The Abdus Salam International Centre for Theoretical Physics

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Workshop on Aerosol Impact in the Environment: from Air Pollution to Climate Change

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Black carbon radiative forcing over a GAW site in Korea

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Black Carbon Characteristics and radiative forcing over a Korean GAW site

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Introduction

- Aerosols :Tiny particles in the atmosphere
- Aerosols : Natural & Anthropogenic.
- Anthropogenic Aerosols From.
  - Stationary sources (eg:Industrial chimneys)
  - Area sources (eg: Industrial complexes)
  - Line sources (eg:Automobiles)

CLASSIFICATION OF AEROSOLS BASED ON

- Size
  - (a) Aitken nuclei (radius <0.1µm)
  - (b) Large nuclei (radius between0.1&1µm)
  - (c) Giant nuclei (radius>1µm)
- Source
  - (a) Continental aerosols
  - (b) Marine aerosols
  - (c) Extraterrestrial aerosols
- Shape
  - (a) Isometrics
  - (b) Platelets
  - (c) Fibers
- Formation
  - (a) Primary Aerosols
  - (b) Secondary Aerosols

Observations and Models Used for study…

Instruments

- Aethalometer
- High volume sampler

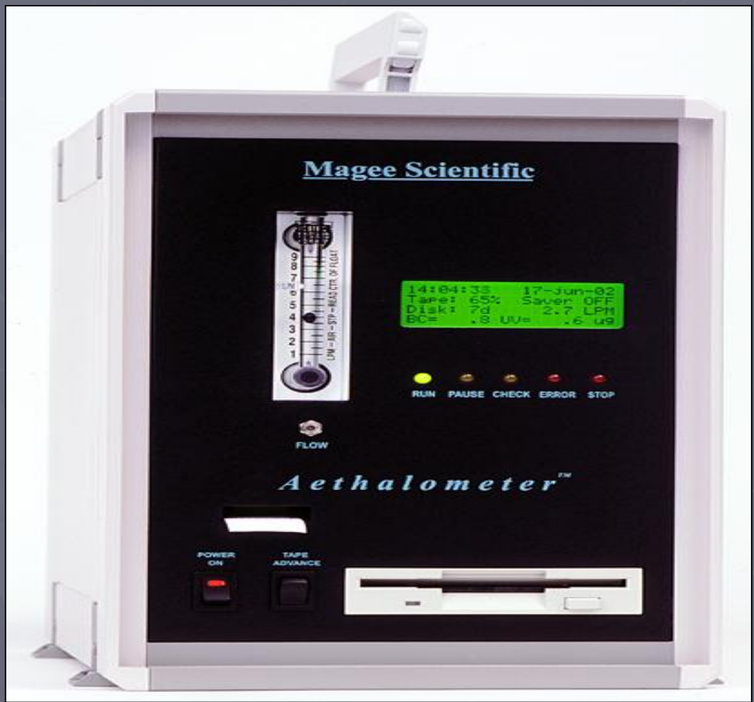
Models

- SANTA BARBARA DISCRETE ORDINATE RADIATIVE TRANSFER MODEL (SBDART)
- OPTICAL PROPERTIES OF AEROSOLS AND CLOUDS (OPAC)

Aethalometer & High Volume sampler

Aethalometer (Magee Scientific) : Black Carbon Observations

High Volume sampler (Envirotech 410)



Aethalometer

High volume sampler

MODELS

OPAC (Optical Properties of Aerosols and Clouds)

- OPAC Estimates Optical properties of aerosols from 0.2-40μm.
- Uses atmospheric chemistry data sets as Input
- Data sets from High volume sampler (water soluble and acid soluble components) and Aethalometer (Black carbon)

SBDART
(SANTA BARBARA DISCRETE ORDINATE RADIATIVE TRANSFER MODEL)

- 1-dimensional model – Incorporates aerosol observations
- Plane parallel atmosphere
- Line-by-Line integration
- Default Temperature & water vapor profiles: **TROPICAL, MID-LATITUDE SUMMER , MID-LATITUDE WINTER , SUB-ARCTIC SUMMER , SUB-ARCTIC WINTER .**

SBDART.....

- **Aerosol Optical Depth**
- **Aerosol Single Scattering Albedo**
- **Asymmetry Parameter**

  - Derived from OPAC
  - Water vapor column (From MODIS)

  Column ozone(From TOMS/OMI)

SBDART……….

- Fluxes at different levels (Surface & TOA)
- Downward, Upward, and Direct Fluxes

$$\text{Forcing} = \left(F\downarrow - F\uparrow\right)_{\text{aerosol}} - \left(F\downarrow - F\uparrow\right)_{\text{clean}}$$

- Heating Rates for different levels
  - From surface to 100km

Aerosol- Shortwave radiative forcing and BC contribution….

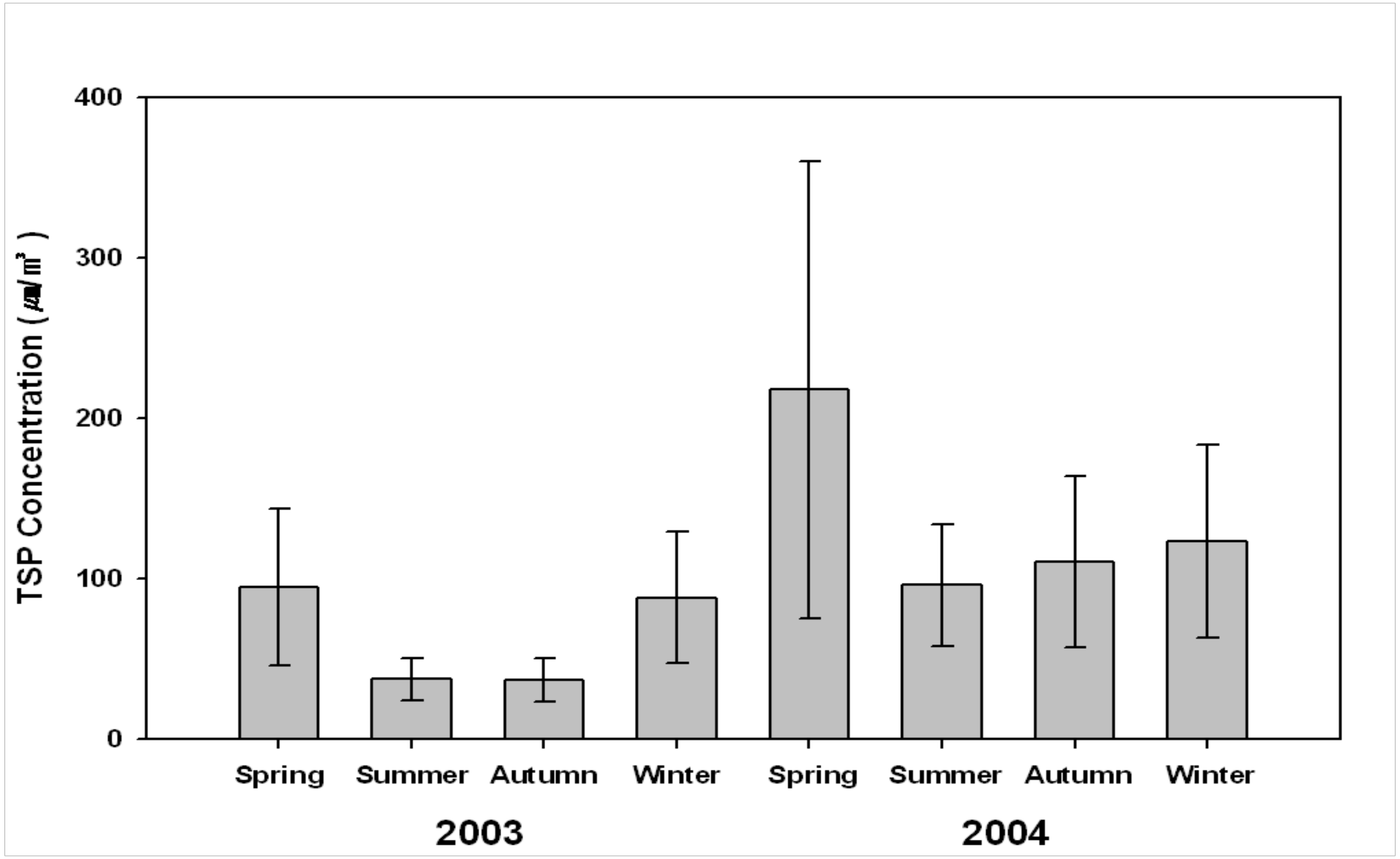
Methodology

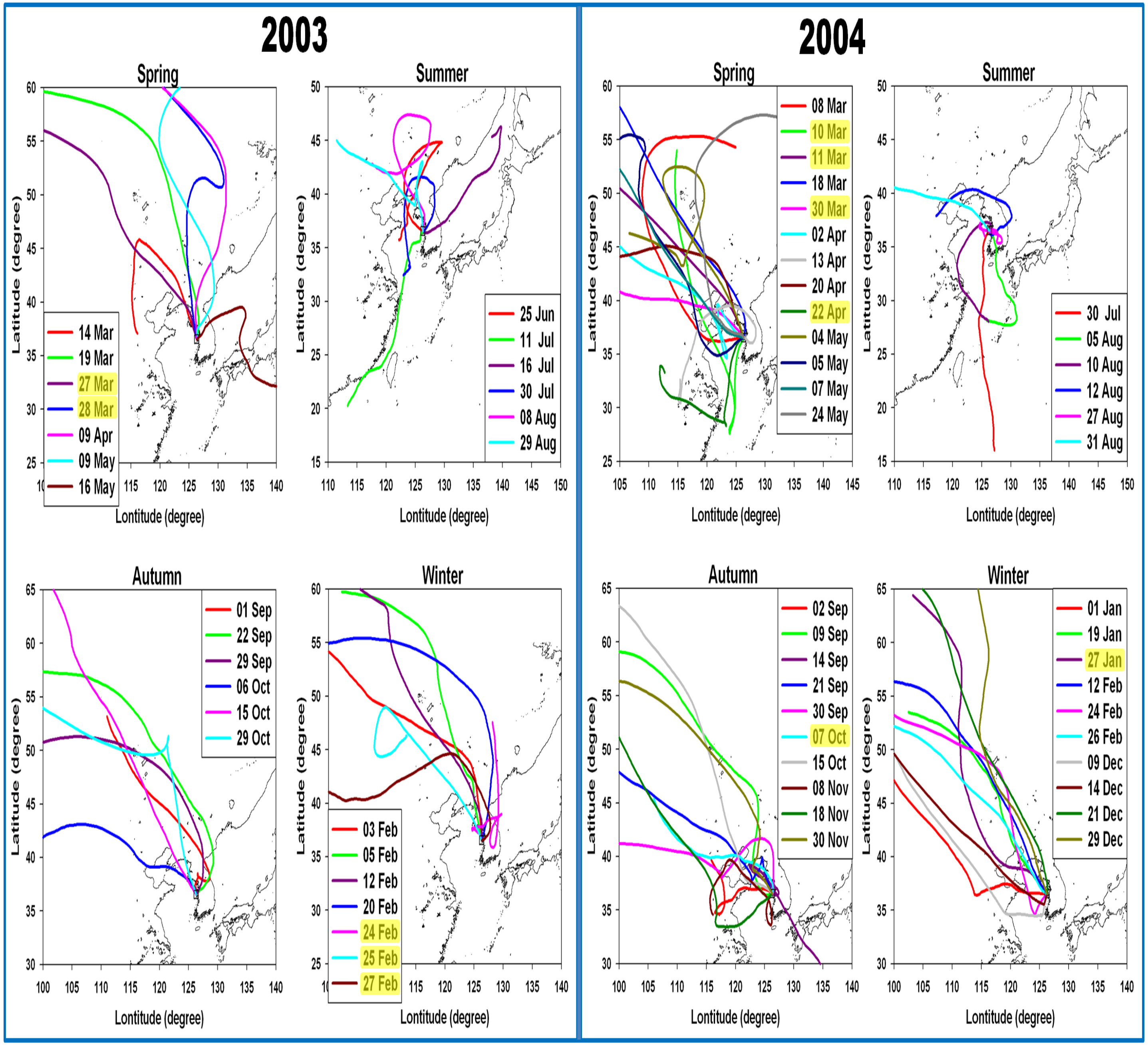
Aerosol Radiative forcing = Fluxes with aerosols- Fluxes with out aerosols

- ❖ **Aerosol Short wave radiative forcing estimation for composite aerosols**
- ❑ **Water soluble, Acid soluble componets and BC data as inputs in OPAC**
- ❑ **OPAC derived Composite aerosol optical properties: AOD, SSA and ASP from 0.2-4 μm as inputs in SBDART**
- ❑ **Short wave radiative forcing at Surface, TOA and Atmosphere by total aerosol mass**

- ❖ **Aerosol Short wave radiative forcing estimation for Black Carbon (BC) aerosols**
- ❑ **Black carbon data alone as input in OPAC**
- ❑ **OPAC derived BC aerosol AOD, SSA and ASP from 0.2-4 μm as inputs in SBDART**
- ❑ **Short wave radiative forcing at Surface, TOA and Atmosphere byBC aerosols**

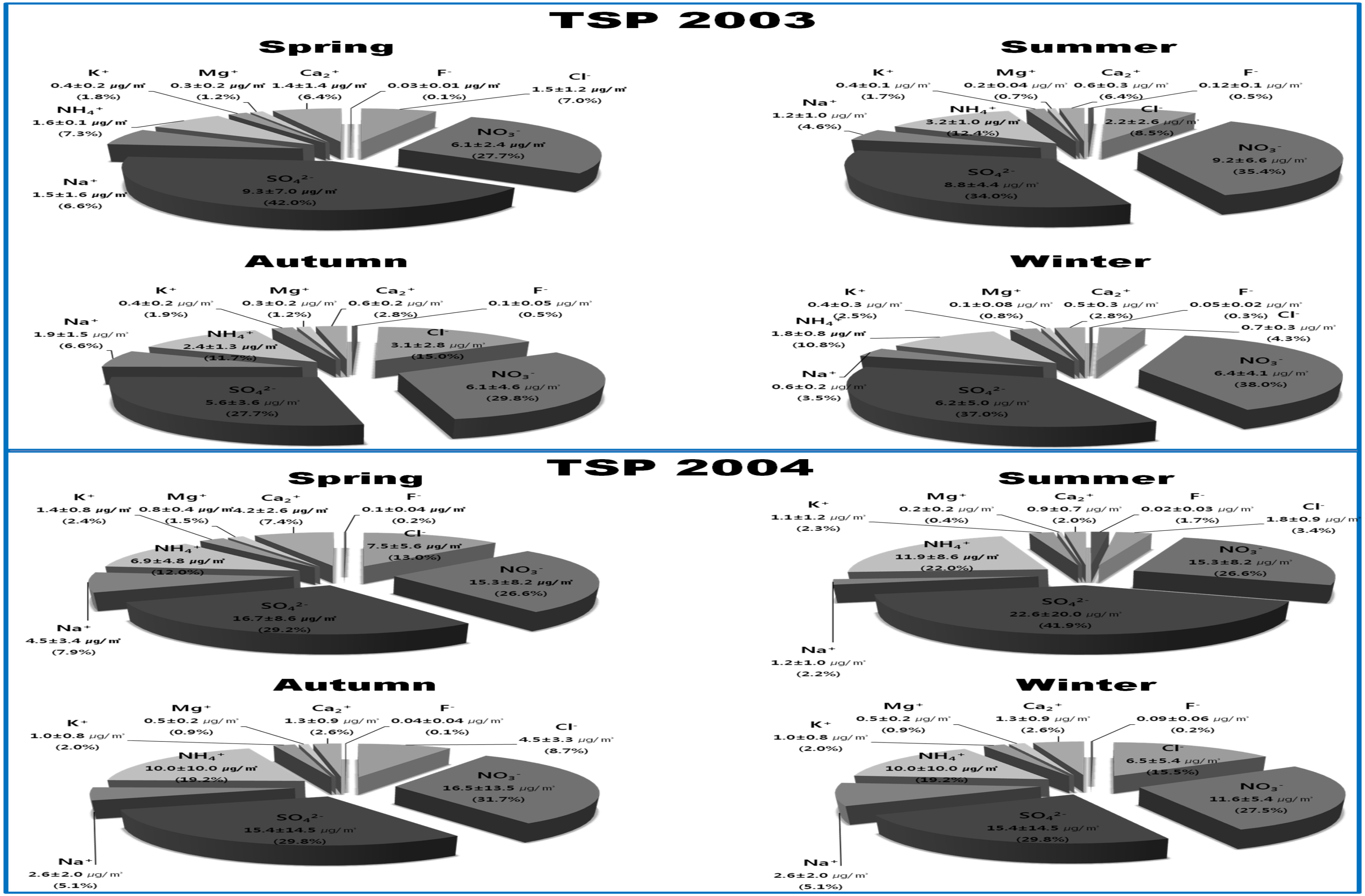
Seasonal variation of TSP Mass





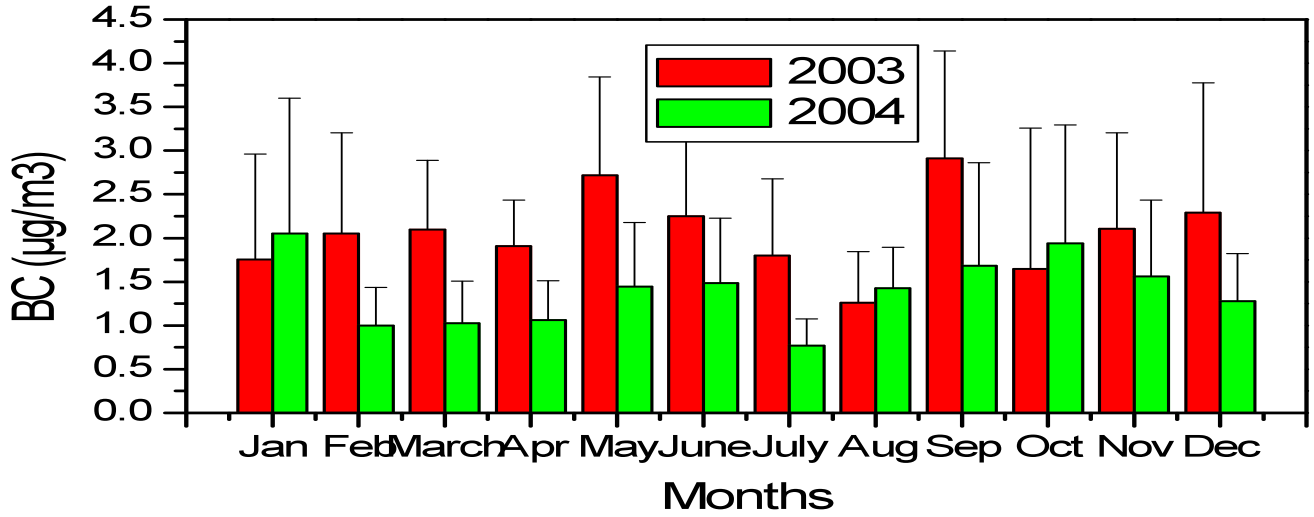
2003
Spring
14 Mar
19 Mar
27 Mar
28 Mar
09 Apr
09 May
16 May
Summer
25 Jun
11 Jul
16 Jul
30 Jul
08 Aug
29 Aug
Autumn
01 Sep
22 Sep
29 Sep
06 Oct
15 Oct
29 Oct
Winter
03 Feb
05 Feb
12 Feb
20 Feb
24 Feb
25 Feb
27 Feb
2004
Spring
08 Mar
10 Mar
11 Mar
18 Mar
30 Mar
02 Apr
13 Apr
20 Apr
22 Apr
04 May
05 May
07 May
24 May
Summer
30 Jul
05 Aug
10 Aug
12 Aug
27 Aug
31 Aug
Autumn
02 Sep
09 Sep
14 Sep
21 Sep
30 Sep
07 Oct
15 Oct
08 Nov
18 Nov
30 Nov
Winter
01 Jan
19 Jan
27 Jan
12 Feb
24 Feb
26 Feb
09 Dec
14 Dec
21 Dec
29 Dec
Latitude (degree)
Lontitude (degree)

Chemical composition of TSP

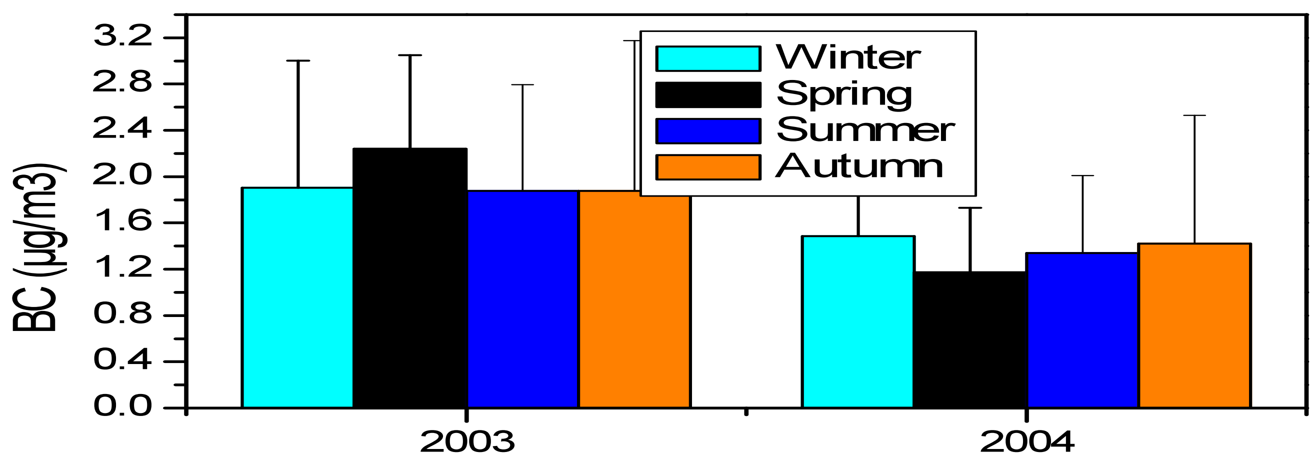


Monthly and Seasonal variation of BC mass

a



b

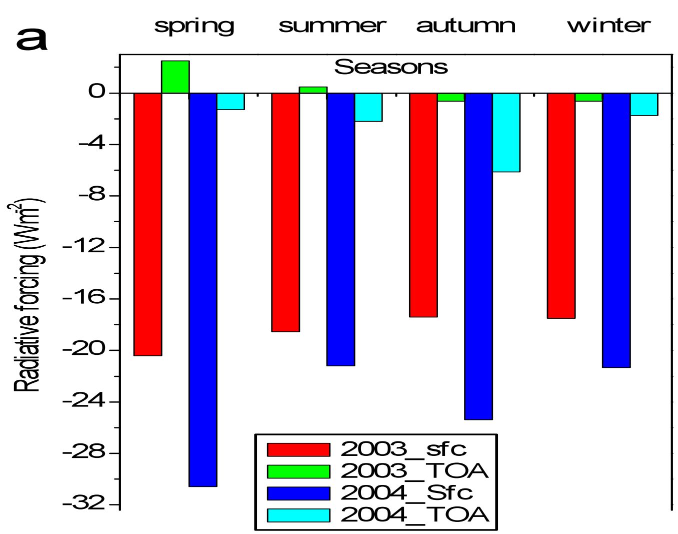


Variation of TSP mass and BC contribution

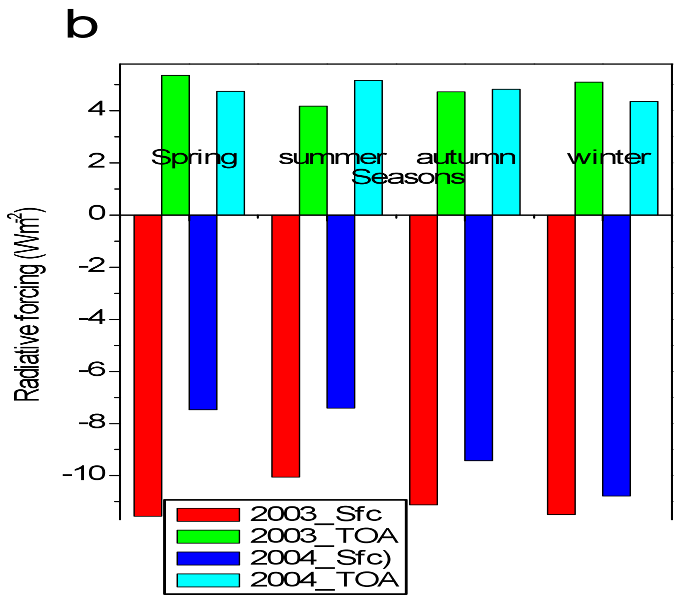
Season	TSP (µg/m^3)	WS(µg/m^3)	BC(µg/m^3)	% of BC mass in TSP
Spring_03	94.47	22.12	2.24	2.37
Summer_03	37.35	25.88	1.77	4.74
Autumn_03	36.71	20.33	1.98	5.39
Winter_03	88.25	16.88	2.03	2.30
Spring_04	217.80	57.38	1.17	0.54
Summer_04	95.89	53.86	1.23	1.28
Autumn_04	110.56	51.84	1.73	1.56
Winter_04	123.10	42.00	1.44	1.17

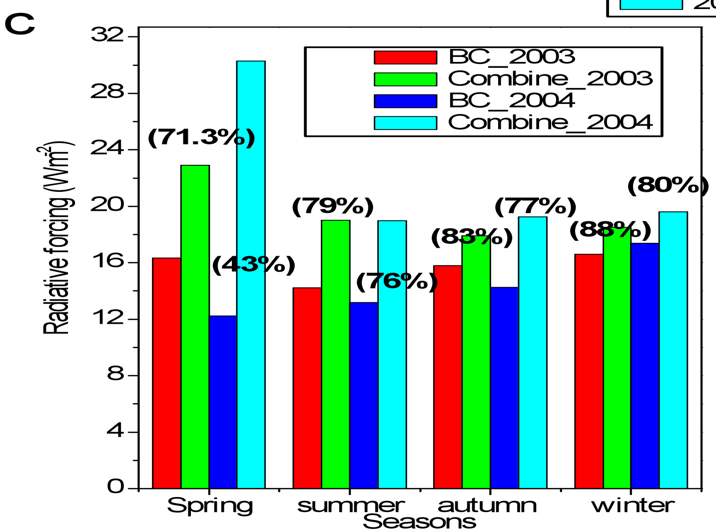
Composite and BC aerosol forcings……..

Composite aerosol forcing



BC aerosol forcing





BC contribution to total aerosol atmospheric aerosol forcing

Summary

- **Black carbon (BC) concentrations and radiative forcing has been estimated over a Korean Global weather watch (GAW) site, Anmyeon during 2003-04 periods.**
- **.BC showed significant monthly and seasonal variations with higher concentrations observed during winter (December-February2) and early spring (March) months. Lower values of BC were observed during summer, especially during July, could be associated with the rain out and washout due to rainfall during monsoon (Changma).**
- **OPAC derived aerosol optical properties for composite aerosols and for BC fraction alone has been incorporated in SBDART to derive composite and BC only aerosol forcing respectively for different seasons**
- **The atmospheric forcing for total aerosol fraction found to be +22.9 to +30.2 Wm^{-2} during spring, +17 to +19 Wm^{-2} in summer, +15.8 to +19.3 Wm^{-2} in autumn and +17.6 to +19.6 Wm^{-2} during winter respectively. The respective BC atmospheric forcing were +12.2 to +16.6 Wm^{-2}, +13 to +14.2 Wm^{-2}, +14.4 to +15.8 Wm^{-2} and +15.4 to +16.6 Wm^{-2} during spring, summer, autumn and winter.**
- **The study suggests that Black carbon induced atmospheric forcing contributes up to 70-88% of total aerosol atmospheric warming, which can alter cloud formation process by inducing lower atmospheric inversions.**

Acknowledgements

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Thank You
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