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Statistics of the Monsoon Low Pressure Systems in the Indian Subcontinent and estimation of related Extreme Precipitation Risk

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Indian Monsoon

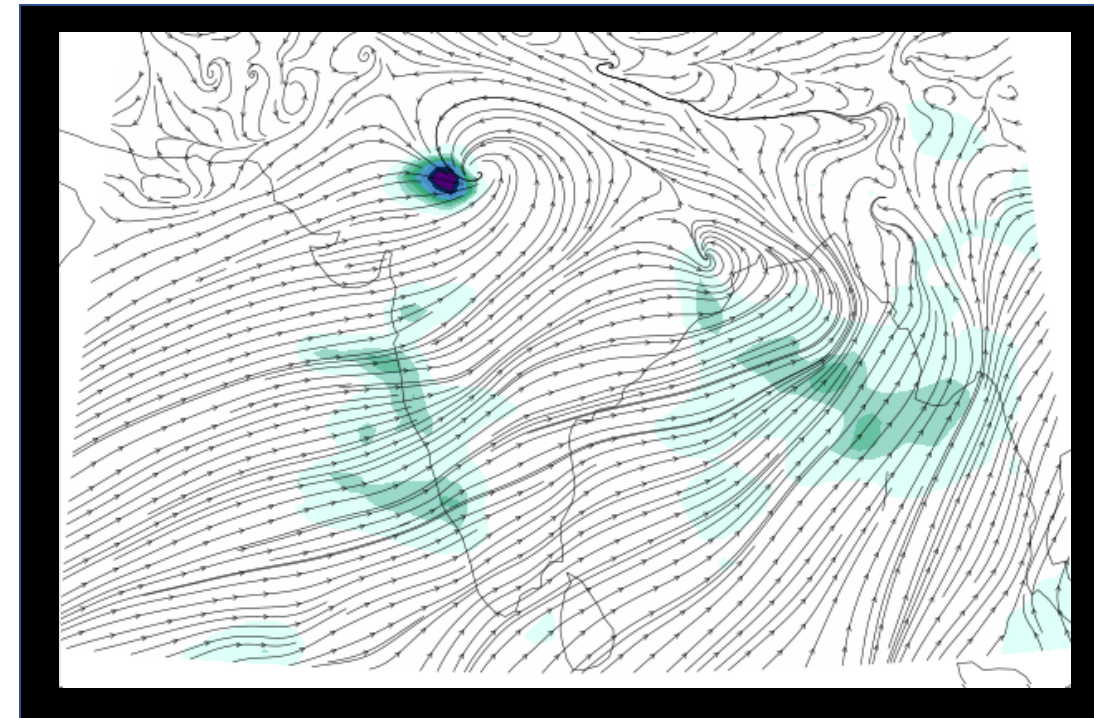
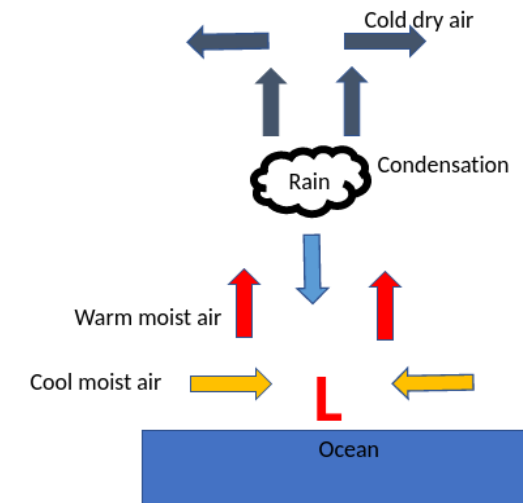
- Derived from '*Mausam*' for season : seasonal change in direction of wind over Arabian Sea.
- Span: June – September
- Indian Summer Monsoon Rainfall (ISMR) : 85cm
- Manifestation of seasonal migration of ITCZ in response to seasonal variation in solar radiation.



Low Pressure Systems (LPS)

- Synoptic scale tropical disturbances which periodically form in quasi stationary monsoon trough during southwest Indian Monsoon Season.
- Major Rain bearer for the country (more than 50% of rainfall from LPS)
- Form mostly over northern Bay of Bengal and move north westwards.

Properties	Values
Direction	West -Northwest
Average Speed	170 km/day
Lifetime	3-6 days
Length Scale	1000-2000 km
Vertical Scale	9 km
Frequency	14 / season



CESM 1.2.2 : 0.5°x0.5°, Fixed SST, Present day Control run

Low Pressure Systems

- Provide copious rain for agriculture depended India.
- But triggers floods causing disastrous effects at many locations



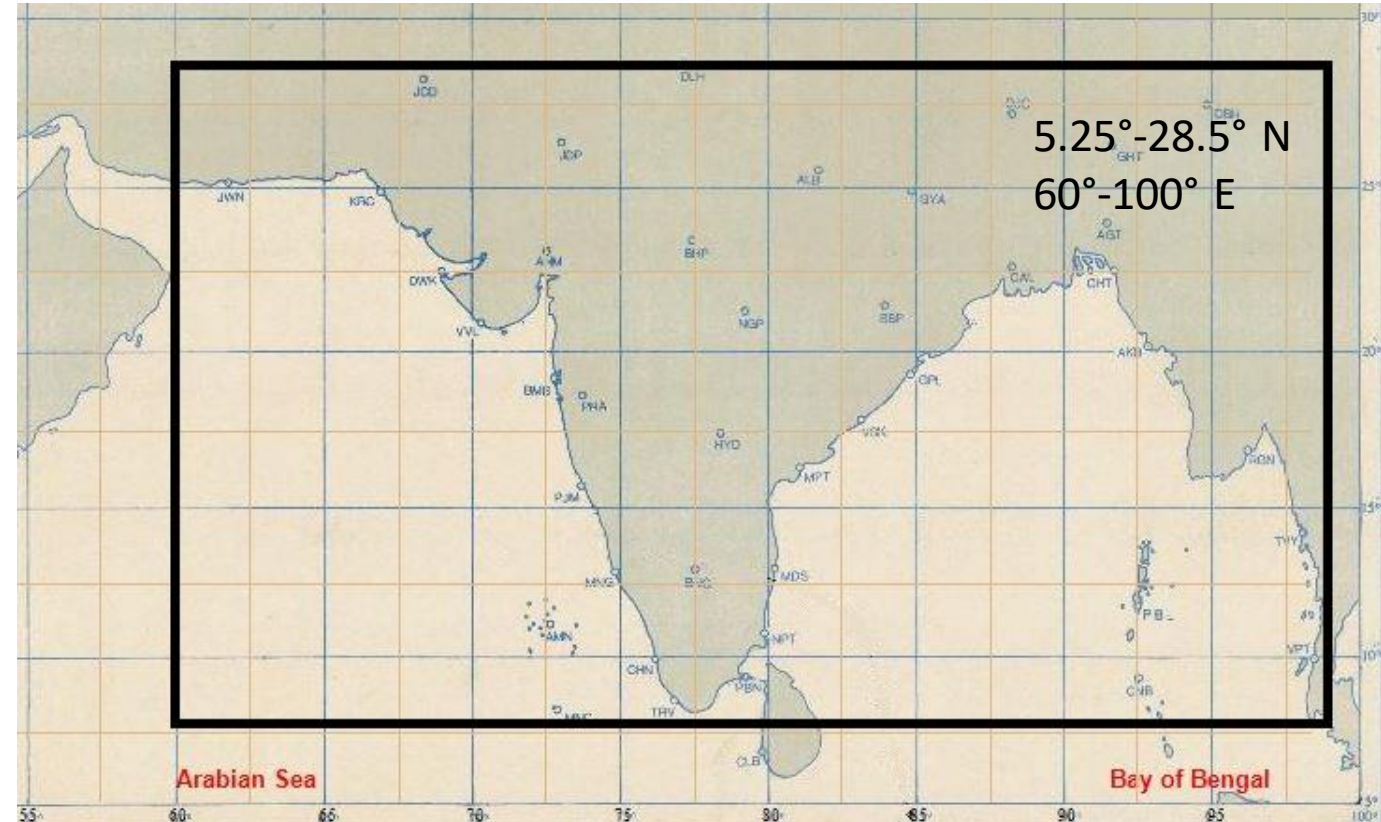
Data Used

For Tracking of LPS: ERA Interim

- **Variables:** Relative vorticity, Geopotential height , Horizontal wind speed.
- **Levels:** 850hPa
- **Resolution:** $0.75^{\circ} \times 0.75^{\circ}$
- **Time scale:** 6 hourly
- **Years:** 1979-2015

For Extreme Rainfall Analysis: IMD

- **Variables:** Precipitation.
- **Resolution:** $0.25^{\circ} \times 0.25^{\circ}$
- **Time scale:** daily
- **Years:** 1979-2015



Automated Tracking Algorithm using Geopotential Criteria (ATAGC)

Segmentation

- **Thresholding (α) of data points into objects and Background.**
- **Quadtree Structure.**
- **Connected Component Labelling: Unique labelling of points belonging to distinct objects.**

Feature Point Detection

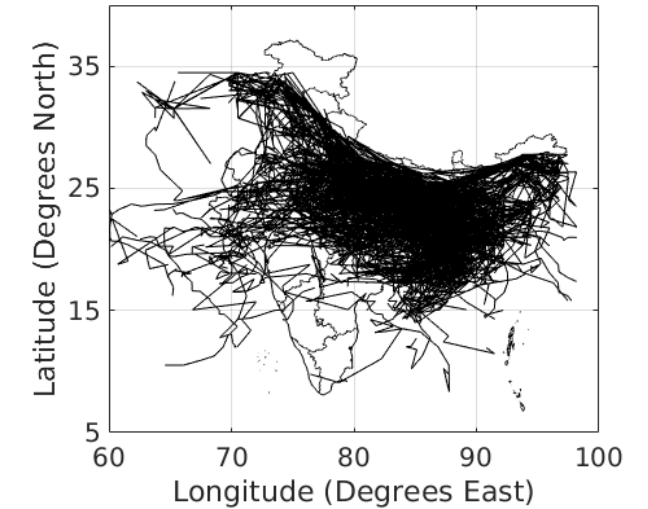
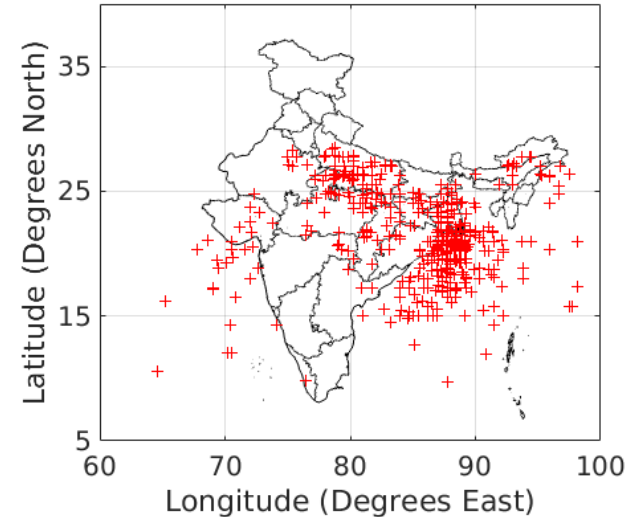
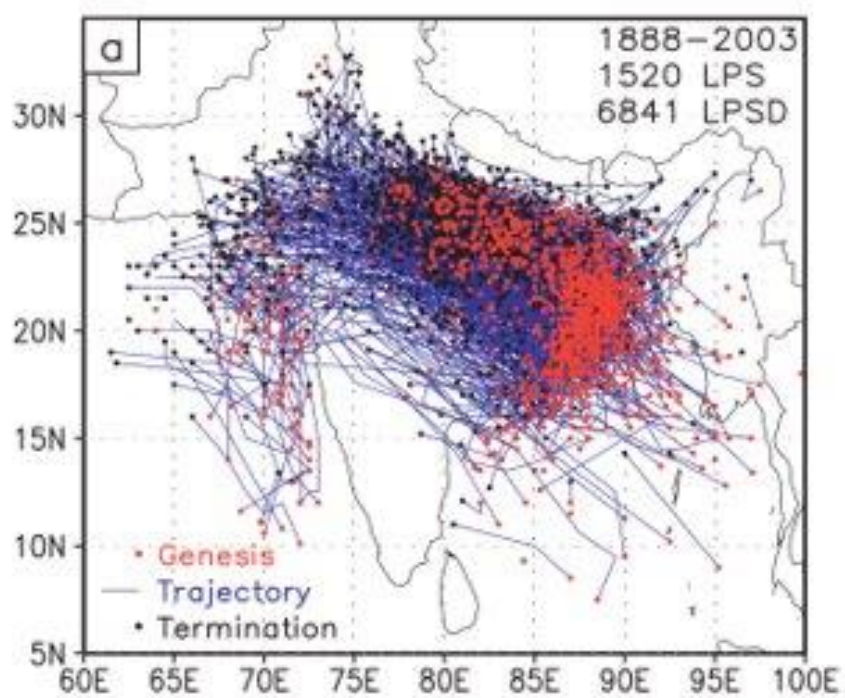
- **Contours are plotted to determine peaks inside objects.**
- **Clustering is adopted to determine peak strength.**
- **Geopotential criteria is considered to determine final feature points.**

Tracking

- **Link feature points based on nearest neighbor distance between consecutive time frames.**
- **Filtering to remove tropical cyclones.**

Results

Genesis and Tracks



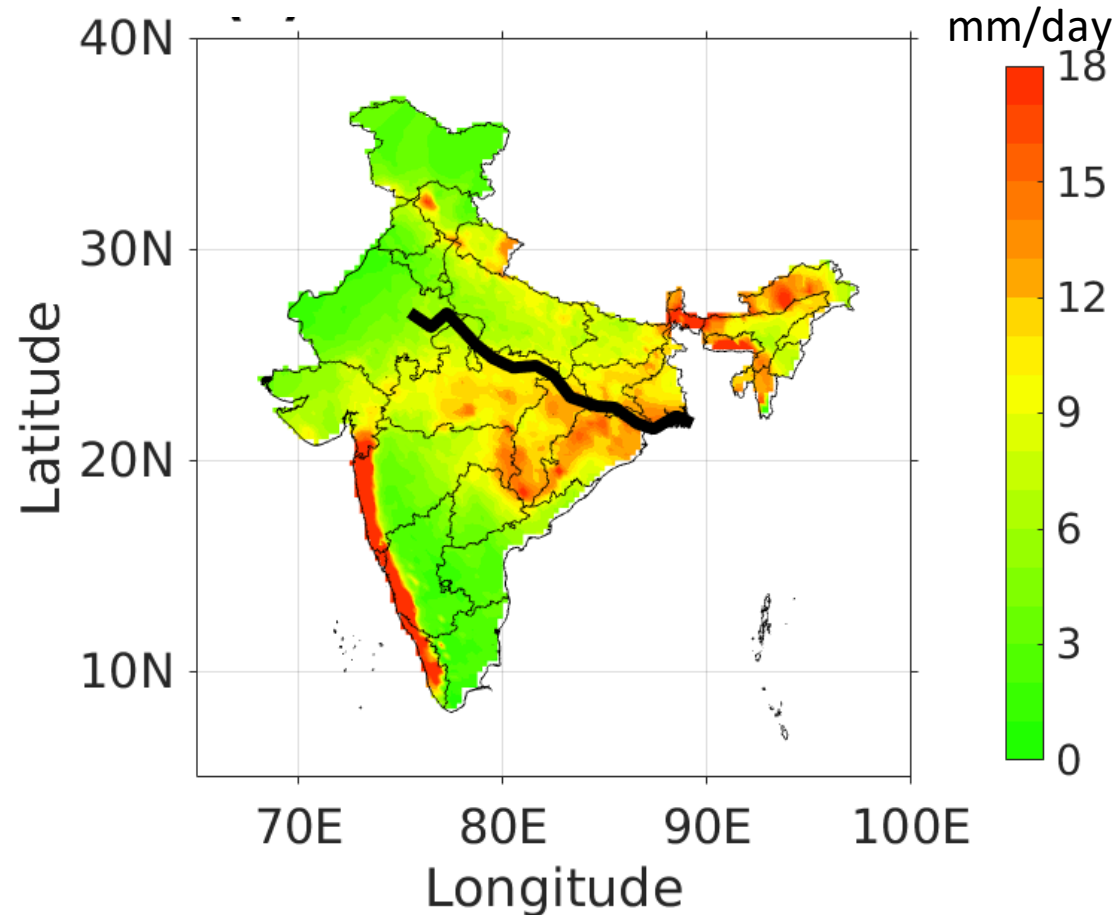
Ajaymohan et al. (2010)

Track data obtained from Sikka's archive

- **Genesis and Tracks obtained by applying ATAGC on ERA interim data.**
- **Most LPS form over north BoB (maximum 6/monsoon) and move north westward.**
- **Average number of Systems : 14 LPS / monsoon (9 lows, 5 stronger systems).**
- **LPS days : 68 / monsoon**

Results

Precipitation Composite on LPS days



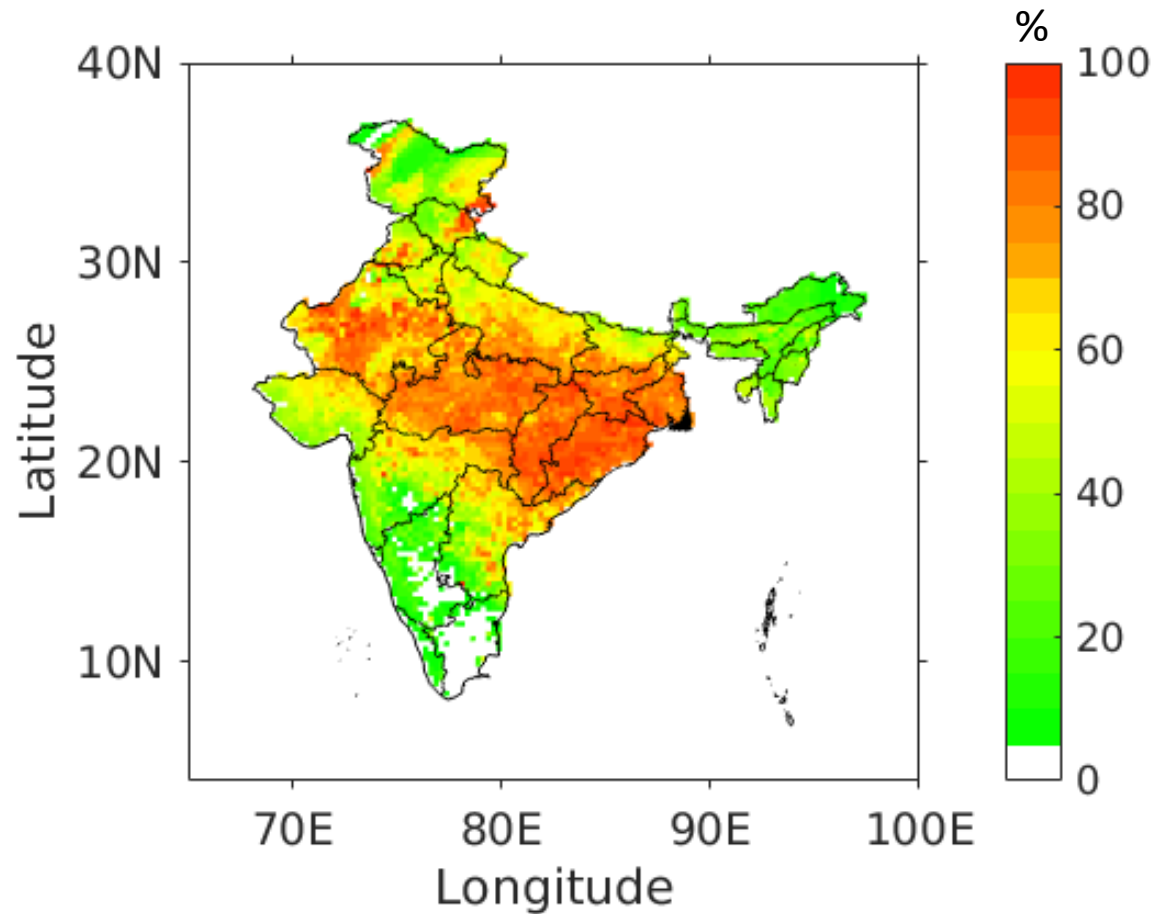
Precipitation over India during LPS days.

Tracks are obtained by applying ATAGC on ERA interim and precipitation data is obtained from IMD ($0.25^\circ \times 0.25^\circ$)

- During LPS days high precipitation is observed along monsoon core region of Central India.
- Orographic influence of Western Ghats is pronounced in the form of very high precipitation along west coast during LPS days.
- Precipitation and hence extreme precipitation due to LPS also occur along these two regions.
- 82% of extreme precipitation occurs in Central India occur during LPS days.

Results

Percentage of Extreme Events associated with LPS



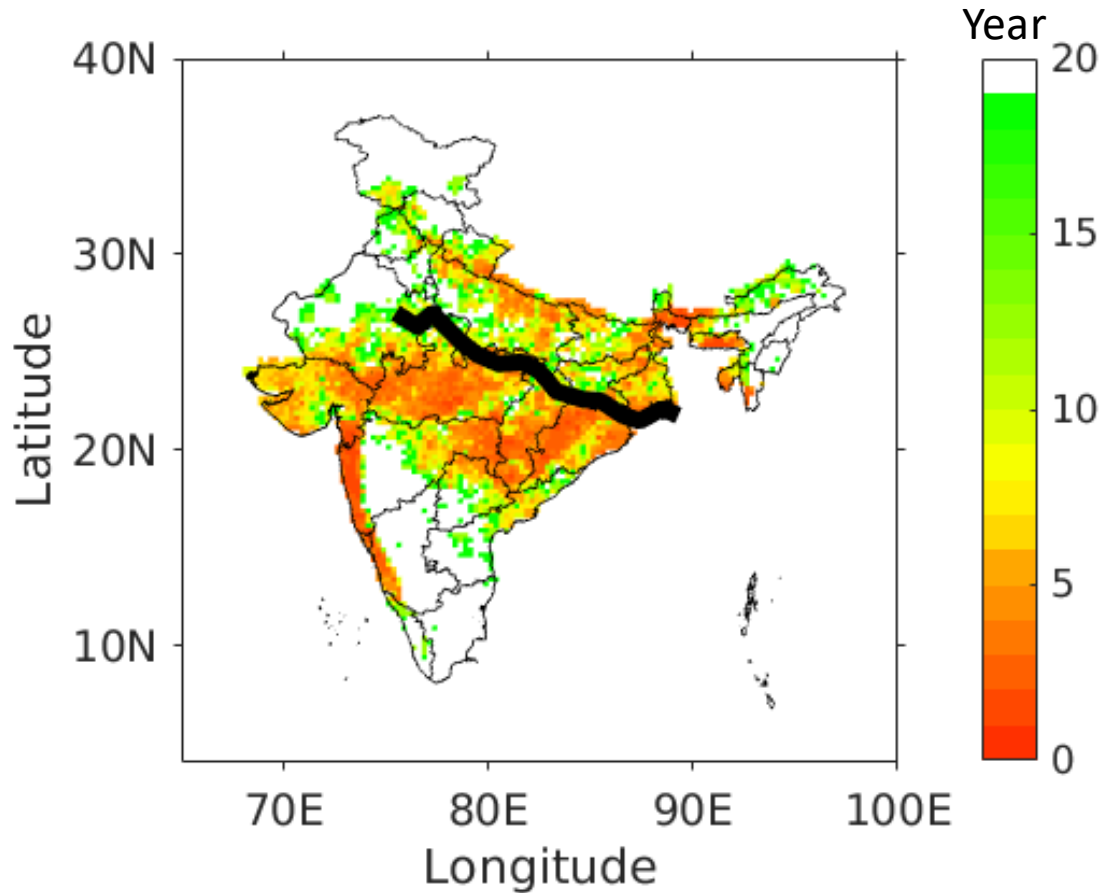
- Extremes due to LPS at a location:
 - Daily precipitation at the location $> 64.5\text{mm}$
 - Location is within 1000km of LPS track.
- More than 80% of extremes in core region of monsoon occur in association with LPS.
- Most of the locations experience around 4 extremes per monsoon season.
- Extremes contribute to around 20-25% of monsoon rainfall at these locations.

Percentage of Extremes due to LPS compared to total number of extremes observed.

Tracks are obtained by applying ATAGC on ERA interim and precipitation data is obtained from IMD ($0.25^\circ \times 0.25^\circ$)

Results

Return period of very heavy rain (>124.5mm/day) associated with LPS



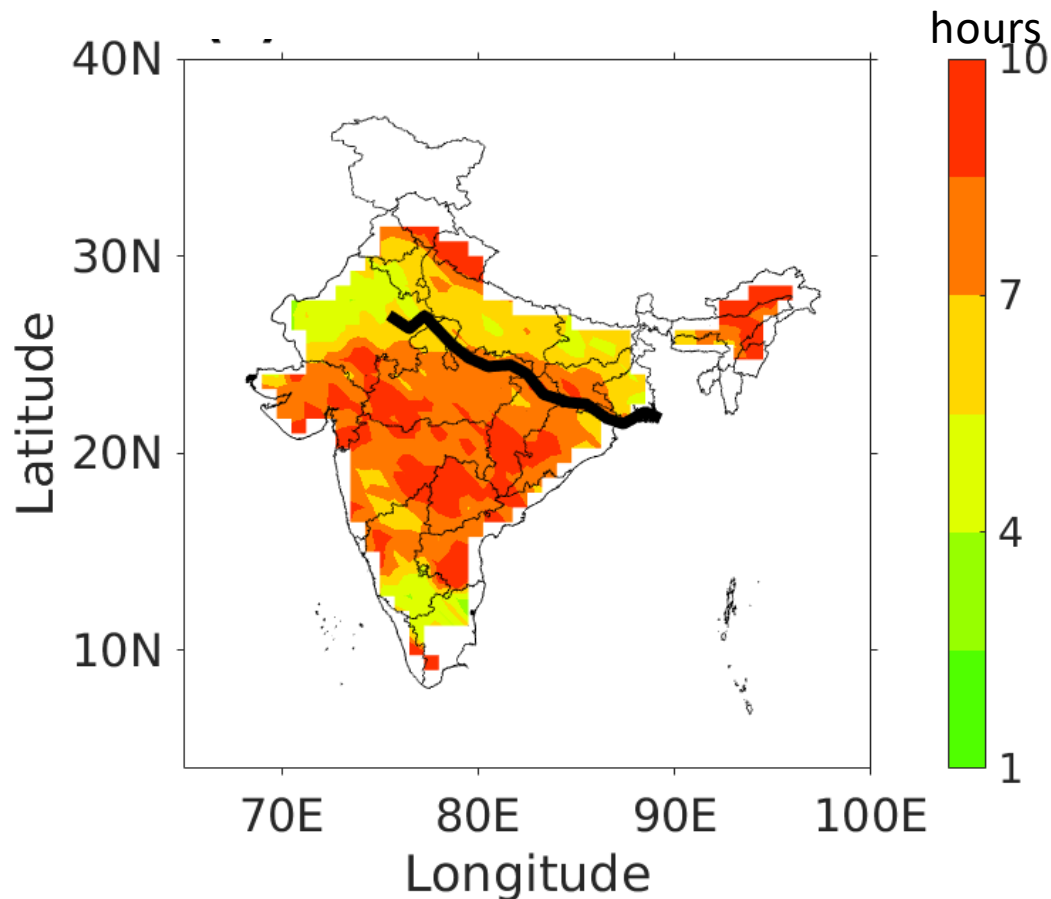
- Frequency analysis is performed on annual maximum precipitation associated with LPS.
- Very heavy rainfall due to LPS at many locations in CI occurs almost every year.
- Most locations have a return period <5 years.

Return period of very heavy daily rain (>124.5 mm/day) associated with LPS

Tracks are obtained by applying ATAGC on ERA interim and precipitation data is obtained from IMD (0.25°×0.25°)

Results

Spell of continuous precipitation



- Continuous precipitation spell at a location due to LPS:
 - 3 hourly precipitation at the location > 5mm
 - Location is within 1000km of LPS track.
- Maximum values of about 9 hours are obtained in Central Indian region

Average heavy precipitation (>5 mm/3 hrs) spell length in hours
Tracks are obtained by applying ATAGC on ERA interim and
precipitation data is obtained from ERA (0.75°×0.75°)

Key Messages

- **Around 14 LPS per year during the Indian summer monsoon season.**
- **82% of extreme precipitation occur in Central India during LPS days.**
- **More than 80% of extremes in Central India are associated with LPS.**
- **The return period of LPS-related very heavy precipitation (>124.5 mm/day) in Central India is about 5 years.**
- **The continuous spell of heavy precipitation (>5 mm/3hr) associated with LPS lasts for about 9 hours in most locations in Central India**

Reference

- **Ajayamohan, R. S., Merryfield, W. J., & Kharin, V. V. (2010). Increasing trend of synoptic activity and its relationship with extreme rain events over central India. *Journal of Climate*, 23 (4), 1004-1013. doi: 10.1175/2009JCLI2918.1**
- **Goswami, B. N. (1987). A mechanism for the west-north-west movement of monsoon depressions. *Nature*, 326 (6111), 376-378. doi: 10.1038/326376a0**
- **Mooley, D. A., & Shukla, J. (1987). Characteristics of the westward-moving summer monsoon low pressure systems over the Indian region and their relationship with the monsoon rainfall. College Park, University of Maryland, Dept. of Meteorology, Center for Ocean-Land-Atmosphere Interactions, 47.**
- **Sikka, D. R. (1977). Some aspects of the life history, structure and movement of monsoon depressions. *pure and applied geophysics*, 115 (5), 1501– 1529. doi: 10.1007/BF00874421**