Prospects for Precision Measurement of CO₂ Column from Space

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Model for the CO₂ channel
Overlap of Fringes and CO₂ Lines

Instrument Design

Comparison of Overlap at Two Temperatures
The flight hardened version

Ground testing results with the fiber-coupled Sun Tracker

Channels for measuring CO₂ (1571 nm), O₂ pressure sensing, and O₂ temperature sensing channel (768 nm)

Sensitivity Estimates using Direct Sun

CO₂ Ratio change per airmass = (1.1 - 1.0)/(2.0 - 6.0) = -0.025
1/10 second CO₂ Ratio Noise = +/- .00025 so SNR ~ 100:1
Since 1 airmass ~ 370 ppm Sensitivity ~ 3.7 ppm in 1/10 sec

O₂ Ratio change per airmass = (6 - 4)/(4.5 - 1.5) = .666
1/10 second O₂ Ratio Noise = +/- .004 so SNR ~ 165:1
Since 1 airmass ~ 1013 mB Sensitivity ~ 6.1 mB in 1/10 sec
ATMOSPHERIC SCATTERING ALTERS THE OPTICAL PATH

FPICC rack and instrument shown installed in DC-8 cabin

Results from PAVE Campaign

Results from PAVE Campaign
Results from PAVE Campaign

Dealing with Atmospheric Scattering

USE THE GLINT!

GLINT IS REFLECTION OF SUNLIGHT OFF THE SURFACE OF WATER—ADVANTAGE IS THAT YOU KNOW THE PATH LENGTH FOR GLINT.

GLINT CAN BE AS MUCH AS 1,000,000 TIMES BRIGHTER THAN REFLECTION OFF GROUND
SUMMARY & STATUS

*SMALL, INEXPENSIVE, PRECISE SYSTEM HAS POTENTIAL FOR GROUND BASED, AIRCRAFT, OR SATELLITE USE.

*FUTURE WORK HIGHLY DESIRABLE AIMED AT VERIFYING TECHNIQUES FOR DEFEATING SCATTER, STABILIZING DESIGN, AND EXTENDING TECHNIQUE TO OTHER SMALL MOLECULES

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ABSTRACT

In order to address the problem of sources and sinks of CO₂ measurements are needed on a global scale. Clearly a satellite is a promising approach to meeting this requirement. Unfortunately, most methods for making a CO₂ measurement from space involve the whole column. Since sources and sinks at the surface represent a small perturbation to the total column one is faced with the need to measure the column with a precision better than 1%. No species has ever been measured from space at this level.

We have developed over the last 3 years a small instrument based upon a Fabry-Perot interferometer that is very sensitive to atmospheric CO₂ and has a high signal to noise ratio. We have tested this instrument in a ground based configuration and from aircraft platforms simulating operation from a satellite.

We will present results from these tests and discuss ways that this promising new instrument could be used to improve our understanding of the global carbon budget.