Temporal Variation and Trend Prediction of Carbon Storage in Subtropical Evergreen Broad-leaved Forest in Jiangxi Province Based on Remote Sensing Images

Zhang Qiugen*, Ding Ruan, Li Jian
School of Environment and Chemistry Engineering, Nanchang HangKong University, Nanchang, Jiangxi Province, 330063, China
Corresponding author’s e-mail: 904644628@qq.com

Abstract. The dynamic change of forest carbon storage can be monitored by remote sensing technology because the change of vegetation index can reflect the dynamic change of forest carbon storage based on the remote sensing images. Combined with remote sensing estimation model of vegetation and soil carbon storage based on the remote sensing classification area data of subtropical evergreen broad-leaved forest in 2015, the vegetation and soil carbon storage and carbon density of subtropical evergreen broad-leaved forest in Jiangxi province from 1985 to 2015 was estimated by using the remote sensing image data of Jiangxi province from 1985 to 2015. The results showed that the carbon storage and carbon density of subtropical evergreen broad-leaved forest in Jiangxi province had shown an overall increasing trend from 1985 to 2015. The carbon storage of vegetation had increased from 0.1254 GtC in 1985 to 0.2092 GtC in 2015, and the carbon density of vegetation had increased from 63.071 t/hm² in 1985 to 76.31 t/hm² in 2015. The soil carbon storage had increased from 0.3820 GtC in 1985 to 0.5474 GtC in 2015, and the soil carbon density had increased from 185.99 t/hm² in 1985 to 199.69 t/hm² in 2015. At the same time, the change trend of carbon storage in subtropical evergreen broad-leaved forests in Jiangxi province from 2020 to 2035 was predicted. The vegetation carbon storage will achieve 0.2774 GtC, 0.2969 GtC, 0.3164 GtC and 0.3359 GtC in 2020, 2025, 2030 and 2035 respectively. The soil carbon storage will achieve 0.5020 GtC in 2020, 0.5335 GtC in 2025, 0.5650 GtC in 2030 and 0.5965 GtC in 2035 respectively.

1. Introduction
Forest vegetation index and forest classified area can be extracted by remote sensing technology[1-3]. The dynamic change of vegetation carbon storage and carbon density can be reflected through the change of vegetation index during vegetation growth[4-7]. Therefore, remote sensing technology can be used to monitor the dynamic change of vegetation carbon storage and carbon density. In the preliminary study, the vegetation and soil carbon storage and carbon density of typical subtropical evergreen broad-leaved forest in Jiangxi province in 2015 were obtained by investigating sample plots in Dagangshan Nature Reserve, Jinggangshan Nature Reserve, Jiulanshan Nature Reserve and Wuyishan Nature Reserve. The NDVI model of vegetation carbon storage of subtropical evergreen broad-leaved forest in Jiangxi province (Y=0.3336e^{3.8899x}) and soil carbon storage NDVI model (Y=1200.8674x^2-869.2141x+740.0559) were obtained through remote sensing technology. The remote sensing estimation model of vegetation and soil carbon storage were verified with field survey data in 2015 and their error were within acceptable range. Therefore, the vegetation and soil carbon storage
and carbon density of subtropical evergreen broad-leaved forest in Jiangxi province during 1985 to 2015 were estimated and their temporal change were analyzed by using the remote sensing estimation model. At the same time, the forecasting model was established to forecast the change trend of the subtropical evergreen broad-leaved forest vegetation and soil carbon storage and carbon density in Jiangxi province in 2020-2035. It will provide scientific basis for regulating the forest carbon in Jiangxi province.

2. Temporal variation of forest carbon storage

2.1. Temporal variation of vegetation carbon storage

Combined with remote sensing estimation model of vegetation carbon storage based on the remote sensing classification area data of subtropical evergreen broad-leaved forest in 2015, the vegetation carbon storage and carbon density of subtropical evergreen broad-leaved forest in Jiangxi province from 1985 to 2015 were estimated and analyzed, as shown in figure 1 and figure 2.

Figure 1. Dynamic change of vegetation carbon storage of subtropical evergreen broad-leaved forest from 1985 to 2015 in Jiangxi province

![Figure 1](image1.png)

Figure 2. Dynamic change of vegetation carbon density in subtropical evergreen broad-leaved forest from 1985 to 2015 in Jiangxi province

![Figure 2](image2.png)

It can be seen from figure 1 that the vegetation carbon storage of subtropical evergreen broad-leaved forest in Jiangxi province had shown an increasing trend from 1985 to 2015. It had increased from 0.1254 GtC in 1985 to 0.2092 GtC in 2015.

As can be seen from figure 2, the vegetation carbon density of subtropical evergreen broad-leaved forest in Jiangxi province had shown an increasing trend from 1985 to 2015. It had increased from 63.071 t/hm² in 1985 to 76.31 t/hm² in 2015.

Between 1985 and 2015, the vegetation carbon storage and carbon density of subtropical evergreen broad-leaved forest in Jiangxi had shown a increasing trend. The main reason was people's protection consciousness improving and the implementation of forest protection policy, especially the implementation of facilitating afforestation and natural forest protection project after the severe floods
in 1998. Since then, the subtropical evergreen broad-leaved forest ecosystem in Jiangxi province had been in little interference. The subtropical evergreen broad-leaved forest had been in a state of natural succession and natural recovery in Jiangxi province. With the increase of forest age, the vegetation maintained sustainable growth and carbon sequestration capacity increased. So, the area of subtropical evergreen broad-leaved forest had increased because of the proportion of mature or near-mature forest had increased, which had lead an increase of forest carbon storage and carbon density.

To be specific, the forest area of evergreen broad-leaved forest and the decrease of its carbon storage had decreased during the period from 1985 to 1995 by the large-scale deforestation, because it need the large amount of timber to reform and open up and develop the economy.

After the catastrophic flood disaster in 1998, people had realized the important role of forests in water conservation and started the construction of natural forest protection project and series shelter forest project. Since then, the forest area and the vegetation carbon storage had began to increase. However, it had caused damage to a large area of evergreen broad-leaved forest because of the massive snowstorm in 2008. It also had reduced the forest carbon storage from 2005 to 2015.

2.2. Temporal variation of soil carbon storage
Forest soil carbon storage is dynamic change with forest age and litter. They are closely related to vegetation carbon storage, and there is a high correlation between soil carbon storage and vegetation carbon storage. Soil carbon storage dynamic balance is mainly affected the vegetation growth, litter decomposition and microbial activity. According to reports in the literature, the dynamic change of the vegetation growth can be directly reflected by the change of vegetation index. So the change of vegetation index can be used to reflect the dynamic change of soil carbon storage[8]. So, combined with remote sensing estimation model of soil carbon storage based on the remote sensing classification area data of subtropical evergreen broad-leaved forest in 2015, the soil carbon storage and carbon density of subtropical evergreen broad-leaved forest in Jiangxi province from 1985 to 2015 was estimated and analyzed, as shown in figure 3 and figure 4.

Figure 3. Dynamic change of soil carbon storage of subtropical evergreen broad-leaved forest from 1985 to 2015 in Jiangxi province

Figure 4. Dynamic changes of soil carbon density of subtropical evergreen broad-leaved forest from 1985 to 2015 in Jiangxi province
According to figure 3, soil carbon storage of subtropical evergreen broad-leaved forest in Jiangxi province showed an increasing trend during the 30 years from 1985 to 2015. It had increased from 0.3820 GtC in 1985 to 0.5474 GtC in 2015.

As can be seen from figure 4, soil carbon density of subtropical evergreen broad-leaved forest in Jiangxi province had shown an increasing trend during 30 years from 1985 to 2015. It had increased from 185.99 t/hm² in 1985 to 199.69 t/hm² in 2015.

The change reason of soil carbon storage and carbon density was similar to the vegetation of subtropical evergreen broad-leaved forest in Jiangxi province. The litter steady accumulated with the mature or near-mature forest increasing, so soil carbon storage and carbon density continued to increase through the decomposition and transformation of organic carbon accumulating in the soil by soil microbes.

3. Trend prediction of forest carbon storage

3.1. Trend prediction of vegetation carbon storage

The biomass remote sensing model was established by using remote sensing data and sample plot survey biomass in 2015. The vegetation biomass and carbon density of the 1985's, 1995's, 2000's, 1995's and 2000's was estimated through the carbon content. Then the vegetation carbon storage was estimated with the results of the classification area. The vegetation carbon storage curve along with the change of year \( y=0.0039x-7.6006 \), \( R^2=0.5265 \) was fitted by regression analysis in SPSS. The vegetation carbon storage of subtropical evergreen broad-leaf forest was forecasted during 2020-2035 in Jiangxi province, as shown in figure 5.

It can be seen from figure 5, the vegetation carbon storage of subtropical evergreen broad-leaved forest will show a slightly increasing trend in the future of 20 years. The total vegetation carbon storage in Jiangxi province can increase to 0.2774 GtC in 2020, 0.2969 GtC in 2025, 0.3164 GtC in 2030 and 0.3359 GtC in 2035.

![Figure 5. Vegetation carbon storage trend predictions of subtropical evergreen broad-leaved forest in Jiangxi province during 2020-2035](image)

3.2. Trend prediction of soil carbon storage

The soil carbon storage remote sensing model was established by using remote sensing data and sample plot survey date in 2015. The soil carbon density of the 1985's, 1995's, 2000's, 1995's and 2000's was estimated. Then the soil carbon storage was estimated with the results of the classification area. The soil carbon storage curve along with the change of year \( y=0.0063x-12.224 \), \( R^2=0.8567 \) was fitted by regression analysis in SPSS. The soil carbon storage of subtropical evergreen broad-leaf forest was forecasted during 2020-2035 in Jiangxi province, as shown in figure 6.

As can be seen from figure 6, the soil carbon storage of subtropical evergreen broad-leaved forest will show a increasing trend in the next 20 years. The total soil carbon storage in Jiangxi province will increase to 0.5020 GtC in 2020, 0.5335 GtC in 2025, 0.5650 GtC in 2030 and 0.5965 GtC in 2035.
4. Conclusion

NDVI model was used to estimate the carbon storage and carbon density of vegetation and soil of subtropical evergreen broad-leaved forest in Jiangxi province from 1985 to 2015. During 1985 to 2015, the vegetation carbon storage increased from 0.1254 GtC to 0.2092 GtC, and the vegetation carbon density increased from 61.07 t/hm² to 76.31 t/hm². The soil carbon storage increased from 0.3820 GtC to 0.5474 GtC, and soil carbon density increased from 185.99 t/hm² to 199.69 t/hm². Meanwhile, the vegetation carbon storage and soil carbon storage of subtropical evergreen broad-leaved forest in Jiangxi province in the next 20 years were predicted. The vegetation carbon storage will be 0.2774 GtC (2020), 0.2969 GtC (2025), 0.3164 GtC (2030), 0.3359 GtC (2035). The soil carbon storage will be 0.5020 GtC (2020), 0.5335 GtC (2025), 0.5650 GtC (2030), 0.5965 GtC (2035).

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