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Research on the Impact of Ecosystem Carbon Cycle on Global Climate Change

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Abstract: With the increasing significance of global warming, climate change and its impacts have attracted more and more attention. Carbon cycle is an important part of the carbon cycle in the ecosystem, and its interference process is the redistribution process of carbon, so it has an important impact on the regional and even global carbon cycle. Therefore, the research on the impact of ecosystem carbon cycle on global climate change is proposed. Through field measurement, remote sensing observation and cross-scale carbon cycle model simulation, the impact of ecosystem carbon cycle and its quantitative evaluation model method are established. Simulation results show that this method can effectively improve the level of ecosystem management, reduce carbon emissions, promote carbon sink and slow down the rate of global change.

Keywords: Ecosystem; The carbon cycle; Climate change

1. Introduction

With the increasing significance of global warming, climate change and its effects are getting more and more attention. In recent years, the interaction between carbon cycle and global climate change has attracted wide attention. After the industrial revolution, due to the large use of coal, oil and natural gas and other fossil fuels, the global annual CO2 released by fossil fuels is about 2.70×1010t, resulting in the rapid increase of atmospheric CO2 concentration at the rate of 1.8 mumol /L per year [1]. According to the data of ice cores in the Antarctic ice sheet, the CO2 concentration in the atmosphere during glacial period was about 201 mol/L, while that during interglacial period was up to 270 mol/L. About 100 years ago, the change of atmospheric CO2 concentration range is 250 ~ 310 mu mol/L, the concentration of 2012 to 372 mu mol/L, the concentration of 2014 to 377.5 mu mol/L, the concentration of 2015 to 380 mu mol/L, the UN climate change conference in Copenhagen in 2019 data showed that CO2 concentration by pre-industrial 280 mu mol/L now increased to 387 mu of mol/L, 2010-2015, the global CO2 emissions increased by 3.2%, and four times the growth in the last 10 years [2]. According to the IPCC estimates that in the northern hemisphere in the 1980 s average temperature 0.4 ℃ higher than the '60 s and over the past century our country the trend of climate change and the trend of global climate change, the temperature increased by 0.4 ~ 0.8 ℃, the global warming performance in our country is very significant, global environmental change in the early 1980 s became the hot topic in the international academia, and ecological system and the global environmental change research also has become an important emerging in the development of modern ecology research. With the deepening impact of global environmental changes and human activities on ecosystems, the structure and function of ecosystems are becoming stronger, and the capacity of ecosystems to provide various resources and services is declining significantly. The increase of population and the improvement of living standards put forward higher requirements for ecosystem services and products. In this context, it has become a major scientific challenge for ecologists to fully understand the structure and function of ecosystems and their relationship with environmental change [3]. For this, put forward the ecosystem carbon cycle research on the effects of global climate change, understanding of climate change and the interaction relationship between the ecosystem carbon cycle, the correct evaluation of the status of the carbon cycle and carbon balance, deepen the understanding of the effect on the carbon cycle, improve the level of sustainable management of ecological system, in a more effective way intervention in ecosystem carbon balance, etc all have important significance. At the same time, it is of great significance to reduce the uncertainty of carbon balance calculation in global change research and to formulate scientific and effective forest fire management strategies [4]. At the same time, the influence of ecosystem carbon cycle and its quantitative evaluation model method are established, and the scientific and effective forest fire management strategies and measures are put forward under the background of global warming.

2. Definition of Ecosystem Carbon Cycle

Carbon cycle refers to all metabolic processes releasing CO2 in the carbon cycle, which can be divided into biological processes, non-biological processes and human factors. Generally speaking, carbon cycle refers to biological processes, including microbial respiration, root respiration and animal respiration [5]. Carbon cycle as the main part of terrestrial ecosystem carbon cycle, and become one of the biggest source of the release of CO2 into the atmosphere, among them, the root autotrophic respiration heterotrophic microorganisms and is the main part of the carbon cycle release CO2, the temperature change is driving the carbon cycle of main influence factor, Q10 is a parameter to reflect the actual changes in the carbon cycle with temperature. Global warming may increase the carbon cycle and the land ecological system from carbon sink to carbon source. As a result, its change in the future have a very important role in the global carbon cycle [6]. Climate warming, autotrophic and heterotrophic respiration breathing the influence of the temperature sensitivity on the carbon cycle of carbon each are not identical. Among them, the root autotrophic respiration to temperature response of the more sensitive than heterotrophic respiration. Main light cooperation with the product of autotrophic breathing, and there are about 10% ~ 90% in the carbon cycle from autotrophic breathing, is the body of the carbon cycle. Under the condition of temperature, significantly increased the Q10 of root respiration, due to the different environment temperature and moisture content, the influence of the carbon cycle of Q10 and temperature change sometimes are not consistent, It shows that Q10 at low temperature is higher than that at high temperature. Using the carbon cycle heating pipe to control the temperature, the changes of carbon cycle autotrophic respiration and heterotrophic respiration within 24h were studied. It was found that the Q10 of autotrophic respiration in the 1cm layer and 5cm layer of carbon cycle during the first 12h were 5.61 and 6.29 respectively, more than twice as much as that of isooxygen respiration (3.04 and 3.53). Through the study of heat sensitivity on carbon circulation root respiration, it was found that temperature change was positively correlated with Q10. Simulated temperature increase was conducted through heating pipes to study the effect of temperature on root respiration with different carbon cycle texture. It was found that the root respiration of carbon cycle in bare land increased significantly with the increase of temperature, but in the growing season, the root respiration of crop carbon cycle was significantly higher than that in bare land. In addition, carbon cycle abnormal respiration also has a certain response to temperature change, showing an increase or decrease [7]. For China subtropical carbon cycle research, found that short-term warming significantly increased the carbon cycle heterotrophic respiration rate, short-term warming reduces the carbon cycle strange breath, think that the reasons for this phenomenon may be due to short-term warmer water in short supply, affect the carbon cycle microbial activity, lead to short-term case carbon cycle of warming into lower respiratory rate. The mechanism of carbon cycle on global climate change is summarized into four hypotheses :

A. substrate deficiency theory;
B. water restriction theory;
C. nitrogen excess theory;
D. biological adaptability theory.

Currently on the global climate warming on carbon cycle simulation test has been in different typical ecological system, such as farmland, grassland, and obtained some important scientific results and research progress, this to a certain extent, increased the accurate estimation of ecosystem carbon balance, and forecast the global temperature increase the uncertainty of the impact on soil carbon balance.

3. Study on the Impact of Ecosystem Carbon Cycle on Global Climate Change

3.1. Extraction of ecosystem carbon cycle parameters

Carbon cycle, as an important influence factor of global climate change, changes the pattern and process of the whole ecosystem, exerts an important influence on global carbon cycle, and then plays an important role in climate change [8]. For the whole ecosystem, the impact of carbon cycle can be divided into direct impact and indirect impact. Effects of carbon cycle on vegetation carbon pool the vegetation carbon pool generally refers to the plant body part, which includes the aboveground part of the plant and the underground living roots. Vegetation biomass can be converted into vegetation carbon storage according to a ratio (the proportion of carbon in the dry mass of fuel) [9]. The extraction process of carbon cycle parameters is shown in the figure 1 below.

It can be seen from the above process that the extraction of carbon storage parameters is generally calculated by multiplying the existing stock of vegetation biomass measured directly or indirectly by the carbon content of biomass [10]. As the producers of the ecosystem, plants have to carry out light cooperation every day to fix CO2 in the atmosphere, so as to maintain the normal operation of the ecosystem. The carbon pool stored by the global vegetation is about 550 ~ 950PgC, which is similar to the atmospheric carbon pool, but its activity is very high. The exchange between the carbon pool and the atmospheric carbon pool is the main process of the carbon cycle, so its changes are very important to the atmospheric carbon pool [11]. Ecosystem is the largest vegetation carbon pool in terrestrial ecosystem, and its carbon flux plays an important role in global carbon cycle and carbon balance. Carbon cycle emission of a large number of carbon-containing greenhouse gases is one of the important ways

to lead to the dynamic change of vegetation carbon storage, which has an important impact on the regional and global carbon cycle and carbon balance [12].. On average, about 1% of the world suffers from carbon cycle every year, which leads to about 4Pg carbon emission into the atmosphere every year, resulting in the net loss of carbon pool of ecosystem vegetation. Global ecosystem carbon cycle parameters are shown in the table 1 below.

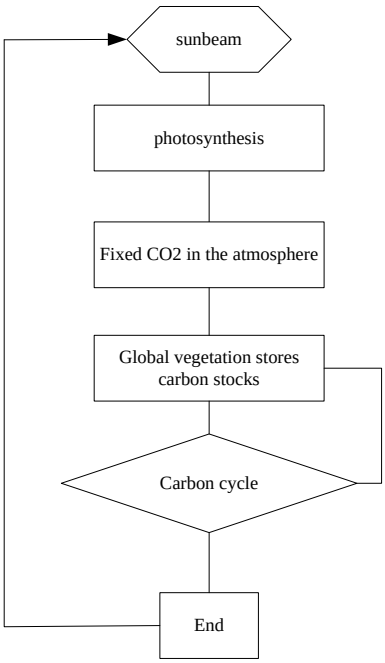

Figure 1. Carbon cycle process

As can be seen from the above table, the carbon cycle process in the global climate change process, the carbon cycle consumes a large amount of wood and other vegetation, and the wood loss caused by the carbon cycle reflects the carbon loss caused by the carbon cycle. There are great uncertainties in the estimation of carbon cycle biomass 13].. Due to the inconsistency of statistical methods and the lack of data, as well as the differences of fire behaviors and characteristics of carbon cycle in different places, the range of estimates varies greatly. From the biomass of global fire combustion, Crutzen et al. estimated the global vegetation carbon pool loss to be 947TgC/a, Levine et al. estimated the global vegetation carbon pool loss to be 1540TgC/a. Crutzen and Andreae estimated the carbon pool loss of tropical carbon cycle vegetation at 1100 ~ 2201TgC/a. Dixon and Krankina calculate the loss of carbon pool of tropical carbon cycle vegetation to be 286TgC/a. Joshi estimated that the loss of carbon pool in the vegetation of carbon cycle in northern forests was 102.6TgC/a.

3.2. Carbon cycle measurement method

Accurate measurement of the amount of carbon emitted by burning fuels during the carbon cycle can effectively improve the understanding of the relationship between climate change and carbon cycle in ecosystems [14]. Many scholars have estimated the trace carbon gases released by combustible combustion during fire. In 1980, Seiler and Crutzen developed a biomass measurement method for fire loss, known as a biomass measurement model for fire loss. So far, the carbon emission measurement model method of global climate is mainly based on the above model, whose expression is:

$$M = A \times B \times a \times b \quad (1)$$

Table 1. Global ecosystem carbon cycle parameters

Region	Total carbon	CO2	Not a paraffin
Global emissions		13400	49
Tropical	1741	5716	271
Temperate	120～250	2010～4000	
Boreal forest	258	235	0.7

Where: M is the amount of combustible consumed by fire (t); A is the burning area (hm2) of the fire; B is the average fuel load per unit area before combustion (t/hm2); A is the proportion of aboveground biomass in the biomass of the whole system (%); B is the combustion efficiency of the ground fuel load.

Assuming that all the carbon in the burned combustible becomes gas, the carbon loss caused by fire (Ct) can be calculated according to the carbon content ratio (fc) of the burnable load, which can be expressed as:

$$C_t = M \times f_c \quad (2)$$

Substitute equation (1) into equation (2) and make it be used to measure the carbon emission in fire. The expression is:

$$C_t = A \times B \times f_c \times \beta \quad (3)$$

In the formula: beta is the combustion efficiency of combustibles, that is, the proportion of combustibles consumed in the fire process per unit area before the fire [15]. The measurement of carbon-containing gas emission in fire is conducted by using the carbon emission calculated in the previous section and the emission factor method [16]. The emission factor method refers to the emission of a certain carbon-containing gas in the fire, which is the product of the emission factor of the gas and the carbon emission in the combustion process. The emission of a certain carbon-containing gas is based on the biomass measurement model of fire loss proposed in equation (1), whose expression is:

$$E_s=E_{fs}\times C_t \quad (4)$$

Where: Es is the emission of a certain carbon-containing gas (g); Efs is a carbon emission factor (g/kg); Ct is the amount of carbon (kg) emitted by combustible combustion. Combined with fire emissions model to estimate the global carbon emissions in the measurement of fire fire carbon emissions and carbon emissions, involves a series of measurement parameters in the formula, how to obtain a more effective and reliable parameters, makes the fire more quantitative measurement of the carbon emissions, this is a fire should be concerned about the problem of carbon emissions measurement model method [16]. For small scale of quantitative measurement and field survey was used to measure method is feasible, and can be quantified, but push the small scale of carbon emissions measurement method to the large-scale fire carbon emissions measurement, produce many problems cannot be quantified, therefore, how to obtain a more effective and reliable parameter, is the need to further research topic [17].

3.3. Application of model method in carbon cycle

As the global climate warms, the frequency and intensity of the carbon cycle will increase dramatically, and so will the impact. Therefore, the quantitative evaluation of the impact of carbon cycle on ecosystem carbon cycle and its response to global warming will promote the study of regional carbon budget in the context of global warming [18]. By climate change - carbon cycle - the complex causal relationship between ecosystem carbon cycle, building space of observation and ground station network series scale data-base of mutual authentication, at the same time in the introduction, digestion, optimization, and on the basis of independent innovation, building based on natural and human activity is driven LUCC process coupling model, LUCC process affect the mechanism of the regional climate model, mechanism model of LUCC process affect the ecological system and so on three big series model, and formed a relatively complete, the land system and its surface atmospheric space simulation system, predict and verify the model [19]. On this basis, through the standardized integration and transformation of multi-source, multi-scale and multi-temporal data resources and the construction of service-oriented architecture (SOA) model base for multi-source and heterogeneous model system, the comprehensive LUCC and its climate/ecological effect integration carbon cycle system model of data-model integration was developed [20]. The carbon cycle model is shown below.

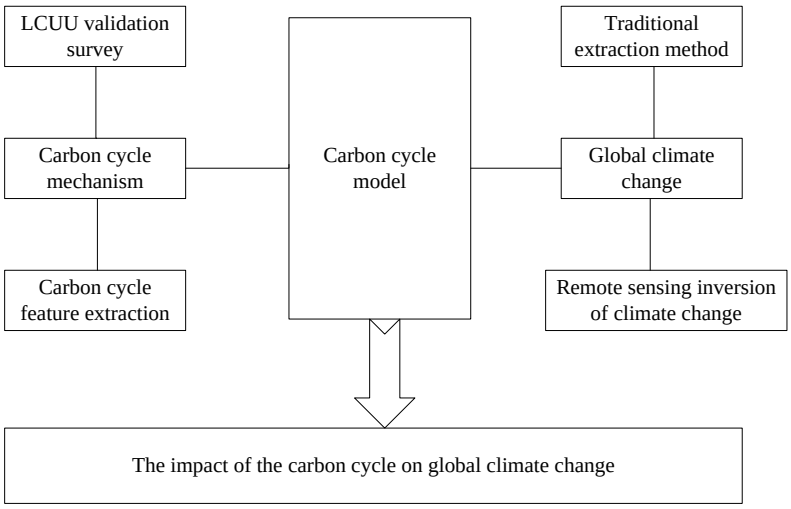

Figure 2. Carbon cycle model

Carbon cycle model considering the interference factor of model simulation, can make us better understand the process of fire disturbance such as large scale, climate change, the large-scale pattern of vegetation change, and the interaction between land biogeochemical cycle process, thus for our scientific understanding of the carbon cycle to climate change, ecosystem biogeochemical cycle and the influence of the carbon flux to provide theoretical basis. Carbon cycle on ecosystem carbon cycle has the complexity and long-term, the influence of the carbon cycle a lot of process and the effects of global climate function is hard to study in detail, carries on the quantitative evaluation still need further in-depth study, in order to quantitatively describe the carbon cycle influence on ecosystem carbon cycle, model become an important research method, the future has the characteristics of simple and effective, fast and practical [21]. At the same time, the model can not only study the current carbon cycle process, but also reveal the influence of the carbon cycle under historical conditions on the carbon cycle and

the influence of the carbon cycle under future warming scenarios.

4. Ecosystem Carbon Cycle on the Global Climate Change Research Progress at Home and Abroad

Although studies on the impact of ecosystem carbon cycle on global climate change have been carried out to some extent, there are still some deficiencies as follows: field warming experiments are mainly conducted for grassland, farmland, tundra and ecosystem in mid-high latitude areas; So far, there are no field warming experiments in tropical and subtropical regions south of 30 ℃, and there are still huge uncertainties in the prediction of tropical carbon exchange capacity's response to warming. Due to the construction cost and fire hazards, the research on warming is usually limited to soil warming, while the research on the whole ecosystem level is still lacking. The variation of rainfall includes rainfall amount, rainfall intensity, rainfall occurrence time and rainfall interval. Most of the existing studies on CO2 rise are on young seedlings and saplings in growth Chambers and open-top boxes, while few studies have been conducted on adult trees in tropical areas, especially under field conditions using FACE facilities. Although more studies have been carried out on the influence of N deposition on carbon cycle in recent years, the existing results still fail to clarify the exact influence of N deposition on carbon cycle process and the direction and magnitude of its effect. There are only a few studies on nitrogen deposition in tropical and subtropical regions. The impact of global environmental change on ecosystems has focused on the carbon cycle, while studies of the cycles of nitrogen, phosphorus and other elements remain sparse. The global environmental change factors are usually not independent, but interact with each other. In addition, experimental studies are usually carried out at the level of sample plots or stands, and the time is relatively short, so there is still a lack of understanding on the long-term impacts of climate change on landscape and regional scales.

5. Summary and Prospect

5.1. Result Analysis

Global climate change is closely related to the carbon cycle, and so on ecosystem carbon cycle feature extraction accuracy simulation experiments, selecting a experimental site, now the carbon cycle is for the exchange of water vapour and carbon dioxide, compared the experimental group and control group in matter and energy exchange process, compares with the database, the simulation results are obtained as shown in the figure below.

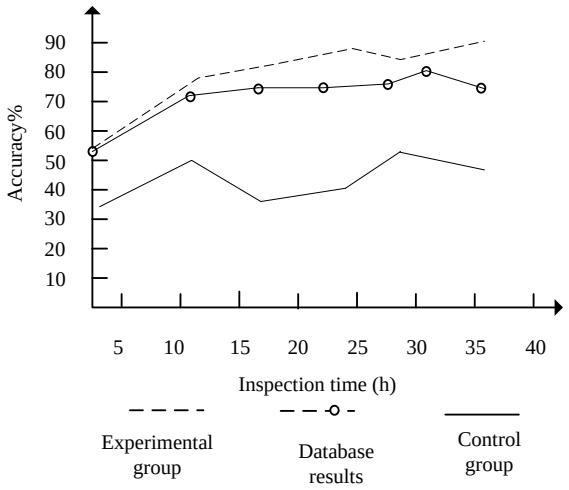

Figure 3. Simulation results

5.2. Conclusion

Through the analysis of the carbon cycle of important scientific problems of global climate impact study and the research status at home and abroad, considering the discipline overlapping, permeability and coupling characteristics of the carbon cycle was proposed and the preliminary design for the star to the integration of the global climate impact study LUCC, climate, ecological system coupling research technique method system, and the impact of land use change on the global climate LUCC evolution and dynamic mechanism, LUCC affect the ecological system and some important scientific problems of the mechanism and effect of climate research approaches, The paper also discusses the application technology route of satellite and earth integrated coupling research technology system in the study of carbon cycle's influence on global climate. Choose typical major LUCC human activity area, based on TM remote sensing interpretation, MODIS/AVHRR secondary classification of LUCC information extraction and field verification, high-precision LUCC in obtaining typical area spatio-temporal data and data, on the basis of using the CERN and ChinaFlux observation data, and remote sensing inversion ET parameters, study the driving mechanism of the carbon cycle and its mechanism of main ecological/climate effect. The combined analysis method of observation data and reanalysis data can explore the climate effect of urbanization by using the difference between observation data and reanalysis data. Global climate model (GCM) can study the impact of carbon cycle on global climate, moderately complex earth system model (EMIC) can evaluate the climate effect of long-term carbon cycle, and regional climate model (RCM) can evaluate the past, present and future regional climate effect of real carbon cycle with high spatial and temporal resolution.

5.3. Research prospects

There is a causal link between climate change and the carbon cycle. As an important part of global climate change, carbon cycle is a redistribution process of carbon, which has an important impact on regional and even global carbon cycle. A correct understanding of the interaction between climate change and carbon cycle, climate change and carbon cycle and two-way feedback effect, the complex relations between model method is applied to simulate the contribution of fire disturbance on forest ecosystem carbon cycle, rediscover the carbon cycle in the role of global climate change, give full play to the ecological effects of the carbon cycle and carbon balance, this to formulate scientific and rational forest fire management strategy, realize the sustainable development of forest, enhance the level of ecosystem management, improve the ability of carbon sequestration, reduce carbon emissions, carbon sinks, slow down the rate of global change has important significance. Due to the complexity and heterogeneity of forest ecosystem, the influence of carbon cycle has a wide range, a long time and a complex mechanism. Therefore, it is necessary to fully understand the influence of carbon cycle on regional and global carbon cycle and carbon balance.

6. Conclusion

In the process of global change, climate warming is often accompanied by other forms of common occurrence, considering the complexity and long-term of the global change, using the method of model building, including the carbon cycle factors, multiple factor interaction model, build under the background of global warming, many factors, including the carbon cycle factors, the carbon cycle model of interaction, the coupling of natural and human factors of carbon cycle model, formulate and implement scientific and reasonable carbon cycle management measures, give full play to the ecological effect of the carbon cycle in response to global warming, in order to achieve harmony between the carbon cycle and global climate change, achieve the harmonious development of man and nature.

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