

We thank the reviewers for their constructive feedback. In the following responses, the reviewers comments are shown in black, our replies in blue, and any text added to the revised manuscript in red.

REVIEWER 1

The paper describes a study to characterise NO_x production from lightning in a specific region and time frame using various ground- and space-based instrumentation which is supported by various modelling and calculation techniques. The paper is incredibly detailed and clearly outlines all aspects of the study, although some further illustrations/schematics would be helpful as certain parts (particularly the method) can become confusing without something to refer too.

The inclusion of uncertainties is important, particularly as the research is essentially trying to cross-reference various measurements, and it relies on some basic assumptions which may not necessarily be true (although this is mitigated to some extent). Lightning phenomena varies widely across the world, and this one specific study in this location may not be representative of other types of storm systems / lightning cells elsewhere –

We thank the reviewer for these encouraging comments. As the reviewer noted, this study is focused on a particular region. We cannot be sure if the obtained relationships between the LNO_x PE and flash metrics are similar in other regions. However, we have included different types of thunderstorms by covering almost one year of data.

It may be worth discussing how this could relate to other similar systems or regions? It is, however, a very good step forwards and a very interesting and comprehensive study.

We thank the reviewer for this interesting suggestion. However, we think that using the obtained results to make assumptions of how thunderstorms in other regions would produce LNO_x is out of the scope of this paper. That would be a original study by itself and would need acquiring new lightning and atmospheric composition data.

A few minor specific comments:

Ln 14-15: The way the references are included here are a little confusing; one from 1947 (a book I cannot fully access) and another from 2007, with the sentence suggesting that NO_x from lightning has, over a period of 60 years, stayed relatively stable at about 10%. But this is not true as, currently, human-made NO_x sources are at around 70-80% but would not have been this high in the 1940s (the absolute amount of NO_x from lightning may not have changed, but the percentage will have). Maybe some recognition that the 10% is just what the LNO_x split is now but that, years ago, it likely had a much bigger split.

We made an effort to include all the most relevant references, starting from the first reference for the Zeldovich mechanism. The reference of 2007 is a highly cited review that includes a detailed description of how lightning produces NO_x. More modern references appear later in the introduction.

We do not claim that LNO_x has stayed relatively stable at about 10% for 60 years. We have rewritten these lines in order to make them clearer:

“Lightning produces nitrogen oxides (NO_x = NO + NO₂) by following the Zeldovich mechanism (Zeldovich et al., 1947). Lightning accounts for about 10% of total emissions of NO_x (Schumann and Huntrieser, 2007) in the atmosphere, producing between 2 and 8 Tg N in NO_x per year, or between 100 and 400 mol NO_x per flash.”

Ln 96: There is a large amount of text describing the methodology in great detail, but it may be helpful to include a schematic illustrating the ground-based networks and satellites used as a ‘quick reference’ – particularly as so many are mentioned and it is quite hard to understand exactly what data is associated with each specific instrument. This extends to including maps with the specific latitude and longitude ranges used both for the case study and from the modelling perspective.

We have added a new figure (Figure 1 in the revised manuscript) to be used as a quick reference for the methodology. We did not add any new map because it is already shown in previous Figure 1.

Ln 257: I can understand where the 311 moles of NO per flash has come from, but does the study not distinguish / can it not distinguish between CG and IC flashes? There is also an over-simplification in the reference quoted here (Price, 1997) – 1112 for CG is just ten times 111.2 for IC; it is quite an old reference which has been observed to be incorrect (and there are some recent publications on this). I appreciate that this is just utilising a number for a model, and that if it is incorrect, it is an incorrectness which is carried through and so relative comparisons can be made.

We have added this text in order to explain this:

“Previous studies have reported substantially different estimates of the amount of NO produced per lightning flash (Schumann and Huntrieser, 2007). In the present study, the specific choice of the absolute LNO_x production per flash is not expected to significantly affect our main conclusions, as our analysis focuses primarily on the relative variability of LNO_x PE among individual thunderstorms, rather than on its absolute magnitude. Therefore, while the assumed emission factor influences the absolute LNO_x concentrations simulated by WRF-Chem, it should have a limited impact on the relative differences in LNO_x PE between the selected storm cases.”