LES/SCM based on well-observed case studies + evaluation of ESM physics using long-term ARM data = A good pairing for community participation?

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- Thanks for attending!
  - First hour presentations and questions, second hour open discussion
  - Type in your question to chat or raise your hand (from phone toggle *9)
  - Video welcomed during open discussion
  - Please keep questions and comments as brief as possible
  - This session will be recorded

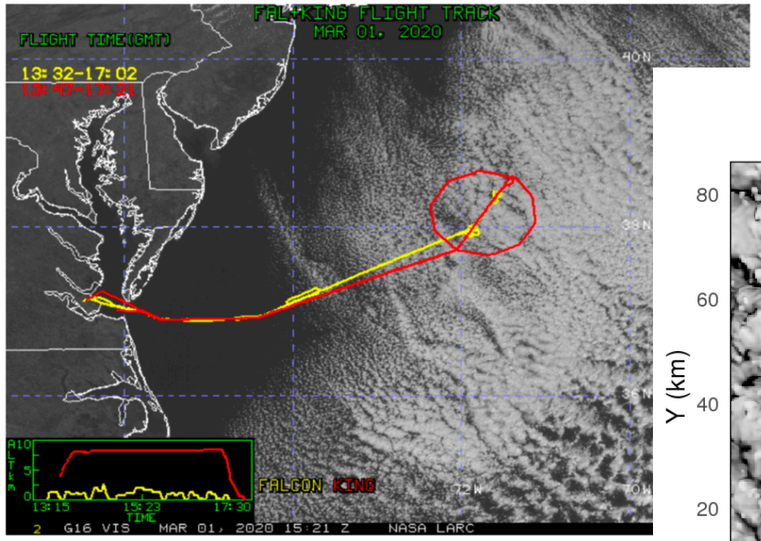
Where is this coming from?

- ARM Cloud and Precipitation Measurements and Science Group
  - "how resources can best be applied ... to increase the scientific impact of these measurements" (charter)
  - "are there subtopics where ARM has strong potential to contribute but is not reaching that potential for various possible reasons?"
  - a draft recommendation: seek and support frameworks that bring individuals and groups together for limited joint exercises
- Examples
  - GCSS model intercomparison studies (cases still widely used)
  - GASS Diurnal Cycle of Precipitation Project (next talk)
  - general pairing: LES/SCM cases + ESM evaluation with long-term obs?
    - latter may usually require forward simulator approach (last talk)

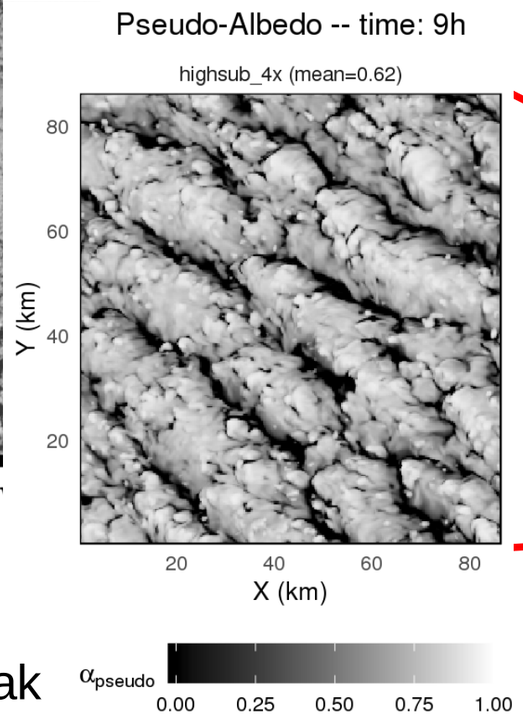
ModelE3 development approach

Global data → GCM tuning

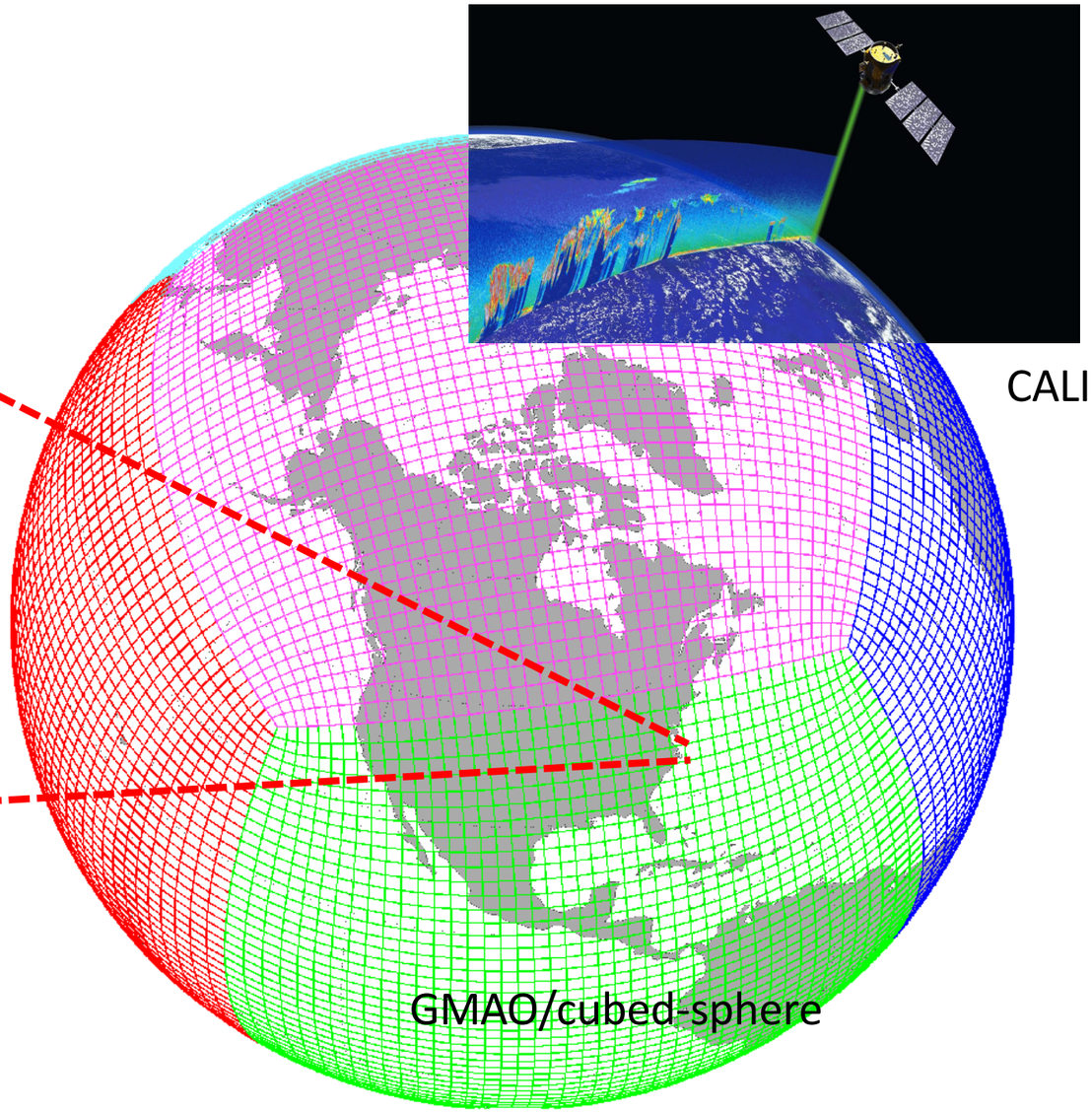
Field campaigns → LES → SCM



From https://satcorps.larc.nasa.gov



ACTIVATE Flight RF13
1 March 2020
mixed-phase cold-air outbreak
(*Tornow et al., in prep*)

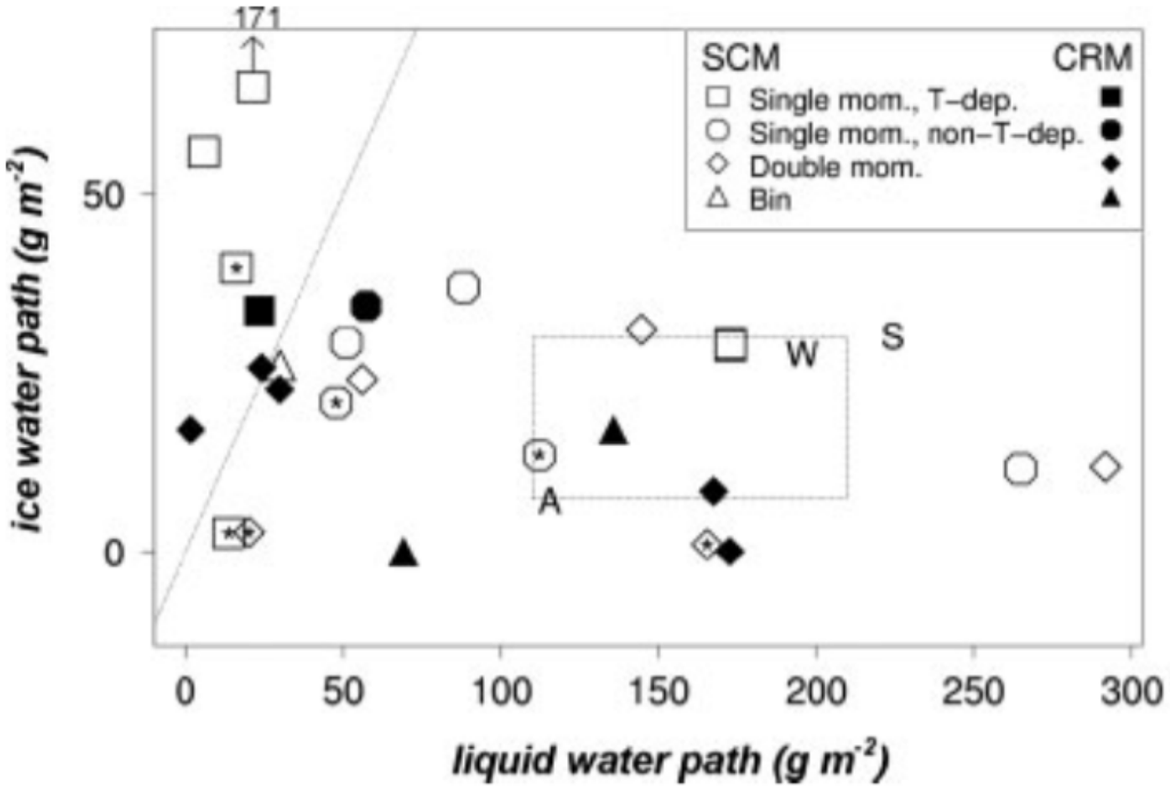


ModelE3 development approach

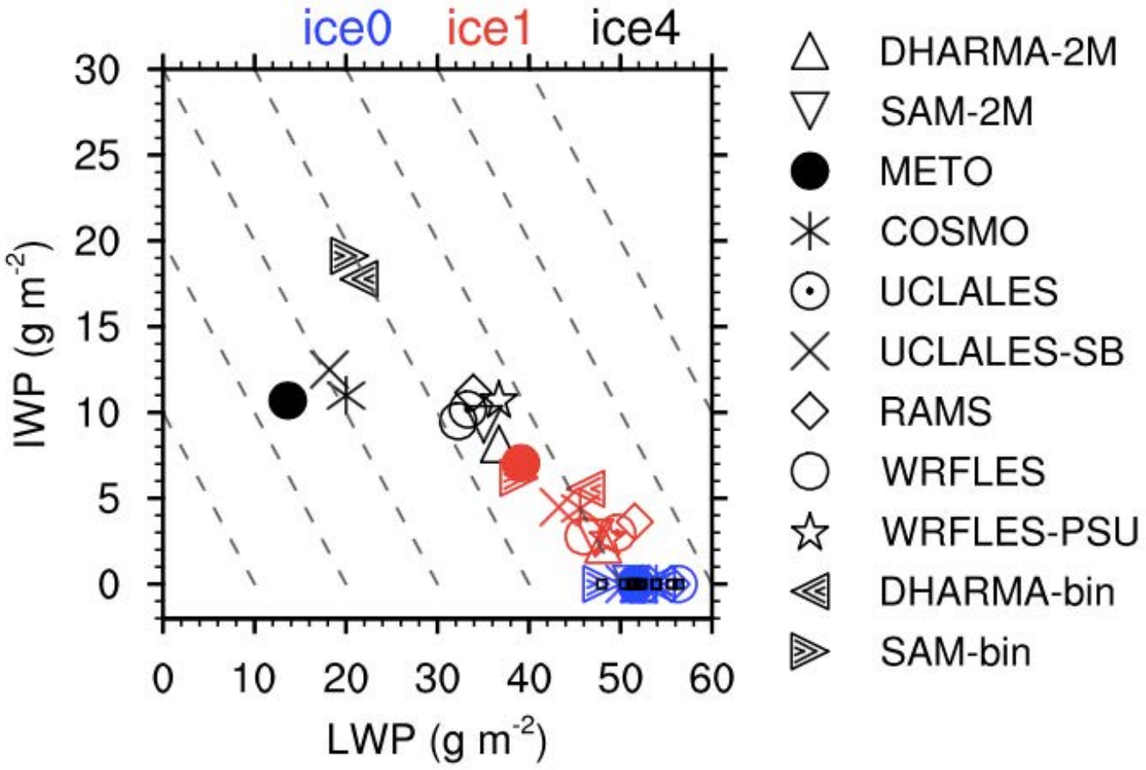
Field campaigns → LES → SCM

Conditions	Case study
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]

M-PACE to ISDAC progress



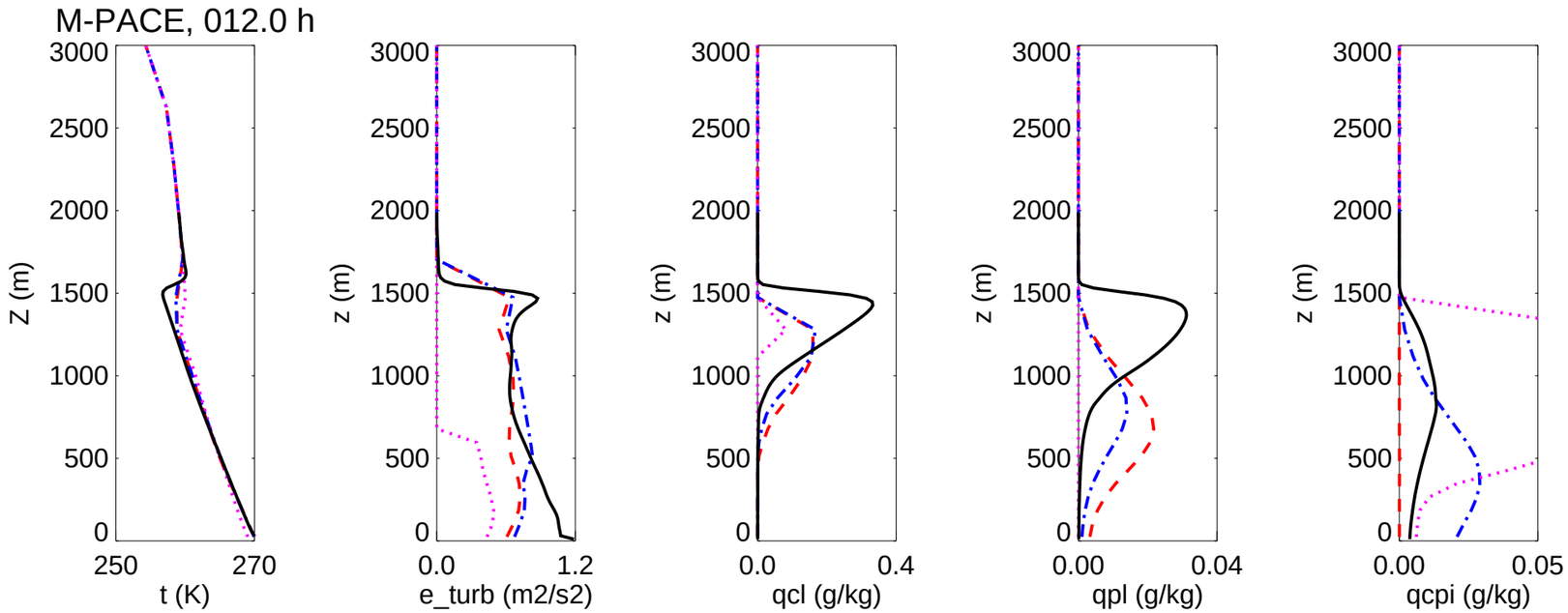
Klein et al. (2009)



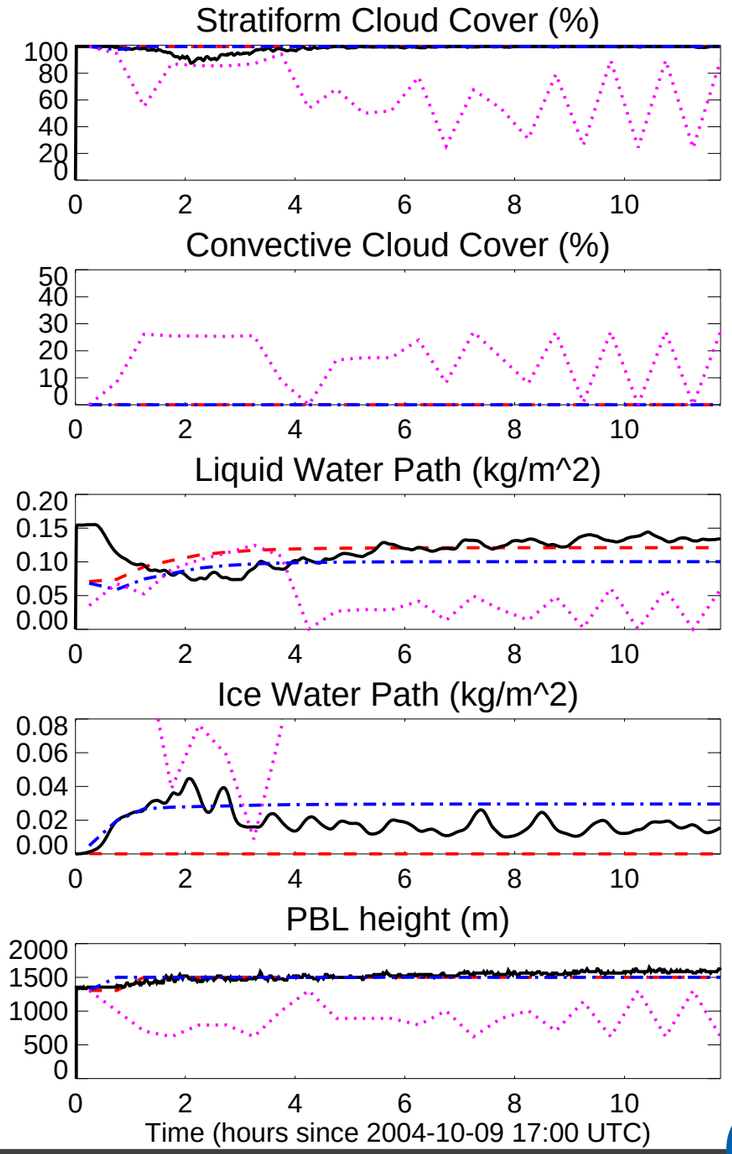
Ovchinnikov et al. (2009)

see also [Fridlind and Ackerman (2018)]

M-PACE LES vs ModelE3 SCM

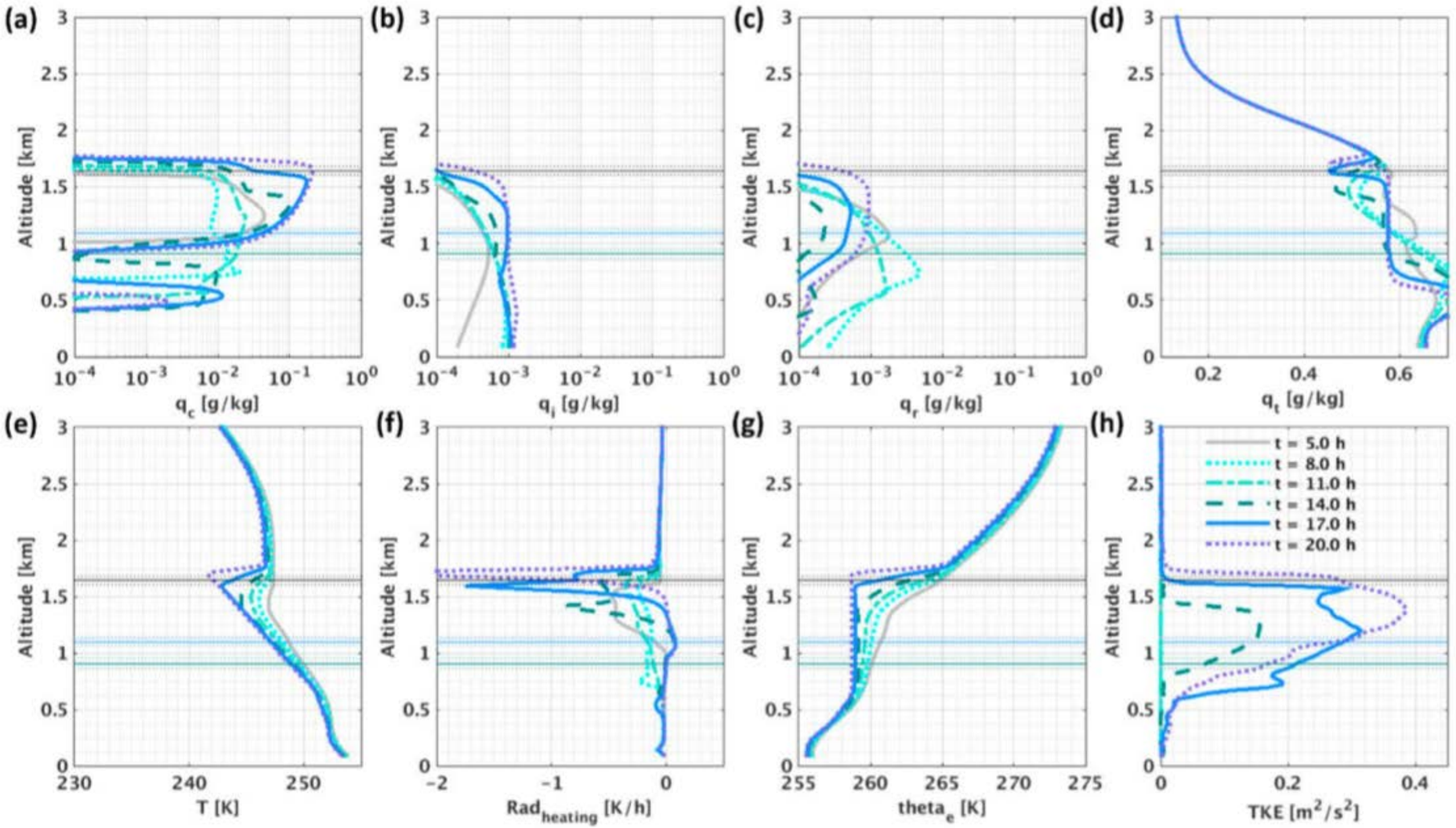


LES_MPACE
SCM_MPACE_Ni0p1
SCM_MPACE_Ni1
SCM_MPACE_Ni10



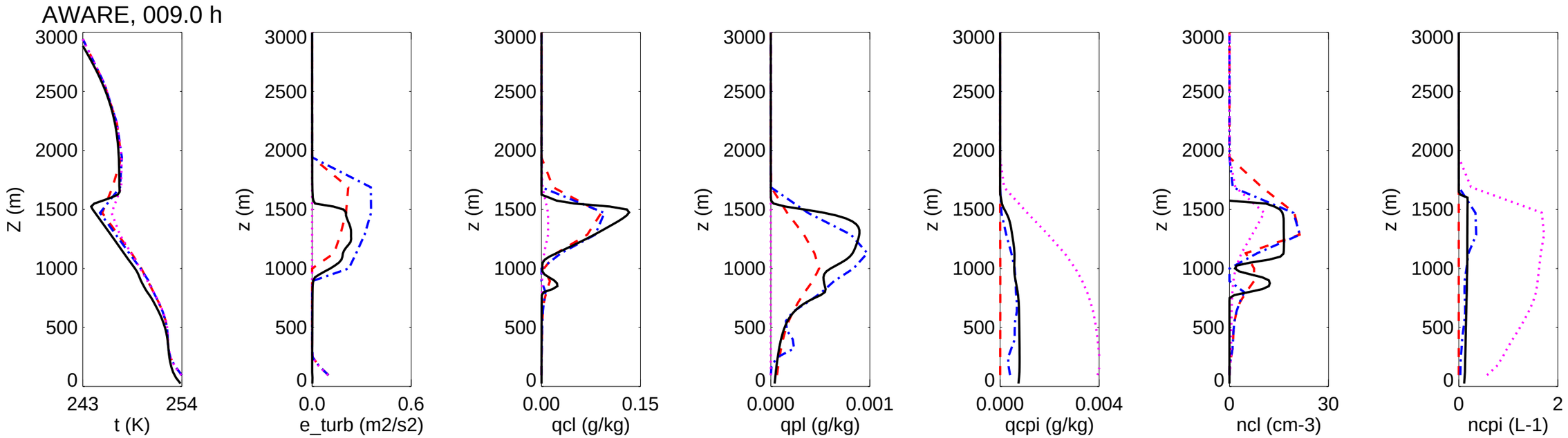
Decoupled Antarctic stratus (Lagrangian LES)

- stable initial profile
- supercooled liquid promotes LW cooling, ice formation
- turbulent layer from ~10 h
  - deepens downward
  - fails to couple (cf. ISDAC)
- possible N_d control by gravity waves (cf. Silber et al. GRL 2020)
- moisture inversion (cf. ISDAC, SHEBA)

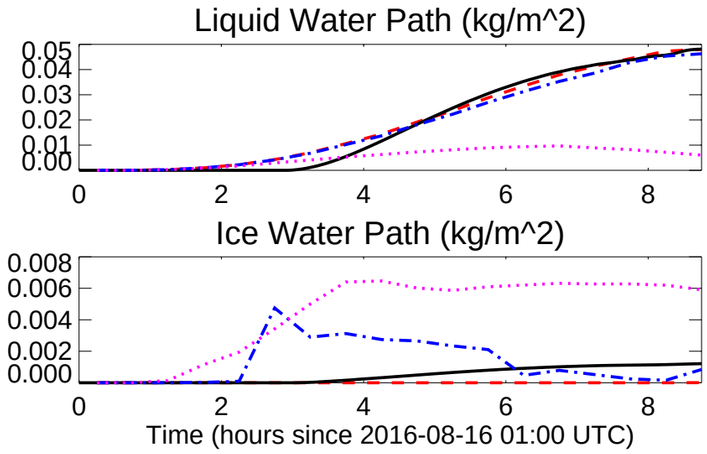


AWARE campaign case study (Silber et al. JGR 2019)

AWARE LES vs ModelE3 SCM



LES_AWARE
SCM_AWARE_iifn0
SCM_AWARE_iifn0p1
SCM_AWARE_iifn1

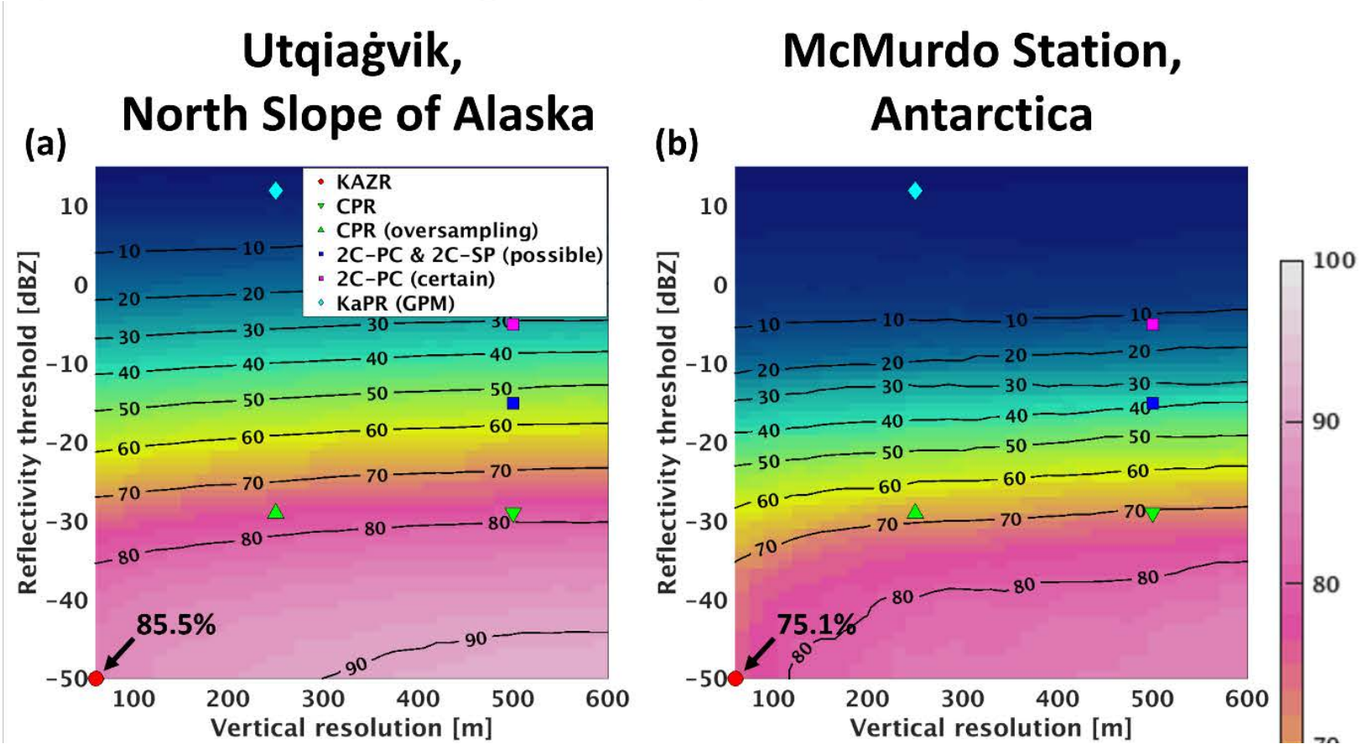


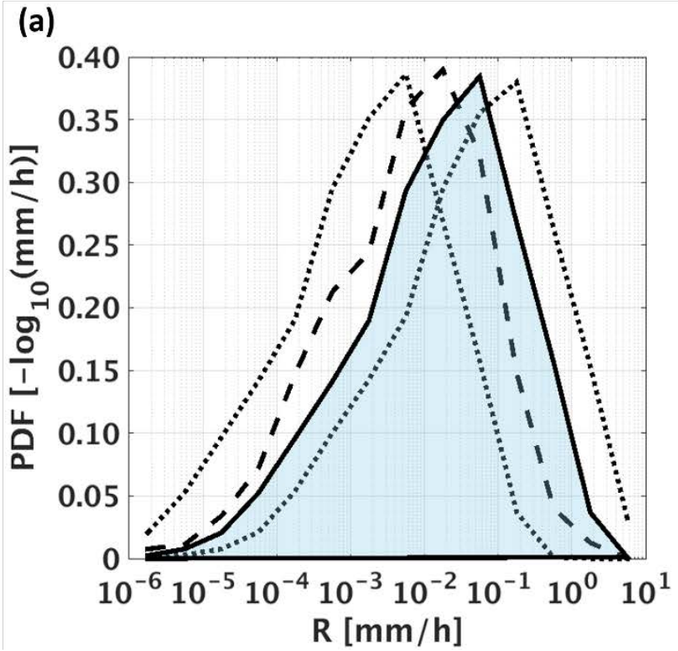
LES/SCM case studies

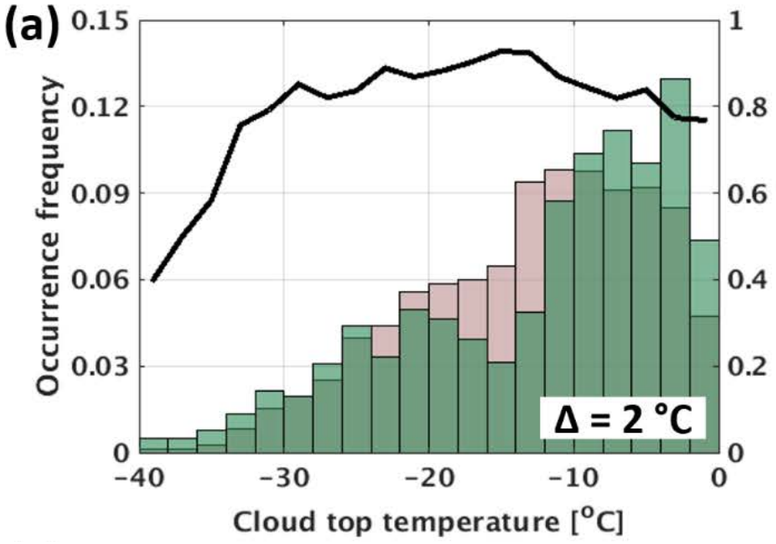
- pros
  - basic tests of ESM column physics
  - convenient framework for model development
  - can be used to tune model parameters (e.g., Williamson et al. 2013)
  - observation-derived cases highlight fundamental knowledge gaps (e.g., ice multiplication, mesoscale structure, CCN and INP budgets)
- cons
  - how to choose? (statistically representative? extremes? ensemble?)
  - are improvements borne out in free-running ESM?
  - useful but not sufficient

Ground-based long-term observations

- great majority of supercooled polar clouds precipitating at cloud base
- poorly observed from space, without ancillary data (LWP, soundings, etc.)







Silber et al. (submitted)

Putting parts together

- A polar cloud pairing
  - Arctic and Antarctic LES/SCM basic tests of supercooled cloud persistence (M-PACE CAO) and formation (AWARE decoupled stratus)
  - evaluation of ESM supercooled cloud occurrence frequency, cloud base precipitation rate vs long-term NSA and McMurdo obs
  - expect that SCM and ESM performance will be related
- Other pairings or additions?
  - warm cloud precipitation statistics at ENA (e.g., Lamer et al. 2019), ...
  - additional relationship of LES/SCM and ESM performance to ECS, MJO or other metrics

Group activities on the GCSS model

- Pros
  - reduced duplication of effort in setting up cases
  - valuable consensus-building & knowledge-sharing re cases & setup (e.g. MPACE to ISDAC)
  - can motivate and efficiently use dedicated efforts from observationalists
- Cons
  - major effort from a lead organizer who is not specifically funded
  - overhead on every group to report specified results & file formats (e.g. TWP-ICE)
- Possible changes
  - introduce community code development (e.g., to convert outputs to unified format, apply forward simulators with assumptions matched to ESM physics, plot results from multiple models vs obs)
    - use DEPHY input/output community standards for LES/SCM component (https://www.lmd.jussieu.fr/~hourdin/Workshop1Dstd.html)
  - introduce use of ARM computing resources
  - emphasize a bare minimum package of runs & diagnostics (low-overhead participation option)
  - decrease emphasis on omnibus manuscripts?
- More opening a discussion than proposing a solution

Discussion

- Need for more organized modeling activities within ASR?
  - reinstitute a model-centric focus group?
  - expand focus beyond IOPs to explicitly harness long-term (and AMF) statistics?
  - could support multiple, diverse group activities with any number of participants
- Overall approach
  - one possibility: pairing LES/SCM cases with ESM evaluation using long-term obs (diverge from relying primarily on airborne field campaigns)
    - start by identifying key uncertainties/biases in climate model physics that attract wide community interest (e.g., cloud phase)
    - then develop SCM/LES tests and use of long-term obs that target the relevant cloud types & physical processes
    - NSA and AWARE AMF? extension to COMBLE AMF? ORACES+LASIC? PBL at SGP?
  - reusable elements to lower overhead on participation
- Elements
  - LES/SCM unified framework
  - open source ground-based forward simulator codes
  - use of ARM computational resources to support model-obs evaluations