

# *Measurements of Small Ice Crystals during TWP-ICE*

**Greg McFarquhar, Junshik Um, Matt  
Freer, Greg Kok and Jay Mace**

**Cloud Properties Working Group**

**8 November 2006**

# Summary of Flights

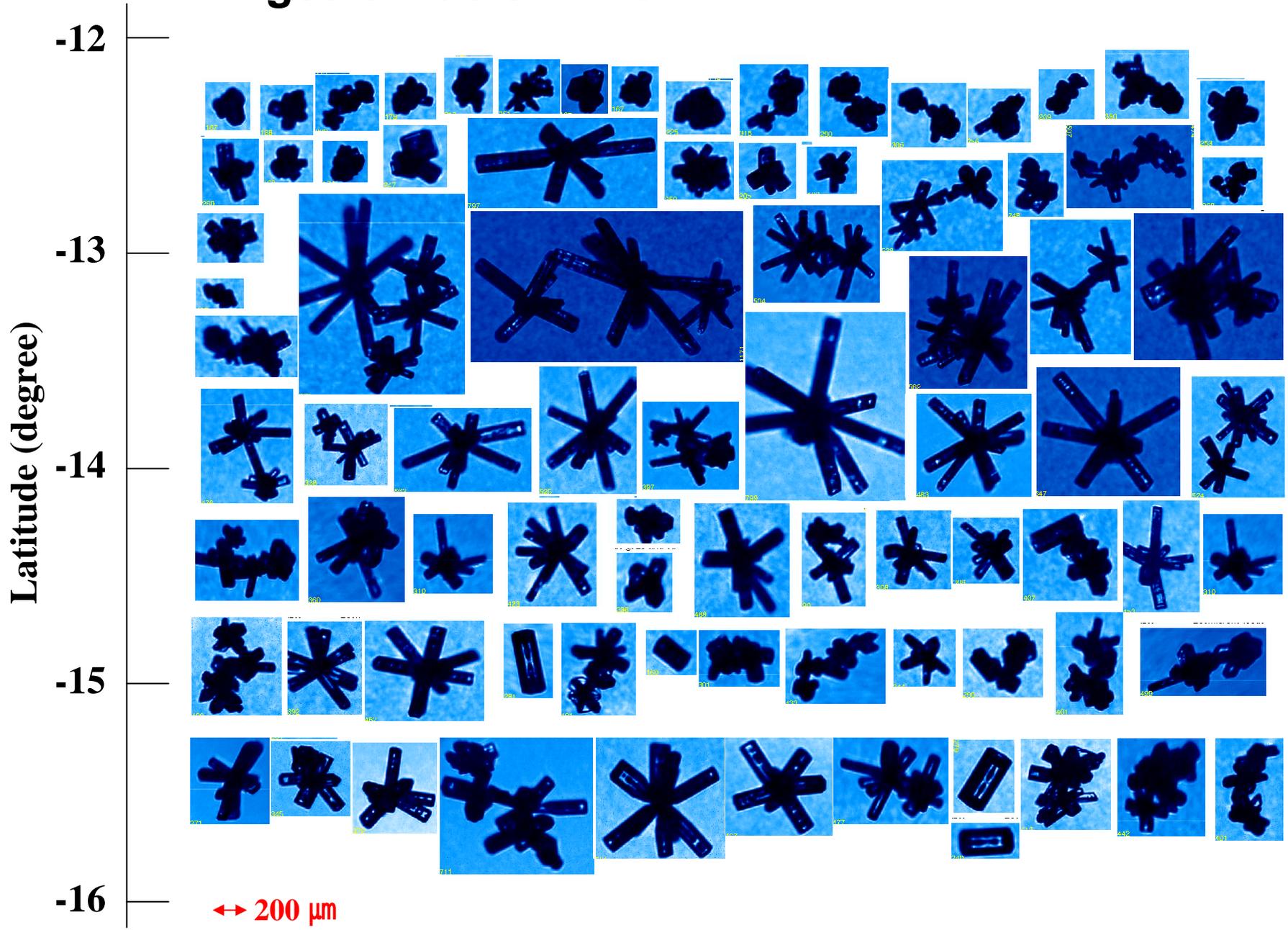
Look at data from 3 flights when all probes worked:

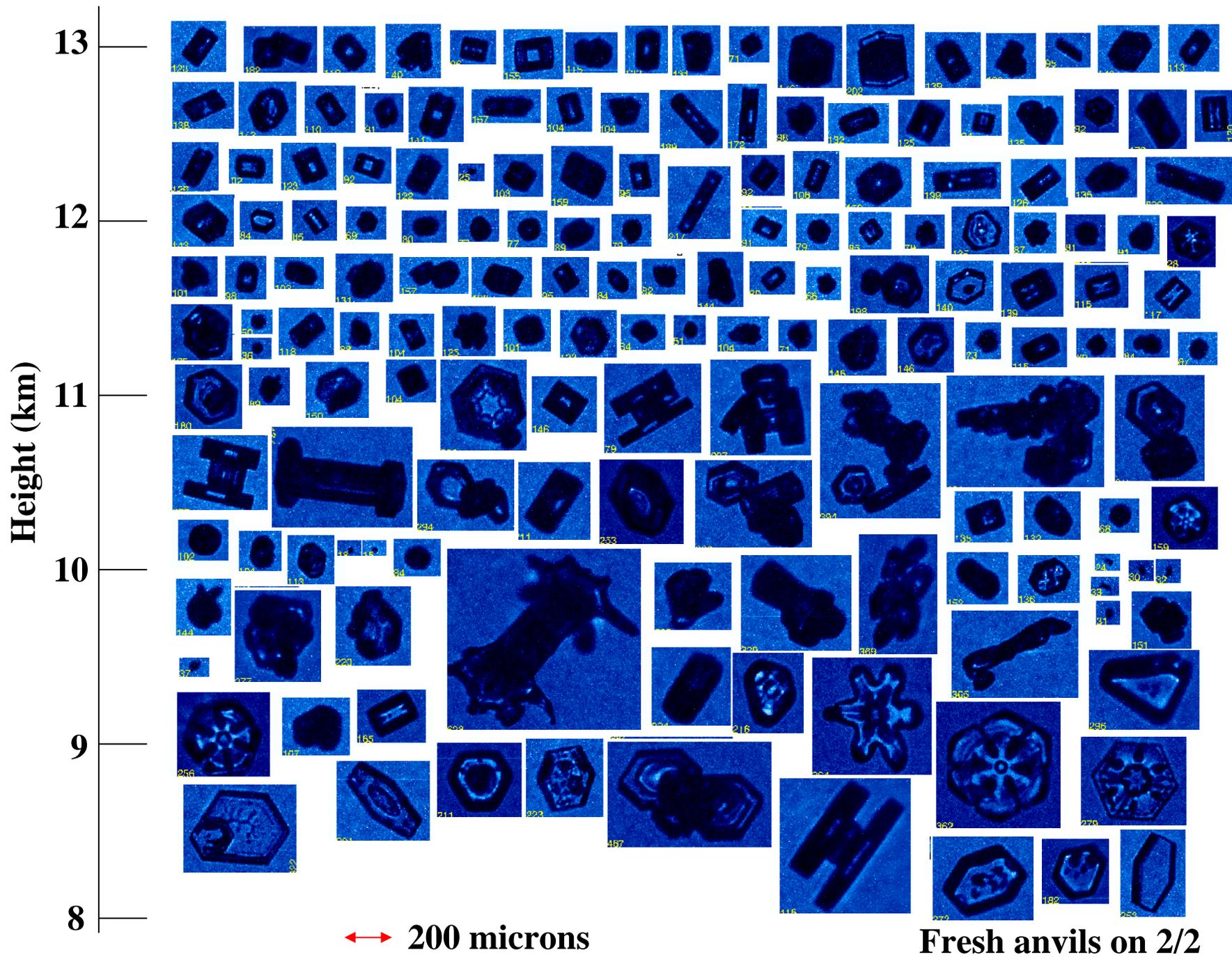
27 January: Horizontal profiles through aged cirrus of varying lifetimes

29 January: Horizontal profiles looking at transition of anvil cirrus to more generic cirrus

2 February: Spiral ascents/descents in fresh anvils

# Aged cirrus on 1/29





# Shattering Effect

... on the protruding tips of a probe giving  
... concentrations of small ice crystals



CPI



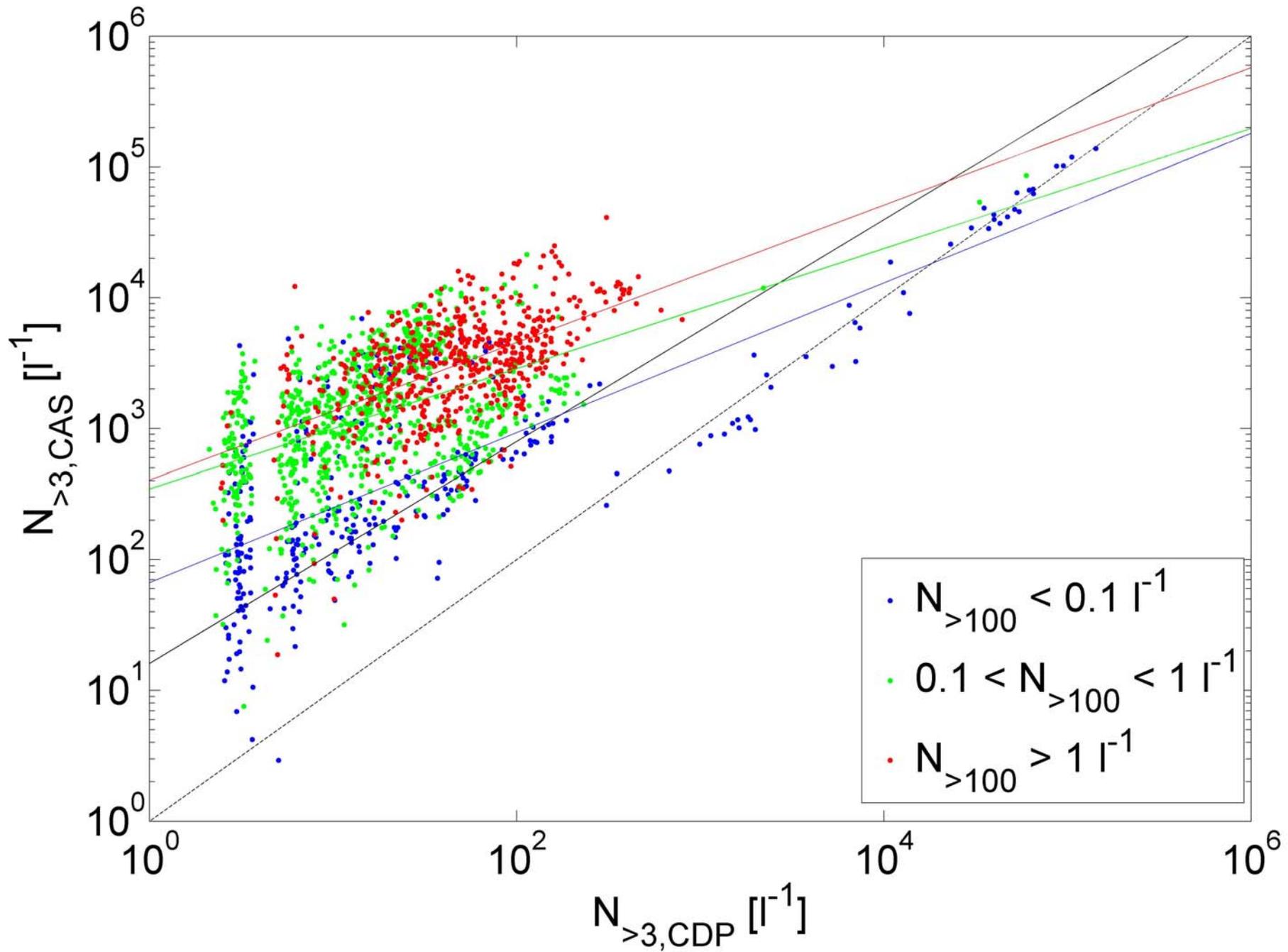
CIP

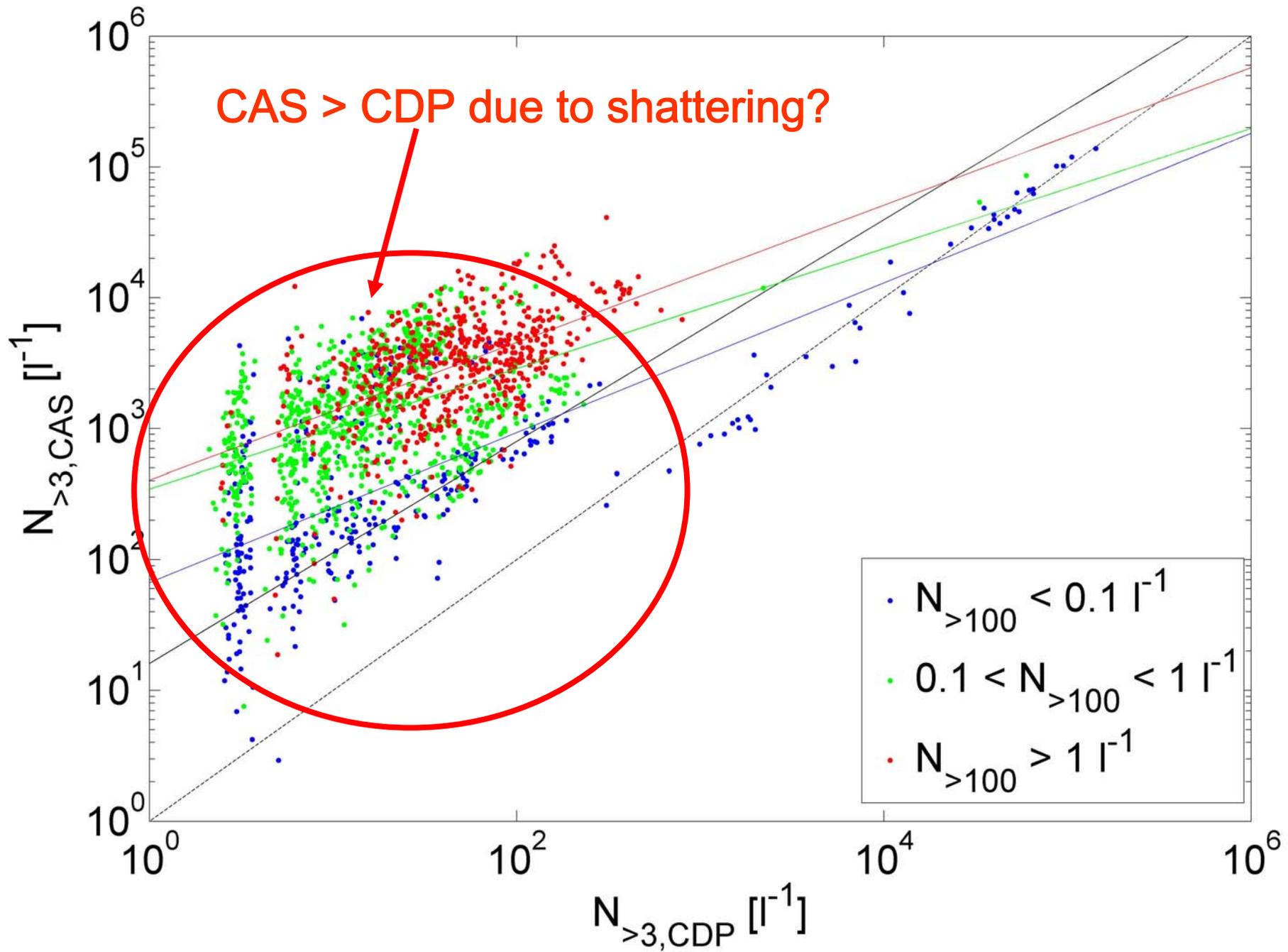
CAS

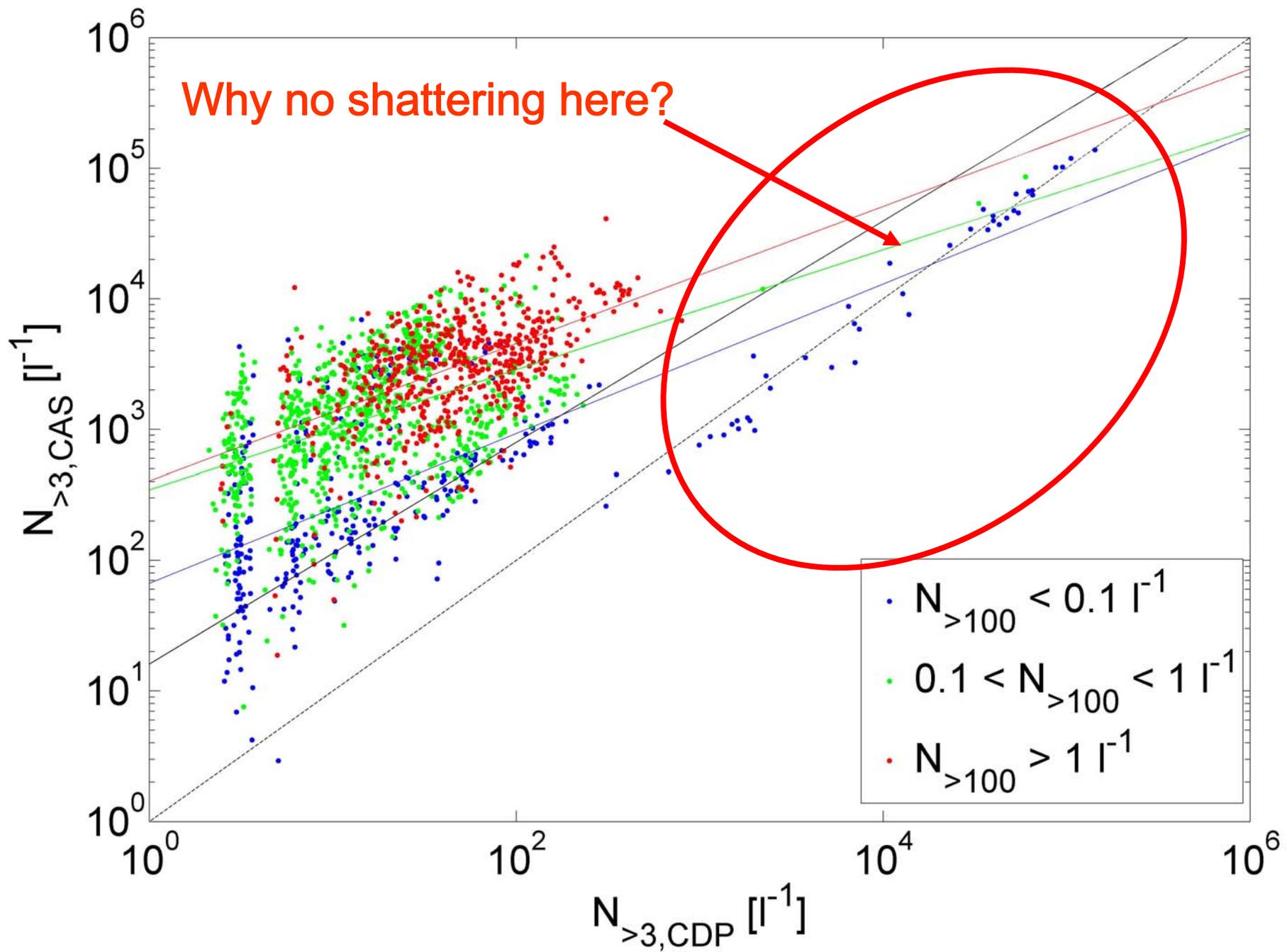


CVI

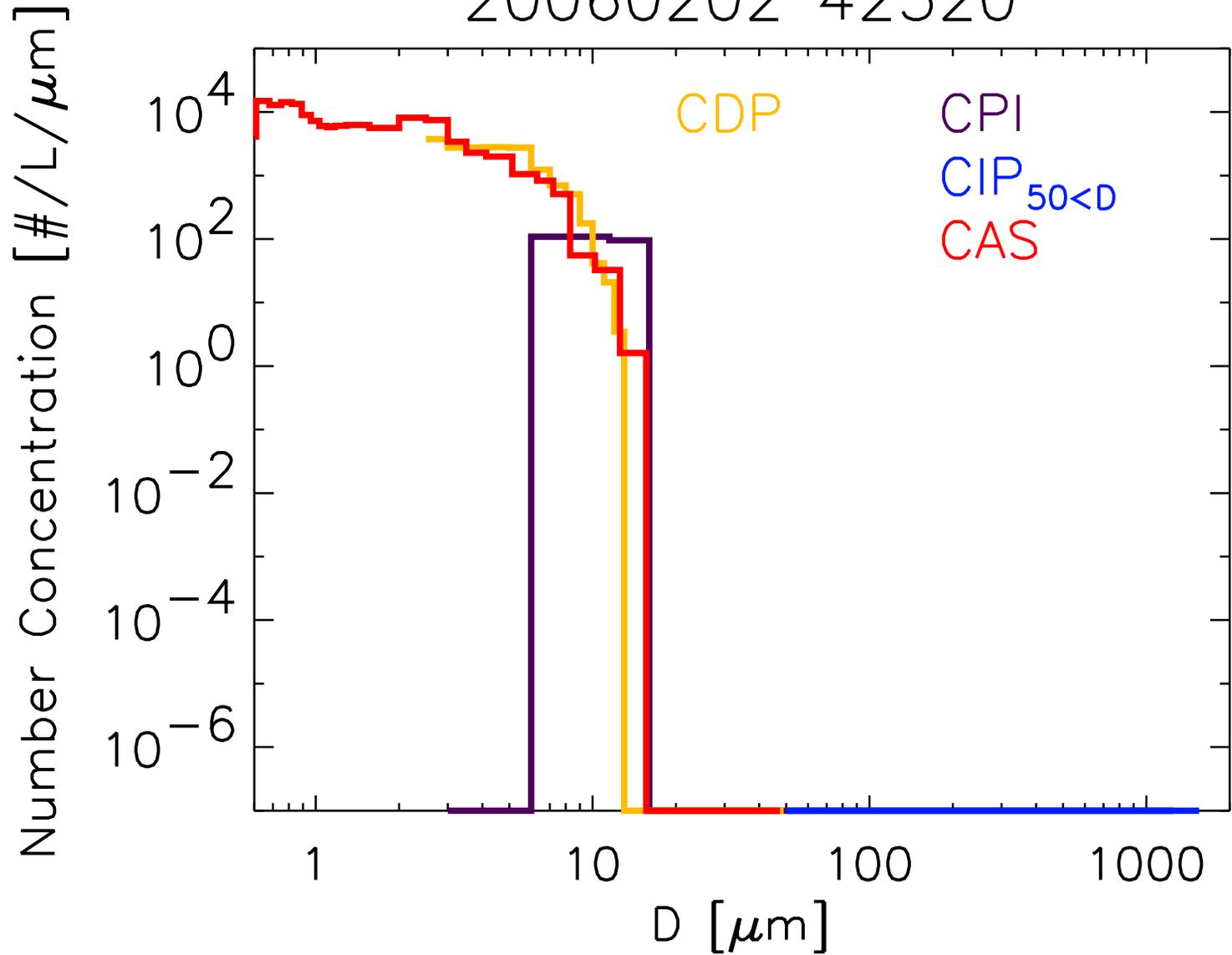
CDP





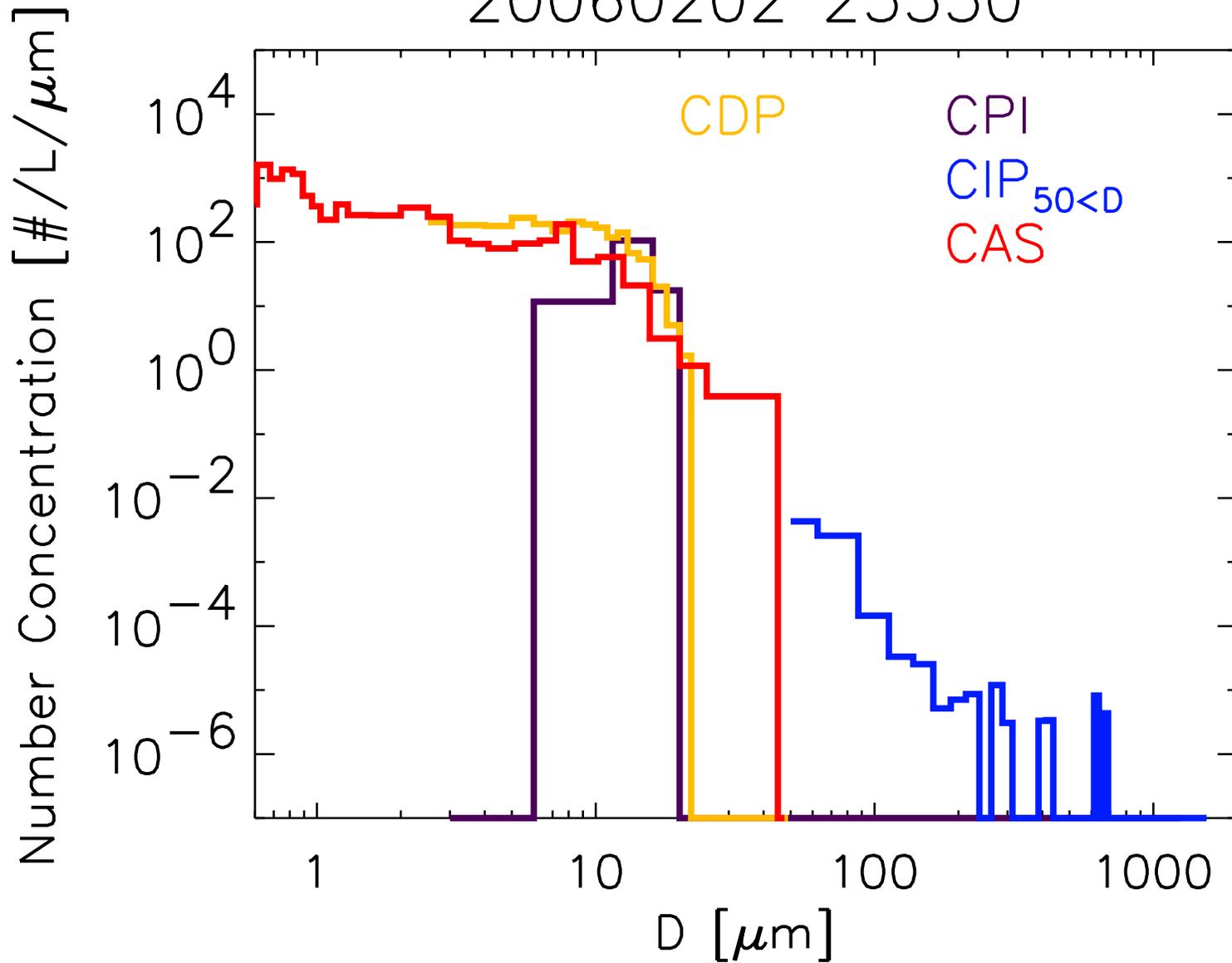


20060202 42320

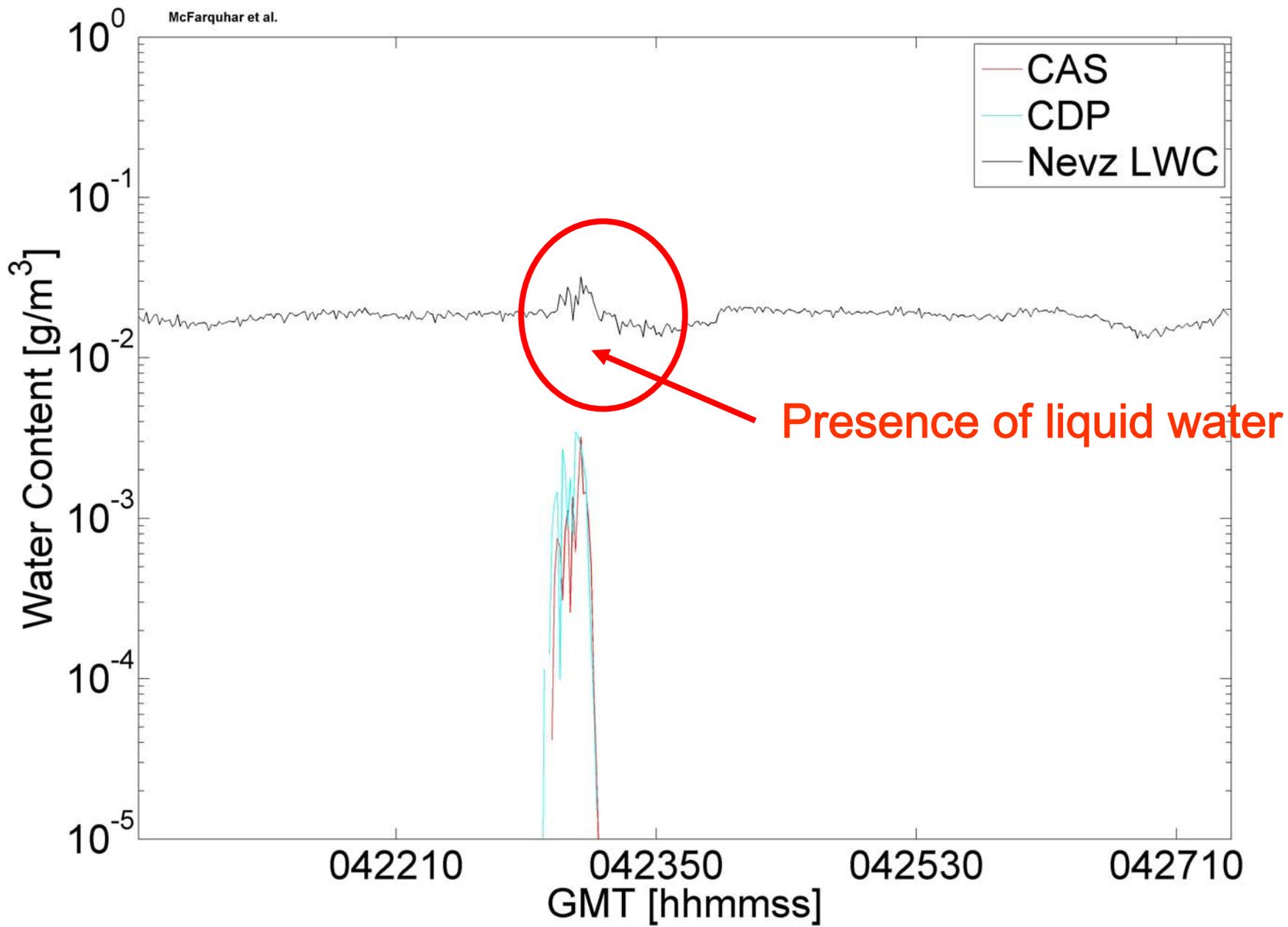


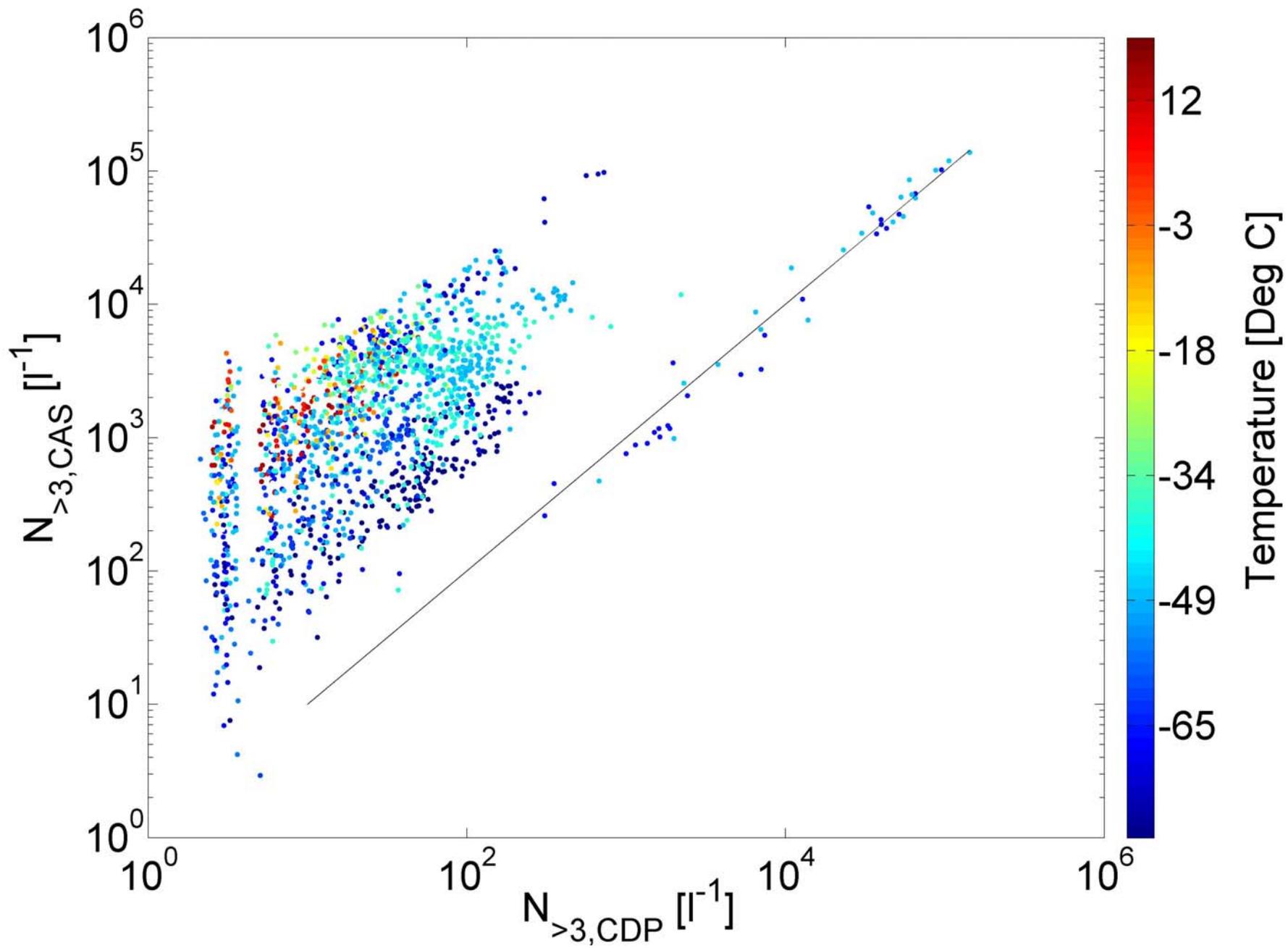
Good agreement between CAS and CDP when  $N > 10^3 \text{ l}^{-1}$ .

20060202 25530

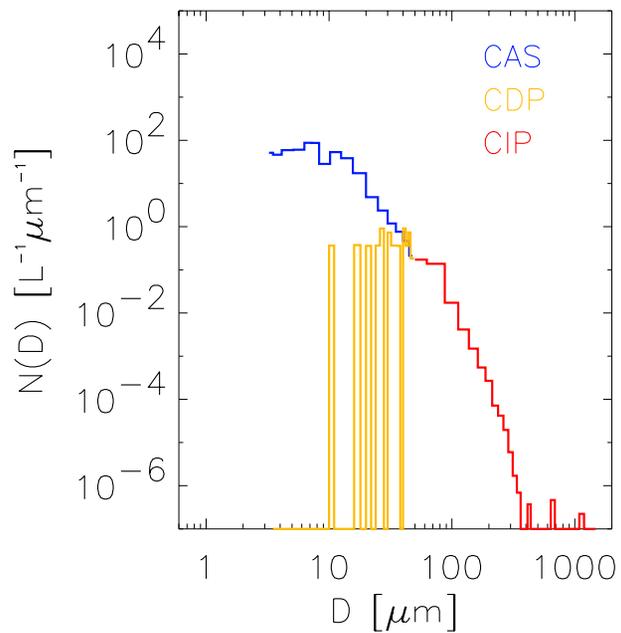


And here in presence of larger particles!

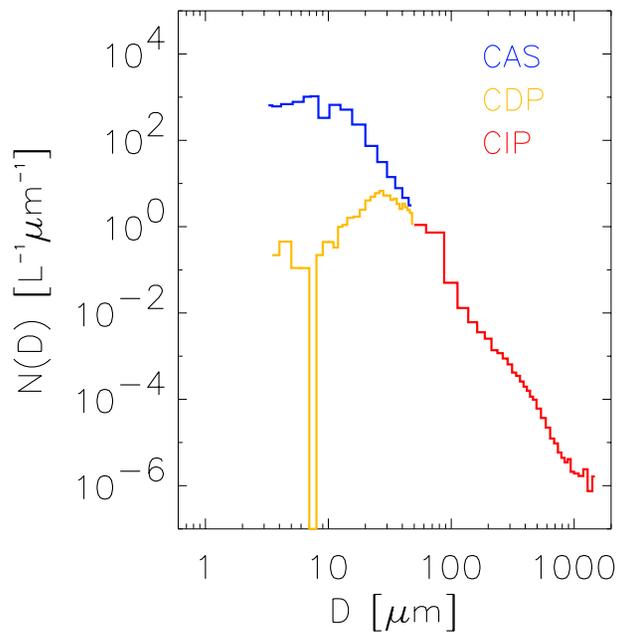




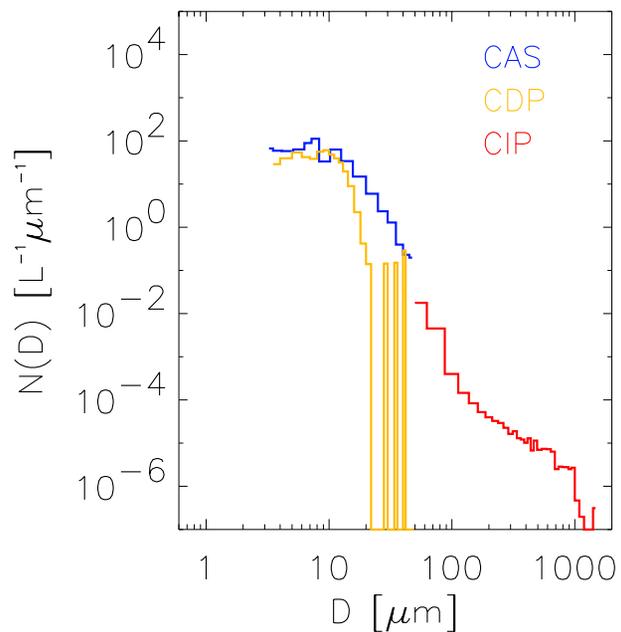
11.4 – 11.7 km



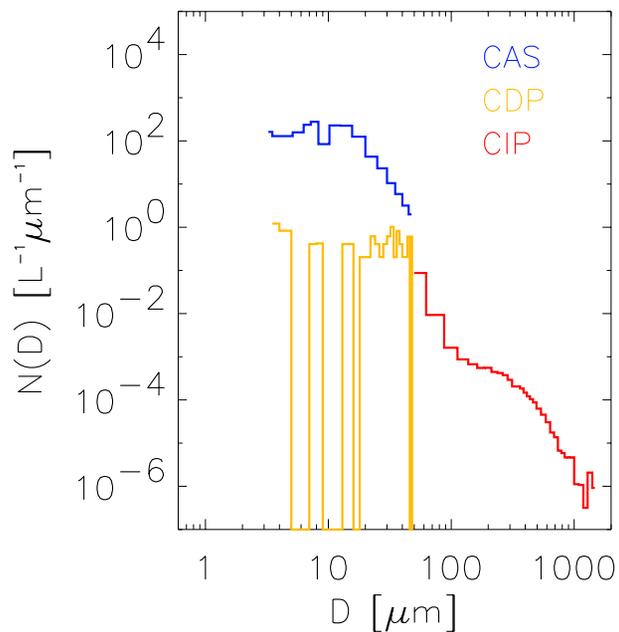
10.2 – 11.4 km



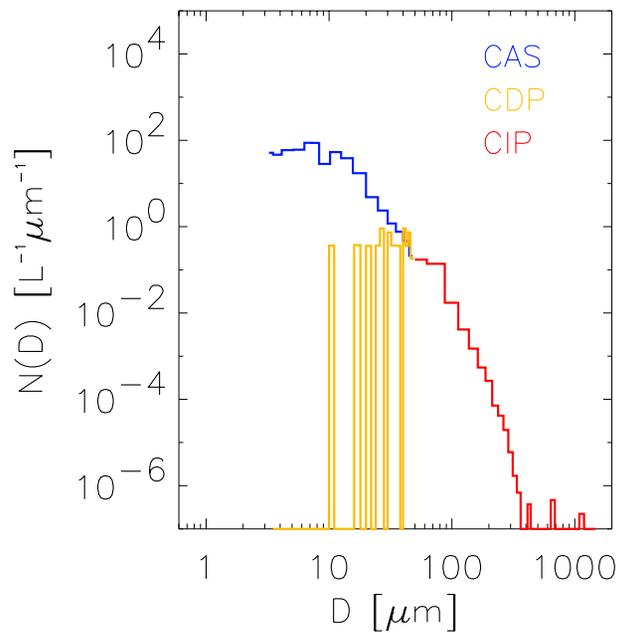
8.5 – 9.2 km



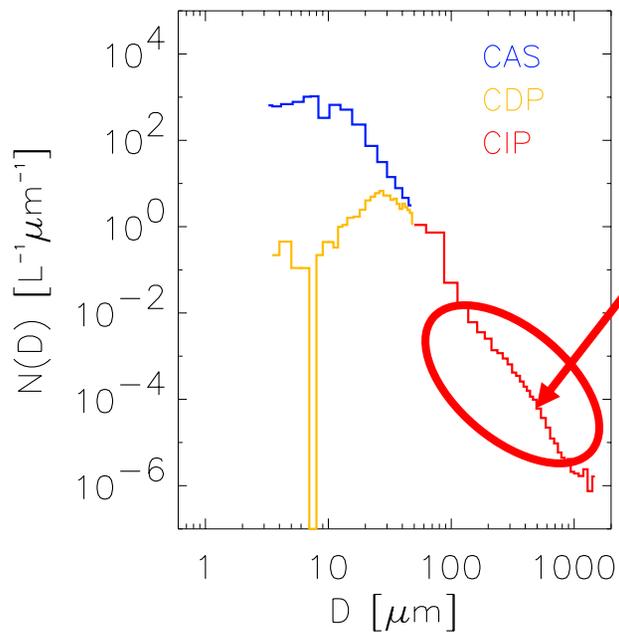
7.7 – 8.1 km



11.4 – 11.7 km

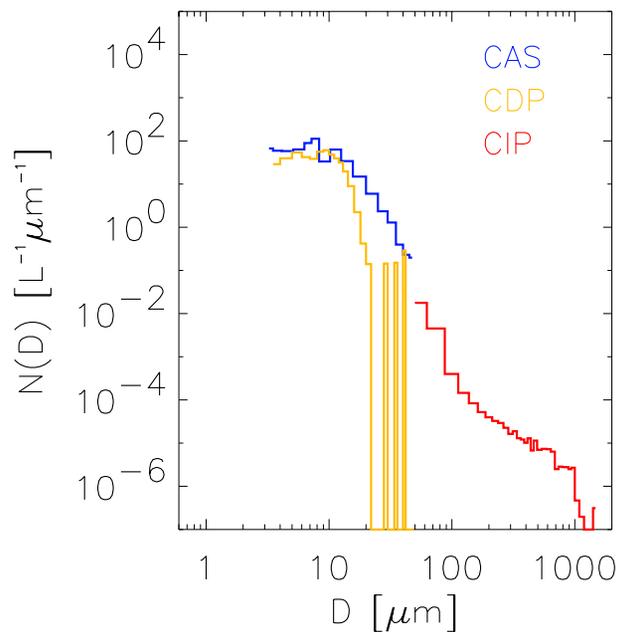


10.2 – 11.4 km

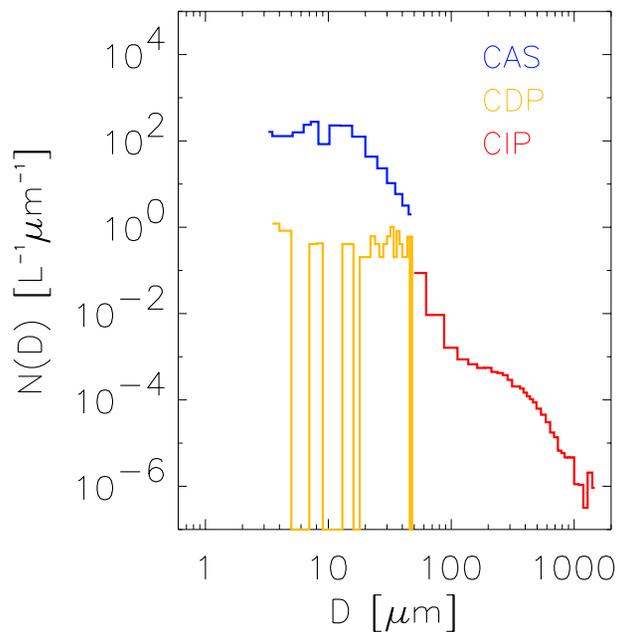


**Impact of  
sedimentation**

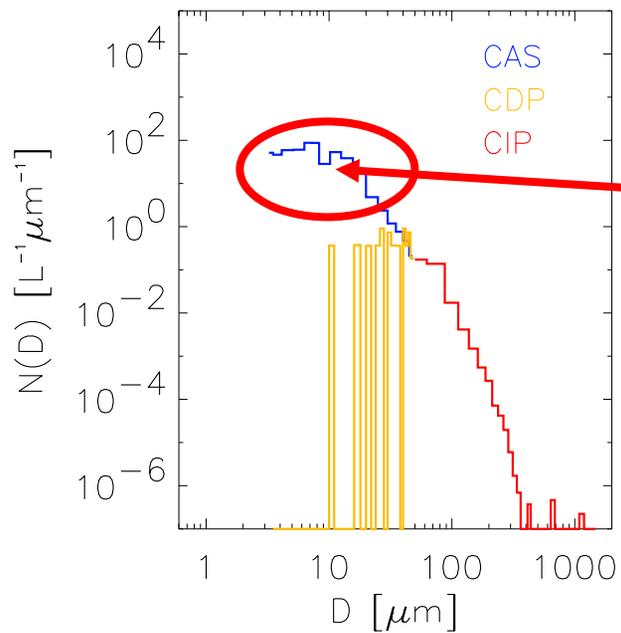
8.5 – 9.2 km



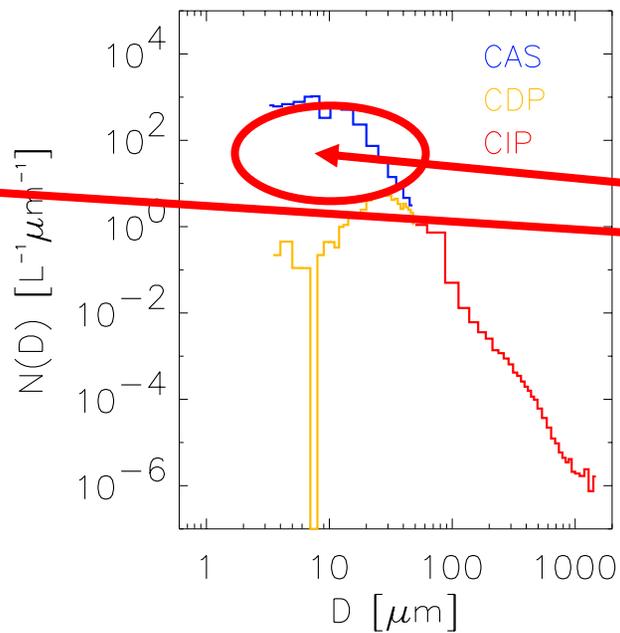
7.7 – 8.1 km



11.4 – 11.7 km

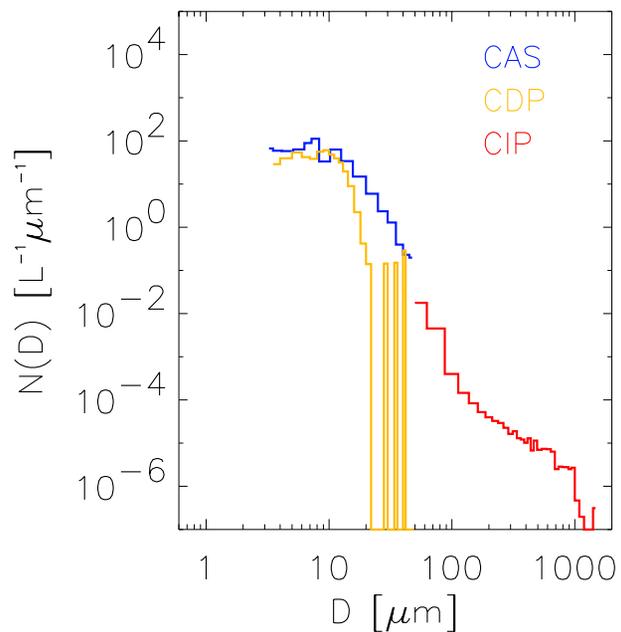


10.2 – 11.4 km

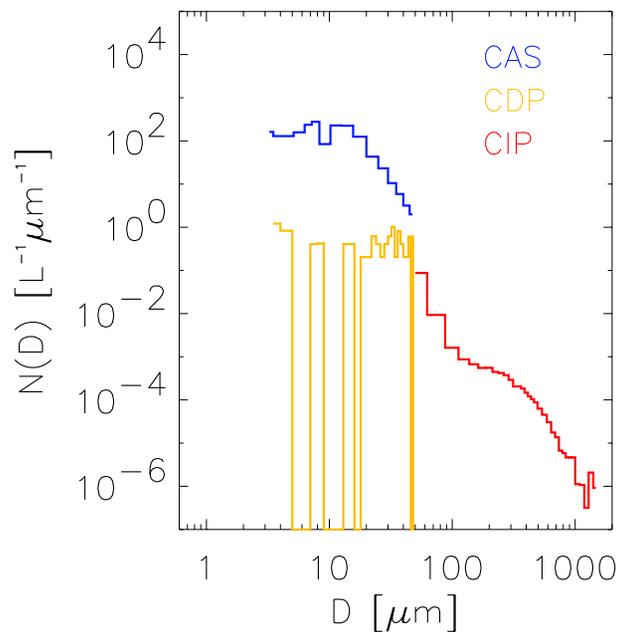


Still lots of  
small crystals

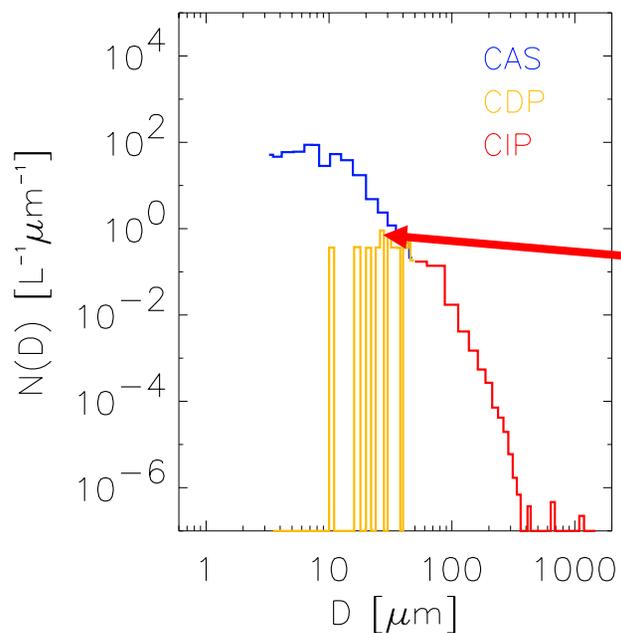
8.5 – 9.2 km



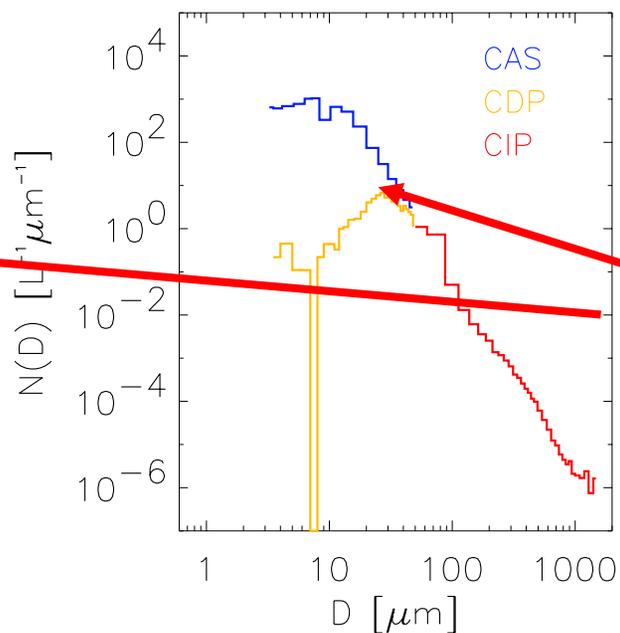
7.7 – 8.1 km



11.4 – 11.7 km

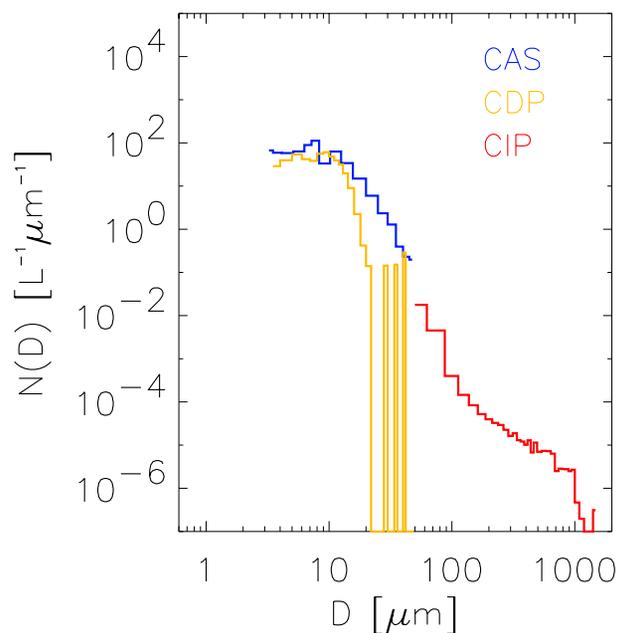


10.2 – 11.4 km

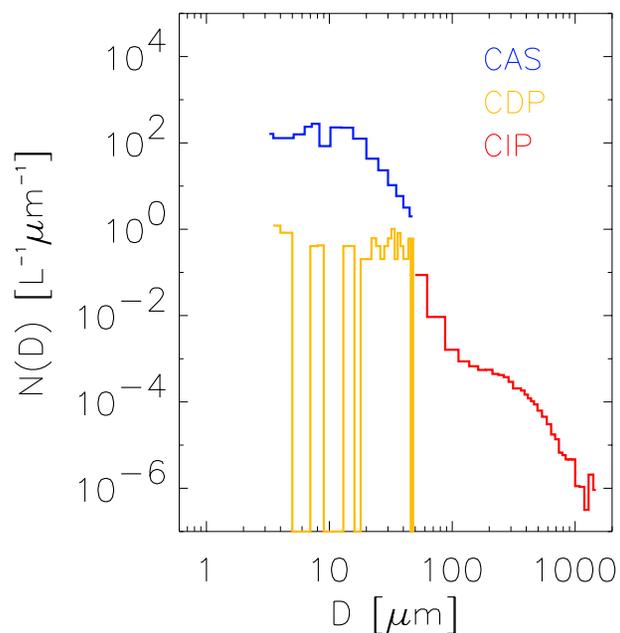


Over prediction is  
for crystals with  
 $D < 25 \mu m$

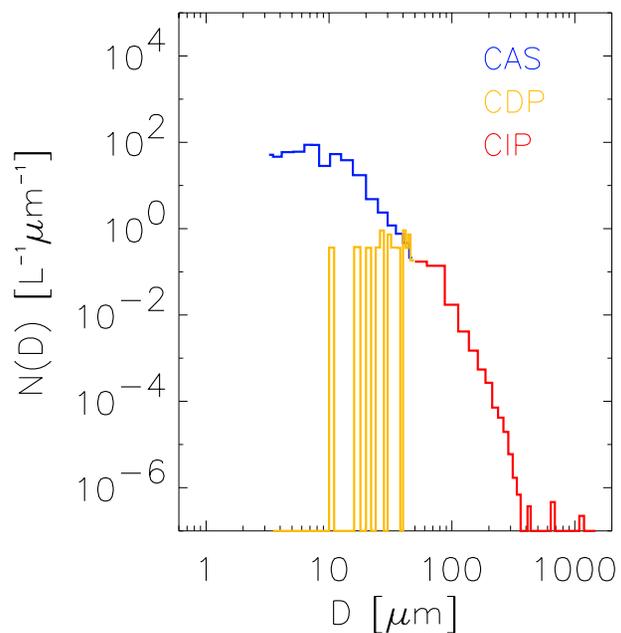
8.5 – 9.2 km



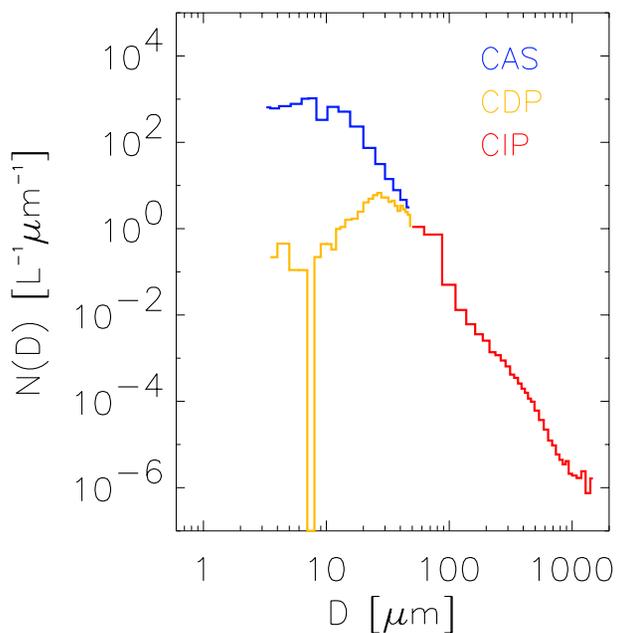
7.7 – 8.1 km



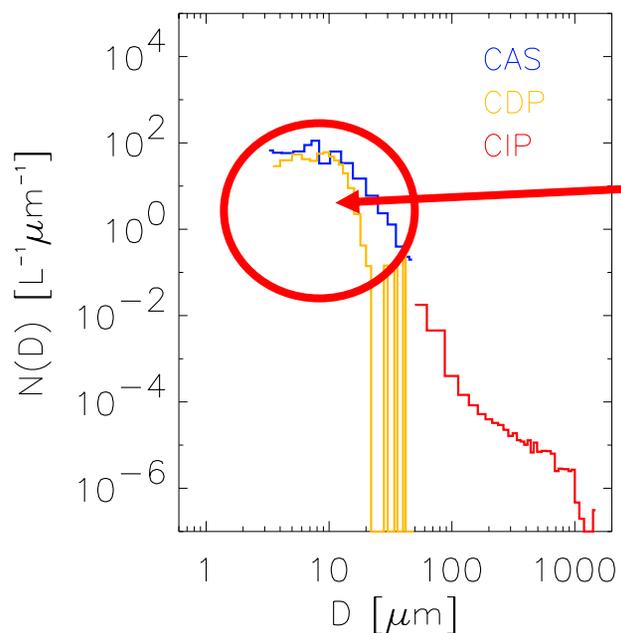
11.4 – 11.7 km



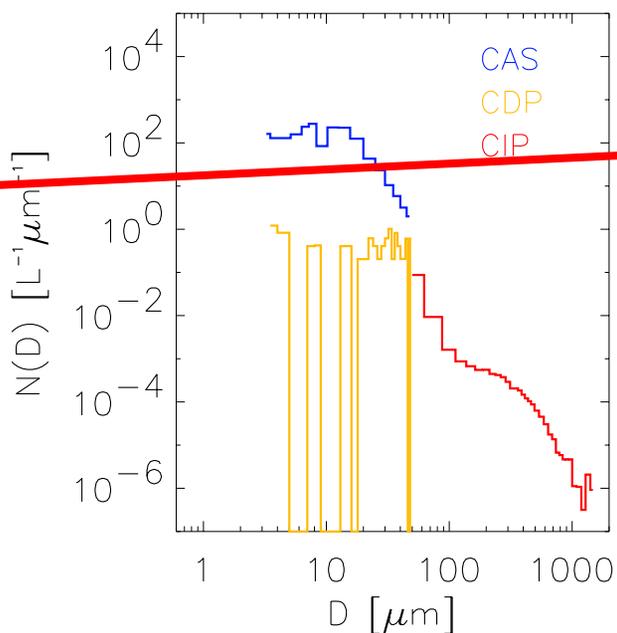
10.2 – 11.4 km



8.5 – 9.2 km



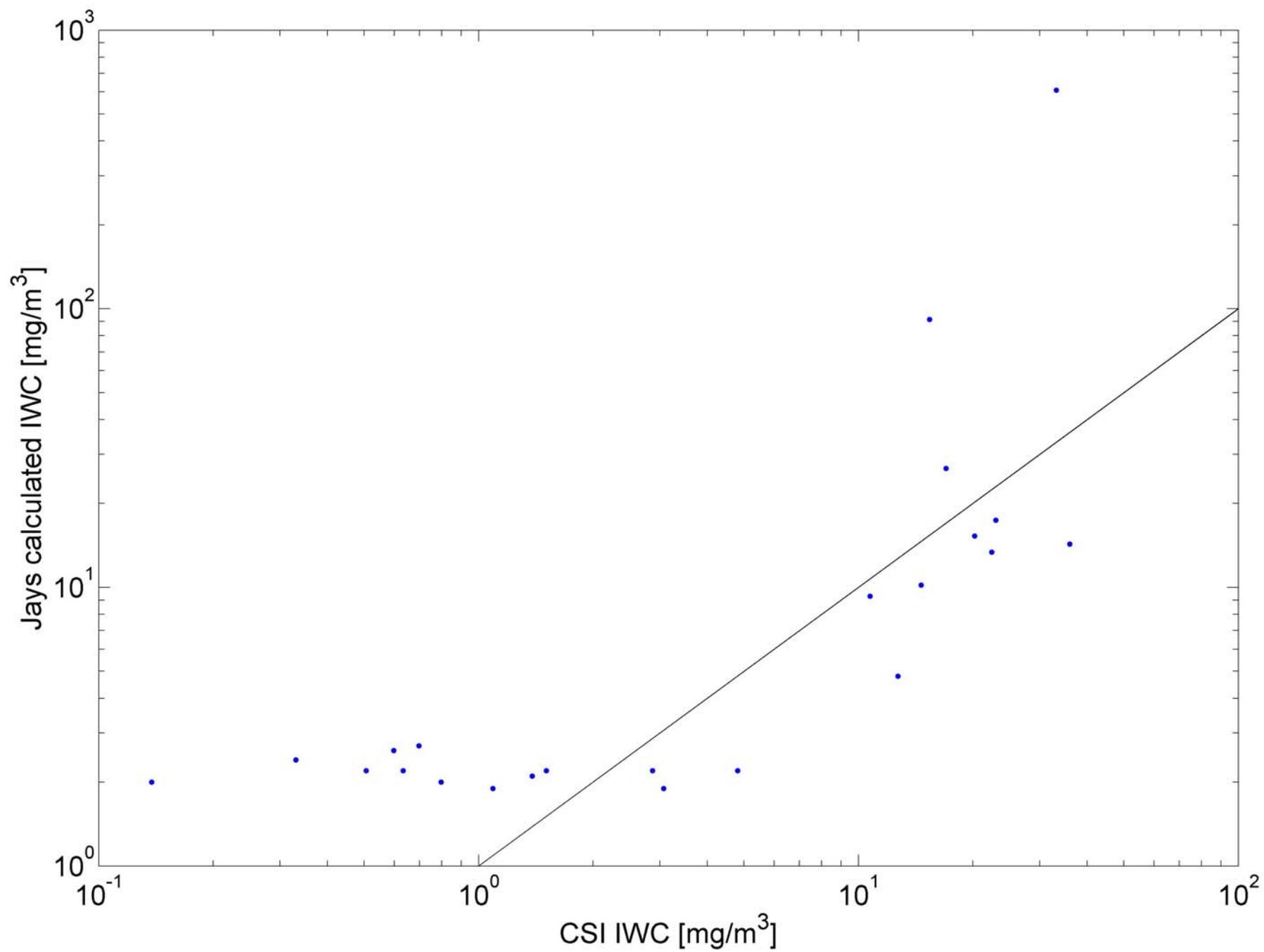
7.7 – 8.1 km

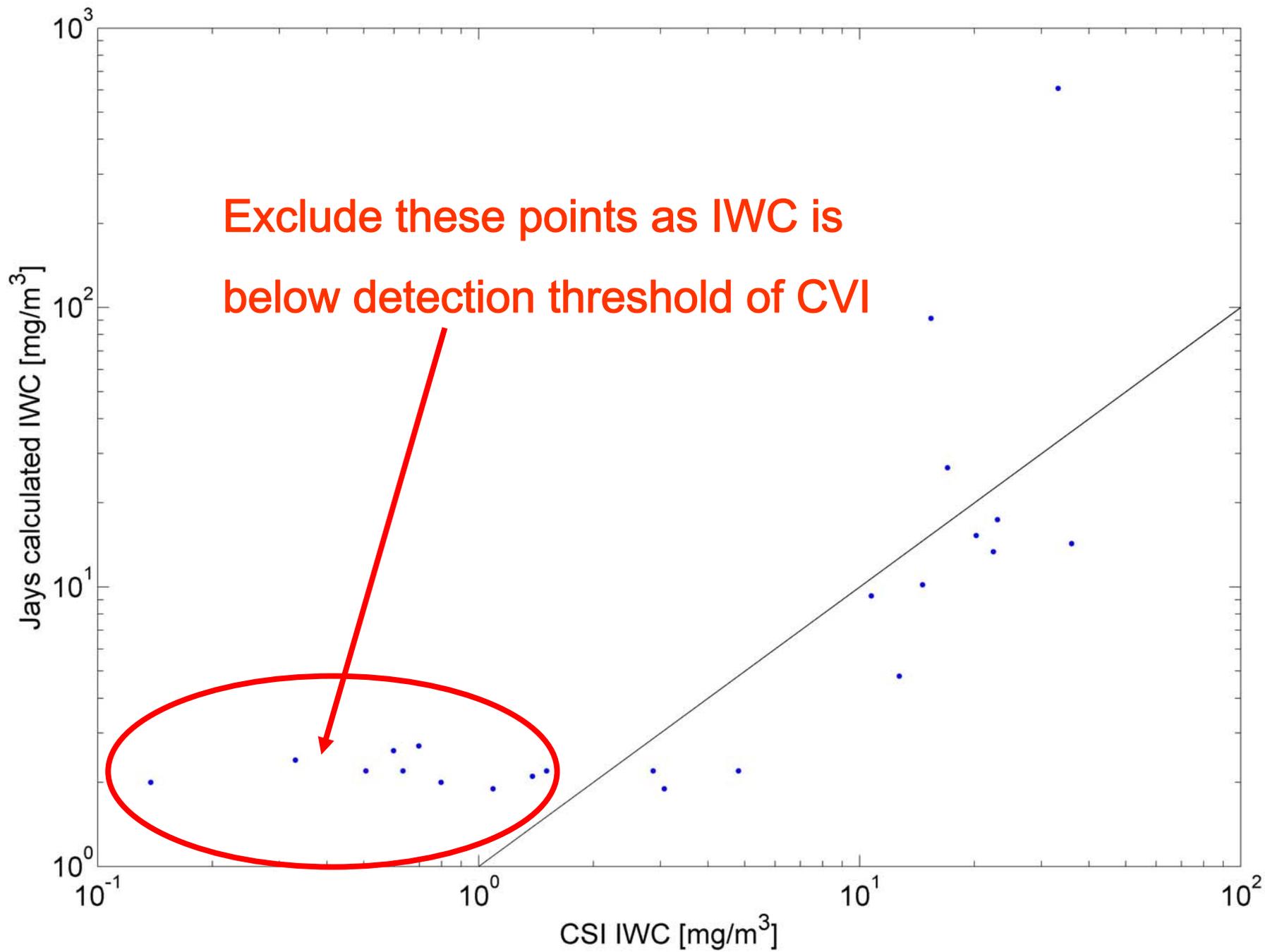


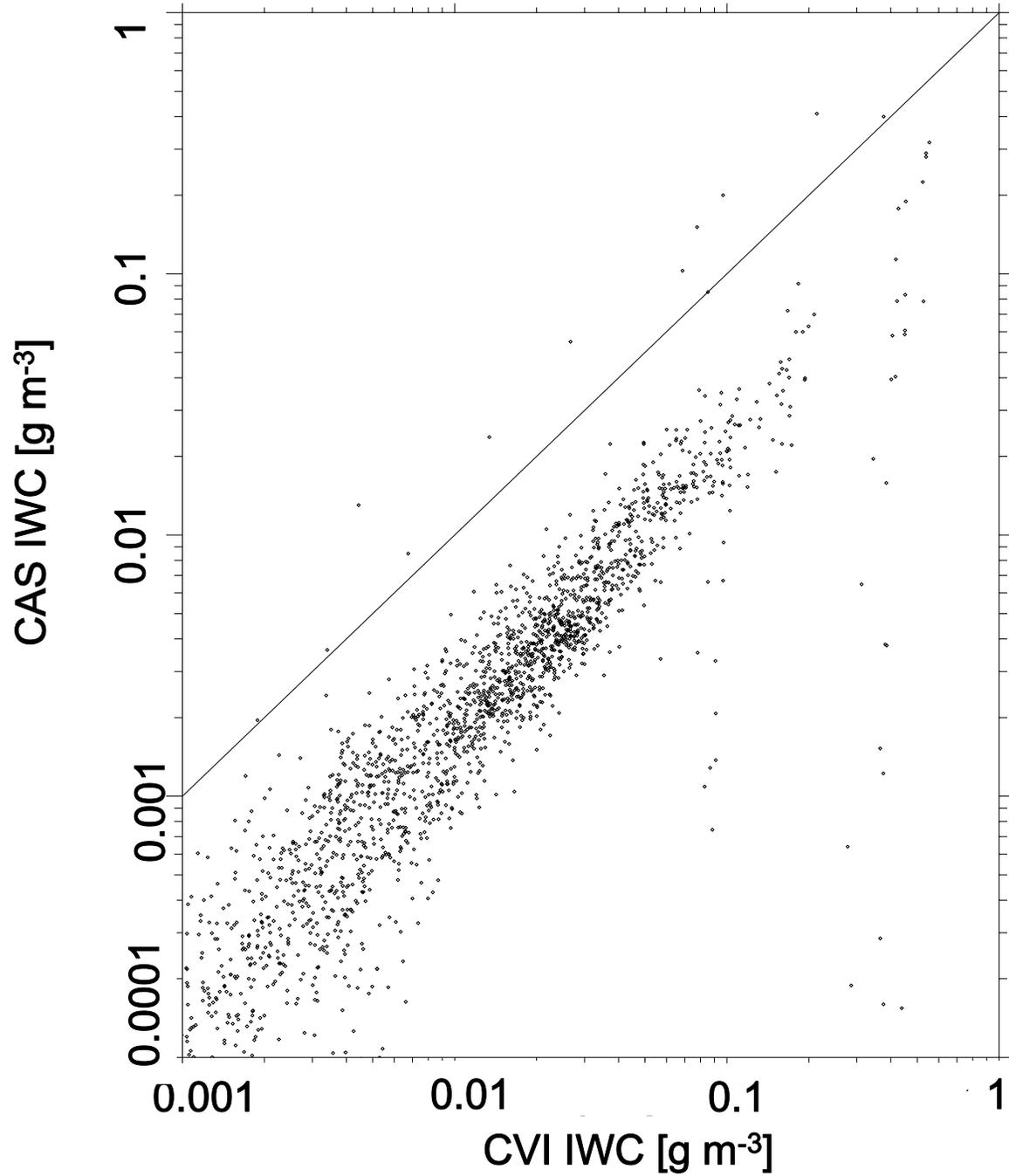
**Good agreement  
between CAS &  
CDP: liquid cloud!**

# Which is correct? CAS or CDP?

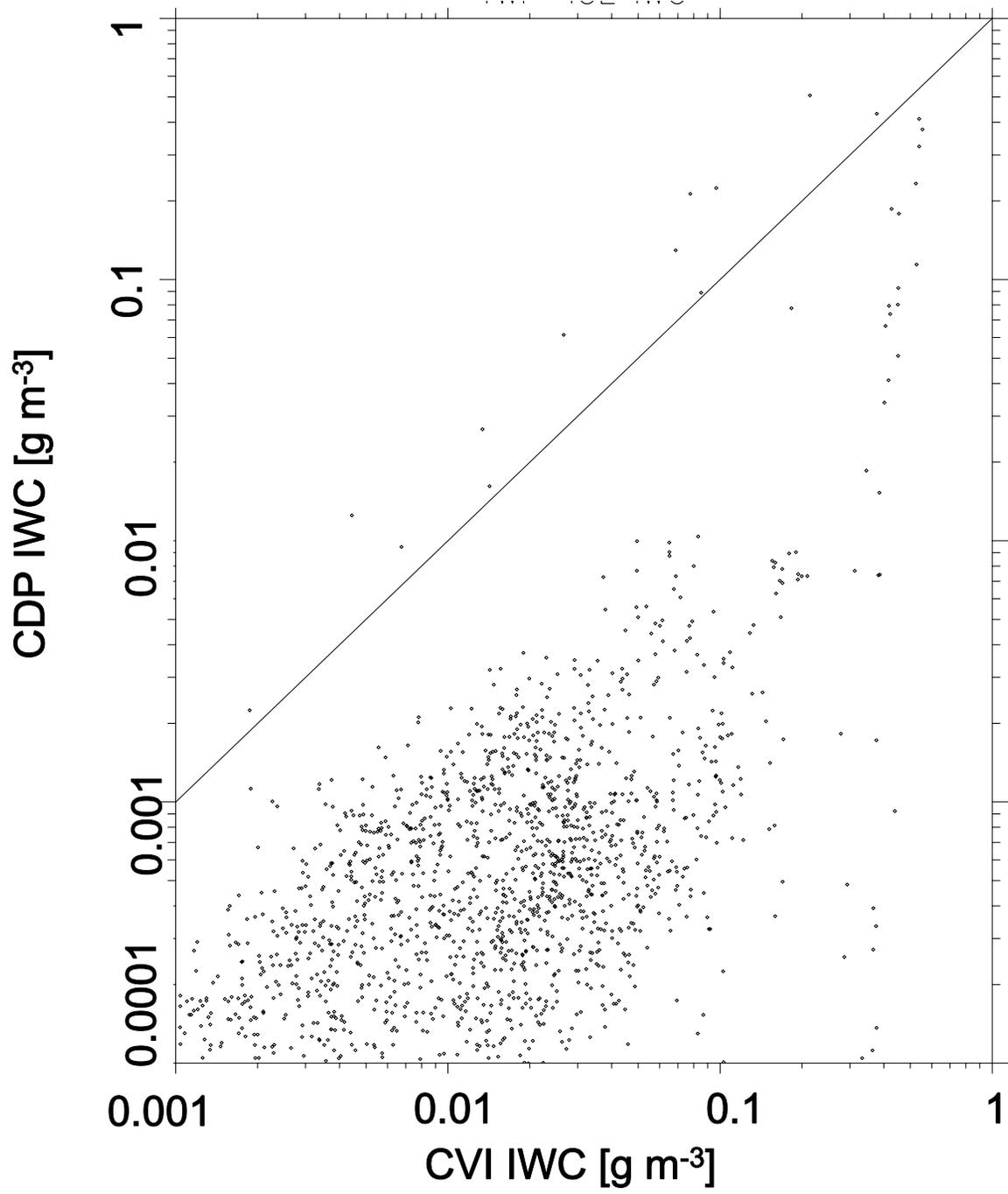
Maybe the bulk water content measured by CVI can provide a clue



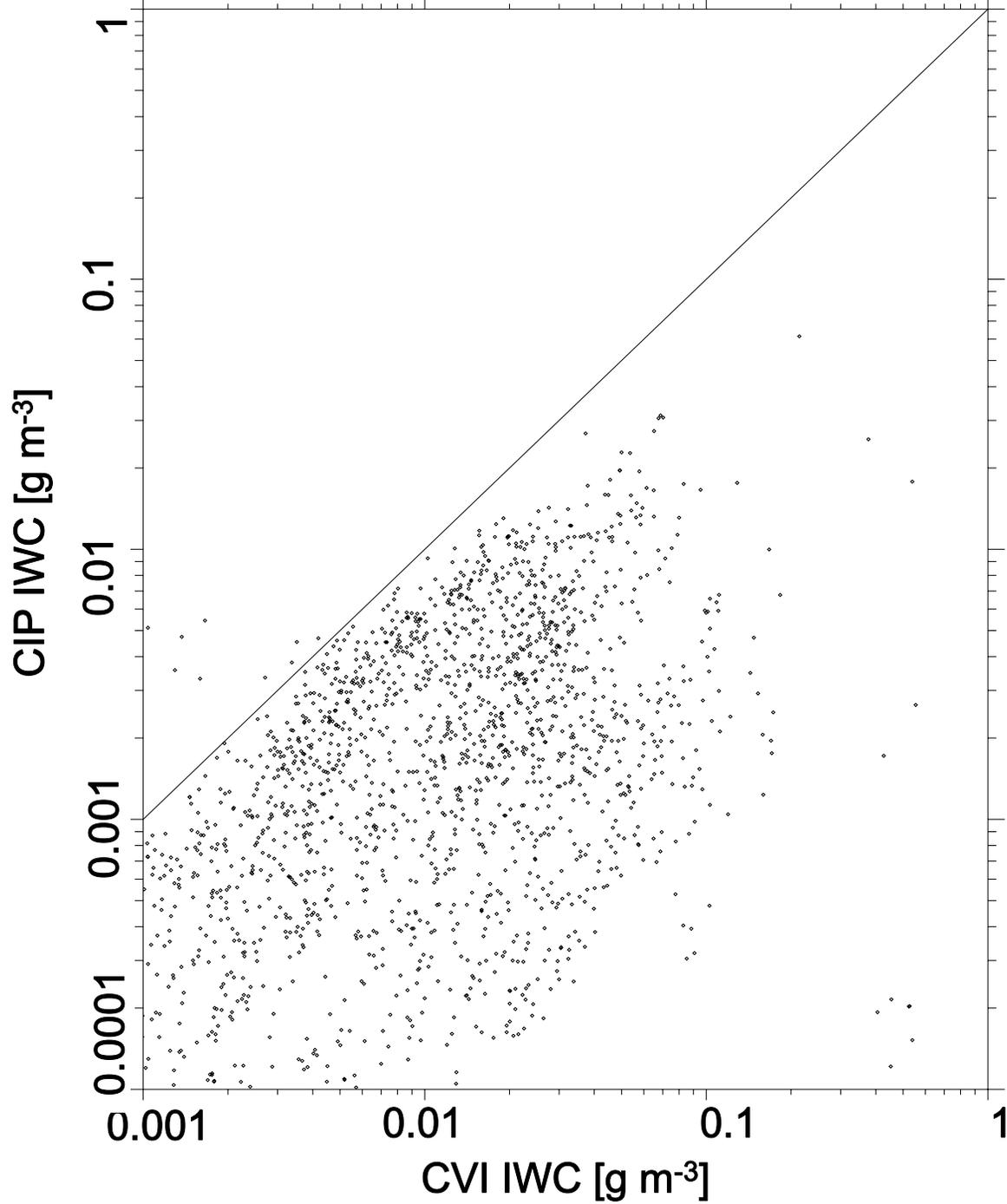




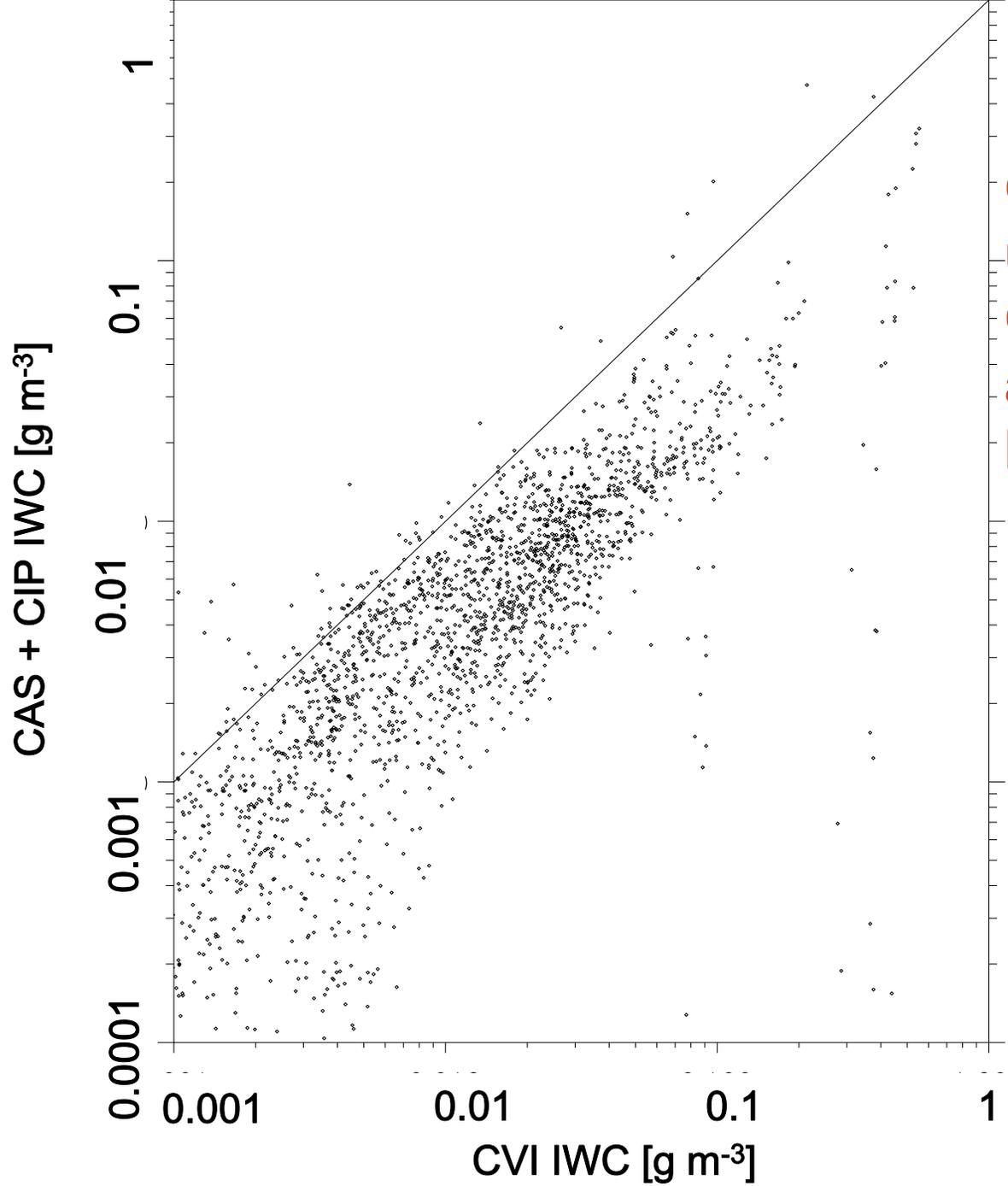
CAS by itself  
underestimates  
CVI IWC



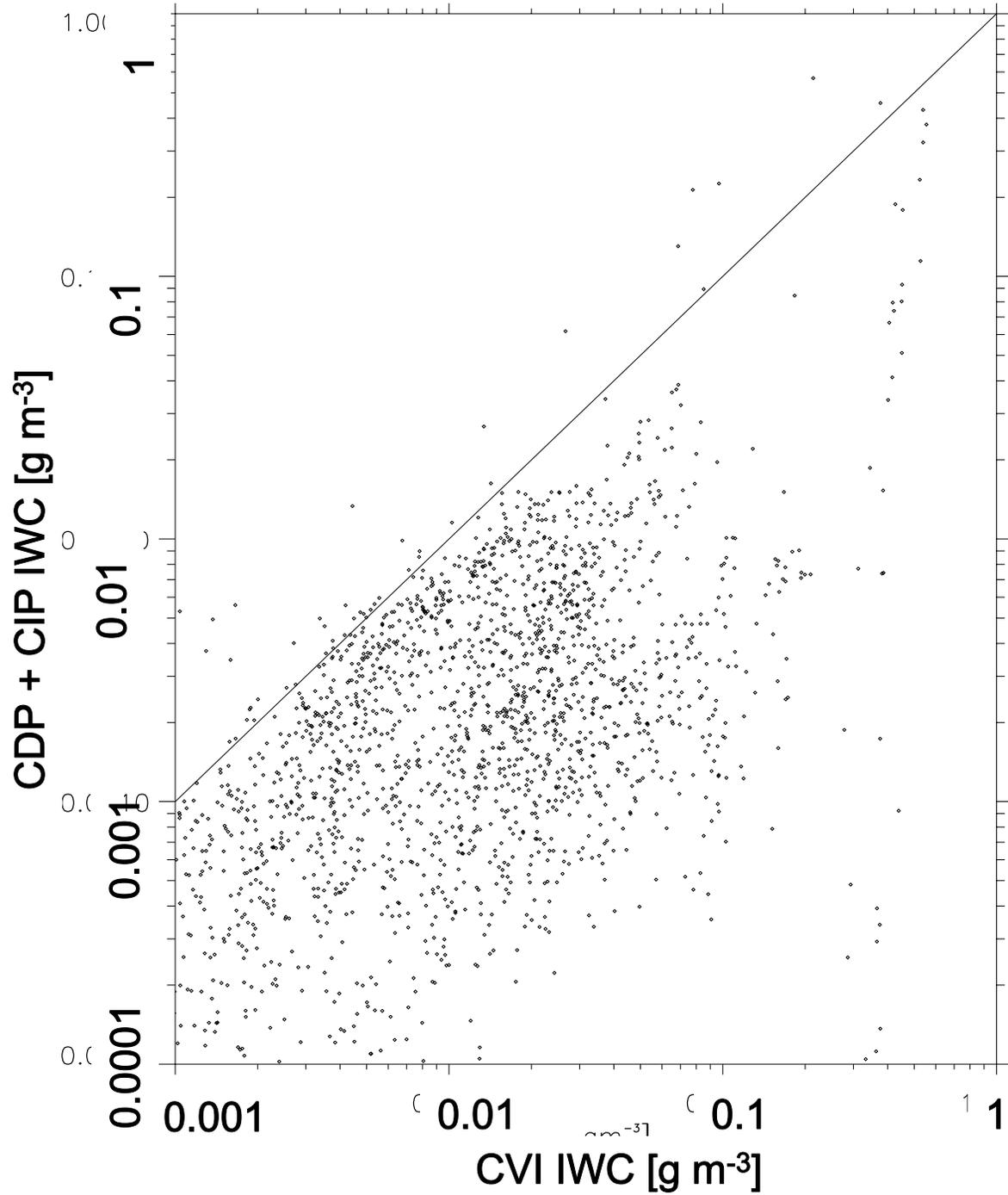
**CDP under-  
estimates IWC  
even more**



CIP seems to dominate the IWC



**CAS+CIP also underestimates CVI IWC, but agreement better**



**CDP + CIP  
agreement with  
CVI IWC does  
not seem as  
good as for  
CAS+CIP**

# What does comparison with CVI mean?

But, CIP IWC estimates are highly dependent on assumed m-D relations

Since CIP dominates IWC, it is very difficult to categorically state whether CAS or CIP is most consistent with CVI IWC

# Summary

- NCAS much larger than NCDP
- Crystals with  $D < 25 \mu\text{m}$  responsible for discrepancy
- Discrepancy does not exist for water clouds
- Comparison with CVI does not allow us to categorically conclude whether CAS or CDP most consistent with bulk IWC



# Summary of Probes

Instrument	Size Range	Parameters	Description
Cloud Particle Imager (CPI)	10 $\mu\text{m}$ to $\sim 1$ mm	2.3 $\mu\text{m}$ res images, SDs	Small sample volume
Cloud Aerosol Spectrometer (CAS)	0.35 to 50 $\mu\text{m}$	SDs	Forward scattering probe: enhanced small crystals?
Cloud Droplet Probe (CDP)	1 to 50 $\mu\text{m}$	SDs	Forward scattering probe: open path
Cloud Imaging Probe (CIP)	100 $\mu\text{m}$ to 1.6 mm	SDs; two-d images	Shadowing of photodiodes
Counterflow virtual im-pactor (CVI)	Bulk measurement from $>\sim 5$ $\mu\text{m}$	TWC	Evaporator probe
Nevzorov Probe	Bulk measurement	LWC, TWC	Hot wire probe
CIN: Cloud Integrating Nephelometer	Bulk measurement	$\beta_e$ , asymmetry parameter	Light scattered by cloud particles

