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

Sentinel4REDD

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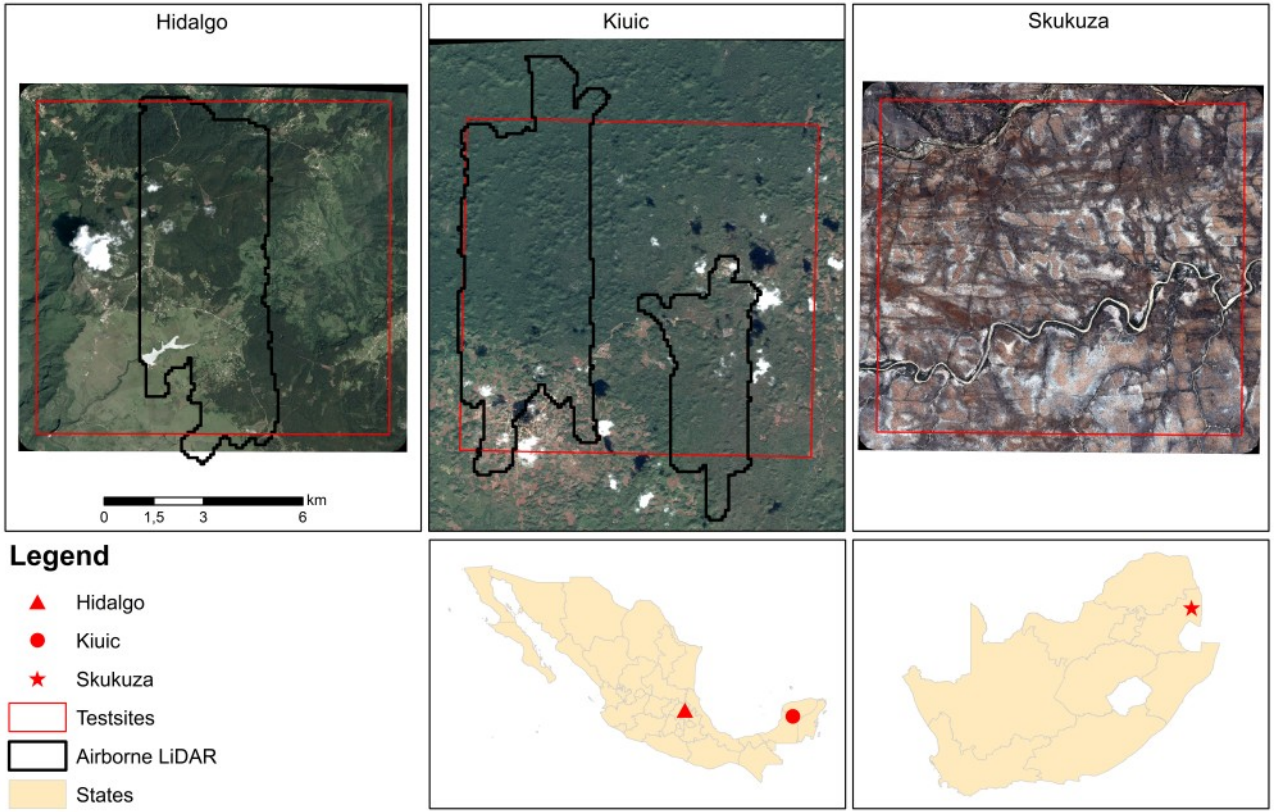
Sentinel4REDD

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

CONAFOR
COMISIÓN NACIONAL FORESTAL

South Africa

CSIR
our future through science

YORK TIMBERS

Multi-temporal speckle filter

New speckle filter

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

This article has been accepted for inclusion in a future issue of this journal. Content is final as presented, with the exception of pagination.

An Image Transform Based on Temporal Decomposition

Felix Cremer, Mikhail Urbazaev, Christian Berger, Miguel D. Mahecha, Christiane Schmullius, and Christian Thiel

***Abstract*—Today, very dense synthetic aperture radar (SAR) time series are available through the framework of the European Copernicus Programme. These time series require innovative processing and preprocessing approaches including novel speckle suppression algorithms. Here we propose an image transform for hypertemporal SAR image time stacks. This proposed image transform relies on the temporal patterns only, and therefore fully preserves the spatial resolution. Specifically, we explore the potential of empirical mode decomposition (EMD), a data-driven approach to decompose the temporal signal into components of different frequencies. Based on the assumption that the high-frequency components are corresponding to speckle, these effects can be isolated and removed. We assessed the speckle filtering performance of the transform using hypertemporal Sentinel-1**

compared with the sensing wavelength [2]. In most remote sensing applications based on SAR imagery, speckle is considered as disturbing noise that should be reduced to obtain images allowing for classic and proven information extraction techniques. Therefore, speckle filtering is a common preprocessing step. A comprehensive overview of monotemporal speckle filters is given in [3]. The backscatter response of a resolution cell is influenced by geometric and dielectric properties of the surface [4]. If we are tracking one resolution cell in time, temporal changes of the geometric and dielectric properties cause variations of the speckle. For instance, changes of the geometric properties can be related to vegeta-

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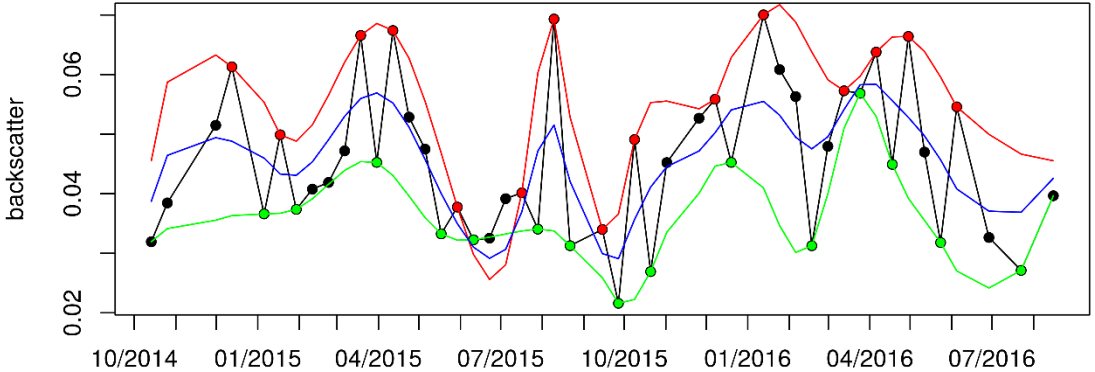
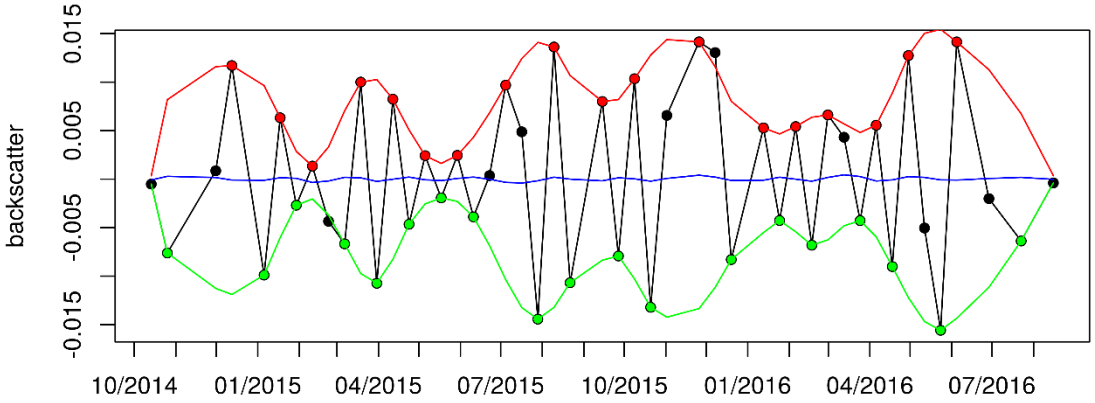
Empirical Mode Decomposition



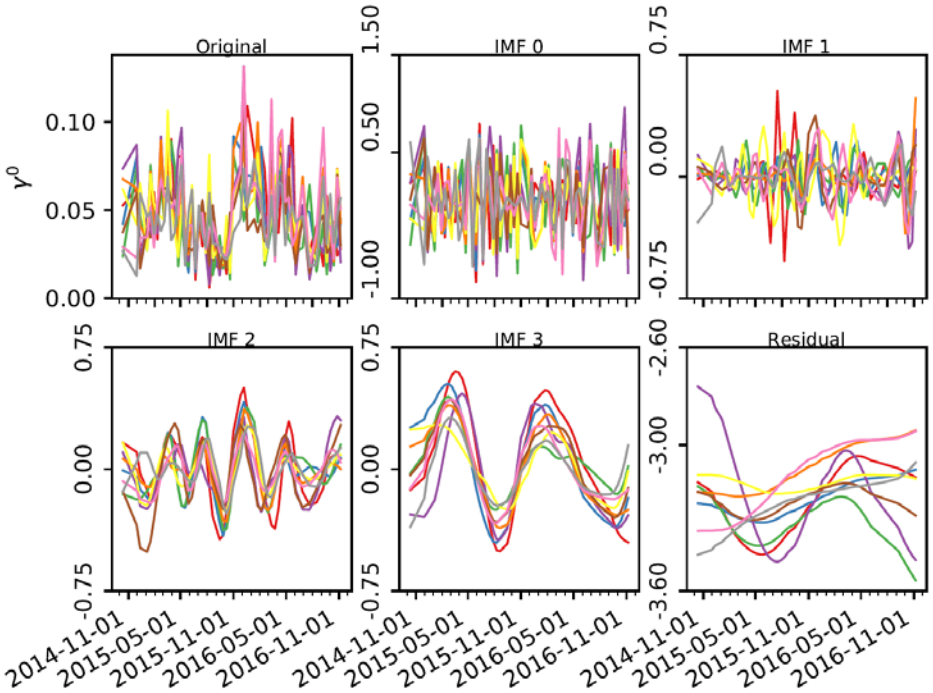
Empirical Mode Decomposition



Empirical Mode Decomposition

1. Detect the local extrema of the original dataset x(t)
2. Compute a spline s_{min},s_{max} through the local minima and maxima, respectively
3. Compute the mean of s_{min} and s_{max} and subtract it from x(t)
4. $h_{1,k}(t) = x(t) - \frac{s_{min} - smax}{2}$
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

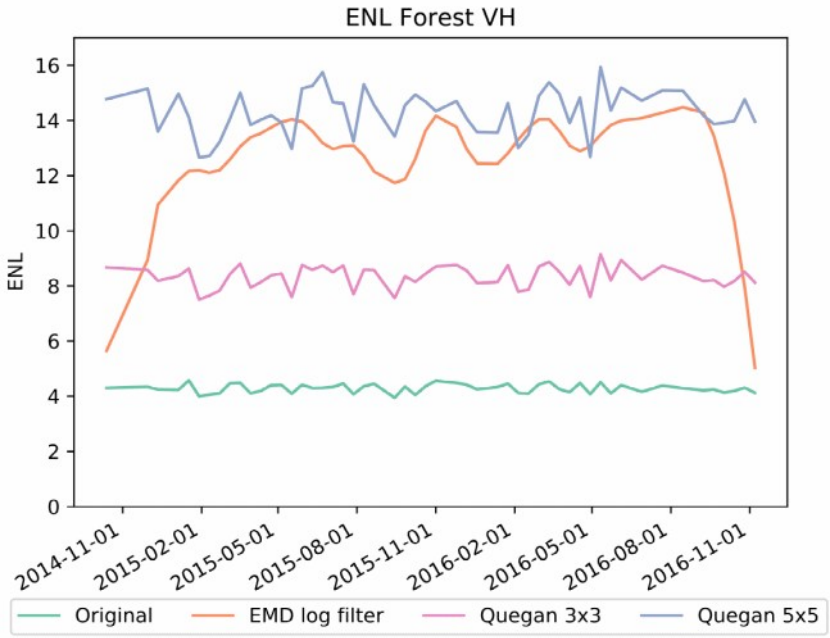
Empirical Mode Decomposition (EMD)

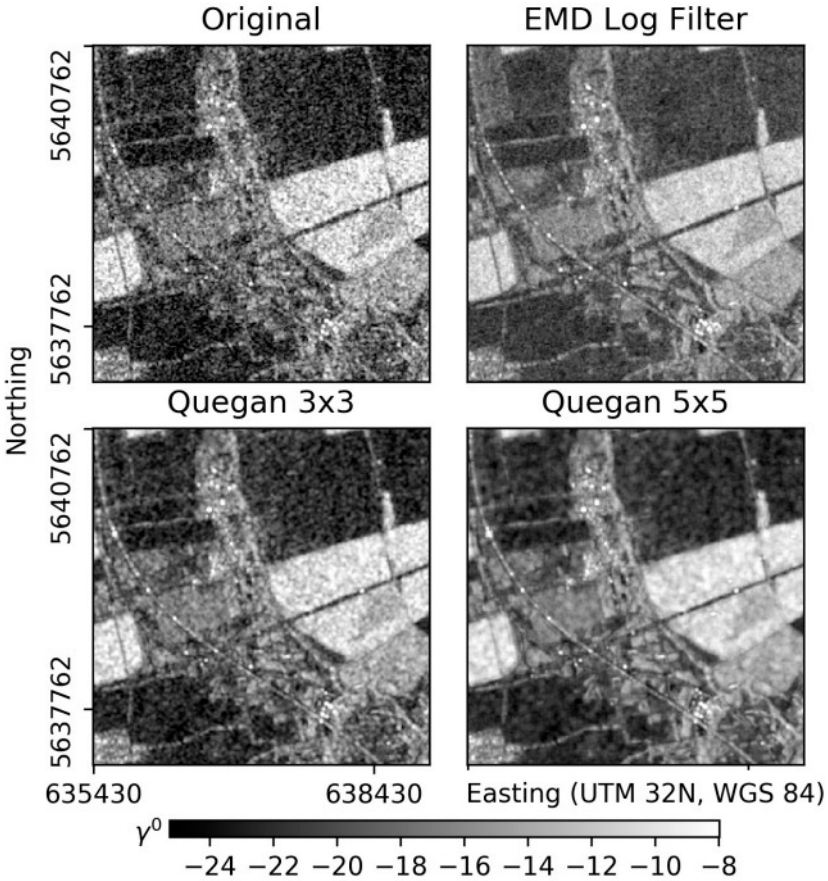


Decomposition of the S1 time series of a 3x3 matrix into the intrinsic mode functions (IMF). All graphs correspond to broadleaved forest.

Speckle filter

based on temporal information only





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Sentinel-1 time series analysis

24.Okt 2016

Sensor: Pleíades

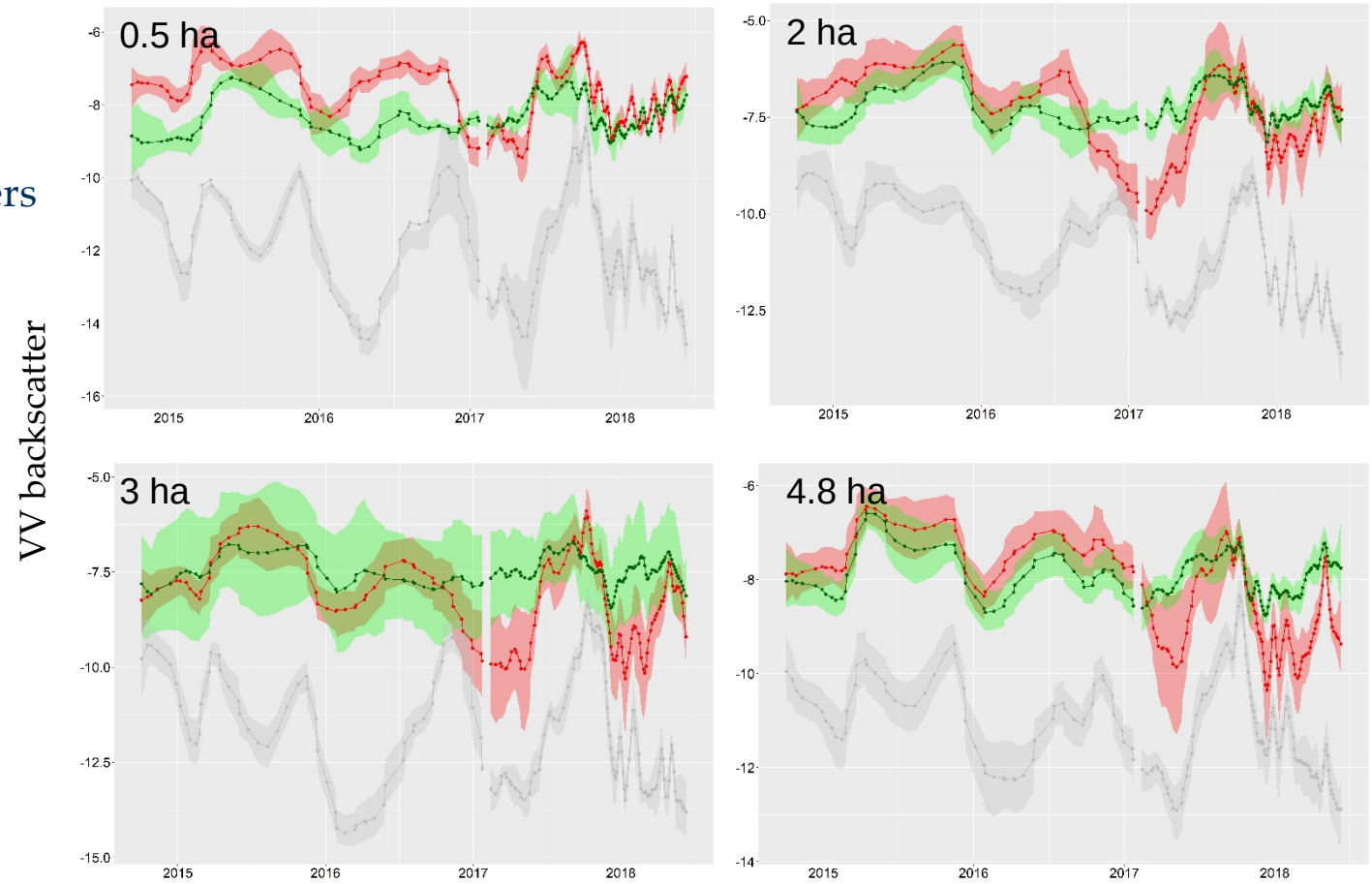
Location: Central Mexico Temperate forests

23.Okt 2017

Sentinel-1
Temperate forests
162 VV-backscatters
20 m resolution

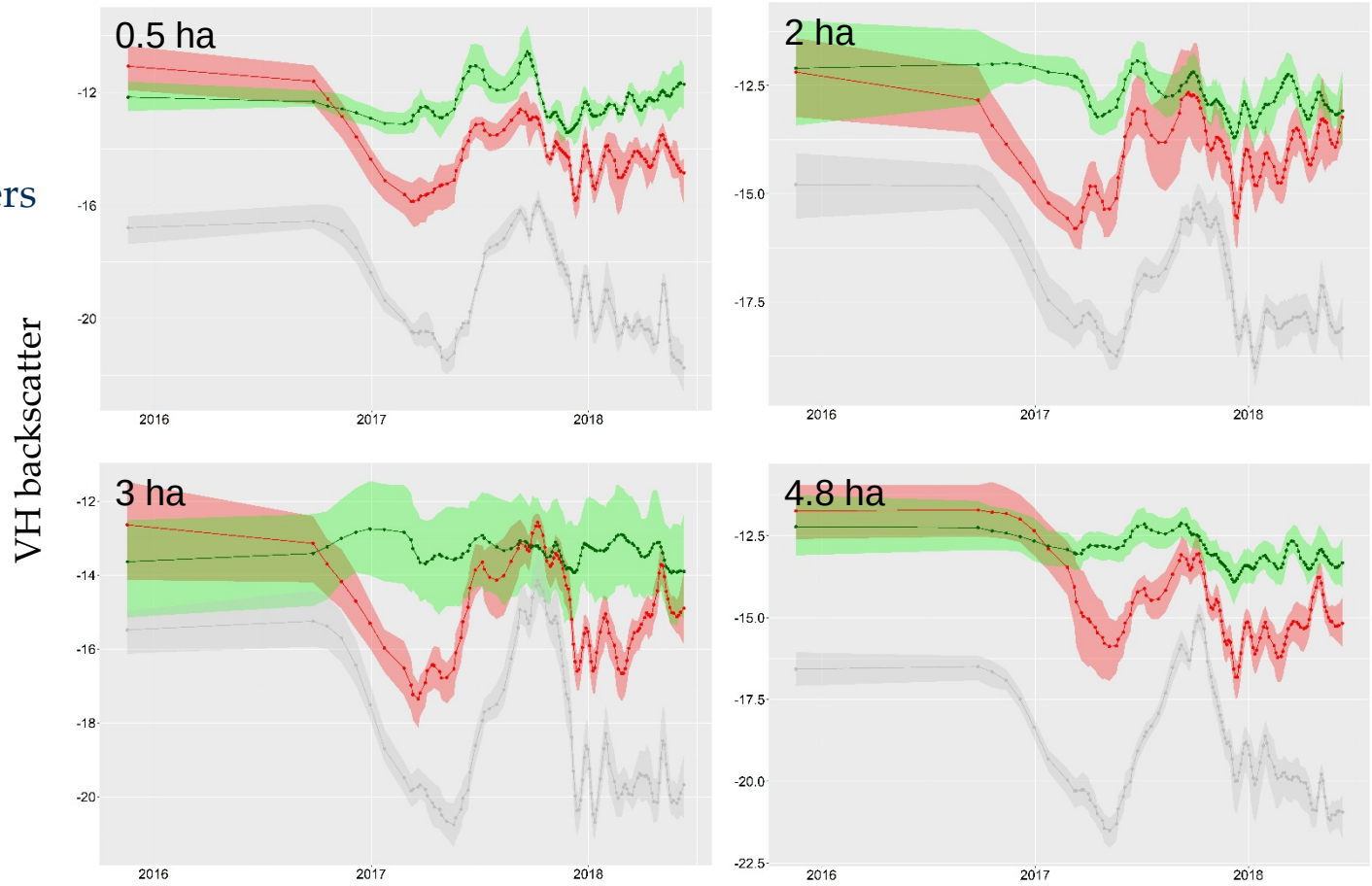
Landwirtschaft
Wald
Abholzung

Sentinel-1
Temperate forests
162 VV-backscatters
EMD-filtered
20 m resolution



Landwirtschaft
Wald
Abholzung

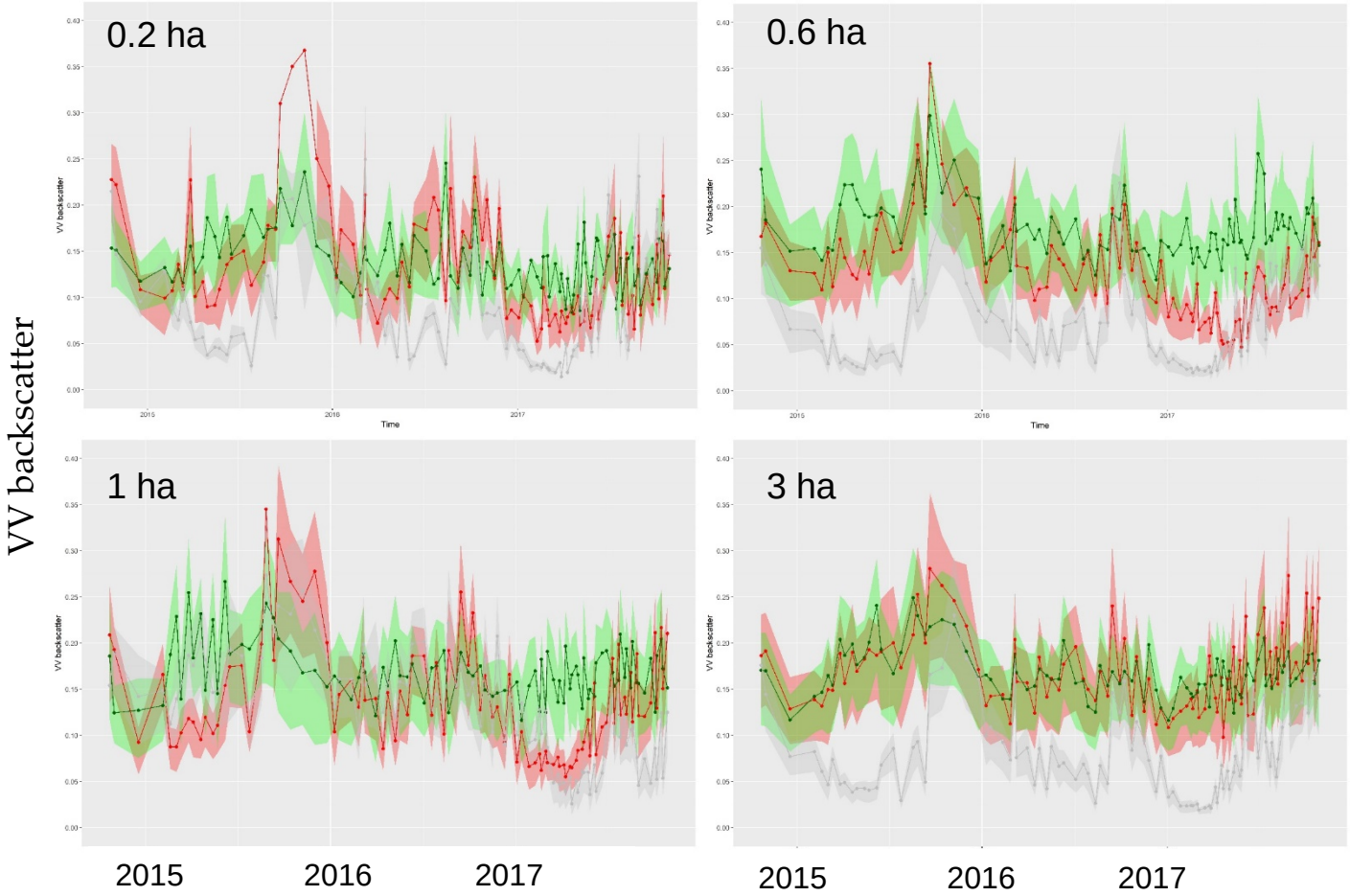
Sentinel-1
Temperate forests
110 VH-backscatters
EMD-filtered
20 m resolution



Landwirtschaft
Wald
Abholzung

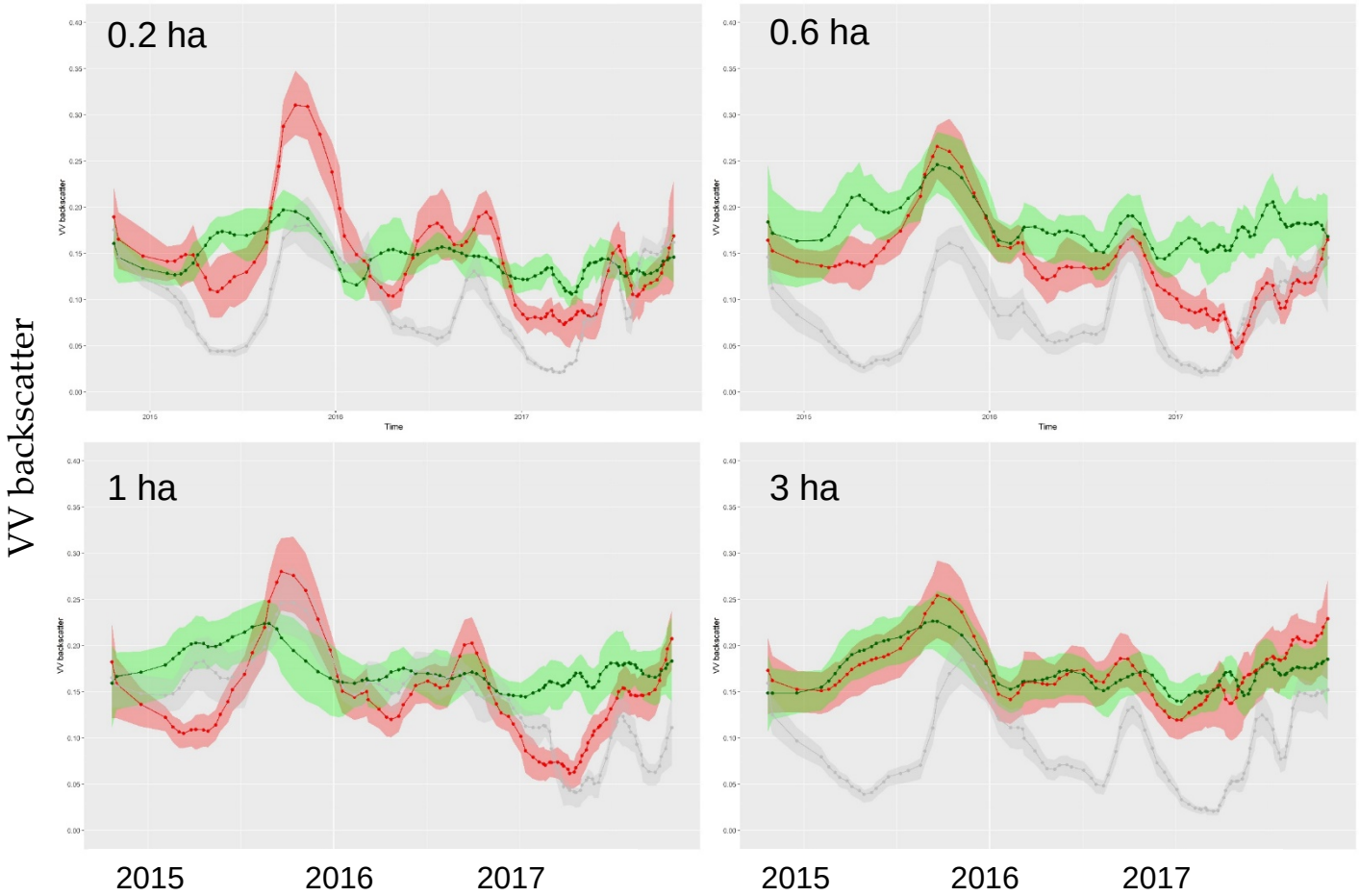
Tropical dry forests

Sentinel-1
Tropical dry forests
95 VV-backscatters
20 m resolution



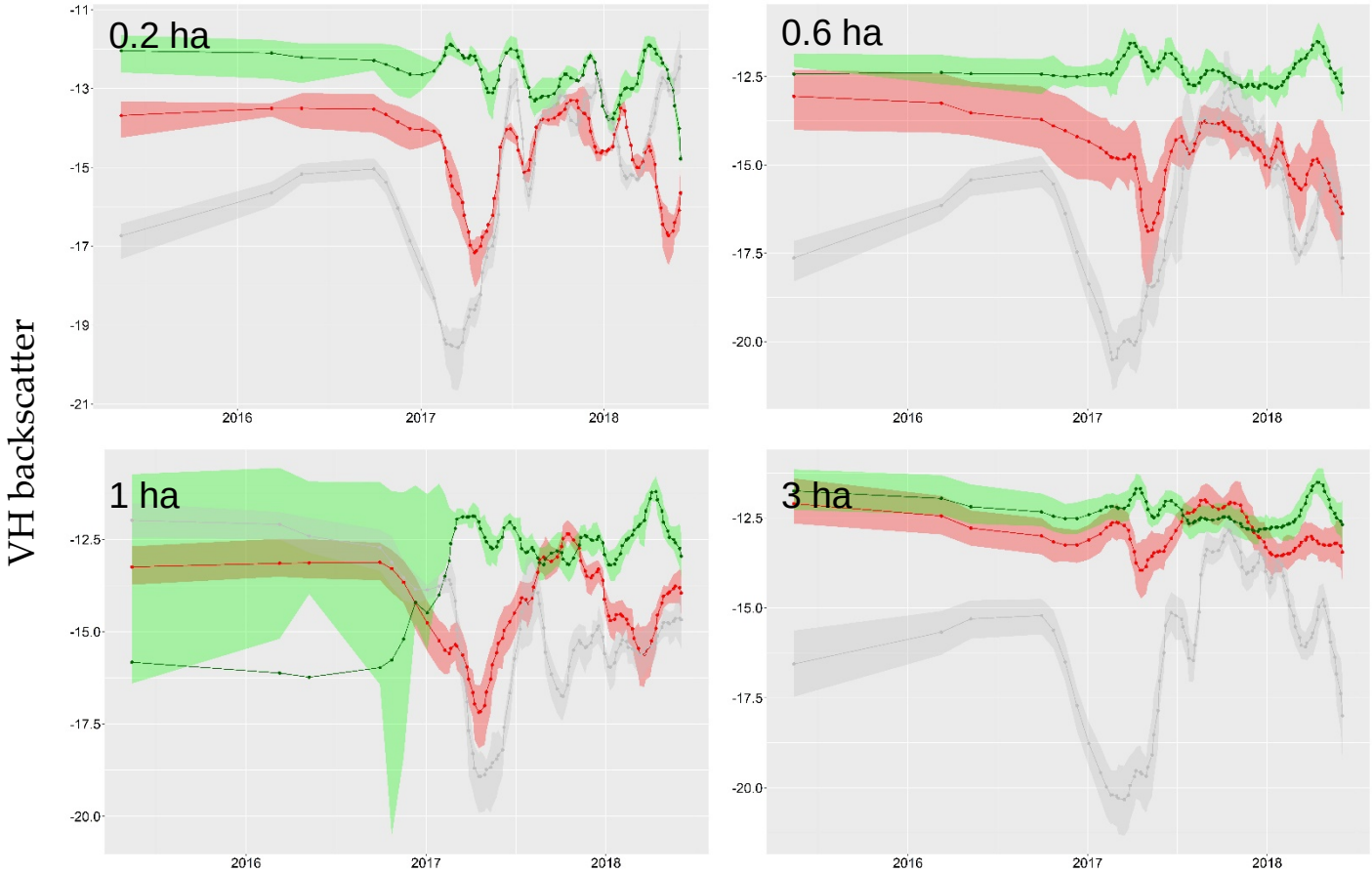
Landwirtschaft
Wald
Abholzung

Sentinel-1
Tropical dry forests
95 VV-backscatters
EMD-filtered
20 m resolution



Landwirtschaft
Wald
Abholzung

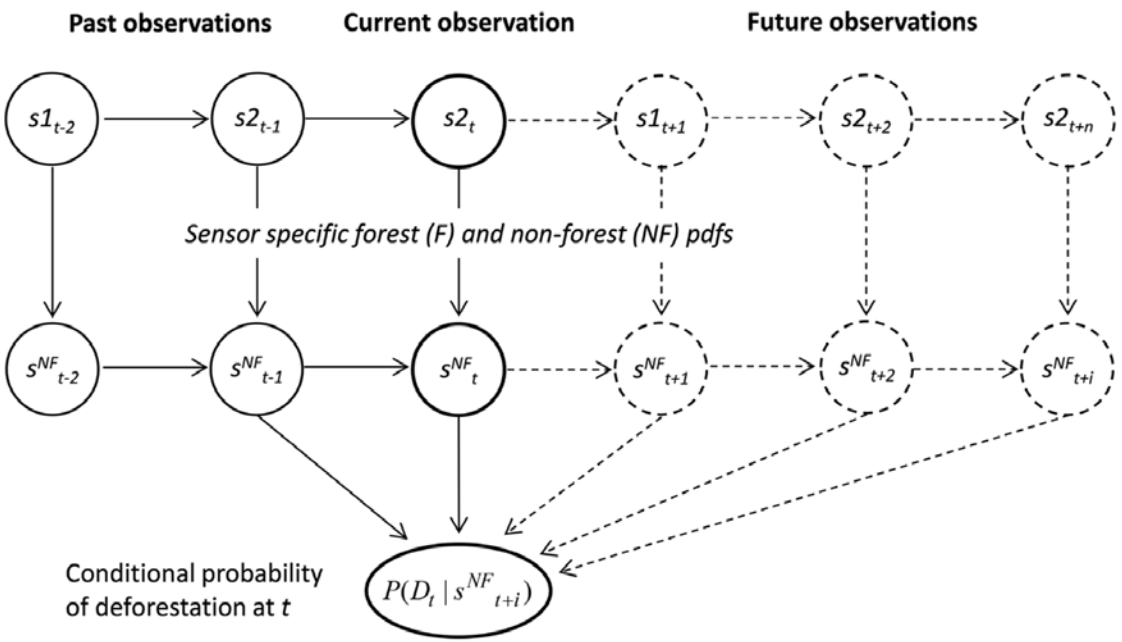
Sentinel-1
Tropical dry forests
84 VH-backscatters
EMD-filtered
20 m resolution



Landwirtschaft
Wald
Abholzung

Deforestation mapping
forest plantations

Bayesian conditional probability (Reiche et al. 2015, 2018)



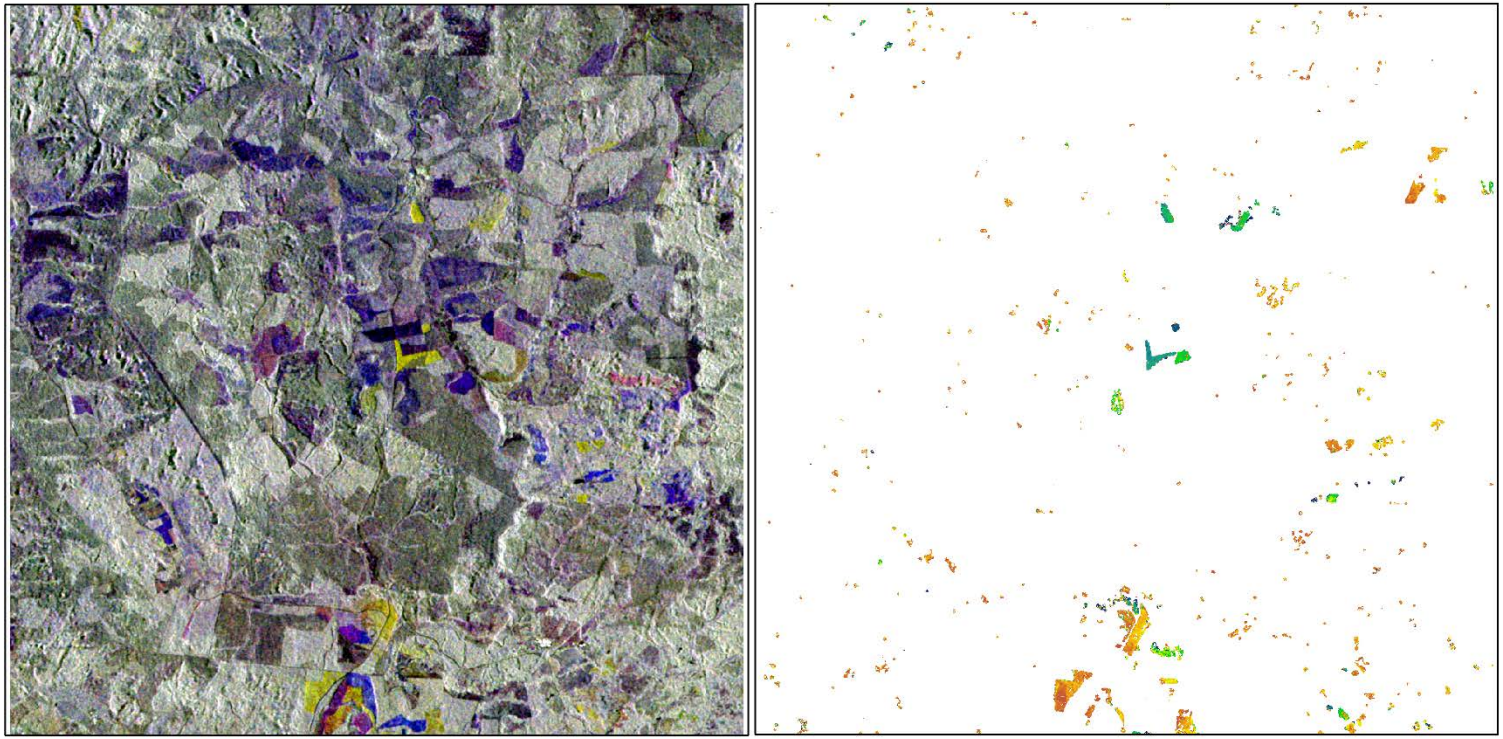
Multi-sensor time series observations (**Input**)

Deriving and combining time series of conditional non-forest probabilities (Step 1)

Normalised conditional non-forest probabilities

Iterative Bayesian updating of the conditional probability for deforestation using previous and future observations (**Step 2**)

Reiche et al. 2015



S1 VH backscatter

2017-04-26

2017-06-01

2018-03-28

Deforestation date

2018 - 03

2017 - 06

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