Using coupled models to place constraints on fluvial input into Lake Ohau, New Zealand

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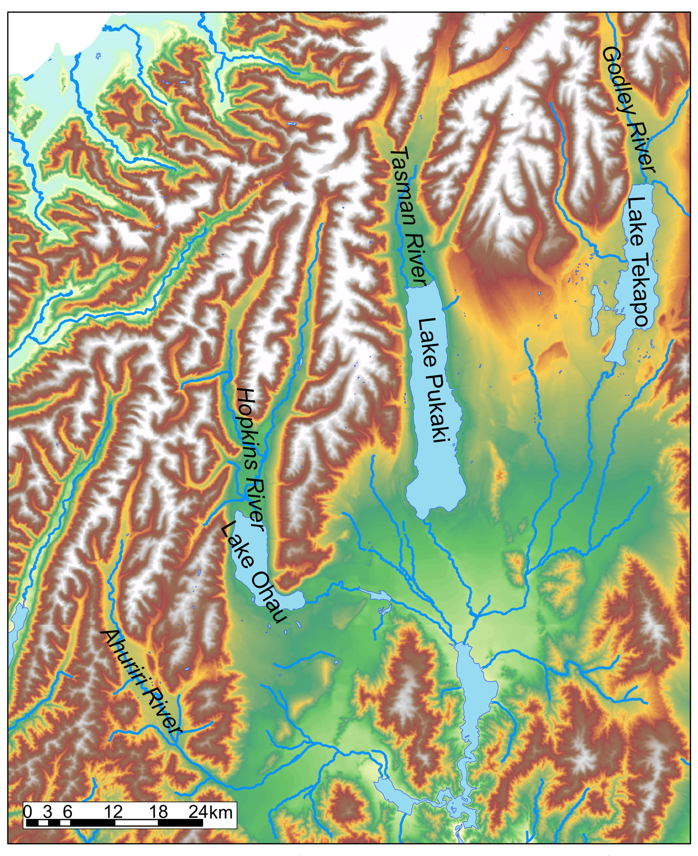


Figure 1: Located east of the main divide in the central Southern Alps, the Mackenzie Lakes; Ohau, Pukaki and Tekapo, occupy fault controlled glacial valleys and contain high resolution sedimentary records of the last ~17 ka. These sediments potentially contain a record of climatic events and transitions, earthquakes along the Alpine Fault to the northwest, landscape response during and following deglaciation and recent human-influenced land use changes. Our study focuses on Lake Ohau, the smallest and deepest of the three lakes.

Figure 2: Lake Tekapo following a large rainfall event in its catchment. A sediment laden inflow plunges into the lake and leaves the surface waters clear. We use HydroTrend (Kettner and Syvitski 2008, Computers and Geoscience, 34) to calculate the overall sediment influx into the lake and couple it to a conceptual model of how this sediment might be distributed through the lake basin depending on the season to produce model cores.

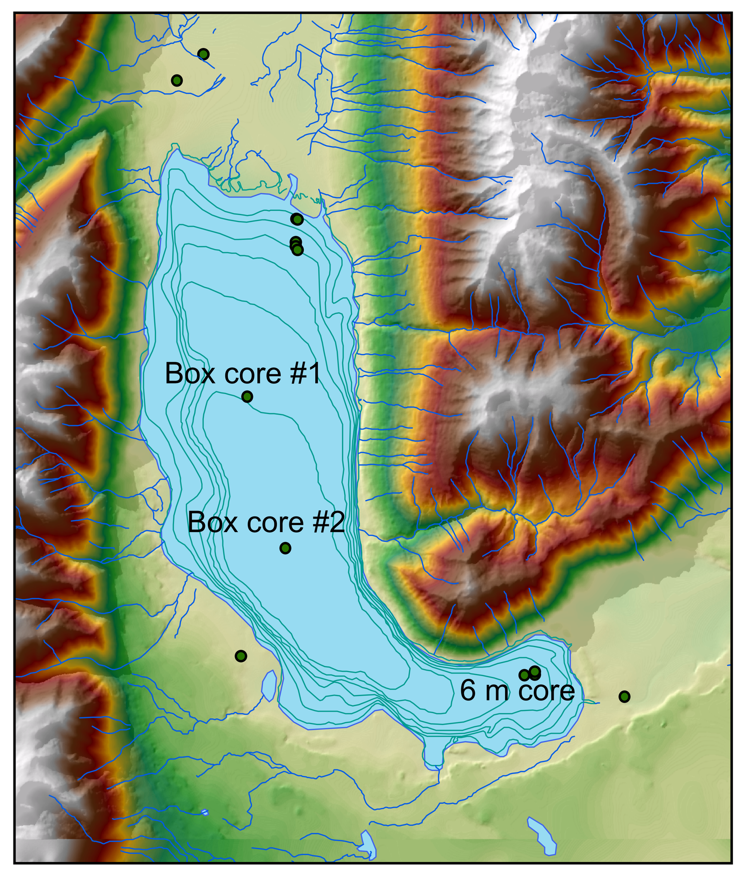


Figure 3: Map of Lake Ohau showing the location of the three cores we compare our models to.

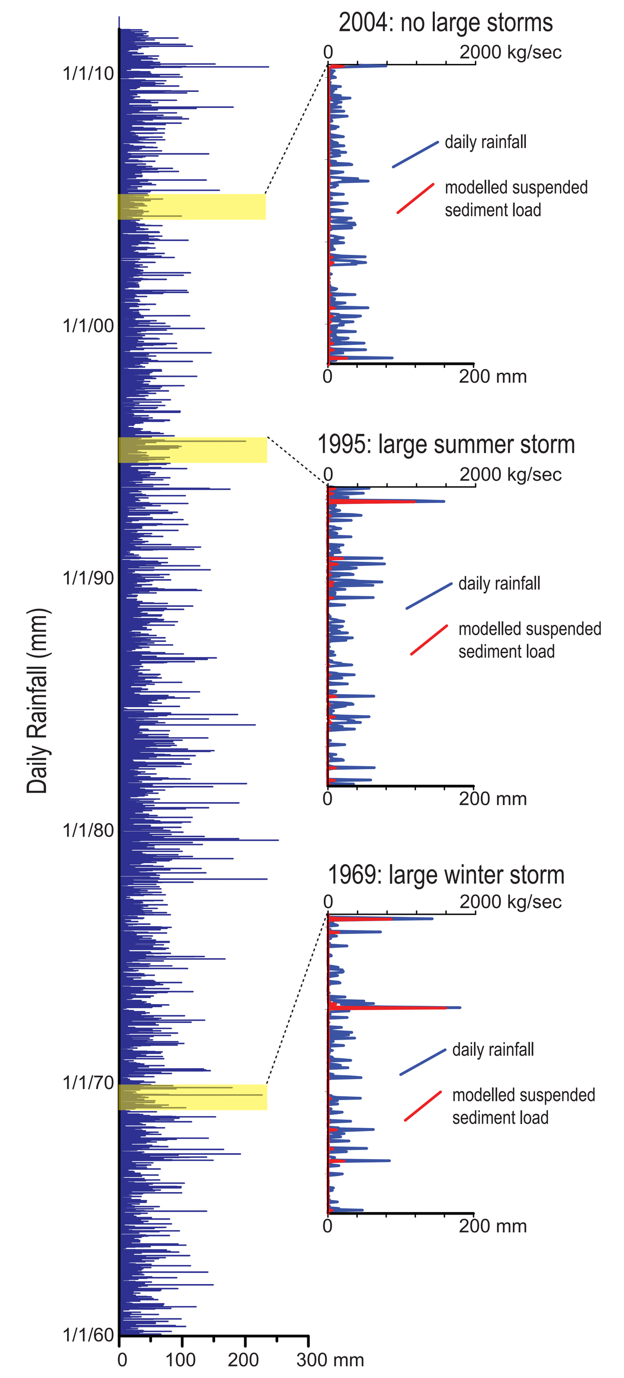


Figure 4: Daily rainfall (NIWA) from 1960 - 2011 averaged across the Ohau catchment and used as an input for HydroTrend models. Three characteristic years are shown. Rainfall (blue) and suspended sediment load calculated using HydroTrend (red).

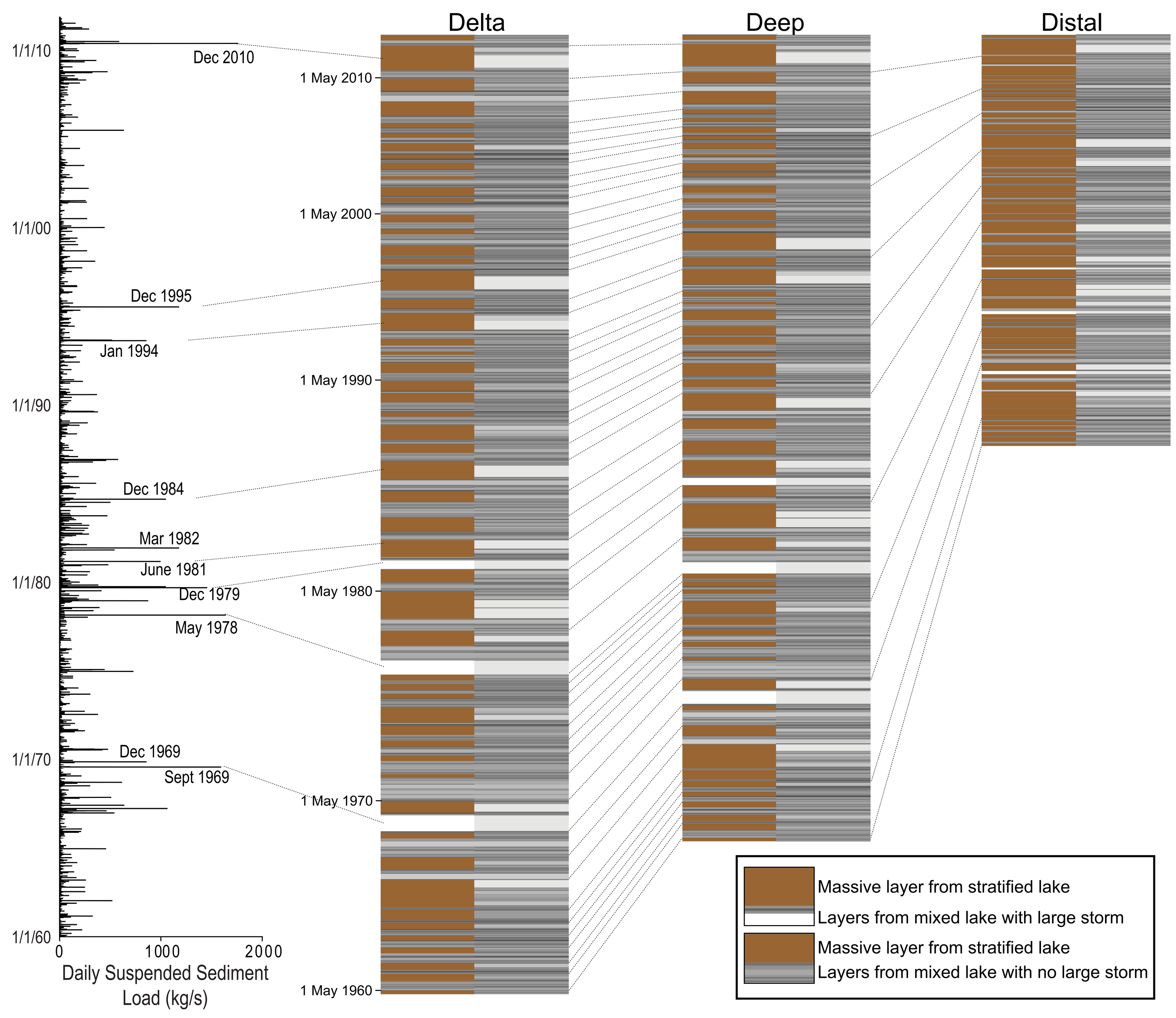


Figure 5: Model results from HydroTrend shown as daily suspended sediment load and converted to synthetic cores for three sites within the lake. On the left hand side of each core, spring/summer inflows are assumed to be mixed through the season producing a massive layer, coloured brown. Winter events form individual layers with the size of the inflow proportional to the greyscale, dark = small, light = large. The biggest winter inflows show up as white layers. On the right hand side of each core, spring/summer inflow events also form individual layers and again the greyscale is proportional to the size of the inflow. Tie lines between the delta and deep regions are shown every year at the beginning of May. Tie lines between the deep and distal regions are shown every 5 years, also at the beginning of May.

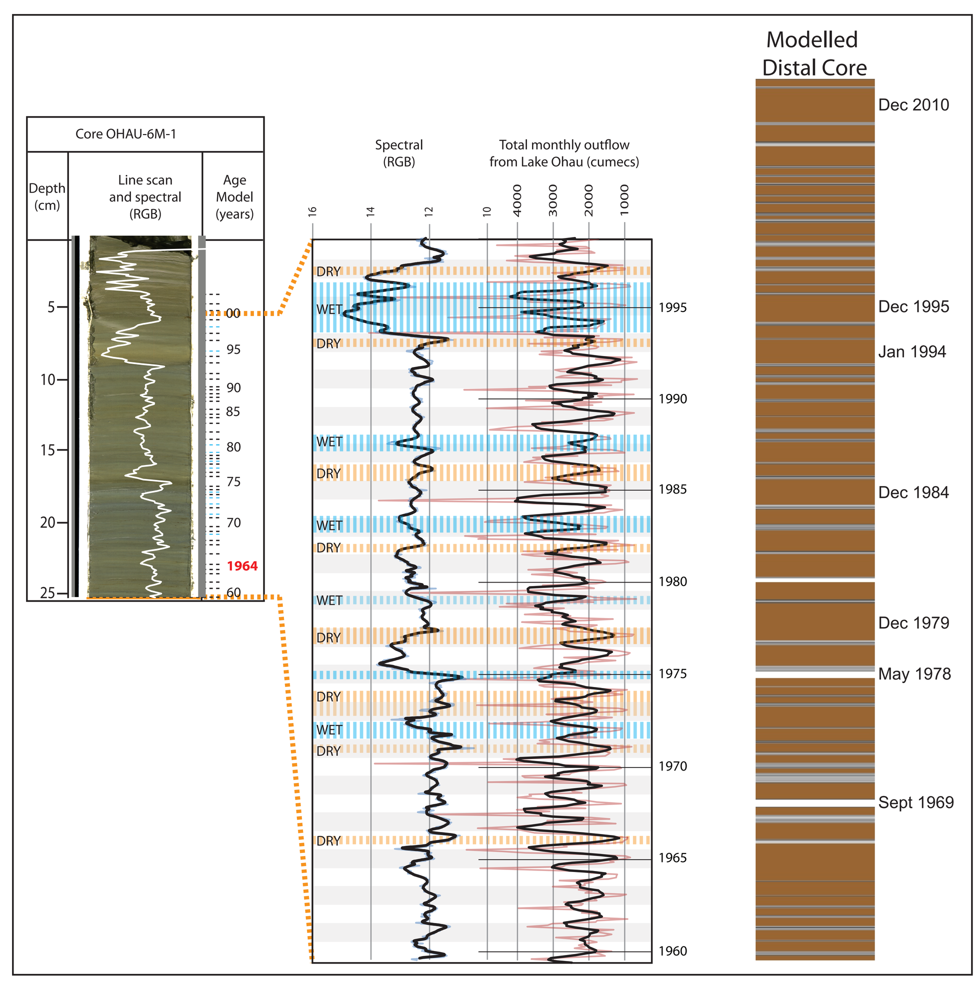
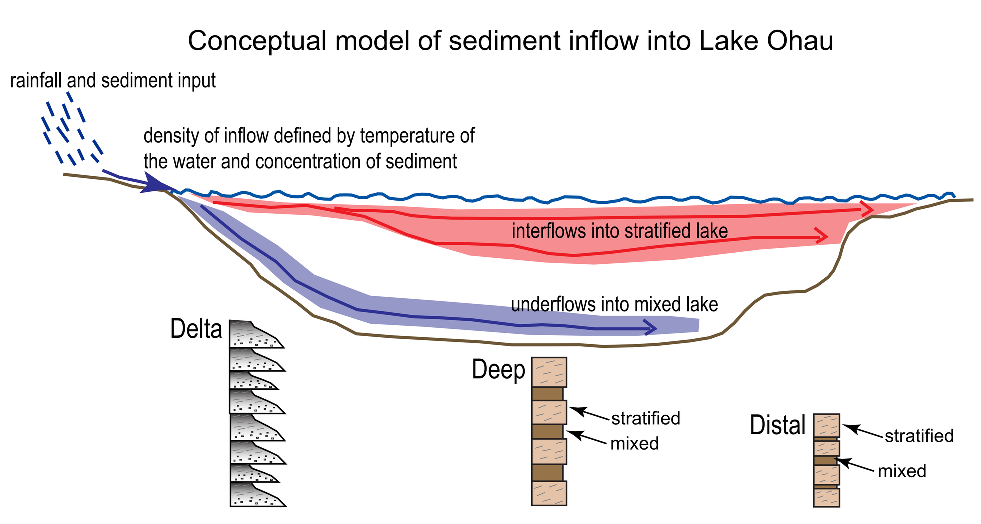


Figure 6: Upper 25 cm of Lake Ohau sediment core 6M-1. Left panel: line scan image with RGB data overlain. Age model is based on cuplet counts with red age based on Cs dating (Ditchburn et al. 2011, GSA Abstract). Middle panel: zoom into 1960 - 2000, RGB specta with South Island precipitation anomalies (Ummenhofer and England 2007, Journal of Climate, 20). Total monthly outflow from Lake Ohau (cumecs). Blue and orange correlation lines highlight wet and dry years. Right panel: modelled distal core with summer layers shown as a massive brown deposit and winter layers shown by greyscale.

Correlation of individual layers with individual storm events is difficult as the size of the resultant layer likely depends on precipitation and other factors such as the time since the last major storm (e.g., McCulloch et al. 2003, Nature 421). For example, both 1994 and 1995 had very large storms, the 1995 storm being the largest, yet only one large layer is obvious in the core. Prior to the 1994, the previous large storm was in 1984. Thus between 1984 and 1994, 10 years of material was available to be moved through the catchment.

Figure 7: Conceptual model of Lake Ohau showing mixed (generally winter, April - November) and stratified (generally summer, December - March) time periods. During the warmer months, the lake is stratified and sediment plumes are expected to form interflows with sediment being deposited along the entire lake basin. During the cooler months, the lake is mixed and sediment inflows are expected to plunge to the bottom of the lake. Sediment deposition occurs predominately on the delta and in the deep lake with the distal regions receiving minimal winter



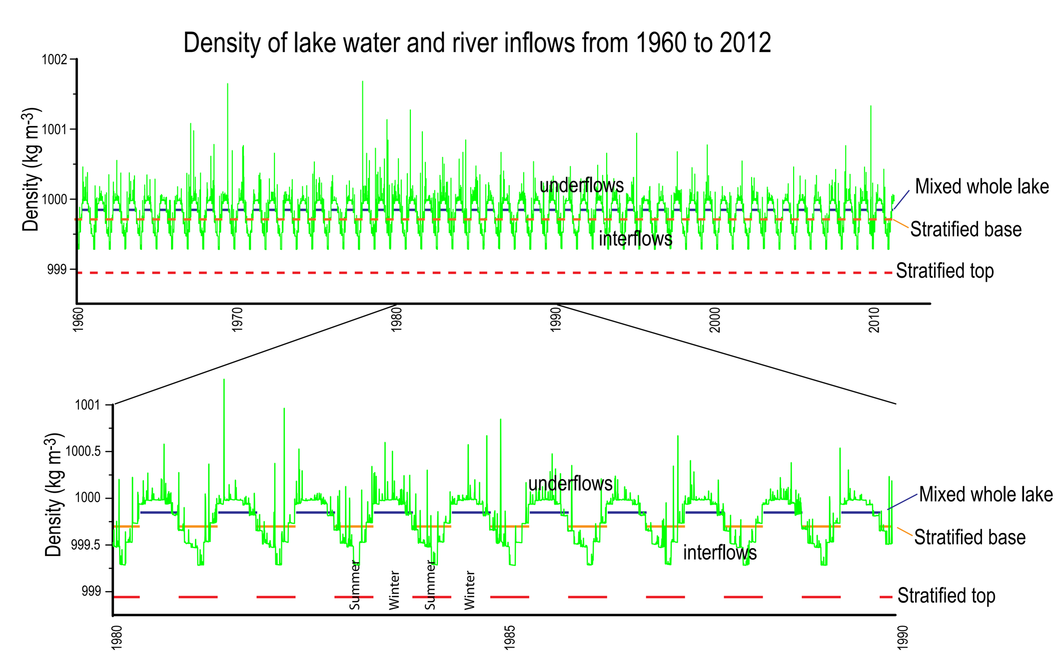


Figure 8: Calculated density of lake water (mixed in cooler months, stratified in warmer months) and river inflows as a function of temperature and sediment concentration. When the lake is mixed, all flows plunge to the bottom of the lake. When the lake is stratified, most flows are interflows but highly sediment laden flows are dense enough to plunge to the bottom of the lake.

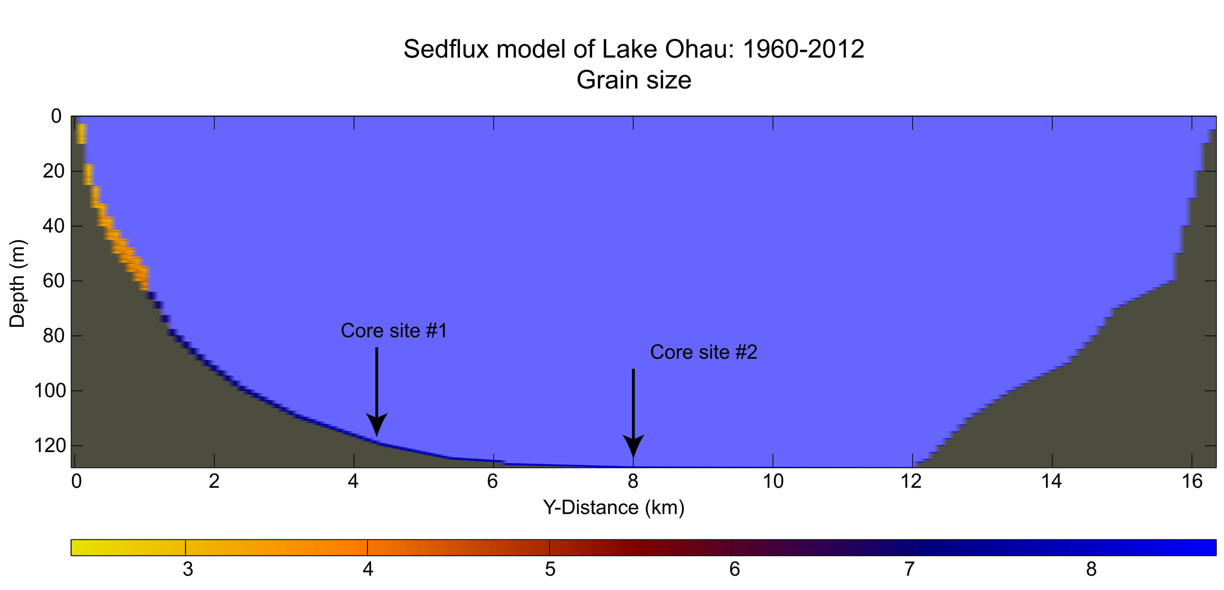
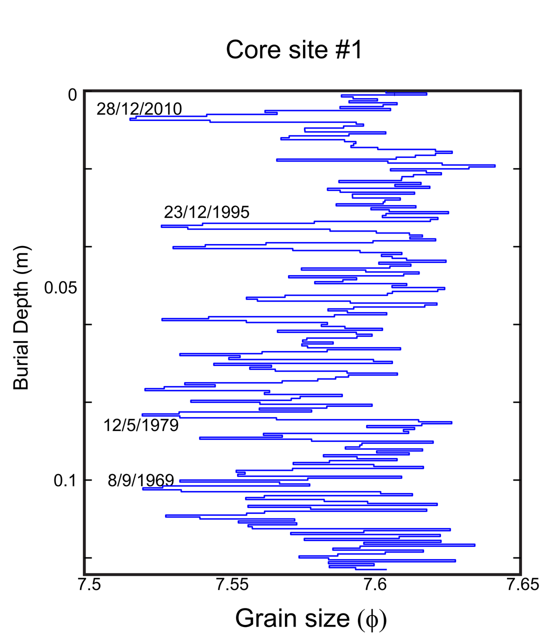
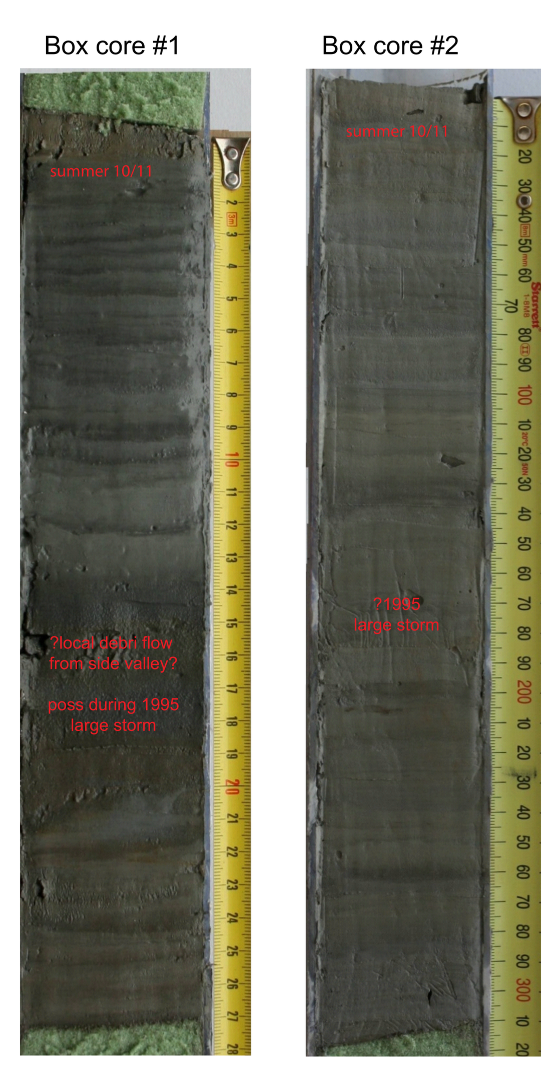
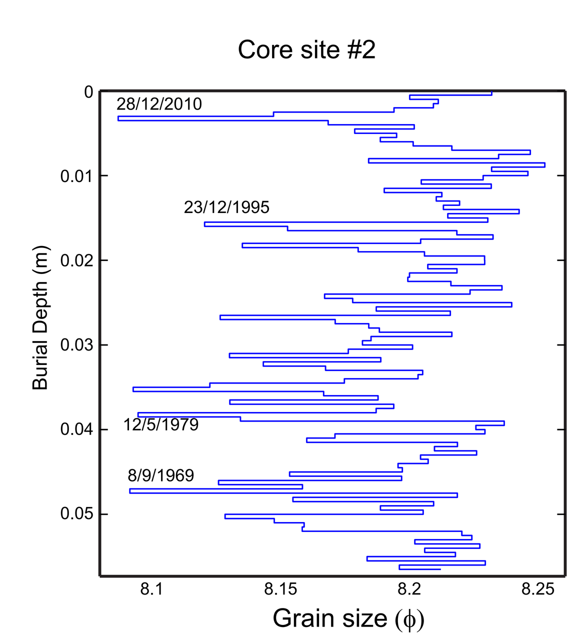


Figure 9: Sedflux model of Lake Ohau run over 53 years (1960-2012) using HydroTrend output as input into the model. Bedload is deposited within 1 im of the delta.







Comparison of models and cores:

- The models greatly simplify the along lake sediment distribution. We use our conceptual model to convert the HydroTrend output into synthetic cores. Temperature records from the lake, short cores and the models suggest that the delta region of the lake records individual events while the depocentre and distal regions of the lake record layers which represent either a stratified or a mixed lake.
- The Sedflux model underestimates the sediment reaching the distal end of the lake. Is this because Sedflux does not include statification of the water column and thus all sediment laden flows are modelled as underflows?
- The grainsize distribution from HydroTrend into Sedflux are very simplified, i.e., there is no change in grainsize distribution with an increase in discharge.