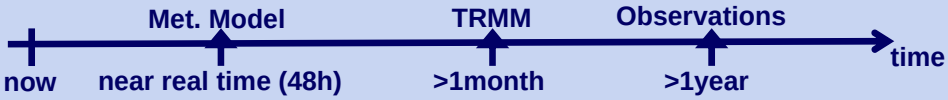
GLOWA Volta

Water balance in a poorly gauged basin in West Africa using atmospheric modelling and remote sensing information

Sven Wagner[1], Harald Kunstmann[1] & András Bárdossy[2]
[1] Institute for Meteorology and Climate Research (IMK-IFU), Forschungszentrum Karlsruhe, Germany
[2] Institute for Hydraulic Engineering, University Stuttgart, Germany

INTRODUCTION

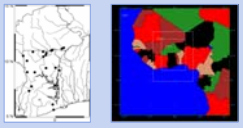
- Sustainable decisions in water resources management require scientifically sound information on water availability
- Central support in hydrological decision making arises from hydrological modelling which depends on meteorological input
- In poorly gauged basins (1) only little hydro-meteorological information is available and (2) station data are often only available with a considerable temporal delay and therefore unsuitable for near real time water management
- Hence, other near real time available meteorological data sources have to be used, which are in this study:



- Besides meteorological driving data, land surface properties are essential input data for distributed hydrological modelling
- Usually literature values of land surface properties are incorporated through tables depending on the land use
- Satellite derived land surface properties: increased level of detail in the spatial and temporal dimension
- MODIS products for albedo (Δt=16day, Δx=1km) and leaf area index LAI (Δt=8day, Δx=1km) are imported

Hydrological modelling using atmospheric modelling and remote sensing information

meteorological input
1. observation data
2. meteorological model: MM5
3. satellite data: TRMM 3B42



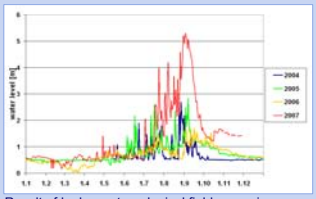
http://trmm.gsfc.nasa.gov/

hydrological model: WaSiM
Δx = 1 km, Δt = 24 h

- digital elevation model
- real time discharge values @ unknown inflows
- soil & land use grid
- soil & land surface properties
- …

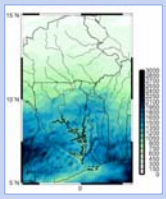
http://modis.gsfc.nasa.gov/

Information about spatial and temporal changes of water balance variables

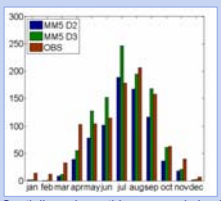


Result of hydro-meteorological field campaign: measured water level [m] at Yarugu from 2004 - 2007

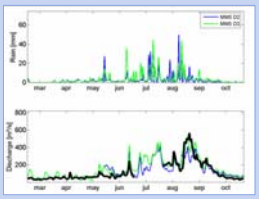
Results of the joint atmospheric-hydrological simulations

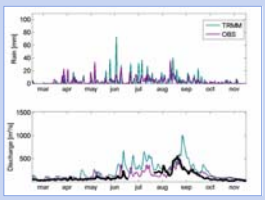


Simulated annual precipitation for 2004 [mm] for the Volta basin using MM5, 9x9km²



Spatially and monthly averaged simulated (MM5 D2 (27x27km²) and D3 (9x9km²)) vs. observed precipitation for 2004



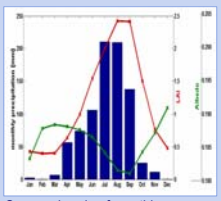


Precipitation and routed vs. measured (black) discharge at Pwalugu using the gridded, near real time MM5 results D2 (27x27km²) and D3 (9x9km²) - left figure, and the scaled TRMM product 3B42 and observations –right figure, as meteorological data sources (2004)

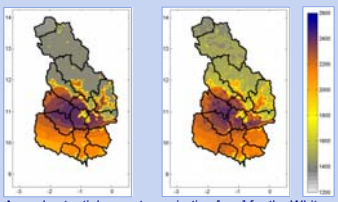
- MM5 is able to provide the required meteorological input data for near real time hydrological simulations
- comparable/better performance to TRMM & OBS
- WaSiM provides moreover distributed information of actual evapotranspiration, groundwater recharge, soil moisture, total runoff, …
- support short-term sustainable decisions in water resources management

Acknowledgements: The collaboration with the Hydrological- and Meteorological Services Department in Ghana and Dr. Conrad and Dr. Colditz from the Department of Geography, University of Wuerzburg is gratefully acknowledged.

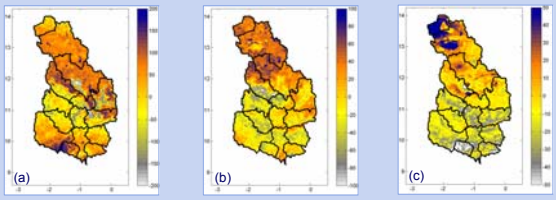
Assimilation of MODIS albedo and LAI



Seasonal cycle of monthly mean precipitation, LAI and albedo averaged over the White Volta basin (2004)



Annual potential evapotranspiration [mm] for the White Volta basin using static tabulated values (left) and dynamic MODIS estimates (right) for albedo and LAI (2004)



Differences [mm] of annual sums with MODIS albedo & LAI with respect to static tabulated for potential evapotranspiration (a), actual evapotranspiration (b), total runoff (c) for 2004

- MODIS albedo & LAI:
  - increased level of detail in spatial dimension & better representation of temporal development
  - all data are based on same data source & time
- hydrological simulation results: impact minor on time series, but clear on spatial distribution

References: Wagner, S., Kunstmann, H. Bárdossy, A., Conrad, C., Colditz, R., Water balance estimation of a poorly gauged catchment in West Africa using dynamical downscaling of meteorological fields and remote sensing information J. Phys.Chem. Earth (2008), doi:10.1016/j.pce.2008.04.002
Wagner, S., Kunstmann, H., & Bárdossy, A. 2006. Model based distributed water balance monitoring of the White Volta catchment in West Africa through coupled meteorological-hydrological simulations. Advances in Geosciences, 9, 39–44
Wagner, S. Water Balance in a Poorly Gauged Basin in West Africa Using Atmospheric Modelling and Remote Sensing Information, Dissertation