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# Short-term variability in atmospheric carbon dioxide as observed from coastal Antarctica and an introduction to the Halley Autonomous Long-term Observational Science (HALOS) Platform

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The British Antarctic Survey (BAS) operates one of the most remote, advanced, and scientifically important research stations on the Antarctic continent – Halley. Located on the floating Brunt ice shelf, the station has provided meteorological and atmospheric observations since it was established in 1956. However, in the face of glaciological uncertainty, Halley Research Station had to close for the first time in its history during winter 2017. To overcome the subsequent data loss from the unmanned research station, engineering and science teams at BAS began automating the station.

In 2018-19, the Halley automation project began with scientific equipment adapted and the installation of an innovative micro-turbine electrical generator. Science experiments ran uninterrupted throughout the nine-month winter period, with the station preserving core science data streams such as Meteorology and Ozone Monitoring, Tropospheric Chemistry and Climate, and Space Weather and Upper Atmospheric Observations. The system proved its ability to withstand the Antarctic environment during the 2019 winter; unaffected by ambient temperatures as low as -55˚C and winds gusting up to 70 knots.

Work is ongoing to automate and reinstate the long-term atmospheric monitoring experiments at Halley. In December 2021, a new automated $CO_2$ and $CH_4$ analyser was installed in Halley's Clean Air Sector (CAS) laboratory which will run continuously over the coming Antarctic winter. Halley's coastal location provides an ideal platform to explore air-sea $CO_2$ exchange in the Southern Ocean region. The Southern Ocean is a globally important carbon sink, estimated to account for ~75% of global ocean $CO_2$ uptake but a sparsity of observations in the region has contributed to uncertainty around the inter-annual and seasonal nature of the Southern Ocean sink.

$CO_2$ mixing ratios have been measured at Halley at high temporal resolution since 2013. Before the installation of the new autonomous system at Halley, measurements were relocated to the German coastal Antarctic research station, Neumayer, at the end of 2017. Both the Halley and Neumayer records show short-term variability in $CO_2$ mixing ratios during the summer, with up to

~0.5 ppb decreases in $CO_2$ over the course of a day, about 1/6 of the average annual growth rate. Trajectory analysis suggests that these decreases in mixing ratio correspond to periods where the air sampled has spent time over the Southern Ocean, suggesting $CO_2$ uptake has occurred. This work will explore the possible drivers for the short-term variability in $CO_2$ mixing ratios. An overview of the automation work carried out so far at Halley and plans for future seasons will also be presented.