Context for a potential AIDA-based cirrus cloud parcel model intercomparison

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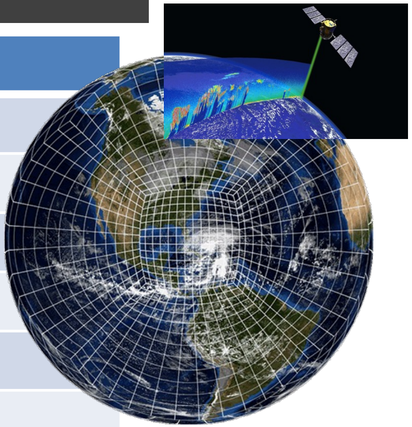
Conditions	Case study for ModelE3 development
dry convective boundary layer	idealized [Bretherton and Park 2009]
dry stable boundary layer	GABLS1 [Cuxart et al. 2006]
marine stratocumulus	DYCOMS-II RF02 [Ackerman et al. 2009]
marine trade cumulus (shallow)	BOMEX [Siebesma et al. 2003]
marine trade cumulus (deep, raining)	RICO [van Zanten et al. 2011]
marine stratocumulus to cumulus transition	SCT [Sandu and Stevens 2011]
continental cumulus	RACORO [Vogelmann et al. 2015]
Arctic mixed-phase stratus	M-PACE [Klein et al. 2009]
Antarctic mixed-phase stratus	AWARE [Silber et al. 2019]
tropical deep convection	TWP-ICE [Fridlind et al. 2012]
mid-latitude synoptic cirrus	SPARTICUS [Mühlbauer et al. 2014]



GCSS Cirrus Parcel MIP (Lin et al., 2002)

- large range of ice number concentrations
- useful framework, but no observational benchmark

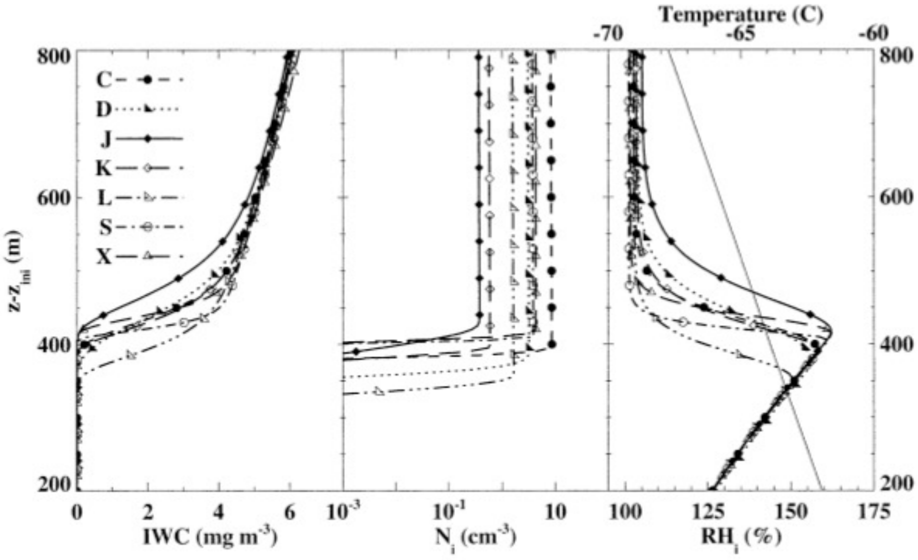


FIG. 7. The evolution of IWC, ice number concentration, relative humidity with respect to ice and temperature of the parcel in case Ch020. Note that z_{ini} is the initial height of the parcel.

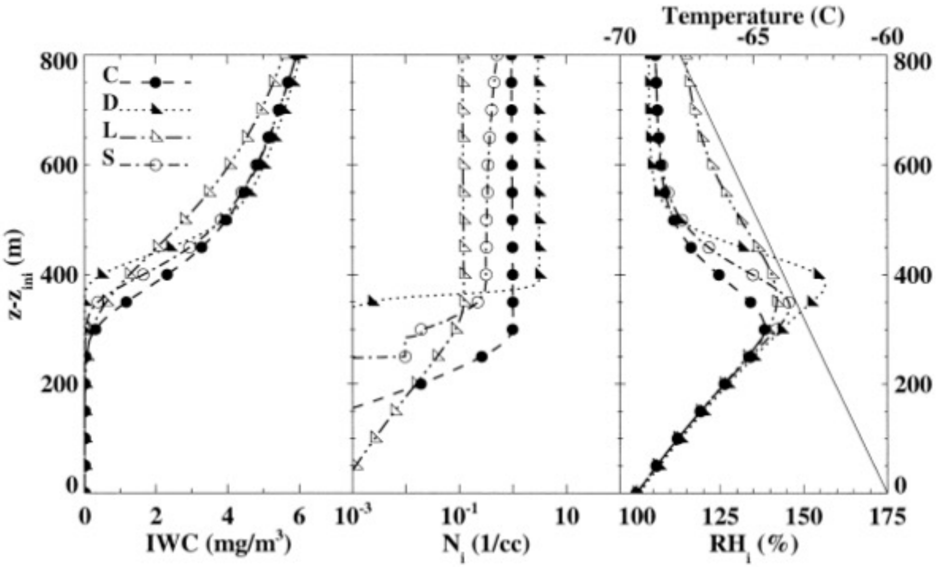


FIG. 10. Same as Fig. 7, except for case Ca020.

homogeneous freezing only

homogeneous + heterogeneous

GCSS 1D Case Study (Yang et al. GMD 2012)

- quasi-Lagrangian approach
- derived 4-h gravity wave forcing
- no other participants? no in situ data?

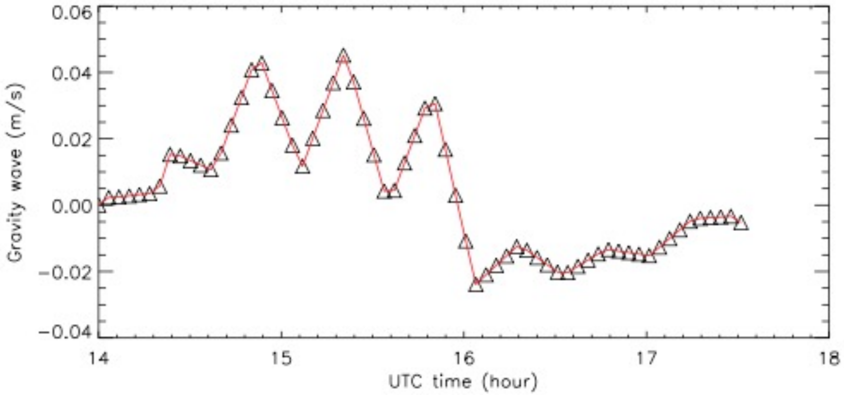
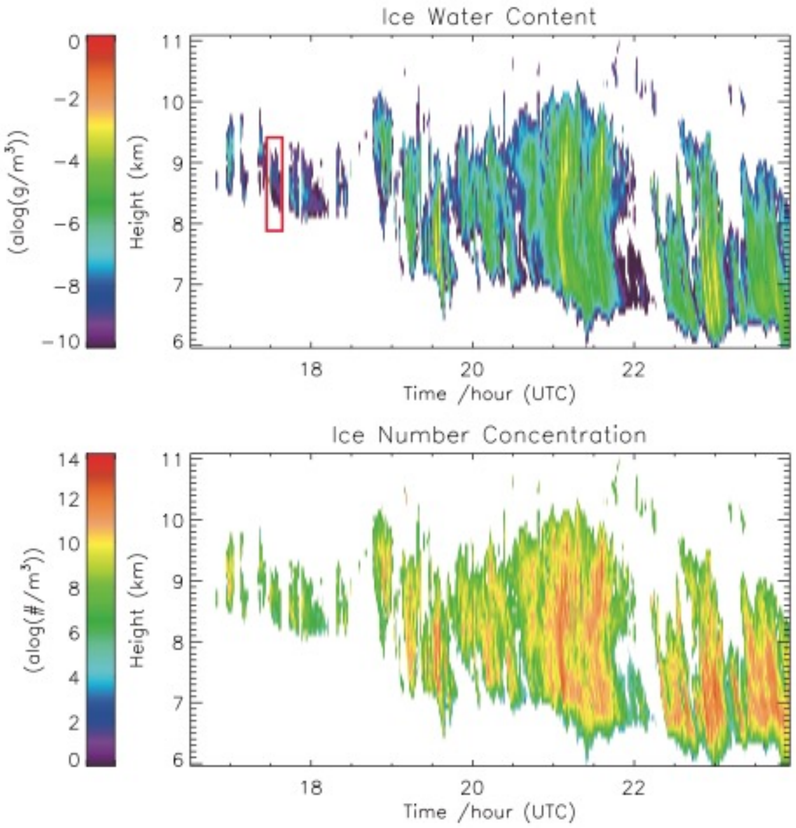
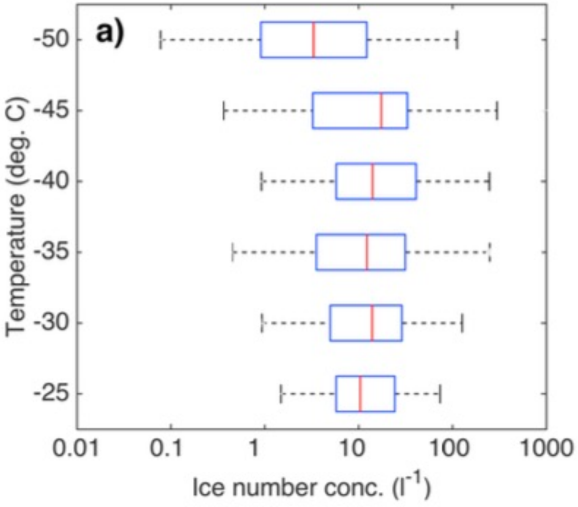


Fig. 10. Modelled gravity wave forcing ($m\,s^{-1}$) versus time (h). This is the modelled gravity wave forcing that the cloud experiences as it advects from where it first formed to when it arrives at the ARM SGP CF, where it is observed by the MMCR radar.

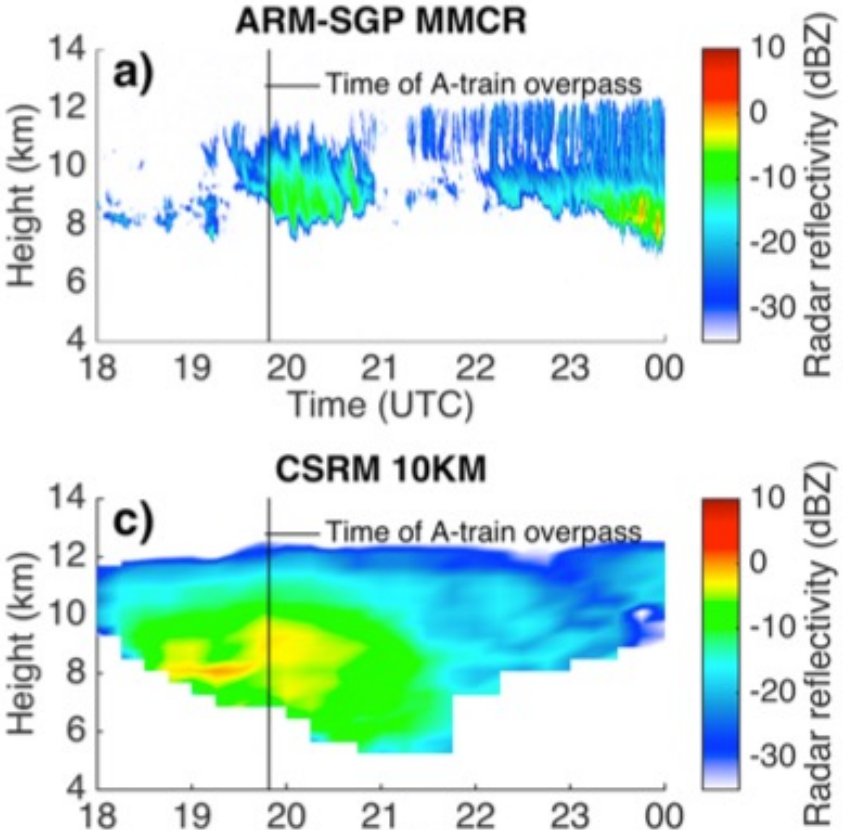


WMO CRM/LES case (Mühlbauer et al. JGR 2015)

- Eulerian approach
- derived 6-h large-scale ascent
- still no other participants?

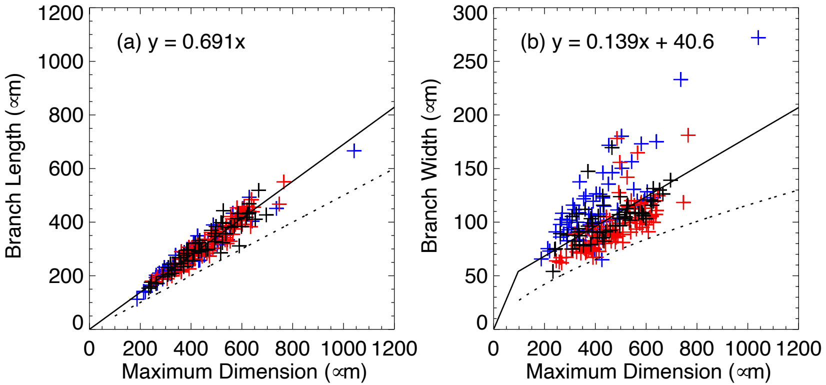


SPARTICUS aircraft observations

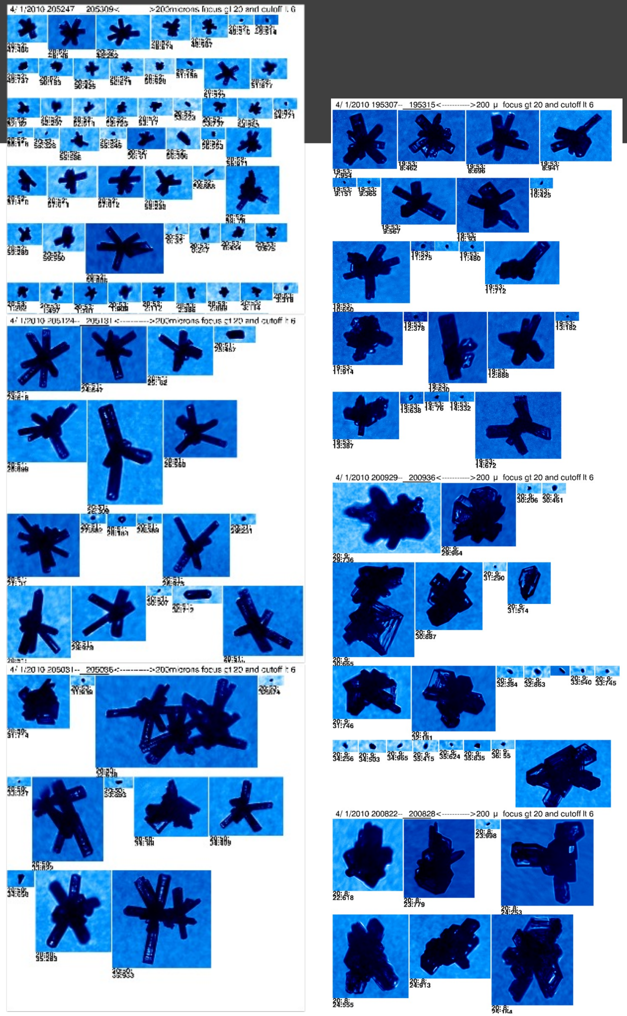


Fridlind et al. 2017

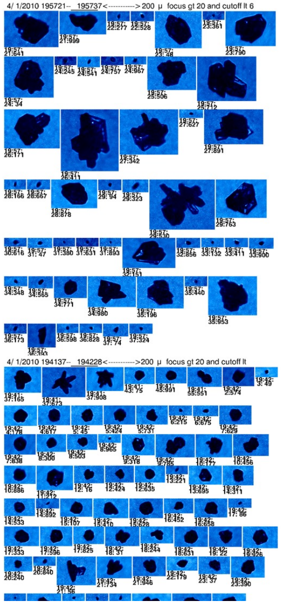
- is ice morphology important?
- develop internally consistent geometry for physical and *optical* properties in a bin model (van Diedenhoven et al. 2014)



6 arms <6 arms >6 arms

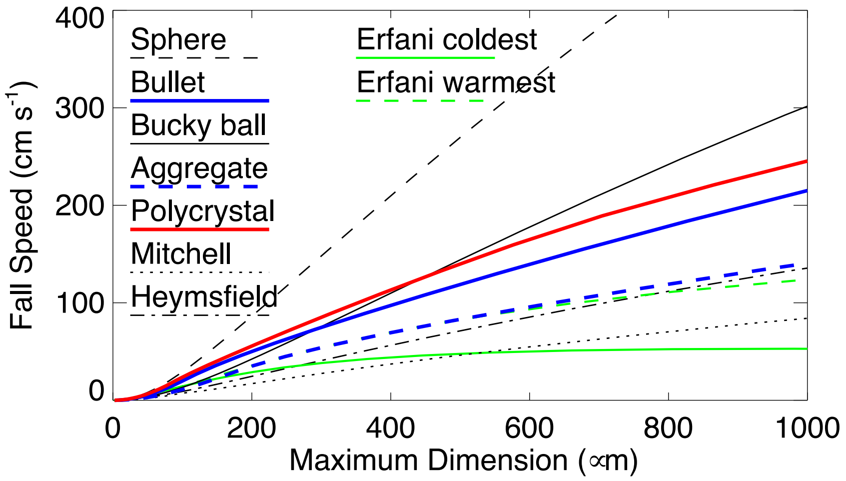


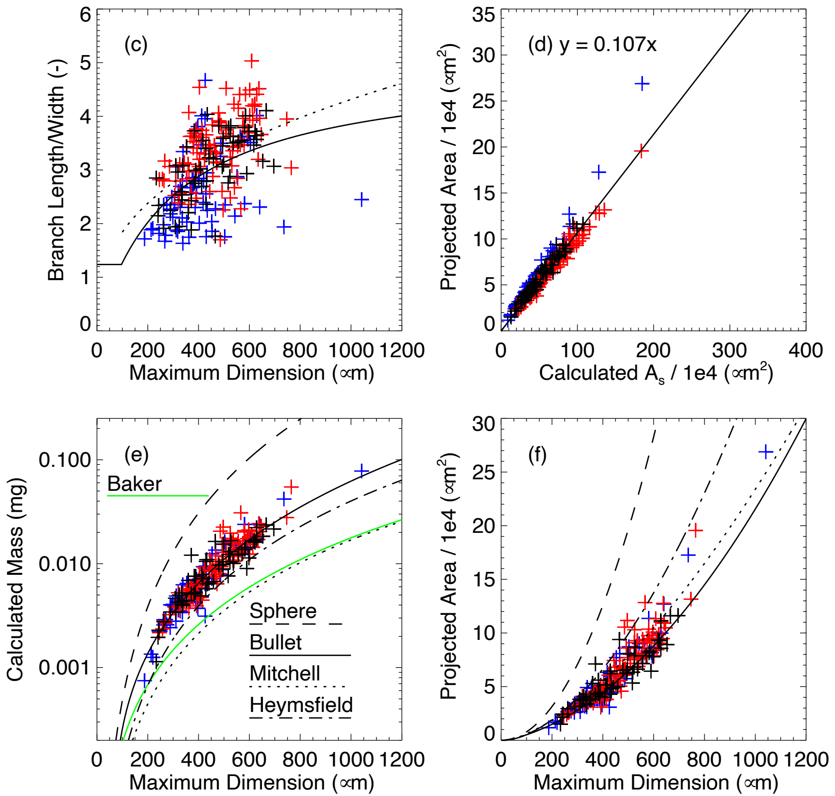
SPARTICUS
in situ images



SPARTICUS ice crystals (Fridlind et al. ACP 2017)

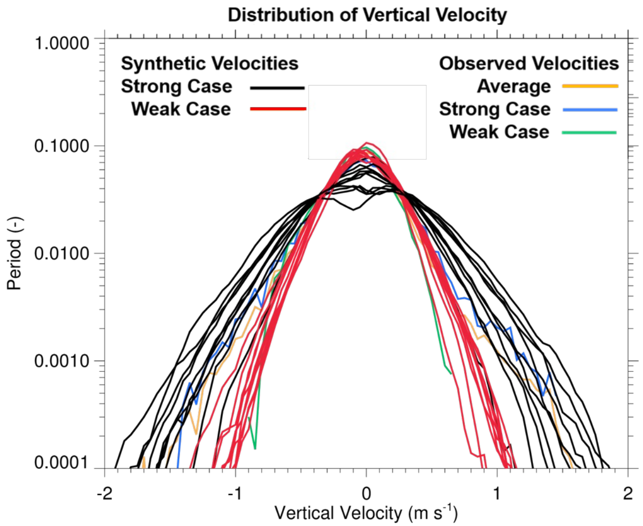
- fall speeds 1.5-2X greater than literature (direct obs of only 45 crystals w/2-5 arms)
- PSD and asymmetry parameter sensitive to assumed ice properties in parcel MIP tests
- thanks to Rachel Atlas for contributions

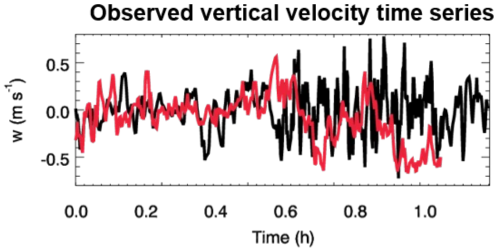


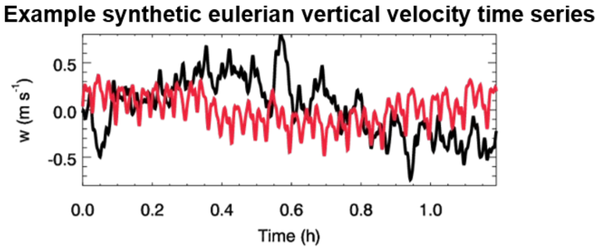


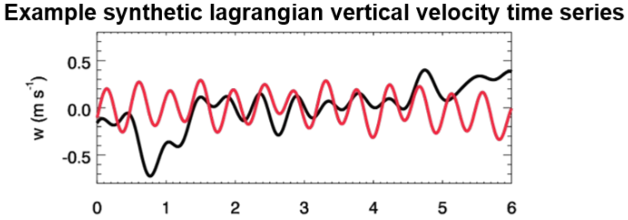
Gravity waves evident in SPARTICUS radar data?

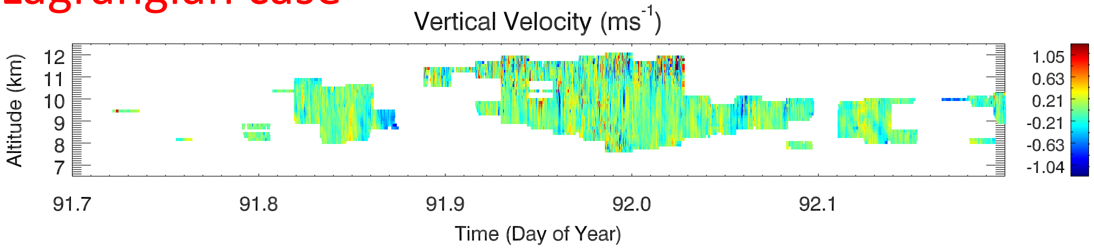
- use radar retrieved w [Kalesse et al. 2012]
- extract time series
- use linear wave theory
- randomize phase
- construct synthetic wave trains
- approximate as Lagrangian case











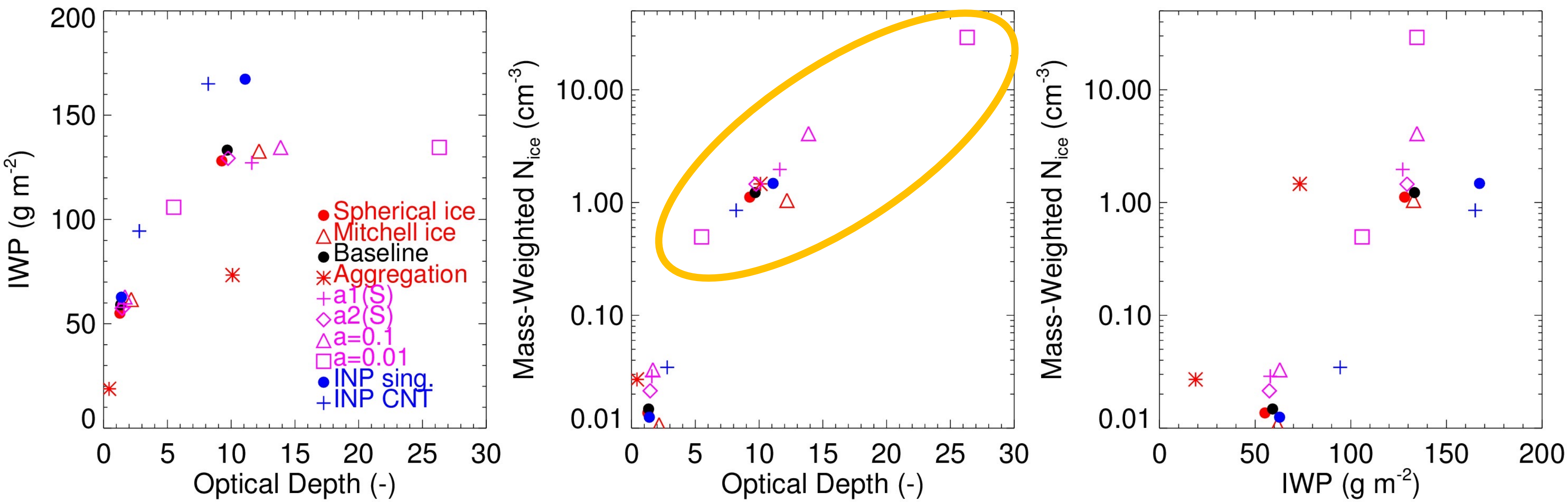
source: Rachel Atlas

Lagrangian ensemble with bin microphysics

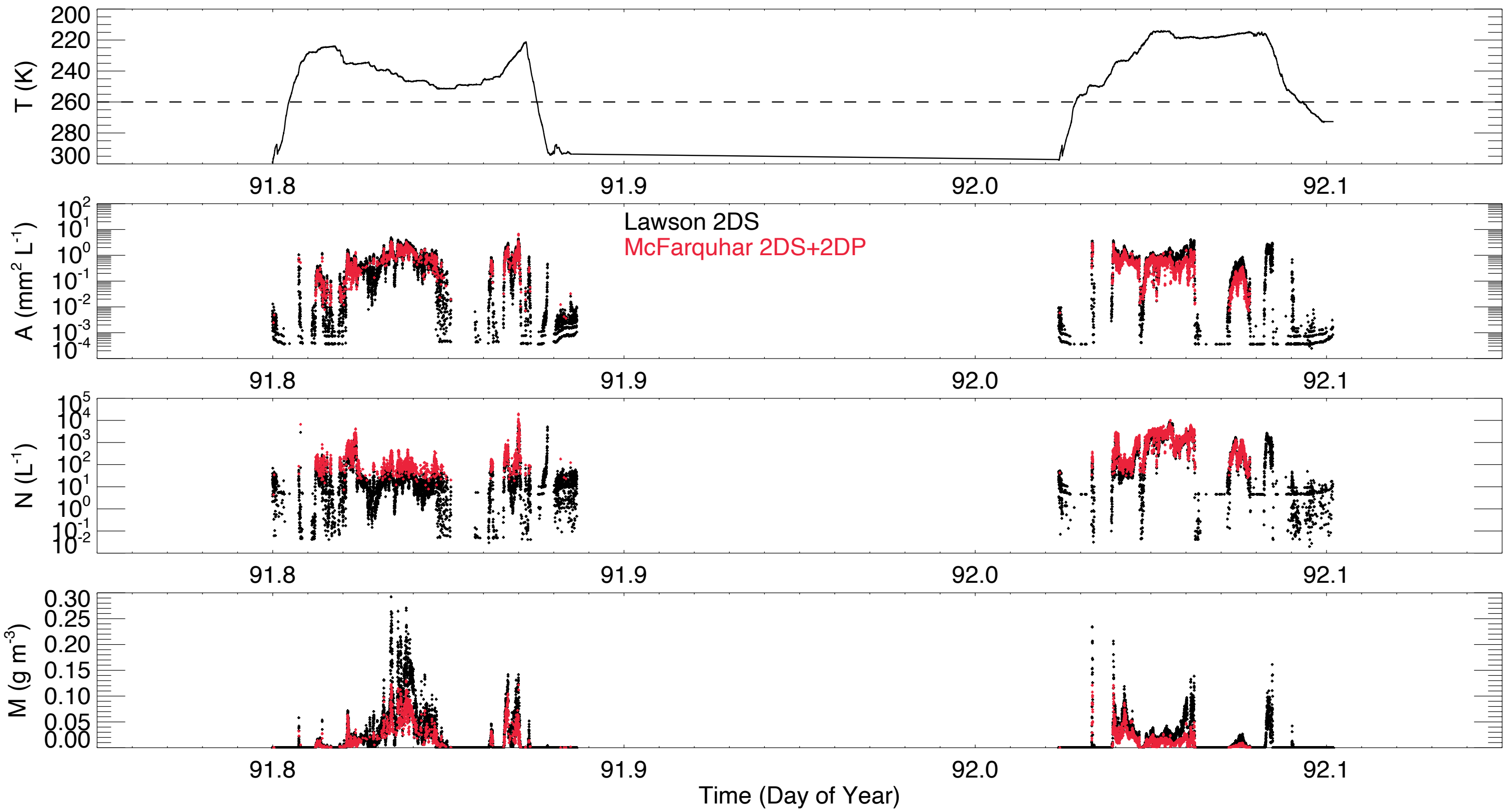
Ensemble	Ice Nucleation	Ice Properties	α
Baseline	homogeneous only	derived bullet rosettes	1
Spherical ice	homogeneous only	solid spheres	1
Mitchell ice	homogeneous only	Mitchell et al. [1994]	1
Aggregation	homogeneous only	derived rosettes and aggregates	1
a1(S)	homogeneous only	derived bullet rosettes	$f(S_i,T)$
a2(S)	homogeneous only	derived bullet rosettes	$f(S_i,T)$
a=0.1	homogeneous only	derived bullet rosettes	0.1
a=0.01	homogeneous only	derived bullet rosettes	0.01
INP sing.	add 30/L singular scheme	derived bullet rosettes	1
INP CTN	add 100/L CNT scheme	derived bullet rosettes	1

sensitivity of two ensemble members

with gravity waves

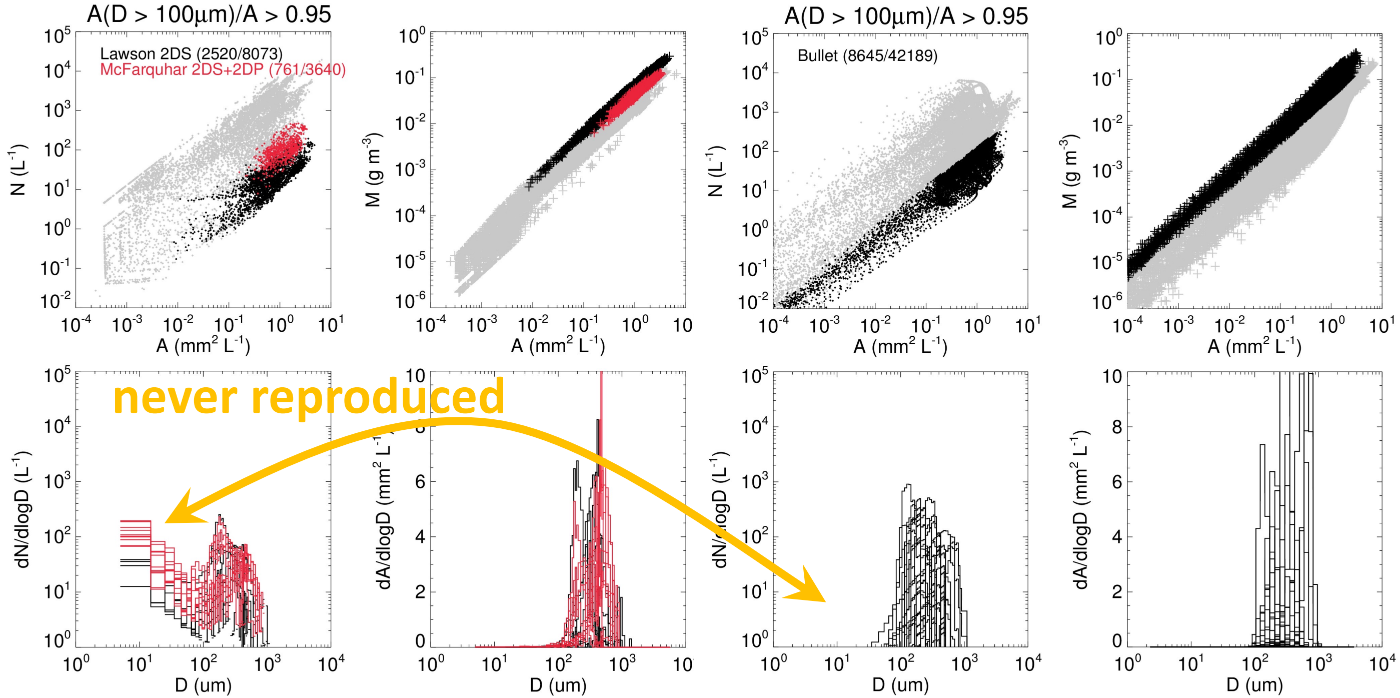


Two SPARTICUS flights



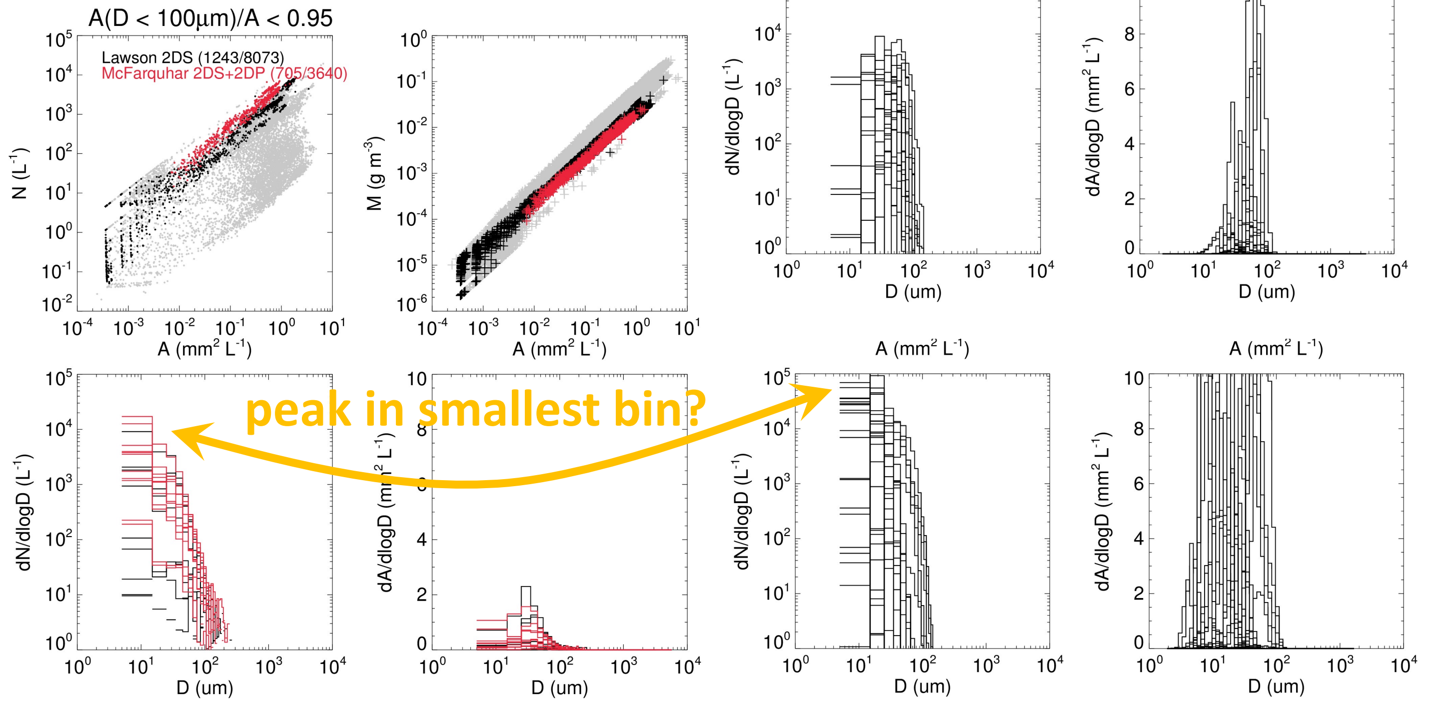
PSDs that are dominated by large ice

observations | baseline ensemble



PSDs that are dominated by small ice

observations

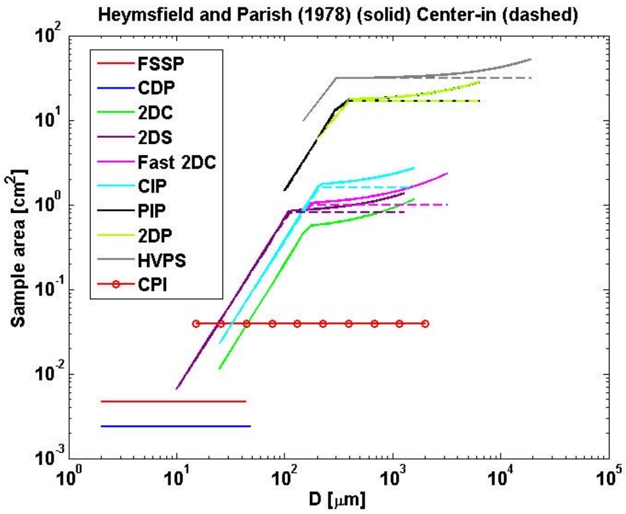


baseline ensemble

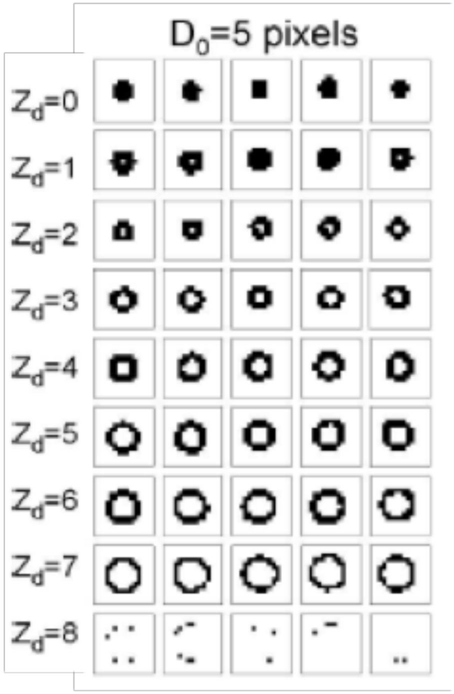
α=0.01 ensemble

D < ~100 μm highly uncertain

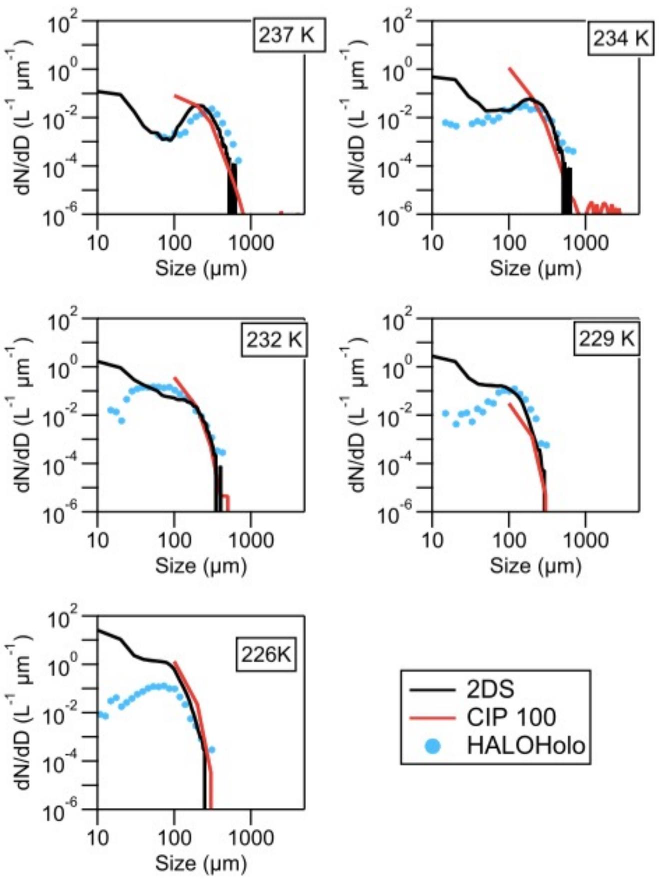
- in situ measurement uncertainties > 2X



Source: Greg McFarquhar

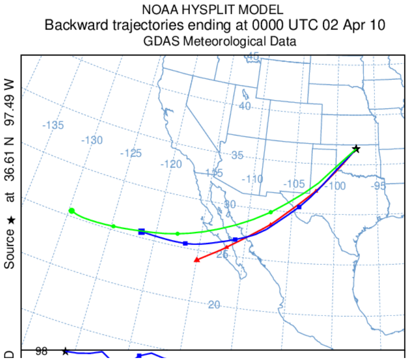


Korolev [2007]

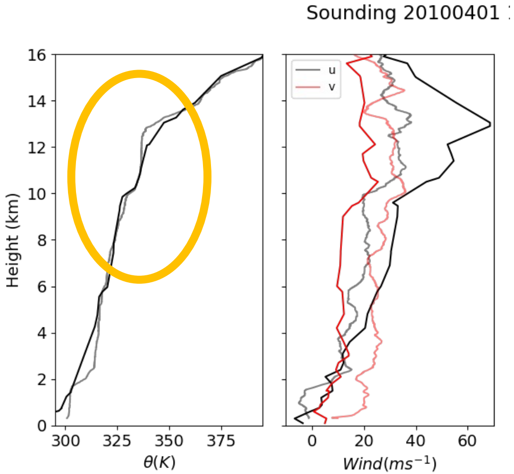


O'Shea et al. [JGR 2016]

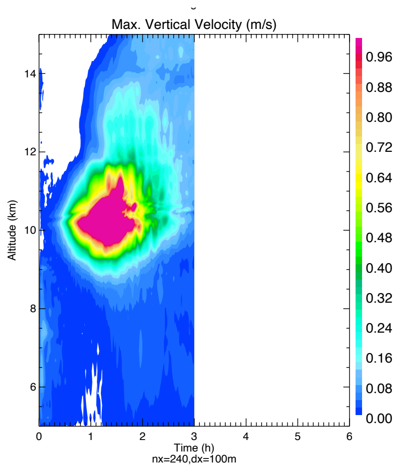
Wind shear-induced turbulence in Lagrangian LES

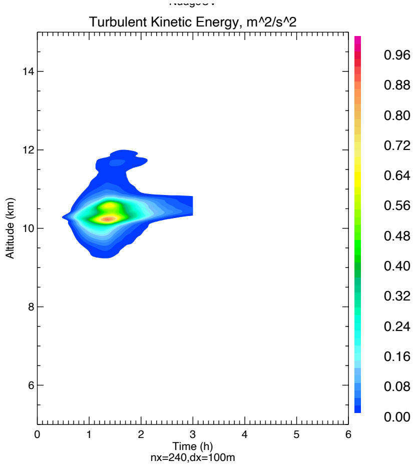


source:
Rachel Atlas

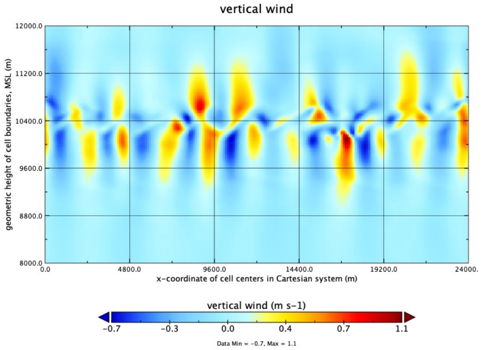


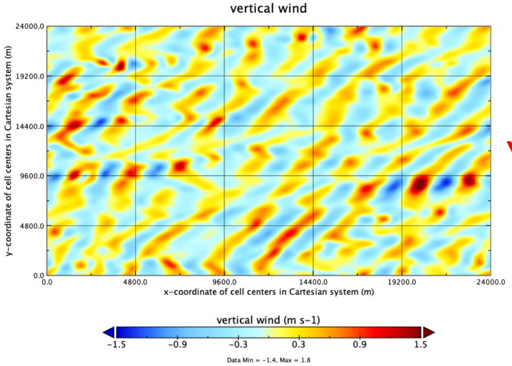
LES
dx = 100 m
L = 24 km





X-Z





Y-Z

Barriers to Progress

- Lack quantification of cirrus single-crystal properties
- Lack observations of upper tropospheric GWs
- Lack reliable observations of cirrus ice PSDs
- Poor understanding of heterogeneous ice formation, especially under synoptic cirrus conditions
- Lack of well defined and widely used synoptic cirrus case studies

- How about a parcel intercomparison based on AIDA data?

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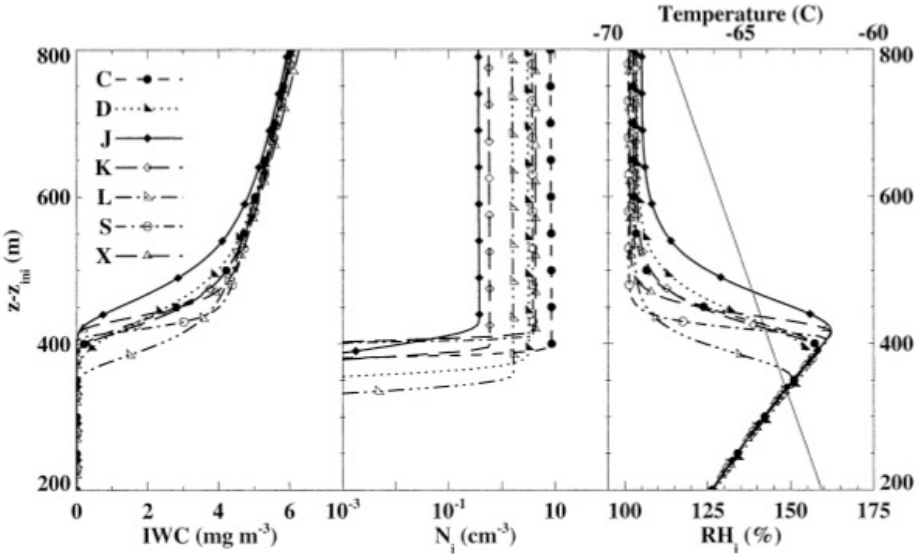
- large range of ice number concentrations
- useful framework for benchmark microphysics, but not an SCM case ...



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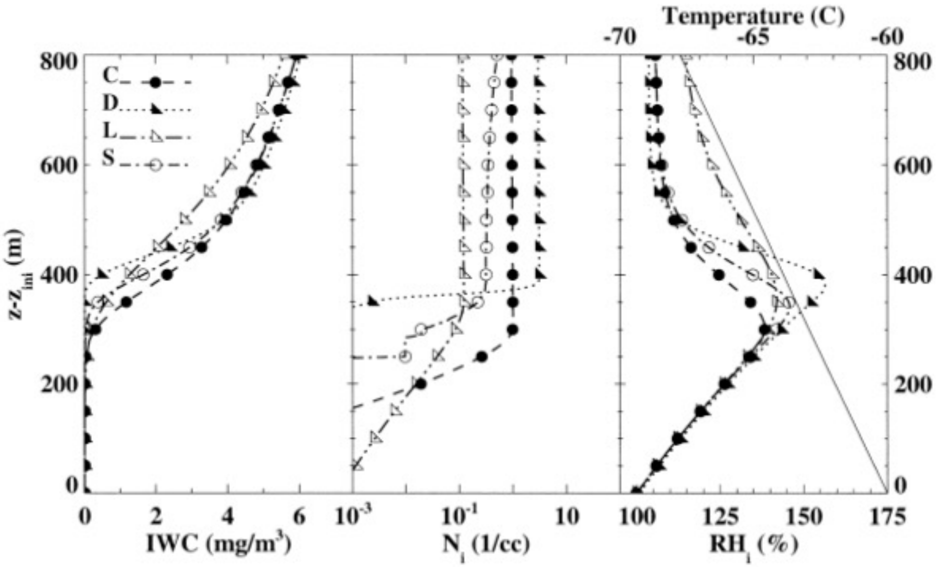

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