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Aerosol Distribution of ASEAN Area Base on LIDAR Monitoring Data at Hanoi and Trajectory Statistics Simulation

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Abstract: Averaged fractional composition of aerosol in Vietnam and Belarus was obtained and the maps of the column on near-ground aerosol content were built on the basics of model calculations. The results show the complexity of the geographic ASEAN areas. It may cause variable of climate in local.

Key words: Aerosol, concentration, composition, spatial distribution, model calculation.

1. Introduction

Atmospheric aerosol influences on transparency and reflective properties of the atmosphere and plays an important role in its radiative balance [1]. Therefore, aerosol is one of the dominant climatic factors largely determining radiative forcing. At the same time, aerosol particles are major atmospheric pollutants containing a lot of harmful chemicals. They have deleterious effect on human health and economic activity and widely determine the environmental situation in the region.

2. Measurement Data

For a long time, only local surface measurements were carried out to control the aerosol content in the atmosphere. However, to assess aerosol burden of the atmosphere and to control the large-scale pollution transfer, we need the data on 3-D aerosol distribution. Only remote methods can provide such information. Ground- and satellite-based lidars and passive optical systems using solar radiation scattered by the atmosphere, increasingly become the basis for the atmosphere monitoring. We used data on AOT (aerosol optical thickness) from the global radiometric network AERONET [1]. Backscatter and aerosol extinction data were available from lidar networks EARLINET [2]. Data on spectral AOT were provided by MODIS instrument [3] installed on the Aqua satellite.

The radiometric network AERONET, lidar networks, and satellite measurements provide valuable information about some aerosol characteristics in the atmosphere. However, the ground-based measurements are possible only for a limited number of geographical locations. Satellite measurements have a sparse temporal coverage (up to a week). Combination of satellite and ground-based observations with a global 3-D chemical transport model allows obtaining an aggregated picture of spatial and temporal atmospheric aerosol distribution including atmospheric aerosol fraction composition.

2.1 Model Description

GEOS-Chem [4, 5] is a global 3-D chemical transport model for atmospheric composition driven

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by meteorological input from the GEOS (Goddard Earth Observing System) [6]. Data from various emissions inventories are used as model input. The aerosol simulation in GEOS-Chem includes major components: sulfate (SO_4), ammonium (NH_4), nitrate (NO_3), black carbon in both hydrophilic and hydrophobic modes, mineral dust in four size bins, sea salt aerosols in both accumulation and coarse modes, and organic aerosols including organic carbon in both hydrophilic and hydrophobic modes and secondary organic aerosols. We simulate aerosol distribution using version v9-02 of the GEOS-Chem model driven by GEOS-5 assimilated meteorology (GEOS-fp for year 2013). The simulation is performed at $4^o \times 5^o$ horizontal resolution with 47 vertical layers up to 80 km.

2.2 Model Evaluation

Evaluations of the GEOS-CHEM simulation of atmospheric aerosol for different regions of the world have been done in a number of papers. Here we focus on comparison of the model predictions with observations of the aerosol over Belarus and Vietnam regions.

Fig. 1 shows the monthly average AOT measured by MODIS spectroradiometer, AERONET photometer, and simulated by GEOS-Chem model. All calculated data are in a reasonable agreement with measurements.

Vertical distributions of the relative aerosol concentrations (referred to the concentration at an altitude of 1 km) measured by lidar in Minsk and Hanoi, and calculated by the model GEOS-Chem, are shown in Fig. 2. Solid line in Fig. 2a is the relative aerosol concentration retrieval averaged over 7 lidar measurements in Minsk in different days in July, 2011. Solid line in Fig. 2b is the backscatter measurements in Hanoi at 10 o’clock on June 26, 2013. Dotted lines are monthly averaged calculation data. It is seen in Fig. 2a that the calculated and measured profiles are qualitatively similar. In Fig. 2b, the calculation and

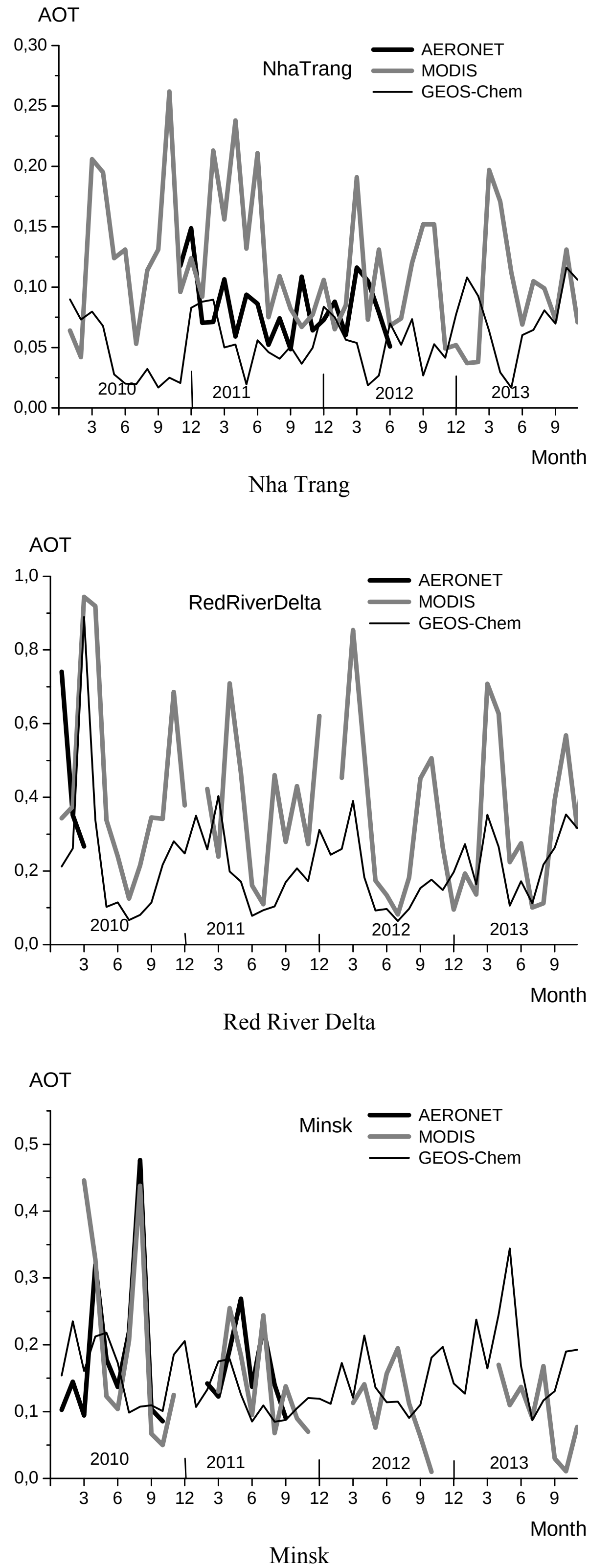


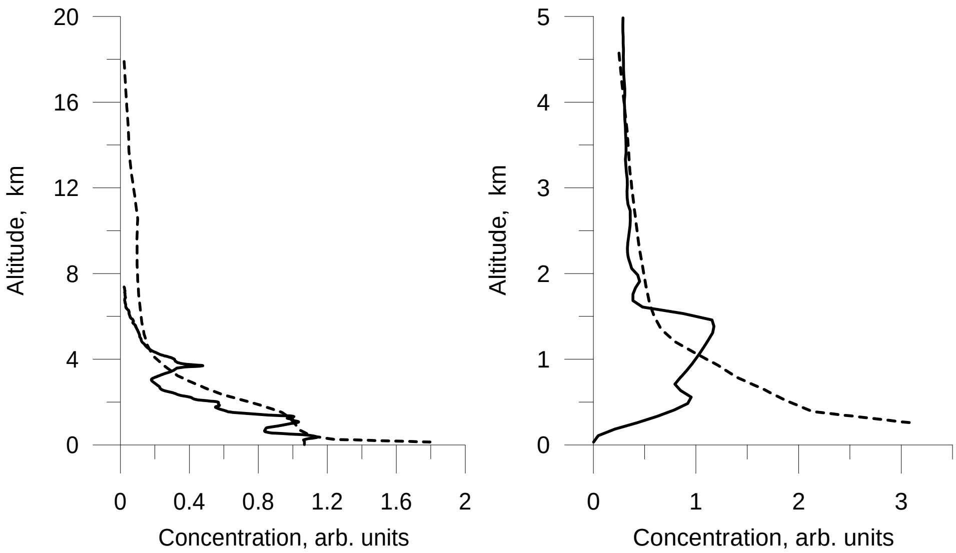
Fig. 1 The monthly averaged Aerosol Optical Thickness measured by MODIS Spectroradiometer, AERONET photometer, and calculated by GEOS-Chem model.

experiment data are in reasonable agreement on the altitudes more than 1 km. But at lower altitudes, the calculation and experiment diverge sharply. This may be due to the fact that part of the laser beam close to the lidar is not in the field of the receiving telescope.

3. Results and Discussion

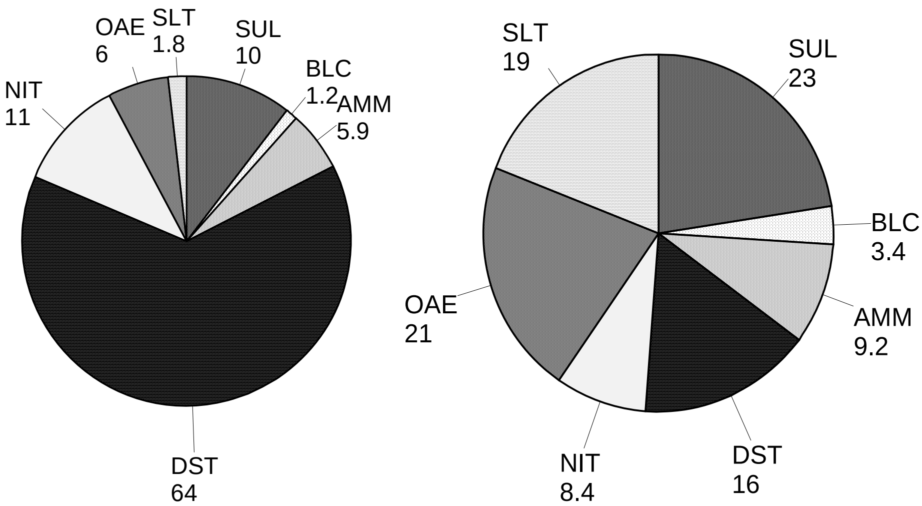
We use the model to find some aerosol characteristics that are difficult to measure directly. Fig. 3 shows the model-simulated aerosol composition over Belarus and Vietnam (averaged over 2010-2013 years). The major aerosol fractions in Belarus are mineral dust (64%), inorganic nitrates (11%) and sulfates (10%). The major aerosol fractions in Vietnam are sulfates (23%), organic aerosols (21%), sea salt aerosol (19%) and mineral dust (16%).

The model-simulated spatial distributions of aerosol column concentration over the Vietnam region in 2010-2013 are shown in Fig. 4. Sulfate, nitrate, black carbon, ammonium, mineral dust, and total (sum over



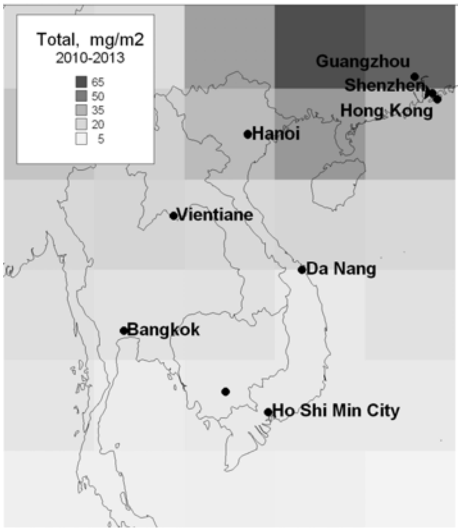
(a) (b)

Fig. 2 Altitude distribution of the relative aerosol concentrations in Minsk and Hanoi. a—Minsk; b—Hanoi; solid line—measurements; dashed line—modeling.

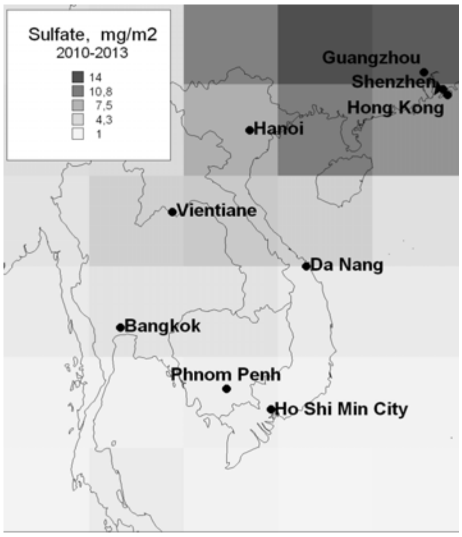


(a) (b)

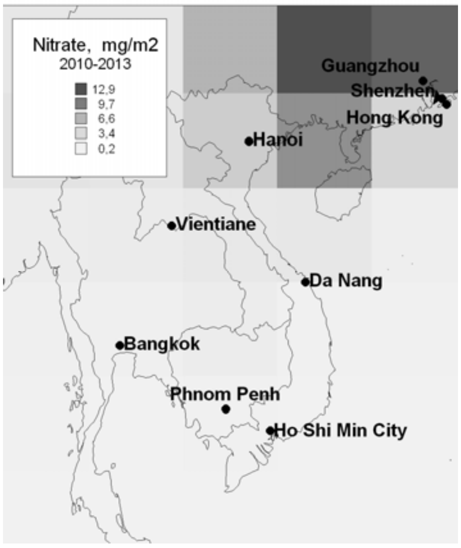
Fig. 3 Model-simulated aerosol composition over Belarus and Vietnam. a—Belarus; b—Vietnam. SUL—sulfate; AMM ––ammonium; NIT—nitrates; BLC—black carbon; DST—mineral dust; SLT—sea salt aerosol; OAE—organic aerosol.


Total, mg/m2
2010-2013
65
50
35
20
5
Guangzhou
Shenzhen
Hong Kong
Hanoi
Vientiane
Da Nang
Bangkok
Ho Shi Min City

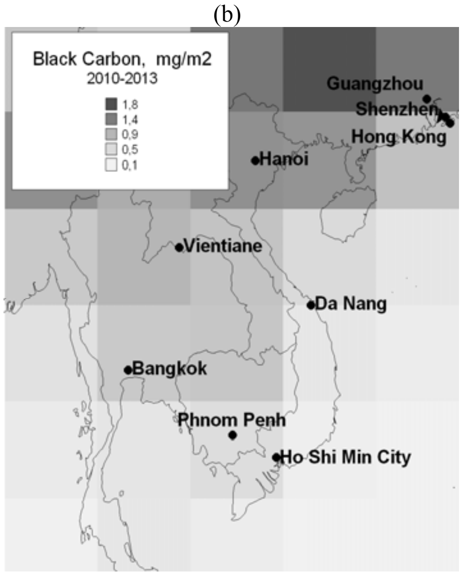
(a)


Sulfate, mg/m2
2010-2013
14
10,8
7,5
4,3
1
Guangzhou
Shenzhen
Hong Kong
Hanoi
Vientiane
Da Nang
Bangkok
Phnom Penh
Ho Shi Min City

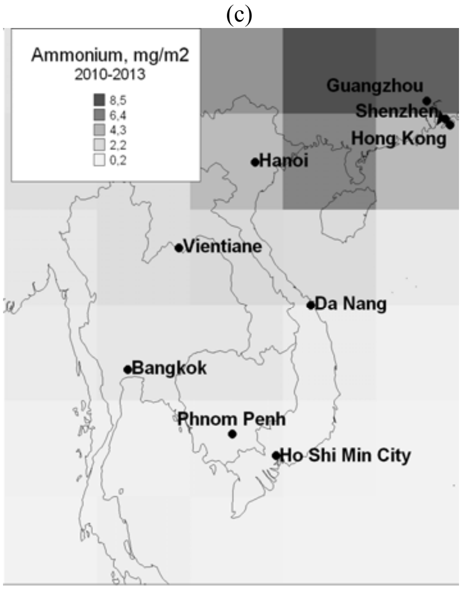
(b)


Nitrate, mg/m2
2010-2013
12,9
9,7
6,6
3,4
0,2
Guangzhou
Shenzhen
Hong Kong
Hanoi
Vientiane
Da Nang
Bangkok
Phnom Penh
Ho Shi Min City

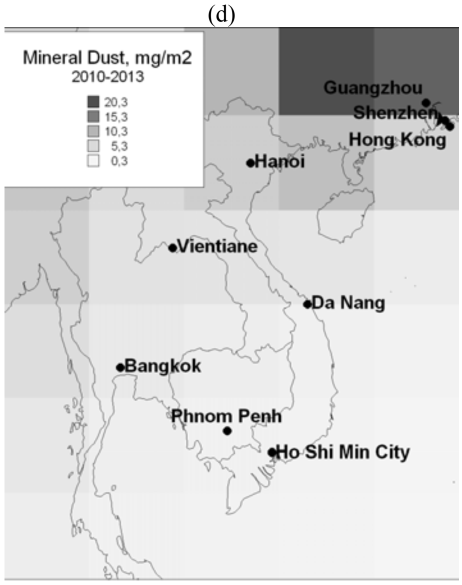
(c)


Black Carbon, mg/m2
2010-2013
1,8
1,4
0,9
0,5
0,1
Guangzhou
Shenzhen
Hong Kong
Hanoi
Vientiane
Da Nang
Bangkok
Phnom Penh
Ho Shi Min City

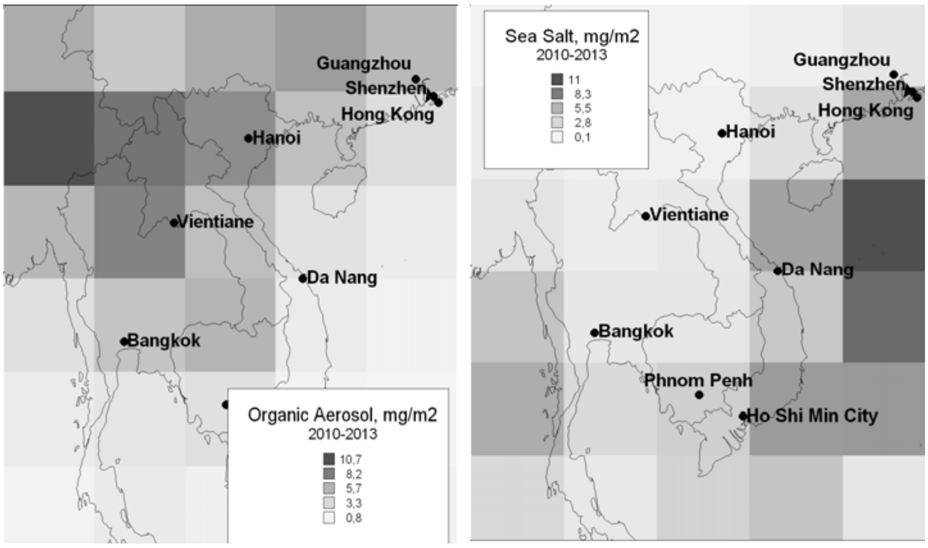
(d)


Ammonium, mg/m2
2010-2013
8,5
6,4
4,3
2,2
0,2
Guangzhou
Shenzhen
Hong Kong
Hanoi
Vientiane
Da Nang
Bangkok
Phnom Penh
Ho Shi Min City

(e)


Mineral Dust, mg/m2
2010-2013
20,3
15,3
10,3
5,3
0,3
Guangzhou
Shenzhen
Hong Kong
Hanoi
Vientiane
Da Nang
Bangkok
Phnom Penh
Ho Shi Min City

(f)



(g) (h)

Fig. 4 Model-simulated distributions of aerosol column concentration (mg/m^2) over the Vietnam region, averaged over 2010-2013. a—total; b—sulfate; c—inorganic nitrates; d—black carbon; e—ammonium; f—mineral dust; g—organic aerosol; h—sea salt aerosol.

all aerosol fractions) aerosols have qualitatively similar distribution pattern. Their concentrations are the highest in the northeast of Vietnam and are decreasing in the southern and western directions. Maximum of organic aerosol concentration is on the northwest. The highest sea salt aerosol concentrations are in South China Sea and Bengal Bay. Lower sea salt concentrations are in the center of Indo-Chinese Peninsula.

4. Conclusions

Aerosol fraction distributions in Belarus and Vietnam and spatial distributions of different aerosol fractions over Vietnam region were obtained using the GEOS-Chem model. Mineral dust prevails over Belarus. Aerosol over Vietnam consists mainly of sulfate, organic aerosol, and sea salt aerosol. Sulfate, nitrate, black carbon, ammonium, mineral dust aerosol, and total aerosol have qualitatively similar spatial distribution patterns in Vietnam region. Their column concentrations are the highest in the northeast of Vietnam and are decreasing in the southern and western directions.

Acknowledgments

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References

[1] AERONET Aerosol Robotic Network. Accessed http://aeronet.gsfc.nasa.gov/.

[2] A European Aerosol Research Lidar Network to Establish an Aerosol Climatology: EARLINET [Electronic resource]. Accessed http://www.earlinet.org/.

[3] MODIS [Electronic resource]. Accessed http://modis.gsfc.nasa.gov/.

[4] Bey, I. et al. 2001. “Global Modeling of Tropospheric Chemistry with Assimilated Meteorology: Model Description and Evaluation.” *J. Geophys. Res.* 106 (D19): 23073-96.

[5] GEOS-Chem Model [Electronic resource]. Accessed http://acmg.seas.harvard.edu/geos.

[6] GEOS-5 system [Electronic resource]. Accessed http://gmao.gsfc.nasa.gov/systems/geos5/.