be positive or negative; the positive ones (such as 'likely' or 'a chance') ask readers to consider occurrences regardless of the numerical probabilities involved, whereas negative terms (such as 'unlikely' or 'not certain') ask readers to contemplate the other side of the coin[9]. Positive words are also more often chosen in a context of increasing probabilities[10]. A closer reading of the IPCC reports reveals that the term 'likely' is used 10–20 times more often than 'unlikely'[11]. This makes sense from a pragmatic point of view, as informing the public about what might happen appears more useful than asking them to consider what might not. ❐

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HYDROLOGY

Probing the monsoon pulse

Identification of long-term changes in periods of extreme heavy and weak rainfall during the Indian monsoon season has been elusive. Now, an observational study provides the firmest evidence so far.

Massimo A. Bollasina

The flooding in northern India in June 2013 was a vivid reminder of the vital socio-economic importance of extreme variations of the South Asian summer monsoon. Given the devastating impact of severe rainfall events on human society and the environment, detecting recent changes in the characteristics of these events is an issue of utmost importance[1]. Understanding recent extreme variability is critical for more reliable projections of future changes[2] and the effective management of future climate-related risks[3]. However, long-term changes in the total precipitation during the monsoon season have received considerably more attention, and existing studies on subseasonal variability have shown rather contradictory results[4,5]. Now, in a study published in *Nature Climate Change*, Deepti Singh and colleagues[6] use a rigorous statistical approach to identify changes in the observed frequency and intensity of extreme monsoon rainfall spells during the past 60 years.

The June–September monsoon season provides up to 80% of the total annual rainfall over the Indian subcontinent, where more than 1.7 billion people (over 25% of the world's population) live and strongly rely on monsoon rainfall for their mainly agrarian societies. Surprisingly, seasonal mean rainfall is remarkably stable from year to year, with variations typically within 10% of the long-term mean[3,5,7]. However, once the monsoon is underway, rainfall is not steady but is punctuated by considerable fluctuations between periods (lasting from days to weeks) of heavy and low rainfall (wet and dry spells)[5,6]. Extremes in these events, which manifest as floods and droughts, have tremendous impacts on agriculture, health, economy and water supply[1]. The prolonged monsoon failure during July 2002, with a 50% rainfall deficit, contributed to a remarkable reduction in agricultural production and the growth rate of gross domestic product.

Figure 1 | During the South Asian summer monsoon season the weather fluctuates between wet and dry spells, which are periods of heavy and weak rainfall. Extreme spells have large impacts on the livelihoods of people living in the Indian subcontinent.

Singh *et al.*[6] conducted a robust statistical analysis of daily precipitation observations and accounted for a number of sources of uncertainty in the methodology. Their work shows compelling evidence of changes in the characteristics of peak monsoon (July–August) extreme spells since the mid-twentieth century. Using rainfall anomalies averaged over the representative central India core monsoon region, extreme wet and dry spells are formally defined as periods of three of more consecutive days with anomalies exceeding the long-term mean variability (one standard deviation).

In addition to reduced seasonal mean precipitation since the 1950s[8], daily rainfall variability increased — rain occurred less frequently but with more variable intensity. This led to an increased frequency of both light and heavy rainfall events, consistent with an earlier study[4], and a 2 mm per day reduction in the peak rainfall. Singh and colleagues show a statistically significant shift towards more intense wet spells and more frequent but less intense dry spells. Although the frequency of wet spells shows a decreasing trend over the past few decades, consistent with the decreasing number of monsoon depressions over the Bay of Bengal, the number and duration of events do not change significantly over the entire period. Similarly, the duration and cumulative length of dry spells show increasing trends, but their weak magnitudes prevent them from being unambiguously isolated. These changes are supported by an increased amount of available energy and a convergence of moisture over the region — two conditions favouring stronger convective activity. Recognizing that their analysis might be hampered by arbitrary methodology choices, the team tested the robustness of their findings against a second precipitation dataset, the size of the core monsoon region and the length of the two sample periods used to build the statistics.

Much work remains to be done. Although their study focused primarily on rainfall, arguably the most important feature of the monsoon, Singh and colleagues did not fully investigate the physical mechanisms associated with the extreme spells. These include, for example, a characterization of their evolution, transitions between spells and their links with the coupled land–atmosphere–ocean monsoon system[5]. Steps in this direction will improve understanding of the temporal and spatial nature of the spells. This requires accounting for multi-scale interactions in the monsoon over the entire season[7] because subseasonal variability is not completely separable from the underlying changes at seasonal and interannual timescales[3].

An additional compelling, but currently unanswered, question is whether (and to what extent) long-term changes in monsoon wet and dry spells could be associated with, and possibly attributed to, human factors such as greenhouse gas or aerosol emissions. Human-induced warming is expected to lead to an increase in heavy rainfall events due to enhanced moisture content in the atmosphere, with less frequent and/or less intense light-precipitation events[3,4]. Evidence shown by Singh *et al.*[6] and by previous studies is partially consistent with this picture. It has also been suggested that increased aerosols affect seasonal and subseasonal monsoon precipitation[8], including potentially the transition from dry to wet spells[9]. Although global climate models are still fraught with uncertainties, especially with regard to simulating the monsoon subseasonal variability[3], they hold the key to addressing these issues and to increasing our ability to predict and interpret future regional climate change. Some results seem promising[2], and the higher spatial resolution of the newest models is expected to reduce current uncertainties.

Despite some limitations, the findings of Singh *et al.*[6] represent a further step towards a rigorous identification of recent long-term changes in the variability of the South Asian monsoon. The results of extreme rainfall — landslides, floods and crop damage — have major impacts on society, the economy and the environment[1]. The study by Singh and colleagues provides important planning information for managing water resources, agriculture, disaster preparedness and infrastructure. ❐

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WARMING TRENDS

Nonlinear climate change

Most studies assume that temperature trends are linear. Now, research demonstrates that warming trends are nonlinear, that warming accelerated over most of the twentieth century and is much stronger since 1980 than calculated by linear methods.

Christian L. E. Franzke

How have temperatures changed due to global warming where you live? The latest IPCC report[1] has again confirmed the fact that our planet is warming due to human activities. While the global mean temperature is an excellent measure of this warming on a global scale, the impact on local scales is much harder to discern because natural climate variability still plays a dominant role[2]. In Europe, some might thing that the cold winters of 2009/2010 and 2010/2011 contradict global warming. However, the most probable explanation is that an imprint of nonlinear natural climate variability was briefly overriding the global warming trend. Writing in *Nature Climate Change*, Fei Ji and colleagues[3] report on the nonlinear spatial–temporal evolution of the land surface temperature trends over the instrumental period (1901–2009).

We all know that climate is changing due to anthropogenic activities, but how can this be quantified? In the past,