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Sensitivity of 21st Century Rainfall Projections over the Tropical Atlantic Sector to Sea Surface Temperature Bias in the Kiel Climate Model

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A long-standing problem in state-of-the-art climate models is the eastern tropical Atlantic warm sea surface temperature (SST) bias. The influence of the bias on 21st century rainfall projections over the tropical Atlantic sector is investigated by means of the Kiel Climate Model (KCM). Simulations are conducted with rising atmospheric CO_2-concentration which increases at a rate of 1%/year. One simulation is conducted with a KCM version that consists of a coarse-resolution ocean model ($2^\circ \times 2^\circ$) coupled to a coarse-resolution atmosphere model (T42, L31). This model version exhibits a large warm SST bias over the eastern tropical Atlantic, similar to that observed in many state-of-the-art climate models. The other simulation is performed with a KCM version which employs the identical ocean model but a higher-resolution atmosphere model (T255, L62). This model version exhibits very little SST bias over the eastern tropical Atlantic.
In the KCM version employing coarse-resolution in its atmospheric component and exhibiting large SST bias, there is hardly any significant rainfall response over the tropical Atlantic sector. On the contrary, the KCM version employing high-resolution in its atmospheric component and exhibiting little SST bias simulates a statistically significant rainfall response in the form of a southward migration of the Intertropical Convergence Zone (ITCZ). The marked difference in rainfall response to enhanced atmospheric CO_2 can be traced back to the SST response. The latter is rather uniform in the presence of large SST bias. In the KCM version exhibiting relatively little SST bias, the SST response is “El Niño-like” and drives a southward migration of the Atlantic ITCZ. This study suggests that climate model projections of tropical Atlantic sector rainfall for the 21st century could strongly benefit from enhancing atmosphere model resolution.