How giant sea salt aerosols affect precipitation in marine stratocumuli: a parameterization based on LES

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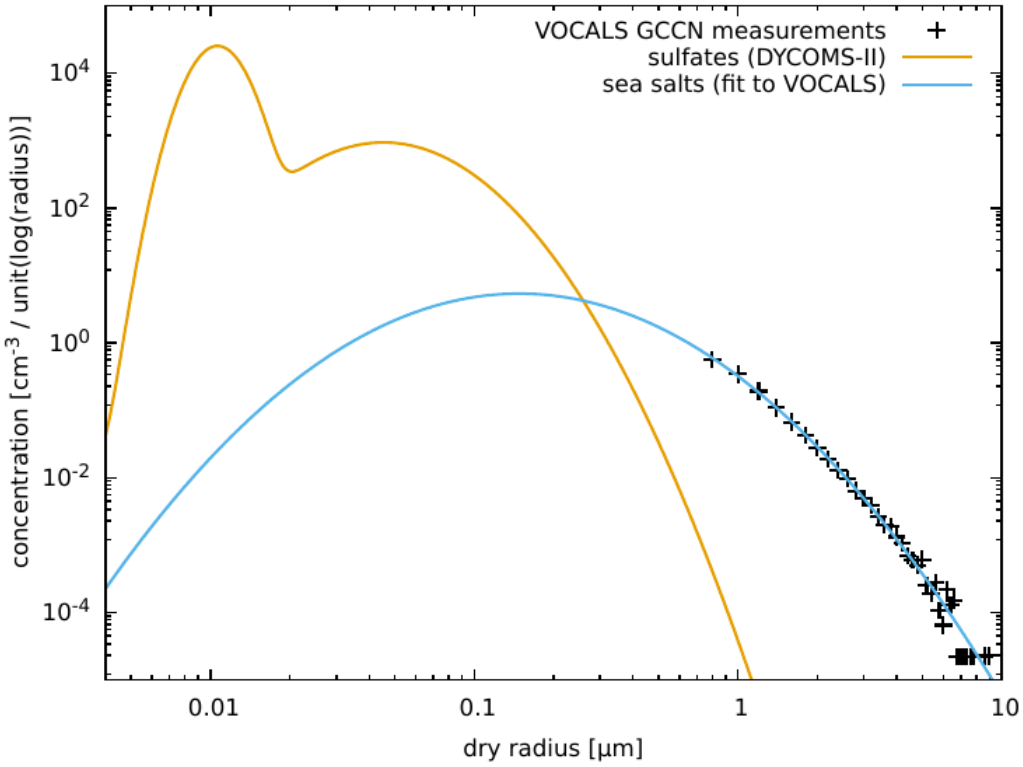
Giant cloud condensation nuclei (GCCN) in LES

- Aerosols with large dry radii, typically r_d > 1μm
- Droplets formed on GCCN can grow to r > 20μm through condensation, hence they can initiate collision-coalescence
- Over oceans, sea salt GCCN are released from breaking waves.
- Sea salt GCCN conc. depends on wind speed,
  e.g 0.2/cc for 5 m/s and
  2/cc for 20 m/s
  (O`Dowd et al. 1997)

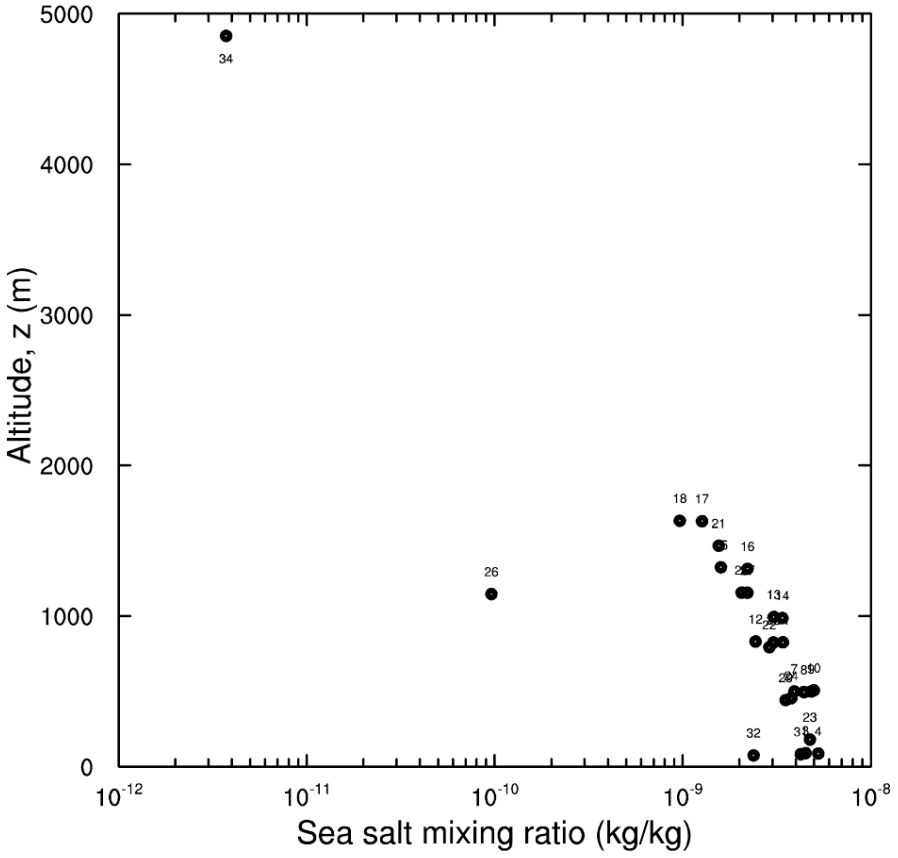
- LES using UWLCM model
- Super-droplet microphysics

CCN spectrum in LES

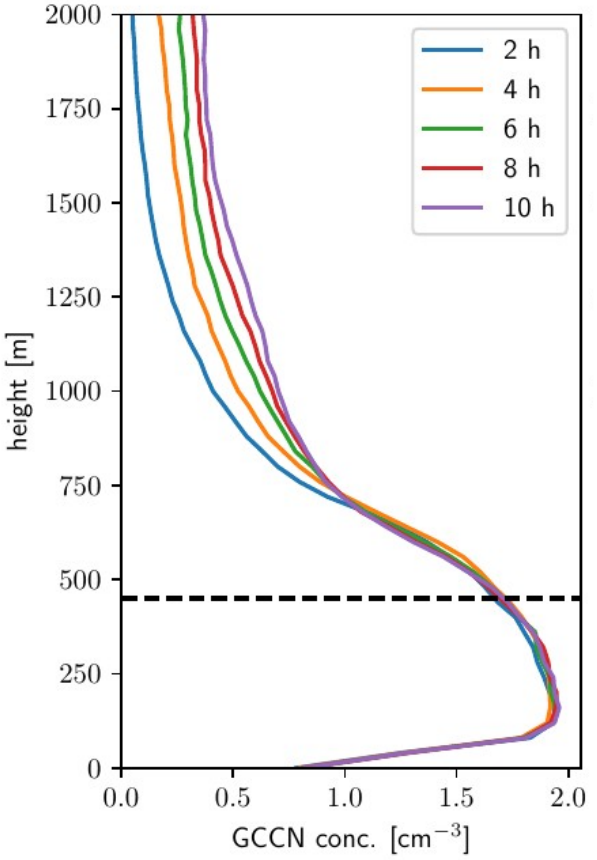


Vertical distribution of sea salt CCN (cumulus)

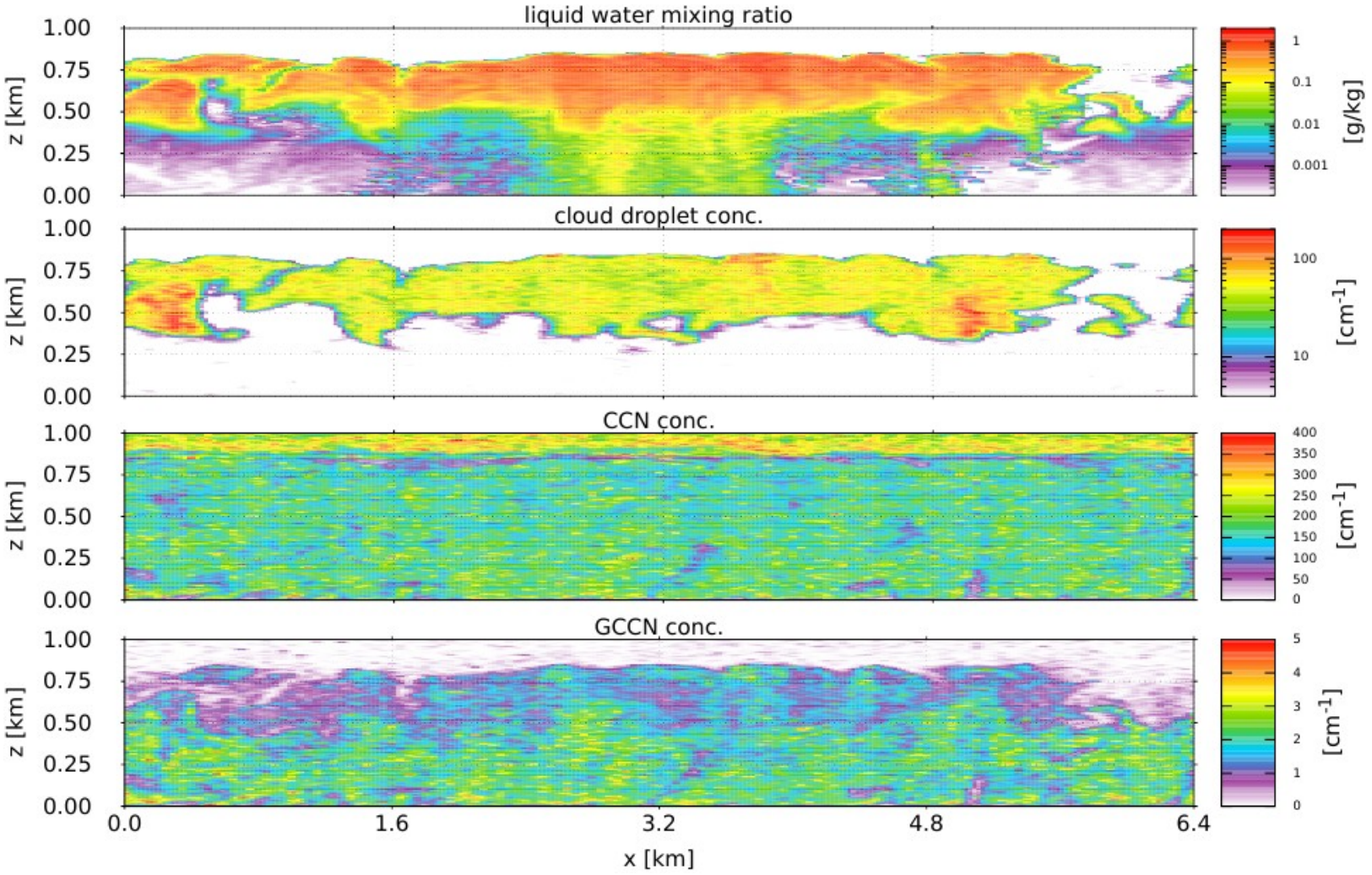
RICO measurements



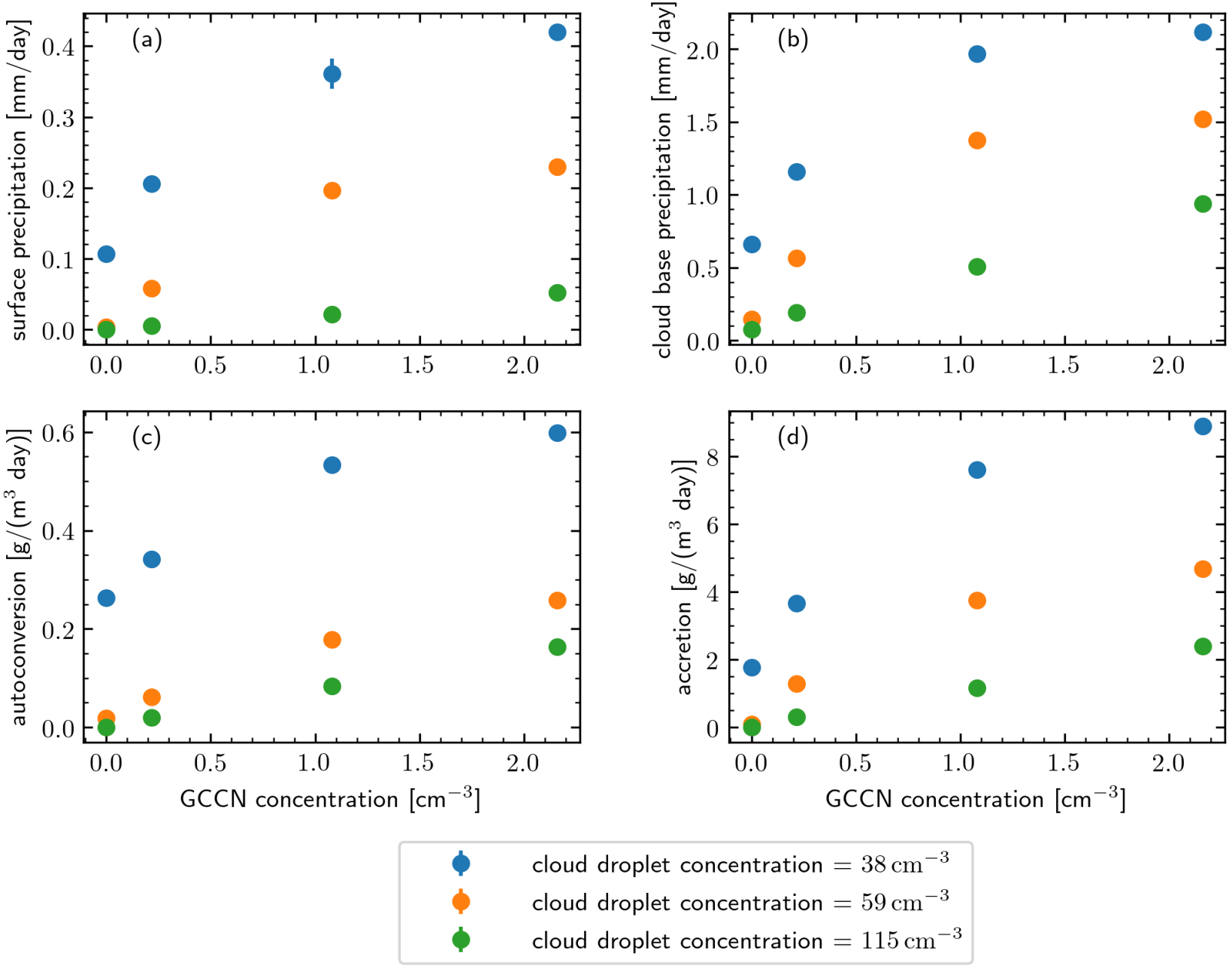
UWLCM results



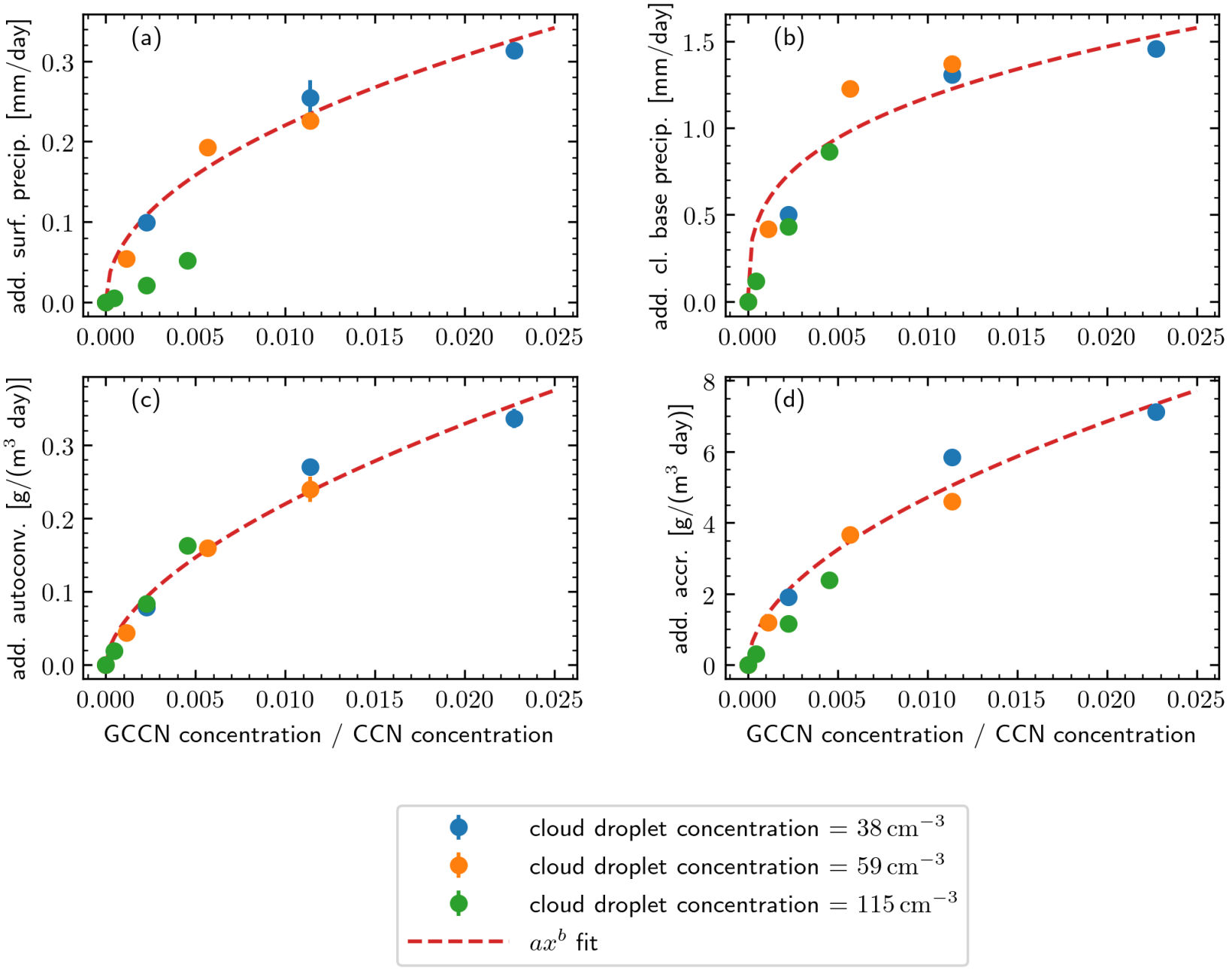
Cross sections



Precipitation vs GCCN conc.



Additional precipitation from GCCN



Comparison with measurements

measurement	LES without GCCN	LES with GCCN
[1]Sc: 0.04 mm/h	0.004 mm/h	0.035 mm/h
[2]Sc: 0.24 mm/d - 0.46 mm/d	0.01 mm/d	0.22 mm/d
[3]Cu: no effect of GCCN on precipitation	Significantly lower sensitivity of cloud base precipitation to GCCN	

[1] Jung et al. *Atmos. Chem. Phys.* (2015)

[2] Ackerman et al. *MWR (2019)*

[3] Reiche & Lasher-Trapp *Atmos. Res.* (2010), Minor et al. *J. Atmos. Sci.* (2011)

Conclusions

- Wave-released giant sea salt aerosols:
  - Significantly increase precipitation in marine stratocumuli.
    - ➔ The effect can be parameterized knowing CCN concentration and wind speed.
  - Increase rain formation in cumuli to a lesser extent.