Signatures of Tropical Recycling Ratio across Monsoon Hotspots

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Introduction

- Water cycle plays a crucial role in regulating natural variability of weather
- Understanding the consequences of changes in the water cycle and their effects on rainfall patterns is important.
- Recycling Ratio (RR) can be used to understand some of these changes
- RR highlights the relative contributions of local and distant sources of moisture
- RR can help uncover the underlying dynamics of local convective storms and larger atmospheric circulations ***[Eltahir et al. (1996)]***

Objectives & Methodology

Can recycling ratio describe:

- *ENSO Signals?*
- *Summer Monsoon Variations?*
- *Drought Signals?*

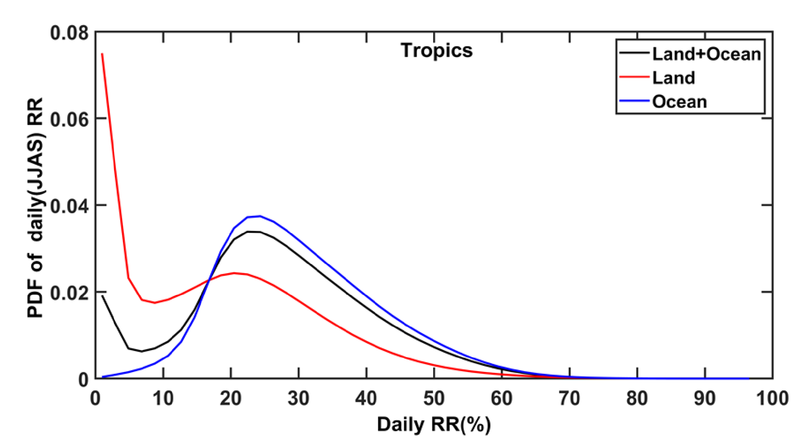

Fig.1: PDF of daily Recycling Ratio (JJAS) for tropics (25N- 25S) using ERA-20C data

- E = Total Evaporation
- L = Length Scale = **500 KM**
- $F_{in} = \frac{1}{g}\int_0^{P_s} q\boldsymbol{v}\,dp$

Recycling Ratio (RR) $= \frac{EL}{EL+2F_{in}} \times 100\%$

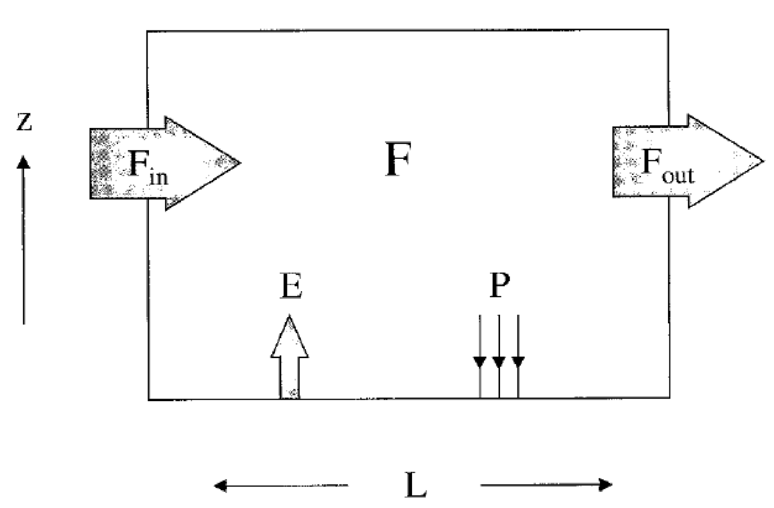

Fig.2: Schematic of the domain (Trenberth 1999)

Datasets

OBSERVATIONS

- **GPCP**: 1979–2010, monthly, 2.5° gridded rainfall
- **Indian Meteorological Department (IMD):**1900-2010, daily, 1° gridded rainfall

REANALYSIS

- **ERA-20C**: 1900-2010, **ERA5**: 1940-2022, daily, 1° gridded data
- **JRA55**: 1958-2010, daily, 1.25° gridded data

CLIMATE MODELS

- **CMIP6**: Historical (1850-2014), SSP5-8.5 (2015-2100), monthly gridded data

Seasonal Variability

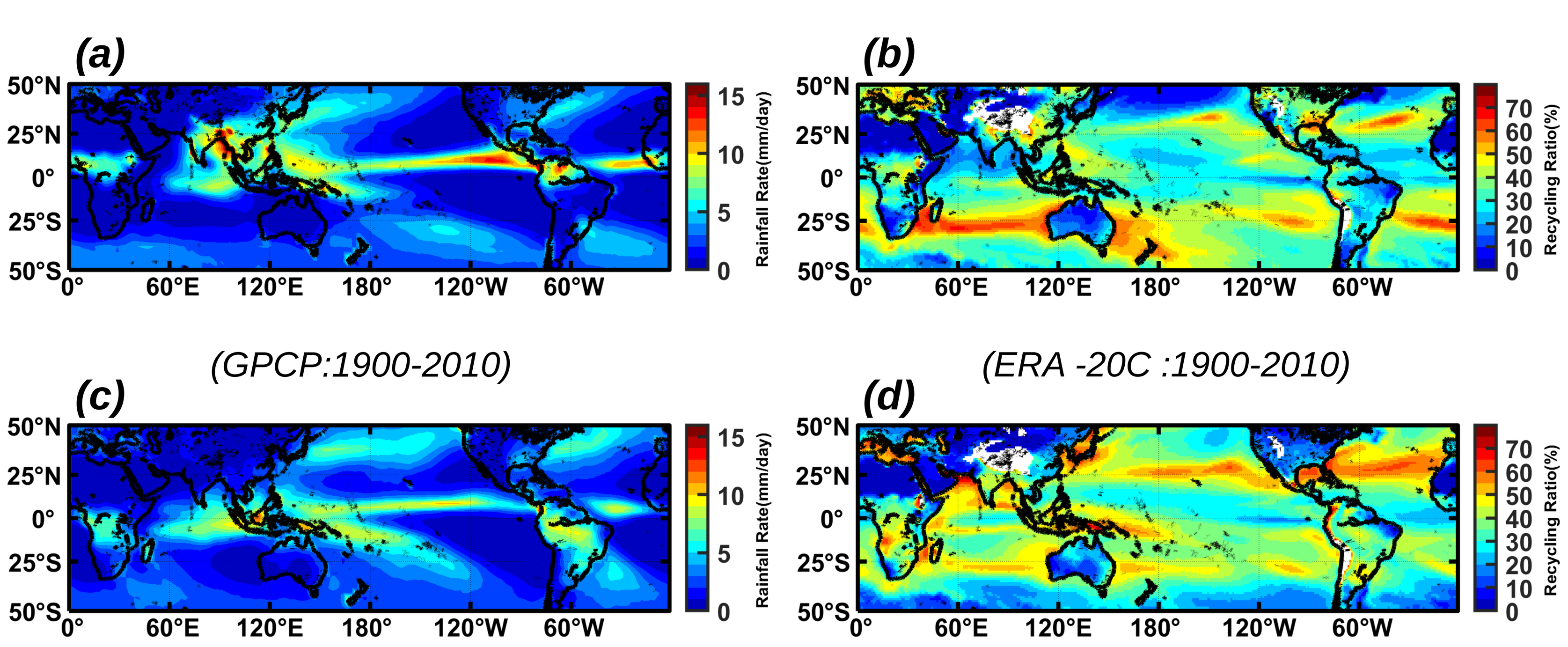

Fig.3: 1900-2010 Climatology of a) JJAS Rainfall, b) JJAS RR, c) OND Rainfall, d) OND RR

- Seasonal contrast in RR pattern over monsoon hotspots.
- Lower RR values over southwestern India during Indian monsoon (JJAS) ➔ dominance of advection over evaporation.

Sub-seasonal Signatures

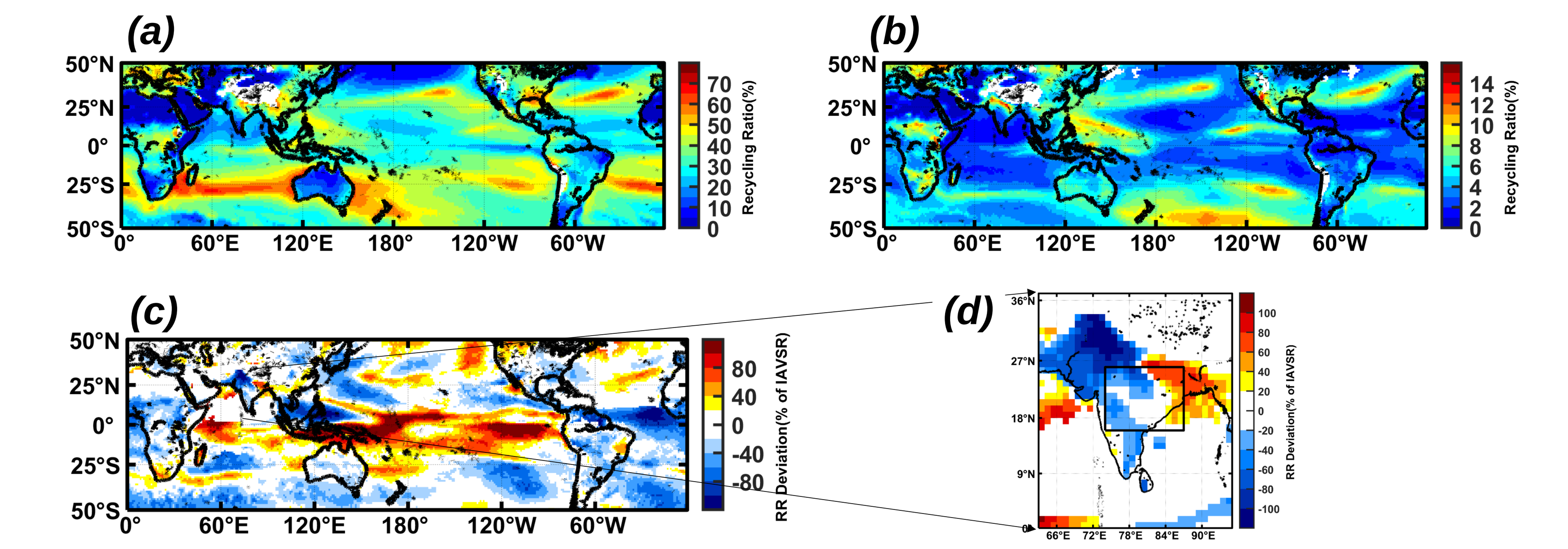

Fig.4: a) JJAS Climatology of RR (ERA-20C) for El Niño-Drought, b) Inter-annual variation of seasonal(JJAS) Recycling Ratio, c)Percentage Deviation [(EN + D)-climatology], d) Same as (c) but for Central India (CI)

- Sensitivity towards ENSO & drought signals

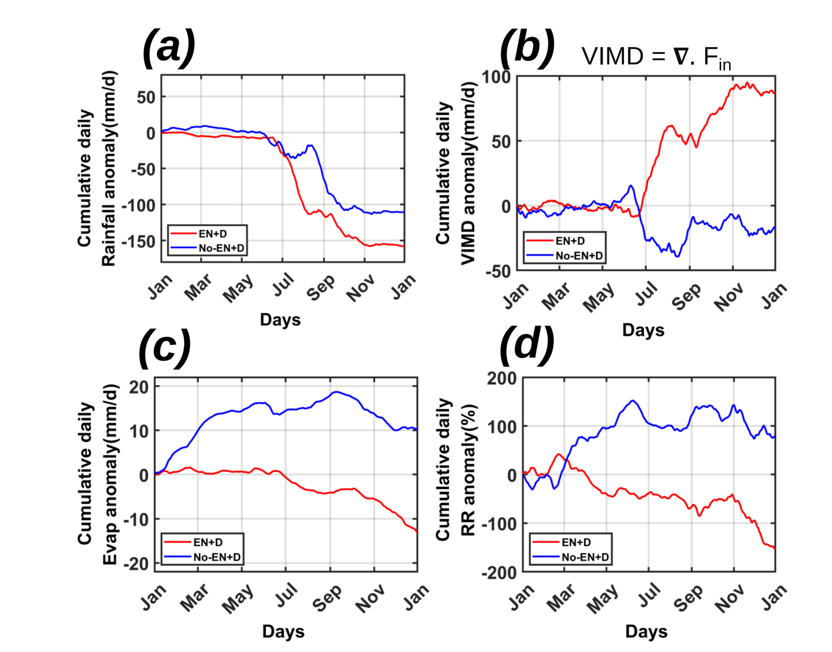

Fig.5: Cumulative anomaly series for Central India during 1900-2010 for a)Rainfall (IMD), b) VIMD, c)Evaporation, d) Recycling Ratio (ERA-20C)

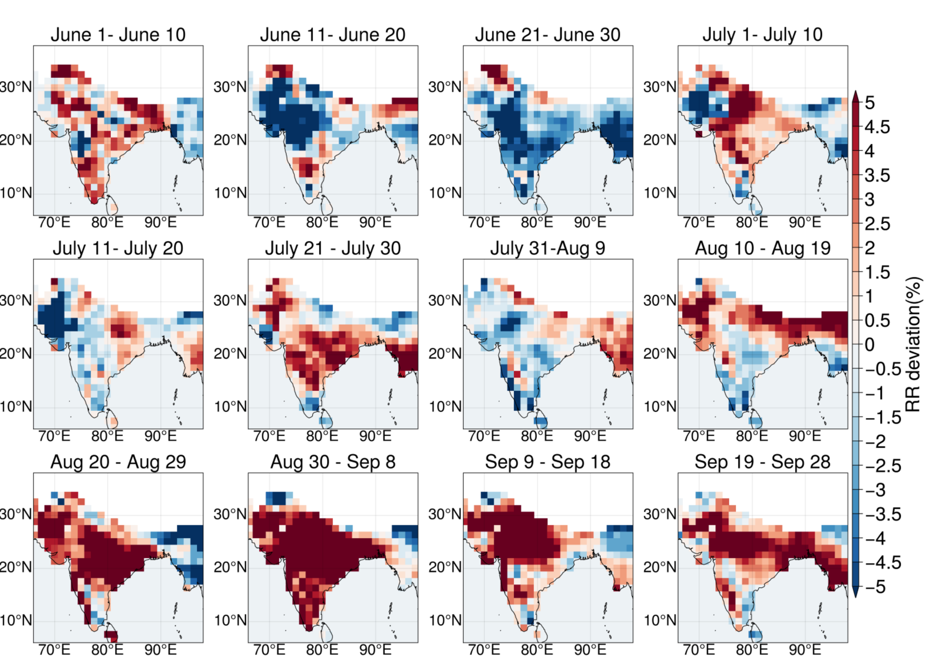

Fig.6: Ten-Daily RR anomalies for No El Niño-Drought (JRA55) during 1958-2010

- Sub-seasonal rainfall deficit & increased RR in Central India (mid-August - early September) for No El Niño-Droughts ➔ shortage of moisture flux.

Trends & Future Projections in Tropics

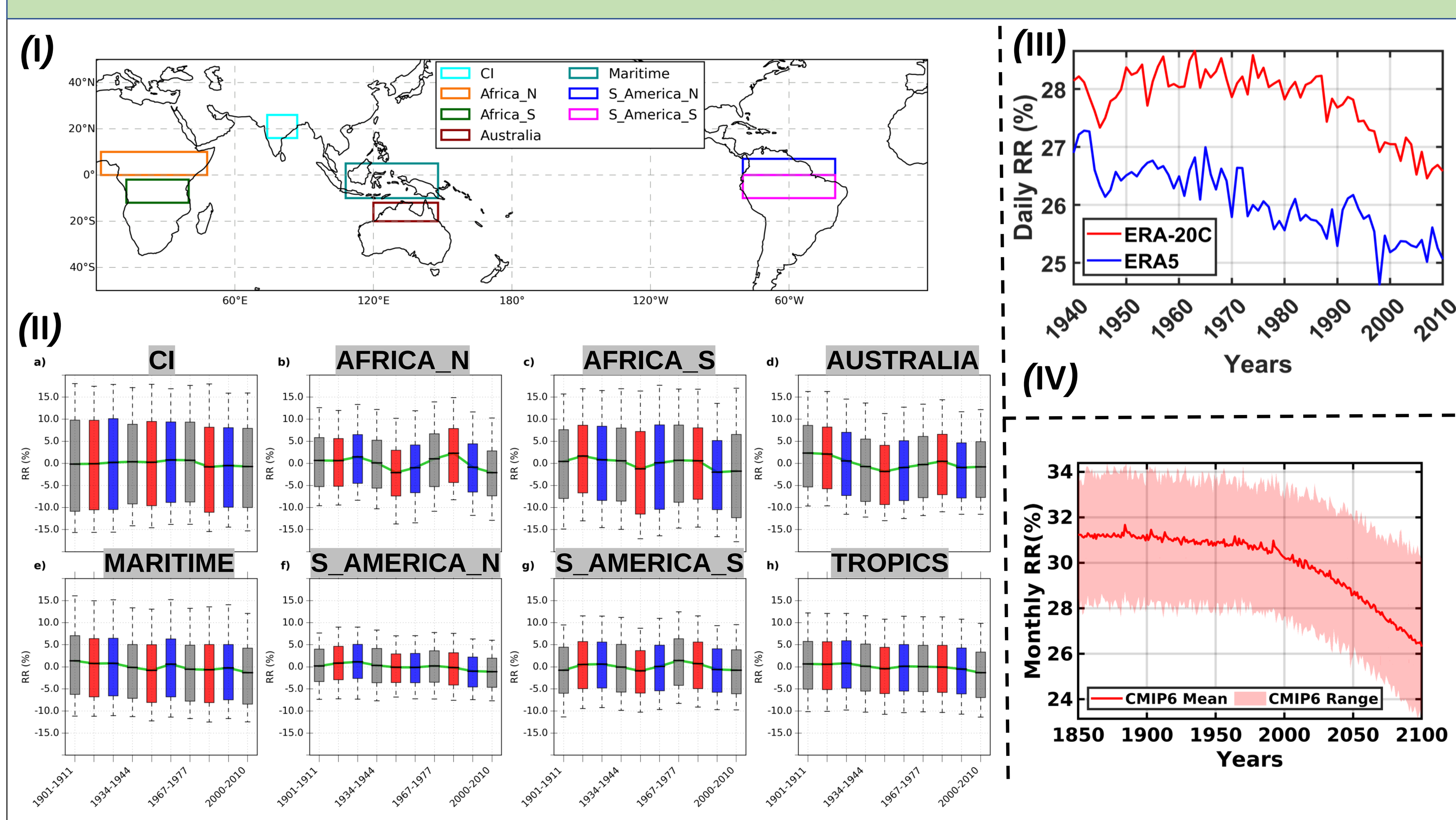

Fig.7: I) Monsoon Hotspots (MH), II) 11 Yearly RR deviations from 1901-2010 climatology for MH, III) Annual time series of RR for tropics (30S-30N) using ERA-20C and ERA5 IV) Annual time series of RR for tropics using Historical (1850-2014) and SSP5-8.5 (2015-2100) scenarios from 11 CMIP6 model outputs

- Declining trend in yearly RR time-series implies disruption of pre-existing equilibrium under warming.

Summary

- ✓ Seasonal and sub-seasonal variations of advective and evaporative components of rainfall are well explained by the recycling ratio **[Fig. 3, 5]**
- ✓ Sensitivity towards El-Niño signals and drought signals **[Fig. 4]**
- ✓ Dominance of advective moisture flux over evaporation under warming **[Fig. 7]**

References

1) Eltahir, E. A., & Bras, R. L. (1996). Precipitation recycling. Reviews of geophysics, 34(3), 367-378.
2) Trenberth, K. E. (1999). Atmospheric moisture recycling: Role of advection and local evaporation. Journal of Climate, 12(5), 1368-1381.
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