BVOC flux from a tropical montane ecosystem estimated using the BIGA biogenic emission model

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1. MOTIVATION

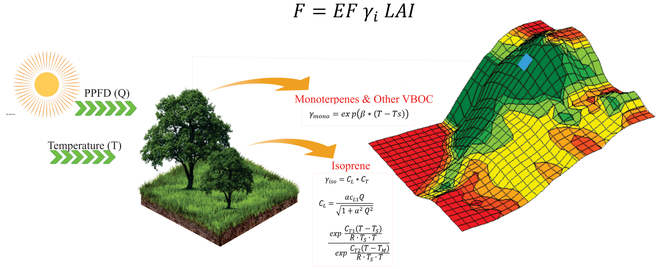
A good representation of biogenic VOC is needed for inputs to climate and air quality models. Several available models developed in North America that are typically driven by global meteorological models with spatial resolution of tens to hundreds of kms. Some tropical and Andean regions have abrupt altitudinal changes over short distances which affect considerably the climate and require information with more resolution and accuracy than is available from global models.
Studies have shown that satellite information could have uncertainties higher than 50% and could increase for Andean regions where clouds are abundant and reduce the visibility from satellites. Local measurement based data are more accurate than global models and are now more readily available due to the implementation of open data laws.

- Biogenic sources contribute approximately 80% of the volatile organic compounds (BVOC) emissions in the world (Guenther et al., 2012).
- VOC are effective at forming CCN (Cloud condensation nuclei), thus increasing cloud cover and causing rainfall (Sheil, 2014).
- VOC have an important role in tropospheric ozone (O_3) production (Fares et al., 2011)
- A recent analysis of ozone concentrations in Manizales revealed that highest leveles are found on rural areas reaching 80 μg m^{-3}

2. BIGA MODEL: FORMULATION AND PROCESSING

The BIGA model -BIogenic emissions considering the altitudinal gradient- at canopy level calculates BVOC emissions. Formulation is based on the algorithm proposed by Guenther et al., (1995).

$$F = EF\ \gamma_i\ LAI$$



The first version of the model was developed using ArcGis and Matlab software to estimate isoprene, monoterpenes, and other BVOC groups with the following methodology

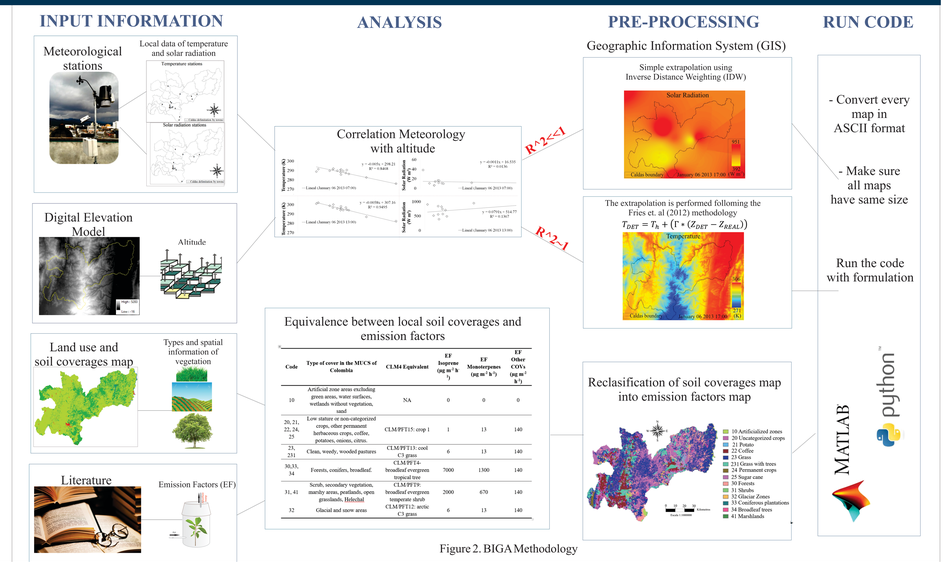


Figure 2. BIGA Methodology

3. WRF RUNNING

BIGA isoprene emission estimates were compared with values estimated using MEGAN BVOC emission model integrated into WRF-Chem.

Table 1. WRF-Chem model configuration

Parameter	Model configuration
Simulation period	One dry day in 2013: January 6th (24 h spin-up)
Domain configuration	D1: 27 km resolution (85x85) D2: 9 km resolution (97x94) D3: 3 km resolution (133x118) D4: 1 km resolution (115x100)
Vertical levels	35
Static data	Topography: USGS Land use: MODIS
Meteorology Chemistry IC-BC	FNL analysis (0.5°; 6 h interval) MOZART-4 global model

Meteorological data was taken from the NCEP -GFS. The physical parameterizations and chemistry options were chosen from the study of González et al. (2018).

Table 2. Physical and chemistry options used in WRF-Chem simulation

	Physical parameterizations						
	M.Phys.	*Cum.*	*PBL*	*LW rad.*	*SW rad.*	*Surf. Layer*	*Land Surf.*
Scheme	WSM6	Grell-Freitas	ACM2	RRTM	Dudhia	Noah-LSM	M–O
	Chemistry options						
	Gas-phase		*Aerosol*		*Photolysis*		
Mechanism	RADM2		MADE / SORGAM		Fast-J		

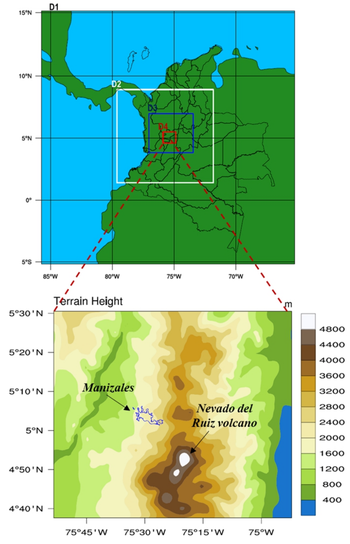


Figure 3. Domain distribution

4. APPLICATION AND RESULTS

MAIN FEATURES OF STUDY AREA
BIGA was applied to Caldas department, a coffee-growing zone with an area of 7436 km^2 located in the Colombian Andean region between the Central and Western Cordilleras.
Mountainous areas with steep slopes ranging from 0 to 72%. It has an altitudinal range between 140 and 5286 m.a.s.l.
The inventory was performed for a typical day of the dry period (January 6, 2013) and another of the wet period (November 29, 2013).
The cell size was 90 m x 90 m, resulting in a rectangular area comprised of 1203 x 1600 cells.

INPUT INFORMATION
- Data from 17 temperature and 12 solar radiation stations
- Emission Factors were taken from MEGAN2.1 algorithms implemented in the Community Land Model version 4 (CLM4)(Guenther et al., 2012)

The year 2013 had approximately 237 days with rain and 128 dry days. The total BVOC annual emissions estimated for Caldas were 24220 tons $year^{-1}$ of BVOCs

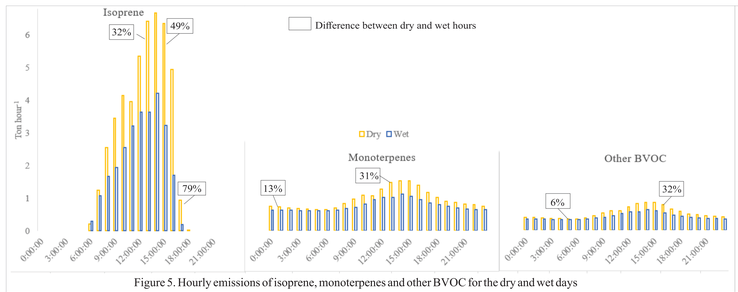


Figure 5. Hourly emissions of isoprene, monoterpenes and other BVOC for the dry and wet days

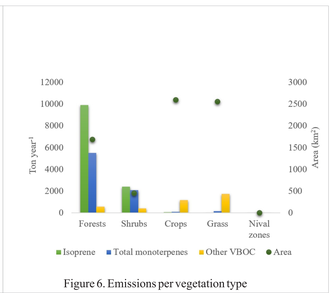


Figure 6. Emissions per vegetation type

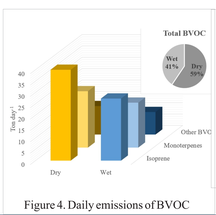


Figure 4. Daily emissions of BVOC

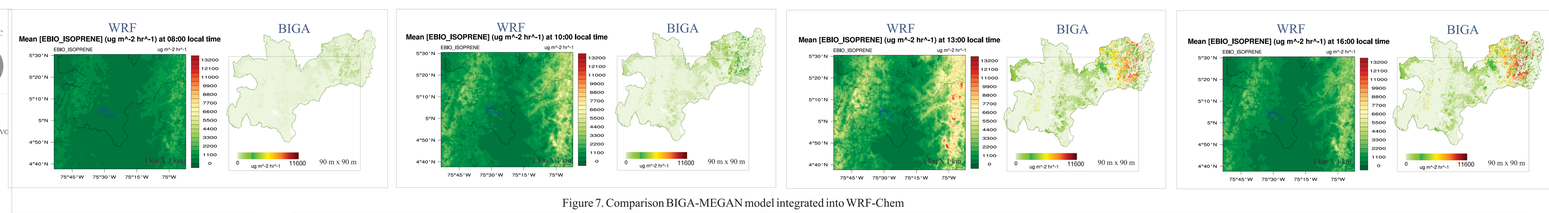


Figure 7. Comparison BIGA-MEGAN model integrated into WRF-Chem

CONCLUSIONS

BIGA is useful for estimating emission hot spots in heterogeneous landscapes and produces regional values that compare well with recognized models like MEGAN.
It offers the advantage that it can be used over small areas at higher resolution, using local information instead global model results allowing a better estimation over Andean regions with steep altitudinal variations and high cloud cover. The predicted emissions are highly correlated with altitude with an inverse relationship.

MODEL PAGE AND NEXT STEPS

The code of the model and a template are available at the official page: http://idea.manizales.unal.edu.co/gta/ingenieria_hidraulica/BIGA/index.php

NEXT STEPS
- The second version (BIGA2.0) will use Qgis and Python free software.
- Develop and apply emission factors using observations in Colombia

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