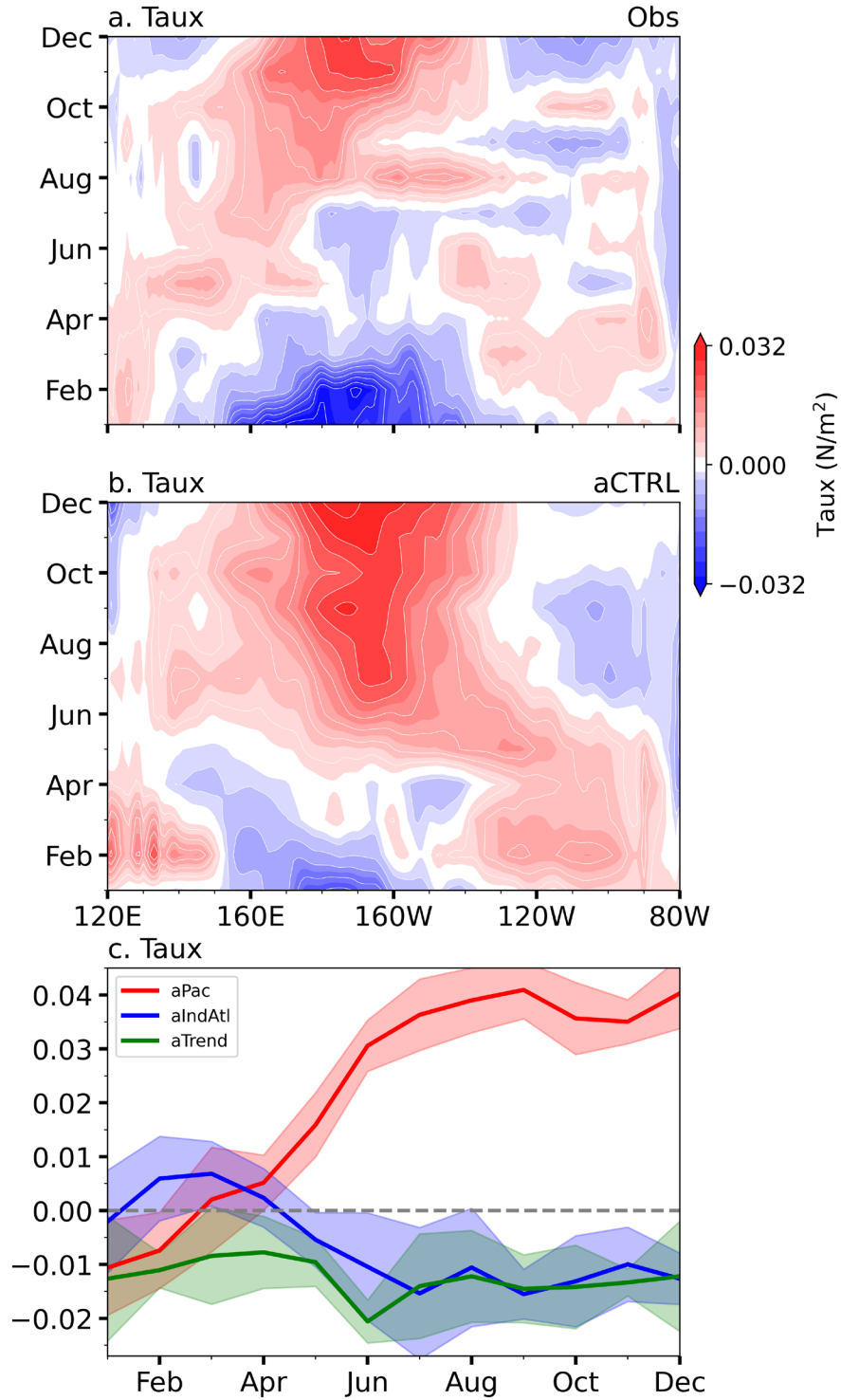
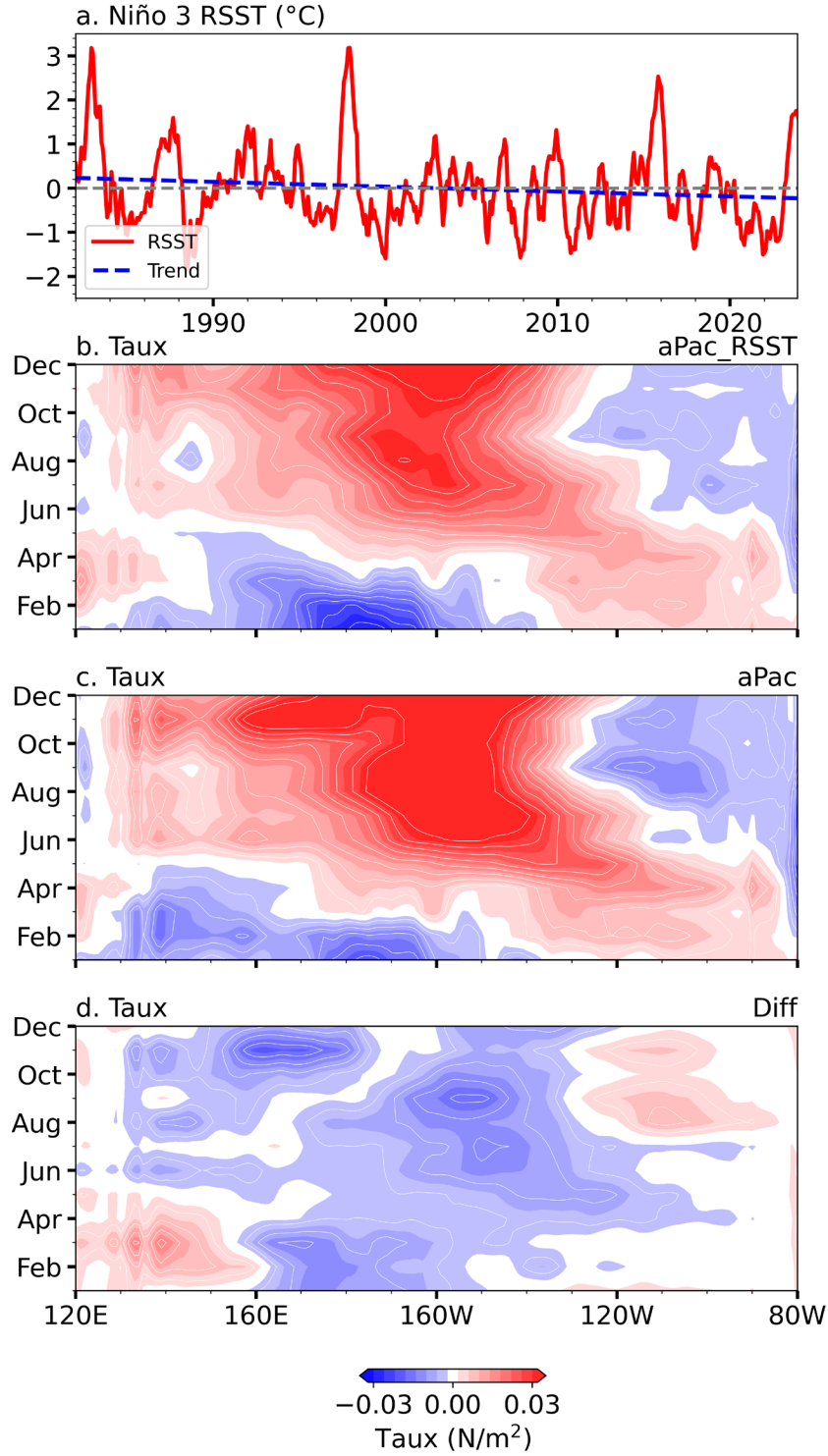

Strong 2023–2024 El Niño generated by ocean dynamics

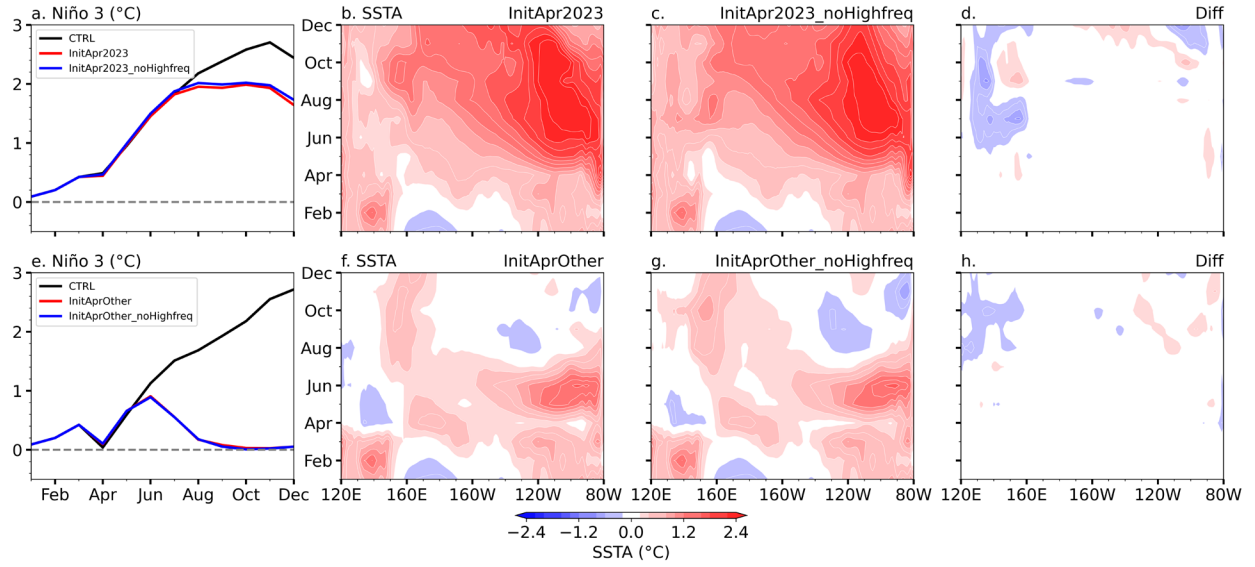
In the format provided by the
authors and unedited



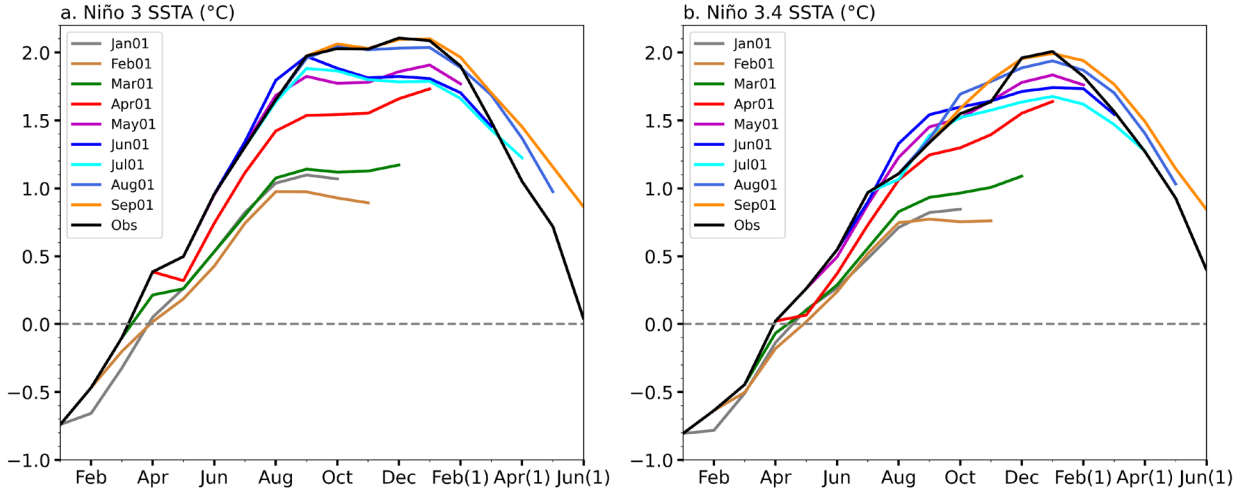
Supplementary Fig. 1 | Observed and simulated surface wind stress changes. Hovmöller diagram of equatorial zonal wind stress anomalies (color shading; N/m^2) from (a) observations and (b) aCTRL. (c) Time series of central Pacific (170°W - 150°W , 2°S - 2°N) zonal wind stress responses from aPac, aIndAtl, and aTrend runs. The line represents the ensemble mean ($n=10$), and the shading indicates one inter-member s.d..



Supplementary Fig. 2 | Impacts of Pacific relative SST. (a) Time series of Niño3 relative SST, including the long-term trend shown in blue. Hovmöller diagram of equatorial zonal wind stress anomalies (color shading; N/m²) from (b) aPac_RSST, (c) aPac, and (d) their differences.



Supplementary Fig. 3 | The impacts of 31-day high-frequency wind stress. (a) Simulated Niño 3 SSTAs from the CTRL, InitApr2023, and InitApr2023_noHighfreq experiment. Hovmöller diagram of equatorial SSTA (color shading) from the (b) InitApr2023, (c) InitApr2023_noHighfreq, and (d) their differences. (Lower panels) Same as (Upper panels) but for the composite results of the other comparable El Niños from CTRL, InitAprOther, and InitAprOther_noHighfreq. Note that only the first member of each experiment is shown here.



Supplementary Fig. 4 | NMME predictions for the 2023-24 El Niño. Seasonal forecast for (a) Niño 3.4 and (b) Niño 3 SSTA ($^{\circ}\text{C}$) from NMME. Each colored line denotes the multi-model ensemble averages of a specific forecast. The start of each curve indicates the month of the forecast's initialization. For example, the red line represents the forecast initialized on April 1, 2023. Observations are plotted in black.