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Inter- and intra-annual variability of snow depth fractal behavior in a sub-alpine catchment

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Understanding and characterizing the spatial variability of snow depth can help to inform the configuration of distributed snowmelt models. The past decades have seen outstanding advances on this topic by using LiDAR (Light Detection and Ranging) technology, which has been critical to identify fractal behavior in many mountain regions worldwide. In this study, we investigate the inter- and intra-annual variability in snow depth scaling behavior at the Izas experimental catchment, located on the southern side of the Spanish Pyrenees (2000 to 2300 m above sea level). To this end, we conduct variogram analysis for 24 snow depth maps derived from terrestrial LiDAR scans, acquired during six consecutive snow seasons (2011-2017). We complement our analyses with bare ground topography and wind speed and direction measurements. Our results show inter-annual consistency in snow depth accumulation patterns, with similar scale break lengths to the best searching distance (25 m) previously reported for the Topographic Position Index (TPI), a terrain-based predictor for snow depth. On the other hand, no scale breaks are observed for bare earth topography. Scale breaks (long-range fractal dimensions) perpendicular (parallel) to prevailing NW-SE winds are larger than those obtained from directional variograms parallel (perpendicular) to dominant winds. Finally, our results suggest that basin-scale snow depth statistics contain useful information to characterize the spatial structure of snow depth.