Global Land Cover mapping using data from Earth observing satellites: current status and future perspectives

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Global Land Cover mapping using data from Earth observing satellites: current status and future perspectives

- The need for global land cover maps
- first steps - IGBP and TREES
- The GLC 2000 map
- Next steps – GlobCover 2005
- Concluding remarks
A growing demand for global land cover information

- **Scientific users and uses**
  - Earth system energy, water and material transport studies
  - General Circulation Models
  - Biological process models
  - Land surface process models

- **Political users and uses**
  - Environmental agreements
    - implementation and compliance
    - negotiation
  - Development and aid programmes
  - Humanitarian interventions
Global Land Cover mapping using data from Earth observing satellites: potential uses supporting EU policy

- **Future land cover and climate scenarios**
  - Inputs into GCMs
  - Locating development projects
  - Scenario building
Actual conditions of Southern Amazonia forest cover, 2000 (GLC2000)
These data can be used for modelling and scenario building.
Actual conditions of Southern Amazonia forest cover, 2000 (GLC2000)
First steps in Global Land cover mapping

- Only a decade of experience to build on

- In 1990 the IGBP identified major limitations to existing global land cover data sets
  - coarse spatial resolution, unknown accuracy, inappropriate classes, variable nomenclature, derived from disparate data sources, mix potential and actual cover and are dated

- The first global “1 km” resolution AVHRR data set was begun in April 1992
  - Contributions from 23 receiving stations, community consensus on data processing methods and standards, development of data processing software and analysis environment
First steps in Global Land cover mapping

–Meanwhile the Joint Research Centre’s TREES project produced the first global map of tropical forests from satellite data (1995)
  –Ad hoc data collection (AVHRR)
  –Targeted only at one biome
Continental mapping
DISCover

- The first 1 km land cover map, DISCover, was released in 1997
  - EROS Data Center, CNES and SPOT Image provided high resolution data for validation. Validation was completed by March 1999
- By end of 2000 alternative products (e.g., continuous fields) based on the 1 km AVHRR data are also available
Some lessons from DISCover

• Global land cover mapping is not a trivial undertaking
  – concerns for national security and national sovereignty
  – the lack of appropriate institutional infrastructures
  – technological and scientific constraints

• A fixed global land cover legend severely constrains the use of a global data set
  – Compromises regional and national relevance
  – Restricts use to specific modelling communities
  – Limited value for resource planning and management
  – Lacks flexibility as a source of reference data for multiple environmental conventions
Global land cover and burnt areas for the year 2000

GLC2000 / GBA2000

Produced by the Joint Research Centre with 30 other institutions
GLC 2000 - Global Land Cover 2000

Produced from 365 VGT satellite images collected in year 2000
Produced by a partnership of 30 organisations
Produced for Millennium Ecosystem Assessment, UNEP, FAO and policy end-users
The conception of the GLC 2000

-Regional maps produced in conjunction with regional experts

-Regional legend – interpreted at the global level using the FAO LCCS to 22 land cover classes

-A preliminary qualitative validation on the general spatial and thematic accuracy, followed by a statistical validation process using high resolution satellite data
Regional Experts working on data

Venezuela

Brazil

Southern Cone

Amazon forest
South America Map Production

- Multi-sensor approach
  - Humid forests detected using the ERS ATSR-2
  - Flooded forests ecosystems detected using the JERS-1 RADAR
  - Urban areas selected using the DMSP ‘night lights’
  - Remaining land cover from SPOT VGT
  - Montane forests from G5 TOPO DEM (amended)
Humid forests detected using the ERS ATSR-2

ATSR-2
1 km resolution: 500 km swath:
Green / Red / NIR / SWIR and TIR channels

- Over 1000 images to create a mosaic based on highest surface temperature – “tropical dry season”
- Unsupervised spectral clustering
- Class labeling for humid forests and non-forests
JERS-1 RADAR for flooded forests

- Two JERS-1 Mosaics – high water and low water

- Radar backscatter is increased by the 'double bounce' off water and trees; high backscatter shows flooded forests

- The difference between the two images shows up seasonally flooded areas
Creation of seasonal mosaics from S10 product

Jan-Mar  Apr-Jun  July-Sept  Oct-Dec
• Combining of VGT seasonal images
• Masking of evergreen forest (use of ATSR forest)
• Unsupervised clustering to 60 classes
• Class labeling and aggregation with seasonal profiles
Seasonal profiles extracted for each class

- Evergreen tropical forest
- Semi deciduous tropical forest
- Deciduous tropical forest (Chaco)
- Open deciduous tropical forest (Caatingas)
Validation Sampling Units
245 Landsat scenes
Secondary Sampling Units

5 blocks of 3x 3 km per Landsat scene
Centre ± 50km in X and Y (spatial autocorrelation)
Interpretation

• **Visual interpretation** of the blocks by 5 regional teams (e.g. Boston University, ECOFORCA, Indian Institute for Remote Sensing)

• Each block is interpreted according to **land-cover classifiers** instead of a predefined legend
  – Advantage: different accuracies can be computed at different levels of abstraction
  – Directly compatible with LCCS

• If more than one LC class, the **two main LC classes** of the block are described
How does the new GLC2000 map compare with the IGBP DisCover?

The use of regional partners has reduced the magnitude of major artefacts being left in the data in tropical regions where cloud contamination is high.

Apart from the global legend far richer thematic maps exist for Africa, South America, South East Asia, China and Eurasia.

IGBP produced a set of global legends for different end users.
Cote d’ Ivoire, Ghana and Togo: IGBP database
Cote d’ Ivoire, Ghana and Togo: University of Maryland database
Cote d’ Ivoire, Ghana and Togo: Global Land Cover 2000 database
IGBP (agriculture in yellow!)
The GVM unit of the JRC has produced a new global land cover classification for the year 2000 (GLC2000), in collaboration with over 30 research teams from around the world. The project was carried out to provide accurate baseline land cover information to the international conventions on Climate Change, the Convention to Combat Desertification, the Ramsar Convention and the Kyoto Protocol.

Furthermore, the GLC2000 land cover database has been chosen as a core dataset for the Millennium Ecosystem Assessment. This means in particular that the GLC2000 dataset is a main input dataset to define the boundaries between ecosystems such as forest, grassland, and cultivated systems.

In contrast to former global mapping initiatives, the GLC2000 project is a bottom-up approach to global mapping. In this project more than 30 research teams have been involved, contributing to 19 regional windows. Each defined region was mapped by local experts, which guaranteed an accurate classification, based on local knowledge.

Each regional partner used the VEG3200 dataset, providing a daily global image from the Vegetation service onboard the SPOT4 satellite. Each partner also used the Land Cover Classification System (LCCS) produced by FAO and UNEP (UNEP 1996, 2000), which ensured that a standard legend was used over the globe. This hierarchical classification system allowed each partner to choose the most appropriate land cover classes which best describe their region, while also providing the possibility to translate regional classes to a more generalised global legend.

The GLC2000 and SPOT Vegetation Global mosaic is now available in a Zoomify viewer.

MODIS Land Cover at 1 km
Different class schemes
Future prospects

GlobCover 2005

A joint venture between the European Commission Joint Research Centre and the European Space Agency (ESA)

-A global land cover map for the year 2005

-Based on the ENVISAT MERIS instrument (300m resolution)

-Data collection starts in 2005

-Map production in 2006

-Global legend, reliable at regional levels

-Incorporate regional experts for map legend and validation
Improvements over GLC2000

- Spatial resolution; from 1 km to 300m
- Thematic classes; improvements in urban / agriculture / wetlands
- Production time; on the basis of experience we expect to half the production time of the map
- Repeatability
Example of the improvement in mapping quality going from GCL2000 to Globcover 2005

University of Swansea, SIBERIA II

1 km land cover: VGT

300 m land cover: MERIS
New constraints, new products

- Legally binding contexts increase requirements for full accountability
  - accurate (and quantified) product descriptions
  - reliable product delivery
  - greater range of products required
  - guaranteed global product availability on demand
Prerequisites

- suitable sensors on suitable platforms
  - VEGETATION, MODIS, MISR, SeaWiFS, (AVHRR), POLDER, GLI, MERIS and ASAR and then……..
- suitable data processing / data distribution strategies and facilities
  - CTIV, EOS and ENVISAT ground segments
- suitable global land cover classifications
  - User specific, generic: discrete, continuous fields, physical
- suitable analytical and data classification approaches
  - supervised, unsupervised, decision tree, neural net, angular
- suitable institutional frameworks
  - production centres, partnerships, networks
We can therefore expect to see in the future

Multi-sensor derived global maps

Finer spatial resolution maps

Sets of derived products (à la MODIS) i.e. User specific, generic: discrete, continuous fields, physical

A far higher turn round on updating and revising