Estimation of carbon sink in surface carbonate rocks of Guangxi Province by using remote sensing images

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ABSTRACT:

Studies of the imbalance of source sinks in the carbon cycle show that CO_2 absorbed during rock weathering is part of the "miss carbon" of the global carbon cycle. The carbon sink contribution of carbonate rocks obviously plays a very important role in the absorption of atmospheric CO_2. Estimation of carbon sinks in karst dynamic system of Guangxi province has great significance for further understanding of global karst carbon cycle and global climate research. This paper quotes the rock data from Tao Xiaodong's paper, which is obtained using RS and GIS techniques. At the same time, the dissolution rate model studied by Zhou Guoqing and others was used to estimate the dissolution rate of carbonate rocks in Guangxi Province. Finally, the CO_2 content consumed by carbonate karstification in Guangxi Province was 1342910.447 ta^{-1}. The results obtained are in the same order of magnitude as the CO_2 content consumed by carbonate rock karstification in Guangxi Province calculated by Tao Xiaodong.

1. INTRODUCTION

The discussion of the relationship between global climate change and the increase of atmospheric greenhouse gas concentration has caused public concern about the earth's carbon cycle (Yuan, 2011). The greenhouse gases that cause global climate change are an important part of the global carbon cycle. Studies of the imbalance of source sinks in the carbon cycle show that CO_2 absorbed during rock weathering is part of the "miss carbon" in the global carbon cycle. Siegenthaler *et al*. (1993) found that 1.8 PgC was an undetected residue of terrestrial carbon sinks, which is called "miss carbon sinks" (Qu *et al*., 2004). It is generally assumed that this unknown carbon sink may have terrestrial vegetation or soil (Pan *et al*., 2011; Friedlingstein *et al*., 1995). The amount of carbon in carbonate rocks stored in the lithosphere is more than 6.0 × 108 million tons, 1562 times and 3.0 × 104 times that of marine and terrestrial vegetation respectively (Falkowski *et al*., 2000). The carbonate rocks stored in the lithosphere are rarely considered. The role of the lithosphere in atmospheric carbon dioxide is listed as a long-term cycle, while ignoring the carbon dioxide absorption and dynamic changes in the lithosphere. Therefore, carbonate karstification can be used to study this unknown carbon sink. Because they consume carbon in the atmosphere or soil (Gombert, 2002).

The relationship between carbon sink and the source sink of atmosphere was analyzed by means of the dissolution test method, dynamic method, hydrochemical methods and model establishment. Internationally, Ichikuni (1976), Kitano (1984), Inokura (1997), Yuan (1997), Ludwig (1998), Liu (2000), Gombert (2002) and other researchers have calculated the carbon of rock weathering consumption, indicating that the contribution of carbonate sinks is greater than that of source. The contribution of carbon sinks to carbonates rocks Karstification obviously plays a very important role in the absorption of atmospheric CO_2. Therefore, it is of great research significance to estimate the exploration of the global carbon cycle and the study of global climate by the carbon sink of karst dynamic system.

China has a large number of karst landform areas, while Guangxi Province is one of the more abundant karst provinces in China. The Karst effect is very strong because of the abundant rainfall and mild climate. In this paper, Guangxi province is selected as the research area, and the rock data (Tao, 2013) of Tao Xiaodong's paper is cited, which are abtained by RS and GIS technologies. At the same time, the dissolution rate model studied by Zhou *et al*. (2017) was used to estimate the dissolution rate in Guangxi. Finally, the carbon sink of surface karstification in the karst area of Guangxi Province was estimated from the rock data and dissolution rate.

2. EXPERIMENTAL DATA

2.1 Rock Data

The area of carbonate rocks in Guangxi Province comes from the master's thesis of Tao Xiaodong. The data acquisition of rock area is based on the sixth band of the original TM remote sensing image in Guangxi area as the original data (Figure 1), and the Landsat TM6 is divided into 7 categories by supervised classification. Classification results shown in Figure 2. Using remote sensing technology can get some effects on lithology extraction, but the classification accuracy is not high, so Tao Xiaodong uses recalciton lithology based on ArcGIS geological map and figure 2(Tao, 2013).

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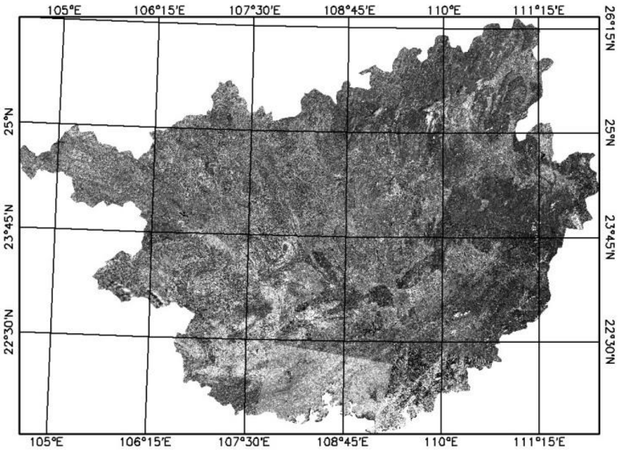

Figure 1. Original TM Remote Sensing Image in Guangxi (Tao, 2013)

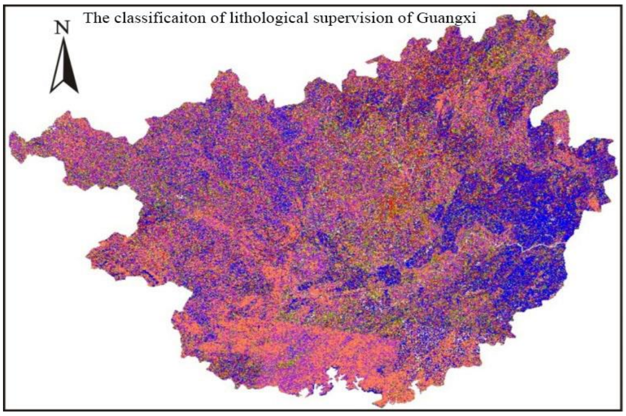

Figure 2. Classification of lithological supervision (Tao, 2013)

2.2 Rainfall Data and Temperature Data

The rainfall data and temperature data calculated in this paper are from the national meteorological data sharing service platform and the data website is data.cma.cn. The rainfall and temperature data are for the 24 meteorological stations in Guangxi in 2010 (Figure 3). We use the common Kriging method in ArcGIS to predict the surface temperature and rainfall data of 24 meteorological stations in Guangxi in 2010 and generalize the point data to surface data. The results are shown in Figure 4 and Figure 5.

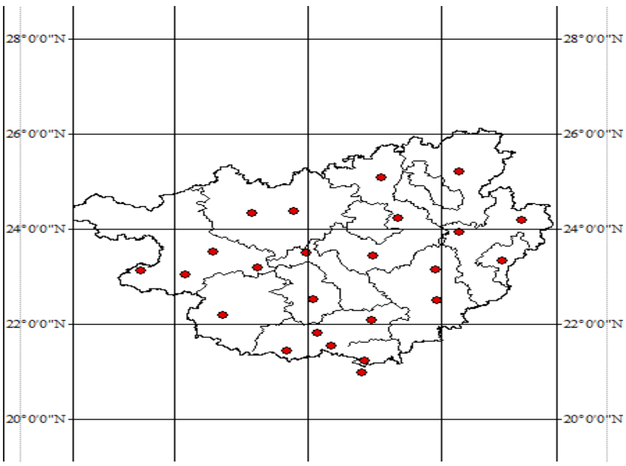

Figure 3. 24 meteorological stations in Guangxi Province

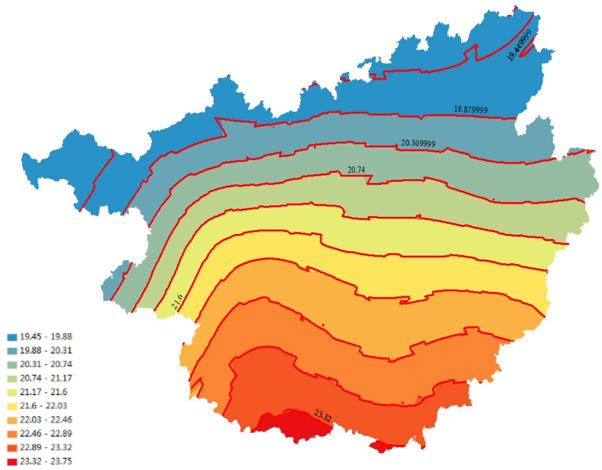

Figure 4. Distribution of temperature data in Guangxi Province

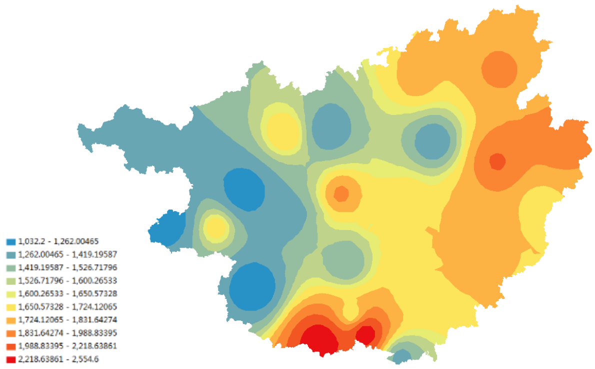

Figure 5. Distribution map of rainfall in Guangxi Province

3. RESEARCH METHODS AND ESTIMATION OF KARST CARBON SINK IN GUANGXI PROVINCE

3.1 Karst Carbon Sink Research Methods

Because karst dynamic system is an open system, there is great difficulty in studying the carbon sink produced by karstification. Researchers often use the following methods to study the karstification of rocks: dynamic method, hydrochemical methods, dissolution test method.

3.1.1 Dynamic method: dynamic method is a method of calculating the reaction rate based on the reactant or product concentration relationship. It is an effective method for analyzing the rate mechanism and reaction mechanism of karstification under experimental conditions and is suitable for karst microscopic studies. Dynamic method is representative of PWP model (Plummer *et al.*, 1978) and DBL model (Dreybrodt *et al.*, 1991). In 2000, Liu Zahua (2000) and others used dynamic method to estimate the karst carbon sink and global karst carbon sink in China.

3.1.2 Hydrochemical methods: The hydrochemical method is considered that runoff is the factor that influences the weathering rate of rocks. The relationship between rock weathering rate and runoff of different types of rocks is analyzed. And the consumption of CO_2 in large scale karst process is estimated. Typical hydrochemical methods include the GEM- CO_2 Model (Amiotte *et al.*, 1995) and the SiB algorithm (Pacheco *et al.*, 1996).

3.1.3 Dissolution test method: Dissolution test strip method is a field experiment method. In the field experiment, the geographical location and environment of the experimentation area should be taken into consideration. In the surface karst dynamic system, the rock has a sink effect with atmospheric CO_2, and the estimation of karstic carbon sink mainly consists of the dissolution equation of limestone:

$$CaCO_3 + CO_2 + H_2O \Leftrightarrow Ca^{2+} + 2HCO_3^- \quad (1)$$

Therefore, the formula for calculating atmospheric CO_2 sinks is as follows:

$$F = E \times S \times R \times M_{CO_2} / M_{CaCO_3} \quad (2)$$

Where F is the sink of CO_2 at 10^{10}g a-1; S is the karst area at km^2; R is the carbonate rock purity of rock specimen at R=0.97; E is the corrosion rate of the rock specimen at $mgcm^{-2}a^{-1}$; M_{CO_2} is the molecular weight of at M_{CO_2} =44; M_{CaCO_3} is the molecular weight of M_{CaCO_3}, usually, M_{CaCO_3} =100.

In the study of rock weathering in Guangxi Province, rock carbon sinks are calculated by formula (2). The dissolution rate model fitted by Zhou Guoqing *et al* based on the data of 18 corrosion test sites in China (using the dissolution test method). The karst carbon sink in Guangxi province is calculated according to the dissolution rate model.

3.2 Estimate of Guangxi Karst Carbon Sink

According to the dissolution rate model fitted by Zhou Guoqing *et al*., it is found that temperature and rainfall are the influence factors of the dissolution rate. The temperature data and rainfall data of 24 meteorological stations in Guangxi Province were predicted by using the Kriging method in ArcGIS in 2010 (Figure 4 and Figure 5). The dissolution rate of carbonate rocks in Guangxi Province is determined by combining the rock classification maps of Guangxi in Figure 6. The carbon sink of carbonate rocks karstification in Guangxi Province are calculated based on the rock area data in Table 1.

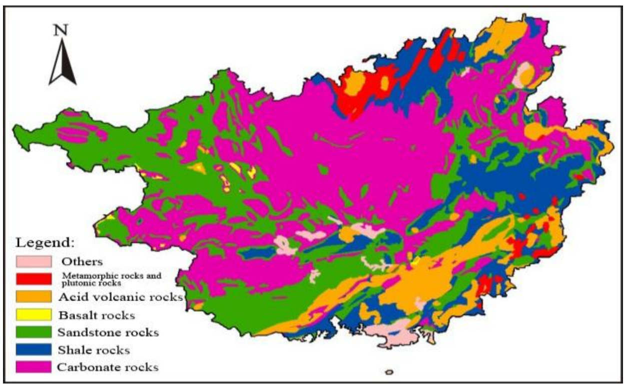

Figure 5. The classification result of lithology in Guangxi (Tao, 2013)

Rock types	Size of area (km^2)
Metamorphic rocks and plutonic rocks	3691.35
Acid volcanic rocks	19669.10
Basalt	874.42
Sandstone	72275.76
Shale rocks	37756.96
Carbonate rocks	99599.16

Table 1. Area Data for Different Rock Types in Guangxi Province (Tao, 2013)

In Figure 5, in addition to carbonate rocks, the remaining five types of rocks are metamorphic and plutonic, acidic volcanic rocks, basalts, sand and sandstone, and shales belong to silicate rocks (Tao, 2013). Because of the solubility of silicate minerals and slow weathering kinetics, it is more than one order of magnitude lower than that of carbonate (Amiotte *et al*., 1995; Pacheco *et al*., 1996; Ludwig *et al*., 1998; Roy *et al*., 1999; Mortatti *et al*., 2003; Wu *et al*., 2008). Therefore, this paper mainly estimates the CO_2 content absorbed by carbonate karstification in Guangxi Province. The dissolution rate model studied by Zhou *et al*. (2017) is as follows:

$$\begin{aligned} E &= 5.322 - 0.9609 \times T + 0.00533 \times P \\ &+ 0.0627 \times T^2 - 0.001133 \times T \times P \\ &+ 0.000007675 \times P^2 \end{aligned} \quad (3)$$

Based on the temperature data and rainfall data (Figures 4 and 5), the dissolution rate of carbonate rocks in Guangxi is calculated by formula (3). Using Equation 2, the CO_2 content consumed by carbonate karstification in Guangxi Province is 1342910.447 t a^{-1} (366248.3037Ct a^{-1}).

4. CONCLUSIONS

According to the influence factors of the fitted dissolution rate model, the rainfall rate and temperature data were selected to calculate the dissolution rate of carbonate rocks in Guangxi Province, which was 3.16mg $cm^{-2}a^{-1}$. Finally, the CO_2 content consumed by carbonate karstification in Guangxi Province is 1342910.447 t a^{-1}. The obtained results are in the same order of magnitude as the CO_2 content consumed by carbonate rock karstification in Guangxi Province calculated by Tao Xiaodong, indicating that this result is still credible.

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