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SatGrass: Satellite based estimation of grassland yield and quality dynamics

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Grassland represents the most important land-use system in European alpine regions. Various utili-sation intensities caused by different site conditions, small-scaled structures and multiple cuts per growing season impede a systematic estimation of yield and forage quality. During the growth of grassland, the biomass increases, while at the same time, the forage quality decreases with continu-ing plant development. Objective estimates of these two parameters in near-real time are difficult to make, even for experienced observers, but would be essential for optimizing grassland manage-ment. In addition, continuous yield and quality monitoring on a regional scale would be an instru-ment for statistical analysis, agricultural policy and advisory services and a basis for risk manage-ment. The impact of climate change, particularly the increasing risk of drought, requires objective and regional-based yield assessments for efficient climate adaptation and mitigation.

In the SatGrass project, we combine remote sensing, weather and grassland data to calibrate and validate yield and quality estimation models based on 211 meadows throughout Austria. On these fields, yields were measured every two weeks during the growing seasons 2021 to 2023 for three randomly selected square meters each (12,063 samples). We also assessed the plant composition and the leaf area index (15,610 AccuPAR measurements). The three replicated fresh matter sam-ples were mixed to 4021 samples and analyzed for dry matter yield and forage quality (crude pro-tein content). The models need to consider the start of the growing season (SOS). Therefore, we established a new methodology for identifying the SOS by combining remote sensing (MODIS NDVI at 250m) and temperature thresholds from daily weather data. The end of each growth is determined by the cut. With 1400 observations of cut dates, we developed two cut models, one based on Sentinel-2 and the other on a combination of Sentinel-2 and Sentinel-1 using a fitted NDVI curve obtained by iteratively smoothing the upper envelope of the actual observations using the Whittaker smoother. Cuts are detected by meeting a threshold in the difference between the fit-ted NDVI curve and the actual observed NDVI values. The yield and quality models are based on machine learning algorithms with a sequential multilayer model implemented in R (Keras for Ten-sorFlow). The input layer for the biomass estimation includes aggregated weather data and Senti-nel-2 based vegetation indices.

The SatGrass scientific approach, which involved collecting extensive ground-truth data and mod-elling SOS, cut dates, grassland yield and forage quality based on this unique database, has been completed successfully. Because of the high quality and robustness of the results, an operational system is now being implemented as a mobile and a dashboard application with the support of the European Space Agency and the Austrian Federal Ministry of Agriculture and Forestry, Regions and Water Management to make the results available to farmers and agricultural organizations as a management and monitoring tool of real-time information of grassland yield and forage quality.

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