Searching for the Cause of Slow Changes in the Equatorial Pacific Ocean

Sea surface temperature (SST) variations in the equatorial Pacific affect global climate. An increase in SST in this region appears to be linked to an increase in global-mean surface temperature since the 1970s and to slow changes in the temporal development of El Niño. (See *A Mechanism for Long-Term Changes in El Niño and the Southern Oscillation*, p. 7.) The cause of these slow variations has been puzzling scientists. **Masami Nonaka**, **Shang-Ping Xie**, and **Jay McCreary**, using an ocean general circulation model (GCM) driven by observed wind stress, have found that on decadal timescales, off-equatorial as well as equatorial wind variations contribute to SST variability (midlatitude winds contribute little). In contrast, the SST variability on interannual timescales (including El Niño) is driven largely by only equatorial winds. Different ocean dynamics must, therefore, govern equatorial Pacific SST variability on these two timescales.

A scenario suggested for the decadal SST variations is as follows: Variations in the off-equatorial trade winds cause variations in the strength (velocity) of the subtropical shallow overturning circulation, or subtropical cells (STCs). Depending upon the strength of the circulation, more or less cold water is transported toward the equator, where the surface water then becomes accordingly warmer or colder. This hypothesized sequence of events is consistent with the velocity anomaly mechanism suggested by Kleeman et al. (1999). The mechanism has received support by McPhaden and Zhang (2001), who used historical hydrographic data to show that the gradual increase in equatorial Pacific SST over recent decades is associated with a decrease in STC transport.

Using a realistic Pacific Ocean GCM that they have developed at the IPRC, Nonaka et al. provide evidence that also supports this mechanism. For details of their findings, see Figure 1 on the opposite page.

This figure shows a meridional section of the central Pacific. Temperatures are in color: thus, warm (red) water is shown floating over the cold (blue-purple) abyssal ocean. The white lines represent the meridional streamfunction along which the zonally averaged ocean current flows in the direction of the black arrows. As indicated by the lines, part of the water subducted below the surface in the subtropics moves to the equator, upwells there, and then returns to the subtropics in the surface layer, creating meridional cells or STCs that connect the subtropics and the equatorial region. The STCs are thought to maintain the tropical thermocline by transporting subtropical cold water (shown by colors from yellow to green) through the subsurface layer.

The lower panels show anomalies in STC strength (black) and equatorial SST (red) for interannual (a) and decadal (b) timescales. At decadal timescales, variations in STC strength are closely related to the SST variations, that is, strong STCs are associated with cold SST anomalies, consistent with the velocity anomaly hypothesis. This relation is not found on interannual timescales, because SST variations over this short time span are determined primarily by equatorial winds.

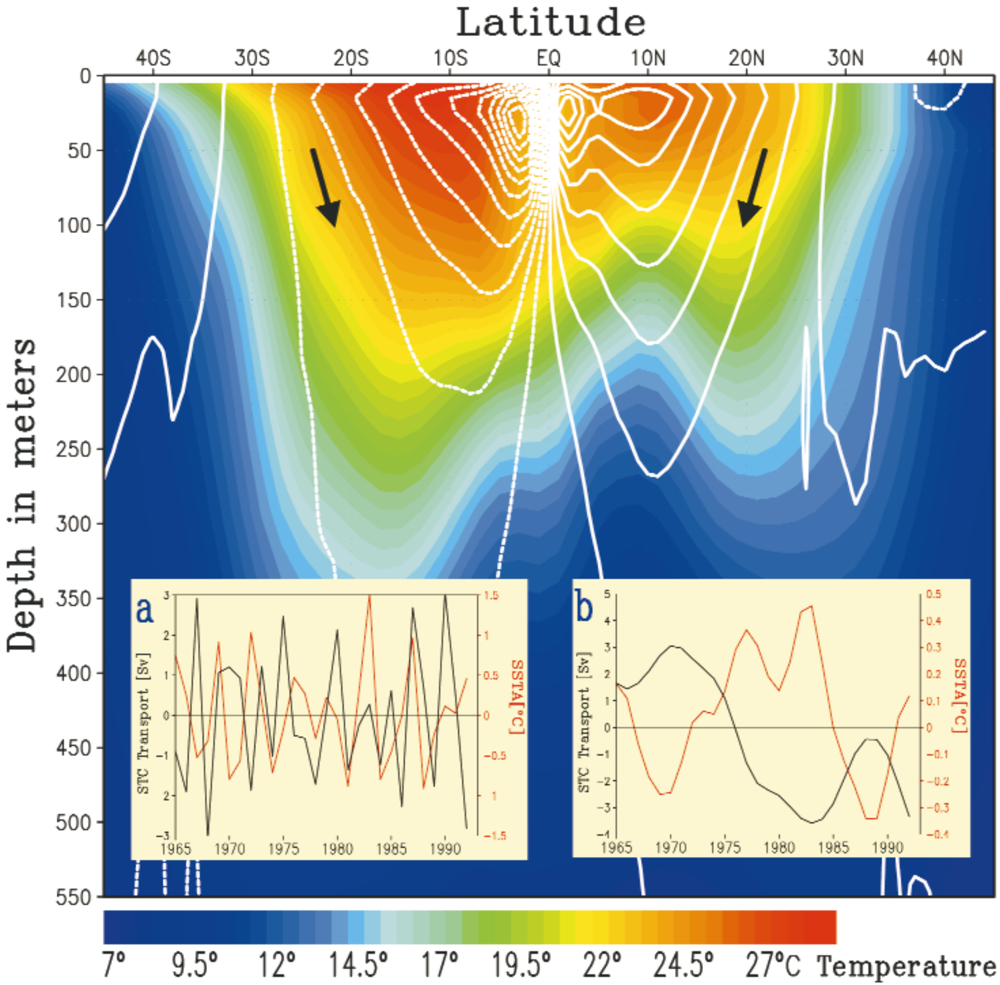

Figure 1. *Central Pacific meridional section of ocean temperature (color) and zonally averaged meridional streamfunction (white contours). Sea surface temperature and Subtropical Cell anomalies at interannual (panel a) and decadal (panel b) timescales.*