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Bias Correction Method and System of TanSat Satellite XCO₂ Retrieval Data.

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The present application provides a bias correction method and system of TanSat satellite XCO₂ retrieval data, the method comprises the following steps: obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a full-solar-spectrum of oxygen gas band and an observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data; calculating an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values; obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value; performing a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient, and the oxygen gas albedo error, the observation angle error of each XCO₂ retrieval value to improve the accuracy of retrieval data.

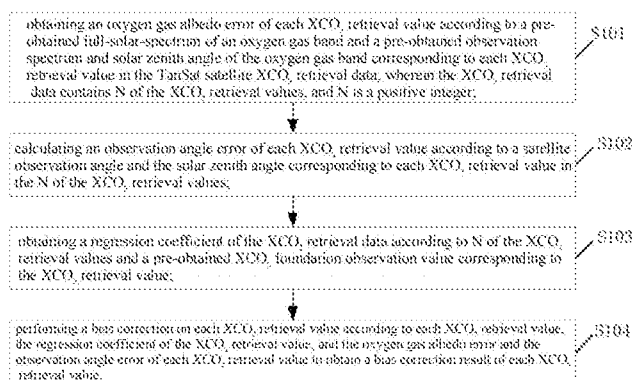


Fig. 1

Background**Field of the Invention**

The present invention belongs to the technical field of remote sensing information, and particularly relates to a bias correction method and system of Tansat satellite XCO₂ retrieval data.

Background Information

Since the Industrial Revolution, with the continuous progress of various technologies, the human society has developed rapidly, and the neglect of environmental effects caused by global climate change has now become the primary issue of human interests. Global climate change is mainly manifested in precipitation redistribution, frozen soil thawing and sea level rising caused by climate warming. Severe climate change has begun to endanger ecosystem balance and gradually threaten human living environment. Wherein, rising atmospheric carbon dioxide concentration is considered to be the main cause of global climate change. In order to improve the understanding of natural and artificial surface carbon sources and carbon sinks, the atmospheric carbon dioxide monitoring technology has been developed rapidly in recent years.

The atmospheric carbon dioxide column concentration (XCO₂) can be effectively monitored by detecting the near-infrared spectroscopy through remote sensing. The Total Carbon Column Observing Network (TCCON for short) based on Fourier Transform Spectrometer (FTS for short) has high observation accuracy and can provide long time series continuous observation data, but the global distribution of observation stations is not uniform enough and the spatial scale of data is too small to reflect the spatial and temporal distribution of global atmospheric carbon dioxide concentration. The development of satellite-based remote sensing technology has effectively solved this problem, and the global XCO₂ spatial distribution and change trend can be obtained through satellite observation. However, the space-based distribution is not as accurate as the ground measurement. The bias of XCO₂ is caused by many factors, such as aerosol optical depth, thin cirrus cloud, ground pressure retrieval error and so on. These biases will lead to large errors in the estimation of regional CO₂ flux by retrieval analysis. Therefore, the satellite XCO₂ products must use the high-precision ground measurement data for bias correction to meet higher precision requirements, so as to provide reference for the international community to formulate greenhouse

gas policies and carbon tariff mechanisms.

In the bias correction of the satellite observation data, some related studies used the linear regression to perform the bias correction of the satellite observation data. Wunch etc. correlated the difference between the XCO₂ retrieval result of GOSAT (a remote sensing satellite for atmospheric carbon dioxide monitoring launched in Japan in 2009) and the earth's surface albedo, the difference between the retrieval result and prior earth's surface pressure, the difference between the air mass and O₂-A band spectral radiance, and the GOSAT data from Southern Hemisphere was used as the reference value for linear regression, and bias correction was performed based on TCCON data. After Wunch etc., Cogan etc. used analog data calculated based on the atmospheric chemical transport model GEOS-Chem to perform the bias correction on the GOSAT XCO₂ data obtained from the UoL-FP retrieval algorithm. Guerlet etc. performed bias correction on the GOSAT XCO₂ data retrieved from the Dutch Space Research Institute/Karlsruhe Institute of Technology based on measurements from 12 TCCON sites as a reference.

The Tansat is a global carbon dioxide scientific monitoring satellite (or carbon satellite for short), which is the first satellite in China to measure atmospheric carbon dioxide concentration from space. Emission in December 2016, satellites equipped with Atmospheric Carbon-dioxide Grating Spectroradiometer (ACGS) and Cloud and Aerosol Polarimetry Imager (CAPI) to detect atmospheric carbon dioxide from near-infrared spectroscopy and acquired clouds and aerosol data simultaneously. The results of the XCO₂ retrieval and validation study for TanSat show that the bias of the uncorrected TanSat XCO₂ retrieval result from the TCCON data is -2.11ppm. So far, there were no bias correction XCO₂ data of TanSat has been published yet.

Accordingly, there is a need to provide an improved solution to the above-mentioned deficiencies of the prior art.

SUMMARY

It is an object of the present application to provide a bias correction method and system of Tansat satellite XCO₂ retrieval data to solve or alleviate the above-mentioned problems in the prior art.

In order to achieve the above object, the present invention provides the following technical solutions:

The present application provides a bias correction method of TanSat satellite XCO₂ retrieval data (TanSat satellite XCO₂ retrieved data), comprising the following steps: obtaining an oxygen gas albedo error of each XCO₂ retrieval value (XCO₂ retrieved value) according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data; wherein the XCO₂ retrieval data contains N of the XCO₂ retrieval values, and N is a positive integer; calculating an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values; obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value; performing a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value.

Alternatively, in any example of the present application, the step of obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data comprises the following steps: calculating an oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value according to the pre-obtained full-solar-spectrum of the oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values; averaging the oxygen gas band non-absorbing region albedo corresponding to N of the XCO₂ retrieval values to obtain an oxygen gas albedo average value of N of the XCO₂ retrieval values; calculating the oxygen gas albedo error of each XCO₂ retrieval value according to the oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value, and the oxygen gas albedo average value.

Alternatively, in any example of the present application, the step of calculating an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values

comprises the following steps: calculating an air mass factor of each XCO₂ retrieval value according to the satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values; averaging the air mass factor of N of the XCO₂ retrieval values to obtain an air mass factor average value of N of the XCO₂ retrieval values; calculating the observation angle error of each XCO₂ retrieval value according to the air mass factor corresponding to each XCO₂ retrieval value, and the air mass factor average value.

Alternatively, in any example of the present application, the step of obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value is specifically: performing linear regression on N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value to obtain the regression coefficient of the XCO₂ retrieval data.

Alternatively, in any example of the present application, the step of performing a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value comprises the following steps: performing an albedo error correction and an observation angle error correction on each XCO₂ retrieval value respectively according to each XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value; performing a quotient operation on each XCO₂ retrieval value after the albedo error correction and the observation angle error correction and the regression coefficient to obtain the bias correction result of each XCO₂ retrieval value.

Alternatively, in any example of the present application, before the step of obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data, further comprising the following steps: extracting a satellite parameter and an observation parameter of the TanSat satellite; performing cloud region data elimination on cloud data, and performing aerosol high value region data elimination on aerosol data; obtaining an analog spectrum based on an atmospheric radiative transfer model of a preset retrieval parameter,

according to the satellite parameter, the observation parameter, a cloud data performed cloud region data elimination, an aerosol data performed aerosol high value region data elimination and an atmospheric profile parameter; solving the analog spectrum and the observation spectrum in the satellite parameter to obtain a solution result based on an optimal estimation method; judging whether the solution result converges, and if not, updating the preset retrieval parameter in the atmospheric radiative transfer model until the solution result converges; obtaining the TanSat satellite XCO₂ retrieval data according to the solution result.

The present application also provides a bias correction system of TanSat satellite XCO₂ retrieval data, comprising: an albedo error unit configured to obtain an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data; wherein the XCO₂ retrieval data contains N of the XCO₂ retrieval values, and N is a positive integer; an observation angle error unit configured to calculate an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values; a regression coefficient unit configured to obtain a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value; a bias correction unit configured to perform a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value.

Alternatively, in any example of the present application, the albedo error unit comprises: an albedo calculation subunit configured to calculate an oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value according to the pre-obtained full-solar-spectrum of the oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values; an albedo average calculation subunit configured to average the oxygen gas band non-absorbing region albedo corresponding to N of the XCO₂ retrieval values to obtain an oxygen gas albedo average value of N of the XCO₂ retrieval values; an albedo error calculation

subunit configured to calculate the oxygen gas albedo error of each XCO_2 retrieval value according to the oxygen gas band non-absorbing region albedo corresponding to each XCO_2 retrieval value, and the oxygen gas albedo average value.

Alternatively, in any example of the present application, the observation angle error unit comprises: an air mass factor calculation subunit configured to calculate an air mass factor of each XCO_2 retrieval value according to the satellite observation angle and the solar zenith angle corresponding to each XCO_2 retrieval value in the N of the XCO_2 retrieval values; an air mass factor average calculation subunit configured to average the air mass factor of N of the XCO_2 retrieval values to obtain an air mass factor average value of N of the XCO_2 retrieval values; an observation angle error calculation subunit configured to calculate the observation angle error of each XCO_2 retrieval value according to the air mass factor corresponding to each XCO_2 retrieval value, and the air mass factor average value.

Alternatively, in any example of the present application, the regression coefficient unit is further configured to perform linear regression on N of the XCO_2 retrieval values and a pre-obtained XCO_2 foundation observation value corresponding to the XCO_2 retrieval value to obtain the regression coefficient of the XCO_2 retrieval data.

Alternatively, in any example of the present application, the bias correction unit comprises: a first correction subunit configured to perform an albedo error correction and an observation angle error correction on each XCO_2 retrieval value respectively according to each XCO_2 retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO_2 retrieval value; a second correction subunit configured to perform a quotient operation on each XCO_2 retrieval value after the albedo error correction and the observation angle error correction and the regression coefficient to obtain the bias correction result of each XCO_2 retrieval value.

Alternatively, in any of the example of the present application, further comprises: a data extraction unit configured to extract a satellite parameter and an observation parameter of the TanSat satellite; a data elimination unit configured to perform cloud region data elimination on cloud data, and performing aerosol high value region data elimination on aerosol data; an analog spectrum unit configured to obtain an analog spectrum based on an atmospheric radiative transfer model of a preset retrieval parameter, according to the satellite parameter, the observation parameter, a cloud data performed cloud region data elimination, an aerosol data performed

aerosol high value region data elimination and an atmospheric profile parameter; a spectrum solving unit configured to solve the analog spectrum and the observation spectrum in the satellite parameter to obtain a solution result based on an optimal estimation method; a result update unit configured to judge whether the solution result converges, and if not, updating the preset retrieval parameter in the atmospheric radiative transfer model until the solution result converges; a retrieval data unit configured to obtain the TanSat satellite XCO₂ retrieval data according to the solution result.

Compared with the closest prior art, the technical solutions of the examples of the present application have the following beneficial effects:

In the technical solution provided in the example of the present application, obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data; calculating an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value; obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value; then, performing a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of each XCO₂ retrieval value, and the oxygen gas albedo error, the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value. Therefore, the oxygen gas albedo error, the observation angle error and the system error of TanSat satellite observation in XCO₂ retrieval value are eliminated, and the XCO₂ retrieval data correction is finally realized, which effectively improves the accuracy of TanSat satellite observation.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this application, are included to provide a further understanding of the application, and the description of the exemplary examples and illustrations of the application are intended to explain the application and are not intended to limit the application. Wherein:

Fig. 1 is a schematic flow diagram of the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application;

Fig. 2 is a schematic flow diagram of step S101 in the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application;

Fig. 3 is a schematic flow diagram of step S102 the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application;

Fig. 4 is a schematic flow diagram of step S104 in the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application;

Fig. 5 is a schematic flow diagram for obtaining TanSat satellite XCO₂ retrieval data provided according to some examples of the present application;

Fig. 6 is a schematic structure diagram of the bias correction system of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application;

Fig. 7 is a schematic structure diagram of the albedo error unit according to some examples of the present application;

Fig. 8 is a schematic structure diagram of the observation angle error unit according to some examples of the present application;

Fig. 9 is a schematic structure diagram of the bias correction unit according to some examples of the present application;

Fig. 10 is a schematic structure diagram for obtaining TanSat satellite XCO₂ retrieval data provided according to some examples of the present application.

DETAILED DESCRIPTION OF EMBODIMENTS

The present application will be described in detail below with reference to the accompanying drawings and in conjunction with the examples. The various examples are provided by way of interpretation of the application and not limiting the application. Indeed it will be apparent to those skilled in the art that modifications and variations may be made in the present application without departing from the scope or spirit of the application. For example features shown or described as part of one example may be used in another example to produce yet another example. It is therefore desirable that the application encompass such modifications and variations falling within the scope of the appended claims and their equivalents.

Exemplary method

Fig. 1 is a schematic flow diagram of the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application; as shown in Fig. 1, the method comprises the following steps:

Step S101, obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data; wherein the XCO₂ retrieval data contains N of the XCO₂ retrieval values, and N is a positive integer;

In the example of the present application, the full-solar-spectrum of oxygen gas band can be selected according to needs, for example, selecting the full-solar-spectrum data published by Dr. Robert L. Kurucz laboratory; the observation spectrum of the oxygen gas band corresponding to XCO₂ retrieval value is observed by the Atmospheric Carbon-dioxide Grating Spectroradiometer (ACGS for short) mounted in the TanSat satellite at the observation point. The solar zenith angle can be obtained from the LIB data (carbon satellite primary calibration data) of TanSat satellite. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 2 is a schematic flow diagram of step S101 in the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application; as shown in Fig. 2, the step of obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data comprises the following steps:

Step S111, calculating an oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value according to the pre-obtained full-solar-spectrum of the oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

In the example of the present application, the albedo of the oxygen gas band non-absorbing region is the ratio of the irradiance obtained without absorption of other molecules in the oxygen gas band and the irradiance corresponding solar spectrum in the process of sunlight being reflected

back to the sensor mounted on the TanSat satellite through atmospheric radiation and through the earth's surface. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, when calculating an oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value according to the pre-obtained full-solar-spectrum of the oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value, the oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value is calculated according to the irradiance of the full-solar-spectrum of the oxygen gas band, the radiance of the observation spectrum of the oxygen gas band corresponding to each XCO₂ retrieval value and the solar zenith angle. Specifically, the oxygen gas band non-absorbing region albedo corresponding to XCO₂ retrieval value is calculated by the following formula (1). The formula (1) is as follows:

$$albedo_O_2 = \frac{radiance_O_{2measured} * \pi}{irradiance_O_{2solar} * \cos \theta_z} \dots \dots \dots (1)$$

Wherein, the *albedo_O₂* is the oxygen gas band non-absorbing region albedo corresponding to the XCO₂ retrieval value, the *radiance_O_{2measured}* is the radiance of the observation spectrum of the oxygen gas band corresponding to the XCO₂ retrieval value, and indicates the radiant flux of per unit of spectral wavelength, per unit of projected area, per unit of solid angle in w/m²/sr/nm; the *irradiance_O_{2solar}* is the irradiance of the full-solar-spectrum of the oxygen gas band, and indicates the radiant flux received per unit area at unit spectral wavelength in w/m²/nm; the *θ_z* is the solar zenith angle corresponding to XCO₂ retrieval value; the *π* is the circumference ratio (the value is 3.14). The oxygen gas albedo may be a positive number, e.g. may range from (0, 1). It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S121, averaging the oxygen gas band non-absorbing region albedo corresponding to N of the XCO₂ retrieval values to obtain an oxygen gas albedo average value of N of the XCO₂ retrieval values;

In the example of the present application, the XCO₂ retrieval data contains N of the XCO₂ retrieval values, and each oxygen gas band non-absorbing region albedo is calculated corresponding to each XCO₂ retrieval value, and thus N of the oxygen gas band non-absorbing

region albedos are obtained. By performing a weighted average calculation on the obtained N of the oxygen gas band non-absorbing region albedos, the oxygen gas albedo average value of N of the XCO₂ retrieval values can be obtained. Wherein, the $\overline{albedo_{O_2}}$ indicates the oxygen gas albedo average value of N of the XCO₂ retrieval values. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S131, calculating the oxygen gas albedo error of each XCO₂ retrieval value according to the oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value, and the oxygen gas albedo average value;

In the example of the present application, when calculating the oxygen gas albedo error of each XCO₂ retrieval value according to the oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value, and the oxygen gas albedo average value, the oxygen gas albedo error of each XCO₂ retrieval value is calculated according to the oxygen gas band non-absorbing region albedo and oxygen gas albedo average value corresponding to each XCO₂ retrieval value based on a preset oxygen gas albedo correction coefficient. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the C_2 indicates the oxygen gas albedo correction coefficient. The product of the difference between oxygen gas band non-absorbing region albedo and the oxygen gas albedo average value corresponding to each XCO₂ retrieval value and the preset oxygen gas albedo correction coefficient is the oxygen gas albedo error of each XCO₂ retrieval value, i.e. the oxygen gas albedo error of each XCO₂ retrieval value is $C_2(albedo_{O_2} - \overline{albedo_{O_2}})$, wherein, the C_2 indicates the oxygen gas albedo correction coefficient. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the albedo error of each XCO₂ retrieval value can be calculated according to the oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value, and the oxygen gas albedo average value, and then the oxygen gas albedo correction coefficient can be obtained by performing the regression analysis on N of the oxygen gas band non-absorbing region albedo and the albedo bias. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S102, calculating an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

In the example of the present application, in the process of forward atmospheric radiation transmission, the XCO₂ retrieval is an estimation of the optical path length, and in this process, influenced by clouds and aerosols and other factors, the optical path length would be wrongly estimated, and the size of the satellite observation angle and the solar zenith angle would further affect the bias of the XCO₂ retrieval result due to the optical path length; therefore, it is necessary to correct the XCO₂ retrieval result by counting the air mass factor of XCO₂ retrieval value calculated by the satellite observation angle and the solar zenith angle, namely, the XCO₂ retrieval value is required to correct by the observation angle error of XCO₂ retrieval value. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 3 is a schematic flow diagram of step S102 the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application; as shown in Fig. 3, the step of calculating an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values comprises the following steps:

Step S112, calculating an air mass factor of each XCO₂ retrieval value according to the satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

In the example of the present application, the air mass factor of XCO₂ retrieval value is calculated by the following formula (2). The formula (2) is as follows:

$$airmass = \frac{1}{\cos \theta_z} + \frac{1}{\cos \theta_v} \dots \dots \dots (2)$$

Wherein, the *airmass* is the air mass factor of the XCO₂ retrieval value, the θ_z is the solar zenith angle corresponding to XCO₂ retrieval value, and the θ_v is the satellite observation angle of the TanSat satellite. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S122, averaging the air mass factor of N of the XCO₂ retrieval values to obtain an air mass

factor average value of N of the XCO_2 retrieval values;

In the example of the present application, the XCO_2 retrieval data contains N of the XCO_2 retrieval value, and each air mass factor corresponding to each XCO_2 retrieval value is calculated, and thus N of the air mass factors are obtained. By performing a weighted average calculation on the obtained N of the air mass factors, the air mass factor average value of N of the XCO_2 retrieval values can be obtained. Wherein, the $\overline{airmass}$ indicates the air mass factor average value of N of the XCO_2 retrieval values. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S132, calculating the observation angle error of each XCO_2 retrieval value according to the air mass factor corresponding to each XCO_2 retrieval value, and the air mass factor average value;

In the present example, when calculating the observation angle error of each XCO_2 retrieval value according to the air mass factor corresponding to each XCO_2 retrieval value, and the air mass factor average value, the observation angle error for each XCO_2 retrieval value is calculated according to the air mass factor and the air mass factor average for each XCO_2 retrieval value based on the preset air mass factor correction coefficient. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the C_1 indicates the air mass factor correction coefficient, which refers to the atmospheric carbon dioxide column error resulting in C_1 parts per million (ppm) concentration unit per caused by 1 atmospheric optical mass (airmass) unit difference. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the product of the difference between the air mass factor corresponding to each XCO_2 retrieval value and the air mass factor average and the preset air mass factor correction coefficient is the observation angle error of each XCO_2 retrieval value, i.e. the observation angle error of each XCO_2 retrieval value is $C_1(airmass - \overline{airmass})$. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the air mass factor correction coefficient (C_1) is obtained according to actual satellite observation angle and error statistics, and the value of C_1 is less than or equal to 5 ppm/airmass. For example, C_1 is empirically set to 2 ppm/airmass. It is to

be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S103, obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value;

In the example of the present application, the XCO₂ foundation observation value is obtained by observing the observation point with the Fourier Transform Spectrometer, which corresponds to TanSat satellite XCO₂ retrieval value in one-to-one correspondence. Wherein, the XCO₂ foundation observation value can be defined as ground-based observation data, and TanSat satellite XCO₂ retrieval value can be defined as space-based observation data. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, compared with the observation of an observation point using the Fourier Transform Spectrometer, when using a satellite to perform XCO₂ observation, due to the limitation of satellite-based remote sensing technology and the uncertainty of observation, the ground-based observation data is closer to the "real atmosphere", and there is still some systematic bias in the space-based observation data. Therefore, the ground-based observation data can be used to correct the space-based observation data, and a more realistic XCO₂ retrieval data can be obtained. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In some alternative examples, when obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value, the linear regression is performed on N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value to obtain the regression coefficient of the XCO₂ retrieval data. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the ground-based observation data is closer to the "real atmosphere", and there are still some systematic bias in the space-based observation data. Therefore, using the pre-obtained XCO₂ foundation observation value (namely, ground-based

observation data) and N of the XCO_2 retrieval value of TanSat satellite (namely, space-based observation data) to perform the linear regression, the regression coefficient of space-based observation data relative to ground-based observation data is obtained, so as to realize the bias correction of space-based observation data by the ground-based observation data and obtain the more realistic XCO_2 retrieval data. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the C_0 indicates the regression coefficient. The unary linear regression equation of N of the XCO_2 retrieval values of TanSat satellite with respect to the XCO_2 foundation observation value is obtained according to the pre-obtained XCO_2 foundation observation value and N of the XCO_2 retrieval values. Assuming that the foundation observation of the TanSat satellite and the Fourier Transform Spectrometer are synchronized at "zero point", i.e. when the foundation observation of the Fourier Transform Spectrometer is zero, the observation of the Atmospheric Carbon-dioxide Grating Spectroradiometer mounted on the TanSat satellite is also zero, so that the intercept of the obtained unary linear regression equation is zero, the regression coefficient C_0 can be obtained. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S104, performing a bias correction on each XCO_2 retrieval value according to each XCO_2 retrieval value, the regression coefficient of the XCO_2 retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO_2 retrieval value to obtain a bias correction result of each XCO_2 retrieval value.

In the example of the present application, when obtaining the XCO_2 retrieval value, the retrieval parameters are used, wherein the retrieval parameters comprise the observation mode, the scattering mode and the trace gas profile, and may specifically include the earth's surface pressure, the albedo, the carbon dioxide and oxygen gas profile, the observation angle, etc. Because the retrieval parameters will lead to uncertainty in the retrieval result, including the earth's surface pressure, the albedo, the air mass parameter and the aerosol, etc. In the retrieval process, the earth's surface pressure is not retrieved synchronously and aerosol parameter is only used as the threshold for low concentration region screening. Therefore, when correcting the XCO_2 retrieval data, the oxygen gas albedo error and the observation angle error need to be corrected. It is to be understood that the above description is intended to be illustrative, and that the present examples

are not restrictive.

In the example of the present application, the correction of XCO₂ retrieval data is achieved by eliminating the albedo error, the observation angle error, and the systematic bias at the TanSat satellite observation in the XCO₂ retrieval data. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the oxygen gas albedo error in the XCO₂ retrieval data is eliminated by the oxygen gas albedo correction coefficient; the observation angle error in the XCO₂ retrieval data is eliminated by the air mass factor correction coefficient; the systematic bias at the TanSat satellite observation is eliminated by the regression coefficient, and the XCO₂ retrieval data correction is finally achieved. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 4 is a schematic flow diagram of step S104 in the bias correction method of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application; as shown in Fig. 4, the step of performing a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value comprises the following steps:

Step S114, performing an albedo error correction and an observation angle error correction on each XCO₂ retrieval value respectively according to each XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value;

In the example of the present application, when performing an albedo error correction and an observation angle error correction on each XCO₂ retrieval value respectively according to each XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value, Performing the difference operation on each XCO₂ retrieval value and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value can complete the albedo error correction and the observation angle error correction of each XCO₂ retrieval value. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the $X_{CO_2}^{retrieved}$ indicates the XCO₂ retrieval value, $X_{CO_2}^{retrieved} - C_1(airmass - \overline{airmass}) - C_2(albedo_O_2 - \overline{albedo_O_2})$ indicates that the

oxygen gas albedo error and the observation angle error of the XCO₂ retrieval value is eliminated and the albedo error correction and the observation angle error correction of the XCO₂ retrieval value is completed. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S124, performing a quotient operation on each XCO₂ retrieval value after the albedo error correction and the observation angle error correction and the regression coefficient to obtain the bias correction result of each XCO₂ retrieval value;

In the present example, the bias correction result of each XCO₂ retrieval value is calculated by the following formula (3). The formula (3) is as follows:

$$X_{CO_2}^{corrected} = \frac{X_{CO_2}^{retrieved} - C_1(airmass - \overline{airmass}) - C_2(albedo_{O_2} - \overline{albedo_{O_2}})}{C_0} \dots\dots (3)$$

Wherein, the $X_{CO_2}^{corrected}$ is the bias correction result of XCO₂ retrieval value; the $X_{CO_2}^{retrieved}$ is the XCO₂ retrieval value; the C_1 is the air mass factor correction coefficient, and the value is 2 ppm/airmass; the $airmass$ is the air mass factor of the XCO₂ retrieval value; the $\overline{airmass}$ is the air mass factor average value of N of the XCO₂ retrieval values; the $C_1(airmass - \overline{airmass})$ is the observation angle error of the XCO₂ retrieval value; the C_2 is the oxygen gas albedo correction coefficient, the value is 10ppm/unit of albedo (column concentration error per unit albedo); the $albedo_{O_2}$ is the oxygen gas band non-absorbing region albedo corresponding to the XCO₂ retrieval value; the $\overline{albedo_{O_2}}$ is the oxygen gas albedo average value of N of the XCO₂ retrieval values; the $C_2(albedo_{O_2} - \overline{albedo_{O_2}})$ is the oxygen gas albedo error of the XCO₂ retrieval value; the C_0 is the regression coefficient. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the correction of XCO₂ retrieval data is achieved by eliminating the oxygen gas albedo error, the observation angle error and the system error at TanSat satellite observation in XCO₂ retrieval value. Calculating the oxygen gas albedo of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data, and the oxygen gas albedo error in the XCO₂ retrieval value is eliminated by the oxygen gas albedo correction coefficient; calculating an air mass factor of each XCO₂ retrieval value and an air mass factor average value of

N of the XCO₂ retrieval values according to the satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values, and the observation angle error in the XCO₂ retrieval value is eliminated by the air mass factor correction coefficient (namely, the air mass factor correction); obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value, and the system bias at the TanSat satellite observation is eliminated by the regression coefficient (namely, the scale bias correction), and the correction of the XCO₂ retrieval data is finally realized, which effectively improves the accuracy of TanSat satellite observation. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In an application scenario, the Atmospheric Carbon-dioxide Grating Spectroradiometer (including 9 sensors) is installed on the TanSat satellite. Each observation of 9 sensors will simultaneously record the spectrum and measure the reflected sunlight from the earth's surface. Different sensors have different spectral radiation responses. Therefore, in the XCO₂ retrieval value processing, the different sensors are performed spectral calibration separately. At the retrieved, a separate instrument response function is used to retrieve the XCO₂ data of TanSat satellite, and finally the XCO₂ retrieval data of TanSat satellite is obtained. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 5 is a schematic flow diagram for obtaining TanSat satellite XCO₂ retrieval data provided according to some examples of the present application; as shown in Fig. 5, before the step of obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data, further comprising the following steps:

Step 501, extracting a satellite parameter and an observation parameter of the TanSat satellite;

In the example of the present application, the satellite parameter of the TanSat satellite comprises the observation angle, the observation time, the observation instrument, the spectral signal-to-noise ratio and the observation spectrum; the observation parameter comprises the longitude and latitude, the earth's surface albedo, the earth's surface elevation, the observation

quality mark and the land and water area mark of the observation point. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the XCO₂ data is retrieved using LIB data (carbon satellite primary calibration data) of the satellite, wherein the LIB data is in a hdf (Hierarchical Data Format) 5 format, and thus the field corresponding to the satellite parameter and the observation parameter can be directly extracted from the LIB data as the corresponding satellite parameter and observation parameter, respectively. Thereby, large-scale monitoring of observation point can be realized and the data extraction can be performed quickly. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step 502, performing cloud region data elimination on cloud data, and performing aerosol high value region data elimination on aerosol data;

In the example of the present application, the cloud data is derived from FY-4A data (the observation data of Fengyun No. 4 satellite) matched in time and space, and the aerosol data is derived from FY-3C data (the observation data of Fengyun No. 3 satellite). It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, when performing cloud region data elimination on cloud data, the cloud filtering and cloud screening are performed using a cloud detection product. When performing aerosol high value region data elimination on aerosol data, the data with Aerosol Optical Depth (AOD for short) value greater than 0.3 in the aerosol data is eliminated. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S503, obtaining an analog spectrum based on an atmospheric radiative transfer model of a preset retrieval parameter, according to the satellite parameter, the observation parameter, a cloud data performed cloud region data elimination, an aerosol data performed aerosol high value region data elimination and an atmospheric profile parameter;

In an example of the present application, the retrieval parameters comprise the observation mode, the scattering mode, and may specifically include the earth's surface pressure, the albedo,

the air mass parameter, the observation angle, etc., the atmospheric profile parameters comprise the carbon dioxide and oxygen profile, the temperature profiles, the potential profiles the humidity profile, and the pressure profile. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the observation spectrum is observed by the Atmospheric Carbon-dioxide Grating Spectroradiometer, and the analog spectrum is obtained based on atmospheric radiative transfer model, whereby the observation spectrum can be compared using the analog spectrum. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S504, solving the analog spectrum and the observation spectrum in the satellite parameter to obtain a solution result based on an optimal estimation method;

In the example of the present application, the forward analog is performed based on the atmospheric radiative transfer model to obtain the analog spectrum, the analog value of analog spectrum is compared with the observation spectrum to generate the cost function, and an optimal solution of the retrieved atmospheric carbon dioxide and oxygen profile is obtained by minimizing the cost function, namely, the solution result (the number of carbon dioxide molecules and the number of oxygen molecules in the atmosphere). It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S505, judging whether the solution result converges, and if not, updating the preset retrieval parameter in the atmospheric radiative transfer model until the solution result converges;

In the example of the present application, the solution result does not converge that indicates the error of the retrieved atmospheric carbon dioxide and oxygen profile is also relatively large. Therefore, the preset retrieval parameter of the atmospheric radiative transfer model needs to be updated to converge the solution result, that is, the cost function of the analog value of the analog spectrum and the retrieval value of the observation spectrum is minimal. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Step S506, obtaining the TanSat satellite XCO₂ retrieval data according to the solution result.

In the example of the present application, the solution result converges (i.e. the cost function between the simulated value of analog spectrum and the inverted value of observation spectrum is

minimal) indicates that atmospheric carbon dioxide and the oxygen profiles are obtained by retrieved, and then the XCO₂ retrieval value can be calculated. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, when obtaining the TanSat satellite XCO₂ retrieval data according to the solution result, the TanSat satellite XCO₂ retrieval value is obtained according to the number of carbon dioxide molecules, the number of oxygen molecules and the percentage of oxygen gas in the atmosphere. Specifically, XCO₂ retrieval value can be obtained by the following formula (4).

$$X_{CO_2}^{retrieved} = \frac{CO_2^{col}}{O_2^{col}/O_2^{ml}} \dots \dots \dots (4)$$

Wherein, the $X_{CO_2}^{retrieved}$ is TanSat satellite XCO₂ retrieval value, the CO_2^{col} is the number of the carbon dioxide molecules (i.e. the solution result), the O_2^{col} is the number of oxygen gas molecules, the O_2^{ml} is the percentage of oxygen in the atmosphere (the value is 20.95%). It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In the example of the present application, the oxygen gas albedo error in the XCO₂ retrieval data is eliminated by the oxygen gas albedo correction coefficient; the observation angle error in the XCO₂ retrieval data is eliminated by the air mass factor correction coefficient (namely, air mass factor correction); the systematic error (i.e. scale programming correction) at the TanSat satellite observation is eliminated by the regression coefficient, and the XCO₂ retrieval data correction is finally achieved; the accuracy of TanSat satellite observation data is improved effectively. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Exemplary system

Fig. 6 is a schematic structure diagram of the bias correction system of TanSat satellite XCO₂ retrieval data provided according to some examples of the present application; as shown in Fig. 6, the system comprises:

an albedo error unit configured to obtain an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂

retrieval value in the TanSat satellite XCO₂ retrieval data; wherein the XCO₂ retrieval data contains N of the XCO₂ retrieval values, and N is a positive integer;

an observation angle error unit configured to calculate an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

a regression coefficient unit configured to obtain a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value;

a bias correction unit configured to perform a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value.

It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 7 is a schematic structure diagram of the albedo error unit according to some examples of the present application; as shown in Fig. 7, the albedo error unit comprises:

an albedo calculation subunit configured to calculate an oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value according to the pre-obtained full-solar-spectrum of the oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

an albedo average calculation subunit configured to average the oxygen gas band non-absorbing region albedo corresponding to N of the XCO₂ retrieval values to obtain an oxygen gas albedo average value of N of the XCO₂ retrieval values;

an albedo error calculation subunit configured to calculate the oxygen gas albedo error of each XCO₂ retrieval value according to the oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value, and the oxygen gas albedo average value.

It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 8 is a schematic structure diagram of the observation angle error unit according to some

examples of the present application; as shown in Fig. 8, the observation angle error unit comprises:

an air mass factor calculation subunit configured to calculate an air mass factor of each XCO₂ retrieval value according to the satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

an air mass factor average calculation subunit configured to average the air mass factor of N of the XCO₂ retrieval values to obtain an air mass factor average value of N of the XCO₂ retrieval values;

an observation angle error calculation subunit configured to calculate the observation angle error of each XCO₂ retrieval value according to the air mass factor corresponding to each XCO₂ retrieval value, and the air mass factor average value.

It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

In some alternative examples, the regression coefficient unit is further configured to perform linear regression on N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value to obtain the regression coefficient of the XCO₂ retrieval data. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 9 is a schematic structure diagram of the observation angle error unit according to some examples of the present application; as shown in Fig. 9, the bias correction unit comprises:

a first correction subunit configured to perform an albedo error correction and an observation angle error correction on each XCO₂ retrieval value respectively according to each XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value;

a second correction subunit configured to perform a quotient operation on each XCO₂ retrieval value after the albedo error correction and the observation angle error correction and the regression coefficient to obtain the bias correction result of each XCO₂ retrieval value.

It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

Fig. 10 is a schematic structure diagram for obtaining TanSat satellite XCO₂ retrieval data

provided according to some examples of the present application; as shown in Fig. 10, the bias correction system of TanSat satellite XCO₂ retrieval data further comprises:

a data extraction unit 1001 configured to extract a satellite parameter and an observation parameter of the TanSat satellite;

a data elimination unit 1002 configured to perform cloud region data elimination on cloud data, and performing aerosol high value region data elimination on aerosol data;

an analog spectrum unit 1003 configured to obtain an analog spectrum based on an atmospheric radiative transfer model of a preset retrieval parameter, according to the satellite parameter, the observation parameter, a cloud data performed cloud region data elimination, an aerosol data performed aerosol high value region data elimination and an atmospheric profile parameter;

a spectrum solving unit 1004 configured to solve the analog spectrum and the observation spectrum in the satellite parameter to obtain a solution result based on an optimal estimation method;

a result update unit 1005 configured to judge whether the solution result converges, and if not, updating the preset retrieval parameter in the atmospheric radiative transfer model until the solution result converges;

a retrieval data unit 1006 configured to obtain the TanSat satellite XCO₂ retrieval data according to the solution result.

It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

The bias correction system of TanSat satellite XCO₂ retrieval data provided by the example of the present application can realize the various processes in the above-mentioned bias correction method examples of the TanSat satellite XCO₂ retrieval data and achieve the same functions and effects, and will not be described in detail herein. It is to be understood that the above description is intended to be illustrative, and that the present examples are not restrictive.

The foregoing is merely a preferred example of the present invention and is not intended to limit the present invention so that various modifications and changes may be made by those skilled in the art. All changes, equivalents, improvements, etc. that come within the spirit and scope of the invention are intended to be contained therein.

CLAIMS

1. a bias correction method of TanSat satellite XCO₂ retrieval data, characterized in that, comprising the following steps:

obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data; wherein the XCO₂ retrieval data contains N of the XCO₂ retrieval values, and N is a positive integer;

calculating an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

obtaining a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value;

performing a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value,

wherein, the step of performing a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value comprises the following steps:

performing an albedo error correction and an observation angle error correction on each XCO₂ retrieval value respectively according to each XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value;

performing a quotient operation on each XCO₂ retrieval value after the albedo error correction and the observation angle error correction and the regression coefficient to obtain the bias correction result of each XCO₂ retrieval value.

2. The method according to claim 1, characterized in that, the step of obtaining an oxygen gas

albedo error of each XCO_2 retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO_2 retrieval value in the TanSat satellite XCO_2 retrieval data comprises the following steps:

calculating an oxygen gas band non-absorbing region albedo corresponding to each XCO_2 retrieval value according to the pre-obtained full-solar-spectrum of the oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO_2 retrieval value in the N of the XCO_2 retrieval values;

averaging the oxygen gas band non-absorbing region albedo corresponding to N of the XCO_2 retrieval values to obtain an oxygen gas albedo average value of N of the XCO_2 retrieval values;

calculating the oxygen gas albedo error of each XCO_2 retrieval value according to the oxygen gas band non-absorbing region albedo corresponding to each XCO_2 retrieval value, and the oxygen gas albedo average value.

3. The method according to claim 1, characterized in that, the step of calculating an observation angle error of each XCO_2 retrieval value according to a satellite observation angle and the solar zenith angle corresponding to each XCO_2 retrieval value in the N of the XCO_2 retrieval values comprises the following steps:

calculating an air mass factor of each XCO_2 retrieval value according to the satellite observation angle and the solar zenith angle corresponding to each XCO_2 retrieval value in the N of the XCO_2 retrieval values;

averaging the air mass factor of N of the XCO_2 retrieval values to obtain an air mass factor average value of N of the XCO_2 retrieval values;

calculating the observation angle error of each XCO_2 retrieval value according to the air mass factor corresponding to each XCO_2 retrieval value, and the air mass factor average value.

4. The method according to claim 1, characterized in that, the step of obtaining a regression coefficient of the XCO_2 retrieval data according to N of the XCO_2 retrieval values and a pre-obtained XCO_2 foundation observation value corresponding to the XCO_2 retrieval value is specifically: performing linear regression on N of the XCO_2 retrieval values and a pre-obtained

XCO₂ foundation observation value corresponding to the XCO₂ retrieval value to obtain the regression coefficient of the XCO₂ retrieval data.

5. The method according to any one of claims 1-4, characterized in that, before the step of obtaining an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data, further comprising the following steps:

extracting a satellite parameter and an observation parameter of the TanSat satellite;

performing cloud region data elimination on cloud data, and performing aerosol high value region data elimination on aerosol data;

obtaining an analog spectrum based on an atmospheric radiative transfer model of a preset retrieval parameter, according to the satellite parameter, the observation parameter, a cloud data performed cloud region data elimination, an aerosol data performed aerosol high value region data elimination and an atmospheric profile parameter;

solving the analog spectrum and the observation spectrum in the satellite parameter to obtain a solution result based on an optimal estimation method;

judging whether the solution result converges, and if not, updating the preset retrieval parameter in the atmospheric radiative transfer model until the solution result converges;

obtaining the TanSat satellite XCO₂ retrieval data according to the solution result.

6. a bias correction system of TanSat satellite XCO₂ retrieval data, characterized in that, comprising:

an albedo error unit configured to obtain an oxygen gas albedo error of each XCO₂ retrieval value according to a pre-obtained full-solar-spectrum of an oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the TanSat satellite XCO₂ retrieval data; wherein the XCO₂ retrieval data contains N of the XCO₂ retrieval values, and N is a positive integer;

an observation angle error unit configured to calculate an observation angle error of each XCO₂ retrieval value according to a satellite observation angle and the solar zenith angle corresponding

to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

a regression coefficient unit configured to obtain a regression coefficient of the XCO₂ retrieval data according to N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value;

a bias correction unit configured to perform a bias correction on each XCO₂ retrieval value according to each XCO₂ retrieval value, the regression coefficient of the XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value to obtain a bias correction result of each XCO₂ retrieval value,

wherein, the bias correction unit comprises:

a first correction subunit configured to perform an albedo error correction and an observation angle error correction on each XCO₂ retrieval value respectively according to each XCO₂ retrieval value, and the oxygen gas albedo error and the observation angle error of each XCO₂ retrieval value;

a second correction subunit configured to perform a quotient operation on each XCO₂ retrieval value after the albedo error correction and the observation angle error correction and the regression coefficient to obtain the bias correction result of each XCO₂ retrieval value.

7. The system according to claim 6, characterized in that, the albedo error unit comprises:

an albedo calculation subunit configured to calculate an oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value according to the pre-obtained full-solar-spectrum of the oxygen gas band and a pre-obtained observation spectrum and solar zenith angle of the oxygen gas band corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

an albedo average calculation subunit configured to average the oxygen gas band non-absorbing region albedo corresponding to N of the XCO₂ retrieval values to obtain an oxygen gas albedo average value of N of the XCO₂ retrieval values;

an albedo error calculation subunit configured to calculate the oxygen gas albedo error of each XCO₂ retrieval value according to the oxygen gas band non-absorbing region albedo corresponding to each XCO₂ retrieval value, and the oxygen gas albedo average value.

8. The system according to claim 6, characterized in that, the observation angle error unit comprises:

an air mass factor calculation subunit configured to calculate an air mass factor of each XCO₂ retrieval value according to the satellite observation angle and the solar zenith angle corresponding to each XCO₂ retrieval value in the N of the XCO₂ retrieval values;

an air mass factor average calculation subunit configured to average the air mass factor of N of the XCO₂ retrieval values to obtain an air mass factor average value of N of the XCO₂ retrieval values;

an observation angle error calculation subunit configured to calculate the observation angle error of each XCO₂ retrieval value according to the air mass factor corresponding to each XCO₂ retrieval value, and the air mass factor average value.

9. The system according to claim 6, characterized in that, the regression coefficient unit is further configured to perform linear regression on N of the XCO₂ retrieval values and a pre-obtained XCO₂ foundation observation value corresponding to the XCO₂ retrieval value to obtain the regression coefficient of the XCO₂ retrieval data.

10. The system according to claim 6, characterized in that, the bias correction system of TanSat satellite XCO₂ retrieval data further comprises:

a data extraction unit configured to extract a satellite parameter and an observation parameter of the TanSat satellite;

a data elimination unit configured to perform cloud region data elimination on cloud data, and performing aerosol high value region data elimination on aerosol data;

an analog spectrum unit configured to obtain an analog spectrum based on an atmospheric radiative transfer model of a preset retrieval parameter, according to the satellite parameter, the observation parameter, a cloud data performed cloud region data elimination, an aerosol data performed aerosol high value region data elimination and an atmospheric profile parameter;

a spectrum solving unit configured to solve the analog spectrum and the observation spectrum in the satellite parameter to obtain a solution result based on an optimal estimation method;

a result update unit configured to judge whether the solution result converges, and if not,

updating the preset retrieval parameter in the atmospheric radiative transfer model until the solution result converges;

a retrieval data unit configured to obtain the TanSat satellite XCO₂ retrieval data according to the solution result.

ANSPRÜCHE

1. Verfahren zur Abweichungskorrektur von XCO_2 -Inversionsdaten für TanSat-Satelliten, dadurch gekennzeichnet, dass es umfasst:

Erhalten eines Sauerstoff-Albedo-Fehlers für jeden der XCO_2 -Inversionswerte auf der Grundlage eines zuvor erhaltenen Sonnenspektrums des Sauerstoffbandes und eines Beobachtungsspektrums des Sauerstoffbandes, das jedem XCO_2 -Inversionswert in den zuvor erhaltenen XCO_2 -Inversionsdaten für TanSat-Satelliten entspricht, und eines solaren Zenitwinkels,

wobei die XCO_2 -Inversionsdaten N XCO_2 -Inversionswerte enthalten, wobei N eine positive ganze Zahl ist;

Berechnen eines Beobachtungswinkelfehlers für jeden der XCO_2 -Inversionswerte auf der Grundlage des Satellitenbeobachtungswinkels, der jedem der XCO_2 -Inversionswerte von N XCO_2 -Inversionswerten entspricht, und des Sonnenzenitwinkels;

Erhalten der Regressionskoeffizient der XCO_2 -Inversionsdaten auf der Grundlage von N XCO_2 -Inversionswerten und zuvor erhaltenen XCO_2 -Bodenbeobachtungen, die den XCO_2 -Inversionswerten entsprechen;

Durchführen der Abweichungskorrektur für jeden XCO_2 -Inversionswert auf der Grundlage jedes XCO_2 -Inversionswertes, des Regressionskoeffizienten der XCO_2 -Inversionsdaten und des Sauerstoff-Albedofehlers und des Beobachtungswinkelfehlers für jeden XCO_2 -Inversionswert, um ein Abweichungskorrekturergebnis für jeden XCO_2 -Inversionswert zu erhalten;

das Durchführen der Abweichungskorrektur für jeden XCO_2 -Inversionswert auf der Grundlage jedes XCO_2 -Inversionswertes, des Regressionskoeffizienten der XCO_2 -Inversionsdaten und des Sauerstoff-Albedofehlers und des Beobachtungswinkelfehlers für jeden XCO_2 -Inversionswert, um ein Abweichungskorrekturergebnis für jeden XCO_2 -Inversionswert zu erhalten, umfasst:

Durchführen einer Albedo-Fehlerkorrektur und einer Beobachtungswinkelfehlerkorrektur auf jeden XCO_2 -Inversionswert auf der

Grundlage jedes XCO_2 -Inversionswertes und des Sauerstoff-Albedo-Fehlers bzw. des Beobachtungswinkelfehlers für jeden XCO_2 -Inversionswert;

Quotientbilden jedes XCO_2 -Inversionswertes nach der Albedo-Fehlerkorrektur und der Beobachtungswinkelfehlerkorrektur mit dem Regressionskoeffizienten, um ein Abweichungskorrekturergebnis für jeden XCO_2 -Inversionswert zu erhalten.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass das Erhalten eines Sauerstoff-Albedo-Fehlers für jeden XCO_2 -Inversionswert auf der Grundlage eines zuvor erhaltenen Sonnenspektrums des Sauerstoffbandes und eines Beobachtungsspektrums des Sauerstoffbandes, das jedem XCO_2 -Inversionswert in den zuvor erhaltenen XCO_2 -Inversionsdaten für TanSat-Satelliten entspricht, und eines solaren Zenitwinkels umfasst:

Berechnen der Albedo des nicht-absorbierenden Bereichs des Sauerstoffbandes, das jedem XCO_2 -Inversionswert entspricht, auf der Grundlage des zuvor erhaltenen Sonnenspektrums des Sauerstoffbandes und des Beobachtungsspektrums des Sauerstoffbandes, das jedem XCO_2 -Inversionswert aus den zuvor N zuvor erhaltenen XCO_2 -Inversionswerten entspricht, und des solaren Zenitwinkels;

Mitteln der Albedo des nicht-absorbierenden Bereichs des Sauerstoffbandes, der den N XCO_2 -Inversionen entspricht, um einen Mittelwert der Sauerstoff-Albedos der N XCO_2 -Inversionen zu erhalten;

Berechnen eines Sauerstoff-Albedo-Fehlers für jeden XCO_2 -Inversionswert auf der Grundlage der Albedo des nicht absorbierenden Bereichs des Sauerstoffbands, die jedem XCO_2 -Inversionswert entspricht, und des Sauerstoff-Albedo-Mittelwertes.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass das Berechnen eines Beobachtungswinkelfehlers für jeden der XCO_2 -Inversionswerte auf der Grundlage des Satellitenbeobachtungswinkels, der jedem der XCO_2 -Inversionswerte von N XCO_2 -Inversionswerten entspricht, und des Sonnenzenitwinkels umfasst;

Berechnen eines Luftmassenfaktors für jeden XCO_2 -Inversionswert auf der Grundlage des Satellitenbeobachtungswinkels, der jedem XCO_2 -Inversionswert entspricht, und des Sonnenzenitwinkels;

Mitteln der Luftmassenfaktoren für N XCO_2 -Inversionswerte, um einen Mittelwert

der Luftmassenfaktoren für N der XCO₂-Inversionswerte zu erhalten;

Berechnen eines beobachteten Winkelfehlers für jeden XCO₂-Inversionswert auf der Grundlage des Luftmassenfaktors jedes XCO₂-Inversionswertes und des Luftmassenfaktor-Mittelwertes.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass das Erhalten der Regressionskoeffizient der XCO₂-Inversionsdaten auf der Grundlage von N XCO₂-Inversionswerten und zuvor erhaltenen XCO₂-Bodenbeobachtungen, die den XCO₂-Inversionswerten entsprechen, derart ausgeführt ist, dass eine lineare Regression von N XCO₂-Inversionswerten und zuvor erhaltenen XCO₂-Bodenbeobachtungen, die den XCO₂-Inversionswerten entsprechen, durchgeführt wird um einen Regressionskoeffizienten für die XCO₂-Inversionsdaten zu erhalten.

5. Verfahren nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass vor dem Erhalten eines Sauerstoff-Albedo-Fehlers für jeden XCO₂-Inversionswert auf der Grundlage eines zuvor erhaltenen Sonnenspektrums des Sauerstoffbandes und eines Beobachtungsspektrums des Sauerstoffbandes, das jedem XCO₂-Inversionswert in den zuvor erhaltenen XCO₂-Inversionsdaten für TanSat-Satelliten entspricht, und des solaren Zenitwinkels das Verfahren ferner umfasst:

Extrahieren von Satellitenparametern und Beobachtungsparametern des TanSat-Satelliten;

Datenunterdrücken von bewölkten Bereichen für Wolkendaten und

Datenunterdrücken von Aerosolbereichen mit hohen Aerosolwerten für Aerosoldaten;

Erhalten des Analogspektrums auf der Grundlage eines atmosphärischen Strahlungstransfermodells mit vorbestimmten Inversionsparametern und auf der Basis der Satellitenparameter, der Beobachtungsparameter, der Wolkendaten mit Datenunterdrückung von bewölkten Bereichen, der Aerosoldaten mit Datenunterdrückung von Bereichen mit hohen Aerosolwerten und der atmosphärischen Profilparameter;

Lösen des Analogspektrums und des Beobachtungsspektrums aus den Satellitenparametern auf der Grundlage eines optimalen Schätzverfahrens, um ein

Lösungsergebnis zu erhalten;

Bestimmen, ob die Lösungsergebnisse konvergieren, und wenn nicht, Aktualisieren der vorbestimmten Inversionsparameter in dem atmosphärischen Strahlungstransportmodell, bis die Lösungsergebnisse konvergieren;

Erhalten der XCO₂-Inversionsdaten für TanSat-Satelliten basierend auf den Lösungsergebnissen.

6. System zur Abweichungskorrektur von XCO₂-Inversionsdaten für TanSat-Satelliten, dadurch gekennzeichnet, umfassend

eine Albedo-Fehlereinheit, die so eingerichtet ist, einen Sauerstoff-Albedo-Fehler für jeden der XCO₂-Inversionswerte auf der Grundlage eines zuvor erhaltenen Sonnenspektrums des Sauerstoffbandes und eines zuvor erhaltenen Beobachtungsspektrums des Sauerstoffbandes, das jedem XCO₂-Inversionswert in den XCO₂-Inversionsdaten für TanSat-Satelliten entspricht, und eines solaren Zenitwinkels zu erhalten; wobei die XCO₂-Inversionsdaten N XCO₂-Inversionswerte umfassen, wobei N eine positive ganze Zahl ist;

eine Beobachtungswinkelfehlereinheit, die so eingerichtet ist, einen Beobachtungswinkelfehler für jeden XCO₂-Inversionswert auf der Grundlage des Satellitenbeobachtungswinkels, der jedem der XCO₂-Inversionswerte von N XCO₂-Inversionswerten entspricht, und des solaren Zenitwinkels zu berechnen;

eine Regressionskoeffizienteneinheit, die so eingerichtet ist, einen Regressionskoeffizienten für die XCO₂-Inversionsdaten auf der Grundlage von N XCO₂-Inversionswerten und zuvor erhaltenen bodengestützten XCO₂-Beobachtungen, die den XCO₂-Inversionswerten entsprechen, zu erhalten;

eine Abweichungskorrektureinheit, die so eingerichtet ist, eine Abweichungskorrektur für jeden XCO₂-Inversionswert auf der Grundlage jedes XCO₂-Inversionswertes, eines Regressionskoeffizienten der XCO₂-Inversionsdaten und eines Sauerstoff-Albedofehlers und eines Beobachtungswinkelfehlers für jeden XCO₂-Inversionswert durchzuführen, um ein Abweichungskorrekturergebnis für jeden XCO₂-Inversionswert zu erhalten;

wobei die Abweichungskorrektureinheit vorzugsweise umfasst:

eine erste Korrekturuntereinheit, die so eingerichtet ist, jeden XCO_2 -Inversionswert um den Albedofehler und den Beobachtungswinkelfehler auf der Grundlage jedes XCO_2 -Inversionswertes und des Sauerstoff-Albedofehlers und des Beobachtungswinkelfehlers für jeden XCO_2 -Inversionswert zu korrigieren;

eine zweite Korrekturuntereinheit, die so eingerichtet ist, die um den Albedofehler und den Beobachtungswinkelfehler korrigierten XCO_2 -Inversionen mit den Regressionskoeffizienten zu quotieren, um ein Abweichungskorrekturergebnis für jede XCO_2 -Inversion zu erhalten.

7. System nach Anspruch 6, dadurch gekennzeichnet, dass die Albedo-Fehlereinheit umfasst:

eine Albedo-Berechnungsuntereinheit, die so eingerichtet ist, die Albedo des nicht-absorbierenden Bereichs des Sauerstoffbandes, das jedem XCO_2 -Inversionswert entspricht, auf der Grundlage des zuvor erhaltenen Sonnenspektrums des Sauerstoffbandes und des Beobachtungsspektrums des Sauerstoffbandes, das jedem XCO_2 -Inversionswert aus den N zuvor erhaltenen XCO_2 -Inversionswerten entspricht, und des Sonnenzenitwinkels zu berechnen;

eine Albedo-Mittelungsberechnungsuntereinheit, die so eingerichtet ist, die Albedo des nicht absorbierenden Bereichs des Sauerstoffbandes, das den N XCO_2 -Inversionswerten entspricht, zu mitteln, um einen Mittelwert der Sauerstoff-Albedos der N XCO_2 -Inversionswerte zu erhalten;

eine Albedo-Fehlerberechnungs-Untereinheit, die so eingerichtet ist, einen Sauerstoff-Albedo-Fehler für jeden XCO_2 -Inversionswert auf der Grundlage der Albedo des nicht-absorbierenden Bereichs des Sauerstoffbands, die jedem XCO_2 -Inversionswert entspricht, und des Sauerstoff-Albedo-Mittelwertes zu berechnen.

8. System nach Anspruch 6, dadurch gekennzeichnet, dass die Beobachtungswinkelfehlereinheit umfasst:

eine Luftmassenfaktor-Berechnungsuntereinheit, die so eingerichtet ist, einen Luftmassenfaktor für jeden XCO_2 -Inversionswert, der jedem XCO_2 -Inversionswert entspricht, auf der Grundlage des Satellitenbeobachtungswinkels und des solaren

Zenitwinkels, der jedem XCO_2 -Inversionswert von N XCO_2 -Inversionswerten entspricht, zu berechnen;

eine Luftmassenfaktor-Mittelwertberechnungsuntereinheit, die so eingerichtet ist, die Luftmassenfaktoren der N XCO_2 -Inversionswerte zu mitteln, um einen Mittelwert der Luftmassenfaktoren der N XCO_2 -Inversionswerte zu erhalten;

eine Untereinheit zur Berechnung des Beobachtungswinkelfehlers, die so eingerichtet ist, einen Beobachtungswinkelfehler für jeden XCO_2 -Inversionswert auf der Grundlage des Gasmassenfaktors jedes XCO_2 -Inversionswertes und des Gasmassenfaktordurchschnitts zu berechnen.

9. System nach Anspruch 6, dadurch gekennzeichnet, dass die Regressionskoeffizienten-Einheit ferner so eingerichtet ist, dass eine lineare Regression von N XCO_2 -Inversionswerten und zuvor erhaltenen bodengestützten XCO_2 -Beobachtungen, die den XCO_2 -Inversionswerten entsprechen, durchgeführt wird, um einen Regressionskoeffizienten für die XCO_2 -Inversionsdaten zu erhalten.

10. System nach Anspruch 6, dadurch gekennzeichnet, dass das System zur Abweichungskorrektur von XCO_2 -Inversionsdaten für TanSat-Satelliten umfasst:

eine Datenextraktionseinheit, die so eingerichtet ist, Satellitenparameter und Beobachtungsparameter des TanSat-Satelliten zu extrahieren;

eine Datenunterdrückungseinheit, die so eingerichtet ist, eine Datenunterdrückung von bewölkten Bereichen für Wolkendaten und eine Datenunterdrückung von Aerosolbereichen mit hohen Aerosolwerten für Aerosoldaten durchzuführen;

eine Analogspektrumeinheit, die so eingerichtet ist, ein Analogspektrum auf der Grundlage eines atmosphärischen Strahlungstransfermodells mit vorbestimmten Inversionsparametern und auf der Basis der Satellitenparameter, der Beobachtungsparameter, der Wolkendaten mit Datenunterdrückung von bewölkten Bereichen, der Aerosoldaten mit Datenunterdrückung von Bereichen mit hohen Aerosolwerten und der atmosphärischen Profilparameter zu erhalten;

eine Spektrallösungseinheit, die so eingerichtet ist, das Analogspektrum und das Beobachtungsspektrum in den Satellitenparametern auf der Grundlage eines optimalen Schätzverfahrens zu lösen, um ein Lösungsergebnis zu erhalten;

eine Ergebnisaktualisierungseinheit, die so eingerichtet ist, zu bestimmen, ob die Lösungsergebnisse konvergieren, und wenn nicht, so die vorbestimmten Inversionsparameter in dem atmosphärischen Strahlungstransportmodell aktualisiert werden, bis die Lösungsergebnisse konvergieren;

eine Inversionsdateneinheit, die so eingerichtet ist, die XCO₂-Inversionsdaten für TanSat-Satelliten basierend auf den Lösungsergebnissen zu erhalten.

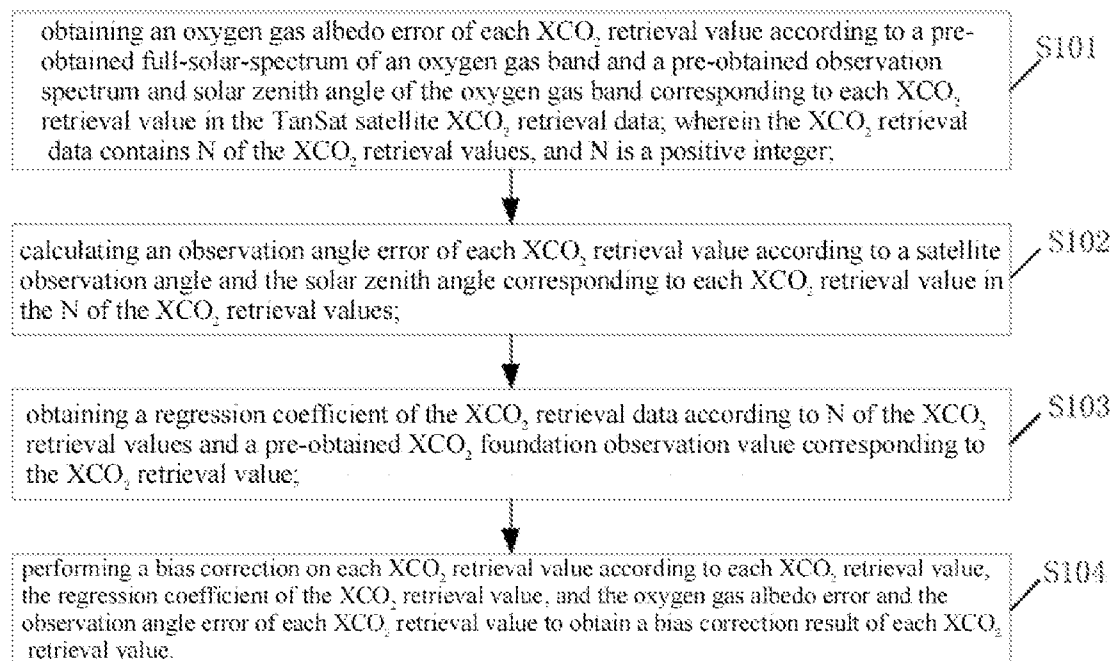


Fig. 1

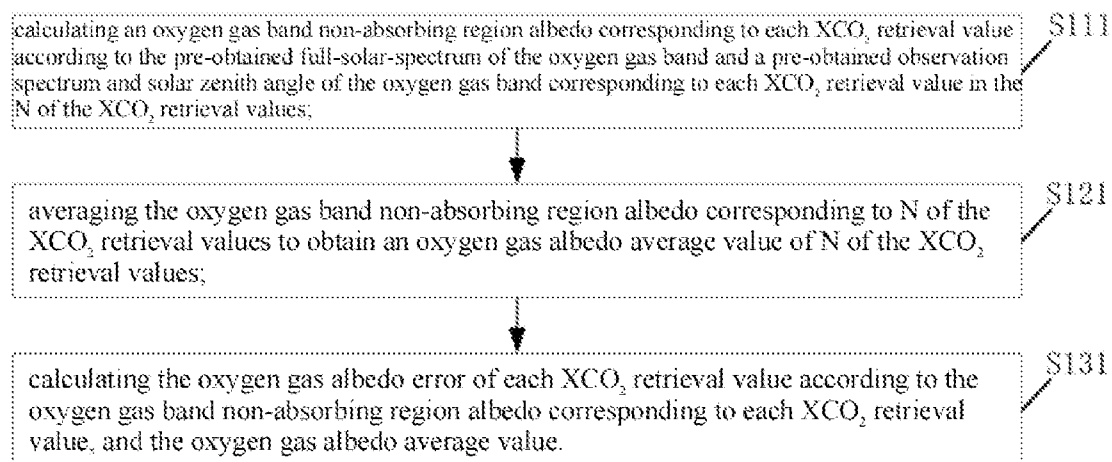


Fig. 2

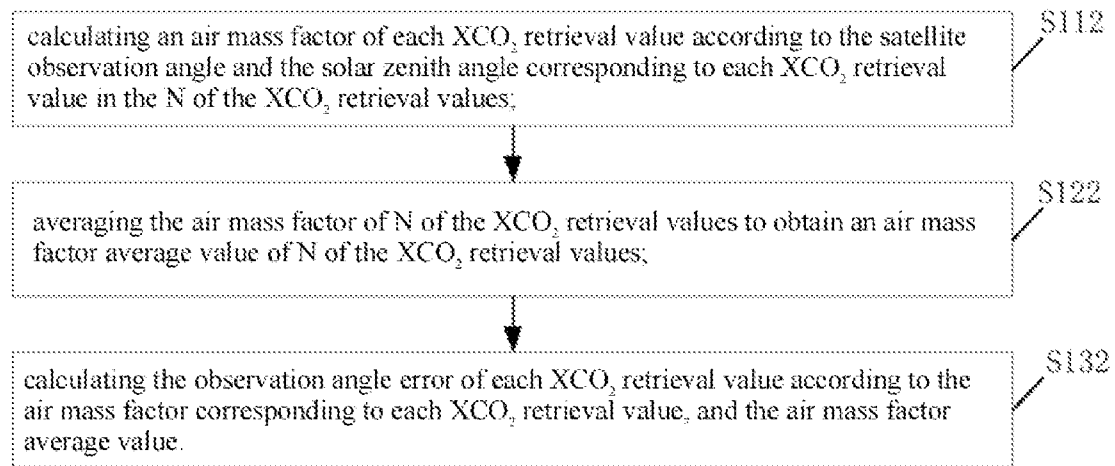


Fig. 3

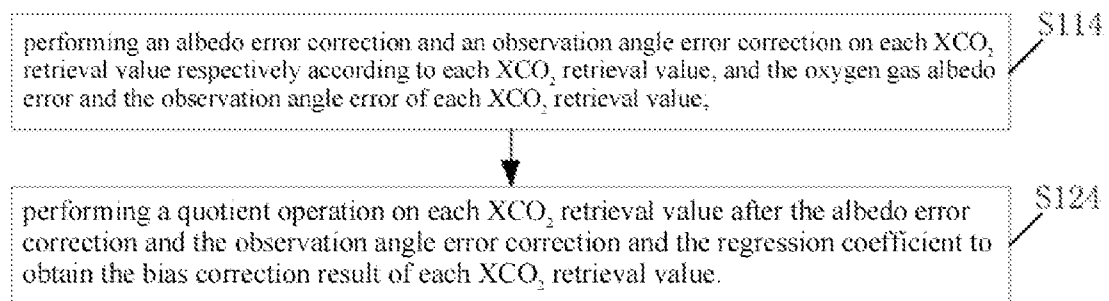


Fig. 4

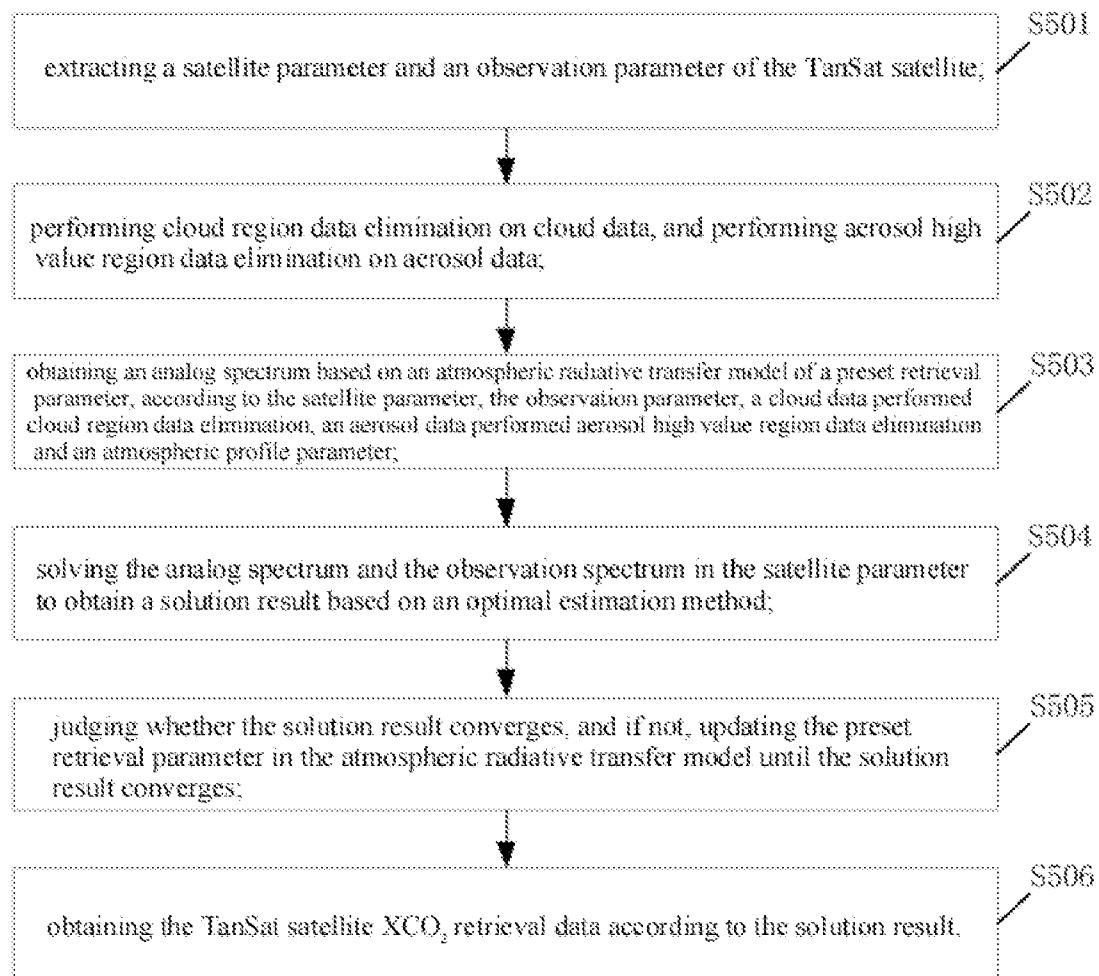


Fig. 5

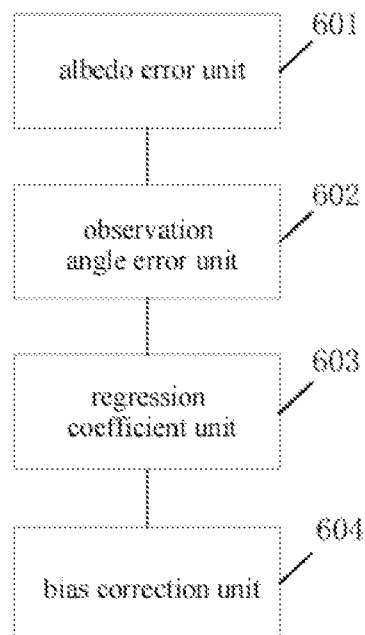


Fig. 6

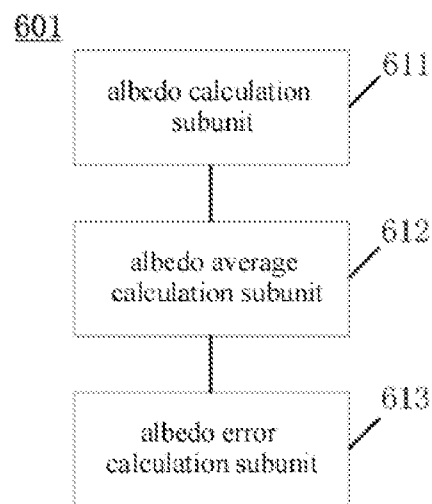


Fig. 7

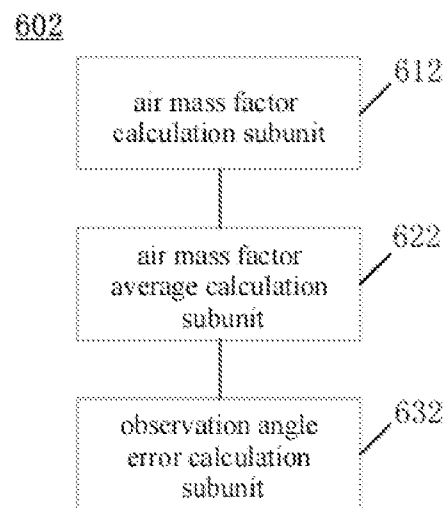


Fig. 8

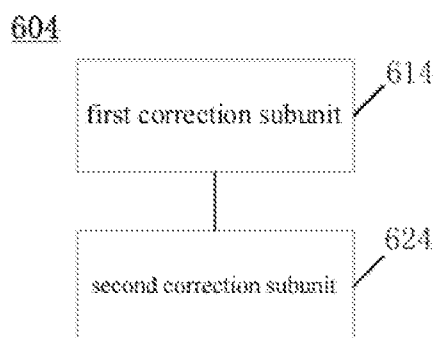


Fig. 9

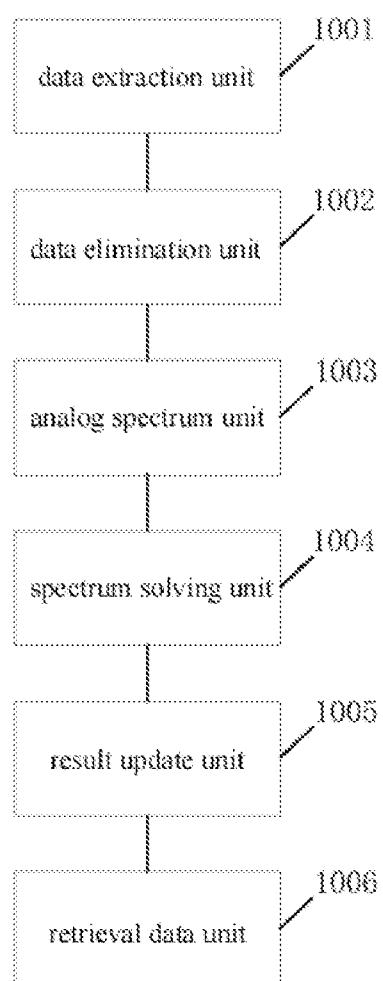


Fig. 10