DEPARTMENT OF PHYSICS & ATMOSPHERIC SCIENCE

TITLE OF THESIS: INSIGHT INTO GLOBAL GROUND-LEVEL AIR QUALITY USING SATELLITES, MODELING AND IN SITU MEASUREMENTS

TIME/DATE: Monday, October 26th at 3:00pm

PLACE: Room 3107, The Mona Campbell Building, 1459 LeMarchant Street

EXAMINING COMMITTEE:
Dr. Norman O’Neil, Department of Applied Geomatics, Université de Sherbrooke (External Examiner)
Dr. Rachel Y.-W. Chang, Department of Physics & Atmospheric Science, Dalhousie University (Reader)
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ABSTRACT

Ground-level air quality depends on the ambient concentration of atmospheric aerosols and trace gases. We applied information on aerosols and trace gases gathered from satellite remote sensing, in situ observations, and atmospheric chemistry modelling to improve estimates of air quality. We inferred fine particulate matter (PM$_{2.5}$) chemical composition at 0.1° x 0.1° spatial resolution for 2004-2008 by combining aerosol optical depth retrieved from the MODIS and MISR satellite instruments, with coincident profile and composition information from the GEOS-Chem global chemical transport model. Evaluation of the satellite-model PM$_{2.5}$ composition dataset with North American in situ measurements indicated significant spatial agreement. We found that global population-weighted PM$_{2.5}$ concentrations were dominated by particulate organic mass (11.9 ± 7.3 μg/m$^3$), secondary inorganic aerosol (11.1 ± 5.0 μg/m$^3$), and mineral dust (11.1 ± 7.9 μg/m$^3$). Secondary inorganic PM$_{2.5}$ concentrations exceeded 30 μg/m$^3$ over East China. Sensitivity simulations suggested that population-weighted ambient PM$_{2.5}$ from biofuel burning (11 μg/m$^3$) could be almost as large as from fossil fuel combustion sources (17 μg/m$^3$).

We developed a simple method to derive an estimate of the spatially and seasonally resolved global, lower tropospheric, ratio between organic mass (OM) and organic carbon (OC) from the primary organic aerosol fraction measurements of the Aerosol Mass Spectrometer, and the ground-level NO$_2$ concentrations derived from the OMI satellite instrument. The global OM/OC ratio ranged from 1.3 to 2.1 μg/μgC, with distinct spatial variation between urban and rural regions. The seasonal OM/OC ratio had a summer maximum and a winter minimum over regions dominated by combustion emissions.

We assessed the sensitivity of chemical transport models to the duration of the chemical and transport operators used to calculate the mass continuity equation. Increasing the transport timestep increased the concentrations of emitted species, and the production of ozone. Increasing the chemical timestep decreased sulfate and ammonium but increased nitrate. The simulation duration decreased by an order of magnitude from fine (5 min) to coarse (60 min) timesteps, while simulation error increased by more than a factor of 5. We recommend choosing the finest possible spatial resolution before considering different temporal resolutions.