Response to Referee

RC1: 'Comment on amt-2024-25', Anonymous Referee #1, 26 Mar 2024
This study proposed and established a technical framework based on the lidar and photogrammetry carried by drones, utilizing image recognition technologies to identify plant species to obtain accurate BVOCs emissions. It is expected that the combination of the Lidar characterization technology, the identification technology of tree species, and the tree-species emission factor database could create a new way to accurately quantify the biogenic emissions over a large region. However, in current form, details of technique and the uncertainty discussion are somewhat less satisfactory for AMT journal. In addition, the language of this manuscript need refinement. Overall, I suggest providing more information on method descriptions and uncertainty sources before the manuscript can be accepted. Specific suggestions are listed below.

Thank you for the reviewer's comments and suggestions. We have made significant revisions to the paper according to the reviewer's comments. Specific point-to-point modifications, such as subsequent blue font text and corresponding difference files.

Line 127: What does the 'forest gap' mean? Why is it needed to avoid the gap?

Thank you for the comments. This is the problem caused by our unclear expression when translating into English. The original meaning here is as follows: the airborne lidar we use needs to first complete inertial guidance to ensure surveying accuracy, and usually needs to fly out of a circular shape during takeoff. However, on the underlying surface of the forest, there are various restrictions on the landing site of drones, the most prominent of which is that the forest canopy is too dense, which poses a risk of crashing during the landing process. At this point, it is necessary to find a "forest gap" to reduce this risk. And the forest gap is generally choosing as a tomb, ridge, or other natural bare ground. This situation also restricts the application of this method in forests in different regions.
We revised this part as follow:
"It is worth noting that in forest areas, due to the dense layers of trees, there are significant risks during takeoff and landing, so it is usually necessary to find a suitable landing location. We usually choose the location at the "forest gap", which is usually a tomb, ridge, or other natural bare ground. At the beginning of the takeoff phase, we used manual operation to avoid trees near the forest gap to reduce the risk of a crash, while completing inertial guidance for the IMU. After the takeoff reaches the specified height, it changes to automatic flight."

Method 2.4: Since the drone would obtain large number of photos on different terrain and elevations, it is important to reconstruct the whole targeted area from each photo and avoid the replicated identification of every single tree. Please provide more details on how to combine the information of individual tree location from lidar data with photo taken.

Thank you for your suggestion. We also believe that this is important to reconstruct the whole targeted area from each photo and avoid the replicated identification of every single tree in the process of identifying. Therefore, we adopted a relatively mature airborne LiDAR method to first obtain a large number of laser point clouds, and then perform single tree segmentation based on layer stacking algorithm. The principle of this algorithm is to first obtain the seed points of each single tree and then find its watershed (Li et al., 2012). This single tree segmentation technique has been widely used in various forestry projects based on airborne LiDAR. At the same time, we fuse and concatenate the airborne visible light image into a complete image raster data, and then segment it based on the boundary layer of single tree segmentation. The specific parameter settings for our airborne image data processing are shown in the table below. We have also supplemented the paper according to your suggestions.

Table 1 The specific parameter settings for airborne image data processing

Parameter	Value	Unit
Ground sample distance	7.2	cm
Overlap in flight direction	85%	-
Side overlap	60%	-
Aera Coverd	0.372	km^2
Mean absolute geolocation variance	0.0138-0.0361	cm
Mean point density	42.6	$point/m^2$

Methods: Although this study provide an innovative method to recognize BVOC emission from drone-based lidar and camera, details of specific techniques used here still require further clarification, for example, how to design the flight route, the lidar data processing and the algorithm of identifying tree species.

Thank you for the reviewer's suggestions. We fully agree with the reviewer's view that the focus of this study is to provide a new methodological framework for estimating BVOCs emissions, which integrates multiple relatively mature methods from different scientific fields. Therefore, the details of each technology were not previously presented. For example, designing automatic drone routes based on the scope of the research area is already built-in in DJI's software, and corresponding professional software has been developed for processing airborne lidar and identifying tree species, respectively. Thus, we provide additional setup details and discussion of them in each related section of route design, lidar data processing, and methods for identifying tree species.

Discussion 4.1: The authors presented several types of uncertainty sources. Then it is curious for readers to know the dominant uncertainty and the exact uncertainty level. In addition, authors could propose some possible solution and research directions to mitigate these uncertainties on emission estimation.

Thank you for the reviewer's suggestions. We also believe that the lack of direct quantification of uncertainty levels for each source is a major issue in this paper. We believe that this is caused by two factors. On the one hand, the entire technical framework process is too long, with a considerable number of unknown or random sources of uncertainty. On the other hand, the uncertainty of some source is difficult to verify or lacks quantitative method. However, we fully agree with the reviewer's suggestions on providing some solutions or research directions to mitigate these uncertainties on emission estimation, so we have added corresponding discussions in the paper.

Another uncertainty of this method could come from the emission of vegetation below the tree canopy which cannot be detected by lidar or photo. I suggest providing some algorithm to approximate those emissions or at least carry out some sensitivity test.

We fully agree with the reviewer's suggestion. Yes, the vegetation below the forest canopy also emits a considerable amount of BVOCs. Although airborne LiDAR can detect their presence through leaf gaps, visible light images cannot obtain their information due to canopy occlusion, making it an important source of underestimation of BVOC emissions for this method. It may be possible to try using lateral aerial photography or airborne multi-band enhanced penetrating LiDAR technology to achieve detection and modeling recognition of understory plants. Thank you for the reviewer's suggestions. We have added them to the main discussion. And we are also deploying corresponding sensitivity flight tests, but this may require further design and positioning measurements to be achieved.