Microwave radiometry for remote sensing of plant water status dynamics: Stand-scale evaluation in a temperate deciduous forest

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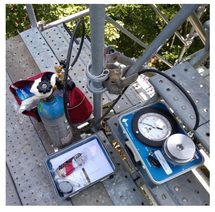
Background

- Vegetation optical depth (VOD) retrieved from microwave radiometry is known to correlate with vegetation water content (VWC).
- VWC depends on biomass and on relative water content, which in turn is related to water potential.
- Remote sensing of water potential through VOD would enable a range of ecosystem-scale plant hydraulic studies.
- In forests, the sensitivity of VOD to leaf and/or xylem water potential has only been tested on the scale of satellite pixels (10s of km).
- Here we present results from a field experiment that avoids scaling errors by combining tower-based radiometer observations with intensive ground observations.

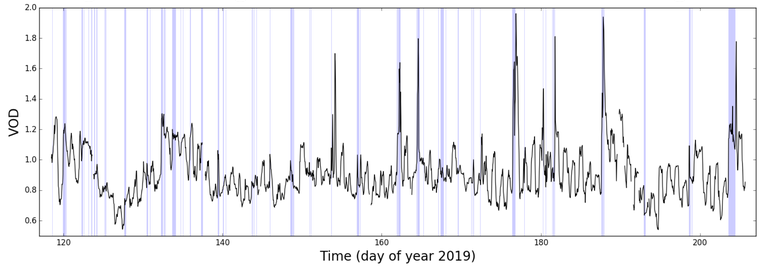
Field methods



- Field site: Harvard Forest in central Massachusetts
- L-band radiometer on 30 m tall tower, looking down at 20x25 m stand of red oak from late April through October 2019
- TreeHugger dendrometers and TEROS dielectric probes continuously measuring trunk circumference and stem dielectric
- Soil moisture and temperature sensors
- In early July, we measured:
  - Xylem water potential using stem psychrometers, continuously over a week
  - Leaf water potential using a pressure chamber every 80 minutes over about 2 days during daytime

VOD retrieval

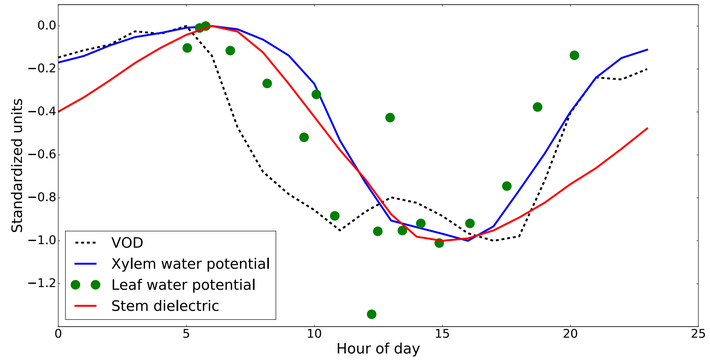
- Dual-channel algorithm did not produce accurate soil moisture retrievals, possibly due to calibration issues with H-pol sensor
- We then used a single-channel algorithm (SCA), retrieving VOD given observed soil moisture and V-pol brightness temperature
- Retrievals used observed soil temperature, and air temperature at weather station 1 mile away for canopy temperature
- Single scattering albedo retrieved in 1-week moving window



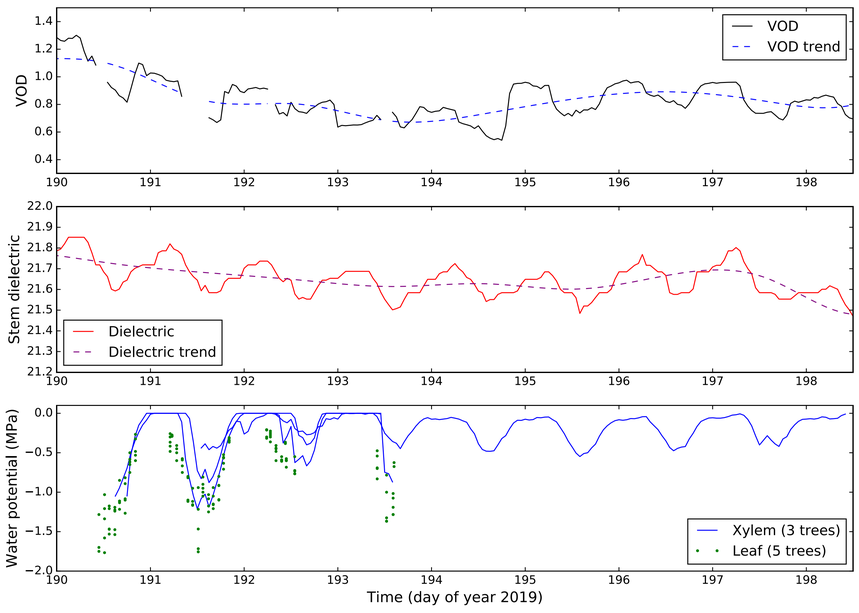
Times with rain shown in light blue

Results

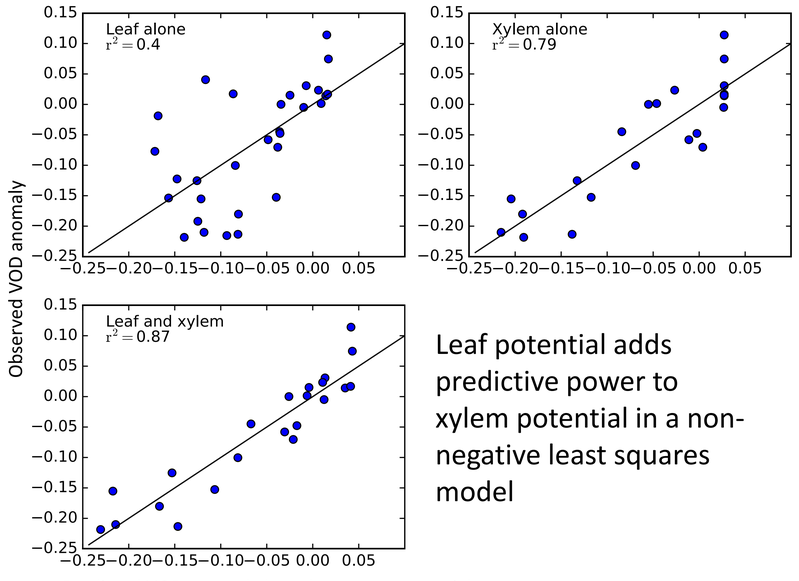
VOD, water potential, and stem dielectric all show diurnal cycles typical of hydraulic stress during daytime and refilling at night



VOD is in phase with stem dielectric and leaf water potential

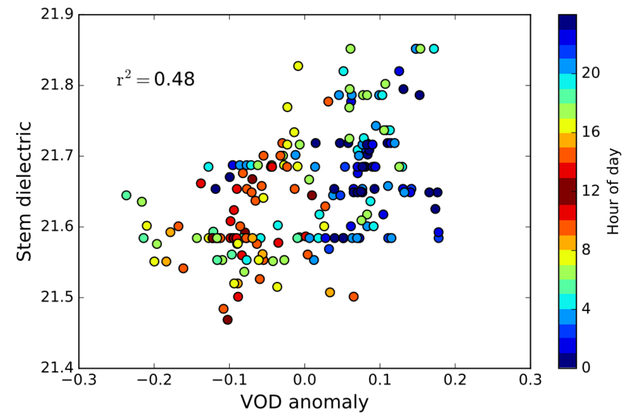


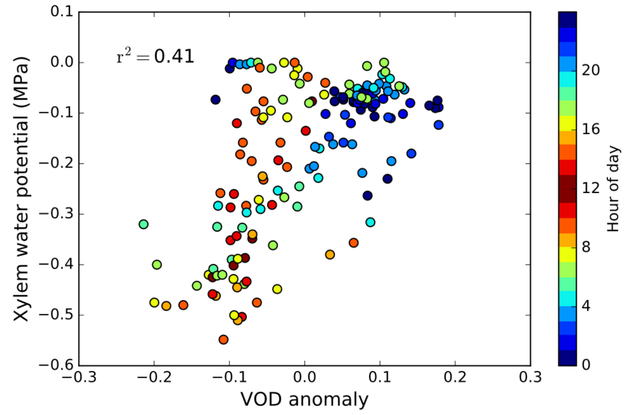
Over three days, detrended VOD positively correlates with xylem water potential, and more weakly with leaf water potential



Leaf potential adds predictive power to xylem potential in a non-negative least squares model

Over one week, detrended VOD relates to stem dielectric more linearly than to xylem water potential.





Conclusions

- Over the course of the day, VOD shows a signal related to plant hydraulics.
- Because of nonlinearity between potential and dielectric, the relationship between VOD and water potential may be stronger during dry periods and during day relative to night. VOD during a 6PM satellite overpass could be representative of plant water potential.
- On longer time scales, the relationship between plant water status and VOD is still uncertain. We are working to use LAI (proxy for biomass) and dendrometer data to clarify this relationship.

Acknowledgements

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