AN OPERATIONAL ALGORITHM FOR SNOW COVER MAPPING IN HYDROLOGICAL APPLICATIONS

S. Pettinato, M. Brogioni, E.Santi, S.Paloscia, P. Pampaloni,

Institute of Applied Physics - IFAC-CNR
Via Madonna del Piano 10, 50019 Sesto Fiorentino, Firenze, Italy

Presenting author: S. Pettinato; e-mail: S. Pettinato @ifac.cnr.it,
Ph: 0039 055 522 6463 – FAX: 0039 055 522 6434

During the past decades, natural hazards such as floods, landslides and forest fires have caused major loss of human lives and the destruction of economic and social infrastructure, as well as environmental damages.

The Italian National Project: PROSA-PRodotti di Osservazione Satellitari per l'Allerta Meteorologica – (Earth Observation products for meteorological alert) aims at contributing to civil protection from floods and landslides by developing a series of products derived from satellite sensors that can be useful in these dramatic events to permit immediate assessments of the areas at risk and/or aid decision-making on relief and clean-up operations. The products to be developed include two main groups: Precipitations and Land Surface parameters (soil moisture, snow and vegetation cover). This work deals with the use of Earth Observation data for the retrieval of the snow cover extent and snow wetness from optical and microwave sensors. In particular, this paper describes the implementation of an operational algorithm to produce snow cover maps and detect wet snow. In the absence of clouds the algorithm produces images of the snow cover and the percentage of pixels covered by snow using optical images, moreover, in case of wet snow, its extension is obtained from microwave data. For cloudy sky wet snow only can be monitored by using ENVISAT ASAR images. More in detail:

Input data to the algorithm are:

1. Images (Level 1b data) from MODIS at 500 m spatial resolution (MOD02HKM and MYD02HKM) and at 1 Km resolution (MOD021KM and MYD021KM).
2. ASAR/ENVISAT images in VV pol. (SLC, swath 2) calibrated and geolocated by using a commercial software
3. The Digital elevation model DEM of the area (30 m spatial resolution
4. Land Cover area from Corine 2000
5. Air temperature at a reference level
6. MODIS auxiliary data (MOD03 and MYD03) for geo-location of optical image

Output data are delivered in HDFformat

The main steps of the algorithm implemented in IDL language are the following:

1. Extraction of the requested optical bands (Level 1B), sun position and non usable pixels from MODIS files and computation of radiance and reflectance.
2. Classification of snow cover from the NDSI (Normalized Difference Snow Index) and a threshold criterion on the reflectance.
3. Masking for water bodies, clouds, and non usable pixels.
4. Estimate of cover fraction (percentage of area covered by snow in each pixel)

For clear sky the obtained map represents the final product.

Reliability (number of pixels classified as clouds in the image) and quality (a posterior non usable pixels) indexes are introduced

For cloudy sky the generation of snow cover map is possible in presence of wet snow only. In this case the procedure is the following:

1. Selection and preprocessing of SAR data by using a commercial software.
2. Generation of a reference image
3. Application of a threshold (-2/-3 dB) to separate wet snow by dry snow or bare soil
4. Masking for shadow, layover and forest, water bodies, or urban areas.
5. Resampling and mosaicking of optical and SAR data

In this case too, reliability and quality indexes are produced based on the ranges of both input and output values. It should be noted that, obviously, the second part of the algorithm can be used in clear sky conditions for detecting wet snow

The algorithm has been tested and validated with ground data. An example of the of results obtained for a region partially covered by clouds by combining optical and SAR data is shown inFig.1. The left hand panel represents the snow cover areas (white), while the right panel represents the cloud cover, which masks the upper part of the optical image. Snow cover has been retrieved from the optical image in the lower part (cloud free) of the image and from SAR data in the upper cloudy region.

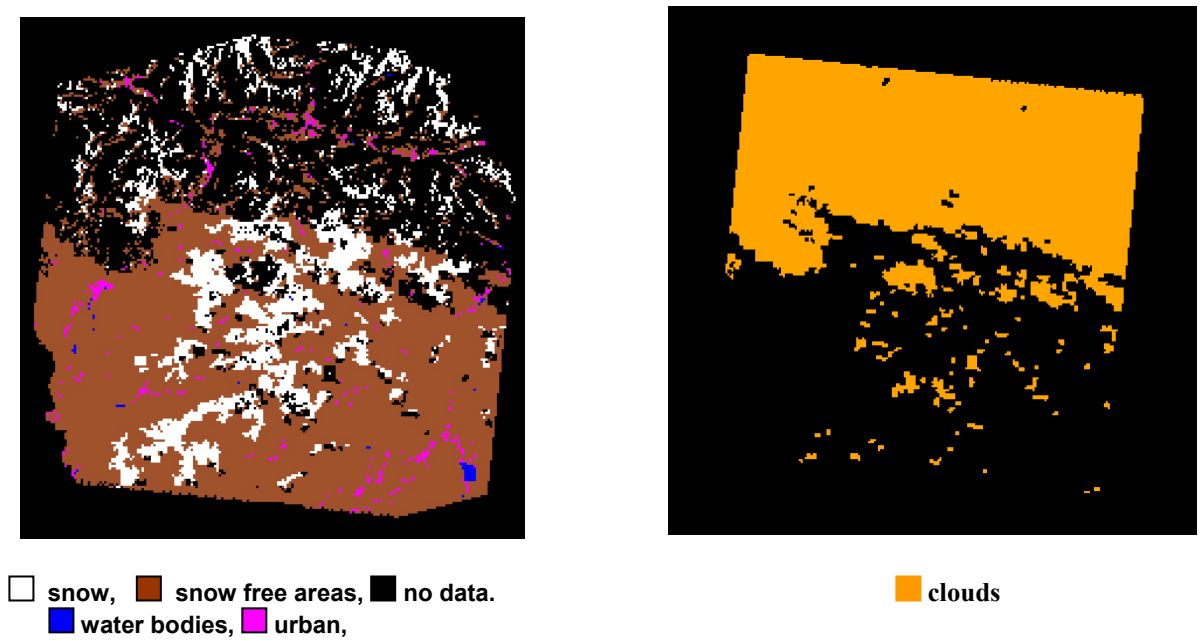

Fig. 1. Snow cover retrieved from optical and SAR data (left panel) and cloud cover (right panel)