Study projects weakened monsoon season in South Asia

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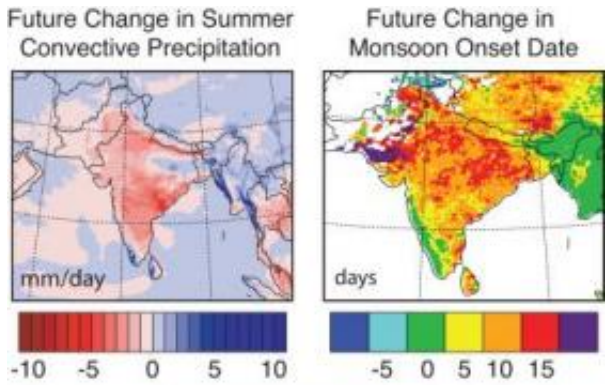

These maps show projected future changes in South Asian summer precipitation and monsoon onset date. A Purdue-led team found that rising future temperatures could lead to less rain and a delay in the start of monsoon season by up to 15 days by the end of the 21st century. Diffenbaugh lab image

(PhysOrg.com) -- The South Asian summer monsoon - critical to agriculture in Bangladesh, India, Nepal and Pakistan - could be weakened and delayed due to rising temperatures in the future, according to a recent climate modeling study.

A Purdue University research group found that climate change could influence monsoon dynamics and cause less summer precipitation, a delay in the start of monsoon season and longer breaks between the rainy periods.

Noah Diffenbaugh, whose research group led the study, said the summer monsoon affects water resources, agriculture, economics, ecosystems and human health throughout South Asia.

"Almost half of the world's population lives in areas affected by these monsoons, and even slight deviations from the normal monsoon pattern can have great impact," said Diffenbaugh, an associate professor of earth and atmospheric sciences and interim director of the Purdue Climate Change Research Center. "Agricultural production, water availability and hydroelectric power generation could be substantially affected by delayed monsoon onset and reduced surface runoff. Alternatively, the model projects increases in precipitation over some areas, including Bangladesh, which could exacerbate seasonal flood risks."

The summer monsoons are responsible for approximately 75 percent of the total annual rainfall in major parts of the region and produce almost 90 percent of India's water supply, he said.

General circulation models have been used for projections of what may happen to monsoon patterns for this region, but the models have disagreed as to whether precipitation will increase or decrease, said Moetasim Ashfaq, lead author of the study and a graduate student in earth and atmospheric sciences at Purdue.

"South Asia is a unique region with very complex topography," he said. "It ranges from 0 meters elevation from sea level in the south to more than 5,500 meters from sea level in the north. So in terms of topography playing a role in climate and weather, this region of the world is where we expect to see a large impact. Global models like the ones featured in the Intergovernmental Panel on Climate Change reports can resolve large-scale interactions but have difficulty capturing some of the more subtle atmospheric processes."

The research team used a high-resolution climate model believed to have the greatest detail currently available for this region. A paper detailing the work was published in the Jan. 3 issue of *Geophysical Research Letters*. Co-authors from Purdue include assistant professor Wen-wen Tung and associate professor Robert J. Trapp, both from the Department of Earth and Atmospheric Sciences. Additional co-authors include Ying Shi and Xueijie Gao of the National Climate Centre in Beijing and Jeremy S. Pal of Loyola Marymount University.

"Our simulations are the most detailed to date for this part of the world, but it doesn't mean we have the answer," Diffenbaugh said. "It highlights the importance of spatial complexity in the climate response and suggests that understanding the potential impacts of future climate change in this region requires improved understanding of a host of climate processes."

The model projected a delay in the start of monsoon season from five days to 15 days by the end of the 21st century and an overall weakening of the summer monsoon precipitation over South Asia. Ashfaq said increasing temperatures in the future strengthen some aspects of large-scale monsoon circulation but weaken the fine-scale interactions of the land with the moisture in the atmosphere, which could lead to reduced precipitation over the Indian subcontinent.

"It is the more subtle, local-scale processes that are key in this case," he said. "Our model shows a decrease in convective precipitation, which is critical for summer precipitation in this region. Our findings show it is not just a question of whether monsoon circulation is stronger or weaker. Even with a strong monsoon system, if circulation changes enough to change where and when rain is delivered, then that could have an impact that has not been captured in the large-scale evaluations."

The atmospheric conditions that lead to reduced precipitation also can

lead to intensification of extremely hot conditions, he said.

"In the past when we have seen extremely hot days, we have observed a similar circulation anomaly," Ashfaq said. "These circulation changes decrease moisture flow over the land, and we see longer periods without rain, along with hot conditions."

The model shows an eastward shift in monsoon circulation, which would mean more rainfall over the Indian Ocean, Bangladesh and Myanmar, and less over India, Nepal and Pakistan, Ashfaq said. Less moisture over the land in combination with the ambient dry summer air would lead to less moisture in the clouds and reduced rainfall.

Monsoon moisture flow comes from ocean to land. In the summer, the land warms faster than the ocean. This creates a pressure gradient that draws air masses from the ocean to the continent, bringing moist air that promotes formation of a large-scale monsoon system.

Monsoon season, which starts in early June and ends in late September, begins at the southeast tip of India and moves northwest to the rest of India and Pakistan.

The climate model used by the research team accurately recreated the monsoon season of past years, and its future projections are consistent with what has been seen in recent drought years over this region, Diffenbaugh said.

The team next plans to examine a broader range of global climate models and to assess the impact of potential future changes on food security and the economy.

More information: "Suppression of South Asian Summer Monsoon Precipitation in the 21st Century," *Geophysical Research Letters*, Jan. 3

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Provided by Purdue University (news : web)