



HAL
open science

Analysis of polarimetric GNSS-R airborne data as a function of land use

Karin Dassas, Mehrez Zribi, Pascal Fanise, Vincent Dehaye, Emna Ayari,
Michel Le Page

► **To cite this version:**

Karin Dassas, Mehrez Zribi, Pascal Fanise, Vincent Dehaye, Emna Ayari, et al.. Analysis of polarimetric GNSS-R airborne data as a function of land use. European Geophysical Union (EGU), Apr 2023, Vienne (AUT), Austria. 2023, 10.5194/egusphere-egu23-2641 . hal-04263716

HAL Id: hal-04263716

<https://hal.science/hal-04263716v1>

Submitted on 22 Nov 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0
International License

ANALYSIS OF POLARIMETRIC GNSS-R AIRBORNE DATA AS A FUNCTION OF LAND USE

Karin Dassas¹, Mehrez Zribi¹, Vincent Dehaye¹, Pascal Fanise¹, Emna Ayari^{1,2}, Michel Le Page¹



¹CESBIO, University of Toulouse, CNES/CNRS/INRAE/IRD/UPS, Toulouse, France.

²Institut National Agronomique de Tunisie, Université de Carthage, LR 7AGR01 GREEN-TEAM, 43 Avenue Charles Nicolle, Tunis 1082, Tunisia.

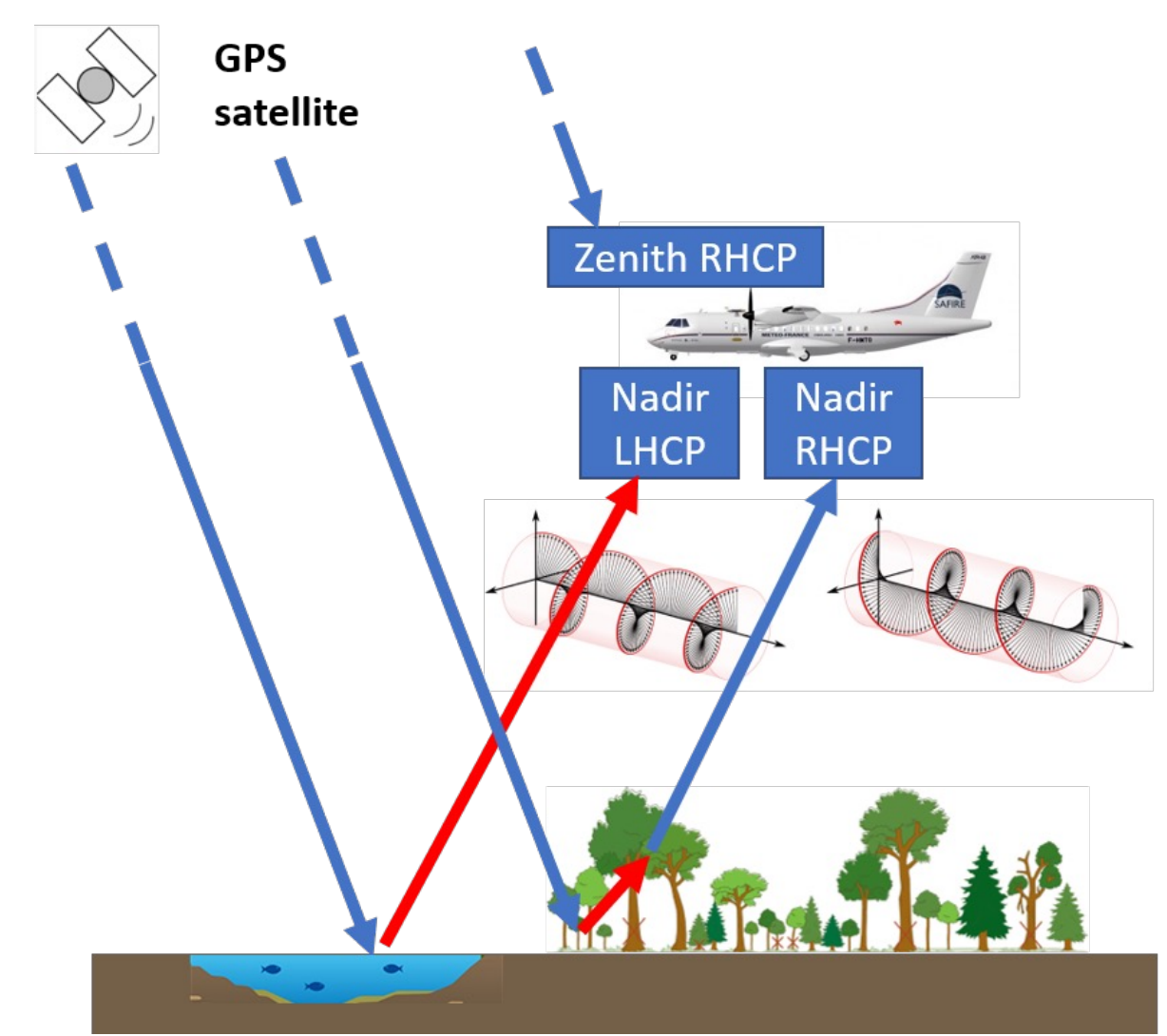
Introduction

The objective of this study is to analyze GNSS-R data variations as a function of land cover using airborne measurements obtained with the GLOBal Navigation Satellite System Reflectometry Instrument (GLORI). In situ measurements describing the soil and vegetation properties were obtained simultaneously with flight measurements. The behavior of the observable copolarization (right-right) reflectivity Γ_{RR} and the cross-polarization (right-left) reflectivity Γ_{RL} as a function of land use is discussed. The distribution of coherent and incoherent components in the reflected power is estimated for different types of land cover.

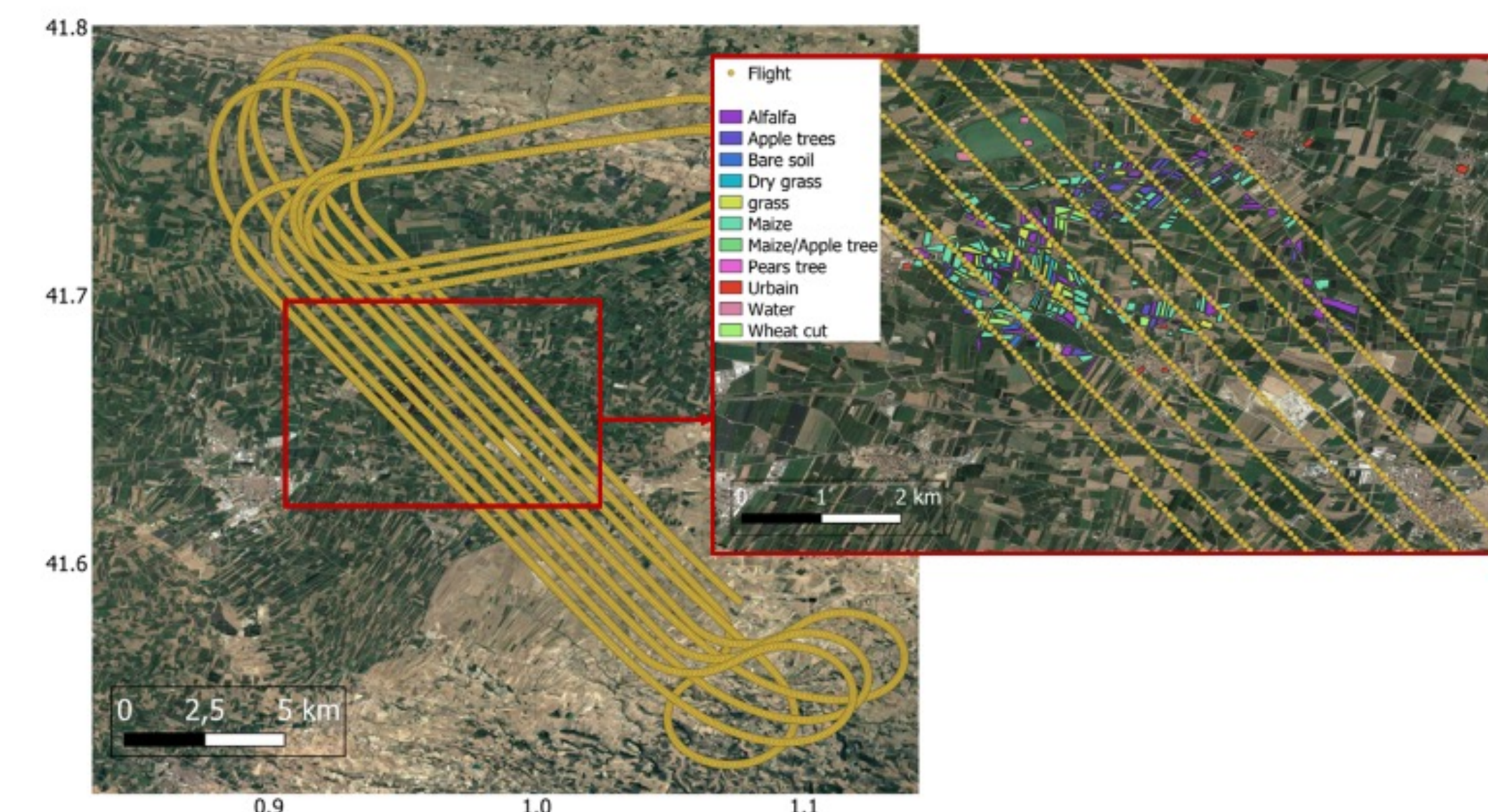
Study site and data

The Urgell site is located in Catalonia (Spain). It is an agricultural site with intensive irrigation mainly coming from the Pyrenees through the Urgell canal. The land use at this site varies with annual crops (corn, cereals, and alfalfa) and arboriculture (apple and pear orchards). The climate is semi-arid.

The GLORI instrument used in this study is described in [1]



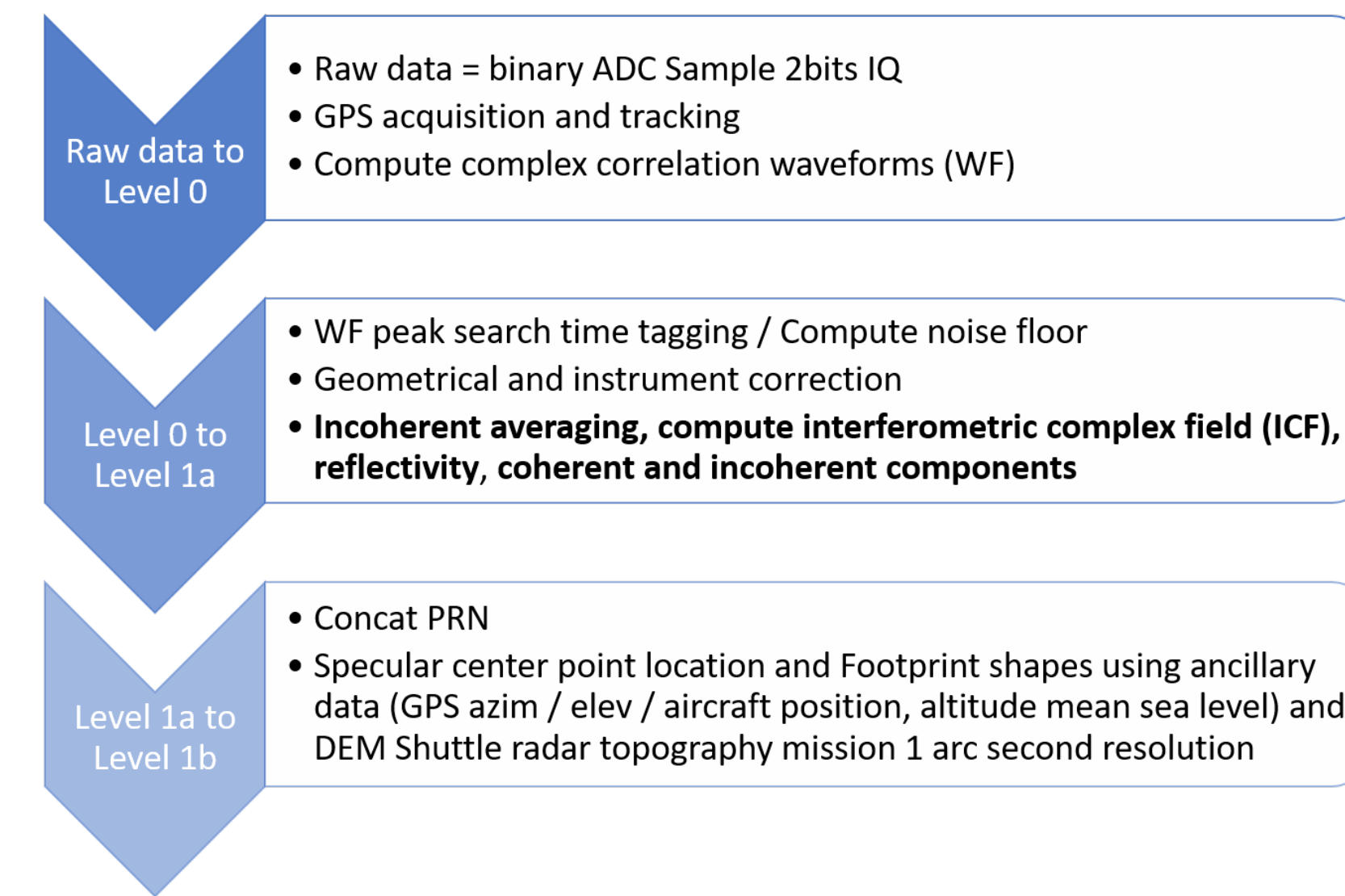
This study is based on airborne campaigns with 3 flights carried out in July 2021 (flight 45/46/47 respectively on July 22nd, 27th and 28th) over the Urgell site (SAFIRE ATR-42 plane), altitude around 1100m



Location of the GLORI 2021 flights and plots for ground truth in the Urgell basin (Spain).

Methodology

A GLORI Data Processing



Reflectivity Γ : we consider a calculation based on the Interferometric Complex Field which is defined as the ratio between the reflected and direct waveforms' peak time series

$$\Gamma_{pq} = \frac{\langle |ICF_{corr}|^2 \rangle - \sigma_{ICF_{corr}}^2}{\langle |ICF_{corr}|^2 \rangle}$$

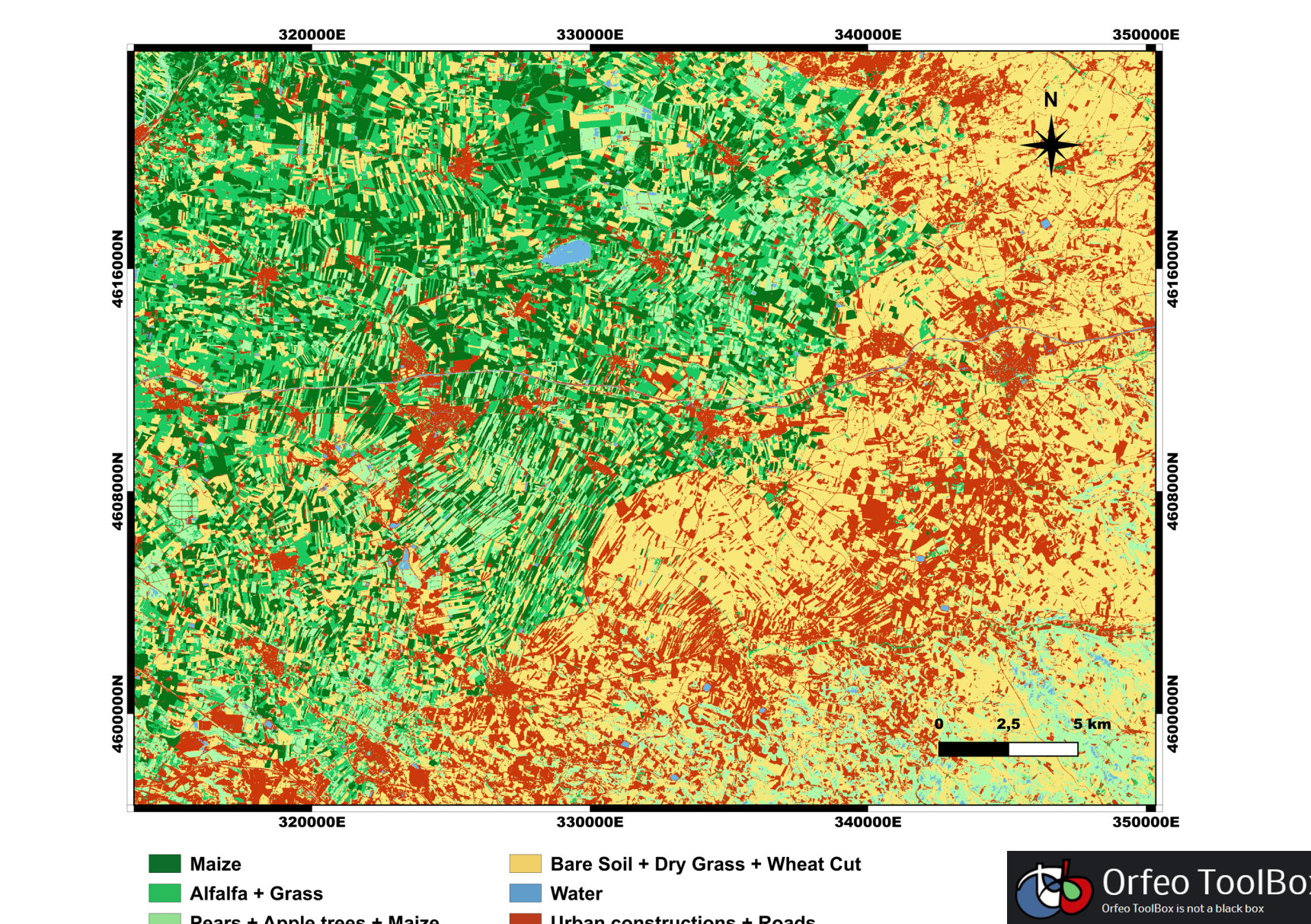
where $\sigma_{ICF_{corr}}^2$ is the variance of the ICF over the incoherent averaging period (200 ms) and pq is RR or RL

Incoherent component relative to the total scattering power α

$$\alpha = \frac{\sigma_{ICF_{corr}}^2}{\langle |ICF_{corr}|^2 \rangle}$$

Only data with incidence angles $< 30^\circ$ are taken into account to limit the effect of the angle in the discussion of land use contributions

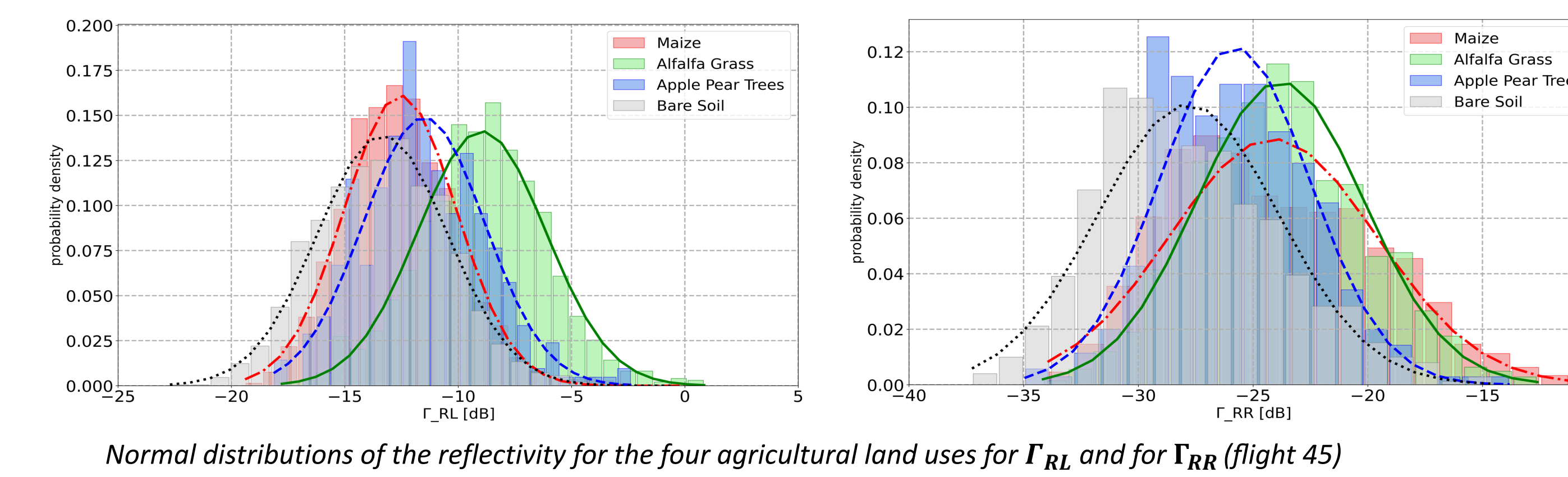
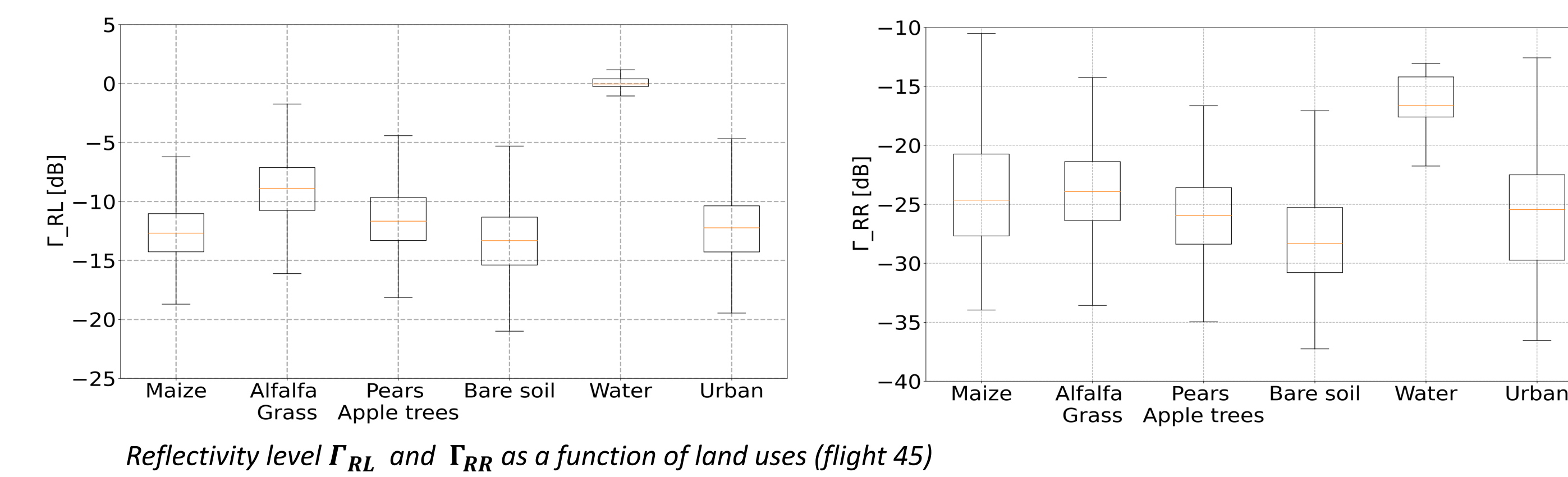
B Land use mapping



Land use map of the study area in the Urgell Basin based on Sentinel-2 images from the summer of 2021, supervised classification with random forest classifier. 385 fields for ground truth, 6 classes

Results

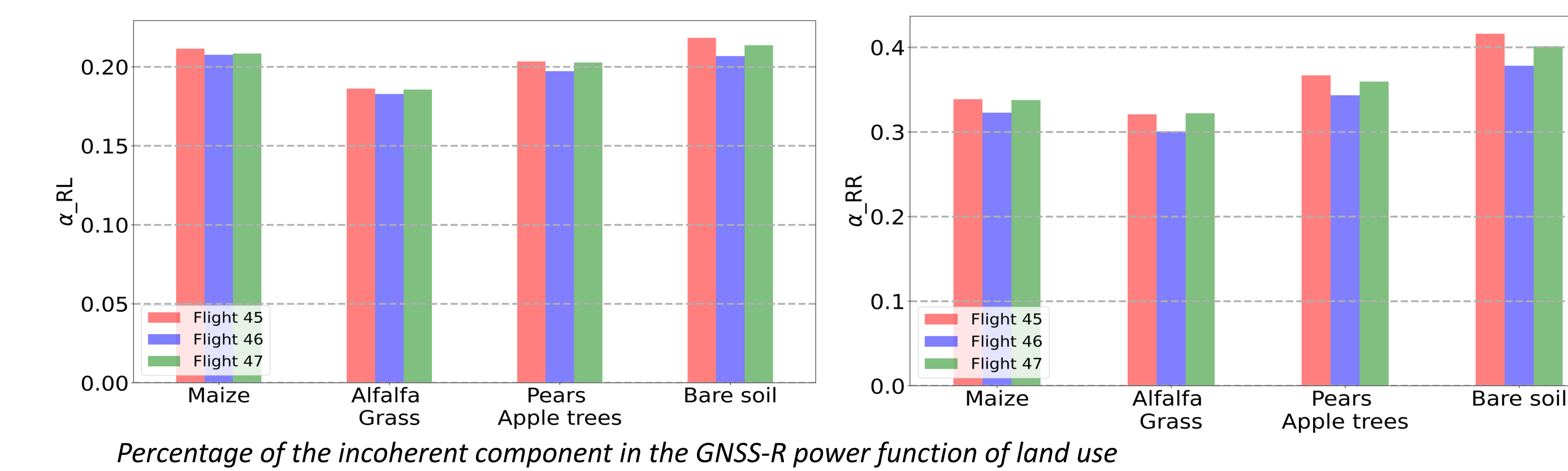
1 GNSS-R reflectivity level as a function of land use



OCS	Γ_{RL}		Γ_{RR}	
	μ	σ	μ	σ
Bare soil	-13.34	2.87	-27.82	3.95
Maize	-12.55	2.48	-24.13	4.50
Alfalfa Grass	-8.96	2.82	-23.81	3.65
Trees	-11.50	2.68	-25.80	3.28

Same trends for flights 46 and 47

2 Incoherent distributions as a function of land use



The dependence of our observations on moisture is analyzed by examining the evolution of α over the three flights : highest α with the driest conditions

- Flight 45 = very dry context
- Flight 46 = after a precipitation event
- Flight 47 = after the beginning of the drying process

Check our study [2] on soil moisture estimation with GLORI for this campaign:



Conclusion and discussion

At the study site, over water cover, very strong signals for the RL and RR polarizations were observed. The four agricultural classes (maize, bare soil, alfalfa, and trees) considered in this study showed averages over a range of 4.5 dB. The potential of GNSS-R data to clearly distinguish land uses is well demonstrated.

The hypothesis of coherent scattering over continental surfaces is very generally applied to data acquired by airborne or satellite measurements. This study shows the dominance of this component for different land uses in the case of RL polarization (around 80%). However, this hypothesis is surely less valid in the case of RR polarization, with a percentage approximately ranging between 60% and 65%.

In the case of a depolarized signal (RR), the probability of signal acquisitions coming from different structures of vegetation cover or soil in an incoherent mode is higher. This could explain the differences observed in the distribution of the coherent and incoherent components between the two polarizations RL and RR.

This scientific question will be essential in the analysis of data from future polarimetric GNSS-R satellite missions (like HydroGNSS), in the context of a sharp drop in the incoherent contribution between airborne and space measurements [3].

References

- E. Motte, M. Zribi, P. Fanise, A. Egado, J. Darrozes, A. Al-Yaari, N. Baghdadi, F. Baup, S. Dayau, R. Fieuzal, P.L. Frison, D. Guyon, J.P. Wigneron, "GLORI: A GNSS-R Dual Polarization Airborne Instrument for Land Surface Monitoring," *Sensors*, 16, 732. doi:10.3390/s16050732, 2016.
- M. Zribi, V. Dehaye, K. Dassas, P. Fanise, M. Le Page, et al. "Airborne GNSS-R Polarimetric Multiincidence Data Analysis for Surface Soil Moisture Estimation Over an Agricultural Site," in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 15, pp. 8432-8441, 2022, doi: 10.1109/JSTARS.2022.3208838
- S. H. Yueh, R. Shah, M. J. Chaubell, A. Hayashi, X. Xu and A. Colliander, "A Semiempirical Modeling of Soil Moisture, Vegetation, and Surface Roughness Impact on CYGNSS Reflectometry Data," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1-17, 2022, Art no. 5800117, doi: 10.1109/TGRS.2020.3035989

Aknowledgments

The authors wish to thank the technical teams from the SAFIRE, CESBIO, and SAFIRE pilots for their support and contributions to the success of the airborne and ground campaigns.

This work was supported by the French National Research Agency (HILIAISE ANR-19-CE01-0017 project) and the French Space Study Center (CNES SCOMAG project).

