



## **Asian Monsoon Variability from the Monsoon Asia Drought Atlas (MADA) and Links to Indo-Pacific Climate**

Caroline Ummenhofer (1), Rosanne D'Arrigo (2), Kevin Anchukaitis (3), Manuel Hernandez (4), Brendan Buckley (2), and Edward Cook (2)

(1) Woods Hole Oceanographic Institution, Physical Oceanography, Woods Hole, United States (cummenhofer@whoi.edu), (2) Tree-Ring Laboratory, Lamont-Doherty Earth Observatory of Columbia University, Palisades, United States, (3) Woods Hole Oceanographic Institution, Geology & Geophysics, Woods Hole, United States, (4) Department of Geography, Texas A&M University, College Station, United States

Drought patterns across monsoon and temperate Asia over the period 1877–2005 are linked to Indo-Pacific climate variability associated with the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). Using the Monsoon Asia Drought Atlas (MADA) composed of a high-resolution network of hydroclimatically sensitive tree-ring records with a focus on the June-August months, spatial drought patterns during El Niño and IOD events are assessed as to their agreement with an instrumental drought index and consistency in the drought response amongst ENSO/IOD events. Spatial characteristics in drought patterns are related to regional climate anomalies over the Indo-Pacific basin, using reanalysis products, including changes in the Asian monsoon systems, zonal Walker circulation, moisture fluxes, and precipitation. A weakening of the monsoon circulation over the Indian subcontinent and Southeast Asia during El Niño events, along with anomalous subsidence over monsoon Asia and reduced moisture flux, is reflected in anomalous drought conditions over India, Southeast Asia and Indonesia. When an IOD event co-occurs with an El Niño, severe drought conditions identified in the MADA for Southeast Asia, Indonesia, eastern China and central Asia are associated with a weakened South Asian monsoon, reduced moisture flux over China, and anomalous divergent flow and subsidence over Indonesia. Variations in the strength of the South Asian monsoon can also be linked to the Strange Parallels Drought (1756-1768) affecting much of Southeast Asia and the Indian subcontinent in the mid-18th Century. Large-scale climate anomalies across the wider region during years with an anomalously strengthened/weakened South Asian monsoon are discussed with implications for severe droughts prior to the instrumental period.

Insights into the relative influences of Pacific and Indian Ocean variability for Asian monsoon climate on inter-annual to decadal and longer timescales, as recorded in the MADA, provide a useful tool for assessing long-term changes in the characteristics of Asian monsoon droughts in the context of Indo-Pacific climate variability.