68. Reconstructing long-term snow cover dynamics in the Maritime Alps using Landsat, Sentinel-2, ancillary data and machine learning

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Mountains are among the environments most vulnerable to climate change, and its effects appear clearly in components such as snow cover and vegetation; measuring how these have changed over decades helps to quantify those effects. Satellite images are the only spatially continuous source for such longterm studies, but in mountain areas clouds and the few acquisitions of the earliest archive years leave many temporal gaps. Within the ACLIMO project, whose regional-scale component is presented here, we analyzed all usable Landsat and Sentinel-2 acquisitions from 1990 to 2025 to map snow cover at 30 m spatial resolution over a 3,218 km² area of the Maritime Alps. Snow was detected with the Normalized Difference Snow Index (NDSI). Based on recent literature, we built a daily March–April record in which clear observations are kept and every pixel not observed on a given day is filled, in turn, by i) the agreement of neighboring dates, ii) a temperature-based persistence rule and iii) a gradient-boosting classifier driven by terrain and ERA5-Land predictors. The resulting snow-covered area was corrected for classification errors. The record agreed with independent snow-depth stations, MODIS data, and the Copernicus snow product with overall accuracies of 0.86–0.95. April snow cover declined by 7.1% per decade (−83 km² per decade), three-quarters of it in the 1000–2000 m belt, consistent with warmer Aprils and less late-spring snowfall, while March showed no significant trend. The product gives protected-area managers a consistent baseline for monitoring the possible impact of climate change on snow cover.