Marine Heatwaves in the East Asian Marginal Seas (EAMS)

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1. DESCRIBING THE PHENOMENON

- Marine heatwaves (MHWs) are prolonged periods of unusually high ocean temperatures, often lasting days to months and spanning large regions. The East Asian Marginal Seas (Japan/East Sea, Yellow Sea, East China Sea) are warming faster than the global average. These events severely impact ecosystems, causing coral bleaching, habitat loss, and economic damage to fisheries and aquaculture. Understanding their drivers is key to improving prediction and mitigation.

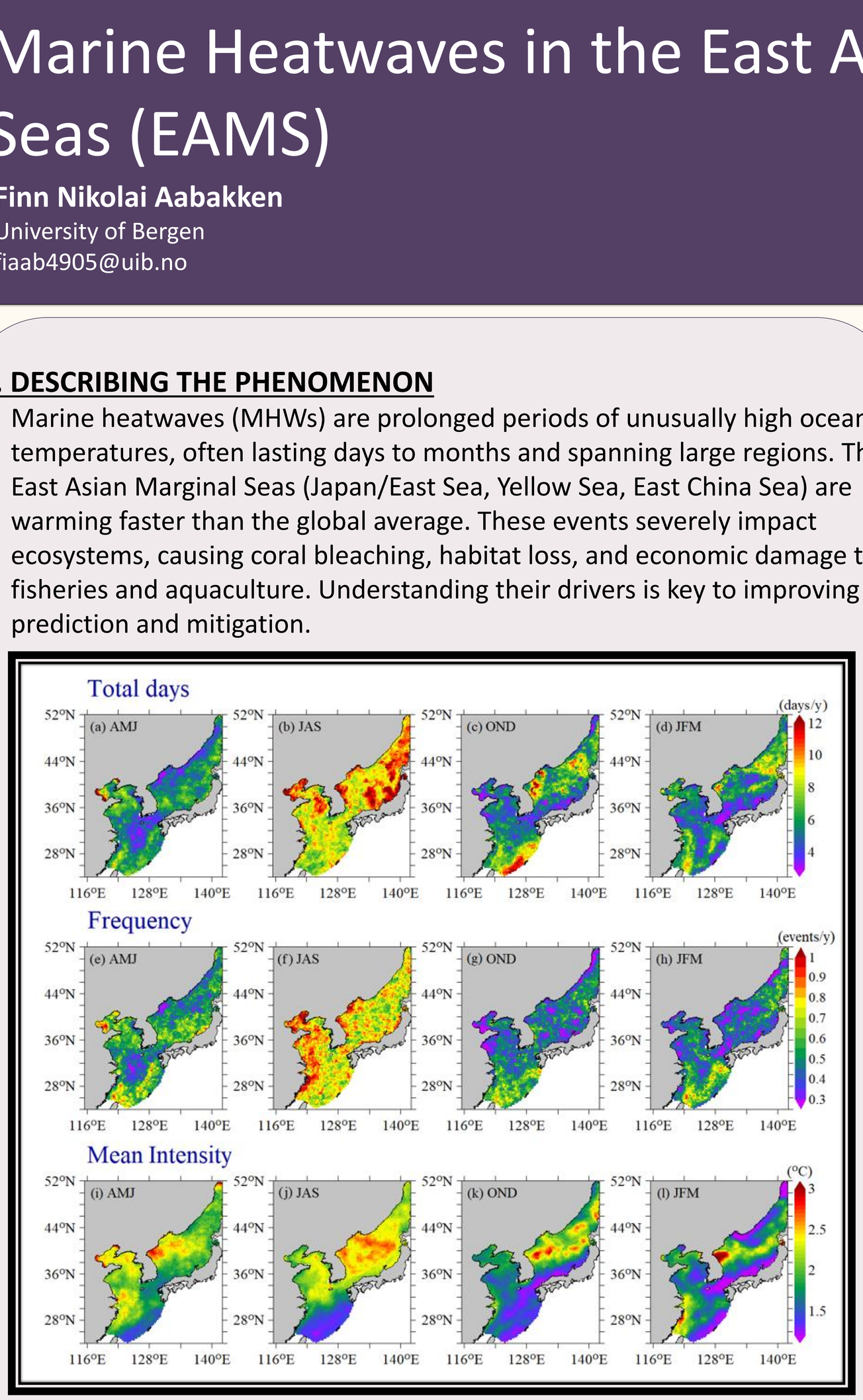

Figure 1 (Choi et al., Fig. 3): *Seasonal Spatial Distribution of MHWs.* Distribution of MHWs by season—spring (AMJ), summer (JAS), autumn (OND), and winter (JFM)—across three metrics: total days, frequency, and mean intensity. Note how summer events are widespread across the basin, whereas winter events are sharply concentrated along the Subpolar Front (see Section 3) at 40°N.

3. THE SUBPOLAR FRONT: A DYNAMIC WINTER HOTSPOT

- **Frontal Boundary Formation:** The Subpolar Front (SPF), located near 38-40°N in the Japan/East Sea, forms where the warm East Korean Warm Current (EKWC) meets the cold North Korean Cold Current (NKCC).
- **Seasonal Heatwave Pattern:** Winter marine heatwaves are tightly concentrated along this front, unlike broader, atmospherically driven summer events.
- **Driving Mechanism:** Negative wind stress curl weakens northern cold currents, allowing the EKWC to push the SPF northward and transport subtropical heat, producing local anomalies up to ~3.7 °C.

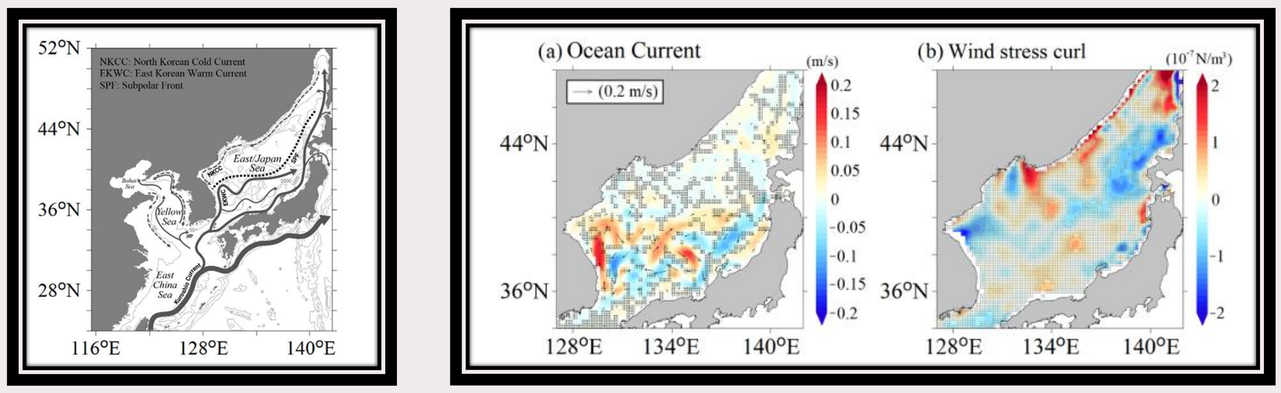

Figure 3 (Choi et al., Fig. 1 & 9): *SPF and Winter MHW Mechanisms.* (Left) SPF as the boundary between warm EKWC and cold NKCC. (Right) During strong winter MHWs, the EKWC shifts north to 40°N (a) as negative wind stress curl (b) weakens northern cold currents, trapping intense heat along the front.

REFERENCES

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- Choi, W., Bang, M., Joh, Y., Ham, Y.-G., Kang, N., & Jang, C. J. (2022). Characteristics and Mechanisms of Marine Heatwaves in the East Asian Marginal Seas: Regional and Seasonal Differences. *Remote Sensing*, 14(15), 3522.
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2. DATA AND METHODS

- **Data Integration:** Satellite SST (OISST, OSTIA) combined with atmospheric reanalysis (ERA5, NCEP-CFSR).
- **Heat Budget:** Mixed-layer heat budget separates surface flux contributions from oceanic advection.
- **Statistical Analysis:**
  - **Composite:** Compare strong vs. weak MHWs to identify seasonal drivers
  - **EOF:** Detect dominant variability patterns
  - **GEV:** Estimate likelihood of extreme events

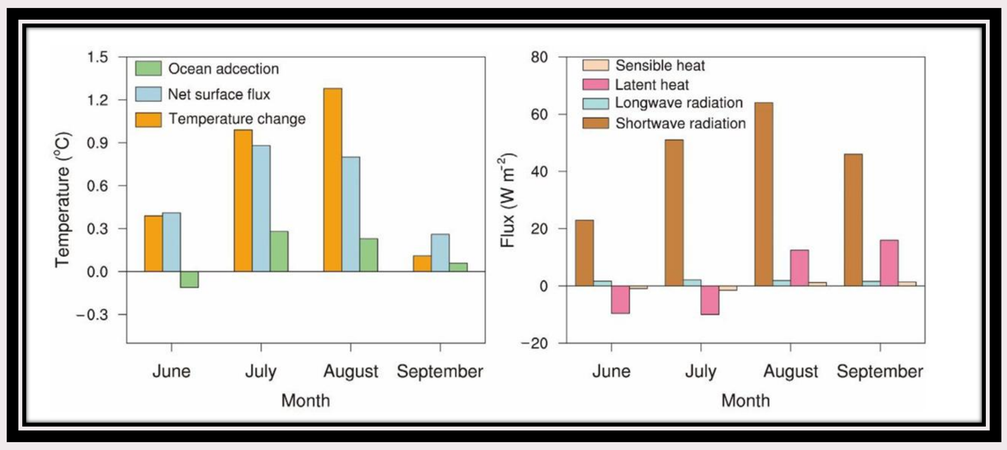

Figure 2 (Tan et al., Fig. 4): *Mixed-Layer Heat Budget (Summer 2022).* This quantitative breakdown shows that surface net heat flux (solar radiation) is the primary driver for summer MHW development, while ocean advection plays a secondary maintenance role. This does not apply to winter MHWs (see Fig. 3).

4. SUMMARY/CONCLUSIONS

- **Driver Divergence:** Summer MHWs are primarily driven by atmospheric forcing, specifically the expansion of the Western Pacific Subtropical High, which increases incoming solar radiation and reduces wind-driven mixing and cooling.
- **Oceanic Dominance in Winter:** In contrast, winter MHWs in the Japan/East Sea are largely driven by ocean dynamics, specifically a northward shift of the Subpolar Front advecting warm water poleward.
- **Climate Change Signature:** While natural modes like the Indian Ocean Dipole (IOD) regulate individual events, long-term trends are dominated by anthropogenic warming.
- **Future Outlook:** Extreme events that were once rare are projected to occur every 10 to 20 years as global temperatures rise by 1.5–2 °C

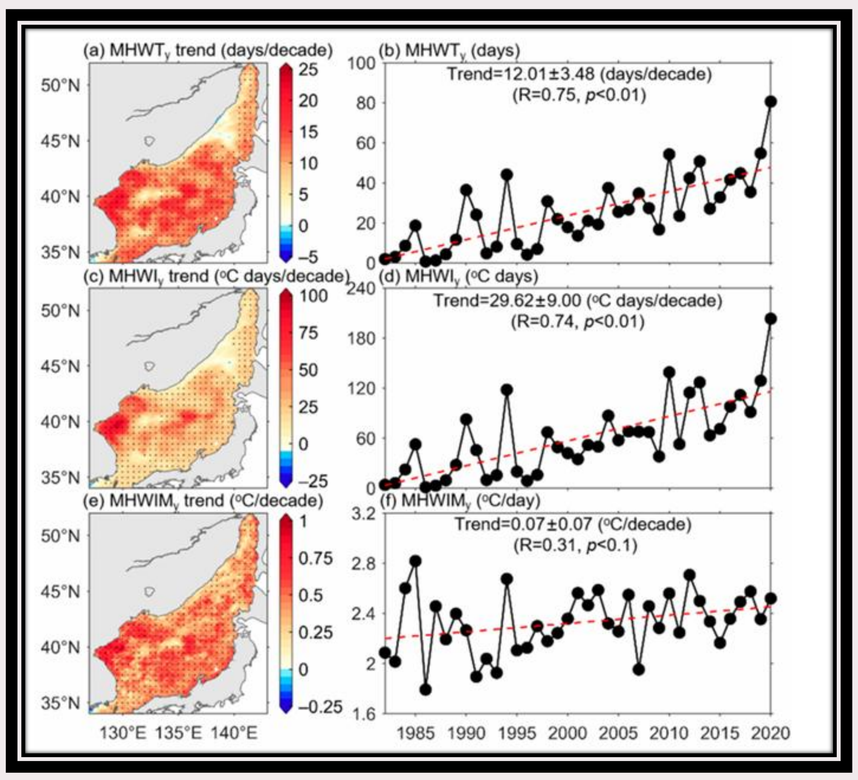

Figure 4 (Wang et al., Fig. 11): *Long-Term Intensity Trends.* The annual sum of MHW intensity in the Japan/East Sea is climbing at 29.62 °C days per decade, a rate double the global average.