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Remotely sensed monitoring of urban greening in China from 1990-2019 to support SDG11

Ping Zhang[1], Hao Wu[1], Hao Chen[2], and Qiangqiang Sun[3]
[1]National Geomatics Center of China, Research and development, Beijing, China (zhangping@ngcc.cn)
[2]Hunan University of Science and Technology, Xiangtan, China
[3]College of Land Science and Technology, China Agricultural University, Beijing, China

Understanding and accurate identification of long-term urban greening dynamics in China are critical for the sustainable urban management (Sustainable Development Goals, SDG11) and living environment of humans. But it was often challenging because a lack of continuous high-frequent data at high spatial resolution and over large time scales. Here, we proposed a framework for identifying detailed evolution processes and regime shifts in relation to urban greening based on characterization of urban greenness in continuous fields over space and time. We utilized annual, fractional estimates of urban green vegetation (GV) endmember time series from per-pixel Landsat composites, using a standardized spectral mixture Vegetation-Impervious surface-Soil (VIS) model in China over the past three decades. A Google Earth Engine platform-based non-linear model (logistic curves) was developed to derive the magnitude, timing and duration of urban greening at a per-pixel basis during these time series records. These parameters were combined to characterize heterogeneous pattern of urban greening throughout the entire China in 1990-2019. We found that the unmixed fractions of urban GV exhibited a generally consistent agreement with estimated fractions from high-spatial-resolution Google earth images (RMSE =11.30%), demonstrating its high suitability and reliability. Using detailed geographic process model with logistic trajectory fitting curves, our findings indicate that the ratio of the area with significant greening trends during 1990-2019 account for nearly 3.0% to the overall urbanized area in China. These greening changes are predominantly distributed in eastern coastal region and northeast Plain. In particular, the Jing-jin-ji, Ha-Chang and Middle-Southern Liaoning are the top three urban agglomerations contributing the greening for this period. Notably, Urumqi, the capital city in north-western China, has the highest ratio of the area with significant increasing GV relative to the urbanized space of the entire city, due to great achievements of urban green construction (i.e., the newly established parks or street plants), and relatively low greenness before 1990. Based on the derived change parameters, our results also reveal the economic impacts on the timing of urban greening are prevalent. For instance, the timing of turning points for urban greening in three major highly-urbanized and developed urban agglomerations, that is, the Jing-jin-ji, Yangtze River Delta, Pearl River Delta showed 2-3 years earlier than other regions. Compared to the state-of-the-art approaches, this framework has the potential to detect high-frequent urban greening process as continuous spatial and time fields with multi-dimensional thematic, thus could help support sustainable urban management practices.