Pacific Northwest
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When are models good enough?

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All models are wrong

Box (1976); Carslaw et al. (2018)

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All models are wrong, but some are useful

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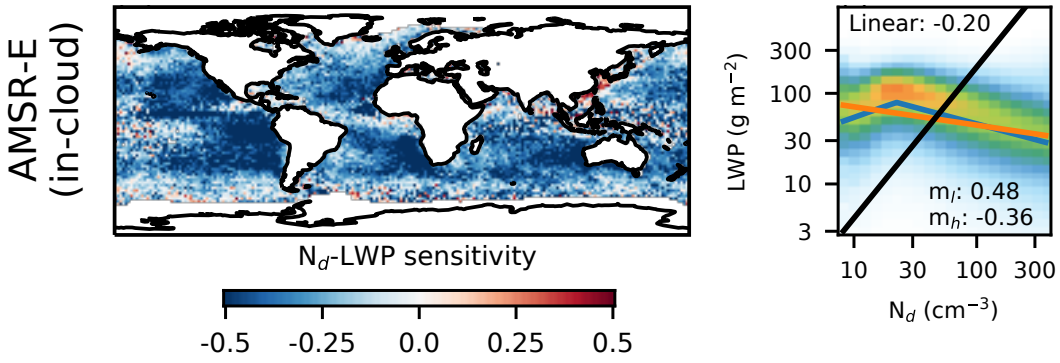
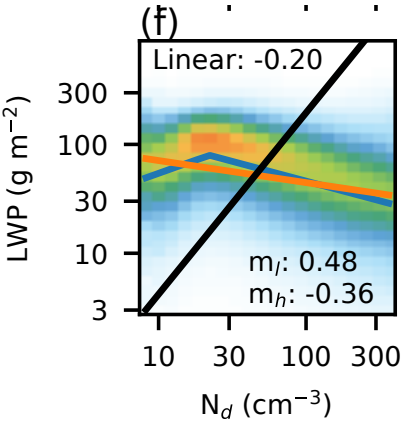
The “inverted v” in N_d–$\mathcal{L}$

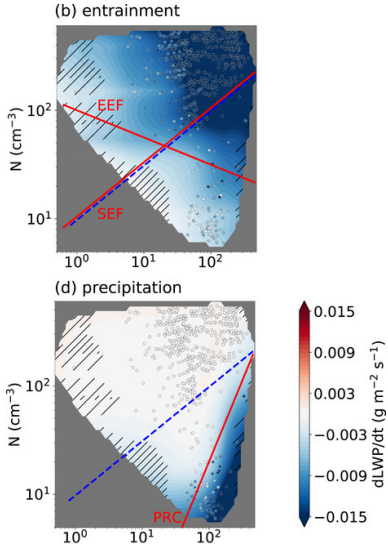


Interpretation: precip suppression at low N_d, enhanced evaporation at high N_d; partial cancellation, but evaporation wins

Gryspeerdt et al. (2019)

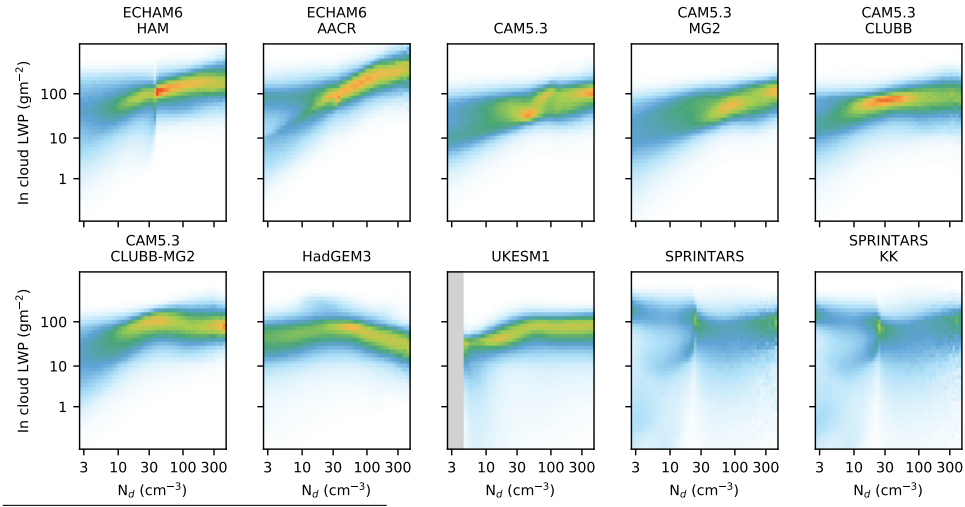
Process fingerprints in N_d–$\mathcal{L}$ space





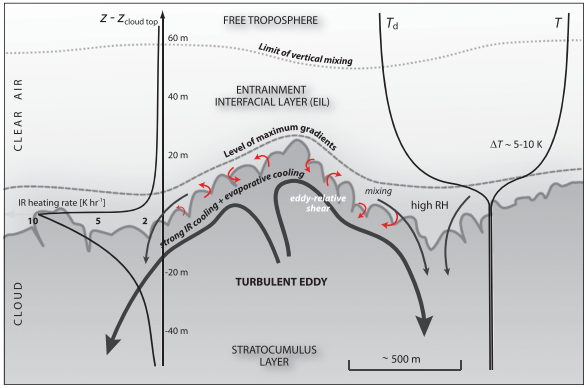
Gryspeerdt et al. (2019); Glassmeier et al. (2019); Hoffmann et al. (2020)

There's no v in GCM



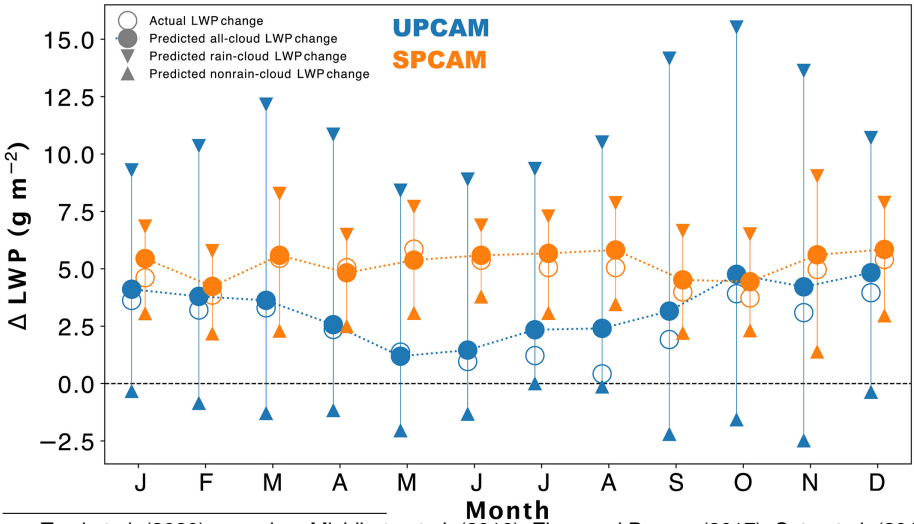
Dipu and E. Gryspeerdt (priv. comm.); see also: Michibata et al. (2016); Zhou and Penner (2017); Sato et al. (2018)

This is what we should expect, based on process scales



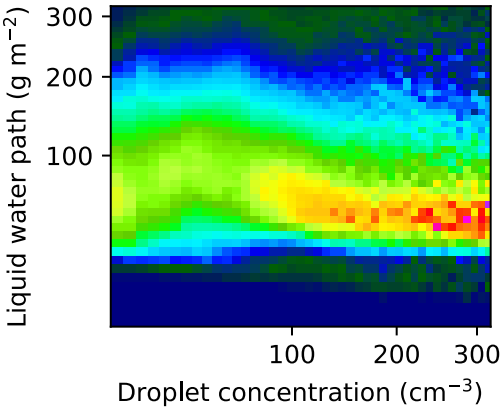
Wood (2012); see also: Michibata et al. (2016); Zhou and Penner (2017); Sato et al. (2018)

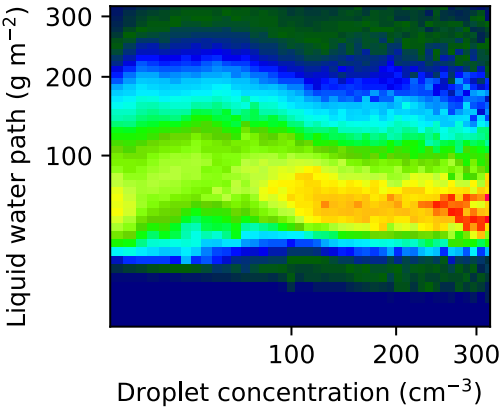
But there's UPCAM: global model with correct regime dependence



Terai et al. (2020); see also: Michibata et al. (2016); Zhou and Penner (2017); Sato et al. (2018); Mülmenstädt and Wilcox (2021)

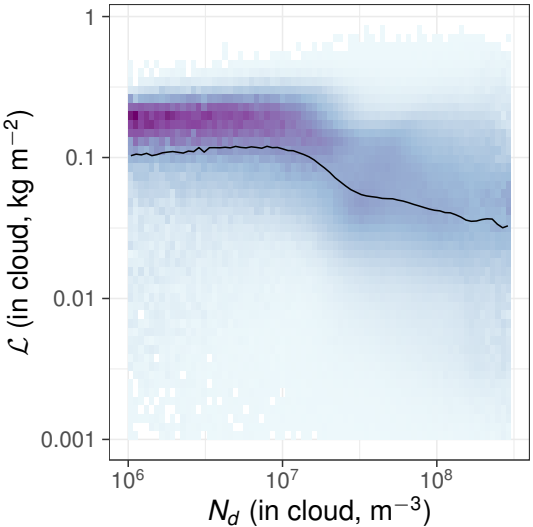
A funny thing happened on the way to CMIP6





A. Ackerman and J. Quaas (priv. comm.)

Multiple CMIP6 models have a descending N_d–$\mathcal{L}$ branch



- E3SM and GISS both produce descending branch
- Checking in other GCMs (with Ackerman, Bauer, Dipu, Fridlind, Gettelman, Gryspeerdt, Ming, Quaas, Zheng)
- This is the case whether or not we "expect" enhanced evaporation based on the model physics
- Having a model that (at least qualitatively) matches observations allows us to formulate and test hypotheses about the cause of the relationship

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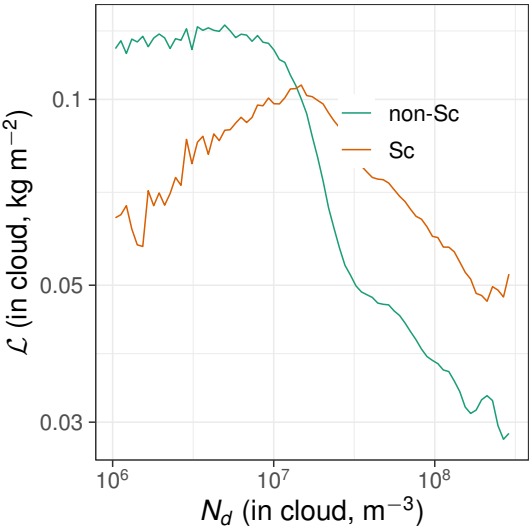

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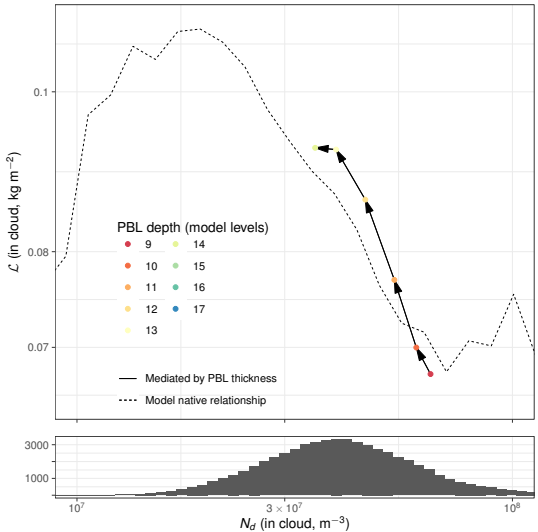
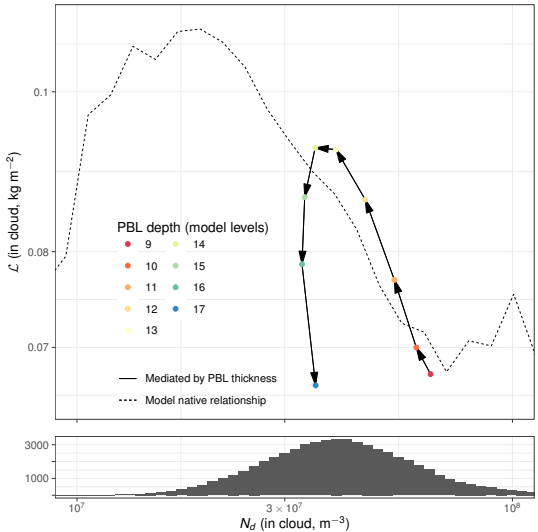
Why?

Does CCN sorting by PBL thickness explain the descending branch?



- Slopes are consistent with precip/evap process signature
- But there confounding by meteorology: thin PBL co-occurs with high CCN
- This explains part of the negative slope

Does CCN sorting by PBL thickness explain the descending branch?



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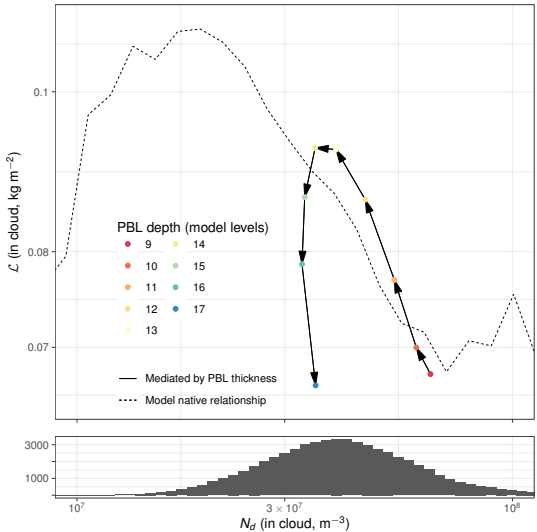
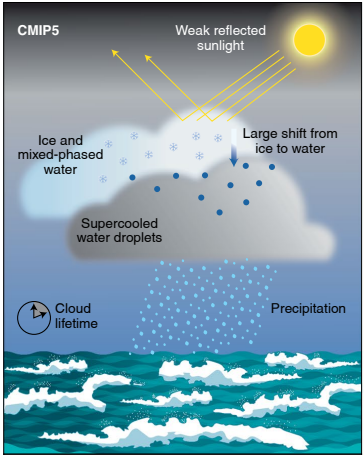
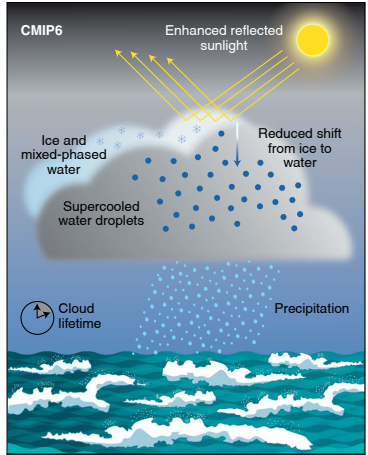


- Slopes are consistent with precip/evap process signature
- But there confounding by meteorology: thin PBL co-occurs with high CCN
- This explains part of the negative slope, but not all of it
- Global model (GCM, GSRM) represents this confounding
- And explores the meteorological phase space in general
- And can establish causality

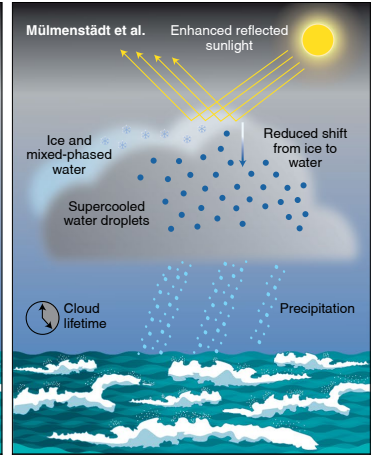
Precip/evap partitioning matters for cloud feedback, too (maybe)



- Too little supercooled cloud (liquid) water
- Too frequent warm-cloud precipitation
- Cloud lifetimes too short
- Cloud albedo too low
- Large negative phase (ice-to-water) feedback



- Increased supercooled cloud (liquid) water
- Too frequent warm-cloud precipitation
- Cloud lifetimes too short
- Enhanced cloud albedo
- Weak negative phase (ice-to-water) feedback



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- Large negative cloud lifetime feedback

Summary

- Models (LES, SRM, GCM, whatever) are good enough when they contribute significantly to the overall (multiple lines of evidence) understanding
- I used to think (based on process scales) that it was impossible for GCMs and borderline for SRMs to be good enough for evaporation processes

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See also: Mülmenstädt and Wilcox (2021)

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- Observational constraints on models are great, but so are model “constraints” on observations
- Urgently needed observations: partitioning between precip, evap, (precip evap)

See also: Mülmenstädt and Wilcox (2021)

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