Decadal Variability of extreme precipitation in Northern Oman

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Motivation

Climate change, and **climate variability** are considered to be the main drivers of **extreme weather** worldwide. There is a need to understand the resulting decadal trends and variabilities in rainfall, particularly in arid countries such as Oman where changes in rainfall can have a large impact upon agriculture and **extreme rainfall events** can lead to hazardous flash flooding. In addition, there is a need to identify any changes in rainfall in the **Al Hajar Mountains** of **Northern Oman** due to the **cloud seeding** project active from summer 2013 to 2019.

Reseach Questions

- Are there significant decadal/ interannual variabilities in the extreme precipitation in different parts of Northern Oman?
- What are the controlling factors of extreme precipitation variability in Northen Oman?
- What may be the consequences for cloud seeding operations in Oman?

Methodology

- **Precipitation Climatology:**
  - Yearly, Seasonal, Monthly precipitation variability of a subset of observed stations precipitation daily data from Directorate General of Oman Meteorology (DGMET) and the Ministry of Agriculture, Fisheries and Water resources (MAFWR). Only the 20 stations with the longest and most complete data series were used in order to maintain the integrity of the analysis.
  - Extracted stations monthly high resolution (0.5 x 0.5 degree) grids precipitation data from Climatic Research Unit (CRU) Time Series (TS) version 4.05 dataset from 1950 to 2019 are analysed to overcome the limitations of the observed temporal records.

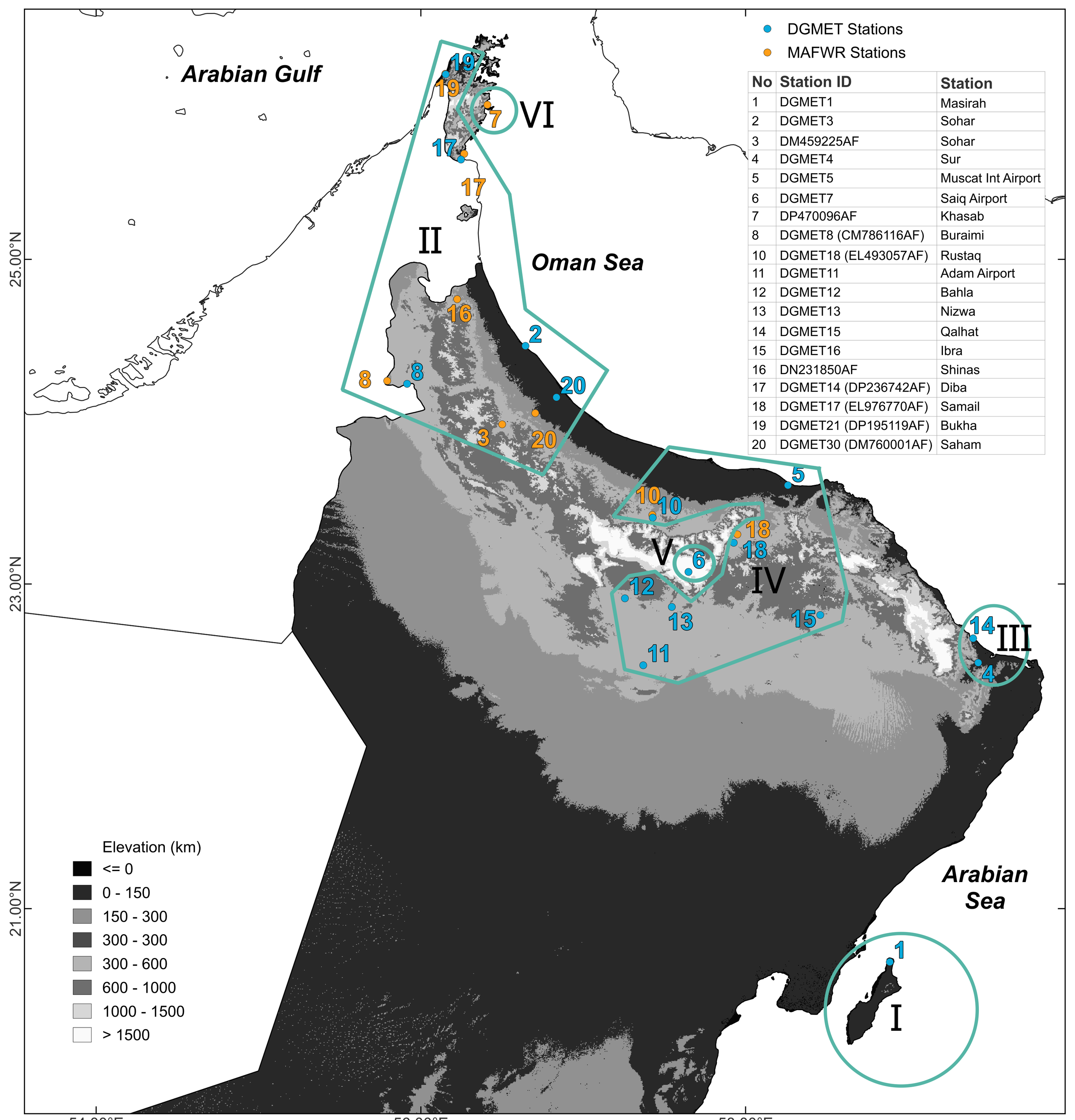

Fig1. Six Regional Clusters for the 20 DGMET and MAFWR stations in the north of Oman based on agglomerative hierachical (Ward's) method for the observed data.

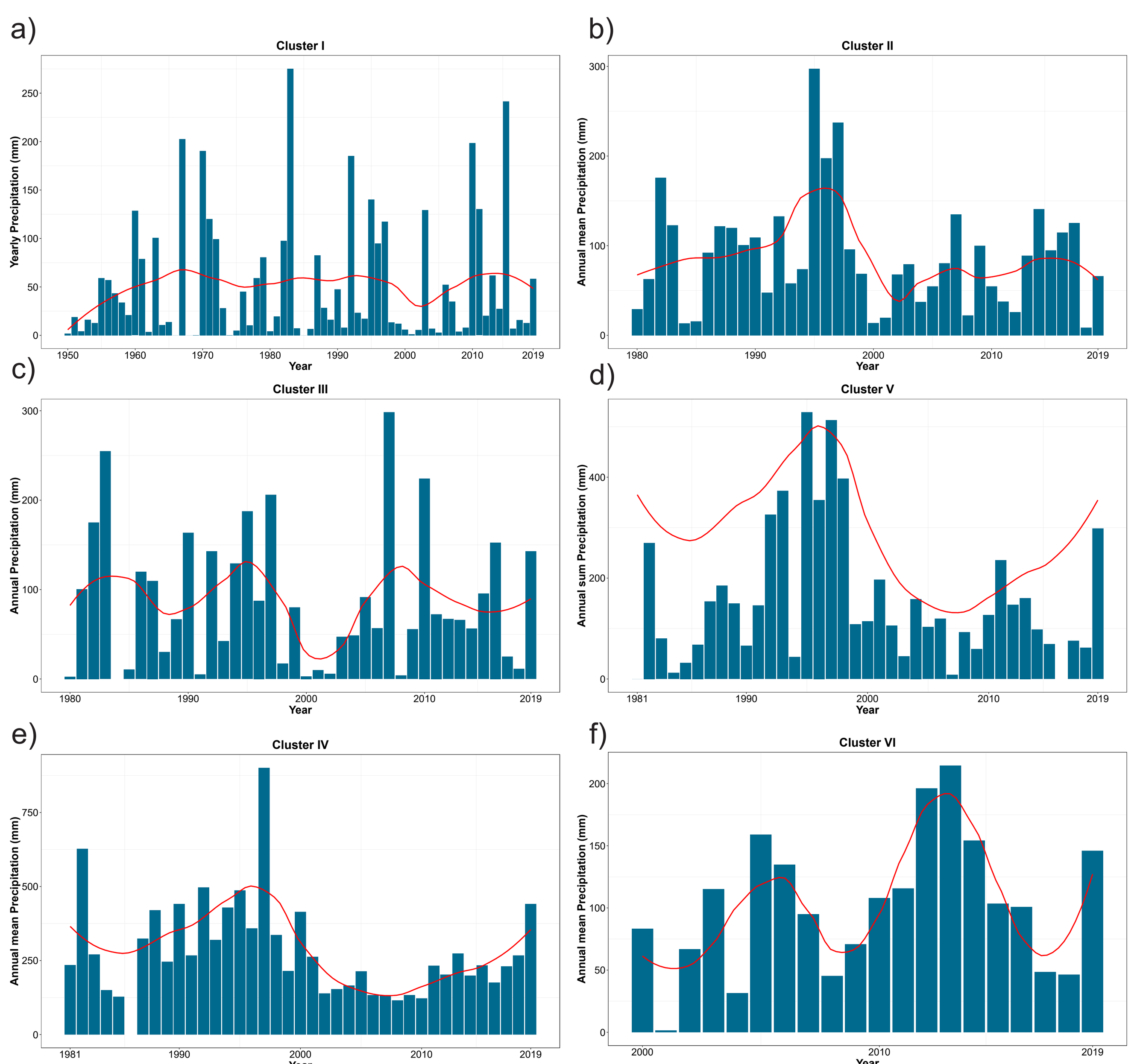

Fig2. Annual mean precipitation for a) Cluster I, b) Cluster II, c) Cluster III, d) Cluster IV, e) Cluster V, and f) Cluster VI.

Preliminary Findings: Observed stations data

Rainfall sources: Tropical systems, Mediterranean extra-tropical systems (extended troughs/ low-pressure systems), Inter-Tropical Convergence Zone (ITCZ), easterly waves and local convective systems.

Table1. Trend analysis of the Clusters' annual precipitation, Cluster I (1950-2019), Cluster II (1980-2019), Cluster III (1980-2019), Cluster IV (1981-2019), Cluster V (1981-2019), and Cluster VI (2000-2019), based on the higher correlation coefficients from Spearman's rank correlation, Mann-Kendall (MK), and Modified Mann-Kendall tests (MMK).

Cluster	Significance of annual trend	Trend*	Wettest decade
I	Insignificant	0.07	2010s
II	Insignificant	-0.09	1990s
III	Insignificant	-0.06	1990s
IV	Significant	-0.35	1990s
V	Insignificant	0.01	1990s
VI**	Significant	0.18	2000s

* The trend analysis coefficients for Clusters I to V are based on Spearman's rank correlation, while Cluster V is based on MMK.

** The key limitation with Cluster VI is short precipitation data time span (2000-2019).

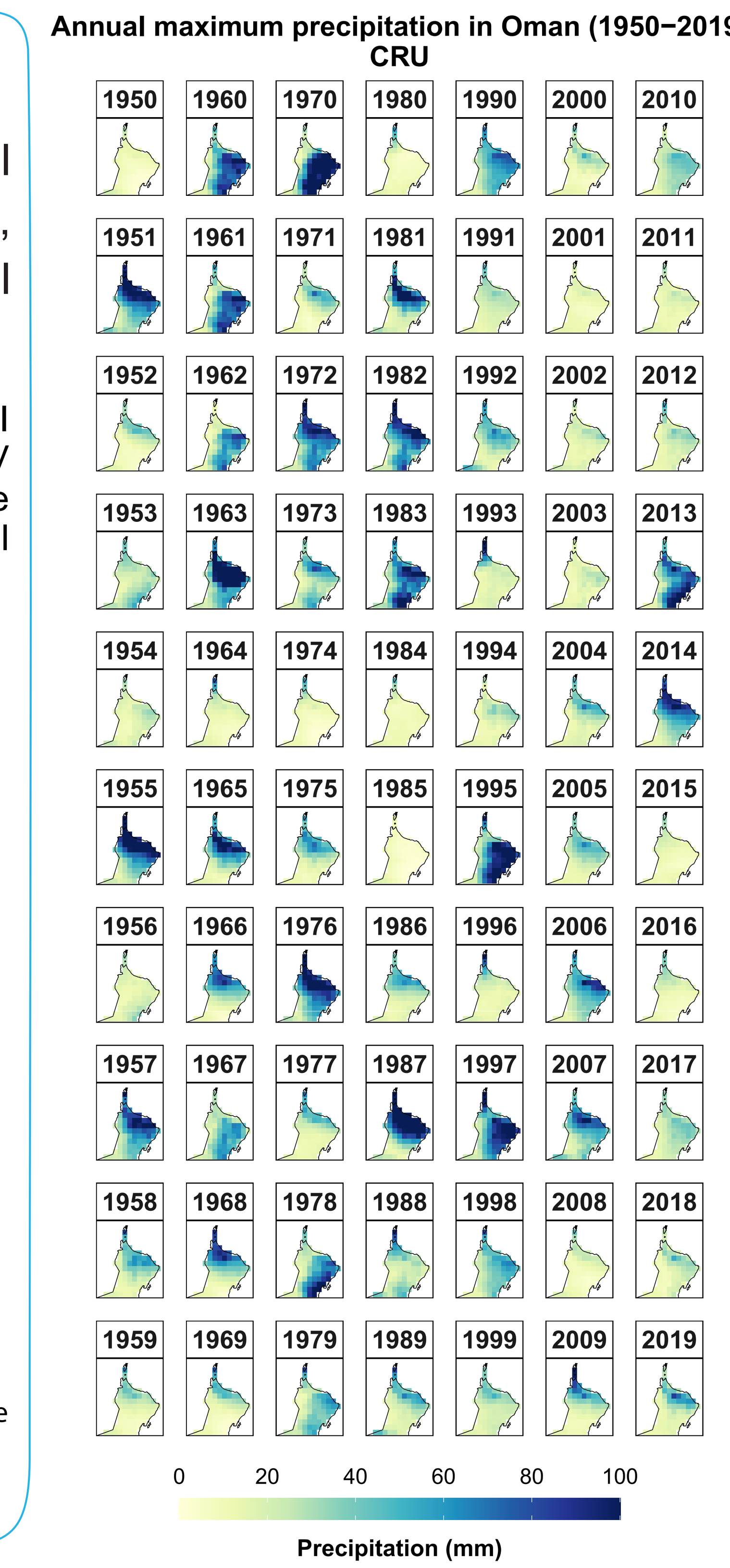

Fig3. Annual maximum precipitation (1950-2019) for Northern Oman according to gridded CRU TS v. 4.05.

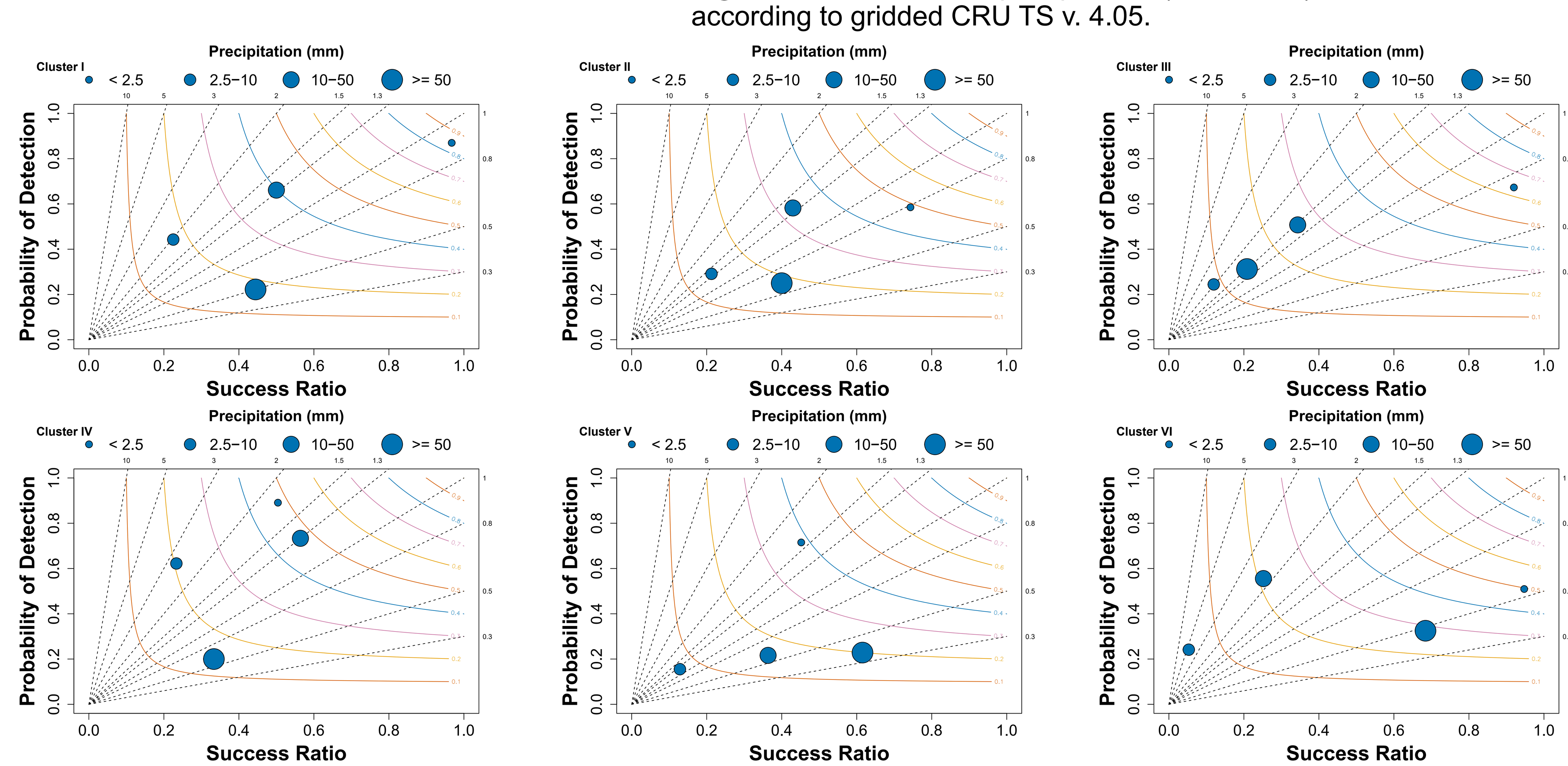

Fig4. Performance diagrams for CRU depicting the Success Ratio (SR), Probability of Detection (POD), Frequency Bias (BIAS), and Critical Success Index (CSI), for various observed monthly precipitation intensity ranges (< 2.5mm), (2.5-10)mm, (10-50)mm, and (≥ 50mm) in blue circles. The BIAS is displayed with dashed lines with their value presented on the second x-axis (Top) and y-axis (Right). The coloured contours are CSI.

Comparison between observed precipitation records and CRU

CRU demonstrates a moderate to high ability to detect slight precipitation (<2.5mm) across all Clusters with POD values ranging from 0.51 to 0.89. However, as precipitation intensity increases, CRU detection performance drops. Apart from Cluster V, CRU overestimates heavy precipitation. CRU underestimates extreme precipitation (≥50mm), except for Cluster III where it overestimates (by 0.5 mm) relative to the observed precipitation. Notably, Cluster IV exhibits greatest positive bias (4.6mm/month) for moderate precipitation. The CSI for CRU is very low for extreme precipitation across all clusters, while the SR is weak for Cluster III and IV. There is variability in the CRU performance; nevertheless, CRU performs better in estimating the lower precipitation compared to higher intensities.

Future Works:

- **Precipitation Decadal Variability:**
  - Quantile Pertubation method (QPM) will be used to analyse the decadal extreme precipitaiton, and their confidence interval are tested by non-parametric Monte Carlo Simulation.
- **Teleconnection patterns and the precipitation variability:**
  - Investigation of the relationship between extreme precipitation and the following patterns: Optimum Sea Surface Temperature (OISST), Mean Sea Level Pressure (MSLP), North Atlantic Oscillation (NAO), Indian Ocean Dipole (IOD), Arctic Oscillation (AO), Pacific Decadal Oscillation (PDO), El Niño-Southern Oscillation (ENSO).
  - Ougtoing Longwave Radiation (OLR) data are to be analysed to investigate the severity, spatial and temporal variability of heavy to extreme precipitation and deep convection on the Al Hajar mountains.

Acknowledgment

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