ORCAS (2016) Project Manager Report

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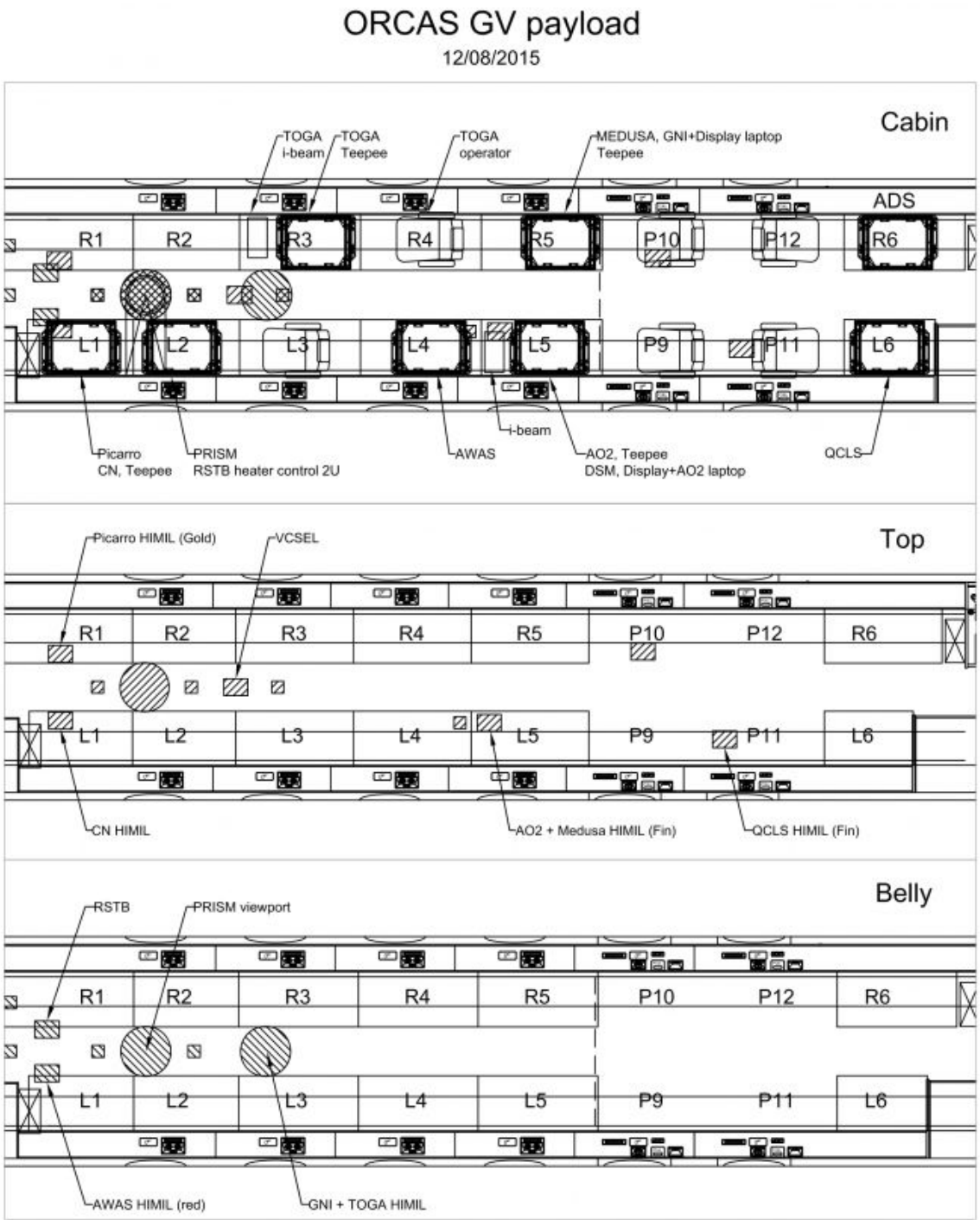
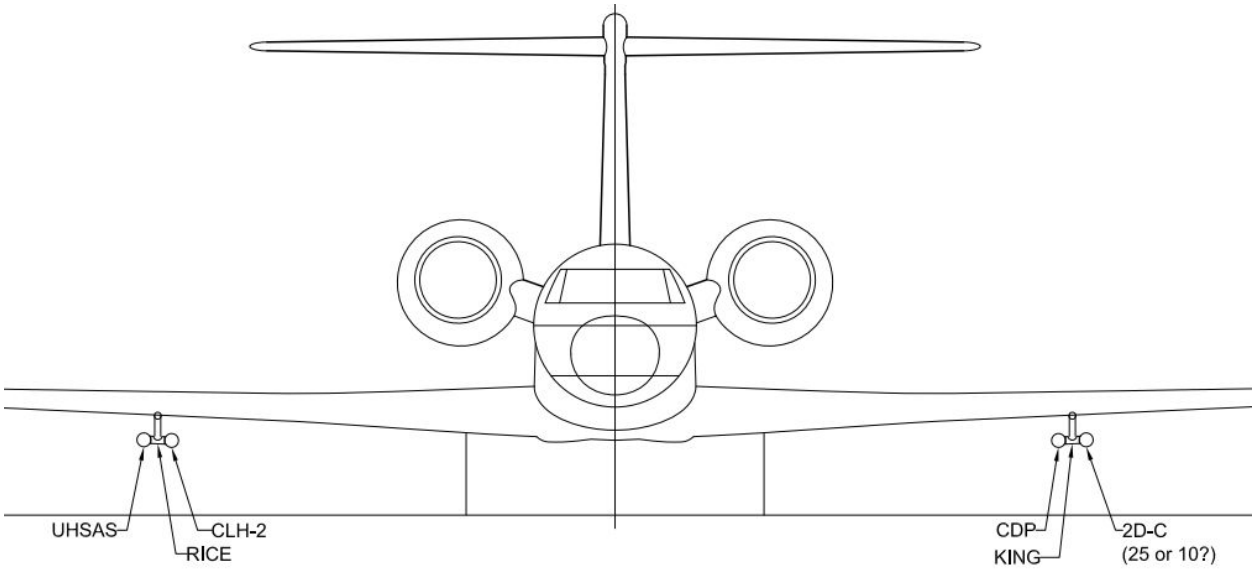
I. Aircraft Payload and Layout





This summary has been written to outline basic instrumentation problems affecting the quality of the data set and is not intended to point out every bit of questionable data. It is hoped that this information will facilitate use of the data as the research concentrates on specific flights and times.

This summary covers only the RAF supplied instrumentation on the GV and is organized into the following sections. Section II provides a general overview of the data collected and lists recurring problems, general limitations, and systematic biases in the standard RAF measurements. A discussion of the performance of RAF specialized instrumentation (i.e. GNI) will be provided separately, along with the data. Section III describes any issues occurring on a flight-by-flight basis. The final section is a list and description of variables found in the quality controlled netcdf data files.

II. General Data Notes

RAF staff have reviewed the data set for instrumentation problems. When an instrument has been found to be malfunctioning, specific time intervals are noted. In those instances the bad data intervals have been filled in the netCDF data files with the missing data code of -32767. In some cases a system will be out for an entire flight.

1. Position and Altitude Data

There were quite a few data dropouts, especially when heading northwest, directly towards the Inmarsat geosynchronous satellite. Most of these result in missing data so no blank outs are needed. Sometimes, as the receiver recovers a fix, it has a 1-2

seconds of poor data, especially in GGALT where the elevation may be off by > 100 m. Most of these can be found by looking for times when the altitude standard deviation (GGALTSD) is greater than 50 m.

2. Three Dimensional Winds

Information on general retrieval of radome winds can be found here. The vertical wind data obtained from the radome has been corrected via the algorithm/processing method documented in a NCAR Tech Note authored by Al Cooper et al. that is currently under review. The premise of this wind calibration methodology is to calculate a reference Angle of Attack (AOA) by assuming that the mean vertical wind over a level flight segment is zero. After the reference AOA is calculated, linear regression is used to determine the coefficients that provide the best fit. There is a known altitude dependency of the corrected vertical winds (WIC). For ORCAS, the same sensitivity coefficients defined for a previous project have been applied in three altitude ranges. They are surface - 6500 m, 6500 to 9300 m, and 9300+ m. WIC should not be used during climbs and descents.

3. Pressure

Static pressure (PSF) on the GV is measured using a static port on the fuselage and then corrected (PSFC) using the angle of attack and dynamic pressure. This sensor worked well through the entire project. There are two measurements for dynamic pressure: a heated pitot tube on the fuselage (QCF) and the forward hole on the radome (QCR), which is unheated. Both are also then corrected (QCFC and QCRC) using the static pressure and angle of attack. Water can sometimes get into the radome tubing and cause poor measurements. QCF and QCFC are chosen as the reference raw and corrected dynamic pressures, respectively, for ORCAS.

4. Ambient Temperature

Temperature measurements were made using heated (ATH1 & ATH2) and fast response (ATF1) sensors. The temperature sensors generally tracked well throughout the project. There were occurrences where ATF1 iced up due to flight segments in clouds with supercooled liquid water. The probe recovered after every instance but care should be taken when using the fast response measurements. ATH2 is chosen as the reference temperature (ATX) as ATH1 has some slight deviations from the other sensors at high altitude.

5. Humidity

Humidity is measured by two collocated thermoelectric dew point sensors and the VCSEL hygrometer. The chilled mirror dewpointers (_DPL, _DPR) typically perform

poorly in the flight profiles of the GV as they flood on descent and take time to restabilize. There are also non-physical oscillations that occur occasionally in the chilled mirror sensors. The chilled mirror dewpointers should only be used when VSCEL data is missing and even in these situations, should be used with caution. The VSCEL performed generally well throughout the campaign. There were short dropouts on mode changes, some flights when it didn't start up properly, and some low laser intensity periods (which have been blanked out). The VSCEL is the reference humidity (DPX) for ORCAS. DPL was inoperable until RF04.

6. Radiometric Temperature

The measurements of radiometric surface temperature is generally good throughout the project. Subsequent to the field deployment, a new calibration was applied in response to observations that RSTB observations over a lead were unrealistically cold compared to the theoretical lower limit for salt water. The new calibration better characterizes sensor behavior at very cold scene temperatures. Users are cautioned to avoid using RSTB at times when TRSTB (sensor temperature) does not fall within 15C to 22C. During rapid ascents and descents the heater may not keep the sensor temperature in the desired range.

7. Liquid Water Content

In almost every flight the King liquid water content measurement (PLWCC) had spurious, high values right after takeoff into clear air or clouds before returning to zero. These instances have all been blanked out. For clouds encountered during these times the LWC measurements from the Cloud Droplet Probe (PLWCD_LWI) should be used. There were also some issues with the King probe voltage that caused some flights to have poor PLWCC measurements. PLWCD_LWI should be compared with PLWCC for all liquid cloud penetrations.

8. Supercooled Liquid Water Indicator

The RICE supercooled liquid water indicator was affected by noise due to a pinched cable for RF01 - RF06. The signal from RICE may be negative on occasion during these flights and should be used with caution. RICE should be used only as a qualitative indicator of the presence of icing.

9. CN Concentration

The CN counter operated well throughout ORCAS. However, failure of a vital I/O card in a DSM, with no spare immediately on hand in the field, prevented the collection of CN data for all of RF02 through RF06.

The length of sample tubing between the external inlet and the CN counter induces a time lag in the instrument response to changes in particle concentration. The sample line is made as short as possible within the constraints of rack and inlet positioning, but some lag is unavoidable. Measured total flow, and comparisons with the wing-mounted UHSAS total concentration, indicate the CN counter lags by about 1 +/- 0.5 seconds, and a constant 1 second correction has been applied to the CN data. Two factors contribute to the uncertainty in this time lag. First, the sample flow rate varies somewhat with ambient pressure and other state parameters. Second, and more importantly, CONCN and CONCU are not highly correlated in general due to combined effects of their very different size ranges and variability in the ambient aerosol size distribution. At times, they are instead anticorrelated.

Those making use of CN concentration data are cautioned that butanol CN counters become increasingly inefficient as internal pressure drops below about 300 hPa, or at altitudes above roughly 9 km. In this circumstance reported concentrations are lower than the true values. The effect is size-dependent, and as the CN counter doesn't provide size information, a correction cannot be applied. High-altitude CN data are retained in the netCDF files for informational purposes.

10. Aerosol and Cloud Particle Size

Two 1D particle probes (UHSAS, CDP) and one 2D cloud probe were used on ORCAS.

UHSAS: The UHSAS generally ran well during ORCAS. Although most flights contained some periods of laser instability and occasional serial communication errors leading to loss of data, these gaps were nearly always brief, typically just one to a few seconds. A notable exception occurred in RF07, when laser instability persisted for about 16 minutes.

CDP: The CDP worked very well during the project with only small issues that are discussed in the flight specific notes.

2DC: There were no problems with this probe during the project. Post project processing with in-house software has added new variables to the dataset. These variables contain the string 2DCA or 2DCR where 2DC refers to the 2D cloud probe. “A” represents all counted particles while “R” represents only those that are identified as round. The “round particle” population is intended to represent liquid water particles. The “all particle” population follows the more traditional method of processing 2D image data, placing both round and irregularly shaped particles together into the same particle size distribution.

11. Camera Images

Forward looking camera images and movies from the right wing pylon are available for all flights. The images are taken at one second intervals and then combined at 15 fps to create the movies.

SPECIAL NOTE: No data are available for RF12 and the first half of RF13 due to an unexpected firmware upgrade that caused a problem with the GV aircraft data system syncing with the time server. The issue was fixed during flight on RF13 and the data system recovered. RF12 and RF13 were evacuation and return flights, respectively, due to high winds in Punta Arenas and no science objectives were compromised due to this outage.

Please note that virtually all measurements made on the aircraft require some sort of airspeed correction or the systems simply do not become active while the aircraft remains on the ground. None of the data collected while the aircraft is on the ground should be considered valid.

III. Individual Flight Summary

All times are UTC

RF01

The left dewpointer (DPL) is inoperable for this flight.
VCSEL failed to start due to water on the mirror and has no data until 13:21. Low laser intensity also caused an outage at 16:36:04 - 16:36:09.
The King probe is blanked out from the beginning of the flight until 13:17.

RF02

The fast response temperature probe (ATF1) iced up at 17:35 remains colder than the heated probes (ATH1/ATH2) until 18:34. It should not be used during this period.
VCSEL is blanked out due to low laser intensity 17:18:48 - 17:20:50 and 20:43:42 - 20:44:00.
The King probe is blanked out from the beginning of the flight until 15:13.

RF03

ATF1 appears to ice up at 17:52 - 17:58, 18:01 - 18:07, and 18:18 - 18:23 and should not be used during these times.
VCSEL failed to start and does not produce data until 15:03.

VCSEL is blanked out for excessive laser intensity 15:15:00 - 15:30:00, 15:56:00 - 15:59:00, 16:10:00 - 16:13:00, and 16:27:00 - 16:29:00. It is also out 19:58 - 20:20.
The King probe is blanked out from the beginning of the flight until 15:15.
Water in the radome causes QCR to be bad 19:06 - 20:39 and it is blanked out.
ADIFR is blanked out 18:01:14 - 18:04:18 due to water in the radome lines. This causes an outage in ATTACK and anything depending on that variable, including true airspeed (TAS) and vertical wind (WIC).

RF04
Evacuation flight to Puerto Montt.
ATF1 is iced up 17:32 - 17:36.
VCSEL was rebooted after takeoff and starts logging data at 15:18:11.
The King probe is blanked out from the beginning of the flight until 15:34.
All GPS data were lost from just after takeoff until 15:45:47. Use LATC, LONC, and ALT for position data during this time. WIC is also missing due to the lack of GGVSPD.

RF05
Return flight from Puerto Montt.
The King probe is blanked out from the beginning of the flight until 12:06:45.
QCR is bad from 12:17:12 until the end of the flight and has been blanked out.

RF06
All GPS data were lost 18:56:31 - 18:57:55. Use LATC, LONC, and ALT for position data during this time. WIC is also missing due to the lack of GGVSPD.
The King probe is blanked out from the beginning of the flight until 16:59.
The left wing DSM went down 22:31:54 - 22:35:33. No data from the King, CDP, or 2DC are available during this time.

RF07
VCSEL is blanked out due to low laser intensity 23:18:36 - 23:18:46.
The King probe is blanked out from the beginning of the flight until 16:22:06.
TRSTB (sensor temperature) was outside the desired range near the beginning and end of the flight, so RSTB behavior was erratic and the data should be used with caution.

RF08
VCSEL is blanked out due to low laser intensity 21:47:51 - 21:48:52.
The King probe is blanked out from the beginning of the flight until 15:05:32.
Water in the radome causes QCR to be bad 20:48 - 21:24 and it is blanked out.

RF09
Evacuation flight to Puerto Montt.
The King probe registered abnormally small voltages on this flight and the data should not be used. PLWCD_LWI should be used for liquid water content measurements.

RF10
Return flight from Puerto Montt.
VCSEL did not start correctly and is out from the beginning of the flight until 13:19:00.
The King probe registered abnormally small voltages on this flight and the data should not be used. PLWCD_LWI should be used for liquid water content measurements.
RICE quit working before takeoff and is not available for this flight.

RF11
VCSEL was rebooted after takeoff and is out 15:04:00 - 15:21.
The King probe is blanked out from the beginning of the flight until 15:13:34. Data from this probe should be used with caution as it appears to drift and show spurious values outside of cloud. PLWCD_LWI is a better liquid water content measurement.

RF12
No data were collected on this flight.

RF13
No data were collected for the first half of this flight. After the data system came back up the standard variables are available from 14:07 - 14:52.
The King probe is blanked out from the time the data system came back up until 14:52.

RF14
The King probe is blanked out from the beginning of the flight until 15:59. Data from this probe should be used with caution as it appears to drift and show spurious values outside of cloud. PLWCD_LWI is a better liquid water content measurement.

RF15
Evacuation flight to Puerto Montt.
The King probe is blanked out from the beginning of the flight until 21:07.

RF16
Return flight from Puerto Montt.
The King probe is blanked out from the beginning of the flight until 23:30.

RF17

VCSEL required a restart early in the flight and is out 14:30 - 14:32.
VCSEL is blanked out for low laser intensity 19:47:51-19:48:00 and 19:49:55 - 19:50:13.
The King probe is blanked out from the beginning of the flight until 14:49.
QCR is bad 20:28:30 - 20:38:05 due to water in the lines and has been blanked out.
ADIFR is bad due to water in the lines and is blanked out 20:11:50 - 20:35:26. This causes an outage in ATTACK and anything depending on that variable, including true airspeed (TAS) and vertical wind (WIC).

RF18

VCSEL is blanked out due to low laser intensity 19:11:19 - 19:11:30 and 20:43:11 - 20:43:53.
The King probe is blanked out from the beginning of the flight until 16:46.

RF19

The King probe is blanked out from the beginning of the flight until 14:14.
ADIFR is bad 14:22:21 - 15:15:32 due to water in the radome lines and has been blanked out. This causes an outage in ATTACK and anything depending on that variable, including true airspeed (TAS) and vertical wind (WIC).

IV. Variable List

ACINS	IRS Vertical Acceleration
ADIFR	Vertical Differential Pressure, Radome
AKRD	Attack Angle, Radome
ALT	IRS Altitude
ALTG_SRTM	Aircraft altitude above Earth's surface (m)
AQRATIO	Ratio of ADIFR to QCF
ATF1	Ambient Temperature, Fast Response
ATH1	Ambient Temperature, Deiced
ATH2	Ambient Temperature, Deiced
ATTACK	Attack Angle, Reference
ATX	Ambient Temperature, Reference
BDIFR	Horizontal Differential Pressure, Radome
BLATA	IRS Body Latitudinal Acceleration
BLONGA	IRS Body Longitudinal Acceleration

BNORMA	IRS Body Normal Acceleration
CNTS	TSI CN Counter Output
CONC1DC100_LWO	2DC Concentration, 100 micron and larger
CONC1DC150_LWO	2DC Concentration, 150 micron and larger
CONC1DC_LWO	2DC Concentration, all cells
CONC2DCA_LWO	2DC Concentration, All Particles
CONC2DCR_LWO	2DC Concentration, Round Particles
CONCD_LWI	CDP Concentration
CONCN	Condensation Nuclei (CN) Concentration
CONCU100_RWO	UHSAS Concentration, 0.1 micron and larger
CONCU500_RWO	UHSAS Concentration, 0.5 micron and larger
CONCU_RWO	UHSAS Concentration, all cells
DBAR1DC_LWO	2DC Mean Particle Diameter, all cells
DBAR2DCA_LWO	2DC Mean Particle Diameter, All Particles
DBAR2DCR_LWO	2DC Mean Particle Diameter, Round Particles
DBARD_LWI	CDP Mean Particle Diameter
DBARU_RWO	UHSAS Mean Particle Diameter
DBZ1DC_LWO	2DC Calculated Reflectivity, all cells
DBZ2DCA_LWO	2DC Calculated Reflectivity, All Particles
DBZ2DCR_LWO	2DC Calculated Reflectivity, Round Particles
DBZD_LWI	CDP Calculated Reflectivity
DISP1DC_LWO	2DC Dispersion (sigma/dbarx)
DISPD_LWI	CDP Dispersion (sigma/dbarx)
DISPU_RWO	UHSAS Dispersion (sigma/dbarx)
DPXC	Dew/Frost Point Temperature, Reference
DP_DPL	Dew/Frost Point Temperature, Left Dewpointer
DP_DPR	Dew/Frost Point Temperature, Right Dewpointer
DP_VXL	Dew/Frost Point Temperature, VCSEL
DVALUE	D-VALUE (GGALT - PALT)
EWX	Ambient Water Vapor Pressure, Reference
EW_DPL	Ambient Water Vapor Pressure, Left Dewpointer
EW_DPR	Ambient Water Vapor Pressure, Right Dewpointer
EW_VXL	Ambient Water Vapor Pressure, VCSEL
FCNC	Corrected BCN Counter Sample Flow Rate
GGALT	Reference GPS Altitude (MSL, m)
GGALTF	Reference GPS Altitude (MSL, ft)
GGALTSD	Standard Deviation of Reference GPS Altitude (MSL)
GGLAT	Reference GPS Latitude
GGLATSD	Standard Deviation of Reference GPS Latitude

GGLON	Reference GPS Longitude
GGLONSD	Standard Deviation of Reference GPS Longitude
GGNSAT	Reference GPS number of satellites used in solution
GGQUAL	Reference GPS Qual, 0=Invalid,1=GPS,2=DGPS
GGSPD	Reference GPS Ground Speed
GGTRK	Reference GPS Track Angle
GGVEW	Reference GPS Ground Speed Vector, East Component
GGVNS	Reference GPS Ground Speed Vector, North Component
GGVSPD	Reference GPS Vertical Speed
LAT	IRS Latitude
LATC	GPS-Corrected Inertial Latitude
LON	IRS Longitude
LONC	GPS-Corrected Inertial Longitude
MACHF	Aircraft Mach Number, Fuselage
MACHR	Aircraft Mach Number, Radome
MACHX	Aircraft Mach Number, Reference
MIRRTMP_DPL	Raw Dew/Frost Point Temperature, Left Dewpointer
MIRRTMP_DPR	Raw Dew/Frost Point Temperature, Right Dewpointer
MODE_VXL	VCSEL Mode
MR	Mixing Ratio, T-Electric
PALT	NACA Pressure Altitude (m)
PALTF	NACA Pressure Altitude (ft)
PCAB	Interior Cabin Static Pressure
PCN	Pressure in BCN counter inlet
PDUMPPL	Pressure of instrument exhaust duct, left
PDUMPPR	Pressure of instrument exhaust duct, right
PITCH	IRS Aircraft Pitch Angle
PLWC1DC_LWO	2DC Water/Ice Content, all cells
PLWC2DCA_LWO	2DC Water/Ice Content, All Particles
PLWC2DCR_LWO	2DC Water/Ice Content, Round Particles
PLWCC	Corrected PMS-King Liquid Water Content
PLWCD_LWI	CDP Water/Ice Content
PSF	Raw Static Pressure, Fuselage
PSFC	Corrected Static Pressure, Fuselage
PSX	Raw Static Pressure, Reference
PSXC	Corrected Static Pressure, Reference
PS_A	ADC Static Pressure
QCF	Raw Dynamic Pressure, Fuselage
QCFC	Corrected Dynamic Pressure, Fuselage

QCR	Raw Dynamic Pressure, Radome
QCRC	Corrected Dynamic Pressure, Radome
QCX	Raw Dynamic Pressure, Reference
QCXC	Corrected Dynamic Pressure, Reference
QC_A	ADC Impact Pressure
REFF2DC_LWO	2DC Effective Radius, Raw
REFF2DCA_LWO	2DC Effective Radius, All Particles
REFF2DCR_LWO	2DC Effective Radius, Round Particles
REFFD_LWI	CDP Effective Radius
RHODT	Absolute Humidity, T-Electric
RHUM	Relative Humidity
RICE	Raw Icing-Rate Indicator
ROLL	IRS Aircraft Roll Angle
RSTB	Radiometric Surface Temperature
RTF1	Recovery Air Temperature, Fast Response
RTH1	Recovery Air Temperature, Deiced
RTH2	Recovery Air Temperature, Deiced
RTX	Recovery Temperature, Reference
SFC_SRTM	Elevation of the Earth’s surface below aircraft position (m)
SOLAZ	Solar Azimuth Angle
SOLDE	Solar Declination Angle
SOLEL	Solar Elevation Angle
SOLZE	Solar Zenith Angle
SSLIP	Sideslip Angle, Reference
SSRD	Sideslip Angle, Radome Diff. Pressure
STATUS_VXL	VCSEL Status Code
TASF	Aircraft True Airspeed, Fuselage
TASFLG	TAS Humidity Correction Flag
TASDRY	Aircraft True Airspeed, Not Humidity Corrected
TASR	Aircraft True Airspeed, Radome
TASX	Aircraft True Airspeed, Reference
TCAB	Cabin Temperature at ADS Rack Location
TCNTD_LWI	CDP Total Counts (all cells)
TCNTU_RWO	UHSAS Total Counts (all cells)
THDG	IRS Aircraft True Heading Angle
THETA	Potential Temperature
THETAE	Equivalent Potential Temperature
THETAP	Pseudo-adiabatic Equivalent Potential Temperature

THETAQ	Wet Equivalent Potential Temperature
THETAV	Virtual Potential Temperature
TRSTB	RSTB Sensor Temperature
TVIR	Virtual Temperature
Time	Time of Measurement
UI	Wind Vector, East Component
UIC	GPS-Corrected Wind Vector, East Component
UX	Wind Vector, Longitudinal Component
UXC	GPS-Corrected Wind Vector, Longitudinal Component
VEW	IRS Ground Speed Vector, East Component
VEWC	GPS-Corrected Inertial Ground Speed Vector, East Comp
VI	Wind Vector, North Component
VIC	GPS-Corrected Wind Vector, North Component
VMR_VXL	Volume Mixing Ratio, VCSEL
VNS	IRS Ground Speed Vector, North Component
VNSC	GPS-Corrected Inertial Ground Speed Vector, North Comp
VSPD	IRS Vertical Speed
VY	Wind Vector, Lateral Component
VYC	GPS-Corrected Wind Vector, Lateral Component
WD	Horizontal Wind Direction
WDC	GPS-Corrected Horizontal Wind Direction
WI	Wind Vector, Vertical Gust Component
WIC	GPS-Corrected Wind Vector, Vertical Gust Component
WS	Horizontal Wind Speed
WSC	GPS-Corrected Horizontal Wind Speed
WOW_A	Aircraft Weight on Wheels