THE ALL-YEAR RAINFALL REGION OF SOUTH AFRICA: SATELLITE RAINFALL-ESTIMATE PERSPECTIVE

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1. INTRODUCTION

Climate predictability and variability studies over South Africa typically focus on the summer rainfall region and to a lesser extent on the winter rainfall region. The all-year rainfall region of South Africa, a narrow strip located along the Cape south coast, has been neglected in this regard, despite it being a region of great agricultural importance. As a first step to gain understanding into the driving mechanisms of climate variability over this rainfall region, the observed annual rainfall distribution and the rainfall regimes associated with the all-year rainfall region are investigated. Of particular importance is the bi-modal annual distribution of rainfall (Van Rooy, 1972). Three observed datasets, of which two are satellite rainfall estimates, are utilized for this purpose. The satellite rainfall estimates are available for the land and oceanic regions, ideal for investigation of rainfall regimes that influence the all-year rainfall region that is rooted in the adjacent ocean.

2. DATA AND METHODOLOGY

The annual distribution of rainfall over the all-year rainfall region is investigated by utilizing satellite rainfall estimate data and gridded station data. Satellite rainfall estimates from the Tropical Rainfall Measuring Mission (TRMM) at a horizontal resolution of 0.25˚x0.25˚ and the Famine Early Warning System (FEWS, also known as ARC2) at a horizontal resolution of 0.1˚x0.1˚ are available on a daily time-scale. These daily precipitation totals are monthly and spatially averaged over the all-year rainfall region for the period January 1998 to December 2010, the overlapping time period of these two datasets. The ability of these satellite rainfall estimates to capture the rainfall characteristics over the all-year rainfall region of South Africa with its complex topography and oceanic influences is not extensively explored, and needs to be investigated since differences within these datasets in the daily rainfall characteristics do exist for the African region (Sylla et al., 2012). For this reason, gridded station rainfall data from the Climatic Research Unit (CRU) version TS3.1 for the period January 1979 to December 2009, with a horizontal resolution of 0.5˚x0.5˚ are used for the control dataset. The all-year rainfall region as defined for the three rainfall datasets can be seen in Figure 1. It can be noted that the satellite rainfall estimates extend over the immediate ocean, whereas the CRU rainfall data is confined to the land.

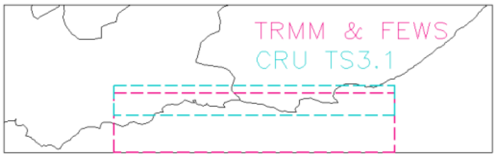

FIG. 1: TRMM, FEWS and CRU TS3.1 domains utilized to calculate the spatially averaged monthly rainfall for the all-year rainfall region.

In order to investigate the rainfall regimes found over the all-year rainfall region of South Africa, a 4x3 self-organizing map (SOM) is applied to the daily satellite rainfall estimates from both TRMM and FEWS for the overlapping period of January 1998 to December 2010 over the domain bounded by 34.875˚S to 32.375˚S and 18.874˚E to 28.875˚E. The SOM domain is chosen to include the influence of summer rainfall producing systems from the north as well as winter rainfall producing systems from the west. Apart from the rainfall regime analysis, a further purpose of the study is to determine the suitability of the FEWS rainfall estimates for inter-annual and intra-annual rainfall studies over the region. FEWS is available from 1983 and combined with its high spatial resolution, these attributes make it well suited for such studies. However, the study period here is from January 1998 to December 2010 as this is the period of available TRMM data. The FEWS daily precipitation totals during this period are mapped onto the TRMM daily precipitation SOM. In order to achieve this, the FEWS daily precipitation data are regridded to the horizontal resolution of the TRMM data by employing bi-cubic interpolation on the daily

FEWS fields. All fields subjected to the SOM analysis are normalized relative to the long-term spatial average.

3. RESULTS

The broad characteristics of the annual rainfall distribution over the all-year rainfall region exhibit similar behaviour in TRMM, FEWS and CRU TS3.1 (Figure 2). In all three datasets, three maximums a year are present. However, the magnitude and timing of these maximums do differ. The exception is the August maximum which is present within all the datasets. Noteworthy is the absence of this maximum in the benchmark analysis of Van Rooy (1972). The autumn maximum occurs during March, April and May in TRMM, CRU TS3.1 and FEWS respectively. It may be noted that the CRU TS3.1 autumn maximum occurs during March when the northern boundary of the rainfall region is shifted 0.5° northwards, indicative of the potential relationship that exists between this rainfall maximum over the all-year rainfall region and that of the summer rainfall region over the western interior. The spring maximum is found during October in FEWS and CRU TS3.1 while it occurs during November in TRMM.

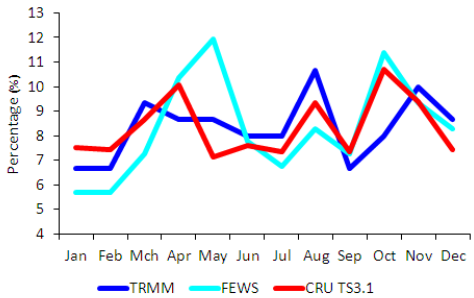

FIG. 2: Area-averaged monthly rainfall over the all-year rainfall region expressed as a percentage of the annual rainfall.

The 4x3 SOM analysis revealed that similar rainfall regimes occur in TRMM and FEWS (not shown). Major rainfall producing systems such as cold fronts, ridging high pressure systems and cloud bands associated with tropical-temperate linkages are present in the SOM rainfall regimes. The nodes representative of days receiving rainfall higher than the domain average are nodes [2;0], [3;0], [2;1], [3;1], [2;2] and [3;2] (Figure 3). The frequency of occurrence of these rainfall regimes is very similar for TRMM and FEWS. The other SOM nodes are indicative of days receiving less rainfall than the domain average (Figure 3). Greater deviations in the frequency of occurrence occur between TRMM and FEWS for these nodes. TRMM has a higher frequency of occurrence of days receiving less rainfall than the domain average of rainfall regimes associated with tropical-temperate cloud bands located over the eastern part of this domain (Figure 3, node [0;0] and node [0;1]). FEWS has a noteworthy higher frequency of occurrence of the node representative of a rainfall regime associated with mostly rain-free conditions over the domain except for frontal activity in the far southwest (Figure 3, node [0;2]).

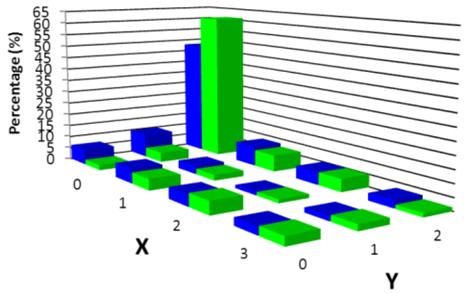

FIG. 3: Average frequency of occurrence of the SOM nodes in TRMM (blue) and FEWS (green).

4. CONCLUSION

The bi-modal rainfall distribution over the all-year rainfall region of South Africa as previously determined from station data, seems instead to be tri-modal according to this derived observed gridded rainfall data. The frequency of occurrence of rainfall regimes associated with dry days yields greater differences between TRMM and FEWS as opposed to the frequency of occurrence of rainfall regimes associated with wet days.

5. REFERENCES

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