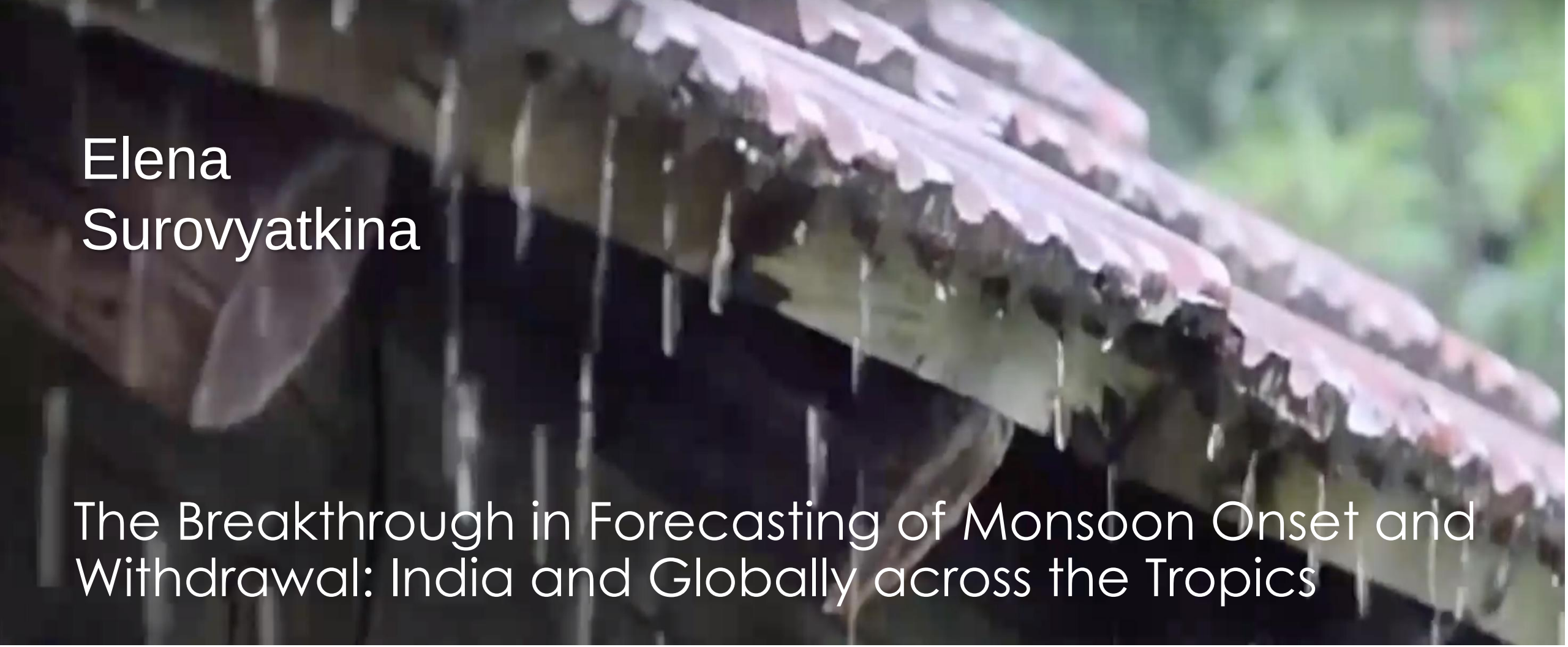


Elena
Surovyatkina

The Breakthrough in Forecasting of Monsoon Onset and Withdrawal: India and Globally across the Tropics

SPACE RESEARCH INSTITUTE
RUSSIAN ACADEMY OF SCIENCES

POTSDAM INSTITUTE FOR
CLIMATE IMPACT RESEARCH

Eighth WMO International Workshop on Monsoons (IWM-8), Puna, India
17-21 March 2025

CONTRIBUTIONS TO THE FIELD OF MONSOON RESEARCH

Together with my colleague, Dr. Veronika Stolbova

- We discovered that the onset and withdrawal of monsoons are critical phenomena.
- We revealed a universal regularity across all regions of the monsoon zone on the Indian continent.
- We developed a new theory of critical transitions from pre-monsoon to monsoon and to post-monsoon.
- We identified new regularities in the spatial-temporal propagation of monsoons.
- We created a universal approach to forecast the onset and withdrawal of monsoons more than a month in advance.

The discovered approach is set to revolutionize our understanding of monsoon onset and withdrawal, paving the way for reliable long-term forecasts.

Stolbova V., Surovyatkina E., Bookhagen B., Kurths J., GRL43, 1–9, (2016), doi:10.1002/2016GL068392

Transition to monsoon

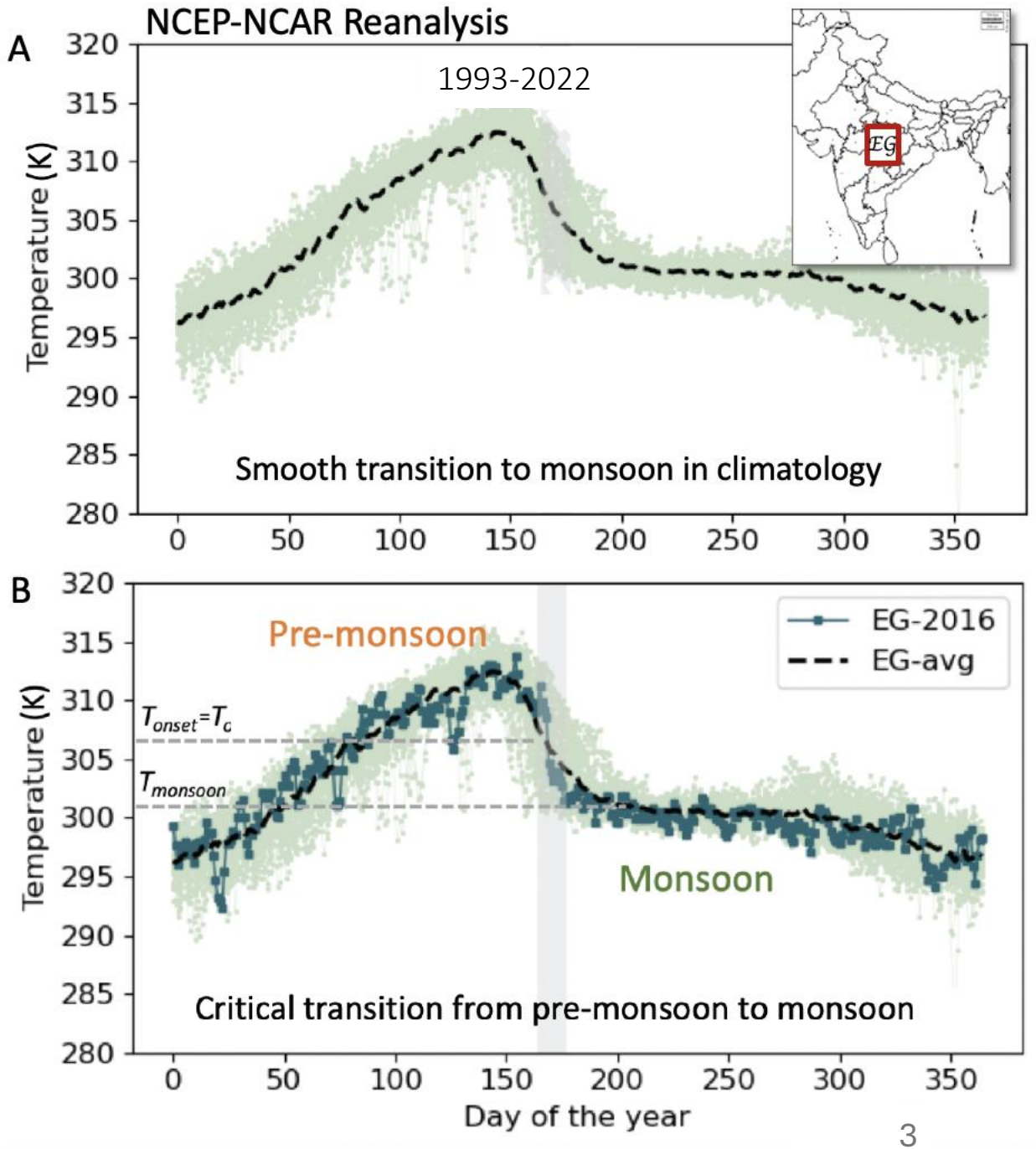
- According to climatology, the transition to the monsoon season happens gradually (Fig. A).

- However, looking at an individual year shows a sharp transition. (Fig. B).

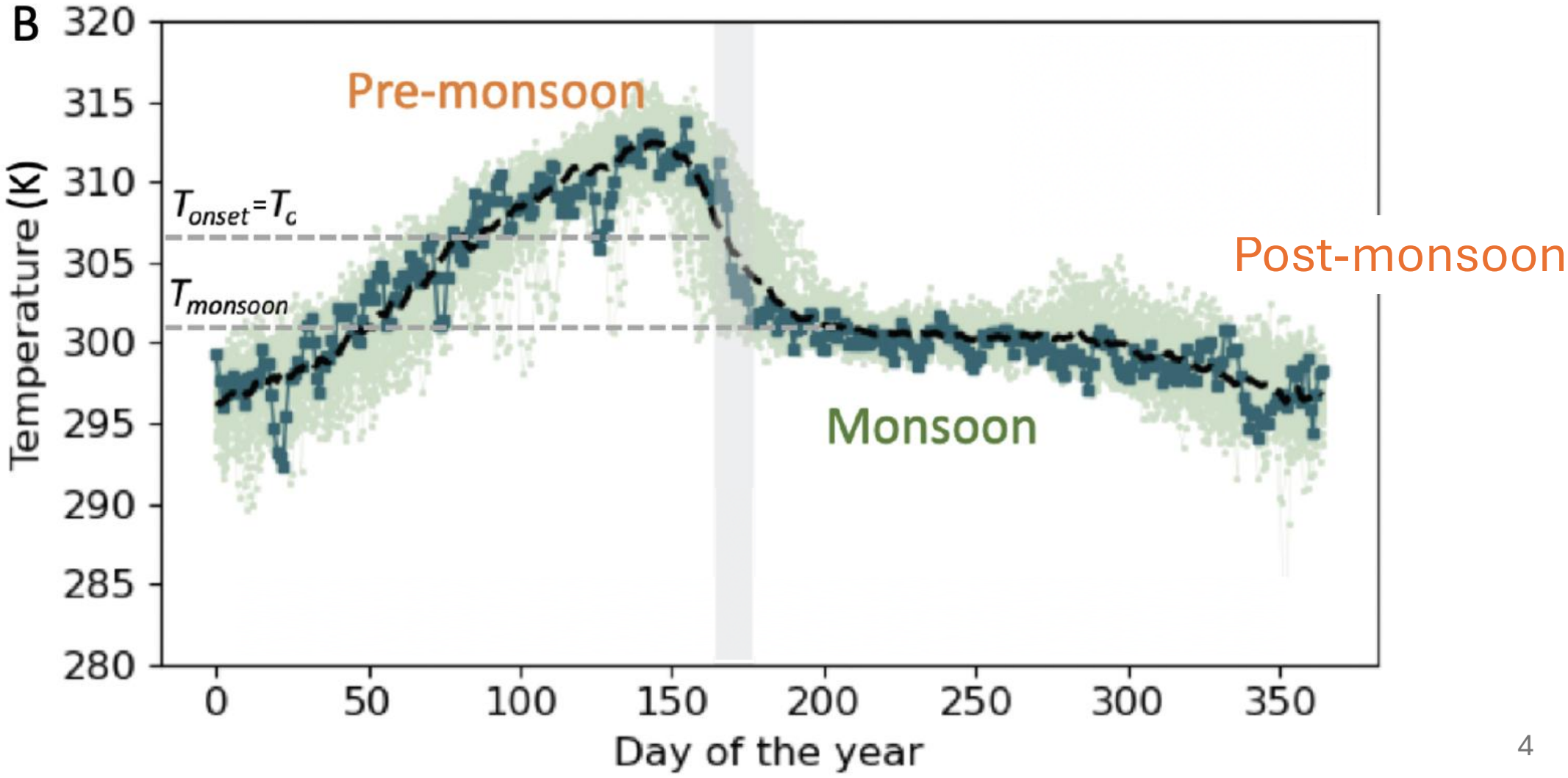
This discovery allows me to apply the theory of critical transitions.

✓ Establish two stable states: pre-monsoon and monsoon.

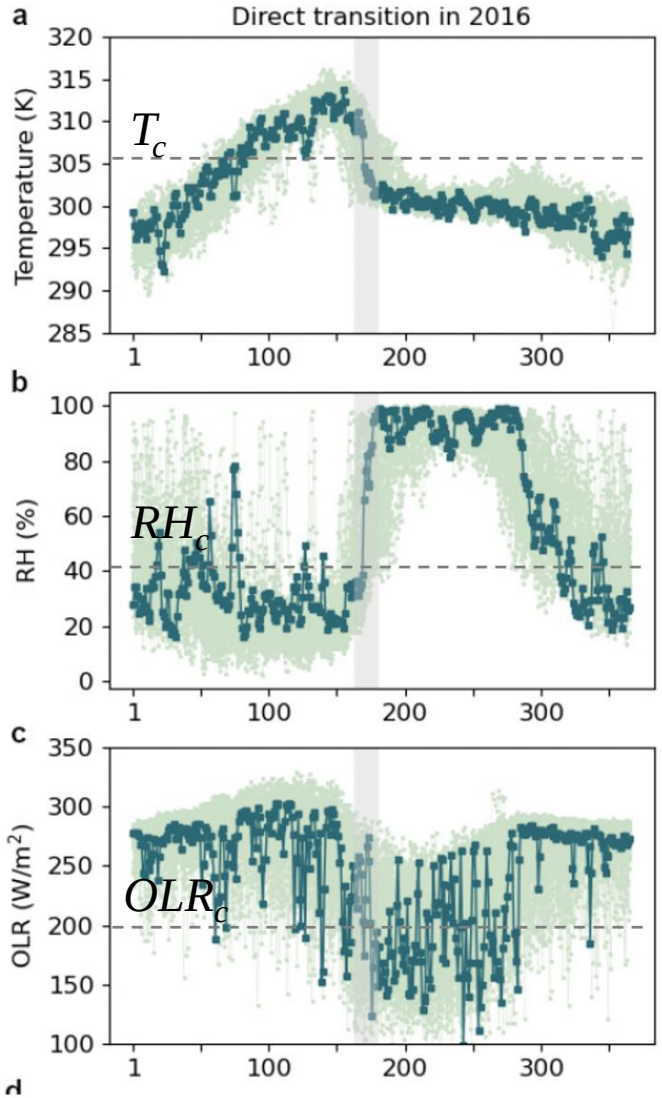
✓ Determine the value of the critical threshold (Tc). The monsoon season begins once the temperature, T, crosses a critical threshold.



Critical transitions: the onset and withdrawal of monsoon



Universal definition of monsoon onset based on critical values of three atmospheric variables: T_c, Rh_c, OLR_c.



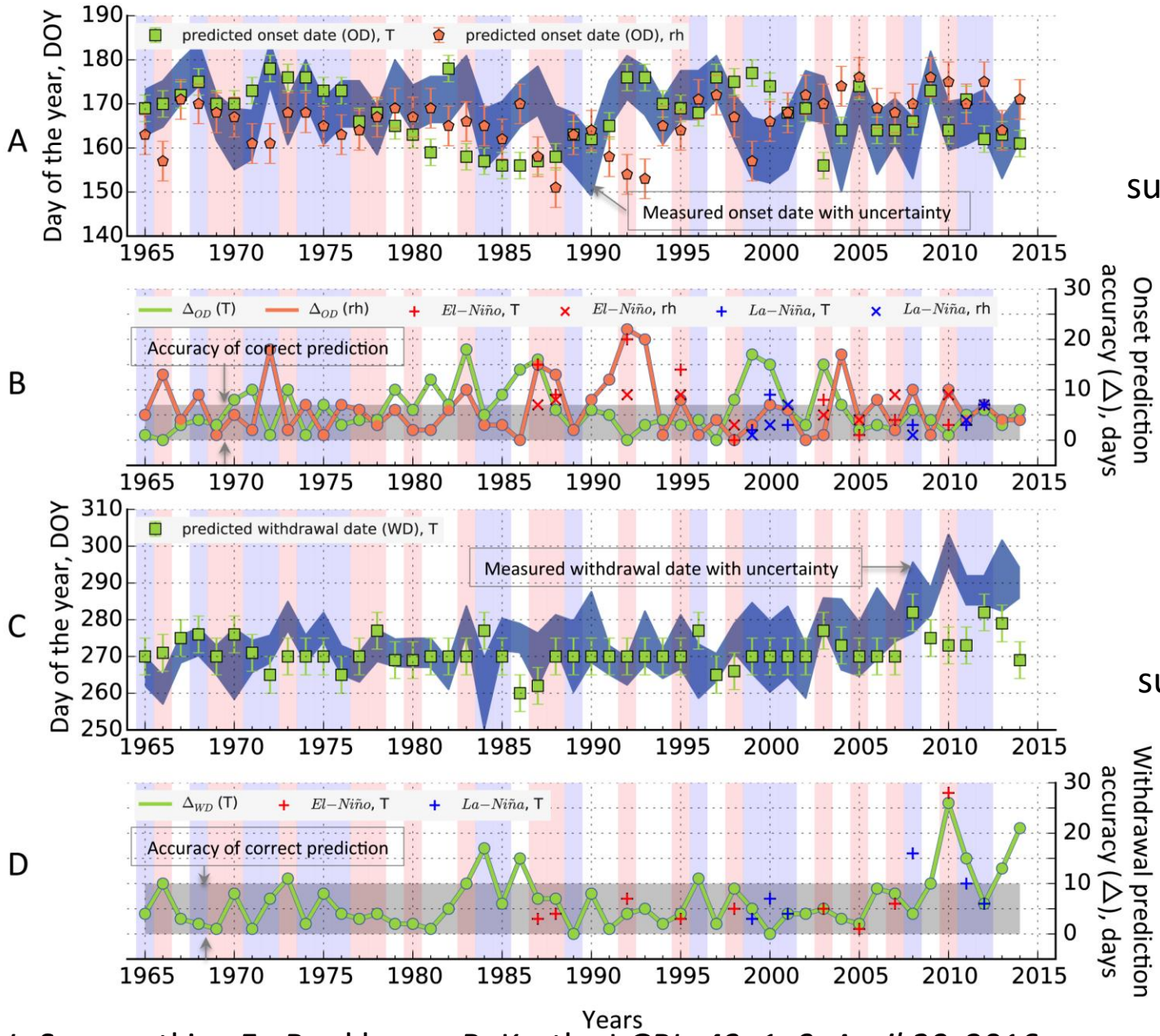
- Here, I present a universal definition of monsoon onset for every location based on critical values of three atmospheric variables: temperature (Tc), relative humidity (RHc), and outgoing longwave radiation (OLRc).
- The OLR is a crucial indicator for the upcoming monsoon characterizing convective activity, implying scarcity or deep convective clouds.
- The critical values (Tc, RHc, OLRc) for every location can be revealed from the historical observations: NCEP/NCAR and NOAA.

Surovyatkina, E.: Local onset of monsoon defined by critical values of atmospheric variables: Indian summer monsoon case, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-8441, https://doi.org/10.5194/egusphere-egu23-8441, 2023.

Performance of prediction scheme

ONSET

WITHDRAWAL



74% of success rate

84% of success rate

Stolbova V., Surovyatkina E., Bookhagen B.,Kurths J.*GRL, 43, 1–9, April 20,* 2016

INDIAN SUMMER MONSOON FORECASTS

Central India, Eastern Ghats, Elena Surovyatkina

20N°, 80°E	ONSET OF MONSOON		WITHDRAWAL OF MONSOON	
Year	FORECAST 40 DAYS IN ADVANCE	OBSERVATIONS	FORECAST 70 DAYS IN ADVANCE	OBSERVATIONS
2016	9-17 June	17 June	1-10 October	10-12 October
2017	14-22 June	16-18 June	7-17 October	15-16 October
2018	11-19 June	9-19 June	13-23 October	18-21 October
2019	10-18 June	18-19 June	14-24 October	14-24 October
2020	18-26 June	26 June	3-13 October	7-13 October
2021	21-29 June	29 June	31-10 October	8-10 October
2022	14-18 June	14-15 June	4-13 October	13-16 October
2023	15-26 June	22-23 June	07-17 October	08-12 October
2024	22-30 June	27 June	8-18 October	13-14 October

https://www.pik-potsdam.de/members/elenasur/forecasting-indian-monsoon

My contributions to the 200-year history of monsoon research include:

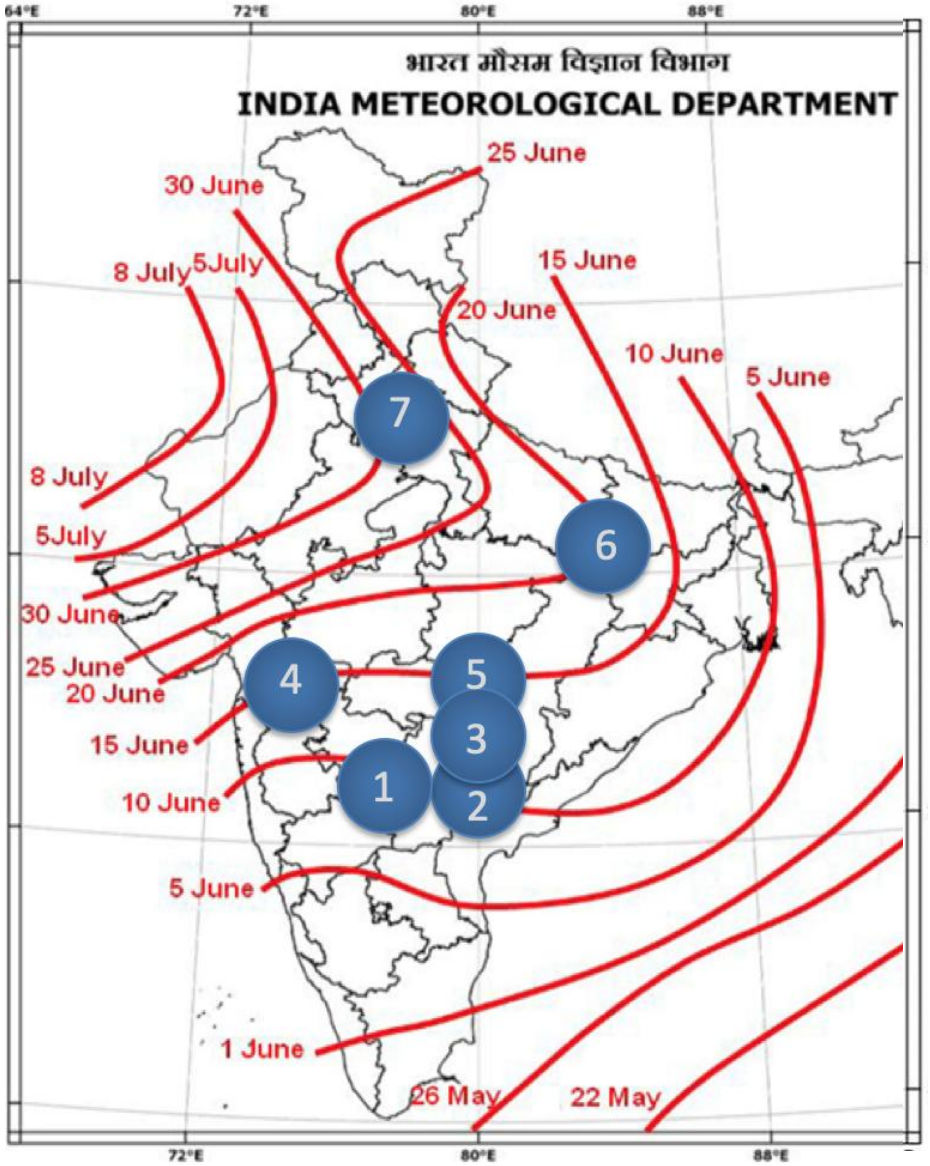
- In 2024, I successfully predicted the onset of the monsoon for 22 out of 36 meteorological subdivisions in India.

- I made the First-ever forecast of monsoon withdrawal dates across India in 2024.

First-Time Forecast of Monsoon Onset Dates for 7 Regions with dry spell

MONSOON ONSET FORECASTS IN INDIA, 2024
FOR SEVEN REGIONS, 40 DAYS IN ADVANCE
by Prof. Dr. Elena Surovyatkina, May 9, 2024

	Regions in India (15°N-30°N)	Dry spell will likely occur after the date:	Onset period:
1	Western Telangana	3 June	20-28 June
2	Eastern Telangana	9 June	21-29 June
3	Northern Telangana	12 June	22-30 June
4	Western Maharashtra, Mumbai, Pune	3 June	22-30 June
5	Central India, Vidarbha	12 June	22-30 June
6	Eastern Madhya Pradesh	14 June	29-6 July
7	Delhi	29 June	14-21 July



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First-Time Forecast of Monsoon Onset Dates for 7 Regions: **Verification**

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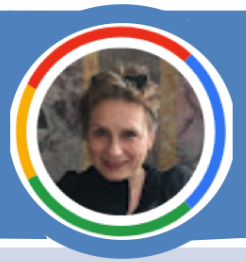

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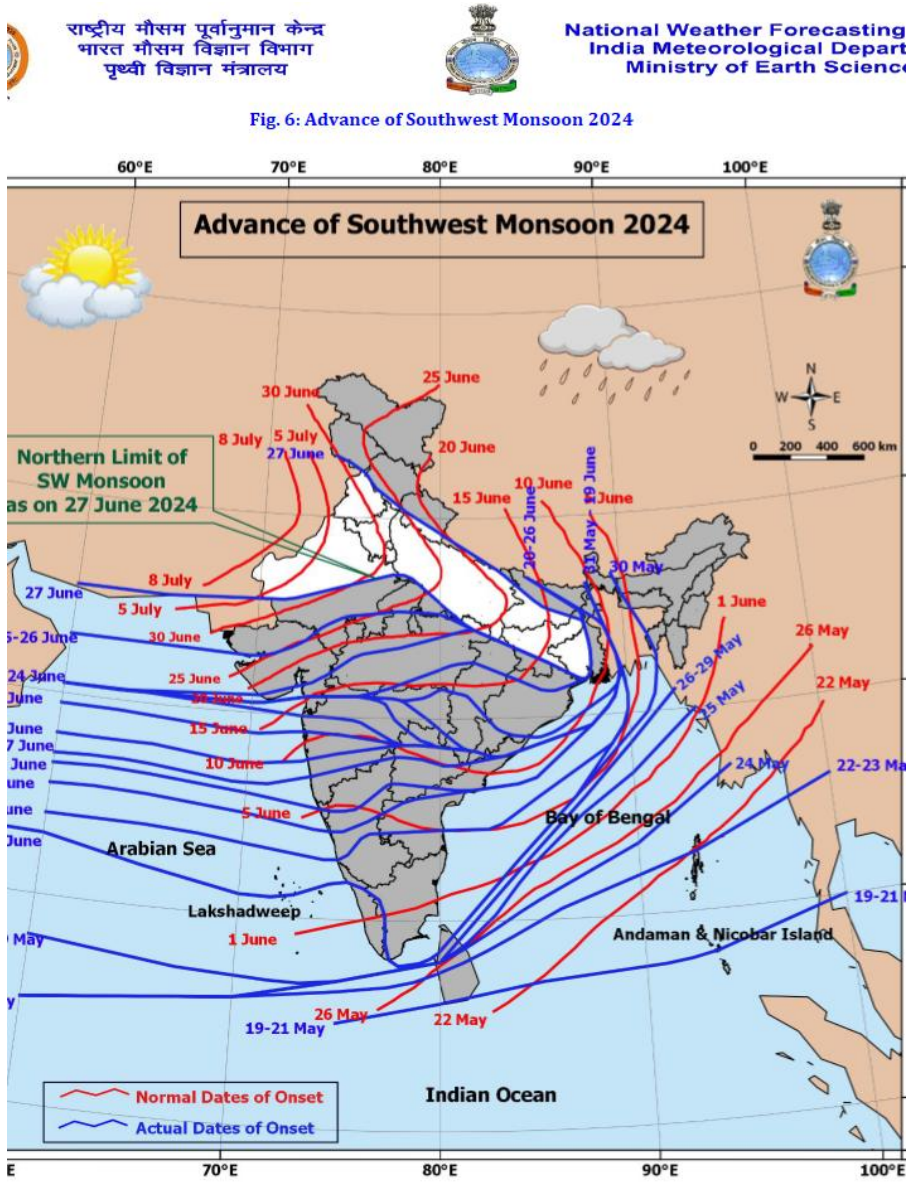

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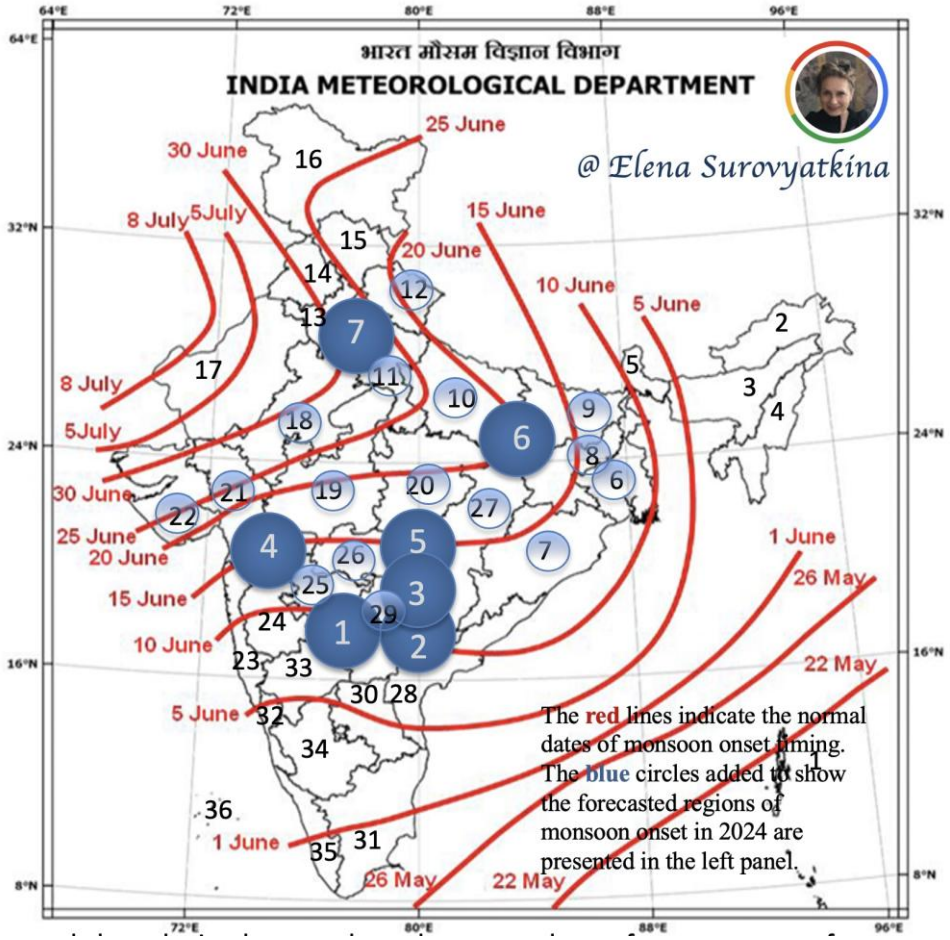


- 29 Telangana (West)
- 29 Telangana (East)
- 29 Telangana (North)
- 27 Chhattisgarh
- 26 Vidarbha
- 25 Marathwada
- 6 Gangetic West Bengal
- 7 Odisha
- 8 Jharkhand
- 9 Bihar
- 12 Uttarakhand
- 10 East Uttar Pradesh
- 11 West Uttar Pradesh
- 13 Haryana, Chhattisgarh, Delhi
- 18 East Rajasthan
- 19 West Madhya Pradesh (South)
- 19 West Madhya Pradesh (North)
- 20 East Madhya Pradesh (South)
- 20 East Madhya Pradesh (North)
- 20 East Madhya Pradesh (East)
- 21 Gujarat Region
- 22 Saurashtra & Kutch

First-Time Forecast of Monsoon Onset Dates for 22 Regions

In 2024, I achieved the first-ever forecast of monsoon onset dates for 22 regions across India, 40 days in advance. These regions correspond to the meteorological subdivisions defined by the India Meteorological Department (IMD). The accuracy of 22 forecasts was verified using temperature and relative humidity data, which confirmed the predicted monsoon onset dates.

The forecast, issued on May 10, 2024, accurately indicated a delayed monsoon in the central and northern parts of India

For more information, follow Elena Surovyatkina's Monsoon Page

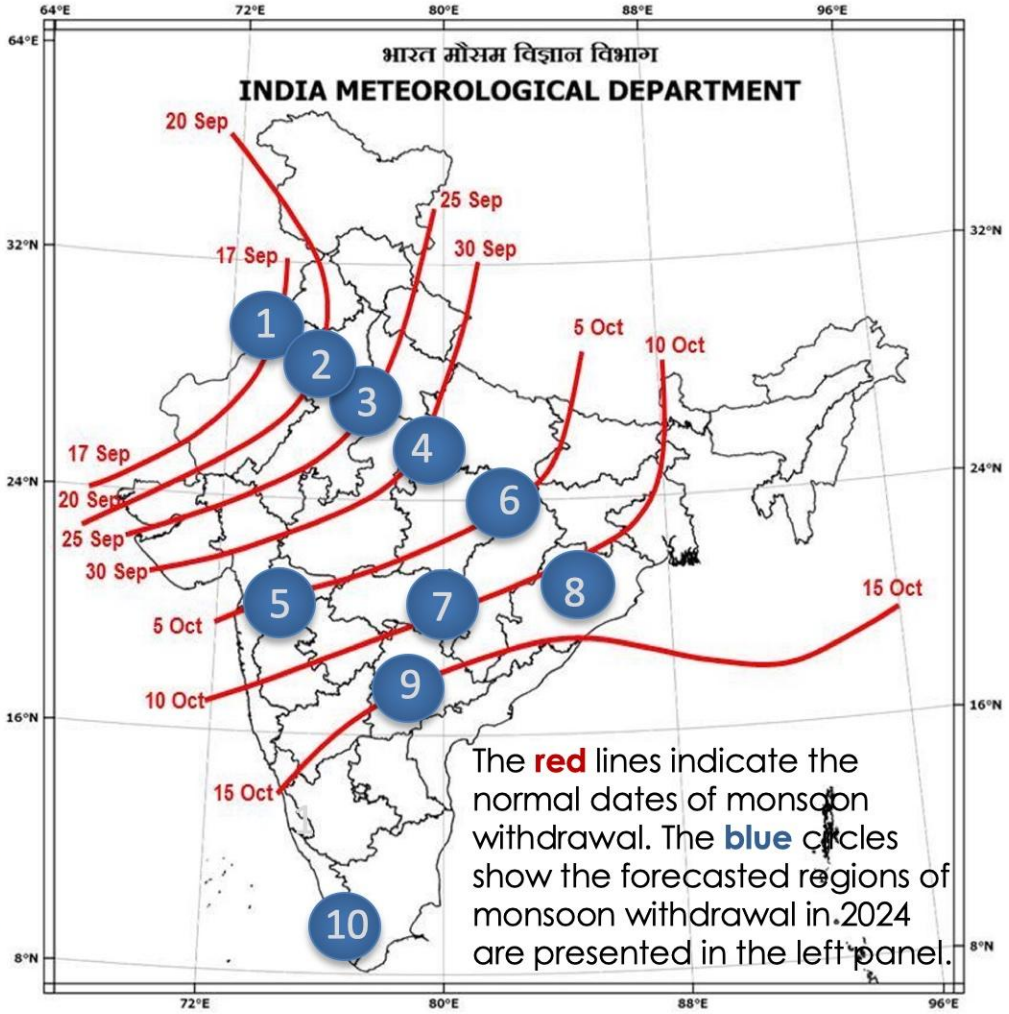
https://www.pik-potsdam.de/members/elenasur/forecasting-indian-monsoon

https://elenasurovyatkina.com/

First Ever Forecast of Monsoon Withdrawal Dates Across India

MONSOON WITHDRAWAL FORECASTS for 10 regions in India, 2024 by Prof. Dr. Elena Surovyatkina

	Forecasted Regions in India	Withdrawal period:
1	North Gujarat, Most Western Rajasthan	15 Sep +/- 5 days
2	West Rajasthan	3 Oct +/- 5 days
3	Haryana, Chhattisgarh, Delhi	5 Oct +/- 5 days
4	West Uttar Pradesh	6 Oct +/- 5 days
5	West Maharashtra, Mumbai, Pune	7 Oct +/- 5 days
6	East Madhya Pradesh	10 Oct +/- 5 days
7	Central India, Vidarbha	13 Oct +/- 5 days
8	Chhattisgarh North	15 Oct +/- 5 days
9	Telangana	16 Oct +/- 5 days
10	Kerala	20 Oct +/- 5 days



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First Ever Forecast of Monsoon Withdrawal Dates Across India: Verification

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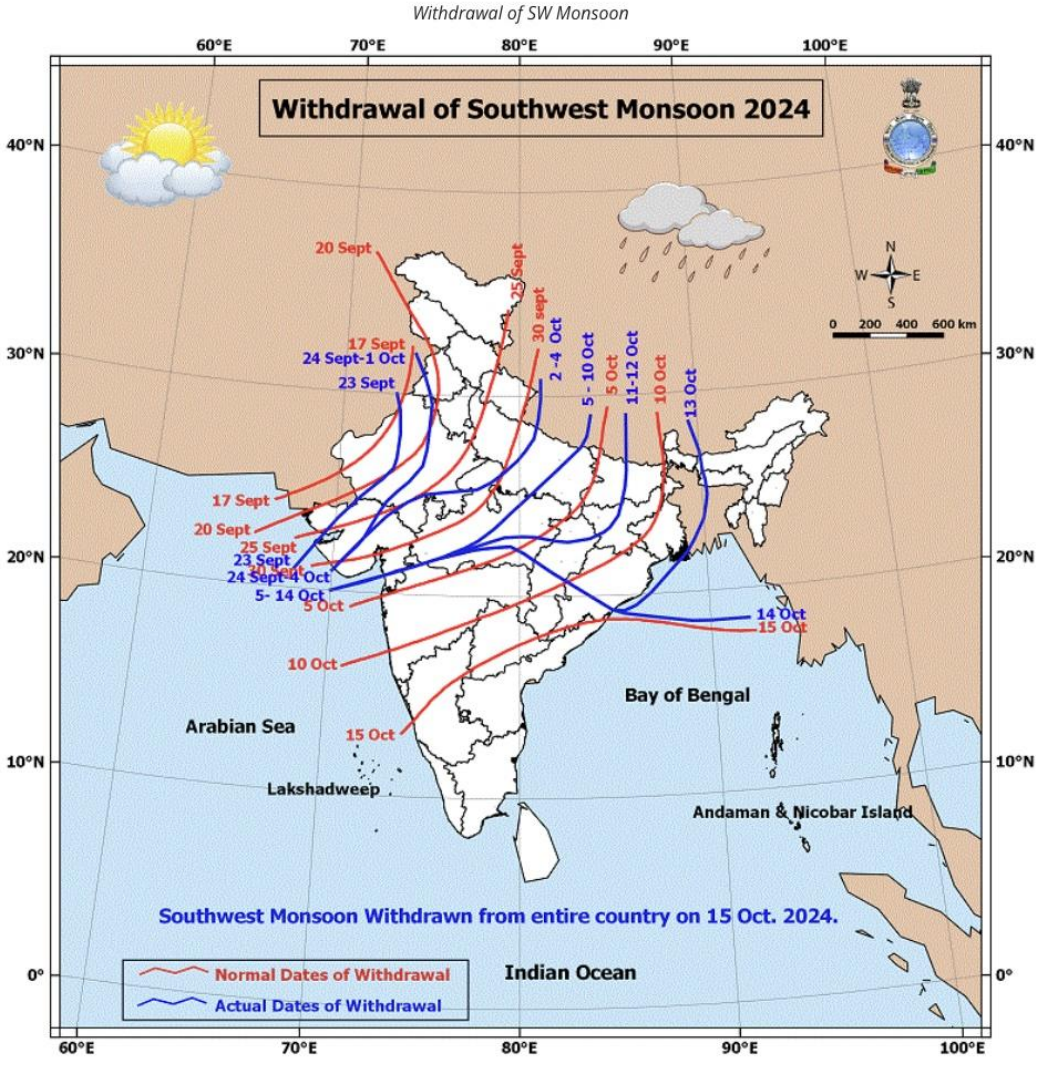

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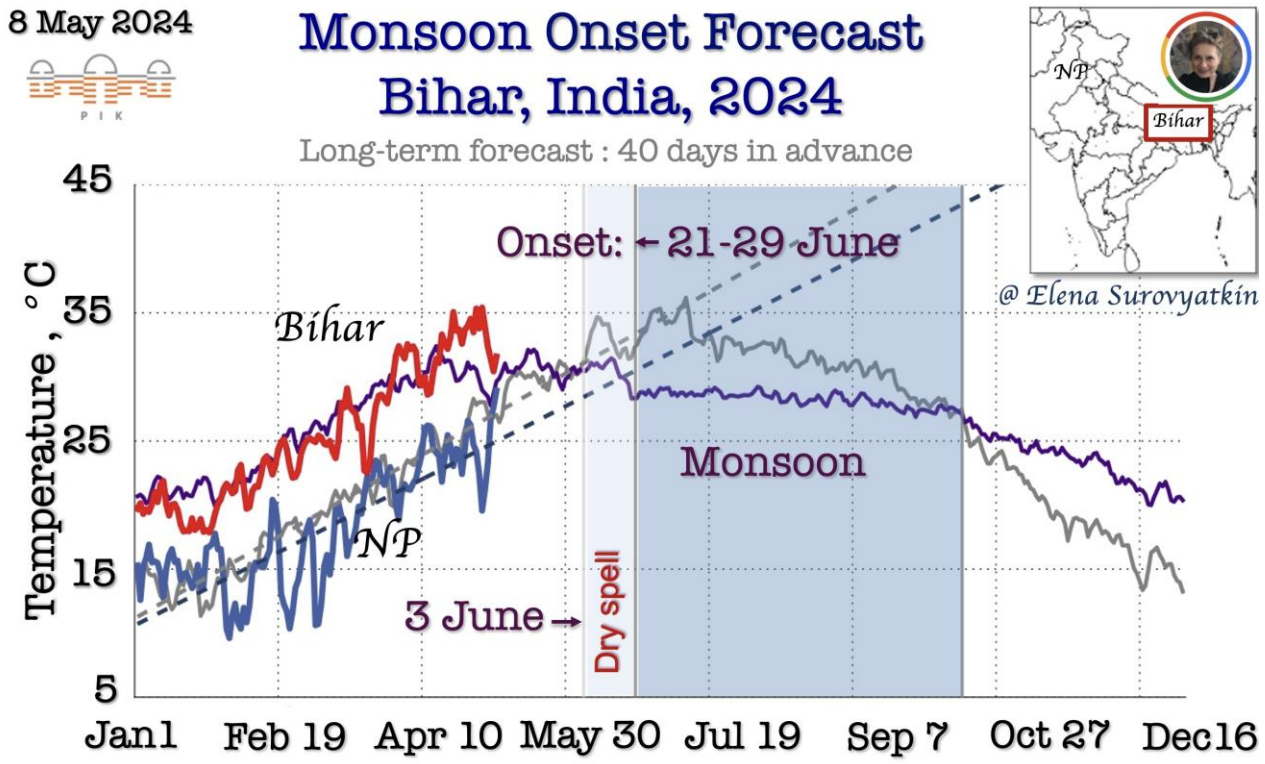
Experiment with the International Rice Research Institute (IRRI) in Bihar to improve the coupled rice-wheat cropping systems



- The ability to predict monsoon timing with such accuracy is a game-changer for India's agricultural sector.
- My forecasting methodology was being tested in collaboration with the IRRI in Bihar. The monsoon onset occurred in Bihar on June 24, which falls within my forecasted period of June 21-29.
- Accurate monsoon onset information helped agricultural scientists improve the coupled rice-wheat cropping systems, enhancing productivity and climate resilience in one of India's critical agricultural regions.

Achievements:

- Indian subcontinent : India
- Africa: Tanzania, Ethiopia
- South America: Peru
- Russia: Sea Ice Season
  in the Sea of Okhotsk

Further advance

- Eurasia: South Asia, South China, Japan
- Africa: Congo, Niger
- South America: Brazil, Bolivia, Peru

Conclusion

The new methodology presents groundbreaking advancements in both theoretical understanding and practical application of monsoon forecasting.

Theoretical Advances:

- Establishes a robust scientific foundation for the dynamics of transitions from pre-monsoon to monsoon and post-monsoon.
- Introduces a universal definition of monsoon onset based on critical thresholds of three atmospheric variables: Tc, RHc, and OLRc .
- Identifies two types of critical transitions to monsoon onset, bridging gaps in the current understanding of local monsoon arrival.

Practical Implementation:

- Enables monsoon onset and withdrawal forecasting across India's monsoon zone, where predictions were previously unavailable.
- Provides 40-day advance forecasts—an unprecedented lead time—offering the only available monsoon withdrawal forecast in India.
- Proven effective through retrospective validation (1965–2014) and real-time success (2016–2024).

This pioneering methodology not only transforms monsoon forecasting in India but also for expansion to other monsoon-affected regions globally, paving the way for more resilient and adaptive climate strategies.

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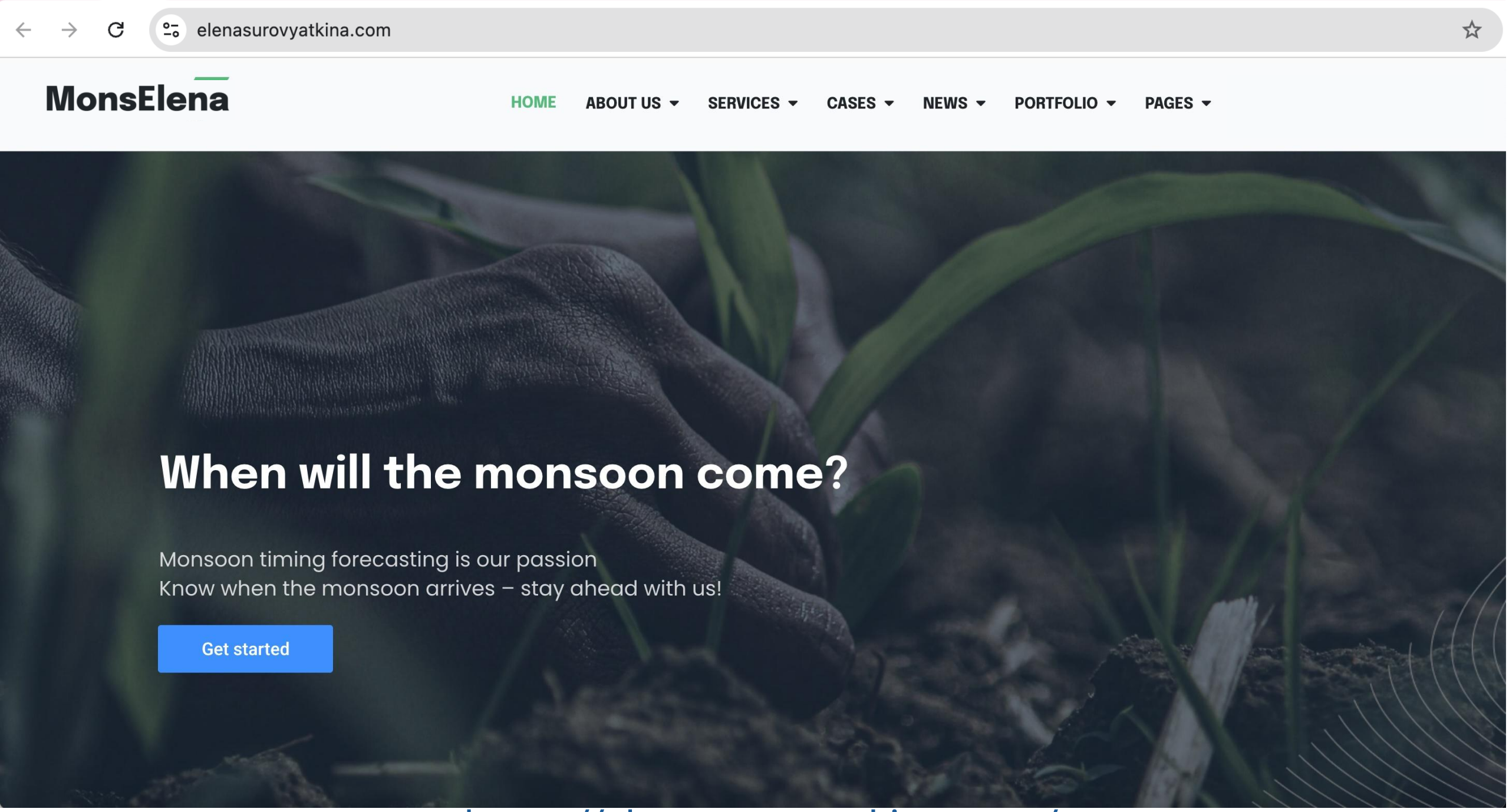
Thanks to my co-authors



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