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Decoding spatiotemporal pattern of flood episodes and climatic variability in western and eastern catchments of the Southern Alps, New Zealand.

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In the Northern Hemisphere, the PAGES Floods Working Group database documents 345 paleoflood studies, while in the humid temperate zones of the Southern Hemisphere, studies are limited due to differences in i) continent and ocean distribution, ii) population density, iii) settlement history, and iv) documentary sources. Assessing Southern Hemisphere flood trends becomes a significant goal in the context of Global Change. Our study focuses on spatial-temporal reconstruction and climatic characterization of floods in New Zealand's southern regions (43° – 47°S) from 1862 to 2020 CE.

Due to limitations in generating continuous flood series from the number of flood fatalities or economic losses over the past 160 years, we opted to reconstruct regional indices of historical flood severity and spatial incidence. To accomplish this, we compiled three regional synthetic flood databases from the New Zealand National Institute of Water and Atmospheric Research's catalogue of historical meteorological events. The flood severity matrix integrates various parameters, including numbers of fatalities, witness descriptions of peak flows, flooded areas, geomorphological impacts, losses of livestock, properties, and infrastructure, as well as information on evacuation and mitigation measures. We reanalyzed information from more than 8,000 data entries and reviewed 903 impact points to characterize a total of 295 floods. Additionally, the influence of climatic variability, as inferred from the Principal EOF of the Sea Level Pressure monthly anomalies, was reconstructed using data from the 20th Century Reanalysis Project.

The three flood damage series, comprising 295 floods, reveal several synchronous flood pulses around the years 1878, 1905, 1913, 1957, 1968, 1978, 1999, and 2008 CE. However, other flood pulses are out of phase due to different physiographic settings, catchment size, location on the western (West Coast) or eastern slope of the Southern Alps (Otago and Southland), and exposure to oceans and paths of weather systems.

Notably, in the West Coast Region with very high relief and steep slopes, the most severe floods

occurred in spring and summer. Seven out of ten flood pulses recorded from 1862 to 2020 correlate with positive Southern Annular Mode, higher sea surface temperatures (SST), blocking weather types in summer, and lows over the Tasman Sea, resulting in increased humid airflows from the north and northwest.

The larger Otago catchments, comprising humid alpine relief in the northwest, dry basins and ranges in the central area, and humid lowlands in the east, experienced the maximum number of severe floods during summer. Ten out of fourteen pulses occurred during the positive phase of the Southern Oscillation Index (La Niña), characterized by higher SST, blocking types in summer and autumn, and an increase in northeasterly winds.

In contrast, the landforms of Southland, featuring lower ridges, gentler slopes, and large floodplains, saw floods primarily in summer and autumn. Ten out of fourteen pulses in this region correlated with negative phases of the Southern Oscillation Index (El Niño), characterized by lower sea surface temperatures, more zonal flow, and troughs with stronger and more frequent winds from the west in summer and the south in winter.