Presented by

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HAIC-HIWC Science Team Meeting 10/11/2015 - Melbourne

Darwin PSD dataset

Contents

Update on data availability

Status on intercomparison exercice UI, EC, CNRS-LaMP/UBP

Work since New York meeting (March 2015)

- m(D) retrieval, mass SD (thus MMD, etc..)
- CDP PSDs

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Data availability

Available on the UBP/CNRS-LaMP archive (see next presentation)

PSD related cloud particle parameter	Avalability
CDP concentrations	✓
CDP Particle Size Distributions (n=1.33 or other)	✘
2DS-PIP Composite Particle Number Size Distribution in Ly	✓
2DS-PIP Composite Particle Number Size Distribution in Deq	✓
2DS-PIP Composite Particle Number Size Distribution in Dmax	✓
Mass SD, Area SD, MMD, other percentiles,…	✘

✘ to be provided in future

Update on data availability

Status on intercomparison exercice UI, EC, CNRS-LaMP/UBP

Work since New York meeting (March 2015)
- m(D) retrieval, mass SD (thus MMD, etc..)
- CDP PSDs

History…

After 1st meeting (Paris 09-2014):	
Objectif 1 - Identify the differences and their main sources in image processing results	Objectif 2 - Come to a consensus about the processing algorithms which will be used for the HAIC-HIWC data analysis
Extrapolation of partial images	Following Korolev and Sussman (2000)
Computation of width in sample volume	
Computation of sample distances	Improvement of the overload computation

➔ Check of the counts and concentrations before applying corrections ✓

After Clermont/Toulouse meetings Jan-2015:

Objectif 3 - Apply all corrections at once and study PSD and MMD differences.
If reasonnable agreement ➔ distribute a preliminary version of PSD/MMDs dataset

Objectif 4 - Continue time consuming detailed step by step processing

Objectif 3

- Apply all corrections at once and study PSD and MMD differences.

- If reasonnable agreement:

➔ distribute a preliminary version of PSD/MMDs dataset

1. Implementing interarrival time algorithm

(a) Determining cut-off-time, counts of rejected images
(b) Applying interarrival time algorithm
(c) Re-acceptance of “good” images trapped within shattered clusters

2. Filtering image artifacts

(a) Identifying noise images
(b) Shattered particles in one image frame
(c) Accept out-of-focus broken images
(d) Filtering diffraction related artifacts

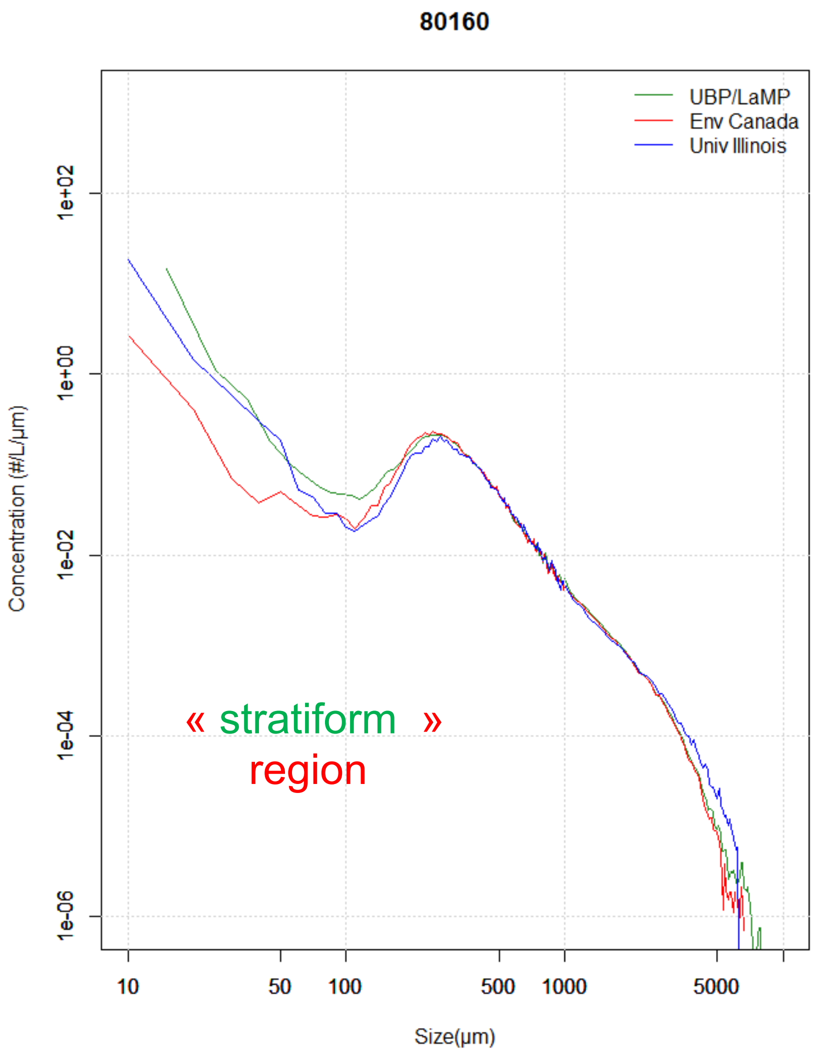
3. Partial image size retrievals

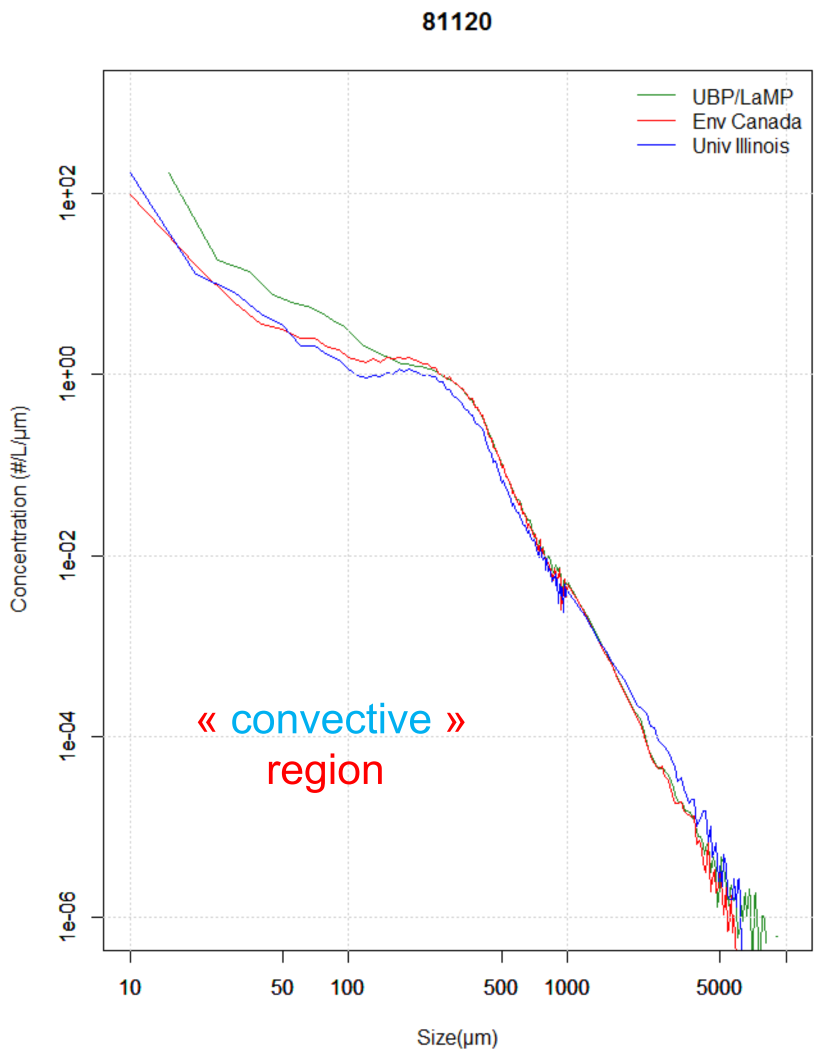
(a) Single partial images
(b) Broken partial images

4. Image size retrieval

(a) Single image retrieval based on Poisson spot ratios
(b) Identification of images for retrieval
(c) Close circle images
(d) Broken images in the same image frame
(e) Broken images split in two image frame

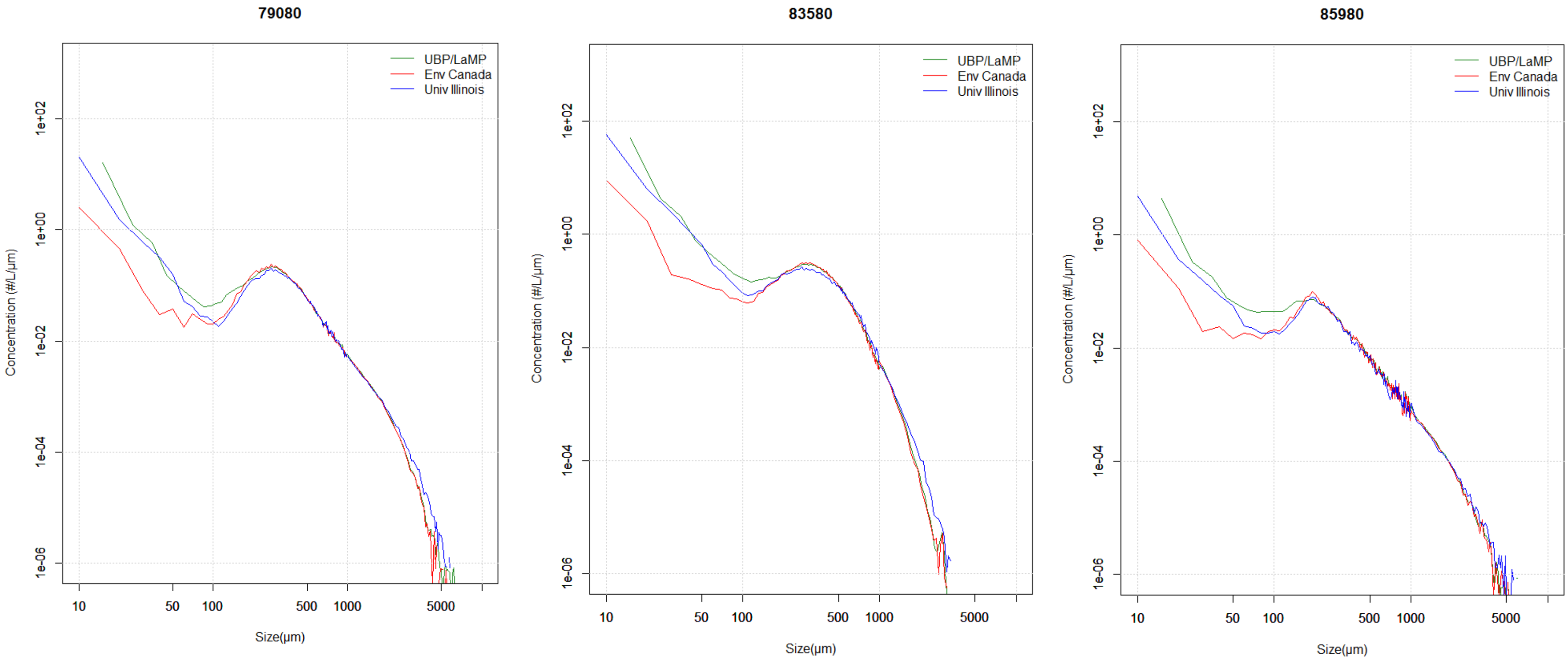
Results 1/11 : Examples of PSDs (mean over 1min)





HAIC – High Altitude Ice Crystals
Data treatment intercomparison

Results 2/11 : Examples of PSDs (mean over 1min – random choice)



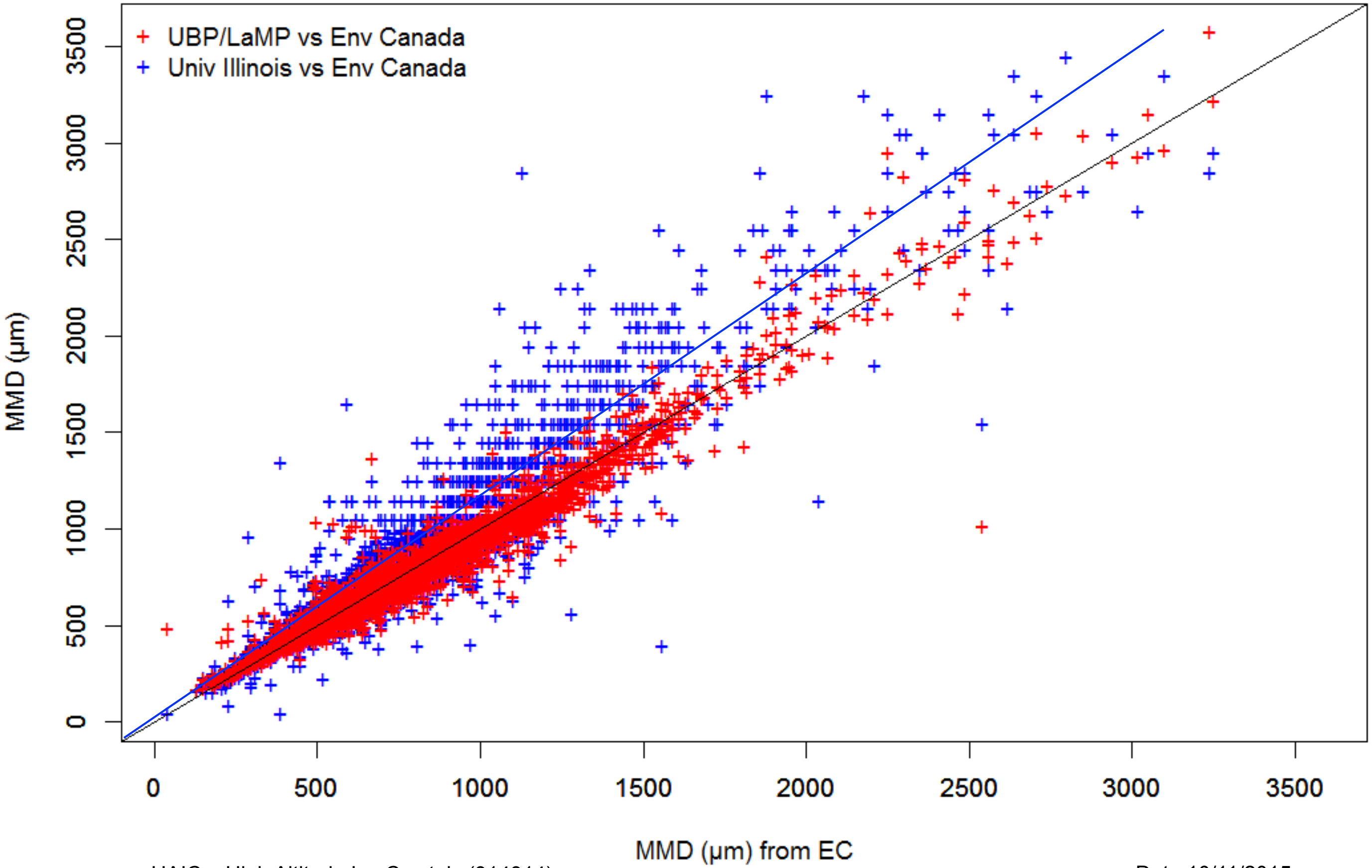
<u>Trends :</u>
- UBP and UI concentrations > EC concentrations in the range 10 to 200 µm
- Excellent agreement between UBP and EC for sizes larger than 200 µm
- UI concentrations and/or sizes larger for sizes larger than 2000-3000 µm

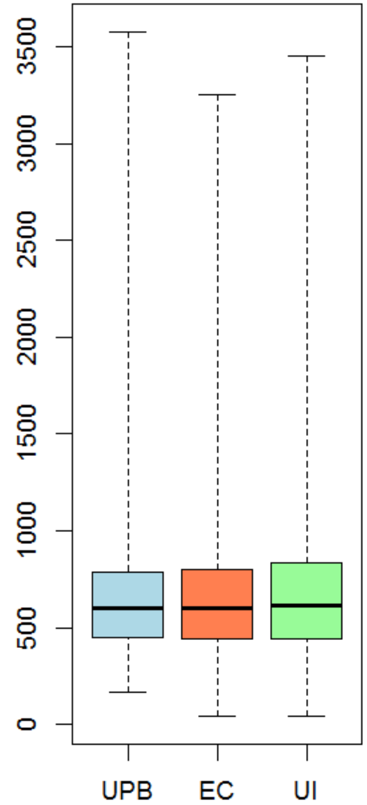
HAIC – High Altitude Ice Crystals
Data treatment intercomparison

Results 3/11 : MMDs

MMDs – Flight 23 from 21h45 to 24h33

Correlation plots: only data points with IKP > 0.1 g/m3



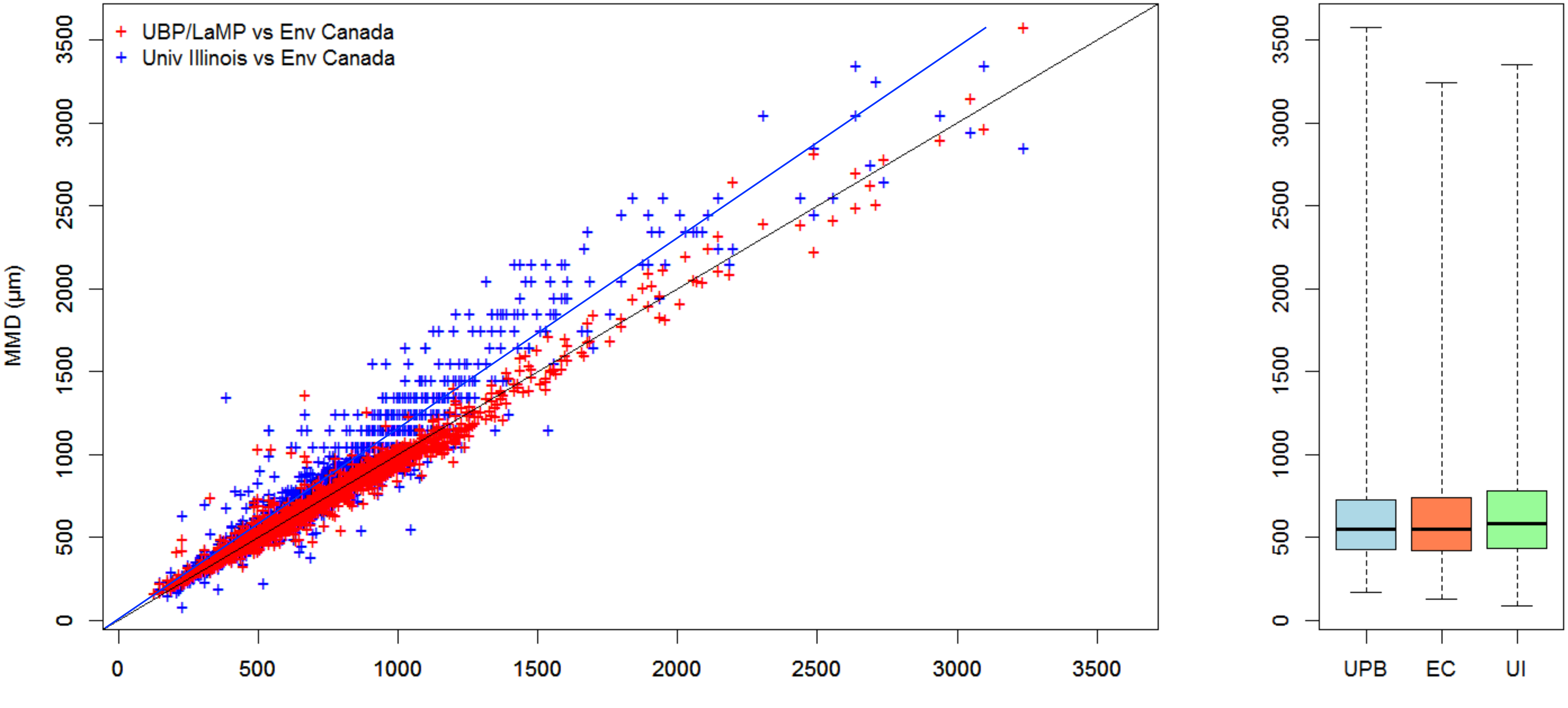


HAIC – High Altitude Ice Crystals
Data treatment intercomparison

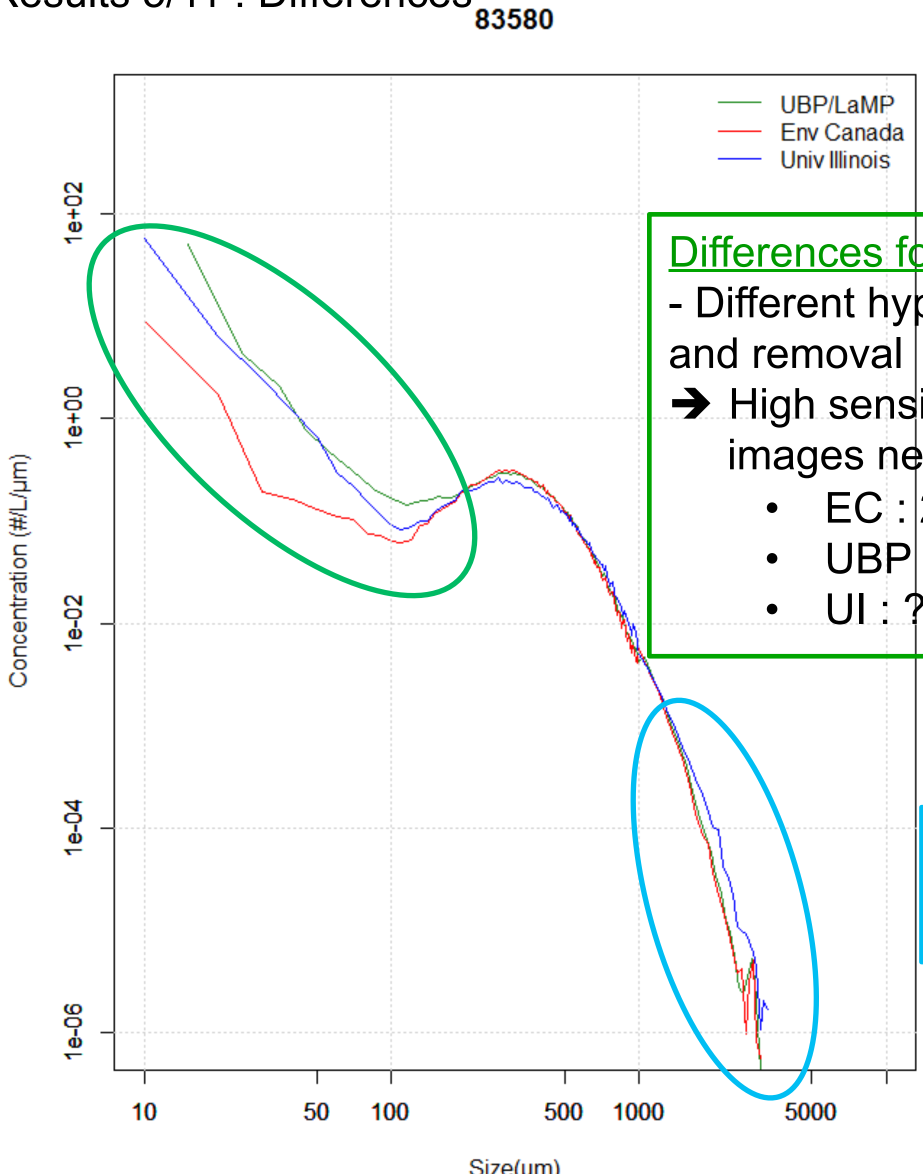
Results 4/11 : MMDs

MMDs – Flight 23 from 21h45 to 24h33

Correlation plots: only data points with IKP > 0.5 g/m3



Results 5/11 : Differences



<u>Differences for small sizes :</u>

- Different hypothesis for shattering events identification and removal

➔ High sensitivity to the minimal number of consecutive images needed to account for a shattering event

- EC : 2 images
- UBP : 3 images
- UI : ?

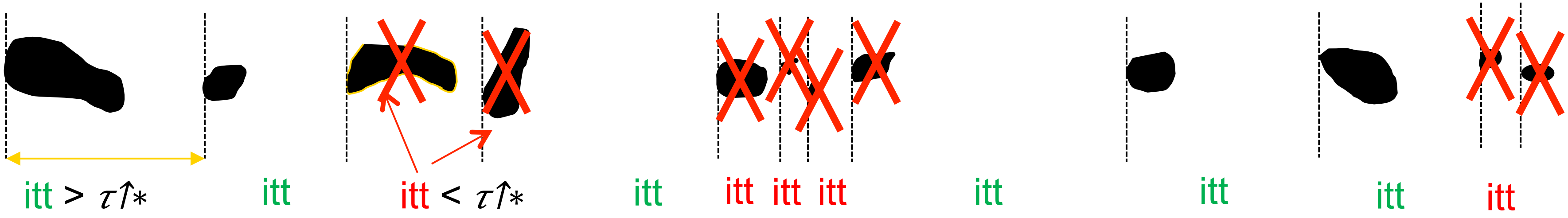
<u>Differences for largest sizes :</u>

- To be investigated; Illinois work?

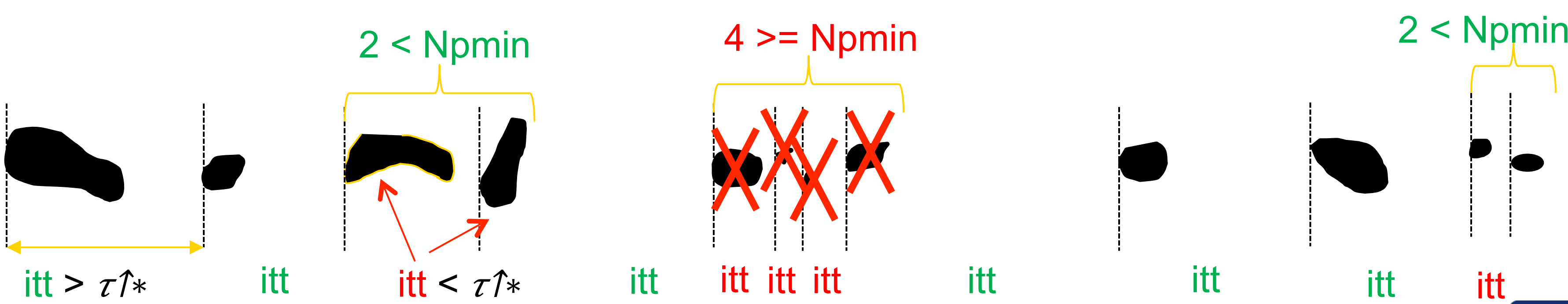
Results 6/11 : Differences

For a given cut-off-time τ^*,

Npmin=2 :
Minimum number of rejected particles per shattering event is **2**

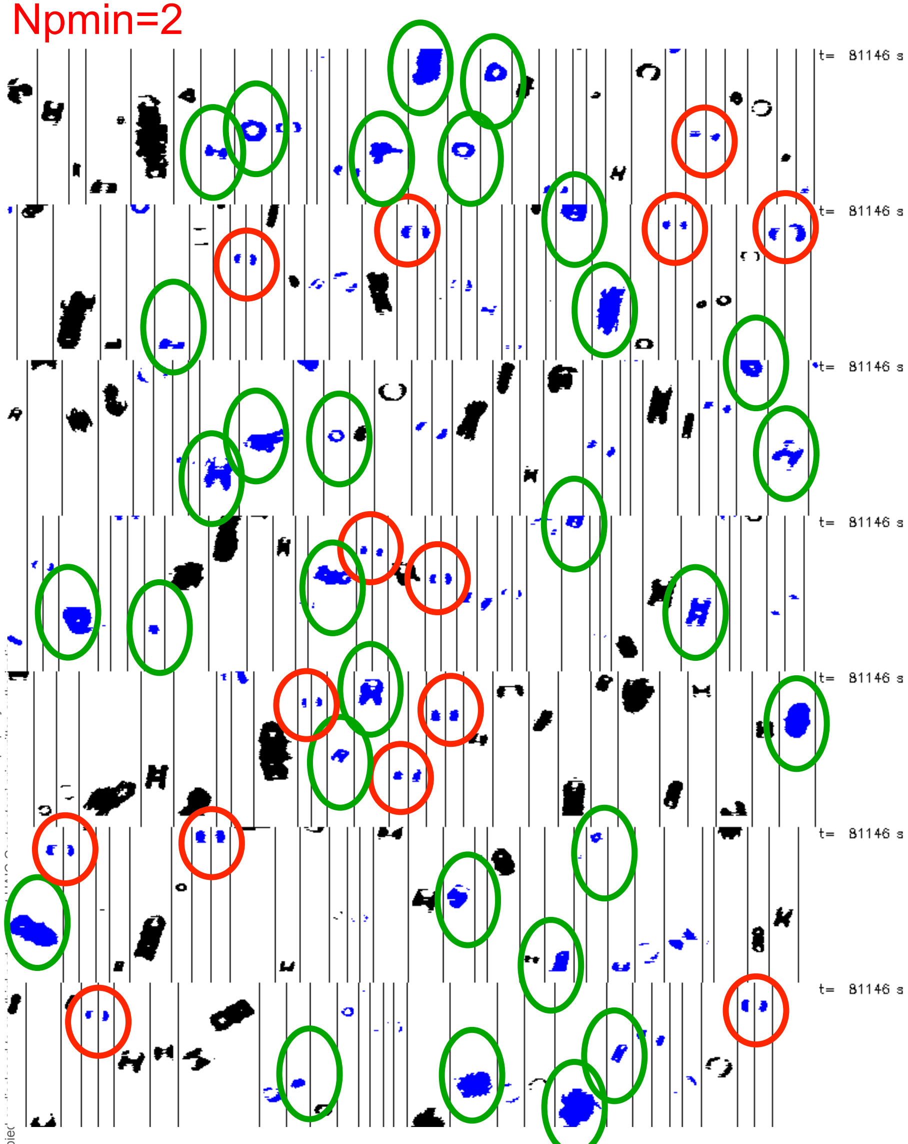


Npmin=3 :
Minimum number of rejected particles per shattering event is **3**



Results 8/11 : Differences

Npmin=2



Blue = particles removed by the shattering treatment

- Out of focus patterns in two different frames are eliminated (red circles)
- A lot of interesting images are removed (green circles)

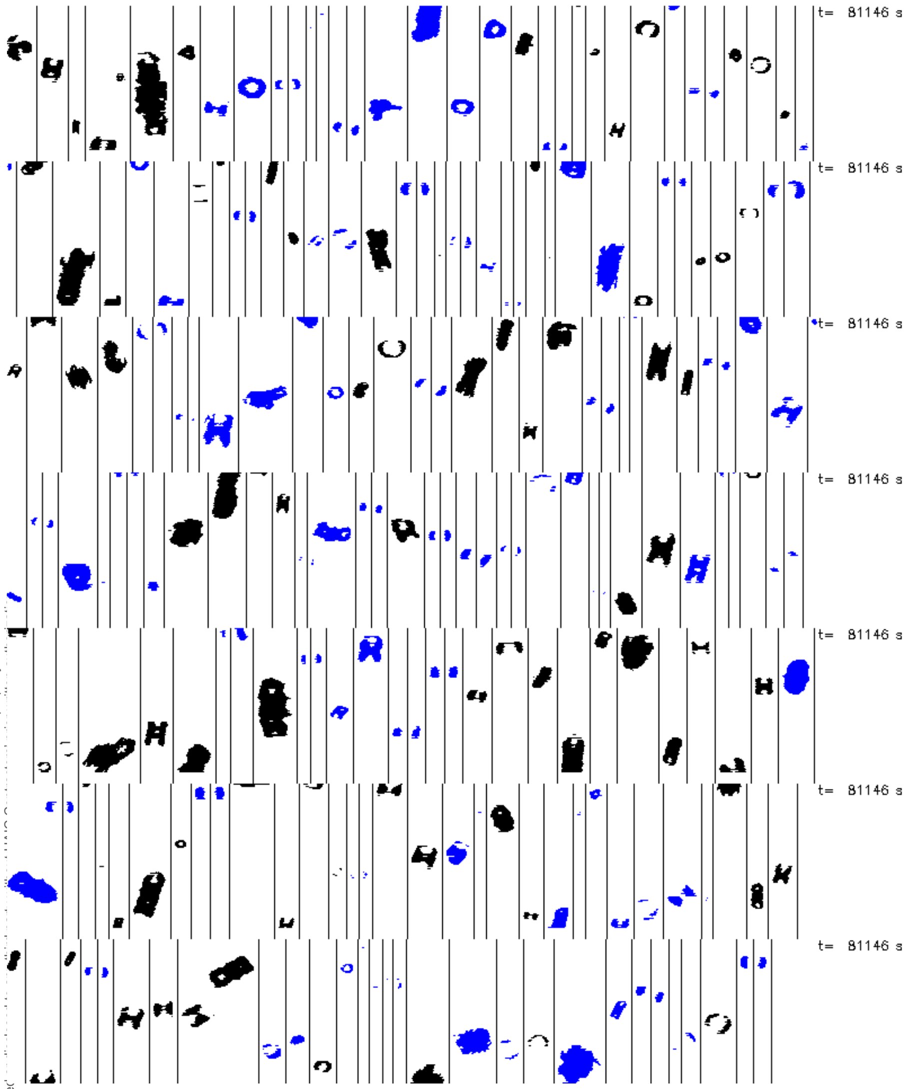
Let's assume that a shattering event should inject at least 3 fragmented neighbouring particles with itt < τ^*

Confront this Npmin=3 result with Npmin=2

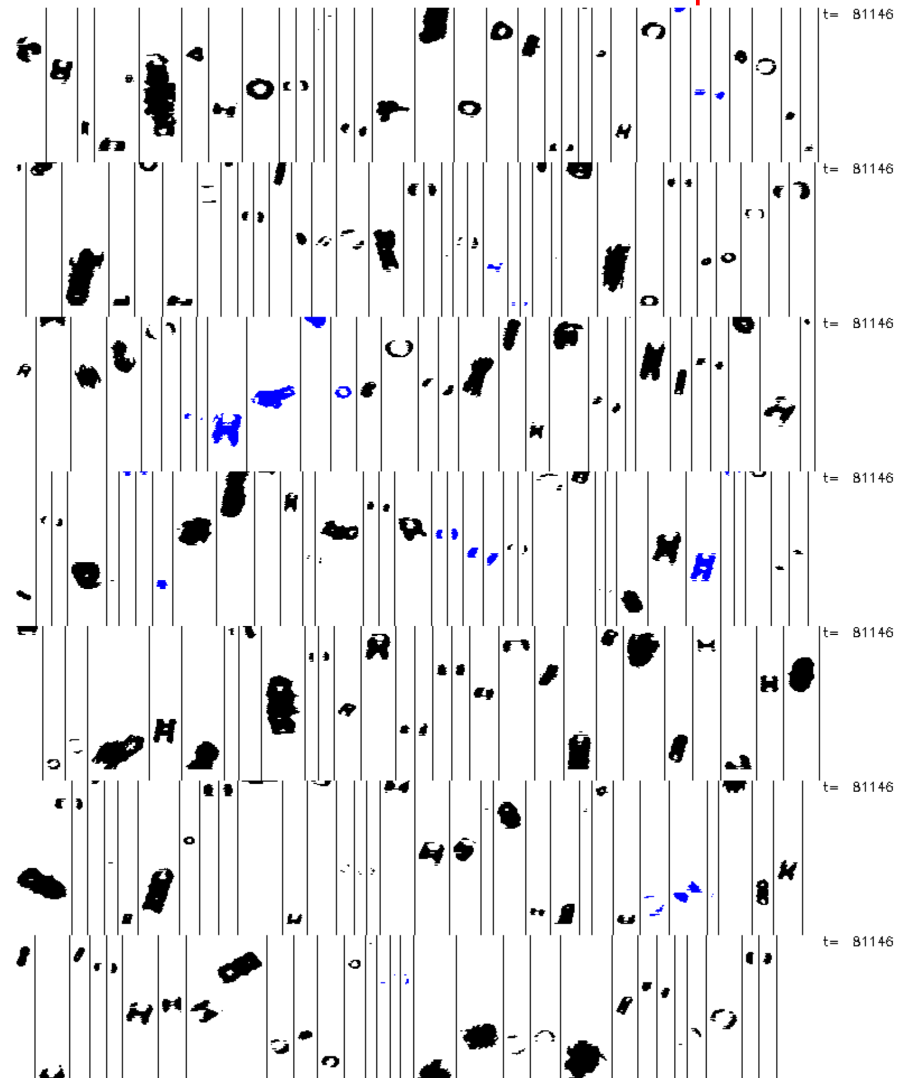
HAIC – High Altitude Ice Crystals
Data treatment intercomparison

Results 9/11 : Differences

Npmin=2

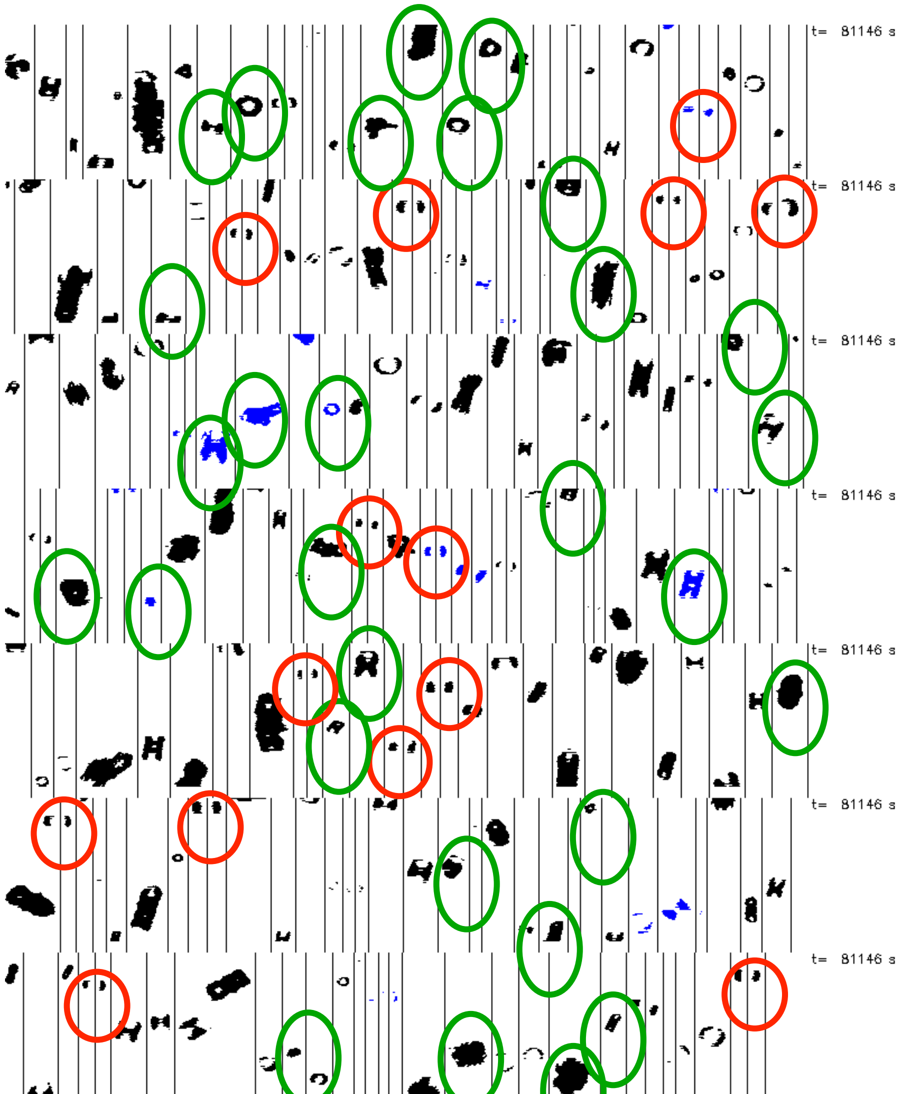


Npmin=3



Results 10/11 : Differences

Npmin=3



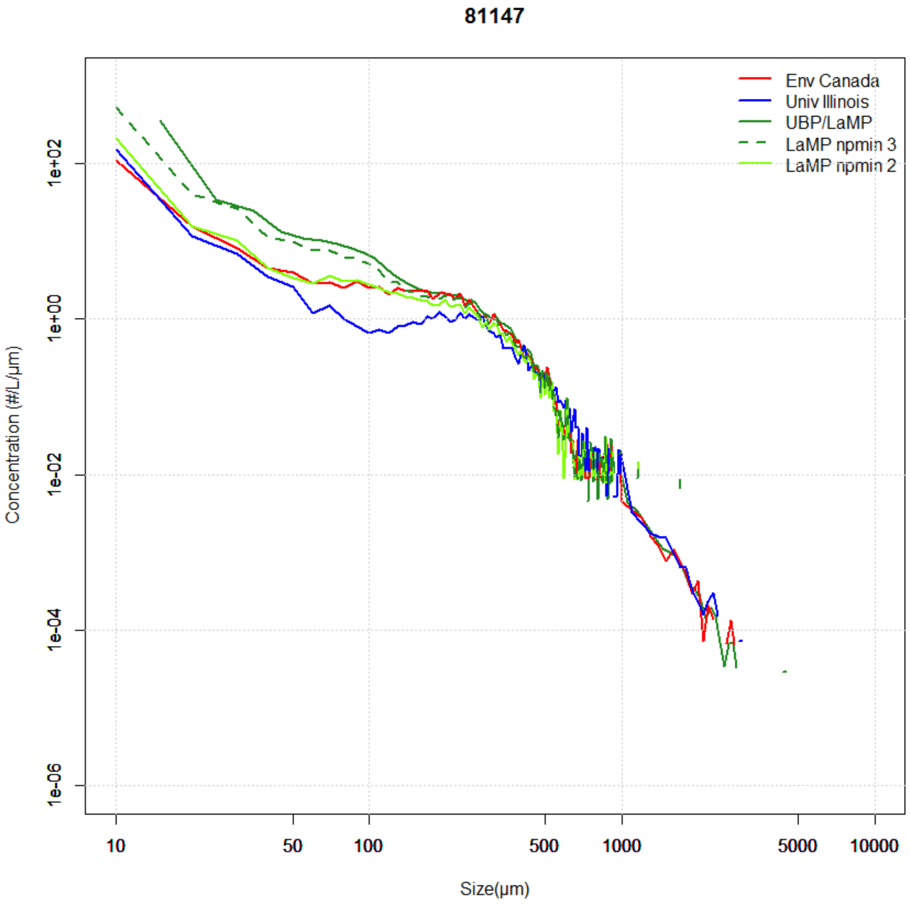
- (red circle) Out of focus patterns in two different frames are conserved and thus have to be treated separately

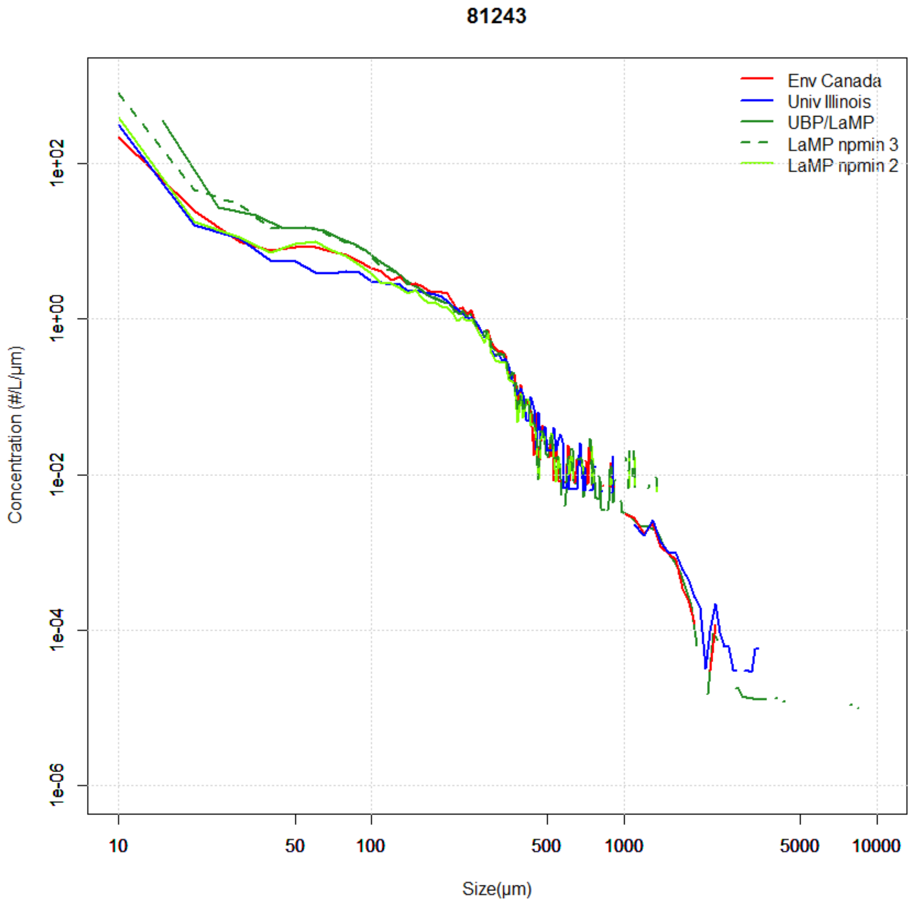
- (green circle) A lot of interesting images are recovered

The number of images removed by shattering is reduced in a significant way

Results 7/11 : Differences

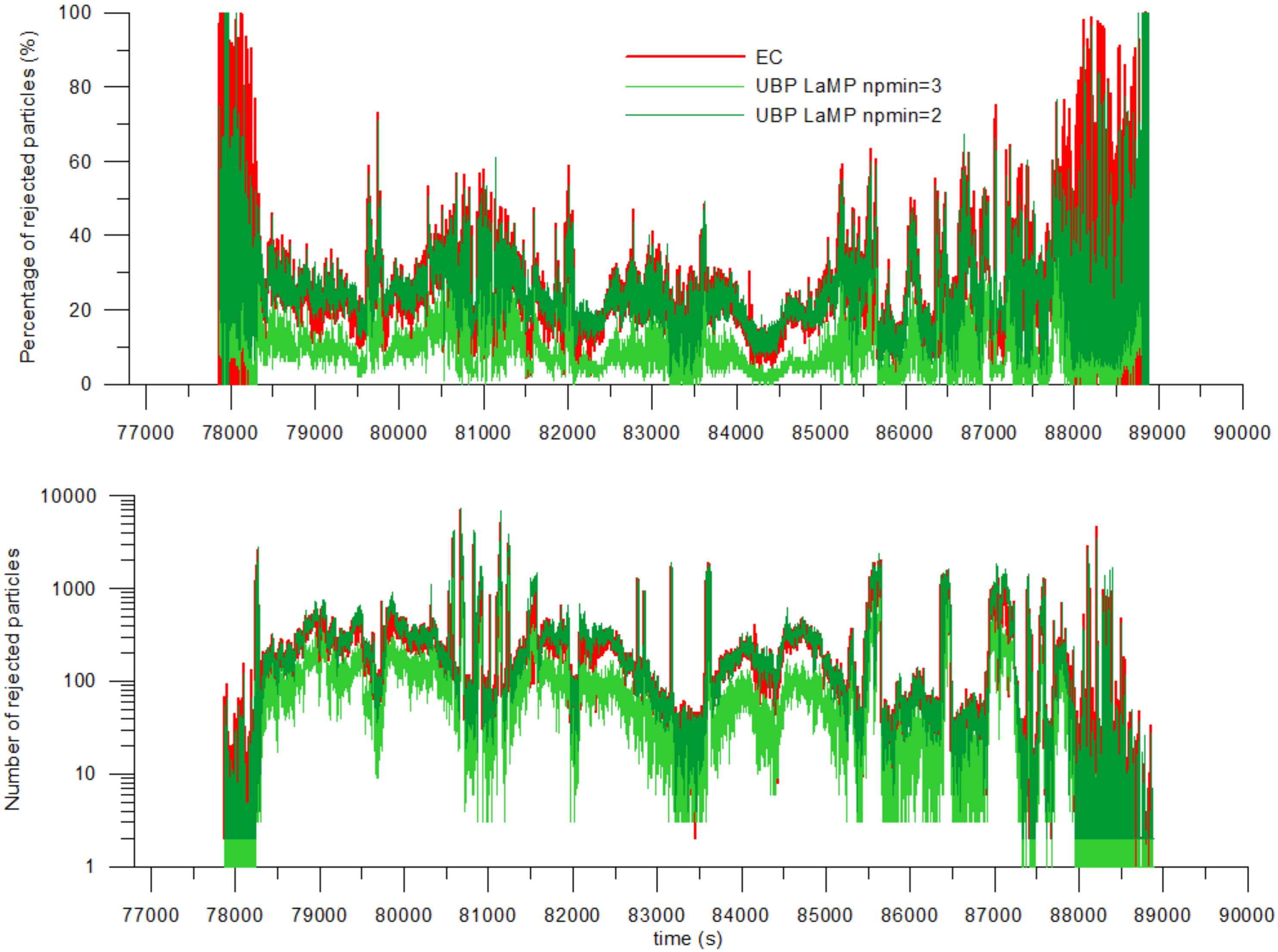
Effect on the particle size distributions (1s)





HAIC – High Altitude Ice Crystals
Way forward

Results 11/11 : Differences



Changing the threshold from 2 particles to 3 particles causes a major reduction in the number of rejected particles.

HAIC – High Altitude Ice Crystals

Way forward after NY meeting (March 2015)

Objectif 3

- All corrections applied at once gives reasonable agreement (studied PSD and MMD differences).

➔ distribute a preliminary version of PSD/MMDs dataset

Objectif 4

- Continue time consuming detailed step by step processing

1. Implementing interarrival time algorithm

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Intercomparison exercice

Timeline	Actions
New York meeting	Next proposed step : compare results with only the shattering treatment
April - June	Stand by due to the preparation and conduction of Cayenne campaign
End July	CNRS-LaMP provided on the ftp the PSDs obtained with only the shattering treatment (message and reminder from Delphine)
End October	UI and EC data not provided

→ Nothing new since New York meeting on the intercomparison exercice

→ LaMP decided to work on the retrieval of m(D) relations for calculation of mass PSD, MMDs and other percentiles and also put effort into processing of CDP PSDs.

Update on data availability

Status on intercomparison exercice UI, EC, CNRS-LaMP/UBP

Work since New York meeting (March 2015)

- m(D) retrieval, mass SD (thus MMD, etc..)
- CDP PSDs

MMD computation method

Previously (Results presented in NYC):

1) Size retrieval → $Deq=\sqrt{4*S/\pi}$ → 2) Particle number SD → $m=\alpha Deq^{\beta}$ → 3) Particle mass SD, MMD, …

α and β from Brown and Francis (1995)

New method:

β(t) deduced from the analysis of the images using results of 3D particle simulations

1) Size retrieval → ***D***=*Deq, Dmax, Ly,* $(Lx+Ly)/2$ → 2) Particle number SD → $m=\alpha(t)\boldsymbol{D}^{\beta(t)}$ → 3) Particle mass SD, MMD, …

α(t) deduced from IKP: $TWC(t)=\alpha(t)\sum_i N(i) D(i)^{\beta(t)}$

MMD computation method

Previously (Results presented in NYC):

1) Size retrieval → $Deq = \sqrt{4 * S / \pi}$ → 2) Particle number SD → $m = \alpha D^{\beta}$ → 3) Particle mass SD, MMD, …

α and β from Brown and Francis (1995)

New method: A) sensitivity tests

1) Size retrieval → here: **D**=Dmax → 2) Particle number SD → $m = \alpha(t) \boldsymbol{D}^{\beta(t)}$ → 3) Particle mass SD, MMD, …

α and β from Fontaine et al. (2014)

Then keep β constant (=1,2,3) and α(t) deduced from IKP TWC : $TWC(t) = \alpha(t) \sum_i N(i) D(i)^{\beta}$

Main conclusions : MMD values

- do not depend on the α parameter
- are sensitive to the value of β
- when α and β are constant in time, then the MMD is very sensitive to the initial size definition (Deq or Dmax) : MMDeq ≠ MMDmax

MMD computation method

New method: B) developpement (extension of Fontaine et al. 2014 work)

Specifications :

Valid for different diameter definitions : *Deq, Dmax, Dy,* $Dm = (Dx + Dy)/2$

+

α and β values should reflect the ice shape and density variabilities

β(t) deduced from the analysis of the images using results of 3D particle simulations

1) Size retrieval

D = *Deq, Dmax, Dy,* or $Dm = (Dx + Dy)/2$

2) Particle number SD

$m = \alpha(t) D^{\beta(t)}$

3) Particle mass SD, MMD, …

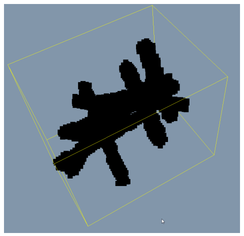
α(t) deduced from IKP: $TWC(t) = \alpha(t) \sum_i N(i) D(i)^{\beta(t)}$

MMD computation method

New method: B) developpement (extension of Fontaine et al. 2014 work)

THEORY

3D particles simulations



→ β

2D particles projections

Surface-size relationship

$$S=\gamma\,\mathbf{D}^{\sigma}$$

Perimeter-size relationship

$$P=\delta\,\mathbf{D}^{\tau}$$

$$\beta=f_D(\sigma,\tau)$$

β(t) deduced from the analysis of the images using results of 3D particle simulations

1) Size retrieval → $\mathbf{D}$=Deq, Dmax, Dy, or Dm=$Dx+Dy/2$ → 2) Particle number SD → $m=\alpha(t)\,\mathbf{D}^{\beta(t)}$ → 3) Particle mass SD, MMD, …

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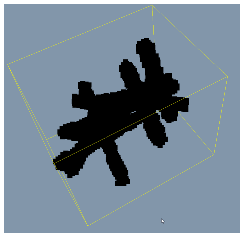
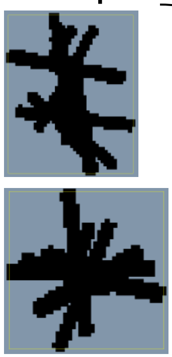


→ β

2D particles projections



Surface-size relationship

$S = \gamma \mathbf{D}^{\sigma}$

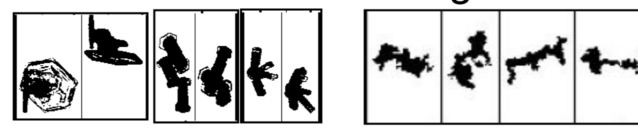
Perimeter-size relationship

$P = \delta \mathbf{D}^{\tau}$

$\beta = f_D(\sigma, \tau)$

IN-SITU DATA

2D-S & PIP images



$\mathbf{D}$ $\quad S = \gamma D^{\sigma}$ $\quad N(D)$

$P = \delta D^{\tau}$

$\beta = f_D(\sigma, \tau)$

1) Size retrieval

$\mathbf{D}$=Deq, Dmax, Dy, or Dm=$Dx + Dy/2$

2) Particle number SD

$m = \alpha(t) \mathbf{D}^{\beta(t)}$

3) Particle mass SD, MMD, …

α(t) deduced from IKP: $TWC(t) = \alpha(t) \sum_i N(i) D(i)^{\beta(t)}$

MMD computation method

New method: B) developpement (extension of Fontaine et al. 2014 work)

Main conclusion :
With the new method, the MMD sensitivity to the initial size definition is significantly reduced:

MMDeq ~ MMDmax ~ MMDy ~ MMDm

➔ Ice Crystal Sizes in High Ice Water Content Clouds. Part I : Mass-size relationships derived from particle images and TWC for various crystal diameter definitions and impact on median mass diameter, Leroy et al., Part I, 2015a, manuscript submitted to JAOT.

3- Analysis of HAIC-HIWC 1st field campaign results

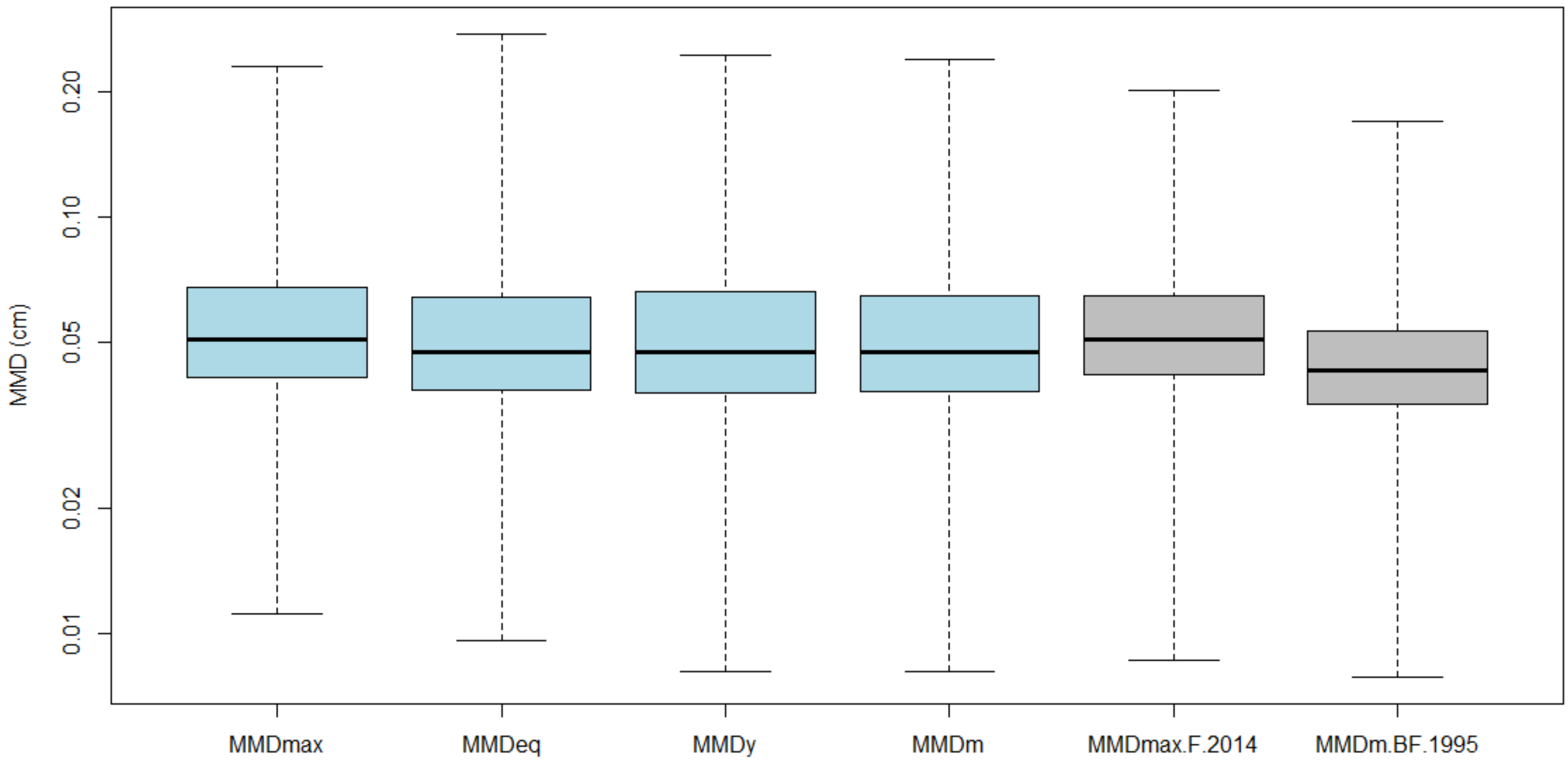
➔ Ice Crystal Sizes in High Ice Water Content Clouds. Part II Median Mass diameters in tropical convection observed within HAIC/HIWC, Leroy et al., Part II, 2015b, to be submitted after Melbourne meeting to JAOT.

MMD results

<u>HAIC Darwin data selection:</u>

- Aircraft is flying on constant level
- IKP TWC is larger than 0.1 g/m3

All flights considered



MMDeq ~ MMDmax ~ MMDy ~ MMDm

Update on data availability

Status on intercomparison exercice UI, EC, CNRS-LaMP/UBP

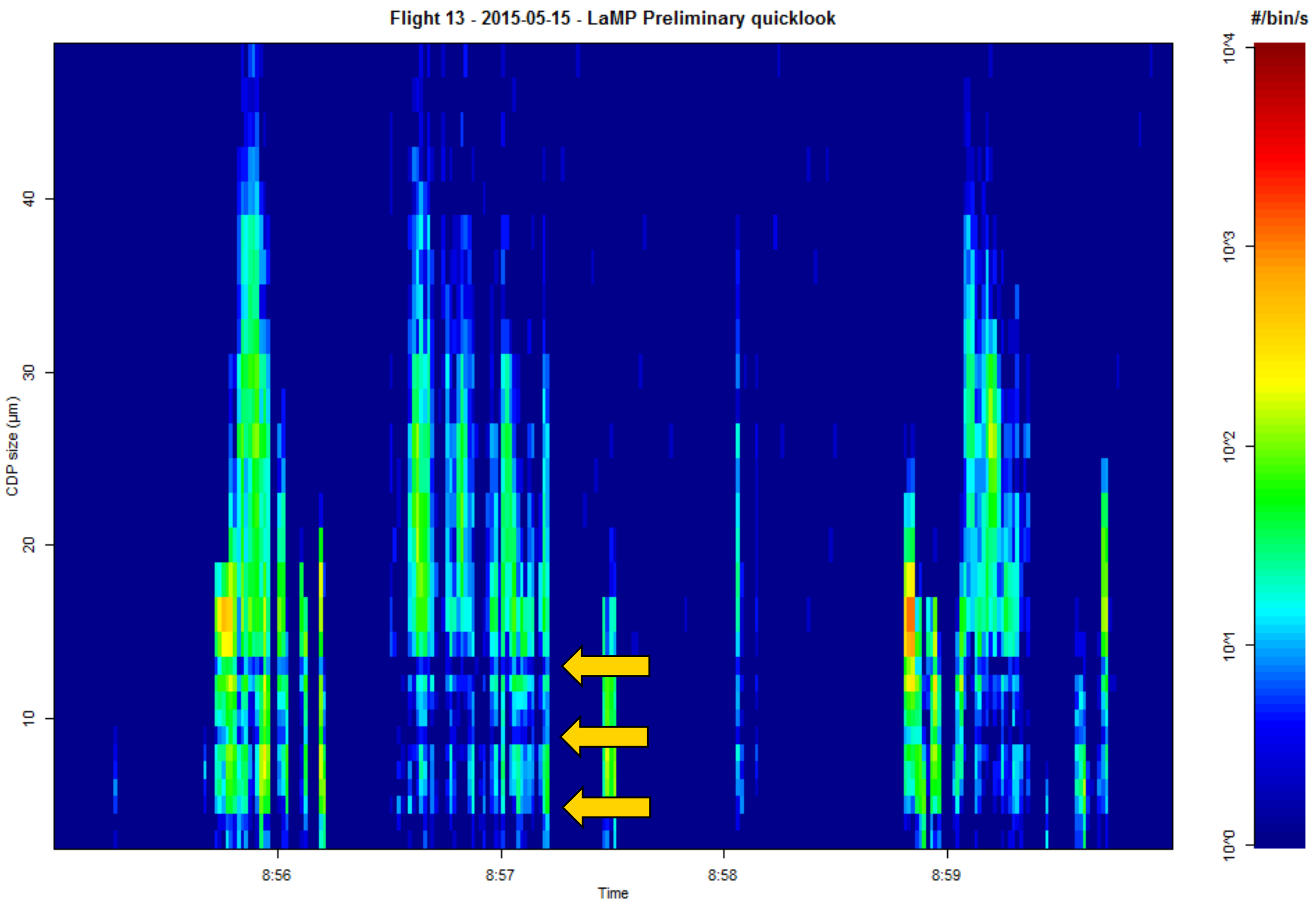
Work since New York meeting (March 2015)

- m(D) retrieval, mass SD (thus MMD, etc..)
- CDP PSDs

CDP PSD retrieval

<u>Aim:</u>

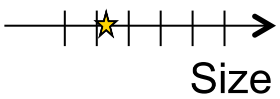
➔ Develop a new method to compute the CDP spectra that will remove the oscillations due to Mie theory



CDP PSD retrieval

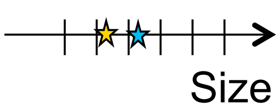
General principle

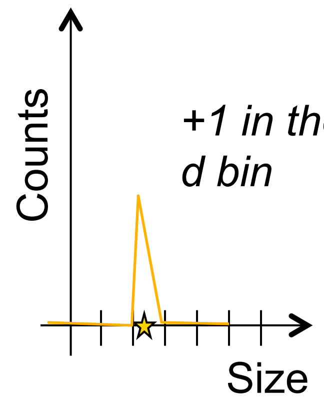
1) Choose one size randomly in the 2-50 µm range



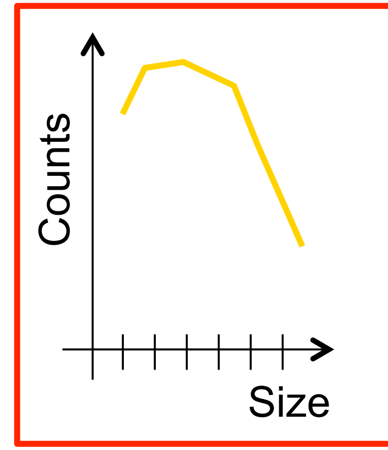
2) Compute the corresponding scattering cross section σ (mie theory)

3) According to the bin limits in σ, compute the corresponding « measured » size ★

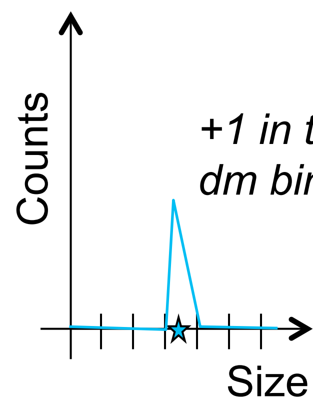




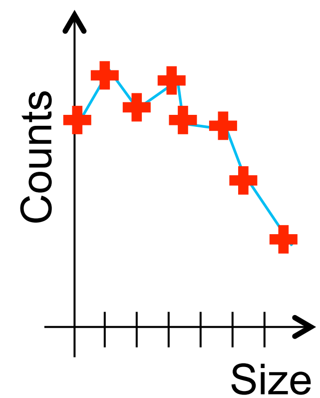
« Real » particle spectra



reconstructed« measured » particle spectra



until you get :

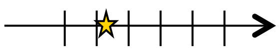


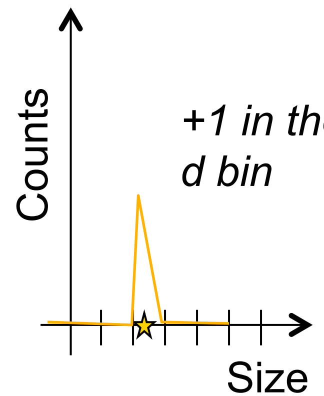
✚ « true » measurment

CDP PSD retrieval

<u>On the go :</u> preliminary sensitivity studies

1) Choose one size randomly in the 2-50 µm range





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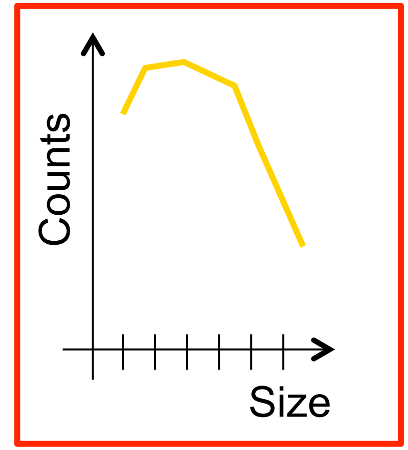


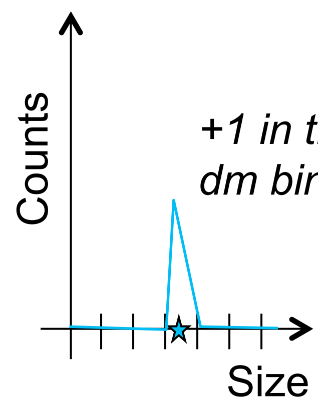
2) Compute the corresponding scattering cross section σ (mie theory)

λ

θ

3) According to the **bin limits** in σ, compute the corresponding « measured » size

recontructed« measured » particle spectra



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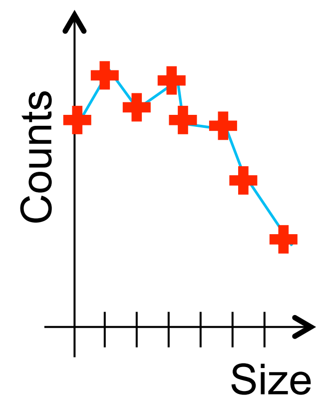

« true » measurment

High Altitude Ice Crystals (HAIC, 314314)

Project co-funded by the European Commission within the Seventh Framework Programme (2012-2016)

EUROPEAN COMMISSION
European Research Area