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Influences of Seaway and CO_2 Changes during the Pliocene on Tropical Pacific Sector Climate in the Kiel Climate Model: Mean Sate, Annual Cycle, ENSO, and their Interactions

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The opening and closing of seaways can have a profound impact on global and regional climate. The El Niño/Southern Oscillation (ENSO) is the leading mode of tropical Pacific interannual variability in the present-day climate. Available proxy evidence suggests that ENSO also existed during past climates, for example during the Pliocene extending from about 5.3 million to about 2.6 million years BP. We investigate the influences of the Panama Seaway closing and Indonesian Passages narrowing, and of carbon dioxide (CO_2) changes during the Pliocene on tropical Pacific mean climate, annual cycle and ENSO. The Kiel Climate Model (KCM) is employed to study the influences of the changing geometry and CO_2-concentration. We find that ENSO is sensitive to the closing of the Panama Seaway, with ENSO amplitude being reduced by about 15% - 20%. The narrowing of the Indonesian Passages marginally enhances ENSO strength by about 6%. ENSO period changes are modest in all experiments.

Annual cycle changes are prominent. The annual cycle in the eastern tropical Pacific intensifies by about 50% in response to the closing of the Panama Seaway, which is largely attributed to the strengthening of meridional wind stress. Bjerknes stability index (BSI) analysis suggests that the growth rate of the ENSO mode does not significantly change due to compensating changes in ocean-atmosphere feedbacks, especially dynamical damping and thermocline feedback. A robust inverse relationship is found between ENSO strength and the strength of the annual cycle.