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# Meteorological Conditions Related to the August 2010 Flood Event in Ladakh, in the West Himalayas

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Ladakh, located in northern India, experienced flooding and debris flow from 4–7 August, 2010. Ladakh is a dry high-altitude (above 3000 m) region in the west Himalayas, with less than 100 mm of annual precipitation. The Research Institute for Humanity and Nature's high-altitude project installed an automatic weather station (AWS) and small temperature and humidity sensors in Ladakh in June, 2009. These instruments recorded the meteorological conditions associated with the unprecedented disaster in Ladakh.

A peculiar atmospheric circulation field and moisture transport process must have occurred during the summer of 2010 because, during this time, Ladakh experienced more precipitation than it had for at least the preceding 100 years. In the boreal summer of 2010, abnormal weather occurrences included a heat wave in Russia, flooding in Pakistan, and a hot summer in Japan. This study presents meteorological data recorded from 4–7 August, 2010, compares these data with data recorded during two other years (2009 and 2011), and investigates linkages between the data recorded in August, 2010 and the large-scale circulation field.

At dawn on 6 August, 2010, Leh, the largest town in Ladakh, was devastated. The rain gauge at Leh recorded 15.5 mm of rainfall between 0:13 and 1:13. Flooding occurred in Ladakh during the nights of 4–7 August, when the rainfall was most concentrated. Recorded AWS pressure and wind data reveal a clear diurnal circulation, suggesting a plateau-scale diurnal variation.

From 4–7 August, 2010, southerly and easterly winds prevailed and surface air pressure was higher than during the other two years. These changes corresponded to easterly winds turning around the south of the Tibetan High located in the northern part of the Tibetan Plateau. Moisture came into Ladakh from the south part of the Plateau.

The timing of the precipitation event in Ladakh differed from that of the moisture/precipitation surge in the northern part of Pakistan. Pakistan experienced a precipitation event in July; most stations in Ladakh recorded relatively high humidity during this time, but Ladakh experienced no precipitation in July except for 1 mm on 28 July at Leh. The Indian monsoon was active in late July when major flooding occurred in Pakistan, and the Tibetan High was located over the eastern part of the Plateau. Around 3 August, 2010, wave energy propagated from the southern jet stream over the south of the Caspian Sea to the Tibetan Plateau, which enhanced the Tibetan High over the western part of the Plateau. This corresponded with the break of the Indian monsoon, which produces less precipitation in the central part of India. The southeasterly flow then brought moisture to Ladakh and converged, resulting in the precipitation events of 4–7 August. The moisture flow pattern associated with the flooding in Ladakh differed from that associated with the flooding in Pakistan, but during the boreal summer of 2010 the heat wave in Russia, the flooding in Pakistan, and the flooding in Ladakh were all related to the wave energy transport of the jet stream.