Global land cover validation and a “Best Currently Available” LC Map

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And the LC IT

www.fao.org/gtos/gofc-gold
www.gofc-gold.uni-jena.de
International drivers

1. United Framework Convention on Climate Change:
   - Reduce uncertainties in monitoring the global climate system through observing essential climate variables
   - Capacity building needs to address stronger role of developing countries in post-2012 agreement

2. Group on Earth Observation (GEO) task DA-07-02:
   - “Provide a suite of global land cover datasets, initially based on improved and validated moderate resolution land cover maps and eventually including land-cover change at high resolution (task co-lead by USGS and GOFC-GOLD)”

3. Global land cover monitoring and assessments:
   - GLOBCOVER, FAO-Forest Resources Assessm. 2010
   - Operational validation / Efforts for deriving “Best map”
## Observing Essential Climate Variables (ECVs)

<table>
<thead>
<tr>
<th>Terrestrial ECV</th>
<th>Observing System (i.e. ESA, others)</th>
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<tr>
<td>River Discharge</td>
<td>In situ networks,</td>
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<td>Water Use</td>
<td>In situ networks, regional remote sensing activities</td>
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<td>Groundwater</td>
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<td>Lake and Reservoir Levels &amp; Volumes</td>
<td>In situ networks, regional remote sensing activities</td>
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<td>Snow Cover</td>
<td>GLOBSNOW</td>
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<td>Glaciers and Ice Caps</td>
<td>GLOBGLACIER</td>
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<td>Permafrost</td>
<td>Regional activities (i.e. circum-arctic)</td>
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<td>Albedo and Reflectance Anisotropy</td>
<td>GLOBALBEDO</td>
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<tr>
<td>Land Cover</td>
<td>GLOBCOVER, MODIS land cover ...</td>
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<tr>
<td>Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)</td>
<td>GLOBCARBON, MODIS and Seawifs products</td>
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<td>Leaf Area Index</td>
<td>GLOBCARBON, MODIS products</td>
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<tr>
<td>Biomass</td>
<td>Regional activities, e.g. Siberia</td>
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<tr>
<td>Fire Disturbance</td>
<td>Several global products from AATSR or MODIS</td>
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<tr>
<td>Soil moisture</td>
<td>SMOS satellite mission</td>
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Overview

1. As the land cover community matures, an increasing emphasis on validation and accuracy assessment - a difficult, somewhat unpleasant and somewhat surprisingly expensive activity

2. The LC IT has decided to try to support the broader community through validation

3. Idea is to collect ground reference data independent of any single land cover product to support validation of many land cover datasets

4. Intent is to supplement and complement ongoing validation activities associated with individual land cover datasets
GLOBCOVER (2005/6)

Beta version in review by GEO task team
Dataset release: September 2008
Notion of a “Best Currently Available” Land Cover Map

Combine the strengths of multiple sources of land cover data across multiple extents and resolutions (national, regional and global sources)

Based on what is learned in the validation exercise

A transparent and community endorsed activity

LCCS compatibility is critical

Simple guidance criteria:
  more accurate is better
  finer spatial resolution is better
  more thematic detail is better
DA-07-02 key activities

Global level

Strategies (IGOS): Integrated Global Observations for land (IGOL)
Standards: LCCS land cover classifiers and validation procedures
Integration of IGOL into GEO
Harmonization: “best” available map
New global products: GLOBCOVER (link to regional level)
Continuity of observations:
Mid-decadal global Landsat survey (MDGLS)
Global Land Survey 2010
Specifications for fine-scale global land cover change dataset (incl. validation framework)
Technical guidance for UNFCCC/REDD (GOFC-GOLD sourcebook)
Capacity building and support of global assessments:
GLCN + GOFC-GOLD networks / FAO-FRA global remote sensing survey

National level
Supporting Developments

1. Prior experiences with global land cover validation
2. Emergence of LCCS - and its value in promoting consistency in land cover descriptors used in the development of legends for land cover datasets
3. Development of community consensus on "best practices for global land cover accuracy assessment (CEOS WGC report)
International consensus on technical issues

“Best Practices Document”

Strahler et al., 2006
A “Living Reference Dataset”

A set of validation sites distributed around the globe.

Based on high resolution (a few meters) imagery interpreted by regional experts (the regional networks).

Checked annually for land cover change, and updated periodically.

Limited set of land cover classifiers:
- Life form - (trees, shrubs, herbaceous)
- Cover
- Leaf type
- Leaf phenology
Land Cover validation framework

- Effort serves purpose for estimating:
  - Individual map accuracy / best available map
  - Area of land-cover classes
- Sampling design:
  - 10 km by 10 km block (Landsat – MODIS)
  - Flexible to increase sample size to provide precise country or region specific estimates
  - Stratification by geographic reporting regions, areas where maps differ, important rare land-cover classes
- Response design:
  - Reference data (high resolution) interpreted by regional experts (i.e. GOFC-GOLD networks) using LCCS classifiers
- Analysis design:
  - Error matrix for each map and region
  - Estimates of class area
  - Supplementary accuracy information on land-cover composition and landscape pattern
Integrated land cover observations

IN-SITU (+ IKONOS type) periodically (usually 1-10 yrs)
Detailed physionomy
Floristics and species distribution
Crop type and rotation etc.

Effort for frequent update

Spatial detail

Assuming observation continuity and consistency

Thematic detail

MODIS/MERIS – type (intra-)annual
Land type/Phenology

Vegetation physionomy

LANDSAT/SPOT – type inter-annual (1-5 yrs)

In situ database
Global archives
Global daily observations

Completed and endorsed by IGOS partnership and GEO in 2007

From Herold et al. 2008, IEEE Systems
Operational LC validation framework

- Design based sample of reference sites
- LCCS-based Interpretation (Regional Networks)
- Updated interpretations
- Updated valid/change
- Validation of new products
- Comparative validation
- Existing global LC products
- Data reprocessing
- Product synergy
- Reference database: statistically robust, consistent, harmonized, updated, and accessible

Legend translations

In-situ global

Degree of usability and flexibility

Time
Categories in existing global datasets

Terminology: land cover classifiers (LCCS)

Translation

**Common classifiers**
(Terminology standard)
- Classifiers commonly used to characterize land cover worldwide
  - i.e. life form & surface type, leaf type & phenology, terrestrial/aquatic

**Generic classes**
(Thematic standard)
- Basic set of standardized classes based on combination of common classifiers and independent of any cartographic standard
  - i.e. broadleaved evergreen trees, herbaceous crops, built up area

**Mapping Categories**
(Cartographic standard)
- Application of cartographic generalization (MMU) to generic classes
- Definition of mixed categories or using density thresholds
  - i.e. Closed to open (>15%) broadleaved evergreen forest (> 5m)
Thematic standards

Common classes (Terminology standard)
- Classes commonly used to characterize land cover/cover
- i.e. forest, surface type, land use & planning, thematic/climatic

Generic classes (Thematic standard)
- Basic set of standard classes, based on combination of common classes and independent of any cartographic standard
- i.e. natural, farming, urban, forest, etc.

Mapping categories (Cartographic standard)
- Application of comprehensive generalization
- UMD to generic classes
- Definitions of novel categories or using density thresholds
- i.e. pixels to objects (15x15 pixels threshold)

Reference database (GLC2000)

Comparative validation & assessment

Class dominance within reference 3x3 pixel neighborhood (%)
Thematic standards

**Common classification** ( Terminology standard)
- Characterize land cover characteristics
- Includes surface type, land cover, land use

**Generic classification** (Thematic standard)
- Based on standardization, based on combination of common classes and independent of any cartographic standard
- Includes: non-urban land, vegetation, etc.

**Mapping categories** (Cartographic standard)
- Application of thematic classification to a geographic domain
- Definition of discrete categories using density thresholds
- Includes: e.g., IGBP land cover classes

Reference database (GLC2000)

Comparative validation & assessment

**Trees (>15%)**, shrubland, grassland, agricultural cropland, Non vegetated land

- GLC2000
- IGBP
- MODIS
- UMD
- Combined Classes

Probability
Thematic standards

- Common classifications (Terminology standard)
  - Classified commonly used to characterize land cover/extent
  - I.e., forest & surface type, climate & precipitation, land use & land cover

- Generic classes (Thematic standard)
  - Based on standardized classes, based on combination of common classes and independent of any cartographic standard
  - I.e., small deciduous groves, deciduous groves, etc.

- Mapping categories (Cartographic standard)
  - Application of thematic category resolution
  - Merging of new categories or using density thresholds
  - Classification for species (e.g., broadleaved evergreen Bay scales)

Reference database (GLC2000)

Comparative validation & assessment

Probability maps

For different datasets, classifiers and landscape heterogeneities

Synthesis/improved maps

Dominant life form

Legend
- 0
- Trees
- Shrubland
- Grassland/herbaceous
- Agriculture/managed land
- non forested

Accuracy
Next Steps

1. Sample Site Selection
2. Find a source for the imagery (several meters)
3. Get the imagery collected and processed
4. Prototype effort
5. Identify regional experts for interpretation
6. Find support for the interpretation by the regional experts
   - training workshops
   - capacity building
   - support for the interpreters
7. Begin validation analysis (working with the land cover data providers)