HAIC/HIWC:
High IWC regions- Particle Size Distributions from in-situ measurements

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Alexei Korolev, *Environment Canada*

Greg McFarquhar, *University of Illinois*

- In situ microphysics measurements
  - Available instrumentation
  - Data treatment : Median Mass Diameter computation

- Size of ice crystals in HIWC regions – Results from the field campaigns
  - Darwin dataset
    - Classical Mesoscale Convective System
    - Long-lasting Mesoscale Convective System
  - Cayenne dataset (preliminary results)

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Instrumentation

Optical Array Probes

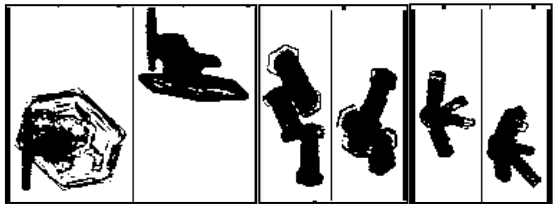
2D-S

PIP

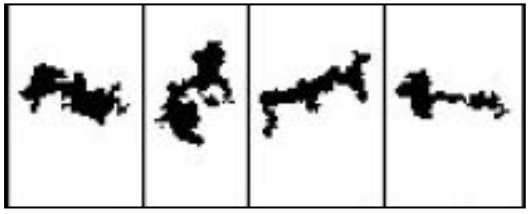
Isokinetic probe (IKP)

Individual ice crystals characteristics

10 - 1280 µm



100 - 6400 µm



Total water content (TWC)

Individual ice crystals characteristics

Plates and multiple plates

Columns

Bullet-rosettes

Graupel

1.28mm

Capped columns

Aggregates

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  - Available instrumentation
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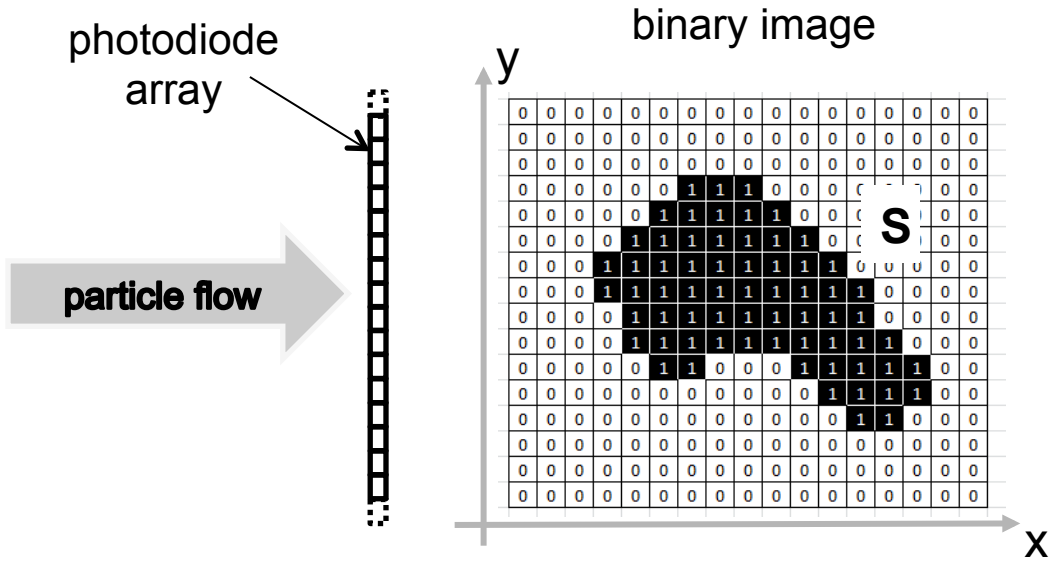
Data treatment

1) Size retrieval



2D area equivalent diameter (assuming a spherical shape)

$$Deq = \sqrt{4 * S / \pi}$$

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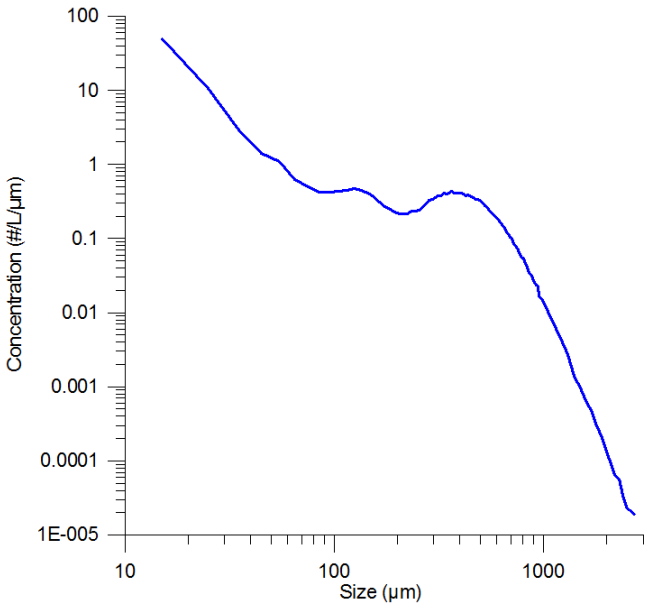
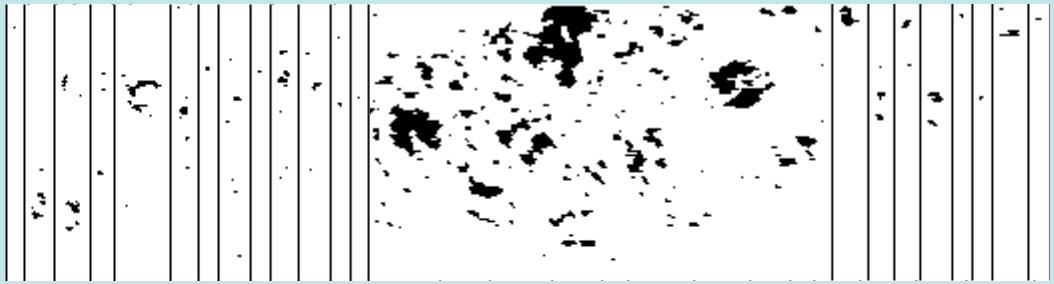
Area equivalent diameter

1) Size retrieval

2) Particle Size Distribution

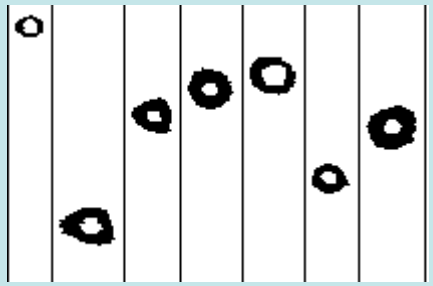


Artefact removal



Splashing/shattering

Multiple particles in single image



Out of focus images

$$Deq = \sqrt{4 * S / \pi}$$

1) Size retrieval

Area equivalent diameter

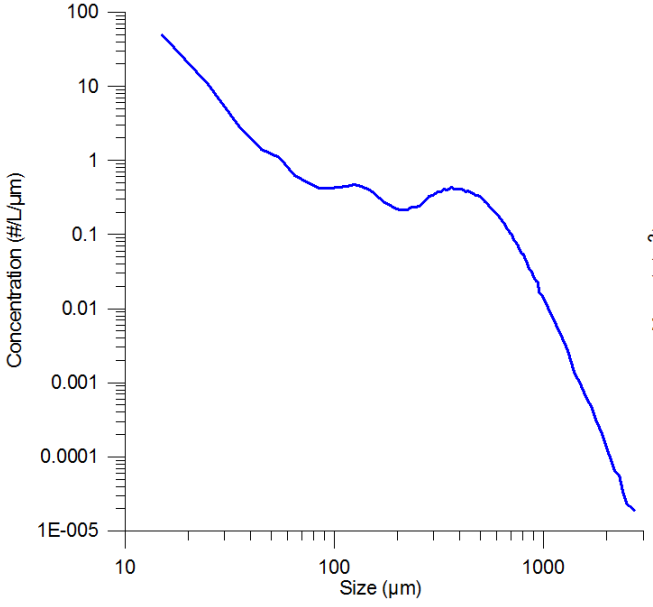
2) Number Particle Size Distribution

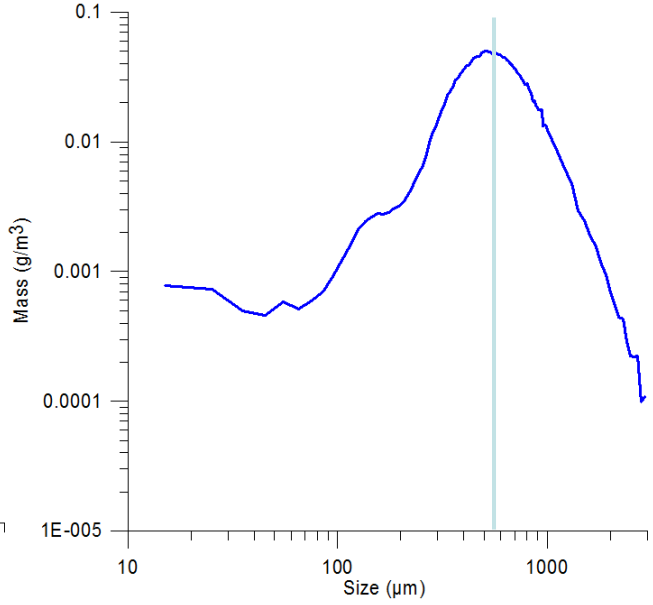
$$m = \alpha D^{\beta}$$

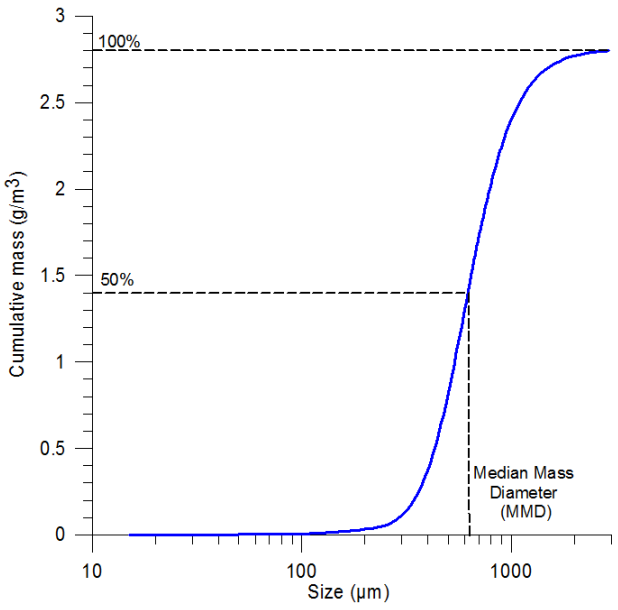
(Brown and Francis; 1995)

3) Mass Particle Size Distribution

4) Median Mass Diameter







- In situ microphysics measurements
  - Available instrumentation
  - Data treatment : Median Mass Diameter computation

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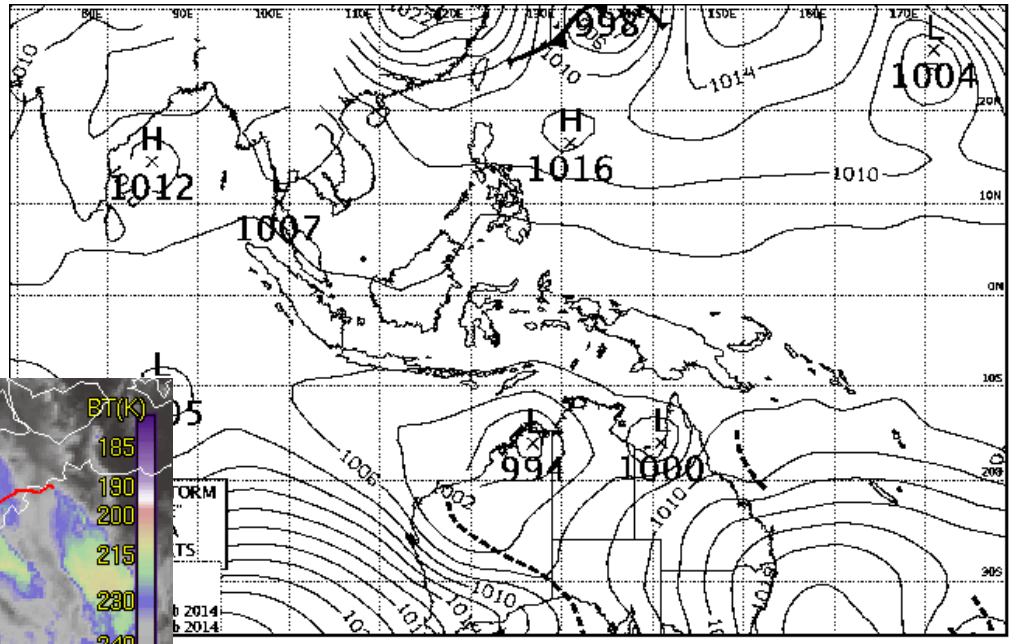
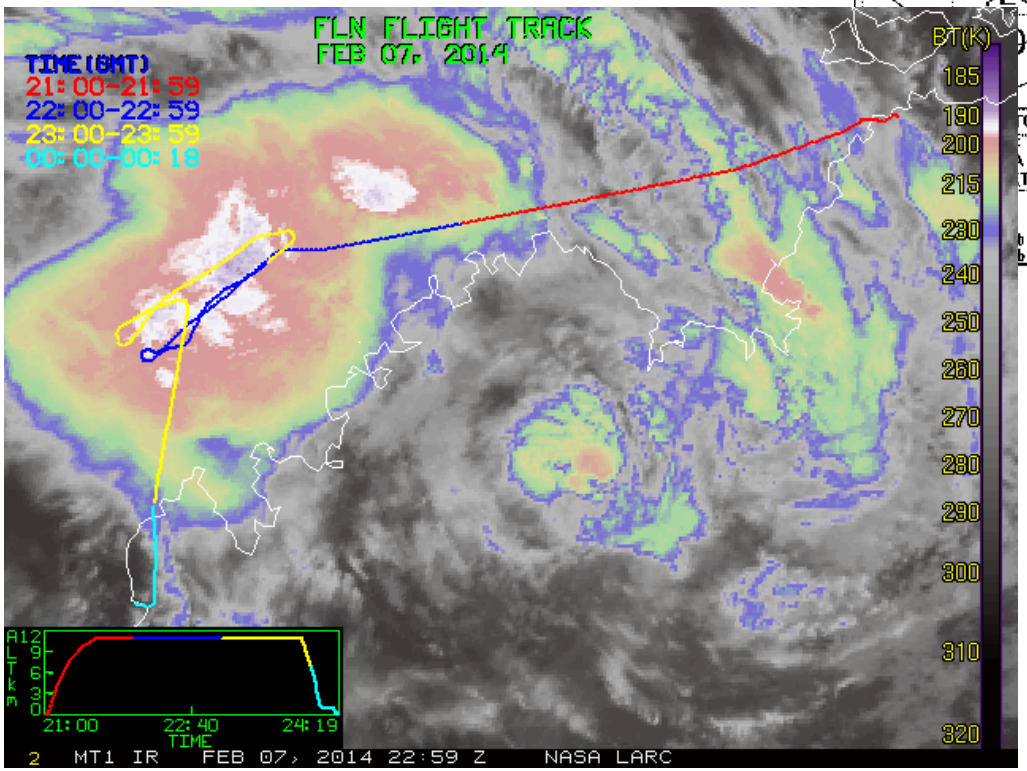
Darwin dataset

Flight 16 example





Darwin•Australia

SAFIRE Falcon 20

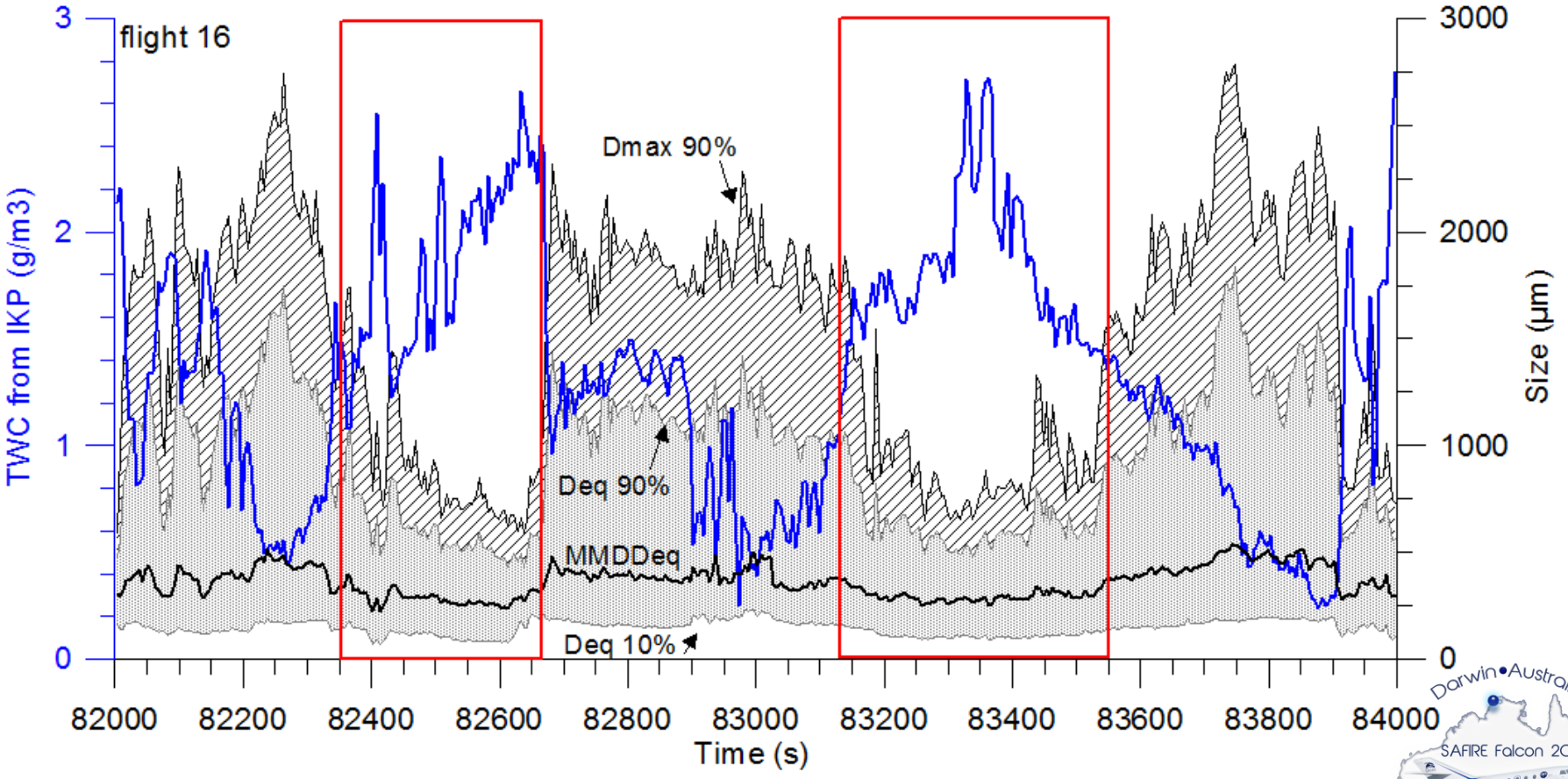
January – March 2014

HAIC •HIWC

International Field Campaign

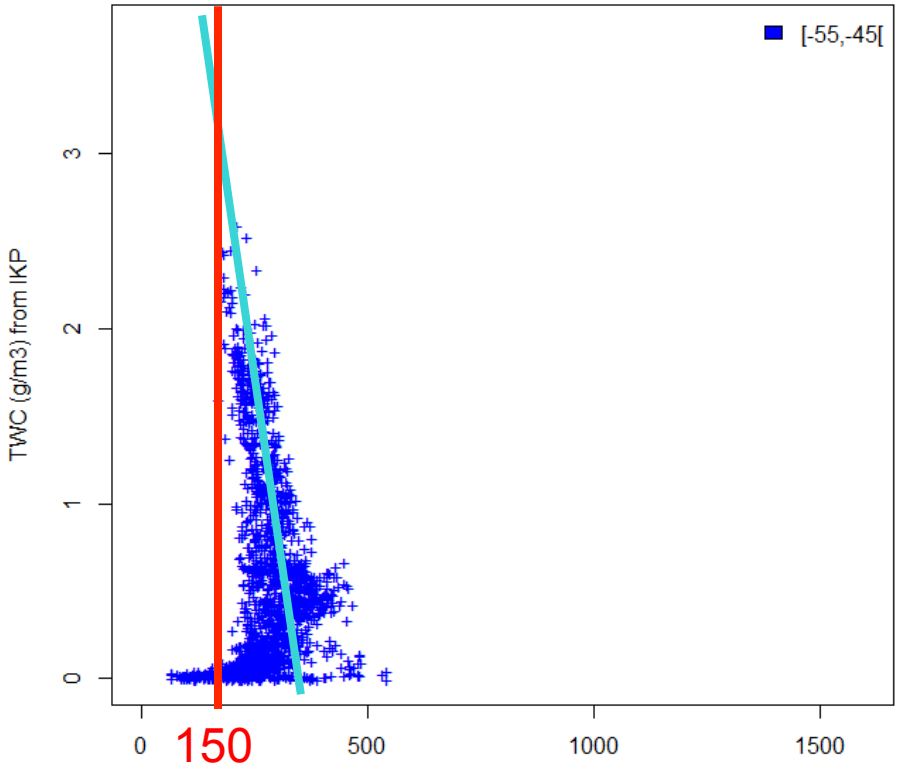
Darwin dataset

Flight 16 example



5s average data from 21 flights in classical MCS:

Isokinetic probe (IKP)



2D-S and PIP

In the -55 to -45°C temperature range, Median Mass Diameters tends to decrease with increasing Total Water Content.

➔ **The higher the TWC, the smaller the ice crystals**

➔ MMDs are **larger than 150 µm**.

(Ice crystals smaller than 100 µm accounts for less than 15% of the total mass)

Darwin • Australia
SAFIRE Falcon 20
January – March 2014
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International Field Campaign

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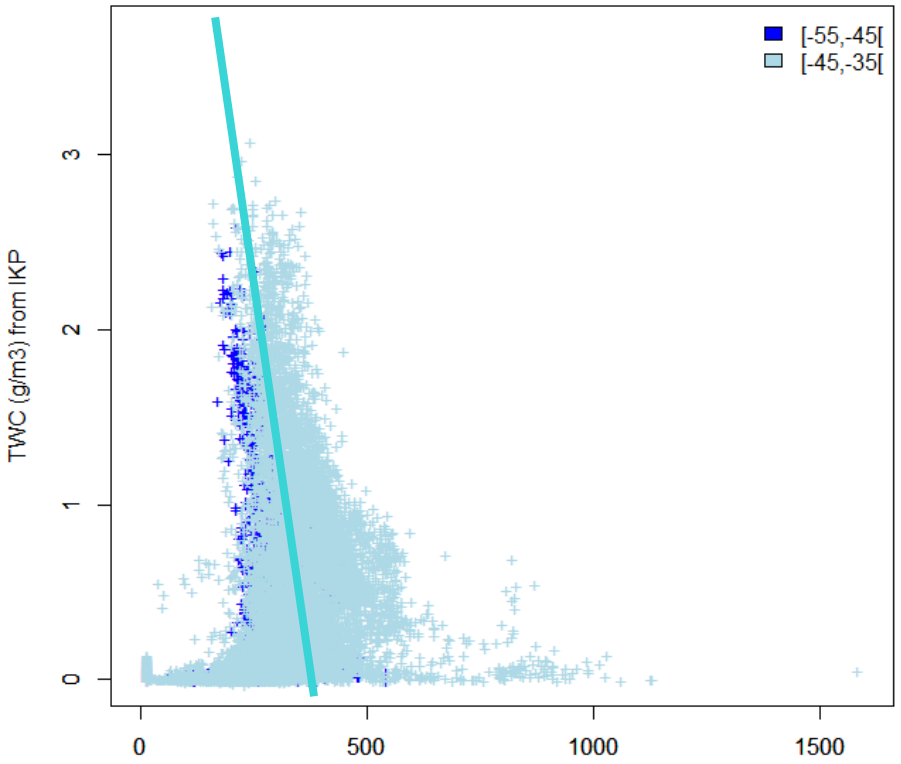

Temperature range : -45°C to -35°C

2D-S and PIP

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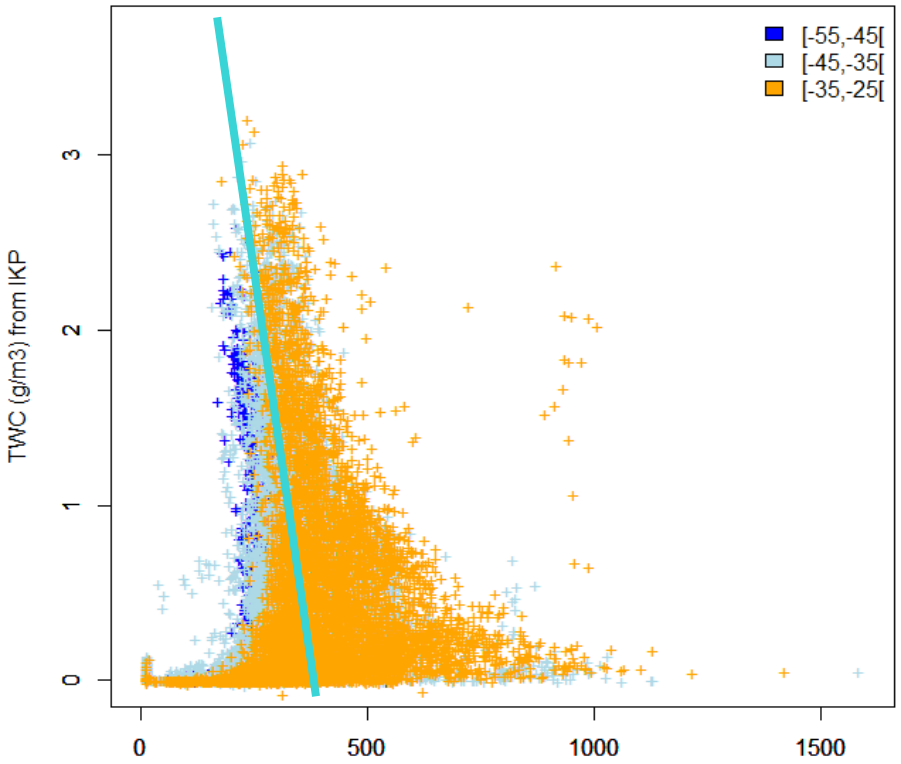
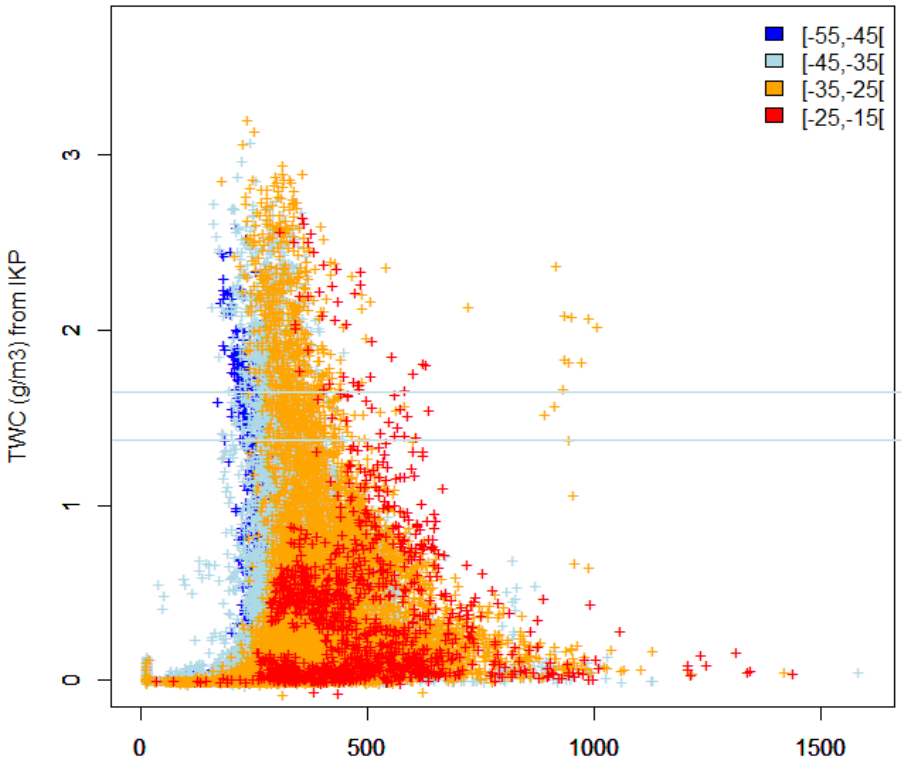


Temperature range : -35°C to -25°C

2D-S and PIP

5s average data from 21 flights in classical MCS:

Isokinetic probe (IKP)



2D-S and PIP

Temperature range : -25°C to -15°C

➔ For all temperature ranges, the Median Mass Diameters decrease with increasing Total Water Contents

➔ **For a given range of TWC, MMDs decrease with decreasing temperatures**

- In situ microphysics measurements
  - Available instrumentation
  - Data treatment : Median Mass Diameter computation

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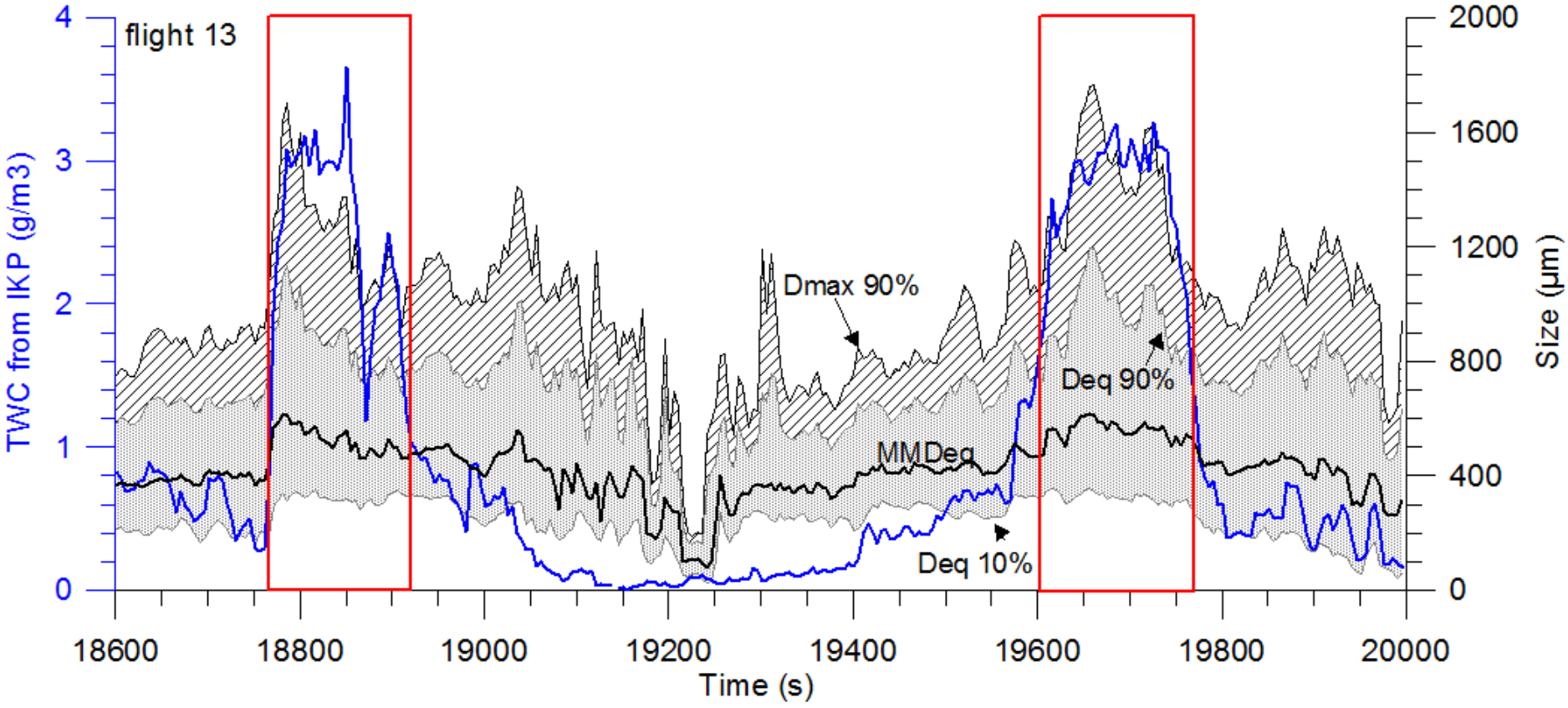
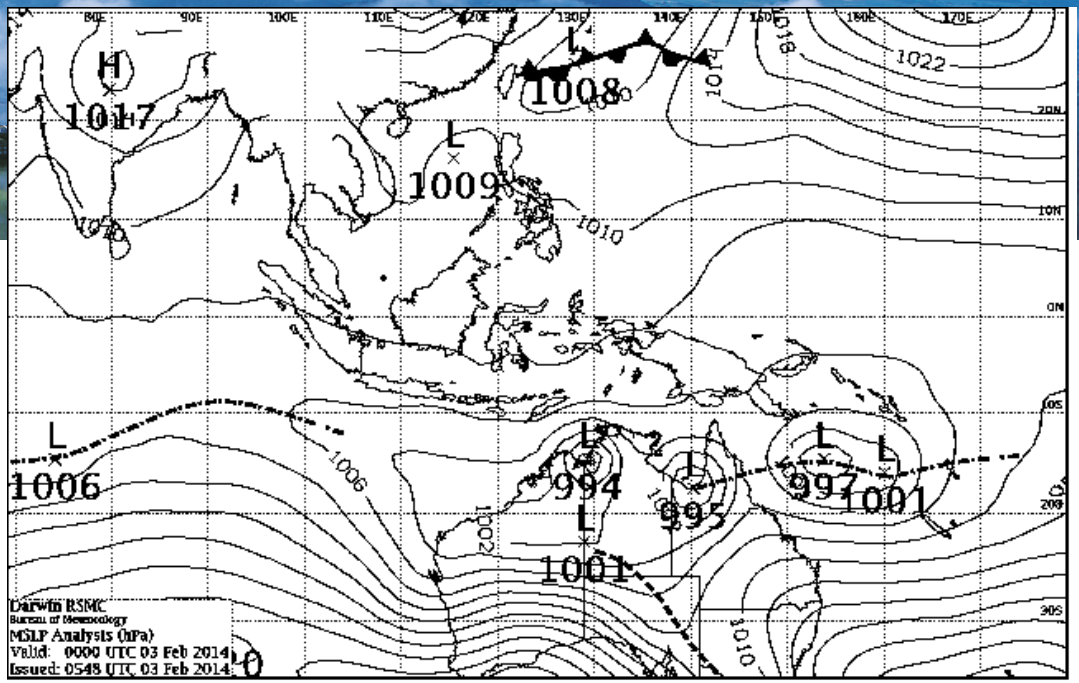
Darwin dataset

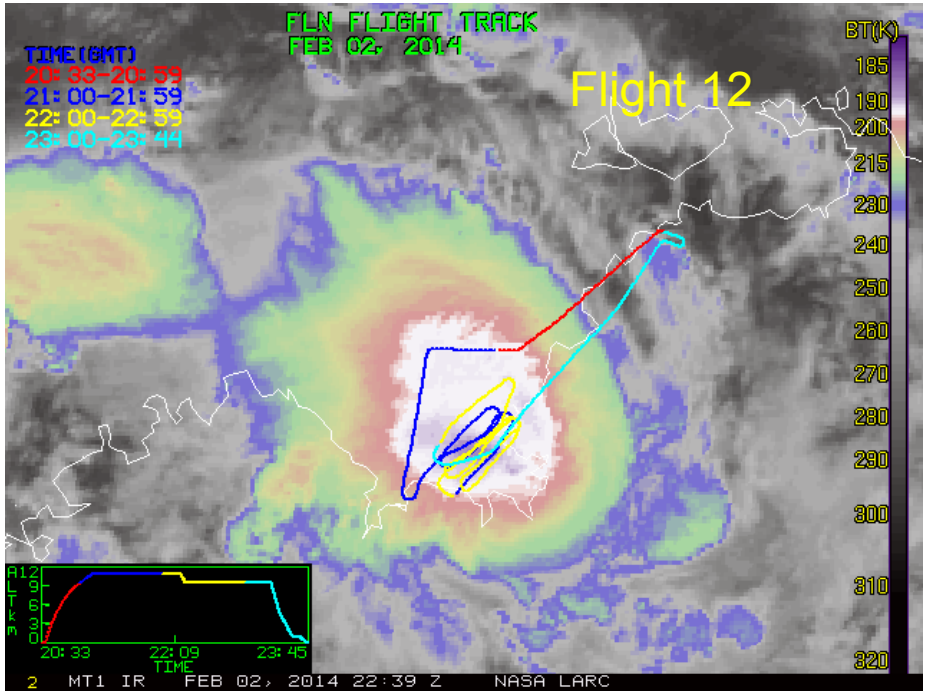
Flight 13 example

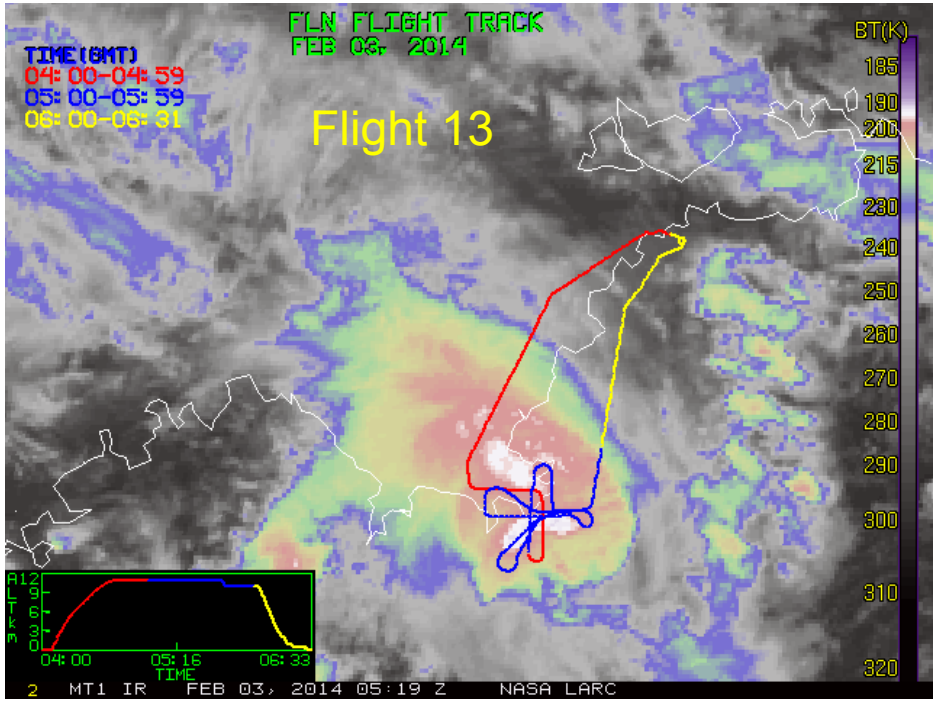


Darwin dataset

Flight 13 example

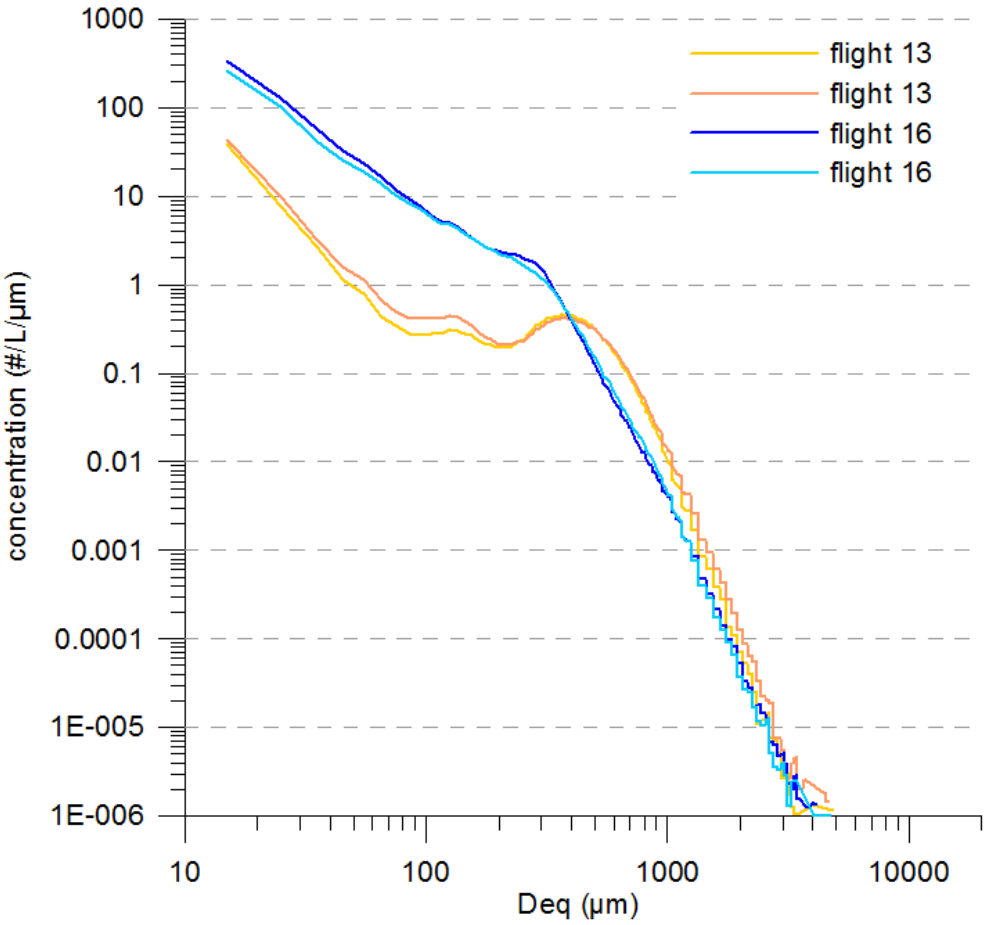


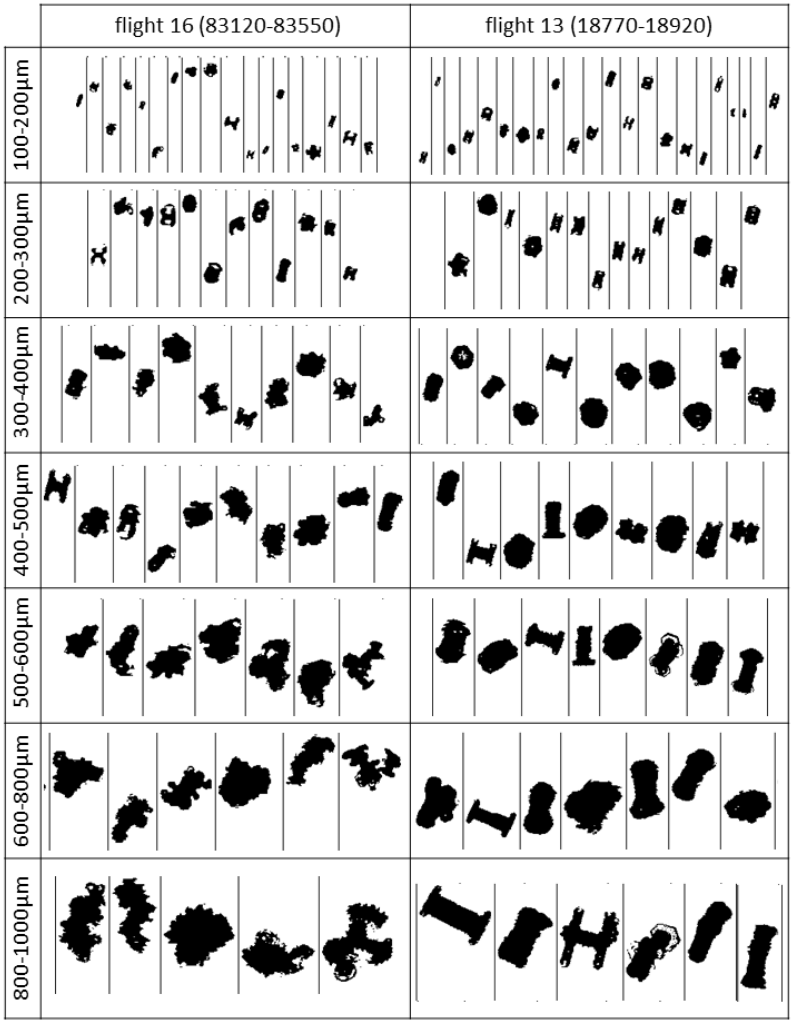




Darwin dataset

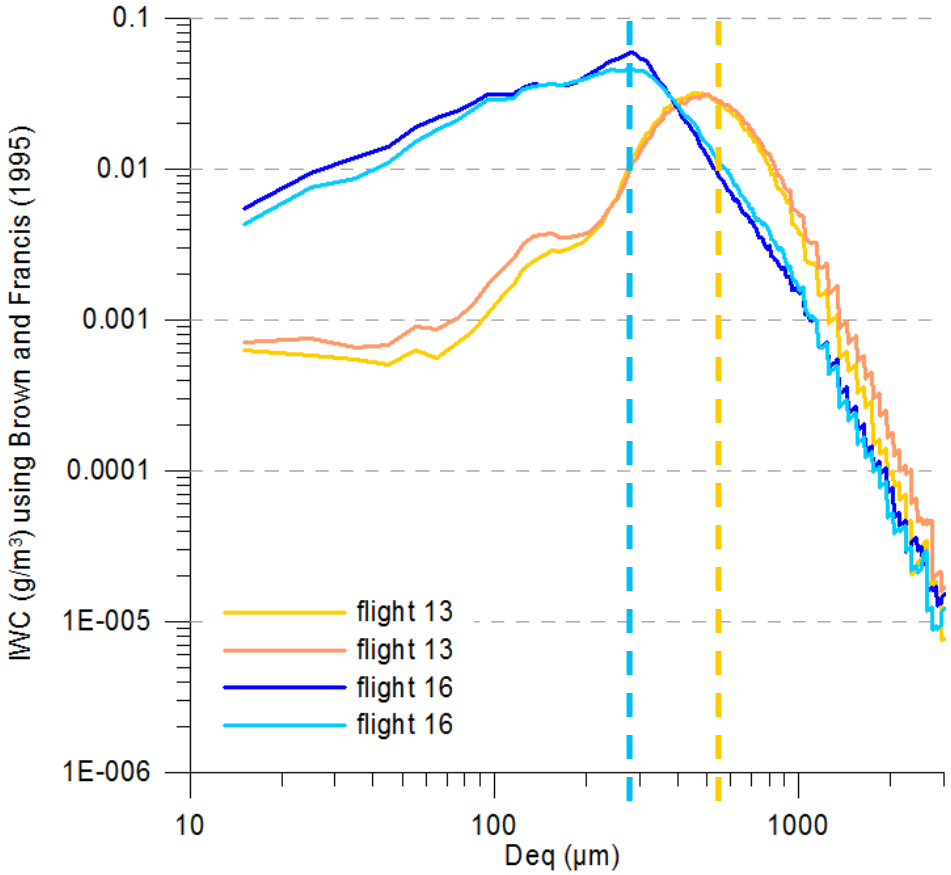
Flight 13 compared to flight 16 – Particle size distributions and ice crystal shapes

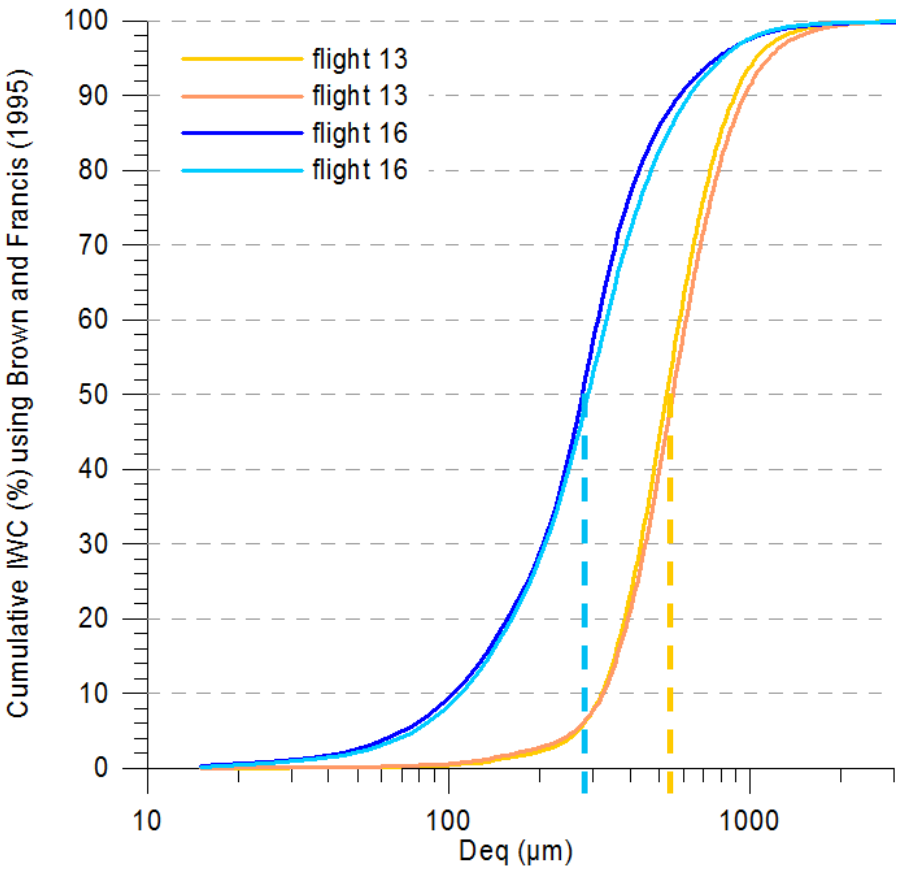




Darwin dataset

Flight 13 compared to flight 16 – Mass size distributions



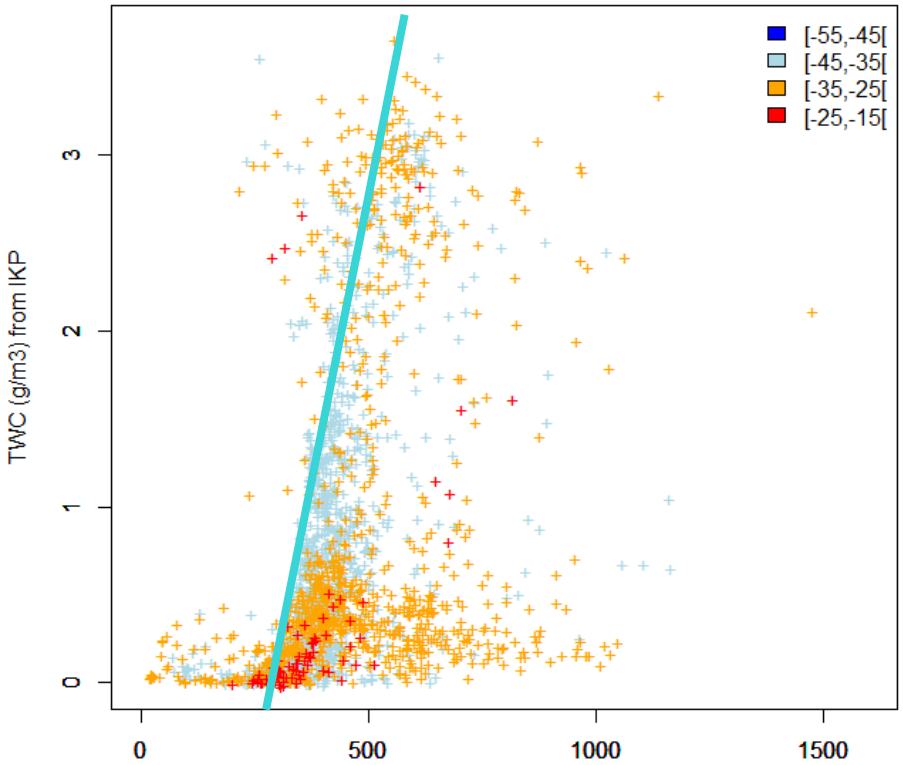


Flight 16 : MMD ~ 300 µm ≠ **Flight 13 : MMD ~ 550 µm**

Darwin dataset

5s average data data from 2 flights in the **same long-lasting** MCS:

Isokinetic probe (IKP)



2D-S and PIP

In contrast to the previous results: here MMDs seem to increase when increasing TWC

➔ **The higher the TWC, the larger the ice crystals**

Dependancy of MMDs with temperature is not obvious

- Ice crystal size in HIWC areas :

	Isolated typical MCS	Long-lasting MCS
Median Mass Diameter range for TWC > 1g/m^3	170 – 700 µm	300 – 1200 µm
MMD variation with TWC	MMDs **decrease** with increasing TWCs	MMDs **'increase'** with increasing TWCs
MMD variation with temperature	MMDs decrease with decreasing temperatures	Not obvious

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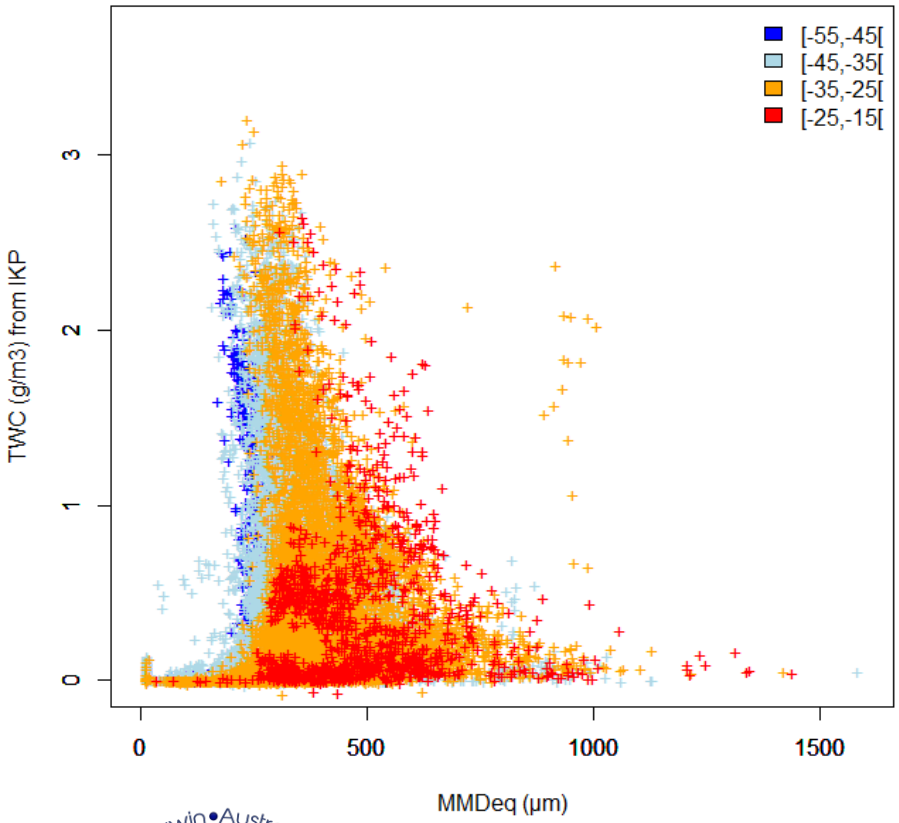
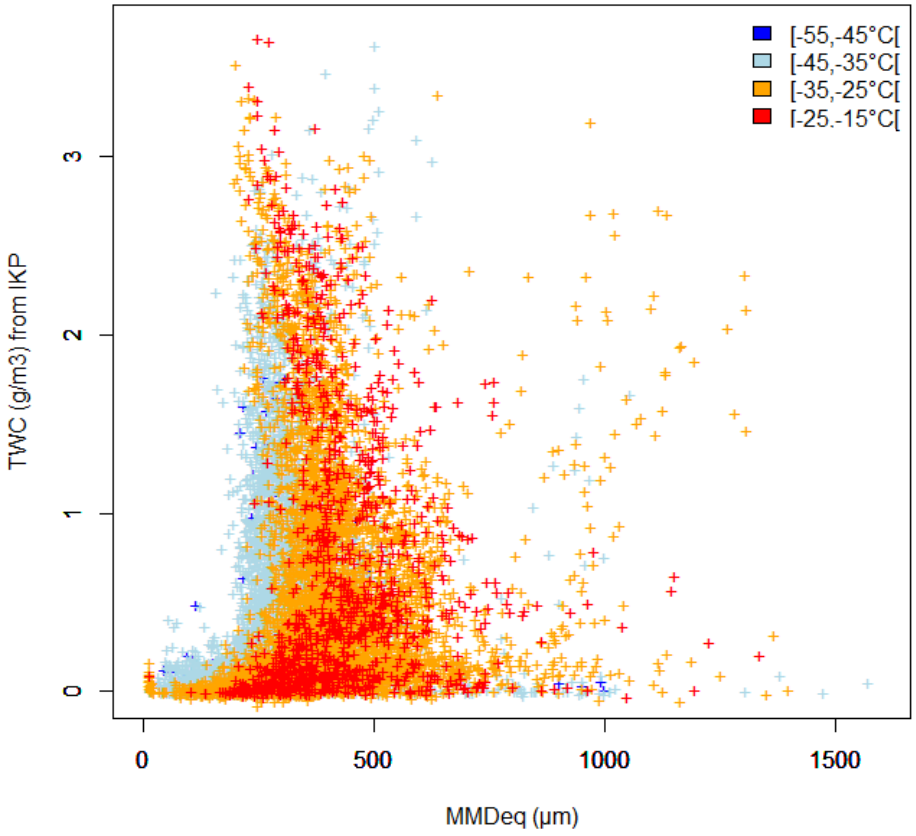
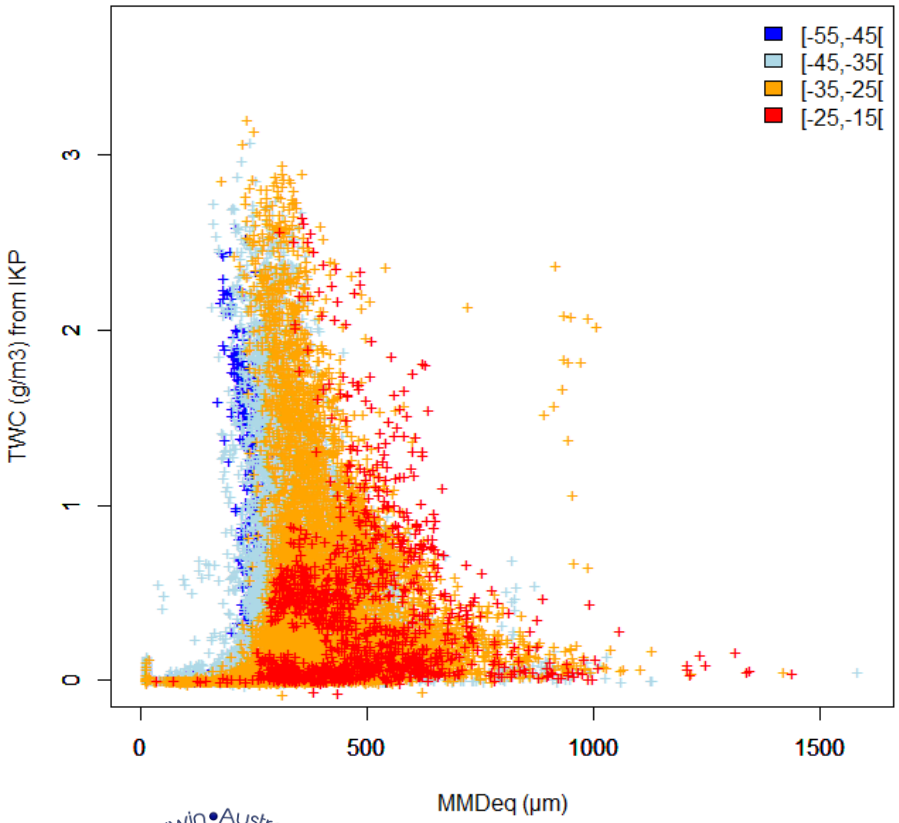
Darwin versus Cayenne dataset: T<15°C

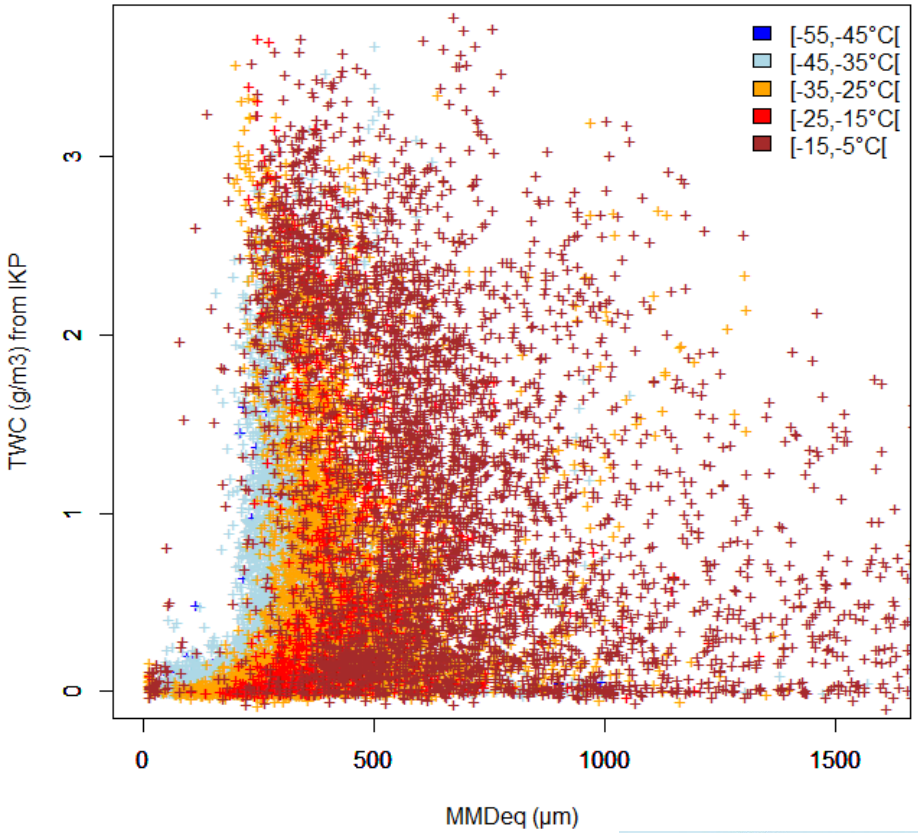




For temperatures below -20°C, MMDs are in the same range for Darwin and Cayenne

Darwin versus Cayenne dataset: al





At warmer temperatures (around -10°C), the range of possible MMDs is clearly wider

Conclusions : Ice crystal sizes in HIWC areas

	Isolated MCS	Long-lasting MCS
Median Mass Diameter range for TWC > 1g/m^3	170 – 700 µm	300 – 1200 µm
MMD variation with TWC	MMDs **decrease** with increasing TWCs	MMDs **increase** with increasing TWCs
MMD variation with temperature	MMDs decrease with decreasing temperatures	Not obvious

Darwin's results are confirmed for temperatures below -20 °C

At warmer temperatures (around -10°C), the range of possible MMDs is clearly wider

Conclusions : Ice crystal size in HIWC areas…

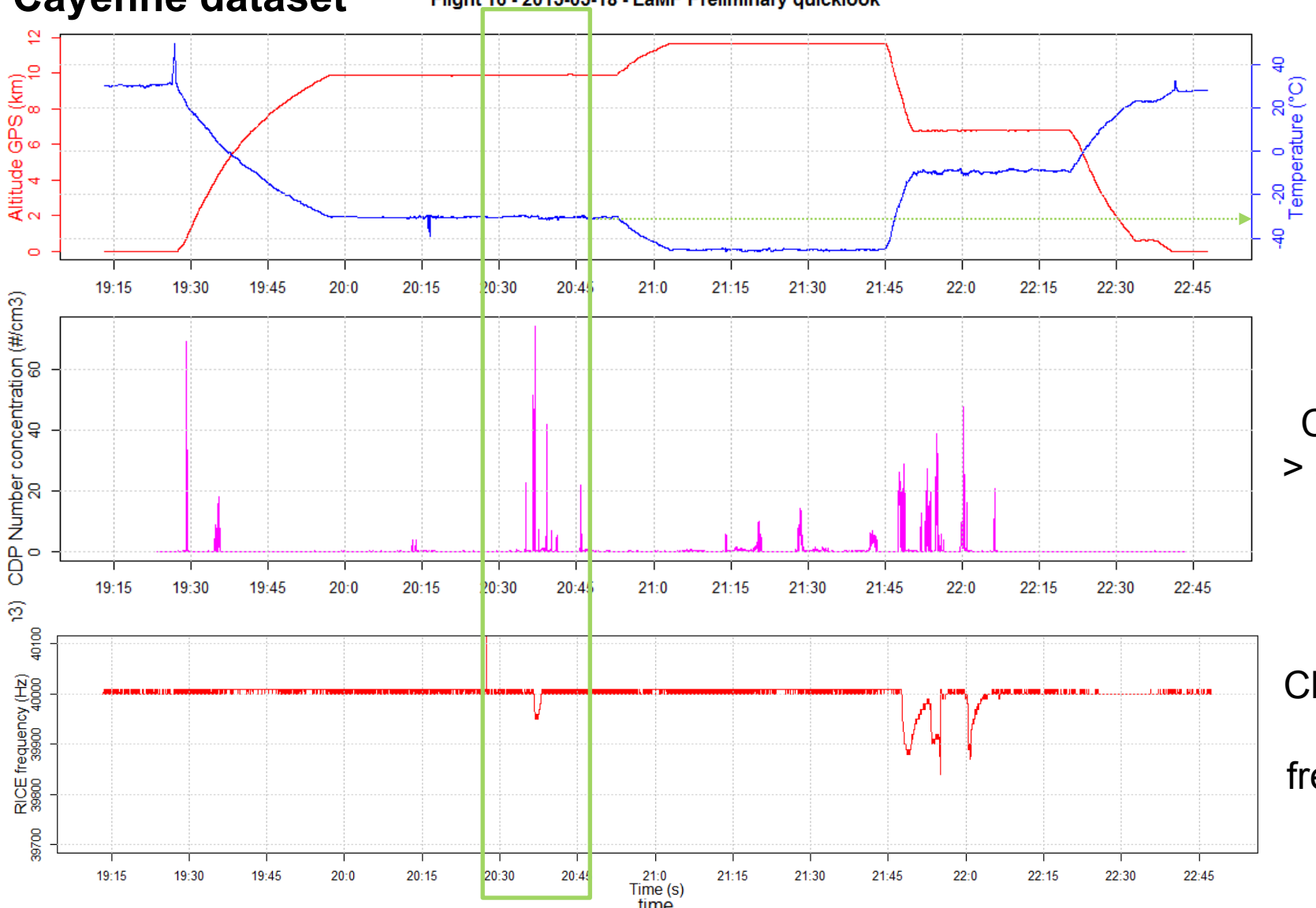
And what about liquid water in MCS ?

CDP : cloud droplet probe

➔ Provides particle counts in the 2-50µm size range

+ Rosemount Ice Detector (and LWC probes).

Cayenne dataset



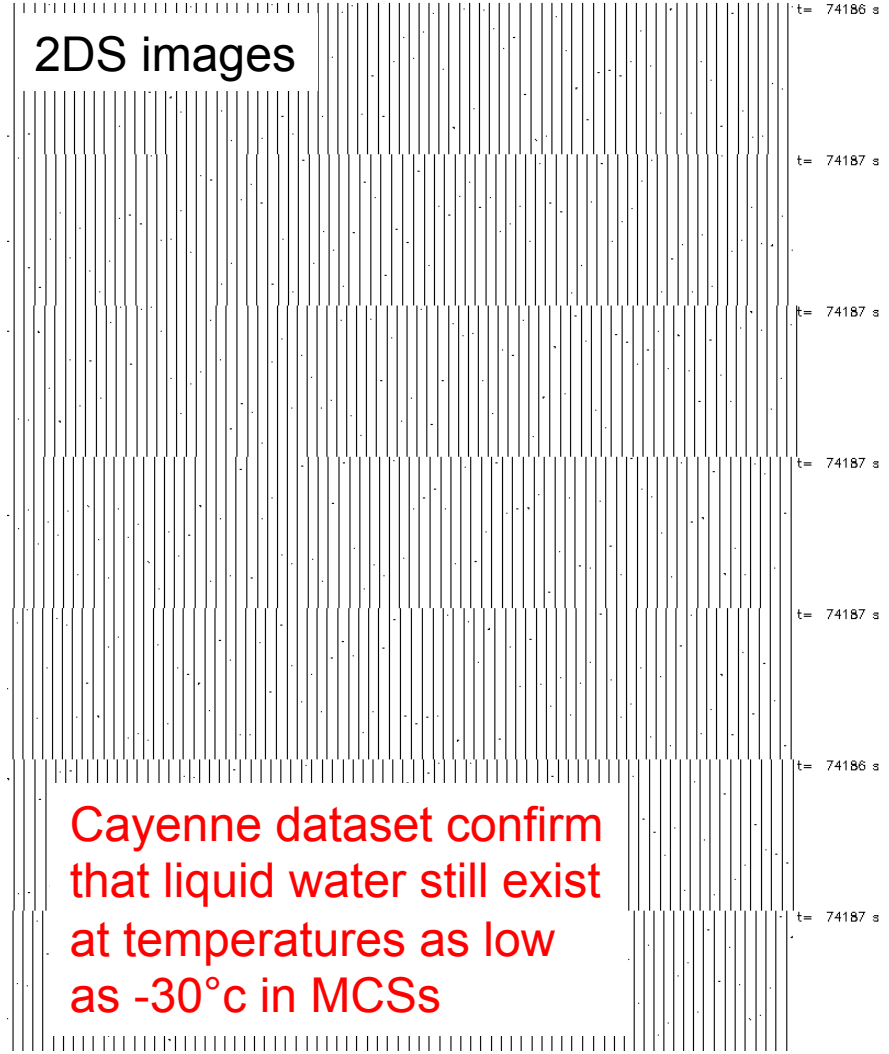
T ~ -30°C

CDP [ ] > 50 cm^{-3}

Change in RICE frequency

Cayenne dataset

Flight 16



Cayenne dataset confirm that liquid water still exist at temperatures as low as -30°c in MCSs