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Discussions

Interactive comment on "Isoprene emissions track the seasonal cycle of canopy temperature, not primary production: evidence from remote sensing" *by* P. N. Foster et al.

Anonymous Referee #2

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General comments

The manuscript of Foster *et al*. applies the seasonal change in remote sensed formaldehyde (HCHO) columns as a proxy to empirically set a statement on possible driving factors for large scale isoprene emission's seasonal behavior estimates. While the general idea to locate the predictors to describe isoprene emission on large scale at the proper scale is very welcome the authors finally try to track down a rather complex system to just one factor. That is, at least at the scale of interest, not possible. The conclusion, to better replace GPP driven seasonal dynamic by a temperature driven one may not be the worst way but a multi-factor system should take the major

drivers into account (see comments below) and therefore (very simplified) without biomass (e.g. GPP) there is no canopy-temperature. Also the statement of the title and the aims set can not be rooted on the simple correlation analysis presented here (see also specific comment below).

The authors claim to "set out to discover general, biome-independent relationships". As there are different definitions of a biome available, it should be specified which one of these definitions was used in the context of this work. It is a bit strange to me that the authors seek that, because their predictors include GPP and canopy temperature. All definitions of a biome include ecosystem(s) or the biome definition equals an ecosystem. The plants within ecosystems, and by that within biomes should have a property like GPP and canopy temperature. How can you get the predictor "biome-independent"? What does that mean?

One problem using HCHO column data over a large range of latitudes is that in high latitudes the "systematic errors" of the product yield up to 50% and that cloudy intervals can lead to even higher errors (de Smedt *et al*. 2008). Therefore, the use of such a product has some limitations. However, these possible limits and their impact on the empirical predictors aimed to develop here are not well addressed. As example, analysis of column data includes application of averaging kernels, inverse modeling approaches and linearization techniques on the data (Rodgers, 2000), i.e. some parts of the "systematic error" rely on the state of the system or the data itself, therefore they are not like "a uniform offset". Given that, the argument in section 2.3 which relies on the fact that the standard deviations remain the same regardless where the mean values are shifted does not hold.

Explicitly, how do you cope with the situation that in high latitudes your eye is half blinded? What are the consequences on your findings due to that? How do these errors impact on your main assumption that HCHO = f(isoprene in air) = g(emission) = h(predictor) outside the tropics?

It is, from a plant physiological viewpoint, not a really new or surprising finding that isoprene emission correlates better to leaf/canopy temperatures than to air temperature or light for example. A clear fact is that, light driven photosynthetic carbon flux is three orders of magnitude larger than the isoprene emission flux on leaf scale (μmol vs nmol). In that sense, even with strong changes in photosynthesis (maybe due to drought) there is enough potential to emit some isoprene as long as there is energy and these changes must not translate into the same changes in isoprene emissions.

Another point in that context is, that GPP represent the biomass of the area in question. As the major emitting tissues are leaves (or needles), there has to be a basal amount of leaf biomass to get that emission. In terms of a seasonal scenario, as aimed in this manuscript, there should be some discussion on possible changes and shifts in the impact of the possible factors that promote emissions. As example, without leaves, there are no isoprene emissions for deciduous emitting trees. In springtime, a portion of the emissions might correlate well to GPP as the emitting tissues are formed. Once established the leaf area is not changed very much anymore until senescence. For sure, that is modulated by temperature as predictor over all the season. The latter will be mostly valid in boreal and temperate zones. Moving to the tropics, the GPP dynamics will be another one as the trees are evergreen. Their change in seasonal leaf biomass may be rather constant and temperature effects may even more modulate the emissions.

To my opinion, the system you look at is a multi factor system and tracking it down to just one factor will always be problematic.

Specific comments

Introduction:

It seems, the authors take it for granted that elevated CO_2 lead to a reduction in isoprene emission. That response is yet only confirmed on small scale and per leaf area as immediate response to concentration change. Centritto *et al.* (2004) and Sun *et al.* (2013) as examples report different behavior where the enhanced leaf number and leaf area either rule the isoprene's down regulation out or lead to enhanced emissions on whole plant level. Especially on larger scales, these isoprene down regulation schemes should be taken carefully and graded to be preliminary. To my opinion, the uncritical application of the leaf scale short term effect on large scales lead to wrong results.

Methods:

The fraction of monoterpene emitting species vs isoprene emitters in boreal zone may lead to the fact that the HCHO column is not linked to isoprene as there are no or very few isoprene emitters around. Is then, the HCHO column still a good estimate for isoprene emission? Or is it a more general "terpene" emission?

To claim that there is "one order of magnitude" less non-isoprene sources is especially a problem as that number is according to the cited literature and therefore it is the estimated or assumed basal emission factor that is one order of magnitude less for monoterpenes as example. But that does not mean that the actual source strength is as well lower because beside the bare emission factor the emitting area (LAI), species distribution, energetic state etc play a role. Again I would like to mention that this system is a multi factor system. Grading it by just one factor will be wrong or lead to wrong assumptions for the chemistry model inputs. Examples can be found in Bourtsoukidis *et al.* (2014) where spruce in a hemiboreal forest emit 14x more monoterpenes than isoprene or Noe *et al.* (2012) where ambient concentrations of isoprene are one order of magnitude lower than monoterpene concentrations.

Supporting Material:

Why do you use a linear relationship to relate HCHO columns seasonal cycles to temperature? I guess you use something like Pearsons correlation coefficient (?) which is a linear relation. But then, it would be better to use a log transformed seasonal cycle to make a valid statement on the correlation.

What are ecobands?

Used references

Bourtsoukidis *et al.* (2014) On-line field measurements of BVOC emissions from Norway spruce (*Picea abies*) at the hemiboreal SMEAR-Estonia site under autumn conditions. Boreal Environment Research 19
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trations within a remote hemiboreal mixed forest. Atmos. Chem. Phys., 12, 3909–3926.

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