Predicting urban 3D maps in the future

Aerospace Information Research Institute，
Chinese Academy of Sciences

27th Aug 2023

Background

Urbanization never stops.

- Recent decades have seen unprecedented growth in the global population, with an estimated 55% of the world’ s population now living in urban areas, the figure is expected to reach 68% by 2050.

- Urban 3D describes the horizontal and vertical development of the city, which has a significant impact on the local climate and the global environment, including economic growth, climate change and sustainable development.

- More and more studies focus on the prediction of future population, future urban land use and even future economic. However, future 3D maps are scarce at present.

Background

When we say ***future cities***, what are we talking about.

- A **high precision**, **high-resolution (1 km), global-scale** dataset of the urban built-up footprint area, height and volume of global urban buildings under five different SSP scenarios.

- This study aims to provide a theoretical basis for understanding the spatiotemporal evolution of **urban 3D growth** under different development paths of human society in the future and provide data support for understanding and studying global climate change and urban socio-economic development.

Background

Shared Socioeconomic Pathways (SSP)

The Intergovernmental Panel on Climate Change (IPCC) has developed Shared Socioeconomic Pathways (SSPs), which correspond to five different future population distributions, levels of economic development, levels of urbanization, and levels of fossil fuel use.

pathways	特征	描述
SSP1	Sustainable	The world is gradually but generally shifting to a more sustainable path, emphasizing more inclusive development that respects the boundaries of the perceived environment. Driven by a growing commitment to achieving development goals, inequality has declined both between and within countries. Consumption is oriented towards low material growth and lower resource and energy intensity.
SSP2	Middle pathway	The world follows a path where social, economic, and technological trends do not deviate significantly from historical patterns. The environmental system experienced degradation, but there was some improvement, with an overall decline in the intensity of resource and energy use. Global population growth is moderate and will level off in the second half of the century.
SSP3	Regional rivalry	Resurgent nationalism, concerns about competitiveness and security, and regional conflicts have prompted countries to focus increasingly on domestic or, at most, regional issues. Over time, policy has become increasingly oriented towards national and regional security issues. Countries have focused on achieving energy and food security goals within their own regions at the expense of broader development.
SSP4	Inequality	Highly unequal investment in human capital, coupled with growing disparities in economic opportunity and political power, has led to increased inequality and stratification between and within countries. Over time, the gap between internationally connected societies that contribute to the knowledge - and capital-intensive sectors of the global economy and the low-income, poorly educated societies that work in the labor-intensive, low-skilled economy has widened. Social cohesion declined, and conflict and unrest became more common.
SSP5	Fossil fuelled development	The world increasingly believes that competitive markets, innovation, and participatory societies can deliver rapid technological progress and human capital development as a path to sustainable development. Global markets are increasingly integrated. There are also significant investments in health, education and institutions to strengthen human and social capital.

Data and methods

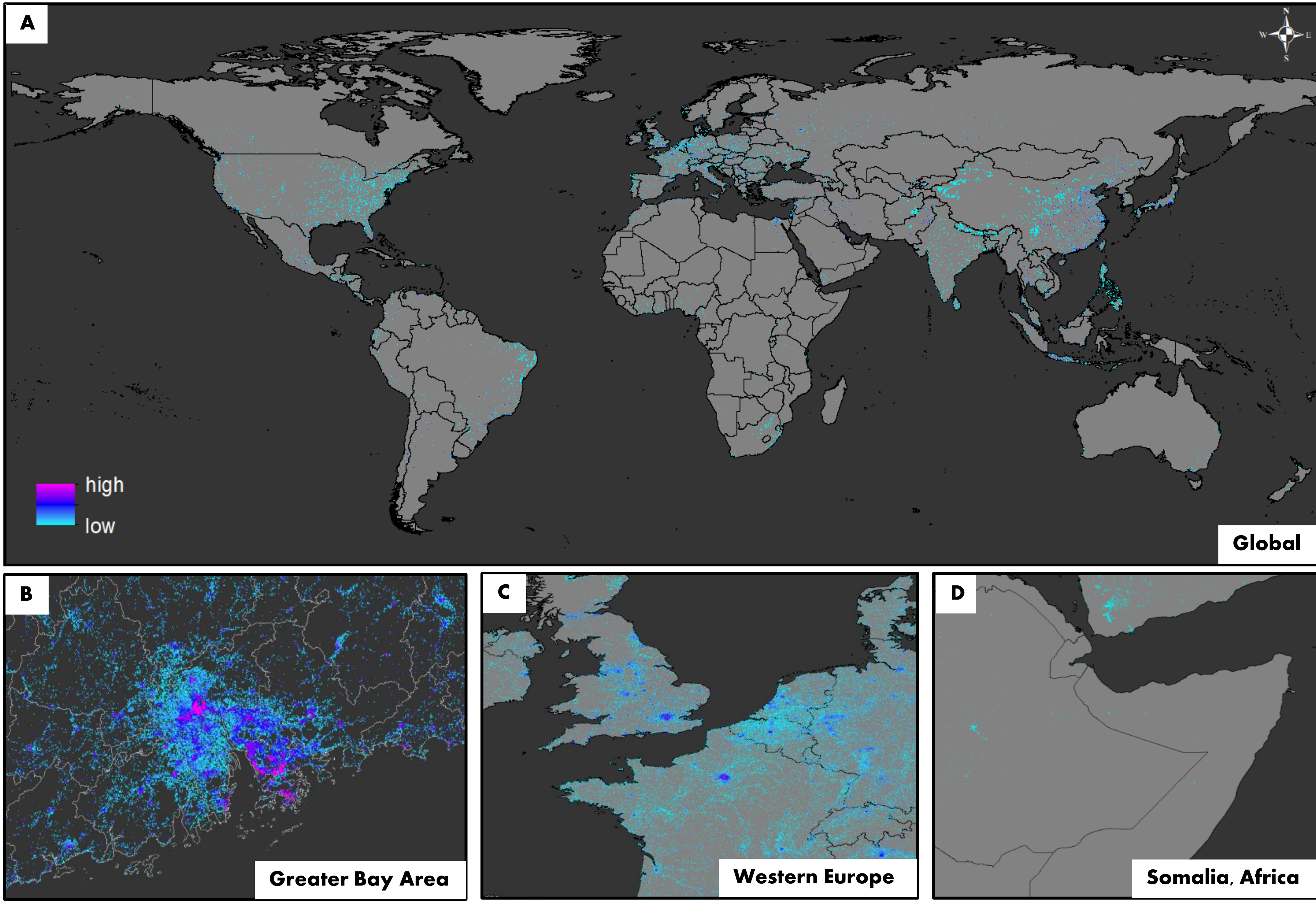
Assumption 1:

Urban 3D expansion is highly correlated with the socioeconomic activities of human beings.

Data Type	Dataset	Year	Resolution	Source
Population	WorldPop	2015	1km	Lloyd et al
	FPOP	2020-2100	1km	Li et al
Urban land	Historical Built-up Land	2015	300m	CCI-LC
	Built-up Land Scenarios	2020-2100	1km	Chen et al
GDP	Historical GDP	2015	1km	Matti et al
	GDP Scenarios	2020-2100	1km	Murakami et al
Road density	GRIP	2015	8km	Meijer et al
Electrical facilities density	Power system maps	2015	1km	Arderne et al
POI density	POI	2015	1km	OpenStreetMap
Topography	GLOBE Topography	2015	1km	NOAA
Accessibility	Travel time to city centers	2015	1km	Daniel et al
	Distance to city centers	2015	1km	Florczyk et al

Table1. Explanatory variables

Global electronic network density



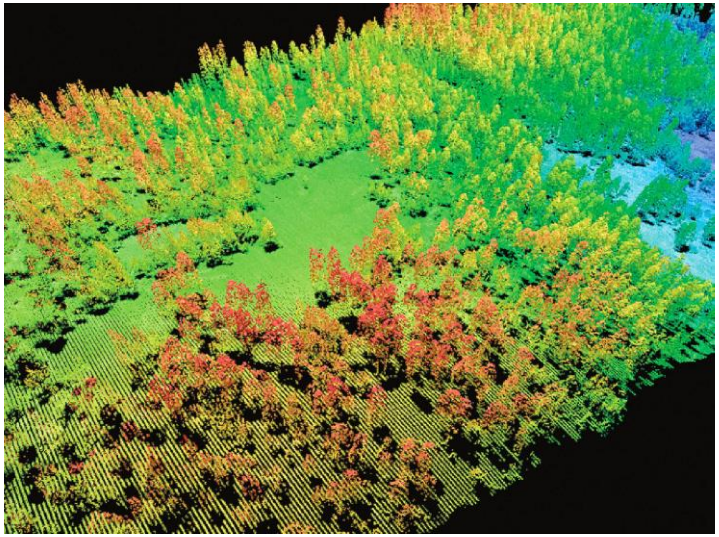
Deep learning framework for 3D urban vegetation extraction using high-resolution stereo satellite data

Reporter：Qingyan MENG

Aerospace Information Research Institute, Chinese Academy of Sciences

1. Background

Vegetation is indispensable to urban ecosystems. At present, research on two-dimensional (2D) vegetation information extraction at the urban scale has been extensively conducted. The vertical vegetation structure is a critical characteristic in the design of urban green spaces.



The efficient and reliable acquisition of 3D vegetation information at an urban scale remains challenging.

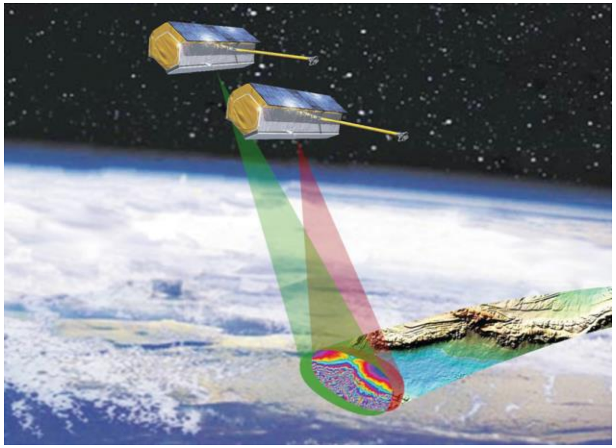
1. Background

Extensive data sources

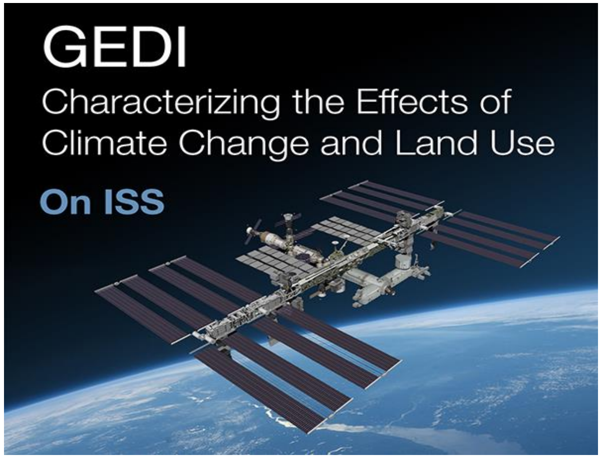
aerial photogrammetry & airborne laser

unmanned aerial vehicles

SAR satellite



spaceborne LiDAR



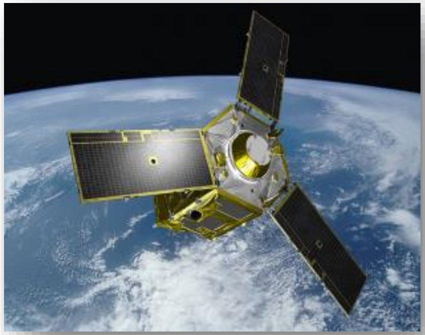
1. Background

Existing methods

Technology	Advantage	Disadvantages	Reference
Field measurement	high accuracy	high time and labor costs	(Stagoll et al., 2012)
Aerial photogrammetry and airborne laser	professional-grade 3D forest survey; high efficiency	high cost and regional restriction	(Hancock et al., 2017; Toschi et al., 2021)
unmanned aerial vehicles	multiple sensors; high resolution	limited daily collection area	(Nex et al., 2022; Yu et al.,2023)
SAR satellite	large scale forest extraction	sight obscured by buildings in cities	(Lv et al., 2022)
Spaceborne LiDAR	large scale observation	spatial sparsity	(Liu et al., 2022)
Optical satellite	Continuous time and space	accuracy needs to be evaluated	(Lang et al., 2019)

1. Background

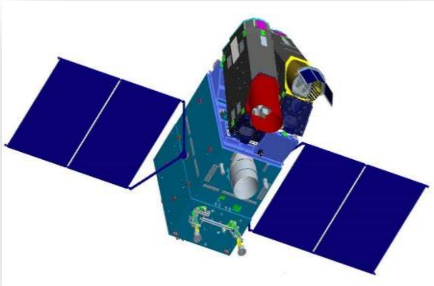
Stereoscopic satellite



Pléiades satellite

WorldView-4 satellite

ZY-3 satellite



GF-7 satellite

- Stereoscopic satellite surveys can provide both 3D information and rich spectral information.

Whether this satellite can be applied to vegetation height extraction remains unknown.

Article Report

HR-UVFormer: A top-down and multimodal hierarchical extraction approach for urban villages

Reporter: Tan Xin

Aerospace Information Research Institute

August 24, 2023

1.1 Research background

Urban Villages (UVs) are informal settlements limited by the conditions of urban infrastructure during Chinese rapid urbanization process.

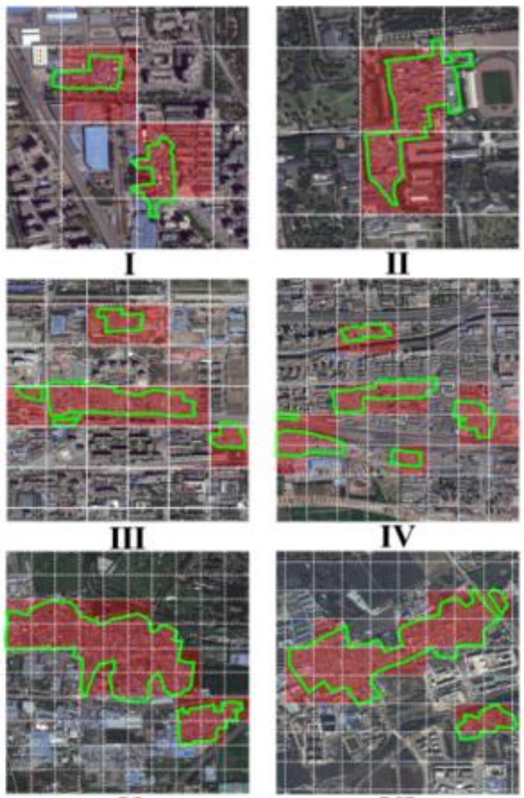
High-rise buildings

Old urban areas

1.2 Research problem

- **Current deep learning methods are all based on a single spatial scale to extract urban villages, which has major limitations.**

Patch based



Pixel based

Incomplete extraction results

Fine boundary extraction

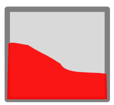
Jaggedness at borders

Complete coverage of urban villages

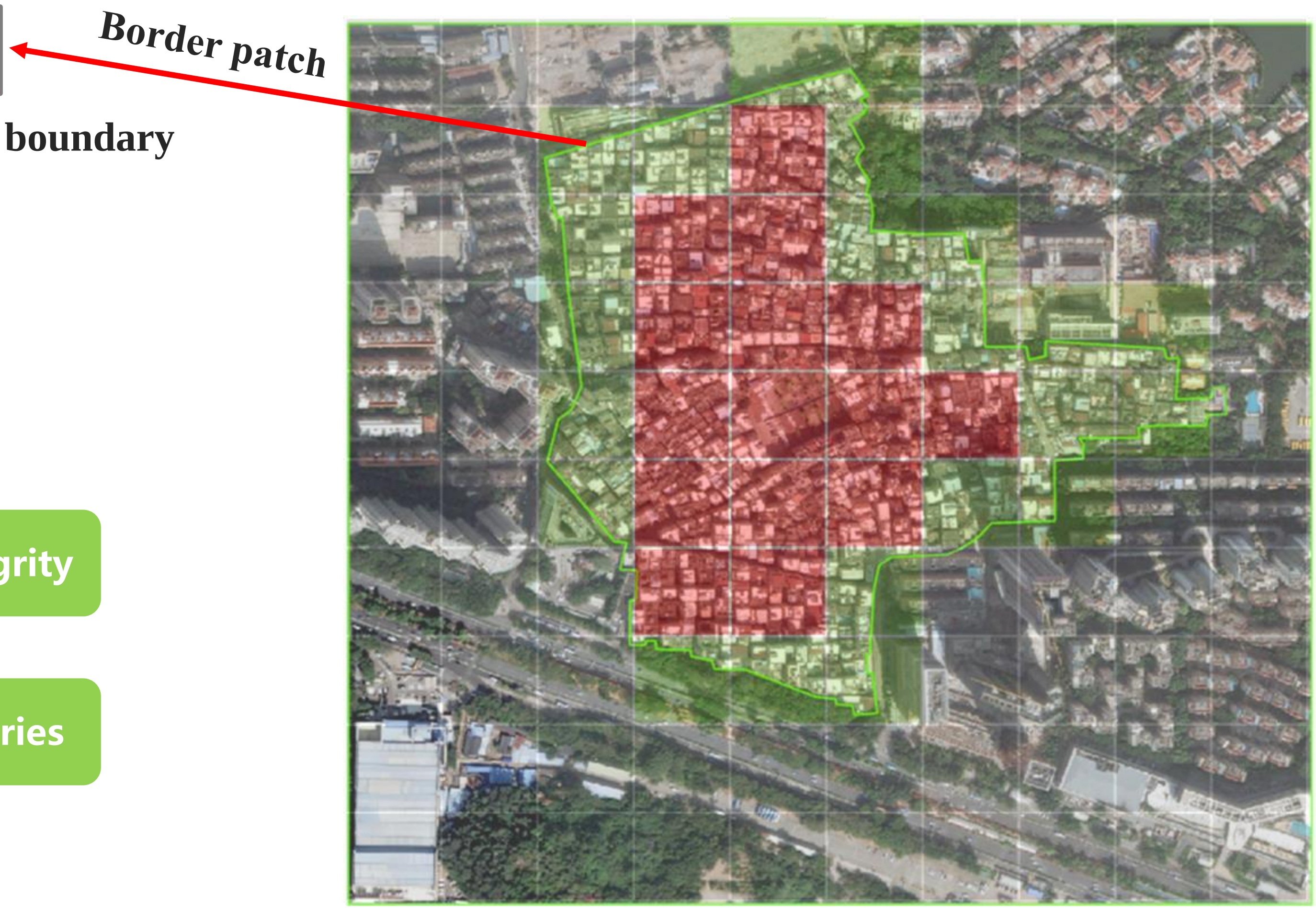
Combining the advantages

2.1 Model overview

- **A hierarchical extraction approach is proposed to perform hierarchical extraction of UVs from coarse scale (patch) to fine granularity (pixel);**



Pixel-level boundary



Internal integrity

Fine boundaries

2.2 Building footprint

- **Building footprint provides direct information on the structural layout of building clusters.**
- **To explore the contribution of Building footprint, this study designed a multimodal deep learning mothod HR-UVFormer.**