Falcon flight leg-mean statistics of aerosol and cloud variables for ACTIVATE campaign

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Overview

This dataset provides derived statistics and analysis for Falcon flights during ACTIVATE campaign, based on flight legs. The main features include:

1. Meteorological, cloud and aerosol measurements (not including trace gases) from all Falcon aircraft for ACTIVATE campaign 2020-2022.
2. **Upper and lower bounds** of time, latitude, longitude and altitude for each flight leg;
3. **Mean, median** and [5, 10, 25, 75, 90, 95] **percentiles** of each variable for each flight leg;
4. Merge aerosol **number size distribution** from LAS and SMPS; use cloud droplet number size distribution from FCDP;
5. **Measured CCN** number concentration binned for specific supersaturations: [0.1, 0.2, 0.3, 0.5, 0.6, 0.37] %;
6. **Calculated CCN** number concentration from aerosol size distribution and hygroscopicity estimated from AMS measurements;
7. **Turbulence variables** (<u'u'>, <v'v'>, <w'w'>, <w'u'>, <w'v'>, <w'T'>, <w'q'>, tke) for each flat-flying flight leg;
8. Cloud microphysical properties (Nd, LWC, Reff) are sampled only with **cloud flag = 1** (LWC>0.02g/m3);
9. Saved in **NetCDF** format.

Variables and input data:

This dataset includes the following variables:

Basic flight location: time, lat, lon, alt;

Meteorological variables: temperature, moisture, pressure, u wind, vwind, wwind;

Aerosol variables: aerosol number concentration, CCN number concentration, aerosol composition, aerosol size distribution

Cloud variables: cloud LWC, droplet number concentration Nd, droplet effective radius, droplet size distribution.

Some flight leg statistics and analysis variables are derived:

Leg statistics:

upper and lower bounds of time, lat, lon, alt for each flight leg;

mean and [5, 10, 25, 75, 90, 95] **percentiles** for each variable;

standard deviation for some variables.

Derived variables:

Turbulence variables (<u'u'>, <v'v'>, <w'w'>, <w'u'>, <w'v'>, <w'T'>, <w'q'>, tke) for each flat-flying flight leg;

Measured CCN number concentration binned for specific supersaturations: [0.1, 0.2, 0.3, 0.5, 0.6, 0.37] %;

Calculated CCN number concentration from aerosol size distribution and hygroscopicity estimated from AMS or PILS measurements;

All the above variables were obtained or derived from the following datasets:

ACTIVATE-SUMMARY, ACTIVATE-DLH-H2O, ACTIVATE-WINDS, ACTIVATE-LARGE-CCN, ACTIVATE-LARGE-AMS, ACTIVATE-LARGE-PILS, ACTIVATE-LARGE-MICROPHYSICAL, ACTIVATE-FCDP_HU25, ACTIVATE-LARGE-LAS, ACTIVATE-LARGE-SMPS, ACTIVATE-LARGE-InletFlag, ACTIVATE-LegFlags.

See the global attributes for each file for the exact version of the input datasets.

Merged aerosol number size distribution:

Aerosol number size distribution is merged from LAS (100 – 3162 nm) and SMPS (3 – 100 nm), using the leg-mean values. The connection between LAS and SMPS at 100 nm is checked and marked in "CN_continue_flag" for the transition smoothness:

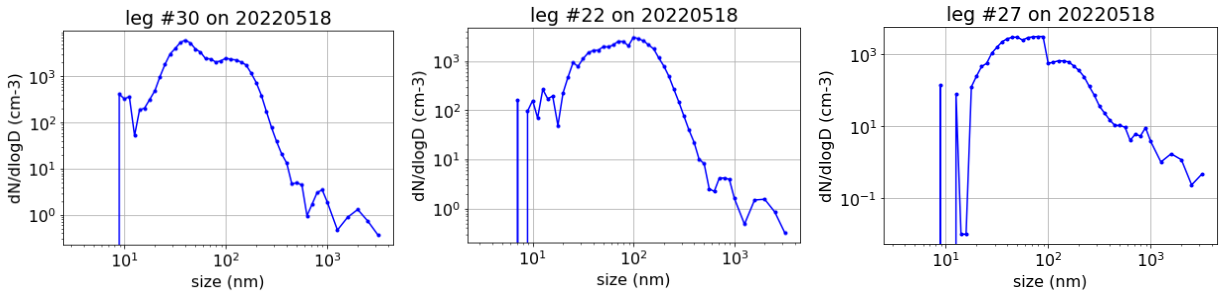
CN_continue_flag = 0: smooth transition

CN_continue_flag = 1: can see clear differences or variations

CN_continue_flag = 2: very large differences or variations

CN_continue_flag = 9: missing data

Examples:



CN_continue_flag = 0 CN_continue_flag = 1 CN_continue_flag = 2

CCN closure analysis variables:

Many flights during ACTIVATE used a scanning supersaturation (SS) mode to measure CCN. In this dataset we bin the **measured CCN** number concentration into specific SS for easier comparison with model output. The target SS are [0.1, 0.2, 0.3, 0.5, 0.6, 0.37] %, with ±0.05% SS range for most SS except SS=0.37, which uses ±0.01% range.

For CCN closure analysis, we also **Calculated CCN** number concentration from aerosol size distribution and hygroscopicity estimation.

Aerosol size distribution: see "merged aerosol number size distribution" above.

Hygroscopicity: we simply use volume fraction of each aerosol species measured by AMS (or PILS), and apply hygroscopicity in E3SM to estimate the bulk hygroscopicity. The E3SM hygroscopicity and density for each species are listed below:

Table S3. Hygroscopicity and density (kg m^{-3}) of aerosol components.

	Sea salt	Sulfate	Ammonium	SOA	POM	BC	Dust
Hygroscopicity	1.16	0.507	0.507	0.14	0.10	10^{-10}	0.068
Density	1900	1770	1770	1000	1000	1700	2600

AMS measures SO4, ORG, NO3, NH4, CHL, but no seasalt measurements. PILS measures sulfate, nitrite, nitrate, sodium, chloride, etc., but no organics and the time frequency is about 20min. With all these limitations, we calculated hygroscopicity from AMS only (ignoring seasalt), PILS only, and AMS + seasalt (sodium + chloride) from PILS. All organics measured in AMS are assumed as SOA. There are data flags indicating hygroscopicity calculation status. CCN number concentration is then calculated using the estimated hygroscopicity and merged aerosol number size distribution.

We also calculate hygroscopicity from measured CCN number concentration and aerosol number size distribution, so that we can also do hygroscopicity closure analysis. But note that hygroscopicity closure analysis has larger uncertainty than CCN closure analysis.

Turbulence variables:

Turbulence variables, or the variance/covariance of winds and thermodynamic variables are calculated only for flat-flying legs (leg type in ['02','03','04','05','06','10','11']). Turbulence kinetic energy (TKE) is also calculated using:

$$TKE = 0.5*(\langle u'u' \rangle + \langle v'v' \rangle + \langle w'w' \rangle)$$

Cloud variables:

Although there are several instruments measuring cloud microphysical quantities, we only use FCDP in this dataset as it is considered as the most accurate instrument.

We did not include cloud ice measurements in this dataset. Using of this dataset is limited to liquid phase cloud.

The statistics for cloud microphysical properties (Nd, LWC, Reff) are sampled only with **cloud flag = 1** (LWC>0.02g/m3), so can be considered as in-cloud value.

Version history:

R0: initial release

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