Elena Surovyatkina

Forecasting monsoon onset and withdrawal in Central Ethiopia more than a month in advance.

The German Physical Society (DPG), DPG Spring Meeting, Technische Universität Dresden (TU Dresden)
10-12 May 2023, Addis Ababa, Ethiopia
What, where, and when will it happen?
To plow or not to plow, that is a question. When does the rainy season begin?
Ethiopia, one of the world's most drought-prone countries, is faced with increasingly unpredictable rains and, in some years, the complete failure of seasonal rains. Understanding natural hazard occurrence and climate conditions is critical to comprehending a country's vulnerability.
The ITCZ follows the maximum solar radiation thus its position varies seasonally. It moves north in the Northern Hemisphere summer and south in the Northern Hemisphere winter.
Advance and withdrawal of monsoon

Monsoon onset forecast by the Indian Meteorological Department (the IMD)

- The Indian Meteorological Department (the IMD) forecasts monsoon 14 days in advance and only for Kerala state on the southern tip of India.
- There is no monsoon onset forecast for the other 28 states of the country.
- The IMD does not forecast withdrawal date due to lack of methodology.
- The monsoon onset conditions for Kerala cannot be applied to other states.
The limitations of current models prevent further progress. A new strategy is desperately needed in weather and climate sciences

[Stevens and Bony, Science 31 May 2013].
The approach is fundamentally different from the numerical weather forecast; it is based on the following ground rules:

- statistical physics principles,
- new spatial-temporal regularities in a monsoon system or teleconnection between Tipping Elements,
- data analysis.

Tipping elements of the Indian monsoon: Prediction of onset and withdrawal

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Abstract Forecasting the onset and withdrawal of the Indian summer monsoon is crucial for the life and prosperity of more than one billion inhabitants of the Indian subcontinent. However, accurate prediction of monsoon timing remains a challenge, despite numerous efforts. Here we present a method for prediction of monsoon timing based on a critical transition precursor. We identify geographic regions — tipping elements of the monsoon — and use them as observation locations for predicting onset and withdrawal dates. Unlike previous methods, our approach does not rely on precipitation analysis but on air temperature and relative humidity, which are well represented both in models and observations. The proposed method allows to predict onset 2 weeks earlier and withdrawal dates 1.5 months earlier than existing methods. In addition, it enables to correctly forecast monsoon duration for some anomalous years, often associated with droughts or floods. These improvements can significantly enhance the planning and management of water resources in the Indian subcontinent.
What does the term 'tipping' mean?

One of the definitions of tip

- overbalance or
- cause to overbalance

“The hay caught fire when the candle tipped over.....”

✔ The candle is an origin of the problem – a tipping element of the system.

✔ The time when the candle tipped over is a tipping point.

✔ An open window which gives the direction of flame propagation is the second tipping element of the system.
DATA

NCEP/NCAR Reanalysis 1

• 4-times daily, daily and monthly values for 1948/01/01 to present
• 2.5 degree latitude x 2.5 degree longitude global grid (144x73)

https://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.surface.html

ERA-Interim

• 4-times daily, daily and monthly values for 1979/01/01 to present (delay 2m)
• 0.125 degree latitude x 0.125 degree longitude global grid

https://www.ecmwf.int/en/forecasts/datasets/archivedatasets/reanalysis-datasets/era-interim
Critical fluctuations

1. Where (geographically) do critical conditions originate?

Tipping elements of Indian Summer Monsoon

DATA: ERA40: near-surface air temperature, 0.25°/0.25° resolution, (1958-2001)
2. How do the critical conditions propagate in space?

https://earth.nullschool.net/#2016/06/17/0300Z/wind/isobaric/1000hPa/orthographic=78.74,8.05,626/loc=80,20
The onset of monsoon in the EG appears when the conditions in two regions NP and EG equalizes.

DATA: NCEP/NCAR reanalysis, 2.5°, near-surface air temperature, (1951-2015)
D: MONSOON FORECAST FOR CENTRAL INDIA – 2021

Onset Date: 21-29 June

Forecast issued: 40 days in advance

Withdrawal Date: 31-10 Oct

47 days in advance

21 - 29 June

31 - 10 Oct

Monsoon

Daily Precipitation, mm

Temperature, °C

Jan 1  Feb 19  Apr 10  May 30  Jul 19  Sep 7  Oct 27  Dec 16
Daily mean near-surface air temperature till **May 8, 2022**, for the Eastern Ghats (red) and North Pakistan (blue). Purple and grey lines - past 5-years average for same regions. The intersection between two time series indicates the critical temperature and the forecasted onset date.
PIK - Monsoon Withdrawal Forecast for Central India, 2022

Withdrawal date forecast: 60 days in advance

Monsoon Withdrawal 4-12 October

@ Elena Surovyatkina
Evidence from Retrospective Evaluation

74% of success rate

84% of success rate
<table>
<thead>
<tr>
<th>Year</th>
<th>ONSET OF MONSOON</th>
<th>WITHDRAWAL OF MONSOON</th>
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<td>FORECAST 40 DAYS IN ADVANCE</td>
<td>OBSERVATION</td>
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<td>2016</td>
<td>9-17 June</td>
<td>17 June</td>
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<td>2017</td>
<td>14-22 June</td>
<td>16-18 June</td>
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<td>21-29 June</td>
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</tr>
<tr>
<td>2022</td>
<td>14-18 June</td>
<td>14-15 June</td>
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</tbody>
</table>

https://www.pik-potsdam.de/members/elenasur/forecasting-indian-monsoon/welcome-to-the-pik-monsoon-page-1
Welcome to Elena Surovyatkina’s Monsoon Page!

This web page provides a long-term forecast of the onset and withdrawal of the Indian Summer Monsoon (the Southwest Monsoon) in the central part of India and the Msimu rains in Southern Tanzania. The long-term forecast means 40 days in advance for the onset date, and 70 days in advance for the withdrawal date. My approach is based on a teleconnection between Tipping Elements of Monsoon. The forecasts are performed by Elena Surovyatkina.

https://www.pik-potsdam.de/members/elenasur/forecasting-indian-monsoon/welcome-to-the-pik-monsoon-page-1
‘Monsoon withdrawal will be sooner this year’

Down To Earth speaks to climate scientist Elena Surovyatkina, who said the overall south west monsoon over India had started in 2020. She issued her forecast for the monsoon withdrawal date from the central part of India on August 14. The unique forecast, made for 50 days in advance, is the only available monsoon onset and withdrawal forecast in India. Edited excerpts:

Akshit Sangomia: What do you think about monsoon behaviour in 2020?

Elena Surovyatkina: According to my observations, pre-monsoon rainfall usually disturbs the organisation of the monsoon, making it delayed and weaker. The year 2020 has been no exception. The very disorganised advance of the onset of the monsoon, a dry spell between June 17 and June 26 is the consequence of unusually strong pre-monsoon rains in spring.

In fact, the real monsoon rainfall began over the Eastern Ghats only...
Rainy season in Central Ethiopia
Rainy season Forecast for Central Ethiopia, 2023

Long-term forecast: 40 days in advance

10 March 2023

Daily mean near-surface air temperature and relative humidity till May 3, 2023, for the Central Ethiopia (red) and Central Sudan (blue). Violet and grey lines are past the 5-year average for the same regions. The onset of rainy season is expected after the 20th of April. My forecasted dates have a narrow uncertainty range of +/- 4 days.
Rainy season Forecast for Central Ethiopia, 2023

Jan 1 Feb 19 Apr 10 May 30 Jul 19 Sep 7 Oct 27 Dec 16

Temperature, °C

Relative Humidity, %

20 April
20 June

Belg
Kiremt

@ Elena Surovyatkina
Forecasting scheme of sea ice advance date

Forecast Okhotsk Sea ice freeze onset date:

Nov 30 – Dec 7, 2019

Daily mean near-surface air temperature at 1000hPa (NCEP Reanalysis) till Nov 8, 2019 for the western (red) and eastern parts (blue). Violet and gray lines - past 19-years average for same regions. The tipping point (red) indicates the critical temperature and the forecasted onset date.
Current Progress:

I offer the following forecasts both in North and South hemispheres:
- in India: summer monsoon in Central India and Telangana state;
- in Africa: Tanzania
- in Russia and Japan Sea Ice Season in the Sea of Okhotsk.

Possible Extensions:
- Eurasia: South Asia, South China, Japan, the Arctic Circle;
- Africa: Ethiopia, Congo;
- South and North America.
Conclusion

The new methodology offers the following advances:

1. Predicting the date of the upcoming rainy season onset for 40 days in advance, that is unprecedently early.

2. Forecasting withdrawal date for 70 days in advance, and it is the only one available withdrawal forecast in Ethiopia.

3. The applicability of the methodology is not limited by specific location; it works for different parts of India, Africa and South America.

The seven years tests (2016-2022) show successful results.
References


• Ludescher et al. Network-based Forecasting of Climate Phenomena, PNAS 2021, Vol. 118 No. 47 e1922872118, https://doi.org/10.1073/pnas.1922872118

Thanks my co-authors
Wind speed @ 850hPa

09.05.2022

09.05.2023
Surface air temperature anomaly for April 2022 and 2023 relative to the April average for the period 1991-2020.