

Reviews

PELLIKKA, P. and W.G. REES, eds. 2010. *Remote sensing of glaciers: techniques for topographic, spatial, and thematic mapping of glaciers*. Boca Raton, FL, CRC Press/Taylor & Francis. 330pp. ISBN-10: 0-415401-66-6, ISBN-13: 978-0-415-40166-1, hardback, US\$138.

This is a timely book, given the current focus on global warming and the double eminence of glaciers as sensitive indicators of change and suitability for study through remote sensing, resulting from their remote locations and limited ground access. The volume is a natural successor to *Remote sensing of snow and ice* (Rees, 2006) which gave a broader background of the physical properties of snow and ice and remote-sensing capabilities relating to the cryosphere. *Remote sensing of glaciers* is co-edited by Pellikka and Rees, who themselves contribute the introductory and concluding chapters, and the main body of the text is authored by 18 European experts in their fields. The book is the final product of the 2001–04 Operational Monitoring of European Glacial Areas (OMEGA) project, designed to synthesize Earth observation data from 19th-century maps to current satellite imagery. Data-processing examples in the text are focused on, but not entirely limited to, two particular well-studied areas: Hintereisferner, Austria, and Engabreen, Norway.

Introductory chapters detail the principles of remote sensing, resolutions and relevant portions of the electromagnetic spectrum to glacier monitoring, the formation and dynamics of glaciers, with methods of measuring mass balance, and glacier parameters monitored using remote sensing including measures of mass balance, area, topography and velocity. A minor annoyance curiously specific to the latter chapter is the low-contrast reproduction of otherwise excellent photographs. The early history of remote sensing of glaciers links the publications of L. Agassiz and others on the growing interest in glaciers, with the earliest development of photography and the principles of photogrammetry. A brief summary of the physics of glacier ice and snow and the interaction of electromagnetic radiation rounds out what might be considered as the background chapters.

The next five chapters focus on the major technologies used in glacier remote sensing, commencing with visible wavelengths and modern terrestrial photogrammetry, and creating digital elevation models (DEMs) of glaciers from ground-based photography and laser scanning. Current practices in aerial photogrammetry for glacier studies examine DEM errors, vertical differences and velocity measurements. Subsequent sections describe the major scanning technologies applied to glacier remote sensing: ratioing and thresholding procedures with optical Landsat and Advanced Spaceborne Thermal Emission and Reflection Radiometer

(ASTER) data, synthetic aperture radar (SAR) interferometric surface and velocity measurements, the rapidly growing airborne laser (lidar) applications, and ground-penetrating radar (GPR) for identifying ice layer structures and thickness, along with the system elements and capabilities in glacier studies. These chapters provide excellent overviews of topics that could each comfortably fill a textbook on their spectrally specific application technologies.

The last group of chapters examine methods of detecting and representing changes and differences in glacier area extents and elevation. The first details orthorectification and overlay procedures using Geographic Information Systems for glacier regions in the Alps, while the latter two maximize the advantages of the unique set of conditions enjoyed in the OMEGA project. The middle chapter (chapter 13) examines possible distortions in DEMs by comparing multiple simultaneously acquired models for one of the sites on a specific date through the project: from IKONOS satellite imagery, aerial and terrestrial photography, and laser scanning. The next chapter examines multiple consecutive DEMs created by laser scanning at both glaciers in Austria and Norway. These case studies combine to create a valuable reference for researchers investigating glacier elevation changes in the new millennium.

The penultimate chapter, prior to brief summary conclusions, describes the role of remote sensing in worldwide glacier monitoring, detailing the activities of the World Glacier Monitoring Service (WGMS) and the Global Land Ice Measurements from Space (GLIMS) programs. All chapters are well illustrated, with useful reference lists, and the book includes 16 pages of colour plates. The technologies documented, along with expanding public and research interests in glaciers, and a continuously growing volume of available remote-sensing data, indeed make this, in the words of the editors, 'an exciting time to be studying glaciers'. This volume represents an excellent overview reference for researchers involved in remote sensing of glaciers.

REFERENCE

Rees, W.G. 2006. *Remote sensing of snow and ice*. Boca Raton, FL, CRC Press/Taylor & Francis.

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