MANCHESTER 1824

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Cloud Particle Imager data from the Egret

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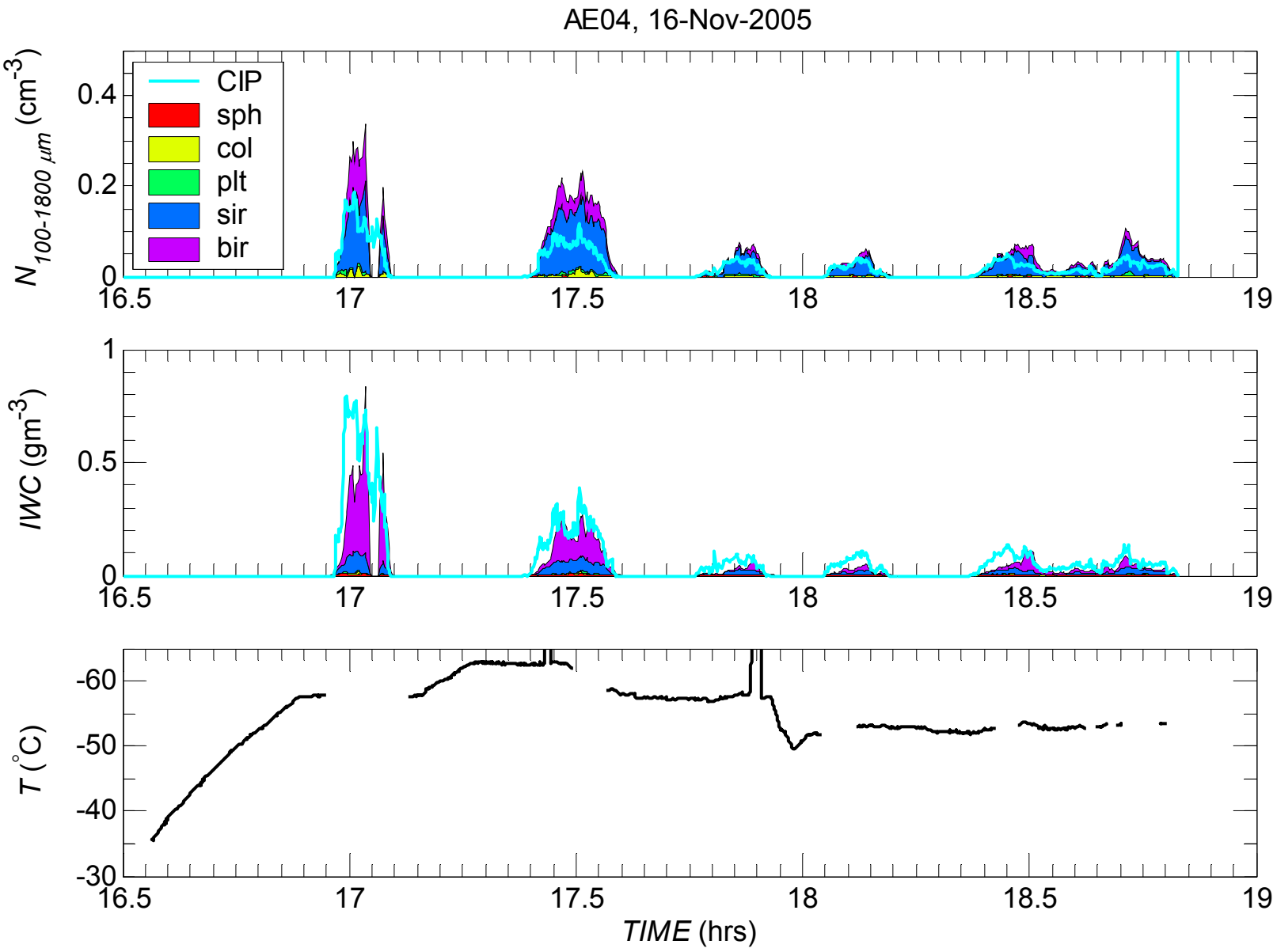
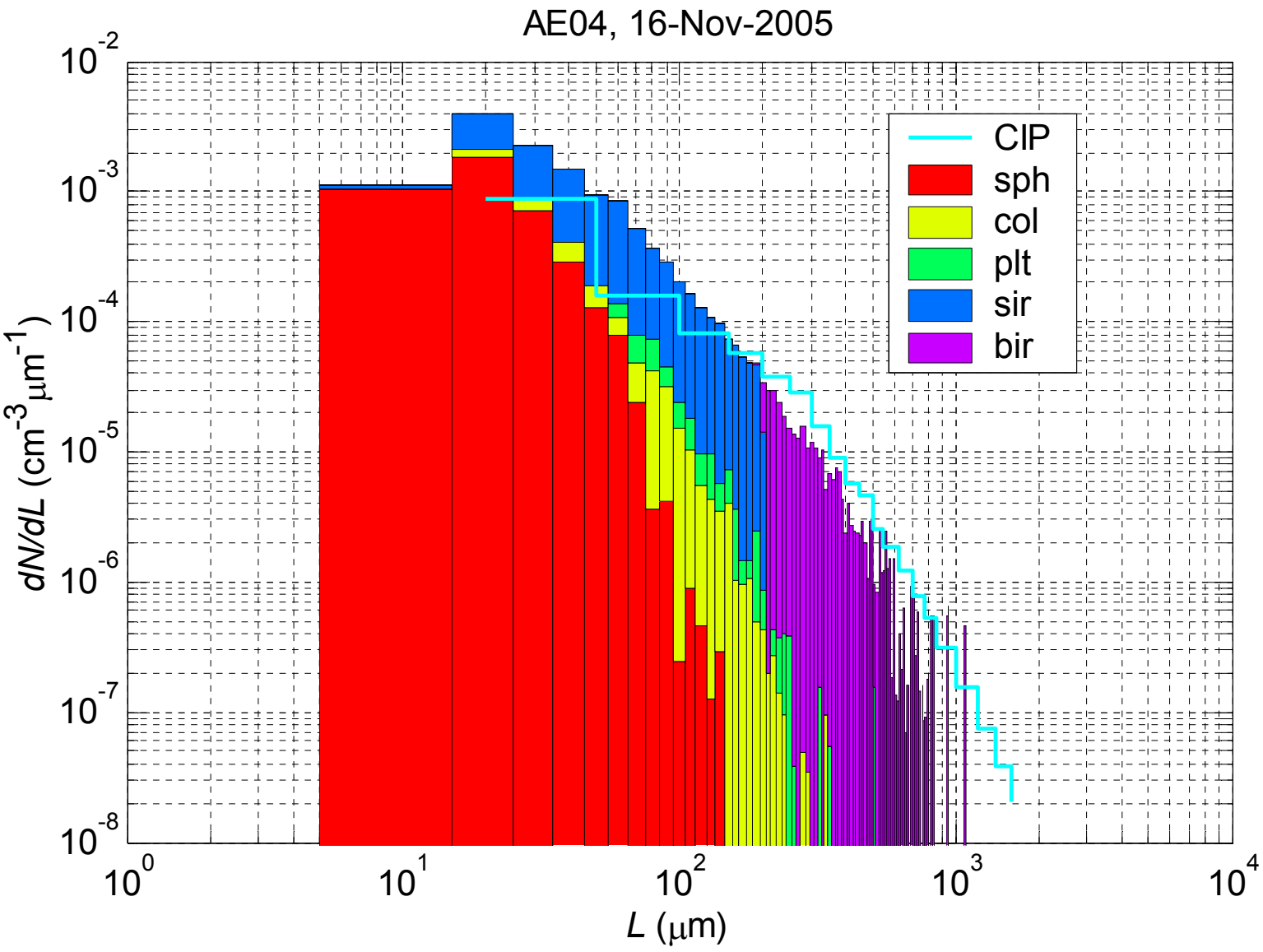
♥NCAR, USA


AE04, 16-Nov-2005
CIP
sph
col
plt
sir
bir
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
0
0.2
0.4
IWC (gm^{-3})
0
0.5
1
T (°C)
-60
-50
-40
-30
16.5
17
17.5
18
18.5
19
TIME (hrs)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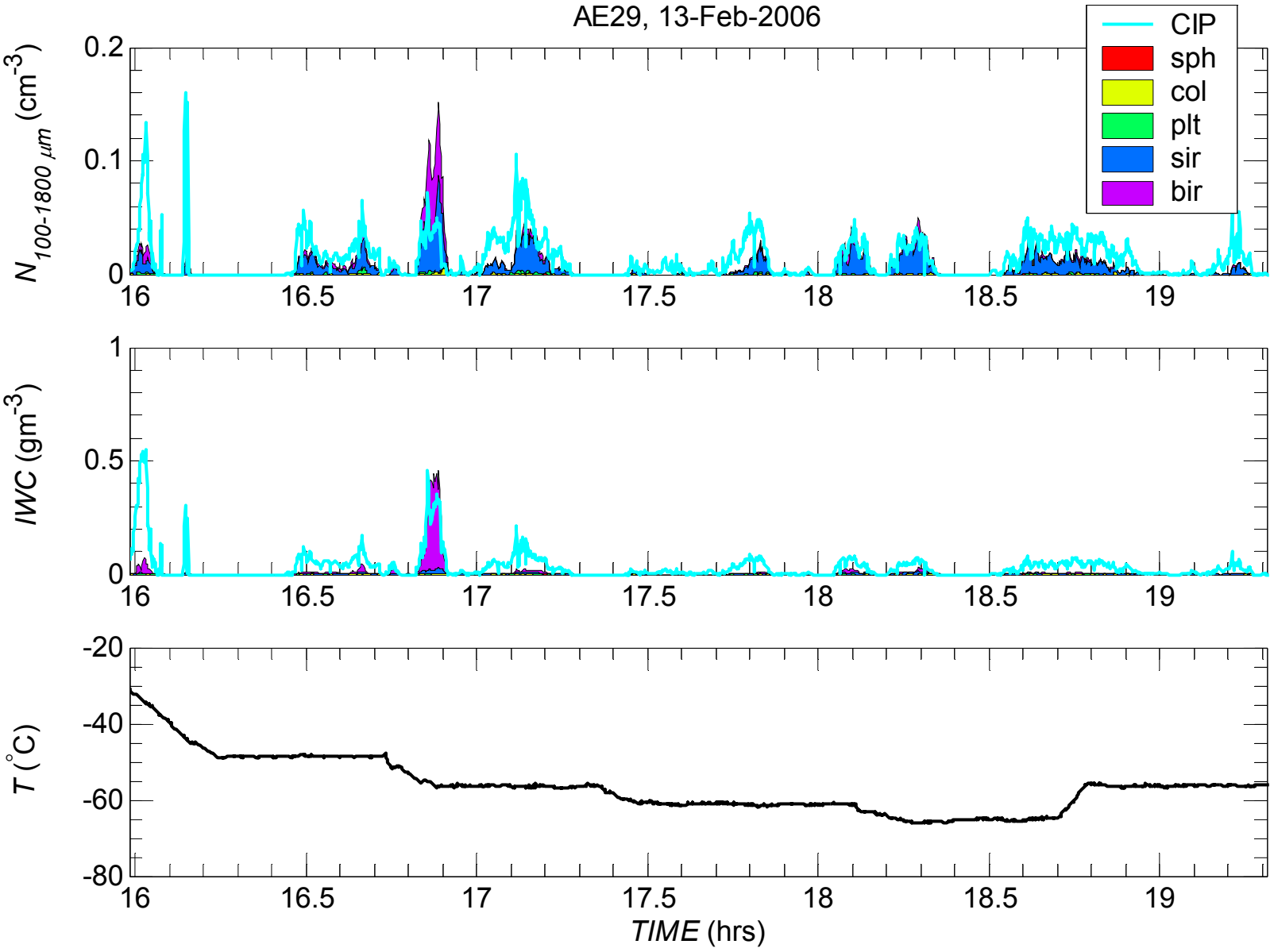
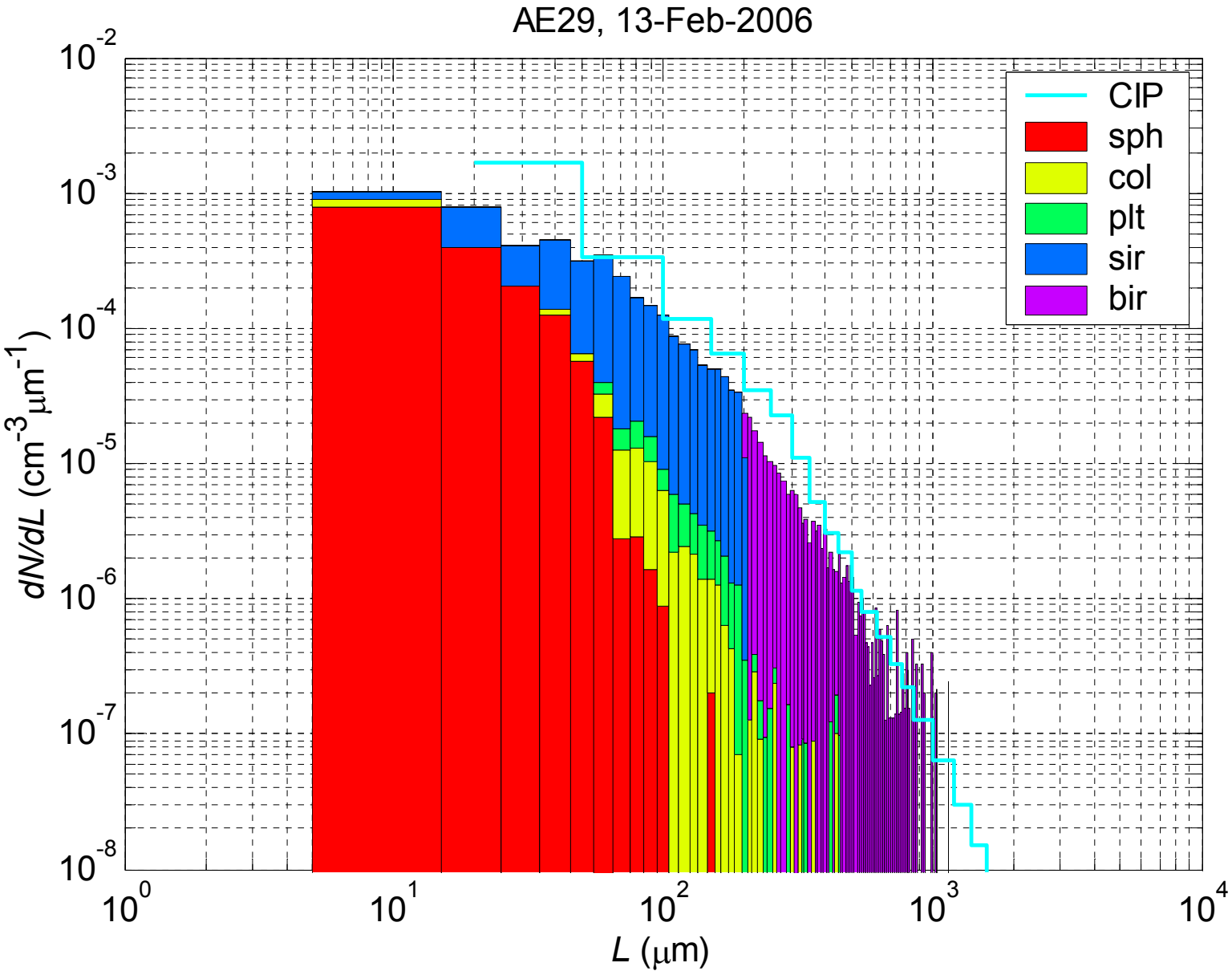
CIP
sph
col
plt
sir
bir
dN/dL (cm-3 μm-1)
L (μm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104


AE29, 13-Feb-2006
CIP
sph
col
plt
sir
bir
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
0.2
0.1
0
IWC (gm^{-3})
1
0.5
0
T (°C)
-20
-40
-60
-80
16
16.5
17
17.5
18
18.5
19
TIME (hrs)


AE29, 13-Feb-2006
CIP
sph
col
plt
sir
bir
dN/dL (cm-3 µm-1)
L (µm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104

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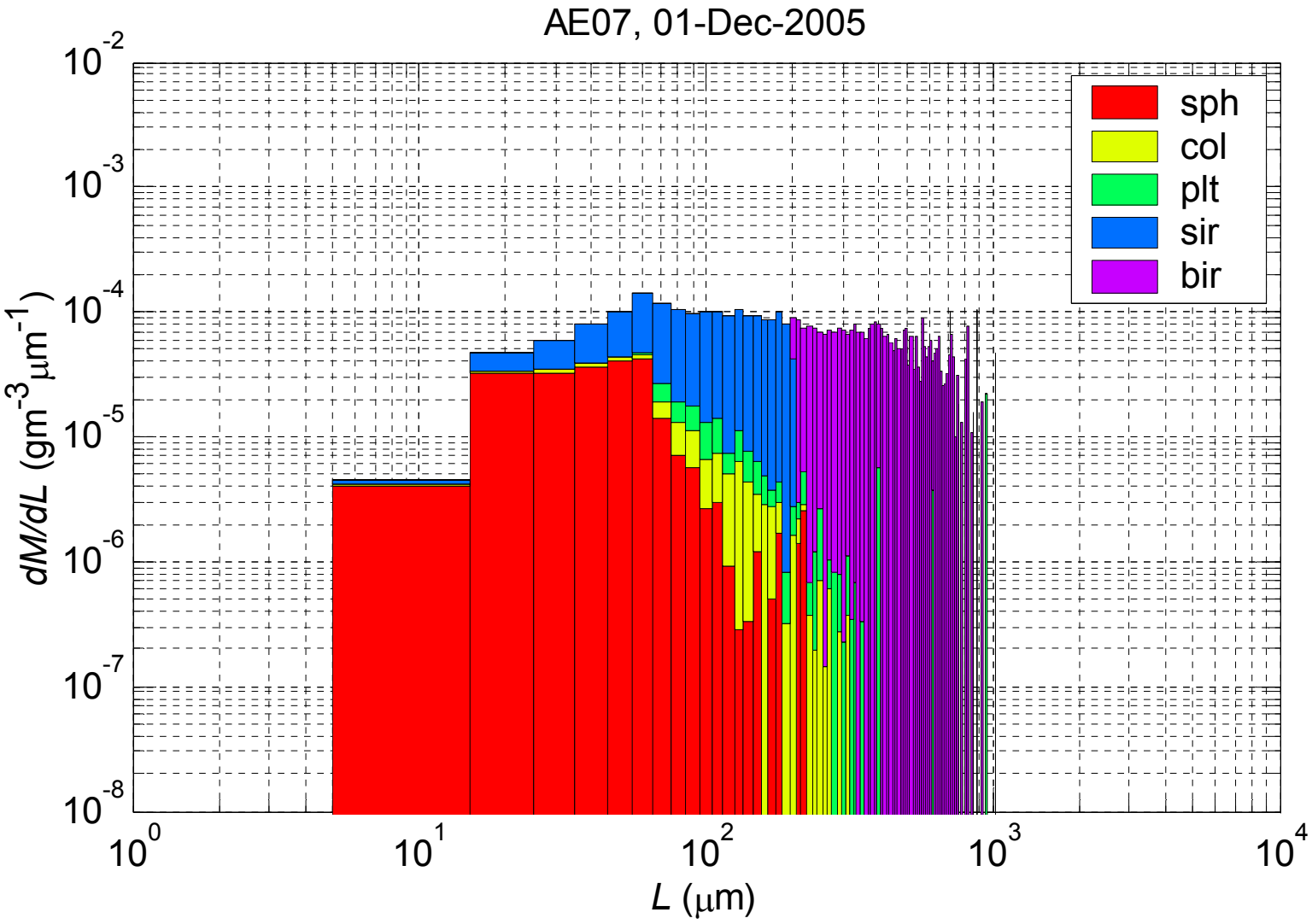
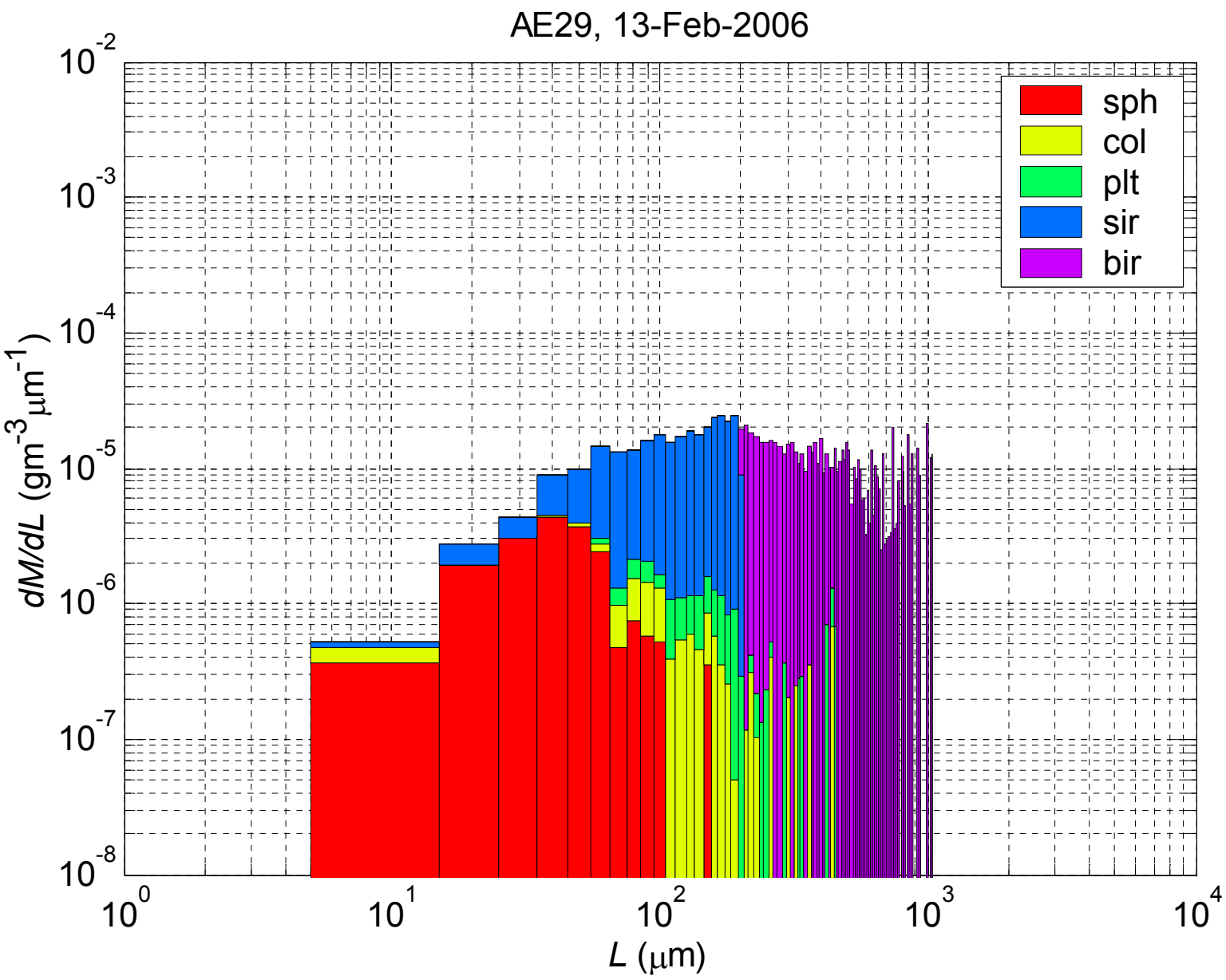
Mass distributions


AE07, 01-Dec-2005
sph
col
plt
sir
bir
dM/dL (gm-3μm-1)
L (μm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104

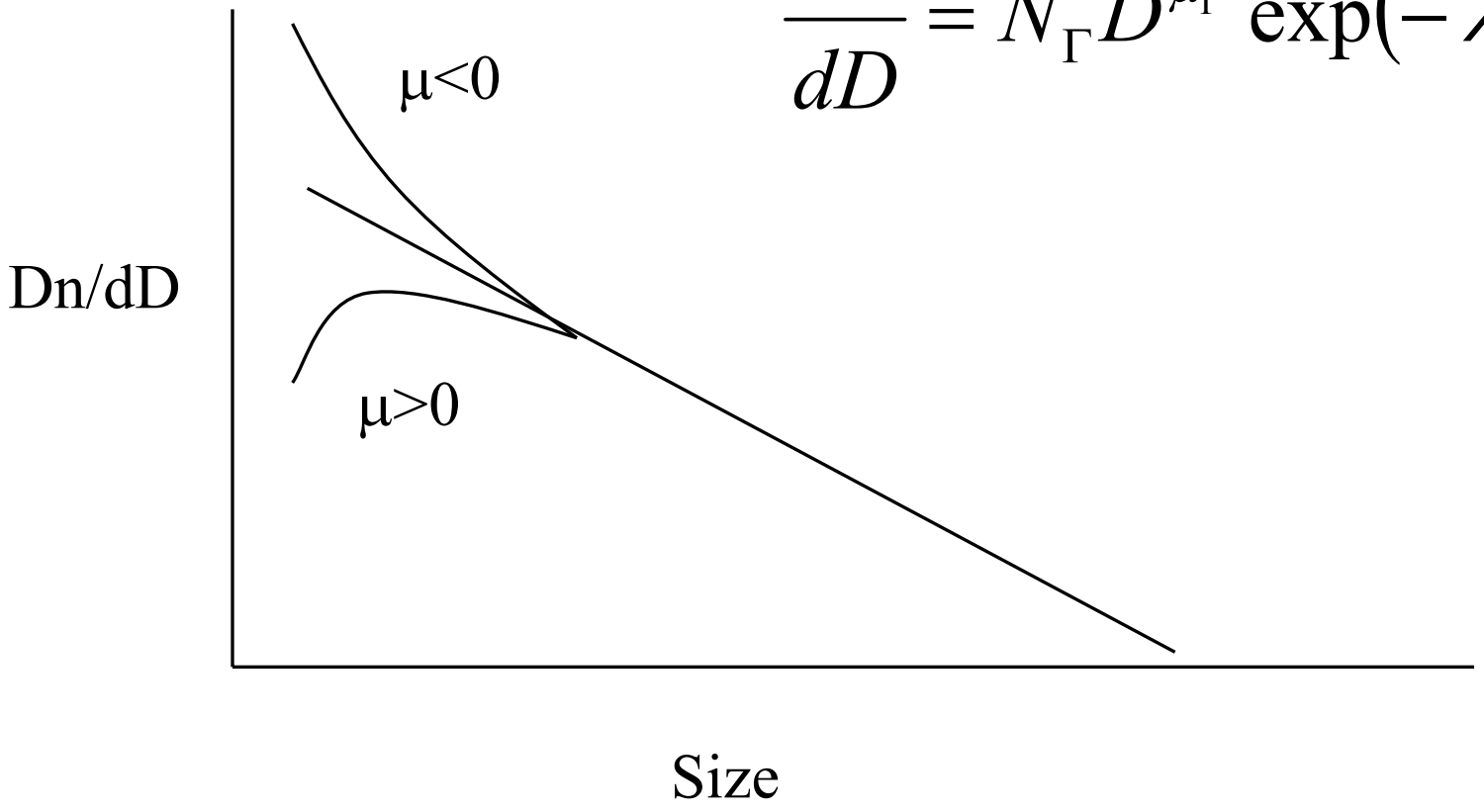

AE29, 13-Feb-2006
sph
col
plt
sir
bir
dM/dL (gm-3μm-1)
L (μm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104

Still an issue with sampling large particles

- Problem due to the low sampling volume
- CPI data will be reported between 20 and 500 microns.

Particle size distributions

$$\frac{dN}{dD} = N_\Gamma D^{\mu_\Gamma} \exp\left(-\lambda_\Gamma D\right)$$



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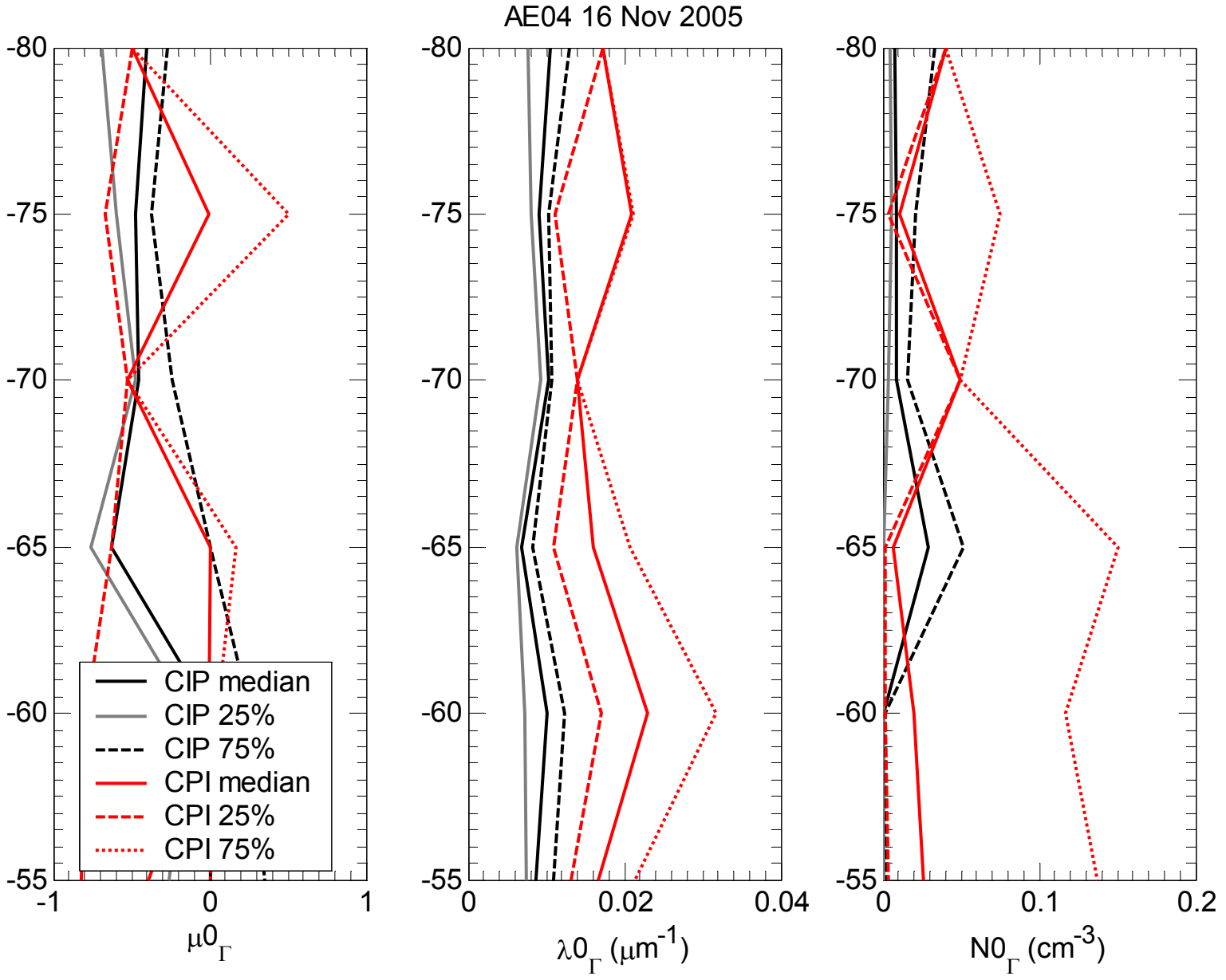
Pre-monsoon



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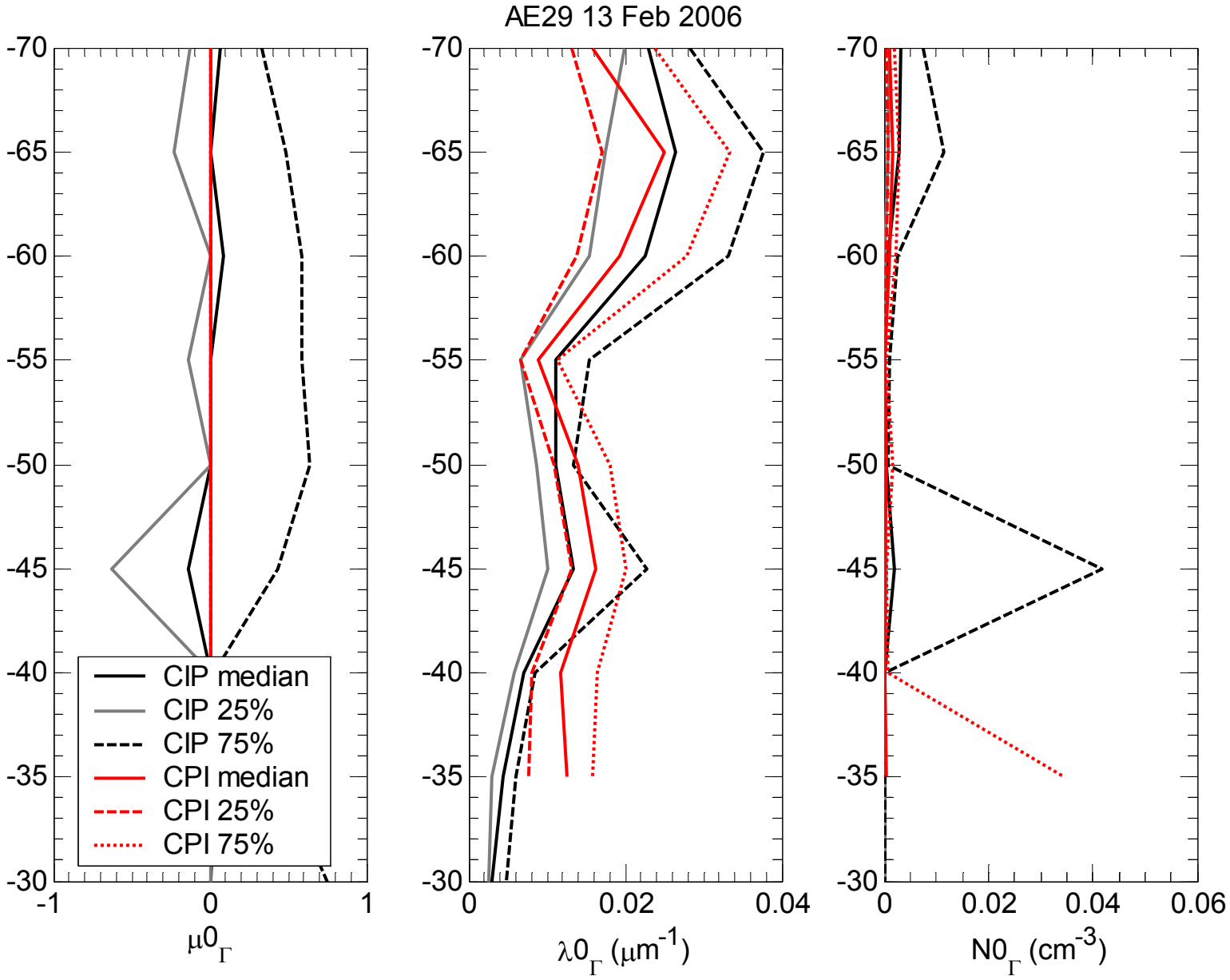
Post Christmas



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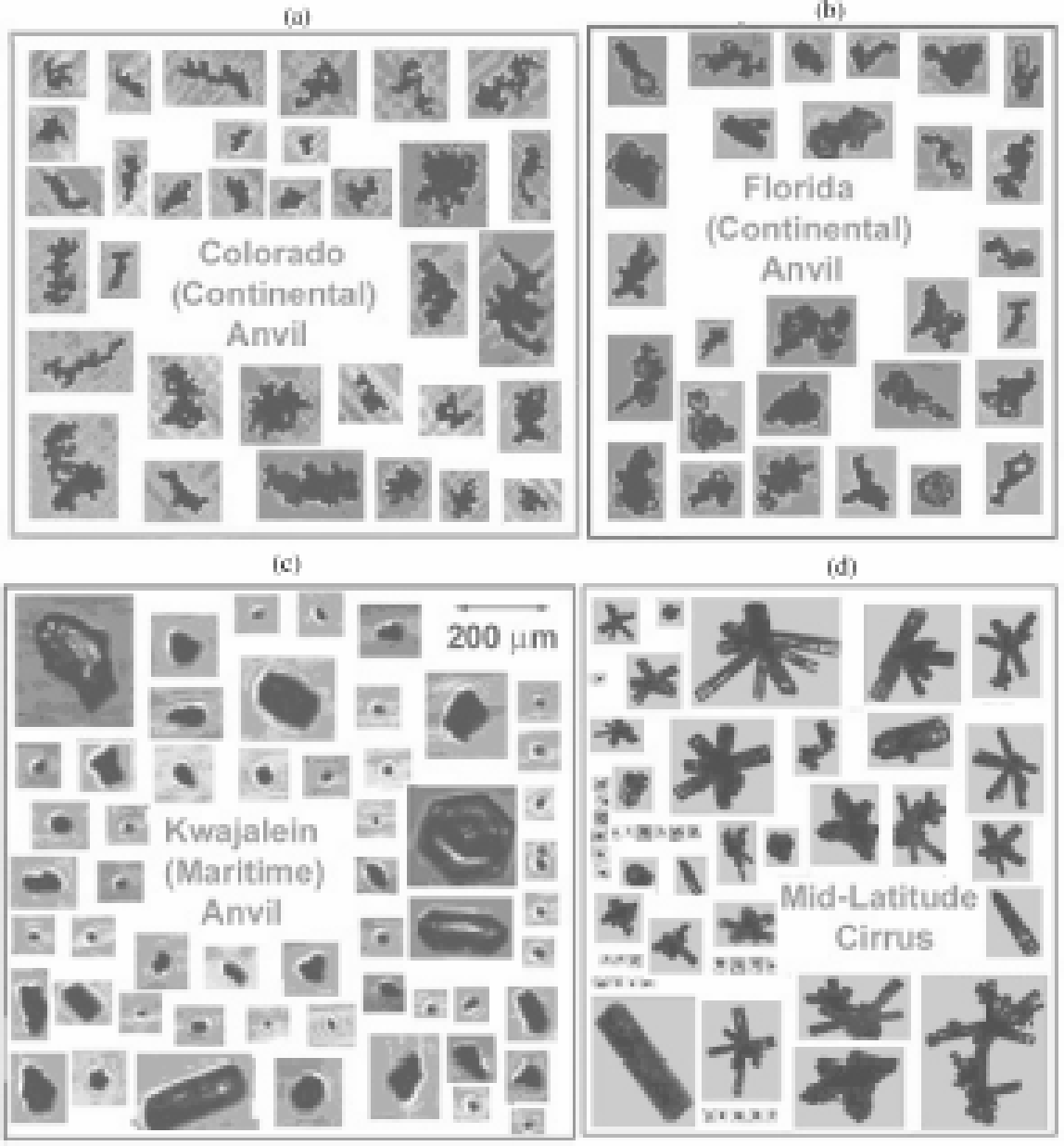
Habits



Storm type	Location	No. of particles examined	Aggregates	Chain-like aggregates	Temperature
Continental	Colorado	8600	28%	5.5%	−47 °C
Maritime	Kwajalein	5600	0.5%	0%	−40 to −60 °C

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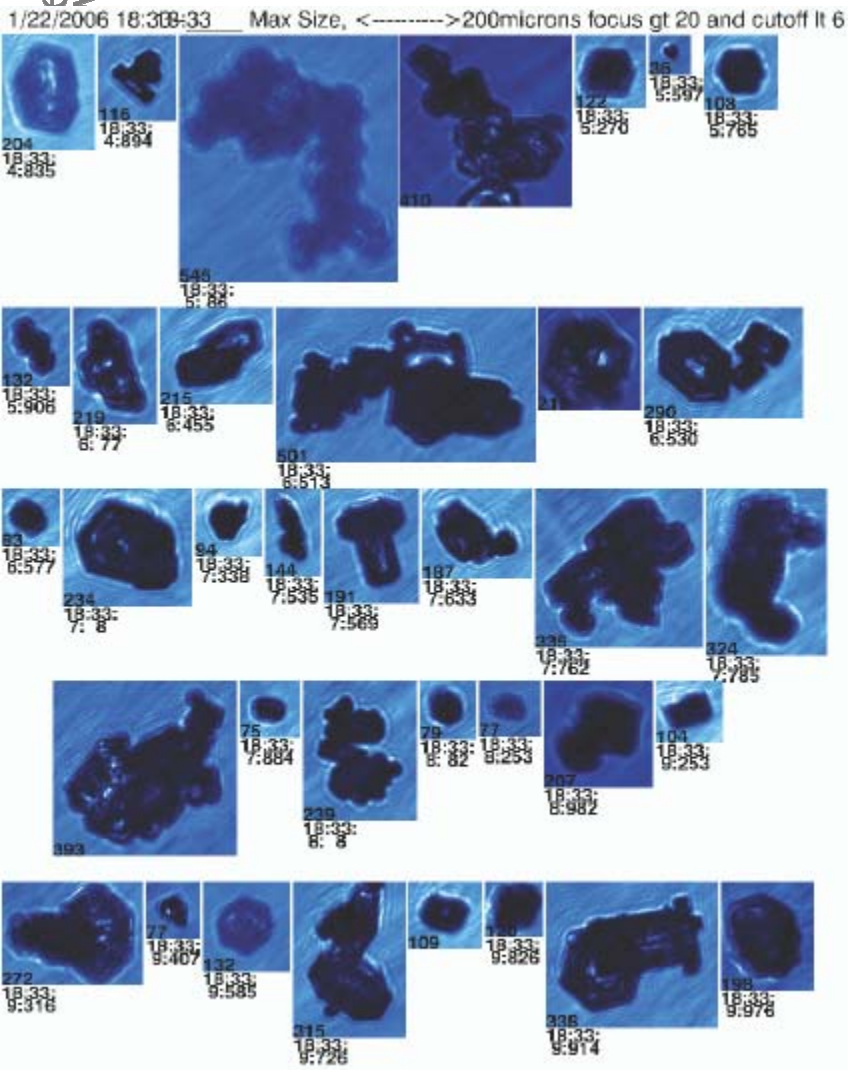
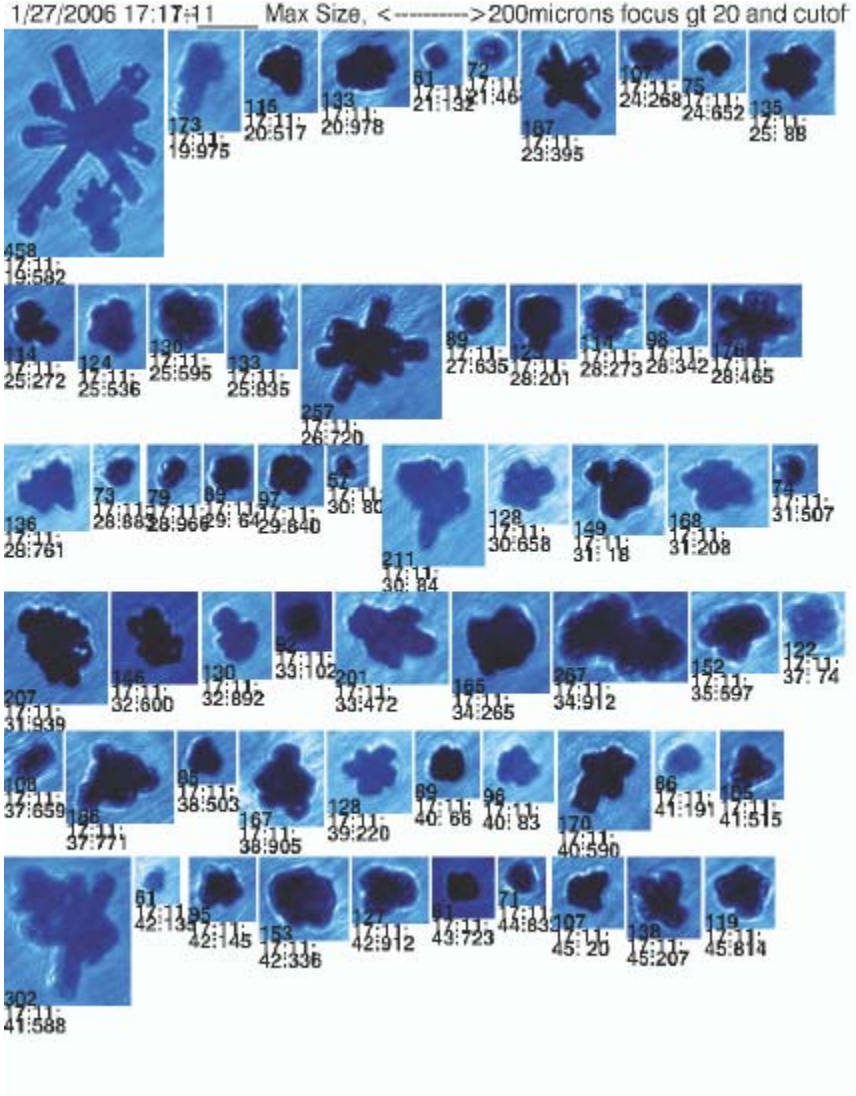
Habits

AE18-Anvil



AE21- Aged anvil



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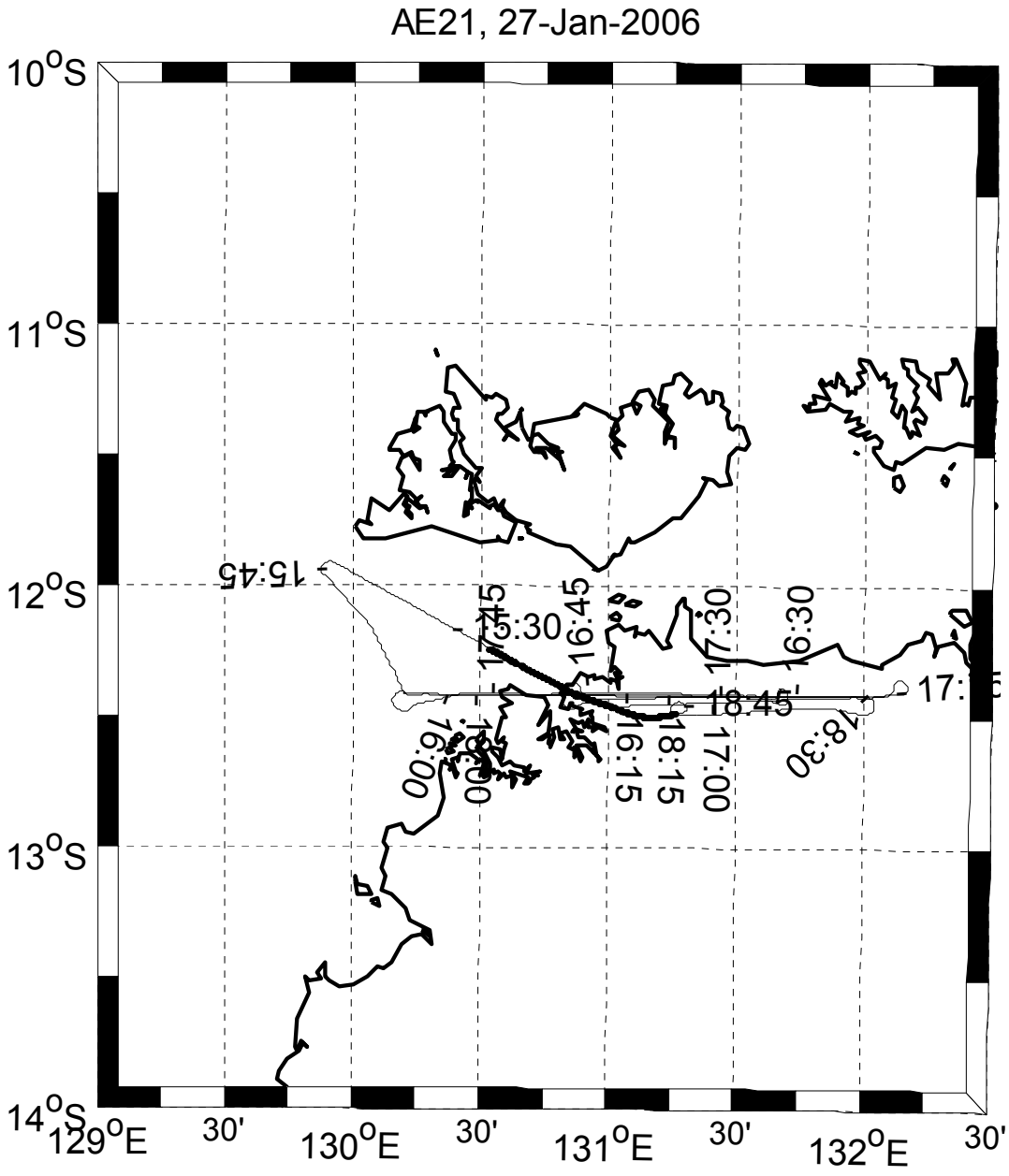

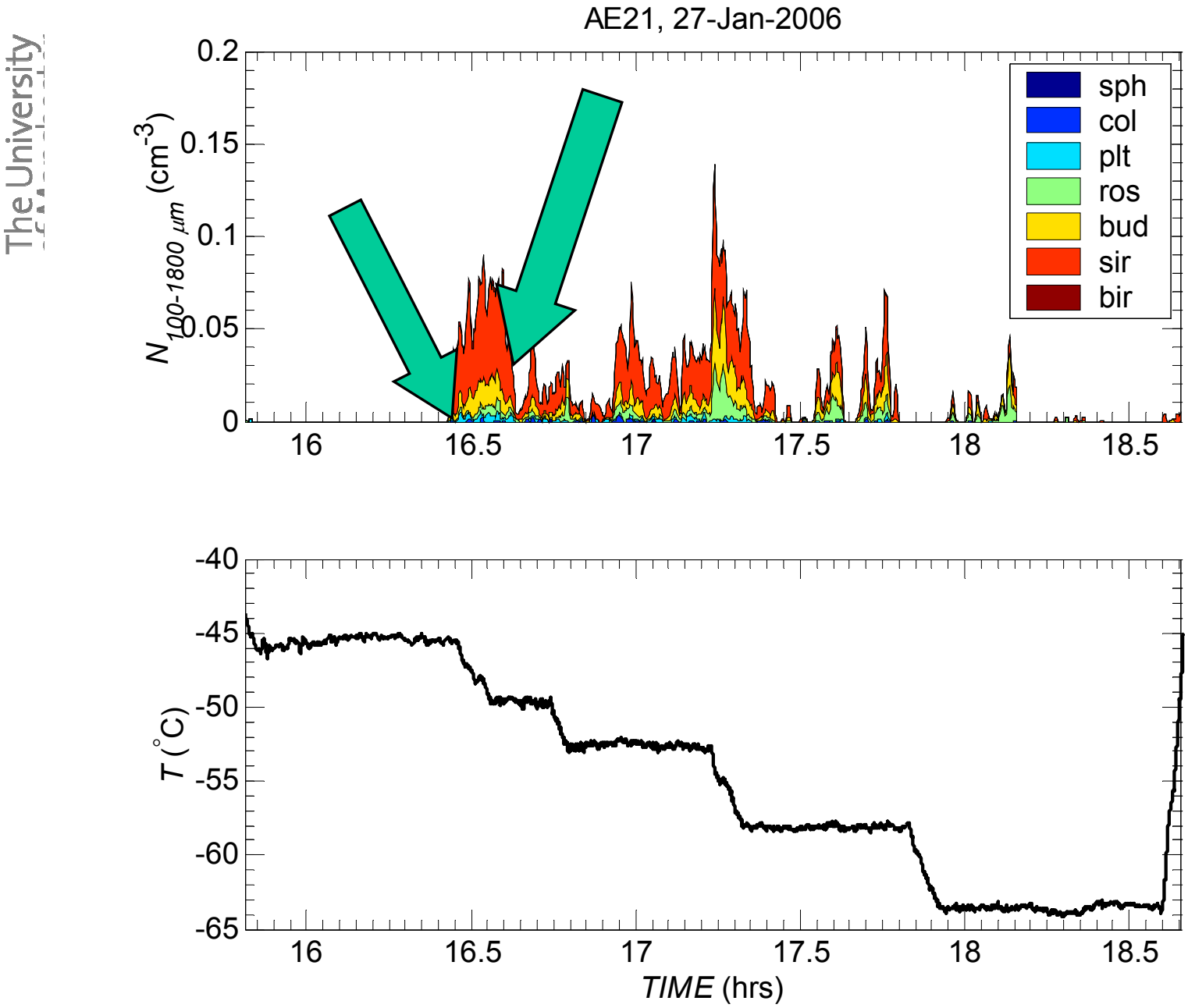
AE21, 27-Jan-2006
0.2
0.15
0.1
0.05
0
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
sph
col
plt
ros
bud
sir
bir
16
16.5
17
17.5
18
18.5
-40
-45
-50
-55
-60
-65
T (°C)
TIME (hrs)

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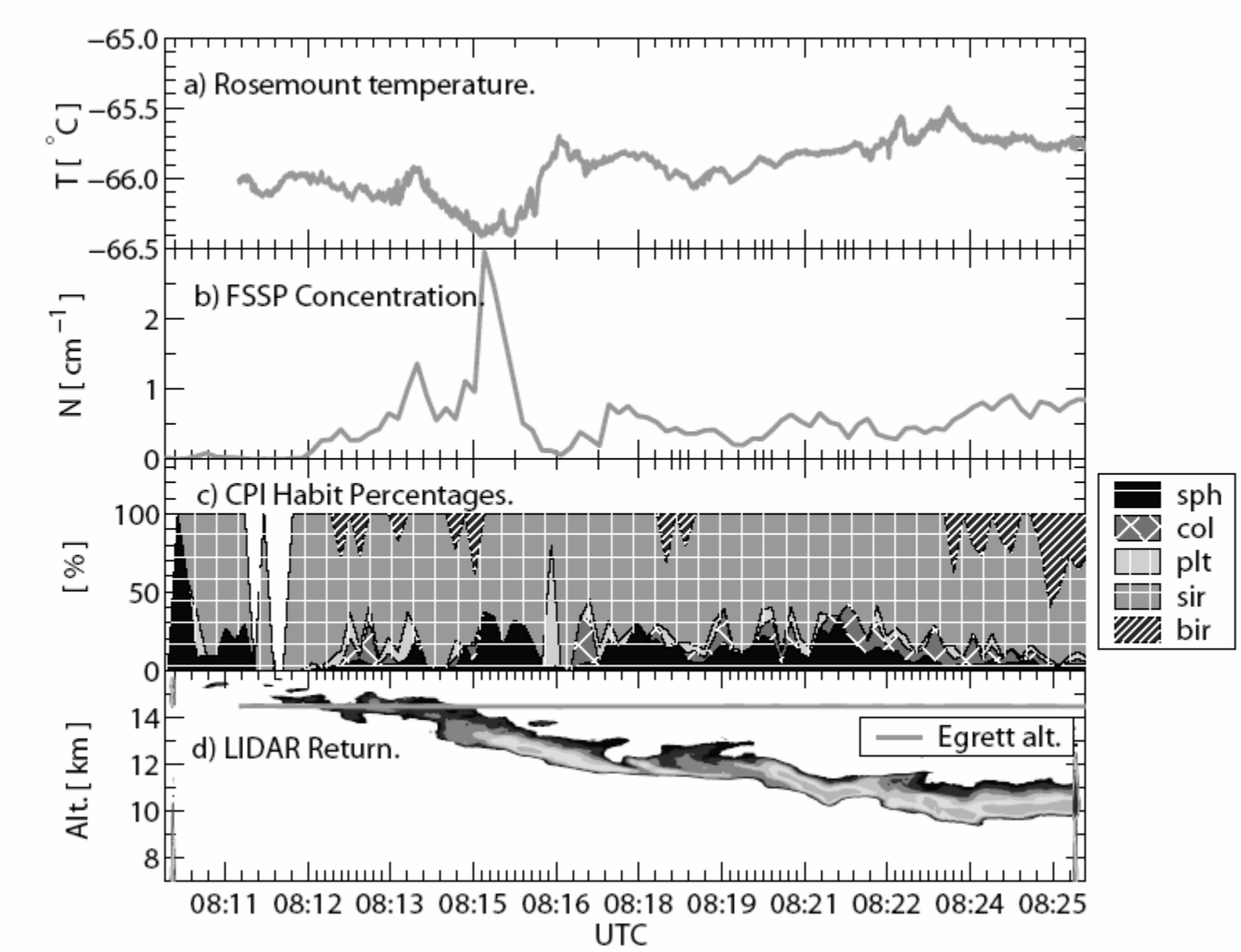
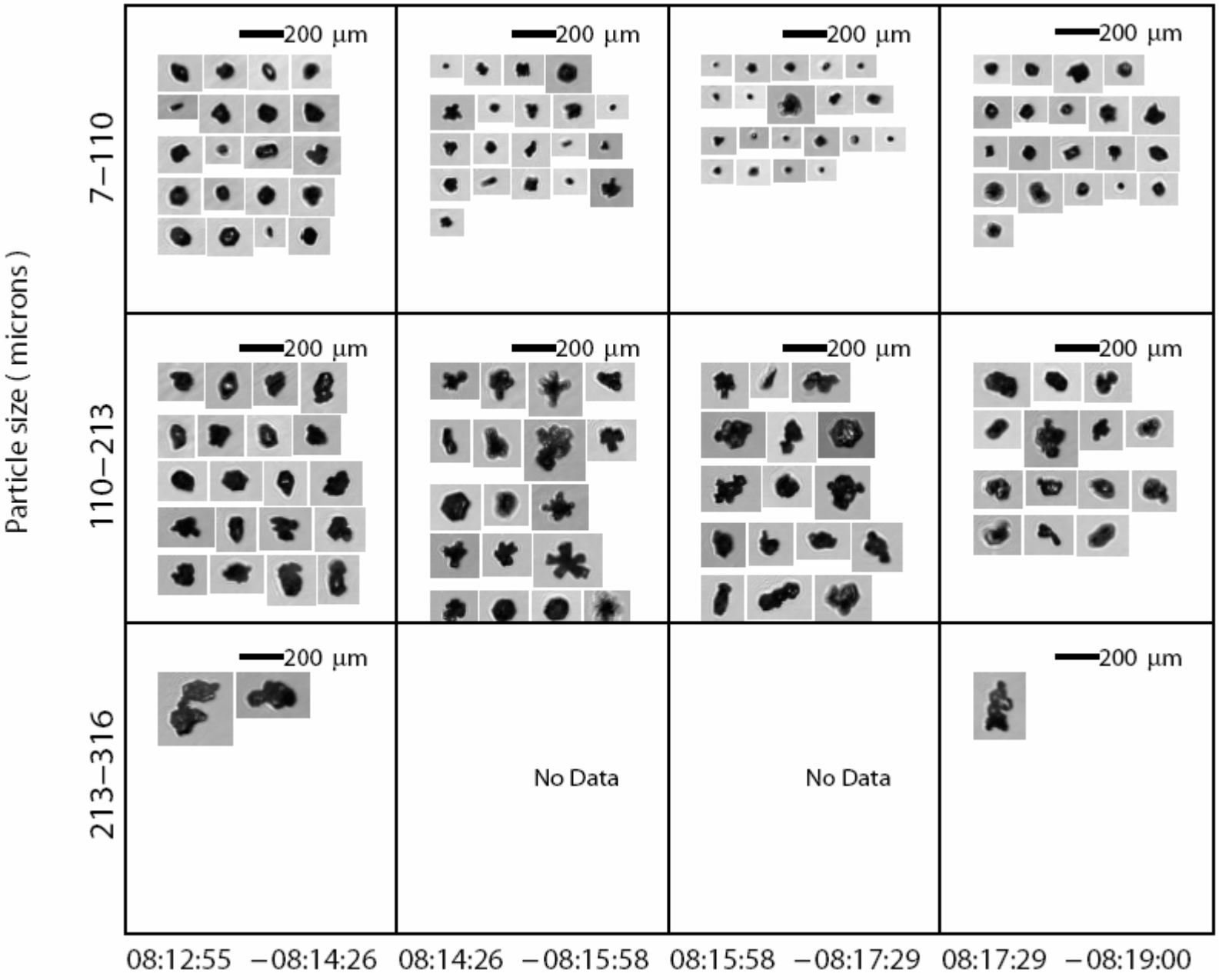
Emerald-2





Growth Rates and Habits of Ice Crystals between −20° and −70°C

MATTHEW BAILEY AND JOHN HALLETT

Desert Research Institute, Reno, Nevada

(Manuscript received 15 October 2002, in final form 2 October 2003)

ABSTRACT

A laboratory study of ice crystal growth characteristics at temperatures between −20° and −70°C has been performed at ice supersaturations and pressures comparable with those in the atmosphere using a horizontal static diffusion chamber. Maximum dimension, projected area, and volume growth rates, in addition to habit frequency, have been measured for individual habit types as functions of temperature, ice supersaturation, and air pressure. It was found that from −20° to −40°C and at ice supersaturations in excess of 2%, the most frequent habits observed were platelike polycrystals and plates, the complexity of forms increasing with increasing supersaturation. Columns appear with low frequency in this temperature range for all supersaturations. At low ice supersaturation (1%–2%), the habit consists of thick plates, compact polycrystals, and occasional short columns and is the region with the highest frequency of pristine crystals capable of producing halos.

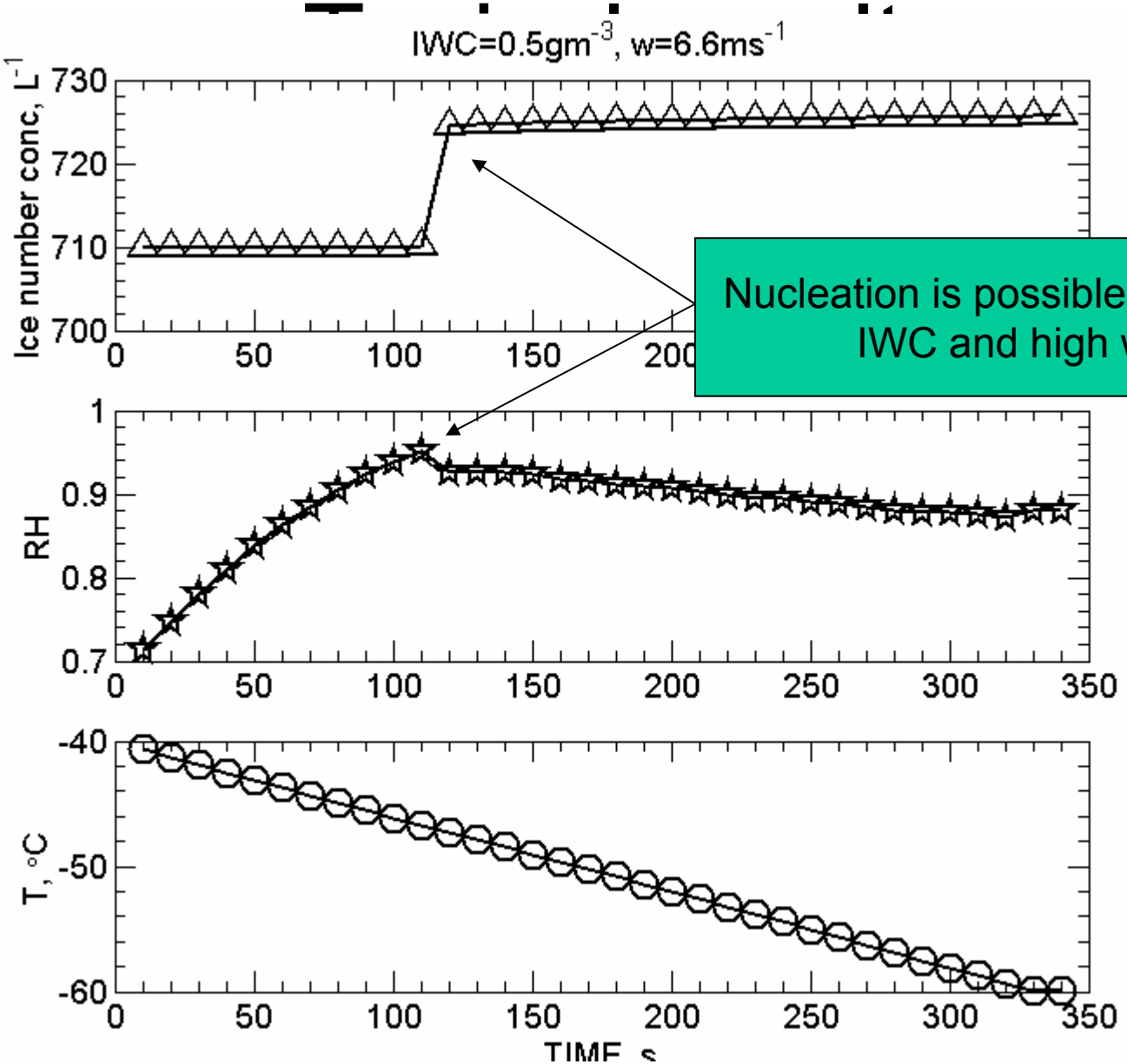
Just colder than −40°C, there is a marked shift to columnar behavior except at low to moderate ice supersaturation (≤10%) where the habit is essentially the same as at warmer temperatures with a small increase in the frequency of short columns. At moderate ice supersaturation (10%–25%), long solid columns and polycrystals with columnar and platelike components are observed. Above approximately 25% ice supersaturation, bullet rosettes, long columns, and column-containing polycrystals are observed, the frequency of bullet rosettes and columns increasing with increasing ice supersaturation. At −60°C and colder, needle forms appear along with columnar forms.

These characteristics are portrayed in a habit diagram as a function of temperature and ice supersaturation and are essentially in agreement with the vast majority of atmospheric in situ observations at these temperatures, both of which depart from the previous habit diagrams at temperatures colder than −20°C compiled by Kobayashi, Magono and Lee, and Hallett and Mason.

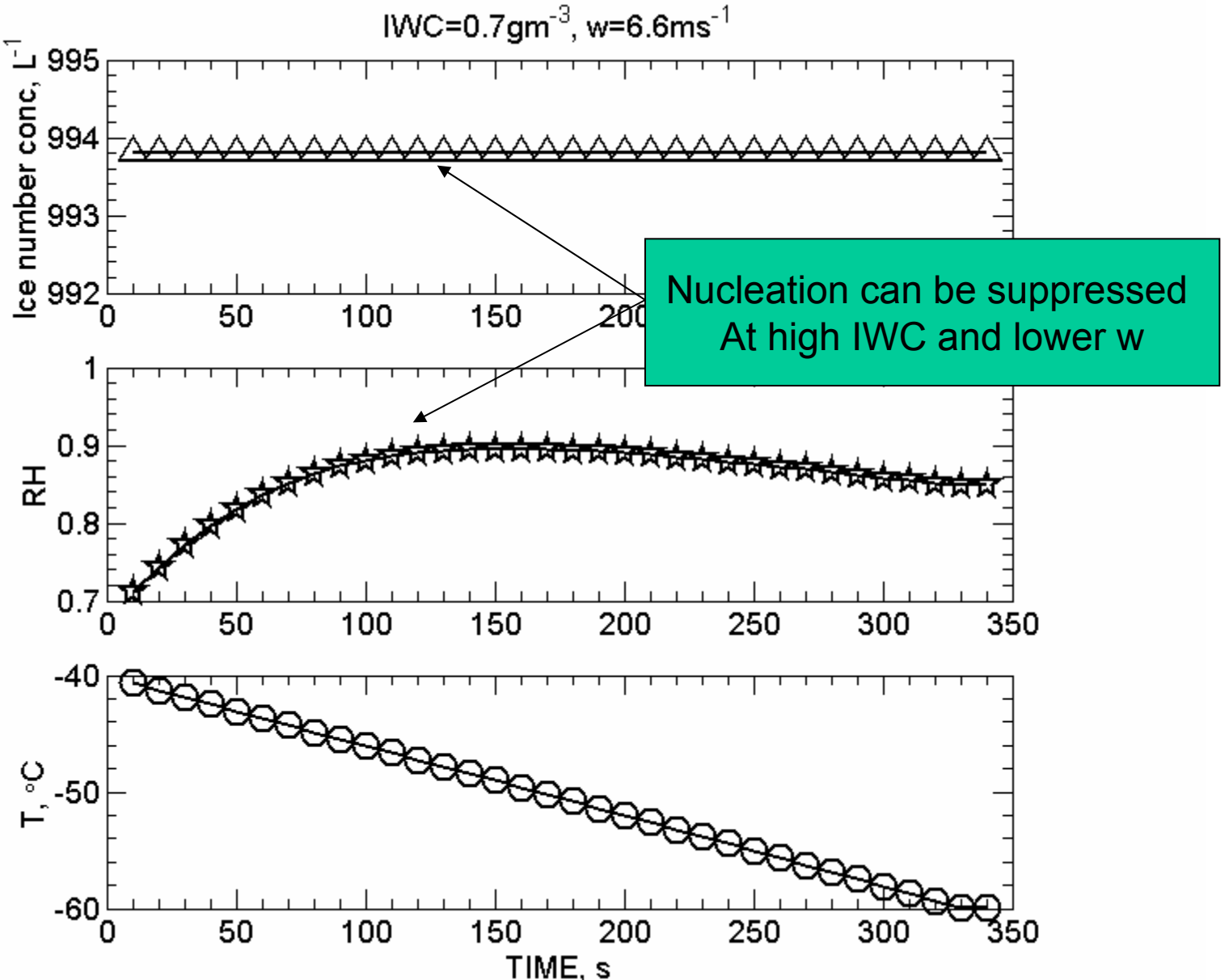
Habit growth rates and habit frequencies have been measured at 10° temperature increments. Exponential fits of these results yield functions that can be used to estimate growth rates and habit distributions at intermediate temperatures for ice supersaturations as low as 1% up to the maximum values, which might be encountered in the atmosphere due to ventilation effects, approximately up to 50% above water saturation between −25° and −40°C and extrapolated water saturation colder than −40°C. Within each habit and under identical growth conditions, observed extremes in growth rates for individual crystals in comparison with average values show variances of ±50%, reflecting a variance in aspect ratio that suggests a critical role of crystalline defects in growth characteristics. These results indicate an even more complex behavior of ice crystal habit than that observed between 0° and −20°C, a behavior that depends not only on temperature and ice supersaturation, but also on vapor diffusivity, related to air pressure, and the initial nucleation process.

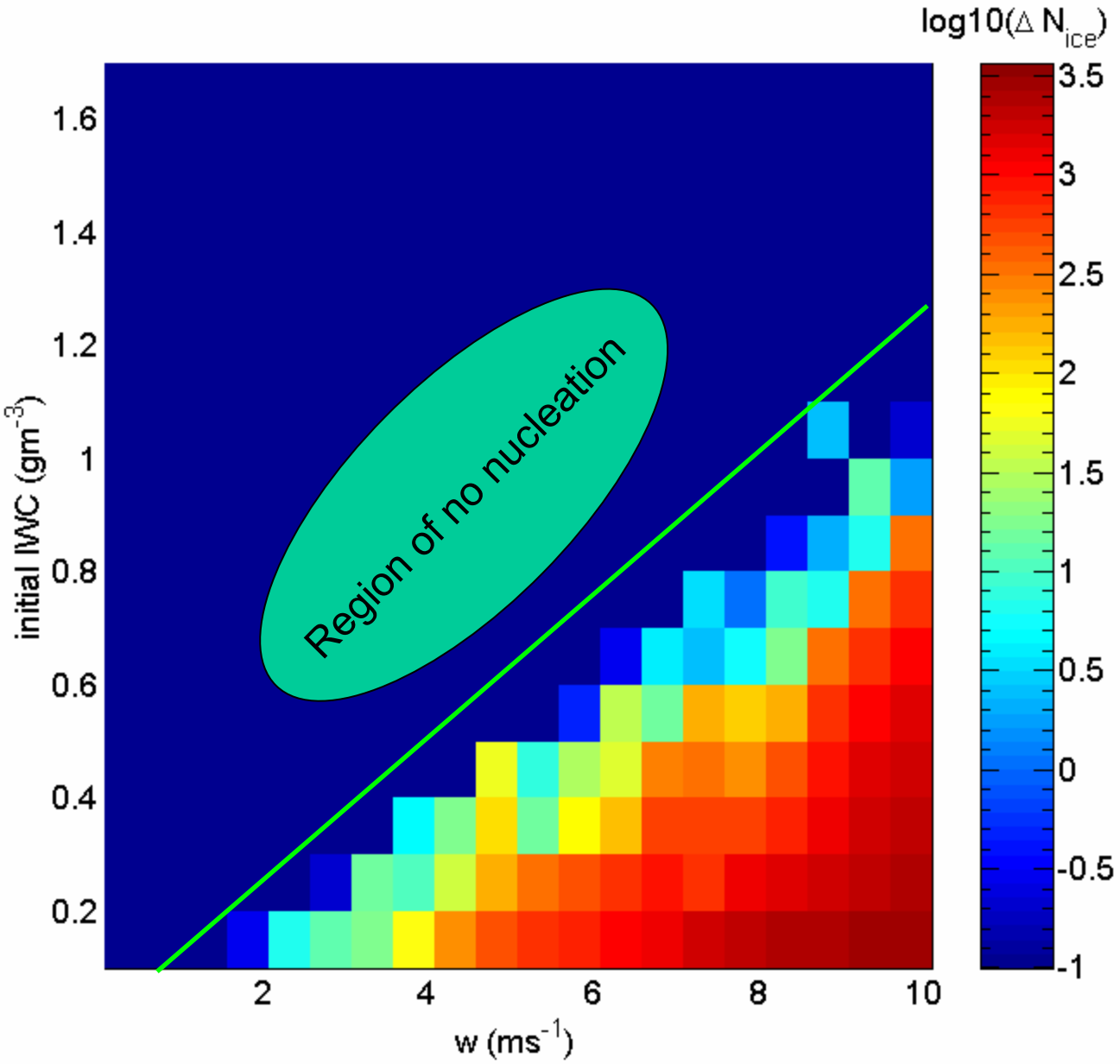
Anvil microphysics?

- Recent theory lets us describe the freezing of soluble aerosol – Koop 2000.
- Parcel model with spectral microphysics (start at -40C and expand to -60C).
- Different values of IWC (size spectra from Heymsfield parameterisation, $\mu 0$, $\lambda 0$ given and N0 inferred from IWC).



Nucleation is possible at lower IWC and high w


IWC=0.7gm^{-3}, w=6.6ms^{-1}
Ice number conc, L^{-1}
995
994
993
992
0
50
100
150
200
Nucleation can be suppressed
At high IWC and lower w
RH
1
0.9
0.8
0.7
0
50
100
150
200
250
300
350
T, °C
-40
-50
-60
0
50
100
150
200
250
300
350
TIME, s


log10(Δ N_ice)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
Region of no nucleation
initial IWC (gm^-3)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
2
4
6
8
10
w (ms^-1)

So as a rough guide…

- homogeneous nucleation is not important in anvil clouds if:

$$IWC \geq 0.125w + 0.1$$

Summary

- Look at the properties of cirrus with regards to convective intensity.
- Look at the evolution of cirrus
- Possibly regeneration when RH is able to rise.

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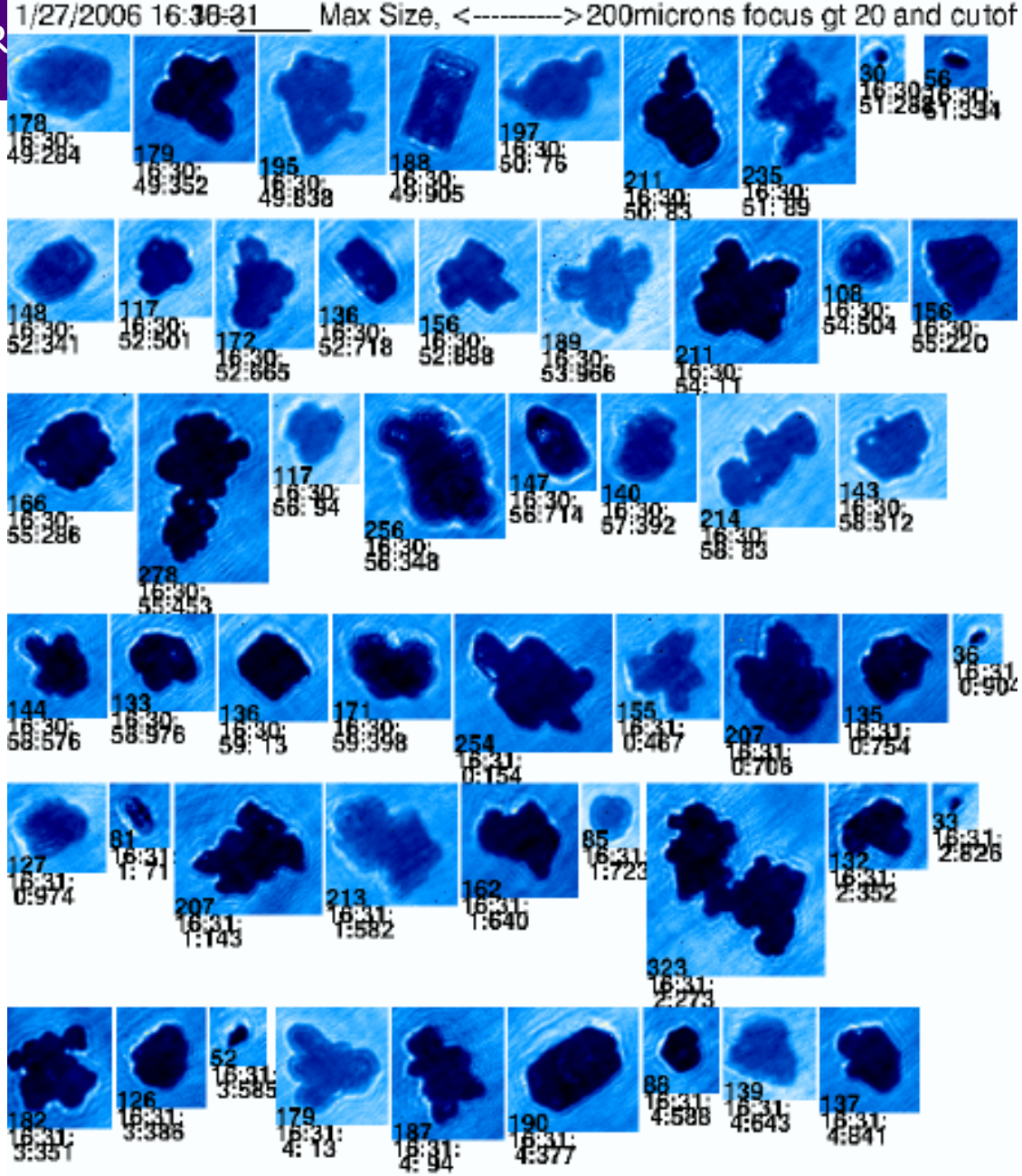
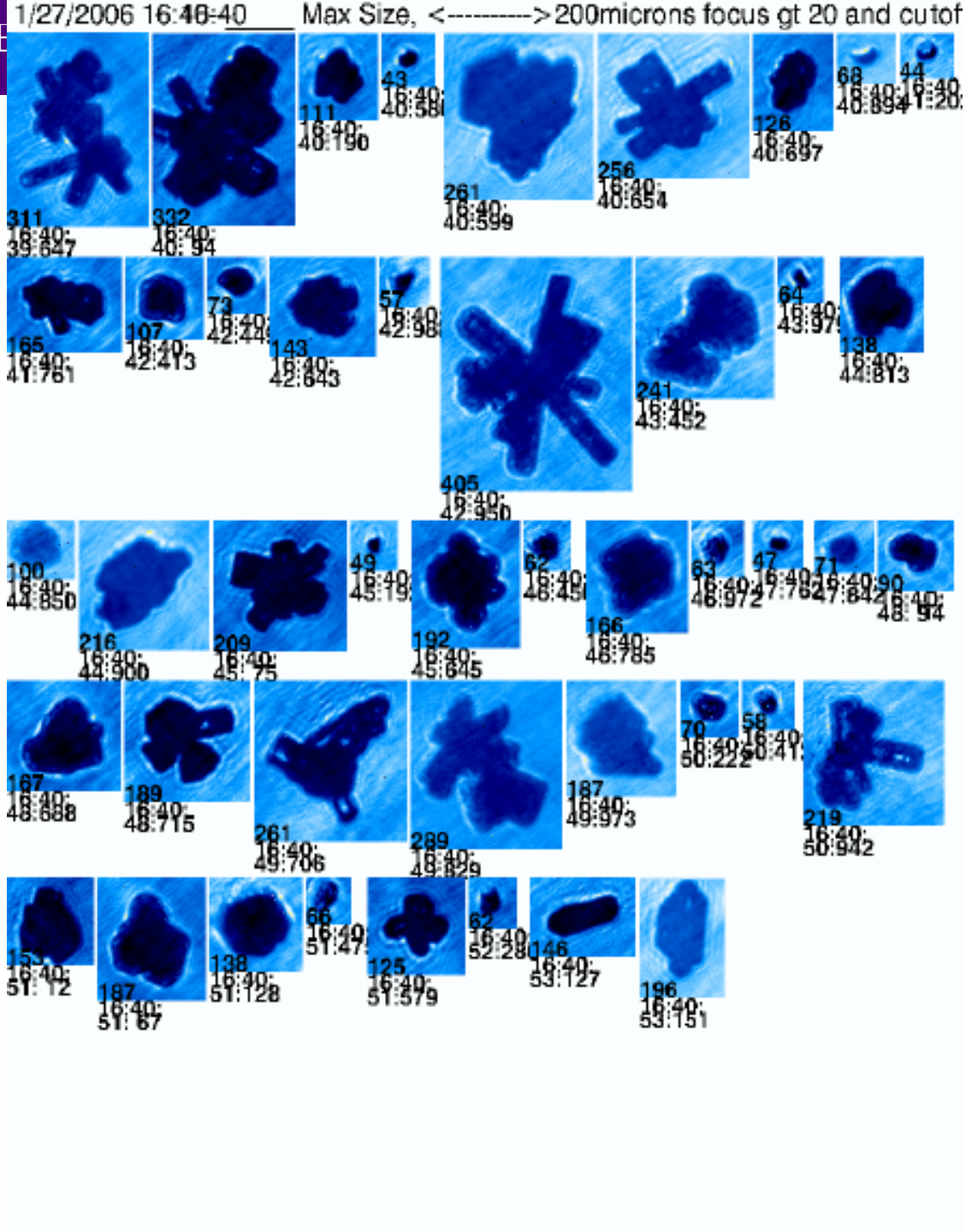
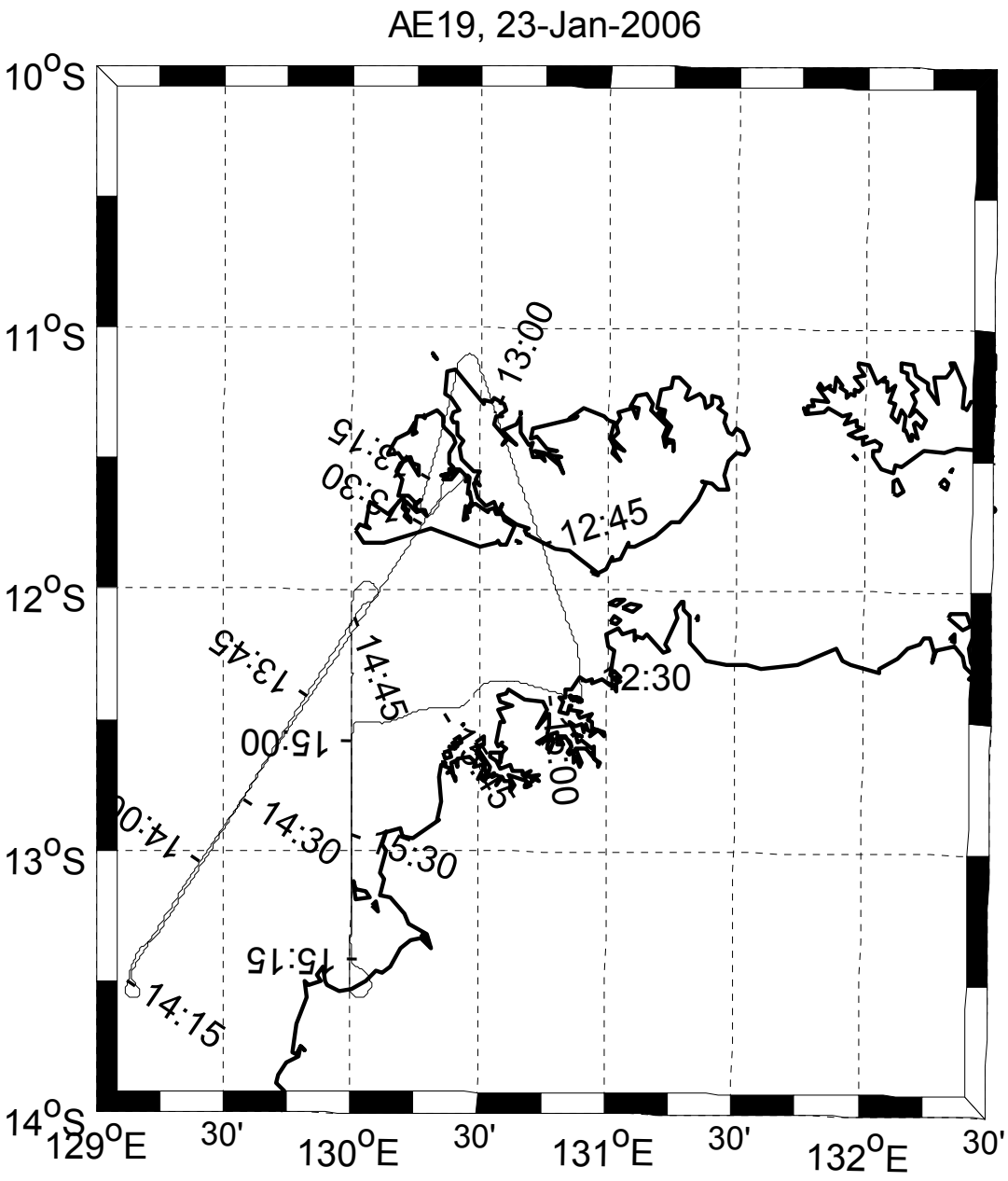
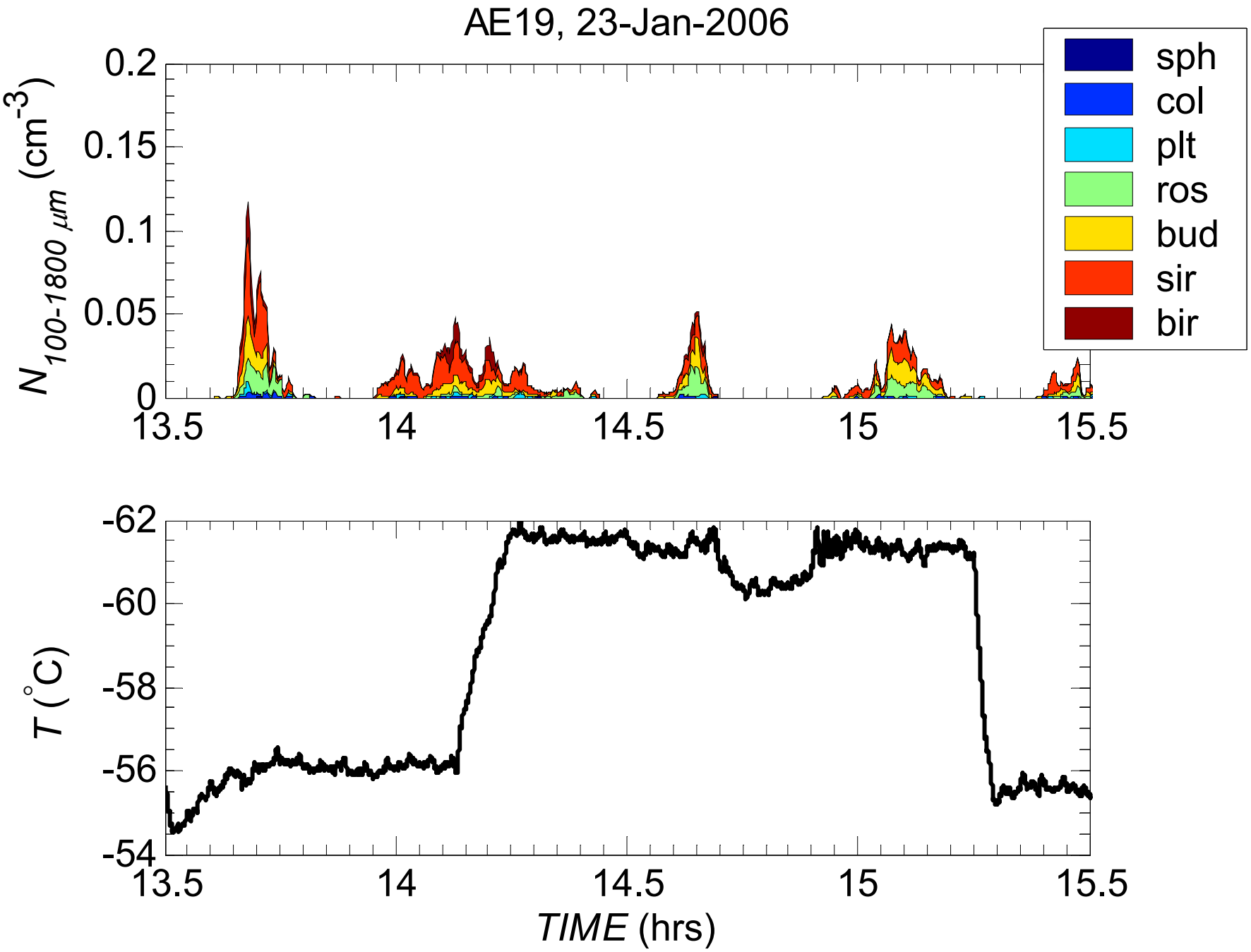


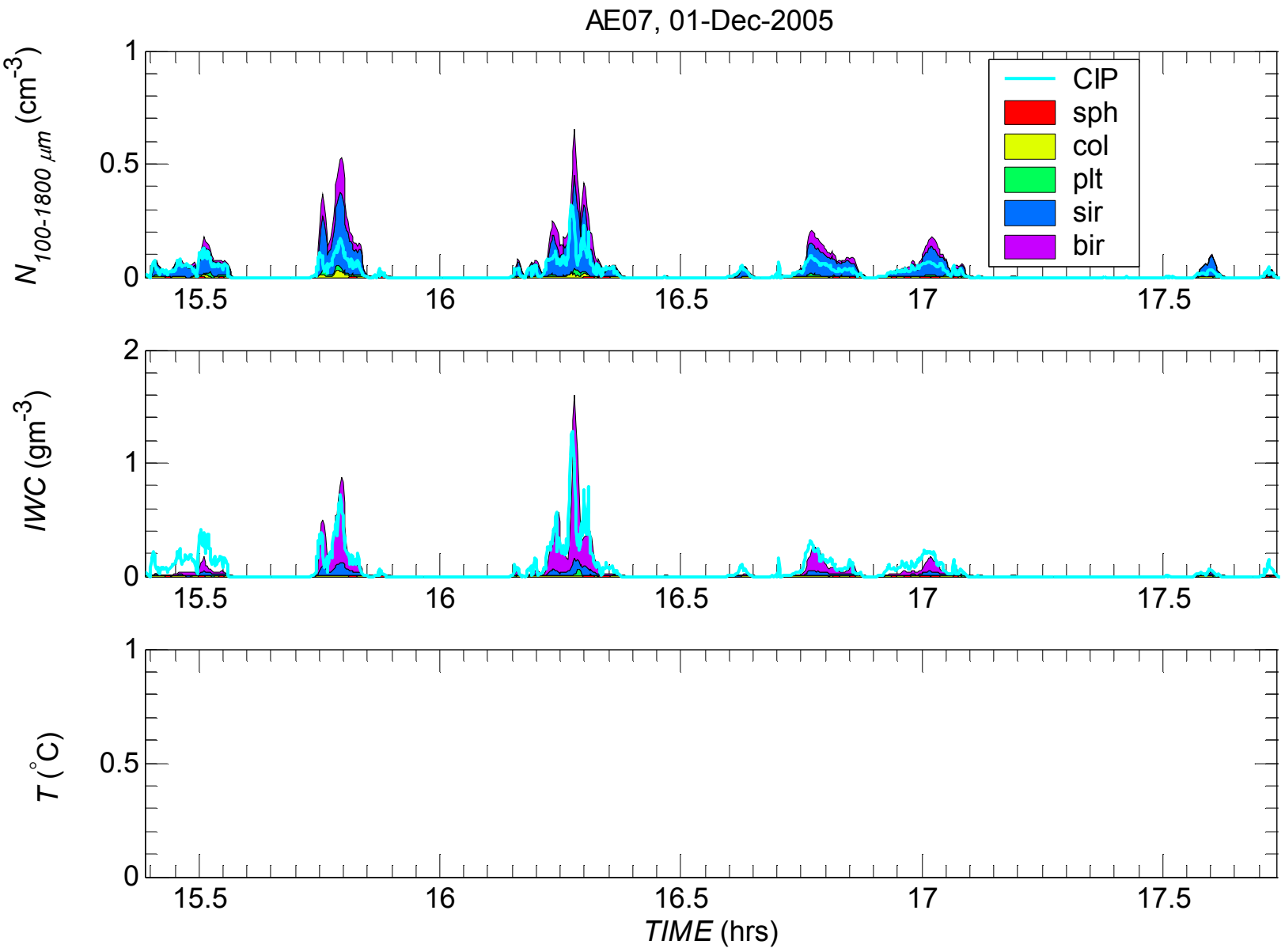
back

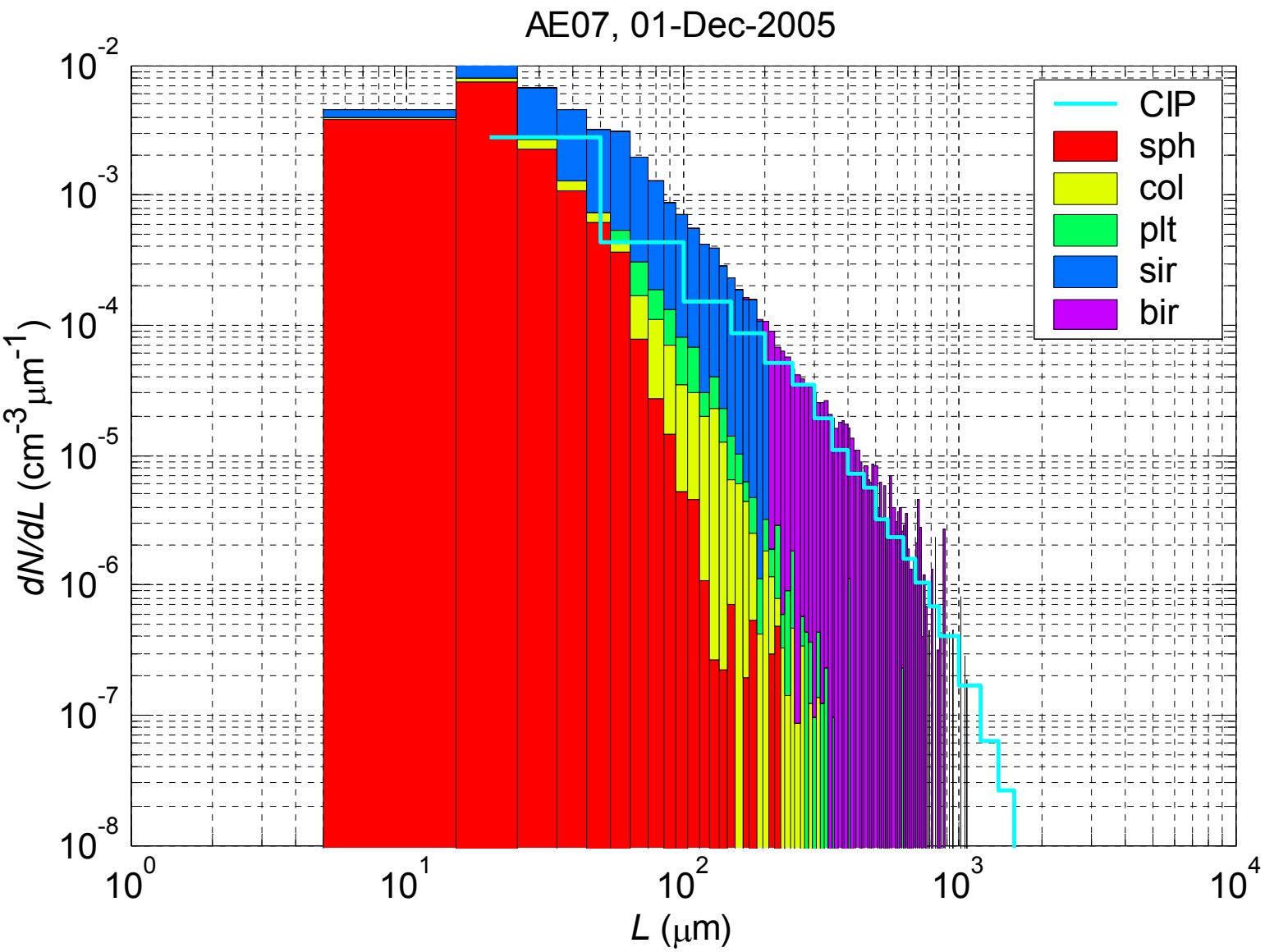


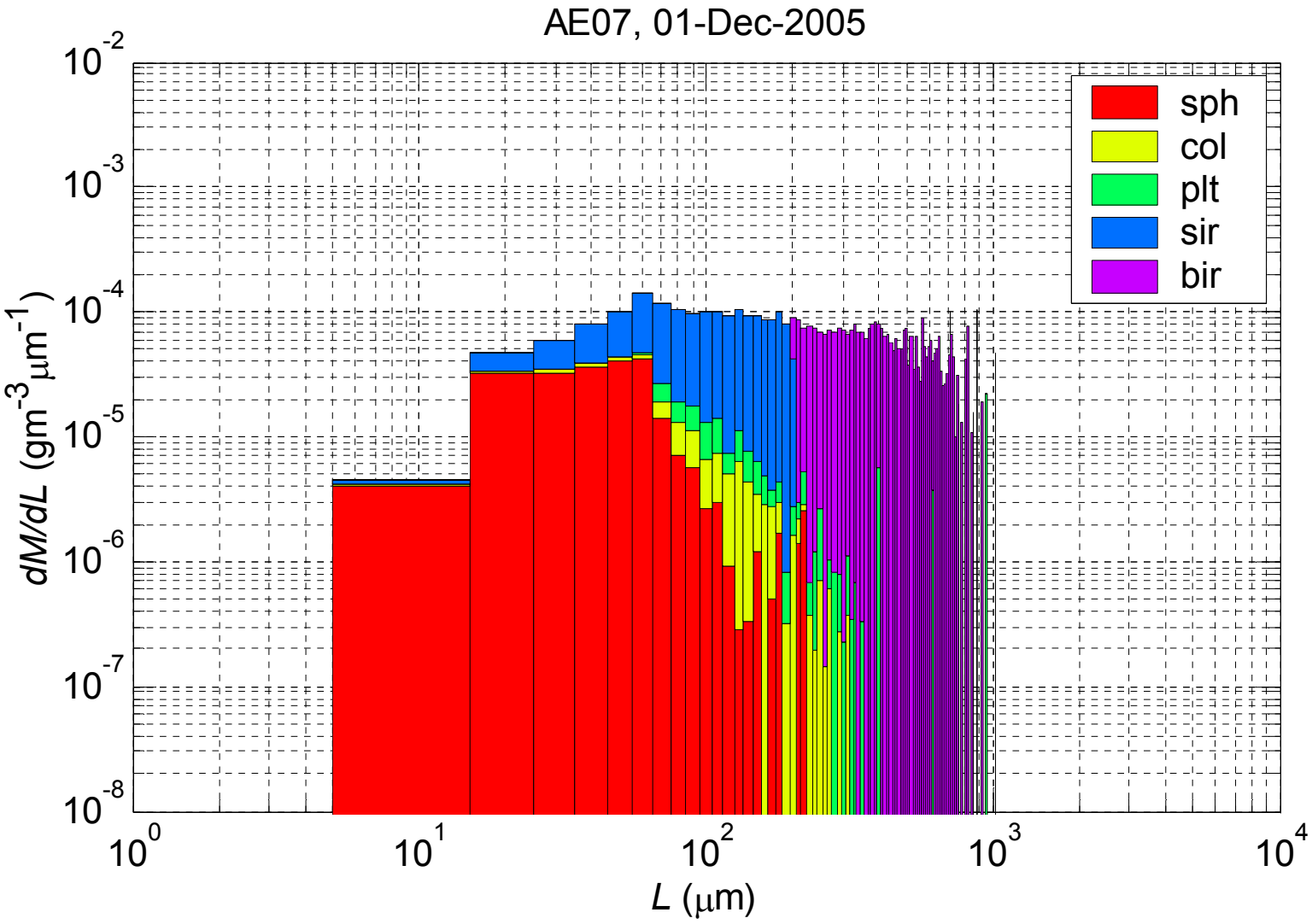
back

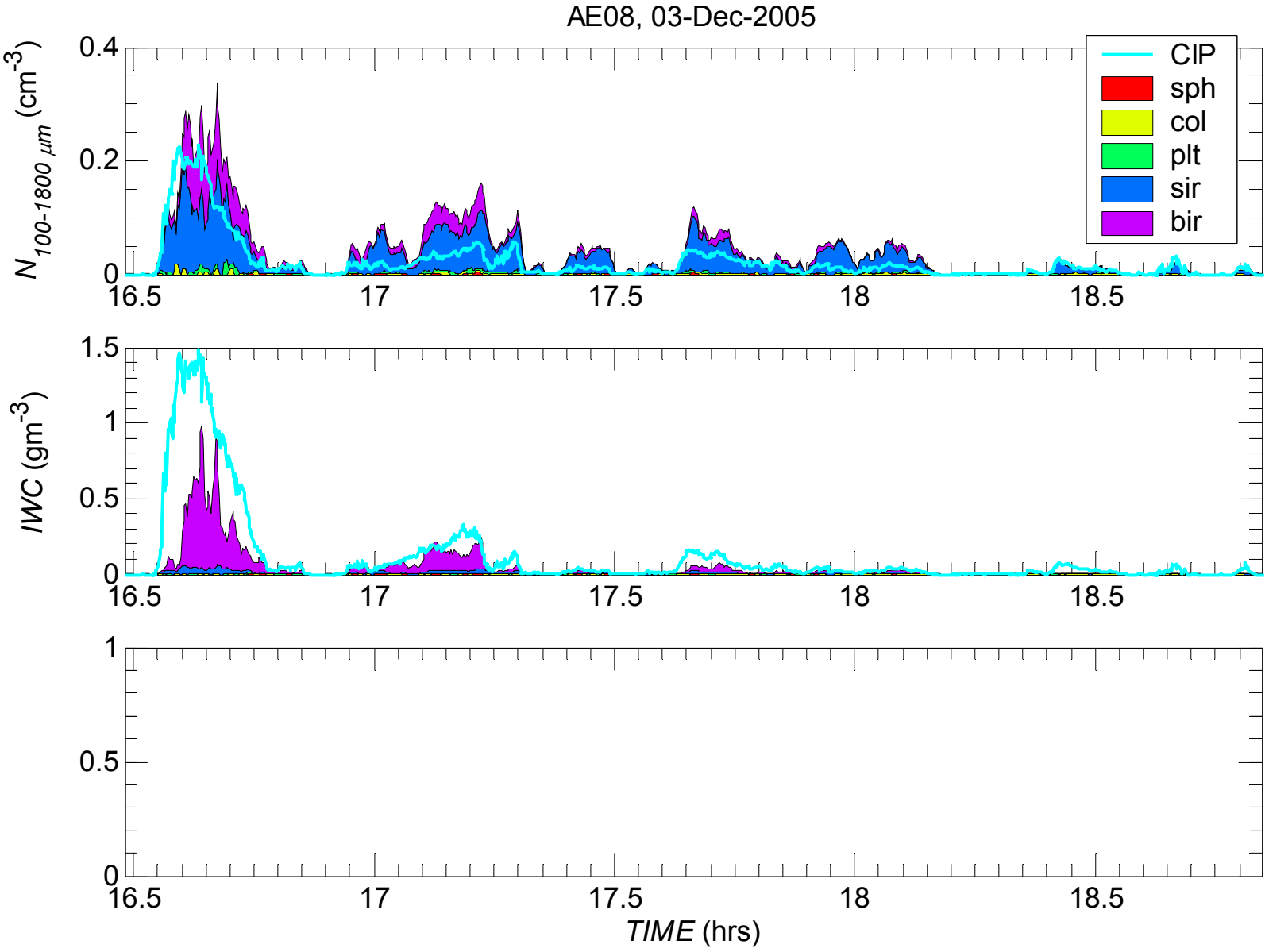


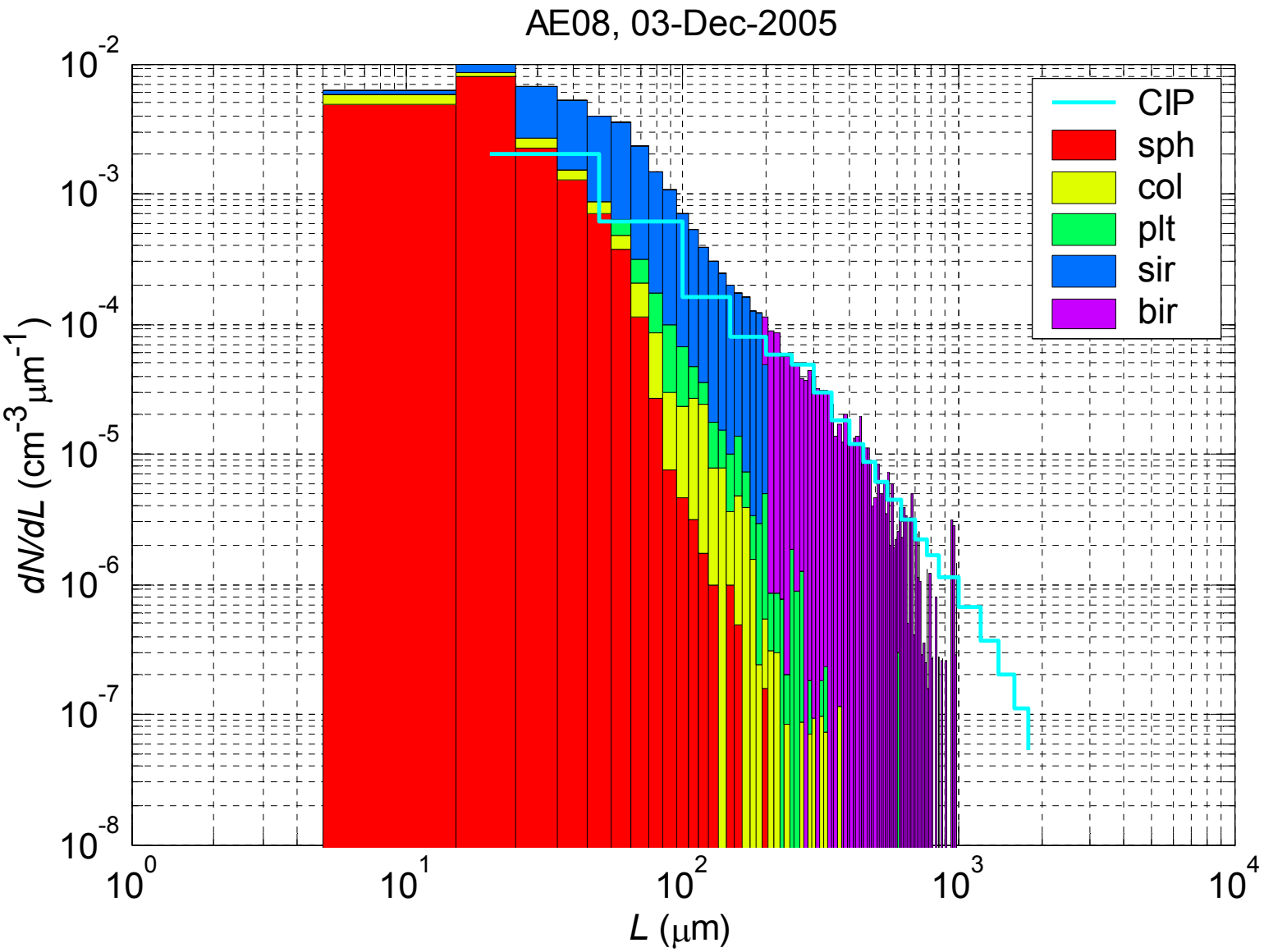

AE19, 23-Jan-2006
sph
col
plt
ros
bud
sir
bir
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
0.2
0.15
0.1
0.05
0
13.5
14
14.5
15
15.5
T ($^{\circ}$C)
-62
-60
-58
-56
-54
13.5
14
14.5
15
15.5
TIME (hrs)

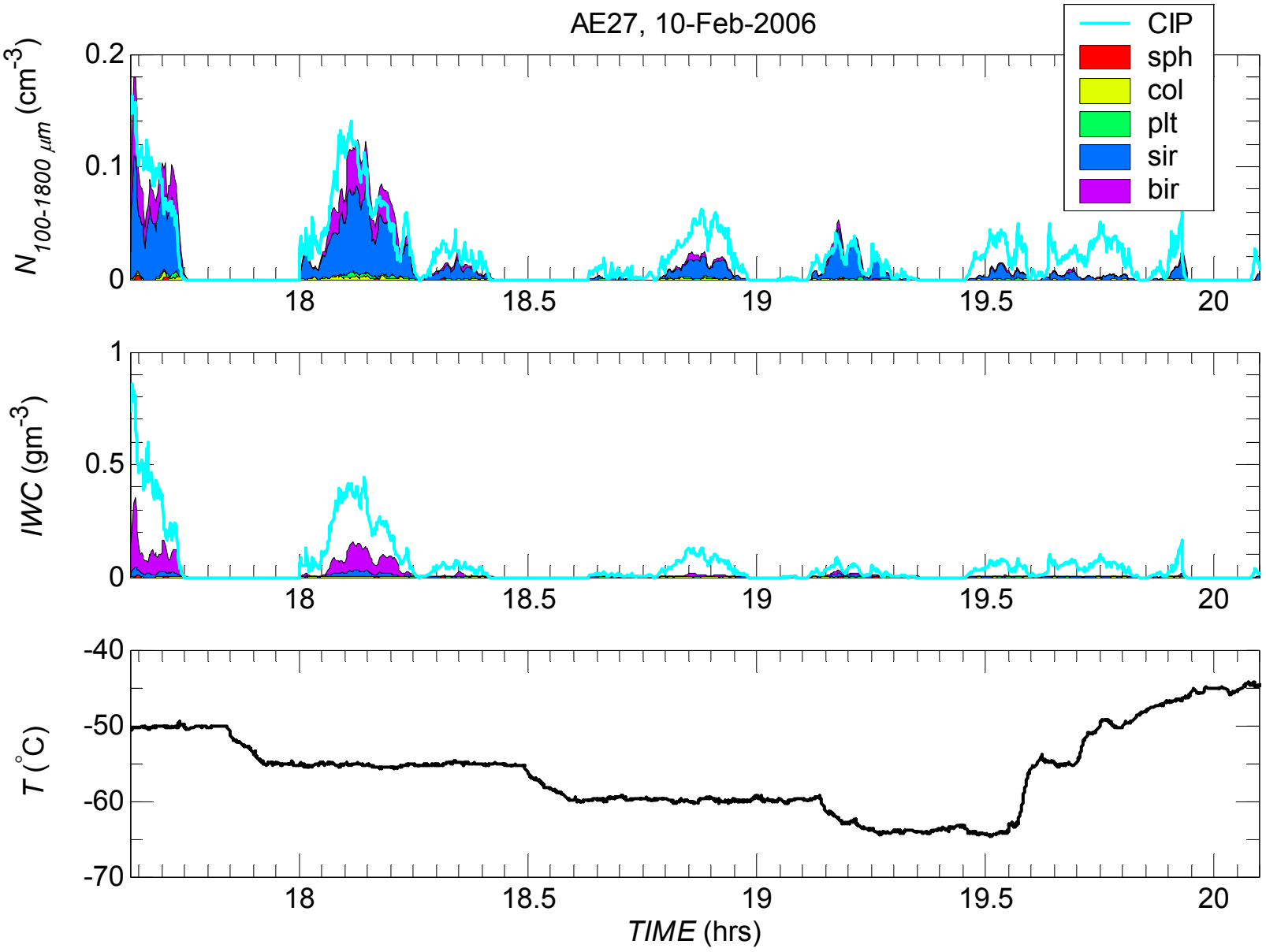

AE07, 01-Dec-2005
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
CIP
sph
col
plt
sir
bir
IWC (gm^{-3})
T (°C)
TIME (hrs)
15.5
16
16.5
17
17.5

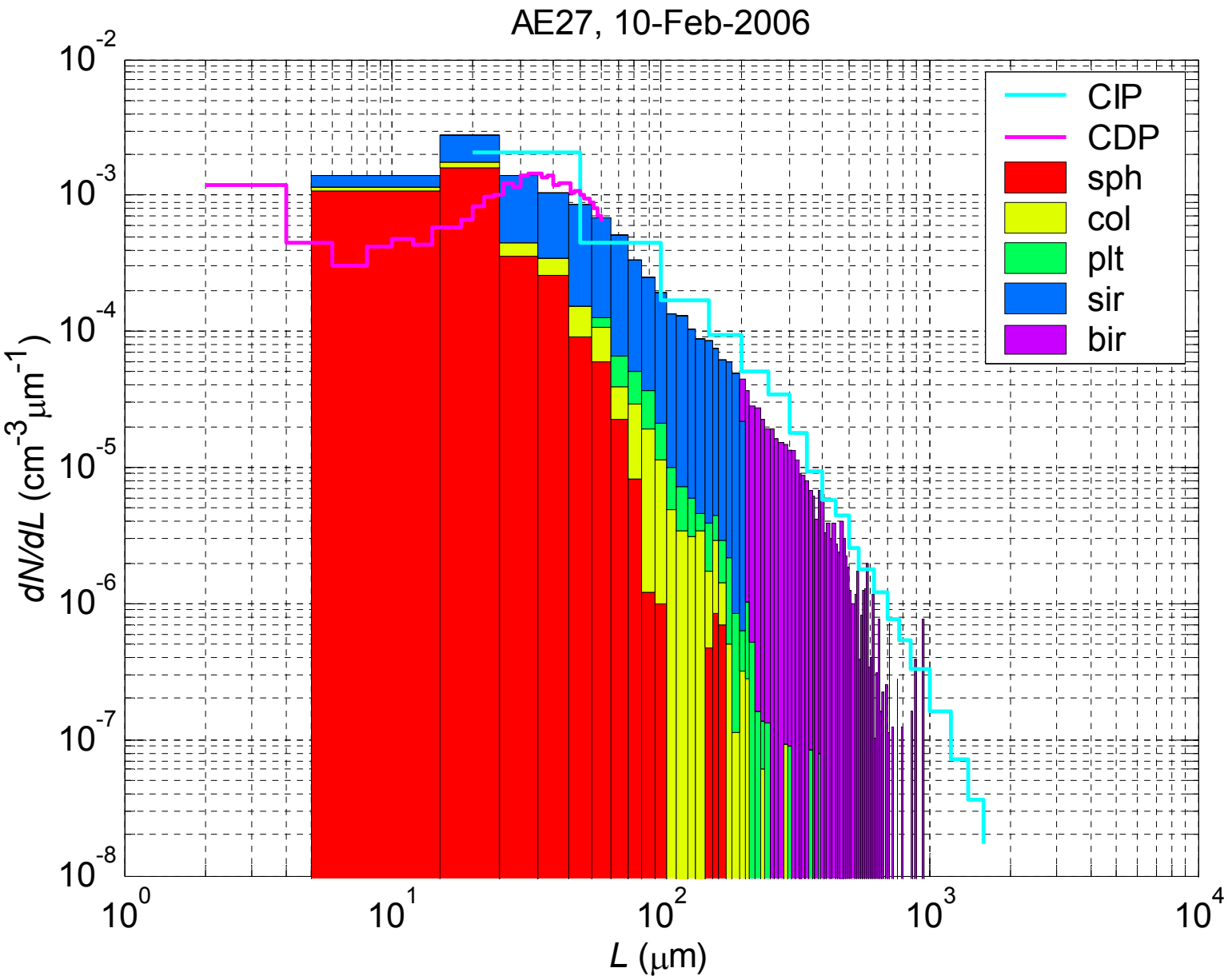

AE07, 01-Dec-2005
CIP
sph
col
plt
sir
bir
dN/dL (cm-3 µm-1)
L (µm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104

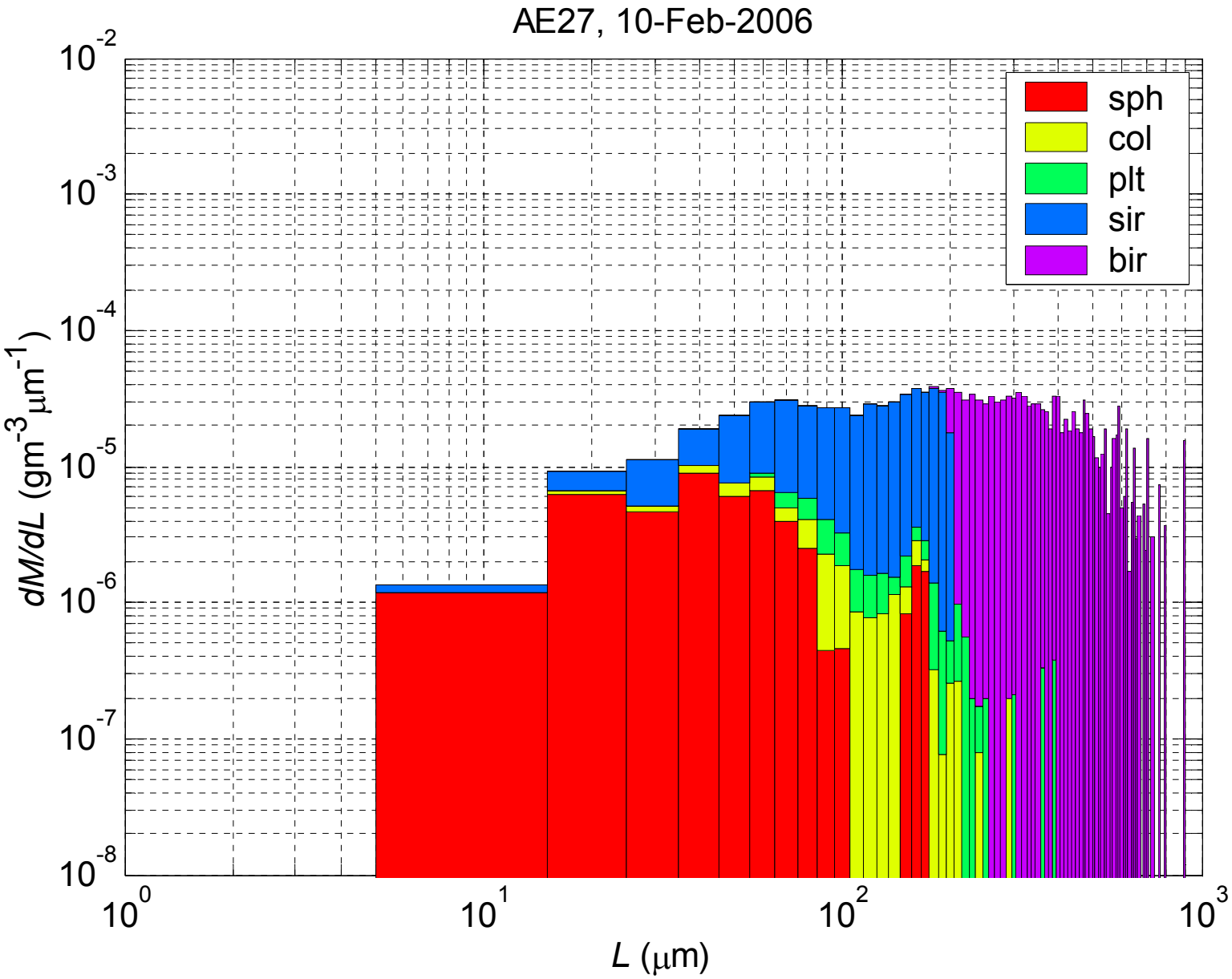

AE07, 01-Dec-2005
sph
col
plt
sir
bir
dM/dL (gm-3μm-1)
L (μm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104

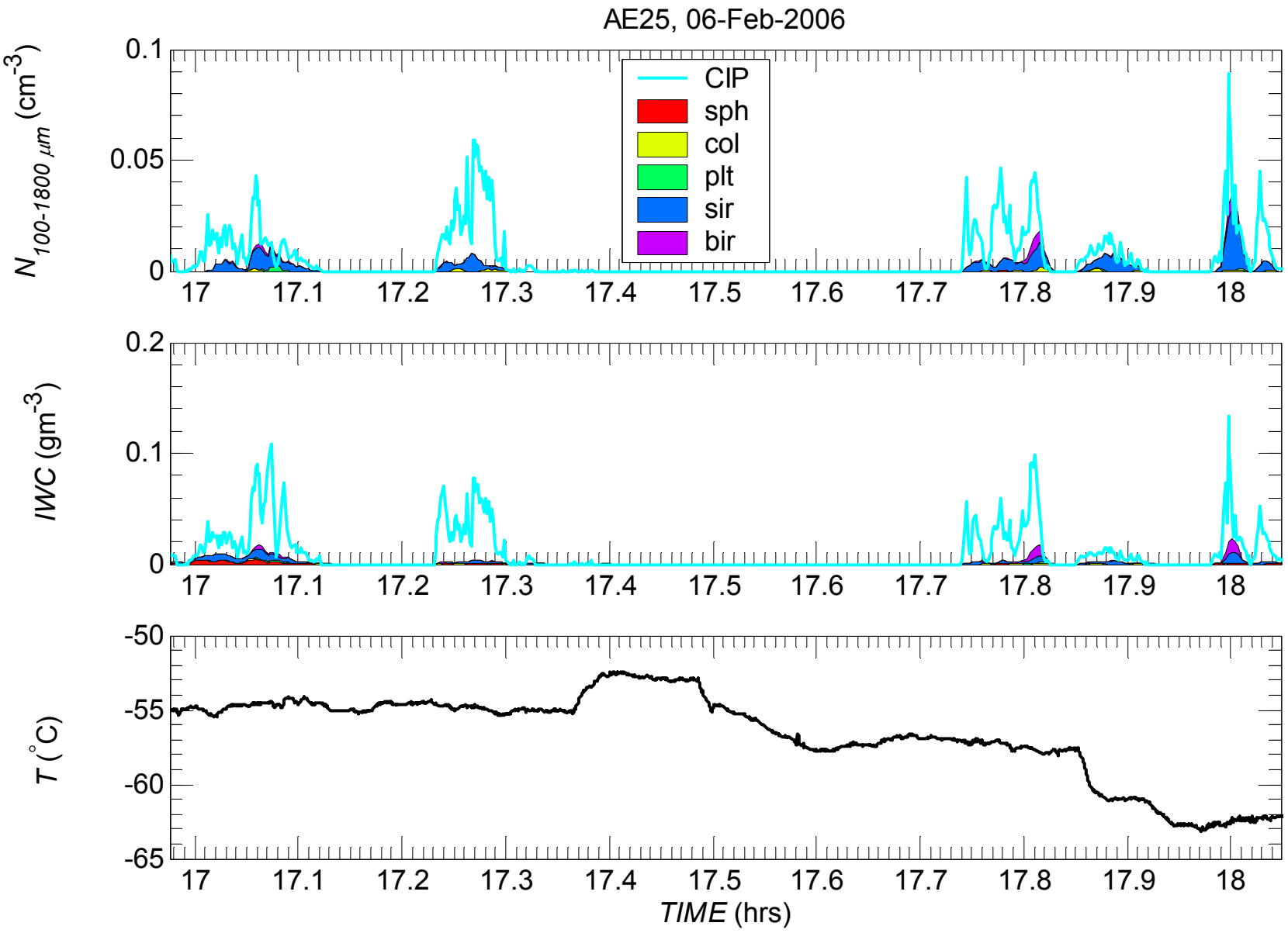

AE08, 03-Dec-2005
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
0.4
0.2
0
CIP
sph
col
plt
sir
bir
16.5
17
17.5
18
18.5
IWC (gm^{-3})
1.5
1
0.5
0
16.5
17
17.5
18
18.5
1
0.5
0
16.5
17
17.5
18
18.5
TIME (hrs)

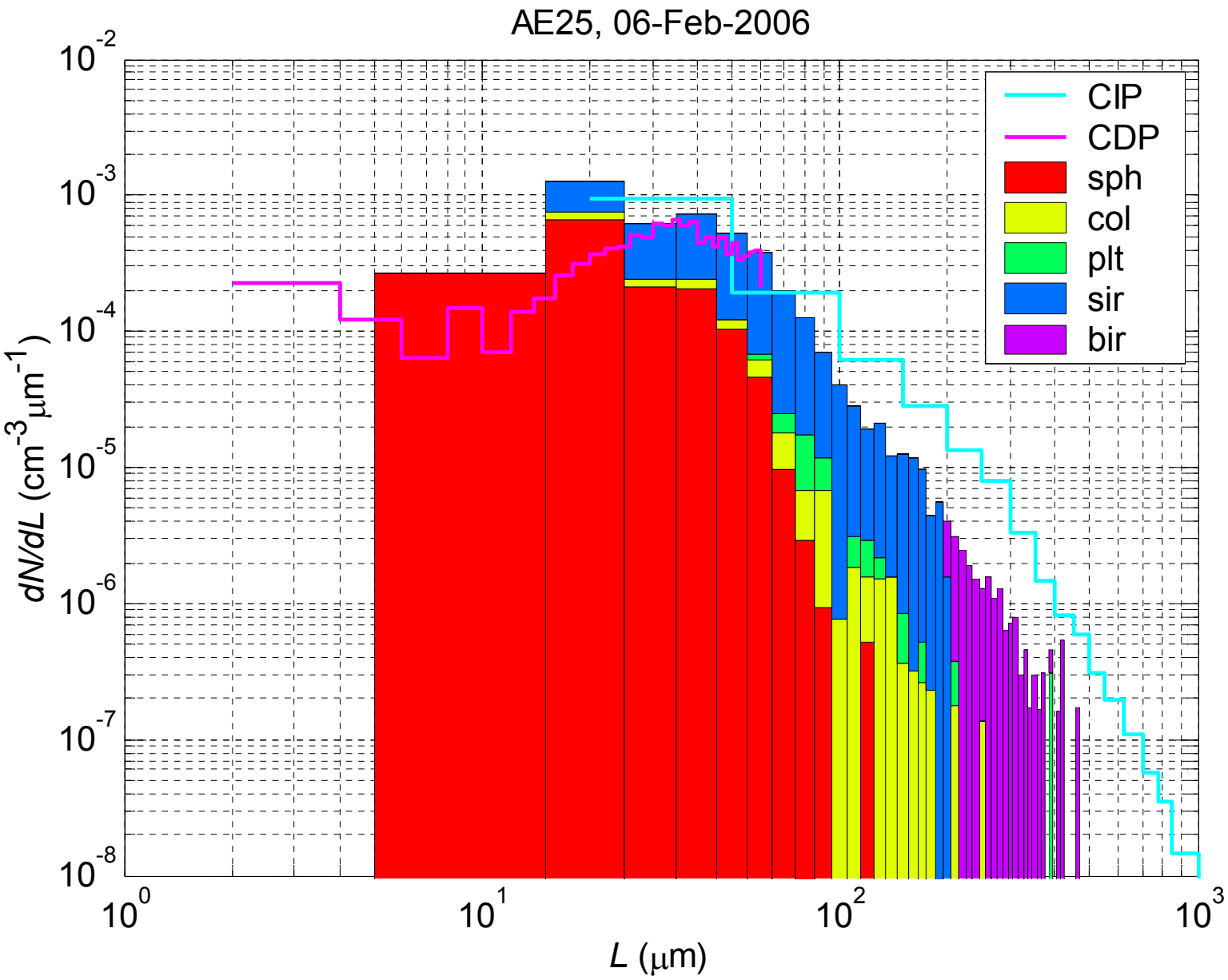

AE08, 03-Dec-2005
CIP
sph
col
plt
sir
bir
dN/dL (cm-3 µm-1)
L (µm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104

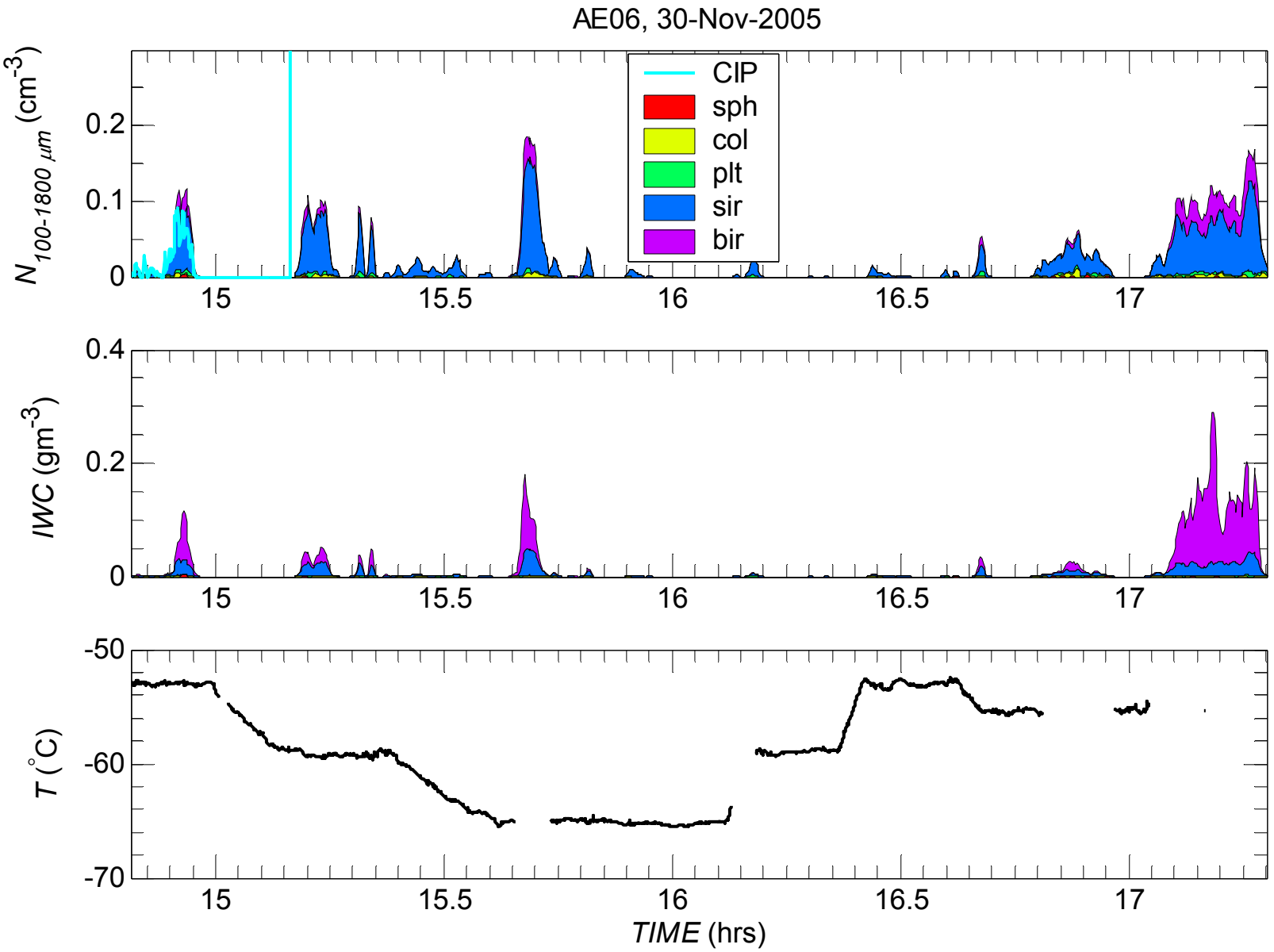

AE27, 10-Feb-2006
CIP
sph
col
plt
sir
bir
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
0.2
0.1
0
IWC (gm^{-3})
1
0.5
0
T (°C)
-40
-50
-60
-70
18
18.5
19
19.5
20
TIME (hrs)

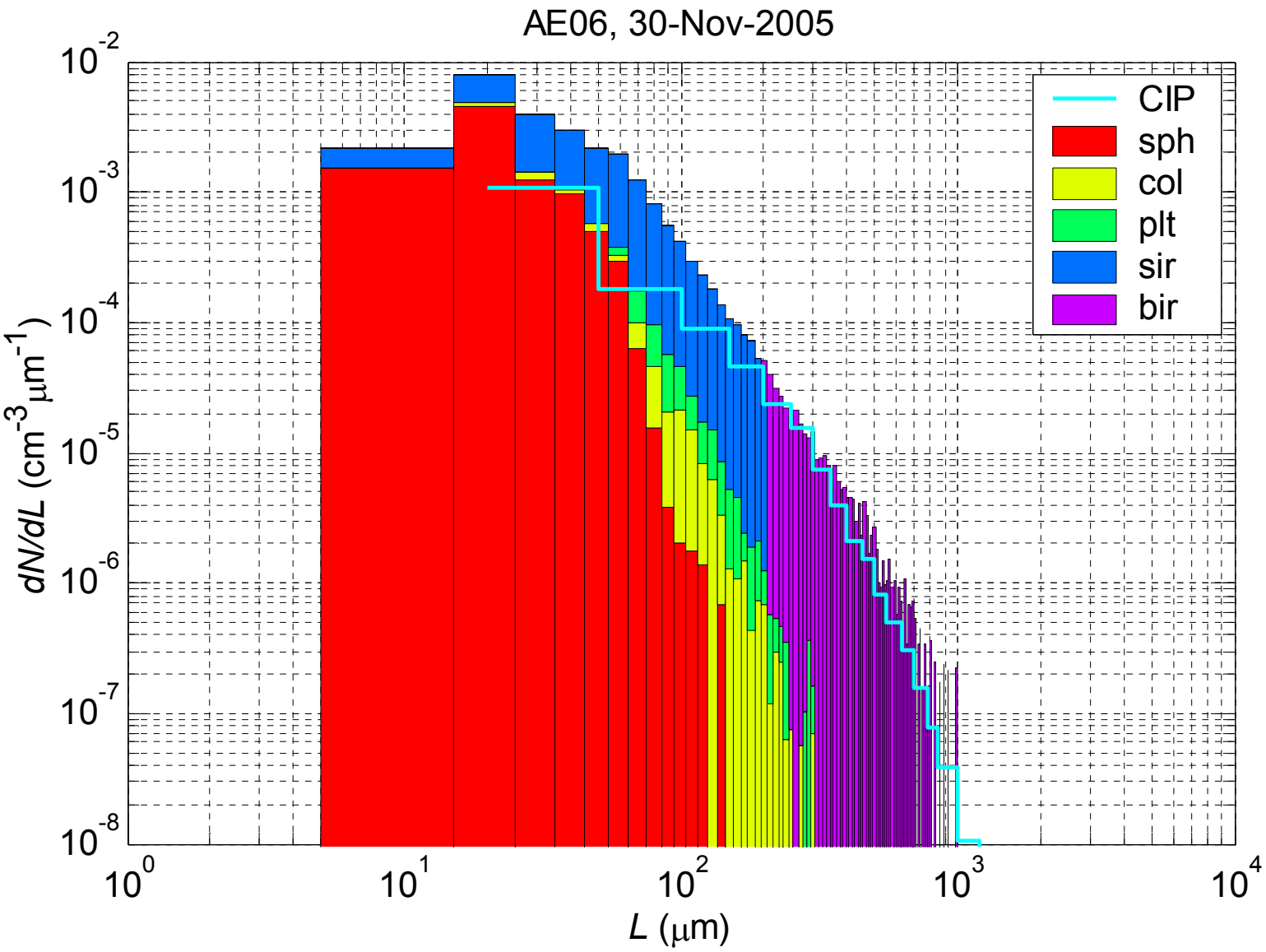

AE27, 10-Feb-2006
CIP
CDP
sph
col
plt
sir
bir
dN/dL (cm-3μm-1)
L (μm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104


AE27, 10-Feb-2006
sph
col
plt
sir
bir
dM/dL (gm-3μm-1)
L (μm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103


AE25, 06-Feb-2006
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
0.1
0.05
0
CIP
sph
col
plt
sir
bir
17
17.1
17.2
17.3
17.4
17.5
17.6
17.7
17.8
17.9
18
IWC (gm^{-3})
0.2
0.1
0
T (°C)
-50
-55
-60
-65
TIME (hrs)


AE25, 06-Feb-2006
CIP
CDP
sph
col
plt
sir
bir
dN/dL (cm-3µm-1)
L (µm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103


AE06, 30-Nov-2005
CIP
sph
col
plt
sir
bir
$N_{100\text{-}1800\ \mu m}$ (cm^{-3})
0
0.1
0.2
15
15.5
16
16.5
17
IWC (gm^{-3})
0
0.2
0.4
T (°C)
-50
-60
-70
TIME (hrs)


AE06, 30-Nov-2005
CIP
sph
col
plt
sir
bir
dN/dL (cm-3µm-1)
L (µm)
10-2
10-3
10-4
10-5
10-6
10-7
10-8
100
101
102
103
104