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Pakistan's extreme floods and the role of climate change

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Meteorological conditions related to the Pakistan floods of 2010 were examined in the context of monsoon dynamics and large-scale circulations. Case and climatological analyses suggest that summer precipitation in northern Pakistan comprises two distinct phases: a) a pre-monsoon trough phase (July) whose rainfall is more episodic and intense, occurring prior to arrival of the monsoon trough; and b) a monsoon trough phase (August) whose rainfall is persistent, yet less episodic, driven by northward migration of the monsoon trough. Analyses of conditional instability, moisture flux, and circulation features support a persistent increase in conditional instability during the July pre-monsoon trough phase, accompanied by increased frequency of heavy rainfall events. Conversely, evidence does not support intensification of the August monsoon trough phase. The increased convective activity during the pre-monsoon trough phase agrees with the projected increase in the intensity of heavy rainfall events over northern Pakistan. Large-scale circulation analysis reveals a cyclonic anomaly over and to the west of Pakistan - a feature empirically associated with weak monsoon. The analysis also suggests that the anomalous circulation in 2010 is not sporadic but rather is part of a long term trend that defies the typical linkage of strong monsoons with an anomalous anticyclone in the upper troposphere.