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Modulation of arid Sahel conditions by earth system modes

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Transport throughout the earth climate system is regulated by interacting waves in the combined ocean – atmosphere system. There is a contemporary concern that anthropogenic forcing may push the earth system through a tipping point causing the earth system hysteresis to change. These changes are anticipated to have a substantial impact on food security, infrastructure and society resilience. Resilience in at-risk tropical regions such as Sub-Saharan Africa (Sahel) is in part dynamically related to the Pacific through teleconnection via the tropical wave guide and its topological features. Sahel has a food-insecure population anticipated to grow to 1 bn by 2050 and has a localised Inter Tropical Convergence Zone (ITCZ) where convective processes can result in extreme high or low rainfall. This whole system exhibits climatic interannual to multidecadal dynamic processes that have a relatively large signal-to-noise ratio. These Sahel rain conditions are hypothesied to be influenced by the El Niño Southern Oscillation (ENSO), Matsuno Gill response and the Pacific Interdecadal Variability (PIV) processes. Recent Pacific resonance results show, with a type of coupled tropical and extratropical oscillator model, that a low frequency modulation mode in ENSO can exist (the Heartbeat of the Southern Oscillation property). Using Dominant Frequency State Analysis extended to the spatial domain in this setting of a relatively high signal-to-noise ratio we report a focused study of how such ENSO modes can, via teleconnection, influence the rainfall and arid conditions of the Sahel. This work shows that due to the relatively large signal to noise ratio the underlying dynamic and extreme value process of the tropical-extratropical system become easier to identify. We discuss the relative benefits of our integrated analysis approach in the context of ENSO and this precipitation risk assessment.

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