Impact of transport of sulfur dioxide from the Asian continent on air quality over Korea in May 2005

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Introduction

❖ Anthropogenic emission of atmospheric pollutants in East Asian countries
- Impact on the atmospheric environment on regional and intercontinental scales
- Atmospheric gaseous pollutants (e.g. SO_2) transported from the Asian continent
- Asian dust storms containing a toxic mixture of heavy metals and carcinogens
- Accumulated as the clouds pass over Chinese industrial and metropolitan areas

❖ SO_2 is an important trace species in the atmosphere (Chin and Jacob, 1996)
- Released as a result of anthropogenic and natural phenomena
- Damage to ecosystems and related formation of sulfate aerosols
  → human respiratory morbidity and mortality
- Most of lower stratospheric sulfate aerosol is of anthropogenic origin
  → a cooling effect on the Earth's surface (Myhare et al., 2004)

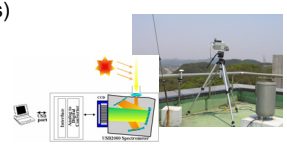
❖ Processes of transport and the regional budget of anthropogenic nitrogen and sulfur compounds over the East Asia region have been investigated using model simulation and aircraft measurement (e.g. Koike et al., 2003)

❖ **Science questions for this study:**
- What is the extent of long-range transport of anthropogenic trace gases (e.g. SO_2) from Asia continent?
- What is the impact of these atmospheric trace gases on local air quality over Korea?

Data set

❖ **In-situ air-quality monitoring** data
- NO_x (ML9841A, Teledyne Instruments), SO_2 (ML9850, Teledyne Ins.), CO (ML9830, Teledyne Ins.), O_3 (ML9812, Teledyne Ins.), PM10 (β-ray PM10, FH62C14, Thermo Anderson)
- Obtained at the Korea Global Atmosphere Watch Observatory (KGAWO) (36.7° N, 127.5° E) from 20 May to 9 June 2005

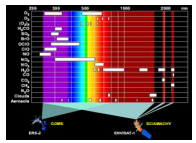
❖ Ground-based **MAX-DOAS** data
- Multi-AXis Differential Optical Absorption Spectrometer system:
  USB2000 spectrograph (OceanOptics)
  Czerny-Turner type 1/f=4
  2400 gr/mm grating,
  CCD detector (2048 pixels),
  spectral coverage 289 - 431 nm
  0.7 nm FWHM



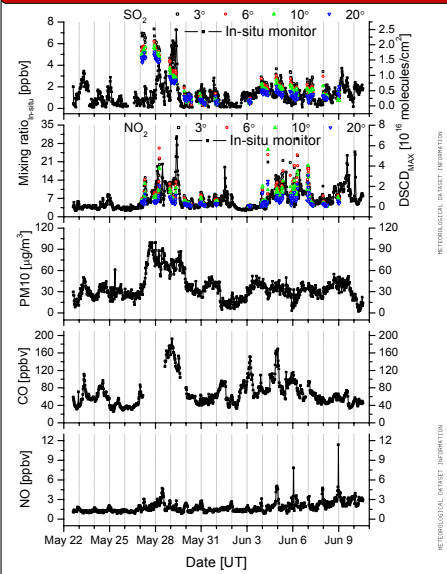
- Sequential measurement of scattered sunlight at KGAWO at elevation angles of 3°, 6°, 10°, 20°, & 90° from 27 May to 9 June 2005
- Differential Slant Column Densities (DSCD) of SO_2 and NO_2 were retrieved in spectral range of 303.5 – 316 and 399 – 418 nm, using the DOAS method

❖ Meteorological data
- Using FNL data (ftp://www.arl.noaa.gov/pub/archives/fnl)
- **Synoptic conditions** (mean sea-level pressure charts with wind vector at 850 hPa)
- **Air-mass backward trajectories** using HYSPLIT-4 model (http://www.arl.noaa.gov/ready/hysplit4.html)

❖ Satellite instrument **SCIAMACHY** data
(SCanning Imaging Absorption Spectrometer for Atmospheric CHartographY)
- Eight channel spectrometer (240 – 2400 nm) onboard ENVISAT satellite launched in a sun-synchronous orbit in 2002
- Several atmospheric trace gases can be retrieved, e.g. O_3, NO_2, SO_2, BrO, OClO, HCHO, CHOCHO, and H_2O
- Spectral resolution of 0.25 nm in the UV
- Typical ground pixel size: 30×60 km²
- Tropospheric SO_2 columns were retrieved in the wavelength range of 315 – 327 nm, using the DOAS method and reference sector method (Afe et al., 2004)

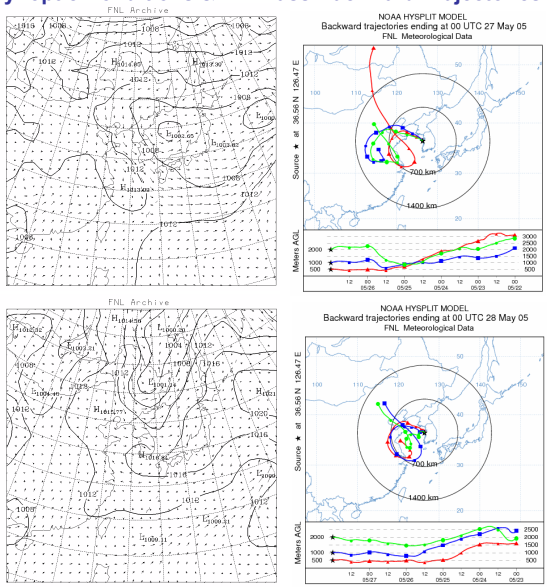


Results and Discussion

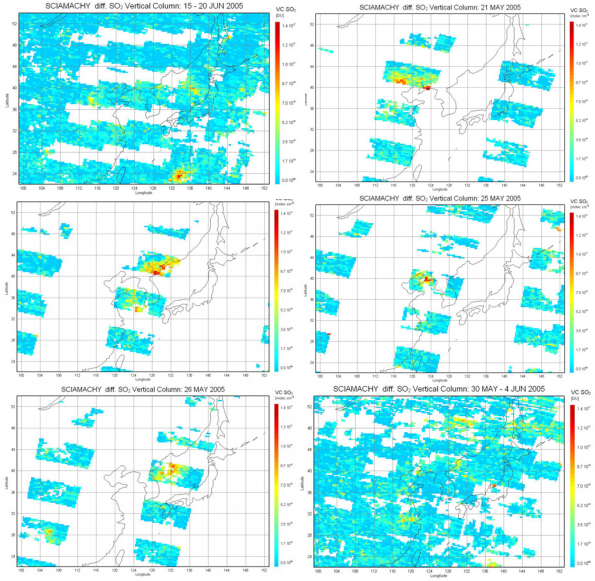


DSCD of SO_2 & NO_2 by the MAX-DOAS system
SO_2, NO_2, PM10, CO, & NO by in-situ monitors at KGAWO

Synoptic Conditions & Air-mass Backward Trajectories



Satellite Images from SCIAMACHY



❖ Ground-based measurements
- Relatively high SO_2 and NO_2 levels were observed in the period: 27-29 May 2005
- SO_2 surface levels of up to 7.6 ppbv by an in-situ monitor
- The air-mass transported from the Asian continent could be in the upper part of the boundary layer over the KGAWO site, and might be spread horizontally and vertically and towards the ground

❖ Meteorological data
- The time series of mean sea-level pressure indicate that the continental high pressure system was located over Northeastern China
- Backward trajectories show that air-masses picking up high SO_2 plumes while passing over the Chinese and metropolitan areas were transported to the Korean peninsula

❖ Satellite images
- High SO_2 values were observed over Chinese industrial areas during the period of 21-25 May and over West Sea during the period of 22 to 26 May 2005
- The tropospheric SO_2 VCDs over Northeastern Chinese industrial and metropolitan areas ranged up to 1.4×10^{17} molec/cm²

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Selected References

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