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Quantifying snowfall from orographic cloud seeding

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Cloud seeding has been used as one water management strategy to overcome the increasing demand for water despite decades of inconclusive results on the efficacy of cloud seeding. In this study snowfall accumulation from glaciogenic cloud seeding is quantified based on snow gauge and radar observations from three days in January 2017, when orographic clouds in the absent of natural precipitation were seeded with silver iodide (AgI) in the Payette basin of Idaho during the Seeded and Natural Orographic Wintertime Clouds: The Idaho Experiment (SNOWIE). On each day, a seeding aircraft equipped with AgI flares flew back and forth on a straight-line flight track producing a zig-zag pattern representing two to eight lines of clouds visible through enhancements in radar reflectivity. As these seeding lines started to form precipitation, they passed over several snow gauges and through the radar observational domain. For the three cases presented here, precipitation gauges measured increases between 0.05-0.3 mm as precipitation generated by cloud seeding pass over the instruments. A variety of relationships between radar reflectivity factor and liquid equivalent snowfall rate were used to quantify snowfall within the radar observation domain. For the three cases, snowfall occurred within the radar observational domain between 25 -160 min producing a total amount of water generated by cloud seeding ranging from 123,220 to 339,540 m3 using the best-match Ze-S relationship. Uncertainties in radar reflectivity estimated snowfall are provided by considering not only the best-match Ze-S relationship but also an ensemble of Ze-S relationships based on the range of coefficients published from previous studies and then examining the percentile of snowfall estimates based on all of the Ze-S relationships within the ensemble. Considering the interquartile range and $5^{th}/95^{th}$ percentiles, uncertainties in total amount of water generated by cloud seeding can range between 20-45% compared to the best-math estimates. These results provide new insights towards understanding how cloud seeding impacts precipitation and its distribution across a region.