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Radiation flux variability over West Africa in observations and CMIP5 models: the role of clouds, aerosols and water vapour

Anna Mackie (1), Paul Palmer (1), Helen Brindley (2), Martin Wild (3), and Doris Folini (3)

(1) University of Edinburgh, School of GeoSciences, Edinburgh, United Kingdom (anna.mackie@ed.ac.uk), (2) Space and Atmospheric Physics Group, Imperial College London, London, United Kingdom, (3) Institute for Atmospheric and Climate Science, Swiss Federal Institute of Technology, Zurich, Switzerland

We explore the ability of CMIP5 models to recreate the seasonal variability in top-of-the-atmosphere (TOA) and surface radiation fluxes, as well as absorption within the atmospheric column, over West Africa. This provides an important test of the CMIP5 models' ability to describe the radiative energy partitioning (TOA, atmosphere, surface in both short- and longwave), which is of key relevance for the current climate, and its future changes, including to the West African monsoon. As a primary reference, we use 15 years of the monthly CERES EBAF product, which we validate using other satellite products, reanalysis and surface station data. We interpret this with respect to cloud processes, column water vapour and aerosol loading across a number of distinct regions within the wider area of West Africa, including the semi-arid Sahel and tropical coastal regions. We find differences between CMSAF GERB/SEVIRI and EBAF are dependent on region and season: while GERB/SEVIRI has a bias of -1.1Wm^{-2} in TOA reflected shortwave radiation (RSR) over the Sahara, this changes to 1.6 Wm^{-2} over the coastal region. Seasonal contrast in the coastal region is also evident, from a -0.2 Wm^{-2} bias in the dry season, to one of 3.1 Wm^{-2} in the wet season. Larger biases (15 – 20 Wm^{-2}) exist in surface insolation between CMSAF SARAH and EBAF surface. We find a wide range of seasonal behaviour across the CMIP5 models, for example a 50 Wm^{-2} range in coastal wet season RSR. Extending this analysis, we use HadGEM2-ES as a case study, to further understand the causes of observation/model differences by examination of spatial differences. We link EBAF/HadGEM2-ES differences in radiative fields to West African monsoon variability and the clear-sky dependence on aerosol and column water vapour.