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Decision-support System for Water Stress Assessment and Deficit Irrigation Management in Wine Grapes

Dissertation presented to Washington State University, Pullman, WA, USA

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WSU

1 Introduction

Grapevine water status: significant effects

Severe water stress
- Reduction in berry size and yield
- Death of plant or plant part

Over watered
- Excessive shoot growth and canopy density
- Low berry and wine quality

Moderate and timely water deficit is desirable

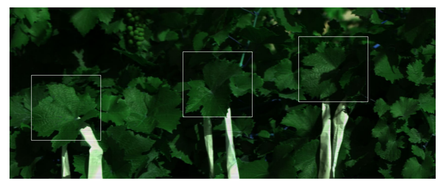
Strategy: Deficit irrigation
- Less water than full water requirements
- Goals: limit growth, maximize quality

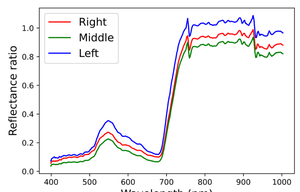
Water status assessment/monitoring

Irrigation regulating/scheduling

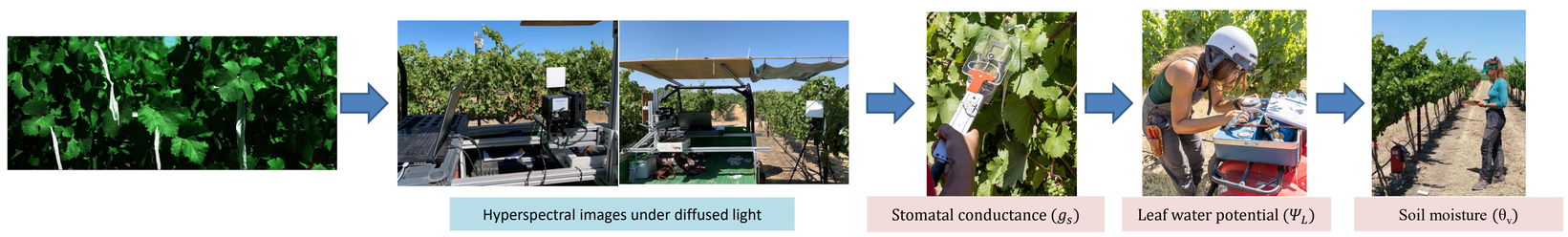
2 Hyperspectral imaging under diffused lighting conditions

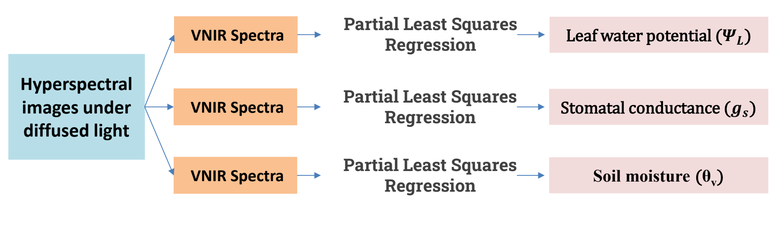
Problems:
- Environmental factors: varying leaf orientations, shadows
- Lighting nonuniformity
- Additional variations in spectral signatures
- Interference in estimating water status

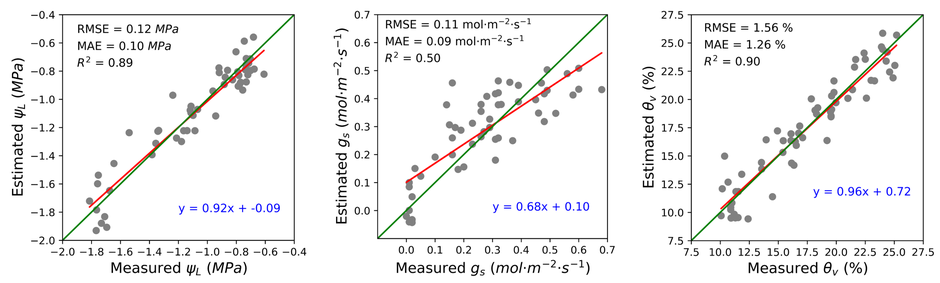




Objective: Estimating soil and grapevine water status using ground-based hyperspectral imaging under diffused lighting conditions





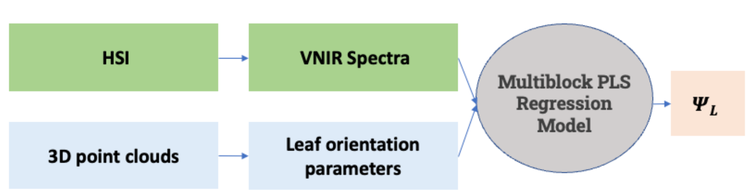


Kang, C., Diverres, G., Achyut, P., Karkee, M., Zhang, Q., & Keller, M. (2023). Estimating soil and grapevine water status using ground based hyperspectral imaging under diffused lighting conditions: Addressing the effect of lighting variability in vineyards. *Computers and Electronics in Agriculture*, 212, 108175. https://doi.org/10.1016/j.compag.2023.108175

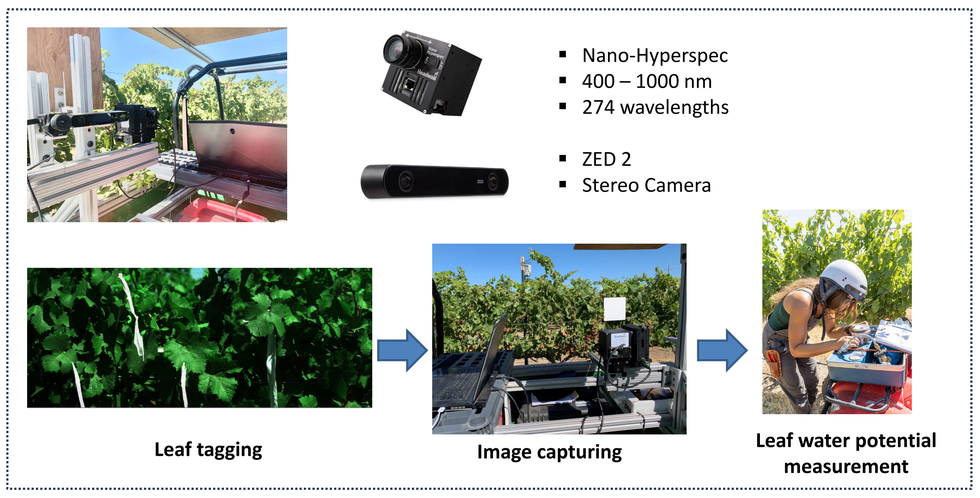
3 Fusion of HSI and point clouds

Objective: Grapevine water status assessment through the fusion of hyperspectral image and 3D point clouds

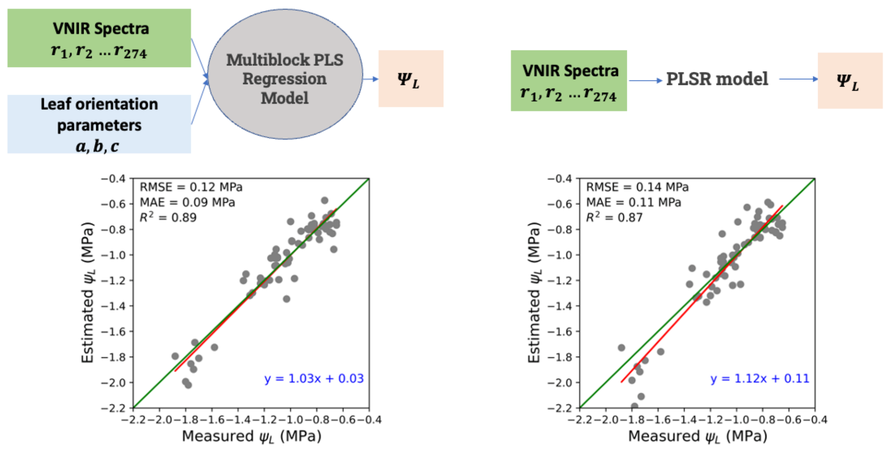
Approaches:



Date collection:



Results:



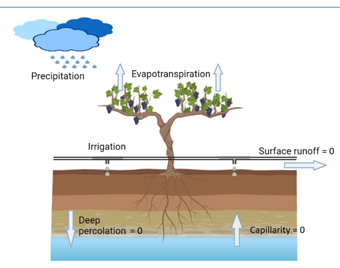
Kang, C., Diverres, G., Karkee, M., Zhang, Q., & Keller, M. (2024). Assessing Grapevine Water Status through Fusion of Hyperspectral Imaging and 3D Point Clouds. *Computers and Electronics in Agriculture*. (under review).

4 Regulated deficit irrigation scheduling

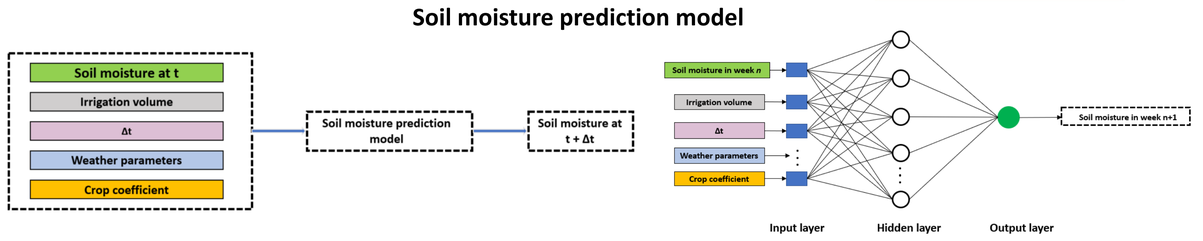
Problem:

Current Regulated Deficit Irrigation scheduling fails to:
- Maintain soil moisture at desired levels;
- Soil moisture targets: dynamic water stress thresholds.

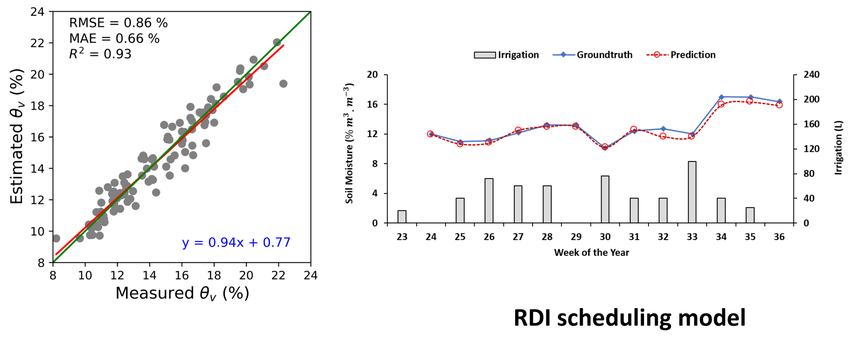
Objective: Incorporating dynamic soil moisture thresholds into irrigation scheduling



Soil moisture prediction model



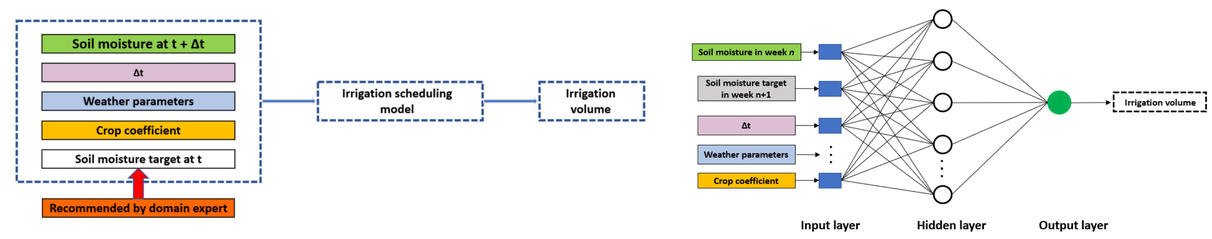
Model was trained using data from 2017-2020 and was tested with data from 2021 growing season



RDI

Under-estimation for weeks 32-36
- Used Kc values higher than actual Kc
- Over-estimation of ET_c
- Under-estimation of θ_v

RDI scheduling model



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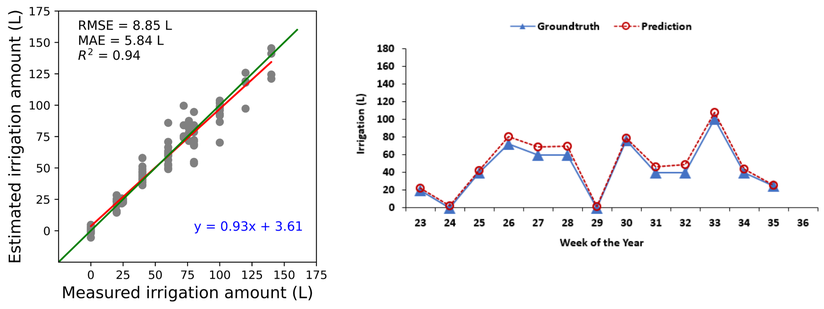

RDI

Over-estimation
- Used Kc values higher than actual Kc
- Over-estimation of ET_c
- Over-estimation of irrigation amount

Kang, C., Diverres, G., Karkee, M., Zhang, Q., & Keller, M. (2023). Decision-support system for precision regulated deficit irrigation management for wine grapes. *Computers and Electronics in Agriculture*, 208, 107777. https://doi.org/10.1016/j.compag.2023.107777

5 Final Remark(s)

This research aimed at developing and validating a comprehensive decision-support system for precision RDI management in vineyards. The proposed system employed ground-based hyperspectral imaging (HSI) to accurately assess soil and plant water status. Concurrently, a RDI scheduling model was developed which forecasted the ideal weekly irrigation volumes needed to maintain soil water content within predefined thresholds. Collectively, these subsystems comprise a comprehensive decision-support framework, aiding human decision-making in vineyards. This framework is suitable for developing a practically adoptable system for automated, site-specific irrigation and balancing of yield and quality in wine grape production. When commercially adopted, this technology has a potential to substantially minimize water use while maximizing crop yield and quality in vineyards.