FLIGHT SUMMARY REPORT

Flight Number: 93-077

Calendar/Julian Date: 28 March 1993 • 087

Sensor Package: Modis-N Airborne Simulator (MAS)
Radiation Measurement System (RAMS)
Cloud Lidar Systems (CLS)
(WOX)

Area Covered: Central Equatorial Pacific Ocean

Aircraft #: 709

Investigator: Valero, NASA-ARC

SENSOR DATA

Sensor Type	Sensor ID #	Quality	Remarks
MAS	108	Fair	Data on: 22:29 GMT Data degraded at 00:51 GMT
RAMS	112	___	
CLS	113	___	
WOX	115	___	

Central Equatorial Pacific Experiment

A NASA high altitude ER-2 was deployed to the Fijian Islands in March 1993 as part of a multiple platform (surface, airborne and space-borne) campaign in support of the Central Equatorial Pacific Experiment (CEPEX). The overall scientific goal of CEPEX was to establish the respective roles of cirrus radiative effects and surface evaporation in limiting maximum surface temperature in the equatorial Pacific. The following executive summary extract describes CEPEX and its project objectives.

Of the atmospheric greenhouse gases, water vapor is the most effective in producing atmospheric warming. Water vapor concentrations increase rapidly over the tropical oceans when sea surface temperatures (SSTs) begin to rise (as in global warming scenarios). This effect is greatest over the huge "warm pools" of the Pacific Ocean. The water vapor content of the atmosphere above the ocean increases by approximate 15-20% for each one percent of increase in the SST. These increasing concentrations of water vapor trap more and more heat, which causes the ocean's surface temperature to rise even further, thus creating a "super-greenhouse effect." Unchecked, this feedback mechanism would result in runaway warming. This is not what is observed, even in the "warm pool," SSTs never exceed 304^{o} K (31^{o} C). This suggests that some kind of "thermostat" might exist. Furthermore, deep intensive convection over the tropical oceans, with cloud tops reaching 18 to 20 km altitude, occurs only when SSTs exceed about 300^{o} K.

It has been argued that the cooling by evaporation from the ocean surface provides such a mechanism. However, observations from space and from the atmospheric boundary layer indicate that this process is not adequate. Rather, it might be the very high and cold cirrus clouds, streaming from the tropical thunderstorms, which stretch over large areas of the Pacific and reflect the incoming solar radiation that may, in fact, act as the thermostat.

Direct in-situ measurement of radiation fluxes, cirrus microphysics, evaporation rates, and water vapor distributions must be obtained over a range of SSTs, from regions where SST is just below the convection threshold temperature, to regions where SST exceeds it. Accordingly, the CEPEX experiment domain was to encompass the transition (with respect to SST) region from the central equatorial Pacific to the tropical south Pacific or the tropical western Pacific "warm pool."

The primary experimental objectives of CEPEX were:

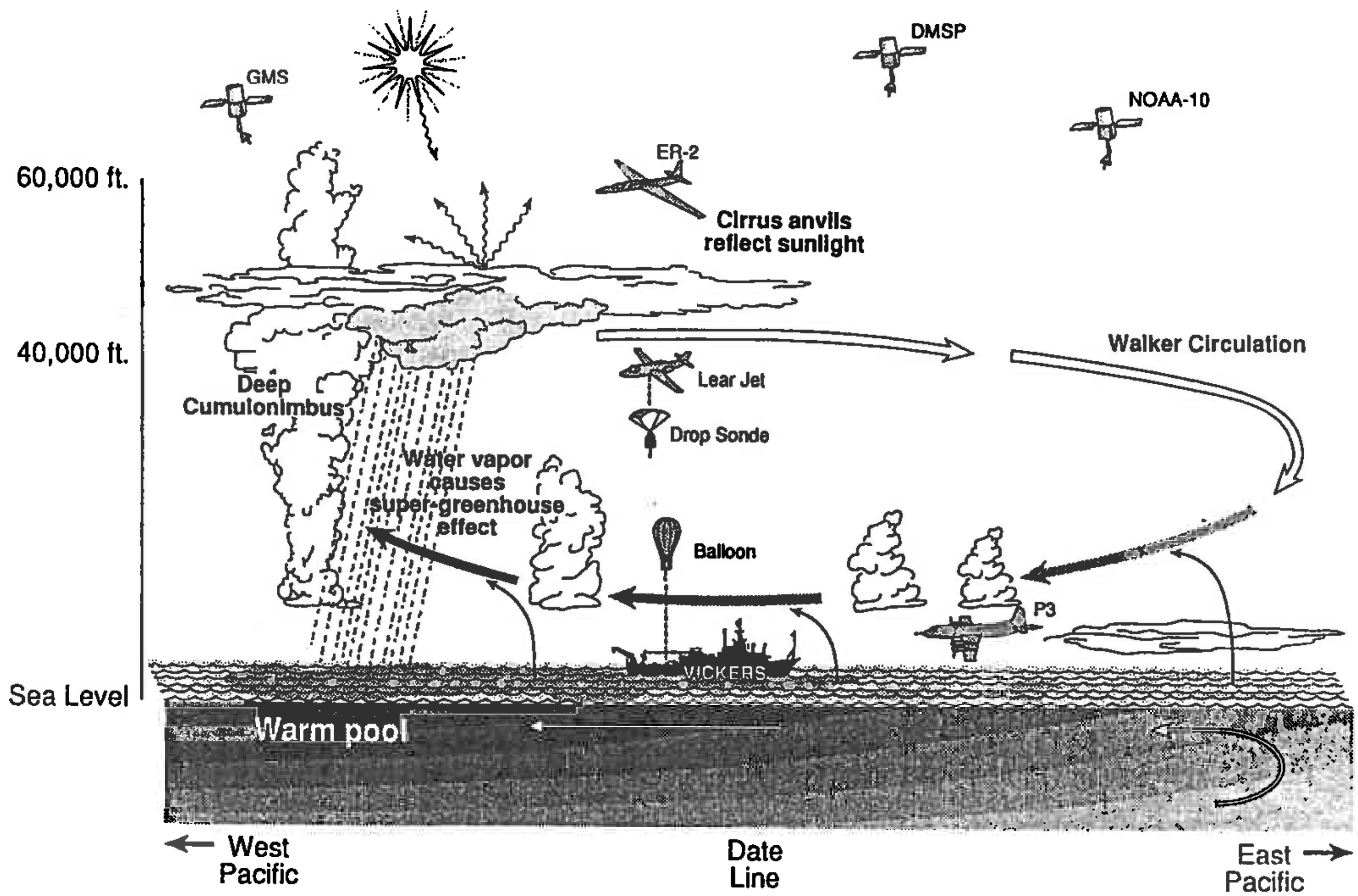
(1) to measure, by direct atmospheric observations, the vertical structure of the water vapor greenhouse effect;

(2) to measure the effect of cirrus on radiation fluxes over the equatorial Pacific;

(3) to measure the east-west gradients of SST and the evaporative and sensible heat flux from the sea surface along the equatorial Pacific;

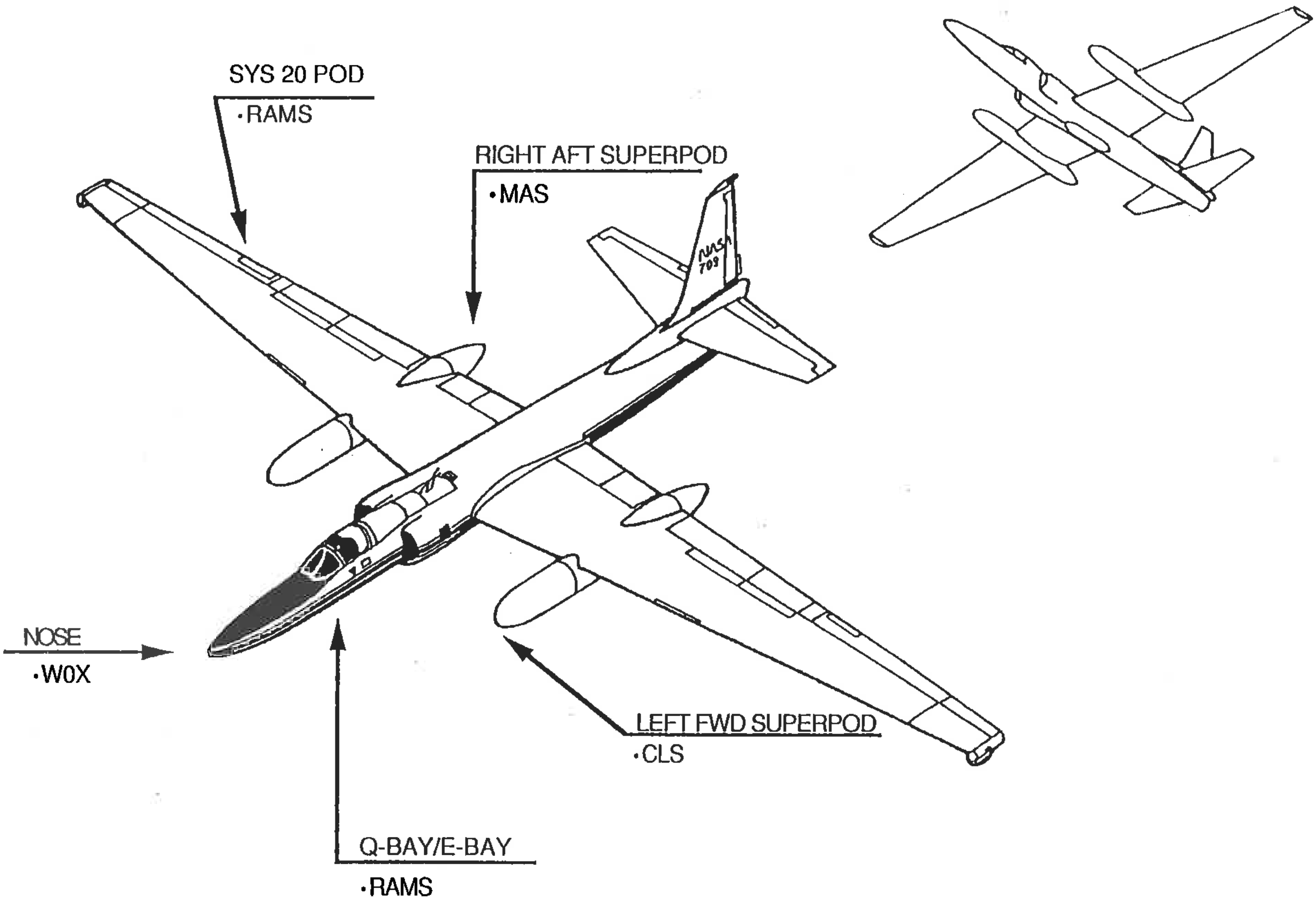
(4) to measure the east-west gradients of vertical distribution of water vapor along the equatorial Pacific and;

(5) to explore the microphysical factors contributing to the high albedo of widespread tropical cirrus layers.



CEPEX employs surface, airborne, and space-borne platforms. The airborne platforms are NASA's ER-2, Aeromet's Learjet, and the NOAA P-3. The surface platforms include the R/V *Vickers* ship, TOGA-COARE moorings (buoys), and upper-air stations on islands. Space-borne platforms are sun-synchronous polar orbiters (NOAA-10 and DMSP) and geo-synchronous satellites (GMS). Instruments on these platforms measure radiation fluxes, cirrus radiative and microphysical properties, vertical water vapor distribution, evaporation from the sea surface, and precipitation.

CEPEX CONFIGURARTION



Airborne Science and Applications Program

The Airborne Science and Applications Program (ASAP) is supported by three ER-2 high altitude Earth Resources Survey aircraft. These aircraft are operated by the High Altitude Missions Branch at NASA-Ames Research Center, Moffett Field, California. The ER-2s are used as readily deployable high altitude sensor platforms to collect remote sensing and *in situ* data on earth resources, celestial phenomena, atmospheric dynamics, and oceanic processes. Additionally, these aircraft are used for electronic sensor research and development and satellite investigative support.

The ER-2s are flown from various deployment sites in support of scientific research sponsored by NASA and other federal, state, university, and industry investigators. Data are collected from deployment sites in Kansas, Texas, Virginia, Florida, and Alaska. Cooperative international scientific projects have deployed the aircraft to sites in Great Britain, Australia, Chile, and Norway.

Photographic and digital imaging sensors are flown aboard the ER-2s in support of research objectives defined by the sponsoring investigators. High resolution mapping cameras and digital multispectral imaging sensors are utilized in a variety of configurations in the ER-2s' four pressurized experiment compartments. The following provides a description of the digital multispectral sensors and camera system(s) used for data collection during this flight.

Modis-N Airborne Simulator

The Modis-N Airborne Simulator (MAS) is a modified Daedalus multispectral scanner. It records up to 12 8-bit channels, which can be selected from an array of 50 available spectral bands. The band selection is made prior to flight and the instrument is hard-wired to that configuration. Channel one can be used to store additional bits which provide 10-bit resolution for channels 9 through 12. The band configuration for this deployment is as follows:

Channel	Band edges µm
1	-----
2	0.675 - 0.685
3	1.605 - 1.655
4	1.955 - 2.005
5	3.675 - 3.825
6	4.325 - 4.575
7	4.575 - 4.725
8	9.000 - 9.400
9*	9.400 - 9.800
10*	9.800 - 10.200
11*	10.700 - 11.200
12*	12.200 - 12.700

* 10-bit resolution

Sensor/Aircraft Parameters:

Spectral Channels:	50
Output Channels:	7 8-bit and 4 10-bit
IFOV:	0.5 mrad
Ground Resolution:	163 feet (50 meters at 65,000 feet)
Total Scan Angle:	85.92°
Pixels/Scan Line:	716

Scan Rate:	6.25 scans/second
Ground Speed:	400 kts (206 m/second)
Roll Correction:	Plus or minus 3.5 degrees (approx.)

The U.S. Geological Survey's EROS Data Center at Sioux Falls, South Dakota serves as the archive and product distribution facility for NASA-Ames aircraft acquired photographic and digital imagery. For information regarding photography and digital data (including areas of coverage, products, and product costs) contact EROS Data Center, Customer Services, Sioux Falls, South Dakota 57198 (Telephone: (605) 594-6151).

Radiation Measurement System

The Radiation Measurement System (RAMS) is an integrated system of several radiometers. The system provides airborne measurements to support analysis and theoretical calculations of cloud properties and radiation fields and to provide validation of satellite radiance measurements. The airborne instruments consist of the following:

1. an electrically calibrated pyroelectric radiometer for hemispherical, broad spectral bandpass, radiative flux measurements in the solar spectral region (0.26 to 2.6 μm). This radiometer has two detectors;

2. an IR net flux radiometer (rotating) radiometer covering the spectral range from 5 to 40 μm;

3. a narrow field-of-view, narrow spectral bandpass IR radiometer (2 channels in the 5 to 40 μm region). This radiometer uses a liquid nitrogen cooled black body reference. This instrument provides upwelling infrared intensities above cloud; and

4. a total-direct-diffuse multichannel narrow spectral bandpass (about 5 to 10 nm) flux radiometer. This radiometer is used for optical depth determinations and direct/diffuse ratios.

For additional information regarding this system contact Francisco P.J. Valero, Atmospheric Physics Research Branch, NASA-Ames Research Center, Mail Stop 245-4, Moffett Field, CA 94035-1000.

Cloud Lidar System

The Cloud Lidar System (CLS) is flown on the ER-2 to conduct cloud radiation and severe storm field experiments. Designed to operate at high altitudes in order to obtain measurements above the highest clouds, the instrument provides the true height of cloud boundaries and the density structure of less dense clouds. The height structure of cirrus, cloud top density and multiple cloud layers may also be profiled. System specifications are as follows:

Transmitter

Laser Type:	Nd:YAG I,II
Wavelength:	1064, 532 nm
Pulse Energy:	90, 30 mJ
PRF:	10 Hz
Beamwidth:	1 mrad
Data Acquisition:	Measurements at 20 m intervals at 200 m/sec aircraft speed

Receiver

Diameter:	0.15 m
Beamwidth:	1.4 mrad
Polarization:	v & h

Data System

Range Resolution:	7.5 m
Number of Channels:	4
Samples per Channel:	3310
Record Capacity:	8 hours

For additional information regarding this instrument contact Dr. James Spinhirne, NASA-Goddard Space Flight Center, Code 917, Greenbelt, MD 20771.

Water Ozone Experiment

The Harvard Water Ozone eXperiment (WOX) resided in the nose of the ER-2 during the CEPEX campaign. Water and ozone molecules are critical for an integrated understanding of deep convection: water vapor is the primary driver of convection, and ozone, in addition to being radiatively important, can be used to identify regions of deep convection because of its steep gradient in the lower stratosphere.

The water vapor instrument uses the techniques of photofragment fluorescence combined with dual path absorption to measure water vapor concentrations ranging from 10^{13} to 10^{16} molecules/cm^3 at pressures from 50 to 500 mb. The detection scheme utilizes Lyman-alpha photons (121.6 nm) to photodissociate water vapor and produce excited OH molecules, which emit photons that are detected by a photomultiplier near 314 nm. Dual-path absorption measurements (path length 8.9 cm), which provide a self-consistent check in the laboratory, are carried out during the ascent and descent part of each ER-2 flight to verify the fluorescence calibration. Inflight diagnostics, such as periodically changing the air flow velocity, confirm that the water vapor measurements are not contaminated by the walls of the instrument.

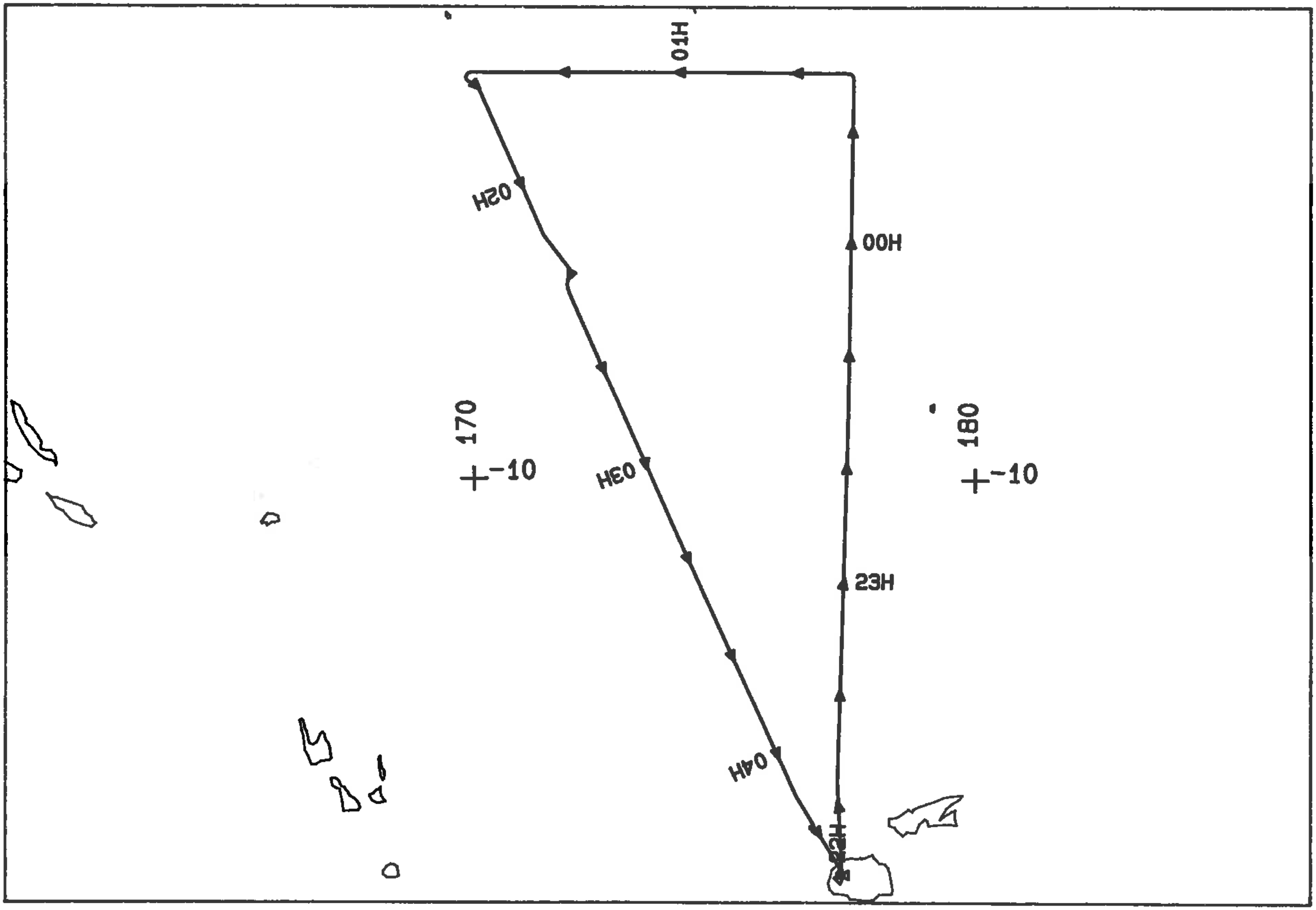
The ozone instrument determines ozone by measuring the absorption of 253.7 nm radiation. Ambient air is alternately drawn through a scrubber that chemically removes ozone and through a teflon inlet tube. With ozone scrubbed air flowing through the detection cell, the reference signal I_0 is determined. The ozone signal I is determined with ambient air flowing through the cell. The ozone concentration is then determined by Beer's law,

$$[O_3] = \frac{-1}{\sigma\lambda} \log \left(\frac{I}{I_0} \right)$$

where σ is the ozone cross section and λ is the path length. Inflight diagnostics confirm proper operation of the instrument.

For further information contact Elliot Weinstock, Harvard University, Engineering Sciences Laboratory, 40 Oxford Street, Cambridge, MA 02138.

Additional information regarding ER-2 acquired photographic and digital data is available through the Aircraft Data Facility at Ames Research Center. For specific information regarding flight documentation, sensor parameters, and areas of coverage contact the Aircraft Data Facility, NASA-Ames Research Center, Mail Stop 240-6, Moffett Field, California 94035-1000 (Telephone: (415) 604-6252).



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