|  |
| --- |
| **Monitoring Forest Management Activities with High Spatial and Temporal Resolution using Multispectral VTOL UAS** |
| **Introduction/Aim:** The importance of harmonizing long-term environmental ground-data to facilitate comparisons within and between ecosystems at different scales is widespread consensus (Haase et al., 2018). However, the costs of maintaining such monitoring are considerable (Zhang et al., 2016), which raises the question of the convenience and reproducibility of ground-based surveys at larger scales. In this sense, drone-based remote sensing has the potential to bridge the gap between ground-based surveys and satellite remote sensing platforms (Guerra-Hernández., 2021, Ecke et al., 2024). In the last years, this field has experienced an exponential development and improvement (Pajares et. al., 2015, Librán-Embid et al., 2020), especially in the field of forestry. However, despite their potential, there is still a lack of comprehensive research on understanding the advantages and the drawbacks of a UAS-based monitoring for forest management activities. This study seeks to address this gap by evaluating the capabilities and limitations of a vertical take-off and landing (VTOL) aircraft equipped with a multispectral camera set-up, focusing on assessing the imagery processing efforts and its performance in spatio-temporal forest monitoring at different levels landscape to individual trees in comparison with ground-truth data.**Methods:** This study took place in the Julius-Maximilians-University Forest in Sailershausen, Central Germany, covering approximatelly 270 hectares. The Uncrewed Aerial Vehicle employed for this study was a WingtraGENII fixed-wing drone equipped with a Micasense Altum camera capable of capturing images across red, green, blue, red edge, near-infrared, and thermal bands. Geometric corrections were performed using fifteen ground sample points established during each visit and measured with an RTK GNSS receiver with precision of up to 1 cm. The field data acquisition took place between the 8th of February and the 22nd of November 2023 with an avergage interval of 1.5 weeks between datasets for a total of 21 visits. To process the datasets, we employ a standard structure-from-motion processing pipeline, for creating digital surface models and orthomosaics. Following the processing of individual flights, we conduct mosaic stitching, dataset co-registration, and base grid sampling. Utilizing the homogenized outcome datasets, we perform single tree detection and crown delineation to extract multitemporal crown spectral statistics, for plots of different management practices. Subsequently, we compare this information with ground truth data provided by the Sailershausen Forest Office, which includes diameter at breast height and information on the species composition as well as management practices. Finally, we conduct spectral resampling to evaluate plot treatment discrimination at different synthetic resolutions.**Expected Results:** From these processes, we expect to obtain a detailed characterization of the spatio-temporal dynamics from forest metrics at individual trees and landscape levels which proves the capabilities of VTOL-UAS. Additionally, we analyze how this methodology adds value to current monitoring schemes by evaluation its cost effectiveness including the downsides of this technology (e.g. data quality impact of different weather conditions), and we describe how they should be addressed to build a relative systematic monitoring system that includes both UAV and space-borne remote sensing as well as ground truth data.   |

**References:**

Ecke, S., Stehr, F., Frey, J., Tiede, D., Dempewolf, J., Klemmt, H. J., ... & Seifert, T. (2024). Towards operational UAV-based forest health monitoring: Species identification and crown condition assessment by means of deep learning. Computers and Electronics in Agriculture, 219, 108785.

Guerra-Hernández, J., Díaz-Varela, R. A., Ávarez-González, J. G., & Rodríguez-González, P. M. (2021). Assessing a novel modelling approach with high resolution UAV imagery for monitoring health status in priority riparian forests. *Forest Ecosystems*, *8*, 61.

Haase, P., Tonkin, J. D., Stoll, S., Burkhard, B., Frenzel, M., Geijzendorffer, I. R., ... & Schmeller, D. S. (2018). The next generation of site-based long-term ecological monitoring: Linking essential biodiversity variables and ecosystem integrity. Science of the Total Environment, 613, 1376-1384.

Librán-Embid, F., Klaus, F., Tscharntke, T., & Grass, I. (2020). Unmanned aerial vehicles for biodiversity-friendly agricultural landscapes-A systematic review. *Science of the total environment*, *732*, 139204.

Pajares, G. (2015). Overview and current status of remote sensing applications based on unmanned aerial vehicles (UAVs). *Photogrammetric Engineering & Remote Sensing*, *81*(4), 281-330.

Zhang, J., Hu, J., Lian, J., Fan, Z., Ouyang, X., & Ye, W. (2016). Seeing the forest from drones: Testing the potential of lightweight drones as a tool for long-term forest monitoring. Biological Conservation, 198, 60-69.