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Precipitation biases over the tropical Atlantic in low and high-resolution CMIP5 models

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The tropical Atlantic climate is governed by processes belonging to a wide range of spatial and temporal scales, which are still at the core of significant biases in most general circulation models (GCMs). Previous studies have indicated that precipitation biases already present in atmosphere-only runs are the main source of error in coupled runs. This study examines the mean state of precipitation in 21 GCMs under the Coupled Model Intercomparison Project Phase 5 (CMIP5) and run in AMIP mode. Precipitation is analyzed using an object-based approach which clusters rainy areas and determines their properties such as size, amplitude, and location. The analysis focuses on the tropical Atlantic region comprised of South America, the Atlantic, and Africa within the domain 90°W-45°E and 30°S-30°N. Based on the distribution of precipitation objects over land and over ocean, two categories of models emerge. The first class of models has a reasonable representation of land objects but misplaces the ocean object too far west, near the coast of Brazil instead of the central Atlantic. The second class of models show small-sized land objects with very high precipitation values. These land objects are usually located in orographic regions. For these models, the oceanic precipitation structure is more longitudinally distributed, with the ocean object located near West Africa. All models tend to exhibit either the Brazil coast bias (class 1) or the peaked precipitation bias (class 2) and none of them matches the observed precipitation distribution.

These two distinct model behaviors seem to be mainly related to the employed horizontal resolution. A reduction in the Brazil coast bias is apparent as the resolution in ECHAM is increased from T63 to T255. The decrease in precipitation over the coast of Brazil is accompanied by an increase in precipitation over the coastal region of West Africa. It is found that class 2 models without the Brazil coast bias tend to be high resolution models which rain excessively over the West African coast starting from boreal spring. This suppresses precipitation on the opposite coast during boreal summer, decreasing the tendency for a Brazil coast bias. Moreover, excessive precipitation over the West African coast due to higher resolution induces a stronger westerly component which sustains rain over this region in the summer season.