VALIDATION OF REMOTELY-SENSED SOIL MOISTURE IN THE ABSENCE OF *IN SITU* SOIL MOISTURE: THE CASE OF THE YANKIN BASIN, A TRIBUTARY OF THE NIGER RIVER BASIN

Djigbo Félicien BADOU

B. DIEKKRÜGER , E. KAPANGAZIWRI, A. A. AFOUDA

Hotel Africana, 28/10/2016

Background (1/3)

Civil engineering

Climate forecasting

Flood/drought forecasting

Agricultural production

Erosion

Livestock

Hydrological modelling

Soil moisture

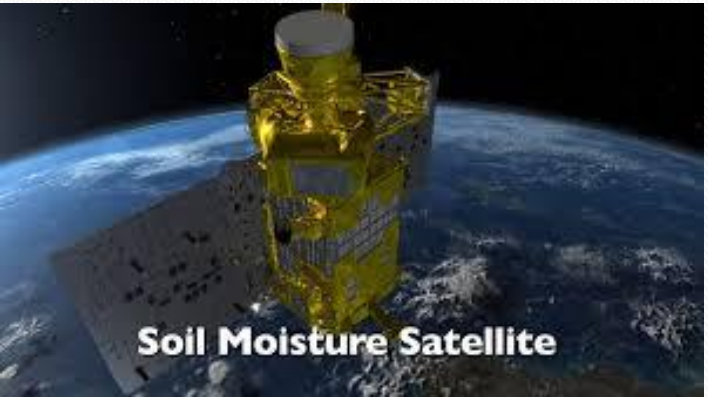
Livelihood

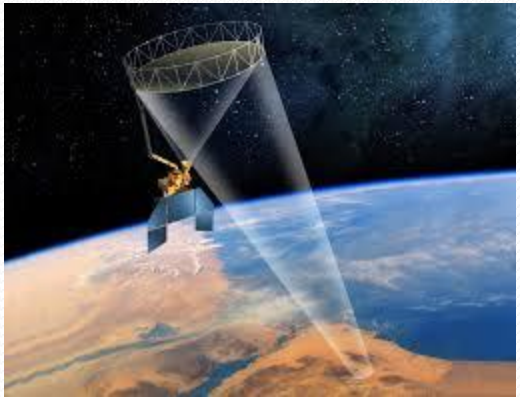
Key component of the environment to be considered in our endeavour to meet the SDGs

Background (2/3)

- Acquisition of soil moisture information?

In situ





Remotely-sensed

Background (3/3)

Tab.1: Pros and cons of in situ and remotely-sensed SM

	In situ	**Remotely-sensed**
Affordability	Cost, time-consuming, destructive	No free but cost benefit analysis
Spatial scale	Point scale	Large scale
Temporal scale	Few days/months	Long term
Applications	Limited	Unlimited

Research questions

- How reliable are satellite soil moisture? What is the quality of these data, especially with respect to clouds cover?

- How do we check the quality of these data **especially in *in-situ* data scarce regions**?

Objective

Test the validity of remotely-sensed soil moisture without *in situ* soil moisture.

Methodology:

Use of hydrological modelling for the validation of satellite data

Calibrate and Validate hydrological models having a detailed soil moisture routine using streamflow.

Multi-model evaluation

Extraction of simulated SM (proxy) of the most behavioural solutions.

Multi-objective validation

Comparison of simulated SM (proxy) with satellite SM

Multi-objective validation

Case study: The Yankin Basin

The Yankin basin

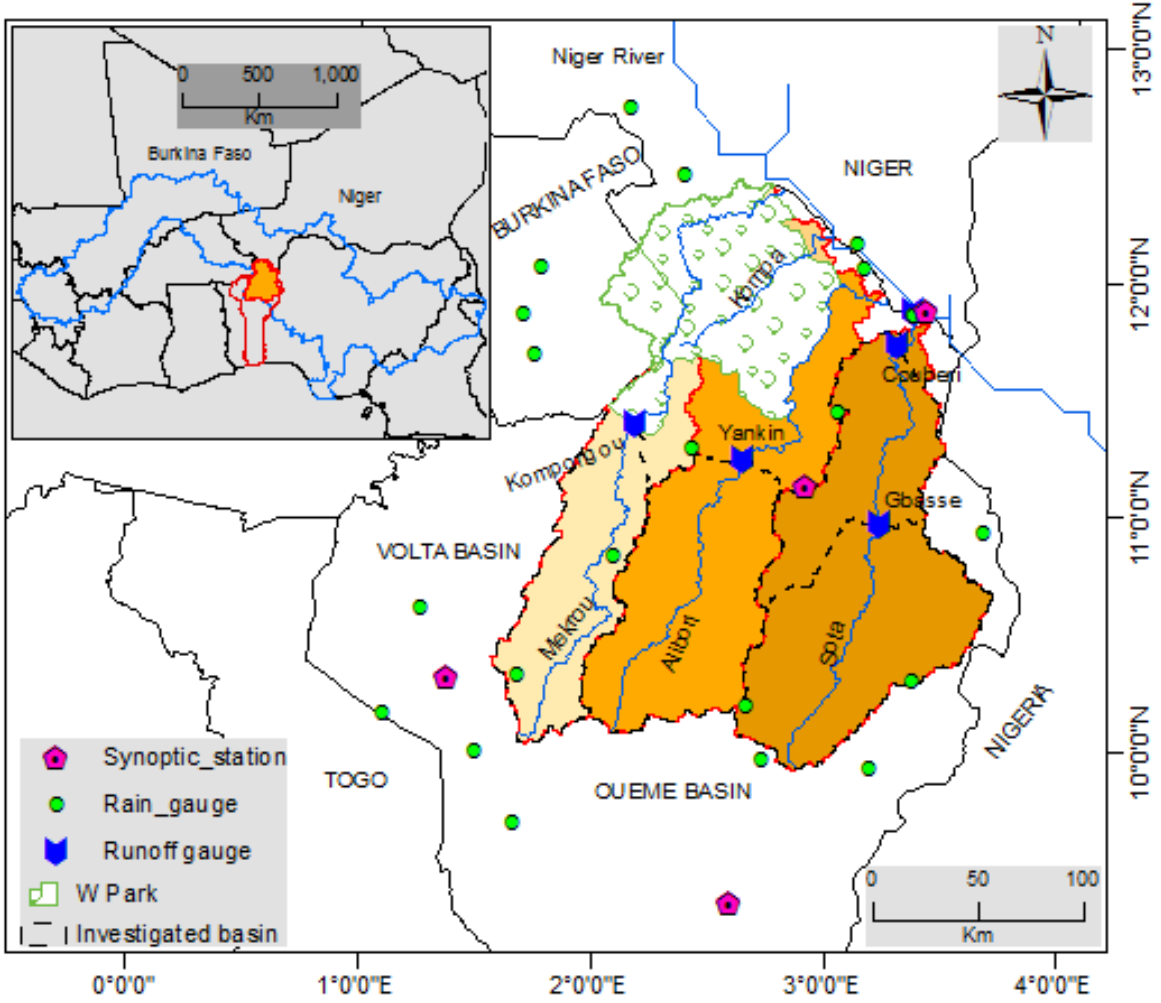


Fig.2: Location of the study area in the Niger River basin.

- Provides lot of ecosystem services (W-Park, forests, etc.) under threat
- Largest cotton production zone (INSAE, 2014)
- Main zone of cattle breeding (ditto)
- Clashes between farmers and herdsmen (Lougbegnon, 2012)

Data used

Tab. 2: Summary of the data collected and used for the study

Data	Resolution (scale) / Time period	Relevance	Sources
Climatic	16 stations / 1971-2010		DMN Benin,
Topographic	30 x 30 m	Delineation of HRU, topographic parameters	ASTER GDEM
Land use	1:50,000 / 1979, 1995, 2006	HRU delineation, root depth, leaf area index, albedo, interception factor, etc.	CENATEL
Soil	1:200,000 / 1978	Texture, bulk density, hydraulic conductivity, etc.	ORSTOM
Streamflow	01 station / 1984-2008	To generate proxy	DGEau
Soil moisture	**0.25°x 0.25° Topmost 2 cm** / 2005-2008		ESA-CCI

Models used (1/3)

- **UHP-HRU** (Giertz et *al.*, 2010)
- Conceptual, semi-distributed for assessing all hydrological processes
- Soil moisture simulated for the root and unsaturated zone
- 17 parameters but 9 were calibrated

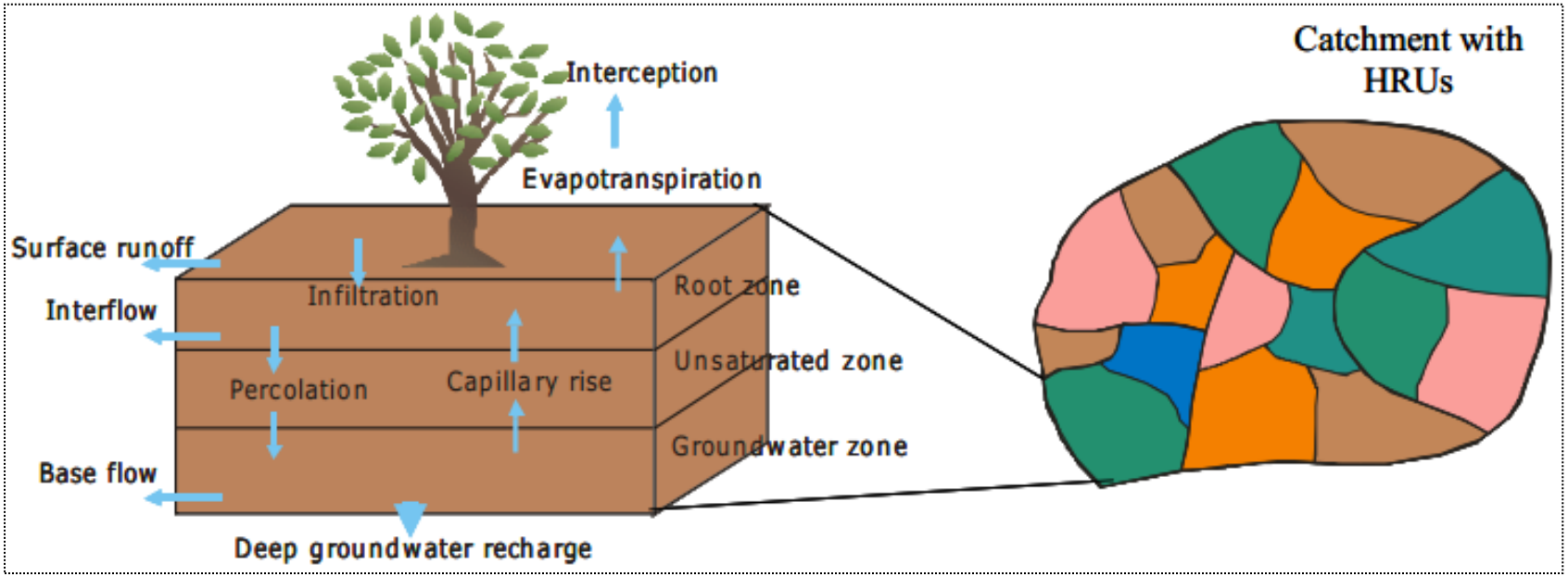


Fig.3: Modelling flow chart of the UHP-HRU model

Models used (2/3)

- SWAT (Arnold et *al.*, 1998) based on the concept of HRU

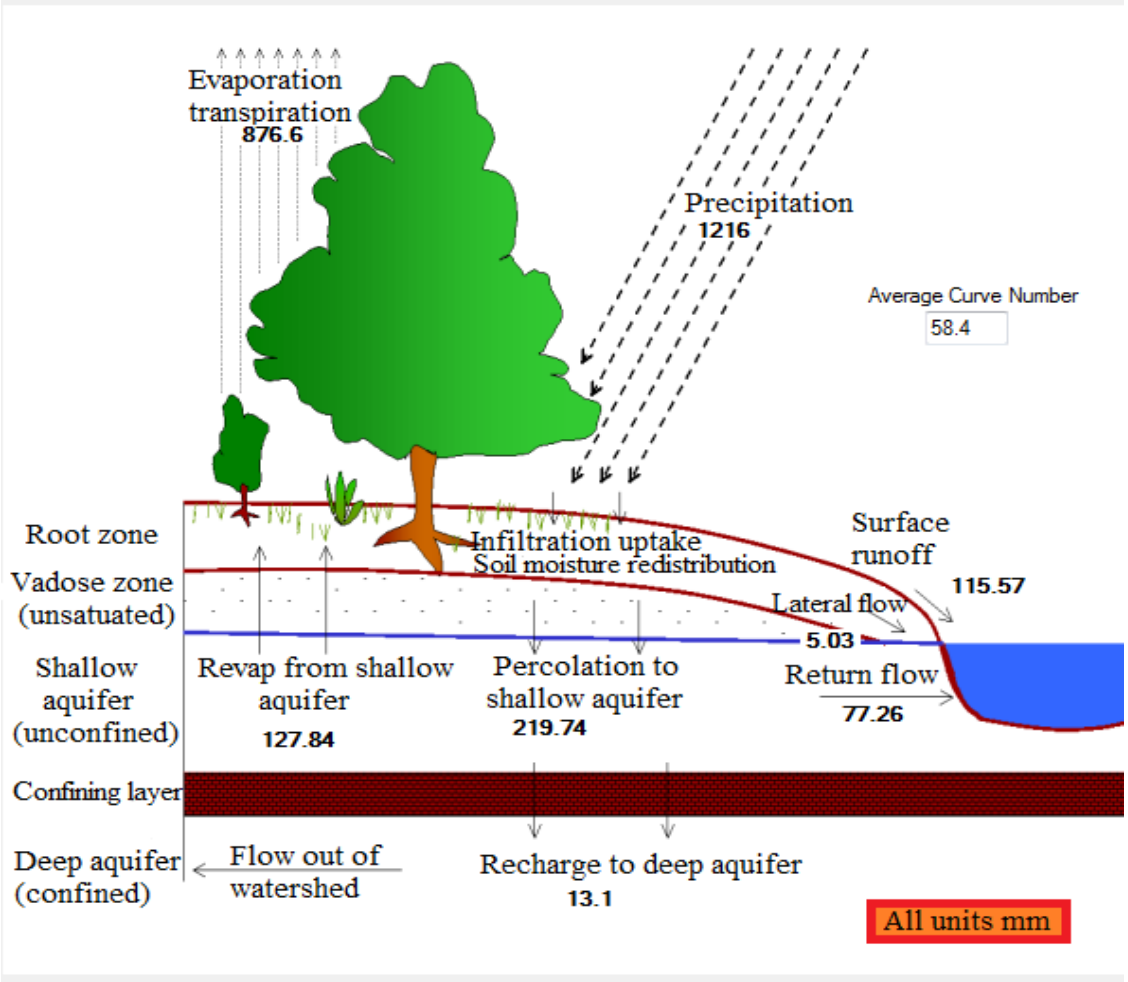


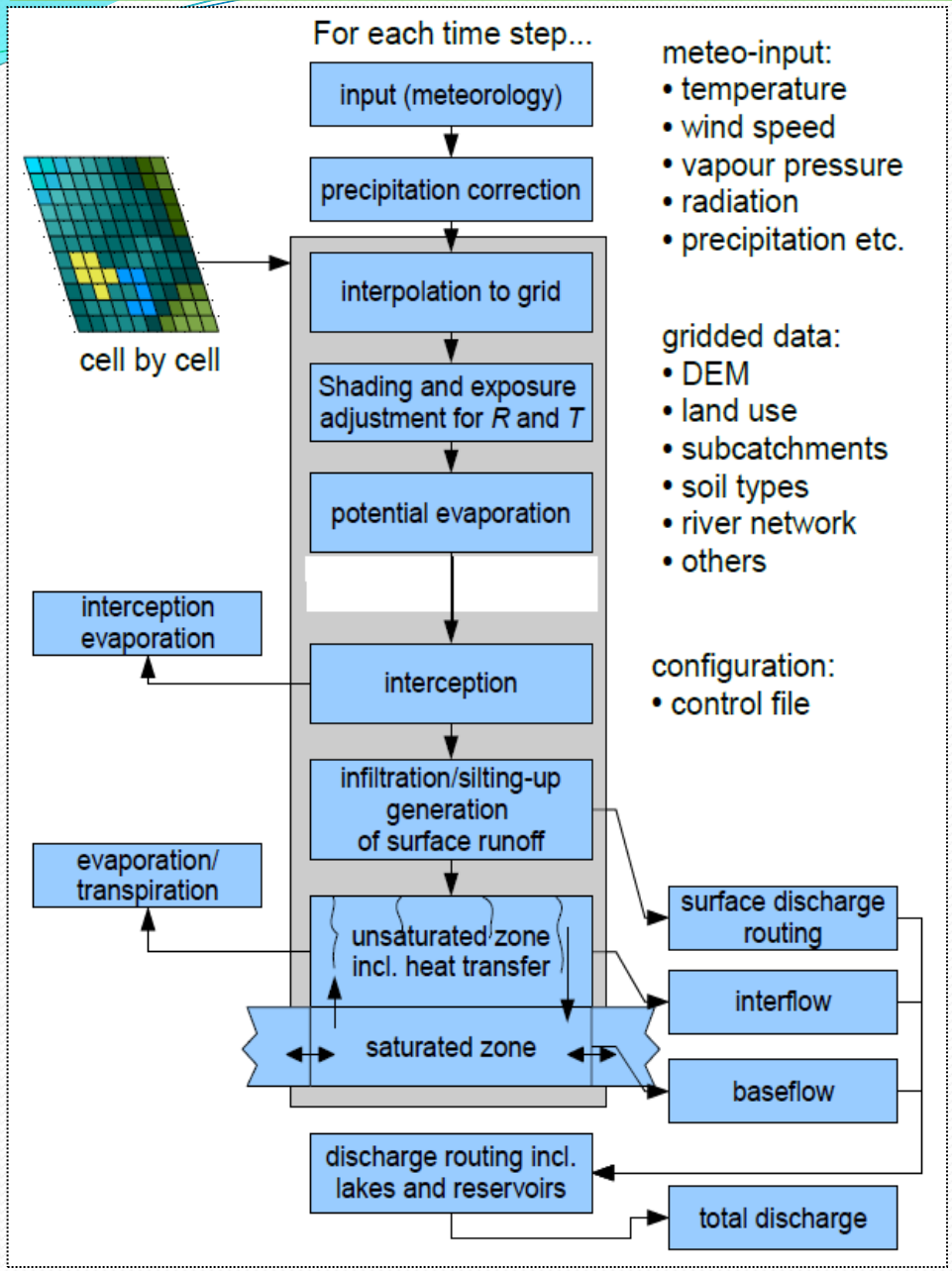
Fig.4: Flow chart of the SWAT model

- Conceptual, semi-distributed model for assessing the impacts of climate, land use and agricultural practices on water quality, water quantity and sediment.

- <u>Soil moisture is simulated for the entire soil depth</u>

- 16 parameters calibrated for each LU and soil types

Models used (3/3)



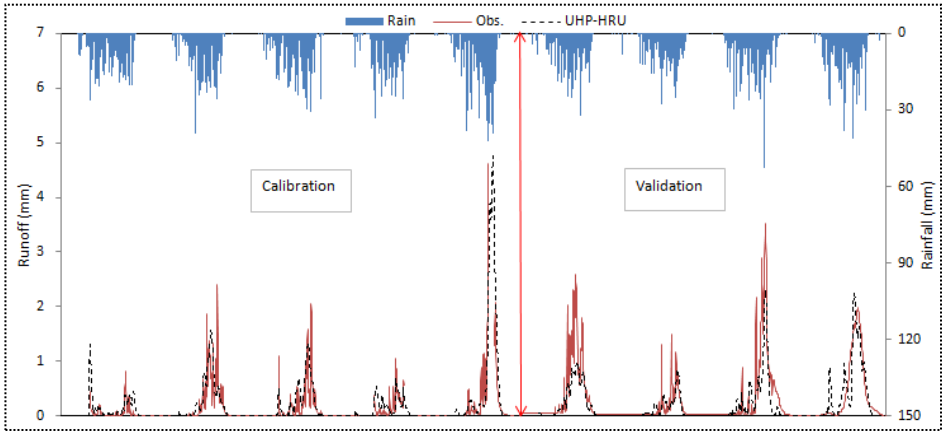
- **WaSiM** (Schulla, 1997)
- Deterministic, physically-based and **distributed** model
- Two main versions:

  Topmodel and the version using the **Richards-equation**
- Vertical soil moisture extraction for desired soil depth
- 9 parameters calibrated for each land use and soil types

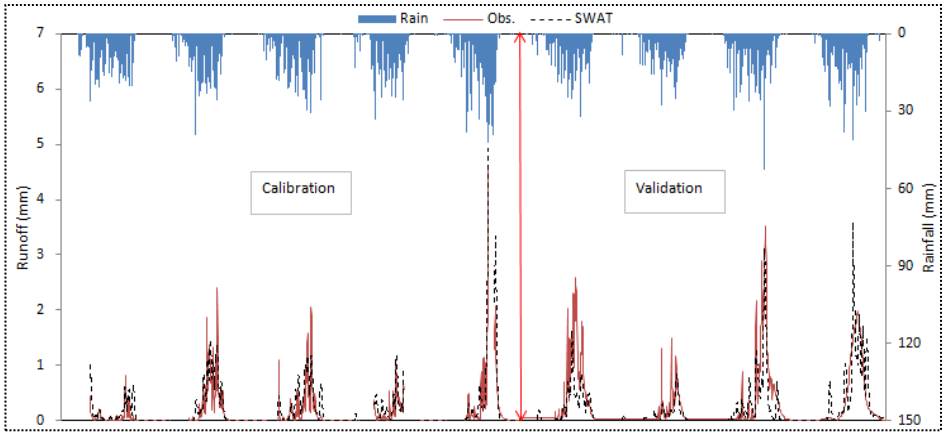
Fig.5: Structure of the WaSiM model

Results and Discussion

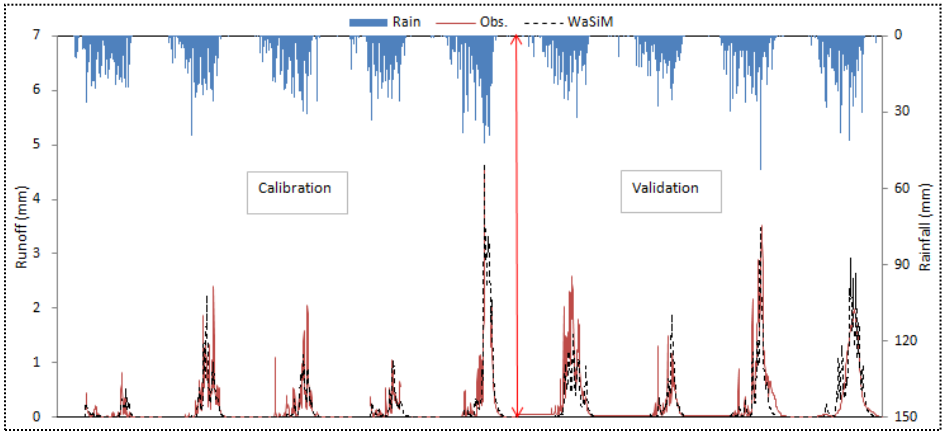
Models calibration/validation and extraction of SM



UHP-HRU	Calibration	Validation
NSE	0.51	0.66
KGE	0.66	0.59
R^2	0.57	0.68
absPBIAS	23	**25.2**

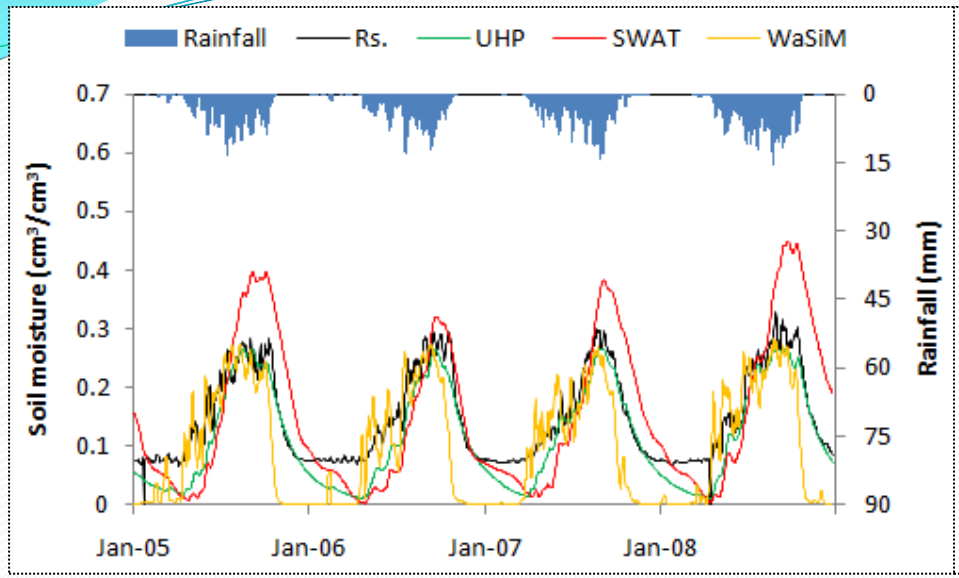


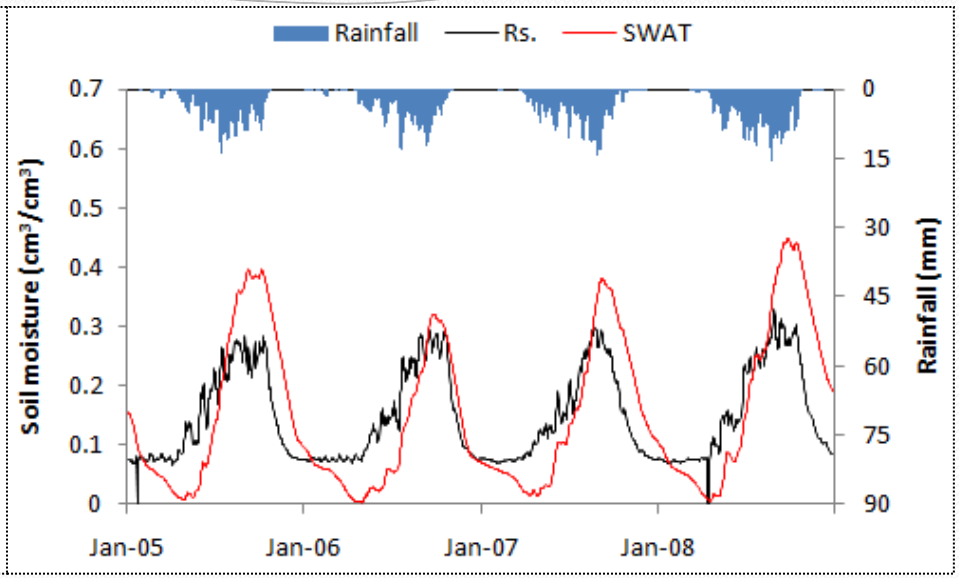
SWAT	Calibration	Validation
NSE	0.63	0.57
KGE	0.52	0.63
R^2	0.77	0.59
absPBIAS	**41**	22.9

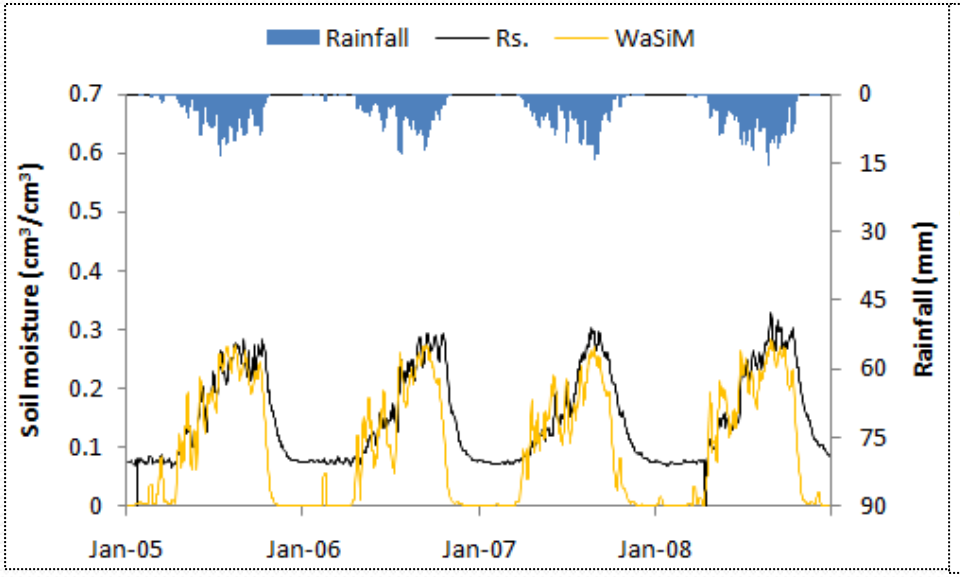


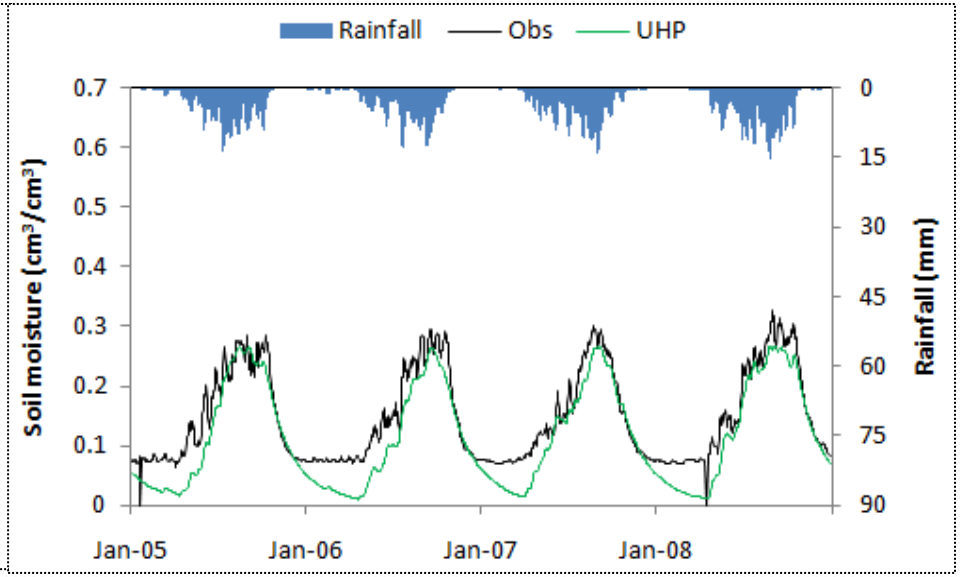
WaSiM	Calibration	Validation
NSE	0.65	0.69
KGE	0.77	0.81
R^2	0.73	0.71
absPBIAS	9.8	8.8

Comparison with Satellite SM: Visual inspection









Comparison with Satellite SM: Quantitative metrics

Tab.: Comparison of remotely-sensed and simulated SM for the period 2005-2008

	UHP	**SWAT**	**WaSiM**
Simulated SM (cm^3/cm^3)	34.40	45.77	29.52
Remotely-sensed SM (cm^3/cm^3)	42.85	42.85	42.85
Bias (cm^3/cm^3)	**0.030**	**-0.010**	**0.048**
R^2	**0.83**	**0.57**	**0.54**

- Remotely-sensed SM is reliable

Conclusion and Future Work

- Proxy for the validation of satellite SM was generated using streamflow data;
- A multi-model approach and multi-objective validation were applied in generating the proxy;
- The ESA-CCI soil moisture dataset can be used for impact studies in study area;
- To evaluate the robustness of the suggested methodology, more research on areas of different climatic conditions and variable (e.g. AET) is needed.

- A physically-based extraction of the simulated soil moisture for SWAT and UHP-HRU. Modification of the structure of SWAT and UHP-HRU to enable the extraction of the topmost soil moisture.

Acknowledgements

- WASCAL Initiative
- Institution who provided the data
  - Meteorological office of Benin, Niger, and Birkina Faso
  - Benin Water Directorate, Benin
  - Research Center Jülich, Germany

- UNDP

WEBALE NYO for your attention!

Dominant processes per basin

	Coubéri	Gbasse	Yankin	Kompongou
UHP-HRU	B>S>I	B>S	B>S	B >I
SWAT	S>B	S>I	S>I (small)	S>B (small)
WaSiM	S>I	I>S	I>S	I >S

- Possible reasons: Paucity of data i.e. four streamflow gauges for an area of 39,726 Km^2 (Badou et *al.*, 2016) and
- Data quality (e.g. use 1997 rating curves for the Sota River).


Boiffo, Malanville
14/01/2014 11:37 AM


Gninkoka, Banikoara
29/01/2014 11:21 AM


Gorobani, Kerou
21/02/2014 11:36 AM


Karimama


Alibori river bed
26/01/2014 01:32 PM


Lougou, Segbana
21/03/2014


Guimbererou, Pehunco
25/02/2014 09:46 AM


Biro, Nikki
01/03/2014 04:50 PM


Guenelaga, Segbana
21/03/2014


Boiffo, Malanville
14/01/2014 11:37 AM


Gninkoka, Banikoara
19/01/2014 11:21 AM


Gorobani, Kerou
21/02/2014 11:36 AM


14/01/2014 11:58 AM


14/01/2014 08:23 AM


18/03/2014

Pictures 2


Guimbererou, Pehunco
25/02/2014 09:46 AM


Biro, Nikki
01/03/2014 04:50 PM


Guenelaga, Segbana
21/03/2014