Propagation of precipitation uncertainties in water balance estimations

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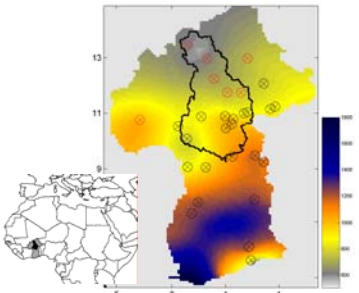


Long-term annual precipitation mean [mm] in Burkina Faso and Ghana; Location of the White Volta basin; available meteorological observation network (black circles) plus location of added stations with TRMM data (red circles)

INTRODUCTION

• Scientifically sound decisions in sustainable water management are usually based on hydrological modelling, which can only be accomplished with meteorological information. Particularly in developing countries where observation networks are coarse, the spatial interpolation is afflicted with uncertainties. This particularly applies to discontinuous variables like precipitation.

• The spatial variability of rainfall is often termed as the major source of uncertainty in investigations of rainfall-runoff processes and water balance estimations.

• The propagation of uncertainties, resulting from the calculation of areal precipitation from point measurements in water balance estimations, is of crucial importance for the prediction variation of hydrological behaviour. Hence,

1. Different spatial interpolation methods for areal precipitation are applied, and their impact on water balance estimates is analysed.

2. Geostatistical simulations using the turning method for areal precipitation are performed in order to investigate the propagation of consequential uncertainties in water balance estimations.

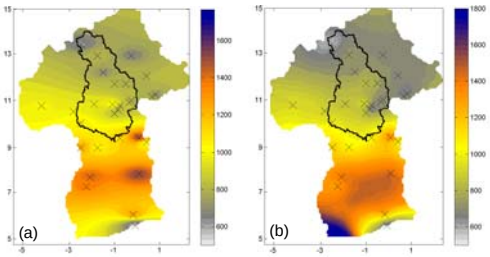
• The study area is the White Volta catchment (94 000 km2) in the semi-arid environment in West Africa, where precipitation intensities as well as annual rainfall amounts show a strong inter-annual and inter-decadal plus a spatially small scale variability.

APPLIED GEOSTATISTICAL METHODS ESTIMATING AREAL PRECIPITATION

• **Inverse distance weighting (IDW)**

• **Kriging: ordinary and external drift kriging (EDK)** (incorporating external knowledge in the calculation)

• Applied external drifts: digital elevation data, LAI, spatial distribution of annual precipitation, …



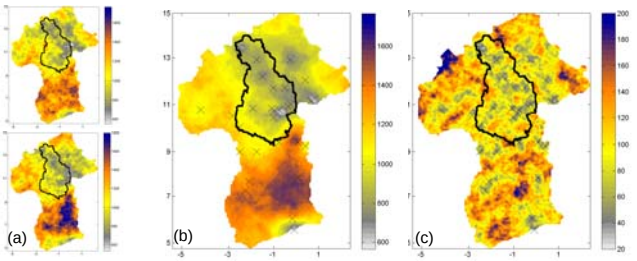
Annual precipitation [mm] for 2004 using (a) IDW, and (b) EDK with annual precipitation mean as external drift

➔ EDK supports spatial interpolation
➔ Kriging methods outperform IDW interpolation (cross validation comparison)
➔ Use of external drifts increases variance of areal precipitation fields
➔ TBs increase variance further

•**Turning band simulations (TBs)**:

• equally probable realizations with prescribed variability

• conditional simulations



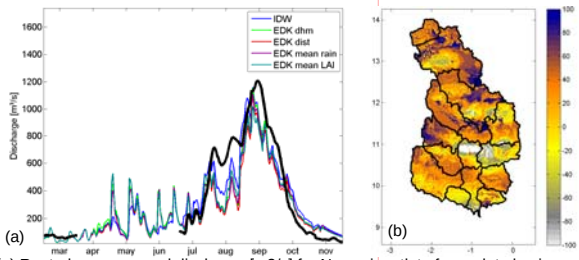
(a) Two random realizations, (b) mean, and (c) standard deviation of turning band simulations for annual precipitation [mm] for 2004

PROPAGATION OF PRECIPITATION UNCERTAINTIES IN WATER BALANCE ESTIMATIONS

• For hydrological simulations, the **Water balance Simulation Model WaSiM-ETH** (Schulla & Jasper, 2000) was used which is a deterministic, fully distributed modular model.

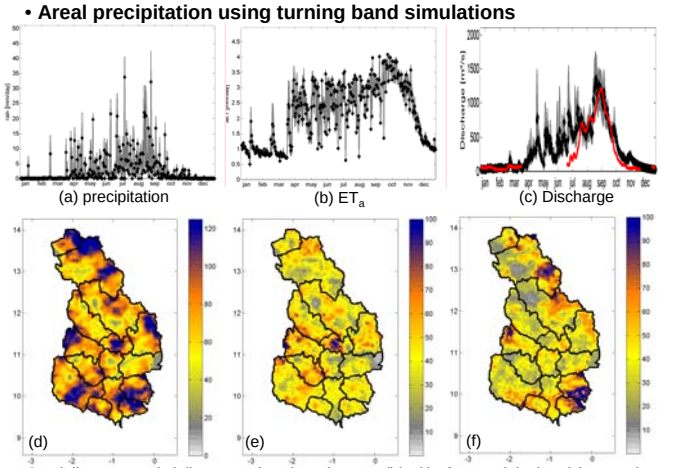
• The spatial resolution of this study is 1 × 1 km^2 which results in a regular grid of 411 × 631 grid points for the White Volta basin. The temporal resolution is 24 h.

• **Areal precipitation using IDW and Kriging results**



(a) Routed vs. measured discharge [m3/s] for Nawuni, outlet of complete basin (2004) using IDW and EDK with several external drifts as spatial interpolation methods for precipitation; (b) Spatial distribution of differences of total runoff resulting from the applied interpolation methods EDK (long-term mean annual rain) and IDW for areal precipitation

• **Areal precipitation using turning band simulations**



Spatially averaged daily range (grey) and mean (black) for precipitation (a), actual evapotranspiration (b), and discharge at Nawuni, outlet of complete basin (c) using all turning band simulation results; corresponding spatial distributions of standard deviation (d) to (f) [mm]

➔ The impact of the selected spatial interpolation method for areal precipitation on the temporal and spatial distribution of water balance variables is minor for spatially aggregated variables and the corresponding time series.
➔ However, the selected interpolation method affects the spatial distribution of water balance variables.

➔ Turning band simulations for precipitation provide ranges of the temporal and spatial distribution of water balance variables.
➔ Ranges are the consequence of uncertainties from the calculation of areal precipitation.
➔ Regions with higher uncertainties are clearly visible
➔ Routed discharge: Width of possible realizations depends on the location of the subcatchment and the uncertainties of the upstream subcatchments.

ACKNOWLEDGEMENTS

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