Thank you for the comments and suggestions. These comments were very helpful for revising and improving our paper. We have responded to the comments point by point and made the detailed revisions embedded in the manuscript with the line numbers indicated in the responses.

Comment 1: In this study, a multi-source data-based method for mapping UISA and UGS fractions in China using Google earth engine was proposed, and datasets for 2000-2018 were obtained. In the subpixel scale, a pixel of 30m $\times$ 30m is regarded as a combination of UISA, UGS and others. The topic of the study is interesting and fits the scope of the journal. In this dataset, the composition of urban landscape is described at a more detailed scale, which makes up for the lack of data in China. However, there are still some problems that need more explanation. What's more, the innovation of this study is not clearly stated, which should be highly improved.

Response: Thank you for the constructive comments. Urban impervious surface (UIS) and urban green space (UGS) are two core components for characterizing urban underlying environments. However, the UIS and UGS often are mosaicked in the urban landscape with complex structures and composites. Therefore, the 'hard classification' or binary single type cannot be effectively used to delineate spatially explicit urban land surface property. Although the six mainstream datasets on global or national urban land use/cover products with 30-m resolution have been developed, they only provide the binary pattern or dynamic of a single urban land type, which cannot effectively delineate the quantitative components or structure of intra-urban land cover. Here we proposed a new mapping strategy to acquire the multitemporal and fractional information of the essential urban land cover types at national scale through synergizing the advantage of both big data processing and human interpretation in aid of geo-knowledge.

Changes in manuscript: In the revised version, we highlighted the innovation of this work in the Introduction section in L75-100. We also discussed the advantages of this method and CLUD-Urban product in discussion section in L285-305.

Comment 2: General comments: 1. What is the main innovation of this research? This directly determines the value of this research. Compared with existing datasets of the same type, such as the NLCD dataset mentioned in this paper, what are the differences and improvements in the calculation method? Or does it just fill in the gap of this data in China?

Response: Thank you for your comments. Cities or towns were classified as a homogeneous feature in original CLUD. In this research, we developed the UIS and UGS fractions to fill the data gap from the requirement of urban environmental management. Here we adopted the advantage of high accuracy and long-time series in mapping urban land from CLUD. Meanwhile we utilized the highly efficient computation and large storage capacities of GEE platform. In mapping CLUD-Urban product, we proposed to quantitively retrieve the UIS and UGS fractions using random forest. The assessment results indicated the higher accuracy of the CLUD-Urban than NLCD UIS. Our product has high reliability owing to using the advantage of manual interpretation and intelligent computation.

Changes in manuscript: We rewrote the method part and added some discussions on this issue in L105-225 and L285-330.

Comment 3:2. Have you considered the unification of images of different years and the unification of images of different satellites, such as China China-Brazil Earth Resources Satellite (CBERS-1) and Huan Jing (HJ-1A/B) satellite with Landsat? I suggest more introduction of data processing.

Response: China-Brazil Earth Resources Satellite (CBERS-1) and Huan Jing (HJ-1A/B) satellite images were only used in extracting the vector polygons of CLUD in 2010. We added more texts to describe the data processing in China China-Brazil Earth Resources Satellite (CBERS-1) and Huan Jing (HJ-1A/B) satellite images.

Changes in manuscript: We revised the data processing on satellite images in L120-125.

Comment 4: 3. When calculating the UGS fraction, have you considered the different vegetation types? Like the difference between trees and grass? Will this make a difference to the results?

Response: Yes, we considered the difference on trees and grass. In mapping green spaces fraction, the training samples on trees and grass in urban areas were selected to input into parameter in random forest model.

Changes in manuscript: We explained this issue in L170-180.

Comment 5: Specific comments: Line 27 on page 1: It should be "environment" since it refers to the overall state of environment. Line 31 on page 1: Does rapid urbanization process result in rapid increase in urban green space? Are there any references supporting this claim? Line 34 on page 2: "other" should be deleted since China is a developing country, not a developed country.

Response: Thank you for the specific suggestions. We revised those sentences.

Comment 6: Line 43 on page 2: Does this sentence mean the definitions of different products for urban areas are based on IGBP or FAO? Line 49 on page 2: I think it's more likely to be cause and effect. So, it should not be "furthermore" here. Line 61 on page 2: The expressions of urban landscape and urban landscape have appeared for many times. The usage of this phrase is different. Please unify the form of this expression. Line 82 on page 3: When CLUD first appears in the text, a full name is required. Line 94 on page 3: "as well as" should not be used here because cultural services are part of the ecosystem services. Line 95 on page 3: Is the "restoration" here a kind of cultural services? How to understand?

Response: Thank you for the specific suggestions. We revised those sentences.

Comment 7: Line 96 on page 3: What does the "exclude this component" mean? Most products do not distinguish between parks, trees and grass? Line 97 on page 4: "a" should be deleted. Line 101-102 on page 4: In extremely dense urban agglomerations like the Yangtze River Delta, the boundaries between some cities are not obvious. How to deal with this? Are there any problems? Line 106 on page 4: The urban impervious surface area and the urban impervious surface area fraction are both abbreviated UISA. So as the UGS. This statement is ambiguous. Please modify it. Maybe you can use UISAF and UGSF to present the fractions. Line 116 on page 4: Is it possible to use probabilities to represent ratios? How do you justify this logic? Are the input UISA classification values from pure pixels or mixing pixels? Line 124 on page 4: It should not be ith here. i should be a total number, or it should be expressed as n. Line 146 on page 5: How many samples were surveyed in the field?

Response: Thank you for the specific suggestions. We address those issues in revised manuscript. Recently, we published a 2020 annual report by Global Ecosystems and Environment Observation Analysis Research Cooperation (http://www.chinageoss.org/geoarc/2020/) through cooperation between the Global Earth Observation System of Systems (GEOSS) and the National Remote Sensing Center of China at the Ministry of Science and Technology. We developed a set of new algorithms to retrieve the UIS and UGS fractions using sub-pixel decomposition method through random forest algorithm using Google Earth Engine (GEE) platform. We improved the methods on mapping UIS and UGS fractions and updated the datasets of CLUD-Urban product.

5 Mapping UIS and UGS fractions using GEE platform

5.1 Collection of training samples

The training samples of UIS and UGS fractions are a pivotal input parameter in random forest model for mapping national settlement and vegetation fraction. In light of large discrepancies among UIS and UGS composites in different climate zones with various geographical and social economic conditions, we collected a total of 2,570 samples from randomly selected cities in different climate zones (Schneider et al. 2010) (Fig. 5). Here we also refer to the existing UIS dataset to acquire samples with 10% intervals of the ISA fraction, and those samples primarily distributed in the homogeneous UIS or UGS areas, which might provide more effective samples and decrease the impact of imagery mismatch. The samples of UIS and UGS covered with diversified types, including buildings, roads and squares, and grass, trees from parks, road and residential green spaces. The UIS and UGS percentages were interpreted within each sample using Google Earth images (Fig. 5b1-b4). Finally, the training samples in 2000, 2005, 2010, 2015 and 2018 were used for training the random forest model, respectively.

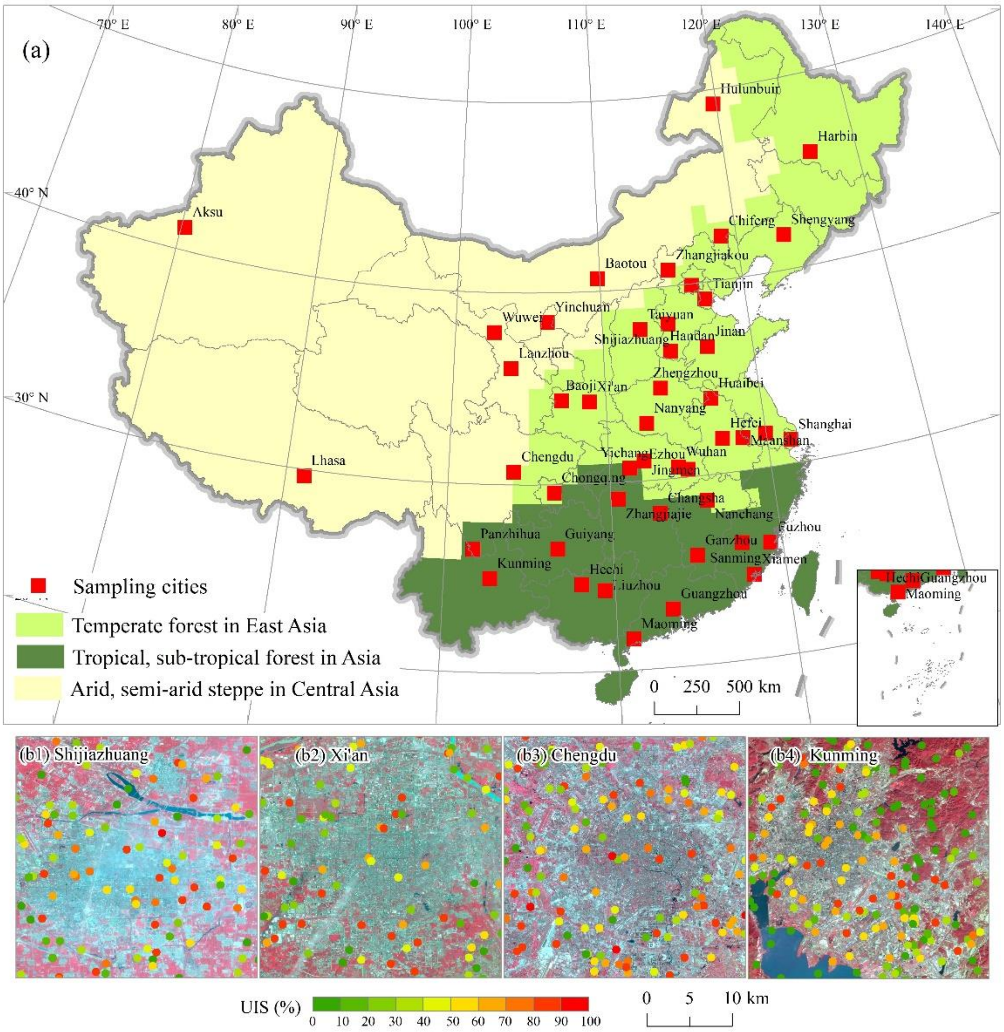

Figure 5: Distribution of sampling cities in China and training samples in selected cities. (The images were provided by Geospatial Data Cloud site, Computer Network Information Center, Chinese Academy of Sciences (http://www.gscloud.cn). The administrative boundaries were provided by National Geomatics Center of China (http://www.webmap.cn))

5.2 Retrieval of settlement and vegetation fractions using random forest model

Many previous studies have indicated that random forest is more effective and accurate in classifying urban land types than other machine learning approaches such as support vector machine (SVM) and artificial neural network (ANN) (Zhang et al., 2020). Random forest exhibits a strong capacity in processing high-dimensional datasets and has been successfully applied to mapping global ISA at 30-m resolution (Zhang et al., 2020). In this research, we proposed a strategy to acquire the settlement and vegetation percentage at pixel scale using the advantage of random forest and big-data processing based on GEE platform.

According to sixteen global urban ecoregions based on temperature, precipitation, topographic conditions and social economic factors (Schneider et al. 2010), China has three urban ecoregions. In each urban ecoregion, the annual maximum NDVI, and spectral bands in Landsat TM/ETM+/OLI, and the slope index derived from SRTM DEM with 30-m resolution were selected as the input parameters to run random forest model. The Landsat images were from January 1 to December 31 of each baseline year. The annual maximum NDVI ($NDVI_{max}$) was retrieved using equation (1):

$$NDVI_{max} = \max(NDVI_1, NDVI_2, \cdots, NDVI_i) \quad (1)$$

where $NDVI_i$ is the NDVI value of the i^{th} image. Individual NDVI was calculated from Landsat images in the period between January 1 to December 31 and all images were collected using GEE (Gorelick et al., 2017).

In GEE platform, the settlement and vegetation fractions were calculated for each urban ecoregion through using the training parametrizations. The lawn, forest or their mosaicked areas were selected as input samples in mapping UGS. A post-processing was implemented to remove the pixels with NDVI values of greater than 0.5 or DEM slope values of greater than 15^{o}. In arid and semi-arid areas, the enhanced bare soil index (EBSI) was utilized to separate UIS from bare soils (As-syakur et al., 2012; Li et al., 2019). As a result, the settlement and vegetation fractions with 30 m × 30 m in 2000, 2005, 2010, 2015 and 2018 were generated for developing CLUD-Urban product (Fig. 6).

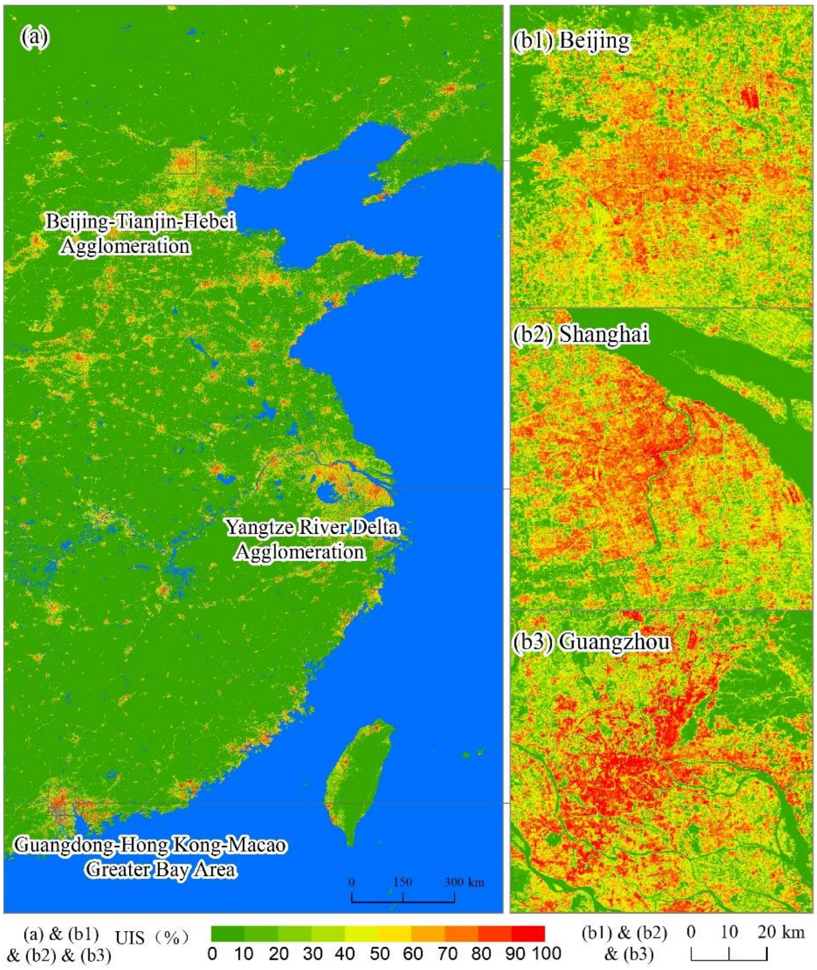

Figure 6: **Distribution of sampling cities in China and training samples in selected cities. (The administrative boundaries and residential points information were provided by National Geomatics Center of China (http://www.webmap.cn))**

5.3 Mapping of UIS and UGS fractions

The settlement and vegetation fractions with 1ºX1ºgrid of each period were downloaded from GEE platform. In ARCGIS 10.0 software, the settlement and vegetation layers were merged respectively at provincial scale with 30 m X 30 m. The national UIS and UGS fractions with 30 m X 30 m resolution in 2000, 2005, 2010, 2015 and 2018 were produced through overlaying the urban boundaries of CLUD with settlement and vegetation fractions, respectively (Fig. 7, Fig. 8 and Fig. 9).

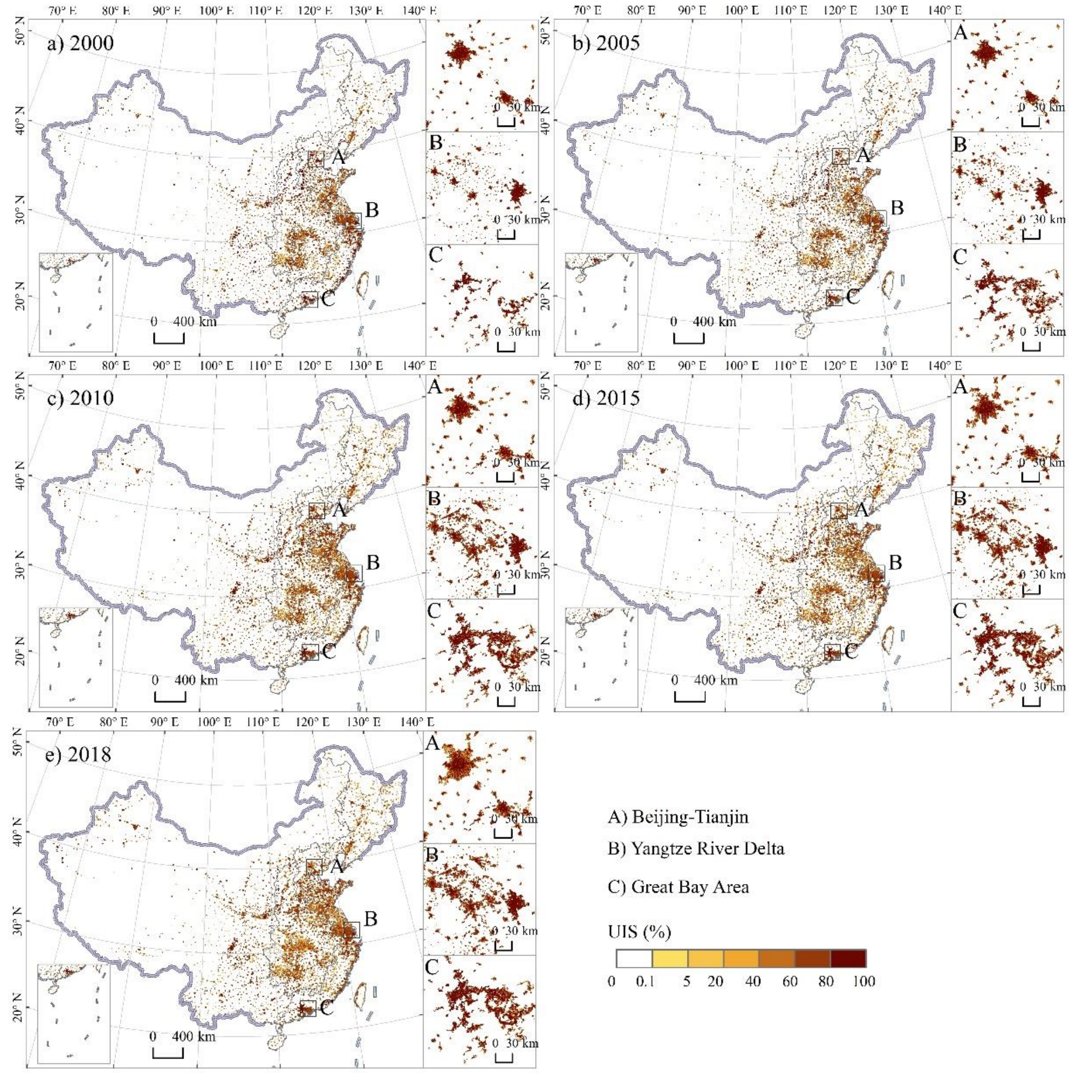

Figure 7: **Spatial distribution of urban impervious surface (UIS) in 2000–2018 across China. (The administrative boundaries were provided by National Geomatics Center of China (http://www.webmap.cn))**

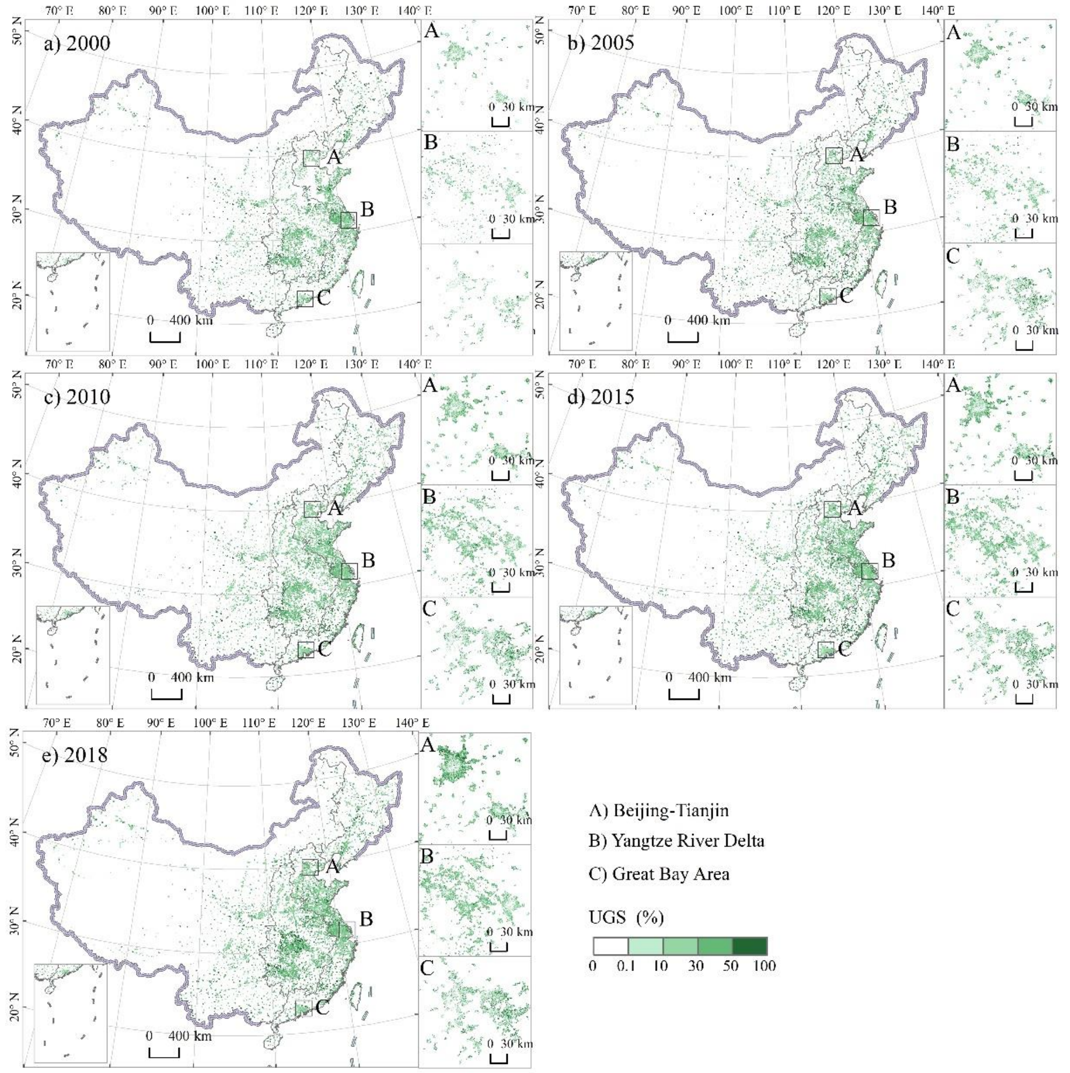

Figure 8: **Spatial distribution of urban green space (UGS) in 2000–2018 across China. (The administrative boundaries were provided by National Geomatics Center of China (http://www.webmap.cn))**

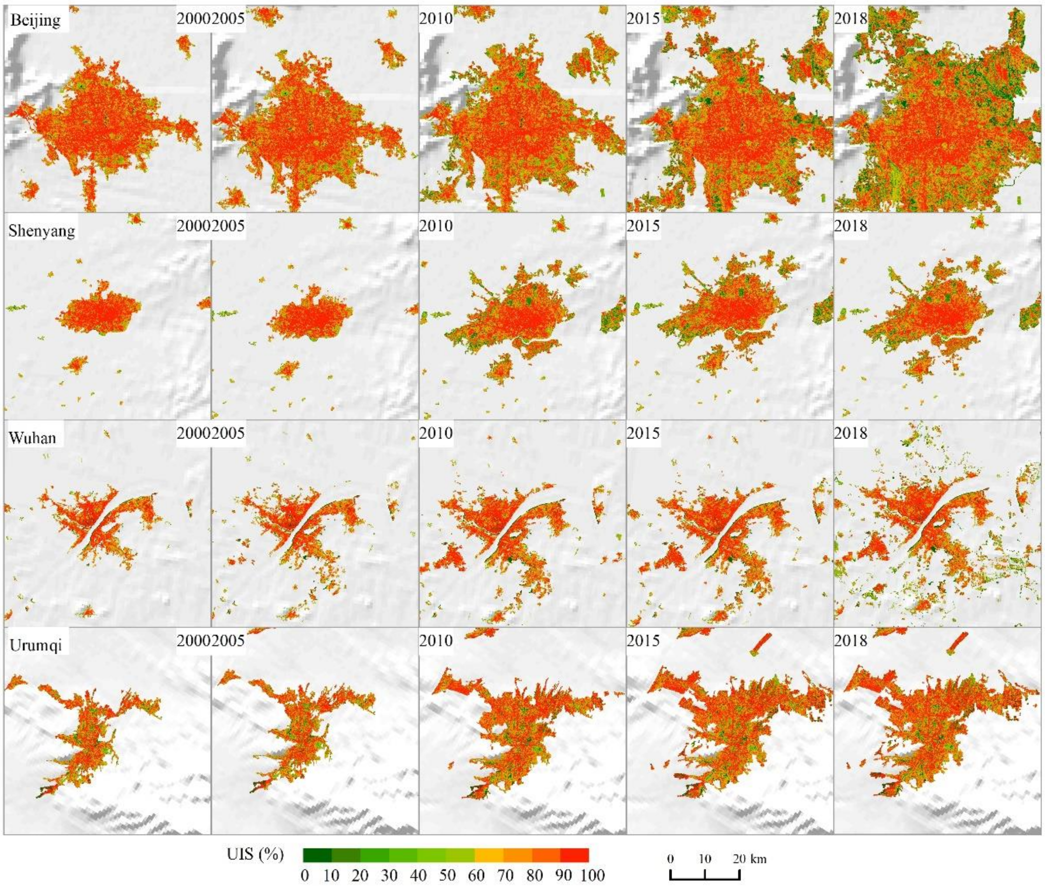

Figure 9: The change of urban impervious surface (UIS) in selected cities from coastal, central, eastern and western zones from 2000 to 2018. (DEM dataset was downloaded from SRTM 90 m Digital Elevation Data (http://srtm.csi.cgiar.org/))

Comment 8: Line 151 on page 6: What is the higher resolution? Does visual interpretation take the smallest unit of Google images as a single pixel to calculate the number of impervious and vegetation units? Line 153 on page 6: “a” should be deleted. Line 154 on page 6: “densities” would be better to be “fractions”. Line 155 on page 6: It should be “values in the same area were”. Line 157 on page 6: “shows” should be “showed”. Line 157 on page 6: There are two “.”. Line 158 on page 6: It should be “, respectively” and “validation of”. Line 167 on page 6: It should be a new sentence form “note”. Line 169-171 on page 6: How is the urban area defined in this study? Are you using existing data and method? If so, it cannot prove the advantages of this study.

Response: Response: Thank you for the specific suggestions. We address those issues.

Comment 9: Line 174 on page 6: What is the actual urban expansion rate? Can you give a value to prove the similarity? Line 175 on page 6: "other" here should also be deleted. Line 181 on page 6: Does the UGS here refer to urban green space or areas with high green space fraction? Line 184 on page 7: The "main urban areas" here may not be a very appropriate statement. Line 188 on page 7: Since there are other components, why don't you say high proportional UGS represents parks and greenbelts with ecological functions? Line 197 on page 7: "was" should be "were". Line 199 on page 7: Please be consistent with the previous. Determine to use "dataset" or "datasets" to express the UISA and UGS data?

Response: Thank you for your comments. We revised the manuscript according the suggestions.

Comment 10: Table 1: "Note" should be left aligned. Table 4: There should be a "Note" before "MRE: : :". Figures: All maps lack a compass. Figure 4: What are the meanings of the small pictures on the right? Please make more explanations. Figure 8: There are two sets of legends in the figure, and some colors are similar. How to distinguish them?

Response: We revised the form and notes on Table 1, Table 4 and all figures.