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On the anthropogenic change of the gradient mode in the northern tropical Atlantic

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Observational evidence indicates that anthropogenic climate changes will also affect the dominant modes of interannual climate variability. We explore changes of the gradient mode in the northern Tropical Atlantic (TA) due to doubling of the atmospheric CO_2 concentration. The gradient mode in current climate is characterized by an anomalous Sea Surface Temperature (SST) in the north Tropical Atlantic and a C-shaped surface wind pattern. It is initiated in boreal winter by trade wind anomalies related to both ENSO and NAO, which in turn via a Wind-Evaporation-SST (WES) mechanism result in SST anomalies, and it peaks in spring. We study the anthropogenic change of the gradient mode in an atmospheric GCM (Speedy, T30L7) coupled to a passive mixed-layer model for the ocean. Two simulations were run. In a control run, the atmospheric CO_2 concentration was fixed at 342.5 ppmv, which is roughly the averaged concentration over the past 50 years. In a second run the CO_2 concentration was twice as large. The control run shows that many characteristics of the gradient mode, as analyzed from observational data, are captured. When doubling the CO_2 concentration, the gradient mode weakens. The standard deviation of the monthly SST anomalies in the northern TA decreases by 10-20% throughout the year, but the seasonal cycle is similar as in current climate. Lagged regressions of monthly SST, surface wind and ocean surface heat flux anomalies onto an index for the gradient mode for boreal spring show that the mechanism by which the gradient mode is generated in a doubled-CO_2 climate has not fundamentally changed. However, the positive WES feedback in the deep TA is substantially weaker than in current climate and explains the weaker SST anomalies. The results from our model simulations will be compared with output from IPCC-class global coupled ocean-atmosphere models.