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Bacterial production of sunscreen pigments increase arid land soil surface temperature

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Biological Soil Crusts (BSCs) are desert top soils formations built by complex microbial communities and dominated by the filamentous cyanobacterium Microcoleus sp. BSCs cover extensive desert areas where they correspond to millimeters size mantles responsible of soil stability and fertility. Despite their ecological importance, little is known about how these communities will endure climate change. It has been shown in North America that different species of Microcoleus showed distinct temperature preferences and that their continental biogeography may be susceptible to small changes in temperature with unknown consequences for the ecosystem function. Using a combination of physical, biochemical and microbiological analyses to characterize a successional gradient of crust maturity from light to dark BSCs (Moab, Utah) we found that the concentration of scytonemin (a cyanobacterial sunscreen pigment) increased with crust maturity. We also confirmed that scytonemin was by far the major pigment responsible of light absorption in the visible spectrum in BSCs, and is then responsible of the darkening of the BSCs (i.e decrease of albedo) with maturity. We measured the surface temperature and albedo and found, as predicted, a negative linear relationship between these two parameters. The decrease in albedo across the gradient of crust maturity corresponded to an increase in surface temperature up to 10º C. Upon investigation of microbial community composition using SSU rRNA gene analysis, we demonstrate that warmer crust surface temperatures (decreased albedo) are associated with a replacement of the dominant cyanobacterium; the thermosensitive Microcoleus sp. being replaced by a thermotolerant Microcoleus sp. in darker BSCs. This study supports at the local scale a finding previously made at the continental scale, but also sheds light on the importance of scytonemin as a significant warmer of soils with important consequences for BSC composition and function. Based on estimates of the global biomass of cyanobacteria in soil crusts, one can easily calculate that there must currently exist about 15 million metric tons of scytonemin accumulated on the surface of arid soils worldwide, whose role on soils temperature has been ignored so far.