Available online at www.sciencedirect.com
ScienceDirect
Particuology 6 (2008) 106–111
PARTICUOLOGY
www.elsevier.com/locate/partic

Long-term trend in aerosol optical depth from 1980 to 2001 in north China

Jiangxia Xie[a,b], Xiangao Xia[c,*]

[a] College of Atmospheric Sciences, Lanzhou University, Lanzhou 730000, China
[b] Hunan Meteorological Bureau, Changsha 410007, China
[c] LAGEO, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China

Received 27 September 2007; accepted 9 November 2007

Abstract

Using the Total Ozone Mapping Spectrometer (TOMS) monthly aerosol optical depth (AOD) at 500 nm data from 1980 to 2001 in north China, the spatial and temporal variations of AOD were examined. Seasonal AODs in Taklimakan Desert were 0.69 and 0.44 in spring and summer, respectively, which were mainly due to frequent occurrences of dust events in this region. Dust activities in spring also led to high aerosol loading in Gobi Desert and in northeast China where spring AODs were 0.33 and 0.29, respectively. Heavily impacted by events such as volcano eruption, forest fires and extraordinary dust storms, AODs showed large inter-annual variations. A decreasing tendency in AOD was observed in north China during 1980–1991, though a reverse tendency was revealed during 1997–2001, especially for spring AOD in northeast China. Further study is required to figure out how much human activities have contributed to the AOD tendency in north China.

Keywords: Total Ozone Mapping Spectrometer (TOMS); Aerosol optical depth (AOD); North China

1. Introduction

Aerosols, microscopic particles suspending in the atmosphere, play an important role in climate and environment. Aerosol is one of the principal atmospheric pollutants and it also influences acid rain and tropospheric ozone pollution (Wang, Zhang, & Pu, 2001). Study indicates links between fine particulate matter and numerous health problems because these particles are so small that they are able to penetrate the deepest parts of the lung (Ren, You, Lu, Zhang, & Wang, 1999). Aerosols influence both visibility and climate through the scattering and absorption of solar radiation (Mao & Li, 2006; Xia et al., 2007). Heavy aerosol loading is believed to have influenced regional temperature and precipitation pattern changes since the mid-1970s in China via direct and indirect effects (Li, Zhou, & Li, 1995; Li et al., 2007; Xu, 2001). Records show that the average amount of surface irradiance went down by almost 3.3% per decade during the period of 1960–2000 in China. This coincided with drops in cloud cover and rainy days but increase in aerosol loading during this period (Liang & Xia, 2005), implying that increased aerosol loading contributes, at least partly, to decreased surface irradiance via direct and indirect effects. Note that there are still large uncertainties about dust effects on climate despite the environmental and climatic importance of dust aerosols. This is partly due to our poor understanding of dust aerosol properties and their spatial and temporal variations (Chen, Xia, Wang, & Zhang, 2007; Wang et al., 2001).

Dust activities, determined to some extent by large-scale synoptic processes, showed large temporal variation; accordingly, one would expect remarkable temporal variation in dust aerosol loading (Sun, Zhang, & Liu, 2001). Long-term measurements of dust concentration have been taken in the downwind regions of western Africa, the largest dust source regions in the world. These data have been used to study the temporal variation of dust activities and its potential causes (Prospero & Lamb, 2003). It is well known that Gobi and deserts in eastern Asia are important source regions of dust aerosols. The frequent outbreaks of dust events not only lead to heavy aerosol loading in source regions but also impact atmospheric environment in downwind regions. Much attention has been paid to dust aerosols in east-

* Corresponding author. Tel.: +86 10 82995071; fax: +86 10 82995073.
E-mail address: xxa@mail.iap.ac.cn (X. Xia).

1674-2001/$ – see inside back cover © 2008 Chinese Society of Particuology and Institute of Process Engineering, Chinese Academy of Sciences. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.partic.2007.11.002

ern Asia (Wang et al., 2001). Maximum aerosol loading occurs in spring as revealed from ground-based and satellite remote sensing data (Xia et al., 2005; Zhang et al., 2003). However, Information on dust properties and the spatial and temporal variations are still limited. A ground-based network of dust aerosols using the state-of-the-art instruments has been established only at the beginning of this century, although dust optical depths have been retrieved using broad-band extinction method since 1980s (Qiu & Yang, 2000). Satellite remote sensing of tropospheric aerosol is believed to be a robust method to quantify aerosol loading with high spatial and temporal resolution (Li et al., 2003). More importantly, aerosol products retrieved from satellite measurements since 1980s have been released, for example, global aerosol data retrieved from Total Ozone Mapping Spectrometer (TOMS) (Torres et al., 2002) and from Advanced Very High-Resolution Radiometer (AVHRR) over the oceans (Mishchenko, Geogdzhayev, Rossow, et al., 2007). With the development of satellite technology that can observe changes in aerosols on a global scale, the inter-annual and the long-term variation of aerosol loading can be derived from these satellite data. The satellite aerosol data suggested a long-term decreasing tendency in the tropospheric AOD since 1990s (Mishchenko, Geogdzhayev, Cairns, et al., 2007). The recent downward trend in the tropospheric AOD may have contributed to the concurrent upward trend in surface solar fluxes. Analysis of TOMS AOD during winter (November to February) indicated that the anthropogenic AOD increased by 17% per decade over the China coastal plain. The result was consistent with the concurrent increase in SO_2 emissions over the same geographical region (Massie, Torres, & Smith, 2004). Dramatic variations of dust activities have happened in north China in recent years, leading one to expect large variations in atmospheric aerosols in source and downwind regions. Full understanding of inter-annual and long-term variation of aerosol loading in this key region is required. The objective of this study is to present the trend in aerosol optical depth (AOD) at 500 nm in this region since 1980, which is achieved through analyzing TOMS AOD data from 1980 to 2001.

2. Data and methodology

The TOMS on Nimbus-7 (N7) provided global measurements from November 1978 to December 1994. The Earth Probe (EP) TOMS was launched on 2 July 1996 to provide supplementary measurements. The TOMS has a coarse spatial resolution of 50 km × 50 km at nadir with a higher value of 150 km × 250 km near the edge with a wide swath width of 2800 km that provides near daily global coverage. The retrieval algorithm (Torres, Bhartia, Herman, Ahmad, & Gleason, 1998) was applied to observations at 340 and 380 nm by the N7-TOMS sensor, and to 331 and 360 nm measurements by the EP instrument. For the sake of continuity, however, the optical depth record is reported at 380 and 500 nm for both instruments (Torres et al., 2002). It should be noted that TOMS AOD values are highly dependent on assumptions in aerosol height leading to an overall uncertainty of about 30% in the retrieved AOD (Torres et al., 2002). The Nimbus monthly mean AOD data set (1° × 1°) for January 1980 to December 1992 and EP monthly mean AOD data set (1° × 1°) for January 1997 to December 2001, were used in the paper.

TOMS AOD are available in very few grids from November to February as the surface is generally covered by snow in north China; therefore, we only present the results obtained in two seasons, i.e., in spring (March to May) and in summer (June to August). The results were obtained in three distinct regions, i.e., Taklimakan Desert [36–42°N; 75–90°E], Gobi Desert [36–42°N; 90–110°E] and northeast China [40–50°N; 120–130°N] (see Fig. 1).

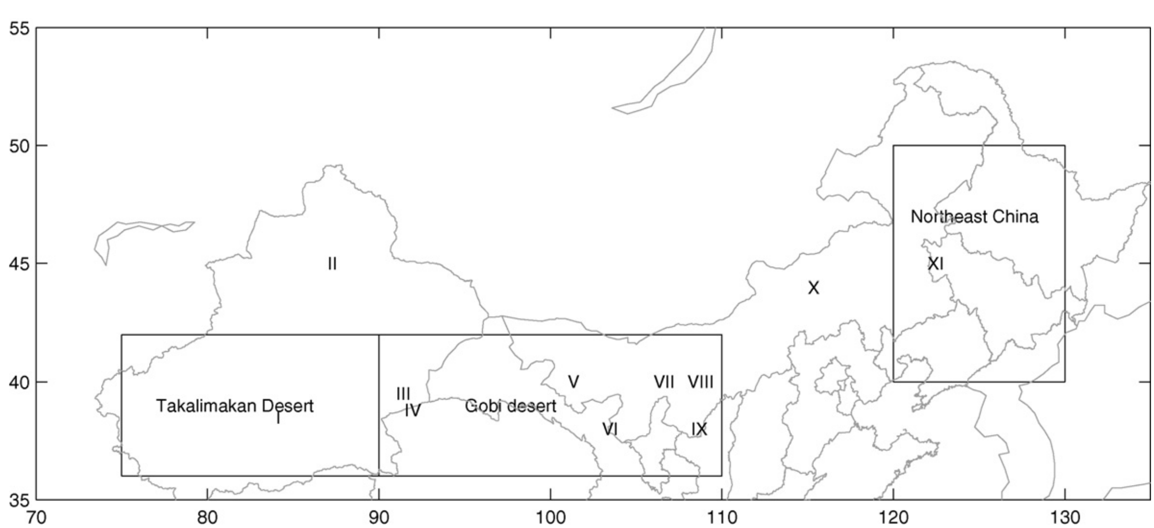

Fig. 1. Location of three regions chosen in this study, also included are 11 deserts that are as follows: I: Taklimakan Desert; II: Gurbantunggut Desert; III: Kumtag Desert; IV: Qaidam Desert; V: Badain Jaran Desert; VI: Tengger Desert; VII: Ulan Bhu Desert; VII: Hobq Desert; IX: Mu Us Desert; X: Hunshandake Desert; XI: Horqin Desert.