

Forestry Yield Prediction Using Sentinel-1 Images

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Introduction



Figure 1: Pandule forest area, Paysandú, Uruguay

Related work

Main insights:

- There is definitely exploitable information in Sentinel-1 images
- The problem of saturation is serious and particularly affects S1

Goals:

- Verify that there is no exploitable information about the AGB of an already mature forest ;
- In doing so, establish methods which could be applied to larger wavelengths ;
- Identify and correct for sources of variation in the radar measurements ;
- Confirm that Sentinel-1 images contain useful information for young forests and try to estimate the saturation point in years

Data

Summary

Data:

- Measurements (ground truth)
- Images
- Polygons
- Weather

Zones:

- North
- South
- New Forest
- Montenativo

Measurements: Exploration

Two zones:

- North
- South

Main fields:

- Date
- Coordinates
- Rodal (segment of forest)
- Height
- Diameter
- Basal area
- Volume

Measurements: Exploration

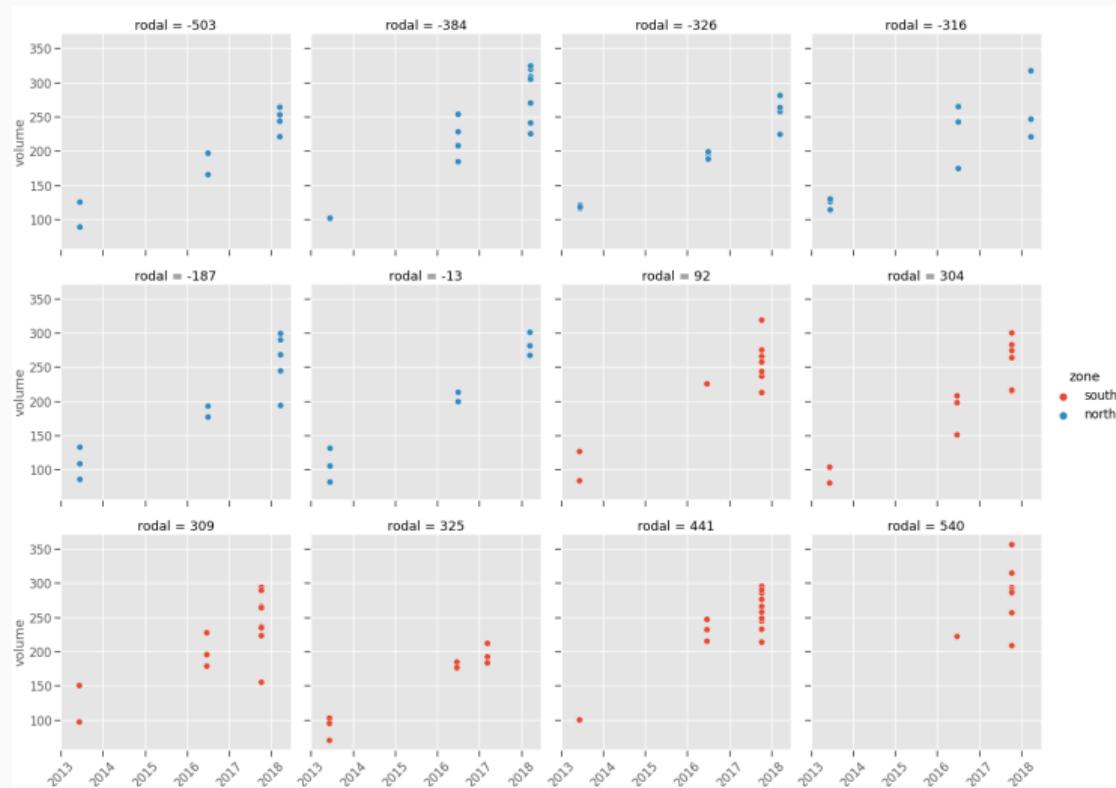


Figure 2: Volume measurements for the 12 most represented rodals

Measurements: Exploration

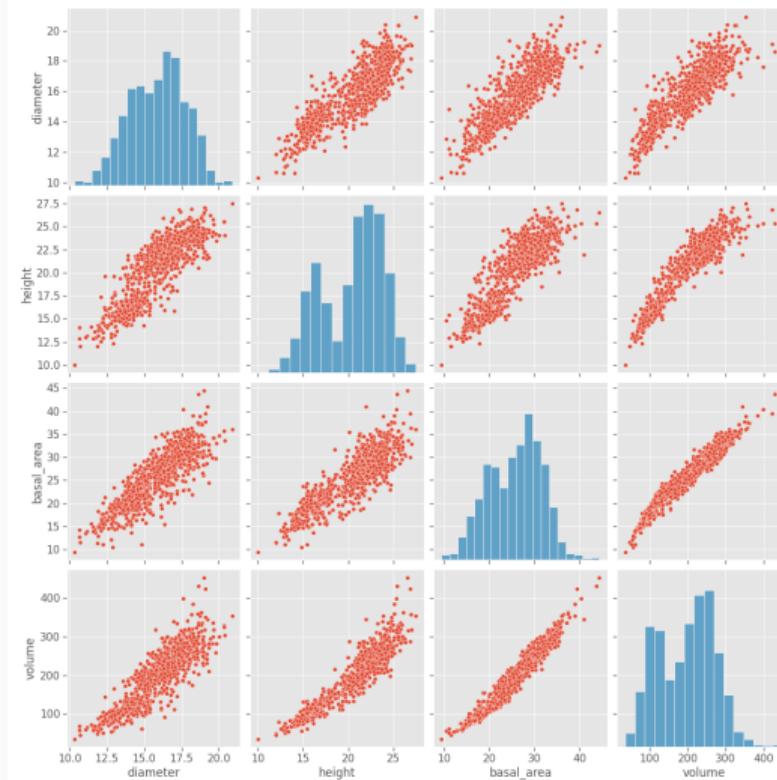


Figure 3: Pairwise relationships between measurements

Measurements: Units

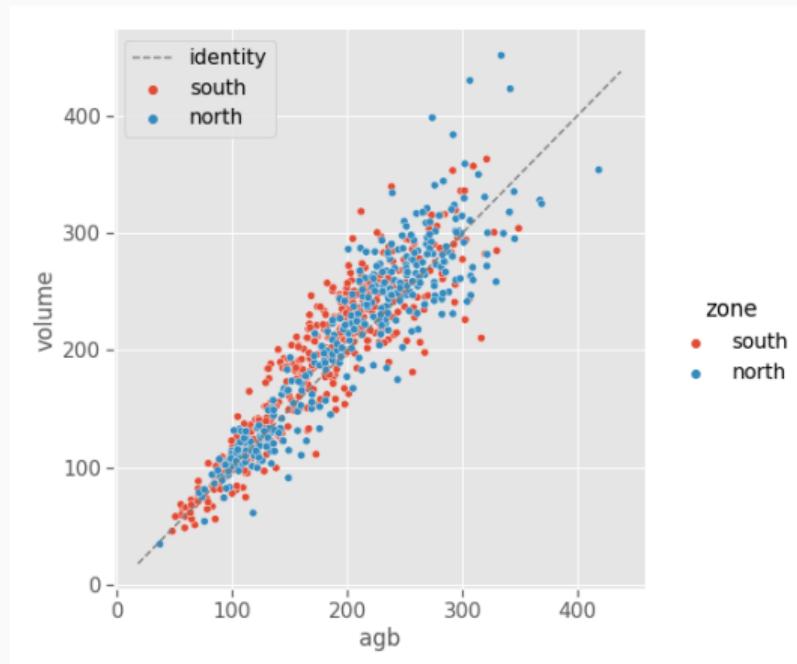


Figure 4: Correspondence between AGB estimation in Mg/hectare and the data

Measurements: Choosing a zone

Table 1: Number of measurements for each year in the north and south zone

year	north	south
2013	103	151
2016	103	147
2017	0	176
2018	144	0
Total	350	474

Measurements: Choosing a zone

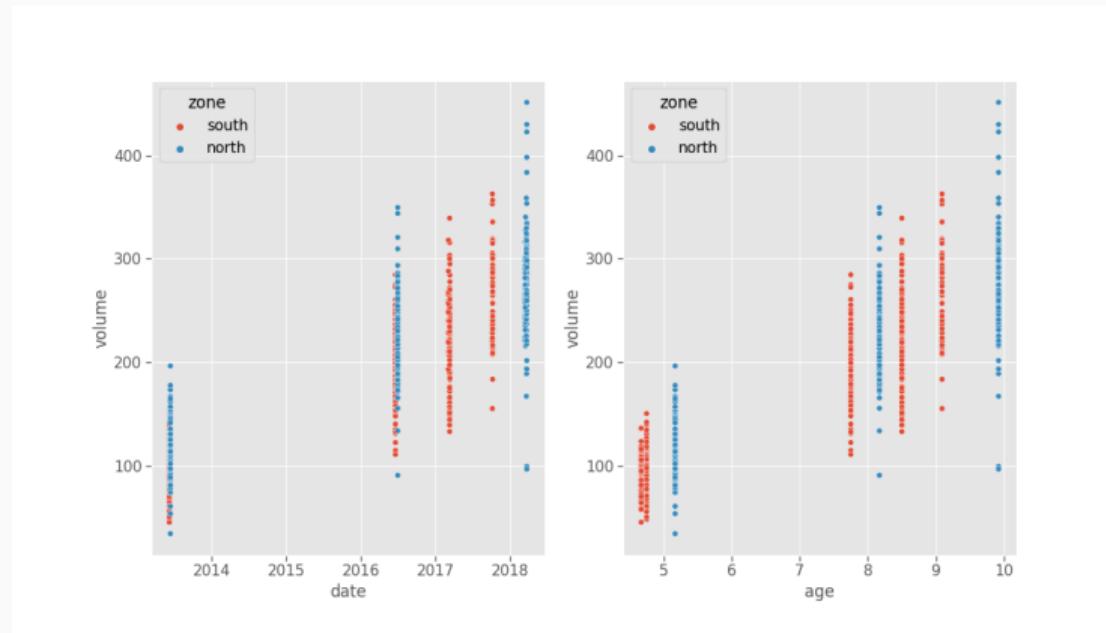


Figure 5: Comparison of the north and south zones

Images

zone	n_images	resolution	first_date	end_date
south	61	588x372	2017-01-04	2018-12-25
new_forest	116	480x288	2017-01-04	2021-04-01
montenativo	116	972x348	2017-01-04	2021-04-01

Images and Polygons: South

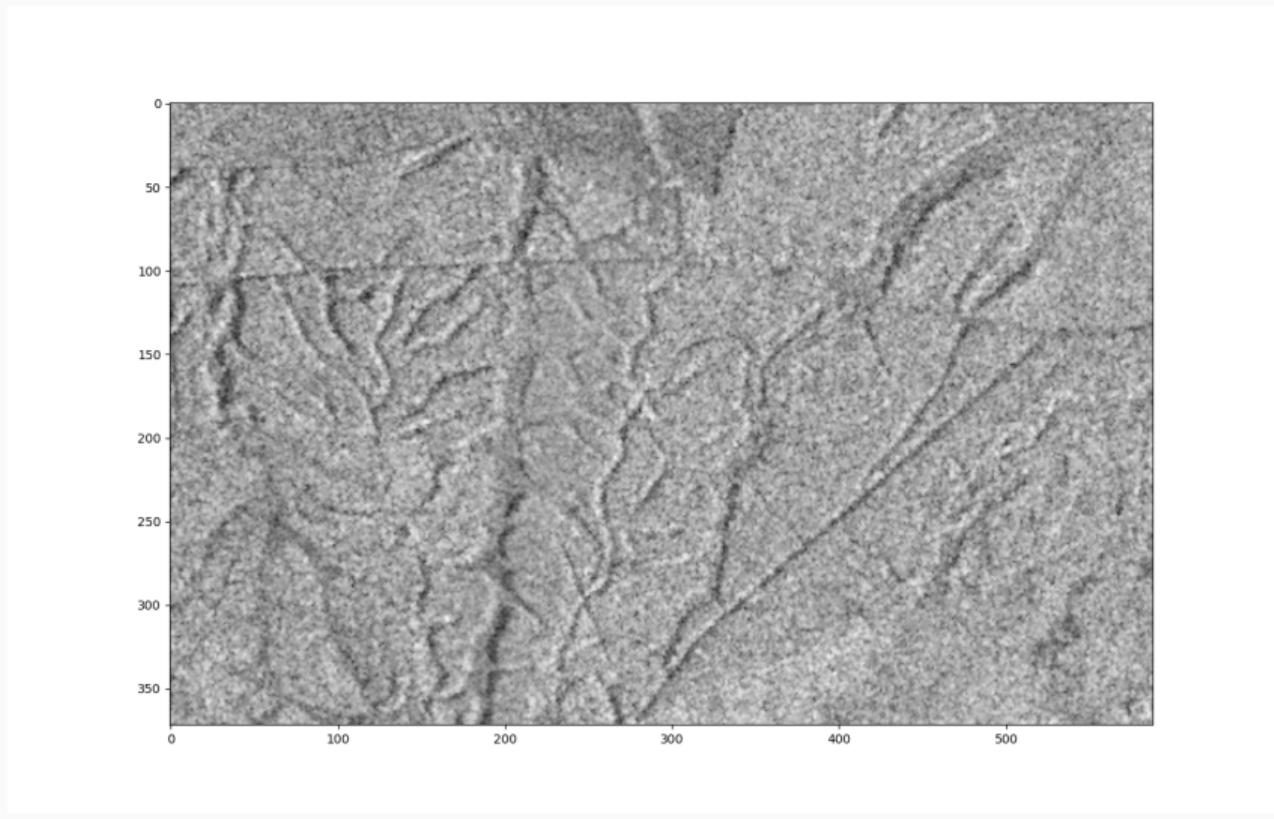


Figure 6: Image of the South zone on 2017-01-04, in VV polarisation

Images and Polygons: South

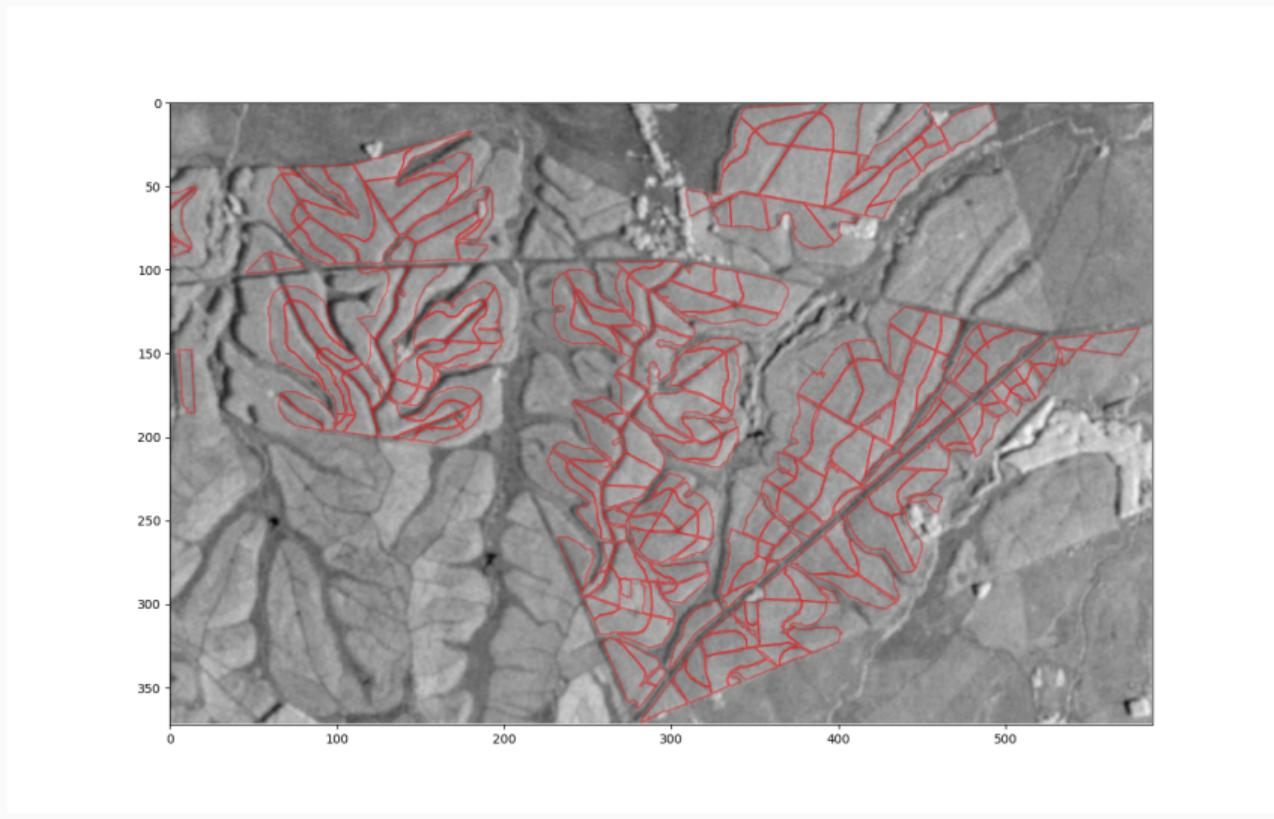


Figure 7: Mean image of the South zone, with its polygons (rodals)

Images and Polygons: New forest

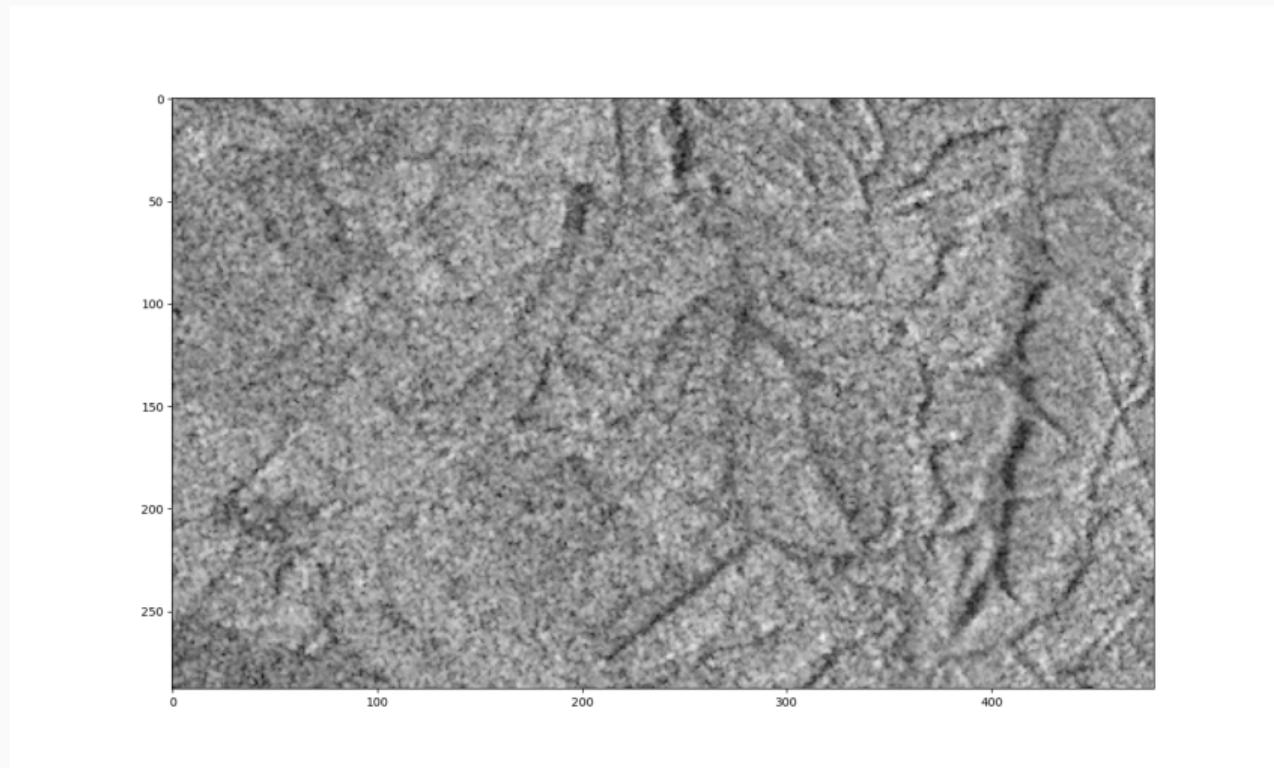


Figure 8: Image of the New forest zone on 2017-01-04, in VV polarisation

Images and Polygons: New forest

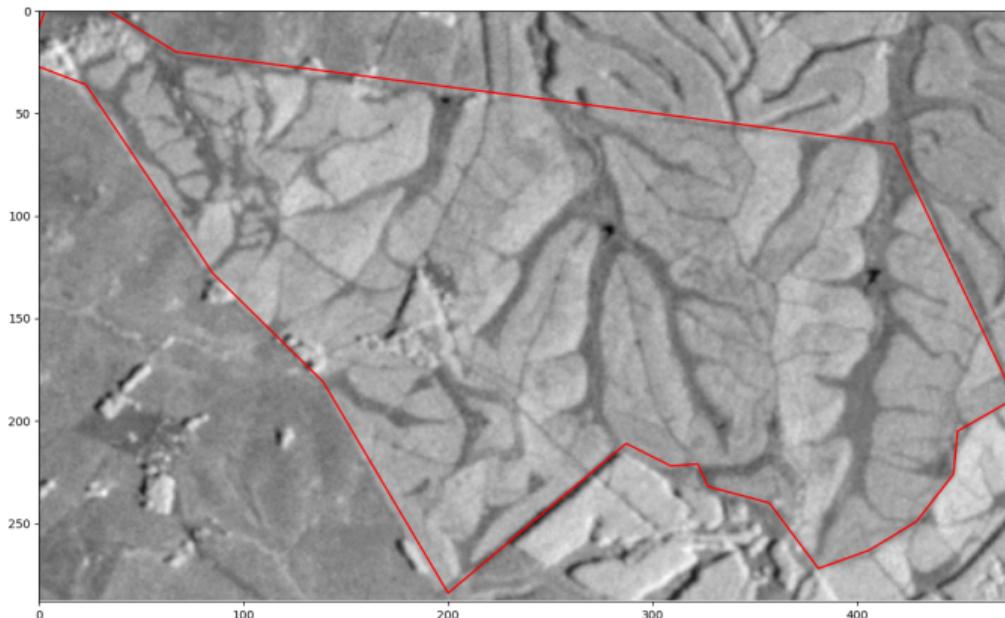


Figure 9: Mean image of the New forest zone, with its polygon

Images and Polygons: Montenativo

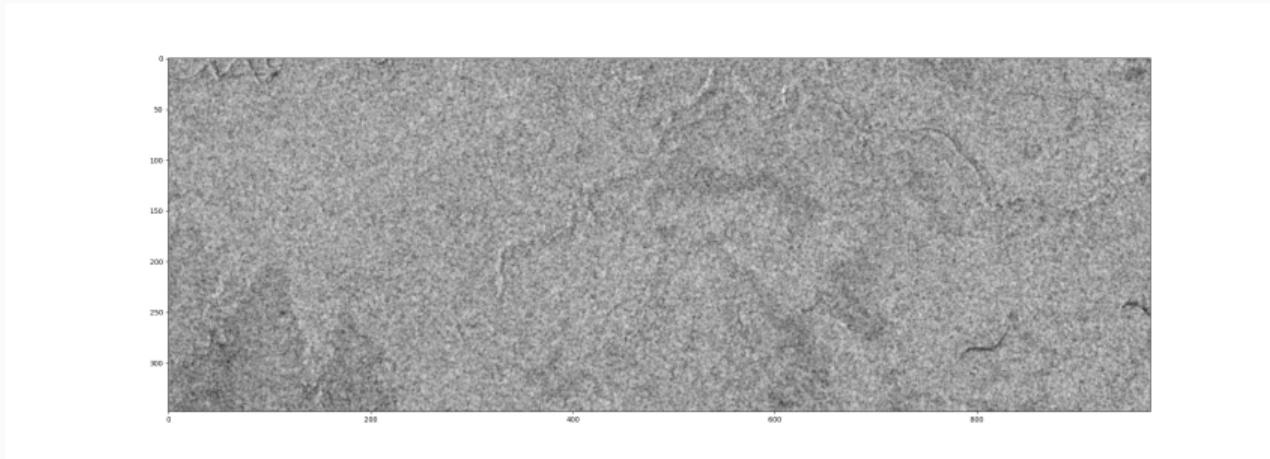


Figure 10: Image of the Montenativo zone on 2017-01-04, in VV polarisation

Images and Polygons: Montenativo

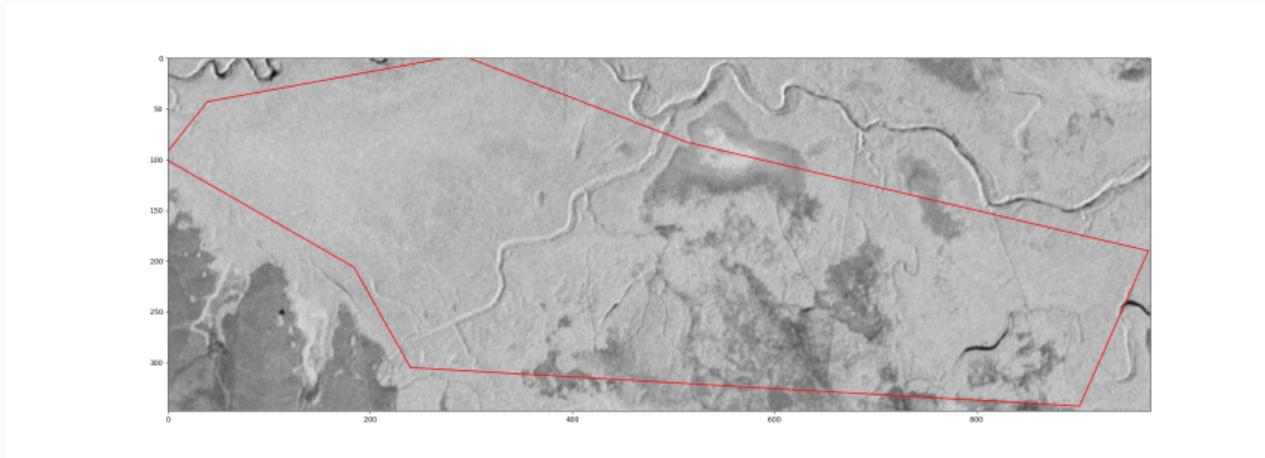


Figure 11: Mean image of the Montenativo zone, with its polygon

Weather

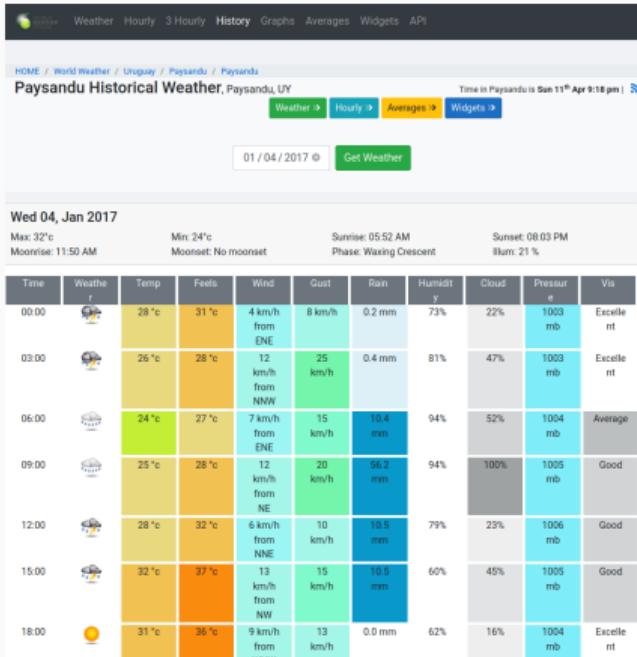


Figure 12: worldweatheronline.com historical weather page

Methods and Results

Normalisation: South

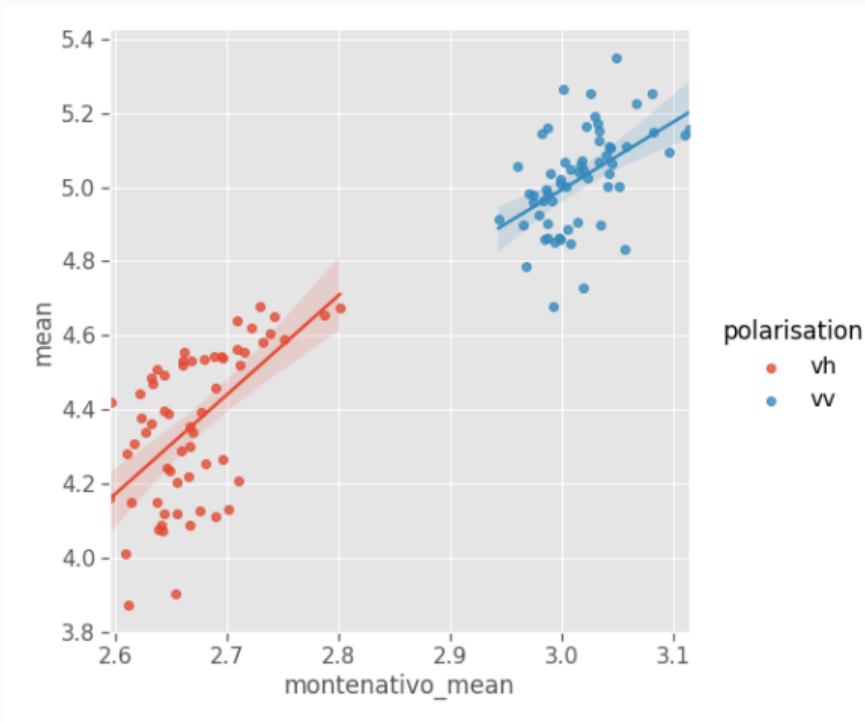


Figure 13: Correlation between South zone backscatter and Montenativo

Normalisation: South

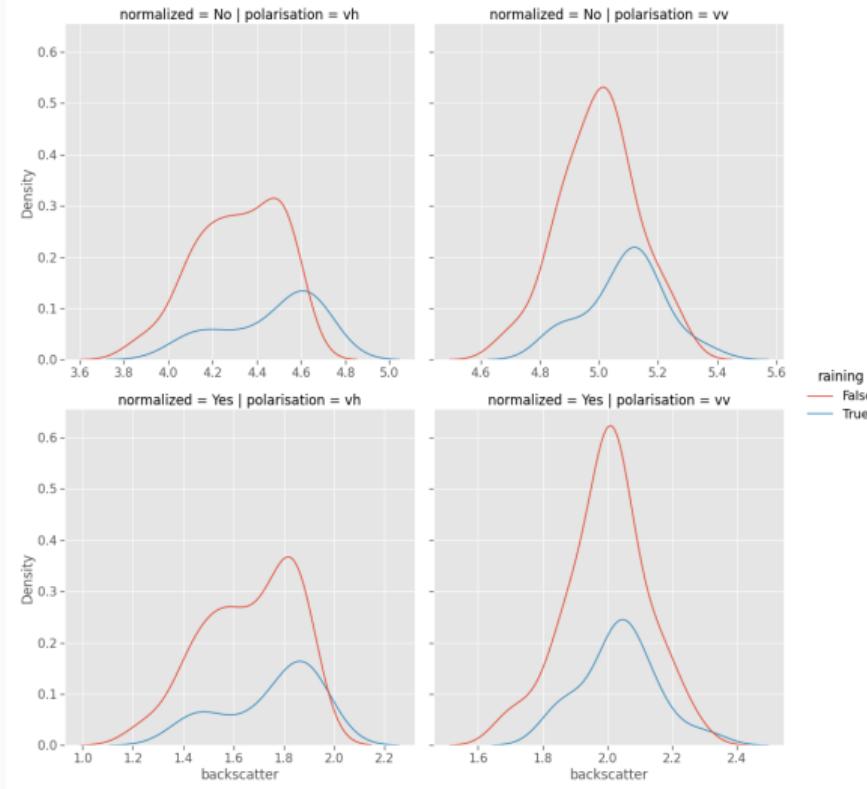


Figure 14: South zone weather effect before and after normalization

Normalisation: New forest

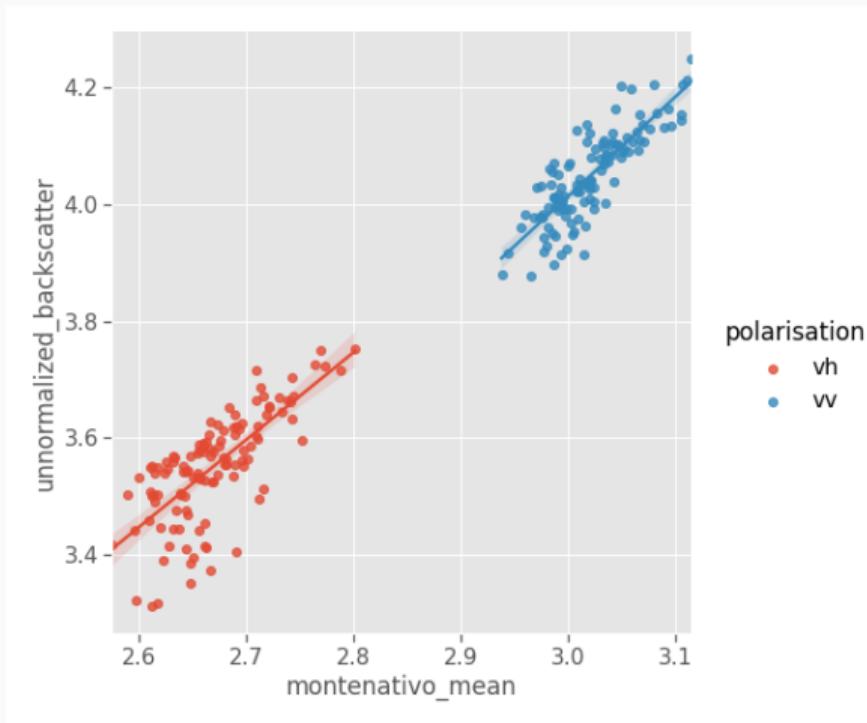


Figure 15: Correlation between New forest zone backscatter and Montenativo

Normalisation: New forest

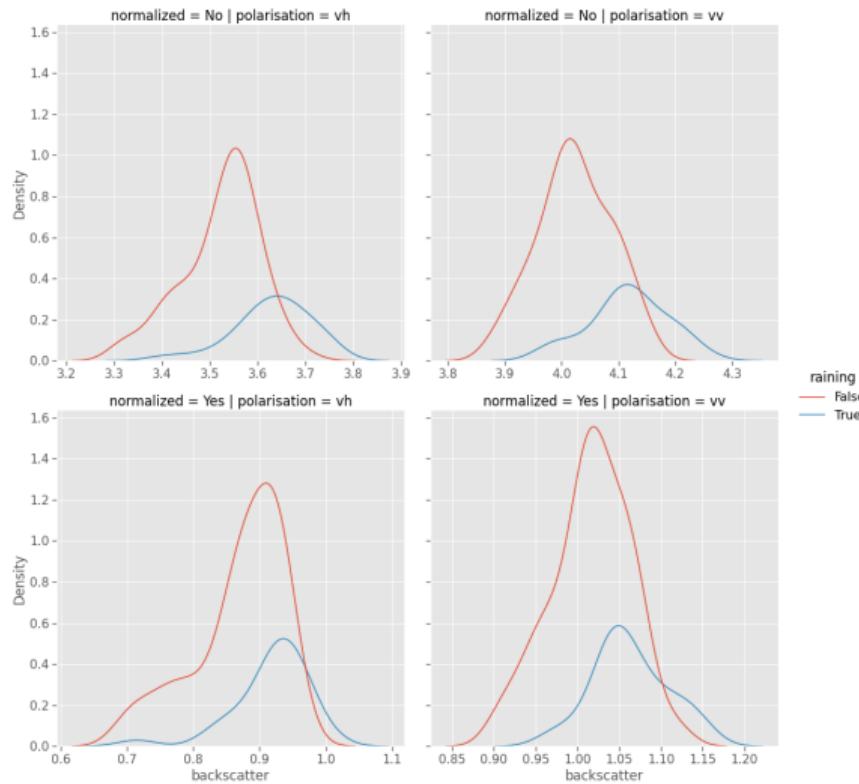


Figure 16: New forest zone weather effect before and after normalization

New Forest backscatter

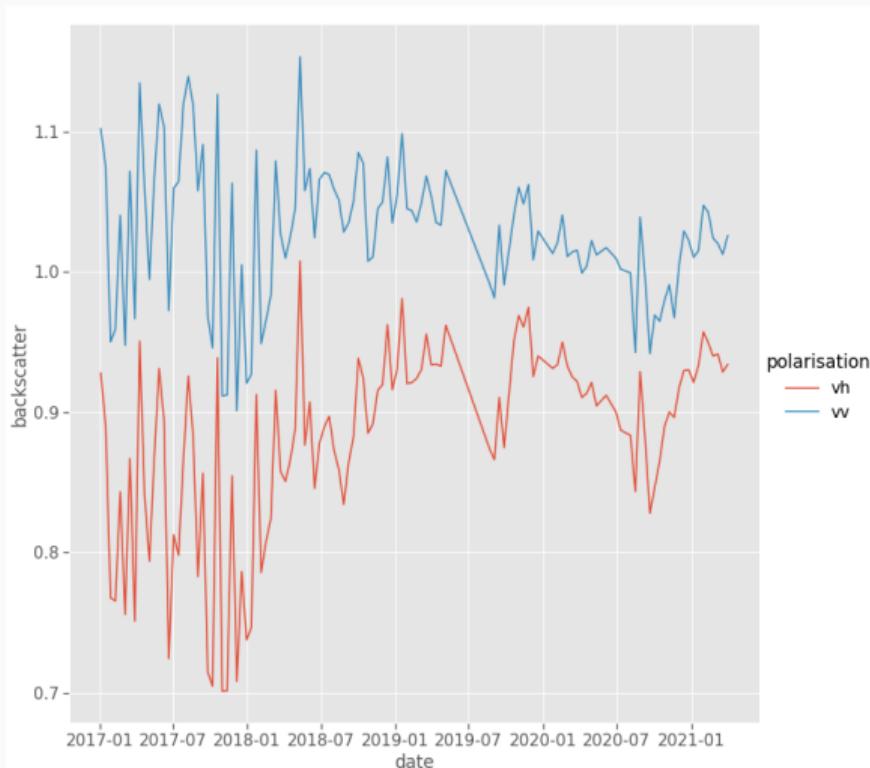


Figure 17: VV and VH backscatter over time in New Forest

New Forest backscatter

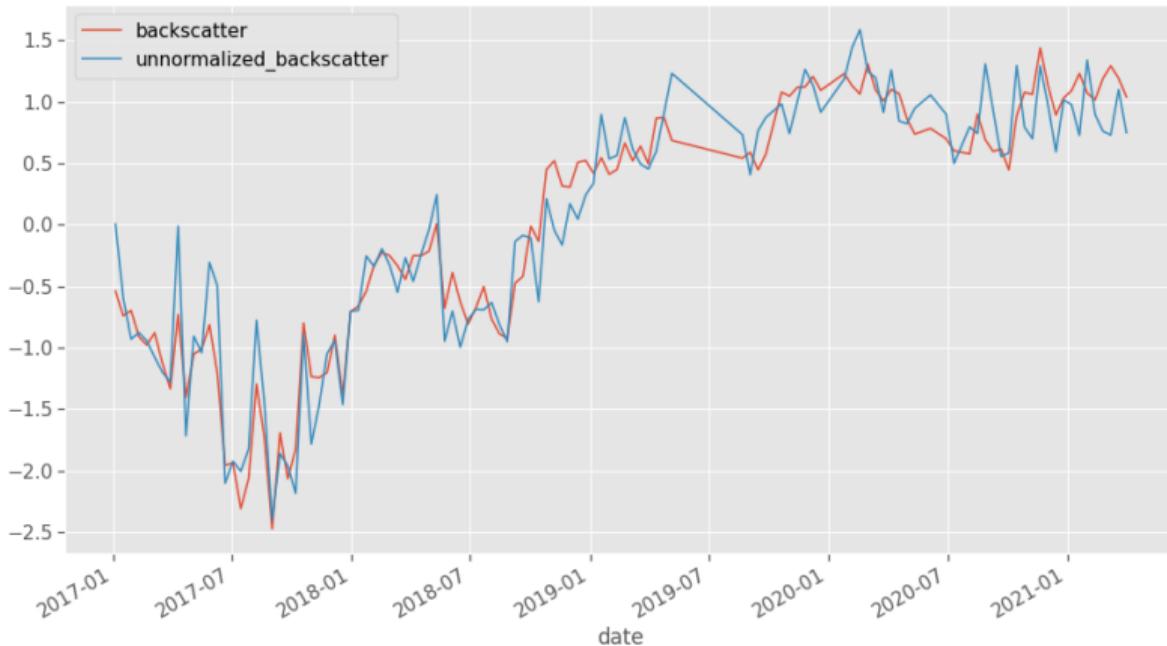


Figure 18: VH / VW backscatter over time, before and after normalization

AGB prediction on the South Zone

Three scales:

- Whole zone
- Rodal (forest segment)
- Tree

Theoretical saturation threshold

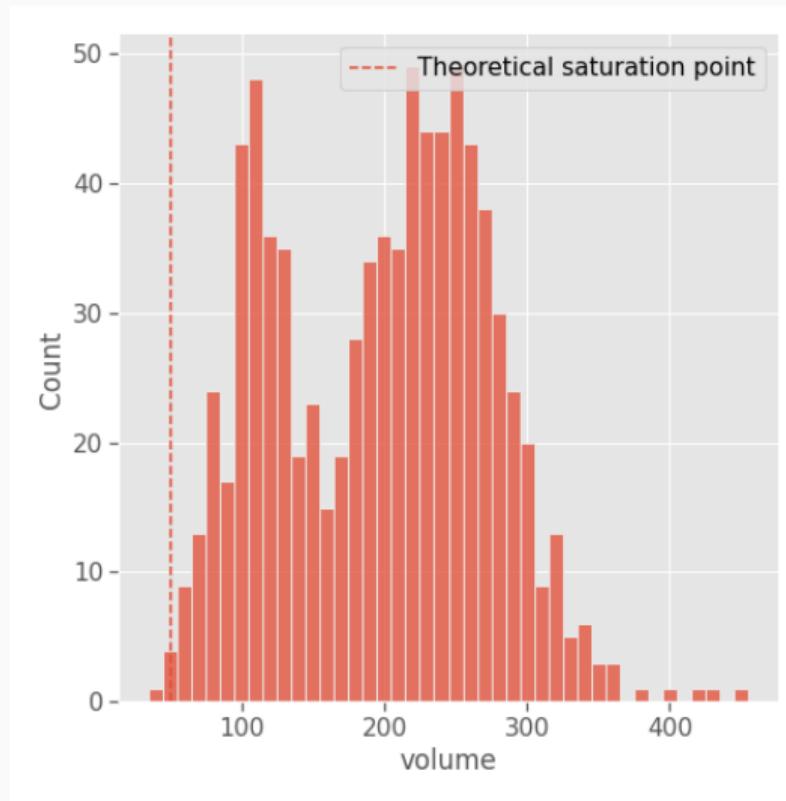


Figure 19: Saturation threshold according to the literature

Zone scale

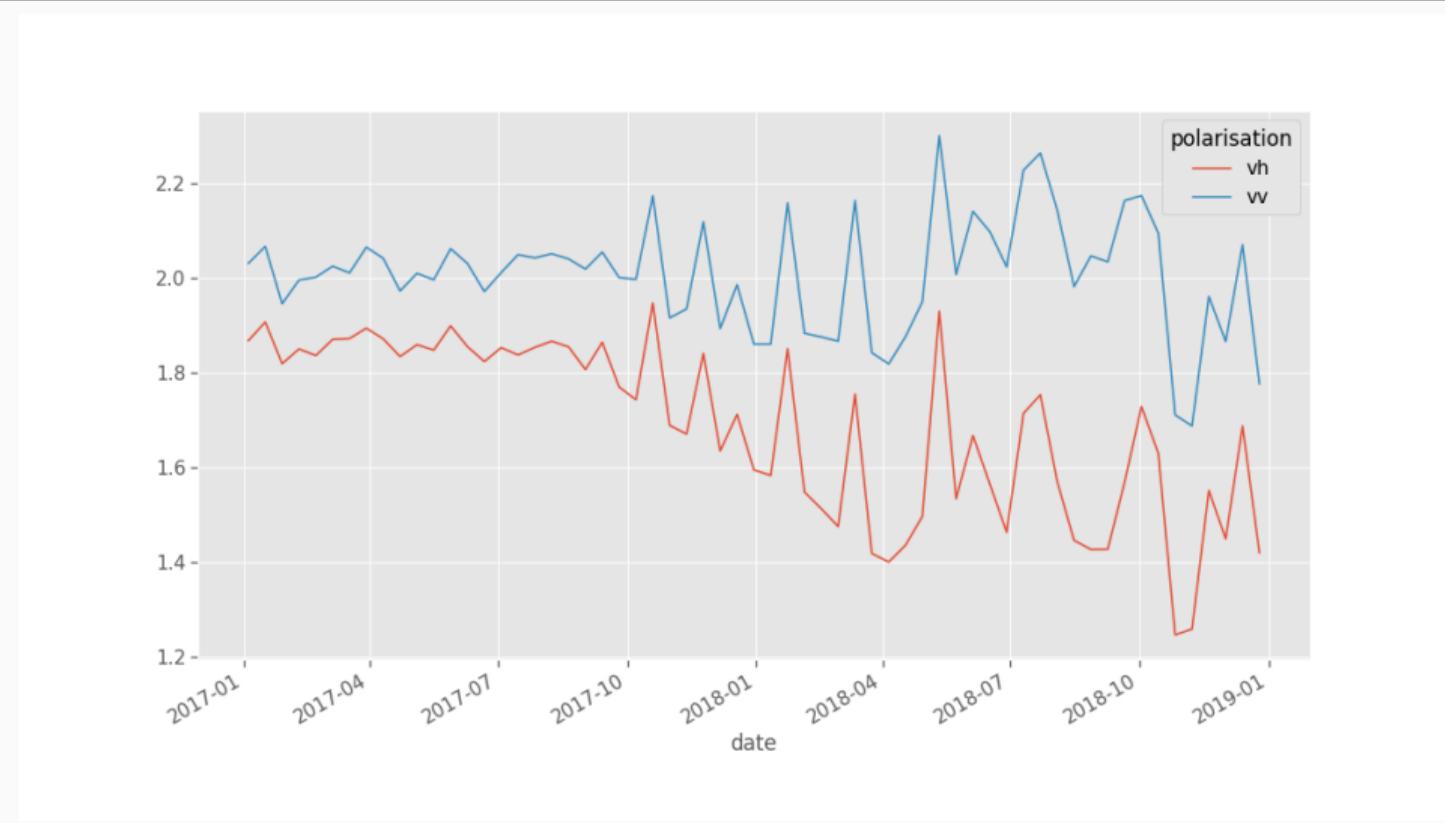


Figure 20: VV and VH backscatter over time in South zone

Zone scale

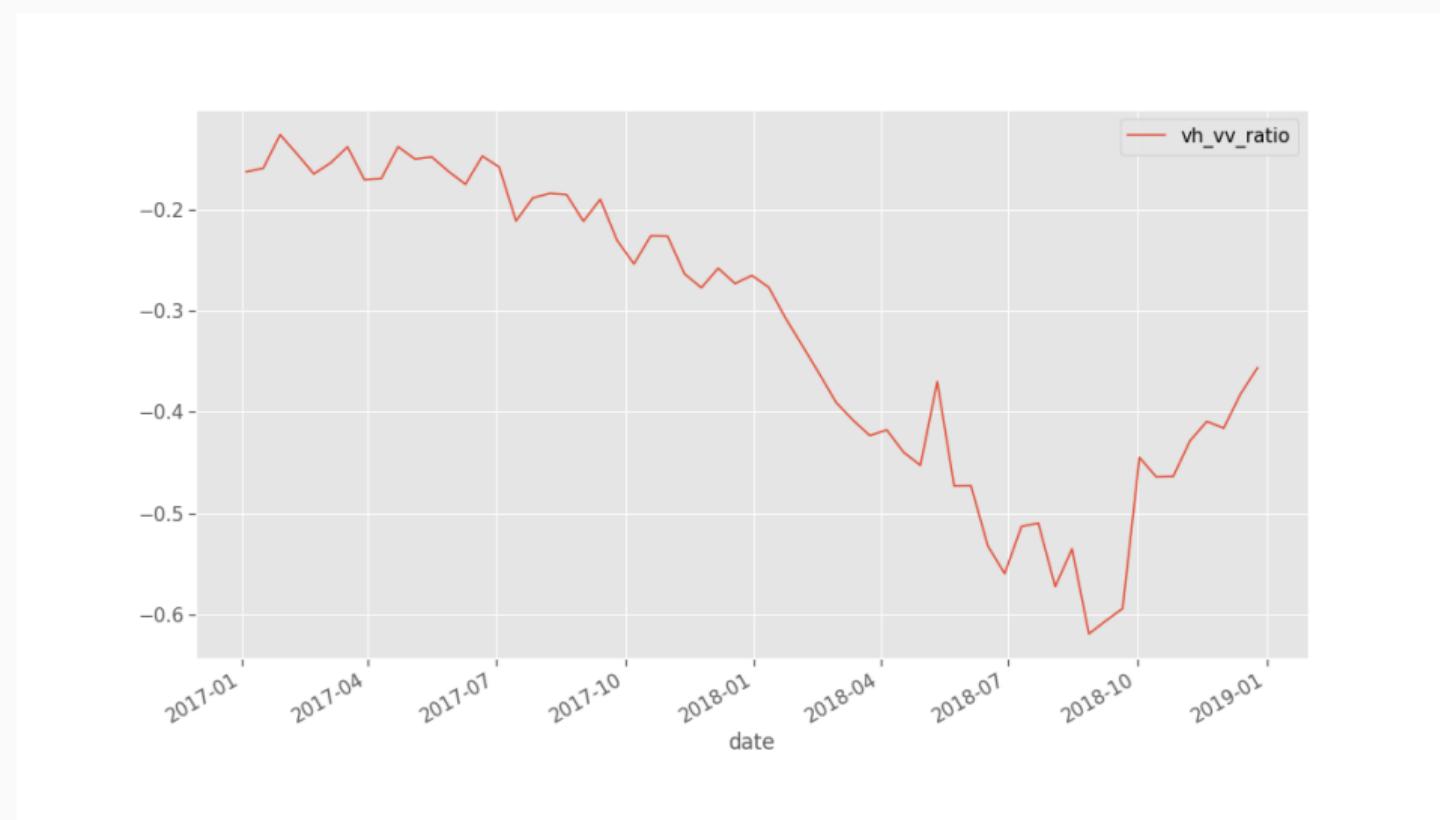


Figure 21: VH / VV backscatter over time in South zone

Rodal scale

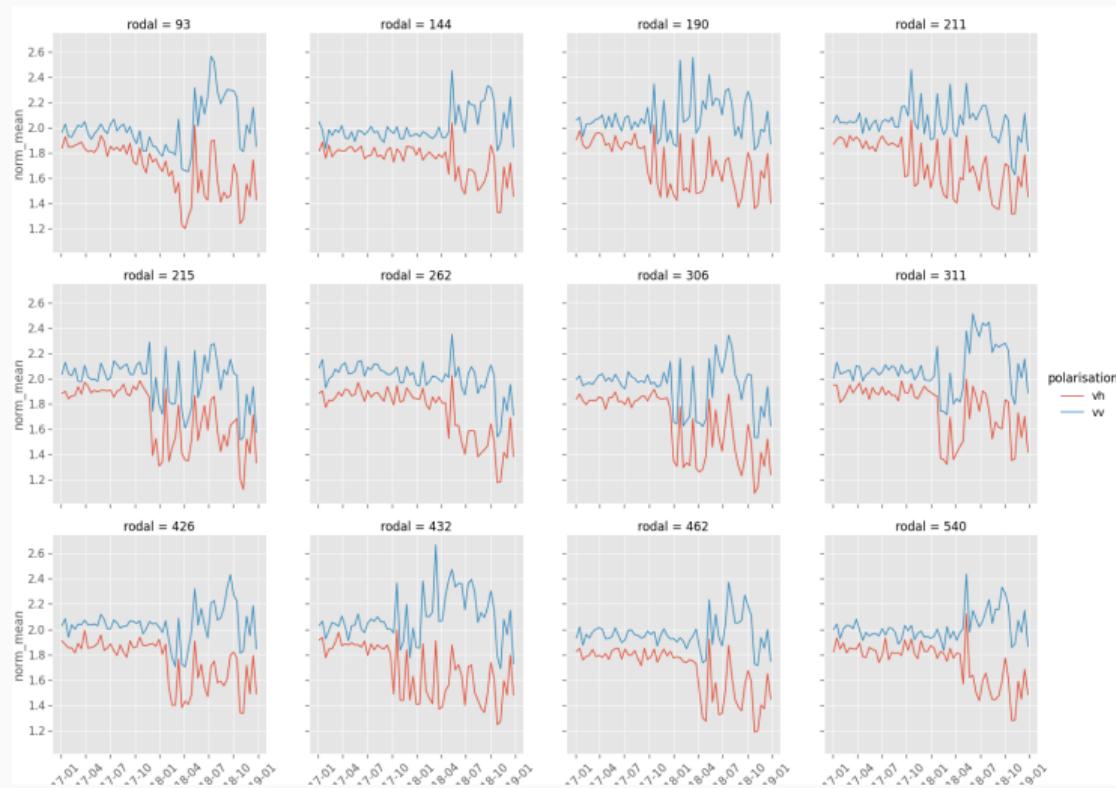


Figure 22: VV and VH backscatter per rodal

Rodal scale



Figure 23: VH / VV backscatter per rodal

Rodal scale

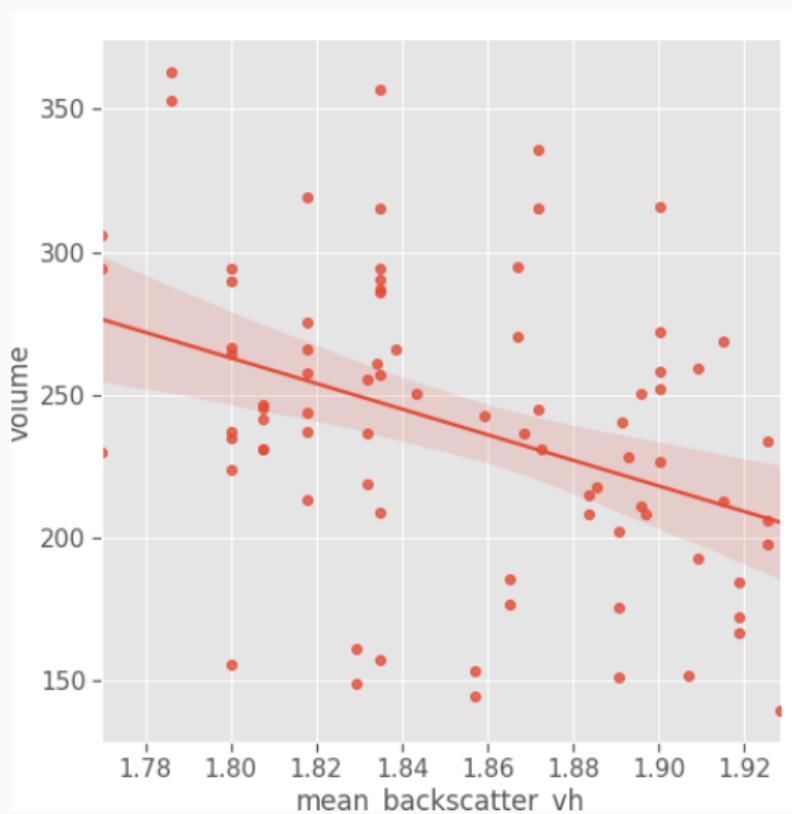


Figure 24: Relationship between VH backscatter and volume

Rodal scale

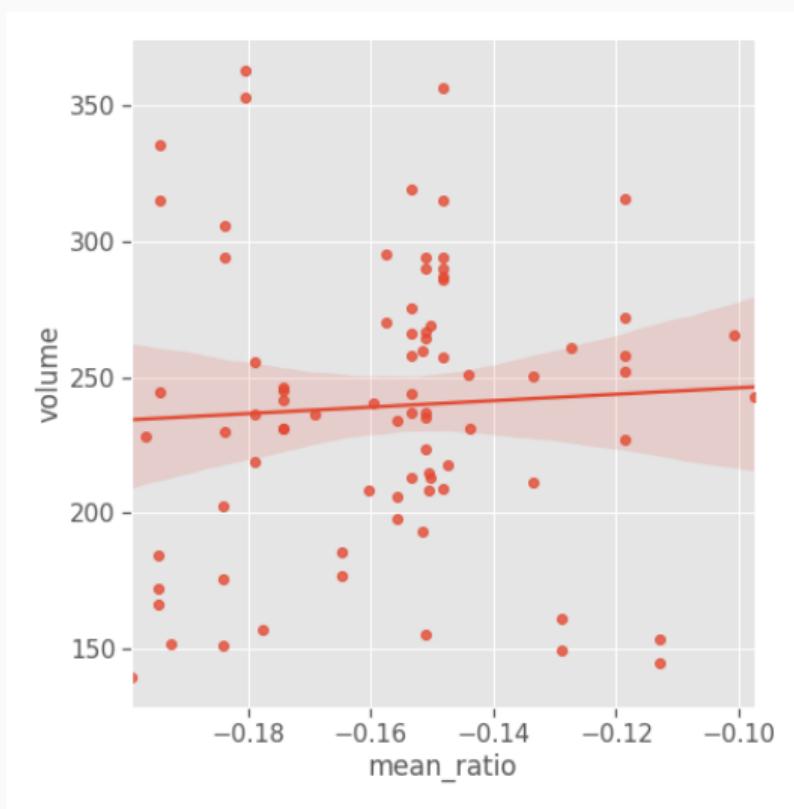


Figure 25: Relationship between VH/VV backscatter ratio and volume

Single-tree scale

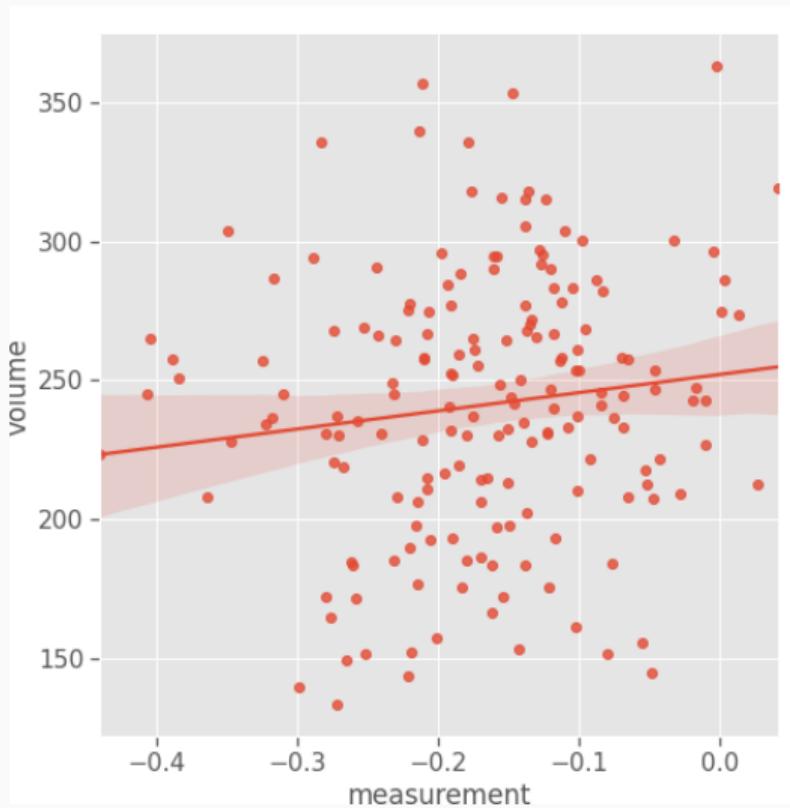


Figure 26: Relationship between per-tree measurement and volume

Conclusion

- We established a method (normalization, 3-scale analysis) for assessing the relationship between backscatter intensities and volume
- The C-band is indeed saturated for our forest
- The saturation point could be around 3 years of age for our species
- Reference-area normalization helps reduce variation a lot but is terrain-specific

Future work

- **Use a larger wavelength**
- Use a more adaptive normalization method that does not leave residual weather effects in young forest
- Make a more precise estimate of the saturation point for our case (using more ground truth data)