Estimates of non-traditional secondary organic aerosols from aircraft SVOC and IVOC emissions using CMAQ

Responses to Anonymous Reviewer #1

We thank the reviewer for providing thoughtful comments. We have responded to each comment below, and have noted the section number for each revision to the manuscript. Each comment by the reviewer is reproduced below, in bold type. Our responses appear below each comment, indented.

General comments: 1. Can the authors comment on the impact of fuel composition on the formation of SOA?

> Fuel composition (conventional vs. alternative fuels) can have a significant impact on the amount of SOA formed from aircraft emissions. To address this comment, we have added the following text to Section 1:
>
> "SOA production was approximately 1200 mg/kg-fuel at 4% power and 15 mg/kg-fuel at 85% power compared to 150 mg/kg-fuel and 70 mg/kg-fuel for secondary sulfate and 35 mg/kg-fuel and 40 mg/kg-fuel for primary PM emissions (Miracolo et al., 2011). These values are based on conventional JP-8 jet fuel, which contain significantly more aromatics (17% by volume) compared to Fischer-Tropsch (FT) synthetic jet fuel (0.7%) and hydrotreated esters and fatty acids biojet fuel (0.3%) (Moore et al., 2015) and produce 20 times more SOA than FT jet fuel or 2 times more than a 50:50 blend of FT and JP-8 jet fuels (Miracolo et al., 2012)."

Specific comments:

pg. 30673. Ln 17,18 - This sentence is not clear. Please rephrase.

> The original sentence found in section 2 has been rephrased to:
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> "Note, that while a number of studies have measured PM from aircraft, those studies either report total PM (Herndon et al., 2005, 2008; Mazaheri et al., 2008), total primary vs. secondary PM (Lobo et al., 2012), or organic 140 carbon in the near field (1-50 m) of the aircraft engine (Agrawal et al., 2008; Kinsey et al., 2010;Timko et al., 2014)."

pg. 30675. Ln 23,24 - Recent studies, e.g. Stettler et al., 2013 have indicated that FOA 3 underestimates aircraft elemental carbon emissions by a factor of 2.5-3. Have the authors taken this into consideration?

> We did not account for FOA3 underestimates of elemental carbon (EC) in this work but would not expect EC emissions to impact modeled predictions of SOA. Additionally, we are preparing a separate manuscript from a follow-on study that incorporates the aircraft SOA parameterization from this study with alternative PM estimates to FOA3. We have revised the manuscript to note the

limitations of FOA3 and indicate the need for future work. The relevant text found in Section 2 now reads:

"…primary PM emissions were based on the First Order Approximation v3 (FOA3) (Wayson et al., 2009). Primary organic emissions were treated as non-volatile, consistent with the assumption used by FOA3. Also, this prevents any possible double counting of NTSOA, as VBS in CMAQ converts a portion of volatile POA (SVOCs) to SOA. However, measurements collected by Presto et al. (2011) indicate the majority of aircraft POA emissions are semi-volatile. Furthermore, comparisons against measurements have shown FOA3 estimates of POA and elemental carbon (EC) vary by an order of magnitude for 40% of aircraft engines (Stettler et al., 2011), suggesting alternative estimates of aircraft PM emissions, which include a semi-volatile treatment of aircraft POA emissions, should be considered in future studies."

pg. 30677. Ln 21-27 - Although the CFM56 family of engines is widely used, differences between older technology (CFM56-3B) and newer technology (CFM56-7B) engines have been reported in the literature, with older technology engines exhibiting higher emissions. The authors should comment on the implications to this work.

We agree that engine technology can serve an import role in the magnitude of emissions. Our approach to normalize SVOC and IVOC emission factors by ICAO-reported hydrocarbon emission factors is meant to, at least, partially, mitigate these differences. To address this comment, we have revised the text in Section 2 as follows:

"It should be noted that applying a normalized EF for SVOC and IVOC emissions from all aircraft based on a single engine type introduces some uncertainty as the CFM56-2B engine is primarily used for military aircraft and represents older technology with higher emissions than newer, more efficient engines. That said, the CFM56 engine family was used on approximately 20% of commercial U.S. flights in 2006 and normalizing SVOC and IVOC emission factors based on ICAO-reported hydrocarbon emission factors is meant to, at least partially, account for differences in engine type and technology. Without the normalization, we would expect the SVOC and IVOC emission estimates to be biased high and future work is needed to test if a bias, either high or low, remains after normalization. At this time, limited data currently exist on SVOC and IVOC emissions from other engines and therefore we consider this an acceptable means to approximate emissions for this work."