TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

Institute of Photogrammetry and Remote Sensing
Junior Professorship in Environmental Remote Sensing

Assessing the sensitivity of multi-frequency vegetation optical depth to biomass and canopy moisture content: towards an application-oriented evaluation

Luisa Schmidt[1], Matthias Forkel[1], Wouter A. Dorigo[2], Leander Moesinger[2], Robin van der Schalie[4], Marta Yebra[4], Thomas Pugh[5]

[1] Technische Universität Dresden, Institute of Photogrammetry and Remote Sensing, 01062 Dresden, Germany
[2] Technische Universität Wien, Department of Geodesy and Geoinformation, 1040 Vienna, Austria
[3] VanderSat, 2011 VK, Haarlem, The Netherlands
[4] Australian National University, Fenner School of Environment and Society, Canberra ACT, Australia
[5] University of Birmingham, School of Geography, Earth and Environmental Sciences, B15 2TT Birmingham, United Kingdom

Sensitivity of VOD to vegetation properties

- Vegetation Optical Depth (VOD) retrievals from microwave satellites provide novel opportunities to observe changes of vegetation on a global scale and over decades
- Theoretically, VOD is sensitive to vegetation water content (VWC), above-ground biomass (AGB), and the relative fuel moisture content (FMC) of vegetation: VOD = b * VWC = b * FMC * AGB
- Past studies found correlations between VOD and Leaf Area Index (LAI), productivity, biomass, or vegetation water status and used VOD to estimate changes in biomass, vegetation isohydricity, or tree mortality
- Different VOD products exist from different:
  - satellite sensors
  - microwave frequencies (Ku, X, C, L-bands)
  - retrieval algorithms

} Differences in temporal dynamics, short-term variability, and different regional relations e.g. with LAI

Key questions:

→ Which vegetation properties is VOD actually "measuring"?

→ Which VOD product might be the most suitable for a certain ecological application?

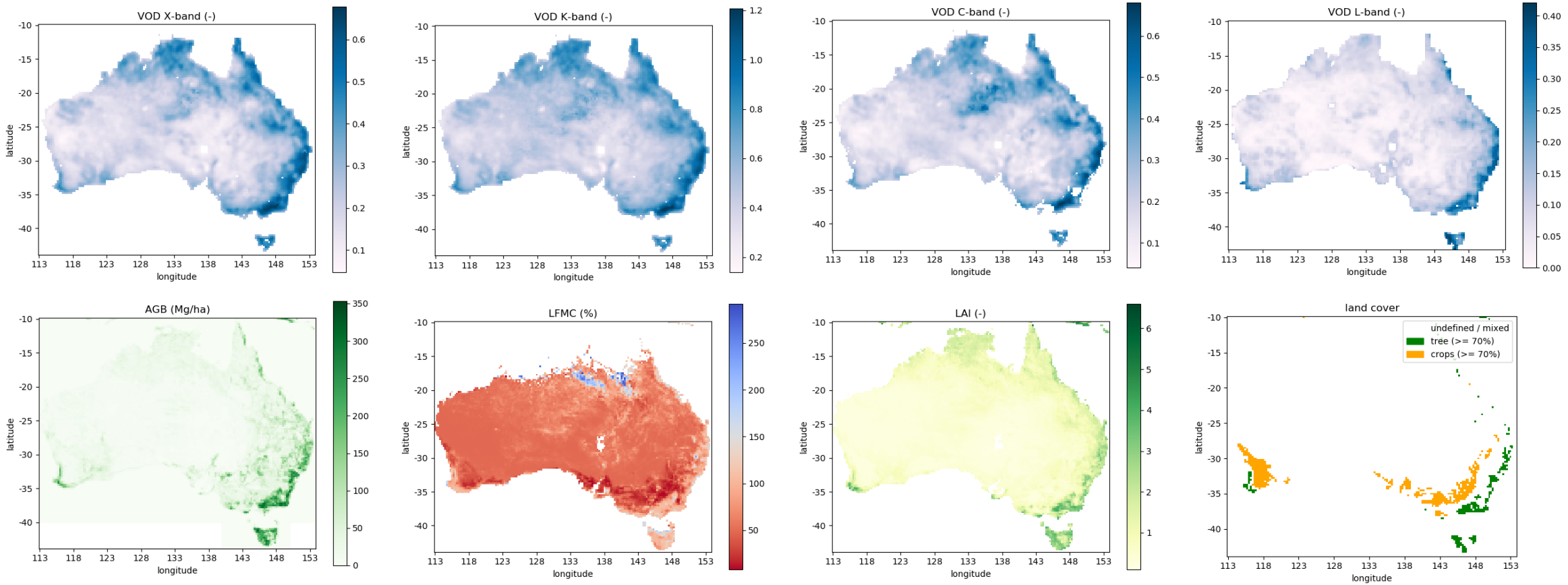
Aim: Assess several VOD products with respect to ecological interpretability and quantify the co-varying sensitivities of high- (Ku, X, C-bands) and low-frequency (L-band) VOD products to AGB, LAI, and LFMC

Data and methods

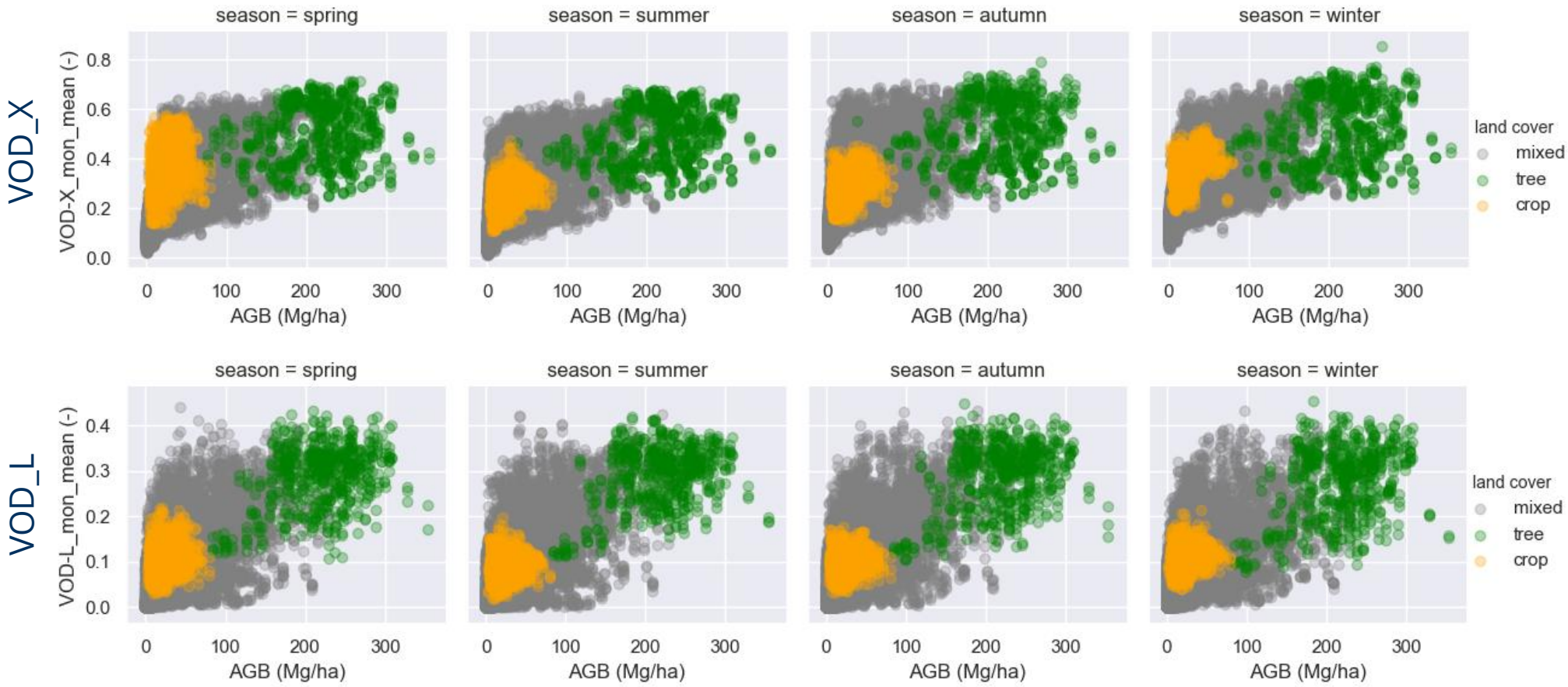
- We currently constrained the analysis to Australia because of the availability of LFMC data (Yebra et al. 2018)
- All datasets were aggregated to monthly time steps and 0.25° spatial resolution
- We used Generalized Additive Models (GAM) to quantify sensitivities of VOD to AGB, LAI and LFMC
- Results are shown for VOD X- and L-band, per land cover, and season

Variable	Used temporal coverage	Dataset
VOD C-band	2017	VODCA (Moesinger et al., 2019)
VOD X-band	2017	VODCA (Moesinger et al., 2019)
VOD K-band	August 2016 – July 2017	VODCA (Moesinger et al., 2019)
VOD L-band	2017	SMAP (van der Schalie et al., 2016)
AGB	2017	ESA Biomass CCI (Santoro & Cartus, 2019)
LFMC	2017	Yebra et al. (2018) – derived from MODIS
LAI	2017	MOD15A2H - MODIS (Myneni et al., 2015)
Land cover	2015	ESA CCI Land Cover

Datasets (Example: monthly mean for January 2017)

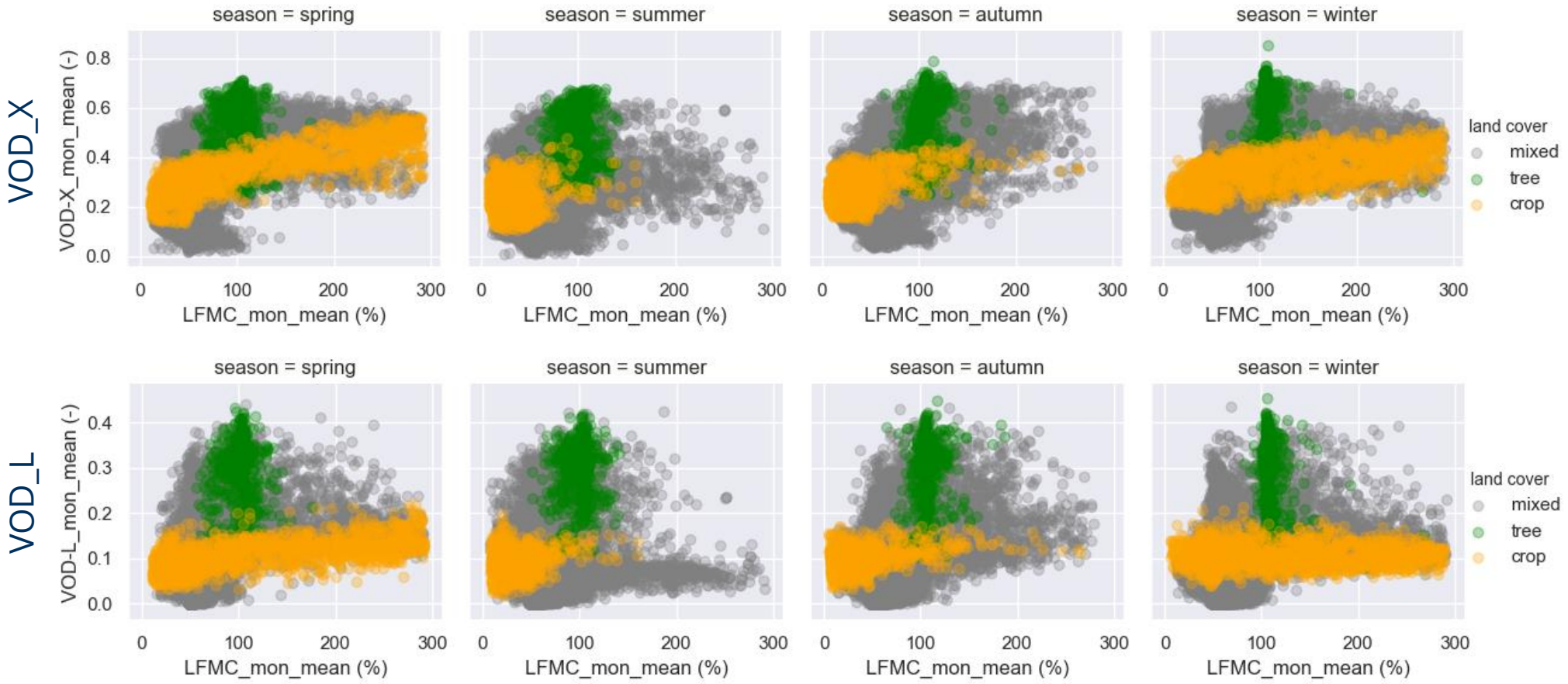


Comparison of VOD X-band and L-band - AGB



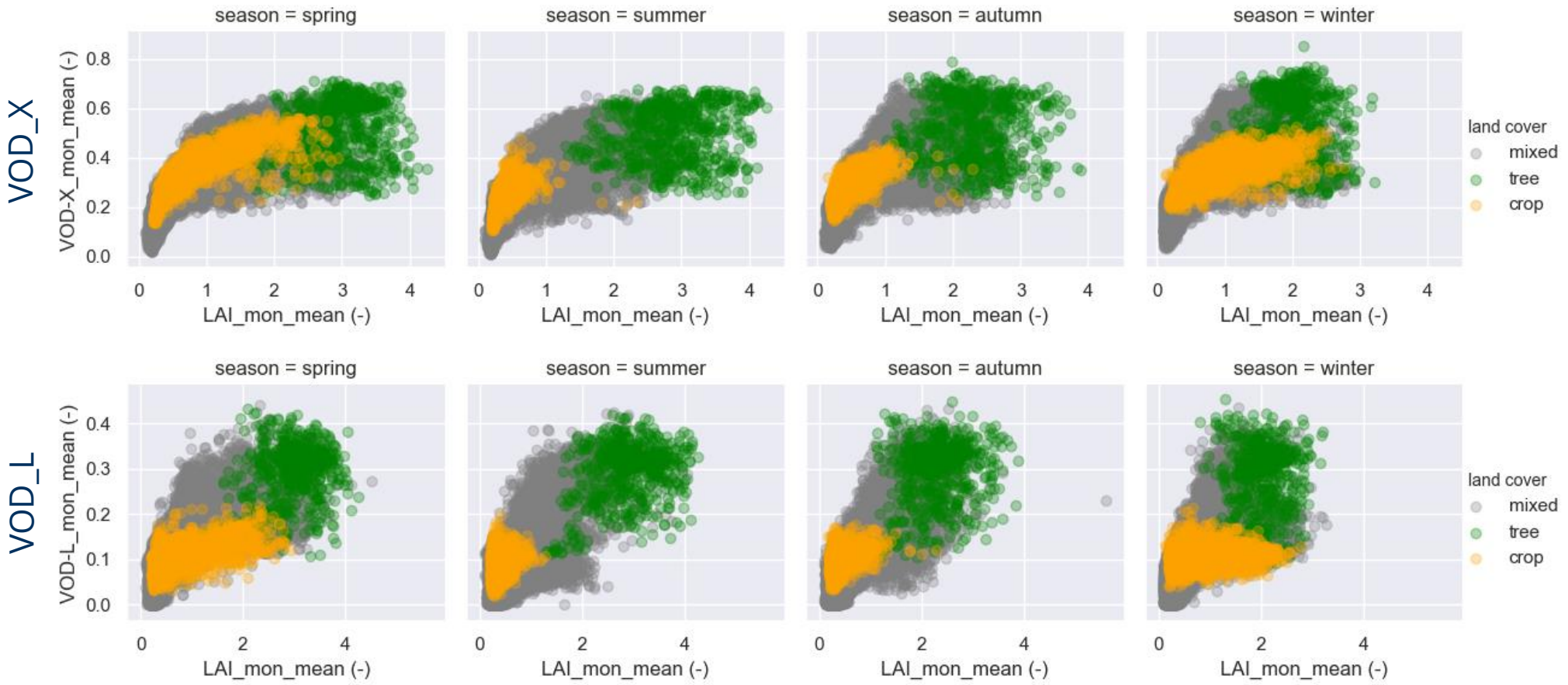
Spatial correlation between AGB and VOD is significant.

Comparison of VOD X-band and L-band – LFMC



VOD and LFMC are correlated over croplands.

Comparison of VOD X-band and L-band - LAI



X-band VOD correlates higher with LAI than L-band VOD.

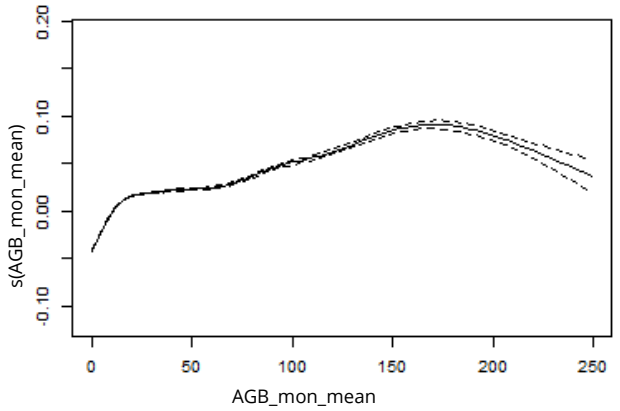
Sensitivity of VOD to vegetation properties: AGB

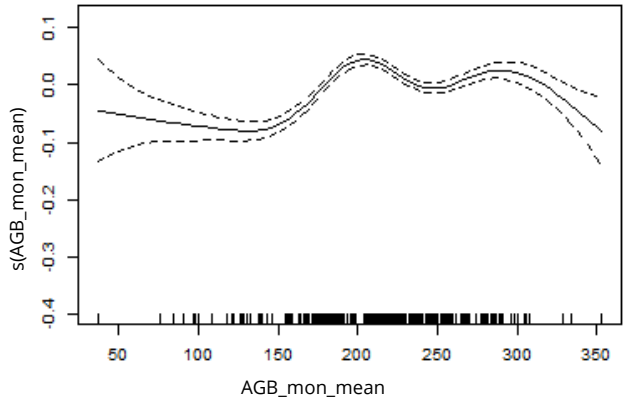
We predict VOD from ecosystem properties using Generalized Additive Models:

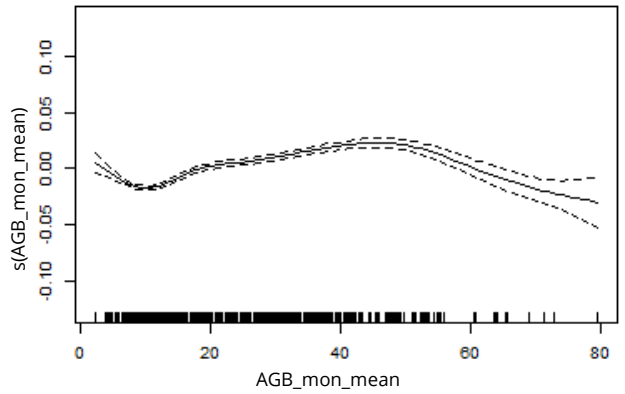
VOD_{band} = s(AGB) + s(LFMC) + s(LAI) … with s() smoothing spline functions of original predictors

Mixed land cover | Forests (> 70% tree cover) | Croplands

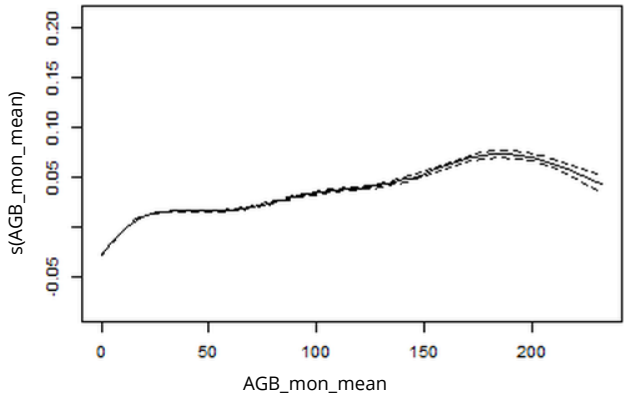
X-band

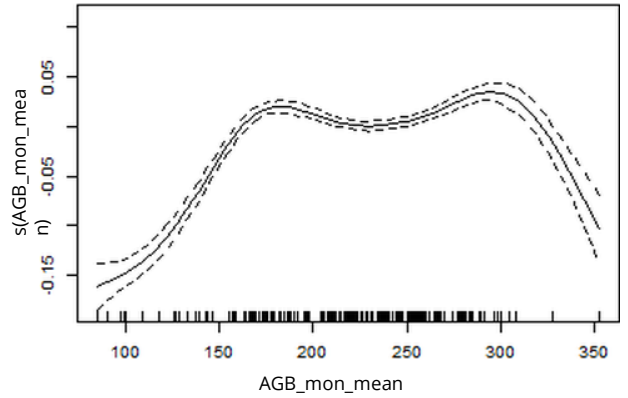


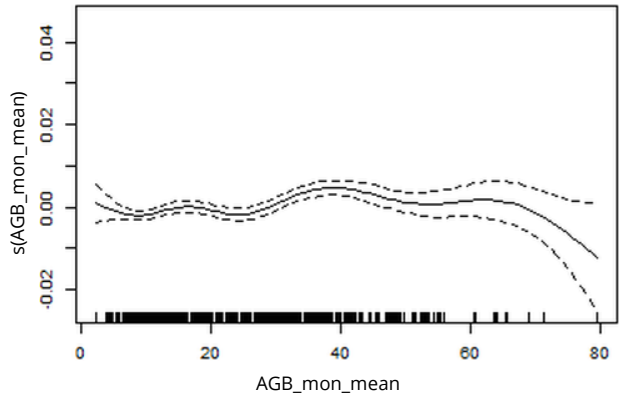




L-band



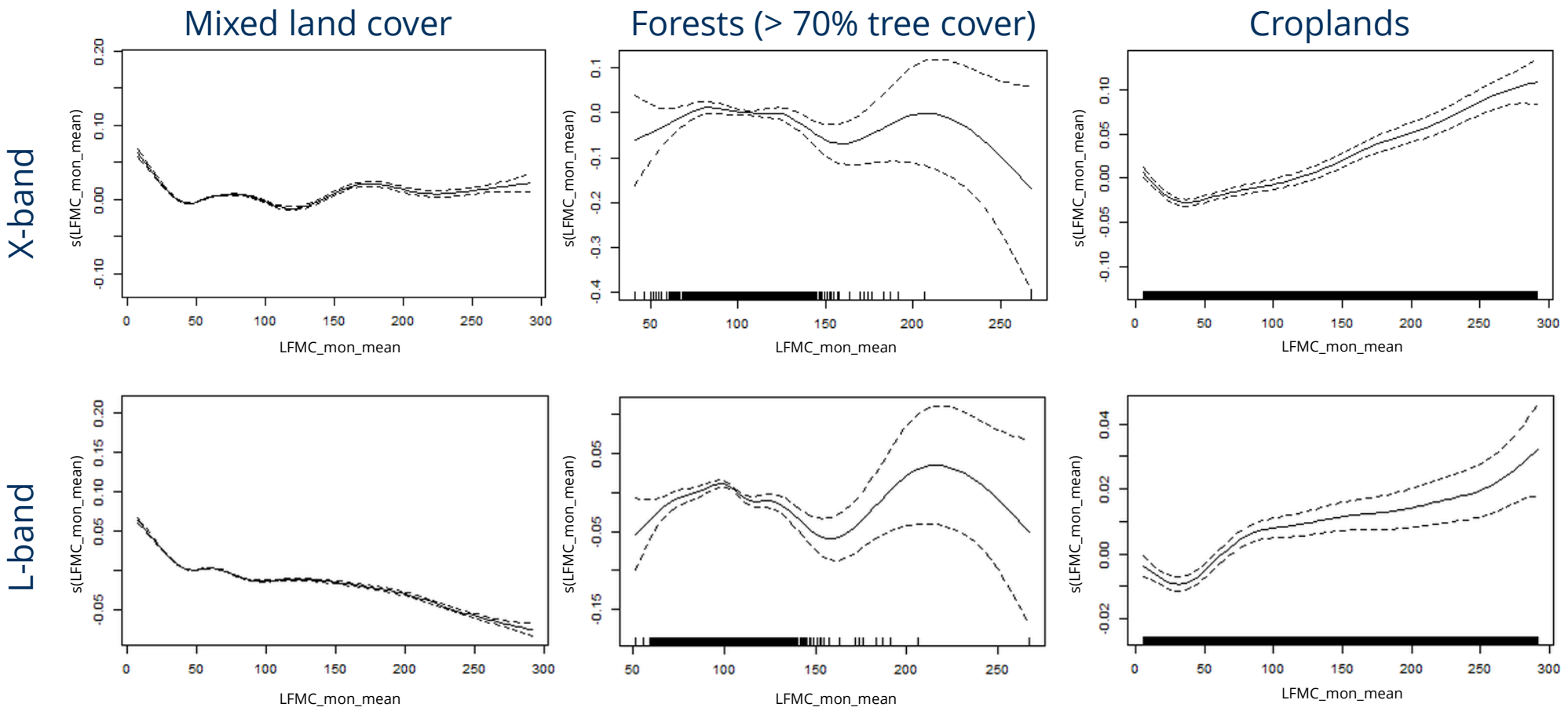




A different contribution of AGB to the two VOD bands is not clearly visible, except in case of forests.

Sensitivity of VOD to vegetation properties: LFMC

- Relationship of VOD and LFMC is only positive in croplands
- No clear difference between X and L-band

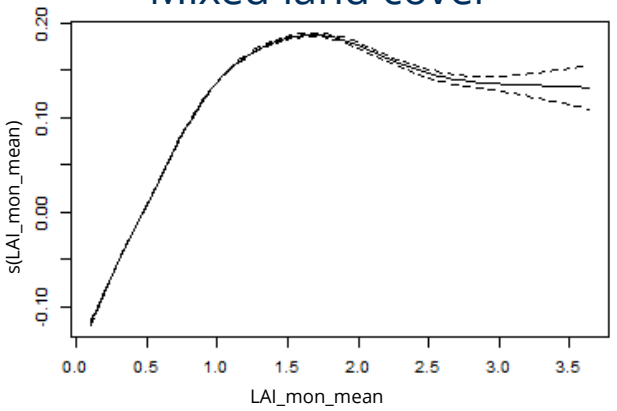


Sensitivity of VOD to vegetation properties: LAI

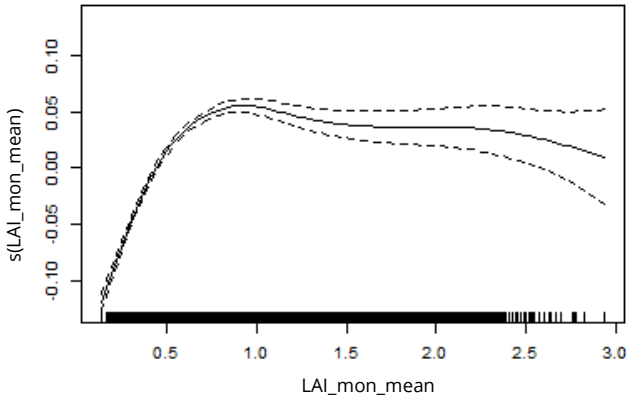
- Relation between VOD and LAI is positive but both VOD bands saturate at high LAI

X-band

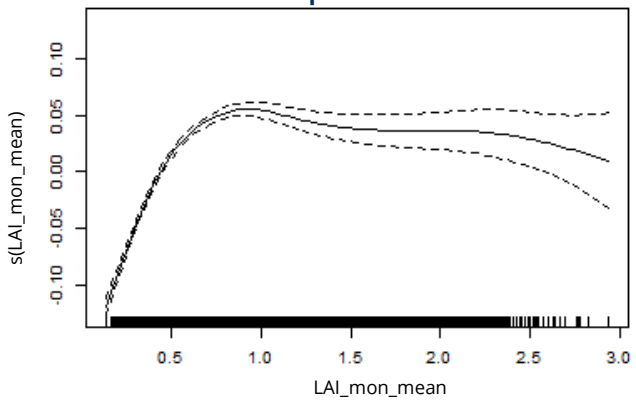
Mixed land cover



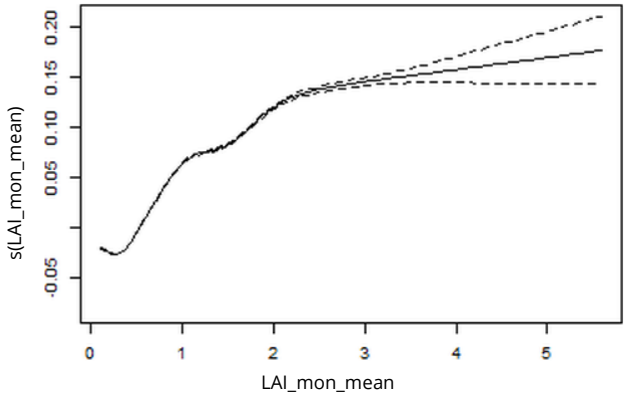
Forests (> 70% tree cover)

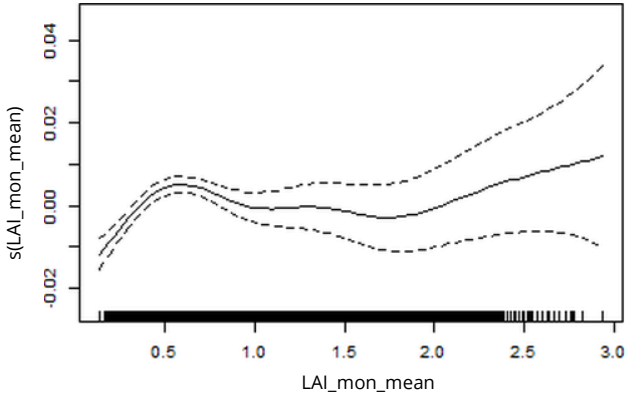


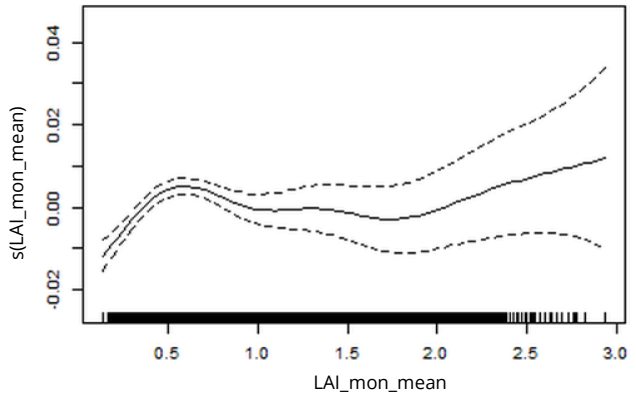
Croplands



L-band







Conclusion

- All VOD bands show the strongest relationship with LAI
- VOD shows positive relation with LFMC in croplands
- Relationship with biomass is non-linear
- Differences between high-frequency (Ku, X, C) and low-frequency (L-band) are rather small
- Sensitivities of VOD to vegetation properties differ per land cover types

Outlook

- Including longer time series
- Moving towards a global-scale analysis
- More detailed assessment of land cover types
- We would like to include VOD datasets from other retrieval algorithms and sensors (e.g. SMOS)
  → VOD producers: Please contact us if you are interested in including your dataset in the comparison.

Literature

Moesinger, L., Dorigo, W., de Jeu, R., van der Schalie, R., Scanlon, T., Teubner, I., & Forkel, M., 2019. The Global Long-term Microwave Vegetation Optical Depth Climate Archive VODCA. *Earth System Science Data Discussions*, (April), 1–26. https://doi.org/10.5194/essd-2019-42

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