Determining the hydrological implications of regulation on Swedish lakes with space observations

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Lakes and reservoirs are critical in providing freshwater resources and ecosystem services to agricultural and urban sectors. The storage and redistribution of water in these water resources for agriculture and energy production are known to induce important changes in the availability and variability of water by increasing evaporation from the artificial reservoirs and regulating the flow of water. For instance, hydropower development has been found to simultaneously increase the evaporative ratio in the hydrological basins and reduce the coefficient of runoff variation downstream, as natural peaks are suppressed. These effects induce significant physical and ecological impacts on dependent terrestrial and aquatic ecosystems. However, understanding the implications of regulations for downstream lakes is unfeasible, at least in the case of Sweden. With more than 100,000 lakes, Sweden has limited continuous gauged water level data in only 35 lakes, limiting the measurement of the impact of regulation on water levels. We here tackle this issue by using satellite Radar altimetry to track water levels in more than 100 lakes in Sweden from 1995 to 2022. We employ data from multiple altimetry missions, including ERS-2, ENVISAT, Jason-1,2,3, SARAL, Sentinel-3A, and Sentinel-3B. We find particular trends in water level that are dependent on the season. Furthermore, we find that changes in the trends, change, range and variability of water levels differ in regulated lakes from unregulated ones. We generate a map of changes for the entire longitudinal and latitudinal Swedish gradients. This study is the first assessment of a large set of water lake changes in Sweden and finds characteristic regulation signals on lakes. It also highlights the need to continuously monitor lake water levels to understand their ecological status and related impacts from climate change.