INTEGRATION OF MEASUREMENTS, REMOTE SENSING AND MODELS FOR SEMIARID SAVANNA-TYPE SYSTEMS MANAGEMENT.

DFH Dinámica Fluvial e Hidrología
UNIVERSIDAD DE CÓRDOBA

UNIVERSIDAD DE CÓRDOBA

EXCELENCIA MARÍA DE MAEZTU 2020-2023

IISTA

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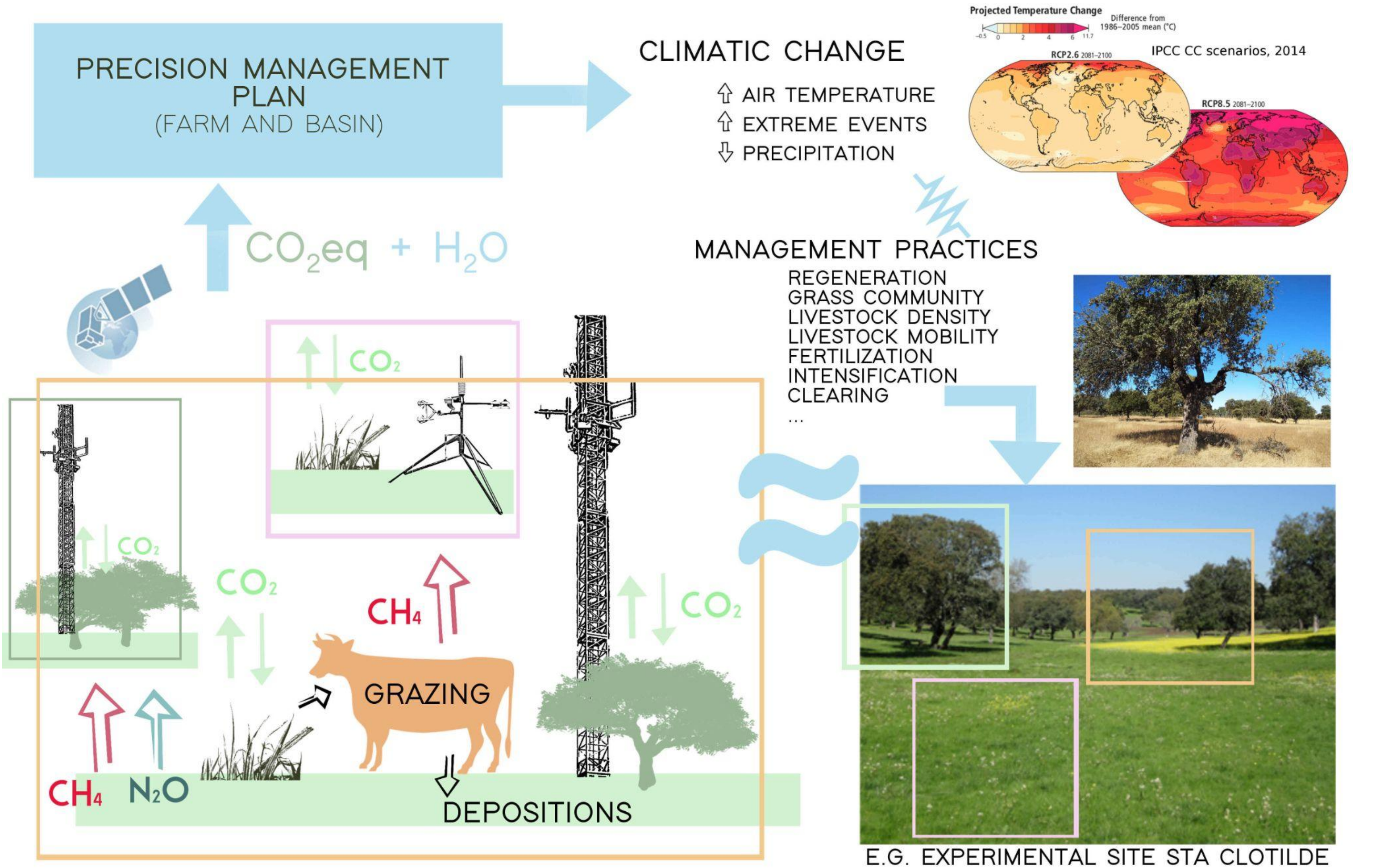
WHAT are we doing?



What are we doing?

To provide recommendations for management that reinforce the ecosystem services that Mediterranean landscapes offer society, on local (e.g., landscape and resources management) and regional (e.g., management mitigation strategies regarding drought and carbon sequestration) scales, **integrating Earth Observation** and **low-cost sensors**

1. Improving the understanding of the processes governing biogeochemical flux exchanges between semiarid partially covered landscapes and the atmosphere.
   - Temperature heterogeneity
   - Spectral Response
   - Phenology…
2. Developing a robust modeling framework for water use and vegetation dynamics monitoring in semiarid partially covered ecosystems.
3. Development of scientific data series.

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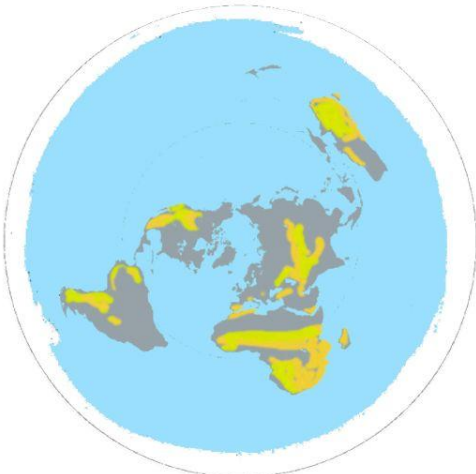
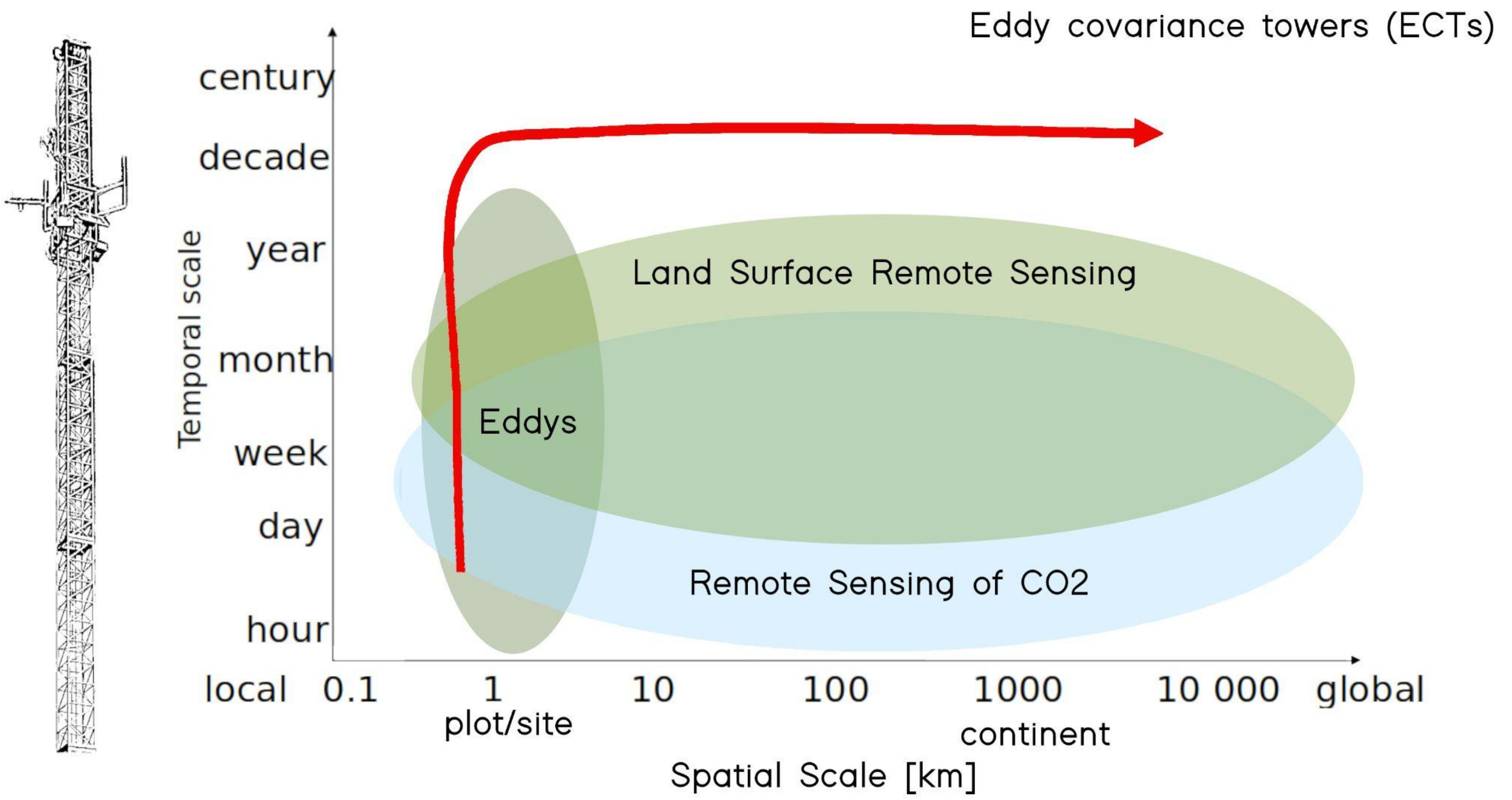
3. Data in Savannas



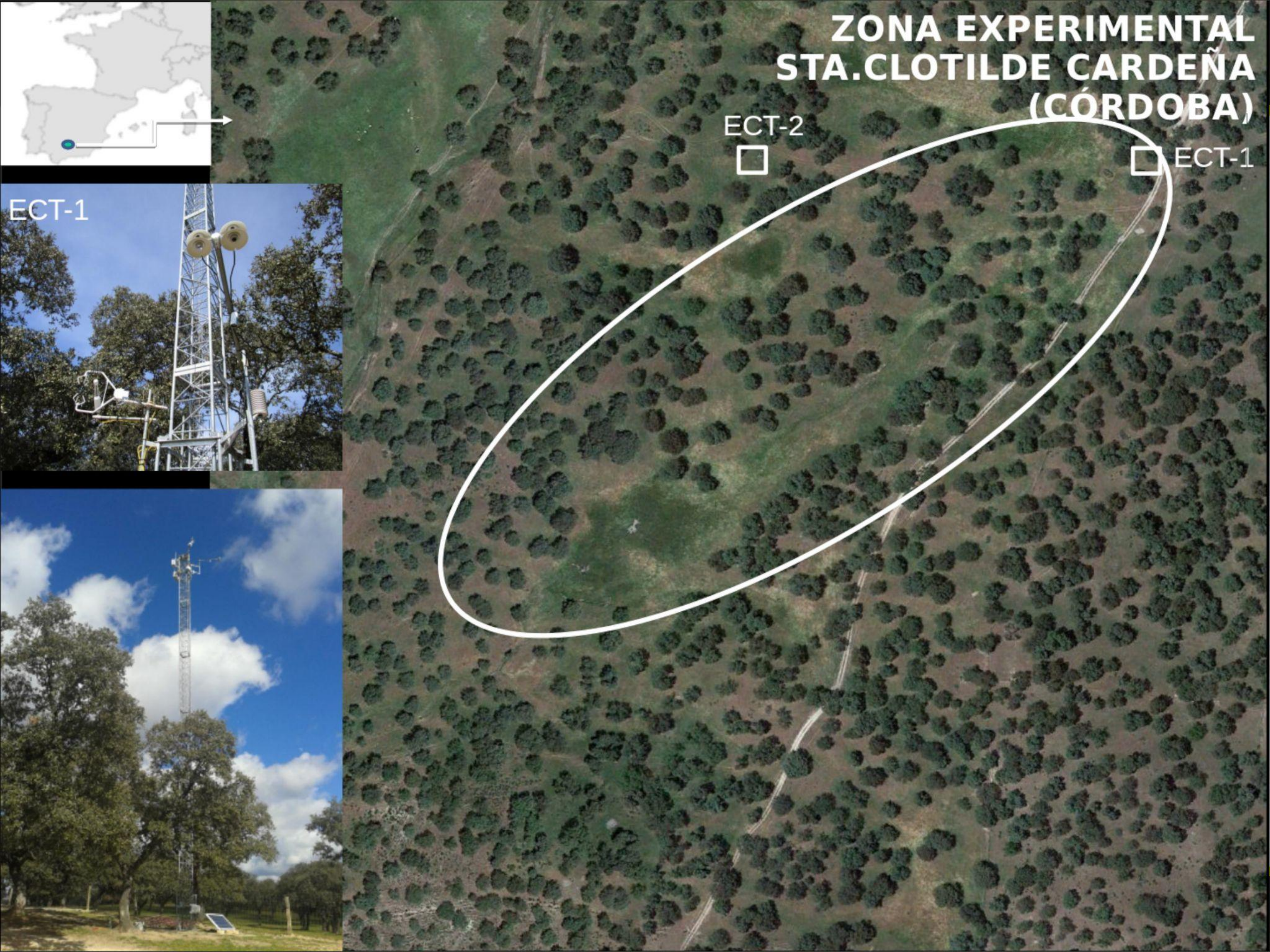
1. Santa Clotilde & Las Morrillas dehesas in Córdoba, Spain.
2. Skukuza savanna in South Africa.
3. Tonzi oak savanna in California, USA.

3. Data in Savannas



Adapted from Markus Reichstein, MPI.


ZONA EXPERIMENTAL
STA.CLOTILDE CARDEÑA
(CÓRDOBA)
ECT-2
ECT-1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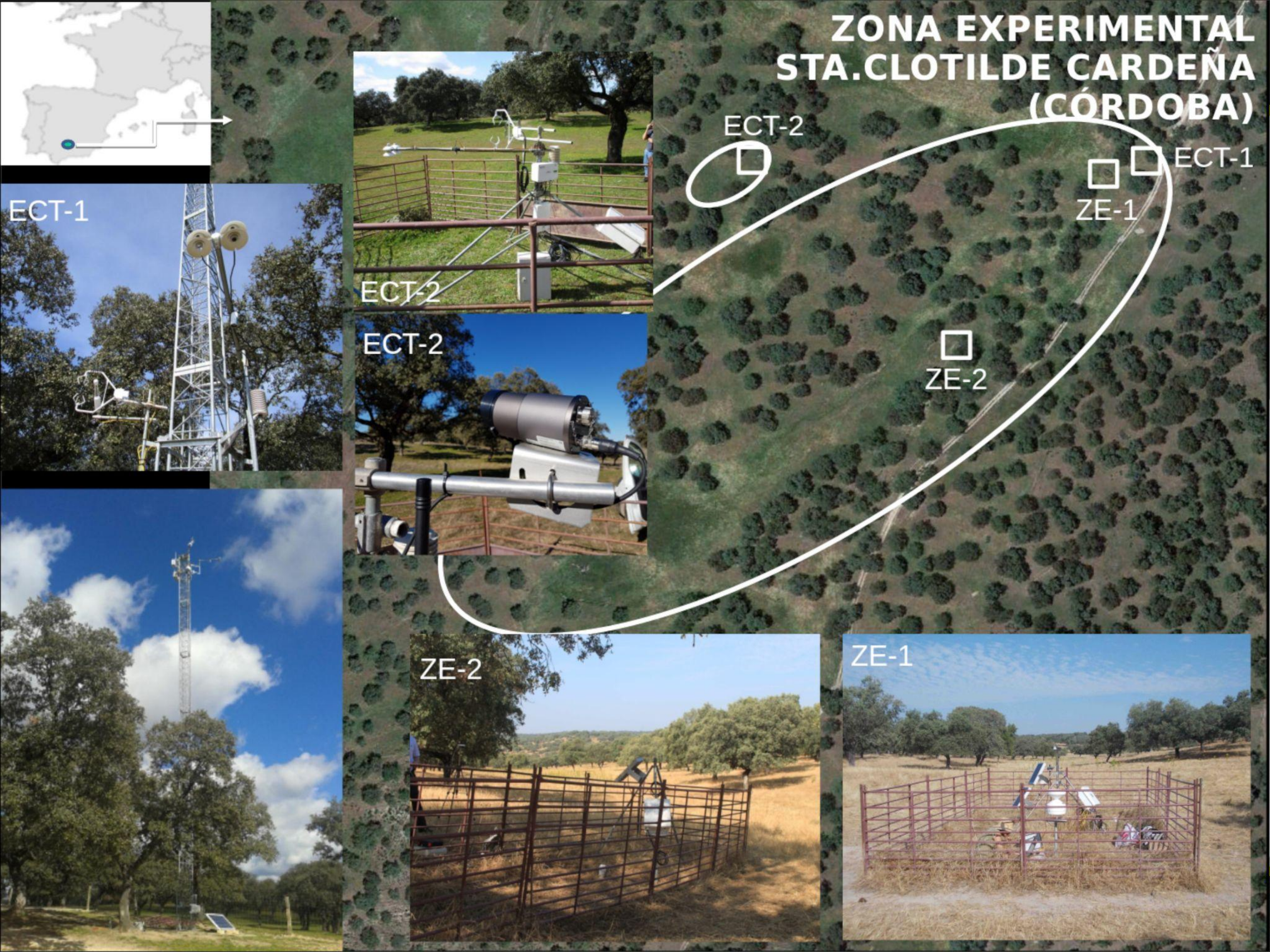
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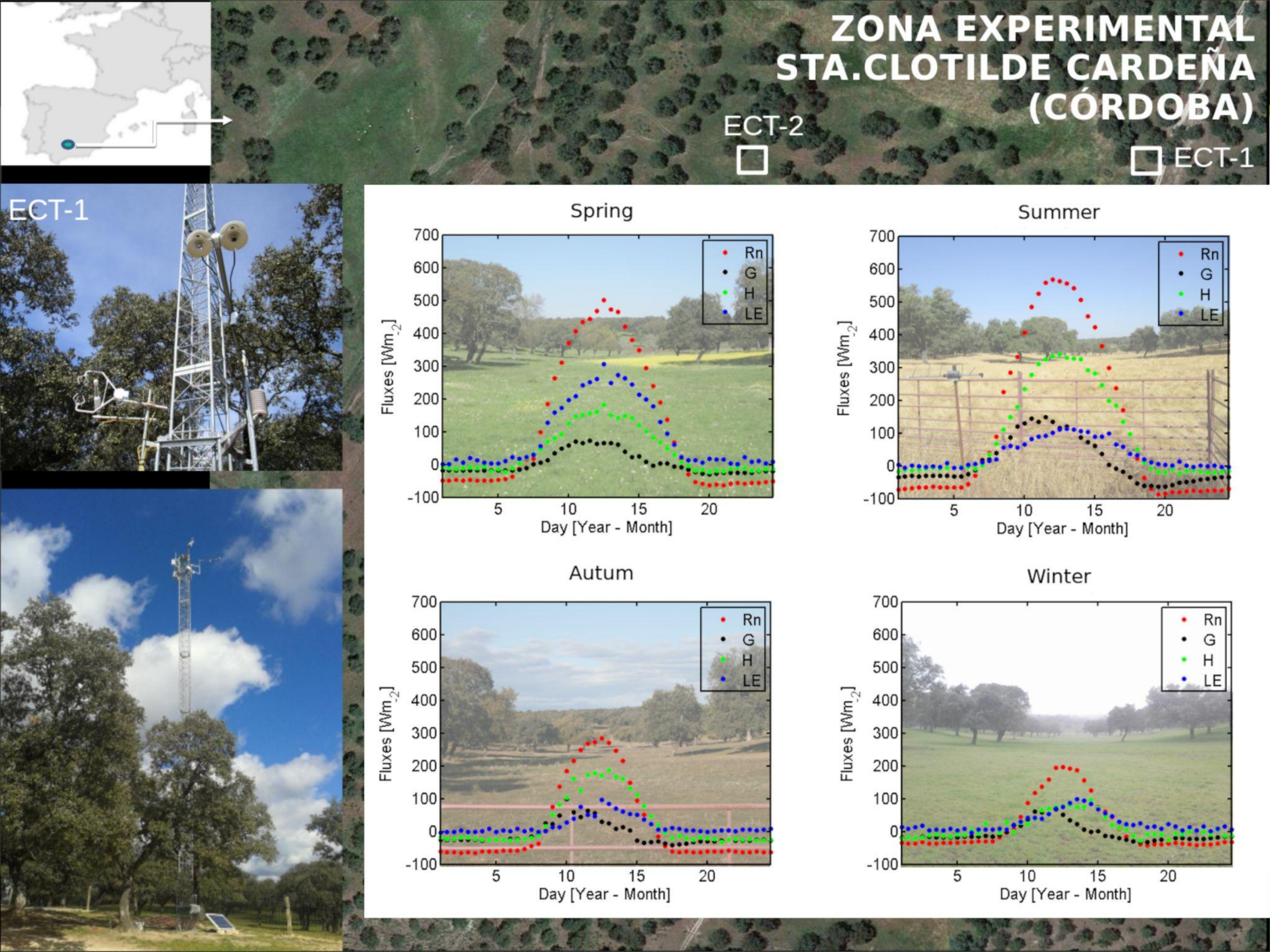
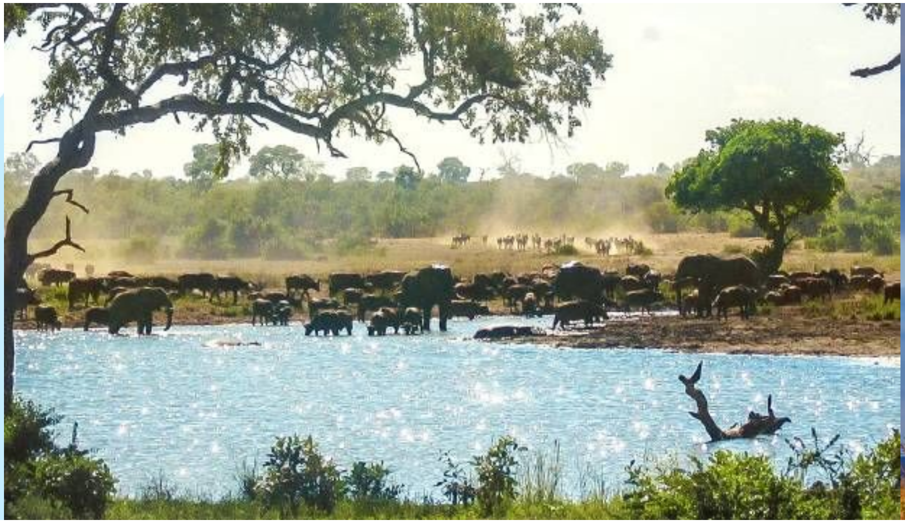
ZE-2
ZE-1


ZONA EXPERIMENTAL
STA.CLOTILDE CARDEÑA
(CÓRDOBA)
ECT-2
ECT-1
ECT-1
Spring
Summer
Autum
Winter
Rn
G
H
LE
Fluxes [Wm_2]
Day [Year - Month]
700
600
500
400
300
200
100
0
-100
5
10
15
20

3. Data in Savannas: skukuza

African semiarid **rangelands** are a **mosaic of land uses**, where extensive **livestock** is the main economic activity.



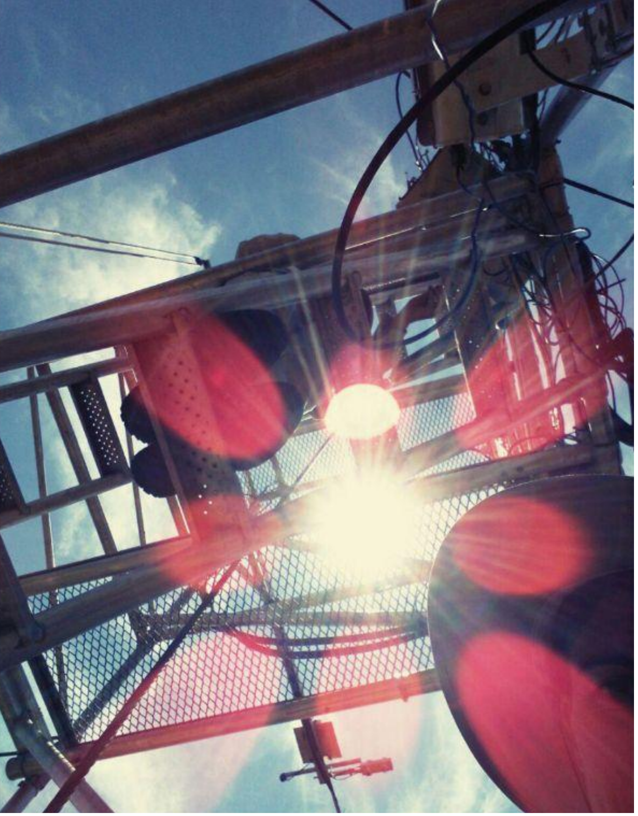

From A. Andreu. Savanna Tiger Guide.

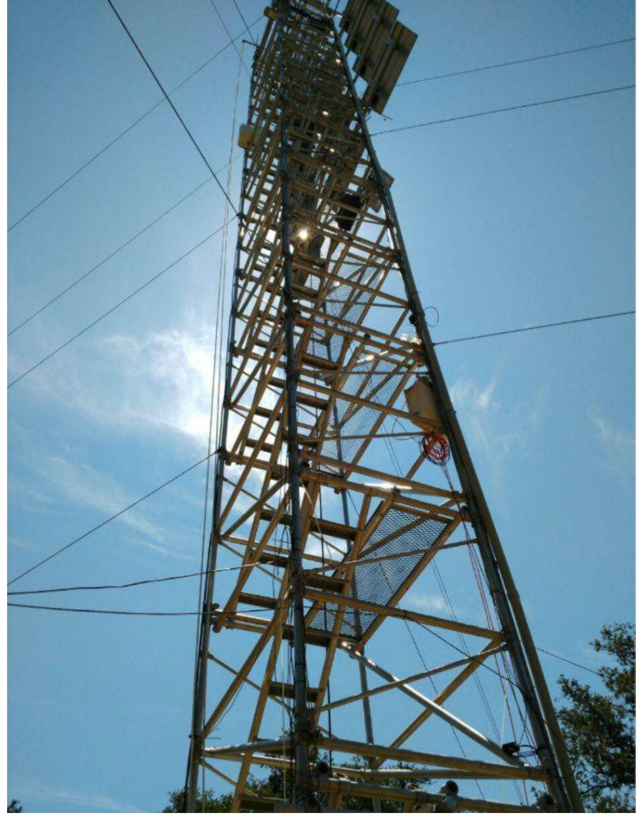
3. Data in Savannas: Skukuza

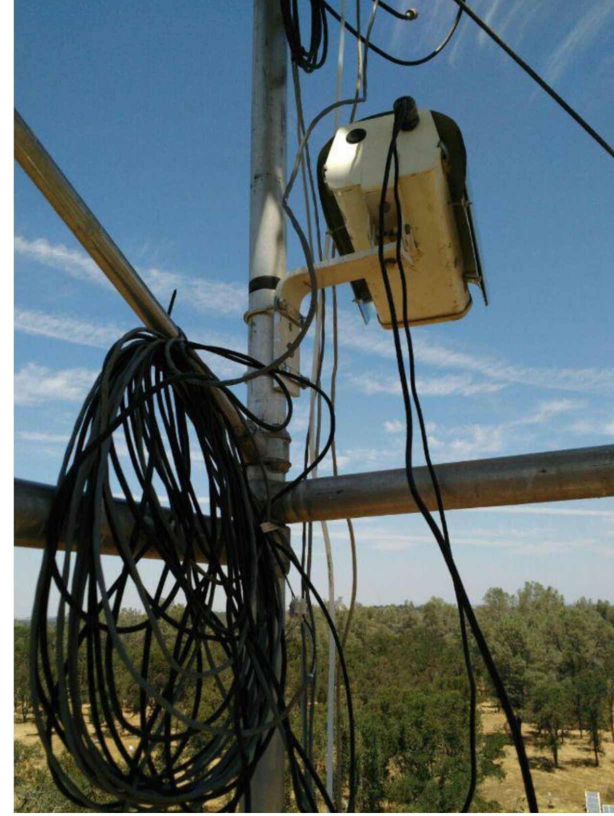
Skukuza **area** is located in the Limpopo region, with great agricultural importance but subject to periodic droughts, and home of the **Kruger National Park**.

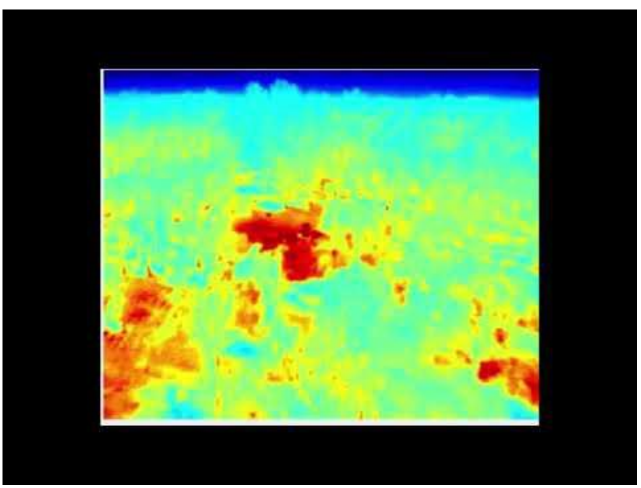
Drought in rangelands of South Africa
by Alexandra Dr. Sandhage-Hofmann

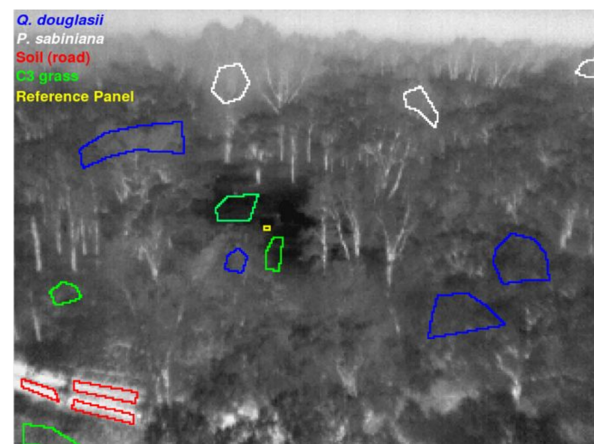
3. Data in Savannas: tonzi










Q. douglasii
P. sabiniana
Soil (road)
C3 grass
Reference Panel

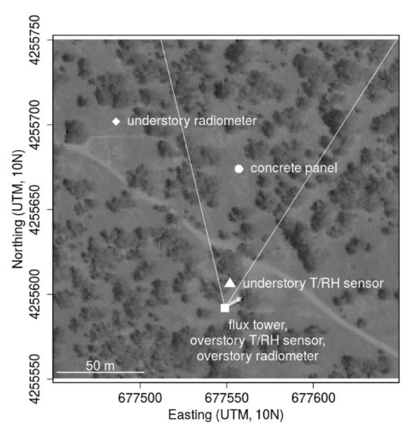
1.Temperature

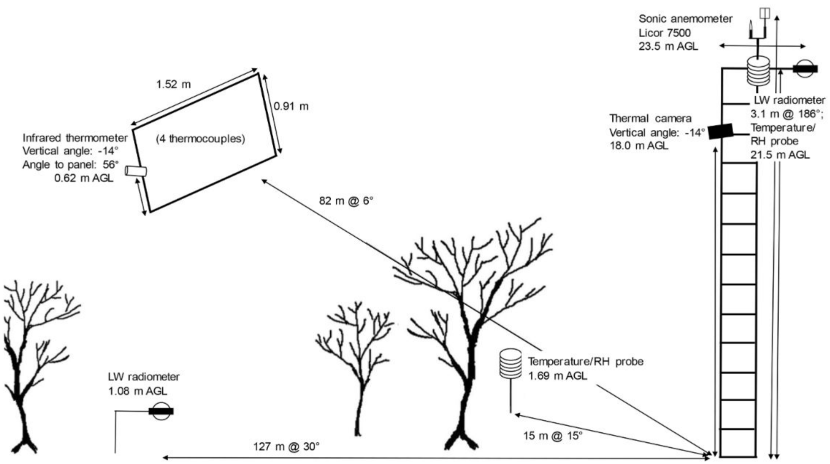
Johnston et al., 2021 and 2022

Analyze canopy temperatures (fundamental controls on plant-level processes) of overstory vegetation, understory vegetation, and soil across space and time.

Challenges:

1. Emissivity (effectiveness in the energy emission as thermal radiation) and background radiation data required for image **calibration** are variable across the scene.
2. **Mixed pixels** are misleading as component temperatures diverge.
3. Targets of interest have very different pixel sizes associated with their different **distances** from the camera.

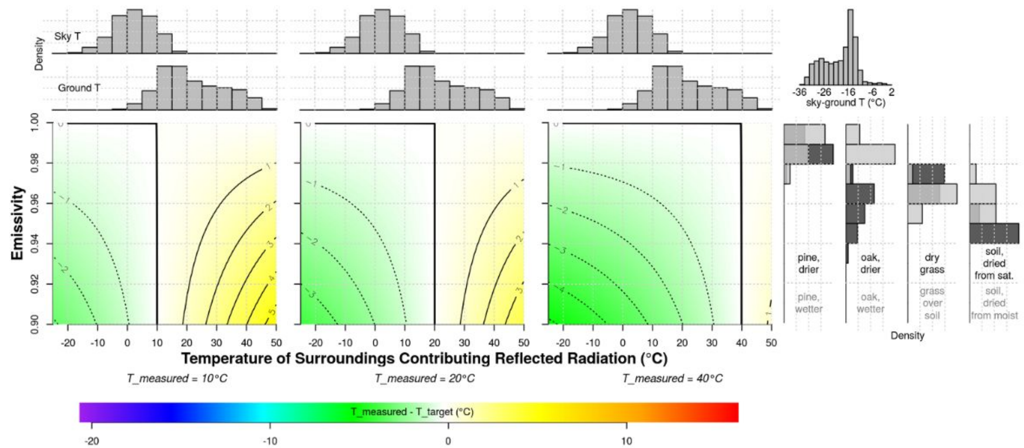


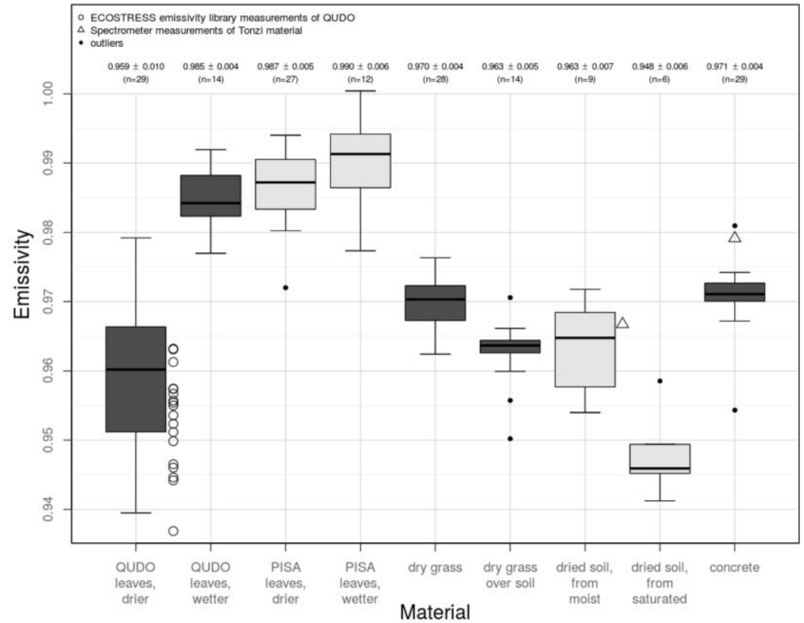


1.Temperature

Johnston et al., 2021 and 2022

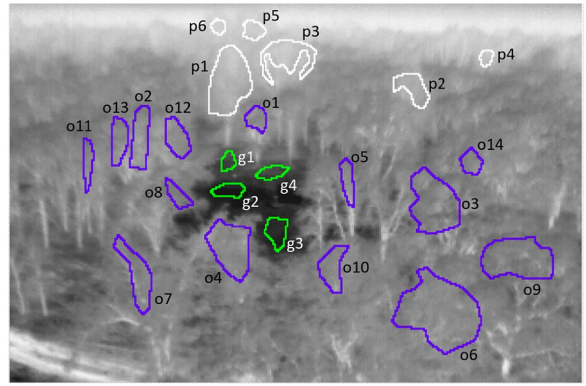
Our ecosystem's relatively high emissivity values facilitate the calibration procedure. In contrast, **mixed pixels** (with the potential of divergent component temperatures) influence the calibrated target temperatures more.

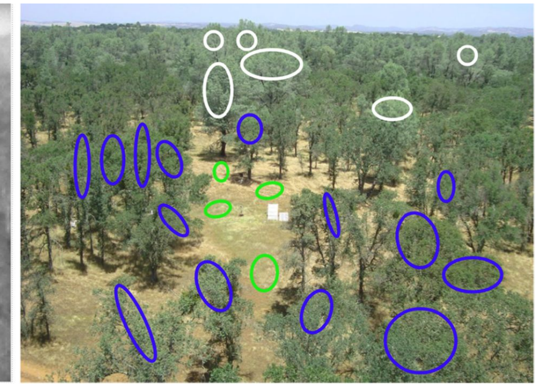


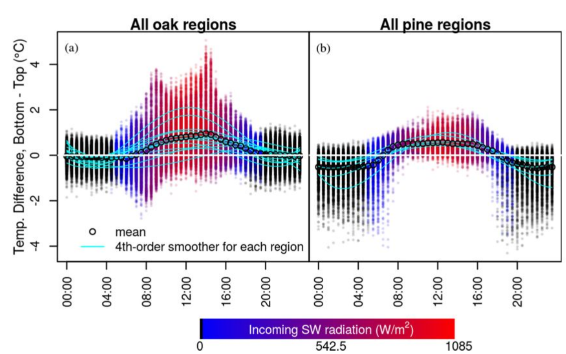


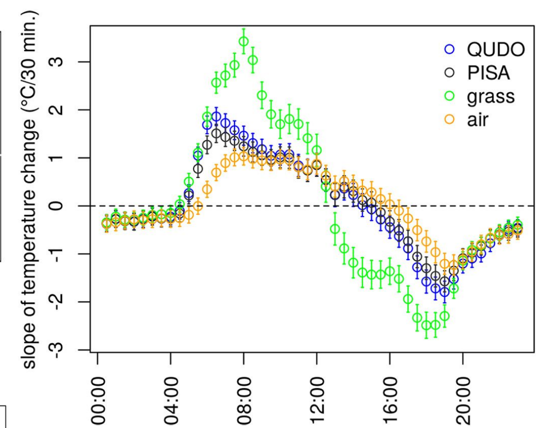
Highlights

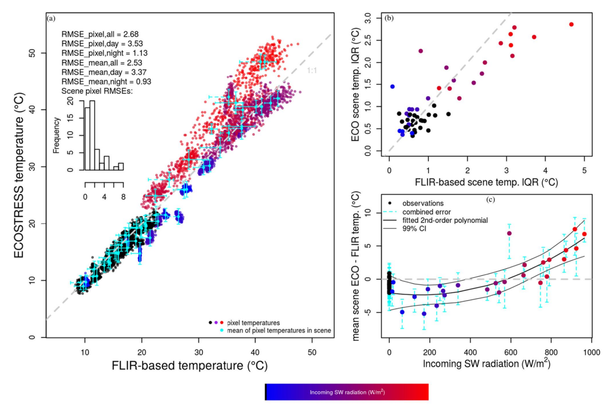
- Field-based thermal remote sensing can resolve vertical tree crown temperatures.
- **In a woodland savanna, canopy tops are cooler than canopy bottoms at midday.**
- Satellite (ECOSTRESS) and field-based (thermal camera) measurements agree at night.
- During the day, ECOSTRESS and camera temperatures diverge considerably.
- ECOSTRESS/camera mismatch is more related to light than to crown thermal gradients.





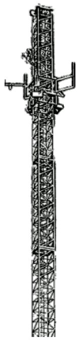






1. Spectral Response

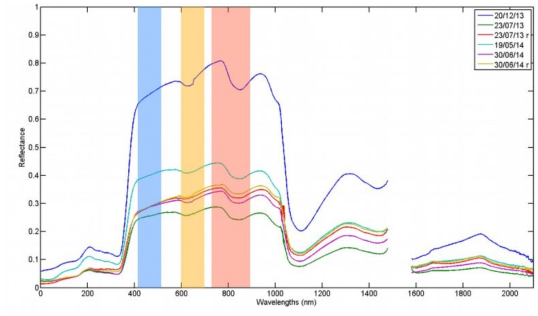
Carpintero 2020a,b, Andreu et al., 2018a

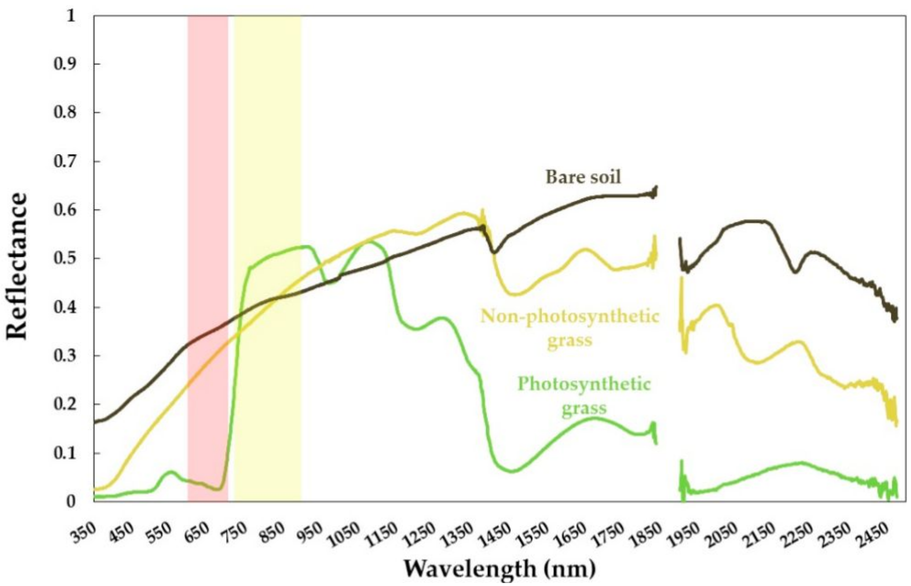


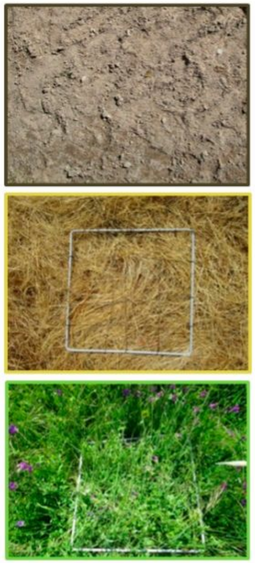
Differential spectral response of oak trees influenced the estimation ET.

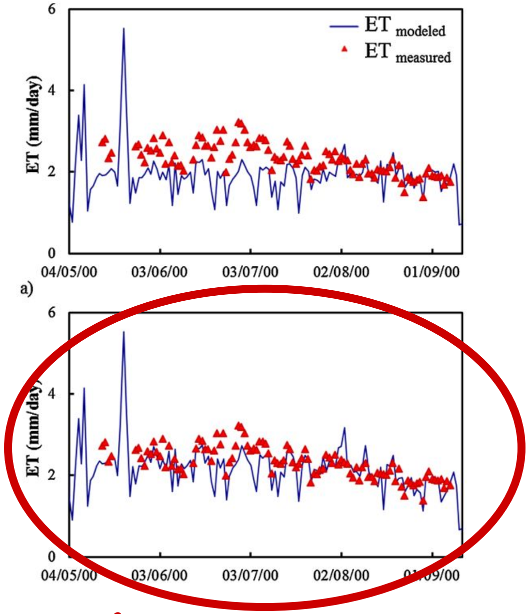
Assumption of non-variability of the spectral properties of the holm oak throughout the year for modeling.

Consider the influence of the dead grass in the ecosystem.





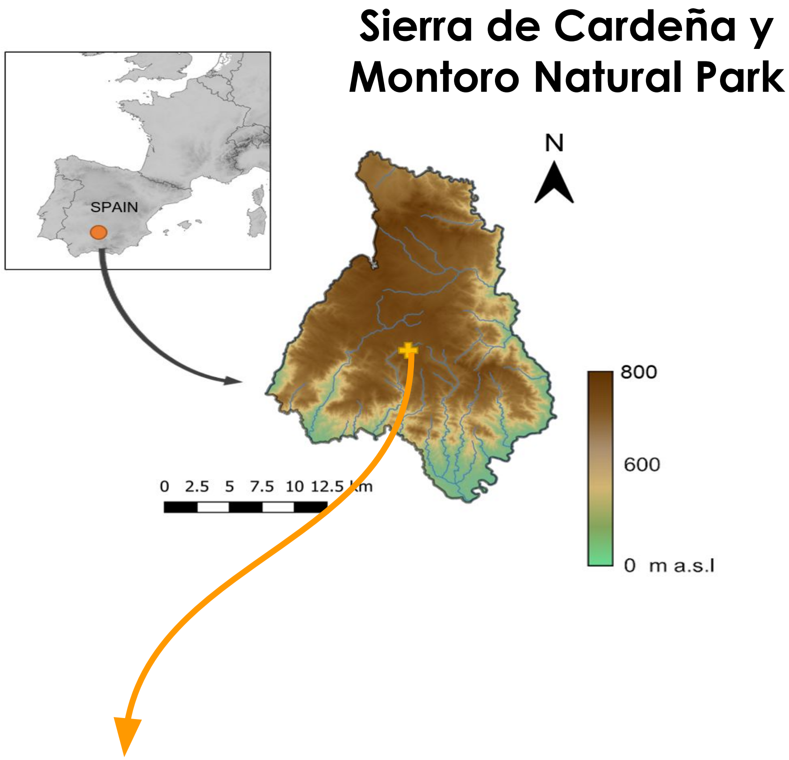




When including Spectral characteristics

1. Phenology

Pimentel et al., 2021 and 2022



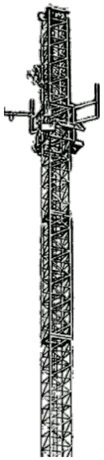
Santa Clotilde experimental site:
- Terrestrial cameras
- Meteorological station

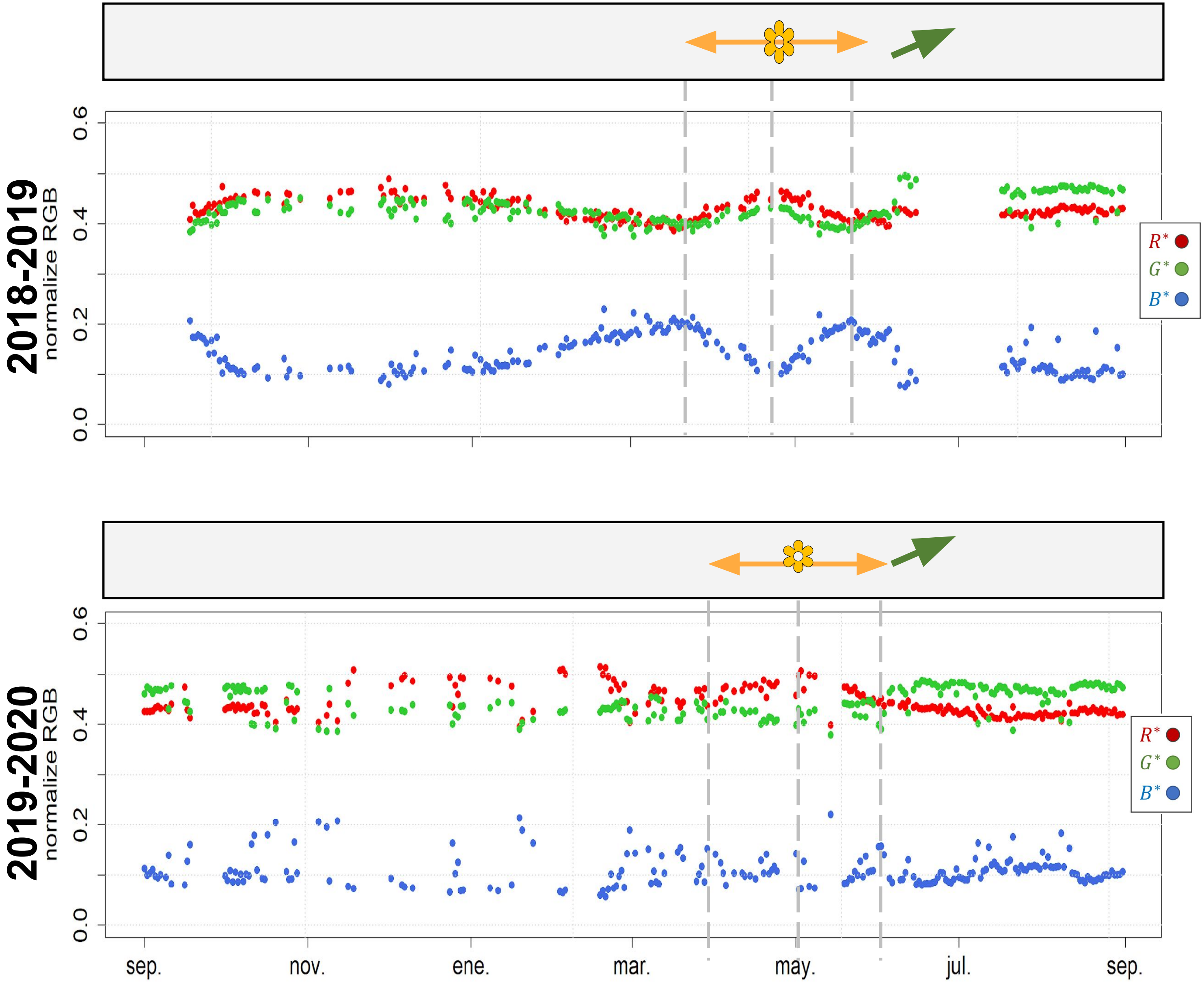
DETAIL SCALE

PLOT SCALE

1. PHENOLOGY: HOLM OAK

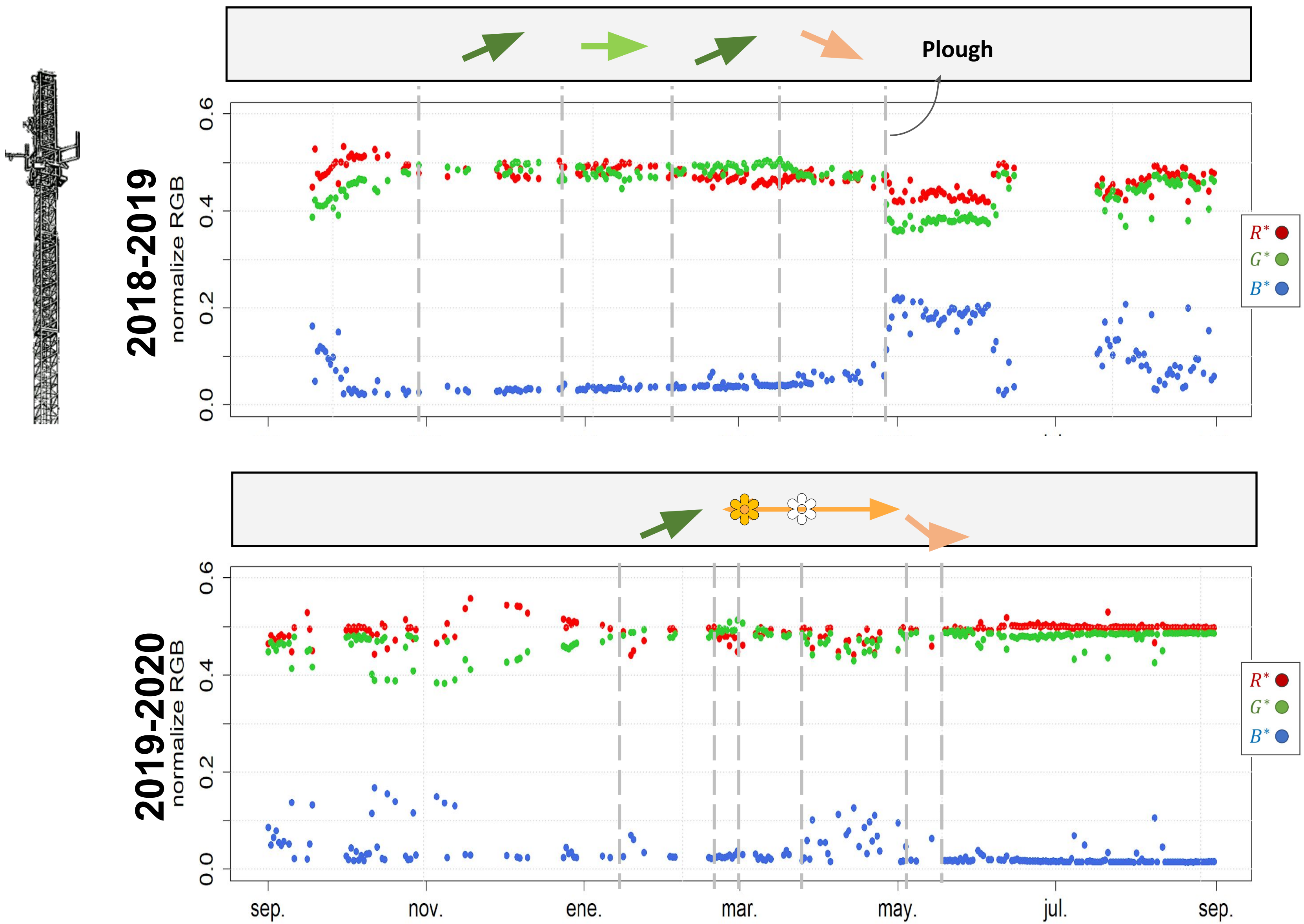
Pimentel et al., 2021 and 2022





1. Phenology: Pasture

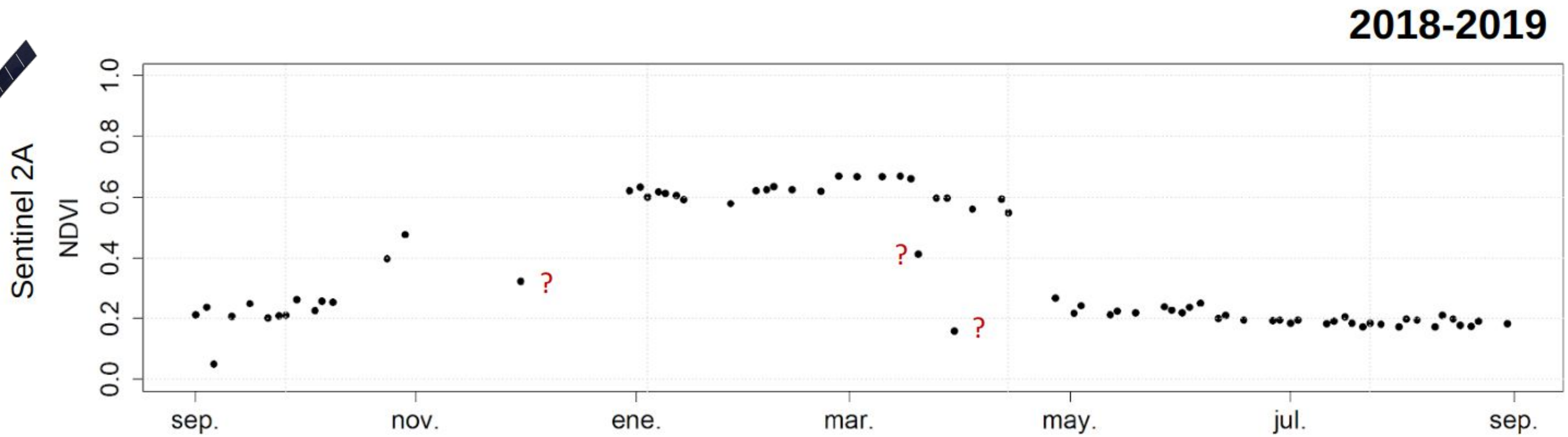
Pimentel et al., 2021 and 2022

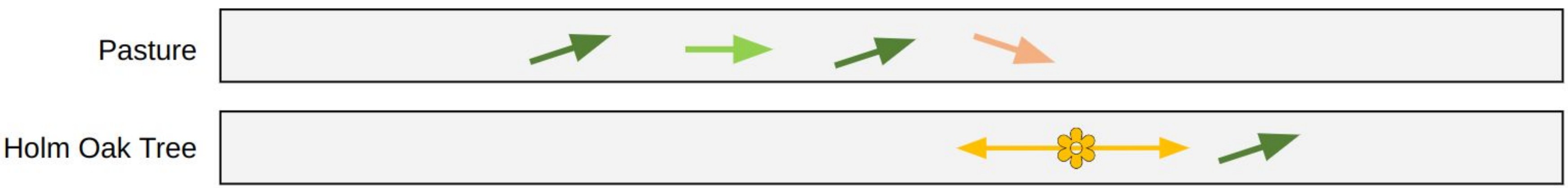



35.5°C
EXPLORING
ECOSYSTEMS´
HEALTH
FROM SPACE

1. Phenology: oak & Pasture

Pimentel et al., 2021 and 2022





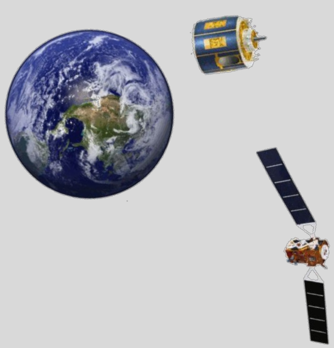
- In general NDVI dynamics are linked to the pasture evolution
- However, autumn’ NDVI increase (nov) not directly linked to any change in the pasture but rather a modification in holm tree greeness due to precipitation during this month.
- Holm oak flowering seems not impact NDVI

2. Water & Biomass

WATER

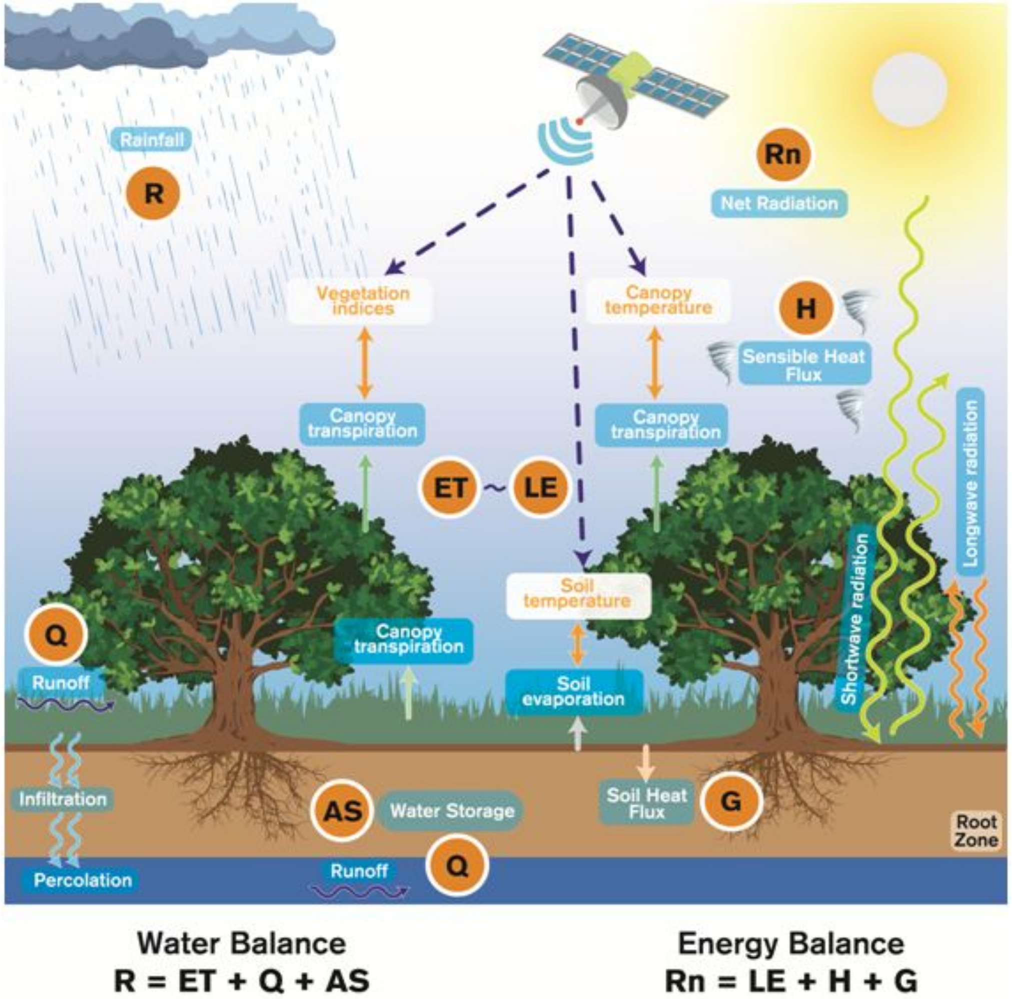
BIOMASS

Base	Surface EB	Soil WB	Light use efficiency
Model	Two-Source EB (TSEB)[23]	WiMMed[26]	LUE model[27]
ED data	Surface thermal data (TIR)	Spectral reflectance (VIS/NIR)	Spectral reflectance (VIS/NIR)
Other	Meteorological data, vegetation characteristics (VIS/NIR)	Meteorological data, soil/vegetation characteristics, precipitation, etc.	Light use efficiency
Why?	-Best accounts for partial canopy cover[24, 25] -Strong physical base[8]	-Distributed hydrological model for Mediterranean watersheds. -Strong physical base	-Evaluated and validated in mostly of the world[11] -Strong relation between VI & fraction of radiation absorbed by green canopies



2. WATER: COMPONENTS OF WATER AND ENERGY BUDGETS

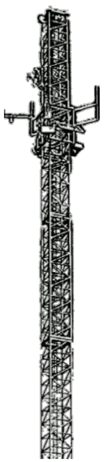
Kc-FAO56 approach



TSEB model

2. Water: energy balance

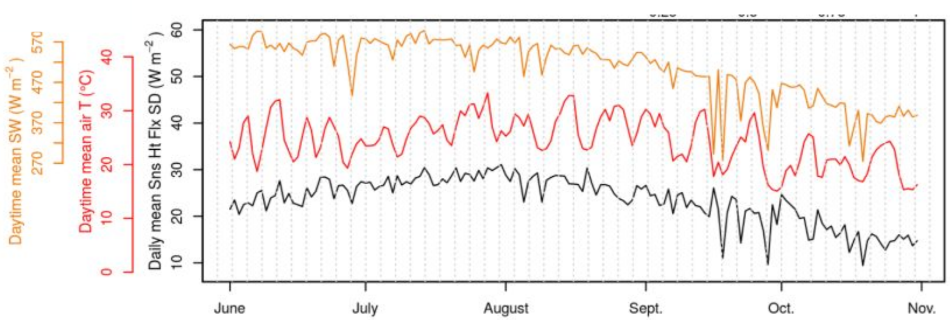
Johnston et al, 2021, Andreu et al., 2018a, Andreu et al., 2015.

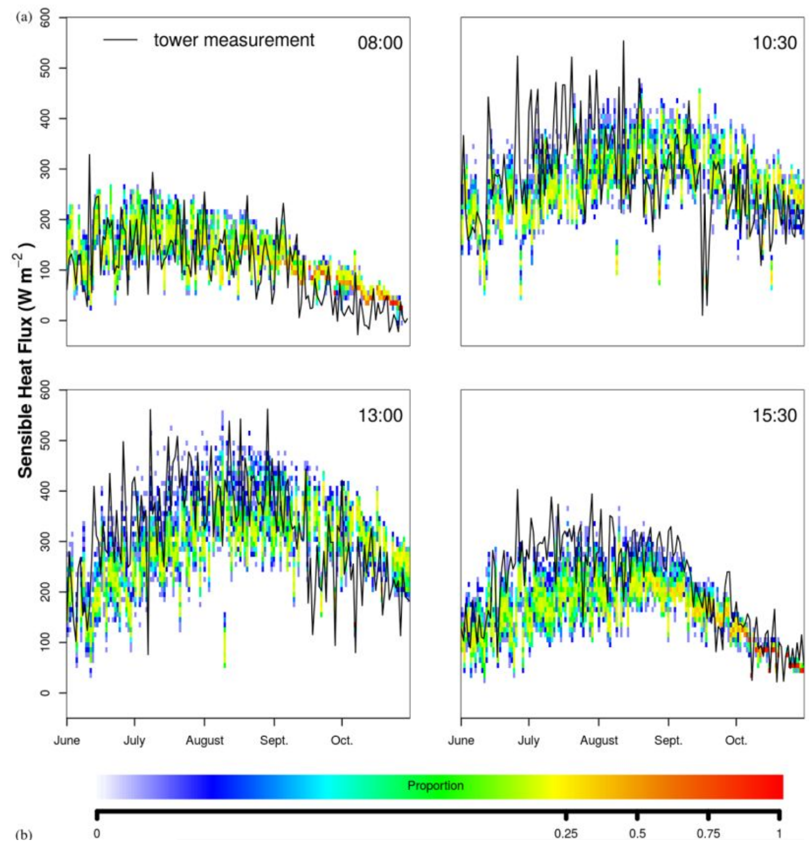


Explore thermal model mechanisms and their physical base.

How the parameterization of EB models influences estimates of transpiration and evaporation?

How thermal images can drive EB models using disaggregate temperatures → uncertainty.





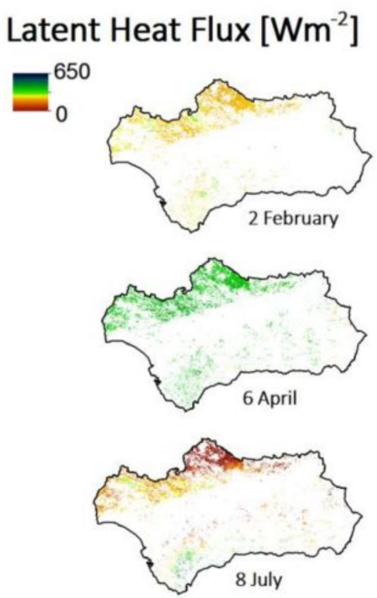
2. Water: energy balance

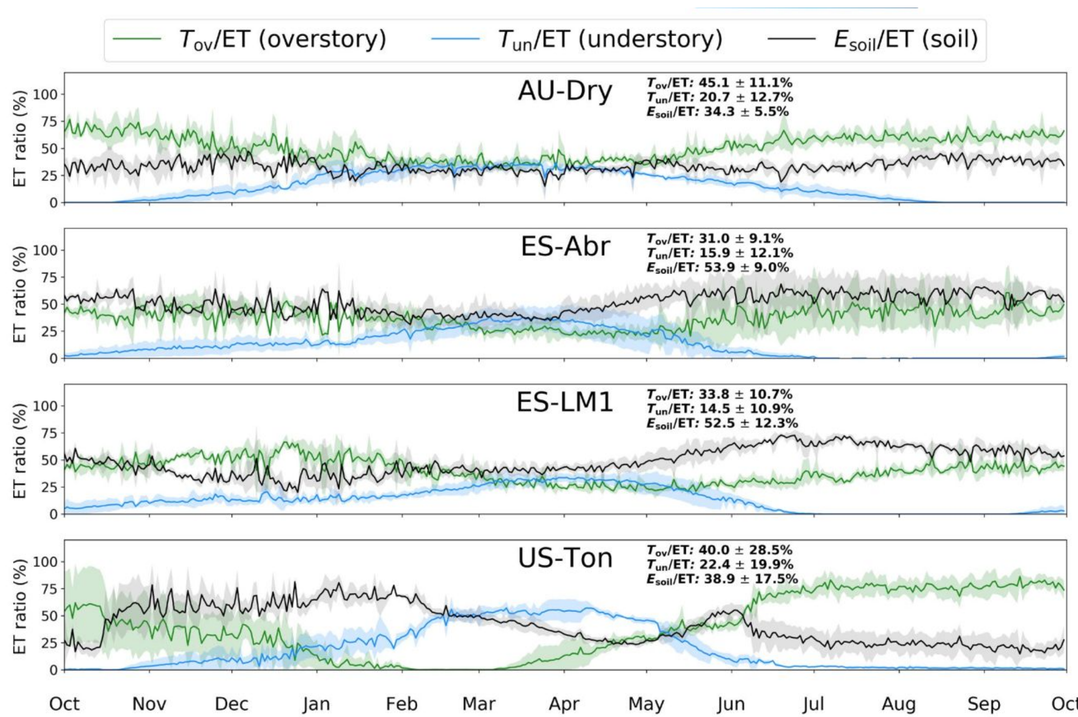
Burchard-Levine 2022, Andreu et al., 2018b.

How the architecture of the vegetation affects the model parameterization?

→ Monitoring water use in Andalusian dehesa.

→ Developing a three-source model (tree, grass, soil) applied and validated in semiarid savannas worldwide.





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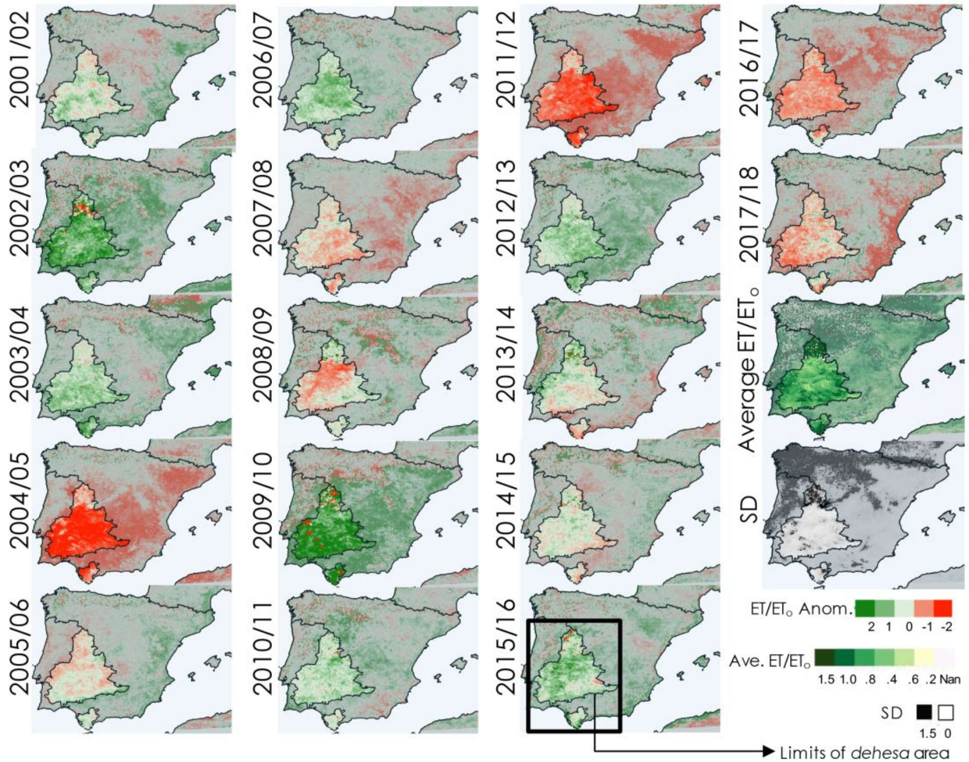
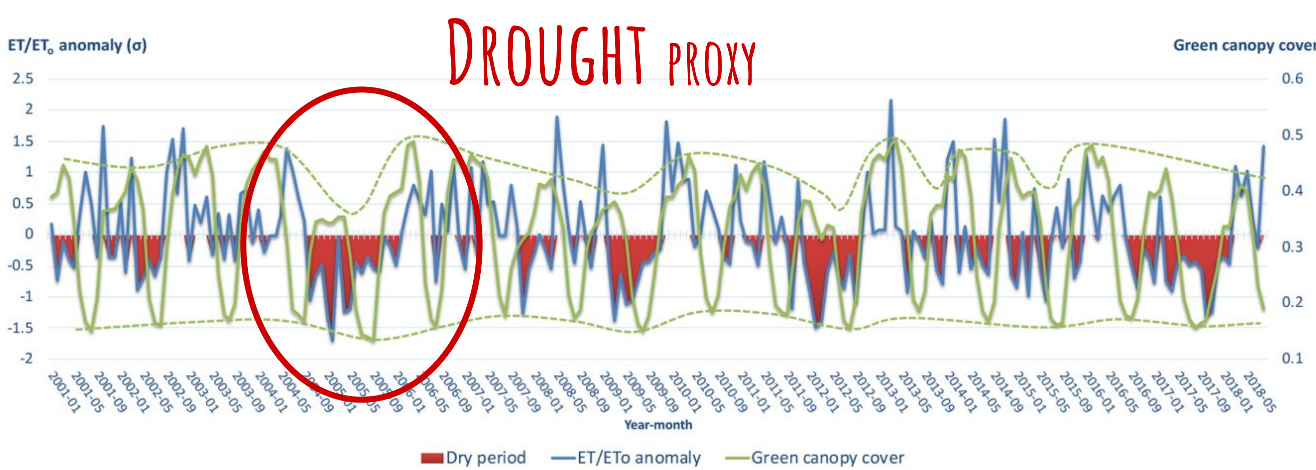
2. Water: energy balance

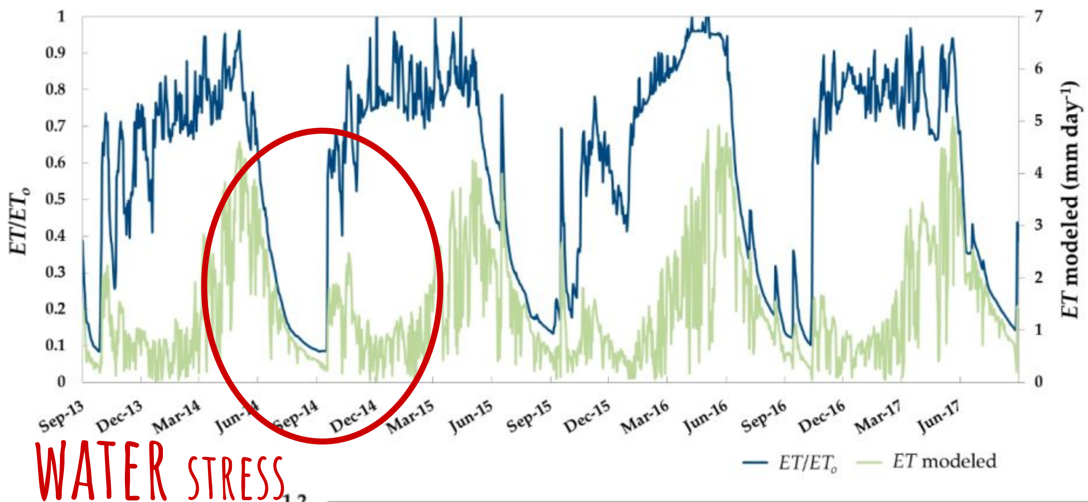
Gonzalez-Dugo et al., 2020



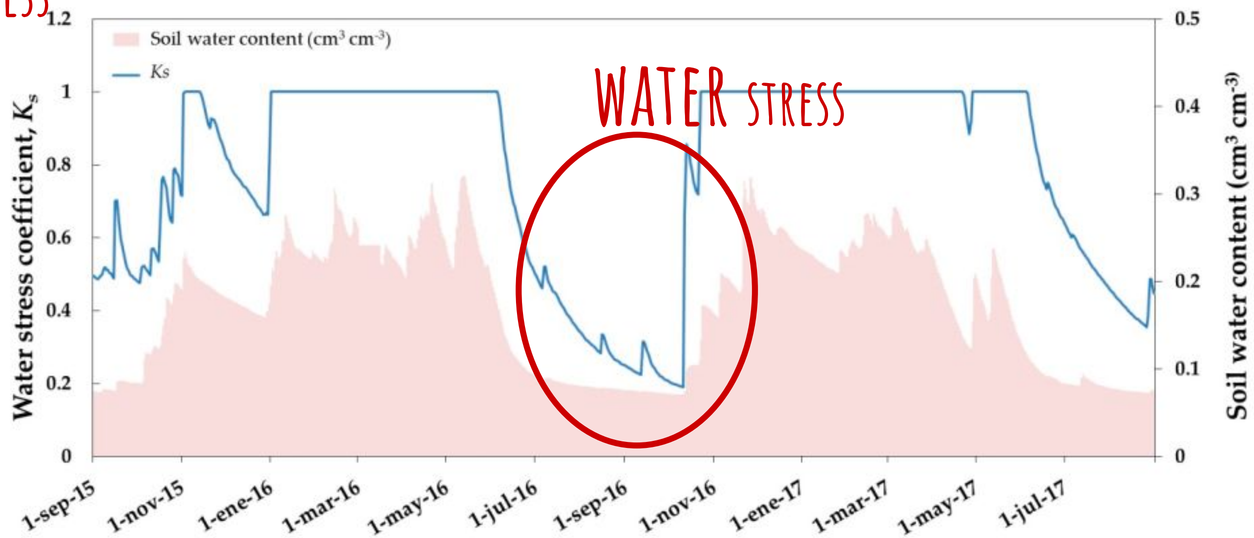


2. WATER: WATER BALANCE

Carpintero et al., 2020



The ET/ETo ratio helped to identify periods of water stress, confirmed for the grassland by measured soil water content.



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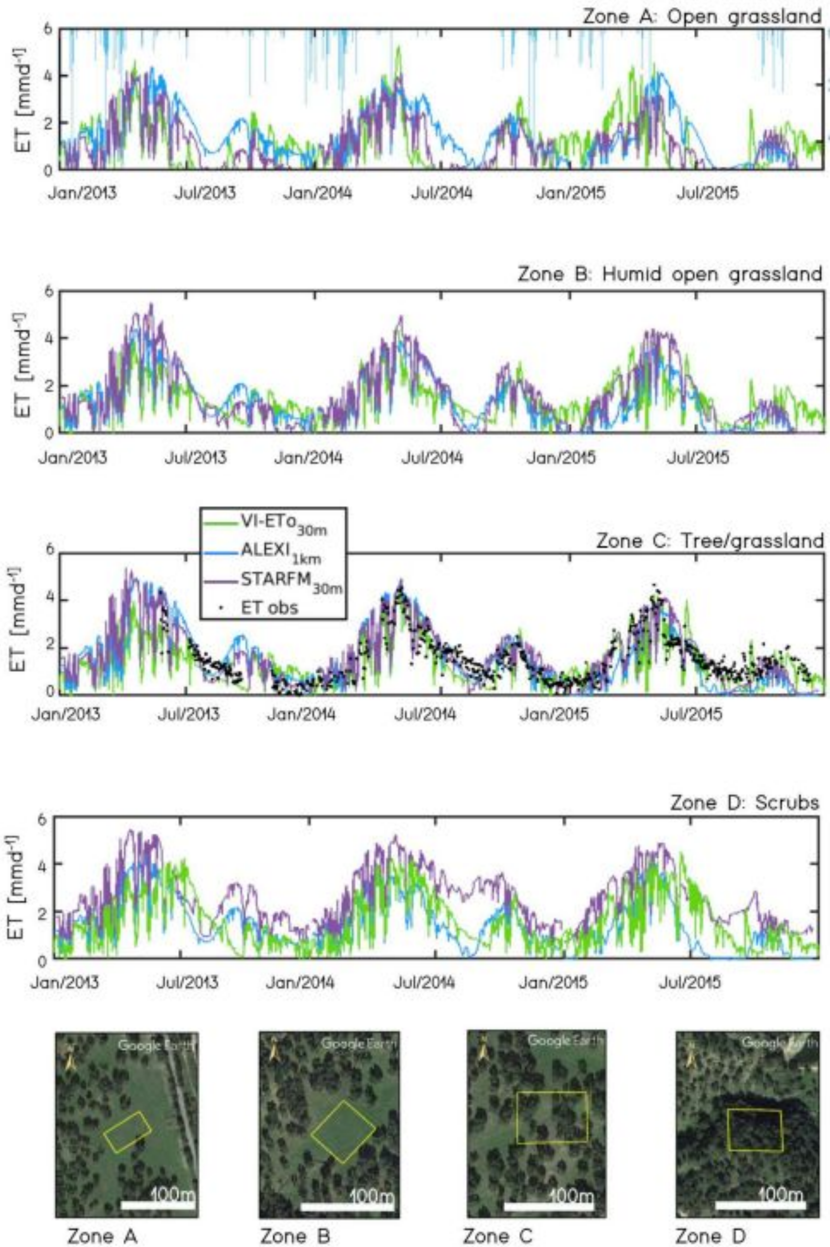
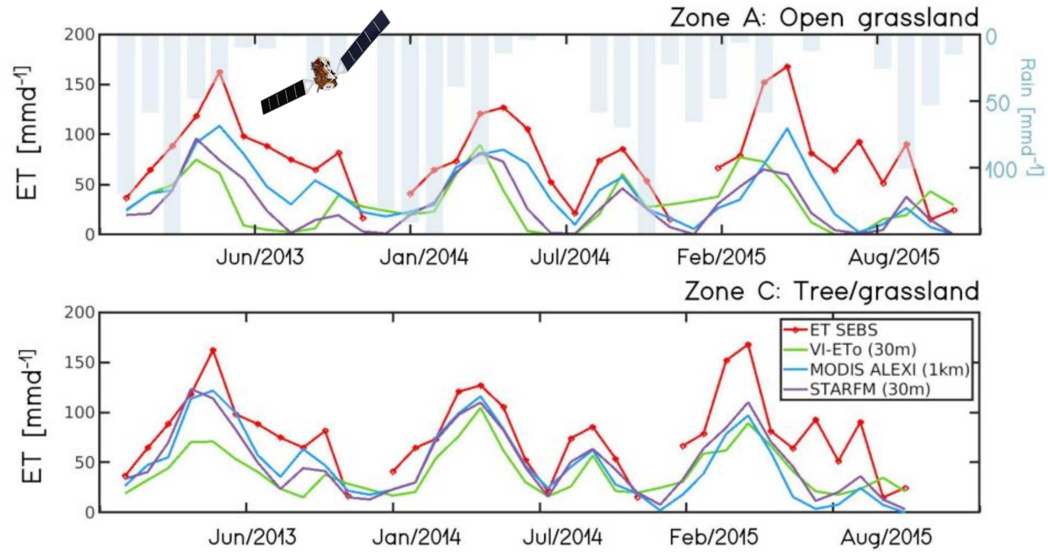
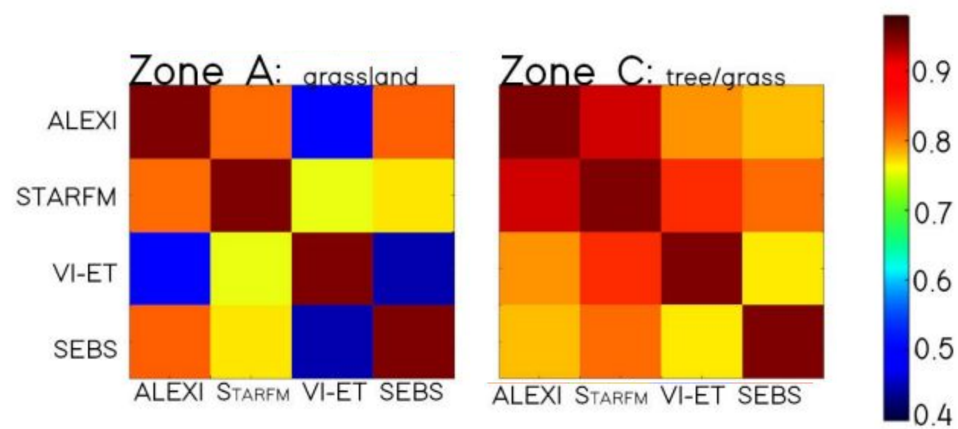
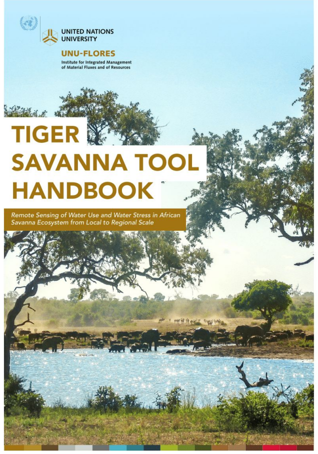
2. Water > different models and resolutions

Andreu et al., 2023 and 2022



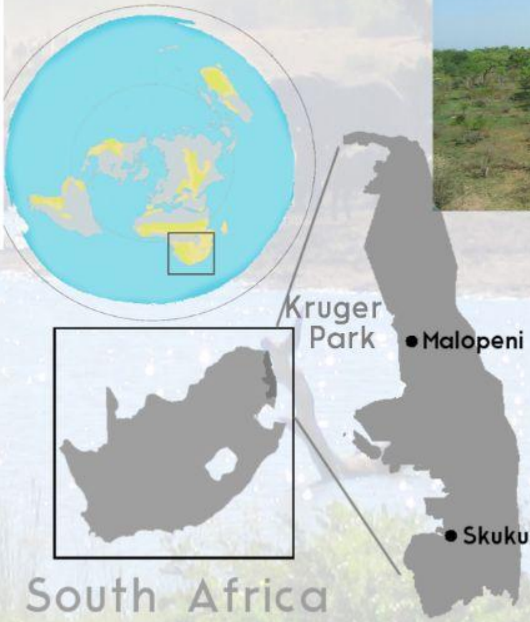






Andreu et al., 2019

MONITORING OF SOUTH AFRICAN **SAVANNA'S WATER USE & STRESS** USING EARTH OBSERVATION



TIGER PROJECT

Savannas are among Africa's most productive multifunctional landscape - supporting wildlife, livestock, crops and livelihoods - but experiencing frequent droughts, aggravated by climate change and other human-induced changes.To maintain ecosystem productivity without reaching the tipping points, while ensuring food security, we should rely on an integrated management and monitoring of resources. The aim of this project is to **map African savannas water use (evapotranspiration-ET) and water stress using Earth Observation** data, to support decision-making at different scales (from local to regional), using as a pilot experience South Africa. The modeling framework was tested during 2010 -2012 with AATSR (thermal data) & SPOT 4/5 (visible and NIR data) satellites and will be next applied with Sentinel 2 & 3 from 2015 to present.

WATER, SOIL AND WASTE DRESDEN NEXUS CONFERENCE DNC 2017 | SDGs & NEXUS APPROACH: Monitoring and Implementation

SEE THE SAVANNA ECOSYSTEM CHANGING!!!
STOP MOTION VIDEO FROM THE STUDY AREA

TIGER AFRICA

UNITED NATIONS UNIVERSITY UNU-FLORES Institute for Integrated Management of Material Fluxes and of Resources

UNIVERSITY OF LIMPOPO

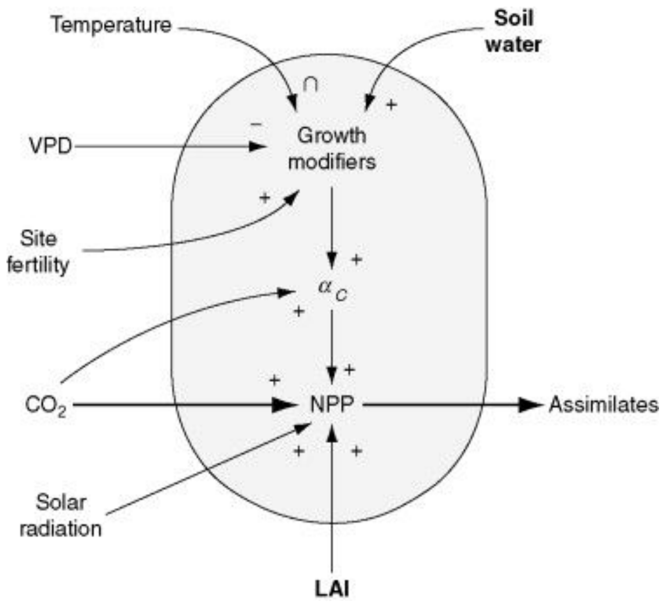
IRTA

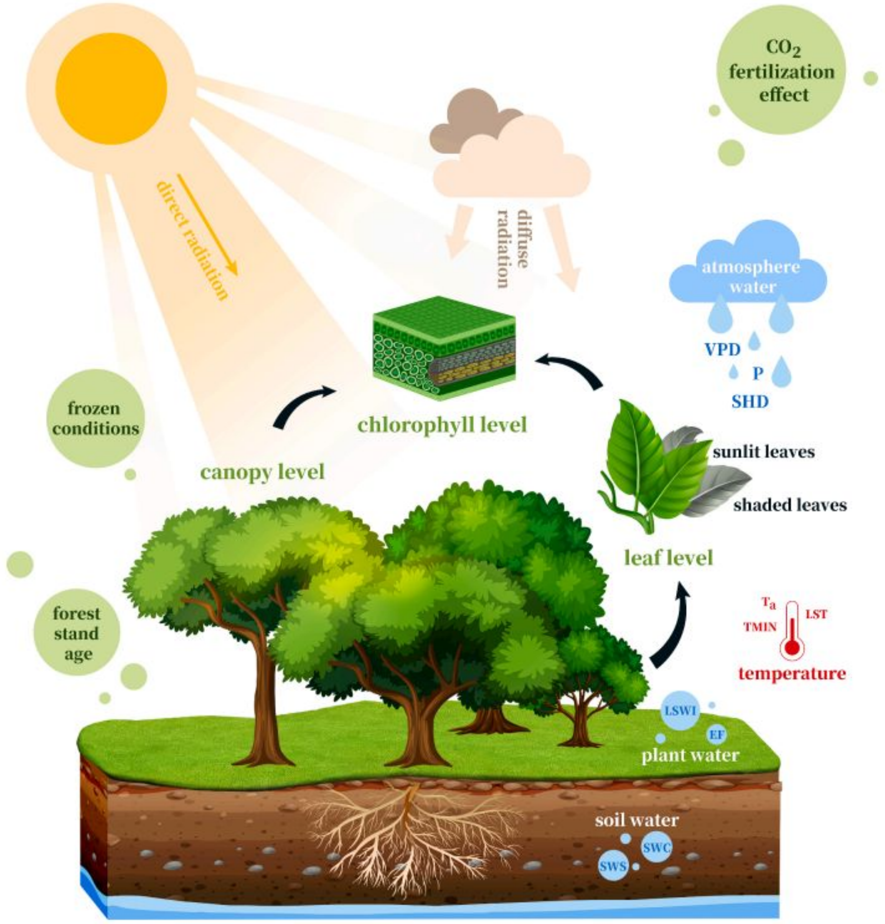
CSIR our future through science

JUNTA DE ANDALUCIA

2. Vegetation production...

$$PNN = \int FPAR \; PAR \; LUE \; dt$$





J. Landsberg and P. Sands, 2011.
https://doi.org/10.1016/B978-0-12-374460-9.00009-3

Y. Pei et al. 2022.
https://doi.org/10.1016/j.agrformet.2022.108905

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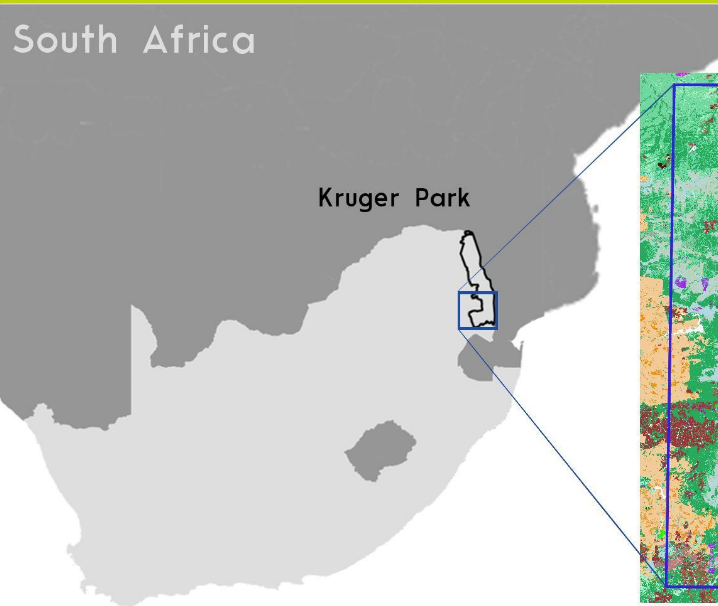
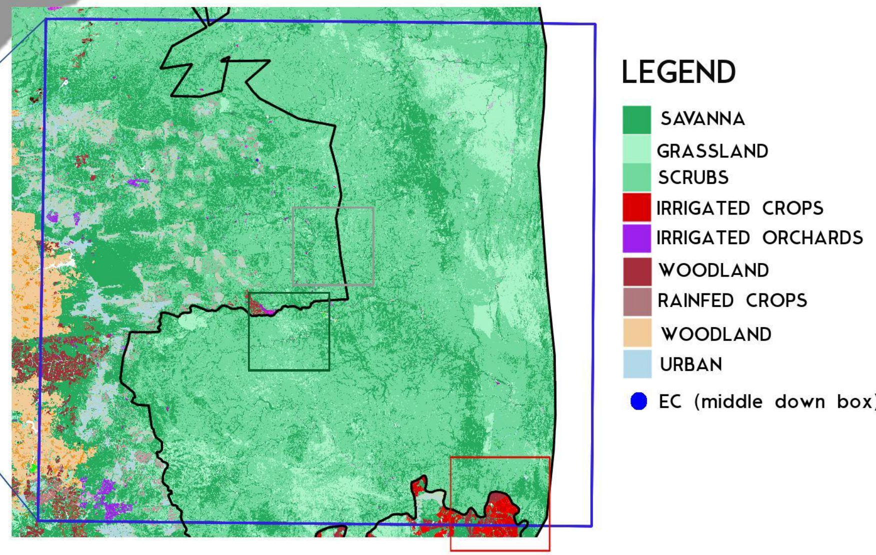
esa

TACTIC: DroughT impACt on the vegeTation of South African semIarid mosaiC landscapes. Implications on grass-crop-lands primary production.

2. VEGETATION PRODUCTION... IN THE FACE OF DROUGHT



Land Use map for the Sentinel 2 36JUT Tile



HUNTING RESERVE AREA - RGB S2

SKUKUZA AREA - RGB S2

CROP AREA - RGB S2

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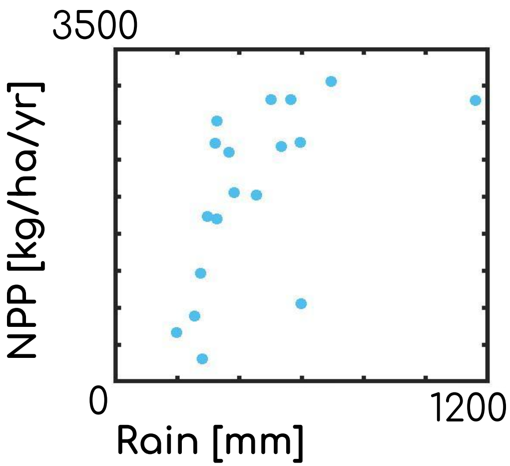
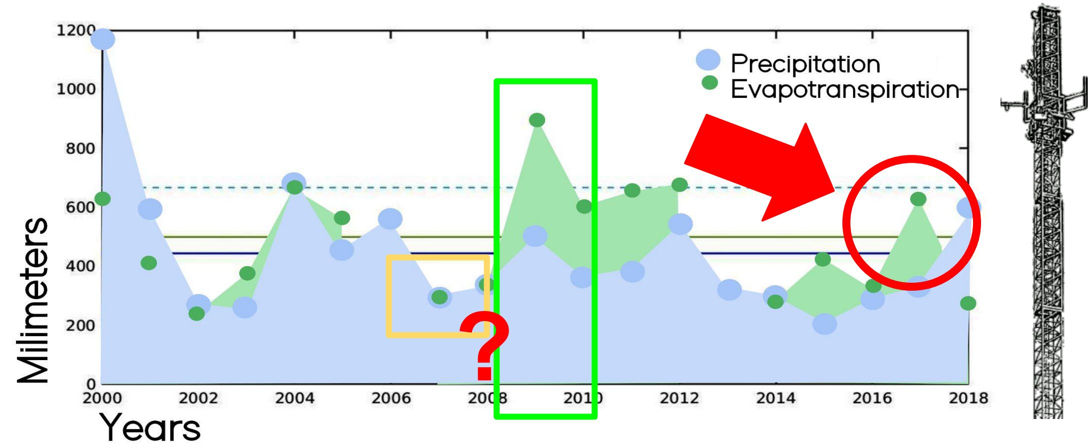
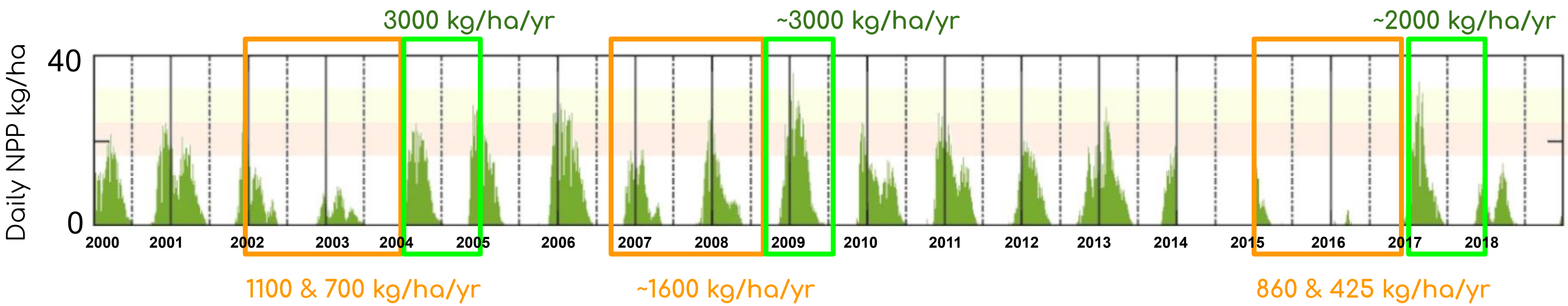
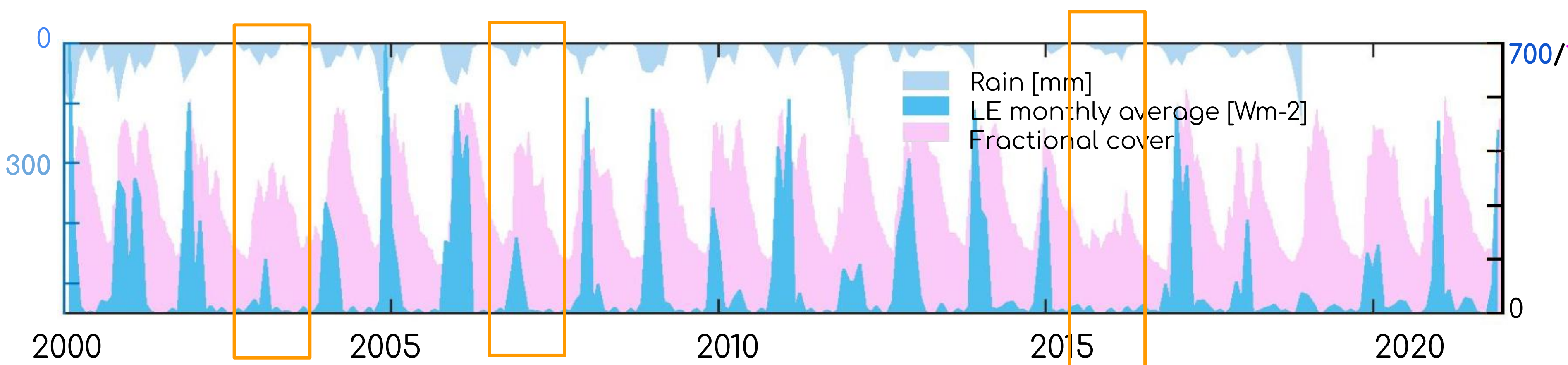
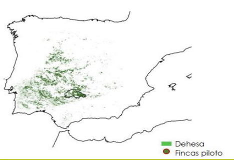
Skukuza savanna



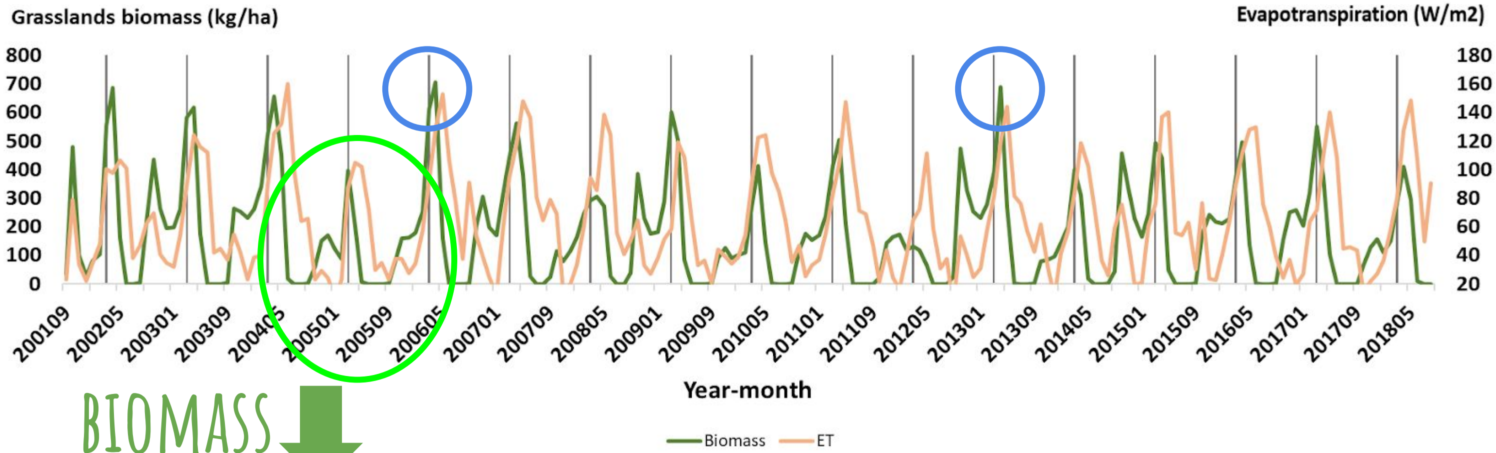






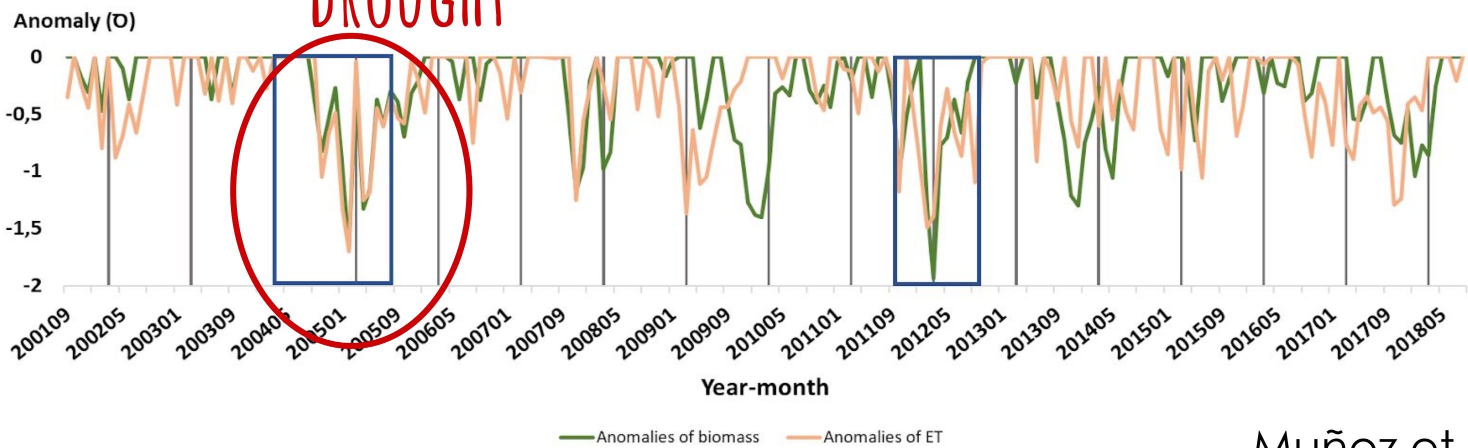


2. VEGETATION PRODUCTION... IN THE FACE OF DROUGHT



BIOMASS

DROUGHT



Muñoz et al., 2022

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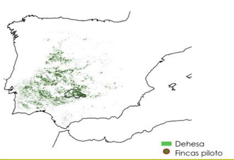
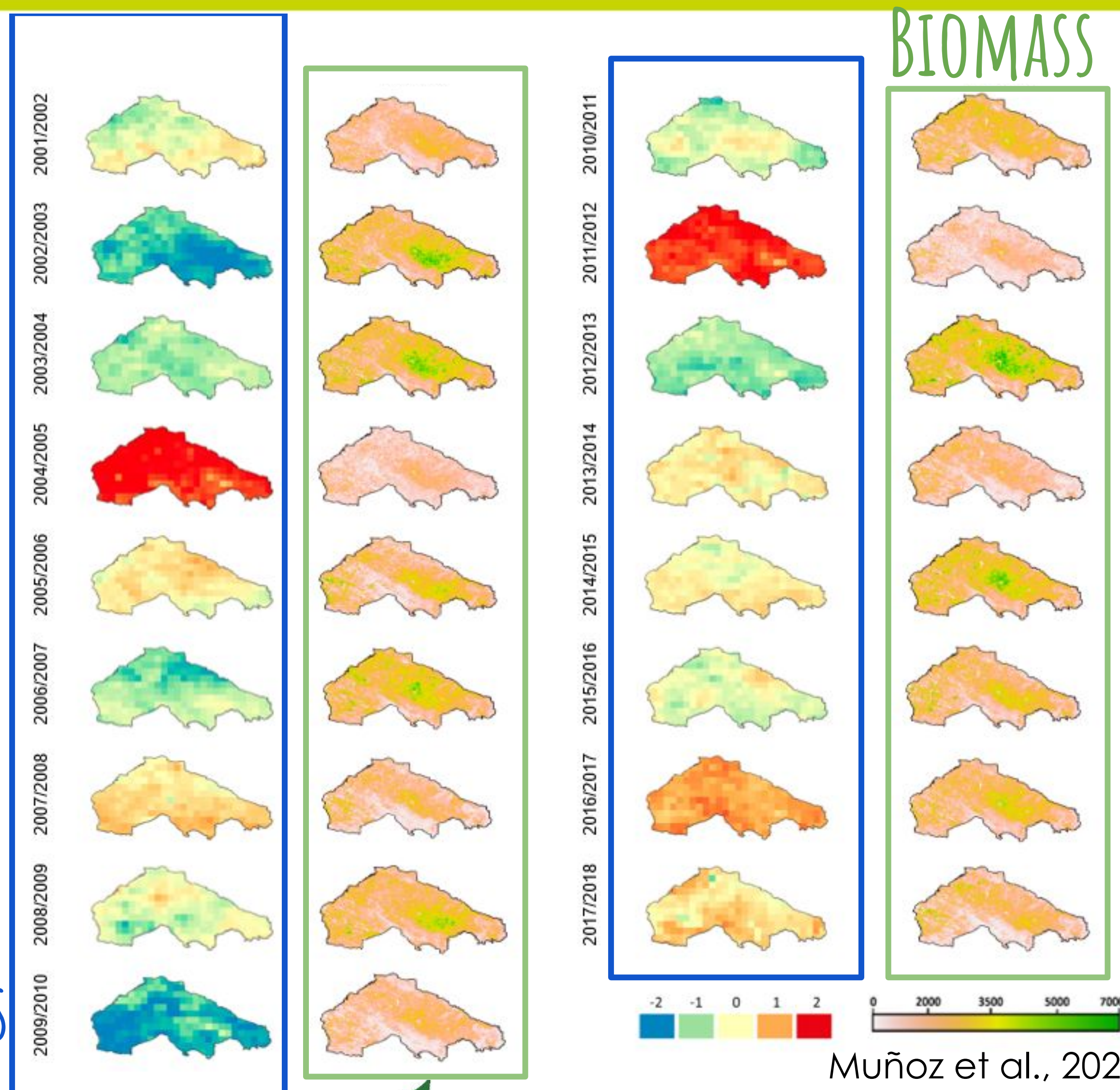


2. VEGETATION PRODUCTION…IN THE FACE OF DROUGHT

The Unseen Attack of Drought

by Alwyn Biju

ET ANOMALIES



Muñoz et al., 2022

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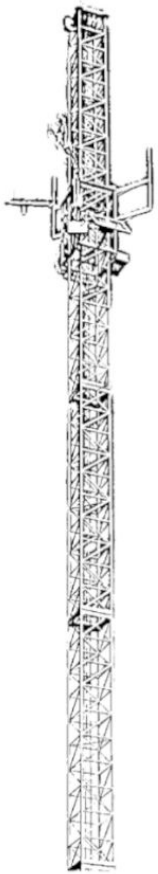
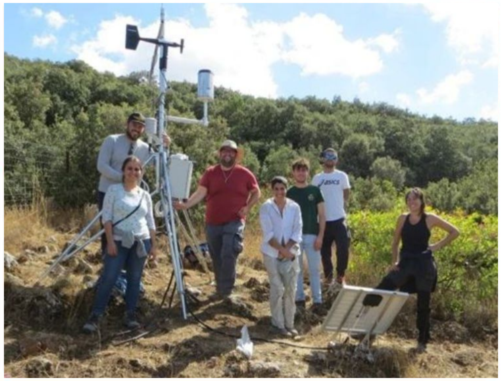
Thanks a lot!!





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