C-Band radar crops monitoring at high temporal frequency: First results of the MOCTAR campaign

P.L. Frison, A. Chakir, J. Ezzahar, P. Fanise, L. Villard, N. Ouaadi, S. Khabba, M. Zribi, V. Le Dantec, M. Kasbani, S. Er-Raki, L. Jarlan

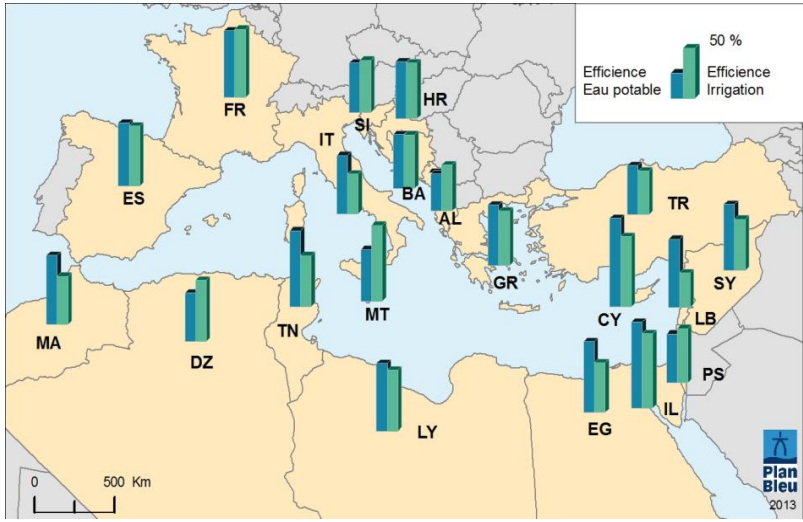
Tensift Observatory

Rationalize the water use in Mediterranean region

- limited resources / **> 80 % for agriculture**
  - **Improper practices / permissive policies**

    ==> low water efficiency
  - Increasing pressure/ **adverse change** (pratices, climate)

Efficience de l'utilisation de l'eau, 2005-2010



Challenge (UN-SDG 2.4):
Increase productivity / sustainable use of water resources

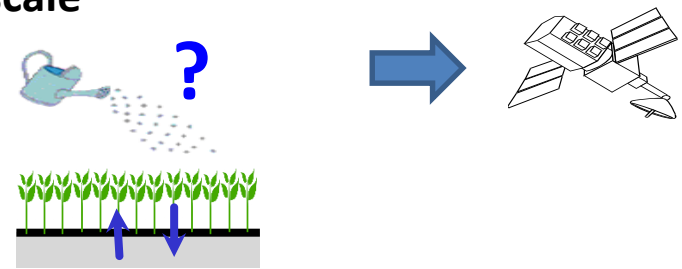
→ implementation resilient agricultural practices

Mediterranean strategy for sustainable development (2005)

Integrated water resources management / **better planning for irrigation**

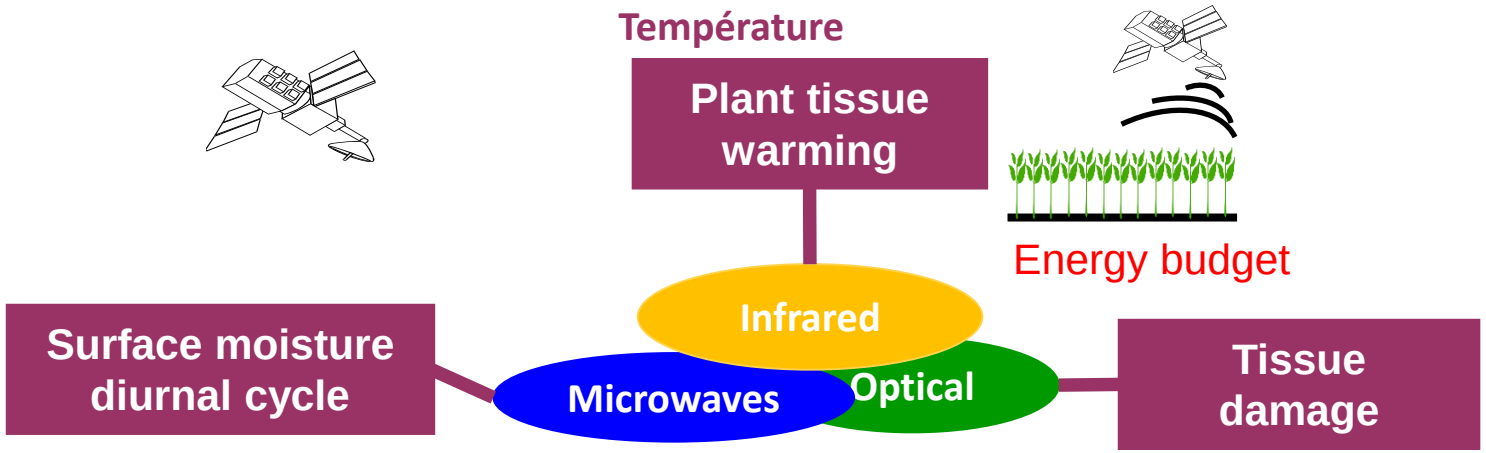
Monitoring the water state of irrigated agricultural areas

Unknown contributions at parcel scale



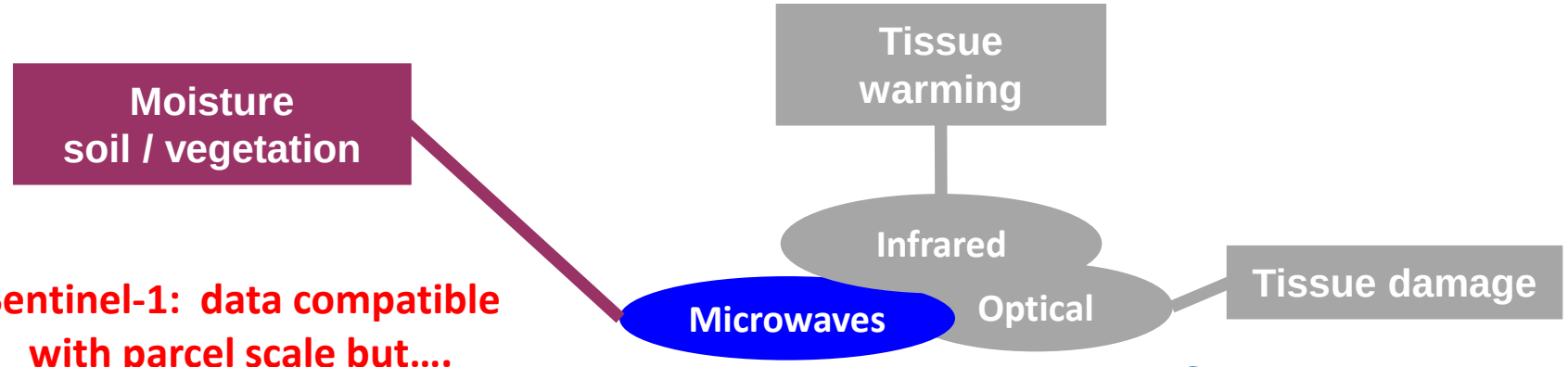
Water balance

Monitoring the water state of agricultural areas



Sentinel-1: data compatible with parcel scale but….

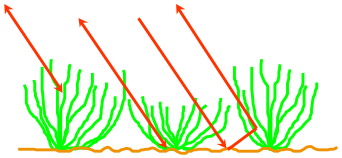
Monitoring the water state of agricultural areas



Sentinel-1: data compatible with parcel scale but….

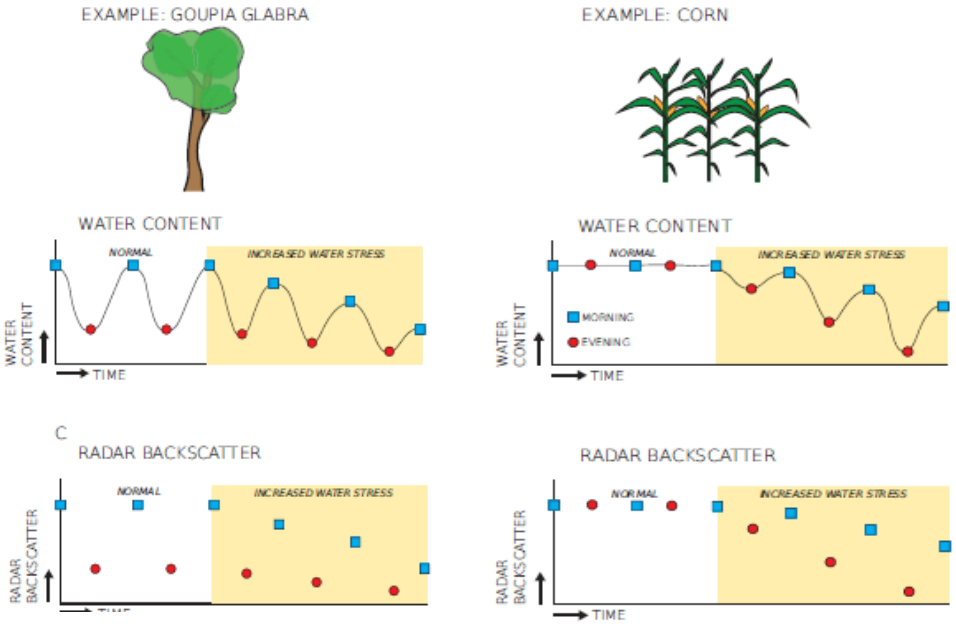
1) Signal comprehension

- C-Band:
  soil and vegetation
  contributions



- Plant geometry
  (phenological stages)

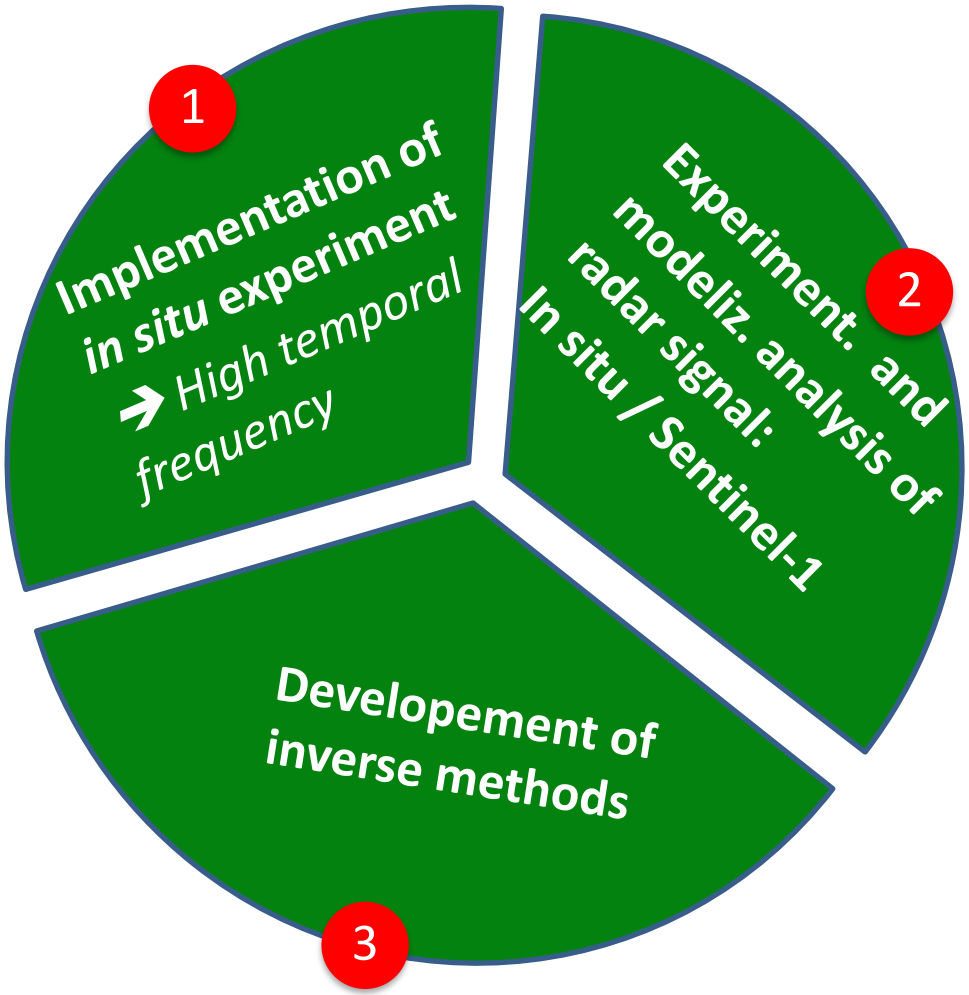
2) diurnal cycle ? physiol. funct



Tim Van Emmerik, 2017 / Steele-Dune et al., 2011

Experiment Objectives

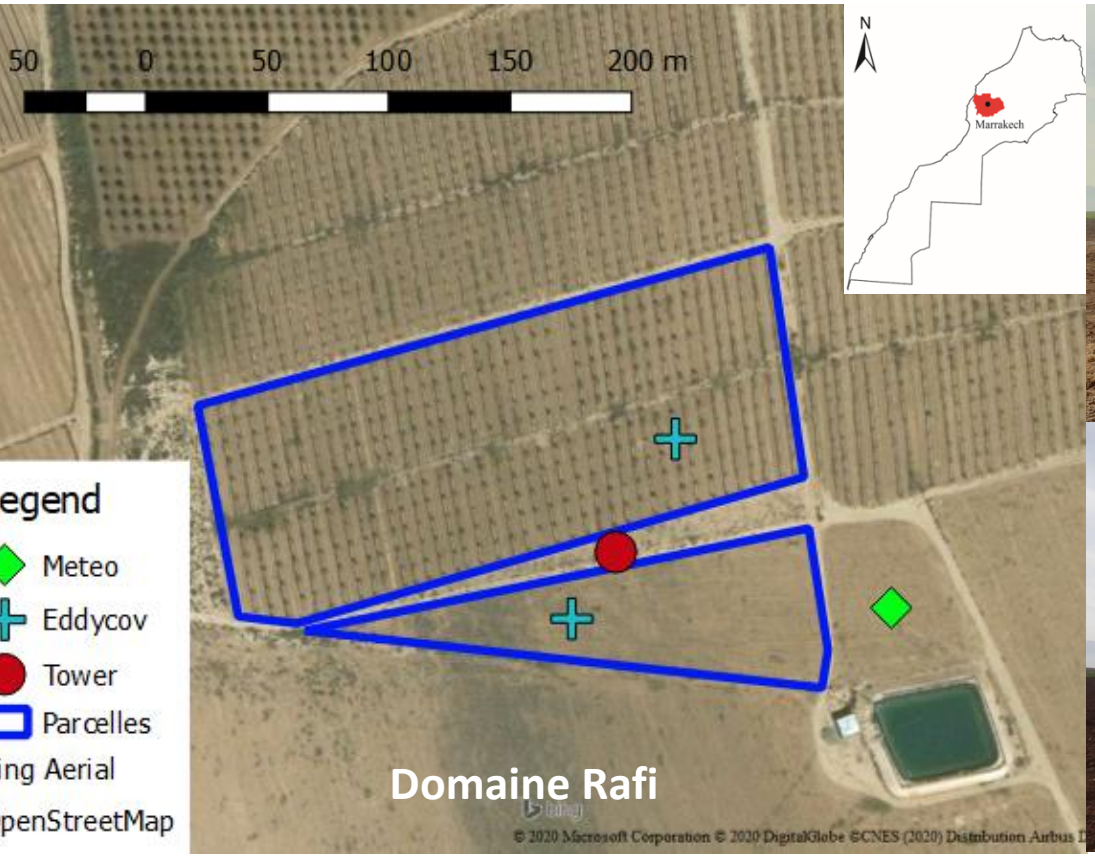
Improve our knowledge of the radar signal at C / L Bands over tree orchards and annual crops with focus on diurnal cycle



Tools for decision support for irrigation planning

4

in situ Experiment / Study site: Tensift region, Marocco



	2019								2020					
	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Olive														
Wheat											Stress			

in situ Experiment / soil & veg. measurements

Automatic measurements

Meteo

Meteo station (alfalfa)

Soil

T° and Hv Profiles

Physiology

Sap flows

- Olive trees / Aug. 2019 →
- Sapflow: 7 sensors

Dendrometer

- Dendro: 1 sensor + 4 (mar. 2020)

Proxy-detection

TIR radiometers

PRI/NDVI sensors

Energy balance

Eddy-covariance

- Olive archard (May 2019 →) and wheat (Jan. 2020 →
- conductive convective flows (ETR) and 4 Rn components

Support TENSIFT obs & LMI TREMA

in situ Experiment / soil & veg. measurements

Automatic measurements

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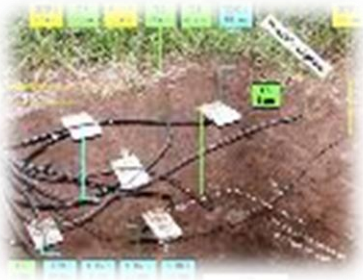

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Manual measurements

Vegetation

LAI / hemispherical photos

Porometer/fluorometer

Biomass / destructive meas.

- Wheat (1/15 days) partition stem/leaf/ear
- Intensive campaigns diurnal cycle monitoring / induced stress

Soil

roughness

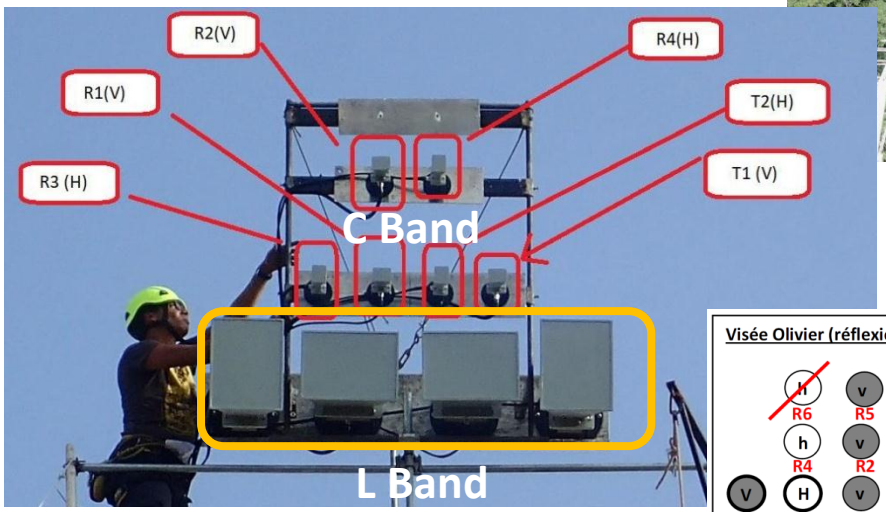
Support TENSIFT obs & LMI TREMA

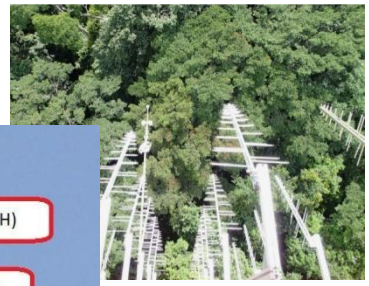
in situ Experiment / radar antennas

TROPISCAT / AFRISCAT **heritage**

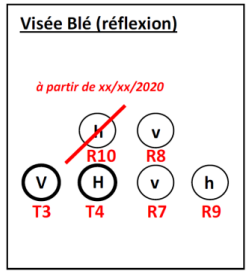
in situ radar antennas

Antennas Configuration





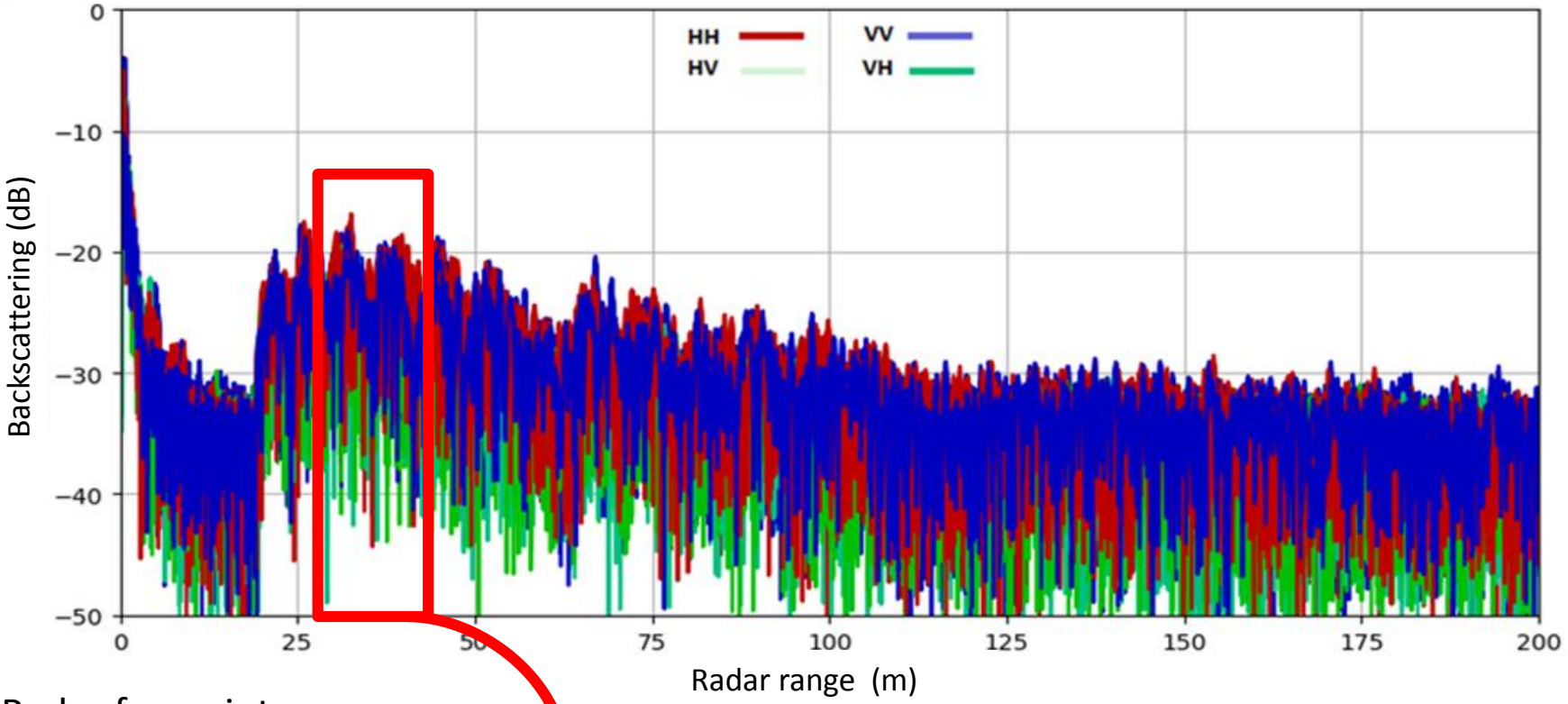
Villard et al., 2019



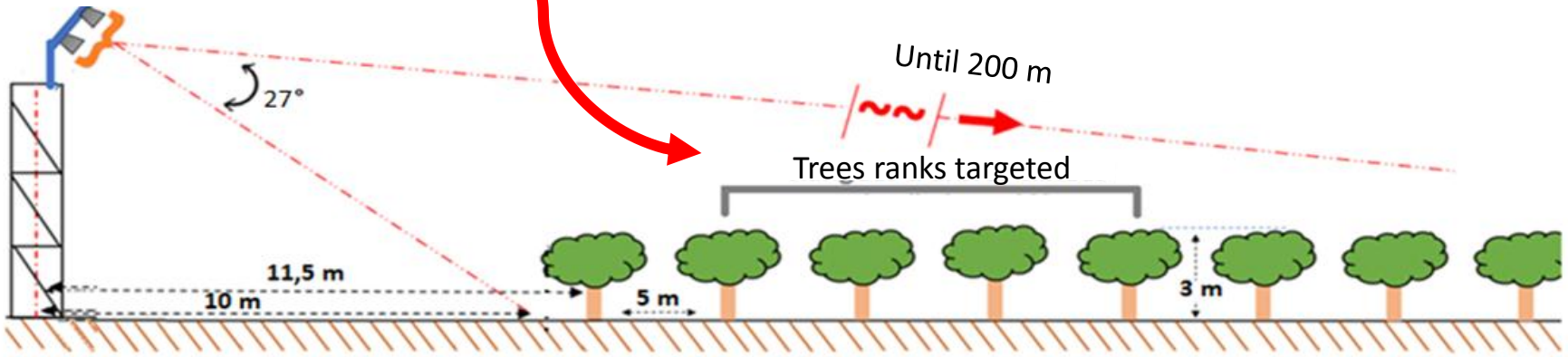
- C-Band: 5.2-5.8GhZ (1601 samples x 3)
- Time step 10 min. (interferometric coherence)
- Fully polarimetric
- Multiple baseline → tomography
- Receiving antenna within the plot ☞ cover attenuation

in situ Experiment / First acquisitions C-Band data

Radar backscattering response for different polarisations

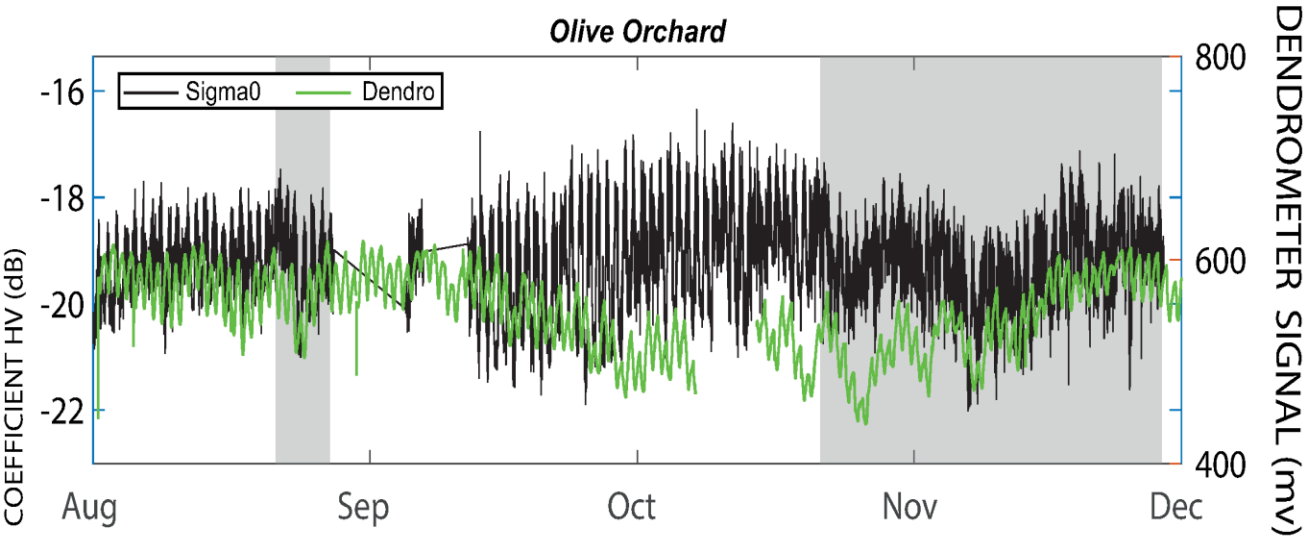


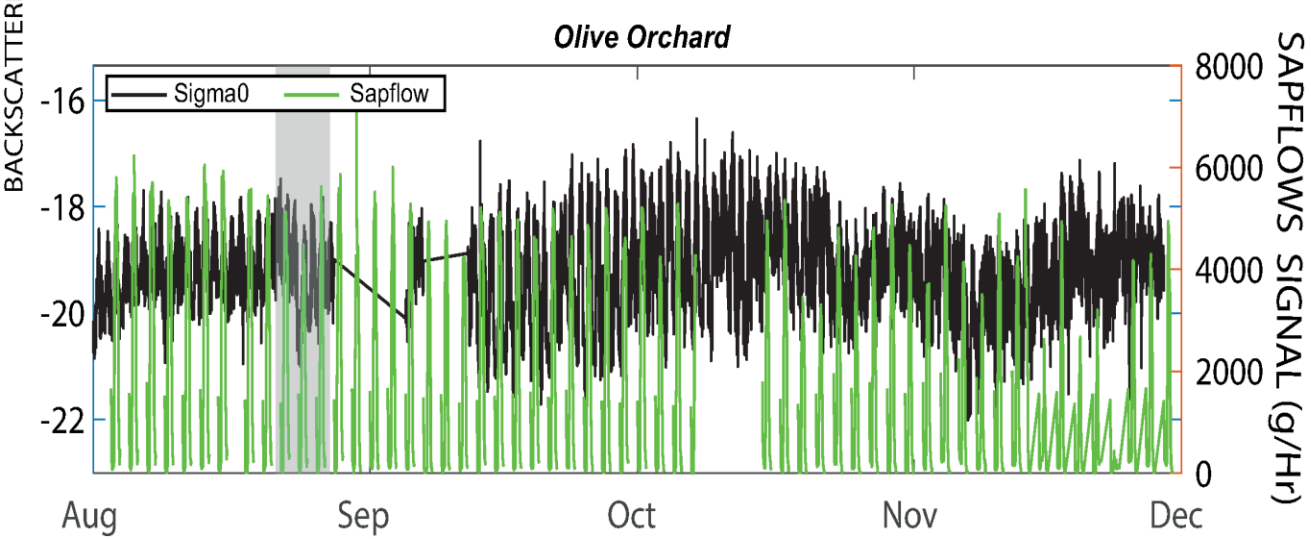
Radar foorprint



in situ Experiment / C-Band temporal signatures

No absolute calibration





- marked daily cycle
- « low frequency »:
  - – Correspondence with dendrometer
    - … depending of the period
- Seasonal variation of the amplitude
- Signal fall ~ Aug. 24 (radar, dendro, sapflow)

in situ Experiment / C-Band temporal signatures

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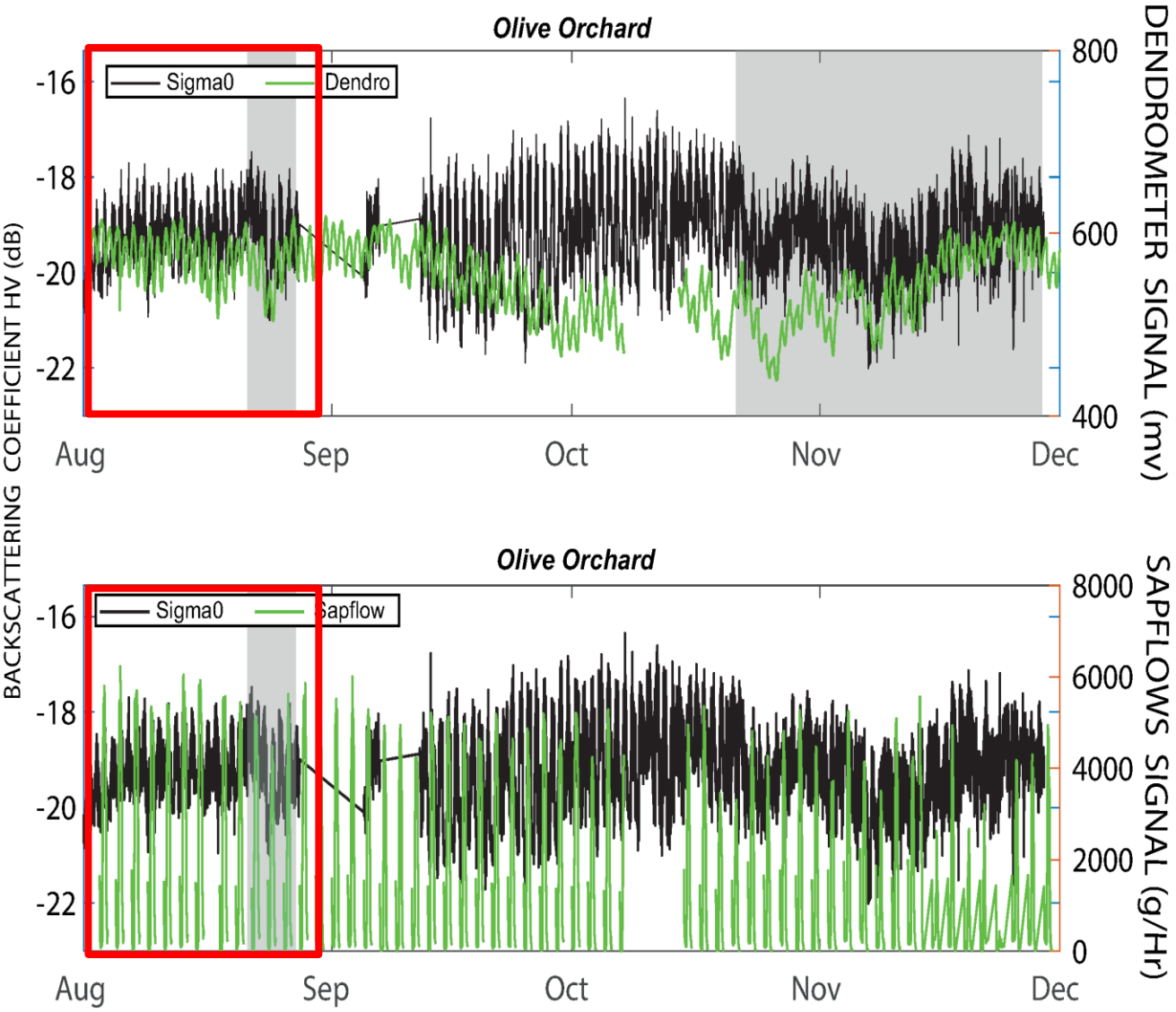
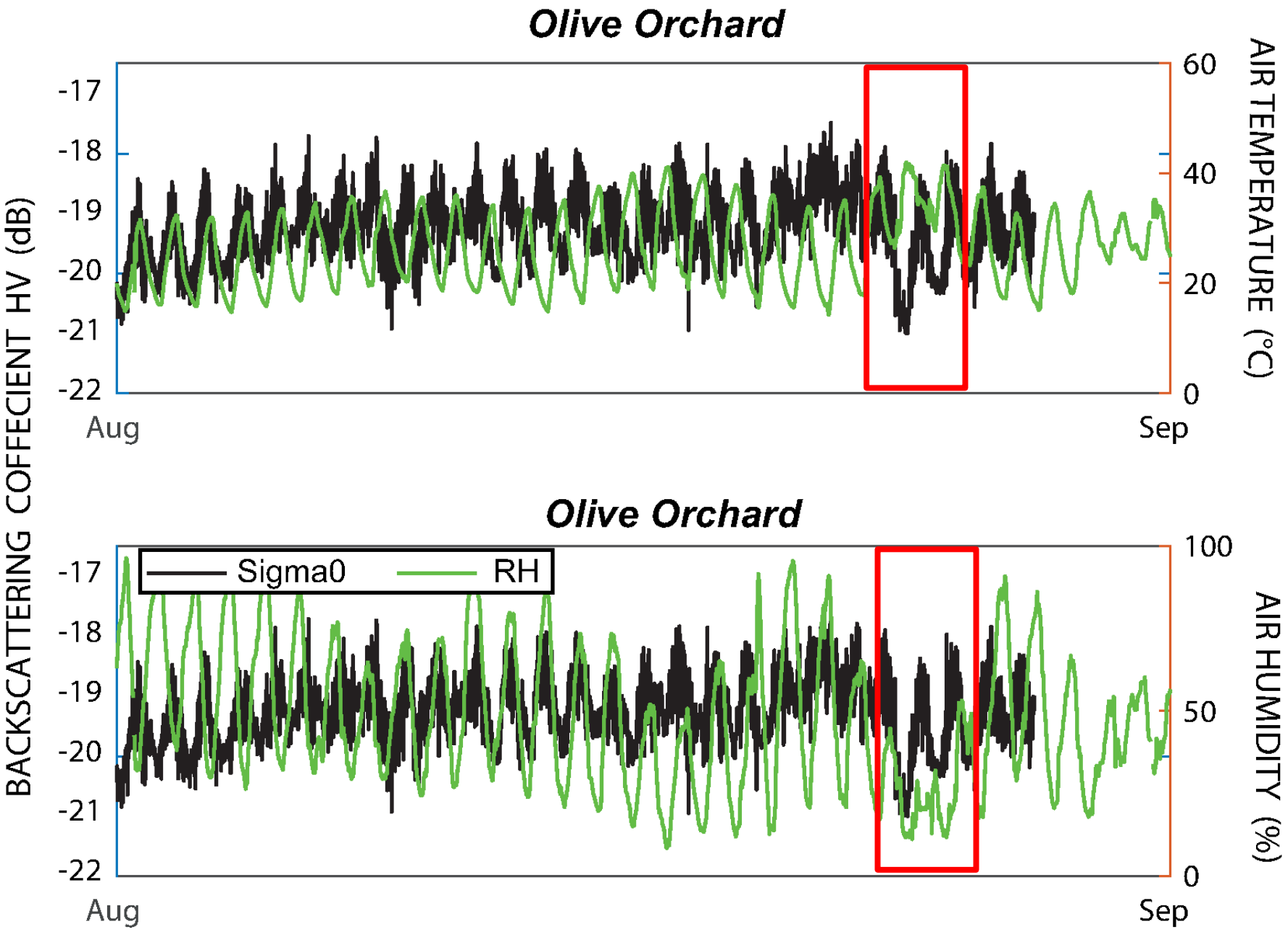


- marked daily cycle
- « low frequency »:
  - – Correspondence with dendrometer
    - … over some periods
- Seasonal variation of the amplitude
- Signal fall ~ Aug. 24 (radar, dendro, sapflow)

in situ Experiment / C-Band temporal signatures



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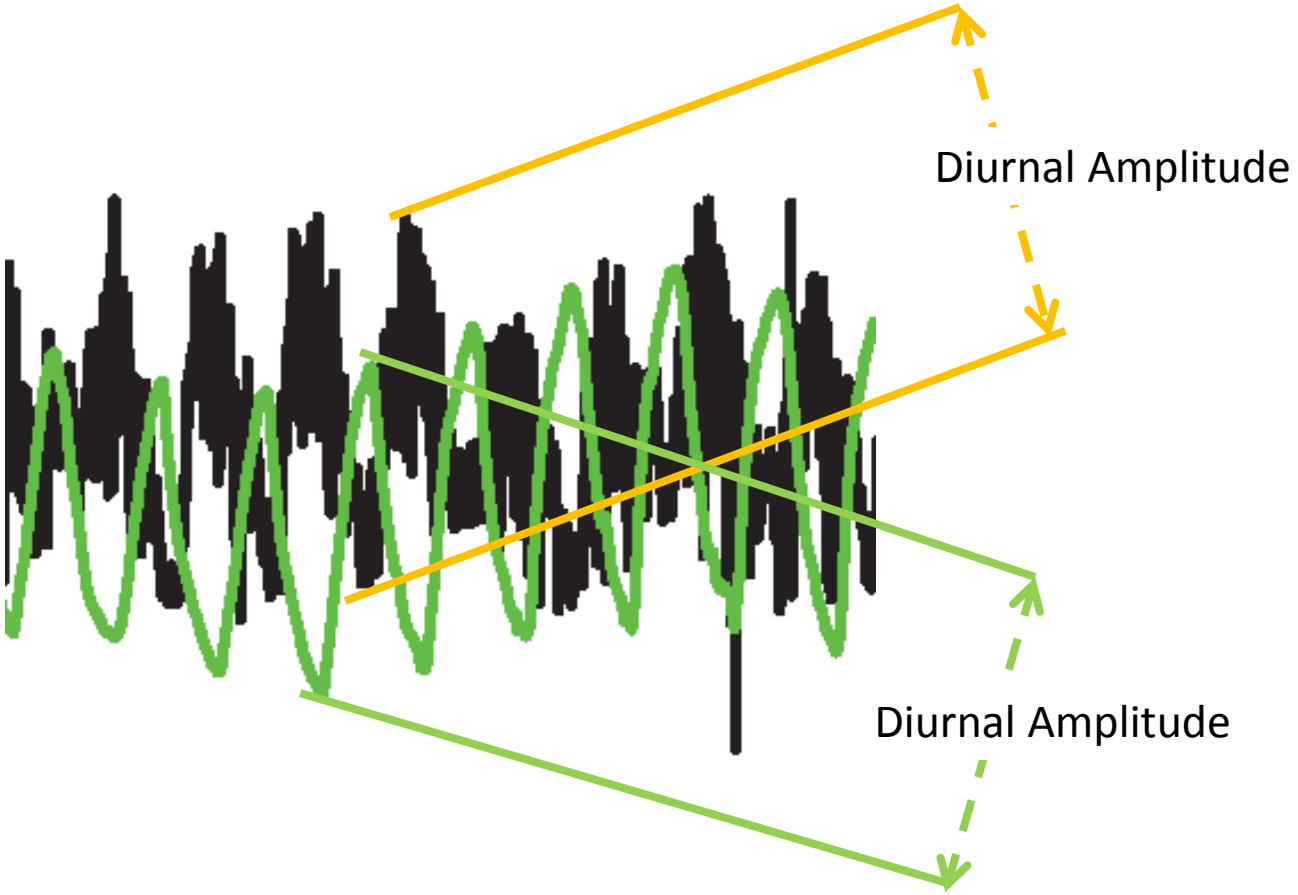
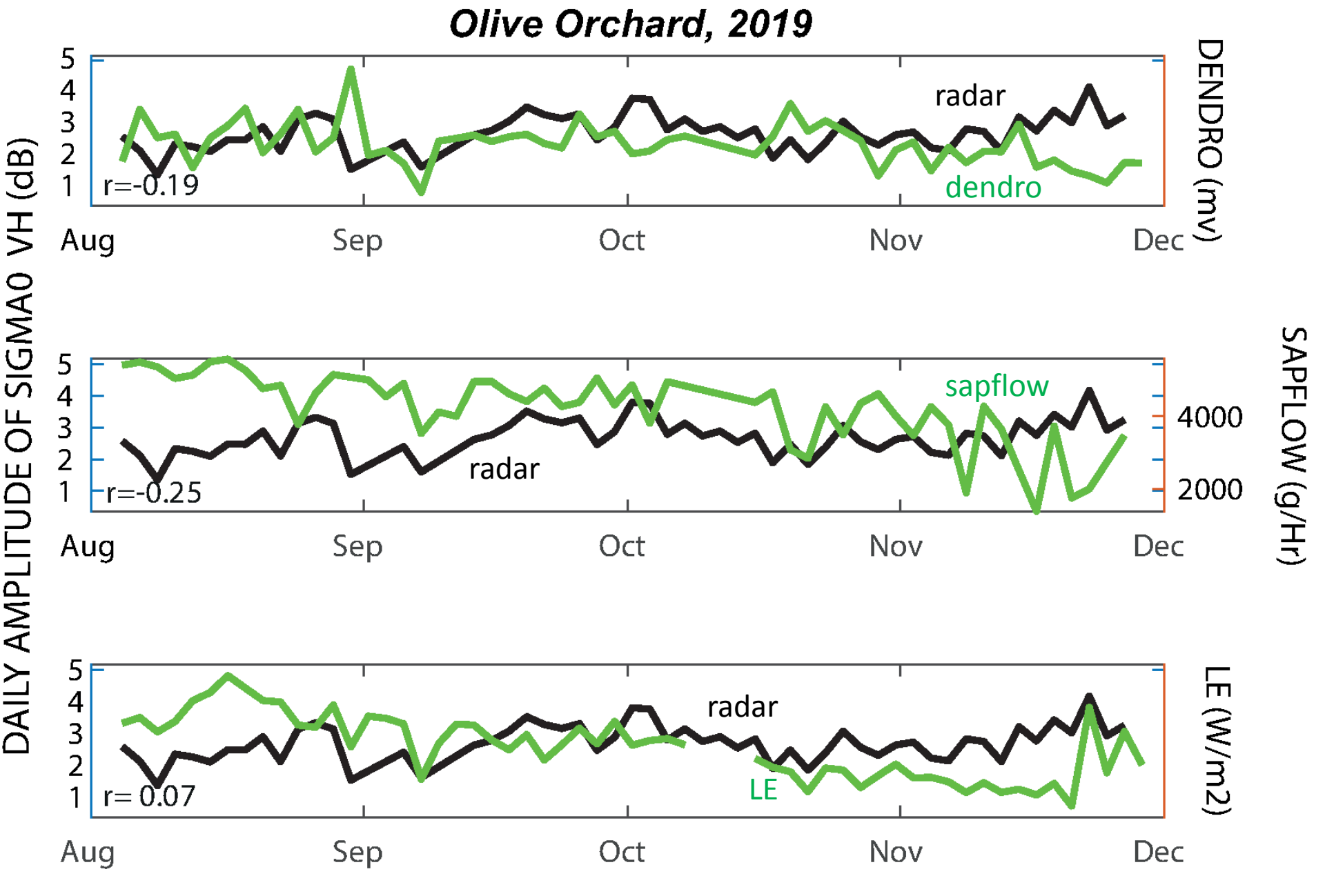
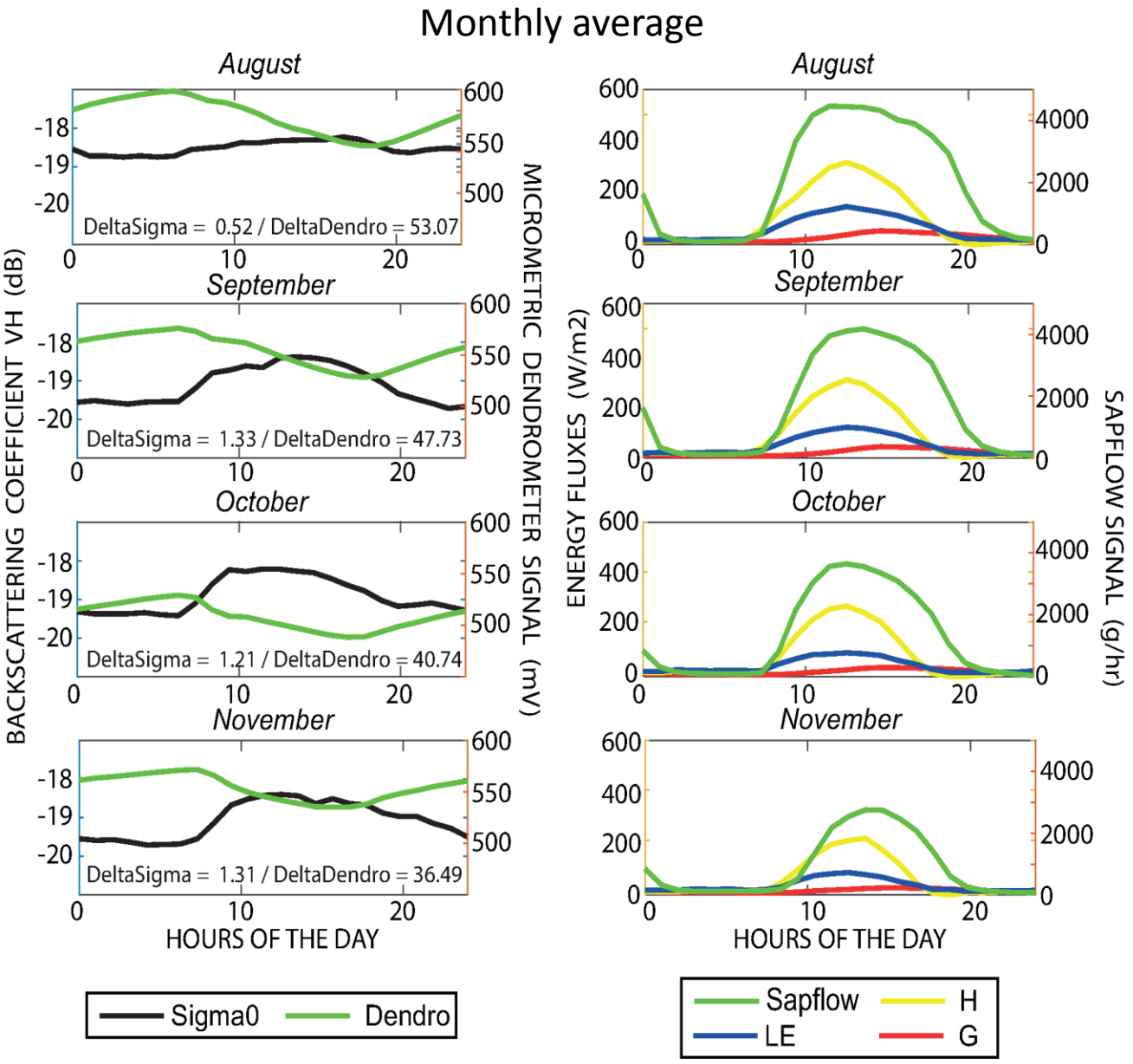


in situ Experiment / C-Band temporal signatures: diurnal amplitude



in situ Experiment / C-Band radar backscattering: diurnal cycle



Radar σ^0

- Diurnal cycle
  - – min. at dawn, peak : 10 AM - 5 PM
  - – Amplitudes: 0.52 - 1.33 dB
  - – no seasonal signal / Contrast with dendrometer & sapflow
- Low correspondence between σ^0 amplitudes and physio. meas.

in situ Experiment / C-Band: Coherence

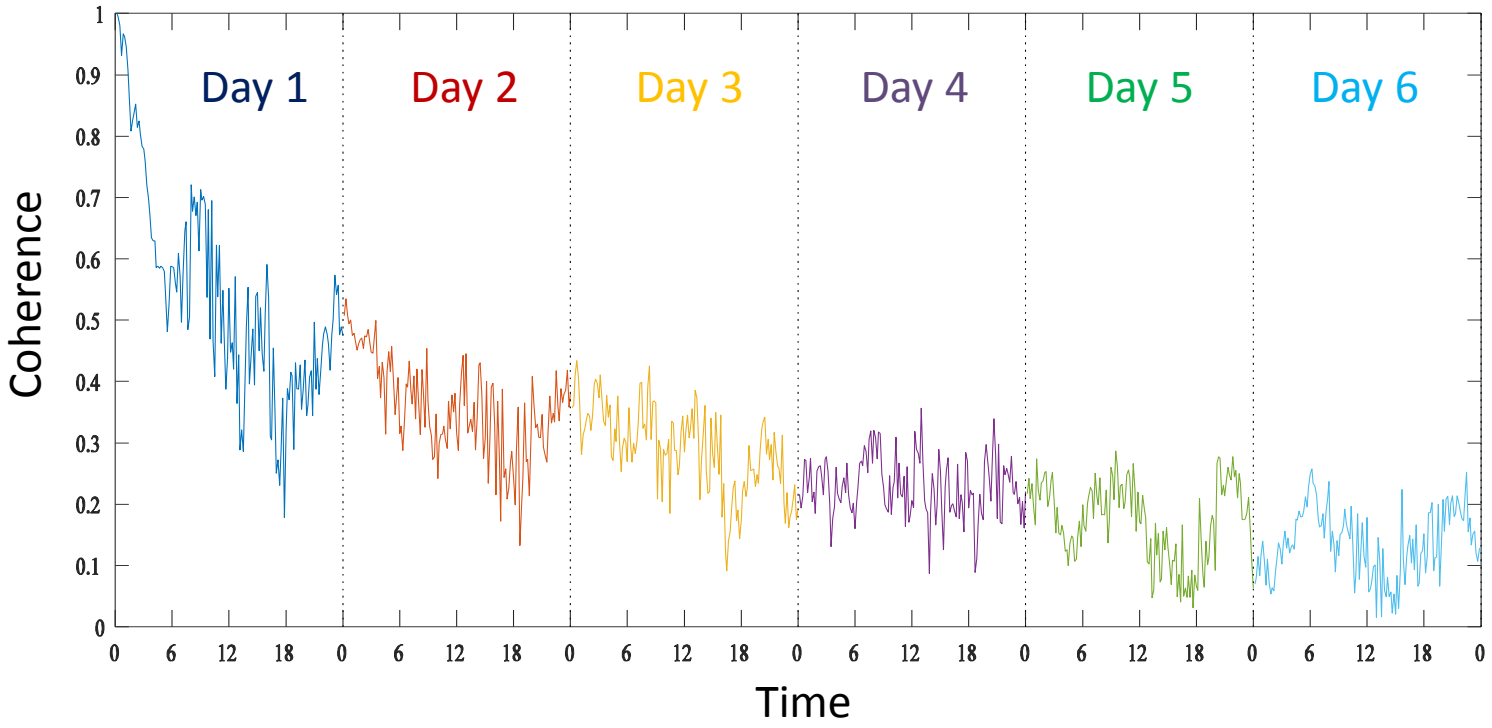
Interferometric Coherence ρ between 2 radar acquisitions:

Change in the scatterers (geometrical position, moisture)

$$0 < |\rho| < 1$$

Stability of the elementary scatterers (leaves and stems) (at the wavelength scale)

☞ Sensitive to wind and vegetation moisture



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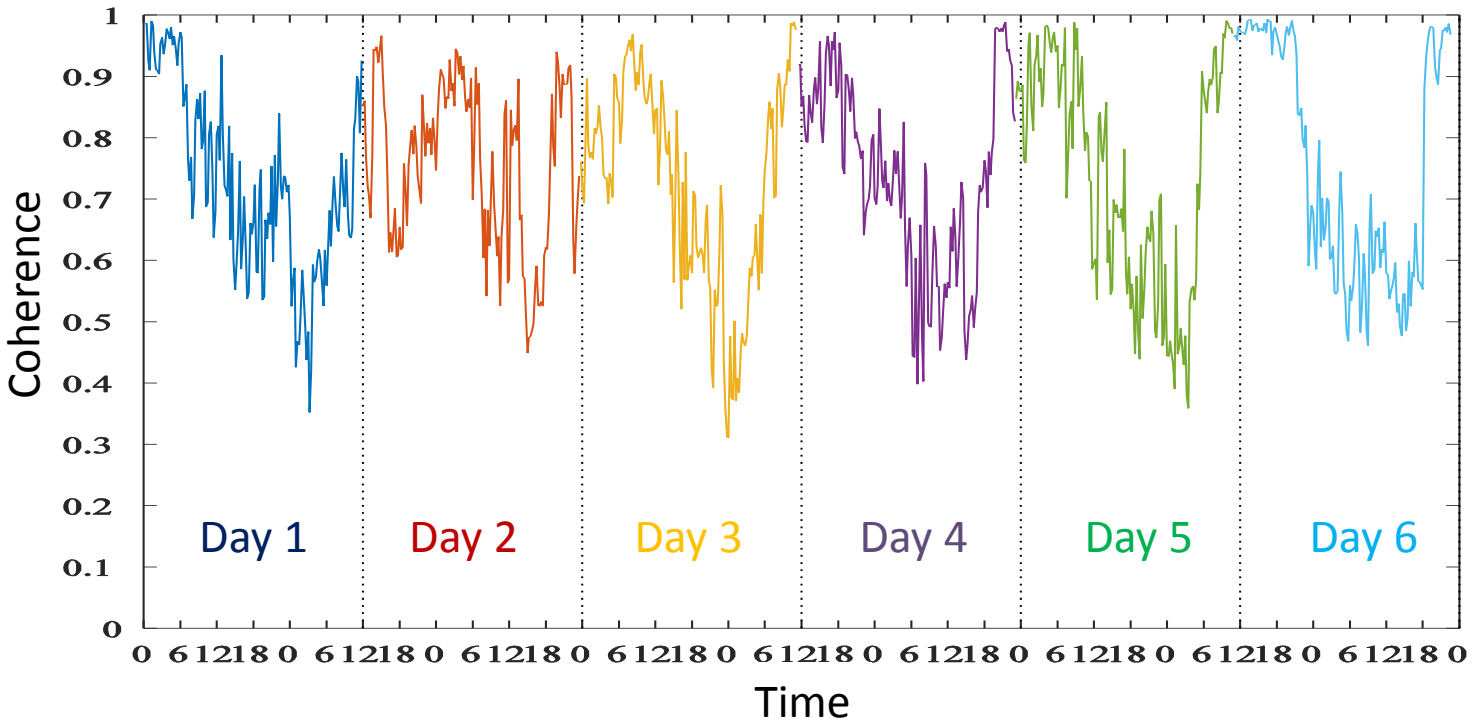
Coherence between 2 consecutive pulses (10 min)



in situ Experiment / C-Band: Coherence diurnal cycle

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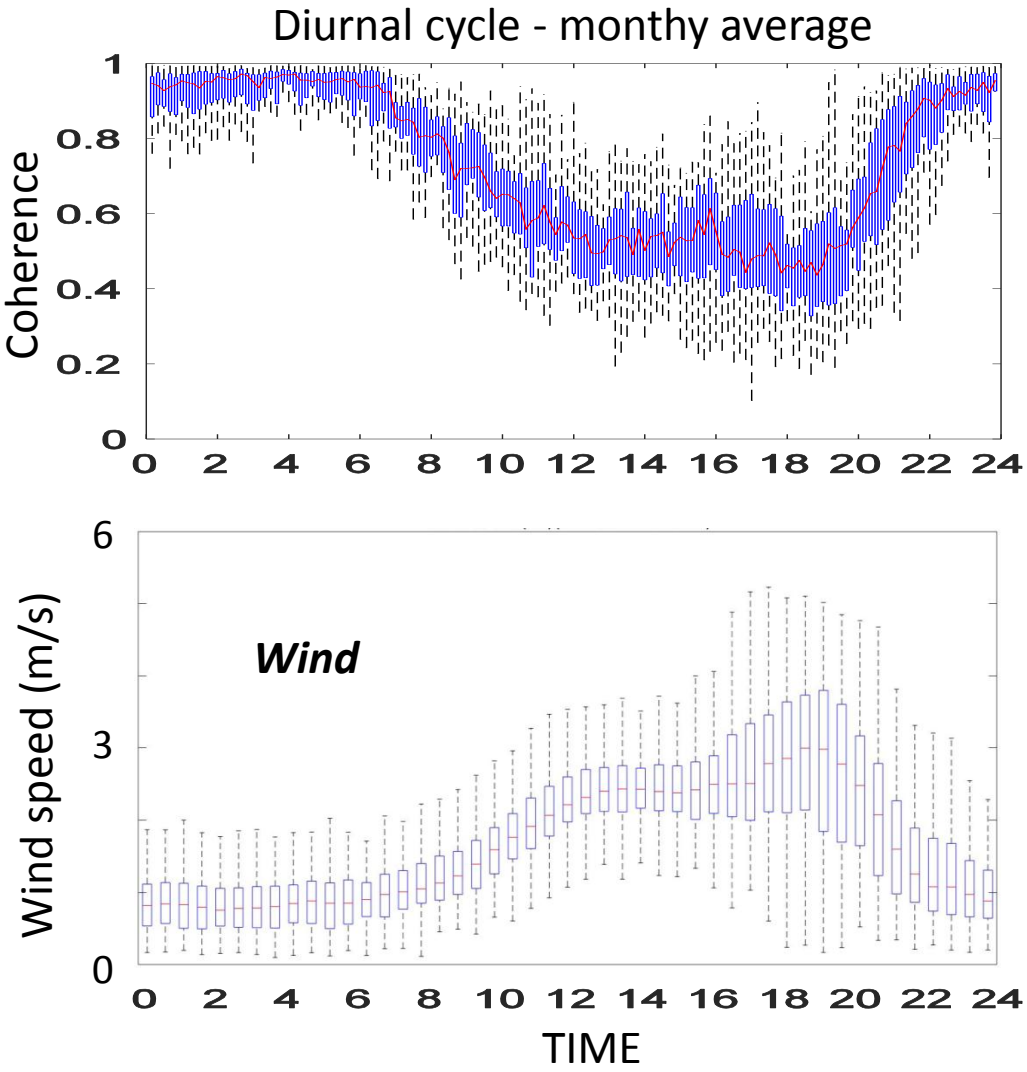
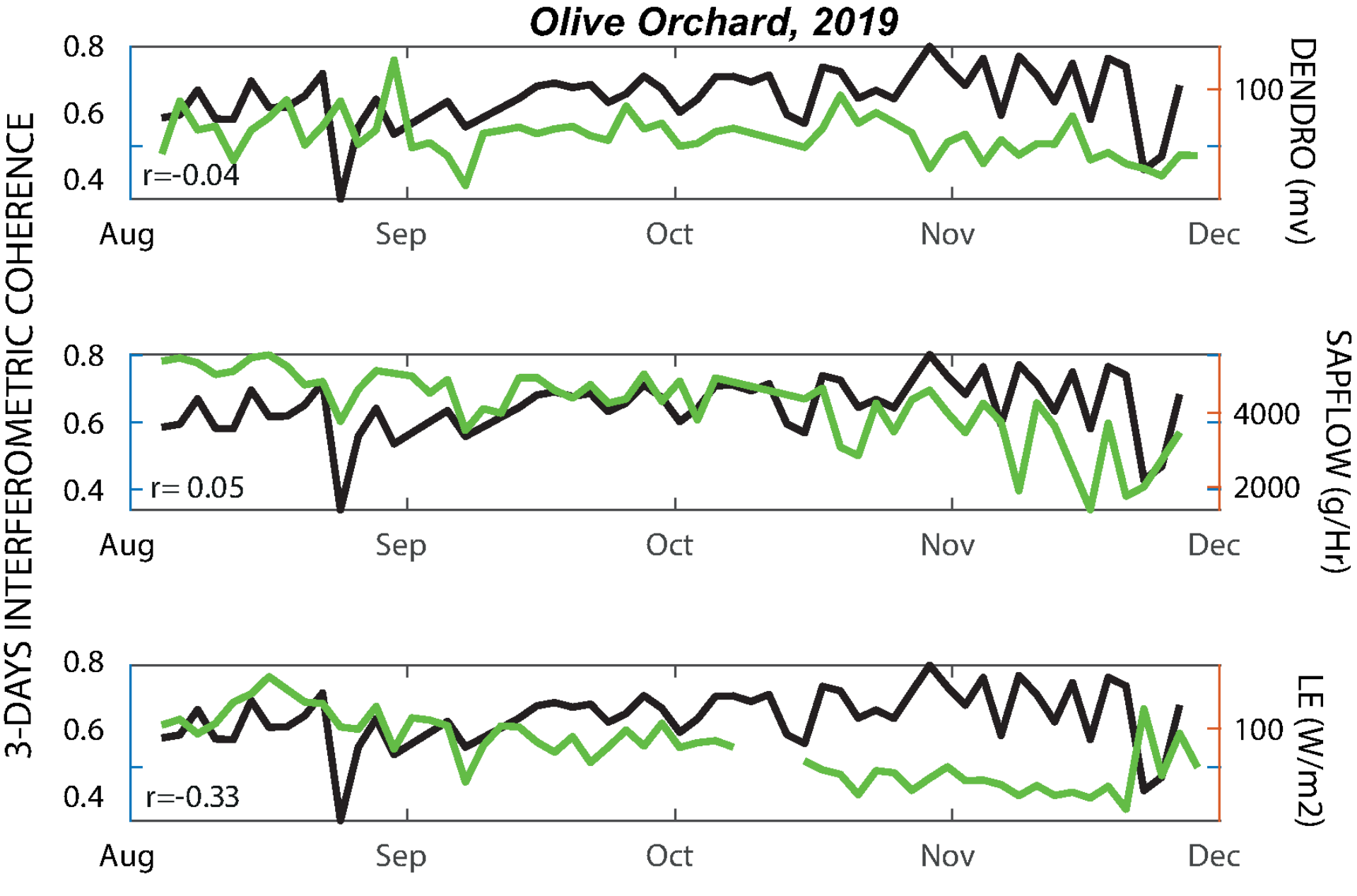


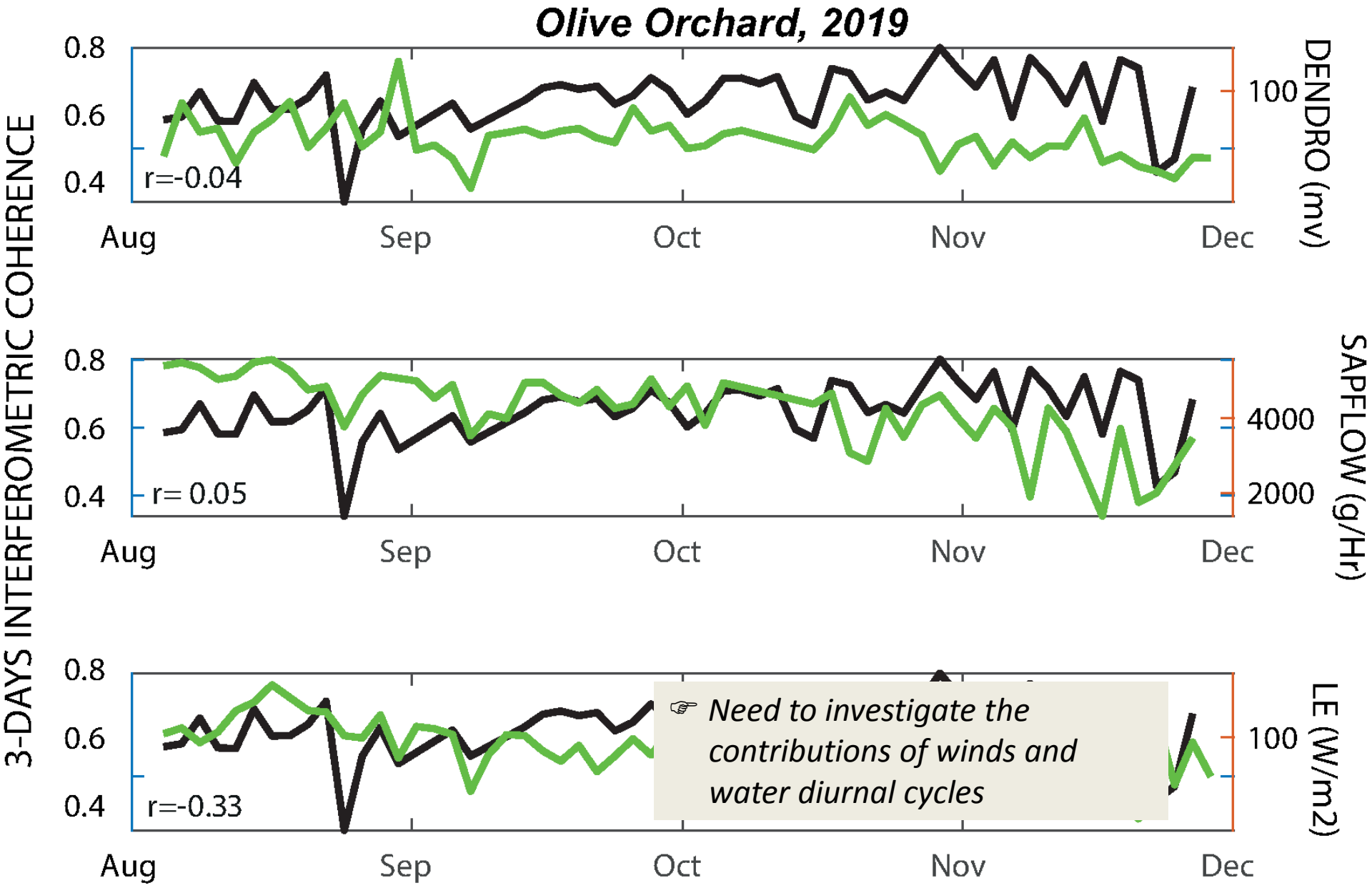
- Fall after 7 AM
- Raise after 8 PM

☞ *Sensitive to wind state*

in situ Experiment / C Band temporal signatures

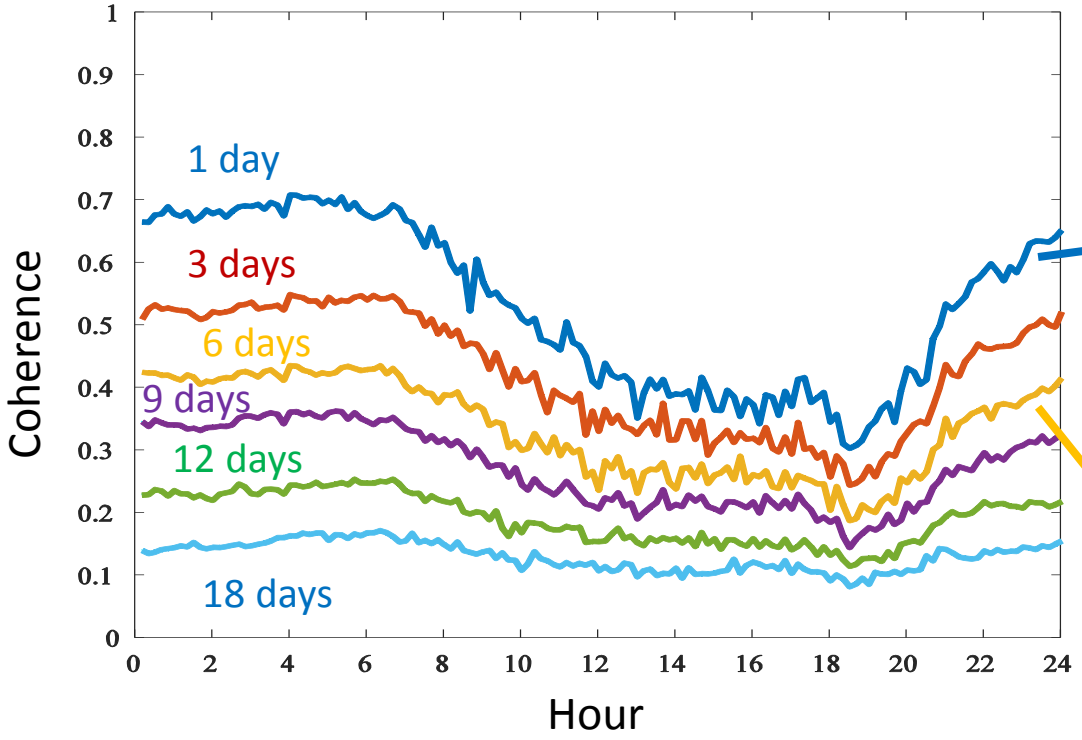


in situ Experiment / C Band temporal signatures

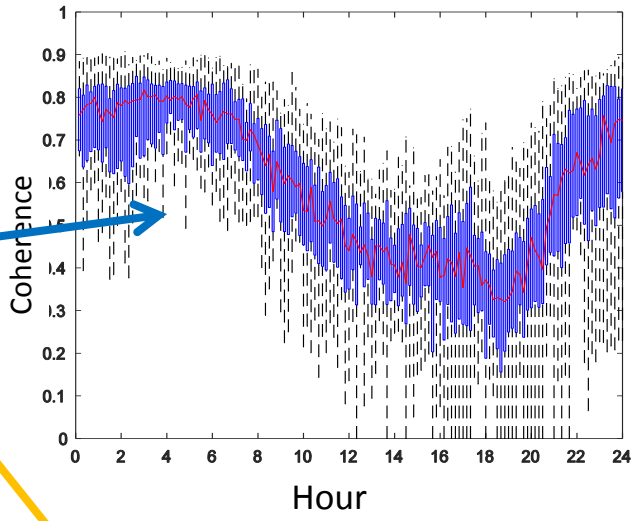


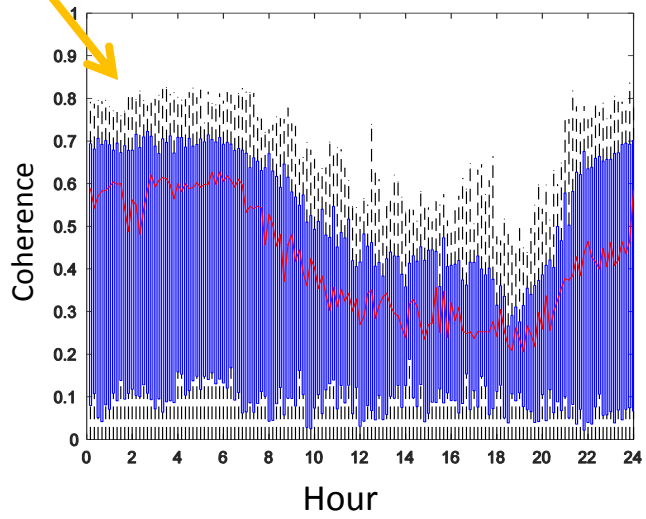
in situ Experiment / C-Band: Coherence diurnal cycle

Diurnal Cycle: Monthly average



Olive orchard





Coherence still significant after 6 days

weak after 12 days

☞ *Good omen for SENTINEL-1*

CONCLUSION

Water state of agricultural areas

C / L Bands Radar *in situ* Experiment for better understanding of crops monitoring

☞ Early detection of water stress

Preliminary results: promising… to be deepened

σ^0 : diurnal variations

Coherence ρ : diurnal variations due to wind state and water cycle

still meaningful after 6 days

Results to be of high interest for spaceborne missions:

Sentinel-1

Geostationnary G-CLASS….