Towards water stress indicators in sub-Saharan West-Africa using high resolution optical satellite data

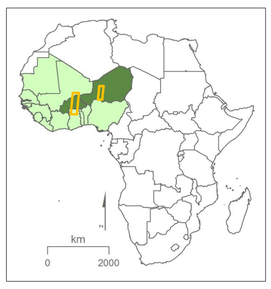
Linda Moser
German Remote Sensing Data Center, German Aerospace Center (DLR), 82234 Oberpfaffenhofen, Germany

Introduction

Sub-Saharan Africa, particularly the **Sahel** region, has been found to be vulnerable to climate change and variability, and has suffered severe **droughts** in the m**id-1970s**, **mid-1980s** and the **last ten years**, among them in 2012. Particularly in drought years, water stress situations (here considered as **critical lack of available water for livelihoods**) are likely to occur towards the end of the dry season, where **pastoralists**, **farmers**, and **villagers** depend on **water availability in surface water bodies** and water points. Increasing **population growth**, **climate change** and **land use change** effects could foster future severe or more frequent water stress events.

Towards indicators related to water stress events?

Water Stress = Critical lack of available water for livelihoods



Study Area:

- West-African **Sahel** region
- Focus on **Burkina Faso** and **Niger**
- High resolution studies in transects (orange boxes): Central Burkina Faso & Tahoua region, Niger

Livelihoods:

- **Pastoralism, farming** (95% rain-fed)
- High dependence on surface water (dry season)

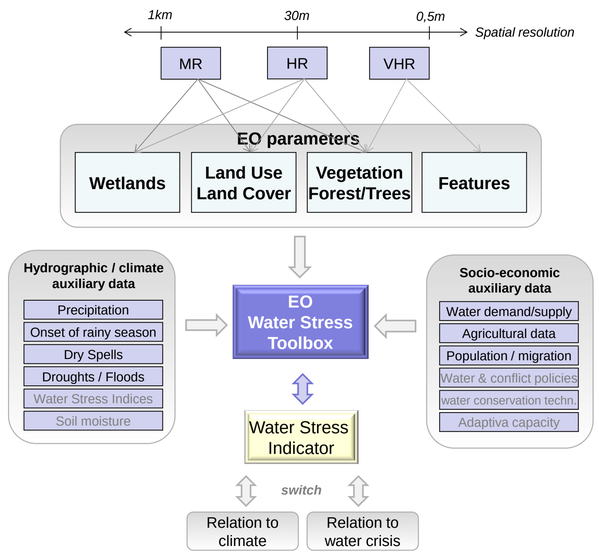
Motivation from a remote sensing perspective:

- **Historical satellite images** (since 60s/70s/80s)
- **Time series** of satellite imagery (available for 10…20…30 years)

Novel remote sensing approaches:

- **Explanation** of **trends** & **hot spots** (derived by time series analysis of medium resolution data) on **higher spatial scale**
- **Seasonal dynamics** with **high spatial resolution**
- Approach **indicating** water stress from **satellite data** shall be tested

Water Stress Indicator scheme



Wetlands and Land Use

Land use change:

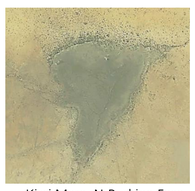
! More crops - more water needed
! No vegetation - no food - hunger crisis
! Conflict of farmers vs. pastoralists

Degradation by pastoral use
© U. Gessner (Okt, 2011)

Trees in agricultural fields, alive (above), dead (down), © M. Brandt, Univ. of Vienna

Wetland change:

! Water source for settlements
! Water source for pastoralists
! Small irrigation areas for crops

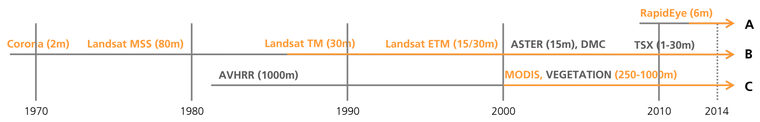


Kissi Mare, N-Burkina Faso
©Google Earth (Spot5, 2012)

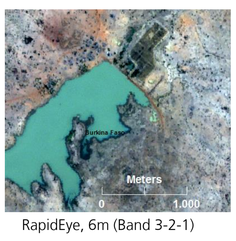
Wetland, regulated by dam , irrigated agriculture, © U. Gessner (Okt, 2011)

Satellite Data

Multi-scale approach



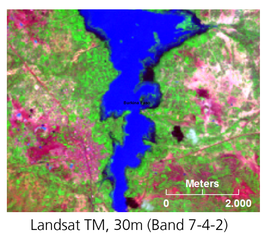
A
Seasonal / inter-year HR monitoring and change detection (2009 – 2014)



RapidEye, 6m (Band 3-2-1)

A) New RapidEye data (6m resolution, 5 bands) and TerraSAR-X ScanSAR data (15m) is acquired between 2012 and 2014.

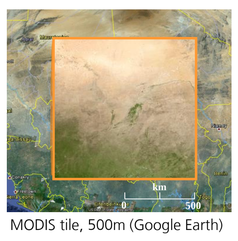
B
Decadal HR image-to-image change detection (1970 – 2014)



Landsat TM, 30m (Band 7-4-2)

B) The Landsat archive from 1972-2012 (USGS & ESA) is exploited. ASTER images can fill major gaps. Historical Corona imagery (1960s) and newly acquired RapidEye data are used for change detection.

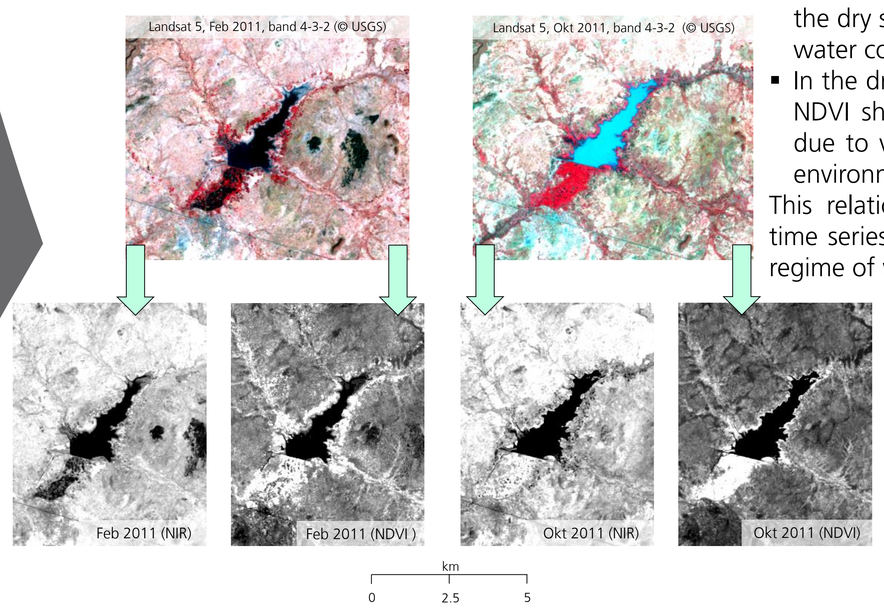
C
Decadal and seasonal change detection of MR time series (1981 – 2014)



MODIS tile, 500m (Google Earth)

C) MODIS Vegetation indices and reflectance products are used for time series analysis (2000-2014).

Strong Seasonality



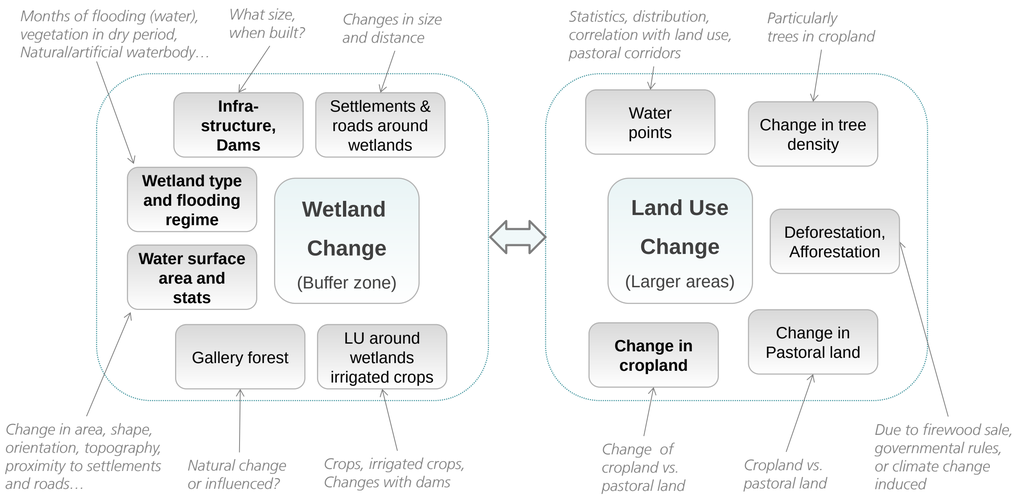
Making use of strong seasonal changes:
Two Landsat 5 images: Febr2011 (dry season), October 2011 (end of wet season)

- In the rainy season the inundated area is larger then in the dry season. NIR reflectance can be used as proxy for water covered area.
- In the dry season the water covered area is smaller. The NDVI shows high values on the edge of the wetland due to vegetation that contrasts with the surrounding environment.

This relationship can be applied to medium resolution time series data as well in order to monitor the flooding regime of wetlands.

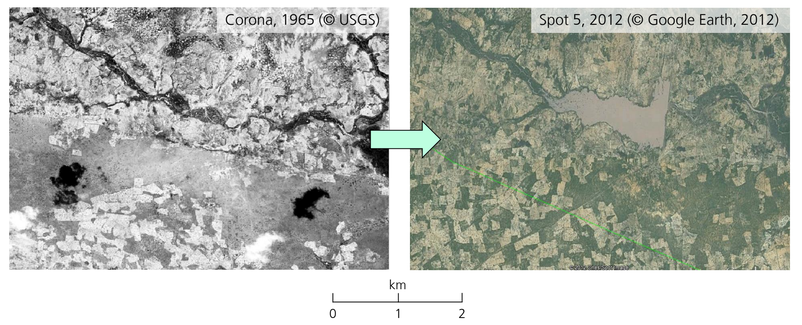
Methodology & Analysis

Wetland and land use change indicators

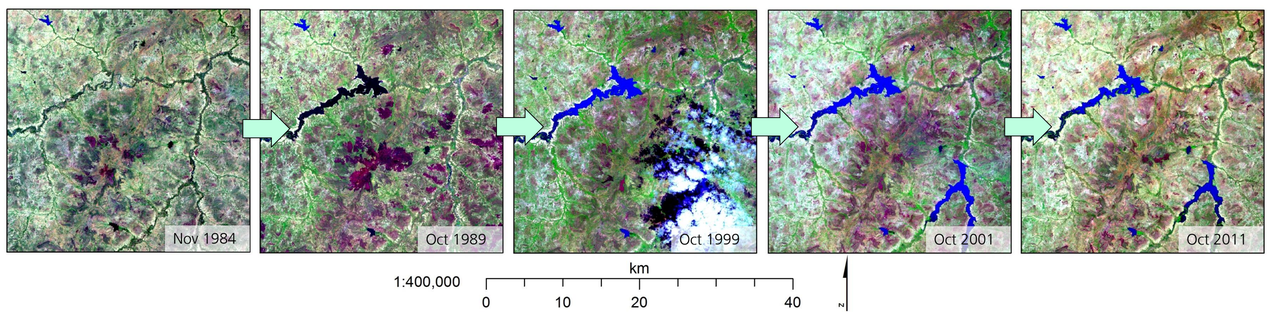


Environmental Change (1965 – 2012)

Land use change (1965-2012) in the North of Burkina Faso: Strong growth of agricultural areas and deforestation are visible when comparing historical Corona and recent Spot 5 imagery. The construction of a dam might have strongly influenced the land use in this area.



Land use change (1984-2011) using two Landsat time series: Landsat TM and ETM time series (Oct/Nov: end opf rainy season, Feb/Mar: end of dry season) are used to investigate land use changes. The evolution of two water bodies created by dams is shown in an Oct/Nov time series.



Conclusions & Outlook

Topical Challenge:

- Wetland and LULC change are most promising indicators
- Interdisciplinary project, small-scale processes not well documented
- No direct replacement of water stress index parameters (socio-political, hydrological) with EO possible

Data challenge:

- Huge data amount needed, though region relatively data-scarce (continuous data)
- Spatial data requirements: frequent HR imagery needed → TerraSAR-X (present), Sentinel-2 (future)
- Seasonal variability (high temporal data requirements → MODIS (13y into past and present)
- Difficult to find reference data, link to water scarcity

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Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Contact: linda.moser@dlr.de
www.gionet.eu - www.dlr.de/eoc - www.zki.dlr.de

Deutsches Fernerkundungsdatenzentrum
DLR Oberpfaffenhofen
D-82234 Wessling
Internet: www.dlr.de/eoc

German Remote Sensing Data Center