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CAPACITY BUILDING FOR HIGH-RESOLUTION LAND COVER INTERCOMPARISON AND VALIDATION: WHAT IS AVAILABLE AND WHAT IS NEEDED

M. A. Brovelli, M. Minghini, M. E. Molinari, H. Wu, X. Zheng, J. Chen

Context

- **Land Cover (LC) maps: a key class of global geospatial datasets**
  - LC maps are fundamental for a wide range of users and applications such as planning, nature and biodiversity protection, natural resources management, etc.
  - LC products represent a key input to monitor the indicators of the Sustainable Development Goals (SDGs)

- LC data promote evidence-based policy-making on issues like soil consumption and deforestation

Context

- **High-resolution LC maps** are rapidly increasing due to the continuous advances in Remote Sensing sensors and mapping technologies
  - Several countries (e.g. EU, USA, Australia) and political organizations have their own high-resolution LC maps
  - Developing countries do not have their own high-resolution datasets but they can benefits from the free availability of global high-resolution LC products (e.g. GlobeLand30)

Context

- It is important that data users and producers in the fields of GIS and RS, especially in developing countries, have:
  - **Awareness** of the existence and importance of global high-resolution LC maps
  - **Capability to perform** high-resolution LC maps **validation** and **intercomparison** to determine their usability for different applications

"Capacity Building for High-Resolution Land Cover Intercomparison and Validation" project

Outline

- Global high-resolution LC maps
- Crowdsourced geographic information for LC
- LC data validation and intercomparison methods
- Capacity buildings on LC project: tasks and results

Global and high-resolution LC maps

Name	Resolution (m)	Temporal Coverage	Producer
FROM-GLC	30	2010, 2015	Tsinghua University
GlobeLand30	30	2000, 2010	National Geomatics Center of China (NGCC)

Global and high-resolution LC maps

Name	Resolution (m)	Temporal Coverage	Producer
FROM-GLC	30	2010, 2015	Tsinghua University
GlobeLand30	30	2000, 2010	National Geomatics Center of China (NGCC)
Global Water Surface	30	1984-2015	Joint Research Centre (JRC)
Forest / Non-Forest map	25	2007-2010 2015-2016	Japan Aerospace Exploration Agency (JAXA)
Global Urban Footprint	12	2011	German Aerospace Center (DLR)
Global Human Settlement Layer	38	1975, 1990, 2000, 2014	Joint Research Centre (JRC)
Tree Cover	30	2000	University of Maryland
Global forest cover gain		2000-2012	
Global forest cover loss		2000-2015	

Crowdsourced geographic information for LC

- Citizen-sensed geographic datasets are highly suitable for LC mapping for their (potential) **ubiquity**, **up-to-dateness**, **richness** and **level of detail**
    - Volunteered in-situ observations are now integrated within EU official projects and programmes (e.g. SCENT, LandSense, GroundTruth2.0)
    - Many initiatives involve citizens in collecting LC data for map training and validation (e.g. Geo-Wiki, VIEW-IT, FotoQuest Austria, Land Cover Validation Game)
    - Data from other crowdsourcing projects may be very useful for LC mapping (e.g. Geograph, Flickr, Instagram, Google's Panoramio, Degree Confluence Project, OpenStreetMap)

Validation and intercomparison methods

- Since the mid-1980s, **error/confusion matrix** is considered *"The standard descriptive reporting tool for accuracy assessment of remotely sensed data"* [1]

	Reference (ground truth) map				
Classified (comparison) map	Class	j=1	j=2	…	j=q
	i=1	n_{11}	n_{12}	…	n_{1q}
	i=2	n_{21}	n_{22}	…	n_{2q}
	…	…	…	…	…
	i=q	n_{q1}	n_{q2}	…	n_{qq}

[1] Lunetta, R.S., Lyon, J.G., 2004. Remote Sensing and GIS Accuracy Assessment, CRC Press, Boca Raton, FL

Validation and intercomparison methods

- Many **accuracy indexes** can be derived from confusion matrix:
  - Most commonly used:
    - ✓ Overall accuracy
    - ✓ Producer's accuracy
    - ✓ User's Accuracy
  - Derived from P0, PA, UA
    - ✓ Average of user's accuracy or of producers accuracy
    - ✓ Combined user's or producer's accuracy
    - ✓ Hellden's mean accuracy
    - ✓ Short's mean accuracy
    - ✓ Classification success index and its variations: Group Success Index and Individual Classification Success Index
  - Margfit

Validation and intercomparison methods

- Derived from information theory
  - ✓ Average mutual information and different ways of normalizing it (arithmetic mean, geometric mean)
- Kappa and kappa-like indexes
  - ✓ Standard kappa index
  - ✓ Conditional kappa
  - ✓ Weighted kappa
  - ✓ Tau
  - ✓ Aickin's alpha
  - ✓ Ground truth index
- Indexes of disagreement
  - ✓ Quantity disagreement
  - ✓ Allocation disagreement

Validation and intercomparison methods

- **Validation** of available high-resolution LC maps is **still undergoing** at the international level:
  - Brovelli et al. (2015) compared GlobeLand30 with high-resolution reference data in Italy obtaining an overall accuracy higher than 80%
  - Manakos et al. (2015) validated the land surface water and the drainage network layers of GlobeLand30 for a region in Greece obtaining an overall accuracy of 91.9%
  - Arsanjani et al. (2016) compared GlobeLand30 in Germany with existing datasets (e.g. the national ATKIS) obtaining up to 92% of agreement
  - Mück et al. (2017) validated Global Urban Footprint for Burkina Faso, showing its enhanced mapping capabilities for rural areas

Validation and intercomparison methods

- Minghini et al. (2017) compared GUF and GHSL both with each other and with official products for Milan (Italy) showing good agreements
- Leyk et al. (2018) developed an accuracy assessment framework for multi-temporal built-up layers using public parcels and building records as validation data. The framework was successfully tested on Global Human Settlement Layer in the United States
- Arsanjani (2018) performed an intercomparison between the 2000 and 2010 versions of GlobeLand30, highlighting massive LC change patterns such as deforestation, desertification, urbanization and shrinkage of water bodies

Capacity buildings on LC mapping project

- It is funded by the International Society for Photogrammetry and Remote Sensing (Educational and Capacity Building Initiatives 2018)

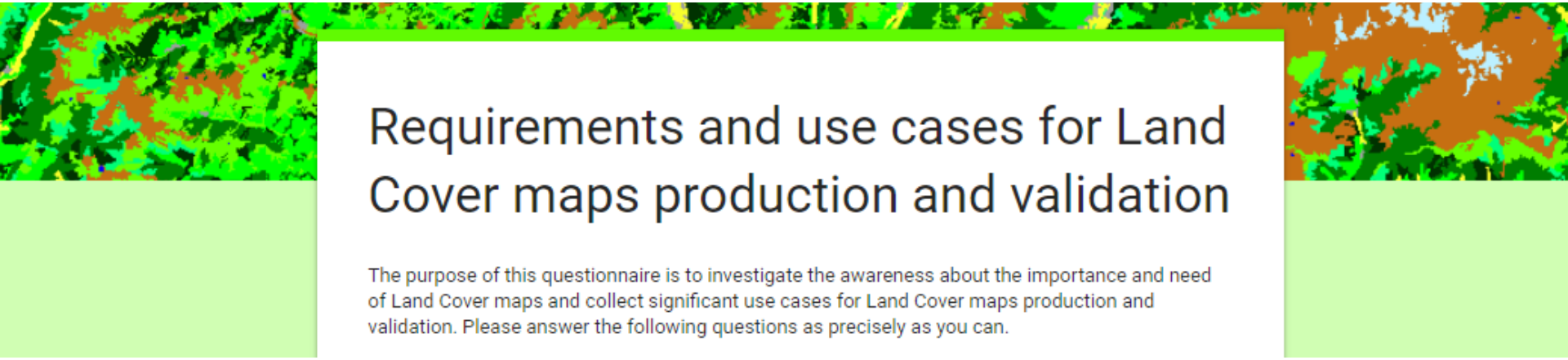
> *"A Declaration ratified by delegates at the XXIII ISPRS Congress calls on international communities to* ***work together*** *and* ***promote multi-disciplinary collaboration*** *towards providing* ***reliable geospatial information*** *to* ***support societal transformations*** *towards* ***global sustainability****."*
>
> ISPRS Prague Declaration, General Assembly, XXIII ISPRS Congress, 12-19 July 2016, Prague

- The objective is to create new knowledge and tools to educate and raise awareness on the intercomparison and validation of global high-resolution LC maps, mainly in developing countries
- The initiative started in February 2018 and will end in January 2019. It is composed of four tasks

Capacity buildings on LC mapping project

- **TASK 1**: Analysis of the needs, requirements and limiting factors in using and validating LC maps from a user's perspective, with special focus on developing countries

  Ad hoc questionnaire aimed at assessing the general awareness about the existence and importance of LC maps as well as the need for their intercomparison and validation



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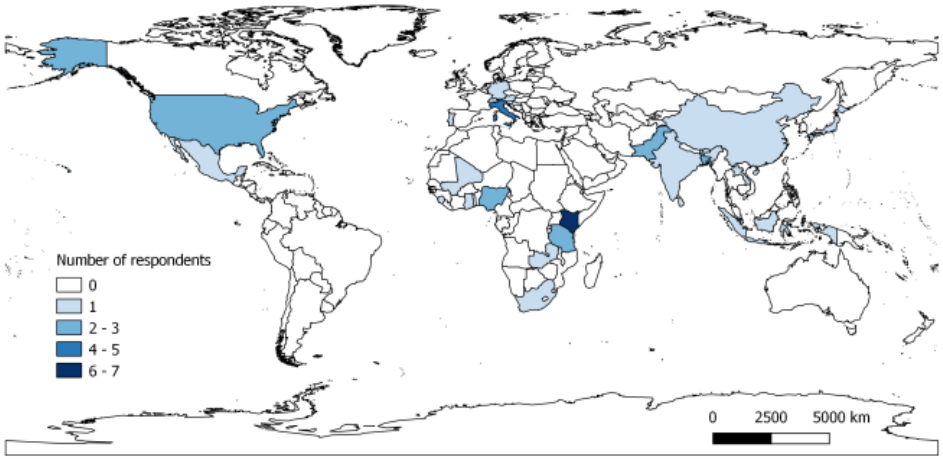
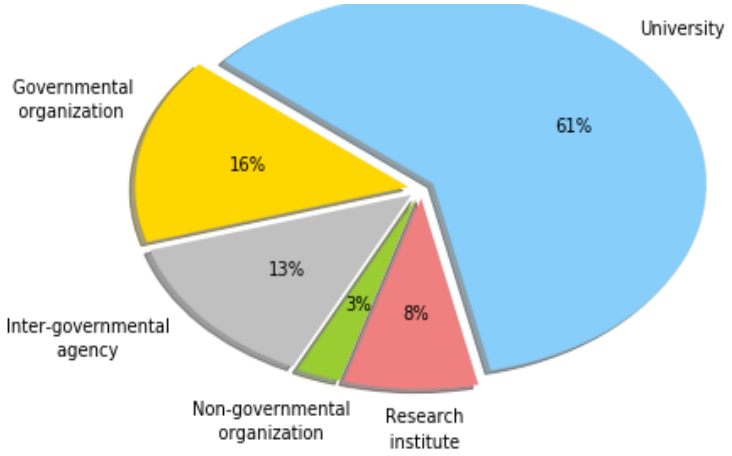
TASK 1 results: ad hoc questionnaire

- 39 respondents from 24 different countries (most of the respondents were from developing countries)





- 92% of respondents are familiar with LC maps and 85% of them have used LC maps in their research or professional work
- 1/3 of the respondents have used LC maps derived from Landsat imagery; 15% have used CORINE LC and 13% have used GL30. Other LC maps have been used by about 5% of the respondents (maps from MODIS and Sentinel, Urban Atlas, Global Urban Footprint, etc.)

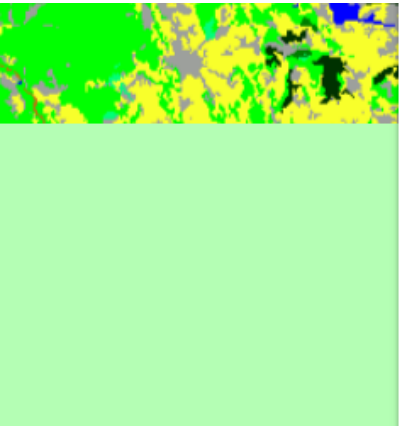
TASK 1 results: ad hoc questionnaire

- Respondents highlighted the use of LC maps for a huge variety of applications:
  - Environmental applications: agricultural monitoring, disaster management, inventories of forests and greenhouse gases, urban planning and urban growth analysis, studies on climate change and food security, etc.
  - Research applications: comparison and validation of diverse LC maps, also with gamification approaches; creation of hybrid LC maps, including OSM-derived maps
  - RS and spatial analysis teaching
- Main reasons for LC validation and intercomparison:
  - need to count on accurate products to quantify and report environmental indicators
  - make users aware of the large disagreements existing between available LC maps
  - identify the best datasets to be used at specific scales and for specific applications
  - guide error-free scientific research
- The best resolution of LC maps depends on the specific application: <10m for urban applications, between 30 and 500m for agricultural applications. High-resolution maps have a wider applicability than medium and low-resolution ones

Capacity buildings on LC mapping project

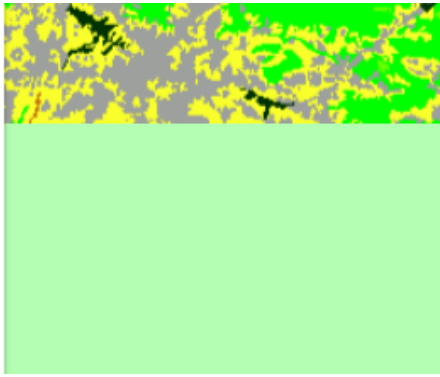
- **TASK 2**: assessment and classification of the available training material on intercomparison and validation of global high-resolution LC maps

  - Manual review of the state of the art (FOSS4G packages and training material)
  - Ad hoc questionnaire that asks respondents to indicate their knowledge of training or educational material



State of the art of training material on Land Cover maps intercomparison and validation

The purpose of this questionnaire is to assess the current state of training material/applications on the intercomparison and validation of Land Cover maps. If you have created/used such kind of material in the past, or if you are aware of its existence, please answer the following questions as precisely as you can.



https://tinyurl.com/yde9ykqg

TASK 2 results: review of the state of the art

- The most relevant **FOSS4G packages** for LC mapping (including specific modules or extensions) and related **learning material**

TASK 2 results: review of the state of the art

QGIS

The most significant tools provided by QGIS to handle LC maps are available into 2 dedicated plugins:

1. **Semi-Automatic Classification Plugin (SCP)**
   - ✓ Download, preprocessing and postprocessing of imagery by ASTER, Landsat, MODIS and Sentinel-2
   - ✓ Algorithms for the supervised and unsupervised classification of satellite imagery
   - ✓ Step-by-step tutorial on how to perform land cover classification

TASK 2 results: review of the state of the art

QGIS

The most significant tools provided by QGIS to handle LC maps are available into 2 dedicated plugins:

1. **Semi-Automatic Classification Plugin (SCP)**
   - ✓ Computation of confusion matrix and the related metrics (overall accuracy, producer's accuracy, user's accuracy, kappa coefficient and its variance)
   - ✓ Availability of learning material about validation (set of tutorial, videos and screenshots)
   - ✓ Plugin available for QGIS 2 and recently rewritten for QGIS 3

TASK 2 results: review of the state of the art

QGIS

The most significant tools provided by QGIS to handle LC maps are available into 2 dedicated plugins:

2. **Accuracy Assessment plugin**
   - ✓ Comparison of two LC raster maps available in QGIS and computation of a confusion matrix as a Comma Separated Values (CSV) file
   - ✓ Short plugin explanation included in the GitHub repository README file. No tutorial or other learning material was found
   - ✓ Plugin only available for QGIS 2. Its development apparently stopped in 2014

TASK 2 results: review of the state of the art

The relevant GRASS modules for managing LC maps belong to the modules for image data and raster data:

- ✓ i.maxlik, i.cluster, i.gensig, g.gui.iclass: supervised and unsupervised image classification
- ✓ r.kappa: validation of LC products. It computes the confusion matrix and returns accuracy measures such as overall kappa, conditional kappa, overall accuracy, user's accuracy and producer's accuracy
- ✓ The GRASS GIS reference manual contains a section related to image processing, which includes both image classification and validation. A short tutorial on image classification is available

TASK 2 results: review of the state of the art

It is specifically developed for Remote Sensing purposes:

- ✓ Algorithms for unsupervised and supervised classification provided by TrainVectorClassifier and TrainImagesClassifier applications
- ✓ Validation capabilities thanks to the ComputeConfusionMatrix application, which returns the error matrix in CSV format together with the overall accuracy and the user's and producer's accuracy for each LC class
- ✓ A guideline on classification and validation and a tutorial on how to perform supervised classification are available

TASK 2 results: review of the state of the art

- ✓ Tools for performing classification of imagery (both supervised and unsupervised)
- ✓ Tools for validating the classification results through the creation of a confusion matrix and the derived coefficients
- ✓ Tutorials on both supervised and unsupervised imagery classification and a tutorial on LC change mapping (including classification and intercomparison steps) are available

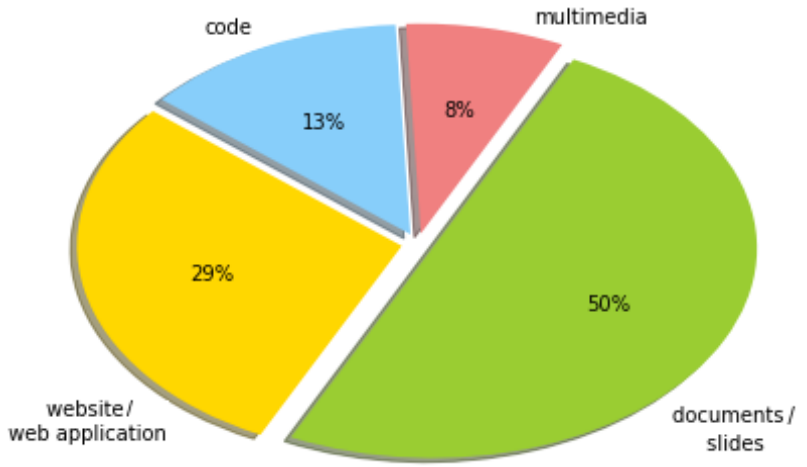
TASK 2 results: review of the state of the art

Sentinel-2 toolbox offers a rich set of tools for the visualisation, analysis and processing of high-resolution optical imagery

- ✓ Algorithms for both supervised and unsupervised classification are available
- ✓ Validation or intercomparison tools are not available
- ✓ Specific tutorials or learning materials are not available but ESA is regularly organizing dedicated training events on land Remote Sensing topics

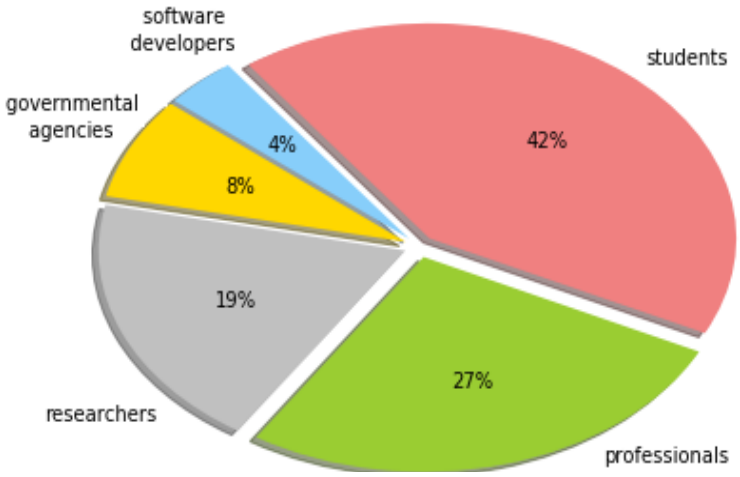
TASK 2 results: ad hoc questionnaire

- 29 respondents from 21 different countries; most of them were the same as in the Task 1 survey. Their geographic distribution is thus similar to the Task 1 survey, with the exception of one new respondent for each of the following countries: Brazil, Canada, Nepal, The Netherlands and Uganda
- The proportions of the respondents' affiliation types are pretty much the same as those obtained from Task 1 survey
- Regarding the type of material the emerging panorama is very heterogeneous:



TASK 2 results: ad hoc questionnaire

- Educational material is based on ESRI ArcGIS (40%), QGIS (28%), ERDAS IMAGINE (17%), OTHERS (ENVI, GRASS GIS, TerrSet, eCognition, IMPACT Toolbox, Google Earth, LULC Mapper, GEOVAL, LACO-Wiki , GL30 Platform)
- Answers about license were discarded (many respondents indicated license of the software instead of the material; others provided generic answers, etc.). It seems that researchers and professionals are unfamiliar with licenses and/or they do not give them so much importance
- Training material objectives and target users:



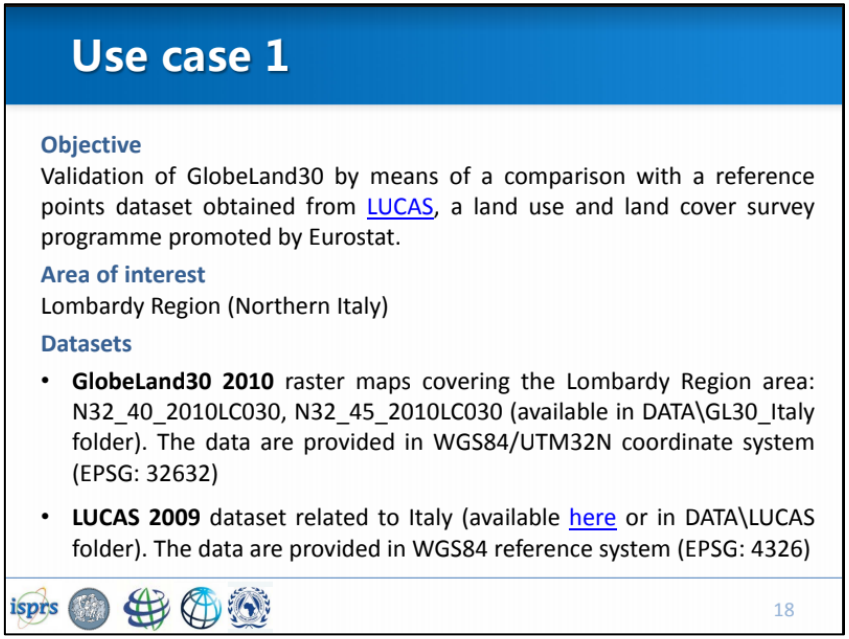
Capacity buildings on LC mapping project

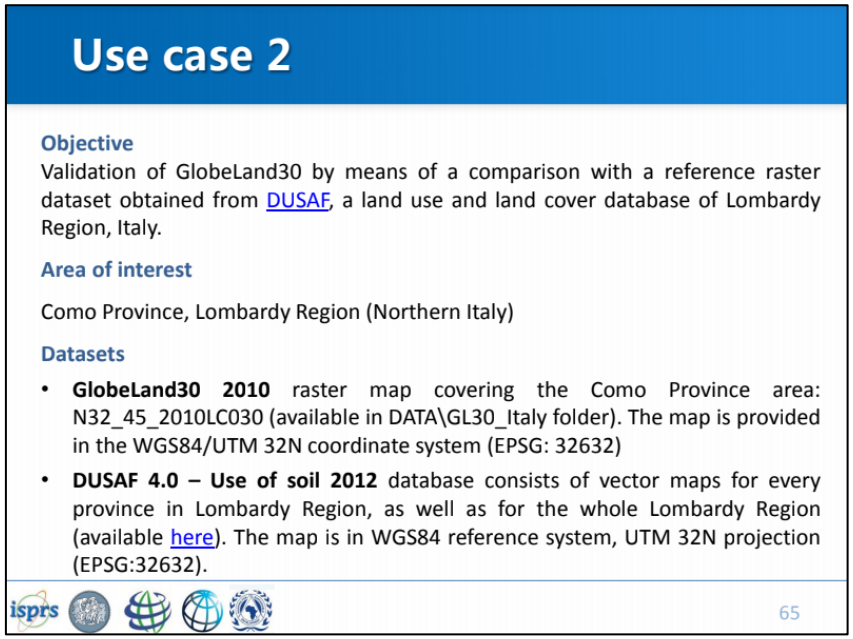
- **TASK 3**: development of new computer aided educational material on the intercomparison and validation of global high-resolution LC maps

  Creation of ad hoc teaching material released under open access licenses, and software-based material released under open source licenses to maximize the exploitation and impact within the community

TASK 3 results: teaching material and software

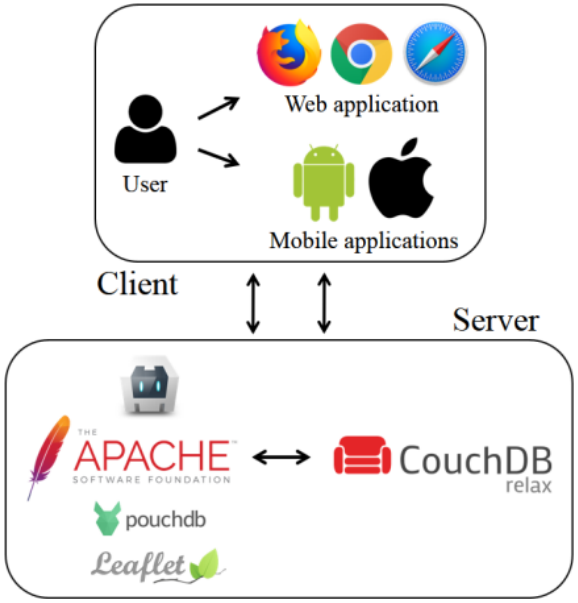
- Desktop procedure for LC map validation, implemented in QGIS and using GlobeLand30 as sample dataset. The teaching material license is CC BY 4.0
- Validation is performed taking advantage of custom scripts for PyQGIS (https://github.com/GoricaB/Land-cover-validation)

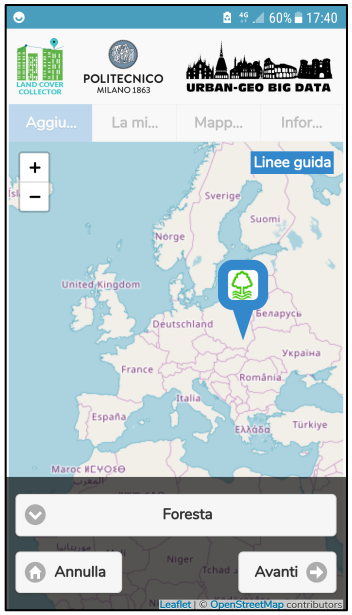




TASK 3 results: teaching material and software

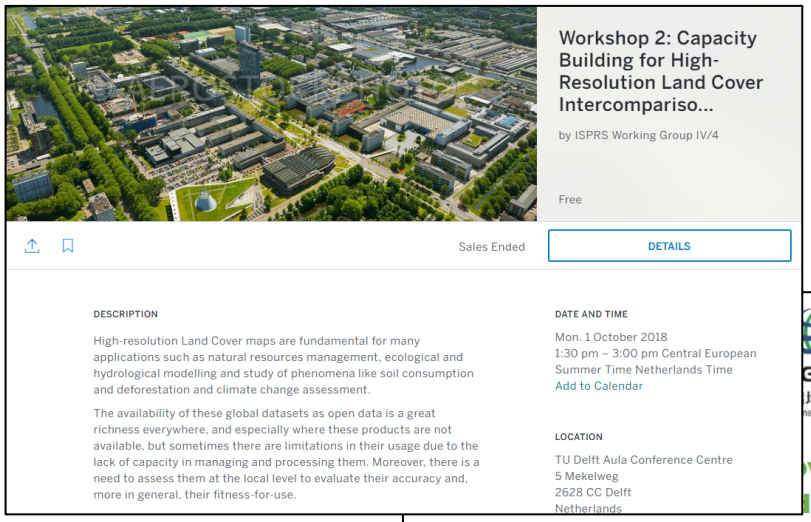
- Development of a web app, named Land Cover Collector, to allow users to collect field data according to the same LC nomenclature of GlobeLand30
- The web app is released under the GPL 3.0. Collected data are released under the Open Database License (ODbL)
- Code is available at https://github.com/kilsedar/land-cover-collector





Capacity buildings on LC mapping project

- **TASK 4**: organization of three workshops on the intercomparison and validation of global high-resolution LC maps



Workshop 2: Capacity Building for High-Resolution Land Cover Intercompariso...

by ISPRS Working Group IV/4

Free

Sales Ended | DETAILS

DESCRIPTION

High-resolution Land Cover maps are fundamental for many applications such as natural resources management, ecological and hydrological modelling and study of phenomena like soil consumption and deforestation and climate change assessment.

The availability of these global datasets as open data is a great richness everywhere, and especially where these products are not available, but sometimes there are limitations in their usage due to the lack of capacity in managing and processing them. Moreover, there is a need to assess them at the local level to evaluate their accuracy and, more in general, their fitness-for-use.

DATE AND TIME

Mon. 1 October 2018
1:30 pm – 3:00 pm Central European Summer Time Netherlands Time
Add to Calendar

LOCATION

TU Delft Aula Conference Centre
5 Mekelweg
2628 CC Delft
Netherlands

REGIONAL CENTRE FOR MAPPING OF RESOURCES FOR DEVELOPMENT

GCC
地理信息中心
atics Center of China

ver Inter-comparison
lation

Nairobi, 3 September 2018, 9:00-13:00 am
Regional Centre for Mapping of Resources for Development (RCMRD)
Kasarani Road, Off Thika Road
P.O Box 632-00618
Nairobi, Kenya
Room: GIS Training Lab
Speakers: Prof. Chen Jun, Prof. Maria Antonia Brovelli, Mr. Peng Shu, Dr. Marco Minghini
Local Organizers: Mrs. Phoebe Oduor and Kenneth Kasera

High-resolution Land Cover maps are fundamental for many applications such as natural resources management, ecological and hydrological modelling and study of phenomena like soil consumption and deforestation and climate change assessments.
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High-Resolution Land Cover Intercomparison and Validation

Dar Es Salaam, 1 September 2018, 9:00-13:00 am
World Bank
Room: Room No. 110 First floor, Address (50 Mirambo Street)
Speakers: Prof. Chen Jun, Prof. Maria Antonia Brovelli, Mr. Peng Shu, Dr. Marco Minghini
Local Organizers: Mr. Msilikale Msilanga, Miss. Devotha Laurent

High-resolution Land Cover maps are fundamental for many applications such as natural resources management, ecological and hydrological modelling and study of phenomena like soil consumption and deforestation and climate change assessment.
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- Mück, M., Klotz, M., and Taubenböck, H., 2017. Validation of the DLR Global Urban Footprint in rural areas: A case study for Burkina Faso. In: *Proceedings of the 2017 Joint Urban Remote Sensing Event (JURSE)*, Dubai, United Arab Emirates.

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Thank you for the attention

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