Exploring source of high predictability of monthly-mean rainfall during Indian Summer Monsoon

Ankur Gupta

National Center for Medium Range Weather Forecasting

Multiweek Hindcasts

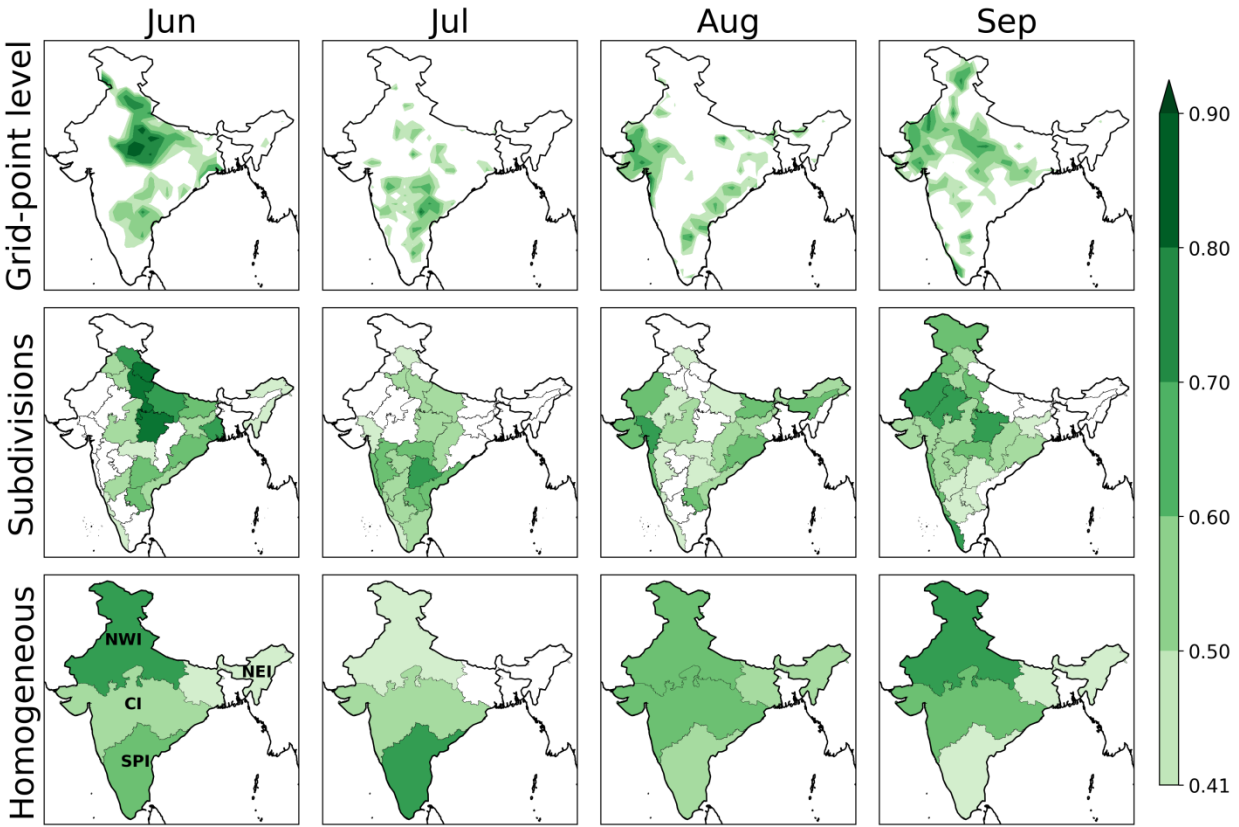
- Coupled Model Runs with 60 km (NCUM) and 25 km (NEMO)
- Initialized on 1st, 9th, 17th & 25th of each month for 23 years (1993-2015)
- ERA-Interim atmosphere and Glosea5-GC2 ocean-seaice reanalysis

Gera, A., Gupta, A., Mitra, A. K., Rao D, N., Momin, I. M., Rajeeavan, M. N., ... & Lea, D. (2022**). Skill of the extended range prediction** (NERP) for Indian summer monsoon rainfall with NCMRWF global coupled modelling system. Quarterly Journal of the Royal Meteorological Society, 148(742), 480-498.

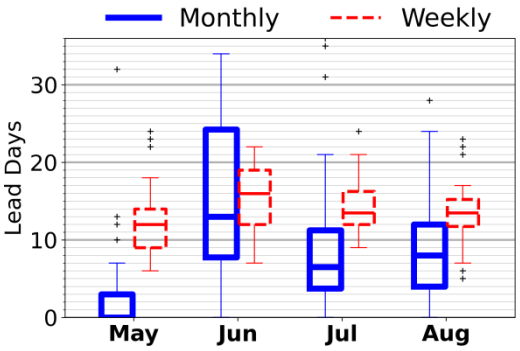
Predictability

- **Low ISMR skill**: Low boundary-forced predictability (Kang and Shukla, 2006; Kumar et al. 2011); misrepresentation of teleconnections (Gadgil, 2012)
- **High spatial heterogeneity** of seasonal mean rainfall anomalies; regional information needed for effective decision making (Webster and Hoyos, 2004). Alternative temporal and spatial scales must be explored (Xavier and Goswami, 2007)
- **Subseasonal forecasts: weekly-mean rainfall is skillful at 7-day leadtimes (subdivisions)**
- Demand for subseasonal forecasts but longer than a week
- IMD provides monthly/seasonal forecasts over homogeneous region, weekly over subdivisions. But skill and source of predictability is not known
- Monthly-mean rainfall averaged over homogeneous regions is a preferable selection of temporal and spatial averaging for subseasonal forecasts
- Skill of seasonal mean rainfall is well documented and drivers of seasonal mean rainfall well-studied.

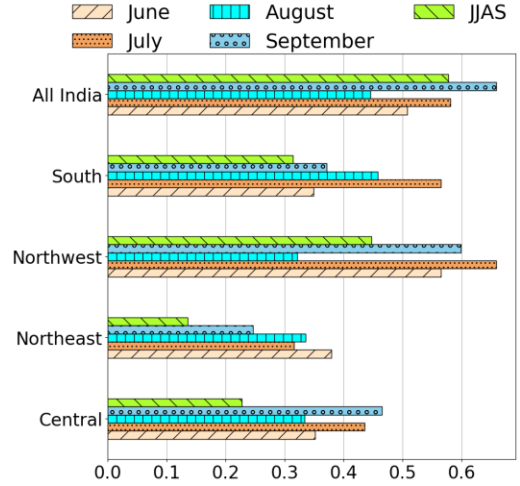
Impact of spatial averaging on skill of monthly-mean rainfall#



Predictability*



Monthly vs Seasonal Skill*

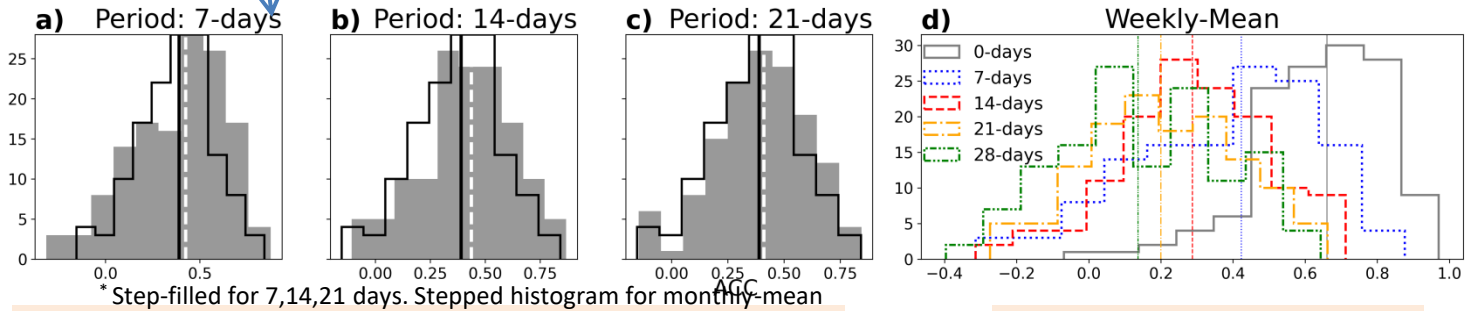


- Large variations in skill of subdivisional rainfall prevents a common confidence level
- Monthly skill is higher than/comparable with seasonal skill
- For ISMR seasonal skill is higher

IC: 25th –day. * IC: 17th-day. Next month forecast. For JJAS IC is 17th May

Monthly-mean closer to 7-day and 21-day mean compared to 14-day mean

Selection of leadtimes and timescales

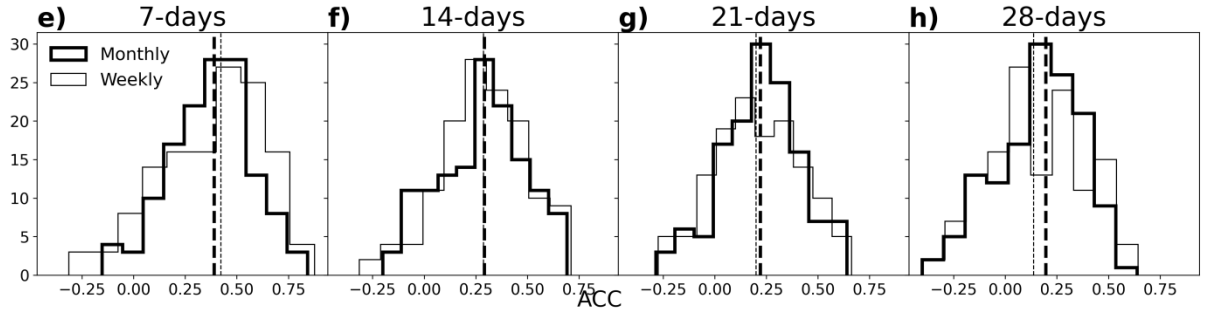


* Step-filled for 7,14,21 days. Stepped histogram for monthly-mean

Impact of averaging period (7-day lead)*

Impact of lead time

Impact of first week of information on monthly forecast at different leadtimes

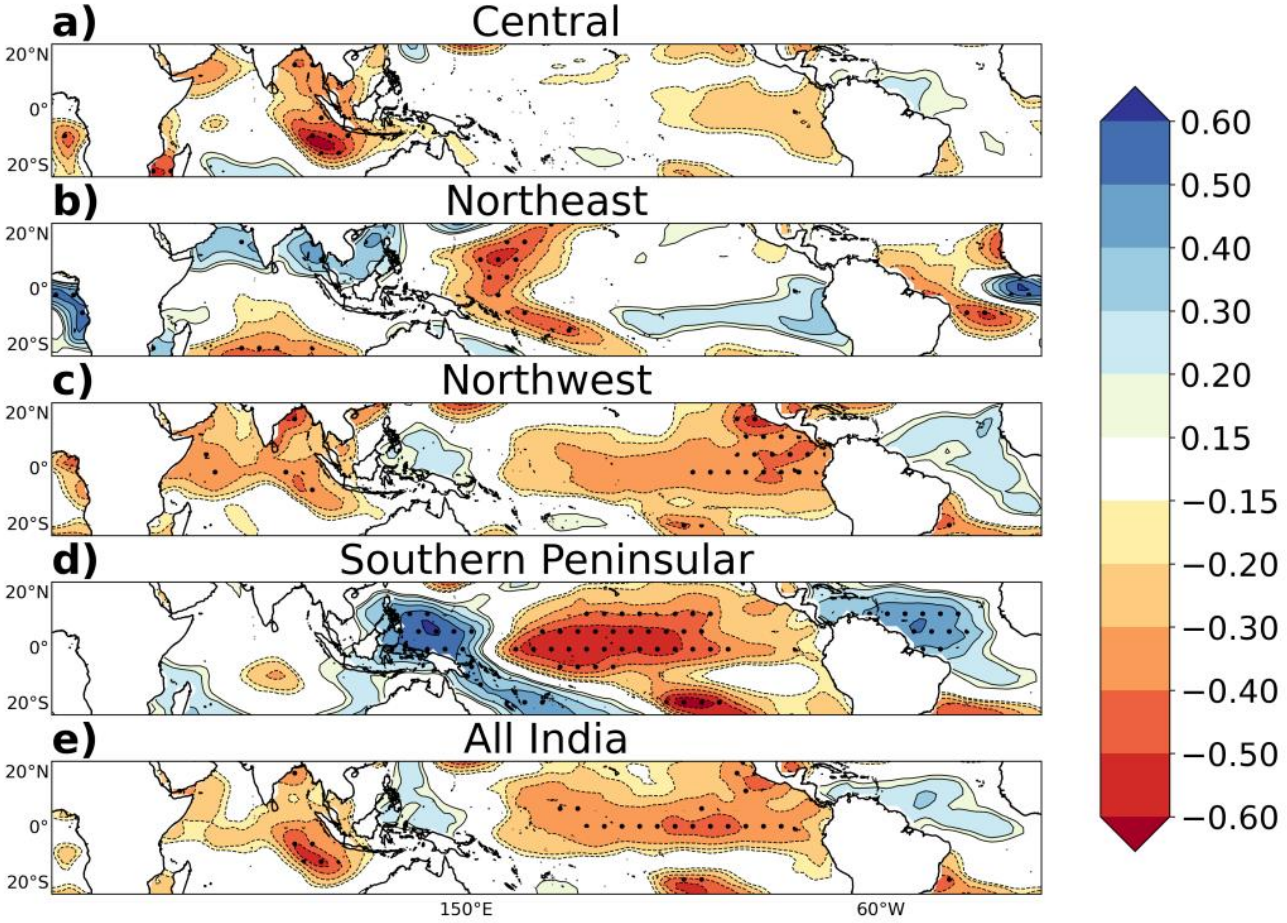


- Impact of averaging period (leadtime) is smaller (higher)
- Impact of temporal averaging is seen at longer leadtimes (skill of monthly-mean surpasses weekly-mean at 14-day of leadtimes)

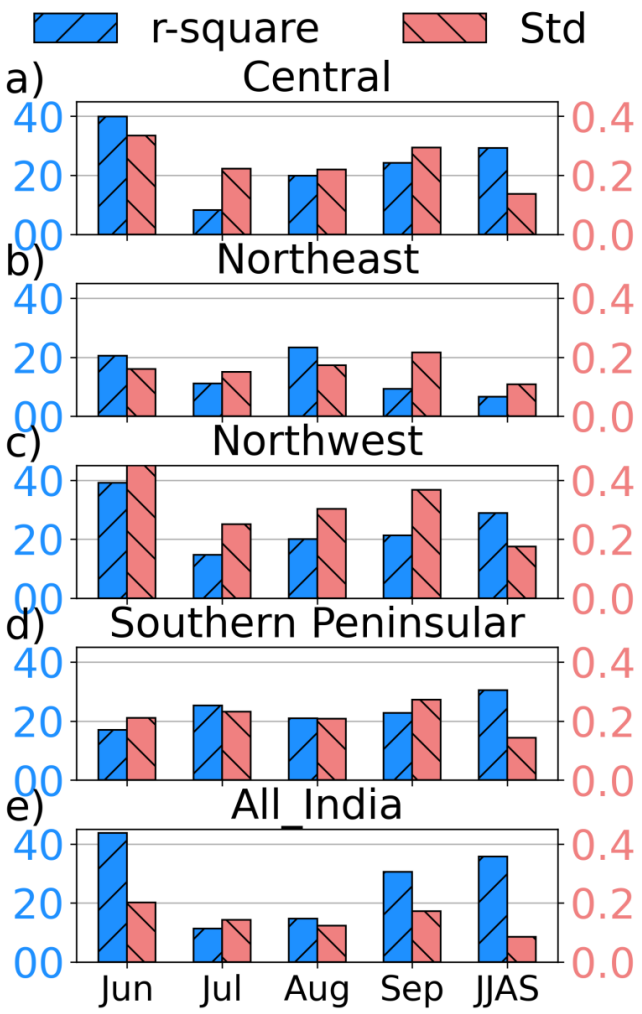
It can be envisaged:

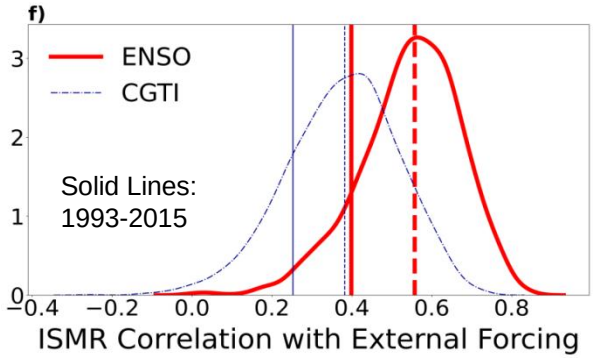
- At shorter leadtimes impact of initial condition more on smaller averaging period.
- **Skill of Monthly-mean rainfall depends heavily on information present in first week of rainfall (particularly at shorter leadtimes).**
- However at longer leadtimes the predictability is not purely because of initialization but also due to external variability

SST correlations with regional rainfall



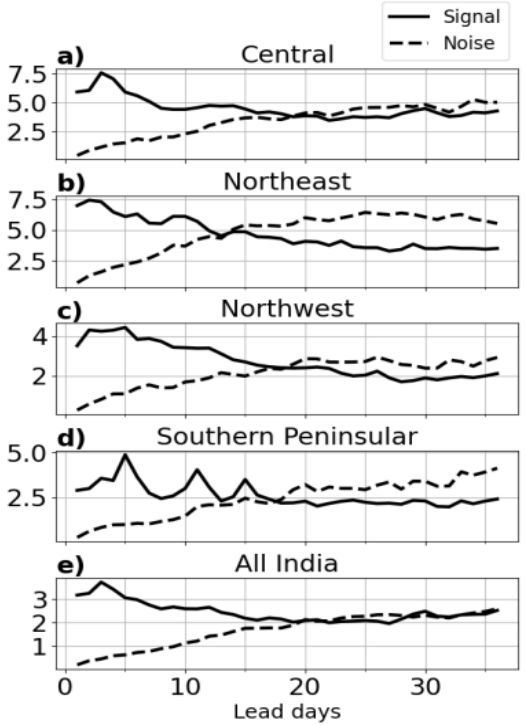
Influence of forcings in observations





Fractional variance of monthly-mean rainfall due to external forcings is very high compared to ENSO-ISMR

- High (low) COV and ExtVAR for AI, CI, NWI in Jun/Sep (Jul/Aug)
- SI has least monthly variation in both COV and ExtVAR



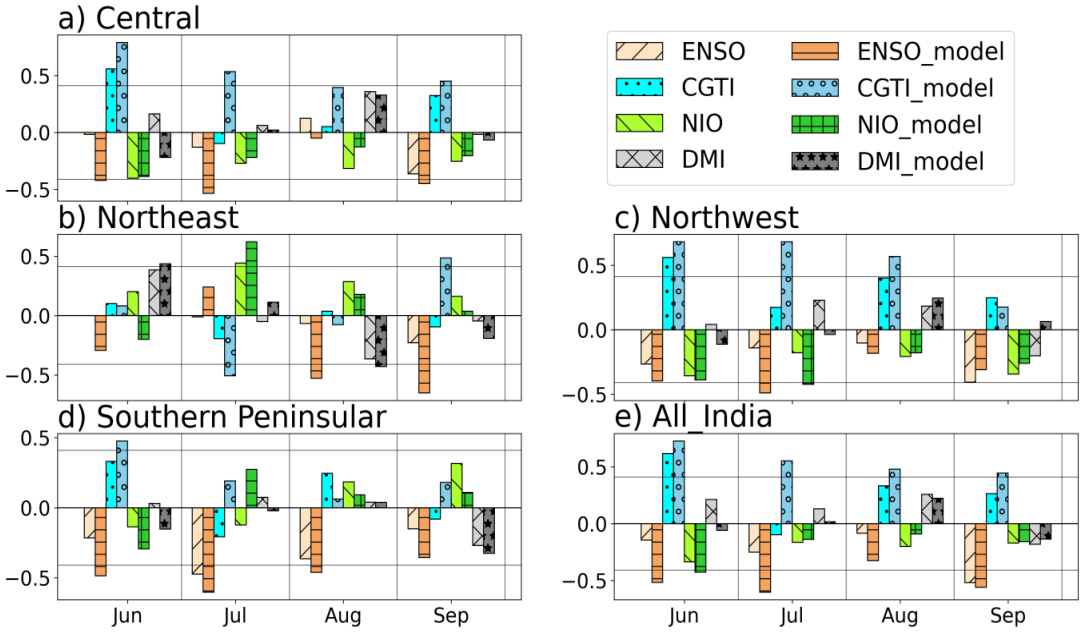
Correlations: Regional Rainfall with Climate Index

•Effect of regional teleconnections on ISMR (mean CI and NEI rainfall is high): high AI-CGTI during Jun/Sep contributed by CI (not NEI). High AI-ENSO during Sep due to CI, NW

•AI skill and teleconnections are strongly influenced by CI

•NEI-NIO and AI-NIO are out of phase

•**CGTI seems to be important driver of monthly-mean rainfall over CI and NWI**



•Over **NWI**: higher skill and stronger teleconnections during Jun/Sep (lower during Jul/Aug)

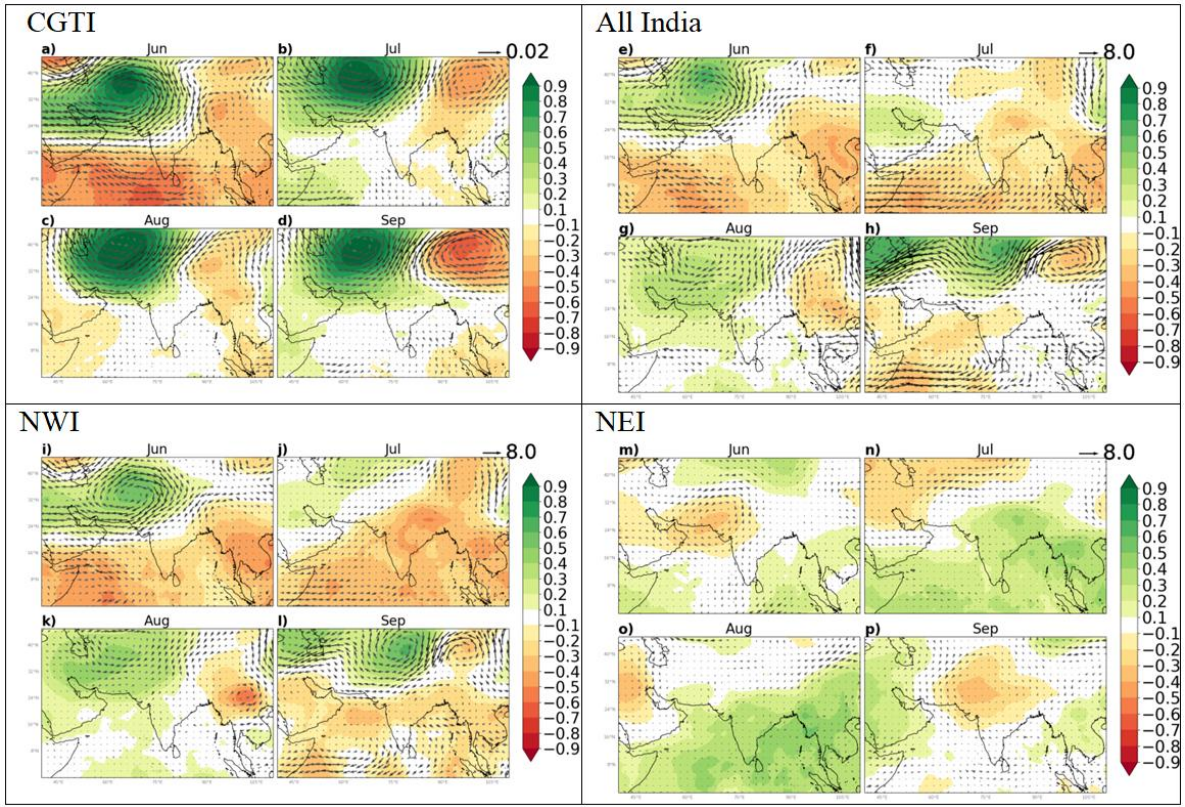
•Over **SPI**: higher skill and stronger teleconnections during Jul/Aug (lower during Jun/Sep)

•**SPI** shows high skill/tele with minimal variations in skill and teleconnections strength

•Weaker SNR/skill over **NEI** due to absence of externally driven variability

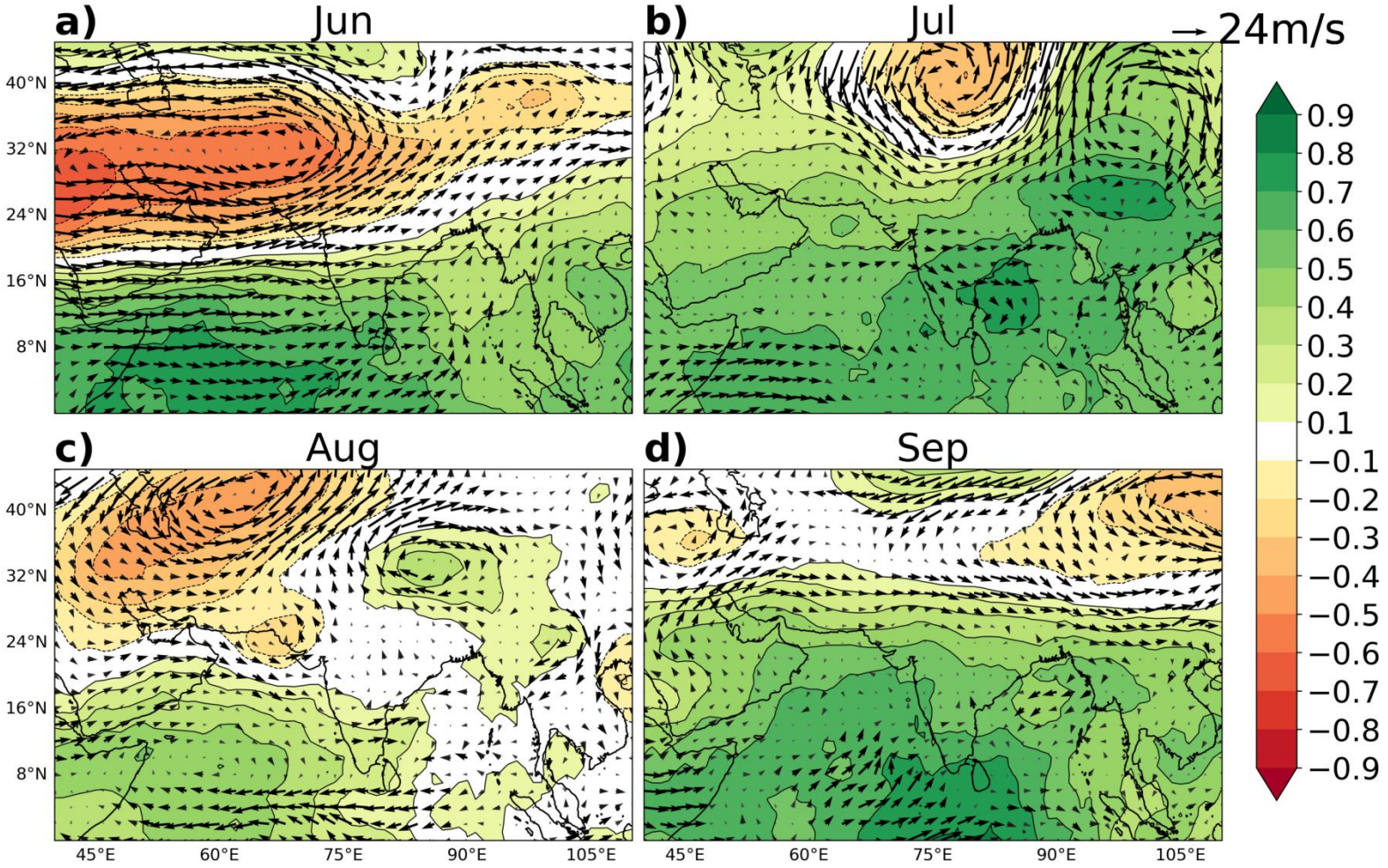
•**Models are over-dependent on external forcings (CI-ENSO)**

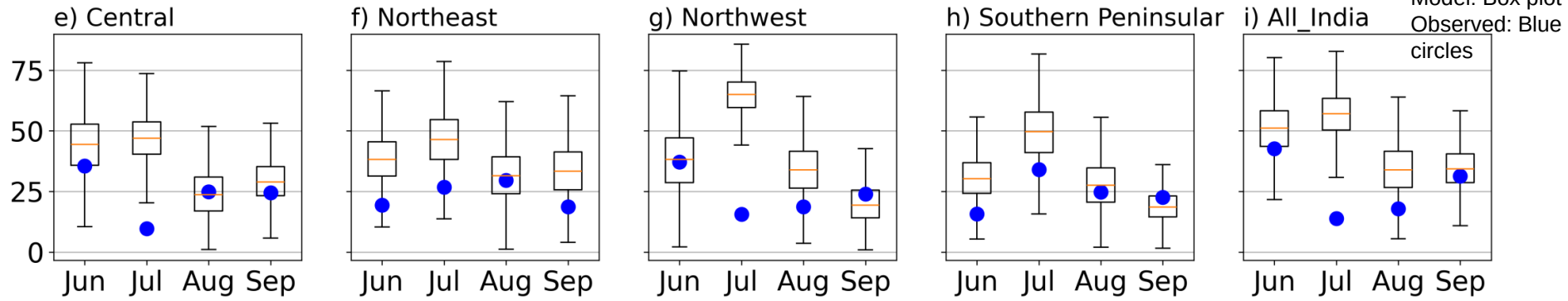
Does Rainfall Creates CGTI pattern or otherwise?



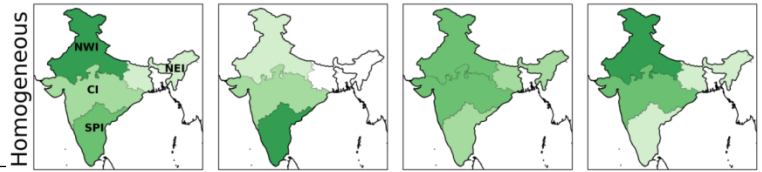
Regressed 200 hPa winds and correlations of GeoH with Indices

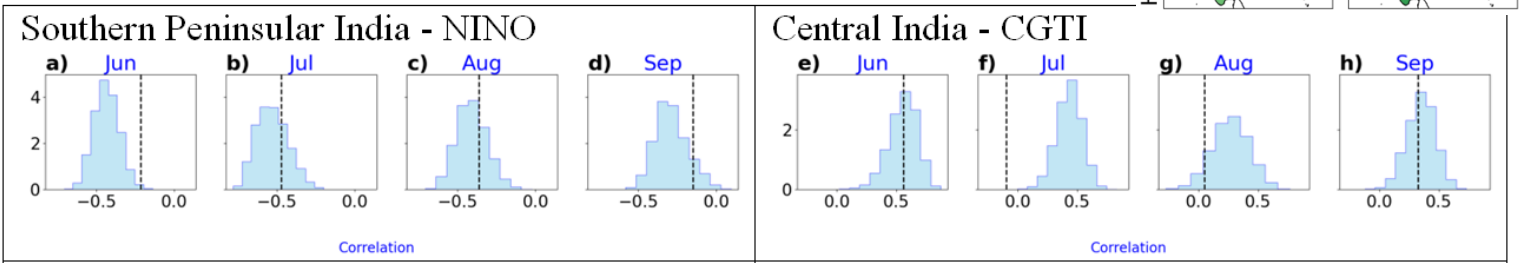
Regressed 200 hPa winds and correlations of GeoH with NIO SSTs

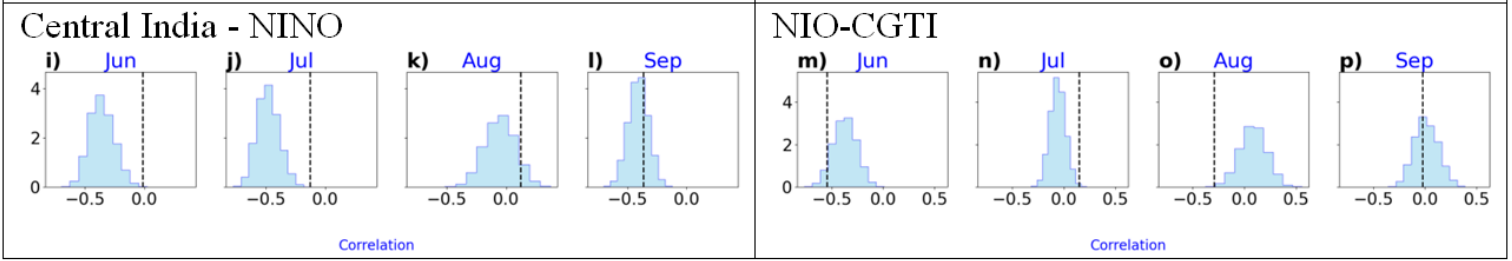




Externally forced variance (%) as fraction of total variance

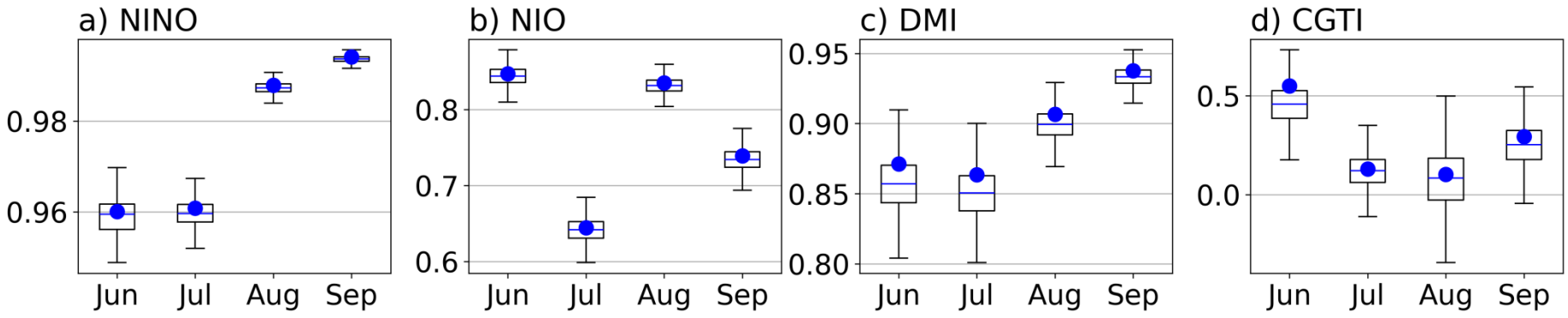






Distribution of Correlations

Skill of Rainfall Drivers



Blue circles: skill of ensemble mean

Conclusions

➢**At subseasonal leadtimes, skill of monthly-mean rainfall averaged over homogeneous regions is the most useful information**.

- ❖This skill is higher than for seasonal mean & comparable to/higher than weekly-mean rainfall.
- ❖Skill of Monthly-mean rainfall depends heavily on information present in first week of rainfall (irrespective of leadtimes)
- ❖Impact of averaging period (leadtime) is smaller (higher)
- ❖Large variations in skill of subdivisional rainfall prevents a common confidence level
- ❖Most impact of spatial averaging at regional scale of homogeneous regions

➢CGT explains large part of externally forced monthly-mean variability

➢Monthly/regional variations in skill can be explained by realistic representation of teleconnections in the model

Thanks …

Questions…

Gupta, A., Mitra, A. K., & Pandey, A. C. 2024. Prospects and status of forecasting monthly mean subregional rainfall during the Indian summer monsoon using the coupled Unified Model. *Quarterly Journal of the Royal Meteorological Society*.