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Simple, ancillary data driven SAR speckle filtering: making SAR images handy for Doñana wetlands water cycles monitoring

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Doñana wetlands are located in South West Spain, near the Guadalquivir River mouth, on the Atlantic Ocean coast. The wetlands undergo yearly cycles of inundation and drying out and, while flooded, constitute breeding site and crucial passage for the Africa-Europe bird migration. Doñana National Park was internationally recognised as a Biosphere Reserve under UNESCO's Man and the Biosphere Programme in 1980 and inscribed on the World Heritage List in 1994.
A number of past events have threatened the preservation of the marshes water cycles, which constitute the strategic basis for the entire ecosystem functioning. The intensive agriculture occupation of the site during the 20th century, for instance, reduced the marshes extension from 180,000 to 30,000 ha and deeply altered its natural hydrologic scheme. Important efforts are currently being made at the local and national levels to monitor the marshes water cycles, ensure its preservation and partially restore the natural hydrological scheme.
As part of these monitoring efforts, Envisat/ASAR images have been used since 2006 to observe the flood extent evolution in Doñana marshes. During the hydrological year 2006–2007, 43 ASAR scenes of Doñana, mostly in HH and VV polarizations, were acquired with the aim to characterize in detail the backscatering evolution of the different land cover types throughout an entire flooding cycle. Such images contributed to the calibration of an existing two-dimensional hydrodynamic model of Doñana marshes and proved to be useful for other environmental parameters retrieval, such as yearly helophyte vegetation development or soil moisture estimation. Nevertheless, despite the obvious usefulness of the SAR data for Doñana marshes monitoring and management, the omnipresent speckle restricts their exploitation by the Park's personnel to retrieve useful information.

As in many marshand areas, the topography of Doñana is extremely flat, but it has a critical effect on the hydroperiod or time that each zone remains flooded, which in turn determines the vegetal species growing in it. A LIDAR-derived high resolution digital terrain model (DTM) of Doñana marshes is currently available. The DTM contributes precious clues for determining filtering regions since it defines highly probable homogeneous areas, in a natural environment basically shaped by the water and gravity endeavor.
A speckle filtering algorithm has been developed which benefits from the existing DTM. The algorithm does not use a fixed size moving window. Instead, a filtering region based on the DTM is defined for each pixel. The region of a pixel (i,j) is integrated by all those connected pixels around with an elevation difference not larger than 0.025 m respect to that of (i,j). Therefore, large regions are used for filtering pixels' backscattering coefficients in very flat areas, while the regions become smaller with increasing terrain slope or other irregularities. The DTM-based filtering regions are delineated at each ASAR image. An edge detection algorithm is then applied. If no edges are found, eiher the region's arithmetic mean or an adaptive filter such as Lee's can yield the pixel's filtered value. If an edge is found, the region is further subdivided and the process above is repeated.
The filtering method sketched above is still at a developing stage and being tested with the extensive ASAR image data set of Doñana marshes. The results so far have been highly encouraging and have allowed the production of thematic maps by means of simple decision trees and thresholding, carried out by non-SAR trained technicians.
The fact that DTMs are becoming higly available and that physical parameters in natural environments are often tighly related to them, points at their potential as an aid for SAR data speckle filtering.