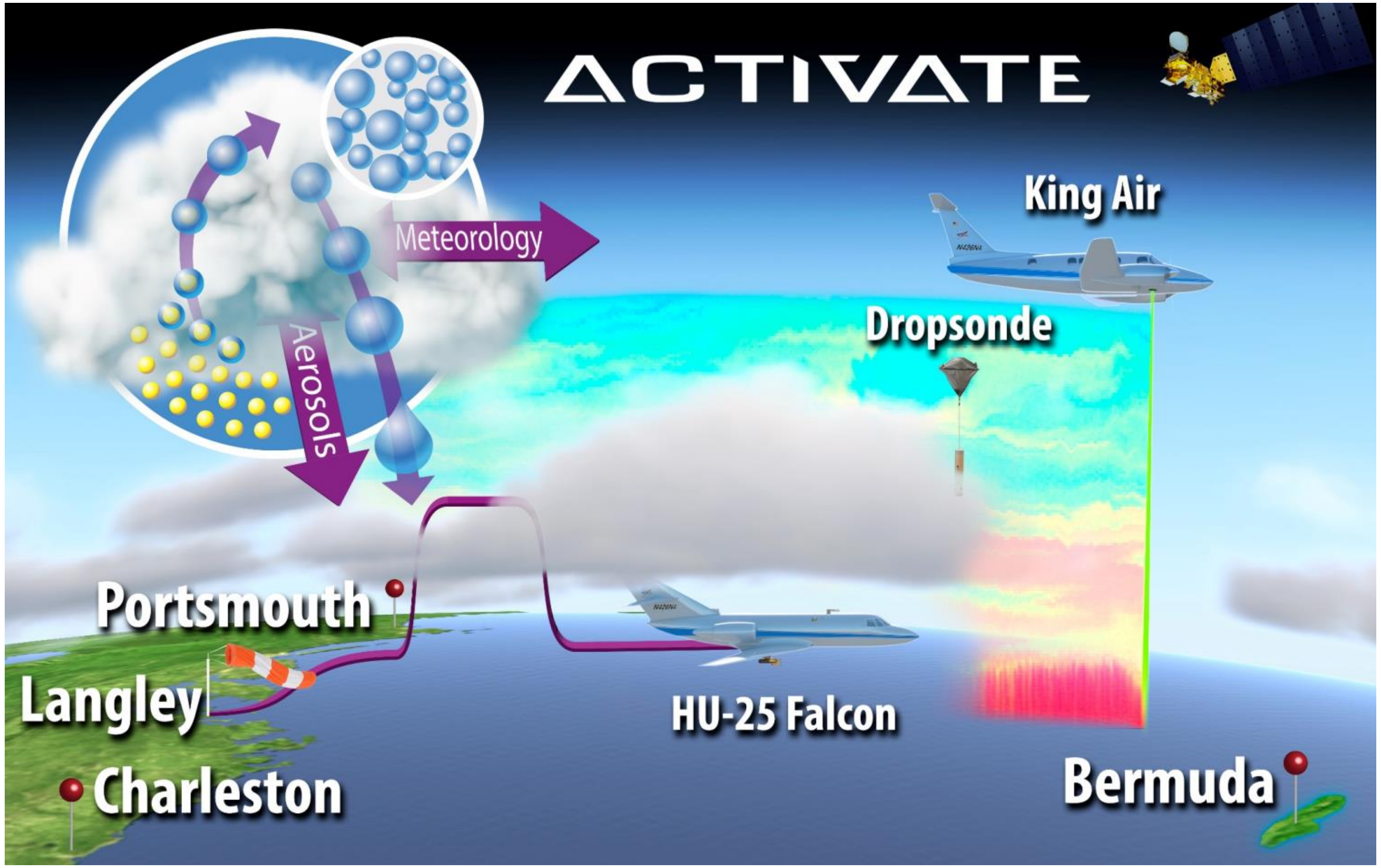


Science: Build **unprecedented dataset** to better understand aerosol-cloud-meteorology interactions, improve physical parameterizations for Earth system and weather forecasting models, assess remote sensing retrieval algorithms, and guide plans for future satellite missions.

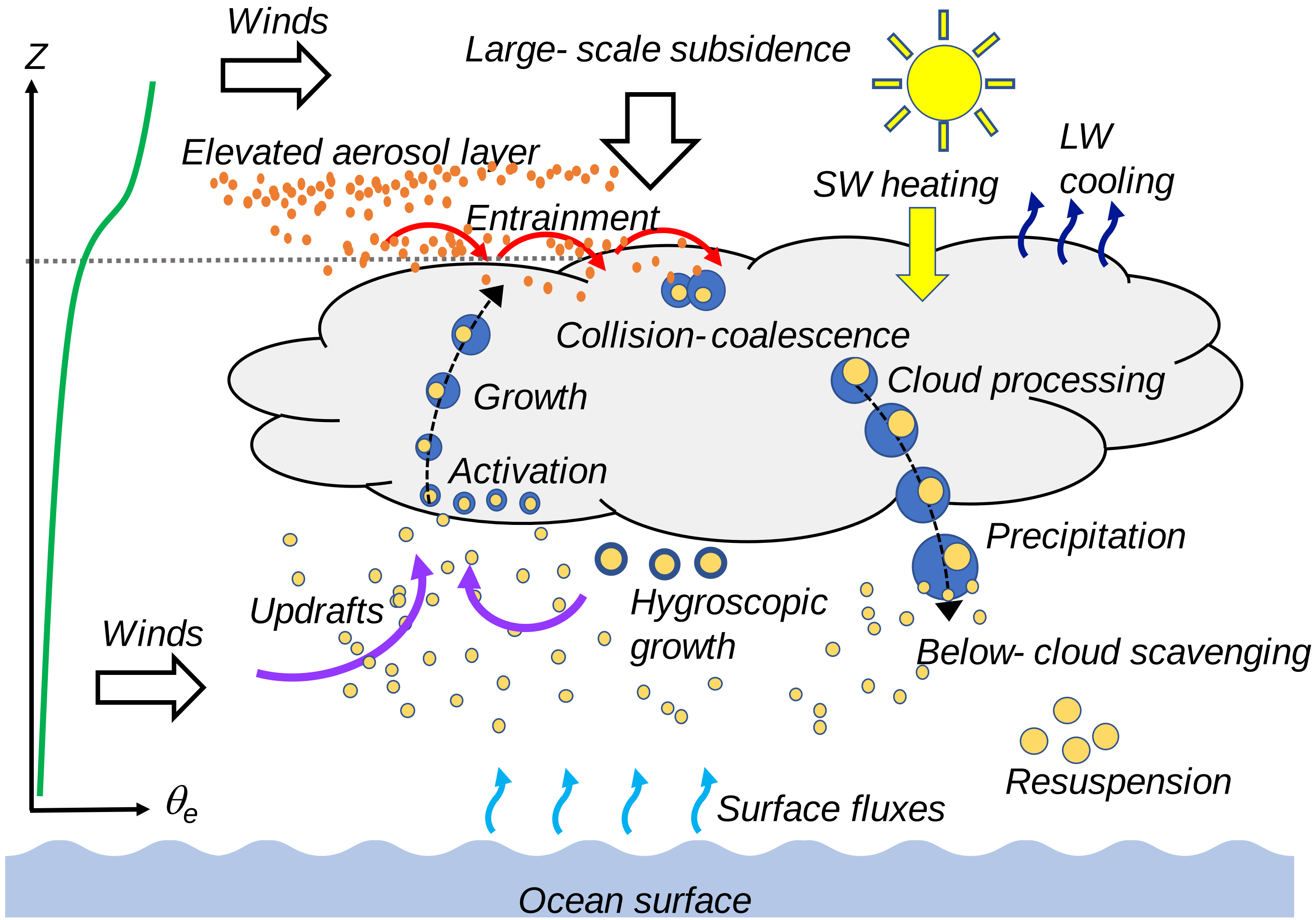
- Platforms: HU-25 Falcon + King Air
- Initial goal of 150 joint airplane missions (~600 hrs per plane) over western North Atlantic Ocean
- Based out of NASA LaRC, Hampton, VA
- Measurements: In situ and remote sensing measurements of aerosol and cloud distributions and properties, atmospheric state

Aerosol Cloud meTeorology Interactions oVer the Western Atlantic Experiment (ACTIVATE)

https://activate.larc.nasa.gov/

Motivation

ACTIVATE



Sorooshian et al. (2019), BAMS

Original Science Objectives

ACTIVATE

Science objectives and questions related to acquisition and use of a large in situ and remote sensing dataset of aerosols and MBL clouds (spanning the continuum from stratiform to cumulus)
Objective 1. Quantify N_a-CCN-N_d relationships and reduce uncertainty in model cloud droplet activation parameterizations. A. How do these relationships depend on aerosol characteristics (e.g., amount, size, composition, type) and dynamic and thermodynamic properties? B. How consistent are these relationships across the complete range of spatial scales provided by in situ measurements and airborne and satellite remote sensing retrievals? C. What are the magnitudes of biases in the N_a-CCN-N_d relationships from satellite aerosol proxies? How do these translate to uncertainties in N_d parameterizations in current global aerosol-climate models? Deliverables: Improved model representations of N_a-CCN-N_d relationships; unique dataset using a sustained long-term strategy for model intercomparison and process-based studies

Objective 2. Improve process-level understanding and model representation of factors governing cloud micro/macro-physical properties and how they couple with cloud effects on aerosol. A. What are the relationships between N_d, cloud micro/macro-physical properties, and meteorology? B. To what extent do uncertainties in N_a/cloud/meteorology relationships within the targeted cloud regimes in global aerosol-climate models come from biases in aerosols, clouds, and meteorological factors? How can the identified model biases and uncertainties be reduced using the measurements? C. How can climate models better represent conditions with known challenges, such as post-frontal clouds and cold air outbreaks? D. What is the signature of cloud effects on the CCN budget (e.g., wet scavenging, aqueous processing). Deliverables: Improved model parameterizations for relationships between cloud microphysical and macrophysical properties; unique dataset using a sustained long-term strategy for model intercomparison and process-based studies
Objective 3: Assess advanced remote sensing capabilities for retrieving aerosol and cloud properties related to aerosol-cloud interactions. A. How well and under what conditions can active and passive remote sensing retrievals provide improved measurements for N_d and proxies for CCN concentration? B. How well can a combination of remote sensors improve measurements of LWP? Deliverables: Evaluation and intercomparison of CCN and N_d retrievals and measurements; evaluation of LWP as a function of scale

ACTIVATE

Threshold and Baseline Requirements

Baseline Mission Requirements	Threshold Mission Requirements
a. Conduct joint flights with two aircraft to sample the equivalent of 250 'cloud ensembles' over the western North Atlantic Ocean. A minimum of 15 additional 'clear air ensembles' will be in clear air conditions during joint flights with two aircraft.	a. Conduct flights to sample the equivalent of 200 'cloud ensembles' over the western North Atlantic Ocean of which 50% are joint aircraft flights with two aircraft; the other 50% will be with the HU-25 aircraft. A minimum of 12 additional 'clear air ensembles' will be in clear air conditions during joint flights with two aircraft.
b. During the flights described in (a), acquire in situ data on aerosol, gas, cloud, and meteorological parameters from an aircraft flying in the boundary layer (see Table 3-1).	b. Same as baseline but with a combination of reduced instruments collecting data and less time for instruments to collect data.
c. During the flights described in (a), acquire remote sensing data for aerosol and cloud parameters from an aircraft flying above the boundary layer (see Table 3-2).	c. Same as baseline but for 100 'cloud ensembles' and 12 'clear air ensembles'.
d. Deliver data, associated information, and data library of measured parameters for individual 'cloud ensembles' to ASDC for archival and public access. All details are in the data management plan. Data delivery latencies in Table 8-1, IIP.	d. Deliver data and associated information to ASDC for archival and public access. All details are in the data management plan. Data delivery latencies in Table 8-1, IIP.
e. Conduct analysis on the collected data in conjunction with multi-scale modeling to determine relationships between aerosols, N_d, cloud micro/macro-physical properties, and meteorology, and to identify model biases in aerosols, clouds, and meteorological factors.	e. Same as baseline but with less comprehensive measurements based on data collected corresponding to rows b-c of the Threshold Mission.
f. Assess lidar-only, polarimeter-only, and combined lidar-polarimeter algorithms to improve the capability to retrieve aerosol and cloud optical and microphysical properties.	f. Assess lidar-only and polarimeter-only algorithms to improve the capability to retrieve aerosol and cloud optical and microphysical properties for half of the flights that involve two aircraft.
g. Use satellite observations to assess spatial and temporal variability in aerosol and cloud properties in the study region and to determine magnitudes of biases in the N_a-CCN-N_d relationships from satellite aerosol proxies and how these translate to uncertainties in N_d parameterizations in current global aerosol-climate models.	g. Same as baseline but for half of the flights that involve two aircraft.
h. Improve how models simulate aerosols, clouds, and their interactions for conditions in the ACTIVATE region.	h. Same as baseline but with less comprehensive measurements.
i. Publish and present science data to the public. Provide open data workshops for the public.	i. Same as baseline.

Ongoing analysis activities

Platforms

High-Altitude Remote Sensing
King Air

<u>Altitude</u>: 9 km
<u>Airspeed</u>: 120 m/s
<u>Duration</u>: ~4 hours

Low-Altitude In-situ
HU-25 Falcon

<u>Altitudes</u>: 0.15 - 3 km
<u>Airspeed</u>: 100-130 m/s
<u>Duration</u>: ~4 hours

Payload: Falcon External Probes

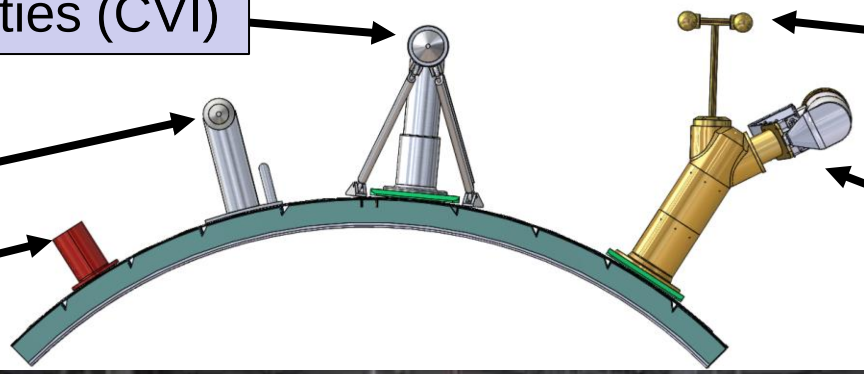
Cloud Residual Properties (CVI)

Cloud Droplet Probe

Isokinetic Aerosol Inlet

AC3 Cloud Collector

Trace Gases



Cloud Aerosol Precipitation Spectrometer (Langley)

Turbulent Air-Motion Measurement

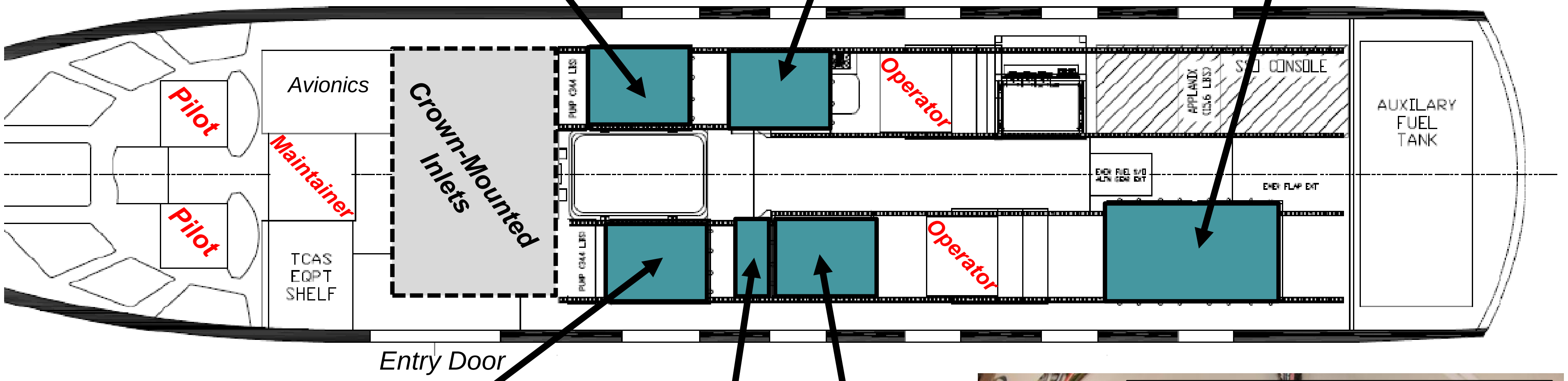
FCDP/2D-S Cloud probe (DLR)

Payload: Falcon In-Situ Measurements

Trace Gases
Ozone, CO, CO_2, H_2O

Aerosol Composition (PILS)

Aerosol Composition (HR-ToF-AMS)



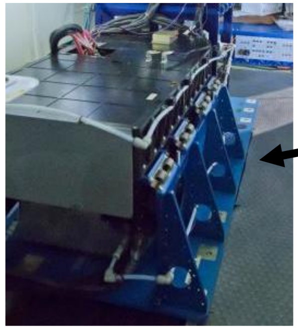
Aerosol Optical
Scattering, Absorption, Hygroscopicity

Cloud Condensation Nuclei

Aerosol Microphysics

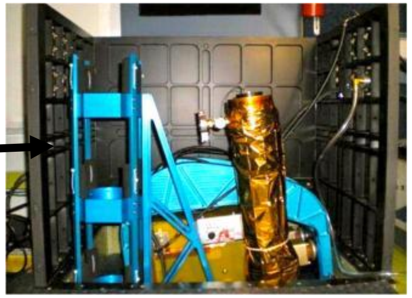
Falcon Layout for ACCESS

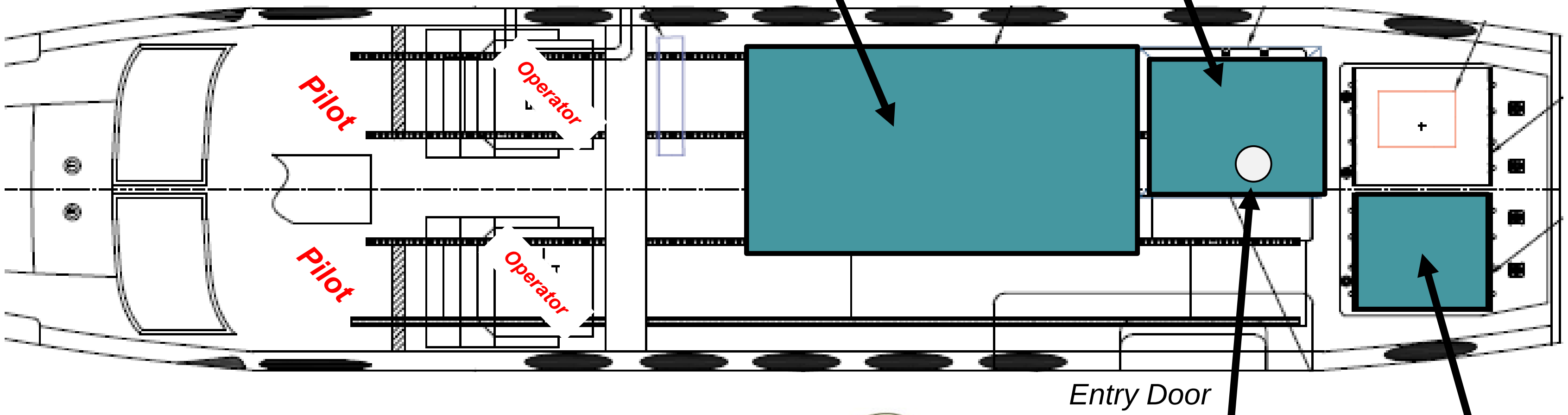
Payload: King Air

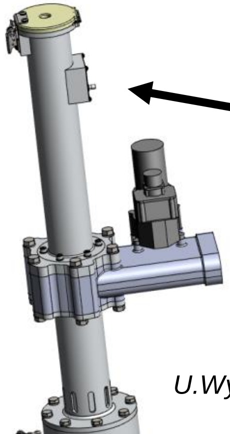


High Spectral Resolution Lidar (HSRL-2)

Research Scanning Polarimeter (RSP)







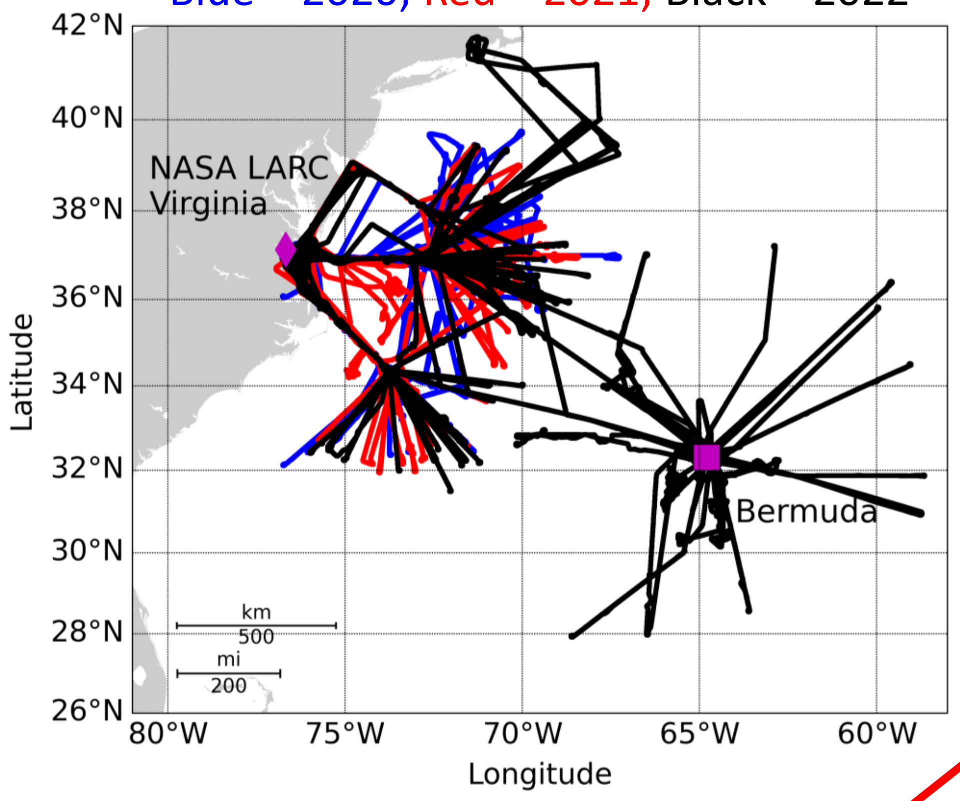
Dropsonde Tube Penetration

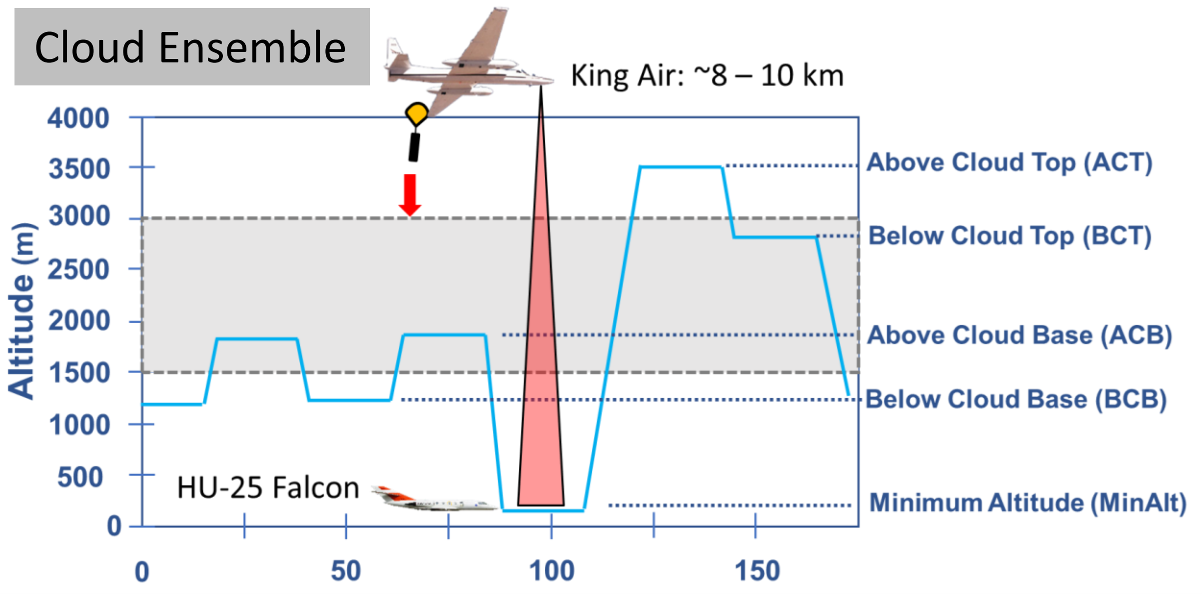
Dropsonde (AVAPS) and RSP support Electronics

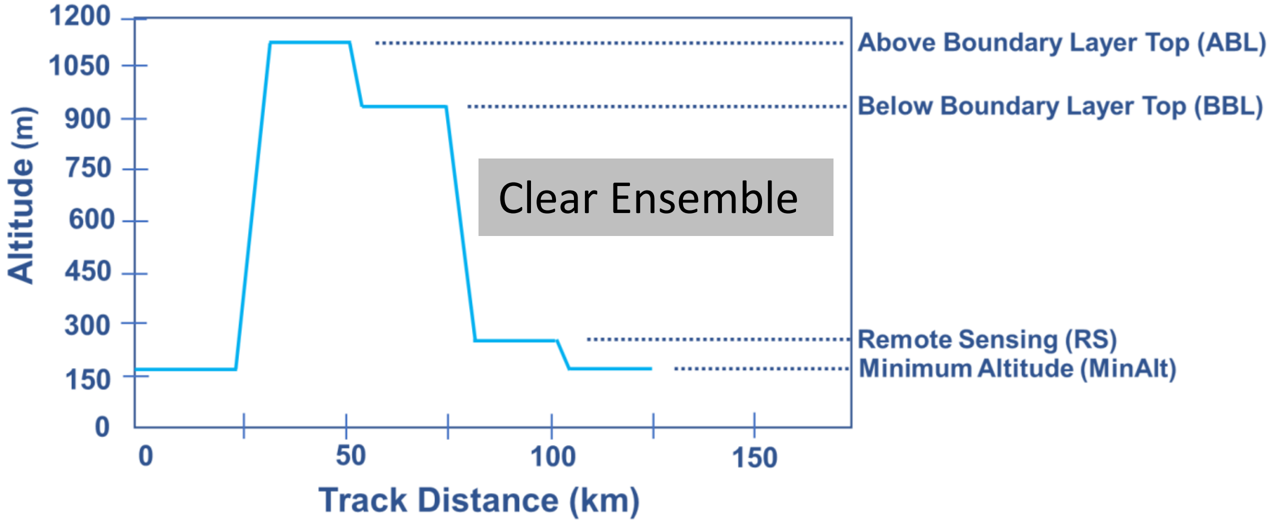
U.Wyo B-200 Launcher

Flight Strategy

Blue = 2020; Red = 2021; Black = 2022







~90% of flights = "statistical surveys"

~10% = Process-studies

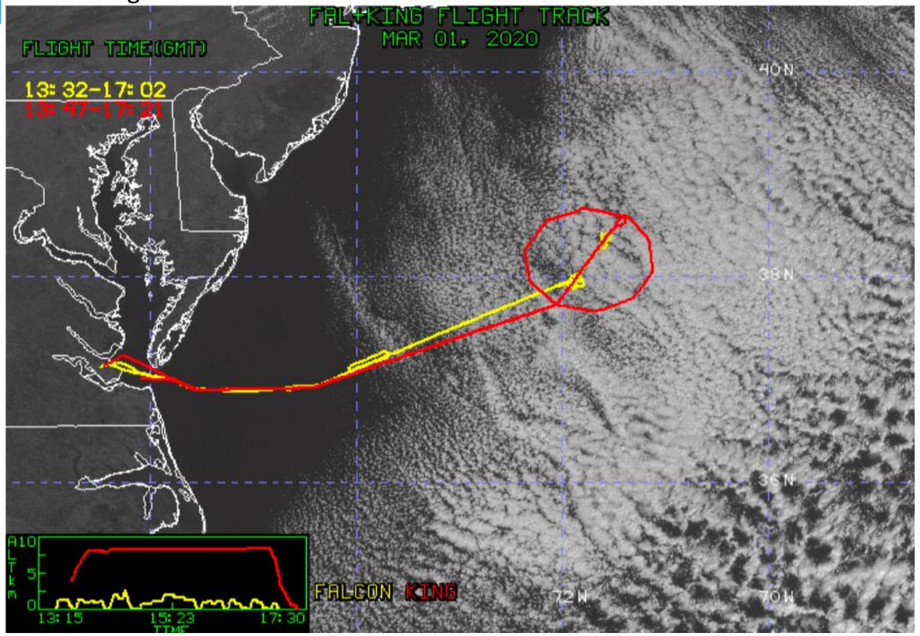
Process Study Example

AM Flight Plan
- King Air (red) performs a dropsonde circle, with a remote sensing transect down the center
- Falcon (yellow) executes a wall pattern along the remote sensing transect
- Remote sensing transect and wall oriented perpendicular to the boundary layer winds

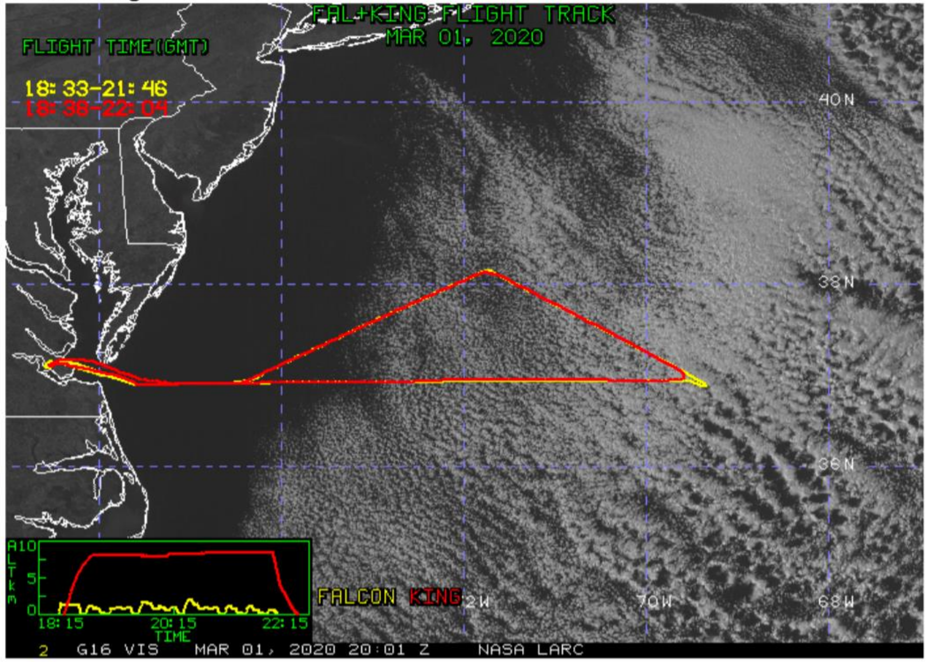
PM Flight Plan
- Both aircraft survey out to the center of the morning circle, then SE before returning to base
- SE leg oriented along the wind for a semi-Lagrangian transect

We discuss this case at length in a previously recorded data workshop:
https://asdc.larc.nasa.gov/news/activate-data-webinar-materials

Visible Image



Visible Image



Final Flight metrics

ACTIVATE

	Research Flights			Flight Hours		Joint Ensembles		Underflights			
	Falcon	King Air	Joint	Falcon	King Air	Cloudy	Clear	ASTER	CALIPSO	Process Study Flights	Dropsondes
Winter 2020	22	17	17	73	59	43	28	1		2	59
Summer 2020	18	18	18	60	67	58	36	1	3	2	108
* Winter 2021	17	19	15	56	66	47	25	1	3		102
Summer 2021	32	32	32	106	108	103	74	1	1	2	150
Winter 2021-2022	55	54	53	182	193	198	72		1	2	215
Summer 2022	30	28	27	97	98	86	46	2	3	4	155
Sum	***174***	***168***	***162***	***574***	***592***	***535***	***281***	***6***	***11***	***12***	***789***
Baseline Mission End Goal						250	15				

**Winter 2021 had reduced Falcon payload (44 cloud ensembles and 25 clear ensembles); no PILS/AMS/CVI/trace gases*

Accomplishments

- Data
  - All flight data have been archived for public use
  - All flight reports available
- Analysis/Science
  - 55 peer-reviewed publications
    - 31 – objective 1
    - 24 – objective 2
    - 9 – objective 3
- Upcoming conference season
  - AGU: 14 presentations and leading one session
  - AMS: 6 presentations and leading one session
- Selected Products
  - Schlosser code for aerosol microphysical properties
  - Stamnes et al. (above-cloud flag)
  - Corral/McCauley leg index files
  - Dmitrovic NetCDF versions of merge files

- Outreach
  - In-person outreach events
    - Media day at LaRC
    - 2 events in Bermuda
    - Middle school in Tucson, Arizona
  - Virtual
    - >10 events (led by Brenna Biggs) including seven graduate students targeting over 400 students across nine schools and three countries
    - 3 open data workshop webinars in 2022 led by Joseph Schlosser – total of over 150 participants
    - 2022 STM Day 1 was a recorded open data workshop

NASA Group Achievement Award (2023)

Data Details

Everything you need to know about the instruments, how to access and cite date, and usage details can be found at these resources

Slides and recordings by the science team about instruments, downloading/using/visualizing data, and other relevant details:

https://asdc.larc.nasa.gov/news/activate-data-webinar-materials

Spatially coordinated airborne data and complementary products for aerosol, gas, cloud, and meteorological studies: the NASA ACTIVATE dataset

Armin Sorooshian[1,2,3], Mikhail D. Alexandrov[4,5], Adam D. Bell[6], Ryan Bennett[7], Grace Betito[2], Sharon P. Burton[8], Megan E. Buzanowicz[6,8], Brian Cairns[4], Eduard V. Chemyakin[6,8], Gao Chen[8], Yonghoon Choi[5,8], Brian L. Collister[8], Anthony L. Cook[8], Andrea F. Corral[1], Ewan C. Crosbie[6,8], Bastiaan van Diedenhoven[9], Joshua P. DiGangi[8], Glenn S. Diskin[8], Sanja Dmitrovic[3], Eva-Lou Edwards[1], Marta A. Fenn[6,8], Richard A. Ferrare[8], David van Gilst[7], Johnathan W. Hair[8], David B. Harper[8], Miguel Ricardo A. Hilario[2], Chris A. Hostetler[8], Nathan Jester[8], Michael Jones[6,8], Simon Kirschler[10,11], Mary M. Kleb[8], John M. Kusterer[8], Sean Leavor[6,8], Joseph W. Lee[8], Hongyu Liu[12], Kayla McCauley[2], Richard H. Moore[8], Joseph Nied[8], Anthony Notari[8], John B. Nowak[8], David Painemal[6,8], Kasey E. Phillips[8], Claire E. Robinson[6,8], Amy Jo Scarino[6,8], Joseph S. Schlosser[6,13], Shane T. Seaman[8], Chellappan Seethala[14], Taylor J. Shingler[8], Michael A. Shook[8], Kenneth A. Sinclair[4,5], William L. Smith Jr.[8], Douglas A. Spangenberg[6,8], Snorre A. Stamnes[8], Kenneth L. Thornhill[6,8], Christiane Voigt[10,11], Holger Vömel[15], Andrzej P. Wasilewski[4], Hailong Wang[16], Edward L. Winstead[6,8], Kira Zeider[1], Xubin Zeng[2], Bo Zhang[12], Luke D. Ziemba[8], and Paquita Zuidema[14]

https://doi.org/10.5194/essd-15-3419-2023

Open Access
Earth System Science Data

The "Data Paper" for ACTIVATE serving as a guide for anything and everything hopefully you need to know. If questions/concerns still remain, contact relevant instrument teams or the PI

Snapshots from ESSD Paper

ACTIVATE

Table 3-5: Instrument summary tables

Table 5. Summary of the HU-25 Falcon instrumentation and measurements. n/a – not applicable.

Instrument	Measured parameter	Uncertainty	Size range (µm)	Time resolution (s)	Reference/ Notes
Aerosol particles					
BMI counterflow virtual impactor vs. isokinetic inlet	Inlet flag	n/a	n/a	1	
TSI-3776 condensation particle counter (CPC)	Particle concentration	10 %	0.003–5	1	Moore et al. (2017)
TSI-3772 CPC	Particle concentration	10 %	0.01–5	1	Moore et al. (2017)
TSI-3772 with thermal denuder (350 °C)	Nonvolatile (350 °C) particle concentration	10 %	0.01–5	1	Moore et al. (2017)
TSI scanning mobility particle sizer (SMPS); Model 3085 differential mobility analyzer (DMA), Model 3776 CPC, and Model 3088 neutralizer	Total and nonvolatile dry aerosol size distributions	20 %	0.003–0.1	45	Moore et al. (2017)
TSI-3340 laser aerosol spectrometer (LAS)		20 %	0.1–5	1	Froyd et al. (2019)
TSI-3563 nephelometer	Dry scattering coefficient	20 %	< 1 (2021–2022), < 5 (2020)	1	Ziemba et al. (2013)

Table 2: Description of each of 179 flights

Table 2. Summary of the ACTIVATE research flights, including pertinent details associated with the date and time, and special notes. Research flights 48–61 included a reduced operational HU-25 Falcon payload due to an aircraft maintenance limitation. Deployments are separated by blank rows: deployment 1 (RF1–RF22), deployment 2 (RF23–RF40), deployment 3 (RF41–RF61), deployment 4 (RF62–RF93), deployment 5 (RF94–RF148), and deployment 6 (RF149–RF179). n/a – not applicable.

				King Air			HU-25 Falcon		
RF	Date (mm/dd/yyyy)	Joint/Single	Flight type	Takeoff (UTC)	Landing (UTC)	No. sondes	Takeoff (UTC)	Landing (UTC)	Special notes
1	2/14/2020	Joint	Statistical survey	17:04:42	20:35:34	4	17:01:23	20:04:20	Landed at Newport News and was stationed there until the end of the Winter 2020 deployment

Table 7: Where to access anything generated by ACTIVATE team

Table 7. Summary of where to access the different datasets and resources described in this paper. n/a – not applicable.

Dataset/Resource	Paper section	Website (last access: 1 May 2023)	DOI
All aircraft instrument data	Sects. 3–4	https://asdc.larc.nasa.gov/project/ACTIVATE	https://doi.org/10.5067/SUBORBITAL/ACTIVATE/DATA001 (NASA Langley ASDC User Services, 2023)
HU-25 Falcon merge files	Sect. 4.8	https://asdc.larc.nasa.gov/project/ACTIVATE/ACTIVATE_Merge_Data_1	https://doi.org/10.5067/ASDC/SUBORBITAL/ACTIVATE_Merge_Data_1 (NASA/LARC/SD/ASDC, 2021a)
Flight reports	Sect. 5.1	https://asdc.larc.nasa.gov/project/ACTIVATE/pdocuments	n/a
HU-25 Falcon leg index	Sect. 5.2	https://asdc.larc.nasa.gov/project/ACTIVATE/ACTIVATE_MetNav_AircraftInSitu_Falcon_Data_1	https://doi.org/10.5067/ASDC/ACTIVATE_MetNav_AircraftInSitu_Falcon_Data_1 (NASA/LARC/SD/ASDC, 2021b)
Aircraft collocation product	Sect. 5.3	Data: https://asdc.larc.nasa.gov/project/ACTIVATE/ACTIVATE_Miscellaneous_Data_1	https://doi.org/10.5067/ASDC/SUBORBITAL/ACTIVATE_Miscellaneous_Data_1 (NASA/LARC/SD/ASDC, 2021c)

Examples of Flexpart Output

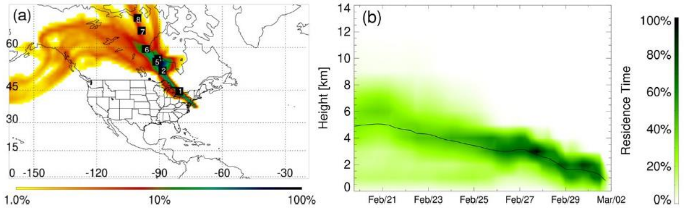


Figure 8. (a) Horizontal and (b) vertical views of the simulated air mass residence time (RT) for flight measurements at 19:22 UTC on 1 March 2020 (RF14). The labels with the white numbers on the map in panel (a) indicate the locations of the maximal RT for the cor-

Snapshots from ASDC Site

ACTIVATE

First Open Data Workshop Recording

October 2021

The ACTIVATE team hosted an open data workshop with over 70 participants over a two-day period from October 20-21, 2021. The purpose of this workshop was to introduce the ACTIVA and applications communities. The first day of the workshop covered how to access and utilize ACTIVATE data, a case study on ACTIVATE Research Flight 12 – a statistical survey flight, ar second case study on Research Flights 13 and 14 – both of which were process study flights – and ended with a continuation on the discussion from the previous day.

Materials

- Meeting Agenda
- Day 1 Video
- Day 2 Video
- ACTIVATE Research Flight 29 Video

Presentations by Instrument/Model teams about their data products

Presenter	Title	Download Recording with Audio
Sorooshian	Introduction to ACTIVATE	Click Here
Ziemba	Langley Aerosol Research Group Experiment (LARGE) Instrumentation	Click Here
Moore	Langley Aerosol Research Group Experiment (LARGE) Cloud Instrumentation	Click Here
Kirchner	German Aerospace Center (DLR) Cloud Measurements	Click Here
Crosbie	Cloud Water	Click Here
Diskin	Diode Laser Hygrometer (DLH) and Trace Gas	Click Here

Last year's STM Slides and Recording

November 2022

The Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment (ACTIVATE) team hosted an open data workshop on November 7, 2 over the progress of the ACTIVATE campaign to date, as well as diving into some of the measurement techniques and data archival processes. The wor associated with instrument and modeling datasets. The webinar aimed to motivate the ongoing studies of aerosol-cloud interactions and the importa

Materials

- Open Data Workshop Agenda

Presenter	Title	View Slides (PDF)
Sorooshian	Welcome/Introductions/Logistics/Goals	Click Here
Smith	Remarks by Deborah Smith	Click Here
Sorooshian	Overall Team Progress to Date	Click Here
Shook	LaRC/ASDC Data Team	Click Here
ASDC	LaRC/ASDC Data Team	Click Here

Open Data Workshop Recordings to Schools and Teachers

September 2022

The Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment (ACTIVATE) team led visualize airborne data. This webinar went over the science motivation of ACTIVATE, as well as included measurements as well as use the Google Colaboratory (Google Colab) environment to examine atmosph

Materials

- Webinar Recording Webpage

July 2022

The Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment (ACTIVATE) team hos analysis ideas and collaborative projects in the area of aerosol-cloud-meteorology interactions. This par atmospheric properties derived from both in situ and remote sensing products.

Materials

- Tools for Analyzing Datasets from ACTIVATE (TADA)
- Create a Gmail Account
- Setup EarthData Login
- ACTIVATE Research Flight 29 Video
- 11 July 2021: Webinar activities (Slides 19-39) Presented to Philippines high schools and universities

Guide for beginners to download and visualize data with Python