Comments are in black and responses in blue.

Response to Reviewer #1

This paper aims at quantifying terpenoid mixing ratios and emission rates of dominant vegetation in northern Alaska. The authors have intensively compared their data with the published data from northern Sweden and Greenland and derived site-specific temperature response curve. This paper is well written and the data from this paper can provide base quantification of BVOC emissions from this less-studied area.

Thank you for the positive feedback. Our responses to the specific comments are provided below.

A variety of measurements have been used in this paper and I, as a modeler, will leave the measurement part to other reviewer(s). My main concern of this paper is that the mixing ratio measurements are not much linked to the emission rate measurements. It is a lot of data presented (which was good), but I think the authors should bring these data together to present a whole story.

We agree with the reviewer and have tried to better link the mixing ratio measurements to the emission rate measurements in the revised manuscript. We have, for instance, made the following additions:

"It is worth noting that the most frequently observed compounds in enclosure samples are among the most frequently seen MT in ambient air (see Section 3.1.3)".

"Regardless of the vegetation type, isoprene emission rates exhibited a significant diurnal cycle with an early afternoon maximum, in line with the mean diurnal cycle of enclosure temperature and PAR. These results are in line with the well-established diurnal variation of BVOC emissions in environments ranging from Mediterranean to boreal forests (e.g., Fares et al., 2013; Liu et al., 2004; Ruuskanen et al., 2005; Zini et al., 2001) and with the correlation between isoprene ambient air mixing ratios and temperature at TFS (see Section 3.1). (…) As can be seen in Table 3 and Fig. 8, PAR and BVOC emissions significantly decreased at night but were still detectable. These sustained BVOC emissions during nighttime confirm observations by Lindwall et al. (2015) during a 24-hour experiment with five different Arctic vegetation communities and explain the higher isoprene levels observed in the nocturnal boundary layer than above during the diurnal balloon experiment (see Section 3.1.2)."

Then, another part is about comparing emission ranges with literature values. The measurement conditions could vary largely and also in different periods of growing season. It is difficult to directly conclude that the measurement values are in the range of published values. I think standardized emission rates (using commonly-used Guenther algorithm) are needed in this case.

We totally agree and have used standardized emission rates (when possible/appropriate) in the revised manuscript (see below). We have also added the average enclosure temperature for each emission rate reported in Table 3.

"A branch enclosure experiment was performed from July 27 to August 2, 2018 on *Salix glauca* to investigate BVOC emission rates per dry weight plant biomass (see Fig.S.I.5). Isoprene emission rates ranged from <0.01 to 11 µgC/g/h (with a mean enclosure temperature of 16.5°C and mean PAR of 880 µmol/m^2/s), in line with non-normalized emission rates reported at Kobbefjord, Greenland by Kramshøj et al. (2016; Supplementary Table 5) for the same species under slightly different environmental conditions (mean temperature of 24.6°C and mean PAR of 1052 µmol/m^2/s). Once standardized to 30°C and 1000 µmol/m^2/s, our emission rates averaged 5 µgC/g/h, in good agreement with standardized emissions reported at Kobbefjord (mean of 7 µgC/g/h) by Vedel-Petersen et al. (2015)."

"The isoprene surface emission rate, as inferred from surface enclosures, was highly variable and ranged from 0.2 to ~2250 µgC/m^2/h (see Fig. 6). The 2250 µgC/m^2/h maximum, reached on June 26, 2019, with an enclosure temperature of 32°C, is higher than maximum values reported at TFS by Potosnak et al. (2013) (1200 µgC/m^2/h at an air temperature of 22°C). It should be noted that these maximum values were observed at different ambient temperatures; we further investigate the temperature dependency of isoprene emissions in Section 3.3. Elevated surface emission rates (*i.e.,* > 500 µgC/m^2/h) were all observed while the vegetation in sampling enclosures was dominated by *Salix* spp.. At TFS, the overall 24-hour mean isoprene emission rate amounted to 85 µgC/m^2/h, while the daytime (10 am-8 pm) and midday (11 am-2 pm) means were 140 and 213 µgC/m^2/h, respectively. To put this in perspective, the average isoprene surface emission rate standardized to 30°C and 1000 µmol/m^2/s (~ 300 µgC/m^2/h) was an order of magnitude lower than emission rates reported for warmer mid-latitude or tropical forests."

Here are some detailed comments:

Introduction: I would think one to two sentences could be needed to justify the importance of studying BVOC emissions on impacting atmospheric chemistry from

this less-polluted arctic region. Then I think the aim of this study should be elevated, so what are the main aim of this study apart from quantifying emissions and mixing ratios.

We thank the reviewer for these suggestions. We have made the following changes in the revised manuscript:

"Changing BVOC emissions in the Arctic due to climate and land cover shifts can thus be expected to perturb the overall oxidative chemistry of the region. Previous studies have hypothesized that BVOC might already impact the diurnal cycle of ozone in the Arctic boundary layer (Van Dam et al., 2016). Changing BVOC emissions can also further affect climate through various feedback mechanisms; Quantifying these changes requires an accurate understanding of the underlying processes driving BVOC emissions in the Arctic" (…). "The data presented here provide a baseline to investigate future changes in the BVOC emission potential of the under-studied Arctic tundra environment. Due to increasing shrub prevalence across northern Alaska, as well as the Eurasian and Russian Arctic, the results of this study have significance to tundra ecosystems across a vast region of the Arctic".

L52-53, the field warming increases of BVOC emission is not only seen with long-term warming but also found with a short-term field warming like 3 years in the same area.

We have replaced "Long-term field warming studies" by "Field warming studies" in the revised manuscript. Thank you for pointing that out.

L97, please describe the start and end of a normal growing season for this site.

We have clarified this in the revised manuscript: "These two back-to-back campaigns cover the entire growing season, from the onset of snow melt mid-May to the first snow fall mid-August".

Table1 Rhododendron tomentosum seems the 2nd highest covered in this area and why not present emission from this species separately?

Rhododendron tomentosum was indeed present in most of the surface enclosures but was difficult to study separately due to low individual plant biomass.

Fig. 3, I have a bit difficulty to find all measurements points at different heights. Suggest to use more distinguishing colors combining with different symbols.

We assume the reviewer actually refers to Figure 5 (vertical profiles with the tethered balloon). We have updated this Figure in the revised manuscript (see below; one panel per balloon flight) to make it easier to distinguish measurement points at different heights.

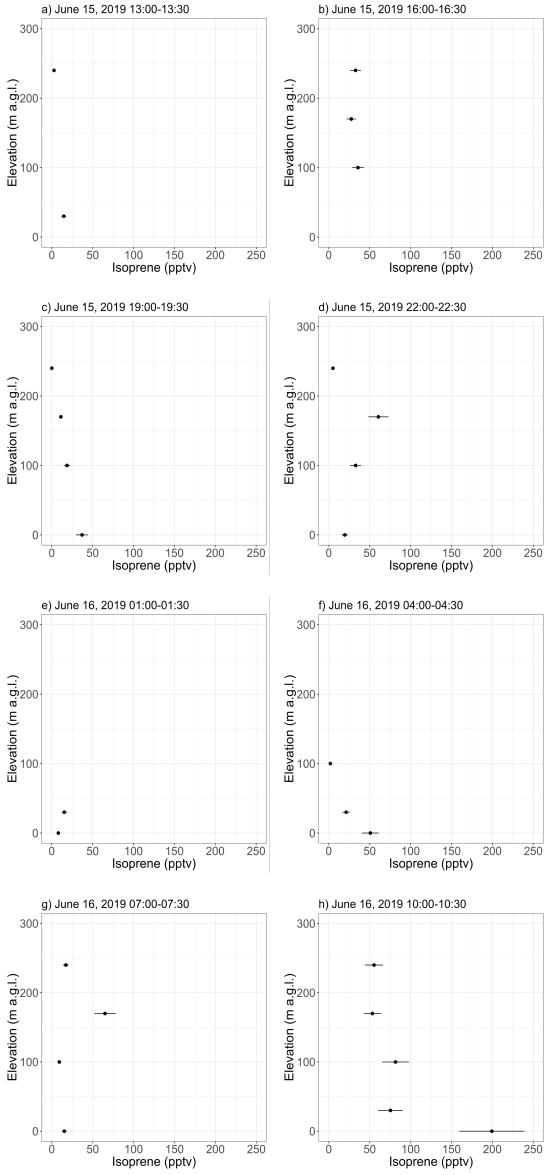

Figure 5: Vertical profiles of isoprene mixing ratios as inferred from 30-min samples collected with a tethered balloon. The error bars show the analytical uncertainty for isoprene (20 %). Samples with an isoprene mixing ratio lower than blanks were discarded. Hours are in Alaska Standard Time (UTC-9).

L362, as far as I know, Cassiope tetragona is also a MT emitter.

Thank you for this suggestion; *Cassiope tetragona* is included in "other high Arctic vegetation".

L372-L380, how valid it is to state that the values are in the range of published values if focusing on the emission rates potentially measured at very different temperature and light conditions. I would suggest comparing the standardized emission rates with other studies if possible.

See response to main comment #2.

L435, What does this mean "account for differing leaf area. . ."? This is the emission rate of the per ground area, right? Please clarify.

We have replaced "leaf area" by "total biomass" in the revised manuscript.

L436, If dividing all fluxes with the standard emission rates at 20 degree, then it gives a multiplication of environmental responses (unit-less). As PAR is measured in the chamber, why not take away the light variation part before only looking at temperature response curve? Then about Fig. 9, how did you deal with the MEGAN temperature response curve, as I did not see the normalized emission rate to 1 around 30 degree?

We followed the same methodology as in Tang et al. (2016) and only used daytime observations with relatively high PAR values. Figure 9 thus only represents the isoprene emission-temperature relationship. This has been clarified in the revised manuscript: "Figure 9 combines daytime (e.g., with relatively high PAR values) isoprene emission rates from different surface enclosures".
Please note that the MEGAN temperature response curve was also normalized by dividing all fluxes by the mean emission rate at 20°C.

L464-L468, MEGAN uses leaf temperature, not ambient air temperature for emission estimations. With predicted strong increase of air temperature in the Arctic, it still remains largely unknown (interesting to know) how plant leaf temperature can change and thus impact on BVOC emissions. I think it is important to have this in the discussion context.

Thank you for raising this important point. We agree that it is important to have this in the discussion and have added the following paragraph in Section 4.2 of the revised manuscript:

"Over the course of the two field campaigns at TFS, BVOC surface emission rates were measured over a large span of enclosure temperatures (2-41°C). While isoprene and MT emissions respond to leaf temperature (Guenther et al., 1993), air temperature was used here in place of leaf temperature – which has been assumed before in the literature for high-latitude ecosystems (e.g., Olofsson et al., 2005; Potosnak et al., 2013). Several studies have, however, suggested a decoupling of leaf and air temperature in tundra environments (Lindwall et al., 2016; Potosnak et al., 2013). With predicted increase of air temperature in the Arctic, it still remains largely unknown how leaf temperature will change and impact BVOC emissions. As suggested by Tang et al. (2016), long-term parallel observations of both leaf and air temperature are needed. The response of BVOC emissions to temperature discussed here should be interpreted with this potential caveat in mind."