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Estimating Biogenic NMVOCs Emissions in Europe

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INTRODUCTION

A vast variety and significant quantities of non methane volatile organic compounds (NMVOCs) are produced and emitted into the atmosphere by vegetation. Biogenic NMVOCs play key roles in determining the tropospheric chemistry, the global carbon budget and global climate.

The purpose of this study is the compilation of a biogenic NMVOCs emissions inventory for Europe, having high spatial and temporal resolution, with the use of remote sensing land use data.

METHODOLOGY

Biogenic NMVOCs emissions are grouped into three categories:

- Isoprene (C_5H_8)
- Monoterpenes ($C_{10}H_x$) and
- Other VOCs ($C_xH_yO_z$).

For all types of vegetation, an appropriate model describing the emissions flux on an hourly basis is that of Guenther et al., 1993:

$$\text{Flux } (\mu\text{gr-C m}^{-2}\text{ h}^{-1}) = \varepsilon * D * \gamma$$

where ε is the emission potential (μgr-C gr dry weight foliage^{-1} h^{-1}) for any particular species, D is the foliar biomass density (gr dry weight foliage m^{-2}), and γ is a unit less environmental correction factor representing the effects of short-term temperature and solar radiation changes on emissions.

DESCRIPTION OF THE COMPUTATIONAL SYSTEM

A Geographic Information System was used in order the typical diurnal variation of biogenic NMVOCs emissions to be calculated for every month of a year with a spatial resolution of 1 km. Presented results refer to biogenic emissions calculated for a winter month (January) and a summer month (July).

LAND USE

The source of the land use information was the Global Land Cover Characteristics database (version 2) compiled from 1-km AVHRR satellite data and distributed by U.S. Geological Survey. The land use classes emitting biogenic NMVOCs are characterized by:

- one vegetation species (e.g. pine) or
- one ecosystem type (e.g. deciduous broadleaf forest) or
- a combination of vegetation species and/or ecosystem types.

EMISSION POTENTIALS AND FOLIAR BIOMASS DENSITIES

Accounting for the seasonal variation of foliar biomass densities of vegetation species and/or ecosystem types, emission potentials and foliar biomass densities were assigned for every month of a year to each land use class emitting biogenic NMVOCs The main references used were the EMEP/CORINAIR emission inventory guidebook and the research study of Guenther et al., 1995. All vegetation species and ecosystems were assigned an OVOCs emission potential of 1.5 μgr-C gr^{-1} h^{-1} (Guenther et al., 1994). The light dependency of monoterpenes emissions from some vegetation species (e.g. evergreen oaks) was accounted for.

TEMPERATURE AND PHOTOSYNTHETICALLY ACTIVE RADIATION

The IPCC Data Distribution Center provided mean monthly climatic data of maximum and minimum temperature values for the 1961-1990 period with 0.5º latitude by 0.5º longitude spatial resolution (CRU Global Climate Dataset).

The Tropospheric Ultraviolet and Visible radiation model was implemented and the typical diurnal variation of the Photosynthetically Active Radiation (PAR) was calculated for the months of January and July with 25 km spatial resolution.

Acknowledgements

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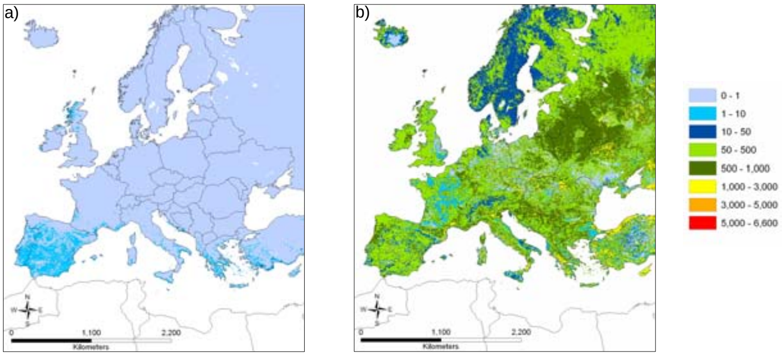

Figure 1. Spatial distribution of isoprene emissions (kgr-C km^{-2} month^{-1}) for a) January and b) July.

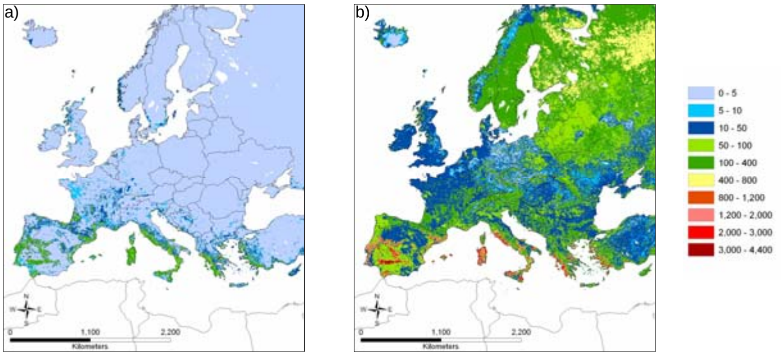

Figure 2. Spatial distribution of monoterpenes emissions (kgr-C km^{-2} month^{-1}) for a) January and b) July.

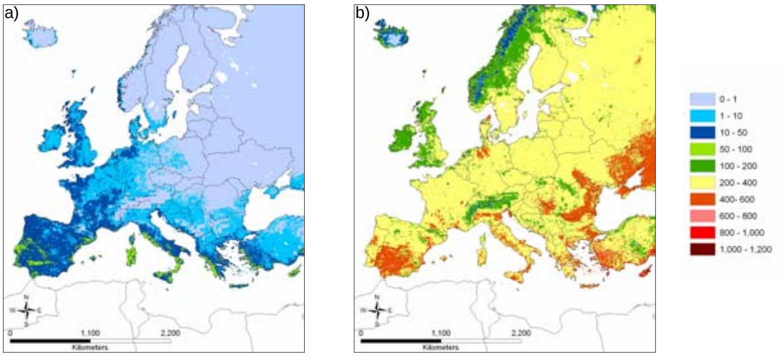

Figure 3. Spatial distribution of OVOCs emissions (kgr-C km^{-2} month^{-1}) for a) January and b) July.

RESULTS - DISCUSSION

- ✓ In January, the monthly European biogenic NMVOCs emissions are composed of 1.8% isoprene, 47.9% monoterpenes and 50.3% OVOCs.
- ✓ In July, the monthly emissions total consists of 42.3% isoprene, 21% monoterpenes and 36.7% OVOCs.

ISOPRENE

- In January, total emissions estimate is 1.67 Ggr-C/month. The highest emission fluxes (up to 267 kgr-C km^{-2} month^{-1}) occur mostly over coniferous forests (Fig. 1).
- In July, isoprene emissions total amounts to 2948.36 Ggr-C/month. Higher emission rates are mostly associated with deciduous oak woodlands and mixed forest landscapes (Fig. 1).

MONOTERPENES

- In January, monoterpenes emissions total is about 44.71 Ggr-C/month. Monthly total emissions increase in July by a factor of 32.
- In January, maximum emission rates are up to 687 kgr-C km^{-2} month^{-1} while in July, they range between 3000 - 4400 kgr-C km^{-2} month^{-1} (Fig. 2). Higher emission fluxes are attributed to woodlands dominated by evergreen oaks.

OVOCs

- Total OVOCs emissions amount to 2552.68 Ggr-C/month in July and are reduced by 98% in January.
- In January, OVOCs emission fluxes are higher mainly over coniferous forests dominated by spruce and fir and over evergreen oak woodlands (maximum values are around 268 kgr-C km^{-2} month^{-1}). In July, higher emission rates are associated mainly with mixed forests and croplands (Fig. 3).