Bulletin of Chinese Academy of Sciences

Volume 36 | Issue 8 Article 8

8-20-2021

Big Earth Data in Support of Marine Sustainable Development

Futao WANG
Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100094, China
International Research Center of Big Data for Sustainable Development Goals, Beijing 100094, China, wangft@aircas.ac.cn

See next page for additional authors

Recommended Citation

WANG, Futao; YU, Rencheng; LI, Jingxi; MAO, Dehua; WANG, Chengyi; JIA, Mingming; LIAO, Jingjuan; HU, Ziyuan; GU, Haifeng; WEI, Qinsheng; ZHANG, Li; and TANG, Shilin (2021
Data in Support of Marine Sustainable Development," *Bulletin of Chinese Academy of Sciences (Chinese Version)*: Vol. 36 : Iss. 8 , Article 8.
DOI: https://doi.org/10.16418/j.issn.1000-3045.20210707003
Available at: https://bulletinofcas.researchcommons.org/journal/vol36/iss8/8

Big Earth Data in Support of Marine Sustainable Development

Abstract

The health and safety of marine ecosystems are directly related to the health and well-being of all mankind. Factors such as insufficient effective monitoring data and lack of scientific decision-making information have affected the smooth implementation of the marine sustainable development goals (SDG 14) to a certain extent. Big Earth Data possesses macroscopic, dynamic and objective monitoring capabilities, and can play an important role in supporting the realization of the sustainable development goals of the ocean. With the support of the Strategic Priority Research Program of Chinese Academy of Sciences, and based on technologies and methods related to Big Earth Data, China has effectively carried out specific practices such as the production of missing ocean data sets and the construction of target localization models. Based on the above analysis, the study puts forward suggestions such as actively participating in the sharing of Big Earth Data in the international community, strengthening the drive of scientific and technological innovation in the realization of sustainable marine development goals, and deep participation in the United Nations Ocean Governance Plan.

Keywords

Big Earth Data, marine sustainable development, Sustainable Development Goals (SDGs)

Authors

Futao WANG, Rencheng YU, Jingxi LI, Dehua MAO, Chengyi WANG, Mingming JIA, Jingjuan LIAO, Ziyuan HU, Haifeng GU, Qinsheng WEI, Li ZHANG, and Shilin TANG

Citation: WANG Futao, YU Rencheng, LI Jingxi, MAO Dehua, WANG Chengyi, JIA Mingming, LIAO Jingjuan, HU Ziyuan, GU Haifeng, WEI Qinsheng, ZHANG Li, TANG Shilin. Big Earth Data in Support of Marine Sustainable Development [J]. Bulletin of Chinese Academy of Sciences, 2021 (8): 932–939.

Big Earth Data in Support of Marine Sustainable Development

WANG Futao[1,2], YU Rencheng[3], LI Jingxi[4], MAO Dehua[5], WANG Chengyi[1,2], JIA Mingming[5], LIAO Jingjuan[1,2], HU Ziyuan[3], GU Haifeng[6], WEI Qinsheng[4], ZHANG Li[1,2], TANG Shilin[7]

1. Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100094, China;
2. International Research Center of Big Data for Sustainable Development Goals, Beijing 100094, China;
3. Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China;
4. First Institute of Oceanography, Ministry of Natural Resources, Qingdao 266061, China;
5. Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Changchun 130102, China;
6. Third Institute of Oceanography, Ministry of Natural Resources, Xiamen 361005, China;
7. South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China

Abstract: The health and safety of marine ecosystems are directly related to the health and well-being of all mankind. Factors such as insufficient effective monitoring data and lack of information for scientific decision-making have affected the smooth implementation of the sustainable development goal 14 (SDG 14) about oceans, seas and marine resources to a certain extent. Big Earth Data possesses macroscopic, dynamic and objective monitoring capabilities and can play a supportive role in the realization of SDG 14. With the support of the Strategic Priority Research Program of Chinese Academy of Sciences, and based on technologies and methods related to Big Earth Data, China has carried out specific practices such as the production of missing ocean data sets and the construction of target localization models. Based on the above analysis, the study puts forward suggestions such as actively participating in the sharing of Big Earth Data in the international community, strengthening the drive of scientific and technological innovation in the realization of SDG 14 and deepening participation in the United Nations ocean governance programme. **DOI:** 10.16418/j.issn.1000-3045.20210707003-en

Keywords: Big Earth Data; marine sustainable development; Sustainable Development Goals (SDGs)

General Secretary Xi Jinping pointed out in the report of the 19th National Congress of the Communist Party of China to adhere to land-sea coordination and speed up the building of a strong maritime nation. The 14th Five-Year Plan for Economic and Social Development and Long-Range Objectives through the Year 2035 further proposes to actively expand the space for marine economic development. It specifies to build a strong maritime nation by coordinated promotion of marine eco-environment protection, marine economic development, and maintenance of marine rights and interests while adhering to land-sea coordination, harmony between water and humans, and win-win cooperation. Building a strong maritime nation is an important part of the cause of socialism with Chinese characteristics. It is also a major measure to follow the trend of world development and actively respond to the United Nations Transforming Our World: The 2030 Agenda for Sustainable Development [1].

The oceans, covering 71% of the Earth's surface area, are one of the three major global ecosystems and play a role in regulating the global water cycle, regulating climate, and supporting life on Earth [2]. Seafood provides at least 20% of animal protein for 3.1 billion people around the world [3], which is particularly important for the livelihood security of economically disadvantaged coastal areas and small island developing states. Coastal ecosystems have a wealth of services that are directly relevant to the human well-being, including stabilizing coasts, regulating coastal water quality and quantity, protecting biodiversity and providing habitats for many important species [4].

However, the oceans, traditionally considered 'invincible', are under threat. The number of people living in coastal areas was over 1.9 billion in 2010 and is expected to reach 2.4 billion by 2050 [5]. Multiple impacts from land-based and sea-based activities have left more than 40% of the ocean surface vulnerable [6]. The studies prior to 2010 assessed that global biodiversity was generally declining, which, albeit being at a small rate, significantly increased the pressure to maintain biodiversity [7]. This trend is also evident in marine and coastal ecosystems, none of which is free from human disturbance [8]. The oceans are becoming warmer, more acidic, and less oxygenated [9], which has a knock-on effect on the global climate. In the future, the rise in global average temperature, ocean acidification, ocean deoxygenation, and sea level rise are expected to have serious impacts on key

Received: 2021-08-02
Supported by: Strategic Priority Research Program of the Chinese Academy of Sciences (XDA19090123); National Key Research and Development Program of China (2019YFC1510202, 2017YFB0504101)

marine ecosystems and ecosystem services [6]. In response to the critical situation facing marine conservation, the Sustainable Development Goal 14 (SDG 14) "conserve and sustainably use the oceans, seas and marine resources for sustainable development" was included in the United Nations 2030 Agenda for Sustainable Development in 2015 and has become one of the topical issues of concern to the international community. Led by the technology facilitation mechanism of the SDGs, science, technology and innovation have been playing an increasingly important role in the implementation of SDG 14.

1 Connotation and implementation status of SDG 14

SDG 14 is formulated by the United Nations on the basis of a comprehensive analysis of the current situation, main problems, expected visions and ways of marine eco-environment protection and marine resource utilization. It is hoped to establish a scientific governance framework for marine and coastal ecosystems, under the guidance of which countries, regions, enterprises and people can protect marine ecosystems and make rational use of marine resources, so as to achieve the overall sustainable development of human society, marine economy and marine environment. SDG 14 contains 10 targets [10]. These targets have different focuses while are partly interlinked with each other, and they are closely interlinked and mutually supportive with the other SDGs [11]. The implementation and related research of SDG 14 can be carried out from the aspects of cleaning up the ocean (SDG 14.1), protecting marine ecosystems (SDG 14.2), understanding of the ocean for sustainable management (SDG 14.3, SDG 14.a), promoting safety from the ocean (SDG 14.1, SDG 14.2), sustainable food from the ocean (SDG 14.4, SDG 14.6, SDG 14.7, SDG 14.b), sustainable economic use of the ocean (SDG 14.2, SDG 14.7, SDG 14.c) and effective implementation of international law as reflected in the United Nations Convention on the Law of the Sea (SDG 14.c).

The development of the 10 targets has provided a direction for global marine conservation, marine resource use and international maritime cooperation. Since the proposal in 2015, the 10 targets have received common attention from the international community and have been promoted for implementation. However, the implementation of most of the SDG 14 targets has so far been unsatisfactory on a global scale. The report of the Second World Ocean Assessment (WOA II) released by the United Nations on April 21, 2021 shows that human activities have continued to generate pressures to induce ocean degradation since the First World Ocean Assessment in 2015, which involves important and typical ecosystems such as mangroves and coral reefs. These pressures include climate change-related impacts, unsustainable fishing, the introduction of invasive species, atmospheric pollution that causes acidification and eutrophication, excessive inputs of nutrients and harmful substances, increasing anthropogenic noise and poorly managed coastal development and natural resource exploitation [11]. At the launch of the report, the United Nations Secretary-General António Guterres called on the world's nations and all stakeholders to give high priority to the crisis of marine ecosystem degradation.

In addition to the insufficient attention to marine environment protection by some countries and regions, or the lack of management due to special circumstances (e.g., war and extreme poverty), the achievement of SDG 14 targets is also seriously hampered by such challenges as insufficient monitoring data on relevant indicators and insufficient information to support decision-making. The ocean system is characterized by large scale, rapid change, and high complexity, which determine that SDG 14 is a huge, diverse, dynamic and interconnected system. Effective measurement and monitoring of the targets is the most important link to ensure the realization of SDG 14. However, how to measure these targets is still facing great challenges, which presses for the establishment of a reasonable and complete index and data support system for sustainable development evaluation [12]. According to the IAEG-SDGs Tier Classification for Global SDG Indicators determined by the 52nd session of the United Nations Statistical Commission (UNSC) in March 2021, five (14.1, 14.2, 14.3, 14.a, 14.c) of the 10 targets of SDG 14 are still in Tier II (with methods but no data) [13]. If progress cannot be made as soon as possible in target monitoring and data analysis and evaluation for decision-making, the full implementation of the 2030 Agenda for Sustainable Development will inevitably be compromised.

2 Big Earth Data supports marine sustainable development practices

The lack of relevant monitoring data is one of the major bottlenecks limiting the objective assessment of SDGs and scientific decision-making by governments. As an important aspect of science and technology innovation, Big Earth Data plays a supportive role in the realization of SDGs [14,15]. With the macroscopic, dynamic and objective monitoring capability, Big Earth Data can integrate and analyze data of land, ocean, atmosphere and human activities and recognize large-scale regions as a whole, providing rich information on a large scale and cyclical changes for SDGs, especially the SDGs associated with environment and resources on the Earth's surface, for decision support [16].

The Big Earth Data in the marine field is mainly produced by large experimental devices, detection equipment, sensors, socio-economic observations and computer simulation processes with spatial attributes. It has the general natures of Big Data, being massive, multi-source, heterogeneous, multi-temporal, multi-scale, and non-smooth. Moreover, it has strong spatio-temporal and physical correlations with ocean elements, as well as the controllability of data generation methods and sources. Therefore, Big Earth Data has become a new key to our understanding of the ocean and a new engine for knowledge discovery [17]. In recent years, relevant research institutions, universities and government departments in China have made great efforts to explore the use of Big Earth Data and related technologies and methods to serve SDG 14 implementation, and have accumulated practical experience in the production of data sets and the construction of assessment models.

2.1 Big Earth Data complements some of the missing data sets for integrated ocean management and contributes to new knowledge discoveries in the implementation of SDG 14

(1) Cleaning up the ocean. In response to the lack of reliable data on the density and composition of marine debris and microplastics in the marine environment in SDG 14.1, the CAS Big Earth Data Science Engineering Program (CASEarth) has systematically compiled the basic research and monitoring results on marine debris and microplastics in China, especially the data from the large-scale monitoring of marine debris in near-shore waters, comprehensive global marine scientific expeditions, Antarctic and Arctic scientific expeditions and other work. It is also closely linked with the Bulletin of Marine Ecology and Environment Status of China and relevant papers published in international journals, providing a reliable monitoring data set for us to understand the current status of marine debris and microplastics pollution and to carry out effective management. The monitoring results show that: (1) The density of floating debris in China's coastal waters has been decreasing since 2015. The density in 2018 is approximately 25% lower than the average density (3 207 pieces/km^2) during 2010–2014 [12,18]. (2) Microplastics are present in the ocean and polar regions. The density of floating microplastics in the ocean around Antarctica was higher in some regions and lower in a wide range of scales. The microplastic species are diverse in the typical waters adjacent to the Antarctic continent, and human activities have had direct or indirect impact on the Antarctic ecosystem.

(2) Protecting marine ecosystems. Over the past half century, the global mangrove resources have declined rapidly, causing a range of eco-environmental problems. The protection, restoration and sustainable management of mangroves has become one of the keys to the realization of SDG 14.2. In order to accurately and objectively learn the actual status of mangroves in China and globally to support the analysis of the spatial and temporal characteristics of mangrove degradation and restoration over the years from a dynamic perspective, Chinese researchers have developed remote sensing-based classification techniques integrating object-oriented, multi-layer decision trees with artificial intelligence based on Big Earth Data, especially long time series and multi-source satellite remote sensing data. They have constructed the mangrove spatial distribution monitoring data set with the largest monitoring time span (resolution of 30 m in China from 1973 to 2020) [19] and the highest spatial precision (resolution of 10 m worldwide in 2020). The monitoring results are as follows: (1) The mangrove area in China decreased from 1973 to 2000 and increased from 2000 to 2020, with the most significant increase in 2015–2020, and the total mangrove area in China in 2020 basically reached the level in 1980 [19]. (2) The area of mangroves along the Maritime Silk Road accounts for more than half of the total mangrove area in the globe. The frequent human activities and natural disasters in the regions along the Maritime Silk Road have caused obvious narrowing and destruction of mangroves. The mangrove area continuously reduced in 84.2% of Asian countries along the Maritime Silk Road during 1990–2020.

(3) Promoting safety from the ocean. Algal blooms in the ocean can threaten human health and ecological security through a variety of pathways, such as producing toxins, harming marine life, destroying marine ecosystems and affecting seawater properties [20]. Effective monitoring and resilience to algal bloom is a key factor in the implementation of SDG 14.1 and SDG 14.2. For the Bohai Sea, where harmful algal bloom hazards are frequent in China, CASEarth has systematically constructed a data set of algal bloom (red tide) events from 1952 to 2017 based on monitoring data from the stations in the Bohai Sea region, combined with literature such as Bulletin of China's Marine Environment Status, Bulletin of China Marine Disaster, China Ocean Yearbook, and Survey and Evaluation of Red Tides in China (1933–2009). Further, the application of *in situ* and remote sensing observations in algal bloom monitoring was promoted to improve the real-time and continuity characteristics of observations [20]. The results show that the causes of algal blooms in the Bohai Sea are diversifying, miniaturising and becoming more harmful, and the hotspots of algal bloom occurrence have shifted from Bohai Bay to the near-shore waters of Qinhuangdao.

(4) Sustainable economic use of the ocean. Mariculture has made an important contribution to global food security and economic development against the backdrop of growing global socio-economic development, rapidly increasing population and overfishing. However, the uncontrolled growth and irrational distribution of aquaculture can affect the offshore ecosystems (e.g., causing a decline in biodiversity and pollution of the water), ultimately leading to unsustainable mariculture. Dynamic and objective aquaculture data are therefore important for achieving SDG 14.2, SDG 14.7 and SDG 14.c. Traditionally, the data on aquaculture scale have been obtained mainly through cascading statistics, which have long been untimely and inaccurate in some regions. To address this problem, CASEarth has organized experts to produce a dataset (with a spatial resolution of 10 m) of coastal pond culture area in China during 2015–2020, a global dataset (with a spatial resolution of 30 m) of coastal

pond culture area in 2020, and a dataset (with a spatial resolution of 30 m) of offshore raft culture area in China during 2017–2020. The results showed that: (1) China's coastal pond culture area was about 9 000 km^2 (26% of the total area of global coastal culture ponds) in 2020 and declined by 1 700 km^2 (15.9%) during 2015–2020. (2) China's offshore raft culture area increased from 2017 to 2020, while the increase rate slowed down in the last two years. More than 90% of the raft culture area was located within 12 nautical miles (approximately 22.224 km) offshore.

2.2 Big Earth Data enriches the assessment and analysis methods for SDG 14 indicators, facilitating the localization of implementation approaches and the scientific formulation of strategies

(1) Assessment of marine ecosystem health. One of the primary ways to achieve SDG 14 is to establish a marine ecosystem-based ocean management model considering the goal of maintaining the ecological health of the ocean [21]. Marine ecosystem health assessment, as an important tool for marine management and exploitation, can provide a scientific basis for the protection and management of marine ecosystems [12]. China's marine ecosystem health assessment has fully considered the evolutionary trends and interactions of meteorological, hydrological, chemical and biological elements. With the support of Big Earth Data, it has realized assessment data screening, criterion development and card-based health assessment report generation based on the structure, services, ecological problems and disasters of marine ecosystems [22]. With this system, the raw data from observation can be transformed into intuitive scientific information for management decisions through assessment, directly serving the relevant national decisions and offshore development and management. The assessment model has been applied to typical bays in China, such as Sishili Bay, Jiaozhou Bay and Daya Bay, and has achieved satisfactory results [14].

(2) High performance numerical forecasting and scenario simulation. With the significant increase in China's high-performance computing capacity, the integration of marine real-time monitoring data with numerical forecasting and scenario simulation for the mining of useful information to serve the realization of SDGs has now been highly recognized. Fruitful results have been gained in the simulation of sea level rise and inundation in multiple scenarios [23]. At the same time, research has been carried out in the simulation of microplastic "source-area" dispersion, short-term prediction of the drift trajectory of macroalgal blooms [20], prediction of typhoon storm surge inundation area and assisted decision-making based on the numerical forecasting system of the marine environment. The implementation of these modeling methods will provide technical support for the prevention and control of marine disasters and pollution.

3 Recommendations for marine sustainable development supported by Big Earth Data

The Chinese government has always attached great importance to and supported the United Nations agenda related to marine sustainable development. Since 2015, bearing in mind its strategic goal of building a strong maritime nation, China has developed marine industries rapidly and achieved significant accomplishments in reducing marine pollution, restoring marine ecology with science-based measures and rationally expanding the marine economy. However, on a global scale, the crisis of marine ecosystem degradation has been intensified instead of being mitigated. China's sustainable marine development is facing challenges due to the dense population and rapid economic development in the coastal areas, which leads to the high demand for marine resources [24]. Three recommendations are put forward here to promote marine sustainable development.

(1) Actively participating in the sharing and application of Big Earth Data in the international community. Big Earth Data technologies and methods can be adopted to provide applicable data products that support the realization of SDG14. By building a Big Earth Data sharing platform, an online computing platform and a data service platform, we can link the acquisition of marine data with the support for the realization of SDGs at the levels of sharing, service and application to break the capacity bottleneck of developing countries in data collection and promote the timely sharing and dissemination of data and knowledge. In this way, the marine data can be integrated with management and decision-making to help achieve practical results in promoting marine sustainable development.

(2) Strengthening the drive of scientific and technological innovation in the realization of SDG14. In the Sustainable Development Goals Report 2019, the United Nations Secretary-General António Guterres has pointed out that "it is abundantly clear that a much deeper, faster and more ambitious response is needed to unleash the social and economic transformation needed to achieve our 2030 goals." He highlights better use of data, science, technology and innovation to produce smarter solutions that support the realization of SDGs. This is in line with the science and technology innovation strategy of China. Therefore, it is suggested to link the strategy of building a strong maritime nation with the science and technology innovation strategy, and to make breakthroughs in key core technologies such as Big Earth Data, marine resources, marine ecology, marine environment, and marine engineering, so as to facilitate the realization of SDG14.

(3) Actively promoting the establishment of a collaborative marine monitoring and governance system and deepening participation in the United Nations ocean governance programme. General Secretary Xi Jinping's remarks on the maritime community with a shared future have profoundly

clarified that the protection and sustainable use of oceans and marine resources require joint governance by all countries. In accordance with the United Nations Convention on the Law of the Sea, China should, on the one hand, actively participate in the formulation of international ocean governance mechanisms and rules, actively explore and promote the construction of a fair and reasonable comprehensive monitoring and governance system for the synergy of ocean areas, and resolutely safeguard the ocean rights and interests of China and other developing countries. On the other hand, we should further participate in the United Nations ocean governance programme, such as the ongoing implementation plan for the United Nations Decade of Ocean Science for Sustainable Development (2021–2030). We will actively showcase our achievements in promoting marine sustainable development through the use of Big Earth Data and other scientific and technological means, improve the influence and decision-making power in the United Nations ocean sector, and promote the realization of SDG14 by contributing Chinese solutions and wisdom.

References

1 United Nations. Transforming our World: The 2030 Agenda for Sustainable Development. United Nations. (2015-09-25). https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.

2 Liang J, Wang W D, Yu B C, et al. Evaluation on removable carbon sink capability of raft culture zones of *Mytilus coruscus* for the marine ranching in Dongji slands. Journal of Zhejiang Ocean University (Natural Science), 2015, 34 (1): 9–14.

3 Food and Agriculture Organization of the United Nations. The State of World Fisheries and Aquaculture 2016: Contributing to Food Security and Nutrition for All. Rome: Food and Agriculture Organization of the United Nations, 2016.

4 UN Environment. Global Environment Outlook—GEO-6: Healthy Planet, Healthy People. Cambridge: Cambridge University Press, 2019.

5 Kummu M, de Moel H, Salvucci G, et al. Over the hills and further away from coast: Global geospatial patterns of human and environment over the 20th–21st centuries. Environmental Research Letters, 2016, 11 (3): 1–15.

6 United Nations. The United Nations Decade of Ocean Science for Sustainable Development (2021–2030). (2020-04-01). https://www.oceandecade.org/assets/The_Science_We_Need_For_The_Ocean_We_Want.pdf.

7 Butchart S H M, Walpole M, Collen B, et al. Global biodiversity: Indicators of recent declines. Science, 2010, 328: 1164–1168.

8 Halpern B S, Walbridge S, Selkoe K S, et al. A global map of human impact on marine ecosystems. Science, 2008, 319: 948–952.

9 Laffoley D, Baxter J M, Amon D J, et al. Eight urgent, fundamental and simultaneous steps needed to restore ocean health, and the consequences for humanity and the planet of inaction or delay. Aquatic Conservation: Marine and Freshwater Ecosystems, 2020, 30 (1): 194–208.

10 United Nations. Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. [2021-07-28]. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202020%20review_Eng.pdf.

11 United Nations. The Second World Ocean Assessment (WOA II). NewYork: United Nations, 2021.

12 The CAS Big Earth Data Science Engineering Program. Big Earth Data in Support of the Sustainable Development Goals (2019). (2019-09-01). https://www.fmprc.gov.cn/web/ziliao_674904/zt_674979/dnzt_674981/qtzt/2030kcxfzyc_686343/P020190924798998014239.pdf.

13 United Nations. IAEG-SDGs Tier Classification for Global SDG Indicators. [2021-03-29]. https://unstats.un.org/sdgs/files/Tier%20Classification%20of%20SDG%20Indicators_29%20Mar%202021_web.pdf.

14 The CAS Big Earth Data Science Engineering Program. Big Earth Data in Support of the Sustainable Development Goals (2020). (2020-09-01). https://www.fmprc.gov.cn/web/ziliao_674904/zt_674979/dnzt_674981/qtzt/2030kcxfzyc_686343/P020200927634068540177.pdf.

15 Wang Q R. Strengthen the scientific and technological guidance and promote sustainable development with the help of the whole society. China Sustainability Tribune, 2020, (Z1): 39–43. (in Chinese)

16 Guo H D. Scientific big data drive the development of Geoscience. Science & Technology Review, 2018, 36 (5): 1. (in Chinese)

17 Guo H D, Wang L Z, Liang D. Big Earth Data from space: A new engine for Earth science. Science Bulletin, 2016, 61 (7): 505–513.

18 Zhou C C, Liu X, Wang Z W, et al. Assessment of marine debris in beaches or seawaters around the China seas and coastal provinces. Waste Management, 2016, 48: 652–660.

19 Jia M M, Wang Z M, Mao D H, et al. Spatial-temporal changes of China's mangrove forests over the past 50 years: An analysis towards the Sustainable Development Goals (SDGs). Chinese Science Bulletin. DOI: 10.1360/TB-2020-1412. (in Chinese)

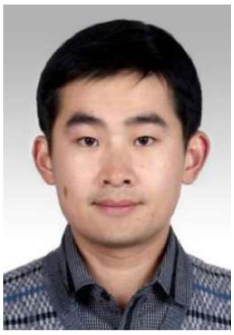
20 Yu R C, Lv S H, Qi Y Z, et al. Progress and perspectives of harmful algal bloom studies in China. Oceanologia et Limnologia Sinica, 2020, 51 (4): 768–788. (in Chinese)

21 Sun S, Sun X X. Marine plankton functional groups variation and ecosystem change. Advances in Earth Science, 2014, 29 (7): 854–858. (in Chinese)

22 Sun X X, Sun S. Conduct long-term observations of coastal ecosystems and lead the marine ecosystem health research. Bulletin of Chinese Academy of Sciences, 2019, 34 (12): 1458–1466. (in Chinese)

23 Liu R, Liu X D, Liu H. Projection of the 21st century sea level change in East China Sea and South China Sea based on CMIP5 model results. Journal of Earth Environment, 2020, 11 (4): 412–428. (in Chinese)

24 Qiu W F, Liu Y. Trends in meeting the 2030 Sustainable Development Goal for the conservation and sustainable use of the oceans in China. Environment and Sustainable Development, 2016, 41 (1): 44–45. (in Chinese)



WANG Futao, corresponding author, Associate Professor of Aerospace Information Research Institute, Chinese Academy of Sciences (CAS), Member of Youth Innovation Promotion Association of CAS, and Editorial Board Member of Journal of Remote Sensing. He is mainly engaged in Big Earth Data to support sustainable development of the ocean and remote sensing monitoring and assessment of major disasters. He has undertaken national research projects sponsored by National Science and Technology Major Program of China, National Key Research and Development Program of China, National Natural Science Foundation of China, and the sub-projects of Category A Strategic Priority Research Program of CAS. He has published 54 academic papers and 13 monographs (atlases), and has 6 authorized national invention patents. He has been awarded a series of honors such as the Remote Sensing Young Scientific and Technological Talent Innovation Grant of Ministry of Science and Technology, the Pei Xiu Award for National Outstanding Map Works, and the Young Mapping and Geographic Information Science and Technology Innovation Talent Award. E-mail: wangft@aircas.ac.cn

