NDUI Data User’s Mannual

The mapped global annual Normalized Difference Urban Index (NDUI)) from 2000 to 2012 at a 30-m resolution is organized by 10-degree grids (totally 224). The NDUI data file format is GeoTiff, packaged in "Year_*i*.zip" (*i* ranges from 0 to 223). Within each file, valid data values range from -1000 to 1000, while -2000 means no data.

1. Data preprocessing

All the Landsat-7/ETM+ L1T data from 2000 to 2015 regardless of the amount of cloud cover are used. Each series of the three-year Landsat-7/ETM+ Top of Atmosphere (TOA) reflectance imagery are used to first generate nominal annual NDVI composites. The entire compositing procedure is carefully designed, to remove the effects of clouds and clouds shadows, and to remove gaps in the images due to scan-line corrector (SLC) failure, and to maximize the degree of separability between fallow land and urban (Fig 1.).

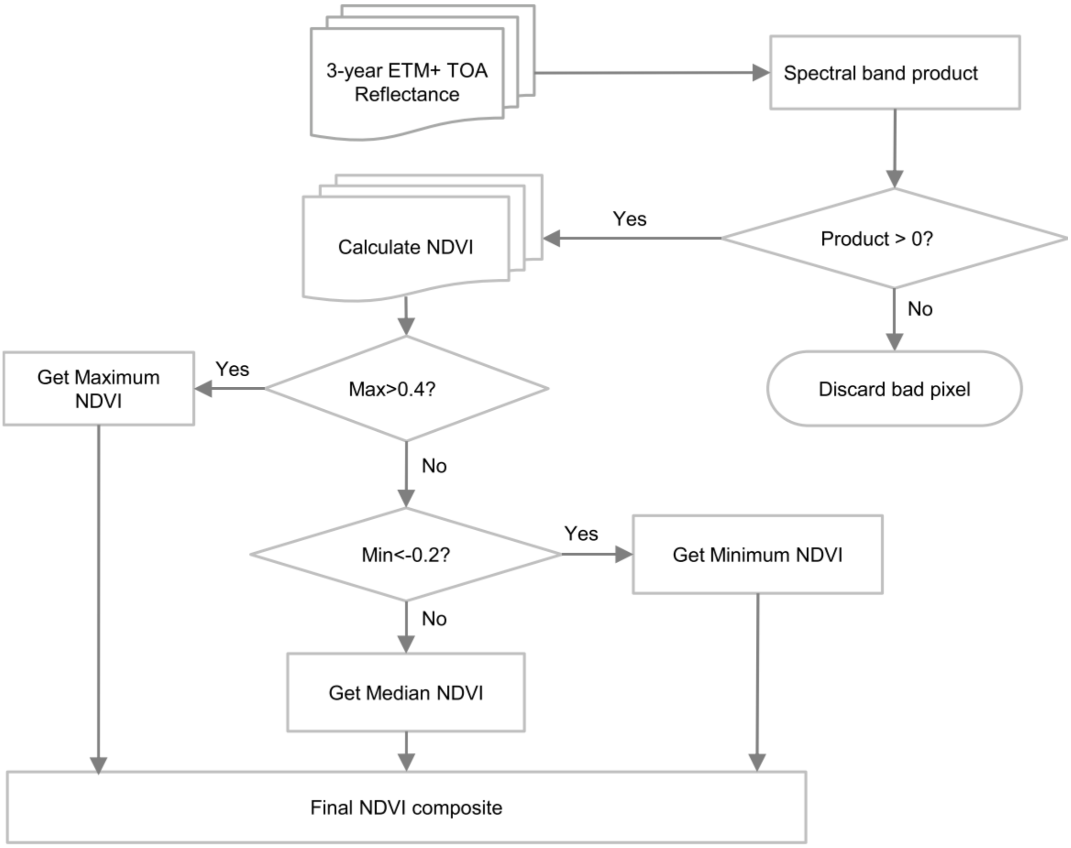


Fig 1. The procedure to generate NDVI composites from multi-year Landsat-7/ETM+ imagery with the proposed Mixed NDVI method on Google Earth Engine.

The version 4 DMSP/OLS NTL data used here are from the website of the National Geophysical Data Center at the National Oceanic and Atmospheric Administration, also hosted on Google Earth Engine. The version 4 DMSP/OLS NTL data from 2000 to 2012 are used. Taking the 2000 data as the reference data, the ridge regression method is used to calibrate the multi-sensor and multi-year DMSP/OLS NTL annual image composite time series.

Both Landsat-7/ETM+ and the version 4 DMSP/OLS NTL images are then automatically reprojected into a common projection (Geographic) on the fly in Google Earth Engine. The 1 km NTL is then resampled to a 30 m resolution to match the spatial resolution of ETM+. While the original DMSP/OLS NTL values are recorded in the range [0, 63], ETM+ NDVI values are generated in the range [-1.0, 1.0]. To make them comparable, we normalize the DMSP/OLS NTL into the range of [0.0, 1.0] through dividing the raw NTL data by its maximum DN value (63.0).

2.The NDUI Calculation

We construct a Normalized Difference Urban Index -- NDUI by combining ETM+ NDVI with DMSP/OLS luminosity data:

$$NDUI = (NTL - NDVI) / (NTL + NDVI), \qquad (NDVI \geq 0)$$

where NTL is normalized DMSP/OLS nighttime light data, and NDVI is cloud-free ETM+ NDVI. Well-lit urban cores with very sparse vegetation cover will have high NDUI values close to 1, and unlit remote rural areas with abundant vegetation will have low values close to -1. Cloud and cloud shadow free NDVI composite from the growing season is critical in order to maximize the separability between urban and vegetated areas, especially agricultural lands experiencing seasonal fallow periods.

3. Demo of NDUI use

A Demo : Automated extraction of urban built-up areas with NDUI using Python and Google Earth Engine.

Urban built-up area is an important attribute to study urban development and change.Using NDUI and Google Earth Engine python api can easily and quantitatively extract the built-up area of a city.Let's take Guangzhou as an example to explain in detail how we extracted the built-up areas.

First,we use the calculation formula mentioned above to calculate NDUI,and then use the Guangzhou vector boundary to crop NDUI to get the region we need.

Second,we perform binarization operation on the NDUI extracted just now, and the threshold was NDVI>0 and NDUI >0.2,and the two are taken as the intersection.The two threshold are an empirical value,which may not be the most appropriate for your choice.

Third,we vectorize the binary data,and then we can get a file in SHP format,from which we can calculate the area and select the top regions we need.

Below is our detailed workflow chart and extracted results of Guangzhou,and the code link is also attached.

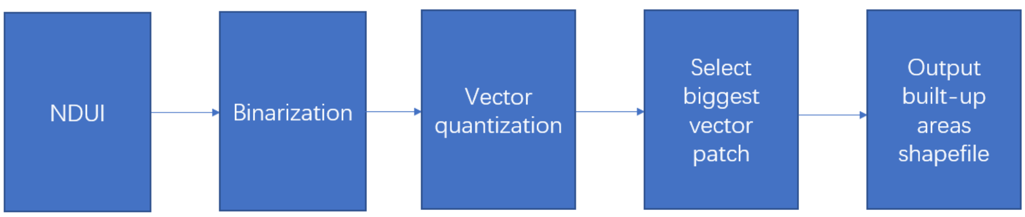
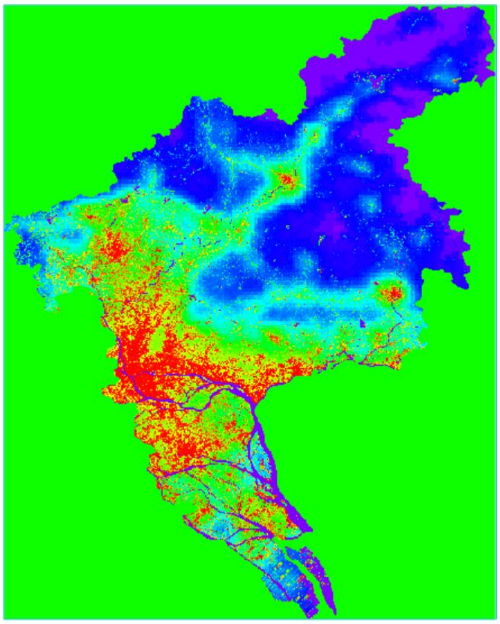
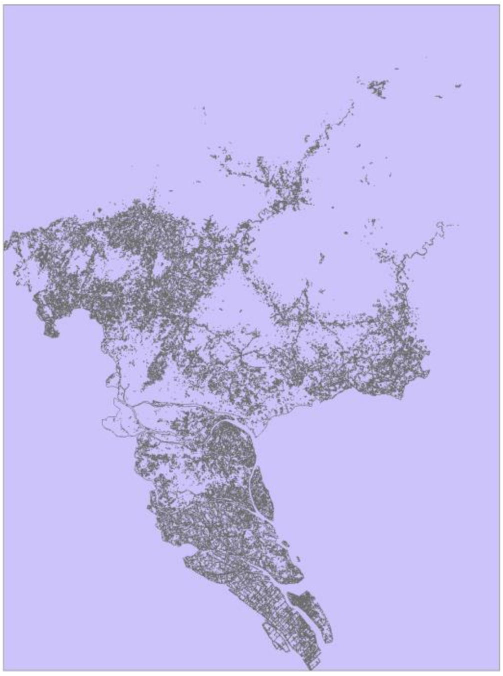


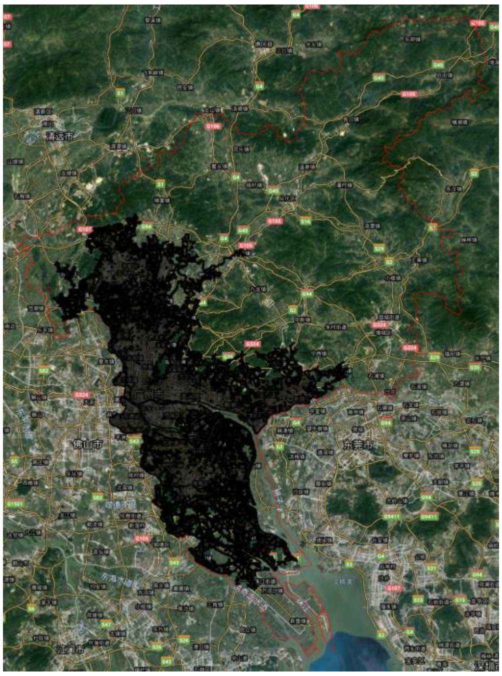
Fig 2.The extraction process of built-up areas



1.NDUI-Guangzhou

2.Binarization Result





3.Vector quantization

4. Built-up Areas Guangzhou

Fig 3. The extraction results of Guangzhou built-up area using NDUI

Code Link: https://github.com/yifwahaha/NDUI_work_flow

References

Zhang, Q., & Li, B. (2015). Building a Better Urban Picture: Combining Day and Night Remote Sensing Imagery. (September).

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Zhang, Q., Pandey, B., & Seto, K. C. (2016). A Robust Method to Generate a Consistent Time Series From DMSP / OLS Nighttime Light Data. IEEE Transactions on Geoscience and Remote Sensing, 54(10), 5821–5831. https://doi.org/10.1109/TGRS.2016.2572724