INVESTIGATING OF AEROSOL EFFECTS ON DIURNAL CYCLE OF PRECIPITATION AMOUNT, FREQUENCY AND INTENSITY OVER CENTRAL AFRICA BY RegCM

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ABSTRACT

Regional climate is affected by a wide variety of aerosols which modify through their radiative effect the precipitation distribution. In this study, the effects of aerosols on diurnal cycle of precipitation amount, frequency and intensity are investigated over central Africa by using the latest version of the Abdu Salam ICTP regional climate model coupled with Community Land Model 4.5 as land surface scheme. land surface scheme. Two sets of experiments have been conducted (one with aerosols interaction with dynamics and thermodynamics processes and another without this interaction) for a 10-year study period (2002-2011) and the Fourier transformation is used to study the 24-hour cycle. The changes in amplitude of the precipitation frequency are not consistent even if the corresponding phase always tends to increase by up to 5 hours.

MATERIALS AND METHODS

6 hourly Era-Interim 1.5° x 1.5° [1] as input dataset. TRMM [2] and PERSIANN [3] (0.5° x 0.5°), MODIS aerosol retrieval [4] (1° x 1°) used as reference datasets.

Study area : (15°S-15°N, 3°E-35°E)

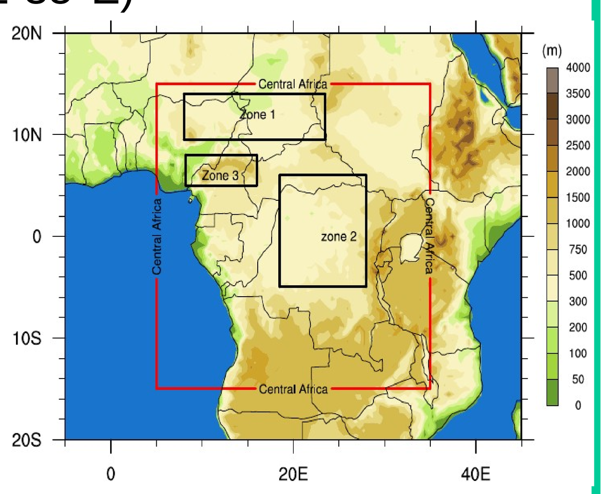


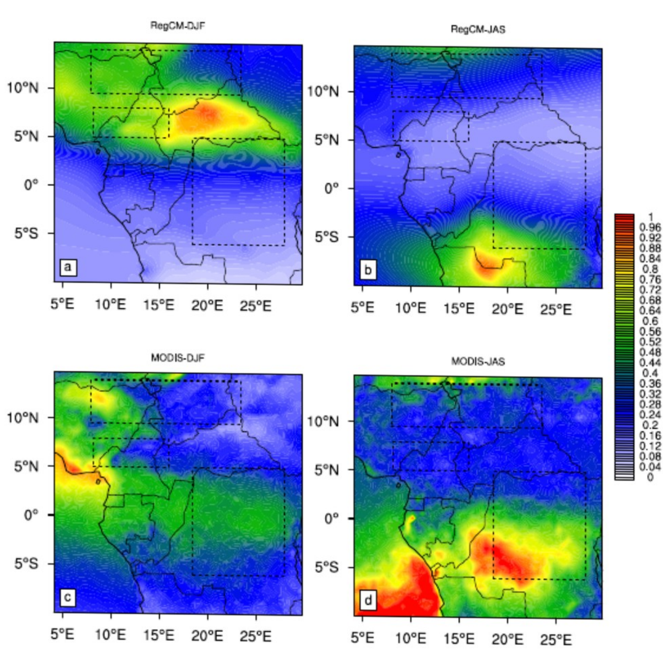
Fig. 1 :Topography (m) of the simulation domain. The three boxes indicate the three sub-region on which the emphasis of the model results has been done.

This study is based on the outputs of RegCM5 at 40 km horizontal resolution. Details about RegCM5 configuration made in this study can be seen in Komkoua Mbienda et al. 2023 [5].

➢ Study period: From Jan 2002 to Dec 2012 preceded by one year of spin-up. For this period, 2 sets of experiments have been conducted: one without aerosols (RegCM) and another with aerosols interactive (RegCM-A). Discrepancies between ExpA and Exp allow us to capture the aerosol impacts.

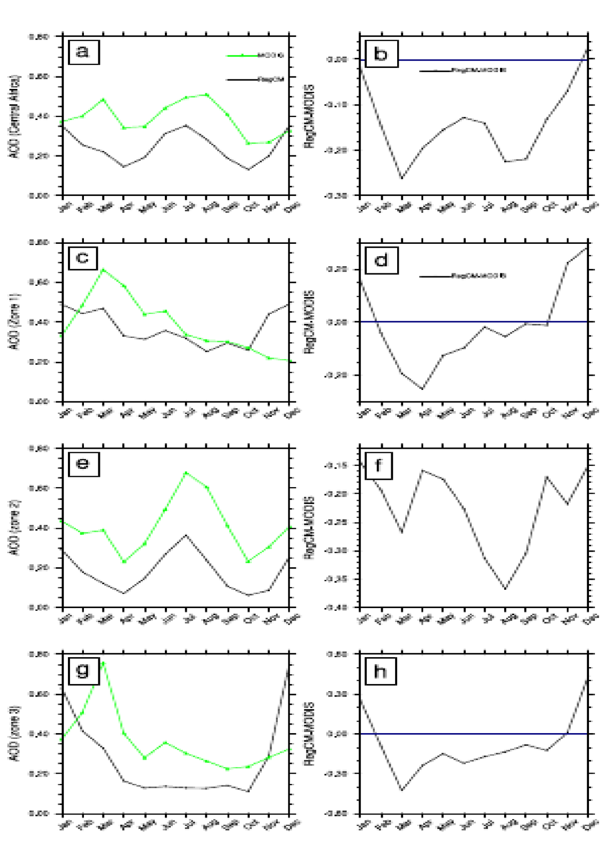
RESULTS

Aerosol loading and distribution



◂**Fig.2:** DJF and JAS seasonal distributions of aerosol optical depth from both (a,b) RegCM and (c,d) MODIS

The analysis illustrates that RegCM is better at simulating the biomass-burning-induced AOD than simulating the dust-induced AOD.



◂**Fig.3:** Annual cycles of aerosol optical depth from both RegCM and MODIS in (a) Central Africa, (c) zone 1, (e) zone 2, and (g) zone 3 and (b,d,f,h) their corresponding biases.

Over the three zones, the simulated AOD patterns are generally in agreement with those of MODIS. RegCM

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Variance, amplitude and phase of precipitation as explained by the first harmonic

*** Precipitation amount**

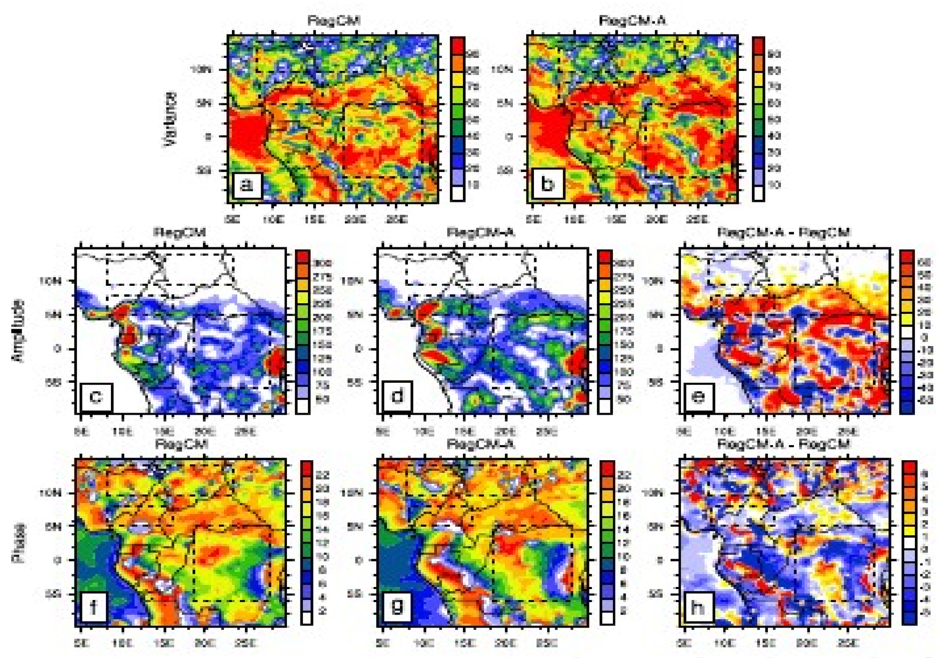


Fig. 4. Percentage variance, (c,d) amplitude and (f,g) peak time of precipitation amount during DJF season for both experiments as well as (e) amplitude and (h) phase Differences.

The percentage of variance is not very affected by aerosols but we can observe that the DJF season has slightly higher values for RegCM unlike RegCM-A . The difference between the two experiments shows that the amplitude and phase changes in the amount of precipitation are systematically affected by either a reduction or a very large increase during the DJF and JAS seasons.

*** Precipitation intensity**

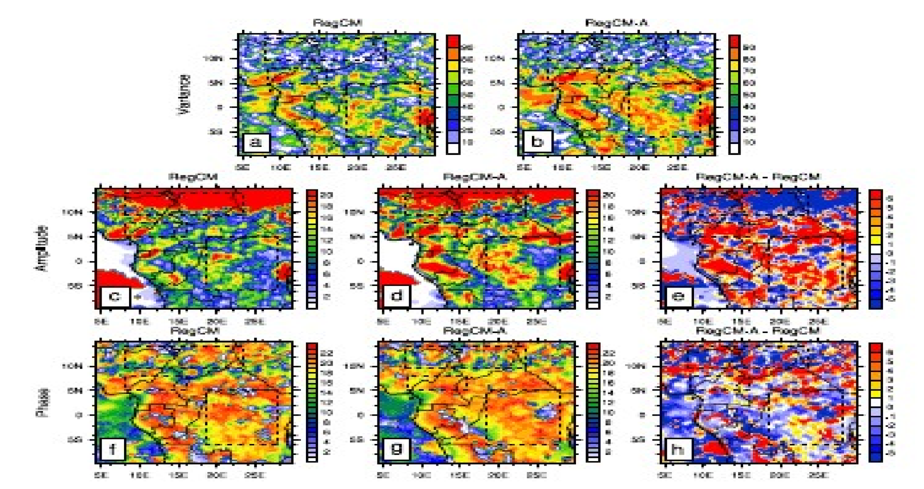


Fig. 5 Same as Fig.4, but for precipitation intensity

With regard to the amplitude of precipitation intensity in DJF season, highest values are found in the Sahelian area. In other regions, the amplitude of the control simulation does not exceed 20 mm/h. Corresponding RegCM-A experiment always tends to increase the amplitude of precipitation intensity with values usually higher than 6 mm/h as shown. The corresponding peak time which always appears in the after afternoon is not systematically affected in the same way.

*** Precipitation frequency**

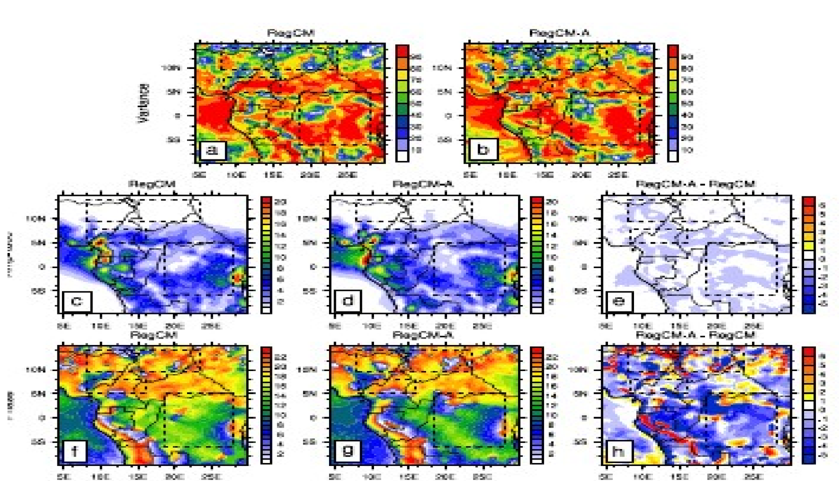


Fig. 6 Same as Fig.4, but for precipitation frequency

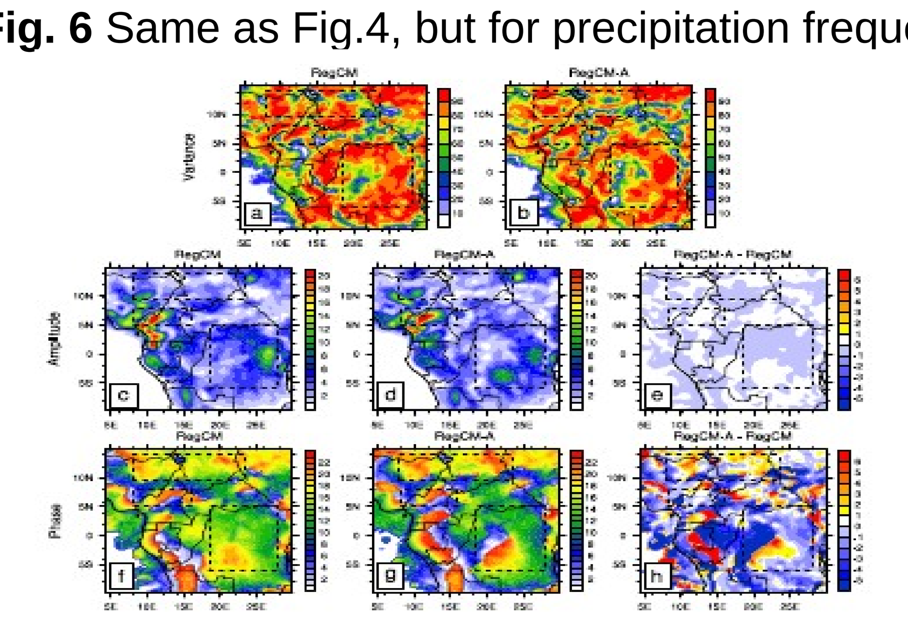
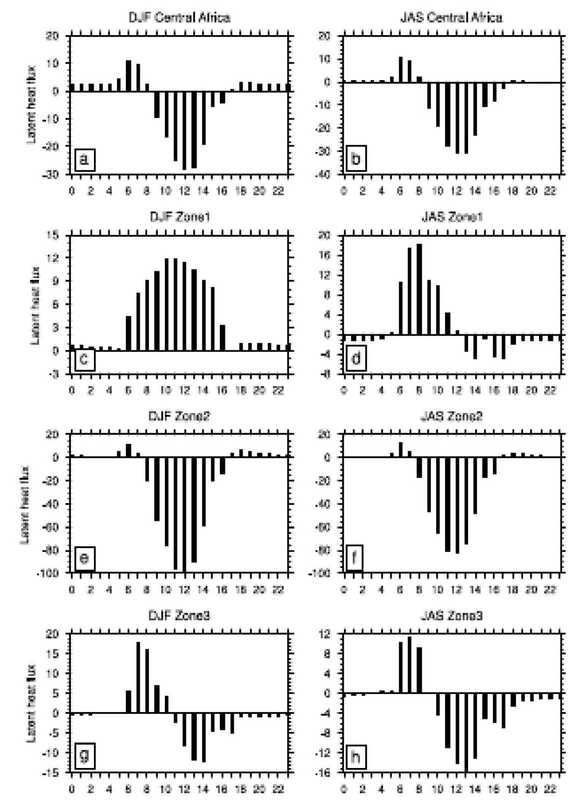


Fig. 7: Same as Fig.6, but for JAS

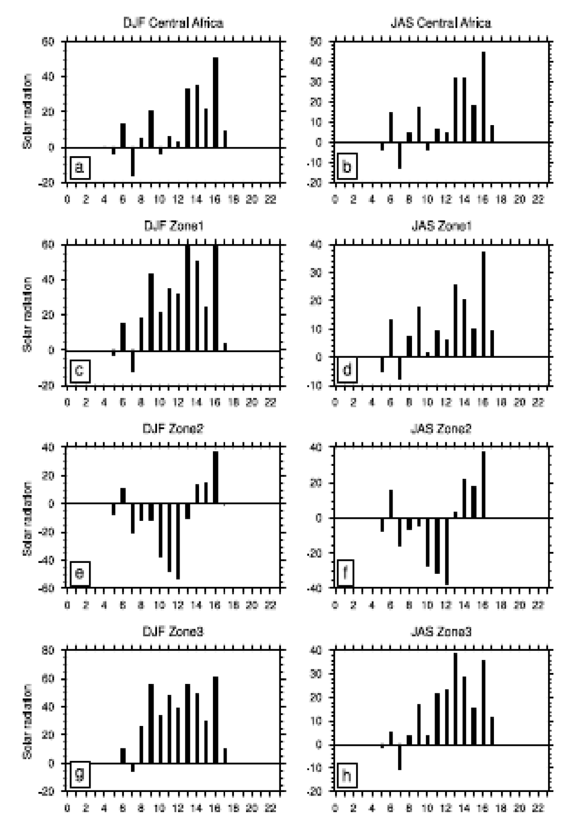
The changes observed in the amplitude of precipitation frequency are very small with values not exceeded -2% in DJF. In fact, one of the remarkable features illustrated in Fig.4 is that the peak time of these amplitudes is very influenced by aerosols, particularly in the southern part of the study area including Cameroon highland (zone 3) and Sahel (zone 1) with values around +/-4h.

Changing in radiative and heat fluxes



◂**Fig. 8**: 24-h cycle of aerosol induced changes in latent heat flux (W/m2) for (a,b) Central Africa, (c,d) zone 1, (e,f) zone 2 and (g,h) zone 3 in DJF (first column) and JAS (second column).

The aerosol induced changes in latent heat flux and also solar radiation is much more important during daytime and occurs during sunrise. In fact, solar radiations warm the surface of the earth thus causing the motion of natural and anthropogenic emissions from the earth surface to the atmosphere.



◂**Fig. 9**: Same as Fig.8, but for surface solar radiation.

The aerosol effect on latent flux is also observed in the diurnal surface solar radiation as shown if Fig.9. This strong absorption of solar radiation is well described by Kim et al. (2010) and Papadimas et al. (2012). It can lead to a significant surface radiative heating thereby increasing atmospheric stability below aerosol levels and increase daytime precipitation as found above.

Arosols always reduce surface latent heat flux in various season and subregions around mid day except in zone 1 in the Sahel. The changes starting from 1800 LST to 5000 LST are negligible, suggesting that the positive aerosols impact on various precipitation characteristics during this period can not be attributed to the interaction between aerosols and latent heat flux.

CONCLUSION

RegCM AOD is able to simulate the aerosol annual cycles pattern, despite some underestimations. Over Congo basin, AOD is mainly contributed by biomass burning activities that are intense during JAS, which reflected in MODIS AOD that are extremely higher in JAS (reaching >0.6) than that other months. However, RegCM AOD is incapable to well capture such AOD from biomass burning activities and even showed slightly lower AOD in JAS than other months. dust-induced AOD than simulating the biomass burning-induced AOD. The increasing of 24-hour cycle of various precipitation characteristics by aerosols over various subregions highlights their removal efficiencies with hight sensitivity in to precipitation frequencies than to precipitation intensity, indicating that the amount of precipitation may lead to different removal efficiencies of atmospheric aerosols. One prominent result of the present study is that the aerosol induced changes in the 24-h cycle of various precipitation characteristics are somewhat in agreement to those changes found in the corresponding amplitude and peak time.

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