ASB Project: ‘The 1610 CO_2 drop: Natural, Anthropogenic or Artefact?’

Project background

Ice core records of carbon dioxide (CO_2) throughout the last 2000 years are key to understanding global carbon cycle dynamics on centennial and multidecadal timescales. Yet the true atmospheric history of CO_2 in some areas of these records remains unresolved. This is because we rely on just two good-quality ice core CO_2 records, from the Law Dome and West Antarctic Ice Sheet (WAIS) ice cores. Atmospheric CO_2 leading in to the Little Ice Age (LIA), a cold period between 1550 and 1850, is a particular source of uncertainty (Macfarling Meure *et al.* 2006, Ahn *et al.* 2012, Bauska *et al.* 2015, Rubino *et al.* 2019). Perhaps the most prolific mention is that of the distinctive Law Dome ‘1610 CO_2 drop’ (Figure 1), where a rapid decrease in CO_2 of ~10 ppm over 90 years leads into the LIA, with a distinct minimum at 1610 CE. Lewis and Maslin (2015) suggest it as one of two potential markers for the start of the Anthropocene. Being termed the ‘Orbis Spike’, the distinctive low in the CO_2 record is posited to be caused by the human new-old world collision and subsequent pandemics, with mass population decrease and land abandonment in the Americas resulting in large-scale land biosphere regrowth and CO_2 uptake. The impact on the CO_2 record, if this were the case, would be the first observation of significant human influence on the climate. Yet, this feature is not observed in the WAIS CO_2 record. Here we ask; ‘What is the true atmospheric history of CO_2 leading into the LIA?’.

Project aims

We aimed to measure CO_2 in a new ice core record, Skytrain, with ages dated around 1610 CE. The project would foster international collaboration, with CO_2 measurements taking place at the Oregon State University ice core gas analysis lab. The measurements would allow us to validate our own, new, CO_2 analysis system at the British Antarctic Survey (BAS), measuring the same ice on both systems.

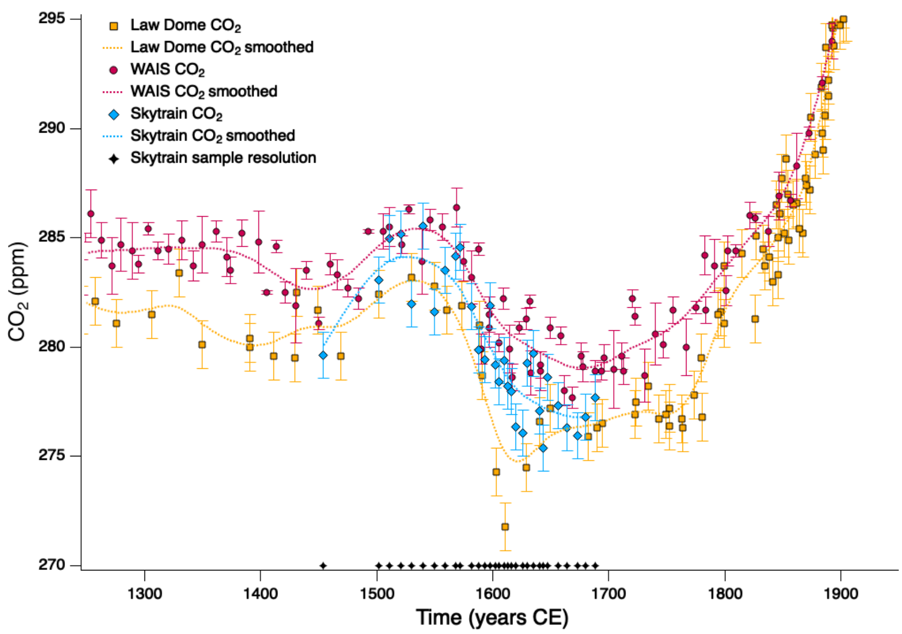

Figure 1: Existing and new (Skytrain, this study) ice core records of the ‘1610 CO_2 drop’.

Challenges: the COVID years

COVID proved particularly challenging to a project relying on laboratory access and international travel. The development of the BAS CO_2 analysis system is somewhat behind schedule, with limited access to labs between the start of the project, in 2020, and the end in March 2022. None-the-less, after a nervous wait through an Omicron-hit 2021 Christmas holidays, samples were shipped and a very quiet flight to Portland, Oregon, finally took off in January 2022 for a 5-week analysis campaign (the main project costs). Rewarding the patience and perseverance to move this project forward, the sample analysis couldn't have gone better, and we obtained great results. While the second goal, that of the lab comparison, has not yet taken place, we have these results ready and waiting for whenever we are.

Results

The new Skytrain record does not show the distinct CO_2 low at 1610, of ~10 ppm decrease over 90 years, as earlier observed in the higher accumulation, but lower measurement precision Law Dome ice core. Observed instead is a steadier CO_2 decrease of ~8 ppm over 150 years. This is akin to that which is observed in the WAIS ice core, a lower accumulation (in comparison to Law Dome) but higher sample resolution and precision record (Figure 1). Because WAIS and Skytrain have lower snow accumulation rates, the gas record is more 'smoothed' because there is more time for gas-mixing in the still open porosity of the upper firn (i.e. before complete bubble close-off). There is therefore an argument that WAIS and Skytrain simply cannot preserve the '1610 event'. However, our model smoothing experiments show that this is not the case. Based on these findings, we suggest it is highly unlikely the 1610 event record is a true atmospheric feature. We are now able to present a compilation spline to best represent the true atmospheric history of CO_2 leading into the LIA, a fundamental contribution to our understanding of CO_2 through the LIA and to future carbon cycle modelling studies.

Next steps

Our findings solidify the importance of the high resolution and precision ice core CO_2 measurements for understanding climate history of the last 2000 years. With improved analytical technology since previous records were measured, our results show how a new, high resolution ice core record of CO_2 throughout the full time-period would be of value. The results of this study are being prepared in a manuscript for publication. They will contribute to future collaborative science proposals, carbon cycle modelling, and lab validation of a new highly precise CO_2 analytical system at BAS.

References

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