

Aspect Ratios, habit classifications and size distributions of ice crystals: construction of a database for the arctic, tropical and mid-latitudes

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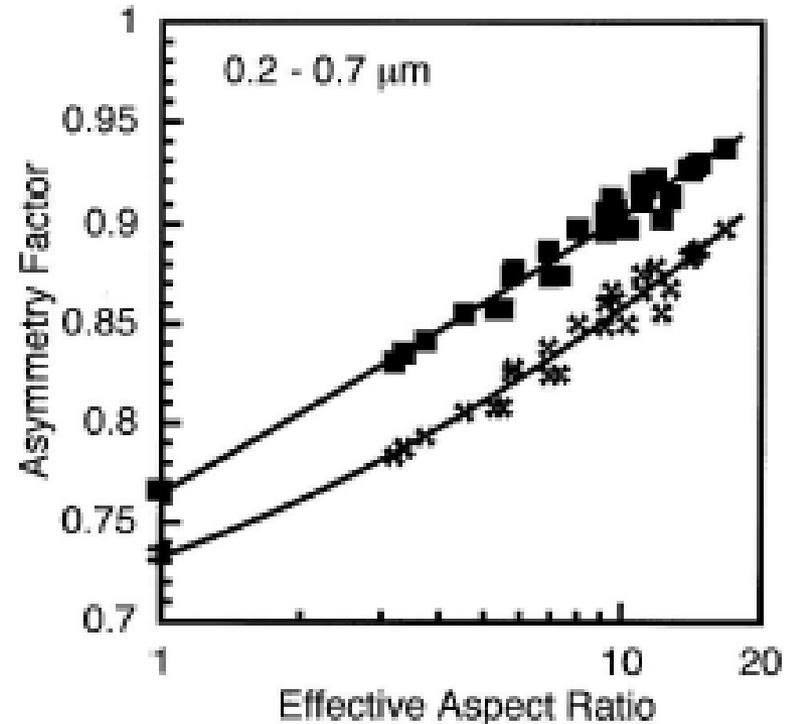
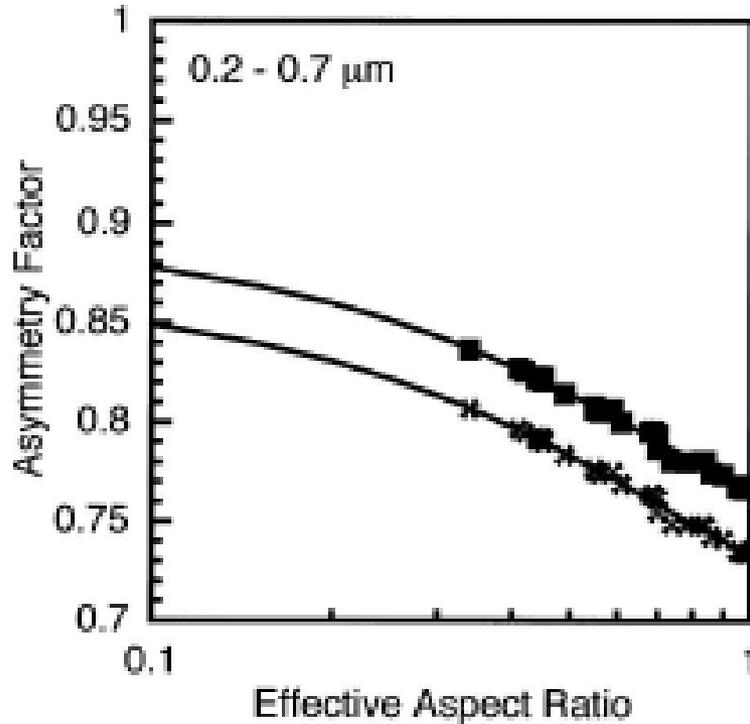
Representations of ice μ physics

- **Single-particle properties:**
 - Aspect ratios, masses, areas of ice crystals
 - Surface roughness and its effect on optics
 - Fall velocities, scattering properties
- **Particle distributions**
 - M-D & A-D relations used in μ physics & optics
 - Size distributions, $N(D)=N_0D^\mu e^{-\lambda D}$
 - Habit distributions, Effective diameter, mass-weighted velocity, scattering properties, process rates, etc.
- **How do uncertainties cascade to larger scales?**
- **How do properties vary by location, cloud type, vertical motion, dynamics, meteorology, etc.**

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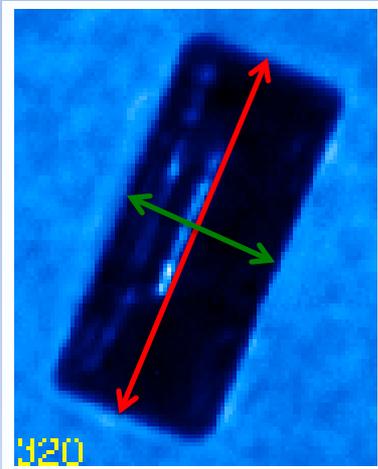
Aspect Ratios



- **Fu (2007): Aspect ratio α is key parameter for determining g for solar radiation (along with effective size)**
 - Need more data on α for single particles and controls of its variance

Aspect Ratio

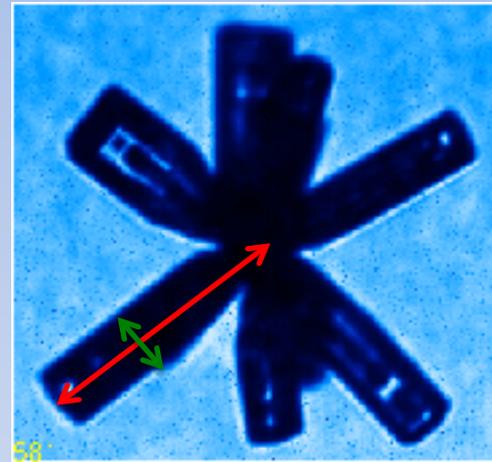
Can be determined for pristine habits: column, bullet rosettes or their aggregates



Column

Length (L)

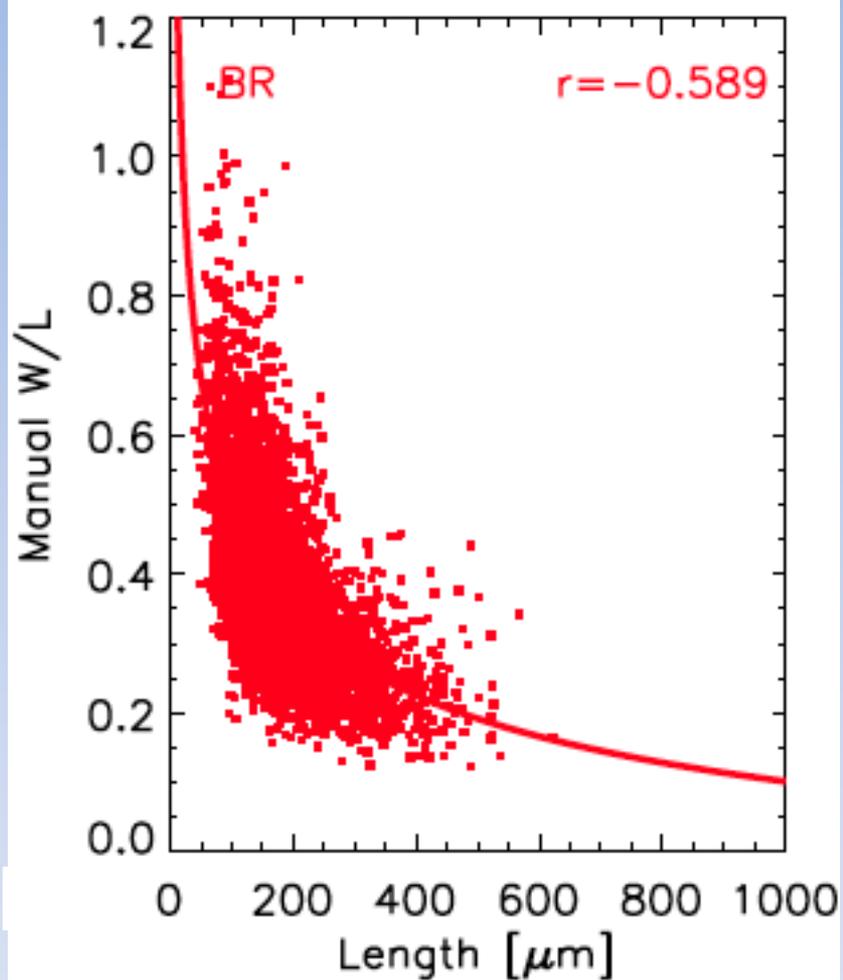
Width (W)



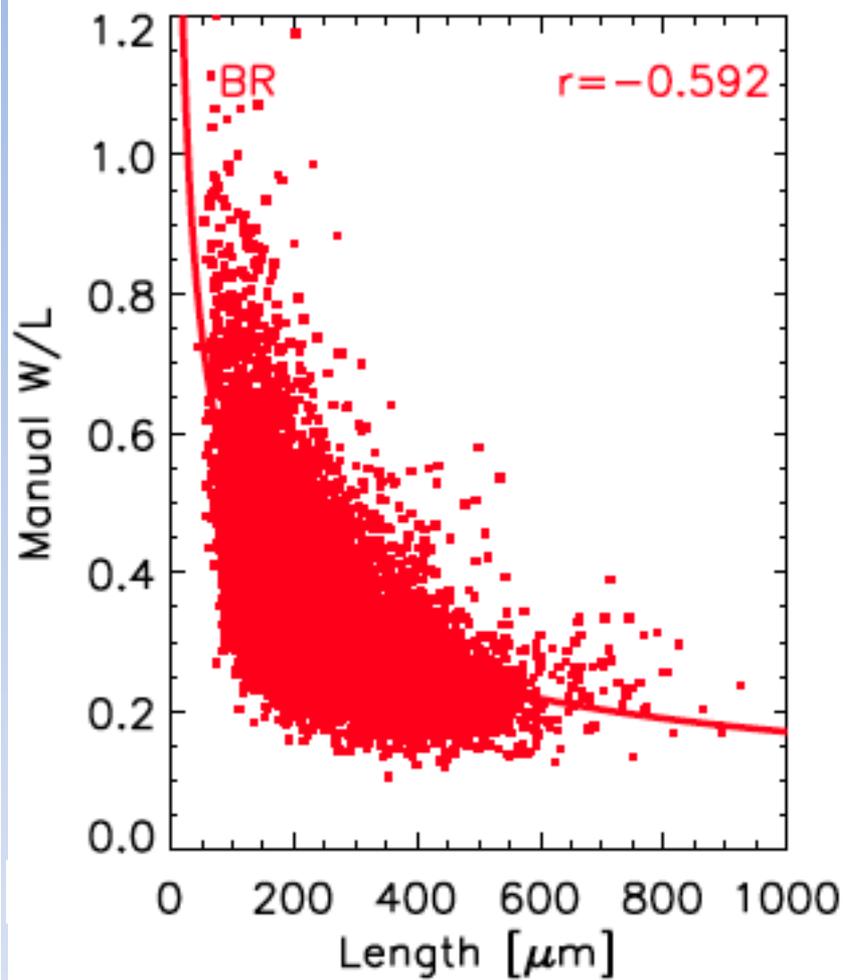
Bullet Rosette

Aspect Ratio = W/L

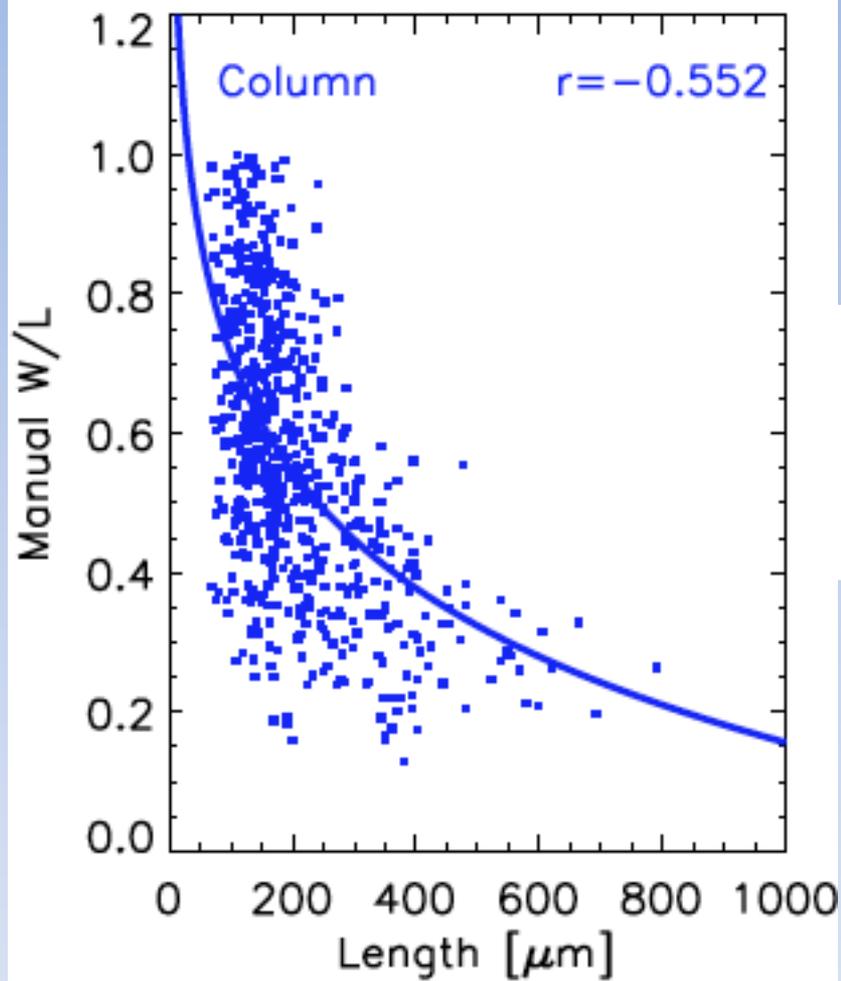
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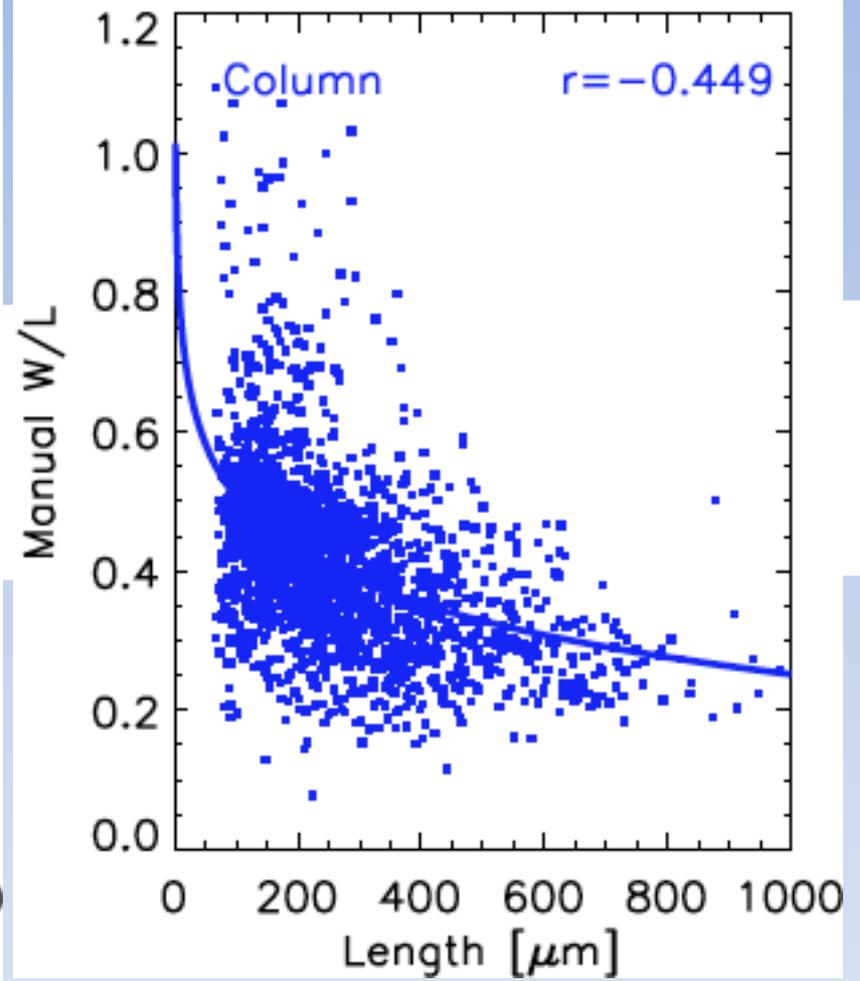
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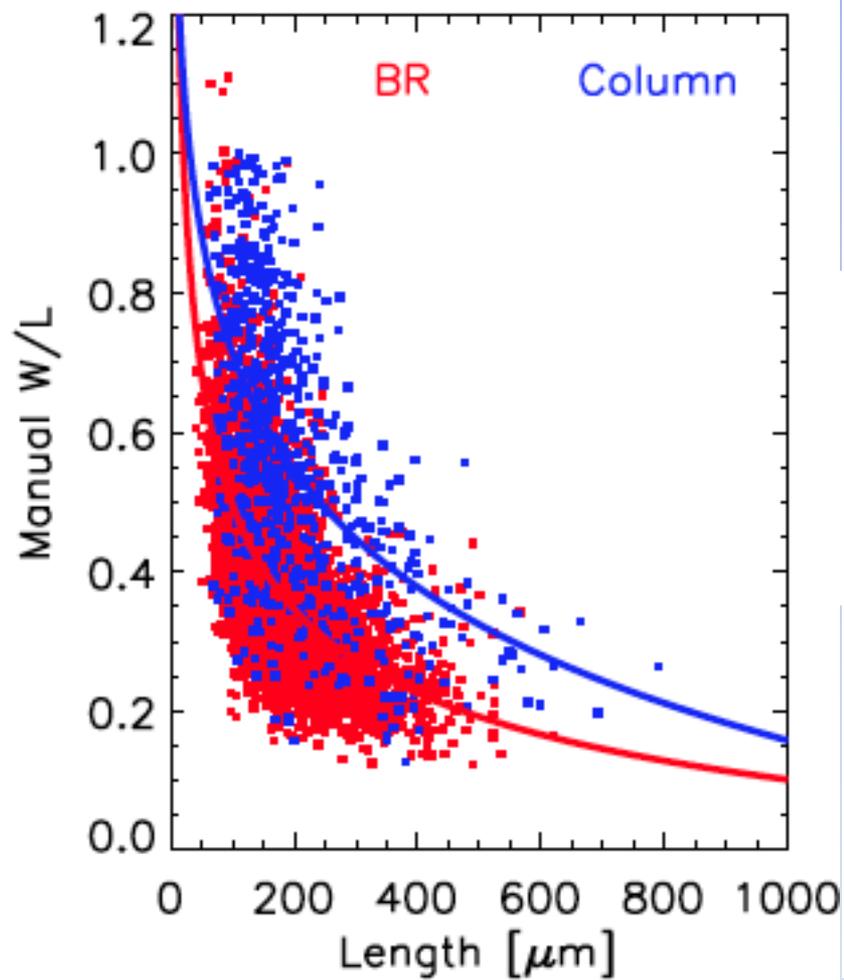
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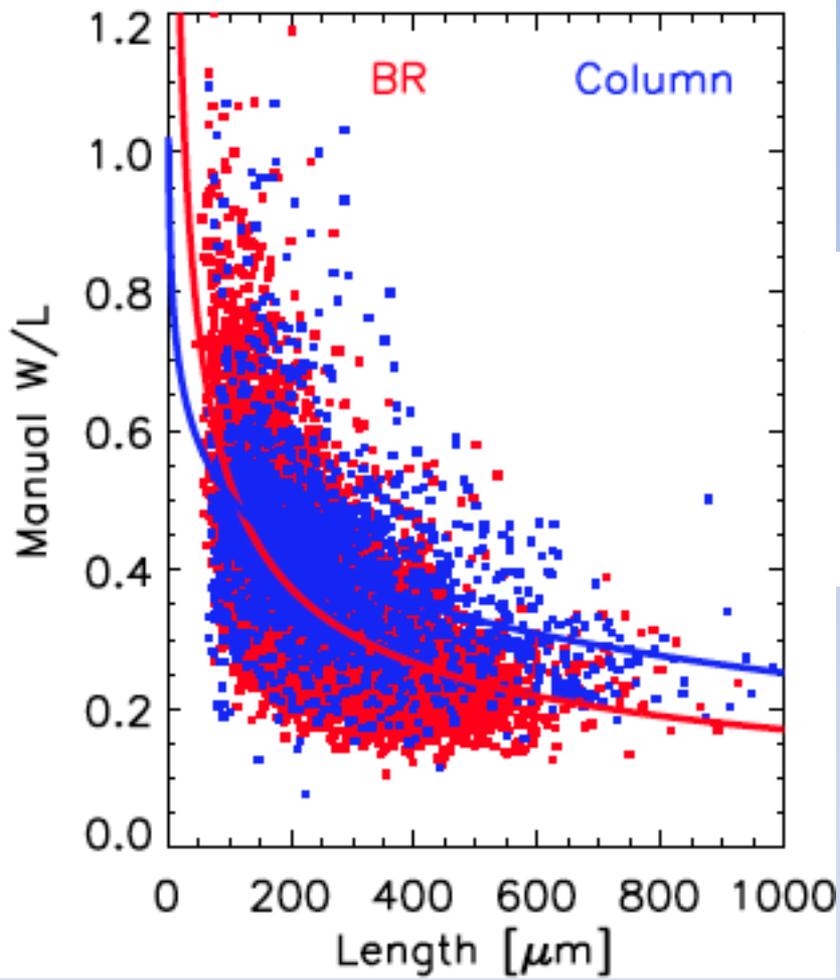
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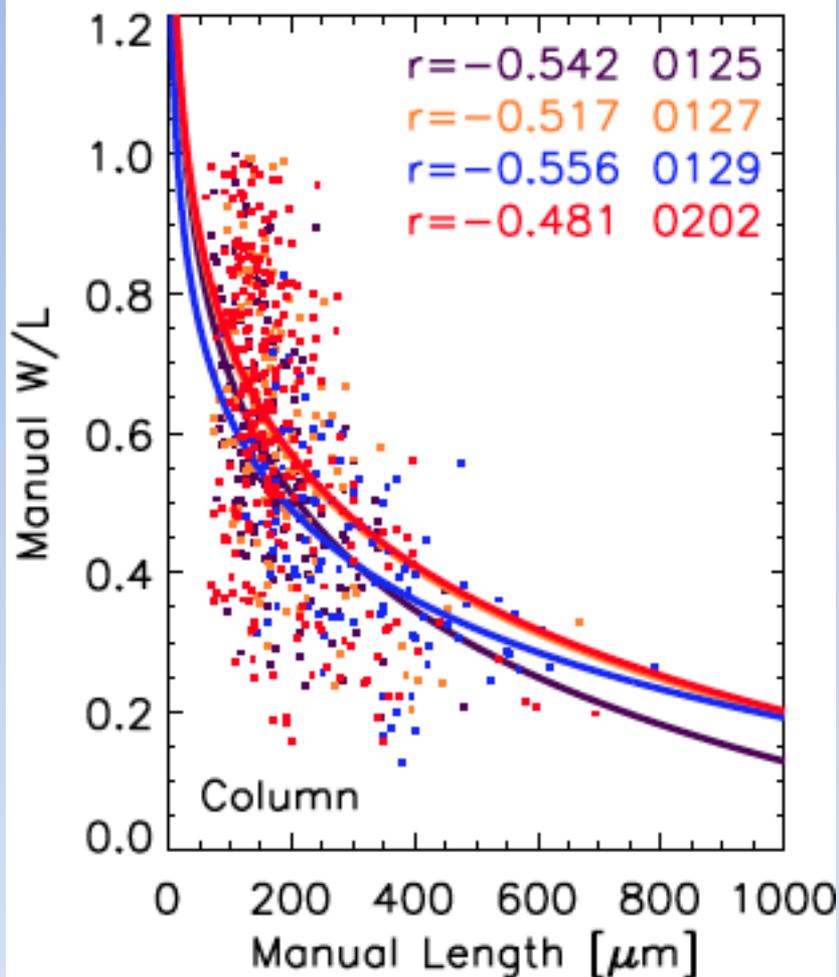
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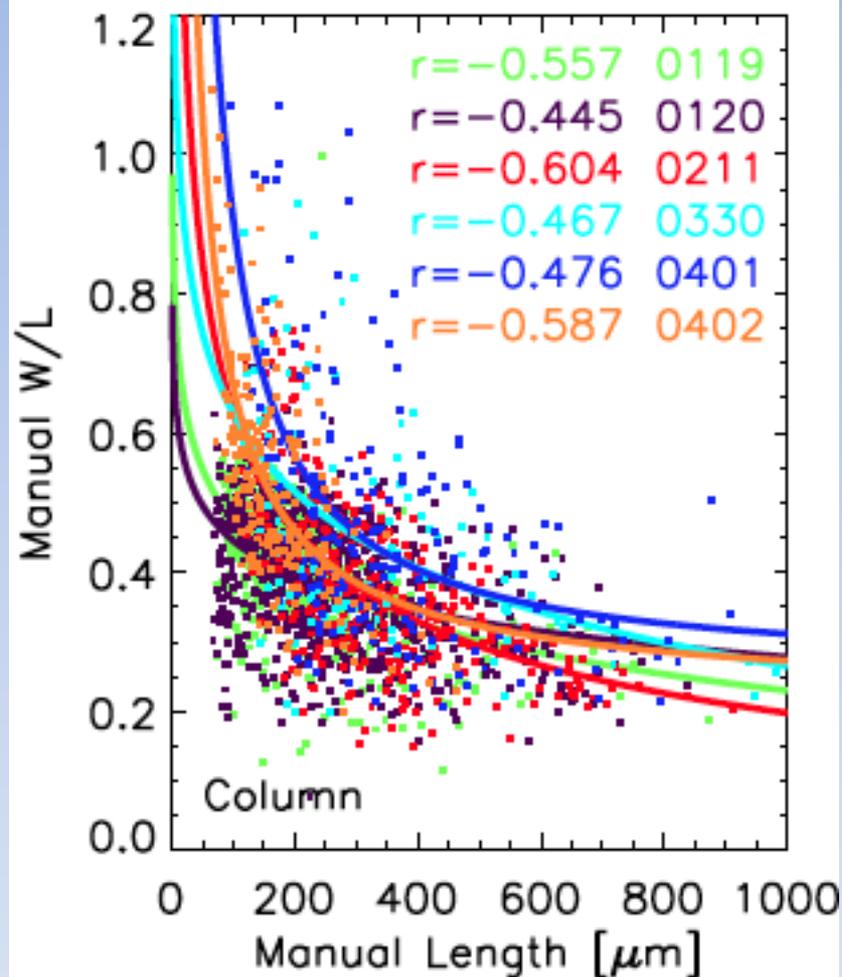
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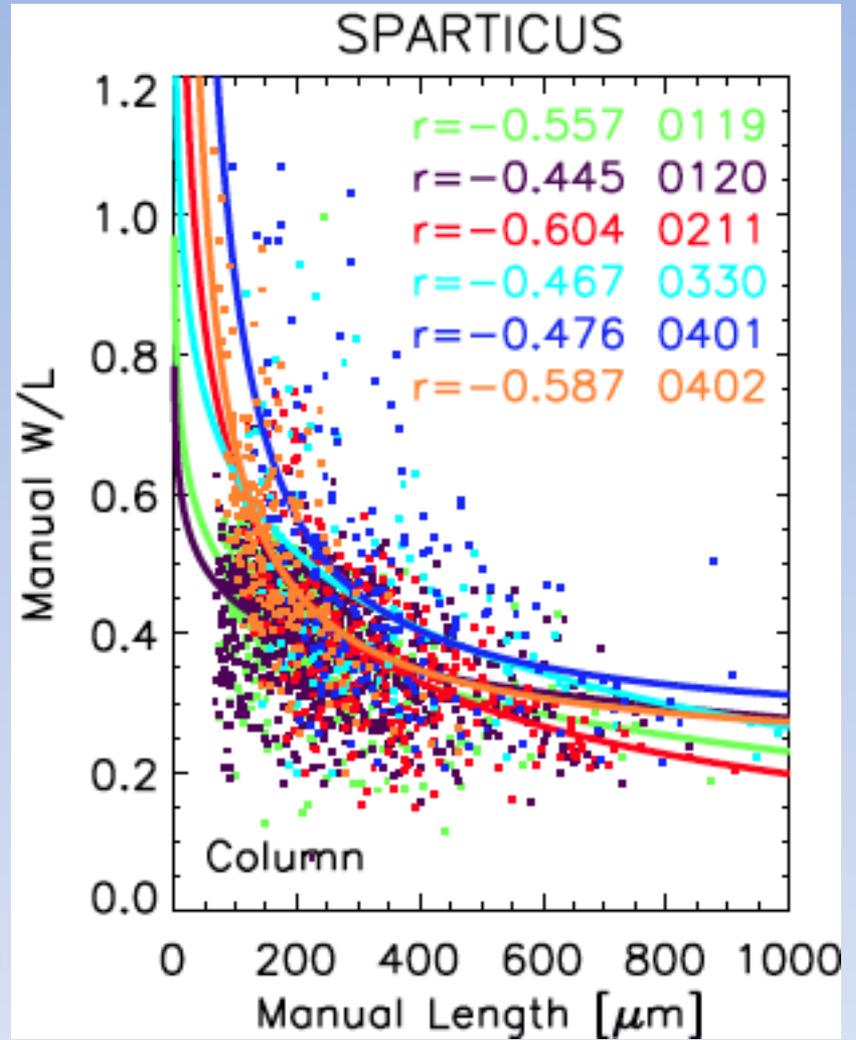
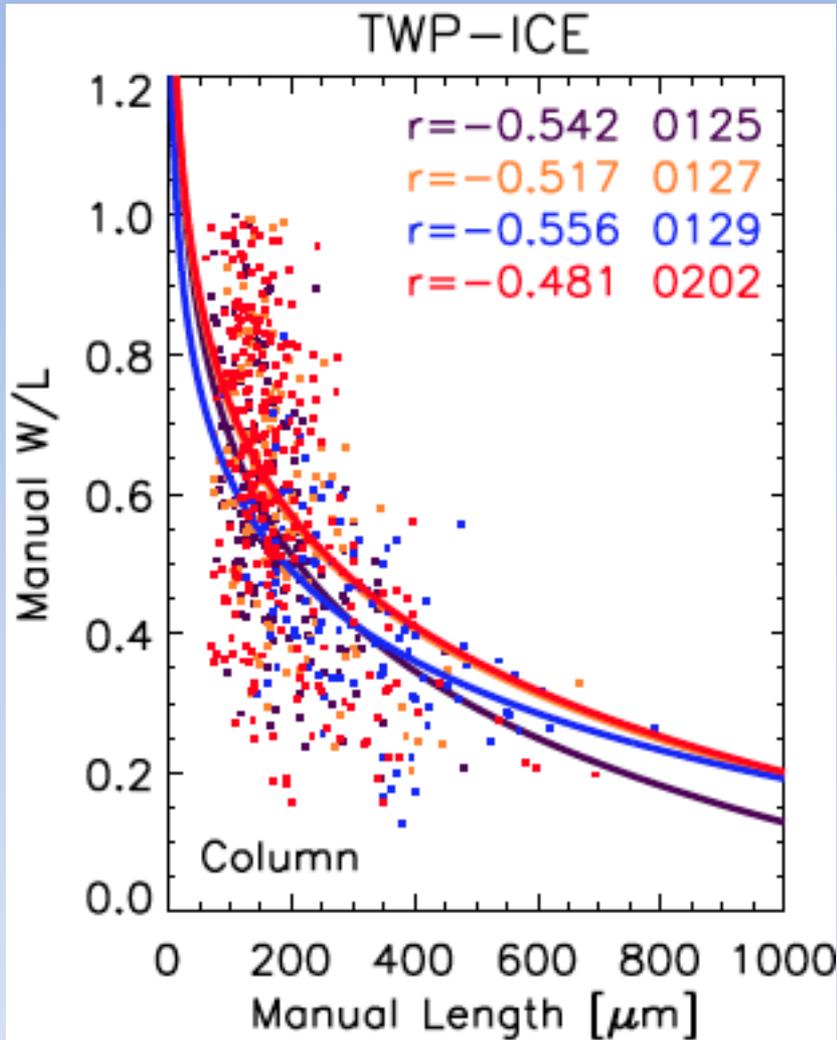


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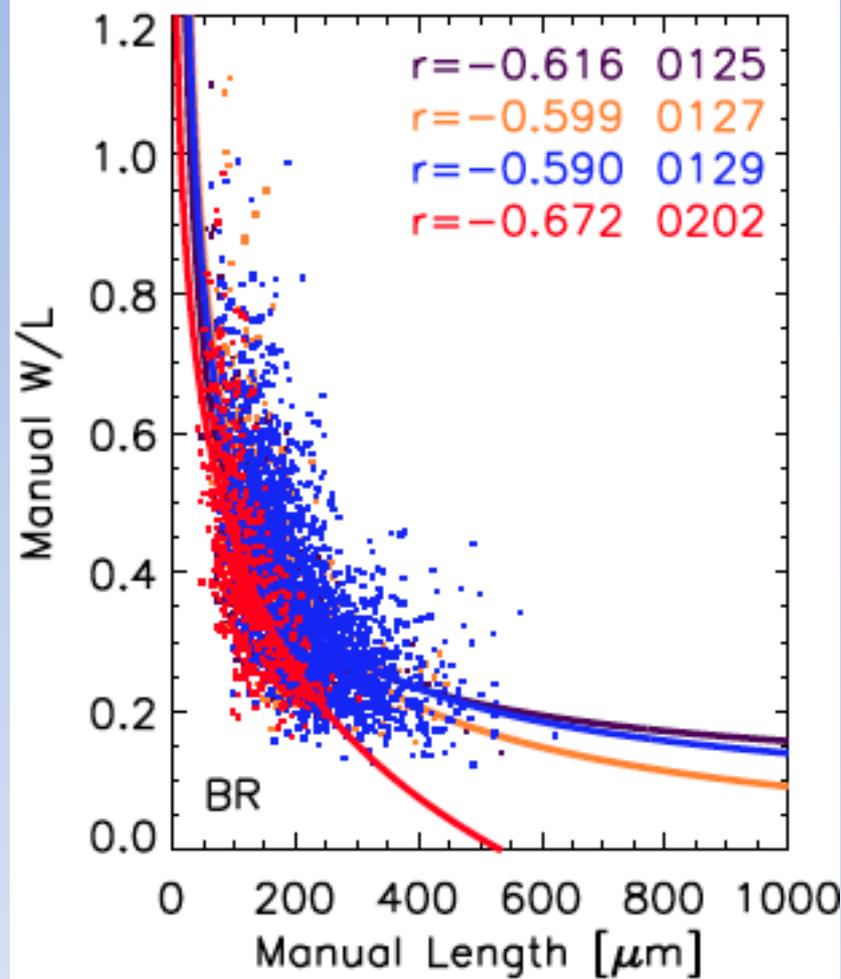
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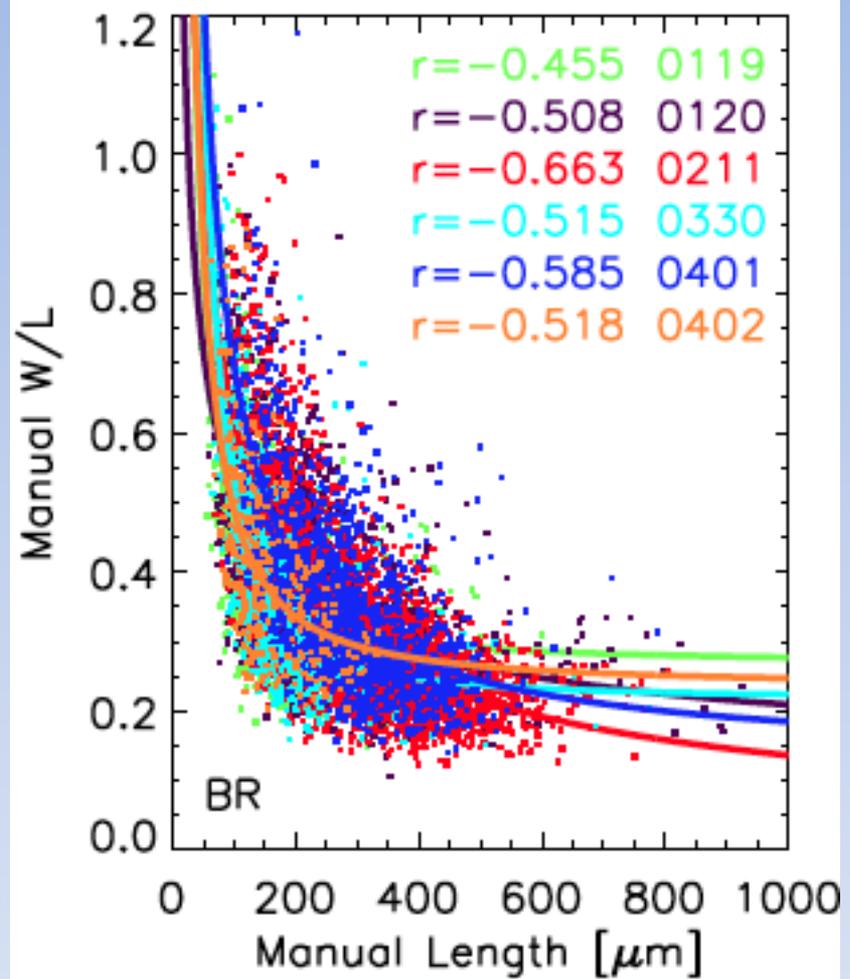


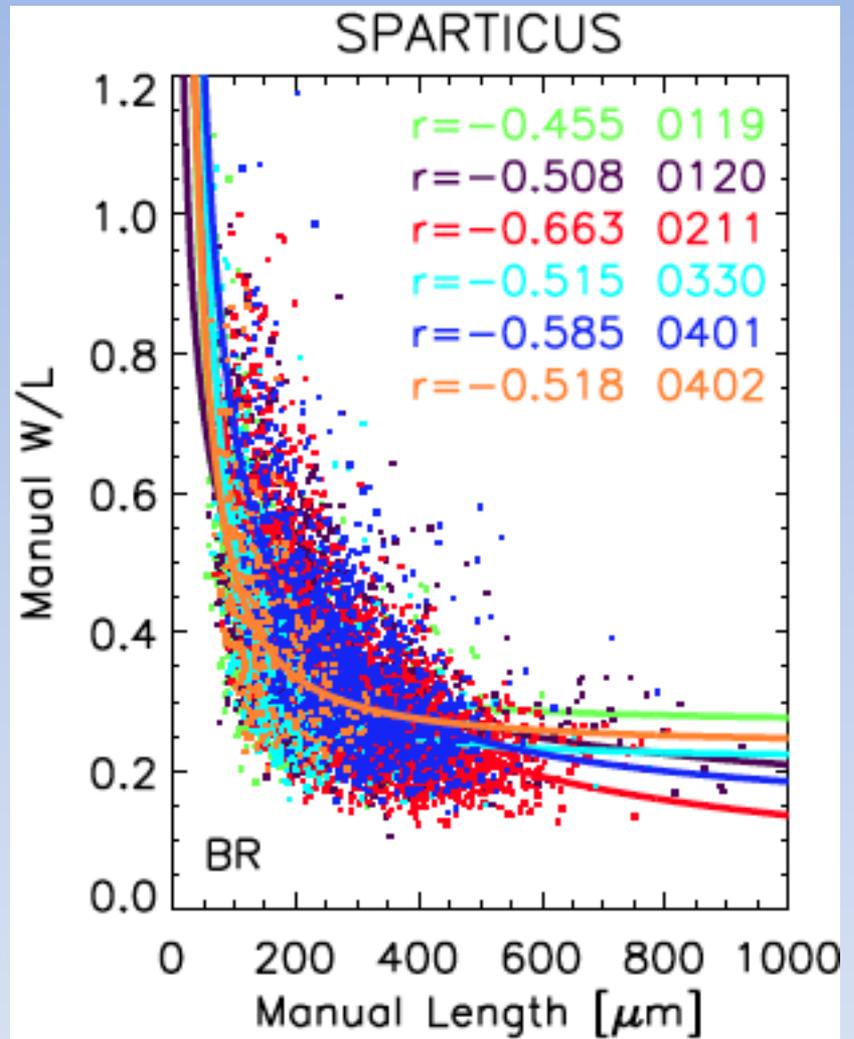
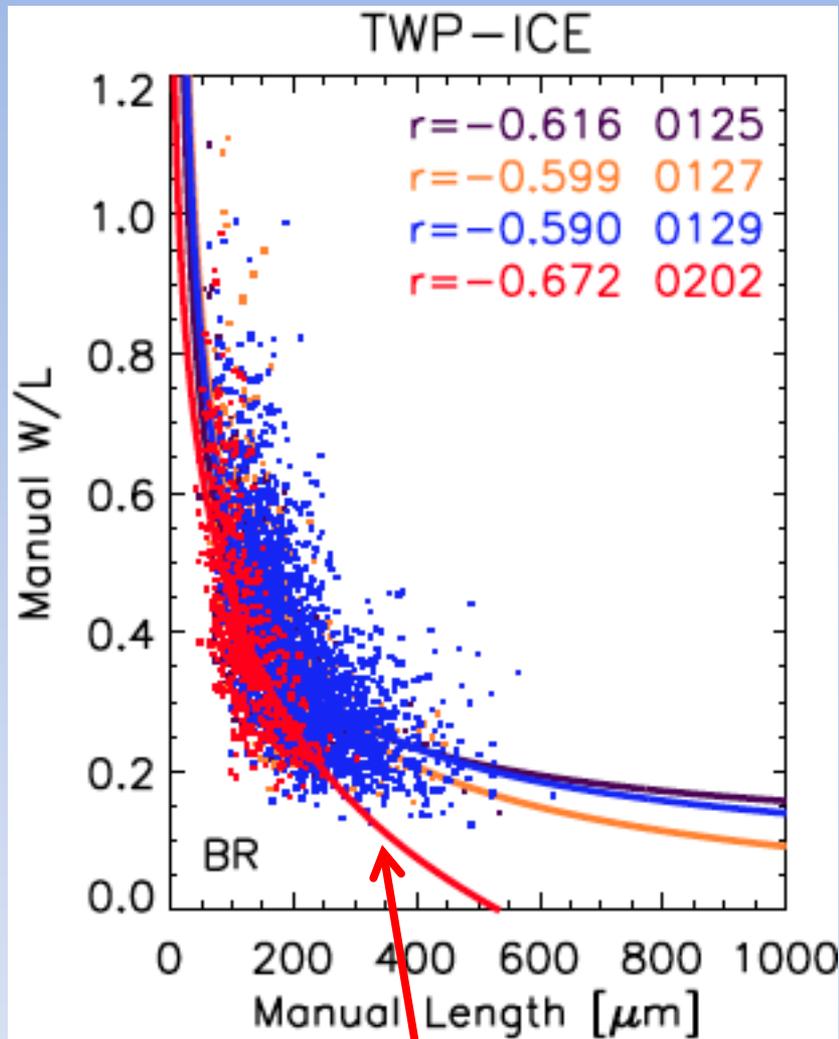
Some variability between days: systematic or random?

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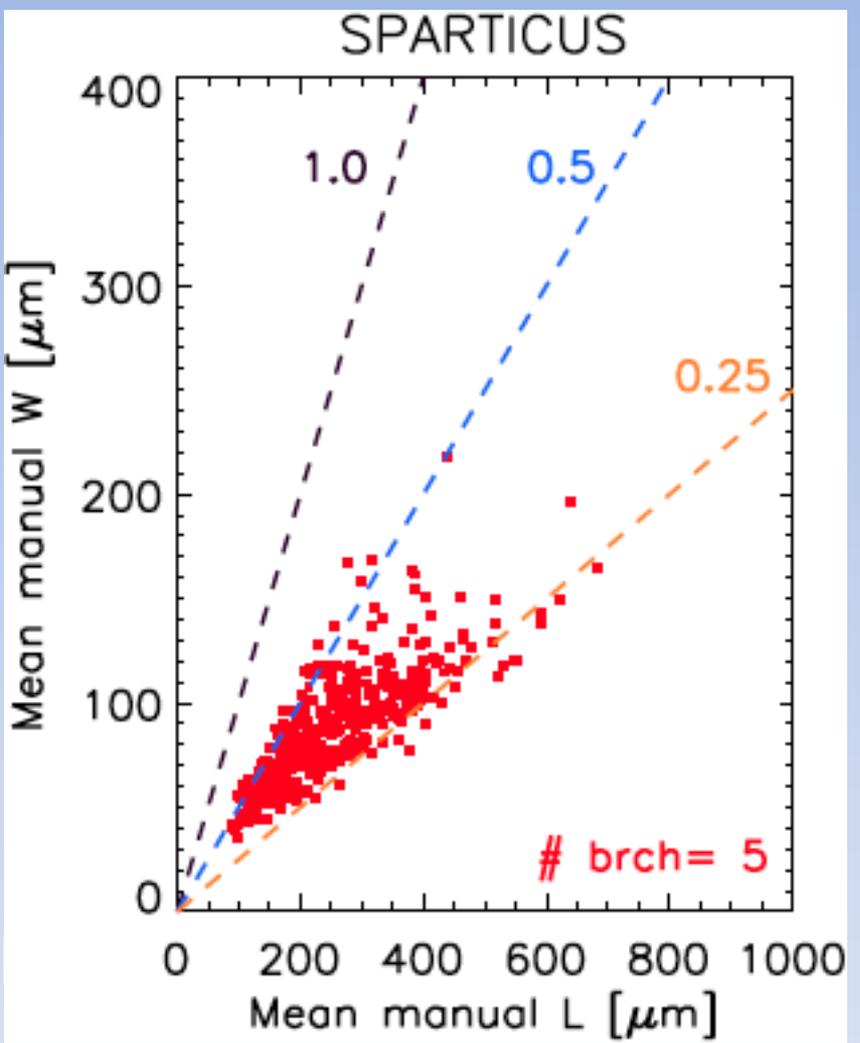
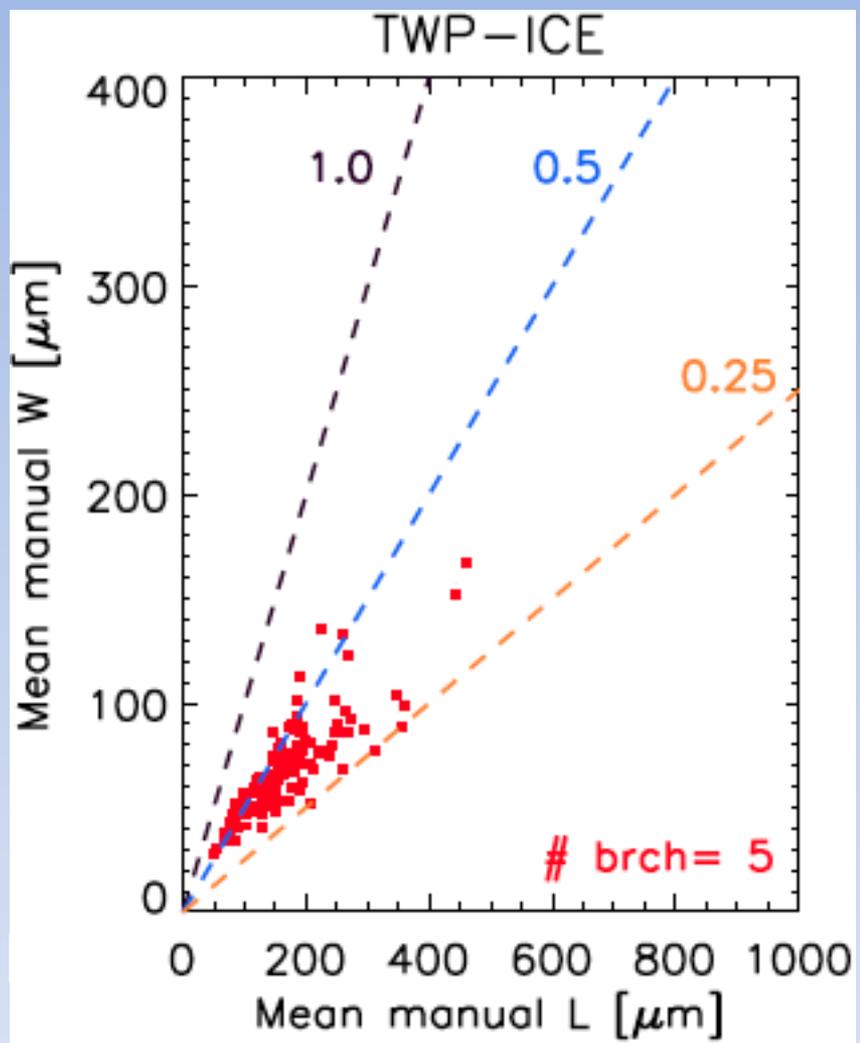


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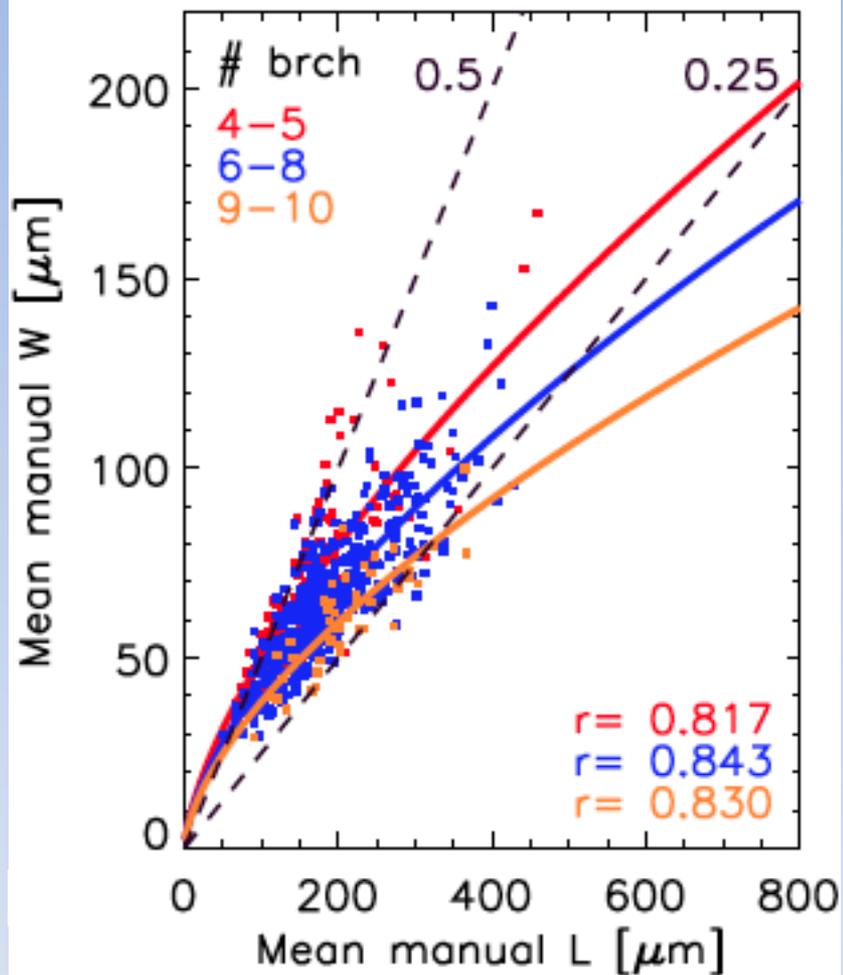




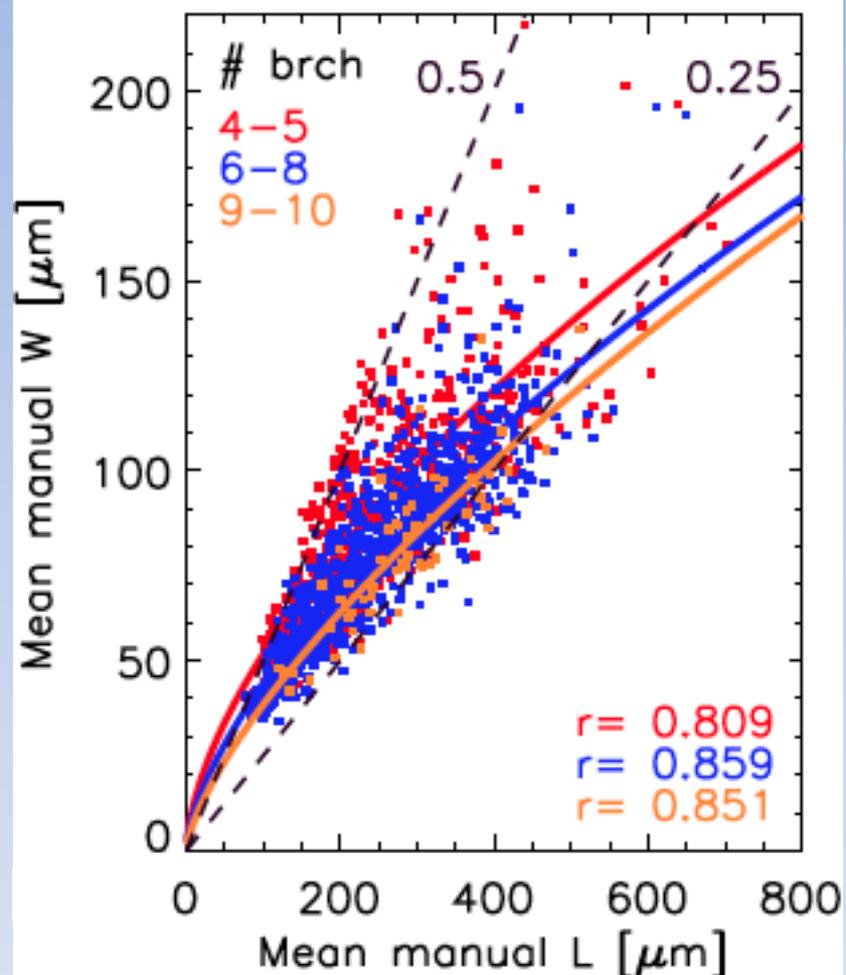
Low AR (W/L) of BR on 2 Feb.: might simply be caused by smaller BRs on that day

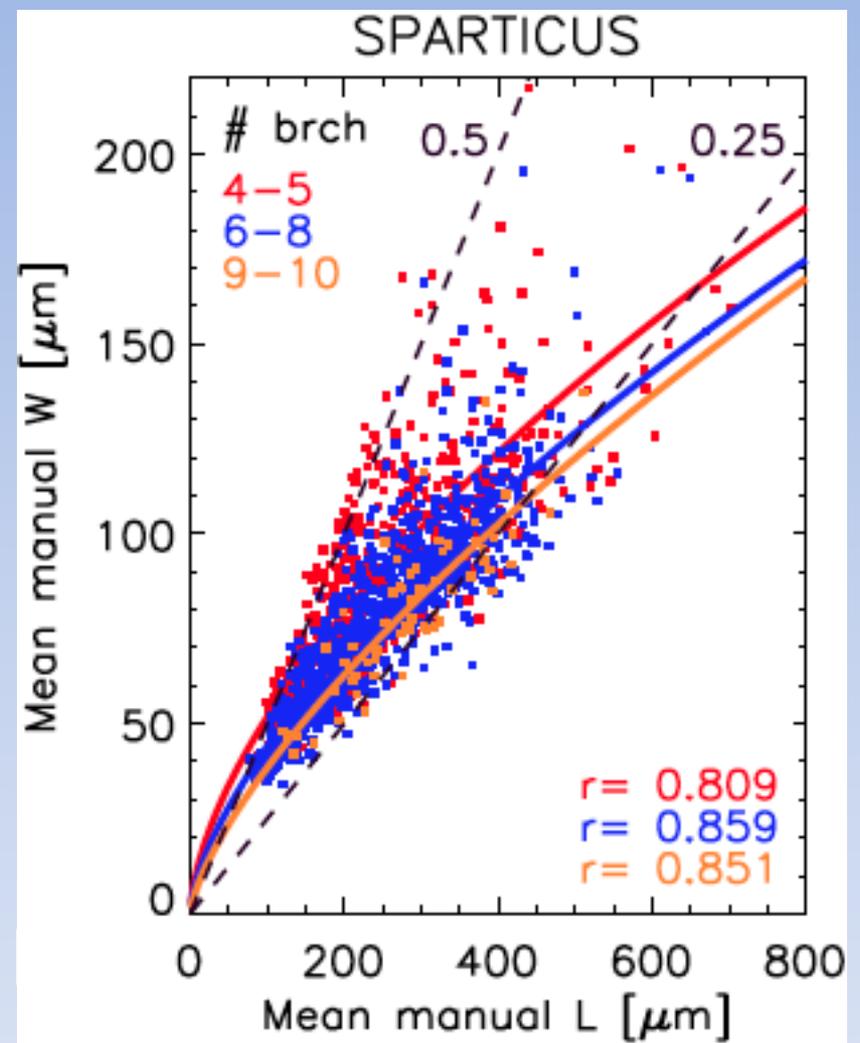
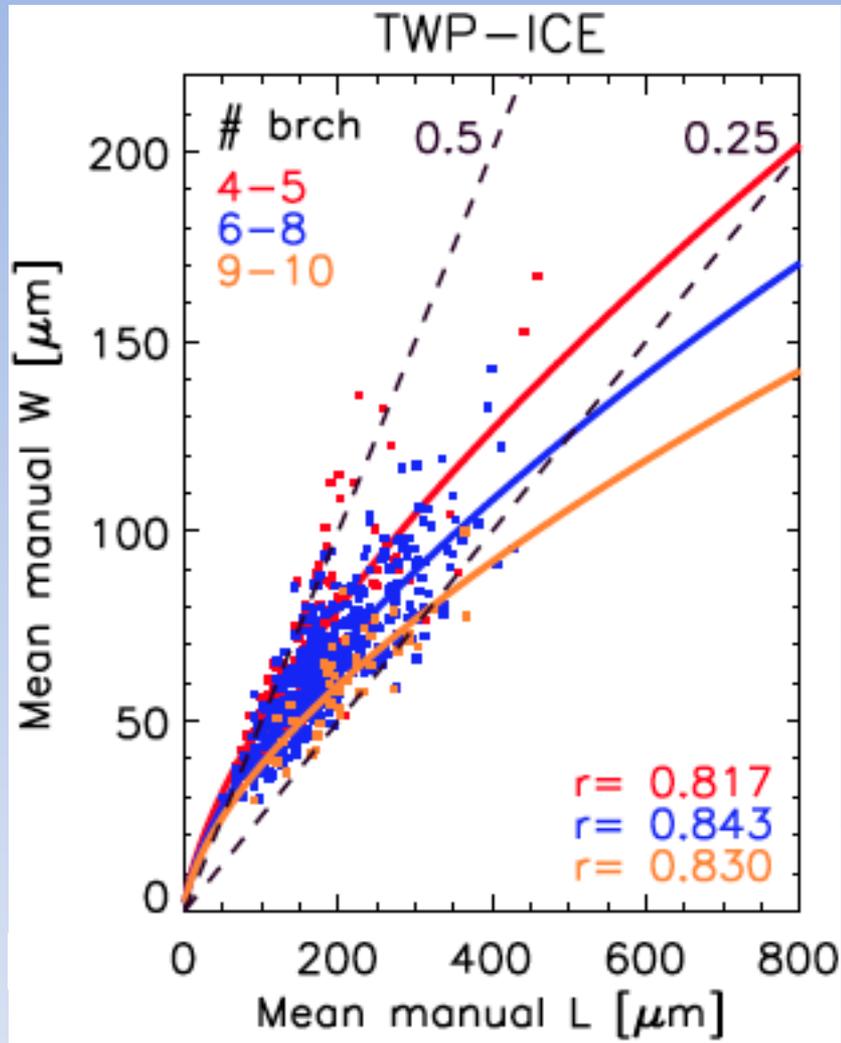


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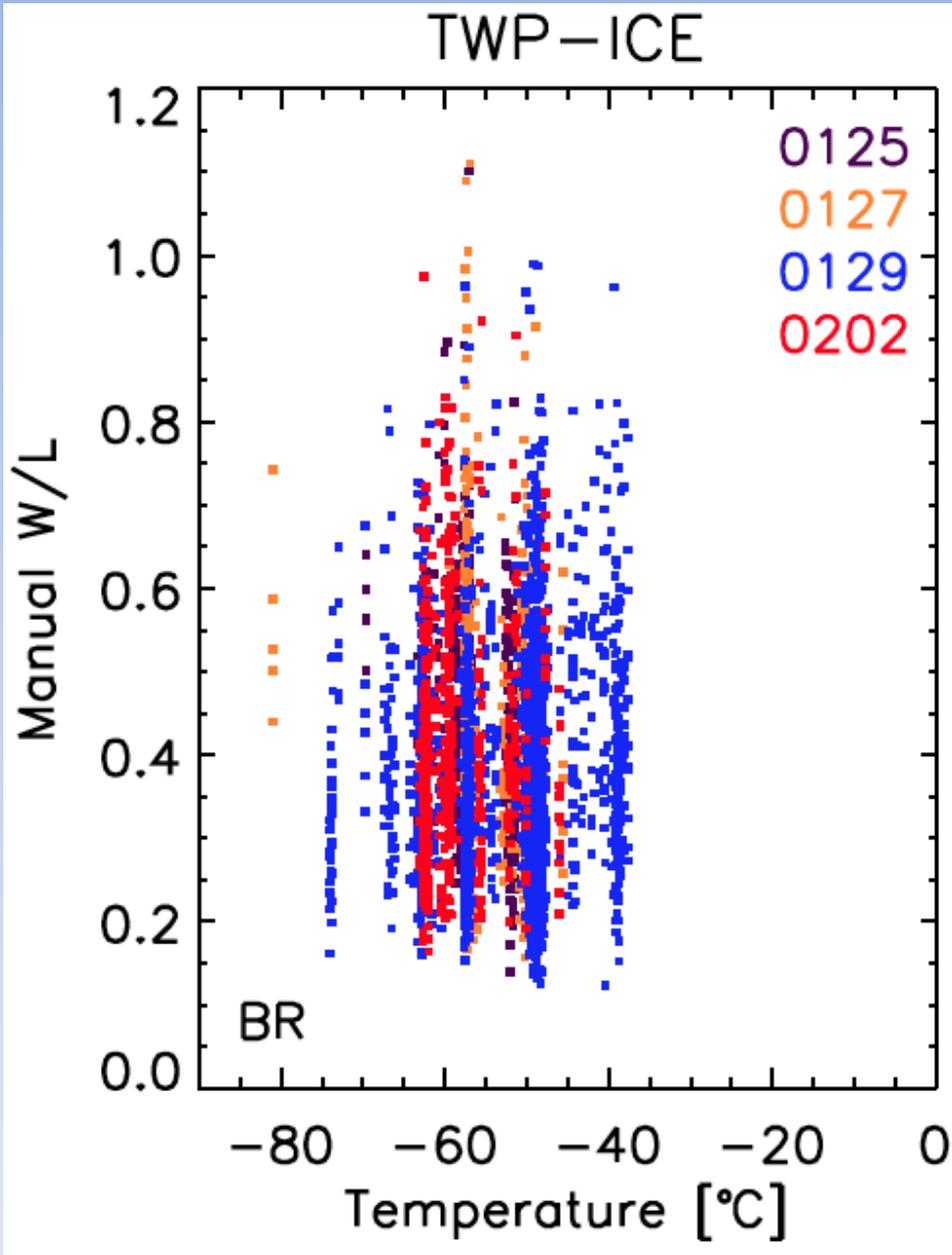


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AR decreases with # of BR branch



**No strong
dependence
on T**

Gamma Distribution:

Mathematical Representation of Size Distributions

$$N(D) = N_0 D^\mu \exp(-\lambda D)$$

- $N(D)$ = Number Distribution Function
- N_0 = intercept
- μ = shape
- λ = slope

Gamma Distribution:

Mathematical Representation of Size Distributions

$$N(D) = N_0 D^\mu \exp(-\lambda D)$$

- **N(D) = Number Distribution Function**
- **N₀ = intercept**
- **μ = shape**
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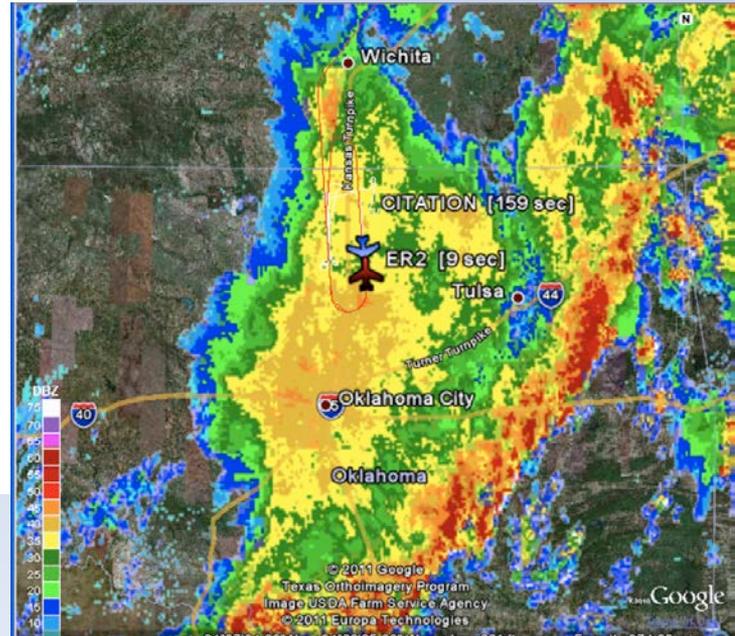
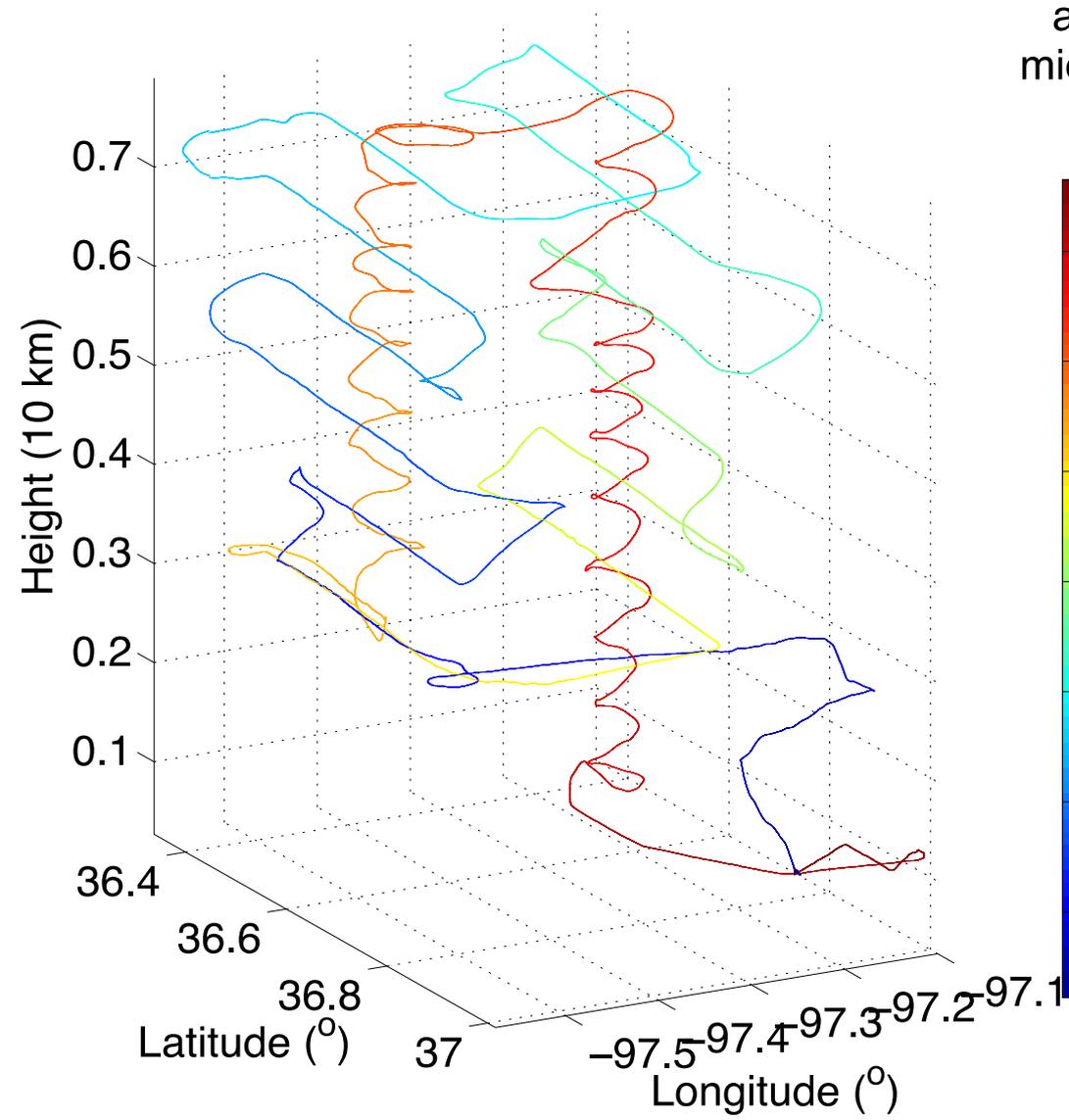
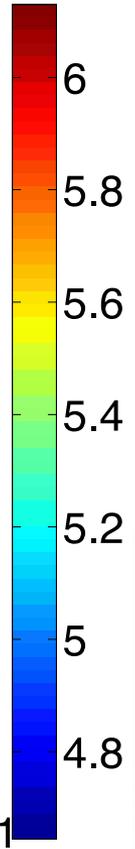
How do N₀, μ, and λ depend on meteorological and cloud conditions?

What are uncertainties in N₀, μ, and λ?

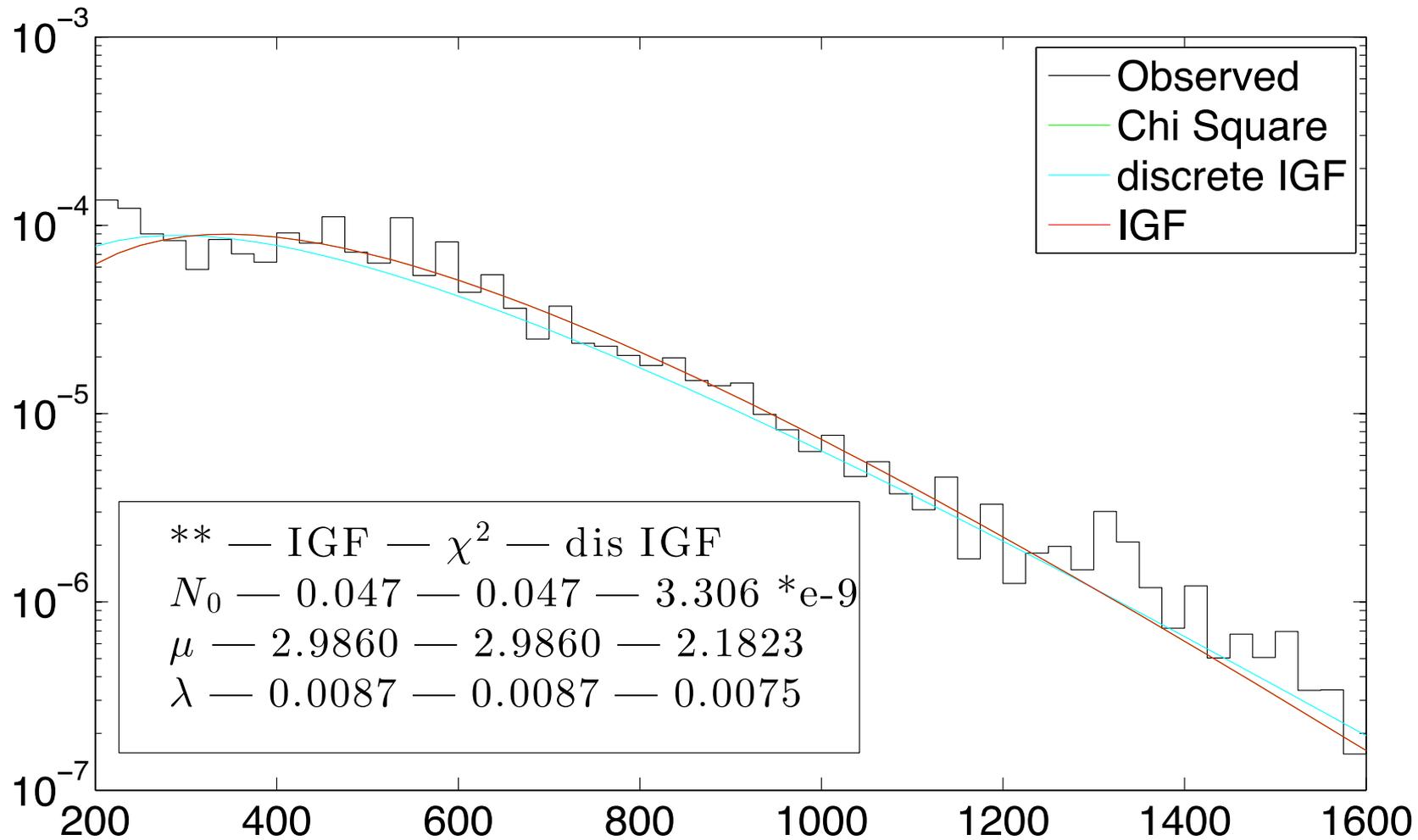
How can covariance of N₀, μ, & λ be accounted for?

Seconds
after
midnight

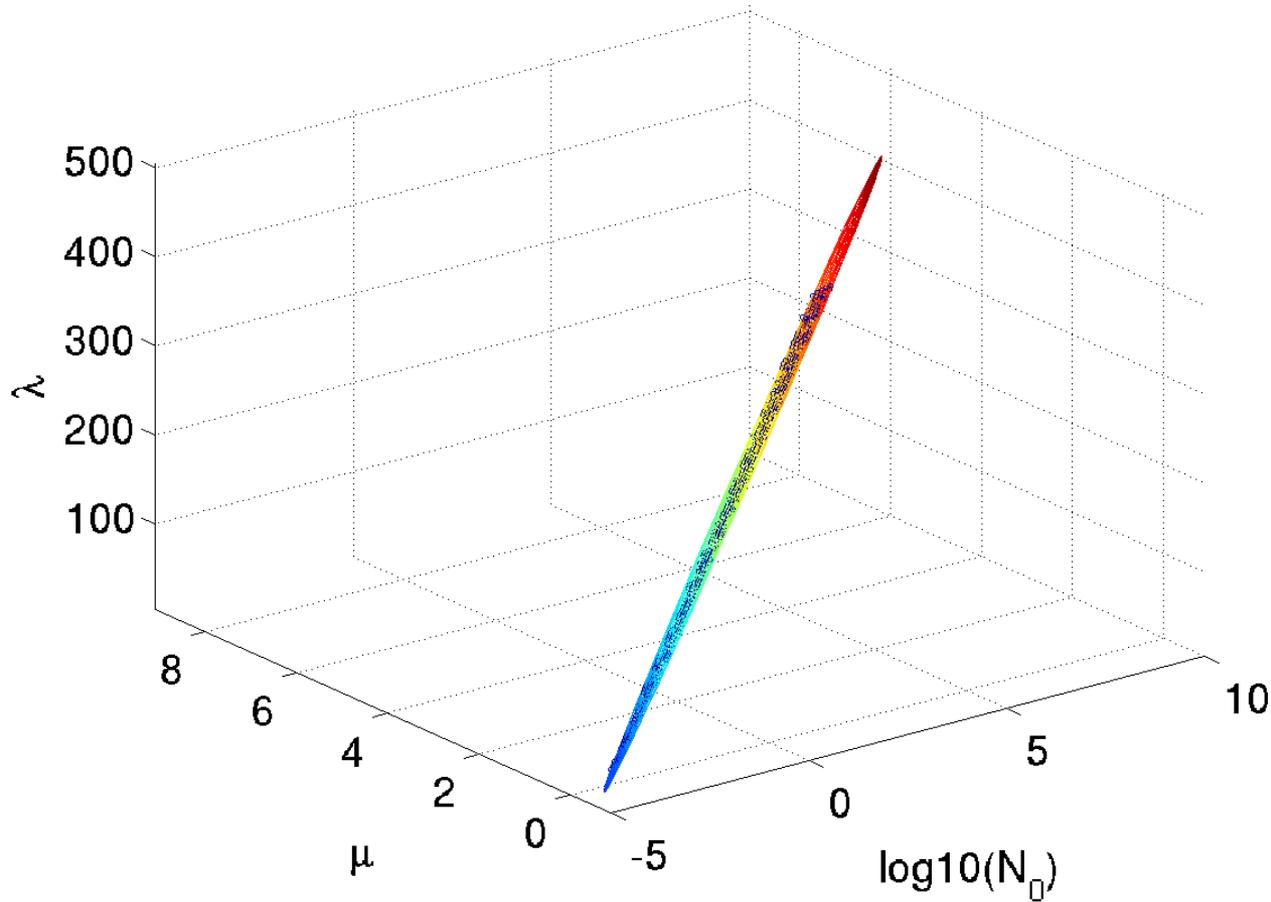
$\times 10^4$



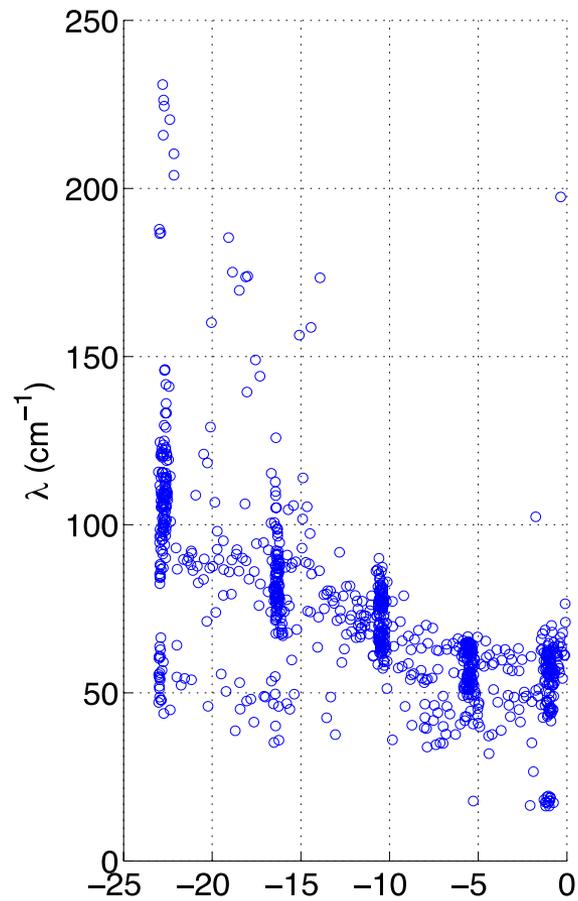
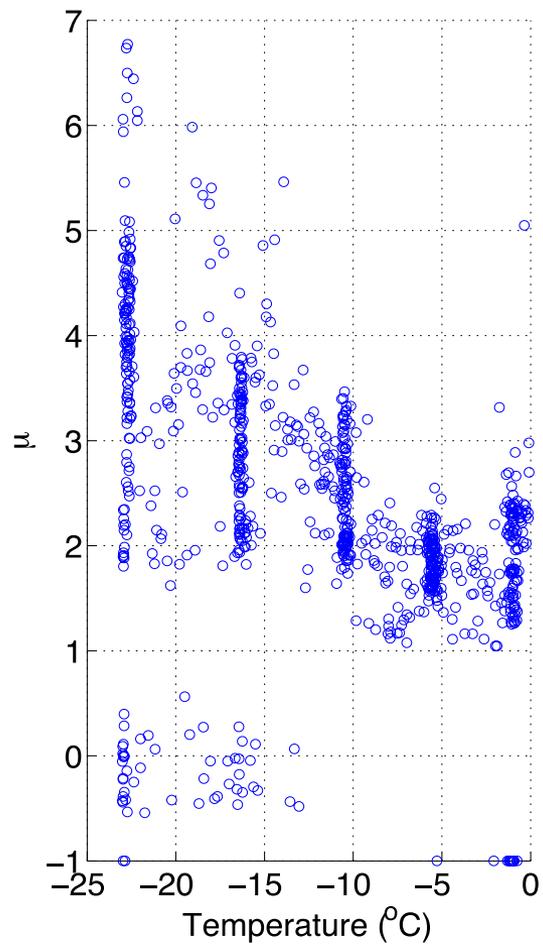
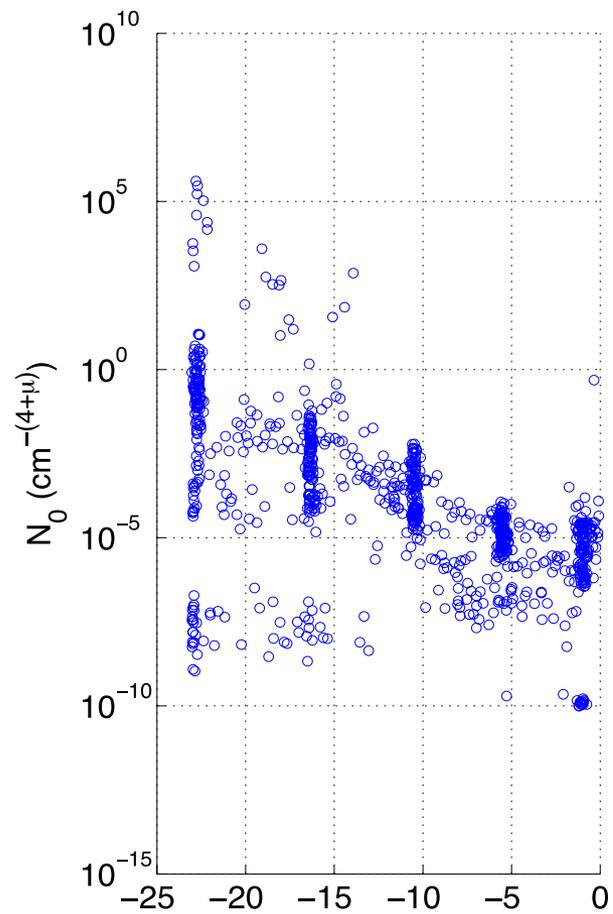
May 20 Case MC3E case

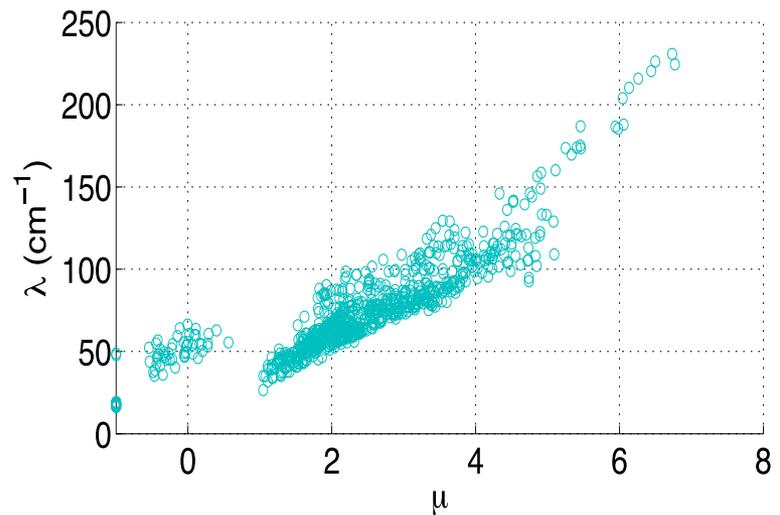
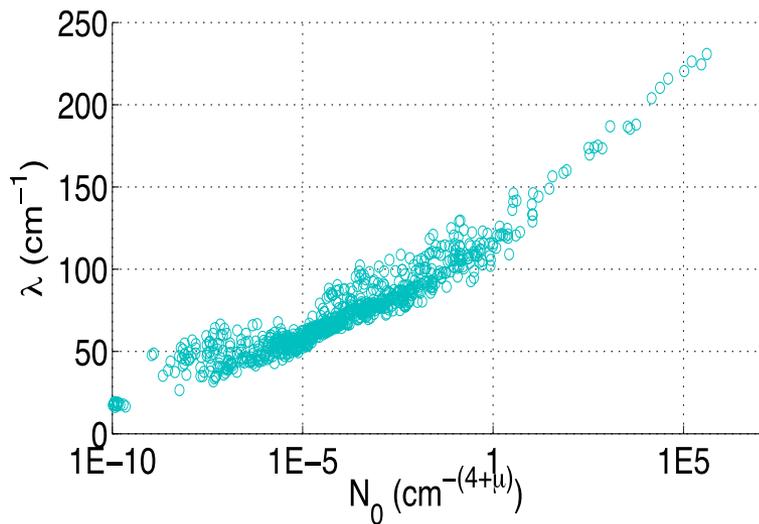
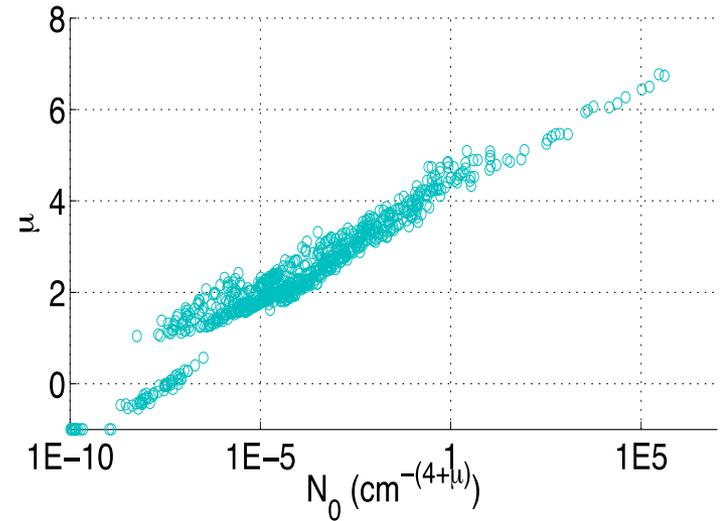
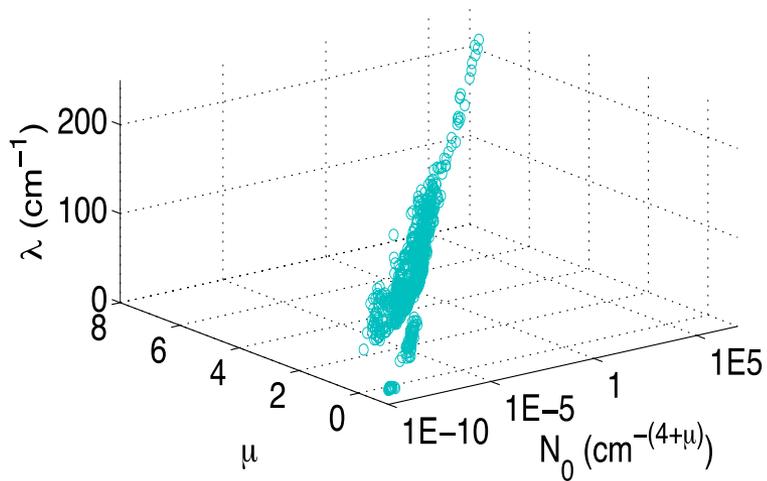


Ellipsoid Hull



**There is broad range of $N_0/\mu/\lambda$ that fit SD well
→ Range determined by allowing derived/
observed moments of a SD to differ by a $\Delta\chi^2$,
determined by statistical uncertainty in
sampled SD**





Need to interpret variation in $N_0/\mu/\lambda$ in context of how much they vary for an individual SD

Habit Classifications

- How well can we identify particle habits from CPI images?
 - Compare schemes from LaMP, Illinois, and Helsinki
- 3 cases :
 - 2 Tropicals : TWP-ICE campaign (2006):
 - One aged cirrus case : January, 29th ;
 - One fresh anvil case : February, 2nd.
 - 1 Arctic case : ISDAC (2008) :
 - Low cloud : April, 25th.
- Look at contributions of particles with $D > 200 \mu\text{m}$

Main Points

GOOD POINTS :

- **Aggregates of rosettes, aggregates of plates, and rosettes classified correctly compared to Illinois semi-manual scheme.**

BAD POINTS :

- **A lot of particles classified as aggregates of columns by Helsinki are classified as other shapes by Illinois semi-manual treatment (aggregates of plates, irregulars, etc.)**
- **Columns overestimated**

Conclusions

- 1. Database of properties of individual particles now available**
 - 1. Useful for remote sensing/modeling studies**
 - 2. Happy to proceed with use of database in collaborative studies**
- 2. Database includes information on base state and statistical uncertainties in derived parameters**
- 3. Currently placing properties in context of cloud and environmental conditions to assist in process-oriented understanding**

Available Data on Ice μ physics

- **Large databases exist with varying accuracies**
 - Not known how properties vary by location, cloud type, formation mechanism, vertical motion, dynamics, meteorology, etc.
 - Such knowledge needed for process-oriented understanding & parameterization development
- **Additional data in variety of conditions needed**
 - properties of individual crystals & global populations
 - Need uncertainties associated with properties
 - Need to investigate optimal representations in models with variety of scales

Mission Statement of IcePro

- 1. Characterize ice physical processes represented in climate models & processes depending on them**
- 2. Establish link between observations characterizing ice particle properties & models investigating how cloud & radiative properties change with environmental conditions**
- 3. Focus not only on mean & statistical distributions of ice properties, but also their uncertainties and consequences for process rates, parameterizations & model results**

Objectives of IcePro

- 1. Use in-situ observations to derive statistical databases (individual crystals & populations)**
- 2. Utilize new ground-based scanning radar to develop retrieval techniques for crystal habits**
- 3. Conduct spectral radiative closure to constrain ice particle physical & optical properties**
- 4. Conduct model studies to assess sensitivity of modeled cloud properties to representation of ice properties**

UNCERTAINTY IMPORTANT FOR ALL ACTIVITIES

Milestones

- **Deliver a database of single particle properties to ARM archive as PI products**
- **Deliver m-D and A-D relations, and SD attributes, to ARM archive that will be useful for model & remote retrieval studies**
- **Develop framework for determining how well physical properties need to be known**
- **Develop framework for evaluating degree to which candidate parameterizations fulfill established goals based on analysis of observations and simulation**

Performance Metrics

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Synergy with QUICR

1. Analysis of in-situ observations provides crucial dataset for evaluating ground-based retrievals and their uncertainties
2. Spectral radiative closure may help constrain ice particle physical & optical properties and their uncertainties that are used in retrievals

NOT DIRECTLY IMPROVING OR EVALUATING RETRIEVALS—THAT WILL BE LEFT TO QUICR

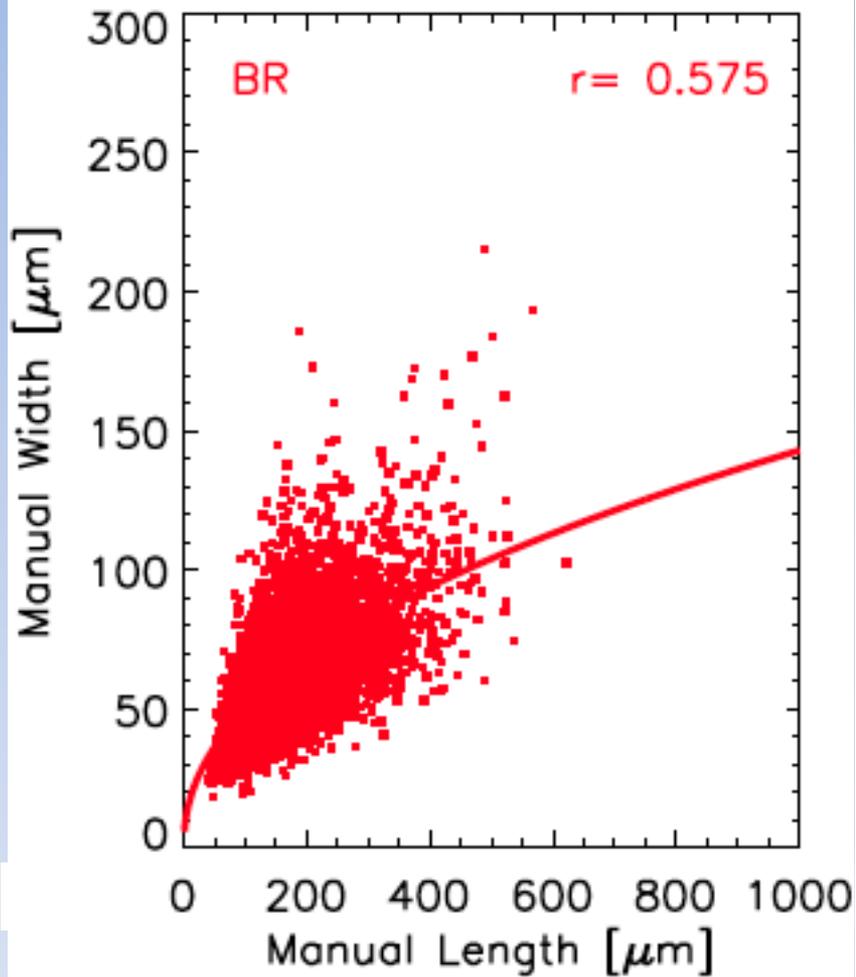
End Result

- **Identify gaps that still exist in ice cloud property database and parameterization, and possibly recommend additional field experiments needed to fill these gaps**

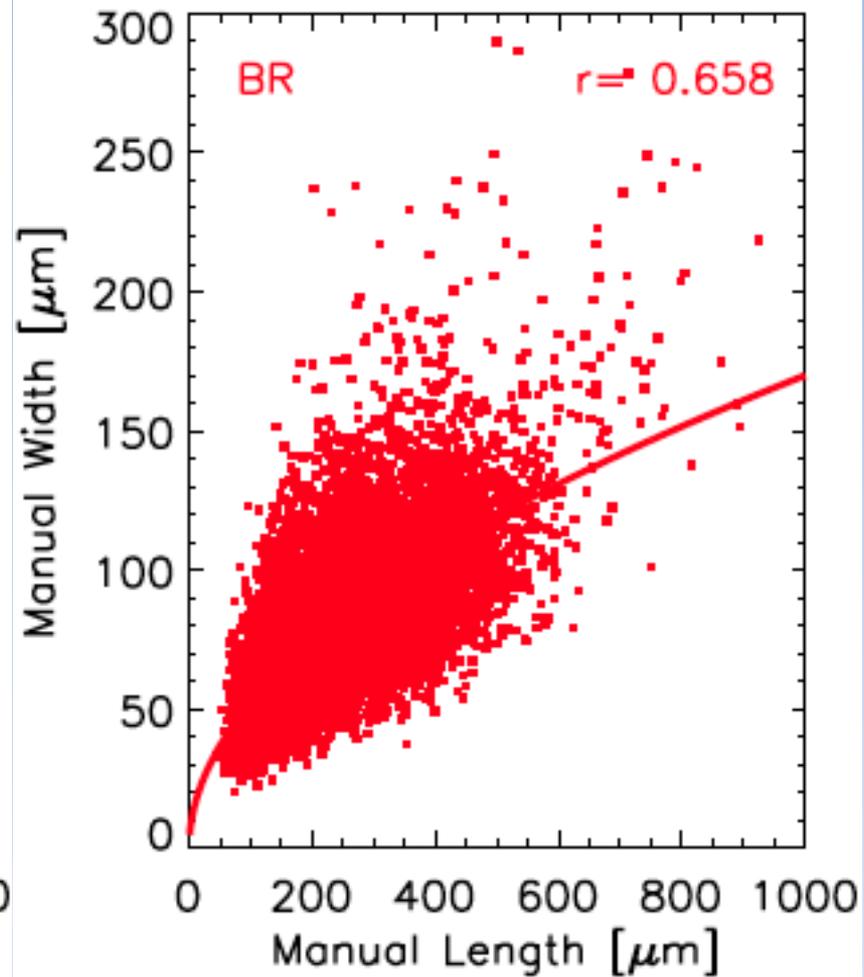
Plan for Today

1. **Comments/critiques on plan for focus group**
2. **Linkage with other focus groups**
3. **Input for Milestones? Metrics?**
4. **VAP/Translator Input –anything we need**

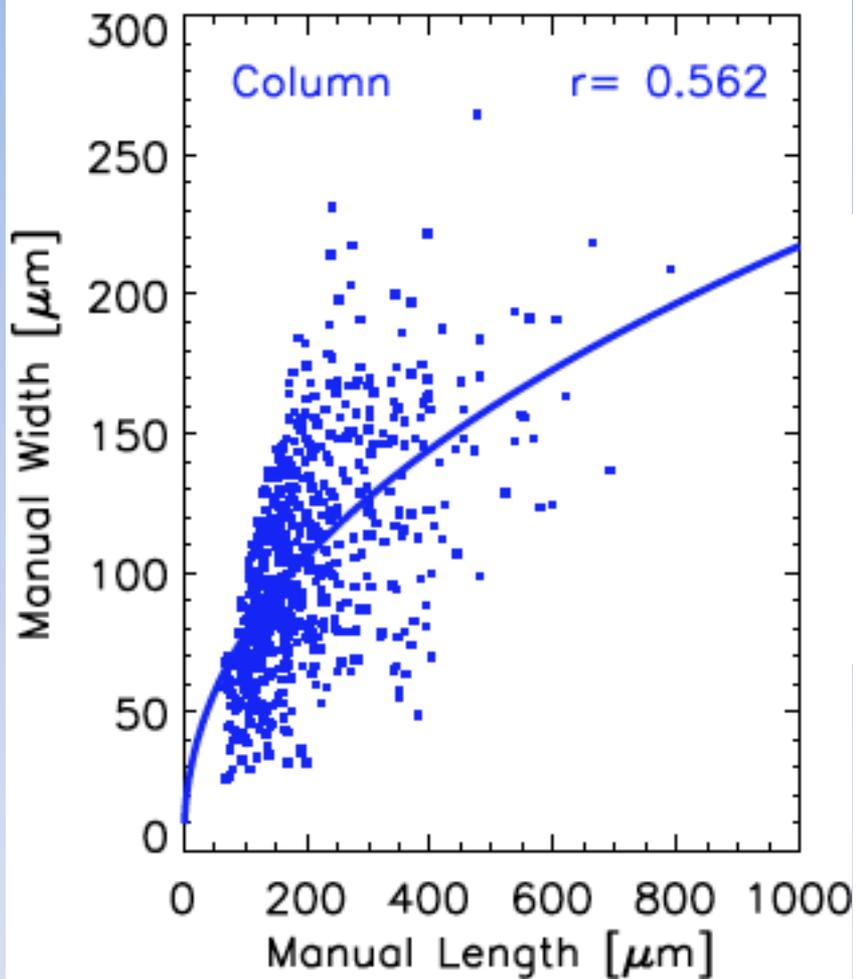
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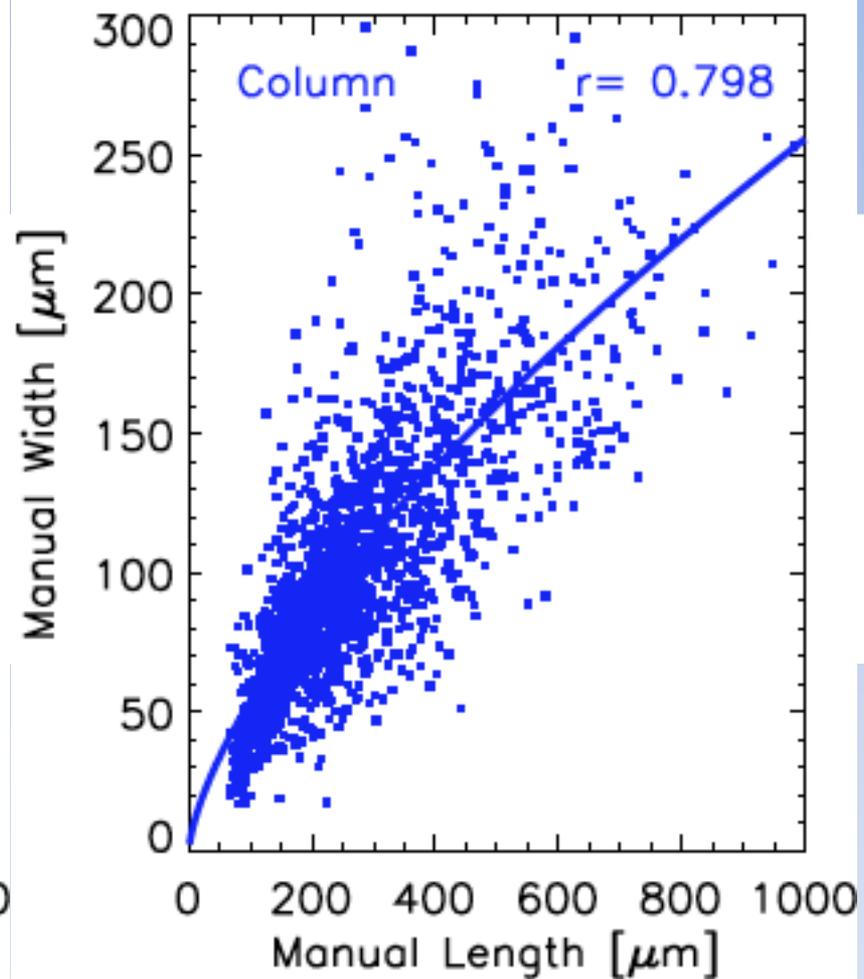
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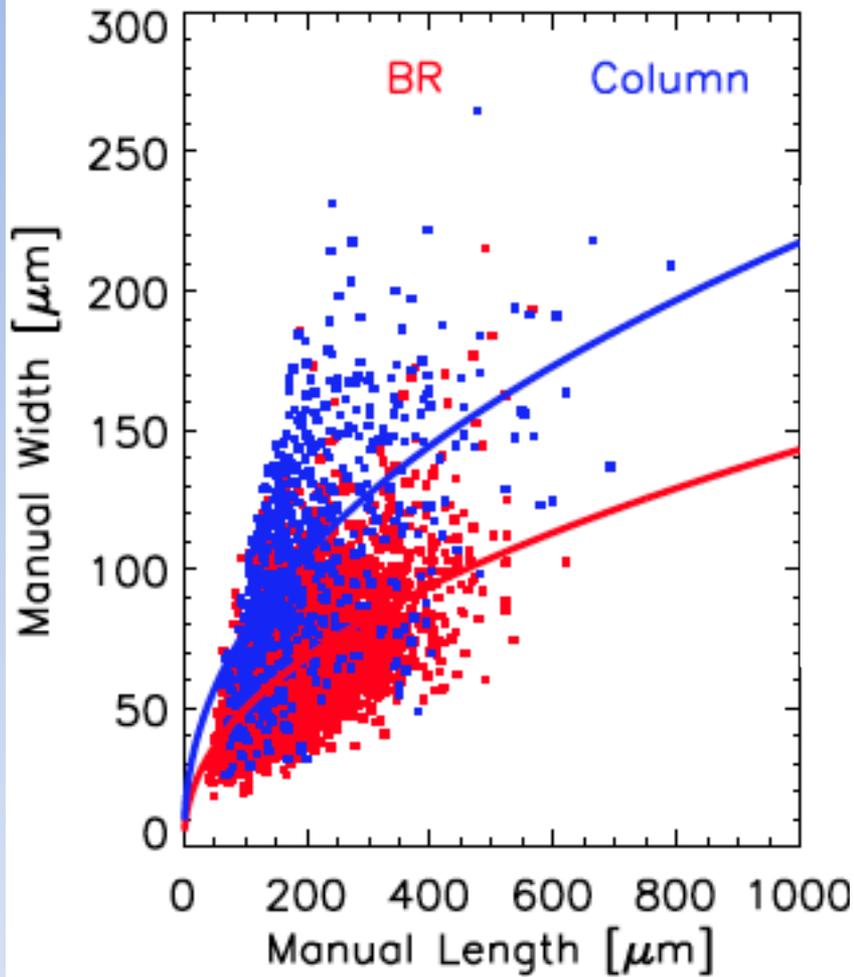
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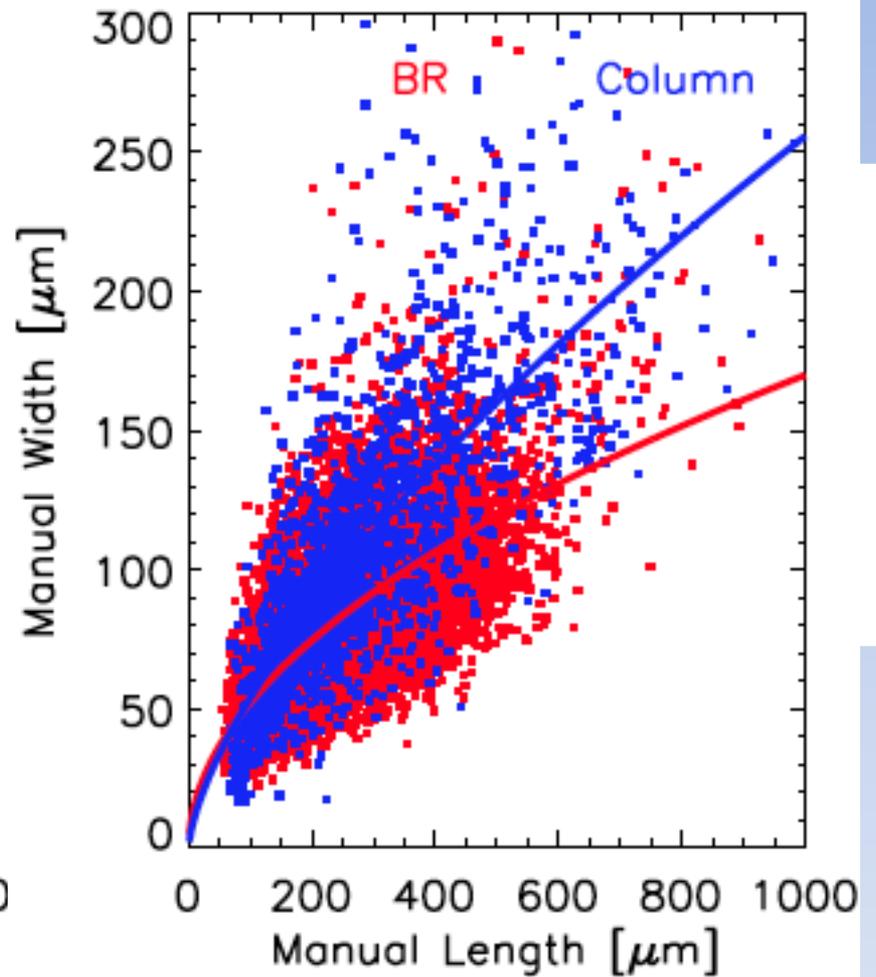
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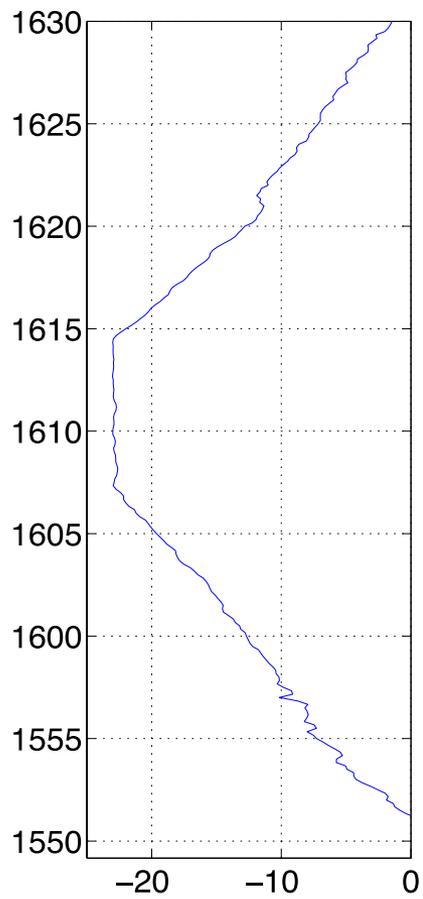


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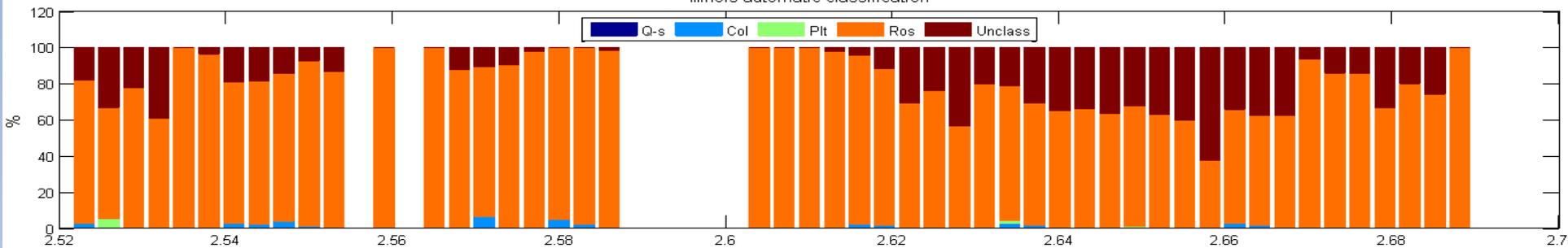
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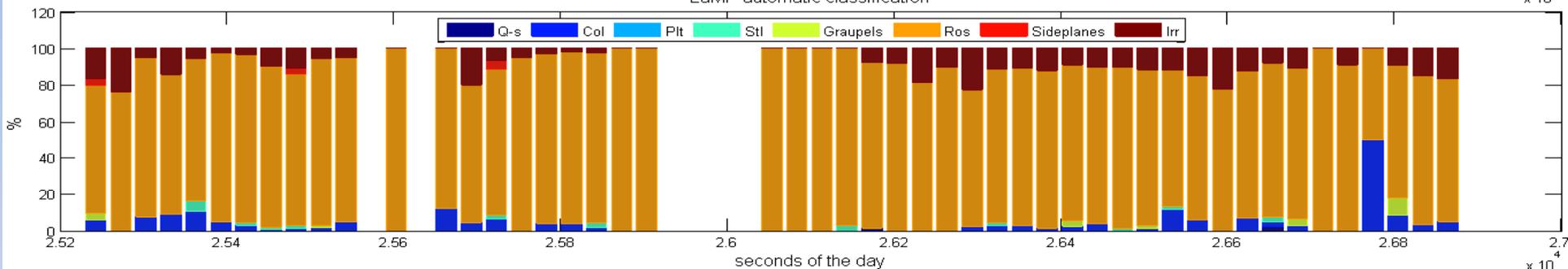


Time serie TWP-ICEcirrus, D>=200µm, 7h00'29"-7h28'05"

Illinois automatic classification

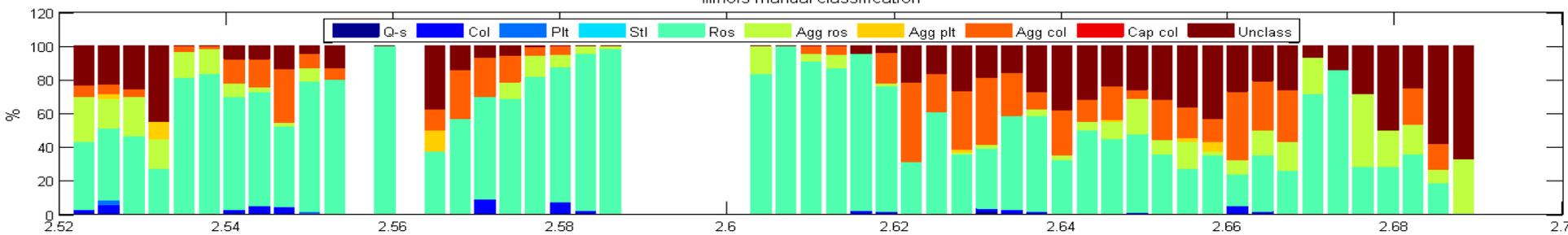


LaMP automatic classification



Time serie TWP-ICEcirrus, D>=200µm, 7h00'29"-7h28'05"

Illinois manual classification



Helsinki classification PCA

