Exceptional Multi-Year Prediction Skill of the Kuroshio Extension in the High-Resolution CESM Prediction System

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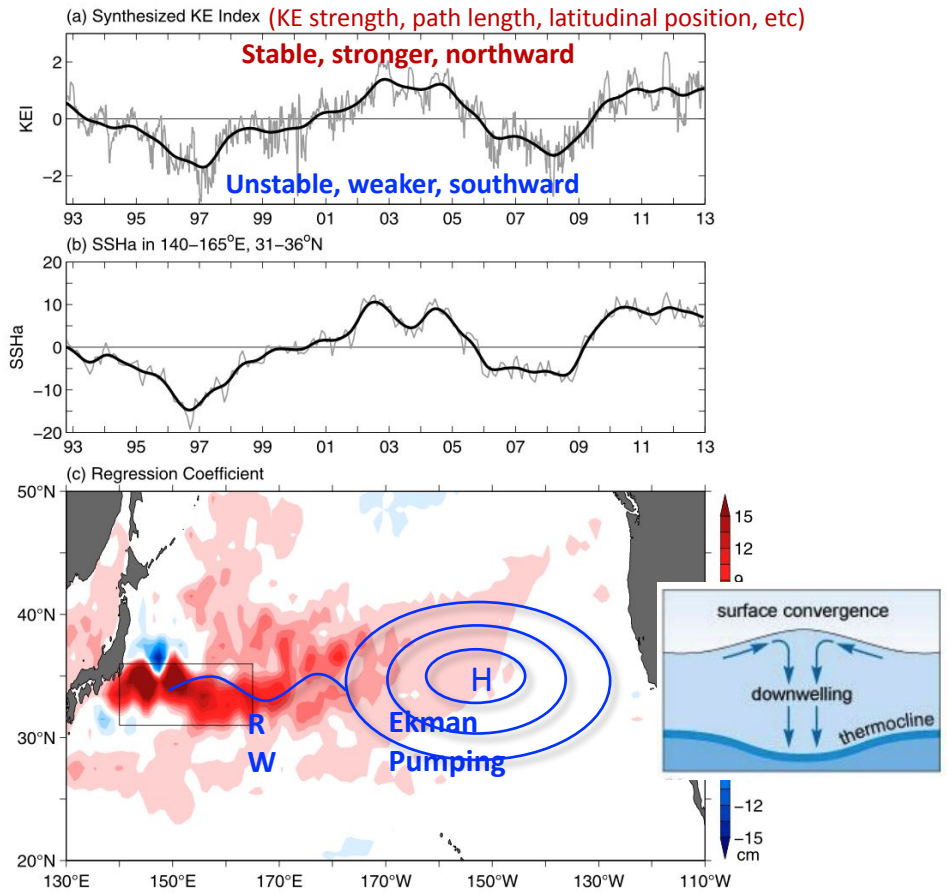
Take-Home Message

- **Exceptionally high skill (ACC ≥ 0.7 up to LY4)** in predicting the decadal Kuroshio Extension (KE) variability in the CESM decadal prediction system at an **eddy-resolving ocean resolution** (HRDP)
- **Substantially higher than** skill in the **low-resolution** counterpart (DPLE with 1º ocean)
- **Source of skill in HRDP**: westward (Rossby wave; RW) propagation of initialized ocean state, guided by the sharp KE front
- The westward propagation is not clear in low-res simulations
- Manuscript in revision (*npj Climate and Atmos. Sci.,* preprint available at https://doi.org/10.21203/rs.3.rs-2402942/v1)

Decadal KE Variability and Predictability

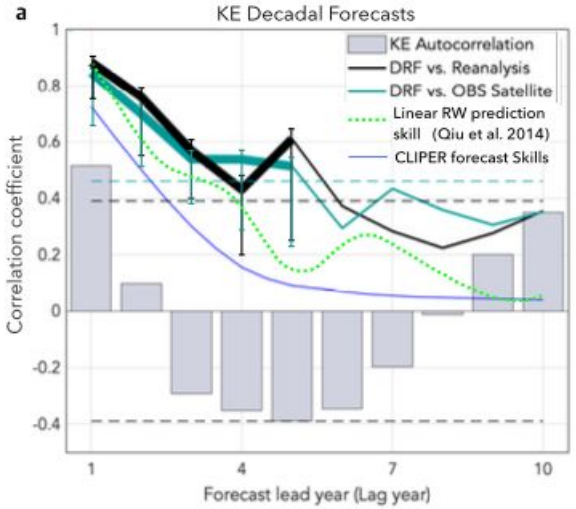
Decadal Variability

Satellite Altimeter Data (Qiu et al. 2014)



Predictiability

Joh et al. (2014)

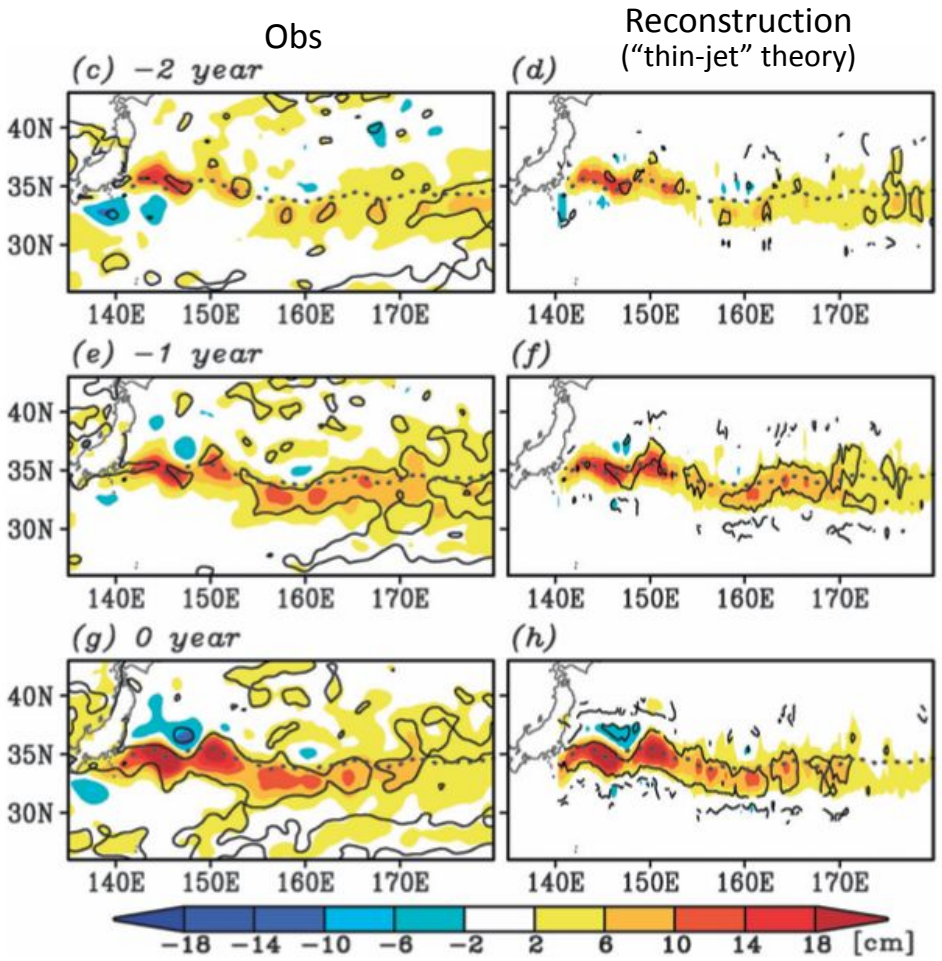


- ✔ Linear vorticity equation (Qiu et al. 2014; green dashed line)
- ✔ GFDL SPHERE (1º ocean; black and dark green lines)
- ✔ Skillful prediction ~ 4 years ahead
- ✔ **Source of skill**: RW propagation
- ✔ Do not consider fronts or eddies

Higher Skill at an Eddy-Resolving Resolution?

- KE: sharp fronts and active eddy activity
- KE front wave guide for the RW propagation (Sasaki et al. 2013)
  - Meridionally large initial signal converging into the KE front

SSH regression on KE index (Sasaki et al. 2013)

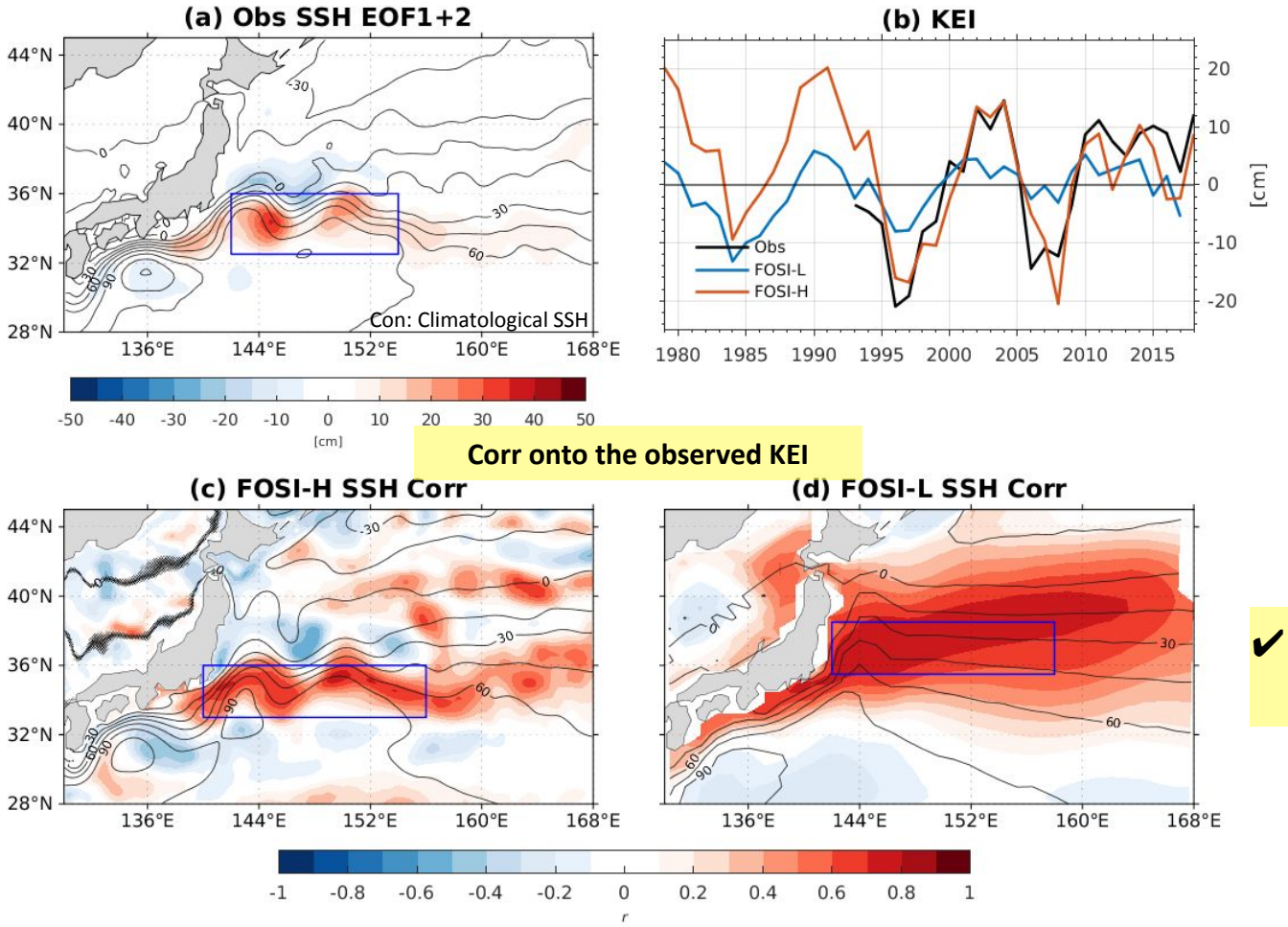


Prediction Systems

		HRDP	DPLE
Model		CESM1.3 Ocn, Ice - **0.1°** Atm, Lnd – **0.25°**	CESM1.1 nominal **1°**
Initialization	Ocn/Ice	**FOSI-H (0.1°)**† Forc: JRA55-do	**FOSI-L (1°)**† Forc: COREII
	Atm	JRA55 Reanalysis	CESM-LE
	Lnd	HighResMIP Tier 1	CESM-LE
Hindcasts	Start Years (Nov. 1st)	**Every second year** for **1982-2016***	Every year for 1954-2017
	Run Length	**5 years** (62 months)*	10 years (122 months)
	Ens. Size	10	40
Reference		Yeager et al., in revision	Yeager et al. (2018)

† Used for analysis
* Analysis restricted by shorter and less frequent HRDP

KE Index (KEI)

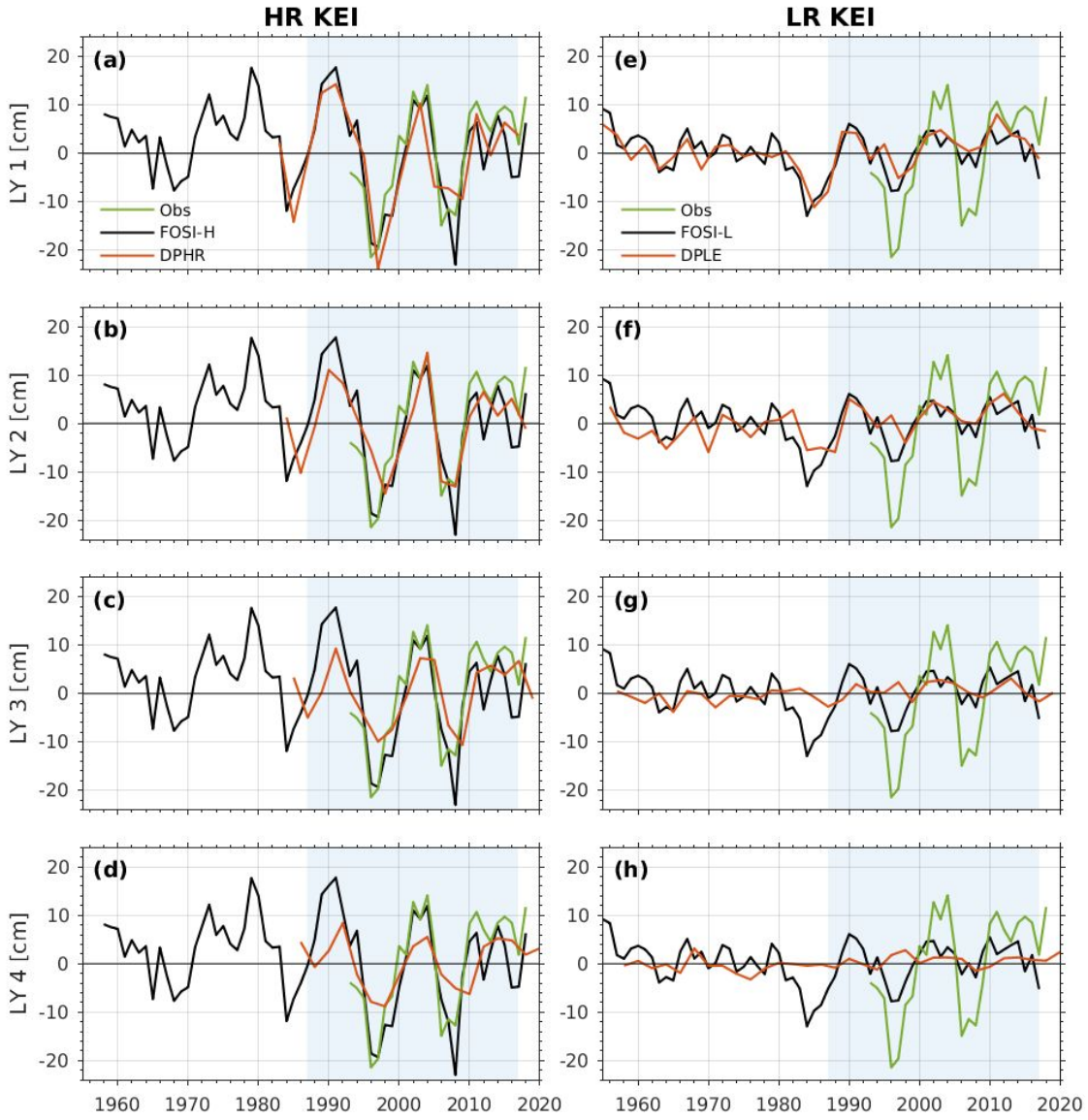


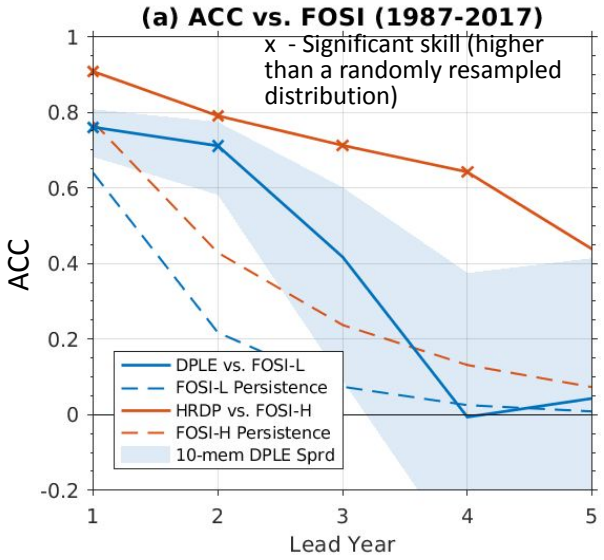
✔ Substantially weaker amplitude in FOSI-L

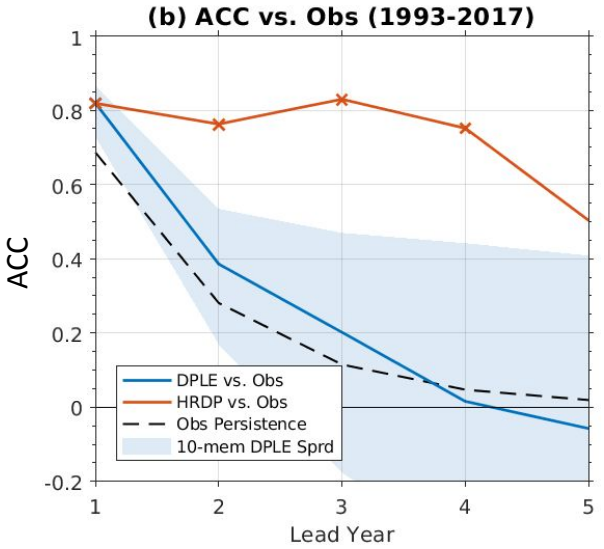
✔ KE biased northward in FOSI-L

☐ **Different KE boxes**

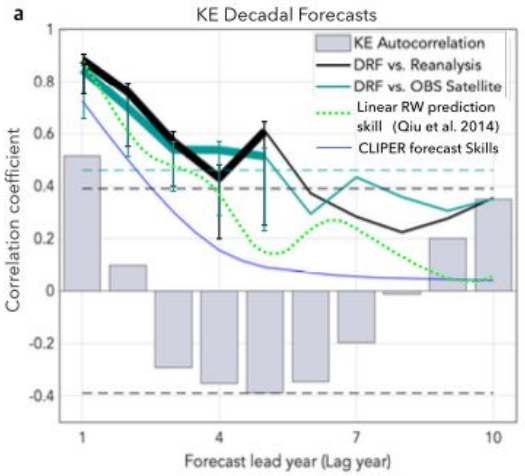
Exceptional KE prediction Skill





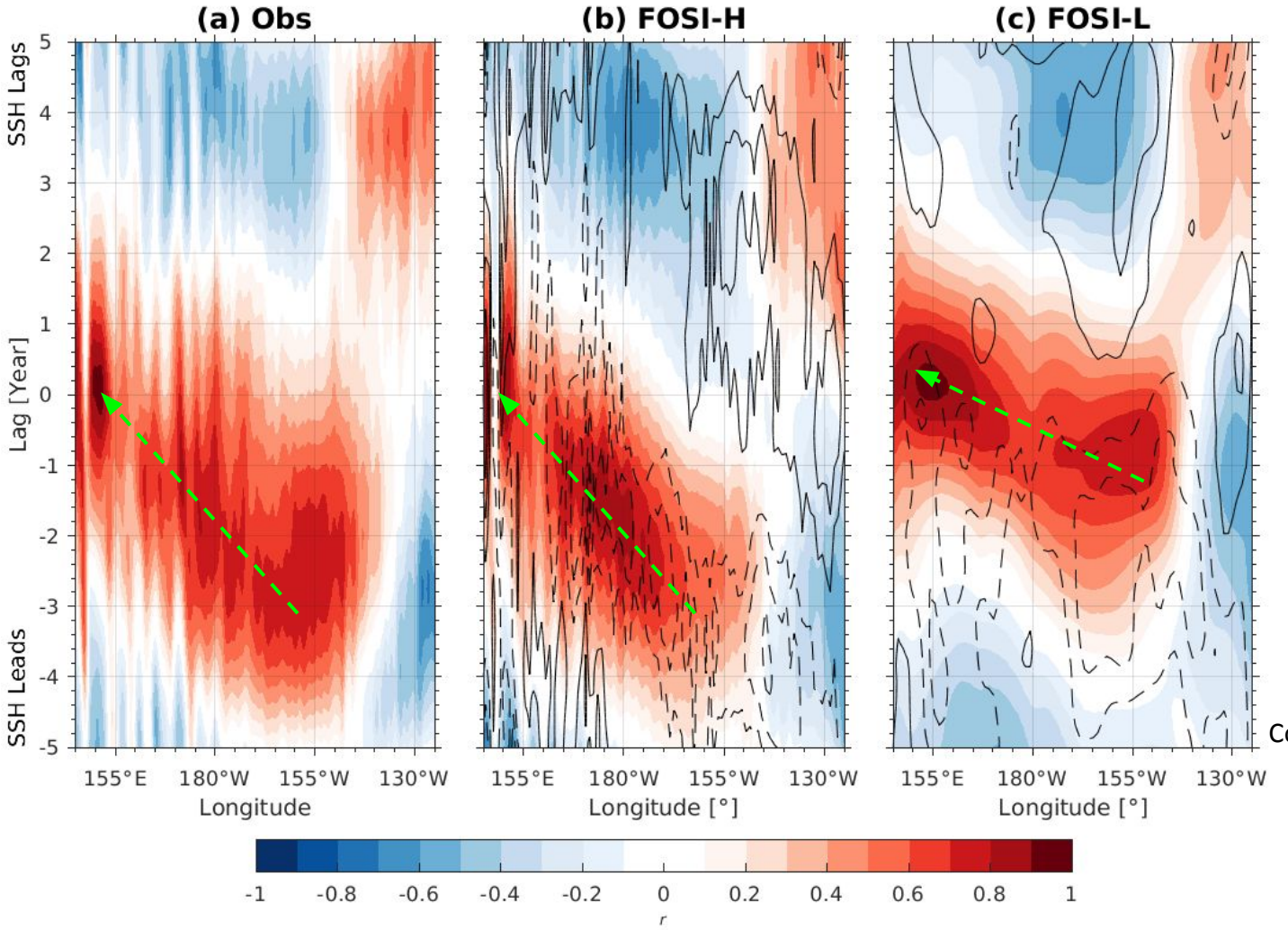


GFDL SPHERE (Joh et al. 2022)



Source of Skill

KE latitude SSH Correlation with KEI as a Function of Longitude and Lag

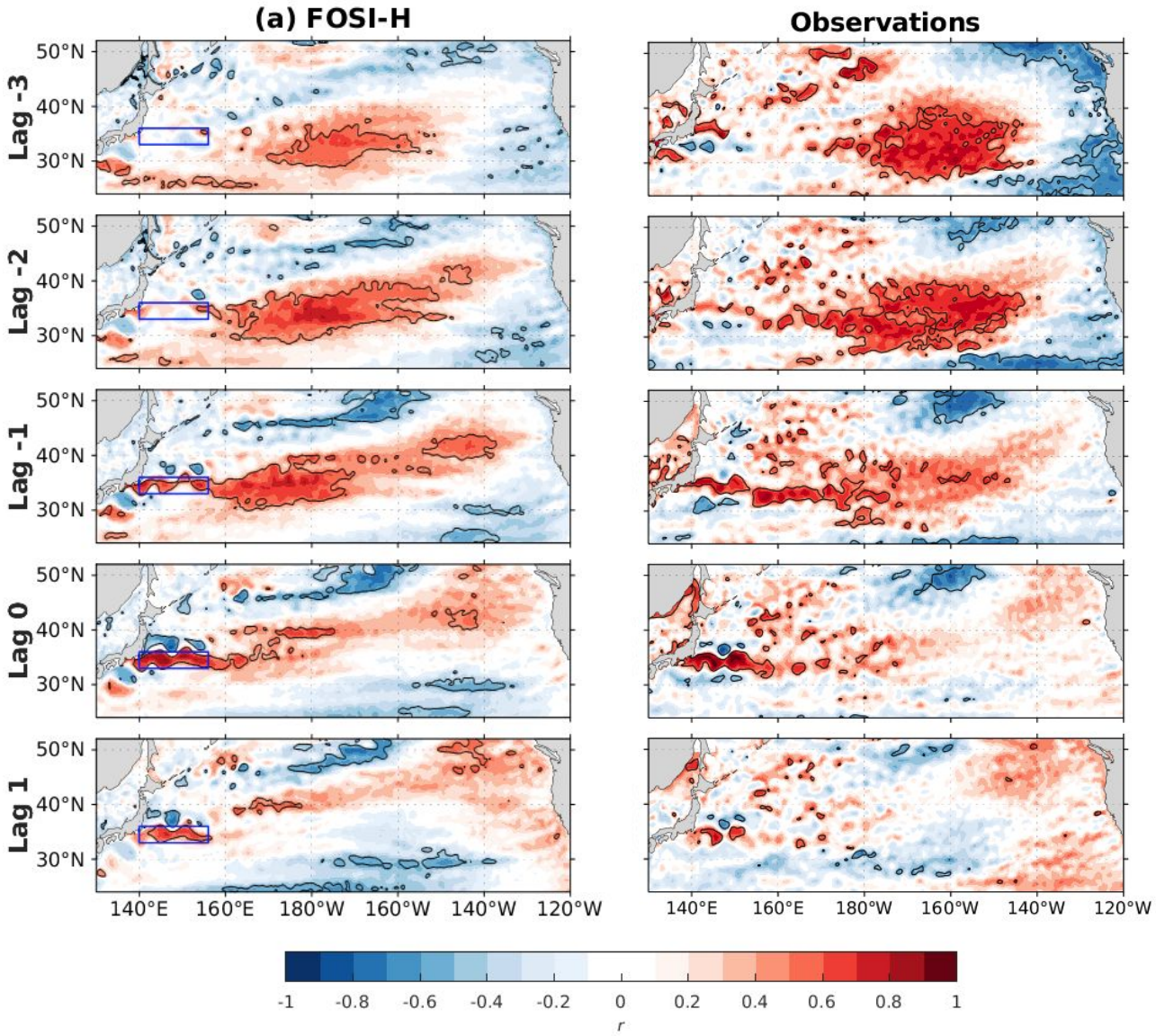


- FOSI-H: Westward propagation consistent with obs (~3-4 yrs)
- FOSI-L: Too fast (~1 yr) to be considered as a RW propagation
- WSC anom in FOSI-H propagating westward in tandem with SSH anom (coupled interaction?)

Con: WSC regression

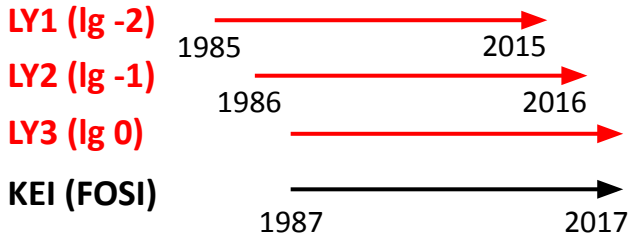
Source of Skill

SSH Correlation on FOSI-H KEI



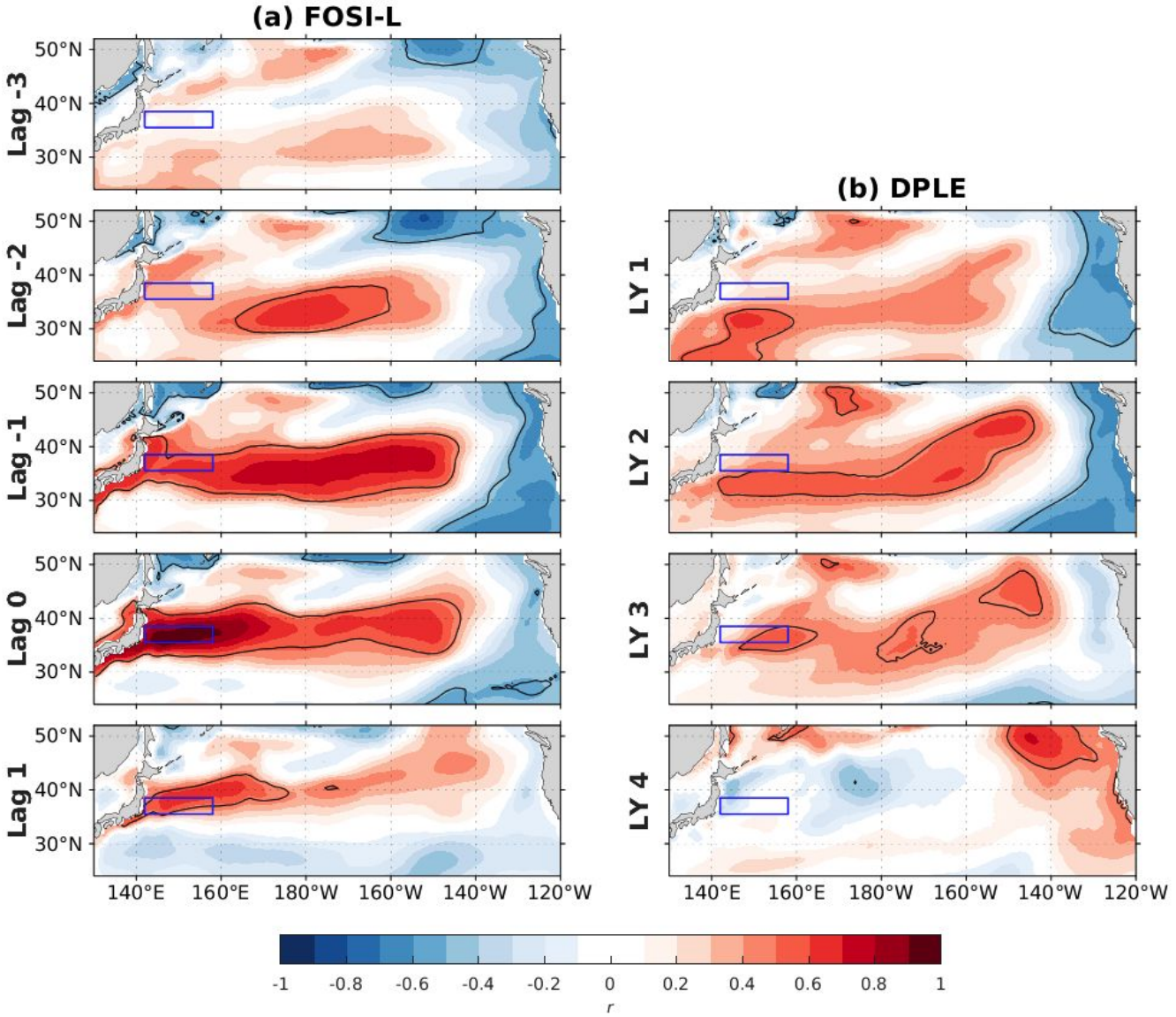
✔ SSH anomaly **converging into the KE front** while propagating westward, consistent with Sasaki et al. (2013)

Lagged Regression across LY in HRDP

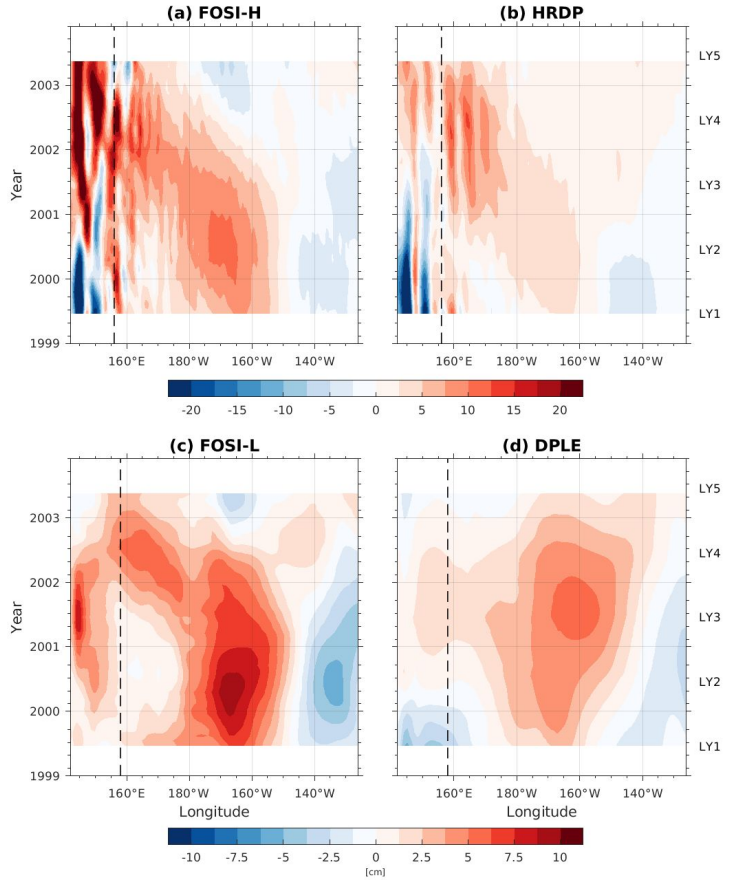


Source of Skill

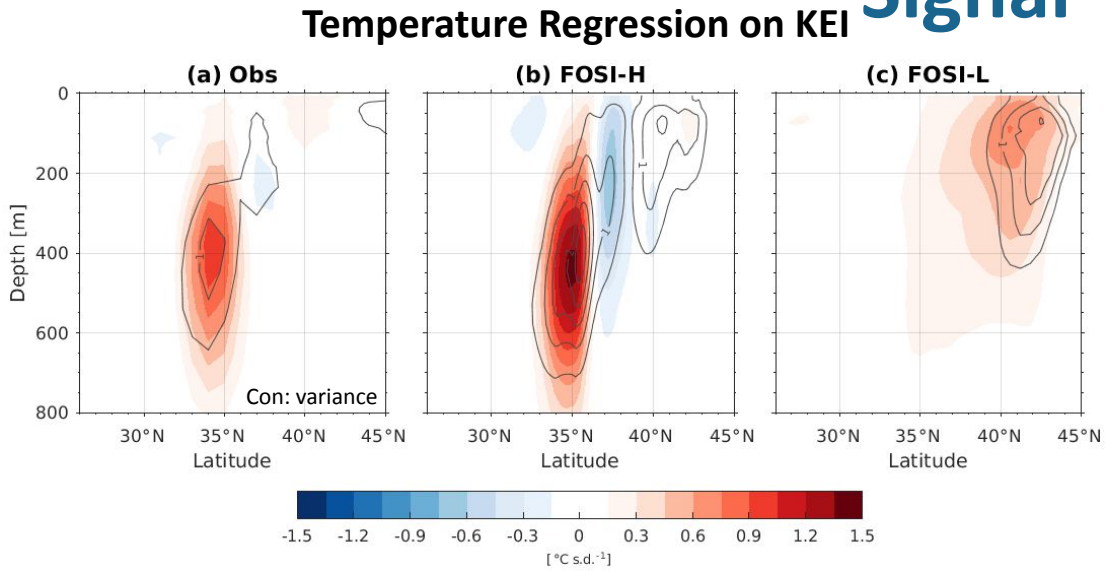
SSH Correlation on FOSI-H KEI

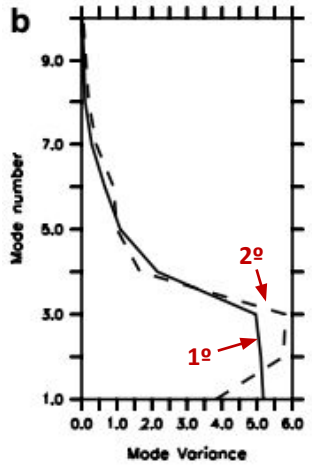


- ✔ Westward propagation is not clear
- ✔ No convergence of SSH anomalies

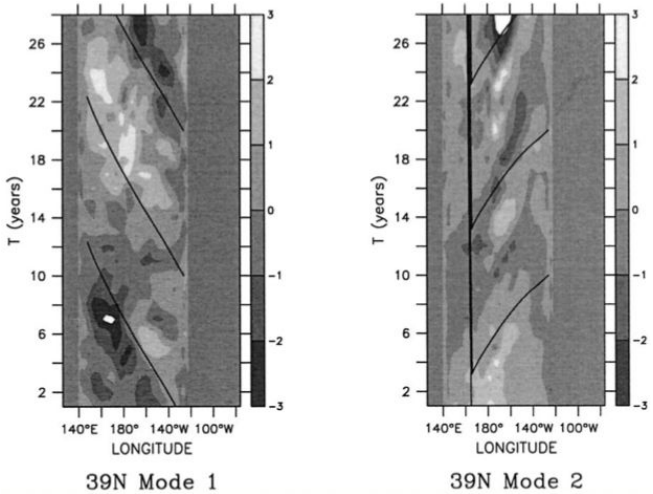


Possible Reasons for the Weak RW Propagation Signal

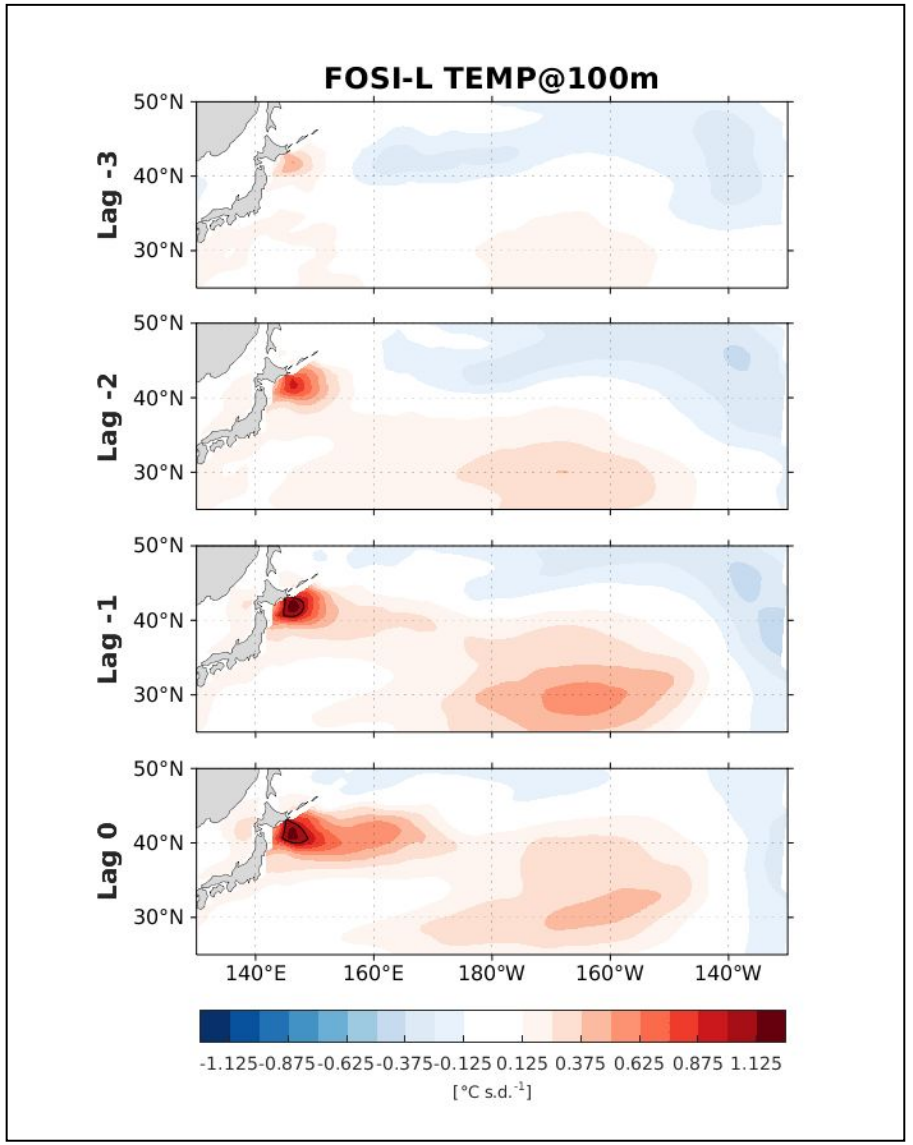




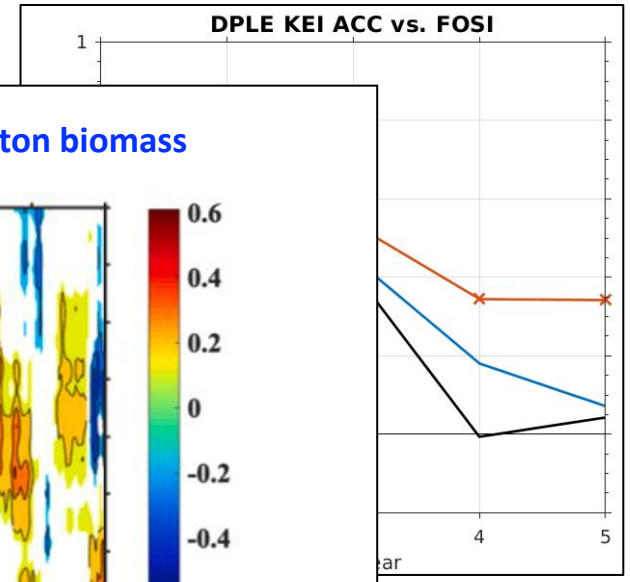
Thompson & Dawe (2007)



Thompson & Ladd (2004)

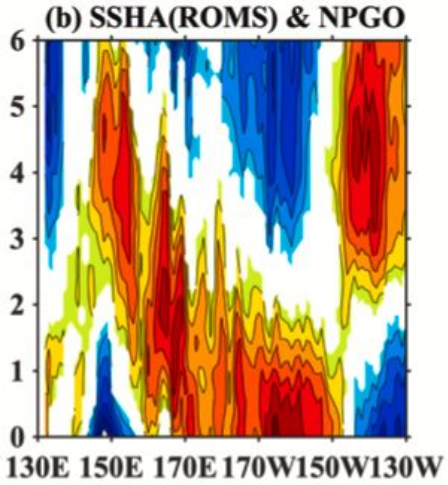


Summary and Discussion

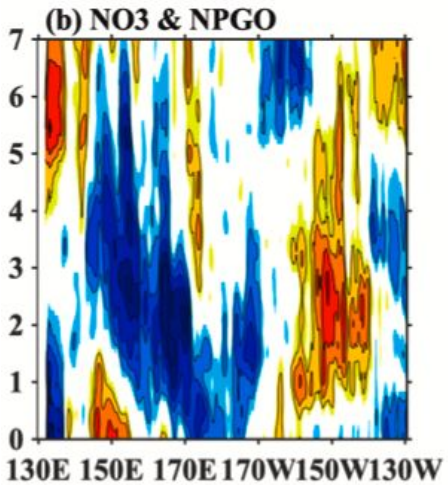


Forced 1/8° ROMS with BGC

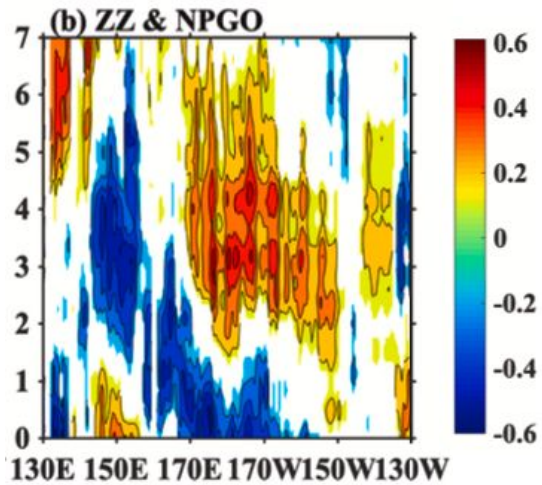
SSH



Nitrate (200m)



Upper 100m zooplankton biomass

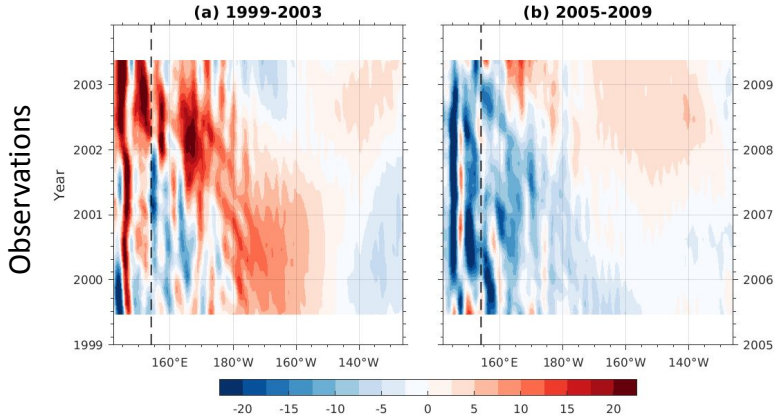


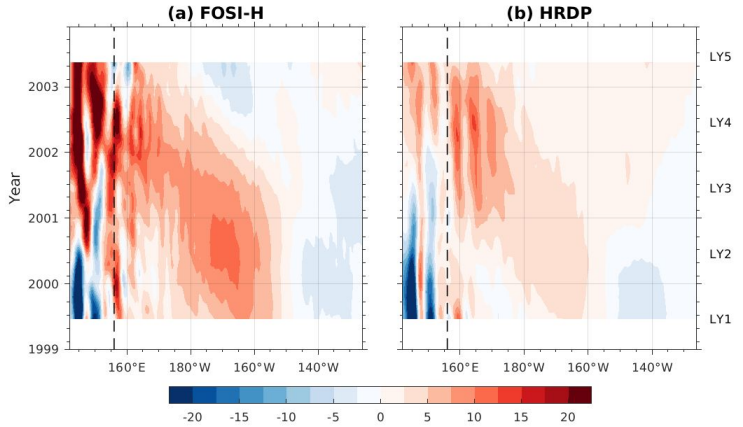
Lin et al. (2020)

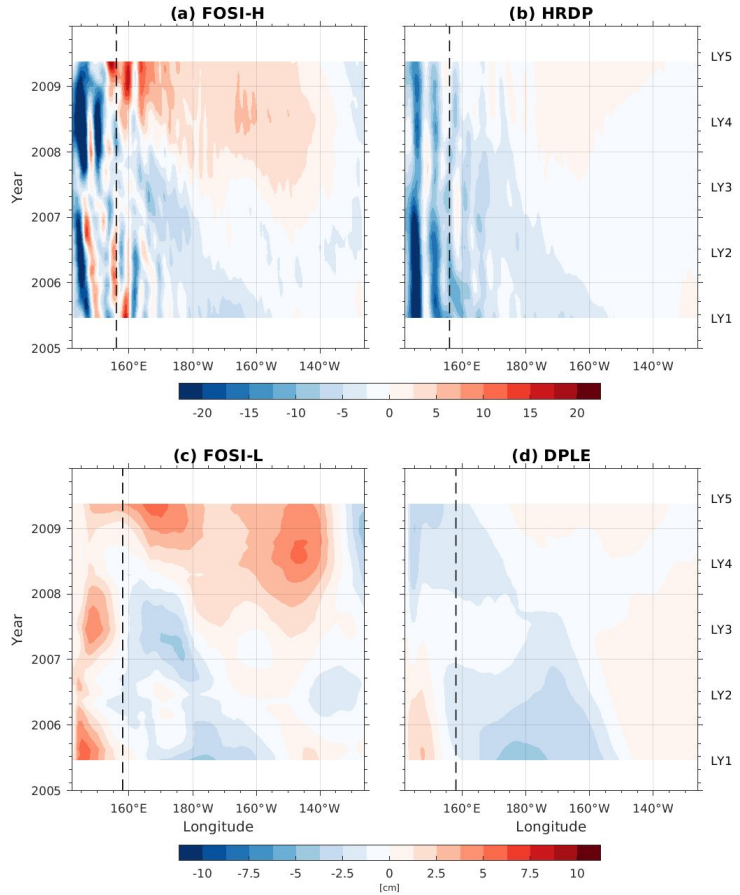
- **Skillful multi-year prediction of biological fields in the upstream KE is expected with HR prediction systems**
- Manuscript in revision (*npj Climate and Atmos. Sci.,* preprint available at https://doi.org/10.21203/rs.3.rs-2402942/v1)

Extra #1

SSH anomalies as a function of time and longitude, tracking the propagation of SSH anomalies for +KE event for 2002-2003 and –KE event for 2008-2009







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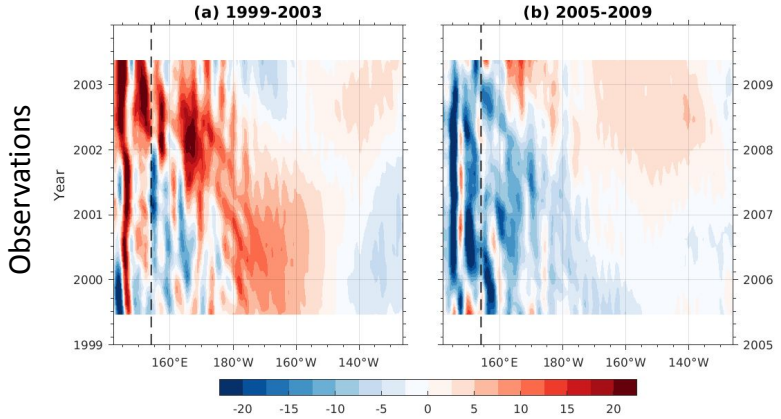
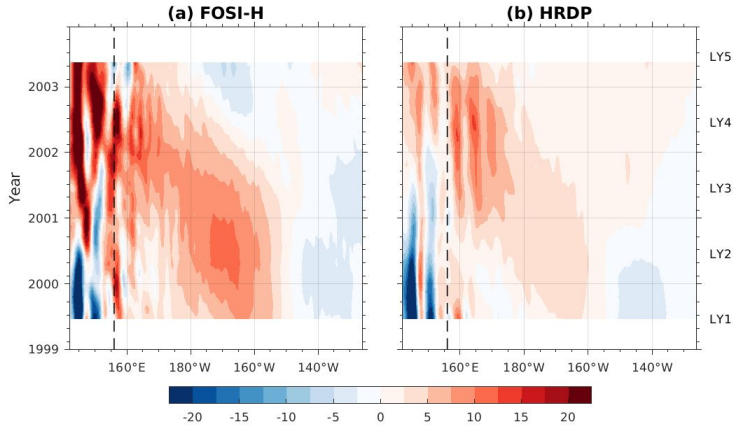
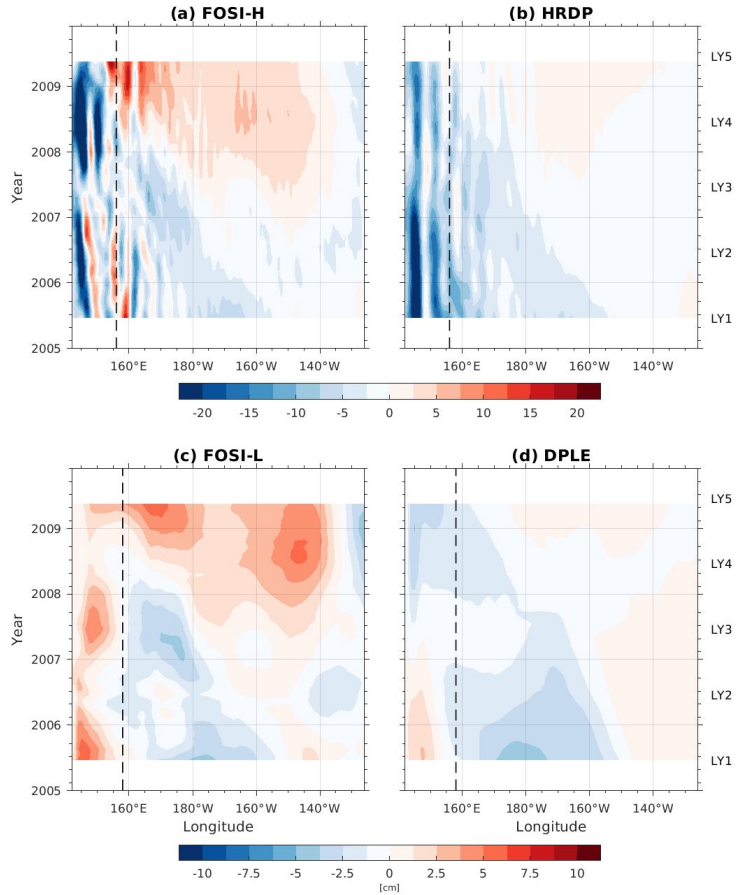
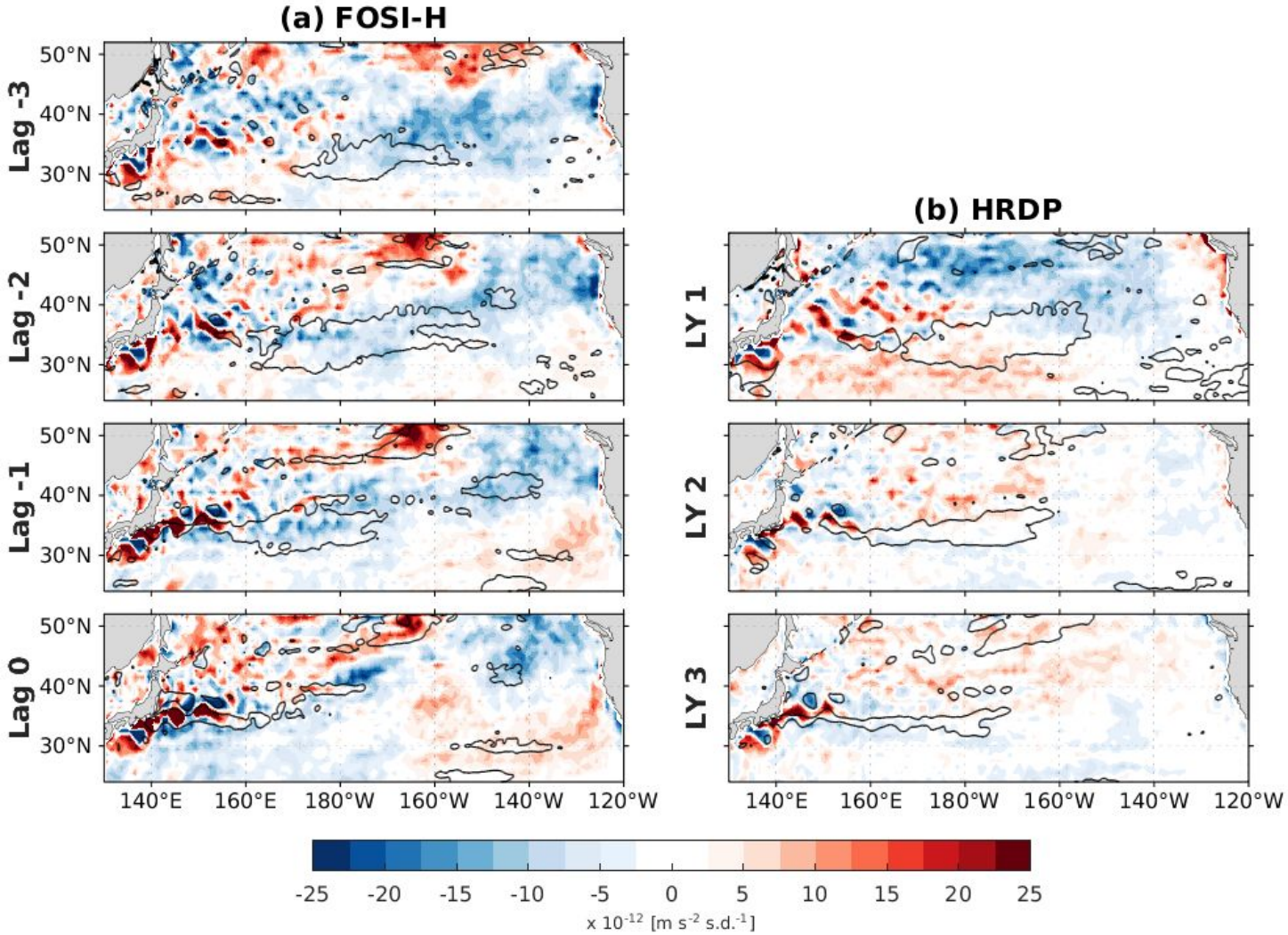






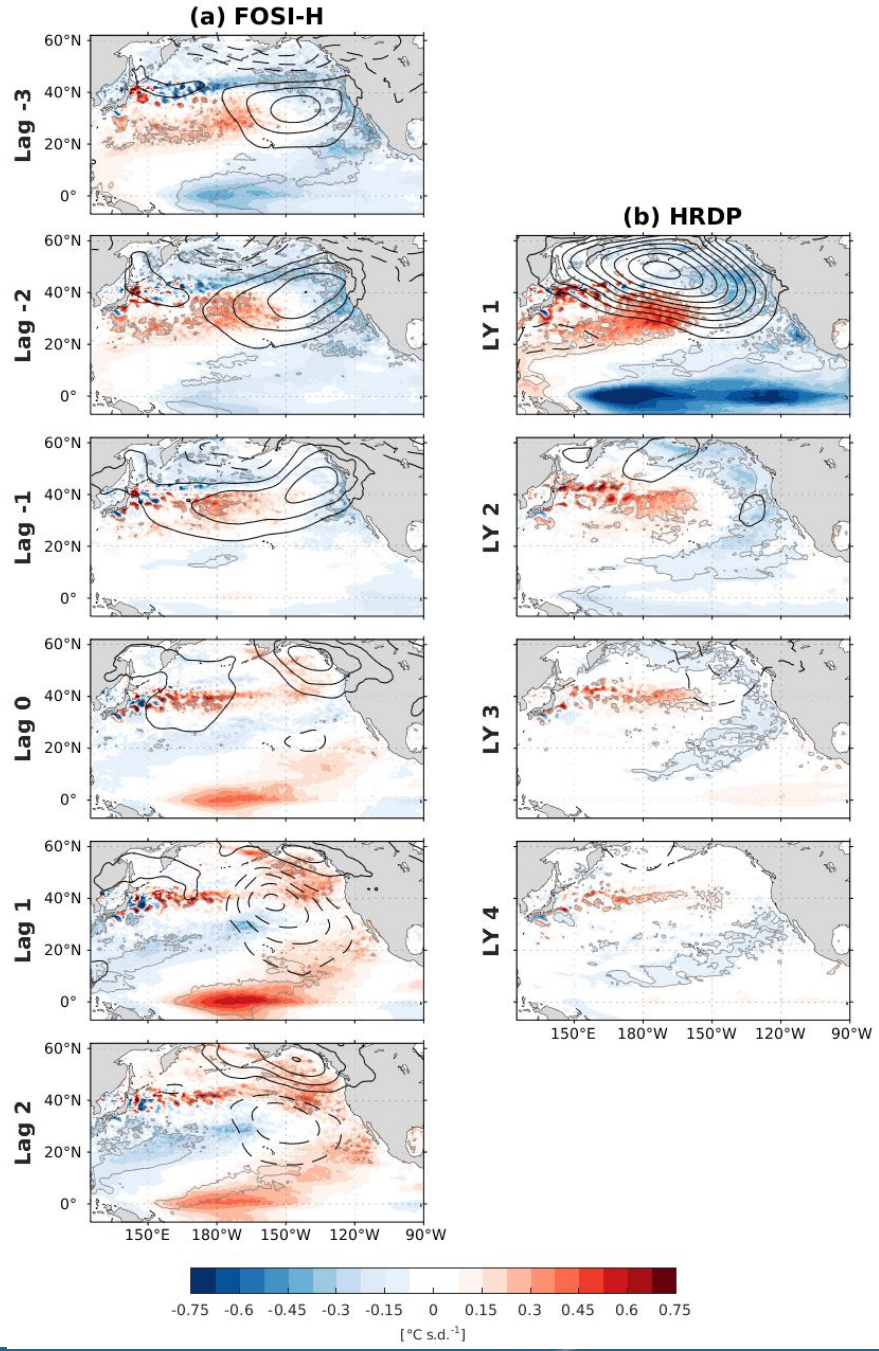
Extra #2

Regression of WSC in high-res simulations



Extra #3

Regression of winter SST and SLP onto KEI



Extra #4

Regression of subsurface temperature onto KEI