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GLOBCOVER: products description and validation report

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GlobCover land cover over South America



→ GLOBCOVER

The most detailed portrait of Earth

Olivier Arino

Directorate of Earth Observation, ESRIN, Frascati, Italy

Patrice Bicheron

MEDIAS France, Toulouse, France

Frederic Achard

JRC, Ispra, Italy

John Latham

FAO, Roma, Italy

Ron Witt

UNEP, Chatelaine, Switzerland

Jean-Louis Weber

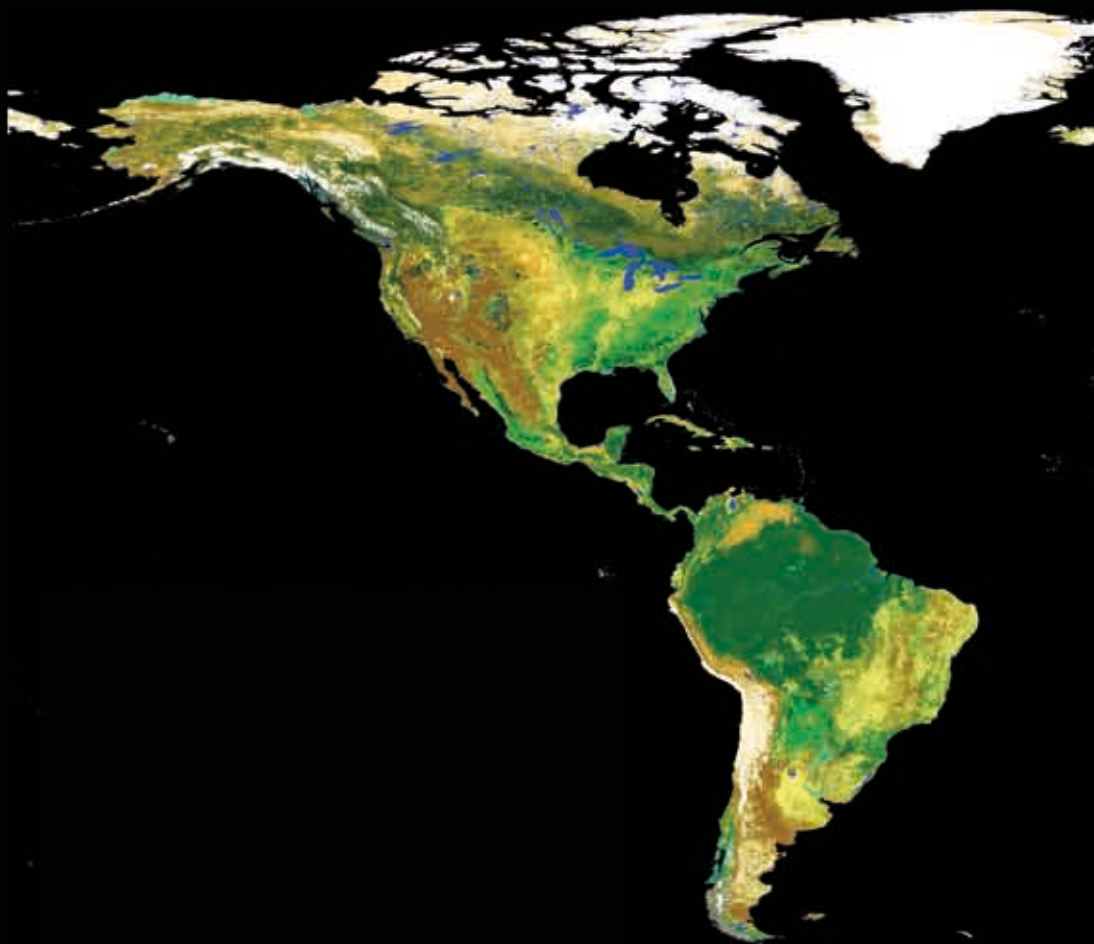
EEA, Copenhagen, Denmark

The most detailed maps ever of Earth's land surface have been created with the help of ESA's Envisat environmental satellite. Land cover has been charted from space before, but this global map has a resolution 10 times sharper than any of its predecessors.

The new global portrait is based on 40 terabytes of imagery – equivalent to the content of 40 million books – acquired by Envisat's Medium Resolution Imaging Spectrometer (MERIS)

instrument. ESA made a continuous effort to ensure the acquisitions and the production of the MERIS 300 m Full Resolution Full Swath (FRS) products for the period from 1 December 2004 to 30 June 2006.

In addition to being made fully available to the public upon its completion in September this year, scientists will use the data to plot worldwide land-cover trends, study natural and managed ecosystems and to model climate change extent and impacts. They are hailing the product – generated under the ESA-initiated GlobCover project – as a 'milestone'.



The GlobCover land cover product

More than a map

Bi-monthly products from January 2005 to June 2006 are available online. They can be accessed through a newly developed map server tool on ESA's GlobCover web site. In June 2007, additional bimonthly global composites were made available as well as the first part of a global land cover map over Eurasia.

However the GlobCover product is much more than a map. It is a scientific and technical demonstration of the first automated mapping of land cover on a global scale, and provides a basis for the detailed description of the land surface states needed for regional climate modelling.

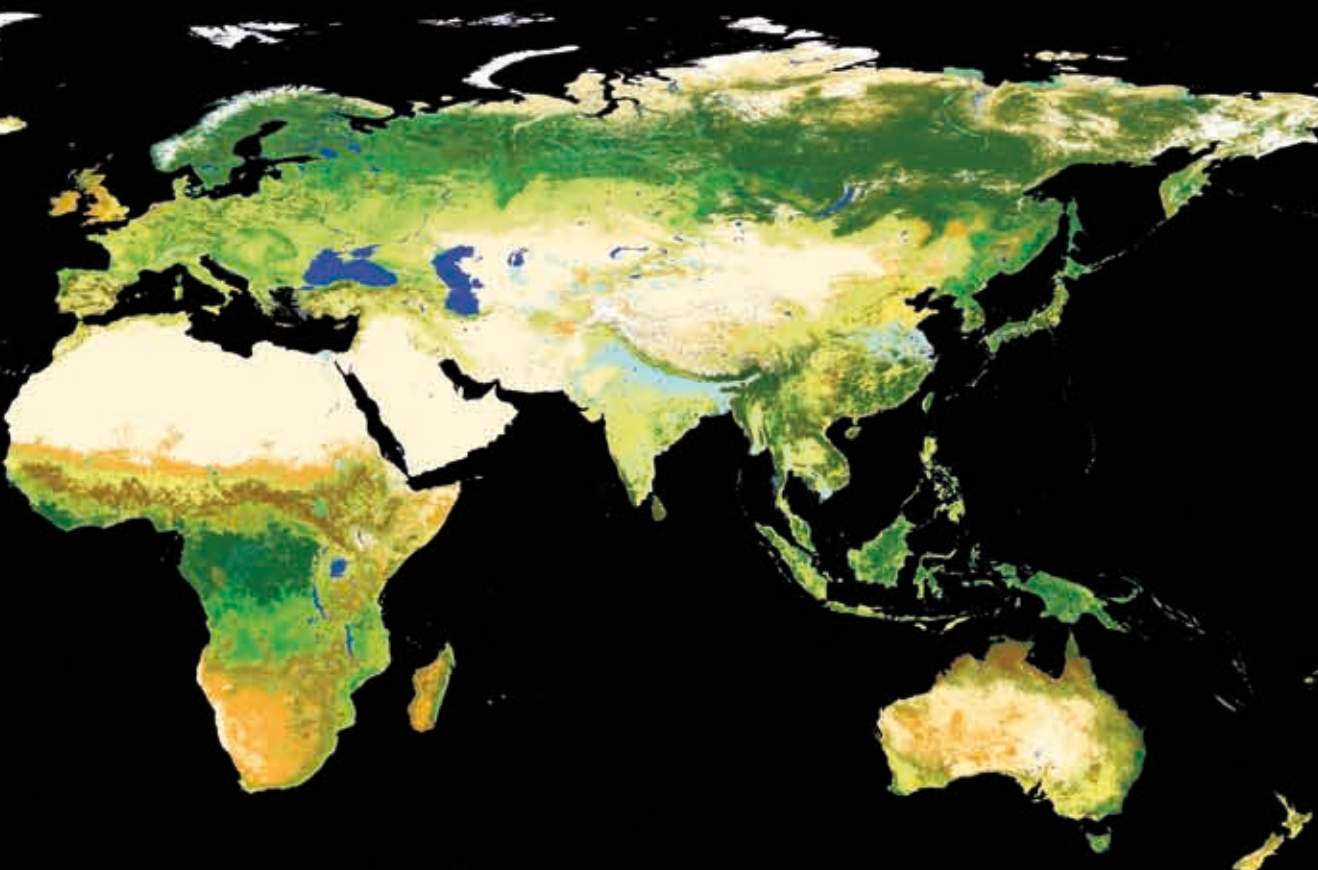
Information on land cover is an essential requirement of the sustainable management of natural resources, environmental protection, food security, climate change and humanitarian programmes. It forms a basis for ongoing studies of land-cover and land-use dynamics particularly to improve our understanding of the variation of the nature-society dynamics of land management, thereby facilitating

the regional and global modelling that is vital for climate impact and sustainability research.

The land cover product

The GlobCover land cover product is the first freely available product at 300 m resolution and is therefore a milestone product that will be fundamental to a broad-level stakeholder community. There are 22 different land cover types shown in the map, including croplands, wetlands, forests, artificial surfaces, water bodies and permanent snow and ice. For maximum user benefit, the map's thematic legend is compatible with the UN Land Cover Classification System (LCCS).

In order to deliver the full dataset, the MERIS (FRS) acquisition capacities had to be dramatically increased. This was achieved through a better strategy of acquisition between ASAR and MERIS instruments outside the view of the Artemis Data Relay Satellite. Nevertheless some parts of the world (east of the Amazonian basin, Central America, the Philippines, north-east Quebec and Labrador, the Korean

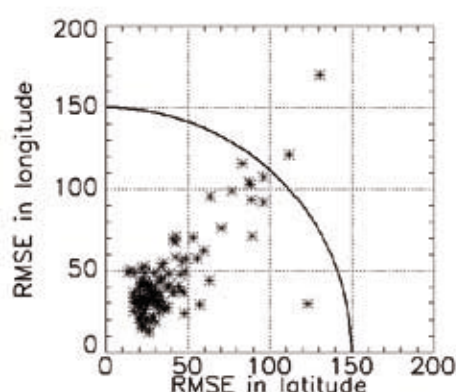


- Cultivated and Managed areas / Rainfed cropland
- Post-flooding or irrigated croplands
- Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)
- Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)
- Closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m)
- Closed (>40%) broadleaved deciduous forest (>5m)
- Open (15-40%) broadleaved deciduous forest/woodland (>5m)
- Closed (>40%) needle-leaved evergreen forest (>5m)
- Closed (>40%) needle-leaved deciduous forest (>5m)
- Open (15-40%) needle-leaved deciduous or evergreen forest (>5m)
- Closed to open (>15%) mixed broadleaved and needle-leaved forest
- Mosaic forest or shrubland (50-70%) and grassland (20-50%)
- Mosaic grassland (50-70%) and forest or shrubland (20-50%)
- Closed to open (>15%) shrubland (<5m)
- Closed to open (>15%) grassland
- Sparse (<15%) vegetation
- Closed (>40%) broadleaved forest regularly flooded, fresh water
- Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded, saline water
- Closed to open (>15%) grassland or shrubland or woody vgt on regularly flooded or waterlogged soil, fresh, brakish or saline water
- Artificial surfaces and associated areas (Urban areas >50%)
- Bare areas
- Water bodies
- Permanent Snow and Ice
- No data

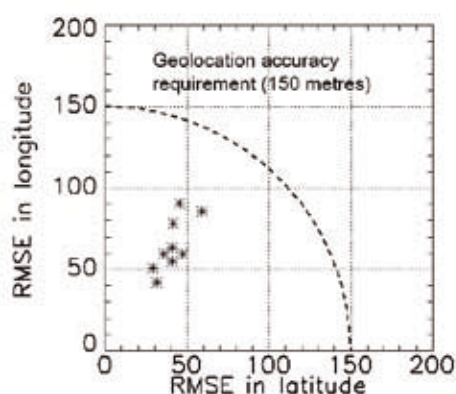
peninsula) are still sparsely covered. A new methodology combining MERIS FR and MERIS RR is under investigation to cover these problematic areas.

In order to be able to use the time series of measurements properly, ESA also made a considerable effort to improve MERIS data geo-location accuracy. A resolution of 150 m was requested by the user community and, as a consequence, GlobCover can use MERIS only if such requirement is satisfied. For this purpose, ESA commissioned ACRI to develop the AMORGOS software that takes as input the Level 1B MERIS FR, the restituted attitude file and operational or precise orbit file. AMORGOS was integrated in the GlobCover processing chain by MEDIAS, complete with a projection toolbox.

Relative Accuracy (Meris-Meris) in metres



Absolute Accuracy (Landsat-Meris) in metres



Geolocation accuracy of the MERIS products after AMORGOS processing. Upper plot shows the relative accuracy between MERIS-MERIS couples. Plot on the bottom shows the absolute accuracy between MERIS-Landsat couples. Semicircles represent the minimum accuracy requested by the GlobCover project

The quality of the geolocation accuracy was assessed using 146 pairs of MERIS products for the co-registration estimation. The absolute geolocation of the ortho-rectified MERIS FRS product was verified using 10 scenes from Landsat ETM+ (30 m spatial resolution) over a test area in Spain and Morocco. The result of this exercise was that the total RMS error associated with geolocation of MERIS FRS data was 77.1 m and thus the accuracy requirement set for the project was achieved, with only isolated images exceeding 150 m resolution.

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 FRS data acquired over a full year plus intermediate and final products of the pre-processing and classification chain. In total this amounts to a data load of 46 TB.

The pre-processing chain starts with the geometric correction of the MERIS Level 1B data. After the geometric correction, the data run through several processing steps to calculate surface directional reflectance (SDR). Algorithms have been implemented to adjust images for atmospheric influences (i.e. gaseous absorption, Rayleigh scattering, aerosol effects), to detect and flag clouds, snow areas and land/water bodies, and to correct the images for the smile effect inherent in MERIS data. Before archiving the resulting MERIS FR Level 2 data, the images are projected and resampled into the plate-carrée projection. The previous full swath images are also subset into $5^\circ \times 5^\circ$ tiles, which represents the standard size for a GlobCover product (HDF format).

Level 3 processing computes bi-monthly, seasonal and annual mosaics. A compositing technique using the Bidirectional Reflection Distribution Function to correct the reflectance for different illumination and viewing geometries is applied for the bi-monthly mosaics. Temporal compositing is then used to generate seasonal and annual mosaics by averaging 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 organised into five steps. The first process classifies the selected mosaics spectrally in a large number of classes. These classes are then temporally characterised 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 of spectro-temporal classes. The fourth processor, the referenced-based labelling function, transforms these spectro-temporal classes into previously defined LCCS land cover classes. The final procedure is the expert-based labelling. This applies an upgraded set of labelling rules to improve the referenced-based labelling and to produce the final land cover map.

(Based on a random sampling of 2186 cases, the experts achieved the following results for homogeneous land cover. For the principal classes, the users' accuracies are as follows: 82.7% for cultivated and managed terrestrial land, 69.5% for natural and semi natural terrestrial vegetation, 19% for natural and semi-natural aquatic vegetation, 63.6 % for artificial surfaces, 88.1 for bare areas, 74.1% for water snow and ice, while that for producers accuracies are 69.6, 87.8, 19.0, 43.8, 77.1 and 82.2%, leading to an overall accuracy of 77.9%. This value is principally due to the difficulty in mapping aquatic vegetation and artificial surfaces, which is being addressed in version 2.)

Interfacing with expert communities

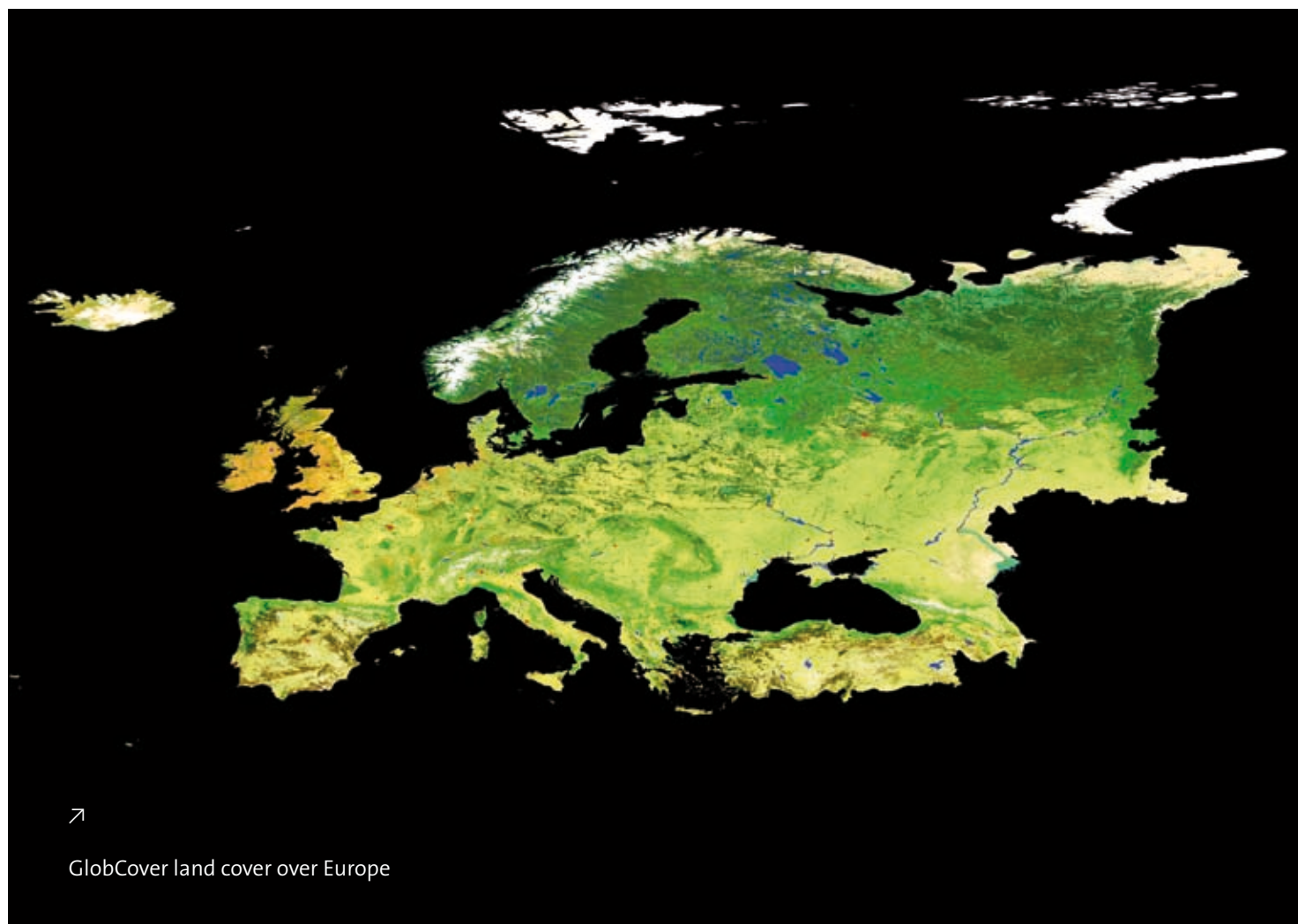
An international network of partners is working with ESA on the GlobCover project, including the UN Environment Programme (UNEP), the UN Food and Agriculture Organization (FAO), the European Commission's Joint Research Centre (JRC), the European Environmental Agency (EEA), the International Geosphere Biosphere Programme (IGBP) and the Global Observations of Forest Cover and Global Observations of Land Dynamics (GOFC-GOLD) Implementation Team Project Office.

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 system, developed and operated by Medias-France, together with Brockmann Consult, the Université Catholique de Louvain and partners, is a great step forward in our capacity to automatically produce new global land cover products with a finer resolution and a more detailed thematic content than ever achieved in the past.

A unique and fundamental component of the project was the continuous interface with this community of eventual users and the land cover expert community, to make sure that the resulting products were 'fit for purpose' and that the user community was ready to exploit the products once they became available.

The user community is represented in the project by key individuals from UNEP, FAO, JRC, EEA, IGBP and GOFC-GOLD. Their involvement was managed through four user consultations held at ESRIN, JRC and FAO where all elements of the project were discussed and reviewed. The automatic rules were tuned according to feedback from the user community received at these meetings. In addition, a team of regional land cover experts was engaged to advise on the interpretation of the spectral-temporal classes and thus improve the automatic labelling procedure.





GlobCover land cover over Africa

Online distribution

The 'online' distribution of gigabytes of data was also a key issue that ESA had to face. The solution was provided by the development of the IONIA GlobCover Access Tool (GCAT) that provides easy and fast internet access to the GlobCover data products. It is accessible to any 'authorised web user' through a simple password-protected registration scheme. Once authorised, users can select any subset of the GlobCover data product through a Graphic User Interface from where the type of product (bi-monthly, seasonal, annual), geographical area and time period can be set.

Data distribution uses the BitTorrent protocol (P2P) to capitalise on the number of simultaneous users and reduce the overall stress on the server during peak user access. For this reason, the GlobCover team (ESA and partners) participating in the distribution operate as 'seeders', in bit torrent terminology. In other words, they share servers where GlobCover products are stored. To optimise distribution performance, each GlobCover composite is sub-divided in Macro Tiles (4x4 GlobCover Tiles). Users can select which type of GCAT product they wish to download

(GlobCover tile, Macro tile, continental or world coverage). More information and data access can be found at : www.esa.int/duel/ionia/globcover

The following people also contributed to this project:

Franck Ranera, Nigel Houghton, Philippe Goryl, Henri Laur & Stephen Briggs

ESA Directorate of Earth Observation, ESRIN, Frascati, Italy.

Marc Leroy MEDIAS France, Toulouse, France.

Carsten Brockman Brockmann Consult, Geesthacht, Germany.

Sophie Bontemps, Pierre Defourny and Christelle Vancutsem

Université Catholique de Louvain, Louvain-La-Neuve, Belgium.

Hugh Eva, Hans Jürgen Stiebig and Philippe Mayaux JRC, Ispra, Italy.

Antonio Di Gregorio FAO, Roma, Italy.

Jaap Van Voerden UNEP, Chatelaine, Switzerland.

Andrus Meiner EEA, Copenhagen, Denmark.

Cristiana Schumullius Martin Herold, GOFC-GOLD, Jena, Germany.

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