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| **Beyond Ice: NASA’s ICESat-2 Spaceborne Lidar Mission for Land and Vegetation applications** |
| **Introduction/Aim:** NASA's Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2) mission emerges as a pivotal asset for studying land and vegetation applications globally. In this work, we provide a detailed overview of the ICESat-2 mission, including its instrumentation, data collection, and mission objectives, with a particular emphasis on its relevance to land and vegetation applications. We also provide a comprehensive literature review on ICESat-2 studies conducted worldwide, focused on land and vegetation applications. Herein, we have two specific objectives: (1) to perform a systematic literature review and analyse a broad spectrum of studies worldwide that have utilized ICESat-2 data for land and vegetation applications, and (2) to critically assess the current capability and limitations of ICESat-2 data for land and vegetation applications. applications.**Methods:** We analysed 203 peer reviewed articles worldwide found on Web of Science and Scopus databases and provided insights into the geographical distribution, methodologies, and outcomes of these research endeavours. Moreover, we identified gaps in the current state of research and proposed avenues for future investigation and technological refinement.**Results:** Overall, the use of ICESat-2 for land and vegetation applications has exponentially increased since 2014, with ATL08 being the most downloaded product from ICESat-2. The number of studies conducted in developed countries (n=81) and developing countries (n=91) were approximately similar, with some studies conducted in both developed and developing countries (n = 24). The majority of studies were conducted primarily on Temperate Broadleaf and Mixed Forests and Temperate Coniferous Forests. ICESat-2 land, and vegetation products have been predominantly utilized in forestry, terrain, and ecology studies. These studies have been published in various journals across disciplines, with remote sensing journals being the most prominent. Validation of ATL08 terrain elevation and canopy height products has been conducted at limited scales. Although improvements have been achieved with updated product versions, there is still a need for a more comprehensive evaluation of these products, covering a range of environmental conditions at a global scale. The development of the ATL18 products, along with new additions to the ATL08, will not only significantly expand but also broaden the utilization of ICESat-2 for land and vegetation applications, introducing novel uses such as wildlife habitat quality assessment and monitoring. Furthermore, the current repeat track retrieval capability of ICESat-2 will enable continuous and unique monitoring of land and vegetation changes, enhancing the detection and monitoring of disturbances, including those caused by fires. **Conclusion:** This comprehensive review article not only encapsulates the current state of ICESat-2 research for land and vegetation applications but also serves as a foundational guide for future investigations, highlighting emerging trends and potential research frontiers in the evolving landscape of Earth observation missions. |