remote sensing

Editorial

Applications of UAVs in Cold Region Ecological and Environmental Studies

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Citation: Yi, S.; Iwahana, G.; Qin, Y.; Sun, Y. Applications of UAVs in Cold Region Ecological and Environmental Studies. *Remote Sens.* **2021**, *13*, 2472. https://doi.org/10.3390/rs13132472

Received:
Accepted:
Published: 24 June 2021

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Lightweight unmanned aerial vehicles (UAVs) have been developed rapidly due to the miniaturization of aircraft components and the low cost of various sensors, as well as embedded computers, and have become a commonly used platform for ecological and environmental studies. UAVs have several advantages: (1) the spatial resolution of aerial photo ranges from millimeters to sub-meters, depending on the fly altitude and camera type. Therefore, UAVs have been applied for studies requiring a high spatial resolution, e.g., plateau pika piles, plant species, bare patches, and so on; (2) they provide an ideal tool for upscaling ground sampling, e.g., vegetation cover, soil carbon and nitrogen, to satellite inversion for regions with high spatial heterogeneity. The reason is attributed to that the space coverage of an aerial photo is larger than that of a traditional ground quadrat; (3) they can obtain image data with a much higher frequency, far exceeding most free satellite datasets, and the observation can be customized flexibly, e.g., to monitor the dynamic of livestock distribution.

Cold regions have experienced rapid warming and intensified human disturbances, the subsequent responses of permafrost, glacier, ecosystem, and so on, are deemed to be substantial, which will have critical impacts on ecosystem functions and services. Field investigations of cold regions are usually limited by road access, and a logistic and unfavorable climate, including strong winds, low temperature and low air pressure, etc. UAVs are especially valuable and imperative for these harsh environments. To verify the suitability and feasibility of UAVs in cold regions, we organized a Special Issue entitled "Applications of UAVs in Cold Region Ecological and Environmental Studies". Eight papers were published in this issue [1–8]. Among them, 1, 2 and 5 papers focused on studies conducted in the Arctic, Antarctic and Qinghai–Tibetan Plateau, respectively. The subjects were permafrost, glaciers, alpine grasslands and wild animals.

Quadrotor UAVs (mainly products from DJI Innovation Industries, China; http://www.dji.com (accessed on 22 June 2021)) were used in most of the studies, while fixed-wing UAVs were used in two studies [2,7]. The common camera (with red, green and blue bands) was equipped with UAVs in all studies; only two studies used multispectral and thermal infrared cameras to retrieve surface temperature and soil moisture [7,8]. The flight height ranged from 2 m to observe grassland vegetation species [6] to 20–65 m to observe vegetation patches, surface type and animal [3,5,6], and 150–500 m to study the features of glacier [1,2]. Half studies used mosaic flight ways, which covered all areas of each study area, and the others used typical ecological sampling methods to take aerial photos at each point [4–6,8]. Some studies performed multiple aerial photographing over each study area at different times to investigate the dynamic changes [1,7,8].

The processing of aerial photos included: (1) visual interpretation to obtain plant species [6] and patchy distribution [4]; (2) retrieving vegetation cover using manual operation with self-developed software [6] and patch indices using Fragstats Landscape Analysis software [5,8]; (3) generating Orthomosaic and DEM using Pix4Dmapper (Pix4D S.A., Prilly, Switzerland) [1,3] or Agisoft Metashape Professional software (Agisoft LLC) [2]. With this information, the majority of the studies focused on the high-spatial-resolution feature itself; two studies related grassland patches with a remote sensing dataset to perform ecological risk assessment [4,5].

Most of the flights were performed in an automatic way, with way points preset with apps or softwares, e.g., FragMAP Fragmentation Monitoring and Analysis with Aerial Photography (FragMAP). The points set with these systems can be retrieved easily to conduct repeated aerial photography, which is beneficial to the generation of a long-term time series dataset at a large scale. Although most of the studies in the current issue are case studies, they can be expended to large regions. We expect more sensors, e.g., high-spectral camera and Lidar, which will be mounted on UAVs to monitor high-precision features over a long-term period on large areas of cold regions.

Aerial photographs provide opportunities for studying subtle ground features. Meanwhile, it is challenging to process the massive aerial photographs. Some studies in this Special Issue involved visual interpretation and manual operation. Artificial intelligence, e.g., machine learning and deep learning, has developed quickly, which will be beneficial in image processing.

Author Contributions: All authors contributed equally to all aspects of this editorial. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the National Key R&D Program of China (2017YFA0604801).

Acknowledgments: We would like to thank the authors who contributed to this Special Issue and to the anonymous reviewers for valuable and constructive comments and suggestions to improve the papers.

Conflicts of Interest: The authors declare no conflict of interest.

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