Rainfall characteristics in Sub-Saharan Africa and their implications for rain-fed agriculture

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Motivation and Aims

90% of Sub-Saharan Africa is depending on rain-fed agriculture; hence proper information about the rainy season and the rain distribution is indispensable
(impact on yields, groundwater recharge, flooding).

challenges: low station density; short time-series

Satellite-derived rainfall estimates (SRFE) enable region-specific investigation of rainfall characteristics and analysis of their impact on agricultural yields, groundwater recharge rates, flooding

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Study Area

- Upper Zambezi River Basin (UZRB): part of ZRB upstream of Victoria Falls
- shared by Angola, Zambia, Namibia and Botswana
- total area: 514.000 km²
- rainfall 500mm – 1400mm with high annual, inter-annual and periodical variability
- frequent floods and droughts; recently: major flooding

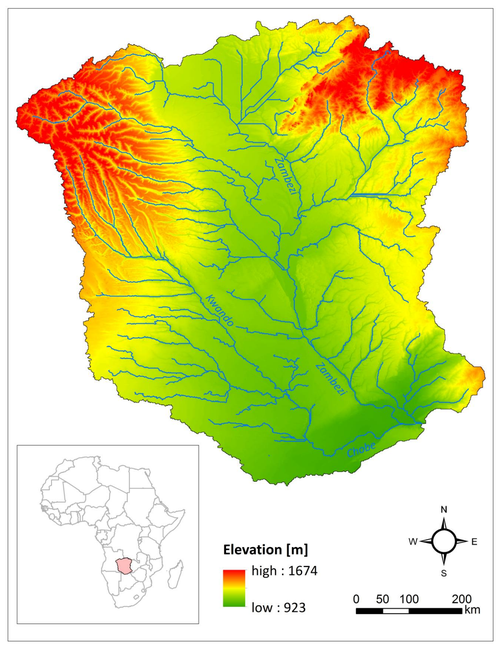

Fig. 1: The Upper Zambezi River Basin

Methods

1. Bias-correction of TRMM data using a quantile mapping approach (Thiemig et al., 2012);
2. Calculation of rainfall characteristics per cell and year:

   17 characteristics chosen, criteria based on previous studies (e.g. Reason et al., 2005);

characteristic description	identifier	criteria for characteristic
onset of rainy season	-on-	first 20 days > 25mm,next 20 days no 10 consecutive dry days
cessation of rainy season	-ces-	3 consecutive dekads with less than 20 mm
duration of rainy season	-dur-	cessation – onset date
no.wet days / no.dry days	-wd-/-dd-	rain > 2mm / rain < 2mm
no.wet spells	-wsp-	5 day sum > 10mm, less than 3 days with no rain
no.dry spells	-dsp-	5 day sum < 5mm
max./mean wet spell duration	-wspdmax/-mean-	based on counts of no. of days for each wet spell
max./mean dry spell duration	-dspdmax/-mean-	based on counts of no. of days for each dry spell
total rain in rainy season	-ptot-	rain sum from onset to cessation
events above 10/20/40/60/80 mm	-p10/20/40/60/80-	rain > threshold

3. Setup, calibration and validation of DAISY soil-crop-atmosphere system model (Abrahamsen & Hansen, 2000):

   Traditional maize variety, only rain-fed (no irrigation);
4. Training of self-organizing map (SOM) for multivariate analysis (Fig. 2+4);

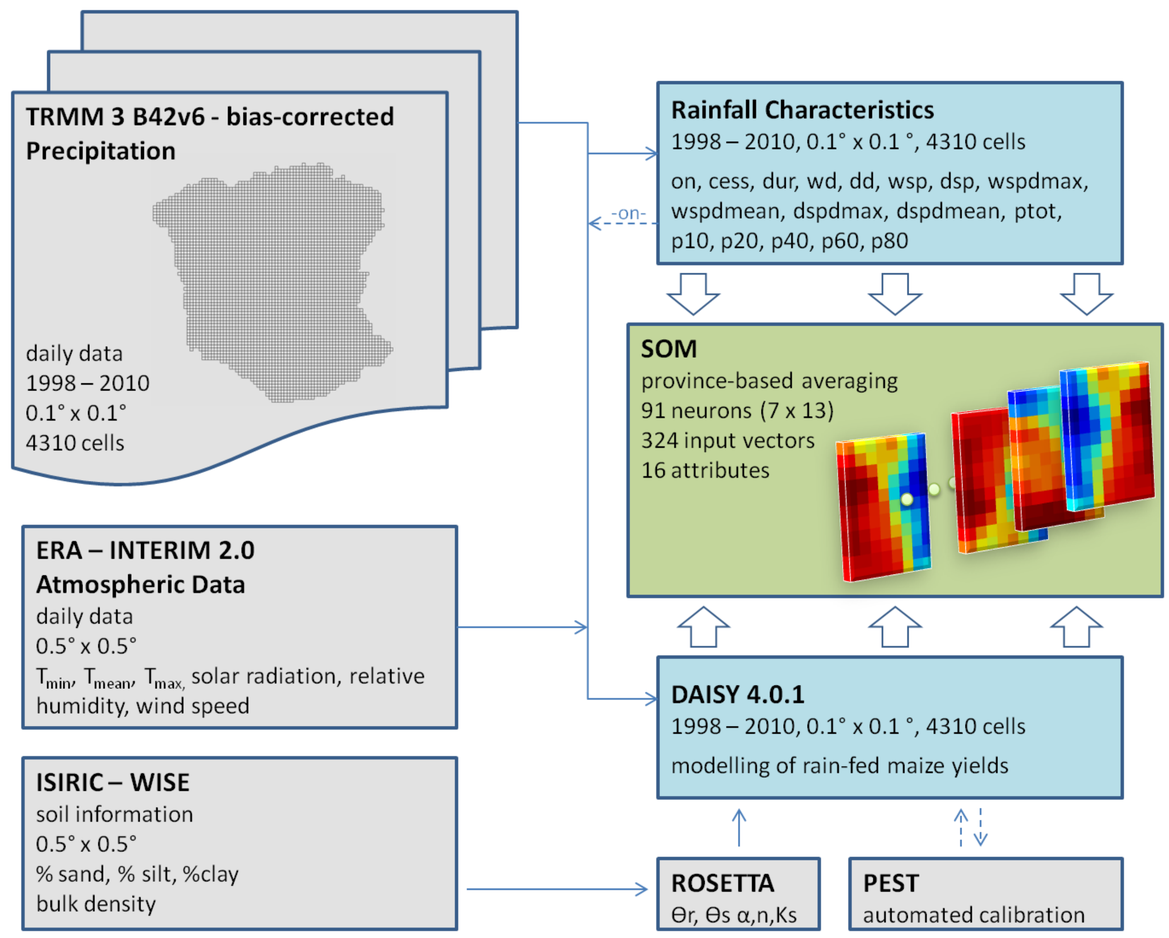

Fig. 2: Research structure

Results

- very high spatial and temporal variability of rainfall characteristics
- successful application of DAISY model (no socio-economic impacts evaluated)
- north-south downward gradient of maize yields
- highest single-parameter impacts: dspdmax (r_{xy}=-0.56), p10 (r_{xy}=0.51), ptot + wspdmean (r_{xy} =-0.48)

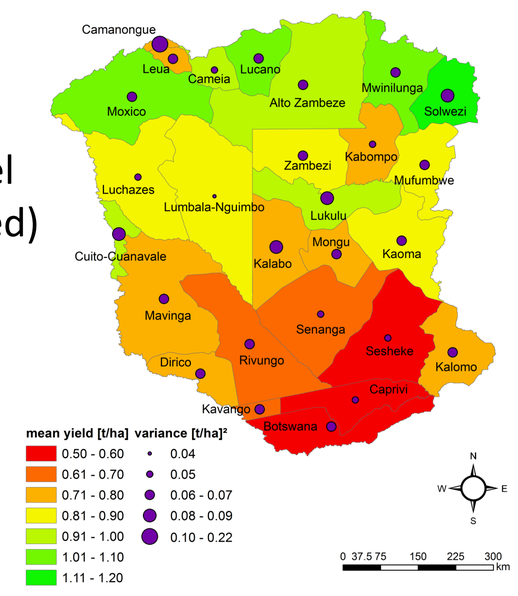

Fig. 3: Mean modeled yields and variance

- multvariate analysis (SOM):
  - highest yields only possible with sufficient duration
  - short rainy season with high no. of wet and dry spells affects yields massive
  - with long rainy seasons, no. and duration of dry spells decreases
  - extreme events affect yields, especially with short rainy seasons

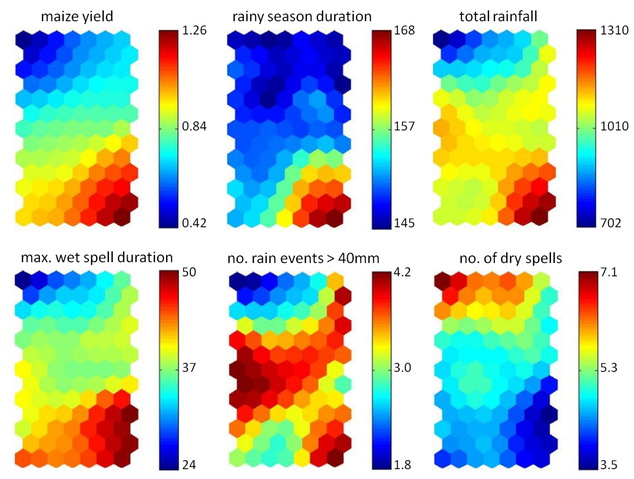

Fig. 4: Examples of SOM – component planes

Rainfall characteristics have a major importance in semi-arid regions; hence their effects on agriculture, groundwater recharge and flooding need to be further investigated. SRFE have been demonstrated suitable for analysis, even though a region-specific validation / bias-correction is necessary (especially for extreme events).

References

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