Increasing Trend of Extreme Rain Events Over Central India: Role of the Indian Ocean
Acknowledgement

- This work is done in collaboration with
  Dr. V. Venugopal
  Prof. D. Sengupta
  Dr. M.S. Madhusoodanan
  Prince K. Xavier
- Indian Institute of Science, Bangalore
Global Temperature: Land-Ocean Index

Temperature Anomaly (°C)

-4 -2 0 0.2 0.4 0.6

1880 1900 1920 1940 1960 1980 2000

- Annual Mean
- 5-year Mean

Updated from Hansen et al. 2001, JGR, 106, 23947
All India Rainfall

Climatological Mean (JJ AS)

Interannual Variability
S. Sen Roy & R. C. Balling, 2004,
Int. J. Climatology, 24, 457

130 Stations, 91 years (1910-2000)

7 Variables:
1. Total Precipitation
2. Largest 1 day rainfall
3. Largest 5 day total
4. Largest 30 day totals
5. Extreme freq. (90pctl.)
6. Extreme freq. (90pctl.)
7. Extreme freq. (90pctl.)

Figure 1. Distribution of the 130 stations in our study (the star symbol represents the one station eliminated from the analysis)
Figure 2. Frequency distribution of the standardized regression coefficients
Figure 1. Stations used in this study for (a) temperature and (b) precipitation with data spanning the period 1961–2000 (dots) or 1901–2000 (dots with crosses).
Figure 3. Regional series for the indices of (a) cold nights TN10, (b) warm nights TN90, (c) cold days TX10, and (d) warm days TX90. The red line is based on the lowess smoother [Cleveland, 1979].
Ratio of index of precipitation falling on extreme days (R99) to total precipitation (in %)
Possible Reasons:

1. Homogeneity in variability
2. Small scale character,
3. Orographic influence,

Mean

Sampling error

Variance

Large No. Stations required
High resolution daily rainfall

1803 stations used

Period: 1950-2003
Daily
Analysed into 1° X 1° boxes
Quality Controlled

Rajeevan et al, 2006, Curr. Sci. 91,

Figure 1. Location of 1803 rain gauge stations.

CURRENT SCIENCE, VOL. 91, NO. 3, 10 AUGUST 2006
Climatoogical mean variance of daily rainfall during JJAS
Variance of daily rainfall over CI during JJAS

CoV (S.D/ mean) daily rainfall over CE, JJAS

SST anom during JJAS over tropical Indian Ocean (50E-100E, 20S-20N)
Contributions of HP, 10-20 day mode, 30-60 day mode to the trend of total daily rainfall variance.
Fig. S2: (A) Frequency Histogram of daily rainfall over CI during summer monsoon for two periods, 1950-1970 and 1980-2000. The regions marked by the shaded rectangles in A are magnified in B, C, and D. For the sake of clarity, rain intensities larger than 250 mm/day have been shown by symbols (blue circles and red triangles) in panel (D).
Time series of count over CI

Low & Moderate events

Heavy events (>10cm)

V. Heavy events (>15cm)
- Increase in intensity of extreme events

Time series of average intensity of four largest events in a year
Why no trend in the seasonal mean?

Proportion (%) of different intensity ranges to the total mean

- $\mu(0 < R < 5) / \mu_{\text{total}}$ (Slope = $-2.6e-005$)
- $\mu(5 <= R < 100) / \mu_{\text{total}}$ (Slope = $-6.9e-002$)
- $\mu(R >= 100) / \mu_{\text{total}}$ (Slope = $6.9e-002$)

Year

Minimum area required for identification of statistically significant trend
CONCLUSION

- Frequency of occurrence as well as intensity of heavy and very-heavy rainfall events have highly significant increasing trends over Central India.
- Low and moderate events have significant decreasing trend over CI.
- The seasonal mean does not have a trend because decreasing contribution from low and moderate events are compensated by increasing contribution from heavy events.
- Arial aggregate of intense events over a reasonable large homogeneous region is required for identifying statistically significant trend.
The trend of extreme events indicate that rain related disasters are going to increase over the CI. Disaster preparedness must be enhanced over the entire region!

Since the low frequency variability of the mean monsoon is influenced by the extreme events, for seasonal and decadal predictability of the Indian monsoon, correct simulation of the statistics of the extreme events by climate models is imperative.
Figure 2. Trends per decade for (a) cold nights TN10 and (b) warm nights TN90 for the period 1961–2000. The dots are scaled according to the magnitude of the trend. Color coding is applied: red corresponds to warming trends and blue to cooling trends.
Figure 2. Trends per decade for (a) cold nights TN10 and (b) warm nights TN90 for the period 1961–2000. The dots are scaled according to the magnitude of the trend. Color coding is applied: red corresponds to warming trends and blue to cooling trends.