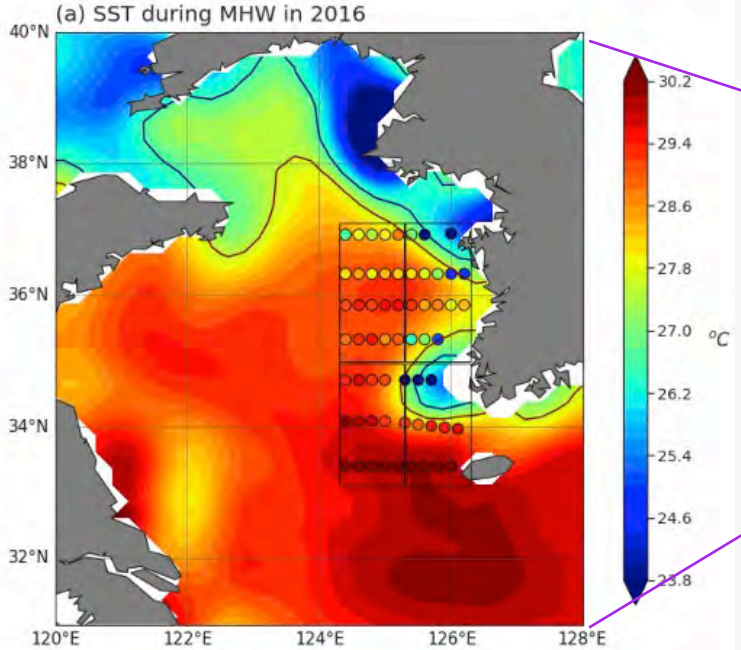
OPST-8, Busan

Local Stratification Preconditions Marine Heatwaves

DONG EUN LEE[1], EUN YOUNG LEE[1], YOUNG-GYU PARK[2]
HYUNJIN KANG[1], HAEDO BAEK[1]

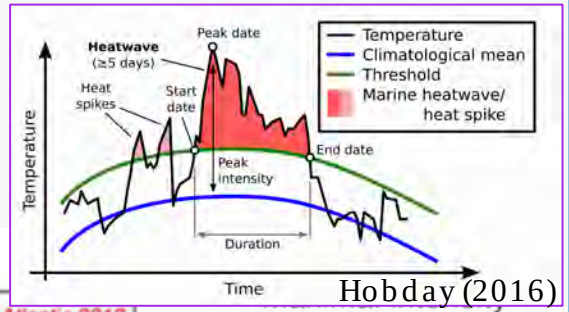
[1]Chungnam National University; [2]Korea Institute of Ocean Science and Technology

Motivation

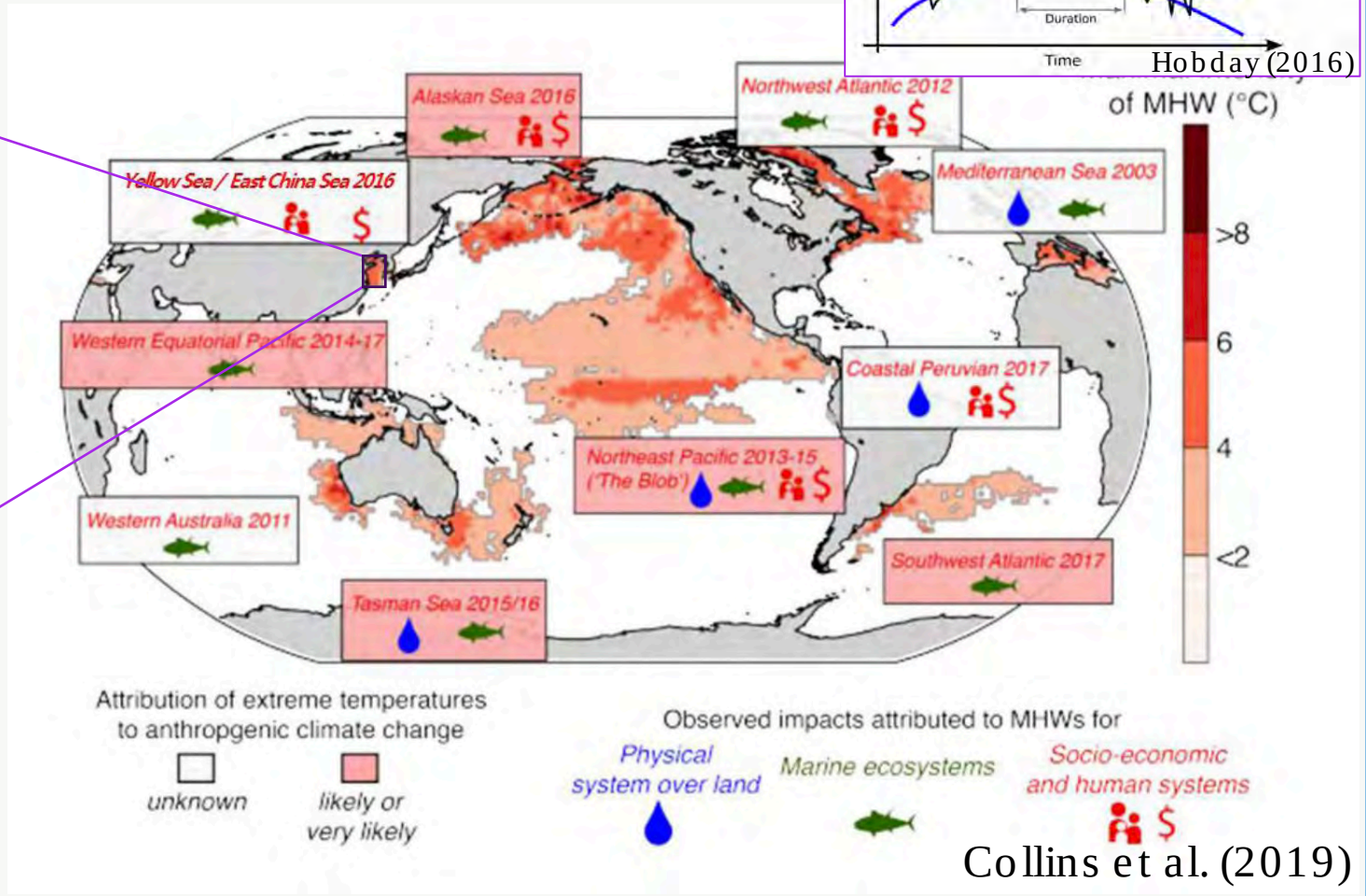


Marine Heatwaves in the YS

- Extreme size of SSTA
- Extreme growth rate of SSTA
- Extreme duration of SSTA

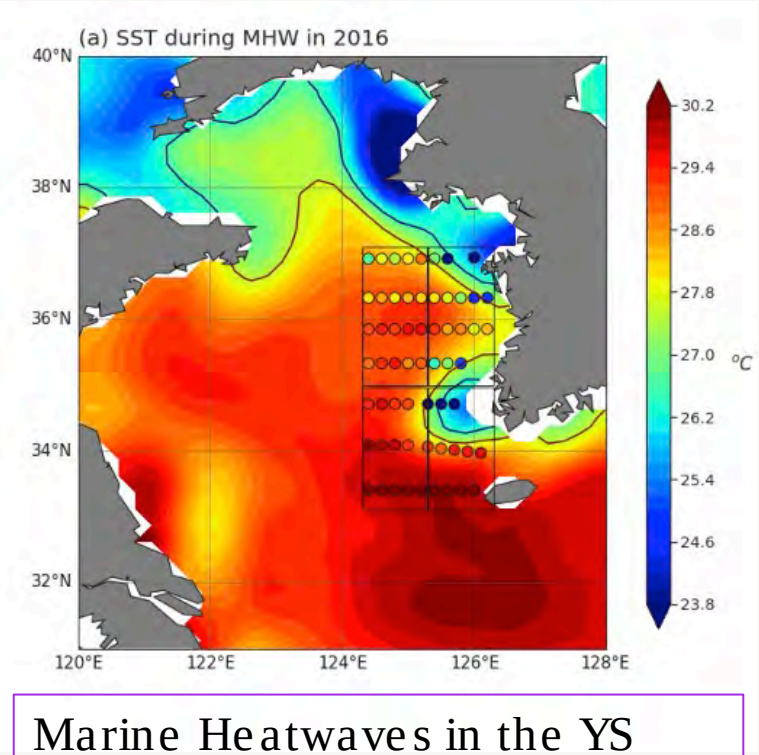


Hobday (2016)



Collins et al. (2019)

Motivation



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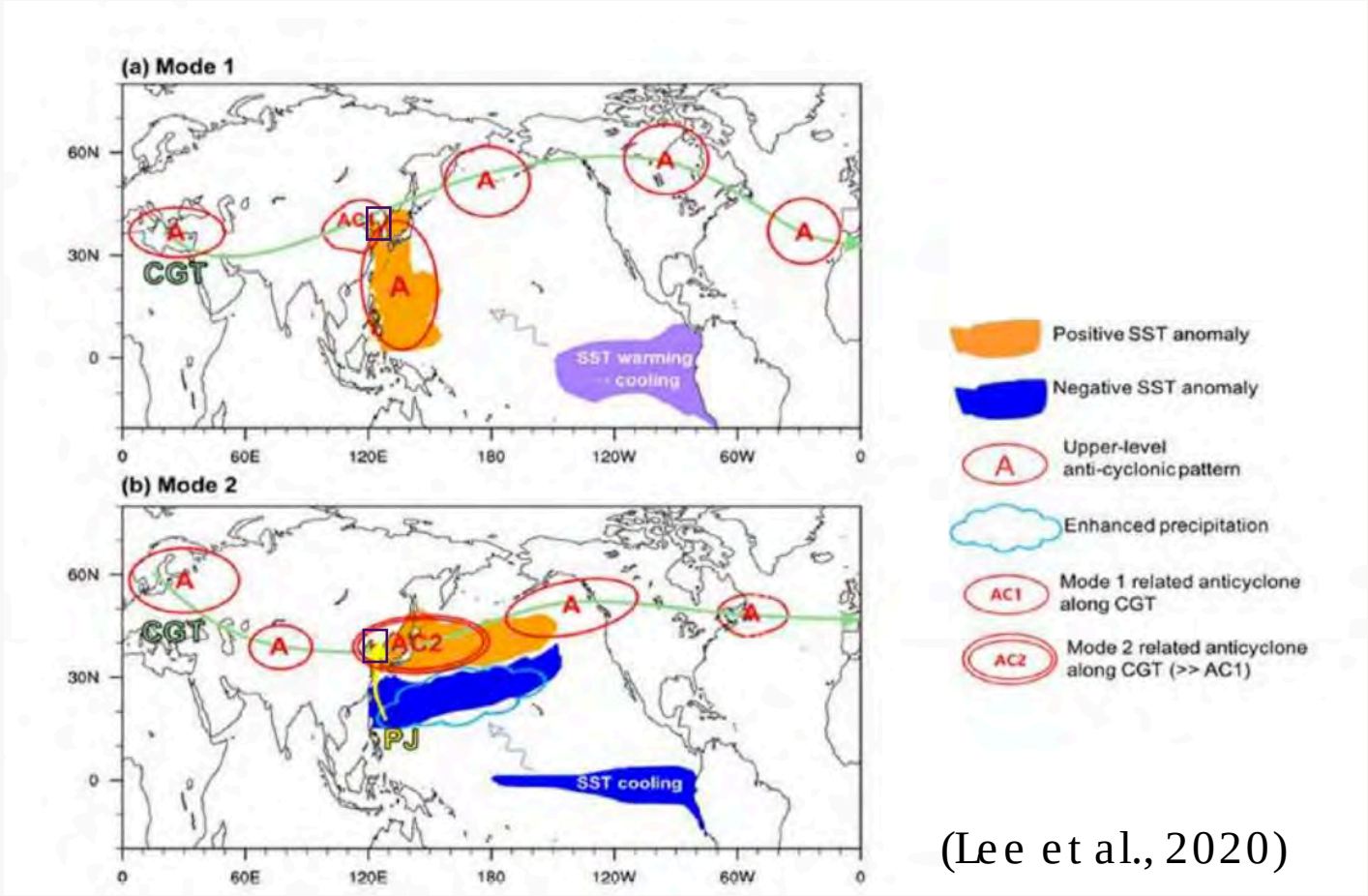
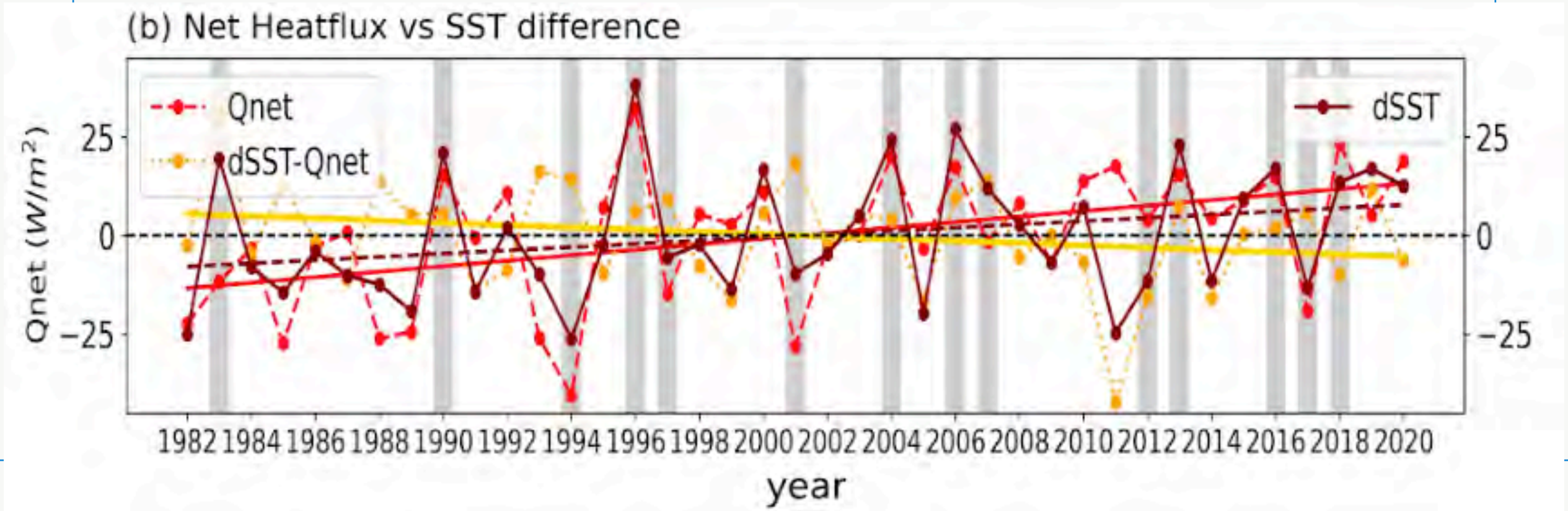


(Lee et al., 2020)

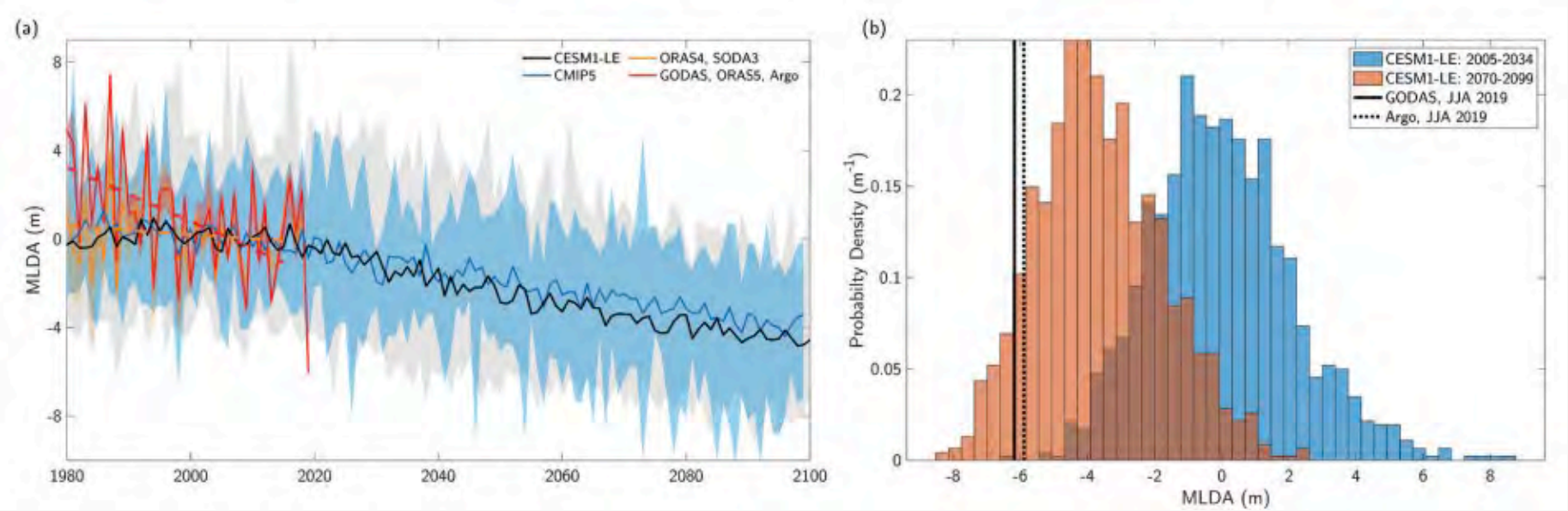
A Motivating Evidence

$$\bar{H}\rho c_p \frac{\Delta T'}{\Delta t} \approx Q' + \left[-\bar{T}\rho c_p \frac{\Delta H'}{\Delta t} + K_v T_{zz} + others \right]$$

- MHW occurs more often now than in the past
- Not all strong Q_{net} triggered MHW
- Oceanic heat flux helped more warming events in the past than now
- Qnet is increasing gradually with time
- In long-term, oceanic heat flux exports excessive Q_{net} into subsurface.



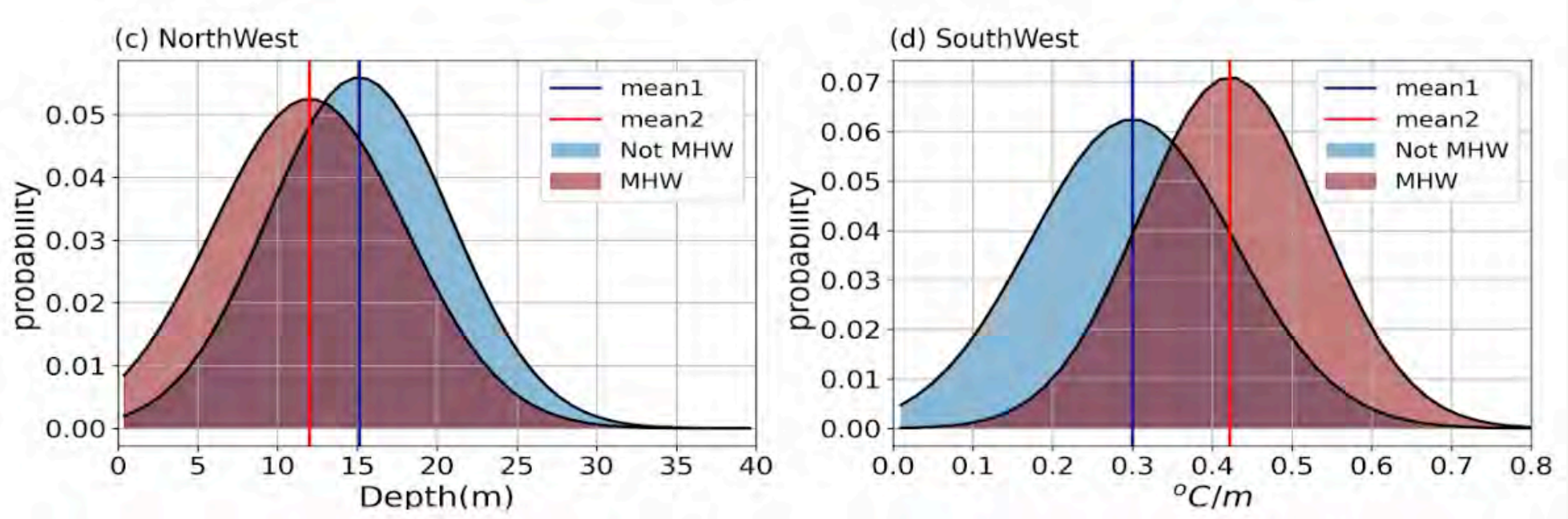
Climate change and MLD



Amaya et al., 2021

- Temperature-stratification positive feedback accelerates surface warming

June Stratification vs August Heatwaves

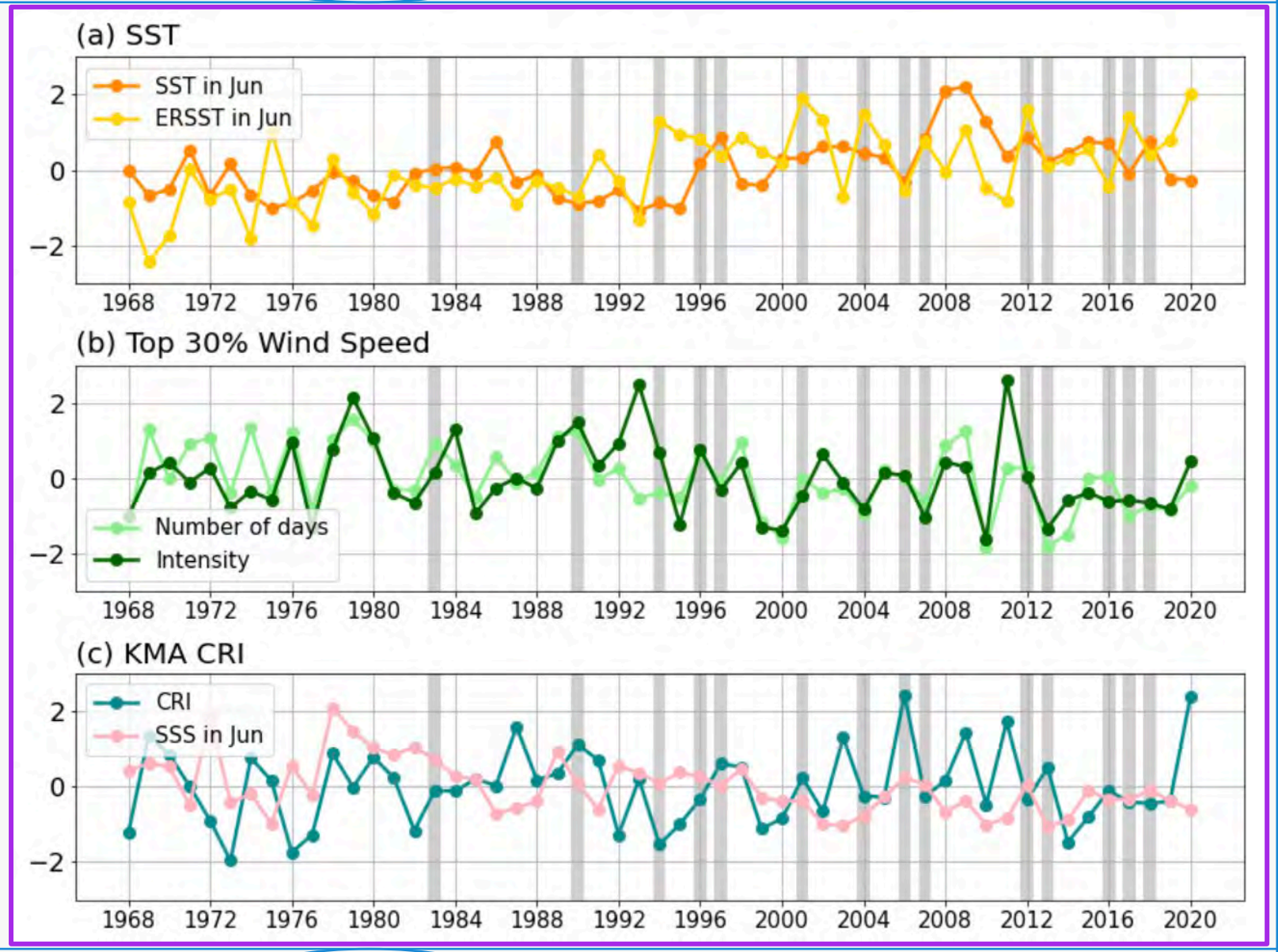


Depth of the maximum vertical T gradient

Vertical T gradient at 20m

- Significantly stronger stratification in June is found preceding MHW events in the later summer

Possible players for Vertical Stratification



Data and Methods

- NIFS DATA 1968-2020
- NCAR/NCEP reanalysis daily wind, precipitation, surface heat fluxes
- KMA Changma (Monsoon Rainfall) index
- OISST
- ERSST4

- PWP (Price-Weller-Pinkel) model

1-dimensional ocean

T&S equations

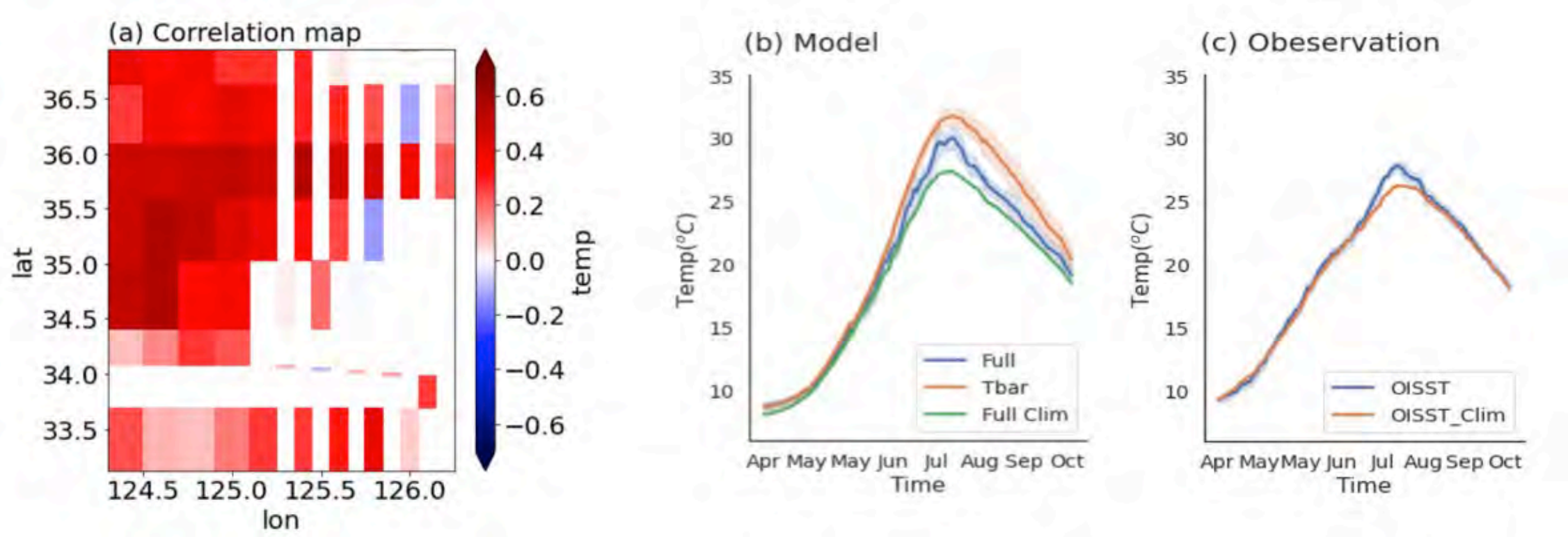
Variable vertical structure with mixing parameters

1-D Model Experiments

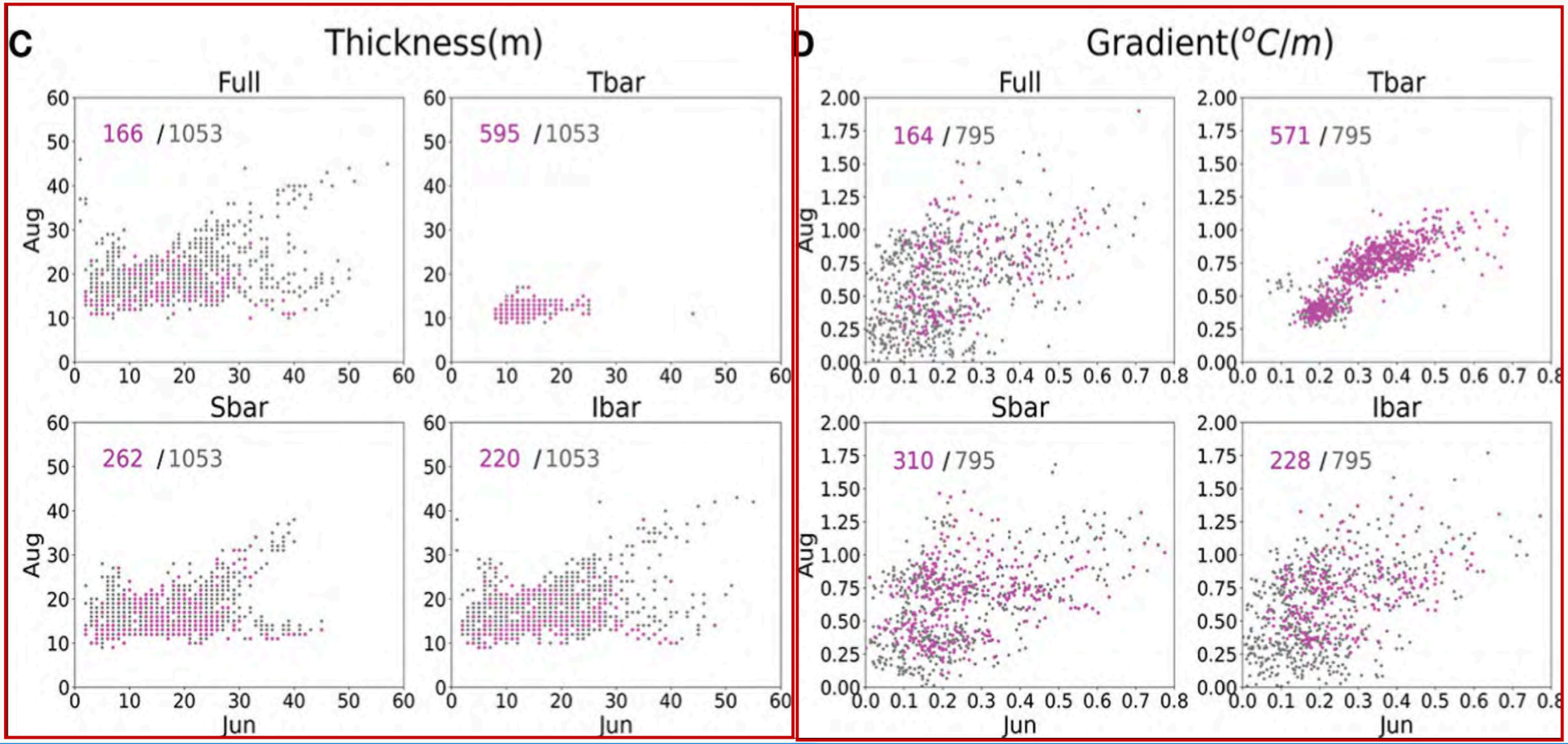
- PWP model : local fitting for mixing parameters
- Initialized on 1st April and finishes on 30th Sep.
- Surface net heat flux is provided for all experiments

Experiments	SSS	Wind speed	Initial T,S
Full	raw	raw	raw
Sbar	daily climatology	raw	raw
Tbar	raw	climatological daily wind speed	raw
Ibar	raw	raw	climatology

6m prediction with Apr01 IC



Removing anomalies boosts MHWs



Removing anomalies boosts MHWs:
Ocean is preventing MHW from occurring more often

Asymmetry found!

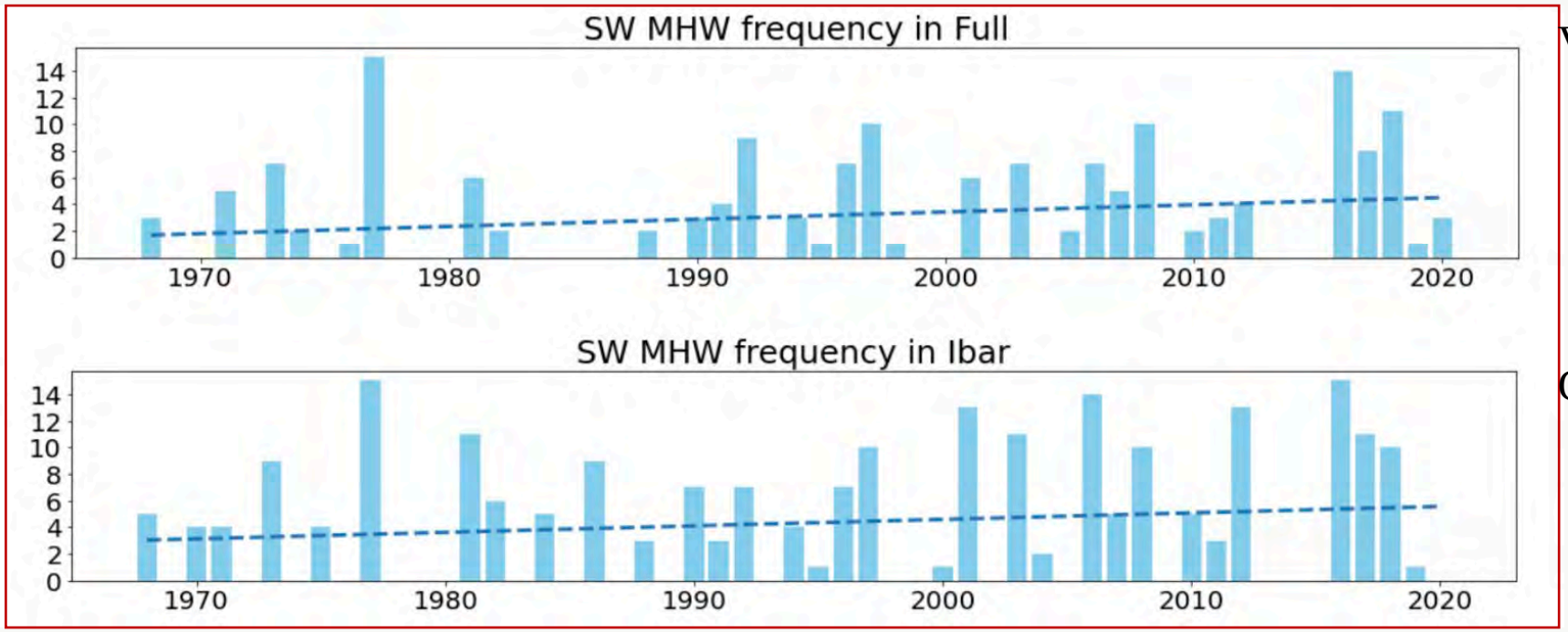
- Removing strong winds
- Removing saltier surface water
- Removing colder ICs

Matters more than

- Removing weaker wind
- Removing warmer ICs
- Removing fresher surface water

Experiments	MHW increase wrt Full
Sbar	60%
Tbar	260%
Ibar	20%

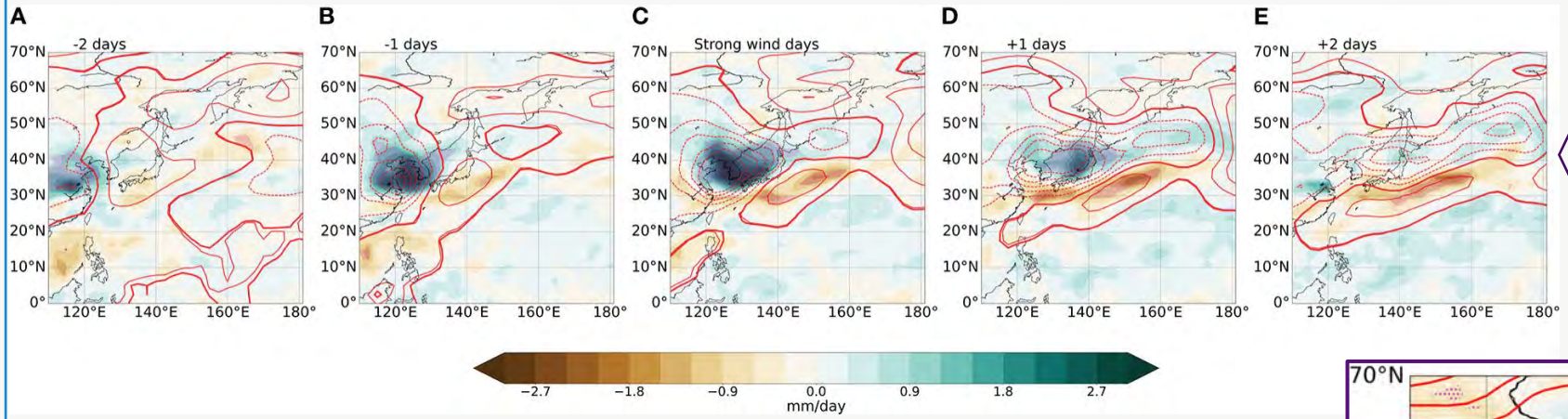
Gradual SST warming is not responsible for the local MHW occurrence



Variable AprIC

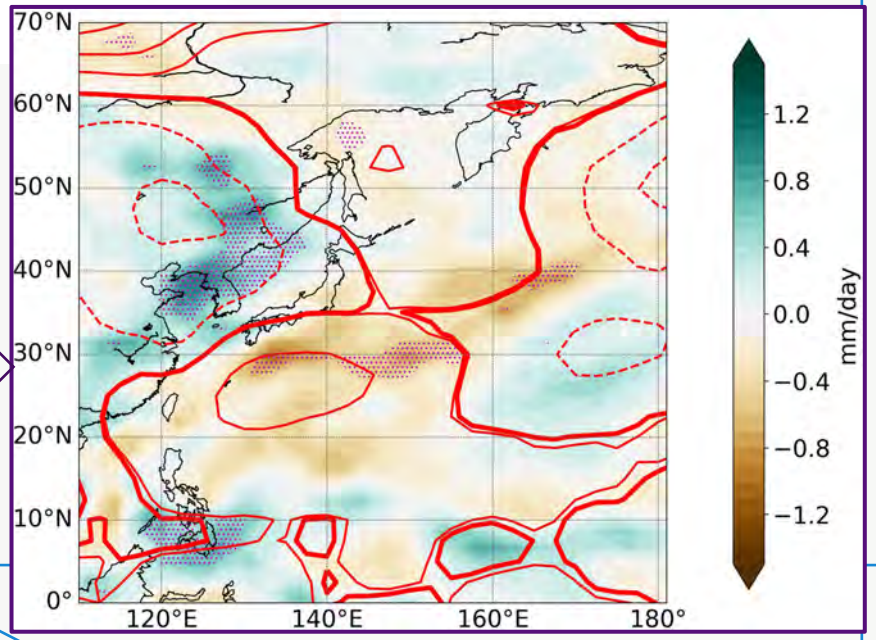
Climatological AprIC

Early summer monsoon brings strong winds



SLP& Precip for 5 days around strong wind days

June Monthly Regression of SLP and Precip onto strong wind days index



Summary

- MHW events highly depend on the physical conditions of the local ocean.
- According to 1-D model experiments, ocean is found preventing MHW from occurring more often.
- Declining daily wind speed in the region can bring more MHW in the future with climate change.
- Relative impact of disturbing vertical stratification is the stronger with the wind speed than with the surface salinity forcing. The early summer disturbance associated with East Asian summer monsoon is likely to be wind-dominated.
- Rising surface temperature is not yet as powerful trigger as the weakening wind for MHWs.
- Since the oceanic conditions forms well in advance, the success of monthly or even seasonal prediction of MHW can be insured by the models' performance in representing a realistic vertical structure of the local ocean.

Reference

Lee, E.Y. et al. (2023) The local stratification preconditions the marine heatwaves in the Yellow Sea, Frontiers in Marine Science, https://doi.org/10.3389/fmars.2023.1118969

Thank you

감사합니다