Surveys in Geophysics (2019) 40:689–691
https://doi.org/10.1007/s10712-019-09552-w

GUEST EDITORIAL

Guest Editorial: International Space Science Institute (ISSI) Workshop on Space-Based Measurement of Forest Properties for Carbon Cycle Research

Klaus Scipal[1] · Anny Cazenave[2,3] · Teodolina Lopez[3]

Received: 29 May 2019 / Accepted: 16 June 2019 / Published online: 26 June 2019

Through their active roles in ecological processes and resources, forests are crucial elements of the Earth system. They sustain a myriad of ecosystems, especially tropical forests that provide habitats for many flora and fauna. Thus, forests play a central role in the local and global carbon cycles. Indeed, forests are an important sink for atmospheric carbon (Bonan 2008; Grace et al. 2014; Pan et al. 2011), and changes in terms of forest biomass (as forest carbon stocks) and forest productivity (forest carbon fluxes) impact the climate change (Foley et al. 2005). Consequently, aboveground forest biomass (AGB) has been recognised as a Global Climate Observing System (GCOS) Essential Climate Variable (ECV), a critical input to the United Nations' Reducing Emissions from Deforestation and Degradation-plus (REDD+) program, and an important input to Earth system models.

In response to the need to monitor forest ecosystems, the number of space-borne missions with a capability to map ecosystem structure steadily increases (e.g., NASA's GEDI and ICESat, NASA/ISRO's NISAR, ESA's BIOMASS, JAXA's ALOS-4 and MOLI, CONAE's SAOCOM and DLR's Tandem-L); the approaches to AGB retrieval using these data diversify. These missions use innovative SAR and LiDAR technologies to measure forest structure parameters (such as forest height and AGB) and their change with time on a global scale with much more precision than is possible today, particularly in areas where insufficient ground or airborne lidar data are available such as in the tropics or the vast Siberian forests. Some of these missions are already in orbit (e.g., GEDI, ALOS, SAOCOM) or are expected to be in orbit within the next 3 years (BIOMASS, NISAR), providing a unique and powerful combination of techniques to monitor Earth's forests.

These missions meet a pressing need for information on forests globally. Analysis of the global carbon cycle shows that the annual emissions of carbon from fossil fuels and land-use change are larger than the annual accumulations of carbon in the atmosphere and oceans. This suggests a largely unknown terrestrial sink for carbon, which has never been measured. Measurements provided by these missions will give a unique opportunity to reduce the uncertainties in both the global net emissions of carbon from forest

✉ Klaus Scipal
klaus.scipal@esa.int

[1] European Space Agency, Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands

[2] LEGOS, 14 Avenue Edouard Belin, 31400 Toulouse, France

[3] International Space Science Institute, Hallerstrasse 6, 3012 Bern, Switzerland

cover change and global changes in aboveground forest biomass. This will significantly improve our understanding of the global carbon cycle, which will be of essential value for climate modelling and policy adaptation actions.

The papers presented in this Special Issue are the outcome of a Workshop on "Space-Based Measurement of Forest Properties for Carbon Cycle Research" held at the International Space Science Institute (ISSI) in Bern, Switzerland, from 6 to 9 November 2017. The main objective of the workshop was to provide an overview of the related science questions, community needs and Earth Observations technologies and capabilities. A specific emphasis was put on the synergies and complementarities of the different observation types and on the potential benefits of a joint exploitation of these data.

The first part of this Special Issue presents the role and benefits of forests and their properties. The first paper, by Reichstein and Carvalhais (2019), provides an overview of the interaction between forest biomass and major ecosystem functions. It also investigates the potential of future Earth Observations missions to better understand the Earth system dynamics. The second article, by Fischer et al. (2019), investigates the role of forest structure heterogeneity for biomass and productivity estimations in temperate forests from lidar remote sensing. The next paper, by Exbrayat et al. (2019), provides an overview of how remote sensing observations of the vegetation have improved our understanding of the terrestrial carbon cycle. The last article in this part on Science and Policy, by Herold et al. (2019), deals with policy needs for environmental management and biomass data provided by space-based biomass monitoring.

The second part contains reviews of the potential of space-based observation techniques to provide information of forest structure. This part paves the way to the synergistic use of the different space-borne techniques, with articles such on SAR tomography, by Tebaldini et al. (2019), or combining Lidar and Multi-baseline SAR data by Pardini et al. (2019), and the benefits of very high resolution visual imagery as Schepashenko et al. (2019).

The third part highlights the challenges and new opportunities of collecting AGB measurements, which are critically needed for the interpretation and validation of the space-based observations. First, Chave et al. (2019) highlight the importance of ground-data for this purpose. Réjou-Méchain et al. (2019) next review the error structure of up-scaled ground-based observations. Phillips et al. (2019) discuss the criticality of tree species' knowledge in the precise estimation of ground-based AGB. The next two articles explore new opportunities in using Terrestrial Laser Scanning (TLS) (Disney et al. 2019) and Ultra-High-Density Drone Lidar (Kellner et al. 2019). The last article of this part provides a review of biomass validation practices from the Committee of Earth Observing Satellites (CEOS) perspective (Duncanson et al. 2019).

This Special Issue concludes with two papers. McRoberts et al. (2019) discuss the statistics of regional, map-based estimates of AGB merging ground and remotely sensed observations; a paper by Albinet et al. (2019) describes the strategy of ESA and NASA to make data available to the scientific community via their Multi-Mission Algorithm and Analysis Platform (MAAP).

We are most grateful to the ISSI for hosting this Workshop, to Thuy Le Toan, Shaun Queqan and Ralph Dubayah for co-organising this Workshop, to those scientists who organised the reviewing of the submitted papers, to all the referees, to the Editor in Chief, and to the staff of Springer Nature for publishing this record of the event.

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