Geophysical Research Abstracts
Vol. 14, EGU2012-3752, 2012
EGU General Assembly 2012

Ultra-Low Clouds over the Southern West African Monsoon Region

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The last IPCC report showed large disagreement between climate models about the sign of precipitation change over large parts of West Africa for the 21st century. This uncertainty hinders the development of adaptation and mitigation strategies for one of the most vulnerable areas of this planet. The main reason is the notorious inability of climate models to realistically represent the complex West African monsoon (WAM) system.

Here we will discuss non-precipitating, low-level (i.e. 200–400 m above ground), thin continental stratus over summertime (July–September) southern West Africa (6–10°N, 7°W–7°E), which has received very little attention in contrast to its counterpart over nearby oceans. This is partly due to the difficulties of current satellite observing systems to detect the nighttime continental stratiform cloud deck due to the low contrast in infrared brightness temperatures. However, due to the enormous difference in albedo between the stratus and the underlying lush green vegetation, daytime cloudiness plays an important role in the regional surface energy budget and thereby affects temperature, pressure and ultimately the WAM circulation. Recently available ground observations from the GLOWA-IMPETUS and AMMA projects of incoming solar radiation and short-term forecasts made as part of the ERA-Interim re-analysis project show typical daily mean values on the order of 160 W m–2 over the region. Satellite retrievals show a wide range of values with some revealing a positive bias. Climate models used for the last IPCC report struggle to reproduce this phenomenon giving a multi-model mean solar irradiance of 190 W m–2 with a large standard deviation of 39 W m–2. Looking into individual models reveals large differences in vertical cloud structures compared to ERA-Interim.

Ground-based observations in recent years have suggested that the stratus forms during the night in relation to the formation of a nocturnal low-level jet (LLJ), which is particularly strong during summer due to the large background pressure gradient associated with the maximum northward extent of the WAM circulation. As soon as the LLJ reaches critical shear, turbulence is induced mechanically and mixes moisture, accumulated in the surface layer through evapotranspiration, upwards, resulting in condensation and cloud formation near the jet level. By morning, the stratus deck is often thick enough to persist until midday or afternoon, when it often transforms into a broken stratocumulus or cumulus cloud deck. While ERA-Interim and the few available radiosondes indicate a clear reduction of LLJ momentum through these mixing events, IPCC models show a large positive bias of low-level wind speed consistent with too little cloud cover and too much incoming solar radiation. Future work will include an assessment of the radiative forcing (and its errors) of the stratus on the WAM circulation and an investigation of potential ways to improve the documented biases.