Relating entrainment and precipitation by tracking water molecules in an LES

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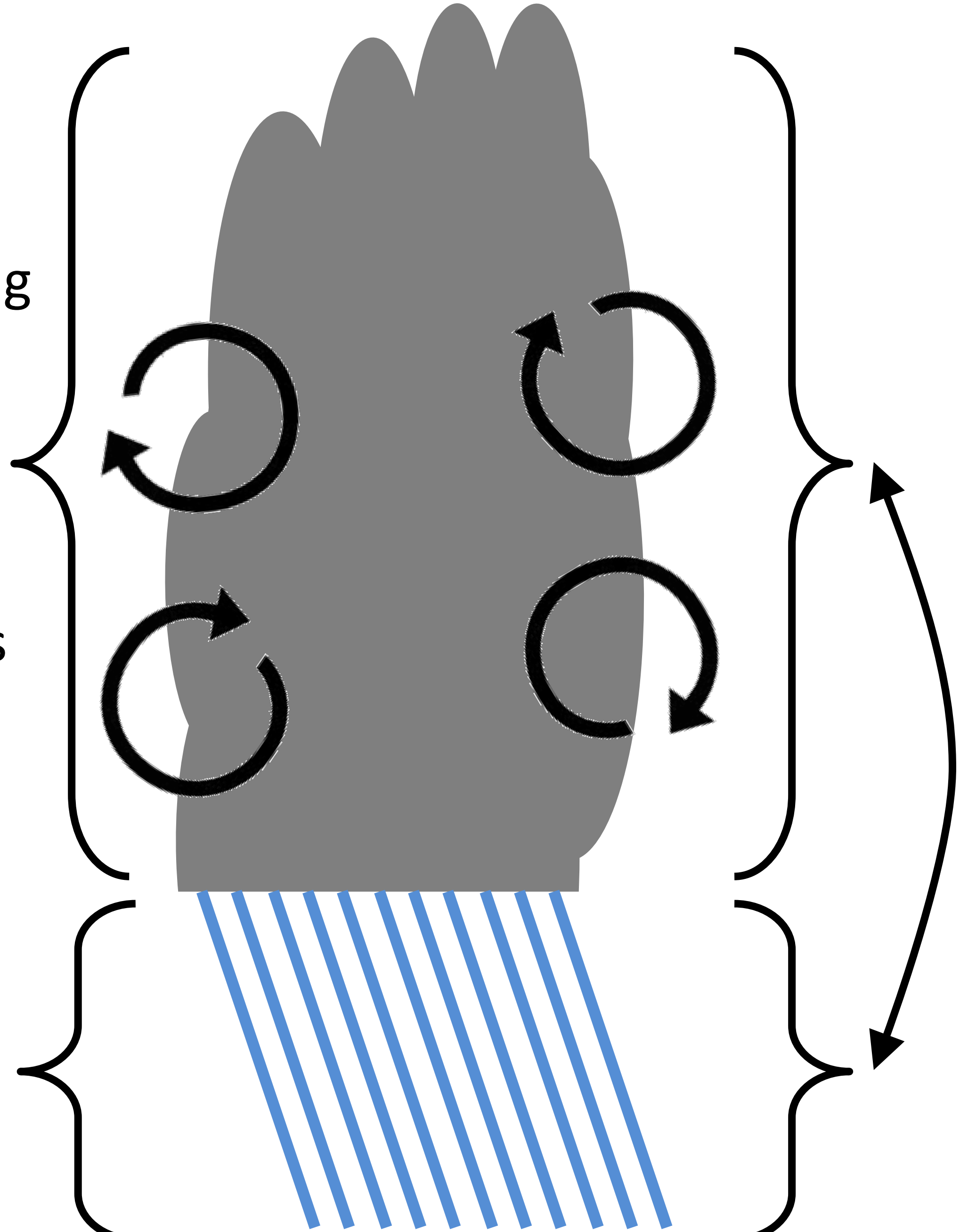
AEFG is working on ways to **observe entrainment** from ARM measurements

At the ARM sites, we also **observe precipitation** rates



Relate the two **(observed entrainment and observed precipitation)** **using LES**

What processes control a cloud’s precipitation efficiency?

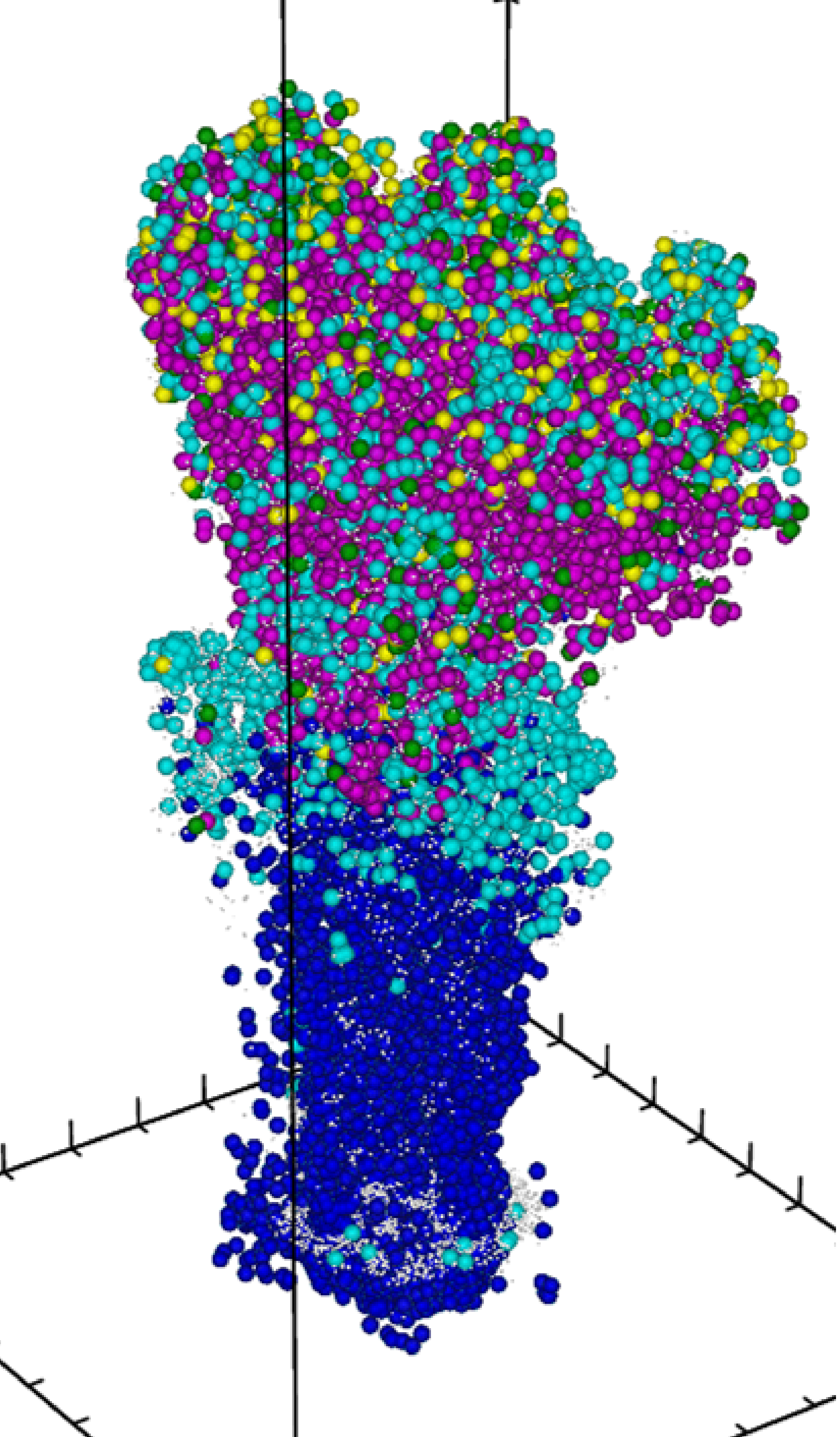
Candidate processes:

- entrainment
- autoconversion
- evap of cloud
- evap of precip in FT
- evap of precip in BL
- interactions among the above

To get some answers, we are using large-eddy simulations with water-tracking particles to map out the physical and microphysical pathways of water.

(Langhans, Yeo, and Romps, in prep)


Kyongmin Yeo
Wolfgang Langhans

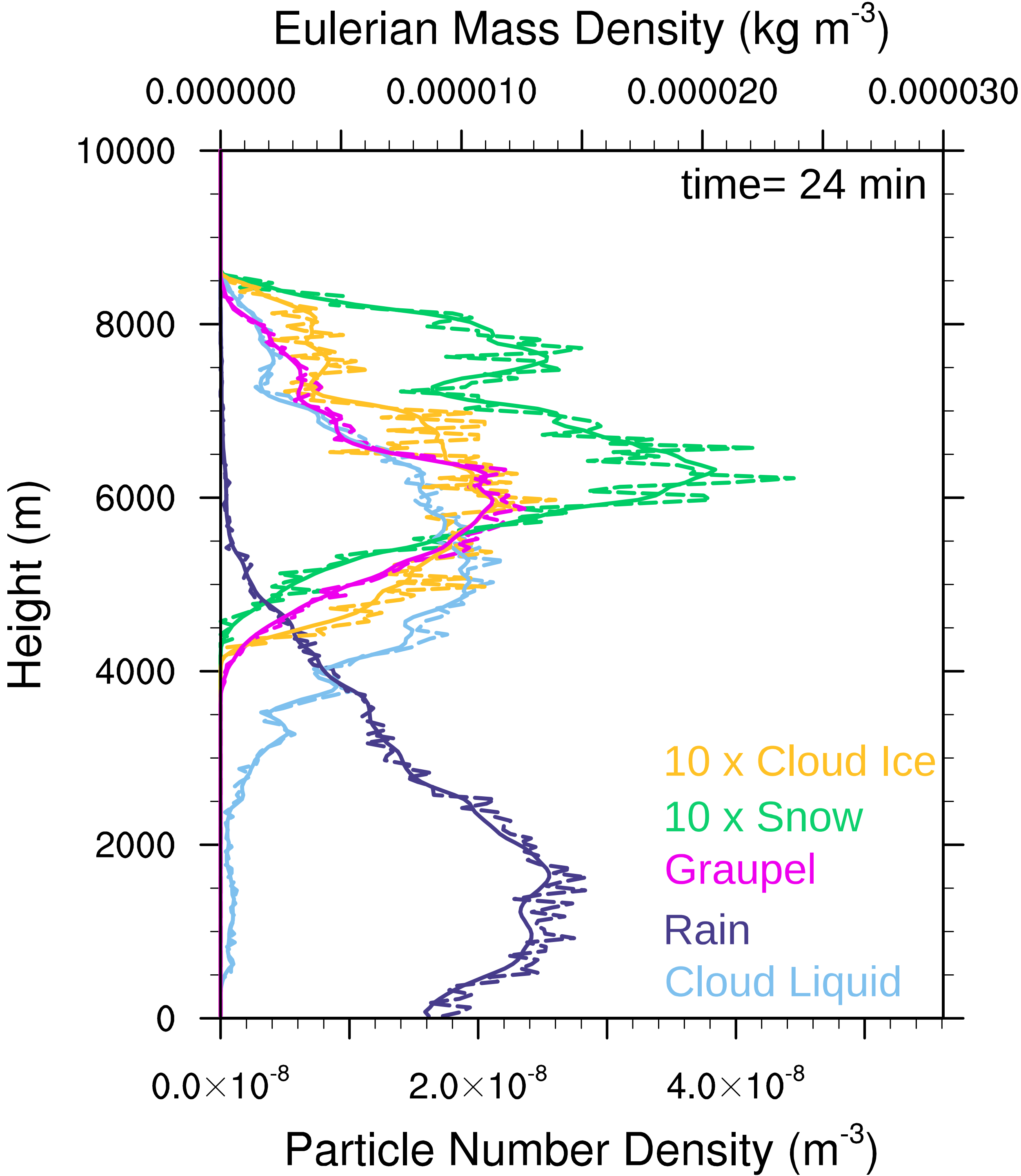


Using Lagrangian particles in LES to **track individual water molecules**.

Each Lagrangian molecule can be in only one of 6 water classes at a time: vapor, cloud liquid, cloud ice, rain, snow, or graupel.

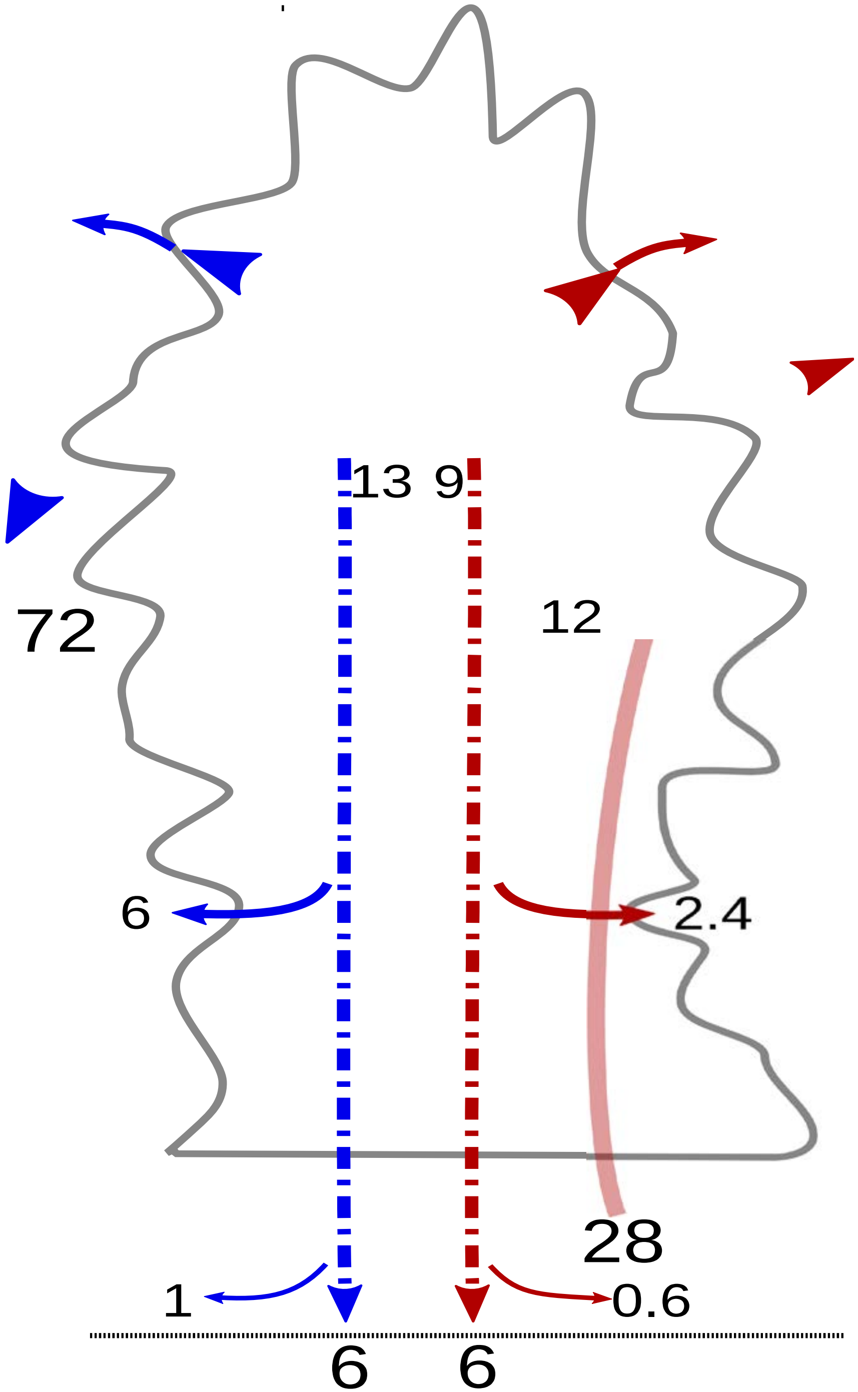
Molecules move between water classes stochastically with probabilities that mirror the microphysical transition rates.

This allows us to track water through both **physical and microphysical** space.



Eulerian (solid) and Lagrangian (dashed) water profiles for a snapshot of a single cloud.

Without any nudging, the concentrations of **Lagrangian particles accurately replicate the Eulerian fields**.

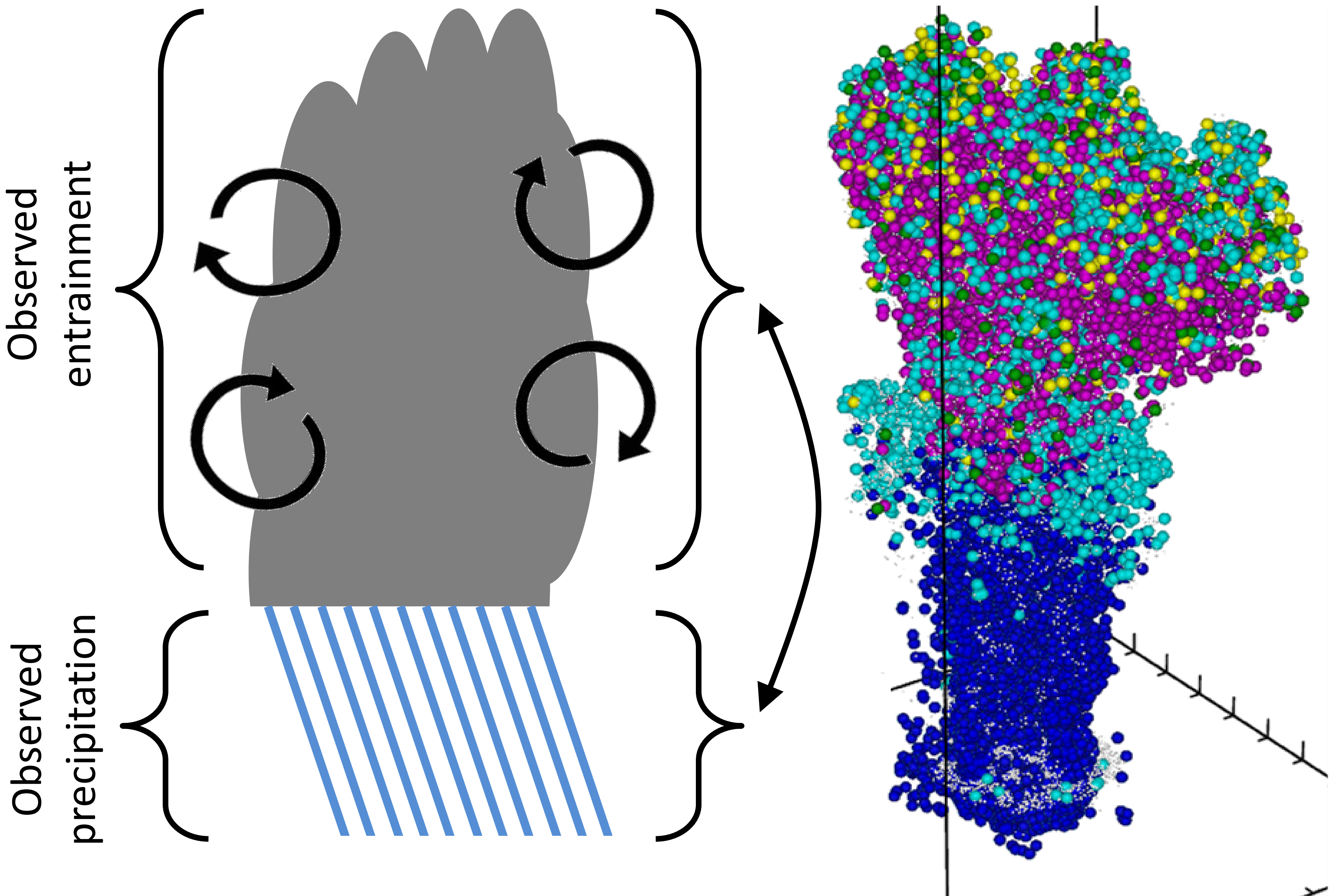


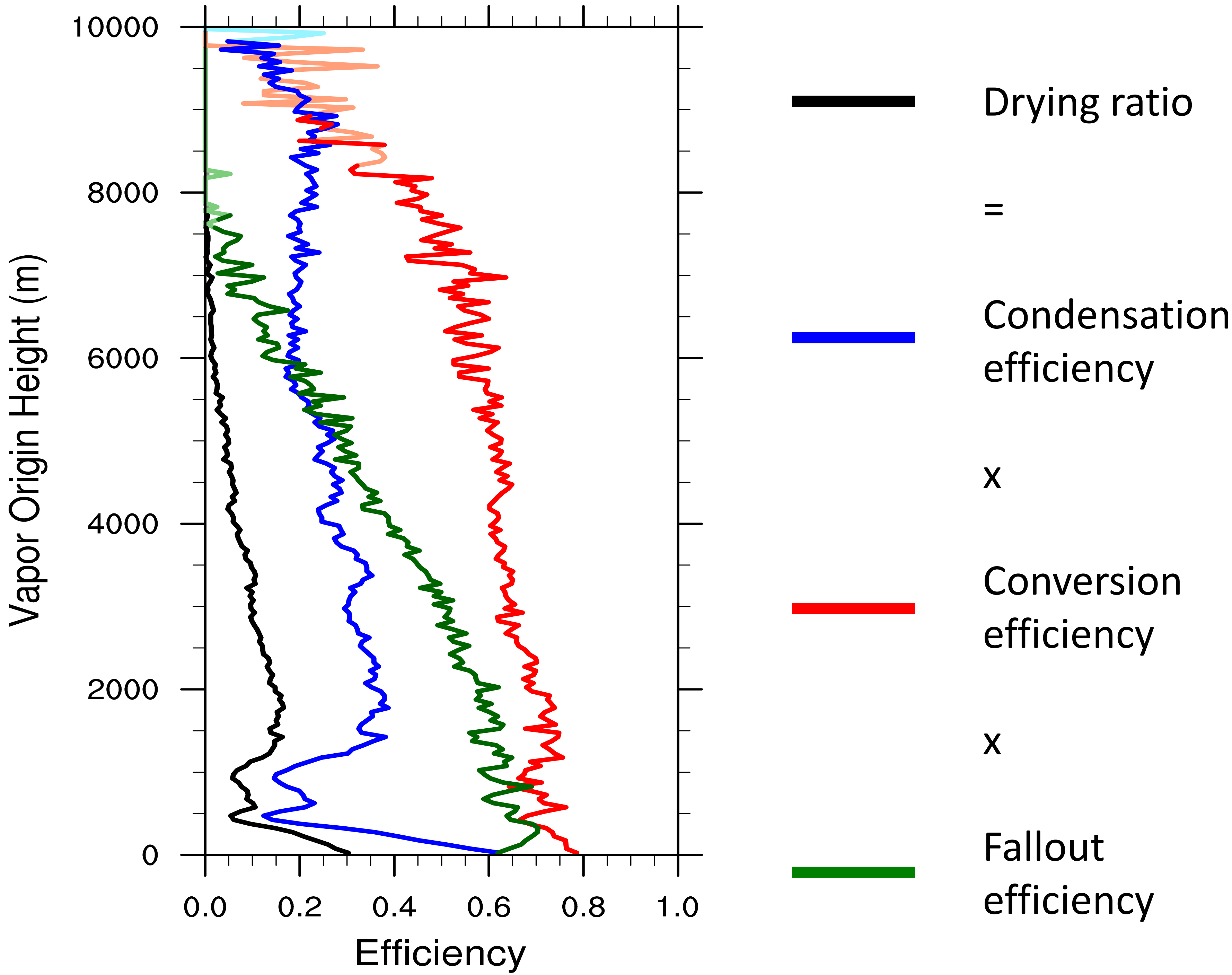
Water budget of a Cb, broken down into vapor that enters the cloud **through cloud base (red)** and **through entrainment (blue)**.

100 units of water mass, 28 enter through cloud base and 72 enter through entrainment.

6 of each reach the surface as precipitation.

Summary




Vapor Origin Height (m)
10000
8000
6000
4000
2000
0
0.0
0.2
0.4
0.6
0.8
1.0
Efficiency
Drying ratio
=
Condensation efficiency
x
Conversion efficiency
x
Fallout efficiency