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EDITED AND REVIEWED BY
Juan Carlos Jimenez,
University of Valencia, Spain

*CORRESPONDENCE
Guoxiong Zheng,
gxzheng@lzu.edu.cn
Sher Muhammad,
sher.muhammad@icimod.org

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Editorial: Cryospheric remote sensing

Guoxiong Zheng[1]*, Sher Muhammad[2]*, Ashim Sattar[3] and Juan Antonio Ballesteros-Cánovas[4]

[1]School of Earth and Environmental Sciences, Lanzhou University, Lanzhou, China, [2]International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, [3]Divecha Centre for Climate Change, Indian Institute of Science, Bangalore, India, [4]The National Museum of Natural Science, Spanish National Research Council, Madrid, Spain

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Editorial on the Research Topic
Cryospheric remote sensing

The cryosphere, including ice caps, ice sheets, ice shelves, mountain glaciers, snow cover, permafrost, and sea ice, is a key component of the Earth system. It plays a critical role in response to climate change and serves as a primary source of freshwater (Li et al., 2018; Yao et al., 2022). In recent decades, the cryosphere has undergone rapid changes, such as the melting of glaciers and sea ice, the decrease of snow cover and the degradation of permafrost. These changes have far-reaching consequences for both Earth's climate system and the living environment of humans. Therefore, cryosphere research is of great importance to understand cryospheric change and its potential impacts on other spheres of the Earth. Over the last decades, there have been notable advancements in cryosphere monitoring through remote sensing technology. The improvement in spatial and temporal resolution of satellite imagery has contributed significantly to enhancing the understanding of cryosphere processes as well as allowing the development of new algorithms, data products and interdisciplinary integration with other fields of study. Despite significant advancements in cryosphere research, certain limitations still exist. Satellite images can be affected by cloud cover, atmospheric interference, and other factors that can limit accuracy and reliability. Furthermore, integrating these data with ground-based measurements and other forms of data is still challenging to comprehensively understand the changes in the cryosphere and its response to climate change.

Remote sensing provides a viable option for studying the cryosphere in space due to its inaccessibility. Modern satellites and high-quality data provide a rich resource for cryosphere-related studies, while efficient algorithms make it more capable. Remote sensing is typically used to evaluate past changes and regularly monitor different components of the cryosphere. This facilitates better attribution and prediction of climatic parameters and their potential impacts on the cryosphere.

In this Research Topic, we have collated three research articles that demonstrate the importance of remote sensing in cryosphere research and highlight recent significant advances in related fields. Small and Sousa explore the potential of spectral analysis in characterizing the spectral feature space of the cryosphere. Specifically, they analyse the hyperspectral reflectance measurements collected over the Greenland Ice Sheet using principal component analysis and clustering methods. They find that the hyperspectral reflectance data from the Greenland Ice Sheet exhibit a complex and heterogeneous spectral feature space that clusters spectral signatures corresponding to different snow and ice conditions. These clusters are characterized by differences in the shape and position of their spectral features, as well as their overall reflectance levels. They also investigate the relationship between the spectral features and physical properties of the snow and ice and find that the spectral features are correlated with several physical properties, including snow grain size, impurities, and the presence of meltwater. Overall, the authors demonstrate that the cryosphere spectral feature space is a complex and multi-dimensional space that can be characterized using hyperspectral data. This characterization could provide valuable information about the composition and properties of the cryosphere, which could be used to improve models and predictions of cryosphere processes. Luis et al. investigate the spatiotemporal changes in snowmelt over Antarctic ice shelves using scatterometers from 2000 to 2018. They constructed maps for the whole Antarctic ice shelf using a pixel-based, adaptive threshold-based approach on backscatter during winter-to-summer transition periods and explored climatic influences on snowmelt by analysing meteorological data from automatic weather stations and investigated how the climate affects the timing and extent of snowmelt. They find that melt usually starts in late November, peaks at the end of December/January, and then vanish in early February across most ice shelves. On average, there was less melting in Eastern Antarctica than in other regions like Antarctic Peninsula. This study highlights the potential of scatterometers to monitor the spatiotemporal changes in snowmelt to improve the understanding of processes driving snowmelt and to develop more accurate mass balance models for the Antarctic ice sheet. Long et al. evaluated the effective resolution of enhanced resolution Soil Moisture Active Passive (SMAP) brightness temperature image products, which are used to study snow and ice cover. They propose a method for assessing the resolution of the images and demonstrate their method using SMAP data from various cryosphere environments. The results show that the SMAP products have an effective resolution of approx. 29.8 km, which is higher than the nominal 36 km resolution of the standard SMAP products. The spatial correlation analysis indicated that the effective resolution of the enhanced resolution SMAP products is slightly larger than the pixel size.

In conclusion, we believe that the papers collected in this Research Topic can contribute to an improvement of novel remote sensing techniques in cryosphere research, and thus enhance our understanding of the processes, mechanisms, and impacts of changes in Earth's cryosphere.

Author contributions

All authors made a substantial, direct, and intellectual contribution to this work and approved it for publication. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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