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BEng (Geomatics Engineering), Wuhan University, 2011
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DEPARTMENT OF PHYSICS AND ATMOSPHERIC SCIENCE

TITLE OF THESIS:	TRENDS AND SOURCES OF ATMOSPHERIC AEROSOLS INFERRED FROM SURFACE OBSERVATIONS, SATELLITE REMOTE SENSING AND CHEMICAL TRANSPORT MODELING
TIME/DATE:	9:00 am, Friday, November 9, 2018
PLACE:	Room 3107, The Mona Campbell Building, 1459 LeMarchant Street

EXAMINING COMMITTEE:

Dr. Jennifer Hand, Cooperative Institute for Research in the Atmosphere, Colorado State University (External Examiner)

Dr. Rachel Chang, Department of Physics and Atmospheric Science, Dalhousie University (Reader)

Dr. Glen Lesins, Department of Physics and Atmospheric Science, Dalhousie University (Reader)

Dr. Randall Martin, Department of Physics and Atmospheric Science, Dalhousie University (Supervisor)

DEPARTMENTAL REPRESENTATIVE:	Dr. Jim Drummond, Department of Physics and Atmospheric Science, Dalhousie University
CHAIR:	Dr. William Currie, PhD Defence Panel, Faculty of Graduate Studies

ABSTRACT

Improving the understanding of sources and processes driving the variation of atmospheric aerosols is critical for quantifying their air quality and climate implications and for formulating regulatory policies. This thesis presents four projects that exploit multiple observation data and modeling tools to quantify and interpret aerosol trends and sources.

Global visibility records are filtered and processed to assess historical trends in atmospheric haze. Spatially coherent trends in the screened inverse visibility (1/Vis) are consistent with trends in collocated aerosol measurements over the US and Europe. Trend transitions of 1/Vis in the eastern US, Europe and eastern Asia are significantly associated ($r \sim 0.7$-0.9) with the variation of sulfur dioxide emissions, reflecting historical socioeconomic events and environmental regulation activities.

The 1/Vis dataset over the eastern US reveals significant changes in the dominant aerosol seasonality from winter maxima to summer maxima over 1946-1975. By interpreting seasonal contrasts in 1/Vis trends with a historical emission inventory of aerosol sources, we attribute these changes to increasing sulfate and decreasing primary carbonaceous aerosols. Summer 1/Vis increases faster over the southeastern US than over the northeast during 1956-1975, suggesting concurrent increase in secondary organic aerosols.

A simulation with the GEOS-Chem chemical transport model downscaled with satellite-derived $PM_{2.5}$ identifies a significant increase (0.28 $\mu g\ m^{-3}yr^{-1}$, $p < 0.05$) in global population-weighted $PM_{2.5}$ concentration over 1989-2013, driven by increasing organic aerosols (0.10 $\mu g\ m^{-3}yr^{-1}$), nitrate (0.05 $\mu g\ m^{-3}yr^{-1}$), sulfate (0.04 $\mu g\ m^{-3}yr^{-1}$) and ammonium (0.03 $\mu g\ m^{-3}yr^{-1}$). These four components predominantly drive trends in population-weighted mean $PM_{2.5}$ over populous regions of South Asia (0.94 $\mu g\ m^{-3}yr^{-1}$), East Asia (0.66 $\mu g\ m^{-3}yr^{-1}$), Western Europe (-0.47 $\mu g\ m^{-3}yr^{-1}$) and North America (-0.32 $\mu g\ m^{-3}yr^{-1}$). Trends in area-weighted mean and population-weighted mean $PM_{2.5}$ composition differ significantly.

Two inversion methods are tested for ammonia emission estimates using the GEOS-Chem model and its adjoint at coarse ($2^\circ \times 2.5^\circ$) and fine ($0.25^\circ \times 0.3125^\circ$) resolutions. Comparing to four-dimensional variational assimilation, the iterative finite difference mass balance approach requires fewer iterations to yield smaller errors in the top-down inventories at coarse resolution, while consistently shows larger errors at fine resolution.