Influence of high evaporative conditions on mosses in the Antarctic Peninsula

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Question

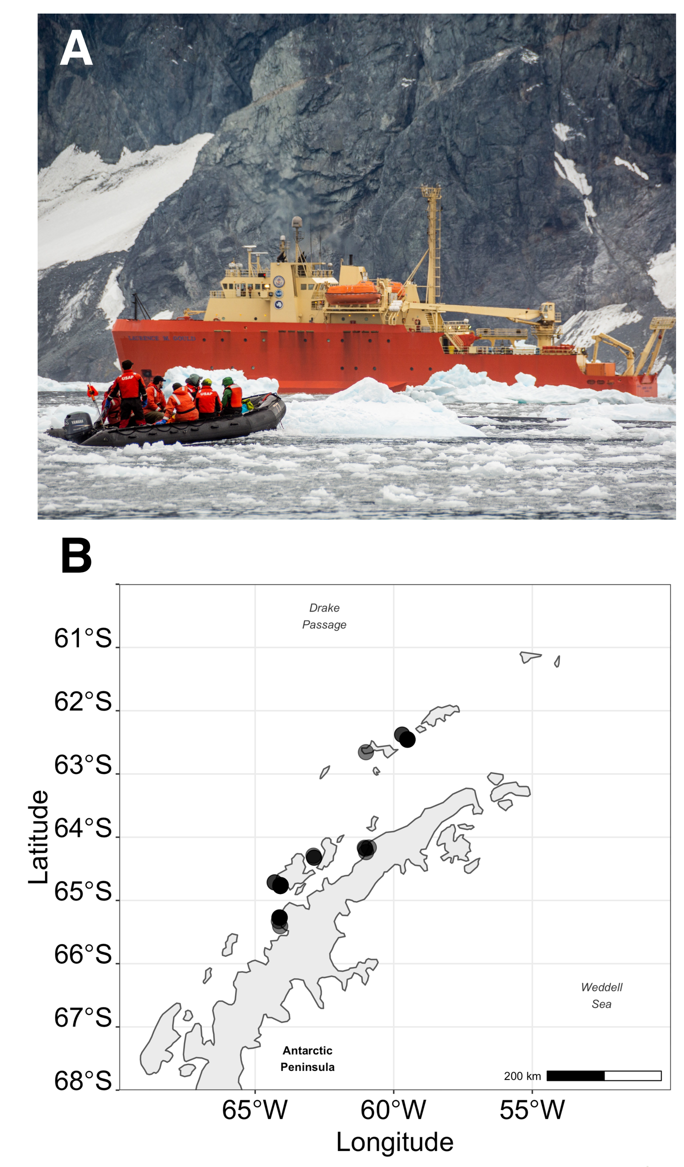
What are the influences of microclimate and evaporative conditions on moss tissue waters and cellulose?

Background

Low-elevation coastal ecosystems are responding to climate change[1]. During the record-setting temperatures of 2020[2] we evaluated the sensitivity of the regionally dominant vegetation (peat-forming mosses) to high evaporative demand.

Stable isotopes ($\delta^{18}O$) of moss α-cellulose are paleoclimate proxies because of their sensitivity to environmental change. Previous research has shown evaporative enrichment may complicate the signal of source water recorded in α-cellulose[3] and that microclimate conditions around moss surfaces influence α-cellulose values[4].

It is unclear how evaporative demand or microclimate influence the isotopic values of moss leaf water or α-cellulose. We used stable isotopes from cryogenically extracted waters and α-cellulose from moss surface samples collected in Antarctica (Fig.1; 62 to 65°S) in February/March 2020.



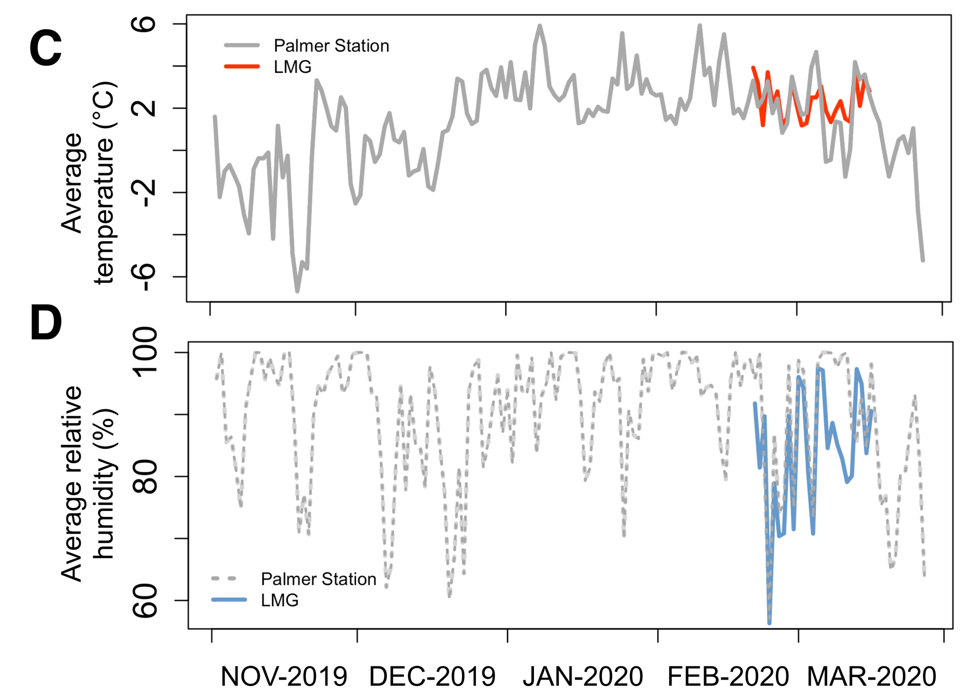
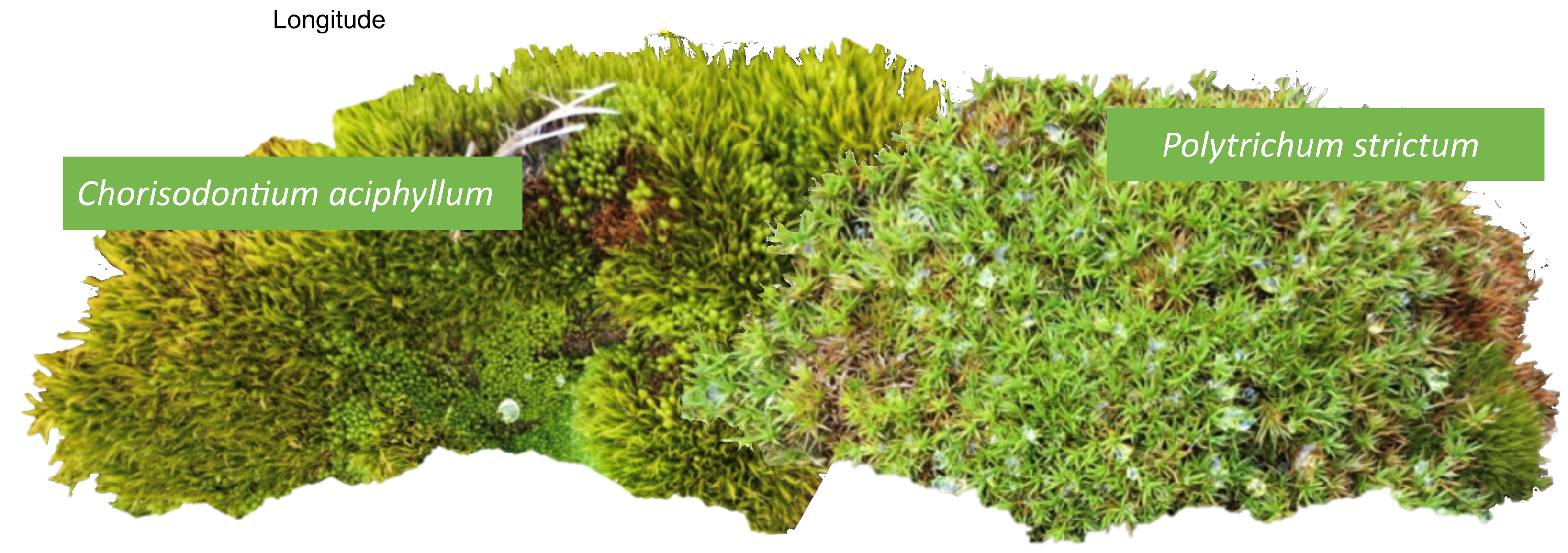


Figure 1. A) Laurence M. Gould R/V (LMG; Photo credit: Mike Lucibella, The Antarctic Sun), B) sampling locations during March/February 2020, **C)** average daily relative humidity and **D)** temperature measured at Palmer Station and by the LMG.



Results

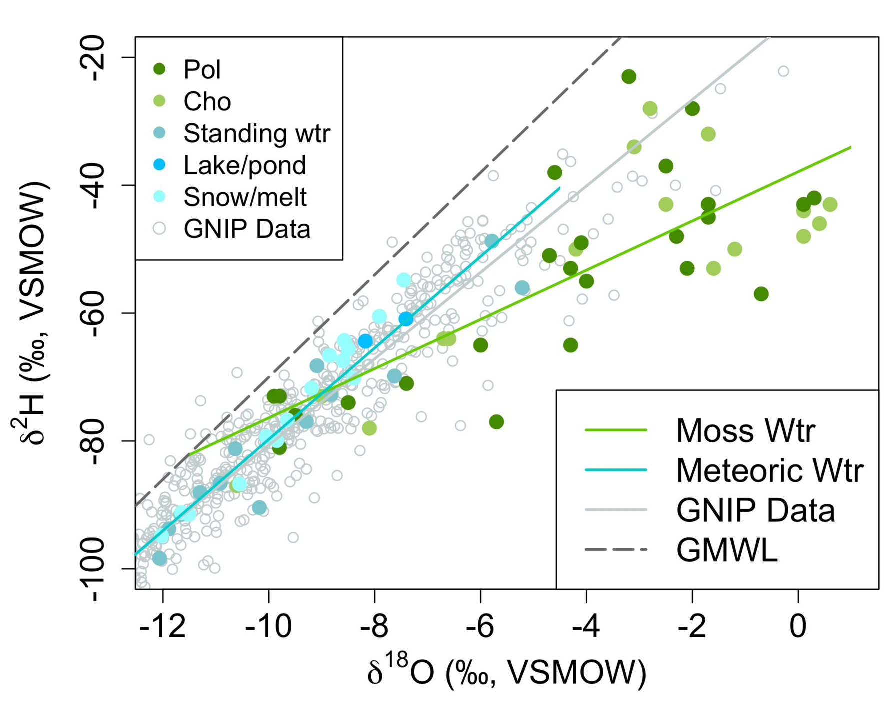


Figure 2. Antarctic Peninsula waters from moss tissues of two species, *Chorisodontium aciphyllum* and *Polytrichum strictum* (green, $y = 3.9x - 38$, $r^2 = 0.63$, $n = 40$, $p<0.001$), environmental sources (Meteoric Wtr, blue, $y = 7.2x - 8.2$, $r^2 = 0.91$, $n = 30$, $p<0.001$), and Global Network of Isotopes in Precipitation (GNIP Data, $y = 6.8x – 13$, $r^2 = 0.93$, $n = 578$, $p<0.001$). The grey dashed line represents the global meteoric water line (GMWL, $y = 8x +10$).

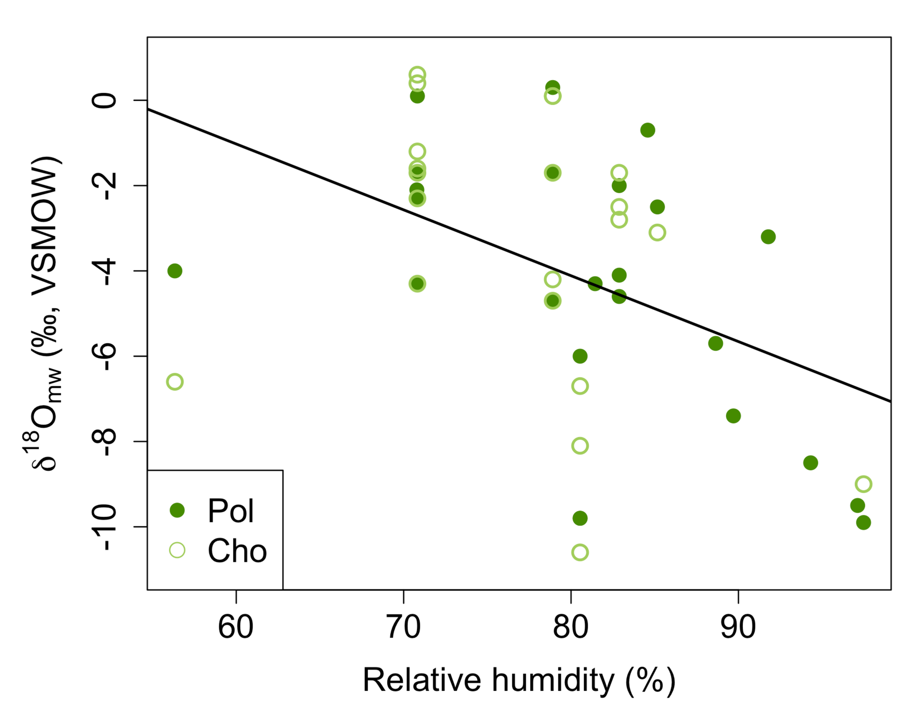


Figure 3. Moss water oxygen isotopes ($\delta^{18}O_{mw}$) in two species, *Chorisodontium aciphyllum* (Cho) and *Polytrichum strictum* (Pol) versus daily average relative humidity measured by the Laurence M. Gould R/V ($r^2 = -0.43$, $p = 0.003$). Unlike relative humidity, temperature had no statistically significant relationship with $\delta^{18}O_{mw}$ ($r^2 = -0.021$, $p = 0.78$).

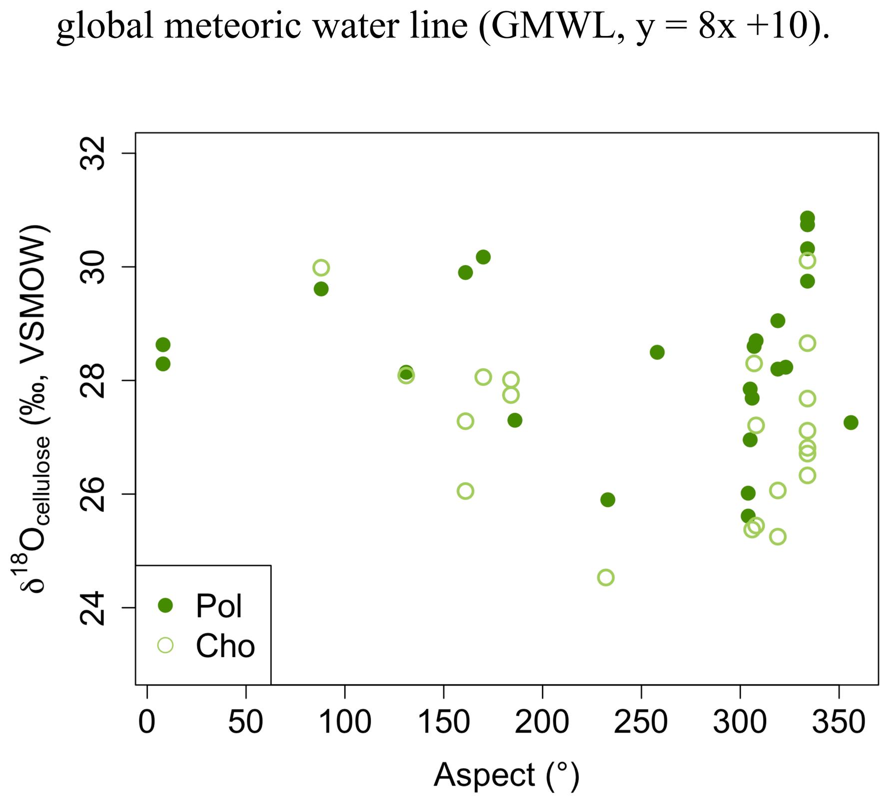


Figure 4. Cellulose isotopic composition ($\delta^{18}O$) of two species, *Chorisodontium aciphyllum* (Cho) and *Polytrichum strictum* (Pol) versus site aspect derived from the Reference Elevation Model of Antarctica[5].

Figure 5. Location of moss samples (green triangles) collected on north- and south-facing slopes on Litchfield Island. Moss α-cellulose isotopic composition ($\delta^{18}O$) did not differ between aspects ($p = 0.500$). Image © 2023 Maxar Technologies

Discussion & Conclusion

The evaporatively enriched moss tissue waters ($\delta^{18}O_{mw}$) reflect the record-setting warm summer temperatures during 2020 in the Antarctic Peninsula. The divergence of the moss water from the local water (Fig. 2) provides further support for the occurrence of evaporation in moss waters. In addition, the negative relationship between relative humidity on the day of sampling and $\delta^{18}O_{mw}$ suggests that average relative humidity (and not temperature) are significant. High evaporative conditions and subsequent enrichment made moss waters not reflect precipitation or latitudinal gradient.

While previous studies showed that evaporative enrichment had no effect on Antarctic mosses,[3] the divergence of the moss water from the local water (Fig. 2) in our study indicates that evaporative recycling is occurring in moss waters due to the record-setting warm summer temperatures.

A non-linear relationship may exist between cellulose $\delta^{18}O$ and aspect in which north-facing aspects undergo greater enrichment (Figs. 4 & 5).

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