

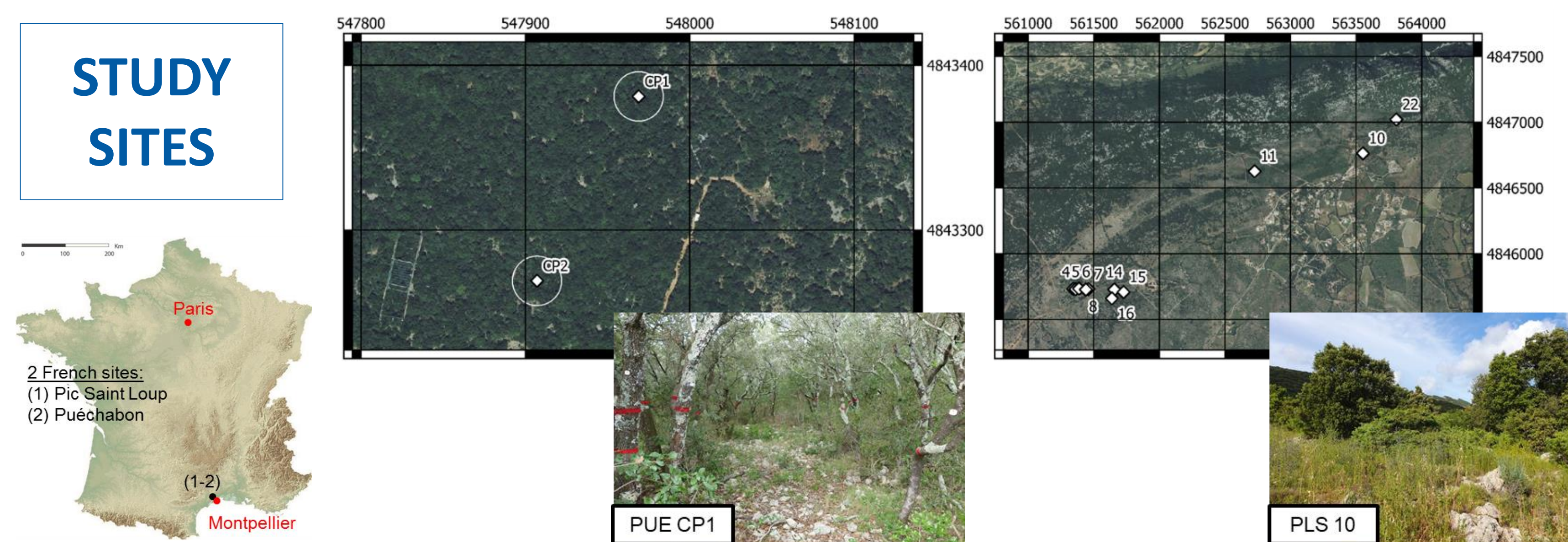
# SENTHYMED/MEDOAK multi-scale experiment to validate Sentinel-2 and imaging spectroscopy vegetation products over French Mediterranean oak forests

Karine Adeline<sup>1</sup>, Jean-Baptiste Féret<sup>2</sup>, Harold Clenet<sup>3,4</sup>, Jean-Marc Limousin<sup>5</sup>, Jean-Marc Ourcival<sup>5</sup>, Florent Mouillot<sup>5</sup>, Samuel Alleaume<sup>2</sup>, Audrey Jolivot<sup>2</sup>, Xavier Briottet<sup>1</sup>, Luc Bidel<sup>6</sup>, Enayat Aria<sup>3,4</sup>, Alexandre T.M. Defossez<sup>2</sup>, Thierry Gaubert<sup>1</sup>, Josselin Giffard-Carlet<sup>2</sup>, Jean Kempf<sup>5</sup>, Damien Longepierre<sup>5</sup>, Fabien Lopez<sup>5</sup>, Thomas Miraglio<sup>1</sup>, Julie Vigouroux<sup>3,4</sup>, Marianne Debue<sup>1,7</sup>

<sup>1</sup> ONERA – DOTA, Univ. of Toulouse, FR; <sup>2</sup> TETIS – INRAE, Univ. of Montpellier, FR; <sup>3</sup> DYNAFOR – INRAE, Univ. of Toulouse, FR; <sup>4</sup> Engineering school of Purpan, Toulouse, FR; <sup>5</sup> CEFE – CNRS/IRD, Univ. of Montpellier, FR; <sup>6</sup> IATE – INRAE, Univ. of Montpellier, FR; <sup>7</sup> CESBIO – UT3 Paul Sabatier, Univ. of Toulouse, FR

Contact: karine.adeline@onera.fr

The objective was to provide reference datasets [1] to calibrate/validate satellite vegetation products to prepare future hyperspectral missions, such as BIODIVERSITY (CNES)[2], Surface Biology and Geology (NASA-SBG) and Copernicus Hyperspectral Imaging Mission for the Environment (ESA-CHIME). In particular, this experiment targeted the measurement of species traits to assess biodiversity-ecosystem functioning and fire risk [3]. The collected multi-scale (from leaf to canopy), multi-temporal (monthly revisit) and multi-platform (in lab, *in situ*, UAV, airborne, satellite) datasets can contribute to a better understanding of Mediterranean oak forest conditions in a context of climate change, increasing droughts and land use change. This work was supported by CNES with the SENTHYMED project aiming to explore Sentinel-2 and hyperspectral imagers synergies, by ESA/NASA with the organization of MEDOAK campaign simultaneously with AVIRIS airborne acquisitions, and by many involved French laboratories.



## Puéchabon (PUE)

- Highly dense oak forest, ICOS/FLUXNET networks
- 2 plots: 100% evergreen oak (*Quercus ilex* - QI), canopy fraction of around 98%

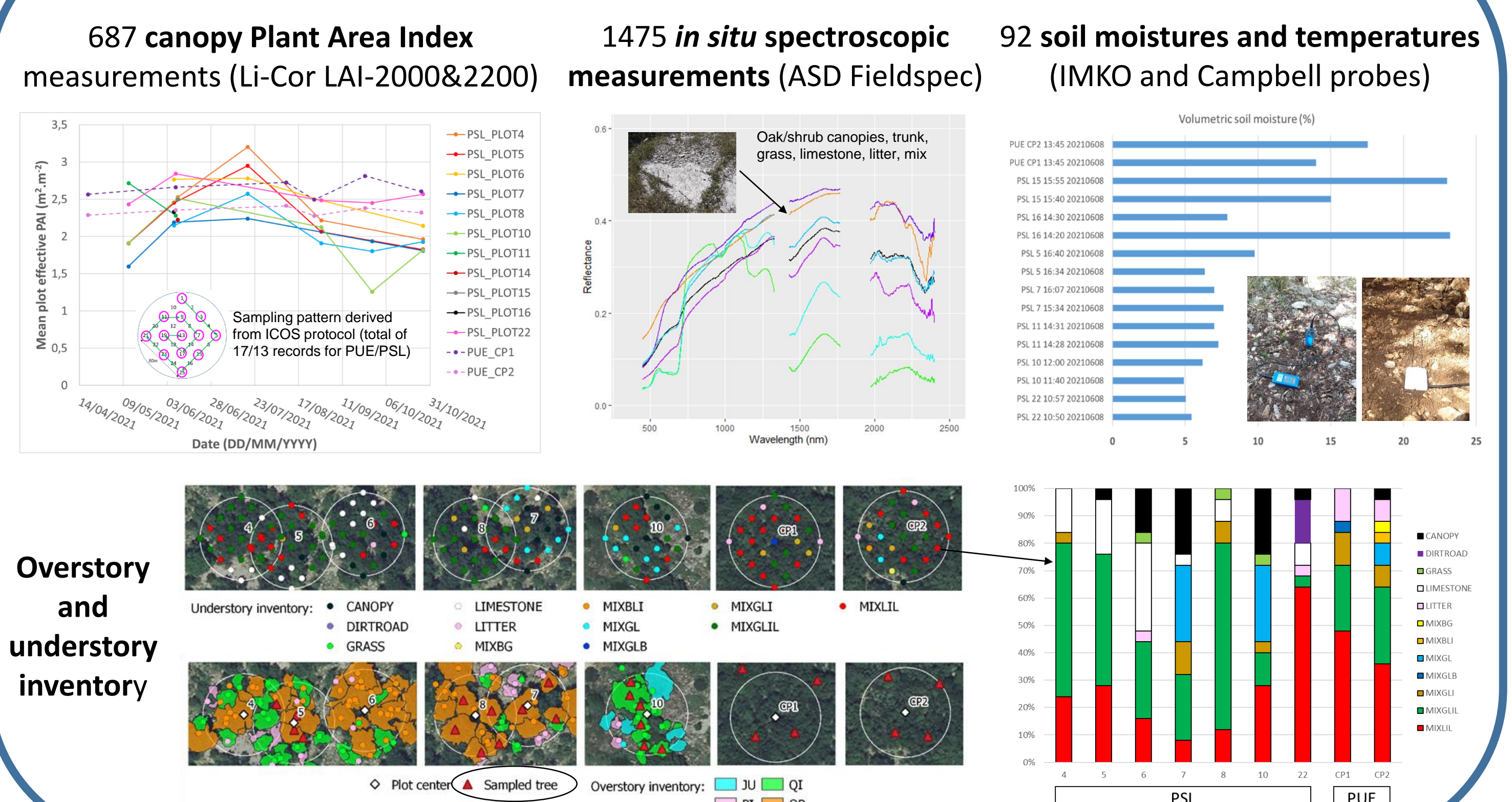
## Pic Saint Loup (PSL)

- Heterogeneous forest (from open to closed canopies)
- 8 plots: mix of evergreen oaks (QI) and deciduous oaks (*Quercus pubescens* - QP), canopy fraction between 47% and 91%

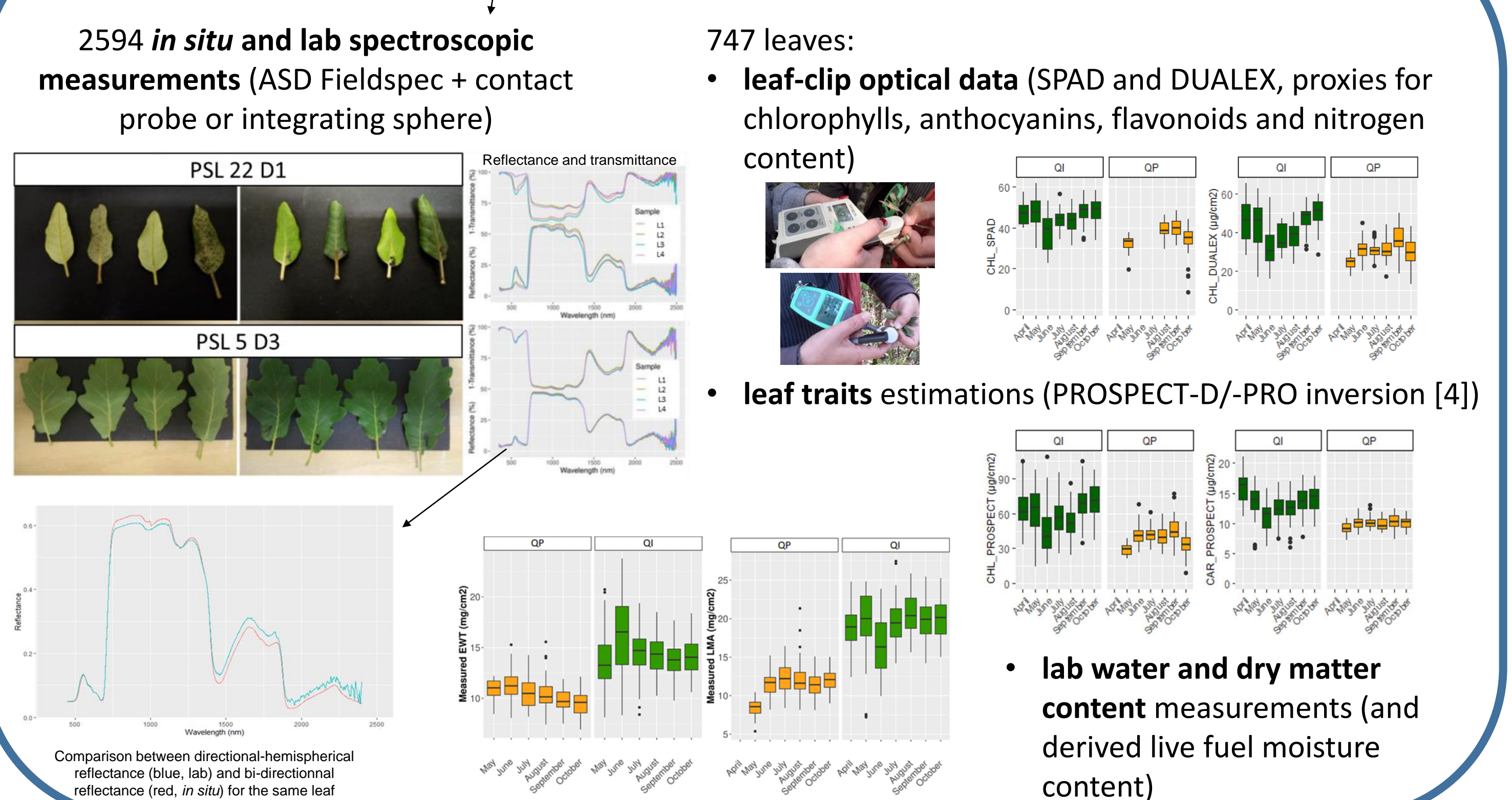
## ORGANIZATION

- Selection of 13 plots (30m diameter) scanning a variability in species composition (monospecific and mixed) and canopy cover (71% - 100%)
- 7 monthly campaigns between April and October 2021 concomitantly with Sentinel-2A + June 2023
- For leaf sampling and biochemical traits measurements, selection of 4-5 dominant oaks within each plot

## Data at plot scale



## Data at leaf scale



## Remote sensing data

**UAV-borne LiDAR 3-D acquisitions in June 2021:**  
YellowScan Surveyor (Velodyne VLP16, bi-écho @905nm) onboard a DJI Matrice 600 Pro UAV, flights at 50m height on some plots

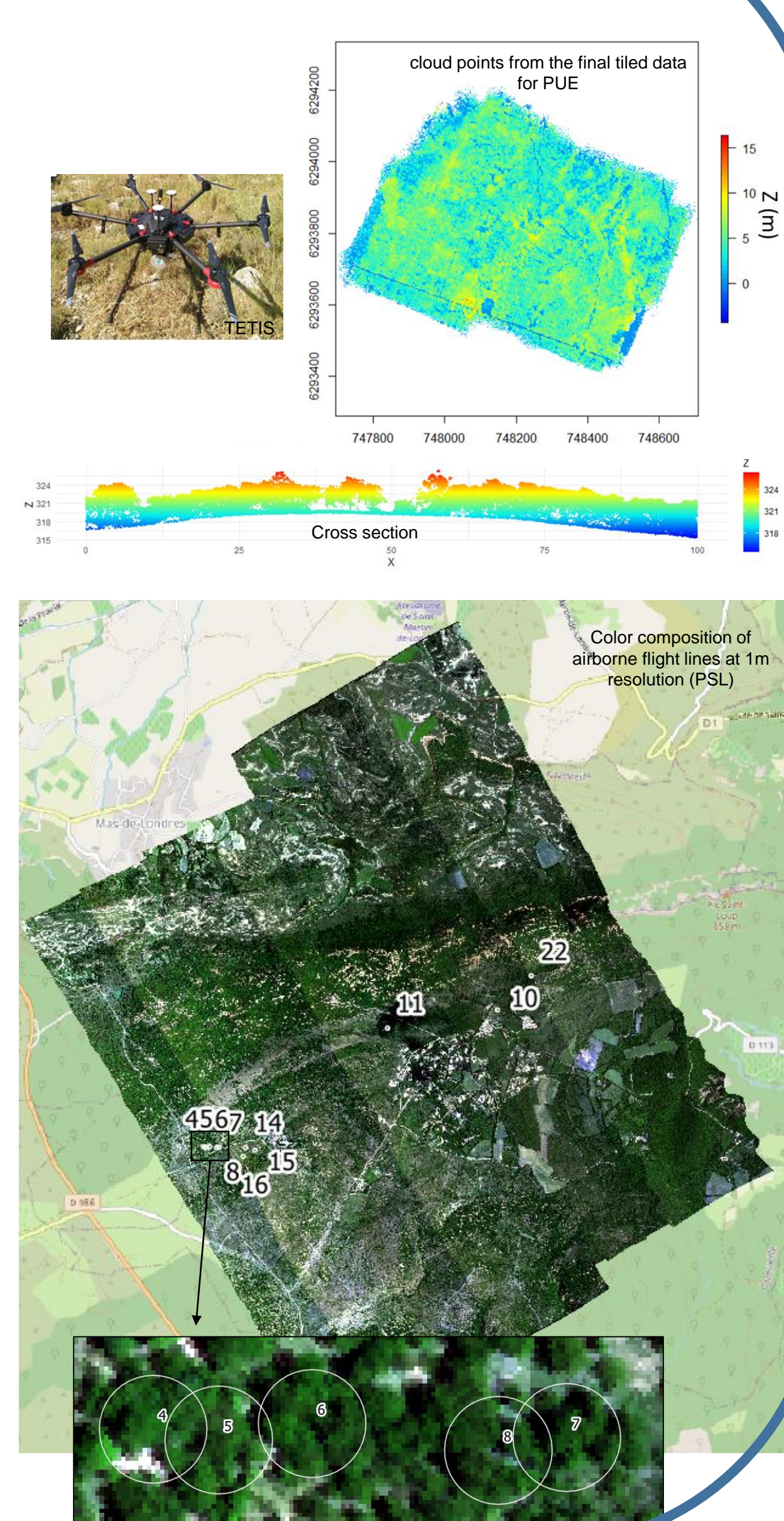
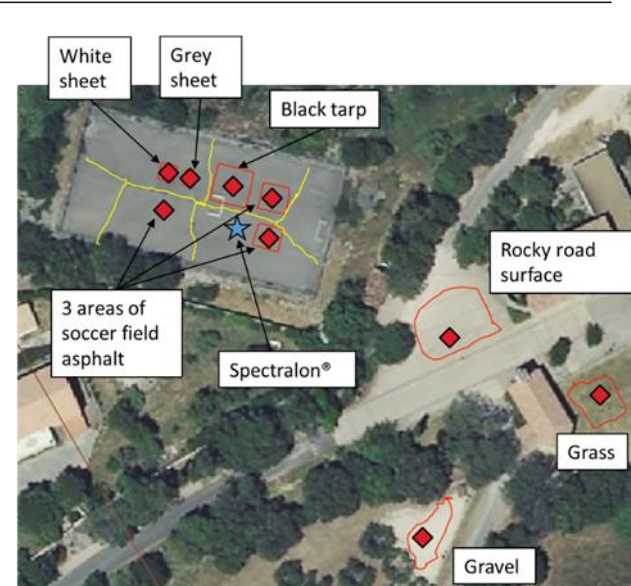
**Hyperspectral airborne imagery in June 2021 operated by NASA-ESA:**  
• AVIRIS-Next Generation acquisitions (concomitant with field samplings)

**Multispectral and hyperspectral satellite imagery in 2021 (maximum temporal interval compared to field samplings):**

- 7 PRISMA images (10 days),
- 4 DESIS images (3 days for 2 of them),
- 48 Sentinel-2 images (3 days for 8 of them).

Platform	Airborne	Spaceborne
Instrument	Aviris-Next Generation	Sentinel-2A/2B, PRISMA, DESIS
Acquisition height	Around 12 km and depending on spatial resolution	786 km, 614 km, 400 km
Spatial resolution	1.2-1.4 m, 3.0-3.1 m	10 m, 20 m and 60 m, 30 m, 30 m
Spectral characteristics	Range: 380-2510 nm, Sampling: 5 nm, Resolution: 15-185 nm, Number of bands: 425	Range: 400-2200 nm, Resolution: <= 12 nm, Number of bands: 239, Range: 402-1000 nm, Sampling: 2.55 nm, Resolution: 3.5 nm, Number of bands: 235

**In situ calibration/validation activities for in-flight calibration correction**



## ONGOING WORK

- Species traits derived from radiative transfer models: inversion at leaf scale [5], forward [6] and inversion modelling at canopy scale
- Time series and phenology analysis
- Fire risk seasonality and precision

[1] Adeline et al. (2024). Multi-scale datasets for monitoring Mediterranean oak forests from optical remote sensing during the SENTHYMED/MEDOAK experiment in the north of Montpellier (France). Data in Brief, 110185.  
 [2] X. Briottet et al. (2022) Biodiversity – a new space mission to monitor earth ecosystem at fine scale, Rev. Fr. Photogramm. Teledetect. 224, doi: 10.52638/RFPT.2022.568.  
 [3] Yebra et al. (2024) Globe-LFMC 2.0, an enhanced and updated dataset for live fuel moisture content research. Sci Data 11, 332.  
 [4] J.-B. Féret, F. de Boissieu, prospect: PROSPECT leaf radiative transfer model and inversion routines. (2023). https://gitlab.com/jbferet/prospect.  
 [5] J.-B. Féret et al. Estimating functional traits in Mediterranean ecosystems using spectroscopy from leaf to canopy scale. 2nd Workshop on International Cooperation in Spaceborne Imaging Spectroscopy, 19-21 October 2022, Frascati, Italy, oral.  
 [6] M. Debue et al. (2023) Adequacy of Mediterranean forest simulations from DART radiative transfer model and UAV laser scanning data to hyperspectral images, in: Proc. SPIE 12727, Remote Sens. Agric. Ecosyst. Hydrol. XXV, 127270U, https://doi.org/10.1117/12.2678531.