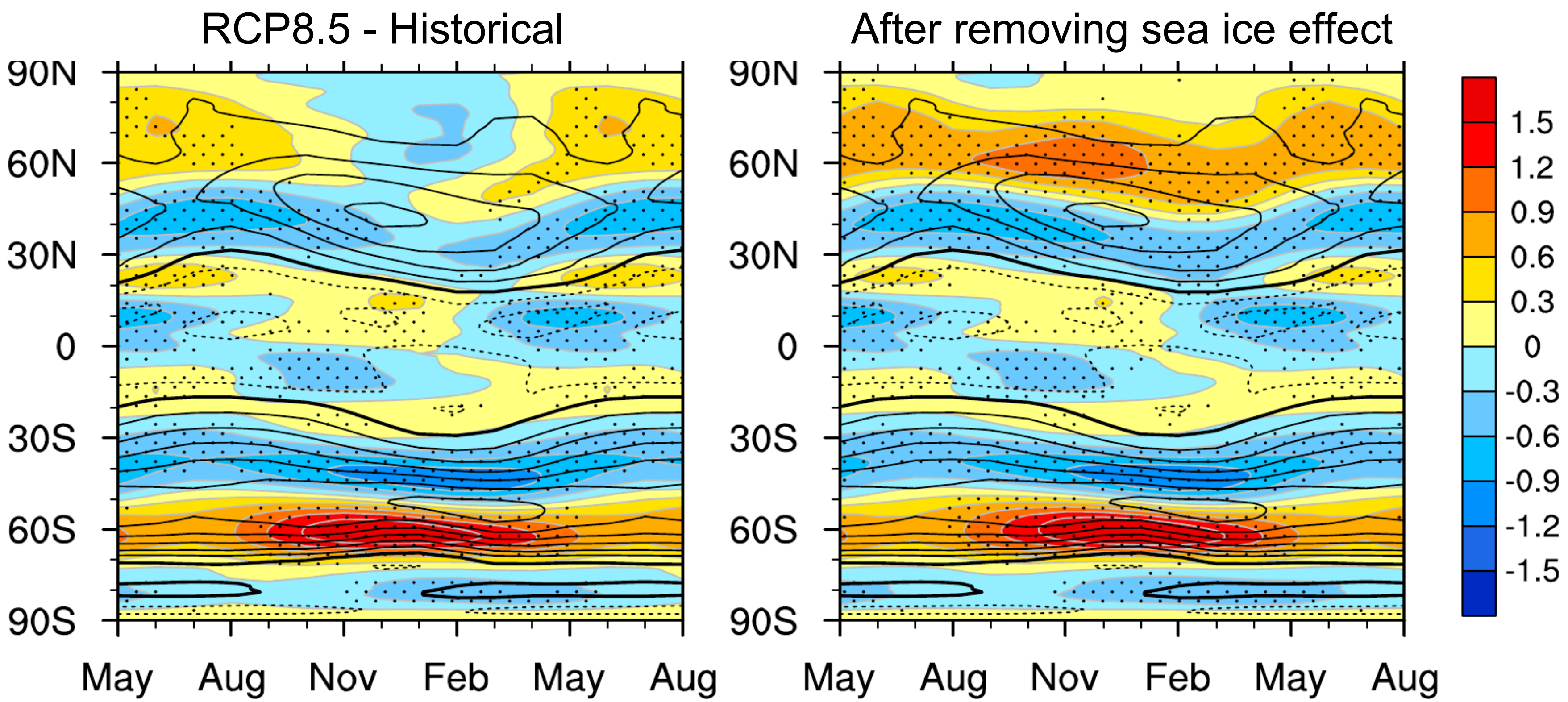
3) Response in terms of cold winter extremes over Europe and North America

**4) Competition between the response to Arctic Amplification and other factors (global warming, oceanic decadal oscillations, etc ...)**

# 4) Competition between Arctic Amplification and other factors

ex : Arctic amplification vs anthropogenic radiative forcing

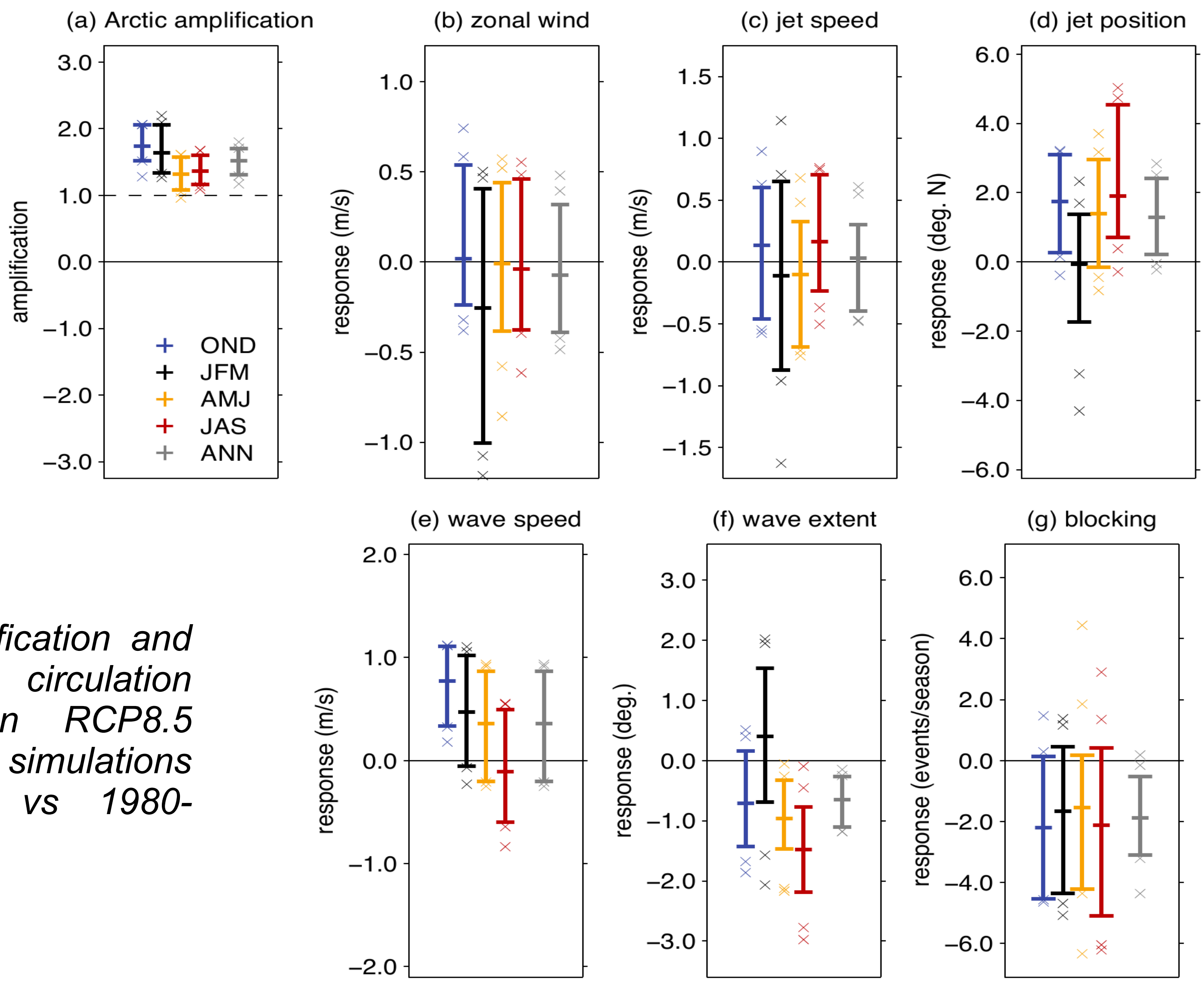
*Response of the 700 hPa zonal wind in RCP85 : role of sea ice loss*




*Deser et al. 2015*

**The response to AA explains the asymmetry between the NH and SH annular mode responses to GHG (competing mechanisms in the NH)**

# 4) Competition between Arctic Amplification and other factors




*Arctic amplification and mid-latitude circulation response in RCP8.5 CMIP5 simulations (2076-2099 vs 1980-2004)*

*Barnes and Polvani 2015*

# Which questions do we want to address ?

- Attribution of past trends or future projections ? Response to long-term sea ice loss or seasonal prediction ?

- Physical mechanisms (role of stratosphere, of ocean dynamics ?)

- Local role of regional sea ice anomalies or large-scale response to global Arctic anomalies ?

- Role of AA vs GHG in future projections of mid-latitudes climate ?

- …

# What types of experiments ?

• Multi-model AGCM experiments with identical SST/SIC anomalies to assess model dependencies

*- large ensemble required to get rid of internal variability, >100 members (Screen et al. 2014)*
*- AMIP vs fixed sea-ice forcing*
*- regional vs hemispheric sea ice anomalies to assess local influences (Kug et al. 2015)*
*- high-top models to assess the role of the stratosphere in communicating the response (Peings and Magnusdottir 2014)*
*- high vertical resolution in the boundary layer (impact on vertical distribution of heat released by the open sea and on the resulting large-scale response ?)*
*- additional contributors to Arctic Amplification, other than sea ice loss (e.g., snow cover decrease)*
*- daily outputs to investigate the response of subseasonal processes such as cold/warm spells, atmospheric blocking, sudden stratospheric warming, ...*

• OAGCM experiments since ocean-atmosphere coupling seems to play a crucial role in the response to Arctic sea ice loss (Deser et al. 2015)

*- feasibility of a common protocol ?*
*- availability of computing resources ?*

• Importance of AA relative to the full response to GHG changes (Deser et al. 2015, Screen et al. 2015b)
*- AMIP-type experiments with projected sea ice loss from RCP scenarios*

• … open to discussion !

# Coordination of the project

• What are the relevant funding opportunities ? (e.g., EU Horizon 2020 "Impact of Arctic changes on the weather and climate of the Northern Hemisphere", Year of Polar Prediction, ...)

• Do we want to suggest a “formal” MIP (Model Intercomparison Project; ArcMIP?)

• Do we want to coordinate with other programs such as CliC (Climate and Cryosphere) that can help with coordination etc … ?

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