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The potential of low-cost UAVs and open-source software for high-resolution glacier monitoring: A case study from the Kanderfirn (Swiss Alps)

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Unmanned Aerial Vehicles (UAVs) are a rapidly evolving tool in geosciences and are increasingly deployed for mapping, monitoring and studying highly dynamic processes of the earth‘s surface and atmosphere. Most of the mapping and monitoring campaigns make use of highly developed off-the-shelf UAVs to acquire aerial images and other geodata in high spatial and temporal resolution. The strength of commercial aircrafts is that they are reliable and ready-to-use. They also require only limited flying experience and knowledge of the technology. However, commercial UAVs in combination with proprietary data analysis software are not always affordable and hamper the testing and implementation of new sensors and experiments. Furthermore, they might not be applied in harsh environments where a damage of the aircraft must be considered. Self-developed fixed-wing UAVs equipped with optical and meteorological instruments are a powerful low-cost alternative to commercial systems. Complete open-source projects like Paparazzi provide the necessary hardware components for the construction of UAVs and the software for flight mission planning and monitoring. During multiple surveys on the Kanderfirn glacier in the Swiss Alps between 2017 and 2018, the potential of autonomous low-cost UAVs for high-resolution mapping and monitoring in harsh environments and complex terrains has been tested. The acquired aerial images were processed with the open-source photogrammetry software OpenDroneMap to generate orthophotos and digital surface models. Based on the analysis and comparison of the orthophotos and surface models from the consecutive overflights, surface height changes, surface displacement, surface roughness, surface brightness etc. were calculated using additional open-source software like R, QGIS, MeshLab and AROSICS. The results demonstrate that low-cost UAVs in combination with open-source software are an affordable alternative to commercial remote sensing platforms and have the potential to deliver geodata in high spatial and temporal resolution. These kinds of data are not only needed for the investigation of highly dynamic processes of the earth‘s surface and atmosphere, but also for the validation of model results and satellite products.