TIME SERIES OF POLARIMETRIC AND INTERFEROMETRIC OBSERVATIONS OF TERRASAR-X DATA OVER RICE FIELDS IN SPAIN

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1. INTRODUCTION

The potential of the new X-band radar imagery provided by the TerraSAR-X sensor for the monitorization of rice fields has been studied in this work. Images acquired during the whole crop cycle at different polarization channels and different incidence angles have been processed in order to identify observables with clear signatures as a function of rice phenology.

2. CAMPAIGN

A 30 km x 30 km site in the mouth of the Guadalquivir river, SW of Spain, where rice is cultivated annually from May to October, has been monitored with three overlapped series of dual-pol TSX images.

2.1. Ground-truth

During the 2008 campaign, the local association of rice farmers (*Federación de Arroceros de Sevilla*) has collected several ground truth parameters on a weekly basis. For this research project, 8 specific parcels, spread over the whole area, were selected for ground-truth monitorization. The area of each parcel is around 8–14 ha. Phenological stage and vegetation height on these parcels have been annotated during the whole period. In addition, specific aspects for some of them have been registered, such as irrigation conditions, water salinity and presence of plagues. There is also climate information provided by the Spanish Agency of Meteorology (AEMET), including daily files of temperature, precipitations, humidity and wind.

2.2. SAR images

In order to investigate the capabilities of the TerraSAR-X sensor, the acquisition of images was organized as a set of three parallel time series. Each time series, with an 11-days revisit period, corresponds to dual-pol stripmap images obtained with a different incidence angle, namely 22, 30 and 40 degrees. Note that the operational range of incidence angles of TerraSAR-X comprises 20 to 45 degrees. In addition, different polarization combinations were chosen for the time series: VH/VV for two of them (22 and 40 degrees) and HH/VV for the 30 degrees case.

The schedule of the acquisitions covers the whole crop cycle, from sowing to harvest. Note that sowing is not simultaneous in all parcels of the site, and the time span dedicated to harvest is about one month because some fields exhibit different development periods and because there were some rain events in the last dates, which complicated the harvest and post-harvest practices.

The temporal sampling of the observations is very dense since for each series there is one image every 11 days and, considering the campaign as a whole, the temporal gaps between acquisitions are only 2, 4 and 5 days, thus providing a very frequent coverage of the test site.

As a consequence of the dual-pol operation, the swath of each image is half the swath of single-pol case, so the final area covered by each image is about 15 km (ground-range) x 40 km (azimuth). Therefore, the rice area is not fully covered by

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the images. However, the experiment is designed to maximize the simultaneous coverage of the central part of the area by all images. Note also that two time series correspond to descending acquisitions, whereas the third series is acquired in ascending mode.

3. RESULTS

Among the large number of observables which can be computed from this rich data set, the first part of this work has been focused on the use of time series of backscattering coefficients at HH and VV, acquired with 30 degrees of incidence angle. As an example, the evolution of the backscattering coefficients at HH and VV channels for a parcel is presented in Fig. 1a. The ratio of both values HH/VV (in dB) is also plotted in Fig. 1b. Similar results are obtained for the rest of parcels, with slight changes depending on the particular condition of the field.

The interpretation of both curves has carried out by taking into account the phenological evolution of the plants, which are characterized by different dielectric architectures of the scene as a function of time. This analysis has been also completed with the use of a full wave electromagnetic model of the rice fields, especially adapted for X band. First results demonstrate a clear signature of the rice condition in these observations. The HH/VV ratio increases with time from 0 to 8-12 dB, from sowing to the end of the vegetative phase. Then, the reproductive phase of the plants produce a reduction of this ratio down to 2–4 dB.

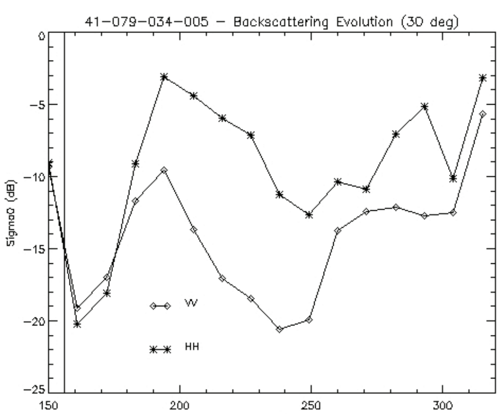
During the vegetative phase, three considerations define this response. First, backscattering at X-band and 30 degrees incidence is dominated by the double-bounce interaction between the flooded soil and the (quasi-vertical) stems. In general, when the double bounce dominates, the value of the HH/VV ratio is almost independent from the vegetation height. Second, for such a scene composed by almost vertical very thin cylinders, extinction coefficient at vertical polarization is larger than at horizontal polarization, i.e. there exists differential extinction, but the values of the extinction coefficients do not depend on vegetation height. Third, as vegetation height increases (plants grow), the total attenuation is stronger for vertical than for horizontal polarization, due to longer propagation paths inside the vegetation volume and the aforementioned differential extinction.

Further interpretations are available for the rest of signatures observed in the data.

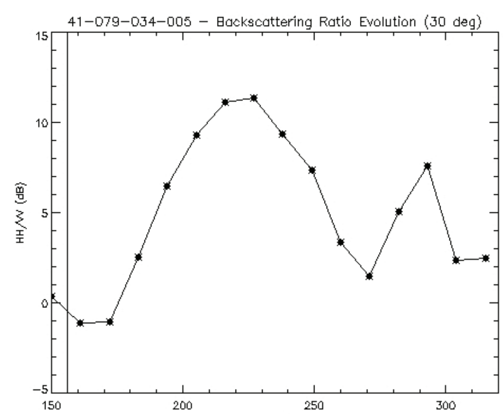
In next IGARSS we will present the complete research results, including the analysis of the following results:

- Phase differences between HH and VV channels.
- Analysis of the angular dependence of the VV channel (incidence angles range from 22 to 40 degrees).
- Interferometric results.

A comparison with previous results in the literature will be also described. Potential applications for crop consition monitoring, identification of cultivated areas, and detection of cultivation problems (such as plagues) will be also demonstrated with these data.



(a)



(b)

Fig. 1. Temporal evolution of the backscattering coefficients for HH and VV (left) and the HH/VV ratio (right) for a single rice field (parcel #34)