CROP AREA ESTIMATES WITH RADARSAT

FEASIBILITY STUDY IN THE TOSCANA REGION – ITALY

G. Narciso

[a] JRC –IPSC –Agriculture Unit –MARS STAT ; Giovanni.narciso@jrc.it[b]
Commission VIIII, WG VIII/10

KEY WORDS: SAR, Backscattering, Land use, Rule base classification, Forward-chaining,

EXTENDED ABSTRACT

Early crop estimates for the Common Agricultural Policy of the European Union (EU), are a key point to manage future intervention on stocks. The current study project has the goal of assessing the suitability of SAR imagery, for such a task A constraint given to the project is that the information extraction stage must involve radar data exclusively (i.e., no optical imagery) and the information provided in near to real time using exclusively SAR without any ground truth.

Base data: SAR images and a set of ancillary data sets: Corinne land cover, DEM, meteorological data, point frame surveys, statistical information and generic information on the Tuscany agricultural and cropping system. On the base of the available data the following land use classes were considered as reference: Autumn and Winter Cereals (AWC); spring and Summer Crops (SSC) crops, Trees (T), Permanent Pastures (PP) and Rotation Forage (RF.

Methodological approach: SAR measures backscattering from soil and/or vegetation and these are function mostly of the surface roughness, the moisture contents and the crop structure in the first layers of the soil (2-3 cm)[1]. These capacities are at the same time SAR potential and limits. In general if the surface roughness changes (e.g. ploughing and sowing) so does radar backscattering. Noise to this is the contemporary presence of both surface and volume scattering. Noise is also due to air moisture contents, temperature, free water and snow.

A number of alternative classification methods were excluded a priori by the set constraints. However since a sequence of SAR images were available, the chosen route was to attempt the identification of land use classes through the analysis of backscattering profiles evolving along the time series. These can be connected to events such as agricultural practices and crop cycles which are locally specific. They are a stable element of reference and only require the knowledge of the agricultural specifics of an area. Such information does not require a "learning phase" for each date and location and is therefore uncoupled from ground truth.

A fixed link between backscattering and the agricultural "events" is labelled as "**RULE**" and such an approach to classification, defined as "**RULE–based**". The classification is essentially an inference function ("if-then") where the "RULES" are the backscattering values characterizing each land use class crop at each distinct time step. There are two main methods of reasoning when using inference rules: "**BACKWARD-CHAINING**" and "**FORWARD-CHAINING**". "BACKWARD-CHAINING" starts with a list of goals and works backwards to see if there is data which will allow it to conclude any of these goals. "FORWARD-CHAINING" implies that the "then-clause" is known and used to build the inference with the "if–clause".

This last approach was chosen on the basis that the "then-clause" is the expected surface roughness of each land use class and the "if-clause" is their backscattering. The "FORWARD CHAINING" analysis runs a loop comparing options of backscattering values with known surface roughness values. It moves to the next date when it achieves an acceptable level of match *provided by as set indicator*. The achievement of a best match however provides a first hypothesis of a stable rule for classification. This rule is coded in the form of a LUT and the images are classified by comparing backscattering to the LUT with minimum-distance logic. The process of identification of the best and most stable RULE can continue in time as more information is acquired, including the efficiency of past classifications. The advantages of such an approach are that it provides consistent answers for repetitive decisions. Disadvantages are that reference ground-truth must in any case be used, at least to set up the rule base itself. Some times human common sense is ignored. In practice once the inferences are established there is no space for 'interpretation. A further limit is the adaptation to changing environments that requires a revision of the inferences (rules).

Implementation: The preliminary implementation work was the preparation of the GIS and the database of reference for the analysis and accuracy assessment. The following phases were:

1) SAR data processing: this was an external activity given out on contract

2) Analysis and identification of the RULES: This implied several investigation activities which found a systematic coding only once accomplished. The first was the analysis of the available data bases, especially the point survey data, to identify the target land use classes. The backscattering values for each image were extracted from the sample points and a t-test was applied to verify if it actually discriminated the 5 chosen classes. Surface roughness and backscattering are independent and in order to be analyzed on a common reference base they required the identification of a common unit of measure. This measure, defined **"SCORE",** relates to features which have the same dimension for both; ranking order of the values at a set date and the rate of change from date to date. The score of backscattering and surface roughness on the known points were subject to a preliminary analysis to verify if there actually was a functional link between them. Results were encouraging for the continuation of the analysis. A forward–chaining program was

implemented which ran for several days and provided a LUT for the classification. A sample of the available point data was used as reference.

3) Classification of the images: The SAR images were converted to the score value and the LUT was applied for the minimum distance classification.

Analysis of the results: The results of the classification were object of an accuracy assessment using confusion matrices. The reference was the JRC point frame survey (576 points). The analysis was run separately for each image of the time series and for each trek. It considered the accuracy of alternative aggregation scenarios for the land use classes. A first scenario kept the used the 5 original land use classes. The second excluded from the trees (4 classes). Derived from this one, a third scenario grouped rotation forage crops and permanent pastures crops (3 classes). A fourth scenario grouped winter cereals with rotation forage and permanent pastures. The results were that the accuracy of classification changed along the time series and with different precision for the 3 scenarios.

DATE of the image	5 classes 1/2/3/4/5	4 Classes 1/2/4/5	3 classes 1/2/(4+5)	2 classes 1+4+5/2
3/10/04	25.00%	30.61%	43.67%	71.84%
27/10/04	26.27%	31.85%	45.56%	77.82%
20/11/04	25.63%	30.86%	46.50%	74.07%
14/12/04	24.05%	29.34%	41.74%	66.12%
7/1/05	21.52%	25.00%	38.14%	64.83%
31/1/05	21.52%	27.43%	38.50%	66.81%
24/2/05	26.27%	31.62%	44.87%	76.50%
20/3/05	25.32%	32.03%	43.29%	73.59%
13/4/05	26.98%	34.63%	47.19%	84.85%
7/5/05	20.32%	25.22%	36.96%	56.52%
31/5/05	16.83%	23.81%	38.62%	64.02%
7/1/05	22.47%	29.60%	43.05%	80.27%

Conclusions

Analysis of backscattering data: Backscattering values fro winter and spring crops were not clearly distinct at the beginning of November and from December to January. The same can be observed in late spring for winter, forage crops, permanent pastures and trees. The values were plotted on a graph and, in order to help the interpretation, meteorological data from local weather stations were also plotted; specifically precipitation (mm), snow depth (mm) and minimum temperatures (º C).. Noticeable is the effect of precipitation and especially snow cover, on the signal. In January the intense snowfall caused the backscattering to be completely confused, the level converge and overlap and the land use classes cannot be discriminated. Meteorological events should not affect the "facts" that link the crop surface roughness to backscattering. These events however, may be local but are certainly not occasional and their interference in the possibility of establishing a direct connection between surface scattering and crop specific surface roughness is a limit to the use of SAR for crop classification. A first comment on this is that the all-weather capability of SAR data is at least questionable.

Classification: The applied methodology eventually brought to a classification of the images. The results are not encouraging concerning the recognisability of even broad land use classes. However a rather accurate discrimination appears between the grouping of winter cereal/rotation forages/pasture and spring crops. The accuracy of such a classification is around 78% between October and November it decrease during winter and reaches again and peak with an accuracy of more that 80 % in April. This period coincides with the most important cultivation practices and especially land preparation. The trend of classification accuracy may relate to a good response to surface scattering while the distinction between the land use classes is probably more related to volume scattering and this is appears to be significantly more relevant.