PRIMAVERA Science discussion
Arctic sea-ice and European climate

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Two science questions:

- Can we quantify the contribution of all contributing mechanisms to the recent Arctic sea-ice loss (complete attribution)?
- Does Arctic sea-ice loss have any significant influence on European climate ?
- Can PRIMAVERA help in answering these two questions ?

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Arctic sea-ice loss: significant influence on midlatitude climate ?

- Here, **significant** means relative to internal variability
- Time scale dependence: intra-seasonal versus multi-decadal ? Time invariance of the response ?
- *« Can it, Has it, or Will it »* (Barnes & Screen 2015)?
- ***Influence of Barents and Kara seas SIC on circulation & Eurasian temperature***
- Current status of the science ?: the McCusker et al. (2016) and the Kretschmer et al. (2016) papers
- McCusker : « In our atmospheric-only simulations, **we find no evidence of Barents and Kara seas sea-ice loss having impacted Eurasian surface temperature**. ...We find just one coupled simulation with Eurasian cooling of the observed magnitude but **Arctic sea-ice loss was not involved**. »
- Kretschmer: « The findings confirm that **sea-ice concentrations in Autumn in the Barents and Kara seas are an important driver of winter circulation in the midlatitudes**. »

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McCusker: Model-driven

- Use CanESM2 large ensemble (50 members) and two derived sets of AGCM integrations.
- Assess links between BK SIC and EUR SAT in both observations and model and compare them
- Test in AGCM-only mode the pure influence of BK seas sic change (1979-1989-CTRL versus 2002-2012-PERT) using coupled model states (from 5 coupled runs based on fixed SSTs 1979-1989 and GHG 1984)

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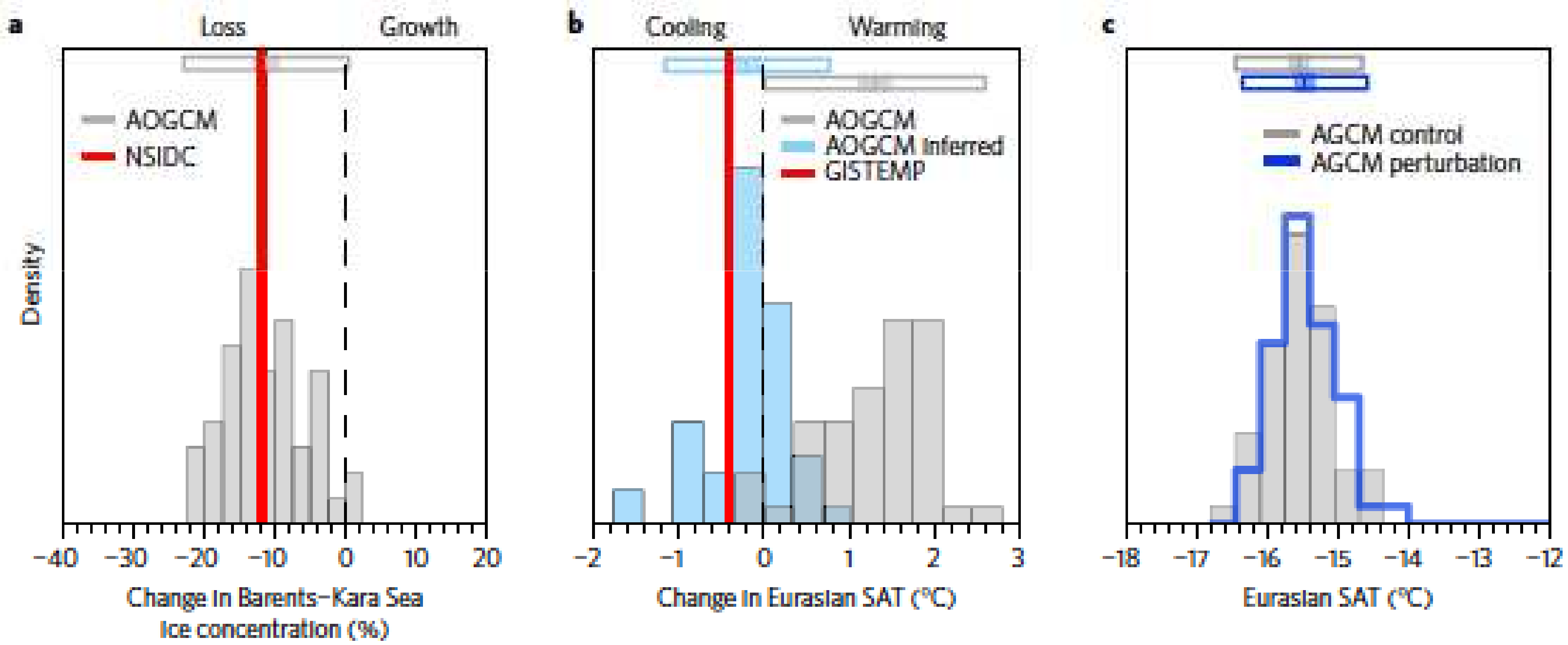
McCusker et al.: no detectable influence of BKS sea-ice



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Kretschmer: data-driven

- Use observed and reanalysis data over 1979-2014
- Perform causal effect network analysis on a set of 7 time series (BKS sic, AO, EA snow, Polar vortex, Sib. and Ural SLP ...)
- Detect and remove spurious correlations due to auto-correlation, indirect effects and common drivers

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What is going on ?

- McCusker et al.: rely on one model
- Kretschmer et al.: rely on a fixed set of predictors
- Not asking exactly the same question: Trends versus stationary time series (time scale invariance)
- Issues of « Correlation is not causation » and necessary versus sufficient causes
- Only sufficient causes have deterministic power
- Quasi-linear sufficient causes (often just 1!) often assumed

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What is next ? Can PRIMAVERA help ?

- Coordinated model studies
- Assess influence of model improvement (High resolution, both horizontal and vertical, physics)
- Towards a joint model-observation approach (based on imperfect model & observations)
- Challenge: how to escape the curse of internal variability ?
- Challenge: mean state dependence and remote drivers

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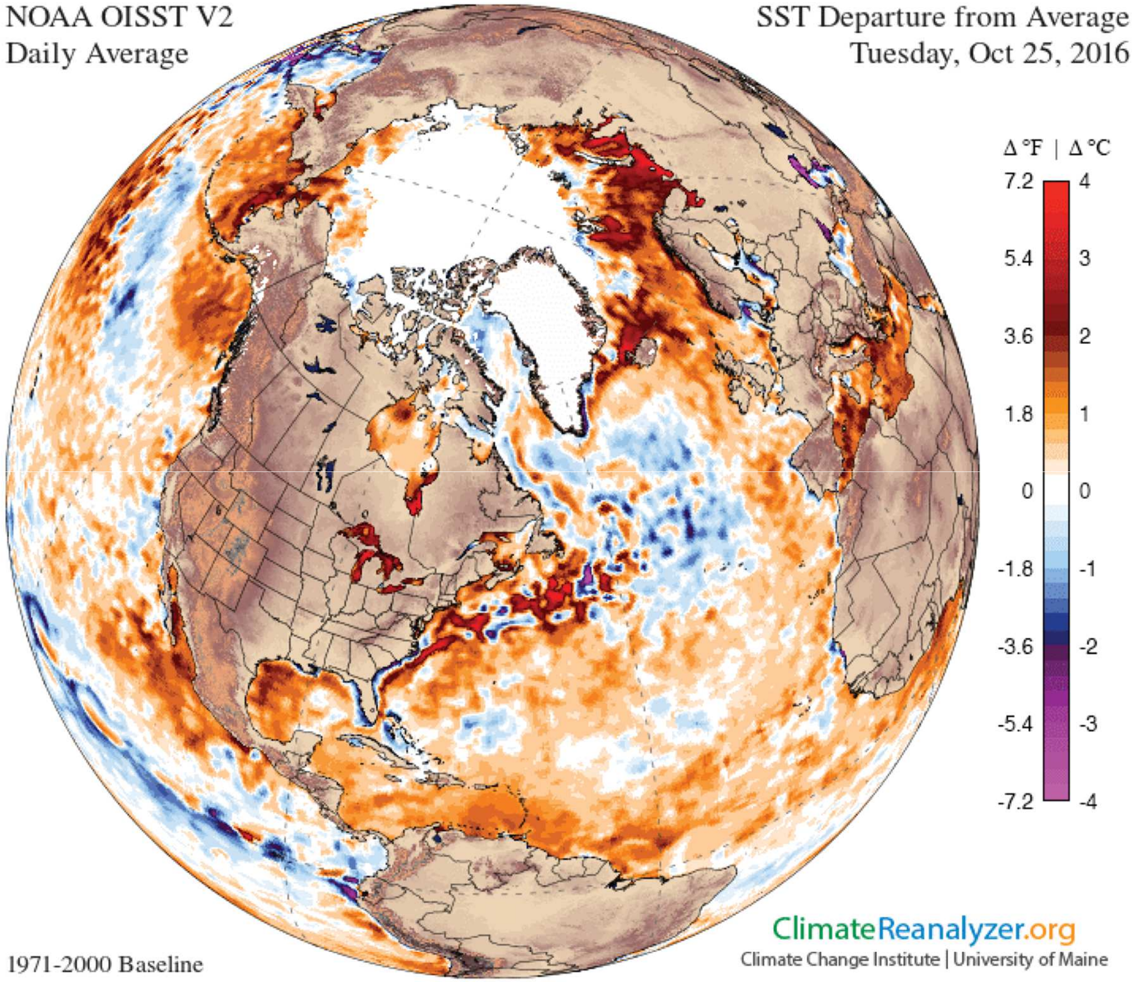
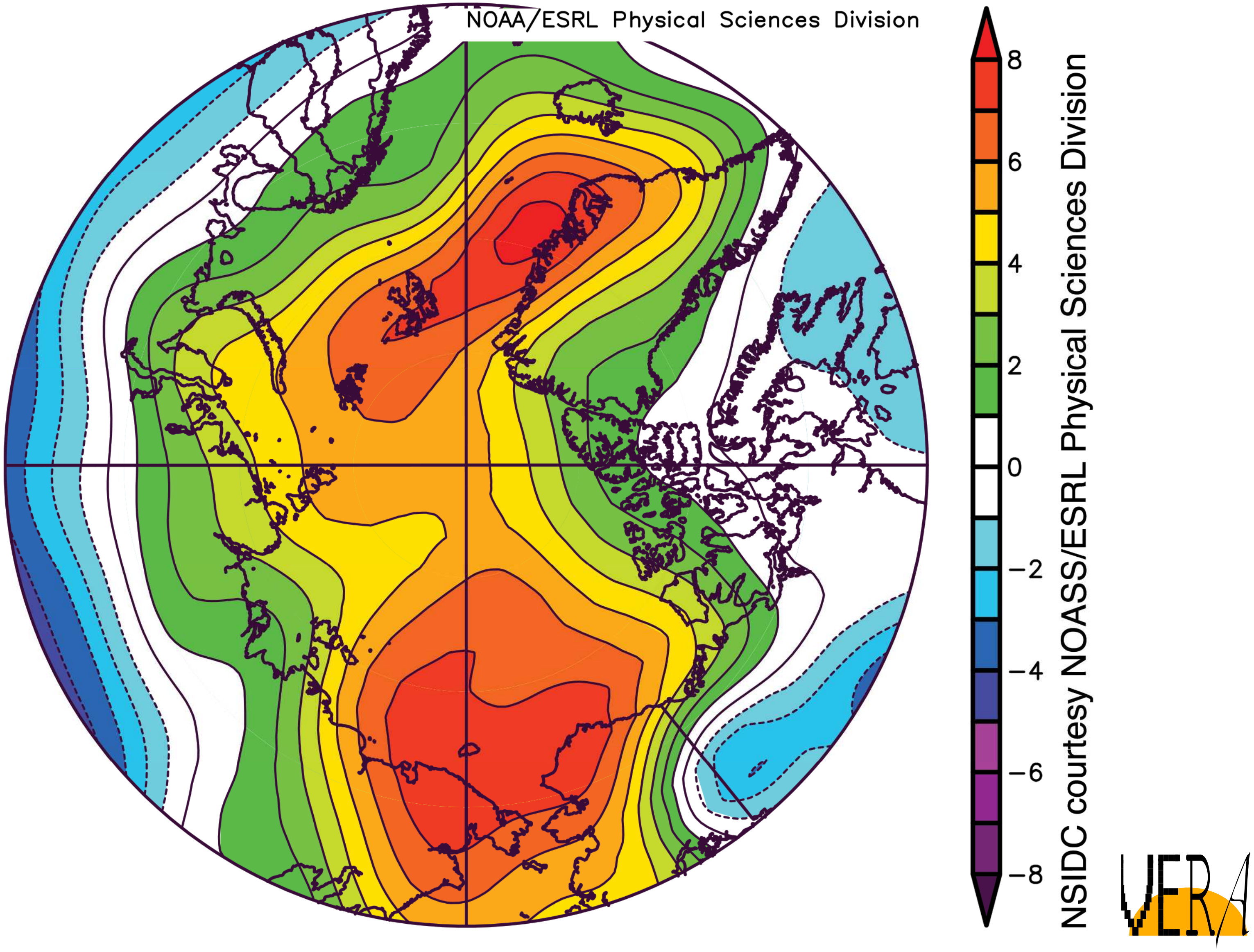
Sea Surface Temperature
October 25, 2016



World	Northern Hemisphere	North Atlantic
+ 0.31 °C	+ 0.47 °C	+ 0.51 °C
Equatorial Pacific	Southern Hemisphere	North Pacific
+ 0.07 °C	+ 0.18 °C	+ 0.40 °C

MAVERA

Air Temperature Anomaly
October 1 to 30, 2016



PRIMAVERA

SMHI

The effect of Ocean resolution, and external forcing in the correlation between SLP and Sea Ice Concentration in the Pre-PRIMAVERA GCMs

Fuentes Franco R, Koenigk T.

Pre-PRIMAVERA-simulations:
First results, Nov 2016

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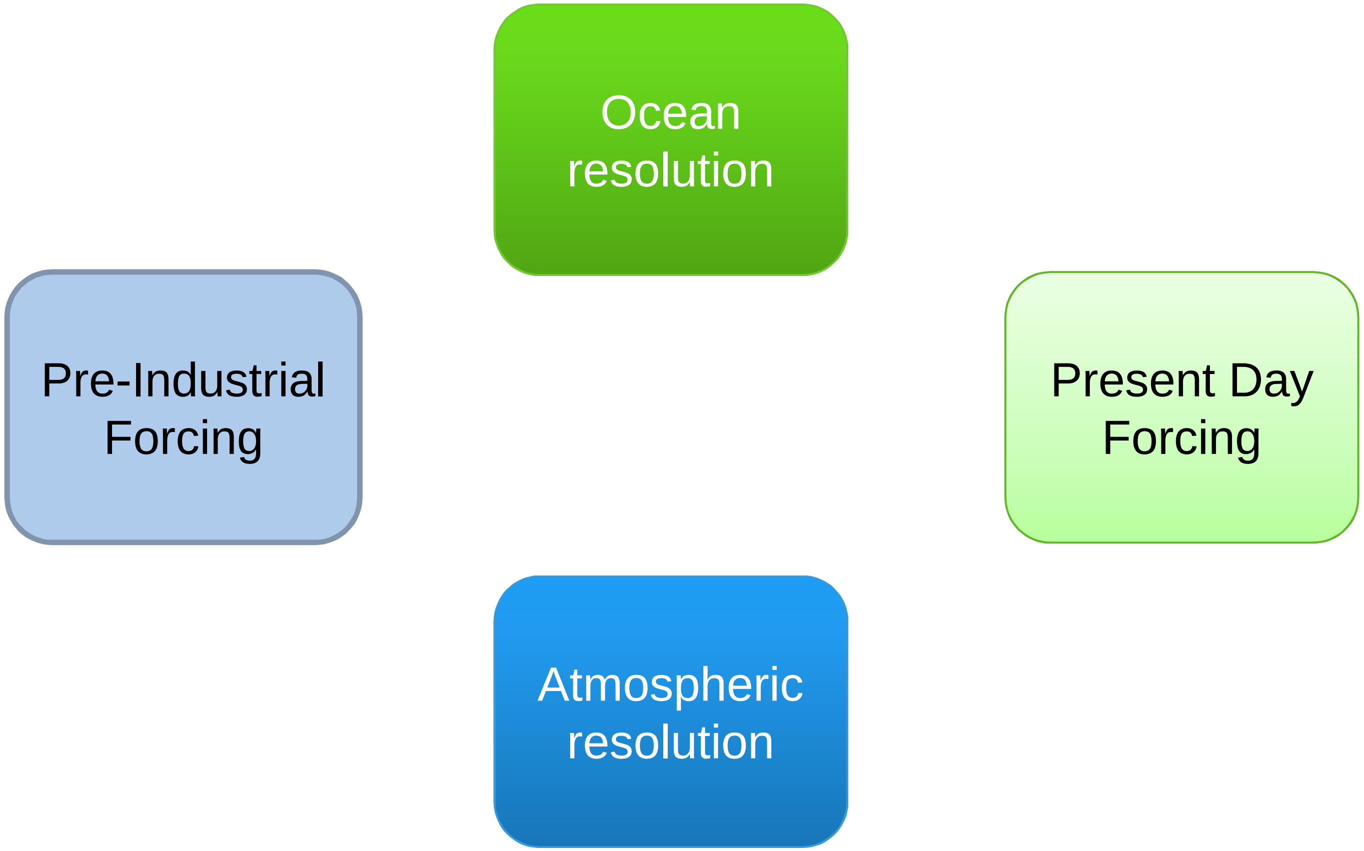
Model	Ocean Res	Atm Res	Simulations
EC-Earth3.1	ORCA1 - 1° ORCA025 – 1/4°	T255 T511	1950-2009 (hist) 1990-2014 (hist)
MPI-ESM	TP04 – 0.4° TP6M – 1/10°	T63 T63	55 y PI 55 y PI
CMCC-CM2	ORCA1 - 1° ORCA025 - 1/4°	~0.8°x1.1° ~0.8°x1.1°	40 y PI, 300 y PD 40 y PI, 40 y PD
CERFACS-HR	ORCA025 - 1/4°	T359	55 y PD
HadGEM-GC2	ORCA025 - 1/4°	N96, 216, 512	3 x 100 y PD

Table: Model simulations used for the analysis

Observations:

ERA-Interim reanalysis data for all atmospheric variables and sea ice concentration at 0.25° resolution from the Ocean and Sea Ice Satellite Application Facility (OSI-SAF 1980-2015) data set (Eastwood et al. 2011).

We analysed ensembles of sea-ice correlation with SLP when grouping GCMs by:



Sea Ice in different Arctic regions

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Northern Hemisphere
NH 0–90N, 0E–360E

Barents/Kara Seas
BAKA 70–82N, 15E–100E

Greenland Sea
GREEN 50–75N, 40W–15E

Labrador Sea/Baffin Bay
LAB 55–80N, 70W–40W

Laptev/East Siberian Seas
LAPSIB 70–82N, 100E–180E

Chukchi/Bering Seas
CHUBER 50–82N, 170E–160W

Beaufort Sea
BEAU 70–82N, 160W–90W

Central Arctic
CARC 80–90N, 0–360E

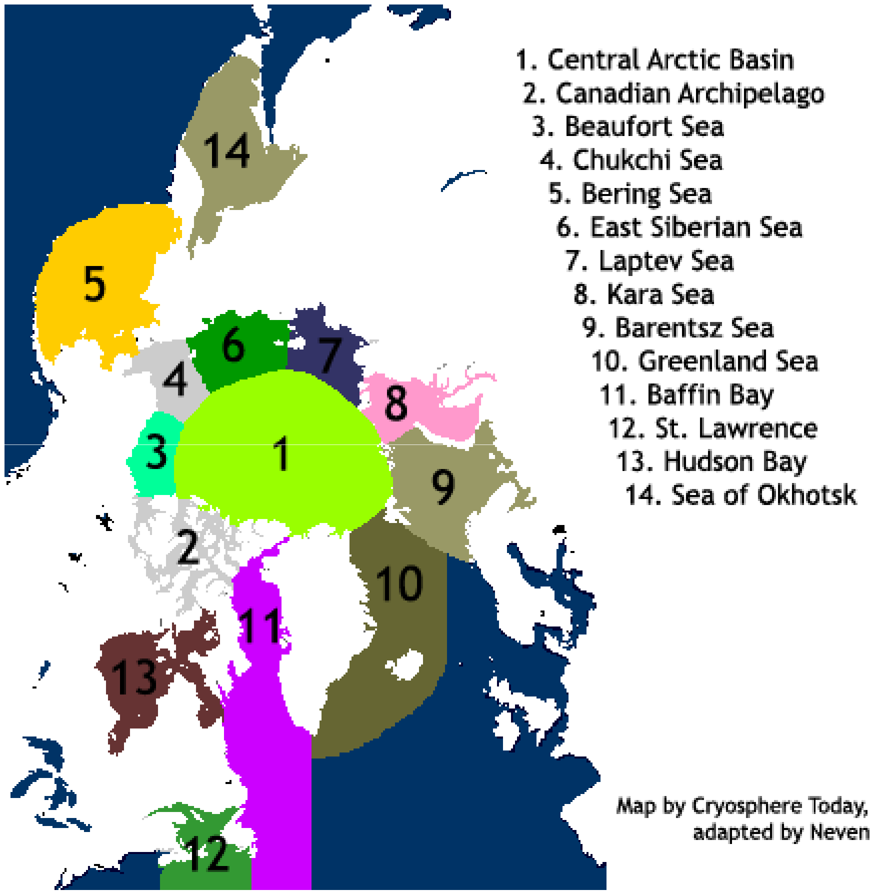
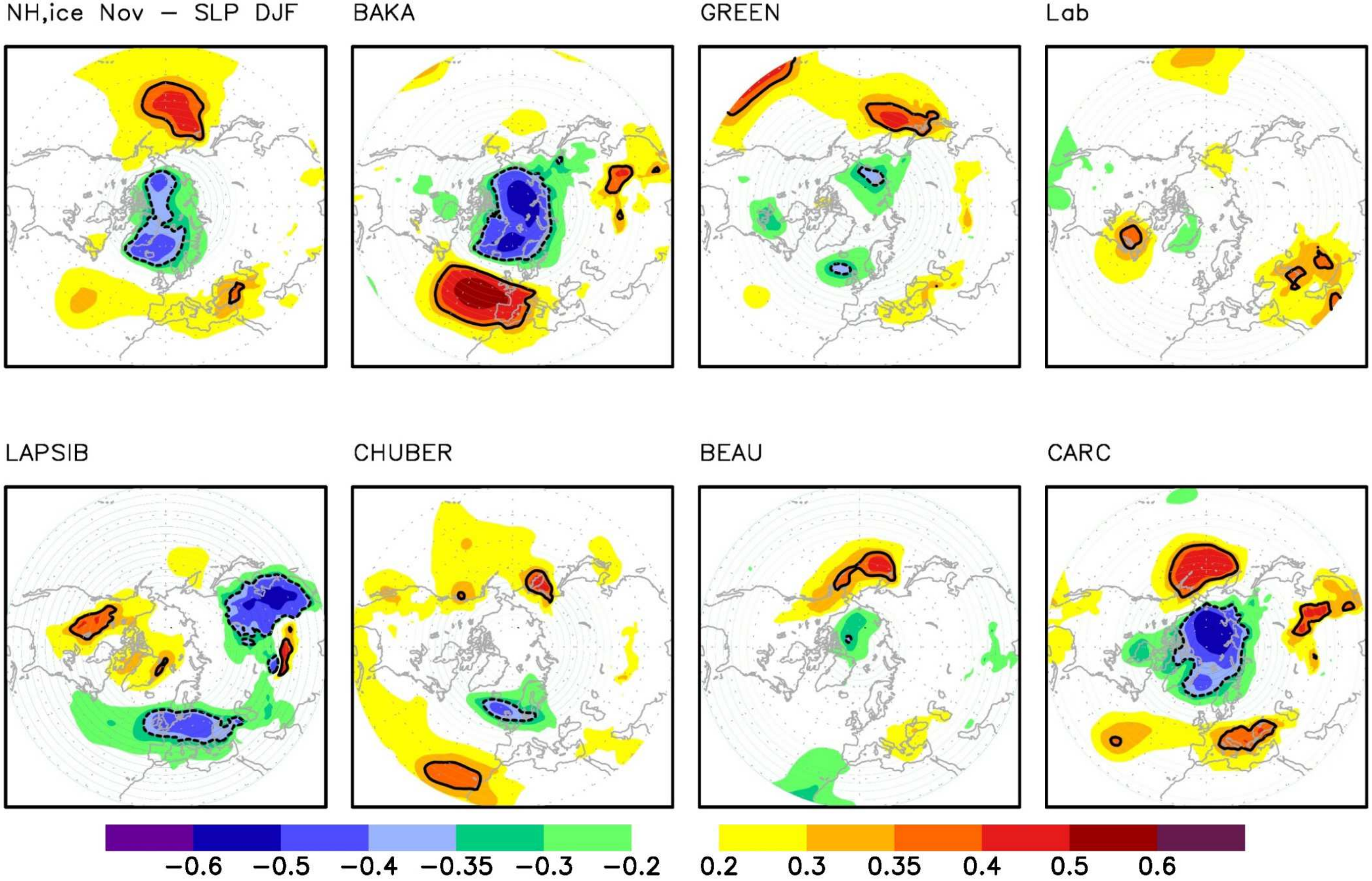


Figure taken from
http://neven1.typepad.com/

Correlation: Nov ice – DJF SLP



Koenigk et al. 2016

Ocean Resolution

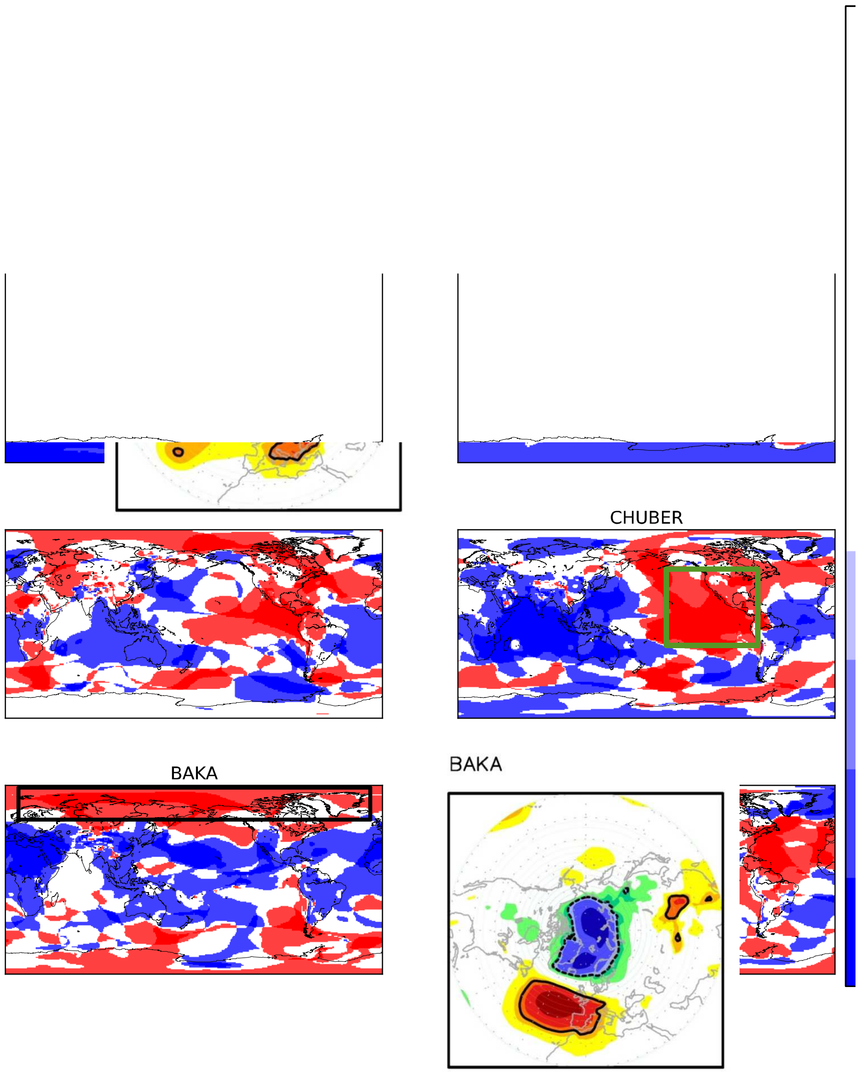
Low resolution

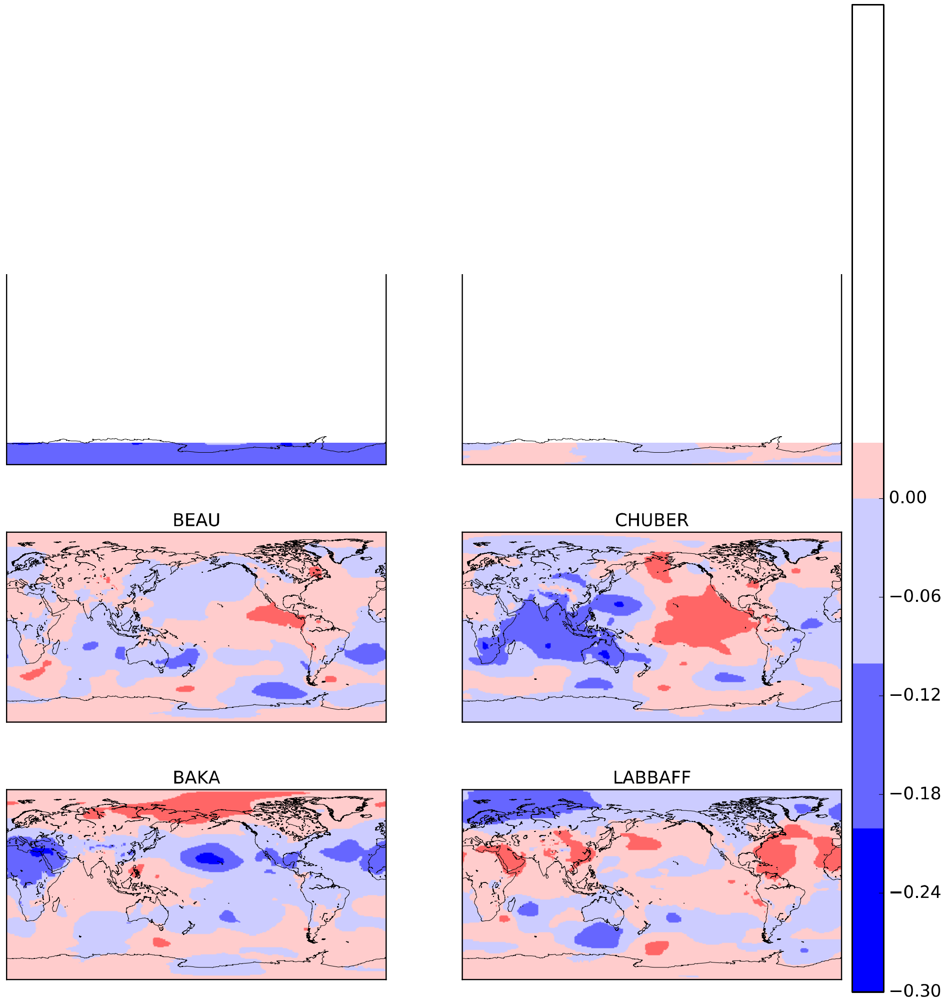
- EC-Earth3.1 (ORCA1)
- MPI-ESM TP04
- CMCC-CM2 PC (ORCA1)
- CMCC-CM2 PI (ORCA1)

High resolution

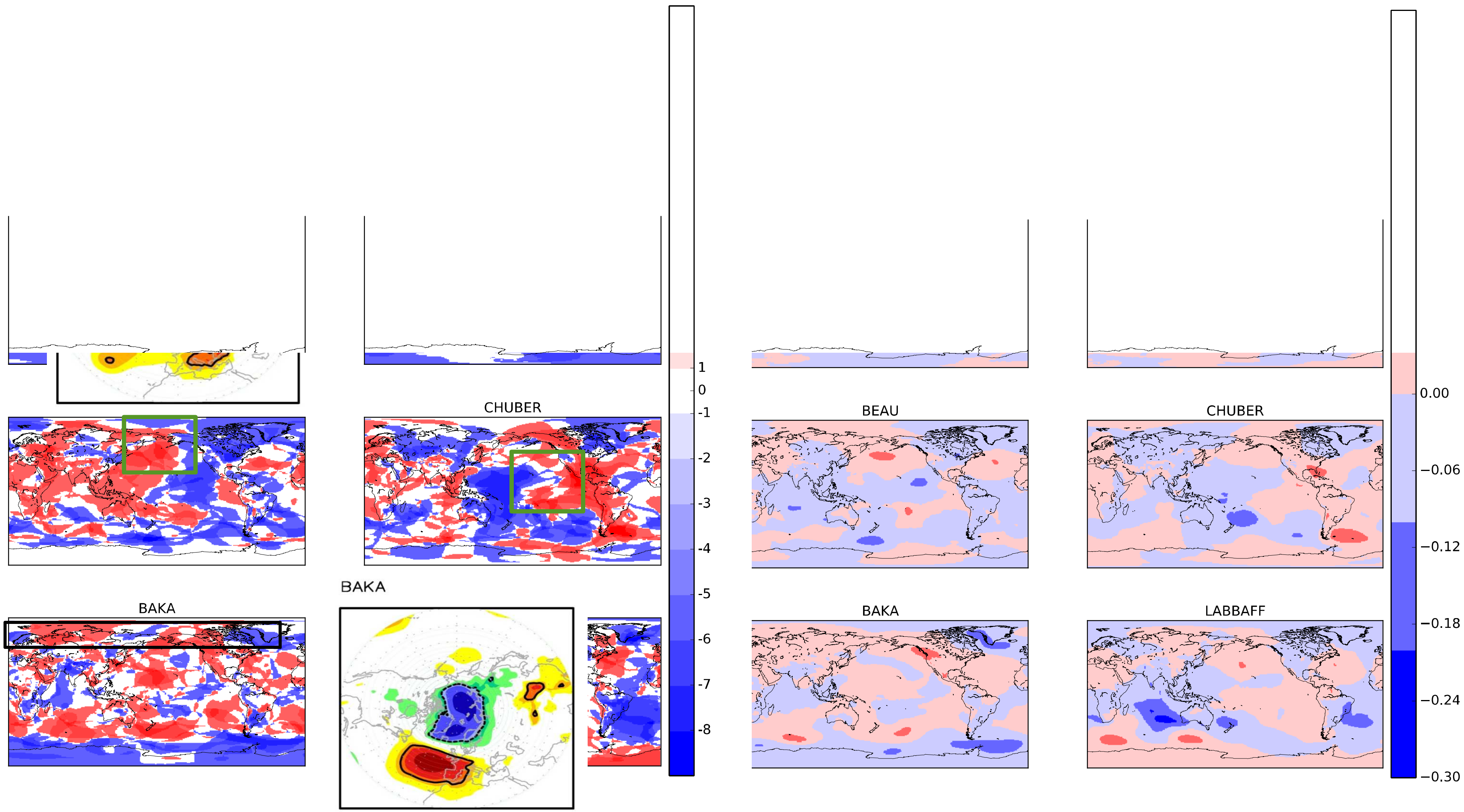
- EC-Earth3.1 (ORCA025)
- CERFACS-HR (ORCA025)
- MPI-ESM TP6M
- CMCC-CM2 PC (ORCA25)
- CMCC-CM2 PI (ORCA25)
- HadGEM-GC2 N96 ORCA25
- HadGEM-GC2 N512 ORCA25
- HadGEM-GC2 N216 ORCA25

Low Ocean Resolution





High Ocean Resolution



First results: Effects of ocean resolution

- The correlation sign between sea ice concentration over the Central Arctic, the Barents/Kara Seas and the Northern Hemisphere is similar to observations in the higher ocean resolution (0.25º) ensemble, but the amplitude is smaller.

- In contrast, over the aboved mentioned regions, the low resolution ensemble shows opposite correlation patterns compared to observations.

- In general, high ocean resolution simulations appear to show similar results to observations than the low resolution simulations.

External forcing

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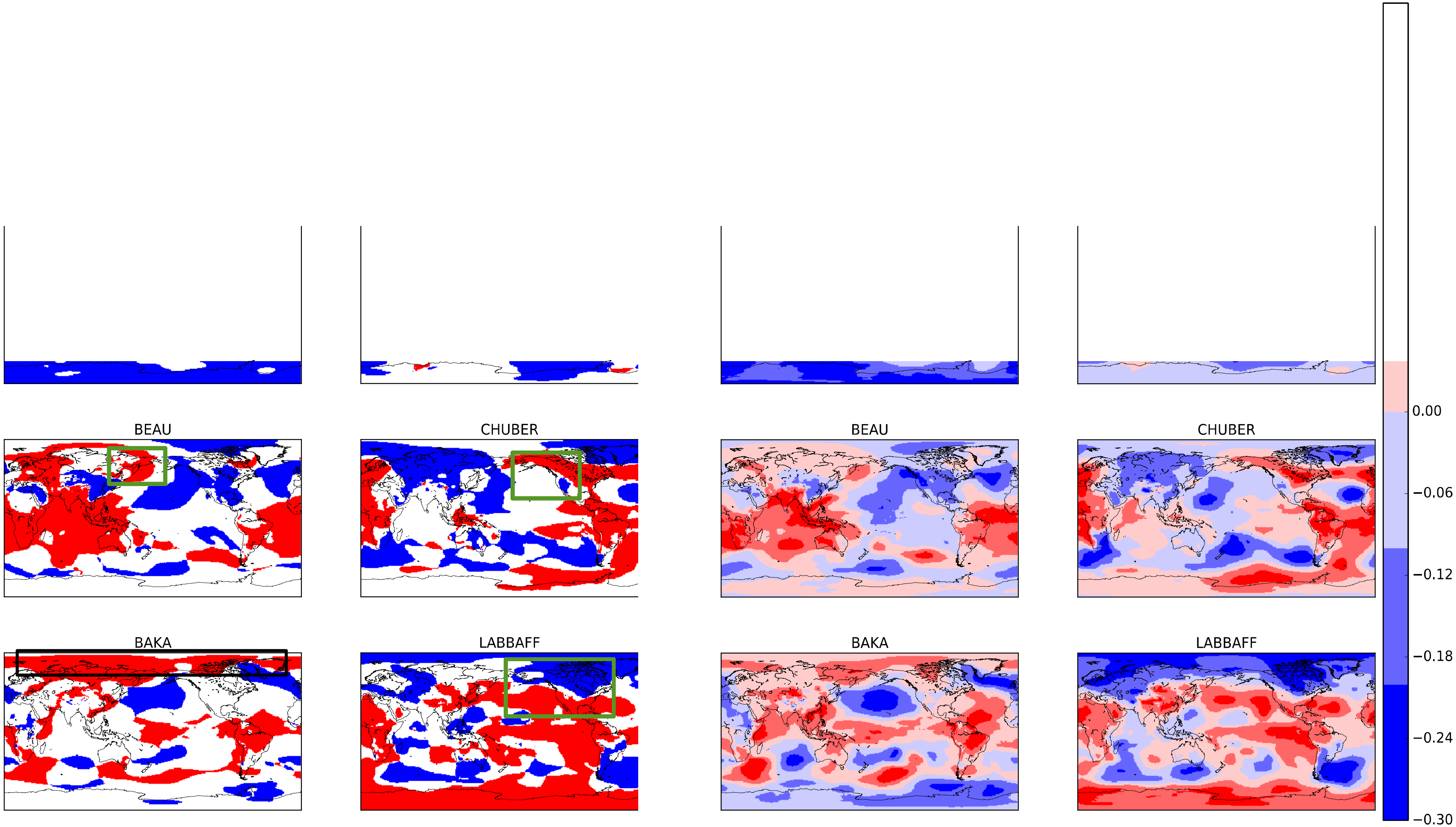
Pre-Industrial

- **CMCC-CM2 PI (ORCA1)**
- **CMCC-CM2 PI (ORCA25)**

Present Day

- **CMCC-CM2 PC (ORCA1)**
- **CMCC-CM2 PC (ORCA25)**

Pre Industrial



Present Day

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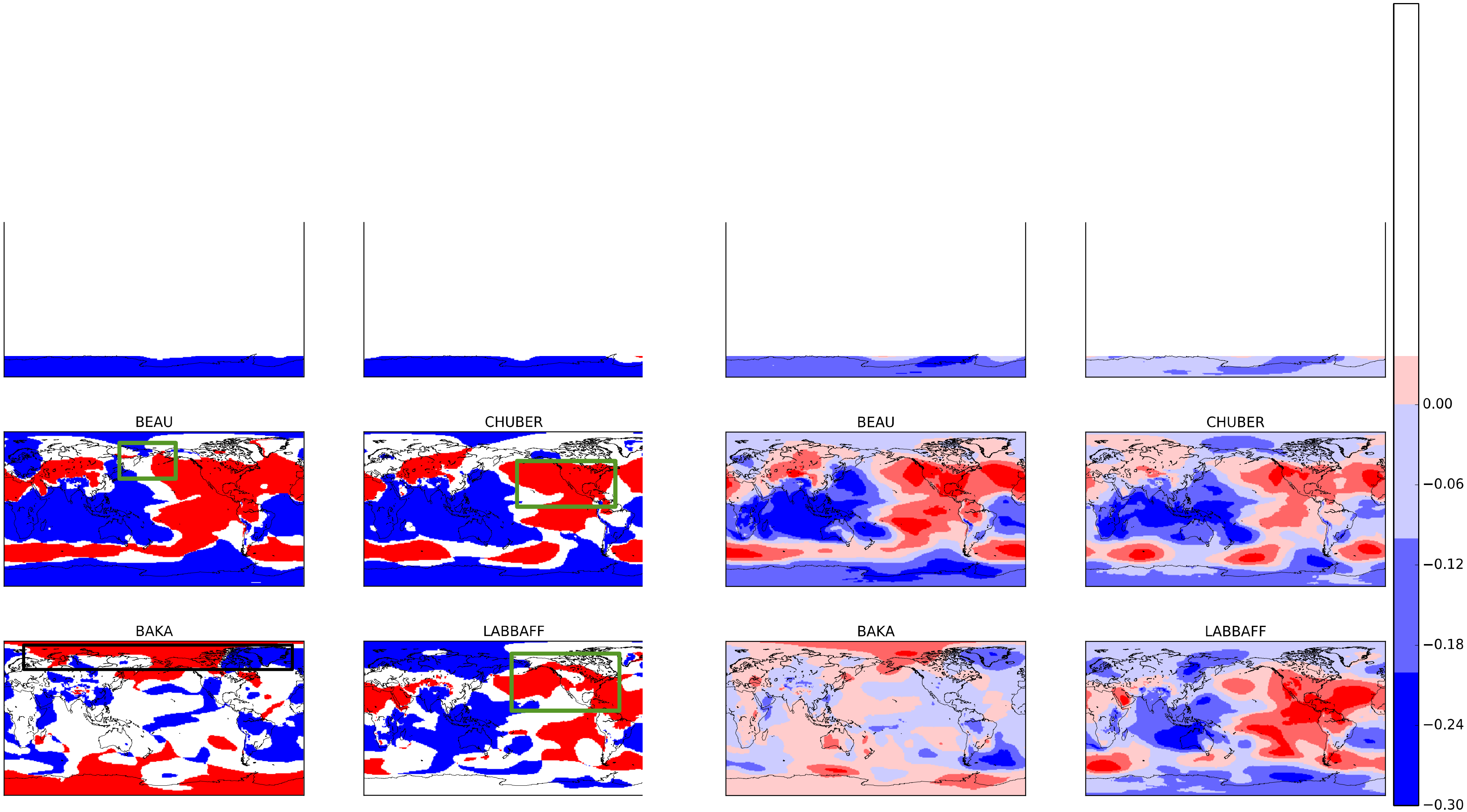


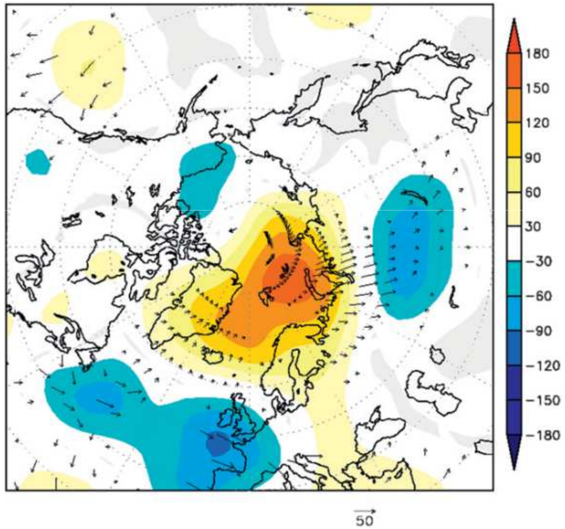
SMHI

First results: Effects of external forcing

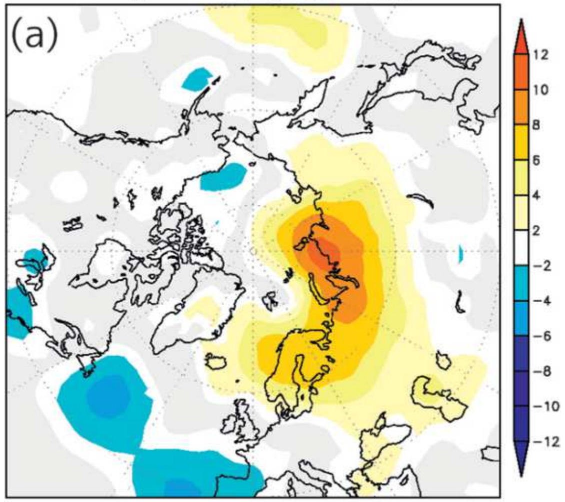
- The correlation sign between sea ice concentration does not show a systematic change dependent on the use of different external forcing (pre-industrial or present day) as for the use of different ocean resolutions.

PRIMAVERA GA2 – discussion on sea-ice

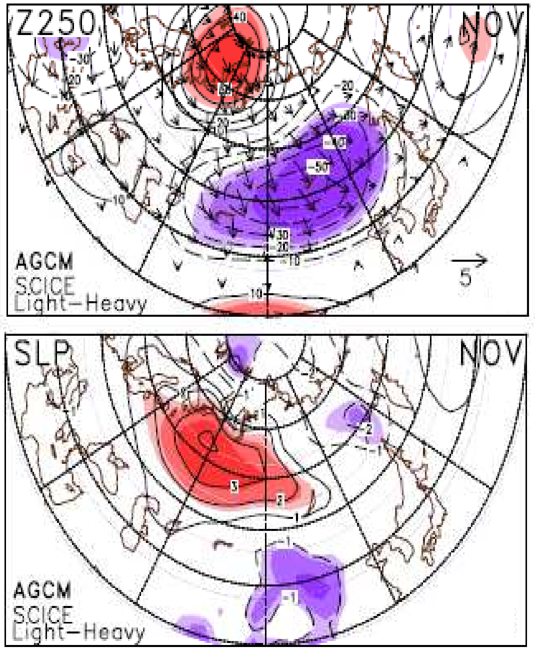
Z250 / WAF (DJF)



SLP$_{key}$ anomaly (Ice$_{light}$−Ice$_{heavy}$)

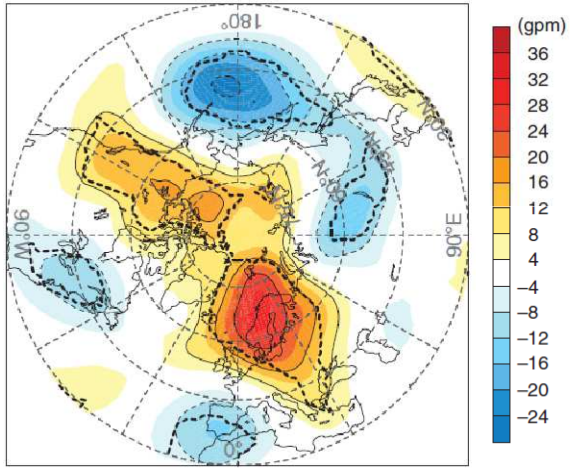


Inoue et al. (2012, GRL)

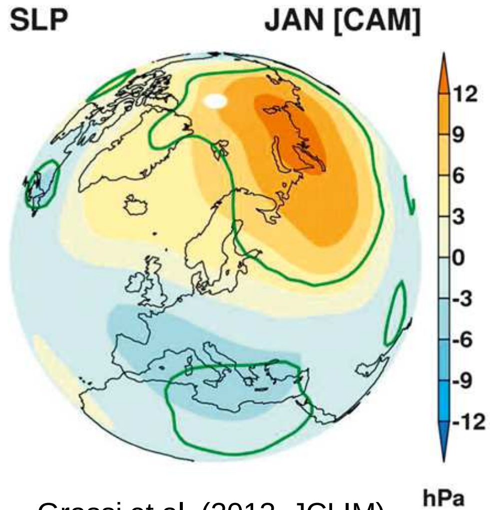


Honda et al. (2009, GRL)

ΔZ500 for ND, CAM5



Kim et al. (2014, Nat.Comms)



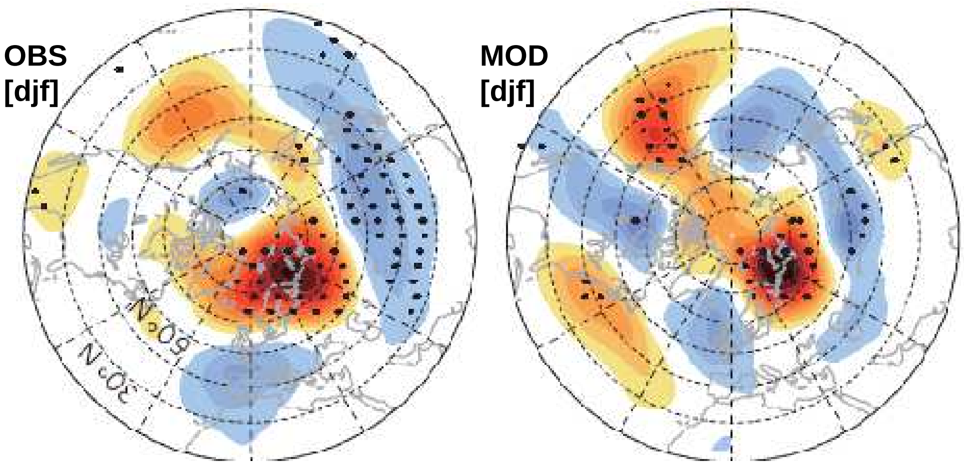
Grassi et al. (2013, JCLIM)

might be non-linear to SIC reduction!

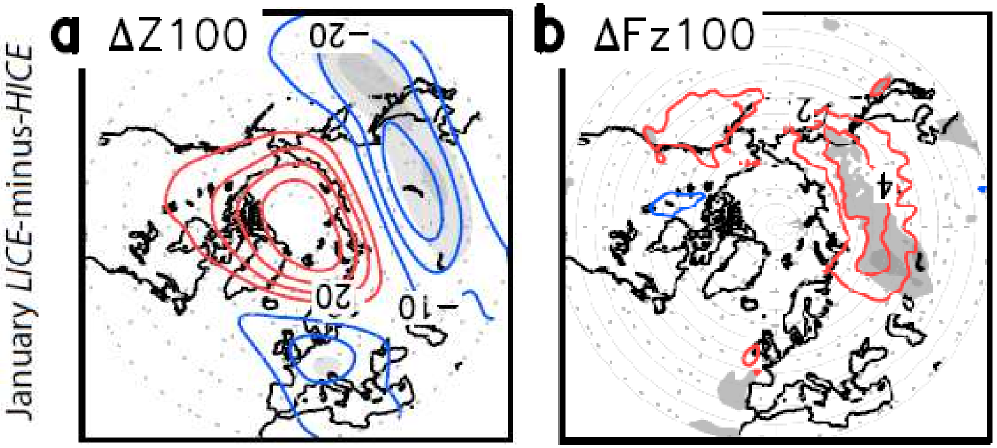
Petoukhov and Semenov (2010, JGR)

RECENT REVIEWS: Bader et al. 2011; Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015

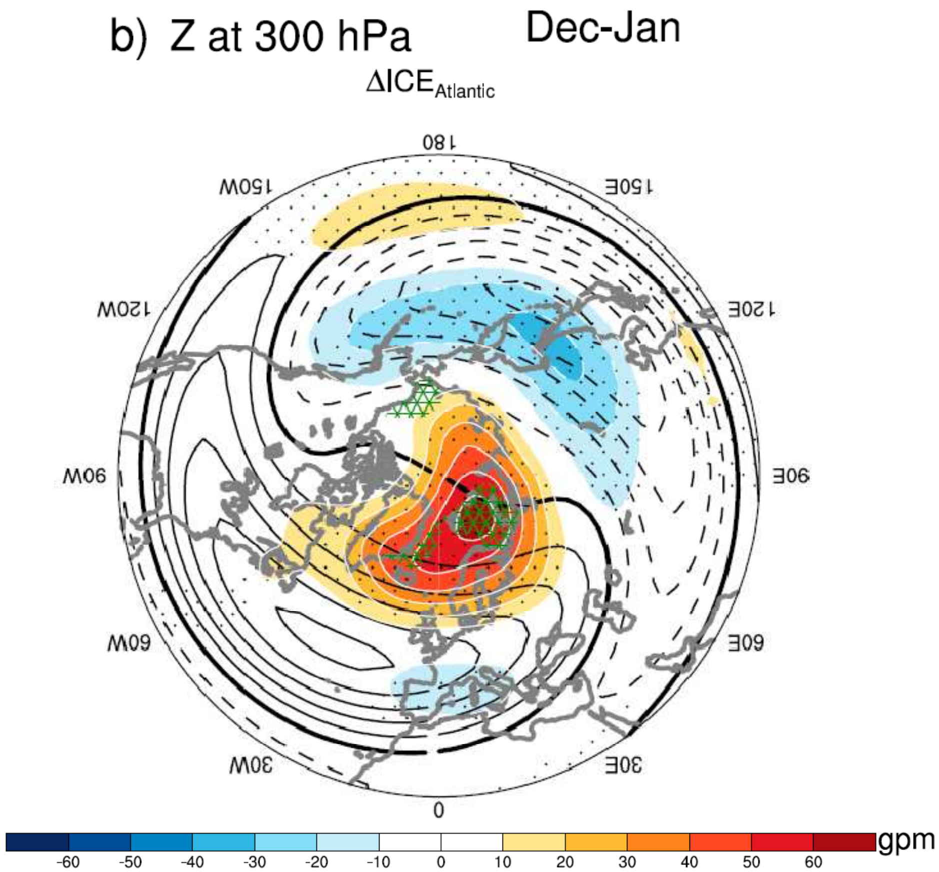
PRIMAVERA GA2 – discussion on sea-ice



Mori et al. (2014, Nat.Geosci)



Nakamura et al. (2016, GRL)



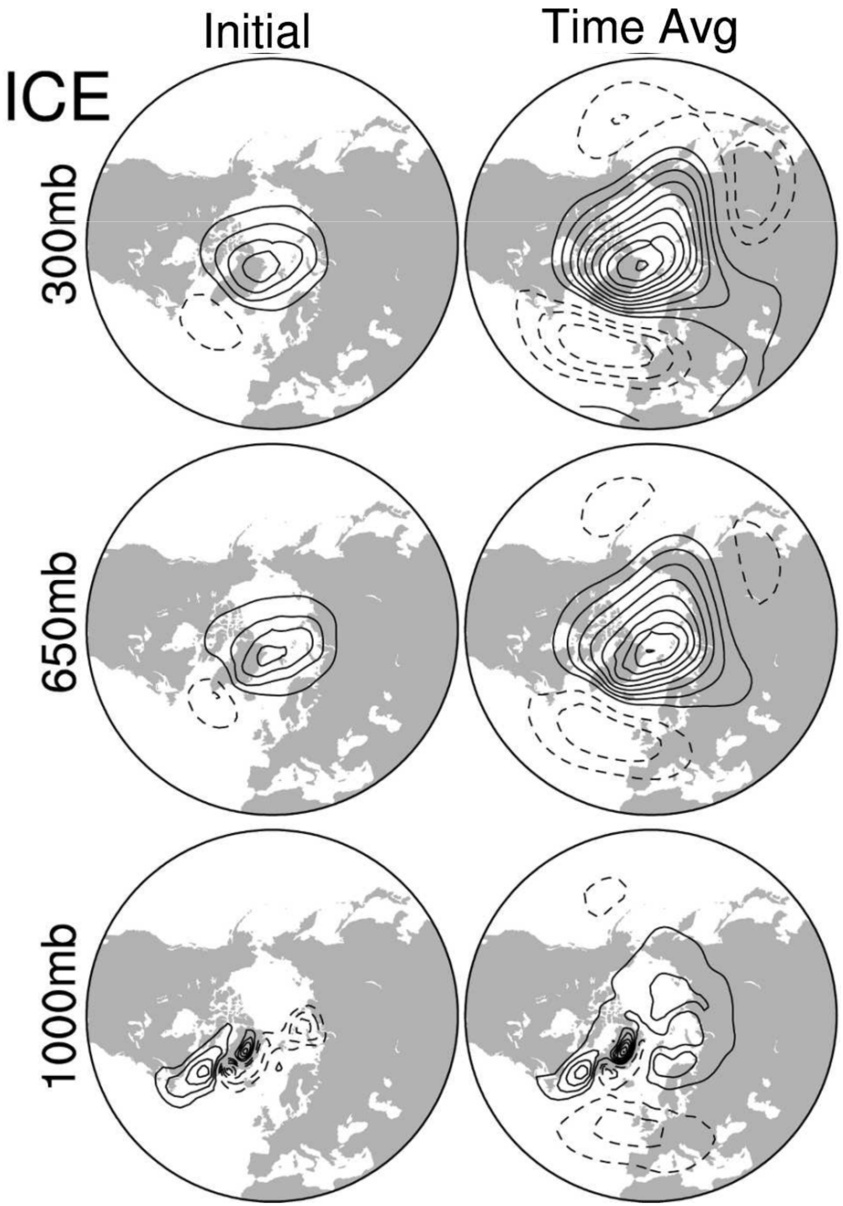
Sun et al. (2015, JCLIM)

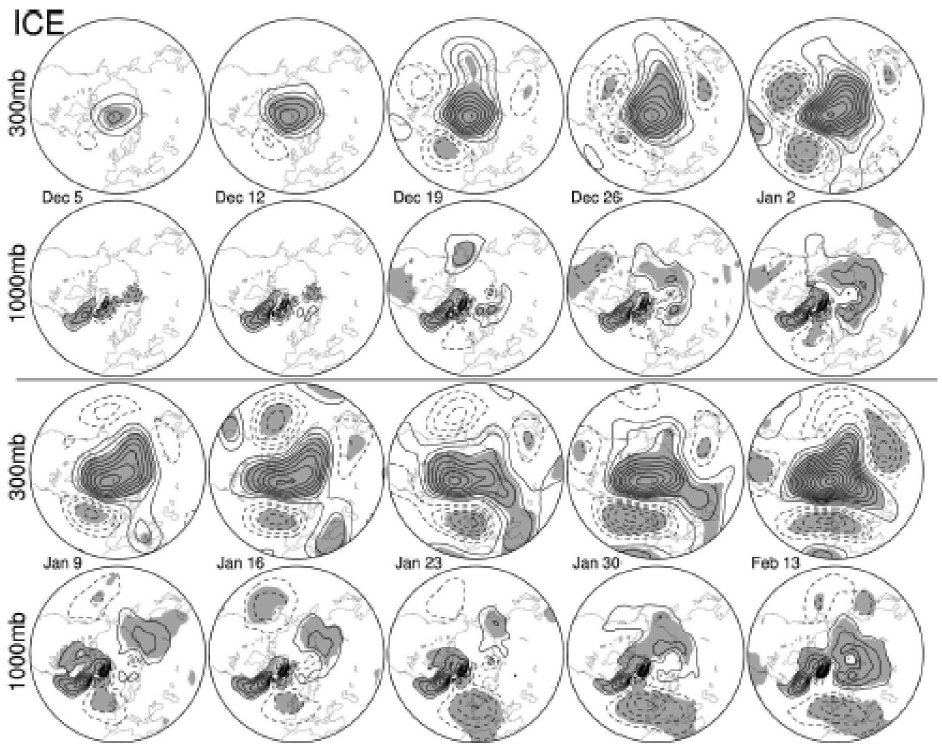
might be non-linear to SIC reduction!

Petoukhov and Semenov (2010, JGR)

RECENT REVIEWS: Bader et al. 2011; Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015

PRIMAVERA GA2 – discussion on sea-ice





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, JCLIM)

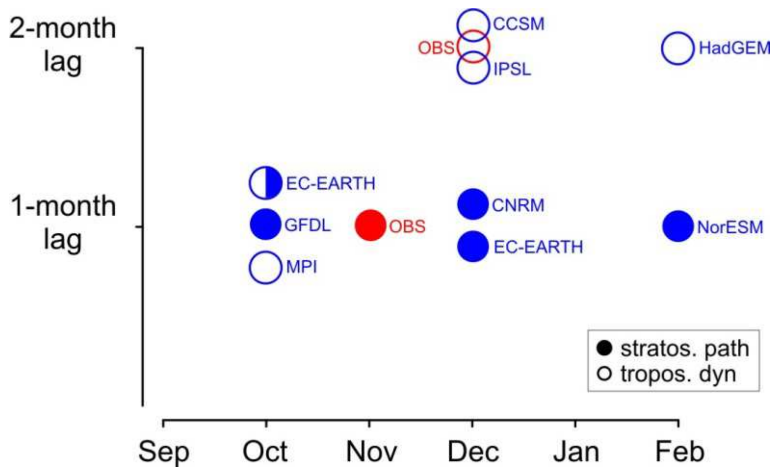
PRIMAVERA GA2 – discussion on sea-ice

SUMMARY

- CMIP5 models analysed here show a significant link with sea-ice reduction over the eastern Arctic (Greenland-Barents-Kara Seas) followed by a negative NAO-like pattern

- The timing of the simulated relationships is strongly model dependent, which suggests that the atmospheric sensitivity to sea-ice changes depends on the simulated mean-flow (internal variability) → source of uncertainty in climate prediction and projection

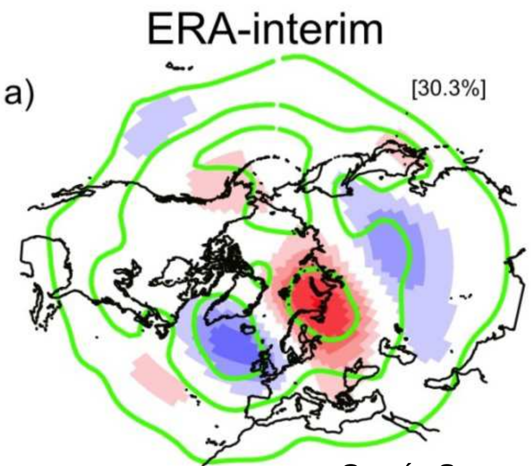
- Target experiments are needed to gain insight into the role played by the background-flow; to be assessed in *PRIMAVERA* (H2020/SC5) and *APPLICATE* (H2020/BG10)



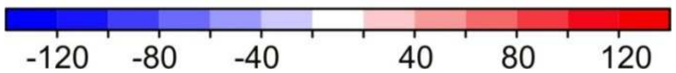
García-Serrano et al. (2016, ClimDyn)

PRIMAVERA GA2 – discussion on sea-ice

EOF1 Z200-Eurasia (**nov**)



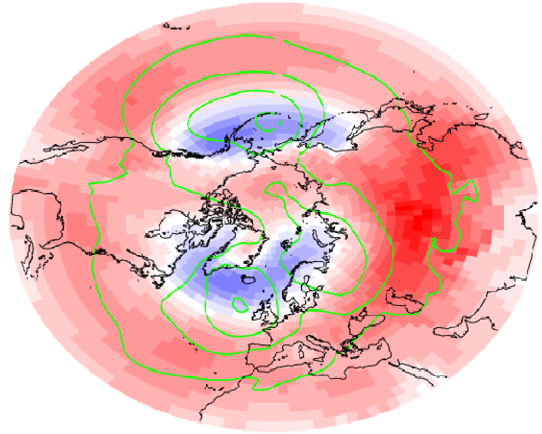
García-Serrano et al. (2016, ClimDyn)



the **Ural-Siberian** anticyclone

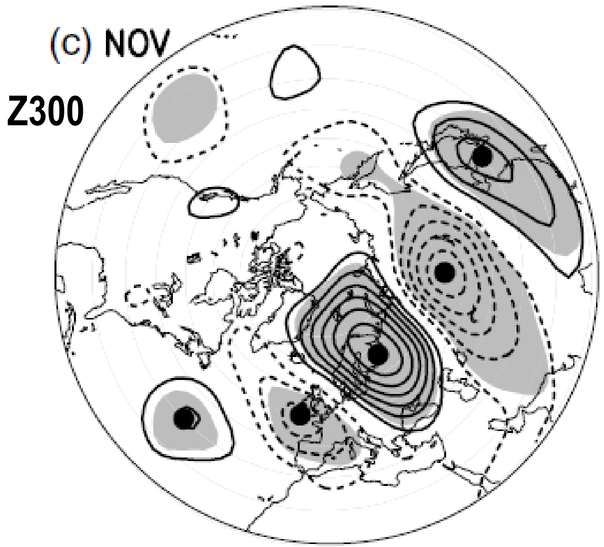
Santolaria et al.
(in preparation)

SLP (Nov) clim. + std.dev.



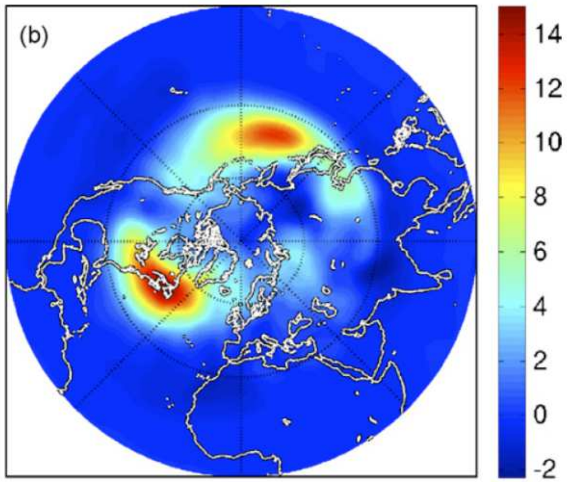
Santolaria et al. (in preparation)

the **SCA** pattern



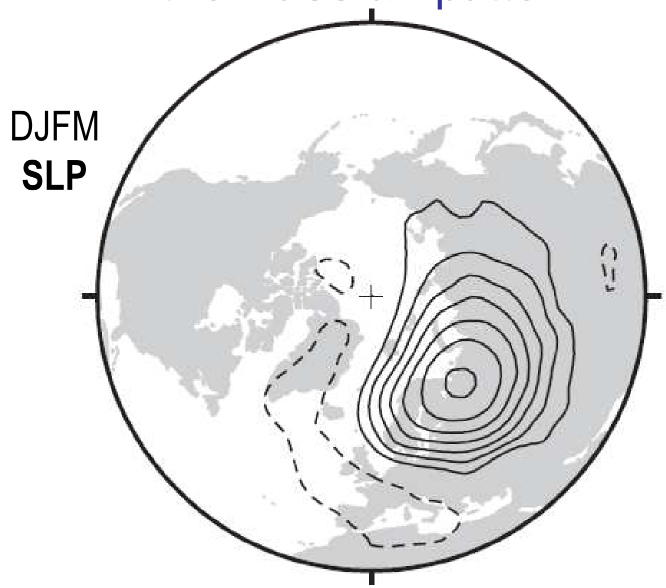
Bueh and Nakamura (2007, QJRMS)

v'T' 500hPa (DJF)



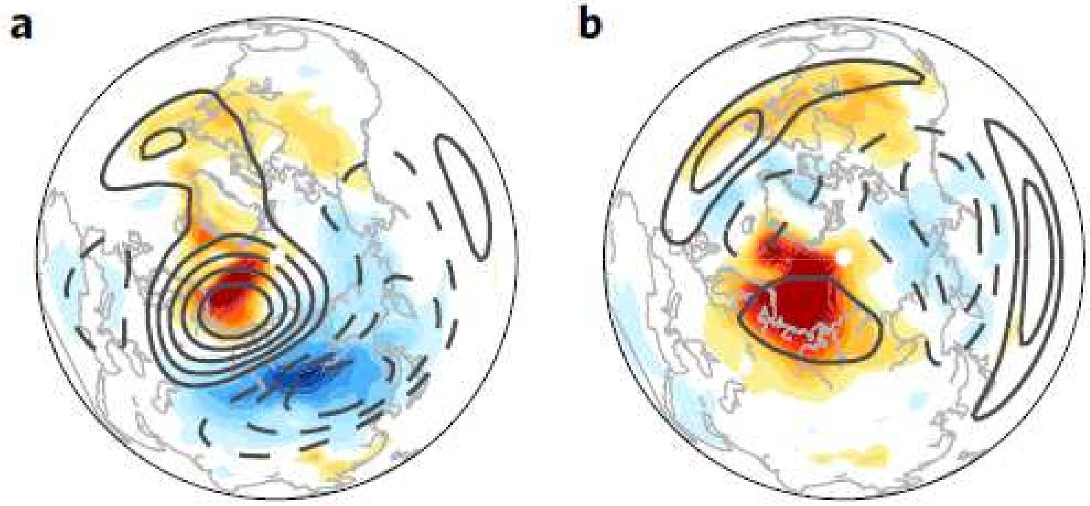
Vallis and Gerber (2008, DynAO)

the **Russian** pattern

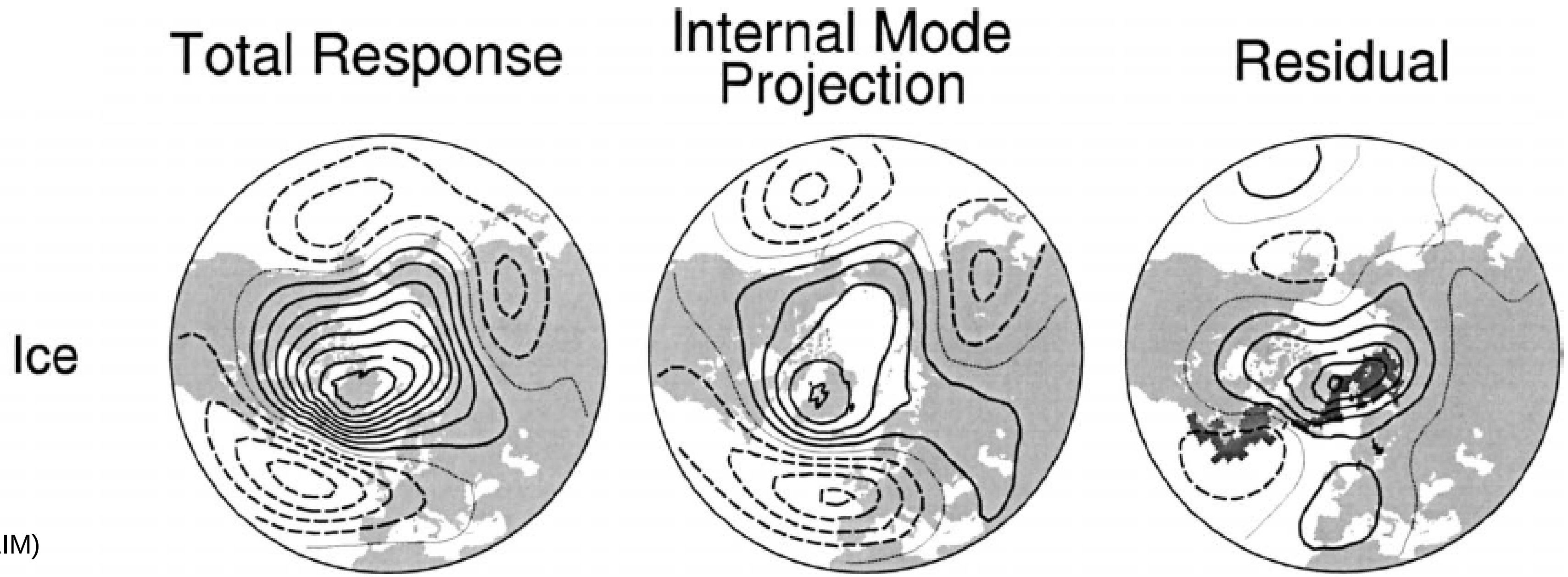


Smoliak and Wallace (2015, JAS)

PRIMAVERA GA2 – discussion on sea-ice

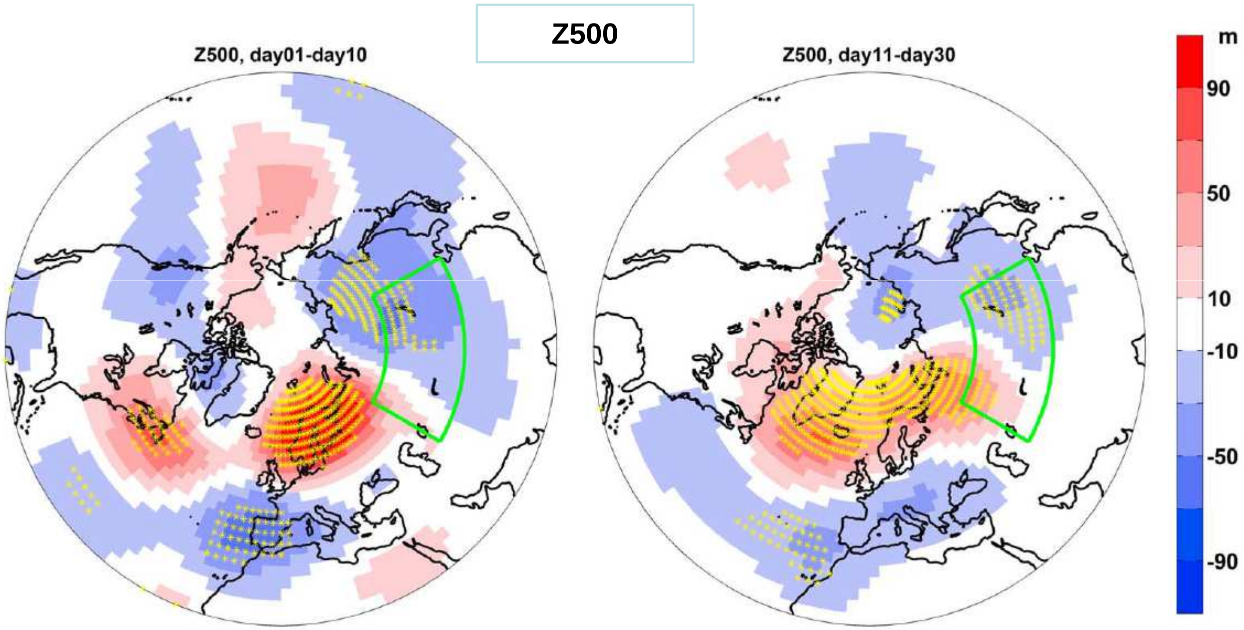


McCusker et al. (2016, Nature Geo.)



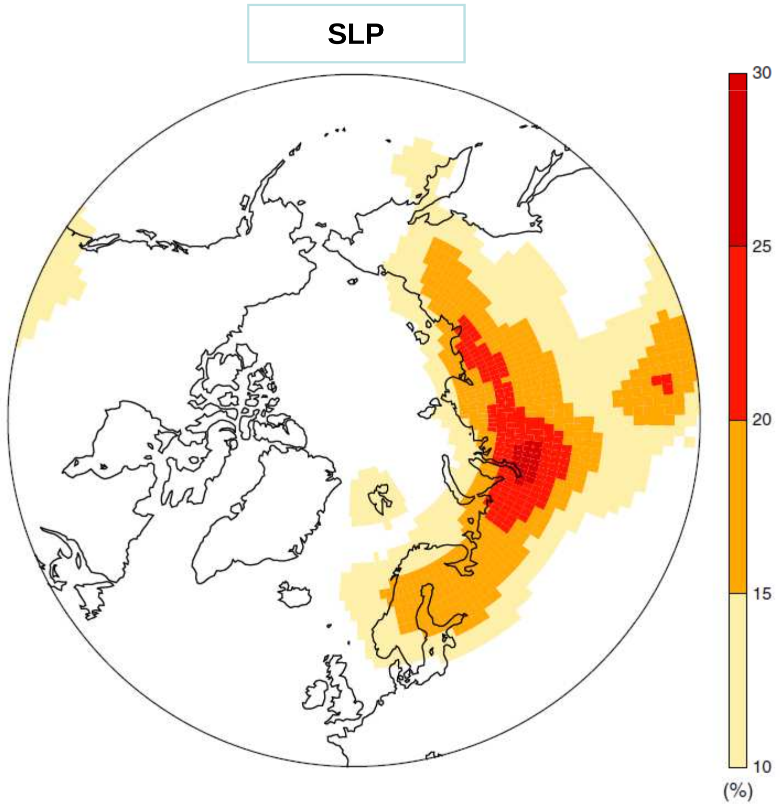
Deser et al. (2004, JCLIM)

PRIMAVERA GA2 – discussion on sea-ice



Jung et al. (2014, GRL)

initializing sea-ice reduces RMSE over Eurasia



Day et al. (2014, GRL)

RECENT REVIEWS: Bader et al. 2011; Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015