A new microphysics scheme for the Met Office Unified Model

New bulk microphysics scheme

Initially developed for high resolution (km-scale) forecasting

Represents droplets, rain, pristine ice, snow and graupel

Up to 3 moments may be selected to represent the hydrometeors

New scheme is common to the Unified Model and the Met Office CRM/LES.

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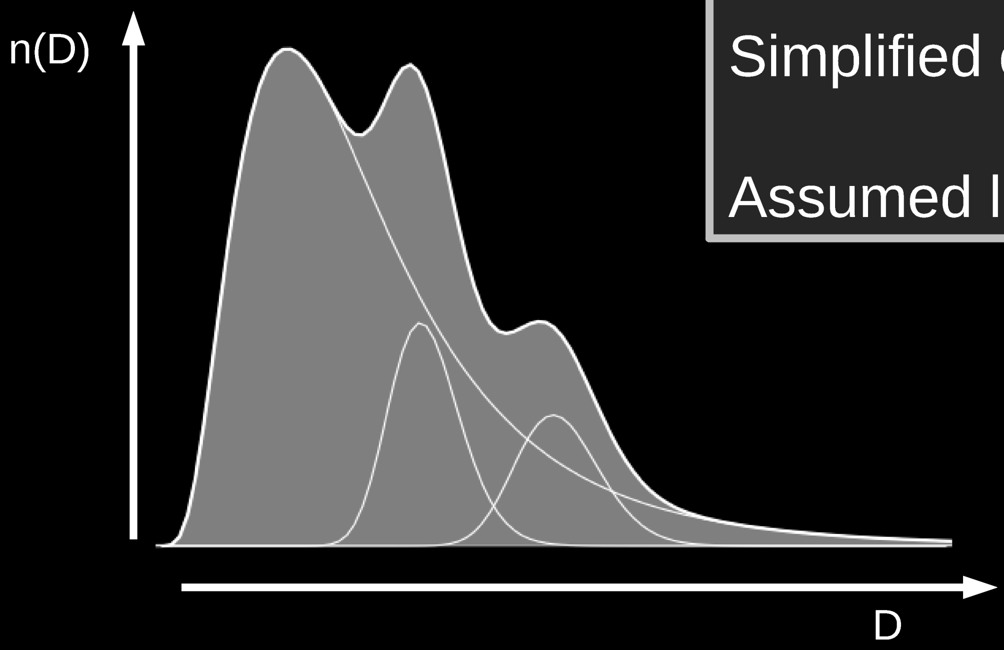
Aerosol processing: *inputs*

Simplified aerosol with 3 modes (m,N).

Simplified chemisty.

Assumed lognormal.



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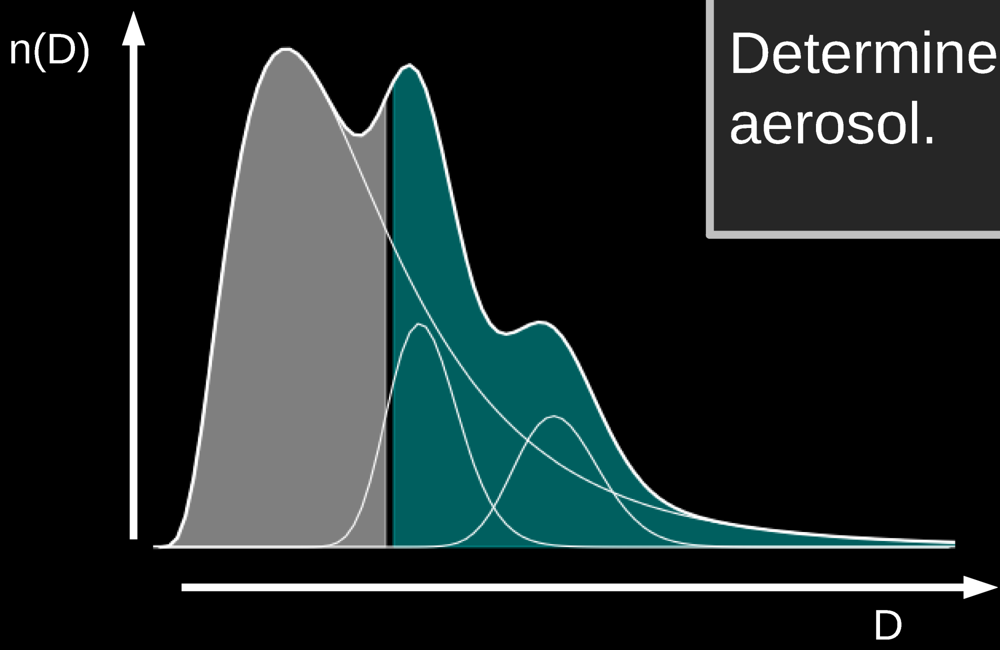
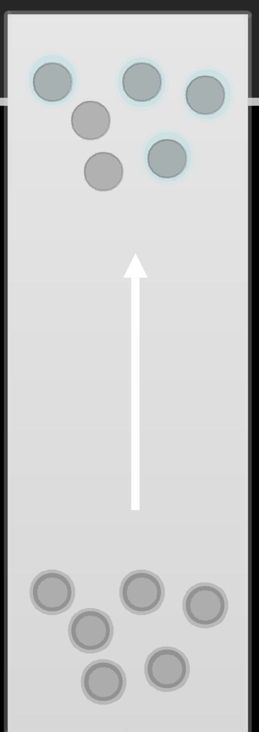
Aerosol processing: *nucleation*

Parametrization uses chemistry and size information, e.g. Abdul-Razzak & Ghan(2000) or Shipway & Abel(2010).

Determines critical radius for activating aerosol.





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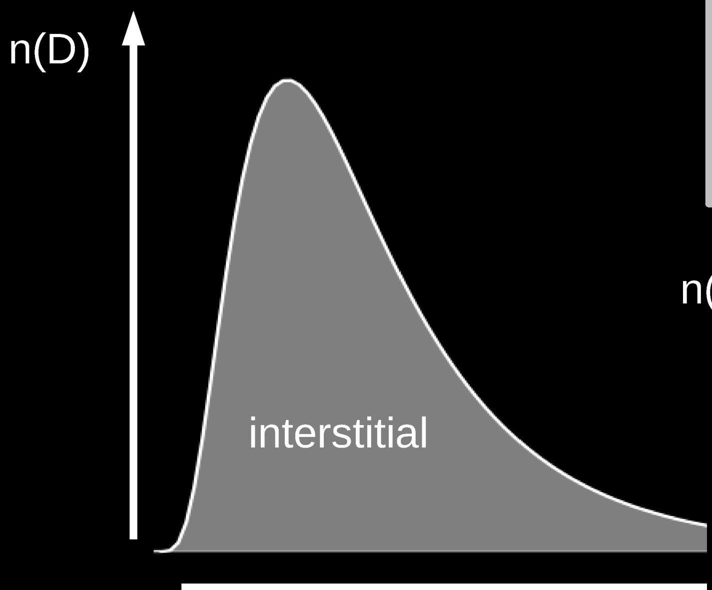
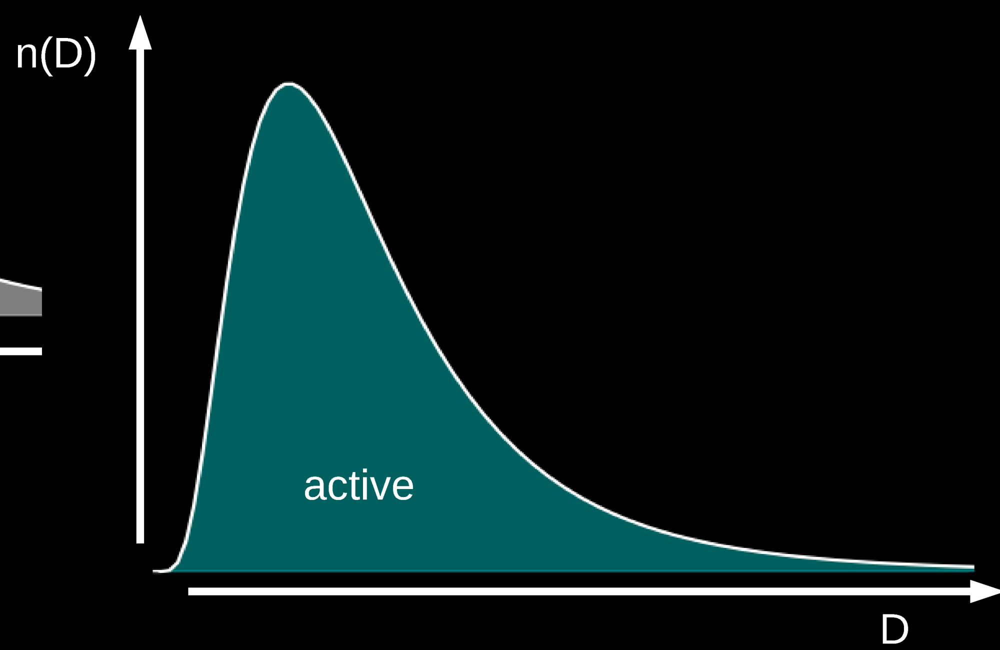
Aerosol processing: *nucleation*

Met Office

Activated aerosol mass is transferred to a new 'active' aerosol prognostic variable, m_{act}.

Activated number is now given as the number of cloud droplets, n_L.





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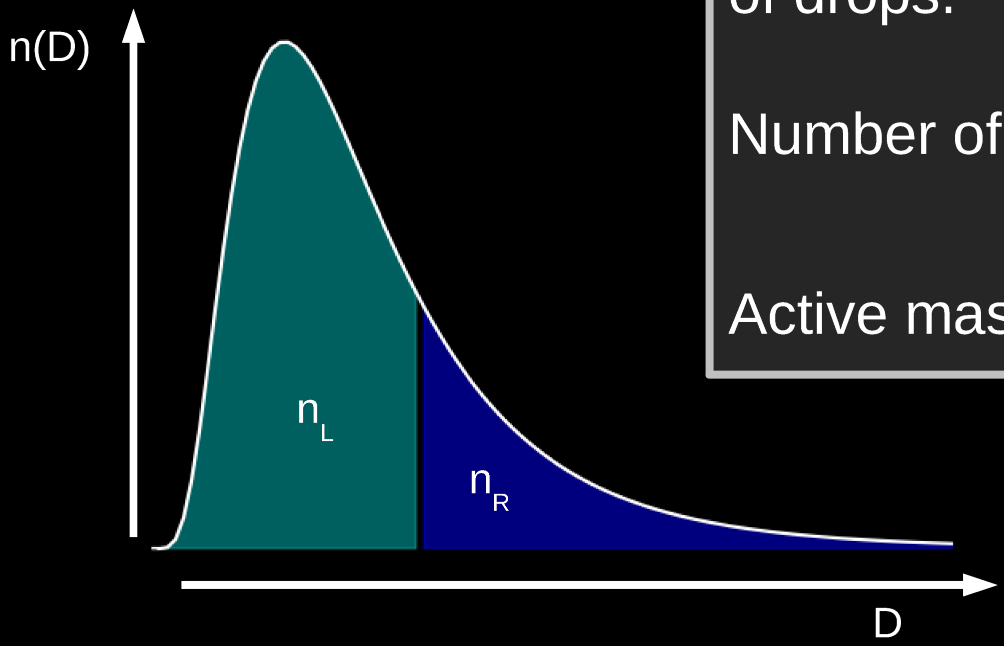
Aerosol processing: *collision/coalescence*



Autoconversion, accretion and aggregation serve to move droplets into rain and reduce the total number of drops.

Number of active aerosol is now $n_L + n_R$

Active mass, m_{act} is unchanged.

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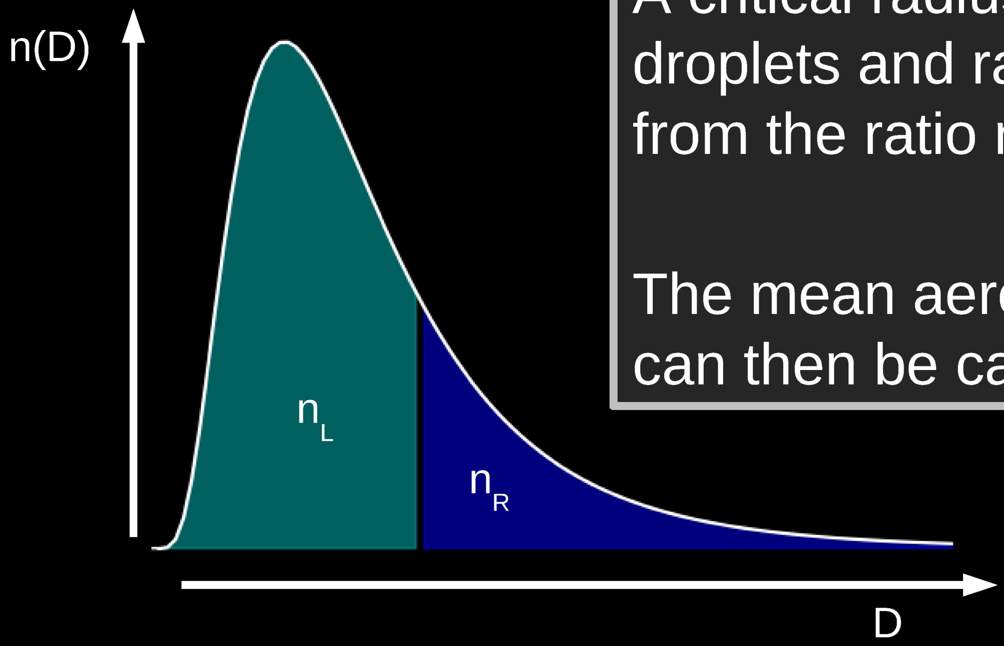
Aerosol processing: *collision/coalescence*

A simple assumption is then made that the largest aerosol reside in the rain drops.

A critical radius partitioning aerosol in droplets and rain can then be determined from the ratio n_L/n_R.

The mean aerosol mass in cloud and rain can then be calculated separately.



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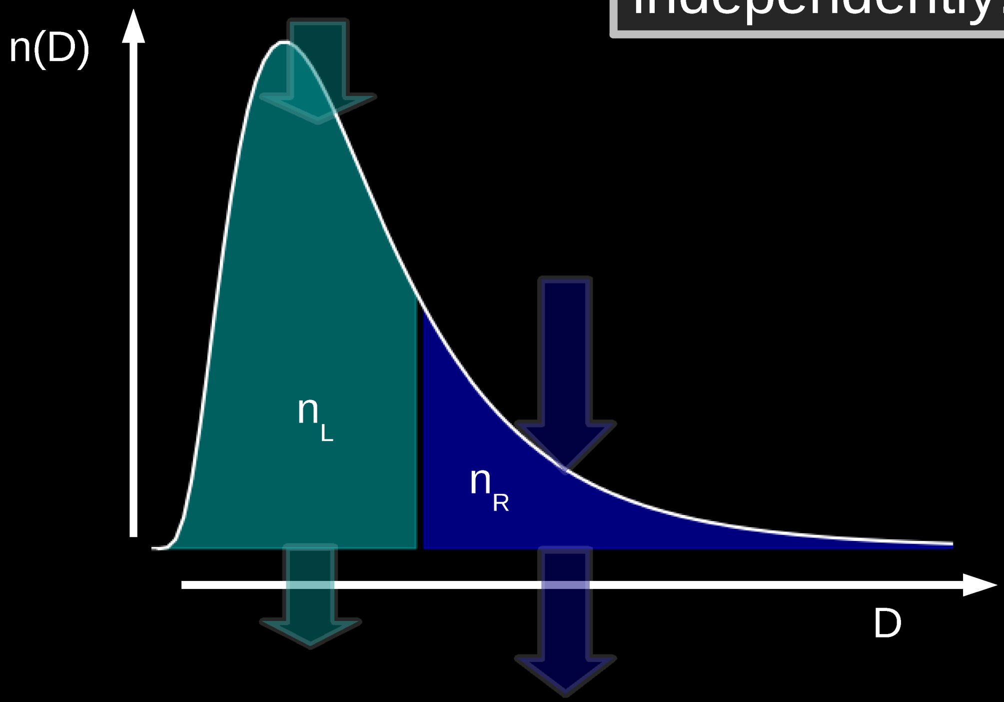
Aerosol processing: *sedimentation*

With knowledge of the (diagnostically) partitioned aerosol, fluxes of active aerosol in cloud/rain can be calculated independently.



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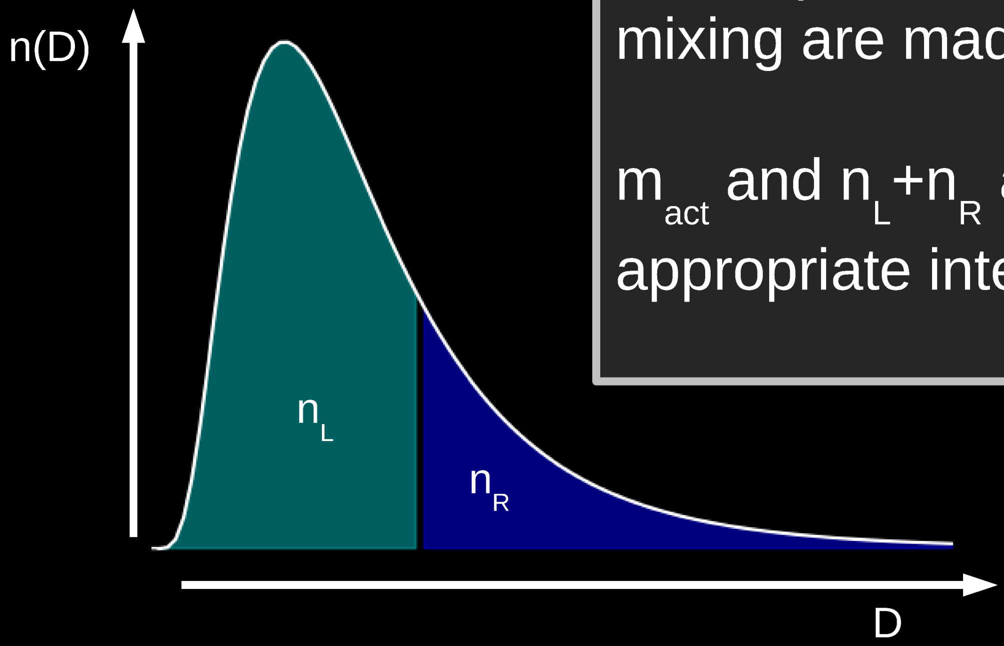
Aerosol processing: *recovery*

Similarly, this information is used in the evaporation of rain and cloud leading to recovery of the interstitial aerosol.

Assumptions about (in)homogeneous mixing are made.

m_{act} and n_L+n_R are returned to a single appropriate interstitial mode.



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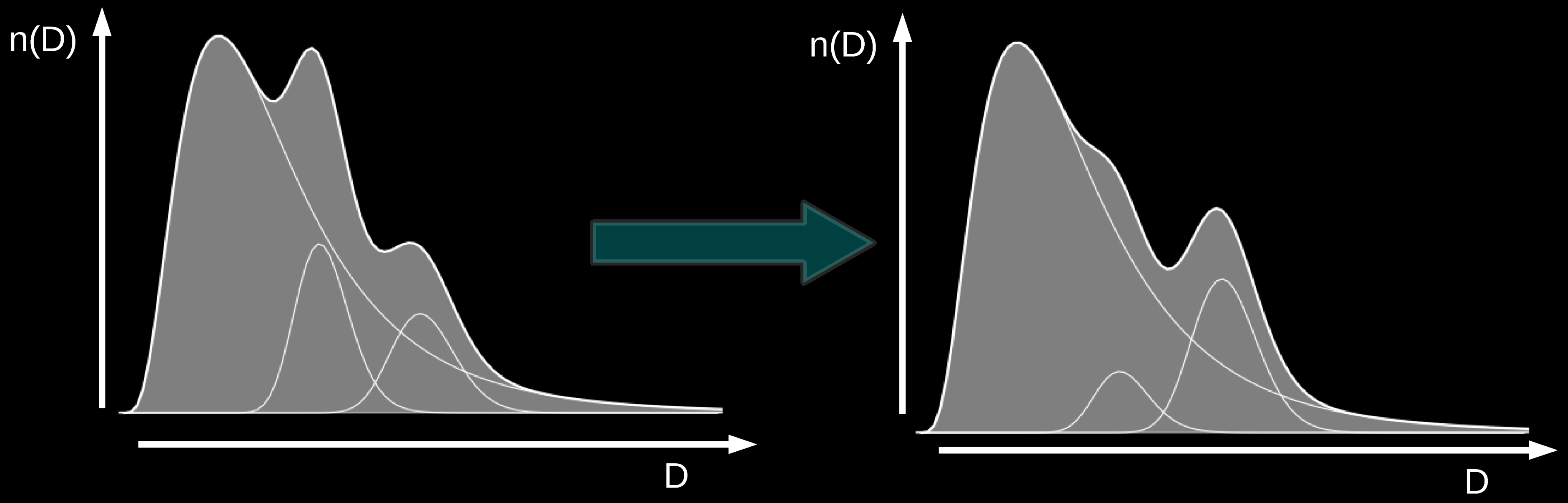
Aerosol processing: *net effect*

Aerosol mass conserved

Overall reduction in number

Distribution moves to larger modes



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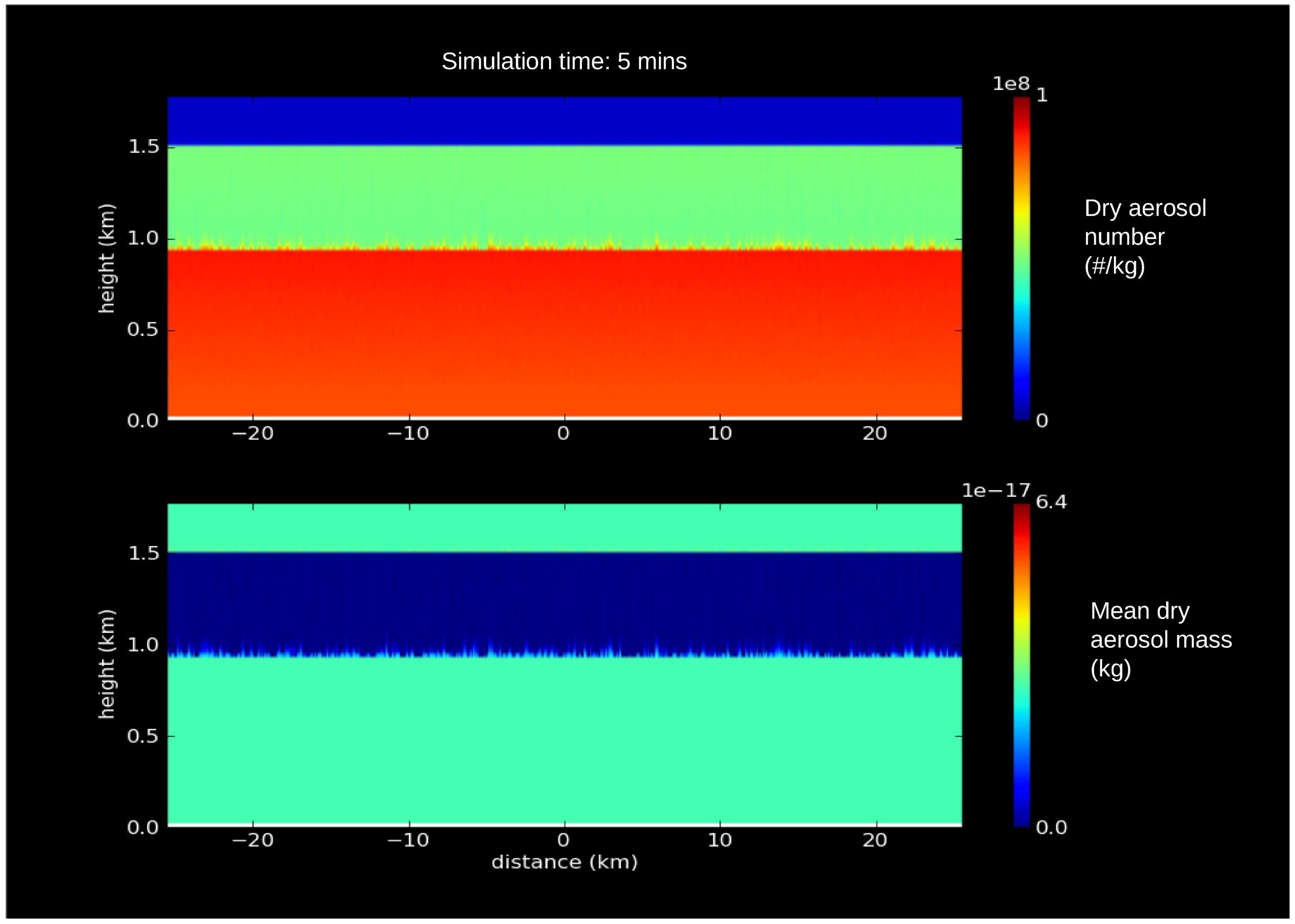
Cloud Modelling Workshop Case I (Vocals stratocumulus)



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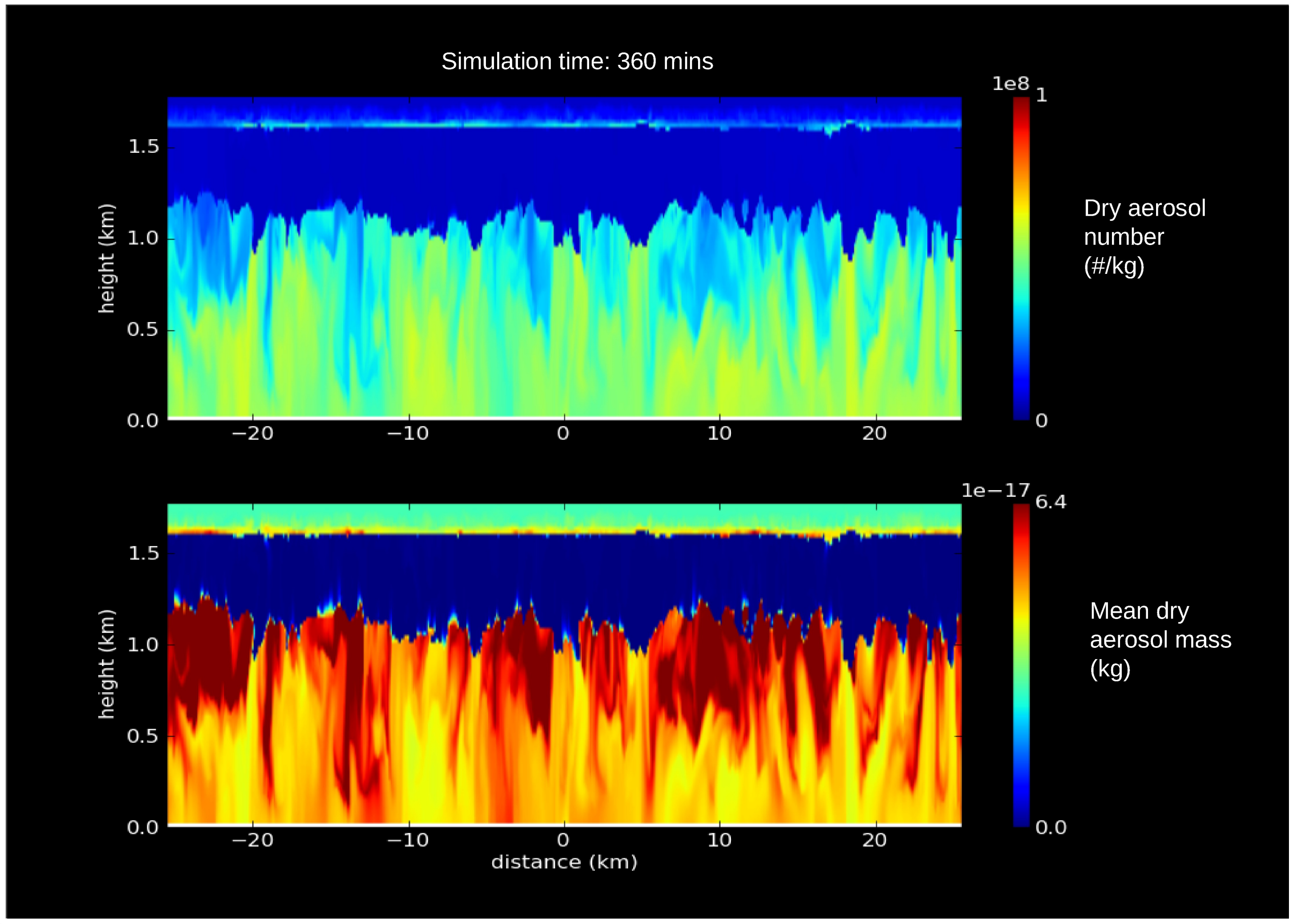
Cloud Modelling Workshop Case I (Vocals stratocumulus)



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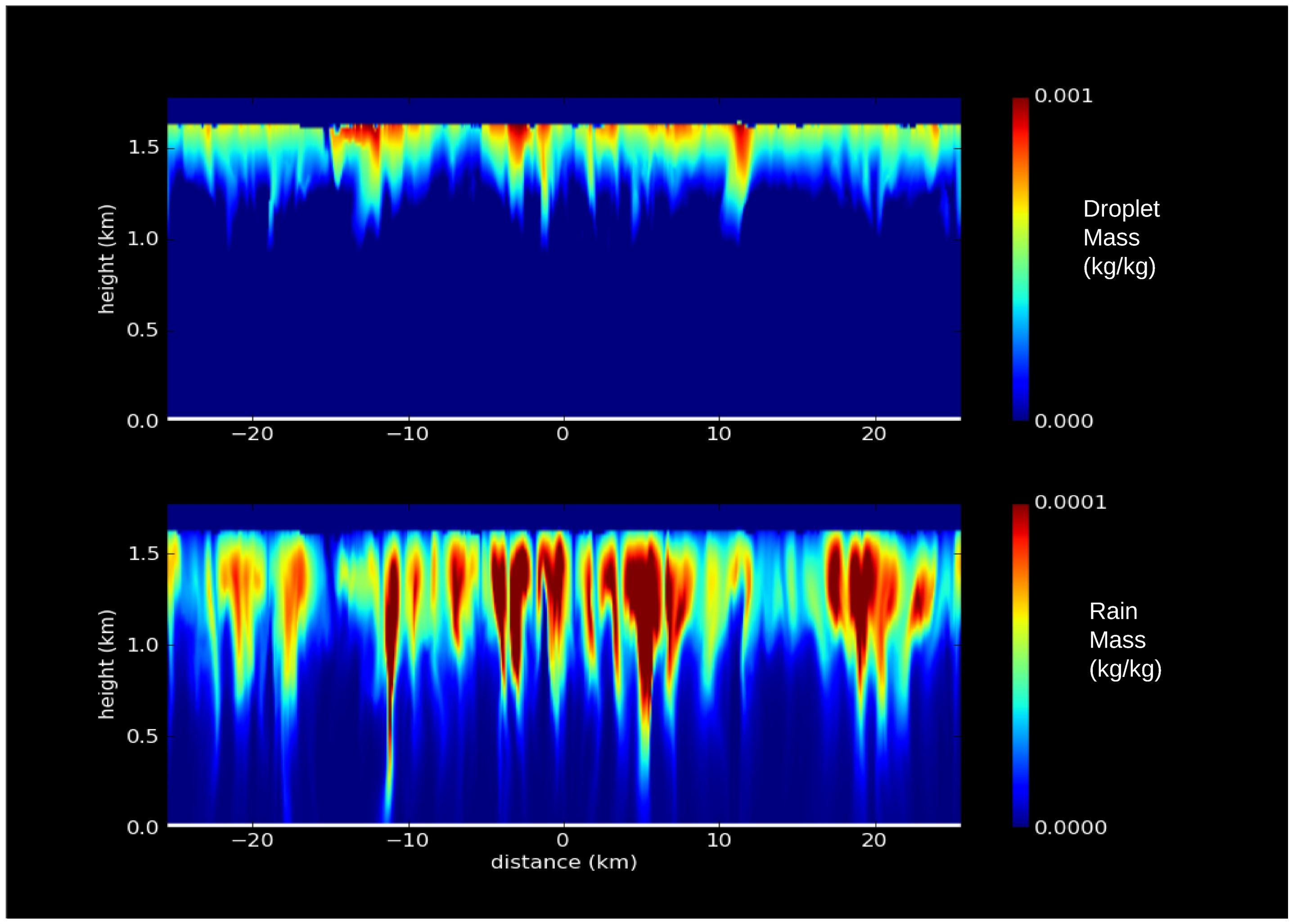
Cloud Modelling Workshop Case I (Vocals stratocumulus)



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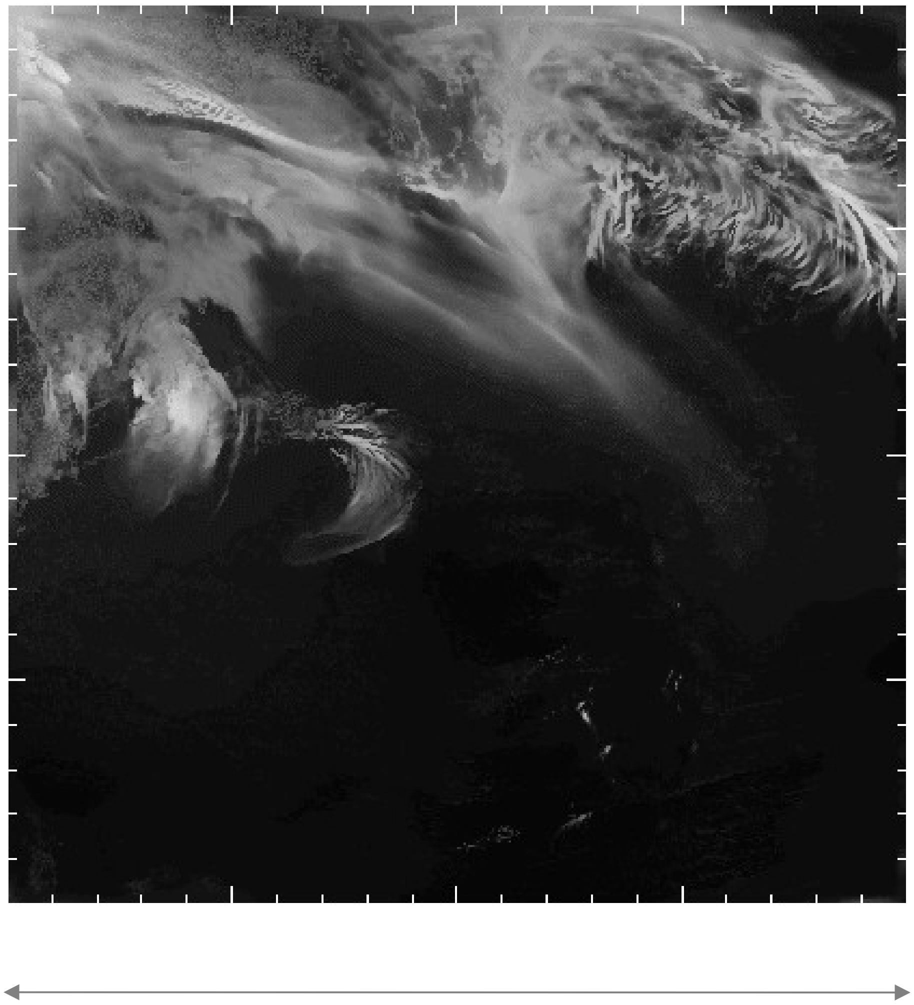
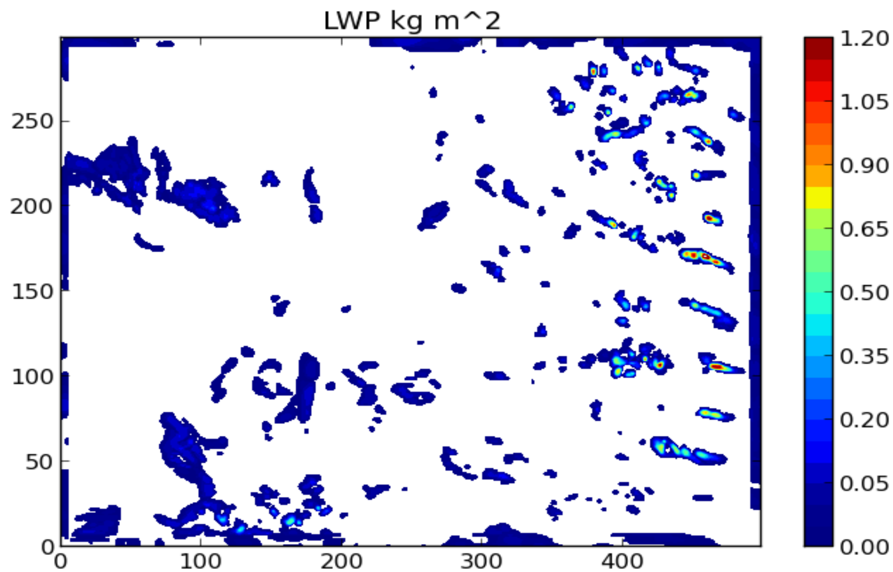
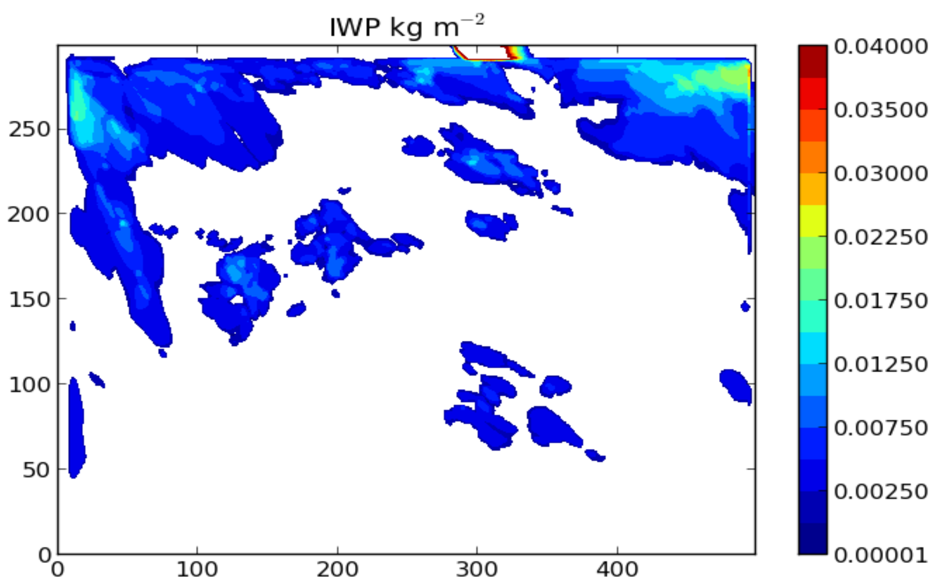
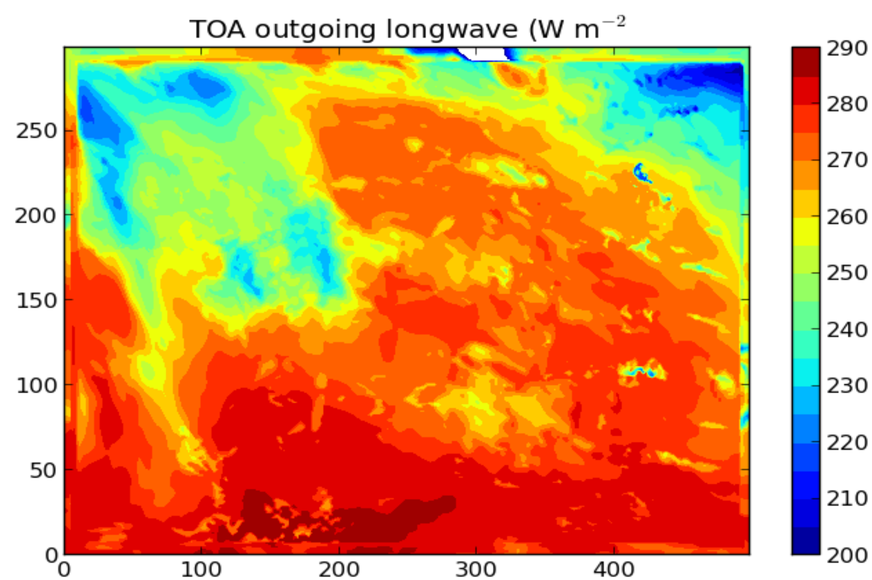


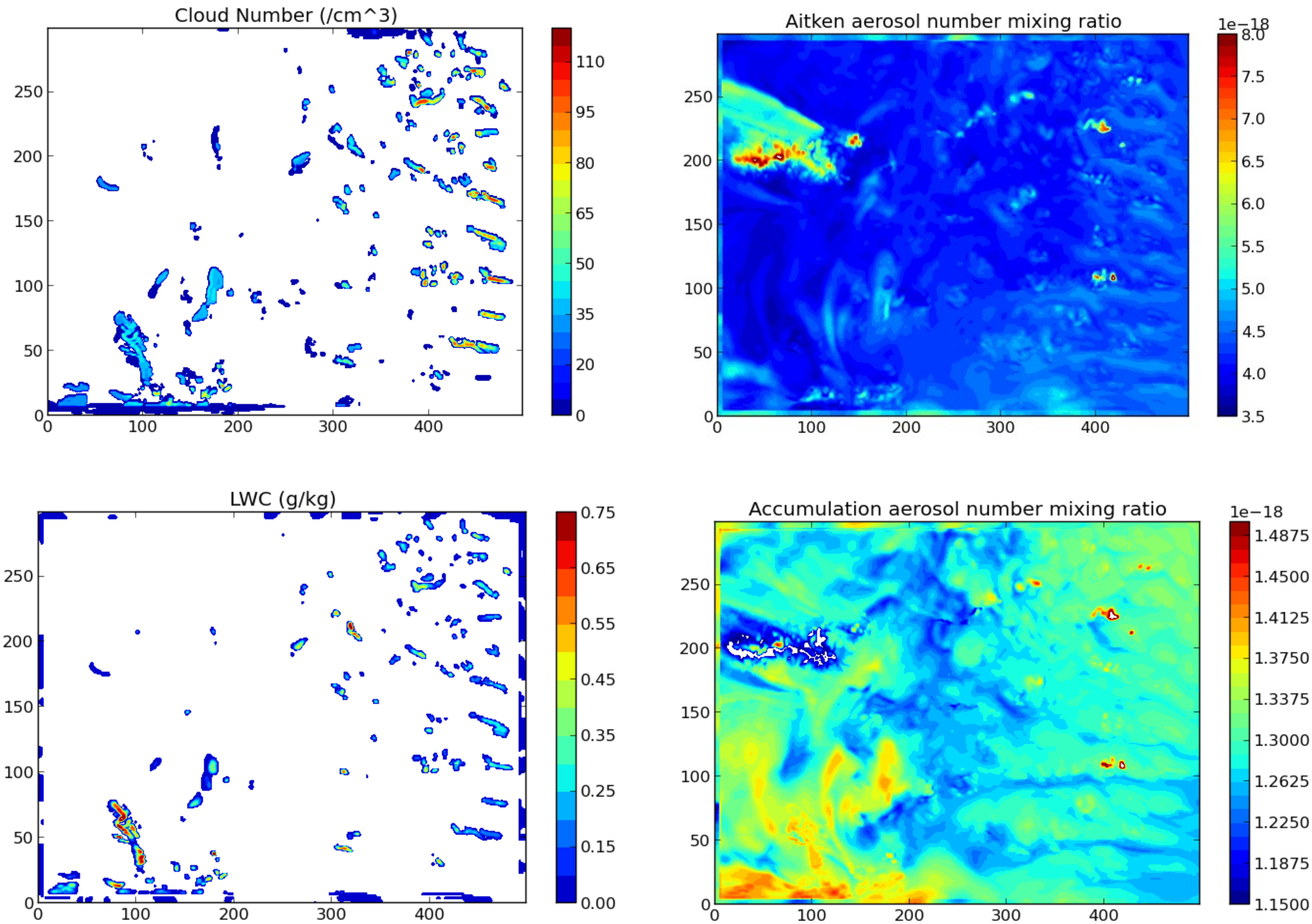
1000 km
dx=500m

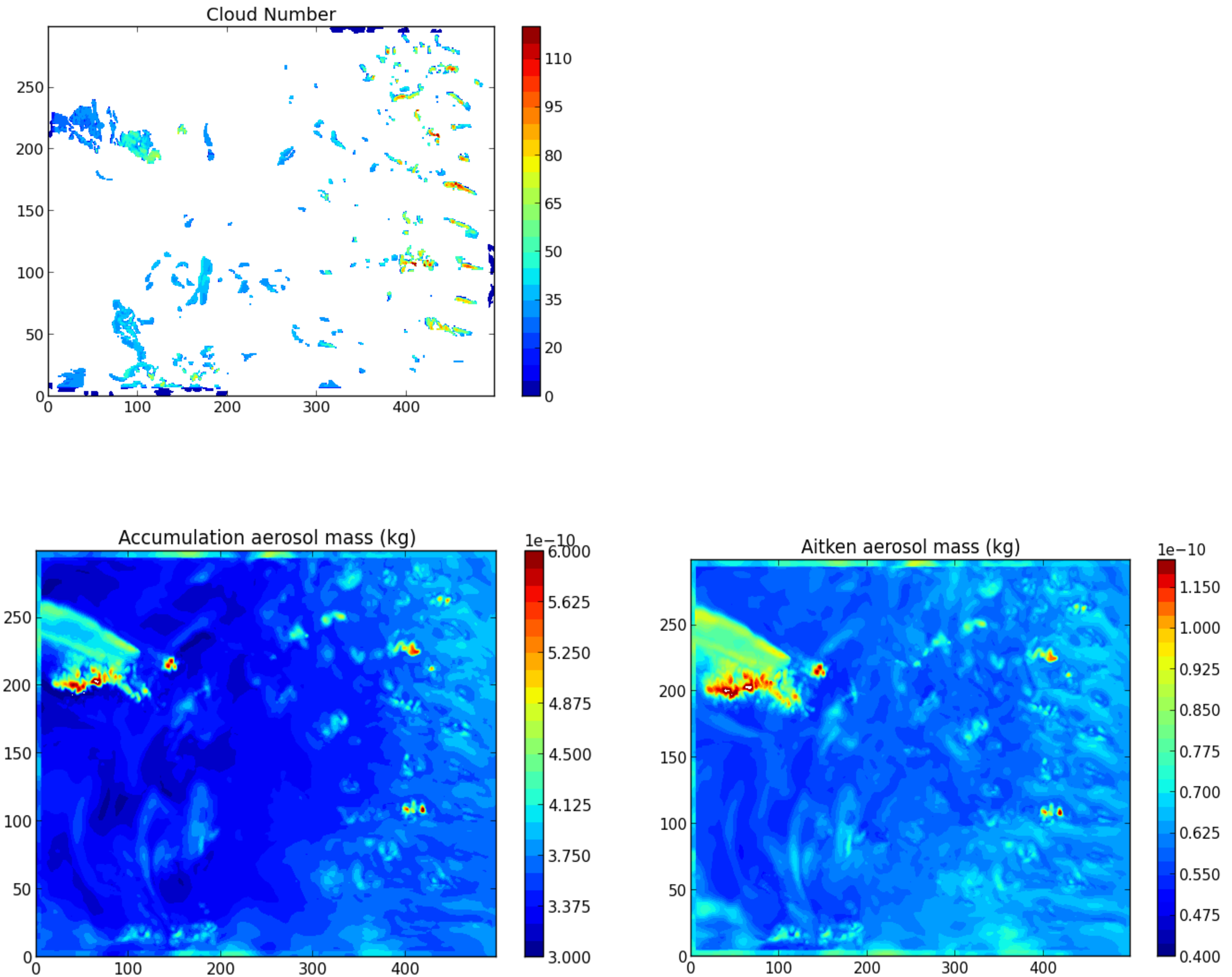


600kmx300
dx=1km

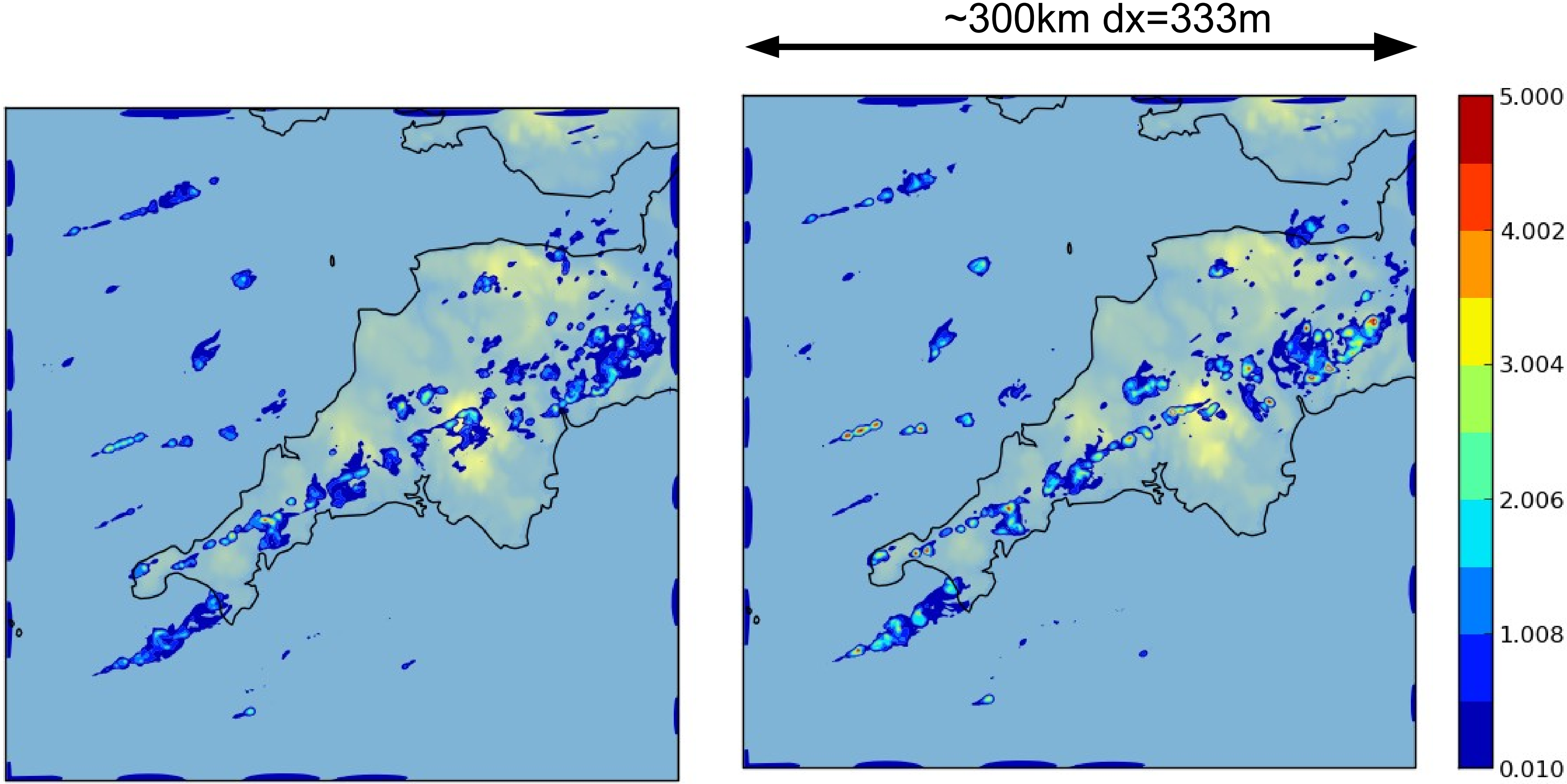





Cloud Number (/cm^3)
0
100
200
300
400
0
50
100
150
200
250
0
20
35
50
65
80
95
110
Aitken aerosol number mixing ratio
1e−18
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
LWC (g/kg)
0.00
0.15
0.25
0.35
0.45
0.55
0.65
0.75
Accumulation aerosol number mixing ratio
1e−18
1.1500
1.1875
1.2250
1.2625
1.3000
1.3375
1.3750
1.4125
1.4500
1.4875


Cloud Number
0
50
100
150
200
250
0
100
200
300
400
0
20
35
50
65
80
95
110
Accumulation aerosol mass (kg)
1e−10
6.000
5.625
5.250
4.875
4.500
4.125
3.750
3.375
3.000
Aitken aerosol mass (kg)
1e−10
1.150
1.000
0.925
0.850
0.775
0.700
0.625
0.550
0.475
0.400

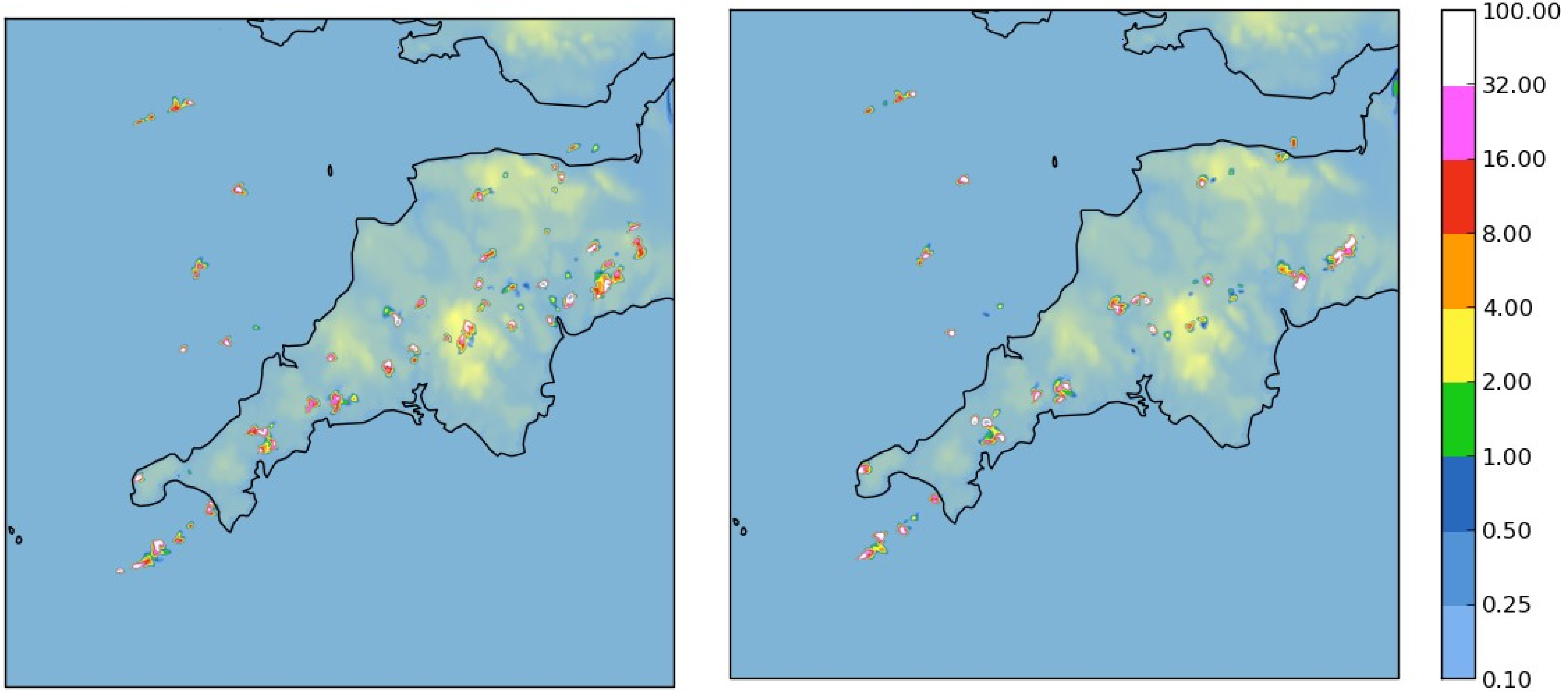
LWP (Cloud) g/m2



Low (100)

High (1000)

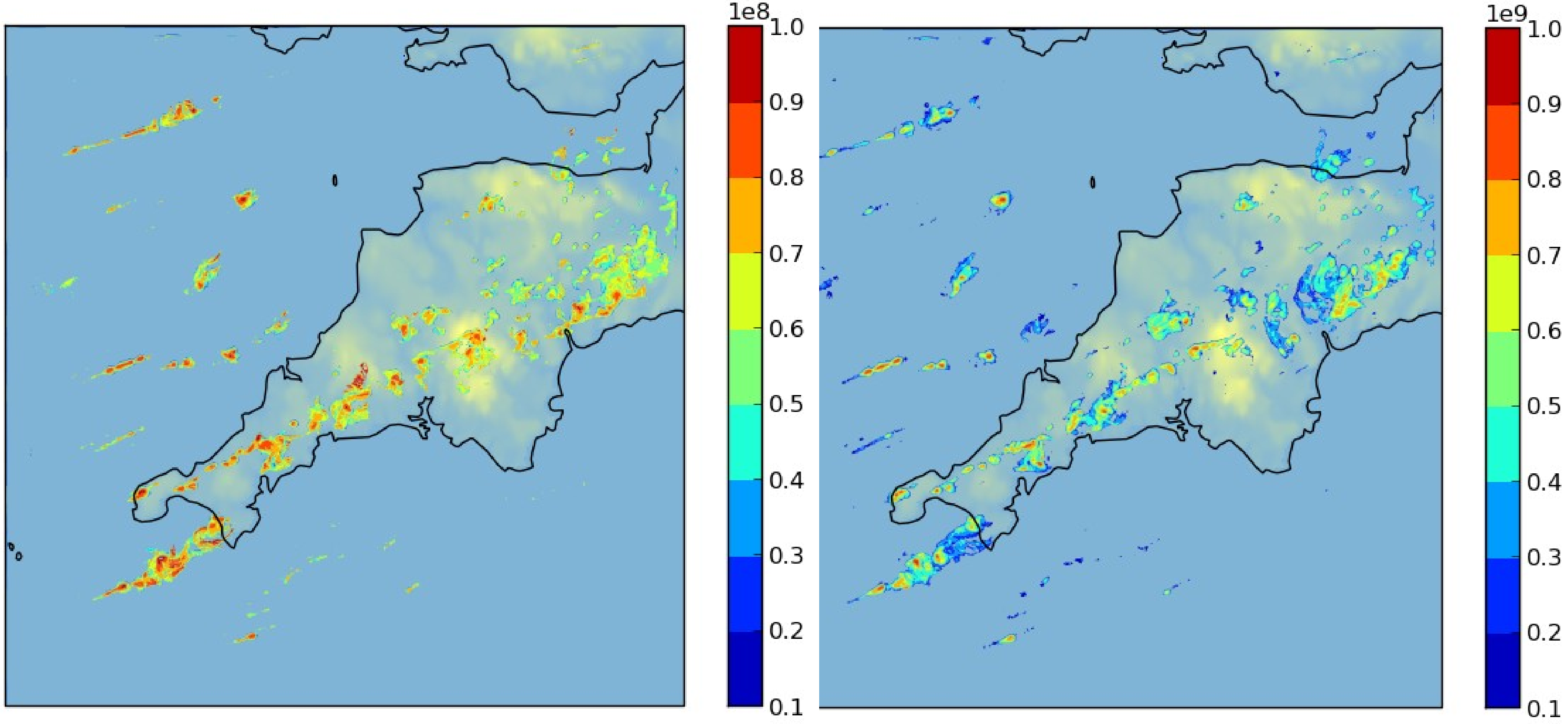
Rainrate mm/h



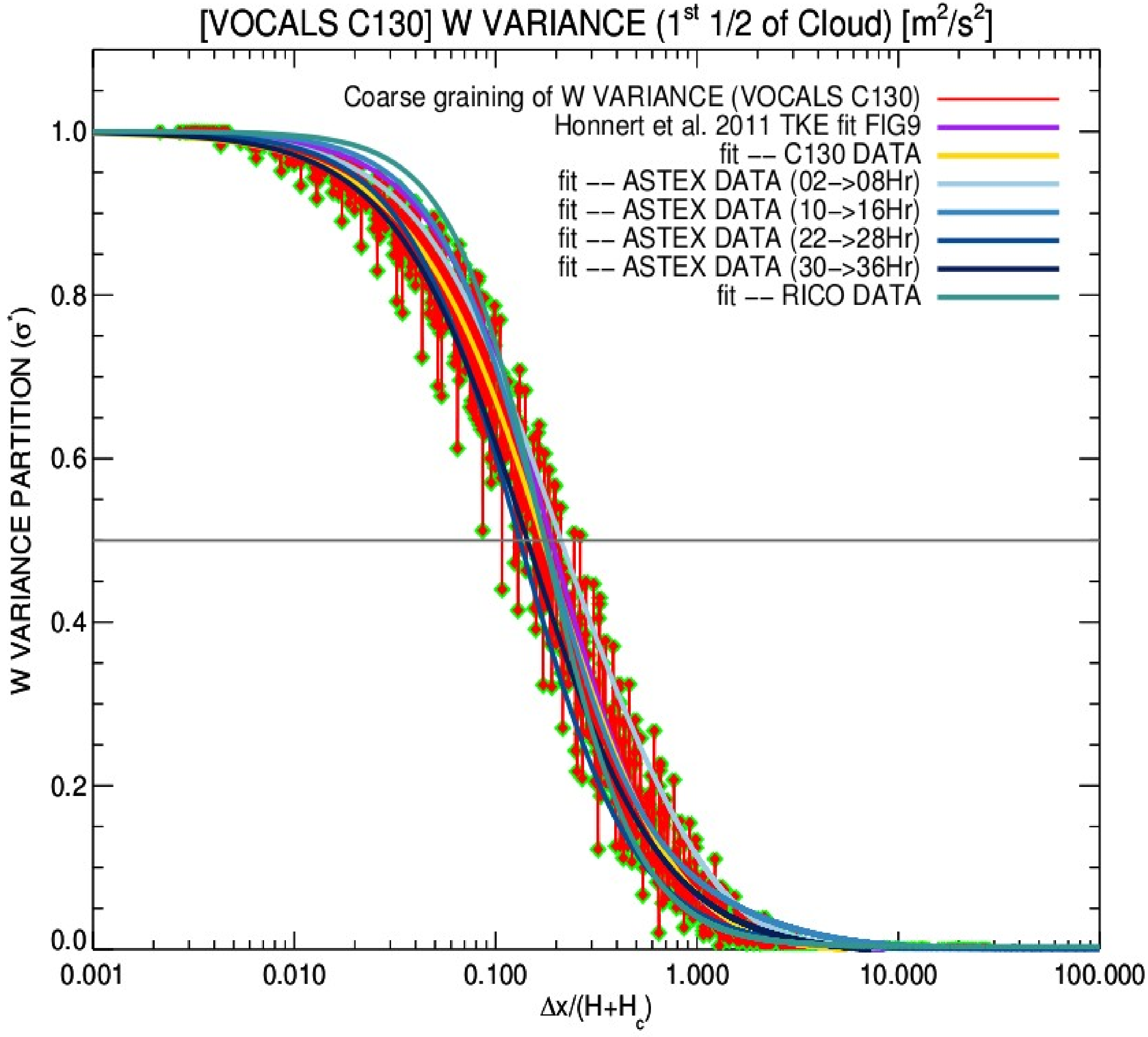
Low (100)

High (1000)

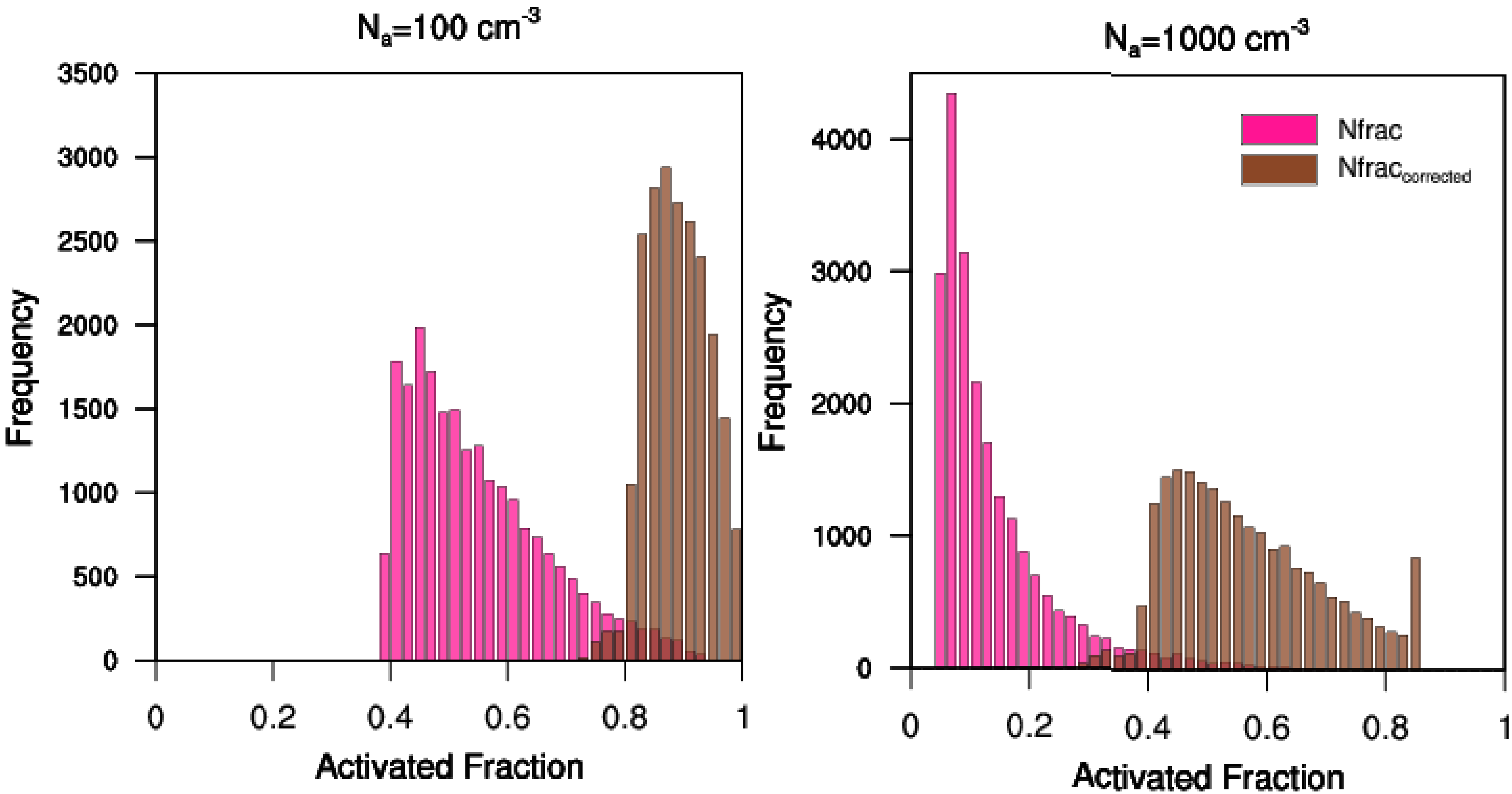
Droplet mixing ratio (1000m) #/kg



Low (100) High (1000)



[VOCALS C130] W VARIANCE (1st 1/2 of Cloud) [m2/s2]
Coarse graining of W VARIANCE (VOCALS C130)
Honnert et al. 2011 TKE fit FIG9
fit -- C130 DATA
fit -- ASTEX DATA (02->08Hr)
fit -- ASTEX DATA (10->16Hr)
fit -- ASTEX DATA (22->28Hr)
fit -- ASTEX DATA (30->36Hr)
fit -- RICO DATA
W VARIANCE PARTITION (σ*)
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.010
0.100
1.000
10.000
100.000
Δx/(H+Hc)



Vocals simulation dx=1km

ICE-T plans

- Use observed aerosol profiles to simulate rf03/04 in first instance.
- Test sensitivity to x10, x0.1 insoluble (dust) profiles
- Same for soluble aerosol profiles
- Switch on/off hallett-mossop
- Include additional IN parametrizations – e.g. ocean surface produced IN.