Comparative LWC and MVD Measurements at NASA IRT, NRC AIWT, and CIRA IWT
Draft Test Matrix

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Test Matrix (LWC SWEEP low TAS)

IRT LWC sweep, 77 m/s (green shaded done in 2014)

Test point	VTAS (nm/h)	VTAS (m/s)	LWC (g/m3)	MVD (µm)	Comments
IRT-1	150.0	77.2	0.5	20	new point
IRT-2	150.0	77.2	1.04	22	Feb 2014 cal point
IRT-3	150.0	77.2	1.53	20	Feb 2014 cal point
IRT-4	150.0	77.2	2.13	21	Feb 2014 cal point
IRT-5	150.0	77.2	2.52	20	Feb 2014 cal point
IRT-6	150.0	77.2	3.03	25	Feb 2014 cal point

CIRA LWC sweep, 80 m/s (green shaded done in 2010)

Test point	VTAS (nm/h)	VTAS (m/s)	LWC (g/m3)	MVD (µm)	Comments
CIRA-1	155.5	80	0.35	20	(Pair/Pwat = 1.9, 1.0), calrun 157
CIRA-2	155.5	80	0.89	23	(Pair/Pwat = 0.85, 0.20), calrun 35
CIRA-3	155.5	80	1.36	20	(Pair/Pwat = 1.9, 1.0), calrun 90
CIRA-4	155.5	80	2.00	20	new point
CIRA-5	155.5	80	2.50	20	new point
CIRA-6	155.5	80	3.00	20	new point

Test Matrix (LWC SWEEP higher TAS)

IRT LWC sweep, 129 m/s

Test point	VTAS (nm/h)	VTAS (m/s)	LWC (g/m3)	MVD (µm)	Comments
IRT-10	250.0	128.6	0.62	19	Feb 2014 cal point
IRT-11	250.0	128.6	1.2	20	new point
IRT-12	250.0	128.6	1.93	25	Feb 2014 cal point

CIRA LWC sweep, 140 m/s

Test point	VTAS (nm/h)	VTAS (m/s)	LWC (g/m3)	MVD (µm)	Comments
CIRA-10	272.2	140	0.44	25	(Pair/Pwat = 1.0, 0.4), calrun 8
CIRA-11	272.2	140	1.38	20	(Pair/Pwat = 1.9, 1.0), calrun 151
CIRA-12	272.2	140	2.00	20	new point

Test Matrix (MVD SWEEP lower TAS)

IRT MVD Sweep, 77 m/s

Test point	VTAS (nm/h)	VTAS (m/s)	LWC (g/m3)	MVD (µm)	Comments
IRT-20	150.0	77.166	0.55	15	Feb 2014 cal point
IRT-21	150.0	77.166	0.5	28	Feb 2014 cal point
IRT-22	150.0	77.166	0.48	45	Feb 2014 cal point
IRT-23	150.0	77.166	0.51	63	Feb 2014 cal point
IRT-24	150.0	77.166	0.48	90	Feb 2014 cal point
IRT-25	150.0	77.166	0.54	141	Feb 2014 cal point
IRT-26	150.0	77.166	0.58	196	Feb 2014 cal point (MVD outside current calibrated range)

CIRA MVD Sweep, 80 m/s

Test point	VTAS (nm/h)	VTAS (m/s)	LWC (g/m3)	MVD (µm)	Comments
CIRA-20	155.5	80	0.4	15	LWC TBD (Pair/Pwat = 2.2, 1.0), calrun 39
CIRA-21	155.5	80	0.65	25	LWC TBD (Pair/Pwat = 1.0, 0.4), calrun 8
CIRA-22	155.5	80	0.65	40	LWC TBD (Pair/Pwat = 0.7, 0.2), calrun 24
CIRA-23	155.5	80	0.68	60	LWC TBD (Pair/Pwat = 0.5, 0.3), calrun 140
CIRA-24	155.5	80	0.89	90	LWC TBD (Pair/Pwat = 0.2, 0.1), calrun 142
CIRA-25	155.5	80	0.83	145	LWC TBD (Pair/Pwat = 0.3, 0.8), calrun 135
CIRA-26	155.5	80	0.89	160	LWC TBD (Pair/Pwat = 0.3, 0.9), calrun 134

Instrumentation - LWC

PRIMARY:

1. IKP2
2. NRC tunnel IKP
3. SEA multi-element probe
4. Robust Probe
5. Nevzorov LWC/TWC (at Ottawa?)

- Is it useful to do icing blade/cylinder comparisons?
    - Does NRC still have rig for multiple icing cylinder diameters?

SECONDARY:

- PDI LWCs (already part of plan for PSDs)
- SEA Ice Crystal Detector? (additional instrument)
- Other hot wires? (King, single-element SEA probes; additional instruments)

Instrumentation - PSDs

PRIMARY:

- NASA IRT standard PSDs from 1D OAPs and CDP
- Malvern
- 2D-S
- PDI (two channel PDI, canister mounted)
- HSI (canister mounted) – 5 micron resolution?
- PIP?
- CIP?

IRT Instrument Configuration

- Instruments at IRT:

1. IKP2 (is it necessary to repeat? Maybe repeat at CIRA)
2. SEA multi-wire (is it necessary to repeat? Maybe repeat at CIRA, AIWT)
3. 2D-S
4. HSI
5. 2-channel PDI
6. Malvern
7. CDP-2
8. CIP ??
9. Test model

- Center position only for testing? Yes, say IRT staff

- Frequent de-icing will be required for (3) and maybe (6) and (8). Not sure about (7)
- Assuming first 7 items, 1-2 days per item? → 7-14 test days?
  - + test model 21”x21” NACA 0012

- Checkout position would help lower the 1-2 days to perhaps 1 day per items 1-7.

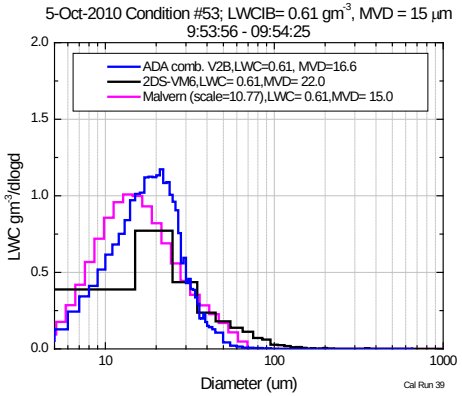
CIRA Instrument Configuration

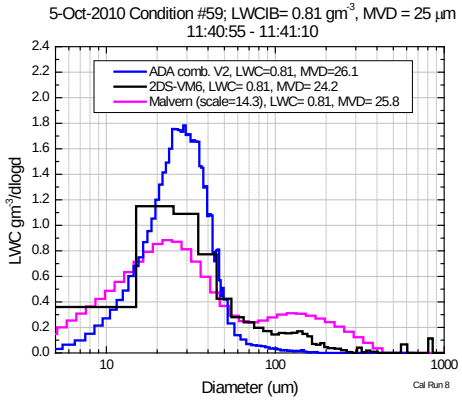
1. IKP2 or NRC tunnel IKP
2. SEA multi-wire and SEA Robust probe
3. 2D-S
4. HSI
5. 2-channel PDI
6. CDP-2
7. ADA?? (large and small)
8. Test model

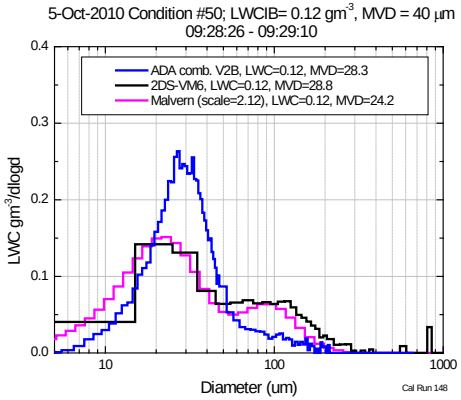
AIWT Instrument Configuration

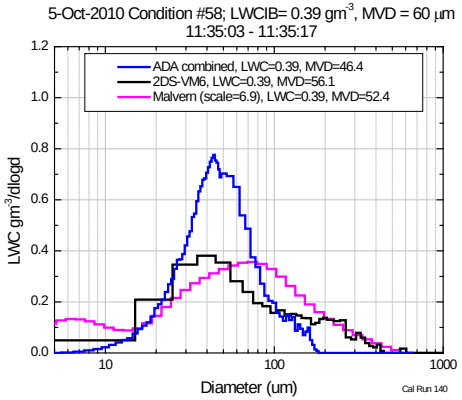
1. NRC tunnel IKP
2. SEA multi-wire, Nevzorov Probe, King probe??
   - What does AIWT use as reference for LWC? King probe?
3. 2D-S
4. CDP-2
5. Malvern
6. Multi-diameter rotating cylinders
7. Test model

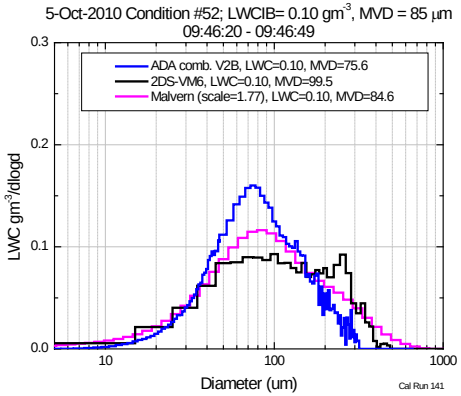
PSD comparison CIRA 2010

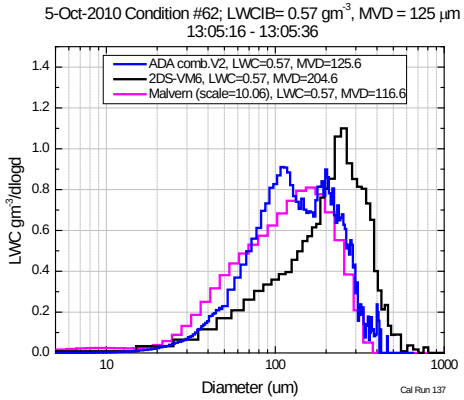


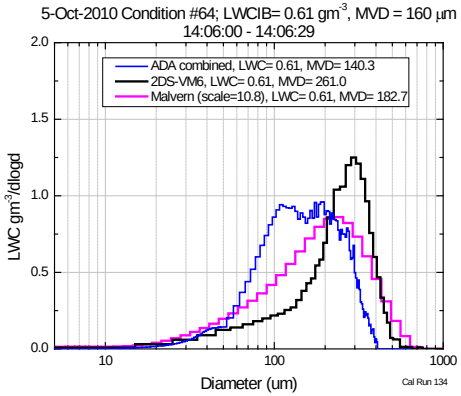




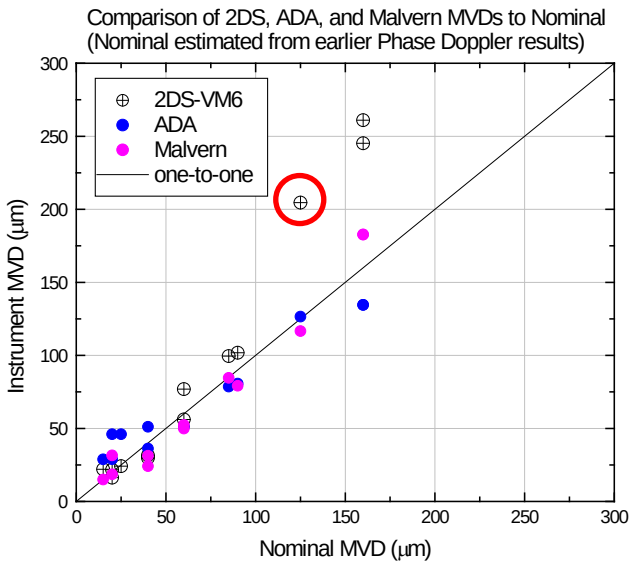


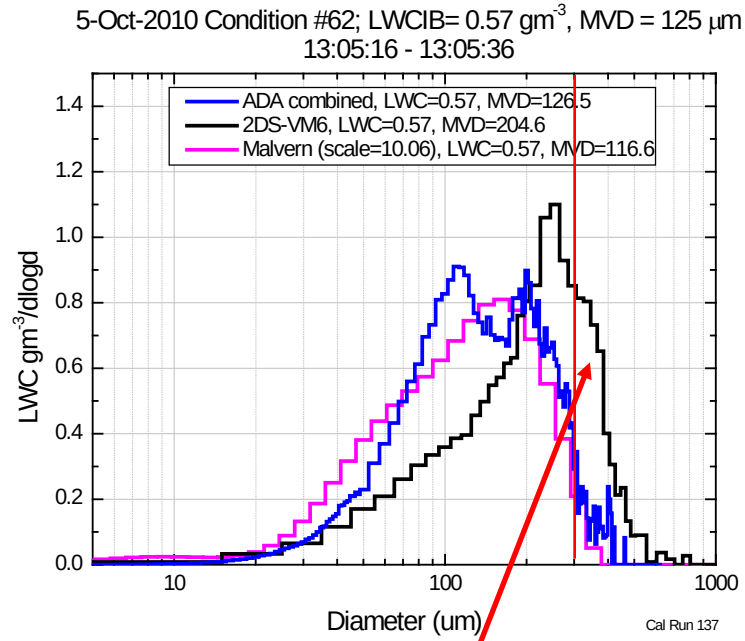






PSD comparison CIRA 2010

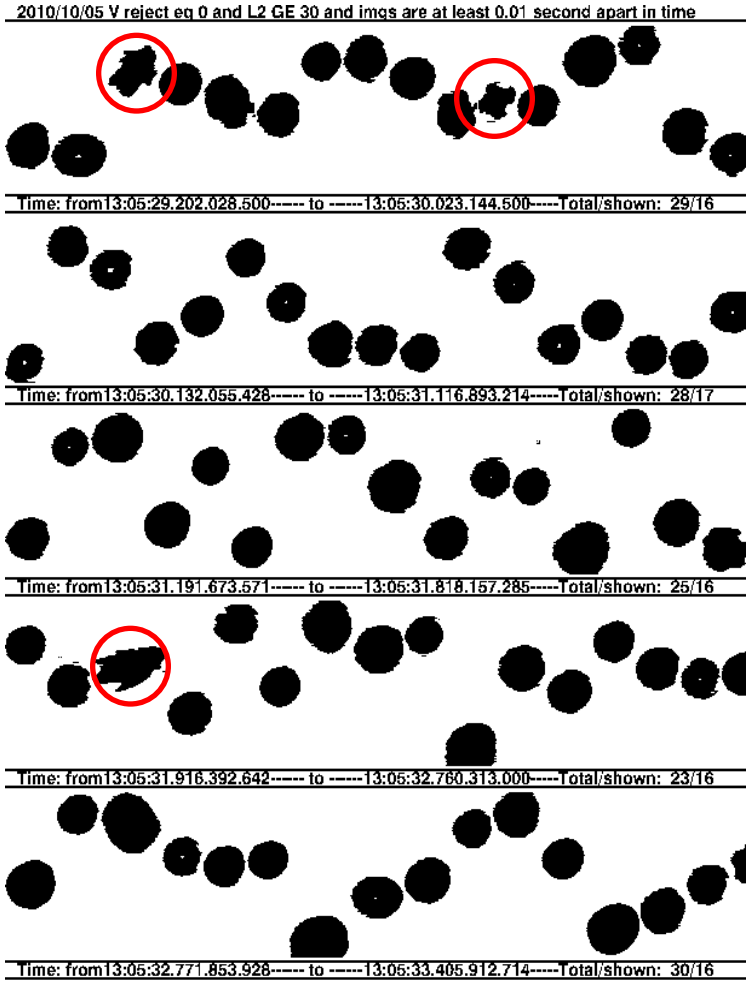




Is there a problem with the imaging of the large particles?

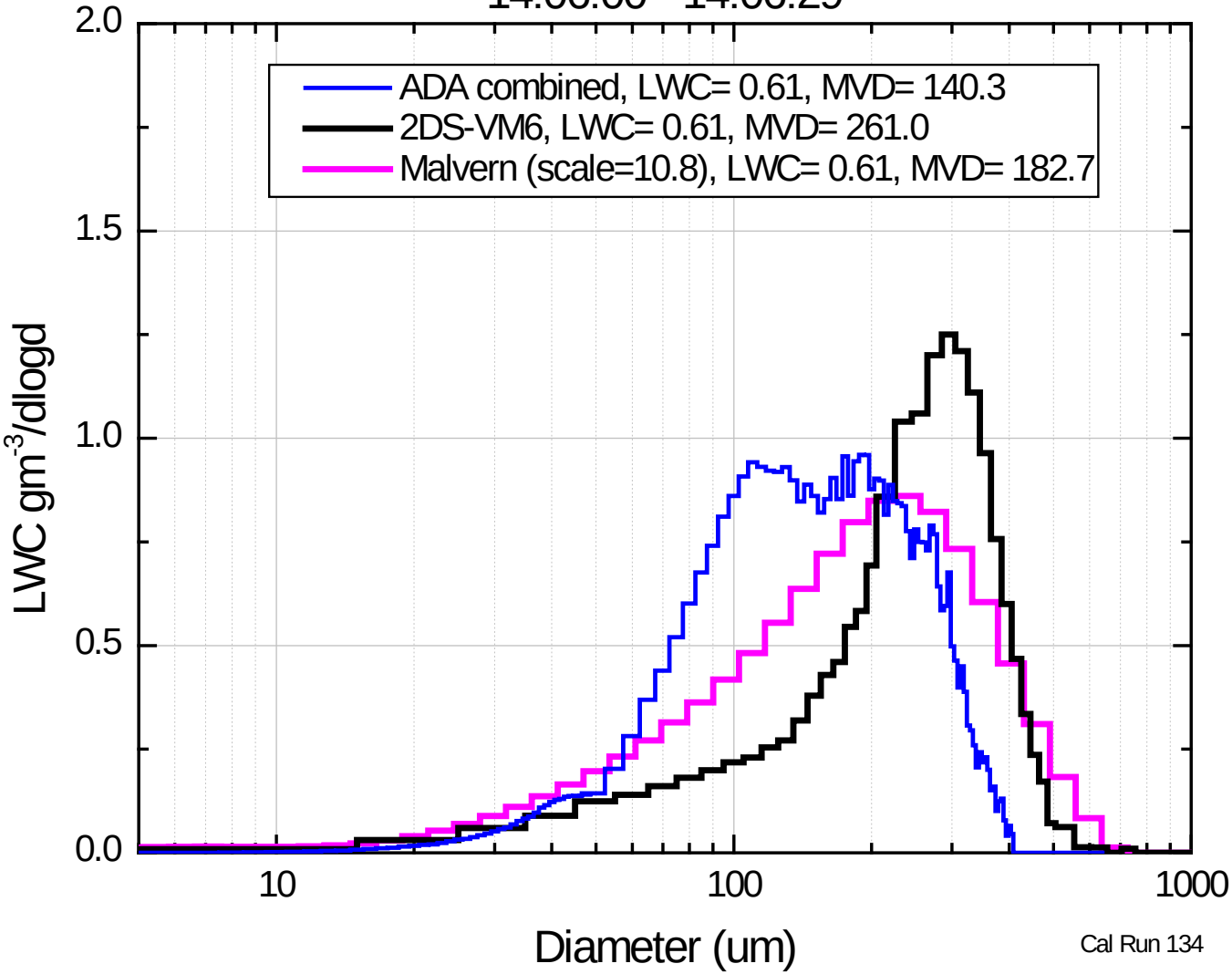
PSD comparison CIRA 2010

- At right, only those 2DS images larger than 300 μm
- Some non-circular particles:
  - ice particles, paint chips? (have seen at other tunnels)
  - water drop breakups on tips of probe?
  - small number, so probably cannot explain spectrum differences with ADA and Malvern



PSD comparison CIRA 2010

5-Oct-2010 Condition #64; LWCIB= 0.61 gm^{-3}, MVD = 160 μm
14:06:00 - 14:06:29



Cal Run 134

NRC slides

Mounting apparatus for Malvern