The Effect of Oceanic Isoprene Emissions on Secondary Organic Aerosol Formation in the Coastal United States

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**Introduction:**

Isoprene (C5H8) is the most ubiquitous biogenic volatile organic carbon (BVOC) with annual global emissions estimated to be 500 to 750 Tg of carbon (Guenther et al., 2006). Isoprene can be oxidized by several reagents including hydroxyl radical (OH), to form secondary organic aerosols (SOA) (Claeys et al., 2004) with a dry yield of approximately 3% (Kroll et al., 2006) and an aqueous yield of up to 42% (Evans et al., 2008).

Marine isoprene emissions have been observed over productive areas of the world's oceans with high chlorophyll-a concentrations ([Chl]a). Isoprene production has been shown to be sensitive to light (Sinha et al., 2007) and species of phytoplankton present (Shaw et al., 2003). Today regional and global contributions of marine isoprene to SOA remain poorly defined.

In this study, we carry out laboratory and model simulations to determine the contribution of marine isoprene emissions to SOA concentrations in the coastal regions of the United States. The importance of productive coastal waters on trace gas emissions extends well beyond the regional scale. A study of halocarbons has shown that while coastal and coastal influenced waters make up only 10% of the ocean surface area, make up an estimated 83% of the global flux (Butler et al., 2007).

**Laboratory Measurements:**

Using a novel approach, we exposed several phytoplankton to various levels of light intensity to assess the effect of changing incoming solar radiation for isoprene production. Using Headspace Gas Chromatography (HS-GC), we measured the isoprene concentrations and converted into isoprene production.

**Model Setup:**

All simulations performed using the Community Multi-scale Air Quality (CMAQ) model and the following configuration (Zhang et al., 2007):

- Time Period: July 2001
- Domain: Continental US
- Spatial Resolution: 36 x 36 km²
- Meteorology: Mesoscale Modeling System Generation 5 (MMS) v. 3.6.1
- Emissions: 2001 National Emissions Inventory (NEI) processed with Sparse Matrix Operator Kernel Emissions (SMOKE) v. 1.4

Simulations:

1. Control with no marine isoprene emissions
2. Control plus simulated marine isoprene emissions
3. Control plus 5x simulated marine-source isoprene emissions (to account for inter-annual changes in [Chl]a)

**Results:**

Marine Isoprene Emissions:

**Formulas**

\[ P_i = 0.002l_i - 0.3 \]

\[ E_{	ext{monthly}} = 0.00036 \times [\text{Chl}]_a \times \sum P_i \times D_i \]

**Diurnal Cycle:**

Three productive regions chosen for diurnal analysis:

1. Washington Coast
2. Louisiana Coast
3. Mid-Atlantic Coast

**Spatial Distribution:**

**Emission Inputs:**

Monthly Average Surface Source Isoprene Concentrations from Marine-Source isoprene at 18UTM for July 2001

**Monthly Average Surface Source Isoprene Concentrations from Marine-Source isoprene at 18UTM for July 2001**

**References:**


Bond et al., 2004, A model and the following configuration (Zhang et al., 2007):

**Acknowledgements:**

This research was supported by the Office of Science (BER), U.S. Department of Energy, Grant No. DE-FG02-02ER64508. The SMOKE-CMAQ simulation without marine isoprene emissions was conducted with support from NASA Award No. NNG04GJ90G and NSF Career Award No. ATM-0458810. Thanks are due to Warren Peters, the U.S. EPA/OAQS, and George Pouliot, Ken Schere, and Tom Pierce, the U.S. NOAA/NEA, for providing CMAQ inputs.

**Future work:**

- Improve emission estimates with phytoplankton speciation and higher spatial resolution (1x1 km²) to capture locally high phytoplankton populations such as those in estuaries.
- Examine the effect of SOA from marine-source isoprene emissions on cloud microphysical and radiative properties.

**Conclusions:**

- The model reproduces diurnal changes in isoprene emissions were captured by the model.
- Isoprene and SOA concentrations from marine emissions of isoprene are low with levels ~5 ppb and ~50 ng/m³, respectively.
- Percent changes in SOA concentrations were low over most terrestrial areas, with modest increases of up to 5% over the coastal regions.
- Very low percent changes in O3 concentrations occurred over terrestrial areas, with the largest increases of ~0.2% occurring over urban coastal regions.
- Despite identical marine isoprene emissions, the changes in SOA and ozone concentrations were different spatially.