Passive warming studies in Arctic and Antarctic: Differences and similarities in the effects of Open Top Chambers on the microclimate

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Organisms in polar terrestrial ecosystems are close to their distribution limits, and biological processes are known to be limited by the twin constraints of water availability and chronically low temperatures. The magnitude of change being experienced by polar terrestrial ecosystems, combined with the sensitivity of their component biota to these changes, leads to the prediction that biological consequences will be relatively larger and easier to detect in these simple ecosystems, compared to lower latitude counterparts. To study the effect of climate change experimentally, (infra red) lamps and warming cables in the soil can be used, but this is often not possible in the polar regions were infrastructure is sparse. Hence passive warming chambers were developed and used both in the Arctic and the Antarctic.

Passive chambers have been used to examine the impacts during the summer warming, but, so far, impacts occurring outside the growing season, or related to extreme temperatures, have not been studied, despite their potentially large biological significance. In our study temperature increases and decreases were recorded throughout the year. Closed chambers caused earlier spring soil thaw (8–28 days) while Open Top Chambers (OTCs) delayed soil thaw (3–13 days). Smaller closed chamber types recorded the largest temperature extremes (up to 20°C higher than ambient) and longest periods (up to 11 h) of above ambient extreme temperatures, and even OTCs had above ambient temperature extremes over up to 5 consecutive hours. The frequency of freeze–thaw events was reduced by 25%. All chamber types experienced extreme temperature ranges that could negatively affect biological responses, while warming during winter could result in depletion of limited metabolic resources. The effects outside the growing season could be as important in driving biological responses as the mean summer warming (Fig 2).

Passive warming chambers had also an effect on soil moisture which was varying per season and per locality (Fig. 3). Few studies on soil moisture were performed and only in OTC's. The OTC's had a positive effect on soil moisture in more extreme (more Antarctic) climate zones; the soils were more moist. Also studies on freeze-thaw events, snow melt and degree-day sums revealed that passive warming chambers had an effect comparable to the expected climate change effects.

We conclude from the combined studies that:

1. The warming effect of passive warming chambers, to simulate temperature changes brought about by climate change, is based on the effect in the summer season. In other seasons the different designs show different effects.
2. Especially the effects on degree-day sums and frequency of freeze-thaw cycles are ecologically significant
3. Spring is the most important season for terrestrial organisms. Especially in this season research should be intensified, choosing the right chamber.
4. OTC effects on snow depth is often regarded an artifact but may not be. Especially in the Antarctic Peninsula, snowfall is increased in winter. An increase in snow cover by accumulation in OTC's can be simulated, and an increase in accumulation may result in a later completion of the snow melt..
5. OTC's in Arctic, Antarctic, and Alpine environments show similar effects on microclimate parameters