Effects of Siberian forest fires on regional air quality and meteorology in May 2003

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MAY 2003 SIBERIAN FOREST FIRES

MODIS fire observations

MODIS/Terra AOD\textsubscript{fine} May 2003

ADEOS-2 satellite image for May 22, 2003

KOREA

JAPAN

Smoke from Siberian fires

[Generoso et al., 2007]

[Lee et al., 2005]

[Siberian Forest Fire Emissions (Tg C mon\textsuperscript{-1})]

factor of 3-10 higher than others

[Siglio et al., 2006]
OBJECTIVE AND METHODS

• Quantify the effect of the Siberian forest fires on regional air quality over East Asia in May 2003.

• Examine the impact of Siberian fire aerosols on regional meteorology over East Asia

GEOS-Chem Global 3-D Chemical-Transport Model
- spatial resolution of 2°x2.5°, 30 vertical levels
- driven by assimilated GEOS-4 meteorological fields
- biomass burning emissions for 2003: Global Fire Emissions Database version 2 (GFED2) based on satellite derived monthly burned areas

Community Climate System Model version 3.0 (CCSM3), NCAR coupled global climate model
- Include atmosphere, ocean, vegetation, sea ice
- Spatial resolution of 2°x2.5°
- Use GEOS-Chem aerosols in CCSM3 simulations
COMPARISON OF SIMULATED VS. OBSERVED DAILY MEAN PM$_{2.5}$ CONCENTRATIONS AT RISHIRI SITE

Fire aerosols increased hourly mean surface PM$_{2.5}$ concentrations up to 108 $\mu$g m$^{-3}$ at the Rishiri site.
COMPARISONS OF OBSERVED AND SIMULATED MONT HLY MEAN VALUES IN MAY 2003

(a) PM$_{10}$ concentration

R$_2$ = 0.60

(b) AOD

MODIS AOD
GEOS–Chem AOD

R$_2$ = 0.84
MONTHLY MEAN AOD (550 nm) for 2000-2005

Northwestern Pacific

East Asian Continent ♫
ENHANCEMENTS IN MONTHLY MEAN SURFACE PM$_{10}$, O$_3$ CONCENTRATIONS AND RESULTING RADIATIVE FORCING

$\Delta$ PM$_{10}$  (7 µg m$^{-3}$)

5-30 µg m$^{-3}$

$\Delta$ O$_3$  (8 ppbv)

6-20 ppbv

At the surface  -37.5 – 0.0 (-5.8)

At TOA         -9.3 – 0.0 (-1.5)

RADIATIVE
FORCING

W m$^{-2}$
Effects of Siberian forest fires on meteorology over East Asia in May 2003: CCSM3 vs. NCEP reanalysis II

Δ Surface Air Temp  Δ Surface Pressure  Δ Precipitable water

NCEP R-II anomaly for May 2003 (2003 - climatology)

CCSM3 differences (fire-nofire)

Statistically 99% significant anomaly data in May 2003

K  hPa  kg m\(^{-2}\)
CONCLUSIONS

- The peak increase in monthly mean aerosol concentrations in surface air from the Siberian forest fires was up to 100 µg/m\(^3\) over Siberia in May 2003.
- In the downwind regions of East Asia, the increases ranged from 5 to 50 µg/m\(^3\).
- Resulting shortwave radiative forcing of fire aerosols averaged over the East Asia was -5.8 W m\(^{-2}\) at the surface and -1.5 W m\(^{-2}\) at the TOA, indicating a considerable solar absorption in the atmosphere.
- CCSM3 simulations showed significant changes in meteorological variables over East Asia caused by aerosols from the Siberian forest fires.
- Simulated changes including increases in cloud and precipitations over the NW pacific were consistent with the NCEP reanalysis II anomaly data for May 2003, indicating an important role of fire aerosols for regional climate.
- The changes in meteorological variables due to fires have an effect on regional air quality by changing ozone and aerosol concentrations, implying an interaction between regional climate and regional air quality over East Asia which needs to be further investigated.