Prediction of Diverse Boreal Summer Intraseasonal Oscillation in GFDL SPEAR model

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UFS S2S Application team all-hands meeting

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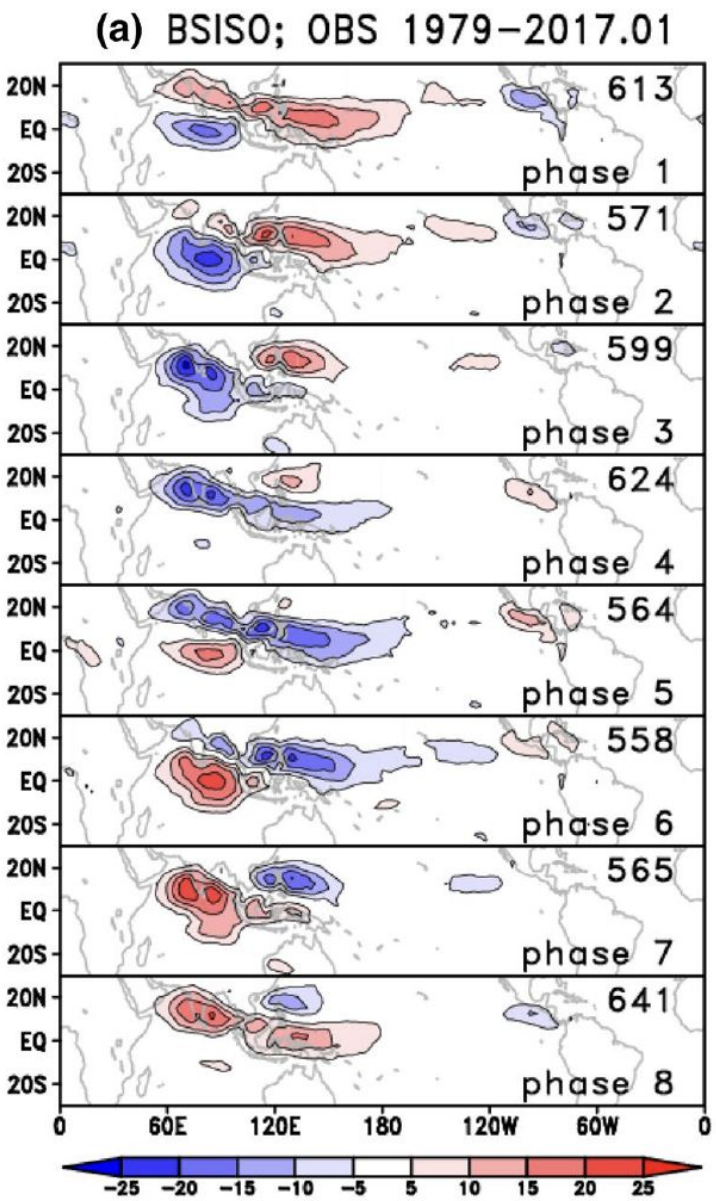
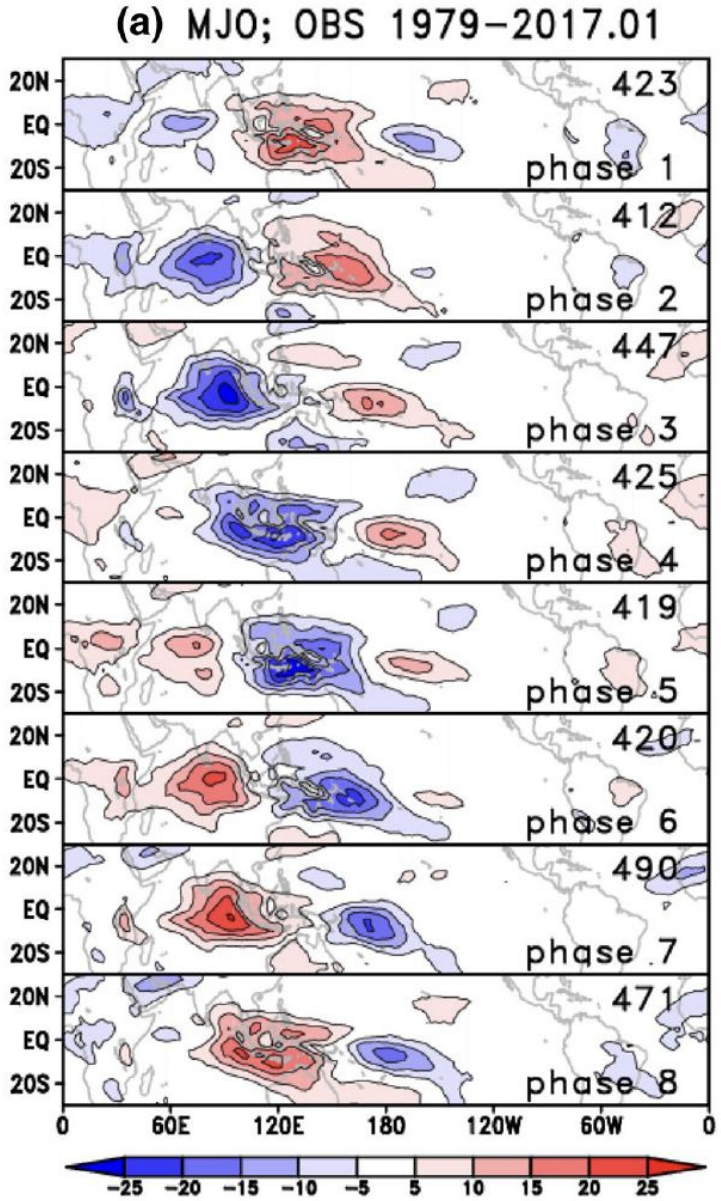
BSISO vs MJO

Impacts of BSISO:

1) Tropical cyclone
2) low-pressure systems
3) Monsoon onset
4) Heat extremes and midlatitude weather
……

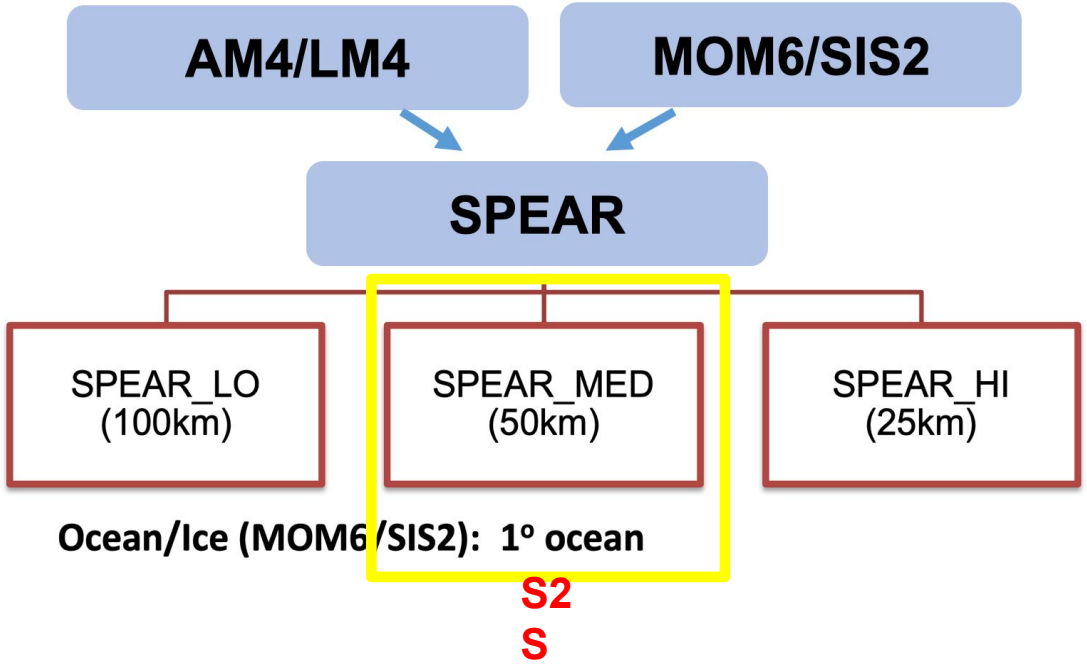




Kikuchi 2020

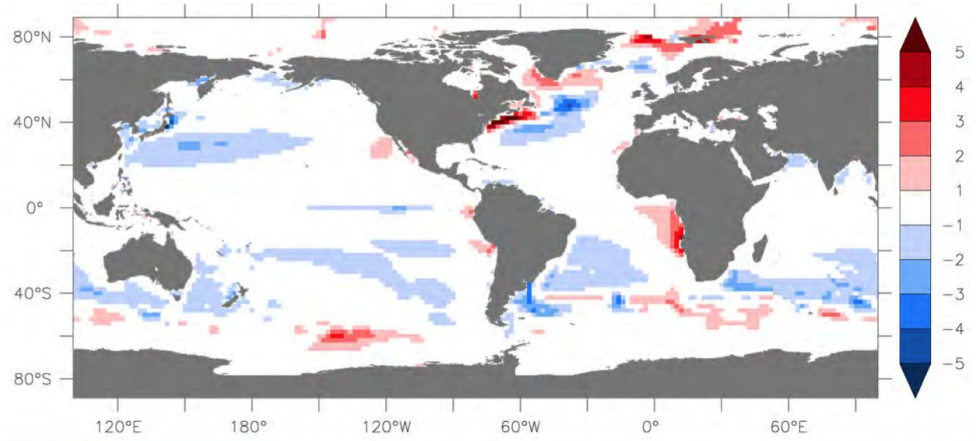
GFDL has developed a new generation prediction system---SPEAR

SPEAR: Seamless system for Prediction and EArth system Research

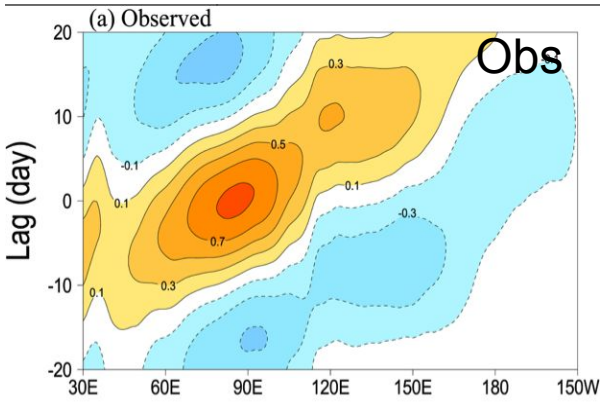


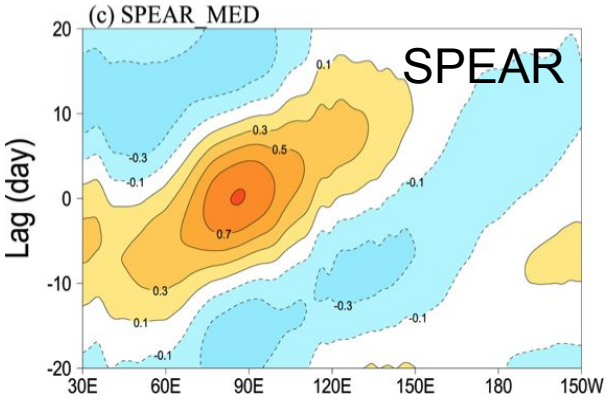
Delworth et al. 2020; Zhao et al. 2018a,b; Adcroft et al. 2019; Lu et al. 2020, Xiang et al. 2021, 2024 ...

SPEAR (rmse = 0.89)



MJO



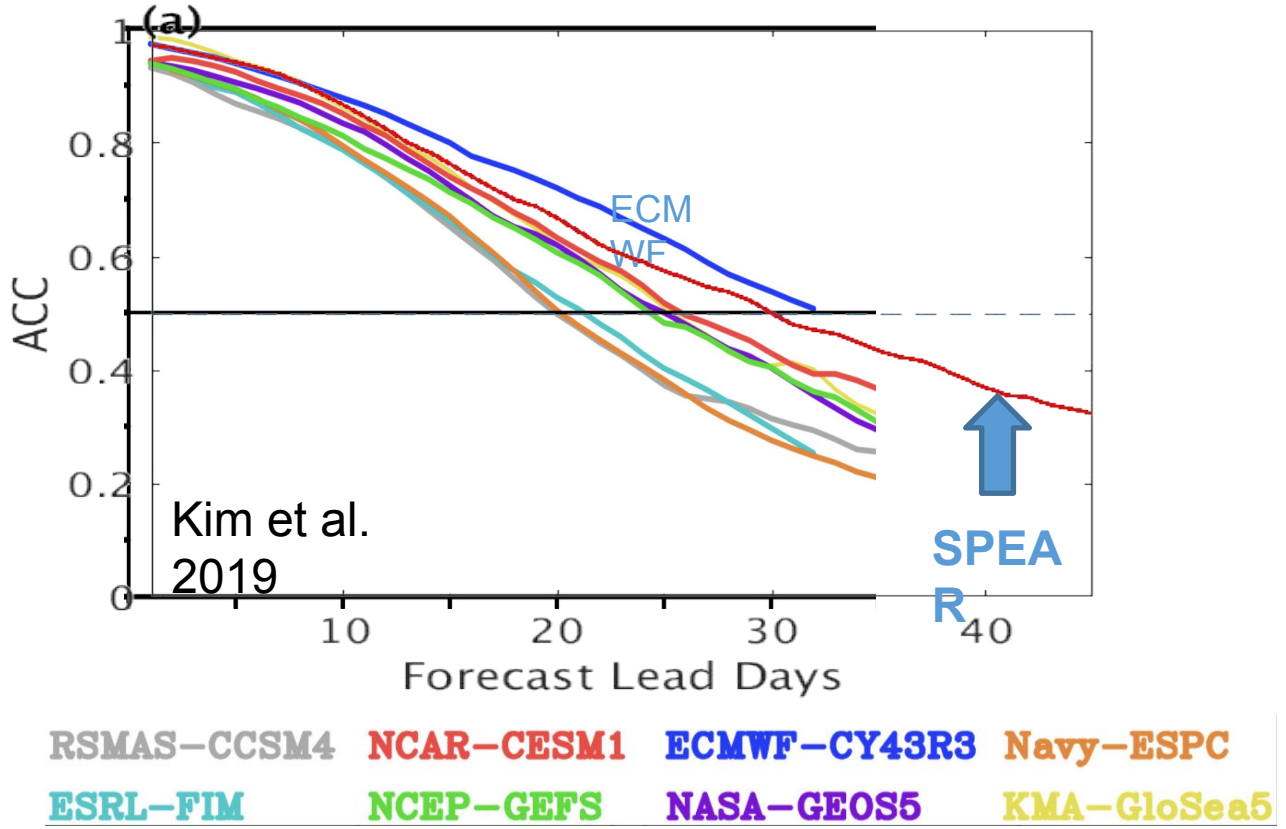


Initialization and experiments

atmospheric initialization	ocean initialization	period	cases	integration	ensemble
Nudging U, V, T, Q to MERRA2 (6 hour)	**Nudging SST to NOAA daily SST**	2000-2019	Every 5 day	45 day	10

Wintertime MJO prediction

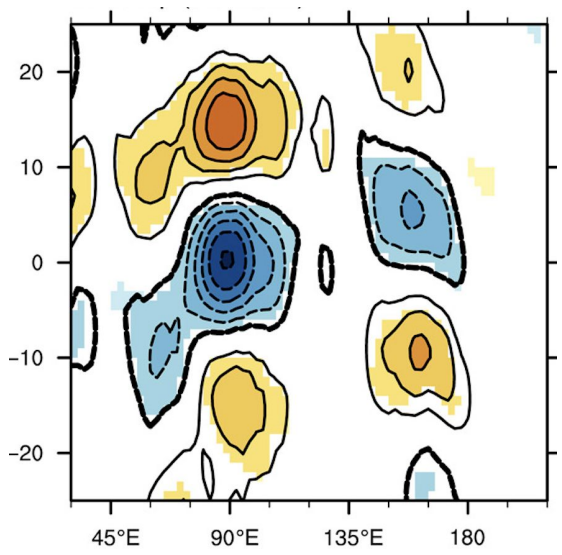
Wintertime MJO prediction (30 days)
(using Wheeler Hendon index)



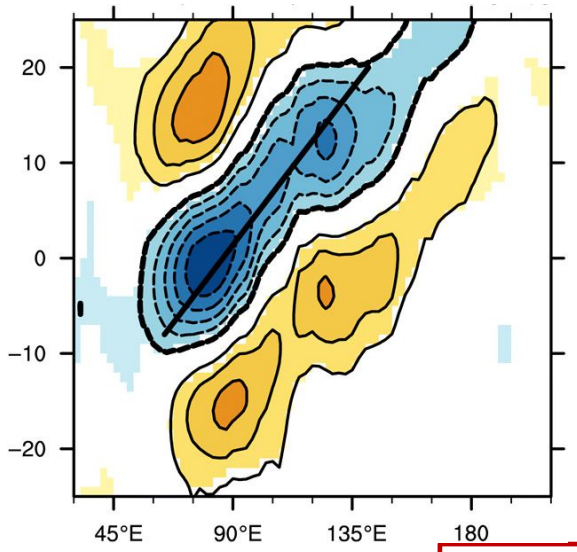
Xiang et al. 2021, BAMS

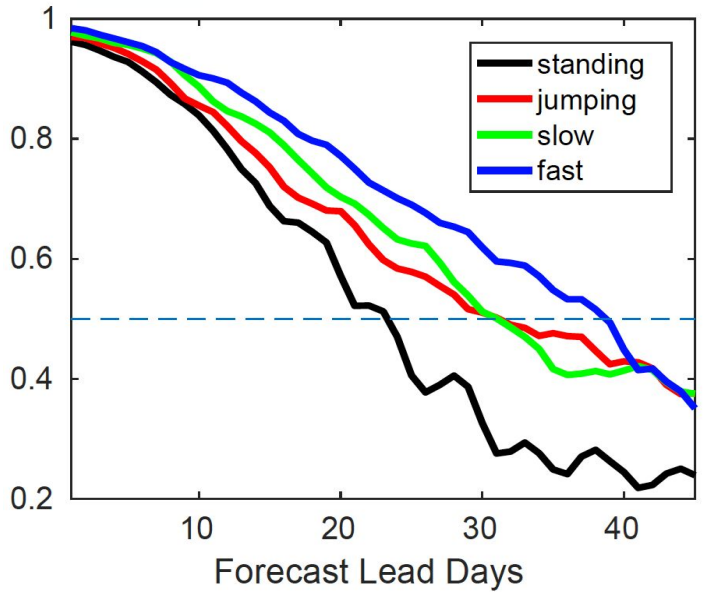
Skill-dependence on MJO diversity

Jumping:
31 days



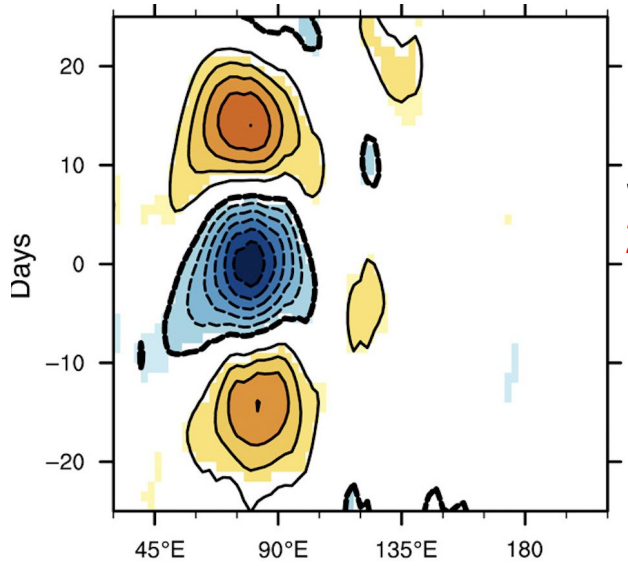
Slow:
31 days



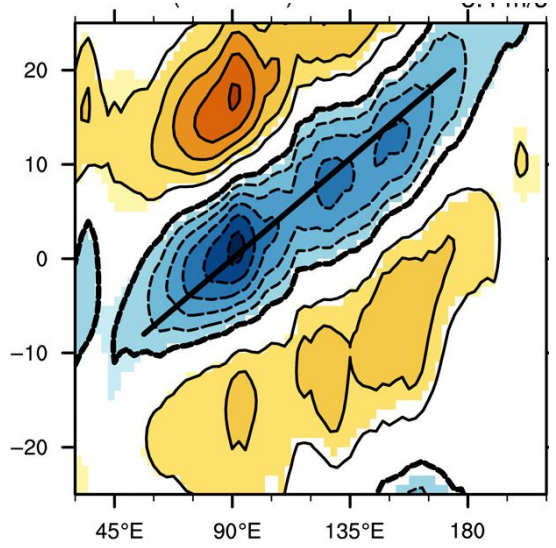


Xiang et al. 2021, BAMS
Wang et al. 2019, Science Advances

Standing:
23 days



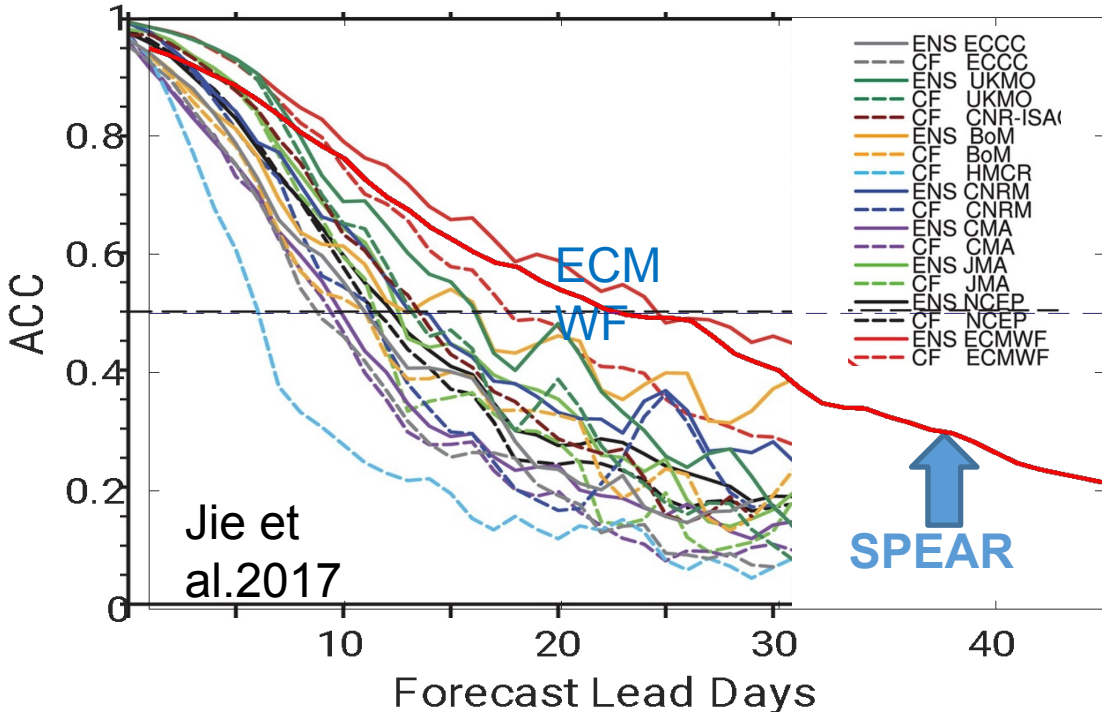
Fast:
38 days



MJO prediction skills depend on its propagation features

BSISO Predictions in GFDL SPEAR model

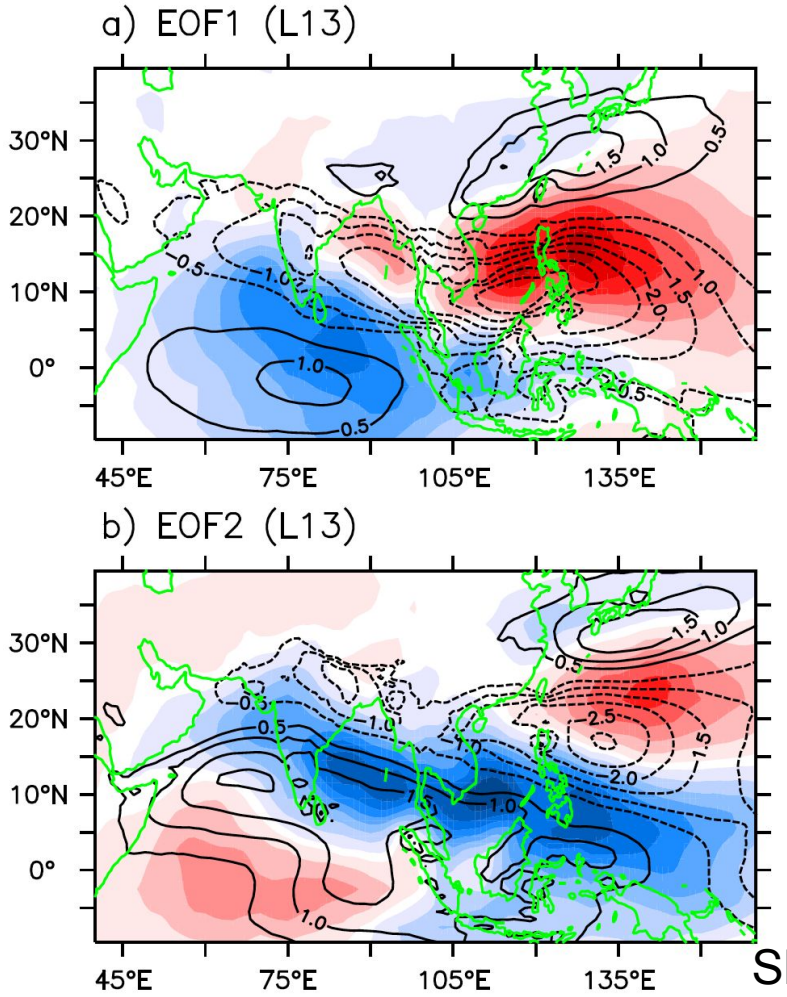
Summertime (May-October) BSISO prediction (22 days) **(using Lee et al. index)**



SPEAR is a top model in predicting BSISO

EOF1

EOF2

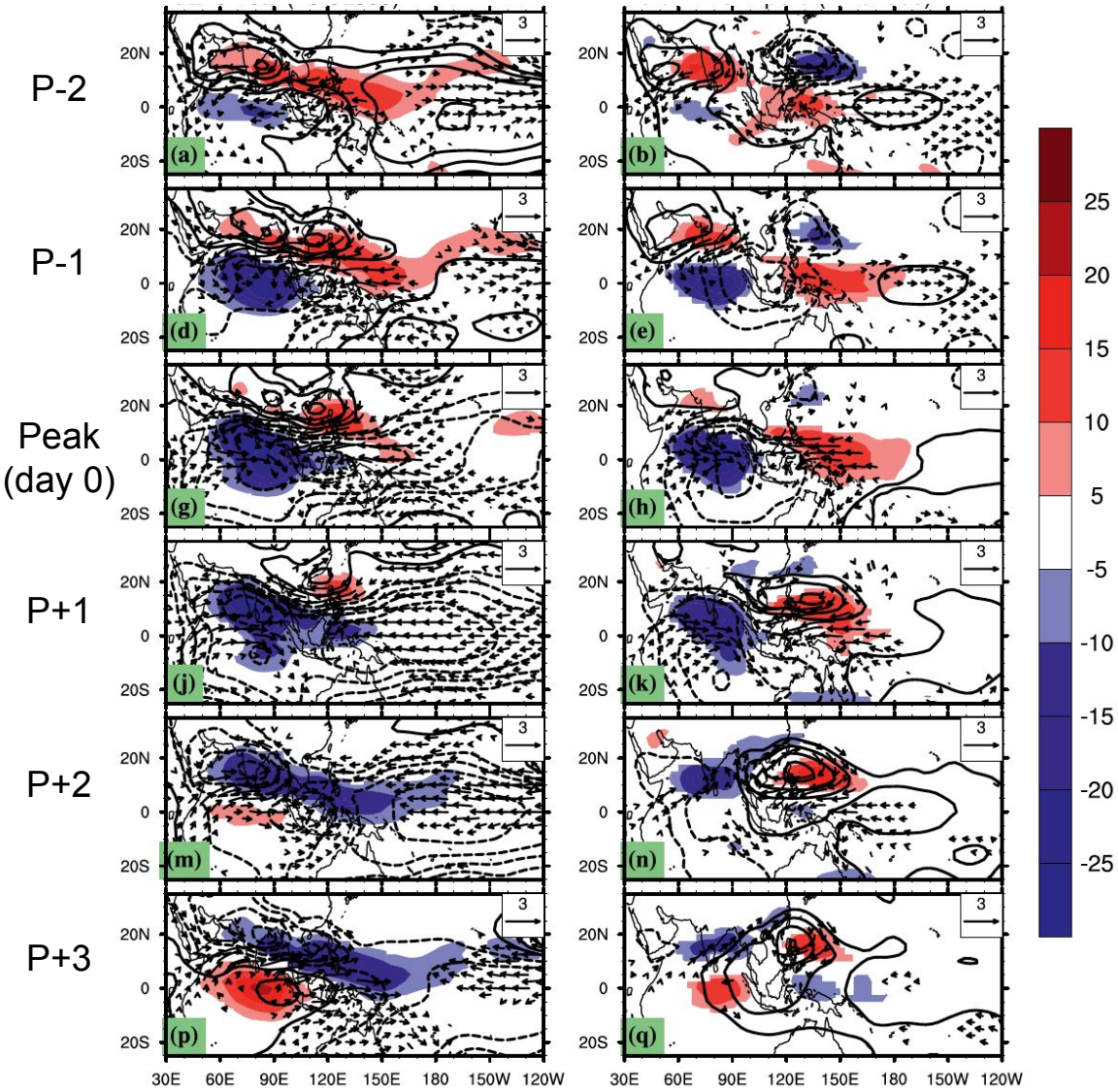


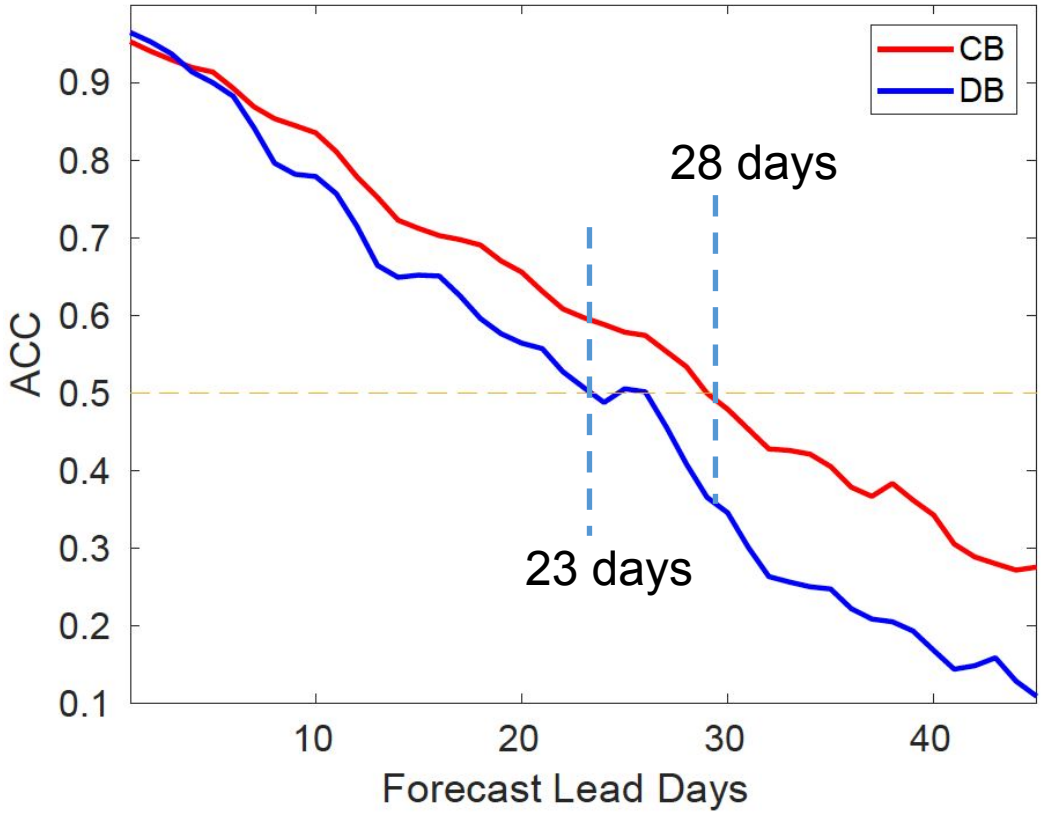
Shading: OLR;
Contours: U850

Lee et al. 2013

Skill-dependence on propagation patterns

Canonical BSISO (CB) Dipole BSISO (DB)



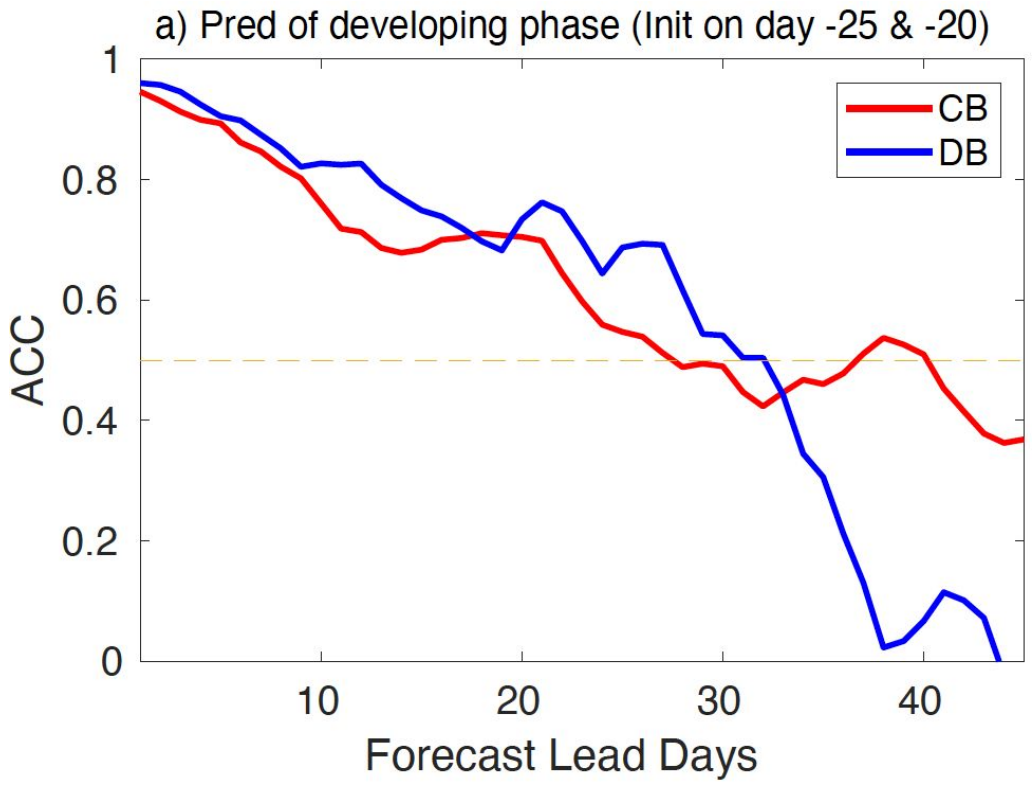


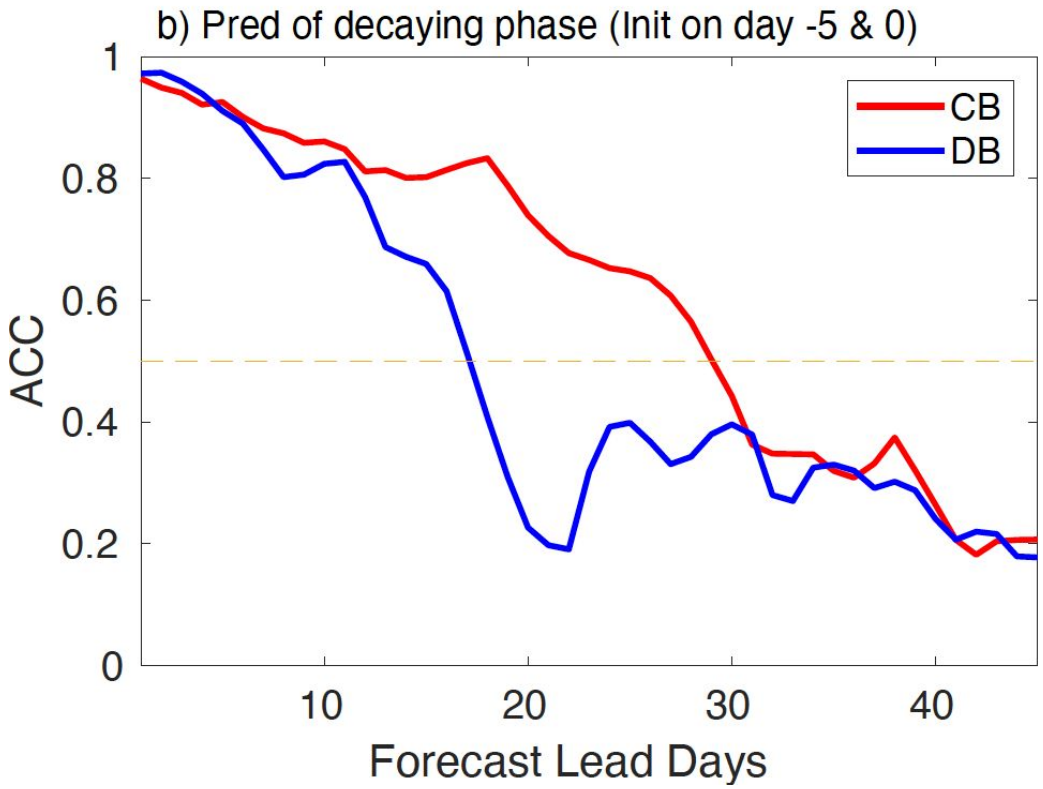
Canonical: 252 forecast experiments (29 events)
Dipole: 102 forecast experiments (11 events)
Each event has 8-9 forecast cases from day -30 to day +15

Canonical BSISO is more predictable than dipole BSISO

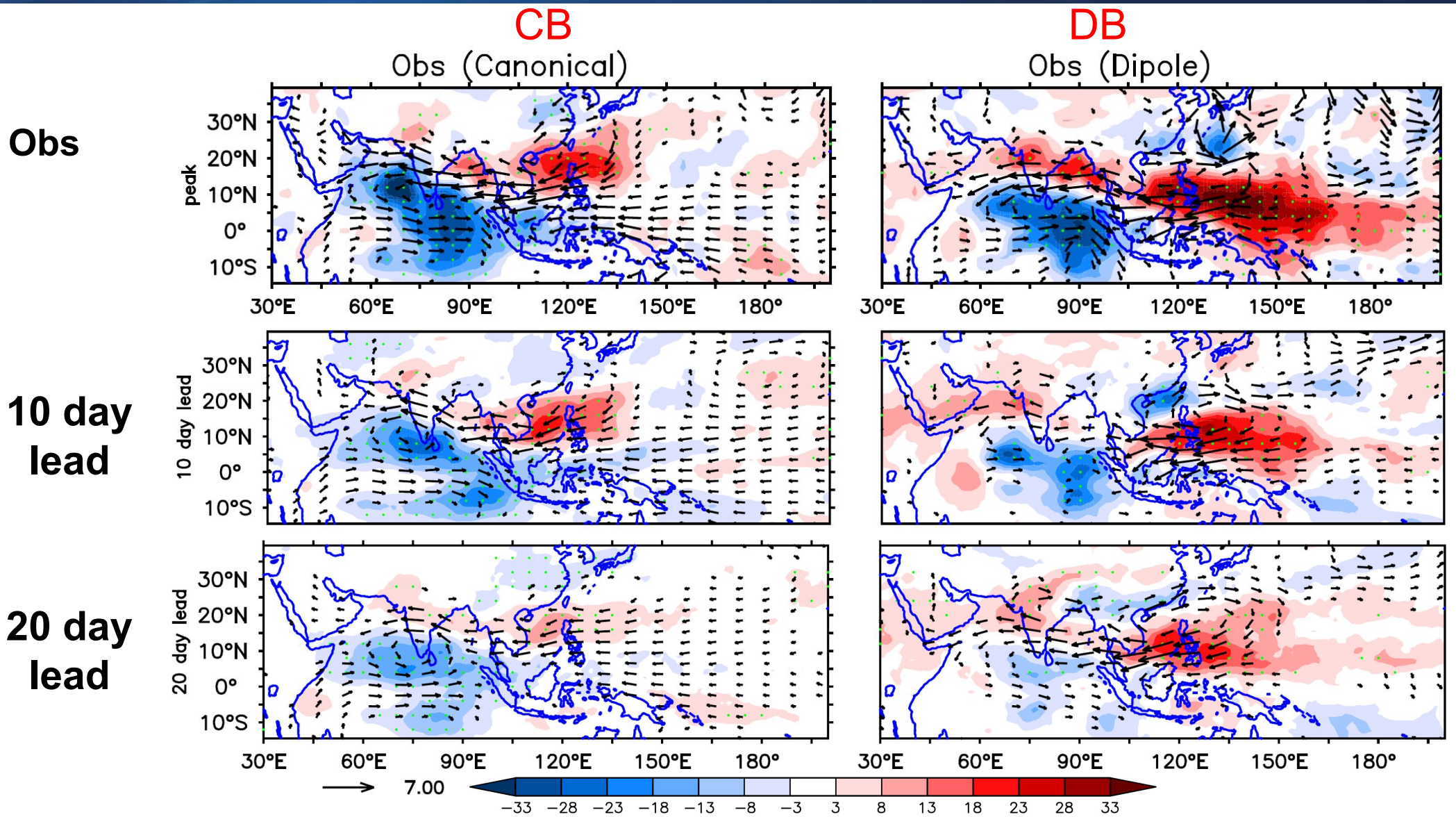
Chen and Wang 2021, JGR-Atmospheres Shading: OLR

Comparison of predictions btw developing & decaying phases



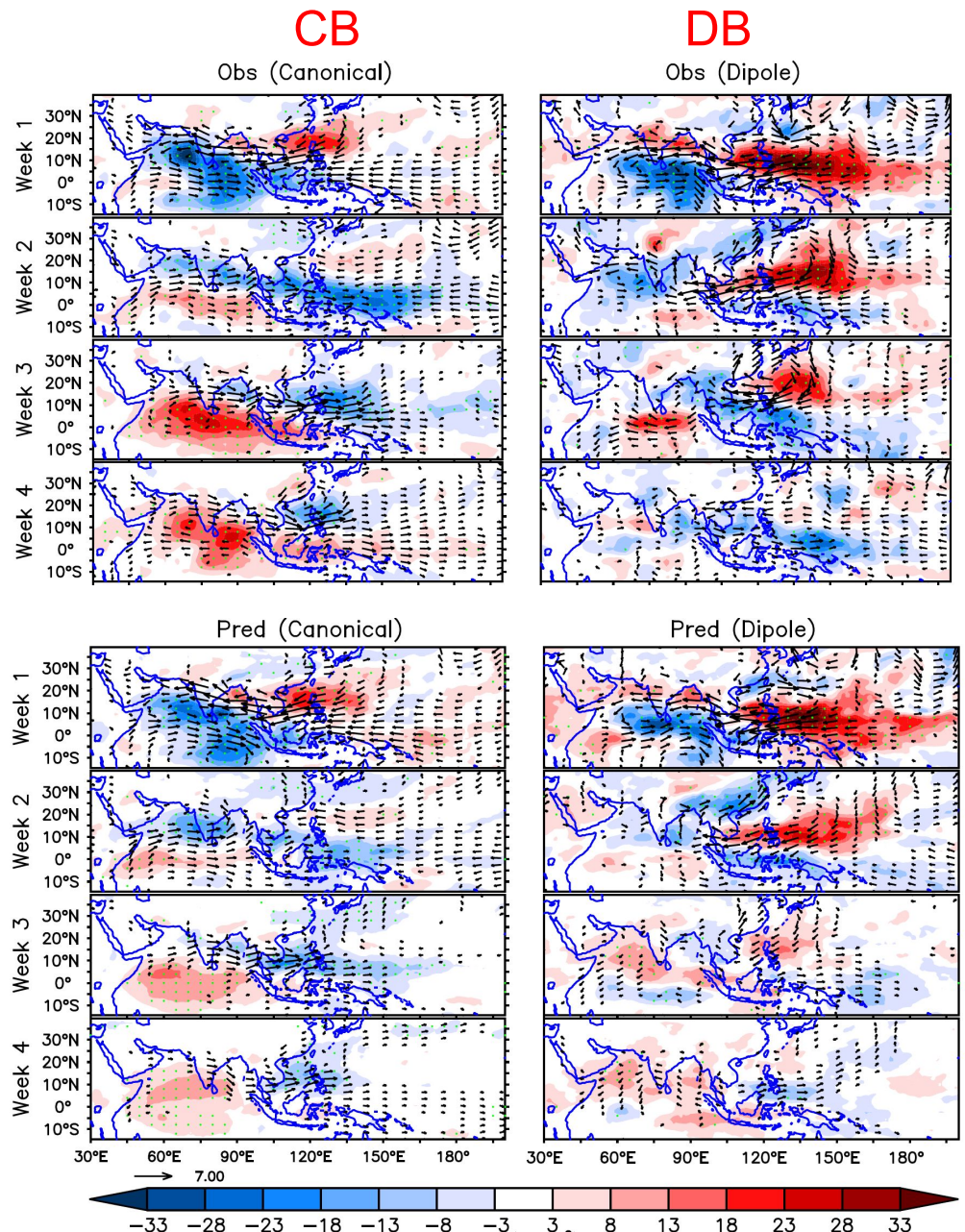


Prediction of the developing phases of BSISO



SPEAR can predict the peak phases 20 days in advance

Predicting the decaying phase of BSISO



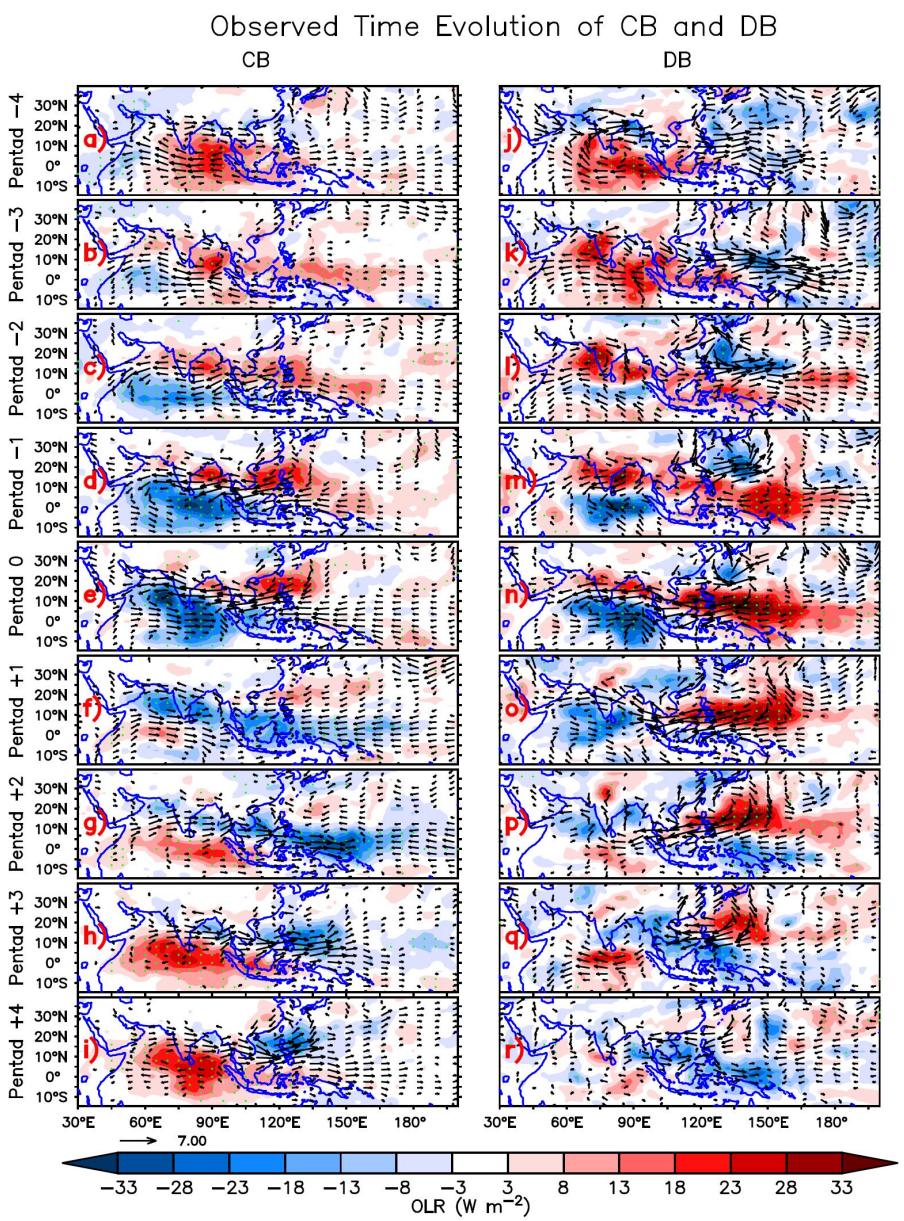
Obs

Pred

The lower prediction skill of the northward dipole BSISO is linked to its rapid decay

Observational difference between CB and DB

CB DB



From Pentad -4 to Pentad +4

Difference:

1) CB is more periodic with longer persistence

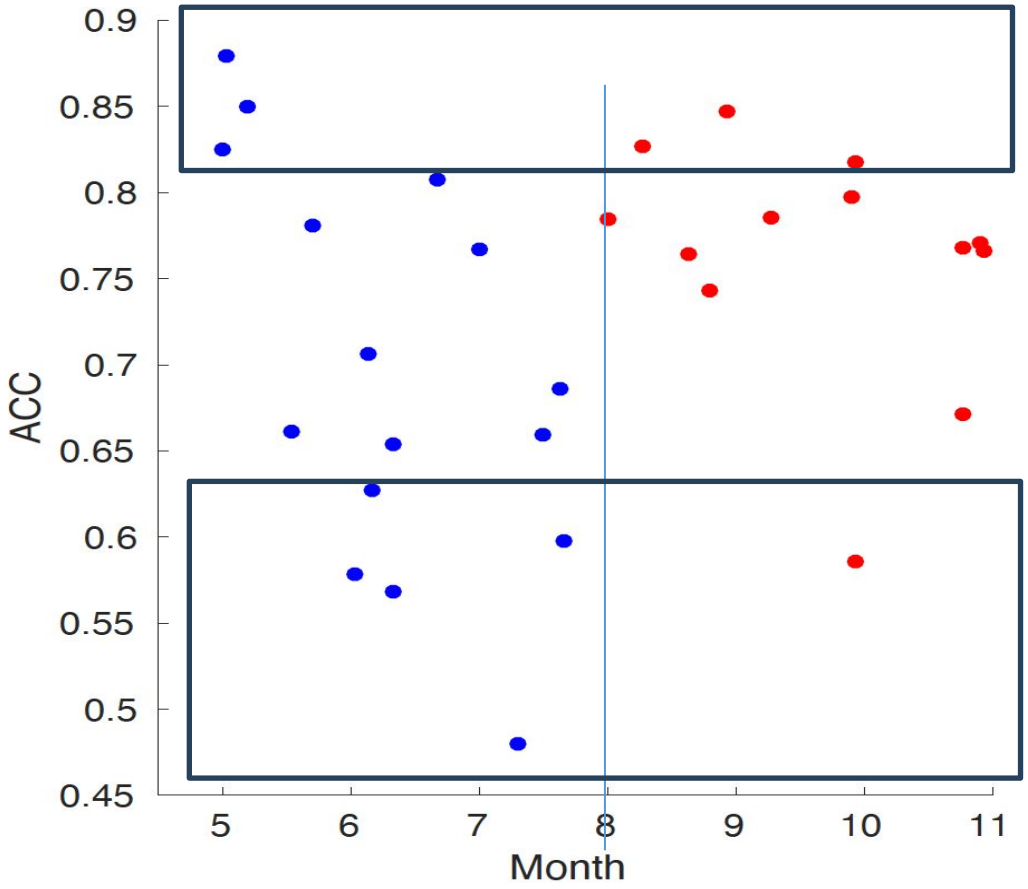
2) CB is more symmetric between the developing and decaying phases

3) CB is more balanced regarding the wet-dry intensity but DB has stronger dry anomalies

4) A precursory strong Kelvin wave component in the equatorial western Pacific signifies the subsequent development of a CB event

Impacts of seasonality on CB predictions

Skill (mean skill in the first 4 weeks) of 29 individual CB events



Good group

poor group

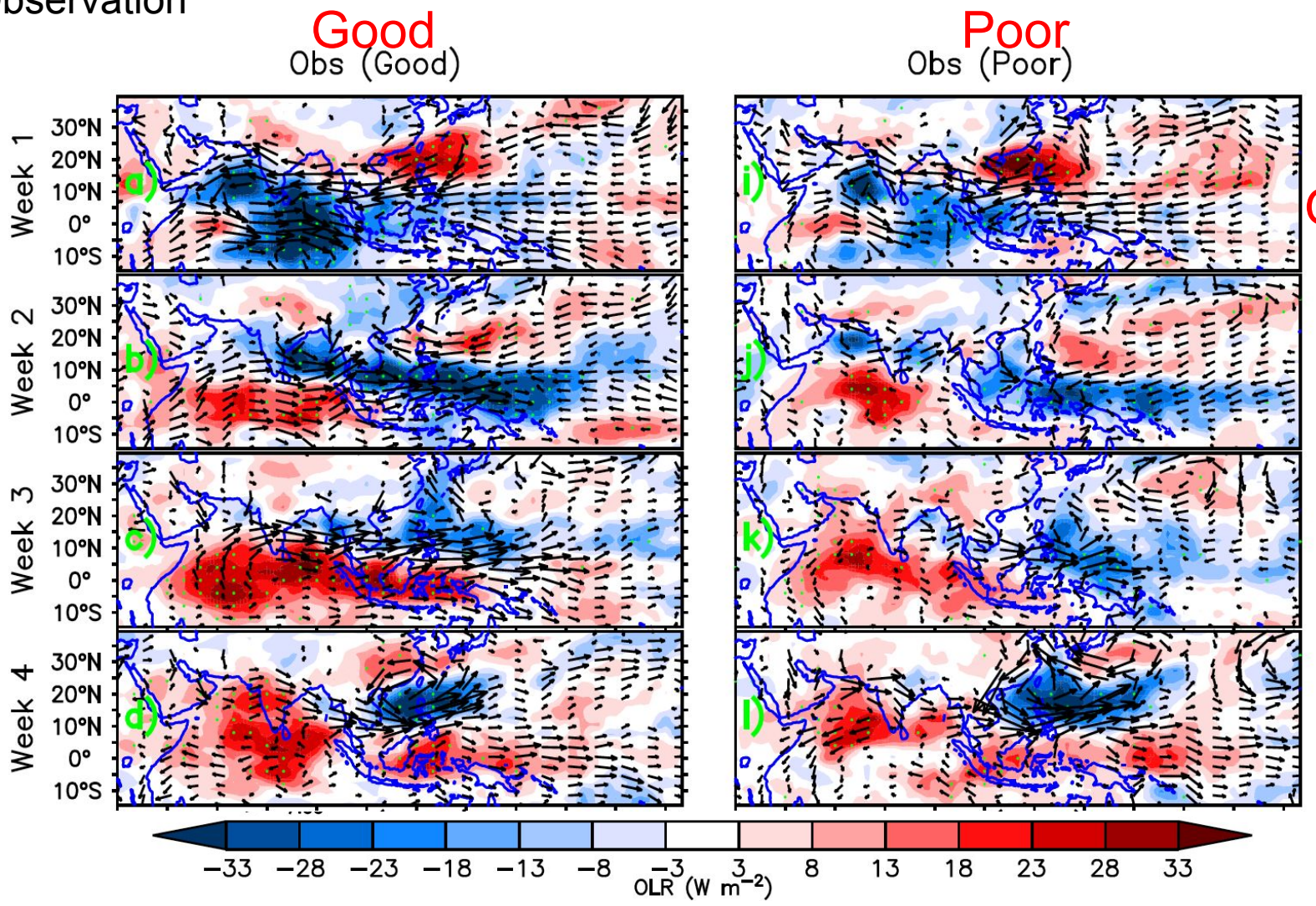
Blue: May-July

Red: August-October

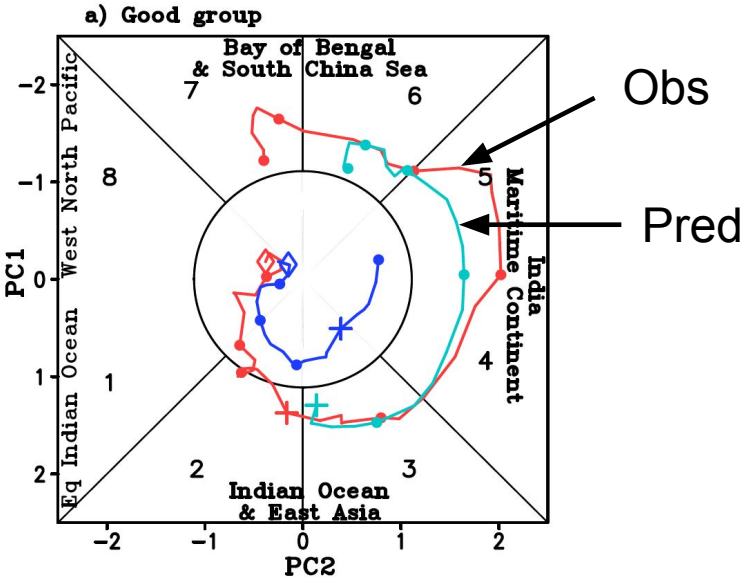
Higher skill and less scattered in ASO than MJJ

Comparison between Good and Poor Groups from Peak phases

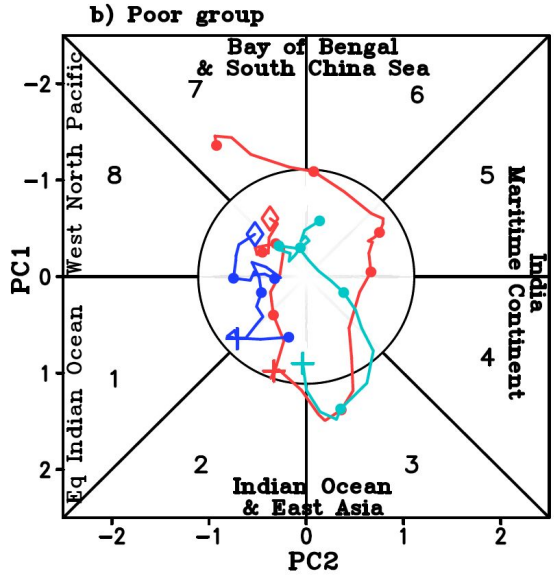
Observation



Good



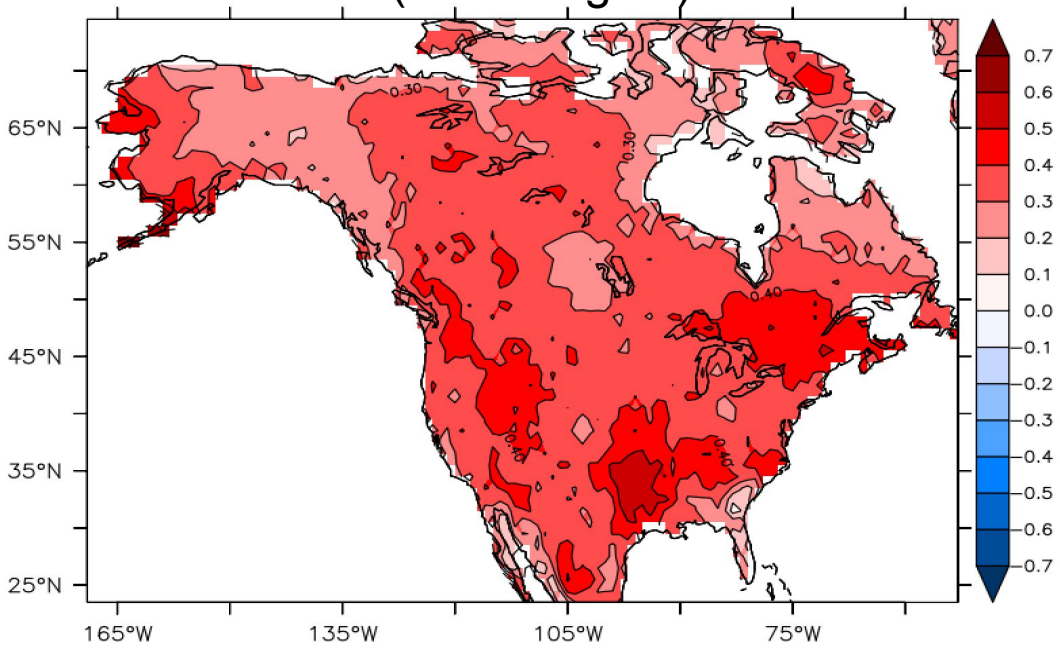
Poor



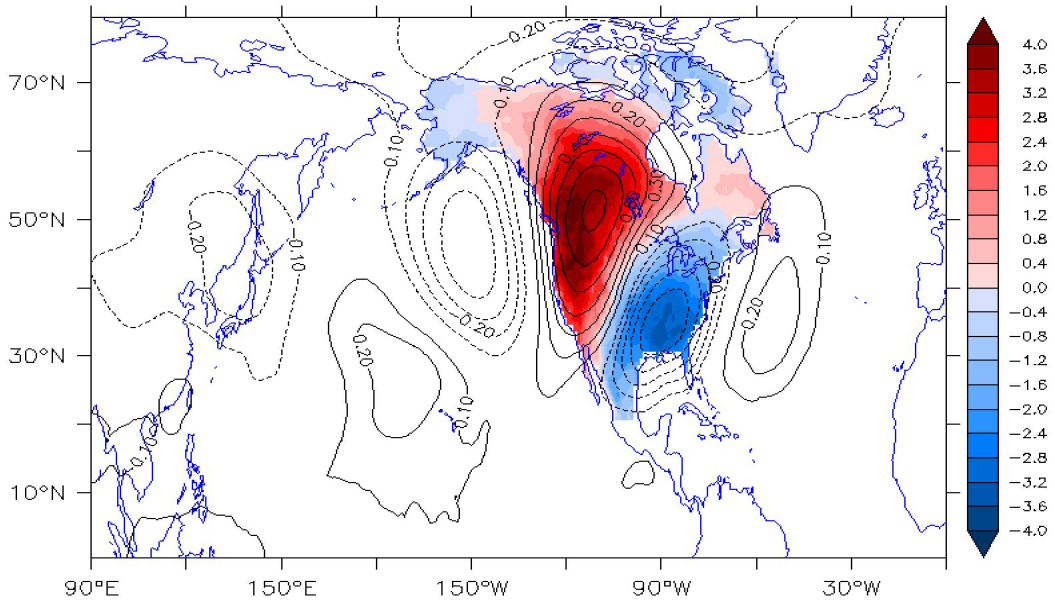
Magnitude, convection-circulation coupling strength(?)

Implication for heatwave prediction over North America

Correlation skill of week 2 extreme hot days (June-August)



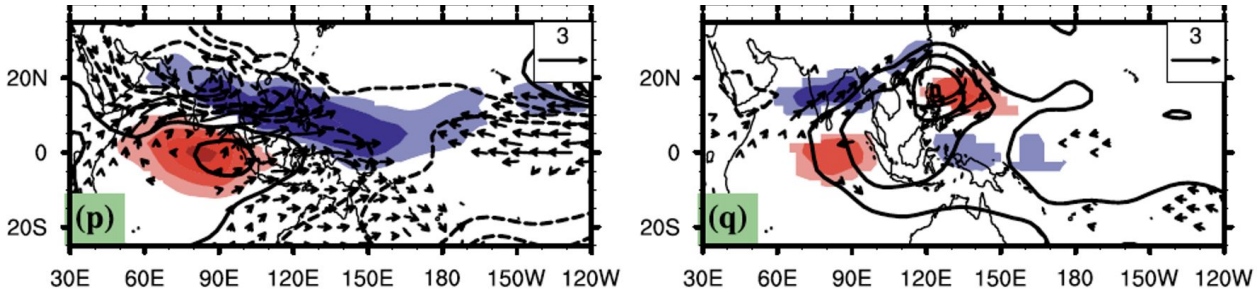
EOF1 mode of extreme hot days (shading) and its correlation with H500 (contours)



CB

DB

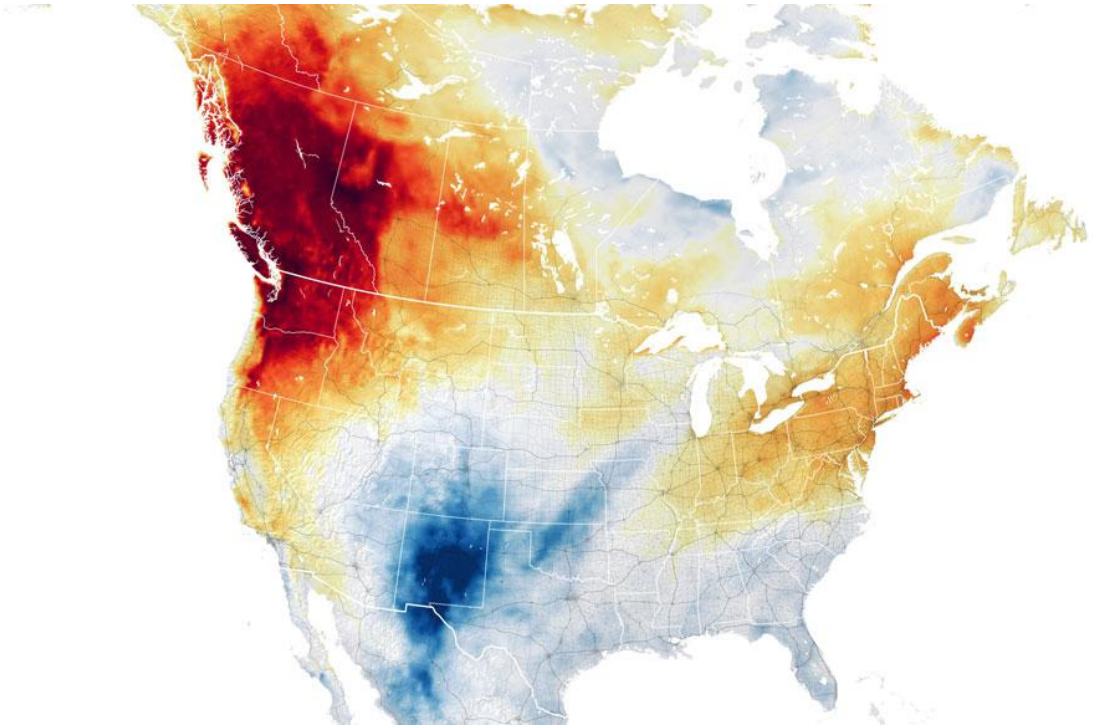
P+3

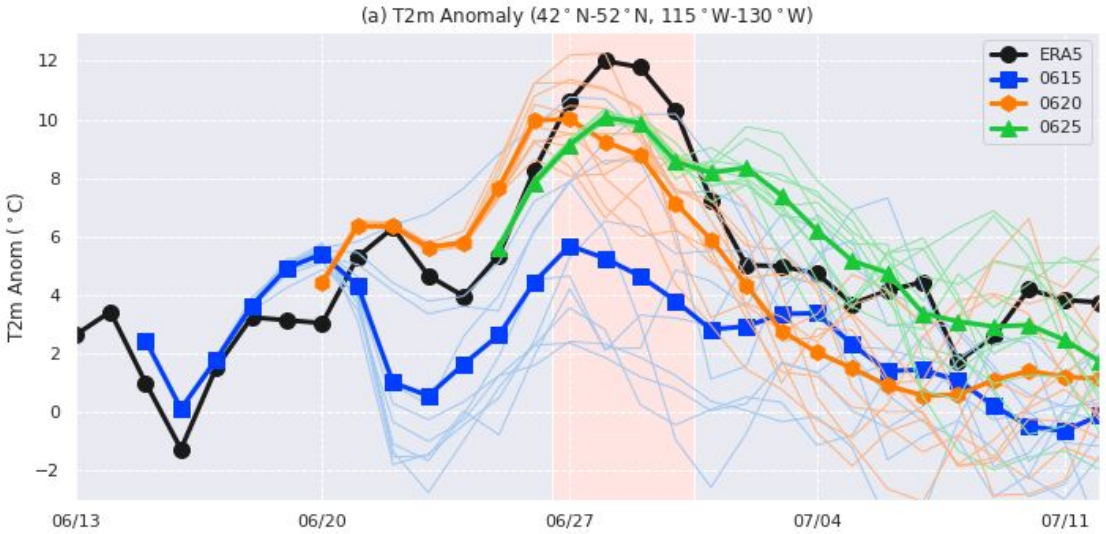


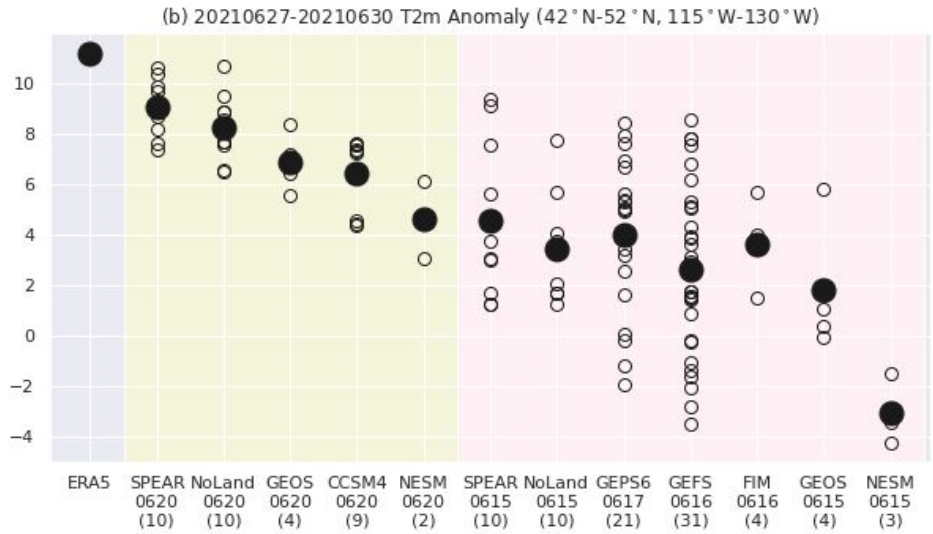
The higher prediction skill of CB provides an opportunity to forecast the NA heatwave on the subseasonal timescale

The importance of BSISO was also reported by Lin et al. 2022 & Lubis et al. 2024 AMS annual meeting……

Prediction of 2021 NA heatwave in SPEAR







One-week lead Two-week lead

Take-away message

- SPEAR is a decent model for predicting BSISO/MJO
- Prediction of CB has higher skill than DB (28 vs 23 days)
  because CB is more periodic with longer persistence, while DB is more episodic with a rapid demise after reaching the maximum enhanced convection over the equatorial Indian Ocean.
- A large spread of forecast skills among individual events
  Factors influencing predictions: **seasonality, amplitude, and the convection-circulation coupling.**
- Prediction of BSISO benefits the heatwave prediction in North America

References:
Xiang, B., et al., Prediction of Diverse Boreal Summer Intraseasonal Oscillation in GFDL SPEAR model. J. Climate, 2024.

Xiang, B. et al., S2S Prediction in GFDL SPEAR: MJO Diversity and Teleconnections. BAMS, 2021