Constraining water limitation of photosynthesis in a crop growth model with sun-induced chlorophyll fluorescence

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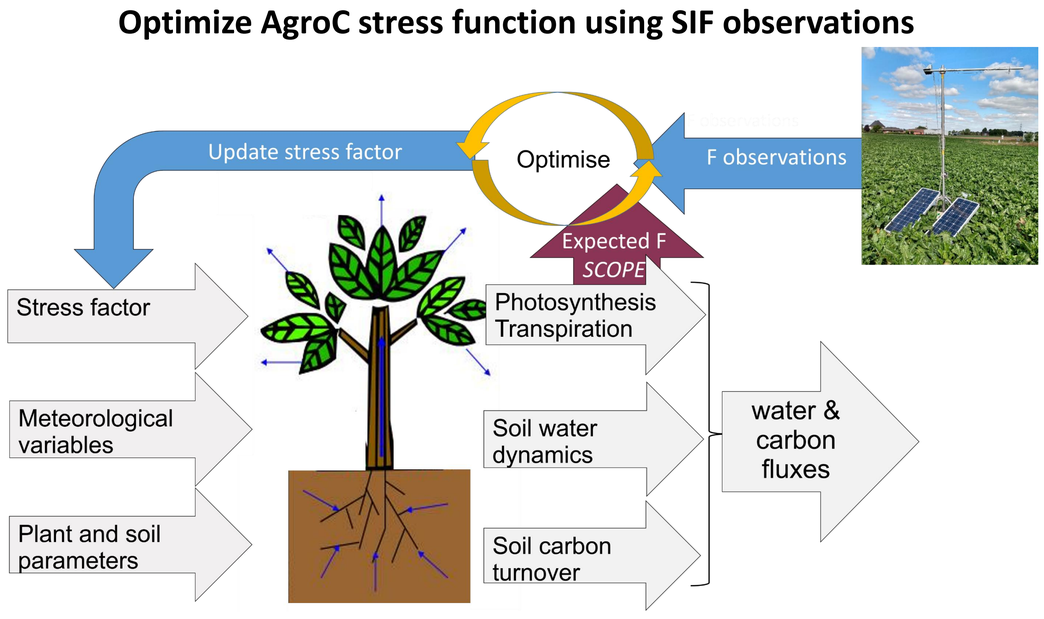
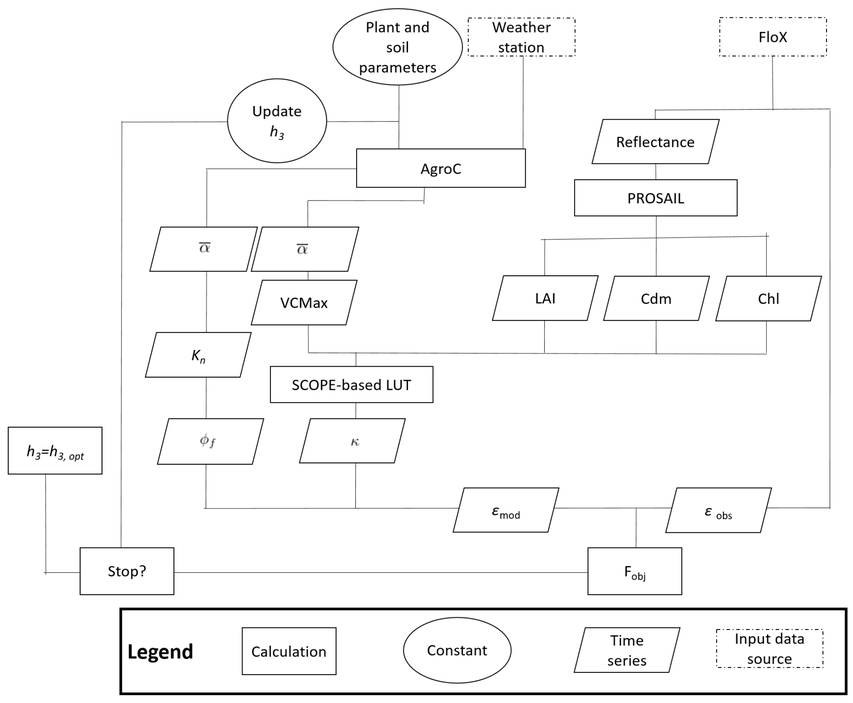
Water fullfills key roles in maintaining a plant's biological activity. Water shortage induces stomatal closure, causing a reduction in photosynthesis and transpiration rates. Sun-induced chlorophyll fluorescence (SIF) emission is sensitive to subtle, stress-induced variations in non photochemical queening and in photosynthetic electron transport, caused by e.g., a fluctuation in the water availability. Based on this sensitivity, a framework for calibrating a water stress function in a crop growth model using ground-based SIF observations is proposed. SIF time series are simulated by coupling the AgroC crop growth model to the Soil Canopy Observations Photosynthesis Energy (SCOPE) model. This allowed parametrizing the water stress function in the AgroC crop growth model, resulting in improved estimates of actual evapotranspiration and net ecosystem exchange over a sugar beet stand during stressed periods. The improvement in the estimation of the water and carbon uses by AgroC during the summer months highlights the ability of canopy-scale SIF observations to serve as a remote sensing metric to indicate the intensity of a stress condition. We argue that our framework, linking SIF emission to stress functions, can be used to extract information concerning drought stress from the Fluorescence Explorer (FLEX) satellite, scheduled for launch in 2024.

Optimize AgroC stress function using SIF observations



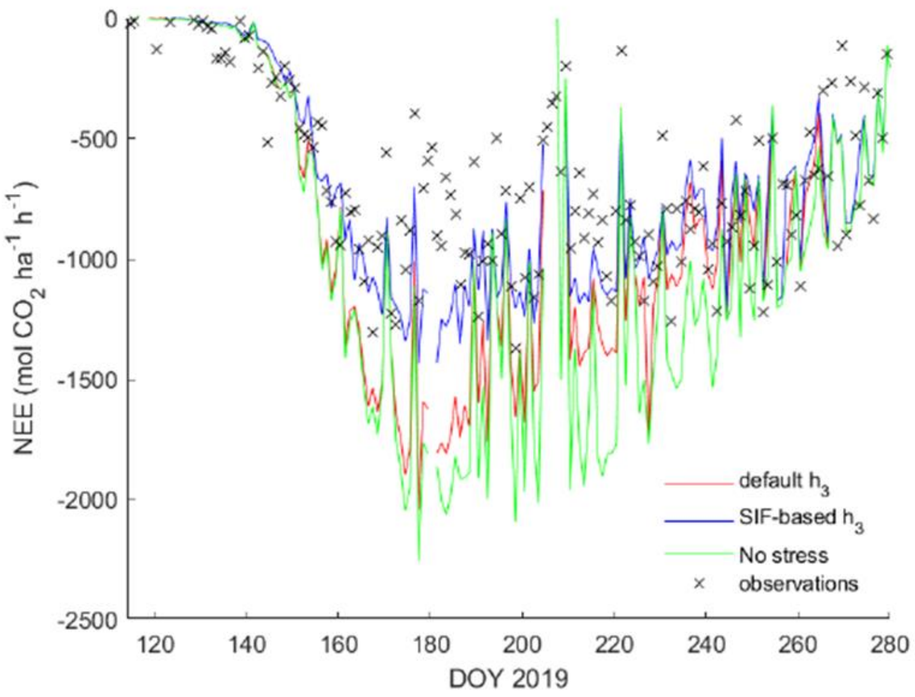
Structure of the coupled AgroC-SCOPE model



The AgroC Crop growth model was run over the whole growing season of sugar beet in 2019. Measurements of SIF were taken during August. By feeding the crop growth model with SIF observations, a water stress function was calibrated.

Feeding one month of SIF observations to a crop growth model

Mid-season improvement in the modelling of Net Ecosystem Exchange



Mid-season improvement in the modelling of Evapotranspiration