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Assessing forest vulnerability to drought by intersecting modeled soil water availability with remote-sensing derived spectral anomalies

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Extreme weather anomalies, including the 2018 drought, provide a large-scale in-situ experiment that offers the unique chance to benchmark process-based hydrological models against empirical data. While the meteorological conditions showed similarities across Europe, tree water stress varied greatly in space. The question that imposes itself is: When does a meteorological drought trigger a physiological drought?

Translation of a meteorological drought (high temperatures and lack of precipitation) into a physiological drought (a water deficiency not fulfilling plant needs) is not straightforward since i) water demands differ for plants species and forest structures, and ii) soils by their ability to retain and store water superimpose the meteorological water availability pattern. Consequently, to predict physiological drought, it is not only essential to establish the link between meteorology and soil hydrology, but also between soil hydrology and plant water stress. In our study, we assessed the link between climate conditions, soil water availability and tree performance for the years with good soil water availability (2016, 2017) and the "drought" year 2018 for 50 forest sites across Switzerland.

The first link between meteorology and soil hydrology is established through a soil water balance model. For the period 2016 to 2018, we implement the soil water balance model LWF-BROOK90 at 50 Swiss forest sites, where soil water potential is continously measured since 2013. The sites follow a water availability gradient (between 600 and 1200 mm MAP) from the Central Valais to Middle Grisons, Engadine and the Eastern Jura mountains. The impact of soil water on tree performance is established with the help of remote sensing data. Severe drought leads to wilting, discoloring and defoliation. All these symptoms result in a decline of alive, photosynthetic active plant tissues that can be observed in-situ, but also from space via vegetation indices (VI) and their deviation from normality. Since 2015, remote sensing images of the Sentinel-2ab satellites are produced every five days with a spatial resolution of 10, 20 and 60 m at 13 bands in the visible, near infrared, and short wave infrared parts of the spectrum. From these freely available images, we extracted the temporal dynamic of VI for the years 2016 to 2018. VI deviations in summer and autumn from the commonly moist spring conditions serve as a proxy for impacted forest health conditions. The data are ground-truthed by in-situ visual assessment of defoliation in 2018. We will present a preliminary comparison of modeled soil water anomalies with the remote-sensing derived spectral anomalies for a subset of sites to pinpoint critical soil water potential thresholds that trigger physiological drought (as detected by VI) and finally to assess the vulnerability of Swiss forests to drought.