26 August 2024

Author's Response to Referees

Measurement report: In-flight and ground-based measurements of nitrogen oxide emissions from latest generation jet engines and 100% sustainable aviation fuel

Report #1, Submitted on 18 Aug 2024

Anonymous referee #3:

The measurements reported in this manuscript are important. The authors have reasonably addressed most of the comments/concerns raised except one on NOy vs NOx by reviewer #1.

RC1 comment 1: "A clarification is needed what is measured and reported in the specific sections and plots. From my understanding for all altitude measurements NOy is measured and reported for all ground level measurements NOx is reported. Since NOx ≠ NOy even at the engine exit (HONO can make up 6% fraction e.g. dx.doi.org/10.1021/es200921t) the actual reported data needs to be better described (or not labelled as NOx) throughout the manuscript. Maybe I misunderstood, but also then it needs a clarification."

In the response, the authors confirmed that NOy was measured for both in-flight and ground level measurements. They explained that "the emission indices for NOx are calculated by using the NOy concentration and the molar mass of NO2, assuming that only a small fraction of NOx is reacting to other reactive nitrogen oxides." The HONO/NOy fraction can be up to 6% based on Lee et al. (2011) and up to 3.6% according to Jurkat et al. (2011). The authors' calculation basically assumes NOx=NOy (Equ. 1), and they justify this by arguing that "fractions of HONO or HNO3 are assumed to be below the total uncertainty for in-flight EI(NOx) of 14%." The authors acknowledged that "by using NOy instead of NOx, EI(NOx) might be slightly overestimated."

It is unclear to me what is the NOx/NOy ratio for the engine studied in this study and how the ratio may vary with power setting (and fuel types). Since NOy was measured and this is a measurement report manuscript, I think that it is more appropriate to report the measured values as NOy. The authors can point out in the abstract and main text that NOx is expected to be close to NOy and the uncertainty/underestimation induced by treating NOy as NOx is likely small and within the measurement uncertainty.

Answer to Comment:

First of all, we like to thank the referee for his comment. Unfortunately, the NOx/NOy ratio cannot be determined with the methods used during ECLIF3 and we cannot determine how the ratio may vary with power setting or fuel types. In the paper, we always use NOy when relating to the measured species and EI(NOX) when we talk about the emission index as we specifically calculated the emission index from the NO2 molar mass according to definition. We hope the wording is very precise enough in this way.

To make it clearer and more understandable what is measured and how EI(NOx) is calculated, we added following sentence to section 2.1 In-flight NOy and CO2 measurement methods during ECLIF3, line 84: "The instrument offers no measurement of NOx or the NOx/NOy ratio."

And we added following explanation to section 2.4 Emission index calculation and plume definition, line 189: "During ECLIF3, only NOy and no NOx concentrations were measured aboard the Falcon. NOx concentrations are expected to be close to NOy and the fraction of nitrogen acids in the exhaust gas is

assumed to be smaller than the NOy mean measurement accuracy. Hence, all reactive nitrogen species in the exhaust are detected and related to the initial NOx emissions."