Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment (ACTIVATE)

Data Management Plan

Version 1.0

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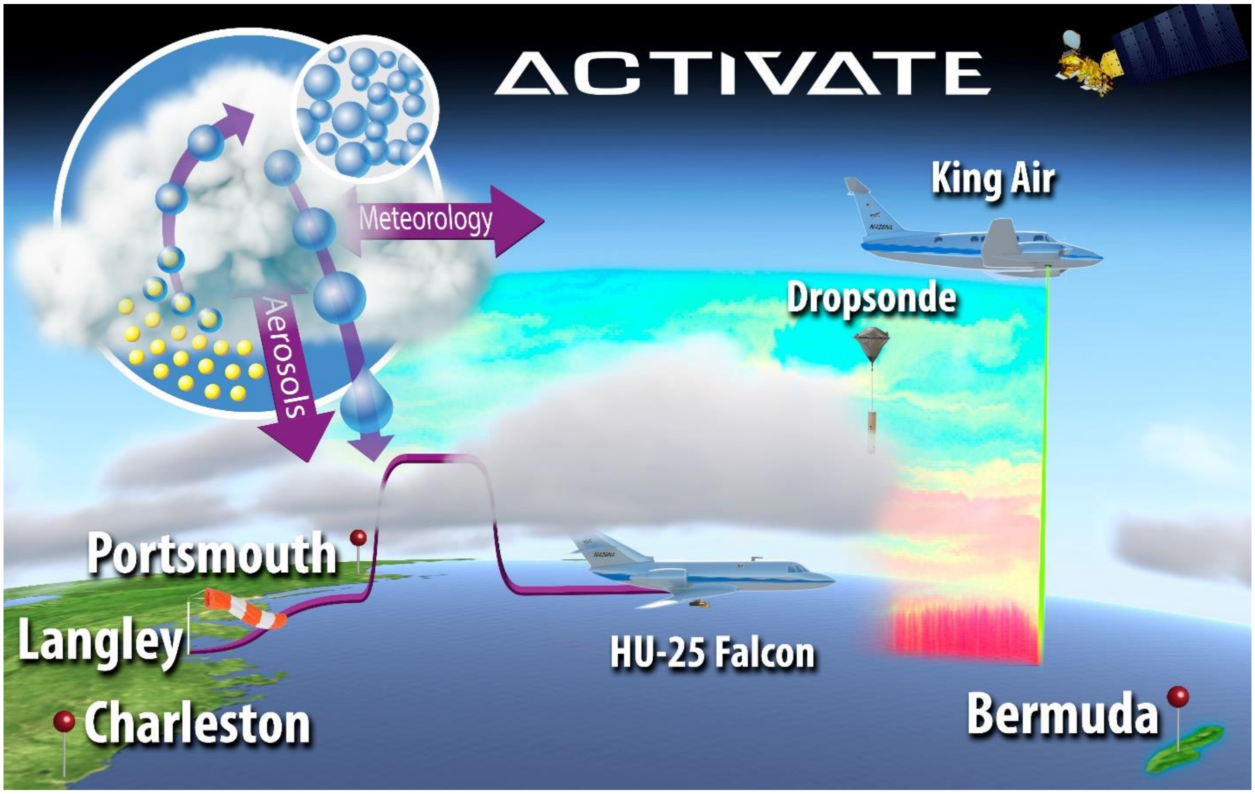

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Change Log

Revision	Date	Description of Changes
V1.0		Baseline DMP

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1. Introduction

The **ACTIVATE** (Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment) investigation is primarily focused on promoting the fundamental understanding of aerosol-cloud interactions and remote sensing capability of aerosol and clouds. The specific science objectives are:

- Quantify relationships between aerosol number concentration (Na), cloud condensation nuclei (CCN) concentration, and cloud drop number concentration (Nd), and reduce uncertainty in model parameterizations of cloud droplet activation.
- Improve process-level understanding and model representation of factors that govern cloud micro/macro-physical properties and how they couple with cloud effects on aerosol.
- Assess advanced remote sensing capabilities for retrieving aerosol and cloud properties related to aerosol-cloud interactions.

ACTIVATE aims to address these objectives through generating statistics of aerosols and clouds under a wide range of meteorological conditions. The ACTIVATE observing strategy is formulated to provide a sufficient data set for sustaining a robust statistical analysis.

Instrument Payload and Sampling Approach: ACTIVATE uses two aircraft: a UC-12 King Air and a HU-25 Falcon. The UC-12 King Air will primarily be used for remote sensing measurements while the HU-25 Falcon will have a comprehensive instrument payload for detailed in-situ measurements of aerosol, cloud properties, and atmospheric state (e.g., temperature and winds). In addition, a few trace gas instruments will be onboard the HU-25 Falcon for the measurements of pollution tracers, which will contribute to airmass classification analysis. A total of 150 coordinated flights over the western North Atlantic are planned through 6 deployments from 2020 to 2022. The accumulated flight duration is 600 hours for each aircraft, with two nominal flight patterns for statistical survey and process study, respectively. The statistical survey pattern is the common flight pattern, which involves close coordination between both aircraft to provide near coincident sampling of cloud droplet number concentration, cloud condensation nuclei concentration, and/or aerosol number concentration at altitudes below cloud base, within cloud, and above cloud top. For these flights, the HU-25 will fly between 0.15 km to ~3 km (above cloud tops) and the UC-12 will maintain a constant nominal altitude of 9 km. The process study pattern is for intensive sampling in localized (~100 km × 100 km) regions targeting specific cloud systems (e.g., post-frontal clouds) when favorable sampling conditions arise. The intensive sampling will require the HU-25 aircraft to conduct extensive vertical profiling.

1.1. Purpose and Scope

The planned ACTIVATE instrument payload and sampling strategy will generate a highly valuable data set, which will promote understanding of aerosol-cloud interactions. The science value of the ACTIVATE data products, however, also rely on the data management activities to support a high degree of usability, discoverability, and accessibility. In this context, the ACTIVATE DMP defines data reporting requirements for the instrument Co-Is to ensure data usability and outlines the process for transferring publication quality data products from the investigation field data repository to the ASDC for long-term preservation and distribution. Specifically, this DMP provides 1) a detailed description of the ACTIVATE data products to be preserved and distributed at the ASDC, 2) the data submission schedule and highlights of the investigation field data repository and its operation, 3) detailed data reporting requirements to ensure the data usability supports research use, 4) a description of value-added data products which are derived from the observations to assist the science team in achieving investigation science objectives, 5) a plan to collect sufficient metadata to support reporting to CMR and to enable data discovery and distribution tools, in particular the new Sub-Orbital Order Tool (SOOT) at the ASDC DAAC, 6) a documentation guideline to sustain reprocessing capability, 7) a description of the data transfer process and assignment of responsibilities, and 8) recommendation of data discovery and distribution requirements for tools at the ASDC.

The development of this DMP is strongly influenced by the on-going data transfer process to the ASDC for the EVS-2 project: NAAMES, which has very similar data products to those of ACTIVATE. This DMP is intended to outline a feasible plan to expedite the ACTIVATE data transfer to the ASDC for archival and public distribution as well as provide a description of data products and the measurements, i.e., who used which instruments to measure what and how the measurements are reported. The last part involves the information related to measurement sampling and reporting.

1.2. Development, Maintenance, and Management Responsibility for the DMP

The EVS-3 investigation ACTIVATE is responsible for the development, maintenance, and management of the DMP. The ACTIVATE investigation data manager, Gao Chen, has overall responsibility for the plan, and has specific responsibility for approving any changes to the plan. All changes to the DMP will be controlled. The ACTIVATE PI, Armin Sorooshian, has the ultimate responsibility for the quality of ACTIVATE data products and the delivery of the data products to the ASDC DAAC.

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2. Instrument Overview

This section introduces the ACTIVATE instrument payload for the HU-25 Falcon and UC-12 King Air aircraft. All instruments onboard these aircraft have been deployed in past R&A and/or EVS airborne field studies. Detailed descriptions for each instrument are given in standardized forms provided in Appendix A. These forms require information on instrument identity, operator(s), literature reference, detection principle and implementation, calibration methodology (if applicable), sampling strategy and sample treatment (if applicable), and data processing. The intent is to provide the data user and/or instrument scientist a straightforward way to quickly find out basic information about the measurement, which can be used for searching additional information if needed. These forms will be finished after the first deployment and updated for each later deployment if the instrument(s) or sampling system has significant change(s).

2.1. Overview of Instrument Payload for NASA HU-25 Falcon

Table 2.1 summarizes the instrument payload onboard the NASA HU-25 Falcon for observing aerosol and cloud properties, meteorological parameters, trace gases, and aircraft navigational parameters. The table lists the instruments, responsible instrument co-investigators (Co-I), Co-I affiliations, and the targeted measurements. Instrument acronyms are given in parentheses, which are cited in the later sections for data product descriptions. Instrument packages are grouped based on the targeted measurements, i.e., aerosol properties; cloud properties; and meteorological state parameters, aircraft parameters, and trace gases.

Table 2.1 NASA HU-25 Falcon Instrument Summary

Instrument	**Co-I**	**Organization**	**Targeted Measurements**
Instruments for Measurements of Aerosol Properties			
TSI-3776 Condensation Particle Counter (CPC-3776)	Luke Ziemba	NASA LaRC	Particle Concentration (> 3 nm)
TSI-3010 Condensation Particle Counter (CPC-3010)	Luke Ziemba	NASA LaRC	Particle Concentration (> 10 nm)
TSI-3010 Condensation Particle Counter with Thermal Denuder (hot-CPC- 3010)	Luke Ziemba	NASA LaRC	Nonvolatile Particle Concentration (> 10 nm)
TSI Scanning Mobility Particle Sizer w/wo Thermal Denuder (SMPS)	Luke Ziemba	NASA LaRC	Particle Number Size Distribution (10 - 200 nm)
TSI Laser Aerosol Sizer w/wo Thermal Denuder (LAS)	Luke Ziemba	NASA LaRC	Particle Number Size Distribution (0.1 - 5 um)
TSI-3563 Nephelometer (TSI Neph)	Luke Ziemba	NASA LaRC	Particle Scattering Coefficients
f(RH) system: TSI-3563 Nephelometers and RH controlled humidifier (fRH)	Luke Ziemba	NASA LaRC	Particle Scattering Hygroscopic Growth Factors
Particle Soot Absorption Photometer (PSAP)	Luke Ziemba	NASA LaRC	Particle Absorption Coefficients
PILS collection coupled to offline ion chromatography (PILs)	Ewan Crosbie	NASA LaRC	Water-Soluble Aerosol Chemical Composition
High-Resolution Time-of- Flight	Luke	NASA LaRC	Non-refractory Particle

Instrument	Co-I	Organization	Targeted Measurements
Aerosol Mass Spectrometer (AMS)	Ziemba		Chemical Composition
DMT Cloud Condensation Nuclei Spectrometer (CCN)	Richard Moore	NASA LaRC	Cloud Condensation Nuclei Concentration at instrument water vapor supersaturation
Instruments for Measurements of Cloud Properties			
DMT Cloud Droplet Probe (CDP) and Cloud and Aerosol Spectrometer (CAS)	Richard Moore	NASA LaRC	Cloud Droplet Size Distribution (0.5 - 50 um)
DMT Cloud Imagery Probe (CIP)			Precipitation Concentration and Size Distribution (25 - 1500 um)
Axial Cyclone Cloud water Collector and offline chemistry (AC3)	Ewan Crosbie	NASA LaRC	Cloud Water Chemical Composition
Instruments for Measurements of Meteorological State Parameters, Aircraft Parameters, and Trace Gases			
Turbulent Air Motion Measurement System (TAMMS)	Lee Thornhill	NASA LaRC	Horizontal and Vertical Winds, Static Pressure
Rosemount Total Temperature Sensor 102 (TTS)			Static Temperature
Applanix POS AV (Applanix)			Aircraft Navigational and Attitude Parameters
PICARRO Cavity Ring-Down Spectrometer (PICARRO)	Glenn Diskin	NASA LaRC	CO and CO2
2B Technologies Ozone Monitor (2B)			O3
Diode Laser Hygrometer (DLH)			Water Vapor
Edgetech frostpoint Hygrometer (cryo)	Lee Thornhill	NASA LaRC	Water Vapor

2.2. Overview of Instrument payload for NASA UC-12 King Air

Table 2.2 summarizes the instrument payload for the NASA UC-12 King Air, which includes three science instruments, the HSRL-2, RSP, and dropsondes, as well as the Applanix POS AV system, which provides aircraft navigational and attitude data for the remote sensing instruments. Table 2.2 lists the instruments, responsible instrument Co-investigators (Co-I), Co-I affiliations, and the targeted measurements. Instrument acronyms are given in parentheses, which are cited in the later sections for data product descriptions.

Table 2.2 NASA UC-12 King Air Instrument Summary

Instrument	**Co-I**	**Organization**	**Targeted Measurements**
Applanix POS AV (Applanix)	John Hair	NASA LaRC	Aircraft navigational and attitude parameters
Dropsondes	Luke Ziemba	NASA LaRC	Vertical profile of temperature, pressure, relative humidity, and horizontal wind
High Spectral Resolution Lidar 2 (HSRL-2)	Richard Ferrare	NASA LaRC	Aerosol properties, cloud top height, cloud top extinction, and mixed layer height
Research Scanning Polarimeter (RSP)	Brian Cairns	NASA GISS	Aerosol and cloud properties

3. Data Product Summary

The focus of this section is to introduce the ACTIVATE data products and how these products are reported, as well as to describe a plan to transfer publication quality data products and associated documentation to the ASDC. Section 3.1 describes the data submission and transfer schedule as well as defining responsibilities. Section 3.2 describes the data file organization to provide contextual information for data product description. Section 3.3 lists the data products by sampling platform, measurement object, instrument, and dataID (an identifier to organized data files). Also provided in the tables are estimated measurement uncertainty and measurement temporal and spatial resolution (for remote sensing measurements only). Data reporting requirements (section 3.4) and data quality issues (section 3.5) are discussed, aiming to enhance the data usability for research. Value-added data products (e.g., merge data and sampling event flags) are described in section 3.6. Finally, the data transfer protocols, discovery and distribution, and documentation requirements are highlighted in the remaining sections.

3.1. Data Flow, Schedule, and Responsibilities

The direct output data (equivalent to L0 data) from the instruments onboard the NASA HU-25 and UC-12 are transferred to instrument Co-Is computers using mass storage devices, e.g., portable hard drives or USB flash drives. This is a well-established process, which has been proven through numerous field studies. Instrument direct output data are processed by instrument Co-Is in two phases to generate field data and publication quality data products, respectively. The field data can be viewed as “quick look” data, which are based on field instrument calibration/characterization, simplified processing procedures, and minimum QA/QC process. This is necessary to help flight planning, check instrument operational status, and assess sampling progress towards achieving the investigation science objectives. Field data are submitted to the ACTIVATE field data repository typically within 24 hours of each research flight. The second phase of data submission involves publication quality data. These data products are processed and submitted to the ACTIVATE field data repository by the instrument Co-Is within six months of the end of last deployment for each year (see Table 3.1). Publication quality data is defined as the data products that can be used in peer-reviewed journal publications, i.e., scientifically defensible. The publication quality data are processed using final calibration and/or post-deployment characterization, full data process procedures, and have undergone full QA/QC processing. The sampling time of in-situ measurements are synchronized to the DLH (Diode Laser Hygrometer) sampling time to account for the difference in the sampling system and instrument time response. Only publication quality data will be transferred to the ASDC and released to the public.

The tentative data submission schedule is summarized in Table 3.1 for both field data and publication quality data products. This schedule is based on the current plan for deployments in years 2020, 2021, and 2022. The submission schedule for publication quality data is subject to change depending on actual deployment operation and/or instrument performance. The ASDC POC (Danielle Groenen) will be notified within 1 week of any changes in the deployment schedule and/or any instrument issues that would cause significant delays in publication quality data product submissions. The latency between the publication quality data submission to the data repository and transfer to the ASDC reflects the effort needed to prepare and submit metadata, as well as inventory the data products for transfer. This is a collaborative effort involving the ACTIVATE science team and ASDC data ingest team (see detailed discussion in section 3.8).

Table 3.1 Tentative Data Submission Schedule for ACTIVATE

Deployment Year	Field Data to Investigation Data Repository	Publication Quality Data to Investigation Data Repository	Publication Quality Data Transfer to ASDC
2020	24 hours after flight	12/31/2020	03/31/2021
2021	24 hours after flight	12/31/2021	03/31/2022
2022	24 hours after flight	12/31/2022	03/31/2023

The investigation data manager and the ASDC data ingest team have had a number of discussions in terms of data product overview and file organization, the investigation field data repository, and planned ASDC data collections for ACTIVATE data products. It is recognized that the data product inventory will need to be updated after each field deployment. The ASDC data ingest team will be have the most updated information through frequent communications with the investigation data manager and direct access to the field data repository.

3.2 Data File Organization and Field Data Repository

3.2.1 Data File Organization

Following the well-established practice often used in airborne field studies, one data file contains the data collected during one flight from one or more instrument(s) operated by one instrument Co-Is team. This is to facilitate data analysis as each flight has its own sampling targets and/or priorities. The instrument Co-

Is may also adjust their instruments for a given flight based on the operating status during the previous flights. When a data file contains data from more than one instrument, the sampling time stamps for all instruments are synchronized so that all data can be reported using a common sampling time stamp.

The data files generated from the same instrument(s) from different flights are required to have consistent structure. These files are organized using the ICARTT file naming convention (see next section), which is constructed by dataID, measurement/sampling platform, data collection date, and revision number. The dataID is a data product identifier. All files with the same dataID are required to have the same number of the variables and in the same sequence.

This type of file organization enables the commonly requested data discovery methods: all variables from one flight and one or several variables from all flights within a field study.

3.2.2 File Naming Convention

The ACTIVATE data files will adopt ICARTT naming convention:

DataID_LocationID_YYYYMMDD_R#_Description.extension

Where:

DataID: A data product identifier, e.g., a short description of measured parameter/species, instrument, or model. The dataID for ACTIVATE data products are prefixed by "ACTIVATE", e.g., ACTIVATE-CPC, ACTIVATE-PICARRO-CO2

LocationID: An identifier of measurement/sampling platform, i.e., HU25, UC12, and Dropsonde, or data source, e.g., Merge and Model

YYYYMMDD: UTC sampling date when the flight takes off

R#: Revision number. The revision number will be RA, RB, RC, … for field data and R0, R1, R2, … for the publication quality data. Note: archived files cannot be overwritten, only replaced by files with subsequent revisions

Description: Optional additional description of the file if necessary

Extension: "ict" for ICARTT files, and "h5" for HDF 5 files, etc.

Examples: The filename for CN concentration measurement made on July 15, 2018 Falcon flight may be:

ACTIVATE-CPC_HU25_20180715_RA.ICT (for preliminary data)

ACTIVATE-CPC_HU25_20180715_R0.ICT (for publication quality data)

3.2.3 ACTIVATE Field Data Repository

The ACTIVATE field data repository has been established and is operational: https://www-air.larc.nasa.gov/missions/activate/index.html. The field data repository has three primary functions: facilitating secure and seamless data exchange among the science team members and partners, maintaining data integrity and usability, and supporting field deployment planning and operation. The ASDC data ingest team has full access to the field data repository.

The data upload tool scans the ICARTT files to ensure their compliance to format standards. It also checks the file names of non-ICARTT files against the file naming convention (but does not check their content). The upload tool will be modified in consultation with the ASDC data ingest team to automatically collect metadata and generate a list of data variables and associated variable standard names when the publication quality data are submitted. This modification is motivated by the experience gained from the DISCOVER-AQ and NAAMES data ingest processes to the ASDC, since most of the CMR required metadata can be extracted from the ICARTT file header. It is believed that this modification will expedite the data ingest process.

A beta-version of a data merge tool will be deployed at the field data repository. This tool allows the science team members to customize merge products in terms of choosing the merge time scales and variables of interest. The goal is to promote the efficiency of data reduction process to quickly generate publication quality data. The source code for the merge tool will be shared with ASDC.

3.3. Description of Data Product Inventory

This section provides a summary of data products from the HU-25 Falcon (Table 3.2 and Table 3.3) and UC-12 aircraft (Table 3.4), as well as a set of proposed data collections (Table 3.5). Table 3.2 lists the data products for in-situ aerosol microphysical, optical, and chemical properties as well as in-situ cloud microphysical and chemical properties, while Table 3.3 summarizes the data products for meteorological state parameters, aircraft position, and trace gases. Table 3.4 lists the UC-12 data products for aerosol and cloud property measurements, profiles of meteorological state parameters, and aircraft position and attitude. Each data product is associated with a tentative dataID. This is to enable the ASDC to define the data collections, which are based on one or multiple dataIDs. It is recognized that the actual dataID and data product association may be different from those listed in the tables. All tables also include information on the instrument and estimated measurement uncertainty, with additional information about the measurement time resolution (Table 3.2 and Table 3.3), measurement size range (Table 3.2), and temporal and spatial resolution (Table 3.4). The size range for aerosol and cloud property measurements are important, reflecting the fact that each instrument can make measurements only within a finite size range, as defined in the table. These tables will be updated after each field deployment to accurately define each dataID and data collection.

Table 3.2 Summary of HU-25 Data Products from Measurements of Aerosol and Cloud Properties

Measured Parameter	Instrument	Uncertainty	Size Range (µm)	Time Resolution (s)	Tentative dataID
Aerosol Property Data Products					
Total Particle Concentration	CPC-3776	10%	>0.003	1	ACTIVATE-CPC
Particle Concentration	CPC-3010	10%	>0.01	1	
Nonvolatile (350°C) Particle Concentration	hot-CPC- 3010	10%	>0.01	1	
Total and Nonvolatile Dry Aerosol Size Distributions	SMPS	N/A	0.01–0.2	60	ACTIVATE-SMPS
	LAS	N/A	0.1–5	1	ACTIVATE-LAS
Dry Scattering Coefficient (450, 550, and 700 nm)	Neph	1 Mm^{-1}	<5	1	ACTIVATE-Optical

Measured Parameter	Instrument	Uncertainty	Size Range (µm)	Time Resolution (s)	Tentative dataID
f(RH) for Scattering (450, 550, and 700 nm)	fRH	15%	<5	1	
Aerosol Absorption (467, 530 and 660 nm)	PSAP	0.5 Mm^{-1}	<5	1	
Non-refractory Chemically Resolved Mass Concentration	AMS	20%	0.06-0.8	10	ACTIVATE-AMS
CCN Concentration and Spectra	CCN	10% 0.04 % SS	<5	1	ACTIVATE-CCN
Water-Soluble Aerosol Chemical Composition	PILS	<20% (species dependent)	<5	300	ACTIVATE-PILS
Cloud Property Data Products					
Cloud Droplet Size and Liquid Water Content (LWC)	CDP	N/A	0.5-50	1	ACTIVATE-CDP
	CAS				ACTIVATE-CAS
Precipitation Concentration and Size Distribution	CIP	N/A	25-1500	1	ACTIVATE-CIP
Cloud Water Chemical Composition	AC3	<20% (species dependent)	>8 (droplet diameter)	Function of cloud LWC	ACTIVATE-AC3

Table 3.3 Summary of HU-25 Data Products from Measurements of Meteorological State Parameters, Aircraft Position, and Trace Gases

Measured Parameter	Instrument	Uncertainty	Time Resolution (s)	Tentative dataID
Meteorological State Parameters and Aircraft Position				
3-D Winds	TAMMS	w: 10 cm/s u,v: 50 cm/s	0.05	ACTIVATE-TAMMS
Static Pressure		1 mb	0.05	
Static Temperature	TTS	0.5°C	0.05	
Aircraft Position	Applanix		1	ACTIVATE-NavHU25
Trace Gases				
Water Vapor	DLH	5% or 0.1 ppmv	<0.05	ACTIVATE-DLH
	Cryo	0.5°C	1	ACTIVATE-Cryo
CO and CO_2	PICARRO	5 ppb (CO) 2 ppm (CO_2)	1	ACTIVATE-PICARRO
O_3	2B	1 ppb	10	ACTIVATE-2B

Table 3.4 Summary of UC-12 Data Products from Measurements of Aerosol and Cloud Properties, Profiles of Meteorological State Parameters, and Aircraft Position and Altitude

Measured/Retrieved Parameter	Instrument	Resolution	Uncertainty[§]	Tentative dataID
Particulate Backscatter Profiles (355/532/1064 nm)	HSRL-2	30 m/1.5 km*	0.2 $Mm^{-1}sr^{-1}$	ACTIVATE-HSRL
Particulate Extinction Profiles (355/532 nm)		150 m/4.5 km*	0.01 km^{-1}	
Particle Depolarization (355/532/1064 nm)		30 m/1.5 km*	1%	
Aerosol Optical Depth (355/532 nm)		150 m/4.5 km*	0.02	
Qualitative Aerosol Type		30 m/1.5 km*	~100 m	
Effective Radius		150 m/4.5 km*	-	
Number Concentration		150 m/4.5 km*	30%	
Surface Concentration		150 m/4.5 km*	100%	
Volume Concentration		150 m/4.5 km*	30%	
Cloud Top Height		150 m/4.5 km*	50%	
Cloud Top Extinction		/75 m	5 m	
Cloud Top Lidar Ratio (extinction-to-backscatter)		/500 m	30-50%	
Mixed Layer Height		/500 m	0.5	ACTIVATE-HSRLMLH
Aerosol Optical Depth for each mode of a bimodal distribution (column)	RSP	100 m x 600 m[†]	0.02/7%	ACTIVATE-RSP
Aerosol Size: effective radius (column)		100 m x 600 m[†,‡]	0.05 µm/10%	
Aerosol Size: effective variance (column)		100 m x 600 m[†,‡]	0.3/50%	
Aerosol Single Scatter Albedo (column)		100 m x 4 km[†,‡]	0.03	
Aerosol Refractive Index (column)		100 m x 4 km[†,‡]	0.02	
Cloud Top Effective Radius		100 m x 600 m[†,‡]	1 µm/10%	
Cloud Top Effective Variance		100 m x 600 m[†,‡]	0.05/50%	
Cloud Mean Effective Radius		100 m x 600 m[†,‡]	20%	

Measured/Retrieved Parameter	Instrument	Resolution	Uncertainty[§]	Tentative dataID
Cloud Optical Depth		100 m x 600 m[†,‡]	10%	ACTIVATE-RSP
Liquid Water Path		100 m x 600 m[†,‡]	25%	
Cloud Thickness		100 m x 600 m[†,‡]	15%	
Cloud Droplet Number Concentration		100 m x 600 m[†,‡]	25%	
Pressure Profile	Dropsonde	(vertical resolution of ~11m)	0.4 hPa	ACTIVATE-Dropsonde
Temperature Profile			0.2°C	
Relative Humidity Profile			2%	
Horizontal Wind Profile			0.5 m s^{-1}	
Aircraft Position & Attitude	Applanix	1 sec.		ACTIVATE-NavB200

[§] Uncertainties, which represent a combination of measurement precision and accuracy, are presented for typical measurement conditions
* "*x* m / *y* m" indicates *x*-m vertical resolution and *y*-m horizontal resolution.
[†] Cross-track by along-track. [‡] Non-imaging: along-track product with single cross-track elements for RSP

Based on discussions with the ASDC data ingest team, a set of data collections are proposed for the ACTIVATE data products. These collection names are consistent with those for NAAMES and ORACLES, which have many common data products from the same type or similar instruments. Table 3.5 defines the association between the proposed data collections, tentative dataIDs, and sampling platforms. The estimated data volumes given in the table are upper limits for each dataID, which are based on previous airborne field studies. This table will be updated after each field deployment to reflect changes in dataIDs. The instrument Co-Is will be encouraged to maximize consistency in data reporting for all deployments. Any changes in this table will be done through discussions between the investigation data manager and the ASDC data ingest team.

Table 3.5 Proposed ACTIVATE Collection Definition

Collection	Platform	Tentative dataID	Estimated Volume (GB)
Aerosol_AircraftInSitu	HU-25	ACTIVATE-CPC	< 1
		ACTIVATE-SMPS	< 1
		ACTIVATE-LAS	< 10
		ACTIVATE-Optical	< 5
		ACTIVATE-AMS	< 1
		ACTIVATE-CCN	< 1
		ACTIVATE-PILS	< 1

Collection	Platform	Tentative dataID	Estimated Volume (GB)
Cloud_AircraftInSitu	HU-25	ACTIVATE-CDP	< 1
		ACTIVATE-CAS	< 1
		ACTIVATE-CIP	< 1
		ACTIVATE-AC3	< 1
MetNav_AircraftInSitu	HU-25	ACTIVATE-TAMMS	< 50
		ACTIVATE-NavHU25	< 10
		ACTIVATE-DLH	< 1
		ACTIVATE-Licor	< 1
		ACTIVATE-Cryo	< 1
	UC-12	ACTIVATE-HSRLMHL	< 1
		ACTIVATE-Dropsonde	< 10
		ACTIVATE-NavB200	< 1
TraceGas_AircraftInSitu	HU-25	ACTIVATE-PICARRO	< 1
		ACTIVATE-2B	< 1
AerosolCloud_AircraftRemoteSensing	UC-12	ACTIVATE-HSRL	< 30
		ACTIVATE-RSP	< 50

3.4. Description of Data Reporting Requirements

The data reporting requirements are designed mostly to enhance the data product usability, especially for research use. These requirements are to ensure: 1) data variables are properly defined; 2) similar data products from different instruments are reported in a consistent way; and 3) variable standard names are reported for all data product variables. It is the responsibility of the instrument Co-Is and the investigation data management team to ensure the data reporting requirements are met. It is noted that these requirements will also increase the efficiency of the data ingest process. The use of standard names will enhance data discoverability, especially from multiple field studies, e.g., NAAMES, ORACLES.

3.4.1. File Format Requirements and General Guidelines

All ACTIVATE in-situ observations will generate geophysical quantity data products, which will be reported as a function of sampling time in the ICARTT 2.0 format. Similarly, the dropsonde data products will also report geophysical quantities as a function of sampling time and location in the ICARTT 2.0 format. The HSRL instrument will produce geophysical quantity data products, which will be reported as a function of sampling time and location in HDF 5 format. The RSP instrument will generate level L1B and L2 data products, which will be reported as a function of sampling time and location in HDF 5 and ICARTT formats, respectively. When using HDF formats, the same metadata required by the ICARTT 2.0 format need to be incorporated into the files to ensure they are self-describing.

3.4.2. Sampling Time Synchronization and Reporting

Considering a cloud spatial scale of ~100 m and aircraft speed of ~100 m/second, it is essential that all in-situ measurements of aerosol and cloud properties as well as meteorological parameters are synchronized to a common time standard to achieve the ACTIVATE science objectives. The primary time standard is determined to be the DLH (diode laser hygrometer) measurement, which plans to report both 1 Hz and 20 Hz data products.

As the ICARTT 2.0 format standards are adopted for ACTIVATE, the timestamp variables shall be reported in UTC and use the standard names, Time_Start, Time_Stop, and Time_Mid. For data reported at slower than 1 Hz, all three timestamp variables must be used (in the order of Time_Start, Time_Stop, and Time_Mid) to fully define the sampling period; for data reported at a resolution of 1 Hz or higher, data providers may choose either to report a single timestamp variable or all three as with the slower resolution data requirement.

3.4.3. In-Situ Aerosol and Cloud Measurement Reporting

All aerosol and cloud extensive properties (e.g., sulfate concentration, aerosol scattering coefficients, and cloud droplet number density) are reported at standard temperature and pressure, specifically 273K and 1013 mb.

The size for all aerosol and cloud size distributions are reported in logarithmic space, e.g., dN/dlogD or dV/dlogD for number and volume size distributions, respectively. The center and width of size bins, i.e., D and dlogD, are provided in the file headers. Also given in the header is the description of the sizing technique.

The aerosol size range for optical property and composition measurements are specified in the file header.

3.4.4. In-Situ Trace Gas Measurement Reporting

The ACTIVATE measurements of carbon dioxide (CO_2) and carbon monoxide (CO) are reported in dry molar fractions. Ozone (O_3) measurements are reported in ambient volumetric mixing ratio. The water vapor measurements are reported in both ambient volumetric mixing ratio as well as dew point for the cryo-hygrometer. Other relevant quantities will be derived, e.g., relative humidity and specific humidity.

3.4.5. Variable Standard Names

A major change of the ICARTT format from version 1.1 to 2.0 is the addition of variable standard names in the data variable descriptions. These standard names are introduced as tags for all science data variables and intended to support data use and data discovery across different field studies. It will also help streamline the data ingest process to the ASDC. The variable standard names can be viewed as an abbreviated description of the measurements with critical measurement, sampling, and reporting information included.

The variable standard names were developed through an ESDIS working group activity. The standard name has a flexible structure, meaning that depending on the type of measurement the standard name is made up of different components, with controlled vocabulary (see https://www.earthdata.nasa.gov/esdis/esco/standards-and-practices/acvsnc for more information). The formulation of this structure, measurement categories, core names, measurement modes, and descriptive attributes were based on extensive input from data providers and data users, as well as DAAC representatives. The core names are very similar to the common names in TAD and STA^{3}CD, which have been successfully implemented to support data discovery features. An early version of the ICARTT standard names was sent to the ATom science team for testing and comments. The use of the standard names has been implemented in the recent FIREX-AQ and CAMP2Ex R&A airborne field studies, and examples of data files including variable standard names from these field studies have been shared with the ASDC data ingest team. Variable standard names have also been used in the data ingest process at the ASDC for NAAMES and ORACLES data products.

3.5. Measurement Quality and Uncertainty Reporting Requirements

One of the major deliverables of ACTIVATE is the observational data products, which can be used to assess the relationship between aerosol properties and cloud properties under various meteorological conditions. These data products will be of publication quality, i.e., scientifically defensible and acceptable for the journal peer review process. The quality of the data products is ensured by the instrument Co-Is, the science team, deputy project scientist, the project scientist, PI, and the Program Scientist.

ACTIVATE observational data quality assurance is a four-step process. The first step involves pre-deployment preparation, which includes instrument characterization/calibration, proper instrument and sampling inlet installation onboard the research aircraft to collect representative ambient air samples, and the integrated tests of the instruments with the aircraft data system to provide consistent time, aircraft state data, and data sharing capability among the investigators onboard the aircraft. The second step is the actual field deployment. Instrument Co-Is have the primary responsibility to ensure instruments are operational and optimized for quality and accuracy during each flight. This is implemented through closely monitoring instrument status and recording all relevant parameters indicating system performance. While in the field, data processing and QA/QC is aimed at producing quick turn-around data, i.e., preliminary data. The in-field QA/QC process is generally targeted at identify obvious anomalies. Post-deployment data processing and QA/QC constitutes the third step of the process. Once the instruments are back in the lab, the instrument Co-Is can conduct post-deployment instrument characterization and calibration and compare the results with those obtained before the deployment. The data are then re-processed using the results from both pre- and post-deployments. Data processing for many instruments depends on utilizing a combination of data products from other instruments and the inclusion of auxiliary data from other sources to ensure consistency. For this reason, the sampling time of in-situ measurements is required to be synchronized to the standard sampling time for the aircraft. This is to account for sampling time differences among the instruments onboard caused by differences in instrument response time and sampling system flow rates. The QA/QC process involves examination of data trends for theoretically related variables, e.g., absorption coefficients and black carbon, scattering coefficients and integrated volume density. Any anomalies identified during the deployment will be closely investigated to determine if the data can be corrected with the assessed uncertainties. The final step occurs after data is released to the public when manuscript development begins. The ACTIVATE data products will be examined/analyzed by both science team members, collaborators, and researchers at large. The ACTIVATE findings will be compared with results from previous studies. Any differences will be closely evaluated to ascertain if the difference can be explained by the difference between the instruments and/or sampling biases.

Measurement uncertainty reporting is required for ACTIVATE. As shown in previous field studies, the uncertainty may be reported in the file header, in a column of data, or a combination of both. It remains a challenge for the current metadata standards to handle the complex uncertainty reporting. For in-situ aerosol property measurements, only the overall uncertainties will be reported. This reflects that fact that there are no calibration standards that can adequately represent the actual ambient aerosols. The uncertainties for these measurements are estimated from evaluations of known factors, e.g., flow controllers, intercomparisons with other similar instruments conducted in previous field studies, and manufacturer's recommendations.

3.6. Value-Added Data Products

Merge data: To facilitate and expedite ACTIVATE data processing, the online merge tool will be deployed at the field data repository. This will allow the science team members and collaborators to create on-demand data merge files. In addition, the data management team will create standard merge files, which will be posted on the repository. The standard merge time intervals will be 1 second, 10 seconds, and 60 seconds. Depending on the science team needs, merge products will also be created for the AMS, PILs, SMPS, and AC3 sampling intervals.

Sampling Event Flags: Data flags and summaries will be created by the science team to identify the cloud types sampled. The data management team will create vertical profile flags for intensive sampling profiles. These value-added products will support data discovery and facilitate the analysis of the ACTIVATE data products.

3.7. Data Product Documentation Requirements

The data product documentation requirements are intended to comply with the NASA data policy, which requires data processing be open and reproducible. Following the practice implemented for DISCOVER-AQ and NAAMES, the ACTIVATE instrument Co-Is will compile ALL information necessary for the reprocessing of the data, if necessary, and submit directly to ASDC before the close out of the investigation. The documentation will include instrument description, instrument primary out, ancillary system output (e.g., sampling flow system), calibration records including methodology and standards (if applicable), ancillary data for data processing, field operation notes (if available), data processing assumptions, algorithm, and code, sampling time standard and synchronization methodology, relevant publication references, and data revision records. This information will enable anyone who has a sufficient understanding of the instrument and airborne sampling system to reprocess the data.

3.8. Data Archiving Requirements and Data Transfer Protocol

As described in section 3.1, the submission of publication quality data to the investigation field data repository is scheduled to be within six months of the last deployment of 2020, 2021, and 2022 (see Table 3.1). This plan is based on the fact that there is only one month time between the first and the second deployment. The experience gained from DISCOVER-AQ and NAAMES show the value of starting the data transfer process before the completion of all publication quality data submission. Instrument Co-Is tend to submit data for one dataID at a time, sometimes significantly before the deadline. Waiting for the completion of all publication quality data could lengthen the time for data transfer. Given this assumption, the ACTIVATE data transfer process is planned to start when the publication quality data submission is complete for one dataID. This is believed to be the more efficient process in terms of minimizing latency and redundant efforts for data distribution at the ASDC DAAC. This section outlines a plan for the data transfer process.

Data Products: All ACTIVATE publication quality observational data products will be transferred to the ASDC DAAC for archival and distribution. The science team generated value-added products will also be transferred, except the data merge products. The current plan is that the ASDC's SOOT tool will be able to generate on-demand merges using the same algorithm as the investigation data repository's data merge tool.

Pre-Deployment: Pre-deployment activities include: 1) define collection and preparation for collection level metadata with available information, e.g., matching instruments and variables with GCMD keywords; 2) modify the current dataID registration tool and file scanning tool for collecting metadata and data file information for reporting to CMR and supporting SOOT; and 3) assign roles and responsibilities to expedite the data transfer process.

During Deployment: The activities during the deployment include: 1) monitor field data submission status and compare dataIDs used by instrument Co-Is with those listed in the DMP; 2) collecting the variable list for each dataID; 3) gather collection level metadata from the dataID registration database at the field data repository; 4) test file scanning tool's variable metadata collection functionality; 4) collect instrument description forms; and 5) communicate with the instrument Co-Is to clarify data reporting and/or metadata issues.

Post-Deployment: Post-deployment activities include: 1) monitor the publication quality data submission status and start data transfer when the submission is complete for one dataID; 2) finalize the collection definitions with the actual dataIDs and granules in the field data repository; 3) finalize the variable list for each dataID and associations between the instrument Co-I, instrument, and dataID; 4) finalize instrument description forms; and 5) start weekly meeting between data manager and ASDC POC to resolve remaining data ingest issues.

Data Transfer Process: The data ingest activities include: 1) pull the data files and associated metadata from the field data repository, which include flight dates, sampling extent, and variable level metadata; 2) verify metadata entries and populate the metadata entries that are not available through automatic collection tools; and 3) ingest the metadata and archive the granules.

Annual Review: An annual review is planned for 2021, 2022, and 2023 to assess the metrics collected during the transfer process, identify issues, and explore solutions. The goal is to improve the data transfer process and reduce the latency for the ASDC to distribute data to the public. The currently planned metrics are to examine the efficiency and effectiveness of the planned data transfer process, which includes the latency between the time of submission to the data repository and the time of public release at the ASDC for individual publication quality data products, number of emails, and number of meeting hours. The review will be focused on identifying the problems that cause data products with longer latencies and seeking solutions through communications among instrument Co-Is, data management team, and ASDC staff.

Post-Investigation Data Update: It is anticipated that there will be files (data from certain flights) that need to be updated even after the lifecycle of the ACTIVATE investigation. It should not be assumed that the ACTIVATE data repository will still be operational at this time. In this context, the ASDC will need to setup a protocol to collect the updated data files, which will involve file format scanning and metadata updates.

3.9. Data Discovery and Distribution Requirements

The data discovery and distribution tools shall support the users by having:

1. Quick access to all ACTIVATE measurements for one given flight or variables of interest for all ACTIVATE flights.
2. On-demand merge of variables of interest at time scale of choice, similar to the data repository online merge tool.
3. Seamless access to similar data products from ACTIVATE and from the previous field studies, especially those with similar science objectives e.g., NAAMES and ORACLES.
4. Discover and subset data from individual vertical profiles or certain type of clouds.

4. References

Stolzenburg, M. R., and McMurry, P. H. (1991). Aerosol Sci. Technol. 14:48-65.
Wang, S. C., & Flagan, R. C. (1990). Scanning electrical mobility spectrometer. Aerosol Science and Technology, 13(2), 230-240. DOI:10.1080/02786829008959441
Szymanski, W. W. (2002), Aerosol concentration measurement with multiple light scattering system and laser aerosol spectrometer, Atmos. Res., 62, 255–265.
Anderson, T. L., & Ogren, J. A. (1998). Determining aerosol radiative properties using the TSI 3563 integrating nephelometer. Aerosol Science and Technology, 29(1), 57-69.
Ziemba et al. (2013)
Modification, Calibration and a Field Test of an Instrument for Measuring Light Absorption by Particles (Virkkula et al. 2010) https://doi.org/10.1080/027868290901963

5. Acronyms

AC3 - Axial Cyclone Cloud Water Collector
ACTIVATE - Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment
AMS - Aerosol Mass Spectrometer
ASDC - Atmospheric Science Data Center
ATom - Atmospheric Topography Mission
CAMP²Ex - Cloud, Aerosol and Monsoon Processes Philippines Experiment
CAS - Cloud and Aerosol Spectrometer
CCN - Cloud Condensation Nuclei
CDP - Cloud Droplet Probe
CMR - Common Metadata Repository
CO - Carbon Monoxide
CO_2 - Carbon Dioxide
CPC - Condensation Particle Counter
DAAC - Distributed Active Archive Center
DISCOVER-AQ - Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality
DLH - Diode Laser Hygrometer
DMP - Data Management Plan
DMT - Droplet Measurement Technologies
ESDIS - Earth Science Data and Information System
EVS-2 - Earth Venture Suborbital 2
EVS-3 - Earth Venture Suborbital 3
FIREX-AQ - Fire Influence on Regional to Global Environments Experiment - Air Quality
GPS - Global Positioning System
HDF - Hierarchical Data Format
HSRL-2 - High Spectral Resolution Lidar 2
ICARTT - International Consortium for Atmospheric Research on Transport and Transformation
LAS - Laser Aerosol Sizer
LOD - Level of Detection
NAAMES - North Atlantic Aerosols and Marine Ecosystems Study
O_3 - Ozone
ORACLES - ObseRvations of Aerosols above CLouds and their intEractionS
PI - Principal Investigator
PILS - Particle Into Liquid Sampler
POC - Point of Contact
PSAP - Particle Soot Absorption Photometer
QA/QC - Quality Assurance/Quality Control
R&A - Research and Analysis
RSP - Research Scanning Polarimeter
SMPS - Scanning Mobility Particle Sizer
SOOT – Sub Orbital Order Tool
STA³CD - Subsetting Tools for Advanced Analysis of Airborne Chemistry Data

TAD - Toolset for Airborne Data
TAMMS - Turbulent Air Motion Measurement System
TTS - Total Temperature Sensor
USB - Universal Serial Bus

Appendix A: Instrument Descriptions

A1. Instrument Description: TSI-3776 Condensation Particle Counter

Attributes	**Description**
Instrument	
Acronym	CPC-3776
Full Name	Langley Aerosol Research Group Experiment – Condensation Particle Counter
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	CNgt3nm, condensation nuclei concertation for particle diameter larger than 3 nm
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	TSI Inc.
Model Number/Development Date	3776
Serial Number	
MeasurementUncertainty	
Overall	10 % of measured value
Accuracy	N/A
Precision	N/A

Attributes	**Description**
Propagation method	Contact PI
ObservableRange	0 – 10,000 particles cm-3. Size range: 50% detection efficiency at 10-nm diameter, 100% detection efficiency at 20nm diameter.
ObservingMethod	Optical particle counting following growth by butanol working fluid
ObservingMethodDetail	
ObservingMethodReference	Stolzenburg, M. R., and McMurry, P. H. (1991). Aerosol Sci. Technol. 14:48-65.
CalibratingMethod	Calibrated using aerosol electrometer
CalibrationStandard	N/A
CalibrationLog	Calibrated prior to mission. Comparison check with parallel identical instrument once per flight using nebulized polystyrene latex spheres.
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	Dried
sampleTreatmentDescription	Air samples are passively dried upon entering aircraft cabin due to temperature difference.
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet
samplingProcedureDescription	Ambient sample is transferred to the instrument using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut.
DataProcessing	Concentrations are output from instrument based on measured flow rates. No corrections are made for diffusion or impaction losses in transfer tubing.
softwareDetails	N/A
DataReportingInformation	Concentrations reported at ambient temperature and pressure or corrected to standard temperature (273K) and pressure (1013mb) – per mission requirement.

A2. Instrument Description: TSI-3010 Condensation Particle Counter

Attributes	**Description**
Instrument	
Acronym	CPC-3010
Full Name	Langley Aerosol Research Group Experiment – Condensation Particle Counter
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	CNgt10nm, condensation nuclei concertation for particle diameter larger than 10 nm
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	TSI Inc.
Model Number/Development Date	3010
Serial Number	70541047
MeasurementUncertainty	
Overall	10 % of measured value
Accuracy	N/A
Precision	N/A
Propagation method	Contact PI

Attributes	Description
ObservableRange	0 – 10,000 particles cm-3. Size range: 50% detection efficiency at 10-nm diameter, 100% detection efficiency at 20nm diameter.
ObservingMethod	Optical particle counting following growth by butanol working fluid
ObservingMethodDetail	
ObservingMethodReference	Stolzenburg, M. R., and McMurry, P. H. (1991). Aerosol Sci. Technol. 14:48-65.
CalibratingMethod	Calibrated using aerosol electrometer
CalibrationStandard	N/A
CalibrationLog	Calibrated prior to mission. Comparison check with parallel identical instrument once per flight using nebulized polystyrene latex spheres.
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	Dried
sampleTreatmentDescription	Air samples are passively dried upon entering aircraft cabin due to temperature difference.
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet
samplingProcedureDescription	Ambient sample is transferred to the instrument using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut.
DataProcessing	Concentrations are output from instrument based on measured flow rates. No corrections are made for diffusion or impaction losses in transfer tubing.
softwareDetails	N/A
DataReportingInformation	Concentrations reported at ambient temperature and pressure or corrected to standard temperature (273K) and pressure (1013mb) – per mission requirement.

A3. Instrument Description: TSI-3010 Condensation Particle Counter with Thermal Denuder

Attributes	Description
Instrument	
Acronym	LARGE-CPC
Full Name	Langley Aerosol Research Group Experiment – Condensation Particle Counter
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	CNgt10nm_nonvol, Number concentration of nonvolatile particles with diameters greater than 10nm
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	TSI Inc.
Model Number/Development Date	3010
Serial Number	TBD
MeasurementUncertainty	
Overall	10 % of measured value
Accuracy	N/A

Attributes	**Description**
Precision	N/A
Propagation method	Contact PI
ObservableRange	0 – 10,000 particles cm-3. Size range: 50% detection efficiency at 10-nm diameter, 100% detection efficiency at 20nm diameter.
ObservingMethod	Optical particle counting following growth by butanol working fluid
ObservingMethodDetail	
ObservingMethodReference	Stolzenburg, M. R., and McMurry, P. H. (1991). Aerosol Sci. Technol. 14:48-65.
CalibratingMethod	Calibrated using aerosol electrometer
CalibrationStandard	N/A
CalibrationLog	Calibrated prior to mission
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	Dried and thermodenuded
sampleTreatmentDescription	Air samples are passively dried upon entering aircraft cabin due to temperature difference. Sample is then passed through a thermodenuder where it is heated to 350°C to remove volatile particles.
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet
samplingProcedureDescription	Ambient sample is transferred to the instrument using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut.
DataProcessing	Concentrations are output from instrument based on measured flow rates. No corrections are made for diffusion or impaction losses in transfer tubing.
softwareDetails	N/A
DataReportingInformation	Concentrations reported at ambient temperature and pressure or corrected to standard temperature (273K) and pressure (1013mb) – per mission requirement.

A4. Instrument Description: TSI Scanning Mobility Particle Sizer w/wo Thermal Denuder

Attributes	**Description**
Instrument	
Acronym	SMPS
Full Name	Langley Aerosol Research Group Experiment – Scanning Mobility Particle Sizer
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	nSMPS, integrated Dry Aerosol Number Concentration by the SMPS (PSL mobility diameter)
	sSMPS, integrated Dry Aerosol Surface Area Concentration by the SMPS (PSL mobility diameter)
	vSMPS, integrated Dry Aerosol Volume Concentration by the SMPS (PSL mobility diameter)
	SMPS_BinXX, Dry Aerosol Number Size Distribution (dNdlogD) by the SMPS (PSL mobility diameter XX)
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	Custom SMPS
Model Number/Development Date	DMA: TSI 3085A Nano DMA, CPC: TSI 3776
Serial Number	N/A
MeasurementUncertainty	
Overall	20 % of measured value
Accuracy	N/A
Precision	N/A

Attributes	**Description**
Propagation method	Contact PI
ObservableRange	Size range: 3-100 nm
ObservingMethod	DMA size selection followed by CPC particle counting
ObservingMethodDetail	The DMA consists of two electrodes and a flow path in which particles move. When a voltage is applied charged particles are diverted from the straight path in the resulting electrical field and classified based on their electrical mobility. When the voltage is constant the DMA generates monodisperse aerosols from a polydisperse particle source. When the voltage is varied the output is a size classified aerosol that when counted with a Condensation Particle Counter (CPC) gives the particle size distribution.
ObservingMethodReference	Wang, S. C., & Flagan, R. C. (1990). Scanning electrical mobility spectrometer. Aerosol Science and Technology, 13(2), 230-240. DOI:10.1080/02786829008959441
CalibratingMethod	Sizing calibrated with NIST-traceable polystyrene latex spheres of various sizes. Concentration calibrated using aerosol electrometer.
CalibrationStandard	N/A
CalibrationLog	Sizing calibrated prior to mission, with standards sampled once per flight. Concentration calibrated prior to mission.
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	Dried
sampleTreatmentDescription	Air samples are passively dried upon entering aircraft cabin due to temperature difference.
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet
samplingProcedureDescription	Ambient sample is transferred to the instrument using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut.
DataProcessing	Size distributions concentrations are output from instrument. Native instrument binning scheme converted to a standardized binning scheme (normalized by bin width). Corrections have been applied for multiple charges and diffusion losses between the DMA and CPC. No corrections are made for diffusion or impaction losses in inlet tubing.
softwareDetails	N/A

Attributes	**Description**
DataReportingInformation	Concentrations reported at ambient temperature and pressure or corrected to standard temperature (273K) and pressure (1013mb) – per mission requirement.

A5. Instrument Description: TSI Laser Aerosol Sizer w/wo Thermal Denuder

Attributes	**Description**
Instrument	
Acronym	LARGE-LAS
Full Name	Langley Aerosol Research Group Experiment – Laser Aerosol Spectrometer
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	IntegN_90to7500nm_PSL_LAS, Number concentration of particles integrated over dry PSL optical diameter 90 to 1000nm measured with LAS
	IntegS_90to7500nm_PSL_LAS, Surface area concentration of particles integrated over dry PSL optical diameter 90 to 1000nm measured with LAS
	IntegV_90to7500nm_PSL_LAS, Volume concentration of particles integrated over dry PSL optical diameter 90 to 1000nm measured with LAS
	LAS_BinXX, Number size distribution per dlogDp for PSL optical diameter at XXX nm measured with LAS
	IntegN_100to1000nm_LAS, Number concentration of particles with diameters between 100 and 1000nm (inclusive) as measured by the LAS
	IntegS_100to1000nm_LAS, Surface area concentration of particles with diameters between 100 and 1000nm (inclusive) as measured by the LAS
	IntegV_100to1000nm_LAS, Volume concentration of particles with diameters between 100 and 1000nm (inclusive) as measured by the LAS
	IntegN_gt1000nm_LAS, Number concentration of particles with diameters greater than 1000nm as measured by the LAS
	IntegS_gt1000nm_LAS, Surface area concentration of particles with diameters greater 1000nm as measured by the LAS
	IntegV_gt1000nm_LAS, Volume concentration of particles with diameters greater than 1000nm as measured by the LAS

Attributes	Description
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	TSI Inc.
Model Number/Development Date	3340
Serial Number	TBD
MeasurementUncertainty	
Overall	20 % of measured value
Accuracy	N/A
Precision	N/A
Propagation method	Contact PI
ObservableRange	Size range: 0.09 – 7.5 um (> 50% of particles at 0.09um counted). Concentration range: 0 – 18,000 particles cm-3.
ObservingMethod	Uses intensity of light scattered from a laser to measure the particle size
ObservingMethodDetail	
ObservingMethodReference	Szymanski, W. W. (2002), Aerosol concentration measurement with multiple light scattering system and laser aerosol spectrometer, Atmos. Res., 62, 255–265.
CalibratingMethod	Sizing calibrated with NIST-traceable polystyrene latex spheres of various sizes. Concentration calibrated using aerosol electrometer.
CalibrationStandard	N/A
CalibrationLog	Sizing calibrated prior to mission, with standards sampled once per flight. Concentration calibrated prior to mission.
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	Dried
sampleTreatmentDescription	Air samples are passively dried upon entering aircraft cabin due to temperature difference.
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet

Attributes	Description
samplingProcedureDescription	Ambient sample is transferred to the instrument using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut.
DataProcessing	Size distributions counts are output from instrument and converted to concentrations based on measured flow rates. Native instrument binning scheme converted to a standard binning scheme (with concentrations normalized by bin width). No corrections are made for diffusion or impaction losses in transfer tubing.
softwareDetails	N/A
DataReportingInformation	Concentrations reported at ambient temperature and pressure or corrected to standard temperature (273K) and pressure (1013mb) – per mission requirement.

A6. Instrument Description: TSI-3563 Nephelometer

Attributes	**Description**
Instrument	
Acronym	Neph
Full Name	Langley Aerosol Research Group Experiment – Integrating Nephelometer
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	Sc450_total, Dry Scattering at 450nm (Total Aerosols)
	Sc550_total, Dry Scattering at 550nm (Total Aerosols)
	Sc700_total, Dry Scattering at 700nm (Total Aerosols)
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	TSI Inc.
Model Number/Development Date	3563
Serial Number	TBD
MeasurementUncertainty	
Overall	5 % of measured value
Accuracy	N/A
Precision	N/A
Propagation method	Contact PI
ObservableRange	N/A

Attributes	**Description**
ObservingMethod	Scattering coefficient measured using the geometrical integration of the angular distribution of scattered light from a light source and an orthogonal detector
ObservingMethodDetail	
ObservingMethodReference	Anderson, T. L., & Ogren, J. A. (1998). Determining aerosol radiative properties using the TSI 3563 integrating nephelometer. Aerosol Science and Technology, 29(1), 57-69.
CalibratingMethod	Calibrated using CO2
CalibrationStandard	N/A
CalibrationLog	Calibrated prior to mission
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	Dried
sampleTreatmentDescription	Air samples are actively dried using a Nafion drier to less than 20%
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet
samplingProcedureDescription	Ambient sample is transferred to the instrument using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut.
DataProcessing	Scattering coefficients are output from instrument. Scattering coefficients are corrected for truncation errors using Anderson and Ogren AS&T, 29, 57-69, 1998. No corrections are made for diffusion or impaction losses in transfer tubing.
softwareDetails	N/A
DataReportingInformation	Reported at ambient temperature and pressure or corrected to standard temperature (273K) and pressure (1013mb) – per mission requirement.

A7. Instrument Description: f(RH) system: TSI-3563 Nephelometers and RH controlled humidifier

Attributes	Value
Instrument	
Acronym	fRH
Full Name	Langley Aerosol Research Group Experiment – Scattering hygroscopic growth factor
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	April 18, 2016 – June 18, 2016
MeasurementVariables	
PI Variable Names	Sc550_total_amb, Mm-1, SCATTERING_GREEN, scattering coefficient of ambient particles at 550nm fRH550_RH20to80, unitless, fRH, derived hygroscopic growth parameter for particles at 550nm
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	LaRC
Model Number/Development Date	TSI Integrating Nephelometers (3563, 3563), Vaisala RH sensor (HMP-60 or HMP-150), Perma Pure Nafion Inlet Dryer (FC125-240-10P), LaRC made humidifier (with Perma Pure FC125-240-10P)
Serial Number	N/A
MeasurementUncertainty	
Overall	contact PI
Accuracy	N/A
Precision	N/A

Attributes	**Value**
Propagation method	Contact PI
ObservableRange	N/A
ObservingMethod	Parallel measurement of dry and humidified scattering coefficients
ObservingMethodDetail	The dry sample is dried to less than 40% RH and the humidified sample is maintained to RH = 80 ± 5%. Sample RH is measured by Vaisala RH sensors.
ObservingMethodReference	Ziemba et al. (2013)
CalibratingMethod	Each nephelometer is calibrated independently based on molecular scattering from pure CO2 gas. Nephelometers are zeroed for each flight with a HEPA filter, and zero values are verified during post-processing. RH sensors are factory calibrated and periodically checked for consistency during flights.
CalibrationStandard	N/A
CalibrationLog	Calibrated prior to, during, and after each deployment.
samplingStrategy	In-situ measurements of ambient air, direct parallel measurements of aerosol scattering coefficients at controlled humidity.
sampleTreatment	Dried and humidified
sampleTreatmentDescription	Air samples are passively dried upon entering aircraft cabin due to cabin heating, and further dried by a Perma Pure Nafion dryer. Humidification is actively controlled using a modified Perma Pure Nafion humidifier system.
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet
samplingProcedureDescription	Ambient sample is transferred to the instruments using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut. Each nephelometer volumetric flow rate is controlled using a critical orifice at 20-22 LPM.
DataProcessing	Ambient scattering and fRH data were not reported when any of the following criteria were not met: 1. Humidified nephelometer humidity must be within 5% of the setpoint 2. Ambient RH must be sufficiently below saturation (less than 95%) 3. Dry scattering must be >= 3 Mm-1 4. Humidified scattering must be >= dry scattering 5. Calculated gamma value must be < 1

Attributes	**Value**
	After processing the individual nephelometer data (dry and humidified), gamma was computed, the filter criteria were applied, and then f(RH) between 20-80% and ambient scattering were calculated from gamma.
softwareDetails	N/A
DataReportingInformation	f(RH) reported as dimensionless ratio

A8. Instrument Description: Particle Soot Absorption Photometer

Attributes	**Value**
Instrument	
Acronym	PSAP
Full Name	Langley Aerosol Research Group Experiment – Absorption
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
PI Variable Names	Abs470_total, Mm-1, AEROpt_Absorption_insitu_blue_RHd_Total_AMB, Dry absorption at 470nm (Total Aerosols)
	Abs532_total, Mm-1, AEROpt_Absorption_insitu_green_RHd_Total_AMB, Dry absorption at 532nm (Total Aerosols)
	Abs660_total, Mm-1, AEROpt_Absorption_insitu_red_RHd_Total_AMB, Dry absorption at 660nm (Total Aerosols)
	AEabsDRY_470to660nm, unitless, AEROpt_AngstromExponentAbs_insitu_BluetoRed_RHd_Total_AMB, derived dry Angstrom Exponent for absorption coefficient over wavelength range from 450nm to 700nm
TimeSynchOrigin	UTC Time synced to DLH
Manufacturer/Developer	Radiance Research
Model Number/Development Date	3-wavelength Particle Soot Absorption Photometer (3λ PSAP)
Serial Number	N/A
MeasurementUncertainty	
Overall	contact PI
Accuracy	No calibration standard available

Attributes	**Value**
Precision	Estimate based on instrument blanks, dependent on integration time
Propagation method	contact PI
ObservableRange	N/A
ObservingMethod	Change in transmittance across a filter
ObservingMethodDetail	Light absorbed by aerosol is calculated using the Beer-Lambert law at 467 nm, 530 nm, and 660 nm (provided by 3 LEDs) by continuously loading sample onto a filter and measuring the change in transmittance of that filter (with respect to a reference filter) over time. The air sample is heated to 40C to reduce sample humidity.
ObservingMethodReference	Modification, Calibration and a Field Test of an Instrument for Measuring Light Absorption by Particles (Virkkula et al. 2010) https://doi.org/10.1080/027868290901963
CalibratingMethod	The PSAP is zeroed each flight with a HEPA filter, and zero values are verified during post-processing. Instrument flow calibrated against known flow rate standard.
CalibrationStandard	Absorption calibration standard not available. Flow rate calibrated against dry cal or Gilibrator instrument.
CalibrationLog	Zeros performed prior to, during, and after each deployment. Flow calibration performed prior to and after each deployment.
samplingStrategy	In-situ measurements of ambient air
sampleTreatment	Dried
sampleTreatmentDescription	Air samples are actively dried by heating the filter cavity to 40C, and further dried by a Perma Pure Nafion dryer.
samplingProcedure	Sampling from a forward-facing shrouded solid diffuser inlet
samplingProcedureDescription	Ambient sample is transferred to the instruments using conductive silicone tubing. Tubing length and number of bends are minimized. Inlet imparts a 5-micron aerodynamic diameter upper size cut. PSAP volumetric flow rate is controlled and logged.
DataProcessing	Time lag, zero, and flow rate adjustments are applied to the raw data. Because the PSAP automatically applies the empirical corrections from Bond et al. 1999 (https://doi.org/10.1080/027868299304435), the data are uncorrected prior to applying a more recent correction using coefficients from Virkkula et al. 2010 (https://doi.org/10.1080/027868290901963) and raw scattering data also measured by LARGE.

Attributes	Value
	Absorption Angstrom exponent is only calculated when the underlying absorption measurements are greater than 2 Mm^-1 (absorption data was smoothed with a 30s running average for the Angstrom exponent calculation).
softwareDetails	N/A
DataReportingInformation	Absorption reported at STP (1 atm and 0°C)

A9. Instrument Description: PILS collection coupled to offline ion chromatography

A10. Instrument Description: High-Resolution Time-of- Flight Aerosol Mass Spectrometer

Attributes	**Description**
Instrument	
Acronym	AMS
Full Name	Langley Aerosol Research Group Experiment – Aerosol Mass Spectrometer
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	Org, mass concentration of organic aerosol
	SO4, mass concentration of sulfate aerosol
	NO3, mass concentration of nitrate aerosol
	NH4, mass concentration of ammonium aerosol
	Chl, mass concentration of chloride aerosol
TimeSynchOrigin	UTC Time synced to DLH water vapor, or cloud probes when DLH is not available – Mission dependent
Manufacturer/Developer	Aerodyne Research, Inc.
Model Number/Development Date	HR-ToF
Serial Number	215-124
MeasurementUncertainty	
Overall	20 % of measured value
Accuracy	N/A
Precision	N/A
Propagation method	Contact PI

Attributes	**Description**
ObservableRange	Size range: 60 – 800nm vacuum aerodynamic diameter. Sensitive only to non-refractory aerosols volatile at 600C. m/z range = 1-1000 with mass resolution of 2000.
ObservingMethod	Aerosol volatilization using a conical tungsten heater followed by 70 eV electron impact ionization and high-resolution time-of-flight mass spectrometry.
ObservingMethodDetail	
ObservingMethodReference	DeCarlo, PF et al. Field-deployable, high-resolution, time-of-flight aerosol mass spectrometer. Analytical Chemistry, vol 78/24, 8281-8289.
CalibratingMethod	Flow rate calibrated using Gilian Gilibrator. Ionization efficiency calibration with monodisperse 400 nm ammonium nitrate aerosol.
CalibrationStandard	N/A
CalibrationLog	Flow rate calibrations performed pre- and post-mission. Ionization efficiency calibrations are done periodically during the mission. Collection efficiency corrections are made on a flight-by-flight basis.
samplingStrategy	In-situ measurements of ambient air, direct measurement of mass concentration
sampleTreatment	Pressure-controlled inlet
sampleTreatmentDescription	Measurements are made at a constant reduced pressure using an Alicat pressure controller and custom inlet hardware to stabilize instrument response time and sensitivity.
samplingProcedure	Manually switched sampling between 1) a forward-facing shrouded solid diffuser inlet and 2) a counterflow virtual inlet (CVI).
samplingProcedureDescription	Ambient sample is transferred to the instrument using stainless steel tubing. Tubing length and number of bends are minimized. A condensation particle counter sampling at the AMS inlet provides auxiliary data and a bypass flow for reduced sampling latency.
DataProcessing	Data are processed using the ToF-AMS Analysis Toolkit according to standard practices. Drift in system response is accounted for using m/z = 28 airbeam signal. Collection efficiency corrections are made using independent ion-chromatography-derived sulfate aerosol mass concentrations from both filter collection and a particle-into-liquid sampler.
softwareDetails	ToF-AMS Analysis Toolkit (v1.57 or higher)
DataReportingInformation	Concentrations reported at ambient temperature and pressure or corrected to standard temperature (273K) and pressure (1013mb) – per mission requirement.

A11. Instrument Description: DMT Cloud Condensation Nuclei Spectrometer

A12. Instrument Description: DMT Cloud Droplet Probe

Attributes	**Description**
Instrument	
Acronym	CDP
Full Name	Langley Aerosol Research Group Experiment – Cloud Droplet Probe
ResponsibleParty	
Name	Luke Ziemba
Affiliation	NASA Langley Research Center
Contact Info	757-864-6246, luke.ziemba@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	DropletNum, number concentration of cloud droplets
	vCDP, volume concentration of cloud droplets
	CDP_BinXX, number size distribution measured at a XX (micrometers) bin center
TimeSynchOrigin	UTC Time synced to DLH water vapor when available.
Manufacturer/Developer	Droplet Measurement Technologies, Inc.
Model Number/Development Date	CDP / 2012-06-27
Serial Number	S/N: 1206-070
MeasurementUncertainty	
Overall	20 % of measured value
Accuracy	N/A
Precision	N/A
Propagation method	Contact PI
ObservableRange	Size range: 2.0 – 50 micrometer geometric diameter (relevant for liquid water drops)

Attributes	Description
ObservingMethod	Single-particle droplet number concentration and size are measured using forward scattering (4 – 12 degrees) intensity by a 658nm 50 mW diode laser.
ObservingMethodDetail	
ObservingMethodReference	Lance, S., C. A. Brock, D. Rogers, and J. A. Gordon. Water droplet calibration of the Cloud Droplet Probe and in-flight performance in liquid, ice, and mixed-phase clouds during ARCPAC. Atmospheric Measurement Techniques, 3, 1683-1706, 2010.
CalibratingMethod	Probe sizing is calibrated using NIST-traceable glass beads with a correction to liquid-water refractive index (1.33).
CalibrationStandard	N/A
CalibrationLog	Calibrations performed pre- and post-mission
samplingStrategy	In-situ cloud measurements in ambient air, typically from a wing-tip, below and ahead of the wing-leading edge, or directly on an aircraft fuselage. Probe placement minimizes flow disruption associated with aircraft surfaces.
sampleTreatment	None.
sampleTreatmentDescription	N/A
samplingProcedure	N/A
samplingProcedureDescription	N/A
DataProcessing	Size distribution data are reported for 30 bins and are normalized to the logarithmic width of each bin (i.e., dlogDp). All concentrations are calculated using true air speed measured by the aircraft data system and a manufacturer-derived sample area. Data are acquired using DMT Particle Analysis and Display System (PADS) software.
softwareDetails	Data processing using Igor Pro from Wavemetrics
DataReportingInformation	Concentrations reported at ambient temperature and pressure

A13. Instrument Description: DMT Cloud and Aerosol Spectrometer

A14. Instrument Description: DMT Cloud Imagery Probe

A15. Instrument Description: Axial Cyclone Cloud water Collector and offline chemistry

A16. Instrument Description: Turbulent Air Motion Measurement System

Attributes	**Value**
Instrument	
Acronym	TAMMS
Full Name	Turbulent Air Motion Measurement System
ResponsibleParty	
Name	Lee Thornhill
Affiliation	NASA Langley Research Center
Contact Info	757-864-4278, kenneth.l.thornhill@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	U_ms-1, East/West Component of the horizontal wind speed
	V_ms-1, North/South Component of the horizontal wind speed
	W_ms-1, vertical wind speed
	WSPD_ms-1, horizontal wind speed
	WDIR_deg, horizontal wind direction
	Latitude_deg, GPS Latitude
	Longitude_deg, GPS Longitude
	GPS_alt_m, GPS WGS84 Altitude reference
	Pstat_mb, Static Air Pressure
TimeSynchOrigin	Initially time synched to UTC time via the NSRC time server or our IRIG-B time server. Post mission UTC Time synced to DLH water vapor if available
Manufacturer/Developer	LaRC
Model Number/Development Date	
Serial Number	
MeasurementUncertainty	

Attributes	Value
Overall	Horizontal winds at +/- 0.5 m/s, vertical winds are +/- 0.15 m/s, temperature is +/- 0.5 deg C and pressure is +/-0.1 mb
Accuracy	n/a
Precision	n/a
Propagation method	Contact P/I
ObservableRange	
ObservingMethod	Combines inertial measurements with pressure measurements from a 5-port setup on the nose of the P-3, along with the fast response temperature to compute the 3-D winds
ObservingMethodDetail	
ObservingMethodReference	Lenschow and Spyers-Duran (1989) RAF Bulletin 23. Measurement Techniques: Air motion Sensing
CalibratingMethod	In-situ calibration maneuvers including speed variations, tailwags, and reverse headings
CalibrationStandard	n/a
CalibrationLog	Done multiple times per mission to validate instrument performance
samplingStrategy	Fast response (>20 Hz) pressure, temperature, and inertial measurements use to derive the 3-D winds
sampleTreatment	n/a
sampleTreatmentDescription	n/a
samplingProcedure	Sampling from pressure ports on the radome of the P-3B and backed up with Rosemount 858Y probes
samplingProcedureDescription	Pressure readings are made on the radome of the aircraft and oversampled to compute 20 Hz winds
DataProcessing	Raw data is collected then extracted and averaged to 20 Hz to derive the 3-D winds using the full equations from Lenschow and Spyers-Duran (1989)
softwareDetails	n/a
DataReportingInformation	Data is recorded at 20Hz per mission requirements

A17. Instrument Description: Rosemount Total Temperature Sensor 102

Attributes	**Value**
Instrument	
Acronym	TAT (Total Air Temperature)
Full Name	Rosemount Total Temperature Probe 102EAL non-deiced
ResponsibleParty	
Name	Lee Thornhill
Affiliation	NASA Langley Research Center
Contact Info	kenneth.l.thornhill@nasa.gov
ValidPeriod	TBD
MeasurementVariables	
	Static Air Temperature
TimeSynchOrigin	UTC derived from GPS time
Manufacturer/Developer	Sensor System, Goodrich Corporation
Model Number/Development Date	
Serial Number	
MeasurementUncertainty	
Accuracy	0.5 deg
Precision	0.1 deg
Resolution:	Continuous
ObservableRange	-99 to 60 deg C

Attributes	**Value**
ObservingMethod	Directly measure total air temperature (TAT) using a resistance temperature detector (RTD). Static air temperature (SAT) derived from TAT with correction for true air speed (TAS) and air density via mach number.
ObservingMethodDetail	
ObservingMethodReference	http://www.flightdatacommunity.com/wp-content/uploads/downloads/2013/02/TAT-Report.pdf
CalibratingMethod	Platinum RTD calibrated via metrology bath
CalibrationStandard	Fluke 5626 RTD
CalibrationLog	Calibrated once a year
samplingStrategy	In-situ sampling
sampleTreatment	De-ice heater was not used
sampleTreatmentDescription	N/A
samplingProcedure	Sampling through a forward facing inlet which is part of the probe to conduct immersion sampling.
samplingProcedureDescription	
DataProcessing	TotalAirTemperature recorded as resistance which is passed through a signal conditioner. Resistance converted to measurement via Callendar Van-Dusen equation and coefficients determined through calibration procedures. Data is simultaneously captured via serial feed. Data reduction involves correction for TAS and air density via mach number. TAS and air density are reverse calculated via pitot-static pressure transducers (Rosemount) installed on aircraft skin.
softwareDetails	Data is first analyzed for integrity along the time series; check for anomalous records, perturbation from expected values. Where appropriate, a comparison is made with nearby observation networks. Empirically determined calibration is then applied. Data is flagged according to instrument tolerance and limitations (e.g. probe contamination by liquid water)
DataReportingInformation	
Subequipment	

A18. Instrument Description: Applanix POS AV

Attributes	**Value**
Instrument	
Acronym	Applanix POS/AV
Full Name	Applanix Position and Orientation System for Airborne Vehicles
ResponsibleParty	
Name	Lee Thornhill
Affiliation	SSAI-Langley Research Center
Contact Info	kenneth.l.thornhill@nasa.gov
MeasurementVariables	
PI Variable Names	Position, Velocity, Roll, Pitch, True Heading
Variable Standard Names	Latitude, Longitude, GPS Altitude , Ground Speed, Vertical Speed, Pitch, Roll, and True Heading
TimeSynchOrigin	UTC derived from GPS time
Manufacturer/Developer	Applanix
Model Number/Development Date	Model 510 V6
Serial Number	TBD
MeasurementUncertainty	
Overall	Accuracy can be enhanced with post-processing
Accuracy	Position, <3 m; Altitude, <5m; Velocity, 0.05 m/s; Roll &Pitch, 0.008 deg; True Heading, 0.03 deg
Precision	See Accuracy
ObservableRange	-70 to +30 deg C
ObservingMethod	Direct georeferencing system

Attributes	**Value**
ObservingMethodDetail	Inertial measurement system, GPS receiver, and computer system utilizing inertial navigation software to produce a position and orientation solution.
ObservingMethodReference	GPS satellites and GPS Base Station Observations
CalibratingMethod	Inflight alignment
CalibrationStandard	N/A
samplingStrategy	Inertial measurements (accelerometers/ gyros) combine with GPS Receiver
sampleTreatment	Processed using Integrated Inertial Navigation Software
sampleTreatmentDescription	Software utilizes strapdown inertial navigator, Kalman filtering, closed-loop error controller, and inflight maneuvers.
samplingProcedure	Ethernet
samplingProcedureDescription	Data output recorded on central data acquisition system at rates up to 100 Hz
DataProcessing software details	See Applanix user manual.
DataReportingInformation	

A19. Instrument Description: PICARRO Cavity Ring-Down Spectrometer

Attributes	**Description**
Instrument	
Acronym	
Full Name	PICARRO
ResponsibleParty	
Name	Glenn Diskin
Affiliation	NASA Langley Research Center
Contact Info	Glenn.s.diskin@nasa.gov 757-864-6268
ValidPeriod	
MeasurementVariables	CO2_ppm, Gas_CO2_insitu_S_DMR, carbon dioxide dry volumetric mixing Ratio
	CH4_ppm, Gas_CH4_insitu_S_DMR, methane dry volumetric mixing Ratio
	CO_ppm, Gas_CO_insitu_S_DMR, carbon monoxide dry volumetric mixing Ratio
TimeSynchOrigin	UTC time synced to NASA Facility instrument DLH (diode laser hydrometer), PI Glenn Diskin
Instrument Source	
Manufacturer/Developer	PICARRO Inc.
Model Number/Development Date	G2401-m
Serial Number	TBD
MeasurementUncertainty	
Overall	
Accuracy	CO2: 0.1 ppm; CH4: 0.5% of measurement; CO: 1% of measurement
Precision	CO2: 0.1 ppm (1 sigma); CH4: 1 ppb (1 sigma); CO: 3 ppb (1 sigma)
Propagation method	Please contact PI for uncertainty propagation when averaging data to a long time interval
ObservableRange	ULOD – CO2: 1000 ppm; CH4: 20 ppm; CO: 5 ppm

Attributes	Description
ObservingMethod	Near-IR Cavity Ringdown Spectroscopy
ObservingMethodDetail	
ObservingMethodReference	https://www.picarro.com/products/flight-co-co2-ch4-h2o-analyzer
CalibratingMethod	Standard displacement (inlet overflow) calibration
CalibrationStandard	WMO Traceable Standards (NOAA ESRL) X2007 (CO_2), X2014A (CO), X2004A (CH_4)
CalibrationLog	Single point calibration every hour during the flight, three point calibrations before/after flight on ground
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	Measured air is dried and compressed. continuously
sampleTreatmentDescription	Samples are dried with high flow Nafion dryers, then the air is compressed to a constant ~800 Torr. Part of this flow is sampled by the PICARRO instrument.
samplingProcedure	Rosemount 6” inlet with 4” standoff from Falcon fuselage located at FS 650, XX degrees starboard from zenith, ~5 ft ¼” OD stainless inlet line
samplingProcedureDescription	
DataProcessing	CO_2 mixing ratio derived from calibration curve calculated from in-flight and ground calibration events
softwareDetails	N/A
DataReportingInformation	Dry volumetric mixing Ratio

A20. Instrument Description: 2B Technologies Ozone Monitor

Attributes	**Description**
Instrument	
Acronym	2BO3
Full Name	Ozone
ResponsibleParty	
Name	Glenn Diskin
Affiliation	NASA Langley Research Center
Contact Info	Glenn.s.diskin@nasa.gov 757-864-6268
ValidPeriod	
MeasurementVariables	O3_ppbv, Gas_O3_insitu_S_AMR, ozone ambient volumetric mixing ratio
TimeSynchOrigin	UTC time synced to NASA Facility instrument DLH (diode laser hydrometer), PI Glenn Diskin
Instrument Source	
Manufacturer/Developer	2B Technologies
Model Number/Development Date	205
Serial Number	TBD
MeasurementUncertainty	
Overall	5 ppbv
Accuracy	
Precision	
Propagation method	Please contact PI for uncertainty propagation when averaging data to a long time interval
ObservableRange	0-250 ppbv
ObservingMethod	UV Absorption at 254 nm; Dual Beam

Attributes	Description
ObservingMethodDetail	
ObservingMethodReference	https://twobtech.com/model-205-ozone-monitor.html
CalibratingMethod	In-flight zeroing, annual ground calibrations
CalibrationStandard	NIST/EPA level 4 transfer standard
CalibrationLog	Single point background zero measurement every hour during the flight, multipoint calibrations annually with 2B Technologies Model 306 Ozone Calibration Source
samplingStrategy	In-situ measurements of ambient air, direct measurement of concentration
sampleTreatment	N/A
sampleTreatmentDescription	N/A
samplingProcedure	Forward facing inlet collects air, which is then subsampled from inside a fluorocarbon manifold
samplingProcedureDescription	
DataProcessing	ozone mixing ratio derived from calibration curve calculated from in-flight zeros and ground calibration events
softwareDetails	N/A
DataReportingInformation	ambient volumetric mixing Ratio

A21. Instrument Description: Diode Laser Hygrometer

Attributes	**Description**
Instrument	
Acronym	DLH
Full Name	Diode Laser Hygrometer
ResponsibleParty	
Name	Glenn Diskin
Affiliation	NASA Langley Research Center
Contact Info	Glenn.s.diskin@nasa.gov 757-864-6268
ValidPeriod	
MeasurementVariables	H2O_ppmv
TimeSynchOrigin	Internal GPS synchronization
Instrument Source	
Manufacturer/Developer	NASA LaRC/Ames
Model Number/Development Date	N/A
Serial Number	N/A
MeasurementUncertainty	
Overall	
Accuracy	5% of measurement + 1 ppmv
Precision	0.1% of measurement
Propagation method	Please contact PI for uncertainty propagation when averaging data to a long time interval
ObservableRange	0-40000 ppmv

Attributes	Description
ObservingMethod	Fourier Transform – Wavelength Modulation Spectroscopy
ObservingMethodDetail	
ObservingMethodReference	Diskin et al. 2002; DOI: 10.1117/12.453736
CalibratingMethod	Calibration-free, concentrations calculated using HITRAN 2012 modeling
CalibrationStandard	N/A
CalibrationLog	N/A
samplingStrategy	Open path, direct measurement, no air sampling
sampleTreatment	N/A
sampleTreatmentDescription	N/A
samplingProcedure	N/A
samplingProcedureDescription	
DataProcessing	Raw signal conditioned and processed using HITRAN 2012 model and project static temperature and pressure
softwareDetails	N/A
DataReportingInformation	Volumetric mixing Ratio

A22. Instrument Description: Edgetech frostpoint Hygrometer

Attributes	**Value**
Instrument	
Acronym	Cryo (Chilled-Mirror Hygrometer)
Full Name	Edgetech Model 137 Vigilant Aircraft Hygrometer System
ResponsibleParty	
Name	Lee Thornhill
Affiliation	NASA Langley Research Center
Contact Info	Kenneth.l.thornhill@nasa.gov
MeasurementVariables	
	Dew Point temperature
TimeSynchOrigin	UTC derived from GPS time
Manufacturer/Developer	EdgeTech
Model Number/Development Date	Model 137 Vigilant
Serial Number	1829
MeasurementUncertainty	
Overall	0.2 – 0.5 deg C (Varies in dynamic response and accuracy as determined by H2O vapor concentrations.)
Accuracy	0.2 deg C
Precision	0.05 deg C (repeatability)
ObservableRange	-70 to +30 deg C
ObservingMethod	Measuring the temperature of a 3-stage thermoelectric cooler chilled mirror when water (ice) condensation (deposition) is detected, via a Platinum Resistance Thermometer. Condensation

Attributes	Value
	conditions are monitored using a photo-detector with the reflection of a light-emitting diode on the mirror.
ObservingMethodDetail	
ObservingMethodReference	See Edgetech data sheet
CalibratingMethod	Calibrated to reference standard
CalibrationStandard	Edgetech RH Calibrator (Model RHCAL) contains reference Vigilant 137 sensor
samplingStrategy	In-situ sampling
sampleTreatment	N/A
sampleTreatmentDescription	N/A
samplingProcedure	Sampled via passively aspirated inlet probe
samplingProcedureDescription	
DataProcessing software details	Sample recorded as analog voltage and converted to representative measurement via transfer curve determined through calibration procedures. Data is first analyzed for integrity along the time series; check for anomalous records, perturbation from expected values. Where appropriate, a comparison is made with nearby observation networks. Empirically determined calibration is then applied. Data is flagged according to instrument tolerance and limitations (e.g. hygrometer overshoots, contamination with liquid).
DataReportingInformation	

Appendix 1