The impact of 1.5°C and 2.0 °C above pre-industrial levels of global warming in semi-arid hot-spots at Africa and India

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Introduction

In its Paris Agreement, the 21st Conference of Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Paris in December 2015 invited the Intergovernmental Panel on Climate Change (IPCC) to provide a special report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways. This research is intended to contribute to the above special report.

Research aims and objectives

Contribute directly to IPCC special report on aspirational goal of 1.5 C. 1.5 degrees has little research evidence and scientific knowledge. This research will investigate the evidence. Testing the "hot-spot" concept against a key international policy question. Drilling down to the place specific conditions with high vulnerabilities (granularity not often provided by big-picture assessments). Outcomes should contribute to inform implementation of Paris Agreement including NDCs. Inform the regional (African and South Asian) policy makers and negotiating groups.
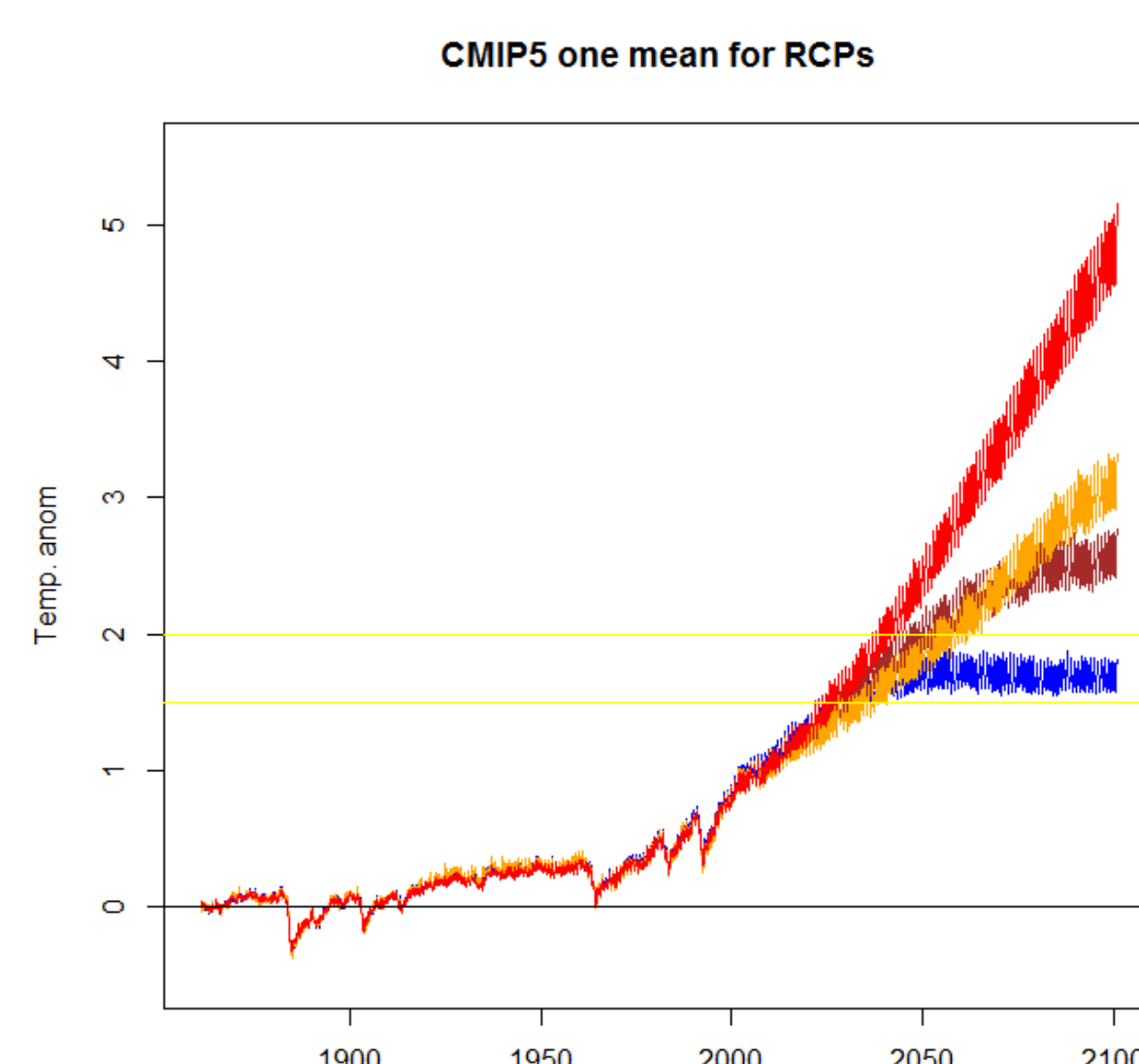
Figure 1: Temperature mean anomalies compared to the pre-industrial period (1861-1900) for RCP 8.5, 6, 4.5, and 2.6. The yellow horizontal lines show the 1.5 and 2 degree.

Methodology and Approach

In general the approach for African Semi-Arid Regions, to check the possibility of using CORDEX, and evaluate whether CORDEX extremes are reliable or not. So the work will start by different GCMs. The result of the CORDEX will be compared later with the results of the CMIP5 to see if the same signals are present across global and regional models and if not what the differences are. In terms of identifying timing of 1.5 and 2.0 degrees, in Africa, I plan to analyze each model individually to see when its 30-year moving average global temperature anomaly reaches 1.5 and 2.0 degrees. Then the 30-year time-slice surround that model's time of reaching 1.5/2.0 will be extracted. So across models, there will be 30-year time slices, but each one anchored to the time it reaches its own 1.5 global temperature, not the ensemble mean. A detailed analysis will be made to the CMIP5 global temperature time-series to identify the time of 1.5 and 2.0 degrees. Finally, it would be possible to do this analysis over SARs of all of South Asia, including India with a collaboration of colleagues at ATREE and IITM who are interested in contributing, in the short term and longer term. Finally, a separate African and south Asia papers should be written. The focus will be on the extreme events, and ask the question, is there a detectable different in the projected changes in extremes important for SARs, when 1.5 and 2.0 degree were compared.
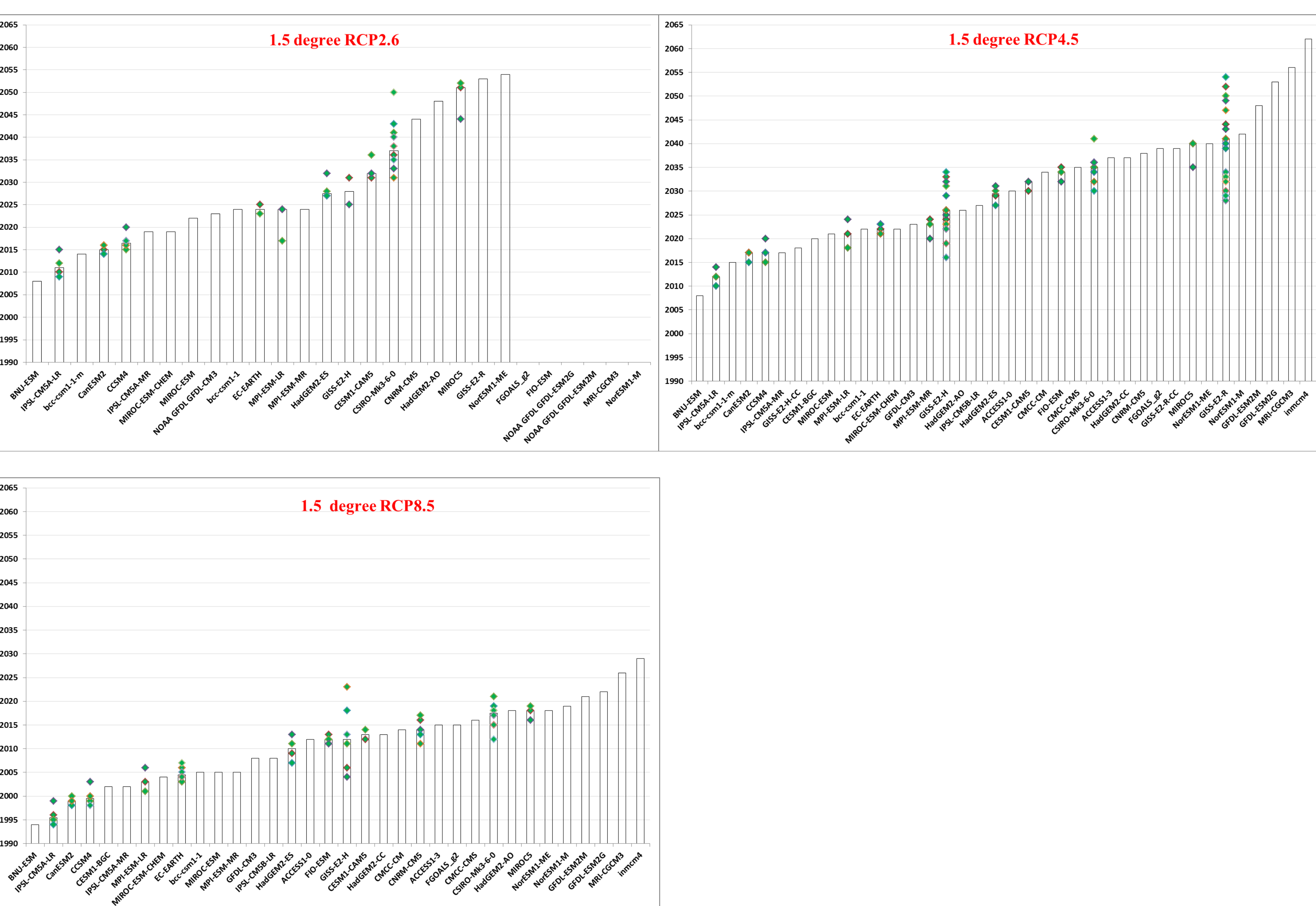

Figure 2: Ranking of all CMIP5 according to their reach to 1.5 degree for RCP 8.5, 4.5, and 1.5. Each column represent a GCM when it reaches the 1.5 degree. When there are several members for a certain GCM, the median was calculated and the members were represented by a green diamon.

Temperature analysis
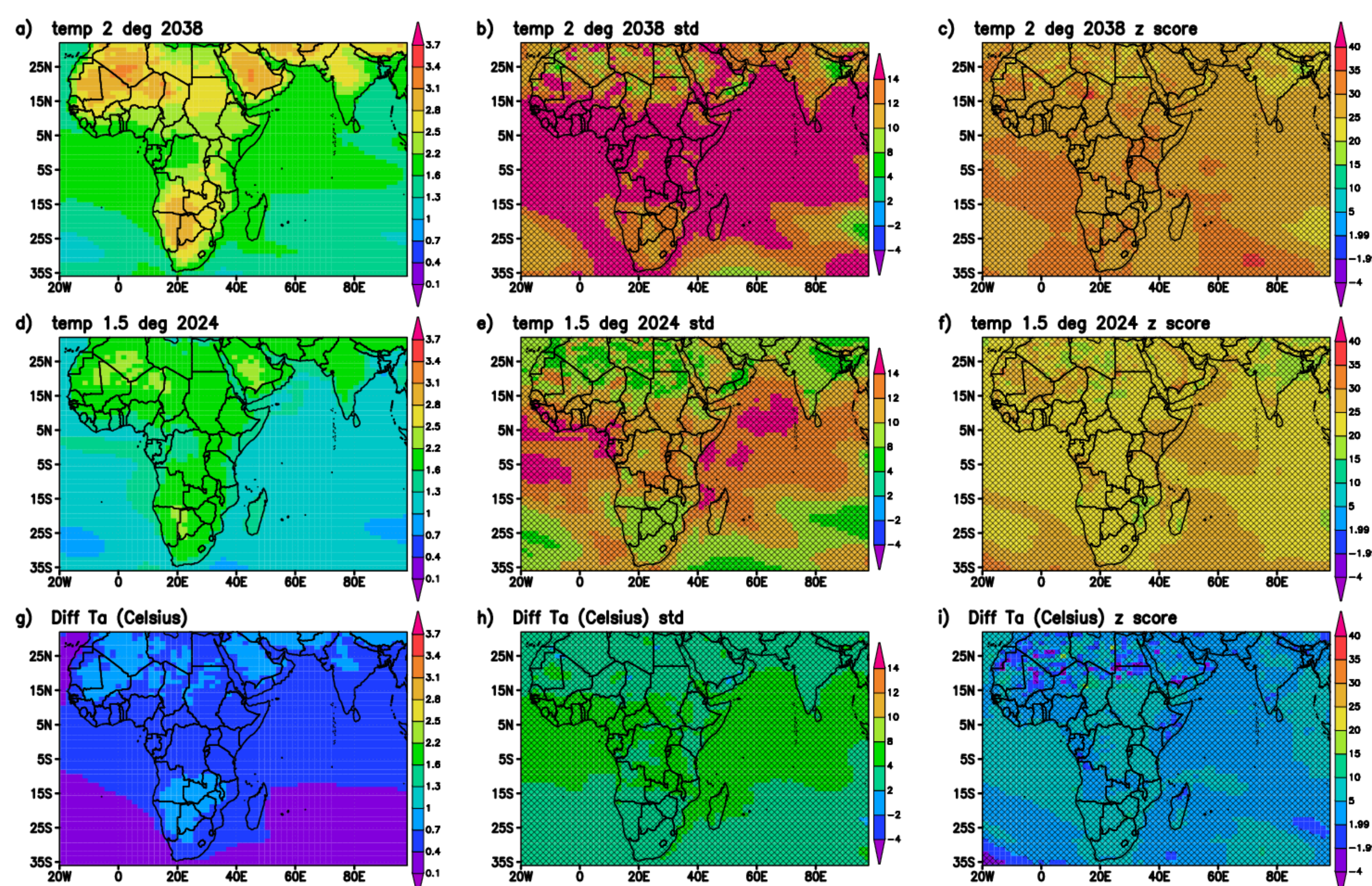
Figure 3: A 30-year moving global average temperature anomaly is used to calculated the reaches to 1.5 and 2 degree temperature, the pre-industrial based period is from 1850 to 1900. These results are based on the ensemble of 10 GCMs (ACCESS1-0, ACCESS1-3, bcc-csm1-1, BNU-ESM, CESM1-BGC, CMCC-CM, CMCC-CMS, FGOALS_g2, GISS-E2-H_p1, GISS-E2-H_p2). a) the 2 degree anomaly, b) the 2 degree anomaly/ pre-industrial standard deviation, c) the 2 degree z score, d) the 1.5 degree anomaly, e) the 1.5 degree anomaly/ pre-industrial standard deviation, f) the 1.5 degree z score, g) the difference between the 2 and 1.5 degree anomalies, h) the difference between the standardized 2 and 1.5 degree, i) the difference between the 2 and 1.5 z scores.

Rainfall analysis
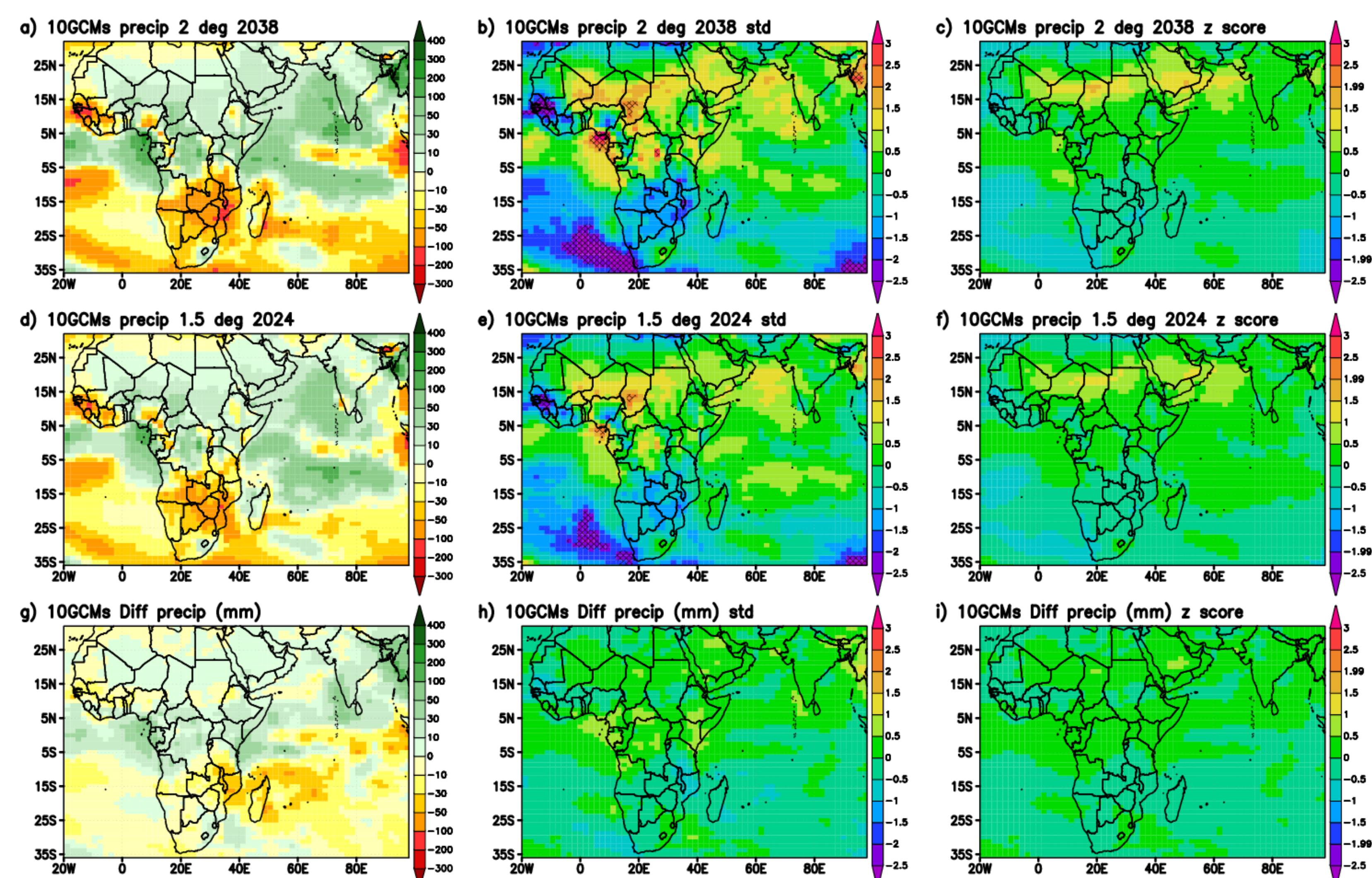
Figure 4: A 30-year moving global average rainfall anomaly is calculated at 1.5 and 2 degree, the pre-industrial based period is from 1850 to 1900. These results are based on the ensemble of 10 GCMs (ACCESS1-0, ACCESS1-3, bcc-csm1-1, BNU-ESM, CESM1-BGC, CMCC-CM, CMCC-CMS, FGOALS_g2, GISS-E2-H_p1, GISS-E2-H_p2). a) the 2 degree anomaly, b) the 2 degree anomaly/ pre-industrial standard deviation, c) the 2 degree z score, d) the 1.5 degree anomaly, e) the 1.5 degree anomaly/ pre-industrial standard deviation, f) the 1.5 degree z score, g) the difference between the 2 and 1.5 degree anomalies, h) the difference between the standardized 2 and 1.5 degree, i) the difference between the 2 and 1.5 z scores.

Conclusion

- Many GCMs in the RCP8.5 already hit the 1.5 degree compared to the pre-industrial period. The average of 81 members showed that it already reached around the mid of 2009, the 2 degree will be reached around 2024.
- 108 RCP4.5 members showed that the 1.5 and 2 degree will be reached around 2029 and 2047.
- 67% of 64 RCP 2.6 members will hit 1.5 degree after 2100, and 89% will reach 2 degree after 2100.
- The analysis of 10 RCP8.5 members showed that the change in temperature is large compared to natural internal variability (i.e., greater than two standard deviations of natural internal variability in 30-year means) for both 1.5 and 2 degree in all Africa and India. The 95% z score confirmed the change in temperature is very significant.
- Unlike temperature, the change in rainfall is less the two standard deviations of Natural internal variability in almost all Africa and India. The 95% z score confirm also the change in rainfall is insignificant.

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