A Remote Sensing-Based Method for Generating a Global Continuous Carbon Dioxide Concentration Dataset

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Abstract

The global carbon dioxide (CO_2) concentration has shown a consistent and substantial increase over the years, representing the dominant component of greenhouse gases (GHGs). Hence, there is an urgent demand to accurately quantify a broad spectrum of CO_2 concentration at a fine-scale level to aid policymakers in making informed decisions. Consequently, we present a novel method aimed at addressing the scarcity of ground-based data, enabling the generation of a globally large-scale, continuous CO_2 concentration data product.

In consideration of the requirements for temporal and spatial coverage of remote sensing imagery, we opt for the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the Terra satellite, which provides daily surface reflectance of MODIS bands 1 to 7 at resolutions of 500m and 1km.

Carbon satellites have developed rapidly and performed well in retrieving the vertically integrated atmospheric column CO_2(XCO_2) concentrations, which can provide independent top-down CO_2 concentration evaluations. Here, the new generated Orbiting Carbon Observatory 3 (OCO-3) with 1.6 km×2.2 km (across x along track) resolution is added three Near Infrared (NIR) wavelength bands, which guarantees a higher accuracy of XCO_2 than OCO-2.

In this study, we propose a regression model-based method that leverages MODIS data and OCO-3 XCO_2 data for training regression models and predicting CO_2 concentrations. The proposed method enables rapid establishment of the relationship between MODIS surface reflectivity and CO_2 concentration, facilitating the generation of continuous CO_2 concentration maps over a large geographical area. Moreover, it offers reliable information for regions lacking ground-based CO_2 measurements, such as suburban areas.

Additionally, to validate the accuracy of the generated XCO2 data product, we utilize the Total Carbon Column Observing Network (TCCON) as an essential validation source. Upon evaluation, it was observed that the relative errors for each month of the year 2020 at the respective TCCON sites consistently remained below 2%. This finding suggests that the proposed method possesses the potential for expansion to additional geographical regions and temporal spans, whilst sustaining a high level of precision.

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Introduction

- CO_2 concentration has consistently increased over the years, creating an urgent need for accurately quantifying CO_2 to assist policymakers in making decisions.
- MODIS provides high-precision surface reflectance data over a wide spatial and temporal range. And OCO-3 is an emerging high-precision carbon satellite capable of providing XCO_2 data.
- A novel method is presented by utilizing machine learning to explore the correlation between MODIS surface reflectance and XCO_2.
- TCCON is used to verify the effectiveness of the proposed method.

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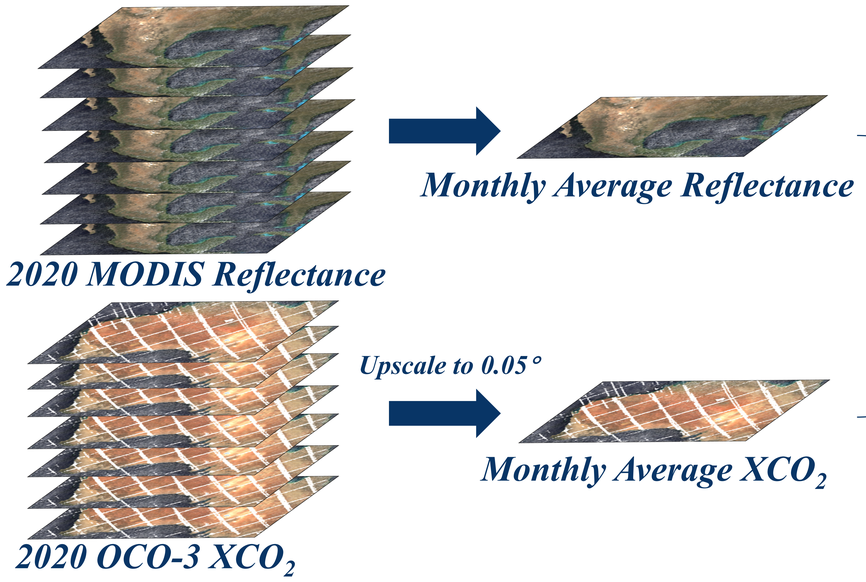
Methods



Results and Conclusions

Validation Results

	Jan	Feb	March	April	May	June	July	Aug	Sep	Nov	Dec
R^2	0.48	0.49	0.58	0.54	0.61	0.42	0.32	0.34	0.45	0.22	0.36
RMSE	1.37	1.50	1.72	1.76	1.62	1.51	1.41	1.37	1.12	1.19	1.32

There is a computing error in the models for October, this error will be addressed in subsequent work.