

Contribution of Intra-Seasonal Variability to Inter-Annual Variability of the Monsoon

Active Periods vs. Break Periods

What is the Effect of Correcting the Tropical Heating Bias?

Simple Methodology:

- k-means cluster analysis on 850 hPa (u,v) winds from ERA-Interim over the Indian region
- Identify a cluster which represents enhanced Monsoon Trough
- Correlate the summer-by-summer frequency of occurrence this cluster with precipitation
- Is this cluster represented in CFSv2, and is it correlated with its counterpart in ERA-Interim

Contribution of Intra-Seasonal Variability to Inter-Annual Variability of the Monsoon

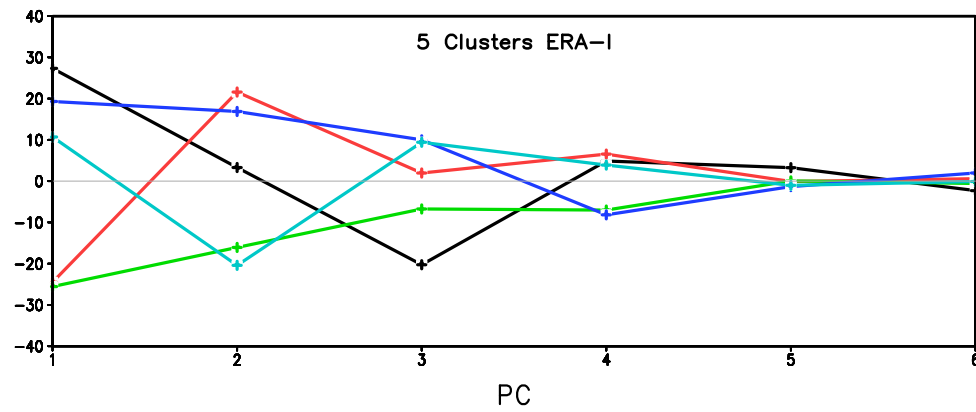
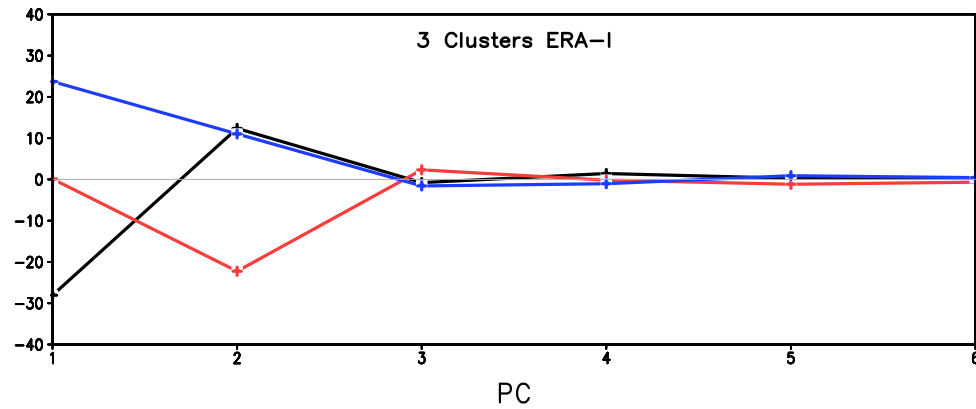
Clustering Details:

- Principal Component Analysis of daily 850 hPa (u,v) winds over the broad Indian region (-1. to 34.9 latitude, 50.6 to 98.4 longitude)
- Period: 120 days starting on 01June for all years 1979 – 2016
- Only climatological seasonal cycle removed
- Using PCs as new coordinates, carry out a k-means cluster analysis using a truncation of 6 PCs (captures ~54% of total variance)
- Assess significance vis-à-vis synthetic data sets constructed using a stochastic process for each synthetic PC, constructed so that the synthetic PC has the same correlation structure as the actual PC. (Synthetic PCs are then independent of each other).

k (No. of clusters)	ERA-Interim	CFSv2 (control)	CFSv2 (add heat)
k=3	93%	87%	64%
k=4	94%	89%	83%
k=5	99%	100%	99%

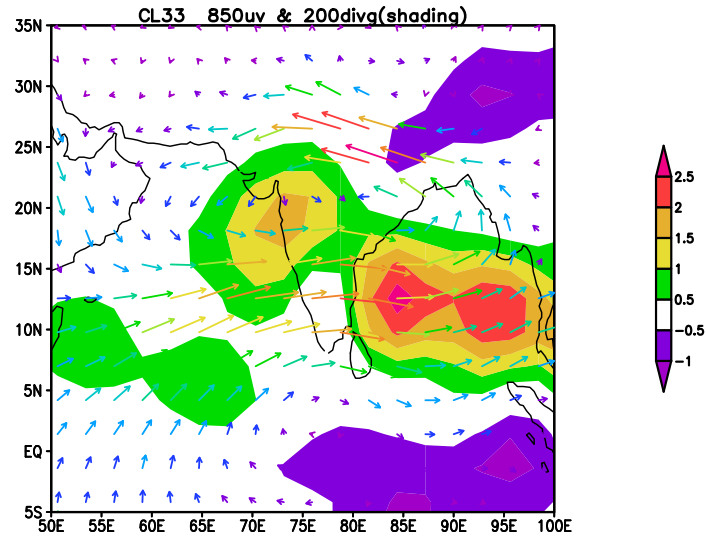
Significance: Number of synthetic datasets (out of 100) for which the *variance ratio* (measure of the clustering) is *lower* than that for the ERA-Interim data

Contribution of each PC to the k=3 and k=5 cluster centroids (characteristic pattern) from ERA-Interim

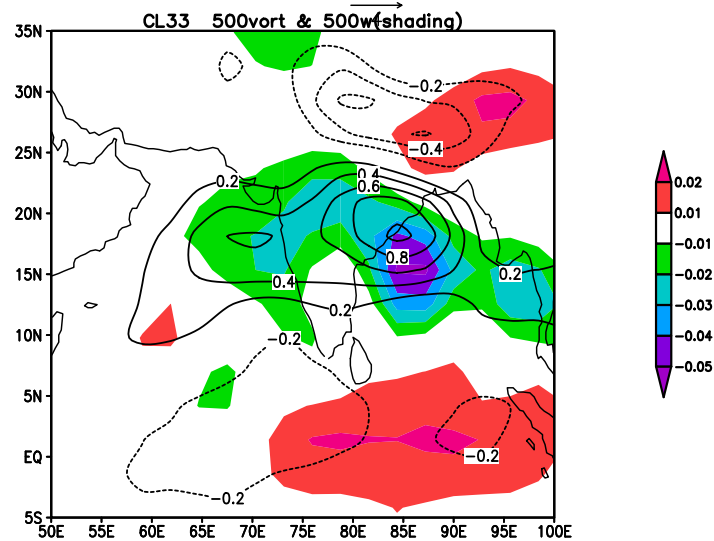


Structure of "Monsoon Trough" cluster from ERAI-Interim k=3

Top panel shows **850 hPa winds as arrows** and **200 hPa divergence as shading** (units of 1.0×10^{-6} .)

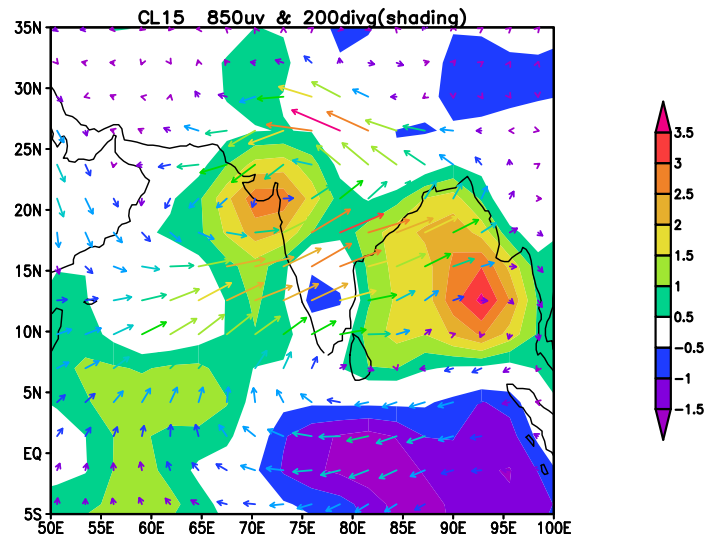


Bottom panel shows **500 hPa vorticity (contours, units of 1.0×10^{-6})** and **vertical pressure velocity (hPa/sec)** as shading.

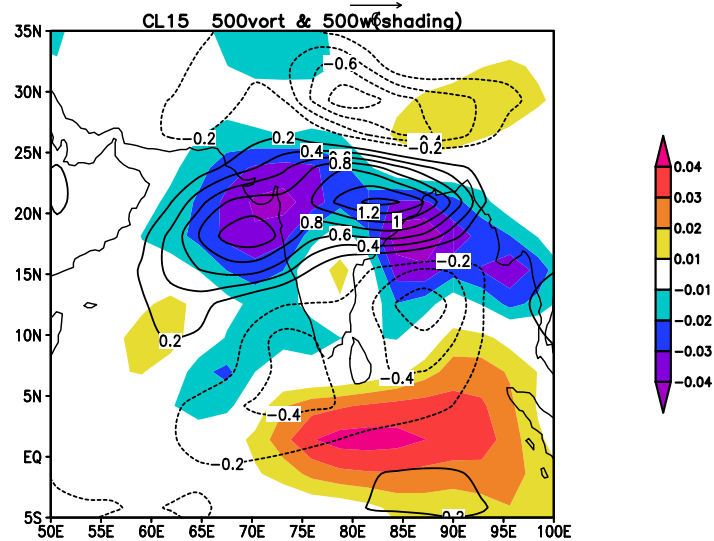


Structure of "Monsoon Trough" cluster from ERAI-Interim k=5

Top panel shows **850 hPa winds as arrows** and **200 hPa divergence as shading** (units of 1.0×10^{-6} .)



Bottom panel shows **500 hPa vorticity (contours, units of 1.0×10^{-6})** and **vertical pressure velocity (hPa/sec) as shading**.

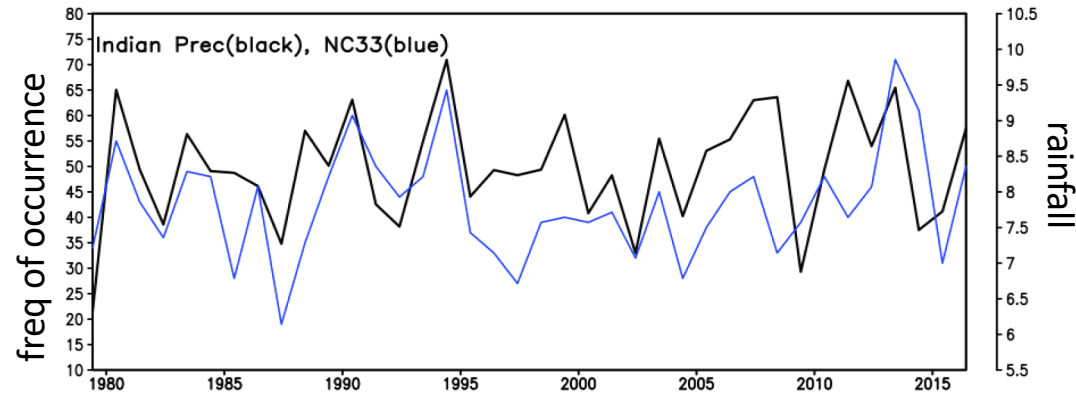


Correlating the frequency of occurrence of the ERA-Interim Monsoon Trough cluster with central Indian rainfall

Time series of central India precipitation (black) (scale on right)

Time series of annual frequency of occurrence of cluster 3 for k=3 (blue) (scale on left)

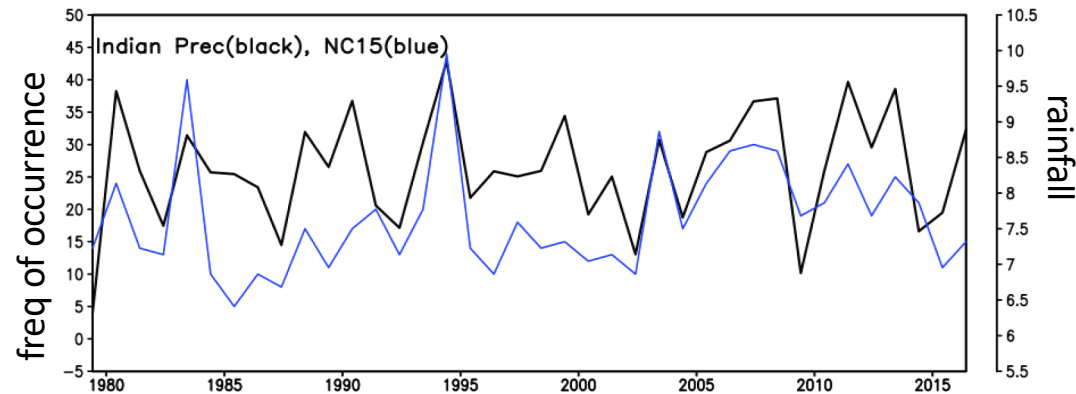
Correl = 0.49



Time series of central India precipitation (black) (scale on right)

Time series of annual frequency of occurrence of cluster 1 for k=5 (blue) (scale on left)

Correl=0.57

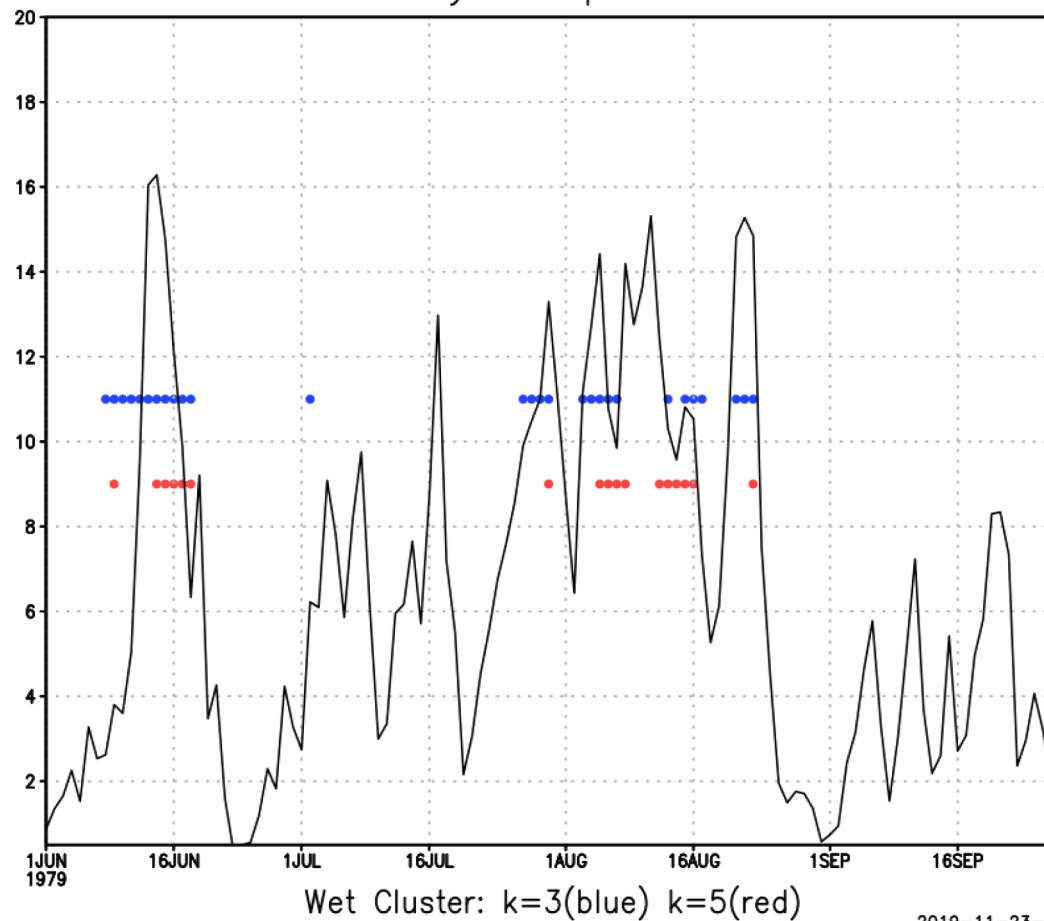


The Monsoon Trough Cluster is related to daily frequency of precipitation

Daily Precip 2004

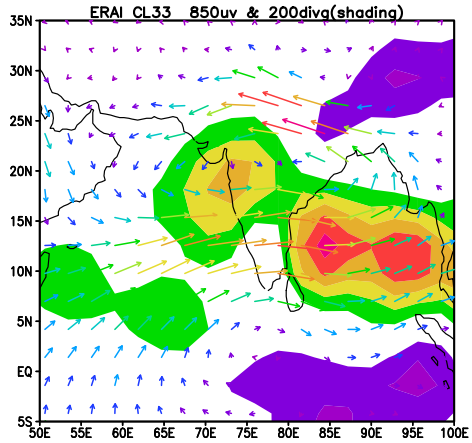
Black line is daily frequency of precipitation for 2004 (averaged over central India)

Blue (red) dots indicate days in which the circulation resides in the Monsoon Trough cluster of $k=3$ ($k=5$) (Clusters from ERA-I)

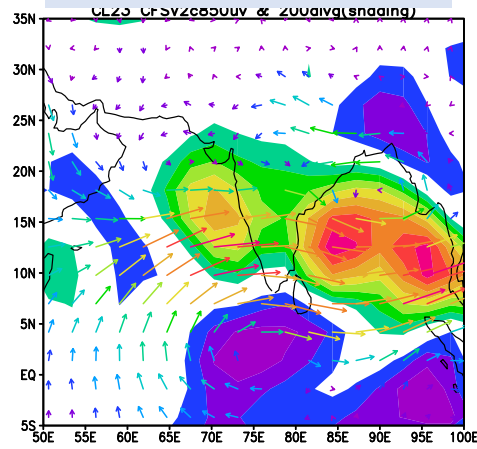


Monsoon Trough Clusters (k=3)

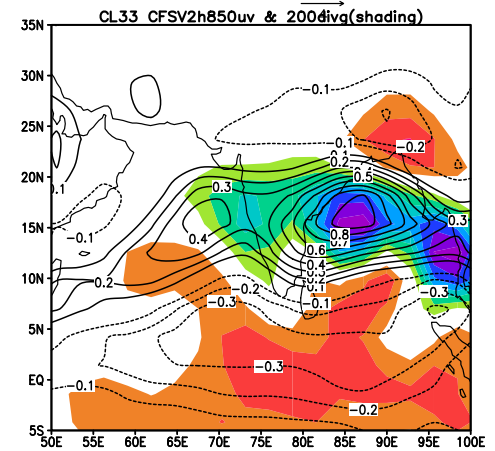
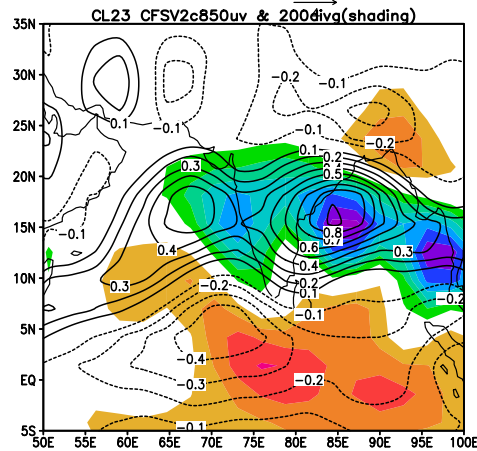
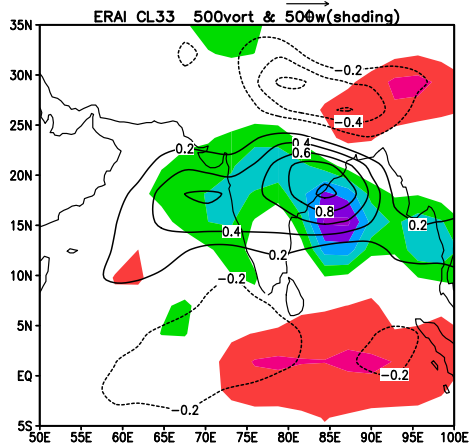
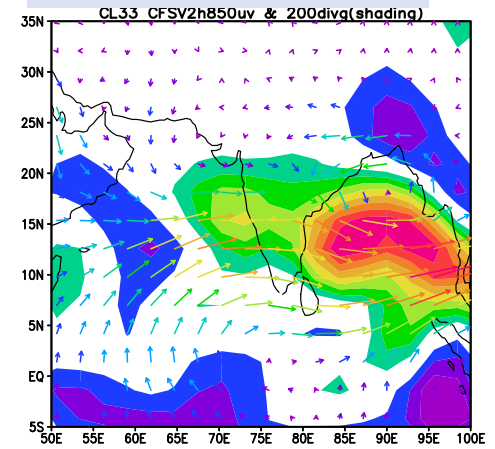
ERA-Interim



CFSv2 (control) 0.42

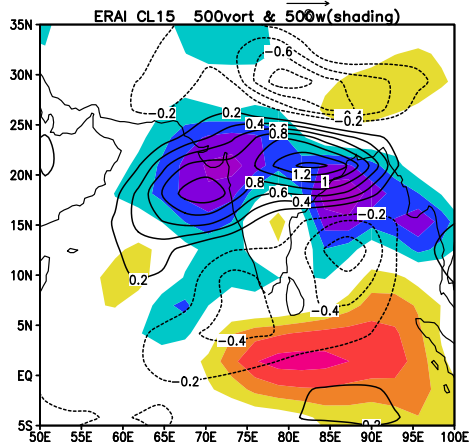
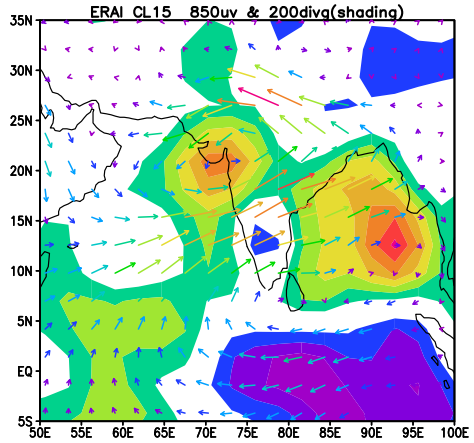


CFSv2 (add heat) 0.58

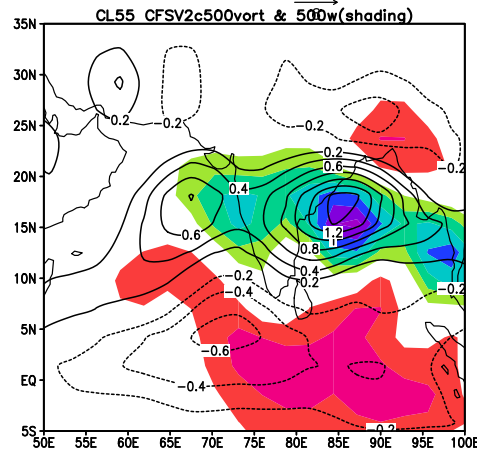
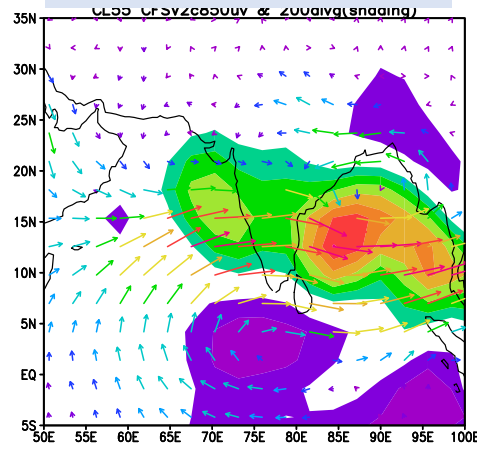


Monsoon Trough Clusters (k=5)

ERA-Interim



CFSv2 (control) -0.01



CFsv2 (add heat) 0.47

