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PROPOSITION DE SUJET DE THESE

Intitulé : Permittivity retrieval in SAR images (Moisture)

Référence : **PHY-DEMR-2021-09**
(à rappeler dans toute correspondance)

Début de la thèse : 1er septembre 2021	**Date limite de candidature :** 30 juillet 2021

Mots clés

Moisture content, permittivity, double bounces, forestry/vegetated areas

Profil et compétences recherchées

Etudiant(e) de grandes écoles ou d’université avec un goût certain pour l’électromagnétisme, le traitement du signal et la programmation

Présentation du projet doctoral, contexte et objectif

Context

Moisture content is useful for a wide range of applications, ranging from agriculture to flooding and trafficability. Today, this can be done using satellites, but with a low resolution (unit is in km for SMOS and SMAP)[1]. On the other hand, we have today many SAR satellites with a resolution of 10 meters or below. Even if some averaging (multi-looking, speckle filtering, etc.) must be applied, the resolution is still way better. So, the objective is to investigate the capability of using SAR images to estimate the moisture content.

On the first hand, we can benefit from classical methods, as Dubois [2] or Oh [3]. They make the assumption of bare surfaces so forestry areas should be masked prior the model inversion involving incomplete dielectric map.

For forests, or all other environments where double bounce scattering mechanism exists, we propose to use the method developed in [4, 5]. During this PhD study, we have shown that the permittivities of the both components of a dihedral structure can be retrieved using dual co-pol radar data. For instance, the complex permittivities of a ground and a wall have been retrieved using the radar signal backscattered by these objects.

Using the permittivities, it is possible to estimate the water content in some well known-conditions for vegetation or for the ground [6,7].

Now regarding the resolution, a possibility is to use X-band SAR data. For forests, we lose the penetration capacity offered by P- or L-band sensors, but we can also benefit from vegetation gaps. If radar waves can reach the ground, we can expect strong double bounces.

Scope of work

The main work will rely on the direct application of the Ph.D. study of Orian Couderc [5]. To do so, this method has to be extended from radar data to SAR data. Furthermore, it has to be applicable to ground-trunks, while now, it has been only tested on perfect dihedral structures. We would then determine permittivity as there exist models to link the permittivity to the water content. Some other steps will have to be performed before: in particular, to study of the effects of speckle on permittivity estimation and how to compensate it, to find a model to link dielectric to water content, to validate with ground truth data.

First year: to apply classical methods on SAR data with known ground truth to get familiar with permittivities. A possibility could be to use Sentinel-1 data (C-band) to benefit from time -series and determine if we can retrieve the variation in the water content. We can also test these methods on X-band data, dual co-pol, to study their robustness. Indeed these tools are known to be sensitive to roughness, which increases with frequency.

In parallel, the PhD candidate could study the extension of the tool developed by Orian Couderc to SAR data. This can be performed using simulations or anechoic measurements.

Second year: once the extension has been validated, the candidate can apply both approaches to forest borders and/or fields borders. In this configuration, the permittivity of the ground retrieved by the two methods can be compared. The SAR data have to be dual co-pol and at X-band, ideally with known ground truth.

In a second time, the permittivities of the trunks/field and the ground have to be studied within the forests. In particular, we can study the consistency of our retrieval first through the forest and then, inside and outside the forest. If SAR data are available, we can also work with various kinds of configurations, with buildings or roads for instance inside the forests, to test our work.

Third year: this last year could be dedicated to the test of some applications depending on the availability of relevant SAR data, like the trafficability of the ground below canopy or the study of the water content variation in the ground to predict flooding or the detection of targets at X-band using forest gaps.

Collaborations envisagées

SONDRA

Laboratoire d'accueil à l'ONERA	**Directeur de thèse**
Département : Département Electromagnétisme et Radar	Thirion-Lefevre / Guinvarc'h
Lieu (centre ONERA) : Salon de Provence	Laboratoire : SONDRA
Contact : Xavier Dupuis	Tél. : 01 69 85 18 12 / 11
Tél. : 04 90 17 01 32 Email : Xavier.Dupuis@onera.fr	Email : laetitia.thirion, regis.guinvarch @centralesupelec.fr

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