Prospects for Precision Measurement of CO_2 Column from Space

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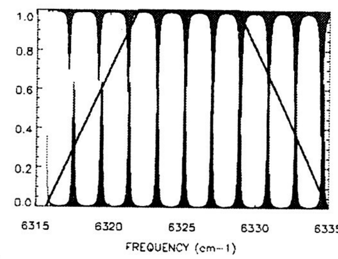
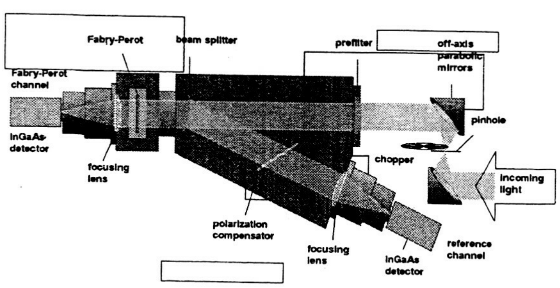
Model for the CO_2 channel Overlap of Fringes and CO_2 Lines



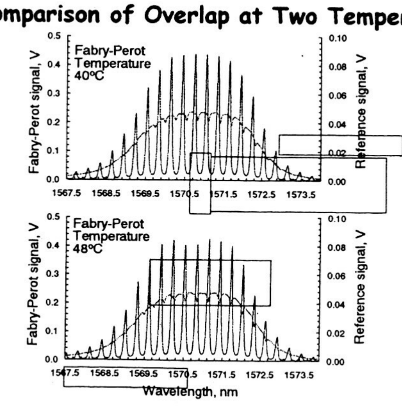
FUSED SILICA FP ETALON .191 CM THICK REFLECTIVE
FINESSE=10
SENSITIVITY=1565

Instrument Design

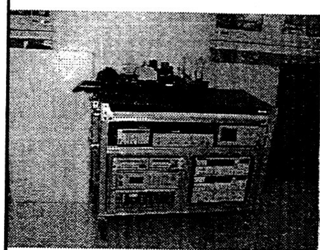


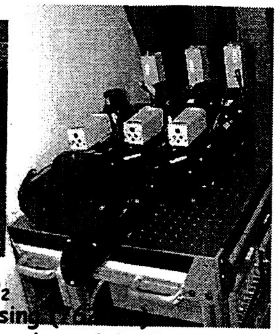
Comparison of Overlap at Two Temperatures

CO_2 channel



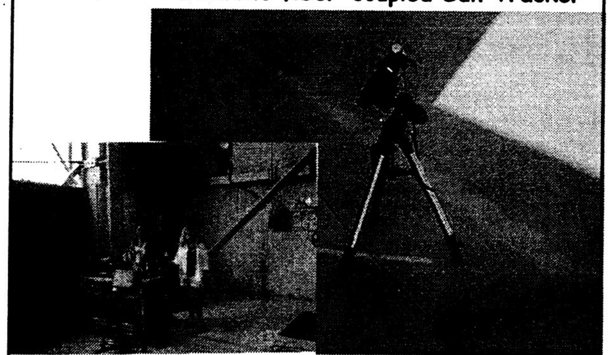
The flight hardened version



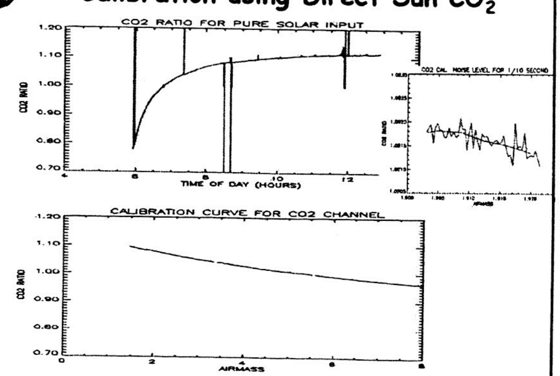


Channels for measuring CO_2 (1571 nm), O_2 pressure sensing and O_2 temperature sensing channel (768 nm)

Ground testing results with the fiber-coupled Sun Tracker



Calibration using Direct Sun CO_2



Sensitivity Estimates using Direct Sun

CO_2 Ratio change per airmass = (1.1 - 1.0)/(2.0 - 6.0) = -.025

1/10 second CO_2 Ratio Noise = +/- .00025 so SNR ~ 100:1

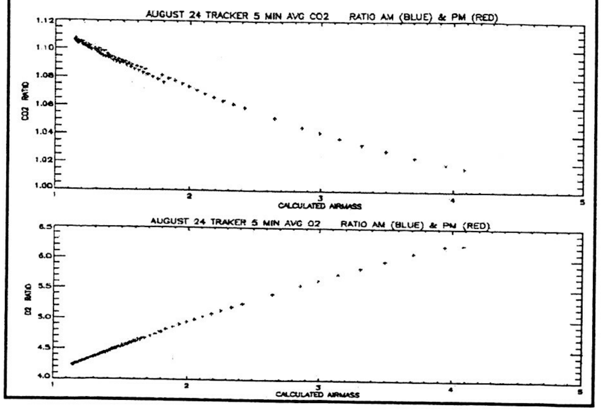
Since 1 airmass ~ 370 ppm Sensitivity ~ 3.7 ppm in 1/10 sec

O_2 Ratio change per airmass = (6 - 4)/(4.5 - 1.5) = .666

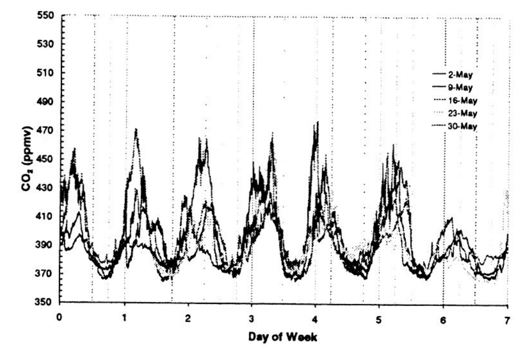
1/10 second O_2 Ratio Noise = +/- .004 so SNR ~ 165:1

Since 1 airmass ~ 1013 mB Sensitivity ~ 6.1 mB in 1/10 sec

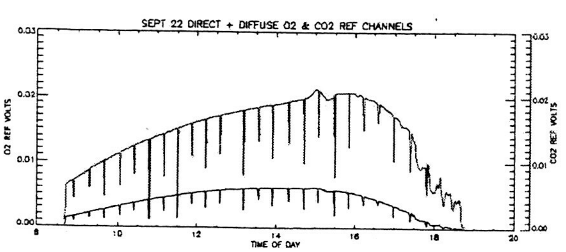
MORE TRACKER DATA



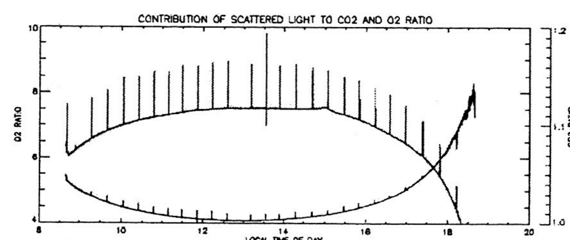
Diurnal Variation of CO_2 at Goddard in May 2004



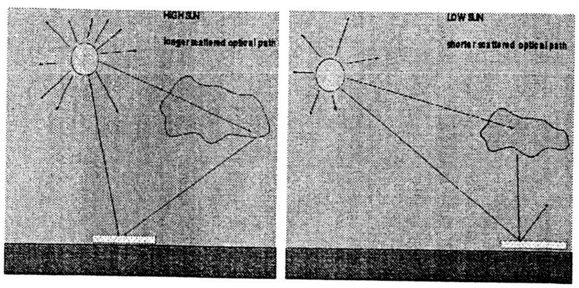
Effects of Atmospheric Scattering



Effects of Atmospheric Scattering

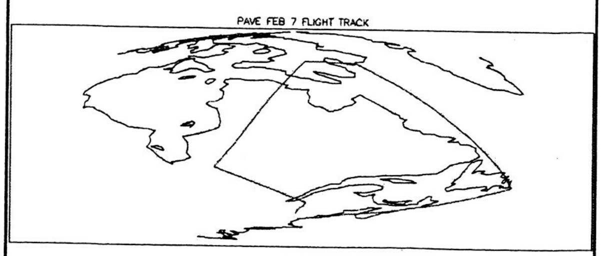


ATMOSPHERIC SCATTERING ALTERS THE OPTICAL PATH



FPICC rack and instrument shown installed in DC-8 cabin

Results from PAVE Campaign



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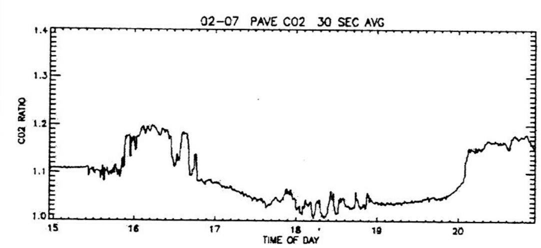

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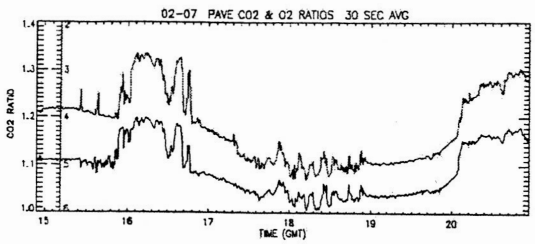
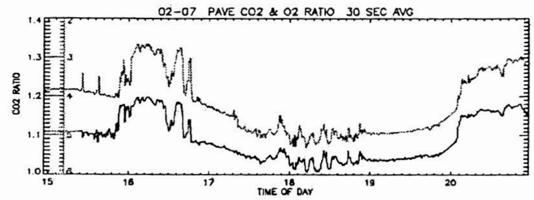
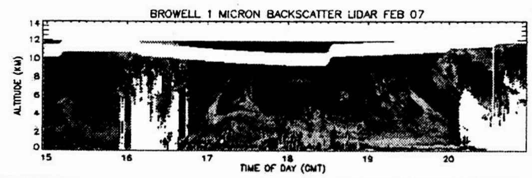


CARBON FROM SPACE FRASCATI June 2005

Results from PAVE Campaign





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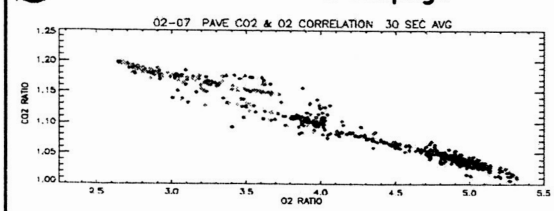
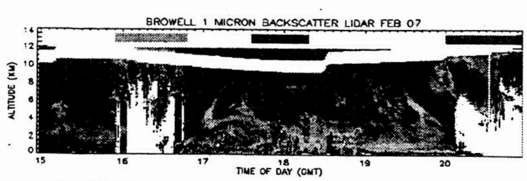




Dealing with Atmospheric Scattering

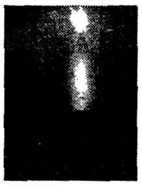
USE THE GLINT!

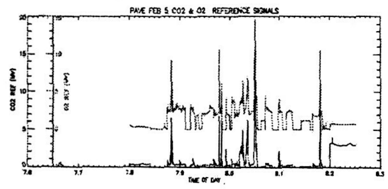
GLINT IS REFLECTION OF SUNLIGHT OFF THE SURFACE OF WATER—ADVANTAGE IS THAT YOU KNOW THE PATH LENGTH FOR GLINT.

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

CARBON FROM SPACE FRASCATI June 2005

GLINT PROVIDES A KNOWN PATH





SUMMARY & STATUS

- INSTRUMENT FOR SIMULTANEOUS MEASUREMENT OF CO2 AND OXYGEN DEMONSTRATED IN FIELD WITH VERY HIGH INTRINSIC PRECISION.
- PATH LENGTH UNCERTAINTY DUE TO ATMOSPHERIC SCATTERING INTRODUCES SERIOUS PROBLEMS IN DATA INTERPRETATION FOR DEVICES OF THIS TYPE
- USING THE GLINT HAS BEEN PROPOSED TO AMELIORATE SCATTERING PROBLEMS BUT THIS APPROACH IS UNTESTED

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

We gratefully acknowledge the support of NASA's Earth Science Technology Office.

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ABSTRACT

In order to address the problem of sources and sinks of CO_2 measurements are needed on a global scale. Clearly a satellite is a promising approach to meeting this requirement. Unfortunately, most methods for making a CO_2 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 CO_2 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.