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# CarbonWatchNZ: Regional to National Scale Inverse Modelling of New Zealand's Carbon Balance

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Atmospheric observations of $CO_2$ and other greenhouse gases have been widely used to constrain estimates of terrestrial and oceanic $CO_2$ fluxes through atmospheric inverse modelling. Yet, applying these methods at national scale to verify and improve the National Inventory Report (NIR) and support the Paris agreement remains at the frontier of $CO_2$ science.

We use inverse modelling to estimate New Zealand's carbon uptake and emissions using atmospheric measurements and model. This effort is part of a five year CarbonWatch-NZ research programme, which aims to develop a complete top-down picture of New Zealand's carbon balance using national inverse modelling and targeted studies of New Zealand's forest, grassland and urban environments. In addition to quantifying New Zealand's carbon emissions on a national scale, we also focus on identifying the prevailing processes driving $CO_2$ changes in New Zealand to support climate mitigation.

In an initial study based on the inversion system used in CarbonWatch-NZ, a significantly stronger (30-60 %) sink was found relative to the NIR (Steinkamp et al., 2017), suggesting a strong $CO_2$ uptake in Fiordland, a region covered by indigenous temperate rainforest in New Zealand's South Island. Here, we present new results of CarbonWatch-NZ by expanding the studied time period from 2011-2013 to 2020, expanding our atmospheric observing network from two (Baring Head, 41.41°S, 174.87°E and Lauder, 38.33°S, 176.38°E) to a total of eleven in situ greenhouse gas measurement sites and improving our atmospheric model resolution by roughly a factor of ten (NAME model, 1.5 km).

Our new results suggest that the strong sink observed in 2011-2013 did not diminish, but for recent years we have found an even stronger sink than for before. Additional measurements collected in the Fiordland region (i.e., mixing ratios, $CO_2$ isotopes, carbonyl sulphide) also suggest a stronger $CO_2$ uptake, supporting our inversion results. Both the measurements and inversion results show that the $CO_2$ uptake does not seem to shut down completely during winter time, suggesting that there might be something about this ecosystem that we do not yet understand. This winter uptake signal is also present in independent data collected in and around New Zealand as part of the ATom campaigns (Atmospheric Tomography Mission). Implementing observations

from an additional site in the North Island (Maunga Kakaramea, 45.034°S, 169.68°E) has increased the strength of the sink, pointing to additional strong sink region at the top of the North Island.

References

Kay Steinkamp, Sara E. Mikaloff Fletcher, Gordon Brailsford, Dan Smale, Stuart Moore, Elizabeth D. Keller, W. Troy Baisden, Hitoshi Mukai and Britton B. Stephens, Atmospheric CO2 observations and models suggest strong carbon uptake by forests in New Zealand, Atmospheric Chemistry and Physics, 2017.