# Exploring the relationship between phenology and hydrology using Sentinel-2 and terrestrial photography in Mediterranean grasslands

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Andalucía se mueve con Europa

## Introduction and objective

Mediterranean grasslands provide important ecological services and are an essential component of rural economy as the primary source of fodder for livestock in extensive areas. These annual grasslands present an escape mechanism to cope with the long summer dry season and the recurrent water scarcity events of the Mediterranean climate, completing their life cycle before serious soil and plant water deficits develop. It results in a close link between grass phenology and soil water dynamics.

The objective of this study is to identify the links between the hydrology and the vegetation phenology derived from terrestrial photography, evaluating the response of the grass and its life cycle to changes in the main abiotic variables controlling this system, and study the relationship between satellite vegetation indices and the hydrological state of the system regarding their ability to monitor grassland phenology

## Study site

Sta Clotilde experimental site
Cardeña (Córdoba, Spain)

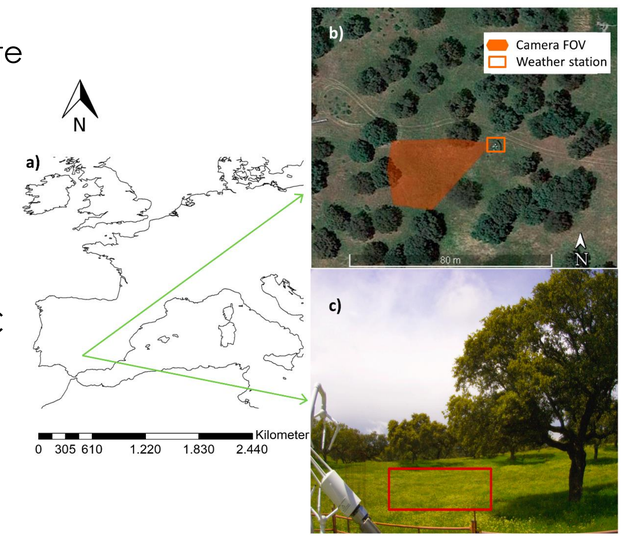
895 mm average rainfall

735 m.a.s.l.

Winter temp. below 0 ºC
Summer temp. above 40 ºC

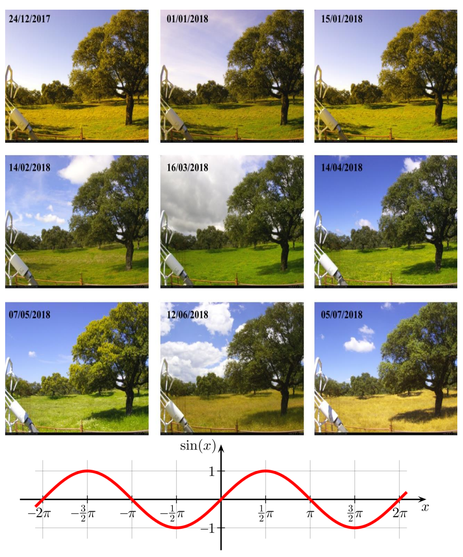
CC5MPX Camera

Field of view (FOV): 790 m$^2$




## Methodology

### The terrestrial photography was used as a ground-truth phenology indicator




Green Chromatic Coordinate

$$GCC = \frac{G}{R+G+B}$$

50 % Amplitude method:

→ Start of season (SOS): 50% amplitude reached
→ Peak of season (POS): maximum
→ End of season (EOS): 50% amplitude on the right of the peak
→ Fitting values to double logistic function

Study period: December 2017 – May 2019

### Abiotic variables from weather station

- Vapour pressure deficit (VPD)
- Temperature: maximum (Tmax), average (Tmed) and minimum (Tmin)
- Radiation (Rad)
- Rainfall (R)
- Soil moisture (SM)

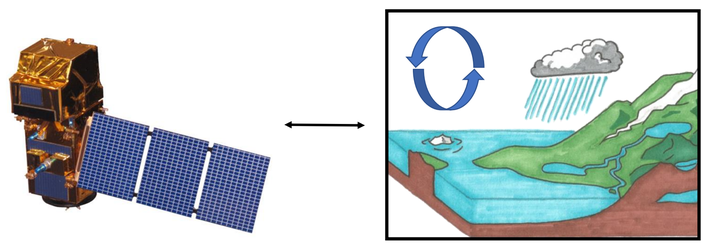
Statistical analysis with GCC:
- Pearson Matrix correlation
- Principal Component Analysis (PCA)

Applying 50% amplitude method to most representative variable

Study period: December 2017 – May 2019

### Analysis satellite phenology – abiotic variable

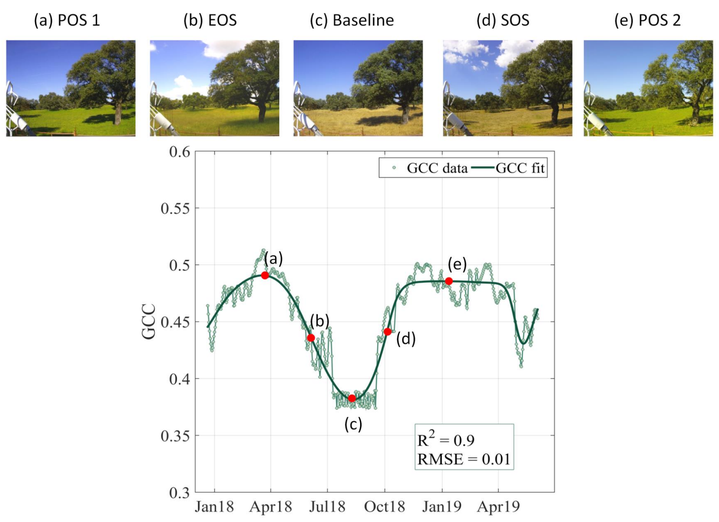
→ Normalized Difference Vegetation Index (NDVI) from Sentinel-2
→ Most representative abiotic variable
→ 50% amplitude method



Extended period: July 2015 – May 2019

## Results

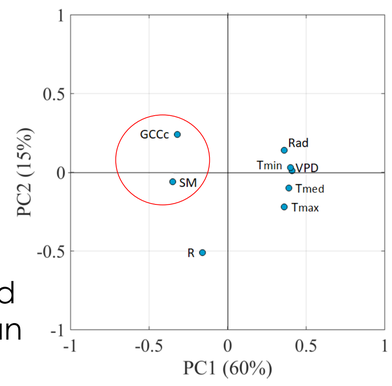
The fitted function presented $R^2$ = 0.9 and RMSE = 0.01
50% amplitude method correctly matched the observations derived from the visual inspection of the digital camera photographs




Pearson matrix correlation

| Variable | r (GCC) |
|---|---|
| SM | 0.75* |
| VPD | -0.68* |
| R | 0.17* |
| Rad | -0.56* |
| $T_{min}$ | -0.68* |
| $T_{med}$ | -0.72* |
| $T_{max}$ | -0.69* |

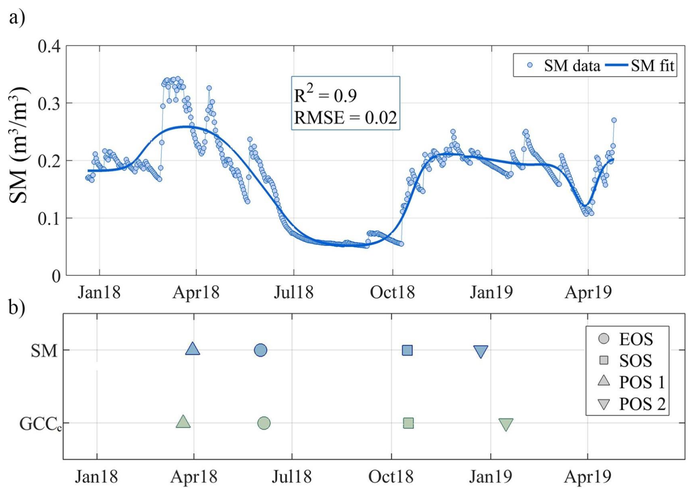
PCA




2 groups:
- Negative coefficients included GCC and variables favoring an increase of soil water content
- Positive coefficients corresponded to variables with high values during the summer when the grass canopy was dry.

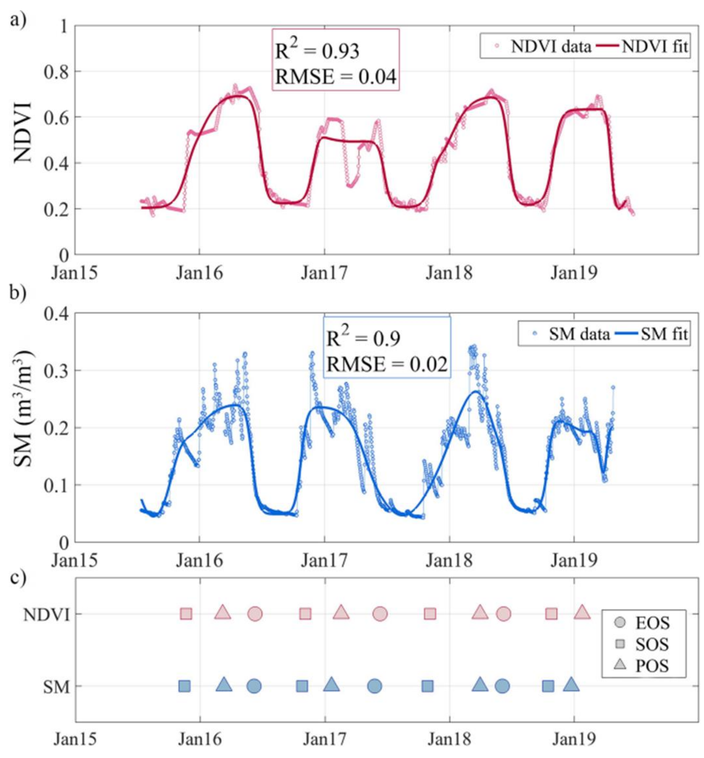
**SM** was the most representative variable with respect to GCC

The SOS and EOS were similar to the timings estimated by GCC, with a slight advance in both dates according to SM estimations.
SM of around 0.14 m$^3$ /m$^3$ marked the beginning and the end of the growing season.




### Extended study period

A marked and mostly synchronized seasonality of both variables can be observed
In general, an average delay between 3 and 10 days can be noted in phenology estimations using NDVI with respect to SM
The highest differences were found in POS of 2016/2017. During that year, the grassland was plowed and sown in the middle of February




## Conclusions

→ The estimation of phenology using field measured GCC and the 50% amplitude method corresponded well with the visual inspection
→ SM was the abiotic variable more related to GCC (r = 0.75), reaching phenological threshold values earlier than GCC
→ NDVI and SM behavior during the four growing seasons showed a high synchronization
→ This results suggest the possibilities of monitoring the hydric state of the soil using the phenological parameters obtained from S2 NDVI under certain conditions

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