Atmospheric response to sea-ice variability: role of continental snow cover and decadal SST variability

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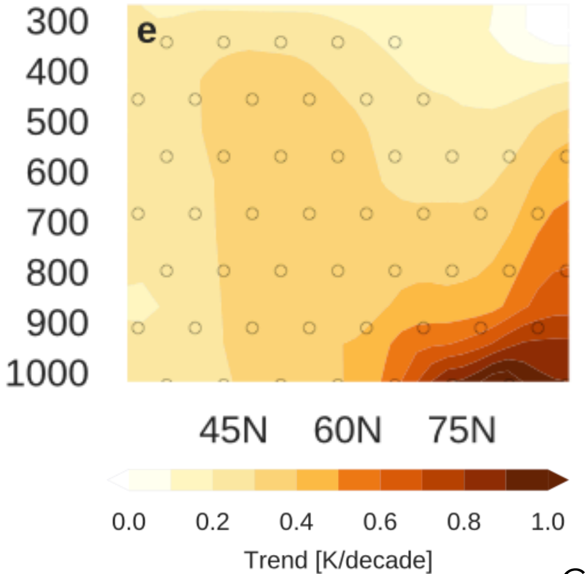
Ongoing work

Sea ice impact for Northern Hemisphere

SON temperature trend
1981-2014; ERA-Interim

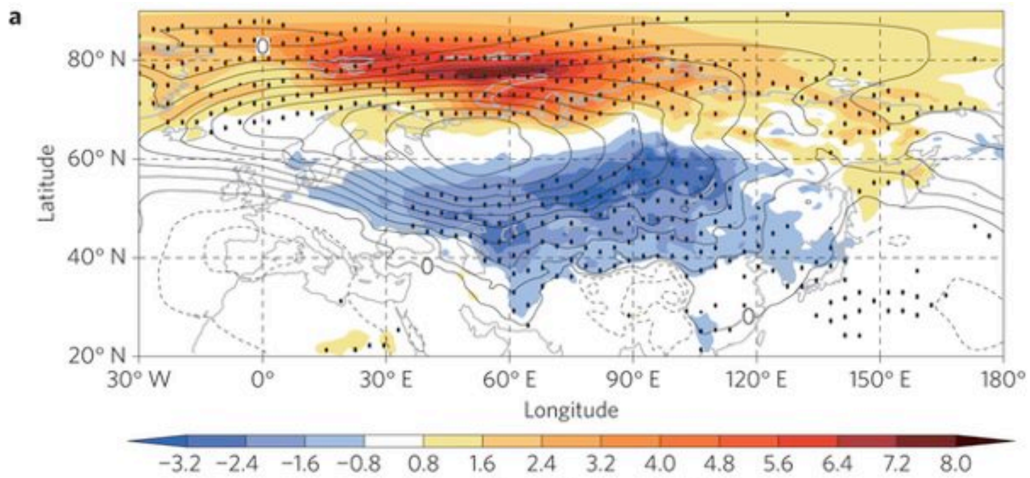


From Cohen et al. 2018

- Arctic amplification (global mean +0.2K/decade ; Arctic mean +0.55K/decade) largest in Fall SON (Cohen et al., 2018).
- Potential role of the Barents/Kara sea ice extent in the warm Arctic / cold continent pattern (Mori, et al. 2014).
- Potential NAO-like impacts (King et al., 2015, Garcia-Serrano et al., 2015)

Composite DJF Low-Ice minus High-Ice years

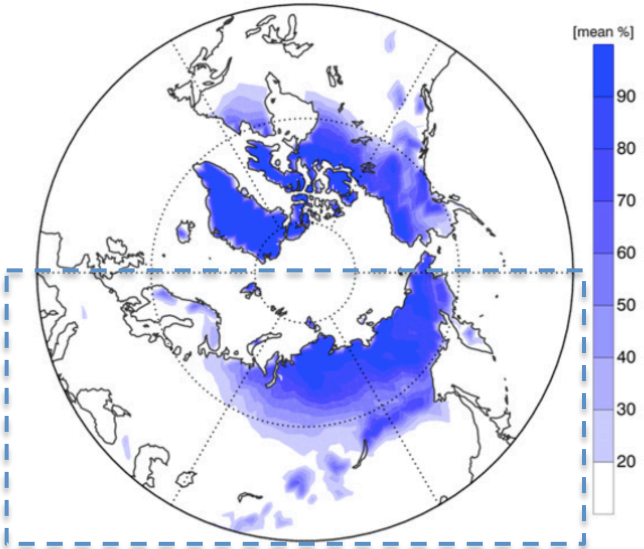
T2m (in K, colors) – SLP (contours, CI=0.8-hPa)



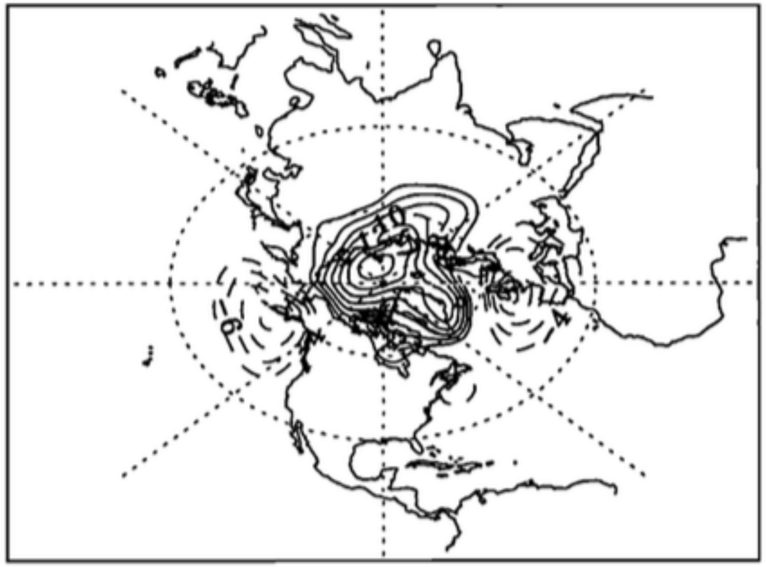
From Mori et al., 2014

Role of concomitant forcing

Mean snow cover in October (SCE)



SLP DJF -> Difference high – low SCE



Cohen and Entekabhi, 1999

Questions:

- What are the processes linking the Arctic sea ice to the atmospheric circulation in observations?
- Can the Arctic sea ice reproduced in model simulations?

Observational analysis

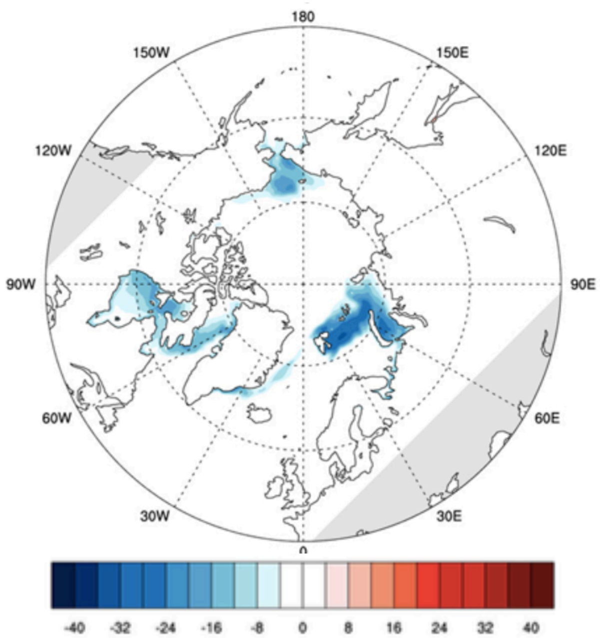
Datasets:

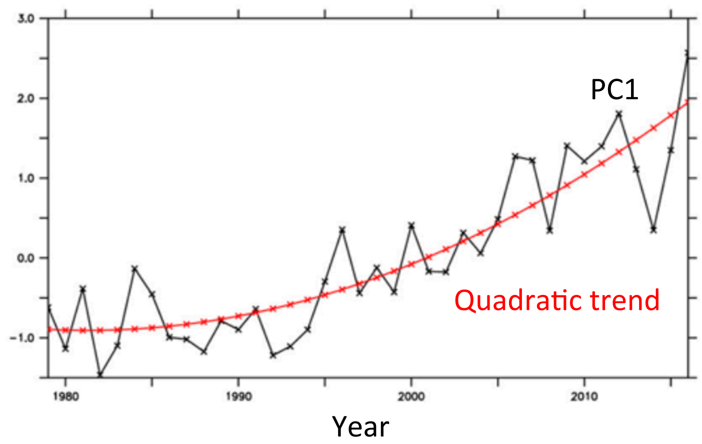
- Observation 1979-2017 from : (1) ERA-Interim
  (2) NOAA/NSIDC passive microwave sea ice concentration
  (3) NOAA/NCDC snow cover (Comiso, 2012)

Methods :

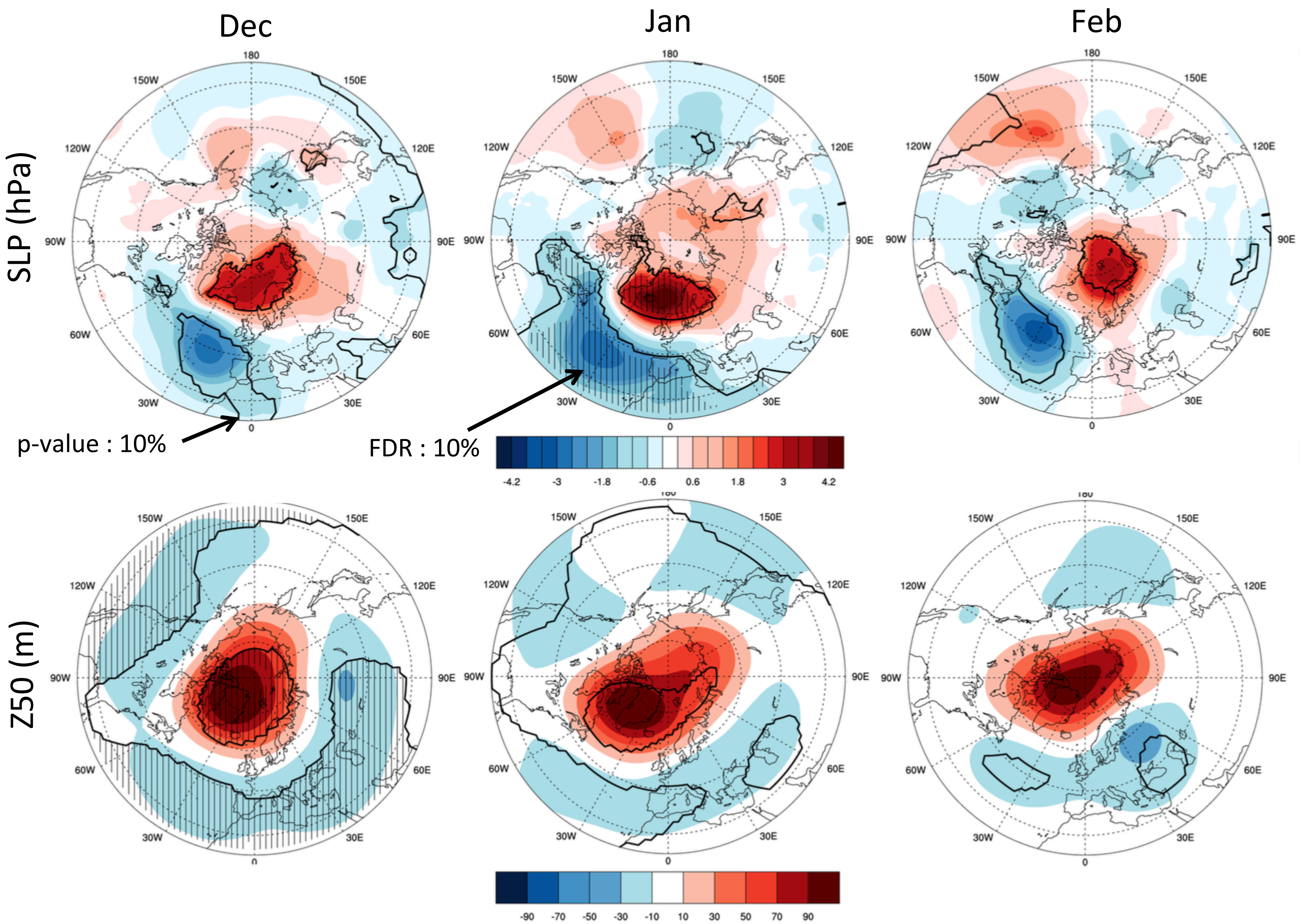
- EOF of SIC data,
- Detrended PC1, called dPC1,
- Linear regressions,
- Statistical significance established using t-test, and field significance using false discovery rate (Wilks, 2016).

EOF1
SIC (%)
November

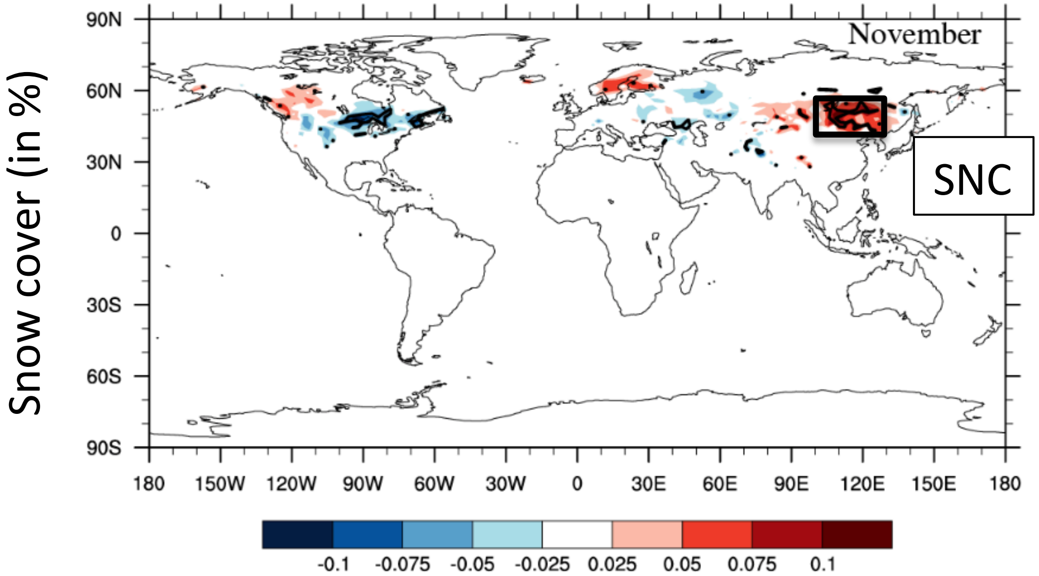




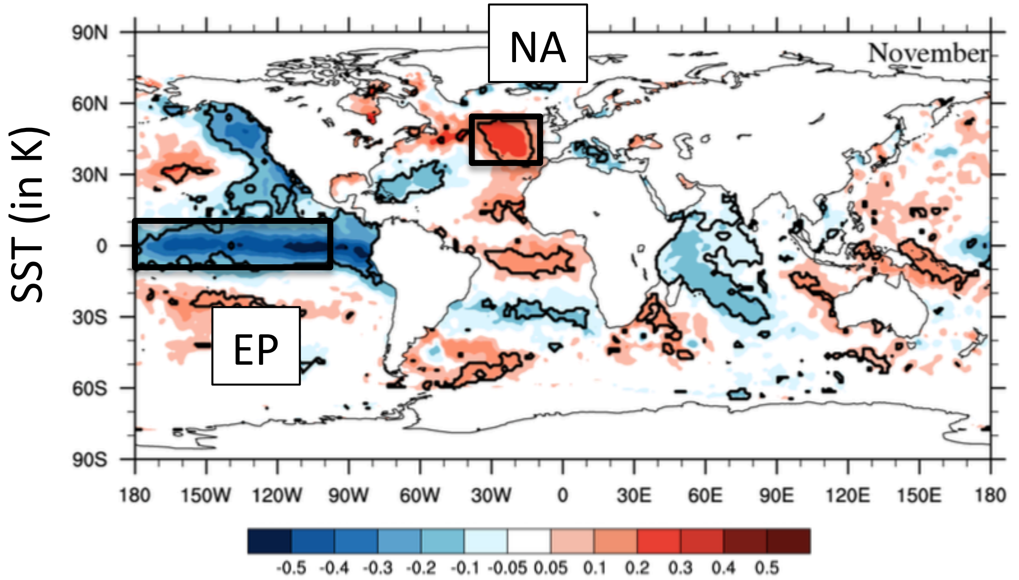
Regression of atmosphere onto dPC1 (Nov)



Simultaneous forcing



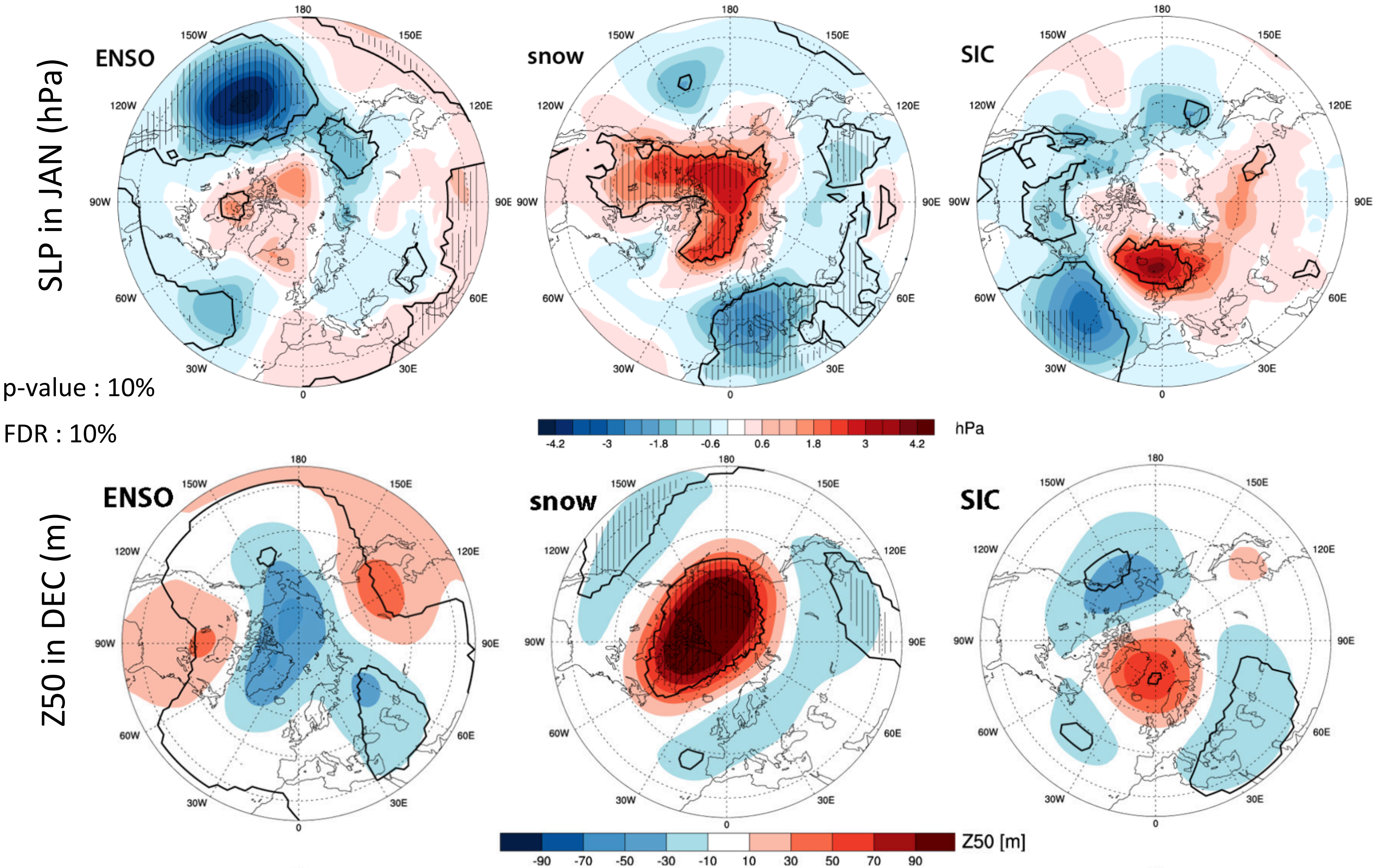
- Positive snow cover anomalies over eastern Eurasia
- Negative snow cover anomalies over NE North America.



- Negative SSTA in Eastern Pacific (La Niña-like)
- Positive SSTA in NE Atlantic

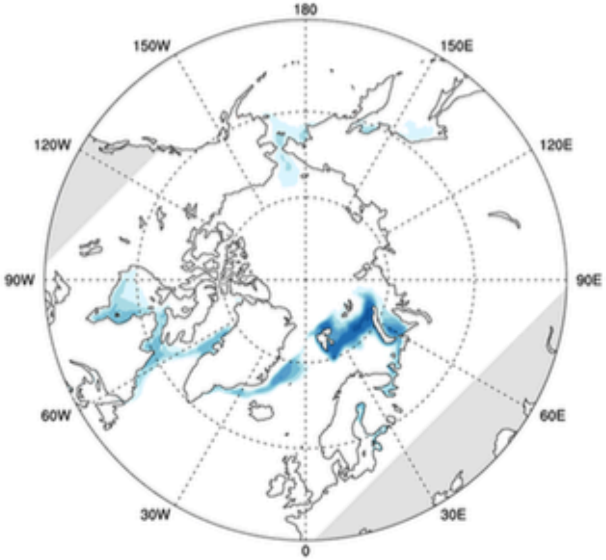
Multiple regression atmosphere onto dPC1(Nov)

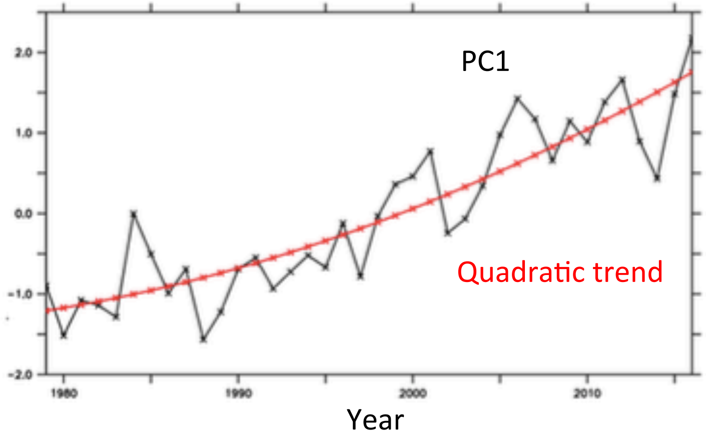
SLP(t) = a + b EP(t) + c SNC(t) + d NA(t) + d PC1(t)



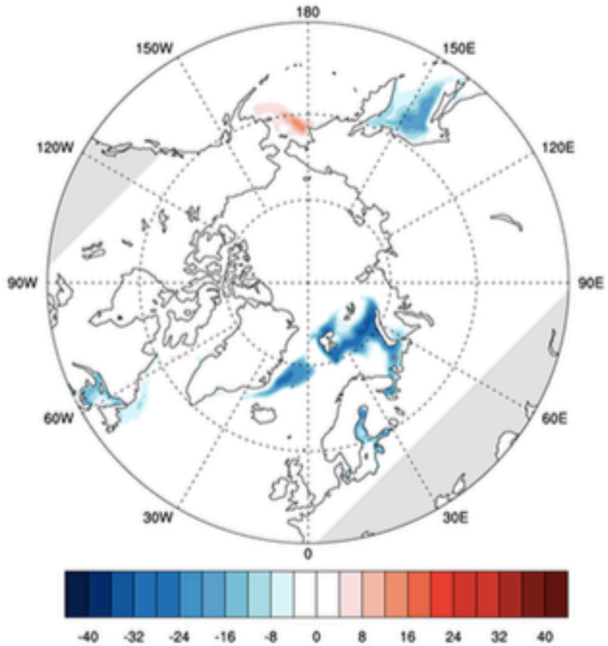
Variability of sea-ice in winter

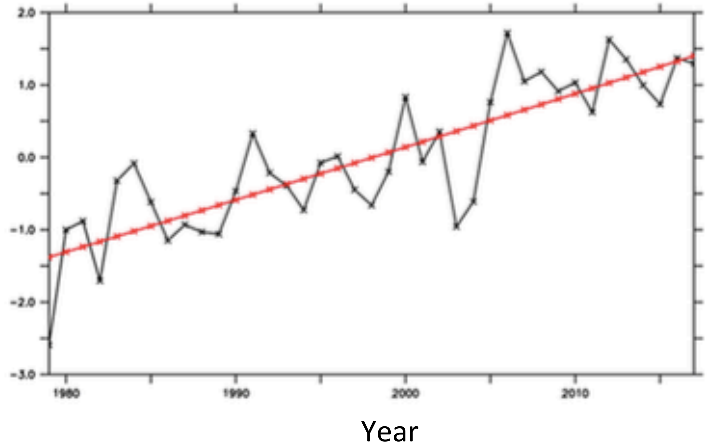
EOF1
SIC (%)
December





EOF1
SIC (%)
January

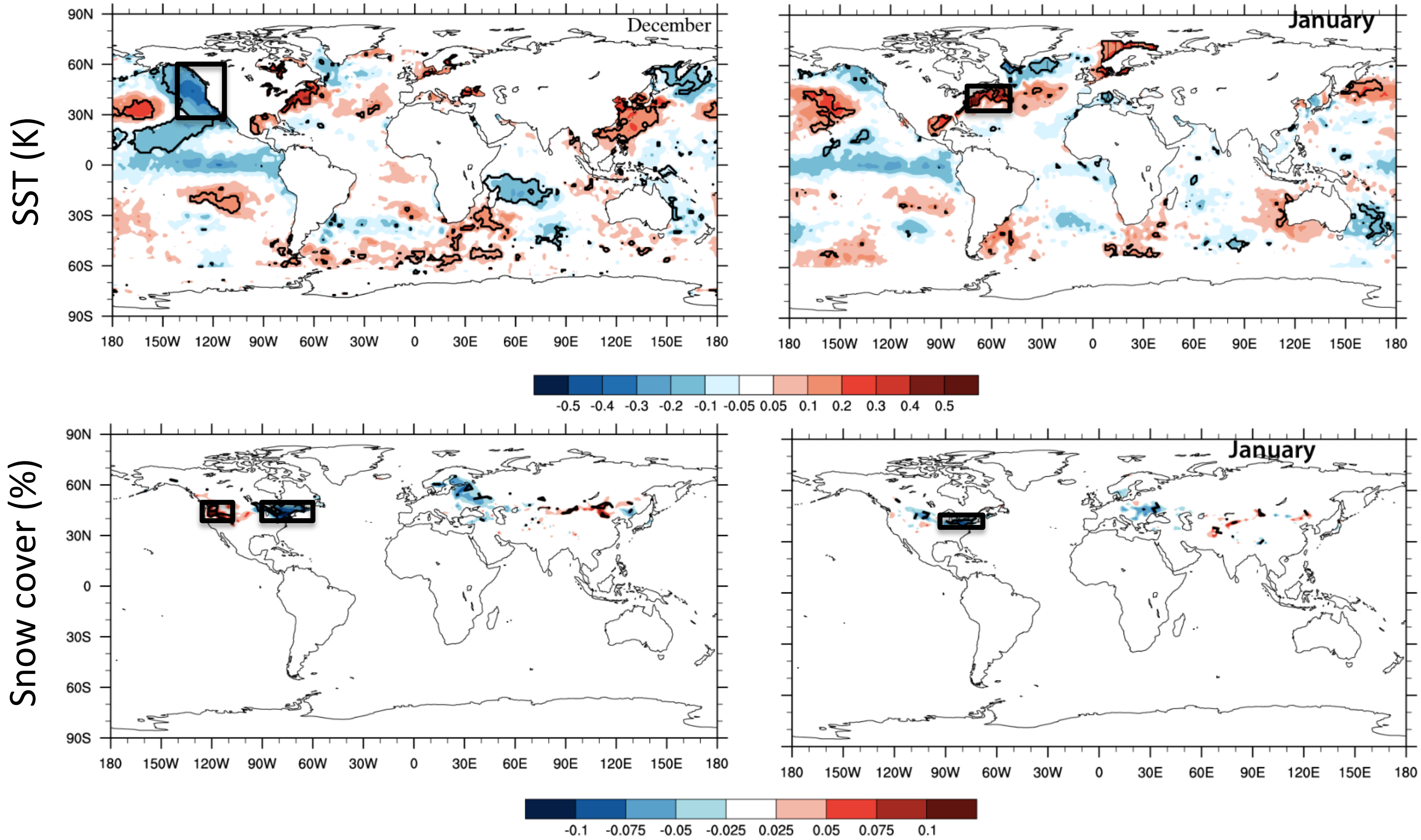




Snow and SST associated to sea ice

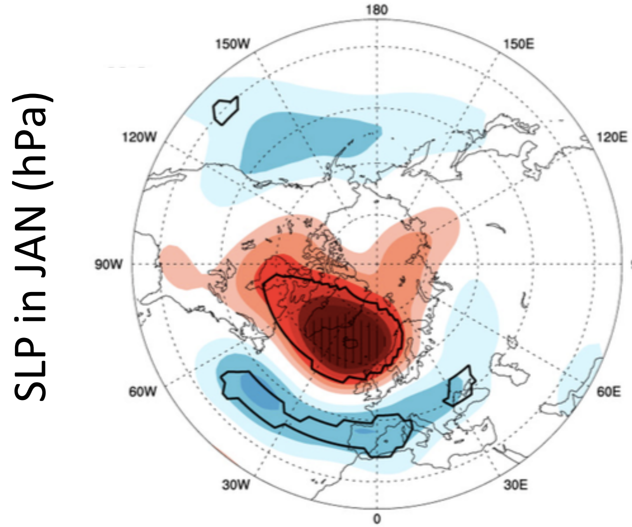
Regression onto dPC1(Dec)

Regression onto dPC1(Jan)



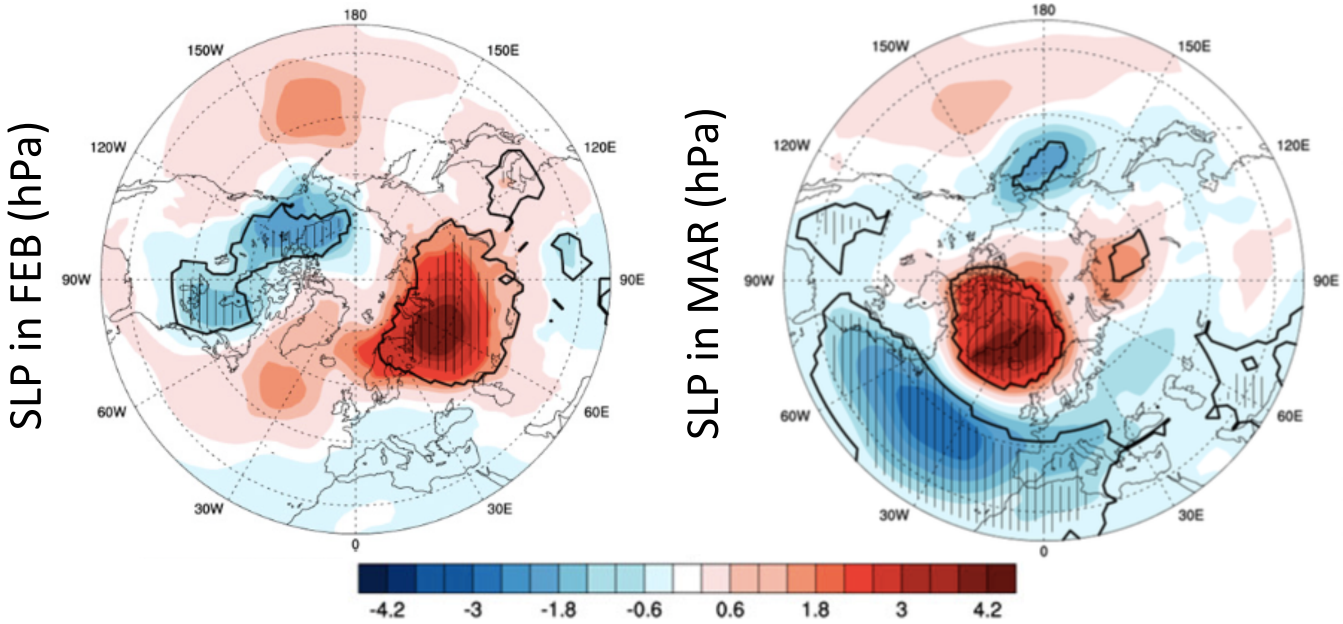
Late Winter sea ice influence

Multiple regression dPC1 (DEC)



- Influence of winter sea ice more significant when using multiple regression,
- No stratospheric anomalies found (not shown).

Multiple regression dPC1 (JAN)



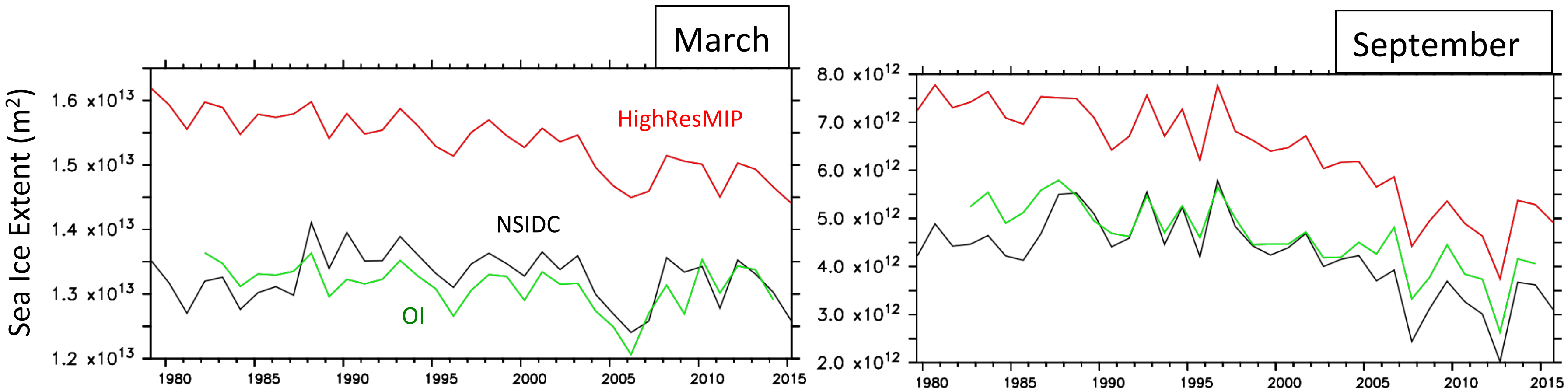
Blue-Action Experiments

Atmosphere-only simulations :

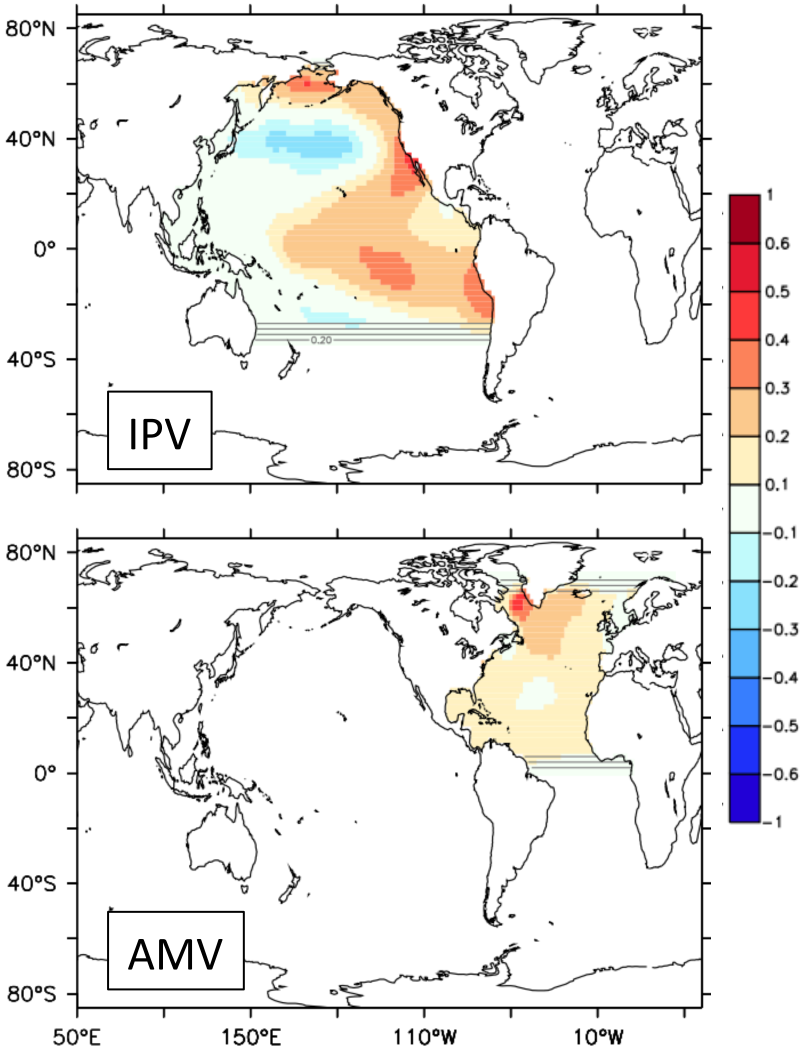
- CMIP6 external frocing,
- Daily varying SST and SIC (from HadISST2.0.0) from 1979 to 2014,
- Six different AGCM, but here results only shown for LMDZORv6 (30 members, IPSL model atmospheric component).

Four different experiments following:

- **ALL** : SST and SIC vary (AMIP-like).
- **NoSIC** : SST varies, but SIC fixed to a climatology,
- **NoIPV** : SST and SIC vary, but IPV (*Interdecadal Pacific Variability*) removed,
- **NoAMV** : SST and SIC vary, but AMV (*Atlantic Multidecadal Variability*) removed.



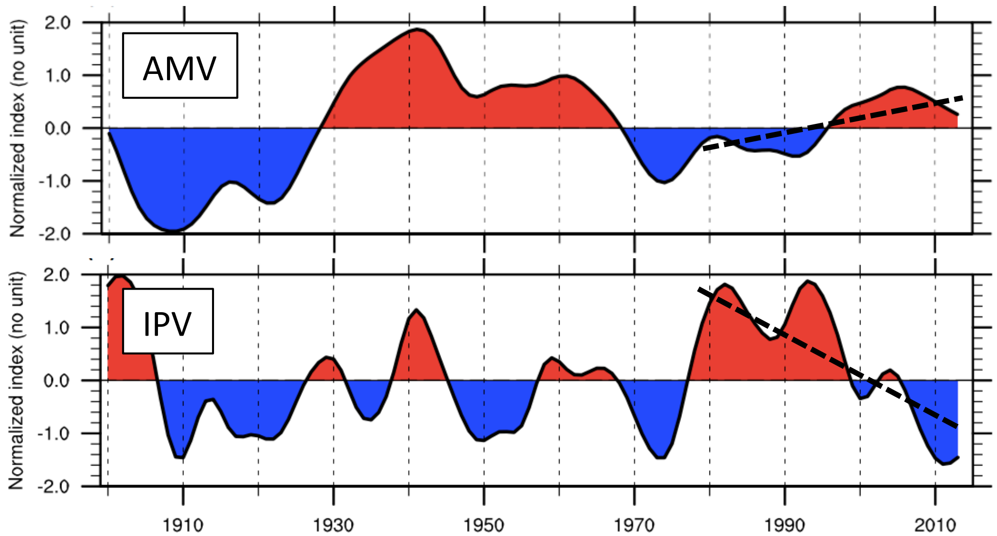
AMV and IPV from DCPP – CMIP6



1. Estimation of the forced signal by signal-to-noise maximizing EOF (Ting et al. 2009) using CMIP5 historical + RCP8.5 ensemble.

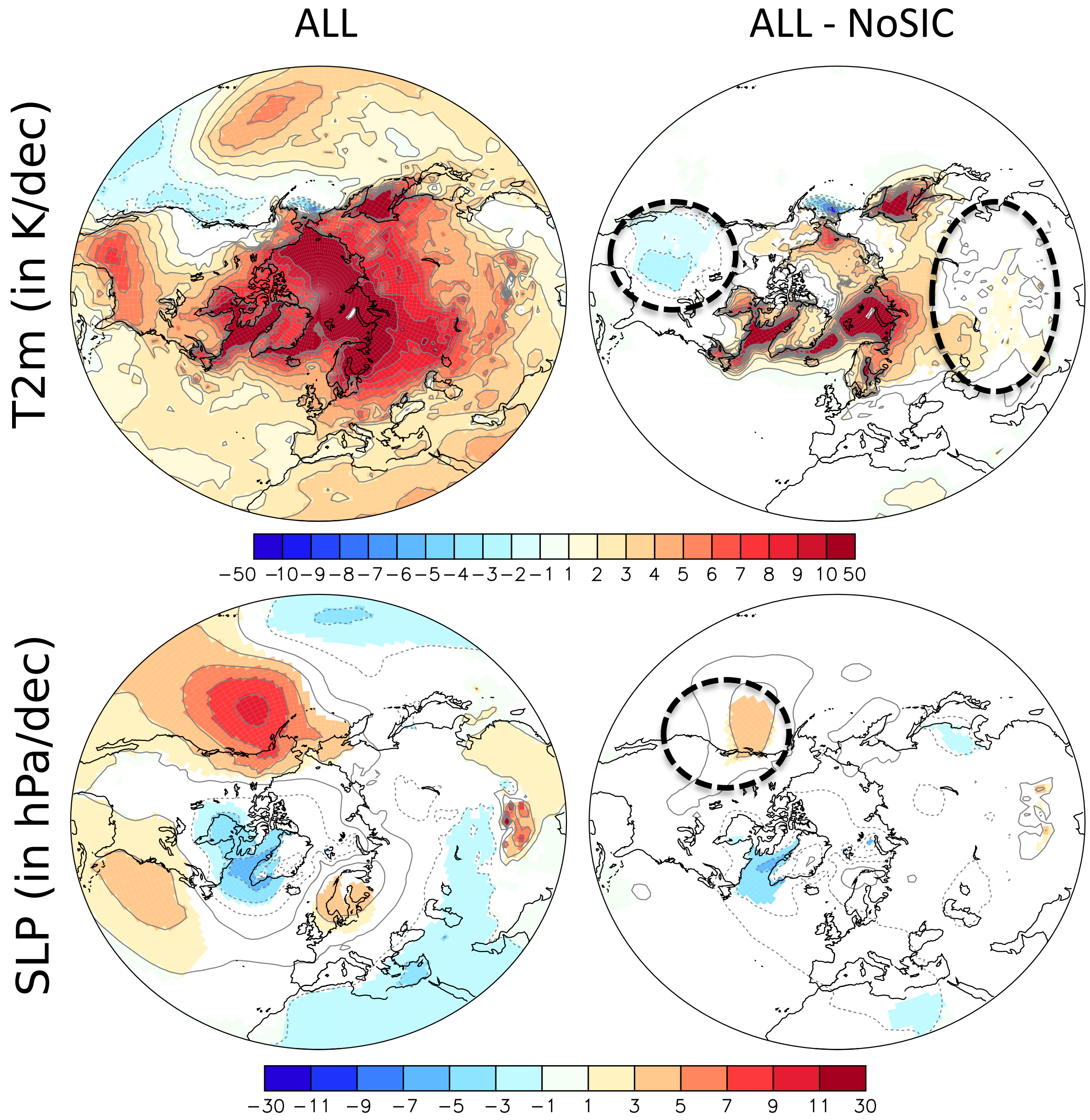
2. From the residual SST :

- AMV : mean Atlantic SST 0°N-60°N (low pass 10-yr).
- IPV : First PC of yearly Pacific SST (40°S-60°N), then low pass 13-yr.



From Boer et al. 2016

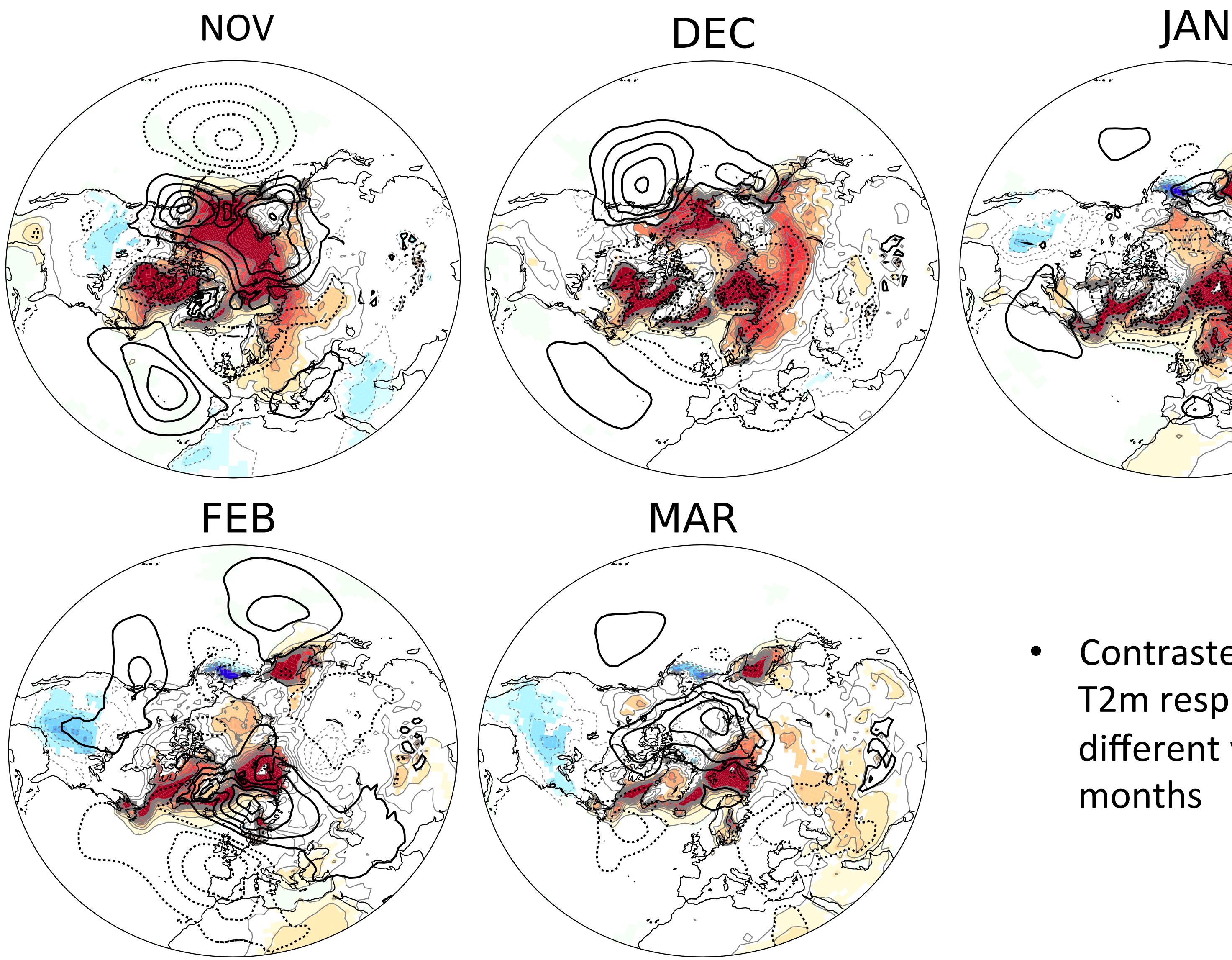
Influence of sea-ice on 1979-2014 DJFM trend



- Warming of sea-ice localized over the sea-ice edges.

- Almost no SLP anomalies

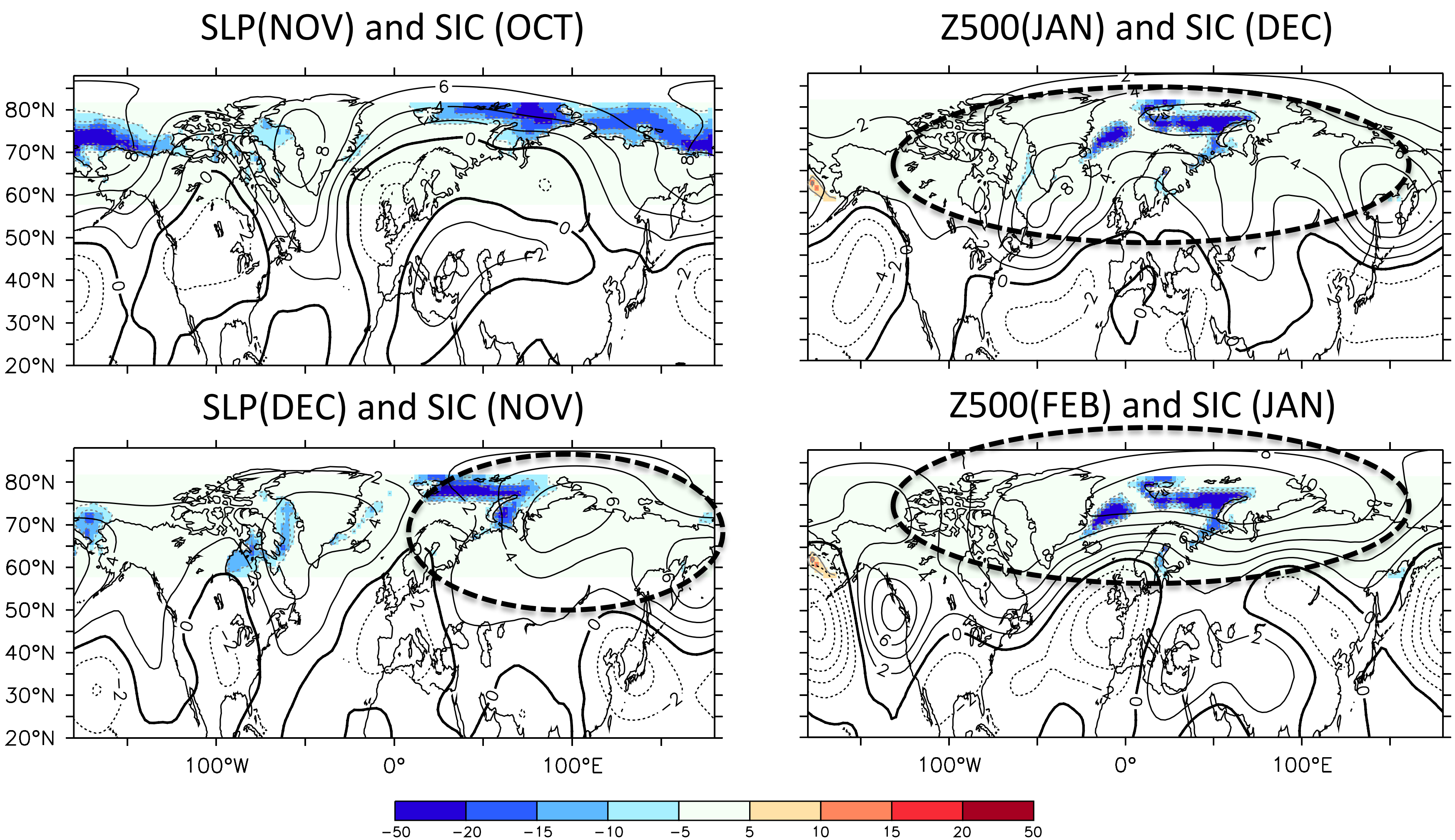
ALL minus NoSIC in winter



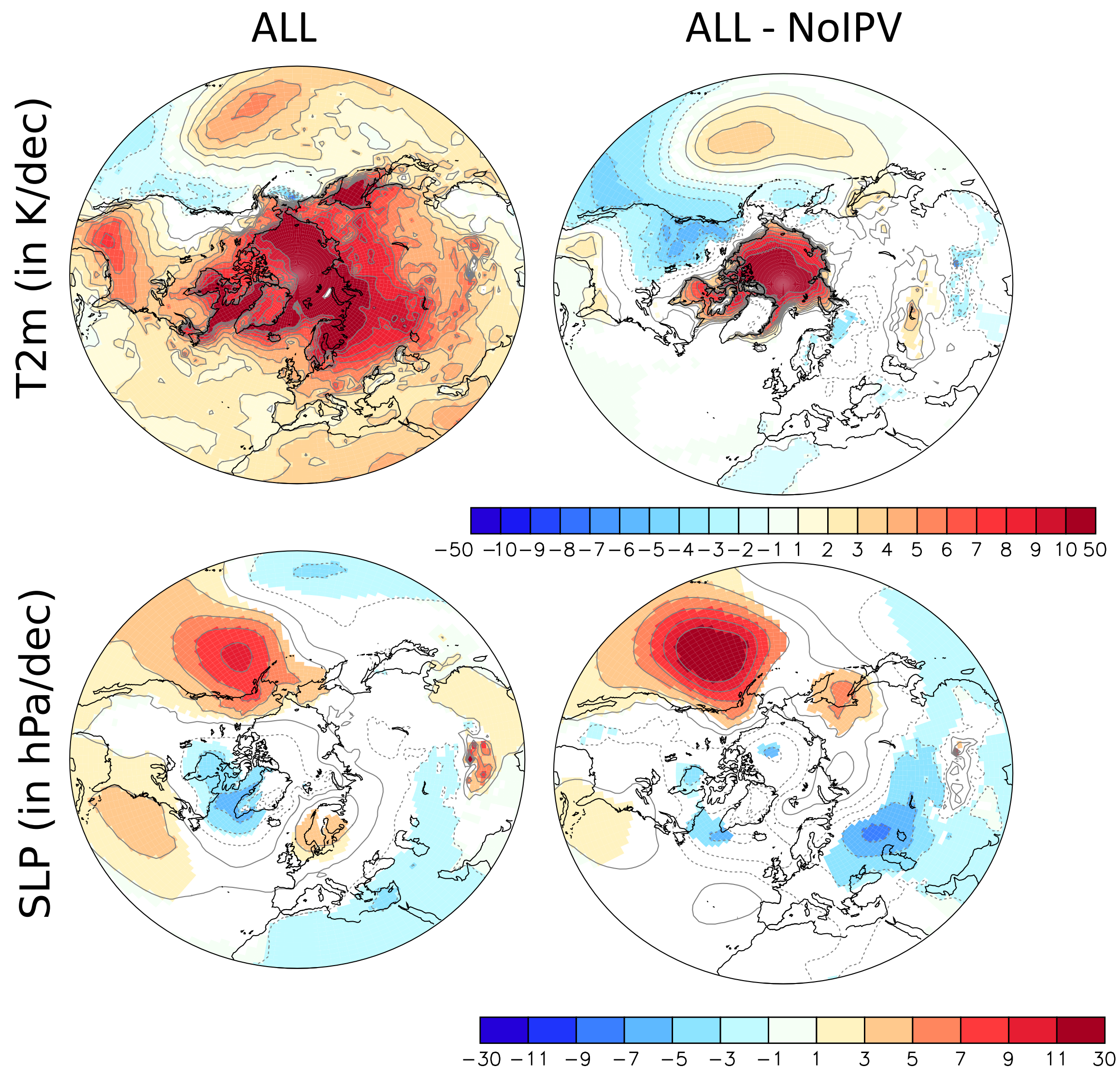
- Contrasted SLP and T2m response in different winter months

Interannual Variability

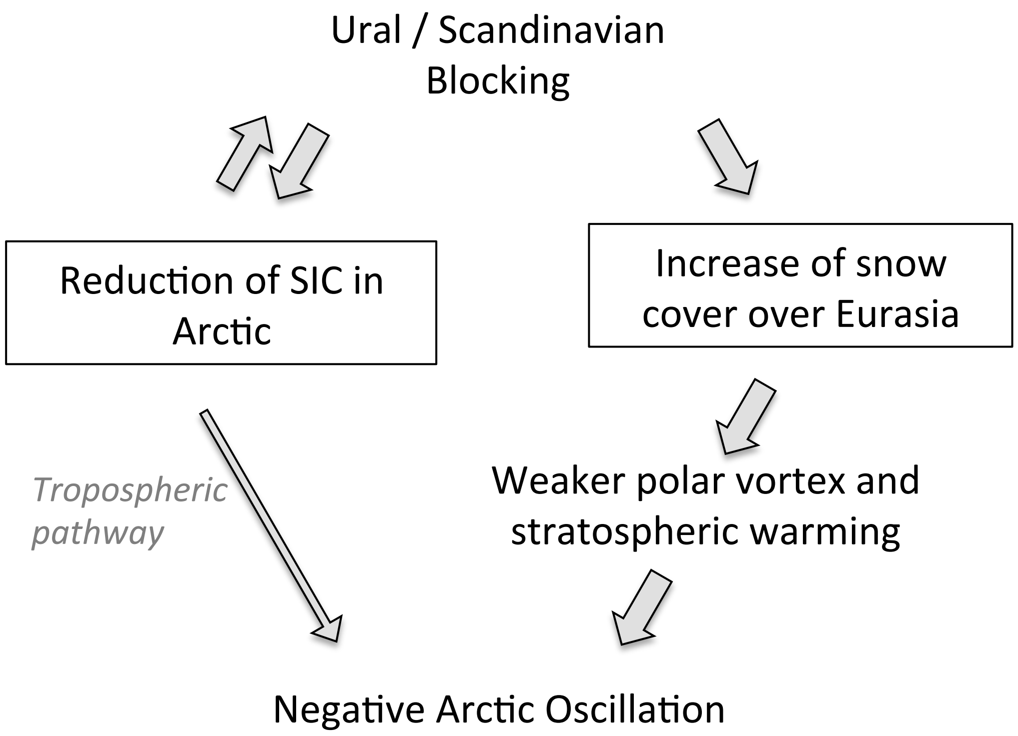
Maximum covariance analysis between ensemble-mean Z500 (in m) of ALL minus NoSIC and SIC (in %), assuming lag of one month.



Role of decadal SST variability



Conclusion



- From multivariate regression the snow cover influence dominates in Fall (as in Gastineau et al., 2017),
- Atmospheric response to sea-ice in winter is detected through a tropospheric pathway, with impacts onto Siberian anticyclone.
- The atmospheric model simulate such SIC influence, but it is underestimated (as in Mori at al. 2019).

- The largest part of the 1979-2014 trend is explained by the IPV phase transition, in particular for the winter temperature over the Arctic.

Thank you for your attention

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