Abstract—The Globcover initiative comprises the development and demonstration of a service that in first instance produces a Global land cover map for year 2005/2006. Globcover uses MERIS fine resolution (300m) mode data acquired between mid 2005 and mid 2006 and, for maximum user benefit, the thematic legend is compatible with the UN Land Cover Classification System (LCCS). This new product updates and complements the other existing comparable global products, such as the global land cover map at 1km resolution for the year 2000 (GLC2000) produced by JRC. It is expected to improve such previous global product, in particular because of the finer spatial resolution. The Globcover project is an initiative of ESA in cooperation with an international network of partner including EEA, FAO, GOFC-GOLD, IGBP, JRC and UNEP.

Keywords: MERIS FRS L1B, Global Mosaic, land cover

I. INTRODUCTION: WHY GLOBCOVER?

Building on the success of the GLC-2000 project (Global Land Cover map for the year 2000) coordinated by the JRC, ESA decided to launch the GLOBCOVER initiative in the framework of its Data User Element (DUE). The GLOBCOVER product is intended for European and international users, such as but not limited to, services of the European Commission, the European Environmental Agency (EEA), UNEP, FAO, GOFC-GOLD and IGBP. By example, GOFC-GOLD, which is an international program to monitor forest cover and land dynamics globally, push strongly to improve global land cover assessment (GEOSS, GCOS IP, IGOL …) because existing land data are not yet fully satisfying. IGBP has an interest in GLOBCOVER as a data source in the ongoing studies of land-cover and land-use
dynamics particularly to improve our understanding of the variation of the nature-society dynamics of land management, thereby facilitating the global modeling that is vital for climate impact and sustainability research. The Globcover concept of global land cover determination at fine spatial resolution with repeatability will contribute significantly to the body of data sources required for this effort.

II. GLOBCOVER MERIS INPUT DATA ACQUISITION

The MERIS 300m Full resolution Full Swath (FRS) products are the unique data source of the GLOBCOVER project. ESA made continuous effort to ensure the acquisitions and the production of the data for the period from 1st December 2004 to 30th June 2006. In order to deliver the full dataset of data, the MERIS FRS acquisition capacities had to be highly increased. This mainly results from a better strategy of acquisition between ASAR and MERIS instruments outside of Artemis Mask. Nevertheless some parts of the world (East of Amazonian basin, Central America, Philippines Islands, NE Quebec and Labrador, Korea Peninsula) are still sparsely covered (Fig 1). A new strategy of acquisition have been implemented in order to better use the ENVISAT on-board recorder and some MERIS FRS data are now available over these problematic regions.

III. IMPROVED GEOLOCATION APPROACH

ESA made also considerable effort in order to improve MERIS data Geolocation accuracy. Accuracy better than 150 metres was requested by Land community and, as a consequence, Globcover can use MERIS only if such requirement is satisfied. For this purpose, ESA provided AMORGOS software (developed by ACRI). This software requires as input the L1B MERIS Full resolution, the restituted attitude file and operational or precise orbit file. Completed with a projection toolbox implemented by MEDIAS, AMORGOS was integrated in the Globcover processing chain. The quality of the geolocation accuracy was assessed by a validation campaign based on 146 couples of MERIS product for the co-registration estimation and on 10 Landsat scenes for the absolute geolocation.

The MERIS-MERIS couples were automatically co-registered to each other using 1000s of tie points. The correlation measurement is performed using MEDICIS, a CNES correlation tool developed by the French company CS (Communication and Systems). Samples site were also selected with different latitude and topography. For each site, 4 season periods were considered in order to include the texture influence in the validation exercise. With a total RMS error of 51.5 metres and a low standard deviation of 26.2 metres, the quality of the co-registration between MERIS L1B products is very satisfactory.

The absolute geo-location of the ortho-rectified MERIS FRS product has been verified using imagery from Landsat ETM+ as reference (30 m spatial resolution). Ten scenes over the Spain-Morocco test area have been selected. Resulting from this exercise, the total RMS error equals to 77.1 metres and thus stays largely below the 150 metres required by the land community.

A representation of the results is given in Fig. 2 and Fig. 3. It shows for all couples (resp. MERIS-MERIS and MERIS-LANDSAT) the RMS error in longitude as a function of RMS error in latitude. The semi-circle represents the maximum RMS error defined by the GLOBCOVER project. Fig. 2 shows only 2 out of 146 tested couples do not satisfy the specification whereas all couples satisfies the Globcover requirements in Fig 3. However, these two couples correspond to deserted areas where, due to missing textures, disparity measurements are difficult to perform.

As the above presented results show, a globally precise ortho-rectified MERIS FRS product has been achieved by the means of AMORGOS completed by the projection tool. The estimated accuracies for co-registration (51.6 m) and geolocation (77.1 m) are largely smaller than 150 metres and
are therefore well in agreement with the GLOBCOVER specifications. It provides a geometrically stable source product for the further mean compositing and land cover classification within the GLOBCOVER processing chain.

IV. THE GLOBCOVER SYSTEM

The GLOBCOVER system consists of three components: (1) the GLOBCOVER software, (2) the execution environment and (3) the hardware. The system has to be capable to ingest all Level 1B MERIS full resolution full swath (FRS) data acquired over a full year plus intermediate and final products of the pre-processing and classification chain. In total it amounts to a data load of 46 TB.

A. Software

The GLOBCOVER software pre-processes and classifies MERIS full resolution full swath (FRS) Level 1b data to generate a time series of global mosaics (bimonthly and annual) and a global land cover map. The pre-processing subsystem (Fig. 4) is divided into Level 2 and the Level 3 processes. The Level 2 processing corrects the MERIS input images geometrically and radiometrically. The Level 3 processing generates MERIS FR temporal mosaics out of all valid pixel values acquired within a specified period. Finally, the classification chain (Level 4 processing, Fig. 5) transforms the mosaics into a meaningful global land cover product.

The pre-processing chain starts with the geometric correction of the MERIS Level 1b data. The geometric correction is handled by the self-standing software tool AMORGOS. After the geometric correction, the data runs through several processing steps to calculate surface directional reflectance (SDR). Algorithms have been implemented correcting images for atmospheric influences (i.e. gaseous absorption, Rayleigh scattering, aerosol effects), detecting and flagging clouds, snow areas and land/water bodies, and correcting the images for the smile effect inherent in MERIS data.

Before archiving the MERIS FR Level 2 data, images are projected and resampled into the plate-carrée projection. The previous full swath images are also subset into 5°x 5° tiles, which represents the standard size for GLOBCOVER product (HDF format).

Level 3 processing computes bi-monthly, seasonal and annual mosaics. The Bidirectional Reflection Distribution Function (BRDF) applies a compositing technique that generates bi-monthly mosaics while correcting the reflectance for different illumination and viewing geometries at the same time. Temporal compositing generates seasonal and annual mosaics by averaging the monthly mosaics over the selected period.

The classification subsystem generates a global land cover map out of these cloud-free mosaics. The classification runs separately for 22 equal-reasoning areas and is organized into five steps. The first process classifies the selected mosaics spectrally in a large number of classes. These classes are then temporally characterized by the computation of phenological parameters (start, end and duration of the vegetation period), using the time series of MERIS mosaics. The subsequent clustering algorithm uses the previous spectral and temporal information to group classes with similar characteristics in a manageable number (x) of spectro-temporal classes. The fourth processor, the referenced-based labelling function, transforms the x spectro-temporal classes into previously defined LCCS land cover classes. The final procedure is the expert-based labelling. It applies an upgraded set of labelling rules to improve on the referenced-based labelling and to produce the final land cover map. Regional land cover experts, who advise on the interpretation of the spectral-temporal classes, will define the improved labelling rules.

B. Execution Environment

The GLOBCOVER system has a modular design enabling a clear separation between the subsystems and their components. Modularity has been a key issue in the design to allow improvements in quality, reusability and performance.
However, clear and standardized interfaces are needed to link and run the individual modules smoothly.

A database-backed catalogue handles data provision to the pre-processing and classification subsystems. It deals with the storage and retrieval of input, auxiliary and output data. By acting as a central communication component, strong decoupling between components is favored, thus facilitating independent verification tasks, as well as integration testing.

Enforcing the modular design, the environment of the GLOBCOVER system has been projected with extended flexibility. The system handles multiple languages allowing the integration of external programs like AMORGOS, BEAM modules or ENVI routines, and the integration of native framework written in C++.

C. Hardware

The hardware system and its components were selected after consideration of robustness, repeatability and performance. The basic hardware architecture is a fibre-channel connected local network of computing resources: data storage and computing facilities interconnected in a multiple-path switched environment. The storage capacity was around 18 Tb during Phase I operated with 12 CPUs (2.6 GHz). In Phase II, additional disk space has been added to reach a final storage capacity of 54 Tb. To accommodate the increased need for computing resources, a doubling of the computing capacity (24 CPUs) guaranteed the data processing within the temporal processing limits of 60 days. Fig. 6 gives details on the high quantity of data processed and time computation for each module.

V. Conclusion

At the beginning of February 2007, ESA receives the first Global bimonthly Mosaic resulting from MERIS FRS data processed by the Globcover pre-processing subsystem. This mosaic shows the Global averaged surface reflectance for May-June 2005. A low resolution version of this mosaic was exhibited during the ENVISAT Symposium in Montreux on an 8 x 4 metres panel. This indicates that the first Globcover products start to be produced (i.e. bimonthly Global mosaic and samples of land cover map). Global mosaic will be open to public whereas the land cover map will be submitted to an intensive validation campaign led by a network of expert from several part of the world. The bimonthly and annual composites will be accessible through a web access tool based on the bit torrent technology. The availability of the products will be announce through international conferences by ESA and Globcover partners but also through the newsletter produced twice a year where the status of the project is described and latest news announced.

REFERENCES