Projected Changes of Kuroshio in a Warming Climate

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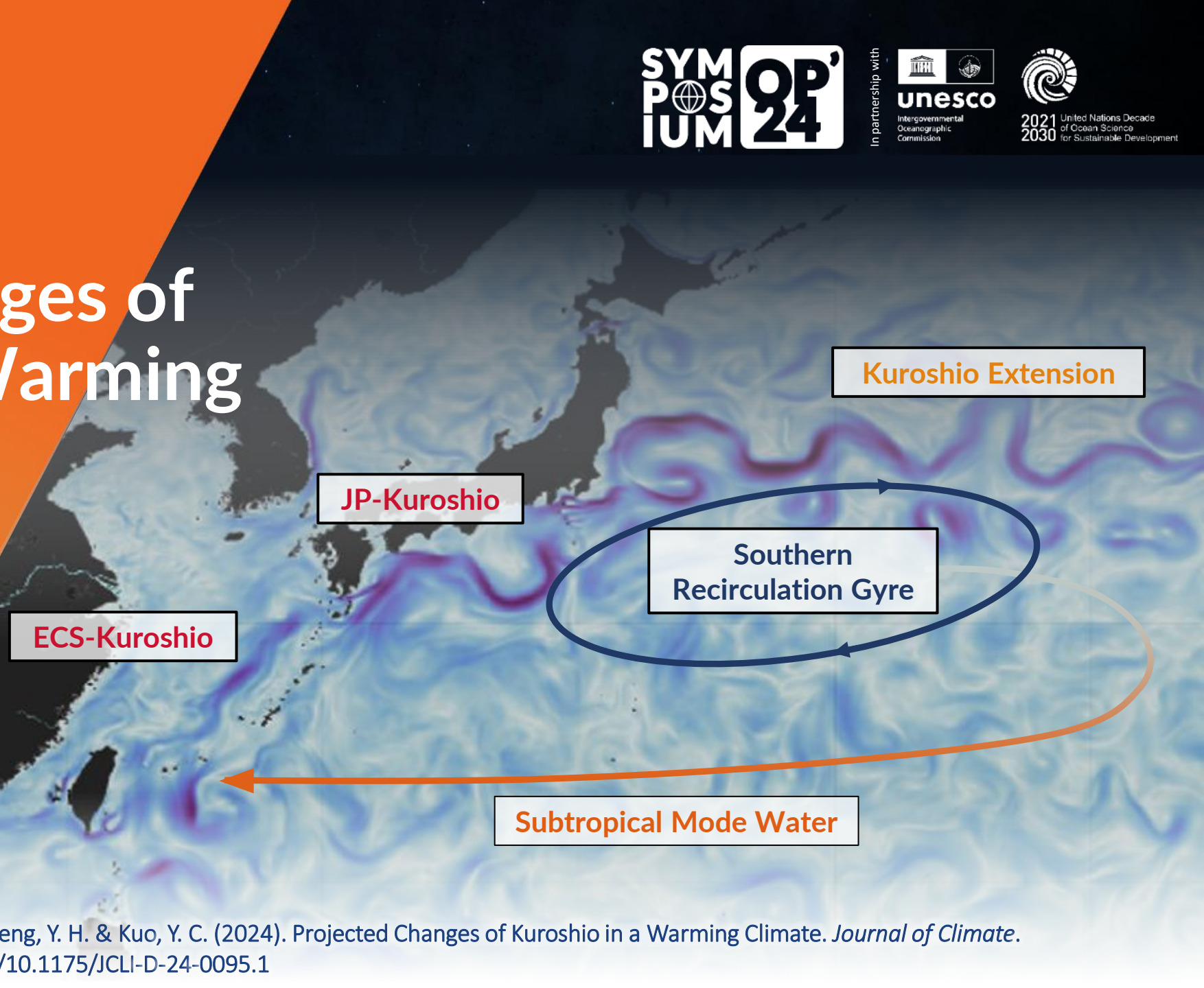

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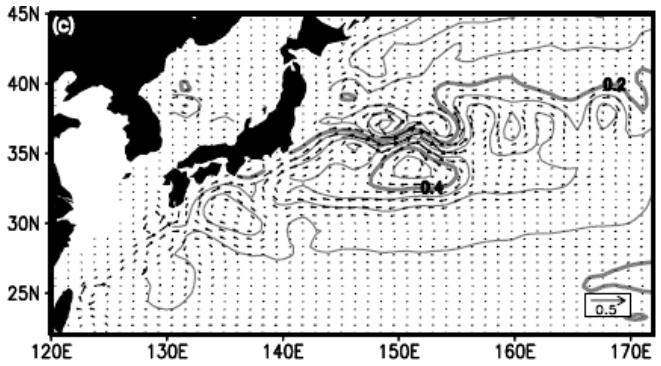
Previous Studies

Reference	Data	Trend	Extension shift	Cause
Wu et al. 2012	reanalyses	+	poleward	wind stress
Yang et al. 2016	reanalyses	+	equatorward	wind stress
	CMIP5	+	poleward	
Sakamoto et al. 2005	MIROCv3.2	+ (JP)	NaN	wind stress
Sato et al. 2006	NPOGCM	+ (JP)	poleward	wind stress
Cheon et al. 2012	CMIP3 MIROCv3.2	+ (JP)	poleward	wind stress
		− (ECS)		
Zhang et al. 2017	MIROC4h	+ (JP)	NaN	stratification
Chen et al. 2019	NEMO OPA	+ (JP)	NaN	sea surface temperature
		+ (ECS, upper)		
		− (ECS, lower)		
Sen Gupta et al. 2021	CMIP6	+ (JP)	NaN	wind stress
		~ (ECS, upper)		
		− (ECS, lower)		
Yamanaka et al. 2021	MRI.COMv4	~ (JP)	poleward	NaN

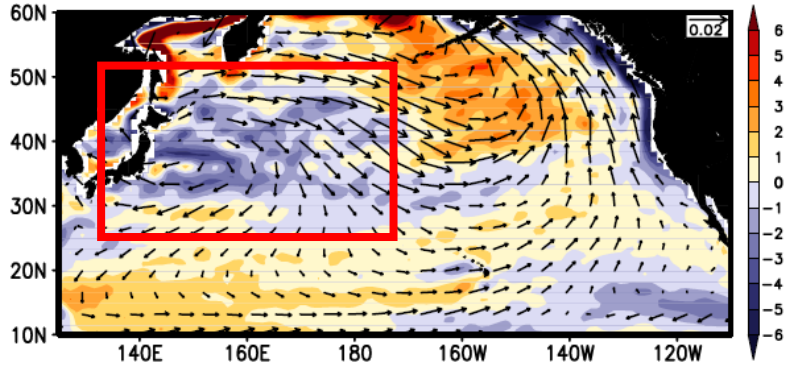
High resolution model

Mechanism 1: Wind

Sakamoto et al. 2005



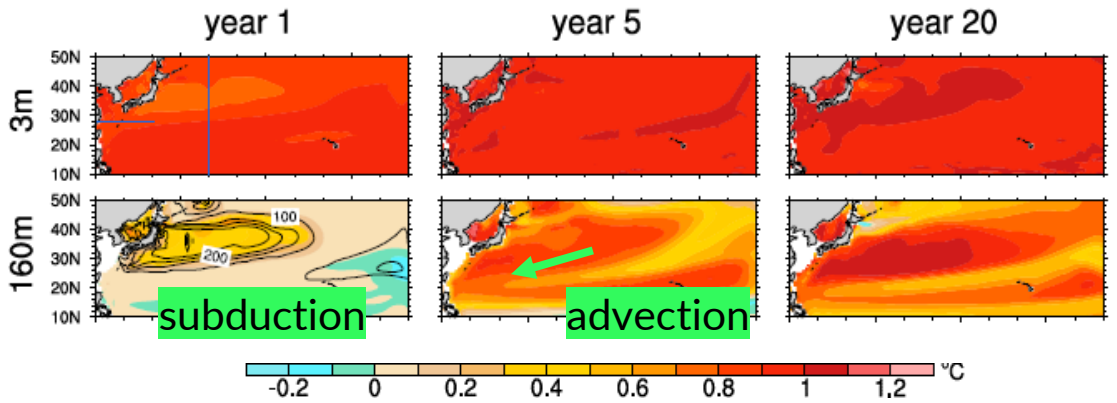
Vector: current velocity change at 100m
Contour: sea surface height change



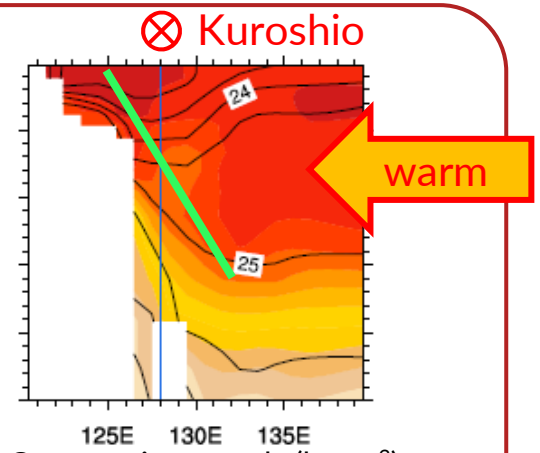
Vector: wind change
Shading: wind stress curl change

Mechanism 2: Subtropical Mode Water (STMW)

Chen et al. 2019



Contour: mixed layer depth (m) in March
Shading: ocean temperature change



Contour: isopycnals (kg m^{-3})
Shading: temperature change

Motivation and Objectives

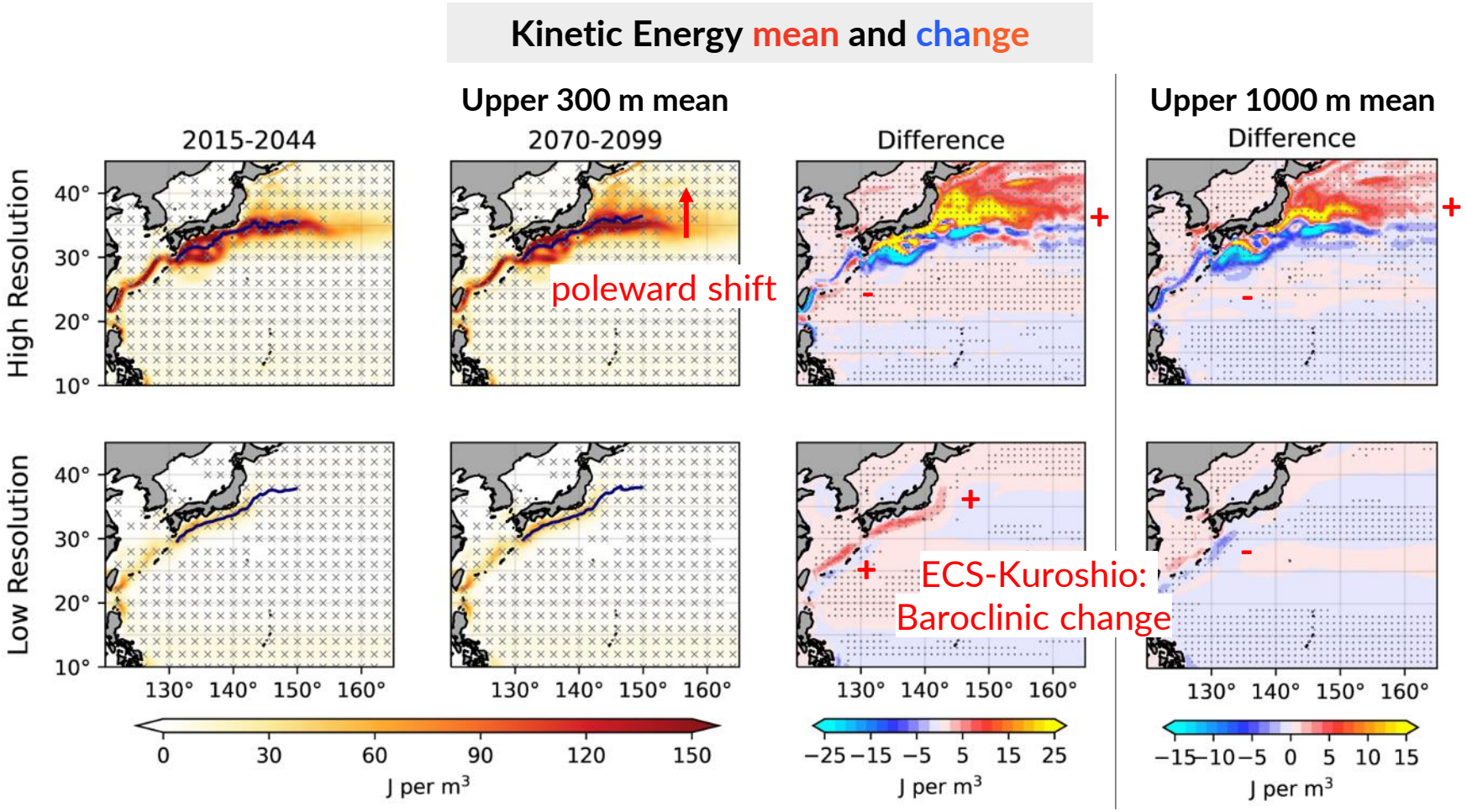
- Investigate the fundamental differences causing the Kuroshio changes among future scenario simulations and the underlying physical mechanisms.
- Examine the impacts of individual forcing in global low resolution (LR) models and regional high resolution (HR) models to identify the role of mesoscale eddies.

CMIP6 SSP5-8.5
- High resolution (HR) vs. Low resolution (LR)

TIMCOM (LR)
- Sensitivity Experiments
- Compare with CMIP6 and Chen et al. 2019

ROMS (HR)
- Sensitivity Experiments
- Compare with CMIP6 and TIMCOM

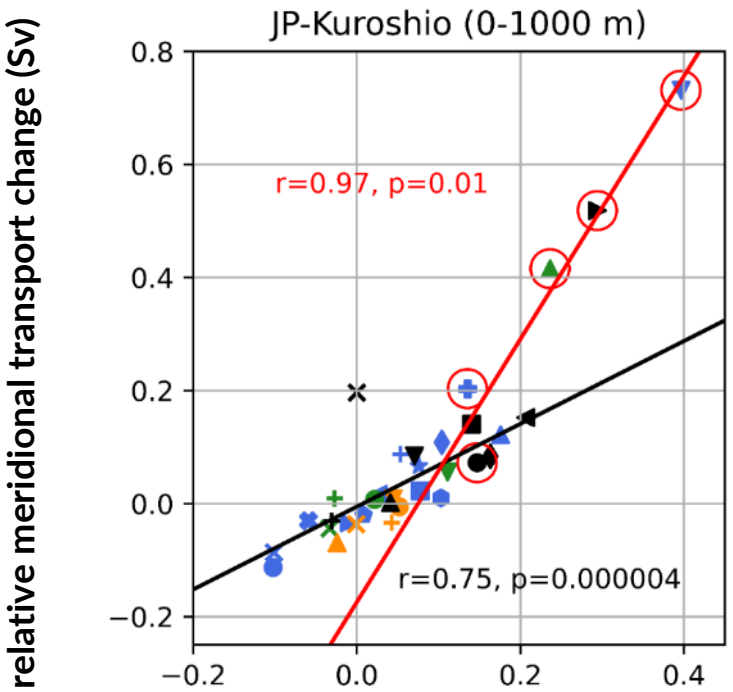
Dynamical Changes



- Strong intensification and poleward shift of Kuroshio Extension in HR models.
- Consistent baroclinic change of ECS-Kuroshio is not evident HR models.

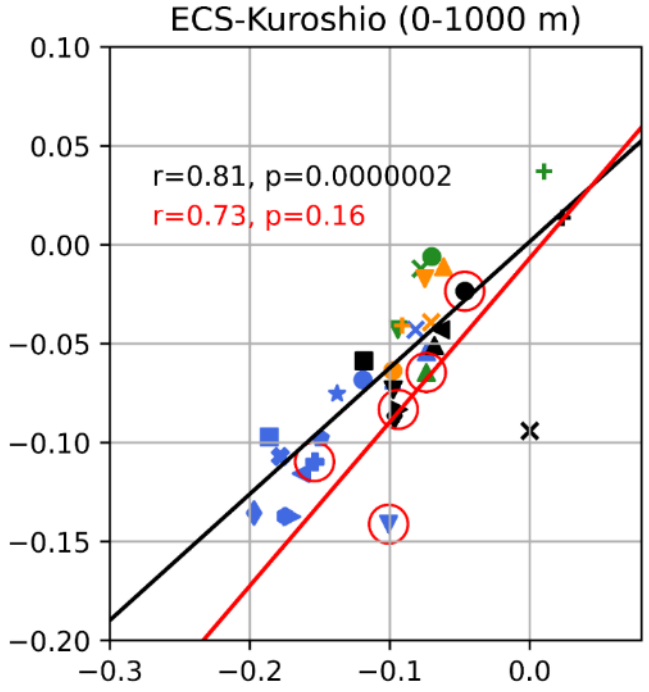
Dynamical Changes

- The transport change of the JP-Kuroshio is more sensitive to the wind stress curl (WSC) in HR models → meso-scale dynamics resolved only in HR models.

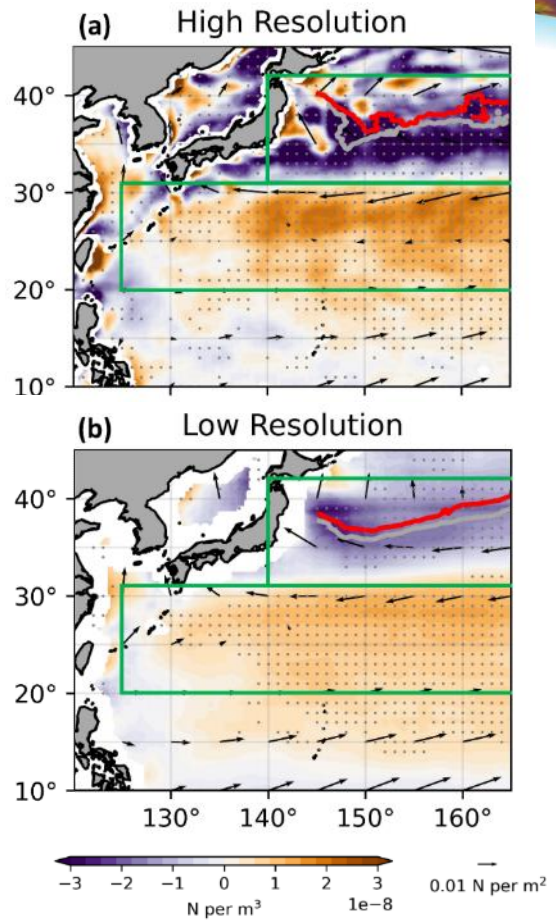


○ : High resolution models

relative WSC change (N/m²)



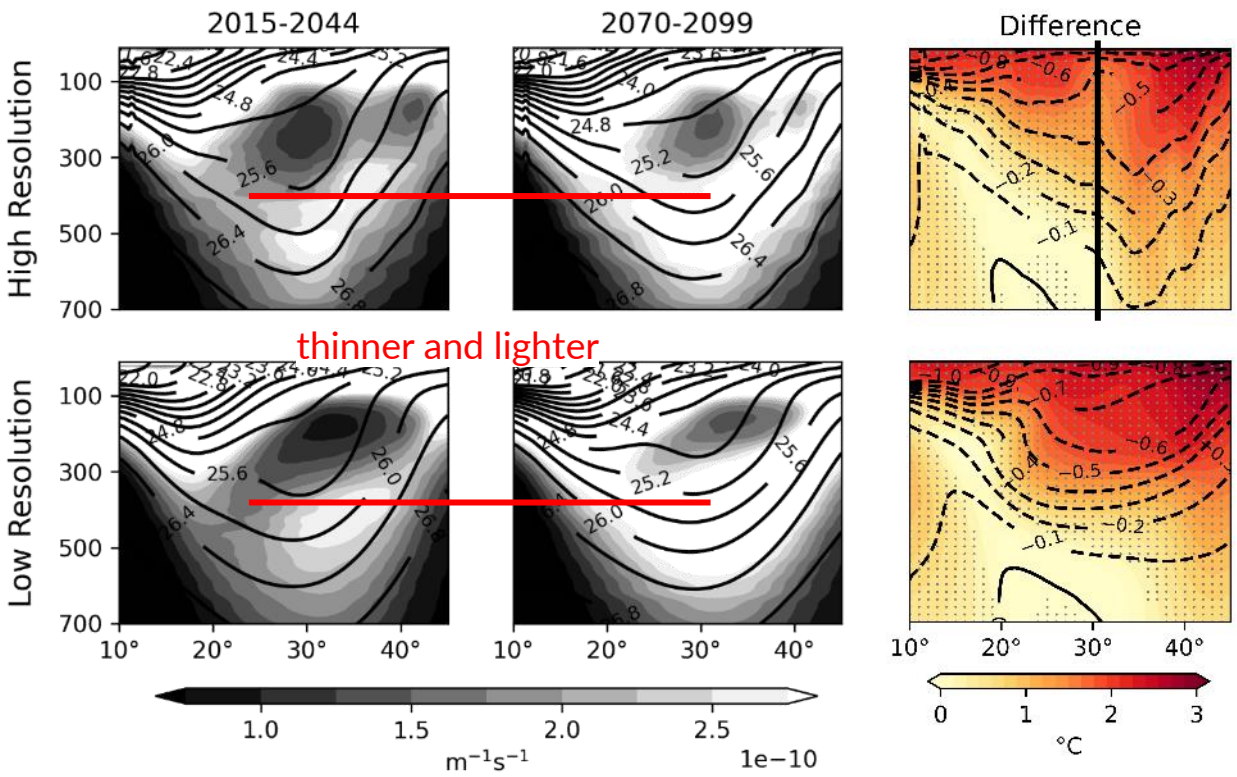
relative WSC change (N/m²)



WSC change

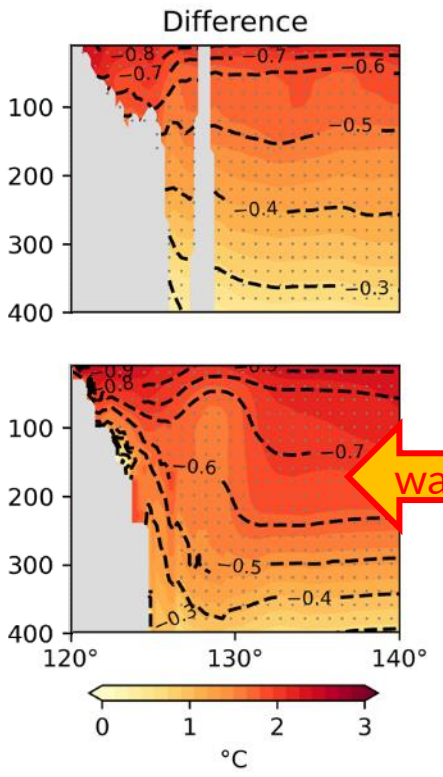
Thermal Structure

Mean Potential Vorticity & Temperature change (P13)

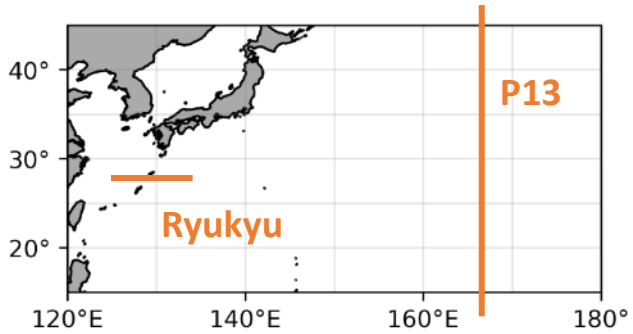


Contour: potential density

Temperature change (Ryukyu)



Contour: potential density change

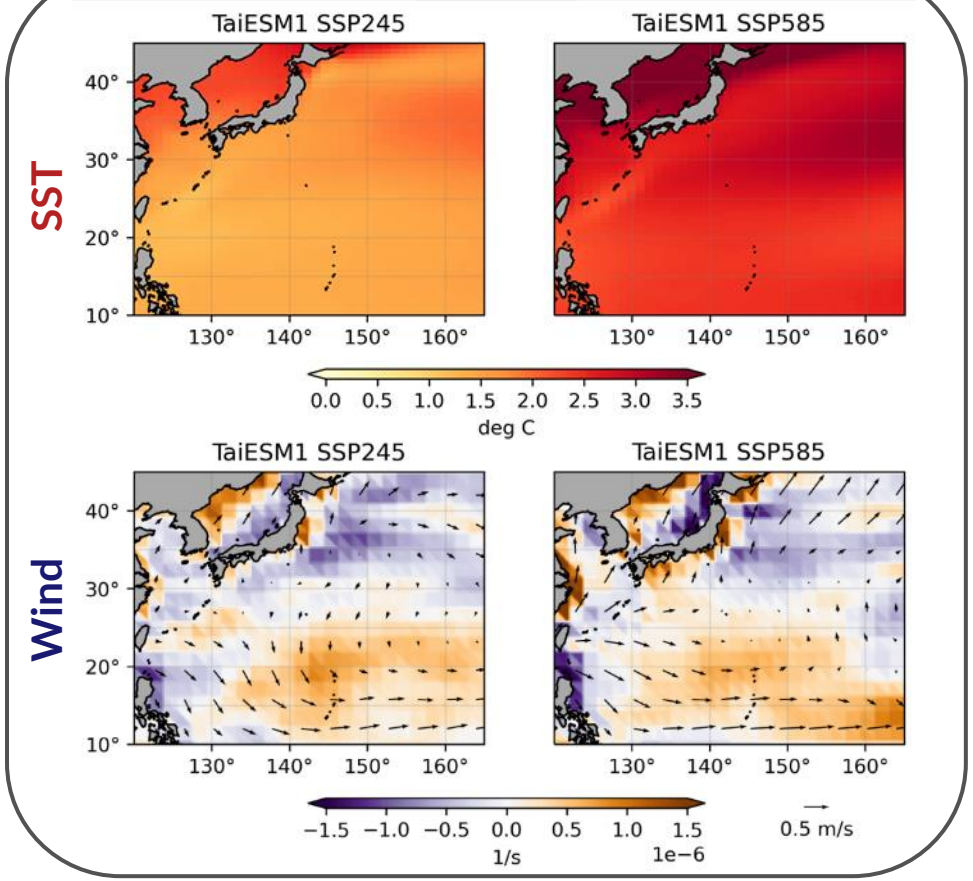


- LR: possibly transported with the STMW pathway.
- HR: blocked around 30 to 35°N.

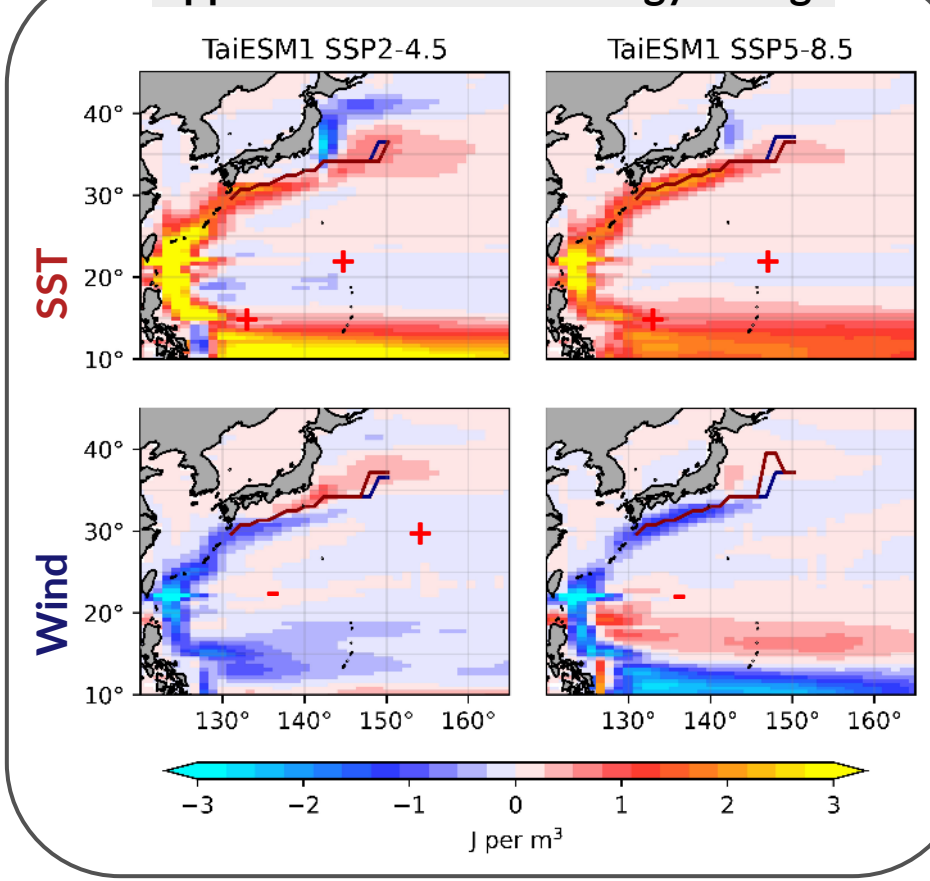
Sensitivity Experiments

- Model: OGCM TIMCOM (1° x 1°)
- Scenario: TaiESM1 SSP2-4.5 and SSP5-8.5
- Forcings: Annual SST restoring / surface winds stress

Forcings



Upper 300 m Kinetic Energy change



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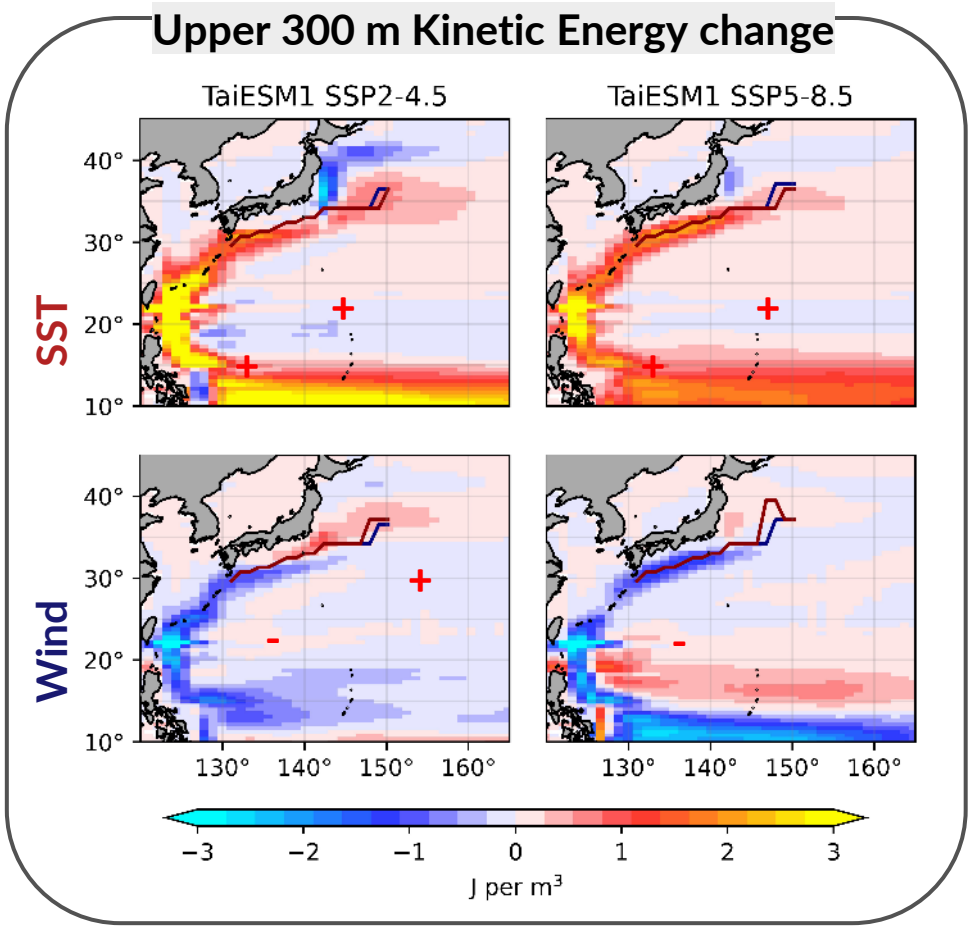
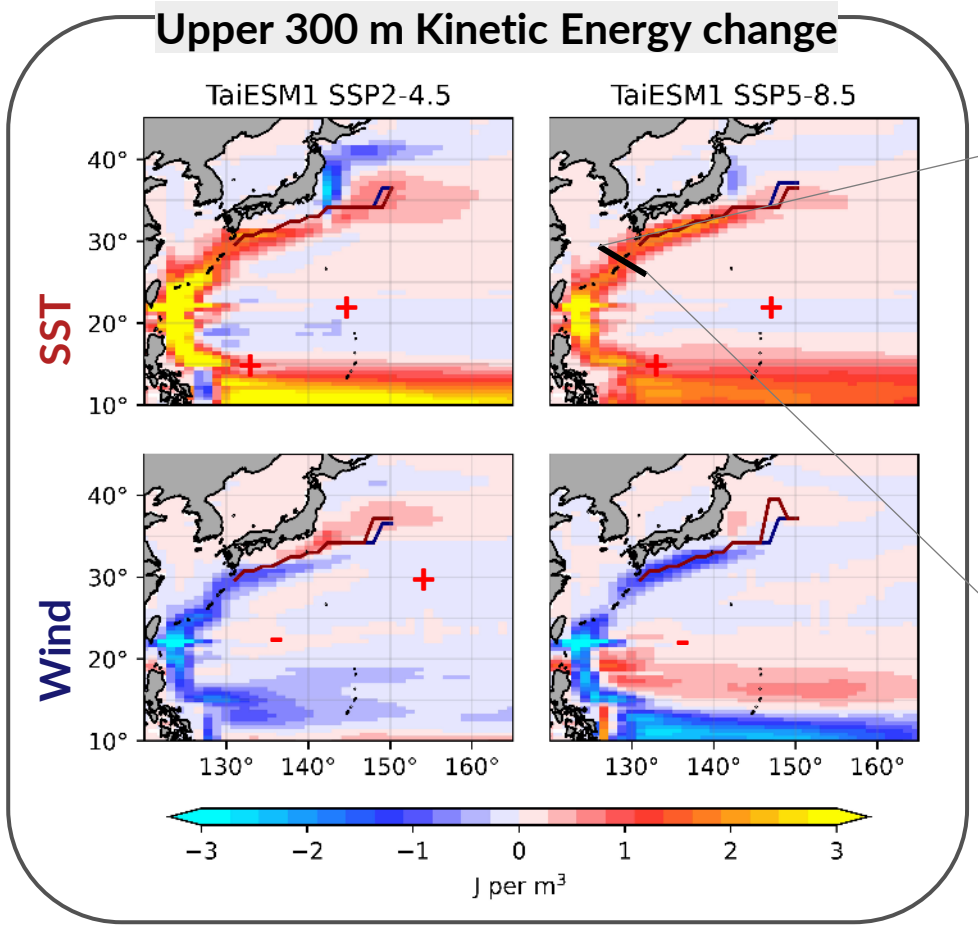
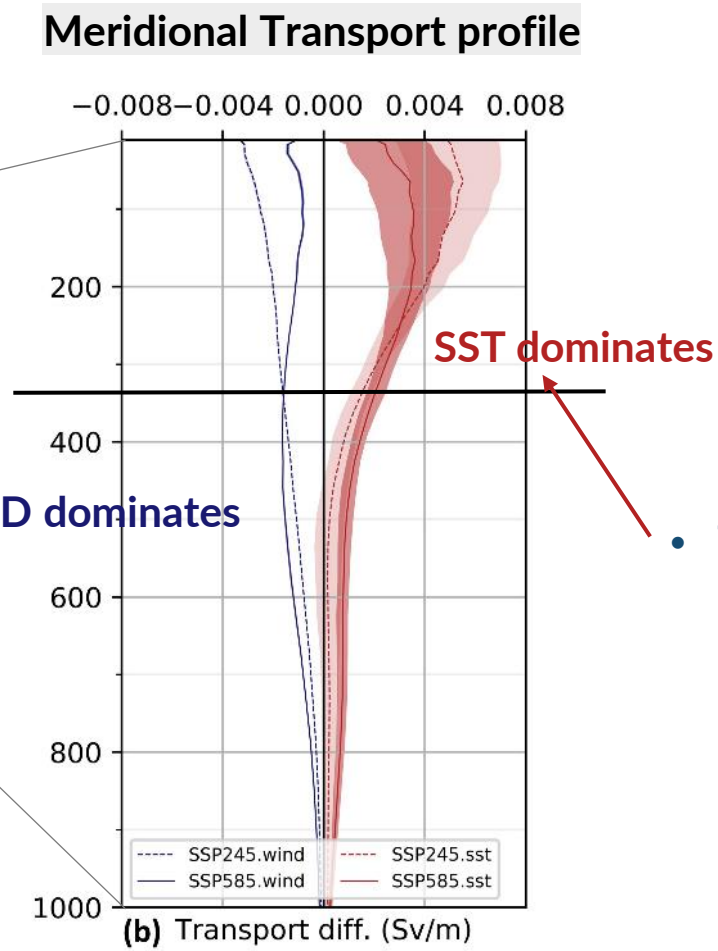


Dynamical Changes

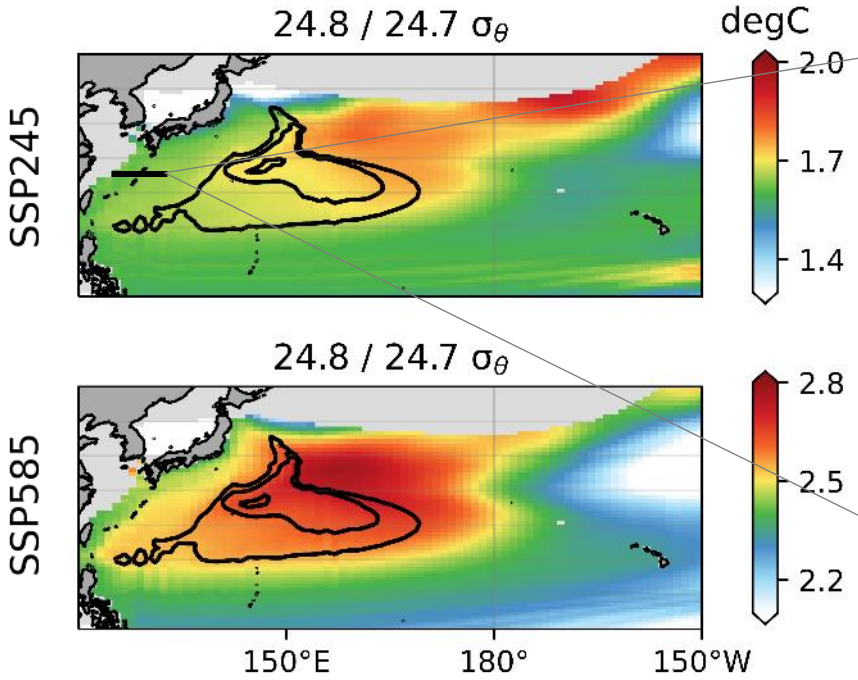




- The STMW locates at around 200 m (next slide)

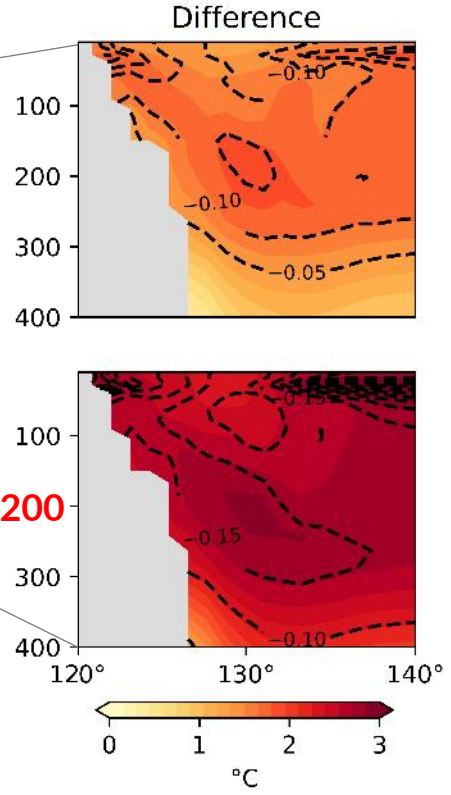
Thermal Structure of SST run

Δ Potential Temperature on the isopycnal



Title: control run / SST.run isopycnal surface density
Contour: potential vorticity ([1, 2, 3]×10^{-10} $m^{-1}s^{-1}$)

Δ Potential Temperature



Contour: Δ potential density

- Warm water pattern corresponds to the STMW pathway.
- The warm STMW (around 200 m), propagating to east of the ECS-Kuroshio (enhance kinetic energy / transport).

Take Home Message

Upper 300 m	LR	HR
JP-Kuroshio	enhanced	enhanced dramatically, poleward
ECS-Kuroshio	KE: enhanced	reduced
	Sv: no changed	

Upper 1000 m	LR	HR
JP-Kuroshio	enhanced	enhanced dramatically, poleward
ECS-Kuroshio	reduced	

- Changes in the upper (lower) layers of ECS-Kuroshio are dominated by SST (wind).
- Isopycnals suggest the impacts of STMW and warm seawater.
- Future works: Performing similar experiments by regional high resolution model to further identify the role of mesoscale eddies.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