Interannual variability of monsoon onset and withdrawal in Bangladesh

Carlo Montes[1], Nachiketa Acharya[2], S. M. Quamrul Hassan[3]

[1]International Maize and Wheat Improvement Center (CIMMYT), Mexico
[2]International Research Institute for Climate and Society, Columbia University, USA
[3]Bangladesh Meteorological Department, Bangladesh

International Conference on Meteorology and Climate Science 2020

IRI

CIMMYT MR
International Maize and Wheat Improvement Center

বাংলাদেশ আবহাওয়া অধিদপ্তর

Outline

1) Motivation

2) Objectives, methods and data used

3) Results
   - Spatial and interannual patterns
   - Drivers of interannual variability

4) Concluding remarks

Motivation

Monsoon timing: important in agriculture

- Water supply for *kharif* rice season
- Land preparation, date of sowing and transplanting
- Consequences for *rabi* season crops (e.g. terminal heat stress)
- 1 SD delay in monsoon onset: 35% profit decrease (Rosenweig and Binswanger, 1993)

Monsoon timing: important as an environmental risk factor

- Bangladesh ranks as the sixth most flood-prone country in the world (UNDP, 2004)

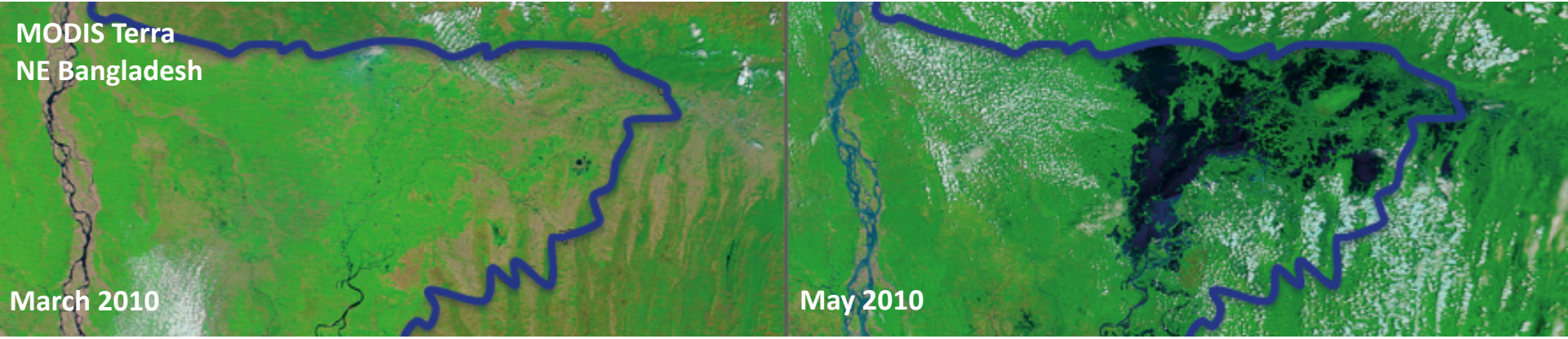
Motivation

Monsoon timing: important in agriculture

- Water supply for *kharif* season rice
- Land preparation, date of sowing and transplanting
- Consequences for *rabi* season crops (e.g. terminal heat stress)
- 1 SD delay in monsoon onset: 35% profit decrease (Rosenweig and Binswanger, 1993)

Monsoon timing: important as an environmental risk factor

- Bangladesh ranks as the sixth most flood-prone country in the world (UNDP, 2004)



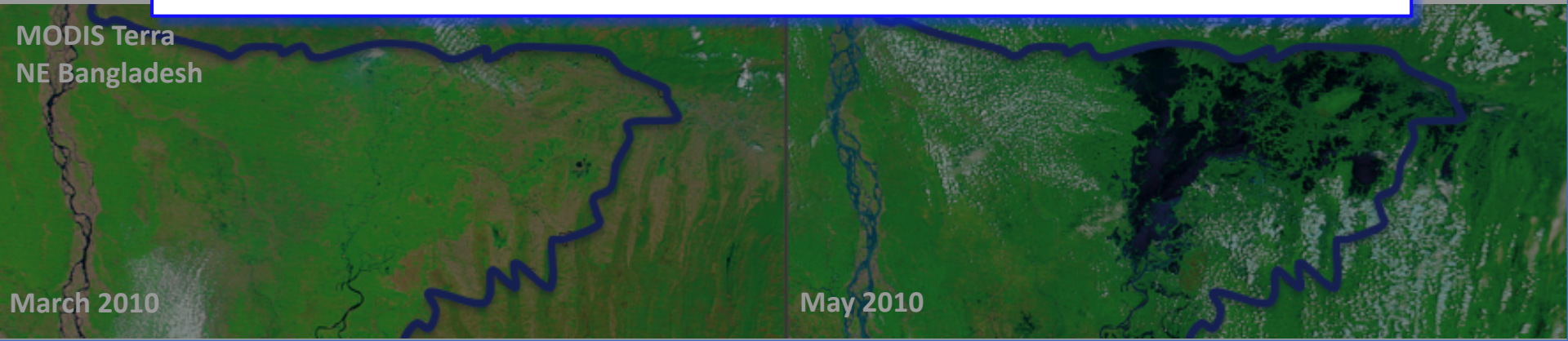
Motivation

Monsoon timing: important in agriculture

- Water supply for *kharif* season rice

993)

The main goal of this work is to statistically characterize the primary regional patterns of variability in monsoon onset and withdrawal in Bangladesh and assess the interannual influence of large-scale teleconnections and potential use for predictability.



Datasets

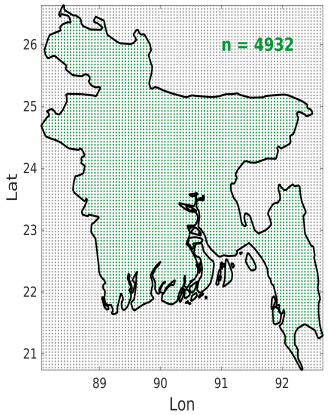
Monsoon onset and withdrawal (1981-2018)

- CHIRPS 0.05 x 0.05º dalily rainfall
- BMD daily rainfall

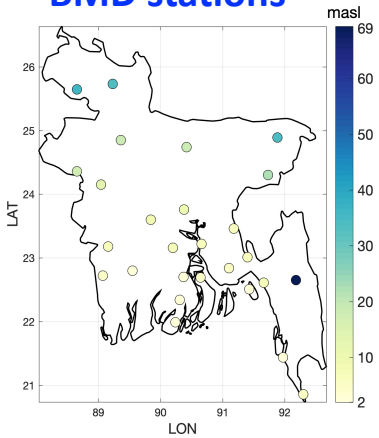
The relationship with global drivers

- Extended Reconstructed Sea surface temperature (ERSSTv5): Niño 3.4
- Dipole Mode Index (DMI): IOD

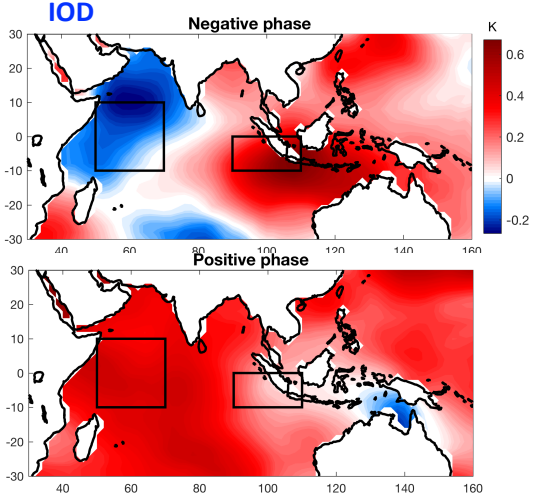
CHIRPS 5 km x 5 km



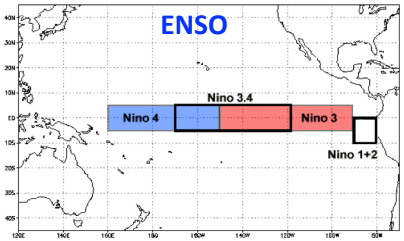
BMD stations



IOD



ENSO



Circulation composites

- ERA5 atmospheric reanalysis
  - 500-hPa: GPH, *u* and *v* wind
  - Surface: SLP, *u* and *v* wind

Analysis

Assessing sptial and interannual variability

- Descriptive statistics for main features, Mann-Kendall test
- Empirical Orthogonal Functions (EOF) for primary modes of variability

Atmospheric circulation associated with onset and withdrawal

- ERA5 composites of GPH, SLP and wind fields
- Early, mid, and late monsoon onset/withdrawal

Identifying homogeneous groups of monsoon onset and withdrawal

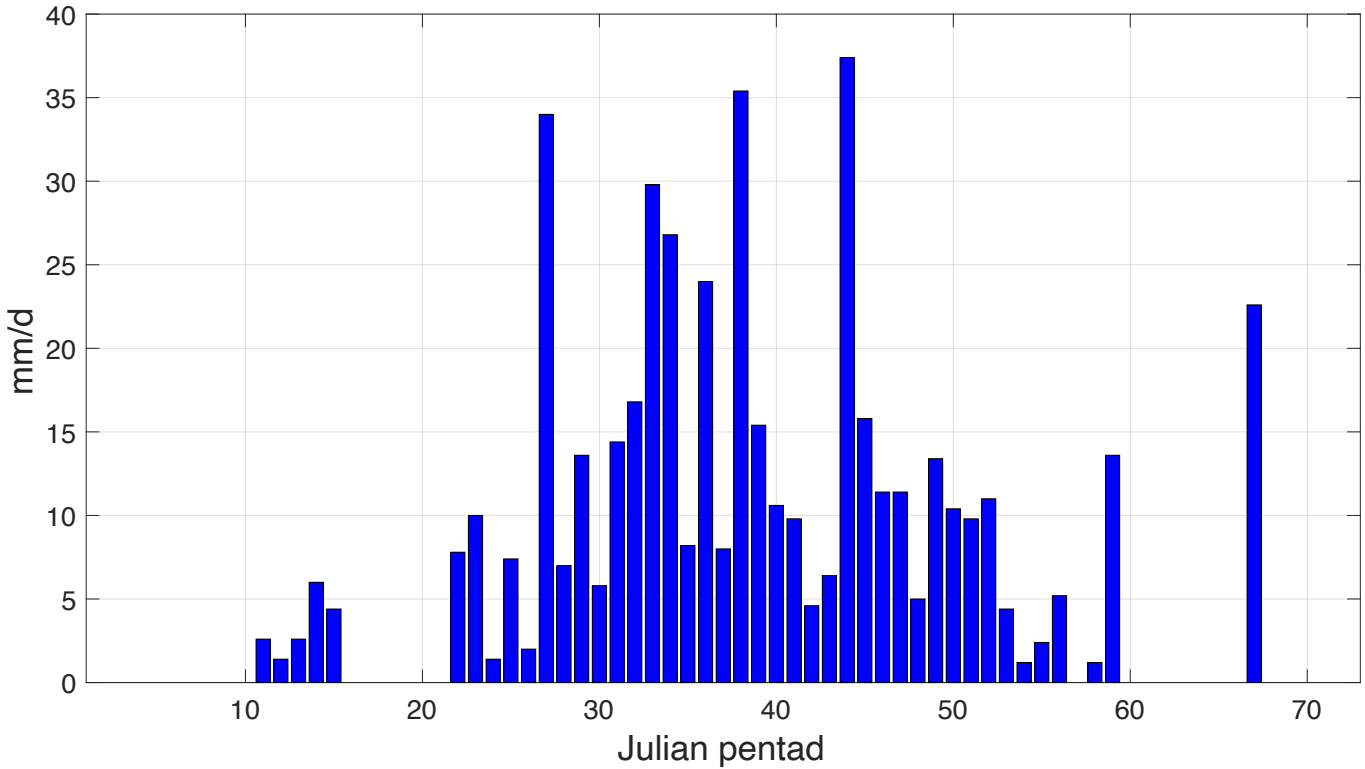
- Relationship between ENSO/IOD and monsoon timing
- Clustering of monsoon onset and withdrawal
  - Hierarchical clustering
  - *k*-means algorithm to previously-selected clusters

The relationship with ENSO and IOD

- 3-month running average El Niño 3.4 region SST: upper and lower terciles
- 3-month running average DMI: upper and lower terciles

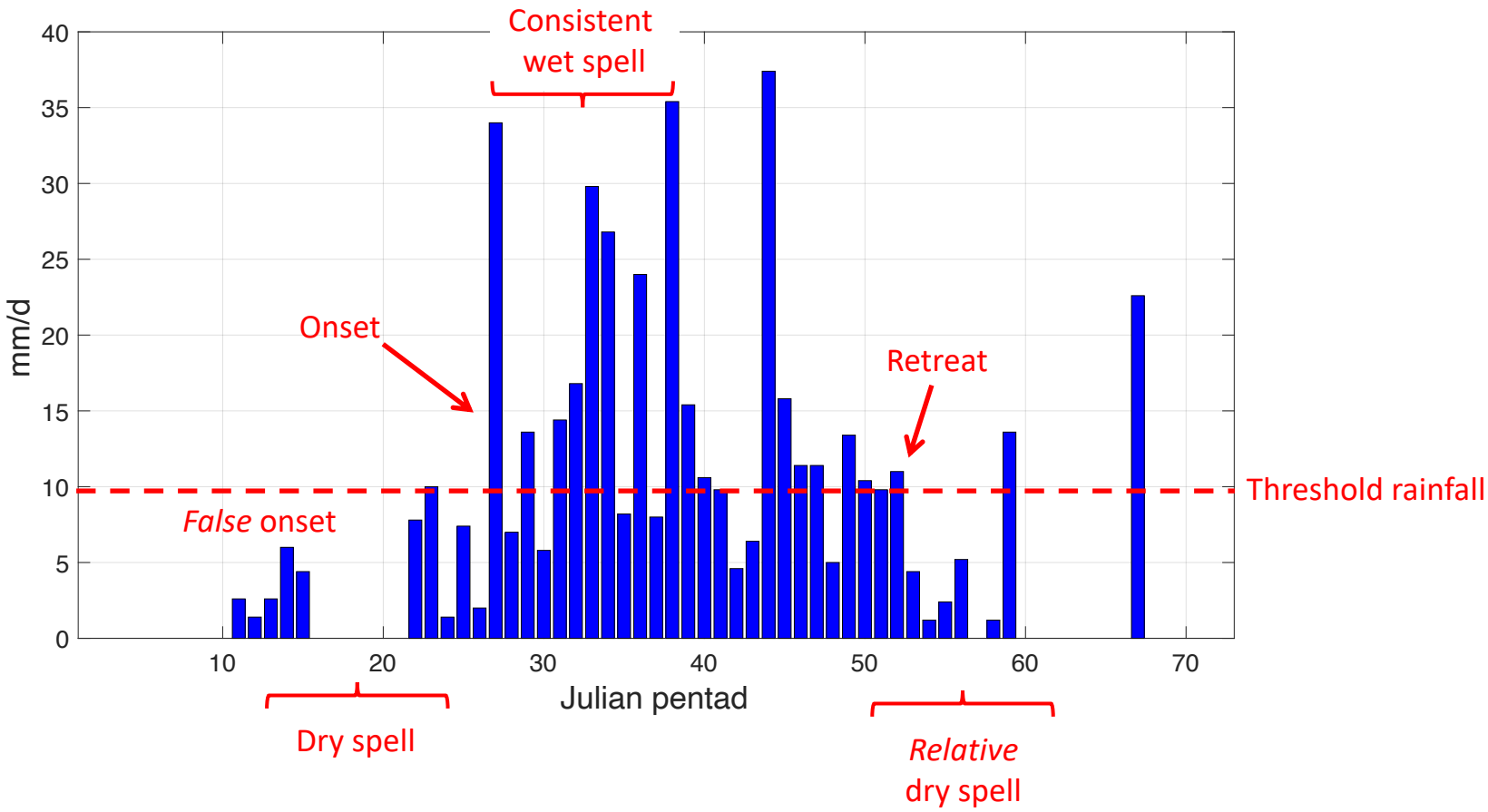
Defining monsoon onset and withdrawal in Bangladesh

A *typical* year



Defining monsoon onset and withdrawal in Bangladesh

A *typical* year

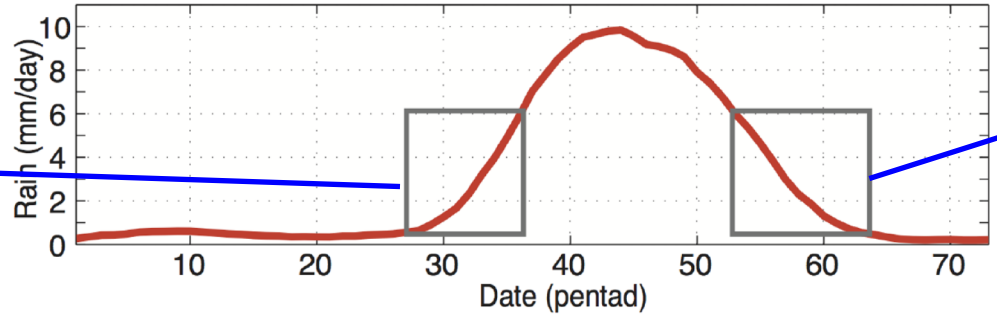


Defining monsoon onset and withdrawal in Bangladesh

Monsoon onset and withdrawal definition

Integrated Onset Matrix

1	1	0	1	0	1
1	1	1	0	1	0
1	1	1	0	0	1
1	1	0	0	1	1
1	1	0	1	1	0
1	1	0	1	1	1
1	1	1	0	1	1
1	1	1	1	0	0
1	1	1	1	0	1
1	1	1	1	1	0
1	1	1	1	1	1



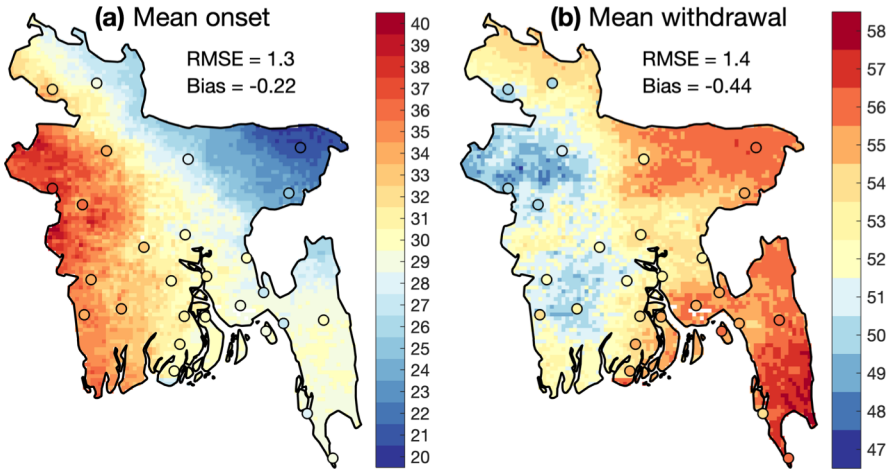
Integrated Withdrawal Matrix

1	0	1	1	0	0
1	0	1	0	1	0
1	1	0	1	0	0
1	1	0	0	1	0
1	1	1	1	0	0
1	0	1	1	1	0
1	0	1	0	1	1
1	0	1	1	0	1
1	1	0	1	1	0
1	1	0	0	1	1
1	1	0	1	0	1
1	1	1	0	1	0
1	1	1	0	0	1
1	1	1	1	1	0
1	0	1	1	1	1
1	1	0	1	1	1
1	1	1	0	1	1
1	1	1	1	0	1
1	1	1	1	1	1

- Monsoon onset and withdrawal
- Monsoon parameter: threshold pentad precipitation
- Pentad binary time series
- 1 = rainfall higher than threshold

Stiller-Reeve *et al.*, 2014

Results: mean features

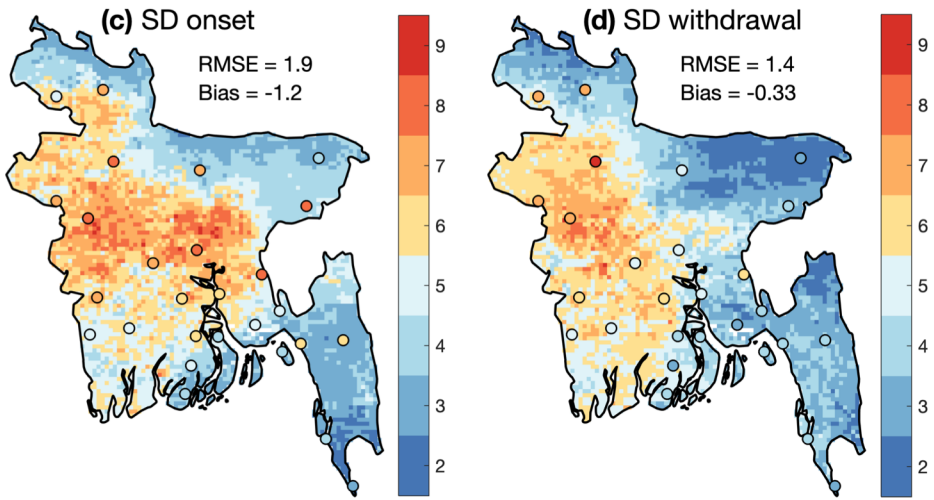


Monsoon onset

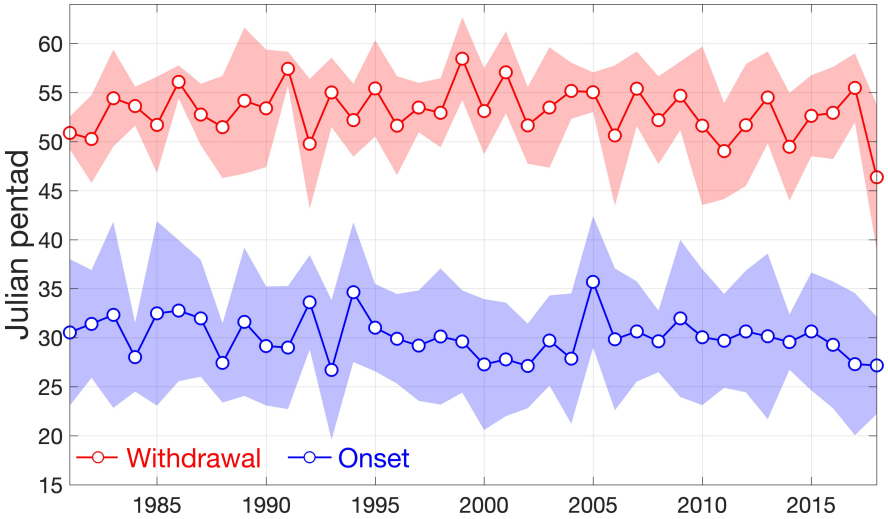
- NE-SW propagation
- Ranging from ~Apr 25th Jul 4th
- Country average June 4th
- SD: 2 to 9 pentads

Monsoon withdrawal

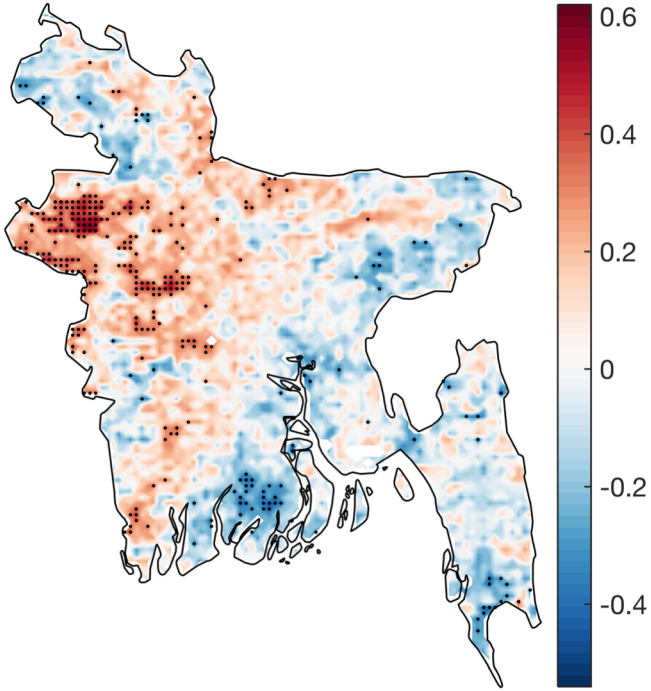
- West-East propagation
- Ranging from Sep 2nd to Oct 7th
- Country average September 27th
- SD: 2 to 9 pentads



Results: interannual variability

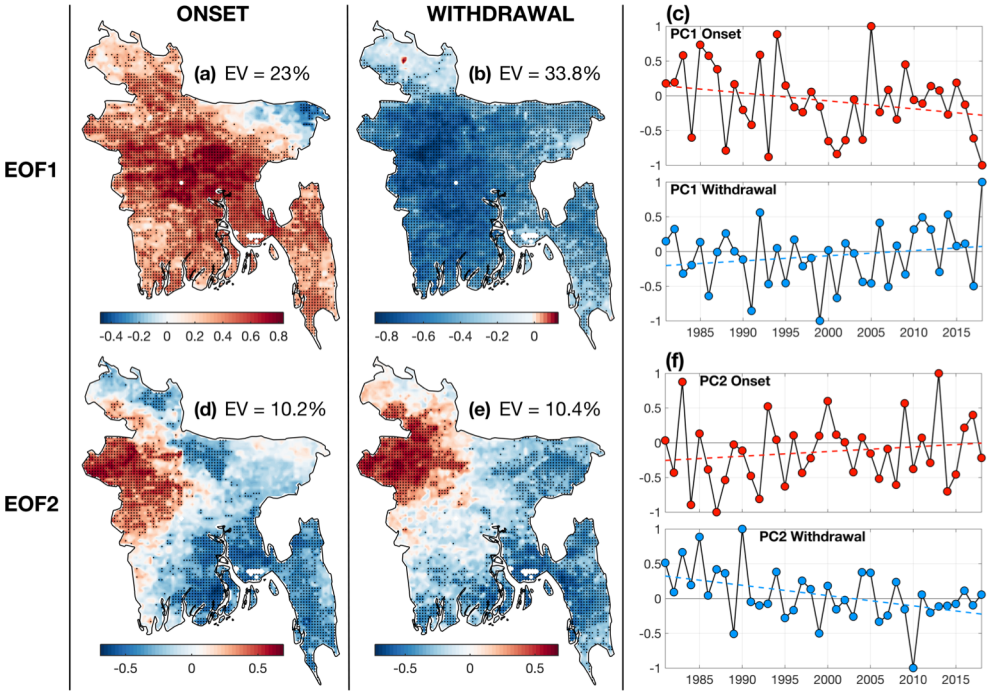


- In average **1 month** of interannual variability in onset and withdrawal
- Correlation = 0



- Regional correlations
- Higher covariability over W areas

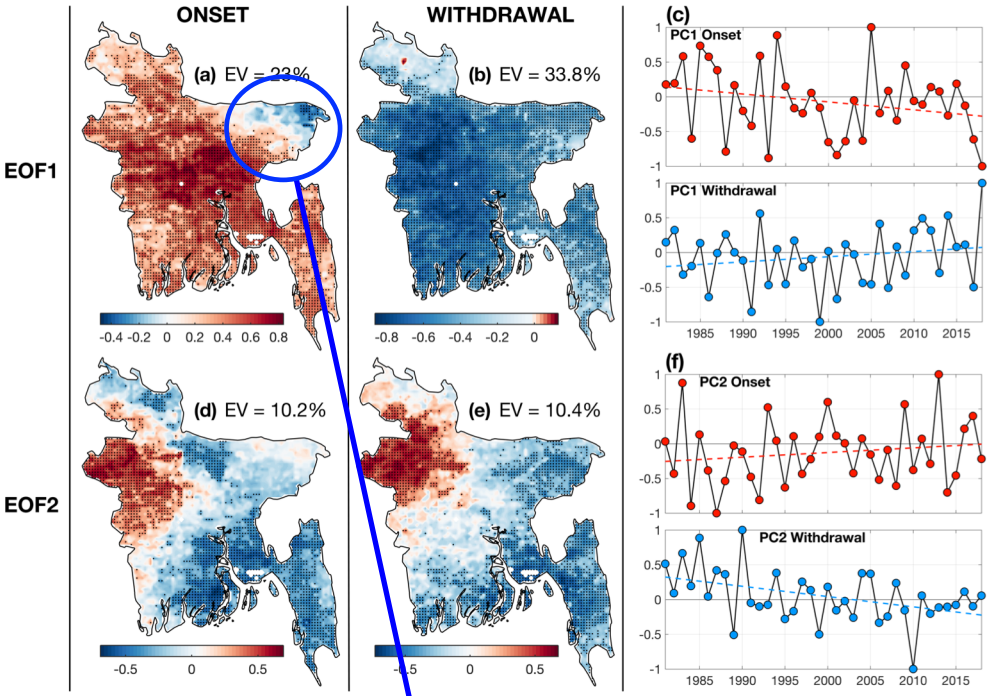
Results: main modes of variability



- Onset: EOF1 + EOF2 = 33.2%
- Withdrawal: EOF1 + EOF2 = 44.2%
- Contrasting trends of PCs
- EOF2: very similar distribution

- Opposite sign EOF1 in the NE
- Earlier onset and pre-monsoon rains

Results: main modes of variability

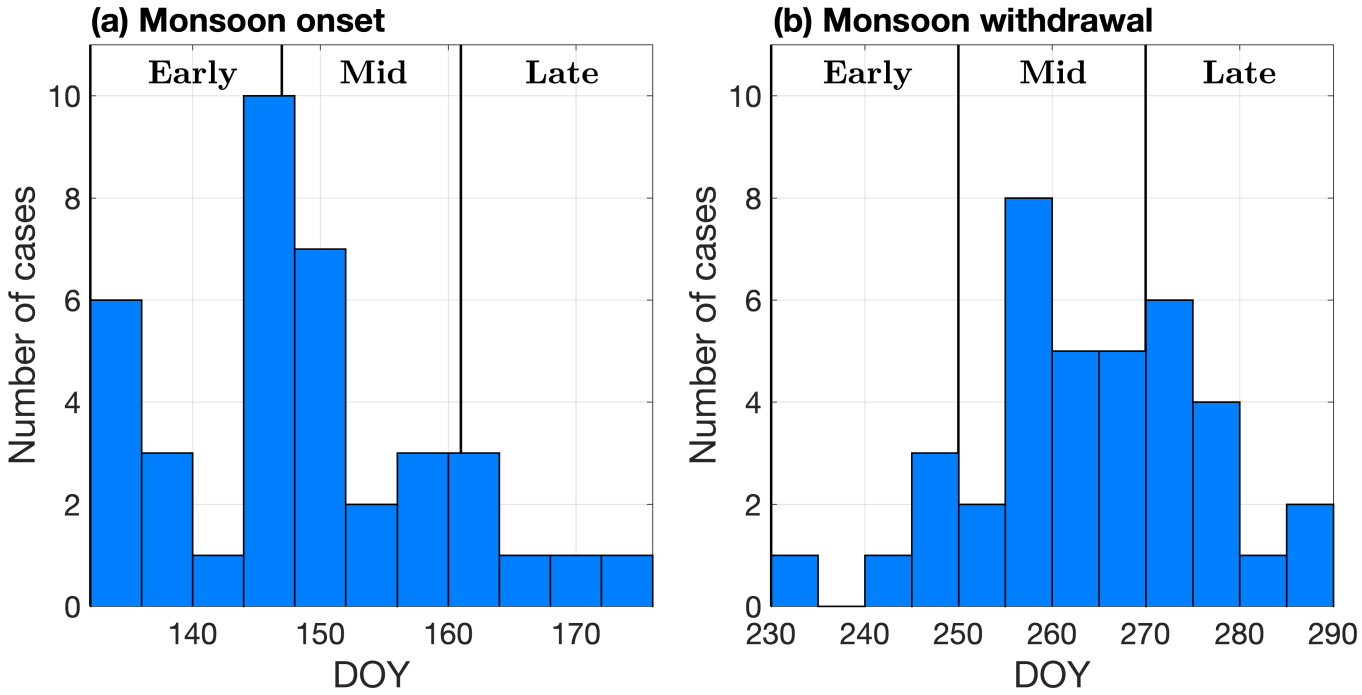


- Onset: EOF1 + EOF2 = 33.2%
- Withdrawal: EOF1 + EOF2 = 44.2%
- Contrasting trends of PCs
- EOF2: very similar distribution

- Opposite sign EOF1 in the NE
- Earlier onset and pre-monsoon rains

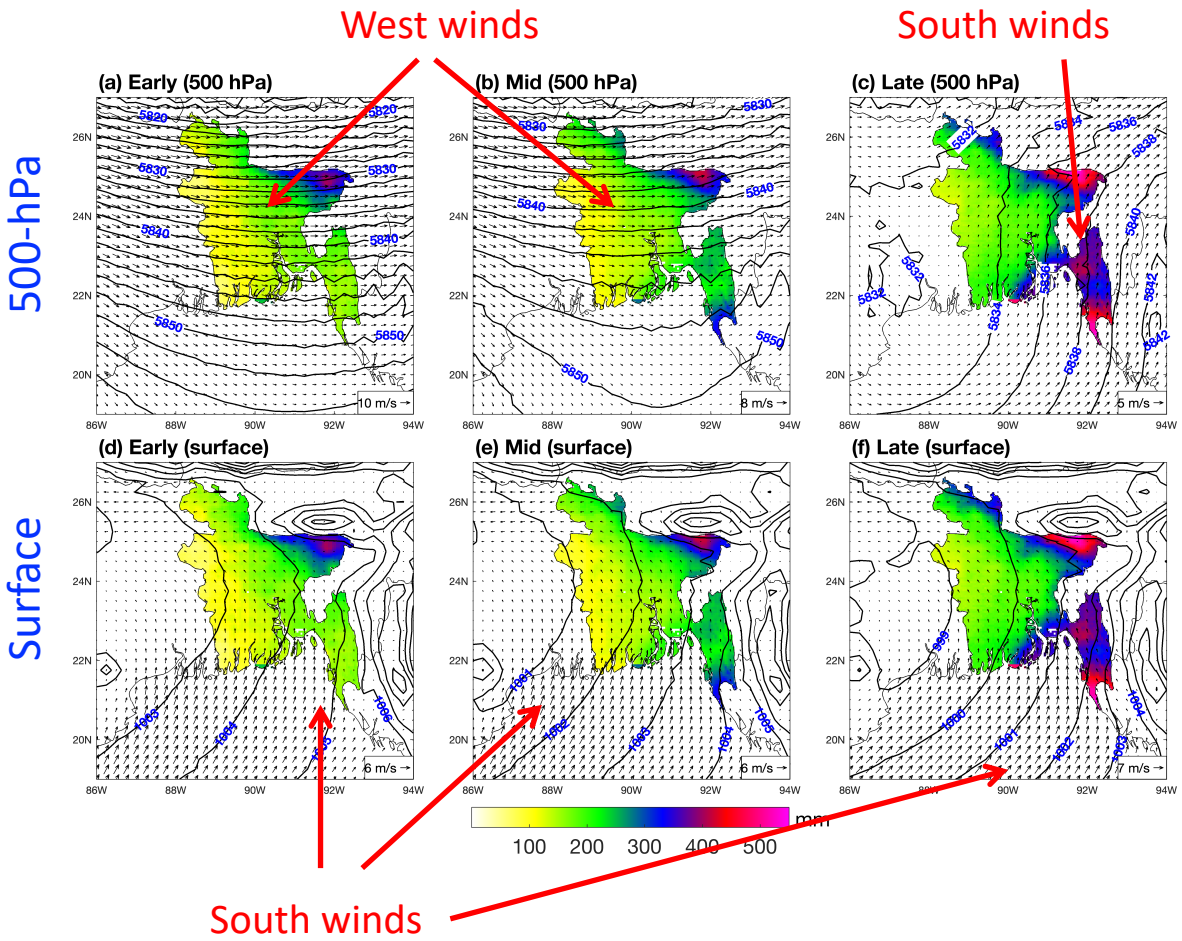
Results: associated circulation

Circulation composites for **early**, **mid**, and **late** onset and withdrawal



Results: associated circulation

Monsoon onset

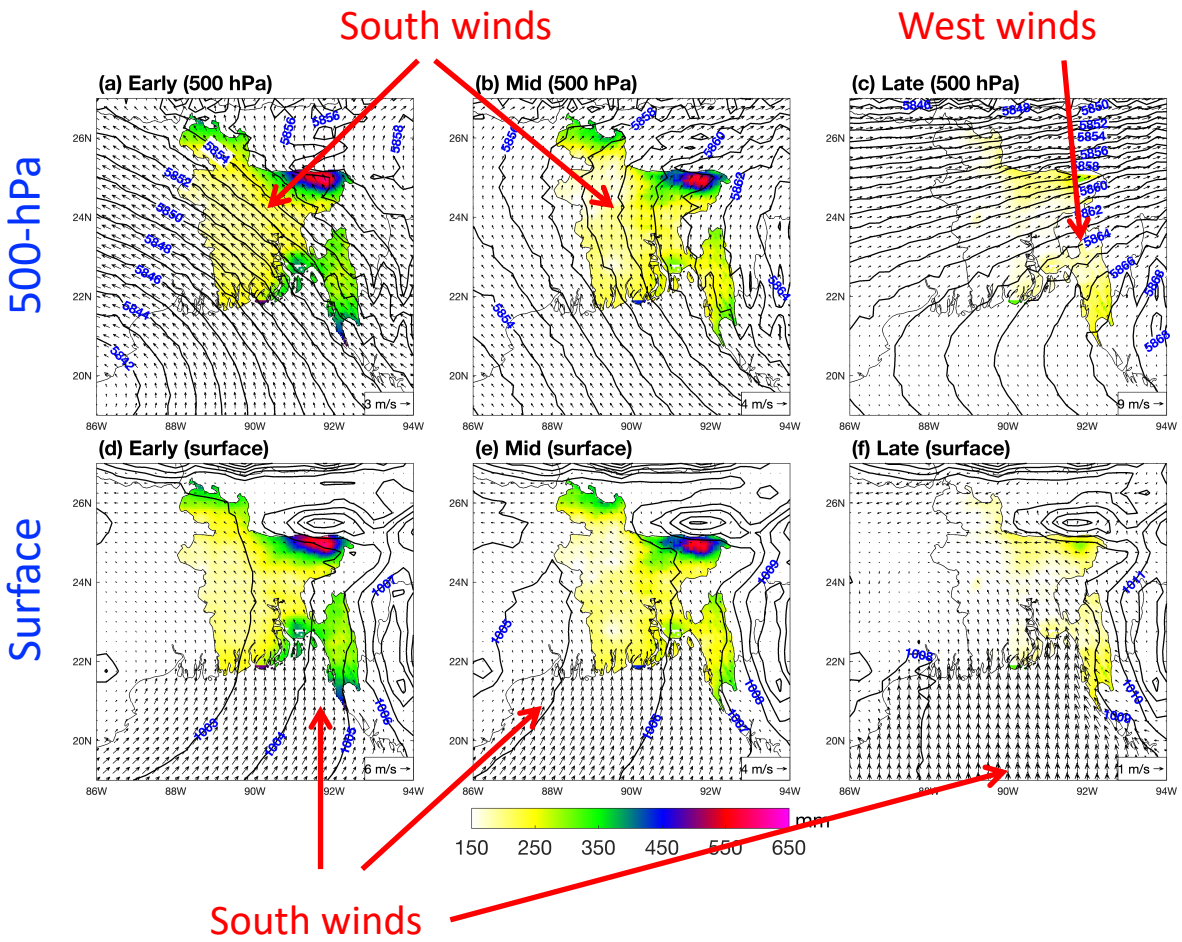


- South 500-hPa component
  - Late onset
- Surface: south component

- Late onset: higher associated precipitation

Results: associated circulation

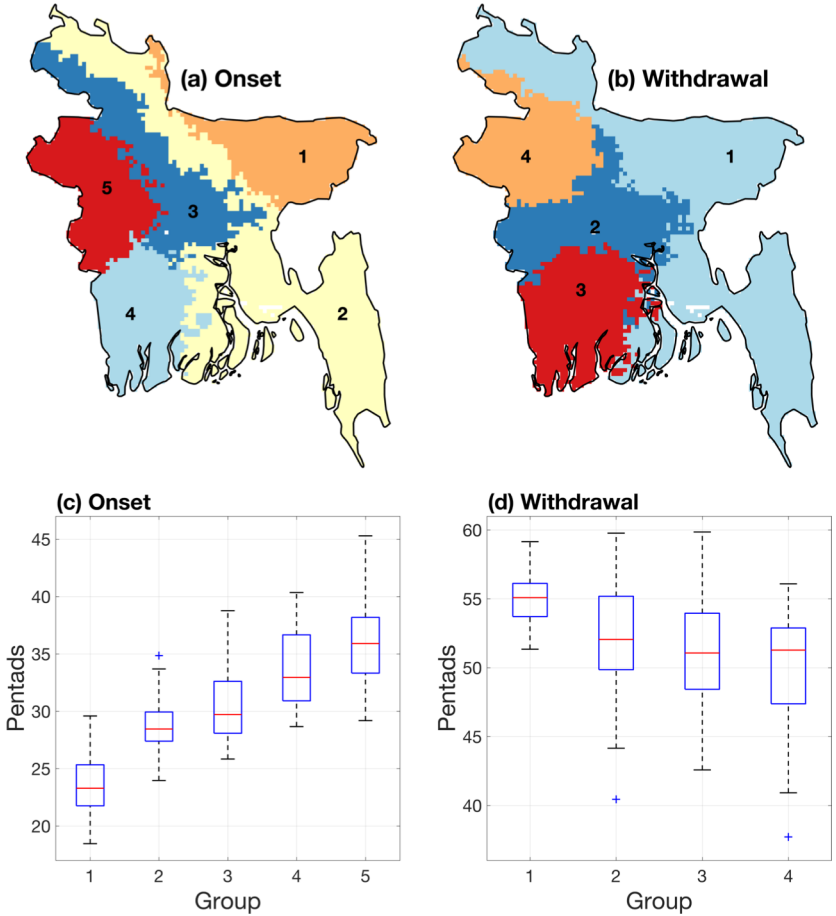
Monsoon withdrawal



- West 500-hPa component
  - Late onset
- Surface:
  - South component
  - Decreasing pressure gradients

- Late withdrawal: lower associated precipitation

Results: clustering



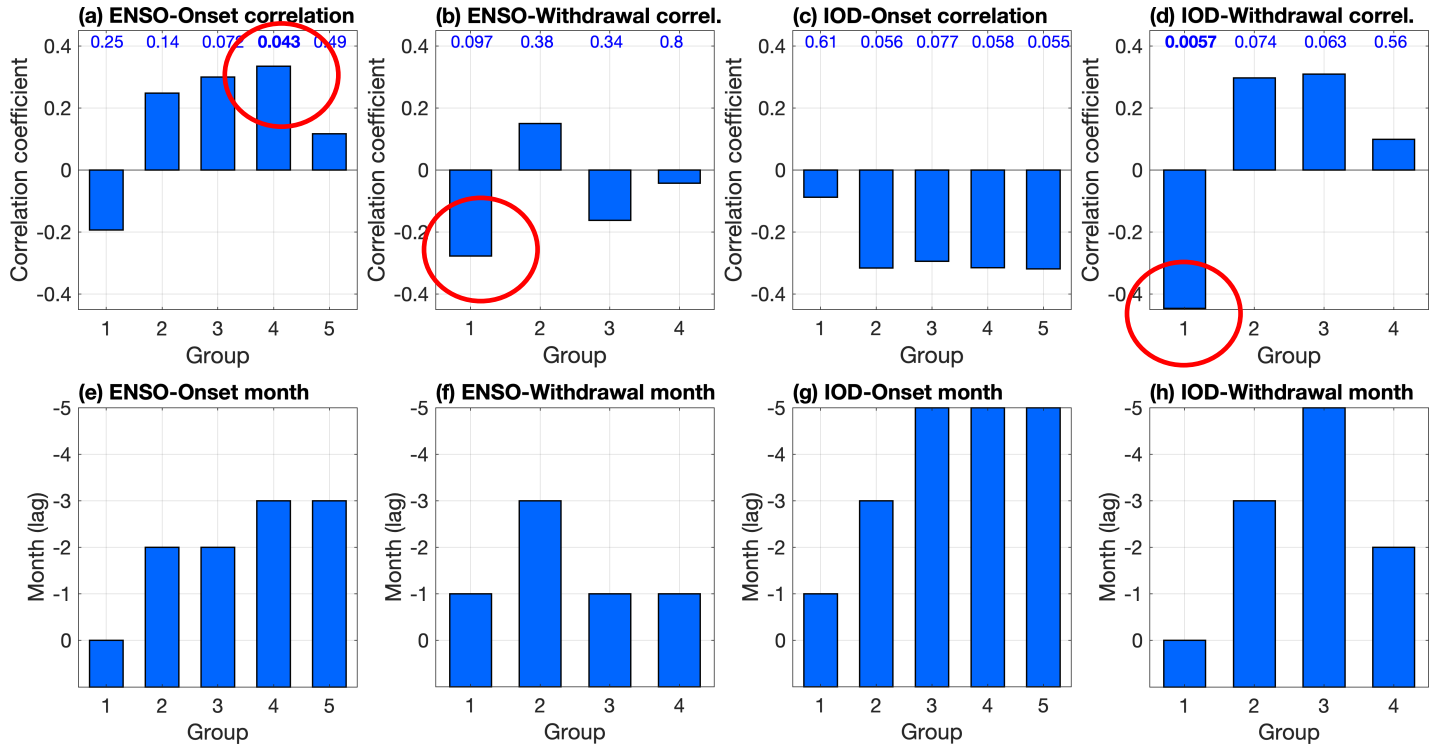
- *Discretization* of average onset and withdrawal
- Earlier onset NE, latest onset W
- Withdrawal: smaller amplitude in dates

Results: correlations between clusters and ENSO and IOD

Possitive corr.
Except C1

Negative corr.

Significant C1



Not clear pattern, potentially useful but significant correlations for some regions

Concluding remarks

- Significant spatial and temporal variability in monsoon timing in Bangladesh
- The bulk of monsoon onset in May and June: dominant westward propagation
- Monsoon withdrawal occurs on average between September and October
- Early, mid and late onset evidence the role of circulation on regional differences in timing and amount of rain during monsoon transitions
- Monsoon timing and ENSO/IOD
  - Increasing predictive power at ther regional level vs country-level
  - Use in statistical forecasting?
  - Additional sources of predictability seem to be necessary

Thank you

Carlo Montes

c.montes@cgiar.org

IRI

CIMMYT MR
International Maize and Wheat Improvement Center

বাংলাদেশ আবহাওয়া অধিদপ্তর