Link between Autumn Arctic Sea Ice and Northern Hemisphere Winter Forecast Skill

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A multi-model seasonal forecast analysis

Model	**CNRM-CM6-1**	**EC-Earth 3.2.2**	**SEAS5**	**GloSea5**
Atmosphere	ARPEGE 6.3	IFS Cy36r4	IFS Cy43r1	UM v6
Ocean	NEMO 3.6	NEMO 3.6	NEMO 3.4	NEMO 3.4
Sea ice	GELATO v6	LIM3	LIM2	CICE 4.1
Atmospheric resolution	tl127l91r (~150 km)	tl255l91r (~80 km)	tCo319L91 (~35 km)	N216L85 (~40 km)
Ocean resolution	eORCA1L75 (~1°)	ORCA1L75 (~1°)	ORCA025L75 (~0.25°)	ORCA025L75 (~0.25°)
Sea ice initial conditions	GELATO-NEMO run constrained towards GLORYS 2V4 (Mercator)	LIM3-NEMO run with ENKF SIC assimilation	ORA-S5	NEMOVAR
Ensemble size	30	25	25	28

→ Different sea-ice models

→ Different resolutions

→ Different flavours of sea ice initialization

→ All at least 25 members

Common reforecast period: **1993-2014**

All systems initialized around the **1st November** **focus on DJF**

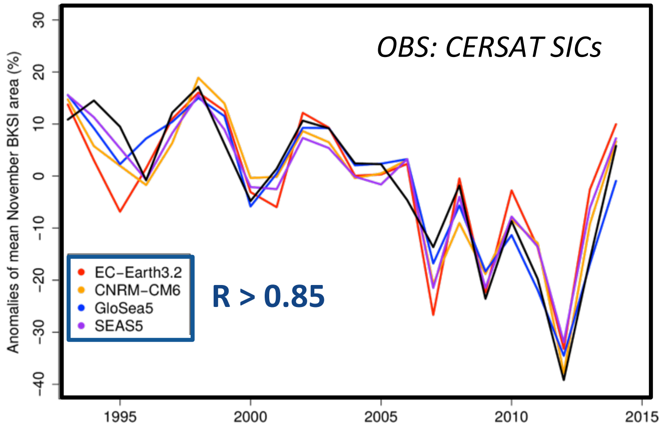
25 members from each system **100 members**

Main Goal - To determine the impact of Barents-Kara Seas on Northern Hemisphere winter predictive skill

Methodology

A new set of seasonal forecasts is synthetically built by **regressing out** (using linear regression) the **Barents-Kara sea ice (BKSI) area in November** of the **winter (DJF)** surface air temperature, sea level pressure and precipitation fields **from the original set**

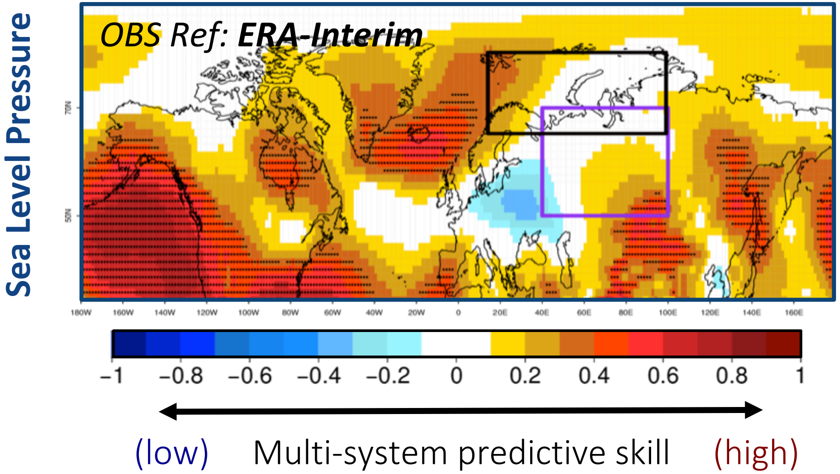
Anomaly of mean November BKSI area



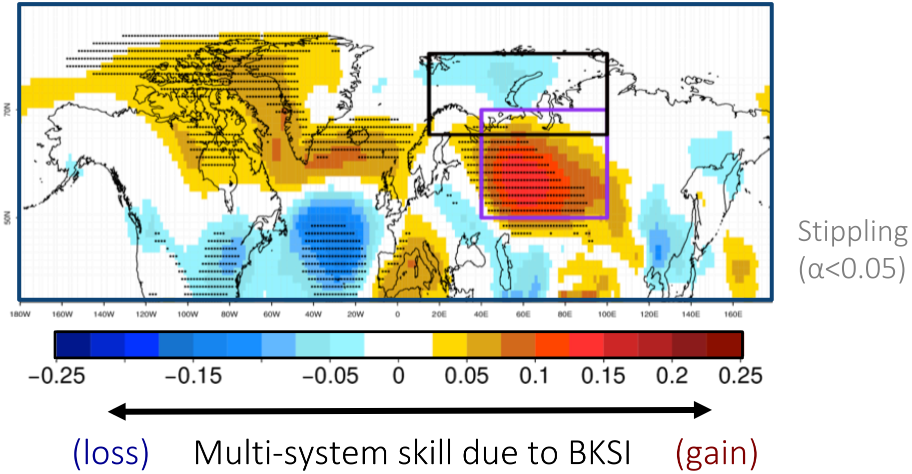
By computing the **differences** in skill **between the BKSI removed and the original set** of seasonal predictions we can now evaluate the BKSI contribution to climate prediction capacity in the Arctic region and the mid-latitudes

Multi-model skill (and skill gain) in NH winter SLP

Multi-model Anomaly Correlation Coefficient (ACC)



Multi-model Original vs no-BKSI ACC difference

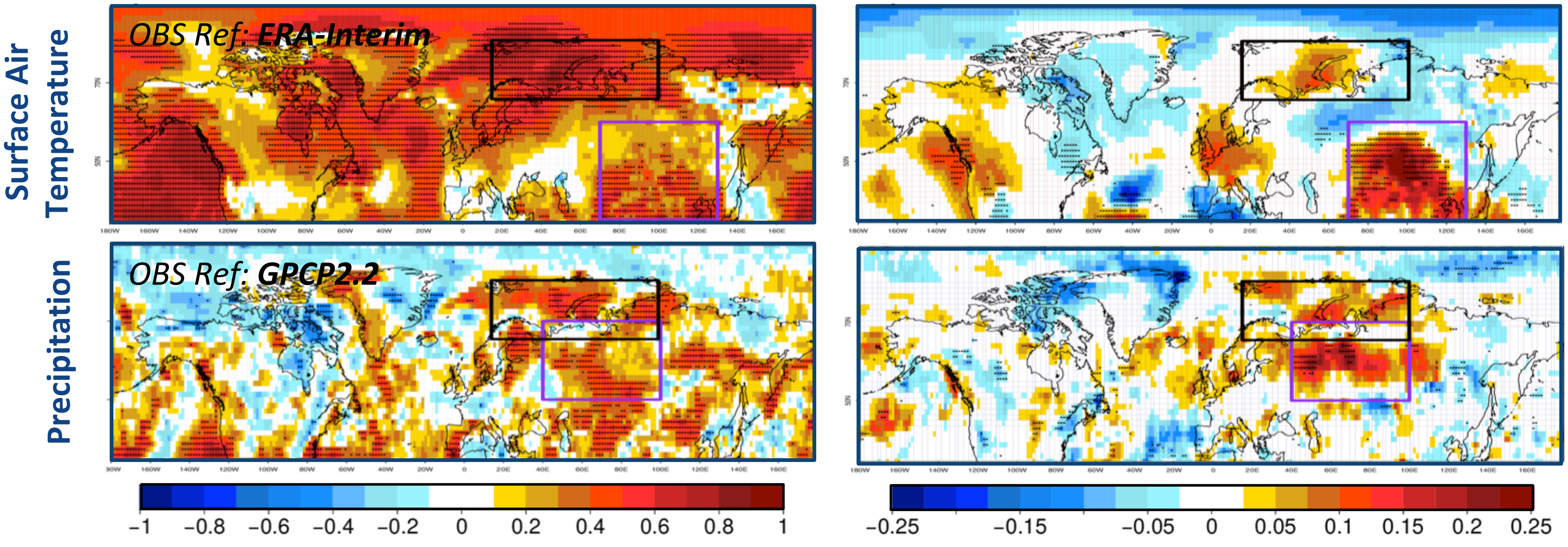


The **multi-model** ensemble prediction system has **limited skill** for SLP over Europe

BKSI is associated with **enhanced predictive capacity** on Western Russia

Multi-model skill (and skill gain) in NH winter climate

Multi-model Anomaly Correlation Coefficient (ACC) | Multi-model Original vs no-BKSI ACC difference



Stippling (α<0.05)

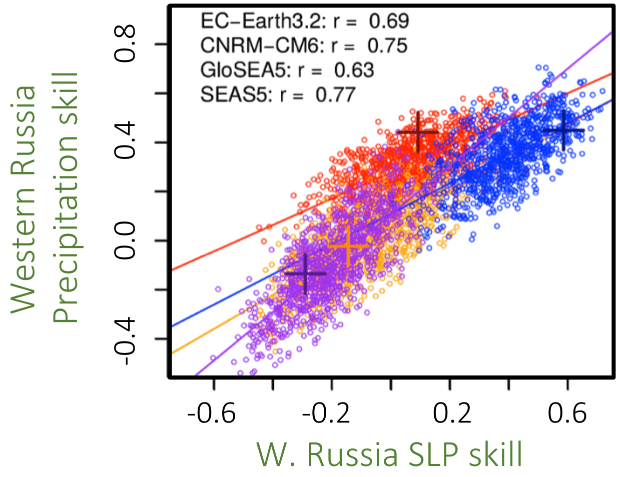
(low) Multi-system predictive skill (high)

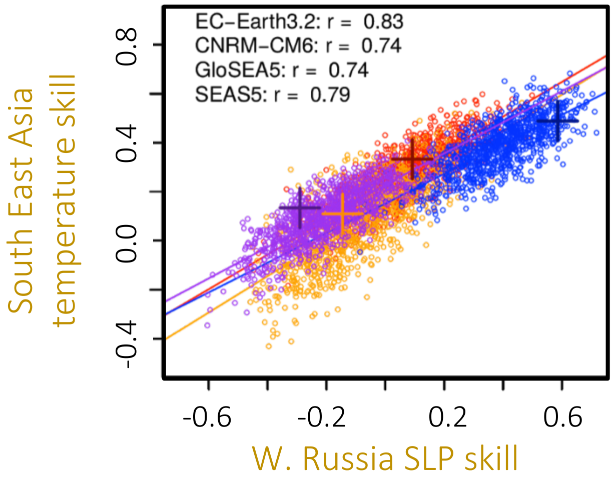
(loss) Multi-system skill due to BKSI (gain)

BKSI also linked with **enhanced predictive capacity on**
Western Russia precipitation and surface temperature in South East Asia

W. Russia SLP skill behind other Eurasian signals

Scatterplots with the DJF skill relationship between

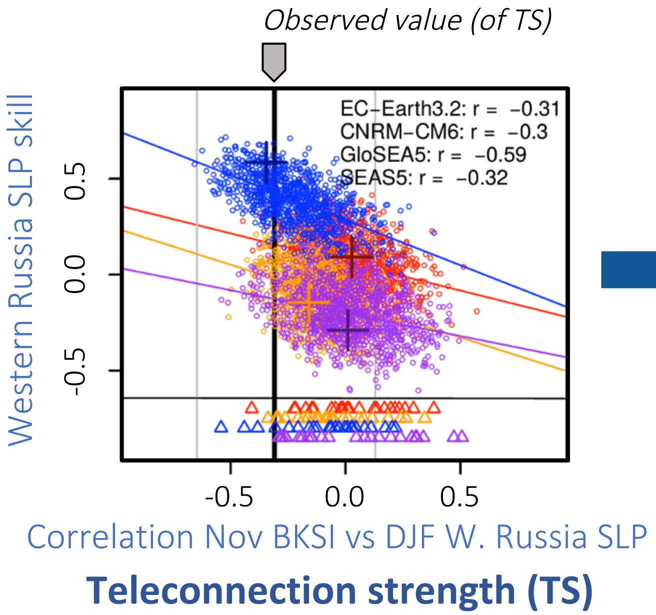




The scatterplot is generated by **randomly sampling 10-members** from each forecast system and computing the respective skill metrics **1,000 times for each system**

There is a **strong linear relationship** between the skill in W. Russia SLP and the skill in W. Russia precipitation and South East Asia temperature

Teleconnection Mechanism: W. Russia SLP link to BKSI

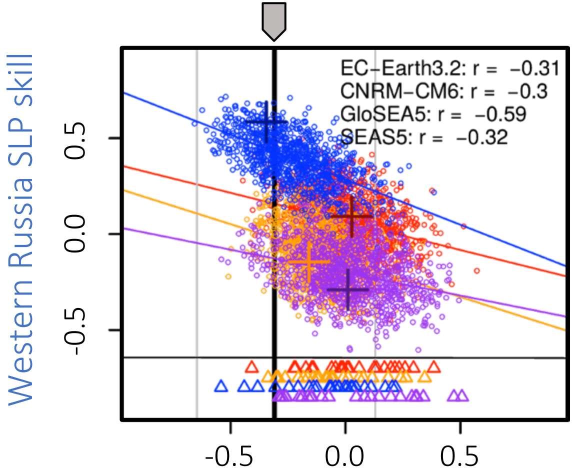


In all systems
the **stronger BKSI-West Russia teleconnection** is,
the higher the SLP skill is in Western Russia

Interestingly, **all systems** tend to **underestimate the TS**

Constrained Forecasts: Sub-selecting of stronger TS sets

Observed value (of TS)

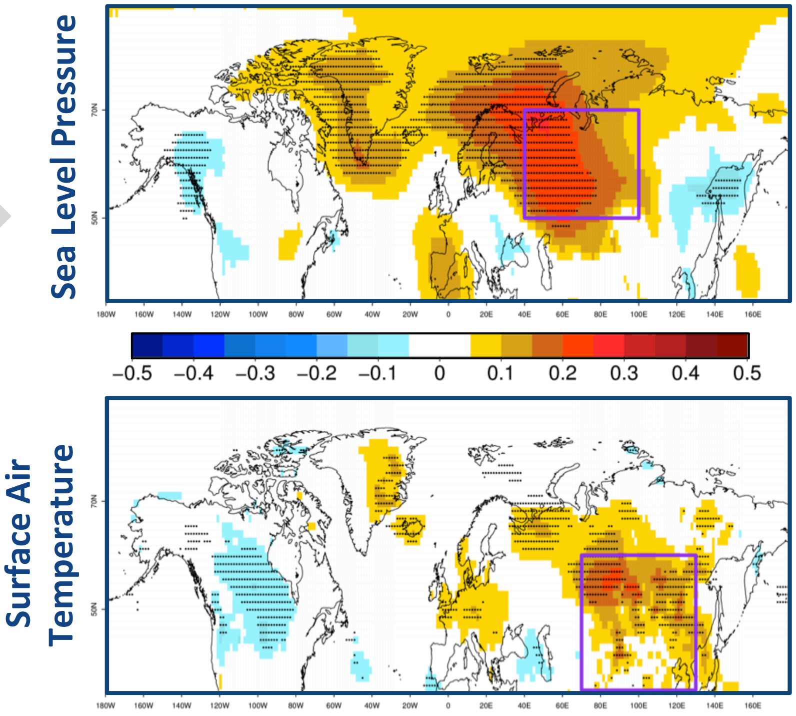


Correlation Nov BKSI vs DJF W. Russia SLP

Teleconnection strength (TS)

10% subsets with **strongest TS**

ACC **skill gain** with respect to original complete set



By subselecting the members for which **TS is more realistic** we improve prediction of areas/variables affected by teleconnection

Take home messages

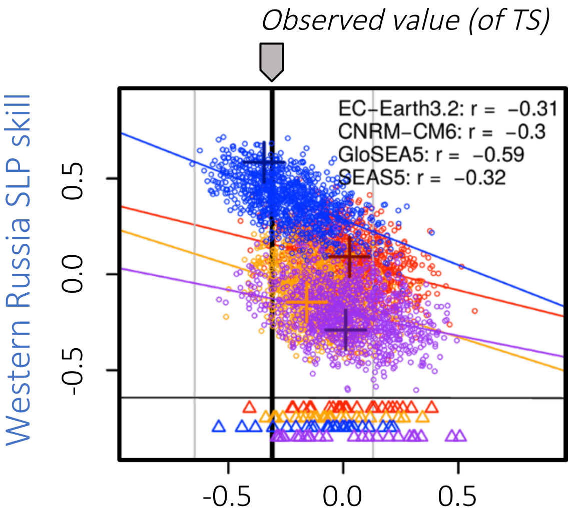
- Climate forecast systems have **limited predictive capacity at seasonal scales** in the Northern Hemisphere midlatitudes

- **Autumnal Barents and Kara Sea ice** (BKSI) is likely a source of winter climate predictability in large regions of northern Eurasia

- Analysis of multimodel initialized predictions suggests that **winter predictability in Eurasia** is enhanced by a sea ice-atmosphere teleconnection with BKSI

- This **teleconnection is hindered by systematic model biases**, which can be partly circumvented through a process-based ensemble subselection

Constrained Forecasts: Link with mean-state SLP biases



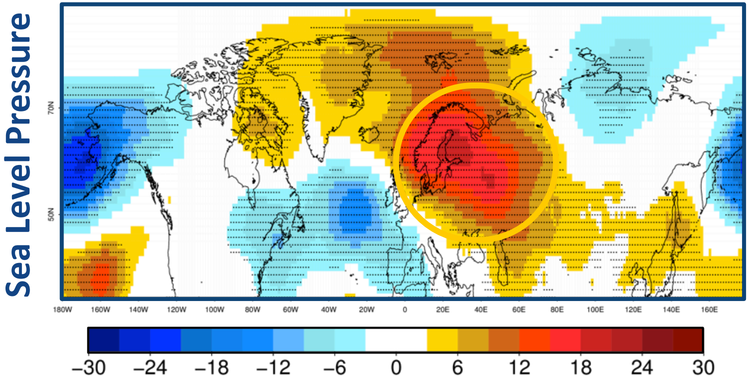
Correlation Nov BKSI vs DJF W. Russia SLP

Teleconnection strength (TS)

The **skill improvement** comes from a reduction in systematic SLP model biases, which enable a more realistic teleconnection

Strong TS members have a reduced **SLP bias**

Multi-model November SLP mean difference between **10%** members with **strongest/weakest TS**



November multi-model SLP bias (in Pa)