Anonymous Referee #2
Received and published: 26 September 2012

The authors would like to thank the referee for their time and valuable comments, which we respond to below. The referee's comments are shown in *italics* whilst our response is in normal type.

Referee comment
The manuscript presented a comprehensive result based on a long-term monitoring of carbon uptake over 12 years. The data was valuable, the description of method was clear and appropriate, and interpretation of the results was reliable. I could not find any serious problems in the paper but the discussion was partly a little simple and weak. The authors would be able to strengthen the manuscript by revising the following parts.

Author response
We are pleased to note that the referee did not find any serious problems with the manuscript. We also acknowledge that the discussion could be strengthened further through addressing the issues that he / she has raised. A detailed description of the changes that have been incorporated into the revised manuscript is given below.

Referee comment
First of all, the inter-annual variations of NEP, GPP, and Reco were affected by several events significantly, and I would like to see more detailed and quantitative discussions on the effects of each event.

For example, the authors mentioned the "relatively high levels of solar radiation over the spring and summer months of 2009 and 2010", "GPP was reduced from the long term monthly mean (in 2009 and 2010)", and "in both years there was a major outbreak of defoliating moth caterpillars" in page 9679, lines16-19. Was there any possibility that the high solar radiation caused the outbreak of the insects?

Author response
We accept the referee's comments and a more detailed discussion on the significant climatic and biotic events have been incorporated in to the revised manuscript. Specifically we have provided more interpretation of the events that occurred in 2000 (high Reco & high GPP), 2003 (Europe wide drought year) and we have revised the text, providing a more detailed description and quantification.

Referee comment
Was there any possibility that the high solar radiation caused the outbreak of the insects?

Author response
Although we cannot rule out the possibility that high solar radiation caused the outbreak of the insects in 2009 & 2010, we have not found any literature backing this up this idea. The forest pest literature indicates that these defoliator species occurring at our site tend towards 'cyclic' population sizes, and while some climatic factors may have important effects, this will be mediated by numerous other influences such as numbers of predators, parasitoids and interspecific competition. The condition of the host plant is also crucial to the growth and survival of defoliating moth caterpillars and has been shown to be strongly linked to the degree of synchronization between larval emergence and bud burst. Furthermore, various studies (Du Merle and Mazet, 1983; Feen, 1970) have shown that the maximum overlap in these two events usually results in maximum survival and growth of the insects.

Referee comment
Could the reduction in LAI explain the reduction in GPP quantitatively?

Author response
The data in this paper suggest that the answer to this interesting question is 'no'; for example the point for 2010 with low LAI falls significantly below the modelled linear relationship between LAI and GPP for all 12 years presented in Fig 8b. However, this relationship is not very strong. So

we cannot discount that either one or more additional factors could be combining with low LAI to reduce GPP in these years. In a parallel paper to this one at the same study site (Mizunama et al., 2012) noted the occurrence in some oak trees of infection with oak mildew (*Erysiphe alphitoides* Griffon & Maublanc 1912) on regrowth following the defoliation by insects, which we suggest may be a contribution factor and we have modified our discussion to incorporate this suggestion.

Referee comment
Was there any change in Reco (temperature and soil water dependence on Reco) after the defoliation? How long did it take the recovery of the leaf area, GPP, and Reco after the event?

Author response
At the annual scale the years of defoliation did not differ significantly from the modelled linear relationship presented in Fig.7.Unfortunately we don't have any detailed time courses of leaf area within season to answer this point further.

Referee comment
What was the cause of year-to-year change in the peak LAI except for 2009-2010?

Author response
Whilst many studies have focused on the factors influencing the variation in LAI either between sites of the same species (e.g. Bequet et al 2012) or on LAI development rate within the same year (e.g. Bequet et al 2011), relatively little is still known about the factors influencing inter-annual variation of LAI within the same site and its effects on GPP (e.g. Granier et al. 2008). In species such as oak, the number and anatomy of leaves are determined during bud formation in July (Eschich et al 1989). It would therefore be reasonable to assume that the environmental and growing conditions in any given year are likely to have a significant effect on the number and viability of buds in the following year; we have not found evidence of such lag effects in the record presented here, but suspect even 12 years of data is too short to identify these where there are multiple drivers at the ecosystem net C flux level.

Referee comment
Secondly, the different temperature dependence on Reco (Fig. 10) seems interesting and more interpretation would be valuable. Was the difference explained only by the soil water content? How was the ratio of growth respiration and maintenance respiration of plants? After the dry season, did the temperature dependence of Reco recover immediately after the recovery of the soil water condition?

Author response
We accept the referee's comments that more interpretation about the differing temperature dependence on Reco would be valuable. In our revised manuscript we have therefore provided a more in depth analysis and have been able to account for more of the residual variation not explained the existing model (Fig.11).

As noted in section 4.2 in the absence of auxiliary measurements the separation of Reco into growth and maintenance respiration is not available from the method of flux partitioning presented here (Reichstein et al 2005).

Given the oceanic climate of the region, precipitation is relatively uniform in its distribution throughout the year (Fig. 3b), as such there is no clear and distinct wet / dry season.

Referee comment
Finally, since the interpretation of year-to-year change in carbon budget components was the essence of the manuscript, would it be possible for the authors to show more information by comparison with other sites in Europe? Could the authors show the patterns of year-to-year variations in the carbon budget components of nearby forests (or forests with similar dominant species in Europe) and discuss the amplitude and synchronicity in the response? Or was it possible to gain some information of year-to year change (or trend) in the productivity from the biometric based estimations (section3.5)?

Author response

We did discuss in section 4.2 the amplitude of the variation in NEP, GPP & Reco at our site compared to others with long-term records. We have strengthened this discussion in the revised ms. The question over wide spatial synchronicity in C flux variation is an interesting one, given other observations of regional interannual climate variation and influence on ecosystem processes (e.g. the north Atlantic Oscillation, Mysterud et al. 2003; Strailer & Stenseth, 2007), and the work identifying the effect of the European 2003 drought referred to in the paper. But as we discussed in the paper interannual variation in start and end of leafed period, although large, does not appear to be a key driver in our woodland. Unfortunately, as Table 6 illustrates there are very few comparable long term C flux sites in deciduous woodlands in Europe, although we have added the data for the Hesse, NE France, 40yr old beech site (Granier et al, 2008). Neither that study, nor the study by Pilegard et al (2011) in a 80-yr old Danish beech forest near Soroe showed any obvious synchronicity of annual NEP, GP or Reco values to those in our study over a similar time span, even when examined as residuals from any underlying linear trends. However, this is not unexpected given the differences in climate regime between our more oceanic site, and their more continental situations, and the mediating influence of species and soil types (as discussed, our site with wetter soil did not show a response to the European-wide 2003 drought) and stand age and other characteristics. The biometric-based estimates of growth have not been taken regularly enough to interpret year-to-year variation, and it would be a very difficult task to make precise enough estimates for the whole woodland area in the flux footprint, including understorey, to examine interannual variation in growth.

Referee comment

Specific comments: - Page 9678, lines 21-23; page 9679, lines 4-5: Are these values based on 'per day (d-1)' or 'par year (y-1)'?

Author response

Thank you: the units of the values should have been per year (y^{-1}), the revised manuscript has been corrected.

Referee comment

- Is there any evidence of spread of insect damage from one site (region) to another?

Author response

Unfortunately the spread of insect damage is not routinely monitored in the region surrounding the study site, so we do not have the data to comment on this.

References

Bequet , R., Campioli, M., Kint, V., Vansteenkiste, D., Muys, B., and Ceulemans, R: Leaf area index development in temperate oak and beech forests is driven by stand characteristics and weather conditions, Trees - Structure and Function, 25, 5, 935-946, 2011.

Bequet, R., Kint, V., Campioli, M., Vansteenkiste, D., Muys B., and Ceulemans, R: Influence of stand, site and meteorological variables on the maximum leaf area index of beech, oak and Scots pine, European Journal of Forest Research, 131, 2, 283-295, 2012.

Du Merle, P and Mazet, R., Stades phenologiques et infestation par Tortrix viridana L. (Lep., Tortricidae) des bourgeons du chêne pubescent et du chêne vert., Acta Oecol Oecol Appl 4:47-53 1983

Eschich, W., Burchardt, R., and Essiamah, S: The induction of sun and shade leaves of the European beech (Fagus sylvatica L.) anatomical studies, Trees 3, 1-10, 1989

Feeny, P: Seasonal changes in oak leaf tannins and nutrients as a cause of spring feeding by winter moth caterpillars, Ecology 51, 565-581, 1970

Granier, A., Breda, N., Longdoz, B., Gross P., Ngao, J: Ten years of fluxes and stand growth in a young beech forest at Hesse, North-eastern France, Ann For. Sci, 64, 704 (2008).

Mysterud, A., Stenseth, N.C., Yoccoz, N.G., Ottersen, G., and Langvatn, R. 2003. The response of terrestrial ecosystems to climate variability associated with the North Atlantic Oscillation. pp. 235-262. In: Hurrell, J.W., Belgrano, A., Ottersen, G., and Kushnir, Y., (eds). The North Atlantic Oscillations. Climatic significance and environmental impact. American Geophysical Union.

Mizunuma, T., Wilkinson, M., Eaton, E.L., Mencuccini, M., Morison, J.I.L. and Grace. : The relationship between carbon dioxide uptake and canopy colour from two camera systems in a deciduous forest in southern England. Functional Ecology (Accepted October 2012).

Pilegaard, K., Ibrom, A., Courtney, M. S., Hummelshøj, P., and Jensen, N.O.: Increasing net CO_2 uptake by a Danish beech forest during the period from 1996 to 2009, Agr. Forest Meteorol. 151, 934-946, 2011.

Reichstein, M., Falge, E., Baldocchi, D., Papale, D., Valentini, R., Aubinet, M., Berbigier, P., Bernhofer, C., Buchmann, N., Gilmanov, T., Granier, A., Grünwald, T., Havránková, K., Janous, D., Knohl, A., Laurela, T., Lohila, A., Loustau, D., Matteucci, G., Meyers, T., Miglietta, F., Ourcival, J. M., Rambal, S., Rotenberg, E., Sanz, M., Seufert, G., Vaccari, F., Vesala, T., and Yakir, D.: On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm, Glob. Change Biol., 11, 1-16, 2005.

Straile D & NC Stenseth (2007) The North Atlantic Oscillation and ecology: link between historical time-series, and lessons regarding future climate warming. Climate Research 34: 259-262 DOI: 10.3354/cr00702