A geospatial technique for estimating urban built volume using remote sensing data

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(1) Purpose: This study introduces a geospatial technique for estimating urban built volume (UBV) from remote sensing data. It also presents a technique for deriving a digital terrain model (DTM) from a digital surface model (DSM).

(2) Data and Methods: The data used in this study include a DSM (10 m) derived from ALOS-Prism data (c. 2009) and a Landsat image (30 m) captured in 2009. A 10 km × 10 km subset of Metro Manila, Philippines was used as a test study site. The DSM had a value ranging from 24 m to 211 m measured from the ellipsoid.

We used a grid-based technique (using a mesh size of 100 m, 150 m, 200 m, 250 m, 300 m, 350 m, and 400 m) to derive seven DTMs (DTM100, DTM 150, DTM200, DTM250, DTM300, DTM350, and DTM400) from the DSM. Firstly, using each of these mesh sizes, we determined the pixel/s with the lowest DSM value within a grid. And secondly, all the pixels identified were converted to points and used in the interpolation process for the seven DTMs employing the Empirical Bayesian Kriging approach. By subtracting each of the derived seven DTMs from the DSM, we produced seven surface feature height (SFH) maps.

Using a maximum likelihood supervised classification, we extracted the built-up lands from the Landsat image. Prior to the calculation of the UBV using Eq. (1), we resampled the built-up map to 10 m.

$$\mathrm{UBV_i}\ (\mathrm{m}^3) = \mathrm{PA_i} \times \mathrm{SFH_i} \qquad (1)$$

where $\mathrm{UBV_i}$, $\mathrm{PA_i}$ and $\mathrm{SFH_i}$ are, respectively, the urban built volume (m^3), area (m^2) and surface feature height (m) of pixel i, where pixel i is a member of the built-up class. Pixels with negative SFH values were not included in the calculation.

(3) Results and Discussion: Results revealed that the minimum value for the derived seven DTMs varied from 24 m to 27 m, while the maximum value varied from 92 m to 148 m. Consequently, the derived seven SFH maps also had different minimum (from -10 m to -19 m) and maximum (from 137 m to 146 m) values. Considering that the DSM values of built-up lands (measured at the roof top of built structures) are supposed to be higher than their respective DTM values (measured at topographic surface), the seven DTMs can be compared in term of the quantity of pixels with negative SFH values (DTM > DSM). DTM100 had the highest number of pixels with negative SFH values (total=36,552; built-up=24,654), while DTM350 had the lowest (total=7,366; built-up=4,909).

In terms of UBV, the seven DTMs also produced different results. DTM100, DTM150 and DTM200 had a total UBV of 386.63, 465.09 and 520.00 million m^3, respectively, while DTM 250, DTM 300, DTM350 (Fig. 1), and DTM400 had 561.14, 599.82, 636.24 and 659.92 million m^3, respectively.

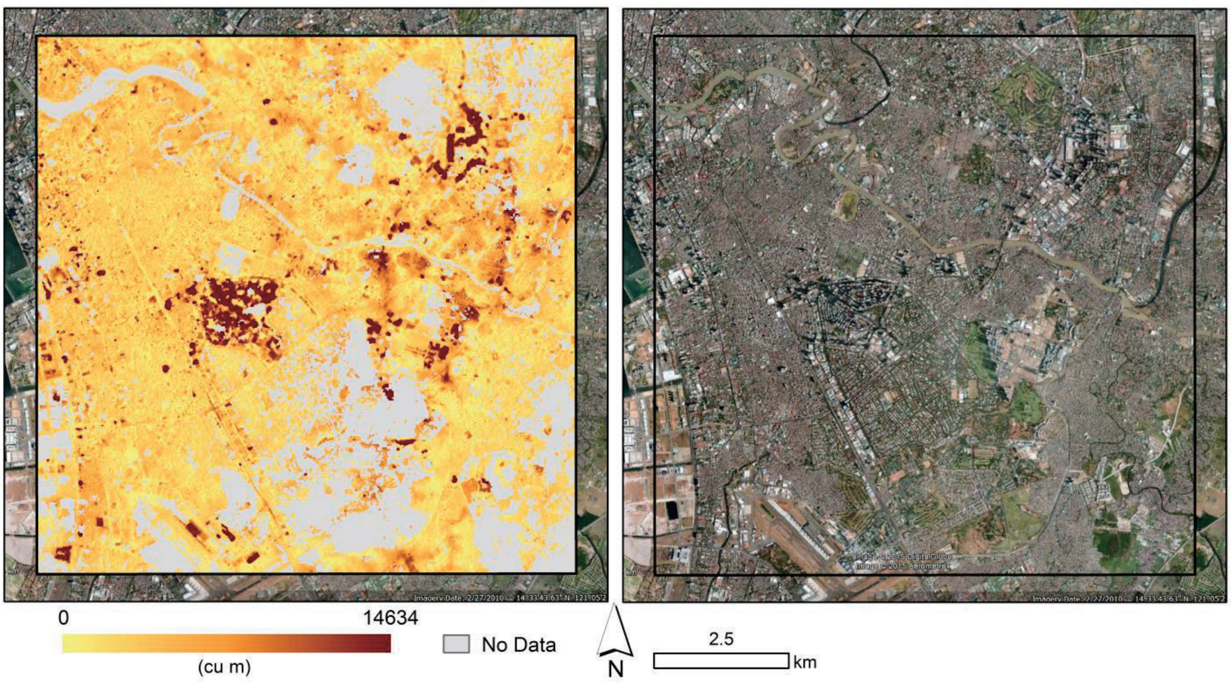

Figure 1: (Left) UBV map produced by using DTM350 and (Right) Google Earth image (2010).