Multifractals, Climate Networks and the extreme variability of precipitation

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Objective

- Construct rainfall climate networks using TRMM-3B42 dataset
- Understanding the scaling properties of network characteristics by constructing layers of networks at different space-time resolutions
- A simple method of upscaling these networks is done here to reproduce the expected scaling behavior.

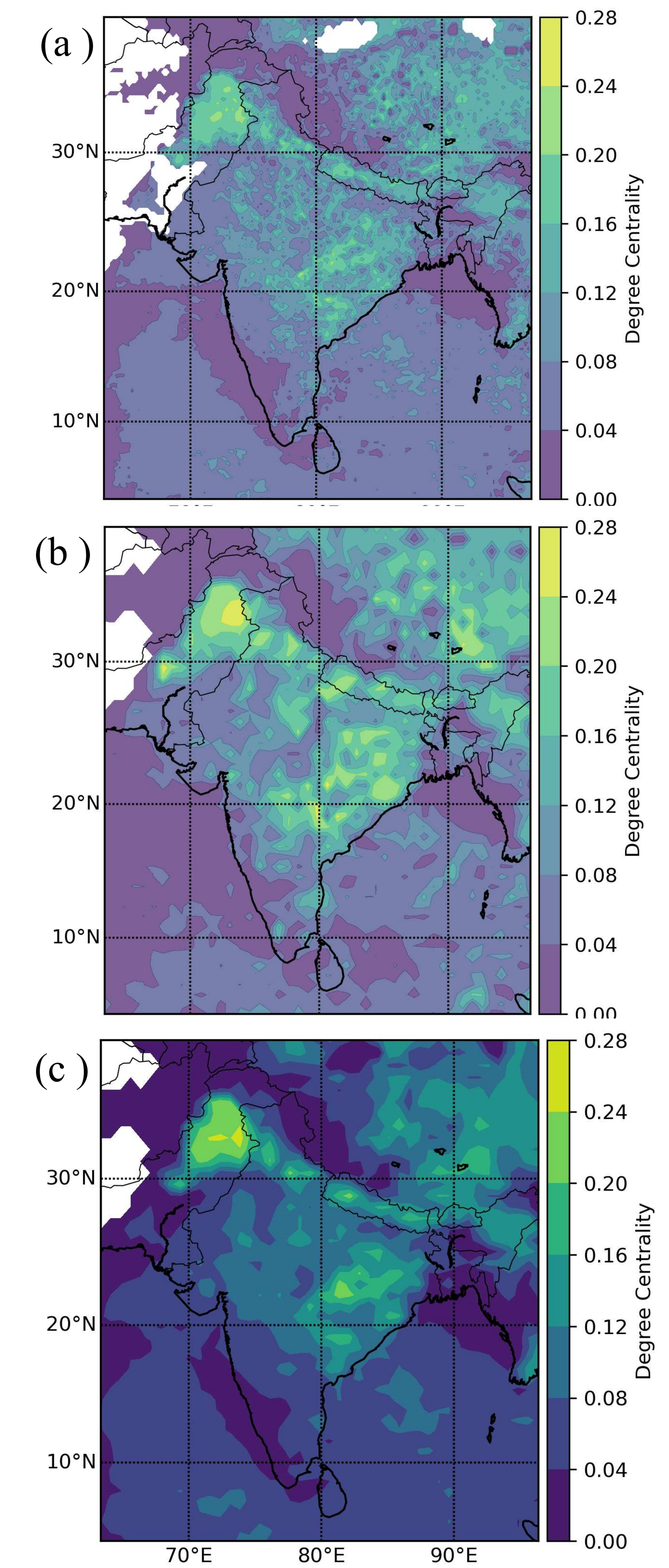
Methodology

- Time-lagged mutual information : $I(X_t, Y_{t+\tau}) = \iint p(x_t, y_{t+\tau}) \log\left(\frac{p(x_t, y_{t+\tau})}{p(x_t)p(y_{t+\tau})}\right) dx_t dy_{t+\tau}$
- Similarity Matrix : $S_{i,j}^{\lambda} = \frac{I_{R_i,R_j}}{\max\left(I_{R_i,R_i}, I_{R_j,R_j}\right)}$, where $I_{X,Y} = \max\left(I(\mathrm{X_t}, \mathrm{Y_{t+\tau}})\right)$ & R_i is rain at time resolution λ
- Network Adjacency : $A_{i,j}^{\lambda} = \begin{cases} 1, \text{if } S_{i,j}^{\lambda} > \theta \\ 0, \text{otherwise} \end{cases}$, where θ is the network density parameter

Upscaling Networks :

- Space-time scaled by factor of 3 and 2 respectively.
- Upscaled network : $A_{i,j}^{\lambda} = \begin{cases} 1, \text{if } K_{i,j} > \theta \\ 0, \text{otherwise} \end{cases}$
- Where $K_{l,m} = \sum_{i,j \in p_l, p_m} A_{i,j}^{\Lambda}$ gives the number of edges between elements of P
- P is set of partitions of vertex set V^{Λ} where Λ is the largest resolution

Results



TRMM precipitation data with smallest time scale 1 day and smallest space scale ≈ 27 kms. Degree Centrality $k_i = \sum_j A_{i,j}$ computed from climate networks (CN) : (a) at largest resolution, (b) at time scale 2 days and space scale ≈ 81 kms, (c) from upscaling CN at the largest resolution

Conclusion

- Various centrality measures were compared and found to be similar for smaller scales
- But the network topology deviates quickly after upscaling of the field
- Analysis done only for 3 scales - bigger domains necessary to consider more scales

References

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