Moisture transport associated with multi-day precipitation events in India

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Introduction

- In recent years, the frequency of multi-day extreme precipitation events has intensified over the Indian subcontinent.
- Variability in frequency, intensity, and duration of extreme precipitation events have an adverse impact on human society and the natural ecosystem.
- Therefore, it becomes essential to rank such extreme events based on their characteristics and understand the underlying atmospheric dynamics driving them.

Objective

- To develop an objective ranking of extreme precipitation events for different durations (from 1 to 7 days) for India using the long-term (1959 to 2021) high-resolution precipitation data.
- To link moisture transport (IVT Trajectories) association with top-ranked extreme precipitation events of different duration.

Study Area

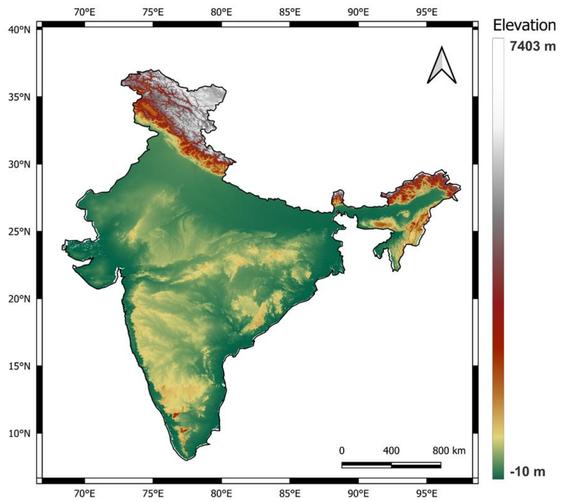

Figure 1: Elevation (shaded, m) map of India

Methodology

Formulas used in Ranking Methodology

- $N95_{d,i,j} = P_{d,i,j} - P95_{t,i,j}$
- $NCC_{p,i,j} = \sum_{d=1}^{n} N95_{d,i,j}$
- $R = A \times M$

Formula for IVT

- $IVT = \frac{1}{g}\sqrt{\left(\int_{1000hpa}^{300hpa} qu\ dp\right)^2 + \left(\int_{1000hpa}^{300hpa} qv\ dp\right)^2}$

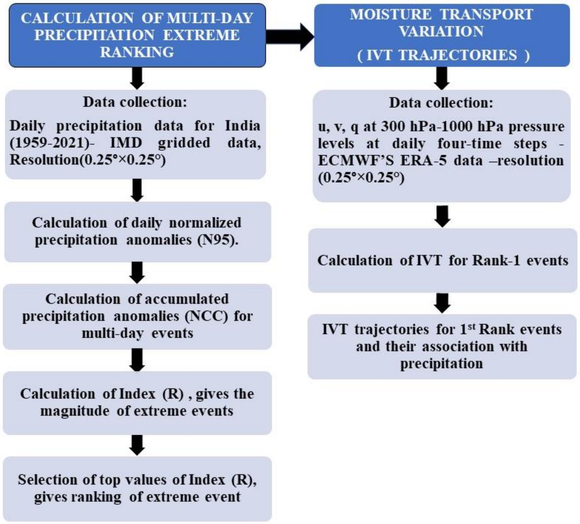

Figure 2: Flow chart depicting methodology used in calculating ranking and IVT.

Results

- **1-day extreme ranking and associated moisture transport**

Table 1. Ranking 1-day extreme precipitation events

Date	% Area (A)	Mean (M)	R= A*M	Rank
24-07-1989	12.08	46.89	566.39	1
05-09-1995	13.20	40.05	528.70	2
16-08-2011	9.35	56.24	525.55	3
23-07-1989	9.24	54.86	507.03	4
23-06-2007	9.28	53.44	496.11	5
09-08-2019	12.45	39.78	495.35	6
07-08-2007	7.81	60.30	471.06	7
04-09-1995	11.71	39.88	466.94	8
04-07-2006	6.96	63.93	445.11	9

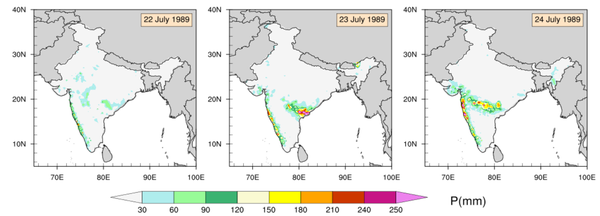

Figure 3. Spatiotemporal variation of precipitation events 2 days prior to the top 1-day rank extreme precipitation event.

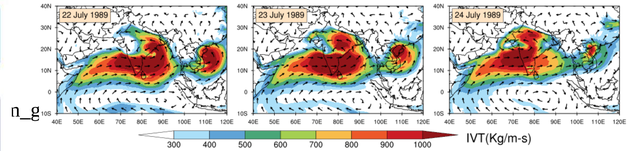

Figure 4. Atmospheric Moisture transport 2 days prior to the top 1-day rank extreme precipitation event.

- **3-day extreme ranking and associated moisture transport**

Table 2 Ranking 3-day extreme precipitation events

Date	% Area(A)	Mean(M)	R= A*M	Rank
05-09-1995	9.24	94.86	876.64	1
05-08-2006	5.93	135.29	801.77	2
06-08-2006	7.21	105.03	757.35	3
24-07-1989	8.56	81.98	701.56	4
03-08-1997	5.41	118.76	642.27	5
06-09-1995	7.81	81.89	639.74	6
25-07-1989	8.50	75.20	638.91	7
04-08-2006	3.81	161.62	616.21	8
09-08-2019	8.60	69.99	601.82	9

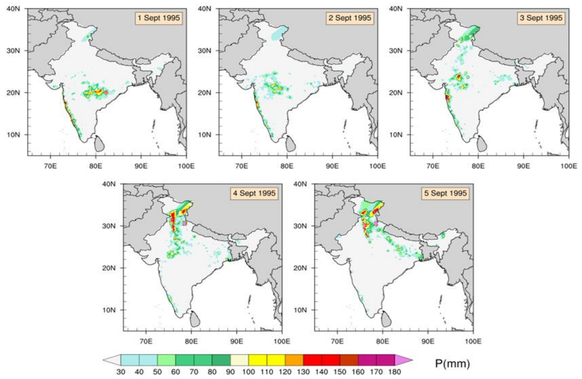

Figure 5. Spatiotemporal variation of precipitation events 2 days prior to the top 3-day rank extreme precipitation event.

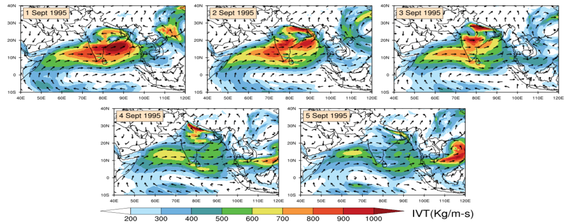

Figure 6. Atmospheric Moisture transport 2 days prior to the top 3-day rank extreme precipitation event.

- **5-day extreme ranking and associated moisture transport**

Table 3 Ranking 5-day extreme precipitation events

Date	%Area (A)	Mean(M)	R= A*M	Rank
07-08-2006	6.78	113.46	768.78	1
10-08-2019	4.43	141.11	625.73	2
06-09-1995	5.53	111.50	616.89	3
11-08-2019	4.06	133.63	542.71	4
13-08-2017	3.42	158.05	540.36	5
08-08-2006	6.01	89.79	539.57	6
09-08-2019	5.26	99.06	521.38	7
07-09-1995	5.14	97.73	502.24	8
27-09-1988	6.42	77.32	496.64	9

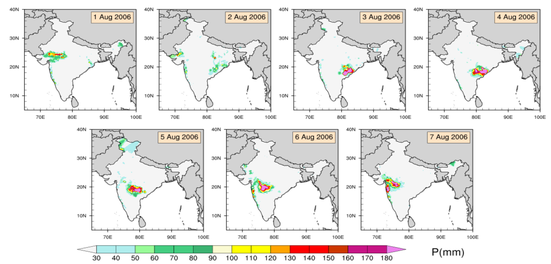

Figure 7. Spatiotemporal variation of precipitation events 2 days prior to the top 5-day rank extreme precipitation event.

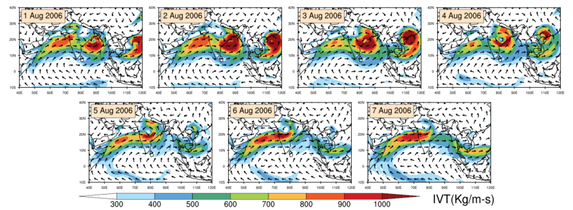

Figure 8. Atmospheric Moisture transport 2 days prior to the top 5-day rank extreme precipitation event.

Conclusion

- Events with more significant amounts of precipitation receive higher rankings than those with more widespread distribution of precipitation or longer-lasting persistent rainy conditions.
- Few top-ranked events coincided in several multi-day events making them the most impactful extreme precipitation events.
- When high moisture incursion over the regions converges near the cyclonic circulation and increases the specific humidity in the atmospheric column necessitating the development of thunderstorms leading to multi-day extreme precipitation.