Potential of Sentinel-1 time series for deforestation and forest degradation mapping in temperate and tropical forests

Sentinel4REDD

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Sentinel4REDD

Developing new methods for REDD+ (Reducing Emissions from Deforestation and Forest Degradation)

Based on hyper-temporal Sentinel-1 and Sentinel-2 data
Local partners

Mexico

South Africa

CONAFOR

CSIR

York Timbers
Multi-temporal speckle filter
New speckle filter

Temporal decomposition
Discard high-frequent part
Filter in time domain
Preserve spatial resolution

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Empirical Mode Decomposition
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Empirical Mode Decomposition

1. Detect the local extrema of the original dataset $x(t)$
2. Compute a spline $s_{\text{min}}, s_{\text{max}}$ through the local minima and maxima, respectively
3. Compute the mean of $s_{\text{min}}$ and $s_{\text{max}}$ and subtract it from $x(t)$
4. $h_{1,k}(t) = x(t) - \frac{s_{\text{min}} - s_{\text{max}}}{2}$
5. Repeat the previous steps with $h_{1,k}$ as $x(t)$ until $h_{1,k}$ suffice a stopping criteria. Then $h_{1,k}$ is the first IMF $c_1(t)$ of $x(t)$
6. Repeat the steps 1 to 4 with the difference between $x(t)$ and $c_1(t)$ until there is no IMF to extract, i.e. the remaining signal has at most one extremum
Empirical Mode Decomposition (EMD)

Decomposition of the S1 time series of a 3x3 matrix into the intrinsic mode functions (IMF). All graphs correspond to broadleaved forest.
Speckle filter
based on temporal information only

ENL Forest VH

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Sentinel-1 time series analysis
Sensor: Pleíades

Location: Central Mexico
Temperate forests

24. Okt 2016

23. Okt 2017
Sentinel-1
Temperate forests
162 VV-backscatters
20 m resolution
Sentinel-1
Temperate forests
162 VV-backscatters
EMD-filtered
20 m resolution
Sentinel-1
Temperate forests
110 VH-backscatters
EMD-filtered
20 m resolution
Tropical dry forests
Sentinel-1
Tropical dry forests
95 VV-backscatters
20 m resolution
Sentinel-1
Tropical dry forests
95 VV-backscatters
EMD-filtered
20 m resolution
Tropical dry forests
84 VH-backscatters
EMD-filtered
20 m resolution

Sentinel-1

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Deforestation mapping
forest plantations
Bayesian conditional probability (Reiche et al. 2015, 2018)

Past observations

- $s_{1,t-2}$
- $s_{NF,t-2}$

Current observation

- $s_{2,t-1}$
- $s_{NF,t-1}$

Future observations

- $s_{2,t}$
- $s_{NF,t}$
- $s_{1,t+1}$
- $s_{NF,t+1}$
- $s_{2,t+2}$
- $s_{NF,t+2}$
- $s_{2_{t+n}}$

1. **Sensor specific forest (F) and non-forest (NF) pdfs**
2. **Multi-sensor time series observations (Input)**
3. **Deriving and combining time series of conditional non-forest probabilities (Step 1)**
4. **Normalised conditional non-forest probabilities**
5. **Iterative Bayesian updating of the conditional probability for deforestation using previous and future observations (Step 2)**

Reiche et al. 2015
Summary / next steps

1. New multi-temporal speckle filter
2. Speckle suppression without losing spatial details
3. Time series analysis of VV and VH backscatter intensities
4. Analysis of multi-temporal statistics (mean, std, RQA) for mapping (see poster)

• Testing approaches for breakpoint detection in time series
• Inclusion of Sentinel-2 time series
• Results validation
• Capacity building for local partners
Thank you