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Onshore-offshore hydrological characterisation of the Canterbury margin (New Zealand) based on geophysical and modelling techniques

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Offshore freshened groundwater (OFG) is an important component of the global water cycle. Bodies of fresh and moderately brackish groundwater have been documented up to 100 km from modern shorelines. Their global volumetric estimates are on the order of 500,000 cubic kilometres, which is two orders of magnitude greater than the volume of groundwater extracted globally from continental aquifers since 1900. The potential use of OFG systems as a source of potable water is a main driving force for their improved understanding. OFG systems also play a fundamental role in biogeochemical fluxes to the ocean and in benthic and sub-seafloor ecology.

The majority of OFG systems were emplaced by groundwater migration across topographic gradients via permeable connections between offshore and onshore aquifers. The characteristics and dynamics of the offshore aquifers remain poorly constrained, however. There are many first order questions waiting to be addressed, mainly related to the geometry, distribution and dimensions of these aquifers, as well as their flow and emplacement dynamics.

In this study we integrate hydrological modelling with borehole data and offshore geophysical observations from the Canterbury margin (New Zealand) to quantitatively characterise an onshore-offshore groundwater system. Onshore, the main aquifers are hosted in gravels down to at least 150 m depth, with unconnected sand and silt/clay layers forming aquitards. The regional flow of groundwater in the Canterbury aquifers is from the foothills of the Southern Alps towards the sea. Offshore, the groundwater system consists of one main, and two smaller, low salinity groundwater bodies. The main OFG body extends up to a distance of 60 km from the coast to a water depth of

110 m, has a maximum thickness of at least 250 m, and an estimated volume that ranges between 56 and 213 cubic kilometres. It exhibits along-shelf variability in salinity, which we attribute to permeability heterogeneity due to permeable conduits and normal faults, and recharge from rivers during sea level lowstands. A meteoric origin of the OFG and active groundwater migration from onshore are inferred. However, the majority of the OFG was emplaced via topographically-driven flow during sea level lowstands in the last 300 ka.

This study demonstrates that the integration of hydrological modelling, borehole and geophysical data is a powerful approach to quantitatively characterise groundwater systems across continental margins. Applying this approach globally is likely to result in a significant revision of global volumetric estimates of OFG.