Canopy Modeling of Emissions and Chemistry in a Forest Environment

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Objective

Forest canopies are large sources for biogenic organic compounds (BVOCs), which are highly reactive in the atmosphere and contribute to ozone and secondary organic aerosol (SOA) formation. Fast chemical and aerosol processes occurring within the canopy are poorly understood, limiting our ability to understand the impact of forest canopies on air quality and climate change at regional and global scales.

A major objective of the CABINEX (Community Atmosphere-Biosphere INteractions EXperiment) project is to study BVOC photochemistry within a forest and investigate how it impacts the formation and transport of ozone and SOA precursors out of the forest canopy into the ambient air. A field intensive was carried out during the summer of 2009 at the University of Michigan Biological Station as part of a an integrated field measurement and modeling strategy to determine the most important canopy-scale processes that potentially impact photochemistry and aerosol processes at regional and global scales.

This project will use modeling studies to complement the measurements conducted during the summer of 2009. Due to the complexities of forest canopy structure and the fast reaction times of many BVOCs, global or regional scale modeling studies currently cannot capture the detailed physical and chemical processes within a forest canopy. Therefore, a one-dimensional canopy model is utilized. The study is carried out using the coupled multilayer canopy-chemistry model CACHE (Forkel et al., 2006). The CACHE model was specifically developed for forest canopies and BVOC chemistry using the RACM chemical mechanism (Stockwell et al., 1997). This model allows for the investigation of the roles of turbulent exchange, chemical processes, emissions, and depositions on fluxes of ozone and SOA precursors out of the canopy into the atmosphere.

Preliminary Training

This project will involve the use of the CACHE model, which is written in Fortran, in a Linux environment. Data meteorological and chemical data from the CABINEX field project will need to be re-formatted for input into the CACHE model. All REU students will receive some exposure to modeling in the Linux environment; more training will be provided as needed to perform this project. Software such as Igor, Matlab, or Excel will be used to analyze and plot model results. Igor and Matlab are more powerful than Excel, but involve a steeper learning curve. The student will be introduced to all three tools, but will be able to choose which software to use.

Project Tasks

1. Perform a base case simulation for CABINEX using CACHE "out-of-the box" and using observed meteorological conditions.
2. Evaluate model-predicted gas-phase concentrations for the base case simulation using data taken during CABINEX.
3. Analyze the relative contribution of emissions, chemical reactions, turbulence exchange, and deposition within the canopy on sources and sinks of ozone and SOA precursors in the atmosphere.

4. Investigate the adequacy of the BVOC emissions model in CACHE and the RACM chemical mechanism on modeling fast chemistry in the canopy. This will require modifying the CACHE model to perform sensitivity simulations.
5. If time permits, investigate the formation of SOA of within the canopy.
6. The student will prepare a poster for the end-of-summer symposium.

References

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