CLOUD AND AEROSOL RESEARCH GROUP

UNIVERSITY OF WASHINGTON CONVAIR-580

OPERATION PLANS FOR CLAMS

by

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Research supported by NASA

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UNIVERSITY OF WASHINGTON CONVAIR-580 OPERATION PLANS FOR CLAMS

1. CLAMS AND ITS OVERALL GOAL

The Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) field study is concerned with validation of NASA EOS-Terra data products. Specially, CLAMS is designed to obtain airborne measurements to validate products derived from remote sensing measurements from the Clouds and the Earth's Radiant Energy System (CERES), the Moderate-Resolution Imaging Spectroradiometer (MODIS), and the Multi-angle Imaging Spectroradiometer (MISR), all of which are aboard the Terra satellite.

2. LOCATION

The University of Washington and the Convair-580 (and some of the other aircraft involved in CLAMS—see Appendix 3) will be based at the NASA Wallops Flight Facility, Virginia.

As far as the Convair-580 is concerned, the research flying while based at Wallops will be, for the most part, at the following locations (see Figure 1):

1) Over the Chesapeake Bay Lighthouse (36˚54.0' N/75˚42.6' W).
2) Over Buoy 44014 (36˚54.0' N/74˚50.2' W).
3) Over the Great Dismal Swamp (36˚36.1' N/76˚28.2' W).
4) "Case 1 Water" (36˚30.0' N/73˚00.0' W).
5) Various locations off the Virginia coast.
6) In addition, and following the end of CLAMS, we may do one roundtrip between Norfolk to Boston flying over the ocean about 50-100 miles from the shore (see Appendix 5).

3. TIME PERIOD AND FLIGHT HOURS

The Convair-580 is scheduled to arrive at NASA Wallops Flight Facility at 1 PM local time on 8 July. The official flight period of CLAMS is from 10 July (first possible research flight) to 2 August (last possible research flight for CLAMS). The day after the end of CLAMS we may do a Norfolk-Boston-Norfolk research flight (see Appendix 5). As soon as possible

Figure 1. General location of research flights for CLAMS.

thereafter, the Convair-580 will depart from Wallops for its return flight to Seattle (possibly via Thunder Bay, Ontario—see Appendix 6).

The total number of research flight hours for clams itself is 40 (not including the possible additional hours for the Norfolk-Boston-Norfolk flight and research at Thunder Bay).

4. SOME FLIGHT SCENARIOS FOR THE CONVAIR-580

The CARG will play a key role in CLAMS by collecting in situ measurements on the physical and chemical properties of atmospheric aerosol, and of the reflectivity properties of surfaces, that are sensed remotely by instruments on the ER-2 aircraft and the Terra satellite. Whenever possible, we will be targeting clear sky (i.e., cloudless) conditions.

(a) Convair-580 Basic Flight Scenario: Measurements in Vertical Cross-Sections over Designated Sites—See Figure 2 and Table 1.

This flight pattern will provide detailed measurements of the physical and chemical properties of aerosols above designated surface sites (the instrumented Chesapeake Bay Lighthouse and Buoy 44014 will generally be the preferred sites). Whenever possible these flights will be during the period of the Terra satellite overpass and/or an ER-2 flight overhead. With the sunphotometer aboard the Convair-580, these flights will also provide the measurements required for "closure" studies of aerosol optical depths derived from our in situ measurements and various remote-sensing techniques.

With reference to Figure 2: after take-off from Wallops instruments will be switched on as soon as possible, and the aircraft will head out to a predetermined location C for a low-level pass CD beneath the Terra satellite overpass. The length of the flight track CD will be about 80 nautical miles (or 30 mins at our research speed of 160 knots). If CD is over the ocean we will aim for about 100 ft msl; if CD is over land the flight altitude will be 2,000 ft.

We will start our vertical climb over a predetermined target area, labeled D in Fig. 2. This will be a climb at ~350 ft/min to a level that takes us just above the main haze layers (to be

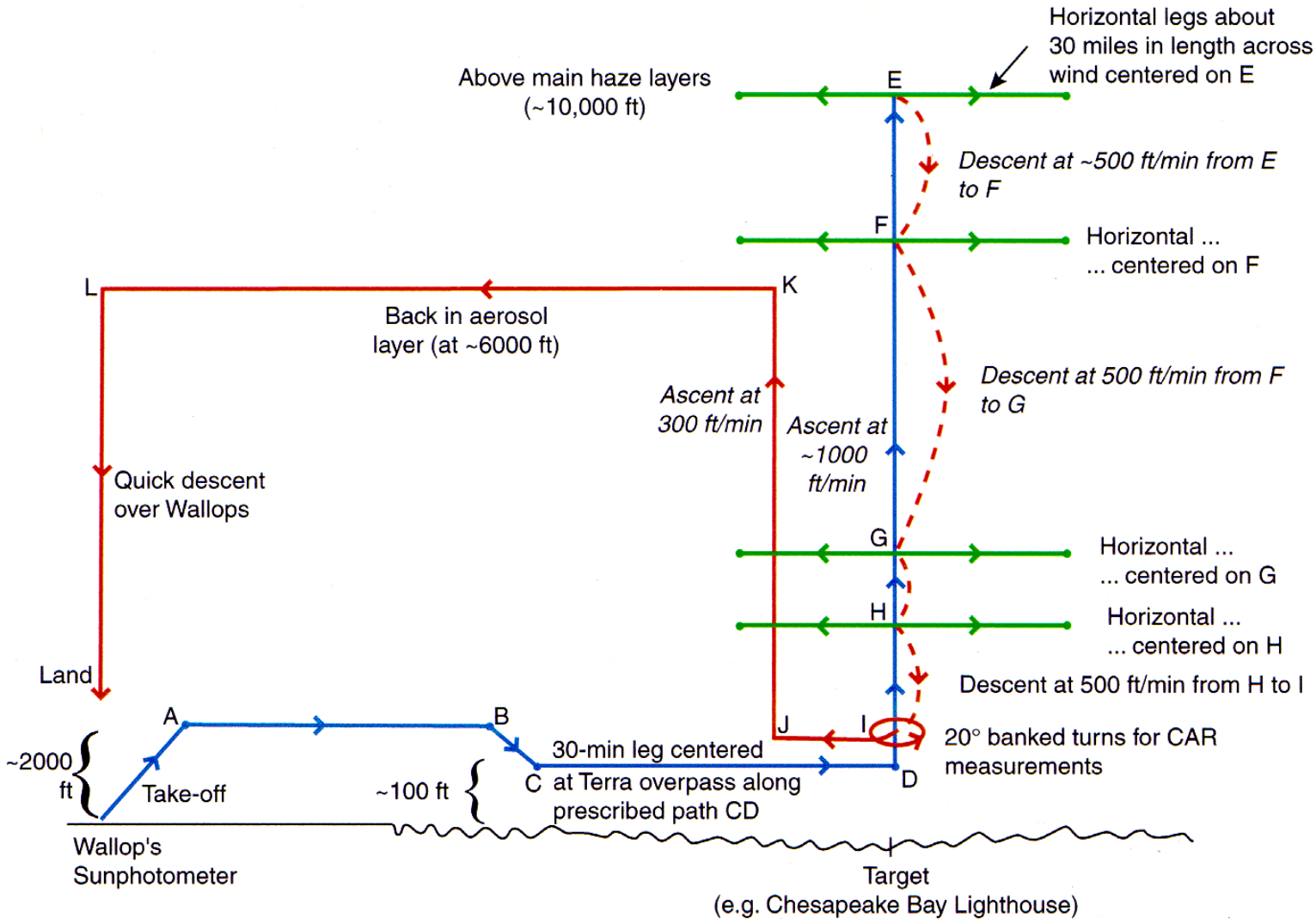

Figure 2. Schematic of basic flight pattern for the Convair-580. The waypoints (A, B, C, D) will be specified prior to the flight. The levels D, E, F, G, H, and I will be determined in flight by the UW flight scientist.

determined by our in-flight measurements). Based on this vertical profile of measurements, the Flight Scientist will determine four levels (marked E, F, G, H in Fig. 2) where the aircraft will have to dwell for ~45 mins in order to obtain detailed measurements (Filters, DMPS, humidiographs, etc.). These horizontal legs will be 30 miles long, centered over the target, and oriented across the wind (which may change with height) to avoid sampling engine exhaust. The rate of descent between the horizontal legs will be 500 ft/min, centered over the target.

At about 2,000 ft above the target (I in Fig. 2), we will do five 20˚ banked turns for BRDF measurements of the surface with the CAR.

The aircraft will then return to Wallops along a prescribed flight path (IJK in Fig. 2), which may be zig-zag and stepped.

An approximate time line for the basic flight scenario is shown in Table 1 below.

The most important measurements aboard the Convair-580 for these studies are humidity, light scattering (with the 3-λ neph), light absorption (with the PSAP), aerosol size distributions (with all relevant instruments), chemical composition of aerosols (with the various filters), humidification factor (with scanning humidograph if available), and sunphotometer measurements.

Table 1. Timeline for Convair-580 basic flight pattern (see Figure 2)

Leg	Time for Leg (mins)	Total Time Elapsed (mins)
Engines On		0
Engines on to A	20	20
A to C	15	35
C to D	30	65
D to E (ascent at 350 ft/min)	30	95 (1 h 35 mins)
4 horizontal legs on descent (45 mins per leg)	180	275 (4 h 35 min)
E to I descent (excluding horizon. legs)	20	295 (4 h 55 min)
CAR turns at I	20	315 (5 h 15 mins)
I to J to K	20	335 (5 h 35 mins)
Descend to land at Wallops to engines off	20	355 (5 h 55 mins)

(b) Measurements of Surface (or Cloud) Reflectivities Using the CAR—See Figure 3

We will fly 2000 ft above a designated surface site (or cloud top) in a circular orbit ~1.5 nm diameter (each orbit will take 2 min at 156 knots). CAR should be in its "Position 3" (20˚ bank angle scanning). Do as many such orbits as possible in designated time period of 20 mins. (NOTE: Position 3 is the same as that used for the "old" CAR turns with aircraft banked 20˚ to the right. However, with the CAR in "Position 3" it can measure both upward and downward radiation simultaneously. Therefore, there is now *no need* to circle with aircraft banked 20˚ *to the left*.)

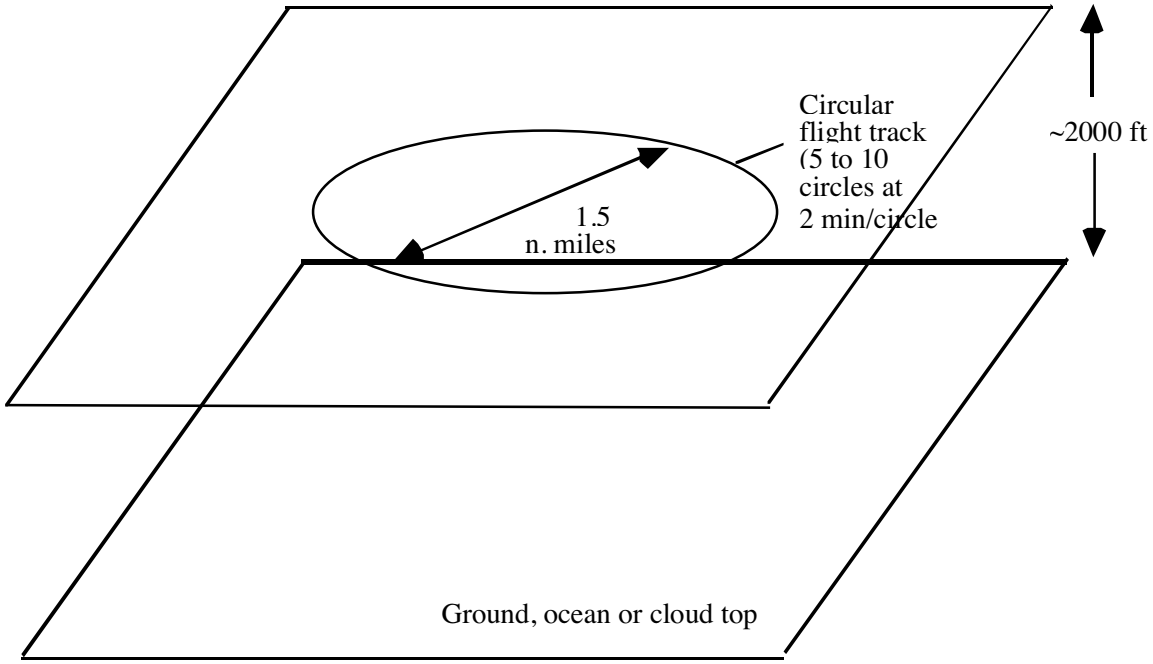

Figure 3. Use of CAR for BRDF Measurements. CAR in "position 3".

APPENDIX 1
INSTRUMENTATION ON THE UNIVERSITY OF WASHINGTON'S CONVAIR-580 FOR CLAMS

(a) Navigational and Flight Characteristics

Parameter	Instrument Type	Manufacturer	Range (and error)	UW Computer Code
Latitude and longitude	Global Positioning System (GPS)	Trimble TANS/Vector	Global (~2-5 m)	tans-lat (deg) tans-lon (deg)
True airspeed	Variable capacitance	Rosemount Model F2VL 781A	0 to 250 m s^{-1} (<0.2%)	tasknt (kts)
True airspeed	Air computer	Shadin	0 to 250 m s^{-1} (<0.2%)	shadin_tas
Heading	From TANS/Vector	Trimble TANS/Vector	0 to 360˚ (± 1˚)	tans-azimth (0 deg is true north)
Altitude	Global Positioning System (GPS)	Trimble TANS/Vector	0-9 km (±15-25 ft)	tans-altft (msl, ft)
Altitude above terrain	Radar altimeter	Bendix Model ALA 51A	Up to 0.75 km	ralt (agl, ft)
Pitch	Differential GPS	Trimble TANS/Vector	0 to 360˚ (±0.15˚)	Tans-pitch (nose up positive)
Roll	Differential GPS	Trimble TANS/Vector	0 to 360˚ (±0.15˚)	Tans-roll (right wing down negative)
Radar reflectivity	3 cm wavelength (pilot's radar)	Bendix/King (now Allied Signal)	250 km	(Not recorded)

(b) General Meteorological

Parameter	Instrument Type	Manufacturer	Range (and error)	UW Computer Code
Pressure	Variable capacitance	Rosemount Model 830 BA	1100 to 150 mb (<0.2%)	pstat
Pressure altitude	Computed from pstat assuming standard atmosphere	—	0-9 km (Error depends on atmospheric conditions.)	palt (ft)
Total air temperature	Reverse-flow	In-house	-60 to 40˚C	ttotr (˚C)
Static air temperature	Calculated from Rosemount total temperature	Rosemount Model 102CY2CG and 414 L Bridge	-60 to 40˚C	tstat (˚C)
Static air temperature	Reverse-flow thermometer	In-house	-60 to 40˚C (<0.5˚C)	tstatr (˚C)
Dew point temperature	Cooled-mirror dew point	Cambridge System Model TH73-244	-40 to 40˚C (<1˚C)	dp (˚C)
Absolute humidity	IR optical hygrometer	Ophir Corp. Model IR-2000	0 to 10 g m^{-3} (~5%)	rhovo = Ophir2k absolute humidity (g/m3). (Also, dp_o = Ophir dew point (degC). oairt = Ophir2k air temperature (degC). rh_o = Ophir2k relative humidity (%).)
Wind direction	Calculated from TANS/Vector and Shadin	Trimble	0-360˚ (0 deg is magnetic north).	wind_dir

(Cont.)

APPENDIX 1 (continued)

(b) General Meteorological (continued)

Parameter	Instrument Type	Manufacturer	Range (and error)	UW Computer Code
Wind speed	Calculated from TANS/Vector and Shadin	Trimble	—	wind_spd (kts)
Video image	Forward-looking camera and time code	Ocean Systems Splash Cam	—	—

(c) Aerosol

Parameter	Instrument Type	Manufacturer	Range	UW Computer Code
Number concentration of particles (continuous flow)	Condensation particle counter	TSI Model 3022A	0-10^7 cm^{-3} (d>0.003 μm)	cnc1 (/cc)
Number concentration of particles (continuous flow)	Condensation particle counter	TSI Model 3025A	0-10^5 cm^{-3} (d>0.003 μm)	cnc2 (/cc)
Size spectrum of particles	Differential Mobility Particle Sizing Spectrometer (DMPS)	TSI (modified in-house)	0.01 to 0.6 μm (21 channels)	dmpsdn = DMPS d(log D) spectrum (/cc).
Size spectrum of particles	35 to 120˚ light-scattering	Particle Measuring Systems Model PCASP-100X	0.12 to 3.0 μm (15 channels)	pcasprt = PCASP 100 total concentration (/cc). pcaspdn = PCASP 100 concentration spectrum (/cc).
Total particle concentration	Forward light-scattering	Particle Measuring Systems Model FSSP-300	0.3 to 20 μm (30 channels)	fsp3rt (/cc).
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-300	0.3 to 20 μm (30 channels)	fsp3dn = fsp300 d(log D) spectrum (/cc).
Aerodynamic size spectrum of particles and relative light scattering intensity	"Time-of-flight"	TSI Model 3320 APS	0.5-20 μm (52 channels)	tsirt = TSI 3320 (total concentration (/cc)).
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-100	2 to 47 μm (15 channels)	fsprt = fssp 100 total concentration (/cc). fspdn = fssp 100 particle concentration spectrum (/cc).
Light-scattering coefficient	Integrating 3-wavelength nephelometer with backscatter shutter	MS Electron 3W-02	1.0×10^{-7} m^{-1} to 1.0×10^{-3} m^{-1} for 550 (green) and 700 (red) nm channels. 2.0×10^{-7} m^{-1} to 1.0×10^{-3} m^{-1} for 450 nm channel (blue)	nepblu = total scatter blue (/m). nepgrn = total scatter green (/m). nepred = total scatter red (/m). bkspbl = backscatter blue (/m). bkspgr = backscatter green (/m). bksprd = backscatter red (/m).

(Cont.)

APPENDIX 1 (continued)

(c) Aerosol (continued)

Parameter	Instrument Type	Manufacturer	Range	UW Computer Code
Light-scattering coefficient (ambient and extinction cell)	Integrating nephelometer	CE	10^{-7} to 10^{-2} m^{-1} at 537 nm	cetspb (/m) cetspgr (/m) cetsprd (/m)
Light-scattering coefficient (for bag-house samples)	Integrating nephelometer	Radiance Research M903	1.0×10^{-6} to 2.0×10^{-4} m^{-1} or 1.0×10^{-6} m^{-1} to 1.0×10^{-3} m^{-1}	Neph bag (m^{-1})
Light absorption and graphitic carbon	Particle soot absorption photometer (PSAP)	Radiance Research	Absorption coefficient: 10^{-7} to 10^{-2} m^{-1}; Carbon: 0.1 μm m^{-3} to 10 mg m^{-3} (±5%)	rams (m^{-1})
Humidification factor for aerosol light-scattering*	Scanning humidogram	In house	b_{sp} (RH) for 30% ≤ RH ≤ 85%	Rhhum
Aerosol mass, elemental composition (Na to Pb), electron microscopy†	Nucleopore filters	University of Sao Paulo (V. Martins)	Mass >1 μg m^{-3} Elemental composition >1 ng m^{-3}	
Spectral reflectance of aerosol†	Aerosol spectroreflectometer	Univ. Sao Paulo/ NASA Goddard/ Analytical Spectral Devices (V. Martins)	Reflectance from 100-50%	

(d) Cloud Physics

Parameter	Instrument Type	Manufacturer	Range	UW Computer Code
Liquid water content	Hot wire resistance	Johnson-Williams	0 to 2 or 0 to g m^{-3}	lwjw0 = cloud liquid water content from JW (g/m^3)
Liquid water content	Hot wire resistance	DMT	0 to 5 g m^{-3}	lwdmt = cloud liquid water content from DMT (g/m^3)
Liquid water content; effective droplet radius; particle surface area	Optical sensor	Gerber Scientific Ins. PVM-100A	LWC = 0.001-10 g m^{-3}	lwpvm = cloud liquid water from PVM (g/m^3). erpvm = PVM100A effective radius (μm). psapvm = PVM100A raw surface area (cm^2/m^3). sapvm = PVM100A surface area [corrected using fssp100 drop rate] (cm^2/m^3).
Total particle concentration	Forward light-scattering	Particle Measuring Systems Model FSSP-300	0.3 to 20 μm (30 channels)	fsp3rt (/cc).

(Cont.)

* Availability depends on whether special membrane tubing needed for this instrument can be obtained.

† Guest instrument

APPENDIX 1 (continued)

(d) Cloud Physics (continued)

Parameter	Instrument Type	Manufacturer	Range	UW Computer Code
Size spectrum cloud particles	Forward light-scattering	Particle Measuring Systems FSSP-100	2 to 47 μm ($3\ \mu$m) (15 channels)	fsprt = fssp 100 total concentration (/cc). fspdn = fssp 100 particle concentration spectrum (/cc).
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-300	0.3 to 20 μm (30 channels)	fsp3dn = fsp300 d(log D) spectrum (/cc).

(e) Chemistry

Parameter	Instrument Type	Manufacturer	Range (and error)	UW Computer Code
SO_2	Pulsed fluorescence	Teco 43S (modified in-house)	0.1 to 200 ppb	so2 (ppb) = Teco 43S
O_3	UV absorption	TEI Model 49C	1-1000 ppbv (<0.5 ppbv)	o3 = Pressure corrected TEI49C ozone concentration (ppb). (o3tei = Raw TEI49C ozone concentration (ppb).)
CO	IR correlation spectrometer	Teco Model 48	0-50 ppb (~0.1 ppmv)	co (ppb) = Teco 48 (ppb)
CO_2	Infrared correlation spectrometer	Li-Cor Li-6262	0 to 300 ppmv (0.2 ppmv at 350 ppmv)	co2 (ppm) = Licor 6262
Total particulate mass and species $SO_4^=$, NO_3^-, Cl^-, Na^+, K^+, NH_4^+, Ca^{++}, Mg^{++}	37 Teflon filters, gravimetric analysis and ion exchange chromatography	Gelman Dionix (UW)	0.1 to 50 μg m^{-3} (for 500 liter air sample)	—
Carbonaceous particles (black and organic carbon)*	Quartz filters (Thermal Evolution Techniques)	T. Novakov and T. Kirchstetter (LBNL)	4-160 μg m^{-3} ($\pm$1.6 μg m^{-3}) for 1 m^3 sample	—

(f) Radiation

Parameter	Instrument Type	Manufacturer	Range (and error)	UW Computer Code
UV hemispheric radiation, one upward, one downward	Diffuser, filter photo-cell (0.295 to 0.390 μm)	Eppley Lab. Inc. Model TUVR	0 to 70 W m-2 ($\pm$3 W m-2)	uvup = uv upward looking (W m-2) uvdn = uv downward looking (W m-2)

(Cont.)

* Guest instrument

APPENDIX 1 (continued)

(f) Radiation (continued)

Parameter	Instrument Type	Manufacturer	Range (and error)	UW Computer Code
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)	pyrup = vis-nir upward looking (W m-2) pyrdn = vis-nir downward looking (W m-2)
Surface radiative temperature	IR radiometer 1.5˚ FOV (8 to 14 μm)	Omega Engineering OS3701	-50˚ to 1000˚C ±0.8% or reading	irtemp (degC) = surface temp. (˚C)
Absorption and scattering of solar radiation by clouds and aerosols; reflectivity of surfaces	Fourteen wavelength all-directions scanning radiometer	NASA-Goddard/ University of Washington	14 discrete wavelengths between 340 and 2300 nm	—
Aerosol optical depth, water vapor, and ozone*	14-channel Sun-tracking photometer	NASA Ames (J. Redemann)	14 discrete wavelengths, 350-1558 nm	—

*Guest instrument

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6/7/01

APPENDIX 2
CODE NAMES OF PARAMETERS AVAILABLE ON COMPUTERS ABOARD THE CONVAIR-580 IN CLAMS

Data System Definitions List - 2001/05/08

a2d_chan##	a2d Channel Voltage [## is channel 00 through 63] (volts)
bkspbl	Norm Alquist's 3-wave Nepholometer Backsplatter Blue (/m)
bkspgr	Norm Alquist's 3-wave Nepholometer Backsplatter Green (/m)
bksprd	Norm Alquist's 3-wave Nepholometer Backsplatter Red (/m)
cetspbl	Civil Engineering Nepholometer Total Scatter Blue (/m)
cetspgr	Civil Engineering Nepholometer Total Scatter Green (/m)
cetsprd	Civil Engineering Nepholometer Total Scatter Red (/m)
cnc1	TSI 3022A Condensation Particle Concentration (/cc)
cnc2	TSI 3025A Condensation Particle Concentration (/cc)
cnc3	TSI 3760 Corrected Condensation Particle Concentration (/cc)
co	CO Concentration (ppb)
co2	CO2 Concentration (ppm)
cpd	Oap200x Centers Based on Diameter Limits (um)
cpdl	Oap200x diameter Limit (um)
cpdn	Oap200x Concentration Spectrum (/cc)
cpdv	Oap200x Concentration Volumes (um3/cc)
cpn	Oap200x counts (particles)
cprt	Oap200x total concentration (/litre)
cpsa	Oap200x Sample Area (cm2)
cpt	Oap200x total particle count (particles)
dmpsdl	DMPS diameter limits (um)
dmpsdn	DMPS DLogD Spectrum (/cc)
dmpsflow	DMPS flow (cc/sec)
dmpsn	DMPS Count Spectrum (particles)
dp	Cambridge Dew Point [cooled-mirror dew point] (degC)
dp_o	Ophir2k Dew Point (degC)
erpvm	PVM100A effective radius (um)
flow1	flow meter 1 (specific to certain projects)
flow2	flow meter 2 (specific to certain projects)
flow3	flow meter 3 (specific to certain projects)
fsp3dl	Fssp 300 Diameter Limits (um)
fsp3dn	Fssp 300 Particle Concentration dlogD Spectrum (/cc)
fsp3n	Fssp 300 Total Count Spectrum (particles)
fsp3rt	Fssp 300 Cumulative Concentration (/cc)
fsp3sa	Fssp 300 Sample Area (mm2)
fsp3t	Fssp 300 Total Count (particles)
fspcf	Fssp 100 Correction Factor (factor)

fspcn	Fssp 100 cumulative particle concentration spectrum
fspcs	Fssp 100 Cumulative Particle Surface Area Spectrum (um2/cc)
fspd	Fssp 100 Centers Based on Diameter Limits (um)
fspdl	Fssp 100 Ideal Diameter Limits Table (um)
fspdn	Fssp 100 Particle Concentration dlogD Spectrum (/cc)
fspdna	Fssp 100 Activity Adjusted Particle Concentration Spectrum (/cc)
fspdnr	Fssp 100 Raw Particle Concentration Spectrum (/cc)
fspds	Fssp 100 Particle Surface Area Spectrum (um2/cc)
fspdv	Fssp 100 Particle Volume Spectrum (um3/cc)
fspdva	Fssp 100 Activity adjusted volume spectrum
fspn	Fssp 100 Particle Count Spectrum (/cc)
fsprt	Fssp 100 Total Concentration (/cc)
fspsa	Fssp 100 Sample Area (cm2)
fspsr	Fssp 100 Sampling Ratio (ratio)
fspt	Fssp 100 total particle count (particles)
fssp_activity	Fssp 100 activity (%)
fssp_samp	Fssp 100 Sample Time (seconds)
irtemp	IR Thermometer (degC)
lwdmt	DMT Liquid water content (g/m3)
lwfsp	Fssp 100 Liquid Water (g/m3)
lwfspa	Fssp 100 Activity adjusted liquid water content
lwjw	Johnson-Williams [JW] liquid water content (g/m3)
lwjw0	Johnson-Williams [JW] liquid water content-zeroed out of cloud (g/m3)
lwpvm	PVM100A liquid water content (g/m3)
lwpvm0	PVM100A liquid water content-zeroed out of cloud (g/m3)
nepbag	Radiance Research Nepholometer [not working] - Bag House (/m)
nepblu	Norm Alquist's 3-wave Nepholometer Total Scatter Blue (/m)
nepgrn	Norm Alquist's 3-wave Nepholometer Total Scatter Green (/m)
nepred	Norm Alquist's 3-wave Nepholometer Total Scatter Red (/m)
no	Nitrous Oxide concentration (ppb)
nox	Nitrous Oxides concentration - NO + NO2 (ppb)
o3tei	TEI49C Ozone Concentration Raw (ppb)
oairt	Ophir2k Air Temperature (degC)
ocant	Ophir2k Can Temperature (degC)
oecext	Ray Weiss's Extinction Cell Coefficient (volts)
orat	Ophir2k Ratio Value (ratio)
palt	Pressure Altitude [computed from pstat] (MSL, feet)
pcaspdn	PCASP 100 Concentration Spectrum (/cc)
pcaspa	PCASP 100 Activity (%)
pcaspdl	PCASP 100 Diameter Limits (um)
pcaspn	PCASP 100 Raw Count spectrum (particles)
pcasprt	PCASP 100 Total Concentration (/cc)
pcaspt	PCASP 100 Total Count (particles)
psapvm	PVM100A raw surface area (cm2/m3)
pstat	Rosemont Static Pressure (mb)
pyralb	Visible Radiance Albedo (ratio of up/down)

pyrdo	Visible Radiance - Eppley PSP Pyranometer-radiance downward (W/m2)
pyrup	Visible Radiance - Eppley PSP Pyranometer-radiance upward (W/m2)
ralt	Radar Altimeter (AGL, feet)
rams	Absorption - PSAP/RAMS (/m)
reff	Effective Radius -- PMS OAP 200X & FSSP 100 (um)
rh_chl	Relative Humidity [cooled-mirror] (%)
rh_o	Ophir2k Relative Humdity (%)
rhhum	Relative Humidity from the humidgraph (%)
rhovo	Ophir2k Absolute Humdity (g/m3)
sapvm	PVM100A surface area [corrected using fssp100 drop rate] (cm2/m3)
shadin_dalt	Shadin Density Altitude (meters)
shadin_delta_palt	Shadin rate of change for shadin_palt (feet/minute)
shadin_drift	Shadin Drift (degs right)
shadin_heading	Shadin Heading (deg From mag N)
shadin_ias	Shadin Indicated Air Speed (knots)
shadin_mach	Shadin Mach (mach)
shadin_palt	Shadin Pressure Altitude (MSL, meters)
shadin_stemp	Shadin Static Temperature (degC)
shadin_tas	Shadin True Air Speed (knots)
shadin_ttemp	Shadin Total Temperature (degC)
shadin_winddir	Shadin Wind Direction (deg From mag N)
shadin_windspd	Shadin Wind Speed (m/s)
so2	Teco 43S SO2 Concentration (ppb)
tans-alt	Tans Vector Altitude (MSL, meters)
tans-altft	Tans Vector Altitude (MSL, feet)
tans-azimth	Tans Vector Azimuth (0 deg is true north)
tans-grspeed	Tans Vector Ground Speed (m/s)
tans-lat	Tans Vector Latitude (deg)
tans-lon	Tans Vector Longitude (deg)
tans-pitch	Tans Vector Pitch (nose up is positive)
tans-roll	Tans Vector Roll (right wing down is negative)
tans-velx	Tans Vector Velocity x direction (true north)
tans-vely	Tans Vector Velocity y direction (east)
tans-velz	Tans Vector Velocity z direction (up)
tas	Rosemont 831BA True AirSpeed (m/s)
tasb	Best True Airspeed (m/s)
tasknt	Rosemont 831BA True Airspeed (knots)
tsi3320_count	TSI 3320 Total Count (particles)
tsi3320_lspw	TSI 3320 Laser Power (%)
tsi3320_pstat	TSI 3320 Static Pressure (mb)
tsi3320_stime	TSI 3320 Sample Time (seconds)
tsi3320_tbox	TSI 3320 Box Temperature (degC)
tsi3320_tflow	TSI 3320 Laser Current (mA)
tsi3320_tinlet	TSI 3320 Inlet Temperature (degC)
tsi3320_toptics	TSI 3320 Optics Temperature (degC)
tsicnt	TSI 3320 Raw Counts Spectrum (particles)

tsidl	TSI 3320 Diameter limits (um)
tsidn	TSI 3320 Particle Concentration dLogD Spectrum (/cc)
tsirt	TSI 3320 Total Concentration (/cc)
tsisv	TSI 3320 Sample Volume (cc/sec)
tstat	Rosemont static temperature (degC)
tstatb	Best tstat measurement (degC)
tstatr	Reverse Flow Static Temperature (degC)
ttot	Total Temperature measured by platinum wire (degC)
ttotr	Reverse Flow Total Temperature (degC)
turb	Turbulence (spilled drinks)
uvalb	Ultraviolet Radiance Albedo (ratio of up/down)
uvdo	Ultraviolet Radiance - Eppley radiometer-radiance downward (W/m2)
uvup	Ultraviolet Radiance - Eppley radiometer-radiance upward (W/m2)
wind_dir	Wind Direction [from TANS & Shadin] (0 deg is mag north)
wind_east	Wind Speed East component [from TANS & Shadin] (m/s)
wind_north	Wind Speed North component [from TANS & Shadin] (m/s)
wind_spd	Wind Speed [from TANS & Shadin] (knots)

APPENDIX 3

AIRCRAFT IN CLAMS

PARTICIPATING AIRCRAFT DATA CLAMS JUL 10 - AUG 2, 2001					
Any Data Found to be in Error Should be Referred to g.c.purgold@larc.nasa.gov					
AIRCRAFT	**CALL SIGN**	**POC**	**VHF FREQ RANGE**	**UHF FREQ RANGE**	**DURATION / AIRSPEED**
CONVAIR-580	Husky-1	Peter Hobbs Phobbs@atmos.washington.edu (206) 543-6027	118.050 - 135.950 MHz	220.000 - 389.975 MHz	6 Hours / 280 Kts Research Airspeed 195 kts
ER-2	NASA-806	Jeannette Van Den Bosch Jeannette.vandenbosch@dfrc.nasa.gov (661) 276-2273	108.000 to 151.975 MHz	225.000 to99.975 MHz	6.5 Hours / 400 Kts Research Airspeed TBD
OV-10	NASA-524	Eric Roback V.E.Roback@larc.nasa.gov (757) 864-1685	116.000 to 151.975 MHz	225.000 to 399.950 MHz	3.5 Hours / 180 Kts Research Airspeed 155 Kts
PROTEUS	SCAT-21	Allen Royal A.C.Royal@larc.nasa.gov (757) 864-7927	118.000-136.975 MHz	Pending	12 Hours / 250 Kts Research Airspeed TBD
CESSNA-210	N7568N	Brian Cairns Bc25@columbia.edu (212) 678-5625	118.000 - 136.000 MHz	Pending	6.0 Hours / 170 Kts Research Airspeed TBD
LEAR-25C	N54FN	Michael Pitts NASA Langley	?	?	?

APPENDIX 4

CLAMS WAYPOINT LISTING

Corrections or Additions should be referred to: < g.c.purgold@larc.nasa.gov > 5/10/01

Position Data Shown in **DEGREES, DECIMAL-MINUTES** for Compatibility with Flight Planning Software and Charts.

All Position and Heading Data Should be Double-Checked for Accuracy Before Applying to Airborne Navigation

WAYPOINT	POSITION	LOCATION	Ck'd
		FROM Waypoints	
COVE Site Chesapeake Light (NDBC CHLV2)	**36° 54.0' N - 75° 42.6' W**	63 nm at 191° True FROM WAL 33 nm at 109° True FROM LFI 15.1 nm at 095° True FROM Cape Henry, VA	
BUOY 44014	**36° 35.0' N - 74° 50.2' W**	87 nm at 159° True FROM WAL 79 nm at 112° True FROM LFI 60.2 nm at 110° True FROM Cape Henry, VA	
CASE 1 WATER	**36° 30.0' N - 73° 00.0' W**	146 nm at 126° True, FROM WAL 165 nm at 101° True, FROM LFI 130 nm at 070° True FROM Oregon Inlet, NC	
DISMAL SWAMP **(Center of Lake Drummond)**	**36° 36.1' N - 76° 28.2' W**	93 nm at 211° True, FROM WAL 30 nm at 191° True, FROM LFI	
		TO Waypoints	
WALLOPS FLIGHT FACILITY (KWAL)	**37° 56.4' N - 75° 28.0' W**	64 nm at 191° True TO COVE Site 87 nm at 159° True TO BOUY 44014 146 nm at 126° True TO CASE 1 95 nm at 211° True TO DISMAL SWAMP	
LANGLEY AFB (KLFI)	**37° 05.0' N - 76° 21.6' W**	33 nm at 110° True TO COVE Site 79 nm at 112° True TO BOUY 44014 165 nm at 101° True TO CASE 1 WATER 29 nm at 189° True TO DISMAL SWAMP	

APPENDIX 5

SOME CLAMS CONTACTS

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NOTES