



New Earth Observation frontiers are being formed continuously by the dynamically changing expectations set by contemporary and expected developments in the geo- and bio-sphere as a counterbalance for pressures and demands emerging from a changing climate and the anthroposphere. Environment, Food security, Energy, Health and Security require continuous, reliable and cost effective monitoring of the Earth's surface and its resources. The 2nd joint Workshop of the EARSeL Special Interest Group on Land Use & Land Cover and the NASA Land-Cover/Land-Use Change (LCLUC) Program was considered supportive to the objectives of the imminent following ESA Living Planet Symposium 2016, as a brainstorming preparation and an opportunity for specialists to formulate a common understanding and language prior to entering the wider discussions of the more diverse audience.

The Workshop was jointly organized between the EARSeL SIG LULC and NASA's LCLUC Science Teams at the Department of Applied Geoinformatics and Cartography, Faculty of Science, Charles University in Prague, Czechia, on May 6-7, 2016. 123 researchers from 30 countries discussed upcoming opportunities and challenges of LCLUC and remote sensing at the beginning of this new big data era.



The Workshop was organized around four representative sessions, covering the latest advances; trending activities and future challenges in land-cover services in the big data era:

1. Harmonization of Sentinel-2 and Landsat products
2. Mapping Land Cover and Land Use with cross-scale and cross-sensors approaches
3. Challenges of Land-Cover and Land-Use Monitoring with Dense Time Series of EO Data
4. EO benefits for ecosystem services and human wellbeing

Each session opened with presentations by distinguished keynote speakers who triggered and set the stage for the discussion among all participants. Each session continued with poster presentation and concluded with discussion wrapping-up the key elements of the session and enhancing collaboration among the participants. The welcome addresses were given by Premysl Stych from Charles University in Prague, Garik Gutman (NASA LCLUC), Lena Halounova and Ioannis Manakos (both EARSeL). Ioannis and Garik provided a short overview of the EARSeL LULC and NASA LCLUC programs, their goals, current activities and future plans.

Jeff Masek, NASA GSFC and Pierre Defourny, University of Louvain started off with keynotes in session 1 on the new opportunities offered by Sentinel-2 and Landsat products, which represent the most widely accessible medium-to-high spatial resolution multispectral satellite data. The potential for synergistic use of the two sources creates unprecedented opportunities for timely and accurate observations of Earth status and dynamics. Thus, harmonization of the distributed data products is of paramount importance for the scientific community. Here, a good collaboration between NASA and ESA was emphasized as an aim to optimize scientific outcomes of the new opportunities. Jeff described possible approaches harmonize reflectance products from Landsat and Sentinel-2, presented the current status and scientific applications, while Pierre showed global land-cover database progresses as well as challenges regarding Sentinel-2 and Landsat data. Keynote presentations and posters proved that activities aiming to harmonize data. The following discussion points are outlined here: 1) Continuous L8 & S2 inter-calibration, 2) Geometric co-registration, 3) Consistent atmospheric correction and cloud/shadow masking, 4) Need for international standardized processing or quantifying the differences between major systems, 5) Interest in pre-processed data ready to be provided to the community.



Alexandra Tyukavina from the University of Maryland and Alexander Prishchepov from the University of Copenhagen opened the second session with keynotes on Mapping Land Cover and Land Use with cross-scale and cross-sensors approaches. This session gave room for presentation and discussion of approaches for multi-sensor analysis, including data and decision fusion approaches for mapping land cover and land use. While Alexandra gave an overview of using Landsat and Sentinel-2 data to baseline and forward monitor land-cover change, Alexander focused on the opportunities and challenges of application of satellite remotely-sensed data in land-systems science. Posters in the session underlined and discussed the need for fusion of data from multiple sources in the era of big data and pluralism of satellite sensors. The discussion points are outlined here: 1) Challenges to go beyond classification, 2) Combination of classes and their characterization, 3) Easy access to multiple data streams, 4) Solutions needed for high volume processing (Earth Engine, NEX, TEPs), 5) Combination of RS time series with ancillary data in (complex) database products, 6) Capacity building/training end-users; alternatively: deriving easy-to-understand end products for decision makers, 7) Improvement of

the accessibility to image data (e.g. microsatellites), 8) Improvement of metadata and searchability of enormous volumes of existing LCLUC datasets, 9) Acknowledgement of the challenge to bridge the gap between R&D results and operational, full-scale implementation.



Day 2 of the Workshop began with presentations by Son Nghiem, NASA JPL, and Sebastian van der Linden, the Humboldt University of Berlin, within the session on Challenges of Land-Cover and Land-Use Monitoring with Dense Time Series of EO Data. The vast amount of data from Landsat-8 and Sentinel-2 a/b lead to unprecedented density in time series of high resolution multi-spectral data. This creates new needs for the efficient handling of large volumes of optical images and approaches to translate temporal developments into land cover/use characteristics. This session was dedicated to aspects of dense and/or long time series with a focus on Landsat and Sentinel data. Son provided an overview of different data sources and land-cover mapping practices followed by specific examples from different disciplines, approaches and challenges in synergistic use of multi-satellite sensors for mapping. Sebastian, on the other hand, illustrated how important and useful are time series analysis in the Sentinel-Landsat era. He talked about time series data applications, mainly in the dry parts of southern Europe including Turkey and southern Portugal. This was a great example of moving away from common classification approaches to more refine and continuous estimates of land-cover components. The poster session showed how many land-use related results and methods are nowadays addressed by analysis of archival data. The discussion points are briefly highlighted here: 1) Availability of Sentinel data, particularly about any start-up costs of finding and using these data, 2) Technical challenges using data from different sensors such as Landsat and Sentinel-2 data including BRDF correction issues in the Sentinel-2 data, 3) Geometric mis-registration between Landsat and Sentinel-2 observations and lack of standard atmospherically corrected Sentinel-2 data, 4) Need to have phenological metrics derived from medium resolution Landsat-like observations, similar to what is available from MODIS, 5) Merging optical and radar observations would increase our ability to monitor various landscapes, especially in areas with persistent cloud cover.

The last session “EO benefits for ecosystem services and human wellbeing” focused on the evaluation of natural and anthropogenic pressures, which cause serious threats to ecosystems, leading to habitat

degradation and loss of ecosystem services. Earth Observation data offer unprecedented capacity in timely and wide-extent monitoring of endangered areas, through the calculation of a variety of indicators and essential variables for fields including climate, biodiversity, and habitat monitoring. Open and harmonised data, e.g. following the principles of the Global Earth Observation System of Systems (GEOSS) and the Copernicus program, offer new potential in ecosystem modeling, enhanced management and restoration, and capacity building. Chris Justice, University of Maryland, gave insight in the field of Earth Observations for agricultural monitoring and food security. Palma Blonda, ISSIA CNR – Bari, emphasized the high value of remote sensing for LC taxonomies for applications to biodiversity and ecosystems monitoring. The discussion points are briefly highlighted here: 1) Policy is an important driver behind the work on this topic, 2) Focus is on monitoring, 3) GEOGLAMS output for AMIS requires simple visuals of crop condition, 4) EO products are needed for managers, 5) Ecosystem condition (beyond crops, and beyond just LCLU), 6) Maintenance of ecosystem services to a sustainable status, 7) Continuity and consistency of EO products provision is particularly important, 8) Consistent taxonomy.



The program of the Workshop led to very intense discussions of both individual presentations as well as entire sessions. It was commonly agreed that the time of organization of the Workshop was just right for this type of event because of the new Sentinel missions. Many studies, projects and cooperation that use the Sentinel and Landsat data, supported by US and European agencies, have been under development. The success of this Workshop suggests that it is desirable to organize a follow-up joint event in about two years. At the closing, some ideas for the future Workshop were suggested, such as longer poster sessions, support of young scientists, etc. The organizers are open for more ideas and suggestions and would be happy to receive them by email.



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*Sincerely,*

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