Abstract

Arctic geoengineering wherein sunlight absorption is reduced only in the Arctic has been suggested as a remedial measure to counteract the on-going rapid climate change in the Arctic. Several modeling studies have shown that Arctic geoengineering can minimize Arctic warming but will shift the Inter-tropical Convergence Zone (ITCZ) southward, unless offset by comparable geoengineering in the Southern Hemisphere. In this study, we investigate and quantify the implications of this ITCZ shift due to Arctic geoengineering for the global monsoon regions using the Community Atmosphere Model version 4 coupled to a slab ocean model. A doubling of CO_2 from pre-industrial levels leads to a warming of ~ 6 K in the Arctic region and precipitation in the monsoon regions increases by up to ~15 %. In our Arctic geoengineering simulation which illustrates a plausible latitudinal distribution of the reduction in sunlight, an addition of sulfate aerosols (11 Mt) in the Arctic stratosphere nearly offsets the Arctic warming due to CO_2 doubling but this shifts the ITCZ southward by ~1.5^0 relative to the pre-industrial climate. The combined effect from this shift and the residual CO_2-induced climate change in the tropics is a decrease/increase in annual mean precipitation in the Northern Hemisphere /Southern Hemisphere monsoon regions by up to -12/+17%. Polar geoengineering where sulfate aerosols are prescribed in both the Arctic (10 Mt) and Antarctic (8 Mt) nearly offsets the ITCZ shift due to Arctic geoengineering, but there is still a residual precipitation increase (up to 7 %) in most monsoon regions associated with the residual CO_2 induced warming in the tropics. The ITCZ shift due to our Global geoengineering simulation, where aerosols (20 Mt) are prescribed uniformly around the globe, is much smaller and the precipitation changes in most monsoon regions are within ±2 % as the residual CO_2-induced warming in the tropics is also much less than in Arctic and Polar geoengineering. Further, global geoengineering nearly offsets the Arctic warming. Based on our results we infer that Arctic geoengineering leads to ITCZ shift and leaves residual CO_2 induced warming in the tropics resulting in substantial precipitation changes in the monsoon regions.