Modeling sensitivity of biogenic VOC emissions to environmental factors

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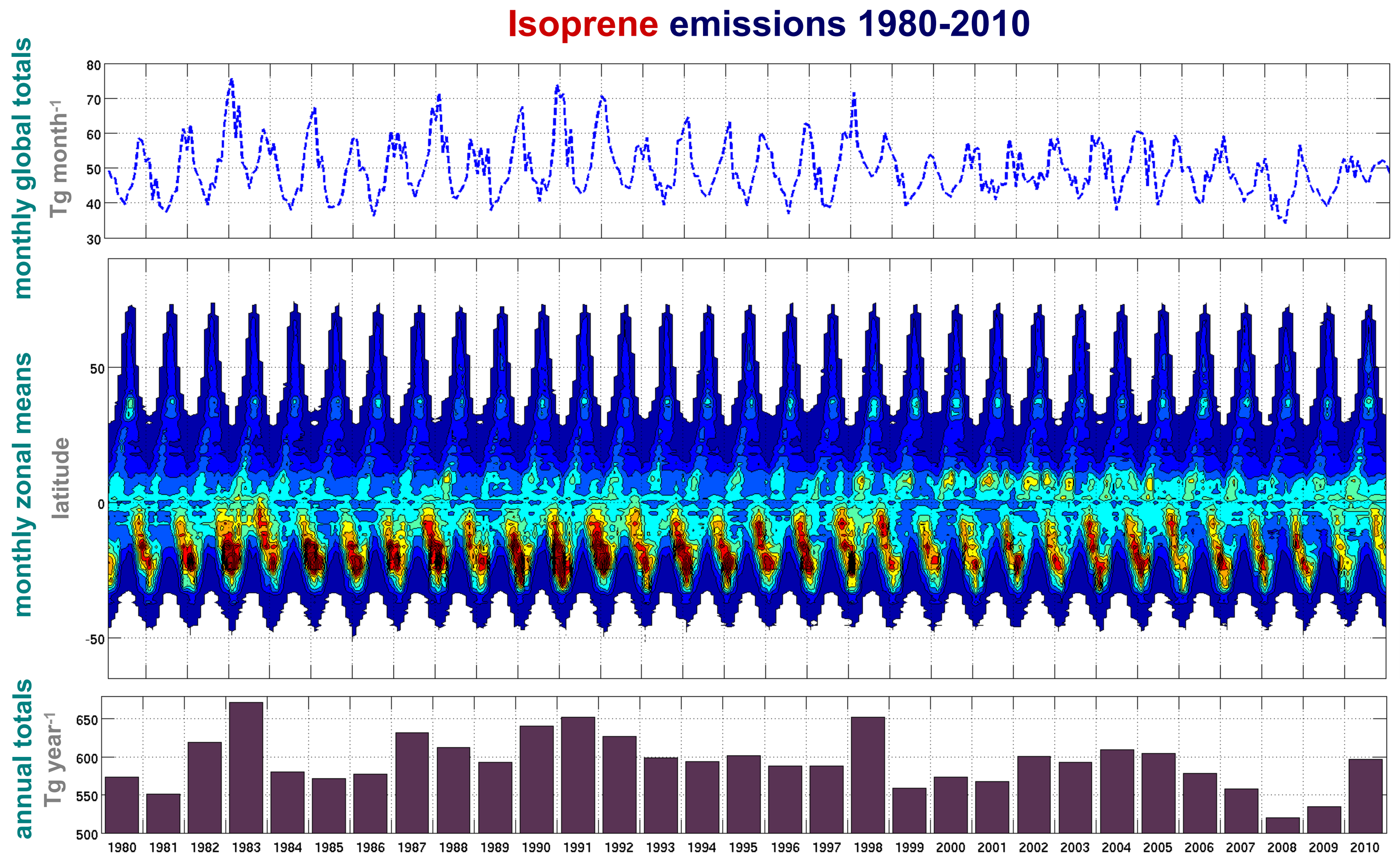
Summary

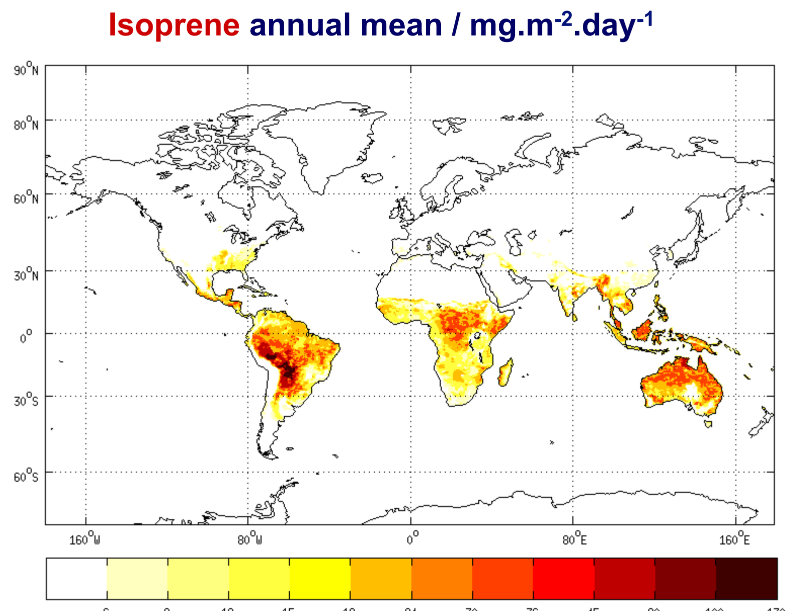
Global inventory of biogenic VOC emissions MEGAN-MACC (REF) has been created using the model MEGANv2.1 (*Guenther et al., 2012*). Emissions of the main chemical species emitted by vegetation were estimated on monthly basis for the period of 1980 – 2010. The global BVOC emission total is dominated by isoprene (69% of global total). Further, we present three sensitivity isoprene emission inventories. Dataset SM accounts for impact of soil moisture deficiency on isoprene emission. In dataset titled SW a simplified calculation of PAR (Photosynthetically Active Radiation) input variable has been used assuming that PAR equals to ½ of incoming short-wave radiation. In dataset CRU, we replaced the MERRA meteorological fields (used for the reference as well as for SM and SW datasets) by the meteorological inputs from the CRU-NCEP reanalysis. These variations in driving environmental factors resulted in substantial changes of isoprene global total which decreased by 50% in SM, increased by 16% in SW and decreased by 27% in CRU sensitivity model runs when compared to the reference.

Isoprene emission dataset MEGAN-MACC

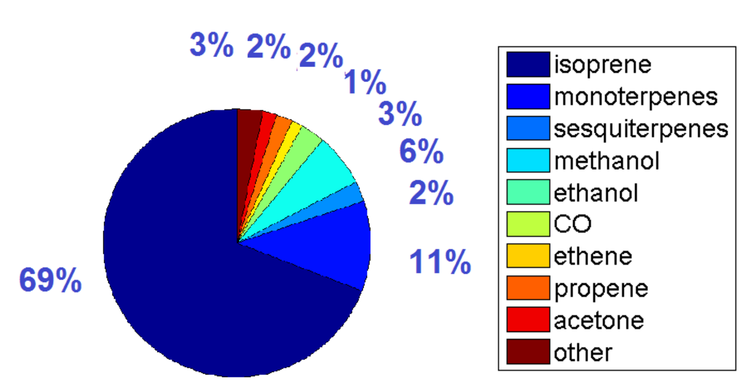
Isoprene emissions 1980-2010



Isoprene annual mean / mg.m⁻².day⁻¹



Relative composition of global BVOC emissions
[expressed as emissions of carbon]



Isoprene emissions with soil moisture effect factor (SM)

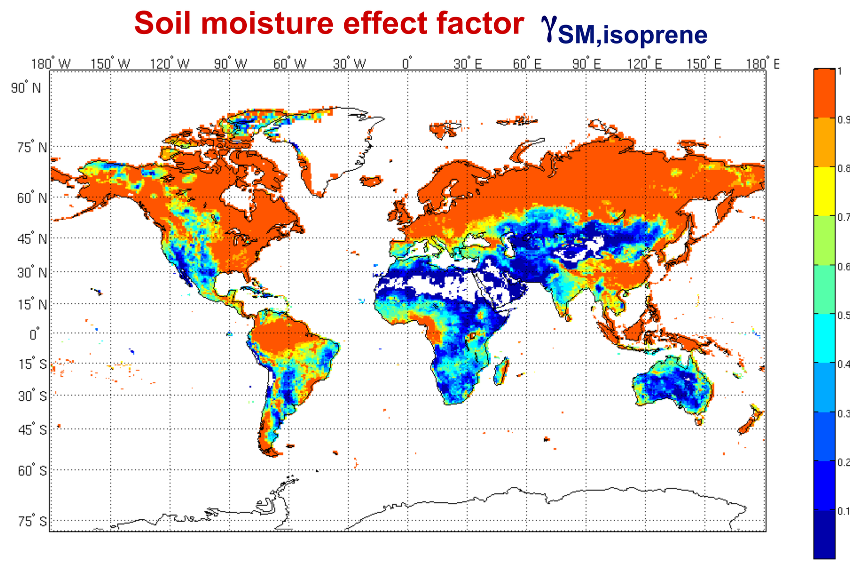
Emission SM = Emission REF * $\gamma_{SM,isoprene}$

Calculation of soil moisture effect factor

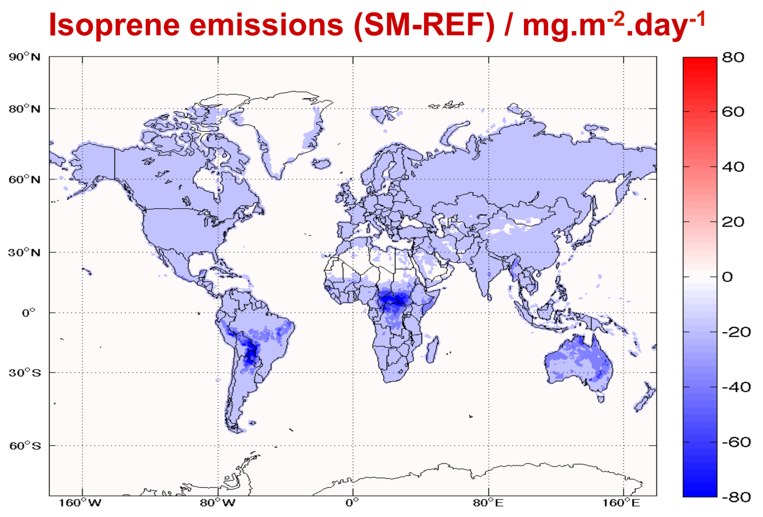
$$\gamma_{SM,isoprene} = 1 \qquad \theta > \theta_1$$
$$\gamma_{SM,isoprene} = (\theta - \theta_w)/\Delta\theta_1 \qquad \theta_w < \theta < \theta_1$$
$$\gamma_{SM,isoprene} = 0 \qquad \theta < \theta_w$$

- θ volumetric water content [m³.m⁻³]
- θ_w wilting point
- $\Delta\theta_1$ empirical parameter
- $\theta_1 = \theta_w - \Delta\theta_1$ (Guenther et al., 2006)

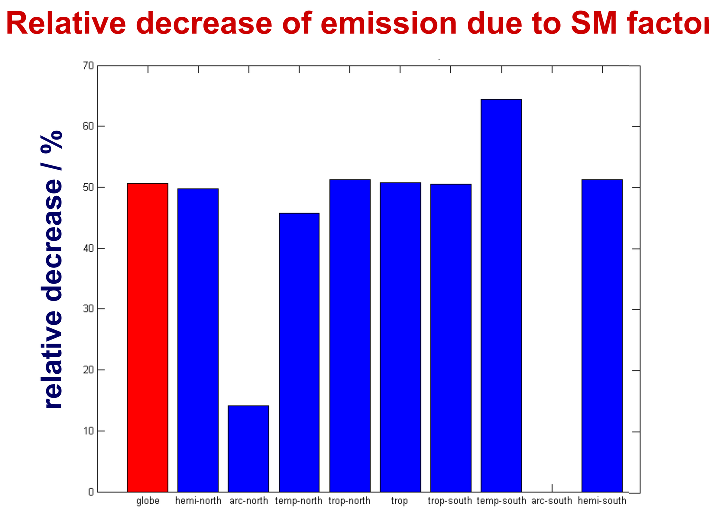
Soil moisture effect factor $\gamma_{SM,isoprene}$



Isoprene emissions (SM-REF) / mg.m⁻².day⁻¹



Relative decrease of emission due to SM factor



MEGAN model setup

- **emission potentials** in the form of high resolution gridded maps (*Guenther et al., 2012*)
- **vegetation distribution** described by 16 PFT categories consistent with Community Land Model v4 (*Lawrence and Chase, 2007*)
- **Leaf Area Index** 8-day values from global retrievals of MODIS (*Yuan et al., 2011*)
- **meteorological driving fields**

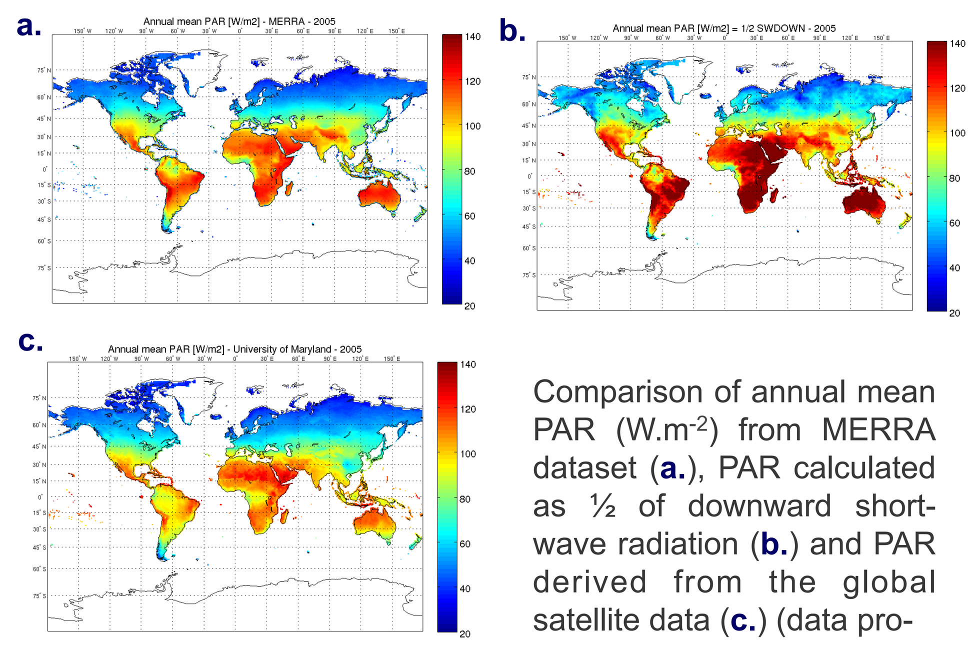
MERRA (Modern Era Retrospective Analysis for Research and Application) NASA Goddard Space Flight Center (*Rienecker et al., 2011*)

- 0.5° x 0.666° horizontal resolution, 1980 – 2010
- 6 h instantaneous fields – temperature, pressure, humidity, wind speed
- 1 h instantaneous fields – Photosynthetically Active Radiation

CRU–NCEP (Climatic Research Unit and National Centers for Environ. Predictions)

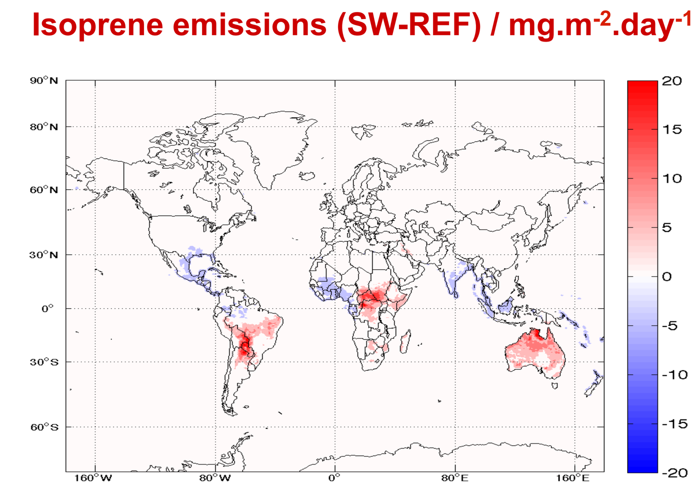
- based on NCEP/NCAR reanalysis (Kalnay et al., 1996), combined with CRU TS 2.1 monthly anomalies (Mitchell and Jones, 2005), with corrections on precipitation bias (credits to Nicolas Vivoy)
- 0.5° x 0.5° horizontal resolution, 1980 – 2010
- 6 h instantaneous fields – temperature, pressure, humidity, wind speed, shortwave solar radiation

Isoprene with simplified calculation of PAR variable (SW)



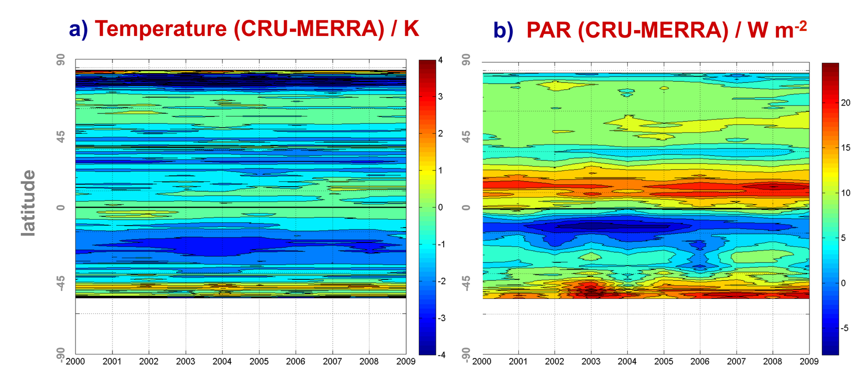
Comparison of annual mean PAR (W.m⁻²) from MERRA dataset (**a.**), PAR calculated as ½ of downward short-wave radiation (**b.**) and PAR derived from the global satellite data (**c.**) (data provided by Pinker et al., University of Maryland). Shown is a comparison for the year 2005.

Isoprene emissions (SW-REF) / mg.m⁻².day⁻¹

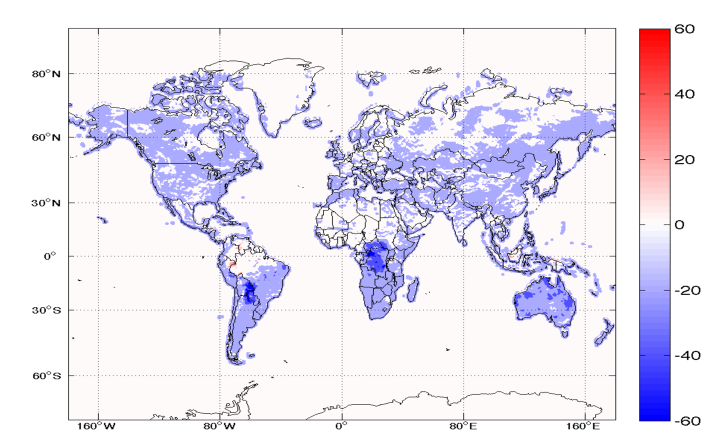


Isoprene based on CRU meteorology (CRU)

Differences in annual zonal means of a) temperature and b) photosynthetically active radiation (PAR) between the CRU and MERRA datasets (2000-2009).

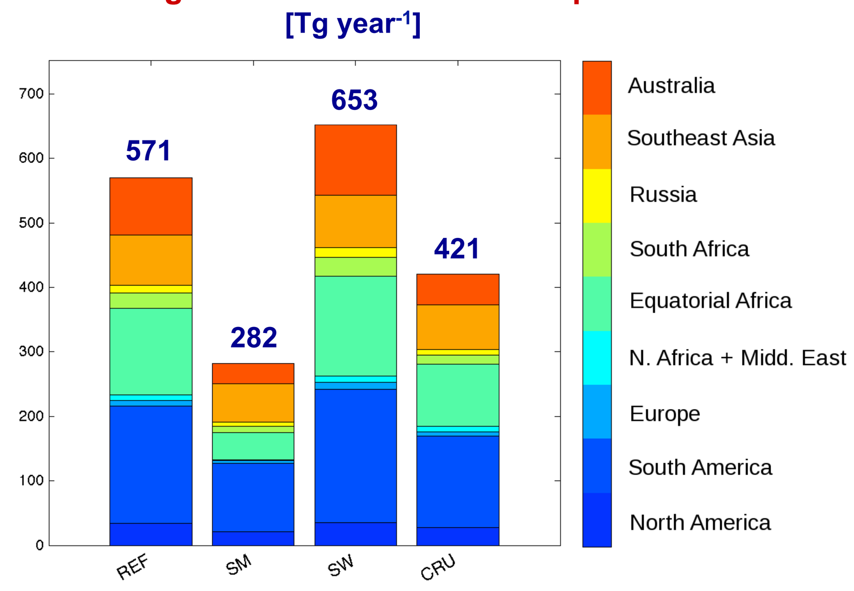


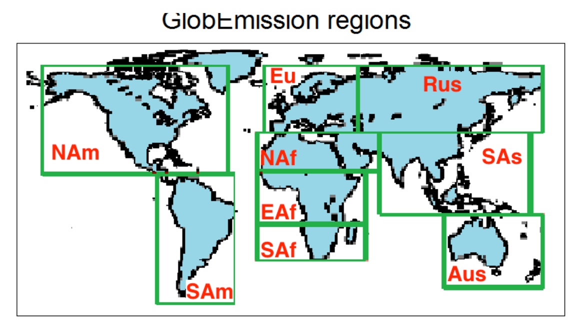
Isoprene emissions (CRU-REF) / mg.m⁻².day⁻¹



Comparison of the datasets

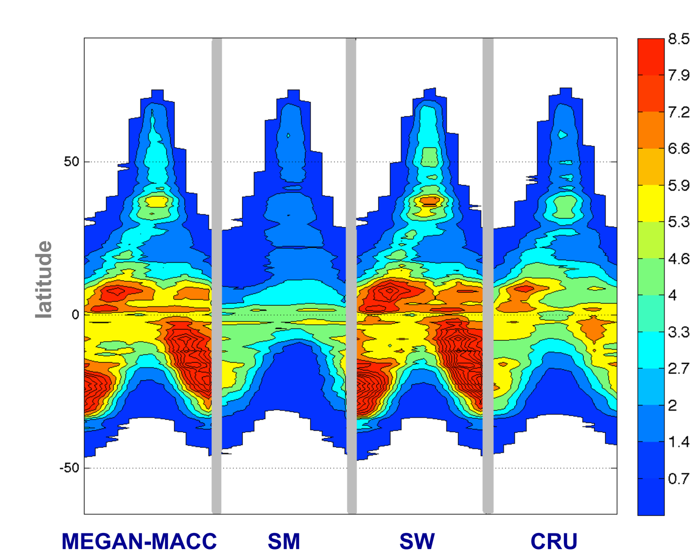
Annual global total emission of isoprene
[Tg year⁻¹]





Comparison of annual global totals of isoprene calculated in the reference and sensitivity model runs. Presented are absolute contributions of different regions (defined below) to the global total. The largest differences between the datasets appear in Australia, Equatorial Africa and South America.

Monthly zonal means of isoprene
[mg m⁻² day⁻¹]



Monthly zonal means of isoprene emissions from the reference and sensitivity model runs (averaged over the period of 2000 – 2009). For all datasets, the tropical region is the main source of isoprene emission. However, its intensity, especially in southern tropics, is much more pronounced in the reference and SW datasets. Application of the soil moisture activity factor leads to dramatic decrease of isoprene emissions in the tropics. The location of emitting regions in the CRU dataset is similar to the reference, however, the sources are less active, mainly in the south-tropical region.

More information

Sindelarova, K., Granier, C., Bouarar, I., Guenther, A., Tilmes, S., Stavrakou, T., Müller, J.-F., Kuhn, U., Stefani, P., and Knorr, W.: Global dataset of biogenic VOC emissions calculated by the MEGAN model over the last 30 years, Atmos. Chem. Phys. Discuss., 14, 10725-10788, doi:10.5194/acpd-14-10725-2014, 2014.

Acknowledgement

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