

S1 Meteorological conditions during the Siyuan Lake campaigns

Figure S1 presents the temporal variations of wind speed, wind direction, air temperature, relative humidity, atmospheric pressure, and precipitation during the Siyuan Lake experiments. The first field campaign was primarily conducted in late summer, while the second took place during winter.

Wind speeds exhibited distinct diurnal variations during both campaigns. Notably, an extreme wind event occurred on 16 September 2024 during the first observation period due to the passage of a typhoon over Shanghai (Fig. S1a). Excluding these extreme values, the mean wind speed was 1.19 m s^{-1} during the first campaign and 0.96 m s^{-1} during the second. The prevailing wind during the first campaign was southeasterly (78% of the recorded wind directions), whereas the second campaign was dominated by northwesterly flow (51%), followed by southeasterly winds (33%) (Fig. S1b).

Air temperature during both campaigns showed typical diurnal cyclic variations on clear days. During the first campaign, the maximum and minimum temperatures typically occurred at 13:00 and 05:00 LST, respectively, with a maximum diurnal temperature difference exceeding 7°C and a mean temperature of 31.8°C . During the second campaign, the maximum and minimum temperatures typically occurred at 14:00 and 06:00 LST, with a maximum diurnal difference exceeding 12°C and a mean temperature of 5.7°C (Fig. S1c).

Relative humidity fluctuated substantially throughout the day during both campaigns (40–100% and 20–100% for the first and second campaigns, respectively). The occurrence of maximum and minimum relative humidity values corresponded inversely with the minimum and maximum air temperatures (Fig. S1d).

The temporal variations of atmospheric pressure are shown in Fig. S1e. During the first campaign, pressure variations were relatively stable, except for an extreme low of 991.8 hPa observed during the typhoon passage on 16 September. In comparison, pressure variations were more intense during the second campaign, strongly influenced by synoptic winter weather systems. A semi-diurnal cycle with two maxima and two minima was observed. During the first campaign, the maxima occurred at 09:00 and 21:00 LST, with minima at 03:00 and 15:00 LST. During the second campaign, the maxima occurred at 09:00 and 22:00 LST, with minima at 04:00 and 15:00 LST.

Four distinct precipitation events were recorded during the first campaign: 27–28 August, 3 September, 10–11 September, and 15–16 September 2024. During the second campaign, precipitation events occurred on 26 January, 31 January to 1 February, 11 February, 14–15 February, and 27 February 2025 (Fig. S1f). As detailed in Sect. 2.2 of the main manuscript, all LAS and EC data collected during precipitation events or typhoon passages were rigorously excluded from the subsequent flux analysis.

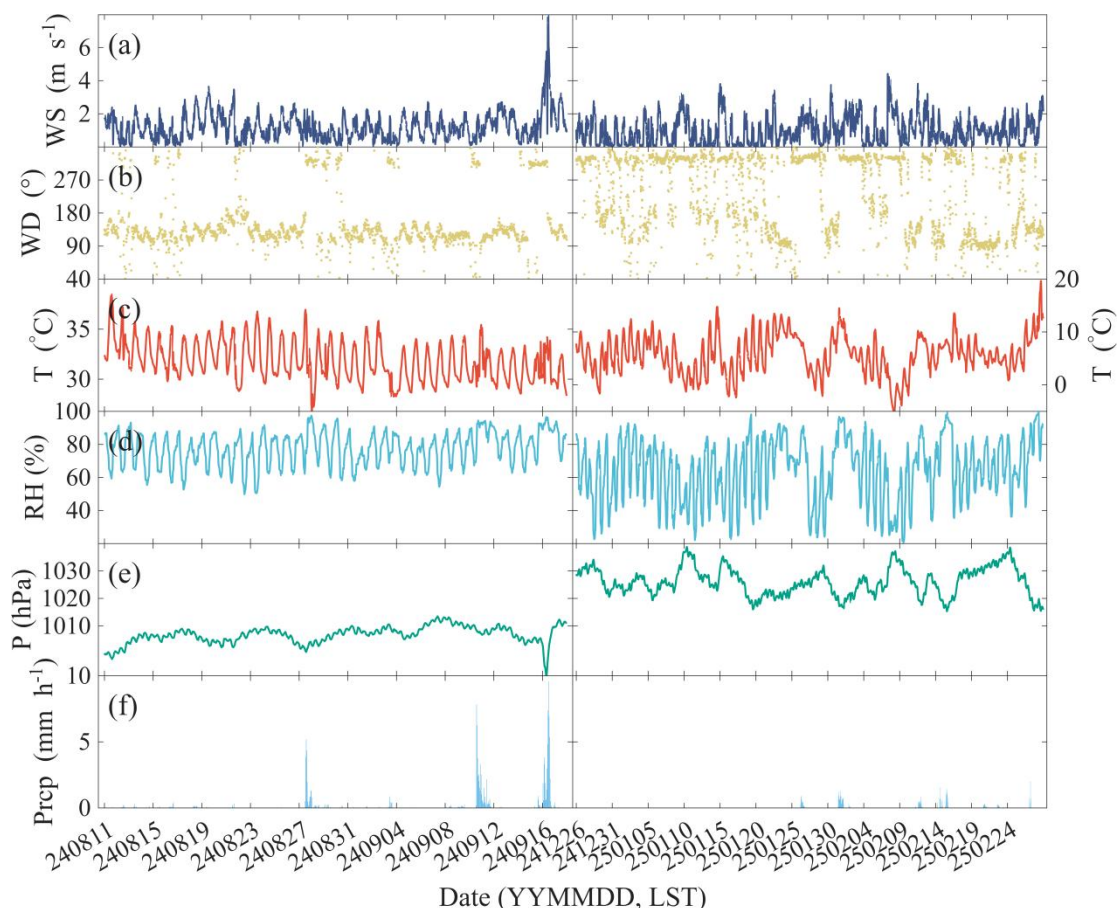


Figure S1. Temporal variations of (a) wind speed (WS), (b) wind direction (WD), (c) air temperature (T), (d) relative humidity (RH), (e) atmospheric pressure (P) and (f) precipitation (Prcp) during the two field campaigns at Siyuan Lake. The left panels display data from the first observation period (11 August to 17 September 2024), and the right panels correspond to the second observation period (26 December 2024 to 28 February 2025).

S2 Meteorological conditions during the Sijiao Island campaigns

The temporal variations of meteorological variables during the two field campaigns at the coastal Sijiao Island site are illustrated in Fig. S2. The first campaign was conducted from 16 to 21 April 2025, and the second from 30 August to 4 September 2025.

Wind speeds during both marine campaigns were significantly modulated by land–sea breezes (Fig. S2a). During the first campaign, the daily maximum wind speeds typically occurred at 12:00 (sea

breeze) and 22:00 LST (land breeze). In contrast, during the second campaign, the daily maxima generally appeared at 15:00 (sea breeze) and 01:00 LST (land breeze). The mean wind speeds were 2.31 m s^{-1} during the first campaign and 2.07 m s^{-1} during the second. Southerly winds (including both southwesterly and southeasterly directions) prevailed during both campaigns, accounting for 72% and 89% of the recorded wind directions, respectively (Fig. S2b).

Air temperature during both campaigns showed typical diurnal cyclic variations on clear days. During the first campaign, the maximum and minimum temperatures typically occurred at 12:00 and 05:00 LST, respectively, with a diurnal temperature difference of approximately $4 \text{ }^{\circ}\text{C}$ and a mean temperature of $16.7 \text{ }^{\circ}\text{C}$. During the second campaign, the maximum and minimum temperatures typically occurred at 15:00 and 06:00 LST, with a diurnal difference of approximately $2 \text{ }^{\circ}\text{C}$ and a mean temperature of $26.9 \text{ }^{\circ}\text{C}$ (Fig. S2c). These relatively small diurnal temperature ranges reflect the moderating effect of the marine environment. Notably, a significant temperature drop was recorded on 20 April 2025 during the first observation period.

Relative humidity fluctuated dramatically throughout the day during the first campaign (60–100%) but remained persistently high and relatively stable (80–100%) during the second. The occurrence of maximum and minimum relative humidity values generally corresponded inversely with the minimum and maximum air temperatures. However, dense fog during 18 to 19 April 2025, and 00:00–02:00 LST on 21 April kept the relative humidity consistently above 90% (Fig. S2d). This high-humidity and fog event led to severe optical attenuation for the LAS system, causing the extended data gaps discussed in Sect. 3.3.1 of the main manuscript.

The temporal variations of atmospheric pressure are shown in Fig. S2e. During both campaigns, atmospheric pressure exhibited a semi-diurnal cycle. During the first campaign, the maxima occurred at 10:00 and 21:00 LST, with minima at 03:00 and 15:00 LST. During the second campaign, the maxima occurred at 09:00 and 22:00 LST, with minima at 04:00 and 16:00 LST. Corresponding with the aforementioned temperature drop, atmospheric pressure during the first campaign began to rise toward approximately 1013 hPa on 20 April 2025. During the second campaign, atmospheric pressure decreased from around 1013 hPa to 1007 hPa between 30 and 31 August 2025, after which it stabilized. Finally, no significant precipitation events were recorded during either coastal campaign (Fig. S2f).

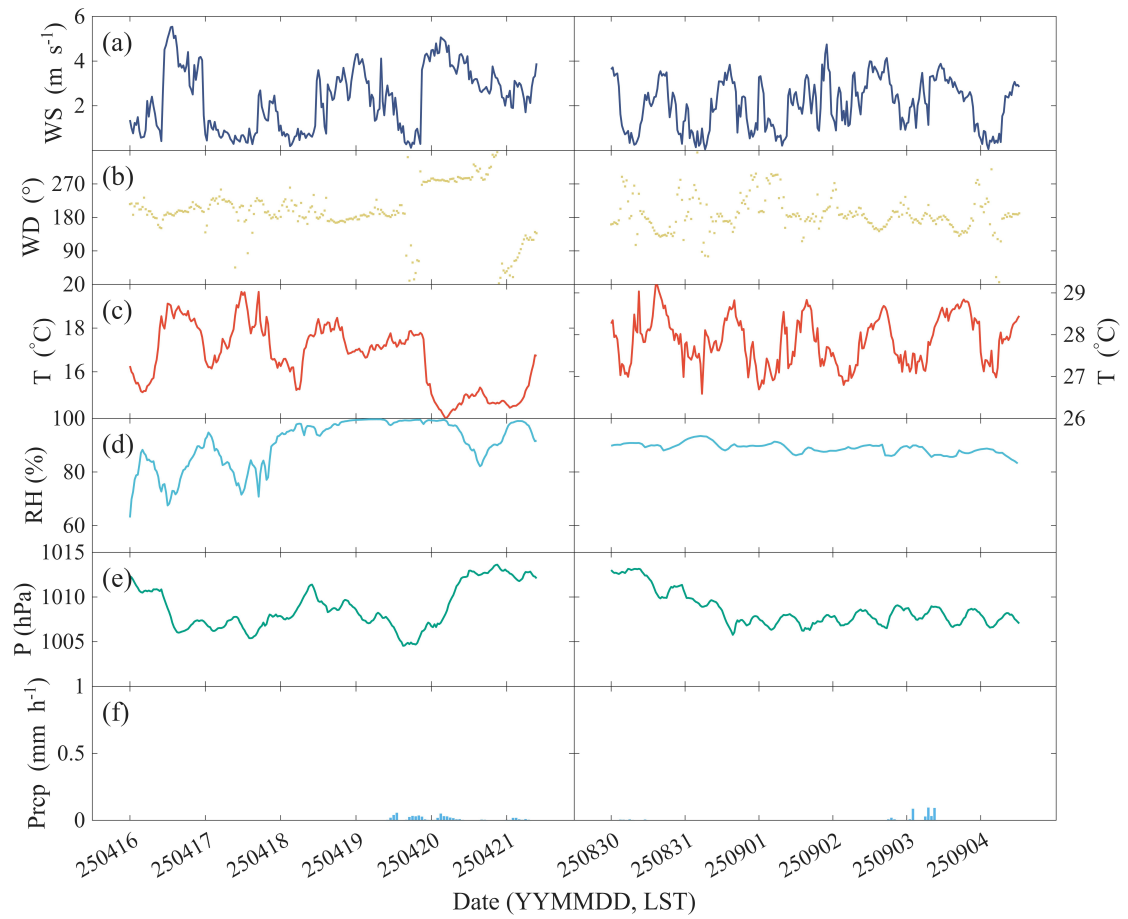


Figure S1. Temporal variations of **(a)** wind speed (WS), **(b)** wind direction (WD), **(c)** air temperature (T), **(d)** relative humidity (RH), **(e)** atmospheric pressure (P) and **(f)** precipitation (Prep) during the two field campaigns at Sijiao Island. The left panels display data from the first observation period (16 to 21 April 2025), and the right panels correspond to the second observation period (30 August to 4 September 2025).