Bulletin of Chinese Academy of Sciences

Volume 36 | Issue 8 | Article 7

8-20-2021

Big Earth Data for UN Sustainable Development Goals: Climate Change and Action

Lei HUANG
International Research Center of Big Data for Sustainable Development Goals, Beijing 100094, China
Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100094, China, huanglei@radi.ac.cn

See next page for additional authors

Big Earth Data for UN Sustainable Development Goals: Climate Change and Action

Abstract

Climate change is becoming a major threat to human sustainable development in the coming decades. How to accurately and real-time monitor extreme weather events and disasters, and provide strong data and scientific support for climate change and disaster prevention and control, has become an urgent major scientific issue and decision-making proposition. The Sustainable Development Goals (SDGs) 13 Climate Action is to alleviate the threat of climate change and enhance human adaptation through the actions of countries. However, indicators of climate action lack the support of spatial data and information. The Big Earth Data is highly collaborative and integrated, which is conducive to reducing the uncertainty of research and assessment results. At the same time, it also reflects the urgent demand of climate change and disaster risk research for scientific data. This study focuses on the two major themes of mitigation of the impact of climate change related disasters and the reduction of greenhouse gas emissions. Through the Big Earth Data platform, the work studies the methods of obtaining the spatial distribution of disasters and the trend of carbon budget change through the comprehensive multi-source data, and obtains the data sets with spatial information to support the SDG 13 Climate Action, providing decision support for disaster reduction and emission reduction.

Keywords

Big Earth Data, Sustainable Development Goals (SDGs), climate action

Authors

Lei HUANG, Gensuo JIA, Shibo FANG, Donghui SHANGGUAN, Yonghong HU, Zhaoming ZHANG, and Dailiang PENG

This strategy & practice is available in Bulletin of Chinese Academy of Sciences (Chinese Version): https://bulletinofcas.researchcommons.org/journal/vol36/iss8/7

Citation: HUANG Lei, JIA Gensuo, FANG Shibo, SHANGGUAN Donghui, HU Yonghong, ZHANG Zhaoming, PENG Dailiang. Big Earth Data for UN Sustainable Development Goals: Climate Change and Action [J]. Bulletin of Chinese Academy of Sciences, 2021 (8): 923–931.

Big Earth Data for UN Sustainable Development Goals: Climate Change and Action

HUANG Lei[1,2], JIA Gensuo[3], FANG Shibo[4], SHANGGUAN Donghui[5], HU Yonghong[1,2], ZHANG Zhaoming[2], PENG Dailiang[1,2]

1. International Research Center of Big Data for Sustainable Development Goals, Beijing 100094, China;
2. Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100094, China;
3. Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China;
4. Chinese Academy of Meteorological Sciences, Beijing 100081, China;
5. Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, China

Abstract: Climate change is becoming a major threat to human sustainable development in the coming decades. How to accurately monitor real-time extreme weather events and disasters and provide strong data and scientific support for climate change and disaster prevention and control, has become an urgent major scientific issue and decision-making proposition. The Sustainable Development Goal (SDG) 13 Climate Action is to alleviate the threat of climate change and enhance human adaptation through the actions of countries. However, indicators of climate action lack the support of spatial data and information. The Big Earth Data is highly collaborative and integrated, which is conducive to reducing the uncertainty of research and assessment results. At the same time, it reflects the urgent demand of the research on climate changes and disaster risks for scientific data. This study focuses on the two major themes of the mitigation of the impact of climate change-related disasters and the reduction of green-house gas emissions. Through the Big Earth Data platform, the work studies the methods for obtaining the spatial distribution of disasters and the trend of carbon budget change through the comprehensive multi-source data, and obtains the data sets with spatial information to support the SDG 13 Climate Action, providing decision support for disaster mitigation and emission reduction. **DOI:** 10.16418/j.issn.1000-3045.20210705004-en

Keywords: Big Earth Data; Sustainable Development Goals (SDGs); climate action

In view of the impact and response of climate change, how to accurately monitor extreme weather events and disasters, predict the trend of disasters in real time, and provide strong data and scientific support for climate change and disaster prevention and control has become a major scientific question and decision-making proposition that urgently needs to be solved. In order to cope with climate change and its impacts, the United Nations has established the Sustainable Development Goal (SDG) 13 Climate Action (taking urgent action to deal with climate change and its impacts), which aims to mitigate the impact of climate change on human beings and improve the ability to respond to climate change [1]. At present, SDG 13 mainly involves 5 targets and 8 indicators (Table 1). Among the 8 indicators, 2 indicators belong to Tier I (with available methods and data) and 6 belong to Tier I (with available methods while no data). According to the characteristics of Big Earth Data, this paper focuses on the two targets (SDG 13.1 and SDG 13.2) of SDG 13 supported by Big Earth Data. The implementation of SDG 13.1 is based on the Sendai Framework for Disaster Risk Reduction 2015–2030. Its main regulator, the United Nations Office for Disaster Risk Reduction, has pointed out in the report issued in 2019 that climate change has been the main cause of disaster losses to the human society ①. The implementation of SDG 13.2 is based on the Paris Agreement, which hopes to reduce the increase in air temperature by reducing greenhouse gas emissions. On September 22, 2020, President Xi Jinping declared at the general debate of the 75th session of the General Assembly that China will scale up its intended nationally determined contributions and take stronger policies and measures to achieve the peak of carbon dioxide (CO_2) emissions before 2030 and achieve carbon neutrality before 2060. This is the key measure for China to deal with climate change and realize SDG 13.

Big Earth Data is highly collaborative and integrated, which is conducive to reducing the uncertainty of research results. At the same time, it also reflects the urgent needs of the research on climate changes and disaster risks for scientific data. The research and development of indicators with spatial information will become an important breakthrough in promoting the realization of SDGs ②. The existing indicators are mostly statistical figures, lacking the support of spatial data and information as well as the guidance and programs for climate change. SDG 13.1 and SDG 13.2 do not fully

Received: 2021-07-29

Supported by: Strategic Priority Research Program of the Chinese Academy of Sciences (XDA19090122)

① Global Assessment Report on Disaster Risk Reduction (2019). https://www.undrr.org/publication/global-assessment-report- disaster-risk-reduction-2019.

② The Sustainable Development Goals Report, 2020. https://unstats.un.org/sdgs/report/2020.

Table 1 Targets and indicators of SDG 13

Target	Indicator	Tier*
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100 000 population	Tier Ⅰ
	13.1.2 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	Tier Ⅱ
	13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	Tier Ⅱ
13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change	Tier Ⅱ
	13.2.2 Total greenhouse gas emissions per year	Tier Ⅰ
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment	Tier Ⅱ
13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025	Tier Ⅱ
13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	13.b.1 Number of least developed countries and small island developing States with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change	Tier Ⅱ

Tier classification is used to characterize the monitoring and evaluation methods and data status of various sustainable development indicators. It is divided into Tier I, Tier II, and Tier II. Among them, Tier I refers to the indicators with clear definition and evaluation methods, and effective monitoring data; Tier II refers to the indicators with clear definition and evaluation methods, but there is still a lack of monitoring data; Tier III refers to the indicator that has not been determined methods or standards

consider the implementation progress of earth observation method monitoring, so it is urgent to expand their connotation by expanding the spatial distribution information of climate change-related disasters and the impact of climate change.

Climate change is a common issue that mankind needs to face for a long time. What impacts China and other places of the world have been or will be affected by climate change, and how to reduce disaster losses, mitigate impacts, and achieve sustainable development in the context of climate change are the focus of academic circles and policy makers [2]. Focusing on SDG 13.1 and SDG 13.2, through the Big Earth Data platform, this work studies the methods for obtaining the spatial distribution of disasters, and obtains the data sets with spatial information to support the SDG 13 Climate Action, and provides decision support for disaster mitigation and emission reduction.

1 Status and progress of implementing SDG 13

1.1 SDG 13.1

In 2019, the global CO_2 emission reached 36.7 Gt, 62% higher than that in 1990. The mean temperature during 2016–2020 was 1.1 °C higher than that in the early stage of industrialization①. The continuous increase and accumulation of greenhouse gas emissions lead to the rise in global temperature and the aggravation of uneven distribution of precipitation, resulting in an increase in the frequency and severity of natural disasters such as heat wave, drought, flood, forest fire, and dust storm②.

Extreme weather caused by climate change and environmental damage caused by human activities will be the main risks facing the world in the next decade③. From 2000 to 2019, 7 348 large-scale disasters caused by extreme weather

① United in Science 2020-A multi-organization high-level compilation of the latest climate science information. https://public.wmo.int/en/resources/united_in_science.

② Global Environment Outlook-GEO-6: Healthy Planet, Healthy People, 2019. https://wedocs.unep.org/handle/20.500.11822/27539; Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. IPCC, 2019. https://www.ipcc.ch/srccl/ chapter/summary- for-policymakers.

③ The global risks report 2021, 16th Edition. https://www.weforum.org/reports/the-global-risks-report-2021.

were recorded in the world, resulting in 1.23 million deaths, 4.2 billion person-times influenced, and 2.97 trillion US dollars in economic losses ①.

However, the available disaster indicators are mostly statistical figures. The types, impact scope, and frequency of disasters and the distribution of affected population lack the support of spatial data and multi-level analysis, which makes it difficult to form detailed guidance and early warning for disaster reduction.

1.2 SDG 13.2

Slowing down the global warming is of great significance to human health, food security, and terrestrial and marine environment. Reducing greenhouse gas emissions is the key to achieving the goal of global warming control in the Paris Agreement ②. At present, there is still a big gap between the current and required greenhouse gas emissions [3], which needs the joint efforts of the whole world. The global COVID-19 pandemic in 2020 slightly reduced greenhouse gase emissions while cannot curb the long-term trend of the continuous increase in the emissions③.

Since 2005④, China has become the world's largest emitter of greenhouse gases [4]. China's carbon peaking and carbon neutrality strategy will reduce the global mean temperature by 0.2 °C–0.3 °C at the end of the 21st century compared with no action, which increases the possibility⑤ of realizing the goals in Paris Agreement and shows the responsibility of a great nation.

To achieve carbon neutrality, we should not only reduce carbon emissions but also increase carbon sink of natural ecosystems. Oceans and land (especially forests) have strong carbon sequestration capacity for anthropogenic greenhouse gases [5,6]. Research shows that the proportion of natural carbon sink in China from 2010 to 2016 is about 45% [7].

Carbon neutrality has become the most urgent task of the current climate action, whereas the current indicators of SDG 13 only include greenhouse gas emissions. There is a lack of sufficient guidance on how to implement and progress carbon neutrality.

2 Big Earth Data platform

Big Earth Data integrates earth observation data, statistical data, ground station data, and basic geography data, which can effectively monitor extreme climate and disasters in a large region. In particular, it can timely and accurately monitor the occurrence of major disasters such as typhoon, flood, drought, and earthquake. In view of the disaster risks along the Belt & Road region, the establishment of the integrated platform of extreme climate and disaster data will support the prediction of disaster occurrence and development and the risk decisions. The integrated monitoring of satellite- airplane-earth will continuously and dynamically monitor extreme climate and disaster events within a large scope at different time and space scales in a real-time manner [8]. The Big Earth Data applied to SDG 13 is shown in Table 2.

Table 2 Big Earth Data applied to SDG 13

Data type	Specific form
Earth observation data	More than 10 satellites including GaoFen satellites, Landsat satellites, National Oceanic and Atmospheric Administration (NOAA) satellites, Moderate Resolution Imaging Spectroradiometer (MODIS) satellites, and Orbiting Carbon Observatory-2 (OCO-2)
Statistics	Statistical yearbooks of relevant disasters
Field observation	Temperature, precipitation, soil moisture, etc.
Basic geography	Population distribution, land cover change

The data used is integrated on the Big Earth Data cloud platform, and the production and index calculation of products are carried out through cloud computing, artificial intelligence and other analysis methods. Every global product will use remote sensing data of tens of thousands or hundreds of thousands of scenes, which, plus basic field data, requires high-speed computation. The use of cloud computation platform and intelligent processing algorithm greatly improves the computation and processing efficiency.

Focusing on the two specific targets SDG 13.1 and SDG 13.2 on the scales of the Belt & Road region and the globe, we take the heat waves, forest and grass fire, greenhouse gas emissions, and carbon sink change during 2010–2020 as examples to introduce the application of Big Earth Data in the research on SDG 13 (Figure 1).

3 Cases

3.1 Heat waves along the Belt & Road region

The frequency of heat waves along the Belt & Road region will increase due to global warming. The accurate space exploration and climate law analysis will timely warn and

① Dramatic rise in climate disasters over last twenty years. https://philippines.un.org/en/95345-un-report- dramatic- rise-climate-disastersover-last-20-years.
② Special report: Global warming of 1.5 °C. https://www.ipcc.ch/sr15/chapter/spm.
③ Emissions gap report 2020. https://www.unep.org/emissions-gap-report-2020.
④ Different data sources have slightly different representations of the time, which is about 2005.
⑤ The recent wave of net zero targets has put the Paris Agreement's 1.5 °C within striking distance. https://climateactiontracker.org/publications/global-update-paris-agreement-turning-point.

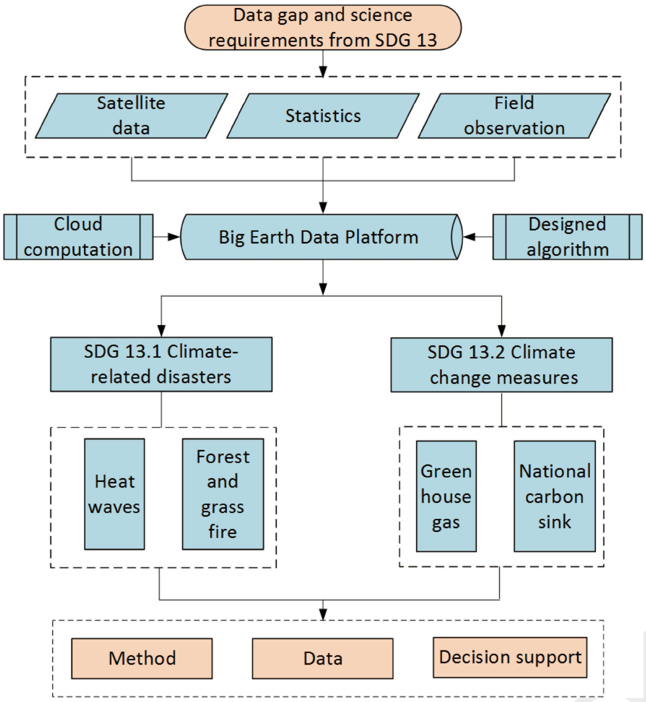

Figure 1 Flow chart of research on SDG 13 using Big Earth Data

mitigate disasters for countries along the Belt & Road. Heat wave events can be predicted with the daily ground temperature data of Aqua/Terra satellite and NOAA satellite and the data of 110 000 air temperature observation stations, in combination with the relative threshold method.

The heat waves along the Belt & Road have been analyzed for years. The key impacted areas are usually in the central and southern Eurasian continent as well as most parts of Africa and Oceania (Figure 2). From 2010 to 2020, the duration of heat waves increased significantly in central and northern Europe, northern Asia, and central and southern Oceania. These areas are also the key areas affected by the disasters coupled with heat waves in recent years, as manifested by the abnormal warming in the near polar region and the frequent occurrence of drought and fire caused by multi-year heat waves in Australia. The extreme high temperature has intensified significantly in the recent 10 years. For example, the extreme temperature in Asia and northern Europe has increased by 2 °C–5 °C, and that in some areas of Australia has increased by more than 10 °C.

3.2 Global forest and grass fire

Forest and grass fire is a common disaster. The occurrence of fire is directly related to temperature, precipitation, combustibles and other factors. The burned area can reflect the spatial distribution of fire. More than 800 000 remotely sensed images and artificial intelligence methods have been used to develop the global 30 m resolution burned land products in 2015 and 2019 (Figure 3). In 2015 and 2019, the total area of global burned land was $3.674\,5 \times 10^6$ km^2 and $3.656\,6 \times 10^6$ km^2, respectively. Africa has the largest burned area, which was $2.701\,2 \times 10^6$ km^2 in 2015 and $2.740\,7 \times 10^6$ km^2 in 2019.

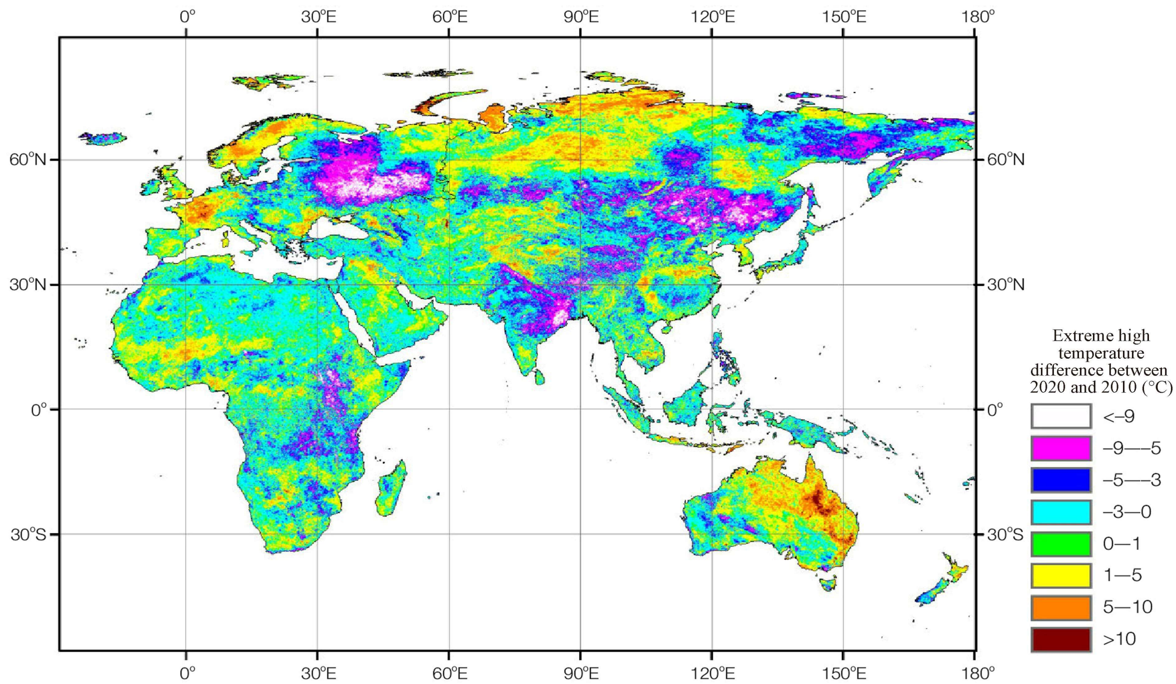

Figure 2 Spatial distribution of extreme high temperature difference between 2020 and 2010 along the Belt and Road region

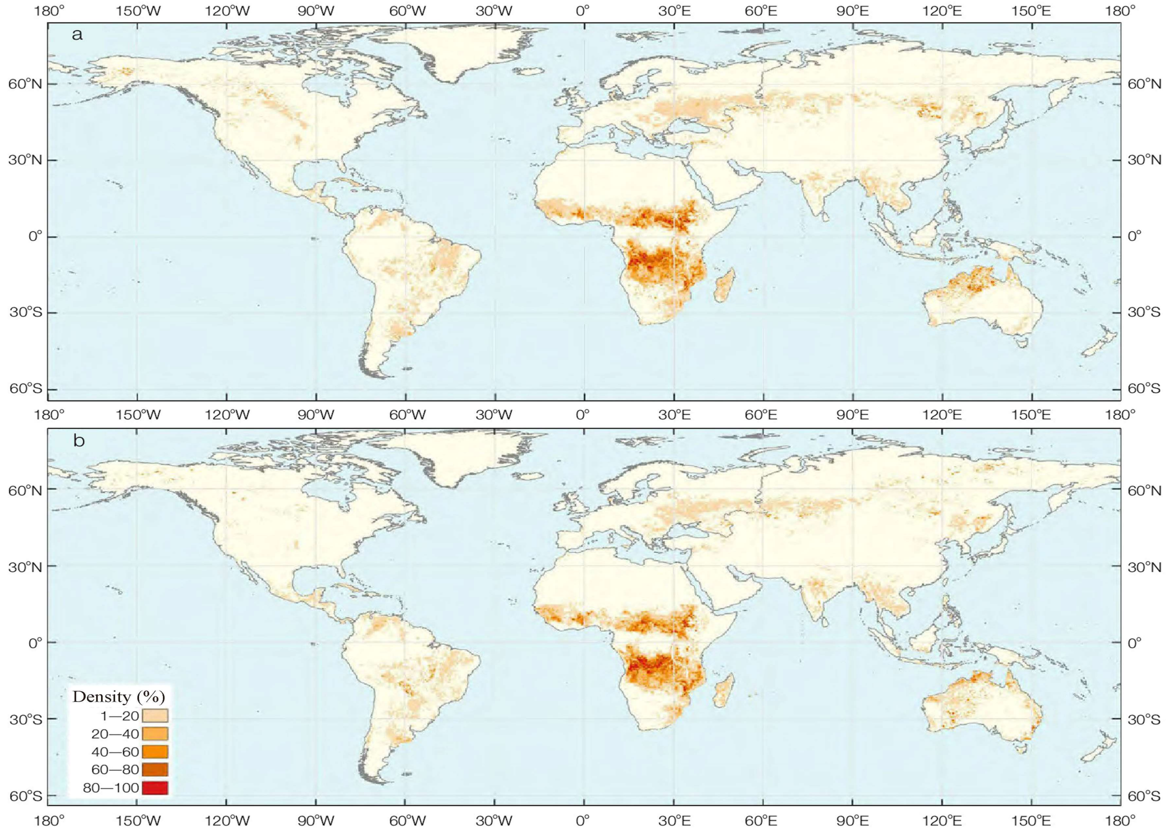

Figure 3 Global spatial distribution of burned area in 2015 (a) and 2019 (b)

From 2015 to 2019, the spatial distribution pattern of burned land in Australia has changed significantly. In 2019, the burned areas along the eastern and southeast coasts of Australia increased significantly. Forests and cities are concentrated in these areas, which are not fire prone areas in history. In the context of global warming, positive Indian Ocean Dipole (pIOD) events occur frequently, and the strong pIOD event in the autumn of 2019 led to heat wave and drought in eastern Australia. Extreme high temperature and drought caused by climate change are important reasons for rare forest fires in this region in 2019.

3.3 Global greenhouse gas emissions

Reducing greenhouse gas emissions is the key to mitigating climate change, controlling global warming, and realizing the goals in Paris Agreement. CO_2 is the greenhouse gas with the highest proportion in the atmosphere. Using the OCO-2 data of the National Aeronautics and Space Administration (NASA) and the atmospheric multispectral data of the European Space Agency (ESA) Sentinel 5 satellite, we obtained the global CO_2 and nitrogen dioxide (NO_2) concentrations. As an associated gas of fossil energy combustion, NO_2 has shorter lifetime and higher data resolution (0.01°), and its concentration has a high correlation with local carbon emissions. The greenhouse gas concentration monitored by satellite is affected by the speed of economic development, seasonal temperature changes, the proportion of fossil energy use and other factors, and thus fluctuates with time.

According to satellite data (Figure 4), the global CO_2 concentration is still increasing from 2015 to 2018. The concentration of CO_2 in China has obvious temporal and spatial differences, being higher in the southeast and lower in the west. Influenced by the COVID-19 pandemic, China's NO_2 in March 2020 reached the trough in recent years. Affected by the economic recovery and the increase in heating demand caused by the strong cold wave, the NO_2 concentration returned to the peak in December 2020, exceeding the level in the same period in 2019.

3.4 Assessment of global terrestrial ecosystem carbon sink change

Based on the Boreal Ecosystem Productivity Simulator (BEPS) model, the data of daily maximum temperature, minimum temperature, average relative humidity, daily precipitation, daily total radiation, leaf area index, CO_2 change, and nitrogen deposition change are used to calculate the contributions of land cover change, climate change, CO_2 change, and nitrogen deposition change to the change of global carbon sink.

The interannual variation of net primary productivity (NPP) obtained by MODIS satellite during 2001–2019 has demonstrated that the global carbon sink increased from 1.57 Pg in 2001 to 2.84 Pg in 2019, with an interannual linear increase of 0.08 Pg. The increase is particularly obvious in

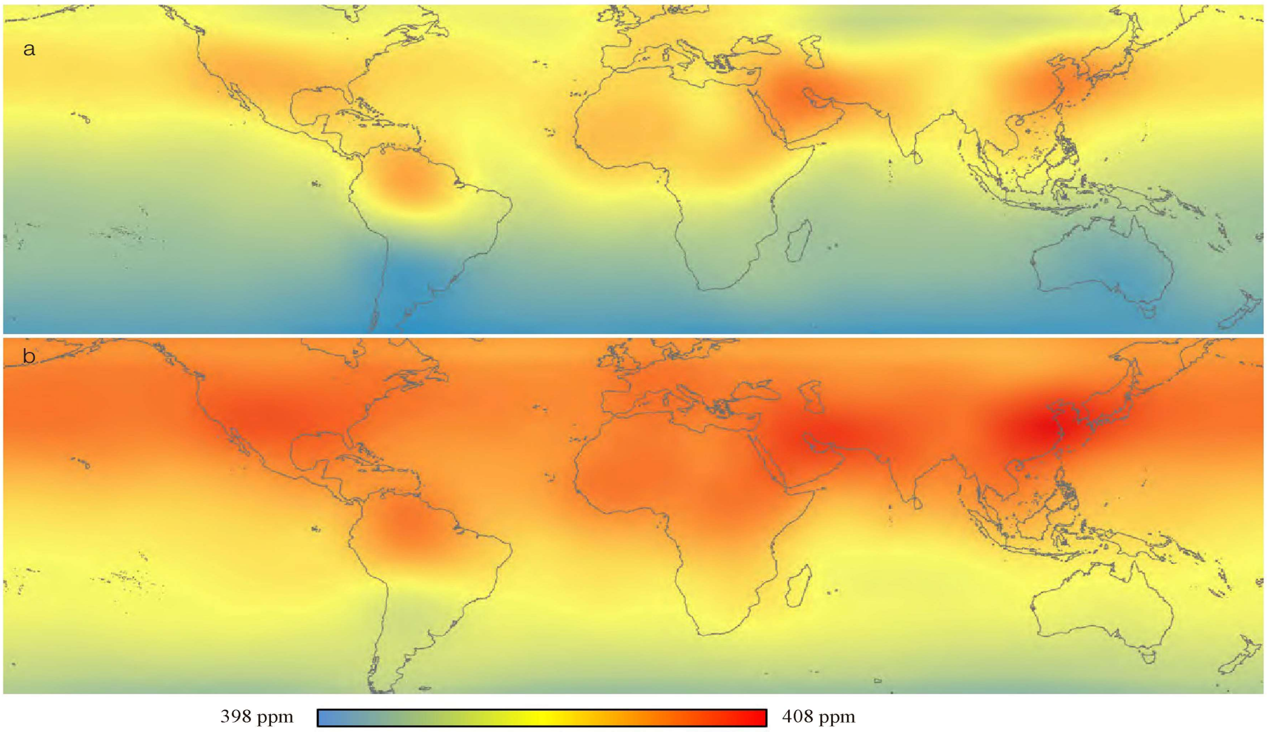

Figure 4 Global carbon dioxide concentrations in 2015 (a) and 2018 (b)

southern and central China, northwestern and northeastern Russia, India, central Africa, northern America, and southwestern America. The regions with obvious reduction include the central and western Australia, central Asia, southern Africa, eastern United States, and Brazil. China's carbon sink increased significantly from 63.95 Tg in 2001 to 223.81 Tg in 2019, with an interannual linear increase of 8.72 Tg.

The contributions of main driving factors to terrestrial ecosystem carbon sink are shown in Figure 5. Land cover change mainly contributes to the carbon sink change in the middle and high latitudes of Europe and North America as well as central and southern China. Climate change plays a major role in carbon sequestration in central Asia, Australia, southern Africa, and the midwest of the United States. The CO_2 and nitrogen deposition change is mainly concentrated in the middle and high latitudes. Globally, the contributions of land cover change, climate change, and CO_2 and nitrogen deposition change to terrestrial ecosystem carbon sink change from 2001 to 2019 are 43%, 33%, and 24%, respectively.

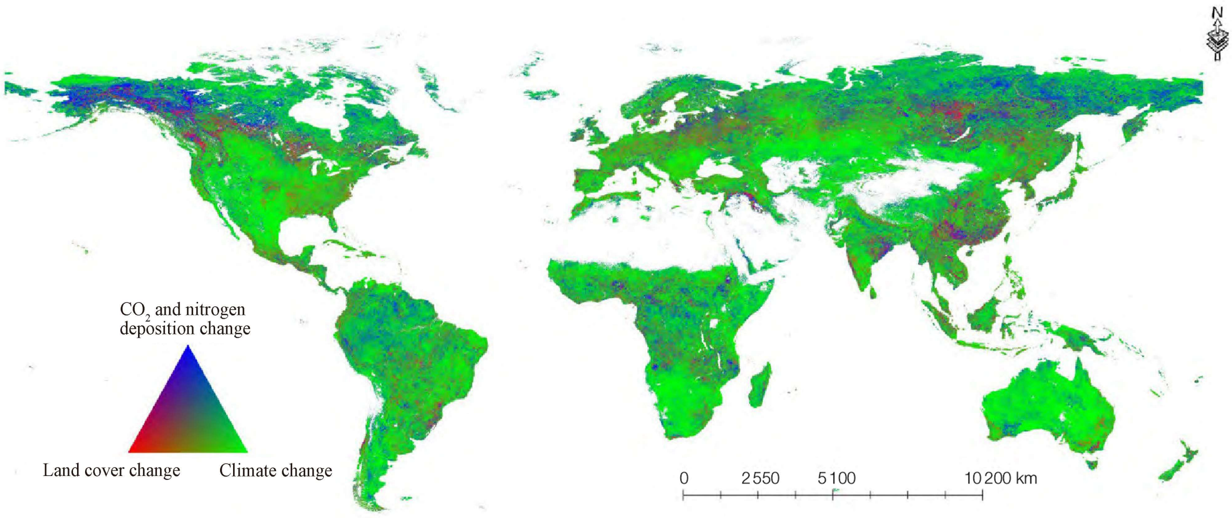

Figure 5 Contributions of land cover change, climate change, and carbon dioxide and nitrogen deposition change to terrestrial ecosystem carbon sink (NEP) change

4 Summary and prospects

This paper expounds the current implementation progress of SDG 13 and the demand for data, and illustrates the contribution of Big Earth Data to climate action through four cases. Focusing on SDG 13.1, this paper shows the temporal and spatial distribution of heat waves and forest and grass fire, as well as the close relationship between the increased occurrence of forest and grass fire and high-temperature drought in some areas. Based on SDG 13.2, the trend of global greenhouse gases and the driving factors of carbon sink change are analyzed. The global CO_2 concentration is still rising. The increase rate of CO_2 concentration in China tends to slow down while fluctuates greatly in 2020. Climate change and land cover change impact global carbon sink. Only by learning the intensity, frequency, and spatial distribution of disasters caused by climate change can we better respond to these disasters and reduce losses. Only by clarifying the source, destination, and trend of carbon can we provide better support for carbon peaking and carbon neutrality strategy, and prevent mankind from facing the risk of climate change out of control.

Big Earth Data provides a series of multi-temporal spatial data sets for SDG 13 to describe the impacts and responses of global climate change, including 4 sets of the heat waves along the Belt & Road, global forest and grass fires, global atmospheric CO_2 concentration, and global terrestrial ecosystem carbon sink change. In addition, the Big Earth Data platform of the Chinese Academy of Sciences has integrated multiple sets of climate change related indicators such as global and regional floods, drought, glacier change and ocean heat, which will provide strong data support for deepening the scientific understanding of the impact and response of climate change, jointly coping with the challenges brought by climate change and enhancing resilience [9,10].

Both facing the impact of climate change and taking actions to deal with climate change are gradually changing human lifestyles and may bring a scientific and technological revolution. The impact of climate change has many aspects, a wide range, and a long time. Efforts should be made to give full play to Big Earth Data to trace back the past, monitor the current state, and point out the future direction of human sustainable development.

References

1 Nerini F, Sovacool B, Hughes N, et al. Connecting climate action with other Sustainable Goals. Nature Sustainability, 2019, 2: 674–680.
2 Cheng H. Future Earth and sustainable developments. The Innovation, 2020, 1 (3): 100055.
3 Crippa M, Guizzardi D, Muntean M, et al. Fossil CO_2 Emissions of All World Countries-2020 Report. Luxembourg: Publications Office of the European Union, 2020.
4 Olivier J G J, Peters J A H W. Trends in Global CO_2 and Total Greenhouse Gas Emissions: 2020 Report. Hague: PBL Netherlands Environmental Assessment Agency, 2020.
5 Pugh T, Lindeskog M, Smith B. Role of forest regrowth in global carbon sink dynamics. PNAS, 2019, 116: 4382–4387.
6 McKinley G, Pilcher D, Fay A, et al. Timescales for detection of trends in the ocean carbon sink. Nature, 2016, 530: 469–472.
7 Wang J, Feng L, Palmer P, et al. Large Chinese land carbon sink estimated from atmospheric carbon dioxide data. Nature, 2020, 586: 720–723.
8 Guo H, Nativi S, Liang D. Big Earth Data science: An information framework for a sustainable planet. International Journal of Digital Earth, 2020, 13: 743–767.
9 Guo H D. Big Earth Data in support of the Sustainable Development Goals: China. Beijing: Science Press, 2020: 178–193. (in Chinese)
10 Guo H D. Big Earth Data in Support of the Sustainable Development Goals: The Belt & Road. Beijing: Science press, 2020: 154–201. (in Chinese)

HUANG Lei, Associate Professor in Aerospace Information Research Institute, Chinese Academy of Sciences, PhD, Member of Youth Innovation Promotion Association of Chinese Academy of Sciences. He is responsible for the research work supporting SDG 13 with Big Earth Data. His research interests include remote sensing of Glacier change and Greenhouse Gas. As the first or corresponding author, he has published 15 papers in Remote Sensing of Environment, Journal of Geophysical Research, and other journals. E-mail: huanglei@radi.ac.cn