Researchers achieve improved prediction of Indian Monsoon onset using machine learning

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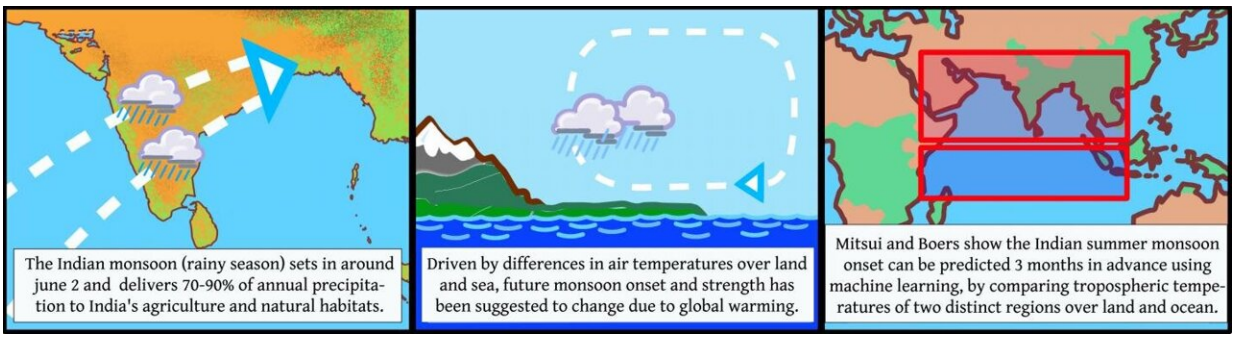

The findings in brief. Credit: TiPES/HP

The onset of the Indian summer monsoon has been predicted three months ahead for the last 40 years with the highest precision up until today. The result indicates longer seasonal forecasts based on machine learning may be a way to mitigate the consequences of an erratic monsoon system under future global warming. Dr. Takahito Mitsui and Dr. Niklas Boers of the Potsdam Institute of Climate Impact Research (PIK Potsdam), Germany, published the results in *Environmental Research Letters*. The work is part of the European TiPES project, Coordinated from The Niels Bohr Institute, University of Copenhagen, Denmark and PIK Potsdam.

Millions of people as well as natural habitats depend on the precipitation from the Indian summer monsoon. Global warming, however, is already changing the monsoon system and will further increase the variation in precipitation patterns as well as monsoon onset and duration in the future. Seasonal forecasts might provide early warnings for farmers and others depending on the Indian monsoon to plan ahead and mitigate the consequences of interannual variabilities.

Climate scientists from PIK Potsdam, Germany now provide an improved three-month preseasonal forecast using machine learning. The predictions use data since 1948 and thus cover the climate changes of the latest decennia. The work provides a promising basis for further research toward predicting the onset of the Indian summer monsoon in the coming decades, as accelerated global warming might change the dynamics behind this monsoon system.

Comparing reconstructed data of tropospheric temperatures over the Indian Ocean and the Indian subcontinent the scientists used a shift in temperature balance between two areas to predict the monsoon onset. The resulting accuracy of +/- 4.8 days is an improvement compared to earlier attempts using traditional weather prediction models to forecast the Indian monsoon onset in a three months range.

"We can confirm with a level of optimism that it should be possible to predict the onsets of future monsoons even as global climate change accelerates in the coming decades. Indeed, our prediction method works well for the last 40 years, during which gradual global warming already has taken place," says Takahito Mitsui.

"Our study reveals the large potential of machine learning methods in forecasting climate phenomena such as the monsoon onset. Ultimately, our goal is to combine traditional weather prediction models with machine learning models such as the one proposed here, which will

hopefully lead to even more skilful forecasts," says Niklas Boers.

The possibility of accurate predictions in a world with a much higher global warming, however, has not yet been investigated. The outlook for the Indian monsoon system in a changing global climate is scientifically debated. The current monsoon system might tip to a more irregular state. But it might also simply change gradually as the seasonal imbalances between the temperatures over regional landmasses and sea surfaces shift with global warming.

"We will be able to examine this with the climate model simulations under global warming scenarios. Then we will be able to answer more confidently if our method can or cannot predict some possible failure in the Indian Monsoon system in advance," says Takahito Mitsui.

The TiPES project is an EU Horizon 2020 interdisciplinary climate science project on tipping points in the Earth system. Eighteen partner institutions work together in more than 10 countries. TiPES is coordinated and led by The Niels Bohr Institute at the University of Copenhagen, Denmark and the Potsdam Institute for Climate Impact Research, Germany.

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More information: Takahito Mitsui et al, Seasonal prediction of Indian summer monsoon onset with echo state networks, *Environmental Research Letters* (2021). DOI: 10.1088/1748-9326/ac0acb

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