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Combined Study of Snow Depth Determination and Winter Leaf Area Index Retrieval by Unmanned Aerial Vehicle Photogrammetry

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A rapid and robust approach using Unmanned Aerial Vehicle (UAV) digital photogrammetry was performed for evaluating snow accumulation over different small localities (e.g. disturbed forest and open area) and for indirect field measurements of Leaf Area Index (LAI) of coniferous forest within the Šumava National Park, Czech Republic. The approach was used to reveal impacts related to changes in forest and snowpack and to determine winter effective LAI for monitoring the impact of forest canopy metrics on snow accumulation. Due to the advancement of the technique, snow depth and volumetric changes of snow depth over these selected study areas were estimated at high spatial resolution (1 cm) by subtracting a snow-free digital elevation model (DEM) from a snow-covered DEM. Both, downward-looking UAV images and upward-looking digital hemispherical photography (DHP), and additional widely used LAI-2200 canopy analyser measurements were applied to determine the winter LAI, controlling interception and transmitting radiation. For the performance of downward-looking UAV images the snow background instead of the sky fraction was used. The reliability of UAV-based LAI retrieval was tested by taking an independent data set during the snow cover mapping campaigns. The results showed the potential of digital photogrammetry for snow depth mapping and LAI determination by UAV techniques. The average difference obtained between ground-based and UAV-based measurements of snow depth was 7.1 cm with higher values obtained by UAV. The SD of 22 cm for the open area seemed competitive with the typical precision of point measurements. In contrast, the average difference in disturbed forest area was 25 cm with lower values obtained by UAV and a SD of 36 cm, which is in agreement with other studies. The UAV-based LAI measurements revealed the lowest effective LAI values and the plant canopy analyser LAI-2200 the highest effective LAI values. The biggest bias of effective LAI was observed between LAI-2200 and UAV-based analyses. Since the LAI parameter is important for snowpack modelling, this method presents the potential of simplifying LAI retrieval and mapping of snow dynamics while reducing running costs and time.