Wetland Monitoring Using Dual-Polarized X-Band Data of Lac Bam, West Africa

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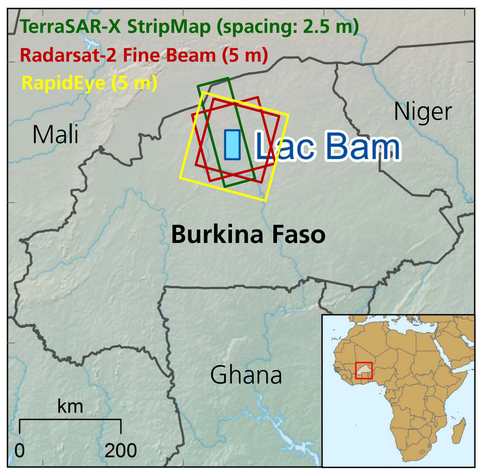
Flooded vegetation in the lake (approx. 100m from shoreline)


Open sediment-rich water

Wetland Monitoring of Lac Bam, Burkina Faso

Study Area: Lac Bam / Data: TerraSAR-X



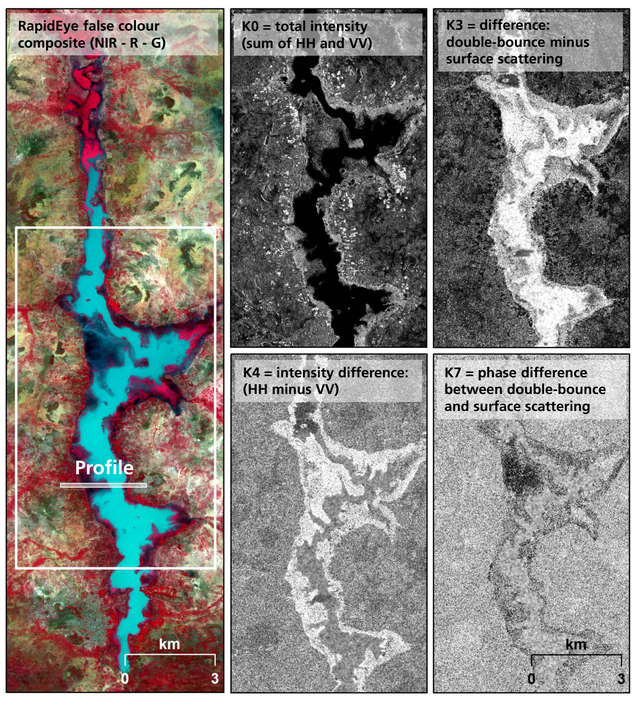
Study Area:

- **Lac Bam,** Burkina Faso, West Africa, Ramsar wetland of international importance
- **Semi-arid Savannah/Sahel**, rainy season: May – Sep (~600 mm/y), prone to droughts
- **Dependence on surface water**: irrigated farming, pastoral corridors (animal watering), fishery, domestic use (settlements)

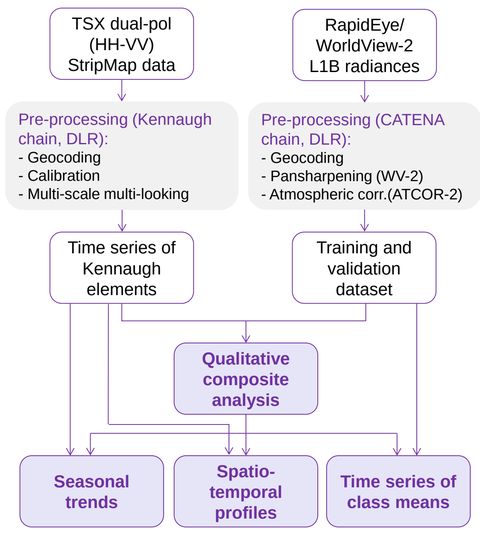
Data:

- **TerraSAR-X** (X-band SAR): HH-VV dual polarized, pixel spacing 2.5m, temporal interval: 11 days (time series August 2013 – April 2014)
- **RapidEye** (multispectral): 5 bands (B, G, R, redEdge, NIR), pixel spacing: 5m, temporal interval: irregular every ~2 months

Kennaugh Elements



Workflow

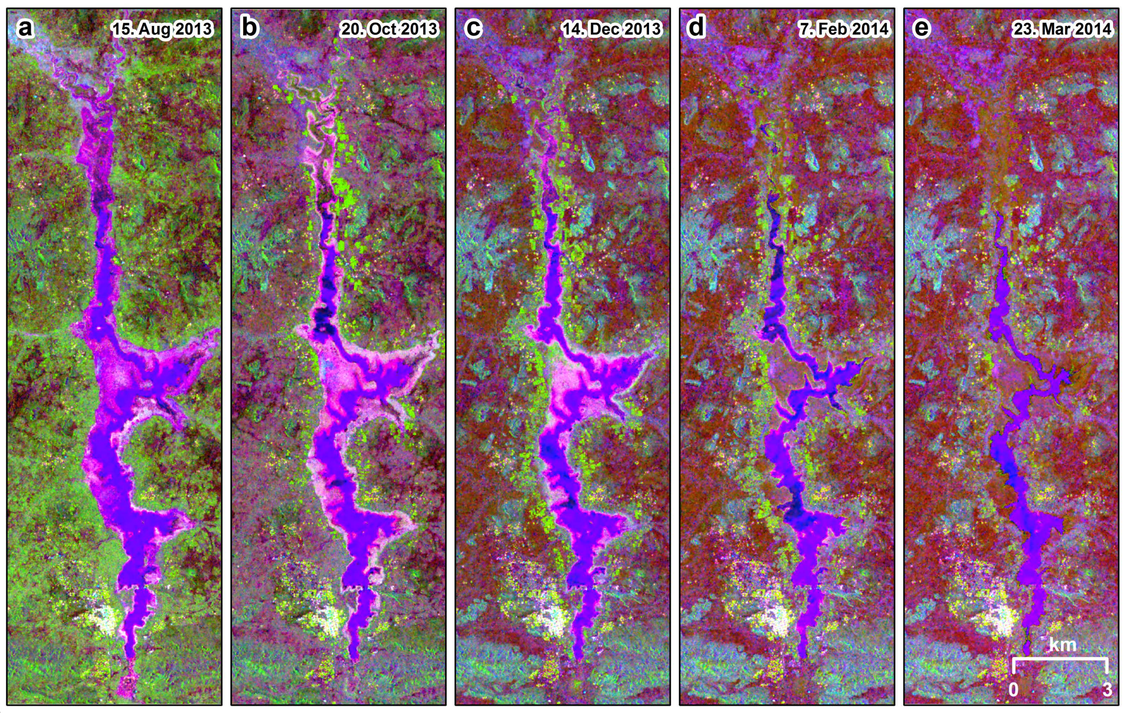


Objectives

- Monitor **open water** and **flooded/floating vegetation**
- **Temporal variability** of time series of Kennaugh elements

Temporal analysis of Kennaugh Elements from polarized SAR data

Water and Flooded Vegetation Dynamics

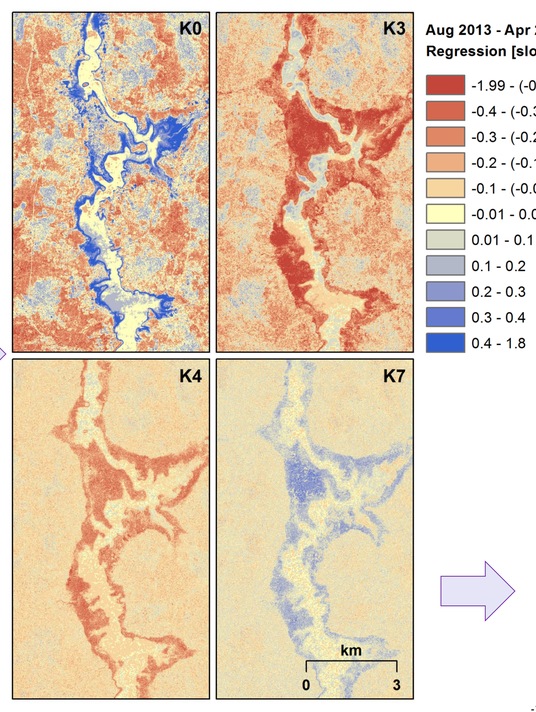


Time series of Kennaugh elements (K3 – K0 – K4), showing open water (blue), flooded and standing vegetation (pink), and vegetation and fields (green): 5 selected images with intervals between 1.5 & 2 months:

- **R = K3:** difference between double-bounce and surface scattering
- **G = K0:** total intensity (sum of HH and VV)
- **B = K4:** difference between HH and VV intensity

Open water is displayed in blue, with blue colours indicating a dominance of HH over VV backscatter. Green colours appear where the sum of the surface intensity of HH and VV is particularly strong, and pink colours are dominant where double-bounce scattering dominates over surface scattering, such as in the areas of flooded vegetation. (Data source: DLR, Figure source: Moser et al., 2014).

Seasonal Trends



Pixel-based linear regression for each Kennaugh element: Positive slope (blue), negative slope (red). Temporal intervals (11 days) from the rainy season (15 Aug 2013) until end of dry season (14 Apr 2014).

- Open water → soil (K0 pos.)
- Flooded vegetation → soil (K3 & K4 neg., K7 pos.)
- Flooded soil → soil (K7 pos.)
- Natural vegetation (K0 & K3 neg.)
- Urban, rock, soil (K0 & K3 stable)

Kennaugh Decomposition (Schmitt et al., 2015):

$$K_0 = \frac{1}{2}\{|S_{HH}|^2 + |S_{VV}|^2\}$$

$$K_3 = -Re\{S_{HH}S_{VV}\}$$

$$K_4 = \frac{1}{2}\{|S_{HH}|^2 - |S_{VV}|^2\}$$

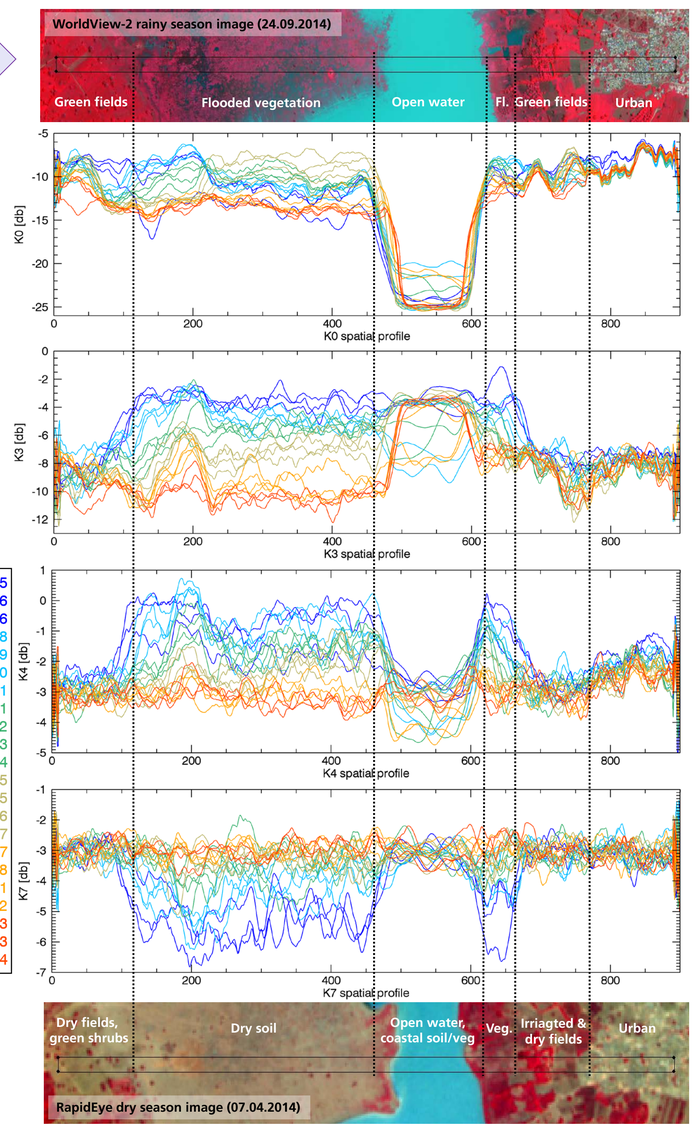
$$K_7 = Im\{S_{HH}S_{VV}\}$$

- Normalized Kennaugh elements related to total intensity
- Kennaugh matrix (based on 4-dimensional Stokes vector)
- K0, K4: Intensity-based
- K3, K7: Real and imaginary part of inter-channel correlation

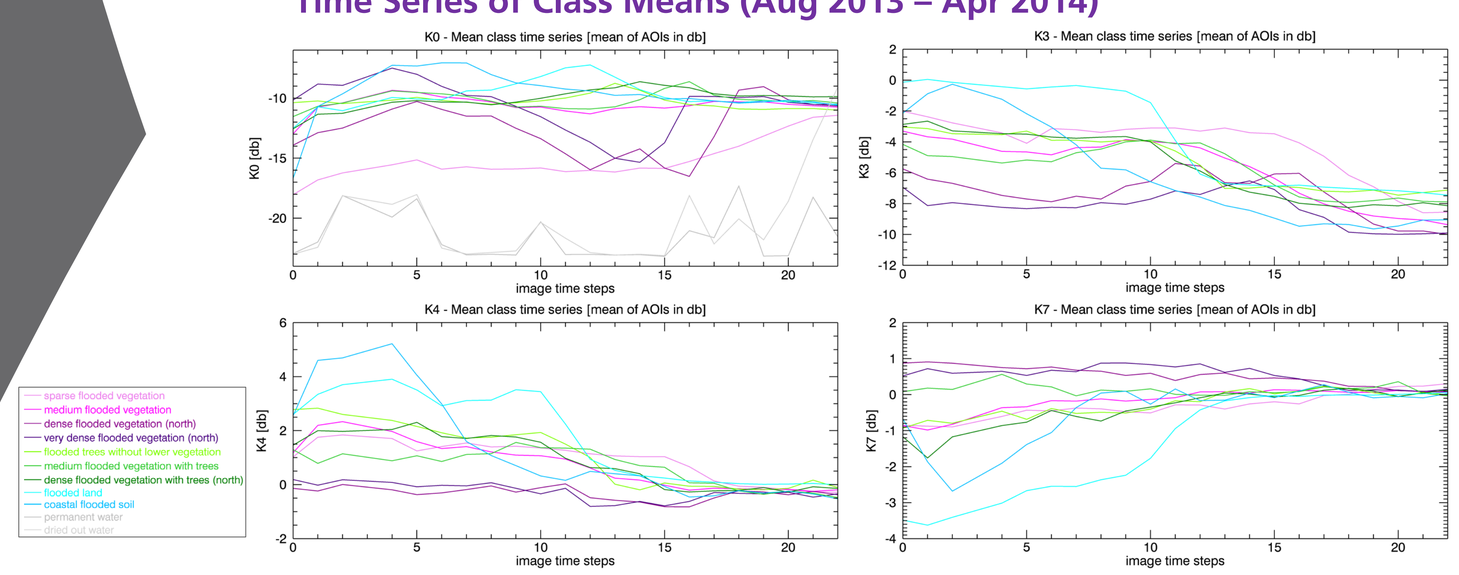
Spatio-temporal profiles: Variability or stability in terms of seasonal development (from blue, over green, beige to red) is shown for all four Kennaugh elements over a spatial profile with different land cover characteristics, as displayed in optical WorldView-2 (start: rainy season) and RapidEye (end: dry season) images. 20 TSX pixels were vertically ageraged and profiles were further smoothed.

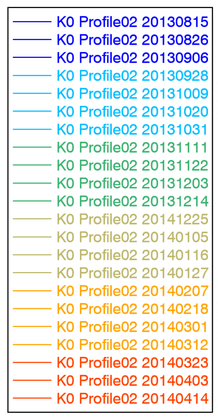
- **Open water** can be best extracted from K0, showing the shrinking water surface over time.
- **Flooded vegetation** shows a high seasonal variability from higher to lower db-values in K3 and K4, complementary to K7.
- **Features on land** show smaller variability, urban areas appear most stable.

Spatio-Temporal Profiles



Time Series of Class Means (Aug 2013 – Apr 2014)





Conclusions

- **Kennaugh elements time series extraction** → enables monitoring of open water, and flooded, standing and floating vegetation in water
- **Seasonal trend** → detects pos/neg backscatter trends of seasonal develpment (rainy to dry season)
- **Time series of class statistics** → seasonal curves characterize time and magnitude of class changes (rainy to dry season)
- **Spatio-temporal profiles** → shows variability/stability of classes in terms of seasonal development of each Kennaugh element over a spatial profile of different land cover characteristics,
- **Advantages** of **multi-polarized SAR data** → over single-polarized SAR intensity data
- **Future work** → 2 seasons of TSX, 1 season of Radarsat-2 (C-band) acquired in two different orbits, RapidEye time series

References:

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