# Response of the Asian Summer Monsoon to Aerosol Reduction due to COVID-19 lockdown regulations

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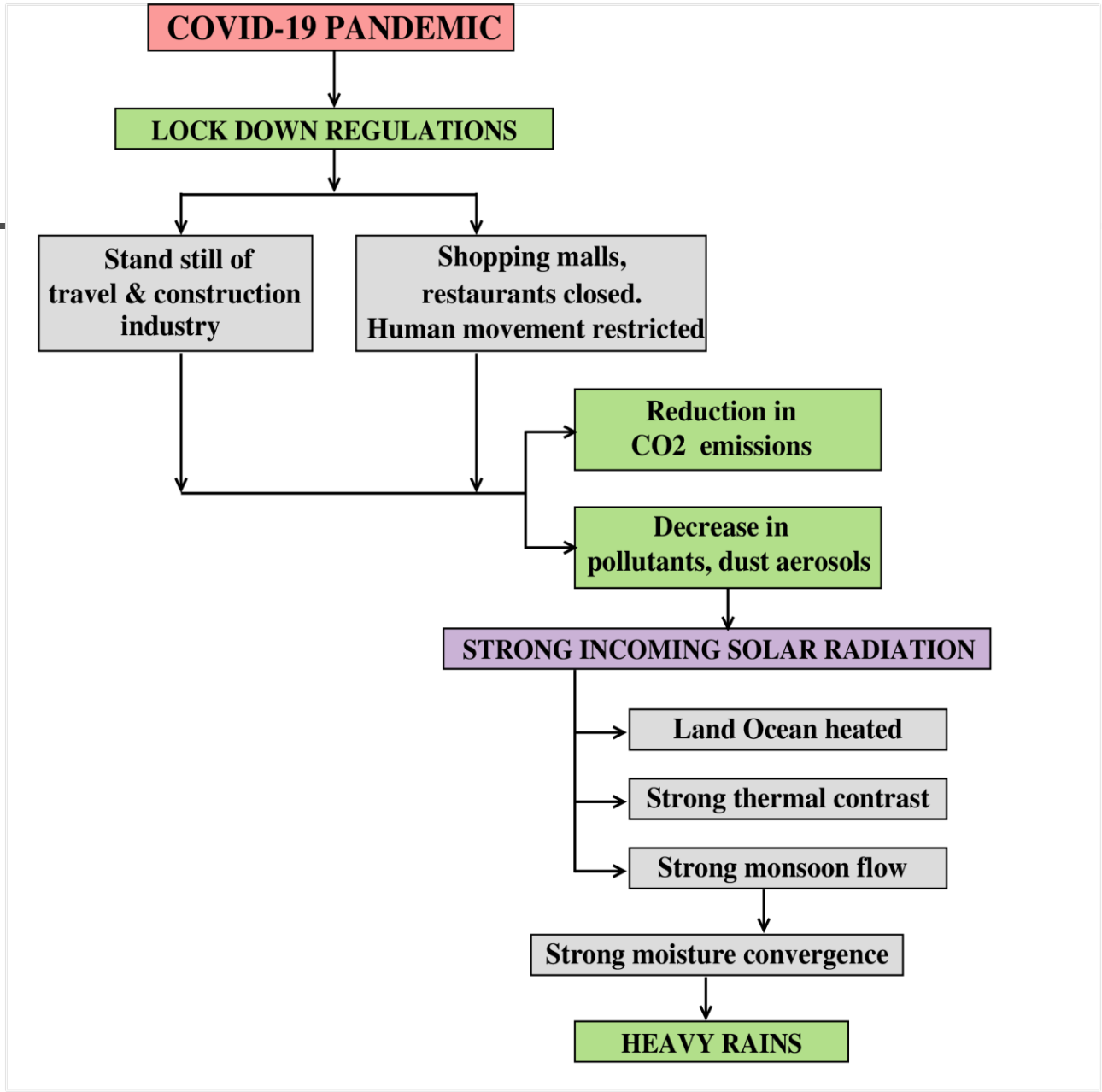
# Highly unusual and unprecedented heavy rains over South and East Asia during Summer Monsoon 2020

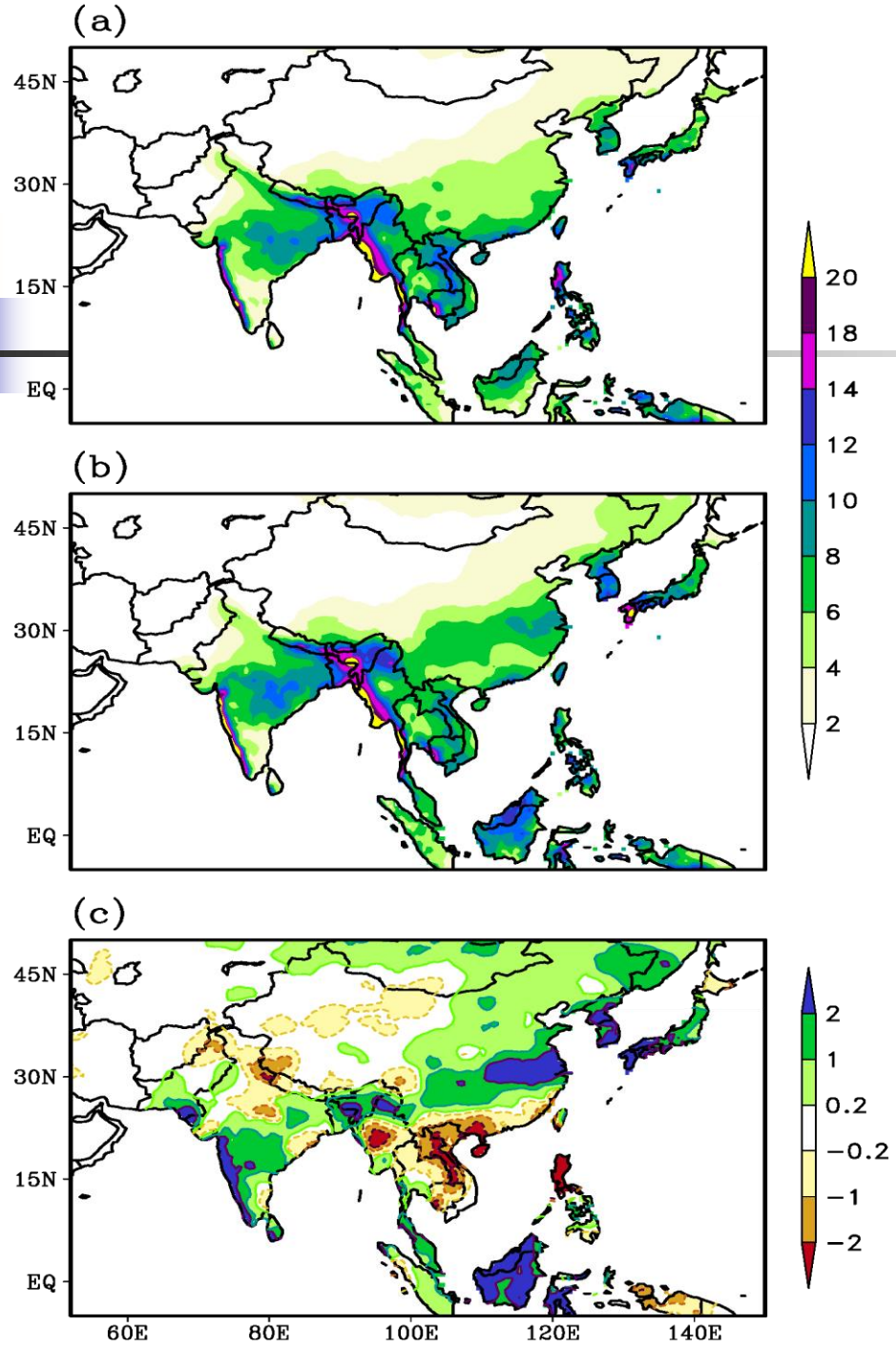
- **Over South Asia: India had one of the wettest monsoons since 1994. August was wettest in record since last 44 years. West coast of India experienced wettest in over 60 years. Withdrawal of monsoon was delayed by about two weeks**

- **Over East Asia: China recorded the longest rainy season and highest precipitation since 1961. Korea experienced its third wettest summer and rainy season was longest since 1973. Highest precipitation since 1946 recorded in one Japan's province. Rainy season ended later than usual over Korea and Japan**

# COVID-19 and Lockdown Initiates

- **Covid-19 identified in Wuhan, China in December 2019 – pandemic reported by WHO – deemed as global health crises**
- **To control the spread of virus various lockdown regulations implemented through out the world during 2020**
- **Movement of vehicular traffic (air, rail, road) and humans restricted resulting in unprecedented impact on the environment**
- **Significant reduction in air pollutants – dust, aerosols etc**
- **Covid-19 lockdown regulations initiated in March 2020 possible cause for the June-September Summer monsoon heavy rains?**


COVID-19 PANDEMIC
LOCK DOWN REGULATIONS
Stand still of travel & construction industry
Shopping malls, restaurants closed. Human movement restricted
Reduction in CO2 emissions
Decrease in pollutants, dust aerosols
STRONG INCOMING SOLAR RADIATION
Land Ocean heated
Strong thermal contrast
Strong monsoon flow
Strong moisture convergence
HEAVY RAINS




**Summer (Jun-Sep) monsoon rainfall patterns based on CRU dataset (mm/day)**

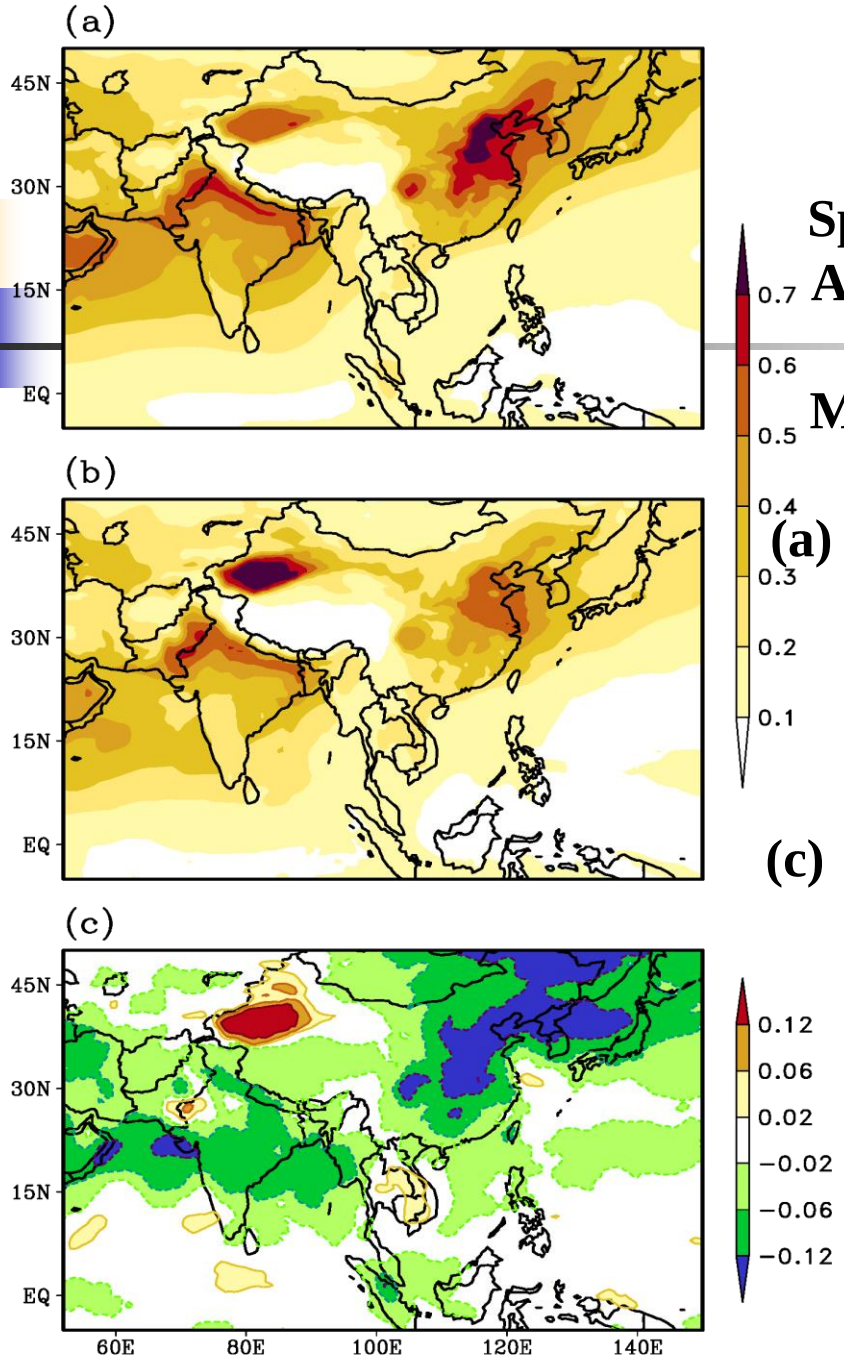
**(a) Climatology based on 1996-2015 period**

**(b) Monsoon 2020**

**(c) Difference (b) – (a)**

**Inference:**
**Excess rains > 2 mm/day West Coast and Central India**

**North East India through to China-Korea Japan**




**Spatial variation of May-June Aerosol Optical Depth (AOD) derived from MERRA2 Reanalysis product**

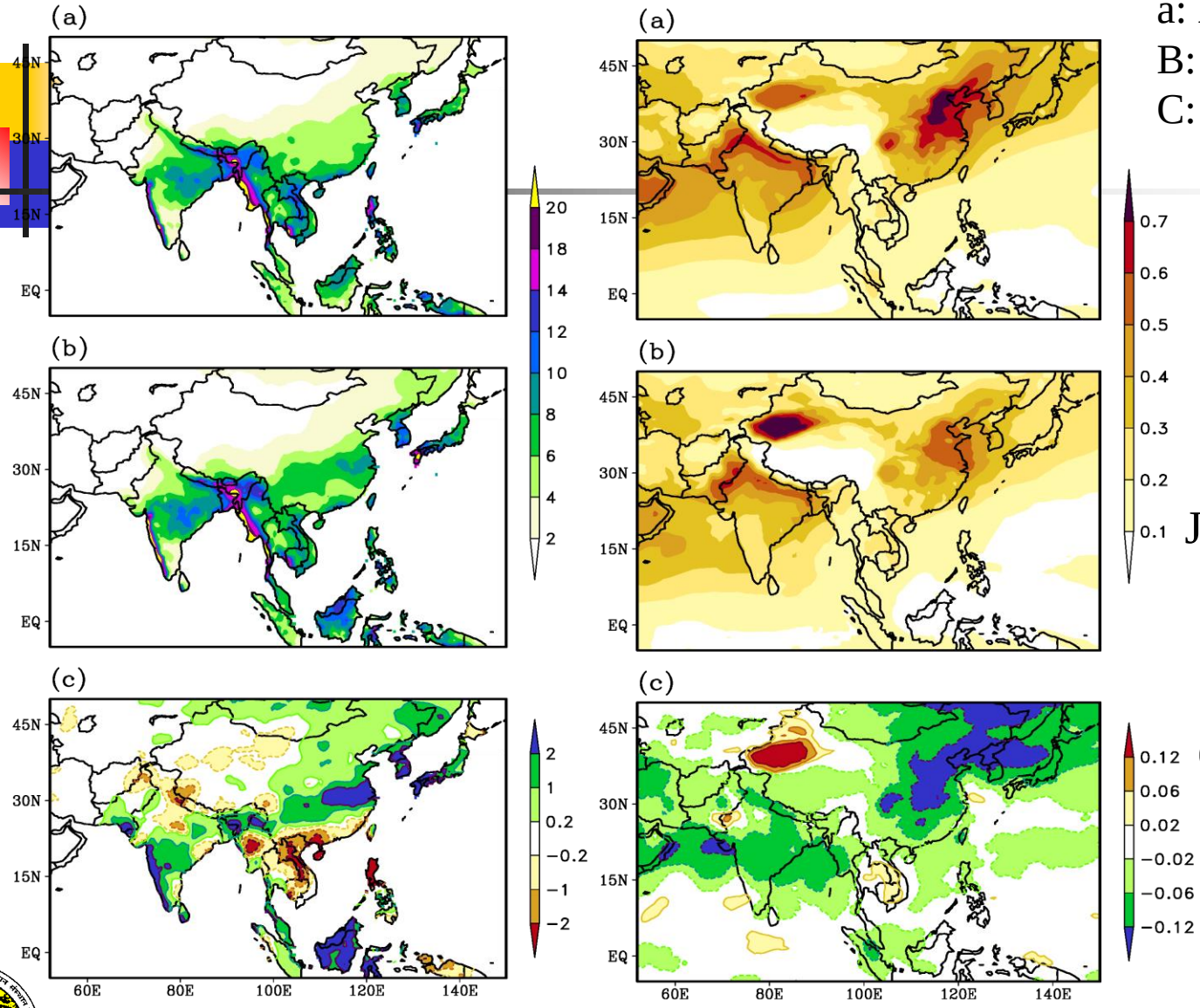
**(a) May-June Climatology 1996-2015**

**(b) May-June 2020**

**(c) Anomaly for May-June 2020: Significant reduction in AOD layers by about 20 % over the Arabian Sea, centrals parts of India,, Bay of Bengal, Yangzte River Valley in China, Korea-Japan peninsula. Higher reduction over East Asia than South Asia**

June-September Rainfall

May-June Aerosol Optical Depth



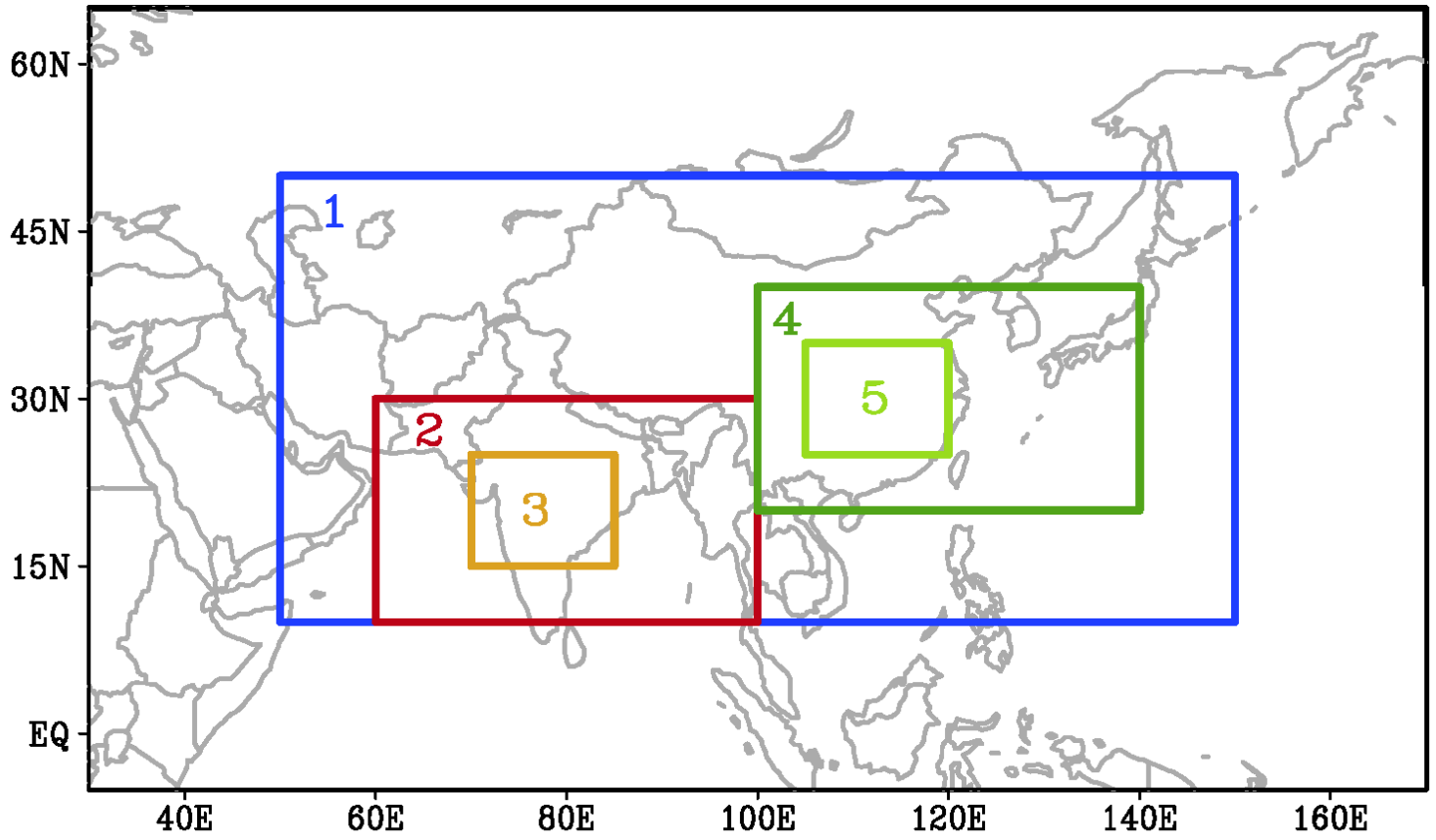

a: Mean patterns

B: Monsoon 2020

C: Diff (b-a)

Compute Pattern Correlations between Jun-Sep Rainfall and preceding May-Jun AOD Anomalies (Lower Panels) Over 5-Regions

# Regions over which Anomaly Correlation Coefficients Computed: 1. Asian domain; 2. South Asia; 3. West-Central India; 4. East Asia; 5. Yangzte River Valley



Pattern Correlations between anomaly (climatological mean removed) rainfall pattern and anomaly AOD pattern based on
CRU rainfall data (land only; resolution 0.5°x0.5° lat / long) and
GPCP data (land and ocean; resolution 2.5°x2.5° lat / lon) over 5 regions.
ACC: Anomaly Correlation Coefficient.

| Region | | CRU | | GPCP | |
|---|---|---|---|---|---|
| | | ACC | No. of grids | ACC | No. of grids |
| 1 | Asian domain (10-50N, 50-150E) | -0.41 | 10103 | -0.33 | 640 |
| 2 | South Asia (10-30N, 60-100E) | -0.34 | 1865 | -0.27 | 128 |
| 3 | West Central India (15-25N, 70-85E) | -0.58 | 502 | -0.57 | 24 |
| 4 | East Asia (20-40N, 100-140E) | -0.57 | 1851 | -0.56 | 128 |
| 5 | Yangzte River Valley (25-35N, 105-120E) | -0.82 | 599 | -0.88 | 24 |

**YRV 0.85x0.85x100 ~ 72% ; WCI 0.58x0.58x100 ~34%**

# Partial Correlations removing effect of Surface Temperature

**Table 1** Pattern correlation coefficient of anomalous (climatological mean removed) rainfall pattern (Fig. 1c) with AOD (Fig. 7c) and surface temperature (Fig. 8c) patterns, for land points over 5 different regions over the Asian domain (see Fig. 9)

| | | ACC: Rainfall and AOD | ACC: Rainfall and Surface temperature | No. of grids |
|---|---|---|---|---|
| 1 | Asian domain (10–50N, 50–150E) | −0.41 (−0.40) | 0.09 (0.01) | 10,103 |
| 2 | South Asia (10–30N, 60–100E) | −0.34 (−0.34) | 0.07 (0.09) | 1865 |
| 3 | West-Central India (15–25N, 70–85E) | −0.58 (−0.58) | 0.37 (0.38) | 302 |
| 4 | East Asia (20–40N, 100–140E) | −0.57 (−0.54) | 0.27 (−0.18) | 1851 |
| 5 | Yangzte River Valley (25–35N, 105–120E) | −0.82 (−0.58) | 0.72 (0.02) | 599 |

*ACC* Anomaly Correlation Coefficient

Pattern correlation coefficient of rainfall and AOD (surface temperature) after removing the effect of surface temperature (AOD) are given in brackets

Number of grids i.e. no of values used to compute the correlation coefficients

# COVID-19 REGULATIONS: IMPACT ON MONSOON 2020:

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## Erratic Asian summer monsoon 2020: COVID-19 lockdown initiatives possible cause for these episodes?

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