We are grateful to the reviewer for their suggestions which have substantially improved this manuscript. We thank the reviewer particularly for their comments which have improved the clarity and readability of the manuscript.

Cook and others incorporate a new model meant to explicitly simulate the impact of ozone on plant nitrogen dynamics and apply it to wheat trials. The results are interesting with a nice and defensible finding that stay green varieties are likely to minimize ozone impacts, which tend to hasten senescence. The manuscript could benefit from a number of adjustments that would make it easier to read and more concise.

The abstract was rather terse and did not enumerate particular findings, quantitatively, that make the study unique.

We thank the reviewer for bringing this to our attention. We have modified the abstract to incorporate the novelty of the study as well as highlighting the key findings (Lines 13-15, 16-18, 20-21)

Please edit the manuscript for flow and redundancies: note for example 'Northern India' is used twice in 28-29.

We have identified and removed several redundancies throughout the manuscript:

- Northern India twice (formerly Lines 28-29 now lines 45-46)
- "Figure 1 provides an overview of which processes are included already in the DO3SECrop model, which processes will be included in the new N module, and which processes will be excluded" (formerly Lines 98-99) -> "Figure 1 provides an overview of processes already included in DO_3SE-Crop, those to be added in the new N module, and those which are excluded" (lines 116-117 of the revised manuscript)
- "As a result of accelerated senescence leading to diminished photosynthesis, less photosynthate is produced (Emberson et al., 2018)" -> "Diminished photosynthesis leads to lesser photosynthate production" (line 138 of the revised manuscript)
- "Wheat yields are reduced due to the reduced photosynthesis and reduced duration of grain filling" (formerly Line 134) -> "Wheat yields decrease due to reduced photosynthesis and grain filling duration" (line 151 of the revised manuscript)

The narrative is tied to the FAO's sustainable development goals, but ozone impacts to wheat is important regardless and becomes a bit of a distraction because the purpose of the manuscript stands alone: the importance of ozone to wheat yield and productivity.

We have modified the sentence (formerly lines 34-35) to remove reference to sustainable development goals but retain the emphasis on O_3 impacts on wheat yields and quality

Note usage errors like the rogue period on line 52.

We have identified the rogue and corrected the punctuation

67: 'possess the capacity to' -> 'can'. Emphasis on removing all unnecessary words and phrases will make the manuscript more succinct and impactful.

We thank the reviewer for bringing this to our attention, we have removed several unnecessary words and phrases to improve clarity of the manuscript:

- “culminate in reductions to” (formerly Line 41) -> “reduce” (line 60 of the revised manuscript)
- “the reduction in yield that occurs under stressors” (formerly line 51) -> “yield reductions under stressors” (line 70 of the revised manuscript)
- “remobilisation of proteins” (formerly line 52) -> “protein remobilisation” (line 71 of the revised manuscript)
- “It is important to understand the mechanisms” (formerly Line 53) -> “Understanding the mechanisms…. is crucial” (line 71 of the revised manuscript)
- “A drawback of experimental work is that it is time consuming …” (formerly Lines 57-58) -> “However, experimental work is time consuming…” (line 76 of the revised manuscript)
- “using fewer resources than would be required for experimental investigation” (formerly lines 60-61) -> “using fewer resources than required” (line 78 of the revised manuscript)
- “conversion factor, such as that from Mariotti, Tomé and Mirand (2008), to convert” (formerly Line 64) -> “conversion factor (e.g. Mariotti, Tome and Mirand (2008)) to convert” (line 82 of revised manuscript)
- “possess the capacity to simulate” (formerly line 67) -> “can simulate” (line 85 of the revised manuscript)
- “which could, in principle, be used to” (formerly Line 71) -> “which could be used to” (line 85 of the revised manuscript)
- “No model currently exists that includes the capacity to simulate the reduced remobilisation” (formerly Line 74) -> “Currently, no model simulates” (line 88 of the revised manuscript)
- “aid with” (formerly Line 97) -> “guide” (line 115 of the revised manuscript)
- “the response of the stomata” (formerly Line 104) -> “stomatal response” (line 125 of the revised manuscript)
- “which reduces” (formerly Line 104) -> “reducing” (line 125 of the revised manuscript)
- “causing damage to the” (formerly Line 106) -> “damaging” (line 126 of the revised manuscript)
- “The degradation of photosynthetic pigments by ROS” (formerly Line 108) -> “ROS degradation of photosynthetic pigments” (line 129 of revised manuscript)
- “The degradation of Rubisco by ROS” (formerly line 112) -> “ROS degradation of Rubisco” (line 133 of revised manuscript)
- “Accelerated senescence as a result of O_3 exposure can reduce the green leaf area available for photosynthetic reactions” (formerly Line 120) -> “O_3 induced accelerated senescence reduces the green leaf area for photosynthesis” (line 137 of the revised manuscript)
- “A larger proportion” (formerly Line 118) -> “more” (line 138 of the revised manuscript)
- “allocation of assimilate to flowers and seeds is prioritised in annual crops such as wheat” (formerly Line120) -> “annual crops, such as wheat, prioritise allocation of assimilates to flowers and seeds” (line 140 of the revised manuscript)
- “Generally, grain protein concentrations are increased under elevated O_3, resulting from a relatively smaller decrease in uptake and re-translocation of N relative to the O_3 induced decrease in grain dry matter” (formerly Lines 139-140) -> “Grain protein concentrations increase under elevated O_3, due to a smaller decrease in N uptake and re-translocation relative to the O_3-induced decrease in grain DM” (lines 158-159 of the revised manuscript)
- “to provide defence” (formerly Line 144) -> “defend” (line 163 of the revised manuscript)

- Approximately 5-10 days after mid-anthesis we see a reduction in grain DM accumulation for the higher O_3 concentrations (formerly Line 428-429) -> "Under higher O_3 concentrations, grain DM is reduced ~5-10 days after mid-anthesis." (lines 449-450 of the revised manuscript)
- "begins to be distinguishable" (formerly line 482) -> "are distinguishable" (line 494 of the revised manuscript)
- "Initially, there is a very rapid increase in grain N%" (formerly line 498) -> "Initially, grain N% increases rapidly (line 507 of revised manuscript)

Eq 1 and elsewhere: don't use the star in formal mathematical equations for multiplication, it has too many meanings (https://en.wikipedia.org/wiki/Asterisk#Mathematics)

We thank the reviewer for bringing this to our attention. We have now removed all use of "*" in equations and replaced them with the multiplication sign "x"

Table 1: just note in the legend that the parameters are unitless. There are also probably too many significant digits given realistic uncertainties.

We have removed the unit column of the table and stated in the legend that the parameters are unitless. We take the comment about parameter uncertainty. However, we cannot reduce the significant figures too much given the models sensitivity to these parameters. We now report the values to either 1 decimal place or 2 significant figures taking into consideration the sensitivity of the model to these parameters and the reviewers comment regarding uncertainties

What do the lightning bolts mean in figure 3?

We thank the reviewer for bringing this to our attention. We have modified the figure caption to explain that the lightning bolts represent the locations where O_3 affects N processes in the newly developed DO_3SE-CropN model (lines 264-265 of the revised manuscript)

320: 'that they were varied' -> 'between which they were varied'?

We have now modified the table caption to correctly explain this point (line 338 of the revised manuscript)

In Figure 4 and elsewhere, why do the 'simulated' variables have no uncertainty estimates?

Uncertainties in crop modelling are difficult to quantify and result from several sources. There are uncertainties associated with the input meteorological and O_3 concentration data used to run the model, associated uncertainties of the experimental data used for model parameterisation leading to uncertainty on calibrated model parameters. There will also be uncertainty due to the data availability and assumptions made during the calibration process. Finally, there will be uncertainty associated with the modelling processes themselves as it is not possible to perfectly replicate crop growth using a model (Chapagain et al., 2022). The most common method for identifying uncertainties is the sensitivity analysis (Saltelli et al., 2008), and the most commonly considered uncertainty source is the input data used (Chapagain et al., 2022). A sensitivity analysis identifying the variability in crop modelling outputs for DO_3SE-Crop that is attributed to differences in crop modelling inputs is underway and will also be published in TOAR2. As sensitivity and uncertainty analyses are complex, they are beyond the scope of the present study.

Chapagain, R. et al. (2022). Decomposing crop model uncertainty: A systematic review. Field Crops Research, 279 (June 2021), p.108448. [Online]. Available at: doi:10.1016/j.fcr.2022.108448.

Saltelli, A. et al. (2008). Global Sensitivity Analysis: The Primer. Chichester: John Wiley & Sons Ltd. [Online]. Available at: doi:10.1111/j.1751-5823.2008.00062_17.x.

345 and elsewhere: a time series figure of yield for different years could help the reader understand some of the variability involved.

We agree with the reviewers comment and have added an extra figure into the supplementary materials (Figure S5) which we refer the reader to in the text to aid with explanations of the variability in grain DM between years (lines 377-378 of the revised manuscript)

The Discussion makes some interesting points and is nice and upfront about the things that the model still struggles with. It could benefit from a bit more brevity if possible.

Based on prior remarks about redundancies and clarity, modifications to the discussion have been made (see response to prior comments). Further, we identified key areas in the discussion that could be summarised more clearly. The main sections that were edited are described below:

- Lines 432-445 in the original manuscript relating to drought stress effects on wheat DM accumulation profiles were summarised from 260 words to 163 words (lines 453-460 of the revised manuscript)
- Lines 461-473 in the original manuscript relating to simulations of grain N% were made more concise, reducing the word count from 271 to 218 (lines 475-485 of the revised manuscript)
- Lines 482-496 relating to profiles of grain N under O3 exposure were made more concise, reducing the word count from 286 to 229 (lines 494-510 of the revised manuscript)

I like the schematics, also in the appendix, that highlight what equations correspond to different processes.

We thank the reviewer for their kind comments regarding the schematics for the present work. We are pleased that they help convey understanding for the model.