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Interactive comment on "Competing effects of nitrogen deposition and ozone exposure on Northern hemispheric terrestrial carbon uptake and storage, 1850–2099" *by* Martina Franz and Sönke Zaehle

Anonymous Referee #2

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This study uses the O-CN terrestrial biosphere model to study the impacts of tropospheric ozone and nitrogen deposition, and their combined effect, on the terrestrial carbon budget of the Northern Hemisphere. Through a set of factorial model simulations results show that ozone damage causes a decrease in simulated GPP and land carbon storage that peaks at the end of the 20th century. During the 21st century however the ozone induced reductions in GPP and land carbon storage are projected to decline. Interestingly the positive effect of nitrogen deposition on plant growth is largely offset by ozone damage, and the authors conclude that "accounting for the stimulating

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effects of nitrogen deposition but omitting the detrimental effect of ozone can lead to an over estimation of carbon uptake and storage". This is an important study that aims to understand the physiological response of plants to the combined drivers of surface ozone, nitrogen deposition and atmospheric CO2 concentration, and how this affects GPP and the land carbon store. It is of interest and relevance to the wider scientific community. I have a few comments outlined below.

Abstract: What is the effect of N deposition on vegetation growth found in this study? The effect of N-deposition is a key part of the study, so it would be good to reflect that here rather than just focusing on the ozone impact.

Methods: Line 69: "Evaluated against biomass damage relationships observed in a range of fumigation/filtration experiments with European tree species (Büker et al., 2015; Franz et al., 2018)." And, Line 75: "The tunV C injury functions were calibrated to reproduce observed biomass damage relationships of 75 experiments with a range of European tree species in fumigation/filtration experiments (Franz et al., 2018)." - The biomass damage relationships are mentioned a lot, it would be good to give some more detail here. Which biomass damage relationships are used for calibration and which for evaluation? Need to make explicit to ensure model has not been evaluated against the same data used for calibration. A bit more detail in general would be good. For example, functions are available for high and low ozone sensitivity, different functions have been derived for vegetation in Mediterranean regions (Büker et al. (2015)), and what about functions for grasslands? Some discussion around which functions are used and how that choice affects the results is needed as this is what the results are based on. Line 76: "Contrary to Franz et al. (2018), the ozone deposition scheme described in Franz et al. (2017) is applied in the simulations here (D-model version in Franz et al. (2017))." - Why? What's the advantage of one over the other, and what is the significance of the D-model version? A bit more explanation and clarification would be good. Line 80: What are the PFTs? Line 145: more information on the model forcing is needed. What temporal and spatial resolution? Is there a diurnal cycle to

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the ozone forcing, for example, or is it a daily/monthly mean? What impact might this have on results? How was the ozone and nitrogen forcing produced? How does it compare to observations? Limitations introduced by the choice of forcing data should be considered and discussed at some point in the manuscript? For example, are the ozone and nitrogen forcing uncoupled from the meteorology and CO2 forcing, what are the implications of this? Is the land cover fixed and is the LAI prescribed or does the model evolve its own land cover and LAI? What does this look like (LAI and land cover), is the model giving a sensible LAI?

Results: Fig. 1 – I'm finding it hard to see the dotted line. Fig. 2 – the lines are difficult to see - the colour is too light. I can only see one line in each plot, but the captions says results are shown for RCP2.6 and RCP8.5? Fig. 8 – The colour scale could be improved for these absolute difference plots as it's hard to see clearly what's going on, for example around -50 0 50 for GPP with ozone damage it's hard to see what's increasing or decreasing and where there's no effect. (I'm starting to wonder whether the above might be down to my poor computer screen resolution!) Can Table 4 and 5 be combined for easier comparison of the effects of N deposition and 03 damage on GPP? Can current day estimates of GPP simulated by the model with the effects of O3 damage and N deposition be compared to observations or other GPP products such as FluxCom or MODIS to give some evaluation of model performance? A check that under current day climate the model behaves sensibly would increase confidence in the results.

Discussion: Section 4.1: What about N-deposition? How does the impact of N-dep on GPP and biomass simulated in this study compare with other studies? Line 374: What causes the regional hotspots of ozone damage? Is it due to hotspots of high ozone burden, or vegetation type or other environmental causes such as water availability?

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