

# Temporal variations in modelled CO and isoprene over Tropical Africa

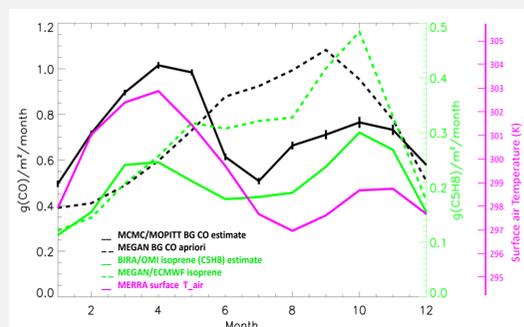
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## 1. Introduction

Isoprene is the most abundant non-methane volatile organic compound (NMVOC) in the atmosphere, accounting for 50% of all NMVOCs (Guenther et al., 2012). It is primarily emitted by tropical trees, and represents a significant source of CO in the troposphere (Fig. 1). Recently, Worden et al. (2019) found that the seasonal variation in emissions of isoprene from tropical northern Africa from the Model of Emissions of Gases and Aerosols from Nature (MEGAN) was different from that estimated from atmospheric HCHO data and also from the biogenic source of CO estimated from CO data. As shown in Fig. 1, Worden et al. (2019) found that “top-down” estimates of the biogenic CO source and isoprene emissions exhibited a twin-peaked seasonal cycle that was similar to variations in surface air temperature. In contrast, the “bottom-up” isoprene emission estimates did not exhibit a well-defined secondary peak. Here we use the GEOS-Chem model to investigate the seasonality of isoprene emissions in MEGAN over tropical northern Africa.



**Figure 1.** Monthly averaged biogenic source of CO (black lines) and isoprene emissions (green lines) and surface air temperature (magenta line). The a priori emission estimates are indicated by the dashed lines, whereas the a posteriori estimates are denoted by the solid lines. [From Worden et al. (2019).]

## 2. GEOS-Chem Model Setup

We use version v35j of the GEOS-Chem adjoint model at a resolution of  $4^\circ \times 5^\circ$ . A 1-year full tropospheric chemistry simulation from January – December 2016 was performed using GEOS-5 meteorological fields. The analysis focused on the northern tropical African region from  $8^\circ\text{N} - 12^\circ\text{N}$  and  $12^\circ\text{W} - 50^\circ\text{E}$ , as shown in Fig. 2.



**Figure 2.** Northern tropical Africa, between  $8^\circ\text{N} - 10^\circ\text{N}$  and from  $12^\circ\text{E} - 50^\circ\text{W}$ . All other plots show averages within this region.

### MEGAN in GEOS-Chem

MEGAN calculates isoprene emissions as a product of different emissions factors as follows (Guenther et al. 2006):

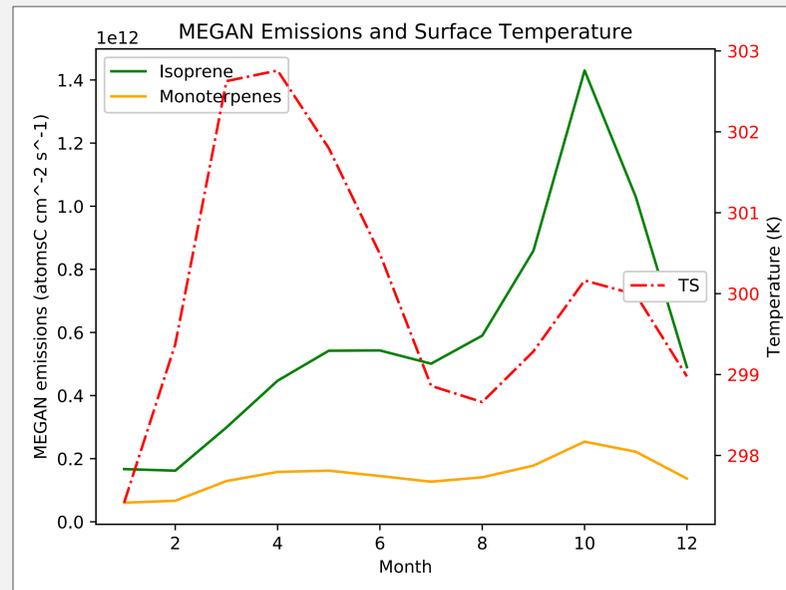
$$E_{ISOP} = E_0 \times \gamma_{PAR} \times \gamma_T \times \gamma_{LAI} \times \gamma_{AGE} \times \gamma_{SM}$$

where  $E_0$  is the emissions for standard conditions that is based on ecosystem type and does not change throughout the year. The factors  $\gamma_{PAR}$ ,  $\gamma_T$ ,  $\gamma_{LAI}$ ,  $\gamma_{AGE}$ , and  $\gamma_{SM}$  reflect the influence of light, temperature, leaf area index (LAI), and soil moisture, respectively. In v35j of the adjoint model, the emissions are specified as:

$$E_{ISOP} = E_0 \times HEA_{TL} \times MEA$$

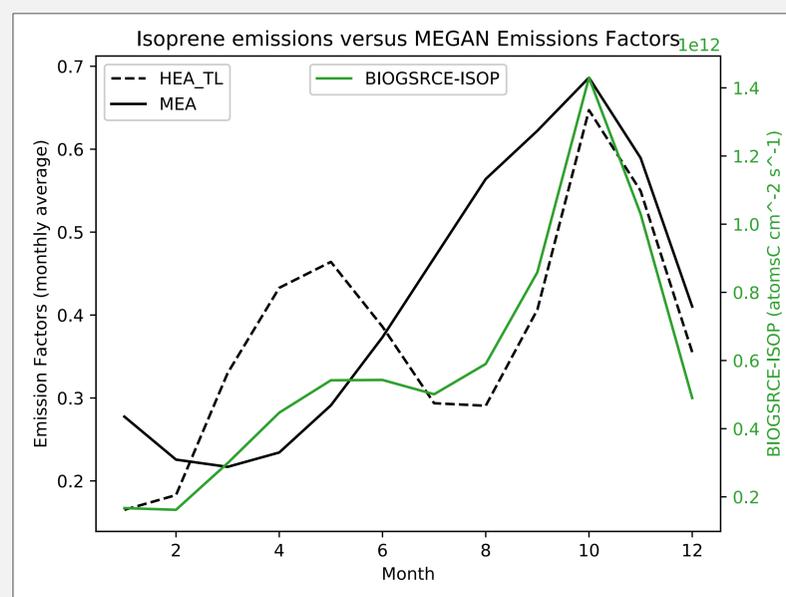
where  $HEA_{TL}$  is an hourly factor that accounts for light and temperature dependence and  $MEA$  is a monthly factor that accounts for the effects of LAI and leaf age. We neglect the influence of soil moisture.

## 3. Results – Timeseries of isoprene emissions



**Figure 3.** Monthly mean emissions of isoprene (green) and monoterpenes (orange) from MEGAN in GEOS-Chem, averaged over the region shown in Fig. 2. GEOS-5 surface air temperature is shown (red). Isoprene emissions exhibit a seasonal cycle which has peaks at roughly the same time as the temperature. Monoterpene emissions follow a similar trend but are much smaller in magnitude.

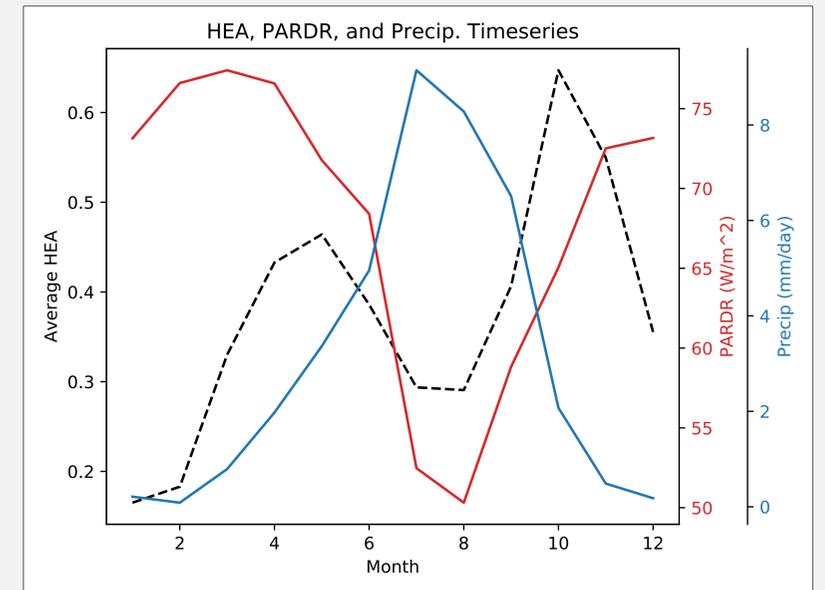
- MEGAN isoprene emissions in GEOS-Chem show a twin-peaked seasonal cycle, with a weak secondary maxima.
- Location of the peaks roughly corresponds with the surface air temperature maxima.



**Figure 4.** Monthly mean isoprene emissions (green) are a product of the monthly (solid black) and hourly (dashed black) emissions factors, scaled by the annual emissions factor (not shown). Both emission factors peak in October.  $HEA_{TL}$  has a secondary peak in April-May.

- $HEA_{TL}$  (hourly) emission factor also exhibits a twin-peaked seasonal cycle
- $MEA$  (monthly) emission factor has single peak in October

## 4. Results – Seasonal cycle in $HEA_{TL}$



**Figure 5.** The late-Summer reduction in  $HEA_{TL}$  corresponds to a minimum in direct photosynthetically active radiation (PARDR), and a maximum in daily precipitation. This is also concurrent with a local minimum in surface air temperature (Fig. 3). These meteorological conditions are indicative of the West African Monsoon.

- Late-summer minimum in  $HEA_{TL}$  corresponds with minimum in direct sunlight (PARDR)
- There is a concurrent maximum in daily precipitation at this time, which is associated with the West African Monsoon

## 5. Conclusions

The twin-peaked seasonal cycle of MEGAN isoprene emissions mainly reflects the influence of the  $HEA_{TL}$  emission factor.  $HEA_{TL}$  has a local minimum in August, which is concurrent with increased precipitation, decreased photosynthetically active radiation, and reduced surface temperatures, which accompany the arrival of the monsoon season. The large isoprene emission peak in October is driven by both  $MEA$  and  $HEA_{TL}$ , possibly as a result of increasing leaf coverage. Future investigations will involve conducting inversion analyses to constrain the emission factors in MEGAN using atmospheric CO data from the Measurement of Pollution In The Troposphere (MOPITT) instrument.

## References

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