Analysis of SIR-C/X-SAR Data on Montespertoli Test Site

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Introduction

Our analysis refers to Multi Look Complex (MLC) data, which have been multilooked and usually re-sampled to a ground range projection. Two different data products, depending on the polarization mode, have been provided by NASA/JPL: quad-pol data, with 10 bytes per pixel, containing the information on all polarization combinations and phase differences between polarizations; dual-pol data, with 5 bytes per pixel, containing information only on two polarization combinations and phase differences between them. From the software development point of view, it is important to point out that there are many differences between AIRSAR format data and SIR-C format data, even if the set of data by itself is very similar. For X-SAR, the standard Multilook Ground-range Detected (MGD) data products have been selected and were provided by I-PAF.

Status of data analysis

The Montespertoli test site. The Montespertoli test site is located in Tuscany (Italy), a few kilometers South East of Florence and has been selected as a SIR-C/X-SAR super-site. It is a representative example of those Tyrrhenian-Appennine slopes where bedrock is made up of Plio-Pleistocene marine deposits and fluvial/lacustrine soft sediments, which were intensively affected by geomorphological processes of erosion and mass movements. More than half of the site is hilly (the average height is 250 m above the sea level), with some small forest areas, vineyards, olive groves, agricultural fields, pastures, and small urban areas. The remaining part is flat with alluvial wetlands of Pesa river, agricultural fields and urbanization. Two areas have been selected for ground truth measurements: a relatively flat area along the Pesa river, including agricultural fields, which, depending on the season, may grow different crops (mainly wheat, barley, alfalfa, colza, sorghum, sunflower and corn), bare soils, and a small sub-basin of Virginio river. The average field size is about 4-5 ha. The Montespertoli super-site was imaged on seven different days with different incidence angles during both the April and October 1994 missions. Due to system limitations and compatibility with data takes over other sites, fully polarimetric SIR-C data were available only for four data takes, i.e., 12, 13, 14, and 15 April, whereas dual-polarization data have been provided for the remaining three. A list of these data take segments is given in Table 1.

The X-SAR data corresponding to the same data take segments are also available.

Data Take	Scene Center Time (GMT)	Incidence Angle (deg)
50.30	12 April 1994, 12:06	26.7
66.41	13 April 1994, 11:46	35.2
82.30	14 April 1994, 11:27	44.2
98.20	15 April 1994, 11:07	48.5
114.31	16 April 1994, 10:46	52.6
130.30	17 April 1994, 10:25	55.6
146.30	18 April 1994, 10:03	57.5

Table 1
Data takes on Montespertoli.

Software development

The software developed and used for analyzing the AIRSAR data taken in the course of the MAESTRO-1 and MAC-EUROPE '91 campaigns has formed the basis for the SIR-C/X-SAR data analysis. However, the mentioned differences between the AIRSAR and the SIR-C/X-SAR data formats and the fact that the previous software had been developed under VMS and basic in a VAX environment, resulted in a major effort to implement the adjourned algorithms in the recently available UNIX/X-window Hp environment. The main features of the developed software include:

1. SAR data reading and image visualization;
2. polygonal area selection with shifting capabilities;
3. computation of average values of
    1. backscattering coefficients at each needed polarization state,
    2. phase differences between polarizations,
    3. correlation coefficients at relevant polarization states within a chosen polygonal area;
4. visualization of single or combined average values;
5. creation of auxiliary input files.

A total of 98 polygonal areas (77 in the Pesa river sub-site and 21 in the Virginio sub-site) have been constructed within the Montespertoli site. Both extensive and intensive ground truth data have been collected in correspondence of the April and October periods of the Shuttle mission. Data collections have taken place on 7, 11, 13, 14 and 19 April and on 5 October, 1994. Ground data regard the soil and vegetation parameters which have a major effect on the radar response of the surface, i.e.:

1. vegetation parameters:
    1. type of crop or grass
    2. phenological state
    3. fresh and dry weights
    4. water content of leaves
    5. water content of stalks and stems
    6. leaf area index
    7. cultivation geometry
    8. dimensions of leaves
    9. dimensions of stalks and stems;

2. soil parameters:
    1. soil moisture profile (between 0 and 2.5 cm, 0 and 5 cm, and 5 and 15 cm)
    2. soil density
    3. soil surface rms roughness
    4. soil roughness correlation length.

Data calibration and validation

A first step consisted in the comparison of SIR-C data with those taken by the AIRSAR on the same Montespertoli area in 1991 (MAC-Europe campaign), which underwent calibration by means of corner reflectors and extensive validation. At this stage of data analysis, backscattering values measured by SIR-C L- and C-band radar appear to be consistent with those of the MAC-Europe campaign.

Data analysis

At present, the following quantities have been computed from the April SIR-C data for each of the 98 polygonal areas selected within the Montespertoli site:

1. backscattering coefficients at hh, hv, vv, rr, rl, 45 degree co-pol, 45 deg cross-pol;
2. phase differences between hh and vv and hh and hv returns;
3. conventional and new (circular polarizations and "scalar") correlation coefficients for the fully polarimetric L- and C-band data.

In the case of dual-polarized data, the computed quantities are consequently and substantially reduced. As far as SAR-X data are concerned, only a single quantity can be computed from the radar data, i.e., the mean vv backscattering coefficient. The computation of the X-band average values for the same surface parcels for which the above L- and C-band quantities were obtained has been carried out. The request for the October mission data has been forwarded.

Obtained results

The aforementioned large preparatory activity needed for the extensive and systematic analysis of the SIR-C/X-SAR data has absorbed a substantial fraction of the manpower available for the SIR-C/X-SAR project. At this stage, only preliminary scientifically significant results have been obtained. The L- and C-band backscattering coefficients have been employed in a vegetation discrimination scheme, and their link with arboreous and crop biomass has been determined, thus establishing a further step towards the monitoring of vegetation by SAR sensors [1], [2]. It should be noted, however, that the season of the flights was not favorable from this point of view, since only few types of crops in spring and almost only bare soil in autumn were present. A study on the correlation with soil moisture content has also been undertaken and results are now being obtained [5]. Inclusion of the April SIR-C/X-SAR and October measurements into our backscattering database is planned to obtain additional important multi-temporal information on the radar response to vegetation and soil moisture [3], [4].

Future activities and data requests

As said, the October data have been requested and their analysis is planned to follow the present April data study, adding relevant pieces of multi-temporal information. However, a real breakthrough in this field would be produced by the availability of SIR-C/X-SAR data covering an extended period of time,

ideally one year, which would provide coverage of the whole cycle of growth of vegetation and would span the entire hydrological cycle. The possible launch of a free-flier multifrequency radar, as already discussed by NASA, could provide such a useful wealth of data of high interest for practical applications of remote sensing technology. Year-round systematic overflies of the AIRSAR could partially replace the free-flier.

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[5] A paper is being planned for submission to Remote Sensing of the Environment (due February 1996).

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