K&C Phase 4 – Final Report

PALSAR-1/2 Data for Vegetation Cover and Biomass Mapping in Various Climates

Mikhail Urbazaev, *C. Thiel, C. Berger, F. Cremer,*
V. Odipo, C. Pathe, M. Stelmaszczuk-Górska, C. Schmullius
Friedrich Schiller University Jena, Germany

Science Team meeting #25
Tokyo, Japan, February 5-8, 2019

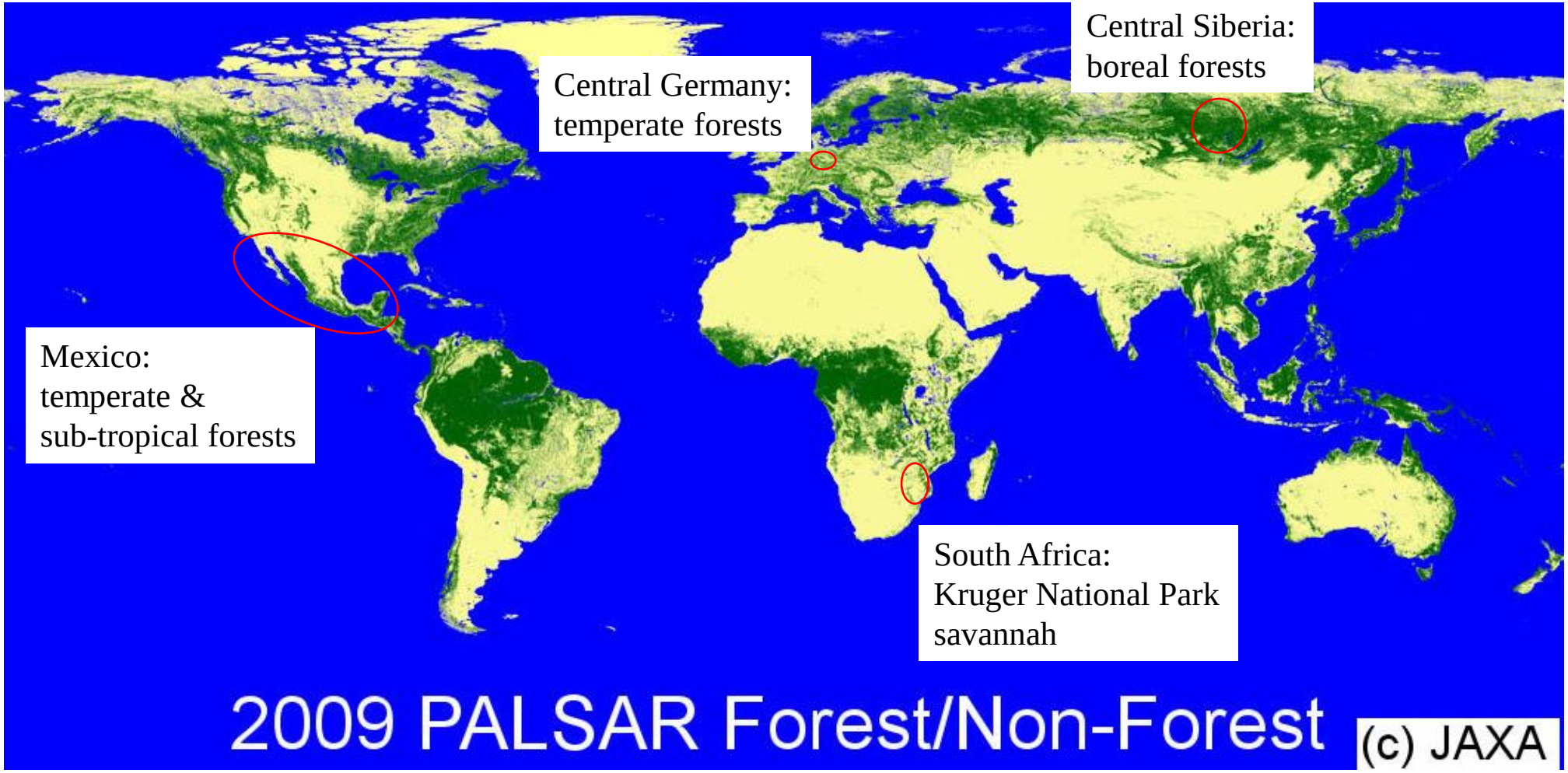
Project outline and objectives

1. Estimation of forest aboveground biomass

2. Estimation of vegetation structural parameters (fractional woody cover, vegetation height)

3. Forest cover and forest cover change mapping

Study areas


Central Siberia:
boreal forests
Central Germany:
temperate forests
Mexico:
temperate &
sub-tropical forests
South Africa:
Kruger National Park
savannah
2009 PALSAR Forest/Non-Forest
(c) JAXA

Project outline and objectives

1. Estimation of forest aboveground biomass

2. Estimation of vegetation structural parameters (fractional woody cover, vegetation height)

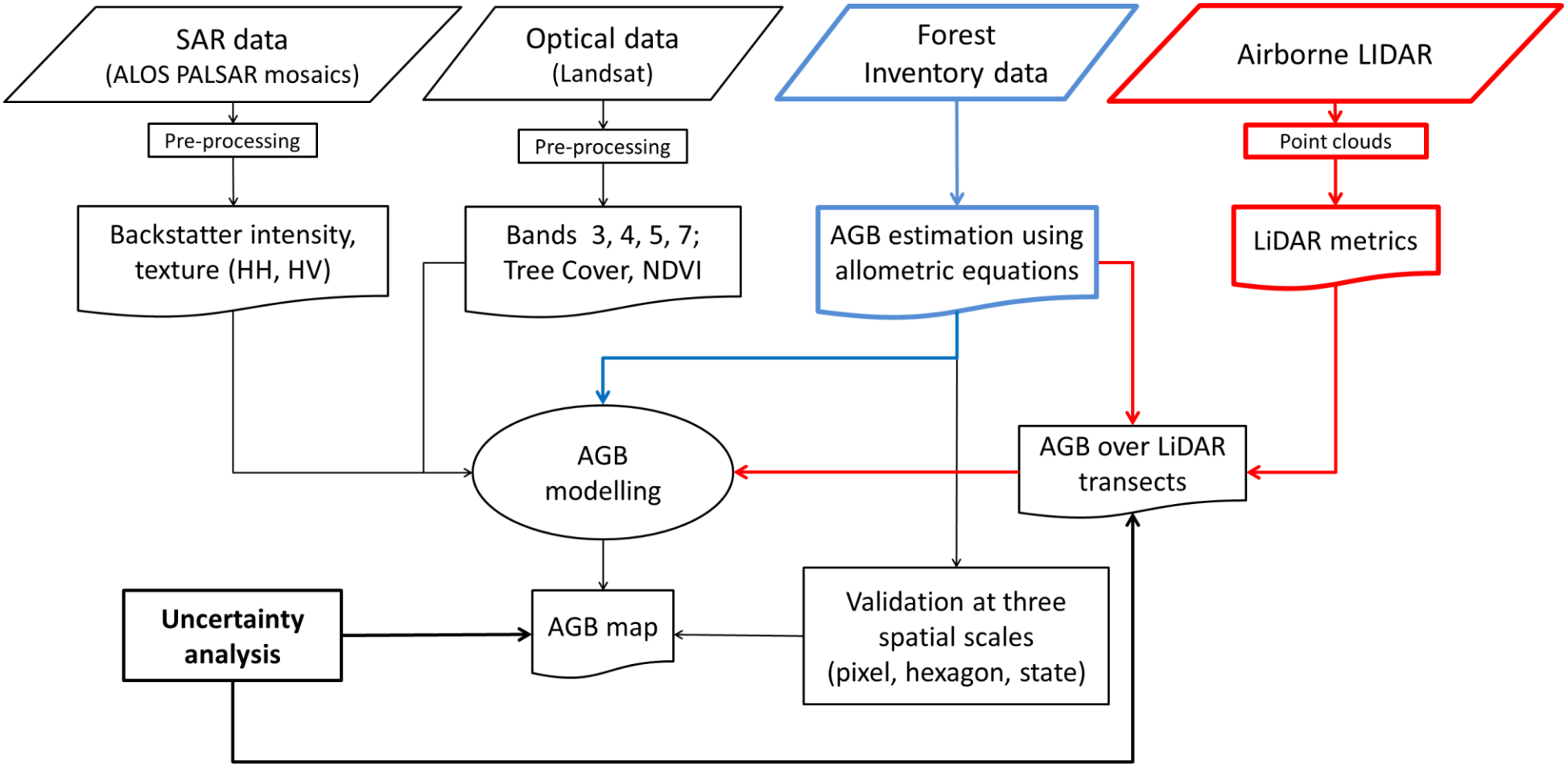
3. Forest cover and forest cover change mapping

AGB estimation in Mexico

- Urbazaev, M., Thiel, C., Cremer, F., Dubayah, R., Migliavacca, M., Reichstein, M. & C. Schmullius (2018):

  Estimation of forest aboveground biomass and uncertainties by integration of field measurements, airborne LiDAR, and SAR and optical satellite data in Mexico. ***Carbon Balance and Management***, 13(1):5. doi:10.1186/s13021-018-0093-5

AGB estimation in Mexico



ALOS

K&C Initiative
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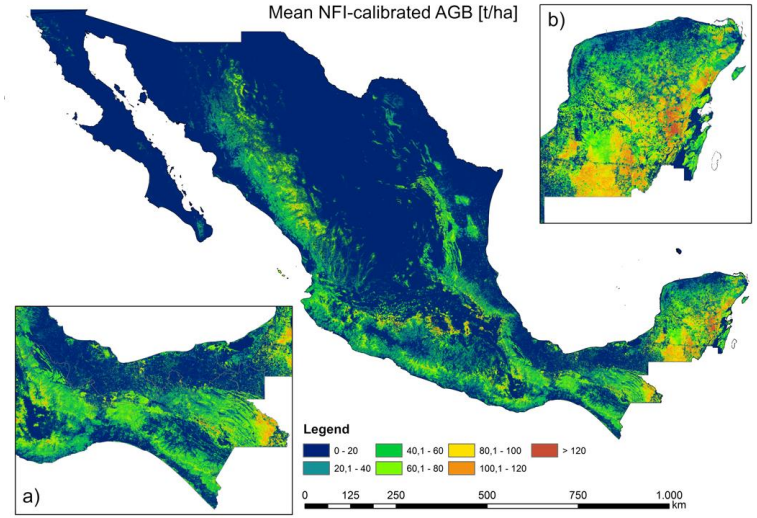
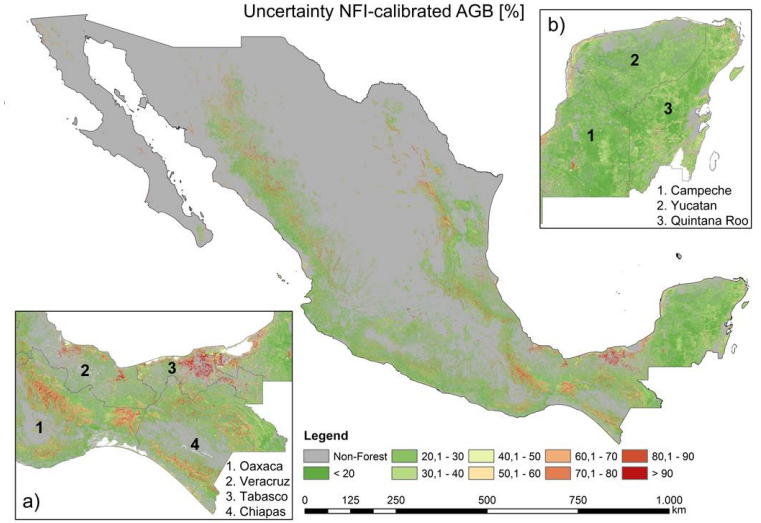
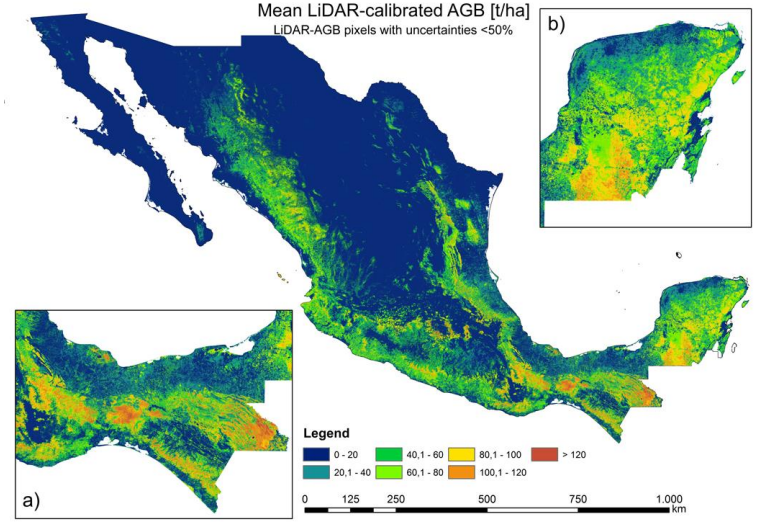
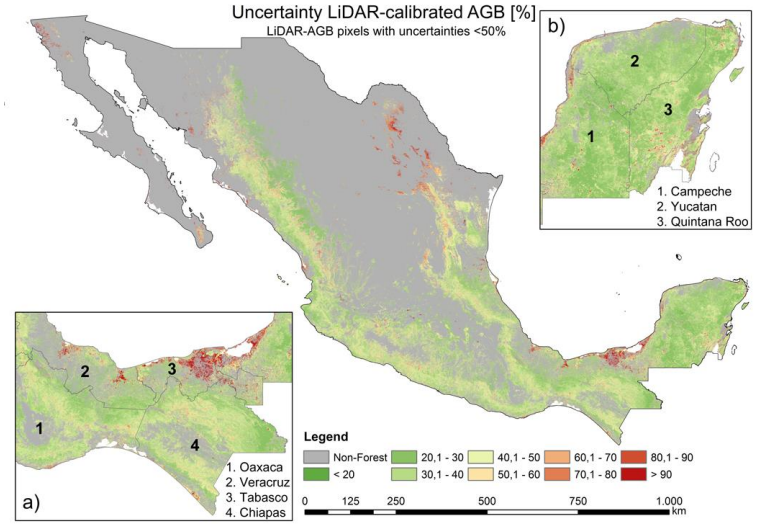
AGB estimation in Mexico









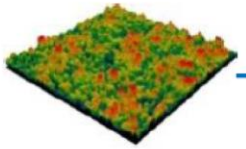
AGB estimation in the Kruger National Park

- Odipo V. O., Nickless, A., Berger, C., Baade, J., Urbazaev, M., Walther, C. & C. Schmullius (2016):

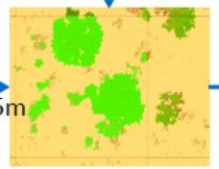
  Assessment of Aboveground Woody Biomass Dynamics Using Terrestrial Laser Scanner and L-Band ALOS PALSAR Data in South African Savanna. ***Forests***, 7(12), 294. doi:10.3390/f7120294

AGB estimation in the Kruger National Park

TLS data
September, 2015
Point-clouds processing with lastools = DSM, DTM and **CHM**

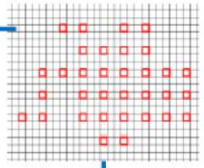


OBIA
Pix H>1.5m



TLS Metrics

CC, CH, CCxCH, CC+CH

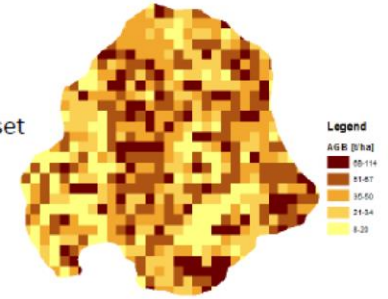


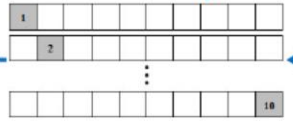
Field data
March, 2015
0.09ha plots
H>=1.5m, D>5cm at H=1m
700 trees in 42 plots

AGB sfter Colgan, et al 2013:

$$AGB = 1.09D^{(1.39+0.14\ln(D))}H^{0.73}\rho^{0.80}$$

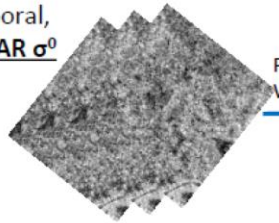
TLS CC+CH Biomass
Training and testing set
For **SAR σ^0**





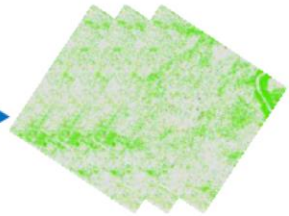
Model calibration & validation
Linear model with AGB and log(AGB)

Multitemporal,
Dual-pol **SAR σ^0**



Pixel-based
Weighted average

Model development
Rsq, aRsq, RMSE



{T1-T2, T1-Tn} > RMSE

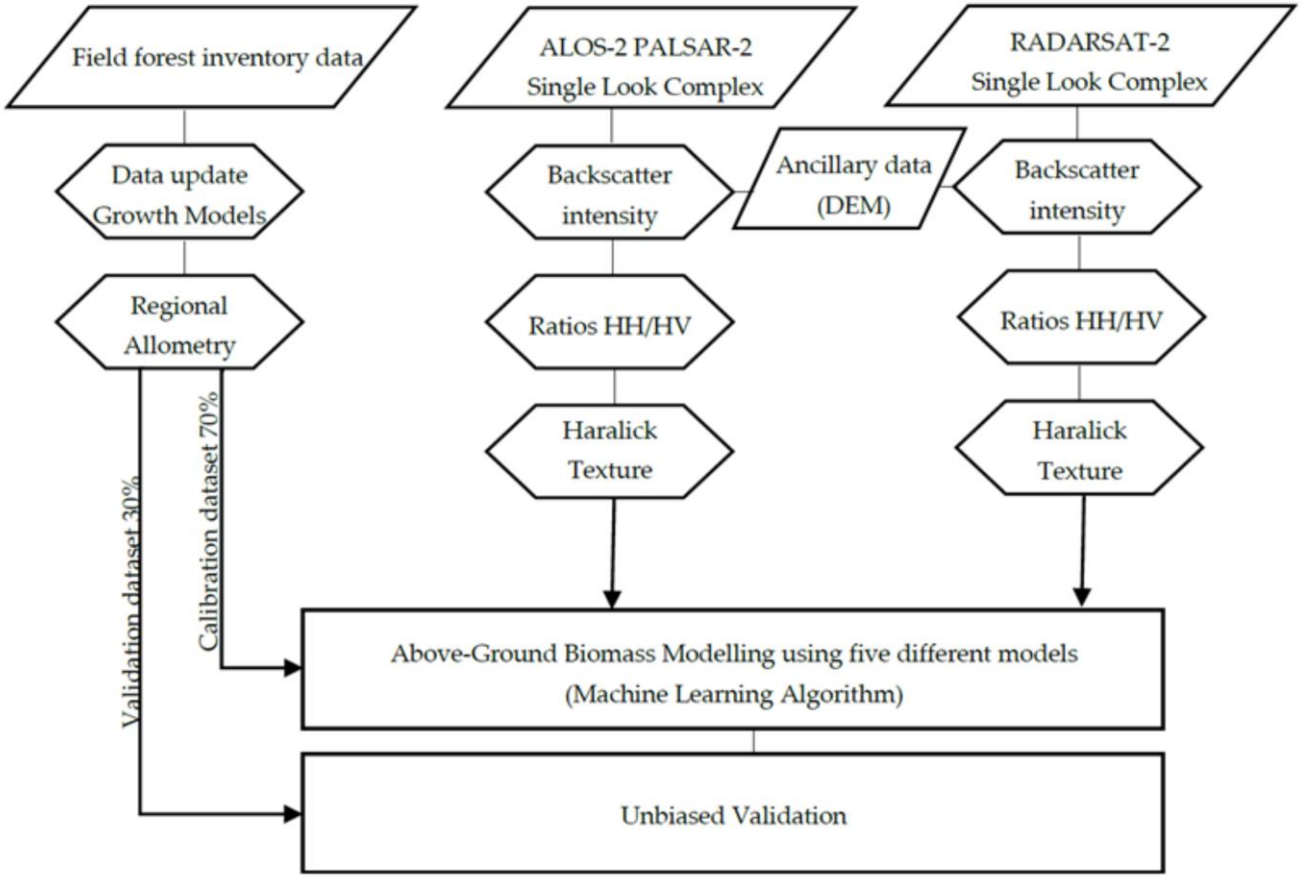
AGB change maps

AGB estimation in Central Siberia

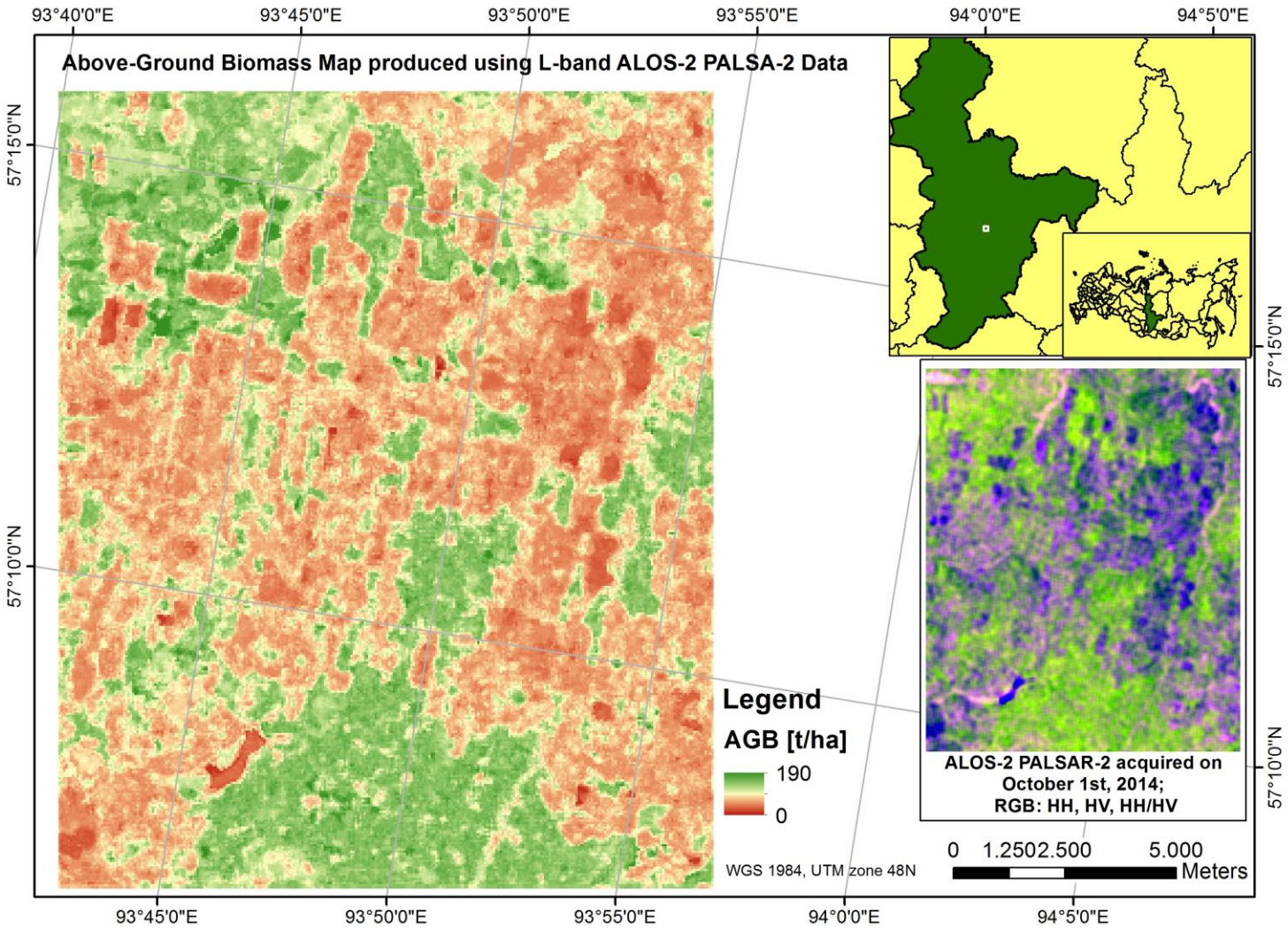
- Stelmaszczuk-Górska, M. A., Urbazaev, M., Schmullius, C. & C. Thiel (2018):

  Estimation of Above-Ground Biomass over Boreal Forests on Siberia Using Updated In Situ, ALOS-2 PALSAR-2, and RADARSAT-2 Data. ***Remote Sensing***, 10(10), 1550. doi:10.3390/rs10101550

AGB estimation in Central Siberia



AGB estimation in Central Siberia



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1. Estimation of forest aboveground biomass

2. Estimation of vegetation structural parameters (vegetation height, fractional woody cover)

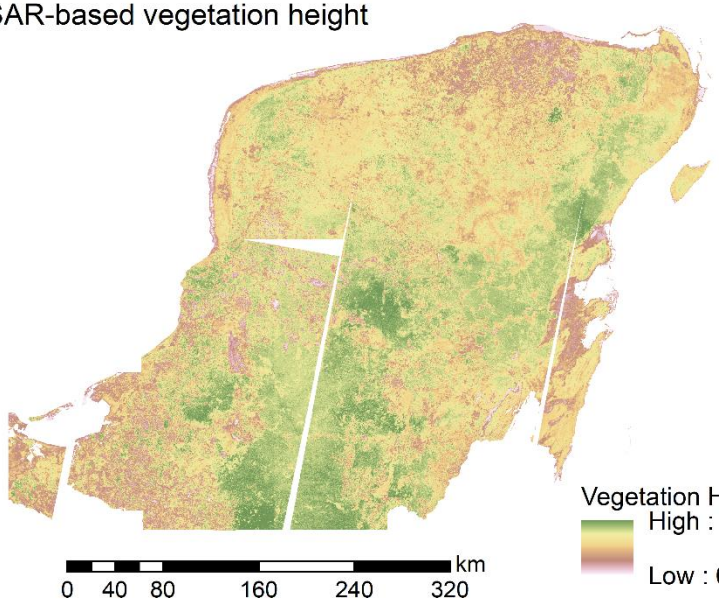
3. Forest cover and forest cover change mapping

Vegetation Height Estimation in Mexico

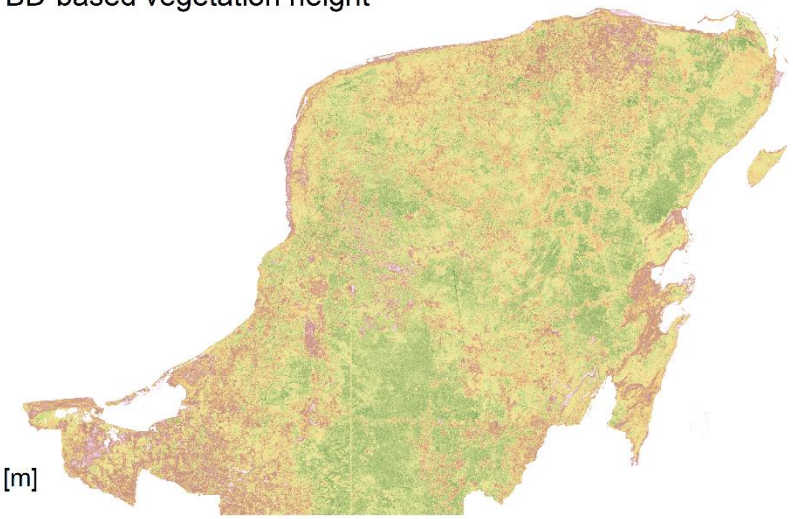
- Urbazaev, M., Cremer, F., Migliavacca, M., Reichstein, M., Schmullius, C. & C. Thiel (2018):

  Potential of Mulit-Temporal ALOS-2 PALSAR-2 ScanSAR Data for Vegetation Height Estimation in Tropical Forests of Mexico. ***Remote Sensing***, 10(8), 1277. doi:10.3390/rs10081277

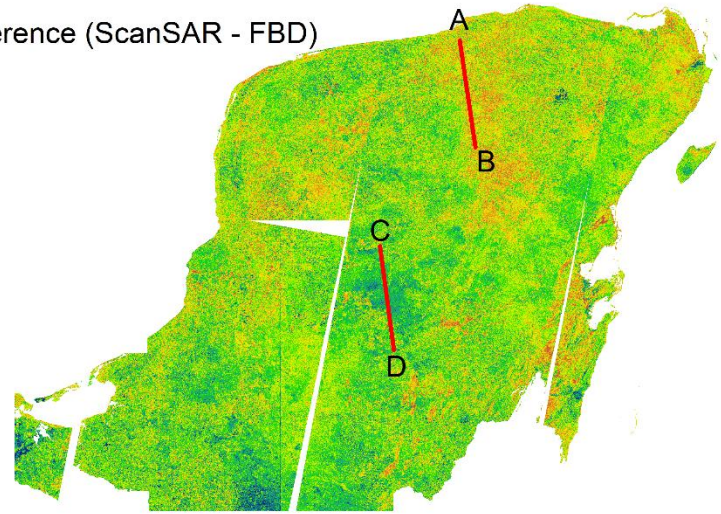
A) ScanSAR-based vegetation height



B) FBD-based vegetation height

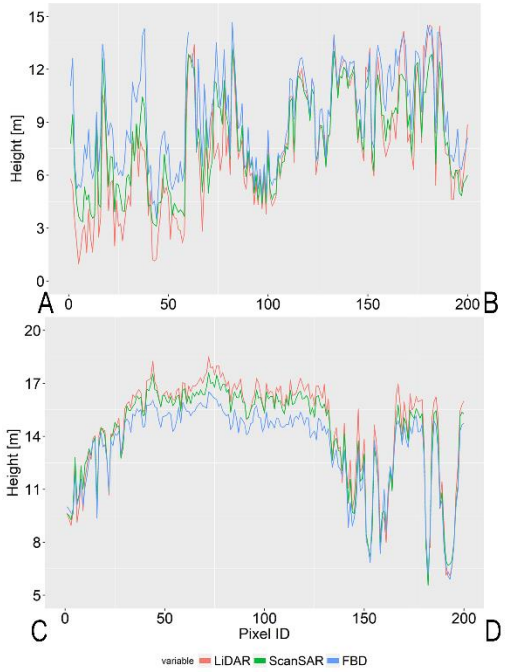


C) Difference (ScanSAR - FBD)



Legend

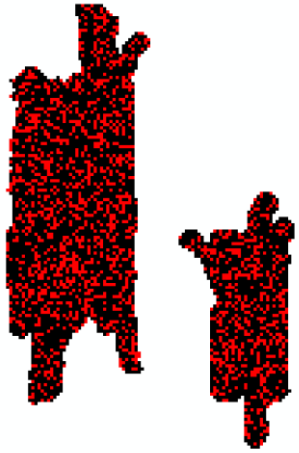
Profiles
< -5
-4,9 - -4
-3,9 - -3
-2,9 - -2
-1,9 - -1
-0,9 - 0
0 - 1
1,1 - 2
2,1 - 3
3,1 - 4
4,1 - 5
> 5



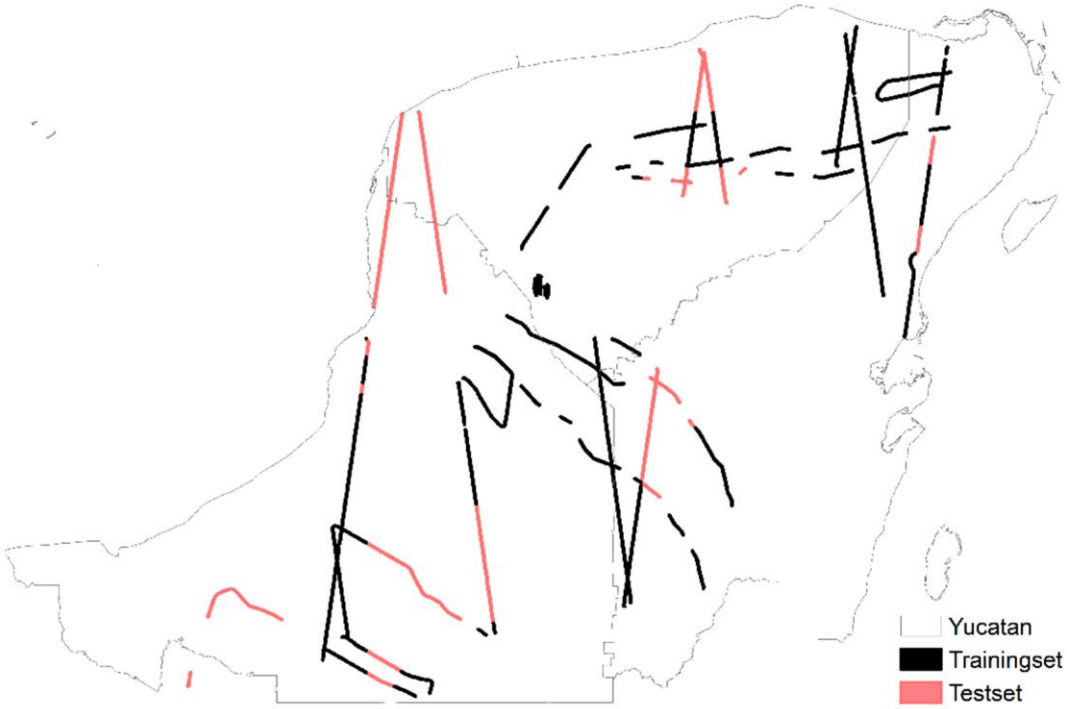
Vegetation Height Estimation in Mexico

Stratified random sampling

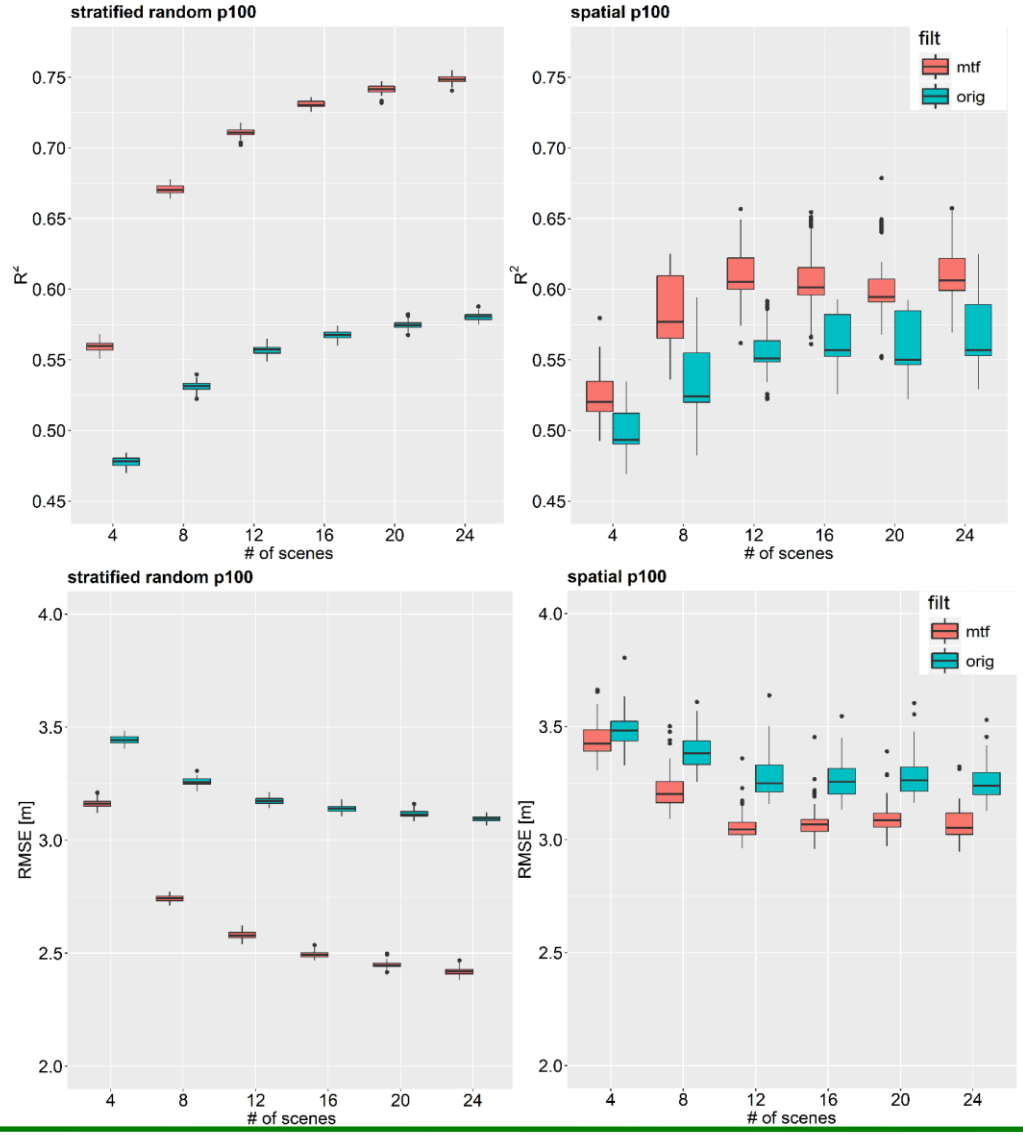
Black pixels training
Red pixels validation



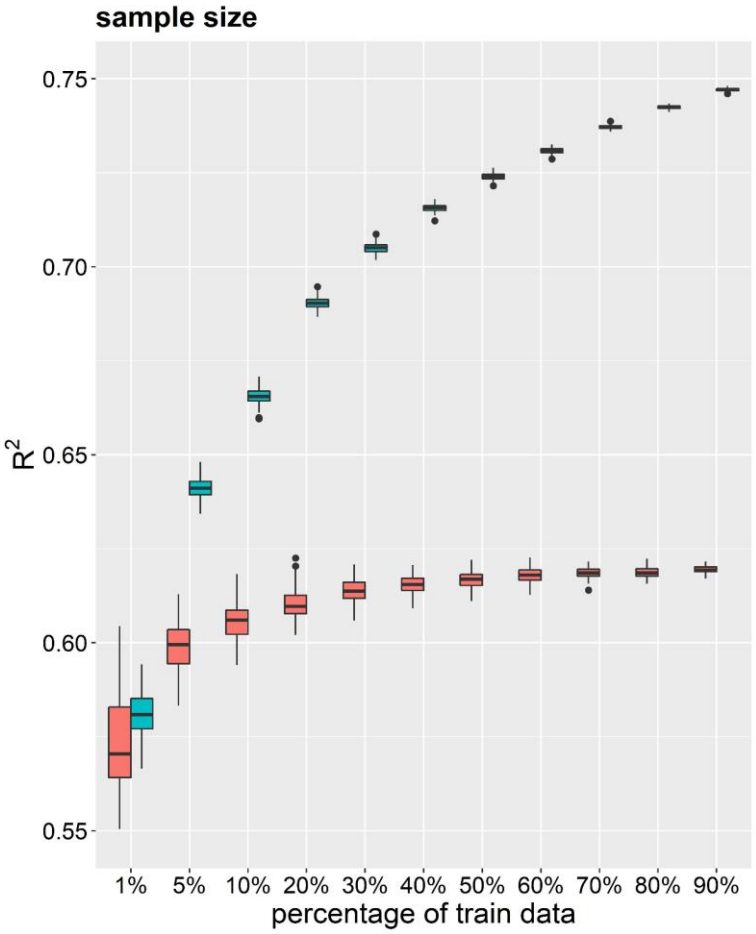
Spatial sampling

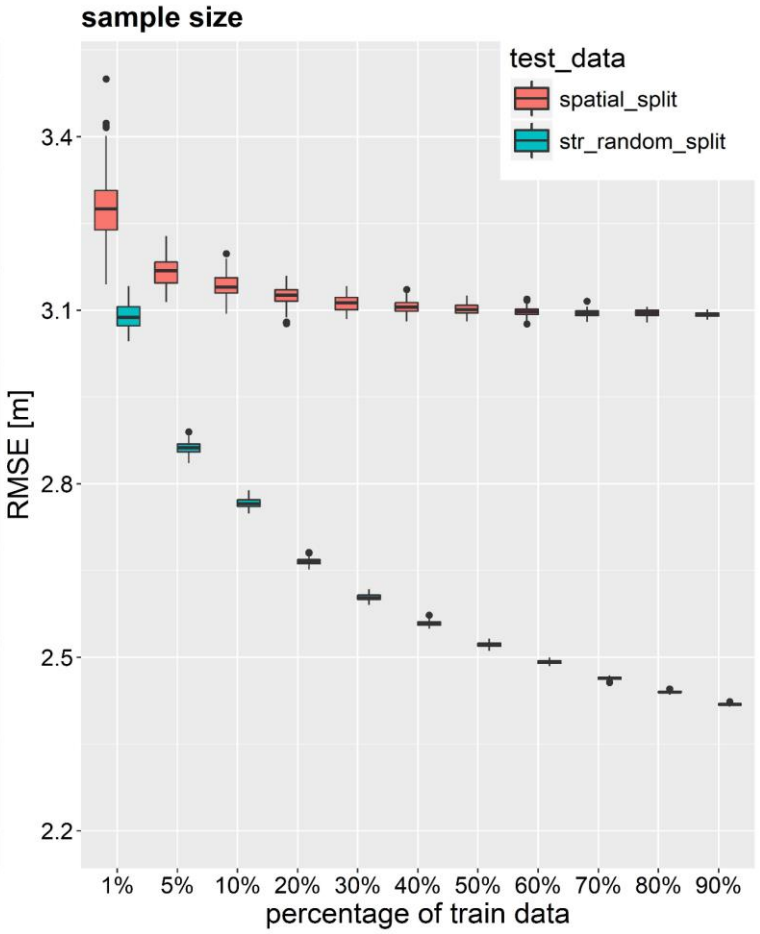


Vegetation Height Estimation in Mexico



Vegetation Height Estimation in Mexico





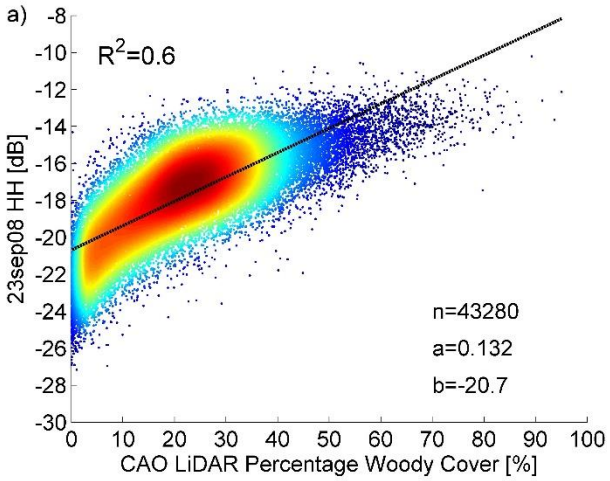
Woody Cover Mapping in the Kruger National Park

- Urbazaev, M., Thiel, C., Mathieu, R., Naidoo, L., Levick, S., Smit, I., Asner, G. & C. Schmullius (2015):

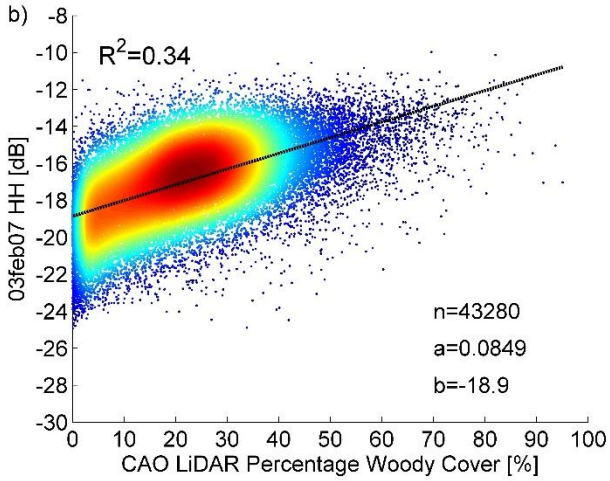
  Assessment of the mapping of fractional woody cover in southern African savannas using multi-temporal and polarimetric ALOS PALSAR L-band images. ***Remote Sensing of Environment***, 166, 138-153. doi:10.1016/j.rse.2015.06.013

Woody Cover Mapping in the Kruger National Park

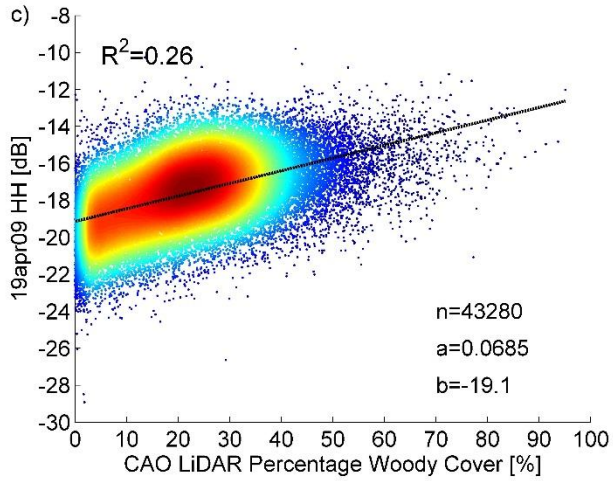
dry season

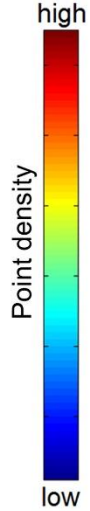


wet season



end of wet season





ALOS

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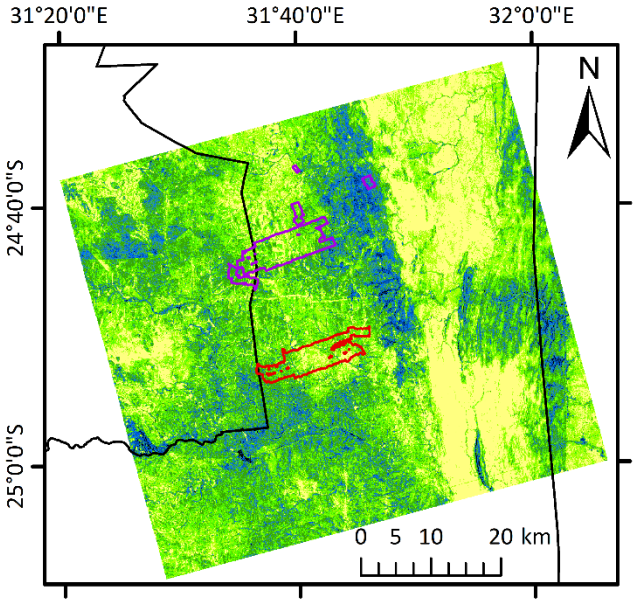
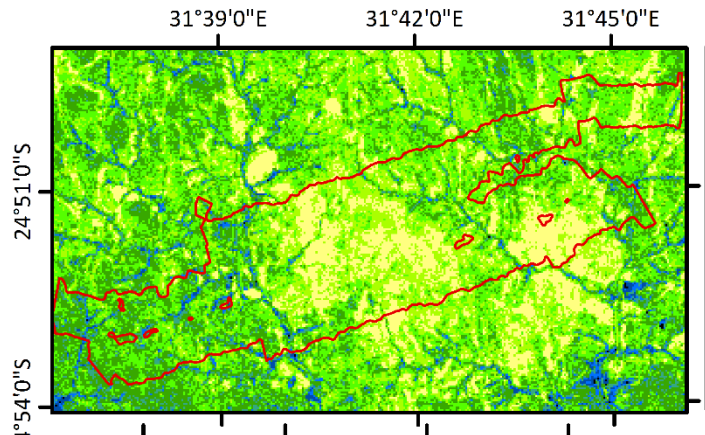
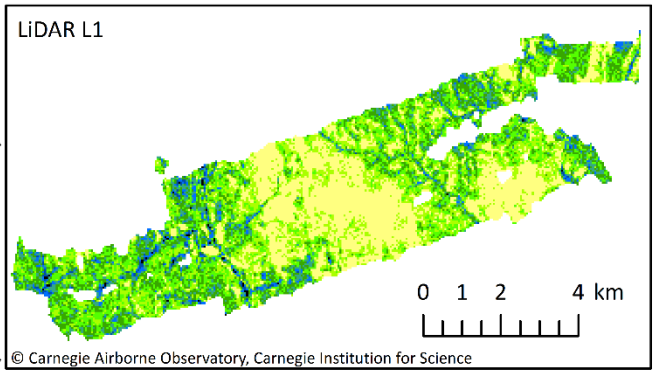
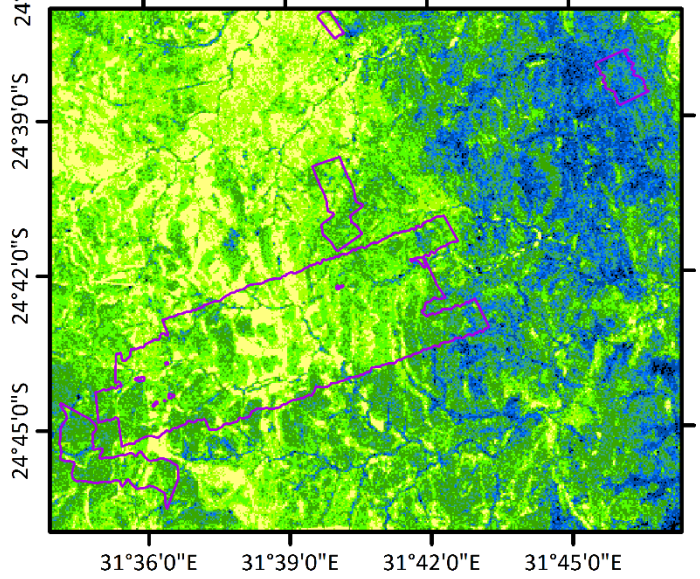
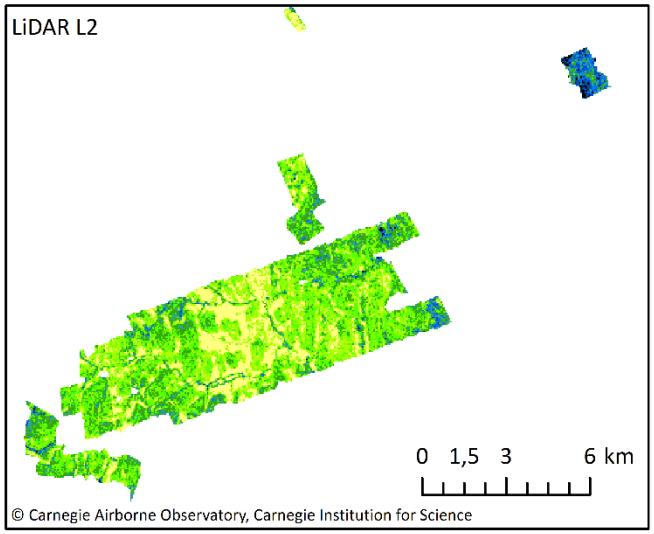
Woody Cover Mapping in the Kruger National Park











Legende

Bedeckungsgrad durch Gehölze [%]

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- > 70
- L1
- L2
- Kruger Nationalpark

Projektion: UTM, Zone 36S
Ellipsoid: WGS84

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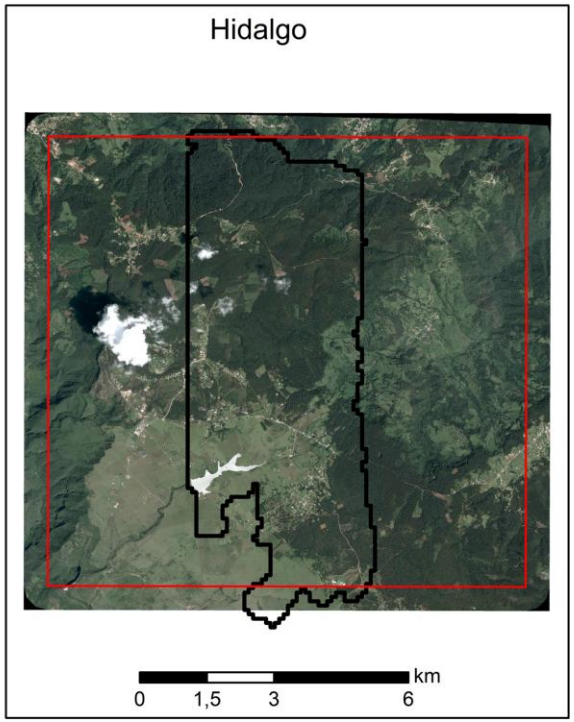
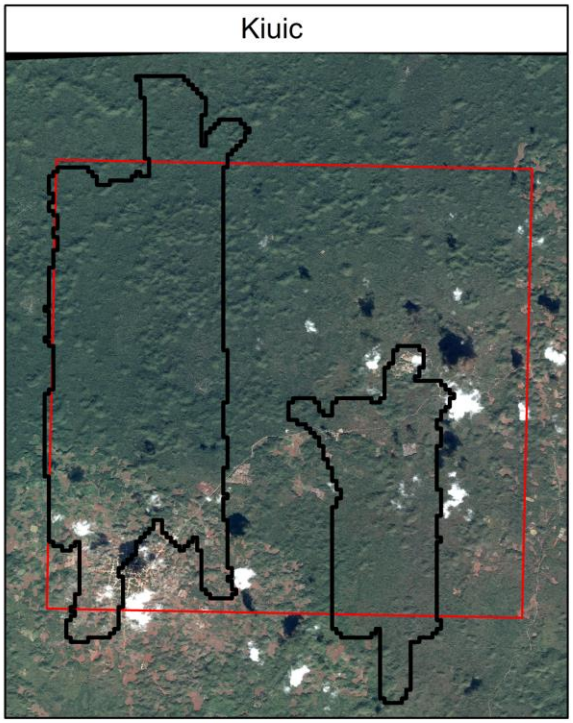
Forest Cover (Change) Mapping in Mexico





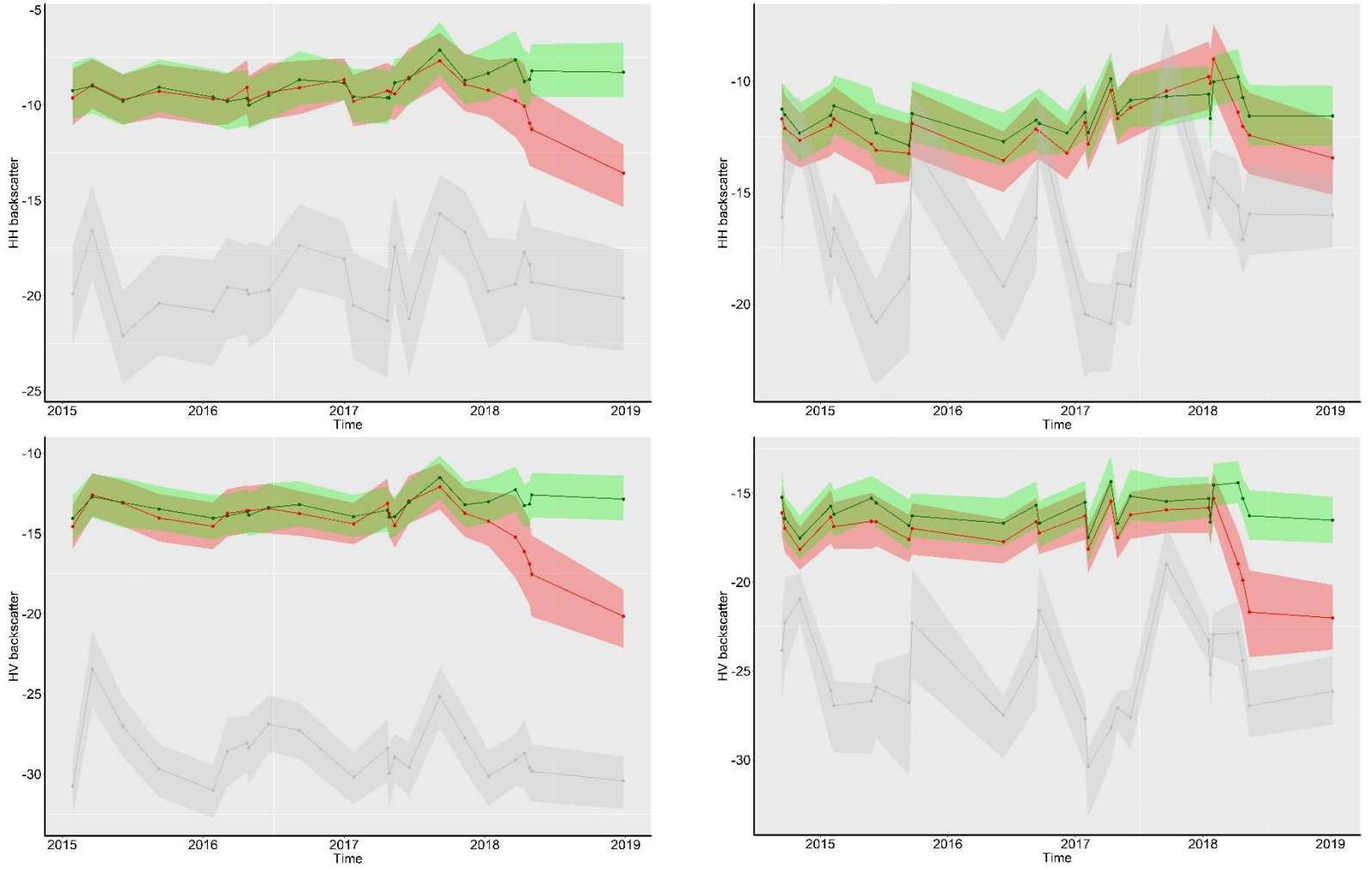
Legend

- Hidalgo
- Kiuic
- Testsites
- Airborne LiDAR
- States

Forest Cover (Change) Mapping in Mexico

Central Mexico (temperate forests)

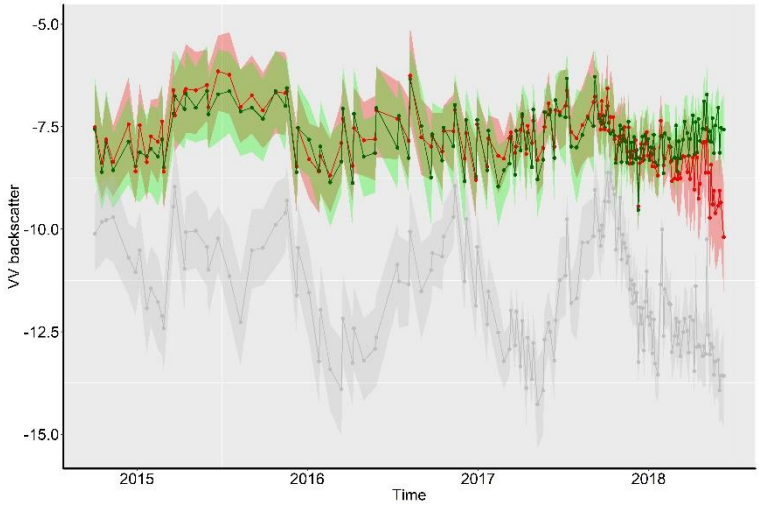
Yucatan peninsula (tropical dry forests)

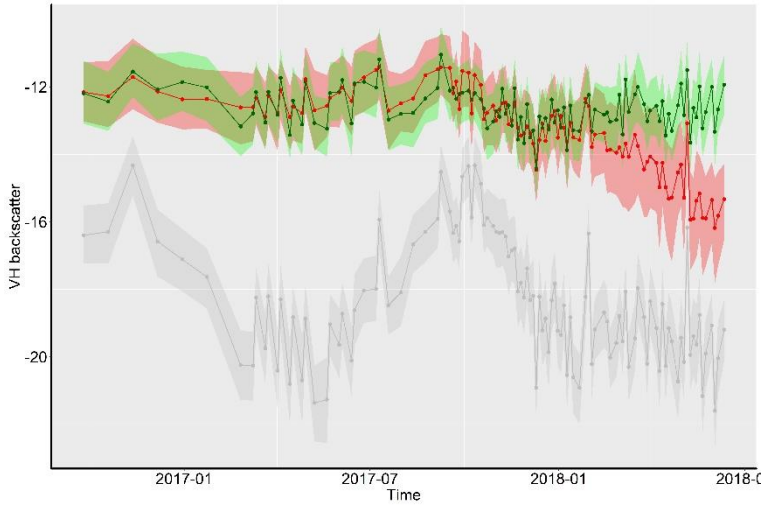


Sentinel-1 time series

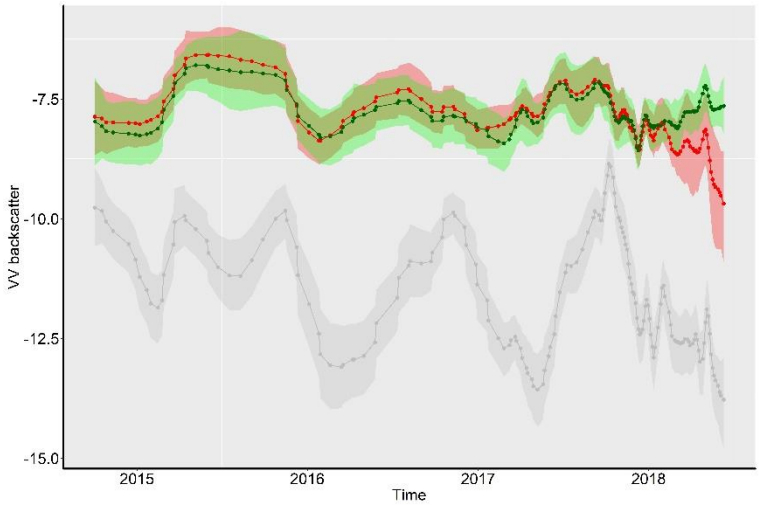
Central Mexico (temperate forests)

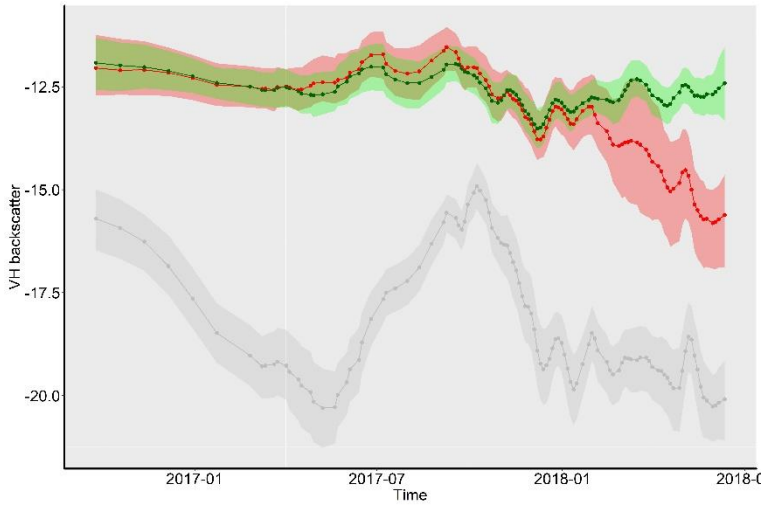
unfiltered





EMD-filtered





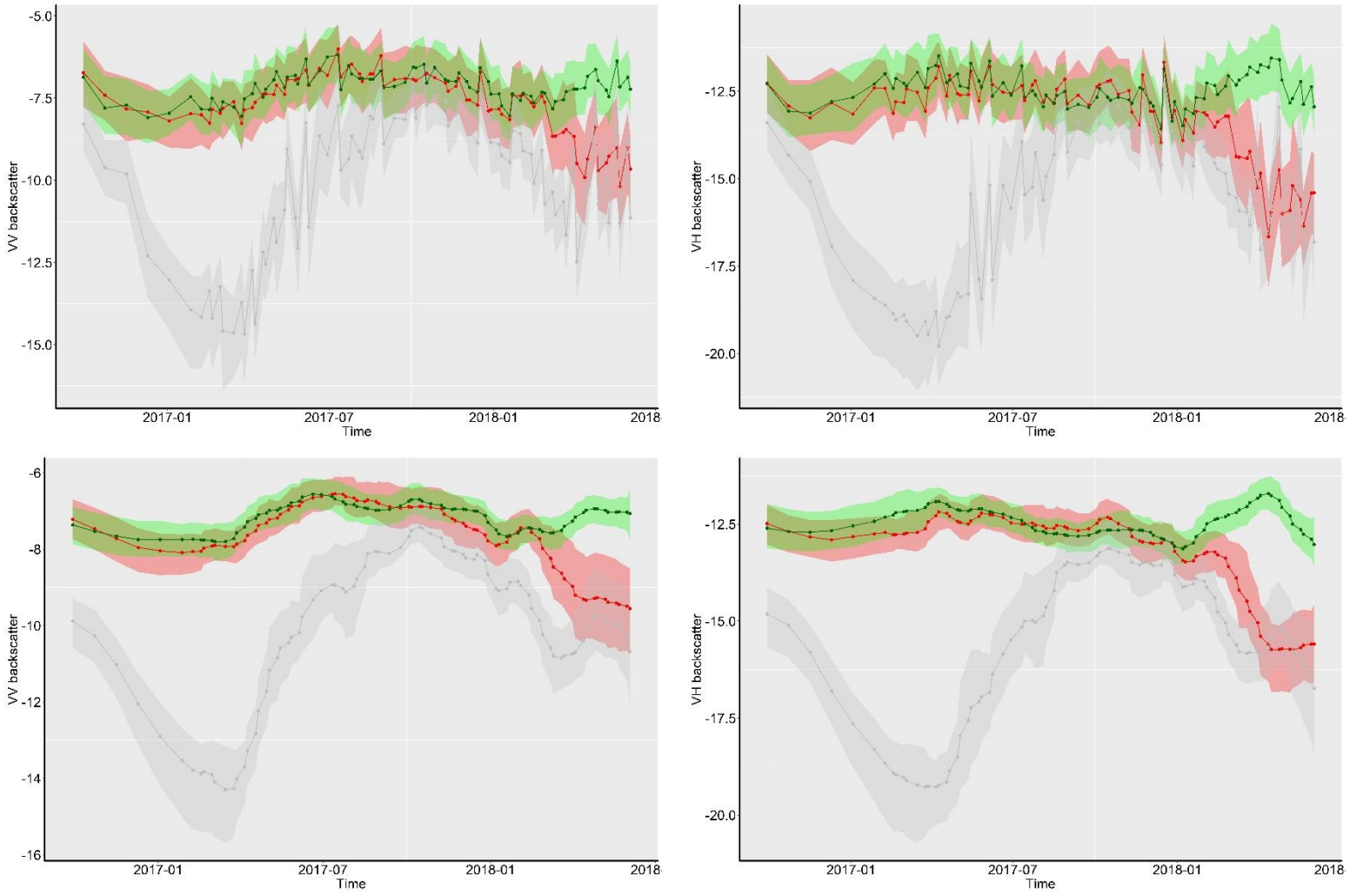
Agriculture
Forest
Deforestation

Sentinel-1 time series

Yucatan peninsula (tropical dry forests)

unfiltered

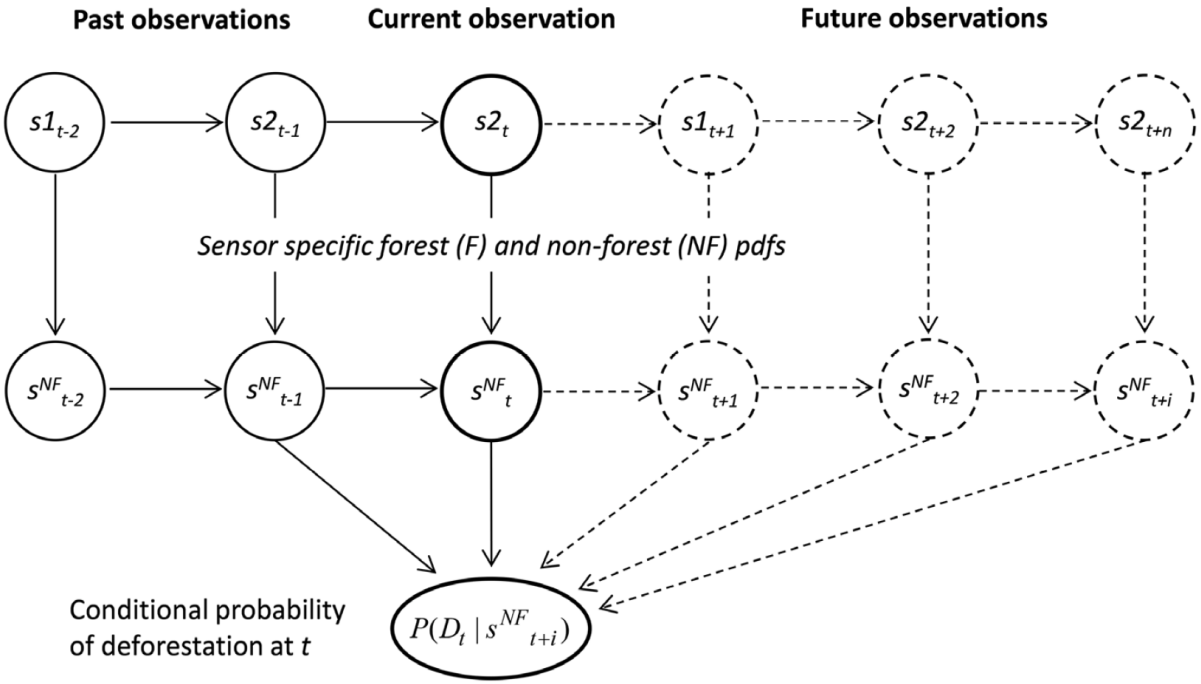
EMD-filtered



Agriculture
Forest
Deforestation

Bayesian conditional probability

Reiche et al. 2015, 2018



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

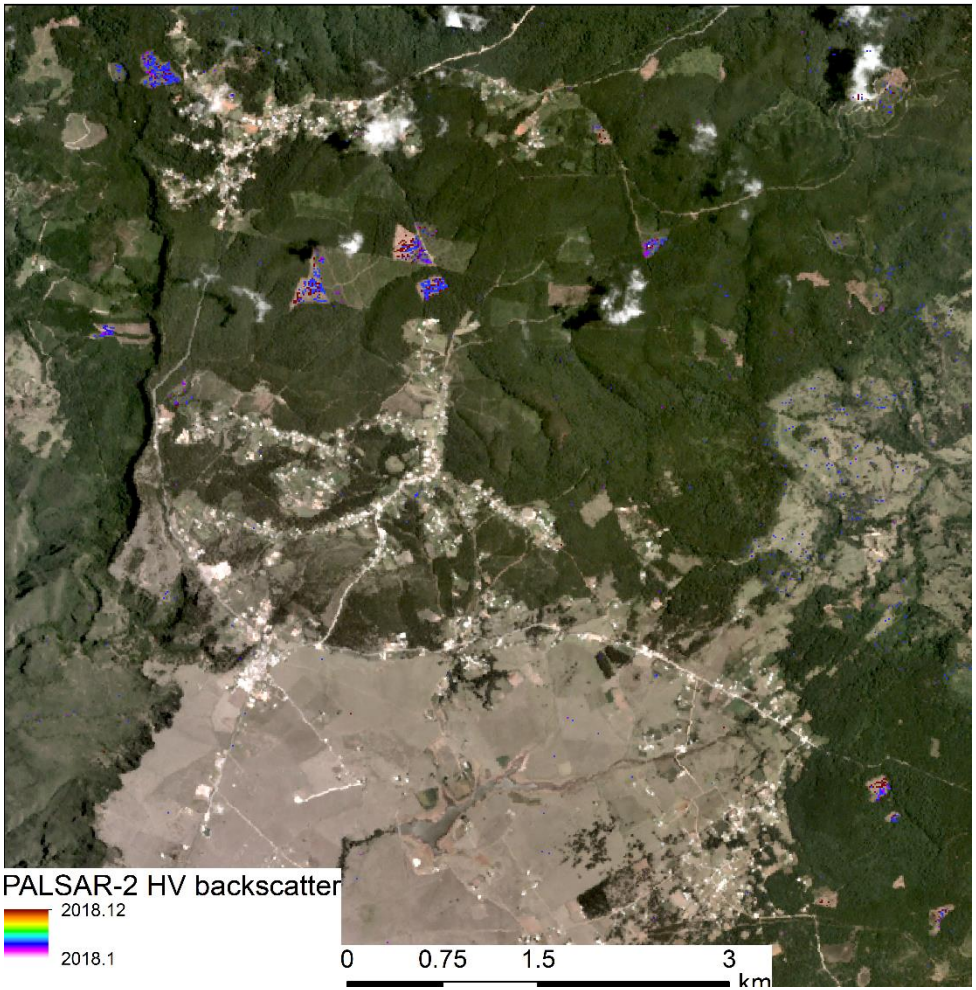
Deriving and combining time series of conditional non-forest probabilities (Step 1)

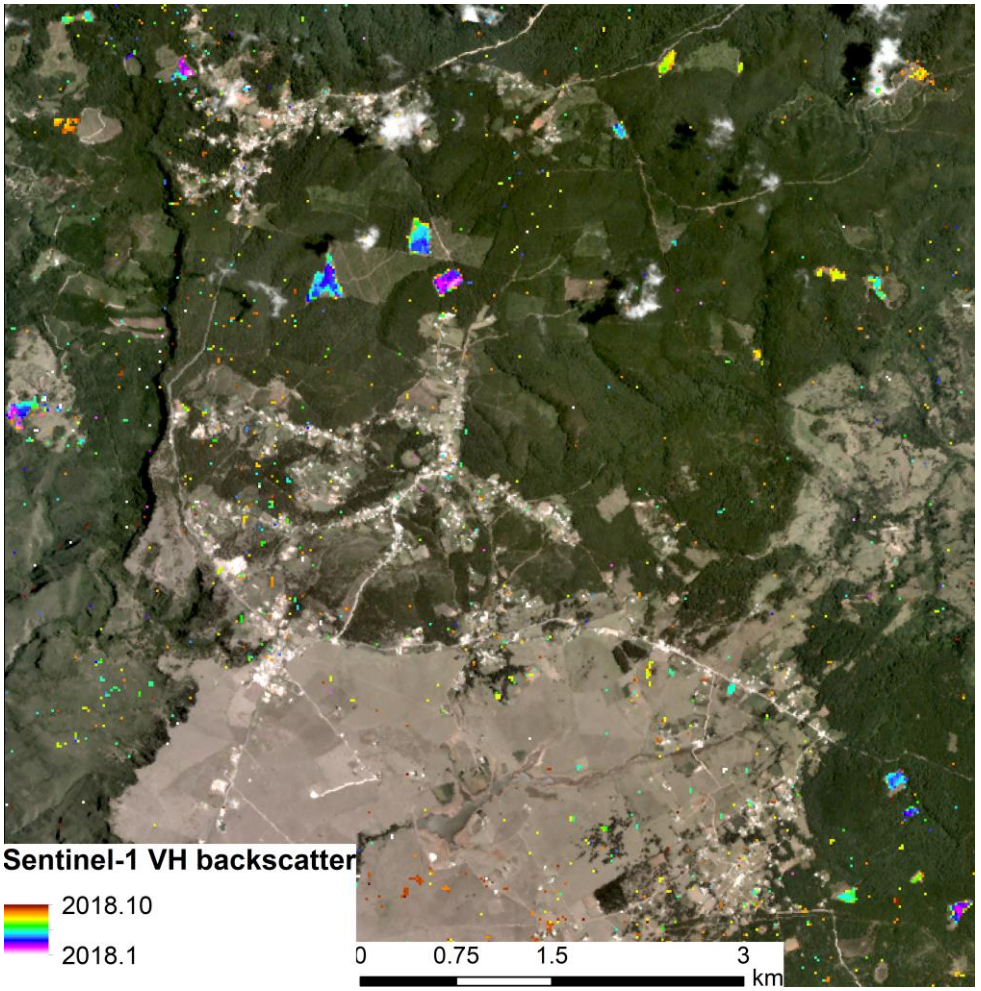
Normalised conditional non-forest probabilities

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

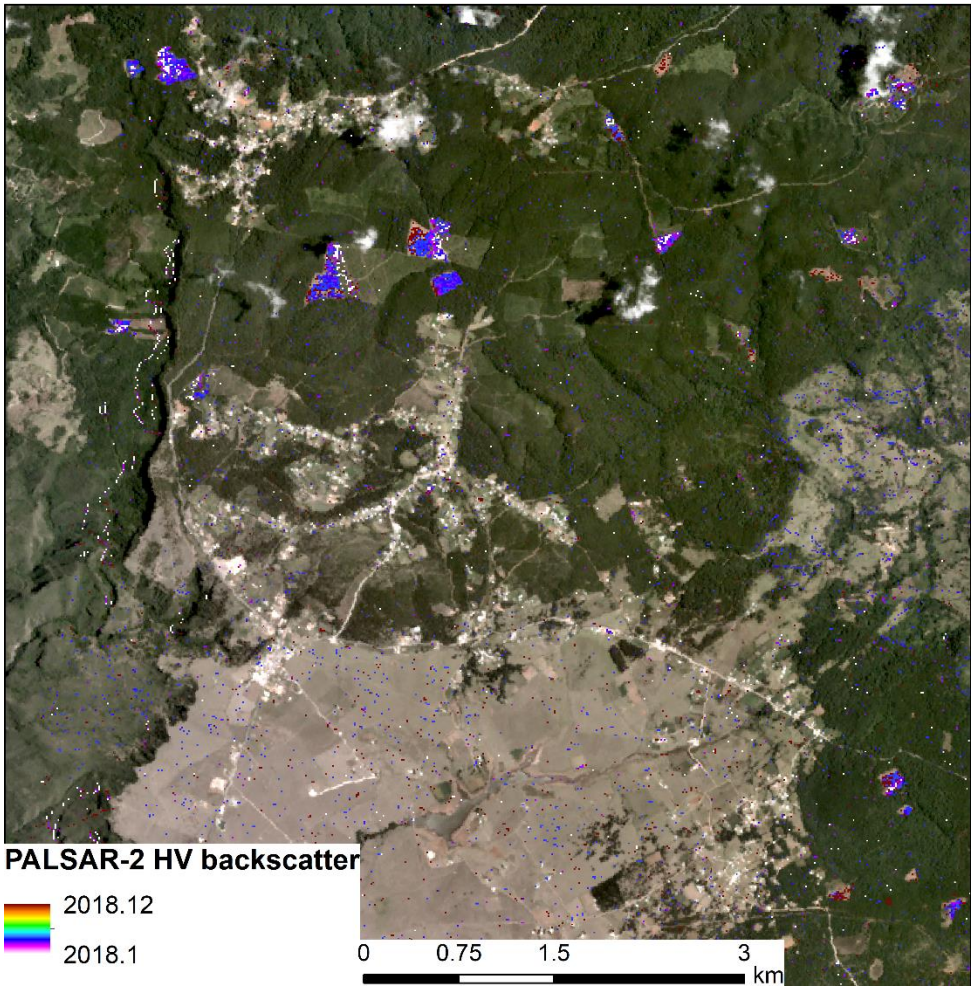
Reiche et al. 2015

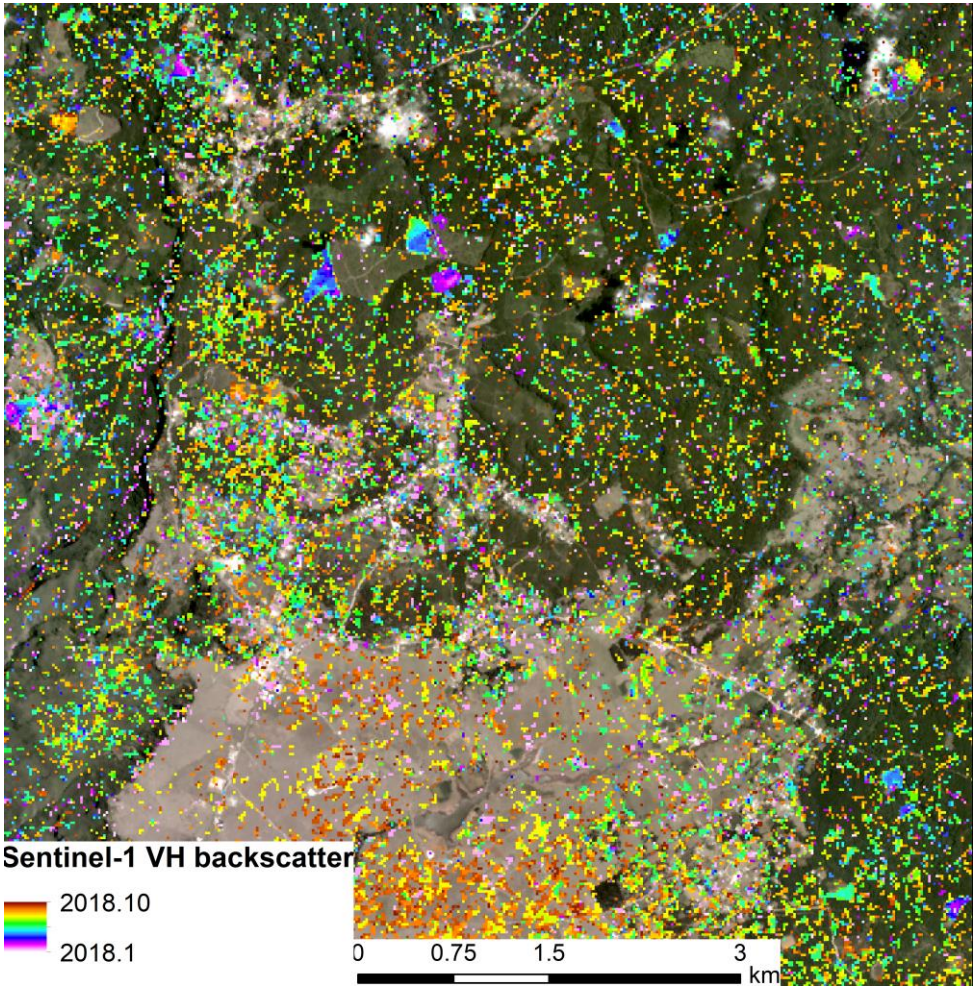
Deforestation probability = 90%





Deforestation probability = 50%





Results and significant findings

- L-band backscatter shows strong sensitivity to forest cover and structural parameters (AGB, height, fractional cover) in different biomes (boreal, temperate, sub-tropical forests and savannah)
- Signal saturation at specific forest density
- Multi-temporal data improve retrieval accuracies of structural parameters (help partly overcome saturation issue)
- Dense time series are needed for near-real time deforestation mapping

Suggestion to JAXA: open PALSAR-2 ScanSAR mosaics

Project deliverables

1. **Forest AGB maps**
   over Mexico, Central Siberia, part of the KNP
2. **Maps of vegetation structure** (height, fractional woody cover)
   over Yucatan, Mexico; part of the KNP
3. **Forest cover, forest cover change maps**
   over two study sites in Mexico and forest plantation in South Africa

Deliverables - Peer-reviewed publications

1. Stelmaszczuk-Górska, M. A., Urbazaev, M., Schmullius, C. & C. Thiel (2018). Estimation of Above-Ground Biomass over Boreal Forests on Siberia Using Updated In Situ, ALOS-2 PALSAR-2, and RADARSAT-2 Data. ***Remote Sensing***, 10(10), 1550. doi:10.3390/rs10101550
2. Urbazaev, M., Cremer, F., Migliavacca, M., Reichstein, M., Schmullius, C. & C. Thiel (2018). Potential of Mulit-Temporal ALOS-2 PALSAR-2 ScanSAR Data for Vegetation Height Estimation in Tropical Forests of Mexico. ***Remote Sensing***, 10(8), 1277. doi:10.3390/rs10081277
3. Urbazaev, M., Thiel, C., Cremer, F., Dubayah, R., Migliavacca, M., Reichstein, M. & C. Schmullius (2018). Estimation of forest aboveground biomass and uncertainties by integration of field measurements, airborne LiDAR, and SAR and optical satellite data in Mexico. ***Carbon Balance and Management***, 13(1):5. doi:10.1186/s13021-018-0093-5
4. Odipo V. O., Nickless, A., Berger, C., Baade, J., Urbazaev, M., Walther, C. & C. Schmullius (2016): Assessment of Aboveground Woody Biomass Dynamics Using Terrestrial Laser Scanner and L-Band ALOS PALSAR Data in South African Savanna. ***Forests***, *7(12),* 294. doi:10.3390/f7120294
5. Urbazaev, M., Thiel, C., Migliavacca, M., Reichstein, M., Rodriguez-Veiga, P. & C. Schmullius (2016). Improved Multi-Sensor Satellite-Based Aboveground Biomass Estimation by Selecting Temporally Stable Forest Inventory Plots Using NDVI Time Series. ***Forests***, *7(8),* 169. doi:10.3390/f7080169
6. Thiel, C. & C. Schmullius (2016): The potential of ALOS PALSAR backscatter and InSAR coherence for forest growing stock volume estimation in Central Siberia. ***Remote Sensing of Environment***, 173, 258-273. doi.org/10.1016/j.rse.2015.10.030

Deliverables - Peer-reviewed publications

7. Stelmaszczuk-Górska, M. A., Rodriguez-Veiga, P., Ackermann, N., Thiel, C. & C. Schmullius (2015). Non-Parametric Retrieval of Aboveground Biomass in Siberian Boreal Forests with ALOS PALSAR Interferometric Coherence and Backscatter Intensity. ***Journal of Imaging***, 2(1). doi.org/10.3390/jimaging2010001

8. Urbazaev, M., Thiel, C., Mathieu, R., Naidoo, L., Levick, S., Smit, I., Asner, G. & C. Schmullius (2015): Assessment of the mapping of fractional woody cover in southern African savannas using multi-temporal and polarimetric ALOS PALSAR L-band images. ***Remote Sensing of Environment***, *166*, 138-153. doi.org/10.1016/j.rse.2015.06.013

Great thanks to JAXA

PALSAR/PALSAR-2 data access

Please list the PALSAR/PALSAR-2 data you have

(1) requested and (2) obtained.

Almost all requested PALSAR/PALSAR-2 data have been obtained

Have you had sufficient data to complete your research (according to your K&C agreement)?

If not, which key data sets are missing?

Yes

Thank you

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For KC members who have submitted proposal for Post-KC

Post-KC proposal

- **Title:** *Characterization of Amazon floodplain forest habitats and inundation dynamics using PALSAR-2 time series*
  (together with L. Hess (UCSB), IRD France, INPE, C. Peres (Univ. of East Anglia))

  Belmont Forum-BiodivERsA project BONDS ("Balancing BiOdiversity CoNservation with Development in Amazonian WetlandS")

- **Study area**: *Amazon floodplain forests (varzea forests)*

- **Satellite data requested from JAXA:**
  ALOS-2 PALSAR-2, Level 1.1 SLC data, 50 scenes per year

- **Expected outcomes and deliverables:**
  land cover and inundation dynamics mapping
  vegetation structure (AGB, height) mapping
  estimation of water storage

- **Relevance to the 4 K&C thematic drivers:**
  Carbon cycle science, Climate Change, International Conventions, Environmental Conservation