EGU21-7902, updated on 28 Oct 2021
https://doi.org/10.5194/egusphere-egu21-7902
EGU General Assembly 2021

Attributing the negative scaling of extreme precipitation with temperature over India to cloud radiative cooling during the monsoon season

Sarosh Alam Ghausi[1], Axel Kleidon[1], and Subimal Ghosh[2]
[1]Biospheric Theory and Modelling group, Max Planck Institute for Biogeochemistry, Jena- Germany (sghausi@bgc-jena.mpg.de)
[2]Department of Civil Engineering, Indian Institute of Technology Bombay, India

Extreme precipitation is expected to increase at the rate of 7% per degree rise in temperature as suggested by the Clausius-Clapeyron equation (also known as CC scaling). Observations however, show deviations from the CC rate, with mostly negative precipitation - temperature scaling in warm tropical regions. Here we explain the negative precipitation scaling in the tropics with the cloud radiative effect on surface temperatures. Temperatures are shaped by the surface energy balance, which is affected by clouds, and hence temperatures are not independent of precipitation. We used observations from India and found negative scaling rates over most regions as extreme precipitation scaling tends to breakdown at temperatures of about 23□to 25□C. We show that these negative scaling rates arise from the radiative cooling of clouds associated with precipitation events which is predominant in India during the summer monsoon season. To test our hypothesis, we used an energy balance model constrained by assumption that convective exchange within atmosphere works at its thermodynamic limit of maximum power. Using the NASA-CERES radiation product, we calculated surface temperatures for “All sky” and “Clear sky” conditions to include/exclude the effect of cloud radiative forcing. Our results show a diametric change in precipitation scaling after removing the cooling effect of clouds on surface temperatures. Negative precipitation scaling (-4% /□C) was found when using “All sky” conditions, but these come close to the CC rate (7% to 9% /□C) when estimated using temperatures derived from “Clear sky” conditions. The breakdown in extreme precipitation scaling at high temperatures also disappeared forthe “Clear sky” temperatures. This implies that the breakdown in scaling may not relate to changes in aridity or the lack of moisture, but rather to the associated changes in cloud cover. Negative scaling rates derived from observations are thus likely to misrepresent the response of extreme precipitation to global warming in tropical regions. Our findings suggest that an intensification of precipitation extremes at CC rate with global warming is consistent with observations.

Keywords: Extreme Precipitation, CC scaling, Maximum Power, Indian Mon-soon