

An assessment of recent extreme weather in Pakistan and Russia

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The northern hemisphere has seen a persistent pattern of waves on the jet stream during much of July, extending from the Atlantic over Europe and Asia^(Fig.1). These waves appear as a succession of northward and southward meanders of the jet stream. The northward meanders are ridges of high pressure that give cloudless skies and, in summer, hot temperatures at the ground. Conversely the southward meanders are troughs of low pressure that give cloud and rain.

This summer a large and persistent northward meander of the jet stream has occurred over western Russia, drawing warm air far northward from the Mediterranean and leading to a so-called "blocking" anticyclone with record high temperatures across the region^(Fig.2). In addition to the heat, forest fires caused by the dry and hot weather have created smog in Moscow and the surrounding region, with serious impacts on human health.

To the east, cold air has been drawn southward towards the Asian monsoon region. This has moved the jet stream further south than normal in a trough whose tip has crossed the mountains over northern Pakistan, intensifying the monsoon rains there. This trough in the high atmosphere strengthened in the last week of July at the same time as, near the surface, a monsoon depression moved west from the Bay of Bengal, taking moisture laden air unusually far across northern India into northern Pakistan, beneath the trough^(Fig.3). It appears to be this conjunction of events that led to the intense rain over northern Pakistan on 28-30 July and the subsequent flooding that has spread south along the Indus river.

Weather in other regions has also been affected by the disturbed jet stream. Further east, intense rain over parts of China at the start of August appears to have been associated with the "next" trough in the pattern, while earlier hot weather in Japan was associated with a ridge still further east. West of the Russian anticyclone, the trough over Western Europe strengthened and extended to the Mediterranean in early August, leading to intense rain and subsequent flooding in eastern Germany on the 6th.

We do not yet know the origin of the persistent pattern of waves on the jet stream this summer. Such patterns are part of the natural variability of the atmosphere that lead to weather variations over weeks, months and seasons. This summer there is a developing La Niña with cool ocean temperatures in the equatorial Pacific and historically there has been a tendency for wetter than average Asian monsoons to occur in La Niña summers. However, there does not appear to be any evidence to link persistent jet stream patterns in recent summers with either La Niña or its warm water opposite, El Niño. During the preceding three northern summers, a persistent pattern of waves has occurred around much of the northern hemisphere jet stream, but Pacific ocean temperatures varied above and below normal in the different years. This jet stream pattern led to flooding in the UK during June and July 2007, and to further wet summers over Western Europe in both 2008 and 2009.

Could global warming be playing any role in this summer's events? It is not possible to attribute individual extreme weather events such as the Russian heatwave or Pakistan floods directly to global

warming. However, higher temperatures overall do increase the risk of experiencing extreme high values. Also, since warmer air holds more water vapour, peak rainfall rates are also expected to increase as temperatures rise. Extreme temperatures and rainfall are indeed being observed to occur more frequently across the globe and model predictions of future climate suggest that these trends will continue. In addition, model projections and basic theory do suggest that the monsoon over Asia will become slightly wetter on average. However, the spatial distribution of these changes (which regions will endure wetter or drier conditions) remains very uncertain, as do changes in the monsoon variability from week to week.

To assess the severity of flooding due to extreme precipitation in the context of previous events, factors on the ground must also be taken into account, in addition to precipitation amounts. In the case of Pakistan, hydrologists have drawn attention to changes in river management and water use over time. These affect the severity of flooding resulting from any given amount of precipitation. In addition, the scale of the human impact and consequently the scale of the emergency relief and longer term recovery increase with increasing population. Pakistan has seen its population double over the last 30 years, following annual increases of around 3% in the 1970s.

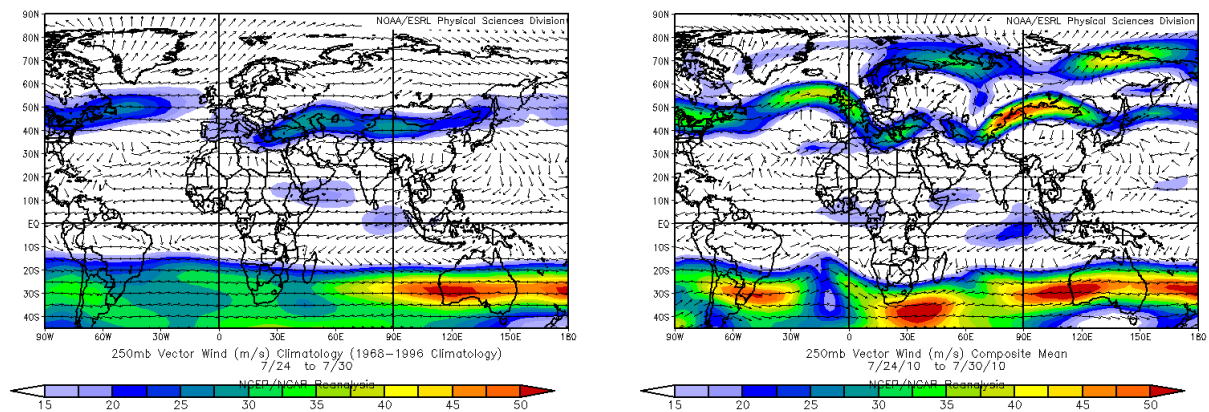


Fig.1. Winds near the tropopause, showing the jet stream over the Atlantic, Europe and Asia. The normal position of the jet stream in late July, averaged over many years, is shown on the left. The last week of July 2010 is shown on the right. NCEP reanalysis data, plotted using software at the NOAA Earth System Research Laboratory, <http://www.esrl.noaa.gov>

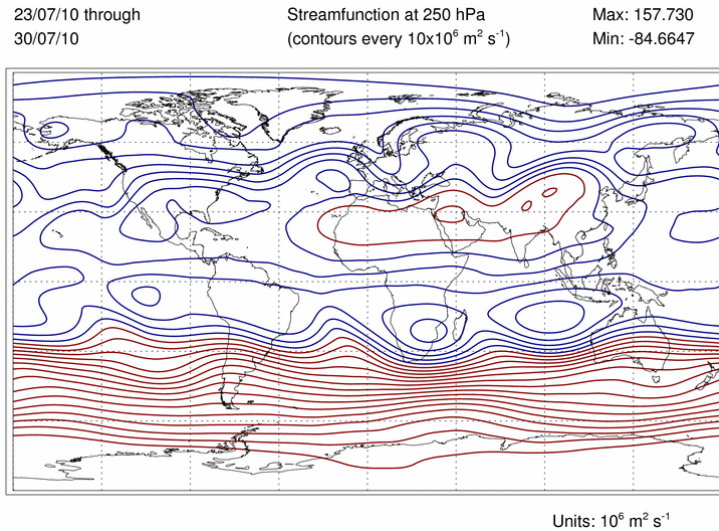


Fig.2. Streamfunction near the tropopause, for the last week of July 2010. The wind blows from west to east in mid-latitudes, approximately parallel to the contours and more strongly where the contours are close together. A large blocking anticyclone appears as the “omega” (Ω) shape over western Russia. The jet stream is split and diverted both north and south around the block. Either side are troughs of low pressure, where the jet stream meanders south. The trough at 70°E intensified monsoon rains over northern Pakistan. Data from ECMWF operational analyses.

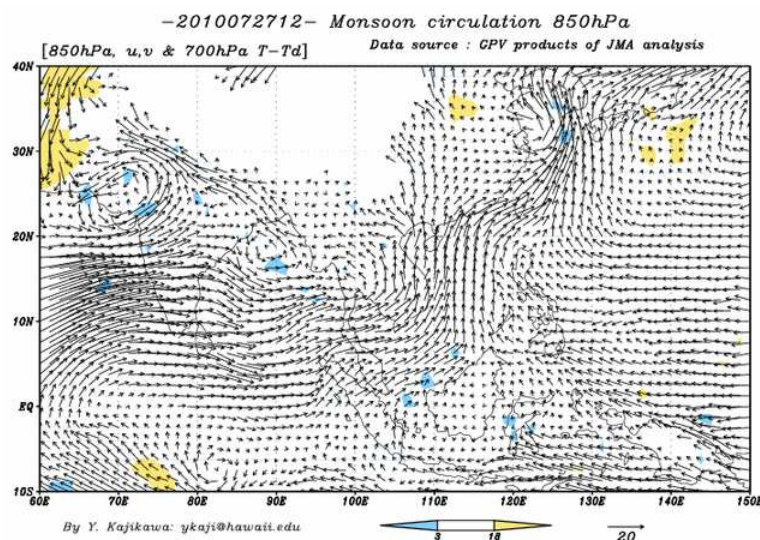


Fig.3 Low-level monsoon winds over South Asia on 27 July 2010, showing moist air being carried north-west along the Himalayan foothills by a monsoon depression, into the region beneath the jet stream trough over Northern Pakistan. Courtesy Y. Kajikawa, University of Hawaii, <http://iprc.soest.hawaii.edu/users/ykaji/monsoon/>