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Retrieving forest vegetation moisture content from a multi-sensor approach in the Western United States

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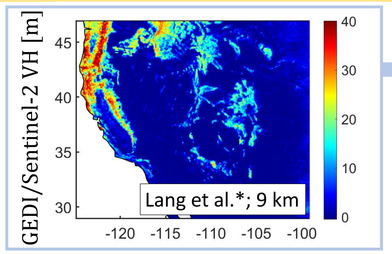
INTRODUCTION

- Vegetation water content (VWC) is obtained from VOD (*) in kg/m^2: not independent of biomass!!
- We disentangle water from VOD retrieving **vegetation moisture in gravimetric units (m_g):**

  m_g (kg water/kg biomass): real hydric status
- We propose a multi-satellite physical approach to estimate Mg in the western USA. Period 2016-2018.
- Regular m_g estimates can support fire prevention, drought assessment and soil-plant-atmosphere continuum modelling.

(*) VOD = vegetation optical depth. It is retrieved from microwave satellites (e.g., SMAP, SMOS, AMSR-2). VOD measures the microwave attenuation of the canopy and is a function of plant relative water content and dry biomass.

DATA & METHODS



Lidar-Derived Vegetation Height VH [m]

Radar-Derived Vegetation Vol. Fraction δ

Radiometer-Derived VOD

1. Model VOD from VH and δ:

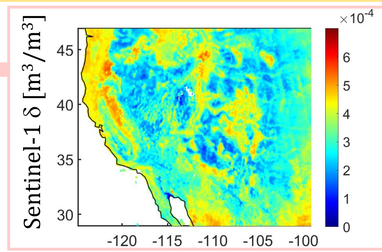
$$VOD = 4\pi\left(\frac{VH}{\lambda}\right)\cdot Im\left[\sqrt{\varepsilon_{can} = f(\delta, \varepsilon_{veg}, Shapes)}\right]$$

2. Minimize VOD differences to obtain ε_{veg}:

$$min\left(\left|VOD_{Model} - VOD_{Radiometer}\right|\right) \rightarrow \varepsilon_{veg}$$

3. Estimate m_g → m_g [kg/kg]

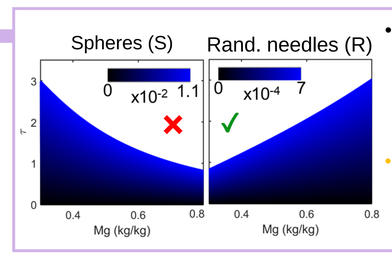
Ulaby & El-Rayes, 1987



$$RVI = \frac{\sigma_{VH}}{\sigma_{VV} + \sigma_{VH}}$$

$$\delta = k \cdot RVI$$

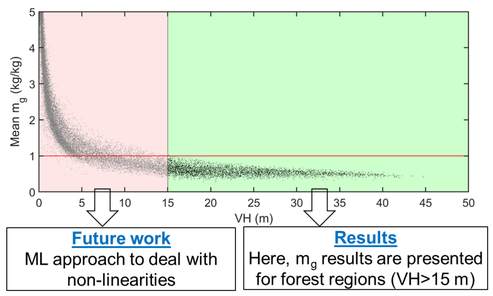
k calibration depends on *Shapes*



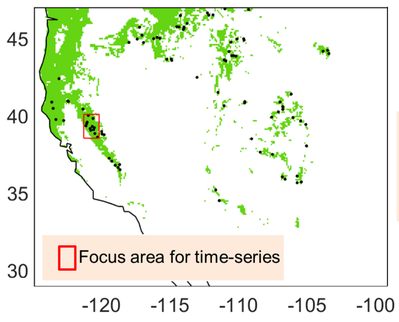
- k fixes δ range:
  - ❖ "Theoric" max. δ
  - ❖ VH_{max} = 40 m
  - ❖ VOD_{max} = 3
- *Shapes* of inclusions:
  - ✗ S: -τ with +water
  - ✓ R: +τ with + water

EVALUATION & VALIDATION

- **First: preliminar algorithm evaluation**
  - ❖ We find m_g in the physical range (0 to 1 kg/kg) in forests taller than 15 m:



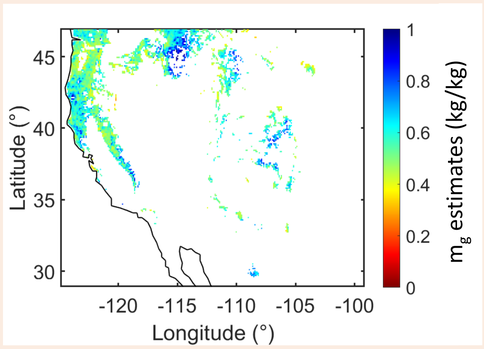
- **Second: validation with in situ measurements**

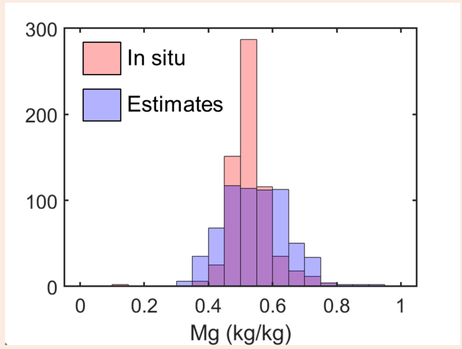


Source: Yebra et al., 2019 (Scientific Data)

RESULTS

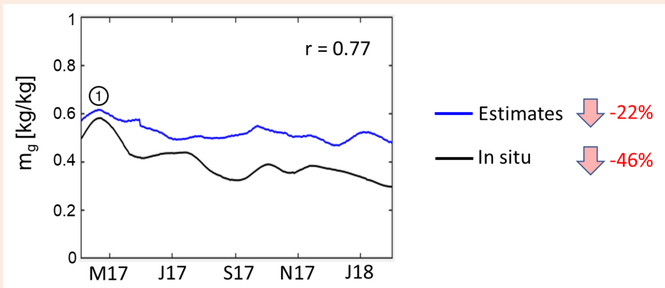
- m_g results are in the expected range, with some overestimation (0.3 to 1 kg/kg).
- Overestimation is found especially in low density (lower VH) forests (eastern and northern regions).
- Comparison between in situ and estimates (per station & day pairs) shows similar results.





m_g [kg/kg]	In situ	Estimates
Mean	0.53	0.55
Mode	0.53	0.61
σ	0.07	0.09

- In Californian forests (focus region) both in situ and estimates show drying trends between May 2017 (①) and January 2018.
- Our estimates capture part (-22%) of the total dry-down registered by in situ samples (-46%)



CONCLUSIONS

- Multisensor retrievals of **vegetation moisture in gravimetric units** are presented (m_g; kg/kg)
- A non-linear relationship between m_g and VH is found:
  - ❖ Current work: m_g in range in forests>15 m.
  - ❖ Future work: machine learning for lower canopies (<15 m).
- Results show **m_g estimates ranging between 0.3 and 1 kg/kg**
  - ❖ Results in range, but with some overestimation.
- **m_g estimates compare well (similar mean and standard deviation) with in situ values.**
- Regional **m_g estimates capture part of the in situ m_g decrease (-22% vs. -46%)** during 9 months.
- High correlation between in situ and estimates (r = 0.77) in the regional time-series.

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