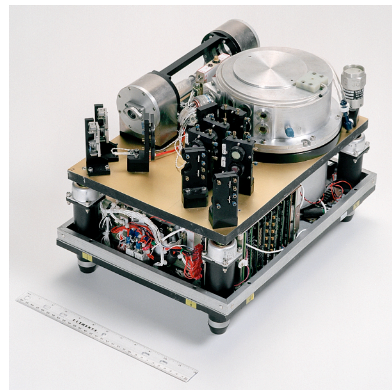
Ames Argus Instrument Laboratory

Instrument Description

Argus is a two channel, tunable diode laser instrument set up for the simultaneous, *in situ* measurement of CO (carbon monoxide), N_2O (nitrous oxide) and CH_4 (methane) in the troposphere and lower stratosphere. The instrument measures 40 x 30 x 30 cm and weighs 21 kg. An auxiliary, in-flight calibration system has dimensions 42 x 26 x 34 cm and weighs 17 kg.



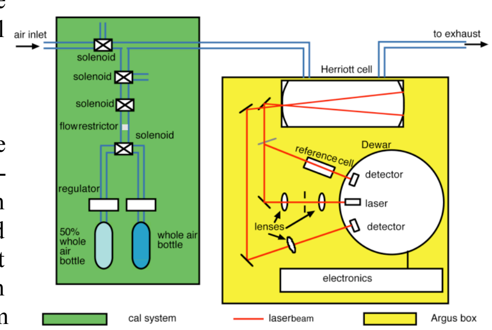
NASA-Ames Research Center Argus instrument. Argus is a relatively small, and light weight instrument that measures in situ gases such as CO, CH_4 and N_2O. The electronics (PC-104 cards sit below the optical table. In flight, Argus is fully contained in a honeycomb composite material lid and flies in fully autonomous mode.

The instrument is an absorption spectrometer operating in rapid scan, second-harmonic mode using frequency-modulated tunable lead-salt diode lasers emitting in the mid-infrared. Spectra are co-added for two seconds and are stored on a solid state disk for later analysis. The diode laser infrared beam is shaped by two anti-refection coated lenses into an f/40 beam focused at the entrance aperture of a multi-pass Herriott cell. The Herriott cell is common to both optical channels and is a modified astigmatic cell (New Focus Inc., Santa Clara, California).

The aspherical mirrors are coated with protected silver for optimal infrared reflectivity. The cell is set up for a 182-pass state for a total path of 36m. The pass number can be confirmed by visual spot pattern verification on the mirrors observed through the glass cell body when the cell is illuminated with a visible laser beam. However, instrument calibration is always carried out using calibrated gas standards with the Argus instrument operating at its infrared design wavelengths, 3.3 and 4.7 micrometers respectively for CH_4 and CO detection. The electronic processing of the second harmonic spectra is done by standard phase sensitive amplifier techniques with demodulation occurring at twice the laser modulation frequency of 40 kHz. To optimize the second-harmonic signal amplitude in a changing ambient pressure environment the laser modulation amplitude is updated every 2 seconds to its optimal theoretical value based upon the measured pressure in the Herriott cell.

Calibration

Argus is regularly calibrated in the laboratory against a CMDL (Climate Monitoring and Diagnostics Lab) whole air standard for CH_4 and CO. Flow-mixing of this standard with a zero gas provides us with absolute calibration and linearity data as inputs to the in situ flight recorded analysis. During field operations Argus is calibrated in the lab both before and after every flight operation with the instrument maintained in its flight setup configuration throughout the calibrations. Argus also employs an in-flight calibration system providing real time calibrations and tightly constrained uncertainty estimates of the returned data.



Argus flight configuration.. During flight, Argus flies with a calibration system that allows switching between ambient air and highly calibrated whole and half air. Typically for every 30 minutes of flight, there is 1 minute of calibration.

Data Analysis

The post-flight data reduction uses a non-linear, least squares Marquardt-Levenberg fitting procedure where theoretical fitting function is the second Fourier component of the modulated Voigt absorption line-shape. One parameter returned by the fitting procedure is the molecule number density (CO and CH_4) in the Herriott cell. This is converted to mixing ratio using the measured gas density in the cell. Argus then reports molecule mixing ratio at 0.5 Hz data rate to the data archive.

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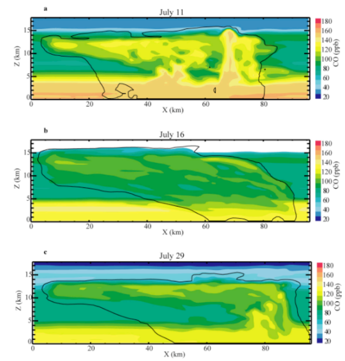
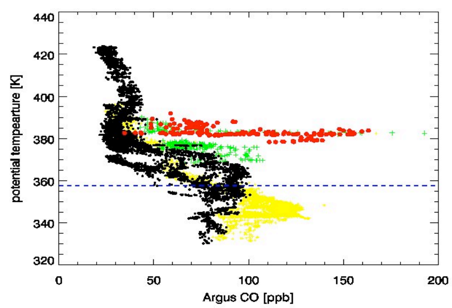
Convective systems are an important mechanism in the transport of boundary layer air into the upper troposphere. The CRYSTAL-FACE campaign, in July 2002, was developed as a comprehensive atmospheric mission to improve knowledge of subtropical cirrus systems and their roles in regional and global climate. *In situ* CO measurements aboard NASA's WB-57F aircraft and U.S. Navy's Twin Otter aircraft were used to study the role of convective transport. Three flights sampled convective outflow on July 11, 16 and 29 found varying degrees of CO enhancement relative to the free troposphere. A cloud-resolving model used the *in situ* CO observations and meteorological fields to study these three systems by properly constraining the model to characterize convective transport. Several methods of filtering the observations were devised here using ice water content, relative humidity with respect to ice, and particle number concentration as a means to statistically sample the model results to represent the flight tracks. A weighted histogram based on ice water content observations was then used to sample the simulations for the three flights. In addition, because the observations occurred in the convective outflow cirrus and not in the storm cores, the model was used to estimate the maximum CO within the convective systems. In general, anvil-level air parcels contained an estimated 20-40% boundary layer air in the analyzed storms.

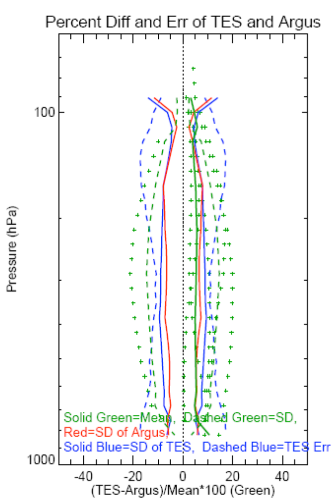


Instantaneous CO cross-section of the three-dimensional model simulations, at a time corresponding to the middle of each flight, at the model location of peak total CO in the convective cores for each flight day.

Elevated CO deep into the stratosphere during CRYSTAL-FACE. Blue dashed lie shows location of the tropopause.



Recent Argus CO measurements during the CRYSTAL-FACE mission showed that mesoscale convective systems helped or triggered by large forest fires inject plumes several kilometers into the stratosphere. A plume was observed 10 days after the injection several thousand kilometers away. Carbon monoxide concentrations increased to 180 ppb, more than 4 times the usual lower stratospheric concentration. Particle concentrations were enhanced, water vapor and CO_2 were increased, and ozone was lower compared to typical values at these altitudes. The single particle analyzer, PALMS, showed a clear biomass burning signature. The CRYSTAL-FACE measurements were the first to unambiguously show that plumes from fires can be injected relatively high into the stratosphere in mid latitudes and that they remain there for many days.



Comparison of Argus CO data with the TES CO data on the AURA satellite during the CR-AVE campaign in 2006. TES averaging kernel has been applied to the Argus vertical profile. Argus measurements always fall between the TES retrieval errors.

Since the launch of the EOS Aura satellite in mid-2004 we have been carrying out validation measurements for instruments on the satellite. Our main objective is to provide data to help validate profile measurements of CH_4 and CO to be made from the ground to 35 km by TES. Additionally some CO, CH_4 and N_2O data will be useful in the validation of MLS (Microwave Limb Sounder; CO and N_2O above 10 km) and HIRDLS (High Resolution Dynamics Limb Sounder; CH_4 and N_2O above 8 km).

Points of Contact:
Max Loewenstein
Argus Principal Investigator
650-604-5504, Max.Loewenstein-1@nasa.gov

Ames Research Center