Response to comments

Paper #: essd-2019-200
Title: Development of a global 30-m impervious surface map using multi-source and multi-temporal remote sensing datasets with the Google Earth Engine platform
Journal: Earth System Science Data

Reviewer #3

This paper presents a new global 30m impervious surface map produced with multi-source and multi-temporal remote sensing datasets and random forest (MSMT_RF). Compared with the currently available impervious products (i.e., GlobeLand30, FROM_GLC and NUACI), this MSMT_RF-based product has higher overall accuracy and kappa coefficient, which are 96.6% and 0.90, respectively. The superiority of the MSMT_RF-based product stems from two significant innovations of the method proposed in this study. First, multi-source and multi-temporal remote sensing data are combined to produce the impervious surface map. The comprehensive information provided by the combined data is useful in classifying land cover types, so the superiority of the MSMT_RF-based product in comparison with the other products is convincing. Second, a novelty method is proposed for selecting training samples based on the available impervious product and VIIRS NTL and MODIS EVI imagery. This method allows for the fully automatic selection of training samples to avoid manual training sample selection, which is time-consuming and laborious, especially at a global scale. This method has significant implications for producing more perfect global data products based on existing data products. I believe this study is a breakthrough over previous works in impervious surface mapping and will appeal to a broad readership. However, there are still some minor issues that should be addressed before final publication.
Great thanks for the positive comment. The manuscript has been improved according to your and other reviewers' comment.

Line 35, "urban the environment" should be "urban environment"
Great thanks for the comment. It has been corrected.

Figure 1, I cannot see the blue rectangles but only black points, which are supposed to be the blue rectangles. The authors should figure out how to make blue rectangles clear.
Great thanks for the comment. As we re-selected the validation regions based on the impervious landscapes, the new spatial distribution figure was changed as:

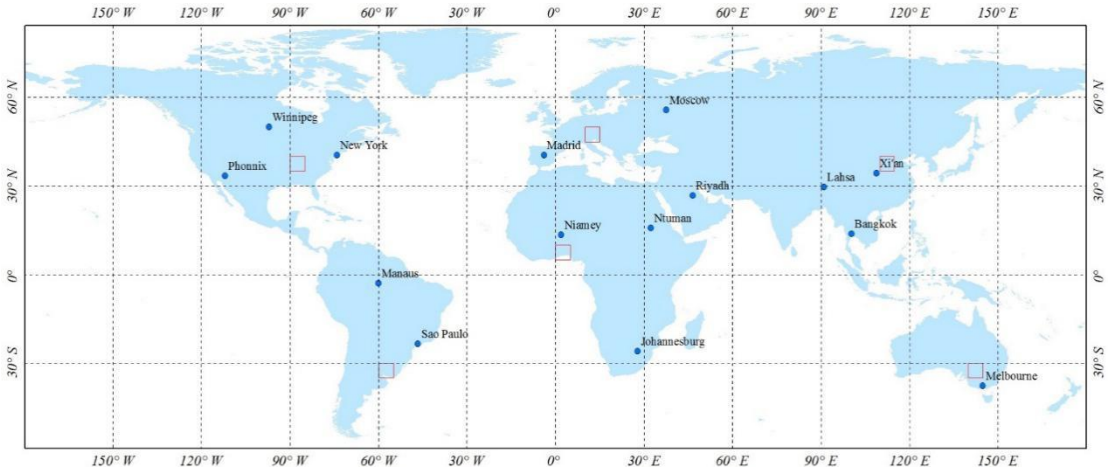


Figure 1: The spatial distribution of the fifteen validation regions (blue) corresponding to regions of different impervious landscapes on different continents together with the six 5° ×5° validation regions (red) used to measure the variable importance.

Why did the authors select training samples based on Globe30 product but not FORM_GLC, which is also a 2015 product and seems to be more appropriate? Please elaborate.

Great thanks for the comment. The reasons why we chose the GlobeLand30 instead of FROM_GLC have been added as:

"The GlobeLand30 land-cover product was used to derive global training samples because it had many advantages including: (1) the impervious surface layer in GlobeLand30 was accurately developed by combining the pixel-based classification, multi-scale segmentation and manual editing based on high resolution imagery and validated to achieve an user's accuracy of 86.7%; (2) it simultaneously contained the impervious surface and other land-cover types similar to impervious surface (such as cropland and bare land), so the global training samples including several non-impervious land-cover types could be easily collected to build the RF model for accurately mapping of impervious surface."

Figure 5, please provide the label of axes.

Great thanks for the comment. The label of axes were added as:

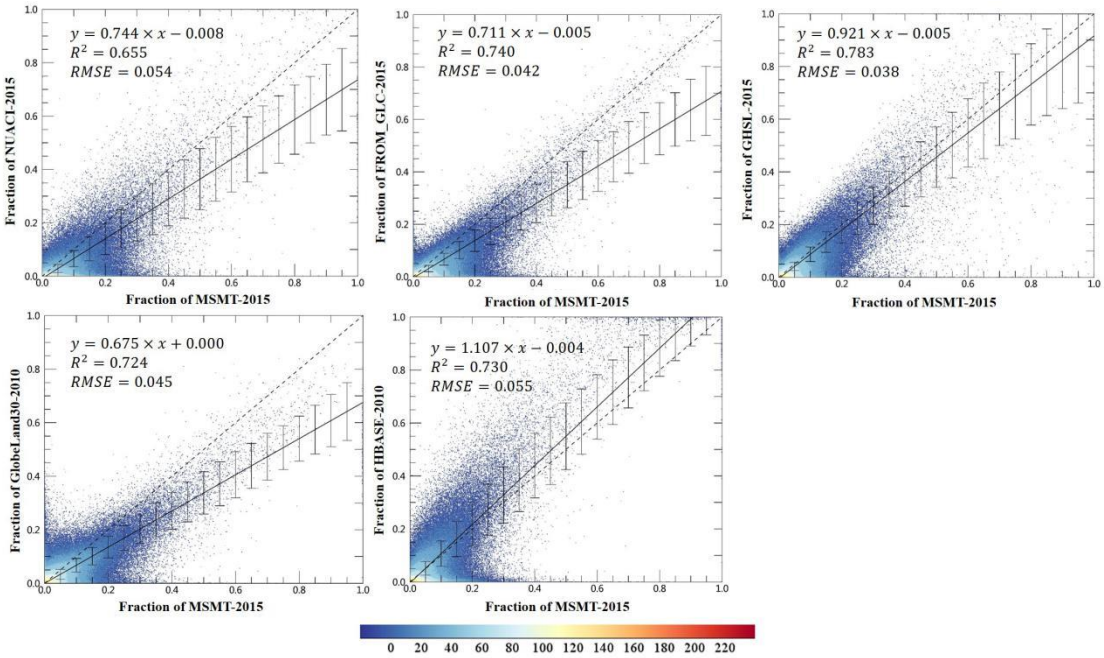


Figure 8: Scatter plots between the MSMT_RF-based impervious map and the GlobeLand30-2010, FROM_GLC-2015, NUACI-2015, GHSL-2015 and HBASE-2010 global impervious surface products at a spatial grid of 0.05°×0.05°. The error bars were the standard deviation between reference datasets with fitted results.

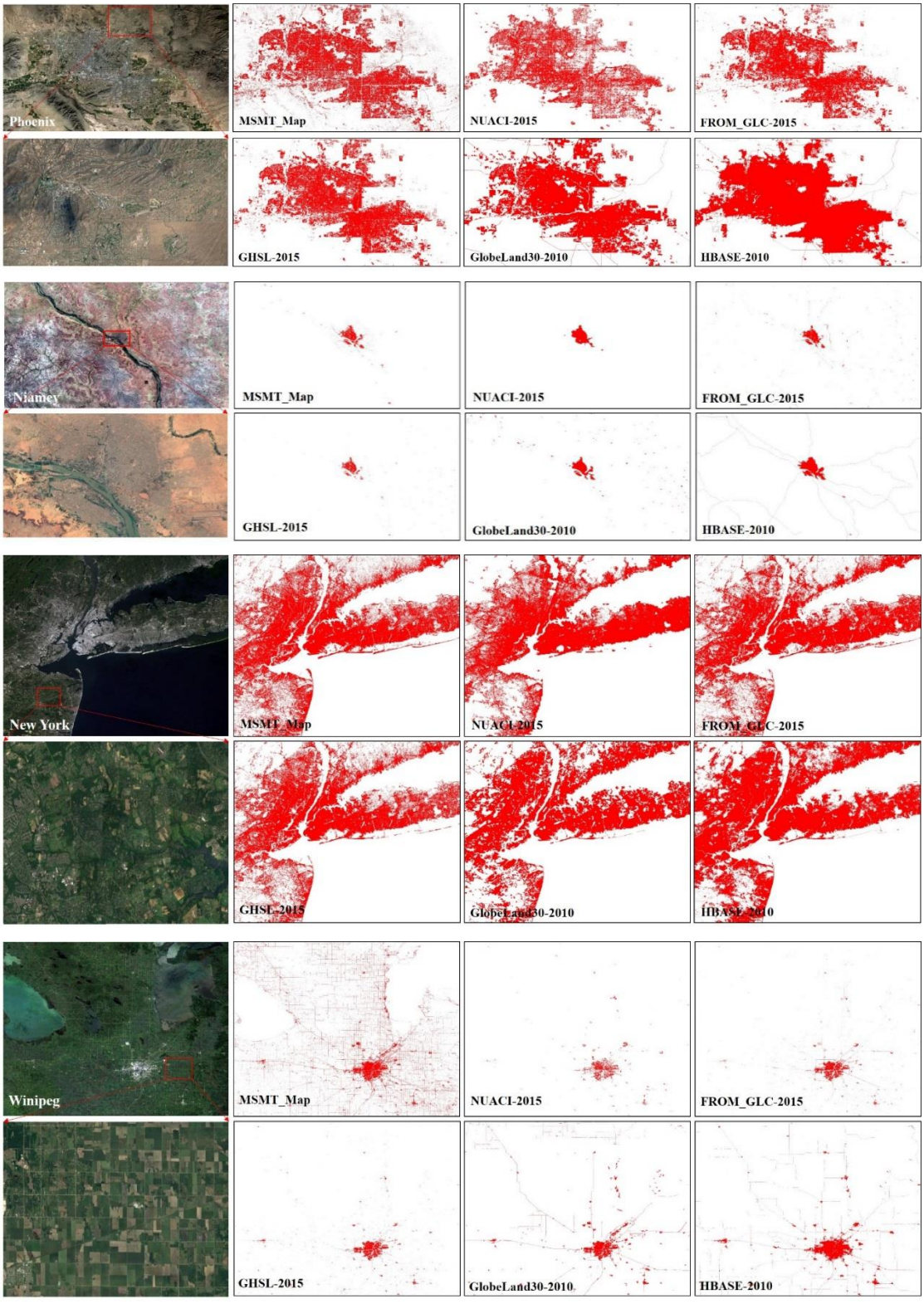
Table 2. How the different categories, e.g., high, low, medium, are defined? Are they defined quantitatively or subjectively? Please elaborate.

Great thanks for the comment. The impervious surface density (low, medium and high) was defined by combining the histogram of impervious areas at 0.05°×0.05°. In the revised manuscript, we re-selected the validation regions through the land-cover landscapes according to the suggestion of Reviewer 1. Specifically:

"To quantitatively assess the performance of the global impervious surface map, fifteen validation regions, covering different continents and various urban landscapes (the bare soil prevalent cities: Phoenix (PNX), Madrid (MDR), Riyadh (RYH), Niamey (NIM), Johannesburg (JHB), Ntuman (NTU) and Lhasa (LHS), vegetation prevalent cities: New York (NYK), Manaus (MNS), Moscow (MSC), San Paulo (SPL) and Melbourne (MBN), as well as cropland prevalent cities: Winnipeg (WIP), Bangkok (BGK) and Xi'an (XAN)), were selected."

Figure 6. I suggest the authors to provide the location information (e.g., city name or latitude-longitude grid) of these areas. It will allow readers to check ground truth in Google Earth.

Great thanks for the comment. The city names were added as:


Phoenix
MSMT_Map
NUACI-2015
FROM_GLC-2015
GHSL-2015
GlobeLand30-2010
HBASE-2010
Niamey
MSMT_Map
NUACI-2015
FROM_GLC-2015
GHSL-2015
GlobeLand30-2010
HBASE-2010
New York
MSMT_Map
NUACI-2015
FROM_GLC-2015
GHSL-2015
GlobeLand30-2010
HBASE-2010
Winipeg
MSMT_Map
NUACI-2015
FROM_GLC-2015
GHSL-2015
GlobeLand30-2010
HBASE-2010

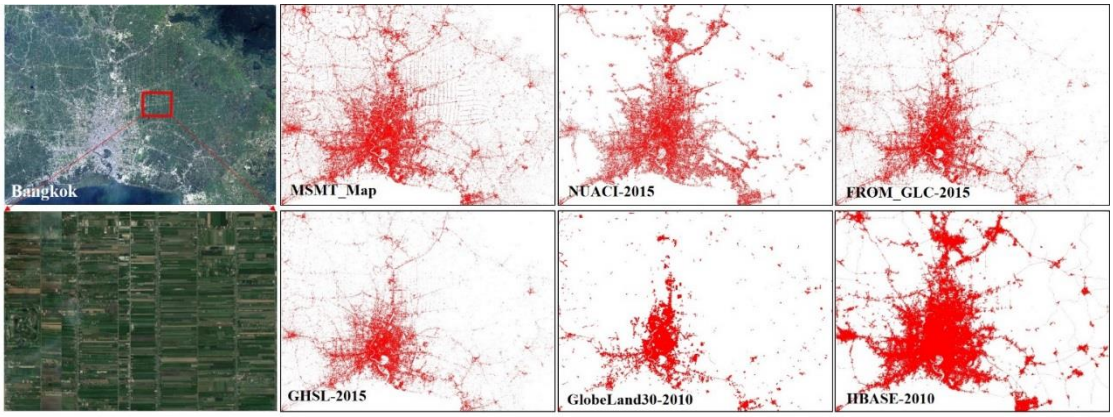


Figure 9: Comparisons between the MSMT_RF-based maps and other impervious surface products (corresponded to the NUACI products developed by Liu et al. (2018), the FROM_GLC products developed by Gong et al. (2013), the GHSL products developed by Florczyk et al. (2019), the GlobeLand30 products developed by Chen et al. (2015), and the HBASE products developed by Wang et al. (2017a), respectively) for five regions with various impervious landscapes.

Page 20, the authors found that the importance of Landsat textural features is low, whereas previous studies confirmed the contribution of textural features to impervious mapping. More explanations can be given on this contradiction. One possible explanation may be the different data sets. Many studies have indicated that textural information is helpful in land cover classification, especially in high-resolution images. Shaban and Dikshit (2001) used the textural information in SPOT images, while the authors used that in Landsat-8 images. The difference in spatial resolution may cause the different contribution of textural features in impervious surface mapping.

Great thanks for the comment. Actually, as the SAR backscatter and texture features also had ability to provide information on the structure and variability properties of surface materials, the importance of Landsat textural features was low. If only considering the optical Landsat imagery, the importance of Landsat textual features were significantly improved. This reasons have been added as:

"Thirdly, the importance of Landsat texture features was lower than 5% in these six regions because the Sentinel-1 SAR backscatter and texture features were able to provide information on the surface material and its spatial structure and variation. Due to the complexity of land-surfaces and different mechanism of optical and SAR imagery, the optical textures could complement a lot to SAR features at mountainous and semiarid areas (Asia and Australia regions). Some studies demonstrated that these features contributed a lot to the improvement of impervious mapping accuracy. For example, Shaban and Dikshit (2001) emphasized that the integration of texture variables increased the accuracy from 86.86% to 92.69% because texture imagery could capture the local spatial structure and the variability of land-cover categories."

Page 20, I agree with that the improvement made by this study is mainly due to the combination of the multi-source and multi-temporal information, but it may be misleading to state that the classification-based method performed better than spectral index-based method since they are performed based on the different data sets. I do not think the classification-based method can

achieve a high accuracy only with Landsat data.

Great thanks for the comment. Yes, it was misleading to state that classification-based method performed better than the spectral index-based method, the improvement of mapping accuracy was mainly due to the combination of the multi-source and multi-temporal information. Therefore, we removed these misleading paragraph in the revised manuscript.