Blue-Action Climate Coffees

The role of sea ice initialization on the Arctic decadal prediction skill with EC-Earth3

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BLUE ACTION

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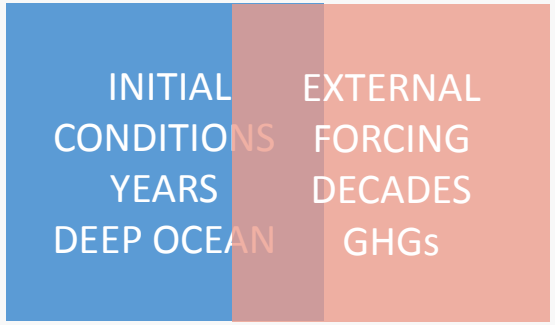
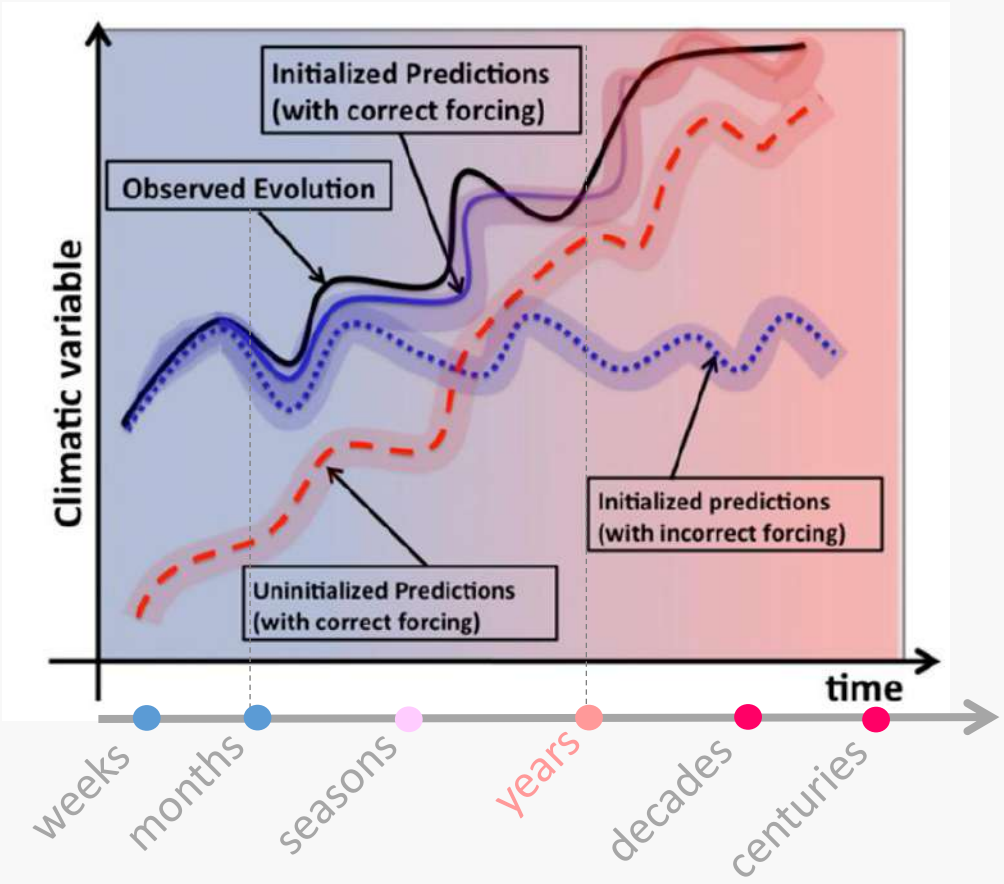
(*Tian et al, 2021*)

1. INTRODUCTION

DECADAL PREDICTABILITY

Multi-year time scales





(Fig.1 from *Corti et al, 2015JCLIM*)

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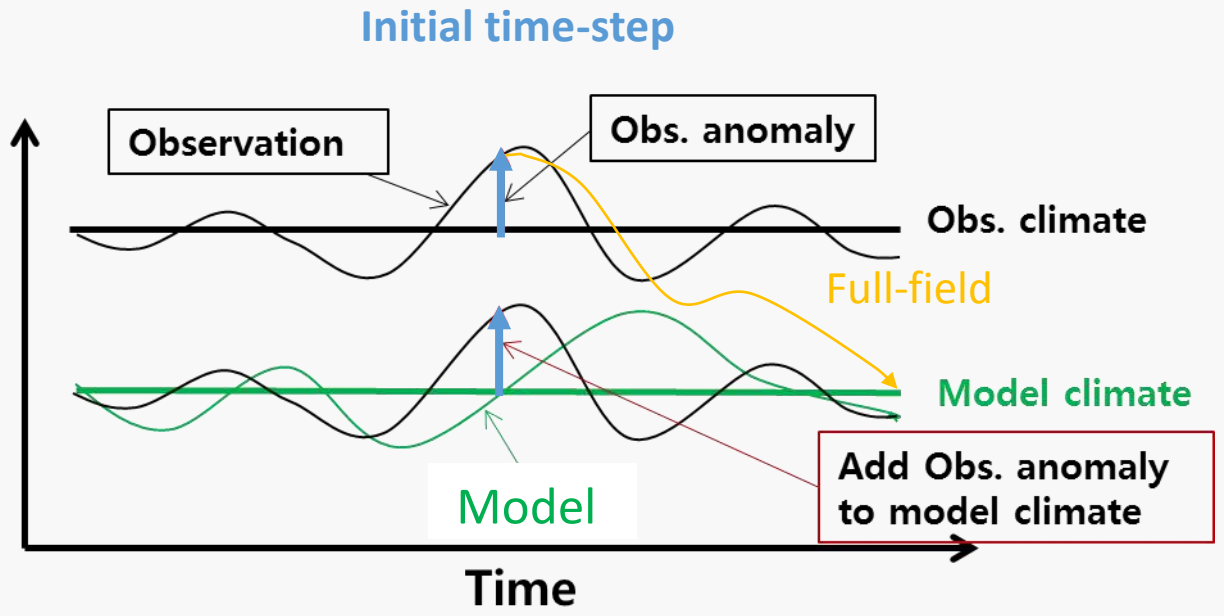
1. INTRODUCTION

INITIALIZATION METHODS

Alternative

DRIFT IN FULL FIELD

LOCAL DYNAMICAL ADJUSTMENT



(*Sterl, 2016; Volpi et al, 2017*)

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1. INTRODUCTION

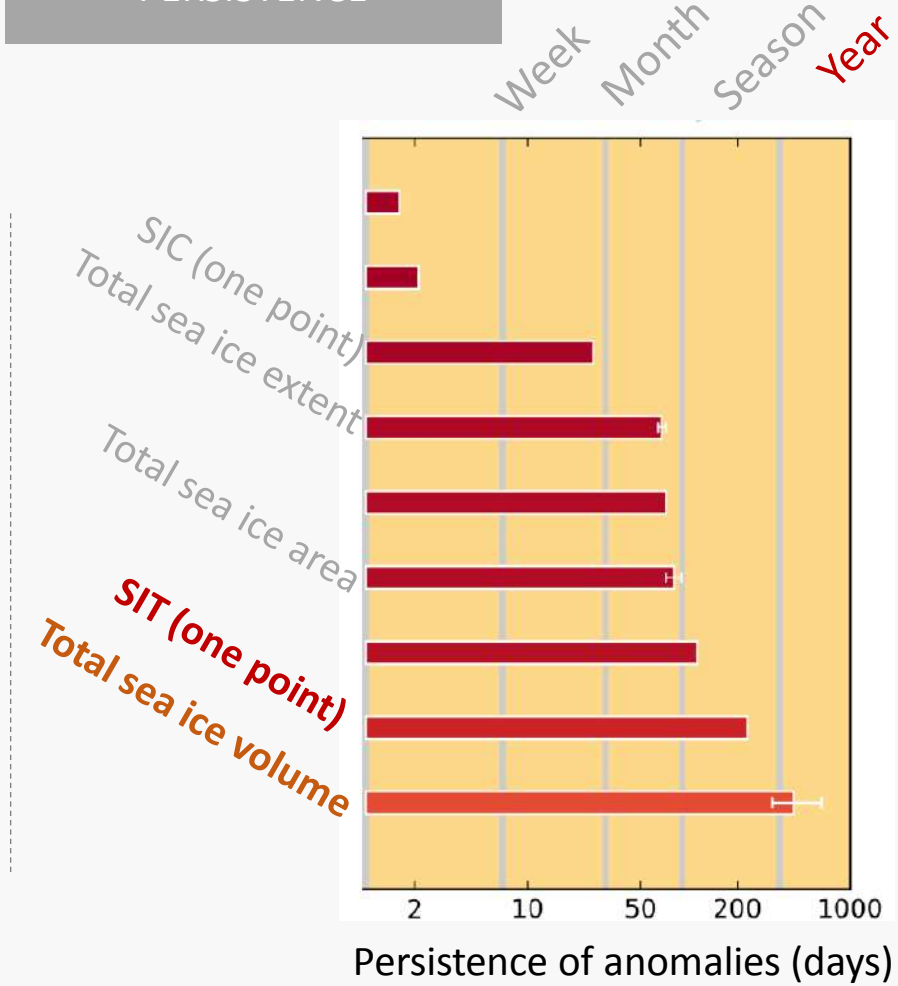
ARCTIC SEA ICE PREDICTABILITY

Beyond persistence

PERSISTENT VARIABLES	PREDICTABLE REGIONS

PERSISTENCE

PREEYOND PERSISTENCE



- TIME SCALE
- SEASON
- REGION
- PARAMETER

(*Figure modified from F. Massonnet's presentation in Arctic Frontiers, 2018; Blanchard-Wrigglesworth et al., 2011; Chevallier et al., 2019*)

(*Yeager et al., 2015; Årthun et al., 2017*)

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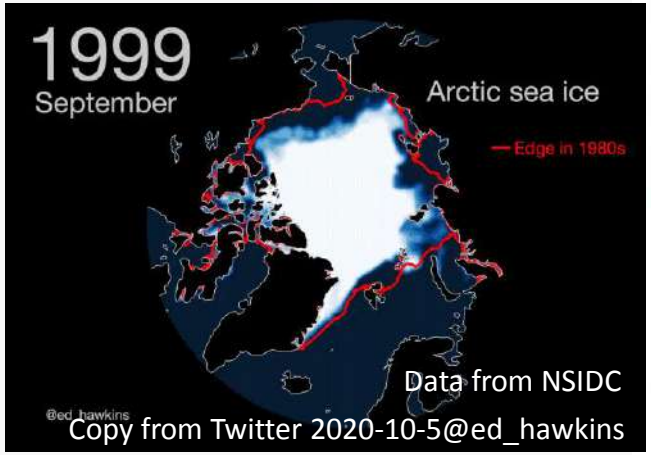
1. INTRODUCTION

Marginal ice zone fraction benchmarks sea ice and climate model skill (Horvat, 2021).
In the N. Atlantic MIZ regions, good skills in winter prediction can be gained by assimilating SST alone, but September SIE in northern BS is more controlled by surface wind than SST (Dai et al., 2020).
The perennial ice in the CAO could be remarkably corrected by directly assimilating SIT if compared with the SIC assimilation (Xie et al., 2018).

A CHANGING ARCTIC

Regime shifts in predictability

CAO	MIZ
MULTI-YEAR THICK	SEASONAL SST



Data from NSIDC
Copy from Twitter 2020-10-5@ed_hawkins

photographed by X. L. Dong (*Lu et al, 2008JGR*)

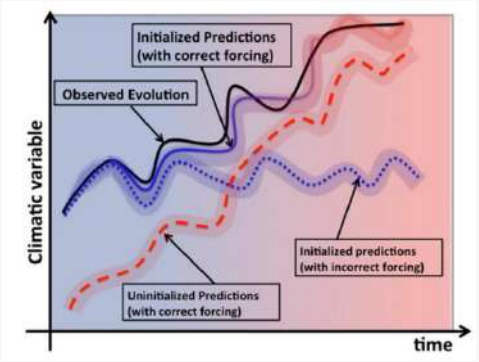
1. INTRODUCTION

Aim of this work

- **Added value of initializing new components/variables, e.g. ocean T&S, SIC and SIT, by sensitivity experiments**
- **Does the added value of SIT initialization change as MYI is reduced in the Central Arctic**

DECADAL PREDICTABILITY

INTERANNUAL TIMESCALES

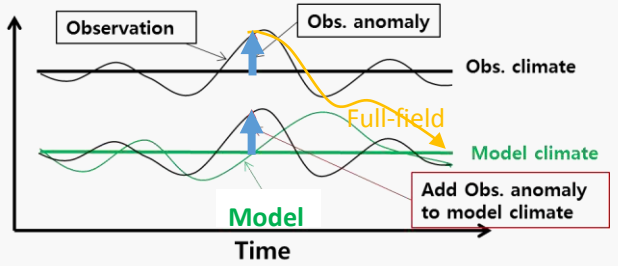


ANOMALY INITIALIZAITON

INITIAL ANOMALY

VERSUS

SYSTEM ERRORS

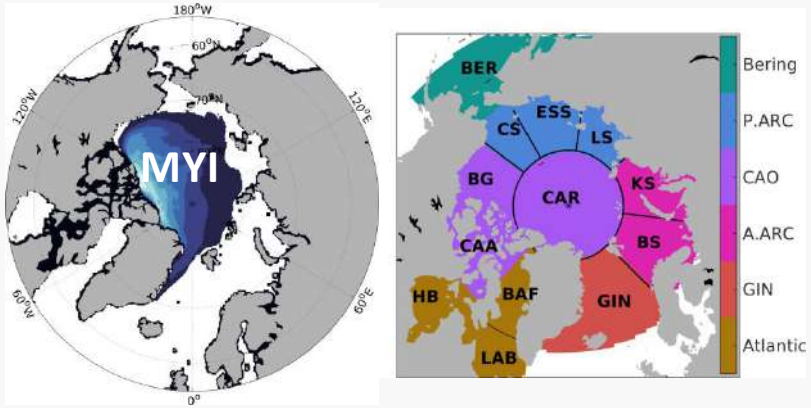


ARCTIC SEA ICE

MULTI-YEAR (THICK ICE)

VERSUS

FIRST-YEAR (SST)



2. DECADAL HINDCASTS WITH EC-EARTH3-CPSAI

EC-Earth3-CPSAI

EC-Earth3 Climate Prediction System with Anomaly Initialization

Atm: IFS cycle 36r4 in T255L91

Ocn: NEMO3.6+LIM3 in ORCA1L75

CMIP6 dcppA-hindcasts (*Boer et al., 2016*)

Start yearly on November 1st, 1979-2017

Each runs 2 months & 10 years long

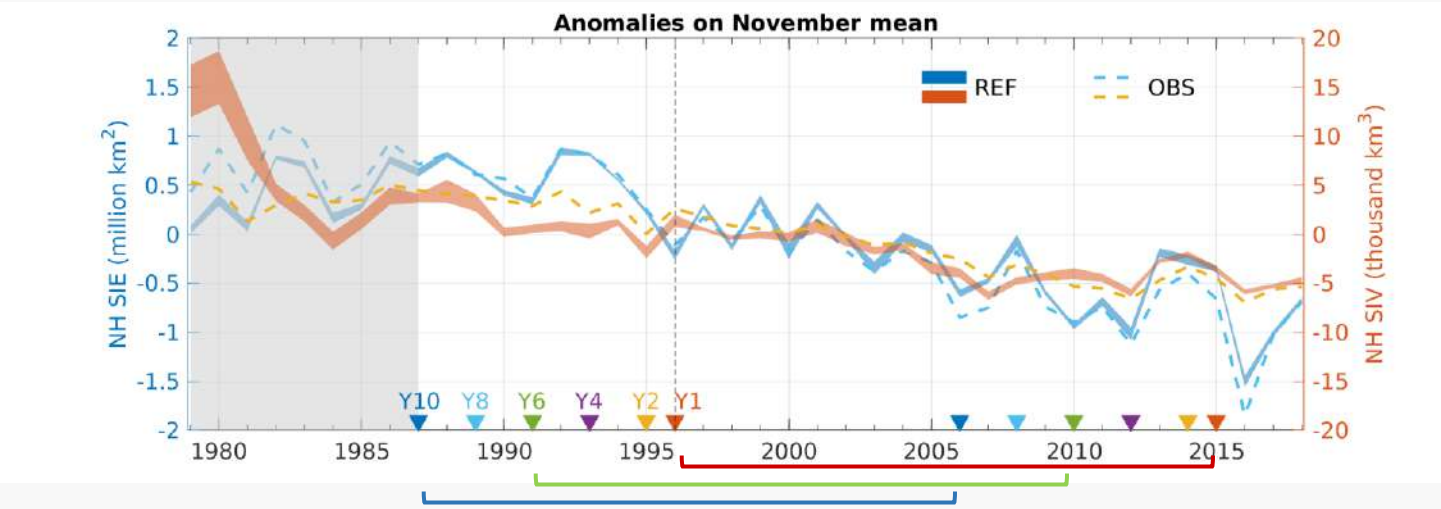
REF: anomaly init with 5 sets of ocean and sea ice ICs

full-field init with ERAI atm ICs

Forecast anomalies (1997-2016)

Y1: init. 1996-2015

Y10: init. 1987-2006



Anomaly from reanalysis (ORAS5)

Representing NH SIE and SIV reasonably well

(REF from ORAS5, OBS from NSIDC/PIOMASS; *Chevallier et al., 2017*; *Tietsche et al., 2018*)

2. DISTRIBUTE CORRECTED SEA ICE STATES to 5-CATEGORY WITH LIM3

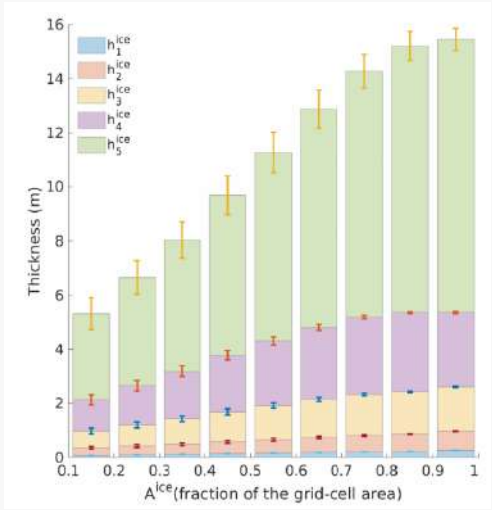
SIV (SIC*SIT)
anom conservative

Weight function region-dependent

$$A^{ice}(x,y) = \sum_{l=1}^{L} g_l^{ice}(x,y).$$

$$weight_l^{\text{ctrl}}(x,y) = g_l^{\text{ctrl}}(x,y,tn)/A^{\text{ctrl}}(x,y,tn).$$

$$g_l^{ice}(x,y) = weight_l^{\text{ctrl}}(x,y)A^{ice}(x,y).$$

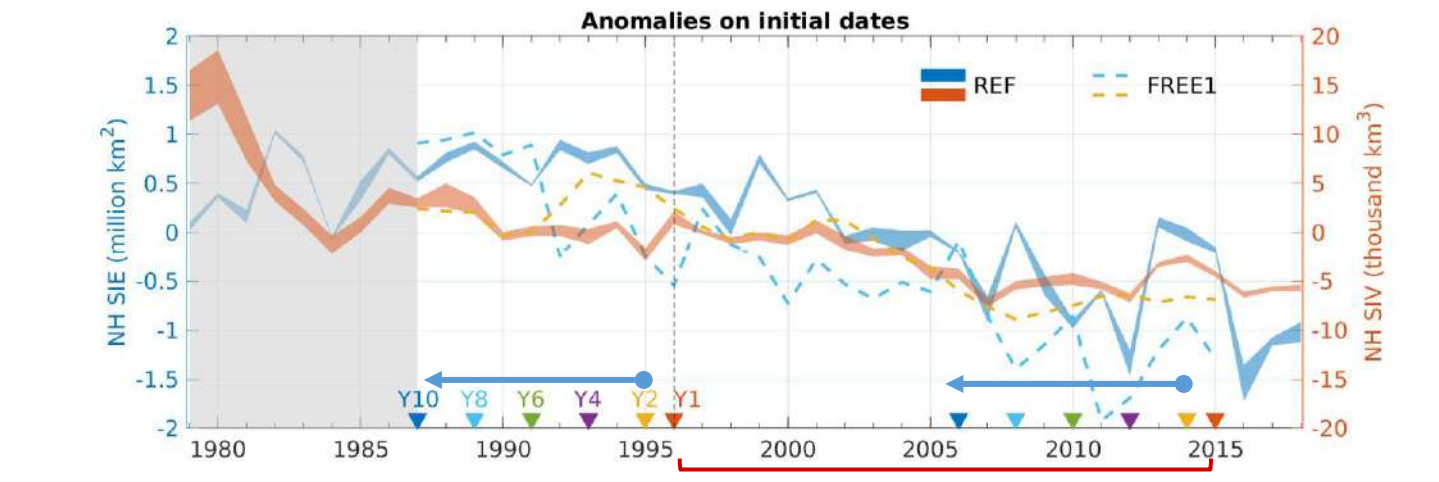


***h*$_{1,\ldots,5}$** distribution depends on total SIC

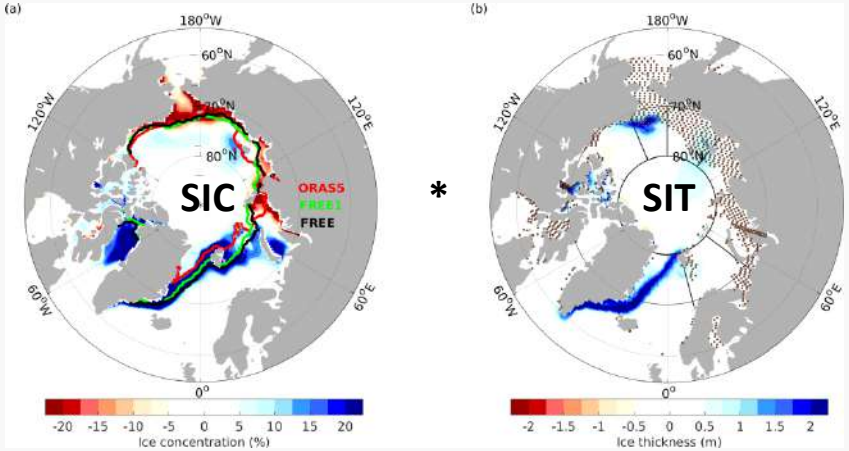
$$V^{ice}(x,y) = \sum_{l=1}^{L} g_l^{ice}(x,y)h_l^{ice}.$$

$$v_L^{ice}(x,y) = V^{ice}(x,y) - \sum_{l=1}^{L-1} g_l^{ice}(x,y)h_l^{ice}.$$

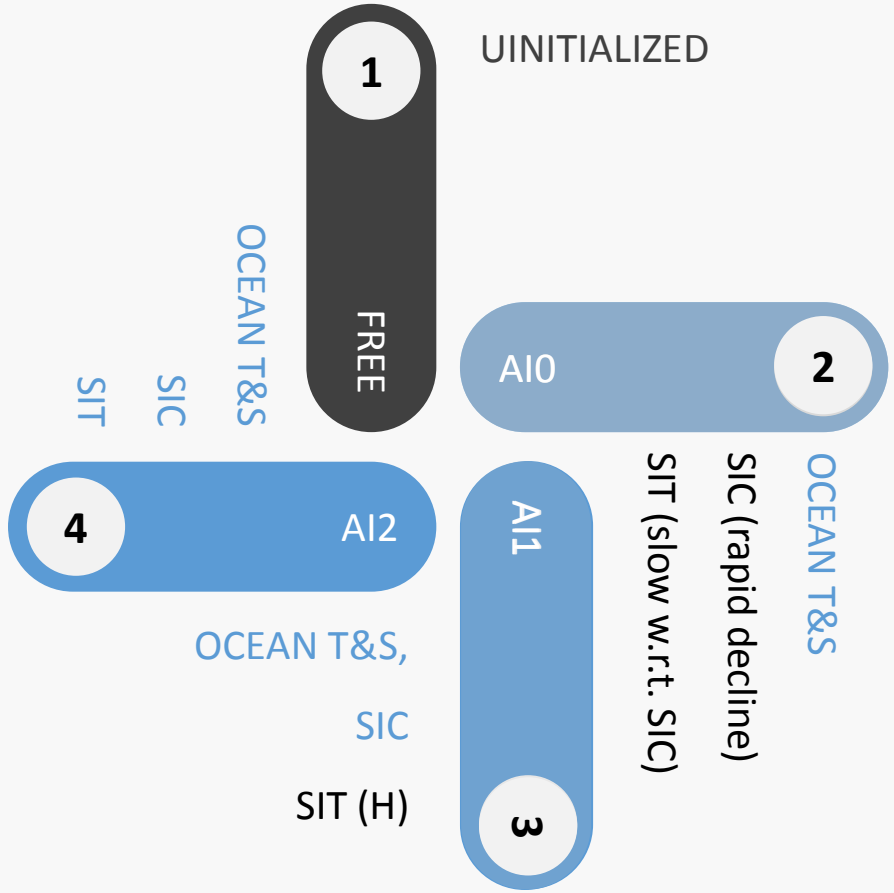
2. SENSITIVITY EXPERIMENTS WITH EC-EARTH3-CPSAI



SIV = SIC * SIT



■ **FOUR EXPERIMENTS**



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3. IMPRINT OF INITIAL CONDITIONS IN FIRST WINTER (M2-4)

- **SIC**

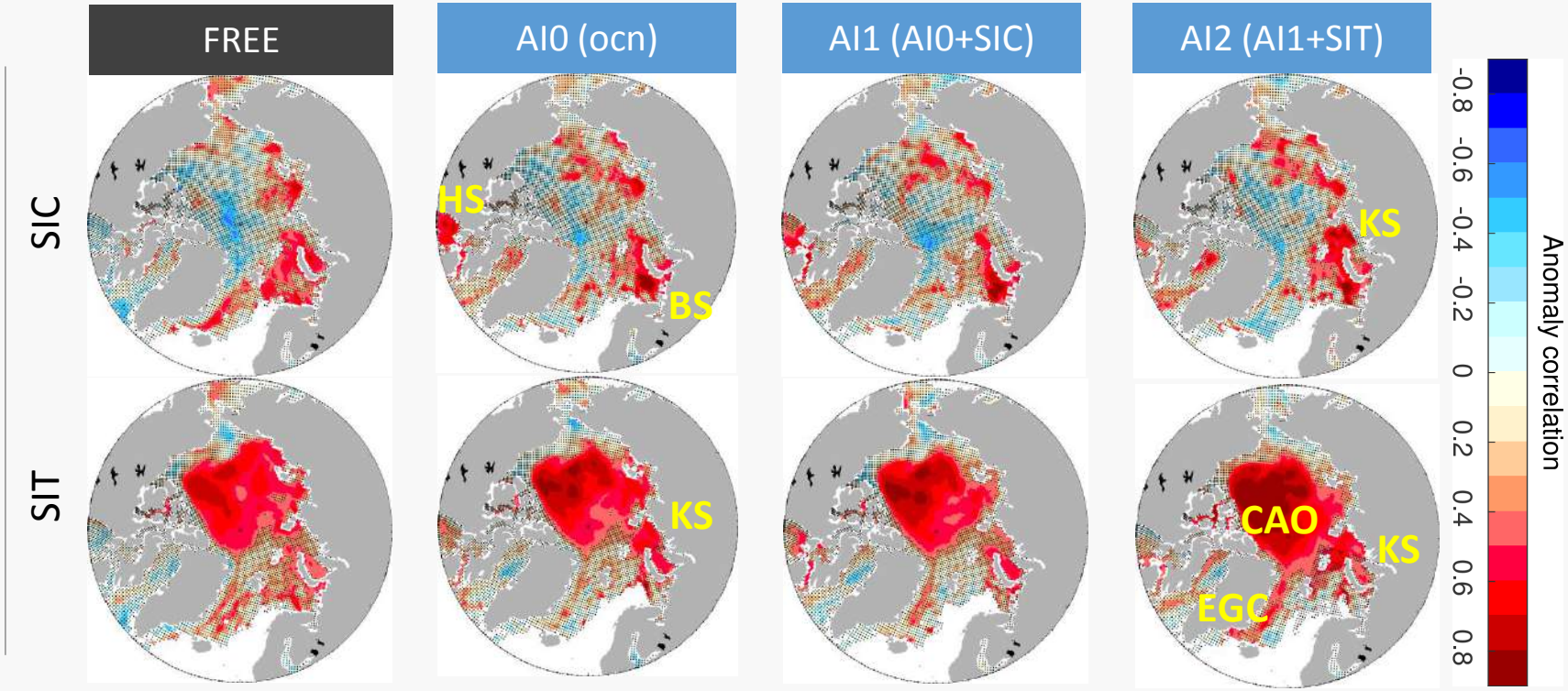
FYI [MIZ]: Hudson, Barents (AI0)

- **SIT**

MYI: CAO and EGC (AI2)

- **FYI<->MYI**

Kara (AI0 and AI2)



MIZ: suffering from cold bias with excessive sea ice (local bias>anomaly), **assimilating SST** performs best, e.g. Hudson, GIN and BS
FYI: correcting SIT may reduce the bias in other variables, e.g. SIC (Kara), **but not vice versa**;

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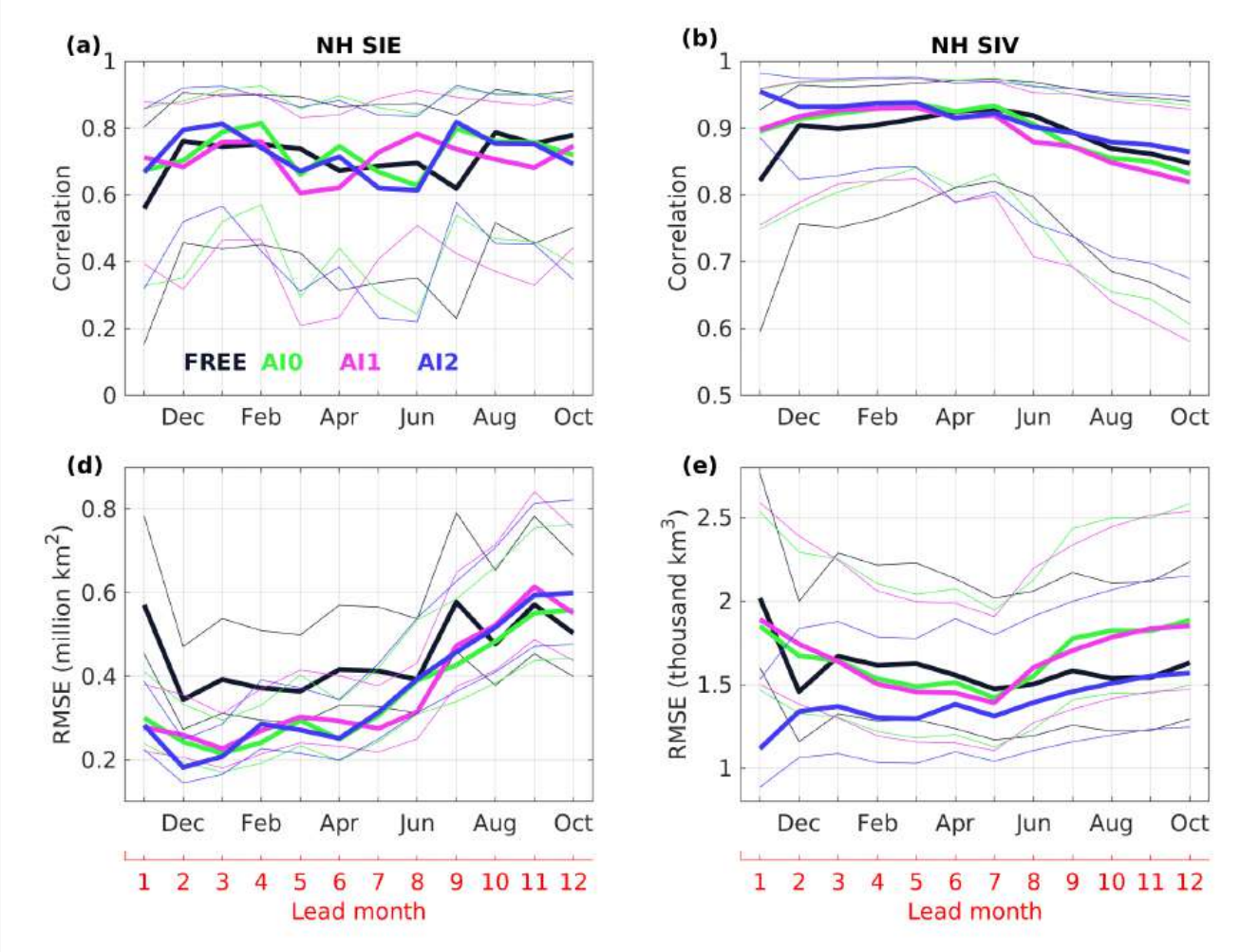
(*Chevallier et al., 2016; Kimmritz et al, 2018; Xie et al., 2018; Dai et al., 2020*)

3. CORRELATION DROPS BEFORE FIRST SUMMER



*Thin lines represent the upper/lower bounds of the 95 % confidence intervals obtained with a t-distribution for ACC and a χ2 distribution for RMSE

- **SIE > 9 months**

Benefit from AI0 (oce-init)

(*Dai et al., 2020*)

- **SIV >10 months**

Benefit from AI2 (SIT-init)

(*Xie et al., 2018*)

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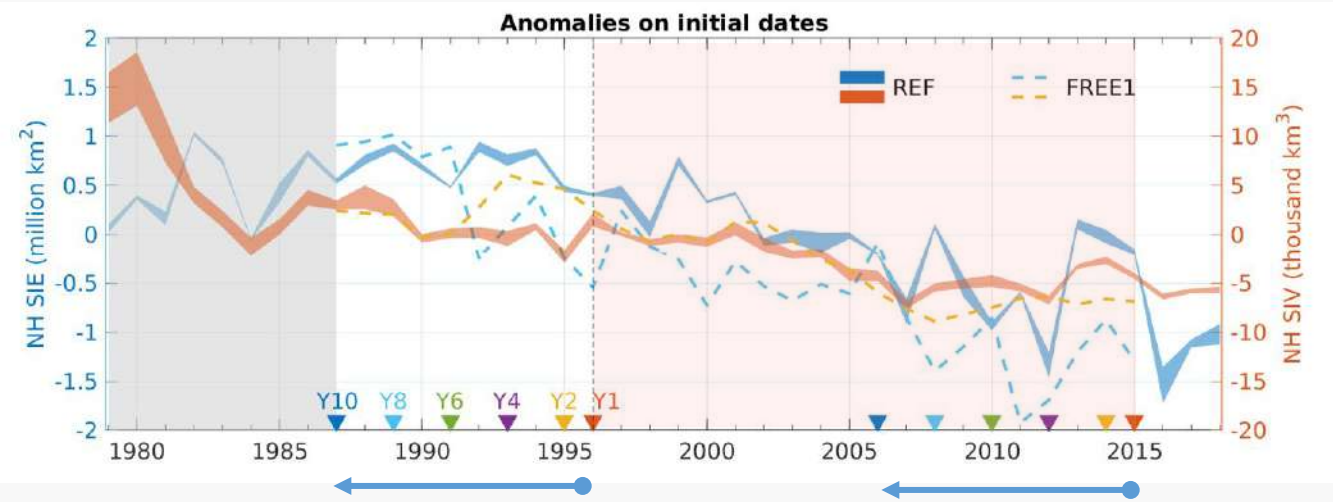
3. ROLE OF INITIAL DYNAMIC ADJUSTMENT AND SYSTEM ERRORS IN EC-EARTH3 CPSAI

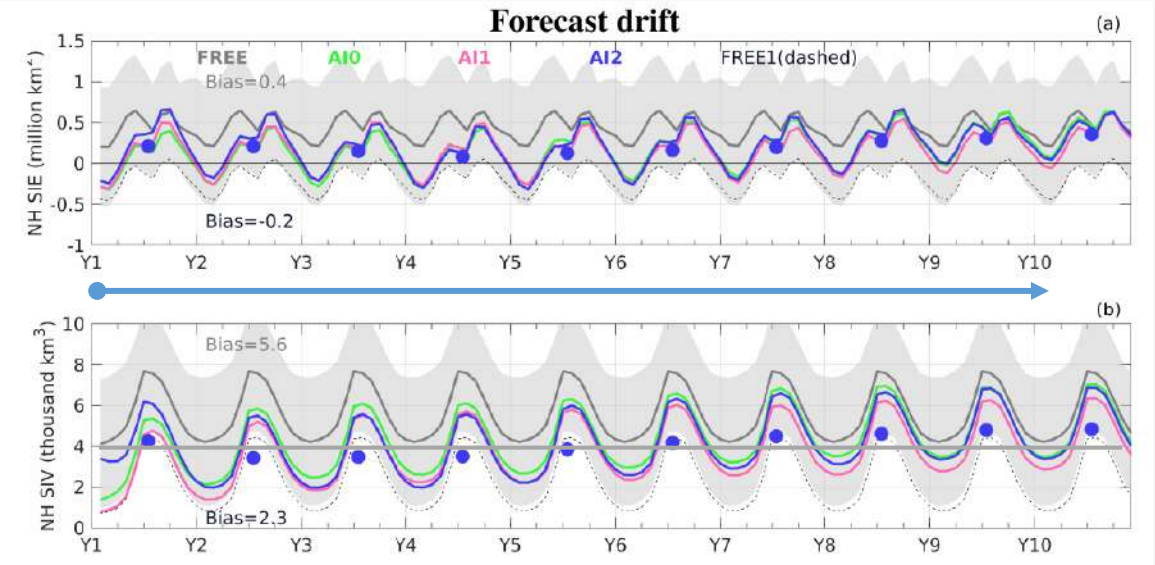
“ Initialization shocks not evident from Y1: the readjustment between surface ICs within the **first few weeks** (*Cruz-García et al., 2021*).

Model biases showing strong seasonal cycles: smaller in winter but much larger in summer

Forecast errors are first attributed to the initial shocks, and then dominated by model inherent bias **in summer**.

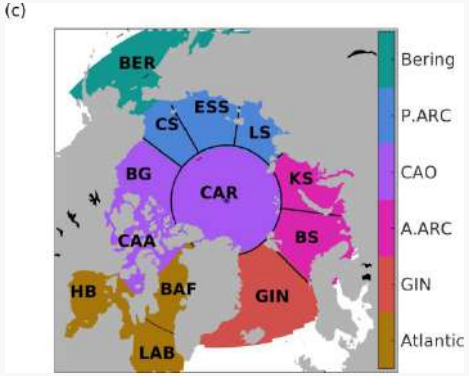


Steeper declines in FREE1 than REF in Y1-5 & Y6-10



(*Cruz-García et al., 2021; Volpi, et al, 2017*)

4. ORIGIN OF DECADAL PREDICTABILITY (Y2-9)



- **SIC**

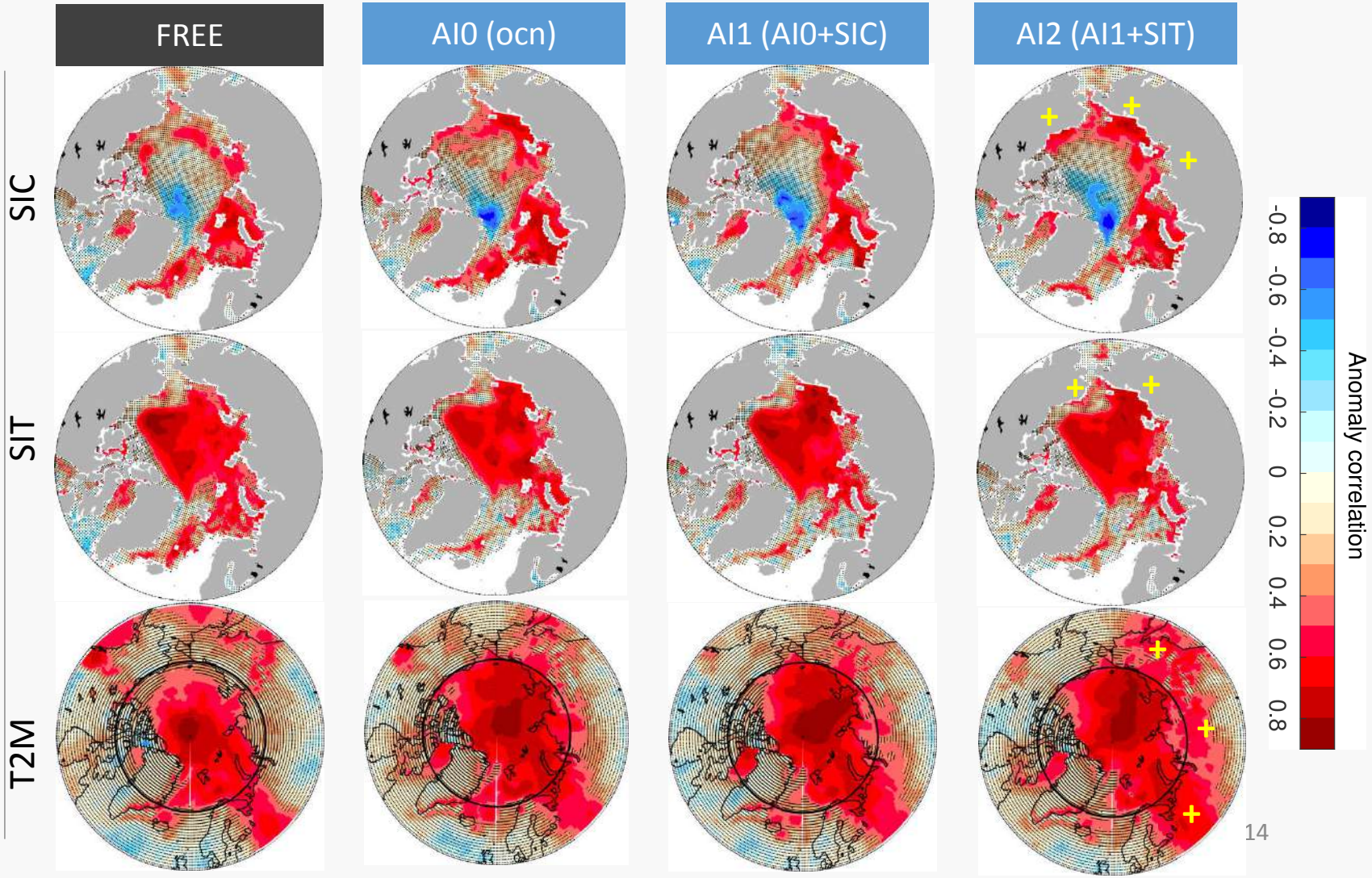
FYI: Pacific/Atlantic ARC waters

- **SIT**

Moving from CAO (MYI) to P. ARC (FYI)

- **T2M**

Following improved SIC (FYI) & expanding over land



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4. LINKING MYI TO A. ARC (THIN FYI)

"covered by thin ice (<1m); SIE varies with interannual variability of the Atlantic ocean heat transport and is strongly modulated by local wind patterns (Tietsche et al., 2018; Bliss et al., 2019)"

$$RMSS_{IN}{}^{I}{}_{x} = 1 - \frac{RMSE_{IN}{}^{I}{}_{x}}{RMSE_{UIN}{}^{I}}$$

- **AI0: improved SIC& SST**

Y1-Y6 Atlantic heat inflow

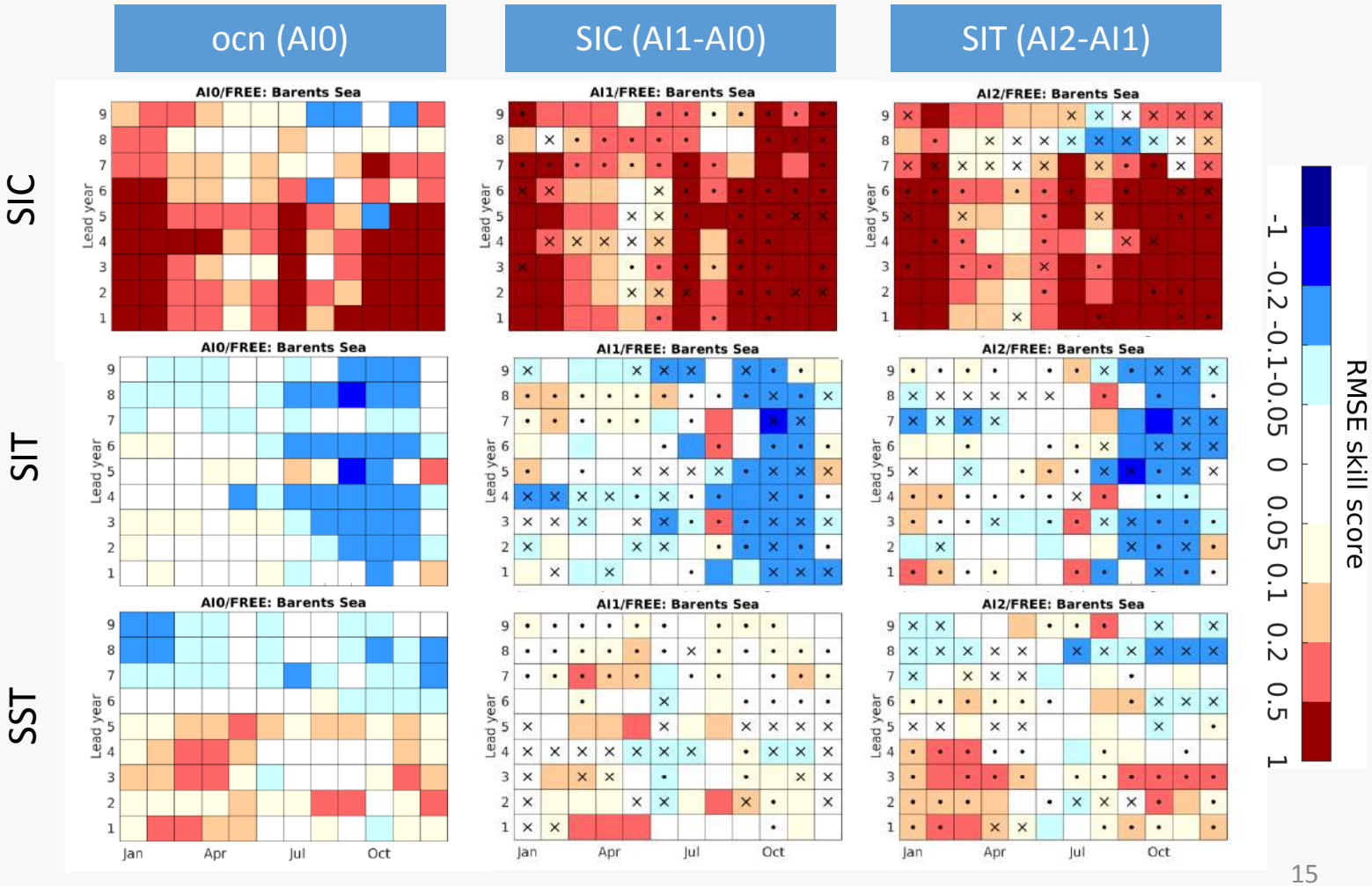
- **AI1: degraded SIC, SIT & SST**

Y1-Y6: incorrected SIT

- **AI2: added skill in first winter SIT and SST**

Followed by improved SIC in Y2-Y6

summer SIE, local wind-driven ice transport during summer (Dai et al, 2020)



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4. LINKING MYI TO P. ARC (THICK FYI)

"The Pacific heat inflow in summer and the Siberian High in the ice-growth months are more important than the Atlantic inflow (Tietsche et al., 2018). FREE tends to produce too thick ice in winter and too slow melting in summer."

- **All: little improvement in winter SIC**

Fully ice-covered

- **AI0: slower IC adjustments**

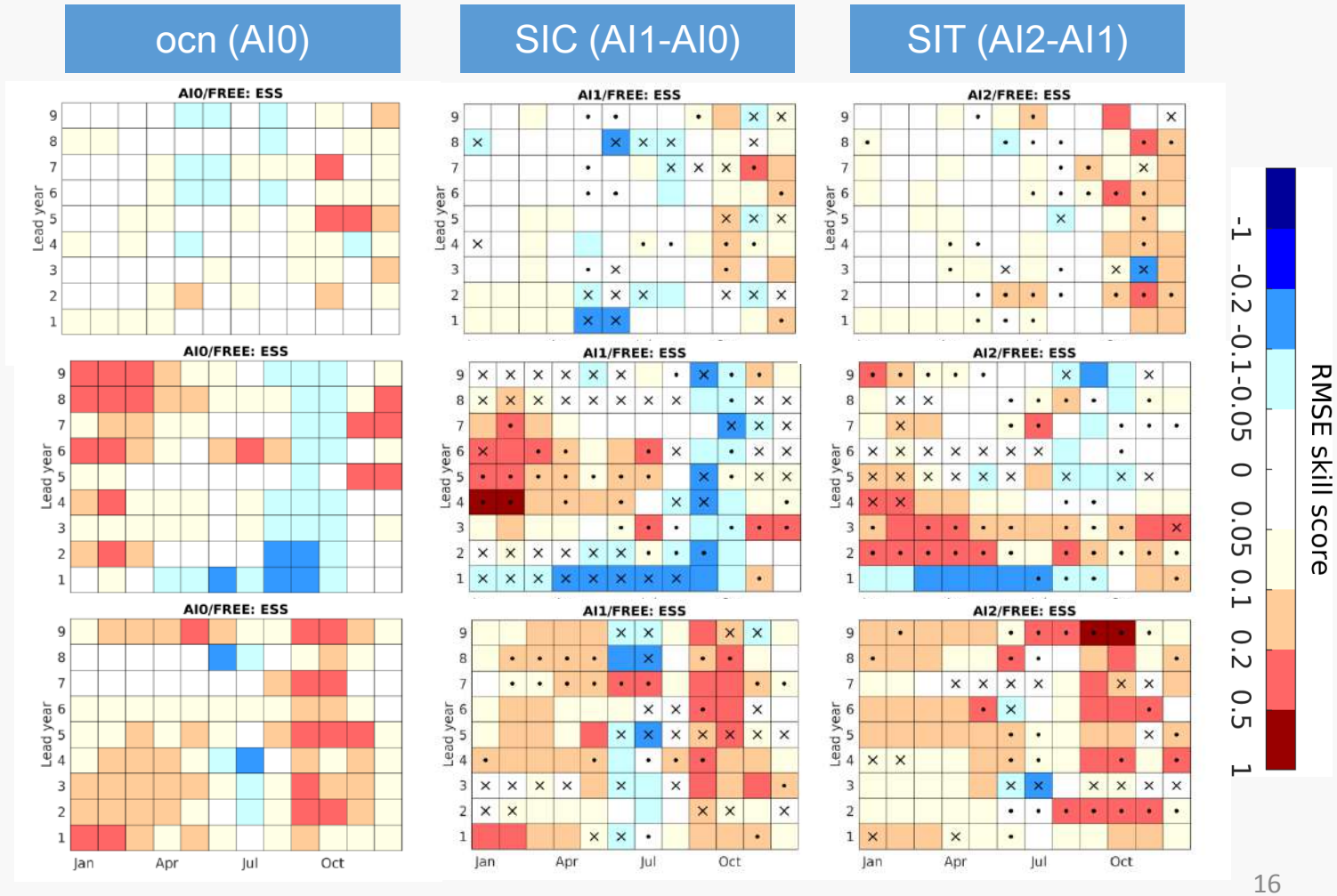
Improved SST versus winter SIC in Y5

- **AI2 lag of 12months**

Local initial sea ice (AI1=AI2)

Added skill in summer SIC and SST Y1-Y2 and SIT in Y2-Y3

remote origins driven by advective processes or winds (Guemas et al., 2016).



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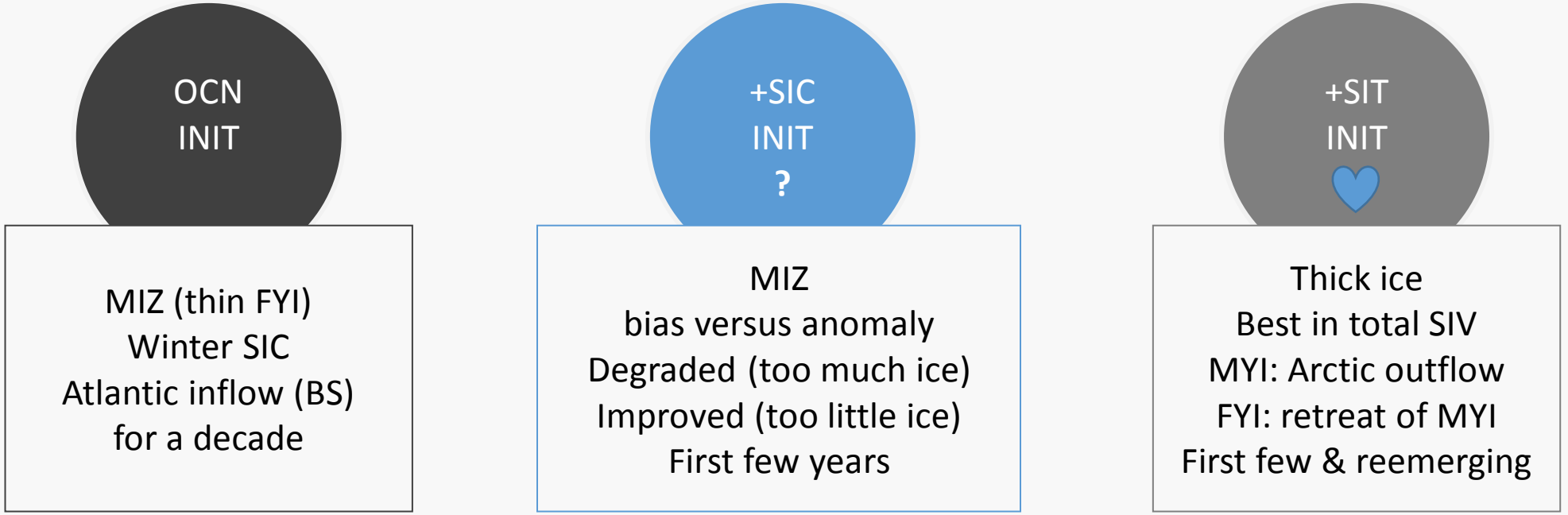
5. CONCLUSION



SIT INIT EFFICIENTLY CONSTRAINS SIV OF CAO-MYI, WHICH IN TURN CONSTRAINS THE EXPANSION OF POLARWARDS SEA ICE RETREAT IN SUMMER AND IMPROVES SIC SKILL (FYI)

Blue-Action Climate Coffees

Blue-Action, in partnership with ECRA, invite colleagues from across the climate science community to join us for a new series of regular online knowledge exchange events.

These relaxed meetings are an opportunity to share ideas, discuss methods and communicate new results.

http://blue-action.eu/training/climate-coffees

FOR YOUR WATCHING

THANKS

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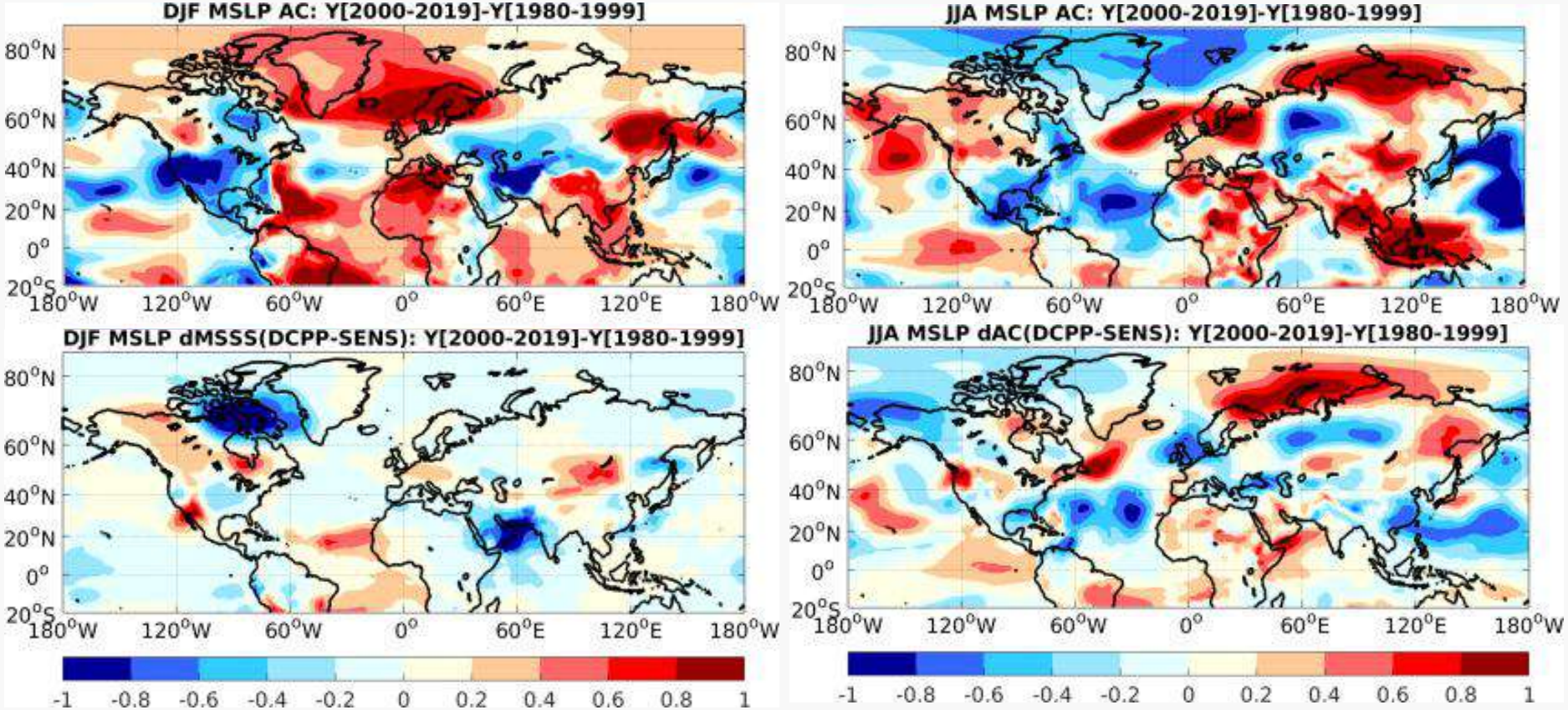
* TO UNDERSTAND HOW ARCTIC SEA ICE MELT COULD AFFECT NH CLMATE

- DCPP – FREE
- Added by SIT



Pressure change over the Arctic can alter atmospheric circulations