Das Potenzial von Sentinel-1 Zeitreihen für die Landnutzungs- und Veränderungskartierung am Beispiel Waldmonitoring und REDD

Project Sentinel4REDD and beyond...

PD Dr. C. Thiel, M. Urbazaev, F. Cremer
Friedrich-Schiller-Universität Jena
Lehrstuhl für Fernerkundung
Motivation
The wood stack on the photo contains approx. 1,000,000 m³. It is 60 m wide, 16 m high, and more than 2 km long. The storm “Gudrun”, which hit southern Sweden in January 2005 fell approx. 75,000,000 m³, which is almost the annual cut in Sweden. Photo: Ola Nilsson
Sentinel4REDD – Objectives

- Utilization of high temporal coverage of Sentinel-1 and Sentinel-2 data to delineate forest cover, forest cover change and degradation
- Achieve a high degree of automation for near real time mapping
- Achieve a high map product quality to generate useful information for decision makers
- Generate generic processing chains that allow for the replacement of EO input data
Sentinel4REDD – Methods

1. Delineation of multitemporal metrics using S1/2 data

2. Adaptation of BFAST algorithm to SAR data to separate trends and changes from periodic component (decomposition of temporal signal)

3. Idea beyond Sentinel4REDD: Development of new multitemporal speckle filter
Sentinel4REDD – Sites: Mexico (Hidalgo and Kiuic)
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Ref. Data:
- LiDAR
- Inv. Data (INFyS)
- Super-Site data
- VHR Pleiades data

...
Sentinel4REDD – Sites: RSA (KNP – Skukuza)
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Ref. Data:
LiDAR data
Inventory data
TLS data (by FSU)
In-situ savannah vegetation measurements during several field campaigns (by FSU)
VHR Pleiades data
...

Idea: Development of Multitemporal Speckle Filter

- Why?
Idea: Development of Multitemporal Speckle Filter

- Why?
- State-of-the-art speckle filters tend to equalize the multitemporal signatures
- Maintain the original (maximum) geometric resolution
Idea: Development of Multitemporal Speckle Filter based on Empirical Mode Decomposition (EMD)

- EMD decomposes signal into several independent mode functions (IMF) representing different frequencies of change
- Frequency decreases with increasing IMF number
- Sum of all IMFs (and IMF residual) equals original backscatter value
- EMD applicable for non-stationary signals
Idea: Development of Multitemporal Speckle Filter based on Empirical Mode Decomposition (EMD)

Sentinel-1a hypertemporal data cube (60 images, Kiuic)
Dots represent one selected pixel
First assessment of potential of EMD Speckle Filter

- Stack of 48 images over Thuringia
- 10/2014 – 09/2016
First assessment of potential of EMD Speckle Filter
First assessment of potential of EMD Speckle Filter

one image out of 48
First assessment of potential of EMD Speckle Filter

one image out of 48
First assessment of potential of EMD Speckle Filter

ENL Agriculture

ENL Forest

ENL: Equivalent number of looks
First results based on multitemporal metrics
First results based on multitemporal metrics

Kiuic, Mexico (60 S-1 VV images)
First results based on multitemporal metrics

Backscatter VV [dB], 28.09.2015

Hidalgo, Mexico
First results based on multitemporal metrics

Backscatter VV [dB], 28.09.2015

Hidalgo, Mexico

5%-Quantile/Median/98%-Quantile
(all 29 images from 2015)
First results based on multitemporal metrics

Kiuic, Mexico (60 S-1 VV images)
First results based on multitemporal metrics

Backscatter VV [dB], 28.09.2015

Hidalgo, Mexico

5%-Quantile/Median/98%-Quantile
(all 29 images from 2015)
First results based on multitemporal metrics

Overall accuracy > 85% (Random forest classification, training based on LiDAR data)
Potential of EMD for REDD+ monitoring

• “BFAST-like” approach
Potential of EMD for REDD+ monitoring

Kiuic, Mexico

Forest
Non-forest

Each line represents one pixel of an 9×9 kernel
Potential of EMD for landcover monitoring

Each color represents one pixel

IMF 0 – 4
Forest
Potential of EMD for landcover monitoring

Each color represents one pixel

IMF 0 – 4 Agriculture
Skukuza (KNP)
TLS data 2016

Christian.Thiel@uni-jena.de
Literature


Empirical Mode Decomposition

- Similar to Fourier analysis, but suitable for non-stationary data
- Break the temporal signal into multiple Intrinsic Mode Functions (IMF)

- Properties of the IMFs:
  - Number of extremas and zero crossings differ at most by one
  - Mean value of the minimal and maximal envelopes is zero
Hypertemporal C-band SAR data (Sentinel-1A/-1B)

Pre-processing (topographic, radiometric corrections, geocoding)

Calculation of multi-temporal metrics (mean, sd, p5..95)

Airborne LiDAR

Vegetation Height (DEM-CHM)

Forest mask extraction: Tree height > 2m, tree cover > 20%

Optical Pléiades

Forest / Non-Forest Mapping (e.g., Random forests and further machine learning methods)

Validation (visual interpretation)

Forest map