WEATHER CLIMATE WATER
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# Predictability over the Arctic Region from sub-seasonal to seasonal time scales


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WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

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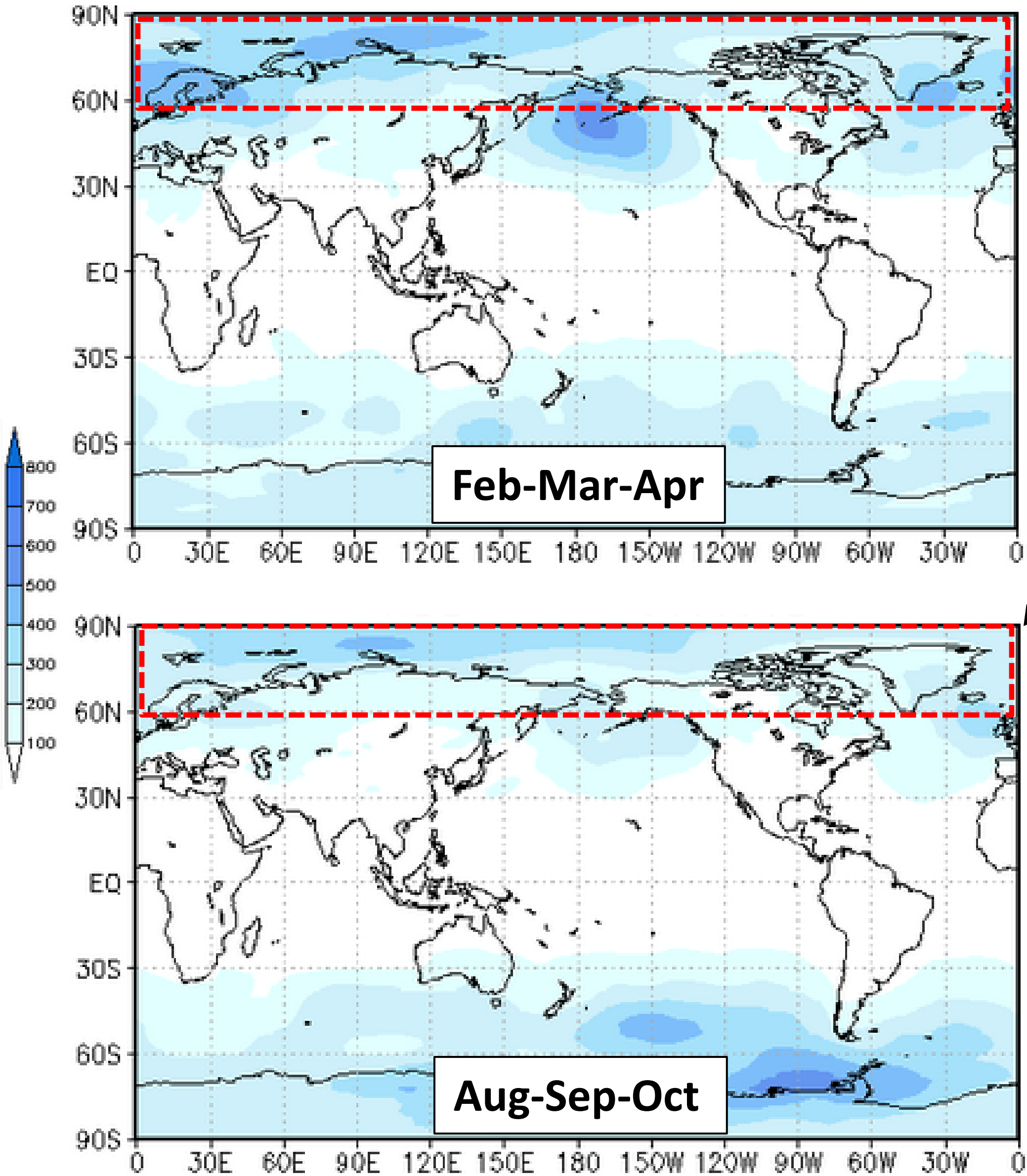
# Content

- Forecast skill over the Arctic compared to other regions
- The role of sea ice
- The role of the stratosphere
- The role of the tropics (MJO)

# Forecast skill over the Arctic compared to regions at lower latitudes



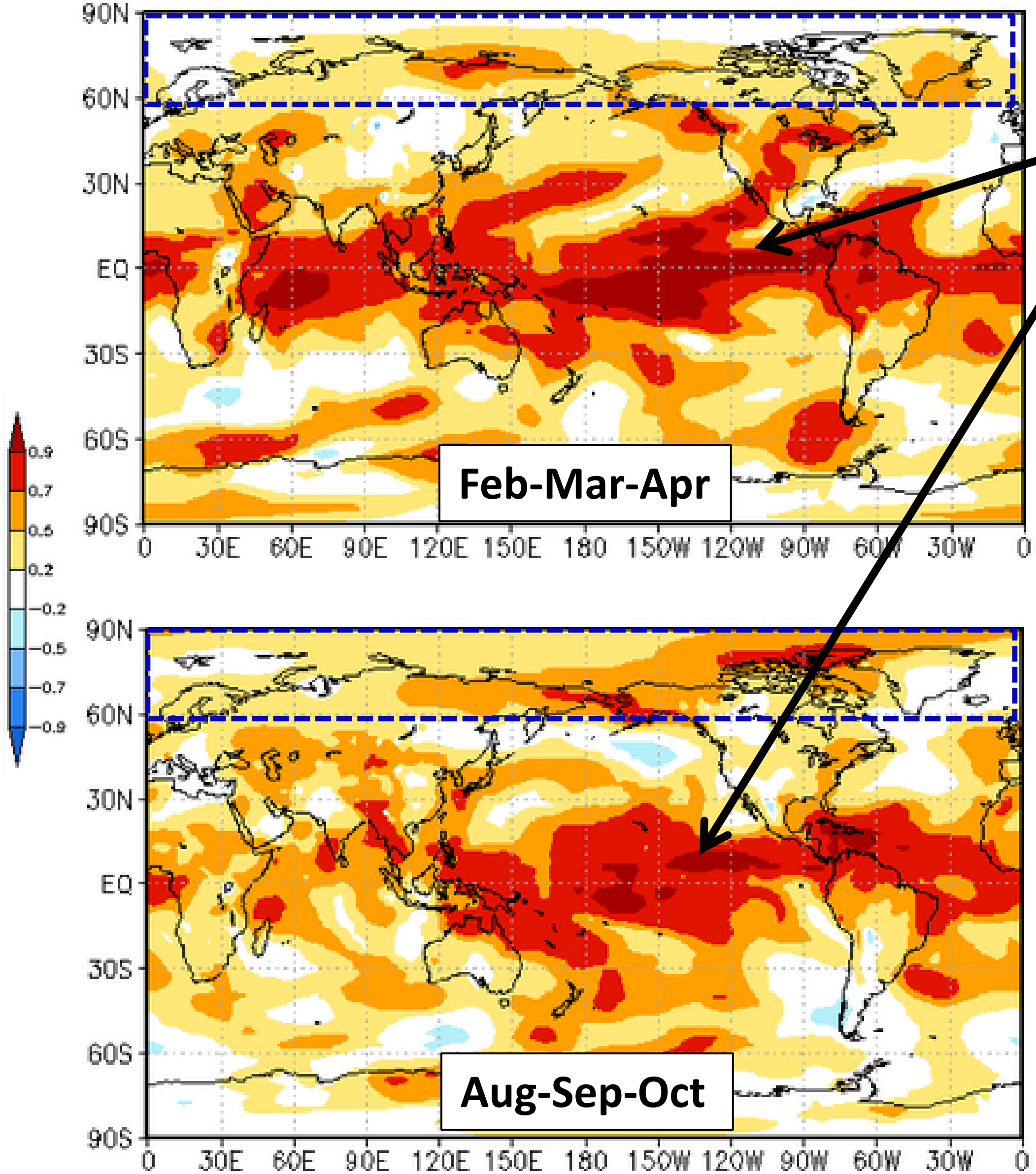

## RMS Error*

### 3-month Mean Sea Level pressure

- Atmospheric mass distribution is much more difficult to predict at higher latitudes
- Much more natural variability
- Less MSLP errors in **Aug-Sep-Oct** than during **Feb-Mar-Apr**

**Based on WMO LRF MME hindcasts verification period: 1993-2009*

# Forecast skill over the Arctic compared to regions at lower latitudes




## Anomaly correlation*

### 3-month Temp@850 hPa

- For temperature, skill at the seasonal time scale is generally higher at lower latitudes (ENSO impacted regions)

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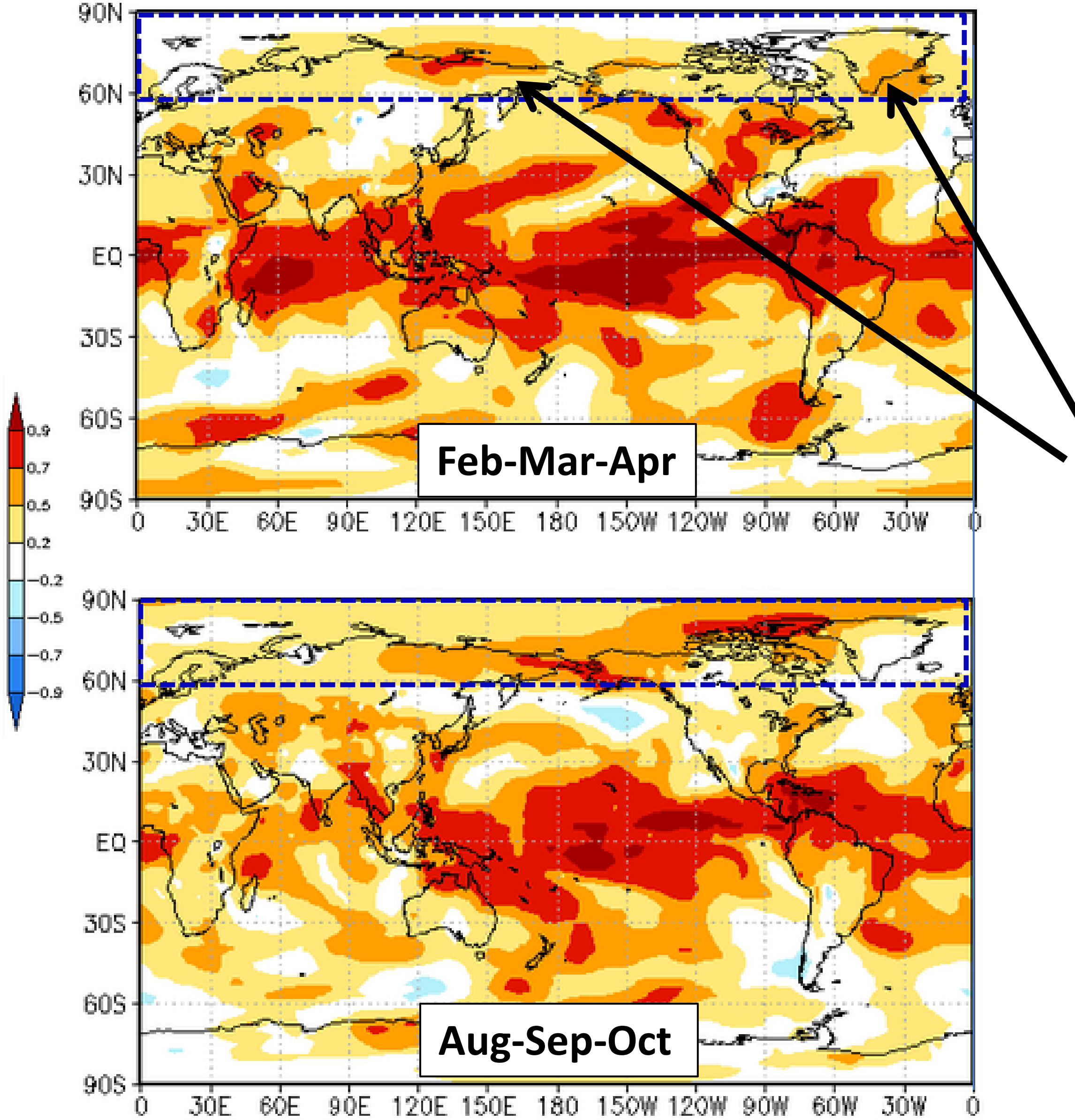


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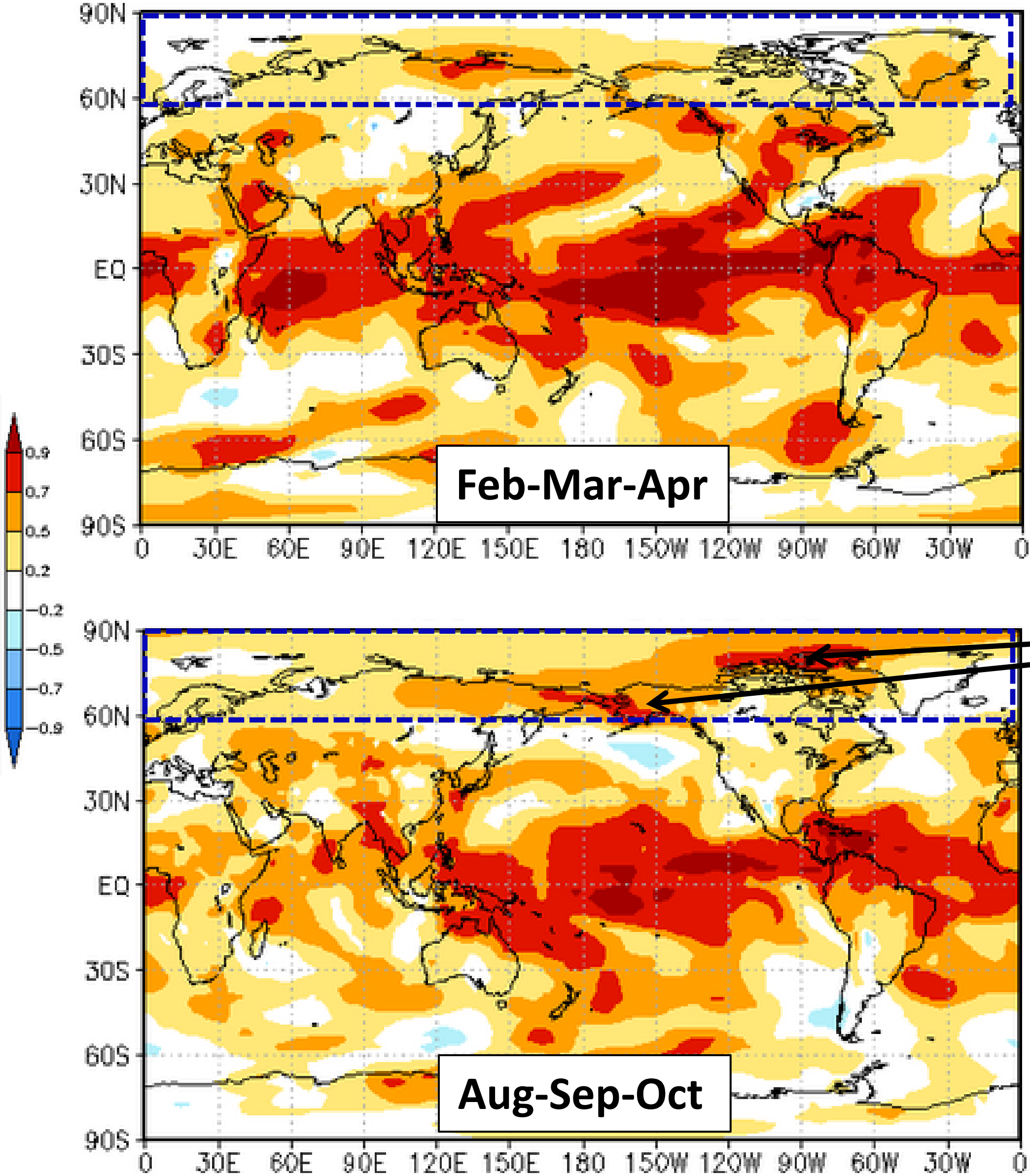


## Anomaly correlation*

**3-month Temp@850 hPa**

- For temperature, predictability at the seasonal time scale is generally higher at lower latitudes (ENSO impacted regions)
- Some skill in **Feb-Mar-Apr** over parts of the Arctic.
- ***But**, there is noticeably more skill in the Arctic in the **Aug-Sept-Oct** season*

***=> role of sea ice?***

**Based on WMO LRF MME hindcasts verification period: 1993-2009*

# Source of predictability: the role of sea ice

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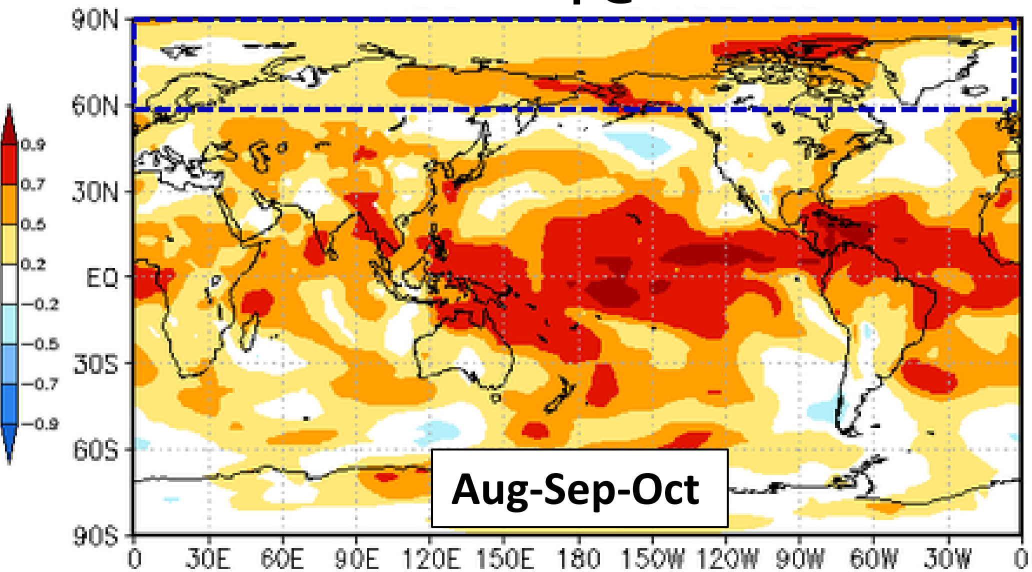


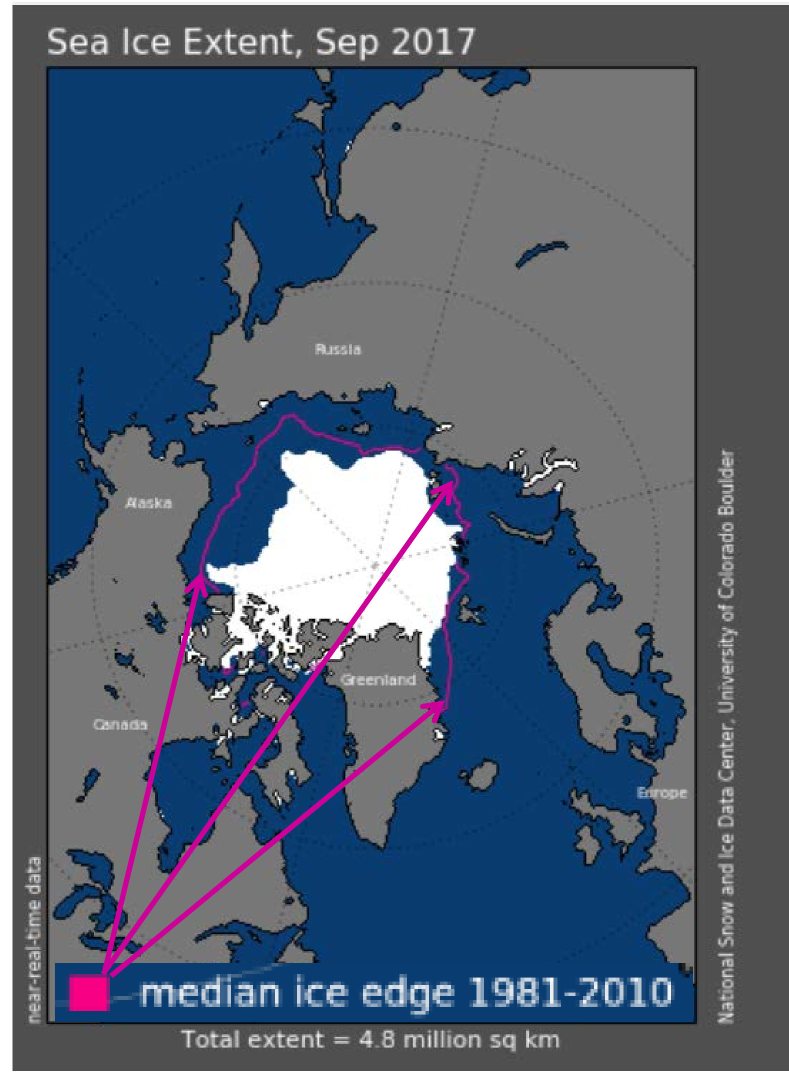


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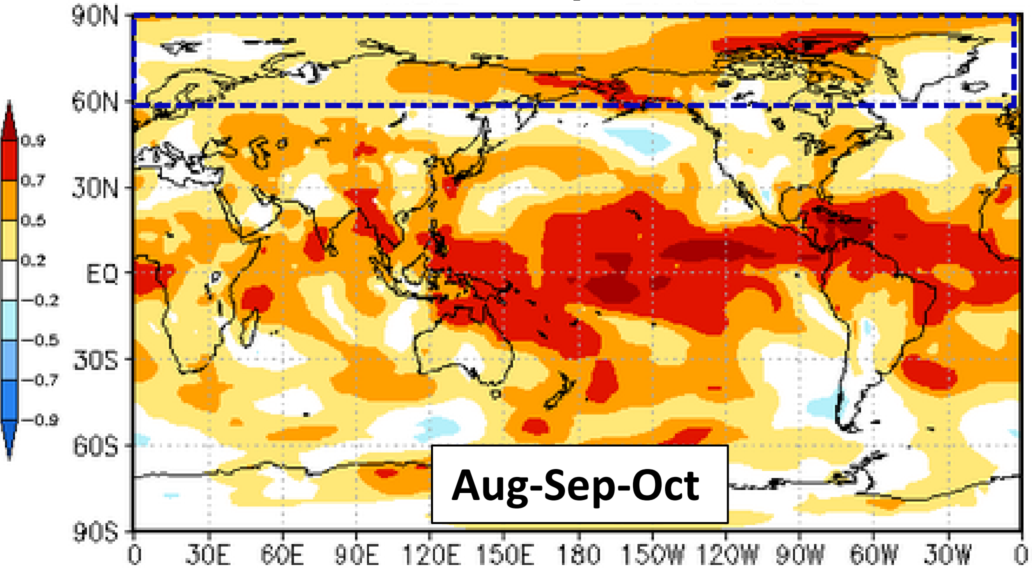
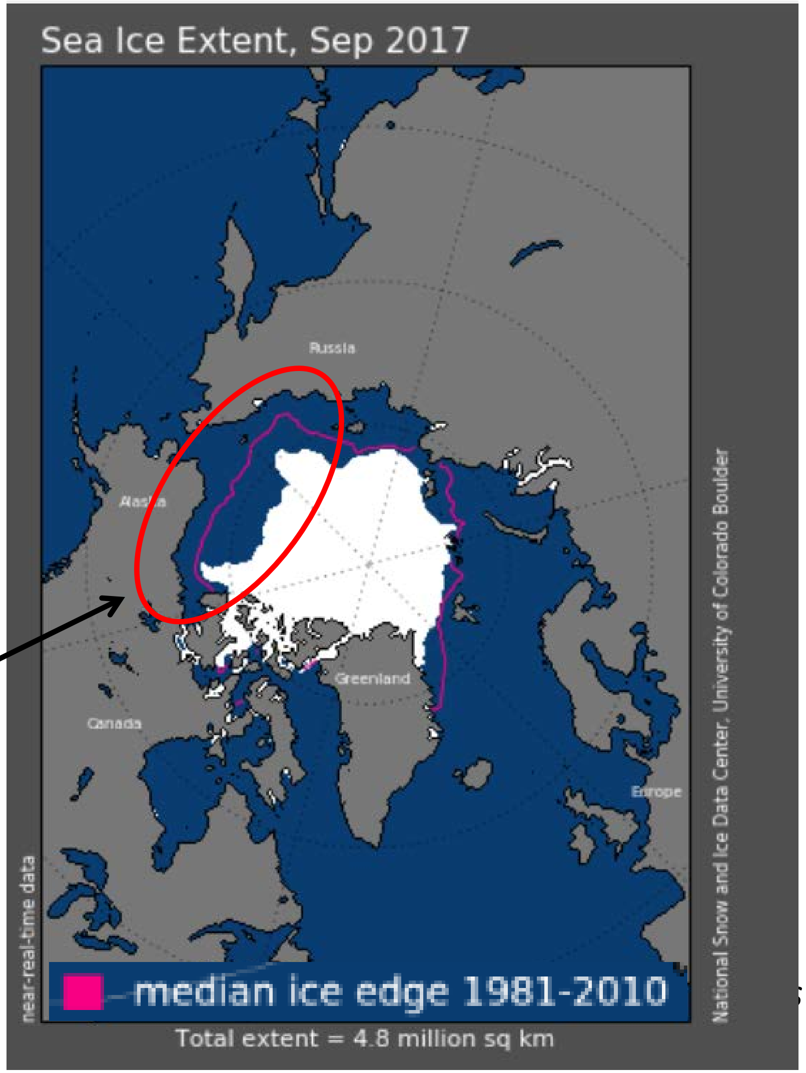



- Presumably, correctly predicting the sea ice extent anomaly can lead to improved temperature and precipitation forecast skill due to enhanced (reduced) heat/moisture flux between the ocean and the atmosphere over open (close) water regions



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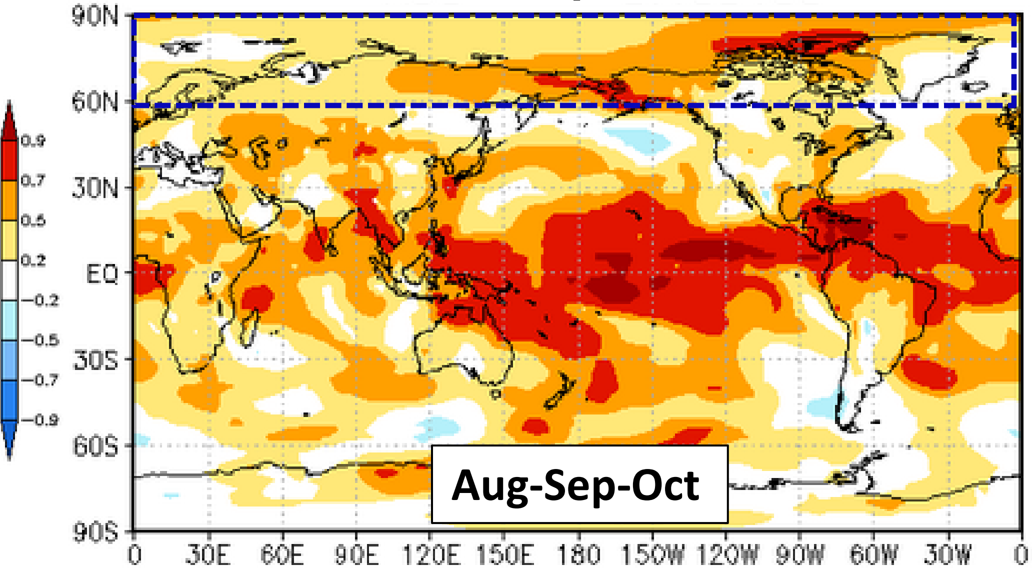
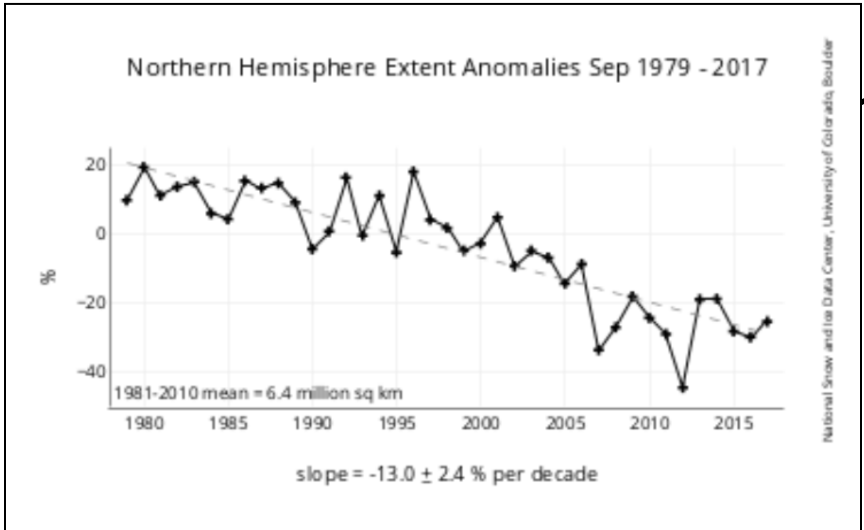
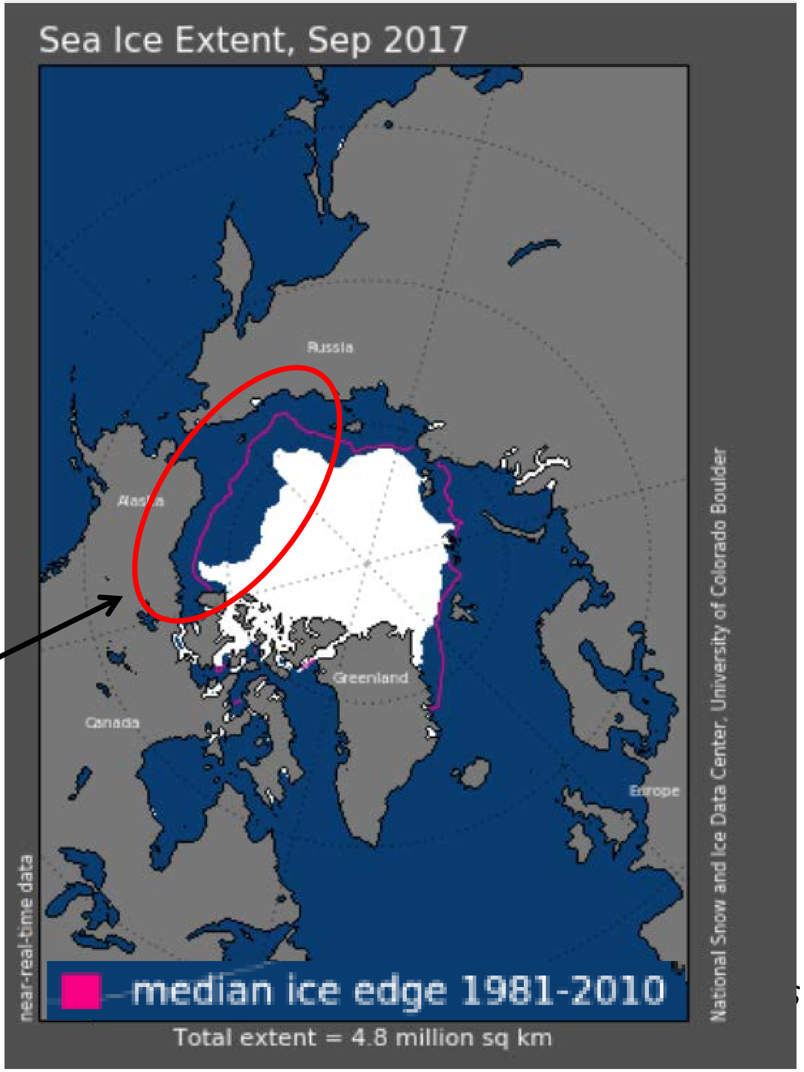
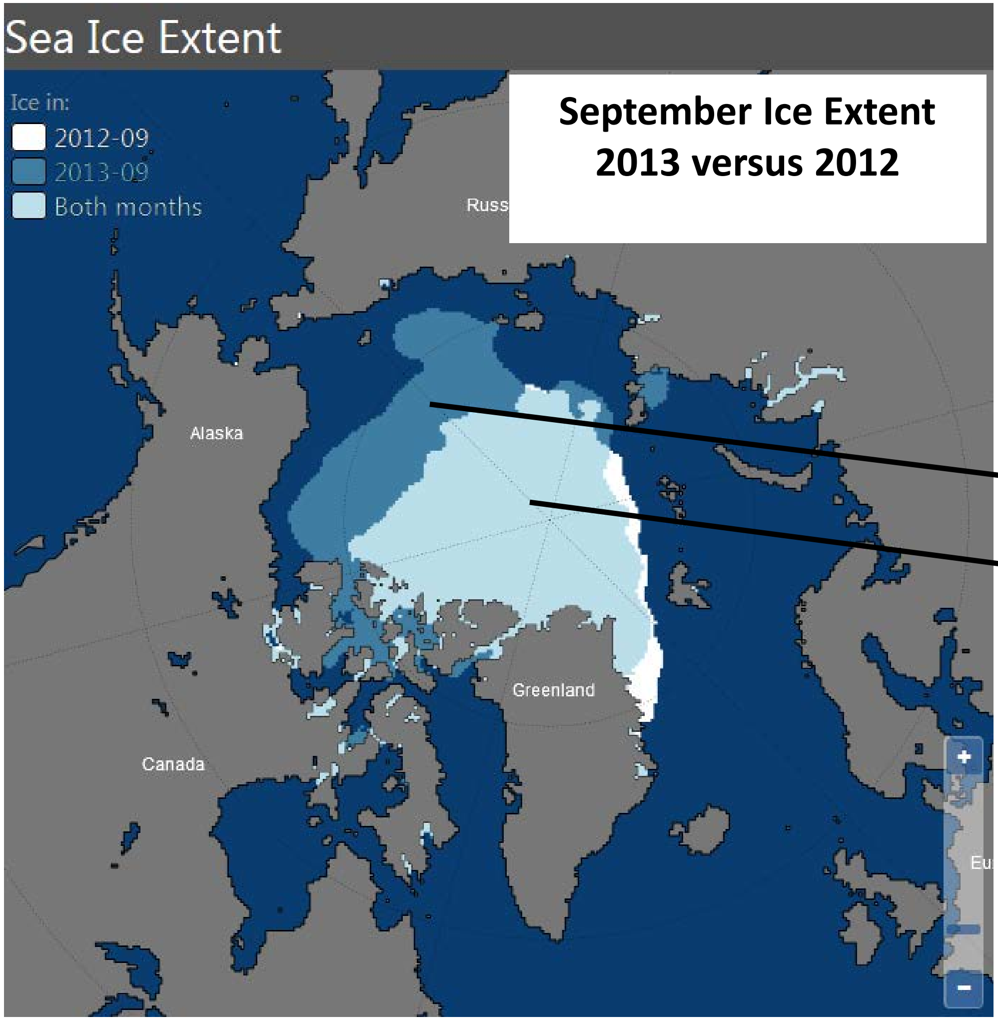


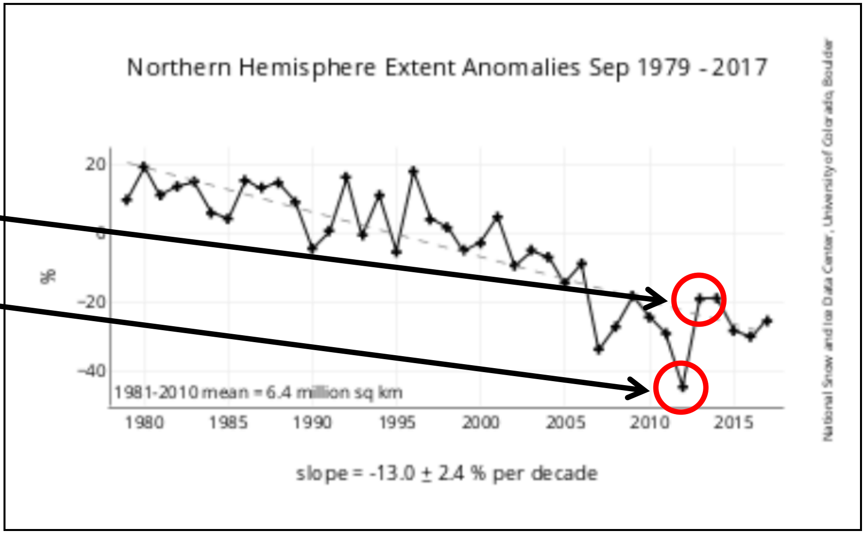



# Source of predictability for the Sea Ice itself

#1 – The long-term trend of total sea ice reduction, but there is a large interannual variability



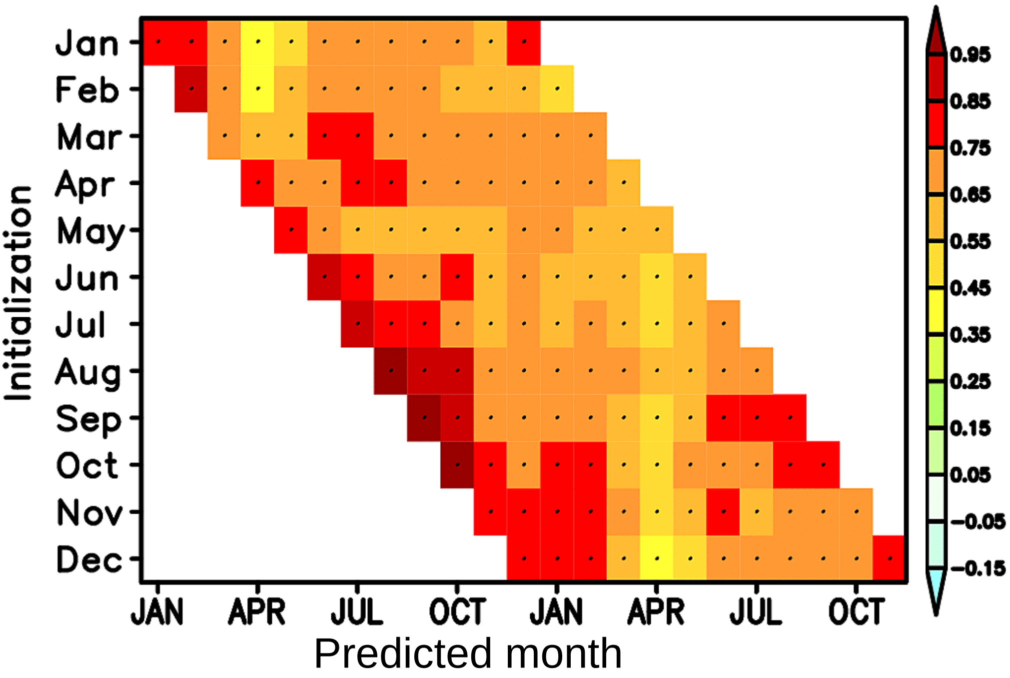



# Source of predictability for the Sea Ice itself

#1 – The long-term trend of total sea ice reduction, but there is a large interannual variability
*How good are coupled climate prediction systems at predicting total sea ice area many months in advance?*

*An example from* ***CanSIPS****:*

**ACC sea ice area (Total anom.)**




- Significant skill up to a year ahead
- Skill at longer lead times mostly stems from model's ability to reproduce long-term trend

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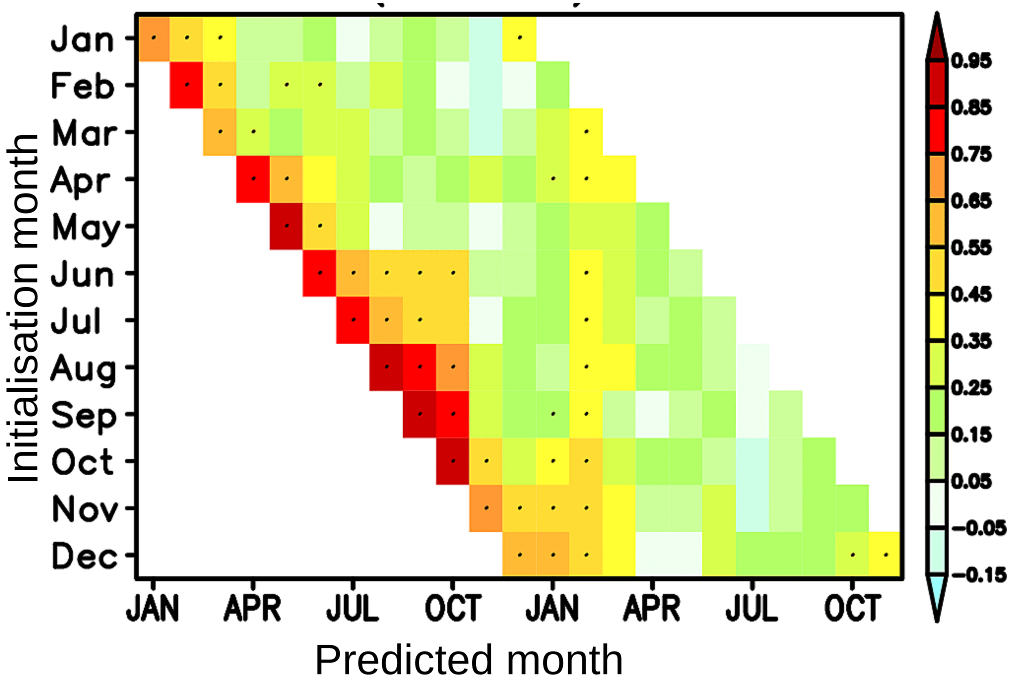


- Model beats persistence !

- These features appeared to be robust for other systems
  (*CFSv2:* Wang et al. 2013, *MetOffice:* Peterson et al. 2014, *GFDL:* Msadek et al 2014)

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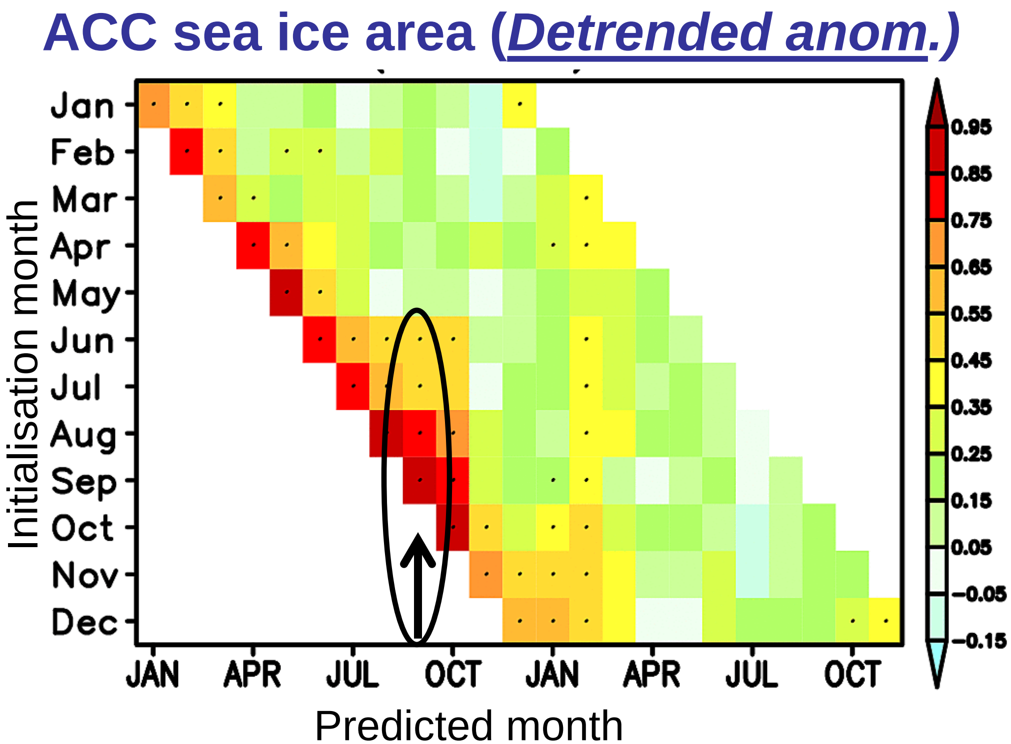


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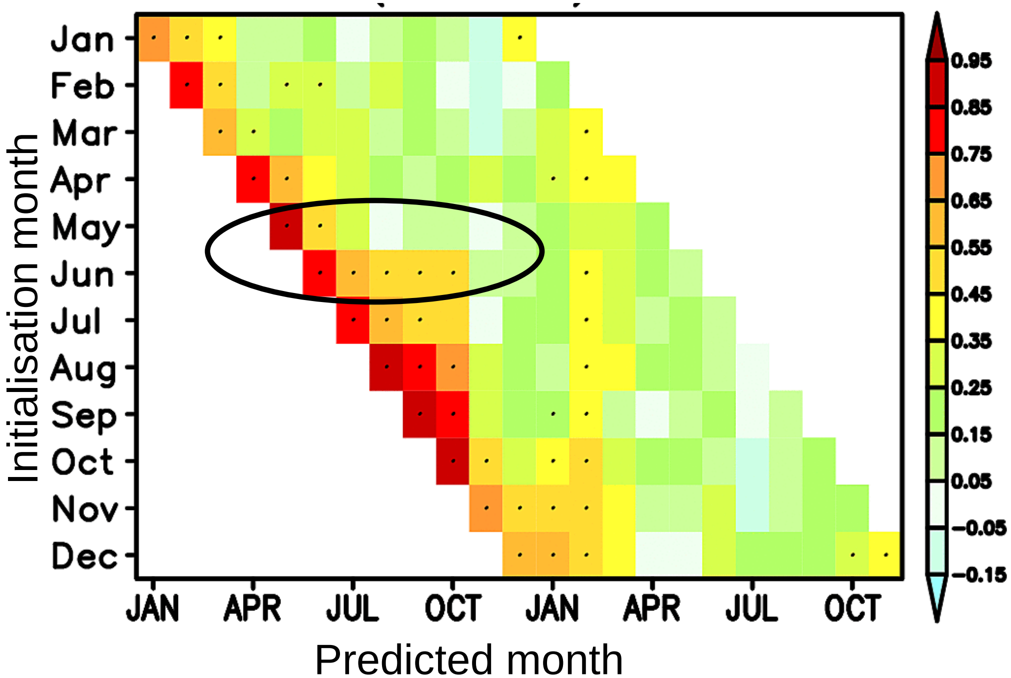


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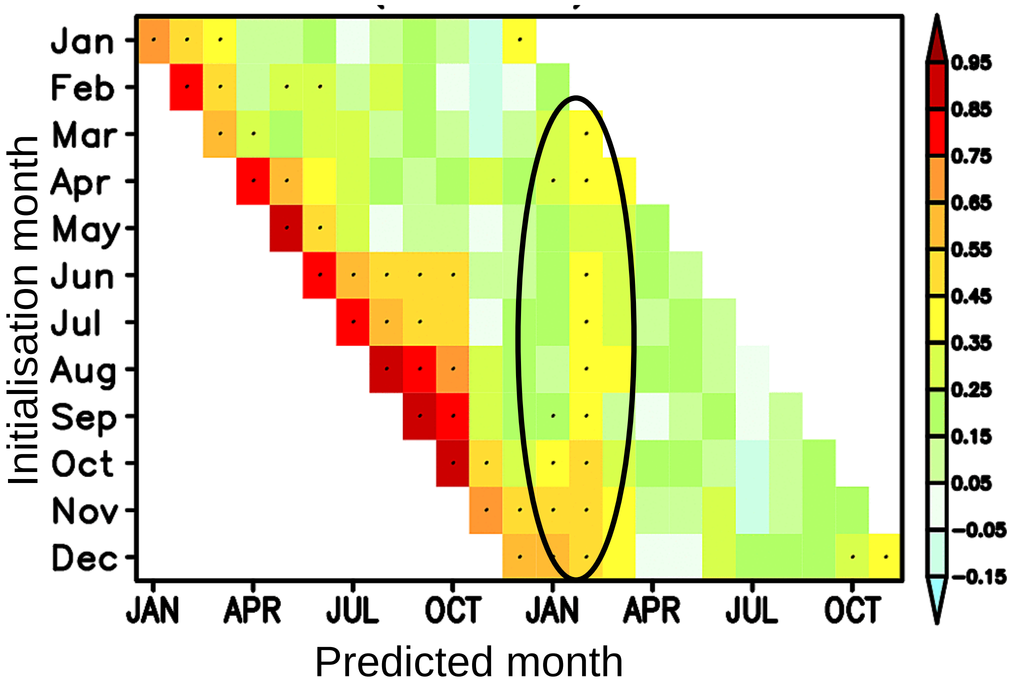


- Model beats persistence
- Detrended Sept. SIA skillfully predicted from June
- Strong dependency of skill on initialization month
- Substantial skill at long lead times for winter predictions

- These features appeared to be robust for other systems
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# Source of predictability of the Sea Ice itself

1- **The long-term sea ice reduction trend**

2- **Persistence of sea ice anomaly (at regional scale)**

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- Ocean current
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**Reemergence:** Important phenomena explaining sea ice predictability between many months apart.

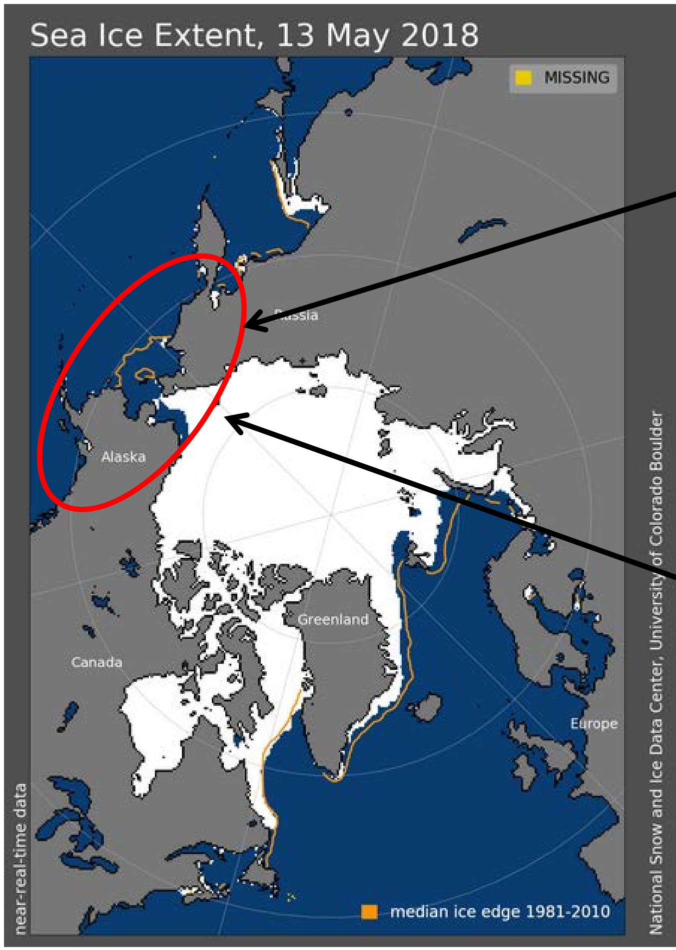
<u>Ex:</u> The reemergence of sea ice anomalies from the melt to the growth season

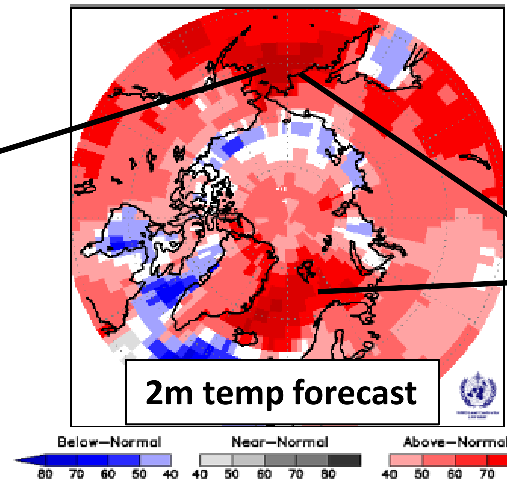
An early disappearance of sea ice during the melt season (as a result of either a positive SSTA, a positive SAT anomaly or anomalous atmospheric circulation patterns) could lead to (or enhance) a positive SSTA. This positive SSTA tend to persist over the summer season and result in an late freeze-up.

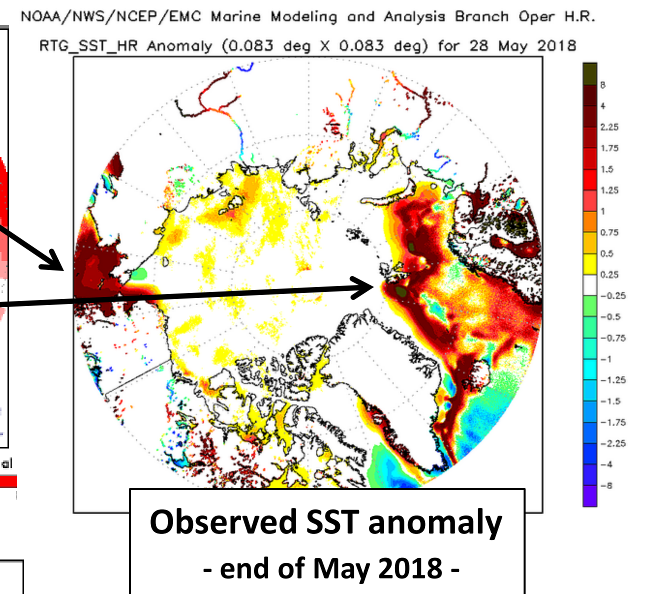
# Source of predictability: Sea ice & SSTA

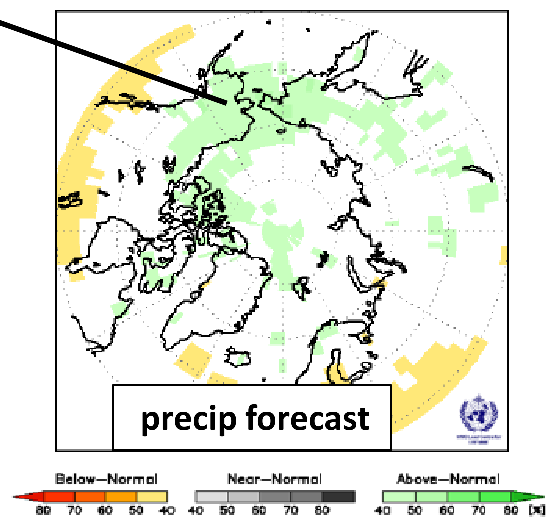
## A recent exemple:

## **Jun-Jul-Aug** WMO MME Forecast from the first PARCOF



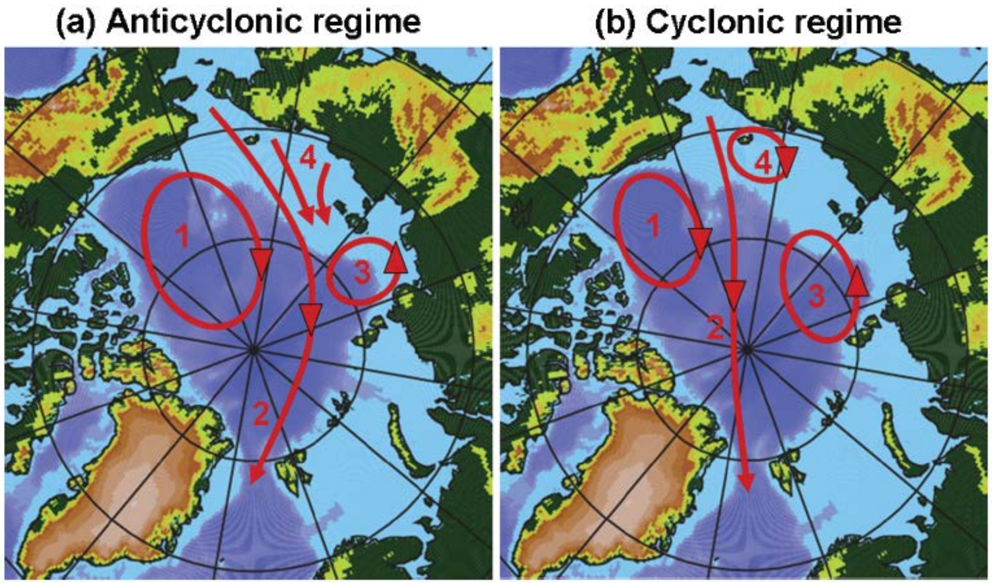




- The MME forecast is consistent with the **persistence of sea ice anomaly as well as SST anomaly**

# Source of predictability of the Sea Ice itself

4- **From the atmosphere**

- Sea ice transport is dominated by wind regimes
  - Modulates the sea ice Pan-Arctic circulation



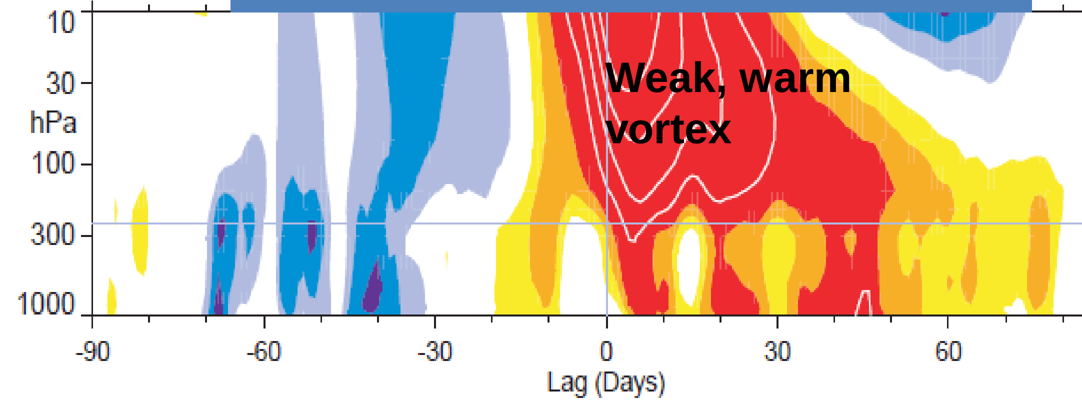

  - North Atlantic Oscillation (**NAO**) / Arctic Oscillation (**AO**)/ Northern Annular Mode (**NAM**) is an important driver for sea ice behavior and predictability

# Source of predictability: the role of the Stratosphere

- Long timescale disturbances in lower stratosphere influences troposphere for up to 2 months **in Winter / Spring**

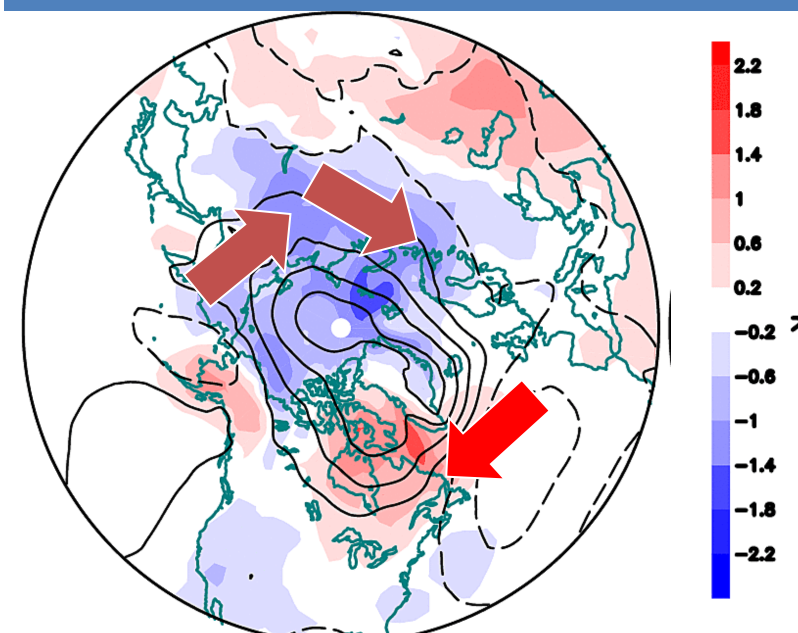
- On average, SSWs followed by high surface pressure at poles (negative AO)

Composites NAM around SSWs




Baldwin and Dunkerton, 2001

SLP and ST 16-60 days after SSW

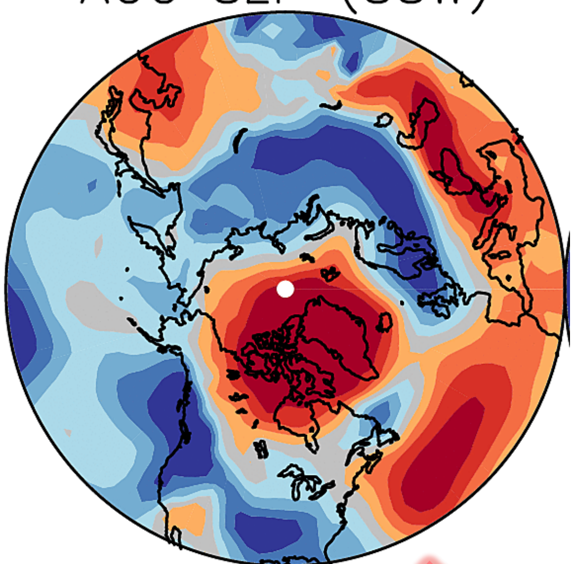



Sigmond et al. (2013), Thompson et al.(2002)

# Source of predictability: the role of the Stratosphere

## *Enhanced forecast skill following Sudden Stratospheric Warming (SSW)*

ACC SLP (SSW)



**Sea Level pressure**

**Orange/Red significant at 95%**

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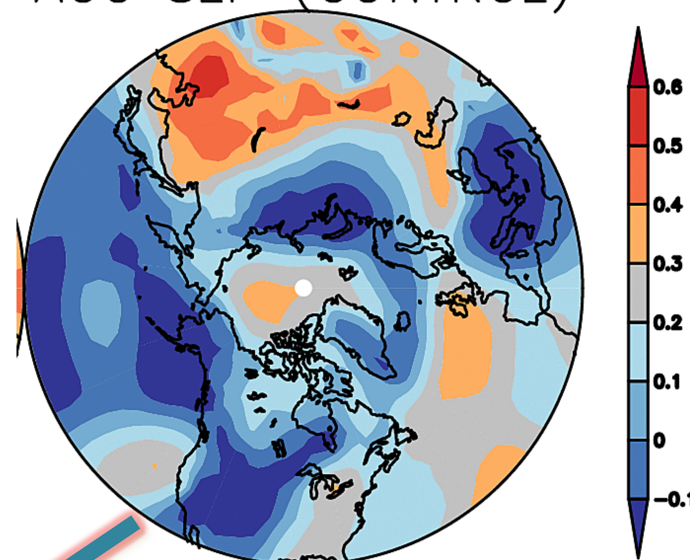
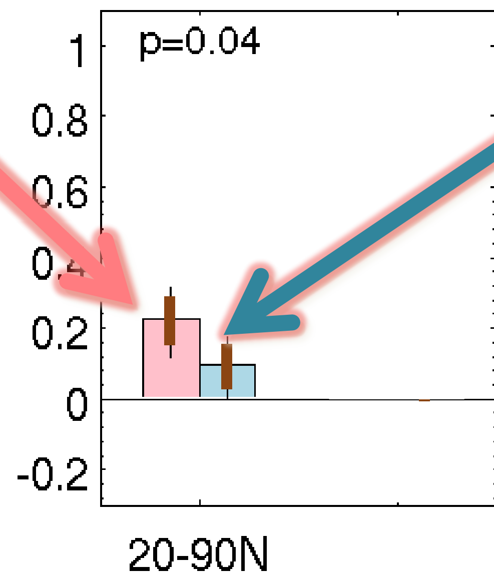



ACC
SLP

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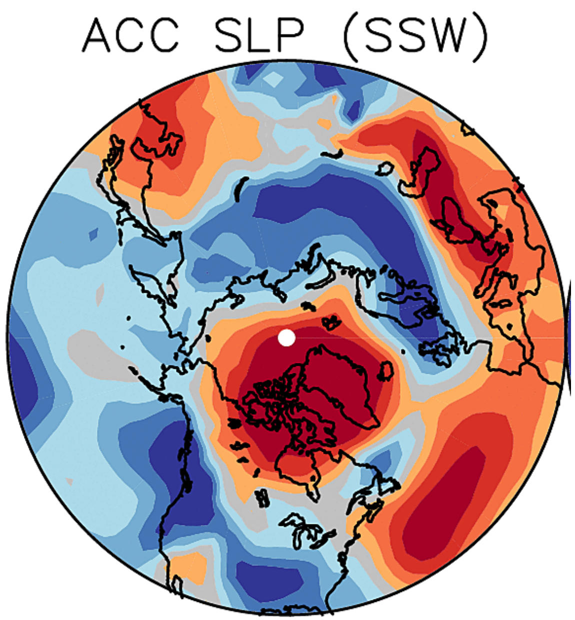


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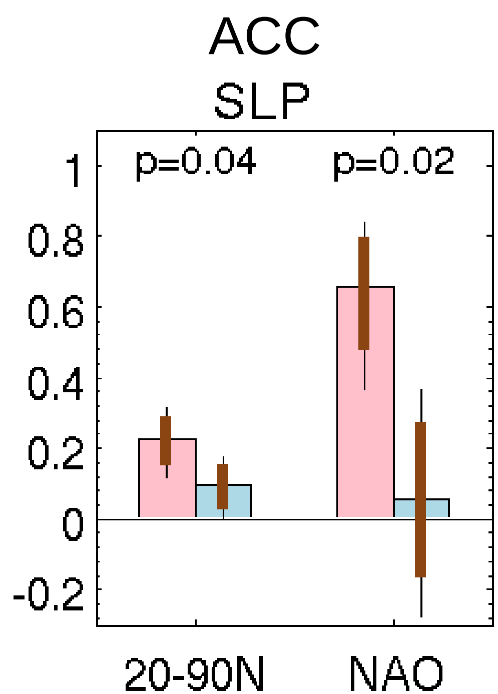


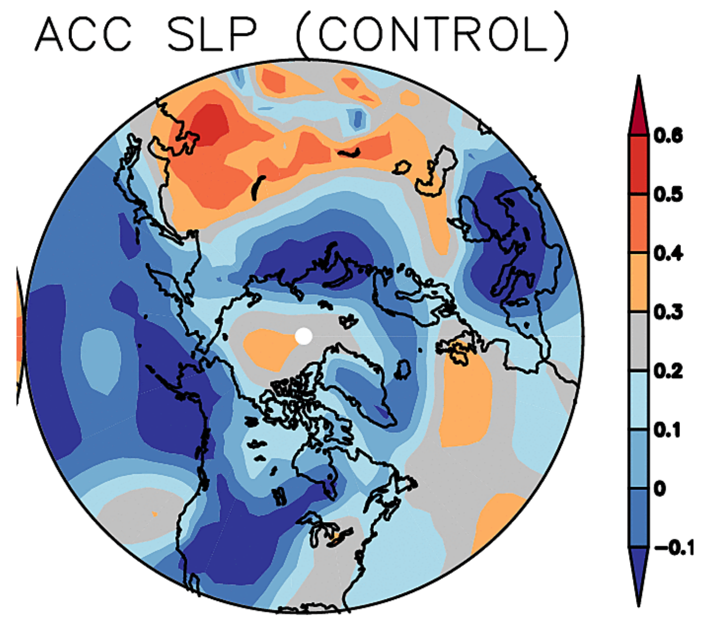


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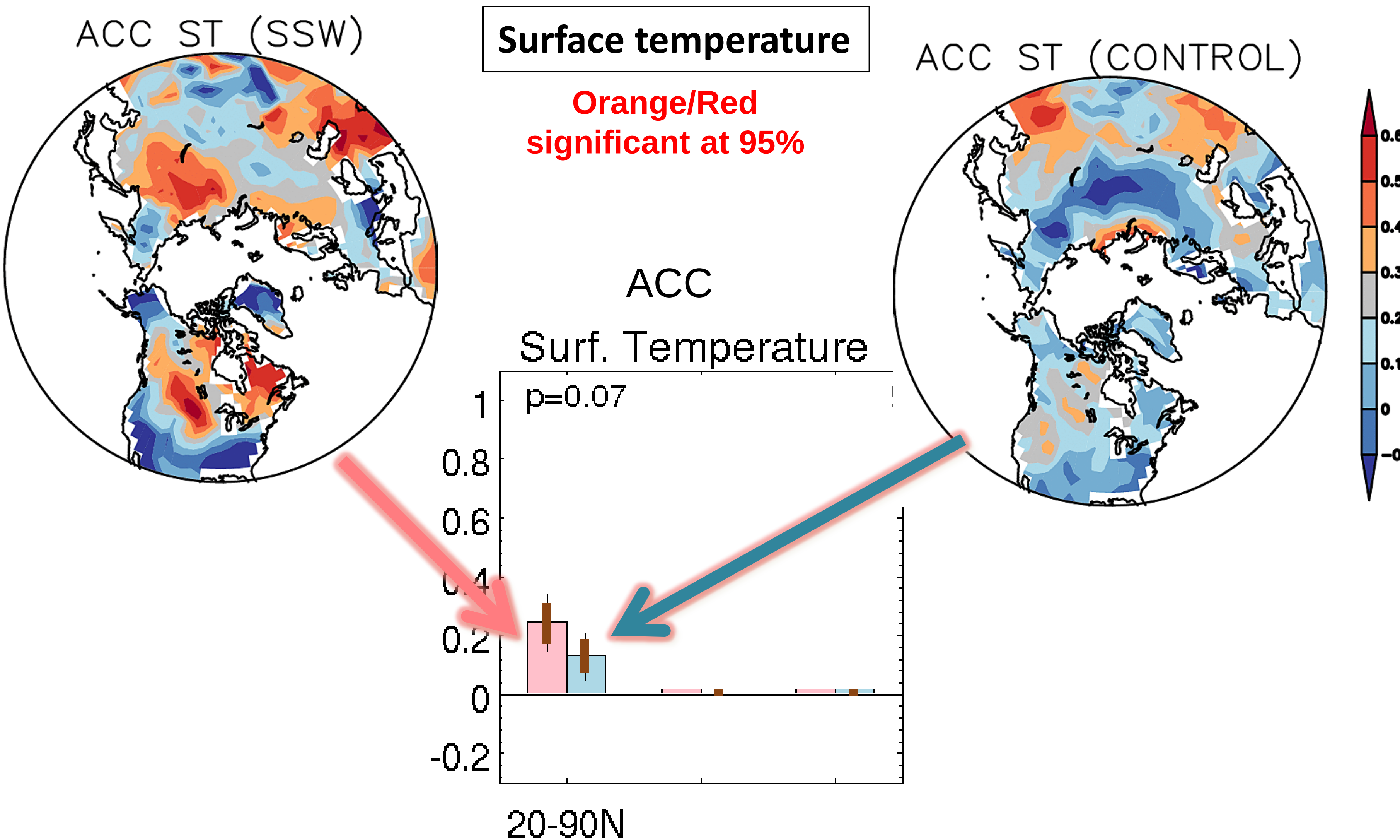


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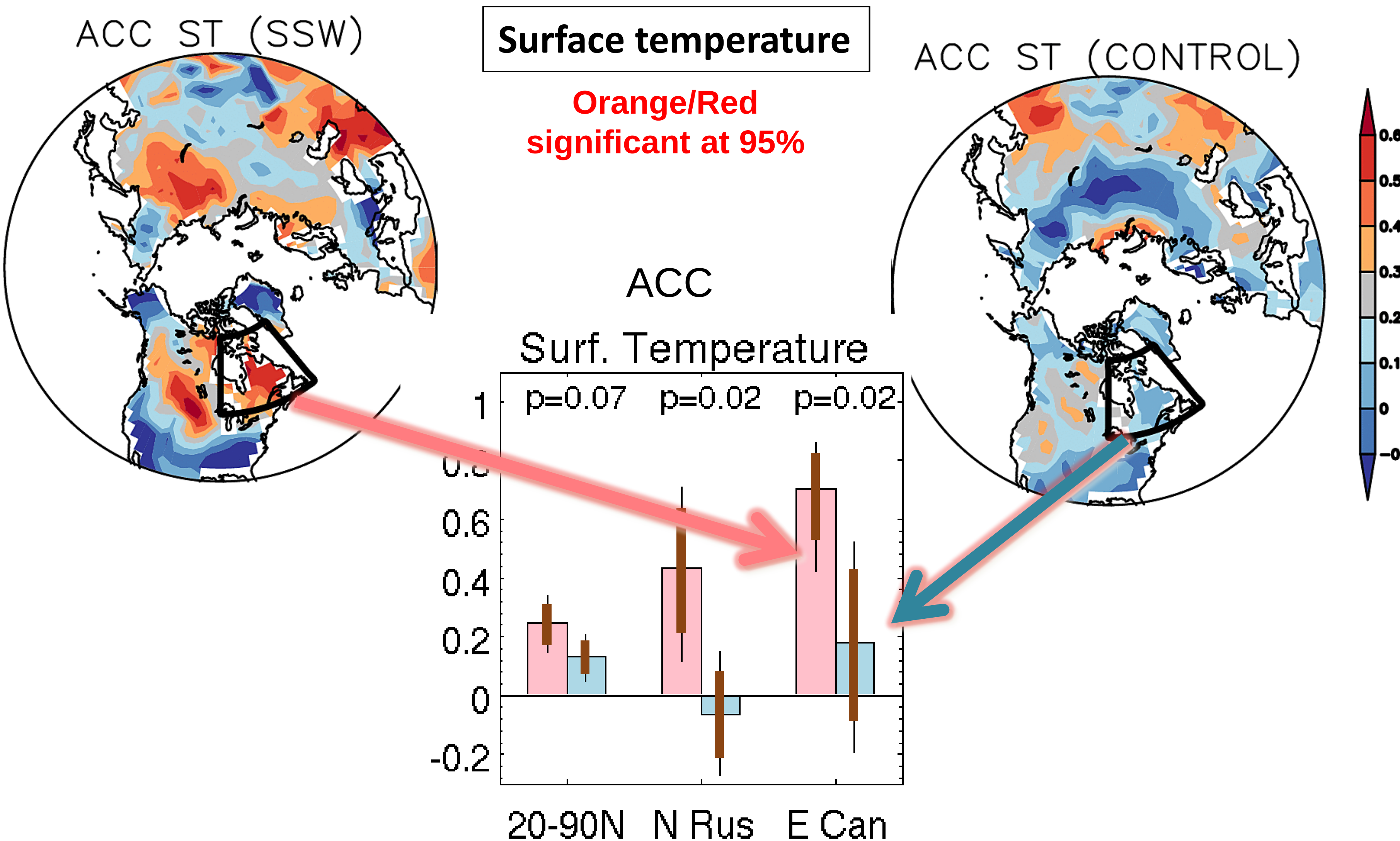



Sigmond et al. (2013)

# Source of predictability: the role of the Stratosphere

- Large enhancement of skill associated with the stratosphere can be realized, but is highly conditional (i.e., only after SSWs)
- Following SSWs we find enhanced forecast skill over large part of the Arctic
- **Implication:** Operational seasonal forecasts which happen to be initialized close to major SSW will yield substantiel enhanced forecast skill
  - The Polar Vortex break-up involved in the SSW cannot be well predicted more than ~10 days in advance
  - It would be recommended to issue a special forecast when SSW happens far from the operational forecast production date
- Note: Major SSWs don't happen very year. There was one last winter (2018). The previous one was in 2013.
- Nevertheless, the influence of the stratosphere on the forecast skill of the AO/NAO and its impact on the surface temperature forecast skill at the subseasonal time scale in winter/spring is now well established (*Jia et al*., 2017)

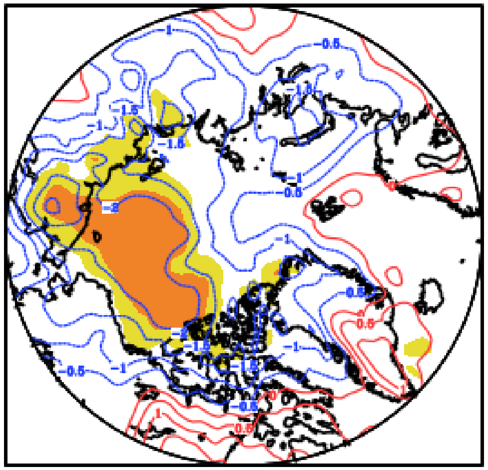
# Source of predictability: The role of the Tropics (MJO)

## T2m anomaly lagged composites

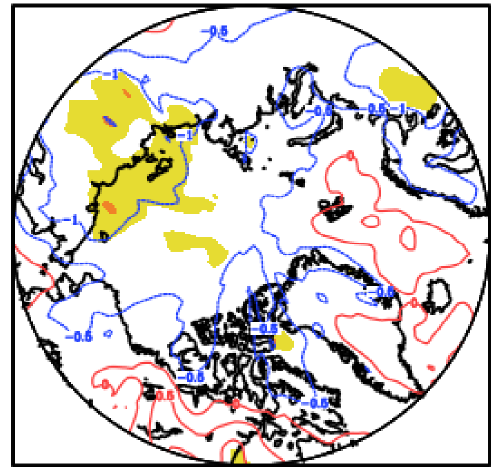
From observation | From Canadian sub-seasonal GEPS

Polar cooling

a) OBS ph3 lag=3



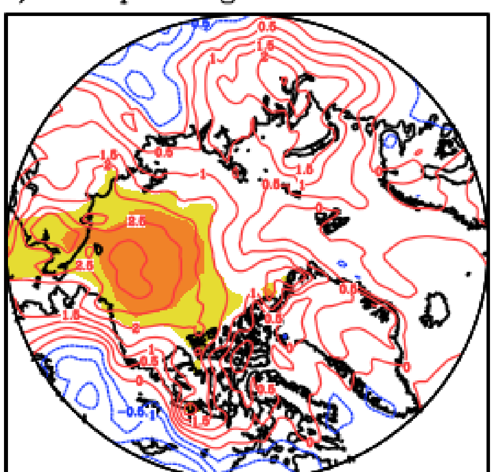
b) ECCC ph3 lag=3



15 days after MJO phase 3

Polar warming

a) OBS ph6 lag=4



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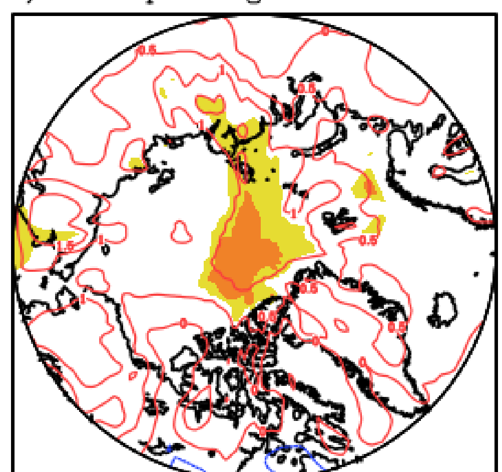

20 days after MJO phase 6

Credit: Hai Lin (ECCC)

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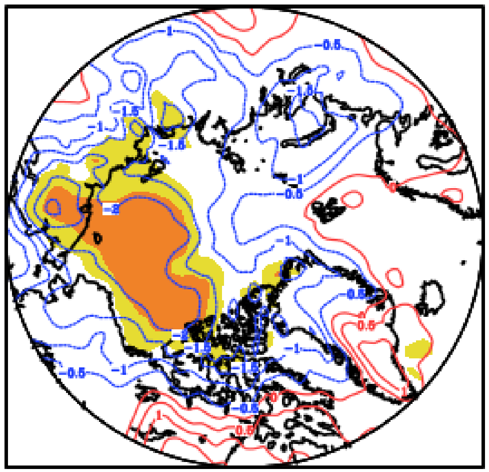

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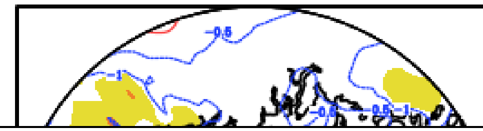


15 days after MJO phase 3

Not a direct impact. The MJO impacts the NAO/AO.

*Lin et al. (2009), Cassou (2008), Lin and Brunet (2010), Yoo et al. (2011)*

10-20 days following MJO phase 3:

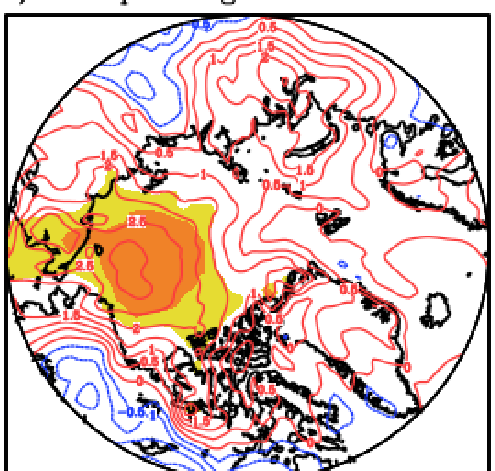
→ positive NAO, Arctic cooling

10-20 days following MJO phase 6:

→ negative NAO, Arctic warming

Polar warming

a) OBS ph6 lag=4



Credit: Hai Lin (ECCC)

# Conclusion

- Many sources of predictability exist for the Arctic
- The sea ice and SST anomalies are important sources
- The stratosphere can contribute, especially after SSW
- Other possible sources exist: (ex: snow cover)
- Improved physical processes in models will most likely lead to improved long range forecasts in the Arctic. For instance, better sea ice representation, better linkage between the stratosphere and the troposphere, improved MJO teleconnection, etc..

# ¡Muchas gracias!

Special thanks to Michael Sigmond, Hai Lin and Bill Merryfield from ECCC

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