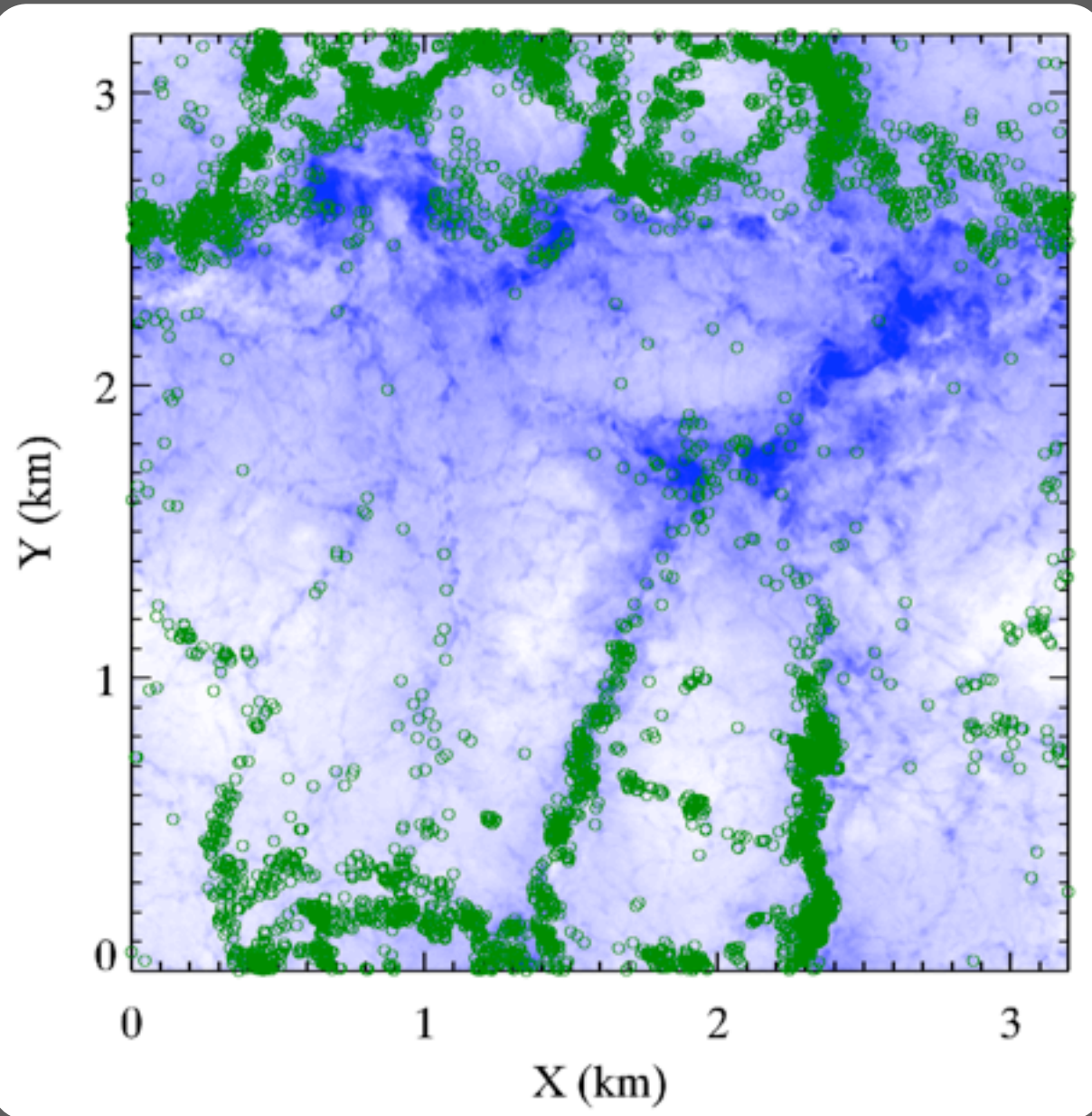


Relationship between stratocumulus cloud hole size and entrainment

Takanobu Yamaguchi^{1,2} and Graham Feingold²

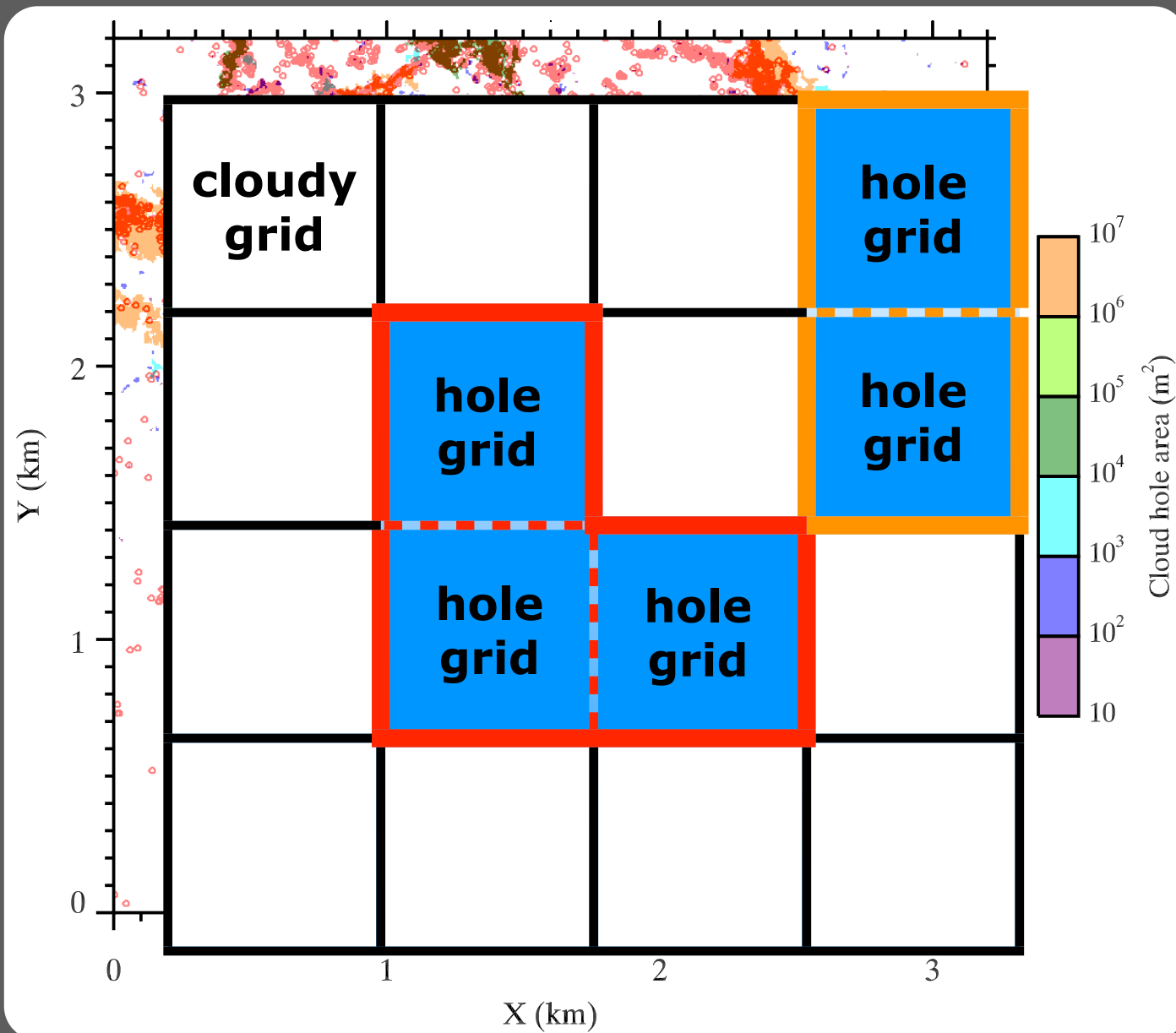
Cooperative Institute for Research in Environmental Sciences, University of Colorado
NOAA Earth System Research Laboratory, Boulder CO

Entrainment occurs in cloud holes



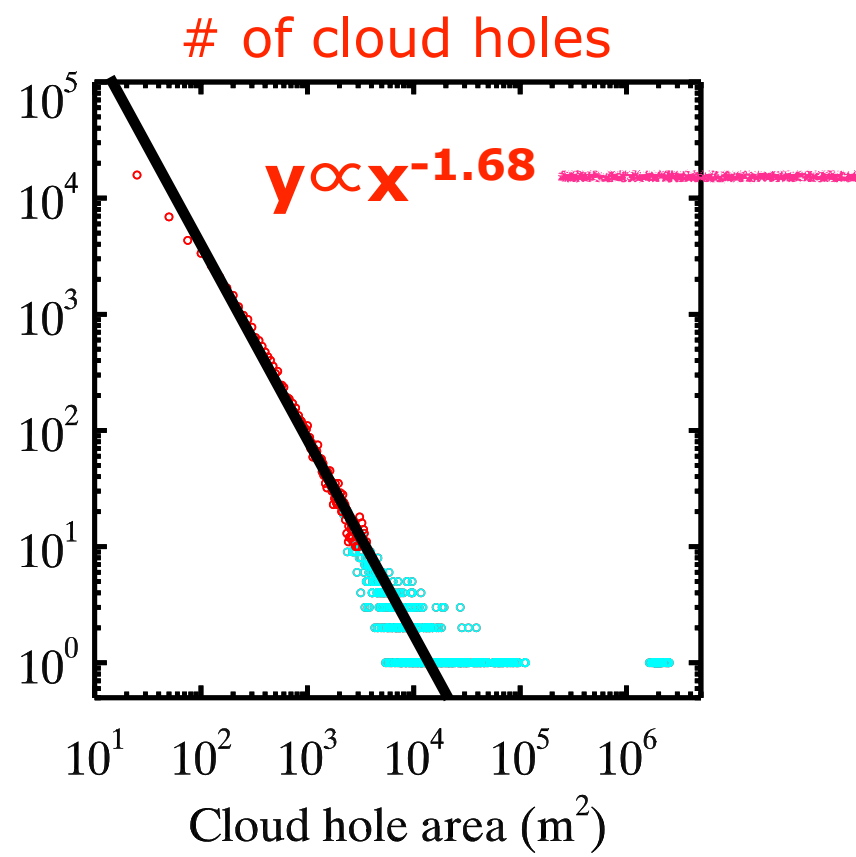
- Cloud holes are relatively dry downdraft regions.
- High resolution LES ($\Delta x=5$ m, $\Delta z=2.5$ m) with a small domain (3.2 km)
- Lagrangian parcel tracking model
- Yamaguchi and Randall (2012, YR12)

Mapping cloud holes



1. Locate the top and bottom heights of the horizontal mean entrainment interface layer (EIL) with method described in YR12.
2. For each column, compute EIL liquid water path (LWP).
3. A grid is classified as a part of cloud hole if $EIL\ LWP < MEAN - STDDEV$.
4. Cloud hole is identified with a 4-neighbor searching method.
 - Cloud hole perimeter is also measured.
 - Data: 61 snapshots every 1 minute apart
 - Entrained parcels located in cloud holes are used for analysis.

Power law?

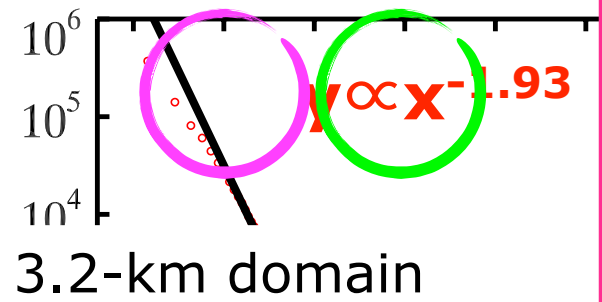


Large domain LES

- Does the cloud hole size distribution hold for larger cloud holes?
- Are the entrainment power laws robust?

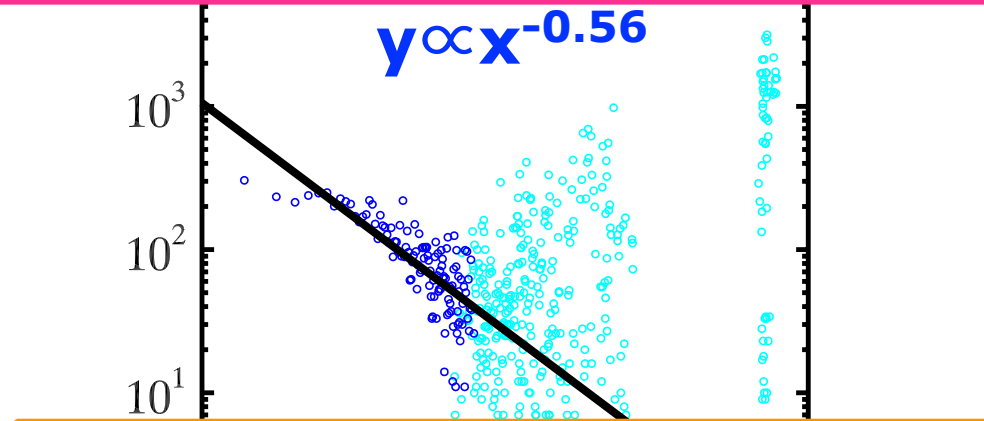
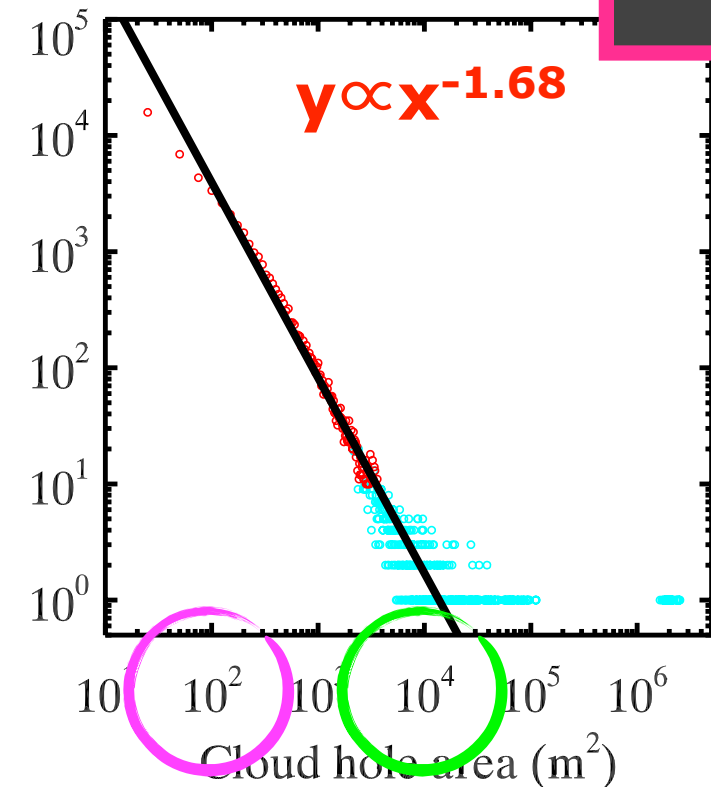
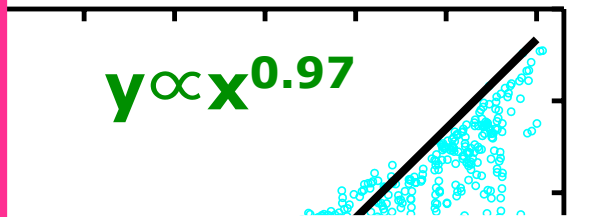
Power law

of cloud holes

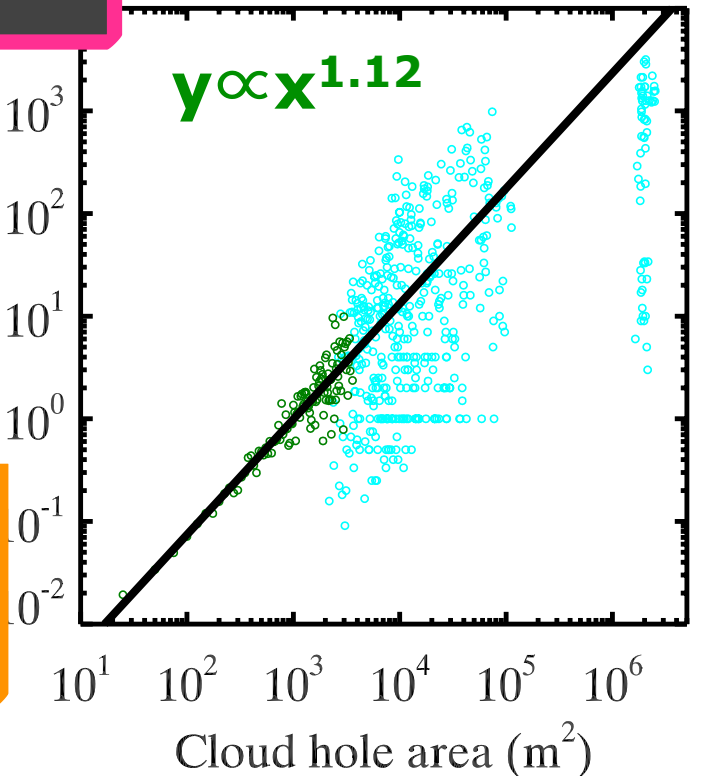


fine grid spacing
 → better fit of the slopes to smaller holes
 +
 larger domain
 → better fit of the slopes to larger holes
 ↓
The slopes (about -1.8, 1.0, -0.8) are expected to fit all hole sizes.

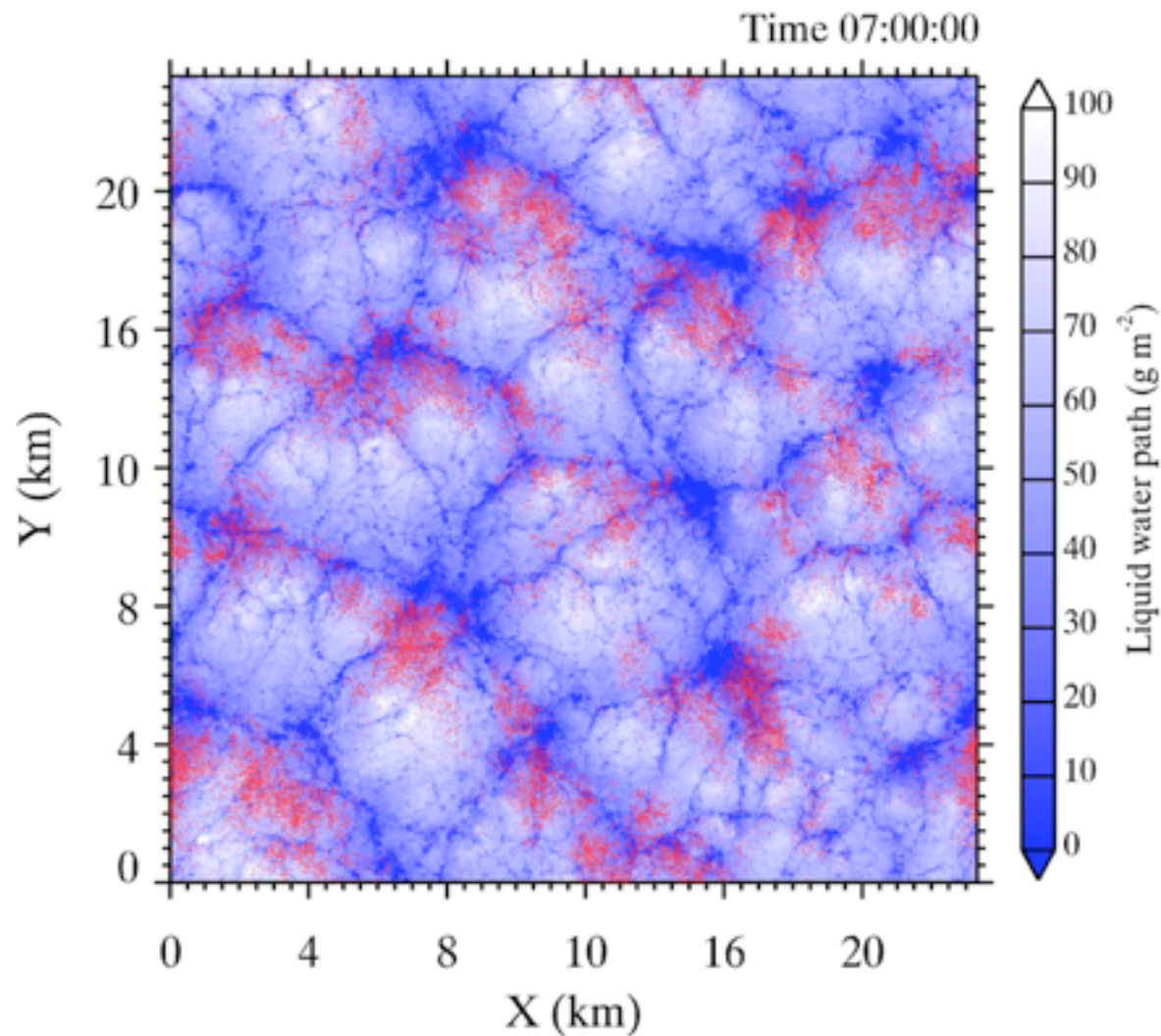
○=○/○
 of entrained parcels
 per cloud hole



Number of entrained parcels found
 in cloud hole may be too small:
 88,584 vs. 1,924,248



Summary



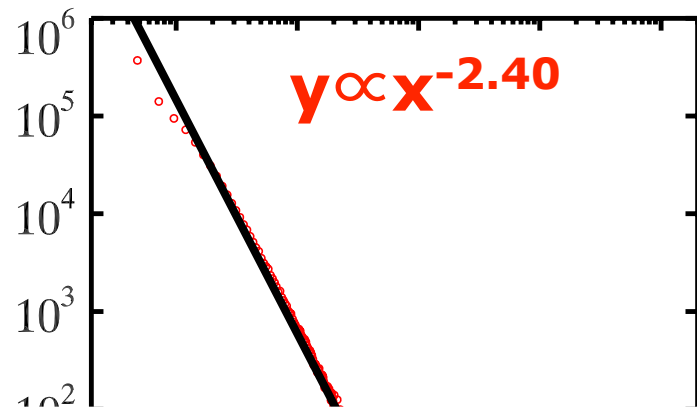
Horizontal position tracking for
the parcel entrained at 7:40

- Cloud *hole* sizes follow a negative power-law much like trade cumulus cloud sizes.
- Small cloud holes are very numerous while large cloud holes are very small in number. ($y \propto x^{-1.8}$)
- Larger cloud holes entrain more efficiently than smaller cloud holes. ($y \propto x^{1.0}$)
- ➔ On balance, **entrainment occurs preferentially in smaller cloud holes.** ($y \propto x^{-0.8}$)
- The same conclusion is also obtained with cloud hole perimeter.

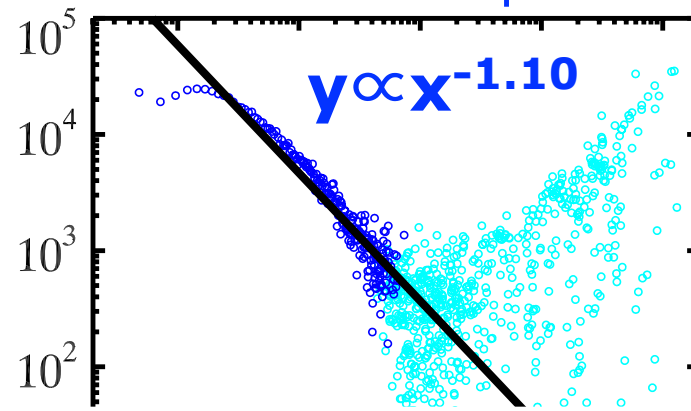
Perimeter?

○=○/○

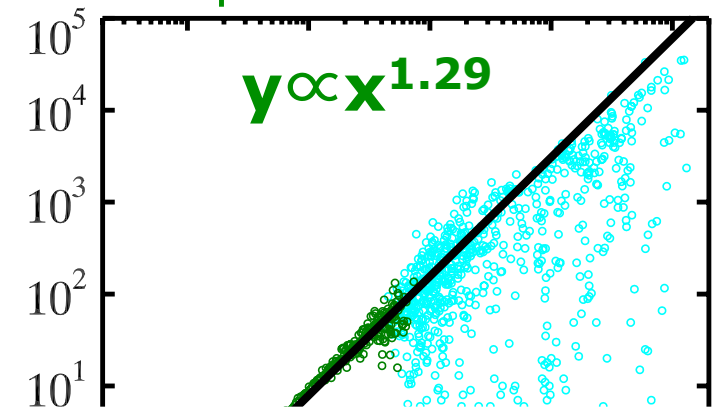
of cloud holes



of entrained parcels



of entrained parcels per cloud hole



Area

