GLOBal Organic Emissions NETwork (GLOBOENET): Observations for evaluating global biogenic VOC emission models

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Observations are needed to parameterize and evaluate Biogenic VOC emission models.

BVOC emissions have been measured at sites around the world but few are suitable for evaluating models.
Bottom-up, Top-down and Direct approaches for characterizing biogenic VOC emissions

Direct measurements are needed to evaluate these model estimates

Bottom-up: Use enclosure measurements to provide emission factors/algorithms for forward model

Top-down approach: Start with ambient concentrations and use inverse model to account for chemistry and transport

Landcover mapping from space

BVOC Emission Estimates

HCHO mapping from space
Eddy covariance and REA methods for measuring whole canopy VOC fluxes were first used in mid 1990s but there are few observations available for model evaluation.
Direct measurements of BVOC fluxes

Eddy covariance and relaxed eddy accumulation (REA) both have advantages (and disadvantages)

Eddy covariance (PTRMS or FIS)
- Direct measurement with no assumptions
- Continuous measurements
- Terpenoids, light oxyVOC, others

Relaxed Eddy Accumulation (GC-MS/FID)
- Low cost, low power, portable, robust
- Requires no special training
- Speciated terpenoids, alkanes, others
Can we use REA?

REA cost is orders of magnitude lower but we need to demonstrate that it can provide the measurements we need.

- Accuracy/precision
- Ability of periodic measurements to characterize seasonal variations

We can determine this by comparison with PTRMS eddy covariance measurements.
Long-term measurements at Manitou Forest Observatory
Ponderosa pine woodland in the Colorado Rockies

Chemistry
- 28-m walk-up tower
- Fluxes: VOC, NO/NOy, ozone, particles
- Conc.: sulfuric acid, OH, OH reactivity, particle formation/growth, CCN, aerosol composition, SO2, CO

Soil
- enclosure CO2, H2O, VOC, NO flux
- soil moisture and characteristics

Micrometeorology
- 45-m walk-up tower with 5 flux levels with CO2, H2O, temperature, turbulence (8 more towers are proposed)
- k-band radar

Vegetation
- branch/leaf enclosure CO2, H2O, VOC flux
- sap flow, 3D canopy description
Summer 2009 REA evaluation at Manitou Forest: Preliminary results

Accuracy and precision

Individual REA measurements can differ from PTRMS-EC values by more than 50% but the average of 3 replicate REA measurements are typically within 15% of the PTRMS-EC values.
Summer 2009 REA evaluation at Manitou Forest: Preliminary results

Continuous vs periodic sampling

![Graph showing MBO Flux (mg m^-2 h^-1) vs Day of Year for MBO daily and MBO weekly sampling with polynomial fits.](image-url)
GLObal Biogenic Organic Emissions NETwork (GLOBOENET)

# of REA Sites
- 2007 (1)
- 2009 (5)
- 2010 (12)
- 2011??

Manitou Forest Observatory, CO: Evaluate REA by comparison to long-term PTRMS eddy fluxes

Building on:
- existing flux tower networks
- development of reliable and inexpensive, low power Relaxed Eddy Accumulators

Niwot Ridge Colorado: MBO

French Guiana: isoprene

Arizona: aromatics, organic acids, alkanes

New Mexico: \( \alpha \)-pinene
Monoterpene emissions increased by factor of 10 after a hail storm.

Initial GLOBOENET site: Niwot Ridge Colorado

6/11/07

7/5/07

Photosynthesis Begins

New Growth

Monoterpene emissions increased by factor of 10 after a hail storm

Date

Turnipseed et al.
New Mexico USA: Pinyon pine - juniper woodland

REA measurements started in June 2009

Daytime terpenoid flux of ~0.6 mg m\(^{-2}\) h\(^{-1}\) is mostly \(\alpha\)-pinene
Arizona USA: Santa Rita creosote shrubland

REA measurements start in August 2009

see oral presentation by K. Jardine
French Guiana: Paracou tropical rainforest

Measurements start on October 20, 2009
How many sites do we need?

- **Niwot Ridge Colorado:** MBO
- **Manitou Forest Observatory, CO:** Evaluate REA by comparison to long-term PTRMS eddy fluxes
- **French Guiana:** isoprene
- **New Mexico:** α-pinene
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Building on:
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**How many sites do we need?**

<table>
<thead>
<tr>
<th>Source Density:</th>
<th>Emission Factor:</th>
<th>Emission Activity:</th>
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<tbody>
<tr>
<td>amount of vegetation foliage and other sources</td>
<td>ability to emit-controlled by genetics</td>
<td>deviations controlled by environment and phenology</td>
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There may be much more variability here- with differences among hundreds of different ecoregions. A complementary strategy may be needed for this.

This may be fairly consistent- at least within the major biomes. An REA network of ~20 sites may be sufficient.
Regional airborne VOC emission measurements using PTRMS eddy covariance

U. Wyoming King Air: Colorado Pine Beetle outbreaks

NCAR C130 Technique Development

CIRPAS Twin Otter: California BVOC emissions inventory evaluation
Summary

Observations for evaluating (and improving) global biogenic VOC emissions
• weekly triplicate REA measurements at existing flux towers
• Airborne PTRMS eddy flux measurements characterizing major landscapes in key regions

GLOBOENET could be proposed as a GEIA – iLEAPS activity. Observations will be available to the scientific community.
Summary

What about other compounds and sources?

Direct flux measurement techniques can be used to evaluate emissions of other constituents (e.g., NO, CO, particles) and sources (e.g., anthropogenic area sources).
Any Questions?

Manitou Forest Observatory
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