Quantifying rainfall seasonality across South Africa on the basis of the relationship between rainfall and temperature

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1. Background and Study Area

-Subtropical location of South Africa (SA; Fig. 1) = distinct summer-, winter- and year-round rainfall zones (SRZ, WRZ and YRZ)

-SRZ depends on tropical temperate trough (TTT) clouds bands for rain[1] and spans eastern coast and most interior regions, with October-March wet-season

-WRZ depends on mid-latitude cyclone cold front rainfall[2] and spans southwestern and western coast, with April-September wet-season

-YRZ = southern coast, with year-round rainfall from ridging high-pressure systems, TTTs, cut-of lows and cold fronts[3]

-Despite understanding of spatio-temporal characteristics of weather systems responsible for rainfall zones, no coherent understanding exists for their spatial distribution and rainfall seasonality characteristics – due to application of many different seasonality metrics

-Need consensus on standard metric or set of metrics for effective cross-study and spatio-temporal comparisons

-Considering all seasonality metrics with quantitative outputs[4], an appropriate method to apply is a ratio of monthly rainfall:temperature[6] because its output offers statistical discrimination between SRZ and WRZ - being the most important requirement for a metric applied to SA[4]

-Aim = to assess how ratio models SA rainfall seasonality

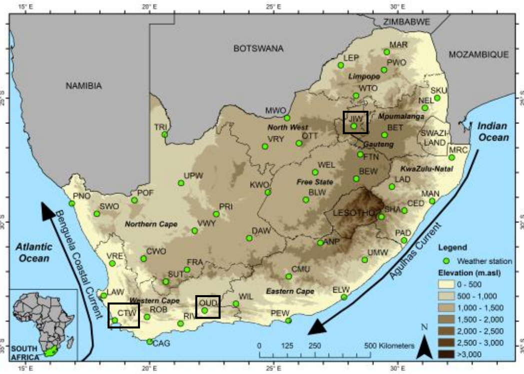

Fig. 1 Study location and weather stations. Key SRZ, WRZ and YRZ locations are highlighted using a black box.

2. Data and Methodology

-Data = Daily rainfall and daily maximum and minimum temperature (1987-2016)
- -Gridded layout of 46 weather stations (≥90% data coverage after quality control; Fig. 1)
- -Gridded data

-Ratio method[1] calculated following steps in Fig. 2
- -Method considers linear relationship between rainfall and temperature
- -Output = seasonality score
- -Score quantifies degree and timing of seasonality
- -Scores >0.3, <-0.3 and -0.3≤ score ≤0.3 classified as SRZ, WRZ and YRZ, respectively

-Ratio is assessed on how its outputs model SA rainfall seasonality, considering:
- -What is known in literature, regarding SA rainfall seasonality characteristics
- -Characteristics of weather systems known to influence SA
- -Statistical stability = resampling
- -Consistency between station and gridded data outputs

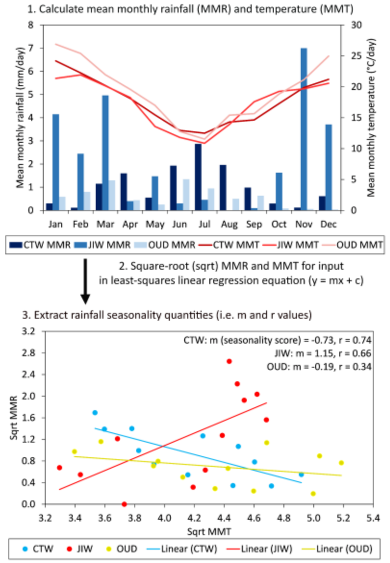

Fig. 2 Seasonality score calculation, for representative SRZ (JIW: Johannesburg International Wo), WRZ (CTW: Cape Town Wo) and YRZ (OUD: Oudtshoorn) locations, using 2016 as an example.

3. Results and Discussion: Ratio outputs

-Scores SRZ, WRZ and YRZ spatial distribution corresponds to many previous SA rainfall seasonality maps, with the range in scores reflecting variation in sign and strength over west–east and south-north gradients (Fig. 3a), which corresponds to spatial characteristics of SA weather systems. YRZ classification is particularly consistent with weather system characteristics and know YRZ definition.

-R values (Fig. 3b) further explain seasonality, especially across the eastern coast where low values reflect notable cool ('dry') season rainfall.

-Strong correspondence exists between scores calculated for stations and gridded data (Fig. 3a, 4).

-Resampling period scores are consistent, reflecting statistical stability and that scores can be calculated for varying temporal periods (Fig. 5).

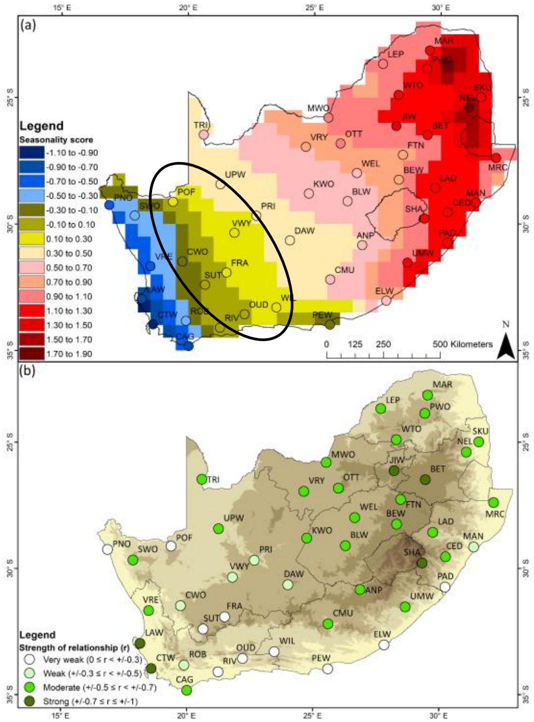

Fig. 3 Ratio outputs for 1987-2016. (a) Mean scores for stations (circles) and gridded data (surface), and (b) Pearson correlation coefficient r values representing the mean strength of relationship between sqrt MMR and sqrt MMT for stations.

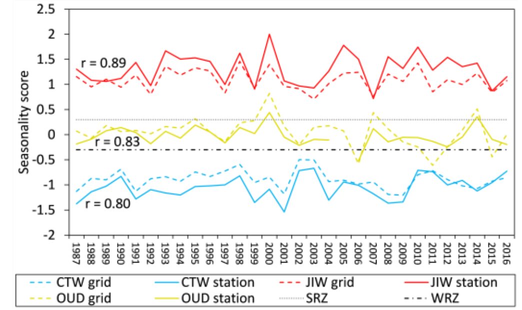

Fig. 4 Annual scores for stations (solid lines) and corresponding grid cells (dashed lines) for representative SRZ (JIW), WRZ (CTW) and YRZ (OUD) locations, with correspondence between the datasets measured by Pearson correlation coefficient values.

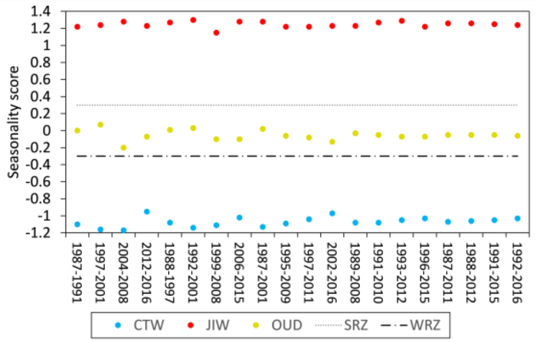

Fig. 5 Resampling period scores for representative SRZ (JIW), WRZ (CTW) and YRZ (OUD) locations.

4. Conclusion: Strengths, limitations and application of the ratio method

-Successful application to all stations and gridded data, confirmation of known seasonality characteristics, and comparability with SA weather systems confirms the score is a relevant SA rainfall seasonality measurement and can be used to promote consistent and comparable investigations. Therefore, application is important, especially for other regions such as Australia.

-Strengths = Objective given input of location-specific rainfall and temperature measurements without underlying assumptions, simple to calculate using station and gridded data, continuous nature of scores is valuable for variability and change investigations, and ratio is statistically stable

-Limitations = Reliance on distinct seasonal temperature cycle limits application to extratropical regions, monthly-scale, and description of seasonality ≠ complete, but scores can be linked to wet-season start- and end-date metrics

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