Programma
SHORT TERM MOBILTY 2008

Relazione sulle attività svolte nell'ambito del programma

VALIDAZIONE DI MAPPE TEMATICHE DI AREE BRUCIATE DA DATI MODIS IN AMBIENTE MEDITERRANEO

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Part I – A validation protocol for the MODIS burned area maps

Introduction

The potential research, policy and management applications of satellite products place a high priority on providing statements about their accuracy (Morisette et al. 2006). Inter comparison of products made with different satellite data and/or algorithms provide an indication of gross differences and possibly insights into the reasons for the differences, however product comparison with independent reference data is needed to determine accuracy (Justice et al. 2000). Validation is the term used here, and more generally, to refer to the process of assessing satellite product accuracy by comparison with independent reference data. Validation is required to provide accuracy information to help users decide if and perhaps how to use a product, and, combined with product quality assessment (Roy et al. 2002), to identify needed product improvements (Morisette et al. 2002, Strahler et al., 2006).

The need for a validated long term record of global burned area was initially established in the context of the international global observing system (GCOS/GTOS, 1997) and was refined by the Committee on Earth Observation Satellites and the Global Climate Observing System to meet the needs of the U.N. Framework Convention on Climate Change (WWW1). There are several outstanding issues in the development of a global scale burned area product validation methodology. These include the need to increase the quality and economy of validation by developing and promoting an international network of validation sites and by establishing accuracy assessment and reporting protocols (Justice et al. 2000; Morisette et al. 2002; Morisette et al. 2006; Trigg and Roy 2007). Common validation sites afford opportunities for independent reference data sharing and can be expected, with the development of validation protocols, to foster standardization of product accuracy reporting. These needs have long been advocated by fire product producers and product users, for example, at the International Geosphere-Biosphere Programme Data and Information Services (IGBP DIS) working group meeting on remote sensing of fires, held in Toulouse, March 19-20 1998, and at the joint Global Observation of Forest Cover (GOFC)/Committee on Earth Observing Satellites (CEOS) Land Product Validation Fire Satellite Product Validation Workshop in Lisbon, Portugal, July 9-11, 2001 (Rasmussen et al. 2001).

The purpose of the present document is to state the basic requirement for the production of reference dataset for the validation of moderate resolution continental and global burned area products. The objective is to promote international collaboration and sharing of validation datasets among projects, and to make it possible to share archives of validation data, as a GOFC fire effort, for the retrospective validation of future reprocessing of burned area products.

This document draws largely from the validation on Southern Africa undertaken by the GOFC-GOLD-Fire SAFNet regional network for the 2001 and 2002 seasons, using Landsat TM data. The interpretation at each Landsat scene, was undertaken by members of the southern Africa Fire Network (SAFNet). The SAFNet members were able to undertake limited fieldwork as part of their existing scientific, resource management and environmental assessment activities, and had expert knowledge of the local drivers of biomass burning. A consensus interpretation protocol was developed to ensure compatibility of the independent reference data derived by the different SAFNet members and to allow the data to be scaled up to provide meaningful sub-continental validation data. The interpretation approach is described in Roy et al. (2005) and was based upon multi-temporal visual comparison of the ETM+ near-infrared and middle infrared bands, augmented by the ETM+ thermal band and a spectral index that is sensitive to burned vegetation, to define the boundaries of the areas affected by burning.

The reference data

Key to any accuracy assessment is the provision of representative, independent reference data that is inherently more accurate than the map to be evaluated; as a consequence, when RS data are used as reference data, they should have higher spatial and/or spectral resolution than the data used for the classification, besides covering the same time period as the map. Providing suitable reference data involves steps to make them best fulfill these criteria in the particular study area. This may therefore require the use of different methods in order to ensure the best reference data in different parts of the world. As a consequence, this document does not provide a procedure for preparing a validation dataset, nor identifies a preferred RS system for the acquisition of the reference data, but instead suggest some standards on the datasets, which should be classified by local experts using the state of the art techniques for the specific area and data.

Three aspects are emphasized:

- the temporal criteria for the selection of reference data
- the thematic content of the reference data
- the format of the reference data for long term archival

Landsat TM and ETM+ data have been widely used for validation, and for simplicity this document will make reference to TM data. However, the considerations are general ones, and they are immediately applicable to any other high resolution dataset.

Temporal criteria for the selection of reference data

Given the nature of burned areas of predominantly non-permanent land cover change, it is important to define what is the temporal interval covered by the validation data. For example, in areas where forests burn, the affected areas will sometimes remain detectable for a long time, in some cases even on a single image taken years after the burn, while in grass and shrubland areas burned areas disappear more rapidly. In fact, the length of time that burned area signals exist after a fire is highly dependent on physical evolution of the post-burn surface in the particular ecosystem, and on the spectral bands available for the analysis (Eva and Lambin, 1996; Trigg and Flasse, 2000).

If it is not possible to determine the signal residence times, it is difficult to ensure that the reference data cover the same time period as the map and that the reference data are suitable for validating burned areas over long, representative time periods.

In general, we have two broad categories: burned areas disappearing before the beginning of the following fire season and burned areas which last for more than one year. Fires in savannah or scrubland are in the first category, while fires in forest domain, where recovery is slow, are in the second category. In the first case our main concern is represented by the burned areas that occurred in the same fire season, which had already faded by the date when the reference data was acquired. In the second case, our concern is represented by those burned areas caused by fire events of the previous years, which are still visible at the time of the high resolution data.

Therefore we can adopt the following criteria:

a) using changes detected between two TM images whose time lag is less than the signal residence time: in this case the validation will be conducting comparing the reference data with areas detected as burned in the moderate resolution product between the two acquisition dates. The use of two images is also recommended in all the complex and fragmented landscapes, like Mediterranean ecosystems, where, in the absence of ground validation data, small burned areas would be difficult to identify on a single image with the degree of confidence required by a validation dataset, but could be mapped reliably using a change detection approach.

b) in the forest domain, and where the landscape is very homogeneous (mainly in boreal forest areas), a single image only if burned areas from the previous season area clearly identifiable: in this case the validation will be conducted comparing the reference data with the all the detections between the start of the burning season and the acquisition date of the reference data.

Thematic content of the reference data

The classification of the reference data must include the three classes of burned, unburned and not mapped:

- the mapped region, i.e., the footprint of the Landsat scene or, in case of a two-image strategy, the region covered by the intersection of the two TM acquisitions.
- areas within the mapped region that could not be interpreted, e.g., because of cloud occurring, or inaccessible areas that could not be unambiguously interpreted; in the case of a two image strategy, the non-mapped area is the union of the non-mapped areas of the two single images.
- burned areas, interpreted as having occurred between the two TM acquisition dates.

In this way, parts of the Landsat scenes that could not be interpreted, or that could not be mapped, would not be mistakenly considered unburned when the Landsat independent reference data were compared with the global burned area products.

Format of the reference data for long term archival

Moderate resolution burned area products have multiple users, who are interested in knowing the accuracy of different aspects of the product, and consequently, there can be no single accuracy measure synthesizing the information needs of all (Boschetti et al., 2006, Roy et al. 2006, Trigg and Roy 2007). Generally, users are interested in the per-pixel detection accuracy for local scale applications, e.g., for ecological and resource management applications, and users are interested in the precision and accuracy of total

burned area estimates at scales much coarser than the pixel size for large area reporting purposes and applications such as fire emissions modeling. (Here we use engineering conventions where precision indicates the repeatability of a set of measurements, usually expressed in terms of their standard deviation; and accuracy is the freedom from mistakes or error of the measurements, i.e. their conformity to independent reference data.)
It is not possible to anticipate a priori what accuracy measures will be computed from the reference data, therefore it is important to ensure that the data is archived and shared in such a format, that guarantees the maximum flexibility of use.
With reference to the CEOS definition of validation stages, if the validation data is part of a level 2 or level 3 validation, information must be provided about the criteria adopted for the selection (if part of a level 2 validation) or explicit sampling probability (if part of a level 3 validation).
The classified reference data should be made available at the original spatial resolution, in a well documented format (binary or self describing HDF- Hierarchical Data Format) with the geographic information provided (projection, pixel size, coordinate of the image corners). Precise information about the RS scene used for the production of the thematic data must be provided. In cases where the data is not covered by copyright, the original data should be made available as well, in order to allow future reprocessing of the validation data, or further characterization of information such as fire severity, combustion completeness.

Citation

This document is largely based on the following papers:

Roy, D.P., Frost, P., Justice, C., Landmann, T., Le Roux, J., Gumbo, K., Makungwa, S., Dunham, K., Du Toit, R., Mhwandagara, K., Zacarias, A, Tacheba, B., Dube, O., Pereira, J., Mushove, P., Morisette, J., Santhana Vannan, S., Davies, D., 2005. The Southern Africa Fire Network (SAFNet) regional burned area product validation protocol, *International Journal of Remote Sensing*, 26, 4265-4292.

Roy, D. and Boschetti, L., 2008. Southern Africa Validation of the MODIS, L3JRC and GlobCarbon Burned Area Products. Submitted to *IEEE Transactions on Geoscience and Remote Sensing*, June 2008.

Boschetti, L., Brivio, P. A., Eva, Hugh D., Gallego, J., Baraldi, A. and Grégoire, J-M., 2006. A Sampling Method for the Retrospective Validation of Global Burned Area Products, *IEEE-Transactions on Geoscience and Remote Sensing*, vol. 44 (7) Part 1, 1765 - 1773.

References

H. Eva, and E. Lambin, 1998. Remote sensing of biomass burning in tropical regions: sampling issues and multisensor approach, *Remote Sensing of Environment*, 64, 292-315.

Justice, C.O., Belward, A., Morisette, J., Lewis, P., Privette, J., Baret, F., 2000. Developments in the 'validation' of satellite sensor products for the study of land surface. *International Journal of Remote Sensing*, 21, 3383-3390.

Morisette J.T., Privette, J.L., Justice, C.O. 2002. A framework for the validation of MODIS land products. *Remote Sensing of Environment*, 83, 77-96.

Morisette, J.T., F. Baret, S. Liang, 2006. Special issue on Global Land Product Validation, *IEEE Transactions on Geoscience and Remote Sensing* 44(7), 1695-1697.

Strahler, A., Boschetti, L., Foody, G., Friedl, M., Hansen, M., Harold, M., Mayaux, P., Morisette, J., Stehman, S., Wodcock, C., 2006. Global Landcover Validation: Recommendations for Evaluation and Accuracy Assessment of Global Landcover Maps, Luxembourg, Office for Official Publication of the European Communities, EUR 22156 EN, 58p.

Rasmussen, K., Russell-Smith, J., Morisette, J.T., 2001, Establishing a validation site network for remote sensing applications to fire research: a joint activity between GOFC-Fire and the LPV subgroup. White Paper available at http://modis.gsfc.nasa.gov/MODIS/LAND/VAL/CEOS_WGCV/GOFC_LPV_fire_sites.pdf

Roy, D.P, Borak, J, Devadiga, S., Wolfe, R., Zheng, M., & Descloitres, J., 2002. The MODIS land product quality assessment approach. *Remote Sensing of Environment*, 83, 62-76.

Roy, D.P., Trigg, S.N., Bhima, R., Brockett, B., Dube, O., Frost, P., Govender, N., Landmann, T., Le Roux, J., Lepono, T., Macuacua, J., Mbow, C., Mhwandangara, K., Mosepele, B., Mutanga, O., Neo-Mahupeleng, G., Norman, M., Virgilo, S., 2006, The utility of satellite fire product accuracy information – perspectives and recommendations from the southern Africa fire network. *IEEE Transactions on Geoscience and Remote Sensing*, Land Product Validation Special Issue, 44 (7), 1928-1930.

Trigg, S.N. and S. Flasse, 2000. Characterizing the spectral - temporal response of burned savannah using in situ spectroradiometry and infrared thermometry. *International Journal of Remote Sensing*, 21, 3161-3168.

Trigg, S.N and Roy D.P., 2007. A focus group study of factors that promote and constrain the use of satellite derived fire products by resource managers in southern Africa. *Journal of Environmental Management*, 82, 95-110.

Appendix: Examples of application of the protocol

A) Time difference between the two images

Image 1: 23 Oct 2000

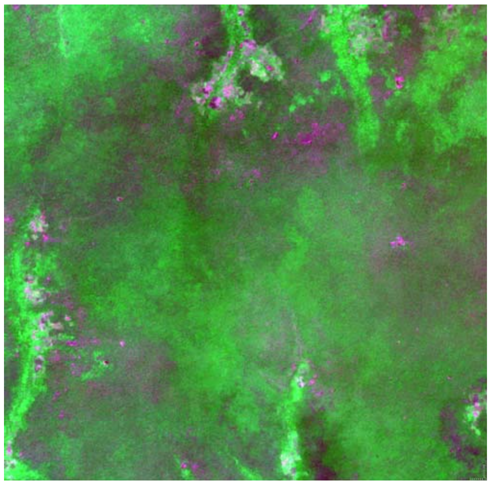
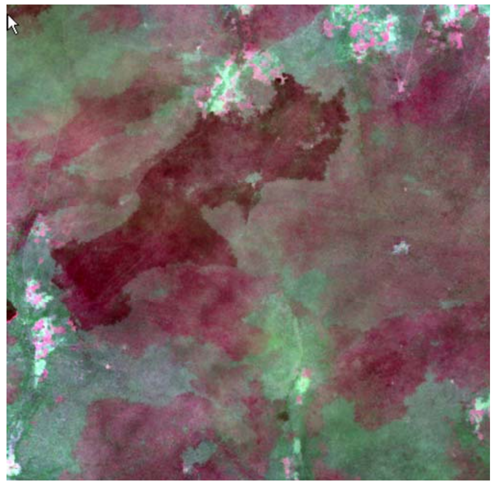


Image 2: 11 Jan 2001



INCORRECT: Excessive distance between the acquisition of the two images; the time interval is longer than the persistence time of the burned area spectral signal, and some of the older burned areas in image 2 cannot be reliably identified

Image 1: 3 Sept 2001

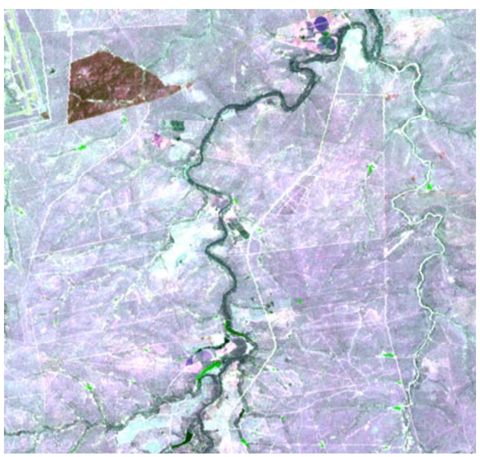
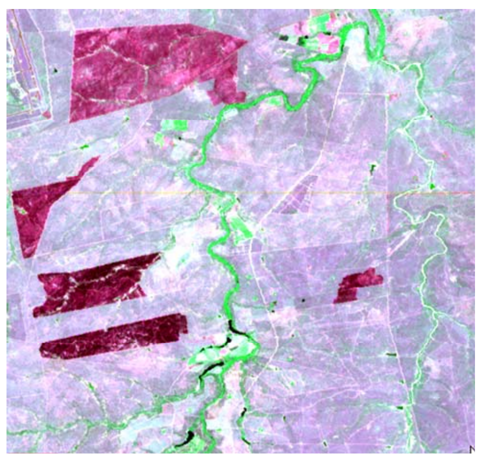


Image 2: 5 Oct 2001



CORRECT: the time interval is shorter than the persistence time of the burned area spectral signal, and all the areas burning between the acquisition of the first and the second image are clearly identifiable

B) Mapping the changes between the two dates

B.1. Burned vs. unburned

Image 1: 18 August 2001

Image 2: 3 Sept 2001

Interpretation

Image 1: 10 Sept 2001

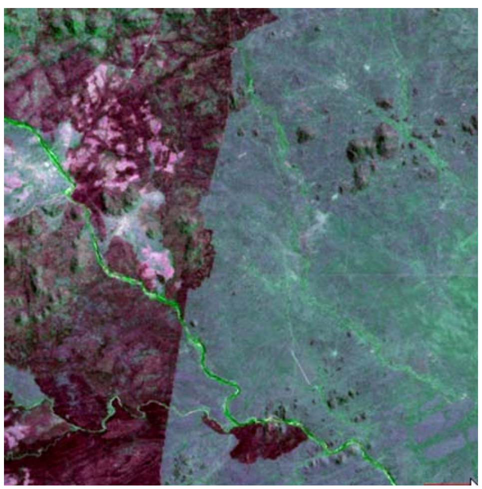
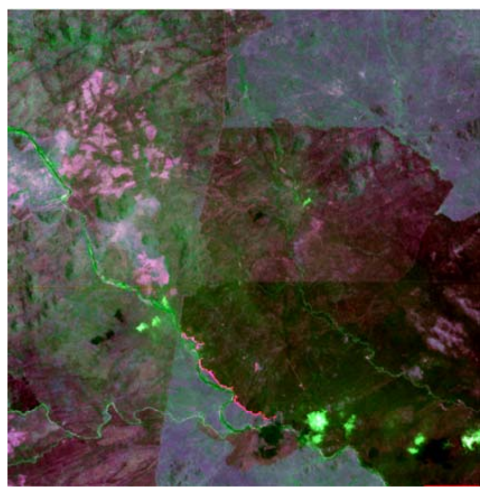


Image 2:12 Oct 2001



Interpretation

Only the portion of the burned area which burns between the two dates is digitised as burned (**red**), while the areas already burned in the first image are considered unburned (**black**)

B.2. Unmapped areas

Image 1: 23 Aug 2001

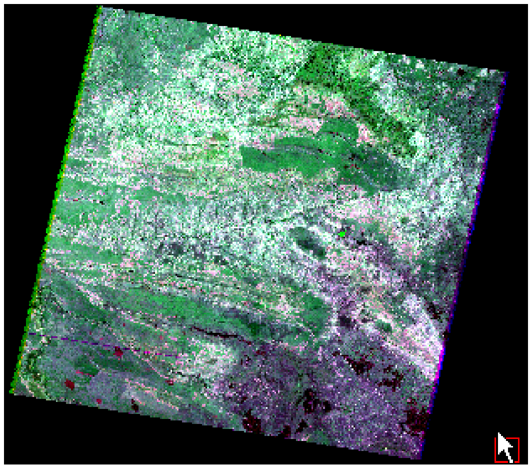
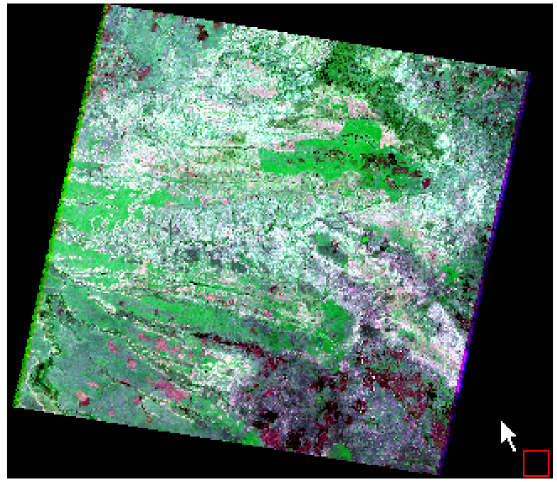
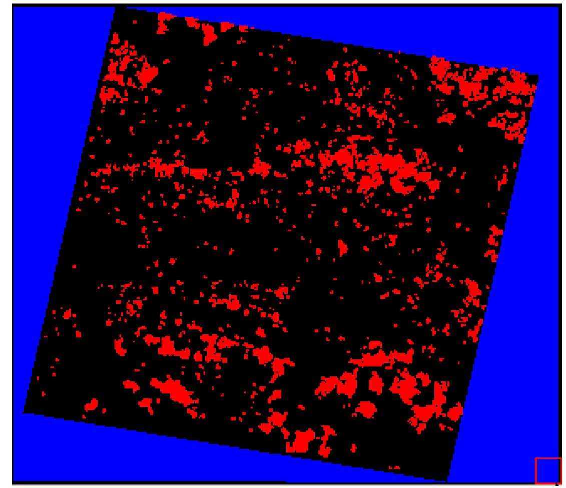


Image 2: 24 Sept 2001



Interpretation



It is important to define the footprint of the image, to differenciate between unmapped (**blue**) and unburned (**black**)

Image 1: 10 Sept 2001

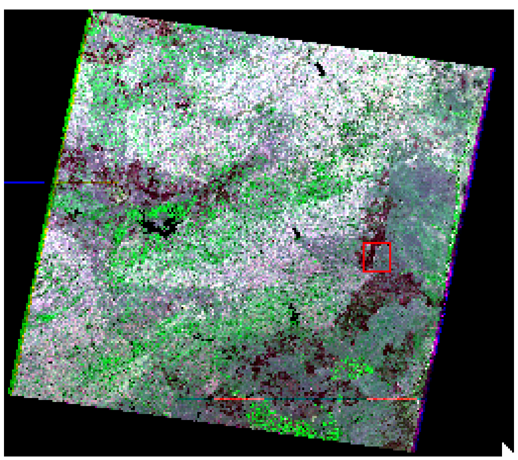
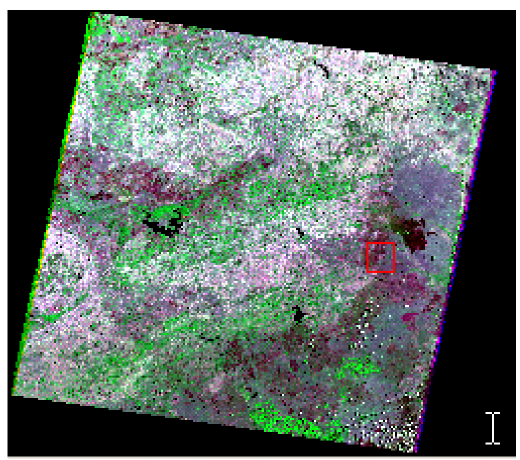
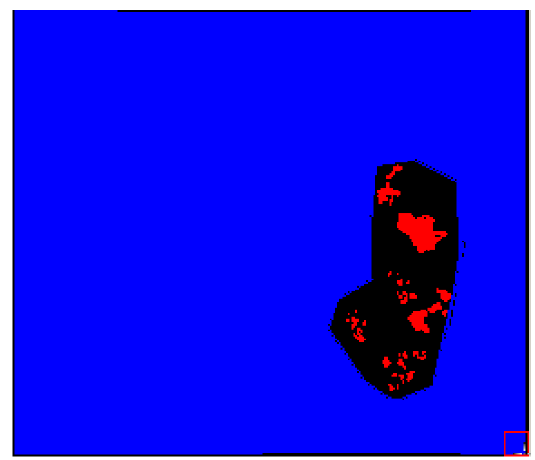


Image 2:12 Oct 2001



Interpretation



If a portion of the image cannot be interpreted because of the quality of the data, or the characterstics of the terrain, it must be labeled as unmapped (**blue**), not as unburned.

B.2. Unmapped areas

Image 1: 10 Sept 2001

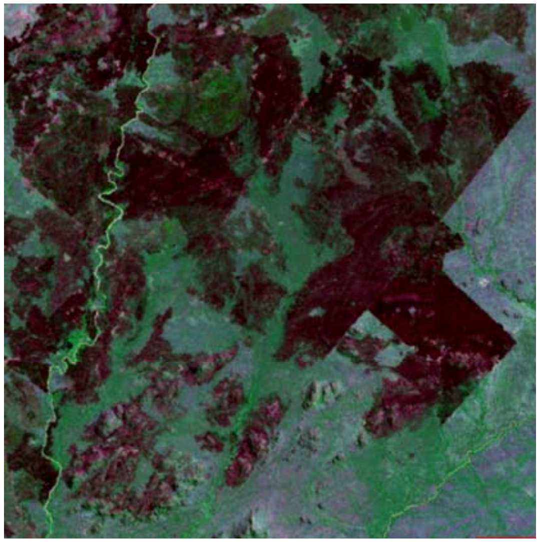
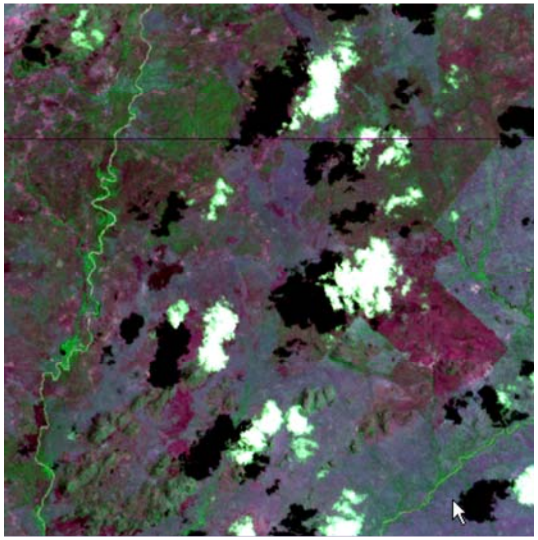
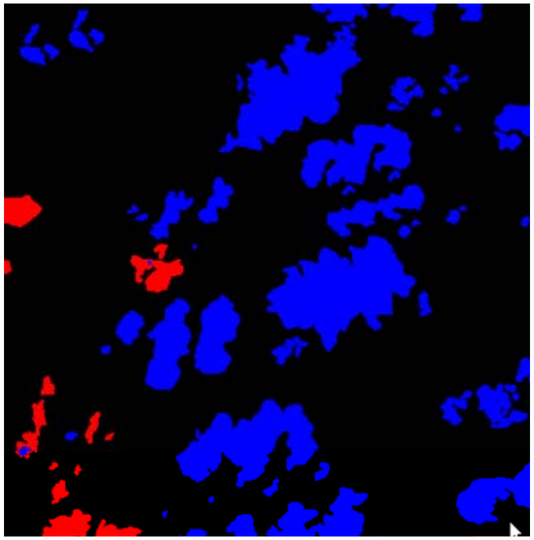


Image 2:12 Oct 2001

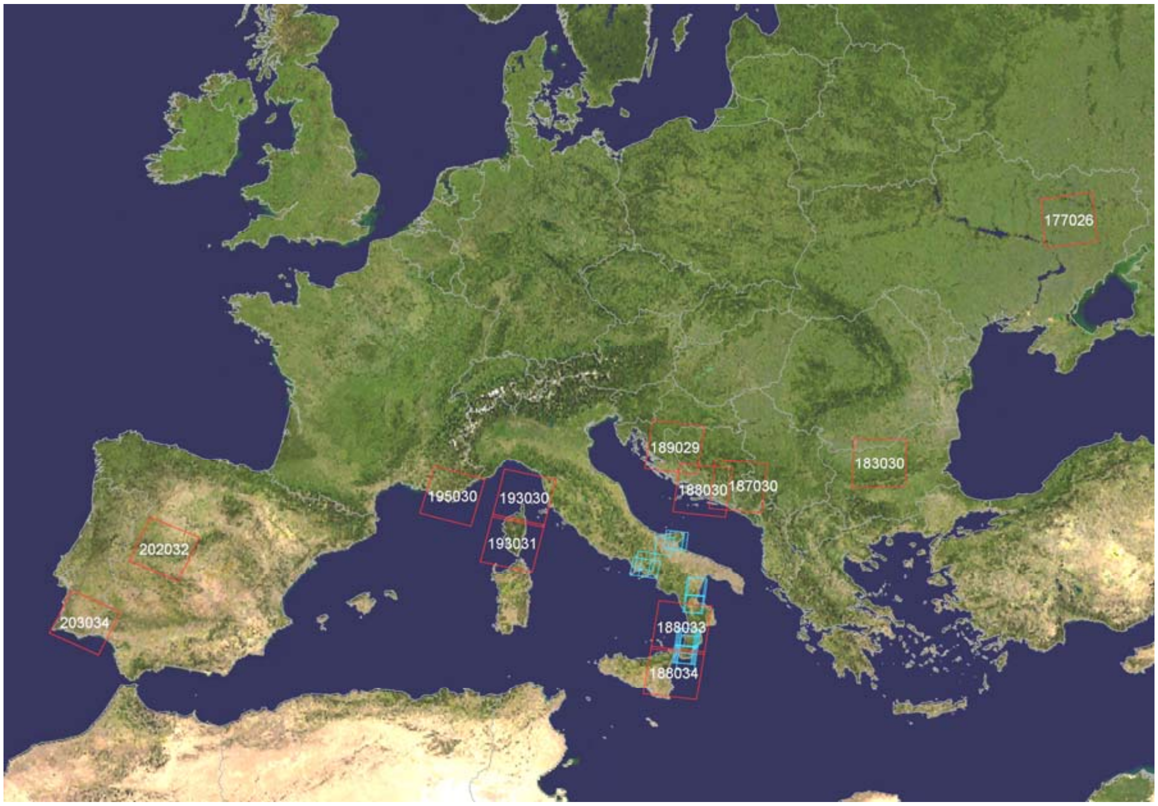


Interpretation



Clouds and cloud shadows that make the interpretation impossible on either image must be digitised and labeled as unmapped (**blue**)

Part 2:
Sites selected for the validation of the MODIS product for the Europe and the Mediterranean ecosystems



Blue: Aster images (already acquired and available at CNR-IREA)
Red: Landsat images, which will be provided by JRC-EC and US Geological Survey
Image list:
Landsat 5

Path-Row	Area	1st Image	2nd Image	
203/34	Portugal	2003/07/20	2003/10/24	
202/32	Spain	2003/07/29	2003/09/15	
195/30	France	2003/07/12	2003/09/14	
193/31	France (Corsica)	2003/07/14	2003/09/16	
193/30	France (Corsica)	2003/07/14	2003/07/30	2003/09/16
177/26	Ukraine	2003/07/30	2003/08/15	
183/30	Bulgaria	2003/08/09(*)	2003/08/25	(*) cloudy
189/29	Croatia	2003/05/07	2003/09/04(*)	(*) Landsat 7
188/30	Croatia	2003/06/25	2003/08/12	
188/34	Italy	2003/07/11	2003/07/27	
188/33	Italy	2003/07/11	2003/07/27	
187/30	Serbia, Bosnia	2003/08/05	2003/08/21	