El Niño and Anomalous Asian–Australian Monsoons: Remote Forcing or Local Air–Sea Interaction?

Monsoon rainfall over the Asian continent has been monitored for over a century because of its importance to agriculture. Both unusually high rainfall and drought are related to ocean–atmosphere conditions, particularly conditions in the eastern Pacific. The precise nature of the ocean–atmosphere influence, however, is still under debate. **Bin Wang** and his IPRC colleagues **Renguang Wu** and **Tim Li** studied the evolution of the Asian–Australian monsoon anomalies over five consecutive seasons during El Niño events by performing an extended singular value decomposition on NCEP/NCAR reanalysis sea-surface temperature, wind, and vertical motion data from 1956 through 2000.

Figure 4 shows the anomalous seasonal mean winds at 850 hPa (vectors) and vertical *p*-velocities at 500 hPa (colored area) during El Niño events. Panels *a* and *b* show the anomalies during the developing El Niño, panel *c* during the mature phase, panel *d* during the decaying phase, and panel *e* when conditions in the eastern Pacific are "normal"again. Panel *f* displays the temporal evolution of Asian–Australian wind (850 hPa) and Indian–Pacific Ocean SST over the 46 years. The anomalous winds and SST are closely related (r = 0.94), with the most significant wind anomalies occurring during an El Niño fall.

The low-level wind anomalies in Figure 4 are characterized by two off-equatorial anticyclones—one located over the South Indian Ocean (SIO), the other over the western North Pacific (WNP). The SIO anticyclone, which is responsible for unusual climate conditions over India, the Indian Ocean, and East Africa, originates in boreal summer while an El Niño is developing, amplifies rapidly, reaches its height in fall, and decays before El Niño matures. On the other hand, the WNP anticyclone, which is responsible for unusual climate in East and Southeast Asia, forms in fall, attains its maximum intensity when El Niño matures, and persists through the next spring and summer while El Niño decays.

Remote El Niño forcing *alone* cannot explain the extraordinary amplification of the SIO anticyclone in the developing stage of El Niño nor the maintenance of the WNP anticyclone in the decaying phase of El Niño. Wang and his colleagues show that the ocean–atmosphere conditions in the two regions of the anticyclones are very similar, namely, *a SST dipole with cold water to the east and warm water to the west of the anticyclone center* (see Figures *5a* and *b*). These conditions, according to the authors, result from positive ocean–atmosphere feedback intensifying and maintaining the anticyclones. They conclude that although the anomalies are often triggered by El Niño conditions in the Pacific, the interaction is controlled by the monsoon seasonal cycle and perhaps induced by other local or remote forcing. Their hypothesis receives support in a study of a series of experiments in which the Max-Planck atmospheric model, ECHAM-4, is coupled to the Wu-Li-Fu ocean model.

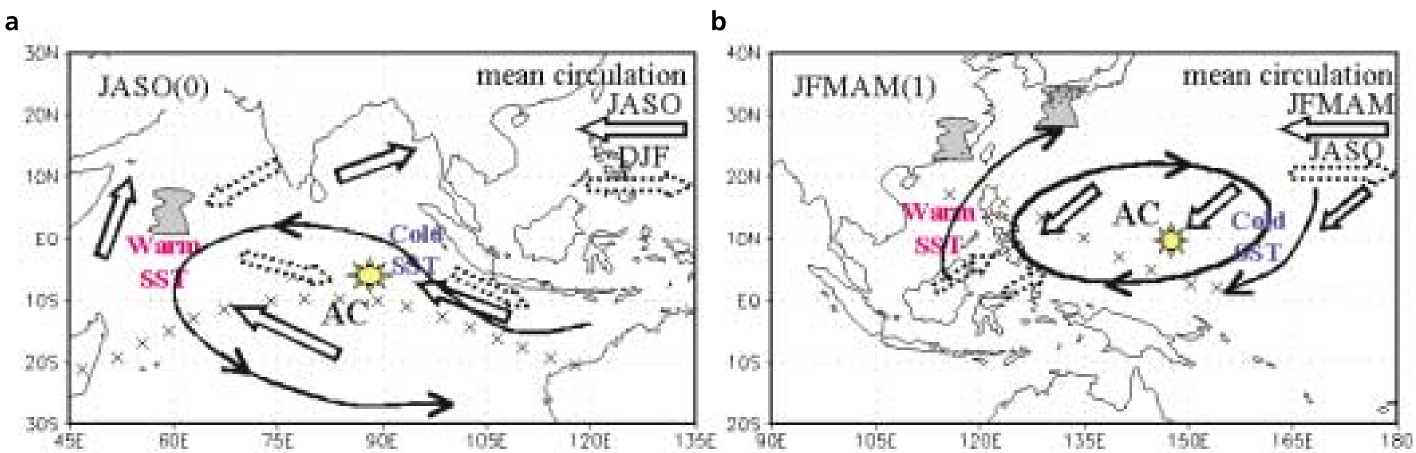

Figure 5. *Schematic of the monsoon-ocean interaction (a) in the Indian Ocean in the summer and fall before the mature El Niño and (b) in the western North Pacific in the winter and spring of the mature and decaying El Niño.*

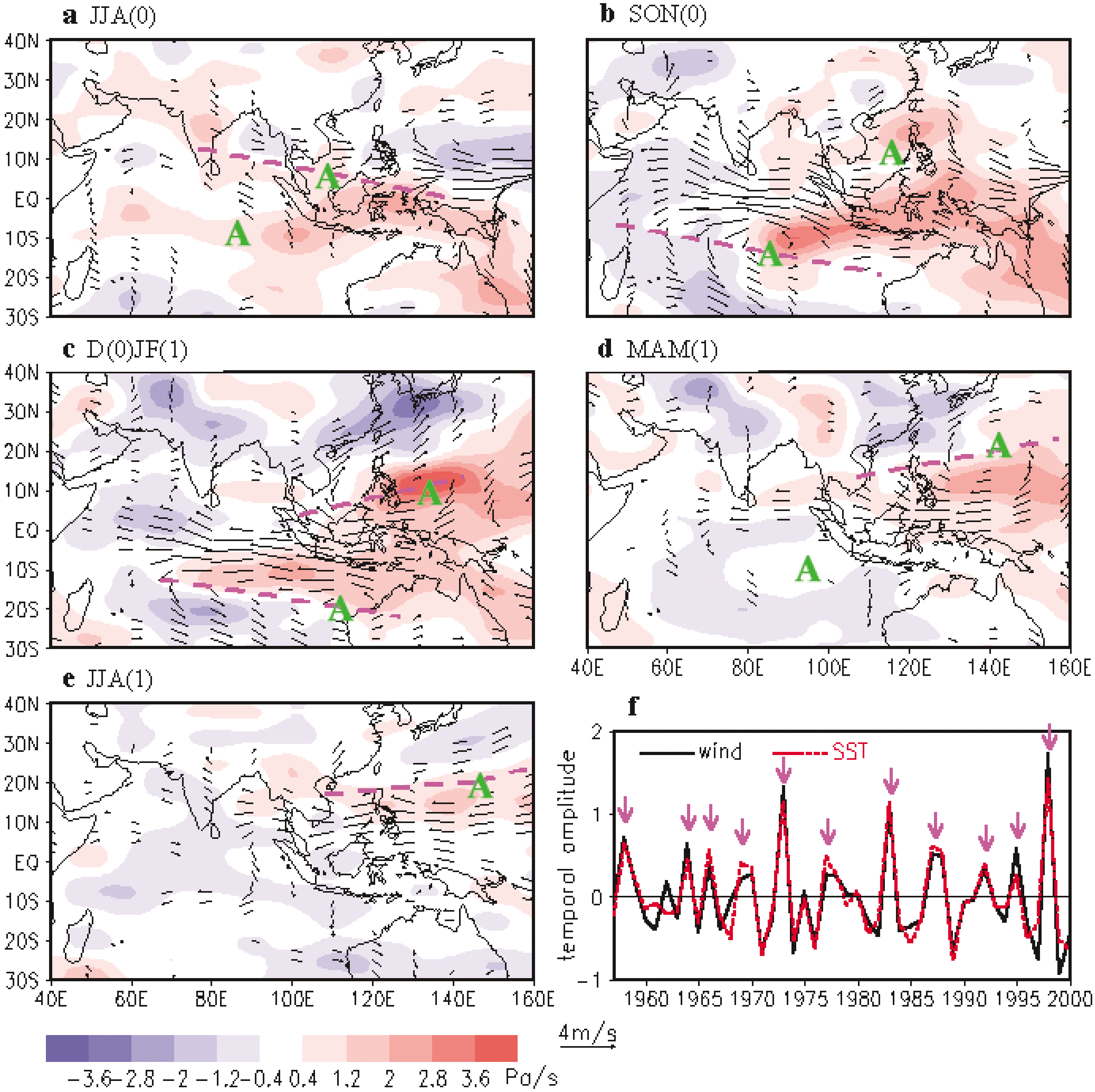

Figure 4. Results of the ESVD analysis. (a – e) The anomalous seasonal mean winds at 850 hPa (vectors) and vertical p-velocities at 500 hPa (shaded area) during El Niño events. (a and b) Conditions in the summer and fall before the mature El Niño; (c) during the mature El Niño; and (d and e) in the following spring and summer; (f) the time evolution of the 850 hPa wind anomalies over the Asian-Australian monsoon region and the SST anomalies over the Indian and Pacific Oceans during the mature phase of El Niño events.