

Interactive comment on “The emission factor of volatile isoprenoids: caveats, model algorithms, response shapes and scaling” by Ü. Niinemets et al.

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The manuscript titled “The emission factor of volatile isoprenoids: caveats, model algorithms, response shapes and scaling” is the first of a series of papers that review biogenic VOC emission model components, discuss their shortcomings, and make some recommendations for future efforts. This is a worthwhile activity but there are several issues that should be addressed in the current manuscript:

1. The authors “argue that ES is largely a modeling concept” (P1235, line 10) and may not be aware that the use of emission factors is a common practice in the air quality modeling community where it is widely recognized as a modeling con-

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cept (i.e., there is nothing to argue about). For example, the USEPA says (e.g. <http://www.epa.gov/ttnchie1/ap42/>) that “An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per megagram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average).”

Where do the authors get the idea that an emission factor is considered a “constant” (e.g., p1235, line 10)? It is simply expected to be representative of a population average which is a different concept. It is widely recognized, at least by the air quality community, that an emission factor is a just an average value that may have a large variability associated with it.

2. The authors make recommendations on what is needed in emission models without providing much background on what is really needed as input to atmospheric models. It should be noted that not all atmospheric models have the same purpose (this goes beyond just spatial resolution) and there is a considerable range of requirements. For example, P1235, line 13 states “In particular, there is now increasing consensus that variations in atmospheric CO₂ concentration, . . . need to be included in the emission models.” That depends on what model is being used and for what purpose. An air quality model simulating the current decade (which includes the vast majority of modeling simulations) does not need to be concerned about the influence of CO₂ concentration on VOC emissions while someone simulating changes in the year 2100 does need to include this. Some models just need a rough estimate of biogenic VOC emissions and the computational expense of increased model complexity may not be warranted.

3. Section 2.5 (scaling) makes the case that a leaf level emission factor is preferable to

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a canopy scale emission factor. The discussion does not consider the advantages and disadvantages of the two approaches and some specific statements should be revised:

a) P1262, I17: "As the scaled-up values are outcomes of models, the aggregated emission factors are subject to vary with the algorithms used for integration of isoprenoid fluxes." and P1265, I18: "The canopy-scale emission factor is a modeled characteristic that is based on available leaf-level ES estimates for given species that are further combined with a canopy model to yield values of Ecan (Guenther et al., 2006)". Canopy scale emission factors should be assigned based on canopy scale measurements and leaf level values used only when no other data are available. With the increasing availability of above-canopy flux measurements, especially aircraft flux measurements, canopy scale emission factors will no longer require any scaling up. On the other hand, the use of leaf-level emission factors will always require a model in order to generate an above canopy emission estimate.

b) P1266, I7: "However, canopy-level emission rates obtained from eddy flux measurements are instantaneous values, while MEGAN runs with average temperature and light conditions." Canopy scale flux measurements provide values on the same time scales as the MEGAN model, and are never instantaneous values, so it is not clear what is meant by this statement.

c) P1266, I13: "In addition, flux measurements, are often not conducted in stands having a "standard" LAI, and converting the values of Ecan,mes to a standard LAI again requires a canopy model," Yes, but the adjustment is typically minimal. In addition, aircraft flux measurements have the potential to provide canopy scale emission values over a wide range of LAI values including the standard conditions. Again, this does not result in emission model results that are any less reliable than a model using leaf level emission factors which is more dependent on the canopy model to get to the canopy scale.

d) P1266, I13: "Particular care should be taken in applying the modeled and aggre-

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gated emission factors, e.g., as Ecan applied in MEGAN (Guenther et al., 2006). Being a modeled variable means that any change in light and temperature response function and their parameterization applied in the emission model, and time-resolution of climatic drivers would require re-computation of Ecan values." I would argue that more care must be taken applied when applying leaf level emission factors. This is because a leaf level emission factor could represent a number of things (and does in various models): the canopy average if all leaves were exposed to certain light and temperature conditions, the actual canopy average after accounting for self shading etc., the sun leaf average, the shade leaf average, or something else. In contrast, the canopy-scale emission factor always represents the entire canopy.

In addition, the discussion in the text does not recognize the advantages of using emission factors based on canopy scale measurements. For example,

- they don't suffer from the inherent disturbances associated with enclosure measurements
- they account for the within canopy losses that can result in a large difference between leaf level emissions and fluxes into the above canopy atmosphere
- they don't have the large uncertainties associated with scaling up leaf level measurements to the canopy scale.
- they average over a much larger number of leaves providing a value that is much closer to the population mean (i.e. one canopy scale measurement is worth a thousand leaf level measurements)

4. This manuscript has similar arguments and covers about the same topics as the BGD companion paper, Niinemets et al. "The emission factor of volatile isoprenoids: stress, acclimation, and developmental responses". It would be better for readers to have this information integrated into one concise paper (with some text trimmed from the current manuscript).

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5. The authors have a too optimistic view regarding recent advancements in emission modeling (e.g., P1267, l16: "The existence of this knowledge means the days of simple emission source modeling are past." And P1267, l8: "However, our knowledge of the factors influencing ES, and its application to different scales of consideration, has greatly increased since the original development of the Guenther et al. algorithms. Significant variations in plant responses to environmental drivers light and temperature, and to so far unaccounted environmental drivers such as CO₂ have been highlighted and emission induction by biotic and abiotic stresses and modifications in emission compositions have been demonstrated. Recent studies have also observed important variability in the share of emission controls between compound synthesis and physico-chemical factors."

These statements require some references that demonstrate how recent model advances have significantly improved emission models. It is not enough to say that the new emission estimates are different – you can make a model worse and it will still be different from the old estimates. What evidence is there that regional scale emission inputs to atmospheric models are any more accurate with a newer complicated model than with an older simpler one?

This is not to say that existing models are good enough (they are not!) or that we are not making any progress in improving models (we are but it is difficult to quantify so you can't justify statements like "has greatly increased") or that we should not add complexity to these models (we should but only if we can demonstrate that it actually improves the model estimates).

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