Impact of sea-ice initialization on decadal prediction in the Arctic

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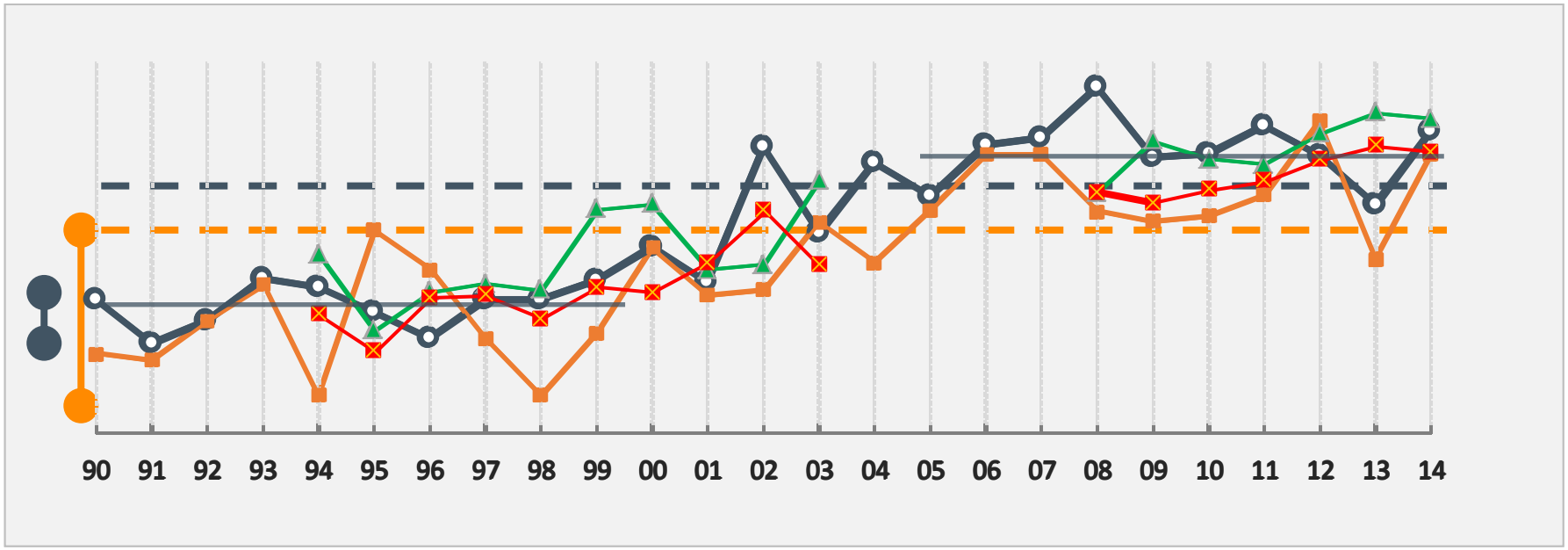
Motivation

Identify added-value from sea ice multi-category initialization in prediction of the Arctic SAT

- 2K increase, vs 90s
- Model bias~ 0.5 K
- Less variability
- O-AI no obvious improvement
- OSI-AI best fit in the warm regime

TAS, DJF, 60-90N

Free run vs. Ocean Initialisation



Free run (CMIP6-historical)

Ocean-only initialisation (O-AI)

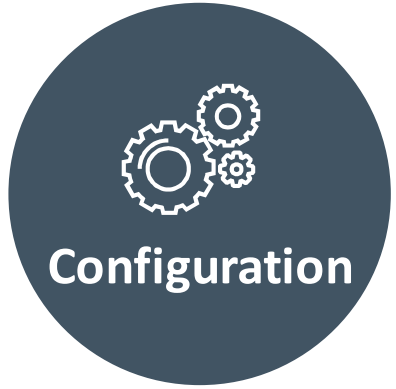
ERA-Interim

Ocean+sea ice initialisation (OSI-AI)

The EC-Earth3 decadal prediction system

Objectives: seasonal-to-decadal prediction

- CMIP6 Decadal Climate Prediction Project (DCPP)
- Climate services



01 OBS mean: 1979-2014 (ORAS5)

02 Model mean: 1979-2014, EC-Earth 3 (AOGCM-historical)

03 Ice multi-categories: constant pre-industrial forcing > 300 yr

04 Secure consistency between the coupling interfaces

01 EC-EARTH3 for CMIP6(T255L91 + ORCA1L75+lim3)

02 3D T & S, sea ice conc. ice and snow volume

03 Yearly start over 1960-2014,10-year long

04 Lagging by 10 days after start, 10 members

Anomaly Initialization

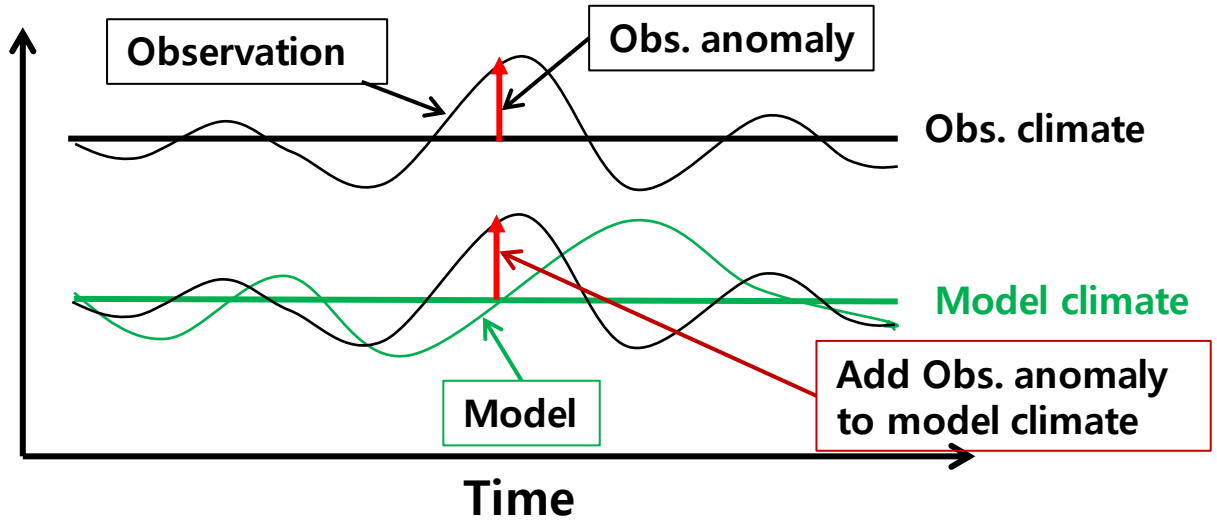
Ocean only (O-AI)
Ocean and Ice (OSI-AI)

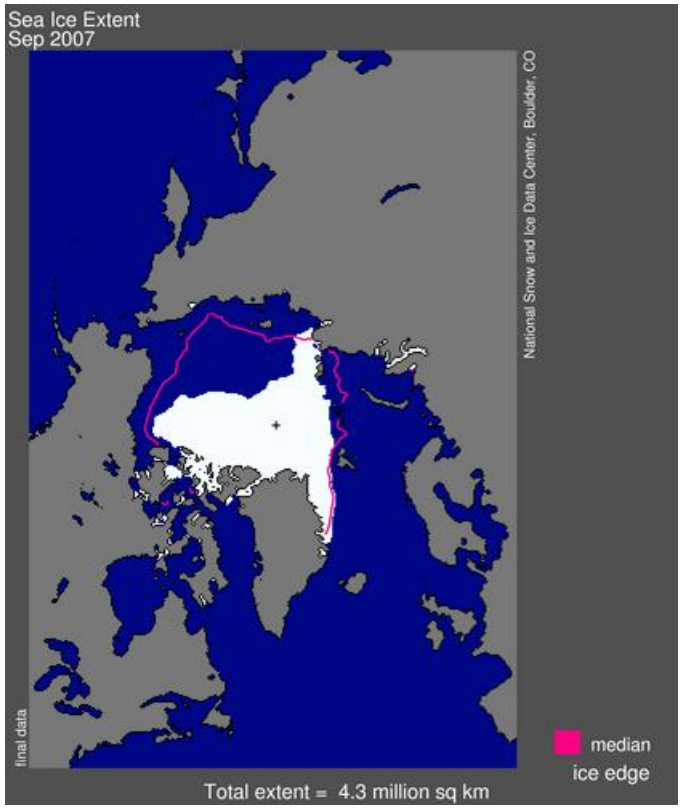
Multicategory sea ice

Uniform or a weight determined by mean state or min. difference calculated over a 300-year pi-ctrl run;
Correction to ice age, ice surface temperature, sic, sit, snt, ice/snow heat content, ice salinity (Massonnet et al, 2015, Kimmritz et al, 2018, Zhang et al., 2018)

OSI-Anomaly initialisation

Methods, limitation & prediction skills over FFI (Volpi et al, 2017a,b)





- Avoid introducing anomalies that are out to the model internal variability range
- Model biases with a spatial drift: locate the anomalies at the wrong place
- A sharp sea ice reduction from the model state: negative values cannot be assigned to the sea ice concentration and thickness in AI

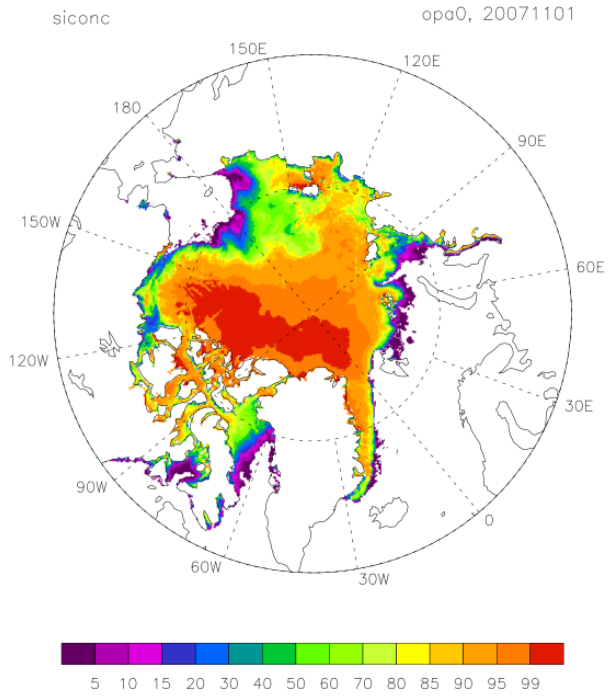
— Median ice edge

OBS Anomaly

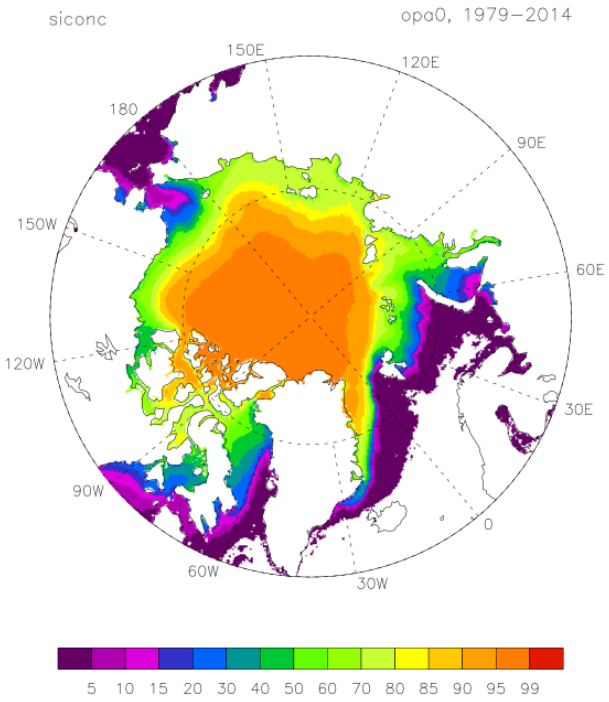
Defined as a field's deviation from the mean state (climate), calculated over a period of at least 30 years (WMO)

- Sea ice cover, ice and snow volume, 3D T & S

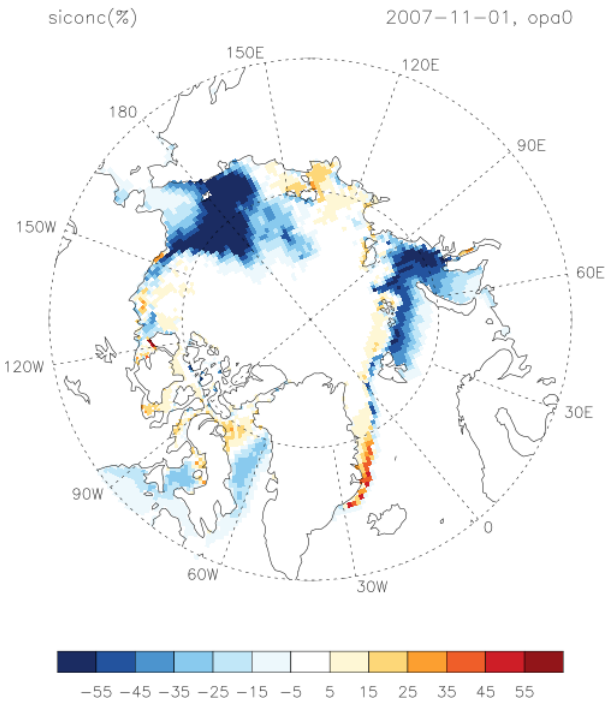
OBS date: 2007-11-01



OBS mean



OBS anom

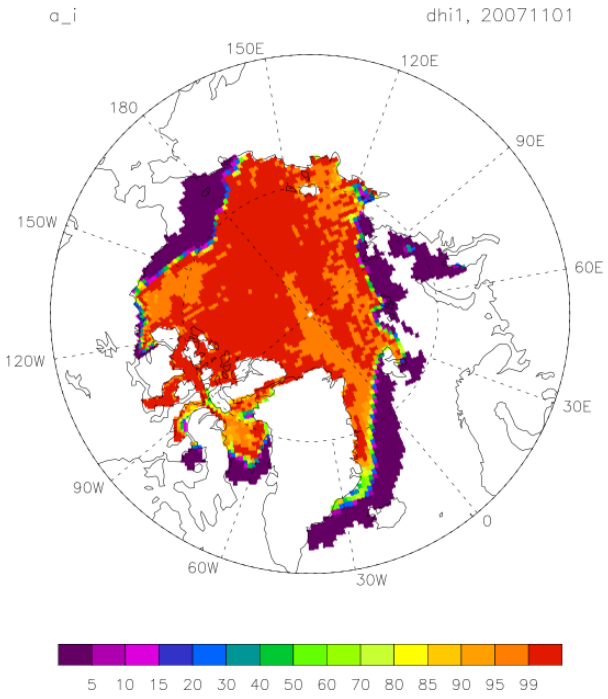


MOD Anomaly

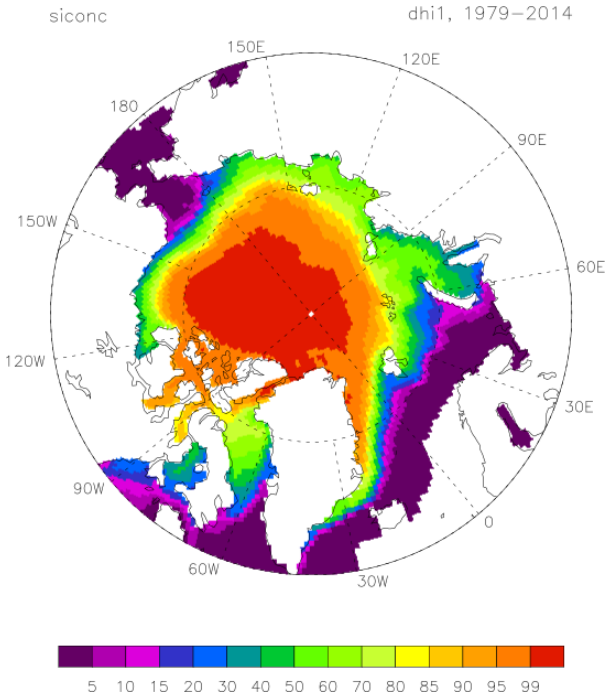
Sea ice cover

- Sea ice volume

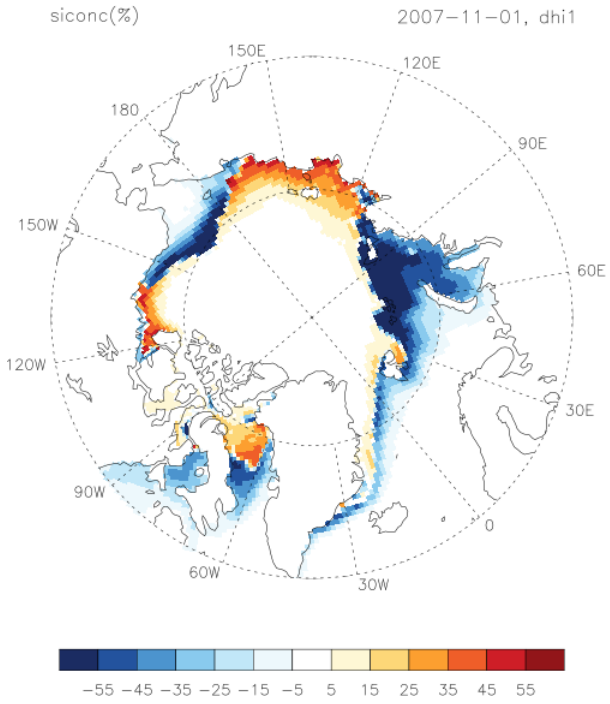
Free run 2007-11-01



MOD mean



MOD anom

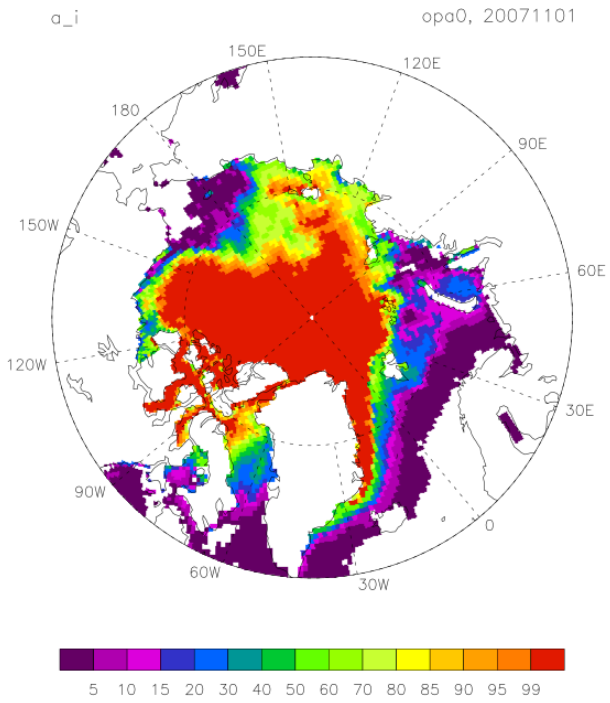


Anomaly initialisation

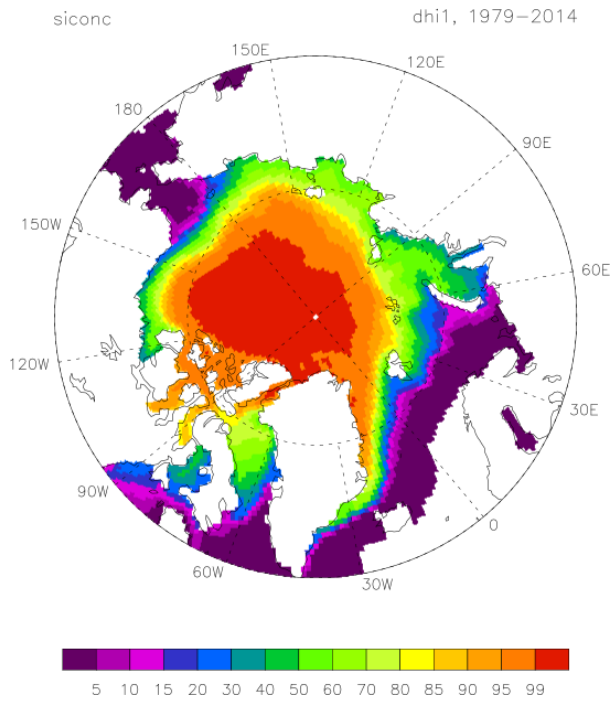
The intial state is obtained by replacing the model anomalies with the observed ones (Volpi, et al, 2017b)

- Limitation in SI-AI in the warming climate: negative values cannot be assigned to the sea ice concentration and thickness
- Giving the potential to refine ice volume AI (unobserved variable) to increase the prediction skill of TAS in the Arctic (Kimmritz et al, 2018)

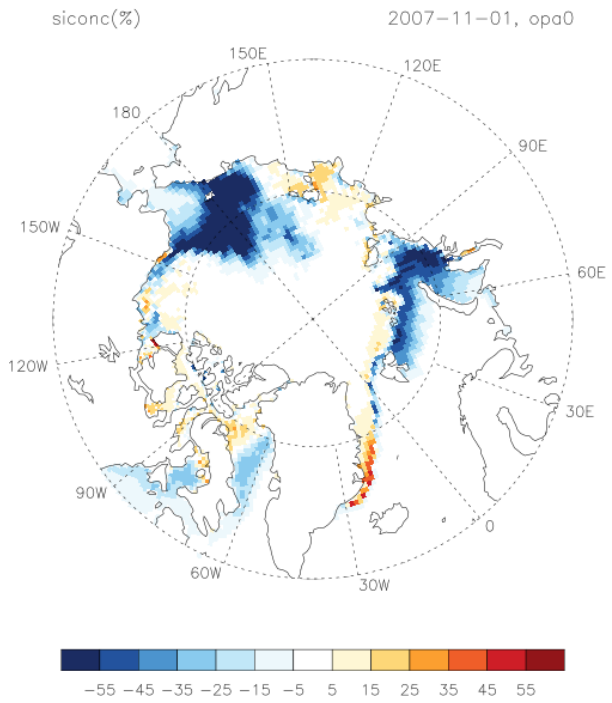
Initial date: 2007-11-01



MOD mean



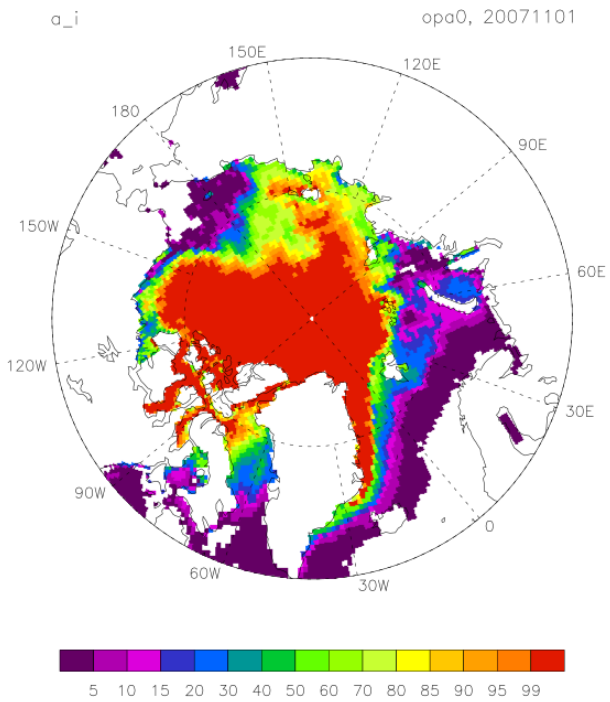
OBS anom



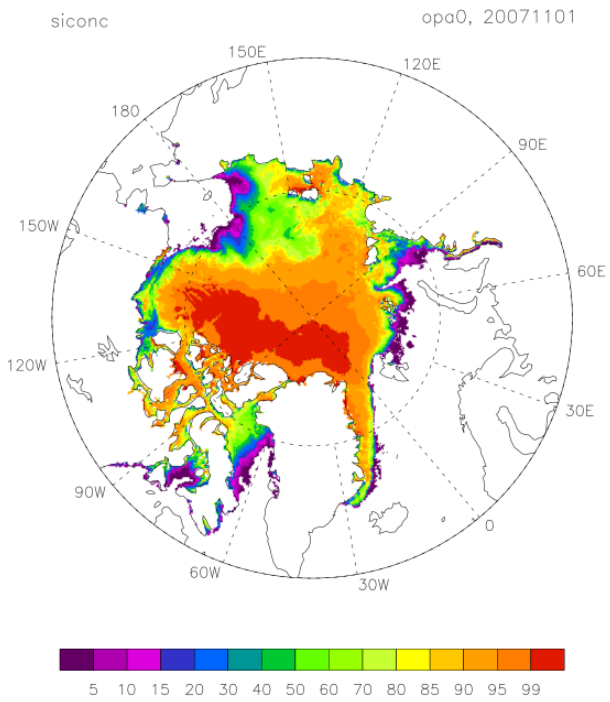
Errors in initial state

Sea ice concentration, total

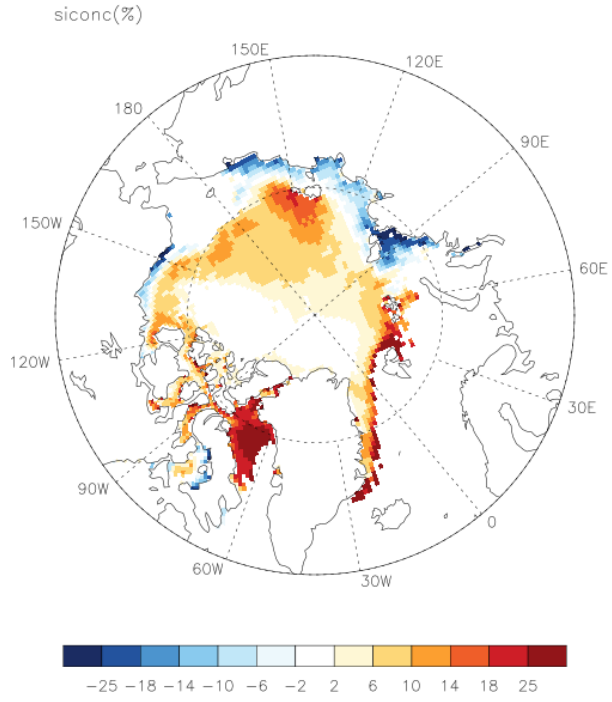
Initial date



OBS date



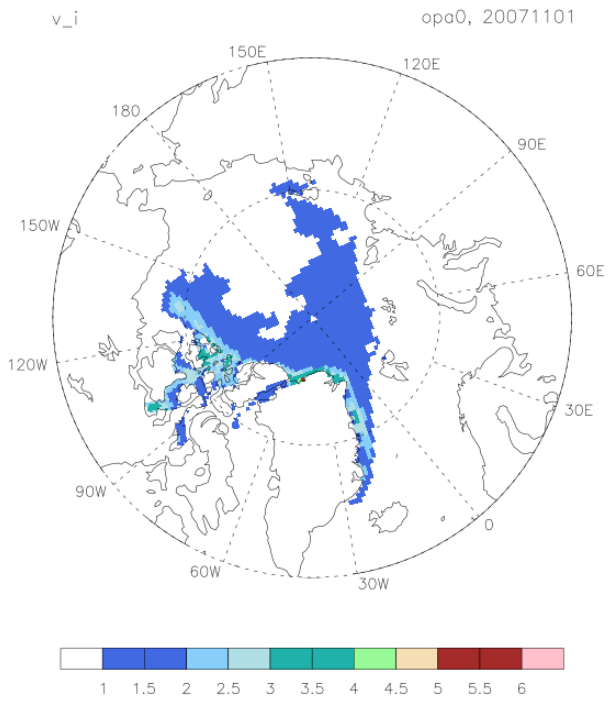
MOD - OBS



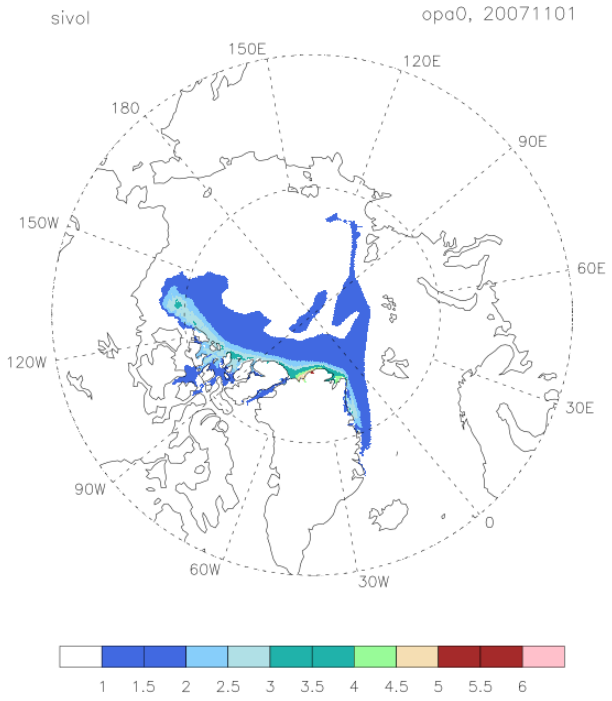
Errors in initial state

Sea ice volume, total

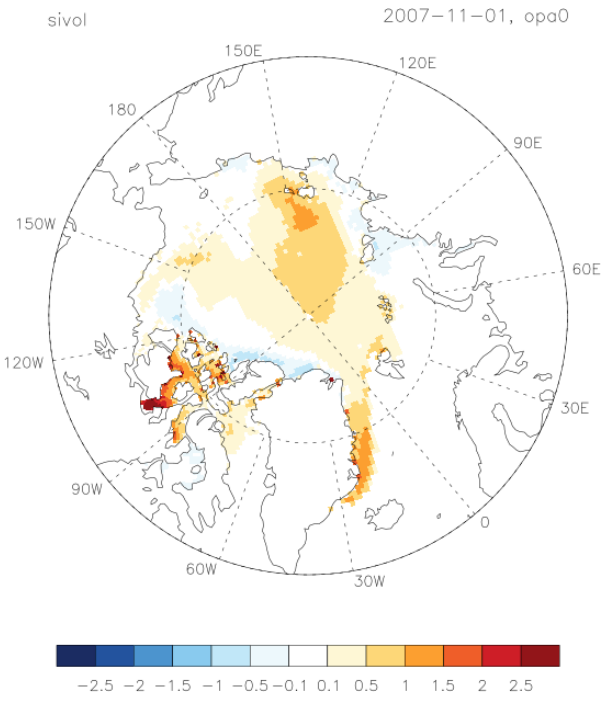
Initial date



OBS date



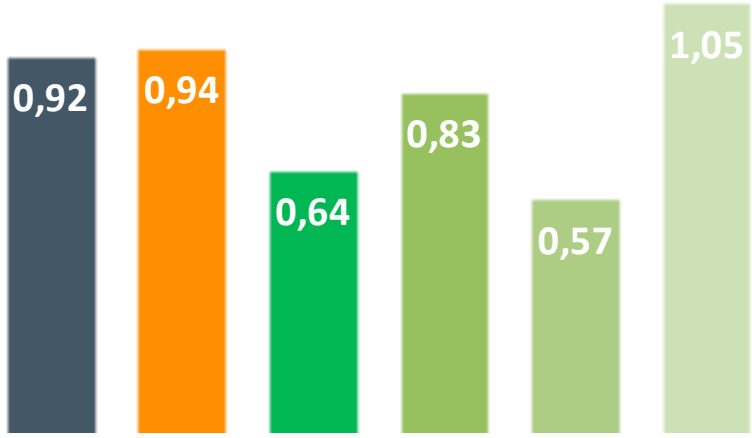
MOD - OBS



Best with Ocean and sea ice initialisation

RMSE (Experiments – Observations)

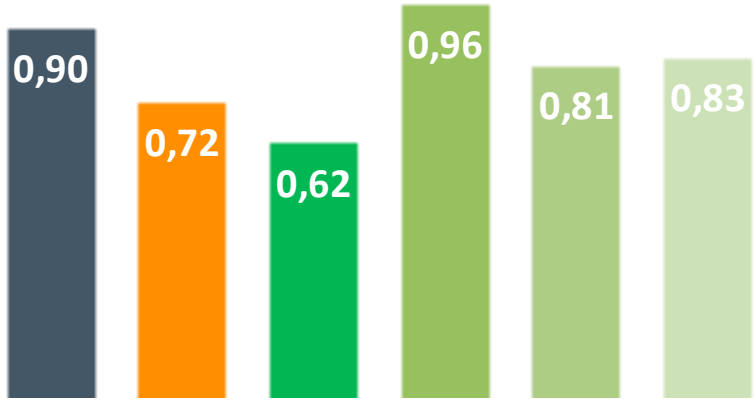
- For the cold winter 1993, OSI-AI also won, suggesting a dominant role of the external forcing. (Hunke 2016)



Near surface temperature

Unit in K

DJF 60-90N



Ice area minimum

Unit in 1e12 m2.

Great improvement in concentration area by multi-sea ice assimilation (Kimmritz et al, 2018)

Free run

O-AI

OSI-AI

OSI-AI-Fmin

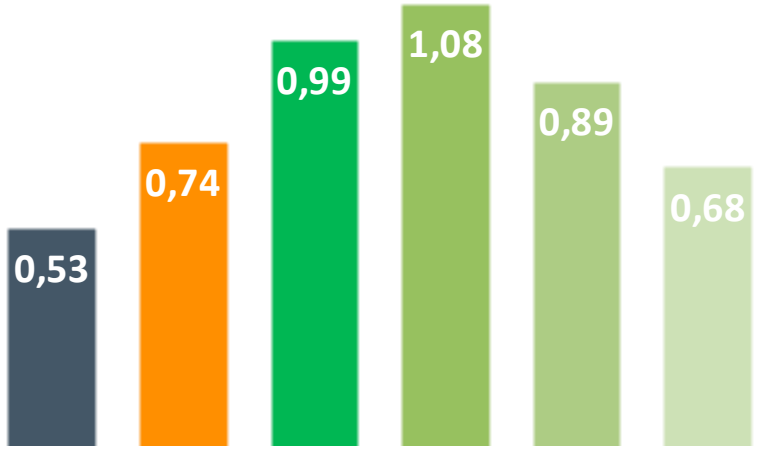
OSI-AI-Fmean

OSI-AI-Funiform

Better with no initialization?

RMSE (Experiments – Observations), beyond 3 years, OSI-AI began to drift away

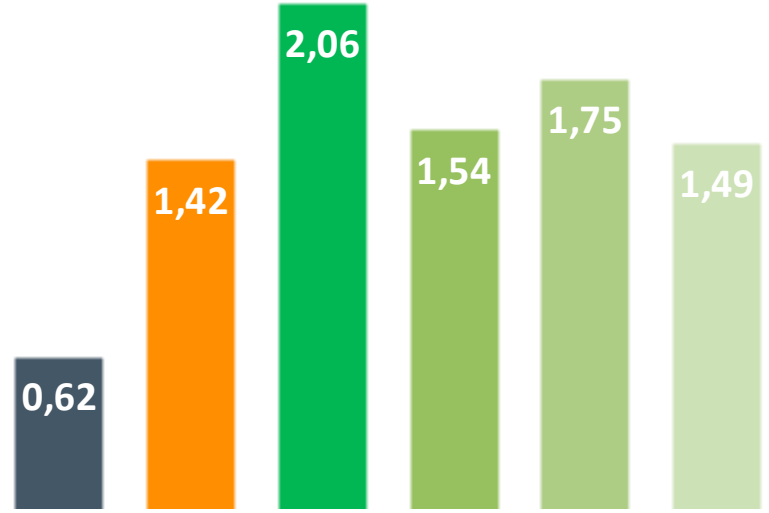
- Internal ice physics parametrizations play a role with persistent positive bias with a lot of ice.



Ice extent minimum

Unit in 1e12 m2.

Persistent model bias with a lot of ice



Ice volume maximum

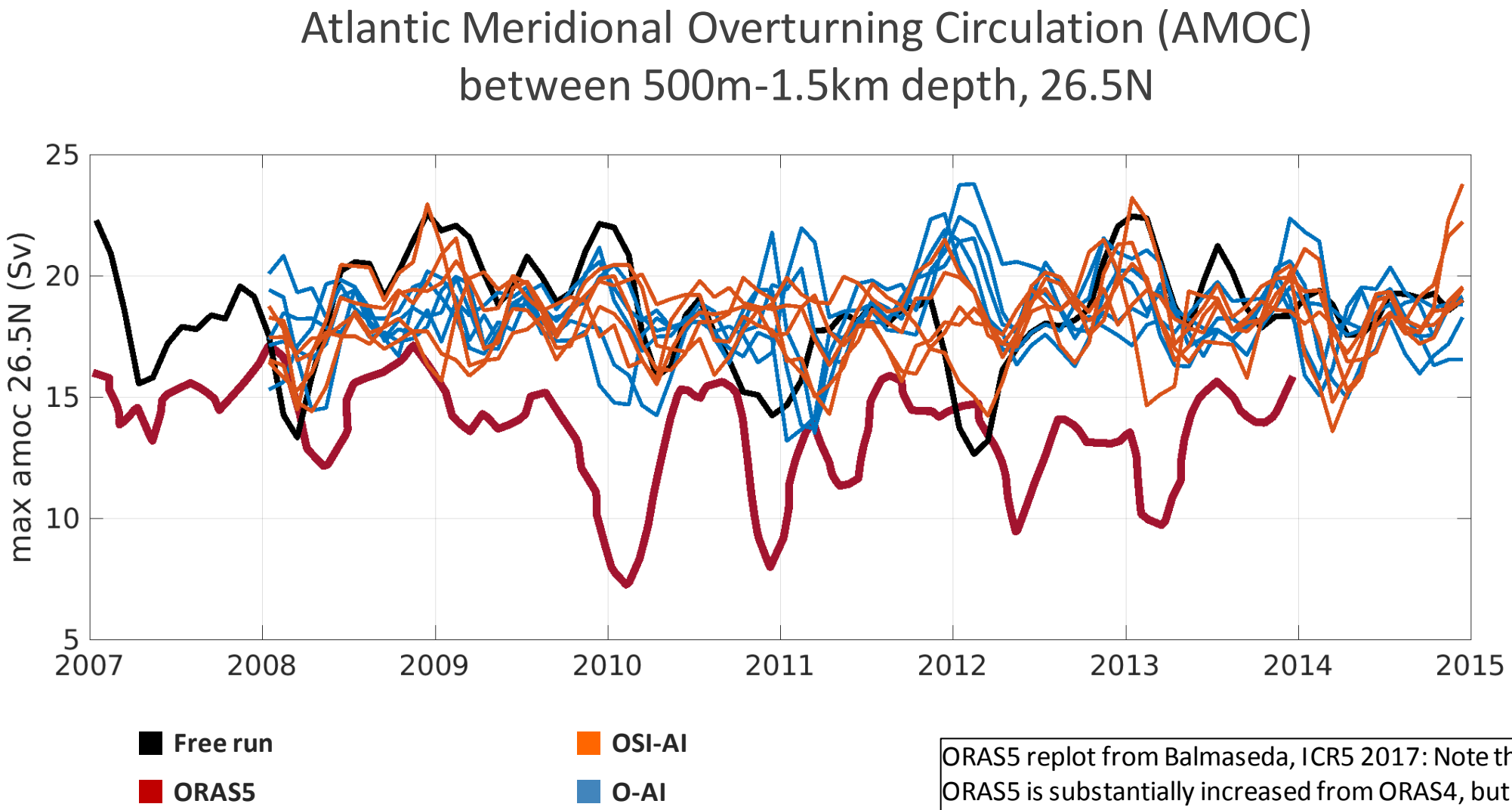
Unit in 1e12 m3

Challenge in multi-category SI-AI with a sharp reduction from the original model state.

Free run
O-AI
OSI-AI
OSI-AI-Fmin
OSI-AI-Fmean
OSI-AI-Funiform

Next steps

1. Pool regional skill in AMOC (Sterl, 2016; Liu et al.,2017; Polkova et al., 2019)



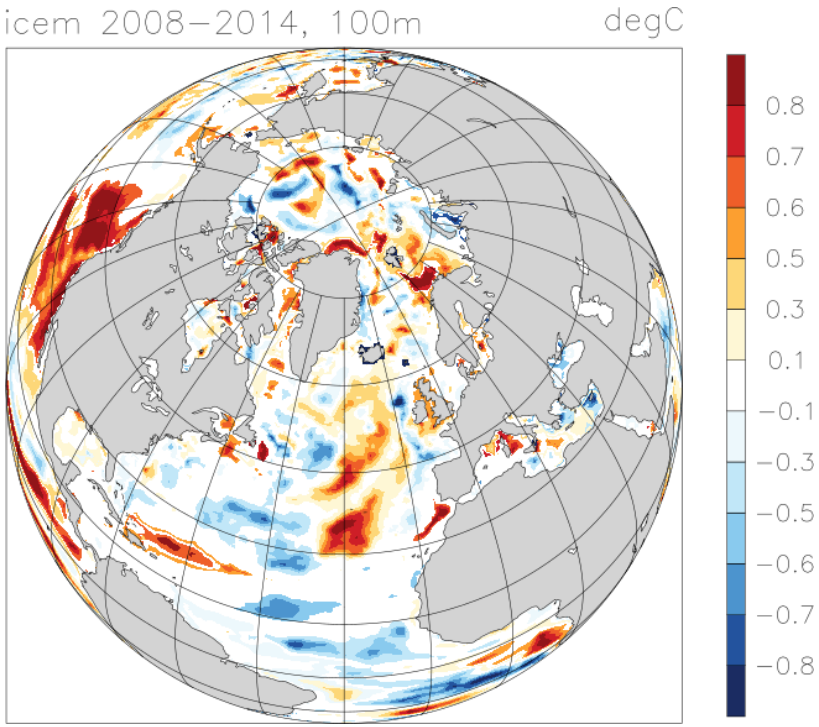
ORAS5 replot from Balmaseda, ICR5 2017: Note that the AMOC in ORAS5 is substantially increased from ORAS4, but still lower than in the observational data set RAPID from 2004 on wards.)

Next steps

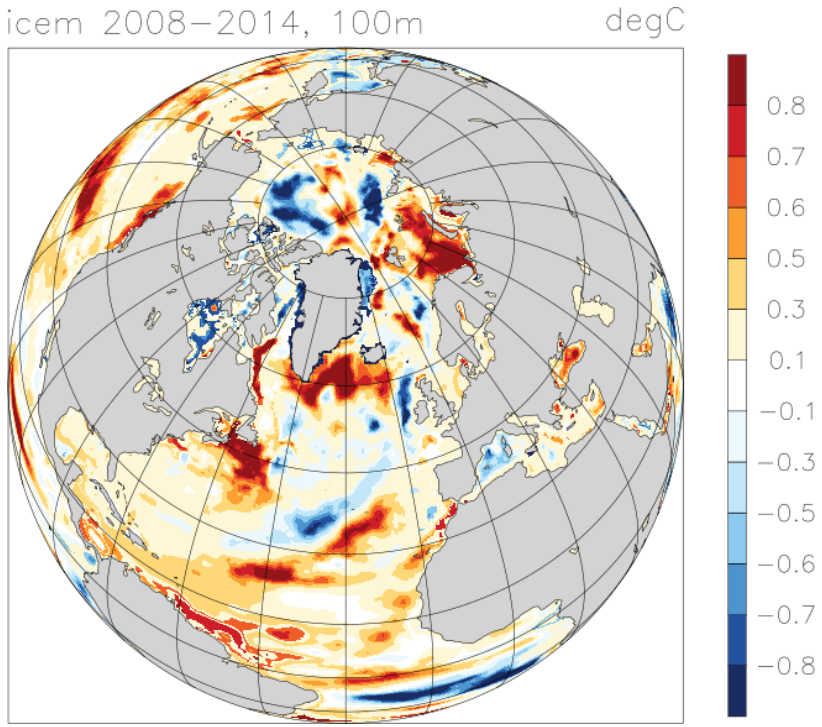
2. Anomaly correlation: improve skill by regional sea ice removal

- Relatively high skill in the subpolar N. Atlantic and part of the Nordic and Barents Seas (Matei et al.2012; Hazeleger et al.,2013; Langehaug et al. 2017)
- Very patchy, possibly caused by the inconsistency between the observed anomalies with the underlying background state of the model as a possible cause (Bellucci et al., 2014, Volpi et al., 2017b)

LagYear=0



LagYear=1



Anomaly: yearly mean minus obs. climate

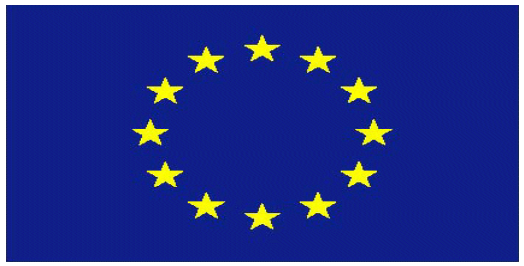
Perspective

Reducing model drift in predicting the Arctic sea ice decline with OSI-AI

- To refine sea ice volume in order to minimize regional errors in sea ice reduction in the initial state.
- To identify the spatial shift between the model and the observed variability (Volpi et al. 2017b)
- To apply weighted anomaly initialisation to make their amplitude more consistent with the simulated variability (Volpi et al. 2017a)

Thank you

BLUE ACTION



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