SUMHAL Sustainability for Mediterranean Hotspots in Andalusia integrating LifeWatch ERIC

Estimation of evapotranspiration and CO_2 fluxes through remote sensing in a Juniper tree ecosystem at the Doñana National Park

Estación Biológica Doñana CSIC

Pedro J. Gómez-Giráldez, Jordi Cristóbal, Héctor Neto, William P. Kustas, Martha C. Anderson, Ricardo Díaz-Delgado

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LifeWatch ERIC

IRTA Institut de Recerca i Tecnologia Agroalimentàries

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

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LifeWatch ERIC is a Consortium of European Research Infrastructures established by the Decision of the European Commission (EU) 2017/499 of March 17, 2017. Its main functions are to provide, investigate and organize e-science services aimed at increasing and deepening in the knowledge of Biodiversity and the functioning of Ecosystems, in order to disseminate this knowledge and understand and manage the challenges of today's world in these aspects..

The SUMHAL Project, Sustainability for Mediterranean Hospost integrating LifeWatch ERIC, is part of the FEDER program of actions related to the pan-European distributed infrastructure of e-Science LifeWatch ERIC, with Headquarters in Andalusia-Spain.

SUMHAL fundamental objective: Conservation of biodiversity in natural or semi-natural systems of the western Mediterranean, based on high-tech infrastructures, and the association between highly specialized research personnel and the public.

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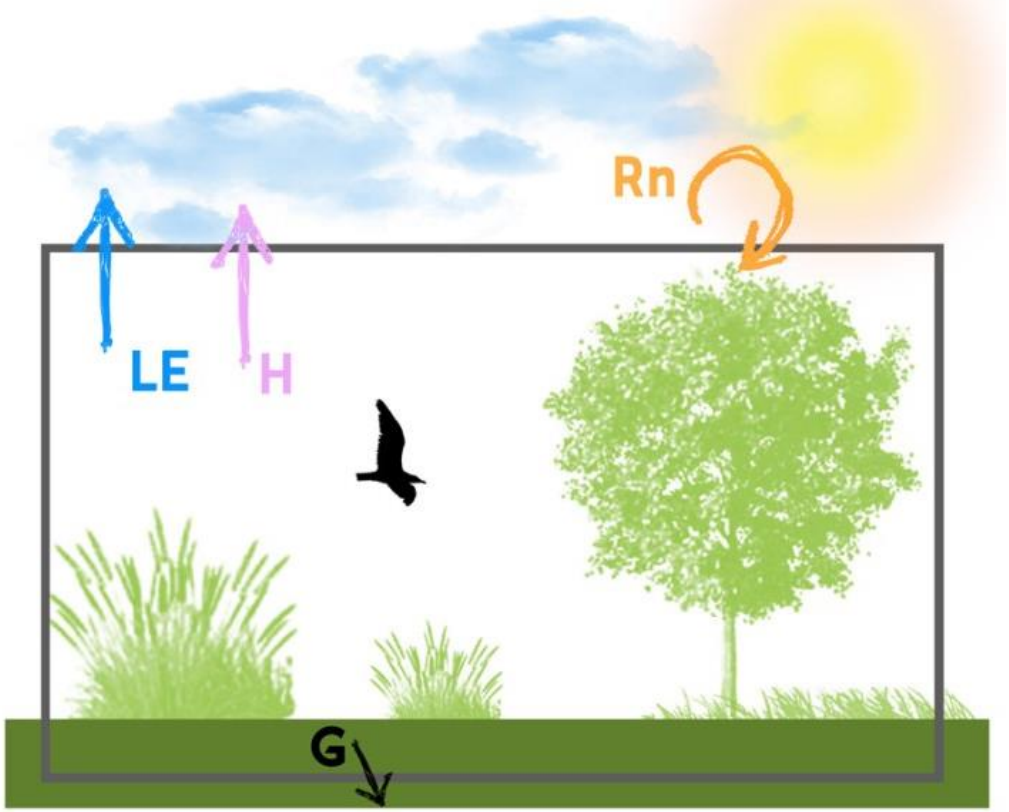
Introduction

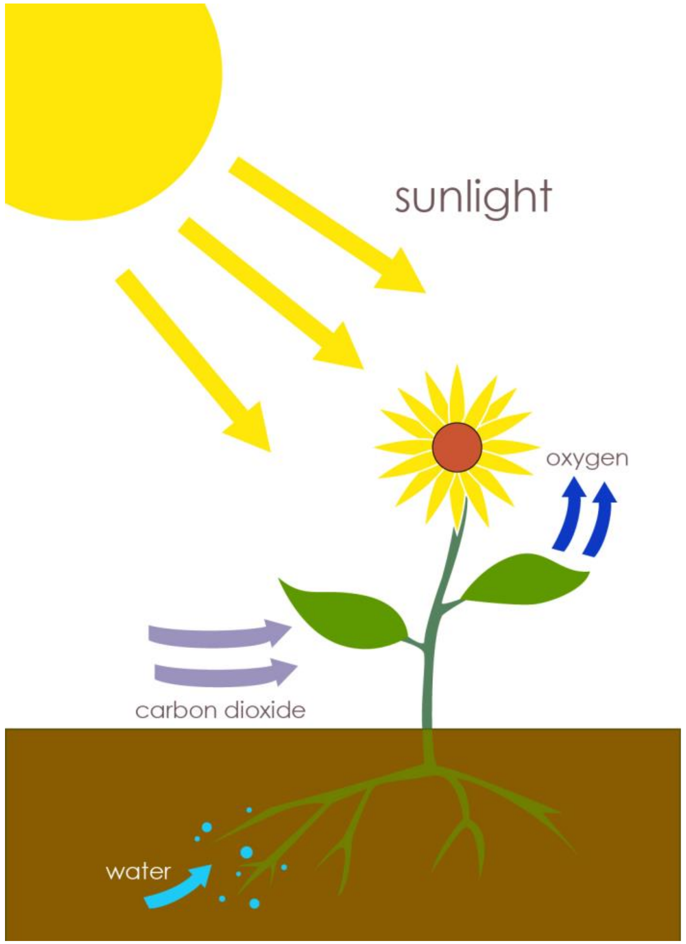
- National Park of Doñana
- The uniqueness lies in the great diversity of ecosystems and species
- Beaches and dunes, marshes, preserves (*Monte Blanco* and *Monte Negro*)

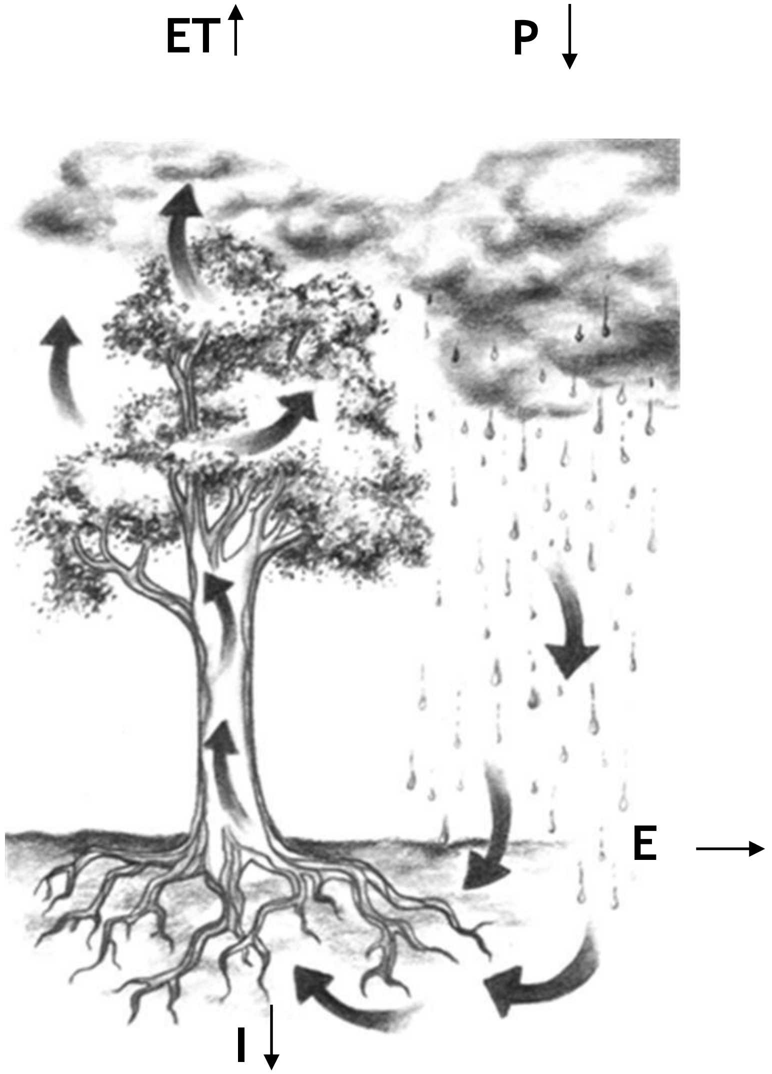
Introduction

WP6.2 SUMHAL:

➡ Carbon, water and energy fluxes





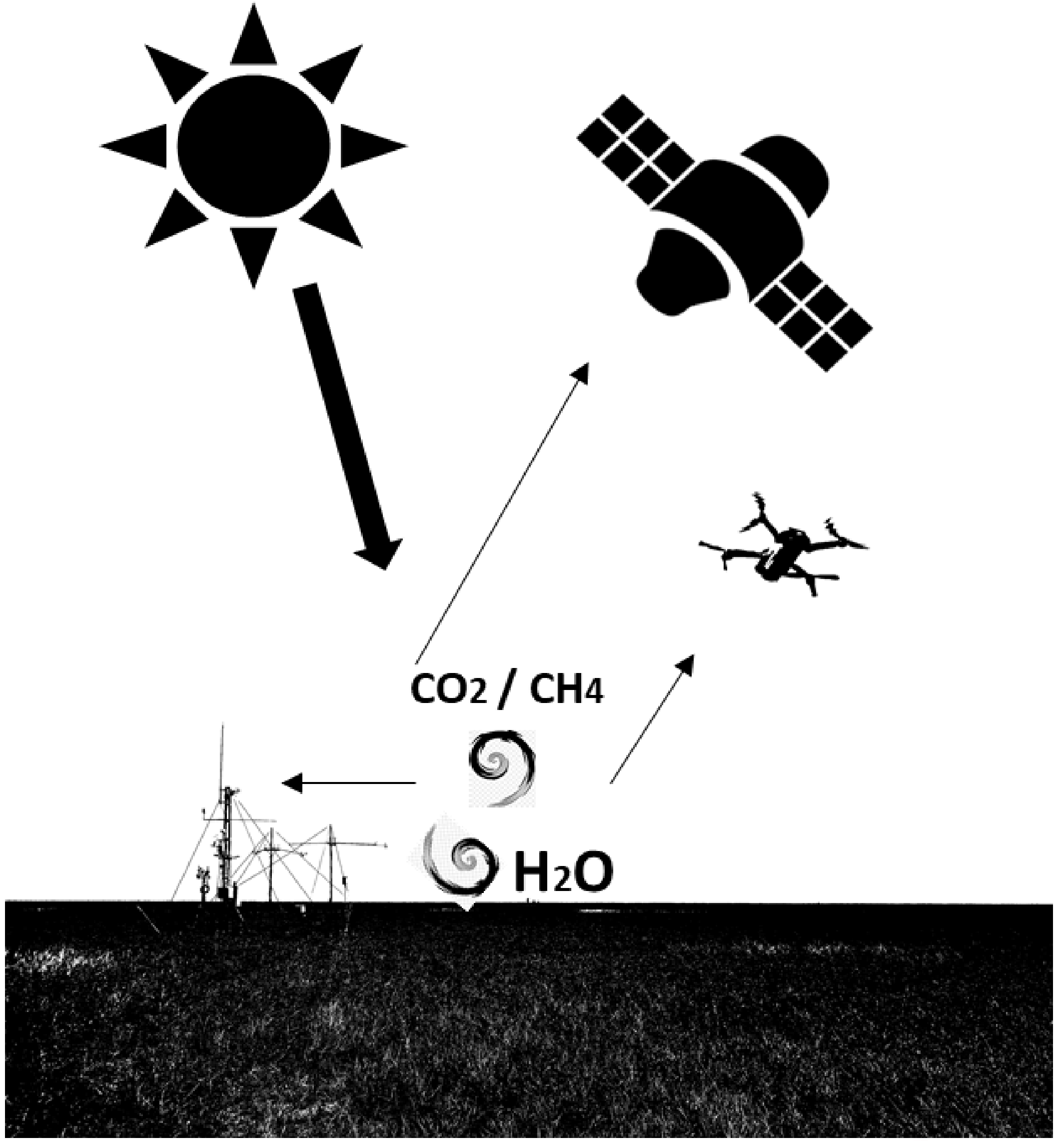


*Ana Andreu

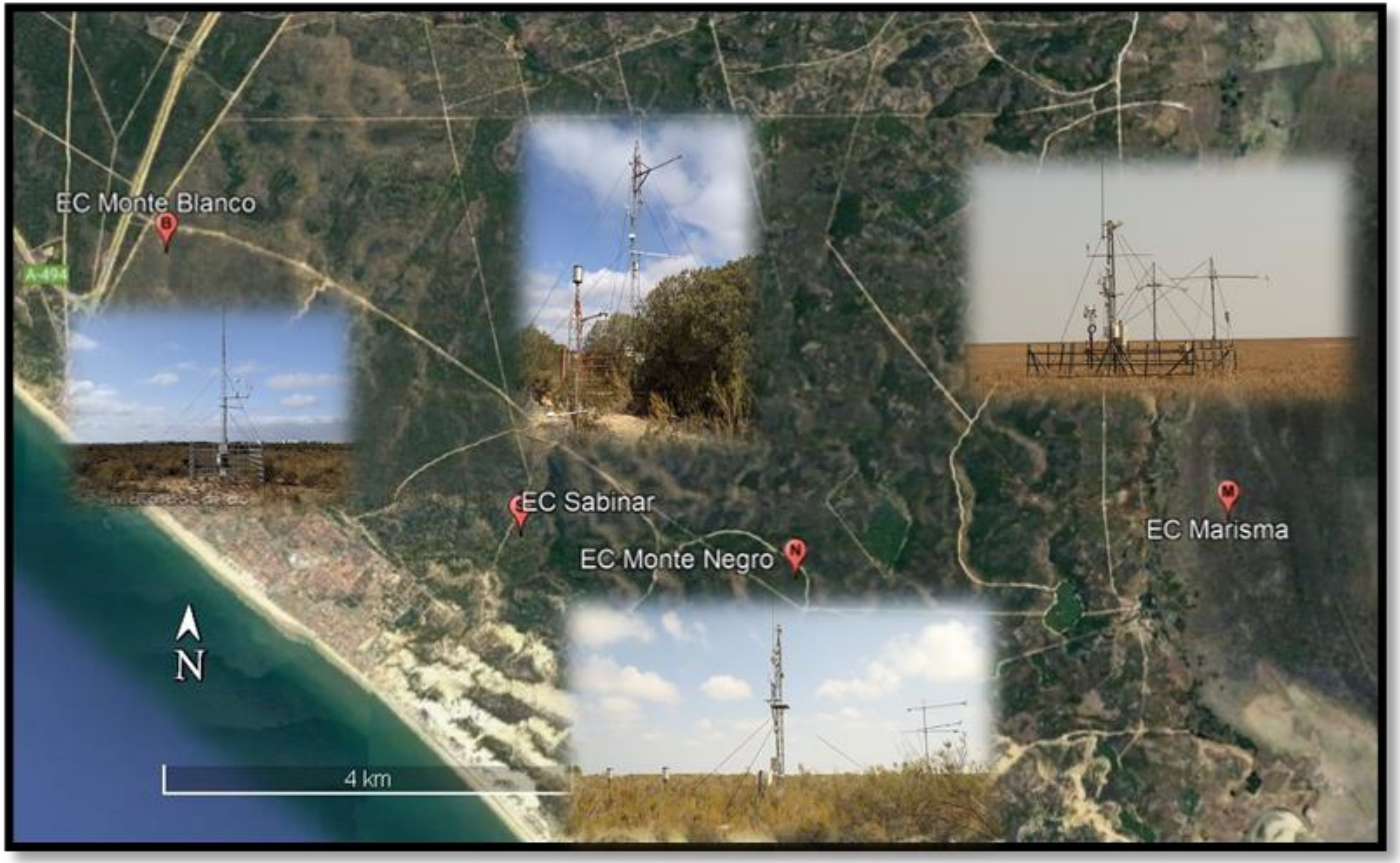
Introduction

WP6.2 SUMHAL:

- Carbon, water and energy fluxes
- At different spatial and temporal scales



Introduction



Aims

➔ First evaluation of the modeling of **water and energy fluxes** as well as **carbon assimilation** (Gross Primary Production, GPP) with flux tower data.

- Energy and water fluxes ➔ **Two Sources Energy Balance** (TSEB) model

- GPP was done through a **Light Use Efficiency** (LUE) model

using Landsat-5 TM and Terra/Aqua MODIS images from 2014 to 2015 in an experimental plot of Juniper (*Juniperus phoenicea*) in the Doñana Biological Reserve.

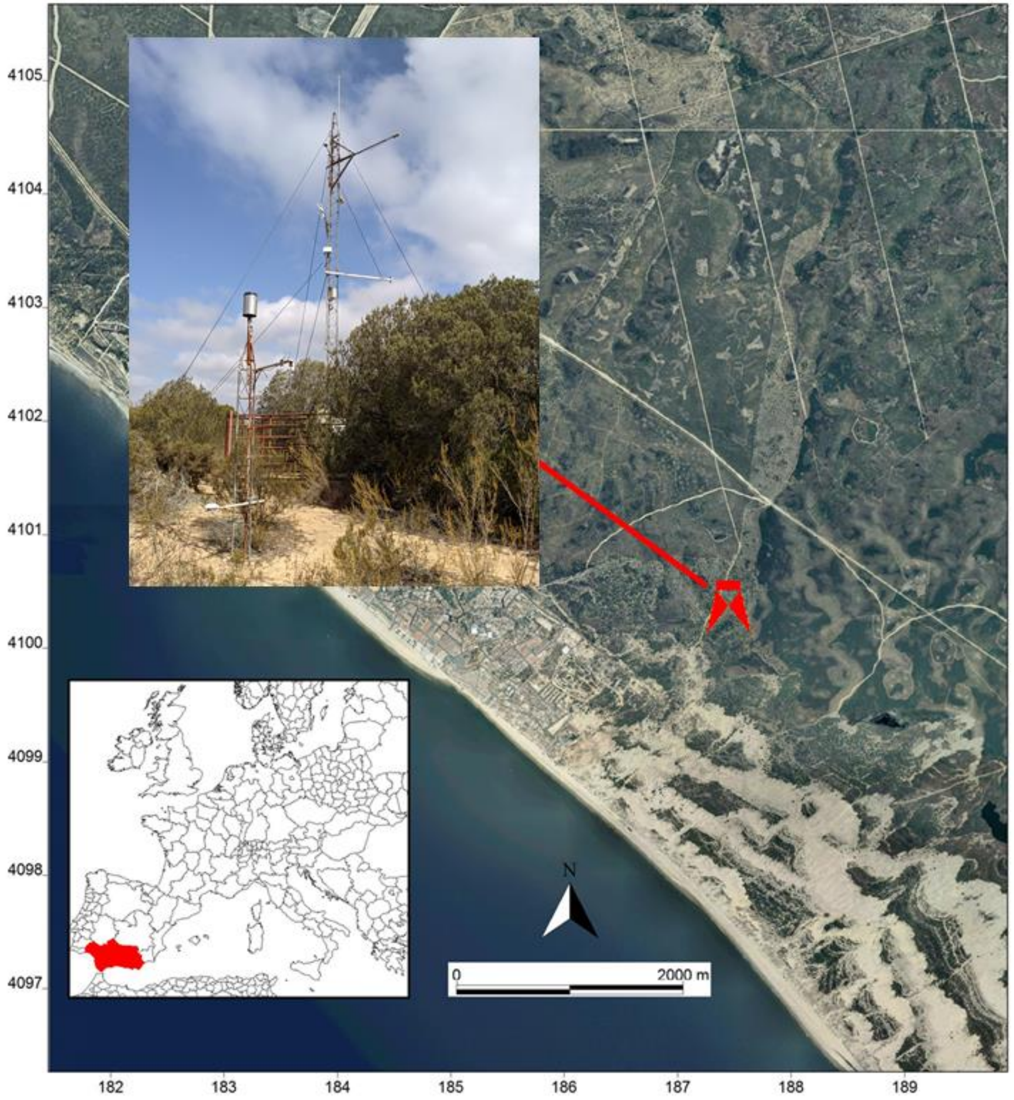
Methodology

Study area and evaluation dataset

- Juniper tree ecosystem (*Juniperus phoenicea ssp. turbinata*) with stone pine (*Pinus pinea*) and sandy soil.

- Flux tower at 7,5 m height with instrumentation to measure Surface energy balance fluxes and CO_2 fluxes.

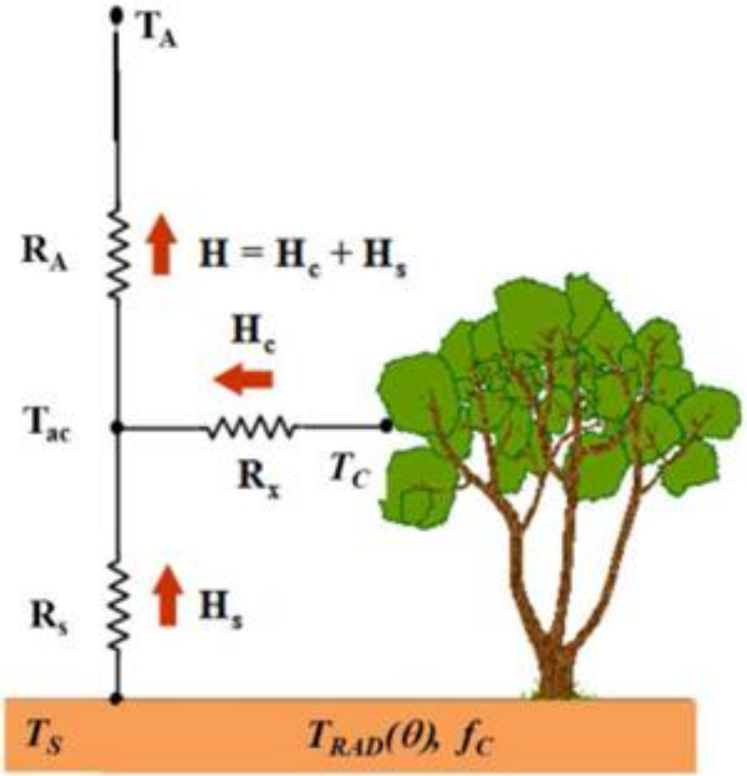
- Ancilliary instrumentaion with surface temperature and radiation sensors above junper tree and bare ground.



Methodology

Surface energy balance modelling

- TSEB model (*Two-Source Energy Balance Model*)



SENSIBLE HEAT FLUX

Norman and Kustas, et al. (1995)

System, soil, canopy budgets

$R_n = H + \lambda E + G$

$R_{n,s} = H_S + \lambda E_S + G$

$R_{n,c} = H_C + \lambda E_C$

Two-source approximation

$T_{RAD}(\theta)^4 \sim f_C(\theta)\, T_C^4 + [1 - f_C(\theta)]\, T_S^4$

Temperature constraint

$H_C, H_S, R_{n,c}, R_{n,s}, G$

PT, PM or LUE R_C model

λE_C

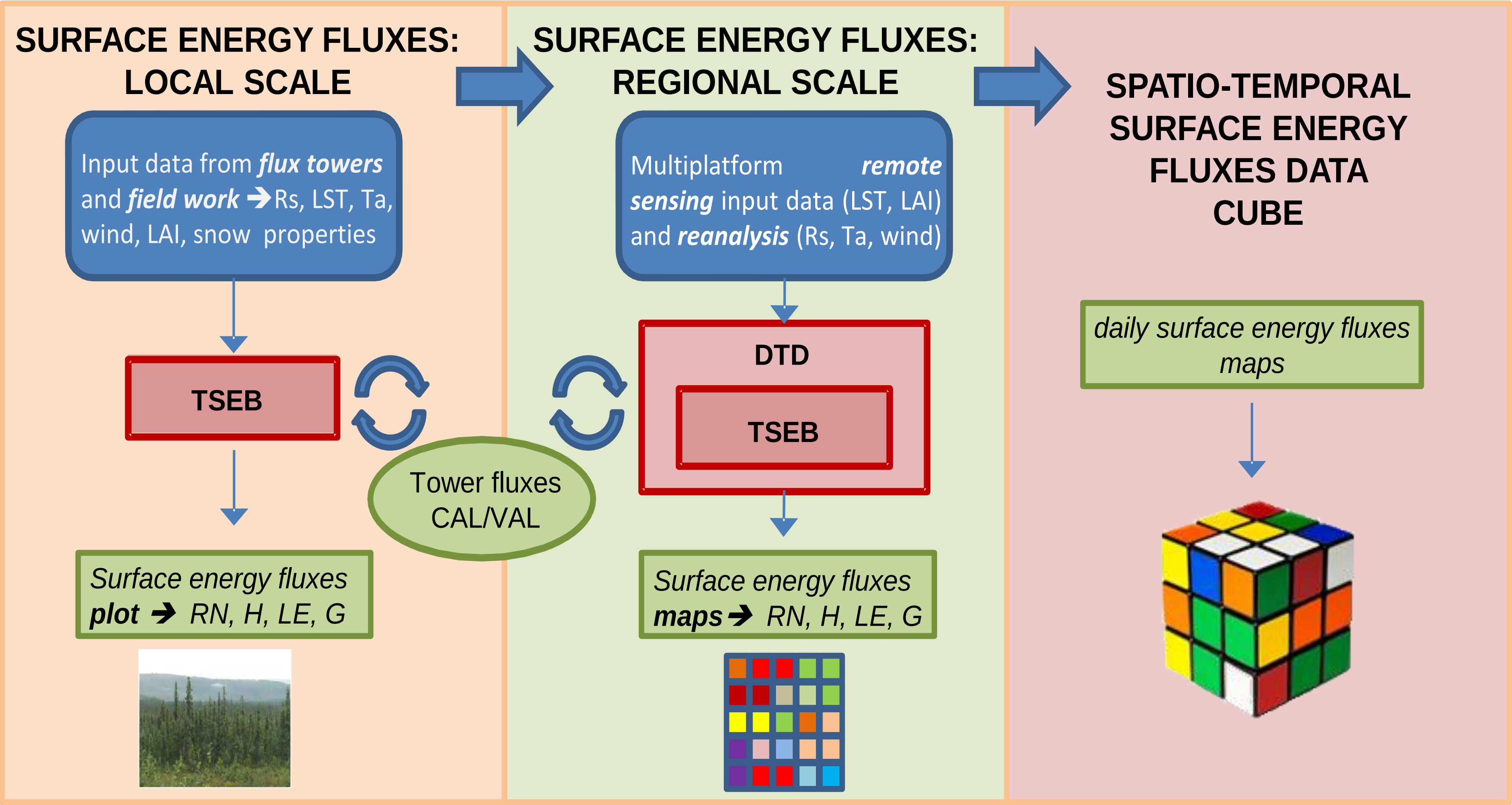
Residual

$\lambda E_S = R_n - H - G - \lambda E_C$

Iterative solution

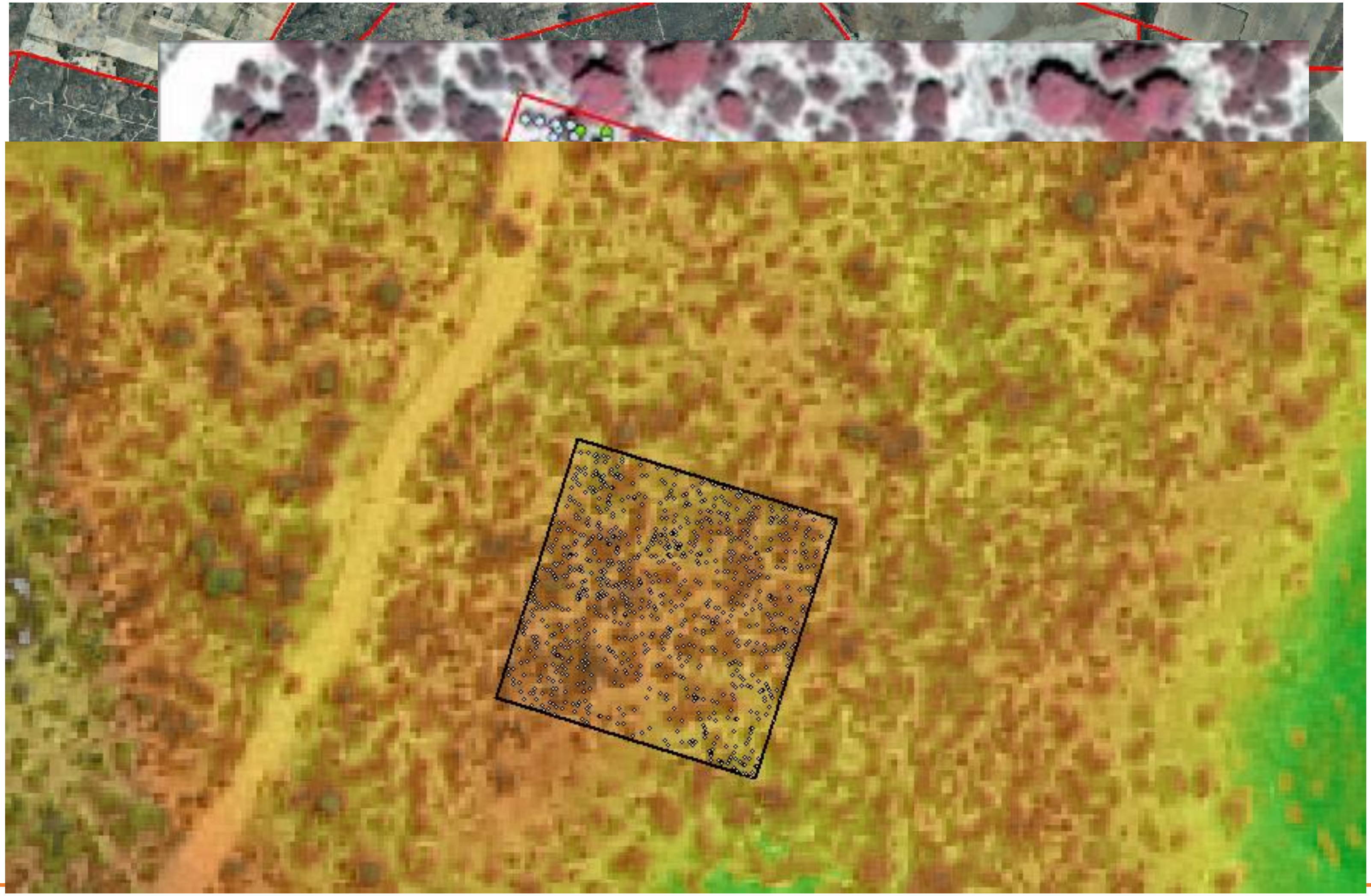
Methodology

Surface energy balance modelling framework



Methodology

Surface energy balance modelling: imput variables



➔ Local scale:

- LIDAR flight
- Orthomosaic
- EC data

➔ Regional scale:

- LST (MOD011/MYD011)
  ➔204 (April 2014 to December 2015)
- Landsat-5 TM LST
  ➔5 images (March to September, 2010)
- LAI (MOD15A2)
- Fg (NDVI y EVI)
- EC meteorological data

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Metodología

Modeling of CO_2 assimilation by vegetation

- *Gross Primary Production*
- Regional scale: LUE model *(Light Use Efficiency)*

Applied in two ways to reduce that maximum efficiency value by:

1) Forcing it with meteorological variables.
2) Forcing it with both meteorological variables and a water stress index from TSEB. $W = \frac{ET_d}{ET_r}$

- Local evaluation: flux tower

Methodology

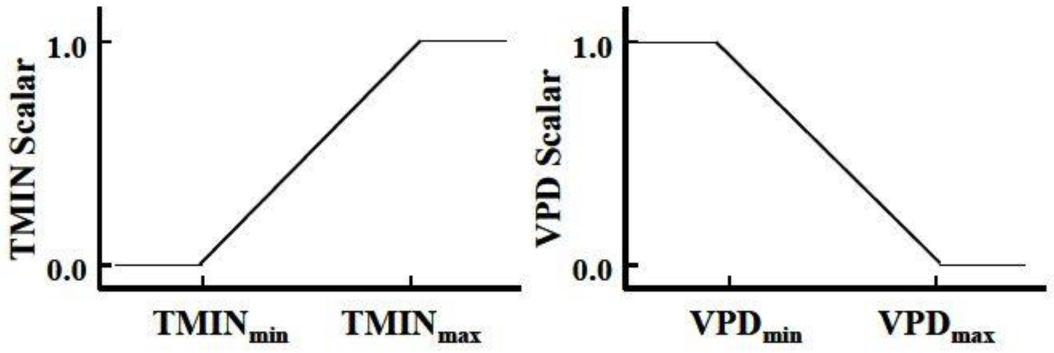
Modeling of CO2 assimilation by vegetation

Regional scale: LUE model *(Light Use Efficiency)*

$$GPP = FPAR \cdot PAR \cdot \varepsilon \, dt^*$$

$$\varepsilon = \varepsilon_{máx} \cdot TMINesc \cdot DPVesc$$

- FPAR: MCD15A3H ➔ 157 images 2014-2015
- PAR: 0,48* Rs
- ε_{max} : 0,841gC/MJ (Open Shrublands*)
- Threshold values: -8 and 8.8 °C for Tmin; 0.65 and 4.8 kPa for VPD



*Monteith 1972
Szeicz 1974
Running y Zhao 2019

Modeling of CO2 assimilation by vegetation

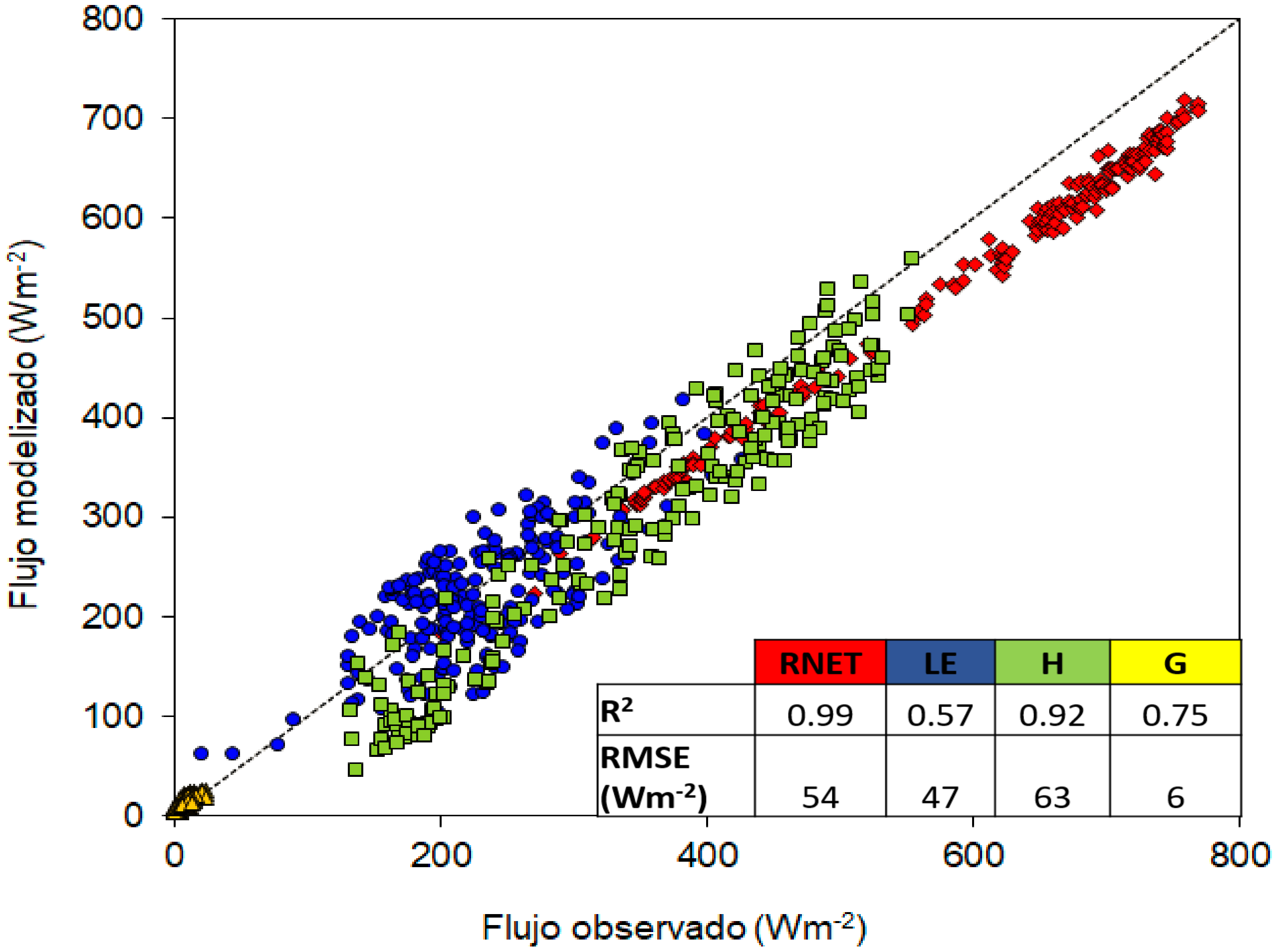
➡ Local evaluation: flux tower

$$GPP = NEE - Reco^{*}$$

*Lasslop et al 2010

Results: surface energy balance Terra/Aqua LST data

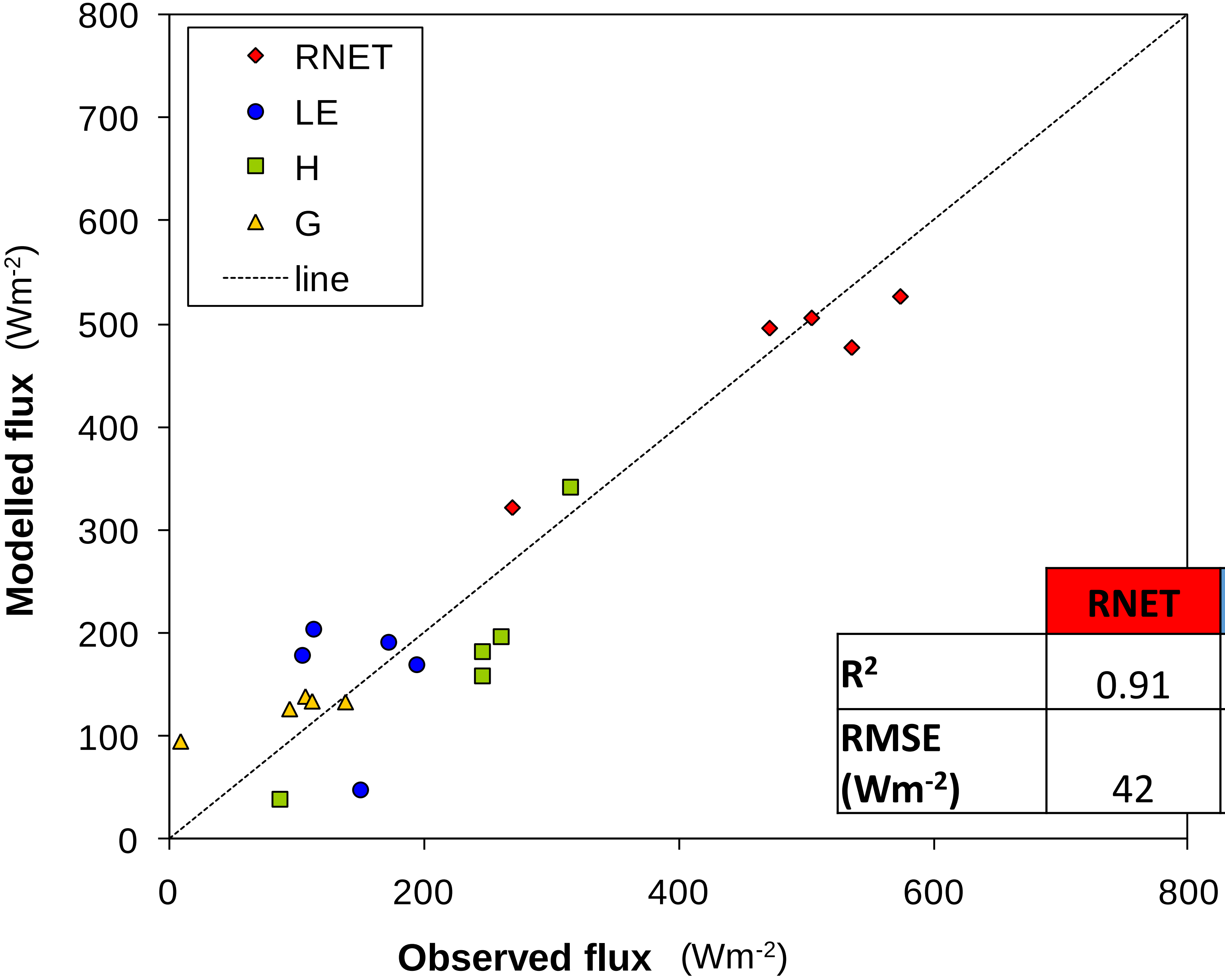
TSEB



	RNET	LE	H	G
R^2	0.99	0.57	0.92	0.75
RMSE (Wm^{-2})	54	47	63	6

- RMSE for all fluxes < 50 $W \cdot m^{-2}$
- Allowing daily upscalling of LE to be <=1 $mm \cdot day^{-1}$

Results: surface energy balance with Landsat-5 TM LST data

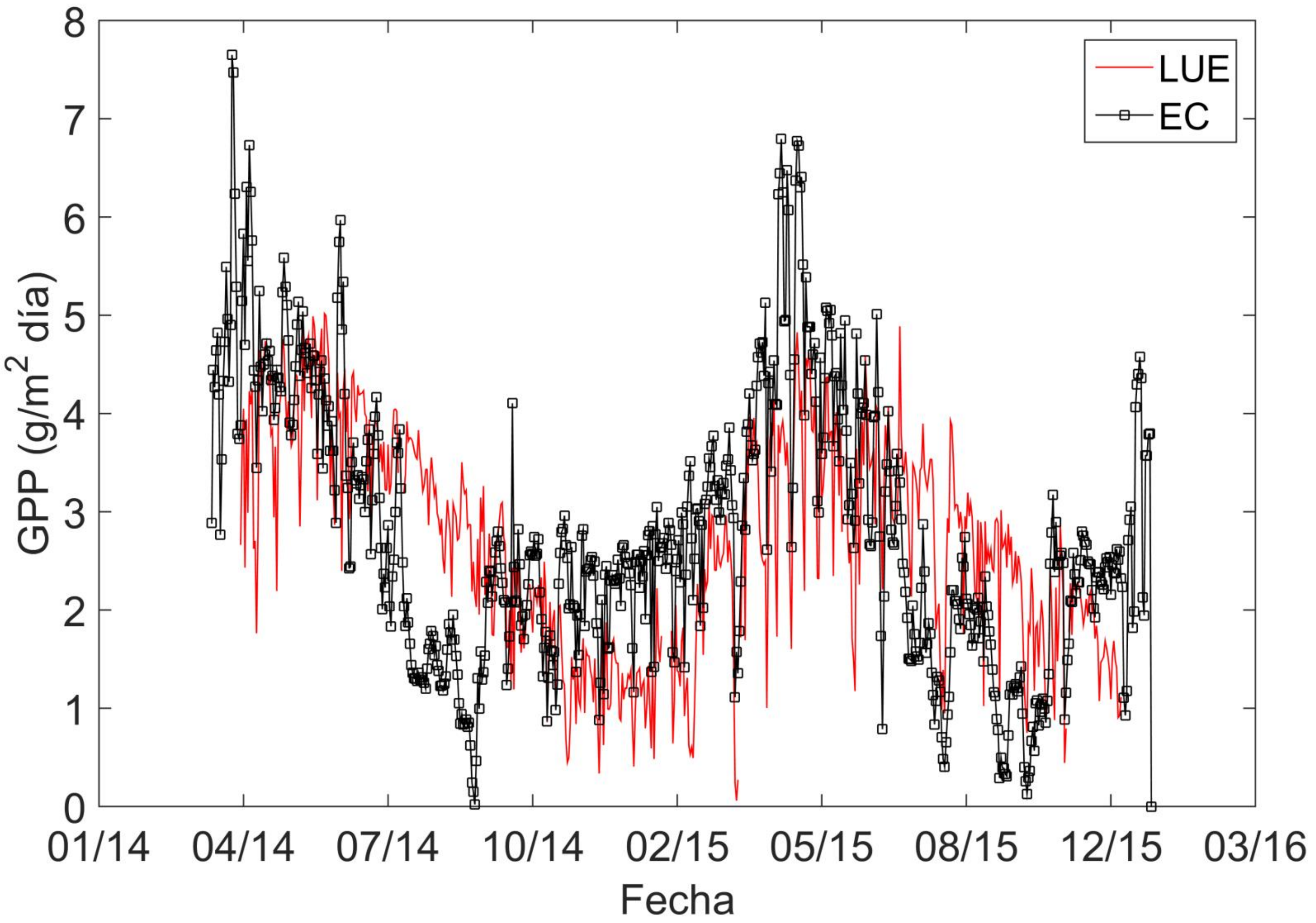


	RNET	LE	H	G
R^2	0.91	0.04	0.86	0.91
RMSE (Wm^{-2})	42	69	62	53

Results: CO_2 fluxes

LUE

- RMSE
  0,9 g C ·m^{-2}

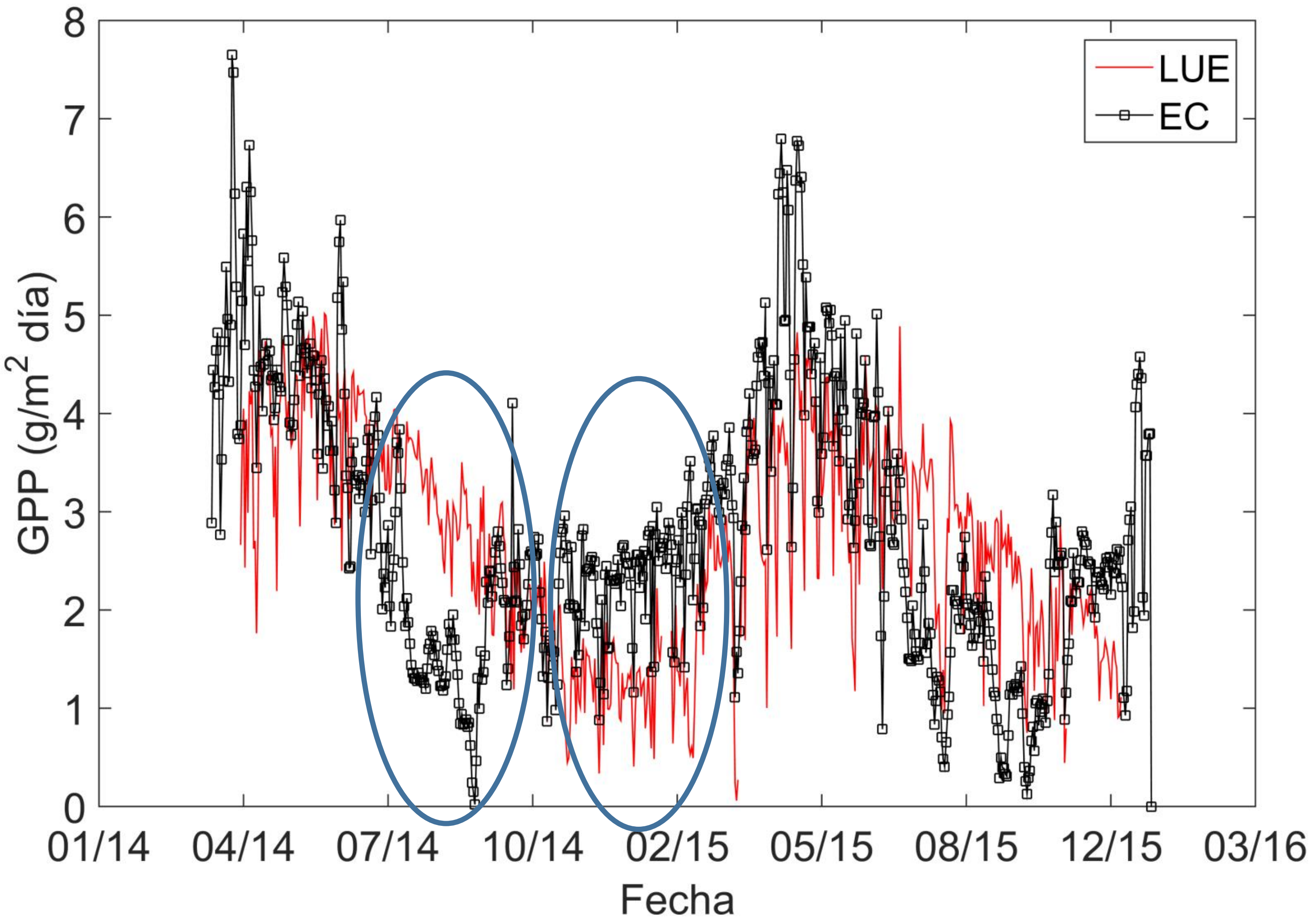


Results: CO_2 fluxes

LUE

- RMSE
  0,9 g C ·m^{-2}

- R^2
  0,42



Conclusions and future work

The TSEB and LUE models yielded satisfactory results in terms of RMSE as a first approximation for estimating both surface energy and CO2 fluxes in a Juniper tree ecosystem:

- 1- In the case of net radiation, latent heat, sensible heat and soil heat fluxes, evaluation results showed an average RMSE of around $W \cdot m^{-2}$ for Landsat and MODIS data.

- 2- Application of the LUE with meteorological data also yielded acceptable results (0.9 $gC \cdot m^{-2}$). Finally, using the water stress index improved the model results (0.7 $gC \cdot m^{-2}$) due to its best performance in water scarcity conditions.

Future studies will expand the time series in the juniper ecosystem and will extend to other covers within the RBD, where there are similar facilities, in order to study the peculiarities of the different ecosystems present in the Doñana National Park

➔ Application of SenET modelling framework to map ET

Thanks for your attention

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pedro.gomez@ebd.csic.es

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