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Interannual variability of surface seawater fCO_2 in the subtropical western North Pacific based on nine years of underway observations

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The subtropical western North Pacific (WNP) is an oligotrophic open-ocean region that is generally considered a neutral to weak source of CO_2 to the atmosphere. Yet, the magnitude and variability of the air-sea CO_2 fluxes are poorly understood due to the lack of observations in this region. Here, we quantify interannual variability of surface seawater fCO_2 and identify its drivers using nine years (2017–2025) of underway measurements during late summer (August–October) along repeated transects (14–22°N, 126–136°E) in the WNP.

Over the study period, atmospheric CO_2 measured along the cruise tracks increased at 2.39 ± 0.36 μatm yr^{-1}, slightly lower than the growth rate (2.56 ± 0.05 μatm yr^{-1}) at Mauna Loa, Hawaii (19.5°N, 155.6°W). Surface seawater fCO_2 increased at a comparable rate (2.34 ± 1.06 μatm yr^{-1}) to the atmospheric trend, indicating that the air-sea fCO_2 gradient remained approximately constant. The interannual variability of surface seawater fCO_2 was 6.6 μatm (ranging from 1.5 to 12 μatm), largely explained by changes in sea surface temperature and salinity. Non-thermal biogeochemical perturbations and wind-driven mixing-induced subsurface CO_2 entrainment also contributed.

These results indicate that late-summer surface waters in the WNP are predominantly thermodynamically regulated and closely track atmospheric CO_2 rise, while exhibiting large interannual variability. Sustained high-resolution observations are therefore essential for constraining the sensitivity of subtropical open-ocean carbonate chemistry to ongoing climate change.