Analysis of land surface characteristics and monitoring of surface changes over Patagony using ERS SAR Interferometric Land Use images

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Abstract. This paper presents one of the interferometric related applications that has recently attracted more interest from the scientific community. The objective is to exploit the coherence information derivable from a couple of ERS SAR images to evaluate land surface characteristics and its changes. An area located in Patagony has been selected for this work. Results should provide information about the surface characteristics and their evolution in time. Simultaneously, they are expected to confirm the potential and validity of a new kind of ERS SAR product for land use analysis and surface changes monitoring that is currently being tested at ESRIN.

Keywords: SAR Interferometry, Coherence, Land Use.

1 Introduction

The confidence on the enormous potential of SAR Interferometry is increasing every day. This regards not only the most known applications as the generation of Digital Elevation Models (DEM) or the detection of surface movements but particularly, those applications related to land use analysis and monitoring. However, there is still the need to investigate and better understand the real potential and limitation of these techniques, and this is the purpose of the work here presented.

The paper is focussed on the use of interferometric images for land use analysis and for the monitoring of surface changes over an area in Patagony. This region is submitted to strong wind conditions and the associated effects produce continuous changes on the surface. The interferometric based techniques can provide very valuable and unique information for monitoring land surface changes, regardless the cloud cover (which make difficult the use of optical data) or the strong wind conditions (which make less reliable the use of only SAR intensity images). Therefore, we will use several interferometric pairs of ERS SAR images to generate the corresponding interferometric products from which the information about the surface evolution of the region will be extracted.

2 Methodology

From an interferometric pair of ERS SAR images it is possible to derive several information. On one hand, by combining the phase information of both images (either using ERS.SAR.RAW or

ERS.SAR.SLC products, where the phase information is still present), an interferogram can be generated. The interferogram represents the phase difference between both images and therefore, it is the starting point for the further derivation of DEM or for the analysis of surface movements. On the other hand, the correlation between the two complex SAR images provides information related to the "similarities" between data acquired at those days and so, between the surface characteristics at the two acquisition dates. This particular correlation is known as interferometric coherence and can reveal valuable information about the land surface characteristics and the surface cover changes. Basically, the interferometric coherence (γ) can be estimated as:

$$\gamma = \frac{E\{\mathrm{Im}_1 \cdot \mathrm{Im}_2^{*}\}}{\sqrt{E\{|\mathrm{Im}_1|^2\} \cdot E\{|\mathrm{Im}_2|^2\}}}$$

Being Im_1 one the complex SAR images (as the ERS.SAR.SLC product) of the interferometric pair and Im_2 the other complex SAR image over the same area.

In simple words, we could say that the coherence provides information about the similarity of the surface response to the SAR at two different days (and by different surfaces). Let' s consider a very arid surface, subject to small modifications. If we measure the coherence over this area using two SAR images acquired close in time (from 1 day to some months apart), we will find out high coherence values, because the surface has almost not changed during the time interval. When we increase the acquisition time between the two images, the possibility that surface changes occur gets higher and thus, the probability to obtain lower coherence values also increases. Let' s imagine now an area covered by water (e.g. a lake, a river or a flooded area). If we measure again the coherence over this area, we will realise that coherence over water bodies is very low (regardless the wind or the atmospheric conditions), and therefore they can be easily distinguished. This low coherence is due to the fact that water surfaces change continuously (note that when only SAR intensity is used for identifying water bodies, low wind conditions are required for obtaining reliable results). Therefore, with the aid of the interferometric coherence it is possible to identify different kinds of surfaces and also to monitor their evolution across the time.

In order to exploit the information provided by the coherence image, a new kind of ERS SAR product is being evaluated. It is called Interferometric Land Use (ILU) image and it is generated from a pair of ERS SAR acquisitions by combining three images: the SAR intensity of one acquisition (usually in the green channel), the difference between both SAR intensities (usually in the blue channel) and the interferometric coherence (usually in the red channel). The result is a colour image joining the traditional information provided by two single SAR images with the additional information provided by the coherence between them.

The basic idea has already been applied over some areas in Europe, see Wegmuller (1996) and Borgeaud (1996), and the interesting results obtained strongly suggest to continue

investigating the possibilities of this technique. The study here presented introduces the possibility to monitor surface changes by means of interferometric image pairs with different time interval between them, which is appropriated over surfaces with characteristics similar to those of the Patagony region.

The ILU images presented in this paper are generated with the Interferometric Quick Look Processor installed at ESRIN.

3 Expected results

Several ERS SAR interferometric pairs have been selected over a large area in Patagony for the study, with different interval of time between them: ERS-1 pairs with 3 days apart, ERS-1/2 tandem pairs with 1 day apart and ERS-1/2 pairs with nx35 days apart (with n ∃1). For each pair, an ILU image (covering an area of about 100 km x 800 km) will be generated (as well as the corresponding interferogram). The analysis of the different ILU images across the time is expected to provide information on the surface evolution during this time, which will be compared with ground true information (through the collaboration with the local scientific community). Additionally, the comparison between the information provided by the ILU images generated with different acquisition intervals is expected to provide information about the potential of the coherence when time between acquisition increases.

On one hand, the result should contribute to better understand the possibilities to use ILU images for analysing areas with similar characteristics and to determine the most appropriated time interval between acquisitions for the generation of these ILU images.

On the other hand, the study is supposed to bring new information about the evolution of the Patagony region and to establish a procedure for performing a systematic monitoring over the area whenever required.

References

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