LARGE SCALE VARIABILITY OF MID-TROPOSPHERIC CARBON DIOXIDE AS OBSERVED BY THE ATMOSPHERIC INFRARED SOUNDER (AIRS) ON THE NASA EOS AQUA PLATFORM

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1. INTRODUCTION

The Atmospheric Infrared Sounder (AIRS) is a hyperspectral infrared instrument on the EOS Aqua Spacecraft, launched on May 4, 2002. AIRS has 2378 infrared channels ranging from 3.7 μm to 15.4 μm and a 13.5 km footprint. AIRS, in conjunction with the Advanced Microwave Sounding Unit (AMSU), produces temperature profiles with 1K/km accuracy, water vapor profiles (20%/2km), infrared cloud height and fraction, and trace gas amounts for CO_2, CO, SO_2, O_3 and CH_4 in the mid to upper troposphere [1]. AIRS wide swath, ±49.5°, enables daily global daily coverage for over 95% of the Earth's surface. AIRS data are used for weather forecasting [2], validating climate model distribution [3] and processes [4], and observing long-range transport of greenhouse gases [5,6,7]. In this study, we examine the large scale and regional horizontal variability in the AIRS Mid-tropospheric Carbon Dioxide product as a function of season and associate the observed variability with known atmospheric transport processes, and sources and sinks of CO2.

2. METHODOLOGY

In this study, we employ monthly representations of global concentrations of mid-tropospheric carbon dioxide produced from 9 years of data obtained by AIRS between the years of 2003 and 2011 to identify regular patterns of horizontal and seasonal variability. We define them as "representations" rather than "climatologies" to reflect that the files are produced over a relatively short time period and represent summaries of the Level 3 data. The monthly representations have a horizontal resolution of 2.0° x 2.5° (Latitude x Longitude) with full global coverage and faithfully reproduce the original 9 years of monthly L3 CO2 concentrations with a standard deviation of 1.5 ppm and less than 2% outliers. The representations are intended for use in studies of the global general circulation of CO2 and identification of anomalies in CO2 typically associated with atmospheric transport. We also use the MODIS Enhanced Vegetation Index (EVI) for correlation of the mid-troposphere with

land surface vegetation. We compile 9 years of MODIS L3 EVI obtained from the MODIS MYDVI Version 5 Data Product. The MODIS data product resolution is 1° x 1° on a monthly timescale. Results from prior studies comparing AIRS CO2 concentrations to ENSO and MJO are also presented [8,9]. The CO2 concentrations measured by AIRS in the mid-troposphere are essential to isolating small scale sources and sinks near the surface (land or ocean) with current and future total column measurements (e.g. GOSAT and OCO-2). Issues associated with measuring ocean sources and sinks of CO2 and the value of AIRS data for this purpose will be discussed.

3. RESULTS

The AIRS mid-tropospheric representations of CO2 show significantly higher horizontal variability than was believed to exist no less than a decade ago. The variability has been confirmed by in-situ aircraft validation by Chahine [7], and Wofsy [10]. The variability is a result of large scale sources and sinks of CO2 and atmospheric transport in the horizontal and vertical directions. ENSO and MJO are tropical atmospheric temperature and water vapor oscillations that produce vertical mass transport that brings air from the lower troposphere with higher concentrations of CO2 into the mid-troposphere where the AIRS is more sensitive. Large scale sources originating primarily in the Northern Hemisphere are clearly seen and the seasonal variability is high due to the seasonal dependence of the terrestrial biosphere in this region. Conversely in the Southern Hemisphere tropics we see significantly lower levels of CO2 with lower seasonal variability that correlates well with the tropical rainforest. Higher than expected CO2 variability in the Polar Regions was also observed in Version 5 yet not well understood. Early testing of the AIRS Version 6 CO2 retrieval shows similar results in the tropics but significant differences in the polar regions indicating that the observed variability in this region may have been related to the retrieval process.

4. CONCLUSIONS

A long term gridded monthly data set of mid-tropospheric carbon dioxide concentrations from the AIRS instrument has been developed. Global distributions show significant horizontal variability with season that is well behaved from year to year. The seasonal variability has a high statistical significance for each 2.0° x 2.5° grid cell. The data set were used to develop a set of 12 monthly representations that are then used to identify anomalies as well as regular seasonal variability. While correlations with large scale sources and sinks are present in the data, the primary value of the AIRS CO2 data at this time is as a tracer for vertical transport to validate the processes involved with seasonal and interannual variability of the global climate system. Future plans include release of stratospheric and lower tropospheric CO2 data products and ultimately a CO2 profile.

5. REFERENCES

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