MicroMAPs

A Low-Cost Nadir-Viewing Remote Sensor for Detection of CO and N2O in the Troposphere

Background

Carbon Monoxide (CO) is a product of incomplete combustion of fossil fuels and natural organic materials. Large quantities of CO are produced hourly from the operation of vehicles, slash and burn agriculture, power plants and forest fires. Increasing levels of atmospheric CO are changing the chemical balance in the troposphere and contribute to changes in the earth's climate.

As MicroMAPS views the earth from an airborne or orbital platform, it produces “snapshots” of the distribution of CO and Nitrous Oxide (N2O) through the technique of non-dispersive correlation spectroscopy. This data is reduced to three-dimensional pictures of percentages of atmospheric CO in the earth’s troposphere.

N2O is a background gas thought to be only slightly affected by man's activities. This gas is used to provide a comparison standard for the measurement of CO above the cloud ceiling. CO is a “greenhouse gas” in its own right, but is equally important as an indicator of the sources of the primary greenhouse gas carbon dioxide (CO2), which results from combustion. A map of CO in the atmosphere can more easily point to the anthropogenic sources of CO2 than a map of CO2 levels. This is because remote sensing CO2 directly is difficult due to its high background level which washes out the relatively small changes due to combustion plumes. This data can then be used in conjunction with other scientific observations to assess the global impact of fossil fuel burning on air quality and climate.

MicroMAPS was developed in the 1990s for launch in 1998 on the Clark Spacecraft as part of NASA’s Small Satellite Technology Initiative (SSTI). It is the successor to the earlier instrument MAPS, which successfully flew on the Shuttle in 1982 and 1994, pioneering the use of remote sensing as a tool for tropospheric exploration. When the program was cancelled the instrument was put into storage for later use in an orbital or aircraft mission.

Airborne at Last!!!

In 2003 an opportunity arose to fly MicroMAPS on the **Proteus** high altitude aircraft developed by Burt Rutan’s company, Scaled Composites.

Proteus at NASA Langley-MicroMAPS is housed in the landing gear housing to the left

Proteus on a test flight over the Western US. MicroMAPS is in the right hand faring.

The first missions were flown by the Proteus pilot, Mike Melvill, in the summer of 2004. Mike recently made aviation history as the first civilian to fly a spaceship out of the atmosphere into low Earth sub orbit. Melvill flew SpaceShipOne to a record-breaking altitude of approximately 62 miles, making him the first private pilot to become an astronaut.

MicroMAPS was flown under the auspices of NASA Langley and a **Virginia Space Grant Consortium (VSGC) team** made up of three Virginia Universities (Old Dominion University, Virginia Polytechnic Institute and University of Virginia) – MicroMAPS is also on Proteus supporting INTEX-NA. **INTEX-NA** is an integrated atmospheric field

experiment with a threefold mission: to identify the quantity of polluting gases and aerosols that flow from North America to the Atlantic Ocean, to understand the transport and chemical changes of these gases over the ocean, and to assess the global impact of this flow on air quality and climate. Dr. Vickie Connors of NASA Langley heads the project.

INTEX-NA is a component of the International Consortium for Atmospheric Research on Transport and Transformation (ICARTT), which takes advantage of the fact that several groups in North America and Europe will conduct concurrent field campaigns this summer with common goals.

TEST FLIGHT OF A MicroMAPS BREADBOARD (DETAILS)

In October 1994 a breadboard model of MicroMAPS was flown on the **NASA** Ames DC-8 research aircraft in an under flight of the **MAPS** which flew on STS68. Approximately 40,000 line km of CO and N2O measurements were made over a 10 day period over the US and southern Canada.

Description of the MicroMAPS Hardware

MicroMAPS is a gas filter correlation radiometer capable of detecting trace atmospheric gasses by remotely sensing their infrared (IR) absorption characteristics. MicroMAPS is based on a commercial instrument called **GASCOFIL** developed by Resonance for pollution monitoring. While the method can be used to detect a number of trace species (including CH4, SO2, and NO2), the current version of MicroMAPS detects CO and N2O from a nadir viewing airborne or orbital platform. To do this, the instrument is equipped with CO and N2O gas cells and configured to observe the earth's IR radiance in a band centered at 4.67 microns. It has been demonstrated that the synchronous detection of alternatively chopped signals through CO, vacuum and N2O view cells can produce a quantitative measure of CO in three tropospheric layers. The simplicity of the method affords a low cost technique for generating global maps of these important atmospheric species when viewing from space.

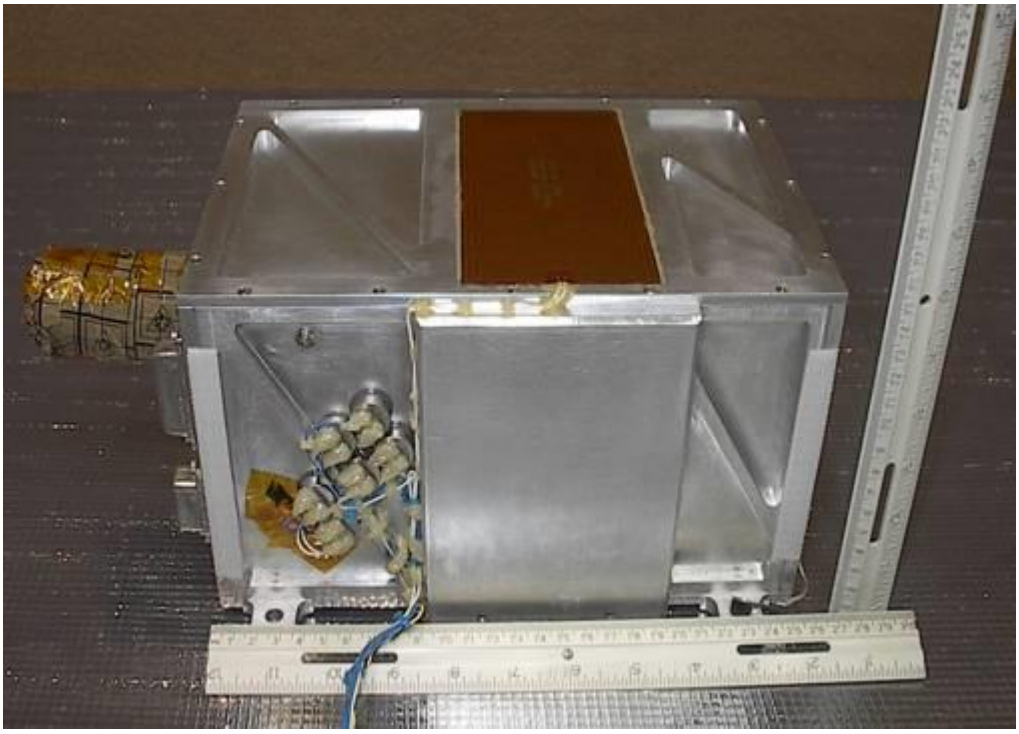

Photo of MicroMAPS at NASA Langley prior to Proteus integration

MicroMAPS uses the same method of detection of trace CO (gas cell correlation spectroscopy) as an older instrument called **MAPS. MAPS (The Measurement of Air Pollution from Satellites)** has heritage from Shuttle missions in 1982, 1984 and 1994 (STS-2, STS-41G and STS-68) See **Reichle et al, [1986]** for a description of **MAPS** over flights.

MicroMAPS differs from **MAPS** in that it has only one optical path with a rotating chopper containing up to eight gas cells instead of three optical paths with two gas cells one clear cell and three detectors. Incoming IR spectral energy from the atmospheric target and ground is collected by a telescope and modulated by gas cell chopper wheel. A PbSe detector converts the optical signals to electronic waveforms which are digitized by a 12 bit A to D converter and processed a digital format by an on board microprocessor.

MicroMAPS Optical Design Specifications

Telescope Aperture	0.8 inches
Telescope field of view	2.4 degrees (Square)
Number of elements	5
Element Material/Coating	Ge/AR Coated gt 99 % T at 4.67m
Etendu (A Omega)	7.2 x 10-3 (cm2 steradian)

Gas Cell Clear Aperture	0.8 inches circular
Beam Size at Gas Cell Chopper	0.2 inches (approx. square)

MicroMAPS Interface Specifications

Size	25.4 x 17.2 x 15 cm (excluding lens tube)
Mass	(6.5 kg max)
Power Consumption	16 Watts max orbital average
Input Voltages	15, -15, 5 Volts
Interface	Serial RS 422 standard with XMODEM protocol