Dear Editor,

We thank the anonymous reviewer for their assessment of our manuscript titled *Dwarf galaxy archaeology from chemical abundances and star formation histories*. We have taken their comments into consideration and updated the document accordingly. We believe these updates have markedly improved the quality of the manuscript. Significant changes to the text of the submitted manuscript are highlighted in red. We have copied the reviewer’s comments below alongside our responses, separated by horizontal lines, with notes pointing to where we have updated the text where applicable.

We also apologize for our delay in responding to this report and thank the reviewer for their patience.

Sincerely,

James W. Johnson, on behalf of the authors

From the reviewer:

- What is an alpha-element according to the H3 survey? Oxygen, Neon and Magnesium? To which percentage? Precise information on this should be provided in the paper. Now it is difficult for an audience of non-expert to appreciate and compare by themselves the results of other works with those presented here if no detailed information is provided on [alpha/Fe], which is one of the main observables in this research.

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Mg is by far the strongest tracer of the alpha elements in the H3 spectral window. The pipeline (MINESweeper) treats all of the alpha elements together, varying them in lockstep, in order to interpolate along the grid of isochrones and synthetic spectra. In comparison to other surveys (e.g., APOGEE), the H3 [a/Fe] ratio shows the strongest correlation with [Mg/Fe]. Because our chemical evolution models would also treat the alpha elements varying in lockstep with solar ratios, we would argue that it is accurate enough to simply interpret the measured [a/Fe] ratios as [Mg/Fe]. We have modified the text in section 5.1 to include this detail.

We thank the reviewer once more for raising this concern, because it has made it clear to us that the similarity between elements like O and Mg and mixing the two in our modeling can be troublesome for readers who are not experts in GCE models. However, [Mg/H] is always exactly [O/H] with how we have parameterized the yields and enrichment rates in our models (i.e., a metallicity independent yield from massive stars, and zero yield from all other sources). This equivalence is supported by both theoretical and observational arguments (massive star models predict the production of both is dominated by alpha-capture nucleosynthesis; [O/Mg] ~ 0 across all Galactocentric radii observed by APOGEE; e.g., Weinberg et al. 2019).

Therefore, the paper would be significantly more understandable to non-experts if we simply state that we model Mg throughout, so we have made exactly this change. This revision is no cause for concern for the reasons stated above ([O/H] = [Mg/H], and therefore [O/Fe] = [Mg/Fe]). Significant updates to this effect in the text can be found at the end of section 2 and near the end of section 4.1.

From the reviewer:

- I do not believe that the H3 survey measured alpha-element abundances with a mixture that exactly matches whatever Weinberg et al. (2017) meant for their y\_alpha. If so, how come? The model should be seen as assuming the exact same mixture of alpha-elements as the measurements of the H3 survey. The assumed (fixed) y\_alpha of the models would otherwise be seen as arbitrary and be subject to strong criticisms. Degeneracies are obviously strong if y\_alpha is let to change. The current strategy to assume a fixed y\_alpha (likely different from the H3 survey) without any physical reason might be improved by finding the combination of massive-star models and IMF that reproduce the assumed y\_alpha. The assumption of a constant y\_alpha vs metallicity could also be justified with some references to massive-star models to avoid strong criticisms, mentioning the specific chemical elements that constitute alpha here.

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Weinberg et al. (2017) focused on O, whereas H3 is most sensitive to Mg, as discussed above. Hopefully we have addressed this concern and removed the source of confusion by stating that we model Mg in this paper. Approximately metallicity-independent yields of O and Mg are discussed in Weinberg et al. (2017) as well, but this point is supported by massive star models that are already cited in the manuscript (Limongi & Chieffi 2018; Nomoto, Kobayashi & Tominaga 2013), especially when one considers the systematic uncertainties introduced by different treatments of, e.g., convection (e.g., Chieffi et al. 2001; Gil-Pons et al. 2022) and rotationally induced mixing (Frischknecht et al. 2016; Heger & Woosley 2010). See also Griffith et al. (2021) for extensive discussion of the model uncertainties in massive star nucleosynthesis models.

The overall normalization of nucleosynthetic yields in GCE models does not need to match that predicted by stellar models. Even if there were no significant sources of systematic uncertainties in stellar models or the IMF, observations suggest that a portion of supernova ejecta can be lost directly to a hot outflow. Chisholm, Tremonti & Leitherer (2018) and Cameron et al. (2021) measure outflow metallicities that are larger than that of the ISM, and both interpret the result as the outflow containing ejected envelopes that did not mix with the ambient gas. Because of this effect, the normalization of yields in GCE models may be some factor below that predicted by stellar models, but there is no way to know by how much.

Nonetheless, comparisons against stellar models are interesting from the standpoint of yield ratios. We have added a new section (5.5) that undergoes such an investigation and clarifies some of the above points (see also discussion below).

From the reviewer:

- It is not clear if the resulting y\_Fe from massive stars are physical given the assumed y\_alpha. For this reason, I suggest that the best-fitting value for y\_alpha / y\_Fe (with fixed y\_alpha and varying y\_Fe for massive stars) be compared against the results of the same massive-star models (and IMF) that can produce the right y\_alpha, to check that y\_Fe from massive stars is also in line with the assumed y\_alpha given the IMF.

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We have computed predicted [Mg/Fe] plateau heights from the resulting yields in the new section 5.5. Fig. 12 is also new in this version of the manuscript. Although the inferred [Mg/Fe] plateau is consistent with the Nomoto, Kobayashi & Tominaga (2013) models, what really dominates this comparison is the “oxygen-magnesium problem,” whereby Mg is underproduced relative to O in massive star models (see Griffith et al. 2022). This is a known problem affecting predicted abundance ratios at the factor of ~3 level. Therefore, although the investigation is worthwhile, we are unable to tell if the derived Fe yields are consistent between massive star models and our empirical inference as this discrepancy dominates the comparison.

Nonetheless, this underscores the utility of elemental yields that are empirically derived in a manner such as in this paper. The quality of our manuscript improved with this addition, so we thank the reviewer once more for raising this concern.

From the reviewer:

- Some alpha-elements like Si and Ca (also O!) have some contribution from SNe Ia. This is not included in the model. Might this change the conclusions?

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To our knowledge, the SN Ia production of O is negligible (though non-zero) compared to massive star yields, with the same being true for Mg. To demonstrate this for the referee, we have computed a handful of IMF-averaged yields of O and Mg with the same parameterization as, e.g., Weinberg et al. (2017), Johnson & Weinberg (2020), and Griffith et al. (2021). Griffith et al. (2021) presents stellar yields extending those of Sukhbold et al. (2016), but with forced explosions where they find a direct collapse to a black hole. We also take the Seitenzahl et al. (2013) SN Ia yields under their “N1” model with 2.2e-3 SN Ia events per unit mass of star formation as suggest by, e.g., Maoz & Mannucci (2012). These calculations predict massive star yields of O and Mg of 0.018 and 8.7e-4 solar masses produced per unit mass of star formation, respectively. The predicted SN Ia yields are 5.79e-5 and 8.8e-6, respectively, which is about two orders of magnitude lower than the massive star yields. This difference can be partially made up for by black hole formation, e.g., if one takes the yields as published by Sukhbold et al. (2016) and incorporates black hole formation, but it can only account for a factor of ~3 (we compute yields of 0.0056 for O and 1.8e-4 for Mg for this model).

However, one could absolutely use an approach such as ours to deduce the SN Ia component of elements like Si and Ca. We have added two sentences to our conclusions pointing out the possibility of these extensions to our methodology.