ARCSIX SPEC Data ReadMe

INSTRUMENTS KEY – P3B

- FCDP (ARCSIX-FCDP_P3B_...ICT) – Scattering probe with a size range of 1.5-50 microns.
- Hawkeye – Combination instrument consisting of 4 parts, 3 of which are archived
    - FCDP – not utilized as of now
    - 2D-S 10-micron (ARCSIX-Hawk2DS10_P3B_...ICT) – 10-micron resolution optical array, capable of viewing particles between 10 and 1280 microns and measuring the size of particles out to about 3 mm with one gray level (black and white).
    - 2D-S 10-micron V channel (ARCSIX-Hawk2DS10_P3B_...ICT) – 10-micron resolution optical array probe, capable viewing particles between 10 and 1280 microns and measuring the size of particles out to about 3 mm with one gray level (black and white).
    - 2D-S 50-micron H channel (ARCSIX-Hawk2DS50_P3B_...ICT) – 50-micron resolution optical array probe, capable of viewing particles between 50 and 6400 microns and recording the size of particles out to about 1 cm with one gray level (black and white).
    - Cloud Particle Imager (CPI) (Images: ARCSIX-HawkCPI-images_P3B_...zip) with 2.3-micron pixel size at 877x2600 pixel grid with 256 gray levels.
- F2D-S – Combination probe consisting of two identical channels (on vertical and horizontal axes)
    - F2D-S 10-micron V channel (ARCSIX-F2DS10V_P3B_...ICT) – 10-micron resolution optical array probe, capable viewing particles between 10 and 1280 microns and measuring the size of particles out to about 3 mm with one gray level (black and white).
    - F2D-S 10-micron H channel (ARCSIX-F2DS10H_P3B_...ICT) – 10-micron resolution optical array probe, capable viewing particles between 10 and 1280 microns and measuring the size of particles out to about 3 mm with one gray level (black and white).
- PPS – Combination instrument consisting of two parts
    - 2D-Gray 5-micron (ARCSIX-PPS2DGRAY50_P3B_...ICT) (Not available yet) – 5-micron resolution optical array probe, capable of viewing particles between 5 and 640 microns with three gray levels (black and white). A gray level of 50% (equivalent to black and white probes) is used for ICT files, all levels available in images.
    - Cloud Particle Imager (CPI) with 0.73-micron pixel size at an 877x2600 resolution and 256 gray levels, images available upon request
- 2D-Gray (standalone instrument) (ARCSIX-2DGRAY50_P3B...ICT, Images: ARCSIX-2DGRAY50-Images_P3B_...zip) – 10-micron resolution optical array probe, capable of viewing particles between 10 and 1280 microns and recording particles out to about 3 mm with three gray levels (black and white). A gray level of 50% (equivalent to black and white probes) is used for ICT files, all levels available in images.
- HVPS-4 – Combination probe featuring 4 different channels of data.
    - HVPS-4 50-micron V channel (ARCSIX-HVPS4V50_P3B…ICT, Images: ARCSIX-HVPS4-V50-Images_...zip) - 50-micron resolution optical array probe, capable of viewing particles between 50 and 6400 microns and recording the size of particles out to about 1 cm with one gray level (black and white).
    - HVPS-4 50-micron H channel (ARCSIX-HVPS4H50_P3B…ICT, Images: ARCSIX-HVPS4-H50-Images_...zip) - 50-micron resolution optical array probe,

capable of viewing particles between 50 and 6400 microns and recording the size of particles out to about 1 cm with one gray level (black and white).
    - HVPS-4 150-micron V channel (ARCSIX-HVPS4V150_P3B…ICT, Images: ARCSIX-HVPS4-V150-Images_...zip) - 150-micron resolution optical array probe, capable of viewing particles between 150 and 19200 microns and recording the size of particles out to about 3 cm with one gray level (black and white).
    - HVPS-4 150-micron H channel (ARCSIX-HVPS4H150_P3B…ICT, Images: ARCSIX-HVPS4-H150-Images_...zip) - 150-micron resolution optical array probe, capable of viewing particles between 150 and 19200 microns and recording the size of particles out to about 3 cm with one gray level (black and white).
    - NOTE 1: Particles passing within the 50-µm overlap region (6.4 mm x 6.4 mm) are imaged by both 50-µm channels and both 150-µm channels. Particles passing within the 150-µm overlap region (19.2 mm x 19.2) are imaged by both 150-µm channels. All four channels run continuously and image particles, regardless of their position in the fields of view.
    - NOTE 2. If a channel is not operating properly or is experiencing excessive noise it is not archived.
- SEA WCM-2000 (ARCSIX-Lwc123_P3B…R0) – Combination hotwire probe containing three water content values based on three sensors. LWC1 is a cylinder with 0.5 mm diameter, LWC2 is a cylinder with 2 mm diameter. LWTA is a 4-mm scoop-shaped sensor designed to measure total water content.
- **Page0 – A spreadsheet containing** an overview of all of the instruments.
    - Example rows of page0 can be found at the end of this document under "Page0 Example"

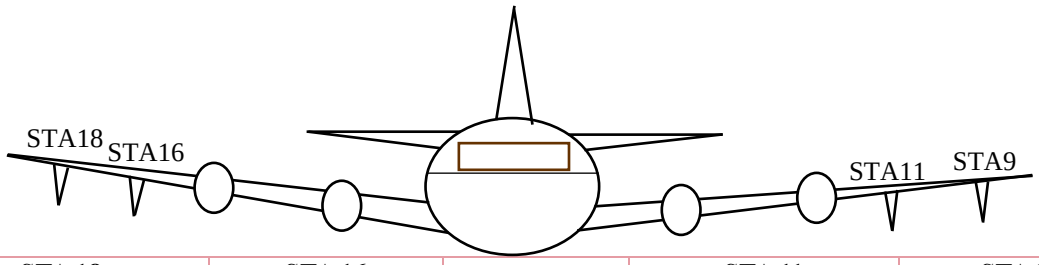
INSTRUMENTS KEY – LEARJET

- FCDP (ARCSIX-FCDP_Learjet_....ICT) – Scattering probe with a size range of 1.5-50 microns.
- 2D-S – Combination probe consisting of two identical channels (on vertical and horizontal axes)
    - 2D-S 10-micron V channel (ARCSIX-2DS10V_Learjet_...ICT) – 10-micron resolution optical array probe, capable of recording particles between 10 and 1280 microns and measuring the size of particles out to about 3 mm with one gray level (black and white).
    - 2D-S 10-micron H channel (ARCSIX-2DS10H_Learjet_...ICT) – 10-micron resolution optical array probe, capable of recording particles between 10 and 1280 microns and measuring the size of particles out to about 3 mm with one gray level (black and white).
- PPS – Combination instrument consisting of two parts
    - 2D-Gray 5-micron (ARCSIX-PPS2DGRAY50_Learjet_...ICT)(Not available yet) – 5-micron resolution optical array probe, capable of recording particles between 5 and 640 microns with three gray levels (black and white). A gray level of 50% (equivalent to black and white probes) is used for ICT files, all levels available in images.
    - Cloud Particle Imager (CPI) with 0.73-micron pixel size at a 877x2600 resolution, images available upon request
- 2D-Gray (standalone instrument) (ARCSIX-2DGRAY50_Learjet...ICT, Images: ARCSIX-2DGRAY50-Images_Learjet_...zip) – 10-micron resolution optical array probe, capable of recording particles between 10 and 1280 microns and measuring the size of particles out to about 3 mm with three gray levels (black and white). A gray level of 50% (equivalent to black and white probes) is used for ICT files, all levels available in images.

- HVPS-4 – Combination probe featuring 4 different channels of data.
    - HVPS-4 50-micron V channel (ARCSIX-HVPS4V50_Learjet…ICT, Images: ARCSIX-HVPS4-V50-Images_Learjet_...zip) - 50-micron resolution optical array probe, capable of recording particles between 50 and 6400 microns and recording the size of particles out to about 1 cm with one gray level (black and white).
    - HVPS-4 50-micron H channel (ARCSIX-HVPS4H50_Learjet…ICT, Images: ARCSIX-HVPS4-H50-Images_Learjet_...zip) - 50-micron resolution optical array probe, capable of recording particles between 50 and 6400 microns and recording the size of particles out to about 1 cm with one gray level (black and white).
    - HVPS-4 150-micron V channel (ARCSIX-HVPS4V150_Learjet…ICT, Images: ARCSIX-HVPS4-V150-Images_Learjet_...zip) - 150-micron resolution optical array probe, capable of recording particles between 150 and 19200 microns and recording the size of particles out to about 3 cm with one gray level (black and white).
    - HVPS-4 150-micron H channel (ARCSIX-HVPS4H150_Learjet…ICT, Images: ARCSIX-HVPS4-H150-Images_Learjet_...zip) - 150-micron resolution optical array probe, capable of recording particles between 150 and 19200 microns and recording the size of particles out to about 3 cm with one gray level (black and white).
- Sky Tech Research Nevzorov (ARCSIX-NevLwc123_Learjet…ICT) – Combination hotsensor probe containing three water content values based on three sensors: LWCA1 is a 2-mm diameter sensor. LWCA2 is a 3-mm diameter sensor. LWTA is a 8-mm cone designed to measure TWC.
- **Page0 – A spreadsheet containing** an overview of all of the instruments. This is an Excel spreadsheet that is available upon request from SPEC for each P-3 and Learjet mission. It is not uploaded because NASA archives do not support CSV spreadsheets.
    - Example rows of page0 can be found at the end of this document under “Page0 Example”

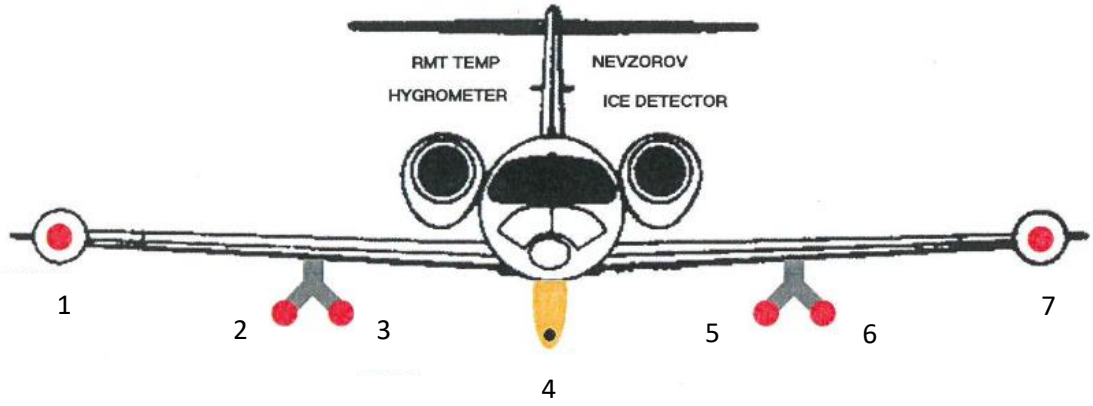
INSTRUMENT LOCATIONS P3B

P-3



STA 18	STA 16		STA 11	STA 9
Probe	**Probe**		**Probe**	**Probe**
PCASP	Hawkeye 3V-CPI		F2D-S/FCDP	PPS 3V-CPI
HVPS-4			2D-Gray	

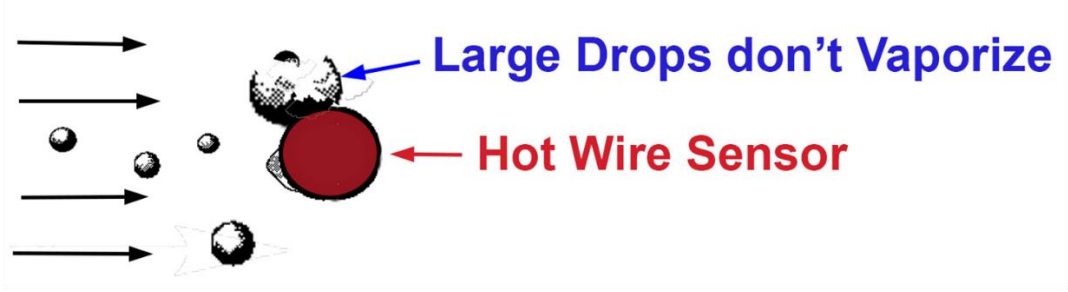
INSTRUMENT LOCATIONS LEARJET

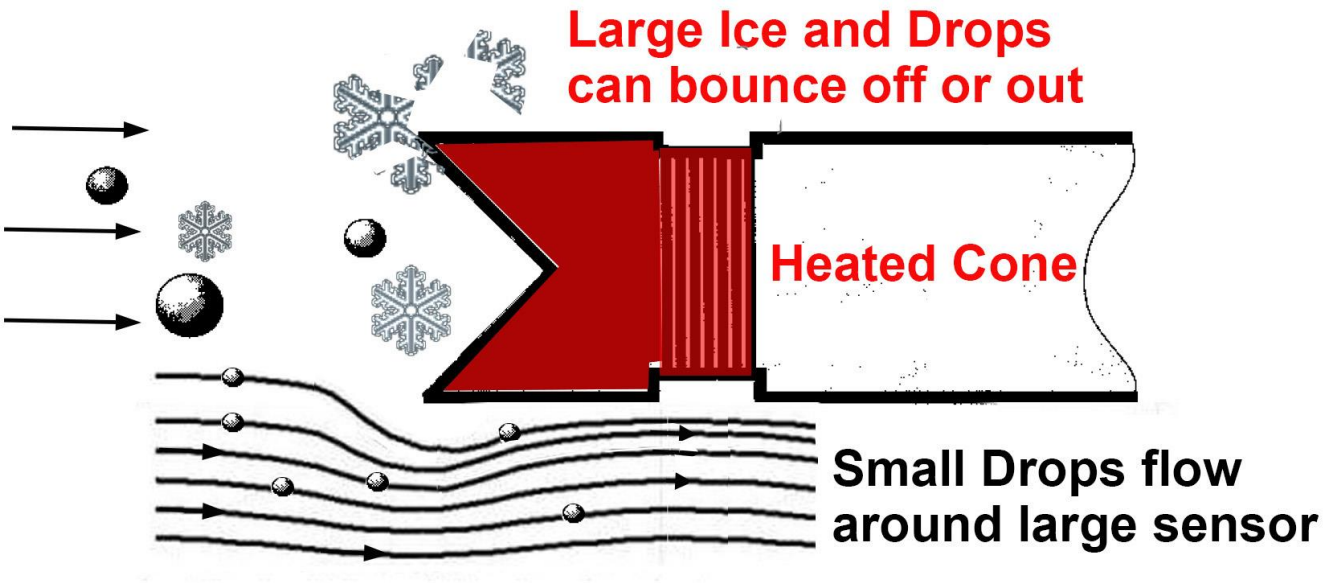


1	2	3	4	5	6	7
Probe	**Probe**	**Probe**	Probe	**Probe**	**Probe**	**Probe**
AIMMS FCDP	2D-S	2D-Gray	PPS	HVPS-4	KPR	FFSSP

ERRORS INHERENT IN VARIOUS INSTRUMENT DESIGNS

ERRORS USING HOTWIRE DEVICES (NEVZOROV, WCM)





ERRORS USING THE FCDP

- The FCDP has a small depth of field
- Since we size individual particles and compute mass using diameter, any sizing error is cubed in LWC calculation
- Only useful for particles <50um

ERRORS USING OAP PROBES

- The depth of field increases as a function of the square of particle size. Thus, the depth of field (and sample volume) increases until it reaches the distance between the probe arms. The concentration of particles up to about 110 µm in maximum dimension are adjusted based on their depth of field
- In general, the first two size bins are less reliable than other bins
- Images of out of focus particles that appear as “donuts”, are resized using the diffraction-based correction found in Korolev (1997)

INSTRUMENT USAGE CONSIDERATIONS

GETTING STARTED WITH THE DATA

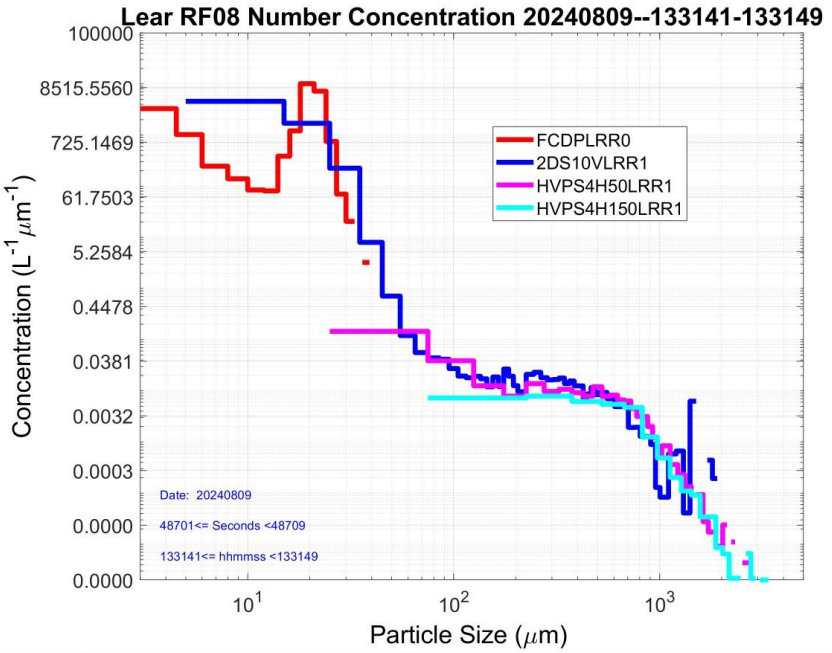
- Page0 gives a good overview of all of our instruments plus important context such as temperature, dew point, altitude, latitude and longitude.
- Looking at our two data sets of images, HVPS-4 and 2D-GRAY will give an idea of the characteristics of the particles. Checking the ice content vs water content and the size of each type will be important.
    - If you need images from other instruments, please reach out to us and we can supply them.

- Due to occasional instrument problems, data collected by a specific probe may not be included for and entire mission, or in rare cases the data may be omitted from the archives for and entire mission. We have significant probe redundancies to avoid a lack of data in specific size ranges, but this may not always be possible. If you have questions about data not on the archive, please reach out to us and we can see if we can recover specific time periods or walk you through what errors we encountered before the data is used.
- Using multiple instruments will be essential throughout most of the mission due to size limitations of each instrument.

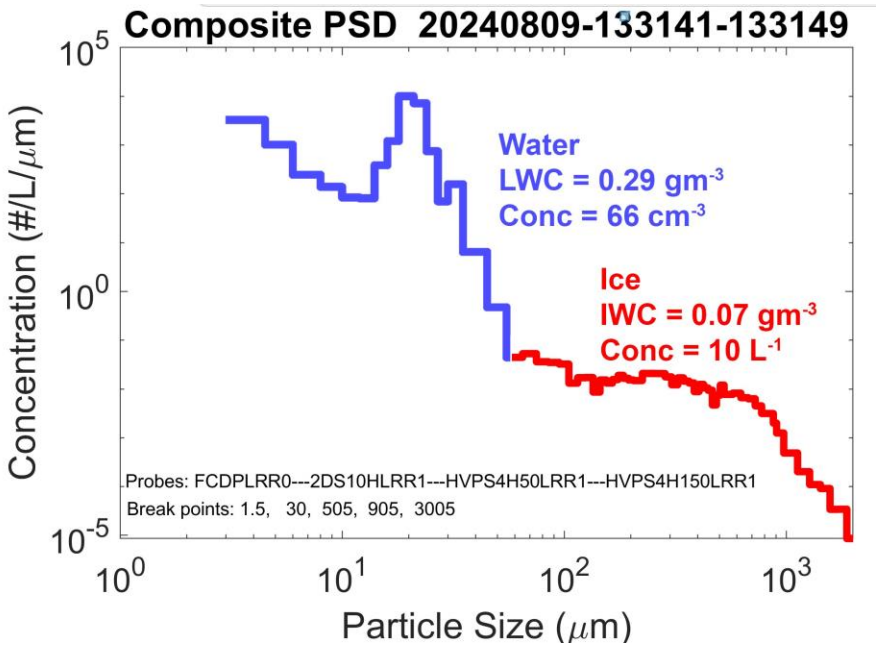
CALCULATING IWC

- FCDP: IWC is to be used only in entirely small ice (<50um) clouds
- WCM and Nevzorov: can be useful in entirely ice clouds
    - Note: small ice can follow airflow around the probe and be systematically excluded, large ice particles may bounce off of the instruments.
- OAPs: can be used for all ice or mixed phase clouds
    - For mixed phase, determine what percentage of each size bin are ice using OAP images, then multiply bins by these percentages before doing the methods below.
    - Estimate IWC from particle size distribution using the D_{max} to Mass power law (Brown and Francis 1995)
    - Estimate IWC from particle size distribution using the Area-to-Mass power law (Baker and Lawson 2006), to be used when doing particle by particle comparison (this is the number that we report in the ICTs)
    - Both D_{max} to Mass and Area-to-Mass calculations are best performed on a composite particle size distribution (where different instruments are used across the particle size range).
    - See examples below.
    - Note: The procedure to compute bulk properties of LWC, IWC, Concentratons, Extinction Coefficient, etc where the sizes of ice particles and water drops overlap requires visual inspection of images and is manually intensive.
- Mixed phased clouds with water droplets <50um (no drizzle)

- Example PSD:



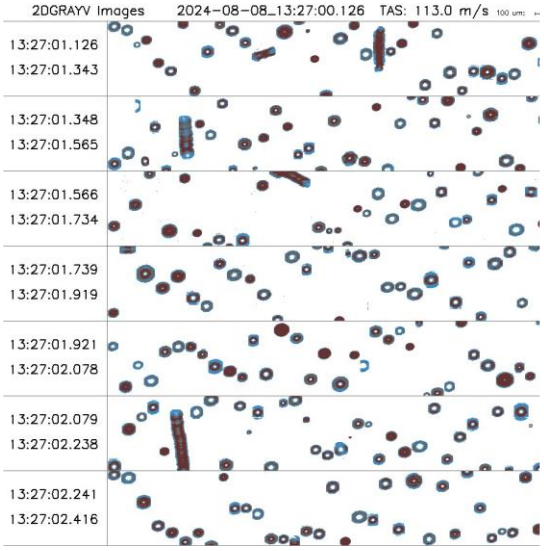
- Using a composite PSD of the FCDP, the 2DS and the HVPS4 (FCDP 1.5-30um, 2DSH10 30-505um, HVPS4H50 505-905um and HVPS4H150 905um+), a breakpoint is made at 50um that distinguishes between ice and water. IWC is calculated for bins greater than 50um and LWC is calculated for bins less than 50um.

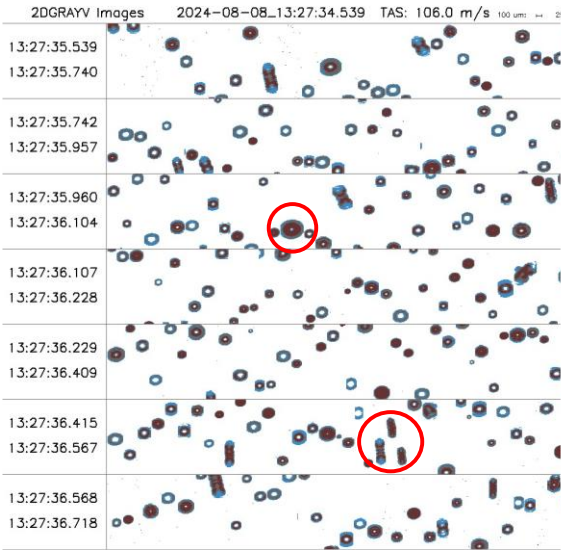


- Mixed phase clouds with drizzle

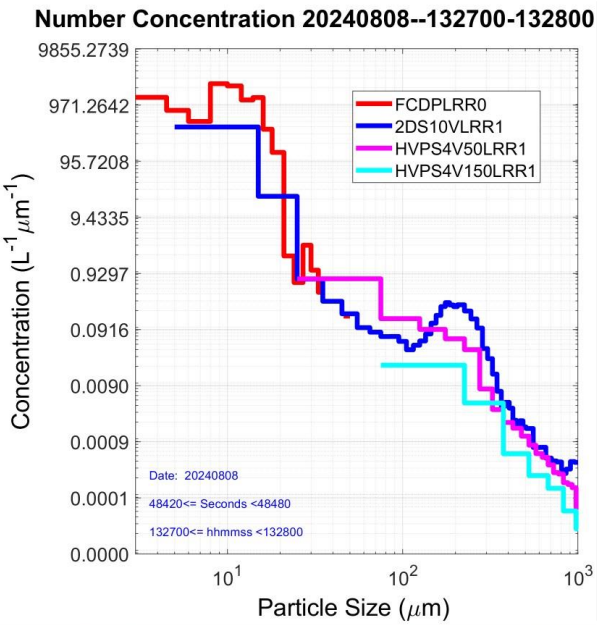
- Example images showing ice crystals in similar size ranges as water droplets (drizzle)

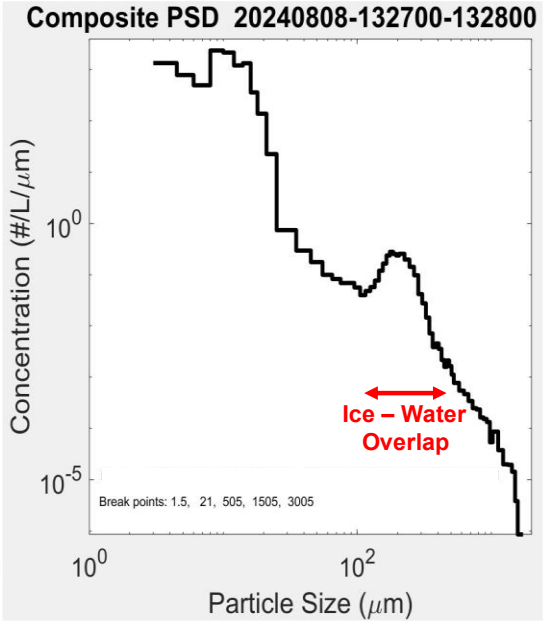
4. LWC and IWC Measurements in Mixed-phase Clouds with Drizzle (Lear RF07)





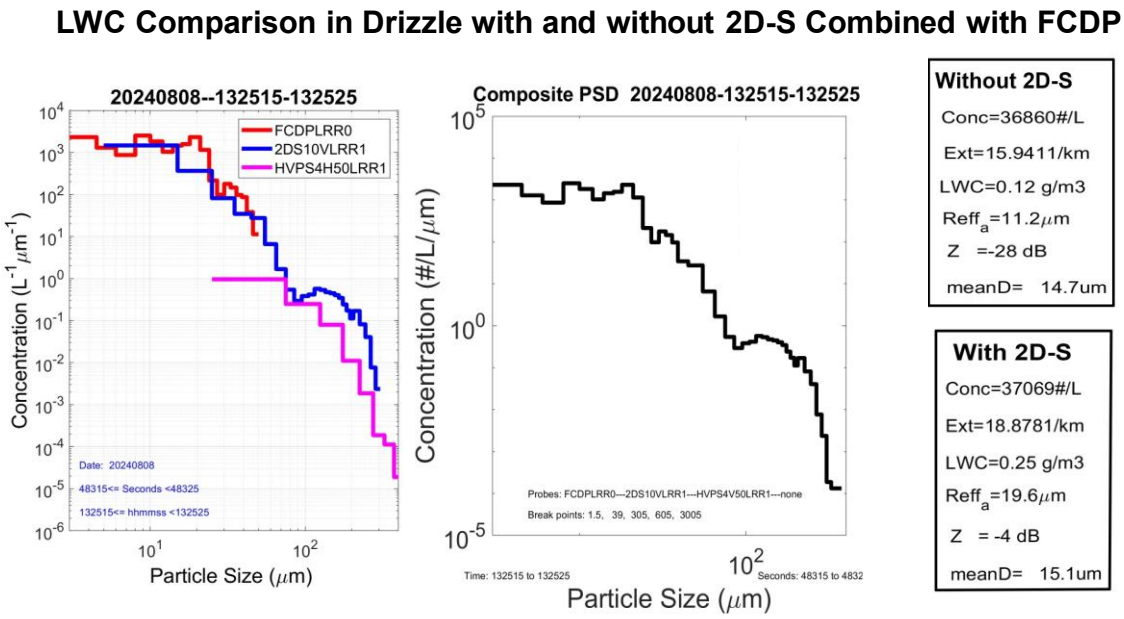
- PSD and composite PSD with the Ice – Water Overlap shown occurring, with the 2DS seeing water where the HVPS4 sees ice.



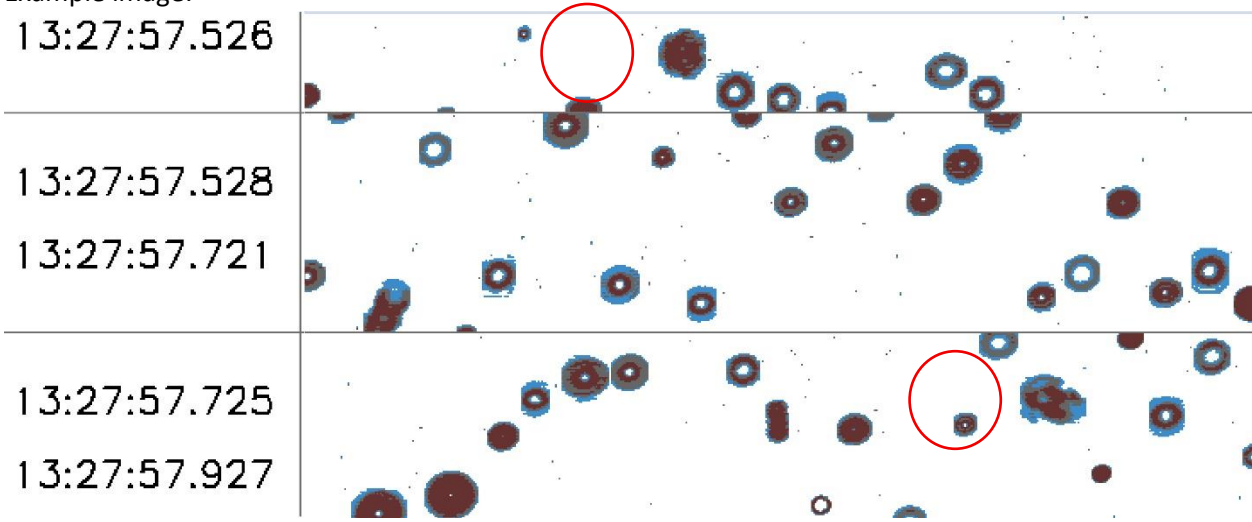


CALCULATING LWC

- FCDP: Size range is limited from 2-50um but can be useful. It will not distinguish between ice and water, so OAP images should be used to determine the cloud is all liquid before the FCDP is used.
- OAPs: useful in determining LWC with some caveats
    - Due to sizing uncertainties in low bins, OAP instruments should be used with the FCDP and other OAP instruments in a particle size distribution.
    - The HVPS4 should be used only when there are drops >1mm.
    - See examples below.



-
-
-
- **Determining Particle Phase using 2D Gray Images**
- Example image:



- The water droplets in this image can be distinguished by all of the levels of gray having a circular shape. Ice particles in the circles show how irregular shapes can be identified with gray levels.

Page0 Example: This product is useful in gaining an overview of several instruments during cloud penetrations. The user sees the time, temperature, LWC, SLW (supercooled liquid water) and particle probe concentrations within one view.

Time	Time	TAS	Palt	Hdg	Temp	Dew	LWC1	LWC2	FCDP	LWTA	Rice	FCDP	2DS	2DS	2D-Gray	PPS	HK10	HK50	H50	V50	H150	V150	CPI	Lat	Long
(HMS)	(s)	(m/s)	(ft)	(dg)	(C)	(C)	(g/m3)	(g/m3)	(g/m3)	(g/m3)	(dHz)	(#/CC)	(#/L)	(#/L)	(#/L)	(#/L)	(#/L)	(#/L)	(#/L)	(#/L)	(#/L)	(#/L)	(#/s)	(deg)	(deg)
135300	49980	116	1788.1	282	-2.25	-5	0	0	0	0	76.9	0	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135301	49981	116	1774.9	282	-2.33	-5	0	0	0	0	77	0.2	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135302	49982	116	1758.5	282	-2.39	-5.1	0	0	0	0	77.1	0.1	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135303	49983	115	1742.1	282	-2.45	-5.1	0	0	0	0	77.1	0.1	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135304	49984	115	1732.3	282	-2.62	-5.1	0	0	0	0	77.1	0	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135305	49985	114	1712.6	282	-2.73	-5.1	0	0	0	0	77.2	0.1	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135306	49986	113	1699.5	282	-2.89	-5.1	0	0	0	0	77.3	0	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135307	49987	113	1683.1	282	-3.4	-5.2	0	0	0	0	76.6	0.5	0	0	0	0	0	0	0	0	0	0	20	73.1	-74
135308	49988	113	1660.1	282	-3.62	-5.2	0	0	0	0	79.1	0.4	252.465	282.147	0	0	0	0	0	0	0	0	187	73.1	-74
135309	49989	113	1643.7	282	-3.78	-5.2	0	0	0	0.005	84.6	1.4	4602.49	5630.13	109.9	19079	8549	0	0.03	0.2	0	0	240	73.1	-74
135310	49990	113	1627.3	283	-3.95	-5.2	0.02	0.02	0	0.024	88	17.5	28641.4	33191.3	16014	1E+05	20968	0	0	0.2	0	0	204	73.1	-74
135311	49991	113	1614.2	283	-4.14	-5.2	0.08	0.08	0.01	0.091	89.8	42.1	53528.4	58551.8	40692	2E+05	79343	0.24	0.31	0	0.02	0	209	73.1	-74
135312	49992	112	1591.2	283	-4.26	-5.2	0.11	0.11	0.02	0.117	91.5	59.8	47785	55556.5	43437	1E+05	72275	0.06	0.12	0.1	0	0	200	73.1	-74
135313	49993	112	1578.1	283	-4.38	-5.2	0.1	0.09	0.02	0.096	91.5	54.8	30088.7	36267.1	22056	1E+05	47517	0	0	0.2	0	0	200	73.1	-74
135314	49994	112	1558.4	283	-4.38	-5.1	0.06	0.05	0.02	0.058	91	49	24828.1	29137.7	26018	74901	26571	0	0	0.6	0	0	211	73.1	-74
135315	49995	112	1538.7	283	-4.43	-5.1	0.06	0.05	0.02	0.056	90.9	63	8430.33	10201.5	9850.1	22923	16681	0.03	0	0	0	0	20	73.1	-74
135316	49996	112	1528.9	283	-4.46	-5.1	0.02	0.02	0.01	0.021	90.9	46.3	1371.87	1424.39	1665.2	15356	2930	0	0	0	0	0	7	73.1	-74
135317	49997	112	1509.2	283	-4.38	-5.1	0.01	0.01	0.01	0.008	90.5	34.4	642.2	739.116	44.424	11376	128.7	0	0	0	0	0	7	73.1	-74
135318	49998	112	1486.2	283	-4.36	-5	0.01	0.01	0	0.007	90.2	13.4	454.329	881.38	20.592	2514	1373	0.25	0	0	0.01	0.02	0	73.1	-74
135319	49999	112	1469.8	283	-4.32	-5	0	0	0.01	0.005	89.8	46.4	13.66	34.189	20.592	110.3	86.93	0	0.03	0	0	0	0	73.1	-74
135320	50000	112	1456.7	283	-4.27	-5	0	0	0	0	89.5	4.6	13.66	0.165	4.69	0	0	0	0.07	0	0	0	0	73.1	-74
135321	50001	112	1437	283	-4.25	-5	0	0	0	0.001	89.2	2	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135322	50002	112	1420.6	283	-4.23	-5	0	0	0	0.001	88.8	1.4	0	0	0	0	0	0.03	0	0	0	0	0	73.1	-74
135323	50003	112	1407.5	283	-4.12	-5	0	0	0	0	88.5	1.2	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135324	50004	112	1384.5	283	-4.15	-5.1	0	0	0	0	88.2	0.9	0	0.451	0	0	0	0	0	0	0	0	0	73.1	-74
135325	50005	112	1368.1	283	-4.12	-5.1	0	0	0	0	87.8	0.9	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135326	50006	112	1348.4	283	-4.08	-5.1	0	0	0	0	87.5	0.7	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135327	50007	112	1332	283	-4.03	-5.1	0	0	0	0	87.1	0.4	0	0	0	0	0	0	0	0	0	0	0	73.1	-74
135328	50008	112	1318.9	284	-3.95	-5.1	0	0	0	0	86.9	0	0	0	0	0	0	0	0	0	0	0	0	73.1	-74

SLW

CLEAR AIR

IN CLOUD

CLEAR AIR