Mineral Dust and Black Carbon at the Summit of Mt. Fuji

Takahashi, H. [(1)]; ***Igarashi, Y.*** [(2)]; ***Tanaka, Y.*** [(1)]; ***Yoshioka, K.*** [(3)]; ***Kaneyasu, N.*** [(4)]; ***Watanabe, K.*** [(5)]; ***Dokiya, Y.*** [(6)]

(2) Atmospheric Environment and Applied Meteorology Research Department, Meteorological Research Institute, 1-1 Nagamine, Tsukuba, Ibaraki, 305-0052 Japan, htakahas@mri-jma.go.jp
(3) Geochemical Research Department, Meteorological Research Institute
(4) Shimane Prefectural Institute of Public Health and Environment Science
(5) National Institute of Advanced Industrial Science and Technology
(6) Toyama Prefectural University
(7) Edogawa University

In order to understand the background level of aerosol concentration and its variability
in the free troposphere,
with high temporal resolution,
with long-term monitoring,
an optical particle counter was installed at the summit of Mt. Fuji (3,776 m a.s.l.) in March 2003. We found two major events of high aerosol concentration detected in first half of 2003. Utilizing our CTM (MASINGAR), we clarified that one is mineral dust event from Asian continent, and the other is black carbon event from Siberian forest fire.

Introduction

As for monitoring of the atmospheric chemical trace species in the troposphere, "long-term time series observed data" are not obtained by satellite, lider, balloon or aircraft observations. We have carried out atmospheric chemistry observations at Mt. Fuji weather station such as

Fog and precipitation chemistry	Hayashi et al, (2001) Water, Soil and Air Pollut.
Aerosol chemical species	Dokiya et al., (2001) Anal. Sci.
CO and O3	Tsutsumi and Matsueda (2000). Atmos. Environ.
O3 and Be-7	Tsutsumi, Igarsashi, et al.(1998) J. Geophys. Res.
H2O2 and MHP	Yonekura et al. (submitted)
SO2	Igarashi et al.(2004) J. Geophys. Res.

Previous studies of observation of size-resolved aerosol concentration at the summit of Mt. Fuji are…

➔ Composition and size distribution of submicrometer aerosol particles observed on Mt. Fuji in the volcanic plumes from Miyakejima : Naoe *et al.*, Atmos. Environ., 37, 3047-3055 (2003)

➔ Size-separated aerosol chemistry and water-soluble gases at the summit of Mt. Fuji during July 7-19, 2000, M. Kido *et al.*, ASAAQ2003

But, long-term monitoring of aerosol number concentration at the summit has not carried out. ➔ In this study, we obtained the data from Feb. to Oct. 2003.

Why Mt. Fuji?

1. Sole peak (3776m a.s.l.) soars above boundary layer (most of the year)
2. Located at the downwind region of the Asian source areas of chemical species
3. No mega-city near the mountain
4. The weather station facility located at the summit are available

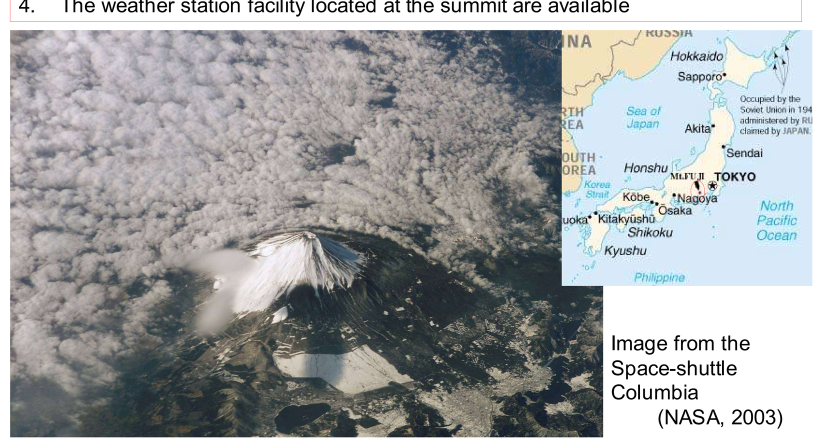
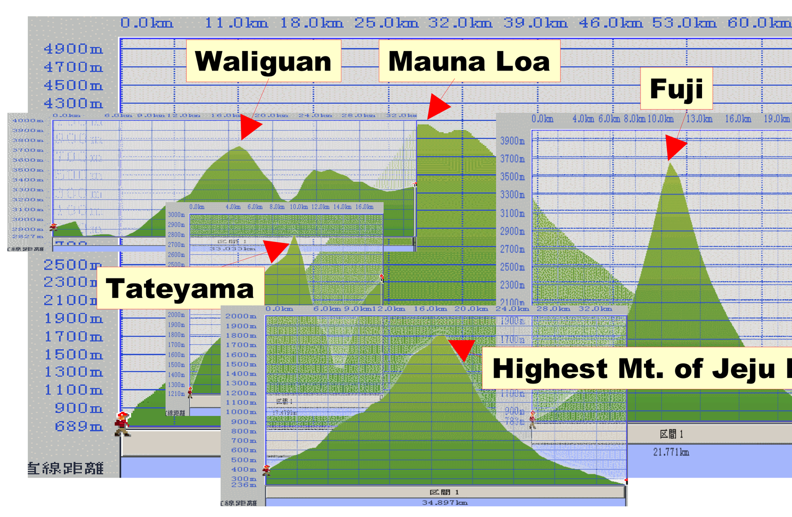


Image from the Space-shuttle Columbia (NASA, 2003)

E-W Cross Section of Mountains



Instrument - OPC

Optical Particle Counter (KANOMAX MODEL3886)
<merit>
➔low-cost and maintenance-free
➔small, light in weight, and portable by mountain carriers
➔obtained at 5 channels (d > 0.3, 0.5, 1.0, 3.0, 5.0mm)
<drawback>
➔Conc. of small particles (r < 0.15mm) is uncertain
➔Not so wide sensible range (saturated in polluted atmosphere on rare occasions)
➔Parameters of optical properties assumed are fixed.

A digital flowmeter (bubble-type) is used to determinate the flow strength, due to evidently higher airflow than standard value written in the operating manual.

No compensation was made for humidity change. (The room where the OPC is installed is warmer than the open air by 10 – 40 deg C.)

Size-distribution is assumed arbitrarily.

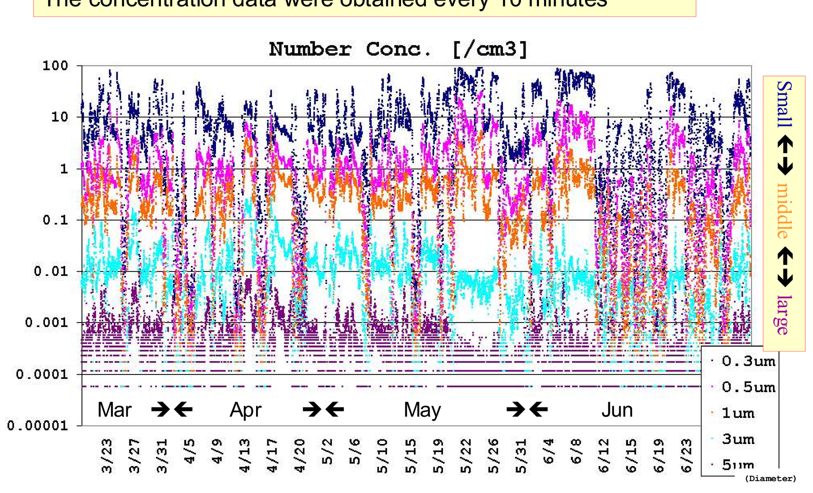
Surroundings

Air-inlet has been installed at the side of the weather station building. Fresh air transported with westerly-jet is able to be taken in.

Contamination from mountain climbers are negligible. The periods when the power generator runs are recorded and taken into account in a quality-check.

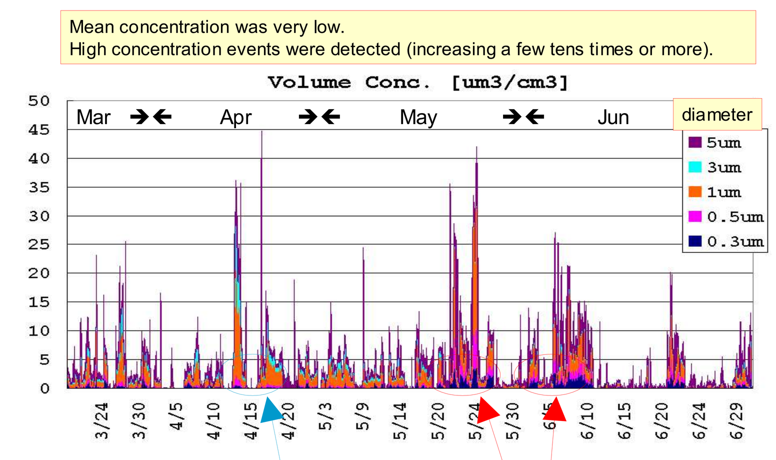
Observed data

[The summit of Mt. Fuji, from 21/Mar/2003 to 30/Jun/2003]
The concentration data were obtained every 10 minutes



Volume Concentration

Mean concentration was very low.
High concentration events were detected (increasing a few tens times or more).



Kosa (Asian dust) events in 2003

The numbers of dust-observed cases were very few.

In winter 2002-2003, large amount of rainfall and snowfall was observed in dust source region.
In spring 2003, severe wind was rarely observed in dust source region.
(Beijing city weather station)

Year	Days
1999	265
2000	727
2001	827
2002	1229
2003	170

Kosa repoted days in Japan [stations × days]

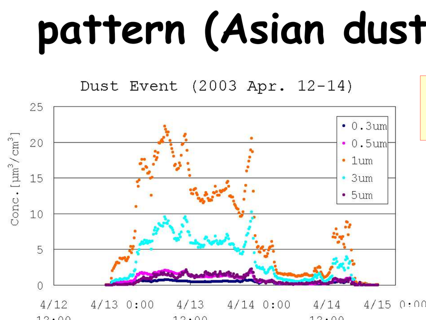
<2003>

Month	Days
1	0
2	0
3	69
4	99
5	2

Mainly in 27 Mar
Mainly in 13 Apr

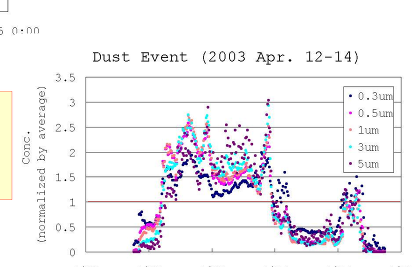
In this case study, we discuss about the kosa event detected at the summit on 13 Apr 2003.

Volume conc. and its normalized pattern (Asian dust case)

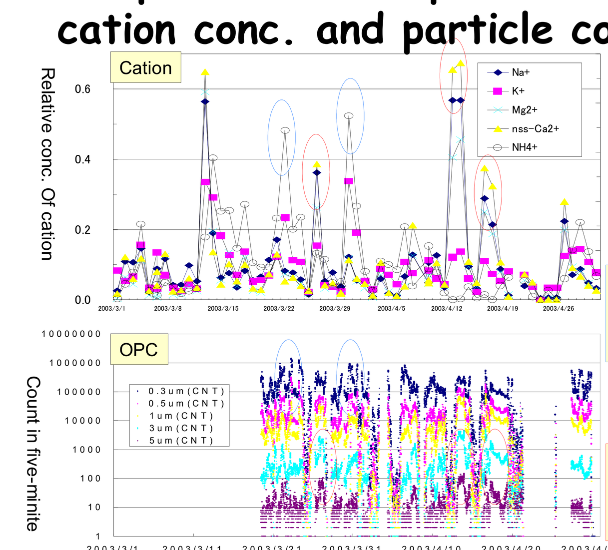


Total volume conc. is dominated by 1μm-size particles.

In dust case, all size-bins of particles fluctuate in similar rates.
Slightly smaller variation in small particles was found.



Comparison of temporal change in cation conc. and particle conc.



(➔by Y. Minami, Ishikawa Agri. Coll.)

NH_4^+,K^+ rich
And
Small particles dominant
(➔biomass-burning?)

nss-Ca_2^+,Na^+,Mg_2^+ rich
And
Large particles dominant
(➔Dust)

Model Description

Layer N	Pres.[hPa]
30	0.5
29	1.0
28	1.5
27	2.0
26	3.0
25	5.0
24	7.0
23	10.0
22	15.0
21	20.0
20	30.0
19	50.0
18	70.0
17	100.0
16	150.0
15	200.0
14	250.0
13	300.0
12	400.0
11	500.0
10	600.0
9	700.0
8	750.0
7	800.0
6	850.0
5	900.0
4	925.0
3	950.0

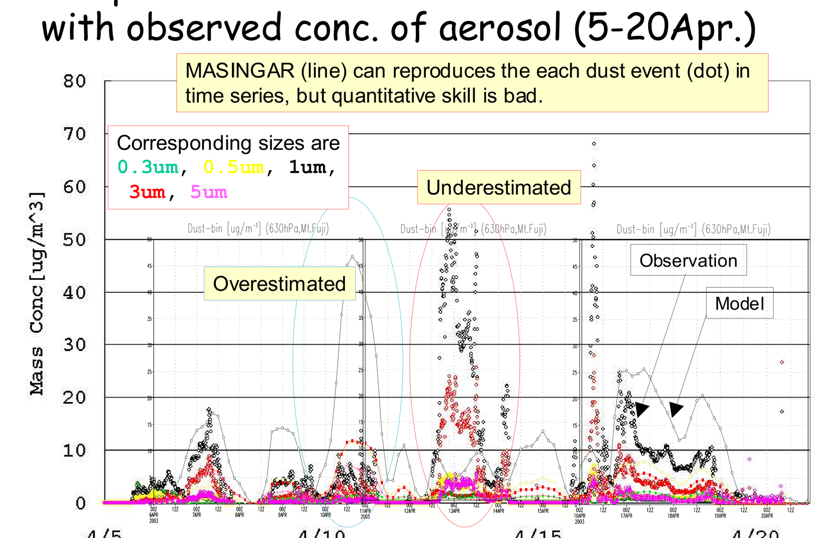
Model : MASINGAR (Tanaka *et al.*, 2003)
(Model of Aerosol Species IN the Global AtmospheRe)
Resolution : T63L30
Pre-run : 2weeks
Horizontal wind is nudged with NCEP40 reanalysis.

MASINGAR can deal with…
Sulfate (SO_2, SO_4^{2-}, DMS, H_2S, CS_2, MSA, DMSO, $DMSO_2$ ･･･GEIA 1B)
Dust, Sea Salt, Carbonaceous (OC, BC), Radon222, Lead210

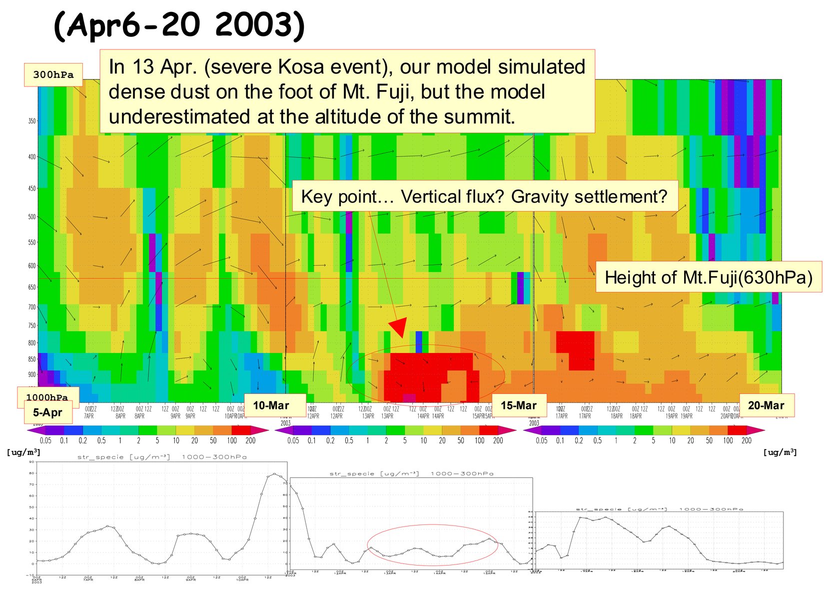
bin	r_min	r_max	r_effective	
Dust01	0.100	0.158	0.136	small
Dust02	0.158	0.251	0.215	
Dust03	0.251	0.398	0.340	
Dust04	0.398	0.691	0.540	
Dust05	0.691	1.000	0.855	
Dust06	1.000	1.585	1.355	
Dust07	1.585	2.512	2.148	
Dust08	2.512	3.981	3.405	
Dust09	3.981	6.310	5.396	
Dust10	6.310	10.000	8.553	large

Comparison of the simulated conc. of dust with observed conc. of aerosol (5-20Apr.)

MASINGAR (line) can reproduces the each dust event (dot) in time series, but quantitative skill is bad.



Simulated dust in time-vertical section (Apr6-20 2003)

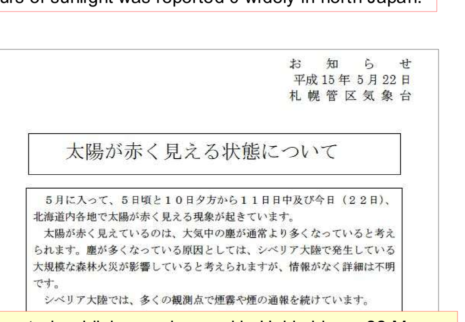


Siberian forest fire in 2003

Siberian forest fire in spring-summer 2003 discharged heavy smoke. The smoke reduced the intensity of sunlight in the north Japan.

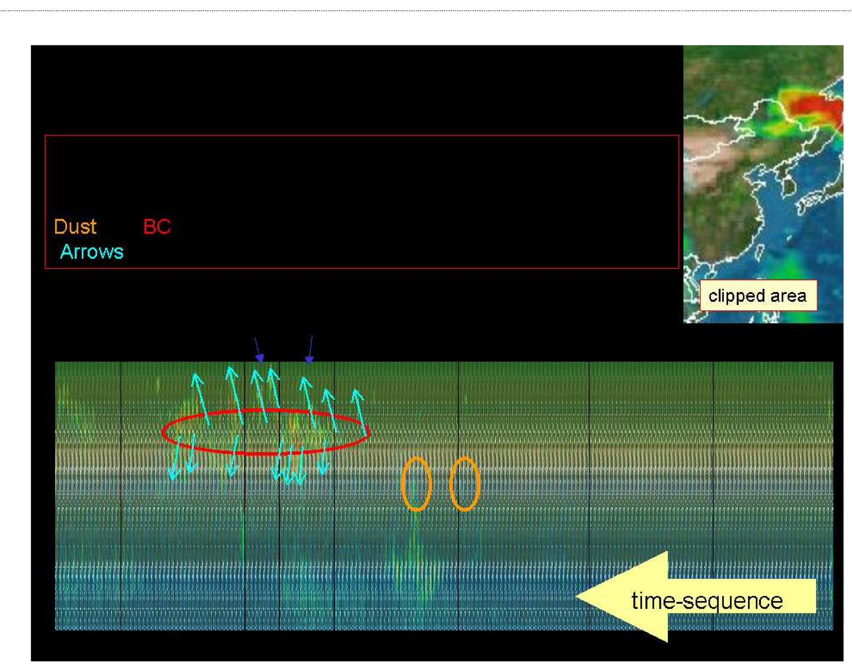
- Burned 21000km² (three times of Hokkaido in Japan) of the forest
- "Smoky, and smell like pyroligneous acid" reported by Mt. Fuji weather station.
- High concentration of aerosols in 3000-4000m a.s.l (Japan Met. Agency)
- No cloud was observed, but hours of sunlight was reported 0 widely in north Japan.

At the top of Mt. Fuji, this smoky event was evident with manual observation. But the change of all-sky solar radiation was not detected obviously.
OPC saturated often in the period.
This period overlapped with our intensive observation period in 2003.

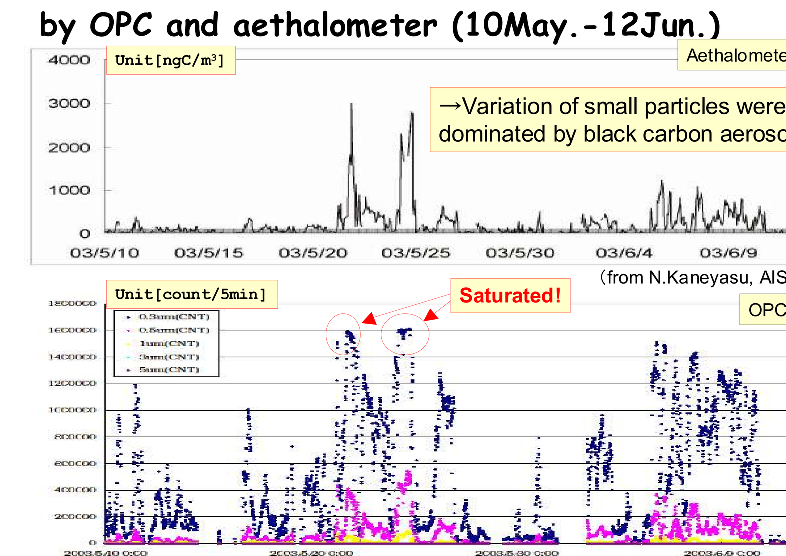


太陽が青く見える状態について

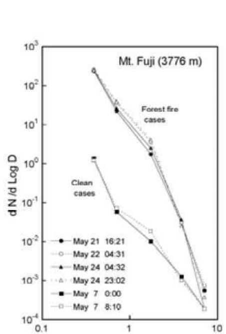
JMA reported reddish sun observed in Hokkaido on 22 May.

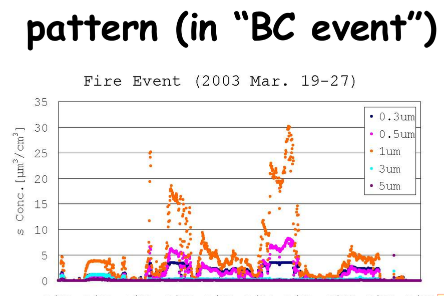


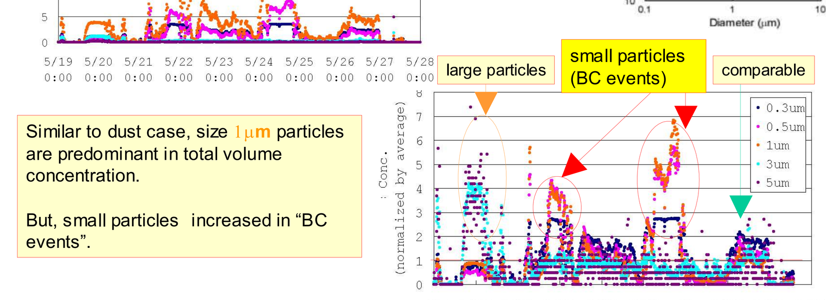
Good correlation between the data obtained by OPC and aethalometer (10May.-12Jun.)



Volume conc. and its normalized pattern (in "BC event")



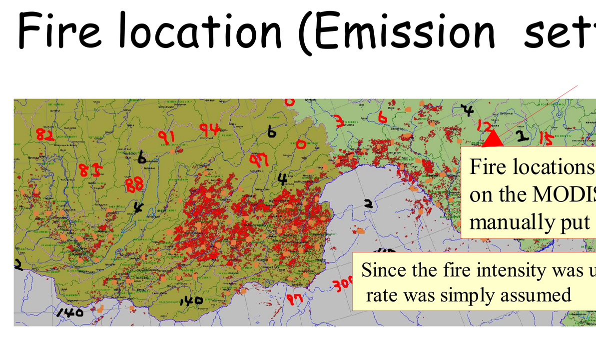




Similar to dust case, size 1μm particles are predominant in total volume concentration.

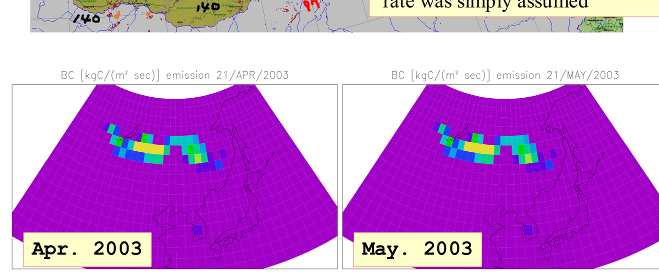
But, small particles increased in "BC events".

Fire location (Emission setting)



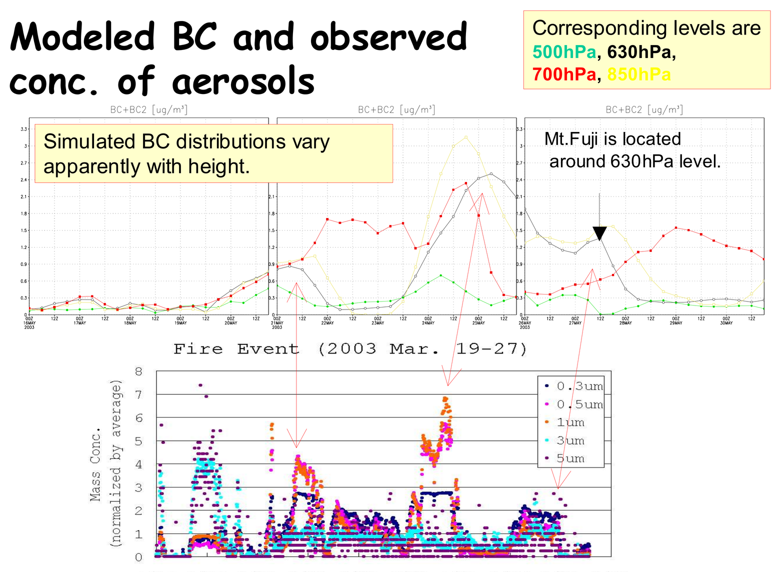
Fire locations were assumed based on the MODIS Satellite and were manually put in the figure.

Since the fire intensity was unknown, a constant emission rate was simply assumed



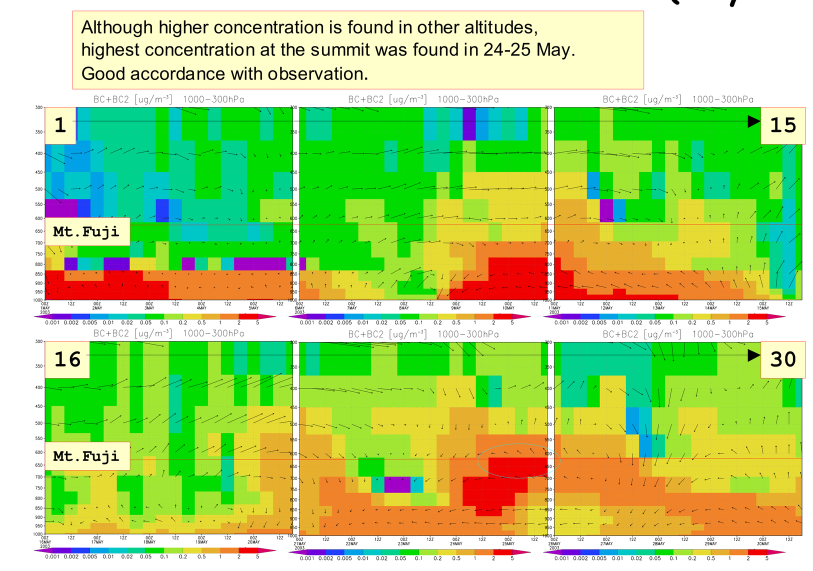
Modeled BC and observed conc. of aerosols

Corresponding levels are 500hPa, 630hPa, 700hPa, 850hPa

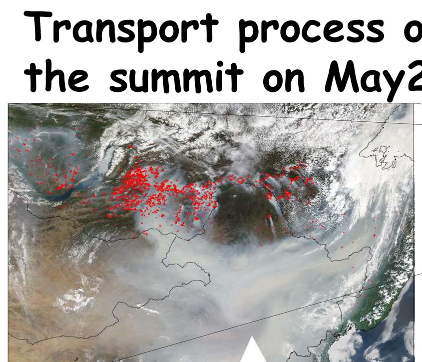


Simulated BC Time-vertical section (May 2003)

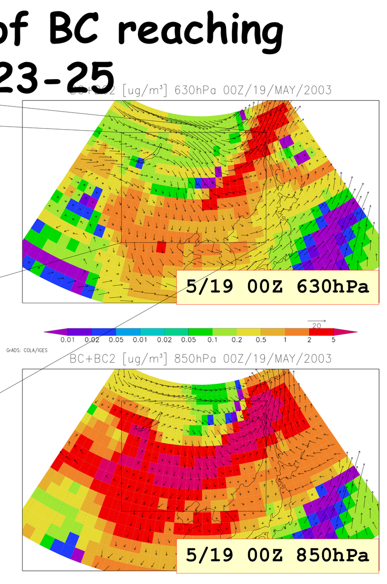
Although higher concentration is found in other altitudes, highest concentration at the summit was found in 24-25 May.
Good accordance with observation.



Transport process of BC reaching the summit on May23-25



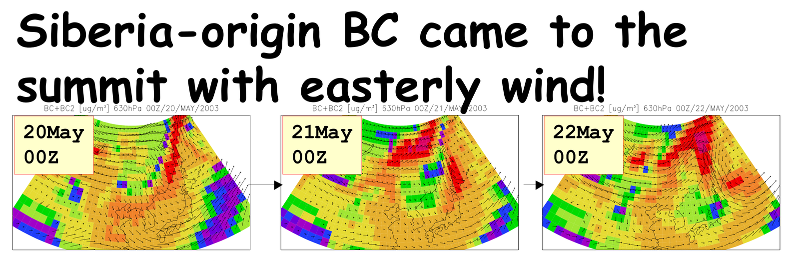
MODIS(NASA)May19 0430Z



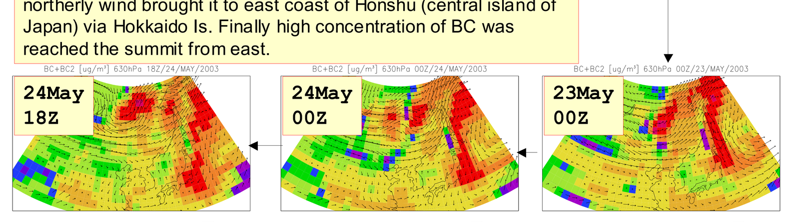
The smoke plume from the forest fire was transported to south by surface wind, and uplifted intermittently with a trough located in the north-eastern China and the eastern Siberia.

This uplift brought the plume to the altitude of the summit of Mt. Fuji (630hPa).

Siberia-origin BC came to the summit with easterly wind!



BC was transported to Okhotsk sea during the first stage, and northerly wind brought it to east coast of Honshu (central island of Japan) via Hokkaido Is. Finally high concentration of BC was reached the summit from east.



Summary

By monitoring aerosols in the free troposphere, we can depict long-range transport processes. The summit of Mt. Fuji serves a good observational site.

From the monitoring time series, we extracted a dust event and BC event. Our CTM developed for investigating transport processes and radiative forcing was utilized for comparison with observed aerosol concentration at the summit.

For the dust case, the model reproduced high concentration events, but the quantitative conc. could not be simulated adequately. An insufficient precision in vertical transport (including gravitational settlement) scheme could brought the error.

For the BC event, we found that even manually set BC emission could reproduce the observed BC. It is indicated that Siberia-origin BC was transported via Okhotsk sea and Hokkaido to Mt. Fuji.