Entrainment and Mixing in Cumulus Clouds

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Mixing Scenarios

- *Entrainment:* single vs multiple events?
- *Parcel trajectory:* isobaric vs ascending?
- *Entrained CCN:* none vs cloud base spectrum

Explicit Mixing Parcel Model

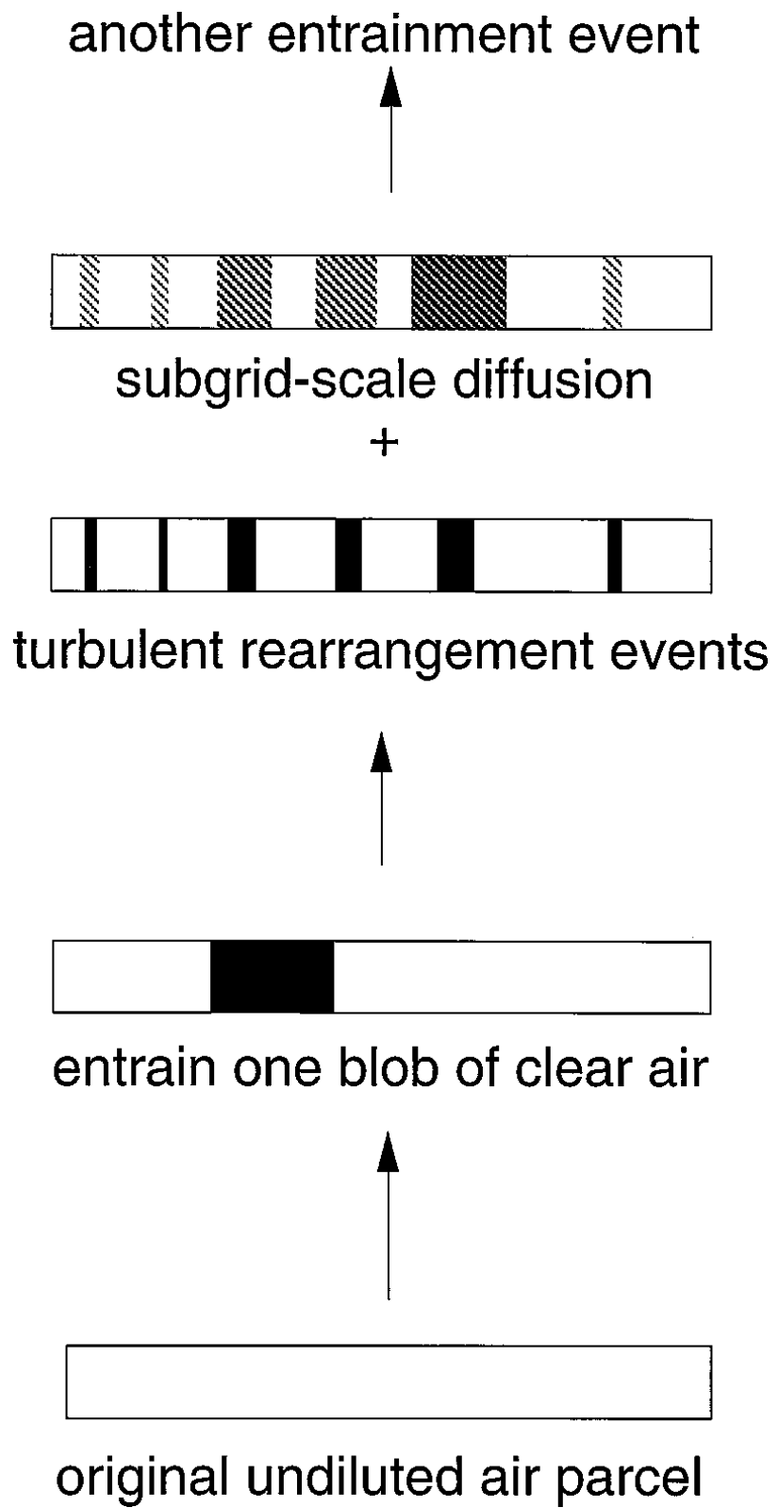


FIG. 3. A parcel is represented by a 1D domain in the EMPM. The parcel's internal structure evolves due to discrete entrainment events and turbulent mixing (rearrangement events and subgrid-scale diffusion).

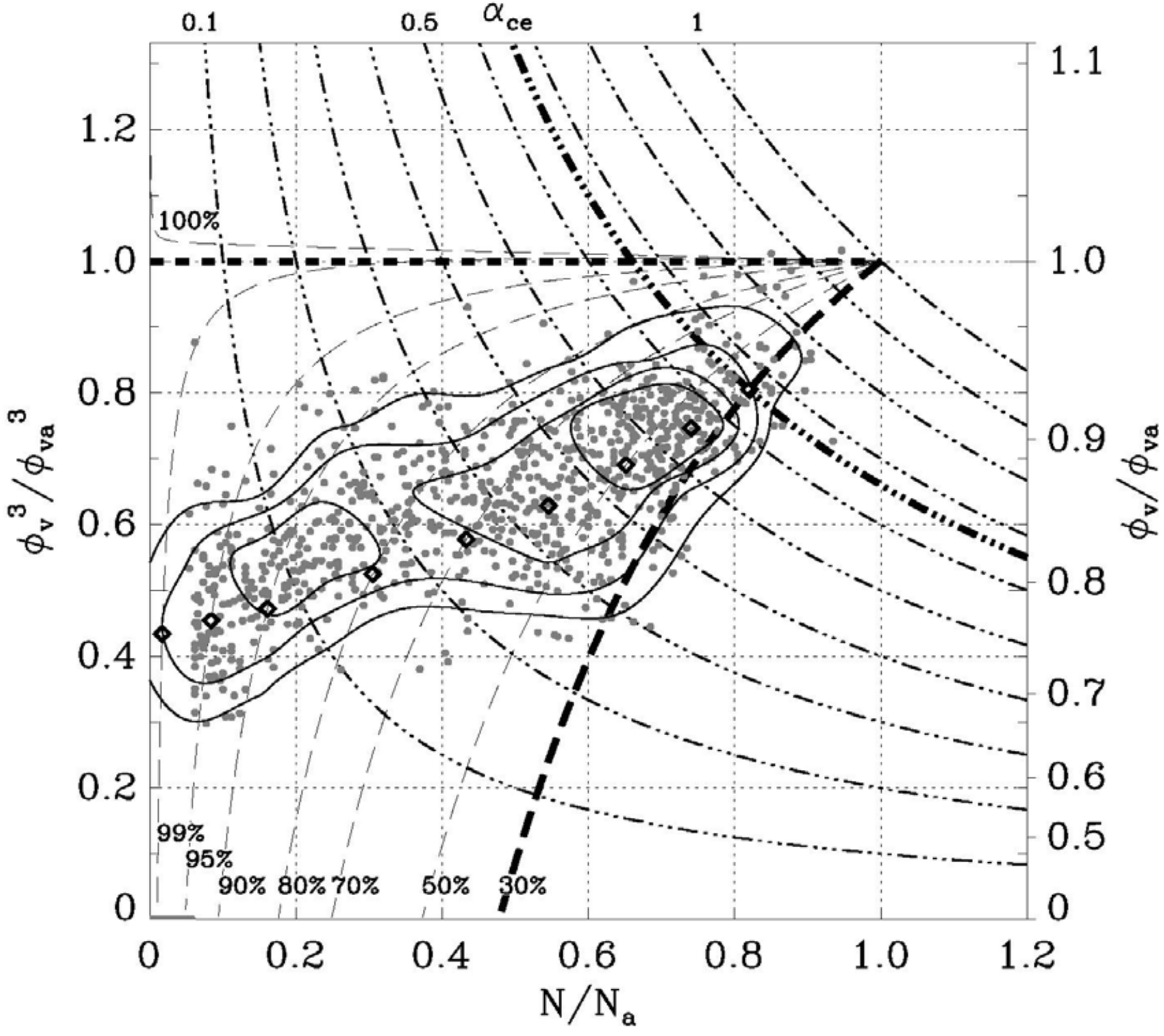
Explicit Mixing Parcel Model (EMPM)

- The EMPM predicts the evolving in-cloud variability due to entrainment and finite-rate turbulent mixing using a 1D representation of a rising cloudy parcel.

- The 1D formulation allows the model to resolve fine-scale variability down to the smallest turbulent scales ($\sim$ 1 mm).

- The EMPM can calculate the growth of 1000 individual cloud droplets based on each droplet s local environment.

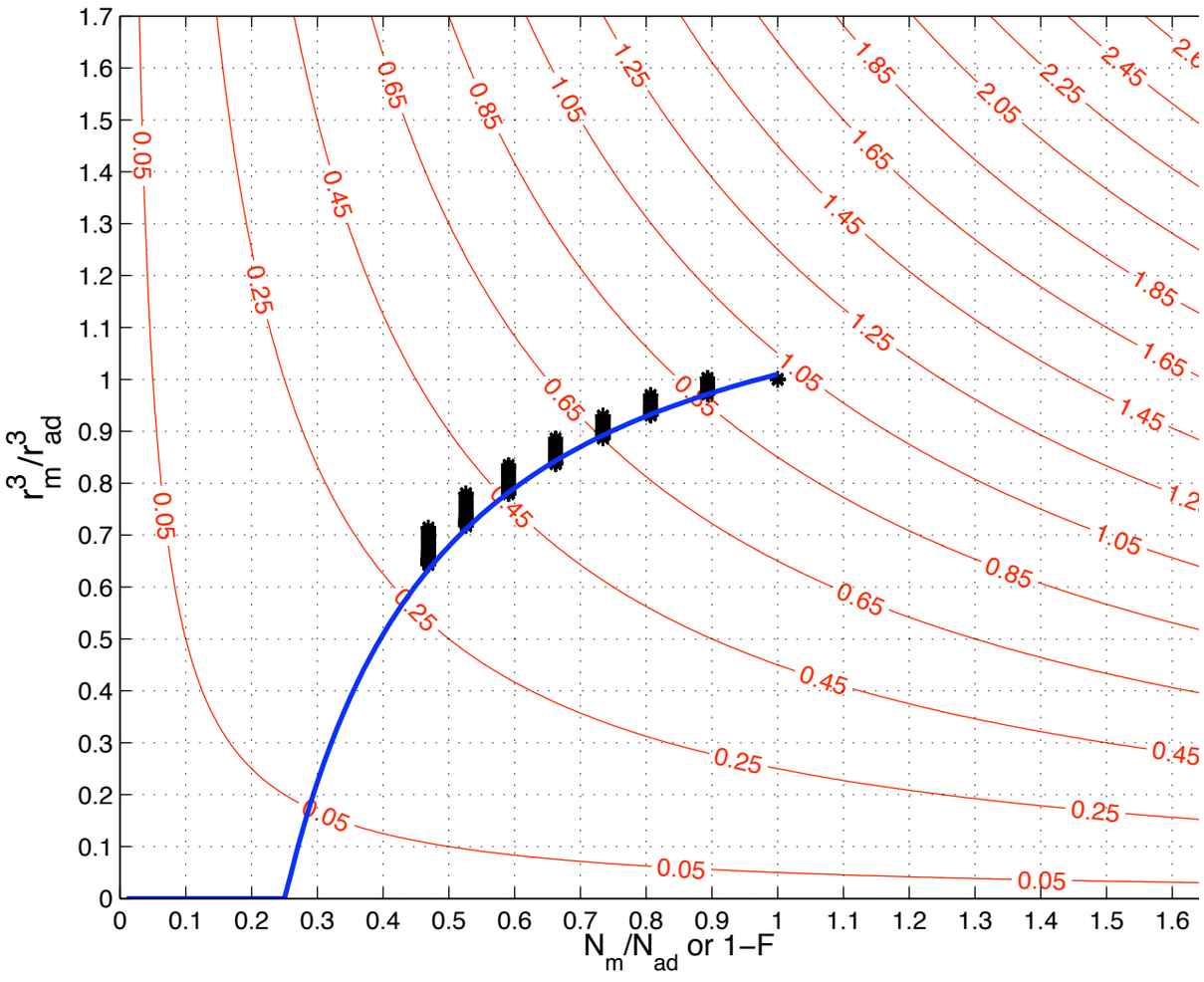
Burnet and Brenguier 2006



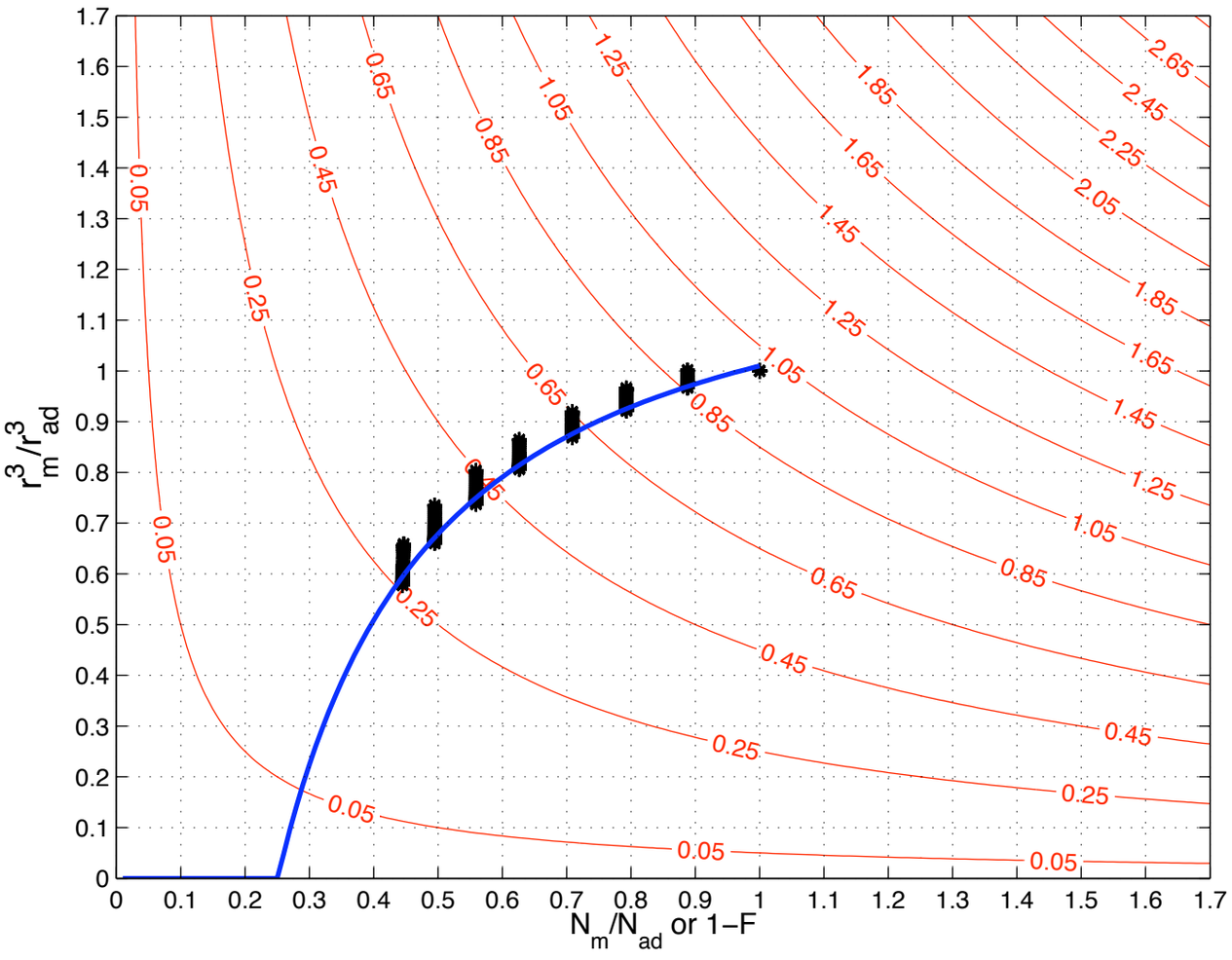
Isobaric: Multiple Entrainment Events

20-m domain

without entrained CCN



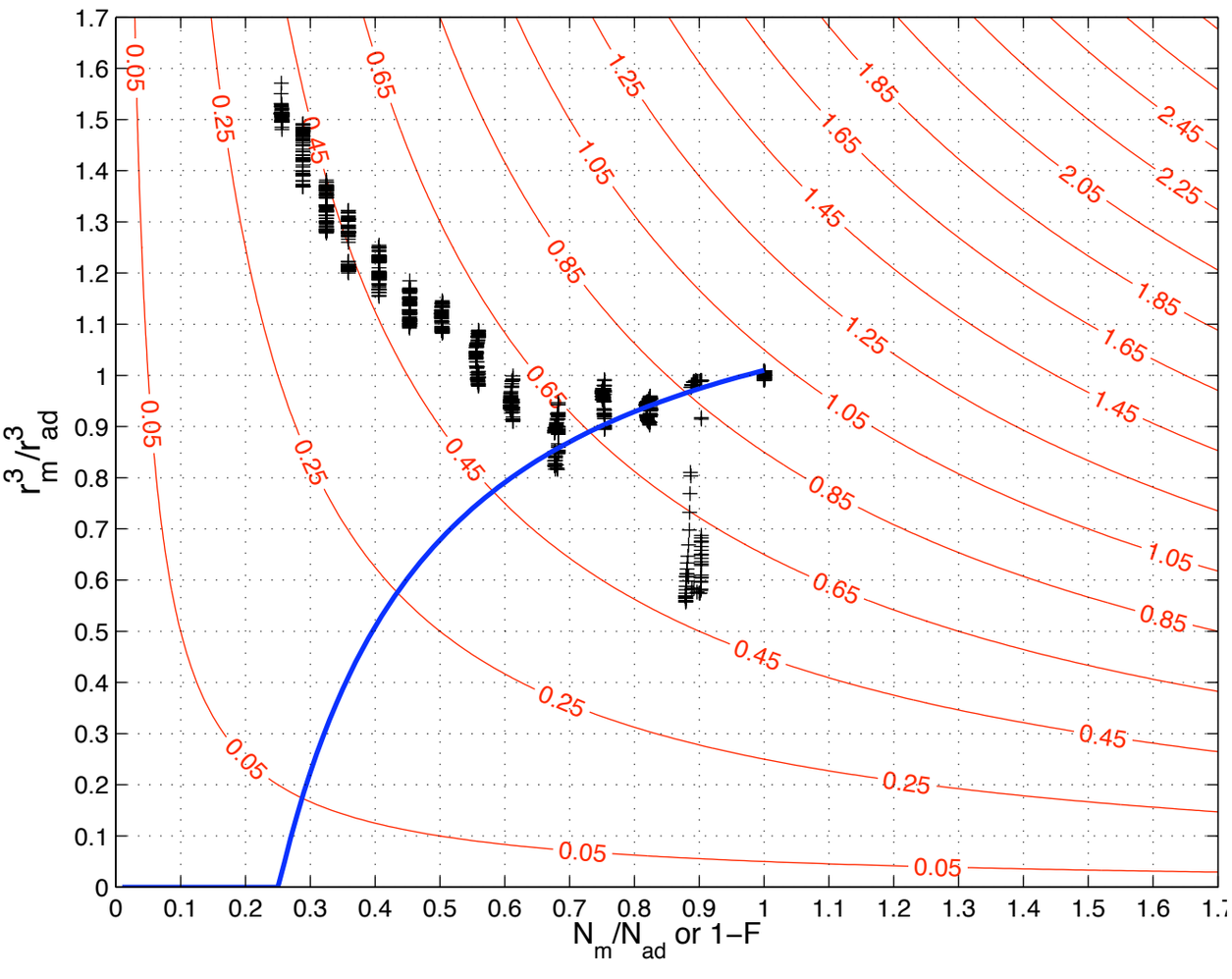
with entrained CCN



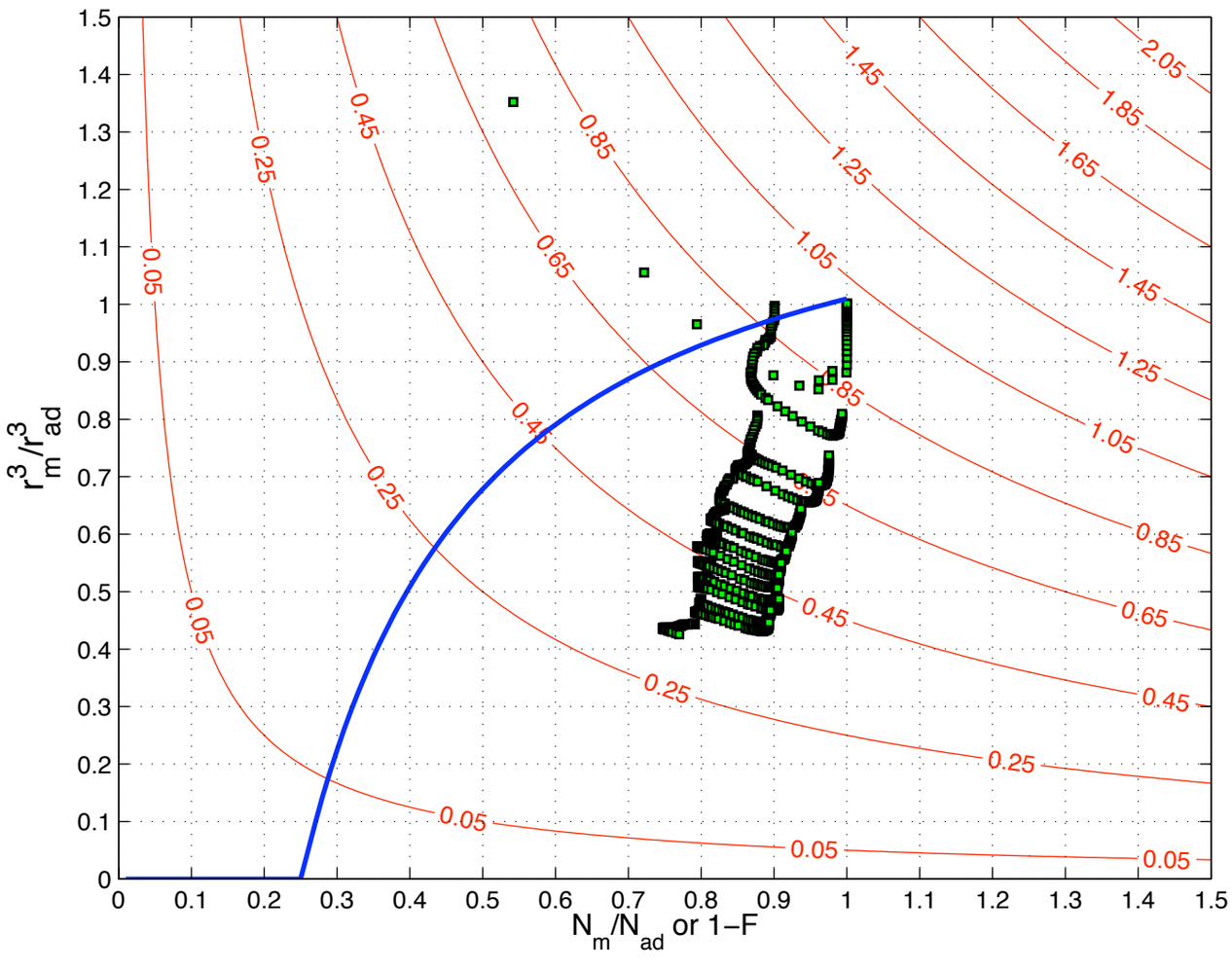
Ascending: Multiple Entrainment Events

20-m domain

without entrained CCN



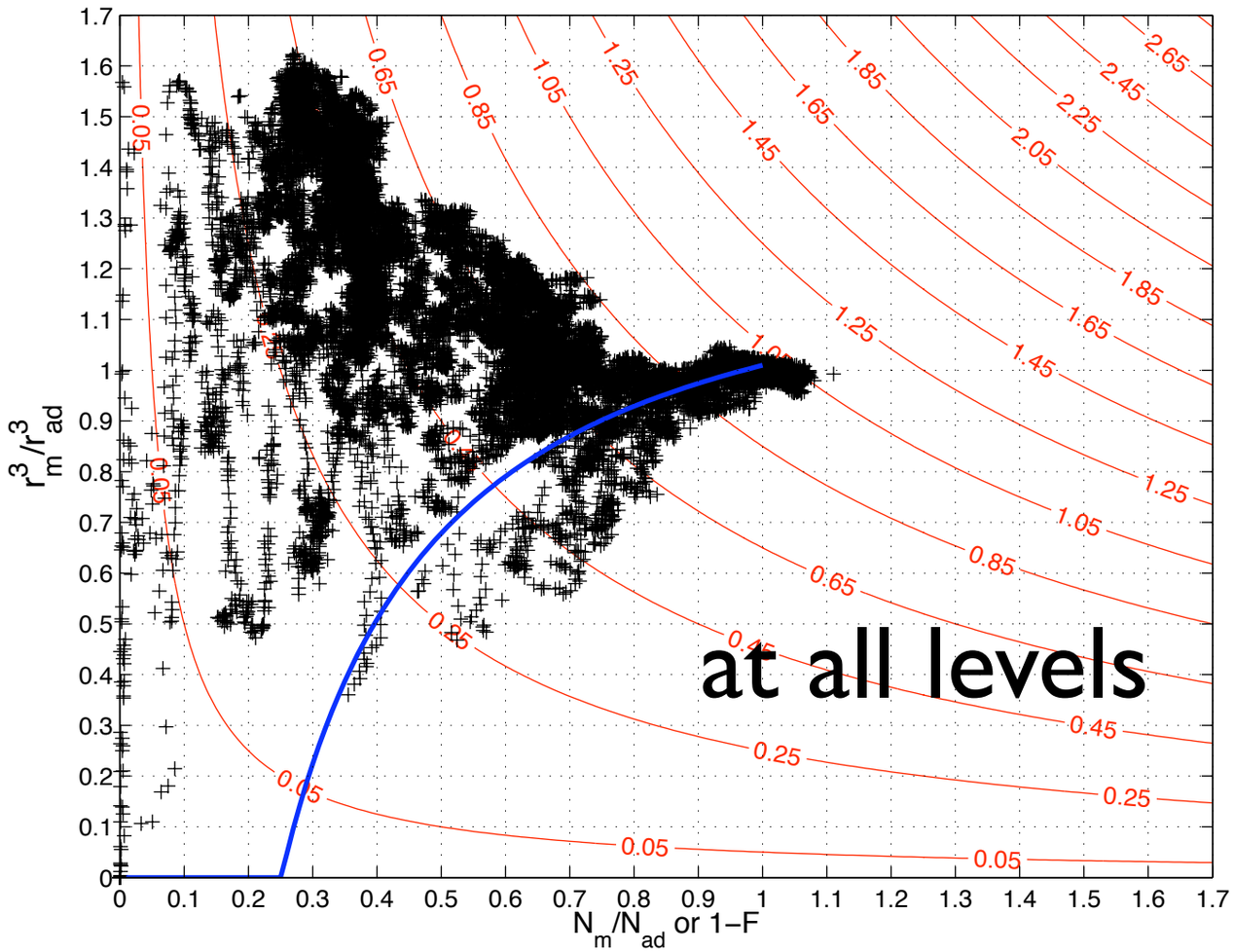
with entrained CCN

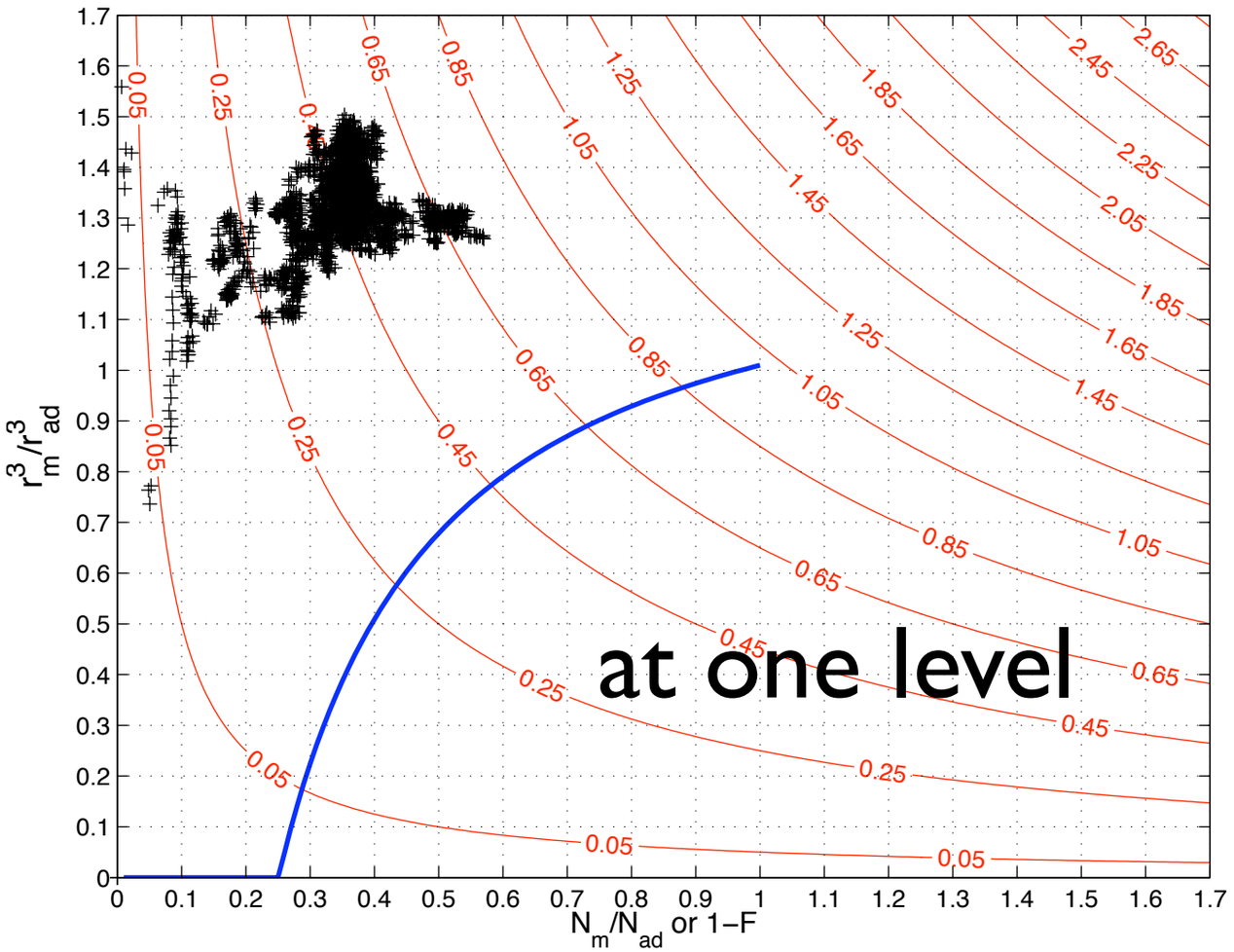


Ascending: Multiple Entrainment Events

200-m domain, 10-m averages

without entrained CCN





Ascending: Multiple Entrainment Events

200-m domain, 10-m averages

with entrained CCN

(in progress)

EMPM assumptions

- No buoyancy sorting (detrainment of negatively buoyant parcels)
- Idealized updraft structure
- Entrained blob size

Isobaric mixing: spectra for various entrained air fractions (single event) (20-m domain)

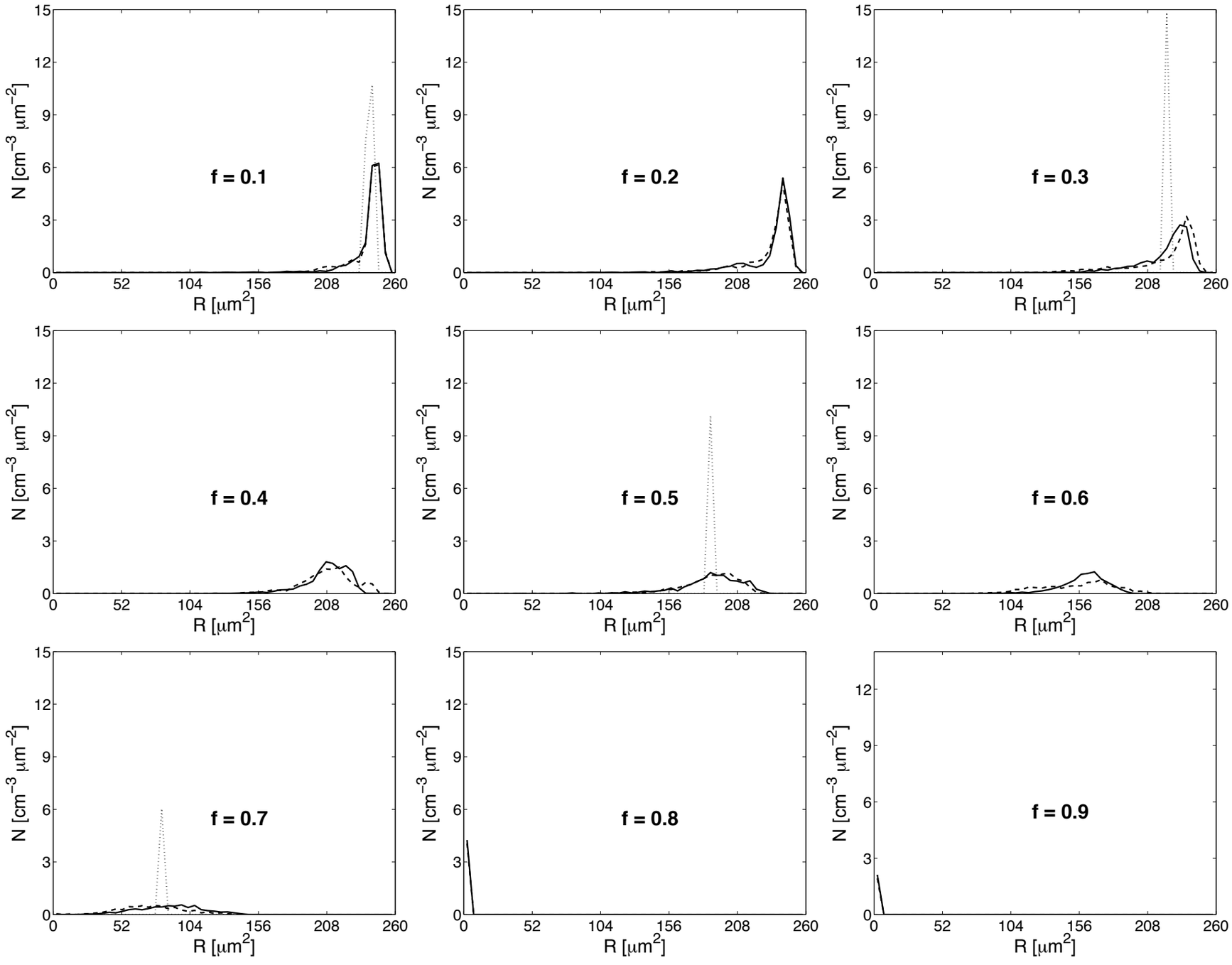


Figure 4.18: Radius squared of the control case with a radius binsize of 5 μm^2 and a domain size of 20 m for different entrained dry air fractions and two random number seeds (solid and dashed line).

Isobaric mixing: spectra for various entrained air fractions (single event vs multiple events)

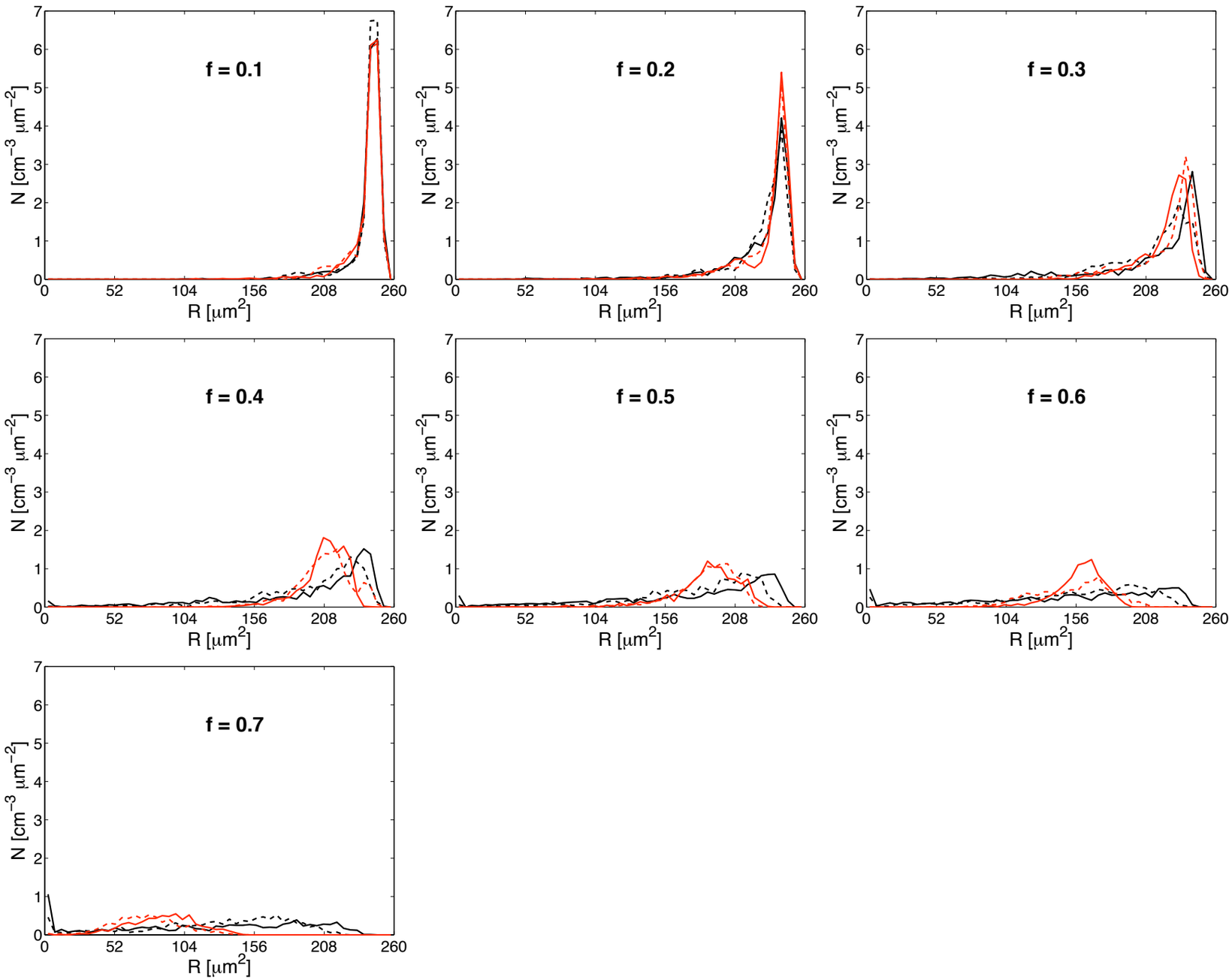


Figure 4.19: Comparisson of the radius squared of the control case (red color) with that of multiple entrainment events (black color) for isobaric mixing for the same "total" entrained air fraction with a binsize of 5 μm^2 and a domain size of 20 m. The runs were conducted with two random number seeds (solid and dashed line).