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Investigation of the diurnal cycles of interferometric coherence and backscattering coefficient on irrigated wheat in the South Mediterranean

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Abstract

Sustainable management of water resources is of critical importance in the South-Mediterranean, which is suffering from water scarcity intensified by the impact of climate change. In this context, early detection of water stress by monitoring the water status of canopies can contribute to an optimal use of irrigation water use. C-band radar data have shown great potential for monitoring the vegetation hydric conditions. Over forests, several studies have observed a diurnal cycle in the backscattering coefficient that can reach up to 1 dB. The objective of this work is to investigate the behavior of radar data over annual crops by collecting in situ measurements of the interferometric coherence (ρ) and the backscattering coefficient (σ^0) every 15 minutes using a radar set-up composed of six C-band antennas (full polarization), installed on a 20 m high tower and targeting a winter wheat field in Morocco. The first results obtained from the analysis of these data collected during the 2020 agricultural season reveal the existence of a diurnal cycle of interferometric coherence whose amplitude increases with canopy development. The decrease of coherence at dawn is most likely related to evapotranspiration while dynamic of coherence in the afternoon is associated to wind intensity. Similarly, these preliminary results show that the daily cycle of the backscattering coefficient is in good agreement with the daily evolution of evapotranspiration.

Key-words: Diurnal cycle; C-band; Backscattering coefficient; Interferometric coherence; Semi-arid Mediterranean region; Wheat.

Study area

The experiment (named hereafter MOCTAR) was conducted in the Haouz plain in Morocco (see figure 1).

The climate in the region is semi-arid with a main annual rainfall around 250 mm and a reference evapotranspiration of about 1600.

The experiment is installed over a wheat field of about 1.5 ha selected within a private farm.

The fields is grown in winter wheat during 2020 agricultural seasons (January to June) and the irrigation method used is the drip technique.

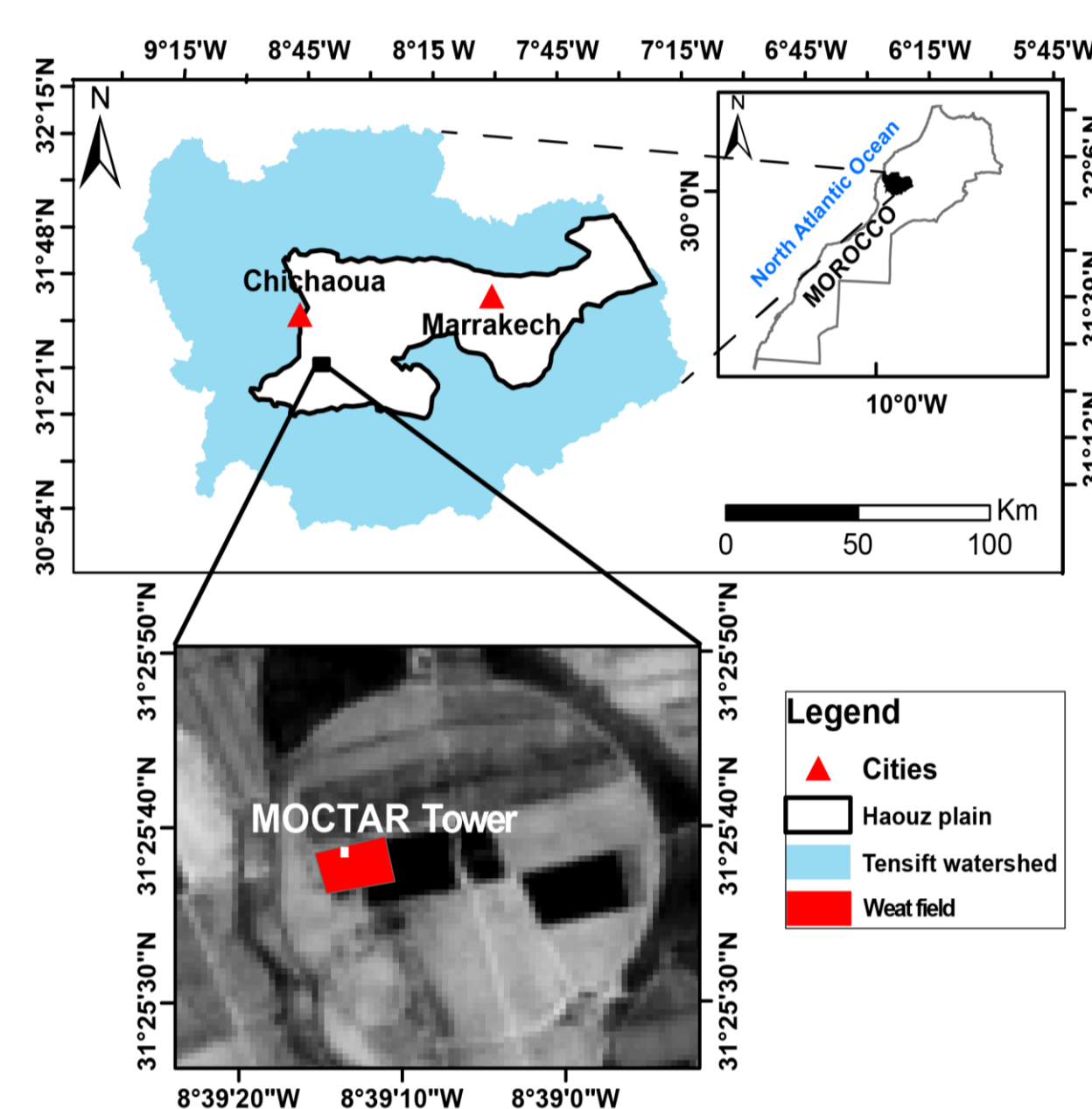


Figure 1: Study area located in Morocco

Results and discussion

TIME SERIES

MOCTAR σ^0 is in agreement with Sentinel-1 data with a typical two-cycle seasonal evolution:

- σ^0 is governed by the soil moisture dynamic at the start of the season
- The signal decreases afterwards with canopy growth due to the signal attenuation
- Heading stage is associated to a drastic change of the canopy geometry. The wet layer at the top of the canopy composed of the green wet ears leads to an increase in volume diffusion
- The signal drops at the end of the season as the vegetation and soil dry out.

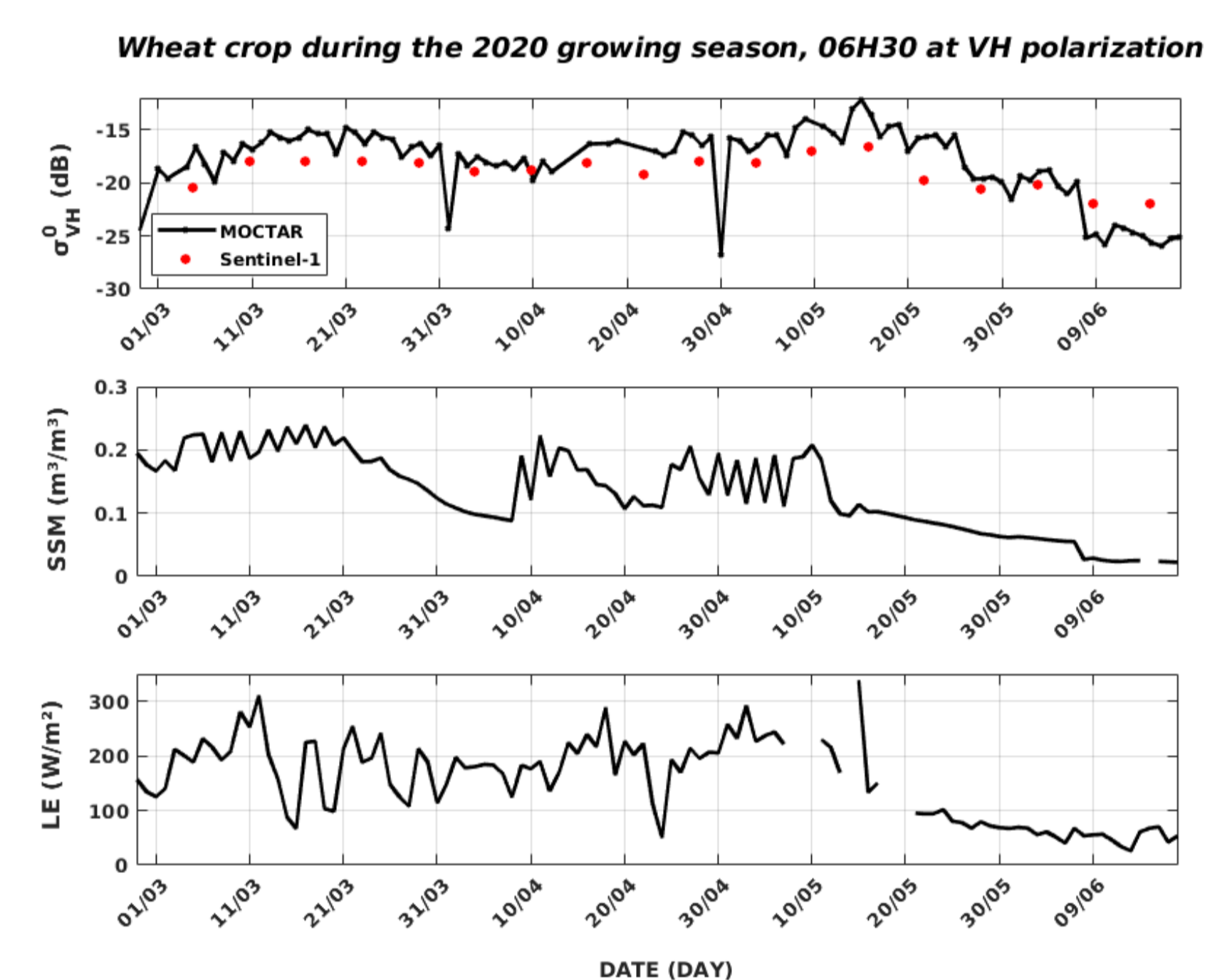


Figure 2: Time series of the σ^0 measured by MOCTAR and Sentinel-1 over the wheat field at 06H30 at VH polarization during the 2020 growing season. The Time series of SSM (surface soil moisture), LE (evapotranspiration) are also plotted

Experiment description

MOCTAR experiment is funded by the LMI TREMA and TOSCA/CNES project. It has been conducted since January 2020. The experimental setup consists of six C-band antennas installed at the top of a 20 m high tower. It allows the full polarization acquisitions of ρ and σ^0 with a 15 minutes time step.

The field is also equipped with an eddy covariance that allow half-hourly measurements of evapotranspiration, soil moisture and wind speed.

Field campaigns are also carried out to measure soil moisture, surface roughness, vegetation above-ground biomass and cover fraction.



MOCTAR Tour



Eddy covariance station

DIURNAL CYCLE

ρ :

- Diurnal cycle is very low during the first two periods when the soil is bare and starts to increase progressively with the development of vegetation
- Drop at dawn is concomitant with evapotranspiration (start of the physiological functioning of wheat).
- Minimum values obtained in the late afternoon correspond to the higher value of wind intensity.

σ^0 :

- A daily cycle is observed when the canopy is developed.
- Increase of the signal in the morning concomitant with the increase of LE.
- SSM have a limited impact on ρ while the marked daily cycle of σ^0 when the soil is bare is more likely related to SSM.

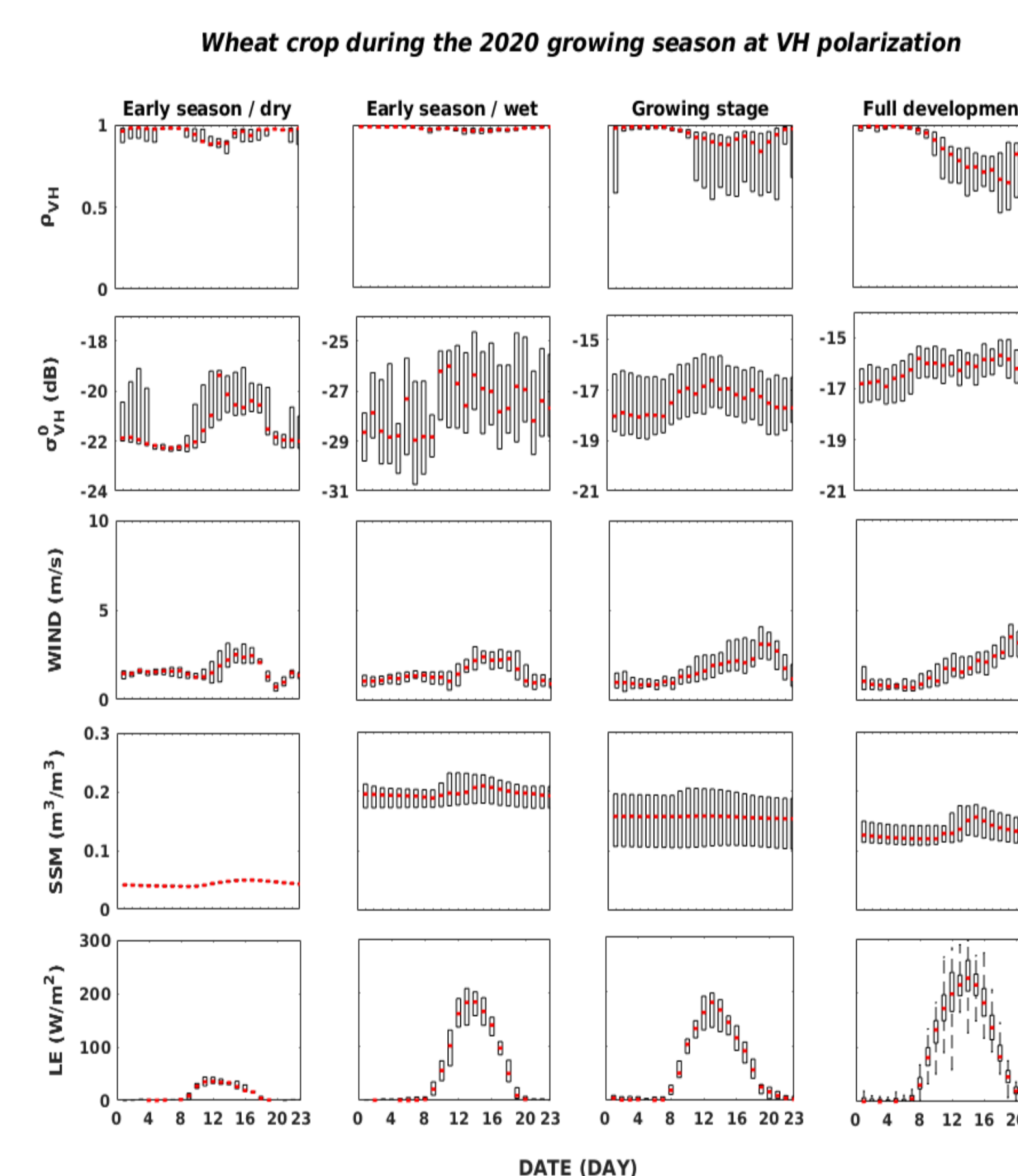


Figure 3: Average daily cycles of ρ and σ^0 at VH polarization, SSM, ET, and V (wind speed) represented by box-plots for 4 key periods of the agricultural season.

Conclusion

- The analysis of the first observations acquired by a in situ C-band radar over an irrigated crop in the south mediterranean region reveals the existence of a diurnal cycle of the interferometric coherence and of the backscattering coefficient whose amplitudes increase with the development of vegetation.
- The low values of ρ observed at the end of the afternoon are related to the strong winds while the drop at dawn is concomitant with the increase in evapotranspiration.
- For the backscattering coefficient, a good agreement is observed between the evolutions of its daily average and the evolution of evapotranspiration.
- These preliminary results demonstrate the existence of important dependencies between the infra-daily C-band dynamic and the physiological functioning of wheat, which could be exploited in the future for the detection of water stress using radar data acquired at a sub-daily timescale.

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