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Coupling process-based models and remote sensing data to predict yield loss by hail damage

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Hailstorm damage in agriculture often results in considerable loss in harvestable product. Currently, crop damage is quantified by insurance companies through field inspectors' assessment, a time-consuming activity that is potentially affected by estimation errors over large areas. Coupling remote sensing and crop modeling represents a promising solution for the crop insurance market for a reliable, objective, and less labor-intensive method to estimate hail damage. With the general aim of developing an automated platform that can identify crop yield failure at field level, the Ceres-Maize (*DSSAT* v 4.7.5) model was integrated with remote sensing data to reproduce maize growth and production dynamics. A two-year experiment was established at the Ca' Tron farm on the low lying of Veneto Plain (NE Italy). The crop damage was performed using a custom-made machine at three intensities (low, medium, and high) depending on crop defoliation and four plant growing stages (early vegetative, flowering, early-milky, and dough stages). Each treatment was replicated three times on plots of 20x20 or 60x60m. Additional four subplots with no damage were used as control. Leaf area index (LAI) and biomass were measured after each damage event. LAI was estimated from both drone-borne multispectral sensors and satellites imageries (Sentinel-2), and ground-validated using a ceptometer. The Ceres-Maize model was used to predict obtainable and potential crop yields: 1. by embedding the estimated LAI reduction at the time of damage into the "PEST" sub-model; 2. by calibrating the model seasonal LAI dynamics using the drone- and Sentinel-based LAI observations over the cropping season. The first year of the experiment was used to calibrate DSSAT, the second one to validate its performance.

Results showed a satisfactory agreement between measured and simulated Ceres-Maize LAI dynamics. The final yields were also well reproduced among treatments. On the other hand, the model did not fully capture the residue biomass and the harvest index. Assimilating remote-sensing-based parameters in crop models appears to have promising benefits for the insurance market, providing more robust and less time-consuming methodologies.