Response of heterotrophic respiration and CH_4-oxidation to changes in soil moisture and temperature in drylands across a global climate and ecosystem gradient

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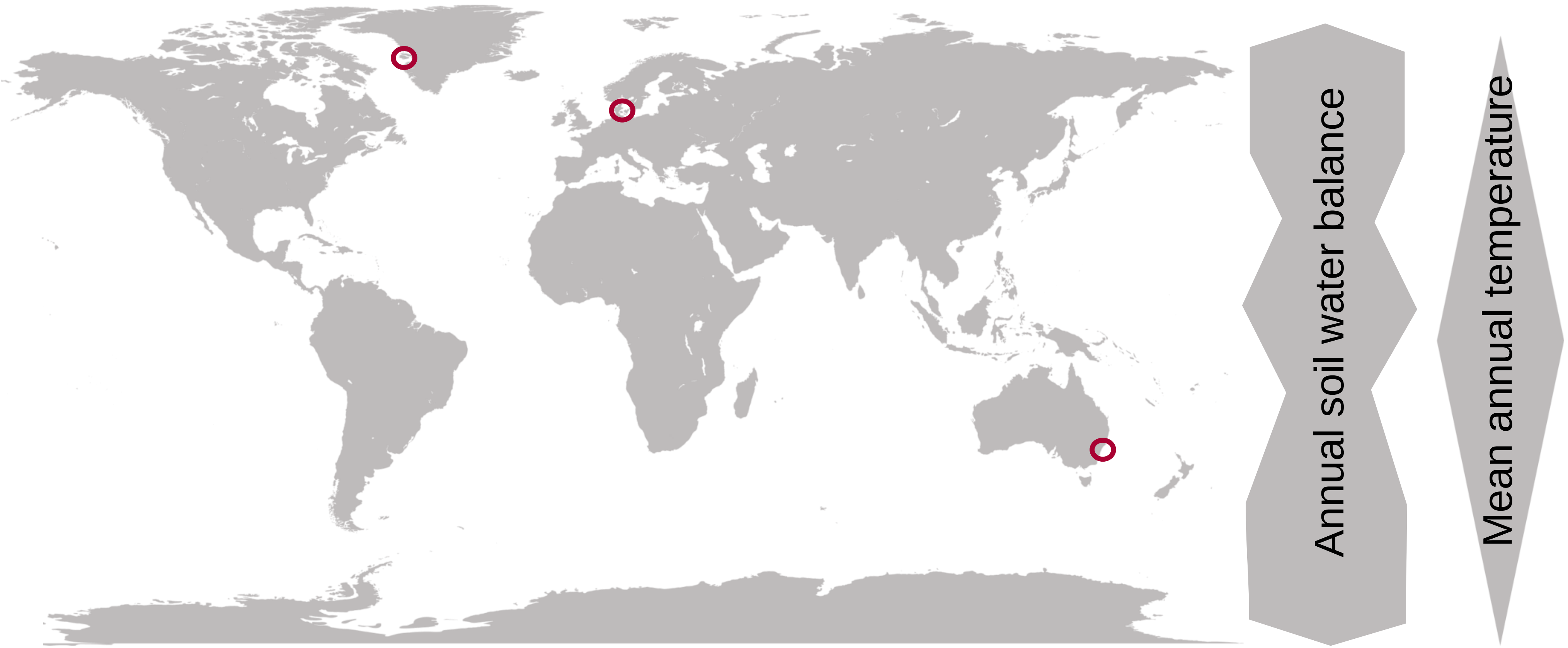

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Methodology

Manipulation of intact soil cores

Preservation of bacterial communities, soil structure root systems etc. which all potentially influences gas fluxes & magnitude of these.

Novel way of performing soil moisture manipulation experiments compared to other studies utilizing disturbed soil cores

Novel standardized laboratory method

Minimised potential artifacts from different methods & labs, enhancing comparability of sites

Temperature manipulation (1 - 50°C) in climate chambers at different moisture levels (0% - 30% - 100%WHC). Temperature increased 5°C every 24hrs

Moisture manipulation of re-wetted soil cores (100% WHC) gradually freely drained in climate chambers (15 °C). Monitored every day until dry (0% WHC)

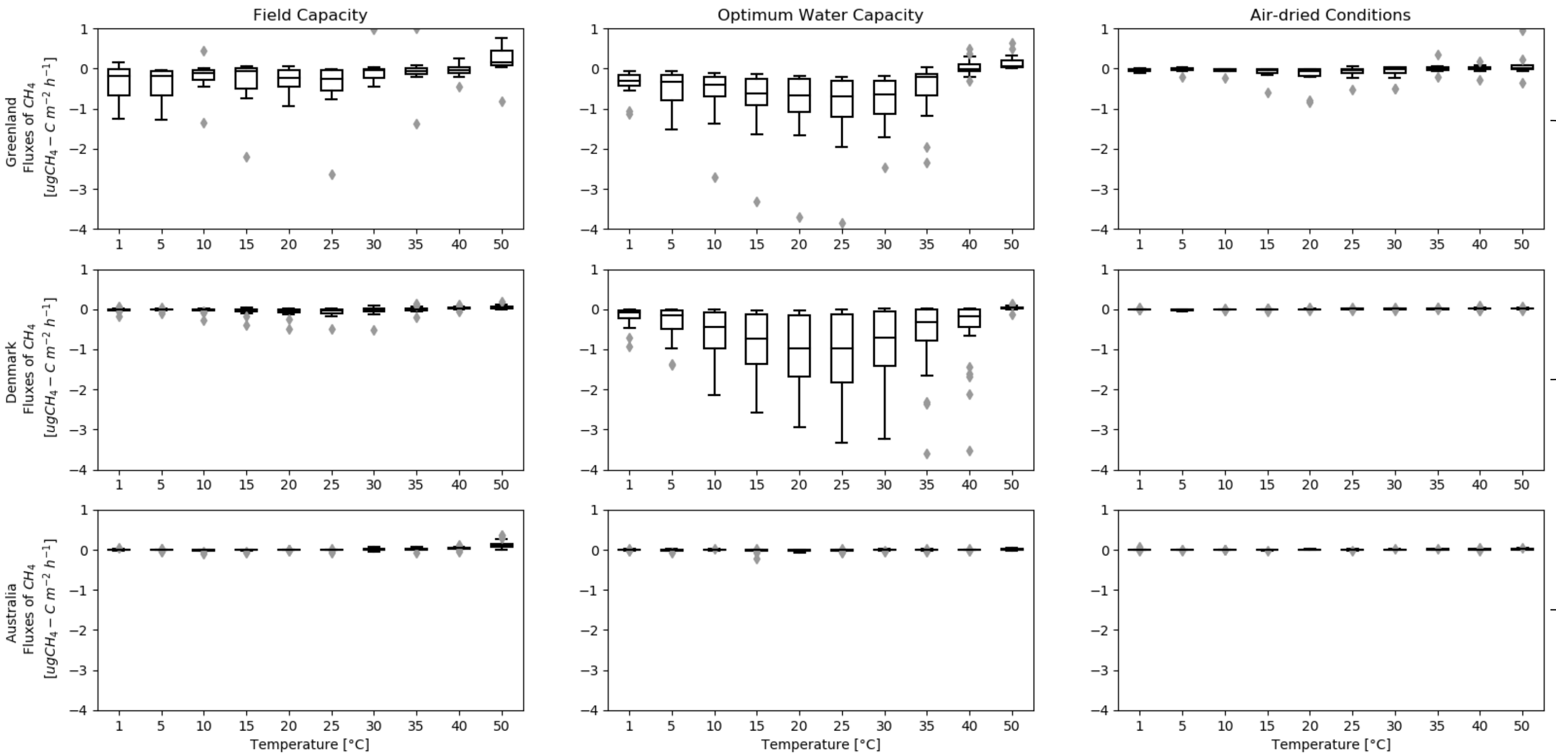
Ultraportable Greenhouse Gas Analyzer

Measurements of both CO_2 & CH_4, simultaneously

Enclosed & accurate measurements of CO_2 & CH_4 with no disturbance.

Incubation at ambient CO_2 & CH_4 concentrations for 10 min with 5 s sampling frequency

Temperature responses (CH_4)

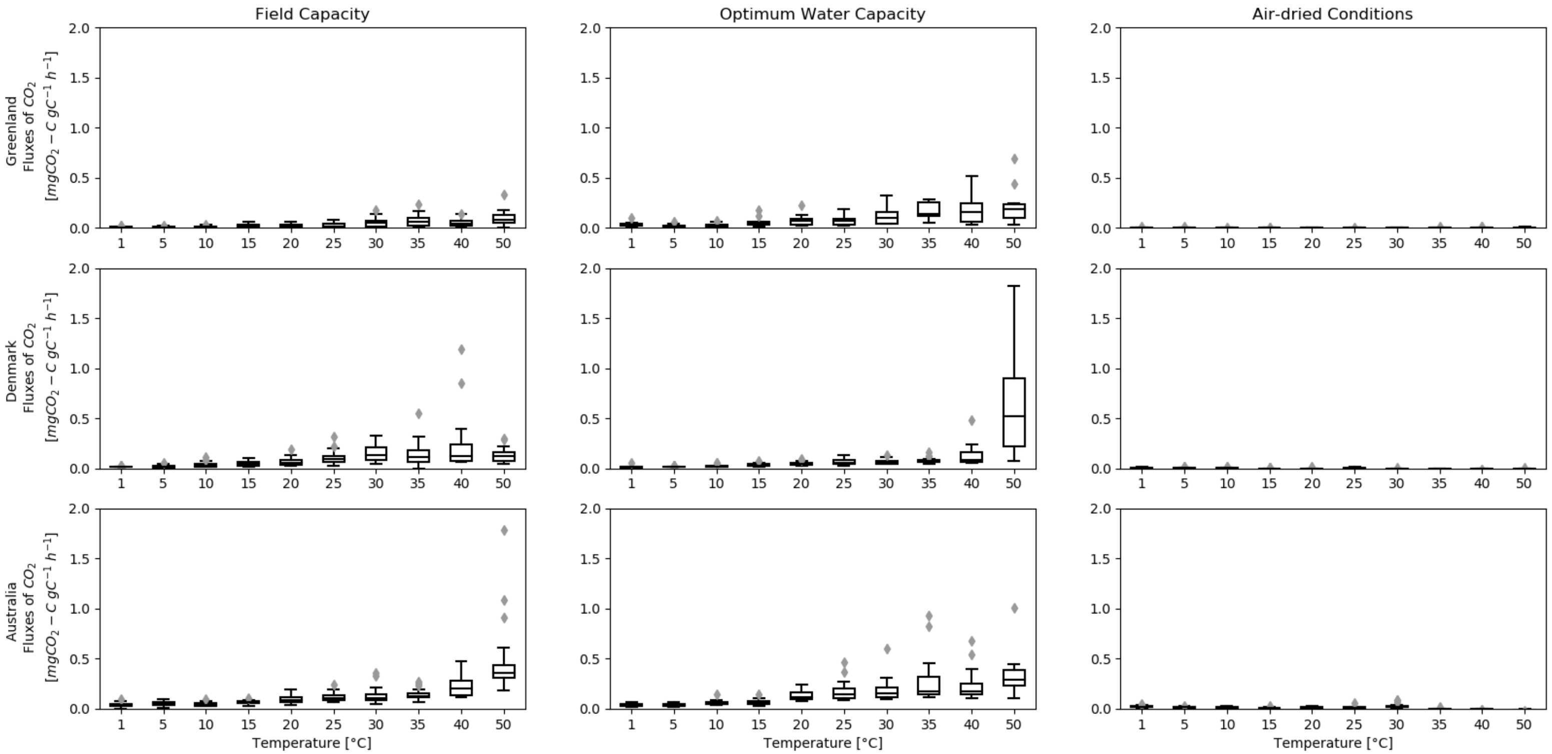


Boxplots of net CH4 uptake rates at field capacity (100%WHC), optimum water content (30%WHC) and air-dried condition (0%WHC) at each site across all depths (topsoil and subsoil) (*n* = 24 ±SE for DK and AUS) (*n* = 12 ±SE for GL). Lines within the boxes are the median, lower and upper edges of the boxes represent the 25 % and 75 % quartiles, respectively, and whisker bars indicate minimum and maximum rate.

For Greenland (GL) & Denmark (DK), a parabola relationship between temperature and oxidation of atmospheric CH_4 was obtained at 100%WHC and 30%WHC. Largest CH_4 rates were found around 25°C at 30%WHC for both DK & GL. At 0 %WHC, there were little to no oxidation of atmospheric CH_4 occurring in DK & GL .

For Australia (AUS), we obtained little to no oxidation of atmospheric CH_4 in the intact soil cores at any temperature and moisture level. However, *in situ* CH_4 fluxes indicated oxidation of atmospheric CH_4 in the soils but at lower depth.

Temperature responses (CO_2)

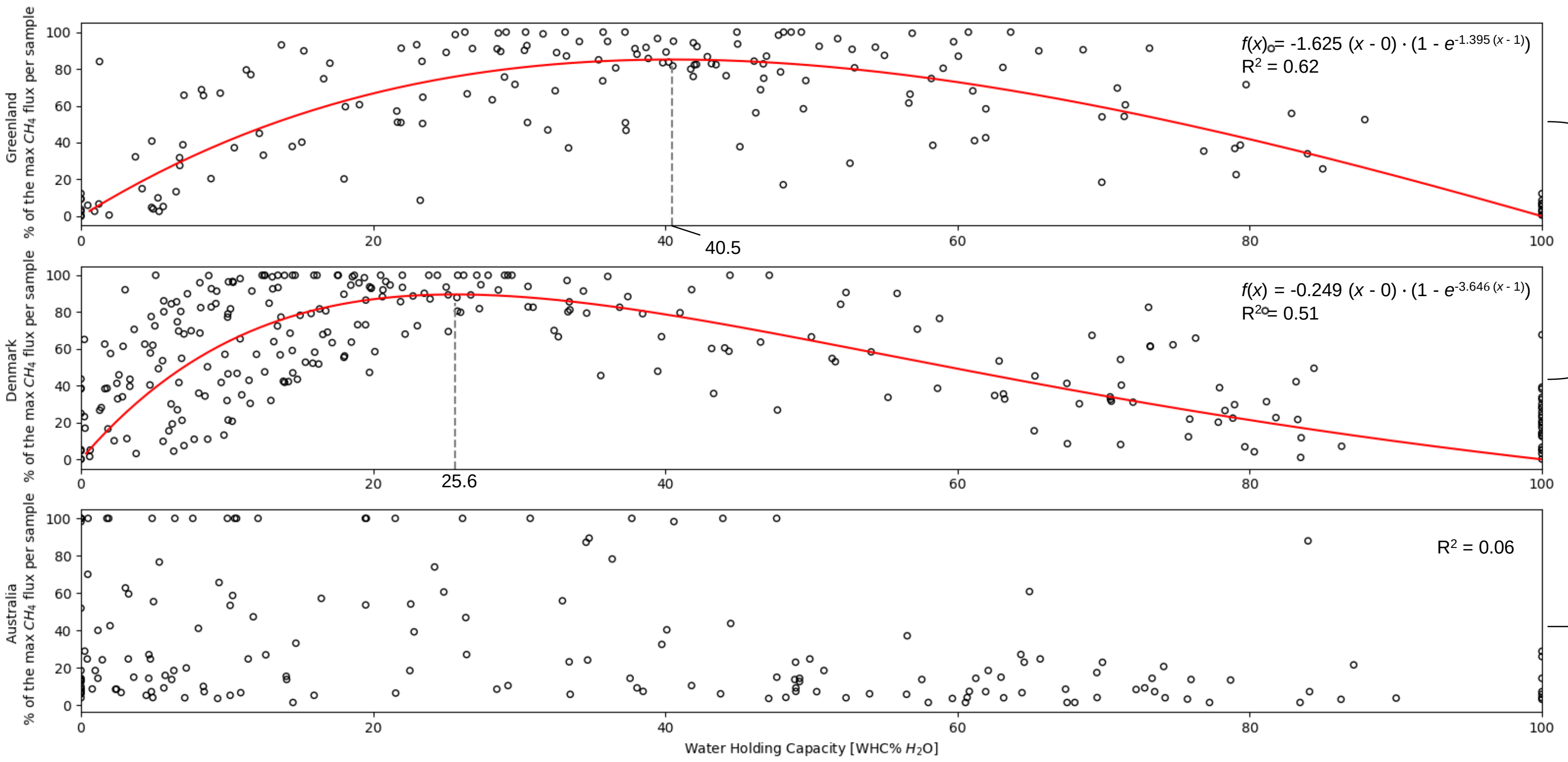


Boxplots of net CH4 uptake rates at field capacity (100%WHC), optimum water content (30%WHC) and air-dried condition (0%WHC) at each site across all depths (topsoil and subsoil) (*n* = 24 ±SE for DK and AUS) (*n* = 12 ±SE for GL). Lines within the boxes are the median, lower and upper edges of the boxes represent the 25 % and 75 % quartiles, respectively, and whisker bars indicate minimum and maximum rate.

For all sites, we observed heterotrophic respiration rates at all temperature intervals at 100%WHC and 30%WHC. As expected, the relationship was nonlinear. However, around 35-40°C a decrease in heterotrophic respiration rates occurred at all sites, before increasing substantially at 50°C again.

For all sites, we did not obtain similar relationship between temperature and heterotrophic respiration rates at 0%WHC. Surprisingly, we measured a negative relationship between increased temperature and heterotrophic respiration at 0%WHC. Moreover, at higher temperatures (>~35°C) and 0%WHC, the soil cores showed uptake of CO_2.

Drought responses (CH_4)

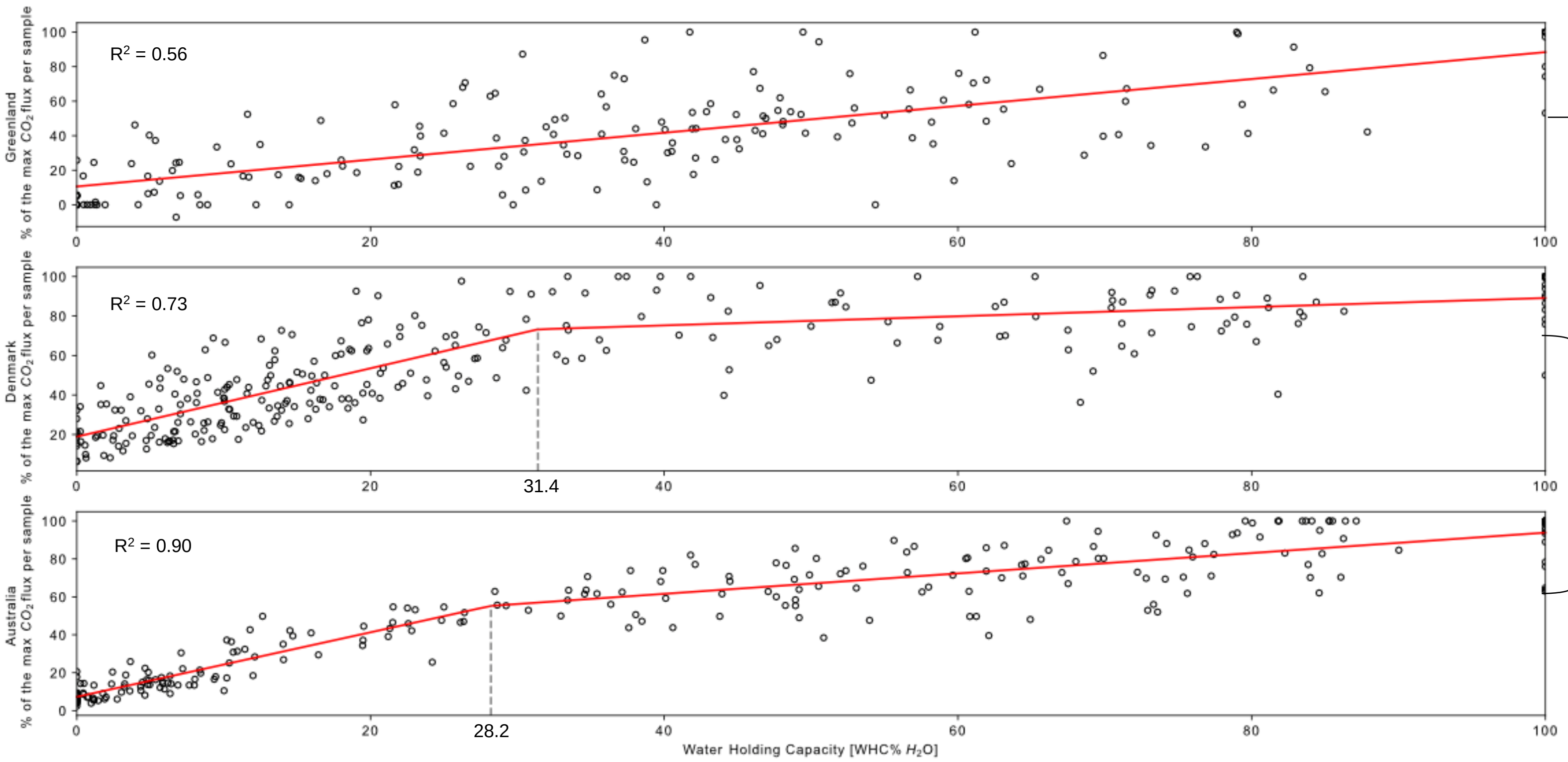


For GL & DK, we observed a bell-shaped relationship between moisture levels and oxidation of atmospheric CH_4 rates. The optimum water level for GL and DK differed and were 40.5 %WHC and 25.6 %WHC, respectively. However, around 35-40°C a decrease in heterotrophic respiration rates occurred at all sites, before increasing substantially at 50°C again.

For AUS, we obtained little to no oxidation of atmospheric CH_4 with different soil moisture levels. There was a similar bell-shaped relationship between soil moisture levels and oxidation of atmospheric CH_4, however not significant.

Atmospheric oxidation of CH4 shows significantly different responses to H_2O changes.

Drought responses (CO_2)

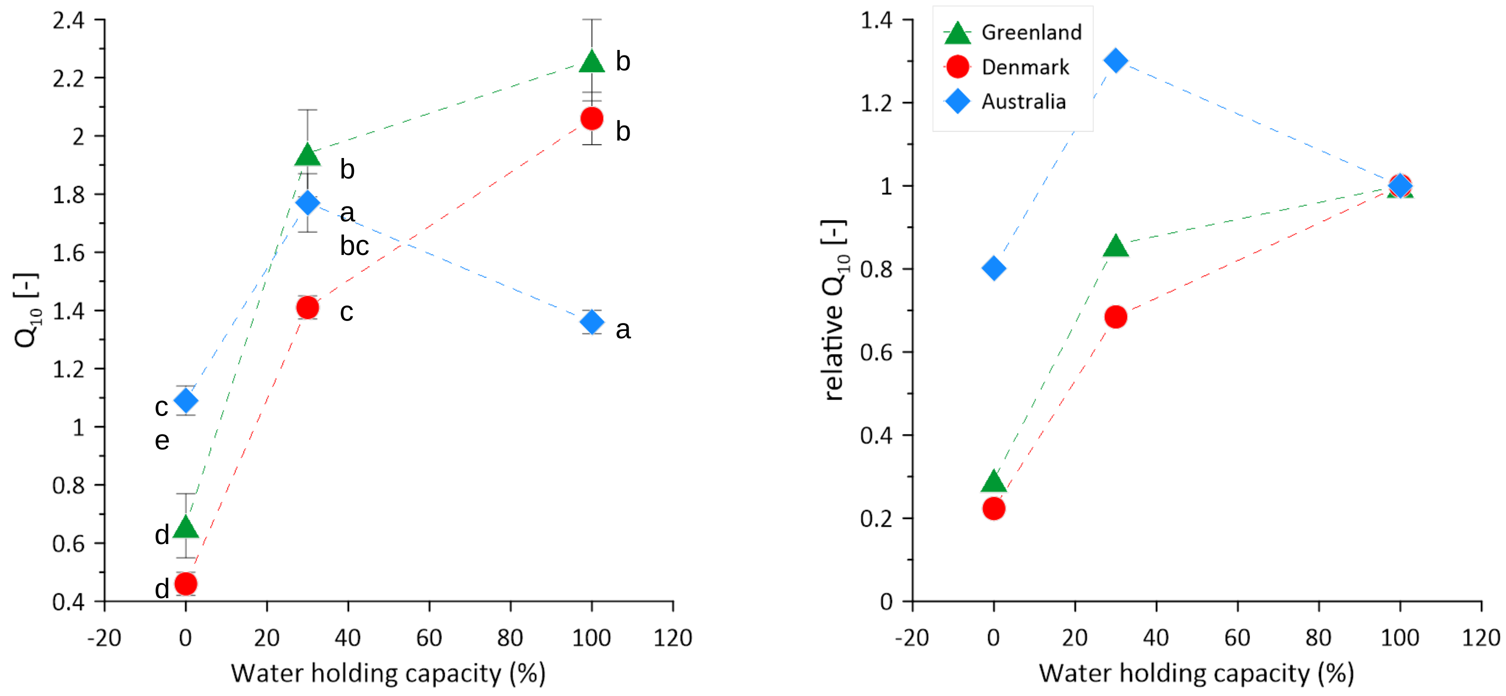


For GL, we obtained did not obtain any breakpoint in which heterotrophic respiration rates showed accelerated decreases with decreased soil moisture levels. However, we did find an overall significant decrease in heterotrophic respiration rates with lower soil moisture levels.

For DK & AUS sites, we observed heterotrophic respiration rates decrease with a decreasing soil moisture level and a significant breakpoint in which the decrease in the rates accelerated. The breakpoint for both sites varied little with 31.4 %WHC & 28.2 %WHC for DK and AUS, respectively.

Heterotrophic respiration shows significantly different responses to H_2O changes.

Q10 responses (CO_2)



Atmospheric oxidation of CH4 shows no significant responses to temperature changes.

Heterotrophic respiration shows significantly different responses to temperature changes.

Conclusion

Apparent microbial acclimatization to both soil moisture and temperature changes.

For atmospheric CH_4 oxidation, the primary acclimatization is related to the soil moisture content and not temperature. Also, this study indicates dormitory & downwards shifts in the soil for methanotrophic communities during sever droughts.

For heterotrophic respiration, there is an apparent moisture controlled temperature response for all sites. In the warmer climate regimes, we displayed a significant breakpoint for heterotrophic respiration rates with lower soil moisture levels.

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