Interpretation of the Report on Temporal Dynamics and Spatial Distribution of Global Carbon Source and Sink

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***Abstract*—*The thematic report on "Temporal and Spatial Distribution of Global Carbon Sources and Sinks" is an important part of "Annual Report on Remote Sensing Monitoring of Global Ecological Environment" in 2018. The thematic report gives full play to the technological advantages of TanSat, the first global scientific experimental satellite for monitoring atmospheric carbon dioxide in China, monitors and analyses the temporal and spatial distribution pattern of global atmospheric carbon dioxide from 2010 to 2017 combining with multi-source remote sensing data, generates the first TanSat global chlorophyll fluorescence product in 2017, analyses the temporal and spatial distribution of carbon sources and sinks in the world and key regions, discusses the driving mechanism of global carbon source and sink change, and provides effective scientific data for realizing national emission reduction targets and coping with climate change. The report pointed out that TanSat can accurately retrieve the atmospheric CO_2 column concentration and monitor the atmospheric CO_2 concentration distribution. TanSat is an important part of the global multi-satellite carbon concentration observation platform and contributes to the construction of the GEO carbon concentration observation system. However, the global carbon concentration remote sensing observation is difficult to achieve all-weather, All-perspective and all-round real-time monitoring of carbon emissions and terrestrial carbon sources and sinks. The construction of global carbon concentration satellite monitoring network still needs the joint efforts of all countries to improve.*

Keywords*—*Annual Report, Remote Sensing, Carbon Source, Carbon Sink

I. INTRODUCTION

With the development of technology and transportation, the whole world has been close linked and became a "global village" gradually. Therefore, the changes in the ecological environment are closely related to the people of all countries, and ecological environment monitor on a global scale is becoming more and more necessary. Remote sensing technology has the advantages of fast, effective and real-time [1]. With the development of remote sensing technology, the ground observation capability is continuously improved, the spatial resolution, time resolution, spectral resolution and radiation resolution of remote sensing data are all improved and the application of multi-source remote sensing data tends to mature [2-4]. For global environmental monitoring, remote sensing technology has become an effective means of global-scale ecological environment change information monitoring by acquiring effective multi-temporal, multi-scale and multi-space remote sensing images [5-7]. With the successive launch of Fengyun series satellites, resource series satellites, environmental series satellites, high-series satellites and carbon satellites, China has gradually established integrated meteorological observation and monitoring systems for meteorology, resources, environment, ocean and high scores, which has laid an important technical foundation for remote sensing monitoring of ecological environment in China and around the world [8].

At present, human beings face a serious ecological crisis. The greenhouse effect caused by greenhouse gases is further triggered by the melting of the North and South polar glaciers, global sea level rise, and frequent extreme weather events, which seriously affect human survival [9]. Carbon dioxide is the main source of greenhouse gases. The increasing of carbon dioxide concentration is adding the greenhouse effect, which seriously affects the regional and global carbon cycle [10]. Therefore, the changes in global atmospheric carbon dioxide concentration have received great attention from various countries and the international community [11-12], and monitoring of global ecological environment change monitoring, especially atmospheric carbon dioxide concentration has become a global hot topic [12-13].

In order to improve global ecological environment monitoring technology and deepen the public awareness of the global ecological environment, China has released a report each year with the theme of global eco-environmental hotspots, global eco-environmental hotspots and global hotspots since 2012. These reports aim to provide a basis for drafting environmental policies for governments, research institutions and international organizations. In the 2018 annual report on remote sensing monitoring of the global ecological environment, it used Multi-source satellite remote sensing data such as GOSAT, OCO-2, global ozone detection tester, and medium resolution imaging spectrometer (MODIS), analyzing the temporal and spatial dynamics change of carbon source and carbon sink, exploring the influencing factor of global warming, to further study its driving mechanism, and to promote green and low

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carbon development in China and the international community.

II. Thematic Determination of "Temporal Dynamics and Spatial Distribution of Global Carbon Source and Sink"

In order to actively implement the United Nations2030 sustainable development agenda[14] and carry out Xi Jinping's thought on socialism with Chinese characteristics for a new era, and adhering to the concept of “Connectivity, win-win cooperation”, under the organization of the National remote Sensing Center, led by the Department of High Technology and Cooperation of the Ministry of Science and Technology, the National remote Sensing Satellite Meteorological Center, Tsinghua University, Nanjing University, Shandong University of Science and Technology and the Environmental Planning Institute of the Ministry of Environmental Protection and soon on., “Global Ecosystems and Environment Observation Analysis Research Cooperation” make full use of the latest achievements made by China in the field of remote sensing, and gradually open to the world to share its global Earth observation data, and provide relevant information products and services, in order to provide Chinese solutions and contributions to global ecological environmental protection, rational use of resources, response to climate change and major government decisions. Contribute to Chinese forces, and further promote the building of a community of human destiny.

According to the hot issues of global ecological environment and key regions, facing the major needs of the country, the sustainable development of the international community and the urgent need of the global response to climate change, the work topic of annual report in 2018 was determined. At present, the global climate change and a series of climate disasters caused by the increase of global atmospheric carbon dioxide concentration are bringing serious harm to the survival and development of human beings, resulting in huge economic losses, which have made the international pay more attention to the related problems of carbon source and sink.[15]. Meanwhile, applying the research results of the national science and technology plan in the field of Earth observation and navigation technology and related departments to make full use of the latest monitoring data for the launch of carbon satellites, the topic of “Temporal Dynamics and Spatial Distribution of Global Carbon Source and Sink” was expanded in 2018 annual report. This topic analyzed. temporal and spatial distribution pattern of global atmospheric CO_2 during2010-2017, the temporal and spatial distribution of carbon source and sink in global and key areas were discussed. At the same time, the driving mechanism of global carbon source and sink changes was discussed, which can provide effective scientific data for achieving national emission reduction targets and responding to climate change, and plays an important supporting role in the implementation of emission reduction effectiveness and related policy formulation.

III. Main Contents of " Temporal Dynamics and Spatial Distribution of Global Carbon Source and Sink"

The temporal and spatial distribution of global carbon source and sink is the newly expanded topic of 2018 annual report. In this topic, China's first scientific experimental satellite for monitoring atmospheric CO_2 in the world has been brought into full play (Tansat), and combined with multi-source remote sensing data, the temporal and spatial distribution pattern of global atmospheric CO_2 during 2010-2017 was analyzed .and has formed the first set of international CO_2 in 2017. The temporal and spatial distribution of carbon source and sink in the world and key areas was analyzed, and the driving mechanism of global carbon sources and carbon sequestration was discussed, which can provide effective scientific data for achieving national emission reduction targets and responding to climate change.

A. Temporal and spatial variation characteristics of global atmospheric CO2 concentrations

As the first global carbon dioxide monitoring scientific experimental satellite in China, TanSat carries hyperspectral greenhouse gas detector and cloud and aerosol detector to fill the technical gap in greenhouse gas detection in China. It is of great significance for China to master the law of global warming and the distribution of global carbon source and to improve China's international voice in dealing with global climate change by providing basic data for carbon source on the global and regional scales.

This chapter analyzed the global CO_2 concentration from three aspects which were spatial distribution, inter annual variation and seasonal variation. First, we obtained Global spatial distribution map of monthly atmospheric carbon dioxide concentration of April and July in 2017 by TanSat using XCO_2Inversion algorithm (IAPCAD), and synthesis of the global distribution map of monthly atmospheric CO_2 concentration obtained from OCO-2 、 GOSAT carbon monitoring satellite. The space of global atmospheric CO_2 concentration was analyzed. Meanwhile, the spatial distribution characteristics of global atmospheric CO_2 concentration were analyzed. And then use Chinese carbon satellite and international satellite data to obtain the spatial distribution of global atmospheric CO_2 concentration during 2010-2017, and analyzed mean atmospheric CO_2 concentration changes from both inter annual and seasonal in global and seven key areas.

The high concentration of global atmosphere CO_2 in 2017 was mainly distributed in the middle and low latitudes of North America, East Asia and South Asia, and the low value areas were mainly distributed in Oceania and Eurasia. From 2010 to 2017, the average annual CO_2 concentration in the global atmosphere showed an upward trend, and the growth rate increased compared with 1970-2010, indicating that since the signing of the Kyoto Protocol, the goal of slowing the growth of global atmospheric CO_2 concentration and curbing global warming has not been met. Reducing greenhouse gas emissions and addressing climate change still require spending together globally..

B. The distribution of global carbon source and sink and the causes of its dynamics

The spatial and temporal distribution of atmospheric CO_2 concentration is affected by atmospheric movement, anthropogenic emissions, and ecosystem absorption [16]. The report used global data such as satellite monitoring, ground monitoring, and energy statistics to obtain global chlorophyll fluorescence using TanSat data and estimated the spatial distribution of global GPP. Then, combined the carbon cycle model and the generalization technology, the

report analyzed the spatial and temporal distribution pattern of global carbon source and sink and the causes of dynamic changes.

The main carbon source in the world were distributed in the east and west of the United States, Western Europe, East Asia and northern South Asia. Low value areas in Africa, Oceania, central South America, northern North America and northern Eurasia, and the high value of carbon sink areas were mainly distributed in the middle and high latitudes of the northern hemisphere and the main tropical rain forests in the world. Global carbon source and sink was the common result of human and natural activities. It is necessary to control carbon source, enhance terrestrial ecosystem carbon sequestration capacity and slow down the global atmosphere by strengthening energy conservation and ecological environment protection.

C. Analysis of carbon sources and sinks in key areas

Based on the carbon emission data caused by global fossil fuel combustion and cement production, CO_2 emission data and electricity generation from each continent and key areas, the carbon source and sink status and changing trend of each continent and key areas were analyzed. Then, according to the measures of energy structure adjustment, promotion of new energy vehicles and index afforestation in China in recent years, the driving mechanism of carbon source and sink in China is analyzed

The total carbon source in Asia was on the rise, although the total carbon sequestration in the terrestrial ecosystem of Asia was higher than that of the others. mainly due to the large number of developing countries in Asia and the developing countries were in a rapid stage of development, especially China and India. Before 2014, carbon emissions in Asia grew faster, and Asian carbon dioxide emissions tended to flatten after 2014. In 2015, China promised that by 2020, the carbon dioxide emissions per unit of GDP will fall by 40%-45% compared with 2005, non-fossil energy will account for about 15% of primary energy consumption; around 2030, CO_2 emissions will peak and strive for Peak as early as possible. China was being actively taking a series of measures to optimize the industrial structure, saving energy and improving energy efficiency, developing non-fossil energy, promoting new energy vehicles, increasing forest carbon sinks, and building a national carbon trading market, with remarkable results.

Although Europe and North America were carbon sources as a whole, the total carbon sources showed a slow weakening trend, and the total carbon sources and sinks were weak carbon sources, which mainly due to the fact that most of the countries in Europe and North America were developed countries, the level of industrialization was high, and the United States government had taken active measures to deal with climate change and reduced the intensity of carbon emissions. South America and Africa were characterized by weak carbon sources, mainly due to the low level of industrialization and low energy consumption in most of the countries of the areas. Oceania was a weak carbon sink. In Oceania, agriculture and animal husbandry developed well, and tourism was an important part of the national economy. Therefore, Oceania's carbon emission intensity was low, and the terrestrial ecosystem showed a strong carbon sink, carbon source and sink were eliminated, Oceania was a weak carbon source.

IV. PROSPECT

The global atmospheric CO_2 concentration was increasing, and slowing down the global atmospheric CO_2 concentration growth required the joint efforts of all countries in the world for a long time. Many countries have made some efforts to reduce emissions. Since the signing of the Kyoto Protocol[17], the growth of global atmospheric CO_2 concentration slowed down, Bu the changing trend of increasing and rising global temperatures still cannot be ignored. Human's goal of being protected from the threat of atmospheric warming has not yet been achieved. Therefore, human activities still need to be further regulated, reduce carbon emissions, strengthen the protection of terrestrial ecosystems, and increase the adaptability of terrestrial ecosystems to climate change. In addition, it is necessary to further construct and improve the global satellite monitoring network of atmospheric carbon dioxide concentration, carbon emission sources and terrestrial carbon sinks, so as to improve the observation ability of carbon sources and sinks, so as to obtain accurate carbon source and sink data.

In order to actively respond to global change and implement the United Nations Paris Agreement[18], accelerate the construction of ecological civilization and practice “the Belt and Road” initiative, Since 2012, China release the annual report on remote sensing monitoring of the global ecological environment every other year or every year. after continuous efforts and reform, the work of the annual report is trending to mature and perfect. In the future annual report work, the application potential of domestic satellite needs to be further developed, the topic selection of annual report needs to keep pace with the times, the sharing degree of annual report result data should be further increased, so that more researchers can use the result data in order to make full use of the annual report results, and have greater impact..

A. Development of the potential of domestic satellites

The satellite of China started relatively late, and there was a certain gap with foreign countries in terms of accuracy, data continuity and accessibility. However, with the development of science and technology, series satellites of Fengyun, high sub-series satellites, resource series satellites, environmental series satellites and carbon satellites have been launched, China has gradually established a perfect Earth observation system. The observation data of domestic satellite can gradually meet the required time series and accuracy, increase the proportion of domestic satellite data in the annual report, make the annual report work more with Chinese characteristics, and give full play to the role of China's space remote sensing country.

B. Improve the monitoring system of carbon sources and sinks

Global climate change seriously threatens the survival and development of human. As the main driving factor of global climate change, Monitoring atmospheric CO2 concentration to further understand the spatial and temporal distribution of global carbon sinks can help to provide scientific reference for decision-making and implementation of carbon sinks[17]。TanSat can be inverted with high accuracy of CO_2 concentration, which is an important part of the global carbon concentration multi-star observation platform and contributes to the construction of the GEO carbon concentration observation system. Although the global carbon concentration observation satellite remote

sensing technology, represented by China, the United States and Japan, has made a key breakthrough, carbon satellites have not yet reached a high spatial resolution, It is difficult to monitor carbon sources and terrestrial carbon sources and sinks in real time from all-weather, full-angle and omni-directional. Therefore, building a global carbon concentration, carbon emissions and terrestrial carbon sinks Satellite monitoring network, and enhancing the observation ability of carbon sources and sinks still need to make joint efforts.

C. Strengthening assistance to less developed countries

In the special report on the temporal and spatial distribution of global carbon source and sinks, there were few analyses of the carbon sinks in South America and Africa, while Africa and South America are rich in tropical rainforests and were important carbon sinks[19]. Therefore, in future reports, we should strengthen the monitoring of the carbon source and sink situation in the regions, increase the assistance of the international community and governments in providing carbon emission reduction, promote the upgrading of its energy structure, and realize the leapfrogging of energy. Reduce carbon intensity, strengthen the protection of terrestrial ecosystems in Africa and South America, enhance the ability of terrestrial ecosystems to adapt to climate change, and increase terrestrial carbon sinks, thereby helping to slow the growth of global atmospheric carbon dioxide concentrations.

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REFERENCES

[1] M. Y. Paltsyn, J. P. Gibbs and G. Mountrakis, "Integrating Traditional Ecological Knowledge and Remote Sensing for Monitoring Rangeland Dynamics in the Altai Mountain Region," *Environ Manage,* June 2019.

[2] R. Shen, A. Huang, B. Li, and J. Guo, "Construction of a drought monitoring model using deep learning based on multi-source remote sensing data," *International Journal of Applied Earth Observation and Geoinformation,* vol. 79, pp. 48-57, 2019.

[3] J. Wang, J. Ding, G. Li, J. Liang, D. Yu, T. Aishan, F. Zhang, J. Yang, A. Abulimiti, and J. Liu, "Dynamic detection of water surface area of Ebinur Lake using multi-source satellite data (Landsat and Sentinel-1A) and its responses to changing environment," *CATENA,* vol. 177, pp. 189-201, 2019.

[4] J. L. Awange, K. X. Hu and M. Khaki, "The newly merged satellite remotely sensed, gauge and reanalysis-based Multi-Source Weighted-Ensemble Precipitation: Evaluation over Australia and Africa (1981 – 2016)," *Science of The Total Environment,* vol. 670, pp. 448-465, 2019.

[5] Y. Pan, R. A. Birdsey, J. Fang, R. Houghton, P. E. Kauppi, W. A. Kurz, O. L. Phillips, A. Shvidenko, S. L. Lewis, J. G. Canadell, P. Ciais, R.

[6] B. Jackson, S. W. Pacala, A. D. McGuire, S. Piao, A. Rautiainen, S. Sitch, and D. Hayes, "A Large and Persistent Carbon Sink in the World's Forests," *Science,* vol. 333, pp. 988-993, August 2011.

[7] Z. Chunhua and J. M. Kovacs, "The application of small unmanned aerial systems for precision agriculture: a review," *Precision Agriculture,* vol. 13, pp. 693-712, 2012.

[8] B. Pradhan, M. H. Abokharima, M. N. Jebur, and M. S. Tehrany, "Land subsidence susceptibility mapping at Kinta Valley (Malaysia) using the evidential belief function model in GIS," *Nat Hazards REV,* vol. 73, pp. 1019 – 1042, 2014.

[9] C. Jiang, L. Wu, D. Liu, and S. Wang, " Dynamic monitoring of eco-environmental quality in arid desert area by remote sensing: Taking the Gurbantunggut Desert China as an example," Chinese Journal of Applied Ecology, vol. 30, pp. 877-883, January 2019.

[10] N. Zheng, L. Jiahong, G. Zhihai, G. E. Du, Z. Songmei, Z. Jing, L. Shuang, O. Xiaoying, and Z. Rui, "Progress and future of China ' s annual report on remote sensing monitoring of global ecosystem and environment," *Journal of Remote Sensing,* vol. 22, pp. 672-685, 2018.

[11] G. P. Asner, G. V. N. Powell, J. Mascaro, D. E. Knapp, J. K. Clark, J. Jacobson, T. Kennedy-Bowdoin, A. Balaji, G. Paez-Acosta, E. Victoria, L. Secada, M. Valqui, and R. F. Hughes, "High-resolution forest carbon stocks and emissions in the Amazon," *Proceedings of the National Academy of Sciences,* vol. 107, pp. 16738-16742, September 2010.

[12] S. A. M, M. M. B and B. M, "Precipitation drives global variation in natural selection," *Science,* vol. 355, pp. 959-962., 2017.

[13] A. N. Suo, D. Z. Zhao and F. S. Zhang, "Carbon storage and fixation by wetland vegetation at the estuaries in northern China: A case of Panjin area,Liaohe Delta," *Journal of Marine Sciences,* vol. 28, pp. 67-71, 2010.

[14] B. Xiaoyan, D. Suocheng, M. Wenbao, and L. Fujia, "Spatial-temporal change of carbon storage and sink of wetland ecosystem in arid regions, Ningxia Plain," *Atmospheric Environment,* vol. 204, pp. 89-101, 2019.

[15] United Nations, "Transforming our World:The 2030 Agenda for Sustainable Development," 2015.

[16] N. U. C. Copenhagen, "Experts, Leaders Agree on Key Ways to Mobilize Accelerated Action for Climate, Sustainable Development," 2019.

[17] M. Panu, K. Topolski, S. Abrash, and M. M. El-Halwagi, "CO2 footprint reduction via the optimal design of Carbon-Hydrogen-Oxygen SYmbiosis Networks (CHOSYNs)," *Chemical Engineering Science,* vol. 203, pp. 1-11, 2019.

[18] United Nations, "United Nations Framework Convention on Climate Change," 1997.

[19] United Nations, " Paris Agreement," United Nations, 2015.

[20] B. Quesada, A. Arneth, E. Robertson, and N. de Noblet-Ducoudré, "Potential strong contribution of future anthropogenic land-use and land-cover change to the terrestrial carbon cycle," *Environmental Research Letters,* vol. 13, 2018.