



## **A Study on Extremely Dry and Wet Summer Monsoon in Pakistan by Focusing on the Anomalous States of the Upper Troposphere**

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Seasonally-changes in wind pattern, monsoon, sometimes results in severe droughts and intense flooding in many parts of the world including South Asian countries like Pakistan. The livelihood of a vast population in Pakistan depends on agriculture and land use is strongly influenced by water-based ecosystems that depend on the monsoon rains. Furthermore, climate change studies undertaken so far reveal that action is essential in order to prevent long term damage to water cycle and thus of great concern to the community and stakeholders. Pakistan Summer Monsoon (PSM) is generally affected by both the disturbances from the tropical and the extratropical regions; however there is lack of understanding of physical mechanisms of PSM compared to other regional studies i.e. Indian Summer Monsoon (ISM) and South-East Asian Monsoon (SEAM). In our study, we applied heat and vorticity budgets and wave train analysis to reveal the mechanisms of the extremely dry and wet PSM events associated with the anomalous upper tropospheric circulation. We found that the extremely dry (wet) PSM events are closely related with the strengthening(weakening) of the upper-tropospheric central Asian high. We also found that in addition to Rossby-wave (Matsuno-Gill) type atmospheric response, the Rossby wave train along the Asian Jet originating from northwestern Europe or North Atlantic Ocean strengthened(weakened) the upper-tropospheric central Asian high. Therefore strong convection anomalies resulting in severe flooding (drought) events over the PSM region are induced by both the tropical and extratropical processes.

**Key Words:** Pakistan, Extremes Monsoon Events, Physical Processes, Heat Budget, Vorticity, Wave Train