Importance of ocean observations for sub-seasonal to seasonal forecast in East Asia

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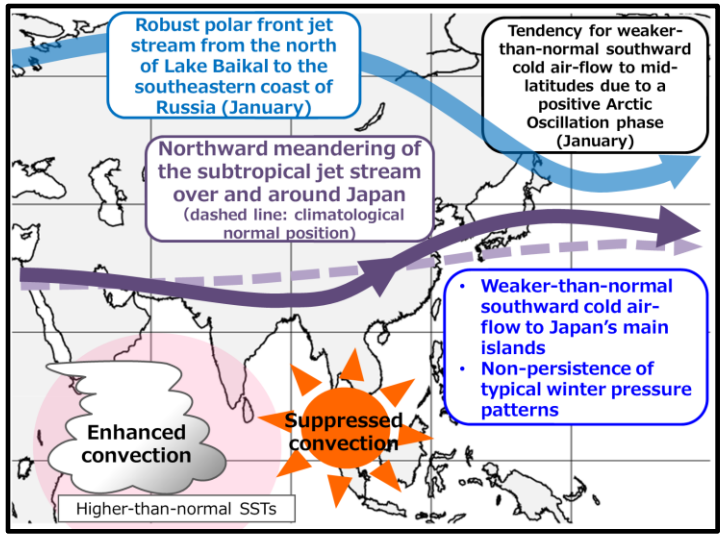
Takaya et al. (2020) Enhanced Meiyu-Baiu Rainfall in Early Summer 2020: Aftermath of the 2019 Super IOD Event, *Geophys. Res. Letts*. *(GRL most cited article in the last 2 years, 10 Nov. 2022)*

Introduction

- Weather and climate in East Asia are affected by tropical Indian Ocean and Pacific conditions.
- Anomalous oceanic conditions in the tropics often trigger weather and climate extremes in East Asia.

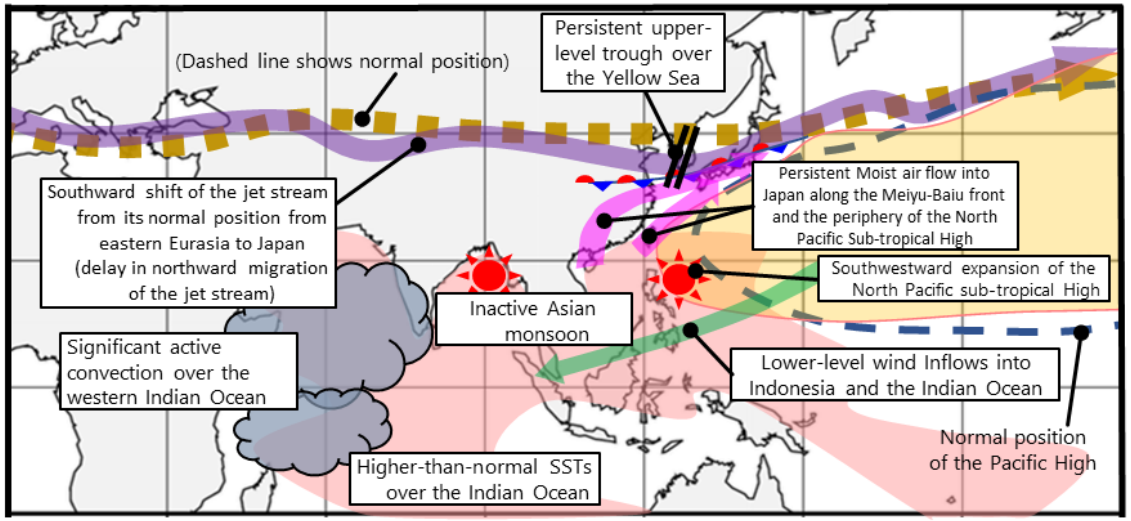
Japan's Warmest-ever Winter in 2019/2020 winter

Atmospheric circulation conditions associated with the climate extremes observed in Jan. 2020



Record-breaking Baiu rainfall in 2020 early summer

Atmospheric circulation conditions associated with the climate extremes observed in Jul. 2020



c.f. Kuramochi (2021) *SOLA* Kobayashi et al. (2022) SOLA

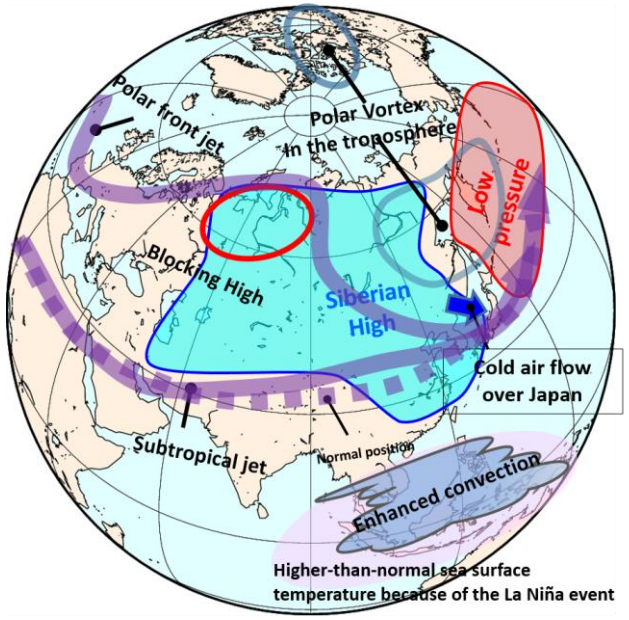
Source: Tokyo Climate Center, JMA

Introduction

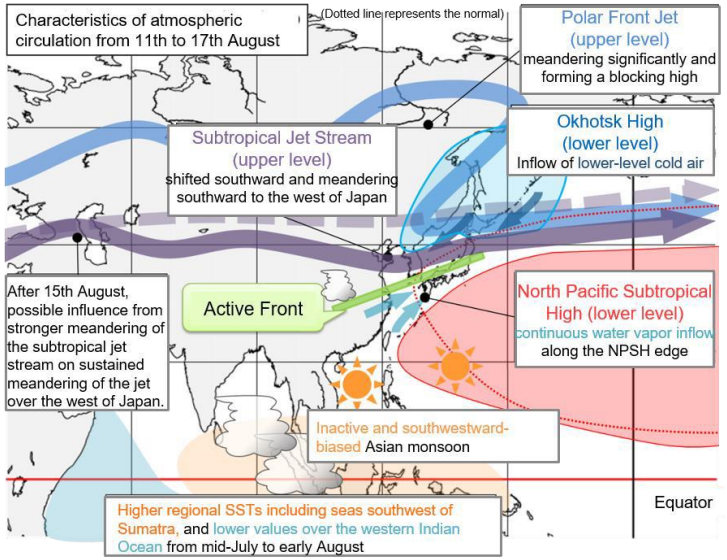
- Weather and climate in East Asia are affected by tropical Indian Ocean and Pacific conditions.
- Their anomalous oceanic conditions in the tropics often trigger weather and climate extremes in East Asia.

Anomalous oceanic conditions repeatedly trigger climate extremes in East Asia

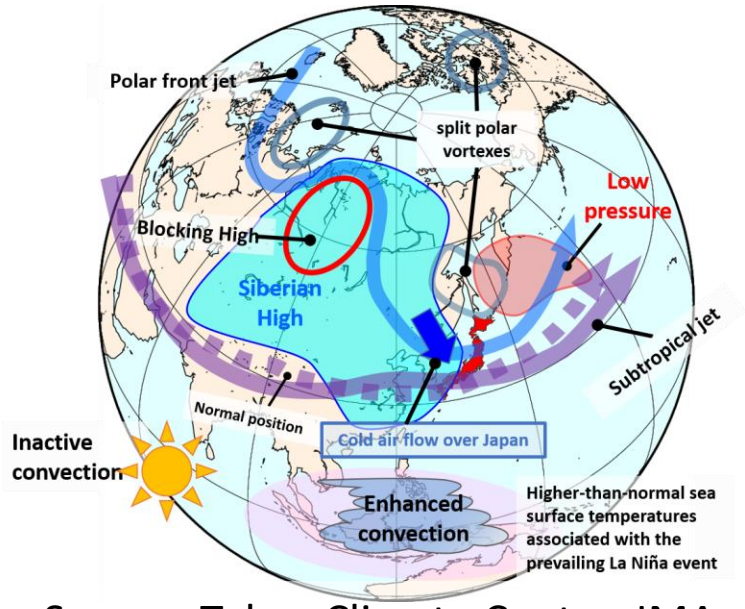
Heavy snowfall and low temperatures (mid-Dec. 2020 – mid-Jan. 2021)



Record-heavy rain in Japan (August 2021)



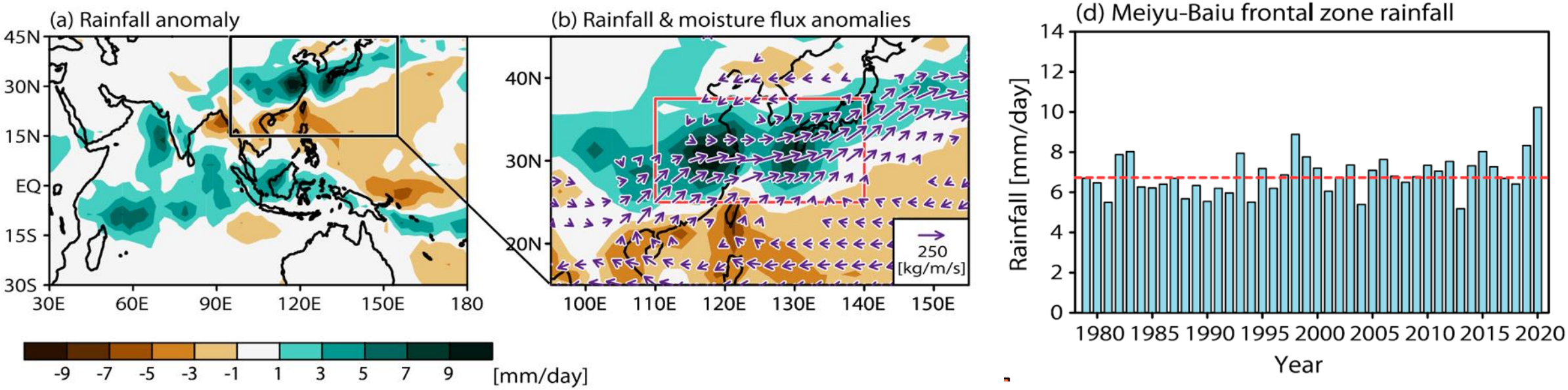
Heavy snowfall and low temperatures (Late Dec. 2021 - early Jan. 2022)



Source: Tokyo Climate Center, JMA

Meiyu-Baiu rainfall in early summer 2020

Early summer (June-July) 2020 exhibited markedly enhanced Meiyu-Baiu rainfall, with a record amount 1.5 times the climatology (~620 mm in June and July 2020).



(a) Precipitation anomaly from the climatology (1981–2010). (b) Precipitation anomaly (colors) and column-integrated moisture flux anomaly (vectors, surface to 100 hPa) , (d) Precipitation (mm/day) averaged in the Meiyu-Baiu region (red box in (b)) in early summer.

Takaya et al. (2020) GRL

Sensitivity experiment to assess tropical influence (1)

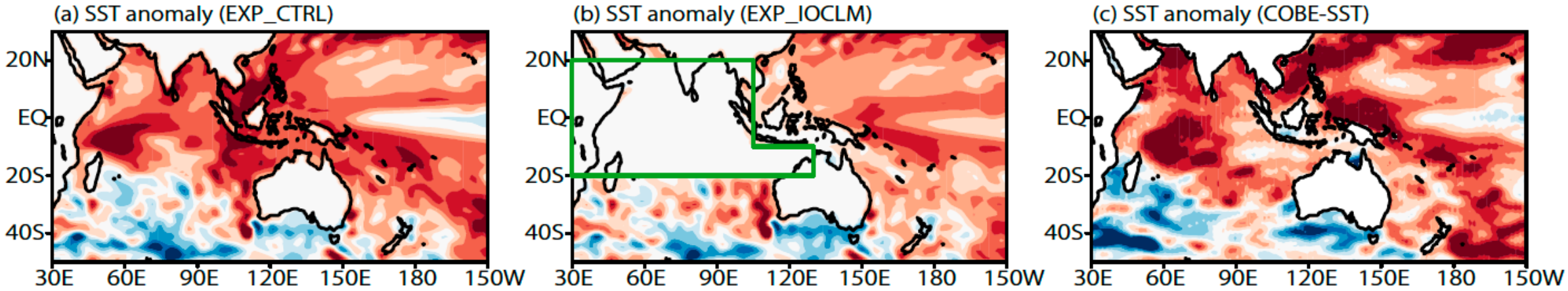
Model: JMA/MRI-CPS2,

Ensemble size: 52 Initial date: 4/26/2020

EXP_CTRL: Control experiment (EXP_CTRL)

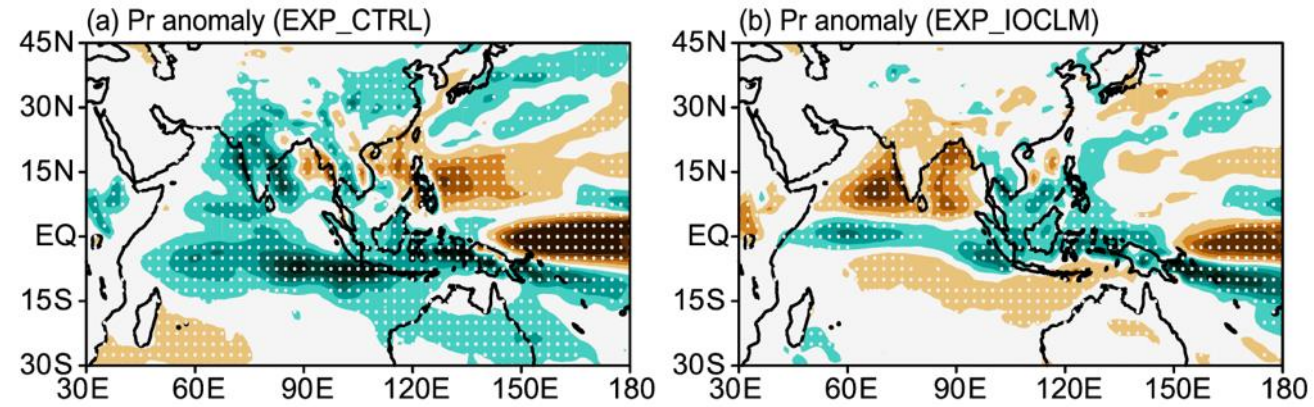
EXP_IOCLM: Sensitivity experiment with a climatological SST condition

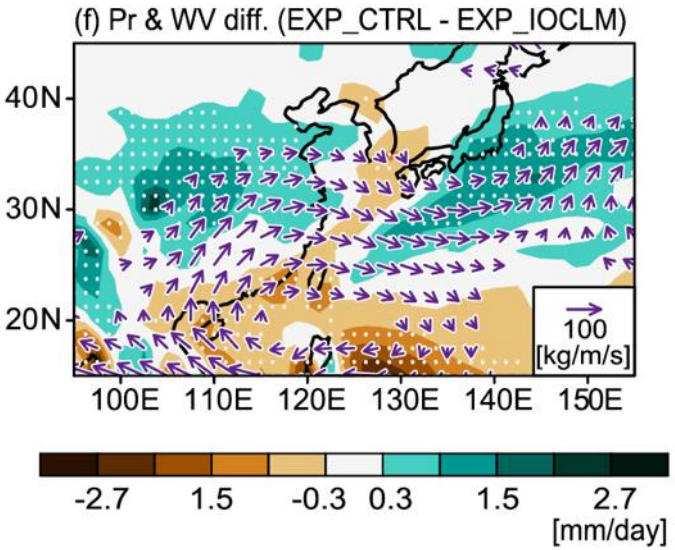
* SSTs in the tropical IO were nudged to the model climatology.



Takaya et al. (2020) GRL

Sensitivity experiment to assess tropical influence (2)





Results of the sensitivity experiments for June-July 2020
Precipitation anomalies simulated from the end of April, 2020 (lead time: 1month)
(a) EXP_CTRL, (b) EXP_IOCLM,
(c) EXP_CTRL – EXP_IOCLM

EXP_CTRL captured above-normal precipitation in the Meiyu-Baiu region (statistically significant at 5%). Whereas, EXP_IOCLM failed to capture it.

→ **This result confirms that the warm IO condition is prerequisite (one of causes) for the extreme Meiyu-Baiu rainfall in 2020.**

Takaya et al. (2020) GRL

What did cause the warm IO? (1)

Mechanisms of IO warming in summer 2020

① **Autumn 2019：Positive phase of Indian Ocean Dipole mode and high SST in the western-central equatorial Pacific** cf. Doi et al. 2019 *GRL*

② Autumn-winter 2019：Record strong downwelling Rossby wave

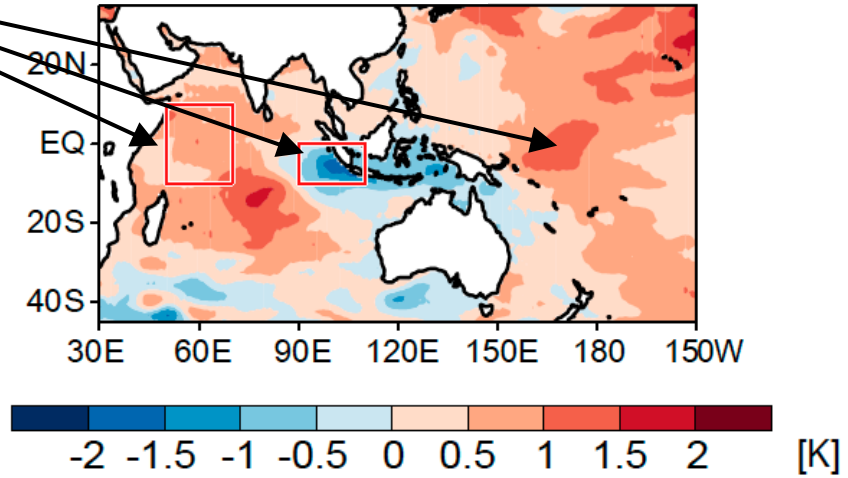
③ Spring 2020：SST warming in the southwestern tropical IO

④ Early summer 2020：Weakened monsoon flow

⑤ Early summer 2020：SST warming in North IO and SCS

⑥ Early summer 2020：Southwestward extension of subtropical high over the tropical WNP and intensified Meiyu-Baiu rainfall

SST anomalies in Aug-Oct 2019



What did cause the warm IO? (2)

Mechanisms of IO warming in summer 2020

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② Autumn-winter 2019：Record strong downwelling Rossby wave cf. Du et al. 2020 *GRL*

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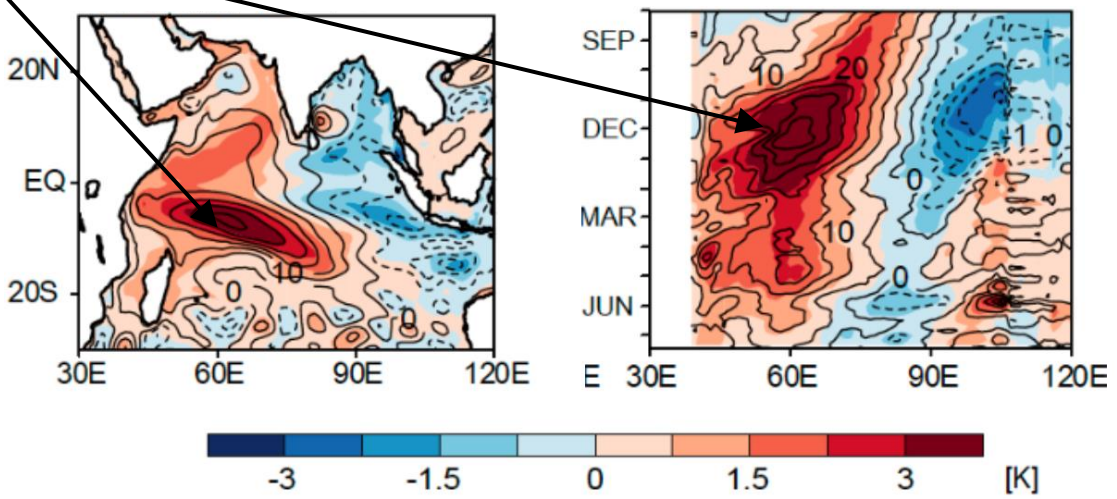
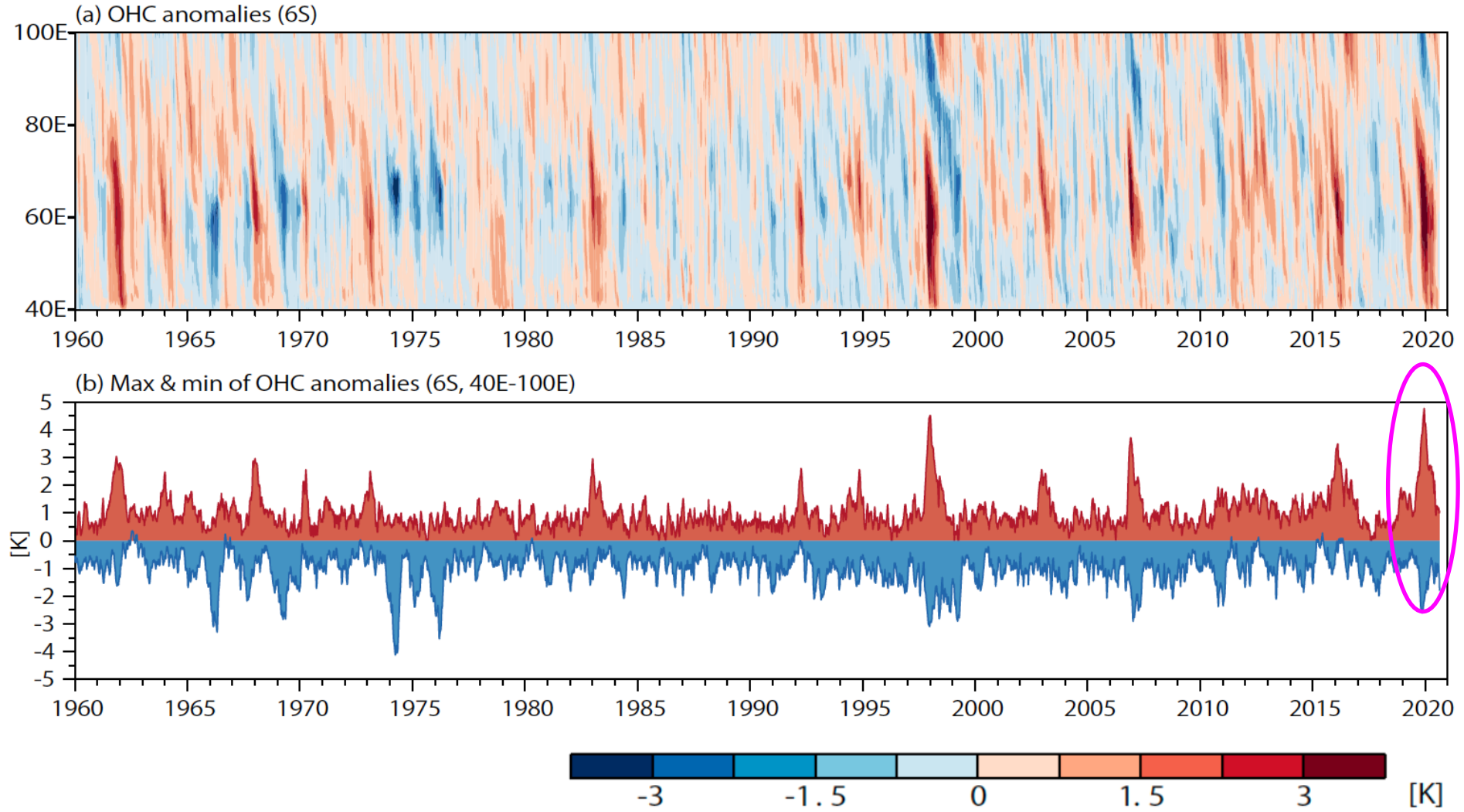
Nov 2019-Jan 2020 Subsurface temp. Anomalies (0-300 m, color) Sea level height anomalies (contour)

6S time-longitude section subsurface temp. anomalies (0-300 m, color)・Sea level height anomalies (contour)



What did cause the warm IO? (3)

Record strong downwelling Rossby wave in the off-equatorial southern IO



What did cause the warm IO? (4)

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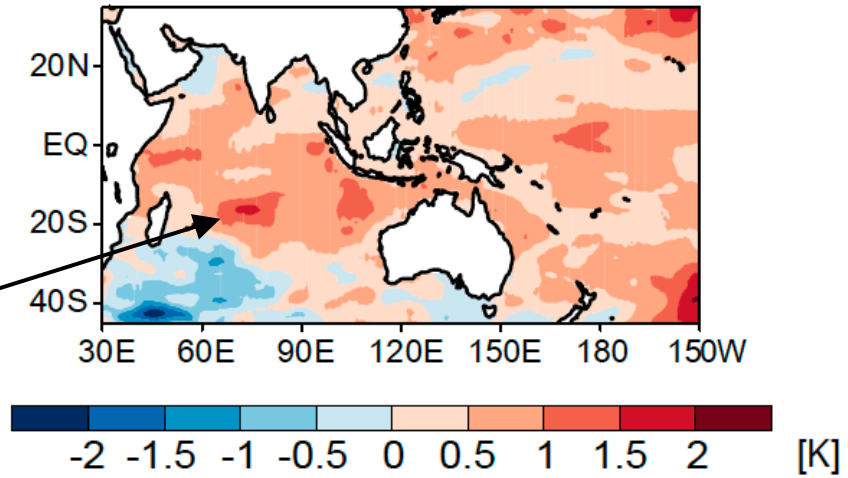
Feb.-Apr. 2020 SST anomalies



What did cause the warm IO? (5)

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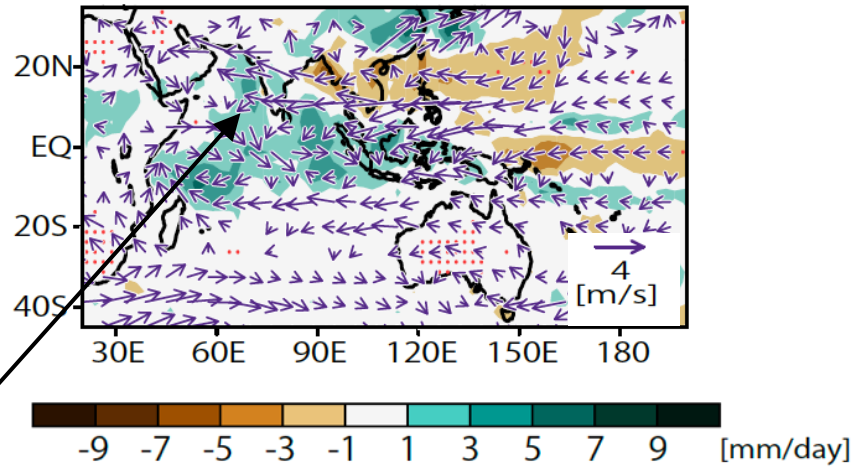
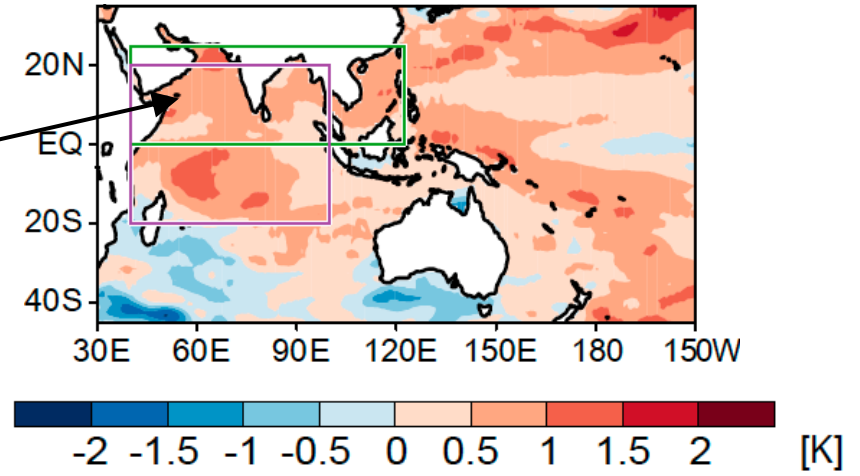
May-Jul. 2020 rainfall, 850hPa wind anomalies

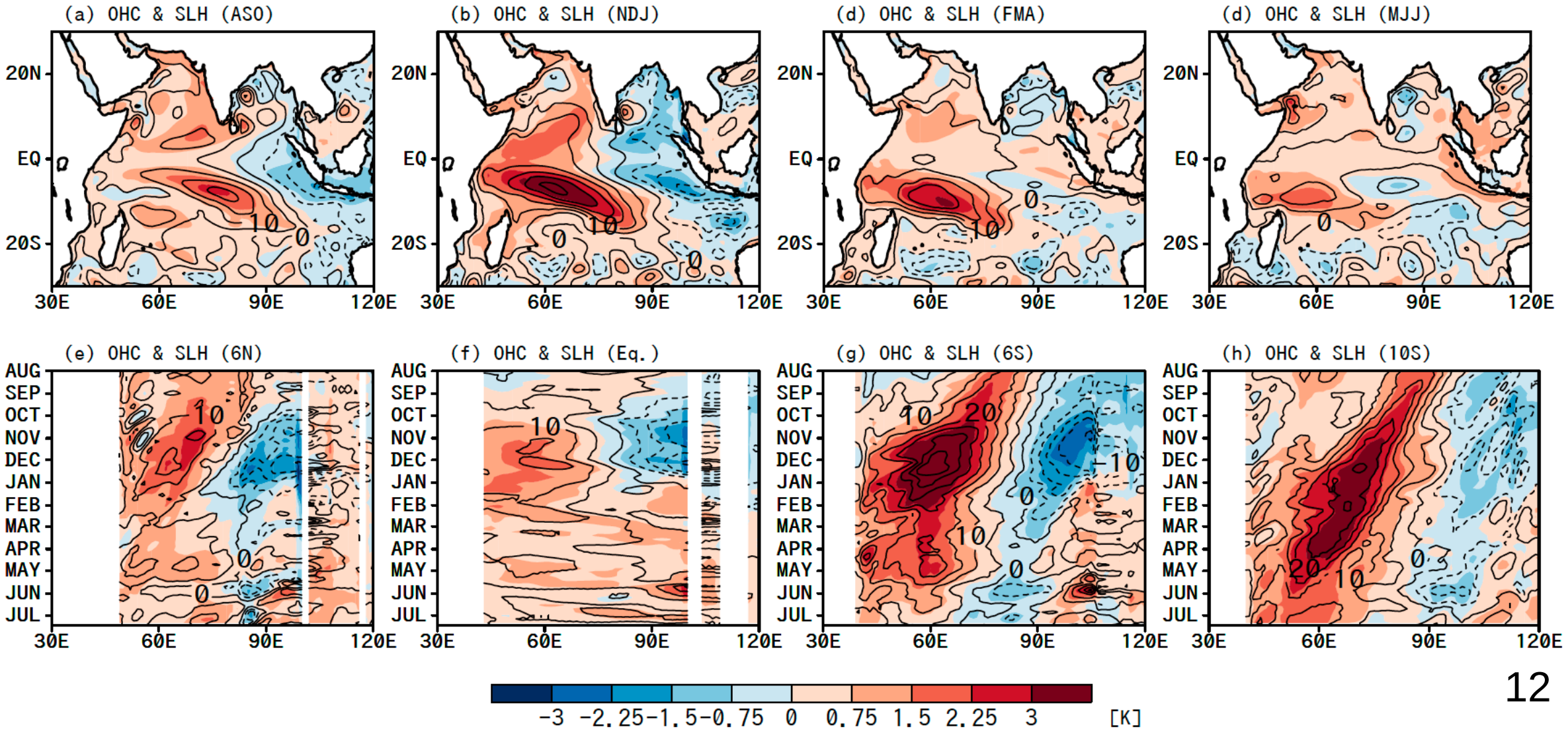


May-Jul. 2020 SST anomalies



IO variability is well analyzed in the current observation network

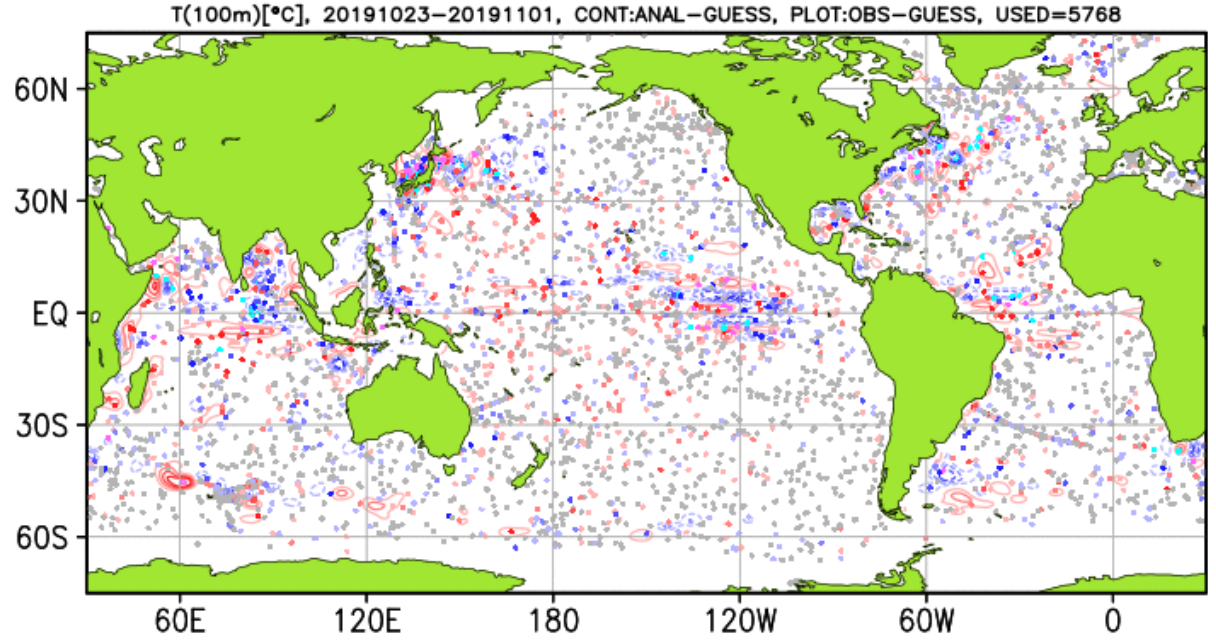
JMA global ocean analysis (MOVE/MRI.COM-G2)



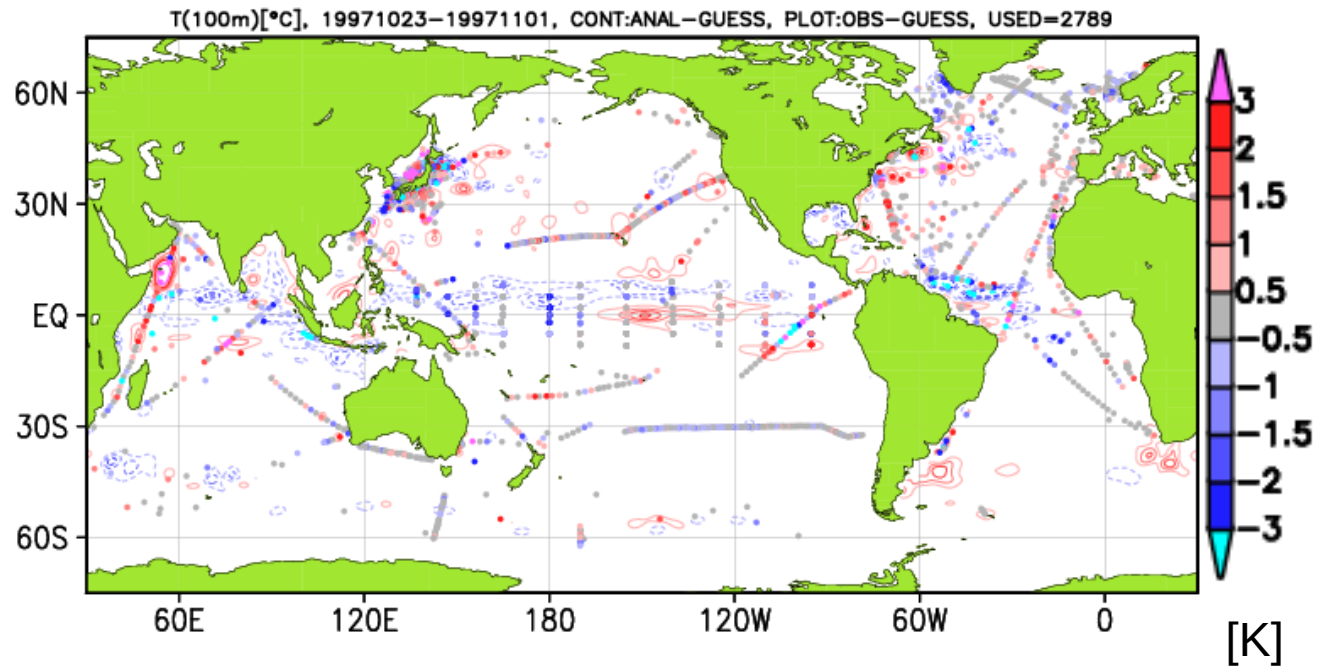
Ocean observation is essential!

Increments (A-B, contours) and departure (O-B, dots) of in-situ obs. Temperature at 100-m depth(MOVE/MRI.COM-G2)

2019 Nov.



1997 Nov.



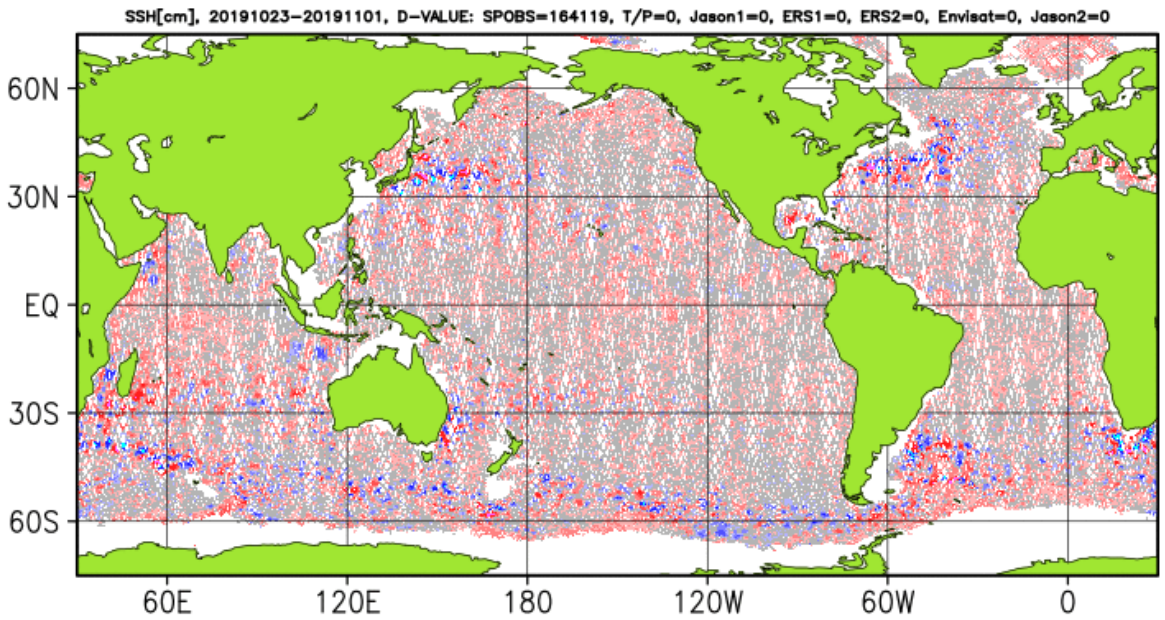
Increased ocean sub-surface observations enable better analysis of ocean states.

Courtesy H. Sugimoto (JMA)

Ocean observation is essential!

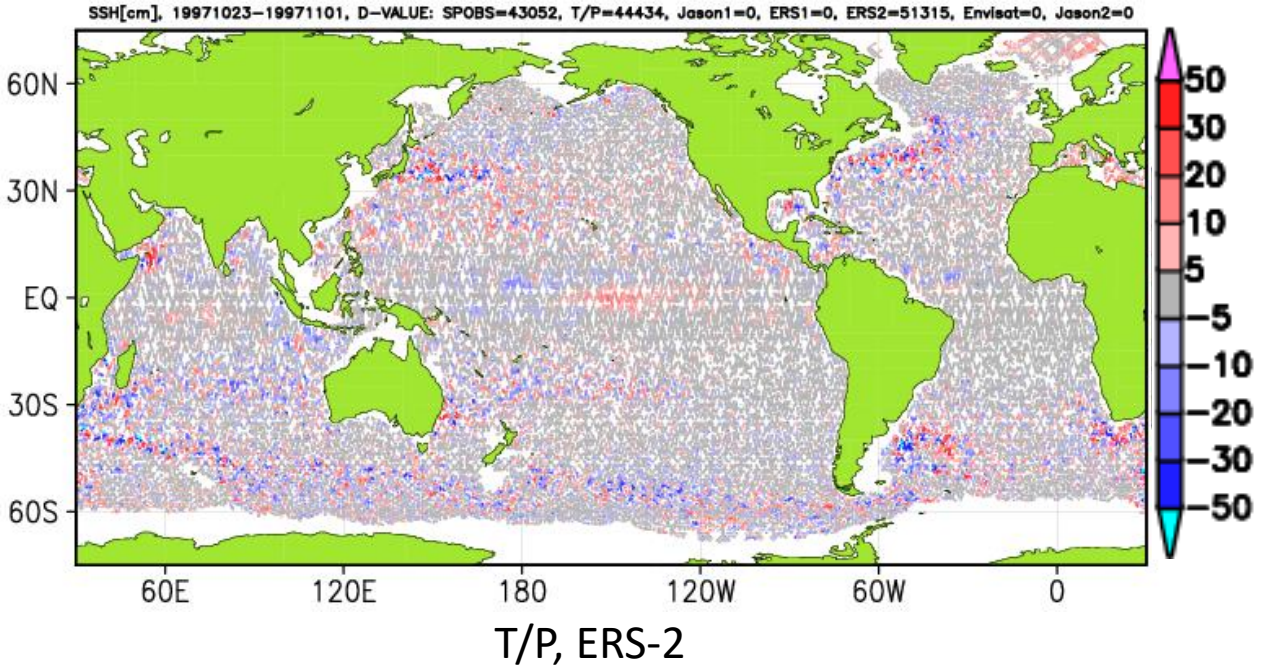
Departure (O-B, dots) of SSH (MOVE/MRI.COM-G2)

2019 Nov.



AltiKA, CryoSAT2, Jason3

1997 Nov.



T/P, ERS-2

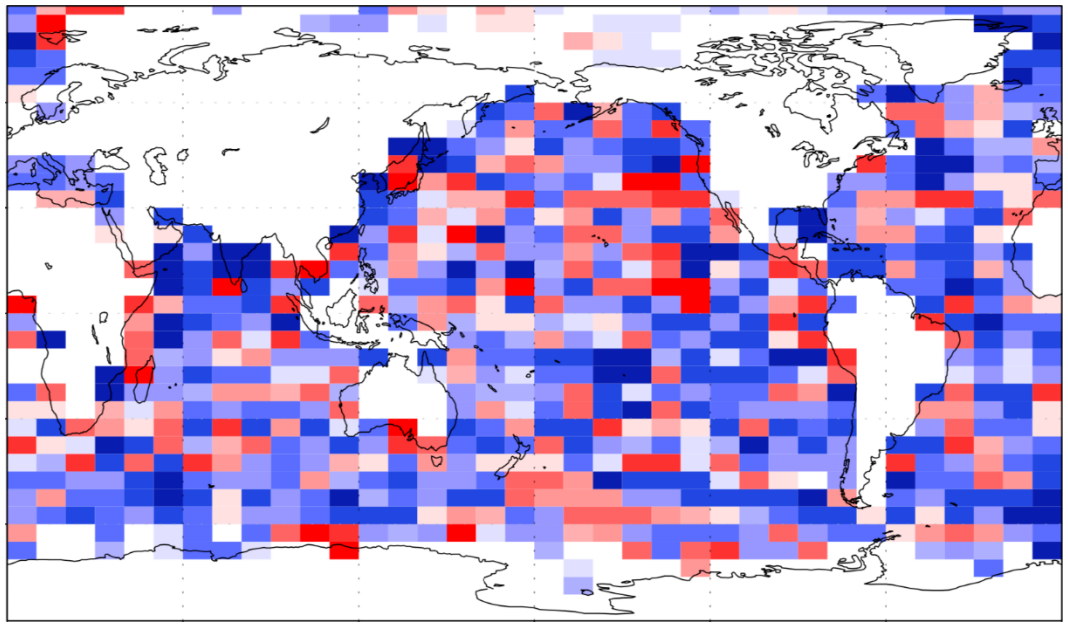
Increased satellite observations enable better analysis of ocean states.

Courtesy H. Sugimoto (JMA)

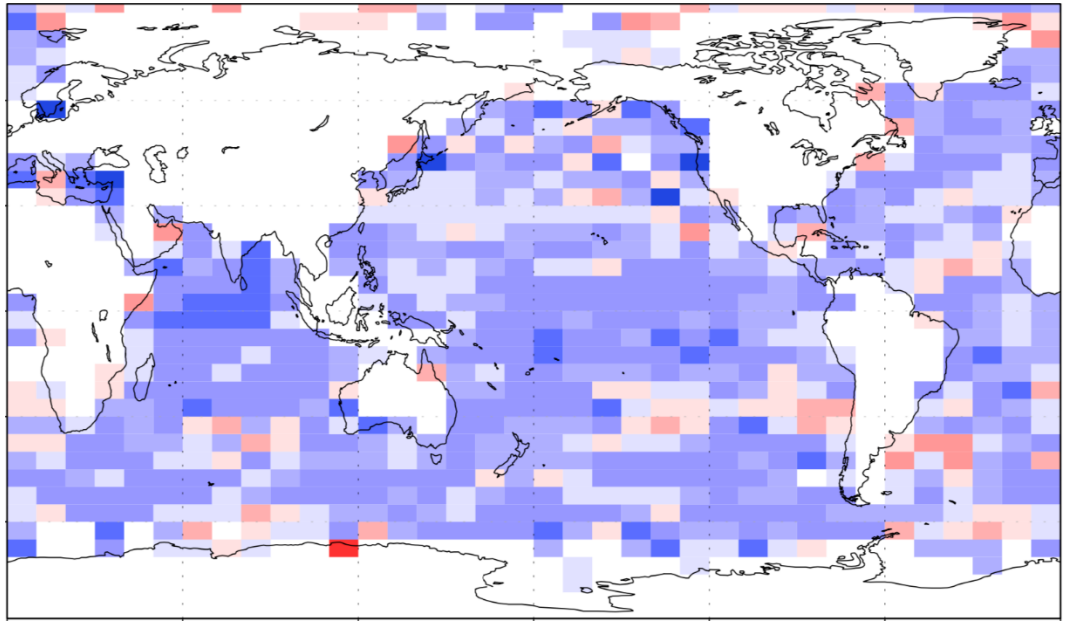
Ocean observation is essential!

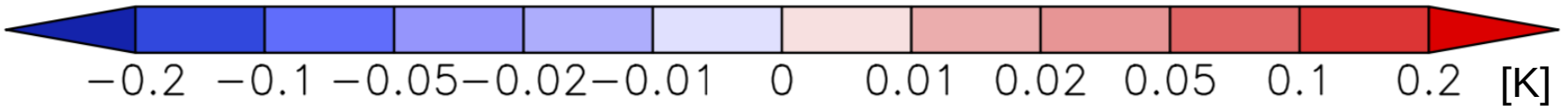
Impact of Algo floats, Analysis (w/ Algo) – Analysis (w/o Algo)

Bias (T at 100m)



RMSE (T at 100m)



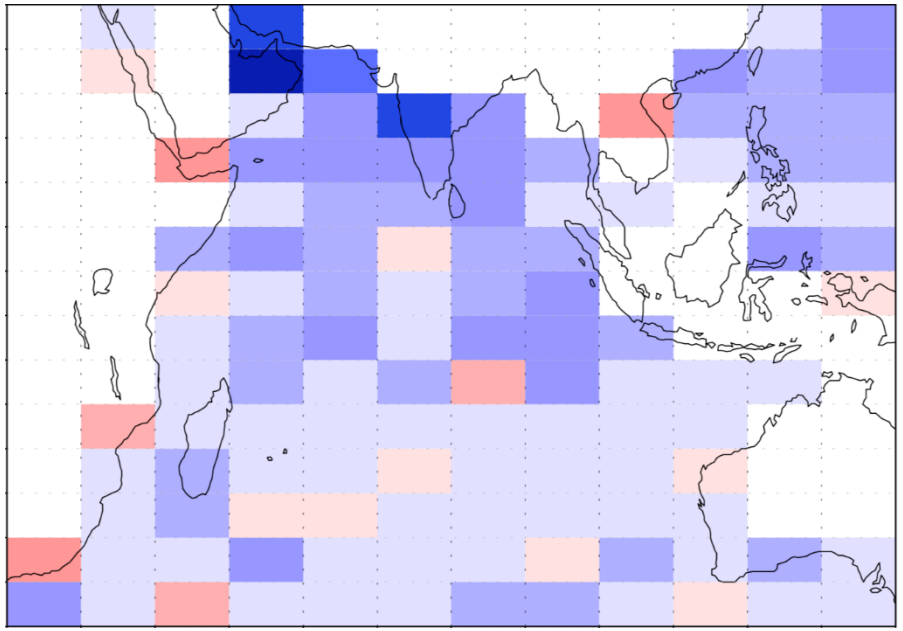


MOVE/MRI.COM-G3

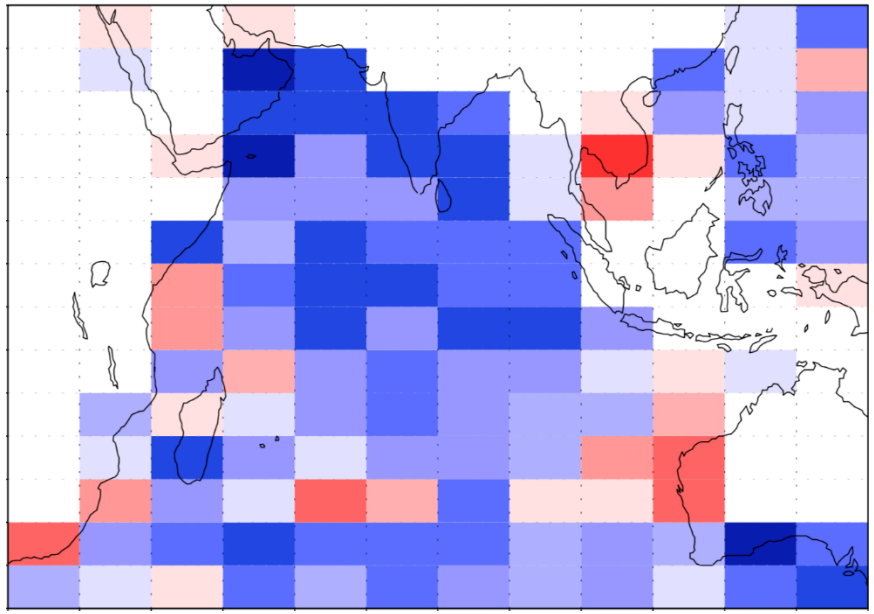
Ocean observation is essential!

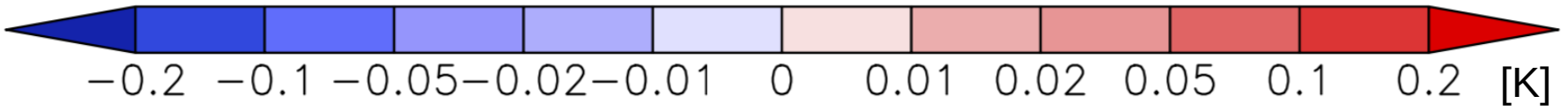
Impact of Algo floats, Analysis (w/ Algo) – Analysis (w/o Algo)

RMSE (T at 25m)



RMSE (T at 50m)





MOVE/MRI.COM-G3

Concluding remarks

- Tropical oceans play a pivotal role in modulating weather and climate in East Asia.
- The developing ocean observation network has offered better capability in monitoring ocean states and predicting sub-seasonal to seasonal climate conditions. Now we can better capture what is going on in the sub-surface ocean.
- Considering forthcoming coupled medium-range prediction, in general, further enhancement of the ocean observation is desired, but we need more justification (qualitative assessment) for such investments.
- Thus, a strong international collaboration on the observation impact studies is recommended.

Takaya, Y., Ishikawa, I., Kobayashi, C., Endo, H., & Ose, T. (2020). Enhanced Meiyu-Baiu rainfall in early summer 2020: Aftermath of the 2019 super IOD event. *Geophysical Research Letters*, 47, e2020GL090671. https://doi.org/10.1029/2020GL090671

Thank you for your kind attention.

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