Rainfall-Runoff Processes in a Mixed Sudanian Savanna Agriculture Catchment: Use of a distributed sensor network

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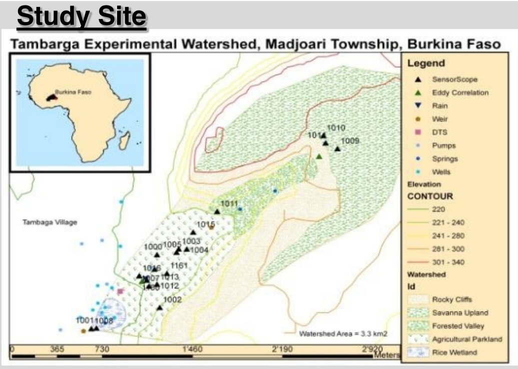
Study Site



Background

- ➢Tambarga catchment : 3.4 km² located in South-East of Burkina Faso
- ➢Elevation (200 m - 400 m) but majority either agriculture flat (200 m) or upper savanna (300 m)
- ➢Upper basin (2.4 km²) which is the main runoff producer, mixed trees and grass open savanna, lithosol rocky escarpement. Two permanent springs and several seasonal springs.
- ➢ Lower basin(1 km²) : flat, sparse agroforestry trees,millet and rice agriculture, soil vertisols, sandy loam only one permanent spring close to the river.
- ➢Annual rainfall > 700 mm, maximum discharge 0 .6 m³/s

Overall goal

Understand the hydrologic processes including surface runoff, base flow mechanisms and the effect of erosion on discharge, under pressure for agricultural expansion.

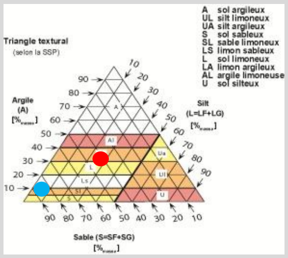
Method

To achieve our goal, the Tambarga subwatershed was instrumented to measuring hydrological, meteorological and soil data at high spatial and temporal resolution. Data were acquired with advanced research equipment such as SensorScope environmental monitoring stations, two weirs, fiber-optic distributed temperature sensing cable (DTS), three-dimensional sonic anemometers and open path infrared H2O/CO2 gas analyzers. SensorScope relies on a distributed multihop network of autonomous meteorological stations which route data through the GSM network to a central data base accessible over the web in real time.

Water balance

$$n\frac{dz(t)}{dt} = R(t) - I(t) - Q[s(t),t] - E[s(t)] - L[s(t)]$$

n = porosity
Zr = active soil depth
$I(t)$ = canopy interception
$L[s(t)]$ = lekeage
$Q[s(t)]$ = runoff
$S(t)$ = relative soil moisture



Upper basin

Lowerbasin

SensorScope station

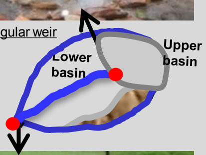
Data collected

- Wind speed & direction
- Solar radiation
- Air temperature
- Air humidity
- Rain gauge
- Surface tempeurature
- Soil moisture

Discharge measure with salt dilution method

Weirs on field

Triangular weir



Mix triangular-rectangular weir

Eddy fluxes station

Rn = net radiation
H = sensible heat
LeE = latent heat
G = ground heat
q = specific humidity
W = vertical wind
T = air temperature
p = air density

Application

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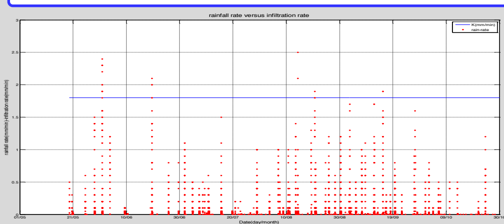
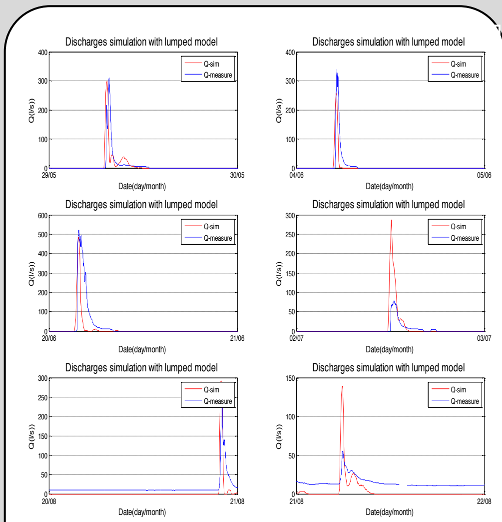
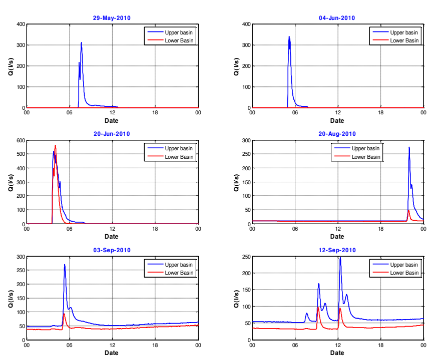
Results





Lower basin

The simulation of runoff looks promissing for the beginning of the rainy season when the soil is dry but it overestimates when the season is completely established with a permanent stream flow.



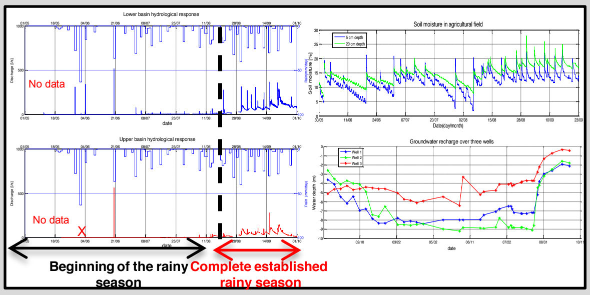
On the upper basin

The hydrologic response is observed to have a single peak over the course of the season. This could be linked to the soil characteristic.

On the lower basin

The hydrologic response is observed to shift between two forms over the course of the dry season. At the start of the rainy season, when the soils are very dry, a typical single-peak hydrograph is observed that evolves into a double-peak hydrograph when the rainy season is completely established. The first peak occurs during the storm, caused by rainfall excess, and the second peak is due to the delayed subsurface flow.

Reference : Mutza C.Masiyandima and al,2003. The hydrology of inland valleys in sub-humid zone of West Africa: rainfall-runoff processes in the Mbé experimental watershed. Hydrological Processes 17,1213-1225



Conclusion

- ➢ Different responses of upper and lower basin to rainfall
  - One single peak over the entire season for upper basin
  - Shift between a single peak and double peaks for lower agricultural basin
- ➢The concentration time (tc) of upper basin is greater than the lower basin. Infiltration in lower basin is greater than upper one.
- ➢More than 90% of rainfall is infiltrated,
- ➢Important contribution of groundwater to stream flow generation.
- ➢The simulation model gives some good results for start of season but overestimates after season established.

Future work

- Complete lumped model calibration
- Simulate and compare Lumped and distributed models
- Water balance
- Study the spatial and temporal variability of rain and evaporation.