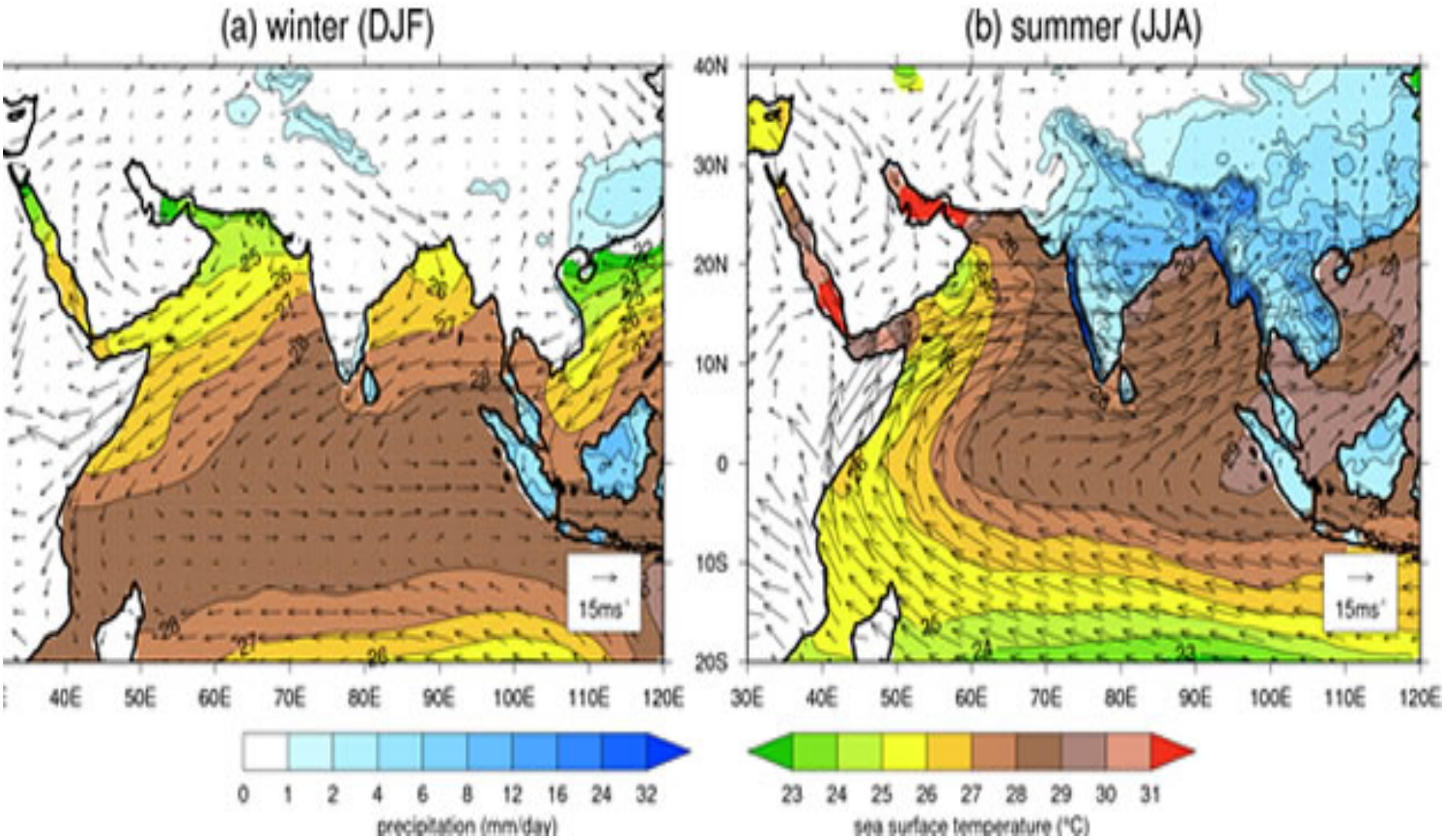
TPE-GHP/GEWEX Joint Workshop

Long-term Changes in South Asian Monsoon

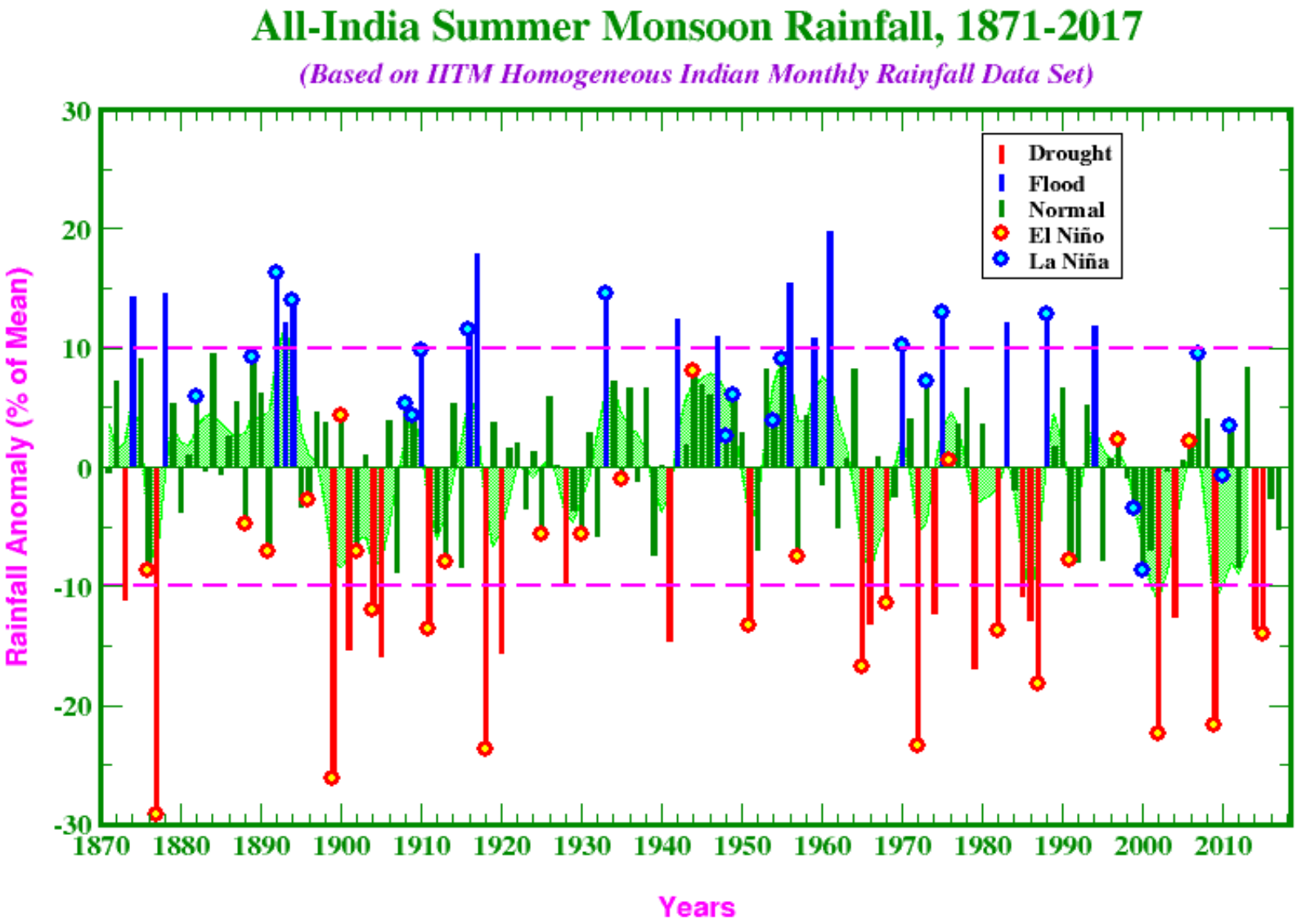
Madan Lall Shrestha
Academician
Nepal Academy of Science and technology

Hotel Himalaya, Lalitpur
Nepal
17-19 October 2017

Schematic diagram of boreal winter (December-February; left) and summer (June-August; right) daily mean precipitation, sea surface temperature (SST) and winds.

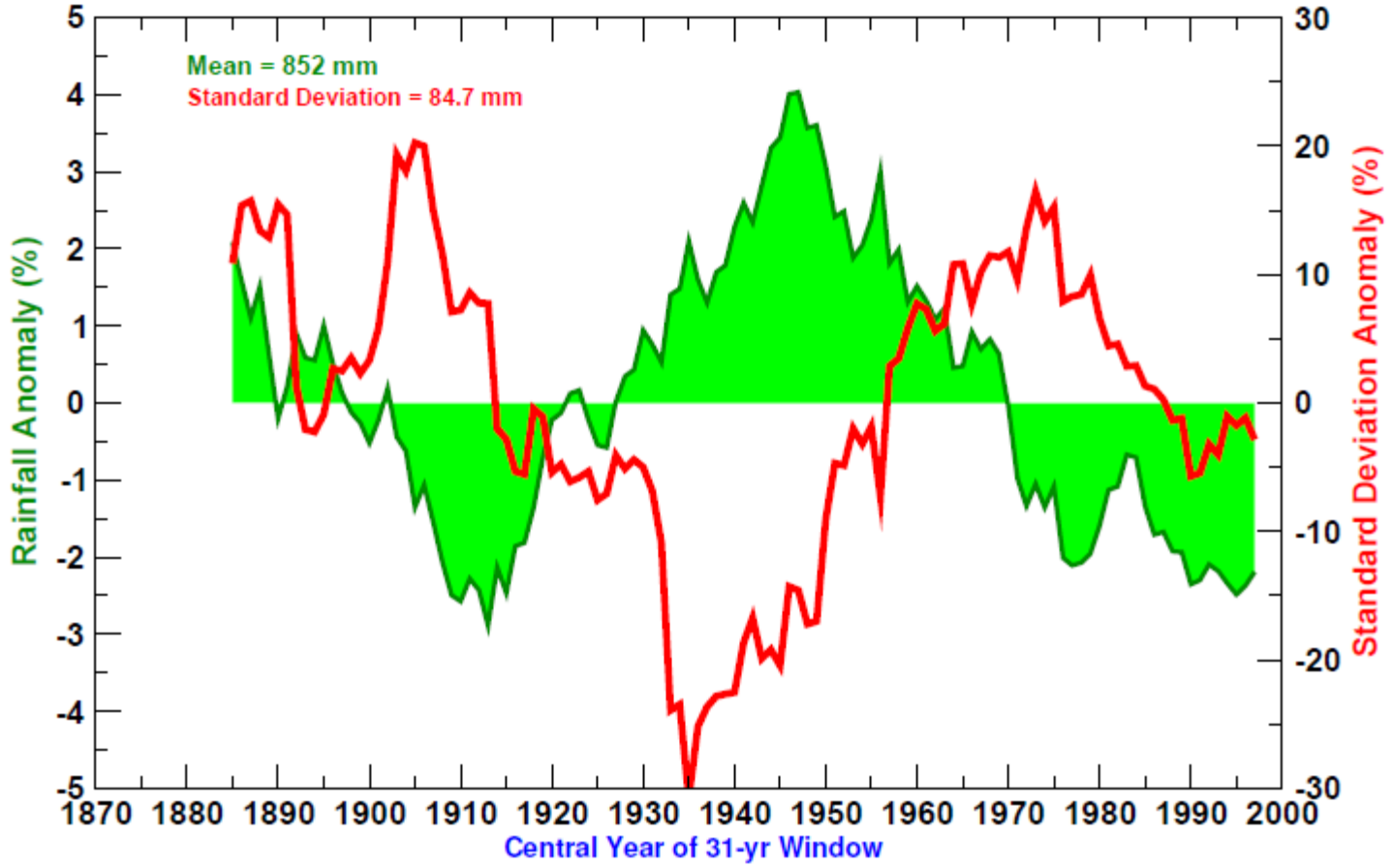


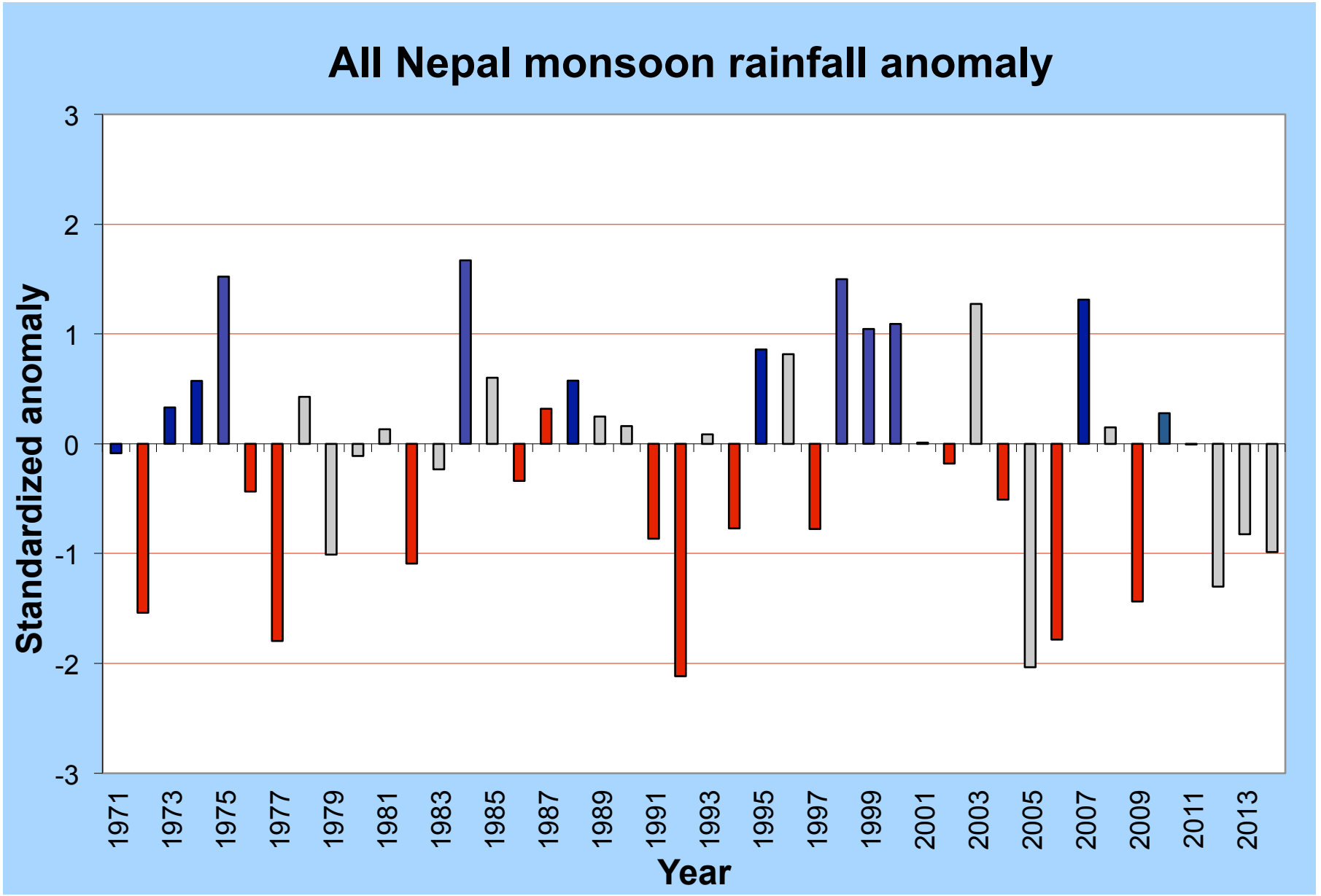
Turner, A. G. and H. Annamalai (2012)

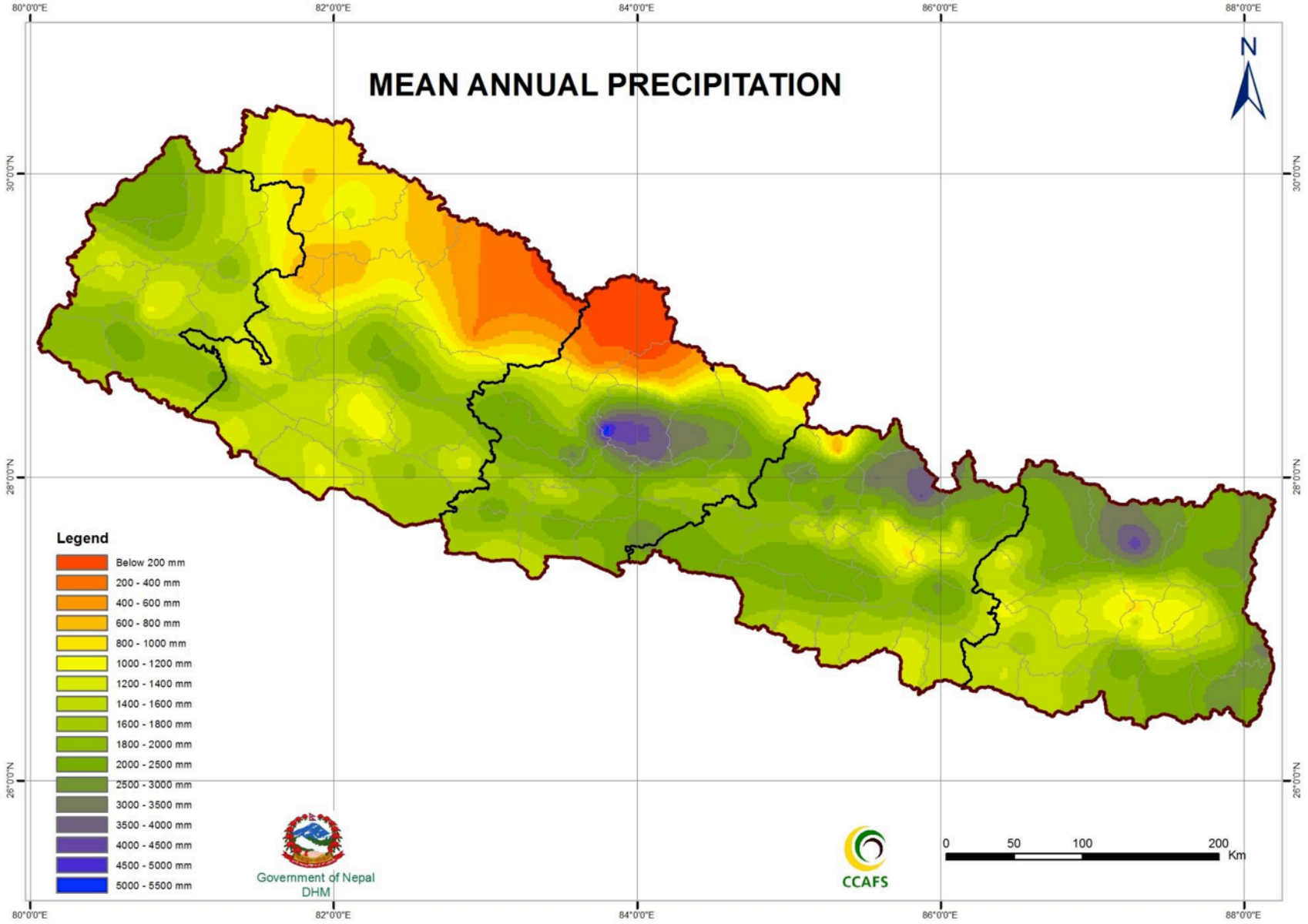

All-India Summer Monsoon Rainfall, 1871-2017
(Based on IITM Homogeneous Indian Monthly Rainfall Data Set)
Drought
Flood
Normal
El Niño
La Niña
Rainfall Anomaly (% of Mean)
30
20
10
0
-10
-20
-30
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Years

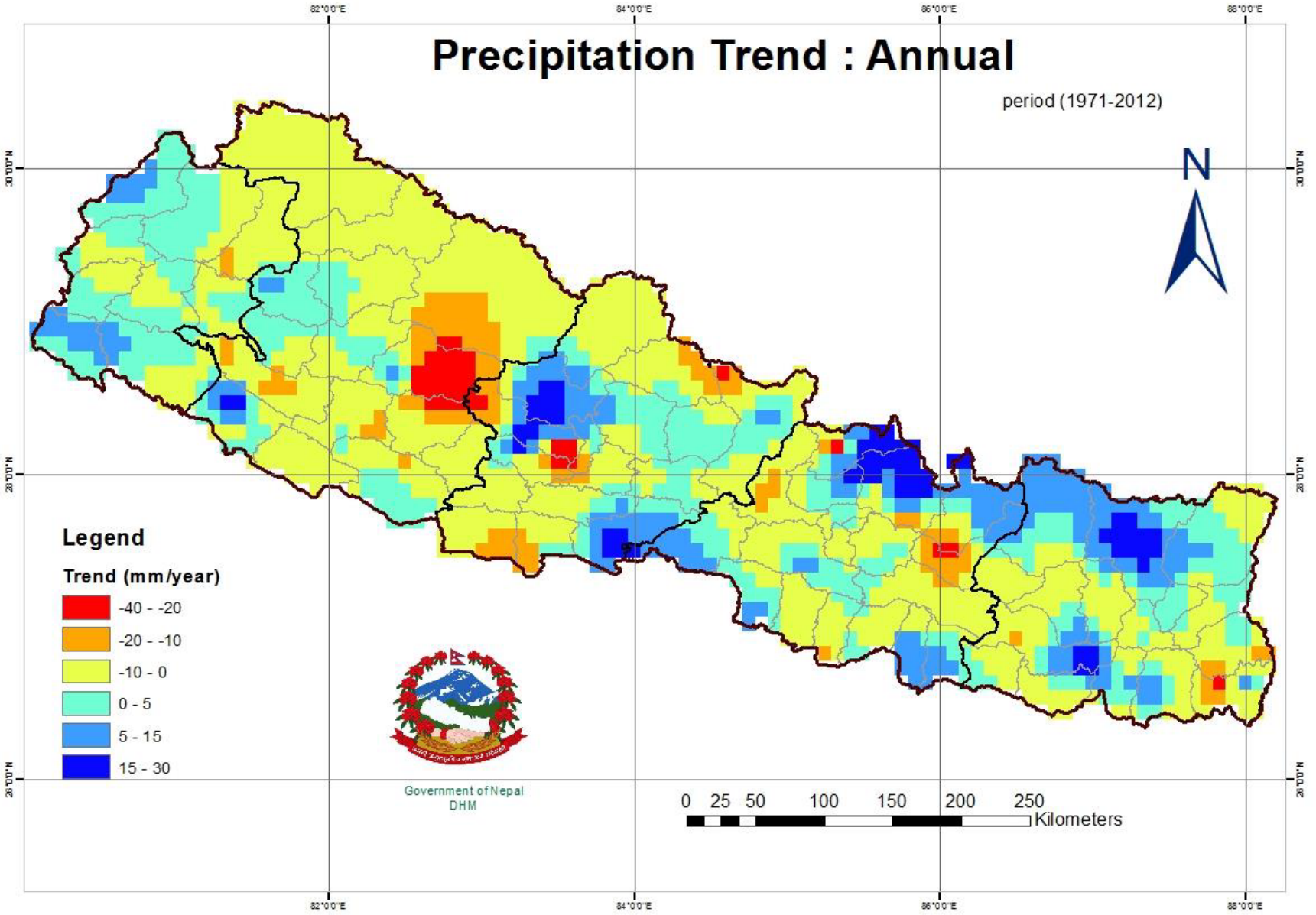
(Source:IITM)

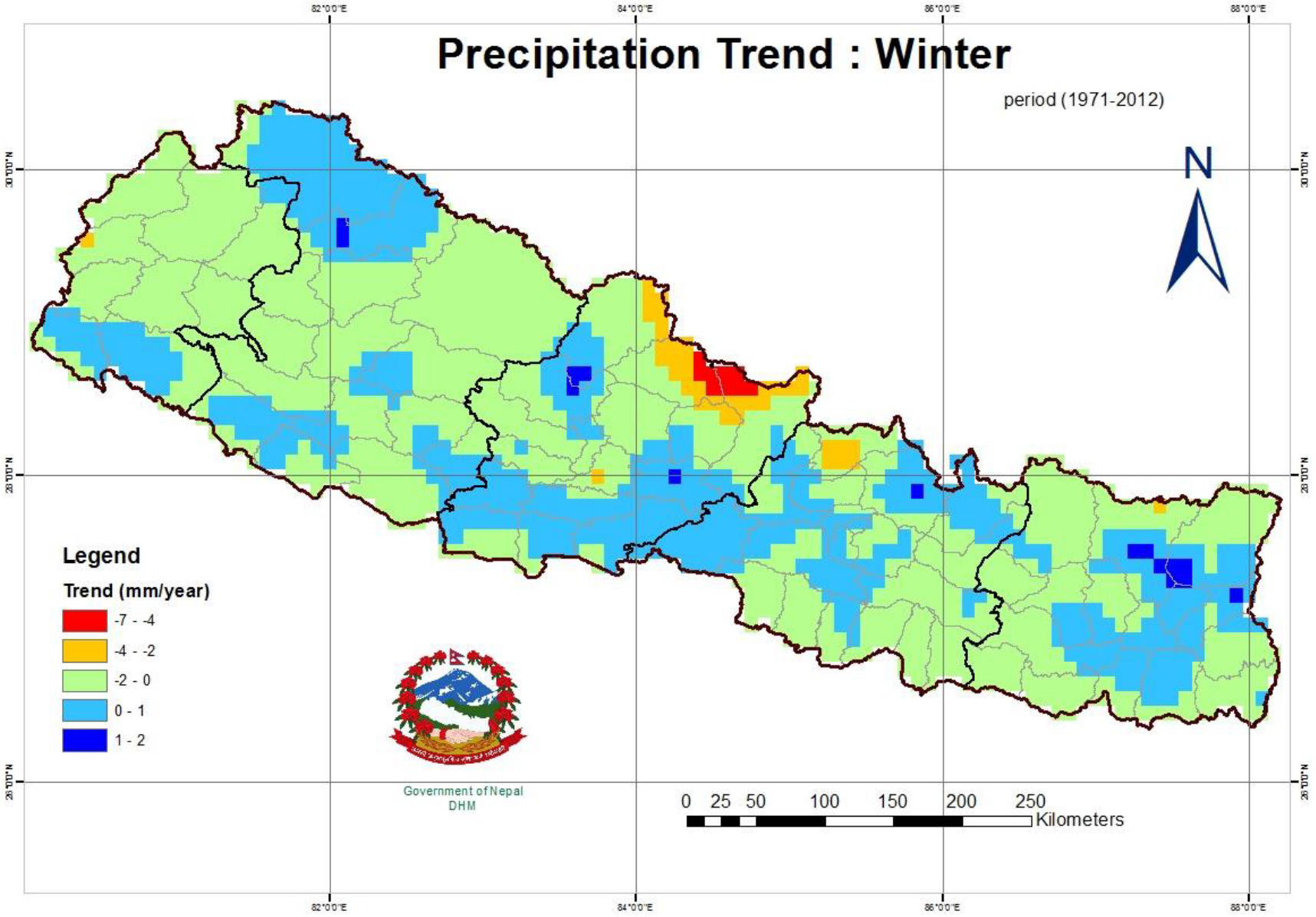
Epochal Patterns of All-India Summer Monsoon Rainfall

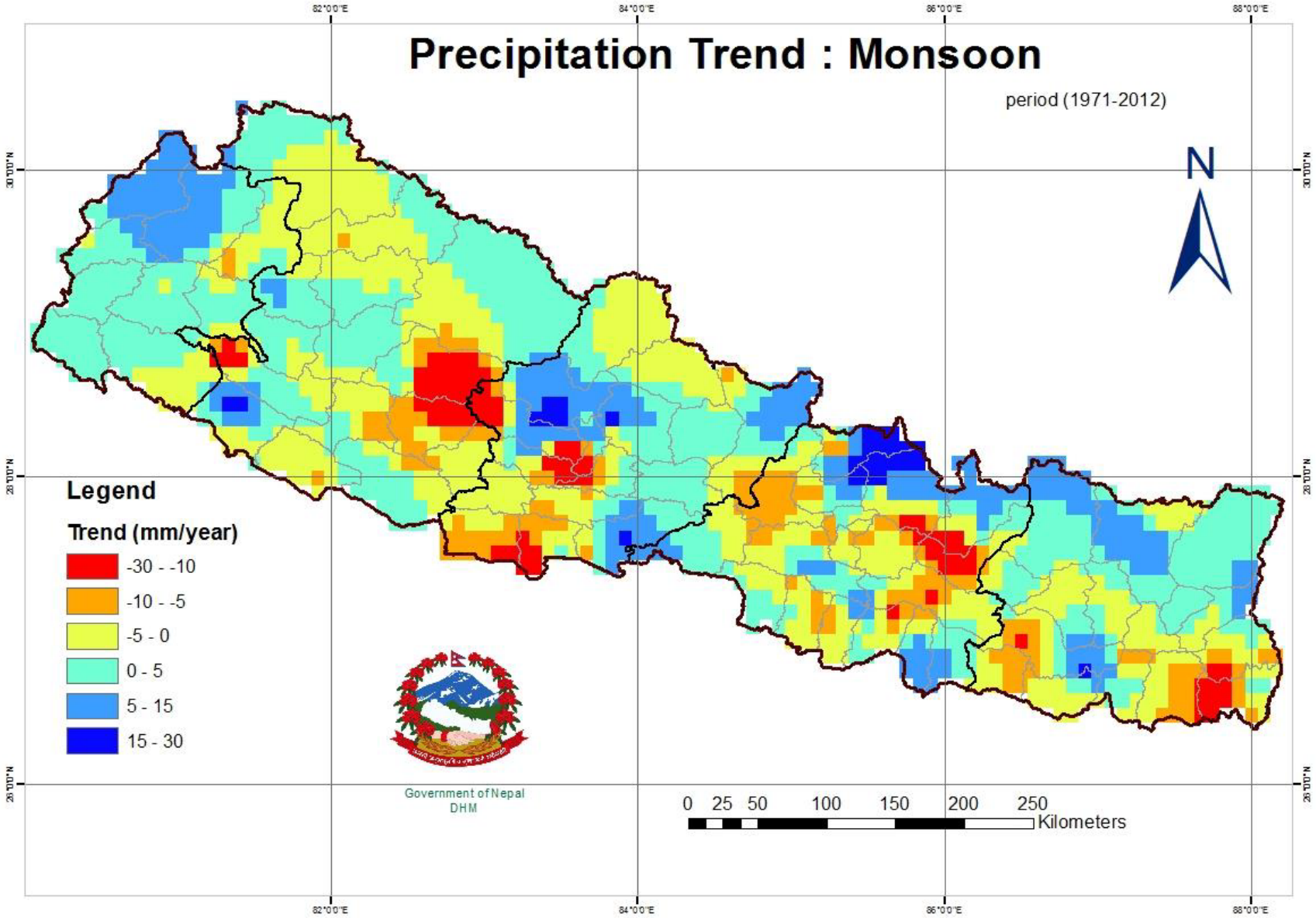


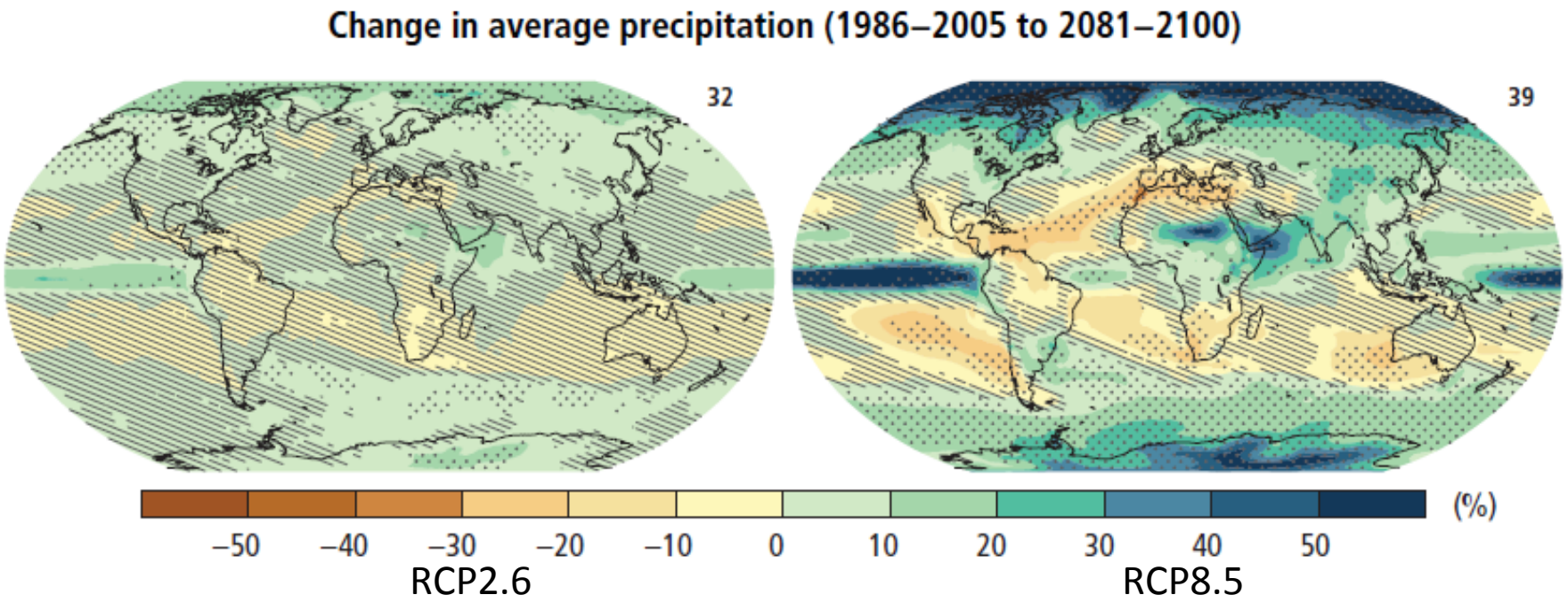

All Nepal monsoon rainfall anomaly
Standardized anomaly
3
2
1
0
-1
-2
-3
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Year


MEAN ANNUAL PRECIPITATION
N
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N
Legend
Below 200 mm
200 - 400 mm
400 - 600 mm
600 - 800 mm
800 - 1000 mm
1000 - 1200 mm
1200 - 1400 mm
1400 - 1600 mm
1600 - 1800 mm
1800 - 2000 mm
2000 - 2500 mm
2500 - 3000 mm
3000 - 3500 mm
3500 - 4000 mm
4000 - 4500 mm
4500 - 5000 mm
5000 - 5500 mm
Government of Nepal
DHM
CCAFS
0
50
100
200
Km

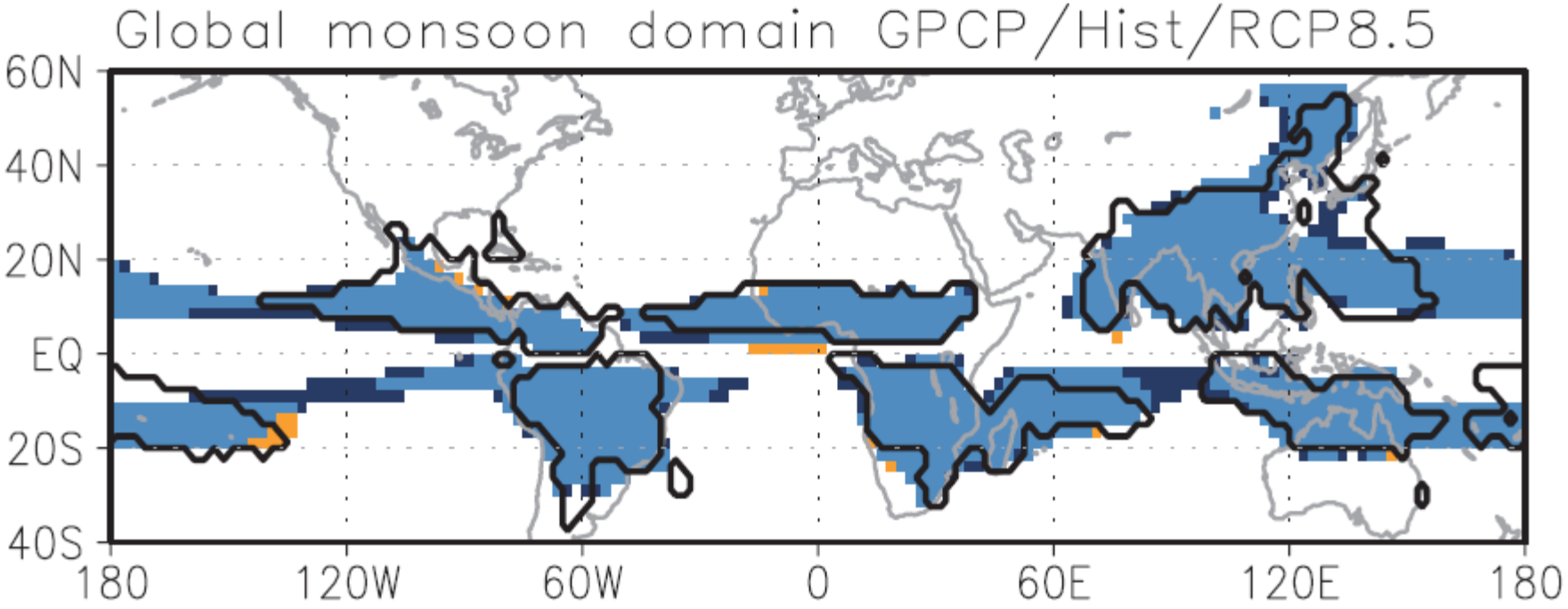

Precipitation Trend : Annual
period (1971-2012)
N
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N
Legend
Trend (mm/year)
-40 - -20
-20 - -10
-10 - 0
0 - 5
5 - 15
15 - 30
Government of Nepal
DHM
0 25 50 100 150 200 250
Kilometers


Precipitation Trend : Winter
period (1971-2012)
N
Legend
Trend (mm/year)
-7 - -4
-4 - -2
-2 - 0
0 - 1
1 - 2
Government of Nepal
DHM
0 25 50 100 150 200 250
Kilometers
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N


Precipitation Trend : Monsoon
period (1971-2012)
N
Legend
Trend (mm/year)
-30 - -10
-10 - -5
-5 - 0
0 - 5
5 - 15
15 - 30
Government of Nepal
DHM
0 25 50 100 150 200 250
Kilometers
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N



Source: IPCC 2014



Observed (thick contour) and simulated (shading) global monsoon domain (Wang et al, 2011). [26 CMIP5 multi-model mean precipitation in the present day (1986–2005) and the future (2080–2099; RCP8.5 scenario)].

Climate models and Global Monsoon

- **There is growing evidence of improved skill of climate models in reproducing climatological features of the global monsoon.**
- **The global monsoon, aggregated over all monsoon systems, is likely to strengthen in the 21st century with increases in its area and intensity, while the monsoon circulation weakens.**
- **Monsoon onset dates are likely to become earlier or not to change much and monsoon retreat dates are likely to delay, resulting in lengthening of the monsoon season in many regions.**

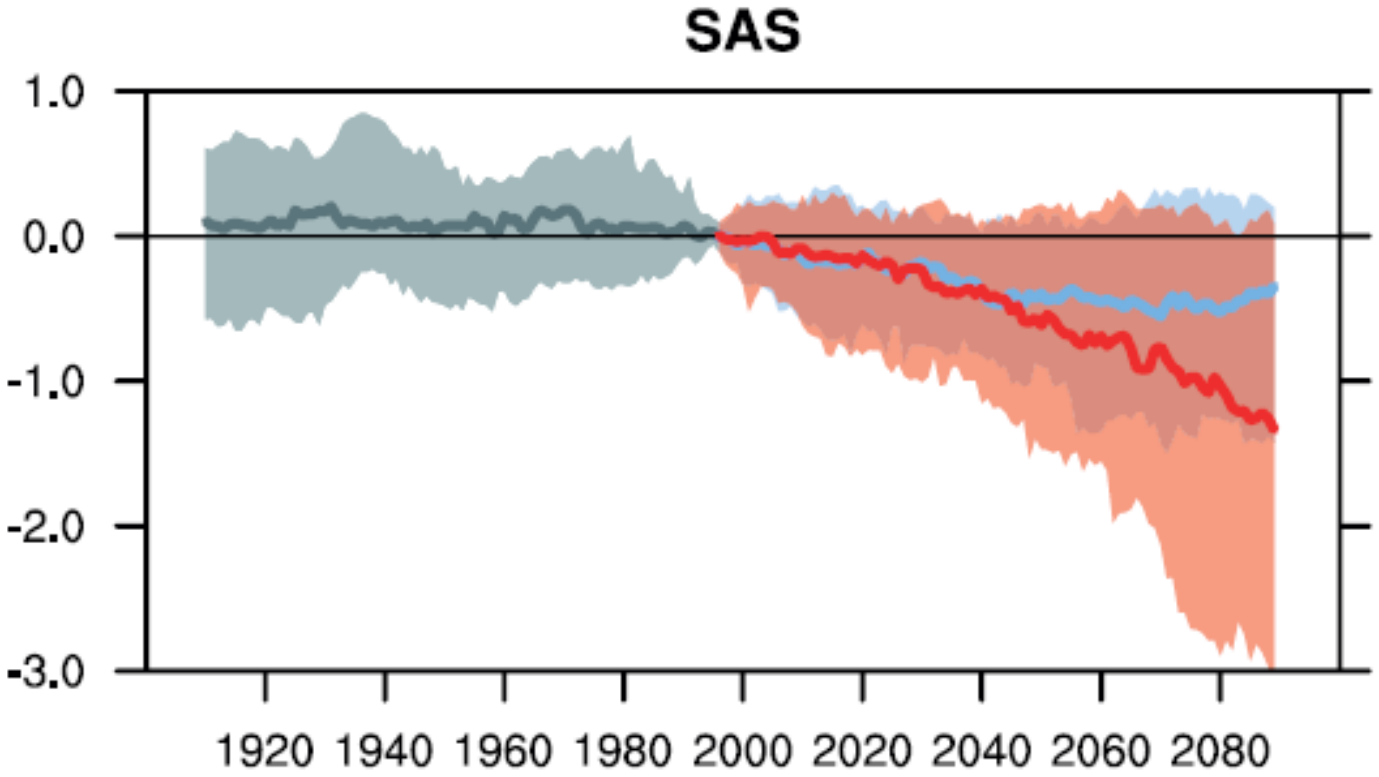
Regional: South Asian Monsoon

- Model skill in representing regional monsoons is lower compared to the global monsoon and varies across different monsoon systems.
- There is medium confidence that the Indian summer monsoon circulation will weaken, but this is compensated by increased atmospheric moisture content, leading to more precipitation.
- The realism of the representation of El Niño-Southern Oscillation (ENSO) in climate models is increasing and models simulate ongoing ENSO variability in the future. Therefore there is high confidence that ENSO very likely remains as the dominant mode of interannual variability in the future and due to increased moisture availability, the associated precipitation variability on regional scales likely intensifies.

IPCC 2014

- There is low confidence in projections of future changes in the Madden–Julian Oscillation owing to poor ability of the models to simulate it and its sensitivity to ocean warming patterns.

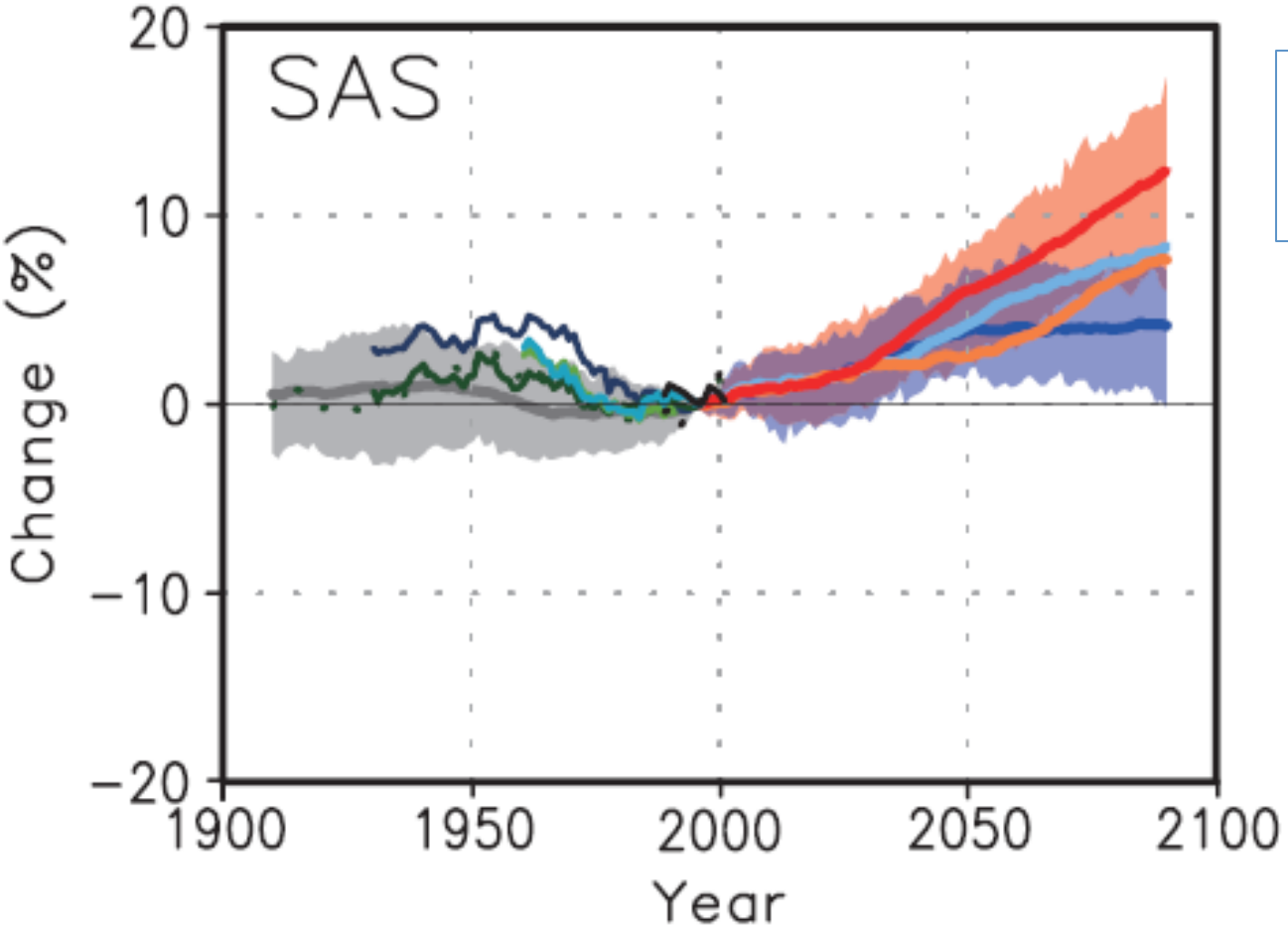
Strength of Monsoon circulation



Time series of summer monsoon index relative to the base period average (1986–2005) over South Asia (defined as meridional differences of the JJA 850 hPa zonal winds averaged over 5°N to 15°N, 40°E to 80°E and 20°N to 30°N, 60°E to 90°E)

RCP4.5 light blue
RCP8.5 red

IPCC 2014



RCP2.6 - dark blue (24)
RCP4.5 – light blue (34)
RCP6.0 – orange (20)
RCP8.5 – red (32)

Changes in precipitation indices over the regional land monsoon domains of Southern Asia Time series of observed and model-simulated summer precipitation anomalies (%) relative to the present-day average

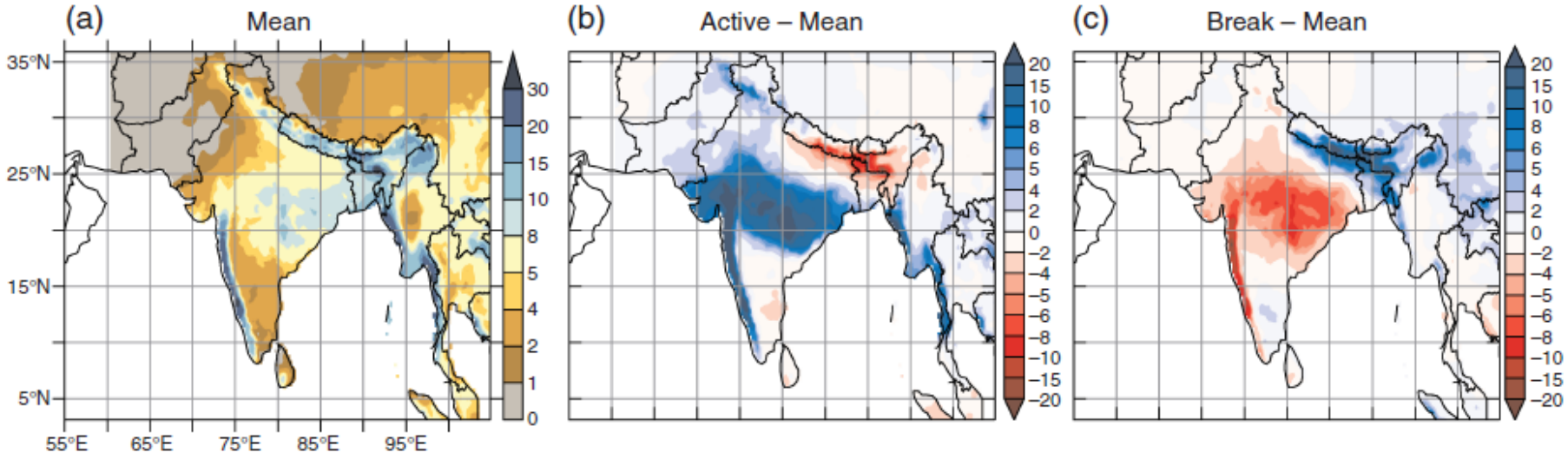
IPCC 2014

- The South Asian monsoon is remarkably stable as a whole with interannual variation of only around 10% in most cases and influence various sectors like agricultural production and the stocks and commodities market, so a 5-10% change on top could have significant impacts. (Turner 2012)

- The flood and droughts are common phenomena and tendency to be more frequent.

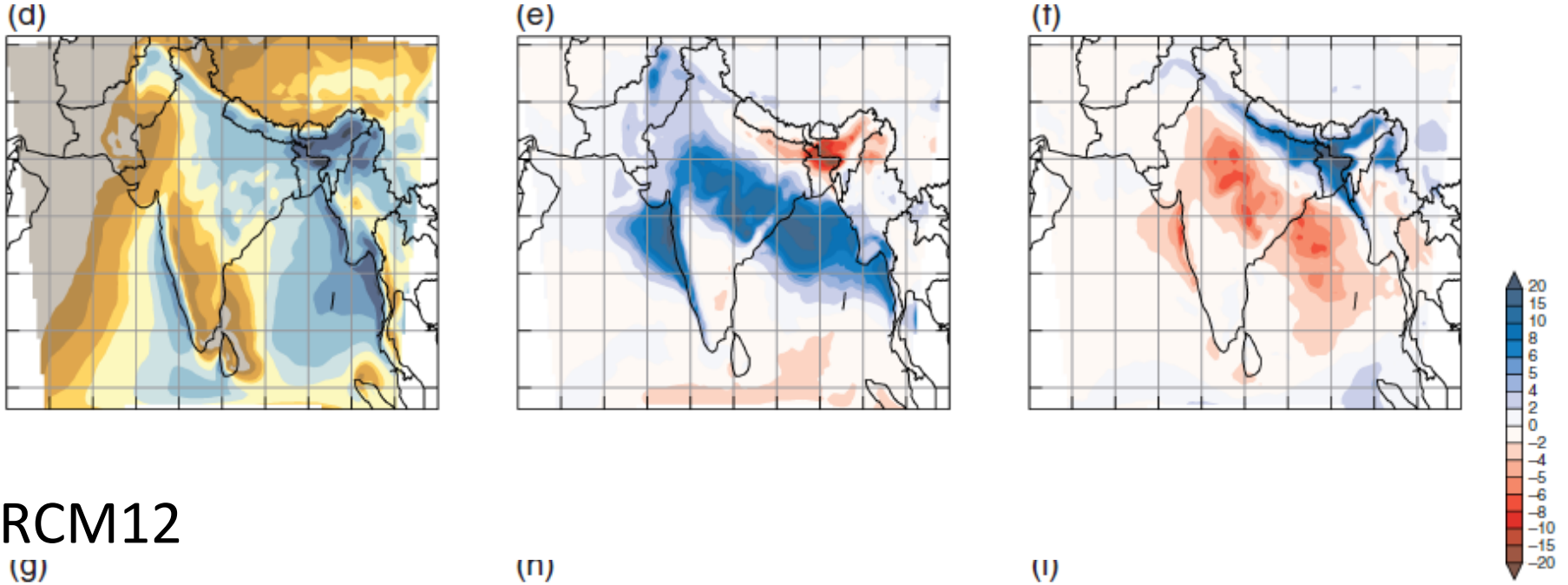
- In 2002 for example in India, a break in the monsoon rains saw July receiving only about 50% of its normal rainfall, leading to cuts in agricultural output and declining GDP. Thinking about climate change in the context of how these extreme events will change can help farmers and other end users to understand its implications.

Intraseasonal changes in South Asian Monsoon

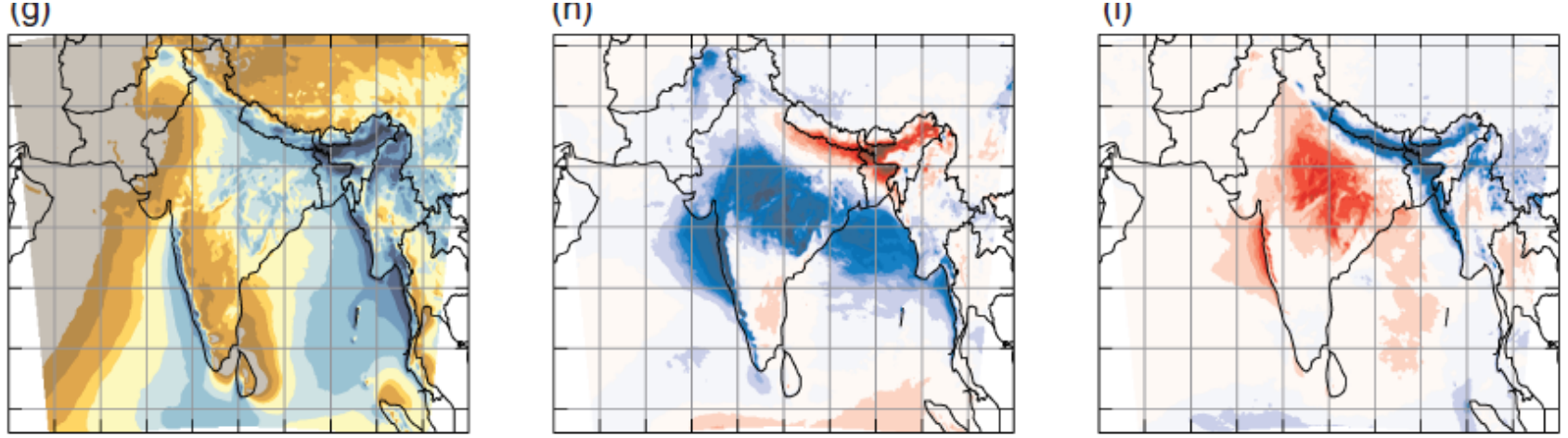


Monsoon mean precipitation, and composite anomalies for (b) active and (c) break phases in APHRODITE . Unit: mmday−1 (Karmacharya et al, 2017)

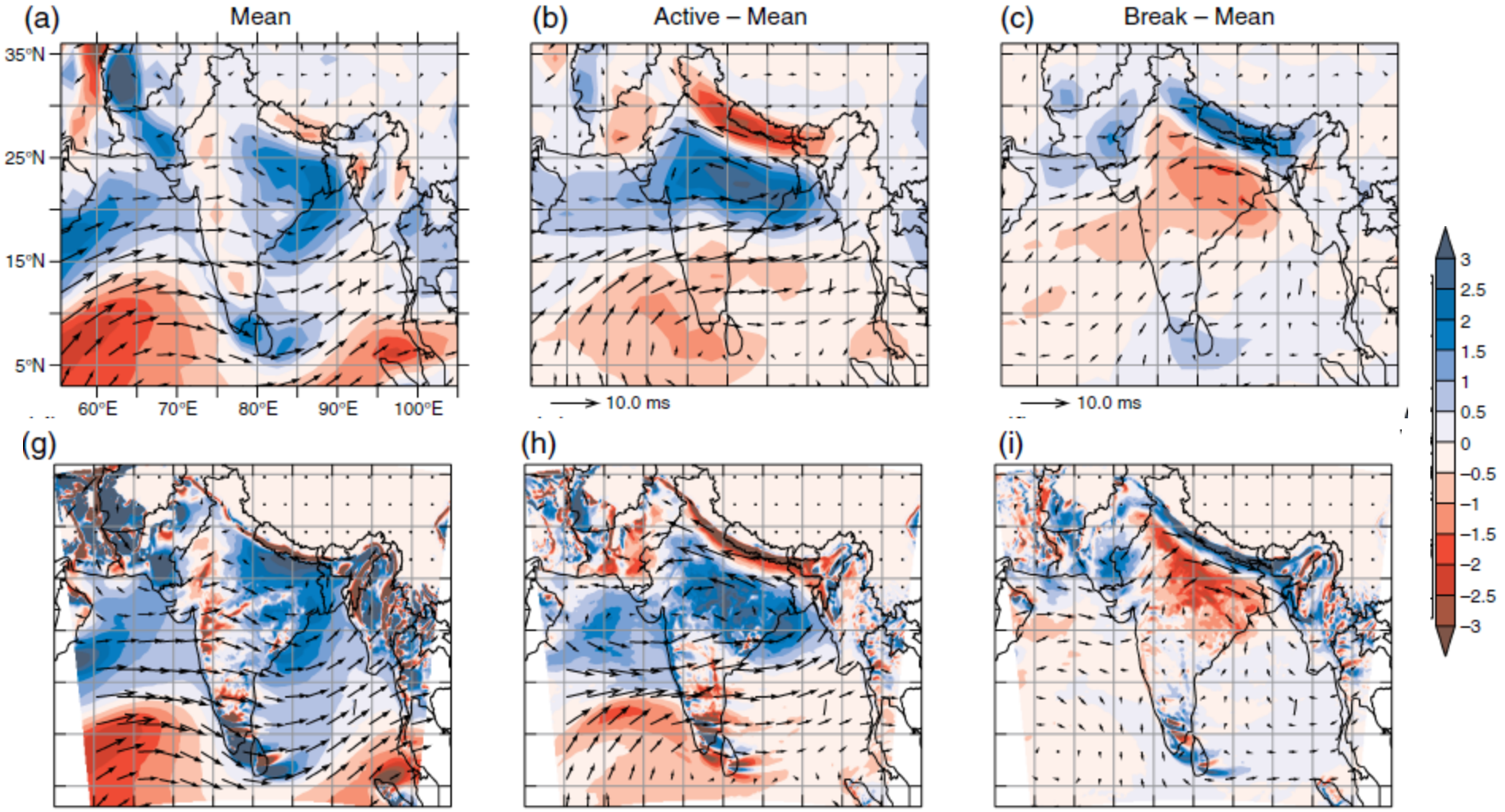
RCM50



RCM12

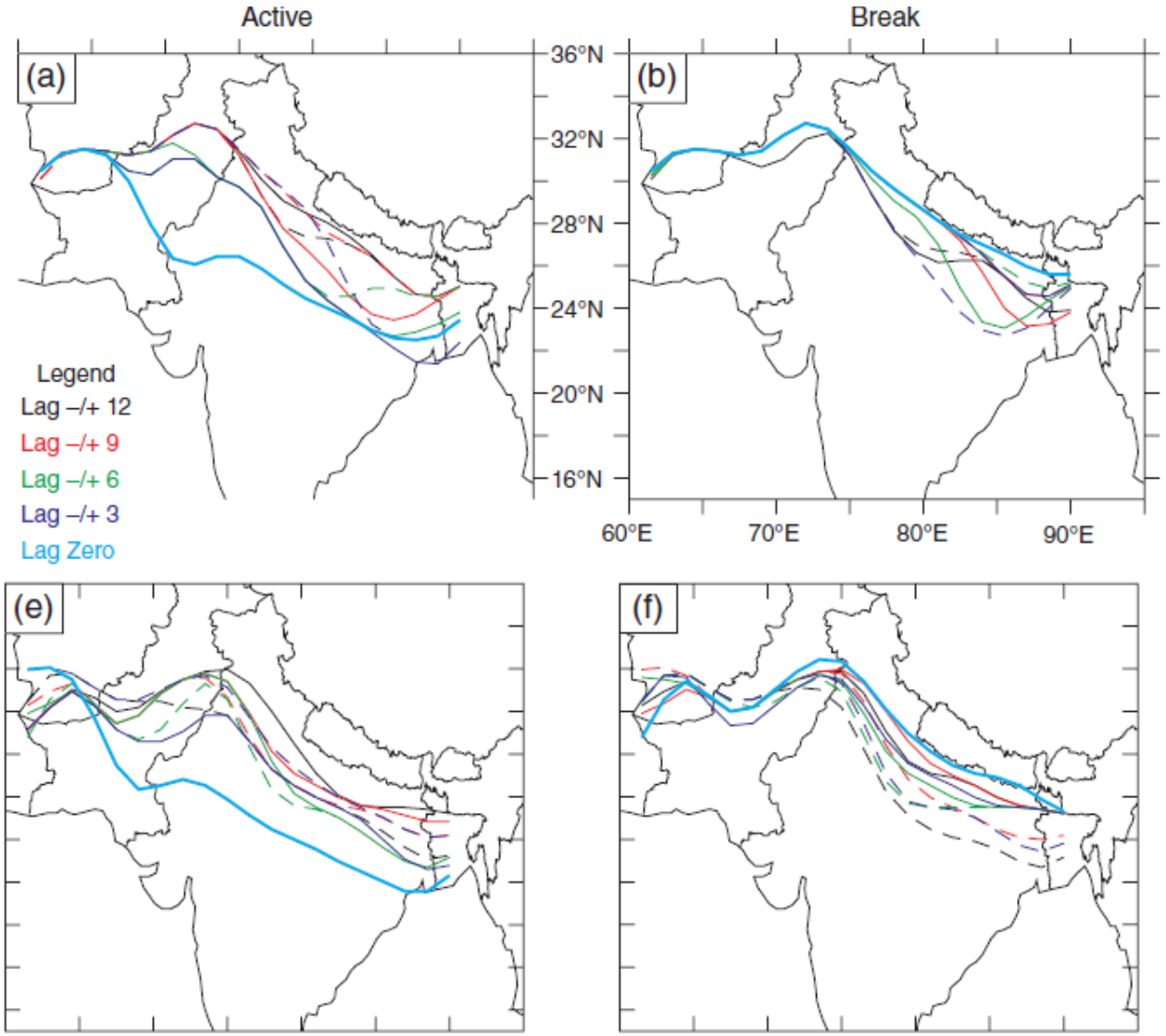


(Karmacharya et al, 2017)



RCM12

Lower level (850 hPa) monsoon mean circulation (wind vector) and vertical component of relative vorticity (shaded), and composite anomalies for (b) active and (c) break phases in ERAI. (Karmacharya et al, 2017)



RCM12

Lagged monsoon trough position at 850 hpa for (a) active and (b) break composites in ERAI.

Conclusion

- There are large interannual variation in long-term precipitation record over South Asia. Significant correlation with ENSO.
- Though the monsoon circulation is getting weaker, there is an strong indication that the precipitation is going to increase.
- Model have been able to capture the intraseasonal changes characteristics.
- The gridded data such as APHRODITE data sets are useful. However, there is also a need to validate and develop a better one.
- There are discrepancies in resolution of the same set of data within the region, which needs to overcome to use effectively in the research.

Conclusion (contd.)

- There is always a huge task to fill up the data sparse region. Need to establish adequate stations in the mountainous region (Himalayan region), which are necessary in validating the model results. Need to explore mechanism to have a good station network.
- Need for a consolidated information (data) platform for further research activities in the region.