

11th MedCOF / 2018

Role of sea-ice and snow cover on predictability of the Northern Hemisphere cold season

Javier García-Serrano (UB, BSC)

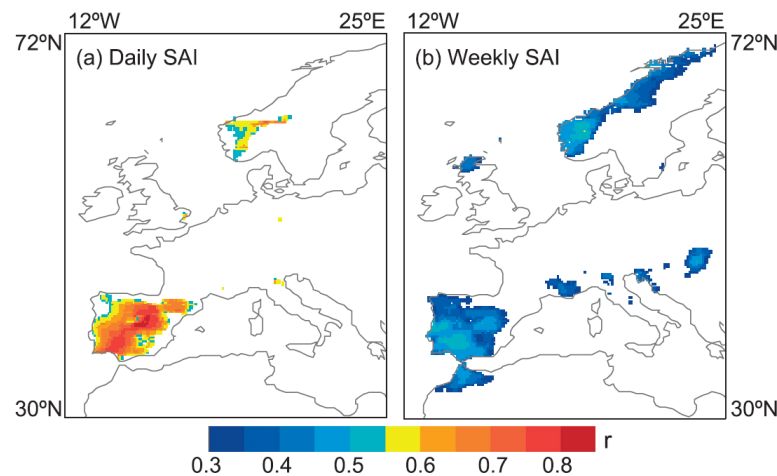
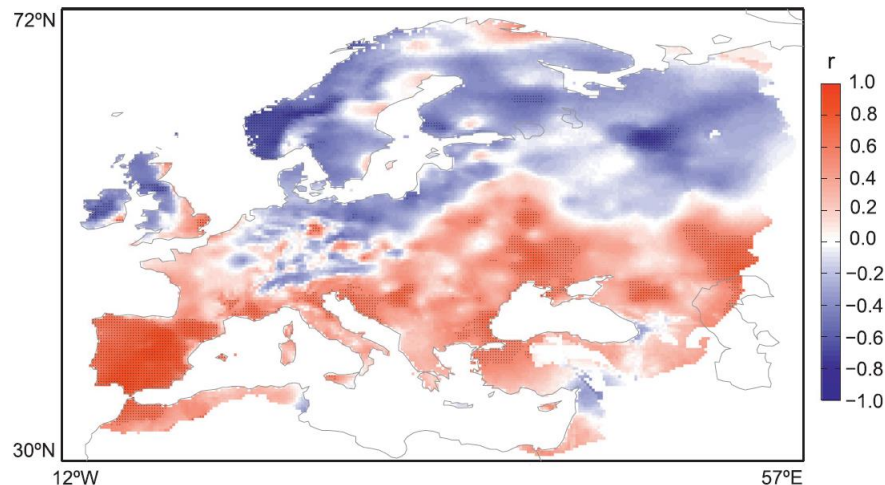
Eurasian snow cover in autumn (OCT)

[Cohen and co-authors]

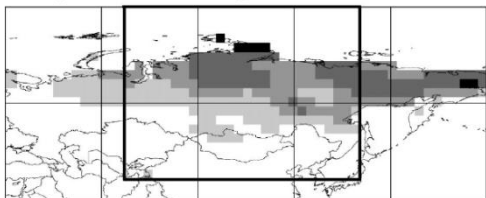
snow advance index - $SAI / r(AO)=0.6-0.8$

[Cohen and Jones 2011]

WINTER



a) October Snow Depth - CTRL Simulation



[Gong et al. 2003]

correlation / empirical prediction skill

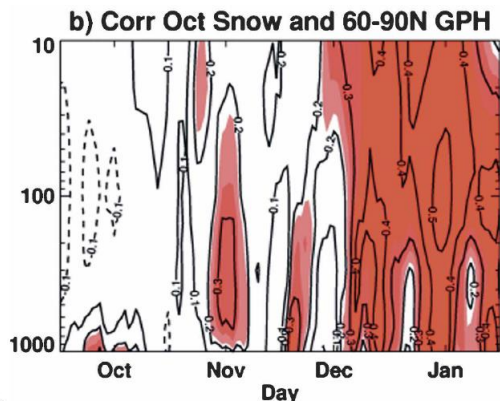
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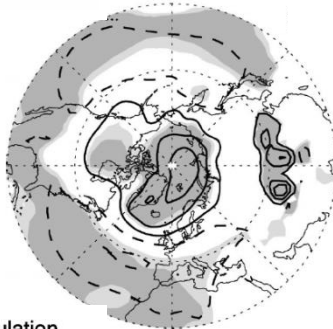
[Cohen and Jones 2011]



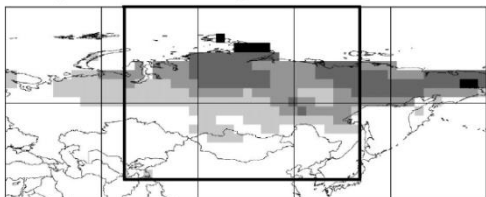
ON

[Cohen et al. 2007]

DJF

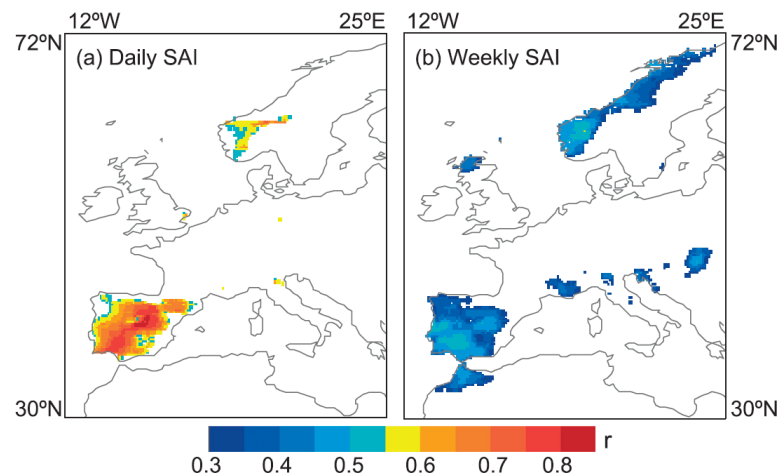
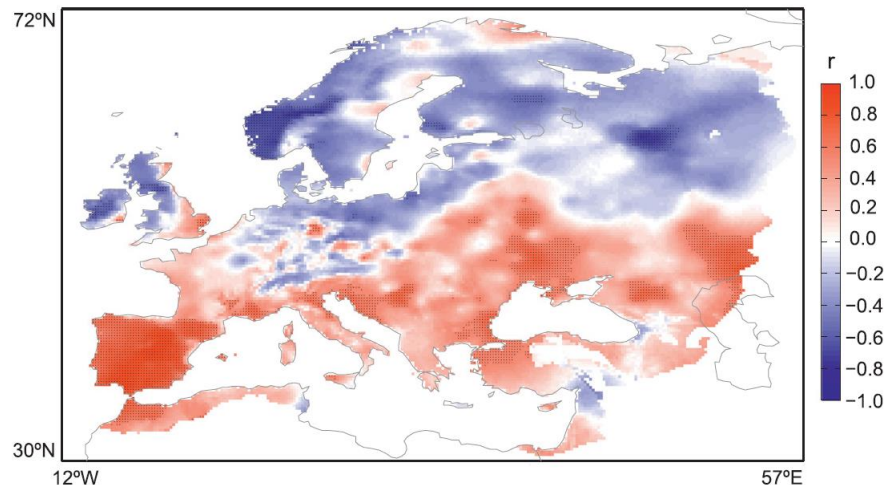


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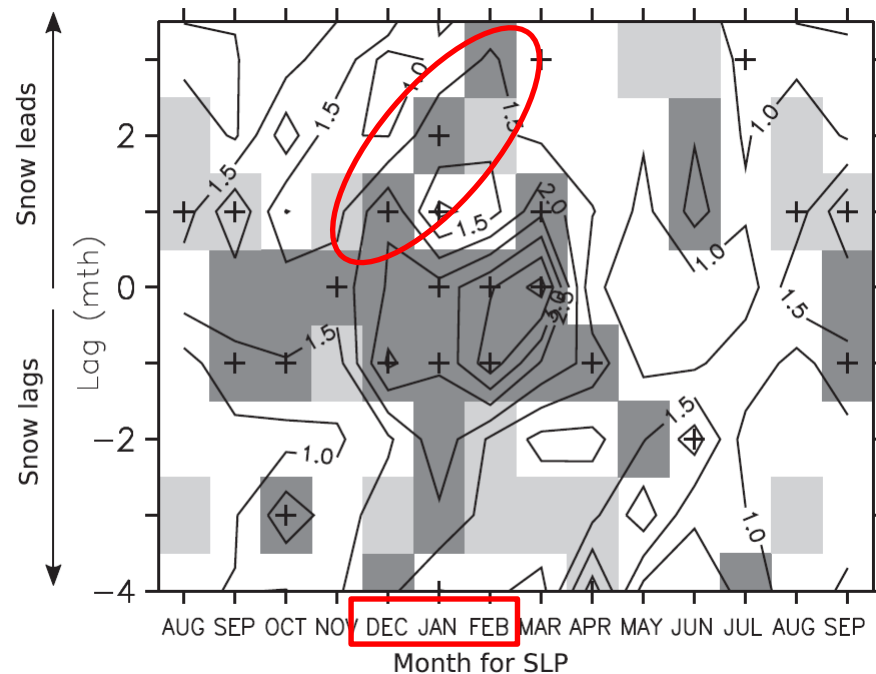
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Eurasian snow cover in autumn (OCT)



Eurasian snow cover in autumn (NOV)

WINTER



[Gastineau et al. 2017]

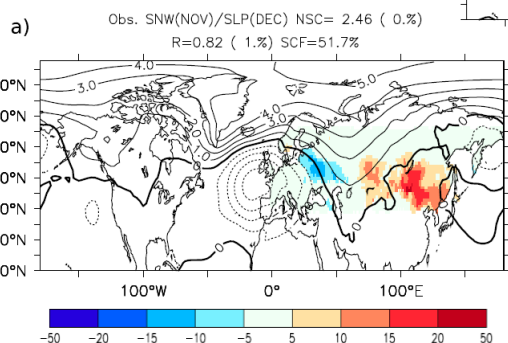
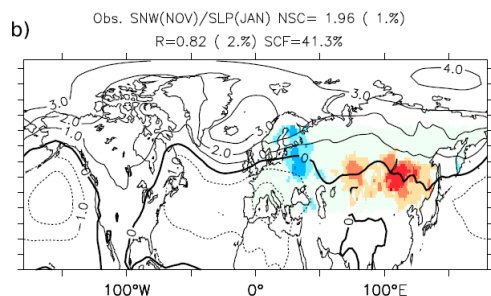
Local and remote impacts of seasonal snow cover on atmospheric circulation have been explored extensively, with observational and modelling efforts focusing on how Eurasian autumn snow-cover variability potentially drives Northern Hemisphere atmospheric circulation via the generation of deep, planetary-scale atmospheric waves. Despite climate modelling advances, models remain challenged to reproduce the proposed sequence of processes by which snow cover can influence the atmosphere, calling into question the robustness of this coupling.

Review in *Nature Climate Change*
[Henderson et al. 2018]

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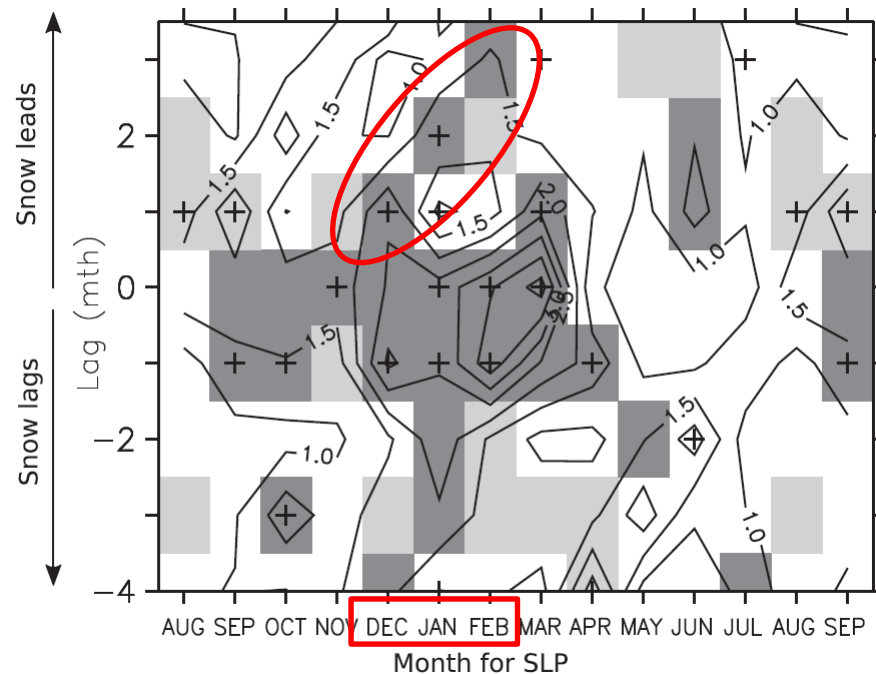


Eurasian snow cover in autumn (NOV)



[Gastineau et al. 2017]

WINTER



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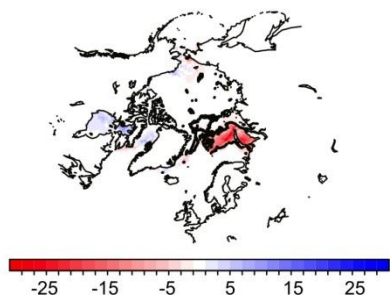
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Barents-Kara sea-ice concentration in autumn (NOV)

[García-Serrano et al. 2015; King et al. 2015; Koenig et al. 2015]

[Scaife et al. 2014; Dunstone et al. 2016]

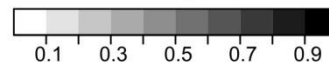
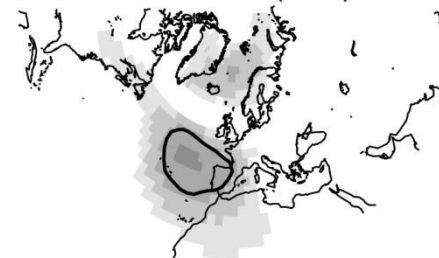
a) $MCA-SIC/BK_{NOV} \times SIC (nov)$



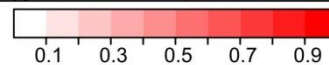
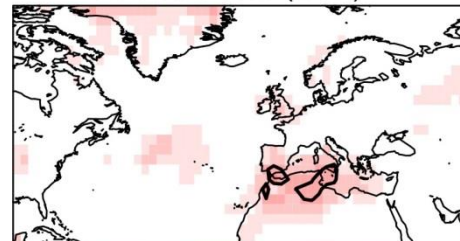
[García-Serrano et al. 2015, 2016]

WINTER

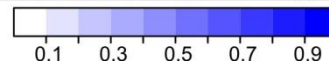
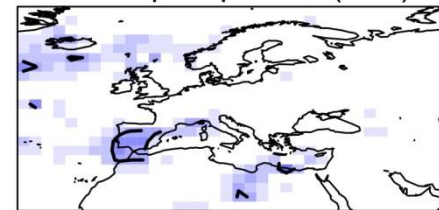
ERA-int SLP (DJF)



ERA-int SAT (DJF)



GPCP precipitation (DJF)



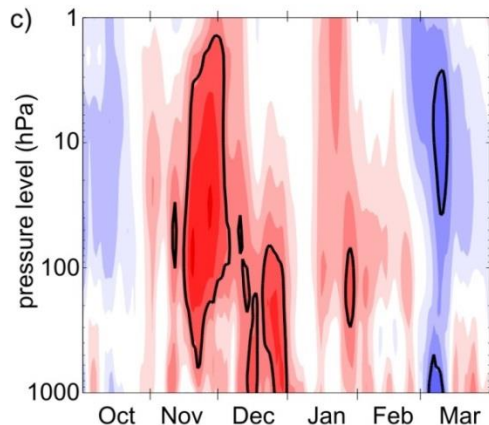
empirical prediction skill
[García-Serrano et al. 2015]

Barents-Kara sea-ice concentration in autumn (NOV)

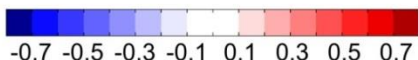
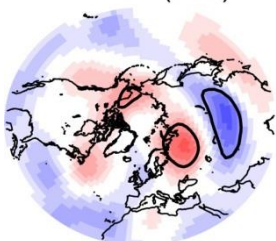
[García-Serrano et al. 2015; King et al. 2015; Koenigk et al. 2015]

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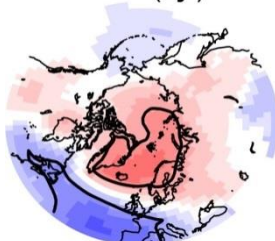
MCA-SIC/BK_{NOV} X HGT [60N-90N]



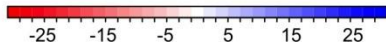
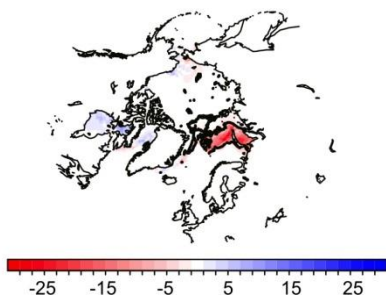
Z200 (nov)



SLP (djf)

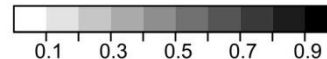
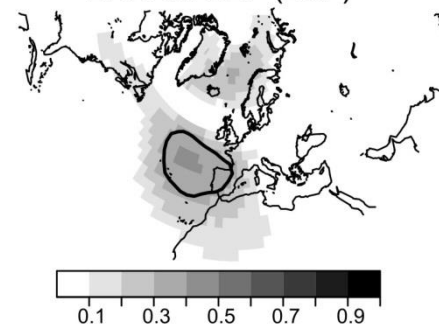


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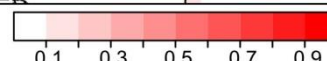
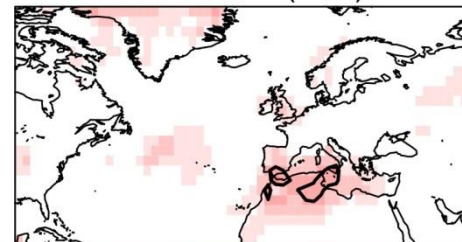


WINTER

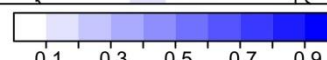
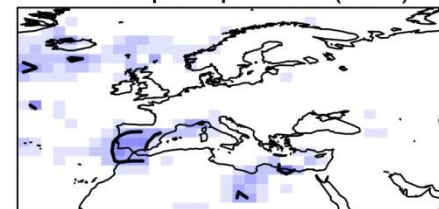
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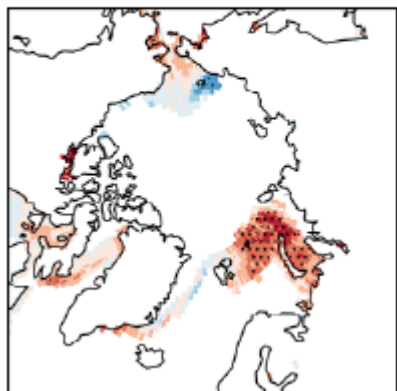
[García-Serrano et al. 2015, 2016]

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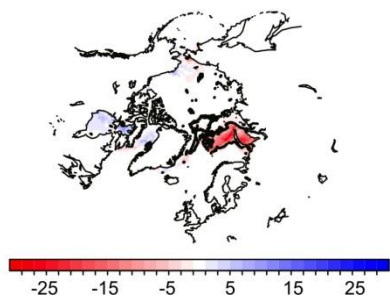
[Scaife et al. 2014; Dunstone et al. 2016]

Obs NAO corr.
Nov ice area



[Dunstone et al. 2016]

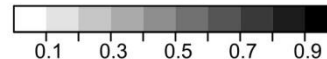
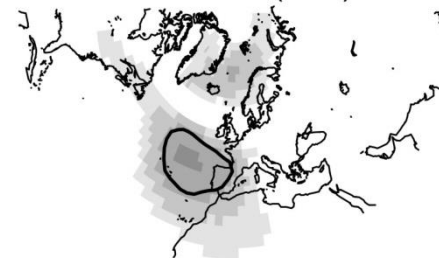
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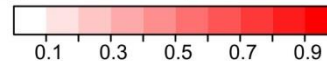
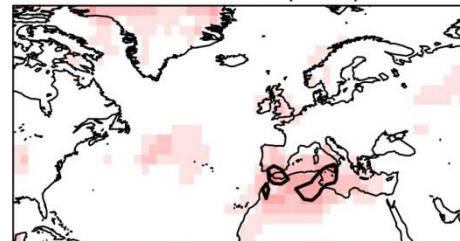
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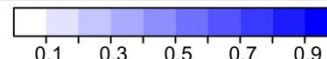
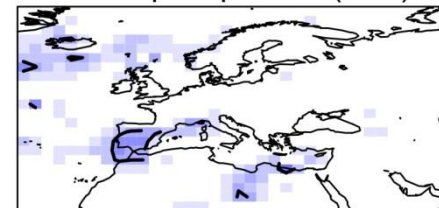
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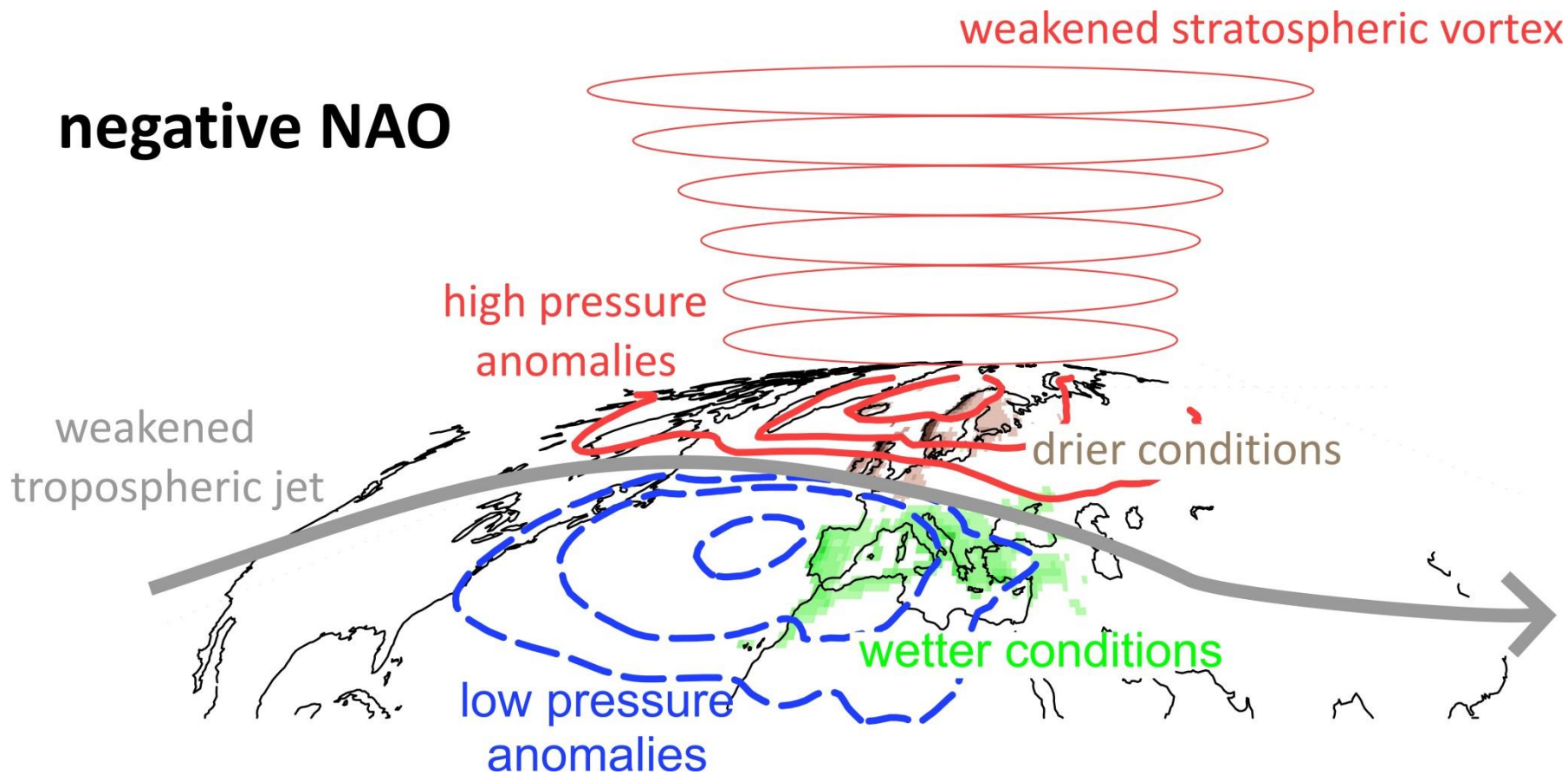
empirical prediction skill

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stratospheric pathway to winter NAO

(sea-ice reduction / increased snow)

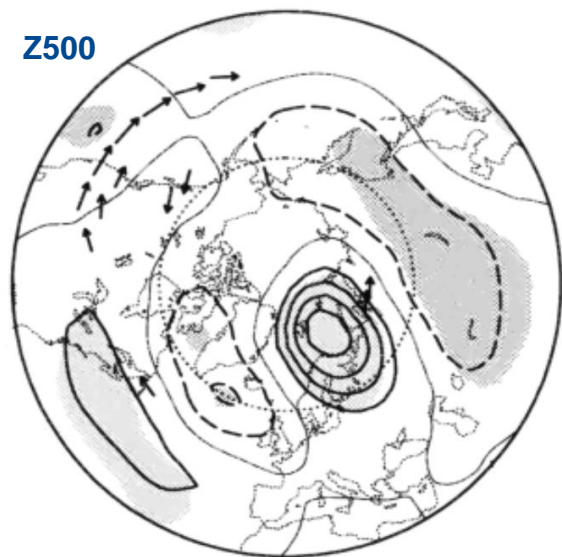
negative NAO



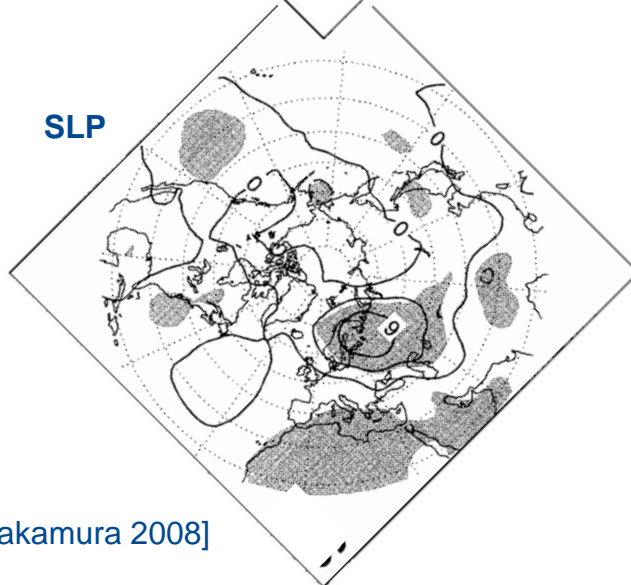
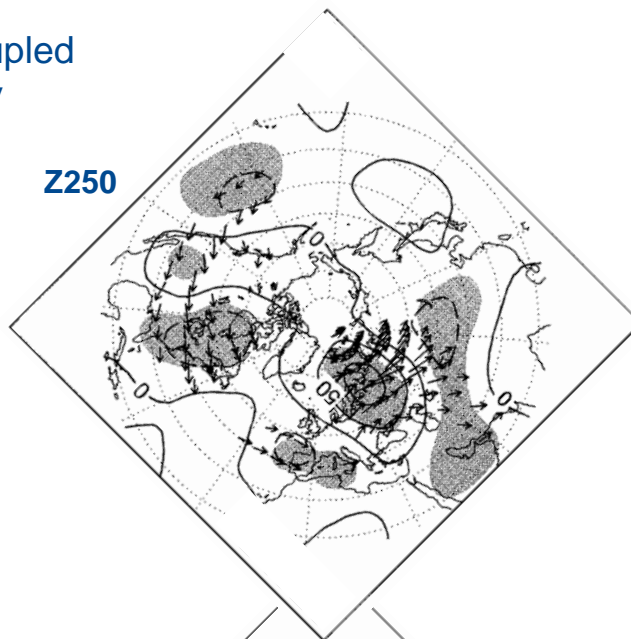
what precedes to the winter NAO → NAO precursors

November

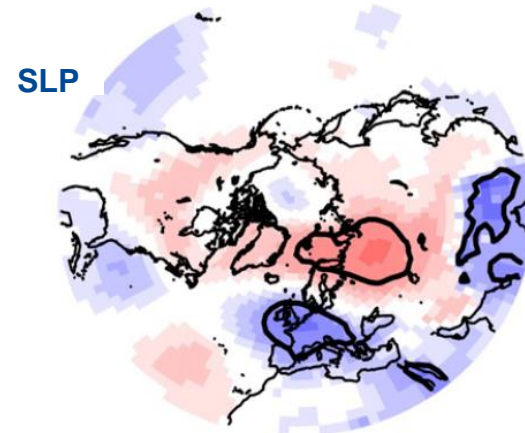
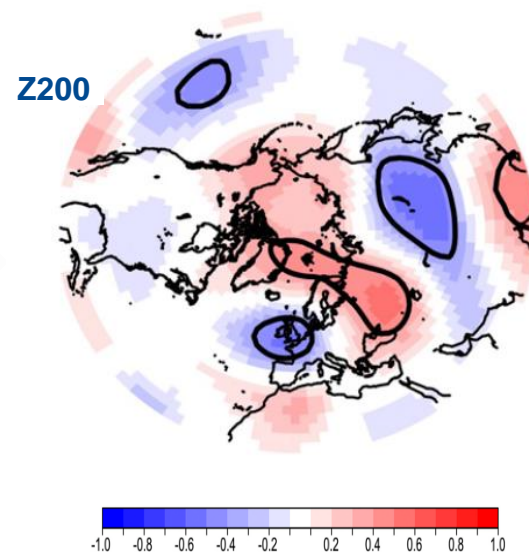
wave-like anomalies over Eurasia coupled to troposphere-stratosphere variability



[Kuroda and Kodera 1999]



[Takaya and Nakamura 2008]



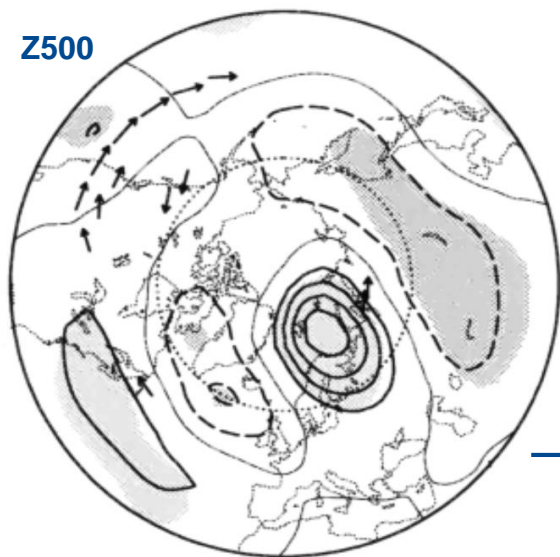
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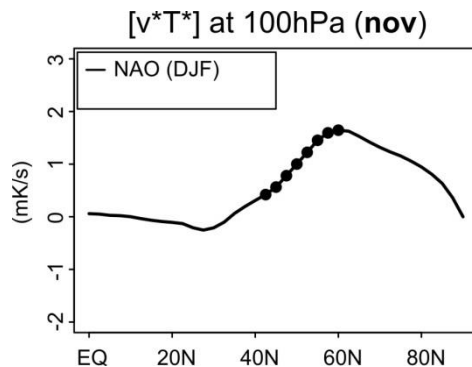
November

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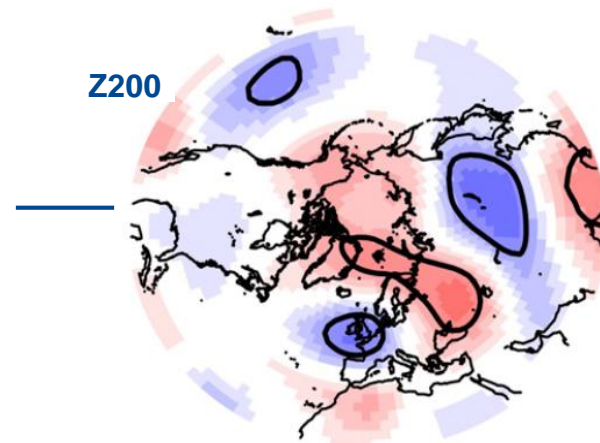
Z500



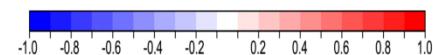
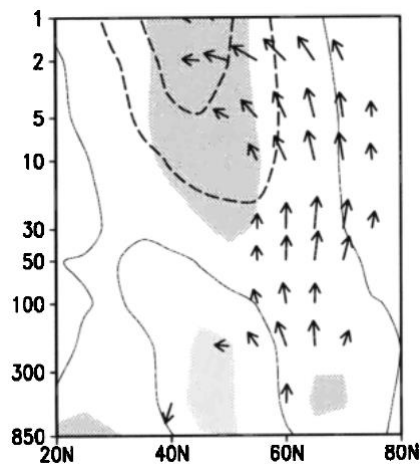
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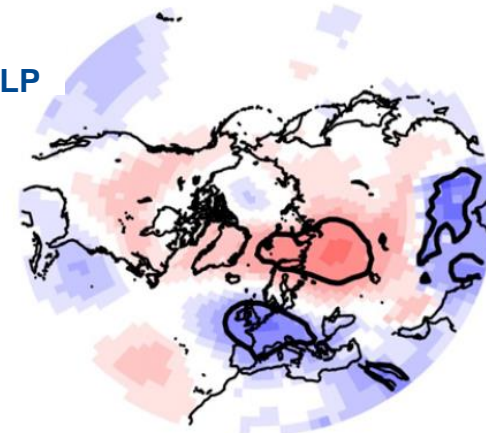
Z200



E-P flux



SLP



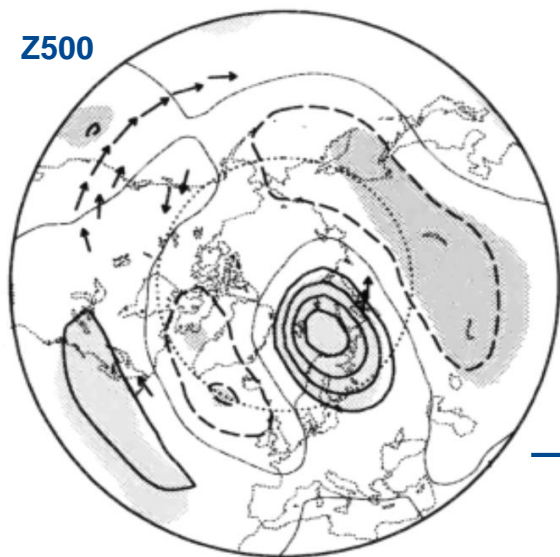
[García-Serrano et al. 2015] 10

what precedes to the winter NAO → NAO precursors

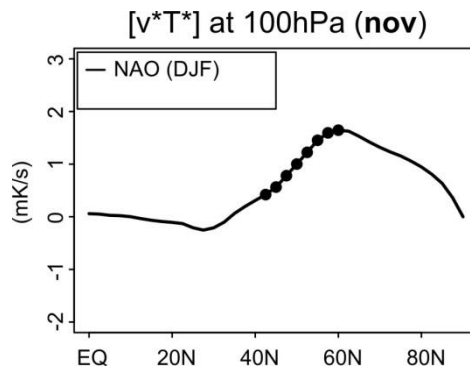
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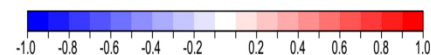
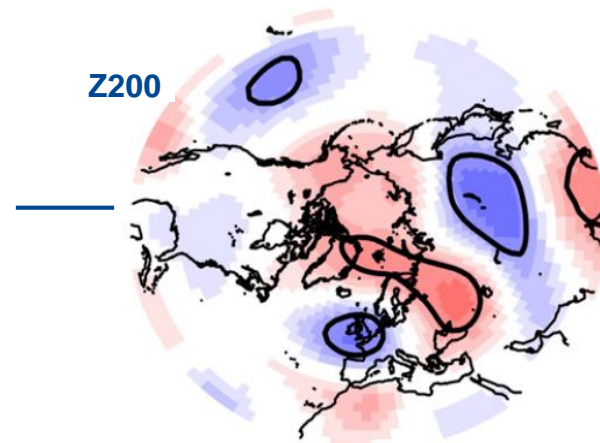
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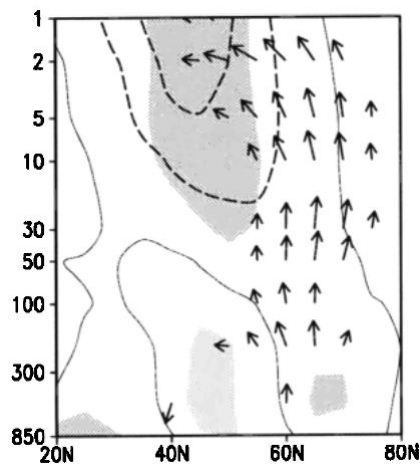


Z200



[García-Serrano et al. 2015]

E-P flux



linear interference with climatological wave pattern



[Garfinkel et al. 2010]

NAO precursors linked to surface forcing ?

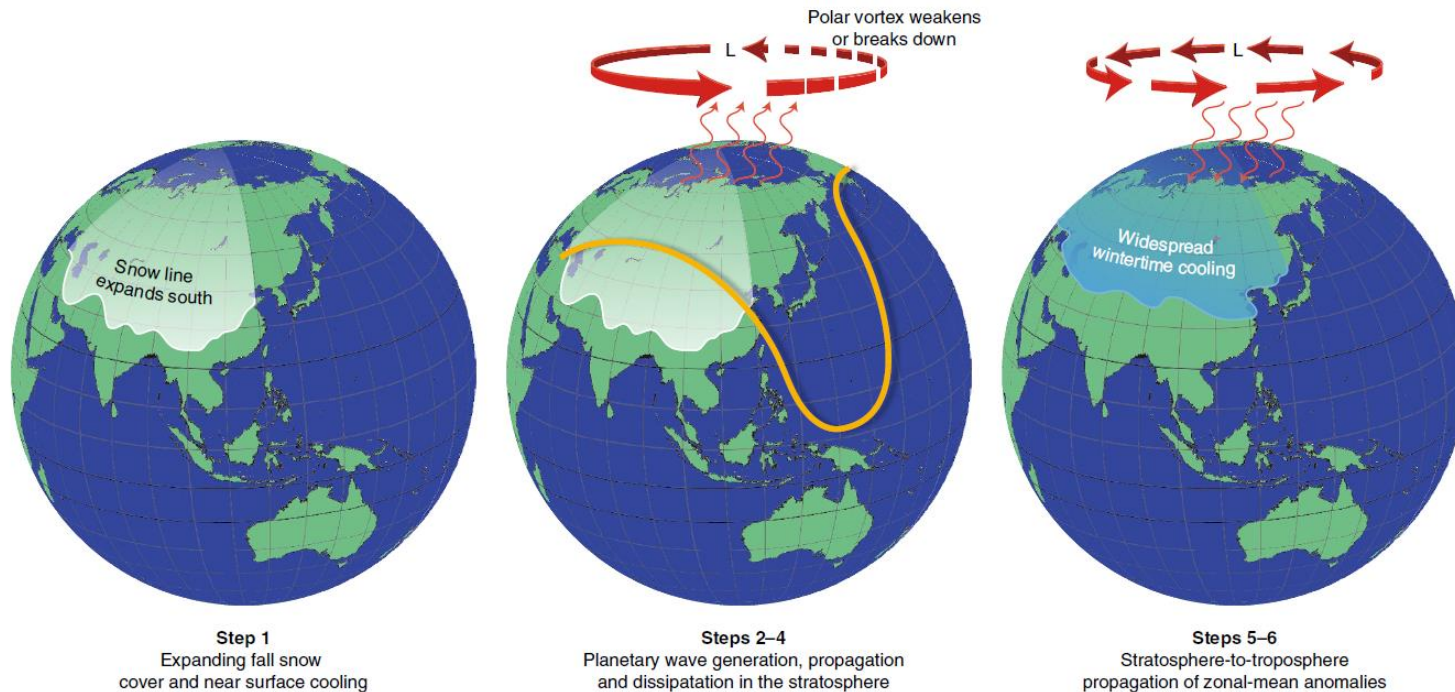
sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

increased snow → cools the boundary layer (*radiative fluxes*)

NAO precursors linked to surface forcing ?

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Review in *Nature Climate Change*
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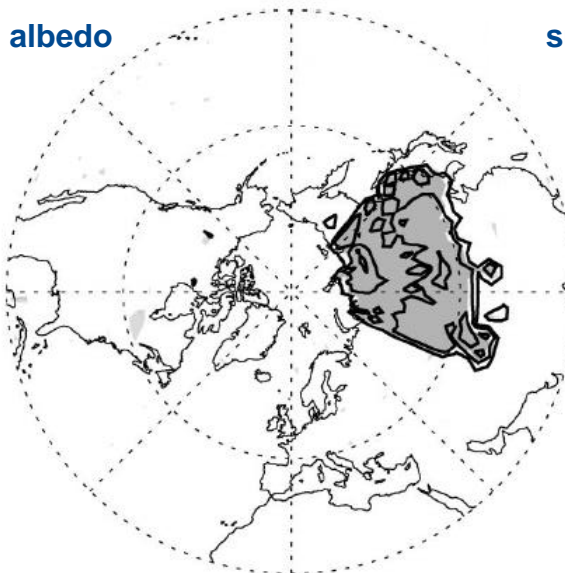
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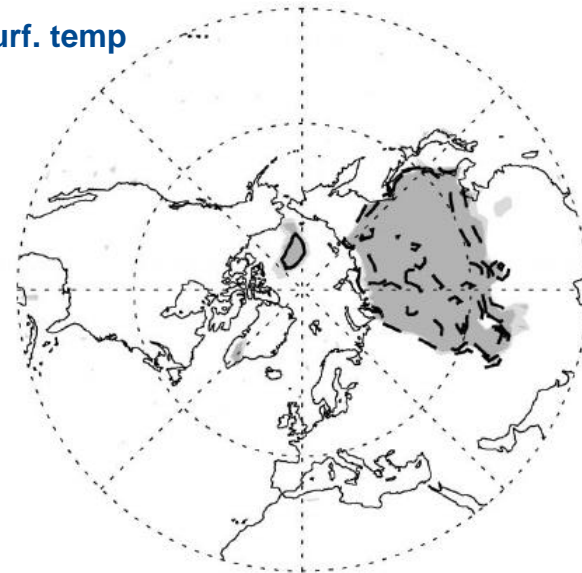
Step 1
 Expanding fall snow cover and near surface cooling

[Henderson et al. 2018]

albedo



surf. temp



[Gong et al. 2003]

NAO precursors linked to surface forcing ?

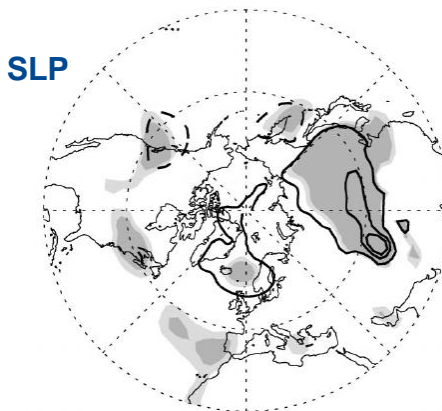
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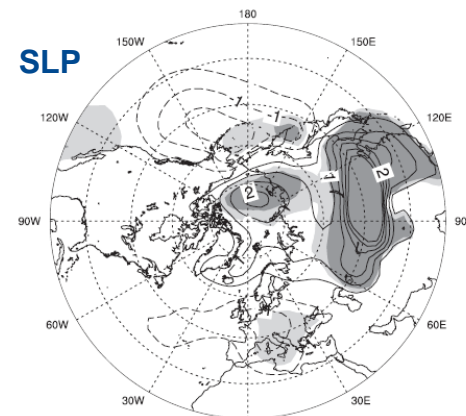
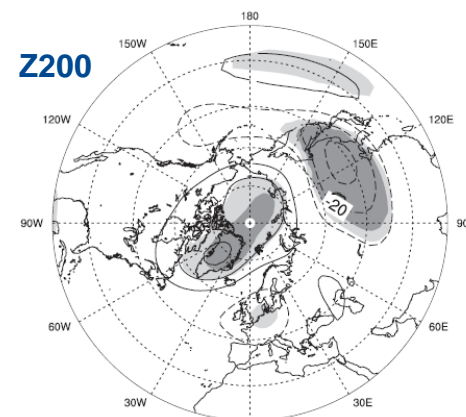


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[Gong et al. 2003]



[Peings et al. 2012]

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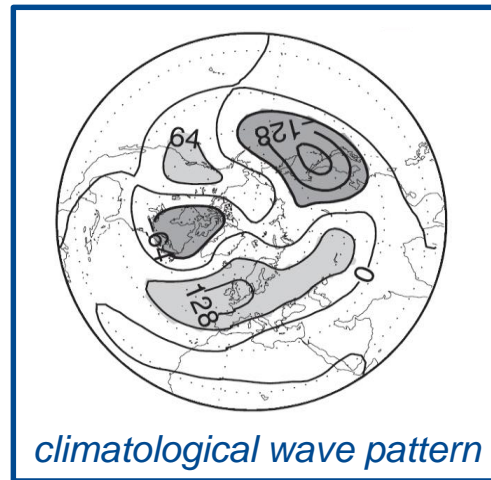
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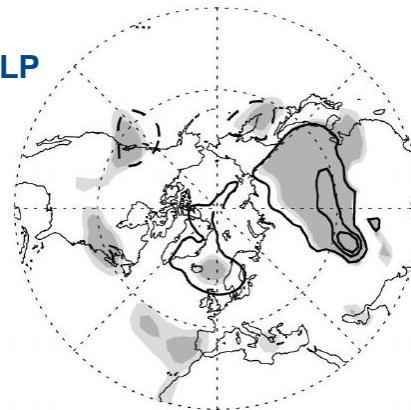


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Expanding fall snow cover and near surface cooling

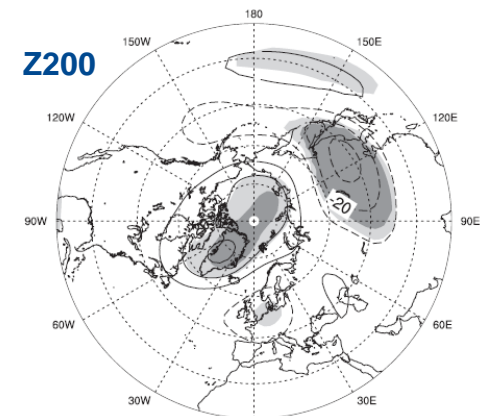
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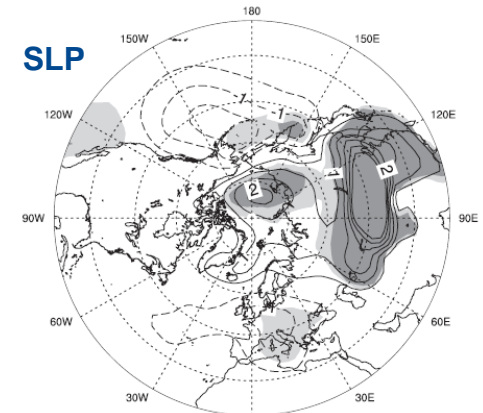
SLP



[Gong et al. 2003]



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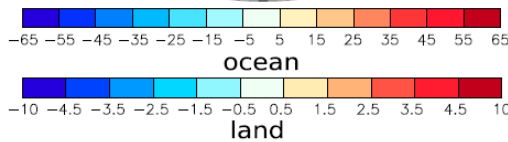
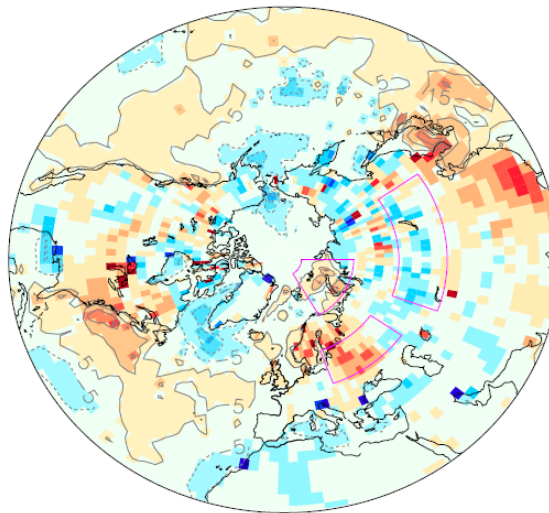
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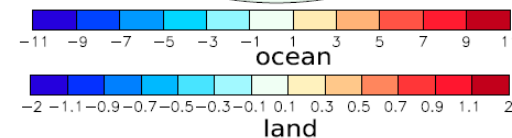
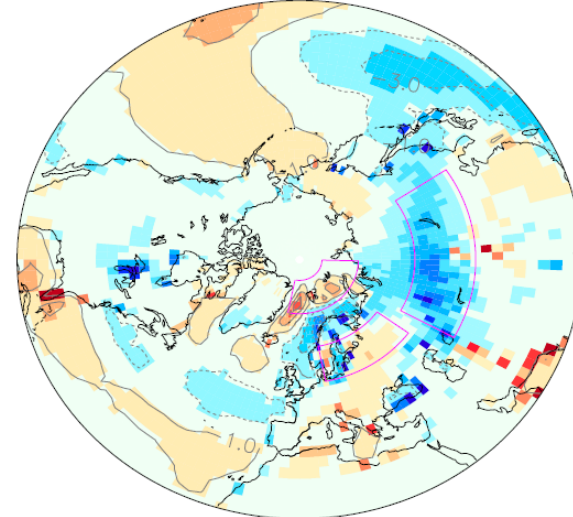
Step 1
Expanding fall snow cover and near surface cooling

[Henderson et al. 2018]

Obs. 79-14



Models



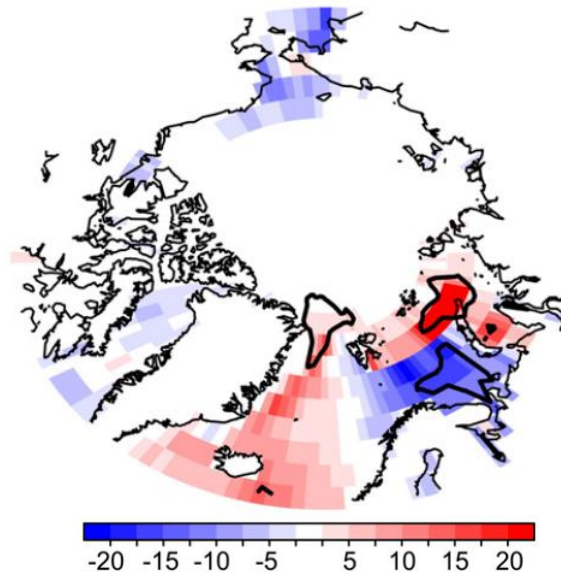
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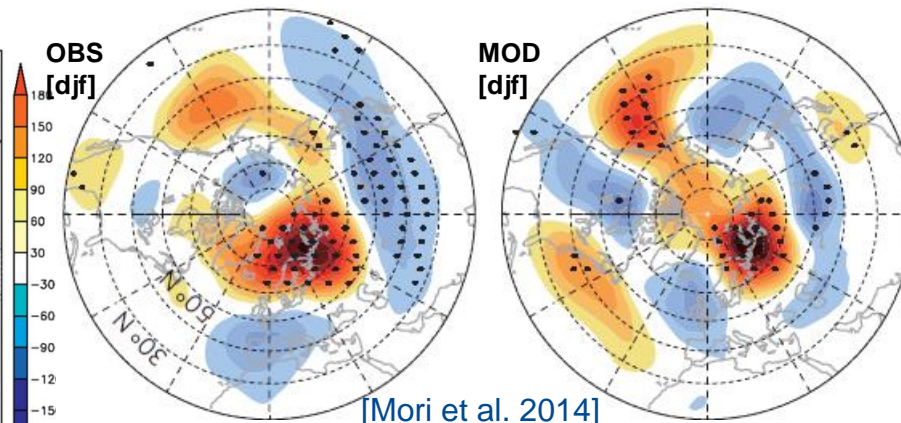
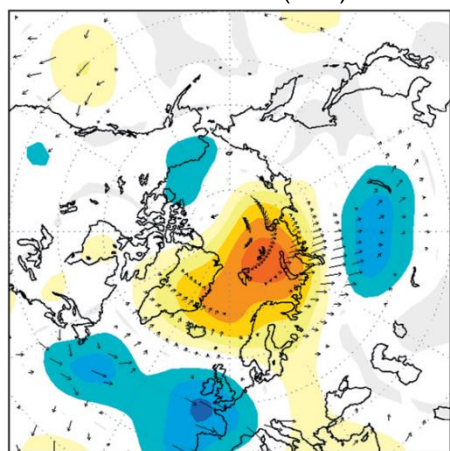
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turbulent heat flux [shf+lhf]
MCA-SIC/BK_{NOV} X (nov)

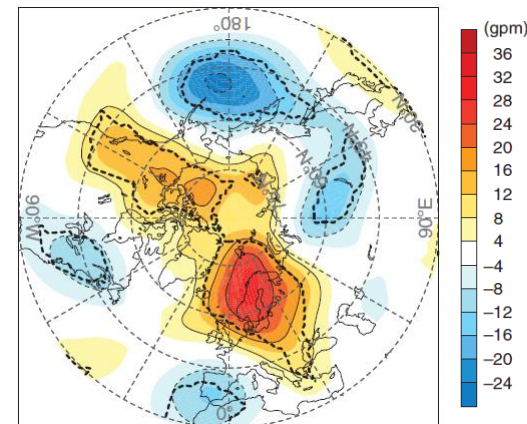


[García-Serrano et al. 2015]

Z250 / WAF (DJF)

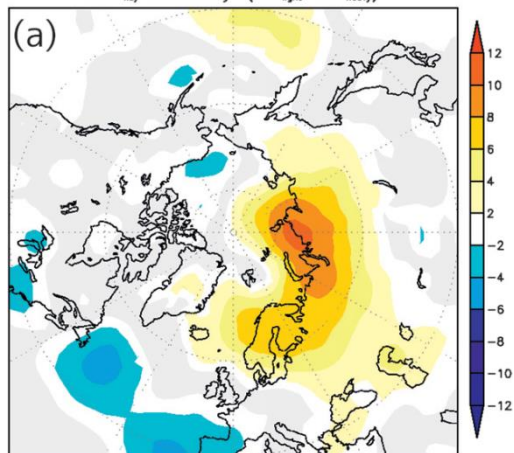


$\Delta Z500$ for ND, CAM5

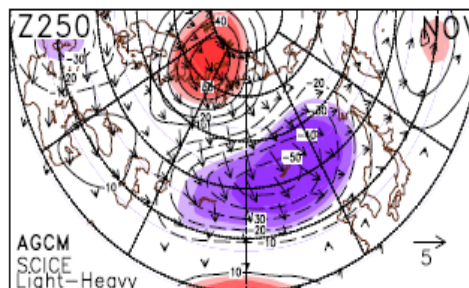


[Kim et al. 2014]

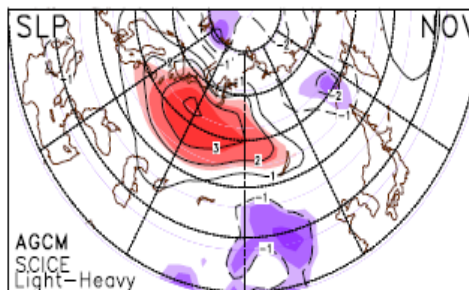
SLP_{key} anomaly (Ice_{light} - Ice_{heavy})



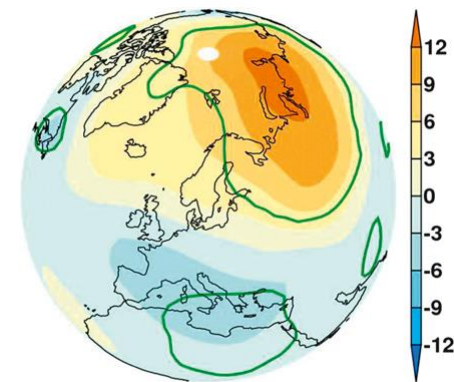
[Inoue et al. 2012]



[Honda et al. 2009]



SLP JAN [CAM]

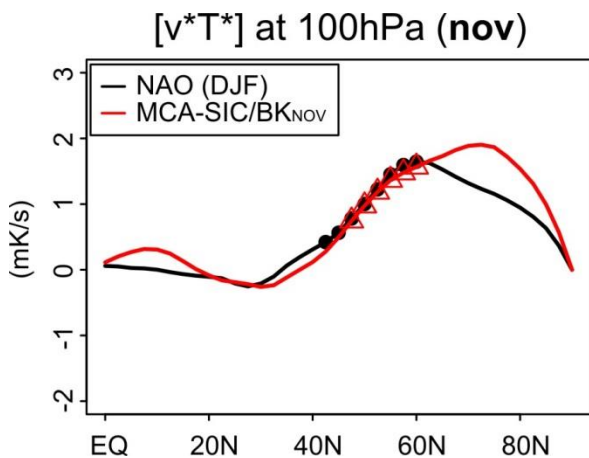


[Grassi et al. 2013]

hPa

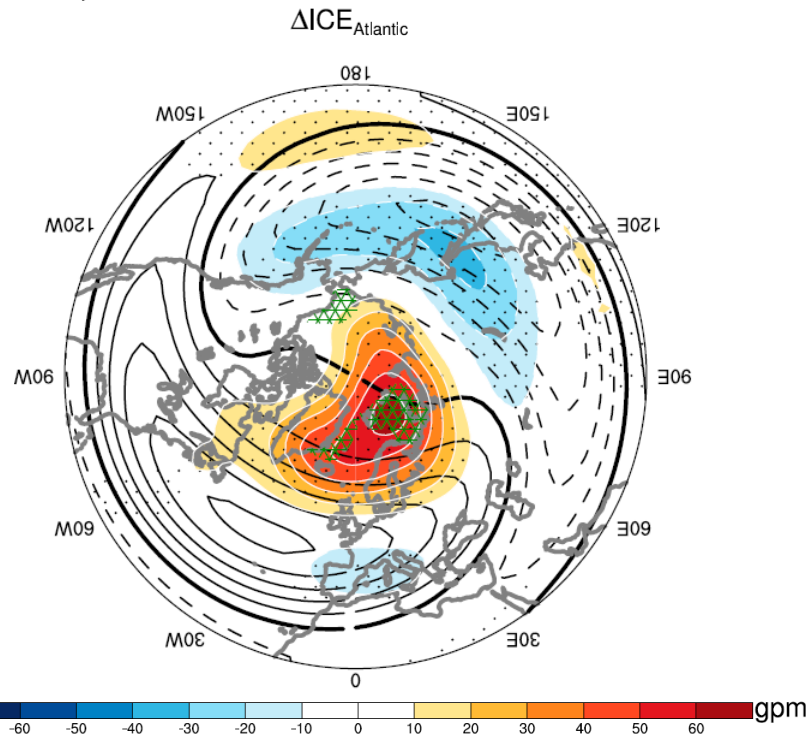
might be non-linear to SIC reduction!

[Petoukhov and Semenov 2010]

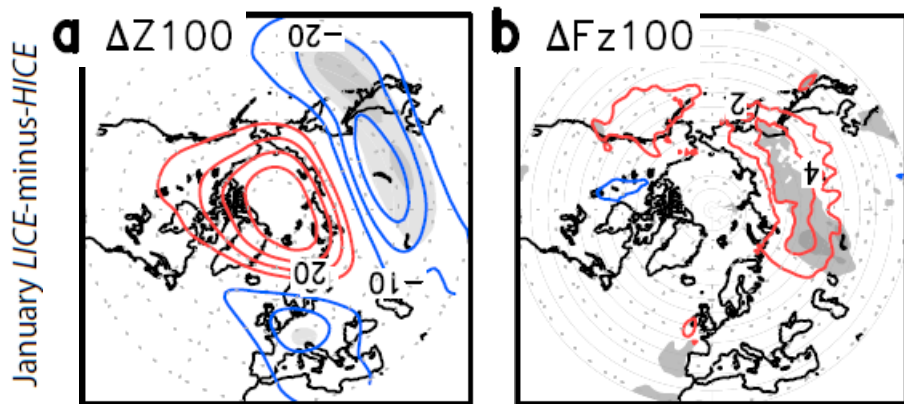


[García-Serrano et al. 2015]

b) Z at 300 hPa Dec-Jan



[Sun et al. 2015]

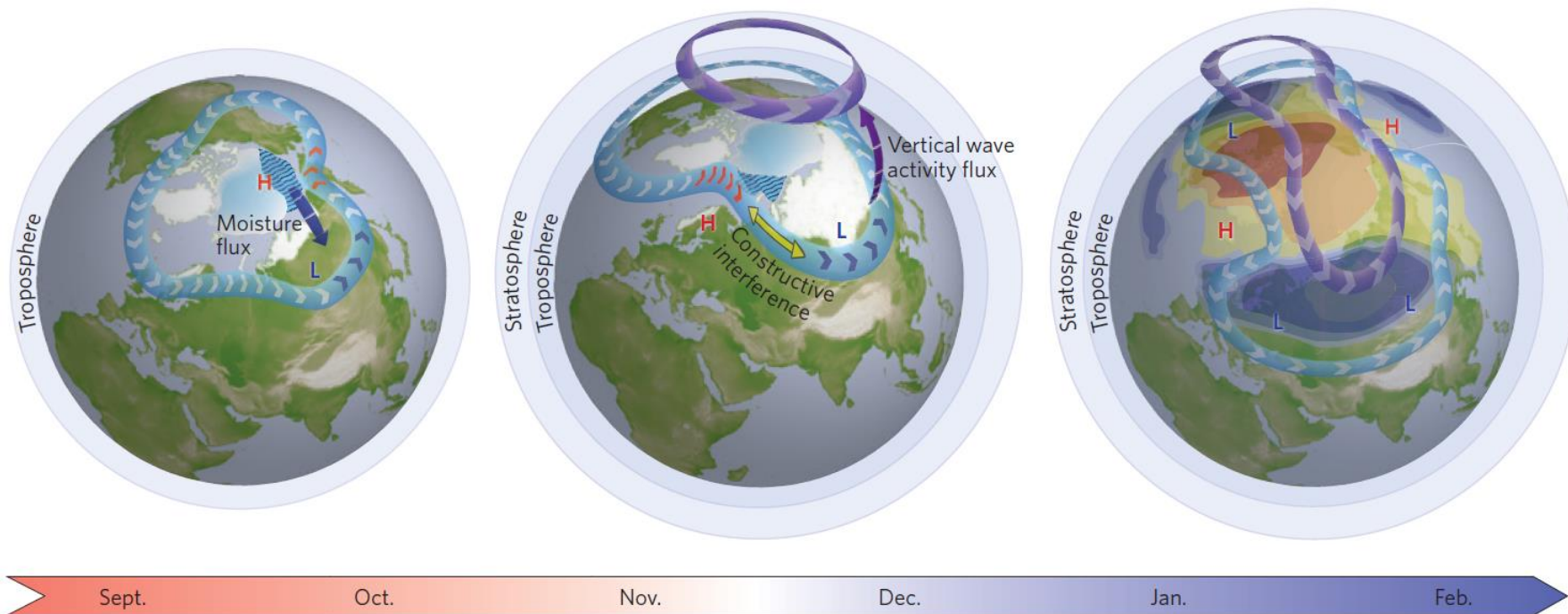


[Nakamura et al. 2016]

might be non-linear to SIC reduction!

[Petoukhov and Semenov 2010]

predictability of Northern Hemisphere climate from cryospheric variability (sea-ice + snow cover)



Review in *Nature Geoscience*
 [Cohen et al. 2014]

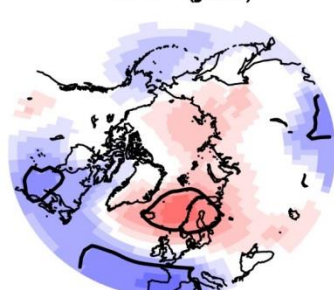
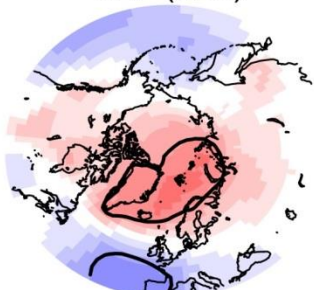
SUMMARY:

- ...other forcings may play a larger role in seasons when ENSO signal is weak
 - SEA-ICE (*Barents-Kara Seas*): thermally-induced / turbulent heat flux (sensible+latent) – Rossby wavetrain – interference with climatological wave pattern
 - SNOW COVER (*Eurasia*): radiatively-induced / albedo feedback – local baroclinic structure – interference with climatological wave pattern
- dynamical forecast systems will require a proper representation of stratosphere
- there is room for comprehensively improving empirical prediction models

MCA-SIC/BK_{NOV}

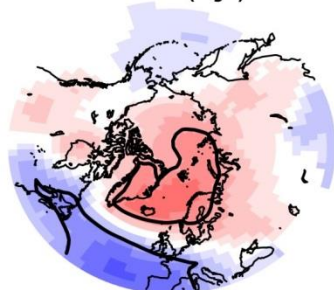
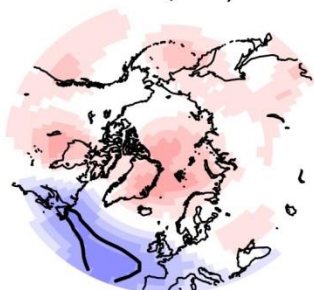
SLP (dec)

SLP (jan)

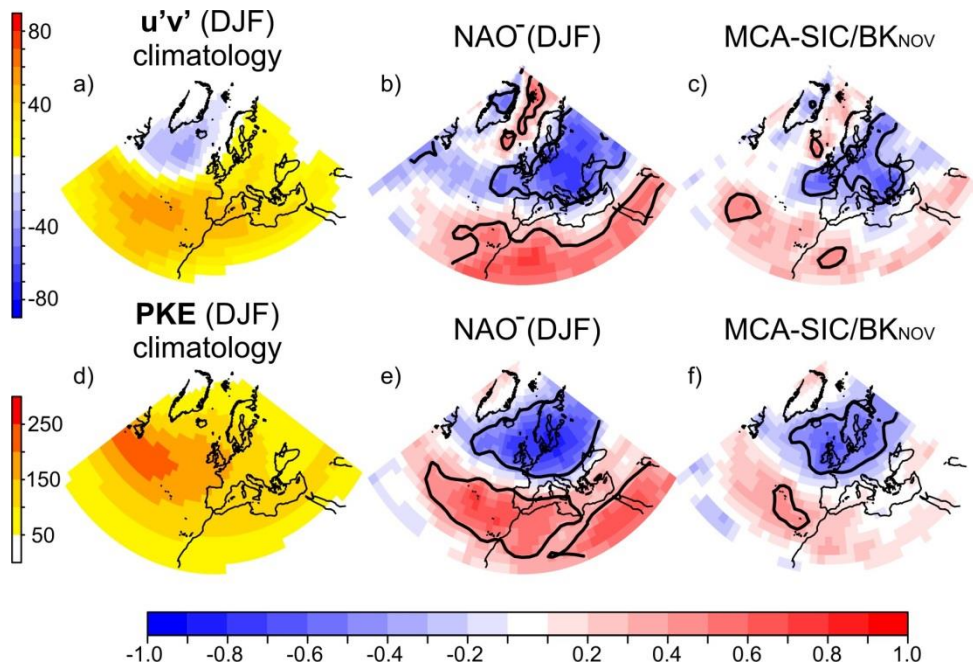


SLP (feb)

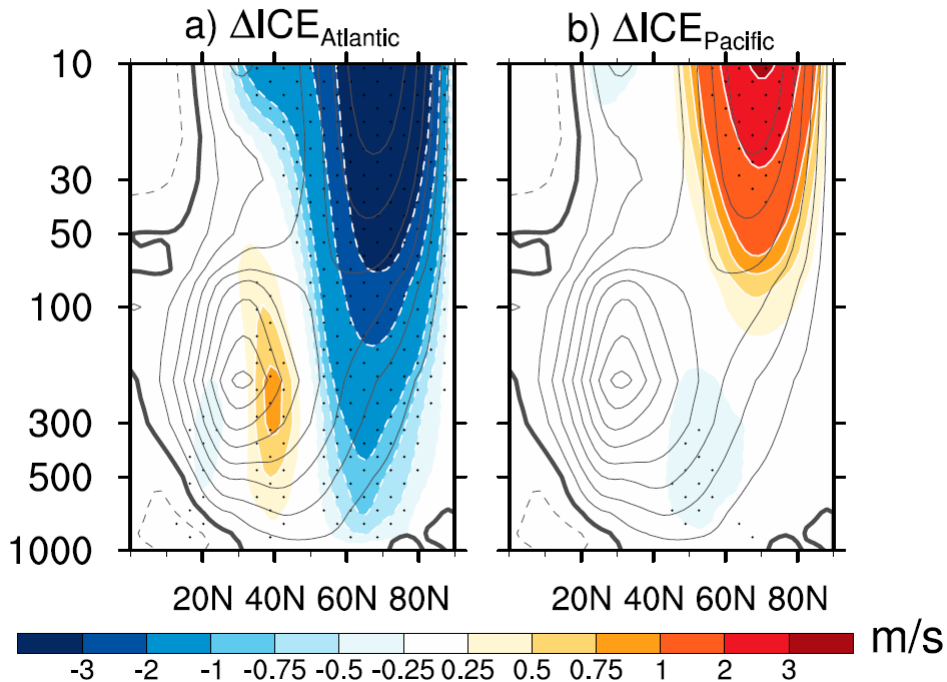
SLP (djf)



[García-Serrano et al. 2015]

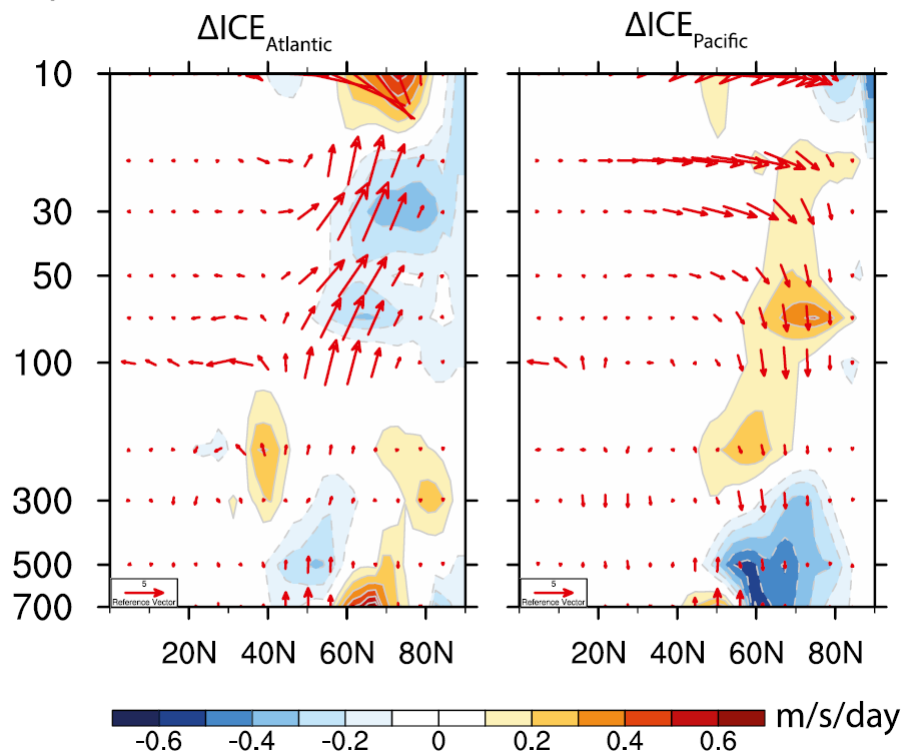


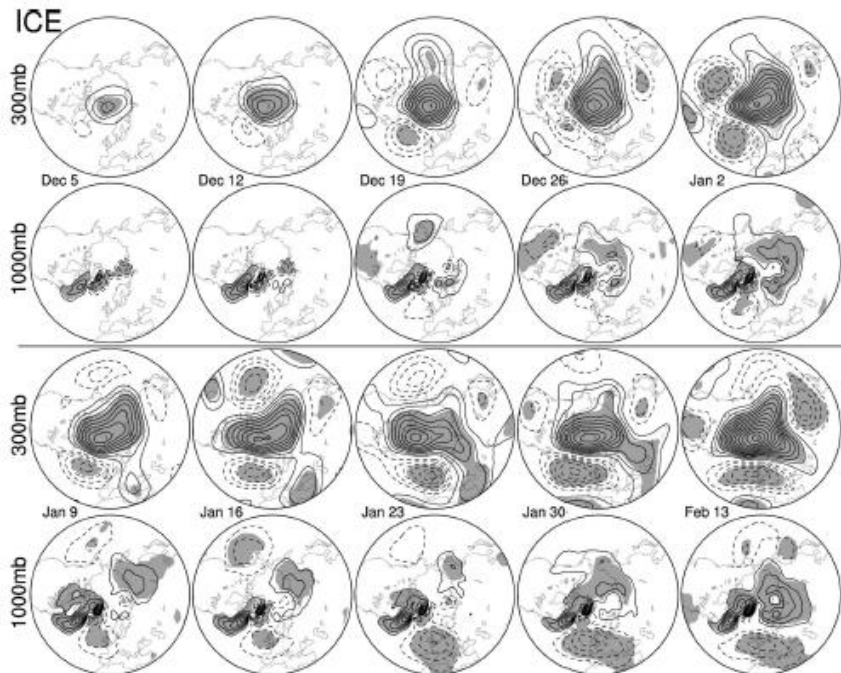
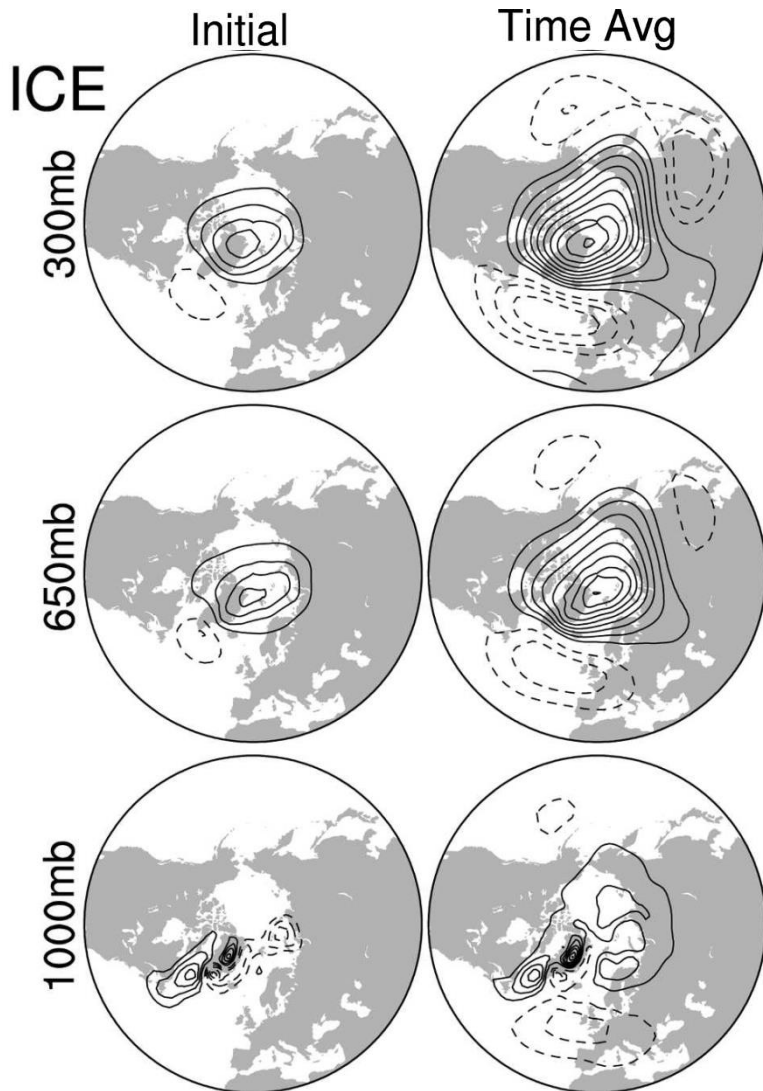
[U] in DJF



[Sun et al. 2015]

b) E-P flux in Dec-Jan

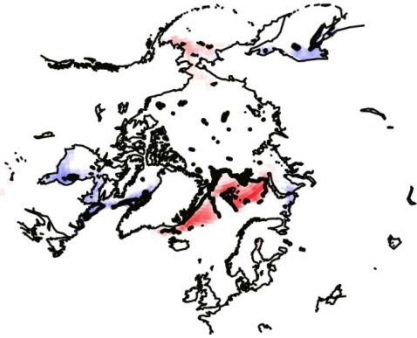




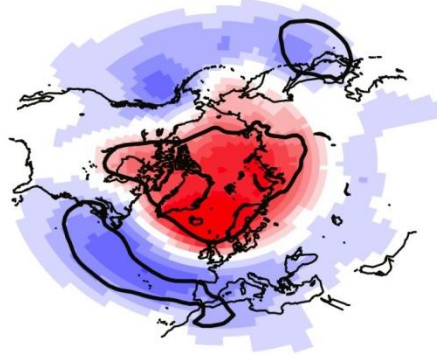
the equilibrium response to SIC reduction over G-B Seas, which projects on the negative NAO, is reached in about two months

[Deser et al. 2007]

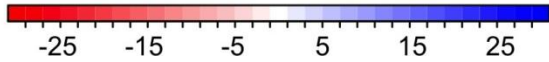
c) **MCA-SIC/eG_{DEC} X SIC (dec)**



d) **MCA-SIC/eG_{DEC} X SLP (feb)**

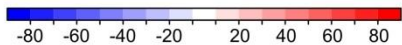
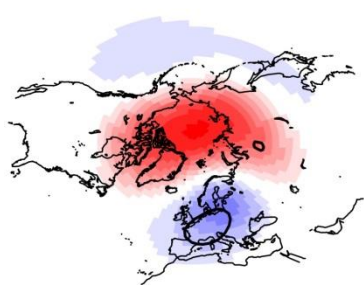


sig.lev.(SC)=0%

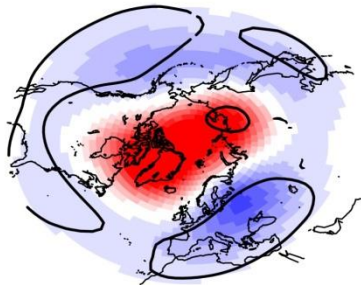


[García-Serrano et al. 2016]

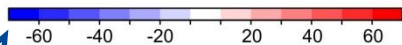
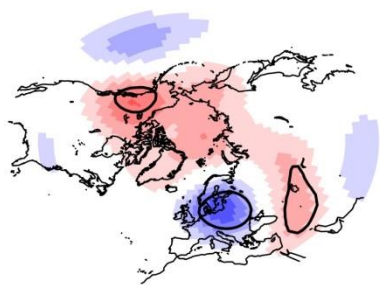
a) SIC-GS_{DEC} X Z050 (jan)



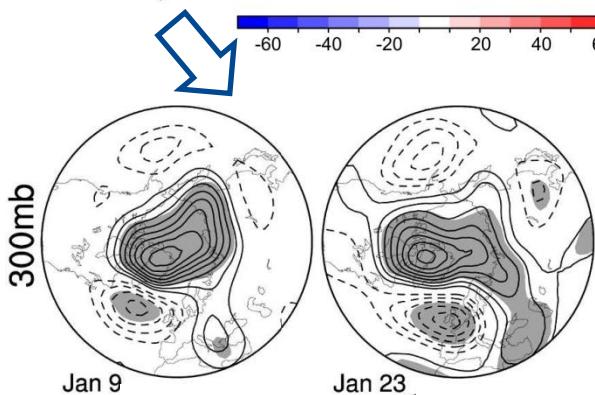
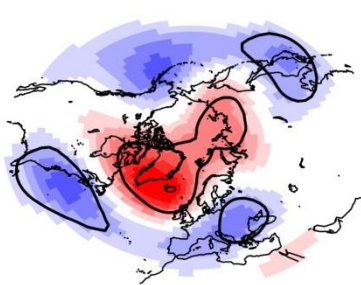
b) SIC-GS_{DEC} X Z050 (feb)



c) SIC-GS_{DEC} X Z200 (jan)

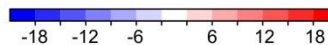
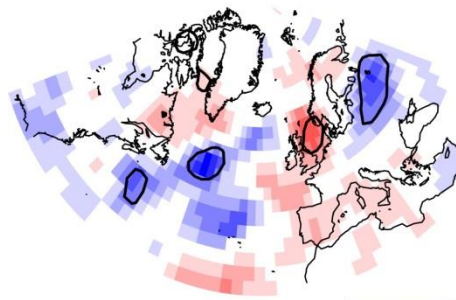


d) SIC-GS_{DEC} X Z200 (feb)

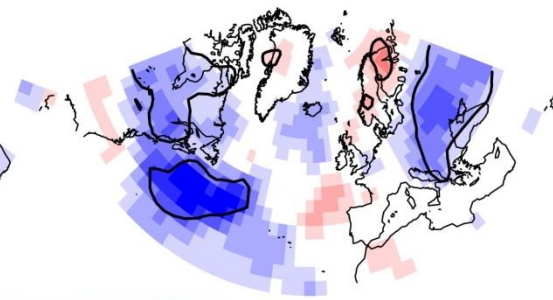


[Deser et al. 2007]

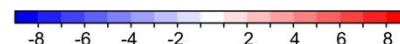
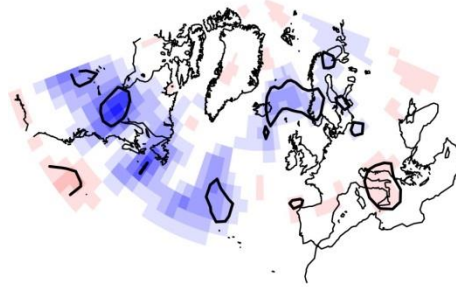
a) SIC-GS_{DEC} X u'v'200 (jan)



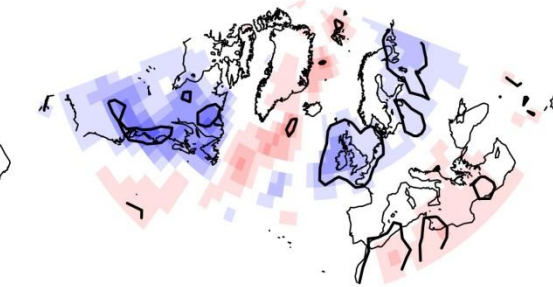
b) SIC-GS_{DEC} X u'v'200 (feb)



c) SIC-GS_{DEC} X v'T'850 (jan)



d) SIC-GS_{DEC} X v'T'850 (feb)



TROPOSPHERIC DYNAMICS

[García-Serrano and Frankignoul 2015]