RESEARCH ON REMOTE SENSING MONITORING AND PREDICTION OF ATMOSPHERIC CARBON DIOXIDE CONCENTRATION IN ZHEJIANG PROVINCE BASED ON DEEP LEARNING

Bachelor's thesis

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ABSTRACT

Relevance of the research. With the increasing severity of global climate change, greenhouse gas emissions have become one of the focal points of concern. Carbon dioxide (CO_2), as one of the primary greenhouse gases, its rising concentration leads to global warming, ocean acidification, changes in climate patterns, and threats to ecosystems, posing one of the most significant environmental challenges today. However, the CO_2 column concentration data directly obtained by remote sensing satellites is limited by the satellite's operating trajectory and has a large number of missing value areas. The structure and attention mechanism of deep learning algorithms effectively solve the complex spatial relationships in atmospheric research. Therefore, this study is based on deep learning, this study combines road network data, meteorological data, Normalized Difference Vegetation Index (NDVI), and Aerosol Optical Depth (AOD) data to compare the performance of multivariate linear regression models, linear neural network models, fully connected neural network models, and convolutional neural network models in predicting atmospheric CO_2 concentration in Zhejiang Province.

The object of the research is atmospheric carbon dioxide concentration in Zhejiang Province, China, and **the subject** is remote sensing monitoring and prediction methods based on deep learning for of atmospheric carbon dioxide concentration research.

The purpose of the research is to conduct the predictions on the CO_2 concentration in Zhejiang Province based on remote sensing monitoring and utilizing the best-performing deep learning model.

To achieve the purpose of the work, the following **tasks** were set:

1. Collection multi-source data including CO_2 remote sensing data, road network data, meteorological data, NDVI data, and AOD data.

2. Development of code to build simple linear neural network models, fully connected neural network models, and convolutional neural network models.

3. Utilizing the best-performing deep learning model, conduction of the predictions on the CO_2 concentration in Zhejiang Province to gain deeper insights into the spatiotemporal variations of CO_2 concentration.

Research methods and main research findings:

Validation of OCO-2 satellite CO_2 column concentration product (Column averaged dry air mole fraction of CO_2, XCO_2) with the atmospheric baseline station in Lin'an demonstrates good consistency between remote sensing observations of atmospheric CO_2 and ground-based observation data, indicating that OCO-2 satellite remote sensing data can serve as a basis for predicting CO_2 concentration in Zhejiang Province.

Investigation of spatiotemporal variations in driving factors of CO_2 concentration: During the period from 2015 to 2020, the road network density in Zhejiang Province exhibited a significant increasing trend. The monthly average temperature in the province typically peaks in July and August, reaching its lowest point in January and February, with a long-term rising trend. Wind speed averaged 9.07 Km/h, with smaller values in spring and late autumn, and larger values in summer, winter, and early autumn, exhibiting a gradually decreasing long-term trend. NDVI demonstrated spatial patterns with higher values in inland areas compared to coastal areas and in the south compared to the north. NDVI values were higher in summer and autumn and lower in spring and winter. AOD values were higher in spring and autumn and lower in summer and winter, showing an overall declining trend.

Prediction of CO_2 concentration in Zhejiang Province using multiple linear regression, linear neural network, fully connected neural network, and convolutional neural network models reveals that the convolutional neural network model exhibits higher predictive performance. The validation set's R-squared (R^2) is 0.62, Root Mean Square Error (RMSE) is 3.21ppm, Mean Relevance Error (MRE) is 1.80%; the training set's R^2 is 0.69, RMSE is 2.87ppm, and MRE is 1.20%. During the period from 2015 to 2020, the multi-year average predicted CO_2 concentration in Zhejiang Province is lower in the southern region than the northern region and lower in coastal areas, while higher in cities such as Hangzhou, Shaoxing, and Jinhua. CO_2 concentration in Zhejiang Province is higher in summer and winter but lower in spring and autumn.

Structure of the work. The qualification work consists of introduction, four chapters and conclusions. The reference list includes 33 positions. The thesis is laid out on 50 pages. Contains 16 figures and 5 tables.