The extraction of urbanized areas based on the high-resolution night lights images:

A case study in Barcelona, Spain

- May, 2022 -

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The definition of urbanized areas, both regionally and globally, is an important basis for urban development monitoring and management, as well as an important condition for studying social policies, economics, culture and the environment.

Table 1. **The parameter comparisons of Defense Meteorological Satellite Program Operational Linescan System (DMSP-OLS), the Suomi National Polar-Orbiting Partnership Visible Infrared Imaging Radiometer Suite (NPP-VIIRS), and Luojia 1-01.**

Satellite	DMSP-OLS	NPP-VIIRS	Luojia1-01
Available years	1992-2013	December 2011-October 2019	June 2017-Present
Wavelength range	400-1100 μm	505-890 μm	480-800 μm
Spatial resolution	2.7km	740m	130m
Width	3000km	3000km	250km
Spectral resolution	0.5-0.9 μm	0.5-0.9 μm	0.46-0.98 μm
Pixel saturated	Yes	No	No
Revisit time	12h	12h	15d
Radiometric resolution	6 bits	14 bits	14 bits
On-board calibration	No	Yes	Yes

Figure 1. **Nighttime imagery from DMSP-OLS, NPP-VIIRS and Luojia1-01 in Barcelona, Spain**

(a)   (b)   (c)
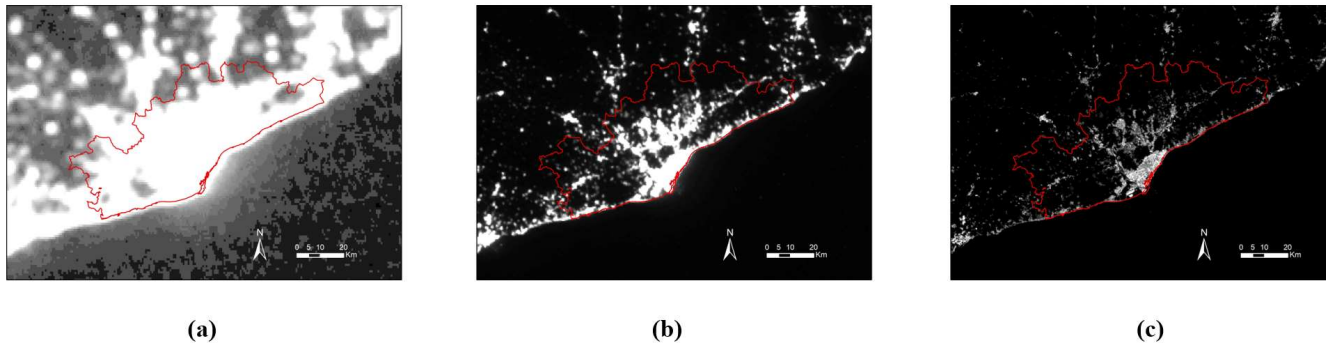
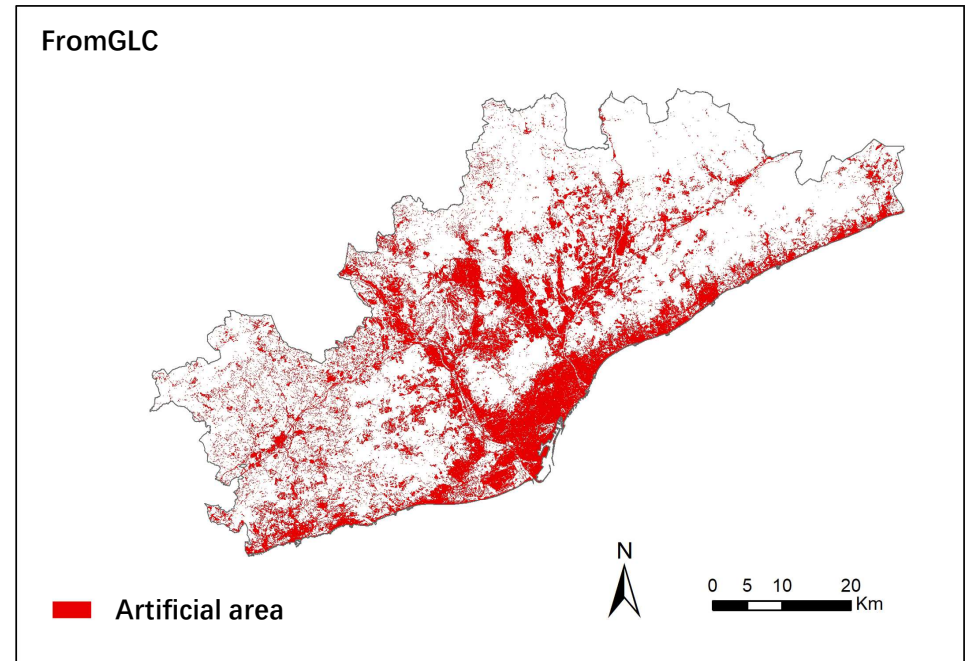(a) is DMSP-OLS in 2013, (b) is NPP-VIIRS in 2019, (c) is Luojia1-01 in 2019.

Object

This work has dedicated the images of night lights (NPP-VIIRS and Luojia1-01) and the images of urbanized areas (FROM-GLC 2017) to construct a logistic regression model to evaluate and compare the accuracy of the two images of night lights in the extraction of urbanized areas. And I hope to explore the potentiality of the night light images of the new generation satellite Luojia1-01 in future studies.
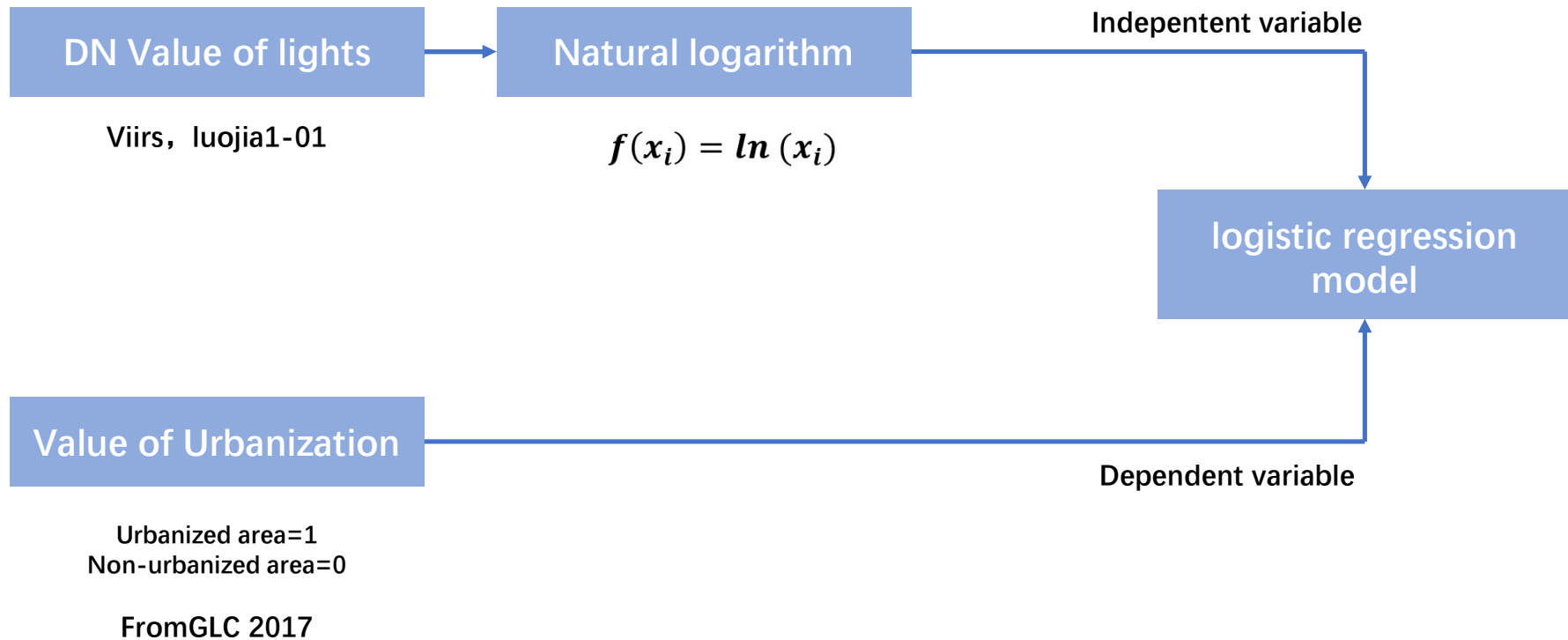
Study area and data soure

In this work, Barcelona Metropolitan Area (MRB, 3,200 km2, 4.7 million inhabitants) is selected as the study area.

To ensure the consistency of the data time, in this work the NPP-VIIRS data is chosen to compare with those of Luojia1-01 and the most recent land cover images (FromGLC 2017) as verification data.

Methodology

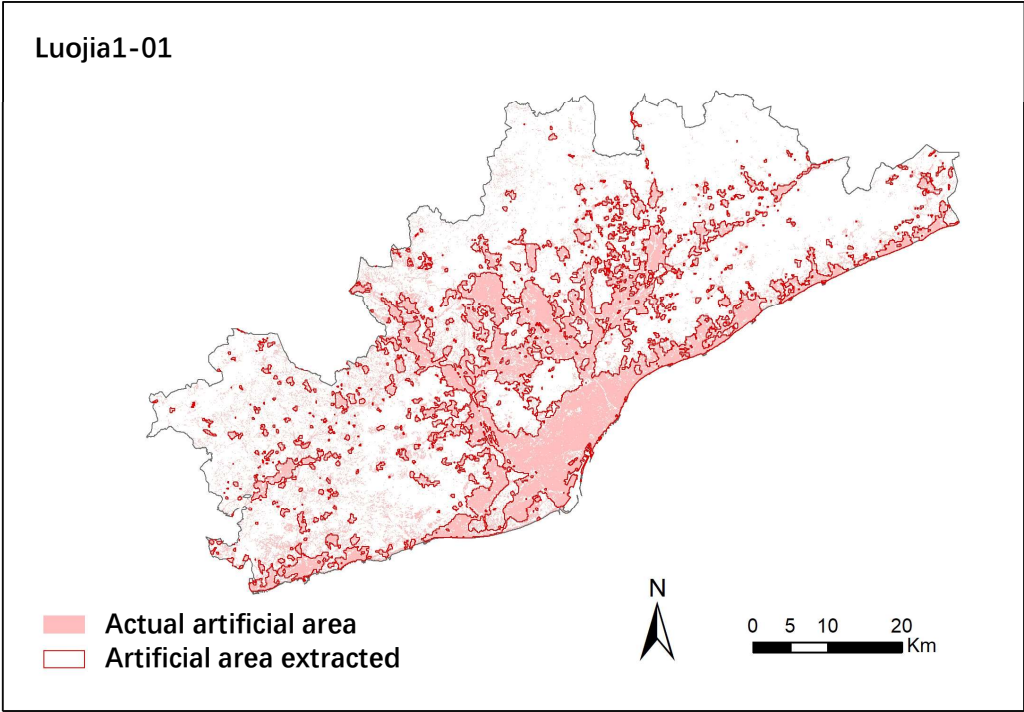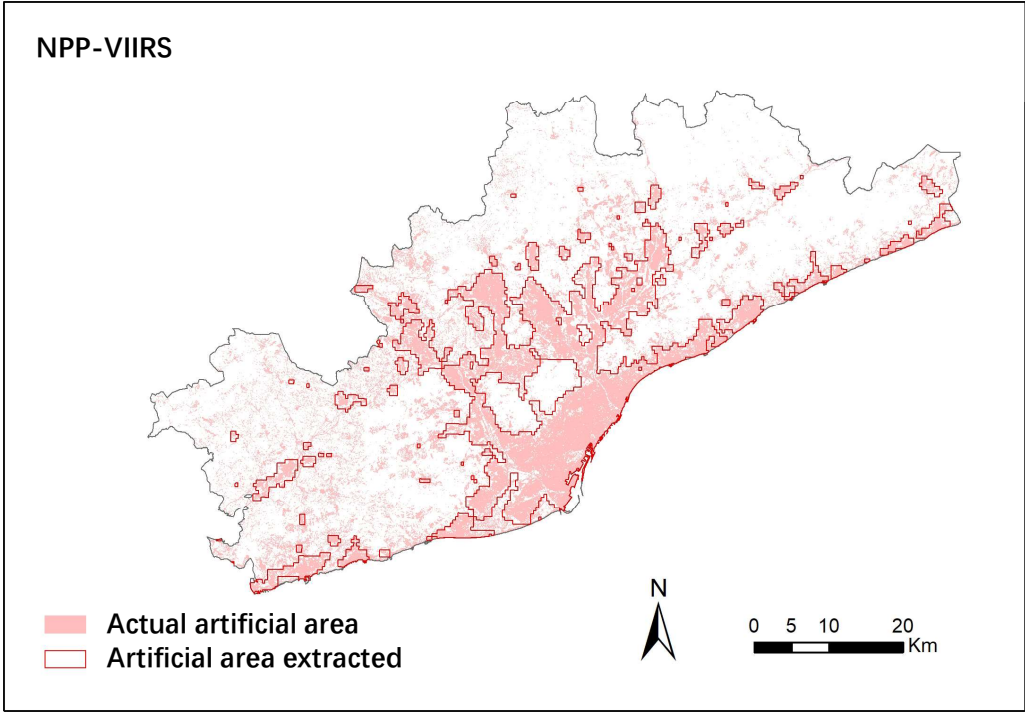DN Value of lights → Natural logarithm

Viirs，luojia1-01

$$f(x_i) = ln(x_i)$$

Indepentent variable

logistic regression model

Value of Urbanization

Urbanized area=1
Non-urbanized area=0

FromGLC 2017

Dependent variable

Results

NPP-VIIRS

Actual artificial area
Artificial area extracted

N

0 5 10 20 Km

Luojia1-01

Actual artificial area
Artificial area extracted

N

0 5 10 20 Km

Tabla 2. **Cross table (Barcelona)**

	Rural (%)	Urbanized (%)	Total (%)	Kappa
NPP-VIIRS	91.6	58.2	82.7	0.569
Luojia1-01	92.1	65.7	85.1	0.602

The extraction precision of the urbanized area of Luojia1-01 is much higher than that of NPP-VIIRS and can get more urban details.

In Barcelona, the precision of the urbanized area increases from 58.2% to 65.7%, while the Kappa has increased from 0.569 to 0.602, and the total precision reaches 85.1.

Spatial analysis

To compare more intuitively the spatial differences between the actual urbanized areas and the predicted urbanized areas, we define the urbanized area as 1 and the non-urbanized area as 0, and do the following calculation

Then we will obtain the 3 possibilities of the Variation:

$$Variation = A_{predicted} - A_{real}$$

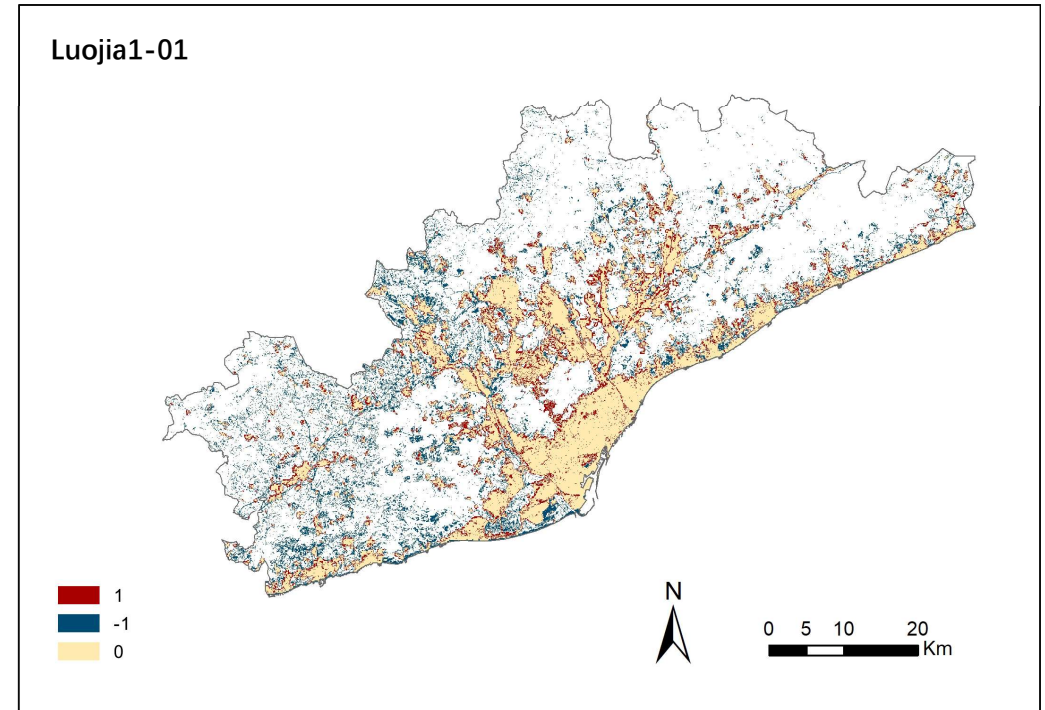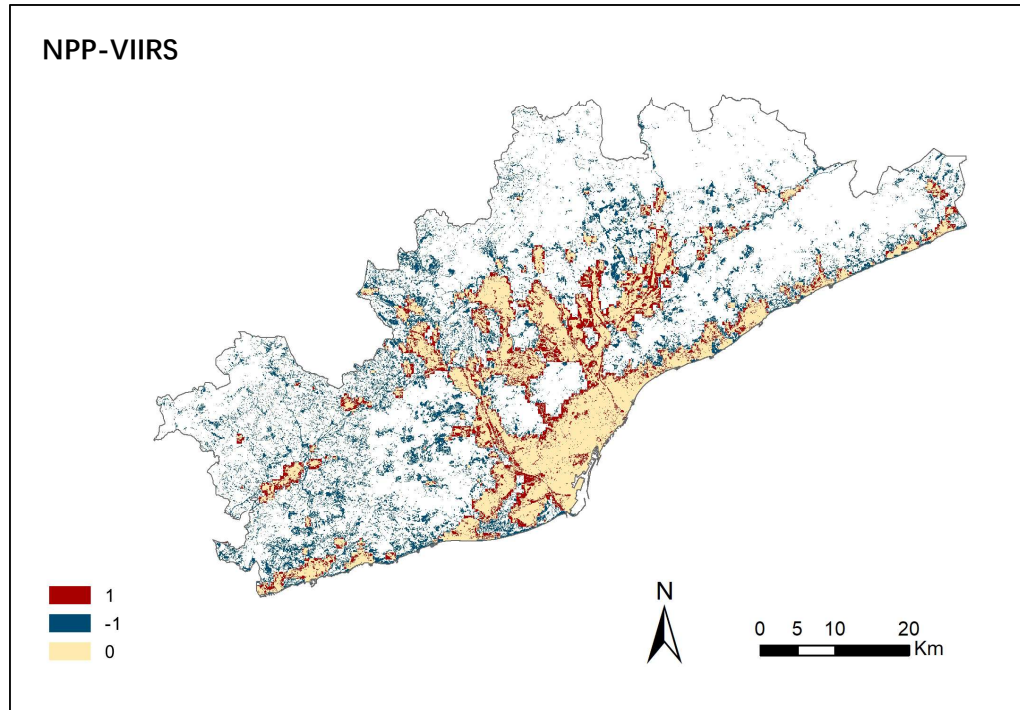| 0	1	1
1	1	0
-1	0	1
0	0	0

Variation = 1, means the pixels belong to the rural, but it is predicted as urbanized area.

Variation = -1, means the pixels belong to the urbanized area but have not been extracted correctly.

Variation = 0, it means the pixels are extracted correctly.

Spatial analysis

It can be seen that the red spots are mainly located inside the city, while the blue spots are located on the edge of the city.

Because we define artificial areas as urbanized areas, most of the red spots is the non-urbanized area in the city, such as green space, they are confused with urbanized areas due to the resolution limitation of the night lights images. And the blue spots are suburban areas with dim light, and thus are not successfully extracted.

Conclusions

In this work, we extract urbanized areas with the logistic regression model based on the night lights images, and to evaluate and compare the accuracy of the images of different resolutions in the extraction of urbanized areas.

The results show that the night lights image of Luojia1-01 with a higher resolution has higher precision in extracting urbanized areas than NPP-VIIRS.

Through spatial analysis, it is found that due to the limitation of the image resolution, there are still many details that have not been distinguished successfully, such as green spaces in cities and the suburban areas with dim light.

Finally, as a new generation of night lights image, Luojia1-01 offers higher spatial resolution, wider range of radiation, and richer urban dynamic information than previous products. It shows great potential in extracting small-scale urbanized areas, and can be widely used to monitor, assess urban morphology and urban economy in the future.

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Thank you