Sea surface pCO_2 in the Eastern North Pacific during the marine heatwave of August 2025

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Marine heatwave and its impact

Marine heatwave (MHW) is defined as
"*a period during which water temperature is abnormally warm for the time of the year relative to historical temperatures, with that extreme warmth persisting for days to months*" in IPCC AR6.

Examples of adverse impacts

- Mass mortalities [Garrabou et al., 2022]
- Coral breaching [Couch et al., 2017]
- Record-Breaking hot summer [Okajima et al., 2025]
- Intensification of tropical cyclones [Radfer et al., 2026]

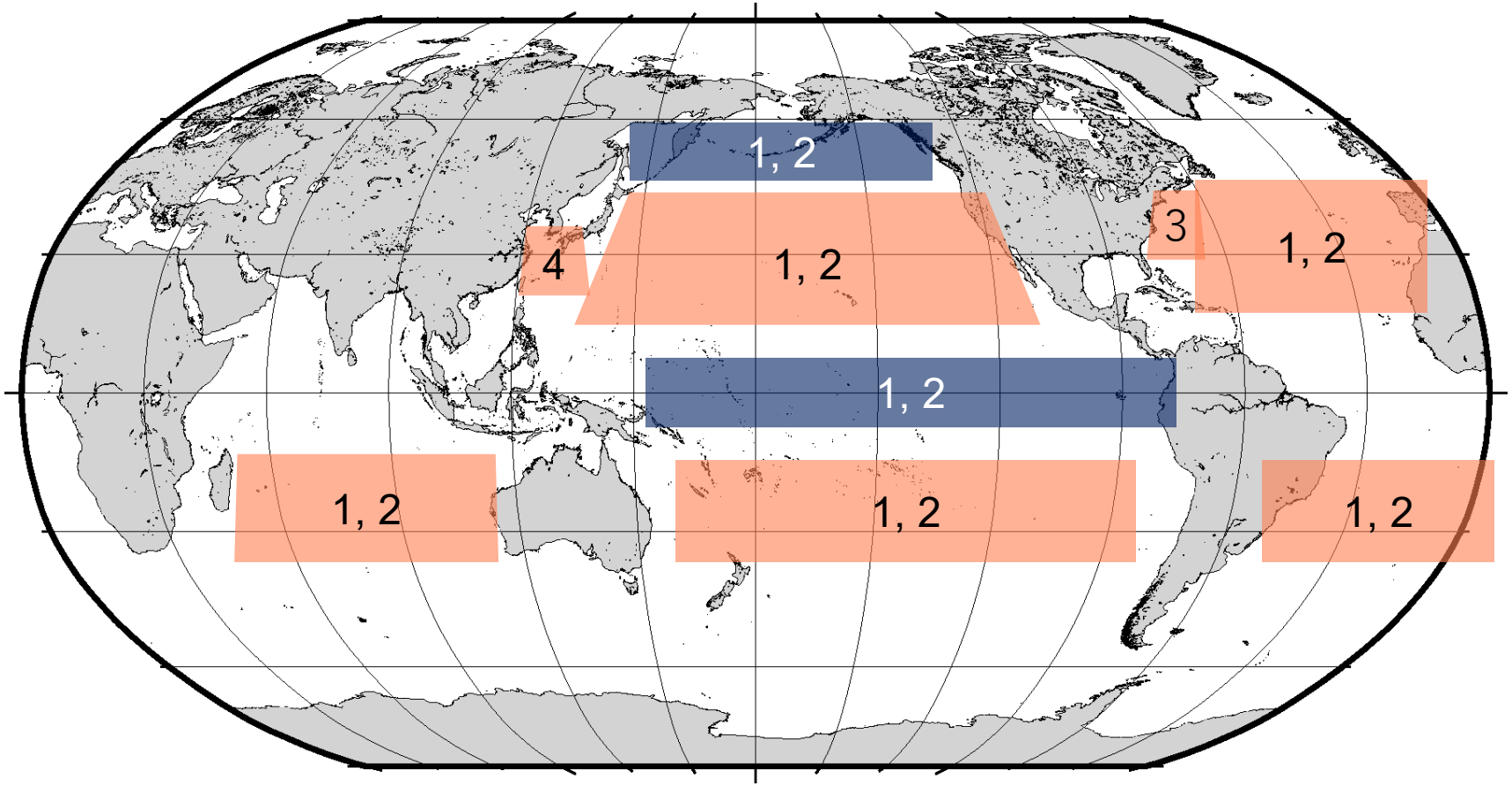
Reported pCO_2 anomaly under MHWs

Thermodynamically, the partial pressure of CO_2 (pCO_2) in seawater increases as the water temperature rises.

pCO_2 in MHWs

Higher (red)

Lower (blue)

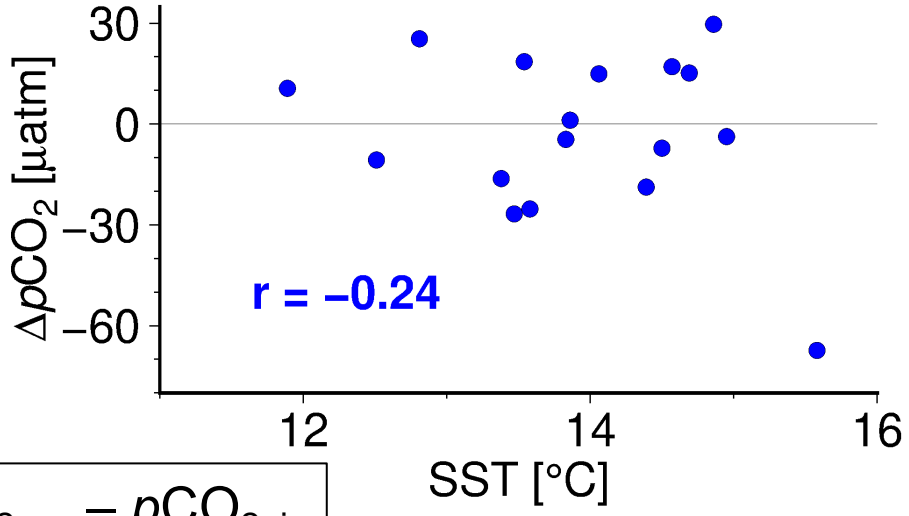


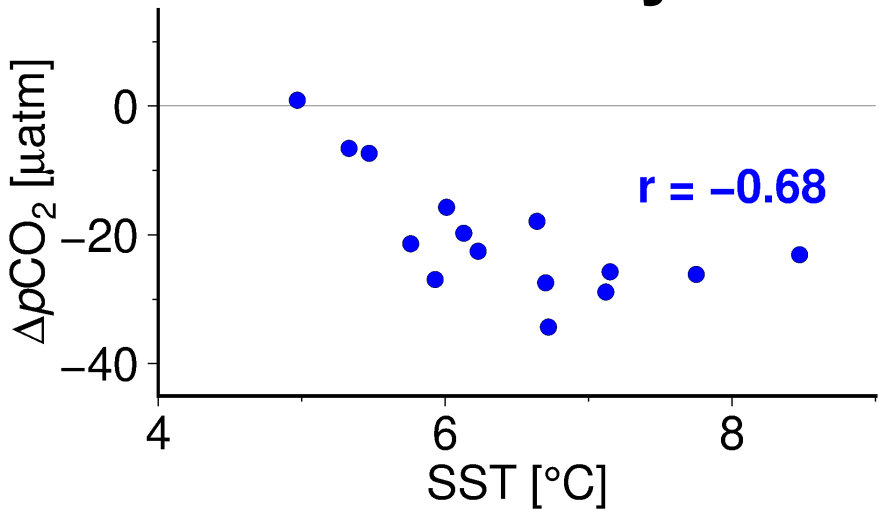
Sources

1: Mignot et al. [2022]
2: Li et al. [2024]
3: Edwing et al. [2024]
4: Ren et al. [2025]

MHWs & pCO_2: Varied by both region and season

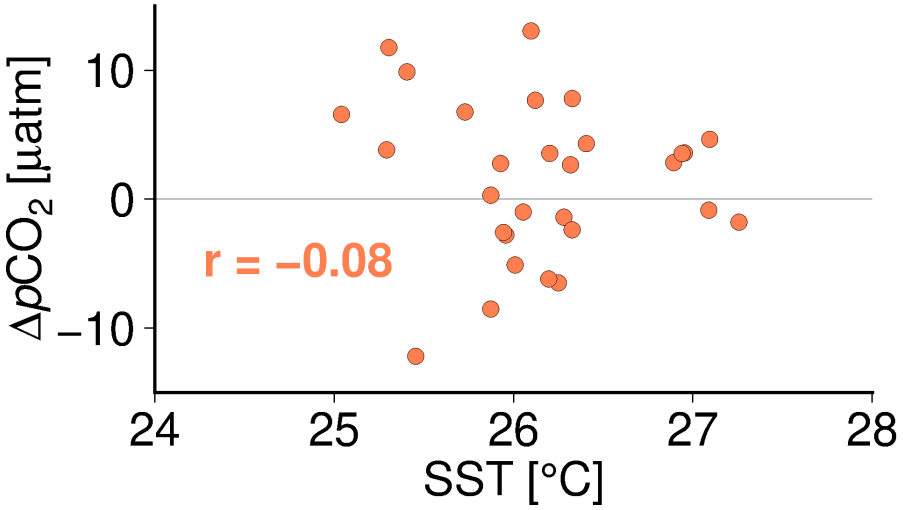
Station P (50°N 145°W)

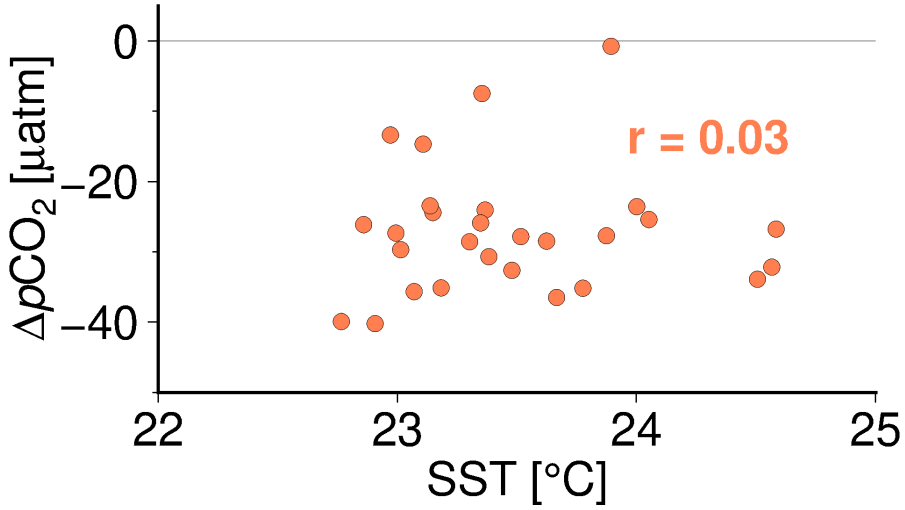




Y-axis: $\Delta pCO_2 = pCO_{2sea} - pCO_{2air}$

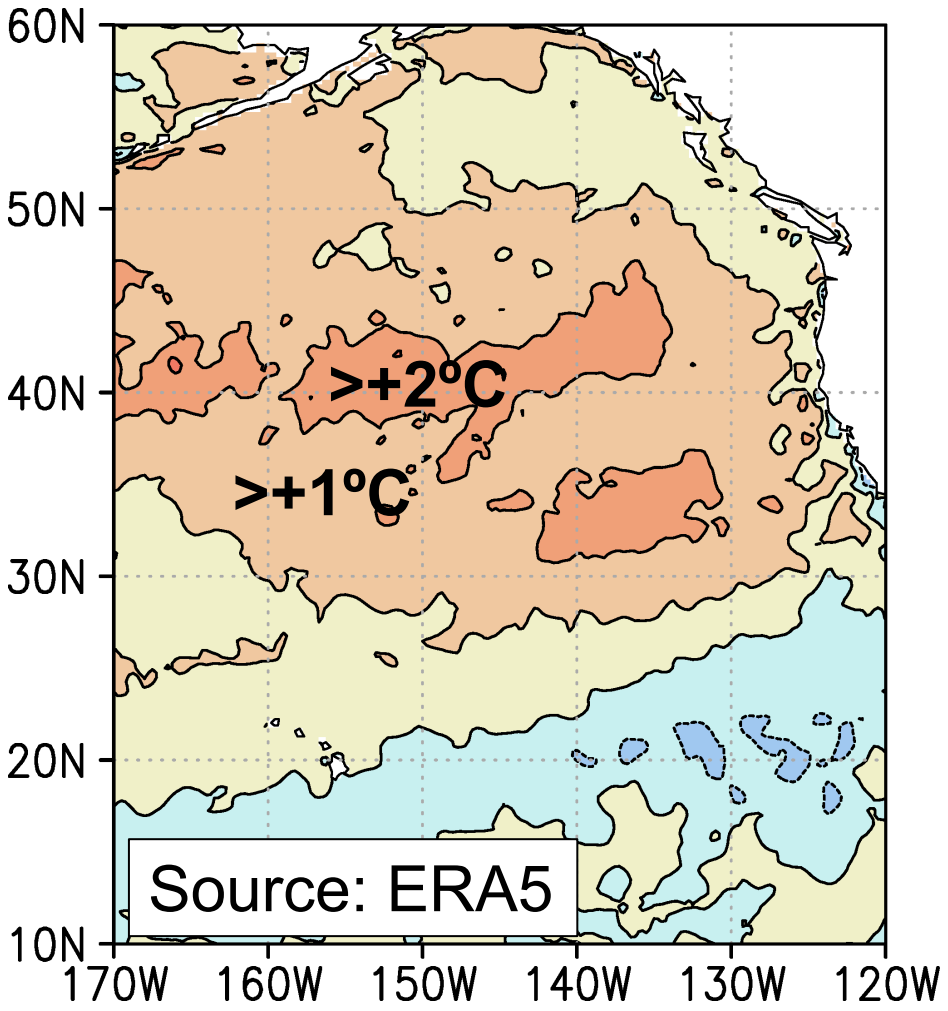
Station ALOHA (23°N 158°W)



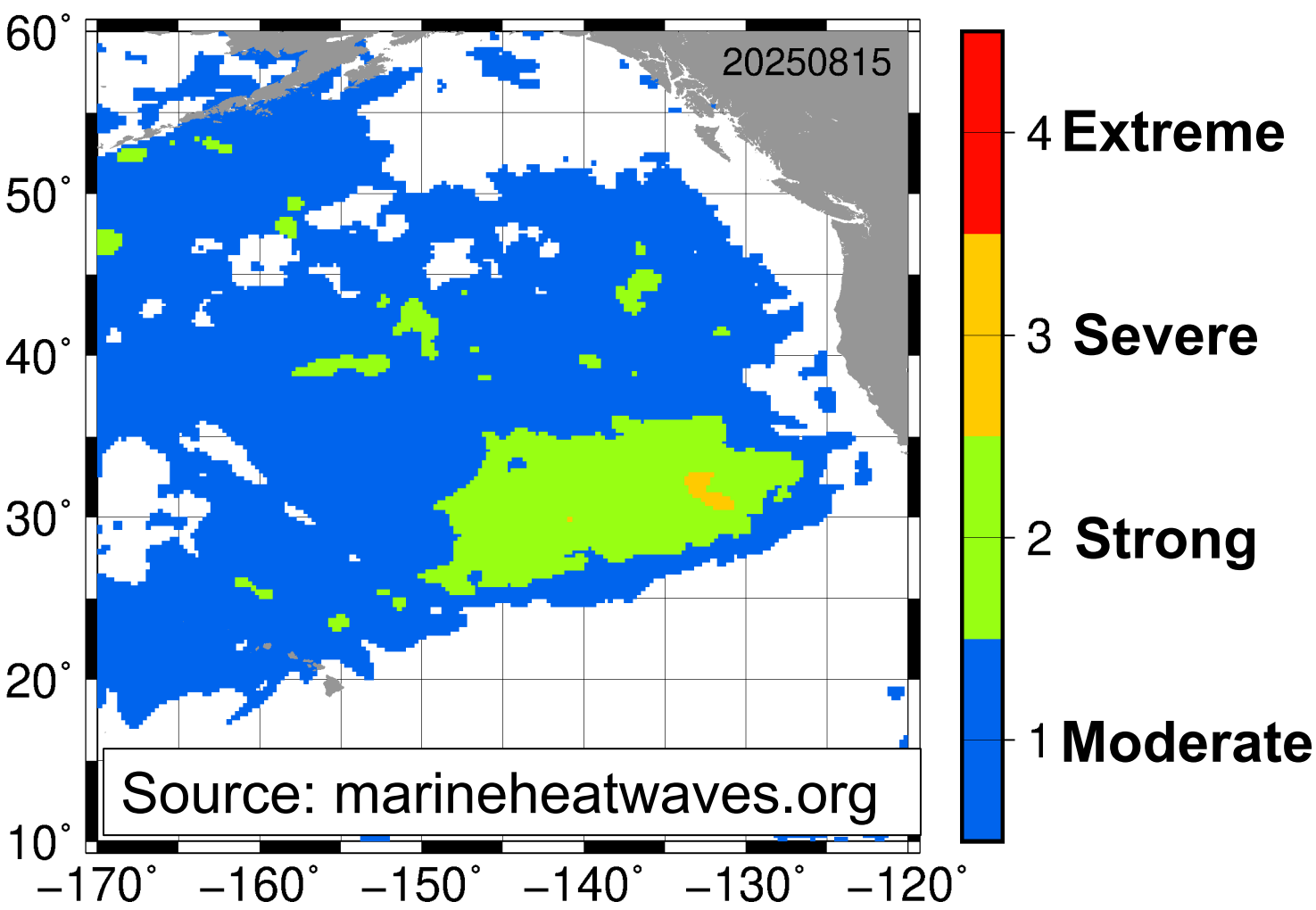


A timely opportunity for assessing MHWs impacts

SST anomaly in August 2025

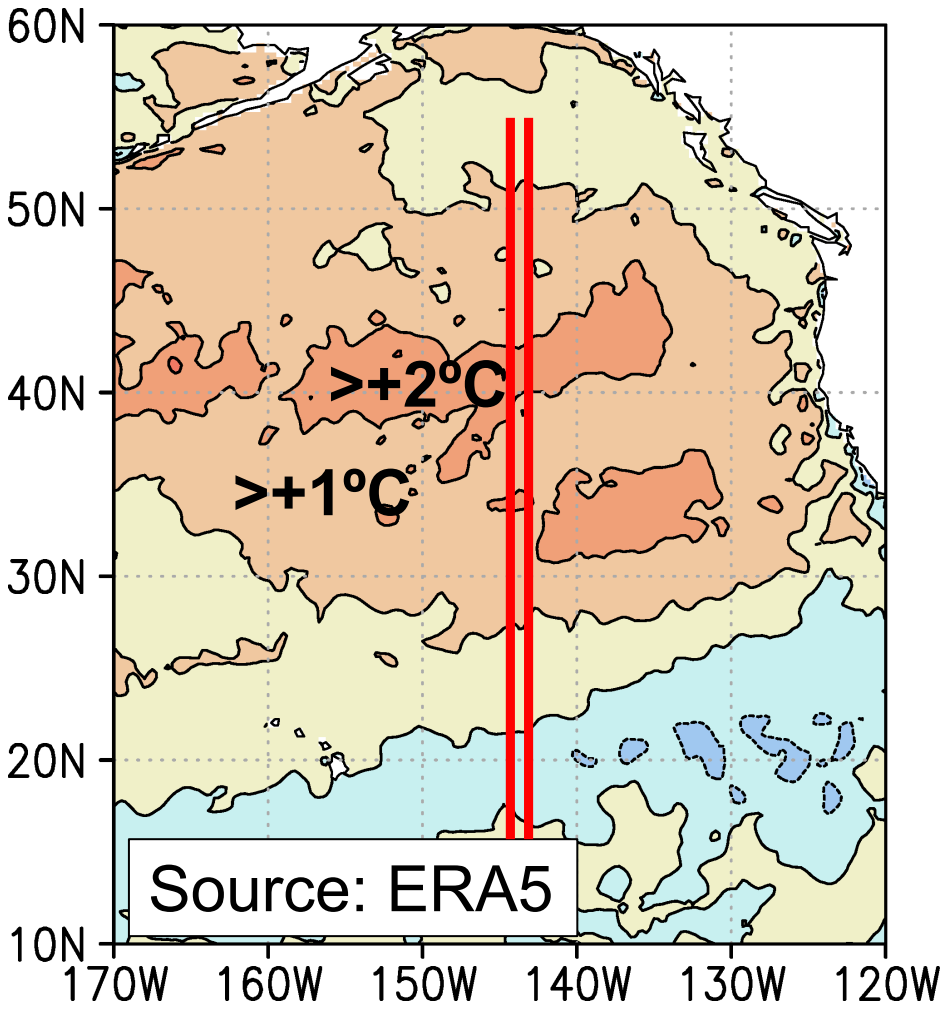


MHW index on 15th Aug. 2025

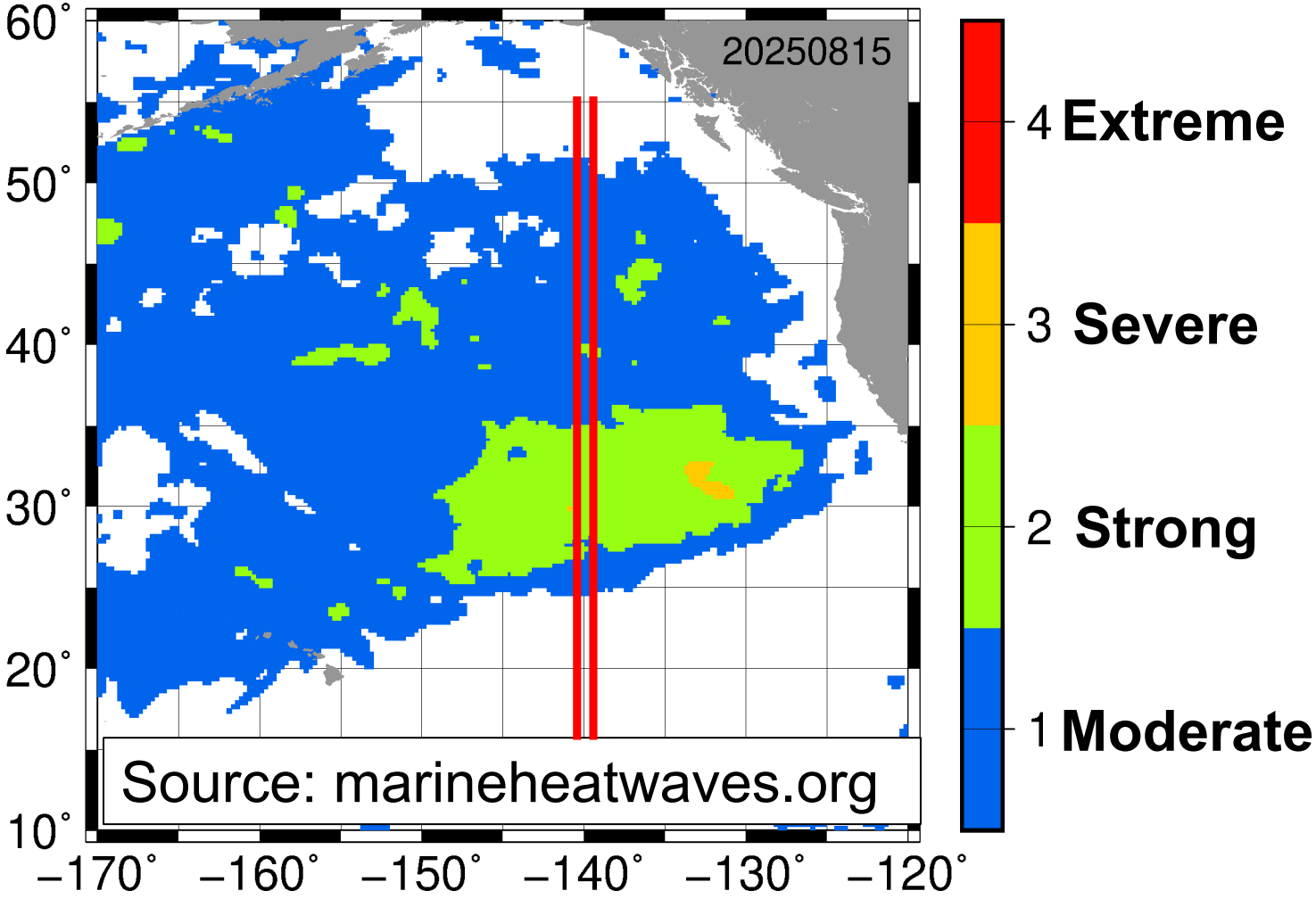


A timely opportunity for assessing MHWs impacts

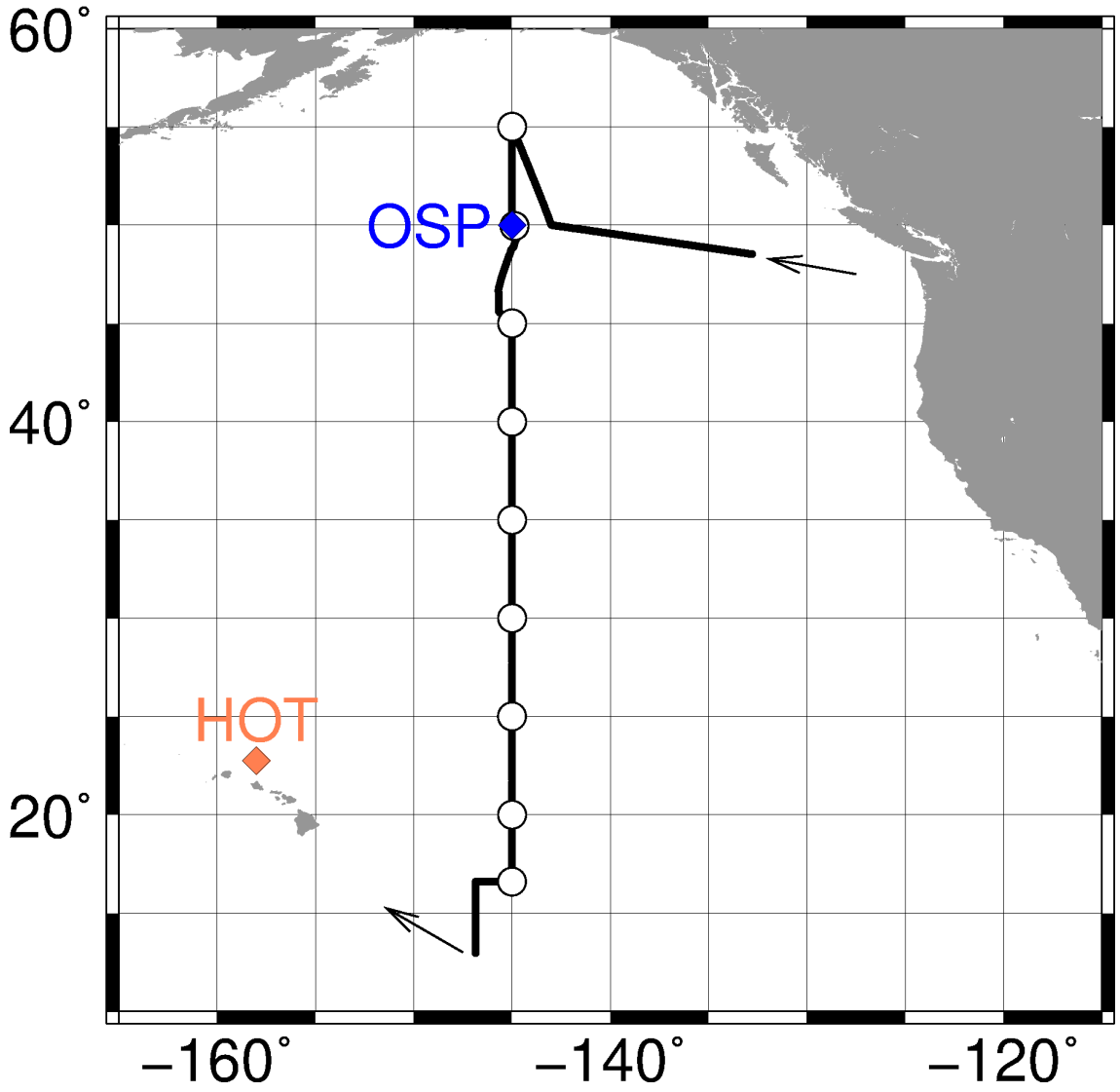
SST anomaly in August 2025



MHW index on 15th Aug. 2025



Cruise summary



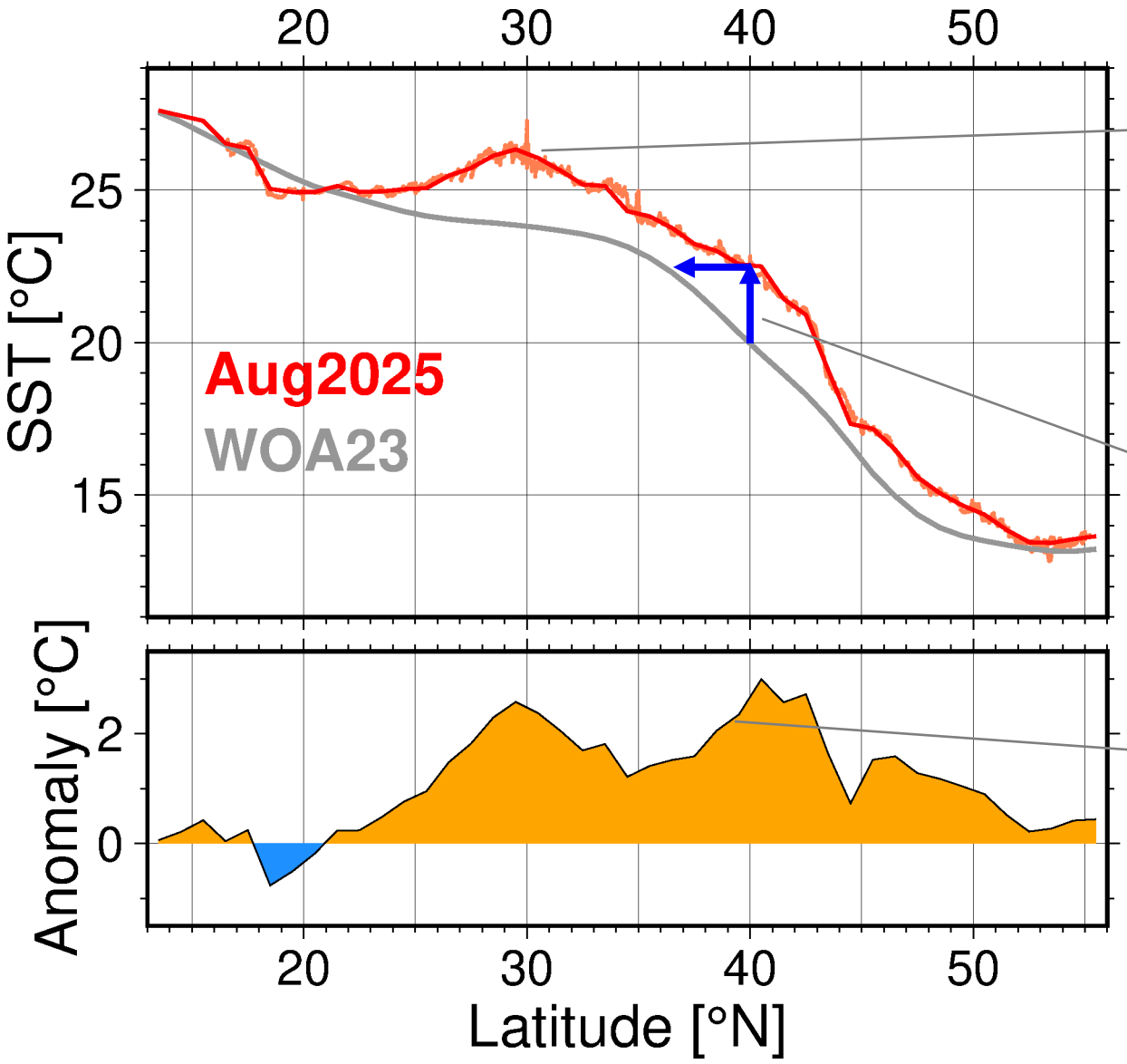
R/V *Hakuho-maru* KH-25-4 cruise
Aug. 07, 2025 (Vancouver) -
Sep. 04, 2025 (Honolulu)

Underway measurement of pCO_2
with *CRDS (Picarro, G2301)

*Cavity Ring-down Spectroscopy

CTD observations along 145ºW
(17º-55ºN; 9 stations)

In-situ MHWs observed by ship



Meridional SST peak

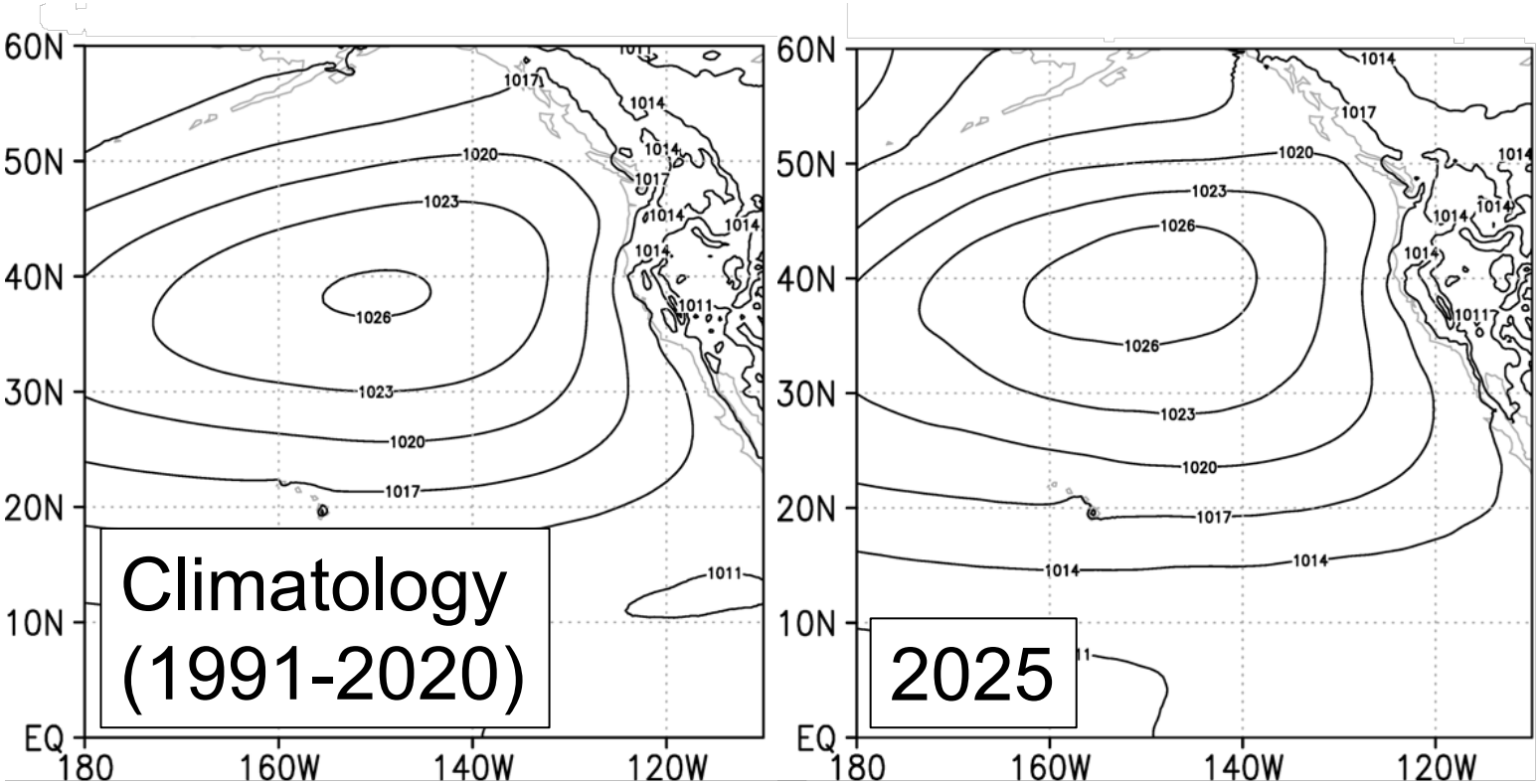
Equivalent to
about 3º shift in latitude

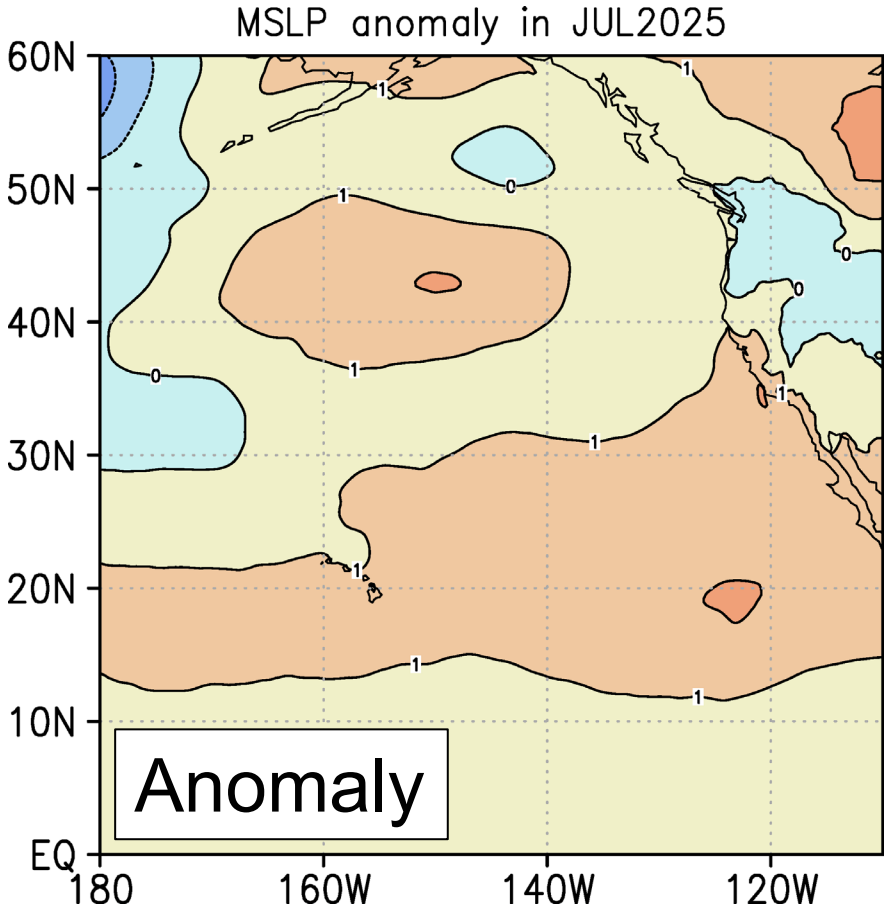
Anomalous high SST
(close to +3ºC)
around 30º-40ºN

Strong subtropical high: the main driver of the MHWs?

Mean sea level pressure (MSLP) in July

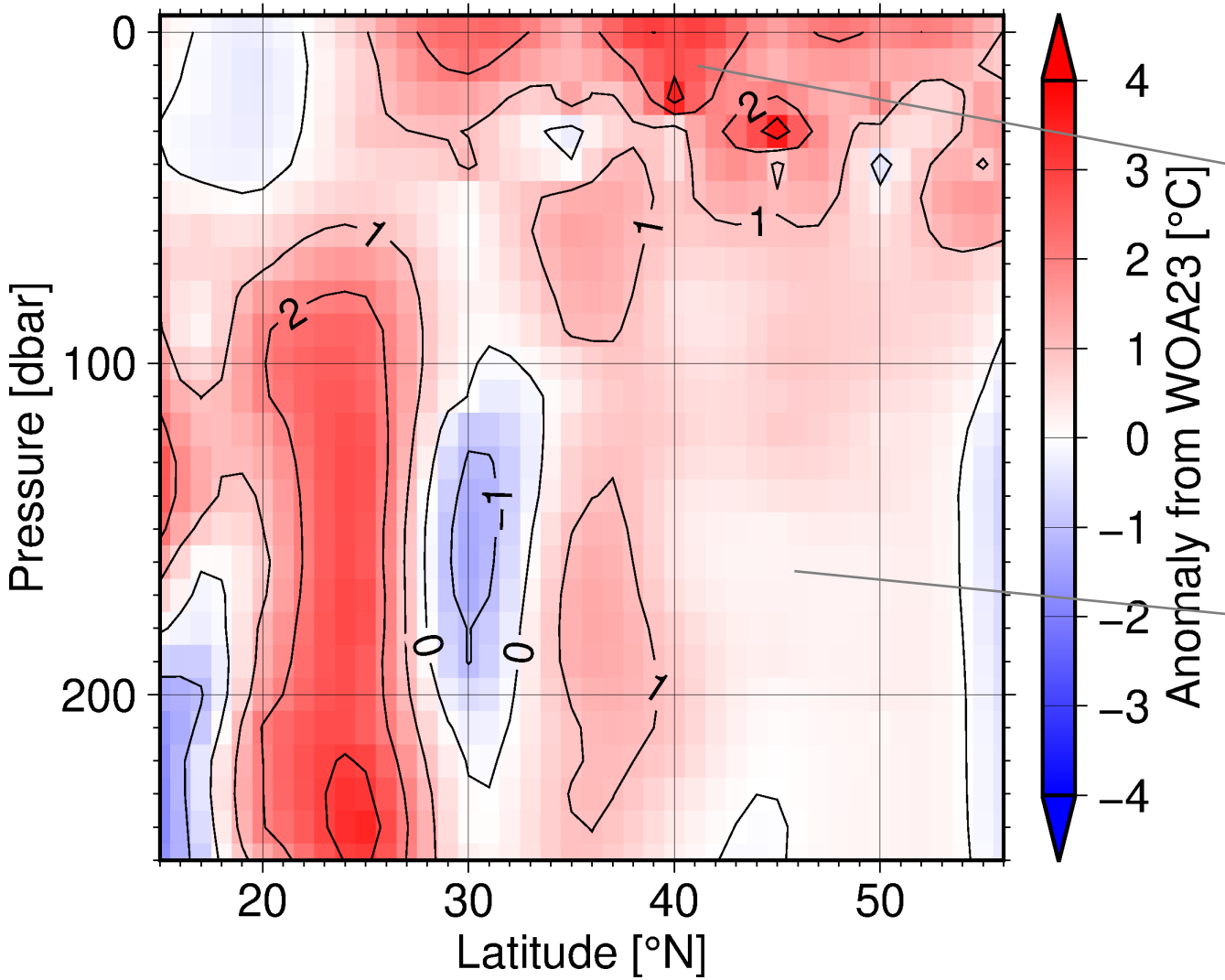
Source: ERA5





Near-surface anomalies imply atmospheric heat input

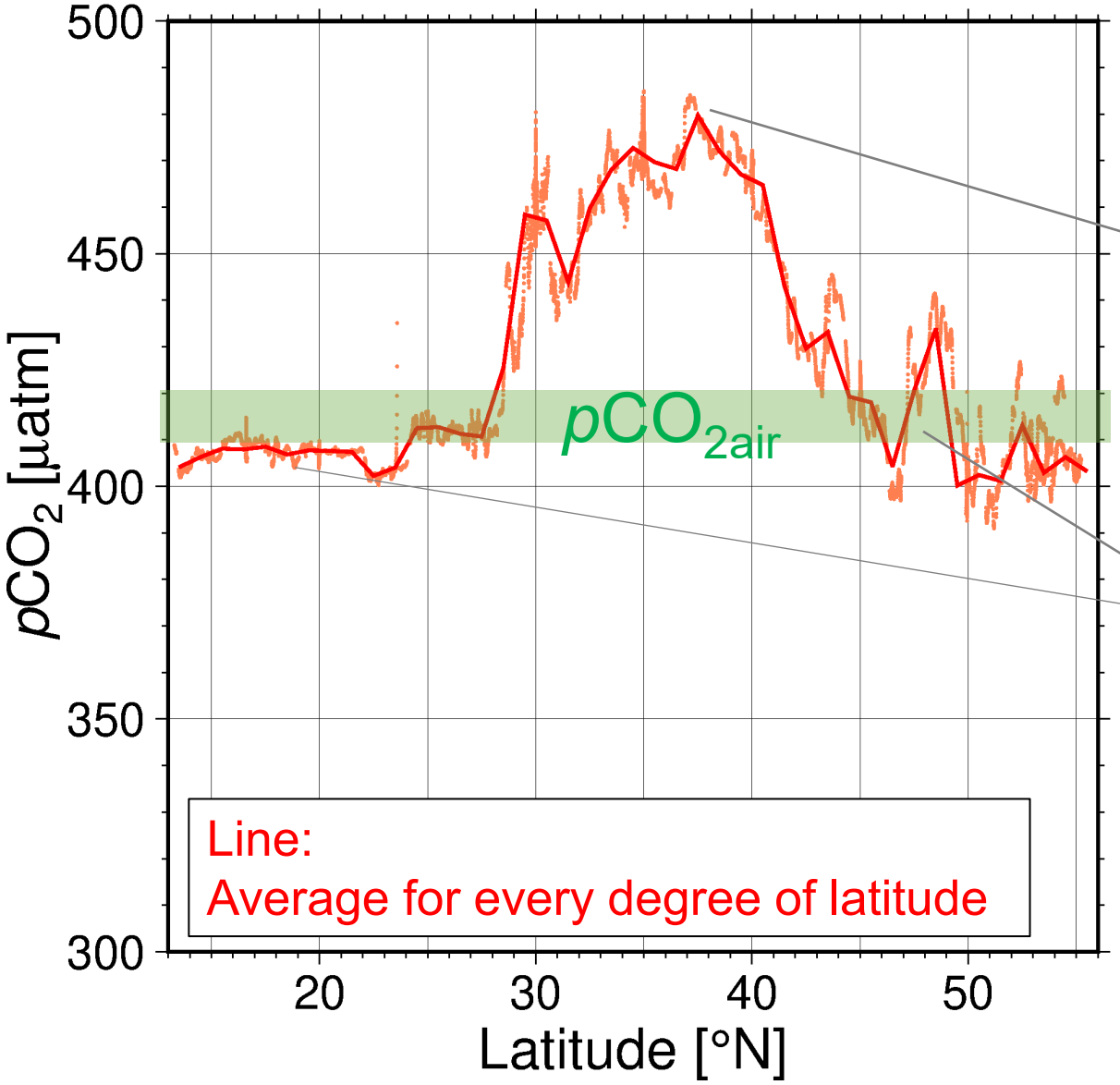
Column temperature anomaly in August 2025 (relative to WOA23)



Pronounced warming concentrated in top 50m.

No significant temperature anomalies in the deep layers.

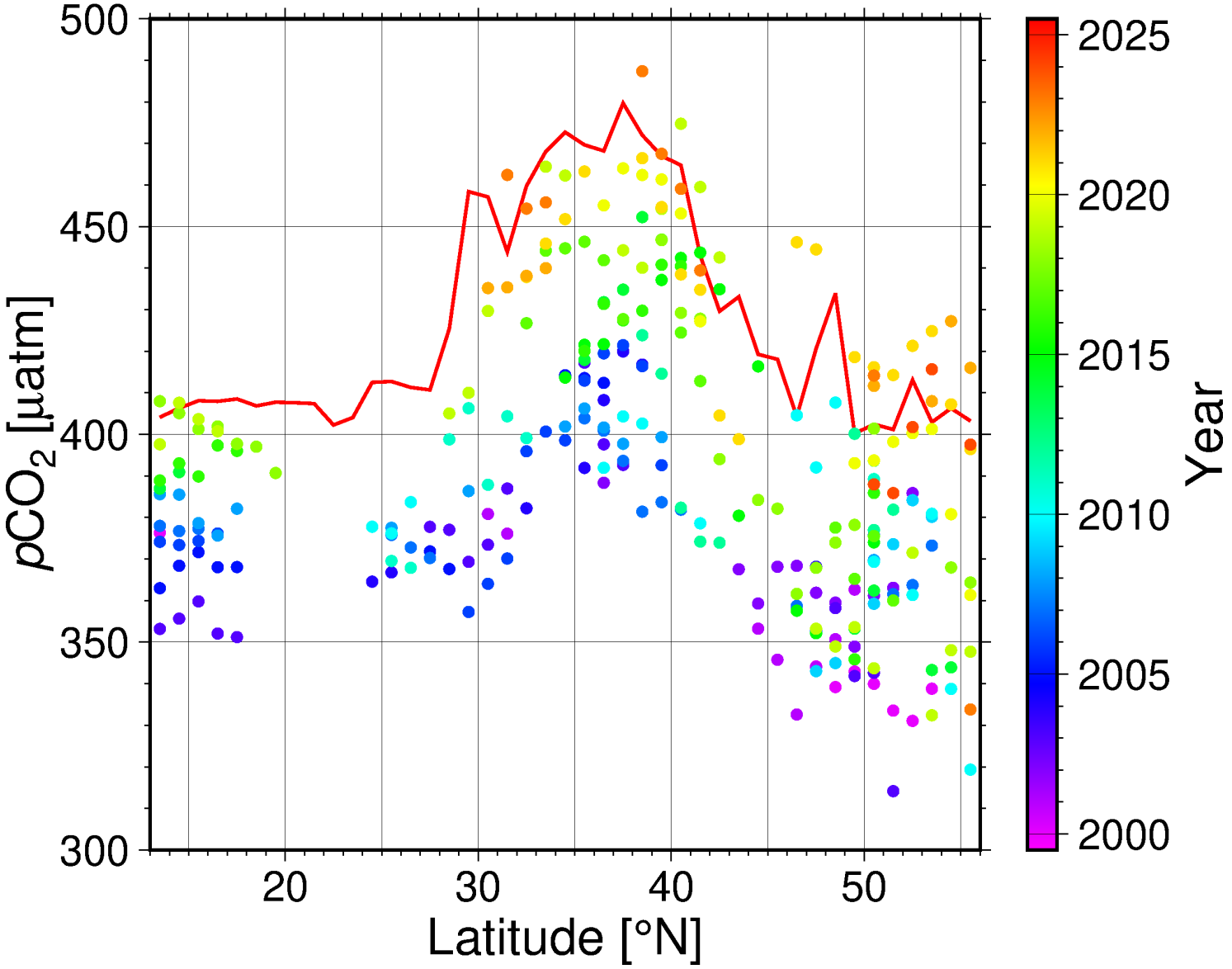
In-situ pCO_2: Meridional maximum in mid-latitude



Meridional pCO_2 peak
$pCO_{2sea} > pCO_{2air}$
CO_2 release from the ocean

Close to the atmospheric pCO_2 outside the peak

Comparison with past pCO_2 in the NE Pacific

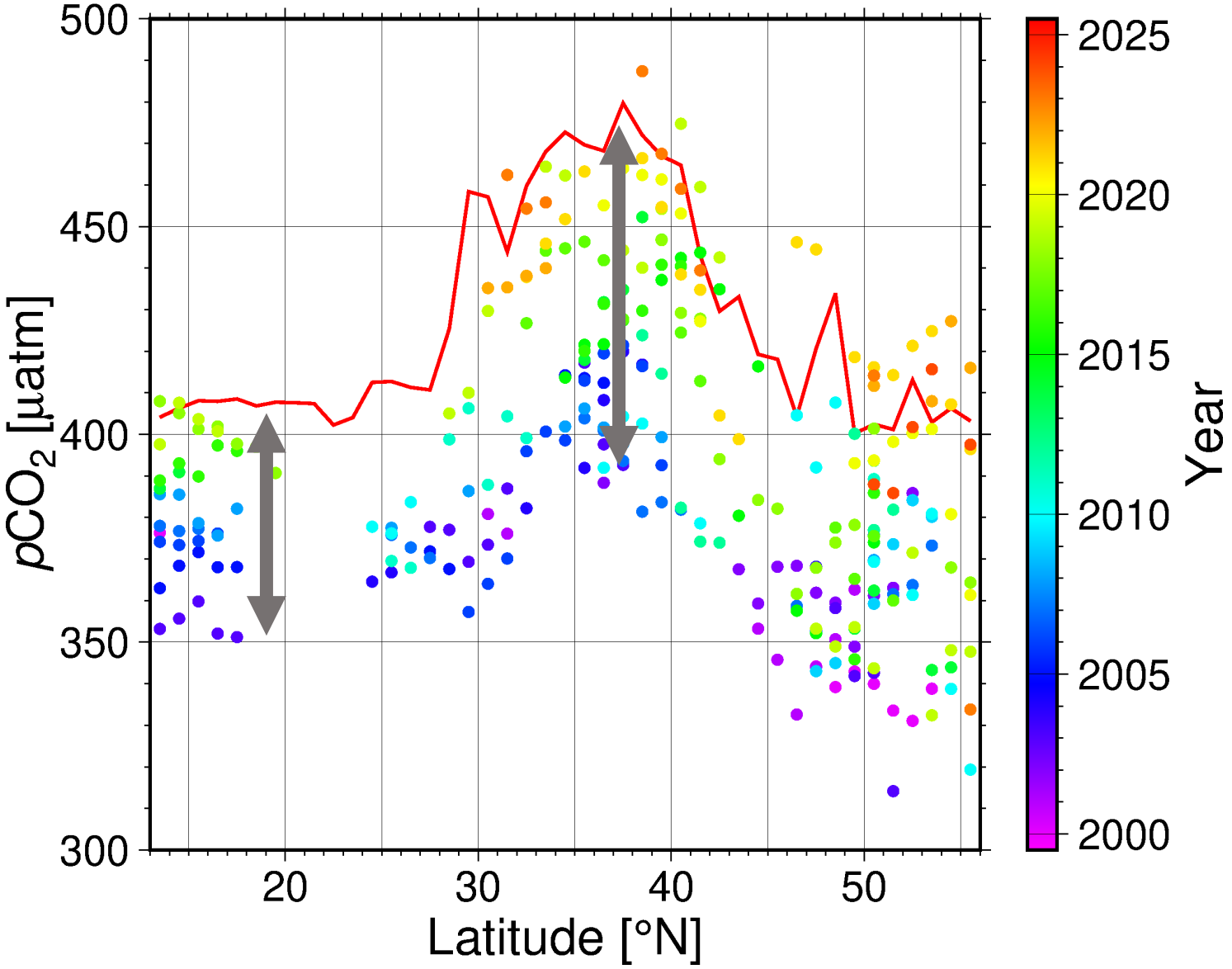


Source:

SOCAT gridded data

- Lon: 140º-150ºW
- Lat: 13º-56ºN
- Jul., Aug. and Sep.

Comparison with past pCO_2 in the NE Pacific



Source:

SOCAT gridded data

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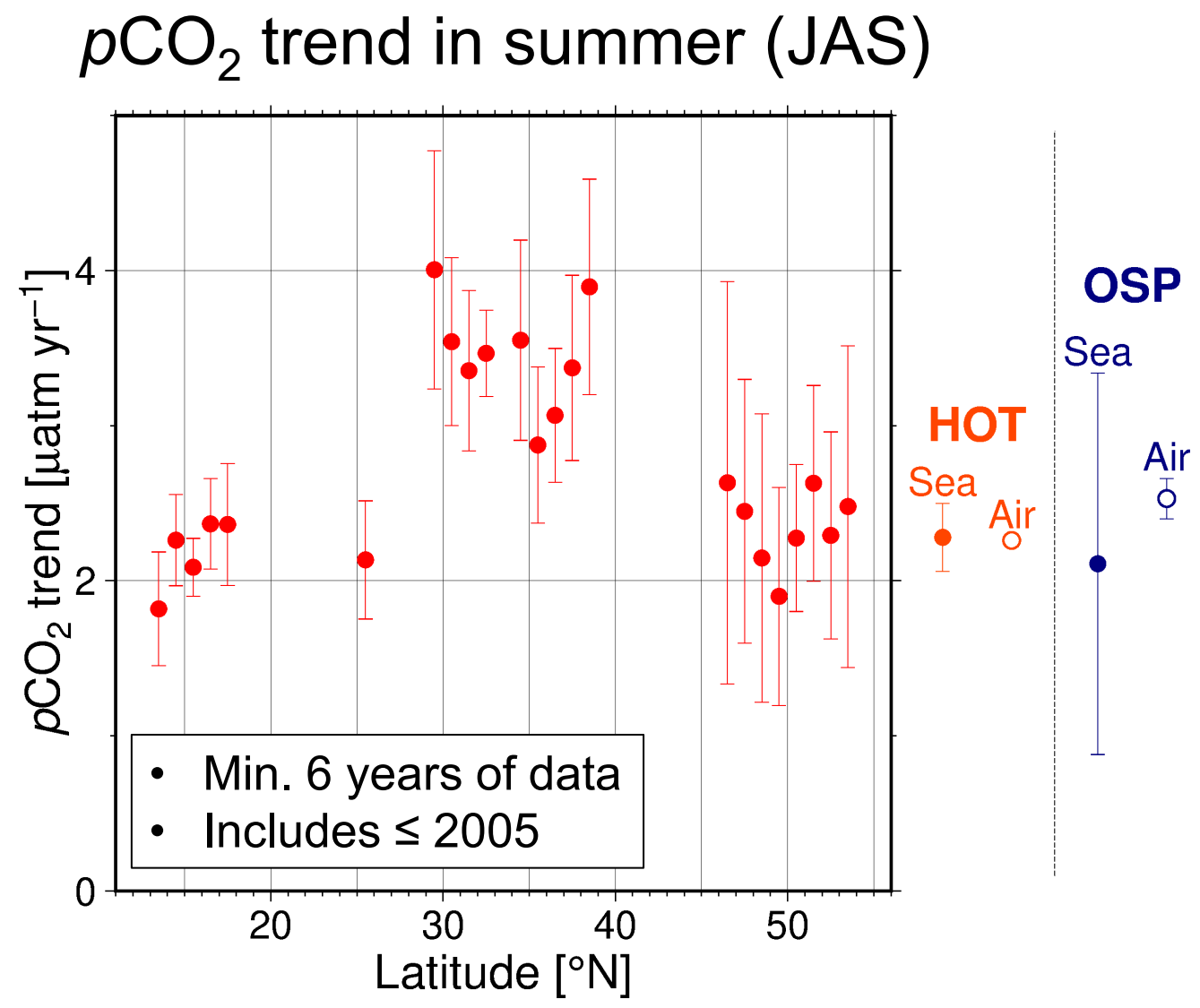
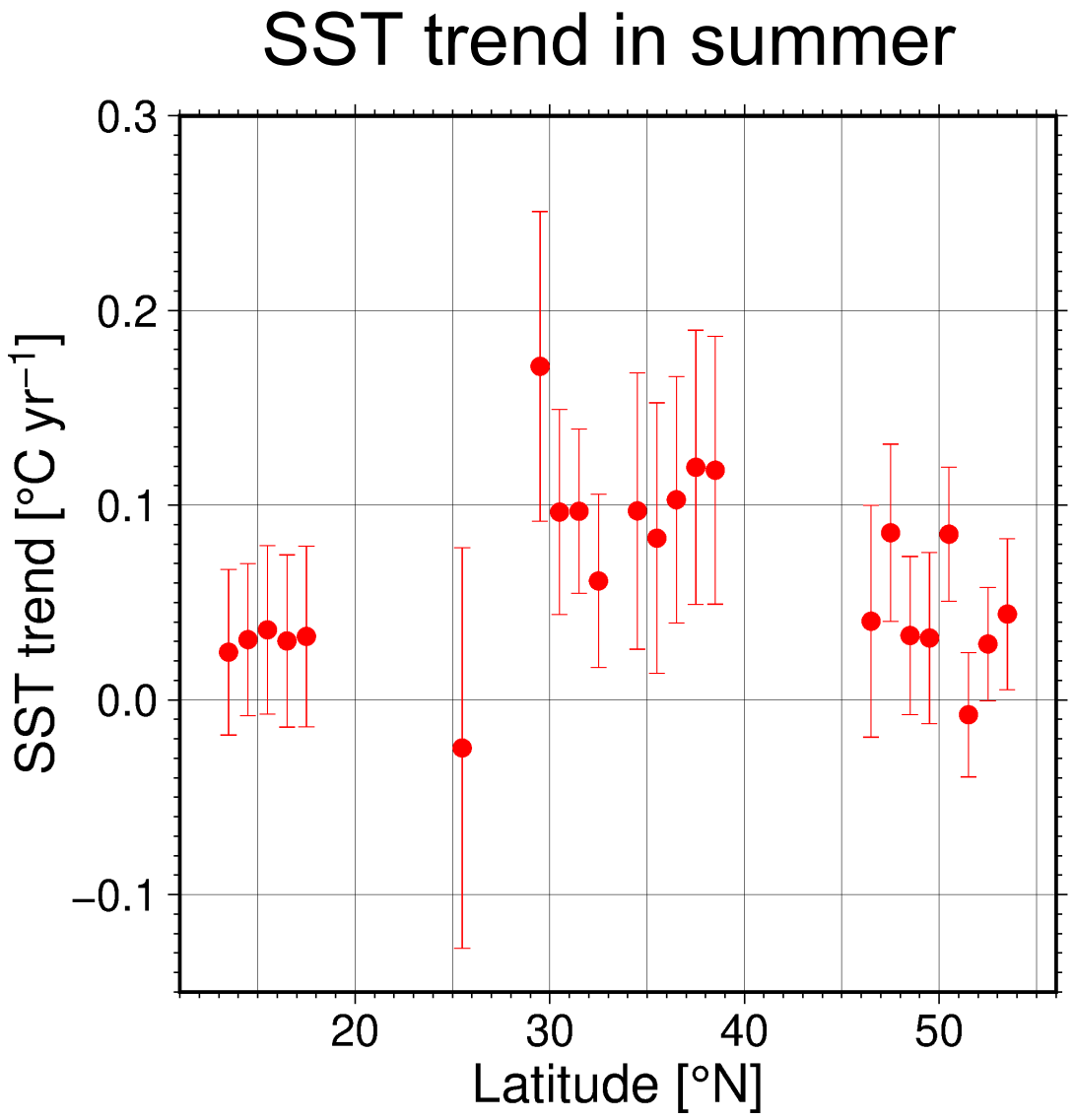
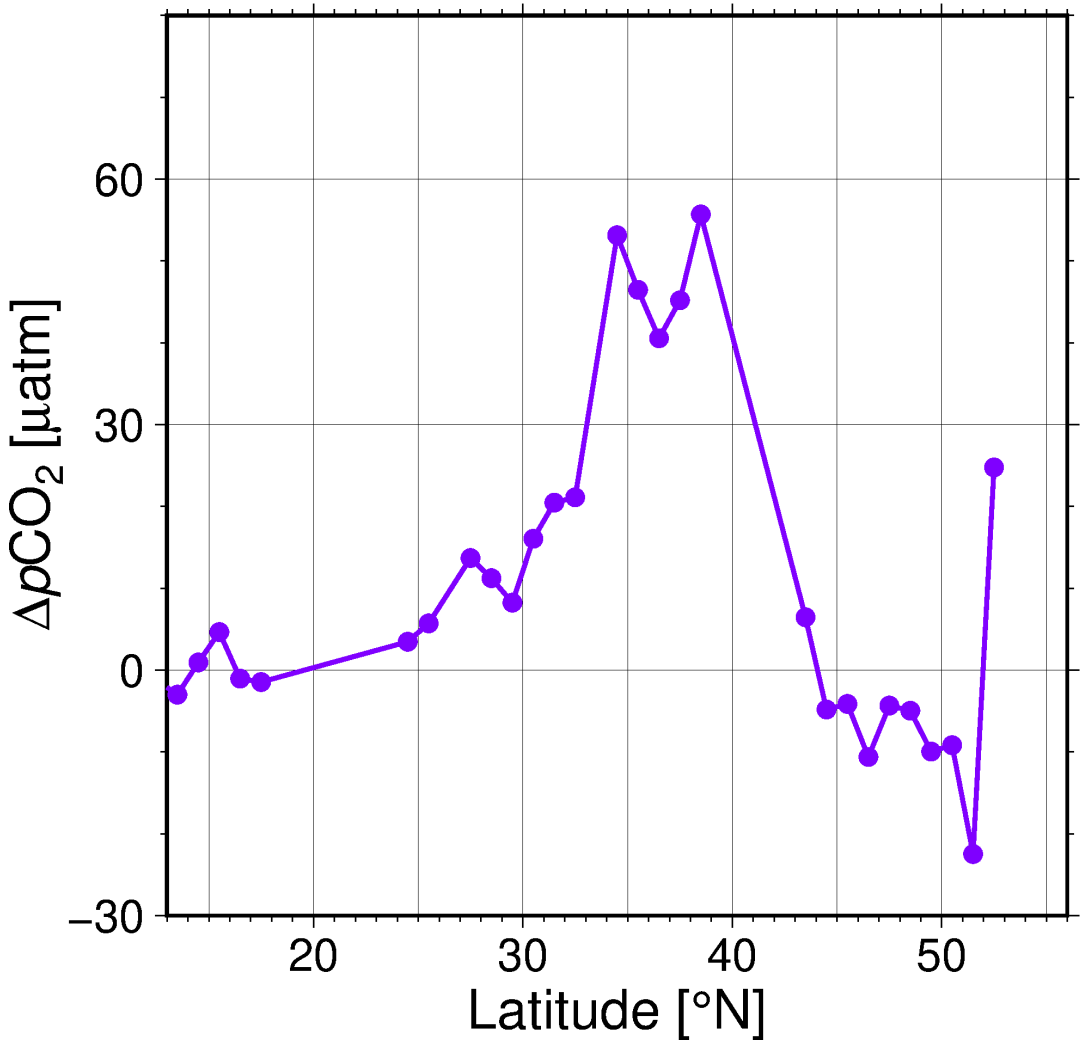
Warming zones match large pCO_2 surges





MHWs drive expansion of pCO_2 peaks

Relative pCO_2 to 13º-20ºN mean



2001–2005

MHWs drive expansion of pCO_2 peaks

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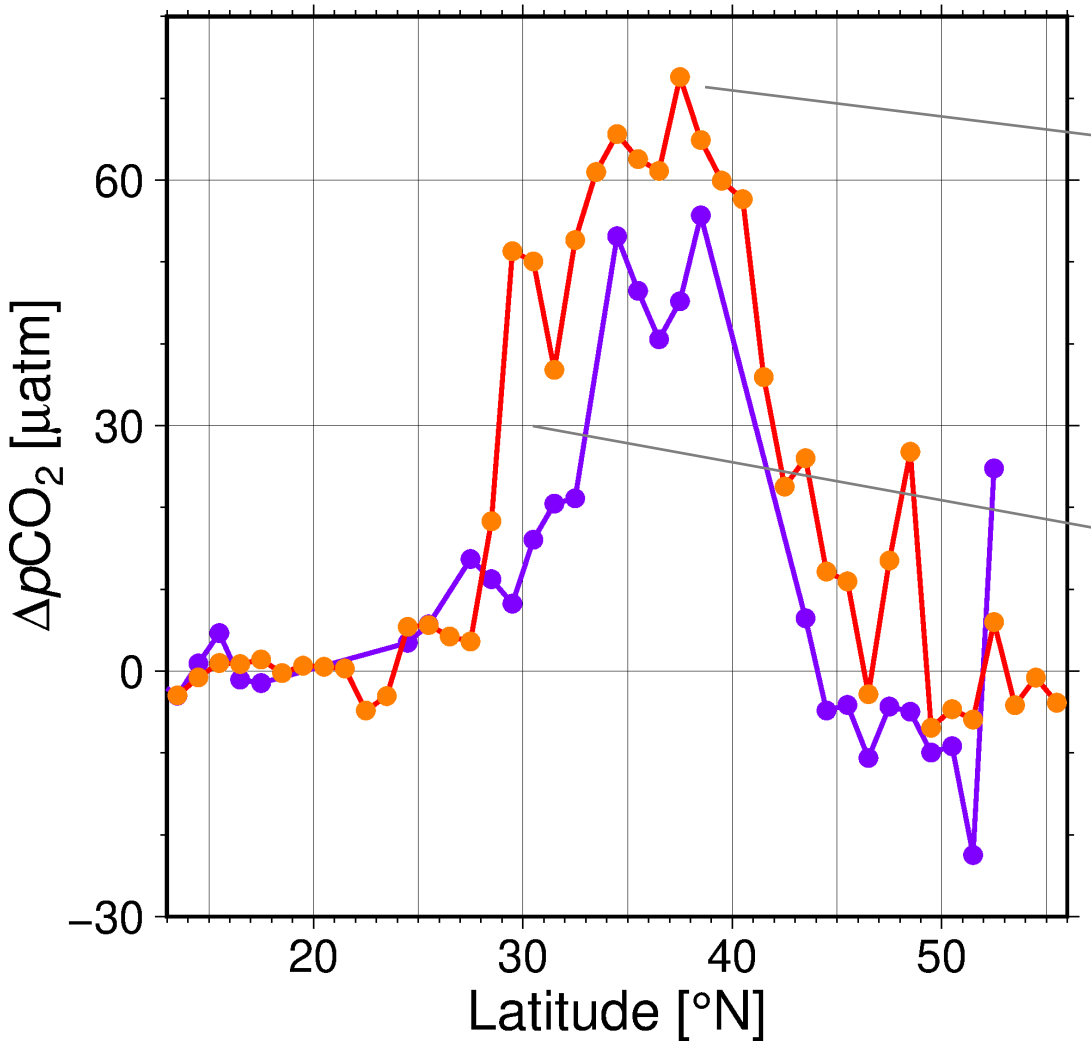

2025
2001–2005

Increase of peak height

Meridional expansion

Conclusion

- In August 2025, sea surface temperatures (SST) in the Northeast Pacific were more than 2ºC above normal across a wide area.

- Meridional surface pCO_2 peak between 30ºN and 40ºN showed greater pCO_2 rise from 2001 than other areas.

- Recent marine heatwaves have amplified this peak and expanded it meridionally.

Acknowledgements

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Dr. Sawa and Dr. Fujita of MRI for providing Picarro G2301

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