Responding to large-scale forest damage with remote sensing, machine learning and webGIS

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Abstract. This paper reports a semi-automated workflow for detection and quantification of forest damage severity from windthrow in an Alpine region, in particular from the Vaia storm on October 2018. A webGis platform allows to select the damaged area by drawing polygons; several vegetation indices (VIs) are automatically calculated and tested to identify the more suitable ones for quantifying forest damage using cross-validation with ground-truth. VIs.

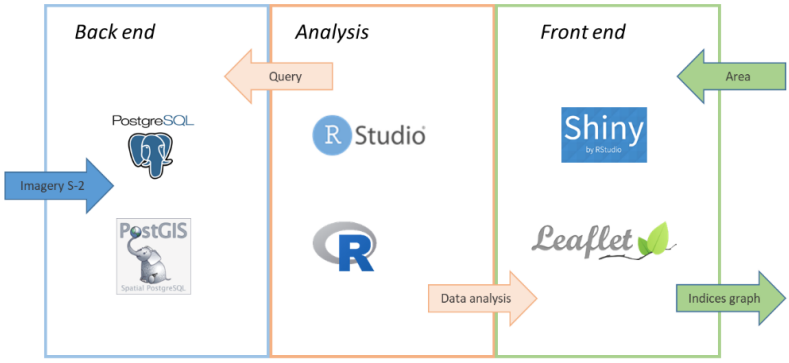

Fig. 1. Schema of the web-based platform for the real-time remote sensing analysis.

Results show that NDVI and NDMI average values decrease in the damaged areas, and have a strong negative correlation with damage severity. RGI has an opposite behaviour in contrast with NDVI and NDMI, as it highlights the red component of the land surface. In all cases variance of the VI increases after the event [1]. Resistant understory - not damaged from the windthrow - if consists in 40% or more of the total cover in the area, undermines significantly the sensibility of the VIs to detecting and predicting damage severity. Using aggregational statistics (average and standard deviation) of VIs over polygons as input to a machine learning algorithm, i.e. Random Forest, results in damage severity prediction with regression reaching a root mean square error (RMSE) of 9.87 (%) using an ensemble of area averages and standard deviations of NDVI, NDMI and RGI indices on a severity scale of 0 – 100 (see Fig. 2).

Results show that combining more than one VI can improve significantly the estimation of damage severity, and webGis tools can support decisions with selected VIs.

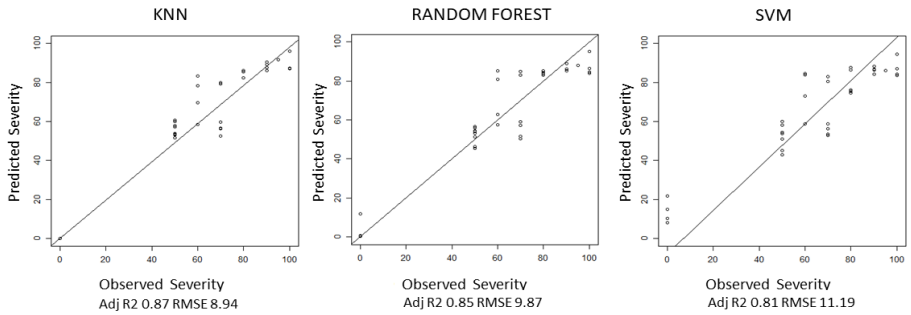

Fig. 2. Severity predicted using KNN, RF and SVM and a combination of indices over the testing set.

The investigation shows that damaged areas can be recognized and severity estimated, but a residual photosynthetic cover greater than 40% influences the indices response (see Fig. 3). Above this percentage, the forestry recovery, due to shrubs, herbaceous vegetation or new trees, so field survey is required. KNN and RF assign different importance to the VI. KNN uses NDMI, RGI and NVI whereas RF focus on NDVI, EVI2 and RGI. RF give less importance to NDVI than KNN. However, Damage severity prediction using RF produced good result using NDMI or NDVI and the NDVI standard deviation.

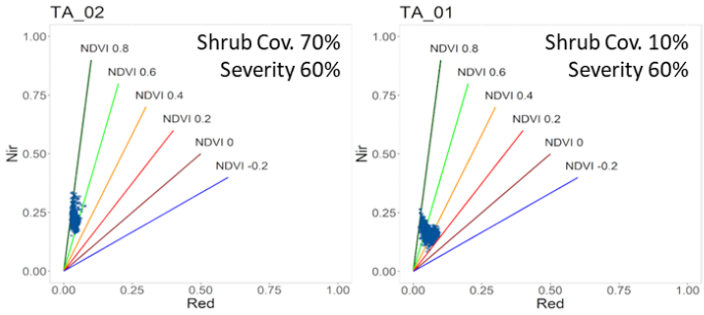

Fig. 3. Effect of residual shrubs over NDVI values.

References

1. Zarco-Tejada, P.J. et al.: Understanding the temporal dimension of the red-edge spectral region for forest decline detection using high-resolution hyperspectral and Sentinel-2a imagery. ISPRS J. Photogramm. Remote Sens. 137, 134–148 (2018). https://doi.org/10.1016/j.isprsjprs.2018.01.017.