EGU22-7656
https://doi.org/10.5194/egusphere-egu22-7656
EGU General Assembly 2022

Monitoring a plant's reaction to drought stress with hyperspectral remote sensing and sun-induced chlorophyll fluorescence

simon De Cannière[1] and François Jonard[2,3]
[1]Université catholique de louvain, Earth and Life institute, environmental sciences, Belgium (simon.decanniere@uclouvain.be)
[2]Agrosphere (IBG-3), Institute of Bio- and Geosciences, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany
[3]Earth Observation and Ecosystem Modelling (EOSystM) lab, SPHERES research unit, Université de Liège (ULiège), Allée du Six Août 19, 4000 Liège, Belgium

Water availability is a major constraint for crop production worldwide. Remote sensing provides an ideal mean to monitor vegetation status from the canopy to the ecosystem scale. Classical approaches have mainly used the reduced vegetation development as a stress indicator. This research discusses short-term reactions on a plant to drought stress as well as their corresponding effects on different hyperspectral remote sensing metrics.

As a first effect, a reduction in the plant water content results in a drop in the leaf turgor, which changes the leaf orientation. This effect changes the canopy structure, changing the near-infrared reflectance.

Second, a water shortage in a plant induces stomatal closure, which limits the gas exchange. This reduces the amount of CO_2 that the photosynthetic apparatus can assimilate, causing an imbalance between the energy demanded by the CO_2 assimilation part and the energy provided by the photosynthetic light reactions. As a consequence, an alternative electron sink is needed at the light reactions side. This is provided for by a series of mechanisms collectively known as non-photochemical quenching (NPQ). The increase in NPQ leads to a change in the hyperspectral photochemical index (PRI) and to a change in the sun-induced chlorophyll fluorescence (SIF) emission. The latter consists of the radiation that is re-emitted by a chlorophyll molecule.

To evaluate the effect of a drought stress on these remote sensing metrics, the hyperspectral reflectance and the SIF emission were measured over a mustard and a lettuce canopy. At the same time, the soil moisture and weather conditions were monitored. The PRI shows a clear diurnal pattern, in which the PRI is anticorrelated with the photosynthetically active radiation (PAR). The pattern is more expressed for stressed days. The canopy structure's reaction to drought stress is very species-specific, as this reaction is affected by the presence of woody material in the canopy. The SIF reaction only becomes clear after it has been normalized for the PAR and for the canopy structure. The link between SIF and PAR depends on the plant stress status. We argue that the combination of these three factors (PRI, SIF and reflectance) provide solid information on the degree of water limitation in the plant.