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| **Sentinel-2 and EnMAP-based analysis of a Red Needle Cast Outbreak in New Zealand** |
| **Introduction/Aim:**  Radiata Pine (*Pinus radiata* D. Don) is the most planted conifer globally and in New Zealand. Red Needle Cast (RNC) is one of several diseases that threaten the species [1]. After some smaller outbreaks in the previous years, a severe outbreak happened in 2023 in the Gisborne region of New Zealand’s North Island.  We use Sentinel-2 time series to document the areal extent, the severity, and the starting date of the outbreaks of 2021 to 2023. Furthermore, EnMAP hyperspectral data is used to characterize the spectra of damaged stands depending on the severity and the age of the infection.  **Methods:**  Analysis-ready Sentinel-2 data of the study area were processed using FORCE [2], including download, geometric and atmospheric correction, cloud masking, resampling of all bands to 10 m spatial resolution and tiling the data into a regular grid. We calculated pixel-wise mean values of the chlorophyll-sensitive Red-Edge Chlorophyll Index (CIre) spanning the years 2017 to 2021 for each month.  As an alternative method to pinpoint the first occurrence of RNC in a stand, instead of calculating monthly means we fitted a harmonic series consisting of three sine functions to the 2017 to 2021 time series of several indices at each radiata pine pixel: an index that uses a continuum removal of the SWIR water absorption, the CIre, and the tasseled cap greenness. This series was extrapolated and for each Sentinel-2 scene the difference between expected and measured index value was calculated. Differences larger than two standard deviations and a minimum threshold were flagged as disturbance.  Thirdly, EnMAP data recorded at four dates between November 2023 and February 2024 were analyzed to characterize spectral reflectance of radiata pine stands without RNC expression and at different number of months after RNC expression was first detected.  **Results:**  Differences from the respective monthly mean value gave a good indication of RNC damage. Maximum RNC expression occurred in September 2023. CIre differences were significant starting March 2023, so pre-visual detection was possible using Sentinel-2 time series. The detection accuracy will be tested on more than 2,200 points for each year from 2019 to 2023. |
| Detection of RNC based on extrapolated harmonic series also gave very plausible results that will be validated using the same reference points. The best spectral index for characterizing RNC damage is still to be determined.  Recovery after RNC infection or lack thereof will be documented using EnMAP and Sentinel-2 data. First results hint at recovery after about one year after mild outbreaks, but since the 2023 outbreak was more severe than previous ones the coming months will show whether the trees are able to recover.  **Conclusion:**  Satellite remote sensing can be used for pre-visual detection of RNC over large areas. Several strategies will be tested and compared in order to find a possible operational strategy for an early warning system. Multispectral and hyperspectral data both can play a crucial role in understanding spread of RNC and recovery or die-off after the first detection.  **References:**  [1] Dick, M.A.; Williams, N.M.; Bader, M.K.-F.; Gardner, J.F.; Bulman, L.S. (2014): Pathogenicity of Phytophthora pluvialis to Pinus 632 radiata and its relation with red needle cast disease in New Zealand. New Zealand Journal of Forestry Science, 44, 1-12.  [2] Frantz, D. (2019): FORCE—Landsat + Sentinel-2 Analysis Ready Data and Beyond. Remote Sensing, 11(9), 1124. |