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Effect of aerosols loading and retention on surface temperature in the DJF months

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Effect of aerosols loading and retention on surface temperature in the DJF months

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Abstract. The effect of aerosols loading most often results in aerosols retention in the atmosphere. Aside the health hazards of aerosol retention, its effect on climate change are visible. In this research, it was proposed that the effect of aerosol retention also affects the fluctuation of the surface temperature. The location of study is Enugu, Nigeria (6.4584° N, 7.5464° E). Twenty-nine years GISS Surface Temperature Analysis (GISTEMP) data set and sixteen years MISR aerosol optical data set were used. The fluctuations in the sixteen years aerosol optical depth (AOD) tallied with the surface temperature. The curve-fitting tool of Matlab was used to generate a polynomial for the surface temperature and used to project a five years prediction of the surface temperature.

1. Introduction

Aerosols comprise mainly of dust particulates and their dynamics in open space will require a systemic approach to the modelling of their dispersion, loading, precipitation, their molecular interactions and kinetics. Aerosols have benefits attached to their use. In agriculture, with large particle entrainment in the clouds, the air is polluted thus, poisoning the carbon dioxide required for green plants to photosynthesize; this may also result in abnormal growth. Aerosols are sprayed over farmlands as pesticides which help to eradicate plant pests but at high concentrations, the soil nutrients may be altered which makes the soil/farmland unfavourable for cultivation/planting. In addition to some of the already mentioned disadvantages, aerosols may be poisonous and injurious to health, plant and animal life if it escapes into the atmosphere. It is also believed that contagious diseases such as flu are trapped in the air by aerosols and are transported to their targets as they disperse. Aside the anthropogenic sources of aerosols loading of the atmosphere, the north-east dust winds are constant influence in all parts of West Africa.

The concept of aerosol retention shows that all aerosols dispersed into the atmosphere do not decay or fizzle-out quickly [1, 2]. These aerosols are retained in the atmosphere and stay for as long as their natural lifetime [3-5]. The estimation technique of the retained aerosol i.e. aerosols retention was propounded by Emetere [1]. Hence, the season of highest aerosols retention in the year is December, January and February [2]. This concept may be arguable looking at the AOD data for these months and the likely events of biomass burning due to farm activities. The statistical approach of Emetere [1] showed a clear argument of highest aerosols retention within the DJF.

The major properties of atmospheric aerosol have been substantiated in mathematical expressions in order to understand its predictability and applicability in meteorological terrains. For example, Hansen *et al*. [6] simplified the radiative forcing of climate.The shown in Figure 1 below.

The largest radiative forcing (Figure 2.1) are the positive forcing initiated by greenhouse gases (GHG) while the negative forcing are initiated by aerosols. Also, it can be seen in Figure 1 that both the positive and negative forcing have significant effect on the global temperature [6]. Aerosols indirect radiative forcing (especially in warm clouds) is traceable to two sources: aerosols cloud condensation nuclei and change in precipitation efficiency.

Popular models used to estimate aerosols' indirect radiative forcing is the aerosol size-resolved model which has been used to show that the influential aerosols physical properties are important to estimate radiative forcing. For instance, the wind field activates the sea salt aerosols' size-segregated surface emission rates and its collective impact on the radiative forcing [8]. The objective of this research is to show the effect of aerosol loading and retention over surface temperature by considering a large data sets.

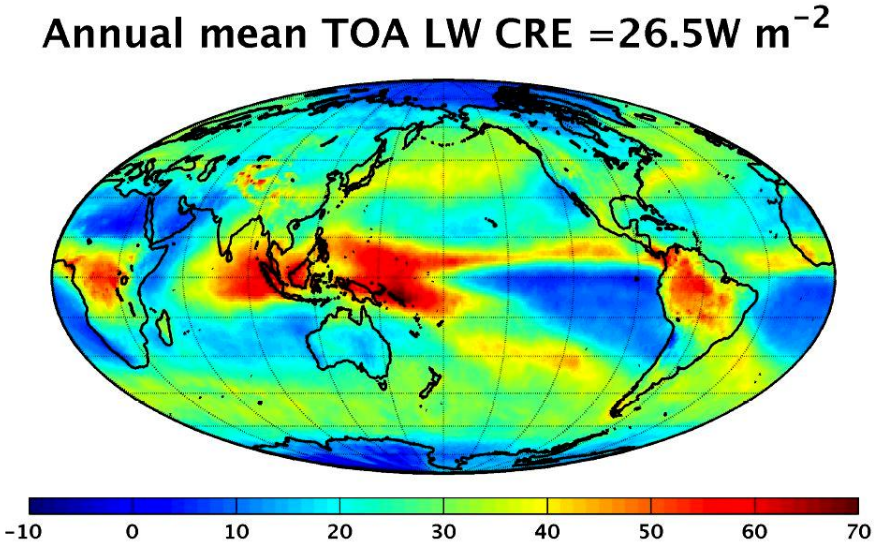

Figure 1. Global effect of atmospheric effect on radiative forcing [7]

2. Methodology

The location of study is Enugu-east Nigeria. The site is located on 6.4584° N and 7.5464° E. Twenty-nine years GISS Surface Temperature Analysis (GISTEMP) data set was obtained from the NASA site. Also, sixteen years MISR aerosol optical data sets were obtained from MISR website. The data processing was accomplished using the Microsoft Excel and Matlab programme. The curve-fitting tool on the Matlab was used to determine the polynomial expression for 29 years GISTEMP data sets. The polynomial expression was later used to project five years event.

3. Results and Discussion

The aerosol loading over the research location for sixteen years is presented in Figure 2 below. It can be observed that the highest and consistent aerosol loading record can be found in the DJF. Hence, the various fluctuations within the DJF should have impact on the climatic forcing. The scanty data sets between March and November is a clear indication of the active aerosols loading and retention in the DJF. Also, it has been reported that scanty over most parts of West Africa was due to atmospheric constant configurations in the MISR algorithm [1, 5, 6] We examined the twenty-nine years GISTEMP data sets for DJF. The GISTEMP for December is shown using the solid line in Figure 3. It can be observed that the scanty data of 2004 (Figure 2) can be corroborated with the drastic fall of the surface temperature in Figure 3. The other AOD fluctuations could also be observed in the surface temperature. Hence, there is a good relationship established between the AOD and surface temperature. We projected the expected surface temperature using mathematical expression from the polynomial curve-fitting for five years (Figure 4).

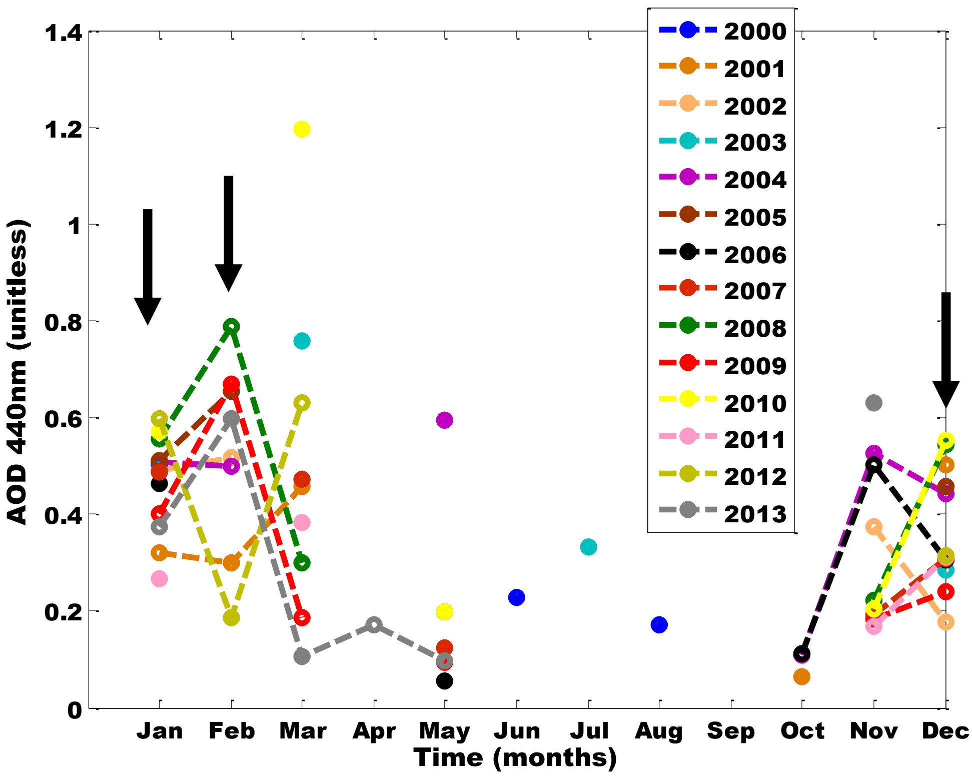

Figure 2. AOD pattern for Enugu (2000 – 2013)

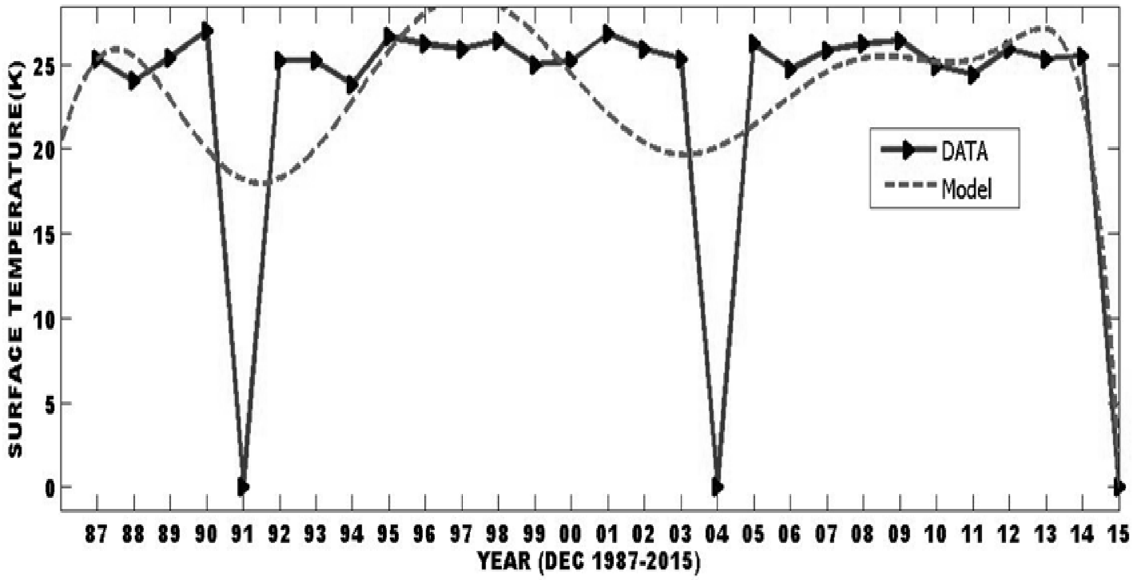

Figure 3. Surface temperature and the polynomial fit from 1987-2015 for December

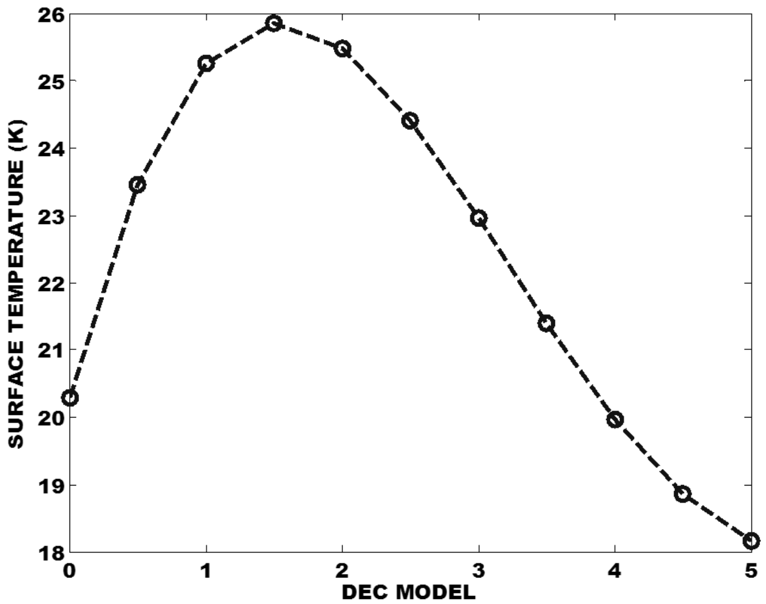

Figure 4. Five years surface temperature forecast for December

It was assumed that the AOD at the five years remains the over the location. It was projected that if the aerosol loading over remains constant for the next five years, the highest surface temperature over Enugu may be observed around mid-2017 while the lowest maybe observed in the year 2020.

The GISTEMP for January is shown using the solid line in Figure 5. It can be observed that the scanty data of 2006 (Figure 5) can also be corroborated with the drastic fall of the surface temperature in Figure 3. It was noted that this sharp decrease of surface temperature was visible in 1992, 1993 and 2015. Unlike the December dataset who had a drastic fall in 1991 and 2015 i.e. showing fair perturbations / fluctuations, the January data set had higher perturbations / fluctuations. We projected the expected surface temperature using mathematical expression from the polynomial curve-fitting for five years (Figure 6). The highest surface temperature over Enugu may be observed around late 2017 while the lowest maybe observed in the year 2020.

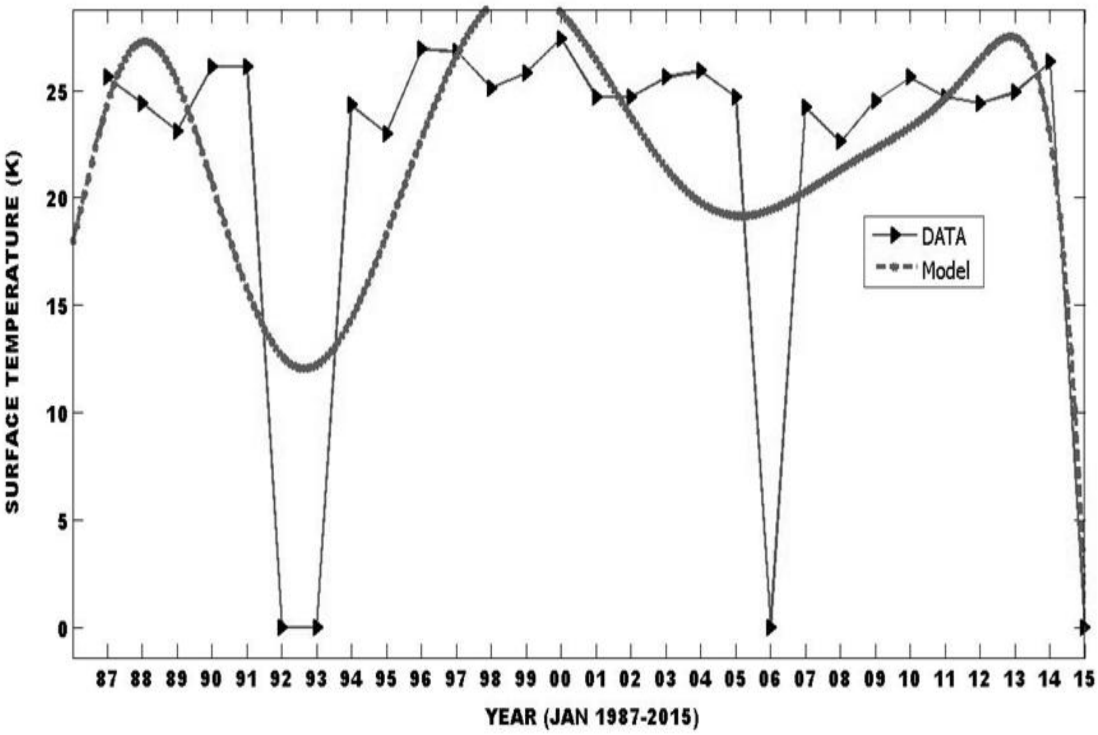

Figure 5. Surface temperature and the polynomial fit from 1987-2015 for January

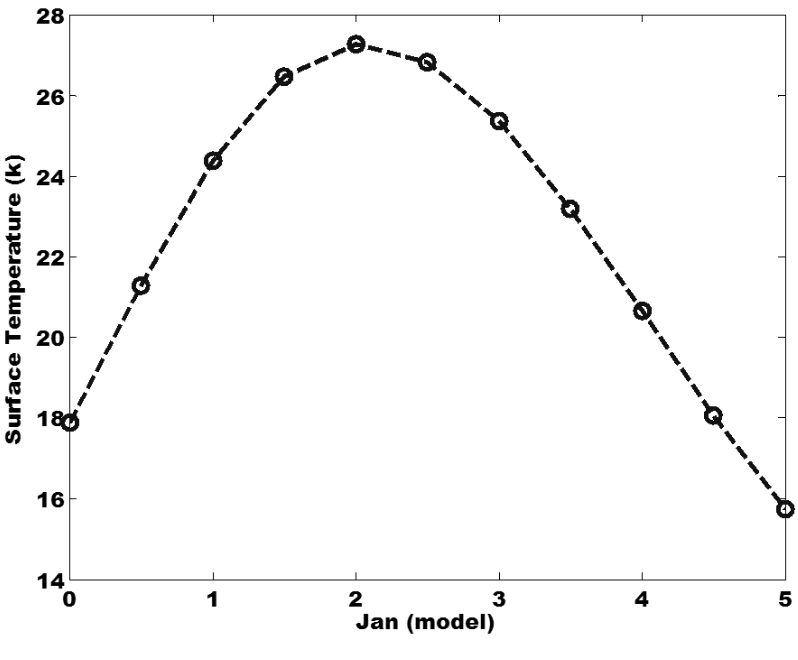

Figure 6. Five years surface temperature forecast for January

The GISTEMP for February is shown using the solid line in Figure 7. It can be observed that the scanty data of 2010 and 2013 (Figure 7) can also be corroborated with the drastic fall of the surface temperature in Figure 3. It was noted that this sharp decrease of surface temperature was visible also in 1993 and 1997. January and February had almost the same surface temperature fall in 1993. Unlike the December and January dataset, the February data set do not tend to fall by 2015. We projected the expected surface temperature using mathematical expression from the polynomial curve-fitting for five years (Figure 8). The highest surface temperature over Enugu may be observed around mid to late 2017 while the lowest maybe was in the year 2015.

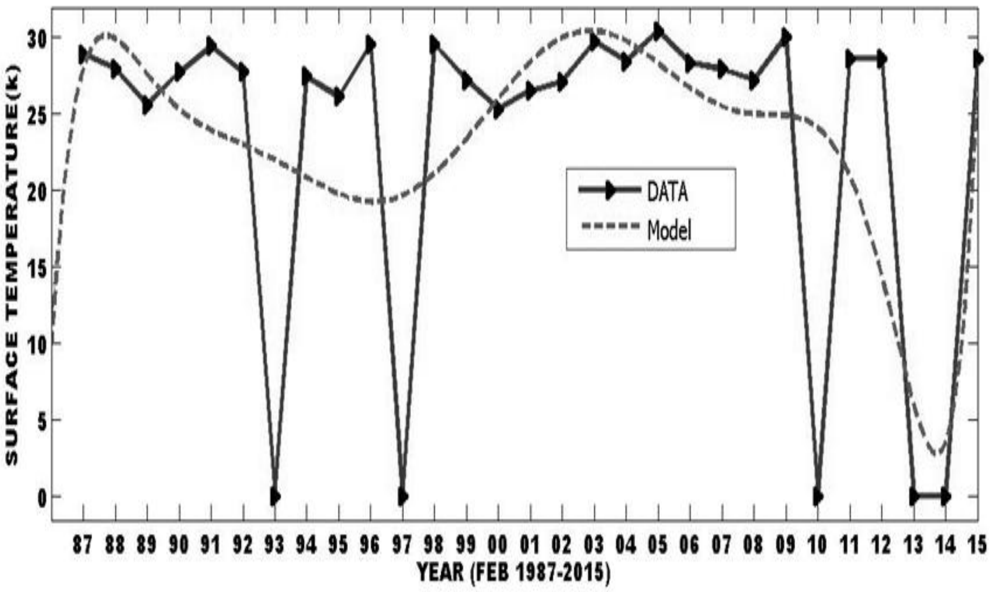

Figure 7. Surface temperature and the polynomial fit from 1987-2015 for January

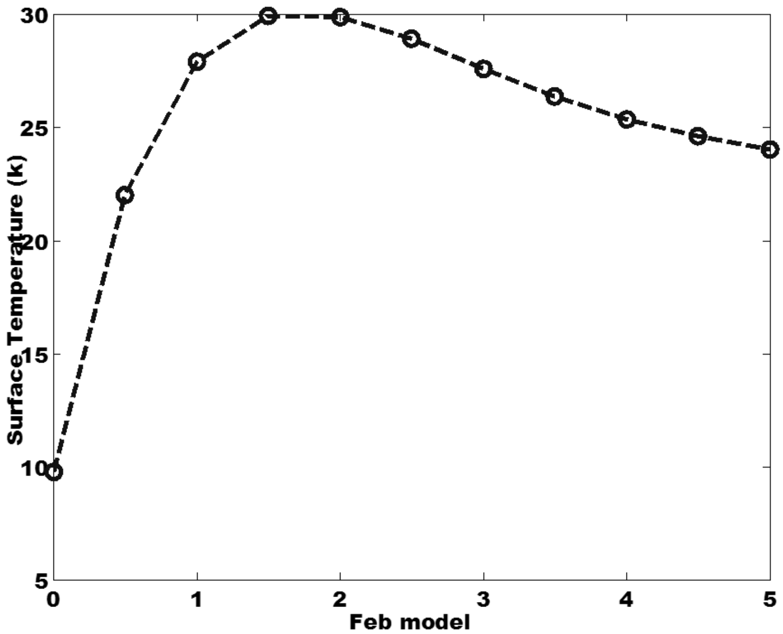

Figure 8. Five years surface temperature forecast for January

4. Conclusion

The impact of aerosol loading which is expected to lead to the increase of the surface is expected to have highest impact in 2017. The effect of tropospheric aerosol is therefore very visible in climate forcing. The five year projection of February shows that the highest aerosol loading and retention is obtained within this period.

Appreciation

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