4th IMS Turbulence Workshop
Clouds and Turbulence
IMS, Imperial, London, 23-25 March 2009

# How observations shall be used to constrain numerical simulations

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# Droplet Spatial Distribution and Clustering

# Impact on Condensational Droplet Growth

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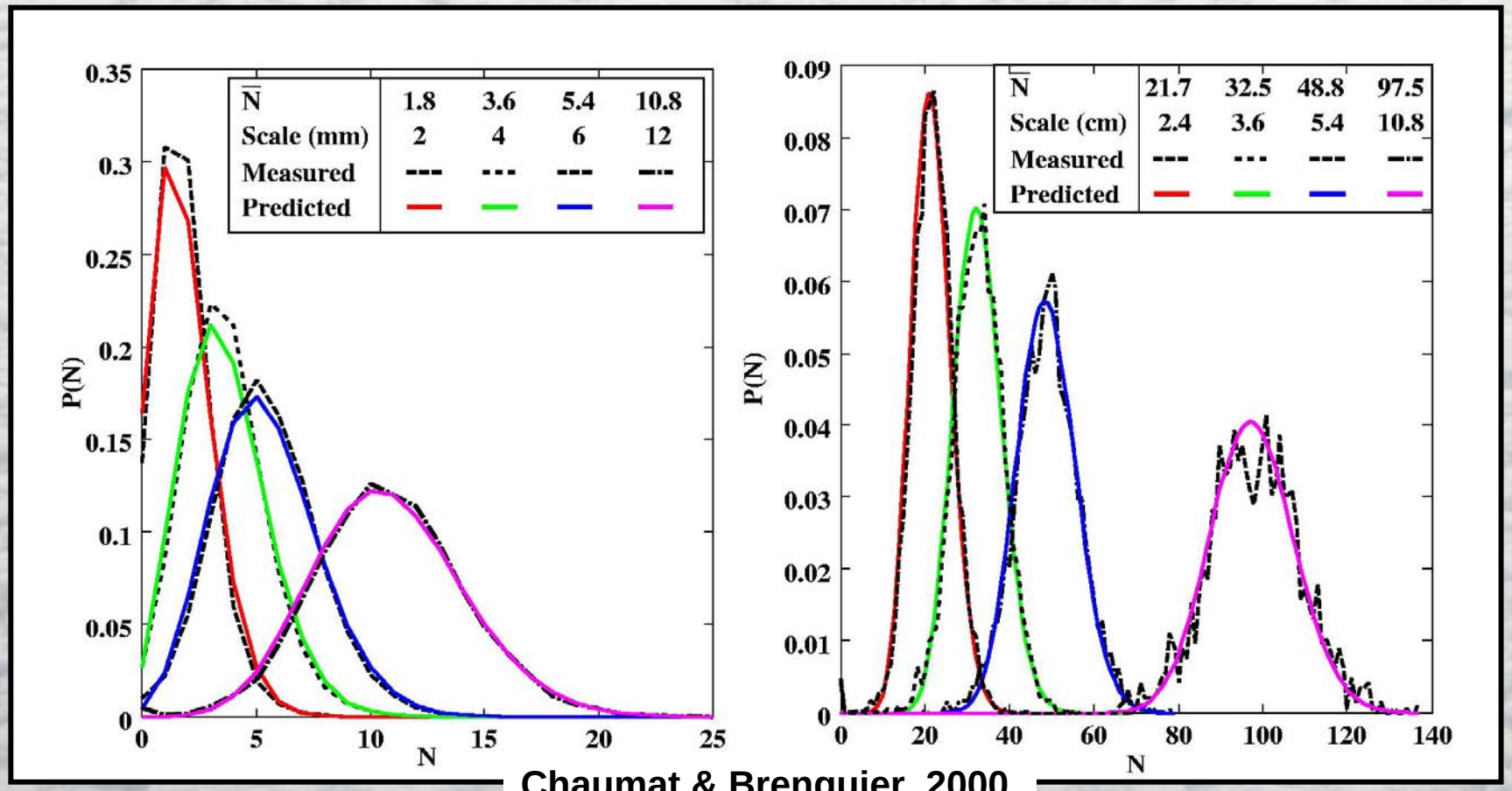
4th IMS Turbulence Workshop, London, 23-25 March 2009

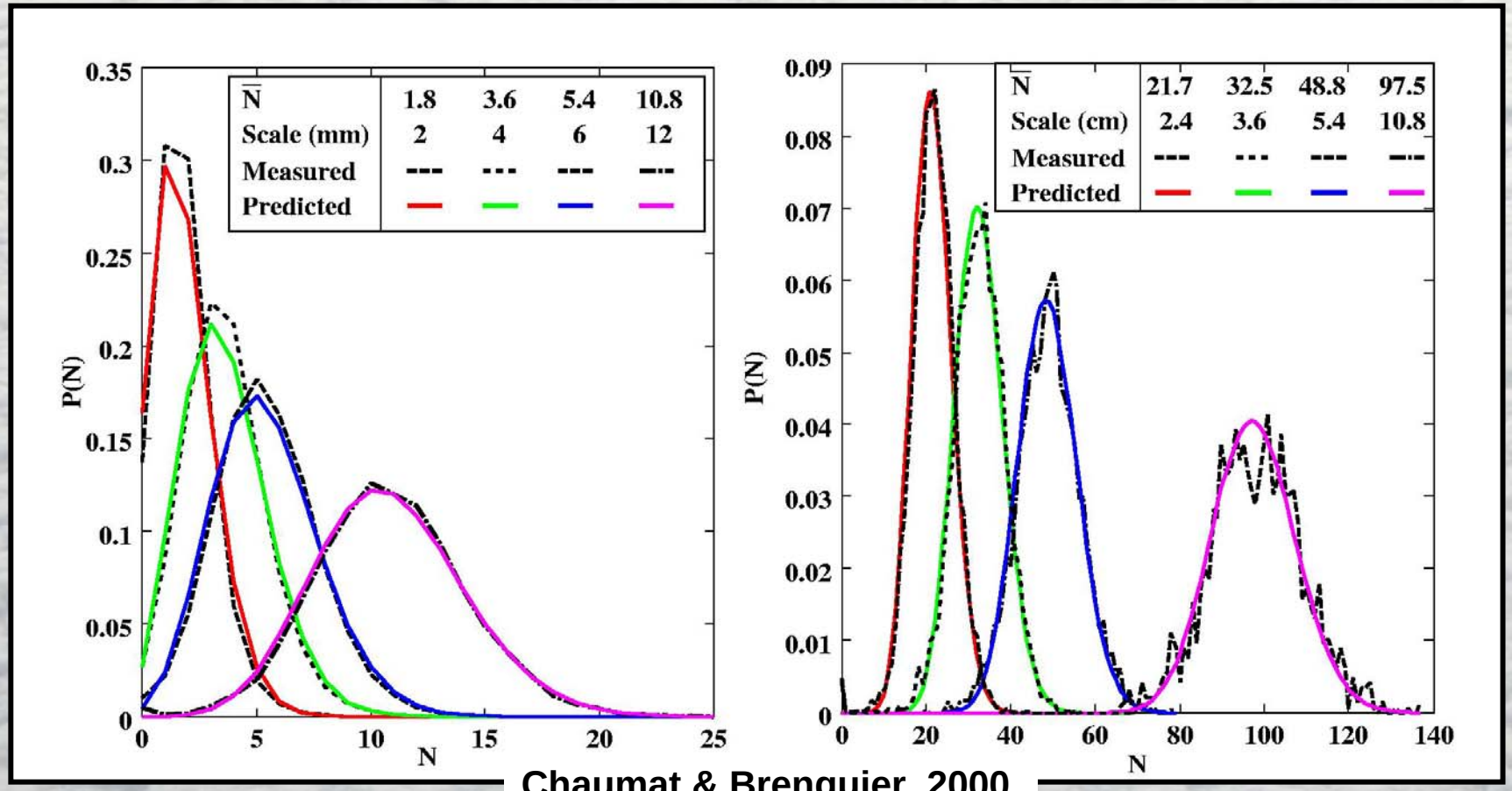
# Observations of the Droplet Spatial Distribution




Chaumat & Brenguier, 2000

**Series of droplet counts are cumulated over sections of various length scales, from 2 mm to 100 mm corresponding to mean number of counts from about 2 to 100. Statistics of counting is compared to Poisson statistics.**

# Observations of the Droplet Spatial Distribution




Chaumat & Brenguier, 2000

**Are the differences between observation and theory significant ?**

# Observations of the Droplet Spatial Distribution

**Are the differences between observation and theory significant ?**

***It has been shown that the counting statistics and the Fishing test do not deviate significantly from the Poisson reference…….***

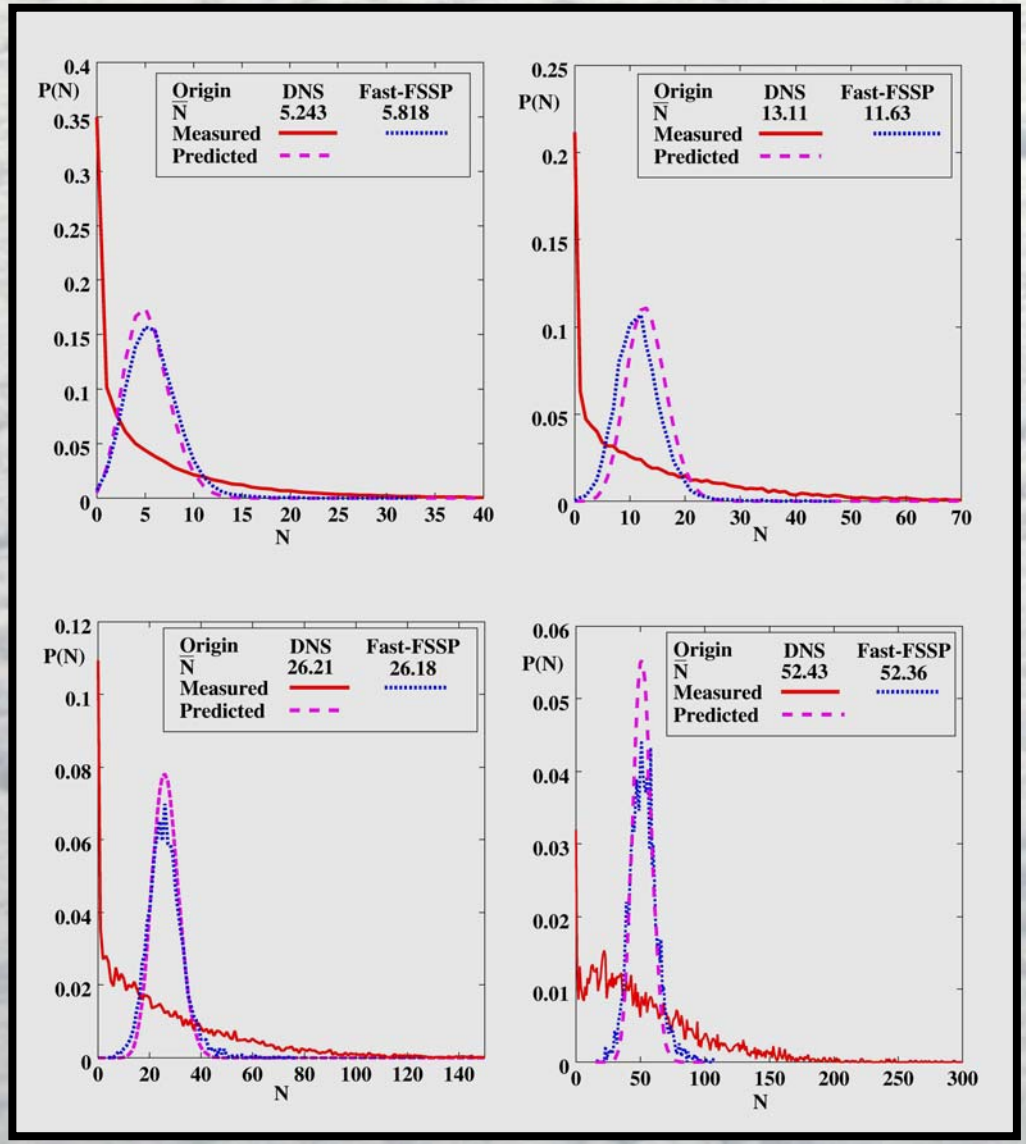
***"Our conclusion is thus that the concentration heterogenities observed in adiabatic cores are not sufficient to support the concept of preferential concentration" (Chaumat and Brenguier, 2000)***

***"The results presented here suggest that previous measurements of droplet spatial distributions may have been `contaminated' by the excluded volume effect. This may be one reason why a previous analysis of data from unmixed cloud cores in the same field experiment ended with the conclusion that there are no statistically significant departures from perfect randomness (Chaumat & Brenguier 2000)." (Kostinski and Shaw, 2001).***

**What is the source of misunderstanding ?**

**A departure is not significant or insignificant in the absolute sense. Only its consequences are measurable !**

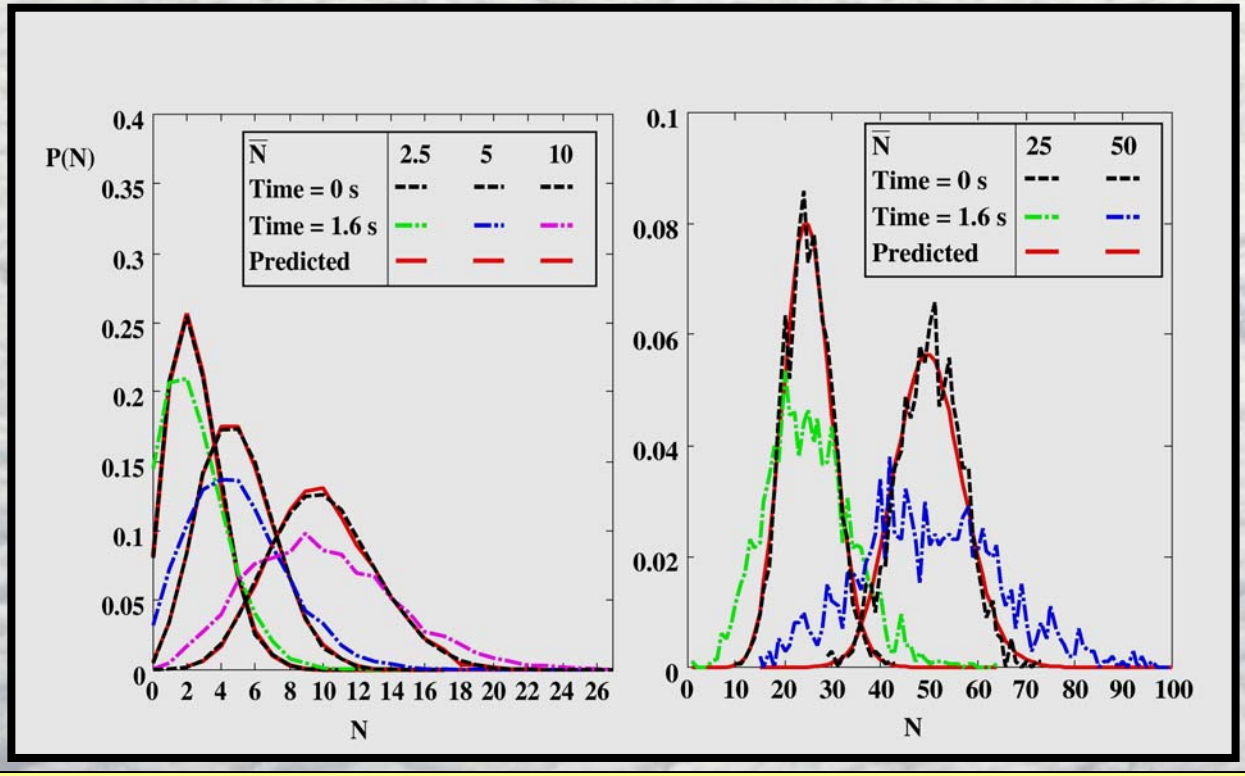
# Observations of the Droplet Spatial Distribution




Comparison with Shaw et al. (1998)

Observed droplet counting statistics compared to the ones obtained by virtually sampling an illustration of DNS simulations.

# Observations of the Droplet Spatial Distribution




.. and Vaillancourt (1998)

Droplet counting statistics obtained by sampling DNS simulated fields.

***"Our conclusion is thus that the concentration heterogenities observed in adiabatic cores are not sufficient to support the concept of preferential concentration" (Chaumat and Brenguier, 2000).***

**This conclusion is only valid within the framework of the two tested models of Shaw et al. and Vaillancourt.**

# Recommendations

**Observations ➔ Models**

**Difficult to achieve because observations are missing crucial parameters required by the models**

**Models ➔ Observations**

**Difficult to achieve because model simulations are specific realizations that cannot be directly compared to observations**

**Models ➔ ←Observations**

**The solution is in between.**

**To provide example of observed fields is definitely not sufficient. Observations shall be analysed in the form of synthetic properties.**

**To conclude that a numerical simulation is "consistent" with observations is definitely not sufficient. Models shall be quantitatively validated against synthetic observed properties.**

# Entrainment and Mixing in Cumulus Clouds

# Impact on Droplet Spectra

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# Entrainment and mixing : Conceptual Model

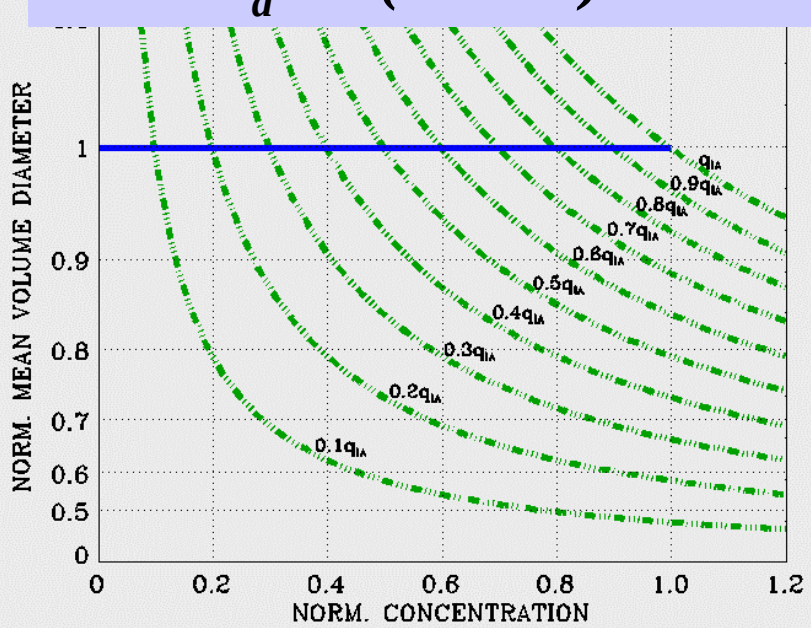
## Inhomogeneous

## Homogeneous

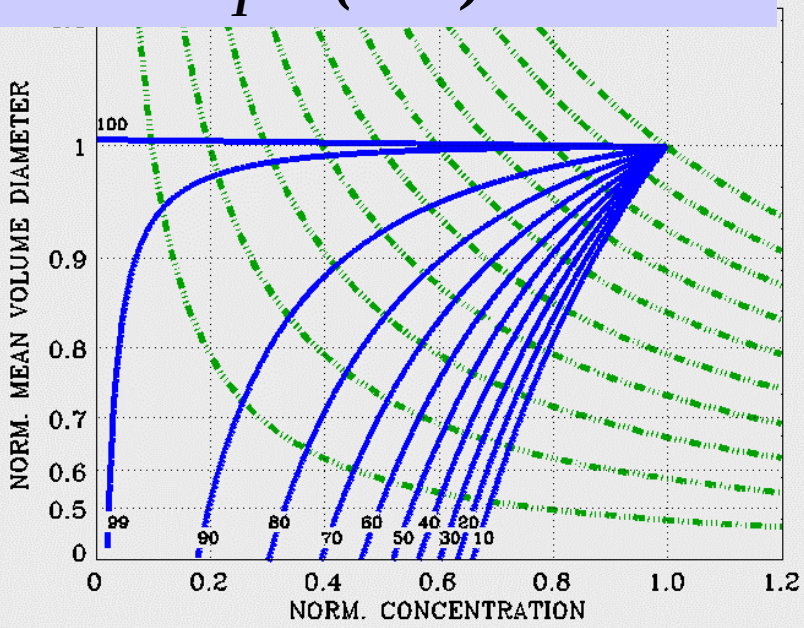
**Key Parameters (Baker et al., 1979)**

**droplet life time** $\tau_d = -(d^2 / AS)$ **>>** **turbulent homogeneisation** $\tau_T = (X^2/\varepsilon)^{1/3}$

$\frac{d_V^3}{d_{VO}^3}$




N / No




N / No

# Entrainment and mixing : Case Studies

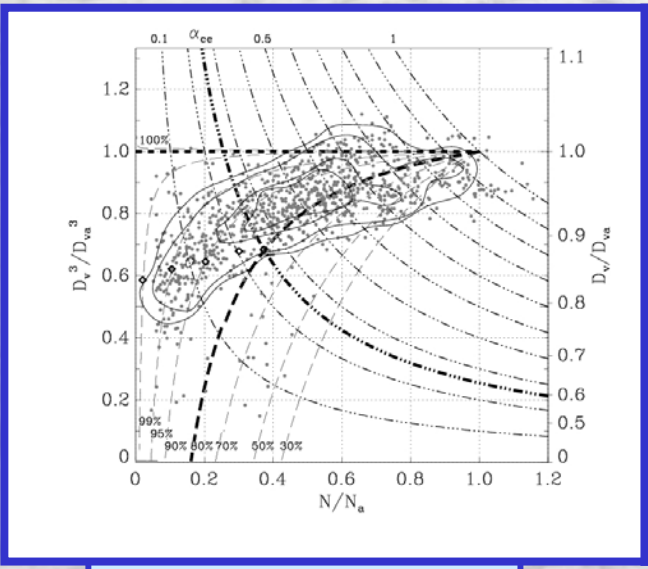
## Key Parameters:

**droplet life time** >> **turbulent homogeneisation**

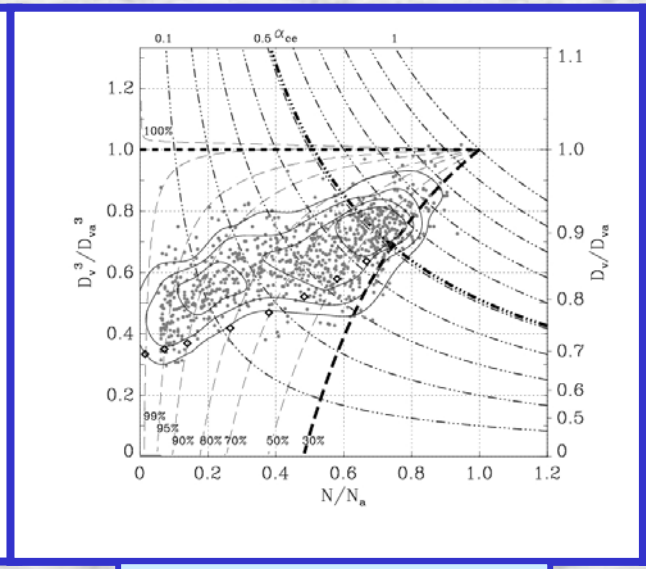
$\tau_d = -(d^2 / AS)$ >> $\tau_T = (X^2/\varepsilon)^{1/3}$

| | DYCOMS-RF03 | SCMS-me9506 |
|---|---|---|
| $S$ | - 0.7 | - 0.7 |
| $d$ | 15 µm | 30 µm |
| $\tau_d$ | 0.8 s | 3.2 s |
| $w$ | 0.5 m/s | 5 m/s |
| $T_c$ | 12.3 C | 14.1 C |
| $q_{lc}$ | 0.7 g/kg | 3.4 g/kg |
| $T_e$ | 16.2 C | 20.0 C |
| $q_{ve}$ | 5 g/kg | 4 g/kg |
| N | 350 $cm^{-3}$ | 250 $cm^{-3}$ |
| P | 950 hPa | 750 hPa |

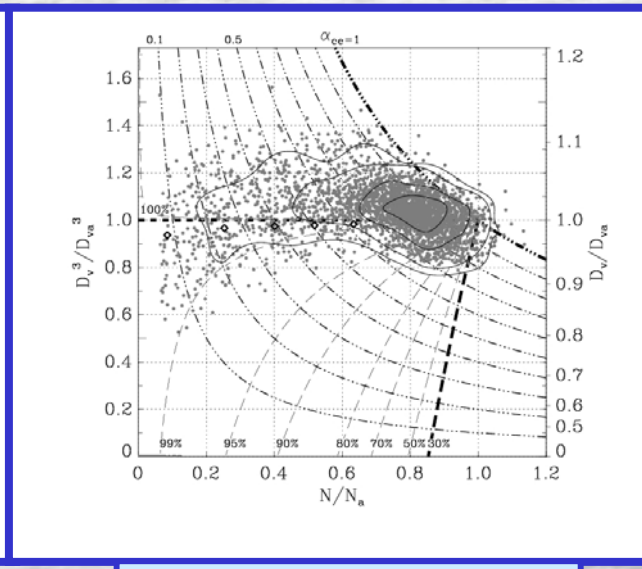
# Entrainment and mixing : Case Studies




$\tau_d / \tau_T = 6.6$




$\tau_d / \tau_T = 1.9$

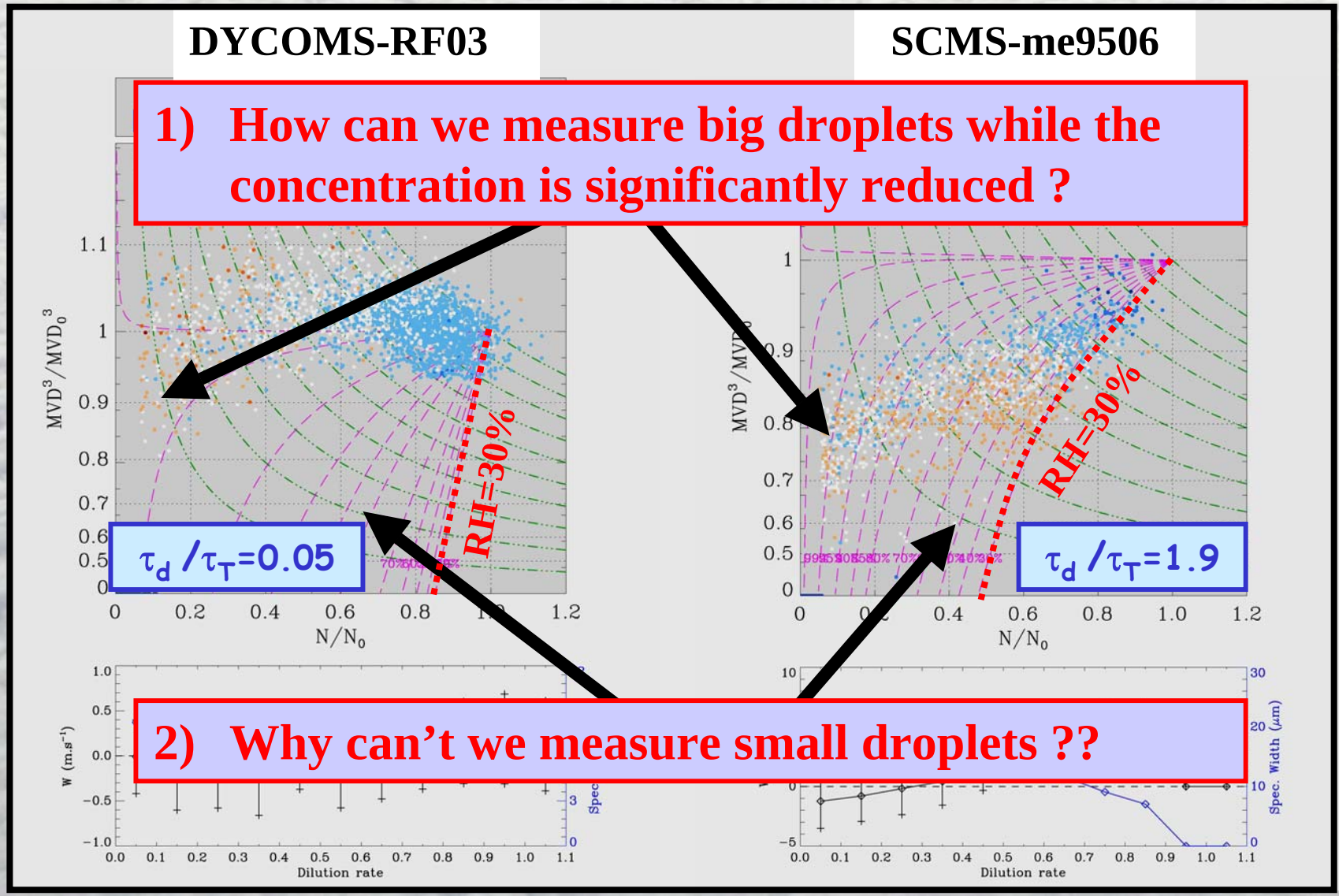



$\tau_d / \tau_T = 0.05$

***Burnet & Brenguier, JAS 2006***

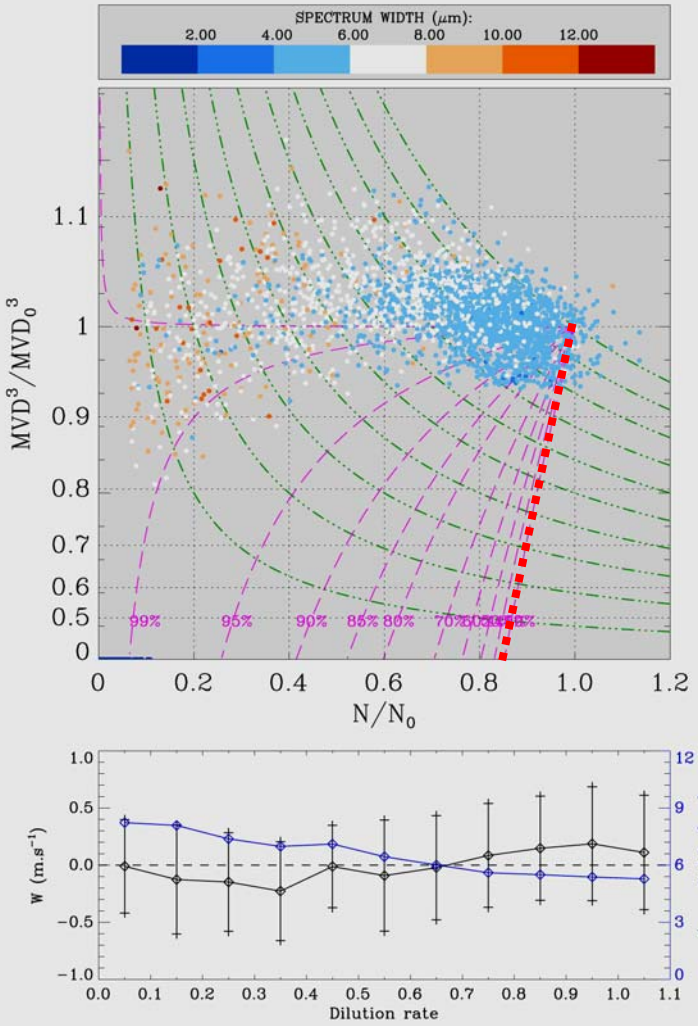
**$\tau_d$ and $\tau_T$ are useful criteria to stratify observations**

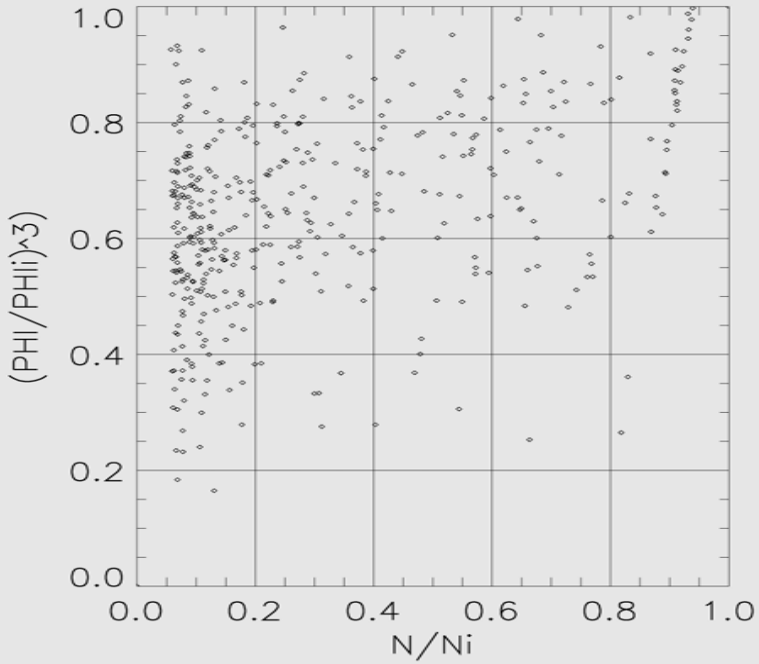
# Entrainment and mixing : Unexpected Features



# Real Phenomenon or Instrumental Artefact

**DYCOMS-RF03**




**Stochastic Model Averaged Realizations**

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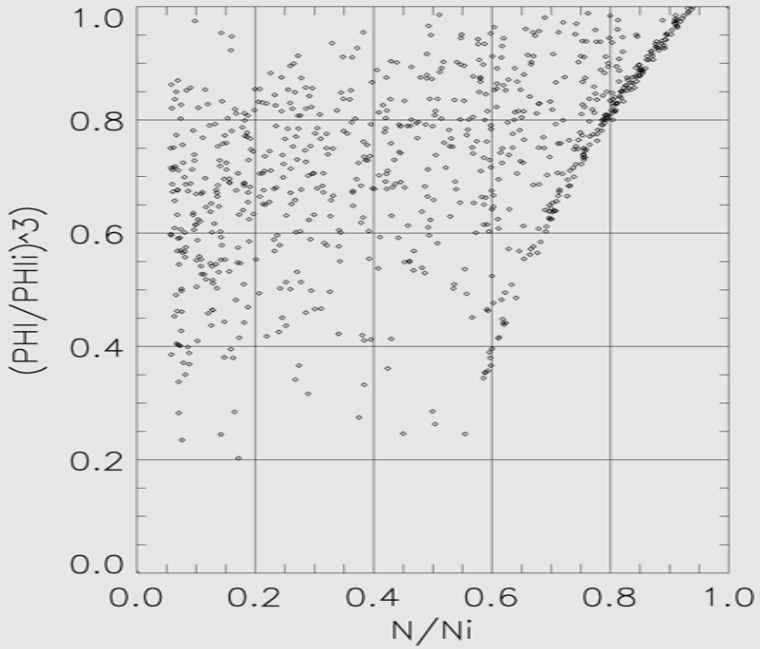
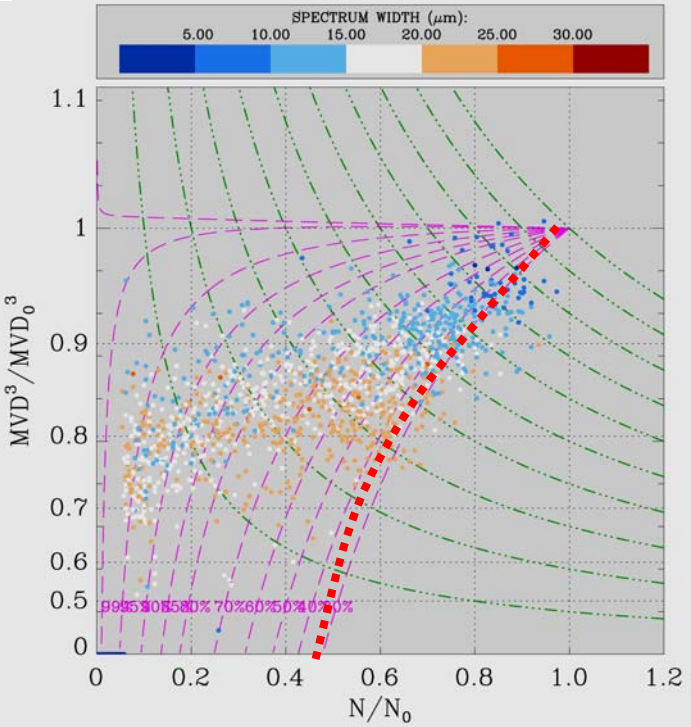
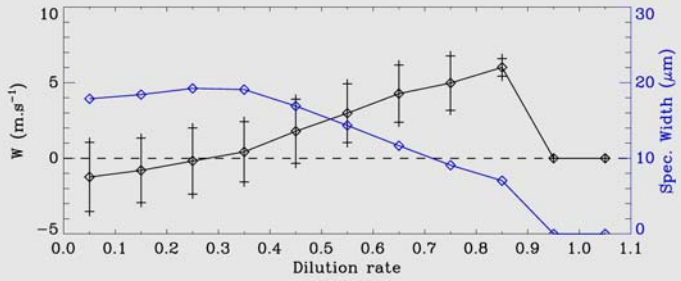
# Real Phenomenon or Instrumental Artefact

**SCMS-me9506**

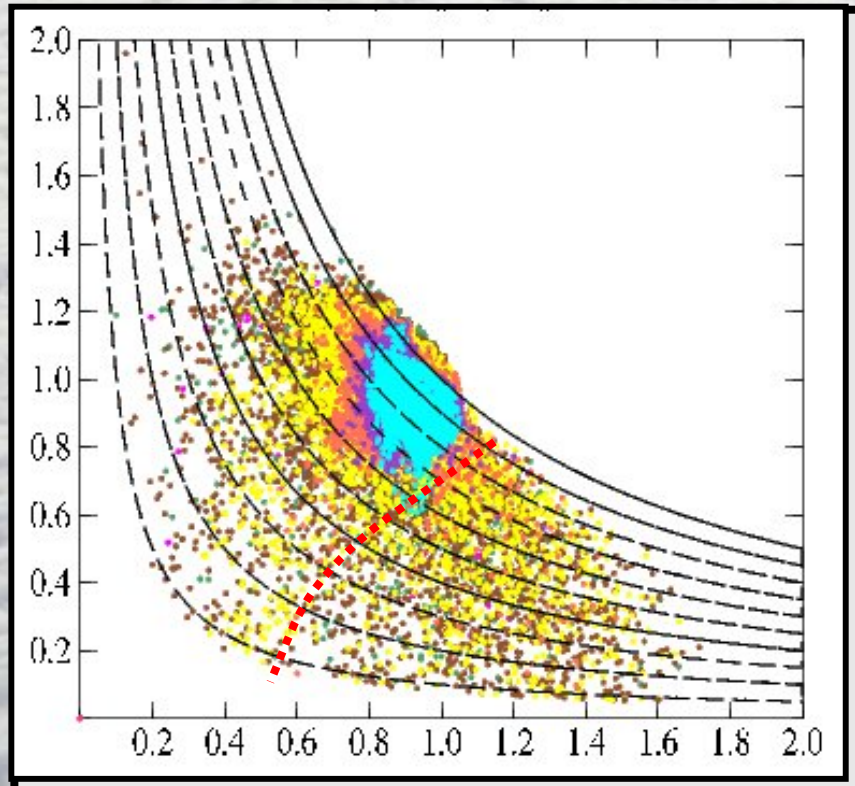


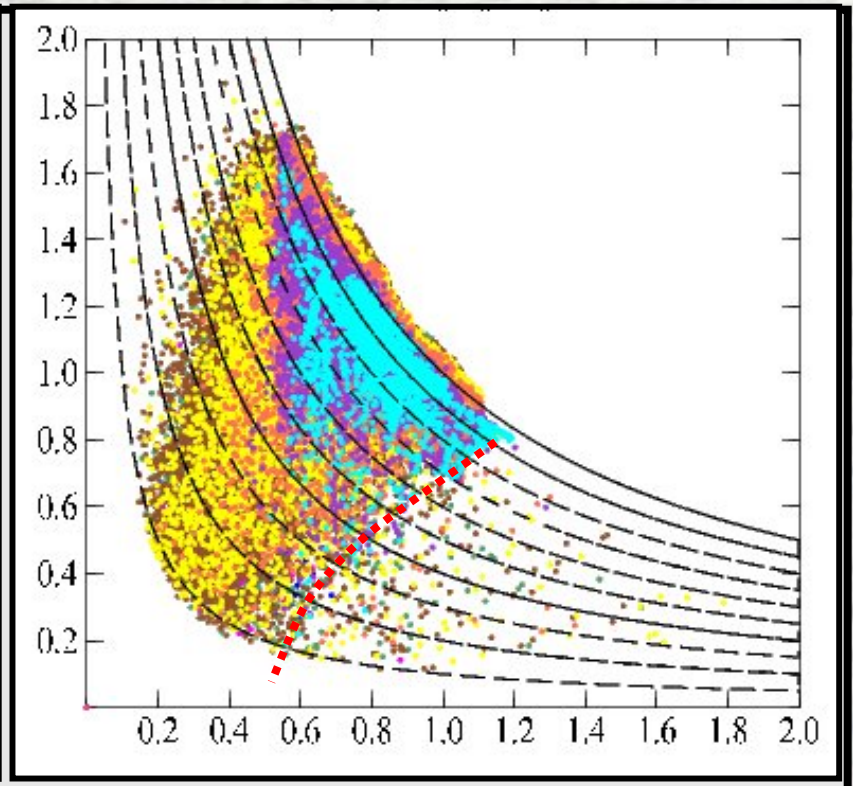




**Stochastic Model**
**Averaged Realizations**

# Test of Model Parameterizations




**Comparison of LES simulations of stratocumulus, using adjustment to saturation and a diagnostic of $S_{max}$ (left)**

**or a prognostic of supersaturation (right)**

# A DREAM!!

Observational data sets shall be carefully analyzed to derive synthetic properties and criteria to stratify observations

When this is done, one might expect that modellers will use these observations to validate their theories.

# RECOMMENDATIONS

When interpreting observations, concluding that deviation from theory is “significant” is meaningless !!

Rather compare the observed deviation to the expected one: is it bigger, smaller than expected.

*Thank you*

*for your attention*

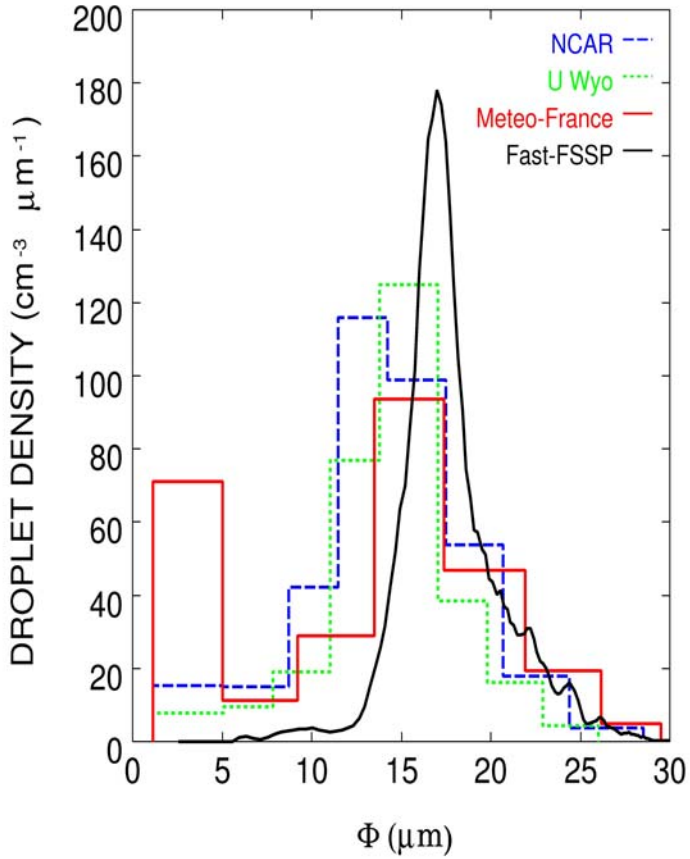
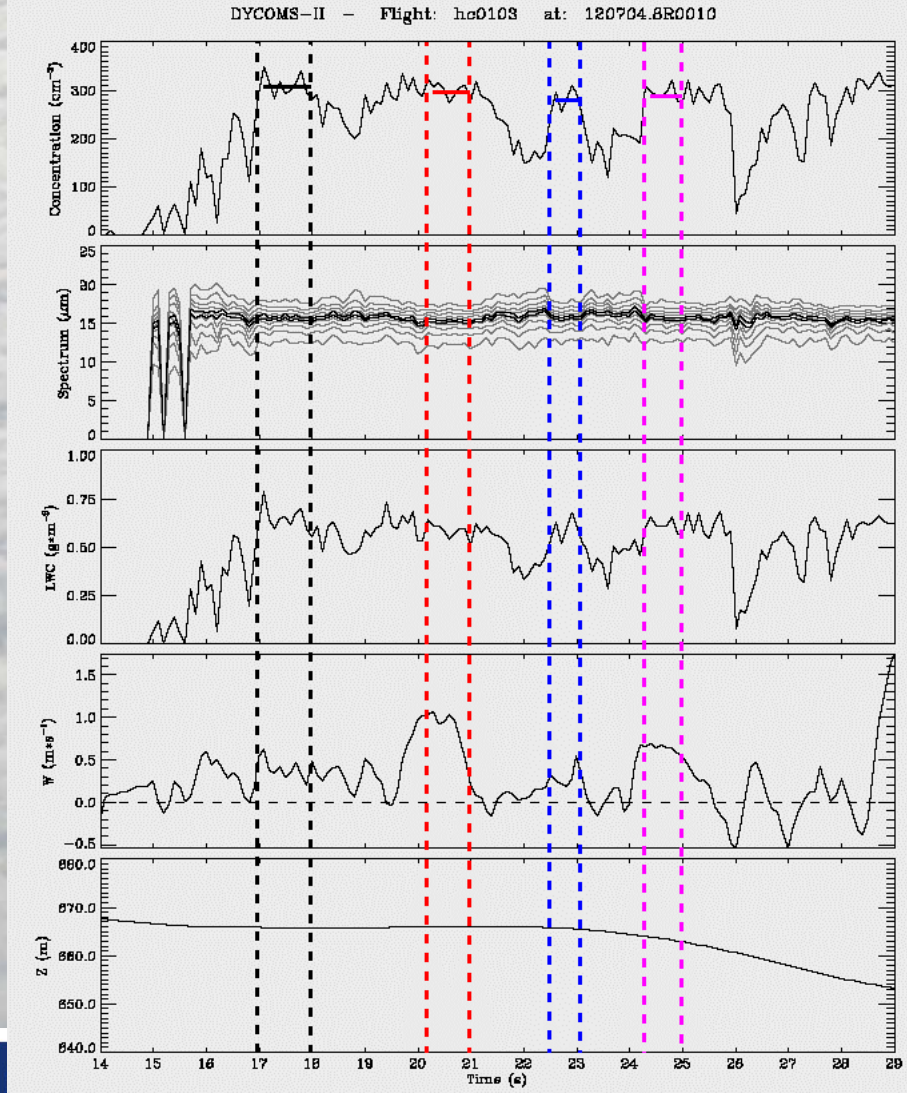
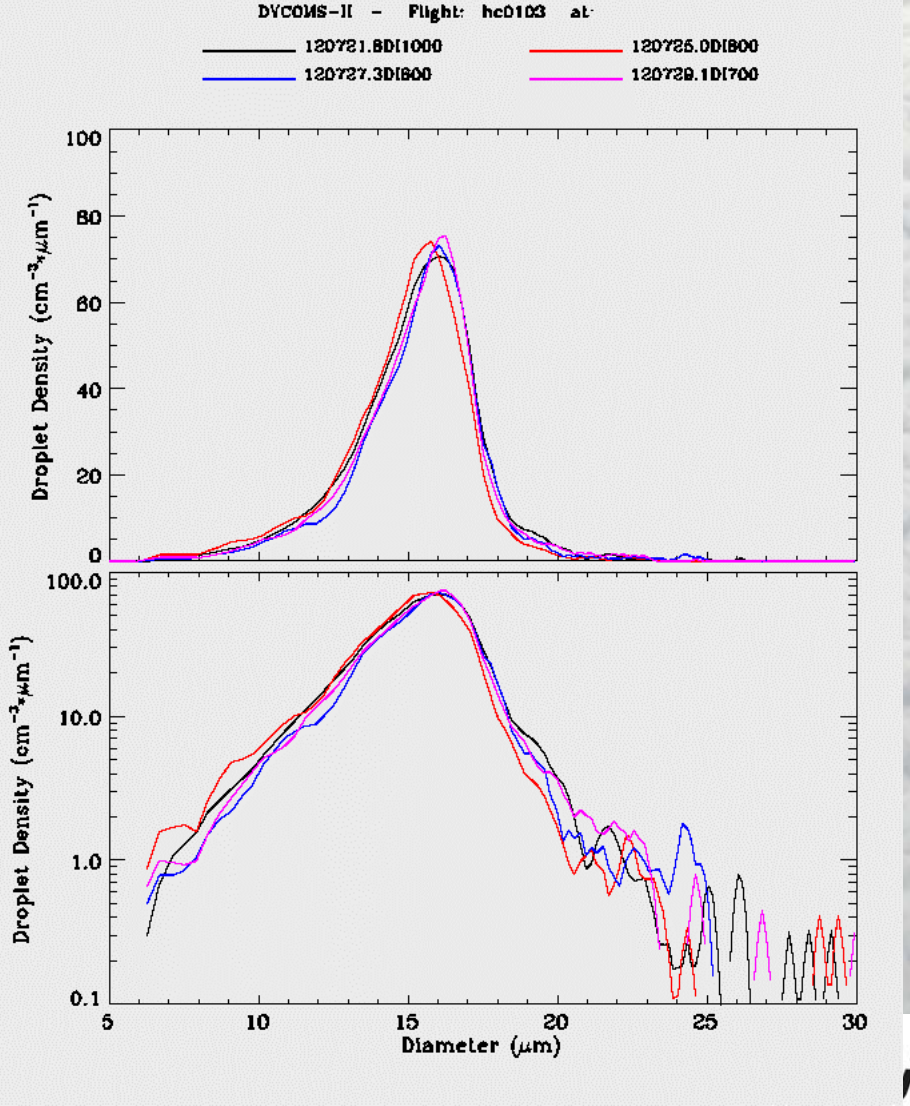



Fig. 1: Comparison of droplet spectra measurements with the FAST-FSSP and three FSSP-100

# Step 3 : Entrainment and mixing : Droplet spectra observations



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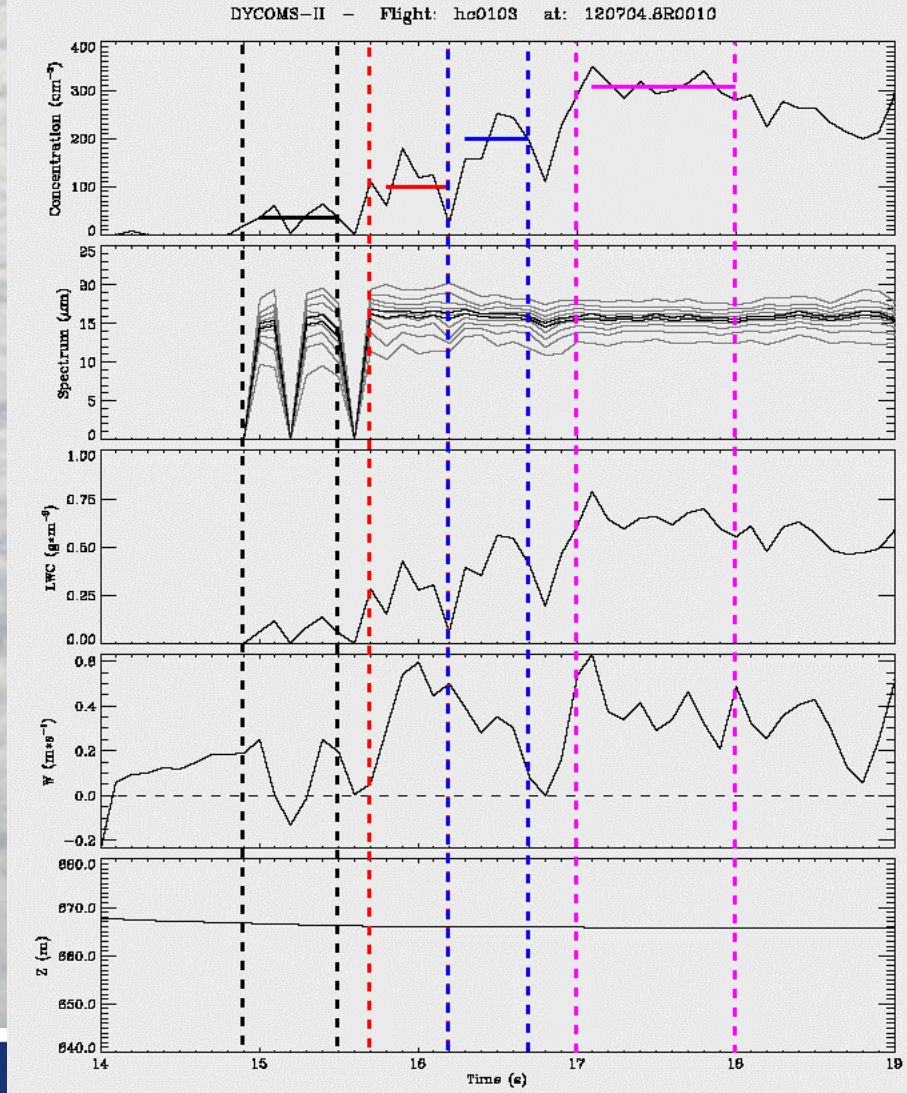


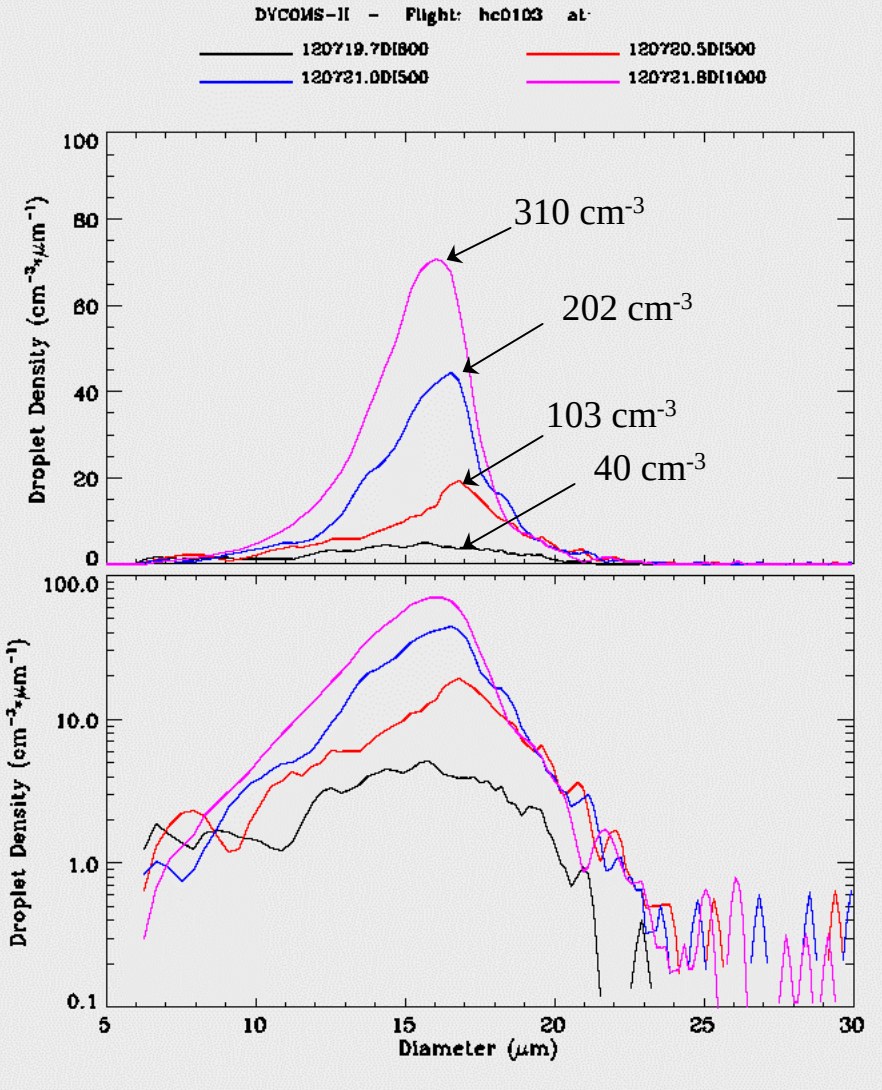

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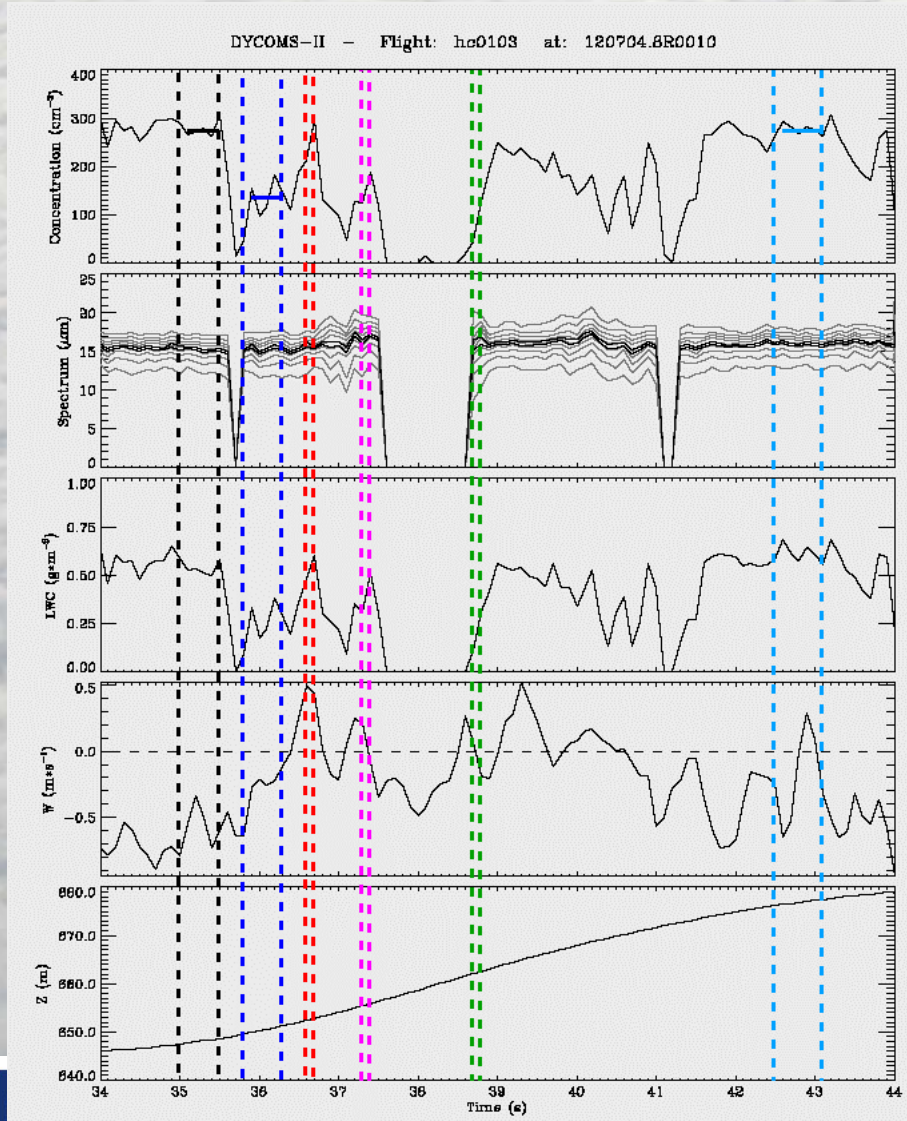
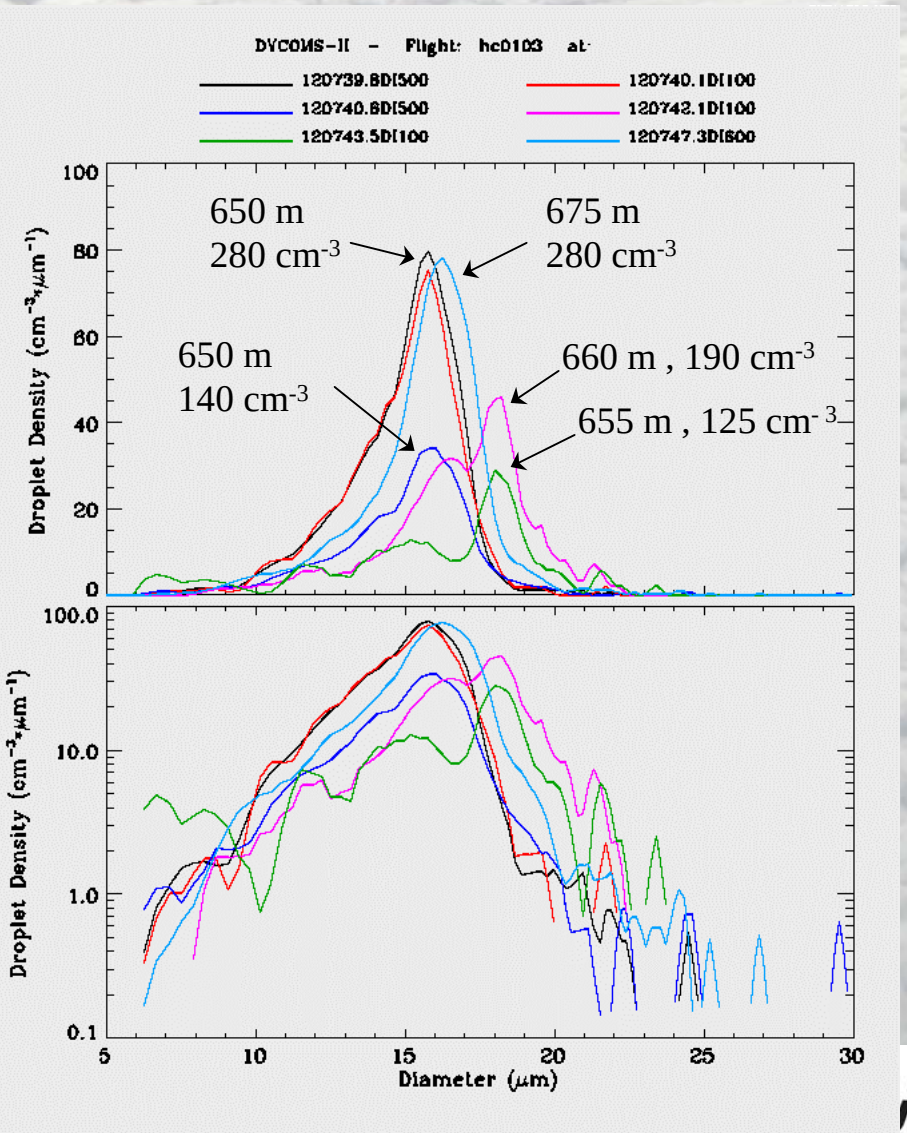
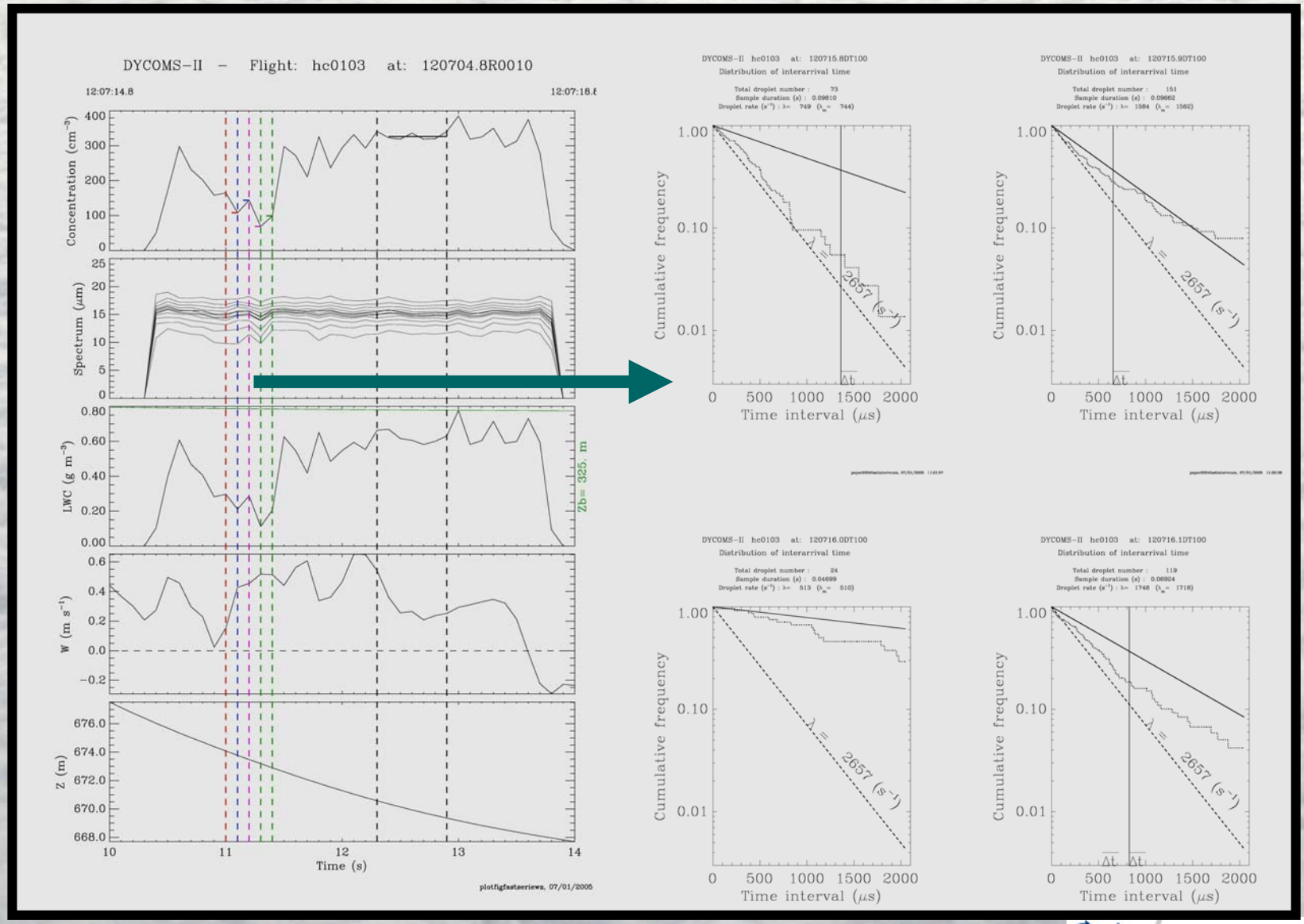


# Step 3 : Entrainment and mixing : Case Studies

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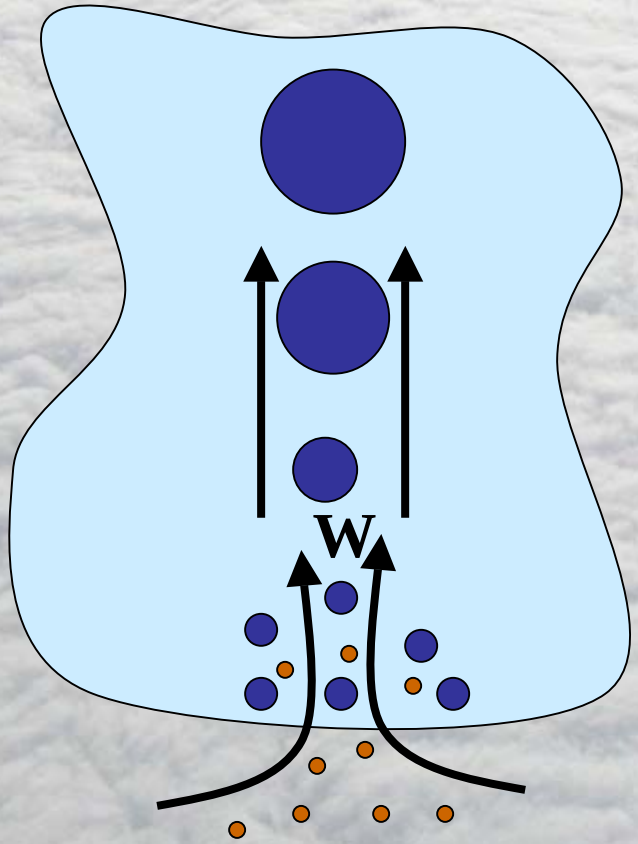
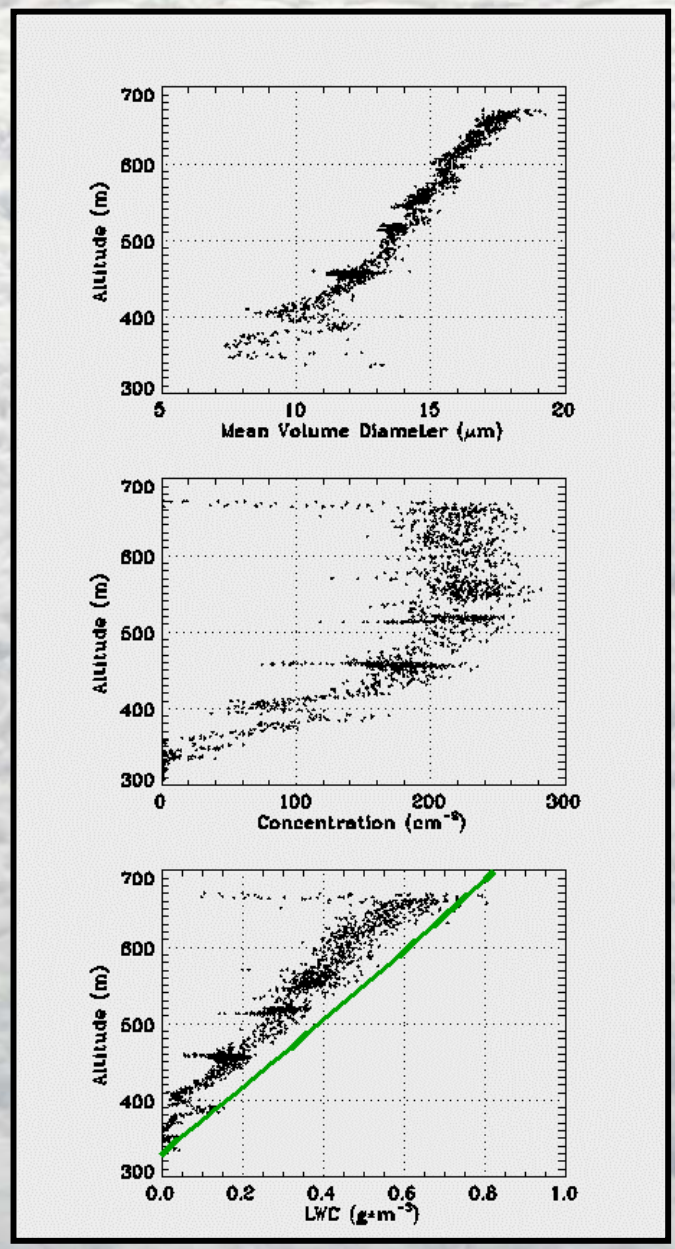
# Step 2 : Droplet growth



# Step 1 : CCN activation at cloud base