

METHOD AND SYSTEM FOR MEASURING URBAN CARBON EMISSIONS

TECHNICAL FIELD

5 The disclosure relates to the field of energy conservation and emission reduction, and particularly relates to a method and system for measuring urban carbon emissions.

BACKGROUND

10 In the background of an increasingly severe problem of global climate change, research on carbon emission gradually becomes a core issue of national governments and international organizations. It is especially significant to measure carbon emissions accurately and research into emission reduction measures for cities which are core regions of energy consumption and carbon emission with a dense population.

15 Currently, a conventional method for measuring carbon emissions is used to estimate total carbon emissions mainly by collecting statistics of energy consumption and unit carbon emissions. However, carbon emission features of different regions are generally neglected in such a method. Consequently, a carbon emission reduction solution cannot be specifically and effectively formulated and implemented.

SUMMARY

20 To overcome deficiencies in the prior art, a first objective of the disclosure is to provide a method for measuring urban carbon emissions which can consider differences between different regions and industries.

To overcome deficiencies in the prior art, a second objective of the disclosure is to provide a system for measuring urban carbon emissions which can consider differences between different regions and industries.

25 The first objective of the disclosure is realized by using a technical solution as follows:

a method for measuring urban carbon emissions includes steps as follows:

obtaining an urban functional region through division as follows: obtaining an urban map, and dividing a city into a residence and office region, an industrial production region, a road, and a green region according to the urban map;

measuring carbon emissions of the residence and office region as follows: setting the

residence and office region to include a residence and an office enterprise, and setting the carbon emissions of the residence and office region as $C_j = (N_1 \times E_Z + N_2 \times E_q) \times A + (N_1 \times G_Z + N_2 \times G_q) \times B$, where N_1 is a total number of the residence, E_Z is average electricity consumption of each residence, N_2 is a total number of the office enterprise, E_q is average electricity consumption of each office enterprise, A is a carbon emission coefficient of electricity, G_Z is average natural gas consumption of each residence, G_q is average natural gas consumption of each office enterprise, and B is a carbon emission coefficient of natural gas;

measuring carbon emissions of the road as follows: dividing the road into T space units, obtaining a type P of a vehicle in a space unit, a number M_p of each type of vehicles, and a traveling distance L_p of each type of vehicles according to monitoring data and mobile phone data, where the carbon emissions of the road are $C_t = T \times \sum_1^P (M_p \times L_p \times C_p)$, and C_p is a carbon emission coefficient of one type of vehicles;

measuring carbon emissions of the industrial production region as follows: classifying enterprises in the industrial production region into X types of enterprises according to energy consumption types, and obtaining total energy consumption D_x of each type of enterprises, where the carbon emissions of the industrial production region are $C_E = \sum_1^X D_x \times C_D$, and C_D is a carbon emission coefficient of one energy consumption type; and

measuring carbon sequestration of the green region as follows: obtaining maps of the green region in different months through satellite remote sensing, analyzing a map of the green region in each month, obtaining a type Z of a plant in the green region and a corresponding area A_z , and computing carbon sequestration $NPP_i = \sum_1^Z A_z \times C_z \times S$ of the green region in a current month, where C_z is a carbon sequestration coefficient of one type of plants, S is a temperature coefficient, the carbon sequestration of the green region is as follows:

$C_G = \sum_1^{12} NPP_i$, and

total urban carbon emissions are $C_T = C_j + C_t + C_E - C_G$.

Further, in the step of measuring carbon emissions of the road, the type of the vehicle includes a private car, a taxi, a motorcycle, an urban rail transit, a road passenger transport, and road freight.

Further, in the step of measuring carbon emissions of the road, in a case that the type of the vehicle is a truck, when the carbon emission coefficient C_p is computed, a load has a relatively large impact on the carbon emission coefficient C_p . A gross weight $g_{i \text{ empty}}$ of goods and fuel consumption $e_{i \text{ empty}}$ per hundred kilometers in a case of empty load, and a gross weight

$g_{i \text{ full}}$ of goods and fuel consumption $e_{i \text{ full}}$ per hundred kilometers in a case of a full load under the condition that different vehicle types of trucks normally travel on a road section are required to be measured. A load correction coefficient z_k of the vehicle is determined through an interpolation method according to an actual load situation of the truck. A carbon emission
5 coefficient of the truck is computed according to the load correction coefficient z_k .

Further, the gross weight $g_{i \text{ empty}}$ of the goods and the fuel consumption $e_{i \text{ empty}}$ per hundred kilometers in a case of empty load, and the gross weight $g_{i \text{ full}}$ of the goods and the fuel consumption $e_{i \text{ full}}$ per hundred kilometers in a case of the full load are determined through a weighted average method.

10 Further, the step of measuring carbon emissions of the industrial production region further includes: checking, according to production capacity data regularly corresponding to each energy consumption enterprise, whether real-time energy consumption corresponding to each consumption energy type matches a production capacity, and if not, correcting the real-time energy consumption corresponding to each consumption energy type until corrected energy
15 consumption corresponding to each consumption energy type matches the production capacity.

Further, in the step of measuring carbon emissions of the industrial production region, the energy consumption types are divided into nine types: electricity, raw coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil, and natural gas.

Further, the method for measuring urban carbon emissions further includes a verifying step
20 specifically as follows: obtaining historical total urban carbon emissions, decomposing the historical total urban carbon emissions into monthly carbon emissions, inputting the monthly carbon emissions as samples into an XGBoost model, carrying out training through a data autoregressive augmentation method, obtaining a monthly carbon emissions measurement model, measuring current monthly carbon emissions by the monthly carbon emissions
25 measurement model, summing the measured current monthly carbon emissions, obtaining measured total urban carbon emissions, comparing the computed total urban carbon emissions with the total urban carbon emissions measured by the model, determining, in a case that an error is less than or equal to a threshold, that the method for measuring urban carbon emissions satisfies a requirement, and correcting, in a case that the error is greater than the threshold, a
30 coefficient in the method for measuring urban carbon emissions.

Further, the inputting the monthly carbon emissions as samples into an XGBoost model, carrying out training through a data autoregressive augmentation method, and obtaining a monthly carbon emissions measurement model are specifically as follows:

augmenting the input samples through the data autoregressive augmentation method; and

inputting the augmented samples into the XGBoost model for training, optimizing the XGBoost model according to a model evaluation index, and obtaining the monthly carbon emissions measurement model. The model evaluation index is as follows:

$$AP = \frac{100\%}{n} \sum_{i=1}^n \left| \frac{y_k - y_i}{y_i} \right|.$$

5 Specifically, AP represents the model evaluation index, y_k is a predicted value output by the model, y_i is a true value, and n is a number of the samples.

The second objective of the disclosure is realized by using a technical solution as follows:

a system for measuring urban carbon emissions is configured for any one of the above methods for measuring urban carbon emissions. The system for measuring urban carbon
10 emissions includes a data acquiring module, an analyzing module, and a measuring module. The data acquiring module acquires an urban map, road monitoring data, mobile phone data, and industrial production region data. The analyzing module analyzes the urban map to divide a city into a residence and office region, an industrial production region, a road, and a green region. The analyzing module acquires a type P of a vehicle in a space unit, a number M_p of
15 each type of vehicles, and a traveling distance L_p of each type of vehicles by using the road monitoring data and the mobile phone data. The analyzing module carries out classification by using the industrial production region data. The measuring module carries out computation according to data analyzed by the analyzing module, to obtain total urban carbon emissions.

Further, the system for measuring urban carbon emissions further includes a verifying
20 module. The verifying module verifies correctness of measured total urban carbon emissions according to historical total urban carbon emissions.

Compared with the prior art, according to the method for measuring urban carbon emissions in the disclosure, an urban map is obtained. A city is divided into a residence and office region, an industrial production region, a road, and a green region according to the urban
25 map. The residence and office region includes a residence and an office enterprise. Carbon emissions C_j of the residence and office region are computed. The road is divided into T space units. A type P of a vehicle in a space unit, a number M_p of each type of vehicles, and a traveling distance L_p of each type of vehicles are obtained according to monitoring data and mobile phone data. Carbon emissions C_r of the road are computed. Enterprises in the industrial
30 production region are classified into X types of enterprises according to energy consumption types. Total energy consumption D_x of each type of enterprises is obtained. Carbon emissions C_E of the industrial production region are computed. Maps of the green region in different months are obtained through satellite remote sensing. A map of the green region in each month

is analyzed. A type Z of a plant in the green region and a corresponding area A_Z are obtained. Carbon sequestration NPP_i of the green region in a current month is computed. Total carbon sequestration of the green region is computed. The total urban carbon emissions C_T are computed according to the carbon emissions of the residence and office region, the carbon emissions of the road, the carbon emissions of the industrial production region, and the total carbon sequestration of the green region.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow diagram of a method for measuring urban carbon emissions according to the disclosure; and

FIG. 2 is a framework diagram of the method for measuring urban carbon emissions in FIG. 1.

DETAILED DESCRIPTION

Technical solutions in embodiments of the disclosure will be clearly and completely described below in combination with accompanying drawings in the embodiments of the disclosure. Apparently, the described embodiments are merely some embodiments rather than all embodiments of the disclosure. All other embodiments derived by those of ordinary skill in the art based on embodiments in the disclosure without making inventive efforts all fall within the scope of protection of the disclosure.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by those skilled in the technical field of the disclosure. The terms used in the description of the disclosure herein are just for the purpose of describing particular embodiments, and are not intended to limit the disclosure. As used herein, the term "and/or" includes any and all combinations of one or more relevant listed items.

With reference to FIG. 1 and FIG. 2, the disclosure provides a method for measuring urban carbon emissions. The method includes steps as follows:

an urban functional region is obtained through division as follows: an urban map is obtained, and a city is divided into a residence and office region, an industrial production region, a road, and a green region according to the urban map.

Carbon emissions of the residence and office region are measured as follows: the residence and office region is set to include a residence and an office enterprise, and the carbon emissions of the residence and office region are set as $C_j = (N_1 \times E_Z + N_2 \times E_q) \times A + (N_1 \times G_Z + N_2 \times G_q) \times B$.

Specifically, N_1 is a total number of the residence, E_z is average electricity consumption of each residence, N_2 is a total number of the office enterprise, E_q is average electricity consumption of each office enterprise, A is a carbon emission coefficient of electricity, G_z is average natural gas consumption of each residence, G_q is average natural gas consumption of each office enterprise, and B is a carbon emission coefficient of natural gas.

Carbon emissions of the road are measured as follows: the road is divided into T space units, a type P of a vehicle in a space unit, a number M_p of each type of vehicles, and a traveling distance L_p of each type of vehicles are obtained according to monitoring data and mobile phone data. The carbon emissions of the road are $C_r = T \times \sum_{p=1}^P (M_p \times L_p \times C_p)$, and C_p is a carbon emission coefficient of one type of vehicles.

Carbon emissions of the industrial production region are measured as follows: enterprises in the industrial production region are classified into X types of enterprises according to energy consumption types, and total energy consumption D_x of each type of enterprises is obtained. The carbon emissions of the industrial production region are $C_E = \sum_{x=1}^X D_x \times C_D$, and C_D is a carbon emission coefficient of one energy consumption type.

Carbon sequestration of the green region is measured as follows: maps of the green region in different months are obtained through satellite remote sensing, a map of the green region in each month is analyzed, a type Z of a plant in the green region and a corresponding area A_z are obtained, and carbon sequestration $NPP_i = \sum_{z=1}^Z A_z \times C_z \times S$ of the green region in a current month is computed. Specifically, C_z is a carbon sequestration coefficient of one type of plants, S is a temperature coefficient, the carbon sequestration of the green region is as follows: $C_G = \sum_{i=1}^{12} NPP_i$, and

total urban carbon emissions are $C_T = C_j + C_r + C_E - C_G$.

Specifically, in the step that a city is divided into a residence and office region, an industrial production region, a road, and a green region, blanking is carried out on a discarded workshop, a discarded residence, and a discarded road, to avoid a computation error caused by discarding a region not used. The office enterprises in the residence and office region include an office building enterprise, a shopping mall, a school, etc.

In the step that carbon emissions of the road are measured, the type of the vehicle includes a private car, a taxi, a motorcycle, an urban rail transit, a road passenger transport, and road freight. When the carbon emission coefficient C_p is computed, in a case that the type of the vehicle is a truck, a load has a relatively large impact on the carbon emission coefficient C_p . Thus, a gross weight g_i empty of goods and fuel consumption e_i empty per hundred kilometers in a

case of empty load, and a gross weight $g_{i \text{ full}}$ of goods and fuel consumption $e_{i \text{ full}}$ per hundred kilometers in a case of a full load under the condition that different vehicle types of trucks normally travel on a road section are required to be measured. A load correction coefficient z_k of the vehicle is determined through an interpolation method according to an actual load situation of the truck. A carbon emission coefficient of the truck is computed according to the load correction coefficient z_k . The gross weight $g_{i \text{ empty}}$ of the goods and the fuel consumption $e_{i \text{ empty}}$ per hundred kilometers in a case of empty load, and the gross weight $g_{i \text{ full}}$ of the goods and the fuel consumption $e_{i \text{ full}}$ per hundred kilometers in a case of the full load are determined through a weighted average method.

The step that carbon emissions of the industrial production region are measured further includes: according to production capacity data regularly corresponding to each energy consumption enterprise, whether real-time energy consumption corresponding to each consumption energy type matches a production capacity is checked. If not, the real-time energy consumption corresponding to each consumption energy type is corrected until corrected energy consumption corresponding to each consumption energy type matches the production capacity.

In the step that carbon emissions of the industrial production region are measured, the energy consumption types are divided into nine types: electricity, raw coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil, and natural gas.

The method for measuring urban carbon emissions further includes a verifying step specifically as follows: historical total urban carbon emissions are obtained. The historical total urban carbon emissions are decomposed into monthly carbon emissions. The monthly carbon emissions as samples are input into an XGBoost model. Training is carried out through a data autoregressive augmentation method. A monthly carbon emissions measurement model is obtained. Current monthly carbon emissions are measured by the monthly carbon emissions measurement model. The measured current monthly carbon emissions are summed. Measured total urban carbon emissions are obtained. The computed total urban carbon emissions are compared with the total urban carbon emissions measured by the model. In a case that an error is less than or equal to a threshold, it is determined that the method for measuring urban carbon emissions satisfies a requirement. In a case that the error is greater than the threshold, a coefficient in the method for measuring urban carbon emissions is corrected. The monthly carbon emissions as samples are input into an XGBoost model, training is carried out through a data autoregressive augmentation method, and a monthly carbon emissions measurement model is obtained specifically as follows:

the input samples are augmented through the data autoregressive augmentation method.

The augmented samples are input into the XGBoost model for training. The XGBoost model is optimized according to a model evaluation index. The monthly carbon emissions measurement model is obtained. The model evaluation index is as follows:

$$AP = \frac{100\%}{n} \sum_{i=1}^n \left| \frac{y_k - y_i}{y_i} \right|.$$

Specifically, AP represents the model evaluation index, y_k is a predicted value output by the model, y_i is a true value, and n is a number of the samples.

A system for measuring urban carbon emissions is configured for the above method for measuring urban carbon emissions. The system for measuring urban carbon emissions includes a data acquiring module, an analyzing module, and a measuring module. The data acquiring module acquires an urban map, road monitoring data, mobile phone data, and industrial production region data. The analyzing module analyzes the urban map to divide a city into a residence and office region, an industrial production region, a road, and a green region. The analyzing module acquires a type P of a vehicle in a space unit, a number M_p of each type of vehicles, and a traveling distance L_p of each type of vehicles by using the road monitoring data and the mobile phone data. The analyzing module carries out classification by using the industrial production region data. The measuring module carries out computation according to data analyzed by the analyzing module, to obtain total urban carbon emissions. The system for measuring urban carbon emissions further includes a verifying module. The verifying module verifies correctness of measured total urban carbon emissions according to historical total urban carbon emissions.

Compared with the prior art, according to the method for measuring urban carbon emissions in the disclosure, an urban map is obtained. A city is divided into a residence and office region, an industrial production region, a road, and a green region according to the urban map. The residence and office region includes a residence and an office enterprise. Carbon emissions C_j of the residence and office region are computed. The road is divided into T space units. A type P of a vehicle in a space unit, a number M_p of each type of vehicles, and a traveling distance L_p of each type of vehicles are obtained according to monitoring data and mobile phone data. Carbon emissions C_r of the road are computed. Enterprises in the industrial production region are classified into X types of enterprises according to energy consumption types. Total energy consumption D_x of each type of enterprises is obtained. Carbon emissions C_E of the industrial production region are computed. Maps of the green region in different months are obtained through satellite remote sensing. A map of the green region in each month

is analyzed. A type Z of a plant in the green region and a corresponding area A_Z are obtained. Carbon sequestration NPP_i of the green region in a current month is computed. Total carbon sequestration of the green region is computed. The total urban carbon emissions C_T are computed according to the carbon emissions of the residence and office region, the carbon emissions of the road, the carbon emissions of the industrial production region, and the total carbon sequestration of the green region.

The above embodiments express merely some types of implementations of the disclosure, and are specifically described in details, but cannot be interpreted as limiting the scope of patent for the disclosure as a result. It shall be noted that those of ordinary skill in the art can further make several transformations, improvements, and evolutions without departing from the conception of the disclosure. All the transformations, improvements, and evolutions are equivalent modifications and evolutions set to the above embodiments according to the essential technology of the disclosure, and all fall within the scope of protection of the disclosure.

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CLAIMS

What is claimed is:

1. A method for measuring urban carbon emissions, comprising steps as follows:

obtaining an urban functional region through division as follows: obtaining an urban map,

5 and dividing a city into a residence and office region, an industrial production region, a road, and a green region according to the urban map;

measuring carbon emissions of the residence and office region as follows: setting the residence and office region to comprise a residence and an office enterprise, and setting the carbon emissions of the residence and office region as

10 $C_j = (N_1 \times E_Z + N_2 \times E_q) \times A + (N_1 \times G_Z + N_2 \times G_q) \times B$, wherein N_1 is a total number of the residence, E_Z is average electricity consumption of each residence, N_2 is a total number of the office enterprise, E_q is average electricity consumption of each office enterprise, A is a carbon emission coefficient of electricity, G_Z is average natural gas consumption of each residence, G_q is average natural gas consumption of each office enterprise, and B is a carbon emission coefficient of natural gas;

measuring carbon emissions of the road as follows: dividing the road into T space units, obtaining a type P of a vehicle in a space unit, a number M_p of each type of vehicles, and a traveling distance L_p of each type of vehicles according to monitoring data and mobile phone data, wherein the carbon emissions of the road are $C_r = T \times \sum_1^P (M_p \times L_p \times C_p)$, and C_p is a

20 carbon emission coefficient of one type of vehicles;

measuring carbon emissions of the industrial production region as follows: classifying enterprises in the industrial production region into X types of enterprises according to energy consumption types, and obtaining total energy consumption D_x of each type of enterprises, wherein the carbon emissions of the industrial production region are $C_E = \sum_1^X D_x \times C_D$, and C_D

25 is a carbon emission coefficient of one energy consumption type; and

measuring carbon sequestration of the green region as follows: obtaining maps of the green region in different months through satellite remote sensing, analyzing a map of the green region in each month, obtaining a type Z of a plant in the green region and a corresponding area A_Z , and computing carbon sequestration $NPP_i = \sum_1^Z A_Z \times C_z \times S$ of the green region in

30 a current month, wherein C_z is a carbon sequestration coefficient of one type of plants, S is a temperature coefficient, the carbon sequestration of the green region is as follows:

$C_G = \sum_1^{12} NPP_i$, and

total urban carbon emissions are $C_T = C_j + C_r + C_E - C_G$.

2. The method for measuring urban carbon emissions according to claim 1, wherein in the step of measuring carbon emissions of the road, the type of the vehicle comprises a private car, a taxi, a motorcycle, an urban rail transit, a road passenger transport, and road freight.

3. The method for measuring urban carbon emissions according to claim 2, wherein in the
5 step of measuring carbon emissions of the road, in a case that the type of the vehicle is a truck, when the carbon emission coefficient C_p is computed, a load has a relatively large impact on the carbon emission coefficient C_p , and a gross weight $g_{i \text{ empty}}$ of goods and fuel consumption $e_{i \text{ empty}}$ per hundred kilometers in a case of empty load, and a gross weight $g_{i \text{ full}}$ of goods and fuel consumption $e_{i \text{ full}}$ per hundred kilometers in a case of a full load under the condition that
10 different vehicle types of trucks normally travel on a road section are required to be measured; and a load correction coefficient z_k of the vehicle is determined through an interpolation method according to an actual load situation of the truck, and a carbon emission coefficient of the truck is computed according to the load correction coefficient z_k .

4. The method for measuring urban carbon emissions according to claim 3, wherein the
15 gross weight $g_{i \text{ empty}}$ of the goods and the fuel consumption $e_{i \text{ empty}}$ per hundred kilometers in a case of empty load, and the gross weight $g_{i \text{ full}}$ of the goods and the fuel consumption $e_{i \text{ full}}$ per hundred kilometers in a case of the full load are determined through a weighted average method.

5. The method for measuring urban carbon emissions according to claim 1, wherein the step of measuring carbon emissions of the industrial production region further comprises:
20 checking, according to production capacity data regularly corresponding to each energy consumption enterprise, whether real-time energy consumption corresponding to each consumption energy type matches a production capacity, and if not, correcting the real-time energy consumption corresponding to each consumption energy type until corrected energy consumption corresponding to each consumption energy type matches the production capacity.

25 6. The method for measuring urban carbon emissions according to claim 1, wherein in the step of measuring carbon emissions of the industrial production region, the energy consumption types are divided into nine types: electricity, raw coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil, and natural gas.

7. The method for measuring urban carbon emissions according to claim 1, further
30 comprising: a verifying step specifically as follows: obtaining historical total urban carbon emissions, decomposing the historical total urban carbon emissions into monthly carbon emissions, inputting the monthly carbon emissions as samples into an XGBoost model, carrying out training through a data autoregressive augmentation method, obtaining a monthly carbon emissions measurement model, measuring current monthly carbon emissions by the

monthly carbon emissions measurement model, summing the measured current monthly carbon emissions, obtaining measured total urban carbon emissions, comparing the computed total urban carbon emissions with the total urban carbon emissions measured by the model, determining, in a case that an error is less than or equal to a threshold, that the method for measuring urban carbon emissions satisfies a requirement, and correcting, in a case that the error is greater than the threshold, a coefficient in the method for measuring urban carbon emissions.

8. The method for measuring urban carbon emissions according to claim 7, wherein the inputting the monthly carbon emissions as samples into an XGBoost model, carrying out training through a data autoregressive augmentation method, and obtaining a monthly carbon emissions measurement model are specifically as follows:

augmenting the input samples through the data autoregressive augmentation method; and inputting the augmented samples into the XGBoost model for training, optimizing the XGBoost model according to a model evaluation index, and obtaining the monthly carbon emissions measurement model, wherein the model evaluation index is as follows:

$$AP = \frac{100\%}{n} \sum_{i=1}^n \left| \frac{y_k - y_i}{y_i} \right|,$$

AP represents the model evaluation index, y_k is a predicted value output by the model, y_i is a true value, and n is a number of the samples.

9. A system for measuring urban carbon emissions, configured to implement the method for measuring urban carbon emissions according to any one of claims 1 to 8, comprising: a data acquiring module, an analyzing module, and a measuring module, wherein the data acquiring module acquires an urban map, road monitoring data, mobile phone data, and industrial production region data, the analyzing module analyzes the urban map to divide a city into a residence and office region, an industrial production region, a road, and a green region, the analyzing module acquires a type P of a vehicle in a space unit, a number M_p of each type of vehicles, and a traveling distance L_p of each type of vehicles by using the road monitoring data and the mobile phone data, the analyzing module carries out classification by using the industrial production region data, and the measuring module carries out computation according to data analyzed by the analyzing module, to obtain total urban carbon emissions.

10. The system for measuring urban carbon emissions according to claim 9, further comprising: a verifying module, wherein the verifying module verifies correctness of measured total urban carbon emissions according to historical total urban carbon emissions.