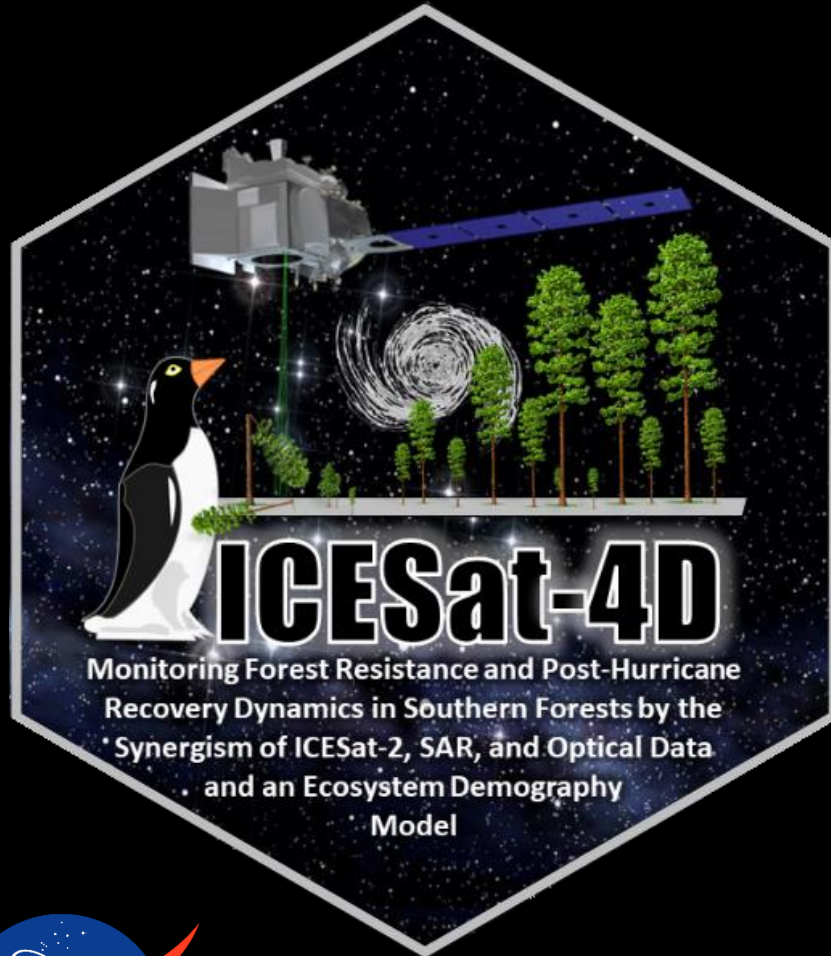


Beyond Ice: NASA's ICESat-2 spaceborne lidar mission for land and vegetation applications

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UNIVERSITY of FLORIDA



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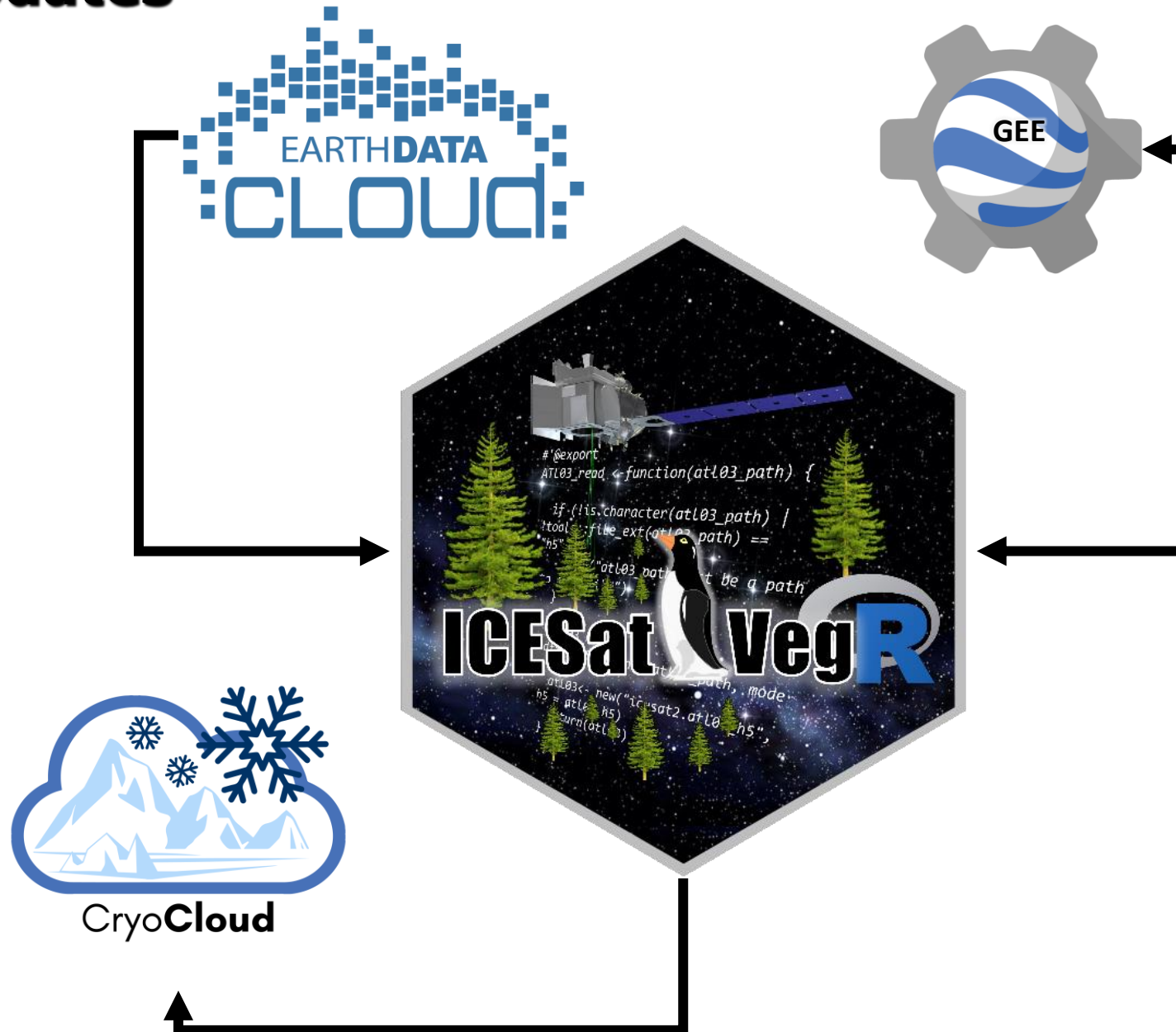
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ICESat-2
ICE, CLOUD, AND LAND ELEVATION SATELLITE-2

1. Quick updates





Mikey Mohan

Applications of remote sensing for mangrove conservation and blue carbon assessment

Carlos Alberto Silva

Beyond Ice: NASA's ICESat-2 spaceborne lidar mission for land and vegetation applications

Davide Andreatta

Challenges and new developments in the use of remote sensing for plant phenology monitoring

Nau mai, haere mai
Welcome to ForestSAT 2024
9 - 13 September

2.1 Introduction

Review Objectives

- (1) systematic literature review and analyze a broad spectrum of studies worldwide utilizing ICESat-2 data for land and vegetation applications.
- (2) critically assess the current capability and limitations of ICESat-2 data for land and vegetation applications

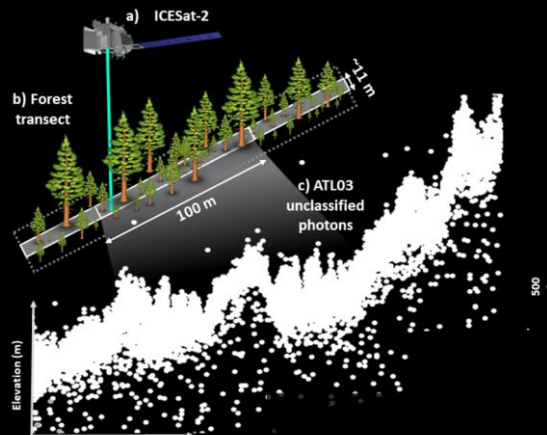


Figure 5. Illustration of how ATL08 terrain and canopy height are computed at 100 m segment from labeled ATL03 photons. ICESat-2 laser beam (a) over a Canadian boreal forest transect (b), unclassified ATL03 photons (c; ATL03_20181210060430_11090106_961a4_01_gt1r) and ATL03 labeled photons from ATL03 and ATL08 products illustrating that determination of terrain elevation and vegetation heights (d) is feasible even in areas with significant topographic relief. e) Distribution of ATL08 terrain and canopy attributes computed.

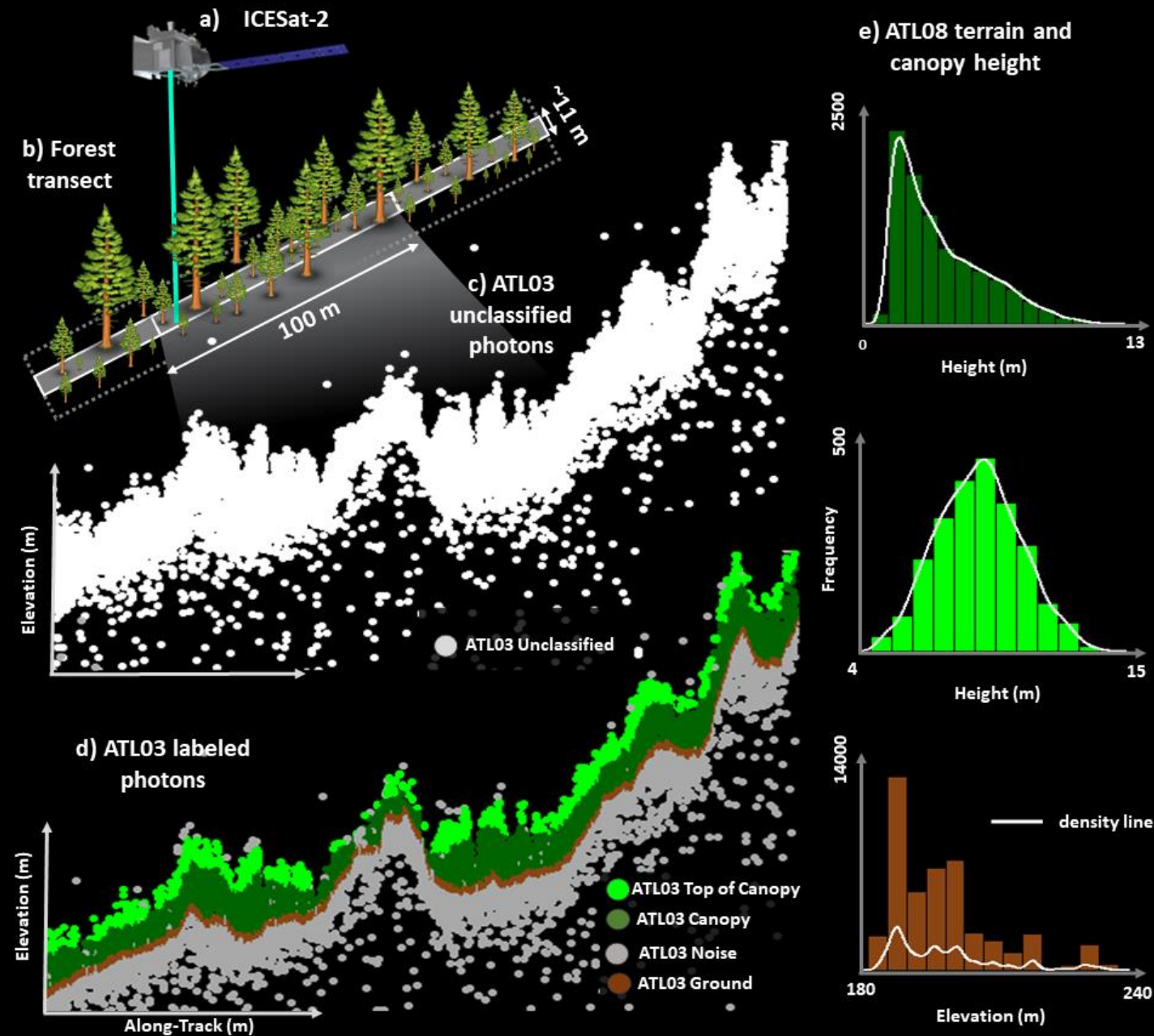


Figure 6. Number of total downloads of ICESat-2 products over time and percentage of ATL08 downloads by countries (top 5). Statistics provided by National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC – November 2023)

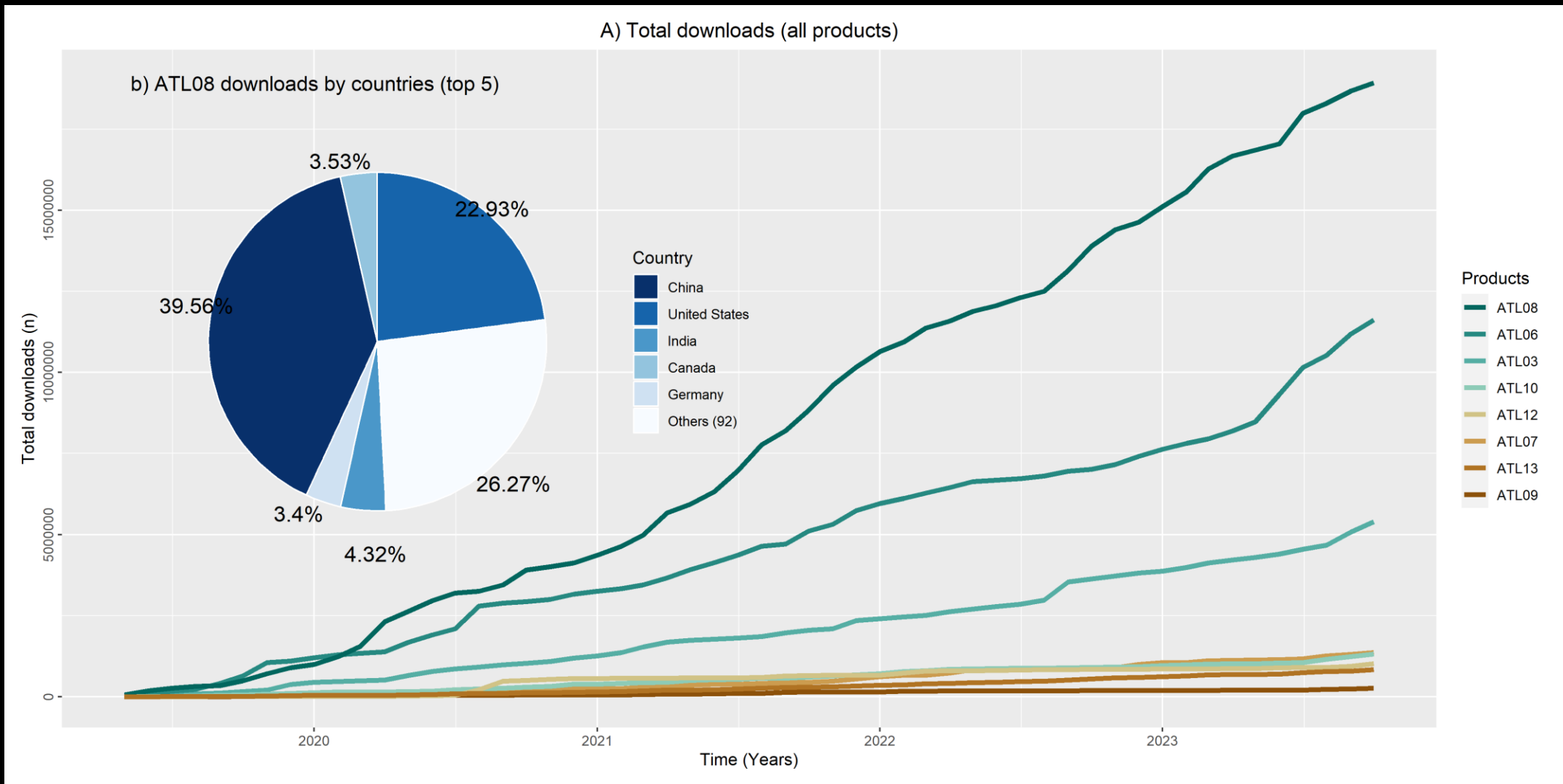
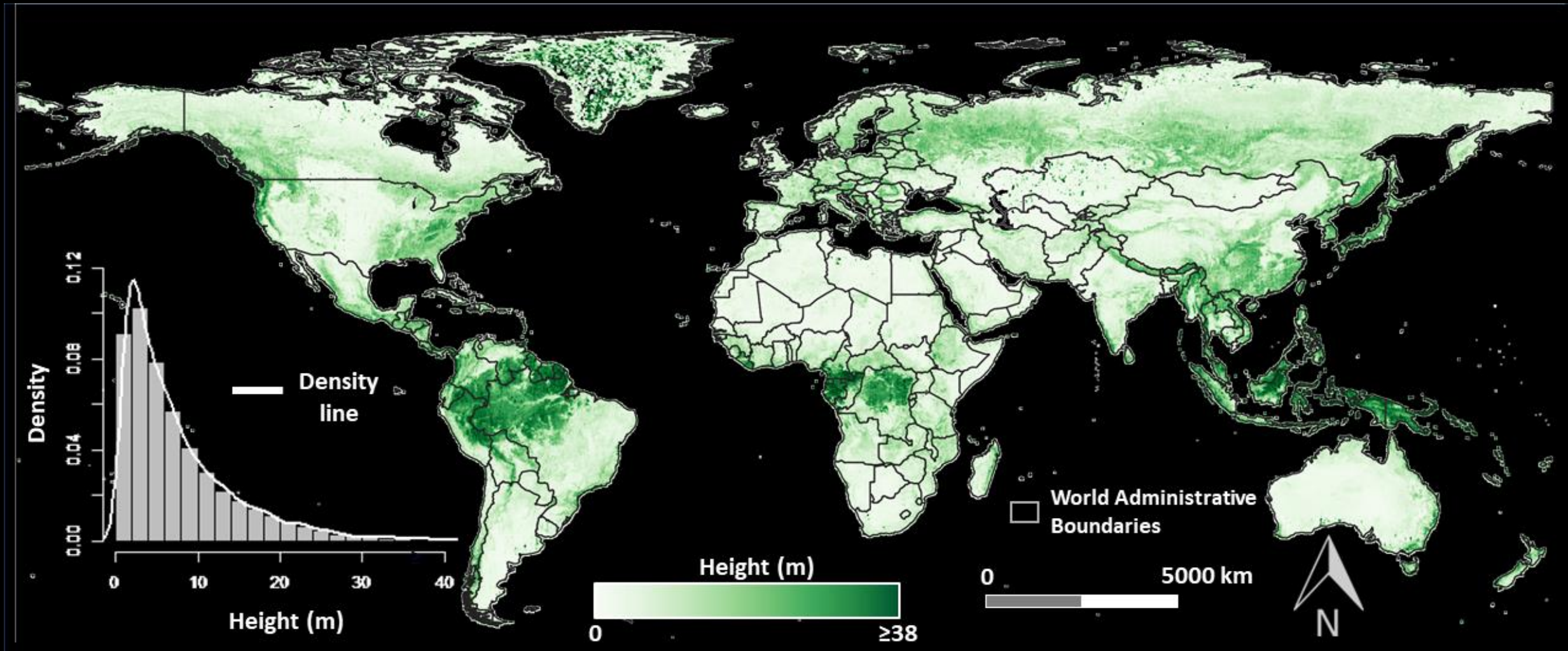


Figure 7. Illustration of the ATL18 canopy height product at 1 km spatial resolution at the global scale. The height values represent the median of all ATL18 height estimates within a given grid size of 1 km. (Jordan Borak)



2.2. Methods applied in the literature review

Table 3. Search conditions for the application database.

Search attributes	Search parameters
Database	Web of Science and Scopus
Keyword	ICESat-2
Publication year	2010 - present
Document Type	Research article
Language	English
Searching date	11/03/2023

Scopus®



Table 4. Search conditions for the application database.

Earth System	Number of articles found	Number of articles included in this review
Atmosphere	6	0
Biosphere	142	142
Cryosphere	152	0
Hydrosphere	162	0
Lithosphere	61	61
Others	46	0
Total	569	203

Table 5. Land and vegetation applications.

Application	Description
Forestry	Studies focused on estimating vegetation height, cover, volume, basal area and fuels
Ecology	Studies focused on modeling biomass, carbon, forest diversity, leaf area index, habitat quality and wildlife
Disturbance	Studies confused on disturbance events, such as fire, hurricanes, drought and impact of snow on vegetation
Education	Studies focuses on education of the ICESat-2 mission
Tools	Studies focuses on the development of tools for ICESat-2 data processing and analysis
Urban	Studies focused on urban landscape, including height of bulging and roads attributes.
Land use	Studies focused on land use
Methods/Algorithm development	Studies focused on methods and algorithm development
Terrain	Studies focuses on terrain elevation estimation and modeling

2.3 Results of the literature review

Figure 8. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram showing the systematic literature review protocol and numbers of articles identified, excluded, and included in the review.

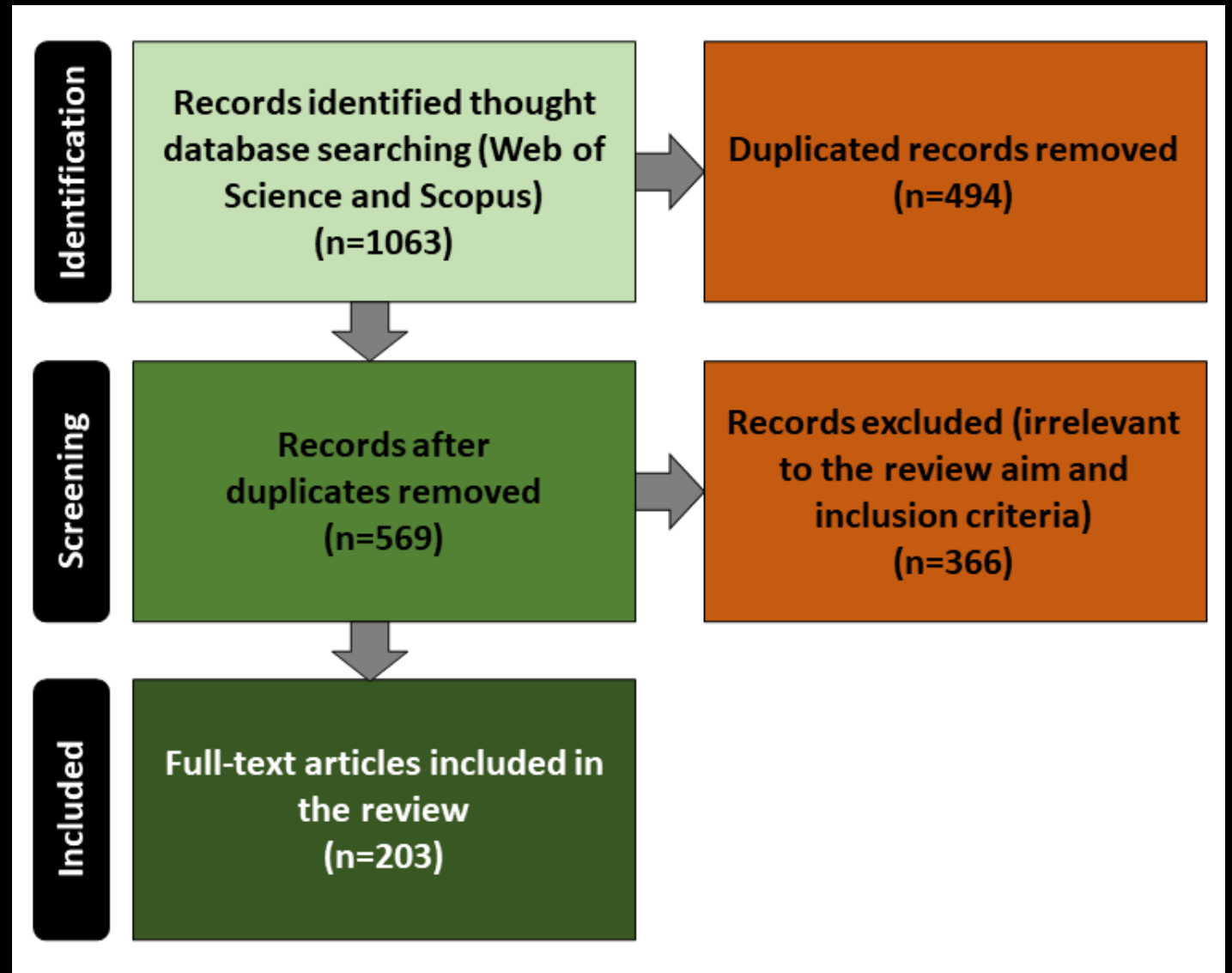


Figure 9. Geographical distribution of the study sites by country (provided by the green color bar) and continents (highlighted in the texts) (A) [...]

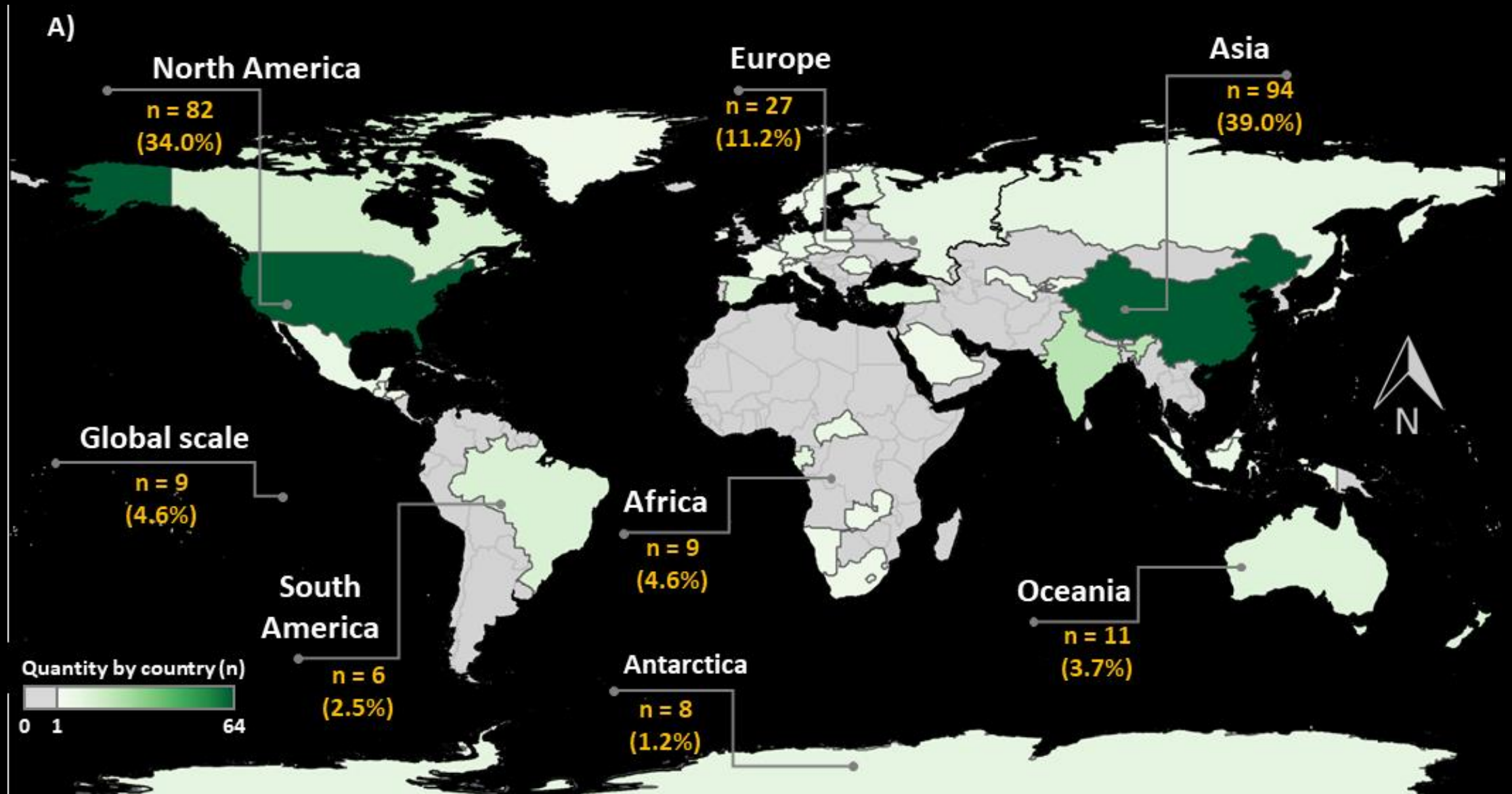


Figure 9. [...] Frequency distribution (B) and percentage (C) of articles published since 2014.

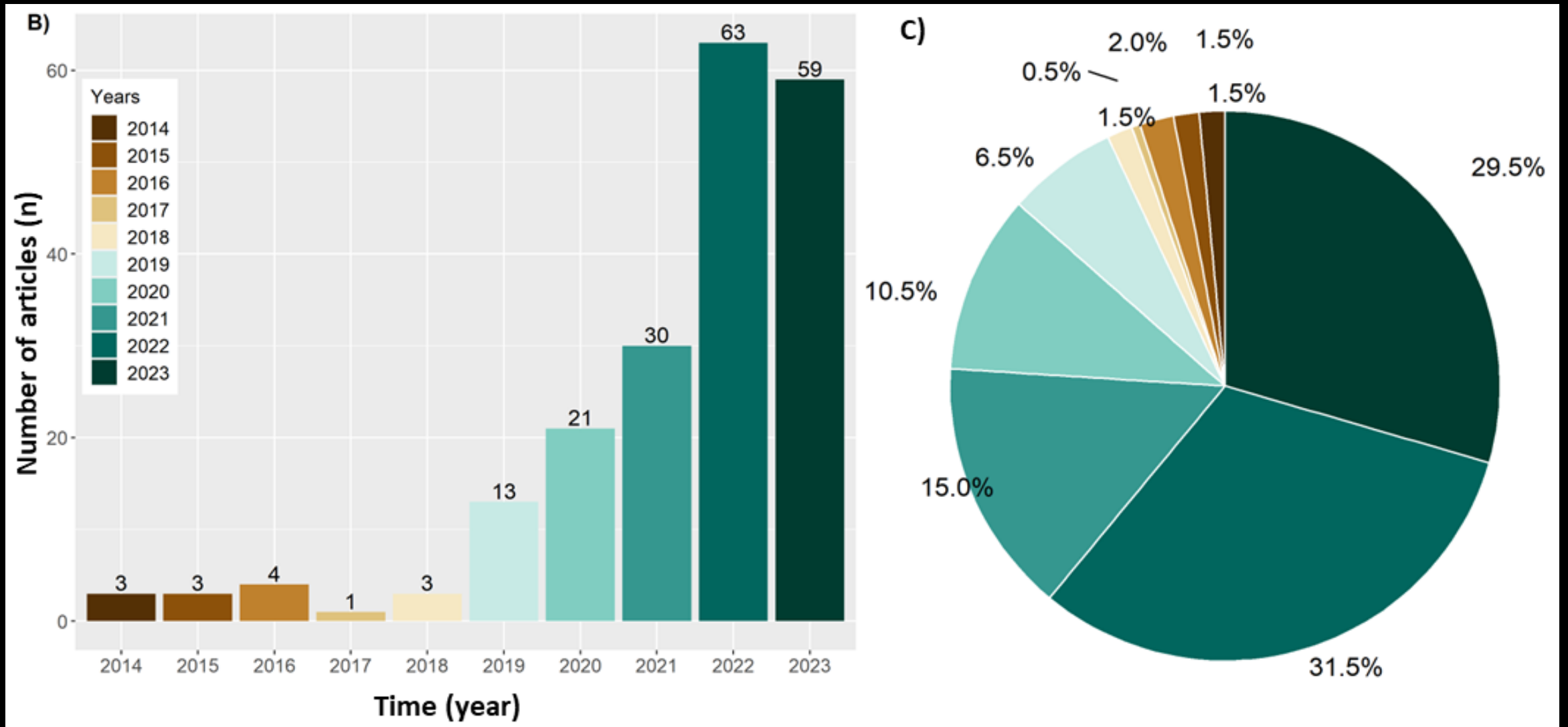


Figure 10. Frequency distribution and percentage of ICESat-2 articles across terrestrial biomes (A1-A2) [...]

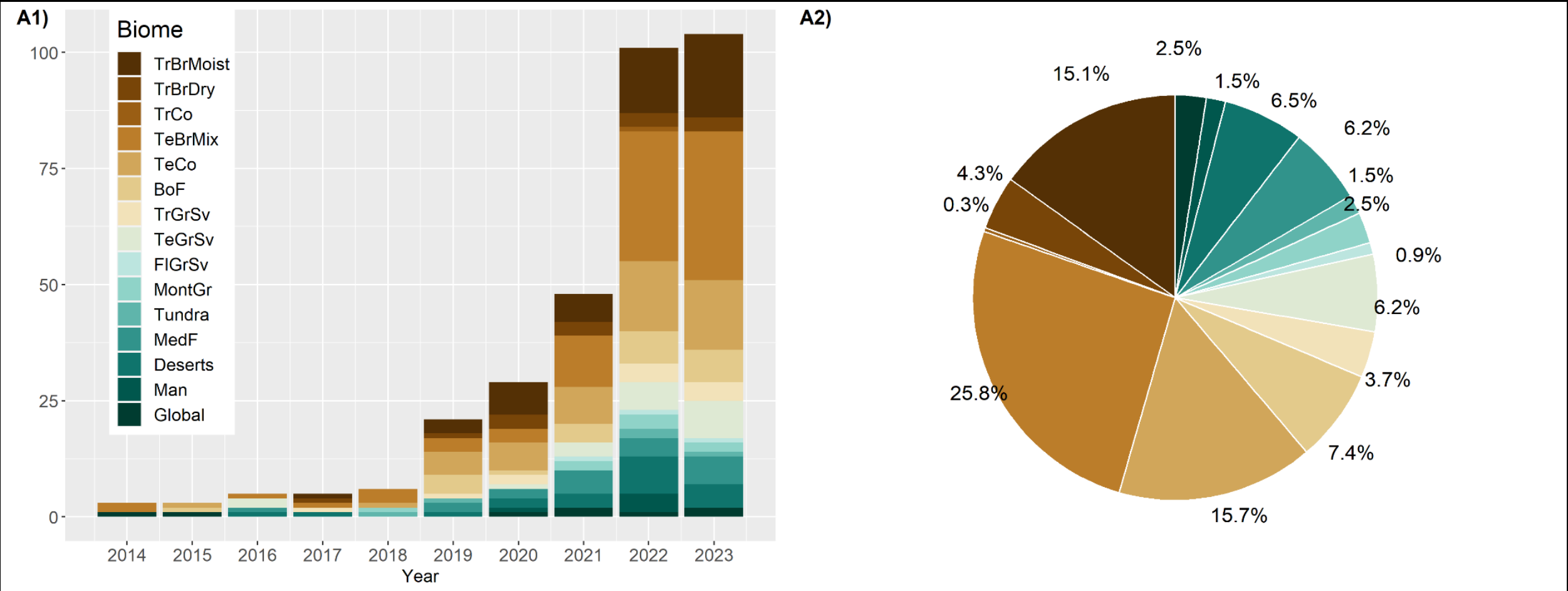


Figure 10. [...] Application (B1-B2)

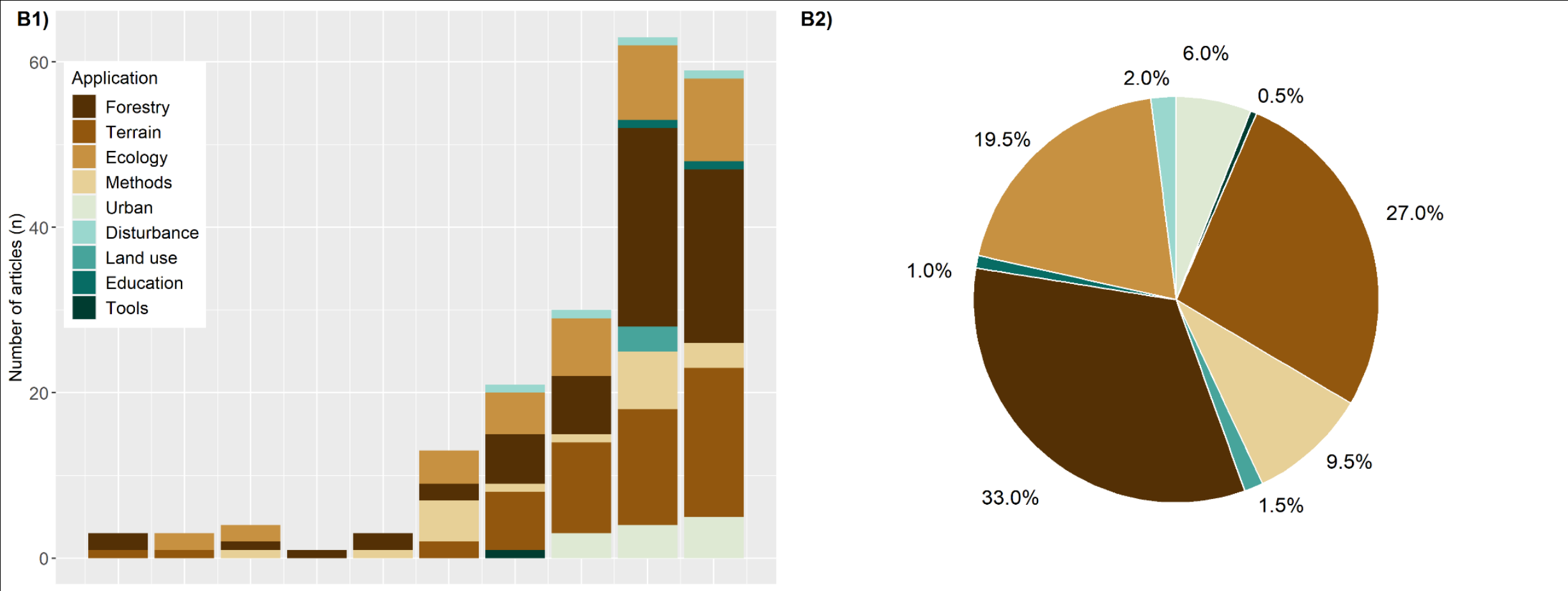
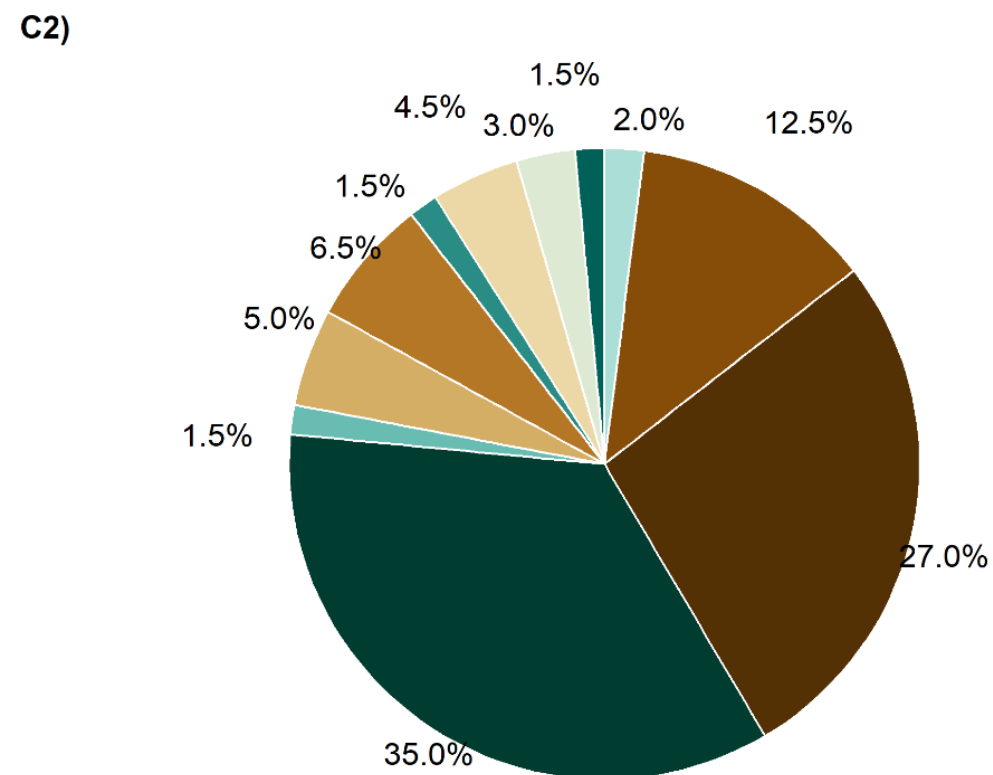
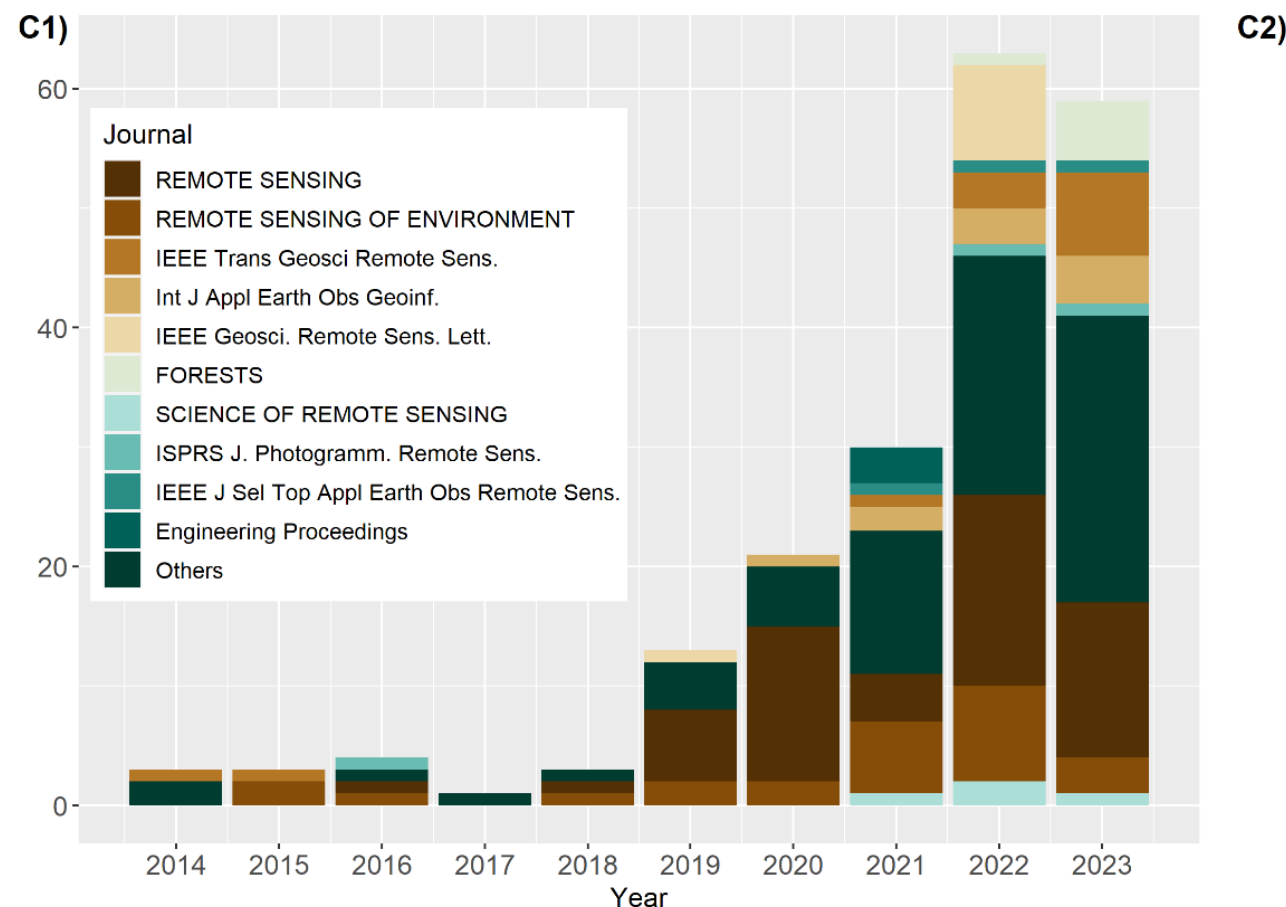


Figure 10. [...] Journal (C1-C2) types.



2.4 Considerations on ICESat-2 current capabilities for land and vegetation applications

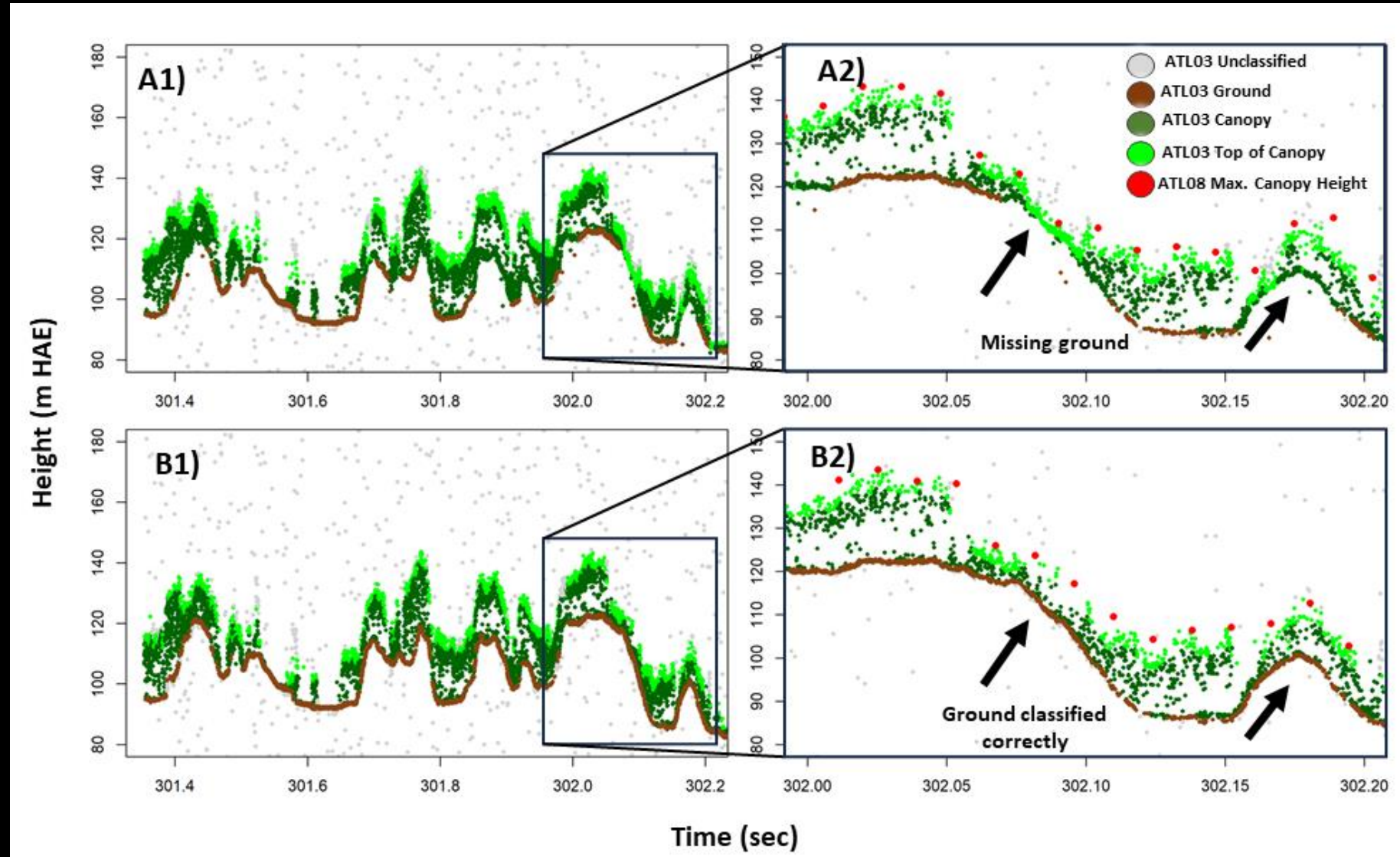


Figure 12. ATL08 released 005 and 006 labeled photons (A1-B1) and maximum canopy height over Finland boreal forest illustrating improvements in the ground finding from Release 005 to Release 006 in areas with significant topographic relief variation (A2-B2).

Table 6. Examples of studies from the literature review assessing the performance of ICESat-2 estimation of terrain elevation and canopy height in forested ecosystems.

Author	Biome	Input Dataset	Reference Dataset	Target Variable	Scale	Performance assessment*
Feng et al. (2023)	Boreal Forests / Taiga	ICESat-2 ATL08 (v005)	LVIS	Terrain	100m segment	RMSE (m) = 2.07-2.35 Bias (m) from -0.13 to 0.19
				Canopy height		RMSE (m) = 3.74-4.68 Bias (m) = 0.08-(-0.78)
Mulverhill et al. (2022)		ICESat-2 ATL08 (v003)	NTEMS (Canada)	Canopy height	100m segment	RMSE (m) = 4.87 (36.99%) Bias (m) = 0.55 (4.17%)
Neuenschwander et al. 2020		ICESat-2 ATL08 (v003)	ALS	Terrain	100m segment	RMSE (m) = 0.65-0.83 Bias (m) = 0.07
				Canopy height		RMSE (m) = 2.5-2.7 (14.5-16.3%) Bias (m) = 0.56-1.47 (3.18 - 9.13%)
Zhang et al. (2023)		ICESat-2 ATL08 (v005)	ALS	Canopy height	100m segment	R = 0.40 – 0.66 RMSE (m) = 4.97-5.83

Musthafa et al. (2023)	Tropical and Subtropical Moist Broadleaf Forests	ICESat-2 ATL08 (v005)	Field	Canopy height	100 grid	R ² = 0.14 RMSE (m) = 5.08 - 5.71 (34.8-39.44%)
Rodda et al. (2023)		ICESat-2 ATL08 (v005)	ALS	Terrain	100m segment	R = 0.97 - 1.00 RMSE (m) 3.2–11.1 (0.8-2.6%); Bias (m) = 1.4 - 7.7 (0.3-1.77%)
				Canopy height		R = 0.22 - 0.68 RMSE (m) = 3.5 - 12.5 (18-65%) Bias (m) = -0.4 - (-10.1) (-2.05 - (-48.87%))



oneearth.org

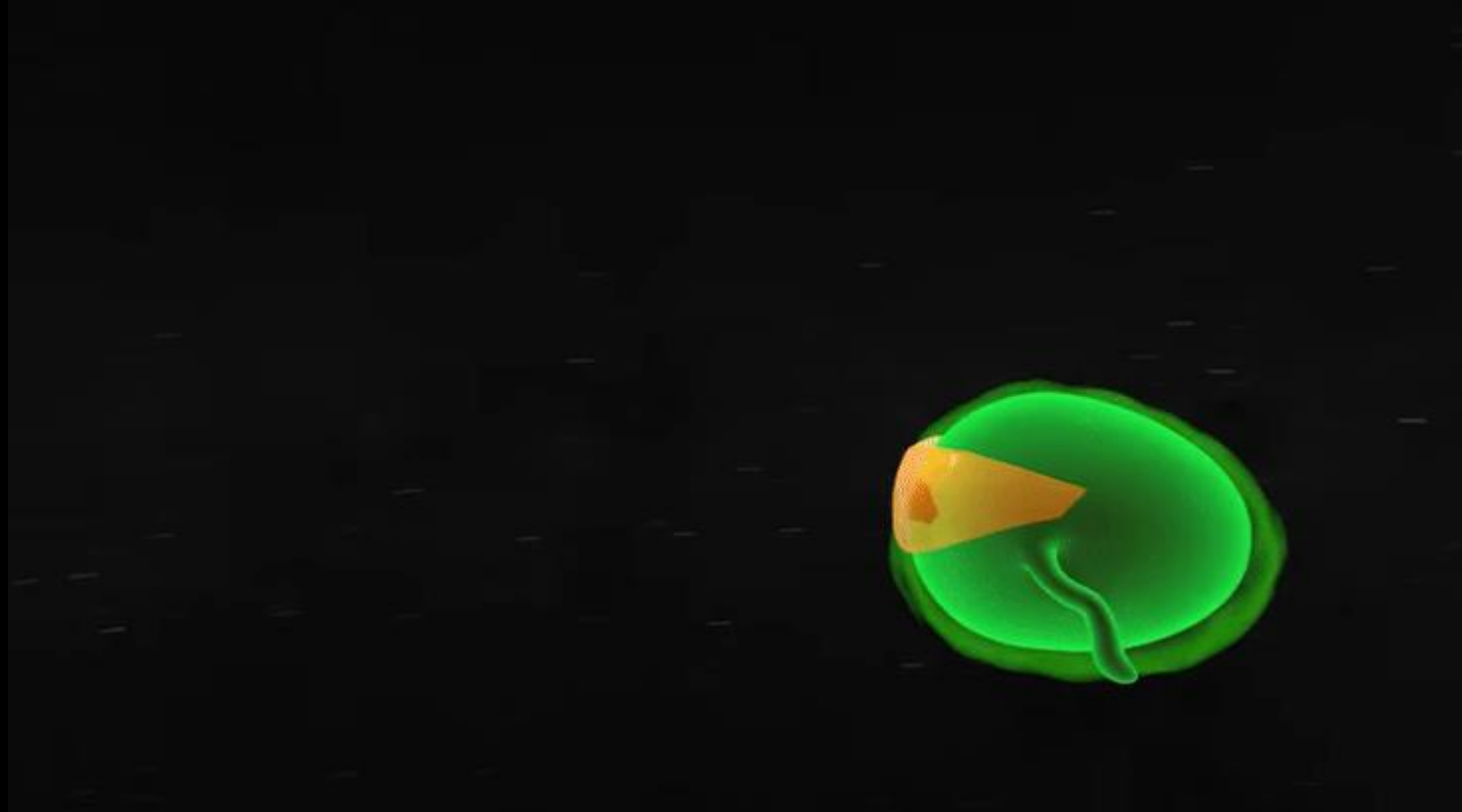
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[nationalgeographic.org](https://www.nationalgeographic.org)

Photon Jump



by



2.5 Considerations on ICESat-2 product improvements and future capabilities for land and vegetation applications

- ATL08 and segment lengths
- Cover, PAI, PAVD
- ATL18 (grided product)

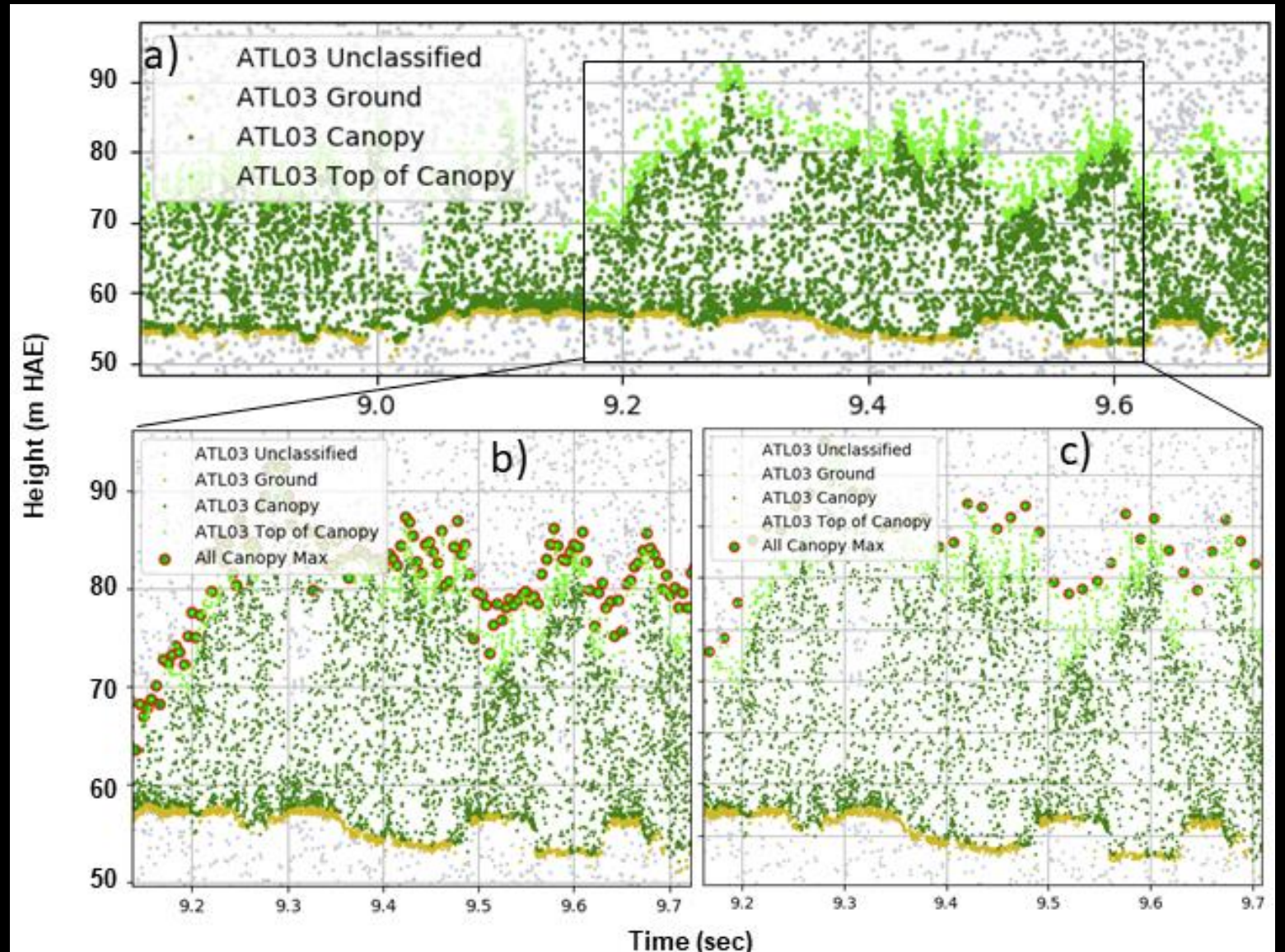
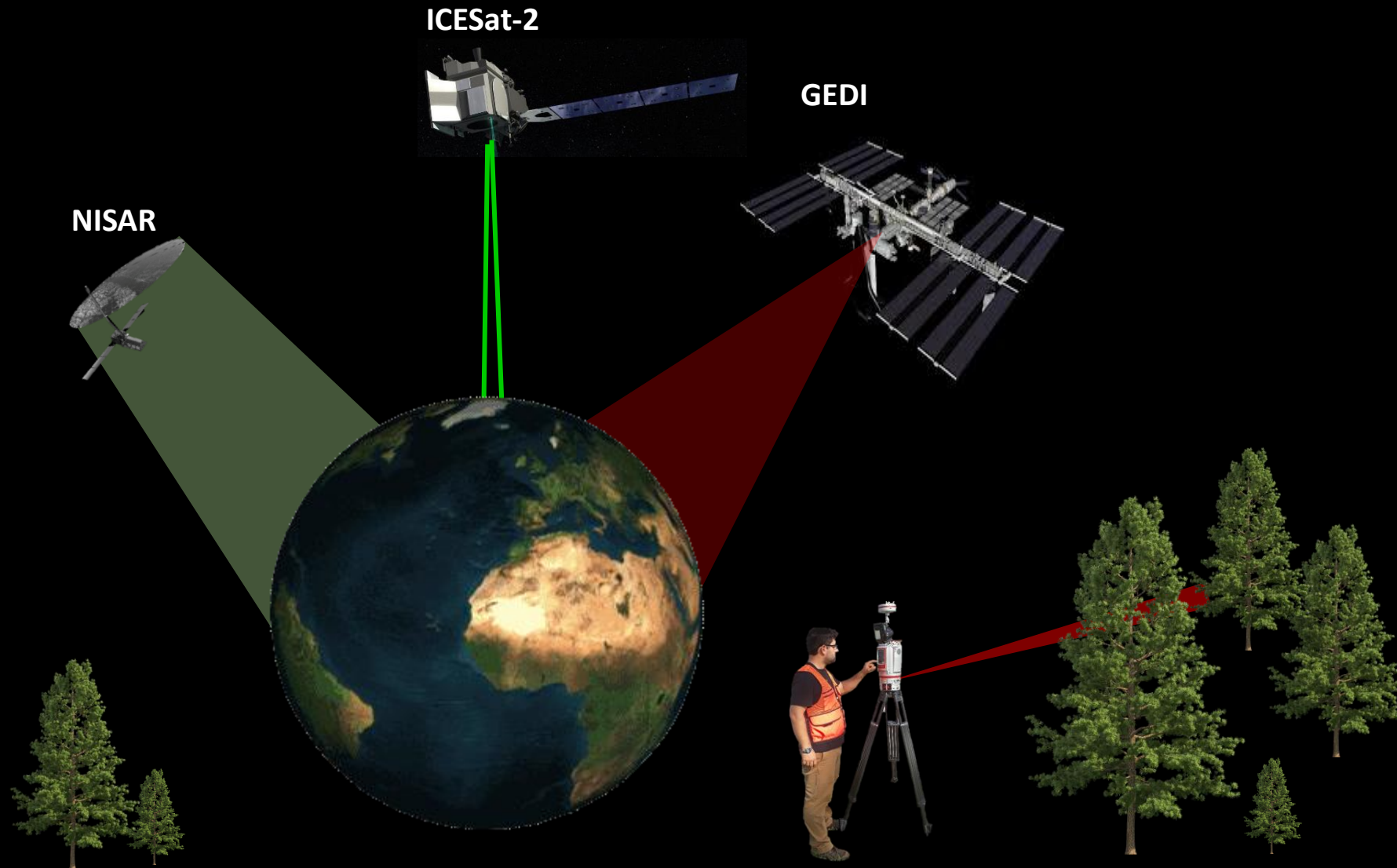


Figure 14. Labeled photons over longleaf pine forests in Florida (a) and an example of top canopy height computed at 30m (b) and 100m (c).

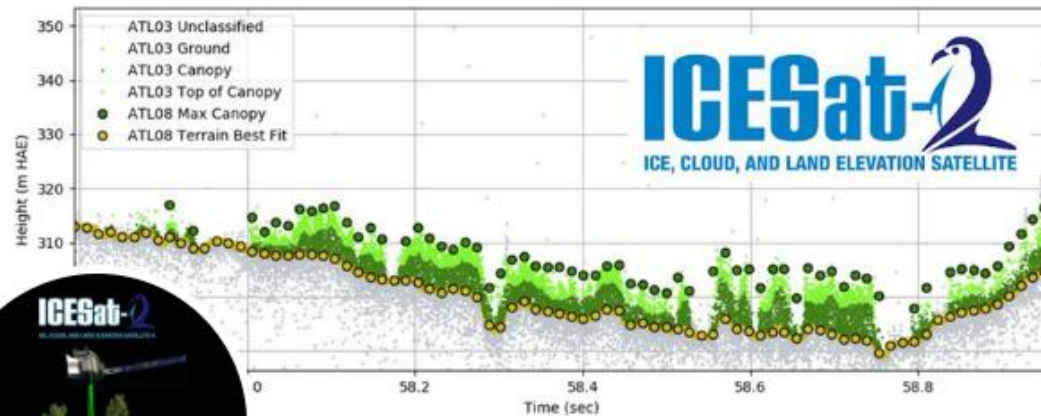
2.6 Synergies of ICESat-2 with existing and upcoming earth observation missions for land and vegetation applications





ICESat-2 Vegetation Applications

9 posts



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ICESat-2 Vegetation Applications

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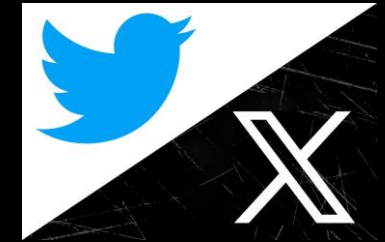
Created by ICESat-2 ST members Carlos Silva (@Web_LiDAR), Amy Neuenschwander (@longhornlam), and Sorin Popescu to share ICESat-2's vegetation research!

Joined in October 2023

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Thank you



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