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Annual development of subalpine grassland observed with UAV: how NDVI evolution is controlled by snow melting

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In the Pyrenees, as in other mid latitude mountain ranges, sub alpine areas have a long lasting snow cover that affect different mountain processes, including river discharge timing, soil erosion, primary production or animal and plant phenology. This work presents and analyzes a complete snow depth and Normalized Difference Vegetation Index (NDVI) spatial distribution dataset, generated by Unmanned Aerial Vehicles (UAV) over two years. This study aims to increase the knowledge and understanding of the relationship of the duration and timing of snowmelt and vegetation cover and its annual cycle.

The dataset was obtained in Izas Experimental Catchment, a 55 ha study area located in Central Spanish Pyrenees ranging between 2000 to 2300 m a.s.l., which is mostly covered by grasslands. A total of 18 UAV snow depth and 14 NDVI observations were obtained by a fixed wing UAV equipped with RGB and multispectral cameras during 2020 and 2021. The melt out date for the different areas of the catchment has been obtained from the snow depth distribution dataset, which in turn has been used to analyze the NDVI evolution. The NDVI values for each UAV flight have been correlated with the snow depth distribution observed in previous dates and with different topographic variables as elevation, solar radiation, curvature (through the Topographic Position Index) or slope.

The maximum seasonal NDVI happens throughout the study area simultaneously in the entire study area; however those zones with the latest snow disappearance do not reach NDVI values as high as those observed in areas with earlier snow disappearance. Oppositely areas with the soonest snow melting (in late February) have lower maximum NDVI values that those observed in areas with snow melting occurring later (around May). NDVI correlations have shown that the snow depth distribution observed about one month prior to each NDVI acquisition has a very important control on pasture phenology. This correlation is particularly evident on the free-snow areas during first melting weeks, with a lower influence in those areas where snow melts at the

end of the snow season. This field study exemplifies how intensive UAV acquisitions allow understanding snow processes over extended areas with an unprecedented spatial resolution.