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Seasonal variation in the surface fCO_2 and sea-air CO_2 fluxes in the Eastern Yellow Sea

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We examined surface fugacity of CO_2 (fCO_2) and sea-air CO_2 flux in the eastern Yellow Sea (EYS) for the first time during four cruises from 2014 to 2017. Surface fCO_2 displayed large seasonal and spatial variations, with the highest values observed in nearshore during fall and the lowest in spring. Spring was the major CO_2 uptake season of the year, with a significant influx of -8.0±5.5 mmol C m^{-2} day^{-1}. The entire study area acted as strong CO_2 sink to the atmosphere in spring. In summer, but most of areas acted as a CO_2 source, but the area north of 36 ˚N served as a CO_2 sink, with an influx of -1.9±2.1 mmol C m^{-2} day^{-1}. In fall, nearshore area behaved as a CO_2 source but the offshore area was CO_2 sink, with an influx of -0.8±1.2 mmol C m^{-2} day^{-1}. In winter, CO_2 sink was observed south of 34.5 ˚N, but the CO_2 source was north of 34.5 ˚N, with small efflux of 0.6±2.8 mmol C m^{-2} day^{-1}. Although spatial and seasonal difference in the sea-air CO_2 flux was substantial, the EYS generally shifted from a CO_2 sink in spring-fall to a CO_2 source in winter. As for the controlling factors on the surface fCO_2, physical process such as temperature and salinity did not played the dominant role, while the non-physical processes were considered as the primary controlling factors in EYS; Phytoplankton activity induced a sink of atmospheric CO_2 in spring, summer, and fall. In winter, surface water was vertically mixed with CO_2-enriched subsurface water caused by strong wind, which resulted in CO_2 efflux to atmosphere.