Response to Reviewers' Comments

Paper #: essd-2026-381

Title: A global urban built-up area dataset for cities with populations exceeding 300,000 (2000–2025)

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Authors: Dinoo Gunasekera, Zhongchang Sun, Wenjie Du, Jian Gao, Yunpeng Zhang, Yuyu Zhou, Robert Ndugwa, Huadong Guo

Correspondence: Zhongchang Sun (sunzc@aircas.ac.cn), Wenjie Du

Dear Reviewer,

We thank the reviewer for the careful and constructive assessment of our manuscript. The comments address the interpretive precision of the manuscript — the language used to describe inter-product differences, the effects of morphological refinement on enclosed open spaces and fragmented peri-urban settlements, the explanation of extreme LCRPGR values, and the scope of the reported urban built-up area (UBA) aggregates. Responding to them has improved the accuracy, clarity and definitional transparency of the revised manuscript. The main revisions are:

- Replacement of "overestimate urban extents" with "delineate larger urban extents" where inter-product differences are not supported by independent reference evidence, and revision of the comparison discussion to distinguish cross-product agreement from validation (Sections 4.2.3 and 5.2 revised).
- Addition of a discussion of how hole filling, minimum-area filtering and morphological closing affect enclosed open spaces and fragmented peri-urban settlements, clarifying that the final UBA polygons represent a processed settlement footprint rather than an exact measure of impervious cover (Section 5.3 expanded).
- Correction of the explanation of extreme LCRPGR values: a population growth rate close to zero decreases the absolute value of the denominator and can produce extreme positive or negative ratios even for moderate land consumption rates; under positive LCR, a negative LCRPGR indicates land expansion alongside population decline rather than a direct land-use-efficiency ranking (Section 5.1 corrected).
- Clarification that the aggregate UBA reported in Section 4.3 refers to the combined built-up area of the 1,611 study cities, with explicit scope statements added to the section text, the Figure 10 caption, and the limitations section (Sections 4.3 and 5.3 revised).

Point-by-point responses follow. Reviewer comments are quoted verbatim in italics; our responses follow each comment; the corresponding changes in the revised manuscript are listed at the end of each response. Blue marks Reviewer 1 amendments. Purple marks Reviewer 2 amendments.

Reviewer #2

We thank Reviewer 2 for the constructive suggestions on the comparison language, the effects of morphological processing, the interpretation of LCRPGR, and the scope of the reported urban built-up areas.

Comment RC2.1 — Sensor transition and the 2020–2025 LCRPGR increase

> *"Section 5.2: Consider replacing "overestimate urban extents" with "delineate larger urban extents," as some differences may arise from the definitions adopted by each dataset."*

Response

We thank the reviewer for this constructive suggestion. We agree that a larger mapped extent should not automatically be interpreted as overestimation. The compared datasets represent different spatial concepts and apply different rules for including open spaces, peripheral settlements and other land within an urban extent. Their differences therefore reflect both mapping performance and the definition of the target object.

We have replaced "overestimate urban extents" with "delineate larger urban extents" where the comparison is not supported by independent reference evidence. We have also revised the interpretation in Section 5.2 to distinguish cross-product agreement from validation. The revised discussion describes GUBAD's spatial characteristics without treating smaller mapped areas as evidence of greater accuracy.

Revised manuscript text in context

Section 4.2.3 · p. 14 · final comparison paragraph

The visual comparisons illustrate differences in the delineation of fragmented and heterogeneous urban structures, particularly in rapidly urbanizing regions. Some products delineate larger urban extents in the examples shown. Differences in mapped classes, boundary definitions and spatial resolution may contribute to these patterns. A common reference assessment would be required to compare delineation accuracy across products.

Section 5.2 · p. 21, liens 412—438 · replace the first three paragraphs with the two paragraphs below

Global products represent urban land using different mapped classes, boundary definitions, resolutions and observation years (Chakraborty et al., 2024). The comparisons in Sect. 4.2 describe agreement among products. In the illustrated coastal and peri-urban examples, MGUP and DEGURBA delineate larger urban extents, while AUE shows smoother boundaries for some fragmented settlements. The mapped targets and delineation procedures may contribute to these differences.

GUBAD complements existing datasets by providing 30 m urban footprints and linked attributes for a common set of cities and epochs. The separation of ISA extraction and UBA delineation makes the footprint definition explicit. Linked population records and precomputed indicators support city-level SDG 11.3.1 analysis. An independent assessment using a common footprint definition and reference information would be needed to compare LCRPGR performance across products.

Comment RC2.2 — Validation sample size and stratification

> *"Section 5.3: Briefly discuss how hole filling and small-patch removal may affect enclosed open spaces and fragmented peri-urban settlements."*

Response

We thank the reviewer for highlighting the implications of these processing steps. We agree that reporting the parameter values alone does not fully explain their effects on the final product. Hole filling can incorporate enclosed non-impervious spaces into the delineated UBA, whereas minimum-area filtering can exclude genuine built-up patches that are small and spatially detached. These effects are particularly relevant when interpreting internal urban open spaces or dispersed settlement patterns.

We have added a short explanation to Section 5.3 linking these operations to the intended use of the dataset. The revision clarifies that the final UBA polygons represent a processed settlement footprint and that their area should not be treated as an exact measure of impervious cover.

Revised manuscript text in context

Section 5.3 · p. 22 · morphology paragraph within the consolidated opening, after the boundary-delineation discussion

Morphological refinement can affect urban footprints in two directions. Hole filling can incorporate enclosed non-built-up spaces, including small parks or other open areas, where a hole is fully surrounded by built-up pixels, falls below the area cap described in Sect. 3.2 and lies outside the boundary-protection ring. Conversely, the removal of connected components below the minimum mapping unit can exclude small, isolated built-up patches in fragmented peri-urban areas. Morphological closing can also bridge narrow gaps between nearby patches. These operations favor spatial continuity and can affect the representation of both enclosed open spaces and dispersed settlements.

Comment RC2.3 — Population constraints and circularity in LCRPGR

> *"Lines 395–399: Please correct the explanation of extreme LCRPGR values: near-zero population growth decreases the denominator's absolute value, potentially producing extreme ratios."*

Response

We thank the reviewer for identifying this error. We agree that the original explanation reversed the relationship between population growth and the denominator. For a given non-zero LCR, a PGR approaching zero decreases the denominator's absolute value and can produce a very large positive or negative LCRPGR. When PGR equals zero, the ratio is undefined.

We have corrected this explanation and clarified the interpretation of negative values under the positive-LCR condition used in the classification. In this case, a negative ratio indicates land expansion alongside population decline; its magnitude should not be interpreted as a direct ranking of land-use efficiency. The revised paragraph therefore encourages interpretation alongside the underlying land and population changes.

Revised manuscript text in context

Section 5.1 · pp. 19–20, original lines 395–399 · full interpretation paragraph

The LCRPGR estimates at city level for all 1,611 cities are provided in the city-level attribute table distributed with GUBAD. Because PGR forms the denominator of LCRPGR (Eq. 3), a PGR close to zero reduces the absolute value of the denominator and can produce a large positive or negative ratio even when LCR is moderate. For positive LCR, a negative PGR yields a negative LCRPGR. The ratio is undefined at PGR = 0. Extreme ratios should therefore be interpreted alongside the underlying population growth and land consumption rates.

Comment RC2.4 — Monotonicity imposed by pixel-level PAVA

> *"Section 4.3: Please clarify that "global UBA" refers to the combined built-up area of the 1,611 study cities, rather than all urban areas worldwide."*

Response

We thank the reviewer for pointing out this ambiguity. We agree that "global UBA" could imply complete coverage of urban land worldwide, whereas the reported totals are calculated from the selected 1,611 cities. The same distinction applies to the continental and national aggregates, which represent the study cities within each geographical grouping.

We have revised the relevant wording in Section 4.3 and the associated figure captions to make this scope explicit. We have also added a brief statement to the limitations section explaining that smaller cities and cities excluded during sample selection are not represented in these totals. This clarification preserves the reported results while defining the population of cities to which they apply.

Revised manuscript text in context

Section 4.3 · p. 16 · insert before Section 4.3.1

The aggregate UBA reported in this section is the sum of the mapped built-up areas of the 1,611 study cities.

Section 4.3.1 · p. 16 · full opening results paragraph

The combined UBA of the 1,611 study cities expanded substantially between 2000 and 2025 (Fig. 10). Asia recorded the largest absolute increase, with UBA expanding from 64,797 km² to 153,165 km², representing an increase of over 88,000 km². North America experienced the second-largest growth, with UBA increasing from 69,550 km² to 103,296 km². Together, these two regions accounted for more than 70% of the total UBA increase across the study cities.

Figure 10 · p. 16 · full caption

Figure 10. (a) Total UBA (km²) by continent for the six GUBAD epochs and (b) continental share (%) of the combined UBA of the 1,611 study cities, 2000–2025.

Section 4.3.1 · p. 16 · full paragraph following Figure 10

Although absolute increases in other continents were smaller, relative growth rates were notable. UBA in Africa approximately doubled between 2000 and 2025, while South America, Europe, and Oceania exhibited increases of around 1.5 times over the study period. By 2025, the combined UBA of the 1,611 study cities reached 367,818.04 km², nearly doubling its extent in 2000.

Section 4.3.1 · p. 16 · replace the paragraph beginning "In relative terms"

The continental shares of the combined UBA of the study cities shifted between 2000 and 2025. Asia's share increased from 32.50% to 41.60%, and Africa's share increased slightly. The shares of North America, Europe, South America and Oceania declined. These changes show how UBA growth was distributed across the study cities.

Section 5.3 · p. 22 · add after the mapping and validation limitations

Reported national, continental and overall totals summarize the 1,611 study cities within the relevant geographic grouping. Smaller cities and cities excluded during sample selection are outside these totals.

We hope the reviewer finds the revised manuscript and these responses satisfactory, and we remain happy to provide any additional material required.

Sincerely,

Dinoo Gunasekera, Zhongchang Sun, Wenjie Du, Jian Gao, Yunpeng Zhang, Yuyu Zhou, Robert Ndugwa, and Huadong Guo

On behalf of all authors