

# Response to Anonymous Referee #1

## Referee #1

P. 12155, line 16-18: The calculation of modelled  $POD_{1,DF}$  is based on a generic deciduous tree species for which no critical level has been defined.  $POD_{1,DF}$  can only be used to indicate the risk of ozone damage. However, a critical level of 4 mmole m<sup>-2</sup> has been defined for beech and birch, based on parameterisations of the DO3SE model for beech and birch, which is different from the parameterisation for a generic tree species. Hence, a comparison between  $POD_{1,DF}$  and the critical level for beech and birch should be avoided. Therefore, I suggest to delete the sentence currently in brackets.

## Reply

Yes, we should have stated that the CL was for beech and birch. Actually, there are actually not great differences between the POD values calculated for the generic deciduous tree used here and a beech+birch categories used in the mapping manual, so the EMEP model predictions of extensive areas above 4 mmole/m<sup>2</sup> are relevant we think, but cannot be used for quantitative risk assessment. We have re-phrased this sentence to be more explicit here:

(For comparison, Mills et al. (2011) recommended critical levels of 4 mmole m<sup>-2</sup> for birch and beech forests; although our generic deciduous forest class is not strictly comparable, the values seen in Fig. 8 suggest extensive areas at risk from ozone.)

## Referee #1

P. 12155, line 20: Can the difference for southern Europe also be due to the fact that not many data from southern Europe are in PAN, hence the model might not be favourable for southern European growing conditions?

## Reply

The differences in the calculations of POD are explicable in terms of the differences in SGS seen in Fig. 7(b). The referees query may concern more the accuracy of the data underlying the T5 model, and here the uncertainties will certainly be higher in southern than in northern Europe. We have added text on this into the Discussion section, where we also refer to the map of model-measurement differences produced in response to Ref #2:

Of course, there are many uncertainties associated with these calculations. The lack of data in southern Europe is one cause for concern: as can be seen in Fig. S1 very many of the observation sites are located in northern Europe. Although the data covers the latitude range of approx. 45-70 N, some areas (e.g. Finland or Netherlands) are particularly rich in data, whereas others (e.g. Spain) have no sites at all. This situation partly reflects our choice of a typical central &

northern European species, *Betula pubescens*, as our model species. Although Fig S1 suggests that that model-measurement discrepancies are similar in both the north and south of the region, the appropriateness of the T5 method for many other deciduous species needs to be investigated.

(We will extend this caveats section with further comments made below concerning the appropriateness of birch.)

## Referee #1

P. 12159, line 22: This sentence is misleading as a reduction of 50% mainly occurs in areas with low  $POD_{1,DF}$  where relatively little risk of ozone damage can be expected. In areas with high  $POD_{1,DF}$  and therefore a high risk of ozone damage, sometimes an increase has been observed, e.g. Portugal and the west coast of France. Therefore, the description by the authors should be more specific here (also the sentence should end with a full stop).

## Reply

Yes, we should have been clearer here. Some areas do indeed show increases and this point is as important as decreases. We do not completely agree that areas with low POD are of lesser interest. At first sight this seems reasonable, but European environmental policies have often aimed at reducing damage in relatively clean areas (e.g. Scandinavia) as well as in the more polluted ones. These areas are also often the ones which are heavily forested. We have anyway reduced the stress on % levels, and expanded the text, replacing the last line with:

The ozone flux metric,  $POD_{1,DF}$  decreased in most areas of Europe, showing largest decreases at high latitudes (e.g. Scandinavia, northern Russia) or at high elevations (e.g. the Alps). Although these areas have quite low base-case POD values, the levels are still appreciable and likely damaging for vegetation, and many of these areas are also heavily forested. On the other hand,  $POD_{1,DF}$  levels are increased in some areas (e.g. Portugal and the west-coast of France) by ca. 3-5 mmole/m<sup>2</sup>, and these areas were already experiencing some of the highest  $POD_{1,DF}$  values in the base-case.

## Referee #1

Figs. 8-10: For consistency and clarity, I suggest to use a similar colour scheme as in Fig. 6 and 7. That way at least the contrast in the (a) maps will be more pronounced (e.g. Fig. 10 (a) is now almost completely red).

## Reply

We have modified the colour schemes and/or levels to be more consistent.

## Technical corrections:

1. P. 12148, line 10: insert the word “decline” after temperature.

Reply: done

2. P. 12149, line 11: replace the word “extract” by “extracted”. Reply: done.

3. P. 12151, line 24; P. 12152, line 19 and 22: replace “2009” with “2010” and accordingly in the reference list. The 2010 version is the most up-to-date version and I assume this has been used here.

Reply: done

4. P. 12152, line 7: the 3 in DO<sub>3</sub>SE should be written as subscript.

Reply: done

5. P. 12152, line 7: the 3 in DO<sub>3</sub>SE should be written as subscript.

Reply: done

6. P. 12156, line 9: Start this sentence as follows: “The prediction of the surface annual average O<sub>3</sub> concentration by using the EMEP: : :.”

Reply: done

7. P. 12157, line 3: Start this sentence as follows: “On the other hand, the annual average O<sub>3</sub> concentration itself: : :.”

Reply: done

8. P. 12157, line 5: Replace the word “experiments” with “changes”.

Reply: done

9. P. 12157, line 8: semi-natural.

Reply: done

10. P. 12159, line 1: include the word “this” after “compared”.

Reply: done

11. P. 12160, line 5: replace the word “to” by “by”.

Reply: done

12. P. 12163: move the reference Loubet et al. up before LRTAP.

Reply: done

13. P. 12174, legend Fig. 4: the two stations marked in yellow do not seem to be visible.

Reply: These two points are almost hidden by proximity to the MAE=21.7 text (x,y points near 98, 140). Rather than changing the scales of all Figures to expose better these two points, we have modified the caption to point out the location of these points.

14. P. 12180, legend Fig. 10: Change to “Modelled values of (a) annual average O3 concentration (units: ppb)” : : .. in modelled O3 concentration when using...

Reply: done