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Establishment of a long-term lake-surface temperature dataset within the European Alps extending back to 1880 and climate change driven scenarios until 2100 – Reconstructions and Projections derived at twelve lakes located within the complex topography of Austria

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Lake surface temperature (LST) is a key characteristic of lakes, shaping the ecological properties of these inland water bodies and their environment. This study aims at establishing a long-term, high-quality, monthly LST dataset within the European Alps reaching back to 1880, which is provided to the scientific community for further research.

Therefore monthly temperature records from Austrian lakes covering a period of about six decades are digitized from hydrological yearbooks. Clustering techniques (REOFs, cluster analysis) are used to identify groups of lakes signified by inner similarity and outer separation. These are not only used for an overall quality assessment, but also provide optimal starting conditions for the application of a homogenization procedure, warranting homogeneous LST data from 1950 onwards.

LST reconstructions back to 1880 are derived from atmospheric covariates (provided by HISTALP) via sets of transfer-functions, which have passed a selection process ensuring mathematical, physical and quality requirements and are selected from about 160 million candidates according to their skill in validation experiments.

From 1880 to 1950 LSTs feature generally slight increases accompanied by a succession of climate states. These are in alignment with outstanding climate periods and sustained, far-reaching repercussions triggered by significant events, which are known from historical documents. LST developments throughout the second half of the 20th century up to date are characterized by a decline until the mid-1980s, indicating the impact of industrial aerosols. This behaviour is superseded by a steep increase, revealing the gradual unmasking of the anthropogenic greenhouse effect by the continuous reduction of aerosol loads in the atmosphere.

In order to derive ensembles of LST projections at each lake until 2100, 60 Global Climate Model (GCM) simulations driven by RCP-pathways are regionalized by empirical, statistical downscaling (ESD) techniques, which have been thoroughly evaluated in various validation experiments. In total there are 30 climate-change projections for each RCP-pathway available at every HISTALP station. These ensembles are subsequently transferred to the lakes via the aforementioned transfer-functions. Hence, 30 LST projections from 2013 until 2100 are available at each lake for each RCP-pathway and each (of three) fransfer-functions. These extensive ensembles of LST-projections are utilized to sketch out probable future LST corridors until the end of this century.

This study attempts (i) to contribute to a better understanding of lake ecosystems by providing long-term LST time-series throughout the past - through which direct measurements and proxy-data describing biological activity and associated processes impacted by LSTs are available as well as (ii) to foster the implementation of efficient and effective protection measures according to the derived potential future LST corridors within the European Alps. Findings will also support decision-makers in ecosystem protection, tourism and water resource management.