ACKMA Cave Climate Project Update – How humid is it underground?

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Thanks to the ACKMA cave climate monitoring team, we have over one and a half years of cave climate data from across Australia and New Zealand. This includes information on the humidity of the cave air.

Apart from our overview of the project in the ACKMA Journal 120, we have not reported in detail on cave air relative humidity data until now, as we were waiting on a calibration of the relative humidity sensors. That is now in progress, and it appears they have excellent accuracy and precision when compared to top-specification weather station sensors. The results are presented in Figure 1. We compared the ProTech QP6013 logger used by ACKMA members with a Vaisala HMP155 RH/T probe for over six months in Daylight Cave, Willi Willi, in collaboration with the Kempsey Speleological Society. Many humidity sensors used in home meteorological stations are inaccurate at humidities greater than 95%, making them of limited use in caves.

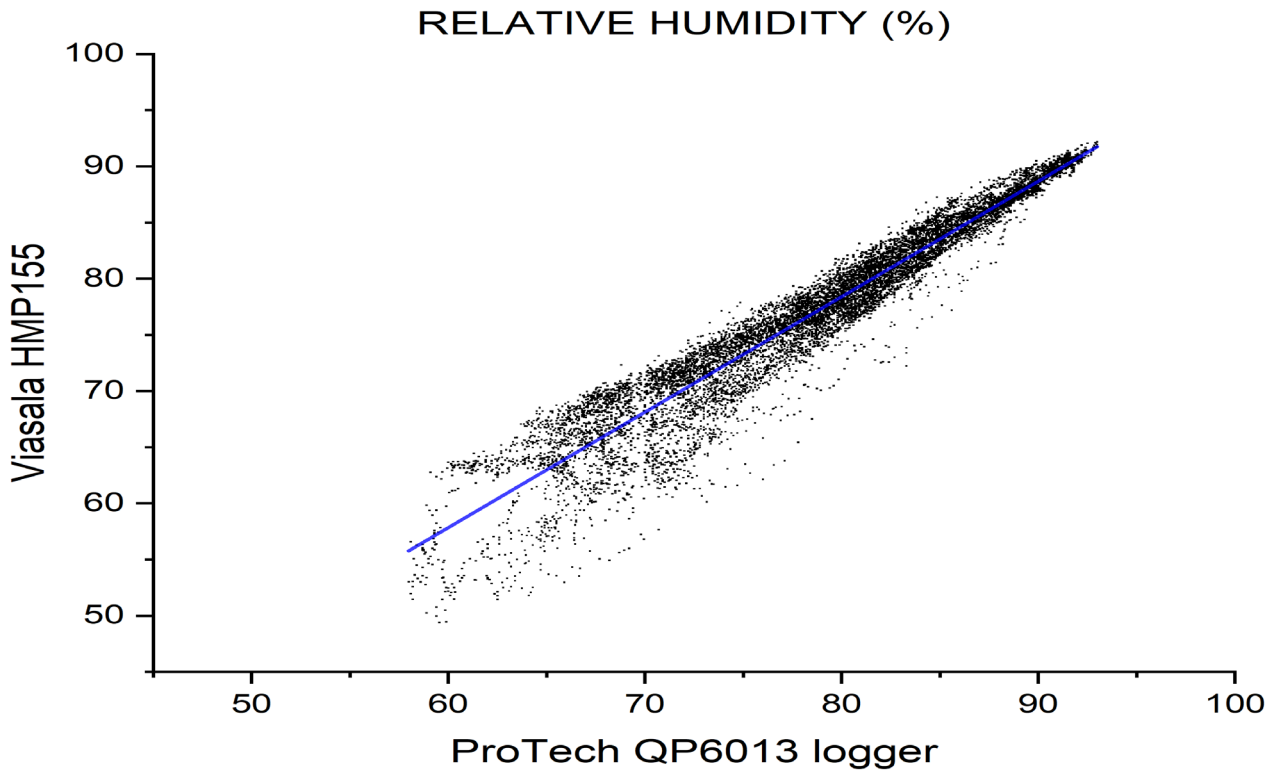

Figure 1. Comparison of relative humidity measured by a ProTech QP6013 logger as used in the ACKMA Cave Climate Project and a Vaisala HMP155 sensor. The HMP155 has a manufacturer quoted relative humidity accuracy of ±1.0% up to 90% relative humidity and ±1.7% when relative humidity is in the range 90-100%.

So, onward with our first detailed overview of cave air relative humidity. Relative humidity is measured on a percentage scale from 0 to 100, where 100% indicates the air contains the maximum amount of water vapour possible. And it is 'relative' humidity as the amount of water vapour in air varies with temperature. Why? Warm air can contain more water in the vapour phase compared to cool air, as there is more energy in warm air to allow water molecules to go into the vapour phase.

What about cave air relative humidity then? This first plot shows the last year and a half of relative humidity data, with data for all twenty-seven caves downloaded from the ACKMA website (http://www.ackma.org/CaveClimate/index.asp) at the end of 2021. Thirteen of the caves have continuous relative humidity of 100% and can't be distinguished from one-another in this plot.

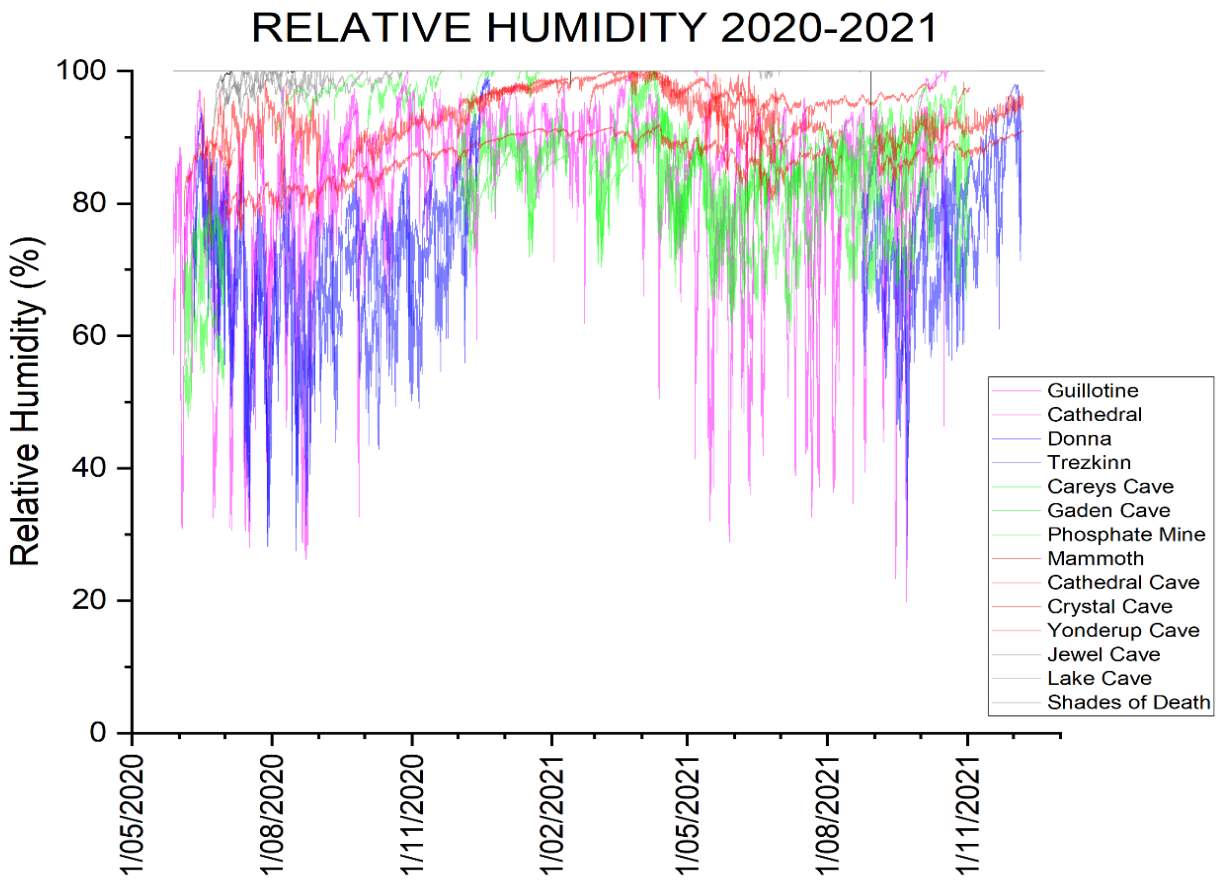

Figure 2: Relative humidity data for twenty-seven Australasian show caves for the last eighteen months. The fourteen caves which have relative humidity less than 100% for some or all of the year are shown in colour.

The other fourteen caves have some variation in relative humidity, and to best display this data we have separated them by Australian state (Queensland, Figure 3; Western Australia, Figure 4; all other states, Figure 5). You can see that for these caves, relative humidity is highest in summer and early autumn, and lowest in late winter and early spring. Ventilation of cave air with external air explains this seasonal pattern. In winter and early spring, the humid cave air can exchange with external air that is likely to be less humid. In summer and early autumn, cave ventilation is limited, and relative humidity of the cave air increases.

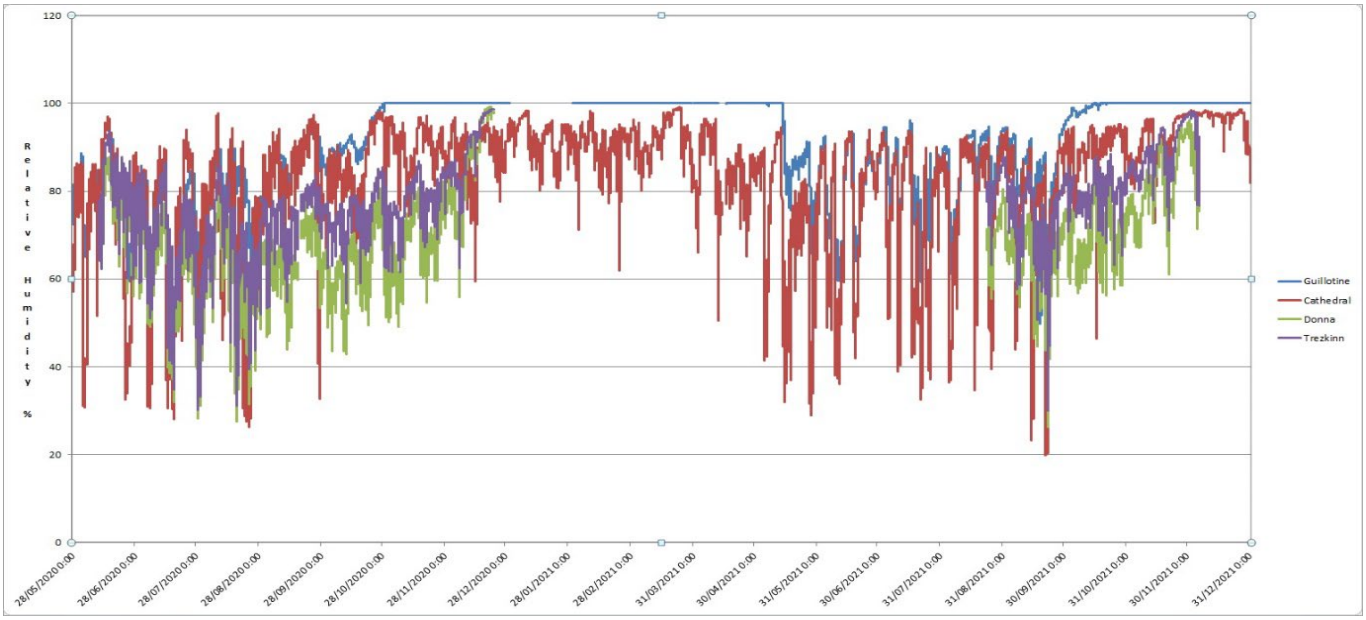

Figure 3: Relative humidity data for the Queensland show caves for the last eighteen months.

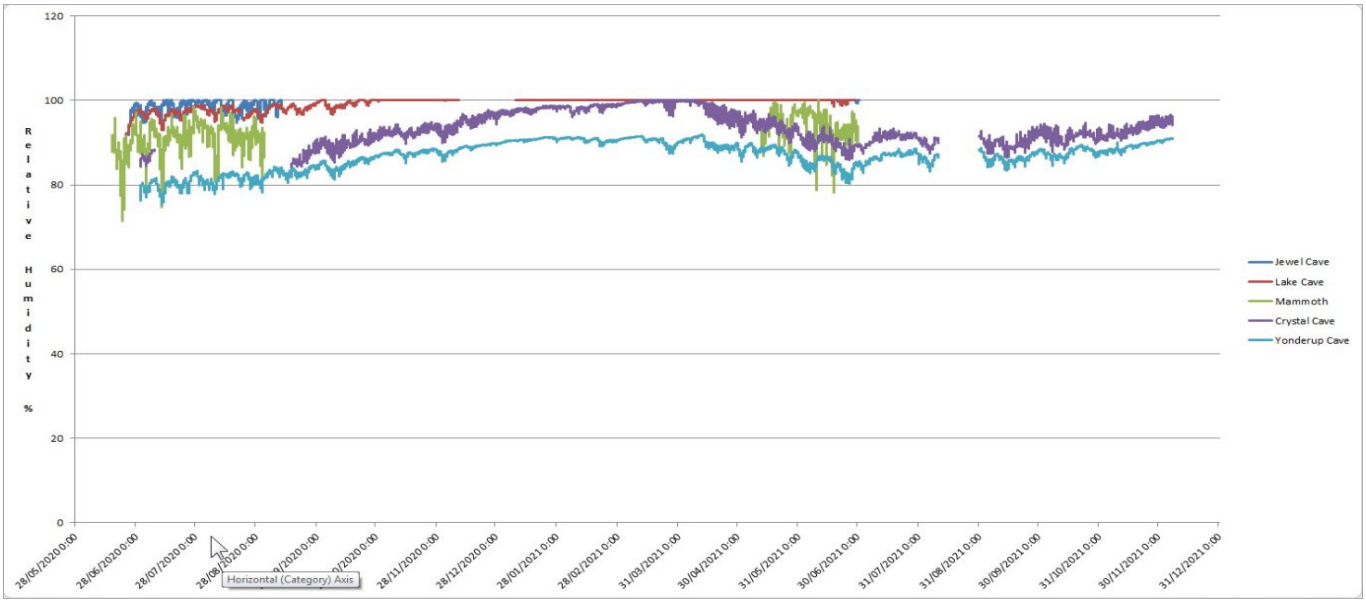

Figure 4: Relative humidity data for the Western Australia show caves for the last eighteen months.

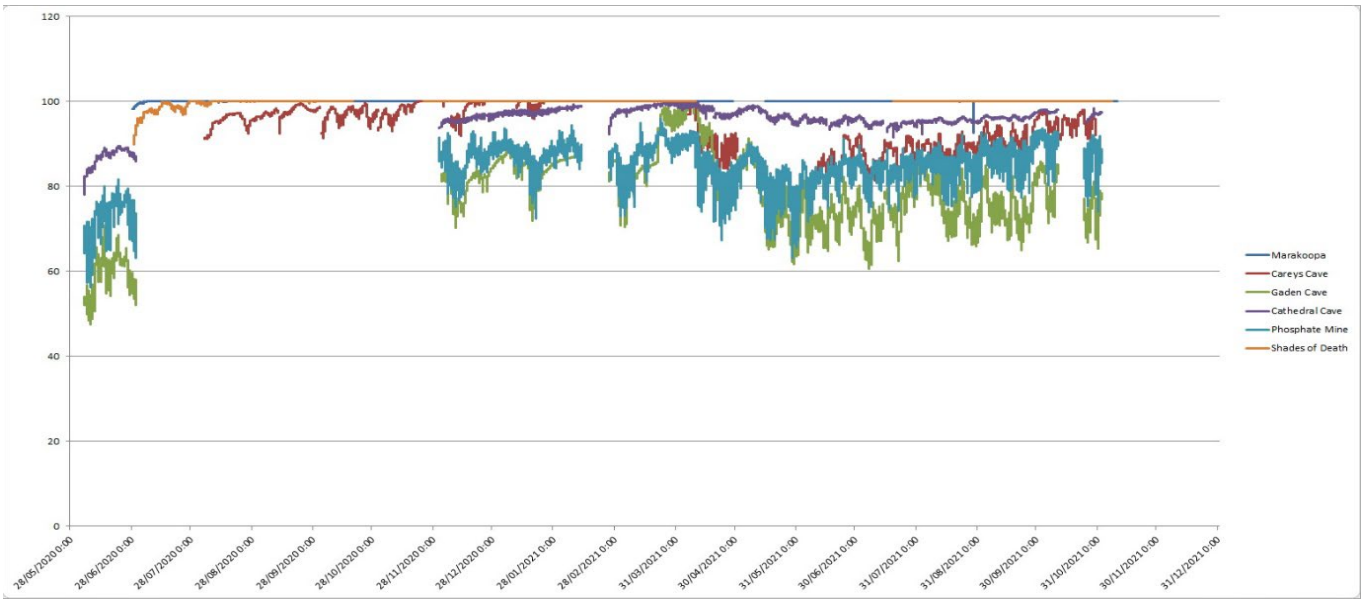

Figure 5: Relative humidity data for the remaining caves which have relative humidity less than 100% for some or all of the year.

The final plot (Figure 6) shows the average relative humidity for each of the twenty-seven caves, and we have plotted that against the average cave air temperature. Again, this is for all data available on the ACKMA website at the time of writing (January 2022). This time, each cave is labelled so you can identify the caves which have relative humidity less than 100%, and from which we would infer would have to be well-ventilated, at least for part of the year.

Delve into this plot and we start to see how cave climate is often very specific to an individual cave, with caves in the same region having quite different temperature and humidity regimes. At Wellington Caves, for example, we observe large differences in temperature and humidity between Cathedral Cave (high humidity due to the cave reaching the water table, see Figure 7), Gaden Cave (low humidity in this seasonally ventilating, dry cave) and Phosphate Mine (cool temperatures as the mine is a cold air trap). Variability between caves can be seen in the Margaret River region (Jewel Cave, Lake Cave, Mammoth Cave and Caldargup Cave) and also within individual caves (for example, the Guillotine and Cathedral Caverns in Capricorn Caves).

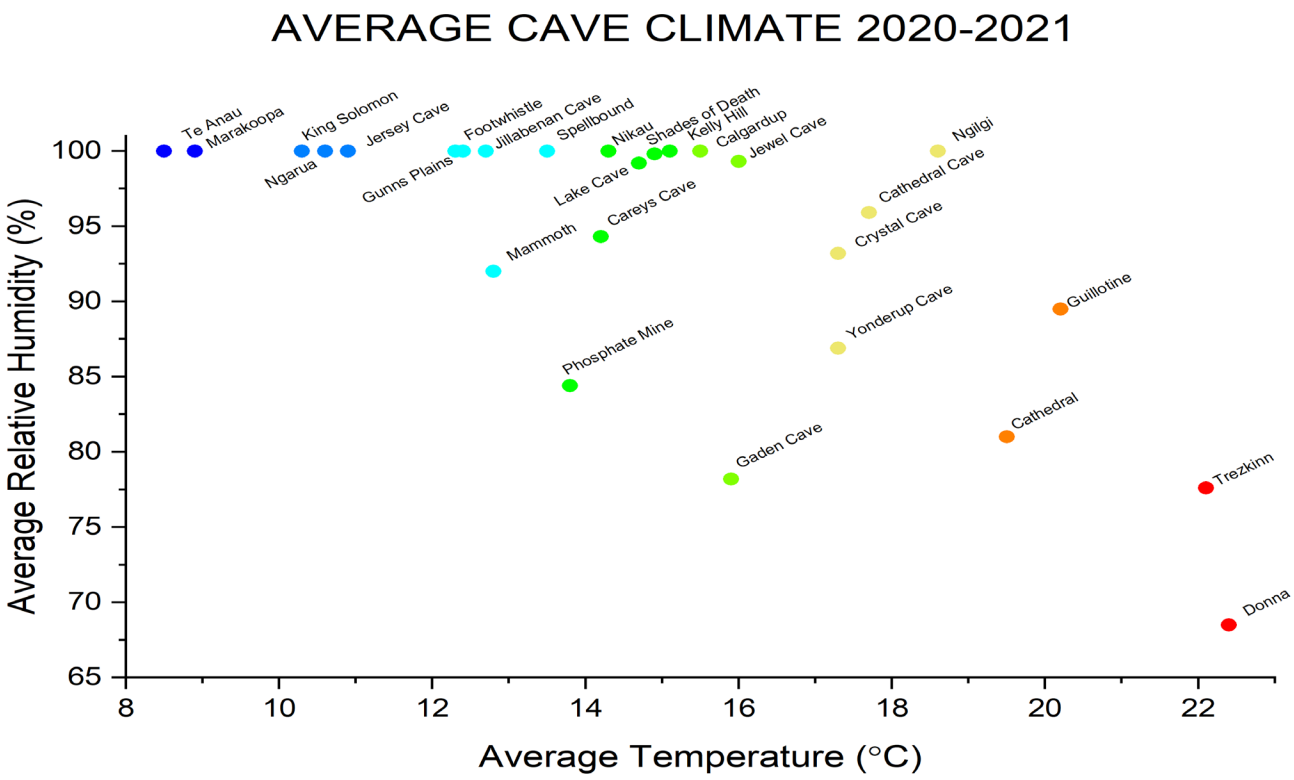

Figure 6: Average relative humidity for twenty-seven Australasian show caves, plotted against mean annual temperature for the sites. Note that Trezkinn and Donna datasets are missing summer data which is likely to have a high relative humidity. The average values plotted are likely to be too low.

If the average temperature is below 13 °C, then the relative humidity of Australasian show caves appears to be always 100%. These caves are predominantly in the cooler and wetter higher latitudes (TAS, NZ) or at altitude (e.g., Snowy Mountains of NSW). But warmer caves can also have a relative humidity of 100%. Such caves require a morphology that limits ventilation and have a source of moisture in the cave. This can either be an open water surface or seasonally saturated sediments.

Figure 7. Cathedral Cave, Wellington. The logger (top, right of photo, next to the thermometer) is situated close to where groundwater enters the cave. The groundwater maintains a high relative humidity in this part of the cave.

We hope you have found this overview of cave air relative humidity useful. Maybe it could be included in interpretations of cave climate and form part of the visitor experience? For those mainland Australian caves where relative humidity is less than 100%, these results suggest that these relative humidity loggers could be used in future projects to better understand seasonal or spatial patterns in cave ventilation. The data could also be used to inform decisions regarding infrastructure such as changes in cave doors, opening of new entrances etc. We still believe that the ACKMA Cave Climate project is unique and that there is no comparable dataset of show cave or wild cave relative humidity elsewhere.

We thank everyone in the ACKMA community who has made this dataset possible. The climate for individual participating caves can be viewed at http://www.ackma.org/CaveClimate/index.asp where data is regularly updated.

Acknowledgements. Thanks to Jillian Neyland and Lydia Georgeson at Capricorn Caves for their comments on an earlier draft.