Mapping Global Population Changes

Yujie Liu and Jie Chen

1 Introduction

The increase in greenhouse gas emissions caused by human activities is considered as the main cause of global warming (Stocker et al. 2013). The rapid growth of population and economic activities in the twentieth century has brought unprecedented pressure on climate and the environment, and population has become an important topic in climate change research (Min et al. 2011; Diaz and Moore 2017; Forzieri et al. 2017). Accurate and robust predictions of population size and spatial distribution will help to assess the impact of climate change on socioeconomic development, human health, and resource demand and distribution, and provide a scientific basis for designing strategies to control greenhouse gas emissions and developing mitigation and adaptation policies (Lutz and Kc 2011; Field et al. 2014; Gerland et al. 2014).

Climate scenarios constitute the basis of climate change research, and the rational setting of socioeconomic development scenarios is the core of climate change impact assessment (Van Vuuren et al. 2012). Shared socioeconomic pathways (SSPs) are reference pathways that describe alternative trends that may emerge in social and economic system development in the twenty-first century in the absence of

climate change or climate policies (O'Neill et al. 2014). Five such SSP schemes (SSP1–5) have been developed. In particular, SSP1 is a sustainable solution that advances in technology and reduces reliance on carbon energy; SSP2 describes a medium-sized solution that can maintain the current trend and gradually reduce the reliance on carbon energy; and SSP3 is a regionalization program that leads to reduced trade flows, adverse institutional development, and poor adaptation to climate change. Based on these SSPs, preliminary studies have been conducted on demographic and economic changes in more than 150 countries (O'Neill et al. 2014). It is expected that there will be more attention paid to the size, as well as the spatial distribution of future populations in the SSP scenarios, with the increasing demand for demographic analysis in small areas related to climate change (Chi 2009; Raymer et al. 2012).

This study aims to evaluate the changes in the global population under SSP1-2030, SSP1-2050, SSP2-2030, SSP2-2050, SSP3-2030, and SSP3-2050. We produced the data at the global and regional scales. The spatial resolution of global projections is $0.5^\circ \times 0.5^\circ$, and the spatial resolution of regional projections is $0.25^\circ \times 0.25^\circ$. The four hotspot regions are the Bohai Rim area in China, the Qinghai-Tibet Plateau in China, the northeastern United States, and western Europe. The present results may provide a scientific basis for climate risk assessment and effective adaptations.

2 Method

The methods for projecting population and its change for future SSP scenarios are as follows: (1) collecting the statistical data of national populations in 2005; (2) analyzing the projections of national populations under the three SSP

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Fig. 1 Technical flowchart for the projection and mapping of the population of the world

scenarios in 2030 and 2050; (3) conducting the spatial downscaling of the populations at the country level to the grid level; and (4) summarizing the results of population projections. Figure 1 shows the technical flowchart for the projection and mapping of the populations of the world.

For population projections, the population at the country level in 2005 was obtained from the World Bank (<https://data.worldbank.org/cn/>), the International Monetary Fund (<https://www.imf.org/en/Data>), the Central Intelligence Agency (<https://www.cia.gov/>), and the United Nations (<https://data.un.org/>).

The global distribution of population in 2010 was assessed based on the population of the baseline period (2005) multiplied by the growth rate of population. The growth rate was calculated based on the population projections at the country level by the International Institute for Applied Systems Analysis (IIASA) (Samir and Lutz 2014). The statistical analysis was performed using ArcGIS. Then, the national population projections were spatially downscaled with reference to the spatial distribution of UN-WPP-Gridded Population of the World (GPW), v4 in 2005 (Doxsey-Whitfield et al. 2015). The spatial analysis was performed using ArcGIS. Then, the gridded population projections were summarized at the national, continental, and global scales, and the proportions of each continent to the world and the proportion of China were calculated for analysis.

3 Results

Global and continental populations under the SSP1–3 scenarios are shown in Fig. 2. The global population for the baseline period is 6575.50×10^6 persons, which increases to 9542.47×10^6 persons by 2050 under the SSP3 scenario. The increase in population is the largest for the SSP3 scenario and the smallest for SSP1. Among the continents, the population is the highest for Asia, followed by Africa, and the lowest in Oceania in both the baseline period (2010) and the SSP scenarios. Population in Asia and Africa in the baseline period is 61% and 15%, respectively. The percentage of population under the three SSP scenarios decreases for Asia and increases for Africa. The percentage of the population by 2050 under the SSP3 scenario decreases for Asia to 57% and increases for Africa to 24% of the global total. Population in China is projected to increase under all the SSP scenarios and time periods compared to the baseline period. However, the percentage of the Chinese population in Asia and the world is likely to decrease. In the baseline period, China accounted for 33% and 20% of the population in Asia and the world, while in 2050 under the SSP3 scenario, the percentage would decrease to 24% and 14%, respectively (Fig. 2).

Fig. 2 Projections of global and continental populations under the Shared Socioeconomic Pathways

4 Maps

Global population distribution (Baseline)

Projected global population distribution (2030, SSP1) **Projected global population distribution (2030, SSP2)**

Projected global population distribution (2030, SSP3)

Projected global population distribution (2050, SSP1)

Projected global population distribution (2050, SSP2)

Projected global population distribution (2050, SSP3)

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