Indian monsoon: Novel approach allows early forecasting

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The Indian monsoon's yearly onset and withdrawal can now be forecasted significantly earlier than previously possible. A team of scientists developed a novel prediction method based on a network analysis of regional weather data, and will propose this approach to the Indian Meteorological Department. The heavy summer rains are of vital importance for millions of farmers feeding the subcontinent's population. Future climate change will likely affect monsoon stability and hence makes accurate forecasting even more relevant.

"We can predict the beginning of the Indian monsoon two weeks earlier, and the end of it even six weeks earlier than before - which is quite a breakthrough, given that for the farmers every day counts," says Veronika Stolbova from the Potsdam Institute for Climate Impact Research (PIK) and the University of Zurich, the lead-author of the study to be published in the *Geophysical Research Letters*. "We found that in North Pakistan and the Eastern Ghats, a mountain range close to the Indian Ocean, changes of temperatures and humidity mark a critical transition to monsoon," explains Stolbova. Conventionally, the focus has been on the Kerala region on the southern tip of India.

Rainfall timing is key for growing rice, but also for generating hydro power

Information about monsoon timing is key for Indian farmers to determine when to carry out the sowing. Crops like rice, soybean and

cotton are normally grown during the June to September monsoon rainy season. Even a slight deviation of the monsoon can lead to droughts or floods, causing damages. Also, the length of the monsoon is relevant for planning [hydro power](#) generation since the rains are necessary to fill the dams and reservoirs.

The scientists tested their method with historical monsoon data. It gives correct predictions for onset in more than 70 percent and for withdrawal in more than 80 percent of the considered years. The main advantage of the proposed approach is that it allows to improve the time horizon of the prediction compared to the methods currently used in India. In addition, the new scheme notably improves the forecasting of monsoon timing during years affected by the global weather phenomenon El Nino - Southern Oscillation (ENSO), particularly in its La Nina phase. This phenomenon significantly alters monsoon timing and decreases the prediction accuracy in existing methods.

Network analysis: "The climate system is just like Facebook"

"We see the climate system as a network, just like the social networks so many people are using in their everyday life," says co-author Jürgen Kurths, head of PIK's research domain Transdisciplinary Concepts & Methods. "On Facebook or Twitter, you can follow how news is spreading, one posting leading to many others. In the climate system, not people but geographical regions are communicating - admittedly in a quite complex way." Like Facebook postings or tweets that get shared over and over again, temperature and humidity get transported from one place to another by atmospheric flows, such as winds.

Using the network analysis of complex non-linear systems, an advanced mathematical approach, for monsoon forecasting is unprecedented - yet

the approach shows good results. The major innovation, the authors say, is to combine the network analysis with the subtle statistical analyses of the early warning signals for the monsoon onset and withdrawal. "These precursor phenomena are often buried by huge piles of weather data and hence get overlooked," says Elena Surovyatkina of the Russian Academy of Sciences' Space Research Institute, currently a PIK guest scientist. "We discovered how to use precursors in a new way - to find regions where critical conditions for an occurence of the Indian monsoon originate." This has been achieved in cooperation with co-author Bodo Bockhagen from the University of Potsdam. In the future, this method can also help to unravel mysteries of other climate phenomena.

Climate change affects rainfall, making accurate predictions more important

Global warming due to mankind's greenhouse-gas emissions from burning fossil fuels already affects the Indian monsoon and - if unabated - is expected to do even more so in the future. "We're seeing this in our data, and other research also points in this direction," says project-lead Jürgen Kurths. "The timing of Indian summer monsoon, on which the livelihoods of many million people depend, is likely becoming more erratic. This makes early and accurate forecasting ever more crucial."