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APPENDIX B--ACRONYMS

(Acronyms for Appendix C and following are yet to be included)

3-D	Three Dimensional
4DVAR	4-Dimensional Variational assimilation
ACE	Arctic Cloud Experiment
ADAM Lite	ARM Data Acquisition System for use at SHEBA
ADCP	Acoustic Doppler Current Profiler
ADEOS	Advanced Earth Observing Satellite
ADT	Alaska Daylight Time
AERI	Atmospheric Emitted Radiance Interferometer
AES	Atmospheric Environment Service(Canada)
AFB	Air Force Base
AIMS	Airborne Imaging Microwave Spectrometer
AiRMISR	Airborne Multi-angle Imaging Spectro-Radiometer
AMPR	Advanced Microwave Precipitation Radiometer
APM	Assistant Project Manager
APU	Auxiliary Power Unit
ARC	Ames Research Center(NASA)
ARCS	Atmospheric Radiation and Cloud Stations
ARCSS	Arctic Systems Science(NSF)
ARGOS	(satellite used to telemeter data to shore station[France])
ARM	Atmospheric Radiation Measurement(Program)(DOE)
AS	Aircraft Scientist
ASCII	American Standard Code for Information Exchange
ASF	Alaska SAR Facility(U. AK)
AST	Arctic Cloud Experiment Science Team
ASTER	Advanced Spaceborne Thermal Emission and Reflection radiometer
ATC	Air Traffic Control
ATD	Atmospheric Technology Division(NCAR)
ATSR	Along-Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
AVNIR	Advanced Visible and Near Infrared Radiometer
BB	Broad band
BBSS	Balloon-Borne Sounding System
BDRF	Bi-Directional Reflectance Function
BL	Boundary Layer
BM	Basic Measurement
BSRDF	Bi-directional Spectral Reflectance Distribution Function
C-130	NCAR aircraft
CART	Cloud and Radiation Testbed
CB	Cloud Behavior(Model)
CCN	Cloud Condensation Nuclei
CCNC	Cloud Condensation Nuclei Counter
CD-ROM	Compact Disk-Read Only Memory
CDT	Central Daylight Time
CERES	Clouds and the Earth's Radiant Energy System
CFD	Continuous Flow Diffusion(Chamber)
CIRES	Cooperative Institute for Research in the Environmental Sciences
CLS	Cloud Lidar System
CMC	Canadian Meteorological Center

CN	Condensation nuclei
CO_2	Carbon Dioxide
CODIAC	Cooperative Distributed Interactive Atmospheric Catalog
CPI	Cloud Particle Imager
CRREL	Cold Regions Research and Engineering Laboratory(Army-COE)
CSPHOT	Cimel Sunphotometer
CSU	Colorado State University
CTD	Conductivity-Temperature-Depth (Profiler)
CVI	Counterflow Virtual Impactor
DAAC	Distributed Active Archive Center(EOS-NASA)
DABUL	Depolarization and Backscatter Unattended LIDAR
DAT	Digital Archival Tape
DD	Downwelling Diffuse
DDMS	Deputy Daily Mission Scientist
DFRC	Dryden Flight Research Center(NASA)
DI	Downwelling IR
DIR	Downwelling Infrared
DMA	Differential Mobility Analyzer
DMS	Daily Mission Scientist
DMSP	Defense Meteorological Satellite Program(DOD)
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DP	Derived Product
DRI	Desert Research Institute(U. of AZ)
DS	Downwelling Solar
DSS	Data Support Section(NCAR)
DW	Downwelling
E	Evaluation
ECMWF	European Center for Medium-range Weather Forecasts
EDT	Eastern Daylight Time
EG & G	Edgerton, Germeshausen and Grier
EOS	Earth Observing System(NASA)
ER	Extended Range
ER-2	NASA Dryden high altitude aircraft
ERS	European Remote-Sensing Satellite
ESD	Environmental Sciences Division(DOE)
ETL	Environmental Technology Laboratory(NOAA)
F	Forcing at Boundaries
FAN	S/W utility program for use of netCDF files on UNIX
FIRE	First ISCCP Regional Experiment
FM-CW	Frequency Modulation-Continuous Wave
FPO	FIRE Project Office
FSSP	Forward Scattering Spectrometer Probe
FTP	File Transfer Protocol
GAC	Global Area Coverage(AVHRR)
GASS	GPS Atmospheric Sounding System
GCM	Global Climate Model
GCSS	GEWEX Cloud System Study
GEWEX	Global Energy and Water Cycle Experiment
GI	Geophysical Institute(U. of AK)
GIF	Graphics Interchange Format
GISS	Goddard Institute for Space Studies(NASA)
GND MFR	Upwelling Multifilter Radiometer

GND RAD	Upwelling Radiation Sensor Suite
GPS	Global Positioning System
GSFC	Goddard Space Flight Center(NASA)
GTS	Global Telecommunications System
H_2O	Water
HDF/netCDF	Hierarchical Data Format/Net Common Data Format
HF	High Frequency
Hg	Mercury
HIRS	High-resolution Infrared Radiation Sounder
Hi Vol	High volume
HRPT	High-Resolution Picture Transmission(AVHRR)
html	Hypertext Markup Language
http	Hypertext Transfer Protocol
Hum	Relative Humidity
I	Input
IAG	Interagency Group
IAR	Institute for Atmospheric Research
ICAO	International Civil Aviation Organization
ID	Identifier
IFN	Ice Freezing Nuclei
IFR	In-flight Rules
IMAU	Institute for Marine and Atmospheric Research Utrecht
IMG	Interferometric Monitor for Greenhouse Gases
IOP	Intensive Observation Period
IR	Infrared
IRBR	Infrared Broadband Radiometer
IRF	Instanteous Radiative Flux(dataset)
IRS	Inertial Reference System
IRT	Infrared Thermometer
ISCCP	International Satellite Cloud Climatology Experiment
JIC	Joint Ice Center
JOSS	Joint Office for Science Suport
JPL	Jet Propulsion Laboratory(NASA)
J W	Johnson Williams
LAC	Local Area Coverage(AVHRR)
LAN	Local Area Network
LaRC	Langley Research Center(NASA)
LES	Large-Eddy Simulation
LIDAR	Light Detection and Ranging
LMS	Lead Mission Scientist
LW	Longwave
LWC	Liquid Water Concentration
MAS	MODIS Airborne Simulator
MASP	Multiangle spectrometer probe
McIDAS	Man-computer Interactive Data Access System
MCR	Multichannel Cloud Radiometer; Multi-Channel Radiometer
mech	Mechanic
MFR	Multifilter Radiometer
MFRSR	Multifilter Rotating Shadowband Radiometer
MHS	Microwave Humidity Sounder
MIR	Millimeter-wave Imaging Radiometer
MISR	Multi-angle Imaging Spectro-Radiometer
MMCR	MMW Cloud Radar
MMTP	Millimeter Wavelength Temperature Profiler

MMW	Millimeter Wave
MOA	Memorandum of Agreement
MODIS-N	Moderate-resolution Imaging Spectrometer-Nadir
MPL	Micropulse LIDAR
MPT	Mission Planning Team
MSFC	Marshall Space Flight Center(NASA)
MST	Mission Selection Team
MTPE	Mission to Planet Earth
MWR	Microwave Radiometer
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Center for Environmental Prediction(NOAA)
NESDIS	National Environmental Satellite, Data, and Information Service
NFOV	Narrow Field of View Radiometer
N.G.C.C.	National Guard of Canadian Coast
Nd:YAG	Neodymium:Ytterbium-Aluminum-Garnet
NIMFR	Normal-Incidence Multifilter Radiometer
NIP	Normal Incidence Pyranometer
NOAA	National Oceanic and Atmospheric Administration(DOC)
NPS	Naval Postgraduate School
NRC	National Research Council(Canada)
NSA/AAO	North Slope of Alaska/Adjacent Arctic Ocean(ARM-DOE)
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
NWP	National Weather Prediction(Center)
NWS	National Weather Service
OAII	Ocean-Atmosphere-Ice Interactions (Program)(NSF)
OAP	Optical Array Probe
OCTS	Ocean Color and Temperature Scanner
OFPS	Office of Field Project Support
OLR	Outgoing Longwave Radiation
OLS	Operational Linescan System
OM	Operations Manager
ONR	Office of Naval Research(DOD)
ONRL	Oar Ridge National Laboratory(DOE)
OrbView	(name of Orbital Sciences, Corp. satellite for SeaWiFS)
PAARCS	Portable Arctic Atmospheric Radiation and Cloud Station
PAM	Portable Atmospheric Mesonet
PCASP	Passive Cavity Aerosol Spectrometer
PDF	(C-130 Ice Nucleus inst.)
PDT	Pacific Daylight Time
PI	Principal Investigator
PIR	Precision Infrared Radiometer
PM	Project Manager
PMEL	Pacific Marine Environmental Laboratory
PMS	Particle Measurement Systems, Inc., Boulder
PNL	Pacific Northwest Laboratory(DOE)
PO	Project Office
POES	Polar Orbiting Environmental Satellite
POLARIS	Photochemistry of Ozone Loss in the Arctic Region in Summer(NASA)
POLDER	Polarization and Directionality of Earth Reflectances
Precip	Precipitation
Pres	Surface Air Pressure

PRT	Precision Radiation Thermometer
PSP	Precision Spectral Pyranometer
PVM	Particulate Volumn Monitor
QA	Quality Assurance
RAD	Radiation Sensor Suite
RADARSAT	Radar Satellite(Canada)
RAF	Research Aviation Facility(NCAR)
RAMS	Radiation Measurment System
RASS	Radio Acoustic Sounding System
R-CL	Routine Climate Data
RDAS	Radiometer Data Acquisition System
RESURS	(French Satellite)
RGPS	RADARSAT Geophysical Processing System
RN	Net Radiometer
RTNEPH	Real-time Nephanalysis
RWP-RASS	Radar Wind Profiler and Radio Acoustic Sounding System
R-WX	(routine surface/aviation weather reports by a weather observer)
SAIC	Science Applications International Corporation
SAR	Synthetic Aperture Radar(RADARSAT)
SBUV	Solar Backscatter Ultraviolet
SCARAB 2	Scanner for the Radiation Budget(RESURS)
SCD	Scientific Computing Division
SCICEX	Submarine Science Ice Experiment
SCM	Single Column Model
SeaWiFS	Sea-viewing Wide Field Sensor
S/F	SHEBA/FIRE
SHEBA	Surface Heat Budget of the Arctic Ocean(Subprogram of NSF ARCSS OAII)
SHIS	Scanning High-resolution Interferometer Sounder
SKYRAD	Downwelling Radiation Sensor Suite
S-MET	Surface Meteorological System
SNL	Sandia National Laboratory
SOM	Surface Optical Model
SpecA	Spectral Albedo
SPEC, Inc.	Stratton Park Engineering Co., Inc.
SPO	SHEBA Project Office
SR	Shadowband Radiometer
SSFR	Solar Spectral Flux Radiometer
SSM/I	Special Sensor Microwave/Imager
SSM/T	Special Sensor Microwave/Temperature sounder
SSM/T2	Special Sensor Microwave/Temperature Sounder; version 2
SSSF	Surface and Sounding Support Facility(NCAR)
SW	Shortwave
TBD	To Be Determined
TBS	Tethered Balloon System
TDDR	Total Direct Diffuse Radiometer
tech	Technician
TECO	Thermal Electron Corporation
Temp	Air Temperature
TIC	Turbulence Instrument Clusters
T/O	Take Off
TOA	Top of the Atmosphere
TOMS	Total Ozone Mapping Spectrometer(NASA)
TSBR	Total Solar Broadband Radiometer

TSI	Thermal Systems, Inc.
U	University
UCAR	University Cooperation for Atmospheric Research
U/D	Up/ Down
UI; UIR	Upwelling IR
URL	Universal Resource Locator
US	Upwelling Solar
UTC	Universal Time Code
UVB	Ultraviolet-B radiometer
UV	Ultraviolet
UW; U WA	University of Washington
VCEIL	Vaisala Ceilometer
WD	Wind Direction
WP	Wind Profiler
WS	Wind Speed
WSI	Whole Sky Imager
WWW	World Wide Web
Wx	Weather

APPENDIX C--SATELLITES, SENSORS, AND DATA PRODUCTS

C.1 NOAA Polar-orbiting Operational Environmental Satellite (POES)

C.1.1 Introduction

The POES satellite system offers the advantage of daily global coverage, by making nearly polar orbits roughly 14.1 times daily. Since the number of orbits per day is not an integer the sub orbital tracks do not repeat on a daily basis, although the local solar time of each satellite's passage is essentially unchanged for any latitude. Currently in orbit are NOAA-12 and NOAA-14, which provide global coverage four times daily. The POES system includes the Advanced Very High Resolution Radiometer (AVHRR) and the Tiros Operational Vertical Sounder (TOVS).

Today's generation of polar orbiting satellites was initiated with the launch of TIROS-N on October 13, 1978. These satellites, like their predecessors, operate in near sun-synchronous orbits. Consecutive equatorial crossings are separated by about 25 degrees of latitude. This produces up to 14.1 orbits per day. Orbital tracks do not repeat on a daily basis, but similar equatorial nodes occur every eight days. The two main sensors on board these satellites include the Advanced Very High Resolution Radiometer (AVHRR) and the TIROS Operational Vertical Sounder (TOVS). The AVHRR is a four/five channel radiometer (depending on the satellite number). Spectral bands range from the visible through the thermal infrared. The TOVS is composed of three different sensors, all measuring incoming radiation in the infrared or passive microwave portion of the electromagnetic spectrum. The three components of the TOVS are the Microwave Sounding Unit (MSU) with four microwave channels, the Stratospheric Sounding Unit (SSU) with three infrared channels, and the High Resolution Infrared Sounder/2 (HIRS/2) with twenty infrared channels.

The next generation of polar orbiting satellites will begin with the launch of NOAA-K sometime in 1997. NOAA-K and its successors, NOAA-L and NOAA-M, represent an improvement over the previous series. There will be more passive microwave instruments and channels. The new Advanced Microwave Sounding Units (AMSU-A1, AMSU-A2, AMSU-B) are state-of-the-art passive microwave sounders that will significantly enhance NOAA'S atmospheric sounding and non-sounding products suite. The AMSU instruments have better spatial resolution and upper atmospheric sounding capabilities than the previous MSU instrument flown on the TIROS-N series. The Advanced Very High Resolution Radiometer(AVHRR/3) will provide improved low energy/light detection and a new channel, called 3A, at 1.6 microns for improved snow and ice discrimination. Channel 3A will be time shared with the previous 3.7 micron channel, now called 3B. The High Resolution Infrared Radiation Sounder (HIRS/3) has spectral channel changes that were made primarily to improve soundings and to be congruent with the specifications developed for the new GOES Sounders.

Because of the polar orbiting nature of the POES series satellites, these satellites are able to collect global data on a daily basis for a variety of land, ocean, and atmospheric applications. Data from the POES series supports a broad range of environmental monitoring applications including weather analysis and forecasting, climate research and prediction, global sea surface temperature measurements, atmospheric soundings of temperature and humidity, ocean dynamics research, volcanic eruption monitoring, forest fire detection, global vegetation analysis, and many other applications.

C.1.2 Data

In addition to providing direct readout, the TIROS-N series satellites carry five digital tape recorders, each with a single electronic module and dual tape transport, to record data for subsequent transmission through the CDA to the data processing facility. Each transport has the capacity to record one of the following:

1) 15 minutes (slightly more than a full orbit) of GAC with embedded TIP data. (TIROS Information Processor is the on board computer system that formats the sensor data for transmission. TIP includes TOVS and auxiliary data.)
2) Eleven and one half minutes of HRPT data (called LAC when recorded), or
3) 230 minutes of TIP data only (called stored TIP).

Between October 1978 and April 11, 1985, direct readout HRPT and recorded GAC, LAC, and TIP data were ingested by NESDIS computers and stored temporarily on staging disks used as work space and for interfacing these computers with the NESDIS Terabit Memory (TBM) mass storage system. The ingested data were then retrieved from disk storage on a time-available basis, processed to Level 1b format (which included appending of Earth location and calibration information) and returned to the disks for subsequent transfer to the TBM for NESDIS product processing and the SSB archive.

On April 11, 1985, NESDIS abandoned the TBM system as a means of storing ingested polar orbiter data. Over the years, SSB's hardware complement has changed with advancing technology, but the corresponding media changes remain transparent to the satellite data user.

During the period of conversion from TBM tapes, SSB attempted to transfer as much of the data from TBM tapes as possible (while simultaneously servicing user requests). Priority was given to recovering the GAC data sets and 88% of these were saved. Similarly, 49% of the TOVS and 6% of the LAC/HRPT were saved. Users should contact SSB for the availability of any Level 1b data which were ingested between October 1978 and April 1985.

As mentioned above, Earth location and calibration data are appended to the data as part of the Level 1b processing. The Earth location data are read from CCTs which contain up to 29 hours of information. These data are updated every 24 hours. These Earth location tapes (called GELDS data) were archived by SSB between March 8, 1985 and September 7, 1992. On September 8, 1992, NESDIS/I.D. discontinued generating the GELDS data since the data were redundant with the Level 1b data.

C.1.3 AVHRR

The Advanced Very High Resolution Radiometer (AVHRR) represents an improvement over the VHRR sensor flown aboard the ITOS series of operational satellites (the last of which was-NOAA-5). The AVHRR is a cross-track scanning system similar to the VHRR, but features four or five spectral channels, compared to just two for the VHRR. The AVHRR flown aboard TIROS-N, NOAA-6, NOAA-8, and NOAA-10 has four channels, and the AVHRR aboard NOAA-7, NOAA-9, NOAA-11, NOAA-12 and NOAA-13 has five channels. Subsequent satellites in the series will have five. Provision has been made for five channels in the data format for all satellites. Channel 5 contains a repeat of Channel 4 data, when only four different channels are available.

The spectral band widths (in micrometers) of the AVHRR channels for the TIROS-N series and those proposed for the remaining spacecraft are shown in Table C.1.3-1. In addition,

the Instantaneous Field of View (IFOV) in milliradians is included for each channel in Table C.1.3-1.

Table C.1.3-1. Spectral band widths (micrometers) of the AVHRR.

Channel #	NOAA-7,-9, -11,-12,-14	NOAA-13	IFOV (mr)
1	0.58-0.68	0.58-0.68	1.39
2	0.725-1.10	0.725-1.10	1.41
3	3.55-3.93	3.55-3.93	1.51
4	10.3-11.3	10.3-11.3	1.41
5	11.5-12.5	11.4-12.4	1.30

The IFOV of each channel is approximately 1.4 milliradians leading to a resolution at the satellite subpoint of 1.1 km for a nominal altitude of 833 km. The scanning rate of the AVHRR is 360 scans per minute. The time within each scan line of AVHRR data represents IFOV #1.

The analog data output from the sensors is digitized on board the satellite at a rate of 39,936 samples per second per channel. Each sample step corresponds to an angle of scanner rotation of 0.95 milliradians. At this sampling rate, there are 1.362 samples per IFOV. A total of 2048 samples will be obtained per channel per Earth scan, which will span an angle of +/-55.4 degrees from the nadir (subpoint view).

The IR channels are calibrated in-flight using a view of a stable blackbody and space as a reference. No in-flight visible channel calibration is performed (although the spaceview is available as one reference point). Although these will vary from instrument to instrument, the design goals for the IR channels were an NEdT (Noise Equivalent differential Temperature) of 0.12 K (@ 300 K) and a S/N (signal to noise ratio) of 3:1 @ 0.5% albedo.

Users should be aware that AVHRR Channel 3 data on each TIROS-N series spacecraft have been very noisy due to a spacecraft problem and may be unusable, especially when the satellite is in daylight.

As a result of the design of the AVHRR scanning system, the normal operating mode of the satellite calls for direct transmission to Earth (continuously in real-time) of AVHRR data. This direct transmission is called HRPT, for High Resolution Picture Transmission. In addition to the HRPT mode, about ten minutes of data may be selectively recorded on each of two recorders on board the satellite for later playback. These recorded data are referred to as LAC (Local Area Coverage) data. LAC data may be recorded over any portion of the world as selected by NOAA/NESDIS and played back on the same orbit as recorded or during a subsequent orbit. LAC and HRPT data have identical formats.

The full resolution data is also processed on board the satellite into GAC (Global Area Coverage) data which is recorded only for readout by CDA stations. GAC data contains only one out of three original AVHRR lines and the data volume and resolution are further reduced by averaging every four adjacent samples and skipping the fifth sample along the scan line.

C.1.4 GAC Data

This section describes the data characteristics and magnetic tape format of Global Area Coverage (GAC) data. NESDIS has enhanced the Level 1b format for GAC and the most recent format (for data collected after November 15, 1994) is included in this section.

Data Characteristics

The processor on board the satellite samples the real-time AVHRR data to produce reduced resolution GAC data. Four out of every five samples along the scan line are used to compute one average value, and the data from only every third scan line are processed. As a result, the spatial resolution of GAC data near the subpoint is actually 1.1 km by 4 km with a 3 km gap between pixels across the scan line, although generally treated as 4 km resolution. All of the GAC data computed during a complete pass are recorded on board the satellite for transmission to Earth on command. The 10-bit precision of the AVHRR data is retained.

C.1.5 LAC/HRPT Data

This section describes the data characteristics of Local Area Coverage (LAC)/High Resolution Picture Transmission (HRPT) data. NESDIS has enhanced the Level 1b format for LAC/HRPT and the current format (for data collected after November 15, 1994) are included in this section.

Data Characteristics

The AVHRR data are digitized to 10-bit precision. The digitized data are both transmitted from the satellite in real-time as High Resolution Picture Transmission (HRPT) data, and selectively recorded on board the satellite for subsequent playback as Local Area Coverage (LAC) data. A maximum of ten minutes of LAC data may be recorded per orbit.

In the event that a user would want SOCC to schedule an AVHRR LAC orbit over a specific area (out of direct readout range of Wallops Island or Fairbanks CDA's), the procedures and requirements are given elsewhere.

C.1.6 HIRS/2

The HIRS/2 instrument measures incident radiation primarily in the infrared region of the spectrum including both longwave (15 micrometers) and shortwave (4.3 micrometers) regions (see Table C.1.6-1). The IFOV of the HIRS/2 channels are stepped across the satellite track by use of a rotating mirror. This cross-track scan, combined with the satellite's motion in orbit, will provide coverage of a major portion of the Earth's surface. The width of the crosstrack scan is 99 degrees or 2240 km and consists of 56 steps. The mirror is stepped from home position in 55 steps of 1.8 degrees. At the end of the scan (at position 56) the mirror rapidly returns to the home position and repeats the scanning pattern. Each scan takes 6.4 seconds to complete (100 milliseconds per step) and there are 42 km between IFOVs along the sub-orbital track. The optical FOV is 1.25 degrees which

gives a ground IFOV of 17.4 km diameter at the nadir. At the end of the scan, the ground IFOV is 58.5 km cross-track by 29.9 km along-track.

HIRS/2 can be commanded to automatically enter a calibration mode every 256 seconds. When the instrument is in the calibration mode, the mirror (starting from the beginning of a scan line) rapidly slews to a space view and samples all channels for the equivalent time of one complete scan line of 56 scan steps. Next, the mirror is moved to a position where it views a cold calibration target and data is taken for the equivalent of 56 scan steps. The mirror is then stepped to view an internal warm target for another 56 scan steps.

Upon completion of the calibration mode, the mirror continues its motion to the home position where it begins normal Earth scan. The total calibration sequence is equivalent to three scan lines (no Earth data are obtained during this period). The analog data output from the HIRS/2 sensor is digitized onboard the satellite at a rate of 2880 bits per second. At this rate, there are 288 bits per step (step time = 100 milliseconds) which includes all 20 channels. The data is digitized to 13-bits precision.

Table C.1.6-1 contains typical values of the HIRS/2 spectral characteristics and noise equivalent differential radiance (NEdN's in units of mW/(m2-sr-cm-1)). There will be some variation in the parameters from one HIRS/2 instrument to another.

Table C.1.6-1. Typical HIRS/2 Channel Characteristics.

Channel	Half-power Bandwidth (cm-1)	Maximum Scene Temperature (K)	Specified NEdN
1	3	280	3.00
2	10	265	0.67
3	12	240	0.50
4	16	250	0.31
5	16	265	0.21
6	16	280	0.24
7	16	290	0.20
8	35	330	0.10
9	25	270	0.15
10	60 17*	290 310*	0.16 0.09*
11	40	275	0.20
12	80	260	0.19
13	23	300	0.006
14	23	290	0.003
15	23	280	0.004
16	23	260	0.002
17	23 26*	280 350*	0.002
18	35	340	0.002
19	100	340	0.001
20	1000	100%A	0.10%A

* NOAA-11 and all subsequent satellites (except NOAA-12) have channels 10 and 17 at different locations in the spectrum. An * (asterisk) indicates the values for NOAA-11.

C.2 DMSP

The Defense Meteorological Satellite Program(DMSP) is a Department of Defense(DoD) program run by the Air Force Space and Missle Systems Center(SMC). The DMSP program designs, builds, launches, and maintains several near polar orbiting, sun synchronous satellites monitoring the meteorological, oceanographic, and solar-terrestrial physics environments.

DMSP satellites are in a near polar orbiting, sun synchronous orbit at an altitude of approximately 830 Km above the earth. Each satellite crosses any point on the earth twice a day and has an orbital period of about 101 minutes thus providing complete global coverage of clouds every six hours.

Each DMSP satellite monitors the atmospheric, oceanographic and solar-geophysical environment of the Earth. The visible and infrared sensors collect images of global cloud distribution across a 3,000 km swath during both daytime and nighttime conditions. The coverage of the microwave imager and sounders are one-half the visible and infrared sensors coverage, thus they cover the polar regions above 60 on a twice daily basis but the equatorial region on a daily basis. The space environmental sensors record along track plasma densities, velocities, composition and drifts.

The data from the DMSP satellites are recieved and used at operational centers on a continual basis. The data are sent daily to the National Geophysical Data Center(NGDC), Solar Terrestrial Physics Division(STPD) for creation of an archive.

C.2.1 SSM/I DESCRIPTION

The SSM/I is a seven-channel, four frequency, linearly-polarized, passive microwave radiometric system which measures atmospheric, ocean and terrain microwave brightness temperatures at 19.35, 22.235, 37.0 and 85.5 GHz. The data are used to obtain synoptic maps of critical atmospheric, oceanographic and selected land parameters on a global scale. The SSM/I archive data set consists of antenna temperatures recorded across a 1,400 km conical scan, satellite ephemeris, earth surface positions for each pixel and instrument calibration. Electromagnetic radiation is polarized by the ambient electric field, scattered by the atmosphere and the Earth's surface and scattered and absorbed by atmospheric water vapor, oxygen, liquid water and ice.

INSTRUMENT DESCRIPTION:

The SSM/I instrument consists of an offset parabolic reflector that is 24 x 26 inches fed by a seven- port horn antenna. The reflector and feed are mounted on a drum which contains the radiometers, digital data subsystem, mechanical scanning subsystem and power subsystem. The drum assembly rotates about the axis of the drum. A small mirror and a hot reference absorber are mounted on the assembly.

The instrument sweeps a 450 cone around the satellite velocity vector so that the Earth incidence angle is always 540. Data are recorded during the 102.40 of the cone when the antenna beam intercepts the Earth's surface. The channel footprint varies with channel energy, position in the scan, along scan or along track direction and altitude of the satellite. The 85 GHz footprint is the smallest with a 13 x 15 km and the 19 GHz footprint is the largest at 43 x 69 km. Because the 85 GHz footprint is so small, it is sampled twice as often, i.e., 128 times a scan. One data cycle consists of 4 85 GHz scans and 2 scans of the 19, 22 and 37 GHz channels. The complete cycle takes 28 seconds and it must be complete to process the data.

DMSP satellites are in a sun-synchronous, low altitude polar orbit. The orbital period is 101 minutes and the nominal altitude is 830 km.

PROCESSING:

The SSM/I processor is queried once a second by onboard computer and the data are placed into the "TS SSP" data field. Data stored on recorders are down linked to Thule AFB once an orbit, sent to Air Force Global Weather Central (AFGWC) via communications satellite,
written to 8 mm tapes by the ARchive Processing System (ARPS) and sent to the National Geophysical Data Center (NGDC) on a daily basis. At NGDC, the "TS SSP" data are decommutated, deinterleaved, bit flipped, reordered and restructured into orbits beginning with the equatorial crossing as the satellite travels from south to north. Satellite ephemeris are computed using a physically-based, orbital mechanics model. SSM/I pixels are geolocated using the satellite ephemeris and satellite attitude corrections. Antenna temperatures are computed from instrumental counts by a linear equation, i.e., the conversion is reversible.
In the decommutation step, we encountered bit reversals that occurred 1.8 - 3.4% of the time and are probably caused by ionospheric scintillation. These are identified through careful checking procedures and corrected. Archive tapes contain an automated format statement, an orbital inventory, metadata by orbit and geolocated antenna temperatures. A typical tape contains 8 days of data from two satellites.

APPLICATIONS:

SSM/I data are used to derive geophysical parameters; notably, ocean surface wind speed, area covered by ice, age of ice, ice edge, precipitation over land, cloud liquid water, integrated water vapor, precipitation over water, soil moisture, land surface temperature, snow cover and sea surface temperature. Most current methods use statistical algorithms which mean or difference channel brightness temperatures [Hollinger et al., 1989]. Brightness temperatures are computed from antenna temperatures using the published antenna pattern correction which includes dynamic adjustments for antenna side lobe, antenna efficiencies and neighboring pixel contributions. Future methods will be physically based using data from all atmospheric sensors on DMSP satellites, i.e., SSM/I, OLS, SSM/T and SSM/T-2.

C.2.2 SSM/T2 DESCRIPTION

The SSM/T-2 sensor is a five channel, total power microwave radiometer with three channels situated symmetrically about the 183.31 GHz water vapor resonance line and two window channels. This instrument was flown on all DMSP Block 5D-2 satellites starting with F11 launched in 1991. SSM/T-2 is designed to provide global monitoring of the concentration of water vapor in the atmosphere under all sky conditions by taking advantage of the reduced sensitivity of the microwave region to cloud attenuation.

INSTRUMENT DESCRIPTION:

The SSM/T-2 is a cross-track scanning, five channel, passive total power microwave radiometer system which consists of a single, self-contained module with a step-scan motion in the cross-track direction of +/- 40.5 degrees. The SSM/T-2 scan mechanism is synchronized with the SSM/T-1 so that the beam cell patterns of the two sensor coincide. The SSM/T-2 observation rate is 7.5 scans per minute. There are 28 observations (beam positions) per scan for each of the five channels, with each observation having a spatial resolution of approximately 48 km. All five channels have coincident centers. The total swath width for the SSM/T-2 is approximately 1500 km.
The SSM/T-2 employs a single offset parabolic reflector with a 2.6 inch diameter projected aperature. The reflector is shrouded to eliminate the possiblity of rays from the sun striking either of the calibration paths and causing unwanted thermal gradients. The feedhorn is a corrugated pyramidal horn with a flare designed to minimize phase center seperation over the bandwith (91 to 183.3 GHz), while providing a spherical wave illumination of the

reflector. To achieve the cross-track scanning, the reflector alone rotates. The rotation of the reflector produces a rotation of the plane of polarization of the upwelling scene TBs which is permitted provided that the polarization remains identical for the two window channels and 183.3 +/- 7 GHz. These channels must have the same polarization characteristics because they measure contributions from both the atmosphere and the surface. Note that all SSM/T-2 channels possess the same polarization.

During each scan period, and for all five channels at twenty-eight discrete earth viewing positions, four discrete calibration measurements of a hot-load target (~300K), and cosmic background radiation (~3K) are monitored.

The SSM/T-2 inflight warm-load calibration target is a derivative of the SSM/T-2 warm load calibration target. The warm load (~300 K) is shrouded to improve radio frequency (RF) coupling of energy to the reflector/feedhorn antenna. This minimizes potential calibration errors arising from the reception of extraneous energy due to scattering of earth or solar radiation off of the spacecraft. The cold path is a cylindrical oversized waveguide tube which permits a direct view of the cosmic background (~3 K) by the antenna reflector during calibration.

The periodic calibration data are modeled by a linear transfer function to characterize the state of the total power radiometer and remove time variations of the receiver gain and offset for frequencies less than half the reciprocal of the calibration period. As a consequence relatively large temperature related receiver gain drifts are taken into account in the periodic construction of the transfer function. The minimal detectable temperature difference is 0.45 K. The SSM/T-2 employs a calibration period of 8 seconds in which four samples are taken of a warm-load calibration target along with four samples of the cosmic background.

PROCESSING:

Processing of imagery in support of DOD operations and scientific research occurs onboard the satellite, at Air Force Global Weather Central (AFGWC) and at the National Geophysical Data Center (NGDC). Satellite telemetry are down linked to Thule AFB and transmitted to AFGWC via communications satellite.

APPLICATIONS:

The imaging of SSM/T-2 data offers a new perspective on the atmosphere that complements other remotely sensed datasets. Conlee (1995, Texas A&M Dissertation) shows that major mid-latitude weather phenomena such as fronts and extratropical cyclones have excellent signatures in SSM/T-2 data, including three-dimensional structure. Other phenomena such as as tropical cyclones, tropical plumes, subtropical anticyclones and surface states such as sea ice and snow cover may be identified.

Applications other than profiling are possible with the SSM/T-2. The retrieval of vertically integrated water vapor is also possible due to the strong sensitivity of the 183.31 Ghz water vapor absorption line.

C.3 RADARSAT/SAR

C.3.1 Summary

RADARSAT-1 is an advanced Earth observation satellite project developed by the Canadian Space Agency (CSA) to monitor environmental change and to support resource sustainability. NASA launched RADARSAT-1 in exchange for access to the satellite on a pro rata basis through its Alaska SAR Facility (ASF). At the heart of RADARSAT-1 is an advanced radar sensor called Synthetic Aperture Radar (SAR). SAR is a microwave instrument which sends pulsed signals to the Earth and processes the received reflected

pulses. RADARSAT-1's SAR-based technology provides its own microwave illumination and thus will operate day or night, regardless of weather conditions. RADARSAT-1 was placed into a sun-synchronous polar orbit in order to provide global coverage. Research emphasis will be on the polar regions, though on-board tape recorders will allow imaging of any region, world-wide. Data downlinked to the Canadian stations (Prince Albert, Saskatchewan and Gatineau, Quebec) will be made available through RADARSAT-1 International (RSI). Data downlinked to NASA's stations (McMurdo, Antarctica and ASF in Fairbanks, Alaska) will be made available through the Alaska SAR Facility.

Some potential applications of RADARSAT-1's data include: sea-ice monitoring - daily ice charts; extensive cartography; flood mapping and disaster monitoring in general; glacier monitoring; forest cover mapping; oil spill detection; assessment of the likelihood of mineral, oil and gas deposits; urban planning; crop production forecasts; coastal surveillance (erosion); and surface deformation detection (seismology, volcanology). Some of the large RADARSAT-1 activities include: the Antarctic mapping mission; "Arctic Snapshots" showing the complete Arctic ice extent at given times (4 snapshots every 24 days); a Geophysical Processor System (RGPS) to provide derived data sets such as sea ice motion products; and a global set of stereographic SAR images. RADARSAT-1 was launched November 4, 1995 and has a design lifetime of 5.25 years.

C.3.2 Synthetic Aperature Radar(SAR)

At the heart of RADARSAT-1 is an advanced radar sensor called Synthetic Aperture Radar (SAR). SAR is a microwave instrument which sends pulsed signals to Earth and processes the received reflected pulses. RADARSAT-1's SAR-based technology provides its own microwave illumination and thus will operate day or night, regardless of weather conditions. RADARSAT-1 offers a variety of beam selections; the satellite's SAR will have the unique ability to shape and steer its beam from an incidence angle of less than 20 degrees to more than 50 degrees, in swaths from 35 to 500 kilometers, with possible resolutions from 10 to 100 meters. The RADARSAT-1 SAR image swath can cover much of the Arctic daily and most of Canada every 72 hours, depending on the beam selected. The entire Earth could be covered every 24 days using the standard 100-kilometer beam mode. Data will be downlinked in real time or stored on one of the tape recorders until the spacecraft is within range of a receiving station. Data is expected to be available for users a few hours after the satellite passes over an area. Receiving stations are located at Prince Albert, Saskatchewan; Gatineau, Quebec; Tromso, Norway; and Fairbanks, Alaska. Additional ground stations are also developing the capability to support the RADARSAT mission.

Spacecraft Parameters:

Design Lifetime:	5.25 years
Spacecraft Mass:	3100 kg (vs 2750 kg)
Bus Mass:	1560 kg
Payload Mass:	1540 kg
Average Power:	
Requirement:	1500 W
Total Solar Power:	2500 W
Batteries:	3 48 Ah NiCd
Available (after 3 years):	1900 W
Hydrazine:	
Yaw Maneuver:	67 kg

Orbit Parameters:

Geometry:	Circular, sun-synchronous (dawn-dusk)
Altitude:	798 km (793-821)
Inclination:	98.6 degrees
Period:	100.7 minutes, 14 orbits/day
Repeat Cycle:	24 days, 343 orbits
Local mean solar time of ascending node:	18:00 GMT
Argument of perigee:	90.0 degrees

Coverage Information:

Data will be downlinked to receiving stations at: Prince Albert, Saskatchewan; Gatineau, Quebec; McMurdo, Antarctica; and ASF in Fairbanks, Alaska. The North American stations can obtain real-time data within their station masks - an area within approximately 3000 km of each station. McMurdo's coverage mask is more limited due to the surrounding mountains. Data may also be recorded over the desired location and later downlinked later - receiving station. Using the maximum swath width of 500 km, the following may be obtained:

- Daily coverage in areas north of 70 N, excepting a small portion at the pole
- Coverage every 4 days for regions between 48 N and 70 N
- Coverage every 6 days for locations north of 80 S
- Daily coverage in areas south of 80 S, excepting a portion at the pole

Direct Downlink Coverage from RADARSAT

When viewing the ground coverage for a RADARSAT receiving station, it is important to note that the ground area that can be accessed and downlinked to the nearest receiving station, is not circular in shape.

To illustrate this point, RADARSAT can provide ground coverage over a 500 Km ground swath and also has a stand-off distance of approximately 250 Km from nadir to the near edge of the swath. Therefore the additional coverage distance from the maximum downlink line-of-sight is 750 Km excluding extended beams. This extended coverage appears as a bulge to the side of the circular line-of-sight transmission circle. The size and the shape of the additional coverage varies for various satellite systems.

Readers should note that the coverage area for side-looking sensors may depend on ascending or descending passes and therefore will provide less frequent coverage in the enlarged regions.

The maximum coverage distance for each of the satellites is dependant on a variety of factors besides the steering capability of the sensor. Other factors include the altitude of the satellite, the minimum elevation angle of the receiving antenna above the horizon and, the elevation of the antenna above sea level. The coverage patterns indicated are theoretical and may have slight variations from actual results which are affected by local conditions such as elevation changes, transmission interference, or other variables.

The presentation of the coverage is also distorted due to the Map Projection System utilized. Readers are cautioned to be aware of these factors when reviewing the coverage diagrams.

The area covered is elongated in the horizontal direction with only a slight deviation in the vertical as the side-looking and steerable sensors provided enhanced coverage across the satellite track which is primarily north-south in direction.

For the RADARSAT receiving stations listed in this site, we have included the coverage based upon on receiving antenna elevation angle of 5 degree reception masks showing the downlink range. Data may be able to be collected outside of these areas, due to either the ability to receive data from smaller elevation angles, extended beams, or the tape recorder.

Attitude Characteristics:

RADARSAT-1 is 3-axis stabilized.

Position Errors:

Along-Track: +/- 1430 meters
Cross-Track: +/- 36 meters
Radial: +/- 26 meters

Velocity Errors:

Along-Track: +/- 0.75 m/s
Cross-Track: +/- 1.5 m/s
Radial: +/- 1.5 m/s

Rotation Measurement Errors:

Roll: +/- 0.1 degrees
Pitch: +/- 0.1 degrees
Yaw: +/- 0.1 degrees

(from 0.05 degrees long term bias, 0.05 degrees short term random errors for each)

Drift Rates:

Roll: +/- 0.001 degrees/second
Pitch: +/- 0.001 degrees/second
Yaw: +/- 0.001 degrees/second

Antenna Pointing Errors:

Elevation/Azimuth Pointing Errors: 0.5 degrees
Elevation/Azimuth Drift Rates: 0.01 degrees/second

Data Collection System:

The S-band command and telemetry link will permit simultaneous reception of commands and transmission of telemetry between the RADARSAT-1 satellite and the Telemetry, Tracking, and Control Stations (TTCS) at ST.-Hubert and Saskatoon. SAR data will currently be downlinked to the Canadian stations and Gatineau and Prince Albert and the U.S. station at Fairbanks, Alaska. Other ground receiving stations may be added in the future.

Latitude Crossing Times:

RADARSAT-1 was launched into a sun-synchronous dawn-dusk polar orbit. The satellite crosses the equator at 6 a.m. and 6 p.m.

C.4 RESURS/SCARAB 2

ScaRaB is a 4-channel cross-track scanning radiometer with angular resolution of 48 milliradians. Scanning is obtained by rotation of a cylinder (the rotor) carrying the optics, filters, detector, choppers and analog-detection electronics about an axis parallel to the direction of rnotion of the spacecraft, within a cylinder (stator) rnounted on the spacecraft. The four channels (Table C.4-1) include two broad spectral bands from which the reflected SW and emitted LW radiances are derived, and two narrower bands similar to operational weather satellite imager channels, one corresponding to the infrared atmospheric window, the other to the visible (green to red) portion of the solar spectrum. Note that the upper 50-μm limit of the TW channel is nominal; there is no abrupt cut-off in spectral response and no practical way to measure the response in this range. The lower 0.2-μm limit of SW and TW channel response corresponds to the cut-off in reflectance of the aluminum mirror optics.
Daytime radiation in the LW band (nominally 4 to 50 μm) is determined by appropriately weighted subtraction of the SW signal from the TW signal. Note that although the ERBE scanner had a LW channel, the unfiltered LW radiances were in practice determined from such TW-SW subtraction. The CERES scanner has an IR window channel in place of the ERBE LW channel, and LW radiances will also be determined by spectral subtraction.

The four channels of identical structure are mounted in parallel inside the rotor cylinder, perpendicular to its axis. Incoming radiation is focused by a spherical aluminum mirror directly onto the detector field stop, with no secondary reflection. Each detector is mounted at the prime focus of a telescope with a single mirror, and each optical system is centered so as to be insensitive to polarization. The scanning is produced by rotating the ensemble of the four telescopes around an axis parallel to the satellite's orbital motion vector. The field of view is defined by a square field stop, whose diagonal is parallel to the scan direction. Half-diagonal overlapping of pixels reduces aliasing. For ScaRaB FM1, which flew on Meteor-3/7 at 1200-km altitude, the projection on the ground, at nadir, of the instantaneous field of view (pixel) is a 60-km square, with pixel spacing on a square grid of 42.5 km.

The detectors are windowless pyroelectrics coated with black paint. The radiation arriving on each detector is chopped at the pixel sampling frequency. Each of the two choppers is a rotating hemispherical mirror with two openings, each detector alternately receives radiation transmitted directly from outside and radiation reflected from a small internal reference black body. This is not a calibration source; its temperature is not actively controlled. The temperature of the reference blackbody for channel 3 is measured by a platinum resistance thermometric sonde and included in the scientific telemetry. These data and thermal modeling of the instrument confirm that these temperatures are stable on time scales as long as several scan cycles.

The pixel signal is in fact the difference between the signal integrated (for 20 ms) when the chopper is fully open to the external scene and the signal obtained when it is fully closed and reflecting the internal black body. Note that because the filters used for channels 1, 2 and 4 are located between the chopper and the detector, their thermal emission is eliminated. Radiometer bias is canceled using a space look at the beginning or end of each scan line (depending on the direction of the Sun, which is avoided). It may be noted that the CERES instrument is similar to the ERBE scanner, but with the imperfect broad LW band replaced by an infrared window channel (8-13 μm) analogous to, but somewhat broader than, ScaRaB IRW channel 4 (10.5-12.5 μm).

Table C.4-1 ScaRaB channels

Channel No.	Description	Wavelength range	Filter Type
1	Visible (VIS)	0.55—0.65 μm	Interference
2	Solar (SW)	0.2 — 4 μm	Fused silica
3	Total (TW)	0.2 — 50 μm	Unfiltered
4	IR window (IRW)	10.5 — 12.5 μm	Interference

TABLE C.4-2 ScaRaB SCIENCE DATA PRODUCTS

	ERBE analog	Organization	Description - Quantities included
Al	pre-PAT	Daily files Pixel by pixel as observed	Geographical location, instrument counts, housekeeping data, calibration data, filtered radiances each channel, for each pixel
A2	PAT S-8	Daily files Pixel by pixel as observed	Geographical location, illumination/viewing geometry, filtered radiances each channel, scene identification, unfiltered SW, LW radiances, SW and LW fluxes
A3	S-9	Monthly files ERBE regions	Regional mean quantities and other statistics
A3 MRI	Record 2	ERBE regions, by satellite overpass	Quasi-instantaneous regional means: all-sky and clear-sky SW and LW fluxes, other statistics, scene-type fractions
A3 MRJ	part of record 1	ERBE regions day by day	as above, daily regional means
A3 MRH	part of record 1	ERBE regions hour by hour	Monthly hourly regional means, i.e. monthly mean diurnal variation of above quantities
A3 MRMJ	part of record 1	ERBE regions	Monthly regional means obtained from daily regional means
A3 MRMH	part of record 1	ERBE regions	Monthly regional means obtained from monthly hourly regional means

C.5 Earth Probe

C.6 LANDSAT

APPENDIX D--AIRCRAFT, SENSORS, AND DATA PRODUCTS

D.1 NCAR C-130Q Instruments

Instrument Name	Parameter(s)	PI
PMS-PCASP 100	Aerosol Spectrum & mean particle diameter	Curry
PMS-FSSP-100	Cloud droplet spectrum & mean particle diameter & water/ice content	Curry
PMS-FSSP-300	Cloud droplet spectrum & mean particle diameter & water/ice content	Curry
PMS-FSSP-2D-C	Total Number of Cloud Particles	Curry
PMS-FSSP-2D-P	Total Number of Water Particles	Curry
OAP-260X	Cloud Droplet spectrum, mean particle diameter, water/ice content & computed reflectivity	Curry
Cryo. Dewpoint Hygrometer	Humidity	RAF
Lyman-alpha absorption hygrometer	Water vapor density	RAF
UV Hygrometer	Humidity	RAF
Dew-point hygrometer	Frost point temperature	RAF
Atmos./satur. water vapor pressure	Derived relative humidity	RAF
Amb./dew pt. temp. & water vapor pressure	Derived absolute humidity	RAF
Stat. press & water vapor pressure	Derived specific humidity	RAF
Water vap. press & stat. press.	Cryogenic mixing ratio	RAF
PMS/CSIRO liq. water probes	Liquid water content	RAF
Near-IR Laser Spectrometer H2O Vapor		May

Instrument Name	Parameter(s)	PI
Multiangle Spectrometer Probe(MASP)	Aerosol Size and Number	Baumgardner
Gerber PVM 100A	Cloud Liquid Water and Effective Radius	Curry
Rosemount 871F ice-accretion probe	Derived supercooled liquid water content	RAF
TSI CN counter	CN concentration	Curry
Heinmann KT19.85 IR Radiometer	Surface Temperature	RAF
NCAR-modified Eppley PIR Pyrgeometer	Hemispheric IR Radiation	RAF
NCAR-modified Eppley PSP Pyranometer	Up/down hemispheric SW Radiation	RAF
Eppley UV radiometer/photometer	UV irradiance	RAF

Multichannel Cloud Radiometer(MCR)	Cloud Fraction, Optical Depth, Surface Temperature, Melt Pond Coverage/depth	Curry
Airborne Imaging Microwave Radiometer(AIMR)	Lead fraction, New Ice Fraction	Curry
Honeywell Laser Inertial Reference System	3D Position, Attitude and Ground Speed	RAF
APN-159 and -232	Radar altitude	RAF
Barometric pressure	Pressure altitude	RAF
Trimble TANS-III GPS Receiver	Time, Position, Ground Speed	FAF
Dynamic/static pressure	Calculated true airspeed	RAF
IRS & plane speed & attitude	wind vector components	RAF
RAF Radome/IRS Wind Gust System	Air Motion	RAF
Cloudscope	Video Tapes of Collected Particles Particle Area/Time Plots Particle Habit and Size Particle Volume Concentration Particle Mass and Density	Hallett
Exter. Video; Down & Left/Right	Video Tapes of Clouds	RAF
Rosemount	Temperature	RAF
Rosemount Model 1201F1 Absolute Pressure Transducer	Barometric Pressure, Pressure Altitude	RAF
Ophir III Rad. Temp. Sensor	Ambient Air Temperature	Curry
Continuous Flow Diffusion(CFD) Chamber	IFN Number Concentration	Rogers
Condensation Nuclei(CN) Particle Counter	CN Number Concentration(total larger than 0.012μm)	Rogers
Cloud Particle Imager(CPI)	Particle Images and Physical Char.	Lawson
CCN Spectrometers & CN counter	CCN Activation Spectrum CN Concentration	Hudson

Radiometers(RAMS)	Up and Downwelling Solar Flux	Valero

D.1.1 Description of Radiation Measurement System(RAMS)

Instrument
Name: Radiation Measurement System (RAMS):
a multi-instrument array of radiometers consisting of:
1 Total Direct Diffuse Radiometer (TDDR)
1 Multichannel Radiometer (MCR)
2 Total Solar Broadband Radiometers (TSBR)
2 Infrared Broadband Radiometers (IRBR)
1 Narrow Field of View Radiometer (NFOV)
1 Radiometer Data Acquisition System (RDAS)
(plus cables from RDAS to instruments)

Weights: TDDR = 5.5 lbs
MCR = 5.5 lbs
TSBR = 3 lbs (each)
IRBR = 3 lbs (each)
NFOV = 21.5 lbs
RDAS = 50 lbs
cables = approx. 40 lbs (depends on distance from RDAS to instruments)

Sizes: TDDR = 10" x 4.25"
MCR = 10" x 4.25"
TSBR = 7.25" x 5.25"
IRBR = 7.25" x 5.25"
NFOV = 24.5" x 9.5"
RDAS = 8" x 19" x 29"

External sensor location:
TDDR = zenith port
MCR = nadir port
TSBR = one in zenith port, one in nadir port
IRBR = one in zenith port, one in nadir port
NFOV = nadir port (requires 2 windows)

Note: Since all of our instruments (except the NFOV) have hemispheric fields-of-view, we require they be located in positions on the plane which minimize obstructions to their view (such as tail fins, radio antennas, other instruments, etc.).

Voltage: 115 V AC; 28 V DC

Signal: Analog and Digital signals

Sample Rate: 2.5 Hz

Hazardous materials: liquid nitrogen required for NFOV

Scientific basis for measurement and measurement accuracy:

TDDR: Shadow-band radiometer with a hemispheric field of view and 7 channels spanning the solar spectrum from the near-UV to the near-IR. The TDDR measures the total, direct, and diffuse components of the downwelling solar flux. Optical depths as a function of wavelength can be retrieved from these measurements.
Accuracy = approx. 1%

MCR: Exactly the same as the TDDR except it does not have a shadow-band. The MCR measures the upwelling solar flux in the 7 spectral channels. When combined with the TDDR measurements spectral albedo, net flux, etc. can be derived.
Accuracy = approx. 1%

TSBR: Radiometer with a hemispheric field of view and a spectral bandpass from 0.2 to 3.9 microns. The TSBRs measure the downwelling and upwelling total solar irradiance. Albedo, net flux, etc. can be derived from these measurements.
Accuracy = approx. 1%

IRBR: Radiometer with a hemispheric field of view and a spectral bandpass from 4.125 to 48.25 microns. The IRBRs measure the downwelling and upwelling infrared flux.
Accuracy = approx. 1%

NFOV: narrow field of view radiometer with two spectral channels (typically 4-40 microns and 8-12 microns). The NFOV measures the upwelling radiance at the given bandpasses. Brightness temperatures can be derived from these measurements.
Accuracy = approx. 1%

D.1.2 Airborne Imaging Microwave Radiometer(AIMR)

- Resolution @ 1000m altitude: 45m (37 GHz), 17m (90 GHz)
- Swath @ 1000m altitude: 3464m
- 37 & 90 GHz, both polarizations
- scans at ±60 deg.
- Data Products: lead fraction, new ice fraction; other possibilities: snowfall retrieval

D.1.3 Multichannel Cloud Radiometer(MCR)

- Resolution @ 1000m altitude: 7m
- Swath @ 1000m altitude: 2000m
- scans at +- 45 deg.
- MCR channel configuration:

Channel No.	Central Wavelength (μm)	Bandwidth (FWHM; μm)
1	0.630	0.065
2	0.761	0.001
3	0.763	0.001
4	1.06	0.07
5	1.64	0.054
6	2.16	0.085
7	10.8	1.0

- Data Products: cloud fraction, optical depth, surface temperature, melt pond coverage/depth

D.1.4 Cloud Particle Imager(CPI)

Description:

The CPI records in situ digital images of cloud particles.

- Particle Size Range: 5 μm To 2.3 mm
- Size Resolution: 2.3 μm
- Max Frame Rate: 40 Per Second
- Max Particle Rate: >1000 Per Second (Depends On Particle Density)
- Number Of Grey Levels In The Image: 256

Data Products:

Raw Data: Particle Images Plus Housekeeping Data.

Derived Data Products:

- Particle Length And Width
- Effective Radius
- Particle Area
- Drop Size Distribution (For Drops > ~10 μm)
- Crystal Size Distribution
- IWC
- LWC (For Drops > ~10μm)
- Ratio Of IWC/LWC (For Drops > ~10μm)
- Particle Habit*
- Degree Of Crystal Riming**

*Simple Particle Classification Algorithm That Is Being Improved On A Monthly Basis.

**Algorithm Under Developement.

D.1.5 CFD Chamber and CN Counter

Continuous Flow Diffusion (CFD) Chamber

OPERATING PRINCIPLES:
Air flows in the space between two cylinders that coated with ice and held at different temperatures. Ice forming nuclei (IFN) activate in this supersaturated region and grow to crystals a few microns in size. The crystals are counted at the chamber outlet with an optical particle counter. Operation and data logging use a PC-based data system. There are three fundamental limitations for this technique: (1) measures at one temperature and humidity (no capability for instantaneous spectra); (2) statistical sampling limit when IFN concentrations are low; and (3) no sensitivity to contact-freezing or homogeneous freezing nucleation.

MEASUREMENT CHARACTERISTICS:
- Range of Sample Temperatures: -10 to -35C
- Range of Sample Humidities: ice saturation to 20% water supersaturation
- Temperature Change Rate: 0-1.5C per minute
- Humidity Change Rate: 0-10% per minute
- Sample Flow Rate: 1-2 liters per minute
- Accuracy: temperature 1C, humidity +/-1%, air flow +/-5%, pressure +/-2%
- Response Time: ~5 seconds (0%-95%) + piping delay
- Temporal Resolution: ~1s
- Data Sample Rate: ~5Hz for particle count; 1Hz for temperature, flow and pressure

DATA PRODUCTS:
- Number concentration of ice forming nuclei (IFN) at sampling conditions.
- Derived products to be provided: time, sampling conditions (temperature, water and ice supersaturation, pressure, flow rate), IFN count
- Other possible derived products: freezing nucleation spectra; contributions from different ice nucleation modes (condensation-freezing and deposition); fraction of total aerosol represented by IFN; size and chemical composition of IFN

OPTIONS:
Ice crystals >3μm that form in the CFD can be collected by impaction onto an electron microscope grid. These crystals contain the nucleating particles, and when the crystals evaporate, the IFN are left behind. The nuclei can be analyzed using electron microscopy and X-ray microprobe techniques to determine the morphology and elemental composition. Collections are typically accumulated for ~30 minutes to get a few hundred particles.

Condensation Nuclei (CN) Particle Counter

OPERATING PRINCIPLES:
This is a butanol type CN counter, commercially manufactured by TSI, Inc., Model 3010. It measures the concentration of all particles larger than about 0.012µm diameter. Sample air flows over a heated reservoir of butyl alcohol and becomes saturated with the vapor. It then flows into a pipe that is about 15C cooler, which creates a high supersaturation (~300%). Butanol droplets nucleate, grow to a few microns and are counted with an optical particle counter. Coincidence errors become significant for concentrations greater than 10^4/cc.

MEASUREMENT CHARACTERISTICS:
- Range of Particle Concentration: 0 to 10^4/cc
- Particle Size Detection Limit: 50% at 0.012um diameter, increasing to ~100% at 0.025um
- Sample Flow Rate: 1 liter per minute
- Accuracy: air flow +/- 2%
- Response Time: < 5 seconds (0%-95%) + piping delay
- Data Sample Rate: approx. 5Hz for particles, 1Hz for flow

DATA PRODUCTS:
- Number concentration of CN (total particles larger than ~0.012µm diameter).
- Derived products to be provided: time, CN concentration at STP
- Other possible derived products: fraction of total aerosol active as CCN and IFN; indicator of air mass origin (clean or polluted, boundary layer, etc.); in-cloud particle scavenging

D.1.6 CCN Spectrometers and CN Counter

<u>DRI Cloud Condensation Nucleus (CCN) spectrometers</u>

- Counts particles in the supersaturation range of 2% to 0.01% with about 50 channels of resolution.
- Sensitivity 1 particle per cm-3.
- Concentration range 1 to 5000 cm-3.
- Sample flow rate about 1 cm3/s
- Sample rate 1 Hz
- Calibrated with monodisperse salt (NaCl or ammonium sulfate), aerosol, which has known critical supersaturations, Sc. This is done with an aerosol generator and an electrostatic classifier (DMA).

The DMA can also be used to size select the ambient aerosol and this can then be passed to one of the CCN spectrometers to obtain relationships between dry particle size and Sc.

An oven can also be used to heat the sample to various temperatures to obtain particle volatility information, which can yield clues about particle composition.

With the two CCN spectrometers one can monitor the ambient CCN spectra continuously while the other is calibrated and/or does volatility and/or size vs. Sc measurements.

TSI 3010 CN counter

- Obtains total particle concentrations--condensation nuclei (CN).
- Sample rate 1 Hz
- Sample flow rate 16 cm3/s
- Concentration range 1 cm-3 to 10000 cm-3.

D.1.7 NCAR Cloud Statistics Data Product

- Data Processing Special Considerations

PCASP
Activity, Flowrate Corrections
Refractive Index Corrections

FSSP-300
Activity Corrections
Refractive Index Corrections

FSSP-100
Beam Fraction Correction
Activity Correction
Airspeed Corrections

OAPs
Airspeed Corrections

Hot Wire LWC
Wire Temperature Corrections

Location Corrections

PVM
???

- Data Products

Standard

10 Hz Size Spectra, Concentrations,
LWC, average diameter, DBZ

Value Added

Cloud Statistics

Cloud Pass # 53 From 17:28:26 To 17:28:29
119.2 Deg., 7.9 nm from CP-2:
Altitude = 2676.m, Cloud Width = 364.m

Air Speed (rn/s)	Avg.=121	Min.= 120	Max.= 122
Temperature(C)	Avg.=10.3	Min.= 10.2	Max.= 10.3
Pressure (mb)	Avg.=729.9	Min.= 729.9	Max.= 730.1
Wind Dir (deg)	Avg.=200.	Min.=194.	Max.=206.
Wind Speed (rn/s)	Avg.=6.0	Min.= 4.7	Max.= 6.7
Vertical Wind (rn/s)	Avg.=0.7	Min.= 0.2	Max.= 1.5
FSSP Conc.(cm-3)	Avg.=218.	Min.=165.	Max.=311.
2D-C Conc. (/l)	Avg.=0.00	Min.=0.00	Max.= 0.00
2D-P Conc. (/1)	Avg.=0.06	Mm.= 0.01	Max.= 0.10
King LWC (g m-3)	Avg.=0.57	Min.=0.37	Max.= 0.86
FSSP LWC (g m-3)	Avg.=0.62	Min.= 0.45	Max.= 0.93
Gerber LWC (g m-3)	Avg.=0.88	Min.=0.73	Max.= 1.09

Composite Size Spectra
0.1-600µm

D.2 NASA ER-2 Instruments

Table D.2-1 ER-2 Instruments and Principal Investigators

Instrument	PI	Location
MAS	Michael King	right wing superpod(rear)
MIR	Jim Wang	right wing superpod(front)
AirMISR	Roger Marchand	nose
AMPR	Robbie Hood	Q-bay
Scanning HIS	Hank Revercomb	spear pod
CLS	Jim Spinhirne	left wing superpod(front)
SSFR	Peter Pilewskie	E-bay

D.2.1 Solar Spectral Flux Radiometer (SSFR)

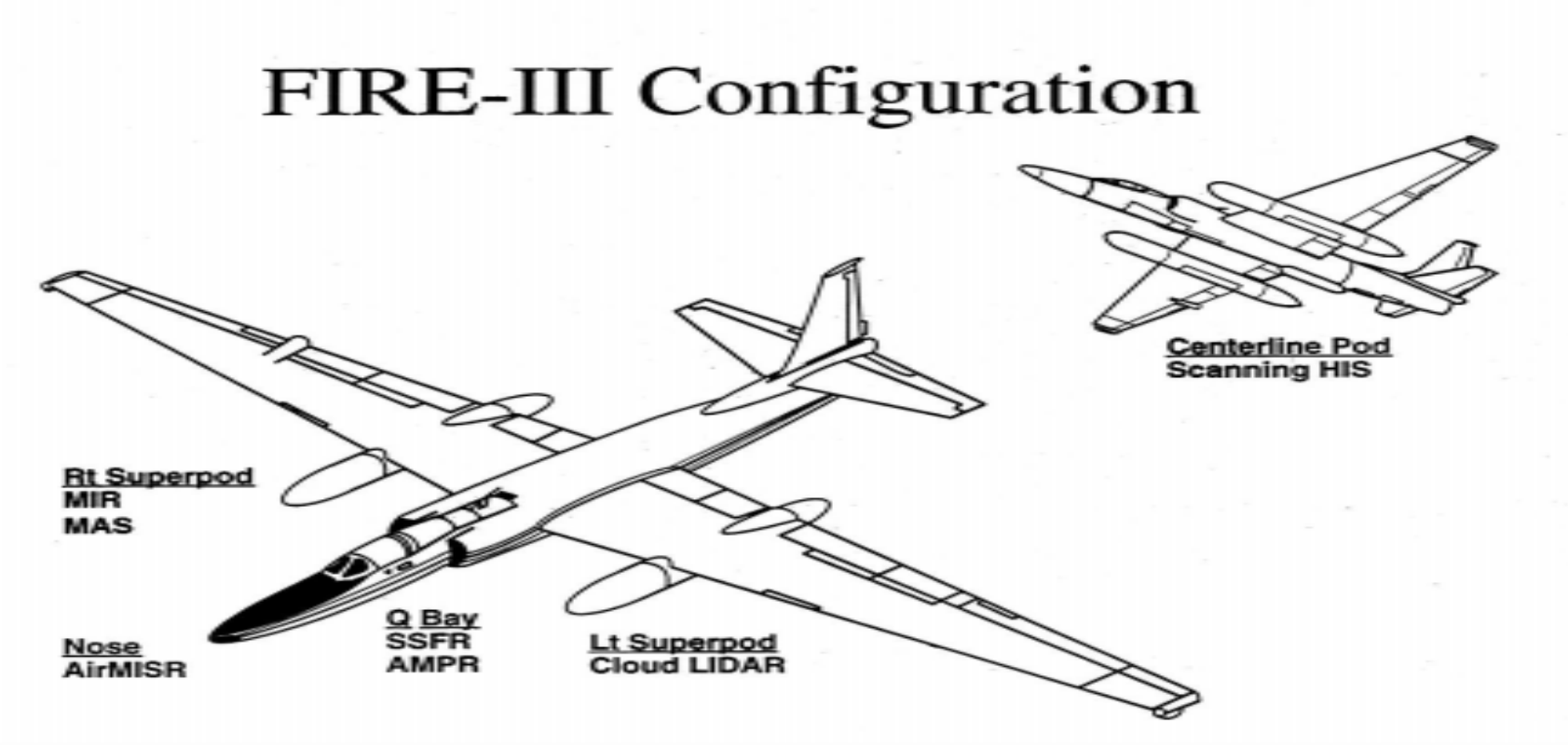
Characteristics:

- 300 nm - 2500 nm spectral range
- hemispheric or narrow field of view (1 mrad)
- 5-15 nm resolution
- $\geq$ 1 Hz spectral sampling rate
- calibration: integrating sphere, standard lamp, standard diffuser, cavity radiometer
- Pressure/Temperature chamber tested
- zenith and nadir pointing.

Data Products

- solar spectral radiance or irradiance
- spectral reflectance and transmittance: $R(\mu_o)=F_{\uparrow}/\mu_o F_o$; $T(\mu_o)=F_{\downarrow}/\mu_o F_o$
- bi-directional spectral reflectance and transmittance: $R(\mu,\mu_o)=\pi I(-1\leq\mu<0)/\mu_o F_o$; $T(\mu,\mu_o)=\pi I(0<\mu\leq 1)/\mu_o F_o$
- surface spectral albedo
- derived products to be provided: TBD; other possible derived products: cloud water phase, optical depth, particle size, liquid/ice water path, liquid/ice water content

Figure D.2-1 ER-2 Instrument Arrangement



D.2.2 MODIS Airborne Simulator(MAS)

The MODIS Airborne Simulator (MAS) is a modified Daedalus Wildfire scanning spectrometer which flies on a NASA ER-2 high altitude research aircraft and provides spectral information similar to that which will be provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) scheduled to be launched on the EOS-AM platform in 1998.

The Wildfire Spectrometer was delivered to NASA Ames Research Center in April 1991. A single visible channel was added and several spectral channels in the infrared port were altered to configure the instrument for the FIRE Cirrus-II experiment. In January 1992 the modified Wildfire was then further modified to become MAS. Beginning in June of 1992, the MAS has been flown in a series of experiments that have lasted on average 2 to 8 weeks, with anywhere from 5 to 15 flights carried during each experiment.

The MAS spectrometer acquires high spatial resolution imagery in the range of 0.45 to 14.5 microns. A total of 50 spectral bands are available in this range. Pre-1995 the digitizer was configured for each mission to record a pre-selected group of 12 bands during the flight. For most of these missions the digitizer was configured to record four 10-bit channels and seven 8-bit channels.

A 50-channel digitizer which records all 50 spectral bands at 16 bit resolution became operational in January 1995. The MAS digitizer is a state-of-the-art design developed by Berkeley Camera Engineering. It is specifically optimized for low-noise digitization of analog signals where radiometric accuracy is of the utmost importance.

The MAS spectrometer is mated to a scanner sub-assembly which collects image data with an IFOV of 2.5 mrad, giving a ground resolution of 50 meters from 20000 meters altitude, and a cross track scan width of 85.92 degrees.

MAS Instrument/Platform Specifications

Platform:	NASA ER-2 aircraft
Ground Speed:	400 kts (206 m/second)
Altitude:	20 kilometers (nominal)
Pixel Spatial Resolution:	50 meters (at 20 kilometers altitude)
Pixels per Scan Line:	716 (roll corrected); nadir scanning
Scan Rate:	6.25 scans/second
Swath width:	37.25 km or 22.9 mi (at 20 km altitude)
Total Field of View:	85.92°
Instantaneous Field of View:	2.5 milliradians
Roll Correction:	Plus or minus 3.5 degrees (approx)
Data Channels:	50 (pre-1995 was 12 selected from 50 spectral

	bands)
Spectral Bands:	50 (digitized to 16-bit resolution) Port 1: 09 bands from 0.451 - 1.010 micron Port 2: 16 bands from 1.593 - 2.406 microns Port 3: 16 bands from 3.044 - 5.438 microns Port 4: 09 bands from 8.266 -14.471 microns
Spectral Range:	0.4451-14.428μm
Spectral Resolution:	0.04-0.4μm(depending on wavelength)
Bits per Channel:	16 bits (pre-1995: 8 bits, configured to have 4 chs @ 10 bits, 7 chs @ 8bits)
Data Rate:	246 Megabytes/hour
Visible Calibration:	Integrating sphere on the ground
Infrared Calibration:	Two temperature-controlled black bodies on board

Data Products:

- solar spectral radiance
- bidirectional spectral reflectance: $R(\mu,\mu_0) = \pi I(\mu,\mu_0,\phi)/\mu_0 F_0$
- derived products to be provided: cloud water phase, optical depth, particle size, liquid/ice water path

Spectral Bands:

By January 1995, modifications that allow the MODIS Airborne Simulator to record information in 50 visible and infrared spectral band regions at 16-bit resolution had been completed. Offered below is the spectral band configuration for the FIRE.ACE 1998 mission. Other MAS deployments may have slightly different spectral band configurations which are offered on their respective Field Experiment Data pages. (All values are in microns)

Spectral Channel	Band Center (μm)	Bandwidth (μm)	Spectral Range (μm)
1	0.4649	0.0397	0.4451-0.4848
2	0.5494	0.0417	0.5285-0.5703

3	0.6550	0.0511	0.6294-0.6805
4	0.7024	0.0415	0.6816-0.7231
5	0.7431	0.0420	0.7221-0.7641
6	0.8248	0.0427	0.8034-0.8461
7	0.8667	0.0414	0.8460-0.8874
8	0.9072	0.0409	0.8867-0.9276
9	0.9476	0.0397	0.9277-0.9674
10	1.6422	0.0519	1.6163-1.6682
11	1.6975	0.0505	1.6722-1.7228
12	1.7499	0.0506	1.7245-1.7752
13	l.8014	0.0491	1.7768-1.8259
14	1.8548	0.0489	1.8303-1.8792
15	1.9044	0.0487	1.8801-l.9288
16	1.9553	0.0483	1.9312-1.9794
17	2.0048	0.0487	1.9804-2.0291
18	2.0551	0.0484	2.0309-2.0793
19	2.1037	0.0486	2.0794-2.1210
20	2.1532	0.0483	2.1291-2.1774
21	2.2019	0.0481	2.1779-2.2259
22	2.2522	0.0486	2.2278-2.2675
23	2.3021	0.0487	2.2777-2.3265
24	2.3512	0.0476	2.3274.2.3750
25	2.4005	0.0483	2.3764-2.4246
26	3.1192	0.1616	3.0384-3.2000
27	3.2809	0.1486	3.2066-3.3552
28	3.4330	0.1617	3.3521-3.5138
29	3.5940	0.1539	3.5I70-3.6709
30	3.7449	0.1449	3.6724-3.8l74
31	3.9069	0.1602	3.8267-3.9870
32	4.0707	0.1554	3.9929-4.1484
33	4.1699	0.0669	4.1365-4.2034
34	4.4029	0.1255	4.3401-4.4656
35	4.5404	0.1512	4.4648-4.6160
36	4.6979	0.1591	4.6184-4.7775
37	4.8536	0.l516	4.7778-4.9294
38	5.0033	0.1468	4.9298-5.0767

39	5.1588	0.1400	5.0888-5.2288
40	5.3075	0.1327	5.2412-5.3738
41	5.3977	0.0755	5.3590-5.4365
42	8.5366	0.3950	8.3391-8.7341
43	9.7224	0.5365	9.4541-9.9906
44	10.5071	0.4579	10.278-10.736
45	11.0119	0.4710	10.776-11.247
46	11.9863	0.4196	11.776-12.196
47	12.9013	0.3763	12.713-13.089
48	13.2702	0.4584	13.041-13.500
49	13.8075	0.5347	13.540-14.075
50	14.2395	0.3775	14.051-l4.428

D.2.3 Millimeter-wave Imaging Radiometer(MIR)

Sensor Characteristics.

The Millimeter-wave Imaging Radiometer (MIR) is a cross-track-scanning total-power radiometer that measures radiation at six frequencies of 89, 150, 183.3±1, 183.3±3, 183.3±7, and 220 GHz. It is installed on the front end of the right superpod of the ER-2 aircraft. The sensor has a 3-dB beamwidth of about 3.5 at all frequency channels and covers an angular swath of ±50 with respect to nadir. In every scanning cycle of about 3 sec in duration, it views two external calibration targets; one of them is heated to a temperature of 330 K and another remains at the ambient temperature that, at the cruising altitude of the ER-2 aircraft, is about 240 K. The temperatures of these calibration targets are closely monitored to within ±0.1 K. The temperature sensitivity of the six low-frequency channels (£ 220 GHZ) is on the order of 0.4 K and the calibration accuracy is better than ±2 K in the brightness temperature range of 240-300 K. The measurement accuracy below 240 K is somewhat uncertain; based on the calibration studies in the laboratory, the accuracy near the liquid nitrogen temperature of 77 K is estimated to be ±3 K. At the ER-2 aircraft cruising altitude of about 20 km, the footprint at nadir is about 1 km. The speed of the aircraft is about 200 m/sec. With a scanning cycle of about 3 seconds, the MIR will produce contiguous images at all nine channels with a ground swath of about 42 km.

- spectal range: 89, 150, 183.3±1, 183.3±3, 183.3±7, and 220 GHz.
- field of view: 3.5 deg. beamwidth
- sampling rate: sampling period of about 3 sec.
- calibration: two external calibration targets used to obtain calibrated brightness temperatures to an accuracy of ±2 K.

- swath: cross-track scanner with angular swath of ±50 deg. centered at nadir

Data Products:

- Calibrated brightness temperatures at 57 beam positions covering 100 deg. swath.
- Water vapor profiles and cloud information (liquid clouds, or ice water path from storm-associated ice clouds) can be obtained from these brightness temperatures with appropriate algorithms.

D.2.4 Advanced Microwave Precipitation Radiometer(AMPR)

Characteristics:

- Passive microwave radiometer
- Four frequency channels (10.7, 19.35, 37.1, and 85.5 GHz)
- Cross nadir track scanner (90 degrees total scan)
- Single polarization rotating from vertical to the left of the aircraft
- to horizontal to the right of the aircraft
- In -flight calibration with external hot and cold blackbodies
- Three second scan period
- Fifty data samples per scan

Direct Data Products to be provided by MSFC / AMPR team:

- Calibrated brightness temperatures
- Imagery of calibrated brightness temperature both in raster format and gridded latitude and longitude maps

Derived Data Products which will be developed by Judith Curry:

- Sea ice emissivity
- Precipitation rates

Derived Data Products which could be developed by others:

- Bulk vertical profiles of hydrometeors

The Advanced Microwave Precipitation Radiometer (AMPR) is a total power scanning multifrequency radiometer which collects data at 10.7, 19.35, 37.1, and 85.5 GHz. The AMPR is composed of two adjacent antenna systems with one large scanning mirror accomodating both systems. One antenna system was designed to use a copy of the SSM/I feedhorn for the three higher frequencies. The second antenna system collects data at 10.7 GHz using a feedhorn designed by the Georgia Tech Research Institute (GTRI).

The AMPR is currently configured to fly aboard the high altitude ER-2 aircraft. The ground spatial resolution of the nadir footprints from the nominal aircraft altitude of 20 km is 0.6 km for the 85 GHz channel, 1.5 km for 37.1 GHz, and 2.8 km for both the 19.35 and 10.7 GHz channels. The AMPR calibrates with external cold and warm loads after every fourth data (surface) scan. A total calibration sequence or a total data scan are each performed in a three second time period. The AMPR scanner sweeps through a total 90 degree (+/- 45 degrees from nadir) data scan collecting a sample for each channel every 1.8 degrees for a total of 50 samples per channel. Based upon an aircraft altitude of 20 km and an aircraft speed of 200 m/s, this scan rate will yield contiguous footprints for the 85.5 GHz channel within a 40 km wide swath. The three other channels will be oversampled by the factors given in Table D.2.4-1. Also listed in Table I are other performance characteristics of the radiometer.

The feedhorns have been aligned such that full vertical polarization is 45 degrees left of nadir and full horizontal polarization is 45 degrees right of nadir. An equal mix of polarization occur at nadir. A more thorough discussion of the instrument may be found in Spencer, et al (1994).

Table D.2.4-1 AMPR Instrument Characteristics

Frequency	IF Bandwidth	3dB Beamwidth	Mainbeam Oversampling	Cross Efficiency	Polarization
85.5 GHz	1400 MHz	1.8 deg	1.0x	93.2%	1.4%
37.1 GHz	900 MHz	4.2 deg	2.3x	98.8%	0.4%
19.35 GHz	240 MHz	8.0 deg	4.4x	98.7%	1.6%
10.7 GHz	100 MHz	8.0 deg	4.4x	97.8%	0.2%

D.2.5 Scanning High-resolution Interferometric Sounder (SHIS)

Measurement Characteristics:

Spectral Coverage: Options for 3-17 & 3-25 microns
Spectral Resolution: 0.5 cm-1

Spatial Resolution: 2 km from 20 km
Cross-track Coverage: 11 earth spots & 2 calibration views every scan
Scan step size: 0.15 radians
Cross-track scan time: 15 sec
Dwell time/sample: 1 sec
RMS Noise per sample: order 0.25 K @ 260 K
Calibration: from 2 onboard reference blackbodies
<1.0 K absolute
<0.2 K reproducibility
Location on ER-2: Centerline pod under fuselage

Data Products:

- IR Spectral Radiances
- Vertical Temperature distributions
- Vertical Water Vapor distributions
- Sea Surface Temperature
- Land Surface Temperature and Emissivity*
- Cloud properties (height, emissivity, particle size, phase, ice/liquid water content)*
- Ozone vertical profile*
- CO total columm*

* Research products, not routinely generated.

D.2.6 Cloud Lidar System(CLS)

The 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. The system specifications are as follows:

Transmitter:

Laser Type:	Nd:YAG I,II
Wavelength:	1064, 532 nanometer

Pulse Energy:	90, 30 mJ
Pulse repetition frequency:	10 Hz
Beam width:	1 mrad

Receiver:

Diameter:	0.15 m
Beam width:	1.4 mrad
Polarization:	vertical and horizontal

Data System:

Sample rate:	Measurements at 20 m intervals at 200 m/s aircraft speed
Range Resolution:	7.5 m
Number of Channels:	4
Samples per Channel:	3310
Record Capacity:	8 hours

For more information on the Cloud LIDAR System, try the CLS home page(section 9.5) or call the principal investigator for CLS, Dr. James Spinhirne at NASA's Goddard Space Flight Center.

D.2.7 Airborne Multi-angle Imaging Spectro-Radiometer(AirMISR)

Instrument Description:

AirMISR is a an airborne instrument for obtaining multi-angle imagery similar to that of the satellite-borne MISR instrument. AirMISR flies on the NASA-owned ER-2 aircraft. It was built for NASA by the Jet Propulsion Laboratory in Pasadena, California. More information on MISR can be obtained at the URL given in Table 9.3-1.

AirMISR consists of one camera, of the exact same design as the nine cameras on the MISR instrument, which makes radiance measurements at 433, 555, 670 and 865 nm with a 10 nm bandwidth. The camera is mounted so that is can point along the direction of flight from +70 to -70 degrees (relative to nadir). The resulting image pixel resolution depends on the distance to the target and the look direction. Taking the ER-2 to be 20 km above the target gives roughly 7 meter resolution at nadir and 22 meter resolution at 70 degrees. The along-track image size depends (primarily) on the length of time the camera is held at a fixed angle. Duplicating the MISR look directions of 0, +/-26.1, +/-45.6, +/-60 and +/-70.5 for one flight line requires a flight path of greater than 100 km in length and yields a

maximum overlapping in the nine images of about 9 km along track and 10 km cross track. For more information about AirMISR or inquires regarding measurements planned during FIRE III contact Roger Marchand.

Data Products:

The basic AirMISR product is a calibrated radiance image at each view angle and at each wavelength.

Ultimately, we plan to coregister the images onto a common position grid. (how well we can do this is not fully known at this time.)

From the coregistered images we hope to extract cloud top height using stereo photogammetric techniques.

D.3 UW CV-580 Instruments

Parameter	Instrument Type	Manufacturer	Range(and error)
(a) Navigational and Flight Characteristics			
Latitude and longitude, ground speed and horizontal winds	Global positioning system	Bendix/King KLN900	Global
True airspeed	Variable capacitance	Rosemount Model 831 BA	0 to 250 m s^{-1} (<0.2%)
Heading	Gyrocompass	King KCS-55A	0 to 360_ (± 1_)
Pressure	Variable capacitance	Rosemount Model 830 BA	150 to 1100 mb (<0.2%)
Altitude above terrain	Radar altimeter	Bendix Model ALA 51A	
Aircraft position and course plotter	Derived from GPS	In-house	180 km (1 km)

Parameter	Instrument Type	Manufacturer	Range(and error)
Pitch and Roll	Differential GPS	Trimble TANS/Vector GPS Attitude System	0 to 360_ (±0.15_)
(b) General Meteorological			
Total air temperature	Platinum wire resistance	Rosemount Model 102CY2CG and 414 L Bridge	–60 to 40_C (< 0.1_C)
Static air temperature	Reverse-flow thermometer	In-house	–60 to 40_C (< 0.5_C)
Dew point	Cooled-mirror dew point	Cambridge System Model TH73-244	–40 to 40_C (< 1_C)
Absolute humidity	IR optical hygrometer	Ophir Corp. Model IR-2000	0 to 10 g m^{-3} (~ 5%)
Air turbulence	RMS pressure variation	Meteorology Research, Inc. Model 1120	0 to 10 $cm^{2/3}$ s^{-1} (<10%)
UV hemispheric radiation, one upward, one downward	Diffuser, filter photo-cell (0.295 to 0.390 µm)	Eppley Lab. Inc. Model 14042	0 to 70 W m^{-2} (± 3 W m^{-2})
VIS-NIR hemispheric radiation (one downward and one upward viewing)	Eppley thermopile (0.3 to 3 µm)	Eppley Lab. Inc. Model PSP	0 to 1400 W m^{-2} (± 10 W m^{-2})
Surface radiative temperature	IR radiometer 1.5° FOV (8 to 14 µm)	Omega Engineering 053701	-50° to 1000°C ± 0.8% of reading
Video image	Forward looking camera and time code	Sony Hi8 camera	SVHS tape

Parameter	Instrument Type	Manufacturer	Range(and error)
(c) Aerosol			
Number concentration of particles	Condensation particle counter	TSI Model 3760	10^{-2} to 10^{4} cm^{-3} (> 0.02 µm)
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-300	0.3 to 20 µm (30 channels)
Size spectrum of particles	35 to 120° light-scattering	Particle Measuring Systems Model PCASP-100X	0.12 to 3.0 µm (15 channels)
Size spectrum of particles	90° light-scattering	Particle Measuring Systems Model LAS-200	0.5 to 11 µm (15 channels)
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-100	2 to 47 µm (15 channels)
Size spectrum of particles	Differential Mobility Particle Sizing Spectrometer (DMPS)	TSI, modified in-house	0.01 to 0.6 µm (21 channels)
Light-scattering coefficient	Integrating 3-wavelength nephelometer with backscatter shutter	MS Electron	1.0×10^{-7} m^{-1} to 1.0×10^{-3} m^{-1} for 550 and 700 nm channels, 2.0×10^{-7} m^{-1} to 1.0×10^{-3} m^{-1} for 450 nm channel

Parameter	Instrument Type	Manufacturer	Range(and error)
Light-scattering coefficient	Integrating nephelometer	Meteorology Research, Inc. Model 1567 (modified for increased stability and faster response time)	1.0×10^{-5} m^{-1} to 2.5×10^{-3} m^{-1}
Light-scattering coefficient (for bag-house)	Integrating nephelometer	Radiance Research	1.0×10^{-6} m^{-1} to 2.0×10^{-4} m^{-1} or 1.0×10^{-6} m^{-1} to 1.0×10^{-3} m^{-1}
Light absorption and graphitic carbon	Particle soot/absorption photometer	Radiance Research	Absorption coefficient: 10^{-7} to 10^{-2} m^{-1}; Carbon: 0.1 µg m^{-3} to 10 mg m^{-3} (± 5%)
Graphitic and/or Organic Carbon	Quartz filters Thermal optical technique	Lawrence Berkely Lab. (T. Novakov)**	4 to 160 µg m^{-3} (± 1.6 µg m^{-3}) for 1 m^3 sample
Humidification factor for aerosol light-scattering	Scanning humidigraph	In house (designed and built for UW by Mark Rood)	b_{sp} (RH) for 30% ≤RH≤ 85%
(d) Cloud Physics			
Cloud and precipitation particle images	Digital holographic camera[†t]	SPEC, Inc. Model CPI-230	5 µm to 3 mm
Size spectrum cloud particles	Forward light-scattering	Particle Measuring Systems FSSP-100	2 to 47 µm (15 channels)
Size spectrum of cloud and precipitation particles	Diode occultation	Particle Measuring Systems OAP-200X (1D-C)	20 to 310 µm (15 channels)
Images of precipitation particles	Diode imaging	Particle Measuring	Resolution 25 µm

Parameter	Instrument Type	Manufacturer	Range(and error)
		Systems OAP-2D-C	
Liquid water content	Hot wire resistance	Johnson-Williams	0 to 2 or 0 to 6 g m^{-3}
Liquid water content	Hot wire resistance	King/PMS	0 to 5 g m^{-3}
Liquid water content; particle surface area; effective droplet radius	Optical sensor	Gerber Scientific Inc. PVM-100A	0.001-10 g m^{-3}; 5-10,000 cm^2 m^{-3}; 2-70 µm
Optical scattering/extinction coefficients at 635 nm, asymmetry parameter, and back-to-forward scattering ratio for cloud and precipitation drops and ice particles	g-meter	Gerber Scientific, Inc.*	Particles 10-2000 µm. Rate 5-100 Hz. Asymmetry parameter (g) to 1-2% accuracy. Optical extinction coefficient to 5-10%.
(e) Chemistry			
Particulate species $SO^{=}_4$, NO^{-}_3, Cl^{-}, Na^{+}, K^{+}, NH^{+}_4, Ca^{++}, Mg^{++}	Teflon filters and ion exchange chromatography	Gelman Dionix	0.1 to 50 µg m^{-3} (for 500 liter air sample)
SO_2	Pulsed fluorescence	Teco 43S (modified in-house)	0.1 to 200 ppb
Ozone	Chemi-luminescence (C_2H_4)	Monitor Labs Model 8410 A	0 to 5 ppmv (< 7 ppb)
CO	Infrared correlation spectrometer	Teco Model 141	0 to 50 ppmv (~0.1 ppmv)
CO_2	Infrared correlation spectrometer	LI-COR Li-6262	0 to 300 ppmv (0.2 ppmv at 350 ppmv)
NO/NO_x	Chemi-luminescence	Modified Monitor	0 to 5 ppmv (~1 ppb)

Parameter	Instrument Type	Manufacturer	Range(and error)
	(O_3)	Labs Model 8840	
(f) Remote Sensing			
Radar reflectivity	Pulsed 35 GHz radar (λ = 0.86 cm)(same as ground units at Barrow and Ship but without doppler)	In-house	Upward or downward pointing (600 m to 20 km)
Absorption and scattering of solar radiation by clouds and aerosols; reflectivity of surfaces	Thirteen wavelength scanning radiometer--Cloud Absorption Radiometer(CAR)	NASA-Goddard/ University of Washington	13 discrete wavelengths between 470 and 2300 nm
Weather radar	Pilot's radar(λ=3 cm)	Bendix/King(now Allied Signal)	160 nm
Solar Spectral irradiance or radiance; Spectral transmission and reflectance	Up and down looking hemispherical signal collectors	NASA Ames Solar Spectral Flux Radiometer (SSFR)*	300-2500 nm (5-10 nm revolution. FOV 1 mrad. 1 Hz spectral sampling rate.
(g) Data Processing and Display			
In-flight data processing and recording	Microcomputer	In-house, based on Motorola MVME-133A technology	
Recording (analog voice transcription)	Cassette recorder	---	

Parameter	Instrument Type	Manufacturer	Range(and error)
In-flight data processing and display	Laptop PC	NEC Versa 5060X	
Digital printout	Impact printer	Epson MX-80	

* Guest instrument (SSP-2 unlikely).
**Guest instrument uncertain
† To be ordered if funding permits.
†† Ordered (to be delivered 1 March or, at latest, 1 April)

D.3.1 Solar Spectral Flux Radiometer (SSFR)

Characteristics:

- 300 nm - 2500 nm spectral range
- hemispheric or narrow field of view (1 mrad)
- 5-15 nm resolution
- $\geq$ 1 Hz spectral sampling rate
- calibration: integrating sphere, standard lamp, standard diffuser, cavity radiometer
- Pressure/Temperature chamber tested
- zenith and nadir pointing.

Data Products

- solar spectral radiance or irradiance
- spectral reflectance and transmittance: $R(\mu_o)=F_{\uparrow}/\mu_o F_o$; $T(\mu_o)=F_{\downarrow}/\mu_o F_o$
- bi-directional spectral reflectance and transmittance: $R(\mu,\mu_o)=\pi I(-1\leq\mu<0)/\mu_o F_o$; $T(\mu,\mu_o)=\pi I(0<\mu\leq 1)/\mu_o F_o$
- surface spectral albedo

- derived products to be provided: TBD; other possible derived products: cloud water phase, optical depth, particle size, liquid/ice water path, liquid/ice water content

D.3.2 Cloud Absorption Radiometer

Instrument Description

The Cloud Absorption Radiometer (CAR), considered the most frequently used airborne instrument built in-house at NASA Goddard Space Flight Center, is capable of measuring how light is scattered by clouds in thirteen spectral bands. The scan mirror, rotating at 100 rpm, directs the light into a Dall-Kirkham telescope where the beam is split into eight paths. Seven light beams pass through beam splitters, dichroics, and lenses to individual detectors (0.30 - 1.27 µm), and finally are registered by seven data channels. They are sampled simultaneously and continuously. The eight beam, on the other hand, passes through a spinning filter wheel to a Stirling cycle cooler. Signals registered by the eighth data channel are selected from among six spectral channels (1.55 - 2.30 µm). The filter wheel can either cycle through all six spectral bands at a prescribed interval (usually changing filter every fourth scan line), or lock onto any one of the six spectral bands and sample it continuously.

The CAR scan mirror scans 360° in a plane perpendicular to the direction of flight. In the normal mode of operation, the CAR views 190° of earth-atmosphere scene around the starboard horizon. This configuration permits observations of both zenith and nadir with as much as a 5° aircraft roll. The CAR instrument can also be used as a downward looking multi-spectral imaging device. In this mode of operation, the CAR instrument and the aircraft nose cone assembly are rotated 90° around the principal axis prior to takeoff. The CAR's viewing area becomes 190° around the nadir. Table 1 summaries the characteritics of the CAR sensor, platform and scanning system.

Table 1. CAR Instrument Specifications

Host Platform	Convair C-131A, University of Washington
True Air Speed	80 m/s (nominal)
Total Field of View	190°
Instantaneous Field of View	1°
Scan Rate	100 scans/minute (1.67 Hz)

Pixels Per Scan Line	395 (nominal)
Spectral Bands	13
Spectral Range	0.3 - 2.3 µm
Data Channels	8
Bits Per Channel	10 bits
Sampling Rate	1250 * 8 channels = 10,000 bytes/s
Data Rate	11,683 bytes/s

At the beginning of each mirror scan cycle, the CAR data acquisition system first records a ten byte header. It contains information such as flight number, current date, roll angle and scan line counter, etc. Following the header is the data stream from eight data channels. Two sync pulses denote the start and end of an active scan segment. These pulses are distinguished by their differing time durations. Assuming zero aircraft roll and pitch angle, the CAR scan mirror should be looking at 5° before zenith direction at the first pulse and 5° past nadir at the second pulse. Also multiplexed into each channel on each scan cycle are the set of reference voltage as well as measurements from the four internal thermistors. The reference voltages range from 0.00 to 8.00 V in steps of 1.00 V and give the appearance of a staircase. This voltage staircase permits the conversion of digital counts to voltage, while the conversion from voltage to radiance is accomplished through a laboratory pre-and-post-flight calibration procedure.

The instrument incorporates several novel features. Since it is flown through clouds, there is the possibility that moisture may be deposited on optical surfaces, especially the scan mirror, producing large errors. The instrument is mounted outside the airplane and cannot be observed in flight. In order to check for water on the mirror, a unique detection system was devised. A thin beam of light is shone on the edge of the mirror, and the reflected beam is monitored by a photodiode. If any condensation appears on the mirror the reflected light scatters, reducing the photodiode's output and flagging data likely to be in error. Another novel feature maintains low offset (ensuring that zero volts at the output always correspond to a zero-radiance input) by using the scan mirror as a type of radiation chopper. It works by forcing the electrical output to zero during each backscan while the detectors are all completedly darkened by means of a scanner-synchronized moveable shutter. Long time constant coupling in the amplifier then ensures that data measured during the active part of the scan remains accurately related to this zero reference level.

Data Product

Calibrated radiances

Please refer to the CAR web site listed in table 9.4-1 for the source of this information and more details.

D.4 Canadian CV-580 Instruments

Instrument	Micro physics	Chemistry	Dynamics/ Thermo dynamics	Radiation
Inboard PCASP	Na and spectra			
Epply UV				Radiative fluxes
Dropsonde			T, Td, U, Z, RH	
LandSat Simulator				Reflectance at 4 channels
U. of Arizona Radiometer				Reflectance at 2 channels
LIDAR(up and downward looking)				Backscatter coefficient, Reflectance
Nephelometer				Volume light scattering coefficient
AES Rosemount Temperature			T	
Reverse Flow			T	
CVI	Ni, IWC, Td, qv, size distribution	Ice nuclei information		

Instrument	Micro physics	Chemistry	Dynamics/ Thermo dynamics	Radiation
Rosemount Ice Detector and Vibrometer Ice Detector	Phase separation			
Airbus Icing Rod	Phase change			
King Probes	LWC			
Nevzorov Probes	LWC, TWC		Td	
FSSP-100-96	Nd, droplet spectra			
FSSP-100-124	Nd, droplet spectra			
2D2-C or 2D-C 2D-GA 2D-P	Ni,ice crystal spectra, shape			
DRI Replicator	Shape, Ni			
DRI Cloudscope	Shape, Ni, IWC			
SPEC. Probe??	Shape, Ni,			
PCASP	Na, aerosol spectra			
FSSP-300	Nd, droplet Spectra; Na, aerosol spectra			

Instrument	Micro physics	Chemistry	Dynamics/ Thermo dynamics	Radiation
Extinction Meter				Visible extinction coefficient
IR Pyrgeometer (up and down)				IR radiative fluxes
SW Pyranometer (up and down)				SW radiative fluxes
PRT-5			Ts	
EG-G Dew point			Td	
Russian Lyman-Alpha Hygrometer	Phase		Td,Tf, latent heat fluxes	
U. of Wyoming CCNC	CCN & %SS			
TSI 3025 CN Counter	CN>3 nm			
PMS 7610, CN Counter Flowmeter	CN>15 nm			
IAR 858 Gust Probe				3-D Wind components
TECO 49,43S		Concentration of O3 and SO2		

Instrument	Micro physics	Chemistry	Dynamics/ Thermo dynamics	Radiation
Hg Monitor Calibrator		Concentration of gas-phase Hg		
Aerosol filter &flow meter		Inorganic and organic ions, black carbon, trace metals, and total organic carbon.		
Moudi Impactor & flowmeter		Size segregated inorganic and organic ions		
Tenax Cartridge flowmeter		Organohalogens		
DMA 3025	Aerosol size distribution (5-200 nm)			
Hi Vol. Flowmeter		Total organic carbon, speciated organics		

SYMBOLS USED IN TABLE

Na: aerosol concentration
Nd: Droplet concentration
Ni: Ice crystal concentration
Td and Tf: Dew point and Frost point temperatures
Ts: Surface temperature
CN: Condensation nuclei
CCN: Cloud condensation nuclei
qv: Mixing ratio
SS: super saturation
RHw: Relative humidity wrt water
LWC, IWC, TWC: liquid, ice, and total water contents

Z: Altitude
U: Horizontal wind
IR and SW: Radiative fluxes

D.4.1 Lidar

Description:

LIDAR will have simultaneous measurements at 10.64 micron in upward/downward directions. This channel also has a polarization capability in both directions.

Resulution in horizontal and vertical: ~65-100 m and 4 m, respectively.

Measurements:

Backscatter ratio, depolarization ratio

Derived parameters: cloud height, cloud base, cloud physical thickness, aerosol boundary height, particle shape, and cloud optical thickness using aircraft particle data.

D.4.2 U. of Arizona Radiometer

D.4.3 LANDSAT Simulator

D.5 SHEBA Ultralight

Specifications of the NOAA ATDD Quicksilver GT500:

- Configuration: enclosed, high wing, pusher
- Empty weight: 195 kg
- Gross weight: 454 kg
- Maximum speed: 47 m/s
- Cruise speed: 24.5-36 m/s
- Fuel capacity: 98.5 liters
- Fuel consumption: 10 liters/hour

Instruments:

Specific scientific instruments that comprise the Multiple Flux Platform (MFP) system are listed below.

- Closed path gas analyzer, LICOR 6260 closed path Infrared Gas Analyzer, for measuring carbon dioxide and water vapor concentrations
- Open path gas analyzer, NOAA ATDD designed and fabricated open path Infrared Gas Analyzer (IRGA) for determination of carbon dioxide and water vapor concentrations at high frequencies.
- Trimble TANS, A 10 Hz aircraft attitude measurement device based on GPS satellite inputs.
- Novatel Inc. Global Positioning System, a computerized system that determines aircraft position and altitude.
- Infrared Temperature Transducer, Everest Interscience series 4000 for measurement of the surface temperature below the aircraft
- Net Radiometer, REBS Model Q7.1, for the measurement of net radiant flux.
- Pressure Transducers, Data Instruments Inc., for measurement of wind velocities.
- Solar radiation sensors (up- and down-looking), LICOR 190S quantum sensors, for measuring short wave radiation and albedo, 400-700 nm, millisecond response time.
- Laser Altimeter, RIEGL Laser Measurement Systems model LD90-3300, for high resolution determination of aircraft altitude and ground surface features.
- Radar Altimeter, TERRA TRA 3000, for low resolution altitude and ground surface features.
- Pressure Sensor for measuring static pressure.
- Accelerometers, Sunstrand Data Control model QA-700, for measurement of aircraft vibration.*
- Dew point sensor, EG&G Dewtrak model 200 chilled mirror dew point hydrometer.
- Four channel Exotech Radiometer with filter bands at 504-597, 598-700, and 805-1042 nm, 1deg. or 15deg. FOV
- True color video with realtime GPS Latitude/Longitude and screen-scale captioning, for determination of surface cover and topographical characteristics.
- Sub-surface interface radar SIR2 (500 and 120 MHz) for the determination of snow and ice depths.

* No known FIRE.ACE interest

D.6 SHEBA Twin Otter

- Video camera
- KT-19 for surface temperature

D.7 SHEBA Helicopter

- high resolution video camera
- KT-19 infrared photometer for surface temperature
- visible and near-infrared SpectroRadiometer
- Nikon 35 mm

APPENDIX E--SURFACE-BASED INSTRUMENTATION AND DATA PRODUCTS

E.1 SHEBA -Ship

Quantity	Instrument	Frequency	Point of contact	Comments
Cloud radar reflectivity (z)	Cloud Radar 35 Ghz	Hourly	Uttal	Retrieved products such as cloud boundary and Doppler velocity (rn/s) layer averages or profiles of cloud microphysical properties will require post processing
Backscatter profiles	Lidar (DABUL)	Seconds	Eberhard	Average to minutes for archival
Cloud boundary height	Lidar (DABUL)	Minutes	Intrieri	Derived product
Cloud phase	Lidar (DABUL, depolarization)	Minutes	Intrieri	Derived product
SW Optical Depth	Lidar(DABUL) Derived product	Minutes	Eberhard	
Cloud microphysics	Lidar with radar/radiometers	Case studies	Eberhard	Derived product
Air temperature (z)	Balloon	Hourly	Stamnes	Profiles in lower 1 km of atmosphere
Humidity (z)	Balloon	Hourly	Stamnes	Profiles in lower 1 km of atmosphere
Cloud microphysical parameters (z)	Balloon	Hourly	Stamnes	Profiles in lower 1 km of atmosphere
Wind velocity	Balloon	Hourly	Stamnes	Profiles in lower 1 km of atmosphere

Mean shortwave intensity	Balloon	Hourly	Stamnes	Profiles in lower 1 km of atmosphere
Air pressure (z)	Rawinsonde	Twice a day	Moritz	Vertical profile
Air temperature (z)	Rawinsonde	Twice a day	Moritz	
Relative humidity (z)	Rawinsonde	Twice a day	Moritz	
Wind velocity (z)	Rawinsonde	Twice a day	Moritz	
Surface air temperature	Vaisala thermistor probe	10 minutes	Moritz	Height 2 m, 10 m upwind and downwind of ship
Surface air humidity	Vaisala humidity probe	10 minutes	Moritz	Height 2 m, 10 m upwind and downwind of ship
Surface wind velocity	RM Young propeller, vane	10 minutes	Moritz	Height 2 m, 10 m upwind and downwind of ship
Surface air pressure	Aneroid	10 minutes	Moritz	Height 2 m, 10 m upwind and downwind of ship
Broadband incident solar radiation	Eppley pyranometer	20 minutes	Moritz	Height l0 m
Broadband incident longwave radiation	Eppley pyrgeometer	10 minutes	Moritz	Height 10 m
Stress, sensible heat flux	Sonic anemometer thermometer			Nominal heights 3,5,10,20 m
Latent heat flux	Ophir rapid-response hygrometer	Hourly	Andreas	Nominal heights 3,10 m
Mean temperature	Vaisala thermistor probe	Hourly	Andreas	Nominal heights 0,3,5,10,20 m

Mean humidity	Vaisala hygrometer probe	Hourly	Andreas	Nominal heights 0,3,5,10,20 m
Upwelling/downwelling solar radiation	Eppley pyranometer	Hourly	Andreas	Nominal heights 1 m
Upwelling/downwelling longwave radiation	Eppley pyrgeometer	Hourly	Andreas	Nominal heights 1 m
Areal heat and momentum fluxes	Scintec scintillometer	Hourly	Andreas	Nominal heights 4 m
Surface temperature	Cooled-mirror hygrometer	Hourly	Andreas	Nominal heights 0.10 m
Surface temperature	Barnes infrared thermometer	Hourly	Andreas	Nominal heights I m
Mean pressure	Setra barometer	Hourly	Andreas	Nominal heights I m
Wind stress, sensible heat	sonic anemometer, thermometer	Hourly	Andreas	
Snow properties				Daily-Weekly Strum Snow depth, density, stratigraphy, particulates
Ice physical properties	Ice cores	Weekly-Monthly	Tucker	Profiles of salinity, density, brine and air volume, crystallography
Particulates	Snow and ice samples	Weekly	Light/Grenfell	
Ice mass balance	Thickness gauges	Days-weeks	Perovich	Snow depth, ice ablation/accretion at several points

Ice mass balance	Acoustic sounders	Hourly	Perovich	Snow depth, ice ablation/accretion
Ice temperature	Thermistor string	Hourly	Richter-Menge	Vertical profiles, every 10 cm
Broadband albedo	Kipp radiometer	Daily-weekly	Grenfell/Perovich	Kipp radiometer
Spectral albedo	Spectroradiometer	Daily-weekly	Perovich/Grenfell	Wave length range of 350-2500 nm
In-ice spectral irradiance	Spectroradiometer	Daily-weekly	Grenfell	Wavelength range 400-1100 nm
Irradiance in the ice	Radiometers	Hourly-daily	Perovich	Vertical profiles within the ice
Spectral transmittance	Spectroradiometer	Daily-weekly	Perovich	Wavelength range of 350-950 om
Ocean salinity (z)	Sea-Bird conductivity	Hourly	Morison	Vertical profiles to a depth of 200 m
Ocean temperature (z)	Sea-Bird temperature	Hourly	Morison	Vertical profiles to 5 depth of 200 m
Ocean heat, salt, and momentum fluxes	Turbulence Instrument Cluster	6 per second	McPhee	Measures u, v, w, T, C at 4,8,12, 16 m below the ice/water interface
Ocean temperature gradient and variance	Thermal microstructure sensor	Hourly	Morison	Vertical profiles to a depth of 200 m
Ocean drag coefficient and eddy viscosity	Acoustic Doppler Current Profiler	Minutes	Pinkel	Vertical profile to 400 m with 3 m resolution

E.2 ARM -Ship

Wind, Temperature, and Humidity Sounding Systems

- Microwave Radiometer (MWR) - 23.8 GHz and 31.8 GHz, passive; integrated column water vapor and liquid amounts overhead
- Millimeter-wavelength temperature profiler (MMTP) - ATTEX, temperature profiles from near surface to height of 300-600 m

Cloud Observation Instruments

- Vaisala ceilometer (VCEIL) - 0.905 micrometer wavelength; detects cloud base height up to heights of 7.5 km
- Whole-sky imager (WSI) - daytime and possibly nighttime; cloud fraction, number, and related statistics

Downwelling Radiation Properties

- Extended range atmospherically emitted radiance interferometer (ER-AERI) - spectra of zenith absolute radiance at wavelengths from about 4 micrometers to 20 micrometers, 1.3-deg field of view
- Infrared thermometer (IRT) - zenith sky temperatures at 223K to 323K in wavelength band 9.6-11.5 micrometers
- Multifilter rotating shadowband radiometer (MFRSR) - solar optical depths in six narrow wavebands (0.415, 0.500, 0.665, 0.862, 0.940 micrometers); derived parameters
- Normal incidence multifilter radiometer (NIMFR) - direct-beam solar irradiance in direct beam in six narrow wavebands; solar optical depths, derived parameters
- Precision Solar Pyranometer, unshaded (PSP/DS) - broadband total hemispherical solar irradiance
- Precision Solar Pyranometer, shaded (PSP/DD) - diffuse broadband hemispherical solar irradiance
- Pyrheliometer (NIP) - broadband direct-beam solar normal incidence irradiance
- Precision Infrared Radiometer-unshaded (PIR/DI) - broadband hemispherical infrared irradiance
- Precision Infrared Radiometer-shaded(PIR/DDI) - broadband hemispherical infrared irradiance
- Ultraviolet-B radiometer (UVB) - hemispherical ultraviolet-b irradiance
- Net Radiometer (RN) - net of upwelling and downwelling solar and infrared hemispherical irradiances
- Duplicate PSPs and PIRs

Upwelling Radiation Properties

- Infrared thermometer (IRT) - zenith sky temperatures at 223K to 323K in wavelength band 9.6-11.5 micrometers
- Precision Solar Pyranometer, unshaded (PSP/US) - broadband total hemispherical solar irradiance
- Pyrgeometer (PIR/UI) - broadband hemispherical infrared irradiance
- Multifilter radiometer (GND MFR) - hemispherical solar irradiance in six wavebands

E.3 ARM - Barrow

Surface Meteorological Sensors

- Wind speed, wind direction, temperature, and humidity at heights of 2, 10 and 40 m
- Dew/Frost point hygrometer, one level, movable from level to level
- Standard precipitation gage

Wind, Temperature, and Humidity Sounding Systems

- Microwave Radiometer (MWR) - 23.8 GHz and 31.8 GHz, passive; integrated column water vapor and liquid amounts overhead
- Radiosondes from NWS upper air station in Barrow
- Raman Lidar -

Cloud Observation Instruments

- Millimeter-wavelength cloud radar (MMCR) - 35 GHz, cloud boundaries at zenith up to 20 km height
- Micropulse lidar (MPL) - 0.5235 micrometer; detects cloud base height up to about 20 km
- Vaisala ceilometer (VCEIL) - 0.905 micrometer wavelength; detects cloud base height up to heights of 7.5 km

Downwelling Radiation Properties

- Extended range atmospherically emitted radiance interferometer (ER-AERI) - spectra of zenith absolute radiance at wavelengths from about 4 micrometers to 20 micrometers, 1.3-deg field of view
- UV spectrometer -
- Infrared thermometer (IRT) - zenith sky temperatures at 223K to 323K in wavelength band 9.6-11.5 micrometers
- Cimel sunphotometer (CSPHOT) - solar optical depths in eight narrow wavebands; derived quantities
- Multifilter rotating shadowband radiometer (MFRSR) - solar optical depths in six narrow wavebands (0.415, 0.500, 0.665, 0.862, 0.940 micrometers); derived parameters
- Normal incidence multifilter radiometer (NIMFR) - direct-beam solar irradiance in direct beam in six narrow wavebands; solar optical depths, derived parameters
- Precision Solar Pyranometer, unshaded (PSP/DS) - broadband total hemispherical solar irradiance
- Precision Solar Pyranometer, shaded (PSP/DD) - diffuse broadband hemispherical solar irradiance
- Pyrheliometer (NIP) - broadband direct-beam solar normal incidence irradiance

- Precision Infrared Radiometer, unshaded (PIR/DI) - broadband hemispherical infrared irradiance
- Precision Infrared Radiometer, shaded (PIR/DDI) - broadband hemispherical infrared irradiance
- Ultraviolet-B radiometer (UVB) - hemispherical ultraviolet-b irradiance
- Net Radiometer (RN) - net of upwelling and downwelling solar and infrared hemispherical irradiances
- Duplicate PSPs and PIRs

Upwelling Radiation Properties

- Infrared thermometer (IRT) - zenith sky temperatures at 223K to 323K in wavelength band 9.6-11.5 micrometers
- Precision Solar Pyranometer, unshaded (PSP/US) - broadband total hemispherical solar irradiance
- Precision Infrared Radiometer(PIR/UI) - broadband hemispherical infrared irradiance
- Multifilter radiometer (MFR) - hemispherical solar irradiance in six wavebands

Aerosol Instrumentation

- Multi Wavelength Integrating Nephelometer -
- Condensation Nuclei Counter(CNC) -
- Filter Samplers -

Gas Instrumentation

- Flask Samplers -
- Gas Chromatography for Greenhouse Gases -
- UV Ozone Monitor
- Column Ozone Monitor

E.4 FIRE -Ship

E.4.1 University of Utrecht

The IMAU will participate in FIRE III from the end of April till early June 1998. To measure the mean boundary layer structure the IMAU will operate a tethered balloon (Table E.4.1-1) (Vilà et al. 1994, van der Hage et al. 1994). With this device the mean wind velocity and direction, temperature, moisture and pressure in the lower 1000 m can be obtained (Table E.4.1-2). Moreover, the actinic flux F, a radiometric quantity which is defined as radiance integrated over all solid angles per unit area, will be measured. The actinic flux increases in clouds due to the enhancement of diffuse radiation by multiple scattering in the clouds and, for example, is a key parameter for the photodissociation rate for chemical species like NO2. In addition, a microwave radiometer will be used to determine the liquid water and water vapor path.
To provide a continuous data set, the tethered balloon will be operated every 12 hours. Data will be checked for accuracy and will be presented as a function of height with a vertical resolution of about 20 m.

Table E.4.1-1. Characteristics of the IMAU tethered balloon (ADAS basic Air-3B)

Characteristic	**Value**
measurement frequency	0.1 Hz
maximum altitude	1000 m
radio frequency	403 MHz
balloon volume	12 m3

Table E.4.1-2. Instruments attached to the IMAU tethered balloon

Instrument	**Parameter**	**Symbol**	**Units**
Tethersonde AIR017	wind velocity	U	[m/s]
	wind direction	deg	degrees
	temperature	T	[Kelvin]
	relative humidity	RH	[%]
	pressure	p	[hPa]
photoelectrical detector	actinic flux	F	[W/(m2 nm)]

Surface-based measurements will be made from a 9 m high meteorological profile mast (Table E.4.1-3) while fast measurements (Table E.4.1-4) will be made to obtain turbulence statistics in the surface layer at a height of about 3 m. Wind and temperature measurements will be performed at five heights with a frequency of 1 Hz. All raw data will be stored on CD and, after postprocessing, will be half-hour averaged and submitted to the FIRE Central Archive.

Table E.4.1-3. Instruments mounted on the IMAU profile mast

Instrument	**Parameter**	**Symbol**	**Units**
Vector A100R	wind velocity	U	[m/s]
Vector W200P	wind direction	deg	degrees
Vaisala HMP35AC	temperature	T	[Kelvin]
	moisture	q	[g/kg]
Kipp CM14	upward solar radiation	Sup	[W/m2]
	downward solar radiation	Sdown	[W/m2]

Instrument	Parameter	Symbol	Units
Eppley PIR	upward longwave radiation	Lup `	[W/m2]
	downward longwave rad	Ldown	[W/m2]

Table E.4.1-4. Surface-based instruments. High frequency measurements allow the calculation of turbulent fluxes which will be included in the data archive

Instrument	Parameter	Symbol	Units	Frequency (Hz)
Campbell CSAT3 3D	wind velocity	u, v, w	m/s	20
Campbell CSAT3 3D	temperature	T	K	20
Lyman-Alpha KOH2	water vapor	q	g/kg	20
PVM-100A	liquid water content	ql	g/kg	20
PVM-100A	effective radius	re	micrometer	20
Microwave radiometer	liquid water path	LWP	g/m2	0.03
	water vapor path	WVP	g/m2	0.03

The balloon flights will be coordinated and scheduled to coincide with overpasses of polar orbiting satellites such as NOAA and DMSP, and satellite data from AVHRR will be used to help 'scale-up' local measurements to geographic areas comparable in size to that of a GCM grid cell.

E.4.2 Solar Spectral Flux Radiometer (SSFR)

Characteristics:

- 300 nm - 2500 nm spectral range
- hemispheric or narrow field of view (1 mrad)
- 5-15 nm resolution
- $\geq$ 1 Hz spectral sampling rate
- calibration: integrating sphere, standard lamp, standard diffuser, cavity radiometer
- Pressure/Temperature chamber tested
- zenith pointing

Data Products:

- solar spectral radiance or irradiance
- spectral reflectance and transmittance: $R(\mu_o)=F_{\uparrow}/\mu_o F_o$; $T(\mu_o)=F_{\downarrow}/\mu_o F_o$
- bi-directional spectral reflectance and transmittance: $R(\mu,\mu_o)=\pi I(-1\leq\mu<0)/\mu_o F_o$; $T(\mu,\mu_o)=\pi I(0<\mu\leq 1)/\mu_o F_o$
- surface spectral albedo
- derived products provided: TBD; other possible derived products: cloud water phase, optical depth, particle size, liquid/ice water path, liquid/ice water content

E.5 Buoys

Four NCAR Portable Automated Mesonet (PAM) stations are deployed in the vicinity of the main Sheba icecamp. These are so-called flux PAMS with instruments to measure turbulent and radiative fluxes. Each station is completely independent with an onboard data acquisition and processing computer. The data are processed into 5-minute averages and statistics which are immediately transmitted via RF modem to a central computer on the ship. The PAMs are deployed at four locations designated Florida, Atlanta, Baltimore, and Cleveland (listed in order of increasing distance from the ship). Florida is actually located in the icecamp near the flux group's main tower. The others are on different ice types 2-6 km away (that is, at the initial deployment)
The information obtained from the PAM stations is:

- Wind speed and direction
- Air temperature and humidity
- Ice-snow interface temperature
- Station orientation and position
- Atmospheric pressure
- Covariance fluxes of momentum and sensible heat
- Upward and downward longwave and solar radiative fluxes
- Heat flux at the ice-snow interface
- Variance of wind components and temperature

APPENDIX F--SHEBA SHIP(ICE STATION)

F.1 Overview

The Canadian Department of Fisheries and Oceans (DFO) is providing the ship and ship related support to SHEBA as defined by the SHEBA Project Office and Logistics Office. The mission profile is described in the next section. DFO believes that in order to met the outlined support needs the services of two ships are required. As the drift platform they offer the Canadian Coast Guard icebreaker the N.G.C.C. Des Groseilliers. As the second (support) ship they offer the N.G.C.C. Louis St. Laurant. The Louis St. Laurant will be available to assist the Groseilliers as needed and to support some of the ancillary project elements

F.2 SHEBA Ship Facilities

While at the research site the Groseilliers will serve as:

- The research platform for some of the SHEBA experiments. Science vans can be positioned on the helo deck or other deck area. Instrumentation can be mounted on the wheel house and other suitable locations. The ship has a multitude of rooms /space /cabins suitable for setting up ship based laboratories.
- The hotel, with victualing and accommodation for SHEBA participants throughout the duration of the drift. The number of personnel is expected to vary between 10 and 30 . Cabins will be maintained by the occupants, with operator furnishing clean bedding and towels.
- Storage area for project equipment and supplies.
- The command and control center, with customer access to the bridge and the communications, network and navigation equipment.

Once in the research area, the ship's crew will be reduced during the drift phase to a number sufficient to be fully self reliant, safely support the vessel as a base/hotel, respond to any ship emergencies, and to render occasional assistance to the logistical aspects of the project , i.e., cargo handling on/off ship, runway building and upkeep, repair of mechanical and electric nature, etc.

Many experiments will be carried out on the ice floes around the ship. Heated tent or plywood shelters will serve as laboratories at some of these on-ice research sites. It is anticipated that everybody will live onboard and that only in special cases will personnel overnight in the on-ice labs. Over the side ships electrical power is planned for the sites within convenient distance, i.e., up to 500 meters from the ship. Ships fuel will be used for heating these huts and for on-site electric power generators at the more distant sites, i.e., beyond 500 meters. The Logistics Office has a variety of shelters with heat and basic furnishings for use as on-ice laboratories. Electric power cables, some transformers to interface to ship's power, and some smaller generators are available as well. Investigators are asked to reexamine their needs and negotiate with the Logistics office for specific support requirements.

F.3 Schedules and Operations Constraints

It is anticipated that the ship will load material at a middle-latitude port such as Seattle or Halifax late in the summer of 1997. After the ship has transited to the Beaufort Sea, it is anticipated there will be an opportunity to load additional material transported to the ship by lighter from an arctic shore base such as Prudhoe Bay. Once the ship is on station in the pack ice, transport of personnel and material will be by aircraft. Typical of the support for past experiments is the Twin Otter. Specifications for aircraft likely to support the SHEBA experiment can be linked via the SHEBA home page. A feasible scenario for transport is to operate the Twin Otter or similar A/C for 5-6 day periods at intervals of 8-10 weeks. Thus personnel at the SHEBA experiment would plan to spend 8-10 weeks at a time in the field.

The tentative, but not final schedule for SHEBA is:

- To the extent possible project equipment and supplies will be loaded on the Groseilliers in Quebec and the LOUIS at Halifax prior to sailing North for the summer-fall cruises.
- The Groseilliers departs on July 2 and the Louis on August 8. Groseilliers will arrive off Prudhoe Bay around 13 September, 1997. Before proceeding West for the mooring work off Barrow , needed personnel and equipment will be loaded using ships helo or barge.
- The Louis will arrive off Prudhoe Bay around 25 September, and using ships helo and barge, take on ancillary science personnel and equipment before proceeding north on the science cruise.
- The Groseilliers will return to Prudhoe around 19 September and all SHEBA project equipment, supplies and personnel will be lightered to the Groseilliers by barge service to be arranged by the SHEBA Logistics Office. Some ship's helo support might be required to ferry personnel from Prudhoe Bay to the ship .
- An alternative to this scenario is to load all equipment on the Groseilliers 13-14 September before departing for the mooring work off Barrow. Ice conditions permitting this would allow the Groseilliers to proceed directly toward the SHEBA site following deployment of the western JAMSTEC mooring and the UW ULS. Personnel would have the option of embarking at Prudhoe on the later arriving LOUIS.
- While the Louis is supporting ancillary Canadian, and US science, she will be close by and available to assist the Groseilliers as required while en route to the SHEBA research area.
- En route to SHEBA, when at the desired location, the Groseilliers will hold for deployment of the IOEB-2 buoy, and a ULS mooring. Other buoys and ULS moorings will be deployed when practical.
- Arrival at the SHEBA site is anticipated to be on September 29.
- At the research location, to be selected in the area of 75.5-76.5^{o}N, 141-145°W the GROSEILLIERS will be parked in a suitable location and project equipment and stores carried by the Louis off-loaded in the vicinity.
- Ships' helicopters, before departing on the Louis, will provide flight support to implant remaining data buoys in an array up to 100 km from the GROSEILLIERS.
- Before departing Louis will top off all fuel tanks on the Groseilliers.
- The Louis is scheduled to depart 10-12 October.
- The Louis, on its way out of the ice, will support additional ancillary Canadian and US science, deploy remaining buoys and moorings and stop at Prudhoe to disembark project equipment and personnel.

- The Groseilliers will be allowed to freeze in and drift passively with the moving pack ice for approximately one year. The requirement for a full summer melt through fall freeze-up cycle, to be observed in sequence, suggests that the drift might not terminate until late October 1998.
- Ice conditions permitting, first air operations to the site is scheduled for 15 October and then every six weeks thereafter.
- At the end of the drift, the Des Groseilliers will return to Seattle for off-loading of project equipment. Some lighter transfer of project equipment and personnel between the Groseilliers and Prudhoe Bay or Barrow is anticipated on the way out, again the responsibility of the SHEBA Logistics Office.
- If necessary, the Louis will be available to help extract the Groseilliers , in which case and if practical, the Louis' helicopter will be available to lift project participants to Prudhoe Bay or Barrow.

Ships helicopters will support the fall 1997 establishment of the SHEBA site. This involves primarily the deployment of the buoy array. Both helos will depart on the Louis. For a 4-6 week period in the spring (tentatively 15 April-30 May) a polar bear tagging project will base at the ship, bringing a Bell 206 helicopter, that to a limited extent is available to support other needs. (Drs. Farley and Ramsey) A helicopter will again be at the ship to support the 1998 summer through fall scientific program. The Logistics Office will contract for this aircraft. An aircraft of the AS350-B2 or MBB 105 type is envisioned. The primary uses, with tentative hour allocations are: Routine photo flights (50 Hours), occasional visits to the primary buoy sites, 3-4 sites 50 Km out (10 hours), recovery/refurb of the buoy array at the end (15 hours), ice sampling at adjacent floes (10 hours), logistics (10).

Throughout the experiment, the service between the ship and shore will be by aircraft, most likely a DeHavilland Twin Otter operating from Prudhoe Bay. The Logistics Office will contract for this aircraft. Such services are planned to take place during a 2- to 4 days time period every 6 weeks, with a higher frequency during the months of April and May, 1997. Project crew rotation, delivery of data tapes, parts, mail, and fresh food are the main purposes of these airlifts. No serious problem is anticipated in meeting this schedule during the fall-winter-spring period. Surface conditions and distance from shore will determine how well the summer flight service can be upheld. The first rotation is tentatively scheduled for mid- October. By that time it is expected that all experiments are installed and checked. The installation crews will depart and the winter crews move in. To the extent that the Groseilliers crew rotation is scheduled around the Project schedule, the Logistics Office will arrange for the needed flight support between ship and shore. The crew rotation and re-supply aircraft, might need an occasional refueling at the ship and some turbine fuel will be carried for this purpose. (15 drums)

Transer of personnel and equipment between the SHEBA site and a shore base, i.e., Prudhoe Bay, Barrow, or other, will be attempted using fixed wing aircraft. Surface conditions at the SHEBA site will change during the course of the 14 month long experiment. As the ship drifts with the moving ice, the distance to shore bases will change as well. A variety of aircraft are therefore likely to be employed as the project evolves.

The first air operations (surface conditions permitting) will be attempted over a 3 - 5 day period to include 15 October (due to crew rotation requirements). After that, again driven by contractual requirements for crew rotation, there will be such flight operations scheduled every 42 days, i.e., centered around 26 Nov., 7 Jan., 18 Feb., 1 April, 13 May, 24 June, 5 Aug., and 16 Sept. Additional Flight operations are planned around 01 Nov., 11 Mar., 22

April, and 31 May. These "additional" periods may be added to and shifted depending upon needs, lead time being offered, and surface conditions.

The ability to carry out summer and fall 1998 operations will depend on surface conditions at the ship, distance to shore, and availability of suitable aircraft. Based on how flying conditions develop during the spring month, an attempt will be made to project when the last opportunity for assured flight operations will be. This will be announced and updated so participants and the aircraft operator have the opportunity to adjust their schedules. The resumption of fall flight operations will be dealt with similarly.

Projects that are deploying to the ship after the start of the drift or terminating before the end should make every attempt to load as much equipment as possible on board prior to the ship's departure. If departing early, projects should plan to leave most equipment behind to come out with the ship at the end. Over the distances involved, the Twin Otter will become an expensive cargo freighter. Also, the 4x4 foot side door "loses" width quickly as cargo items get longer. A larger cargo plane requires more runway which is harder to find and maintain.

Please see the logistics information on the SHEBA home page(section 9.4) for more detailed and current information.

APPENDIX G--DATA PARAMETERS

Data parameters may be sensor direct measurements(basic data) or parameters resulting from further processing and the use of algorithms on basic data(derived products).

G-1 Instruments and Data Parameters for the Arctic Cloud Experiment

Data Parameters	Location/ Platform	Instrument	Instrument Investigator	Category	Archive Location
		Surface - Passive:			
Air temperature (z)	SHEBA	Balloon	Stamnes	1	
Humidity (z)	SHEBA	Balloon	Stamnes	1	
Cloud microphysical parameters (z)	SHEBA	Balloon	Stamnes	2	
Wind velocity	SHEBA	Balloon	Stamnes	1	
Mean shortwave intensity	SHEBA	Balloon	Stamnes	1	
Air pressure (z)	SHEBA	Rawinsonde	Moritz	1	
Air temperature (z)	SHEBA	Rawinsonde	Moritz	1	
Relative humidity (z)	SHEBA	Rawinsonde	Moritz	1	
Wind velocity (z)	SHEBA	Rawinsonde	Moritz	1	
Surface air temperature	SHEBA	Vaisala thermistor probe	Moritz	1	
Surface air humidity	SHEBA	Vaisala humidity probe	Moritz	1	
Surface wind velocity	SHEBA	RM Young propeller, vane	Moritz	1	
Surface air pressure	SHEBA	Aneroid	Moritz	1	
Broadband incident solar	SHEBA	Eppley pyranometer	Moritz	1	
Broadband incident longwave	SHEBA	Eppley pyrgeometer	Moritz	1	
wind stress	SHEBA	Sonic anemometer thermometer	Andreas	1	
sensible heat flux	SHEBA	Sonic anemometer thermometer	Andreas	1	
Latent heat flux	SHEBA	Ophir rapid-response hygrometer	Andreas	1	
Mean temperature	SHEBA	Vaisala thermistor probe	Andreas	1	
Mean humidity	SHEBA	Vaisala hygrometer probe	Andreas	1	
Upwelling/downwelling solar	SHEBA	Eppley pyranometer	Andreas	1	
Up/downwelling longwave	SHEBA	Eppley pyrgeometer	Andreas	1	
Areal heat	SHEBA	Scintec scintillometer	Andreas	1	
Areal momentum	SHEBA	Scintec scintillometer	Andreas	1	
Surface temperature	SHEBA	Cooled-mirror hygrometer	Andreas	1	
Surface temperature	SHEBA	Barnes infrared thermometer	Andreas	1	
Mean pressure	SHEBA	Setra barometer	Andreas	1	

Data Parameters	Location/ Platform	Instrument	Instrument Investigator	Category	Archive Location
Wind stress, sensible heat	SHEBA	sonic anemometer, thermometer	Andreas	1	
Broadband albedo	SHEBA	Kipp radiometer	Grenfell/ Perovich	1	
Spectral albedo	SHEBA	Spectroradiometer	Perovich/ Grenfell	1	
Many parameters	SHEBA	PAMS (several locations)	Andreas/Fairall	1	
integrated column water vapor	SHEBA-ARM	MWR	ARM	1 or 2	
integrated liquid water amount	SHEBA-ARM	MWR	ARM	1 or 2	
temperature profiles from near surface to height of 300-600 m	SHEBA-ARM	MMTP - ATTEX	ARM	1 or 2	
cloud fraction	SHEBA-ARM	WSI	ARM	1 or 2	
cloud number	SHEBA-ARM	WSI	ARM	1 or 2	
related statistics	SHEBA-ARM	WSI	ARM	1 or 2	
absolute radiance at 4 - 20 micrometers	SHEBA-ARM	(ER-AERI	ARM	1 or 2	
zenith sky temperatures at 223 - 323K at 9.6-11.5 micrometers	SHEBA-ARM	IRT	ARM	1 or 2	
solar optical depths in six narrow wavebands (0.415, 0.500, 0.665, 0.862, 0.940 micrometers)	SHEBA-ARM	MFRSR	ARM	1 or 2	
derived parameters	SHEBA-ARM	MFRSR	ARM	1 or 2	
solar optical depths	SHEBA-ARM	NIMR	ARM	1 or 2	
derived parameters	SHEBA-ARM	NIMR	ARM	1 or 2	
broadband total hemispherical solar irradiance	SHEBA-ARM	PSP/DS)	ARM	1 or 2	
diffuse broadband hemispherical solar irradiance	SHEBA-ARM	PSP/DD	ARM	1 or 2	
broadband direct-beam solar normal incidence irradiance	SHEBA-ARM	NIP	ARM	1 or 2	
broadband hemispherical infrared irradiance	SHEBA-ARM	PIR/DI	ARM	1 or 2	
hemispherical ultraviolet-b irradiance	SHEBA-ARM	UVB	ARM	1 or 2	
net of upwelling and downwelling solar and infrared hemispherical irradiances	SHEBA-ARM	RN	ARM	1 or 2	
hemispherical solar irradiance in six wavebands	SHEBA-ARM	GND MFR	ARM	1 or 2	
broadband total hemispherical solar irradiance	SHEBA-ARM	PSP/US	ARM	1 or 2	
broadband hemispherical IR irradiance	SHEBA-ARM	PIR/UI	ARM	1 or 2	
IWC	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
LWC	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
IWP	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
LWP	SHEBA-ARM	ER-AERI/MWR	Uttal	2	

Data Parameters	Location/ Platform	Instrument	Instrument Investigator	Category	Archive Location
cloud optical depth	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
particle size profile	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
particle size layer average	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
particle concentration profile	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
particle concentration layer average	SHEBA-ARM	ER-AERI/MWR	Uttal	2	
solar spectral radiance or irradiance	SHEBA-FIRE	SSFR	Pilewskie	1	
spectral reflectance	SHEBA-FIRE	SSFR	Pilewskie	1	
spectral transmittance	SHEBA-FIRE	SSFR	Pilewskie	1	
bi-directional spectral reflectance	SHEBA-FIRE	SSFR	Pilewskie	1	
bi-directional spectral transmittance	SHEBA-FIRE	SSFR	Pilewskie	1	
surface spectral albedo	SHEBA-FIRE	SSFR	Pilewskie	2	
cloud water phase	SHEBA-FIRE	SSFR	Pilewskie	2	
optical depth	SHEBA-FIRE	SSFR	Pilewskie	2	
particle size	SHEBA-FIRE	SSFR	Pilewskie	2	
liquid/ice water path	SHEBA-FIRE	SSFR	Pilewskie	2	
liquid/ice water content	SHEBA-FIRE	SSFR	Pilewskie	2	
Vertical profiles (sfc. to 1 km) of pressure, temperature, humidity, wind vel. and dir., and actinic flux	SHEBA-FIRE	U Utrecht Tethered balloon	Duynkerke	1	
Vertical profiles (sfc. to 9m) of T, wind vel. and dir., moisture, up/down solar irradiances, and up/down longwave irradiances	SHEBA-FIRE	U Utrecht 9m tower	Duynkerke	1	
Surface air temperature, pressure, wind vel., water vapor, LWC, effective radius, and LWP	SHEBA-FIRE	U Utrecht Tethered Surface	Duynkerke	1	
cloud boundaries at zenith up to 20 km height	ARM-Barrow	MMCR	ARM	1 or 2	
Temperature, wind, and humidity profiles	ARM-Barrow	Rawinsonde	ARM	1 or 2	
Tethered temperature, wind, and humidity profiles	ARM-Barrow	Airsonde-TBD	ARM	1 or 2	
downwelling zenith sky temperature	ARM-Barrow	IRT	ARM	1 or 2	
upwelling surface temperature	ARM-Barrow	IRT	ARM	1 or 2	
solar optical depths in eight narrow wavebands	ARM-Barrow	CSPHOT	ARM	1 or 2	
derived quantities	ARM-Barrow	CSPHOT	ARM	1 or 2	
solar irradiances in 6 bands	ARM-Barrow	NIMFR	ARM	1 or 2	
solar optical depths	ARM-Barrow	NIMFR	ARM	1 or 2	
derived parameters	ARM-Barrow	NIMFR	ARM	1 or 2	

Data Parameters	Location/ Platform	Instrument	Instrument Investigator	Category	Archive Location
broadband total hemispherical solar irradiance	ARM-Barrow	PSP/DS	ARM	1 or 2	
diffuse broadband hemispherical solar irradiance	ARM-Barrow	PSP/DD	ARM	1 or 2	
broadband direct-beam solar normal incidence irradiance	ARM-Barrow	NIP	ARM	1 or 2	
broadband hemispherical infrared irradiance	ARM-Barrow	PIR/DI	ARM	1 or 2	
hemispherical ultraviolet-b irradiance	ARM-Barrow	UVB	ARM	1 or 2	
net of upwelling and downwelling solar and infrared hemispherical irradiances	ARM-Barrow	RN	ARM	1 or 2	
broadband total hemispherical solar irradiance	ARM-Barrow	PSP/US	ARM	1 or 2	
broadband hemispherical infrared irradiance	ARM-Barrow	PIR/UI	ARM	1 or 2	
hemispherical solar irradiance in six wavebands	ARM-Barrow	MFR	ARM	1 or 2	
solar optical depths in six narrow wavebands (0.415, 0.500, 0.665, 0.862, 0.940 micrometers)	ARM-Barrow	MFRSR	ARM	1 or 2	
derived parameters	ARM-Barrow	MFRSR	ARM	1 or 2	
cloud fraction	ARM-Barrow	Whole Sky Imager	ARM	1 or 2	
cloud number	ARM-Barrow	Whole Sky Imager	ARM	1 or 2	
related statistics	ARM-Barrow	Whole Sky Imager	ARM	1 or 2	
integrated column water vapor	ARM-Barrow	MWR	ARM	1 or 2	
integrated liquid amount	ARM-Barrow	MWR	ARM	1 or 2	
temperature profiles from near surface to height of 300-600 m	ARM-Barrow	MMTP - ATTEX	ARM	1 or 2	
Wind speed, wind direction, temperature, and humidity at heights of 2, 10 and 40 m	ARM-Barrow	Surface weather station	ARM	1 or 2	
Dew/Frost point at heights of 2, 10 and 40 m	ARM-Barrow	Surface weather station	ARM	1 or 2	
precipitation at heights of 2, 10 and 40 m	ARM-Barrow	Surface weather station	ARM	1 or 2	
TBD	ARM-Barrow	Transmissometer-TBD	ARM	1 or 2	
profiles of water vapor	ARM-Barrow	Passive microwave	ARM	1 or 2	
TBD	ARM-Barrow	449-MHz WP and RASS-TBD	ARM	1 or 2	
upwelling broadband total hemispherical solar irradiance	ARM-Barrow	PSP/DS	ARM	1 or 2	
upwelling broadband total hemispherical IR irradiance	ARM-Barrow	PIR/DI	ARM	1 or 2	
cloud boundaries	ARM-Barrow	Lidar/Ceilometer	ARM	1 or 2	
absolute radiance at 4 - 20 micrometers	ARM-Barrow	ER-AERI	ARM	1 or 2	
IWC	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	
LWC	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	
IWP	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	

Data Parameters	Location/ Platform	Instrument	Instrument Investigator	Category	Archive Location
LWP	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	
cloud optical depth	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	
particle size profile	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	
particle size layer average	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	
particle concentration profile	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	
particle concentration layer average	ARM-Barrow	ER-AERI/MWR	ARM	1 or 2	

Data Parameters	Location/ Platform	Instrument	Inst. PI	Category	Archive Location
		Surface-Active			
Radar images	SHEBA	Cloud Radar 35 GHz	Uttal	0	
Radar backscatter profiles	SHEBA	Cloud Radar 35 GHz	Uttal	0	
Radar Doppler velocities	SHEBA	Cloud Radar 35 GHz	Uttal	0	
Cloud radar reflectivity (z)	SHEBA	Cloud Radar 35 GHz	Uttal	1	
cloud boundaries	SHEBA	Cloud Radar 35 GHz	Uttal	1	
ice cloud layer mean particle size	SHEBA	Cloud Radar 35 GHz	Uttal	1	
ice cloud layer mean particle concentration	SHEBA	Cloud Radar 35 GHz	Uttal	1	
ice cloud layer particle size profile	SHEBA	Cloud Radar 35 GHz	Uttal	2	
ice cloud layer particle concentration profile	SHEBA	Cloud Radar 35 GHz	Uttal	2	
LW cloud profile	SHEBA	Cloud Radar 35 GHz	Uttal	2	
water cloud turbulence profile	SHEBA	Cloud Radar 35 GHz	Uttal	2	
Radar spectra of velocities	SHEBA	Cloud Radar 35 GHz	Uttal	3	
Backscatter profiles	SHEBA	Lidar (DABUL)	Eberhard/Grund	0	
Aerosol scattering profiles	SHEBA	Lidar (DABUL, depolarization)	Intrieri/Grund	1	
Aerosol extinction profiles	SHEBA	Lidar (DABUL, depolarization)	Intrieri/Grund	1	
Cloud boundaries	SHEBA	Lidar (DABUL)	Eberhard/Grund	1	
lidar depolarization	SHEBA	Lidar (DABUL, depolarization)	Intrieri/Grund	1	
ice/water/mixed phase index	SHEBA	Lidar (DABUL, depolarization)	Intrieri/Grund	2	
optical depth	SHEBA	Lidar (DABUL, depolarization)	Intrieri/Grund	4	
crystal habits	SHEBA	Lidar (DABUL, depolarization)	Intrieri/Grund	4	
Cloud microphysics	SHEBA	Lidar with radar/radiometers	Eberhard	2	

Data Parameters	Location/ Platform	Instrument	Inst. PI	Category	Archive Location
cloud base height up to heights of 7.5 km	SHEBA-ARM	VCEIL		1	
Cloud base height up to about 20 km	ARM-Barrow	MPL	ARM-Barrow	1	
cloud base height up to heights of 7.5 km	ARM-Barrow	VCEIL	ARM-Barrow	1	
Wind profiles up to 2 km	ARM-Barrow	915 MHz Profiler with RASS	ARM-Barrow	1	
virtual temperature profiles up to 0.5 km	ARM-Barrow	915 MHz Profiler with RASS	ARM-Barrow	1	
Water vapor profiles	ARM-Barrow	Raman water vapor lidar?	Philbrick	?	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
		Aircraft -Remote			
multispectral radiance image at 50 wavelengths	NASA ER-2	MAS	King	2	
spectral reflectance	NASA ER-2	MAS	King	2	
bi-directional spectral reflectance	NASA ER-2	MAS	King	2	
solar spectral radiance	NASA ER-2	MAS	King	2	
liquid/ice water path	NASA ER-2	MAS	King	3	
cloud optical thickness	NASA ER-2	MAS	King	3	
cloud water phase	NASA ER-2	MAS	King	3	
RTI	NASA ER-2	CLS	Spinhirne	0	
aerosol scattering profile	NASA ER-2	CLS	Spinhirne	1	
vertical structure	NASA ER-2	CLS	Spinhirne	2	
cloud height	NASA ER-2	CLS	Spinhirne	2	
depolarization	NASA ER-2	CLS	Spinhirne	2	
cloud habit	NASA ER-2	CLS	Spinhirne	2	
calibrated radiances	NASA ER-2	AirMISR	Conel	1	
co-registered radiances	NASA ER-2	AirMISR	Conel	1	
stereo cloud heights	NASA ER-2	AirMISR	Conel	2	
Calibrated brightness temperatures at 89, 150, 220, 184, 186, 190 GHz at 57 beam positions covering 100 deg. swath	NASA ER-2	MIR	J. Wang	1	
Water vapor profiles	NASA ER-2	MIR	J. Wang	2	
cloud information (liquid clouds, or ice water path from storm-associated ice clouds)	NASA ER-2	MIR	J. Wang	2	
IR Spectral Radiances	NASA ER-2	SHIS	Revercomb	1	
Vertical Temperature distributions	NASA ER-2	SHIS	Revercomb	2	
Vertical Water Vapor distributions	NASA ER-2	SHIS	Revercomb	2	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
Sea Surface Temperature	NASA ER-2	SHIS	Revercomb	2	
Land Surface Temperature	NASA ER-2	SHIS	Revercomb	2	
Land Surface Emissivity	NASA ER-2	SHIS	Revercomb	2	
Cloud properties (height, emissivity, particle size, phase, ice/liquid water content)	NASA ER-2	SHIS	Revercomb	2	
Ozone vertical profile	NASA ER-2	SHIS	Revercomb	2	
CO total column	NASA ER-2	SHIS	Revercomb	2	
Calibrated brightness temperatures at 85.5, 37.1, 19.35, 10.7 GHz	NASA ER-2	AMPR	Hood	1	
Imagery of calibrated brightness temperature both in raster format and gridded latitude and longitude maps	NASA ER-2	AMPR	Hood	1	
Sea ice emissivity	NASA ER-2	AMPR	Curry	2	
Bulk vertical profiles of hydrometeors	NASA ER-2	AMPR	Curry	2	
Precipitation rates	NASA ER-2	AMPR	Curry	2	
solar spectral radiance or irradiance	NASA ER-2	SSFR	Pilewskie	1	
spectral reflectance	NASA ER-2	SSFR	Pilewskie	2	
spectral transmittance	NASA ER-2	SSFR	Pilewskie	2	
bi-directional spectral reflectance	NASA ER-2	SSFR	Pilewskie	2	
bi-directional spectral transmittance	NASA ER-2	SSFR	Pilewskie	2	
surface spectral albedo	NASA ER-2	SSFR	Pilewskie	2	
cloud water phase	NASA ER-2	SSFR	Pilewskie	2	
optical depth	NASA ER-2	SSFR	Pilewskie	2	
particle size	NASA ER-2	SSFR	Pilewskie	2	
liquid/ice water path	NASA ER-2	SSFR	Pilewskie	2	
liquid/ice water content	NASA ER-2	SSFR	Pilewskie	2	
microwave emission	NCAR C-130	AIMR	NCAR, Curry	2	
surface roughness	NCAR C-130	AIMR	NCAR, Curry	2	
ice surface topology	NCAR C-130	AIMR	NCAR, Curry	2	
types and ages of ice	NCAR C-130	AIMR	NCAR, Curry	2	
open water	NCAR C-130	AIMR	NCAR, Curry	2	
cloud radiation	NCAR C-130	MCR	NCAR, Curry	2	
Surface temperature	NCAR C-130	infrared temperature radiometer	NCAR, Curry	2	
hemispheric IR radiance	NCAR C-130	PIR Pyrgeometer	NCAR, Curry	1	
hemispheric VIS radiance	NCAR C-130	PSP Pyranometer	NCAR, Curry	1	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
Spectral vegetation index	NCAR C-130	SVR-spectral Vegetation Radiometer	NCAR, Curry	2	
total, direct, and diffuse components of the downwelling solar flux	NCAR C-130	RAMS: TDDR)	Valero	1	
Optical depths	NCAR C-130	RAMS: TDDR	Valero	2	
upwelling solar flux in the 7 spectral channels	NCAR C-130	RAMS: MCR	Valero	1	
spectral albedo	NCAR C-130	RAMS: MCR	Valero	2	
net flux	NCAR C-130	RAMS: MCR	Valero	2	
downwelling and upwelling total solar irradiance	NCAR C-130	RAMS: 2 TSBRs	Valero	1	
Albedo	NCAR C-130	RAMS: 2 TSBRs	Valero	2	
net flux	NCAR C-130	RAMS: 2 TSBRs	Valero	2	
downwelling and upwelling infrared flux from 4.125 to 48.25 microns	NCAR C-130	RAMS: 2 IRBRs	Valero	1	
Upwelling radiance at (4-40 and 8-12 microns)	NCAR C-130	RAMS: NFOV	Valero	1	
Brightness temperatures			Hobbs		
TBD	UW CV-580	Many instruments	Hobbs	?	
cloud-top brightness temperature	UW CV-580	CAR	Tsay	1	
cloud optical depths	UW CV-580	CAR	Tsay	2	
solar spectral radiance or irradiance	UW CV-580	SSFR	Pilewskie	1	
spectral reflectance	UW CV-580	SSFR	Pilewskie	2	
spectral transmittance	UW CV-580	SSFR	Pilewskie	2	
bi-directional spectral reflectance	UW CV-580	SSFR	Pilewskie	2	
bi-directional spectral transmittance	UW CV-580	SSFR	Pilewskie	2	
surface spectral albedo	UW CV-580	SSFR	Pilewskie	2	
cloud water phase	UW CV-580	SSFR	Pilewskie	2	
optical depth	UW CV-580	SSFR	Pilewskie	2	
particle size	UW CV-580	SSFR	Pilewskie	2	
liquid/ice water path	UW CV-580	SSFR	Pilewskie	2	
liquid/ice water content	UW CV-580	SSFR	Pilewskie	2	
		Multiple Flux Platform:	Brooks	2	
surface temperature	Ultralight	Temperature Transducer	Brooks	2	
net radiant flux	Ultralight	Net Radiometer	Brooks	2	
up- and down-looking short wave radiation	Ultralight	Solar radiation sensors	Brooks	2	
albedo	Ultralight	LICOR 190S quantum	Brooks	2	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
		sensors			
aircraft altitude	Ultralight	Laser Altimeter	Brooks	2	
ground surface features	Ultralight	Laser Altimeter	Brooks	2	
low resolution altitude	Ultralight	Radar Altimeter	Brooks	2	
low resolution ground surface features	Ultralight	Radar Altimeter	Brooks	2	
Radiances at 504-597, 598-700, and 805-1042 nm	Ultralight	Four channel Radiometer	Brooks	2	
surface cover	Ultralight	video with GPS position	Brooks	2	
TBD	Twin Otter	video camera		2	
surface temperature	Twin Otter	infrared temperature radiometer		2	
TBD	Helicopter	video camera		2	
surface temperature	Helicopter	KT-19 infrared photometer		2	
		Radiation:			
Reflectance at 4 channels	Can CV-580	Landsat Simulator	Isaac	1	
Reflectance at 2 channels	Can CV-580	U. of Arizona Radiometer	Isaac	1	
Backscatter coefficient	Can CV-580	LIDAR (up and down)	Isaac	1	
reflectance	Can CV-580	LIDAR (up and down)	Isaac	1	
Volume light scattering coefficient	Can CV-580	Nephelometer	Isaac	1	
Radiative fluxes	Can CV-580	Epply UV	Isaac	1	
Visible extinction coefficient	Can CV-580	Extinction Meter	Isaac	1	
IR radiative fluxes	Can CV-580	IR Pyrgeometer (up and down)	Isaac	1	
SW radiative fluxes	Can CV-580	SW Pyranometer (up and down)	Isaac	1	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
		Aircraft - Insitu			
3D Position, Attitude and Ground Speed	NCAR C-130	Laser Inertial Reference System	NCAR, Curry	1	
Time, Position, Ground Speed	NCAR C-130	GPS Receiver	NCAR, Curry	1	
Air Motion	NCAR C-130	Radome/IRS Wind Gust System	NCAR, Curry	1	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
Temperature	NCAR C-130	Rosemount	NCAR, Curry	1	
Barometric Pressure, Pressure Altitude	NCAR C-130	Rosemount Absolute Pressure Transducer	NCAR, Curry	1	
Ambient Air Temperature	NCAR C-130	Ophir III	NCAR, Curry	1	
Aerosol Spectrum	NCAR C-130	PMS-PCASP 100		1	
Cloud Droplet Spectrum	NCAR C-130	PMS-FSSP-100		1	
Cloud Droplet Spectrum	NCAR C-130	PMS-FSSP-2D-C		1	
Hydrometeor Spectrum	NCAR C-130	PMS-FSSP-2D-D		1	
Cloud Liquid Water	NCAR C-130	King Probe (Hot Wire)		1	
Aerosol Size and Number	NCAR C-130	MASP		1	
Ice Accumulation	NCAR C-130	Rosemount Icing Detector		1	
CN concentration	NCAR C-130	CN Counter		1	
cloud water residuals	NCAR C-130	CVI?		2?	
condensed water content	NCAR C-130	CVI?		2?	
cloud liquid water content	NCAR C-130	PVM100	NCAR	1	
droplet integrated surface area	NCAR C-130	PVM100	NCAR	1	
effective radius	NCAR C-130	PVM100	NCAR	1	
CCN spectra	NCAR C-130	CCN Spectrometers (2)	Hudson	2	
total CN concentration	NCAR C-130	CN Counter	Hudson	1	
IFN concentration	NCAR C-130	CFD Chamber	Rogers	2	
IFN composition	NCAR C-130	CFD Chamber	Rogers	2	
water/ice supersaturation	NCAR C-130	CFD Chamber	Rogers	2	
pressure	NCAR C-130	CFD Chamber	Rogers	2	
CN concentration	NCAR C-130	CN Counter	Rogers	1	
CN concentration at STP	NCAR C-130	CN Counter	Rogers	1	
Particle Images	NCAR C-130	CPI	Lawson	2	
Particle Length and Width	NCAR C-130	CPI	Lawson	2	
Particle Images	NCAR C-130	CPI	Lawson	2	
Particle Area	NCAR C-130	CPI	Lawson	2	
Drop Size Distribution, > ~10 µm	NCAR C-130	CPI	Lawson	2	
Crystal Size Distribution	NCAR C-130	CPI	Lawson	2	
IWC	NCAR C-130	CPI	Lawson	2	
LWC, > ~10µm	NCAR C-130	CPI	Lawson	2	
Ratio Of IWC/LWC, > ~10µm	NCAR C-130	CPI	Lawson	2	
Particle Habit	NCAR C-130	CPI	Lawson	2	
Degree Of Crystal Riming	NCAR C-130	CPI	Lawson	2	
Physical characteristics	NCAR C-130	CPI	Lawson	2	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
TBD	UW CV-580	Knollenberg probes	Hobbs	1	
TBD	UW CV-580	condensation and cloud condensation nuclei	Hobbs	1	
optical extinction coeff., 635 nm	UW CV-580	G meter	Gerber	1	
backscatter ratio	UW CV-580	G meter	Gerber	1	
asymmetry parameter	UW CV-580	G meter	Gerber	1	
TBD	UW CV-580	chemistry and trace gases	Hobbs	2	
cloud liquid water content	UW CV-580	PVM100	Hobbs	1	
cloud droplet integrated surface area	UW CV-580	PVM100	Hobbs	1	
TBD	UW CV-580	meteorology	Hobbs	1	
IWC	UW CV-580	Dielectric capacitance/evaporator device	Hobbs	1	
TBD	UW CV-580	aerosols	Hobbs	2	
carbon dioxide	Ultralight	closed path Infrared Gas Analyzer	Brooks	2	
water vapor	Ultralight	closed path Infrared Gas Analyzer	Brooks	2	
carbon dioxide at high frequencies	Ultralight	open path Infrared Gas Analyzer	Brooks	2	
water vapor at high frequencies	Ultralight	Trimble TANS	Brooks	2	
aircraft attitude	Ultralight	Novatel Inc. GPS	Brooks	2	
aircraft position	Ultralight	Novatel Inc. GPS	Brooks	2	
aircraft altitude	Ultralight	Novatel Inc. GPS	Brooks	2	
wind velocities	Ultralight	Pressure Transducers	Brooks	2	
static pressure	Ultralight	Pressure Sensor	Brooks	2	
relative humidity	Ultralight	Dew point sensor	Brooks	2	
		Microphysics:			
Na	Can CV-580	Inboard PCASP	Isaac	1	
spectra	Can CV-580	Inboard PCASP	Isaac	1	
Ni	Can CV-580	CVI	Isaac	2	
IWC	Can CV-580	CVI	Isaac	2	
Td	Can CV-580	CVI	Isaac	2	
qv	Can CV-580	CVI	Isaac	2	
size distribution	Can CV-580	CVI	Isaac	2	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
Ice nuclei information	Can CV-580	CVI	Isaac	2	
Phase separation	Can CV-580	Rosemount Ice Detector/Vibrometer Ice Detector	Isaac	1	
Phase change	Can CV-580	Airbus Icing Rod	Isaac	1	
LWC	Can CV-580	King Probes	Isaac	1	
LWC	Can CV-580	Nevzorov Probes	Isaac	1	
TWC	Can CV-580	Nevzorov Probes	Isaac	1	
Td	Can CV-580	Nevzorov Probes	Isaac	1	
Nd	Can CV-580	FSSP-100-96	Isaac	1	
droplet spectra	Can CV-580	FSSP-100-96	Isaac	1	
Nd	Can CV-580	FSSP-100-124	Isaac	1	
droplet spectra	Can CV-580	FSSP-100-124	Isaac	1	
Ni	Can CV-580	2D2-C or 2D-C	Isaac	1	
ice crystal spectra	Can CV-580	2D2-C or 2D-C	Isaac	1	
shape	Can CV-580	2D2-C or 2D-C	Isaac	1	
Ni	Can CV-580	2D-GA	Isaac	1	
ice crystal spectra	Can CV-580	2D-GA	Isaac	1	
shape	Can CV-580	2D-GA	Isaac	1	
Ni	Can CV-580	2D-P	Isaac	1	
ice crystal spectra	Can CV-580	2D-P	Isaac	1	
shape	Can CV-580	2D-P	Isaac	1	
Shape	Can CV-580	DRI Replicator	Isaac	3	
Ni	Can CV-580	DRI Replicator	Isaac	3	
Shape	Can CV-580	DRI Cloudscope	Isaac	3	
Ni	Can CV-580	DRI Cloudscope	Isaac	3	
IWC	Can CV-580	DRI Cloudscope	Isaac	3	
Shape	Can CV-580	CPI	Isaac	2	
Ni	Can CV-580	CPI	Isaac	2	
Na	Can CV-580	PCASP	Isaac	1	
aerosol spectra	Can CV-580	PCASP	Isaac	1	
Nd	Can CV-580	FSSP-300	Isaac	1	
droplet Spectra	Can CV-580	FSSP-300	Isaac	1	
Na	Can CV-580	FSSP-300	Isaac	1	
aerosol spectra	Can CV-580	FSSP-300	Isaac	1	
CCN	Can CV-580	U. of Wyoming CCNC	Isaac	1	
% SS	Can CV-580	U. of Wyoming CCNC	Isaac	1	

Data Parameter	Platform	Platform/Instrument	Inst. PI	Category	Archive Location
CN>3 nm	Can CV-580	TSI 3025 CN Counter	Isaac	1	
CN>15 nm	Can CV-580	PMS 7610	Isaac	1	
CN>15 nm	Can CV-580	CN Counter Flowmeter	Isaac	1	
Aerosol size distribution (5-200 nm)	Can CV-580	DMA 3025	Isaac	3	
		Dynamics/ Thermodynamics:			
3-D Wind components	Can CV-580	IAR 858 Gust Probe	Isaac	2	
profiles of T, Td, U, Z, RH	Can CV-580	Dropsonde	Isaac	1	
T	Can CV-580	AES Rosemount	Isaac	1	
T	Can CV-580	Reverse Flow	Isaac	1	
Ts	Can CV-580	PRT-5	Isaac	1	
Td	Can CV-580	EGG Dew point	Isaac	1	
Td	Can CV-580	Russian Lyman-Alpha Hygrometer	Isaac	1	
Tf	Can CV-580	Russian Lyman-Alpha Hygrometer	Isaac	1	
latent heat fluxes	Can CV-580	Russian Lyman-Alpha Hygrometer	Isaac	2	
phase	Can CV-580	Russian Lyman-Alpha Hygrometer	Isaac	1	
		Chemistry:			
O3	Can CV-580	TECO 49,43S	Isaac	2	
SO2	Can CV-580	TECO 49,43S	Isaac	2	
Concentration of gas-phase Hg	Can CV-580	Hg Monitor Calibrator	Isaac	2	
Inorganic ions	Can CV-580	Aerosol filter & flow meter	Isaac	2	
organic ions	Can CV-580	Aerosol filter & flow meter	Isaac	2	
black carbon	Can CV-580	Aerosol filter & flow meter	Isaac	2	
trace metals	Can CV-580	Aerosol filter & flow meter	Isaac	2	
total organic carbon	Can CV-580	Aerosol filter & flow meter	Isaac	2	
Size segregated inorganic ions	Can CV-580	Moudi Impactor & Flowmeter	Isaac	2	
Size segregated organic ions	Can CV-580	Moudi Impactor & Flowmeter	Isaac	2	
Organohalogens	Can CV-580	Tenax Cartridge Flowmeter	Isaac	2	
Total organic carbon	Can CV-580	Hi Vol. Flowmeter	Isaac	2	
speciated organics	Can CV-580	Hi Vol. Flowmeter	Isaac	2	

Data Parameter/Product	Satellite	Instrument	PI	Category	Archive Location
0.58 - 0.68 µm lambertian refl.	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
0.73 - 1.10 µm lambertian refl.	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
3.55 - 3.93 µm brightness T	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
10.3 - 11.3 µm brightness T	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
11.5 - 12.5 µm brightness T	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
TOA VIS image (hard copy)	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	1	
TOA IR image (hard copy)	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	1	
TOA VIS radiance	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
TOA IR radiance	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Broadband clear sky albedo	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Broadband cloudy sky albedo	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Cloud cover	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Cloud fraction	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Cloud optical thickness	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Cloud particle size	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Cloud top temperature	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
cloud height	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
cloud emissivity	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	

Data Parameter/Product	Satellite	Instrument	PI	Category	Archive Location
cloud particle size	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Longwave fluxes	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Surface albedo	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Surface temperature	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	2 or 1	
Note: all of the above parameters will be produced in near-real time in time-sequenced loops for locations over the SHEBA ice station, Barrow, and Fairbanks.	NOAA Polar Orbiter 12 & 14	AVHRR/HRPT	Minnis	0	
TOA radiative fluxes	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	1	
TOA VIS image (hard copy)	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	1	
TOA IR image (hard copy)	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	1	
TOA VIS radiance	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
TOA IR radiance	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
Cloud cover	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
Cloud fraction	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
Cloud emissivity	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
Cloud height	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
Cloud IR optical thickness	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
Cloud temperature	NOAA Polar Orbiter 12 & 14	HIRS	Wylie	2	
TOA microwave radiance	DMSP F12 &13	SSM/I & SSM/T2	Rossow	2	

Data Parameter/Product	Satellite	Instrument	PI	Category	Archive Location
ice/water estimate	DMSP F12 &13	SSM/I & SSM/T2	Rossow	3	
total cloud liquid water estimate	DMSP F12 &13	SSM/I & SSM/T2	Rossow	3	
water vapor	DMSP F12 &13	SSM/I & SSM/T2	Rossow	3	
precipitation rate	DMSP F12 &13	SSM/I & SSM/T2	Rossow	3	
filtered radiances	RESURS	SCARAB-2	Rossow	3	
unfiltered SW radiances	RESURS	SCARAB-2	Rossow	3	
unfiltered LW radiances	RESURS	SCARAB-2	Rossow	3	
unfiltered SW fluxes	RESURS	SCARAB-2	Rossow	3	
unfiltered LW fluxes	RESURS	SCARAB-2	Rossow	3	
images (for mission planning only)	RADARSAT	SAR	SHEBA	1	
cloud fraction	various	ISCCP	Rossow	2	
cloud top height	various	ISCCP	Rossow	2	
surface radiative fluxes	various	ISCCP	Rossow	3	
raw radiances	various	ISCCP	Rossow	2	
~ other 130 cloud and radiation parameters	various	ISCCP	Rossow	1	
Surface albedo	various	ISCCP	Brest & Rossow	1	
Surface temperature	various	ISCCP	Brest & Rossow	1	
Cloud optical thickness	various	ISCCP	Han & Rossow	1	
Cloud particle size	various	ISCCP	Han & Rossow	3	
Atmospheric humidity	POES	HIRS	NWS	1	
Atmospheric temperature	POES	HIRS	NWS	1	
Sea ice cover	DMSP	SSMI	NWS/Navy	1	
Snow cover	?	?	Cavalieri	4	
Snowfall	POES/DMSP	AVHRR/SSMI/T2	Curry	4	

Models	Model Investigator	Data Parameters	Category	Archive Location
Operational Models: ECMWF	Bretherton/Miller	Column products - SHEBA ice station	1	

Models	Model Investigator	Data Parameters	Category	Archive Location
	Bretherton/Campana	Column products - Barrow	1	
AES	Bretherton/Isaac	back trajectories - SHEBA ice station - Barrow - Inuvik	2	
	Bretherton/Isaac	operational output	2	
NCEP	Bretherton/Wylie	grid analysis	2	
	TBD	operational output	2	
TBD	TBD	Integrated data sets for FIRE	?	
TBD	TBD	Integrated data sets for SHEBA	?	

Archive Locations: FIRE = NASA Langley DAAC = LD
ARM = DOE Oak Ridge DAAC = OD
C-130 = NCAR = NC
SHEBA = Ship = SH
NWS = NW
NOAA CMDL = CM

See Section 10.5 for Category definition

APPENDIX H--LANGLEY DAAC DATA SET INGEST REQUEST

Please fill out one complete form for EACH data set to be ingested.

Project Title (e.g. Arctic Cloud Experiment):

H.1 Data Set Description
****

Data Set Name:

Data Set Producer:

Name:
Address:
Telephone:
Fax:
Internet Address:

List all geophysical parameters along with the corresponding units, fill values, and minimum and maximum values. (e.g., albedo, unitless, -999, 0, 1)

List all data sources, their respective sensor/instruments, and the parameter(s) measured by each (e.g., ground sites, rawinsonde, temperature).

Provide a definition and/or brief description of all geophysical parameters, sensor/instruments and source/platforms.

Processing Level:

Level 0_____
Level 1A____
Level 1B____
Level 2_____
Level 3_____
Level 4_____

(0=Raw radiance data, 1A=Data unprocessed to sensor units, 1B=Data processed to sensor units, 2=Derived geophysical parameters, 3=Geolocated geophysical parameters, 4=Data from multiple measurements)

Spatial Coverage (Range):

Minimum Latitude:
Maximum Latitude:
Minimum Longitude:
Maximum Longitude:

Describe any gaps that may exist in the spatial coverage.

Spatial Resolution (e.g., 2.5 x 2.5 degree grid):

Temporal Coverage:

Start Date (mm/dd/yy):
Stop Date (mm/dd/yy):

Describe any gaps that may exist in the temporal coverage.

Temporal Resolution:

What is the smallest unit of data collected (e.g., 1 second, daily, monthly, etc.)?

Were the data collected during the day, night or both?

Data Set Point of Contact:

Name:
Address:
Telephone:
Fax:
Internet Address:

H.2 Data Set Processing History

****

When was this data set processed (mm/dd/yy)?

Is this data set still being generated?

If so, at what rate (e.g., 1 file/day)?

Does this data set require further processing by the Langley DAAC?

If so, does the software exist to do this processing?

In what computer language is the software written?

On which computer systems has this software been developed?

On what systems has this software run successfully?

Provide the point of contact for this software.

Name:
Address:
Telephone:
Fax:
Internet Address:

What is the version number of this data set?

Describe the computer system(s) on which this data set was processed.

Software:

Hardware:

Operating System:

Media Used:

Describe verification/validation procedures used with this data set.

Are there currently any plans to reprocess this data set?

If so, when will the data set be reprocessed?

Why will the data set be reprocessed?

Is this data set in HDF (EOS Standard Data Format) or ASCII?

If not, are you willing to convert the data set to HDF prior to delivery to the Langley DAAC?

If you are not willing to convert the data to HDF, why not?

If you are willing to convert the data to HDF, will you need guidance from the Langley DAAC?

Do you need HDF documentation?

Describe the organization of the data set.

If data are not in HDF or ASCII, please describe the header, table of contents, ancillary, data and trailer files in the following sections.

Total number of files (including headers, ancillary files, etc.):

Header files:

Quantity:

Format:

Length of each (in bytes):

Total number of physical records:

Total number of logical records:

Number of variables in each record:

Number of leading/trailing blanks between records:

Table of content files:

Quantity:

Format:

Length of each (in bytes):

Total number of physical records:

Total number of logical records:

Number of variables in each record:

Number of leading/trailing blanks between records:

Ancillary files:

Quantity:

Format:

Length (in bytes):

Total number of physical records:

Total number of logical records:

Number of variables in each record:

Number of leading/trailing blanks between records:

Data files:

Quantity:

Format:

Length of each file (in bytes):

Total number of physical records:

Total number of logical records:

Number of variables in each record:

Number of leading/trailing blanks between records:

Trailer files:

Quantity:

Format:

Length of each file (in bytes):

Total number of physical records:

Total number of logical records:

Number of variables in each record:

Number of leading/trailing blanks between records:

If possible, please submit a sample data file with this request.

Data Processing Point of Contact:

Name:
Address:
Telephone:
Fax:
Internet Address:

H.3 Browse Products
****

Describe any browse products that will be included with this data set.

Format (e.g., GIF, TIFF, HDF, etc.)

Number of browse images:

Size of each image (in bytes):

Uncompressed:

Compressed:

If compressed, what compression scheme was used?

What is the resolution of each image (e.g. 640x480)?

Software used to create browse images (e.g., IDL, NCAR Graphics, PV-WAVE, Spyglass, etc.):

Browse Product Point of Contact:

Name:
Address:
Telephone Number:
Fax:
Internet Address:

If no browse products currently exist, do you have plans to produce any in the future?

H.4 Data Delivery
****

What is the projected date for data set delivery?

How will the data be delivered to the Langley DAAC?

Media:

Type (e.g., 4mm, 8mm, 3480, 6250, floppies, etc.):

Quantity (e.g., 1, 4, 50, etc.):

Have the data been compressed?

If so, what compression scheme was used?

Have you used the UNIX TAR command to write the data to tape?

Total Volume:

FTP:

NOTE: The Langley DAAC prefers to pull the data from your ftp site; however, arrangements can be made for data producers to push data to our ftp site.

Number of files (e.g, 1, 4, 50, etc.):

Size of files (in bytes):

Have the data been compressed and/or tarred for delivery?

Total Volume:

Data Delivery Point of Contact:

Name:
Address:
Telephone Number:
Fax:
Internet Address:

H.5 Read Software
****

The Langley DAAC requires data producers to provide read software for their data sets.

Describe all software being delivered with this data set.

Type (e.g., data dump, etc.):

Language (e.g., Fortran, C, C++, etc.):

On which computer system(s) was this software written?

On which computer system(s) was this software successfully compiled and run?

Is this software portable to other computer systems?

Read Software Point of Contact:

Name:
Address:
Telephone:
Fax:
Internet Address:

H.6 User Community

****

Describe the current user community of this data set (if any).
[For example: number of requests for data, etc.]

Method which is currently used to distribute data to users:

List all ancillary files and documentation currently included with distribution of data set to user.

H.7 Documentation

****

The Langley DAAC requires documentation to be submitted along with each data set that describes the processing history, format, read software, and data.

Please indicate the following information for each document:

Title:
Type (e.g., data format, software, etc.):
Author:
Most recent version date:

List any other documents that would be useful to a new user of this data set.

Documentation Point of Contact:

Name:
Address:
Telephone:
Fax:
Internet Address:

H.8 References

****

Please provide a list of publications and journal articles pertaining to this data set or project (if any).

****

Langley DAAC Science, User, and Data Support Group
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