# OMI Validation Opportunities from the AVE June 2005 Validation Campaign

Ellington Fields, Houston, Tx, USA

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http://cloud1.arc.nasa.gov/ave-houston2/
1 Introduction

This document serves to present the OMI validation opportunities as identified for the AVE June 2005 airborne validation campaign, Houston, TX, USA, aimed to perform validation measurements for the NASA EOS Aura satellite. This document is a follow up on document PL-OMIE-KNMI-652 [1], describing the OMI validation opportunities as identified for the AVE November 2004 airborne validation campaign, which was executed from the same location. As a result, this document also serves to present the lessons learned from previous campaigns. Several OMI validation opportunities will again be pursued but now for different circumstances. The slightly altered payload, with the addition of ACAM, introduces several new validation opportunities.

General considerations on correlative data needs from airborne validation campaign for the validation of the data products of the OMI instrument aboard Aura are presented in document PL-OMIE-KNMI-535 [1]. General considerations on correlative data needs for OMI validation are presented in document TN-OMIE-KNMI-469 [2]. The validation requirements as discussed in the White Paper on OMI Science Goals and Validation Needs [3] update those listed in the Aura Validation Plan and highlight the validation capabilities that need development.

2 The June 2005 AVE Campaign

The June 2005 AVE Campaign will take place from Ellington Field, Houston, Tx, USA, from 10-24 June 2005. From this location the NASA owned WB-57 aircraft is operated which will carry an impressive amount of instrumentation on 5-6 hour flights up to 18 km altitude over more than 4000 km range. Please visit the dedicated website: http://cloud1.arc.nasa.gov/ave-houston2/ for more up to date information.

2.1 Payload instruments

The following suite of instruments will be on board of the WB-57 research aircraft during the June 2005 flights. Instrument details can be found in Chapter 4 of this document.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Product</th>
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<tbody>
<tr>
<td>In situ Argus</td>
<td>CO (carbon monoxide), CH4 (methane), N2O (Nitrous Oxide)</td>
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<tr>
<td>CIMS</td>
<td>HNO3 (Nitric Acid), HCL (hydrochloric acid)</td>
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<tr>
<td>Frost Point</td>
<td>In situ air humidity H2O</td>
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<tr>
<td>FCAS</td>
<td>Aerosols</td>
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<tr>
<td>JIH</td>
<td>Atmospheric H2O (water) vapor</td>
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<td>MSS</td>
<td>Navigation</td>
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<tr>
<td>NMASS</td>
<td>Aerosols</td>
</tr>
<tr>
<td>O3/CH4</td>
<td>O3 (ozone), CH4 (methane)</td>
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<tr>
<td>PANTHER</td>
<td>CH3COCH3 (acetone), PAN, H2, CH4 (methane), CO (carbon monoxide), N2O (nitrous oxide), SF6 (sulfur hexafluoride ), CFC-11, CFC-12, halon-1211</td>
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<tr>
<td>PT</td>
<td>Ambient pressure (p) and temperature (T)</td>
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<td>WAS</td>
<td>CFC</td>
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<tr>
<td>Remote Sensing ACAM</td>
<td>O3 (ozone), NO2 (nitrous oxide), SO2 (sulphur dioxide), BrO (bromine oxide), CHICO (formaldehyde) and aerosols</td>
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<td>CAFS</td>
<td>UV/VIS actinic flux, O3 (ozone) column</td>
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<td>CPL</td>
<td>Cloud height, cloud fraction</td>
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<tr>
<td>MTP</td>
<td>Temperature profiles</td>
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<tr>
<td>Scanning-HIS</td>
<td>Upwelling IR radiance, O3 (ozone) profile</td>
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Table 1: Tentative WB-57 payload for the June 2005 AVE campaign (of interest to OMI.)
3 Validation opportunities

At the moment, nitrogen dioxide (NO2) is the species of interest in the atmospheric science community as an indicator of anthropogenic activity, namely combustion processes (industry, transport), and a key component of air pollution. Under polluted conditions, the tropospheric contribution to the total NO2 column may be comparable to the stratospheric contribution. The tropospheric NO2 column is subject to large spatial and temporal variability, particularly near sources such as power plants, cities and highways. In addition, accurate knowledge of the NO2 altitude distribution is needed in total column retrievals. For an accurate validation of OMI total NO2 column under polluted conditions, the spatial variability as well as the altitude distribution of NO2 should be measured.

There are many sources of correlative data available for total ozone column validation. Ground based Brewer and Dobson instruments suffice for validation of total ozone column under unpolluted conditions. However, validation needs remain for the tropospheric part of the total column, and for total ozone column and tropospheric ozone column under polluted conditions.

It has been well recognized that aerosols play an important role in radiative forcing of the Earth atmosphere. However, the sign and magnitude of the forcing depends on the type of aerosols, their size distributions and the altitude at which they reside in the atmosphere. Aerosols influence the retrieval of atmospheric trace gas species from satellite remote sensing observations. Uncertainties in aerosol abundances influence the (un)certainty of determining the airmass optically sampled and hence the vertical column amounts of atmospheric trace gases. There is a strong need for expanding aerosol observations towards covering more physical and scattering properties of the aerosol material, such as chemical type and physical size of aerosol material and their distributions.

3.1 Nitrogen dioxide tropospheric column observations

The Airborne Compact Atmospheric Mapper (ACAM) spectrometer system is new aboard the WB-57 payload. System details can be found in chapter 4, section 4.2.1. If ACAM performs as expected, AVE flights with the ACAM spectrometer can provide estimates of the tropospheric NO2 column when large amounts of NO2 are present. Performing such flights over pristine regions provides us with a reference spectrum and a background estimate of the tropospheric NO2 column. Performing flights over the Houston regions should provide us with a map of the spatial variability of NO2 in a polluted region. Although at first the measurements may not be quantitative, even a qualitative map will be exciting to compare with OMI. Given the high spatial resolution of ACAM, such flights can provide information on the spatial variability of NO2 at scales smaller than the OMI pixels. Also, if there is boundary layer SO2, it should be possible to measure that.

Flight Requirements:
- Fly along track over regions of low and high air pollution
- Fly near the tropopause for a clear separation of troposphere and stratosphere
- Fly at high altitudes to capture most of the OMI swath as possible.
- Capture the OMI swath near nadir.
- Capture the location of ground based Dobson and Brewer instruments

Opportunities:
0 High altitude overpasses over regions of low air pollution (reference)
0 High altitude overpasses over regions of high air pollution (cities or power plants)
0 Moderate altitude overpasses over regions of high air pollution (cities or power plants)

3.2 Atmospheric pollution

The payload for the AVE Houston June ’05 campaign contains instruments that together could provide a suite of measurements of atmospheric pollution. The CAFS instrument is able to measure the column amounts of ozone above and below the aircraft. The ACAM spectrometers are likely to provide us with column amounts of O3, NO2 and SO2 below the aircraft. The in-situ instruments FCASS and NMASS measure aerosols size distributions and chemical composition in the air mass sampled by the aircraft. When cruising near the tropopause, the remote sensing instruments will yield estimates of tropospheric and stratospheric abundances.
Crenellation flights down to the boundary layer offer the opportunity of sampling large parts of the troposphere and could in principle render limited information of profiles.

**Flight Requirements:**
- Fly along track over regions of low and high air pollution
- Fly near the tropopause for a clear separation of troposphere and stratosphere
- Perform crenellation flights down to the boundary layer particularly for aerosols sampling

**Opportunities:**
- Simultaneous sampling of atmospheric pollution by remote and in-situ sensors
- Aerosol physical properties and their distributions
- Spatial variability of atmospheric pollution

### 3.3 Urban Scales

An interesting scientific question regarding OMI is whether the instrument is capable of measuring atmospheric pollution at urban scales. Such a capability offers the opportunity to pinpoint sources of pollution. Species involved are O$_3$, NO$_2$, SO$_2$ and aerosols. For example, if there is a plume of highly polluted air that is roughly a kilometer wide and several OMI pixels long, ACAM will be able to capture the higher resolution details of the event and comparisons with OMI data will yield an estimate of the pinpointing capabilities of OMI. The Texas Commission on Air Quality could tell us where to look on a daily basis over the Houston region. We can also target a good coal burning power plant. A high altitude over flight of Houston would let ACAM map it out.

**Flight Requirements:**
- Straight and level sampling of the Houston region
- Focused sampling of industrial regions with point sources of pollution

**Opportunities:**
- Flights over highly polluted regions with lots of ozone, NO$_2$, SO$_2$ and aerosols
- Mapping the region with ACAM searching for point sources of pollution
- Sampling of point sources of pollution with ACAM for comparisons with OMI (selected power plants)

### 3.4 Lessons learned from AVE Houston October 2004 campaign

During the October 2004 deployment we mostly obtained data while the WB-57 flew along the OMI nadir track, over open land and ocean and over several types of clouds. This deployment showed that the OMI total ozone column and the sum of the O$_3$ column estimates above and below the aircraft of CAFS are comparable in magnitude and reveal similar spatial features. However, further analysis revealed that scattered light from near the horizon appears to be limiting the accuracy of the total column ozone retrieval from the up-looking CAFS instrument. For the June flights we have recommended modifying the CAFS system to block 5 or 10 degrees above the horizon to remove the contribution from long path length photons. With such a modification in place we suggest that the measurements performed during the October 2004 deployment be repeated on a limited number of flights with a request to cover more of the OMI swath and measure more over low and high clouds. Analysis also showed that the retrievals of ozone below the aircraft from the lower CAFS instrument was heavily influenced by the assumed a priori. More investigation is needed to show the information content of this observation. Excursions to the tropics, as requested by Lucien Froidevaux of MLS can be used for OMI validation as well.

### 3.5 Other opportunities

There are plans to launch ozone sondes around Houston. This would be useful for validating scanning-HIS. It will also be useful for OMI although OMI validation will first focus on validating total column ozone by comparisons with Dobson and Brewer ground based instruments, and TOMS, GOME and SCIAMACHY satellite instruments. Flight tracks over ground sites with such ground based total ozone column measuring instruments or with ozone sondes are highly desired. Microtops measurements of total column ozone should be made at Ellington Fields before and after each flight for comparison with CAFS.
4 Payload Instruments for AVE June 2005 Flights

4.1 In situ

Argus (CO, N2O, and CH4), CIMS (HCl and HNO3), FCAS (particles), Frostpoint (H2O), JLH (humidity), NMASS (aerosols), Ozone/Methane (O3, CH4), PT (pressure, Temperature), WAS (CFC’s).

4.1.1 Argus

PI: Max Loewenstein, Co-PI: Hans Jurg Jost, James R. Podolske

Argus is a two channel, tunable diode laser instrument set up for the simultaneous, in situ measurement of CO (carbon monoxide) and CH4 (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.

Website: http://cloud1.arc.nasa.gov/ave-houston/instruments.cgi

4.1.2 CIMS

PI: David W. Fahey, Co-PI: Ru-shan Gao

The Chemical Ionization Mass Spectrometers (CIMS) instrument has two independent detection channels. For CRYSTAL/FACE both channels are configured for measurements of ambient nitric acid (HNO3). A schematic of the principal components of the CIMS instrument, including the inlets, ion sources, quadrupole mass spectrometers, vacuum chamber, pumps, and gas supply is shown in CIMSdescription.pdf. For HNO3 detection, reagent ions SF5- are generated and mixed into the ambient air sample.

Website: http://cloud1.arc.nasa.gov/crystalface/WB57_files/CIMSdescription.pdf

Website: http://cloud1.arc.nasa.gov/solve/payload/er2/cims2.html
4.1.3 FCAS
PI: Dr. J.C. Wilson

The Focused Cavity Aerosol Spectrometer (FCAS) II sizes particles in the approximate diameter range from 0.07 mm to 1 mm. Particles are sampled from the free stream with a near isokinetic sampler and are transported to the instrument. They are then passed through a laser beam and the light scattered by individual particles is measured. Particle size is related to the scattered light. The data reduction for the FCAS II takes into account the water which is evaporated from the particle in sampling and the effects of anisokinetic sampling.

Accuracy: The instrument has been calibrated with monodisperse aerosol carrying a single charge. The FCAS III and the electrometer agree to within 10%. Sampling errors may increase the uncertainty but a variety of comparisons suggests that total uncertainties in aerosol surface are near 30% (Johnson, et al., 1995). Precision: The precision equals 1/√N where N is the number of particles counted. In many instances the precision on concentration measurements may reach 7% for 0.1 Hz data. If better precision is desired, it is necessary only to accumulate over longer time intervals. Response Time: Data are processed at 0.1 Hz. However, the response time depends upon the precision required to detect the change in question. Small changes may require longer times to detect. Plume measurements may be processed with 1 s resolution. Weight: Approximately 50 lbs.

The FCAS II and its predecessors have provided accurate aerosol size distribution measurements throughout the evolution of the volcanic cloud produced by the eruption of Mt. Pinatubo. Near coincidences between FCAS II and SAGE II measurements show good agreement between optical extinctions calculated from FCAS size distributions and extinctions measured by SAGE II.

Website: http://www.engr.du.edu/aerosol/fcas.htm

4.1.4 Frost Point Hygrometer
PI: ?
Explanatory text ?.
Website ?.

4.1.5 JLH
PI: Robert L. Herman, Co-PI: Randy D. May

The JPL Near-IR Water Spectrometer for the ER-2, DC-8, and WB57F Aircraft is a new instrument for in-situ measurements of atmospheric water vapor from aircraft platforms such as the ER-2, the DC-8, and the WB57F aircraft. It is based upon a near-IR tunable diode laser source operating near 1.37 microns. The spectrometer features an open-path, multipass (Herriott) cell for true in situ monitoring of H₂O concentrations with precision levels exceeding those of Lyman-a and frost-point hygrometers. External sampling outside the aircraft boundary layer minimizes measurement uncertainties and enables high-speed in situ sampling along the aircraft flight track. Measurement precision is ± 0.05 ppmv in the stratosphere for a 2 s measurement integration period.

Website: http://laserweb.jpl.nasa.gov/earthinstruments/h2owb57.html

4.1.6 NMASS
PI: Dr. J.C. Wilson

The Nucleation-Mode Aerosol Size Spectrometer (N-MASS) measures the concentration of particles as a function of diameter. A sample flow is continuously extracted from the free stream using a decelerating inlet and is transported to the N-MASS. Within the instrument, the sample flow is carried to 5 parallel condensation nucleus counters (CNCs). An inversion algorithm is applied to recover a continuous size distribution

Website: http://www.engr.du.edu/aerosol/nmass.htm

4.1.7 Ozone/Methane (O₃/CH₄)
Methane Near IR Tunable Diode Laser Absorption Spectrometer
The tunable diode laser (TDL) absorption instrument consists of a very high resolution scanning near-infrared diode laser spectrometer. By use of the Beer-Lambert law, the methane number density is calculated from the direct absorption measurements.

Website: http://cloud1.arc.nasa.gov/crystalface/WB57_files/CH4noaa.pdf

NOAA Dual-Beam UV Absorption Ozone Photometer
Ozone is measured in situ using a photometer consisting of a mercury lamp, two sample chambers that can be periodically scrubbed of ozone, and two detectors that measure the 254-nm radiation transmitted through the chamber (Proffitt et al. [1983]). The ozone number density is calculated using the ozone absorption cross-section at 254 nm and the Beer-Lambert Law. Website: http://cloud1.arc.nasa.gov/crystalface/WB57_files/O3noaa.pdf
4.1.8 Pressure-Temperature (PT) Instrument  
PI: Tom Thompson  
The PT instrument measures ambient pressure and temperature of the outside air surrounding an aircraft in flight. Since there is always a velocity-heating factor that affects the temperature measurement, ram pressure must also be measured. The PT instruments consists of two accurate pressure transducers for measuring static and ram pressure, an accurate conditioning amplifier for the platinum resistor temperature probe, a means for tapping into the WB-57F pitot/static system, a platinum resistor temperature probe, and a computer for taking the probe measurements and recording the data. The temperature probe must mount outside the aircraft in the free air stream.  
Website: http://cloud1.arc.nasa.gov/crystalface/WB57_files/PTnoaa.pdf

4.1.9 WAS  
PI: Elliot Atlas & Stephen Donnelly (NCAR)  
The Whole Air Sampler (WAS) collects samples for a range of trace gases including CFCs, HCFCs, HFCs, Methane, C2-C5 alkanes, C1 and C2 chlorinated compounds, Halons, methyl halides, Bromochloromethanes, alkyl nitrates, etc. Trace gases are collected in stainless steel canisters for analysis by GC/FID and GC/MS techniques.  
Website: http://www.atd.ucar.edu/dir_off/airborne/was.html

4.2 Remote Sensing  
ACAMS  
CCD Actinic Flux Spectroradiometry (CAFS) - UV/Vis - Rick Shetter, Ned Reidel  
Cloud Physics Lidar (CPL) - Matthew McGill, Kevin Kroliczky  
Scanning High-resolution Interferometer Sounder (SHIS) - Fred A. Best, Joe K. Taylor

4.2.1 ACAM  
Pis: Scott Janz and Paul Newman  
The Airborne Compact Atmospheric Mapper (ACAM) consists of two spectrographs and two cameras. There are two Ocean Optics spectrographs, one optimized for the UV [covering from 290 to 380 nm at 1 nm spectral resolution], and one optimized for the visible [covering from 360 to 520 nm at 1 nm spectral resolution]. The spectrographs share a common fiber optic feed to a collimator which will image a circular FOV of ~1.5 km diameter from an altitude of 18 km. This FOV can be scanned left and right via a small mirror up to angles of +/-40 degrees. The spectrographs cover wavelengths of interest for trace gas measurements (O3, NO2, SO2, BrO, CHCO) and aerosols. A Nikon 8700 digital camera (3,264 x 2,448 pixels) is mounted in the cockpit for forward viewing, pre-programmed to shoot 1 frame every minute. A Nikon 8800 image stabilized digital camera (3,264 x 2,448 pixels) is mounted in the wing hatch looking down, pre-programmed to shoot 1 frame every 30 seconds. The Nikon 8800 will be synchronized with the ACAM scanner such that a pre-programmed number of cross-track scans can be performed in between every Nikon image. The two primary objectives of ACAM on AVE are: (1) Determine whether this type of miniature spectrograph system is stable enough and has sufficient signal-to-noise to perform trace gas retrievals of NO2 for validation purposes, and if so determine the minimum measurable slant-column concentration for a given spatial resolution element is. (2) Determine whether we can calibrate the spectrographs and maintain the calibration sufficiently to enable absolute radiance transfers with satellite instruments (e.g., OMI) at the sub-5% accuracy level.  
Website: http://code916.gsfc.nasa.gov/Public/Ground_based/acam/acam.html

4.2.2 CAFS  
P: Rick Shetter, Co-PI: Ned Reidel  
The CCD Actinic Flux Spectroradiometry (CAFS) measurements we will be making on the WB-57 are wavelength dependent down and up welling actinic flux. The actinic flux optical collectors are a series of concentric quartz hemispheres that provide photons to the transfer fiber optic bundle. These optics collect photons independent of angle over the upper or lower hemisphere. The Zeiss solid state monochromators used have cooled back thinned UV enhanced CCD detectors and a wavelength range of 280-680 nm with a FWHM of ~1.9 nm. We will probably limit the wavelength range to the UV with an optical filter to improve the stray light rejection of the spectrometer for improved UV measurements. The angular acceptance of the up-looking instrument will be limited to approximately +/-80 degrees to enhance the sensitivity to total column ozone.
The WB-57 instruments are small (~40 lbs each) and low power (~8 amps of 28 volt DC power). These instruments have previously flown on the WB-57 and showed a stable performance. We have a lot of experience determining wavelength dependent actinic flux from aircraft. We have been making measurements on the NASA DC-8 and P-3B, the NCAR C-130, and the NOAA P-3 Orion for ~8 years. These missions concentrated on atmospheric photochemistry so we derived atmospheric photolysis frequencies for ~20 photo-chemically important molecules from the UV and visible. We are jointly developing and algorithm to determine the total ozone above the aircraft from the WB-57 measurements. The algorithm will use the UV irradiance in a Dobson like approach. This should allow for some ozone profiles. In addition, we hope to develop techniques to determine some aerosol parameters. We do not believe that we will be able to retrieve NO2, CH2O, or SO2 from our spectra due to the instrument resolution and line shape.

Website: http://www.atd.ucar.edu/dir_off/airborne/safs.html
Website: http://arim.acd.ucar.edu/people/shetter.html

4.2.3 CPL
PI: Matthew McGill
The Cloud Physics Lidar (CPL) is a cloud lidar developed by NASA Goddard and flies on the ER2 high altitude aircraft (McGill, M. et al., 2002). The CPL is an active remote sensing system, capable of very high vertical resolution cloud height determinations (30 meters), cloud visible optical depth, and backscatter depolarization. The depolarization measurement allows for the discrimination between ice and water clouds. Photons backscattered on the surface of spherical water droplets have very little depolarization in contrast to ice crystals where the backscatter results in large depolarization. For CPL measurements, depolarization of greater then 25% are ice while polarizations less then 10% are generally water clouds. The CPL laser transmits at 355, 532, and 1064 nm and fires 5000 shots/sec. For this paper, the 532 nm one second averaged data is used. The high sample rate of the CPL results in a surface footprint that can be approximated as a continuous line with a diameter of 2 meters. A robust collocation algorithm is used to collocate the CPL measurements with the SHIS. On average, ten CPL are measurements are found in each 2-km SHIS field of view. The collocated CPL measurements of cloud height, depolarization, and optical thickness are used in this paper to analyze the sensitivity of SHIS cloud top retrievals.

Website: http://www.sigmaspace.com/www/projects_cloud_physics_lidar.htm

4.2.4 SHIS
PI: Fred. A. Best, Co-PI: Joe K. Taylor
The Scanning High-resolution Interferometer Sounder (SHIS) is an aircraft based scanning Fourier transform interferometer designed to measure atmospheric infrared radiances at high spectral and spatial resolutions (Revercomb, H. E. et al., 1998). The SHIS measures the infrared emission between 3.0 – 16 microns with a spectral resolution of approximately 0.5 wavenumbers. The SHIS has a 100 mrad field of view and is capable of cross scanning. The measured emitted radiance is used to obtain temperature and water vapor profiles of the Earth's atmosphere. SHIS produces sounding data with 2-kilometer resolution (at nadir) across a 40-kilometer ground swath from a nominal altitude of 20 kilometers onboard a NASA ER-2 aircraft or 20 kilometer ground swath from a nominal altitude of 10 kilometers aboard the NASA DC-8 aircraft. With a flight altitude of 20 km the nadir SHIS fields of view have a 2 km diameter surface footprint. The footprint is slightly oval along the flight track due to the 1- second dwell time and 200 m/s along track velocity.

Website: http://deluge.ssec.wisc.edu/~shis/
Website: http://www.kgs.ukans.edu/Hydro/Hutch/NASA/

4.3 Navigation
The MMS instrumentation consists of three major systems:
- Air motion sensing system measuring the velocity of the air with respect to the aircraft (true air speed)
- Inertial navigation system measuring the velocity of the aircraft with respect to the earth (ground speed)
- Data acquisition system to sample, process and record the measured quantities.

The air motion sensing system consists of sensors, which measure temperature, pressures, and airflow angles (angle of attack and yaw angle). The Litton LN-100G Embedded GPS Inertial Navigation System (INS) provides the aircraft attitude, position, velocity, and acceleration data. On the DC-8, the Trimble TANS Vector provides secondary attitude and navigation data. The TANS Vector utilizes the GPS carrier phase shift between multiple
antennas to derive independent aircraft attitude. The Data Acquisition System samples the independent variables simultaneously and provides control over all system hardware. Website: http://geo.arc.nasa.gov/sgg/mms/instrument.htm

5 References


6 Appendix – Targets of Possible Point Source Emission

1) Bowen Power Plant 166,000 tons/yr SO2 Georgia 34º 7.7´N 84º 55.2´W [http://www.climateark.org/articles/reader.asp?linkid=38108](http://www.climateark.org/articles/reader.asp?linkid=38108)

2) EC Gaston Power Plant 121,000 tons/yr SO2 Alabama 33º 14.6´N 86º 27.5´W


4) Big Brown Power Plant 82,000 tons/yr SO2 Texas 31º 49.0´N 96º 2.1´W
5) Monticello Power Plant  76,000 tons/yr SO2  Texas  33º 5.4´N  95º 1.8´W
http://www.txucorp.com/power/plants/monticello.aspx

Environmental Media Services:
“Dirty kilowatts: america's 50 dirtiest power plants emit up to 20 times more pollution than plants with state-of-art controls”. http://www.ems.org/nws/2005/05/11/newsreport_50_di

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