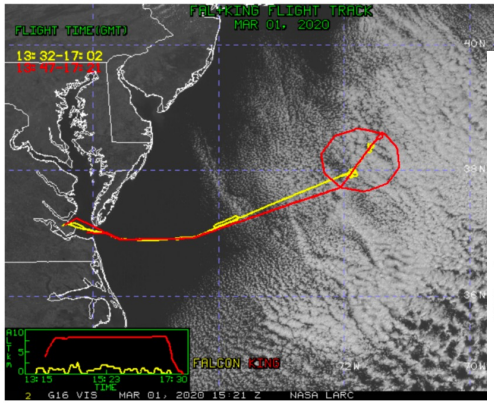
ModelE3 development approach

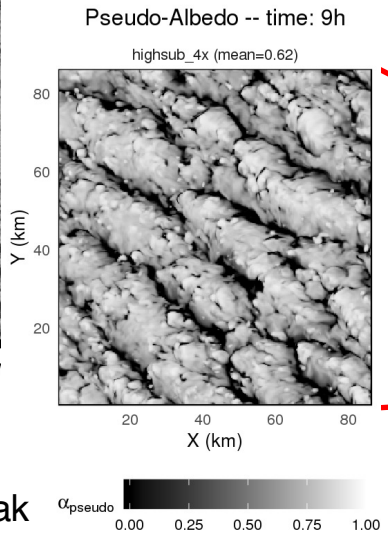
Global data → ESM tuning

Field campaigns → LES → SCM

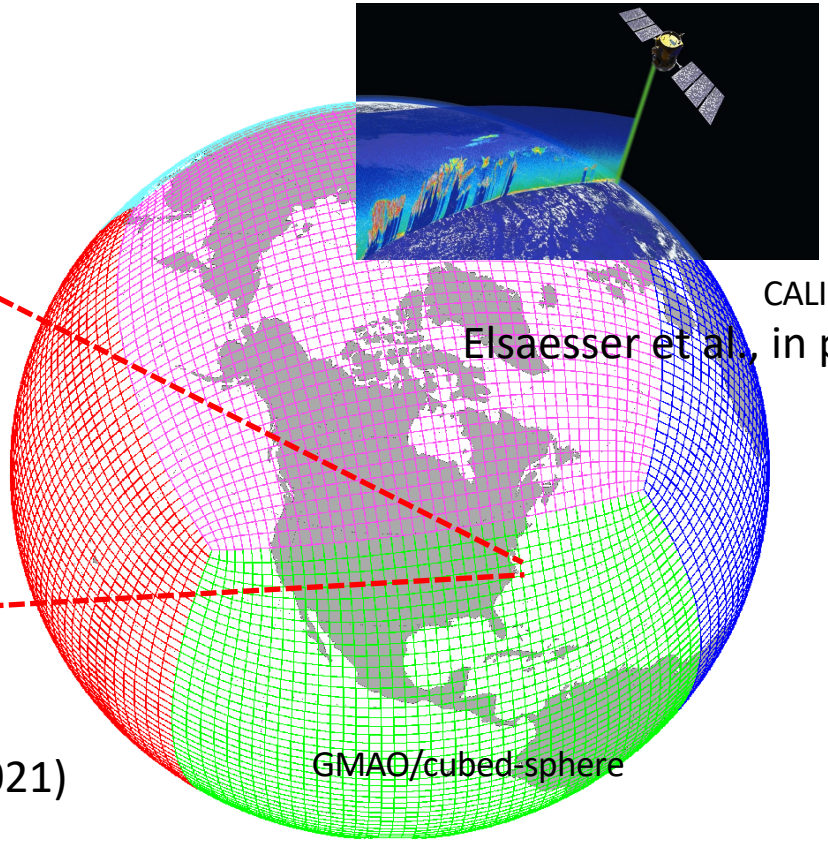


From https://satcorps.larc.nasa.gov

ACTIVATE Flight RF13
1 March 2020
mixed-phase cold-air outbreak



Tornow et al. (ACP 2021)



CALIPSO

Elsaesser et al., in prep.

GMAO/cubed-sphere

Field campaigns —> LES —> Single-column model (SCM)

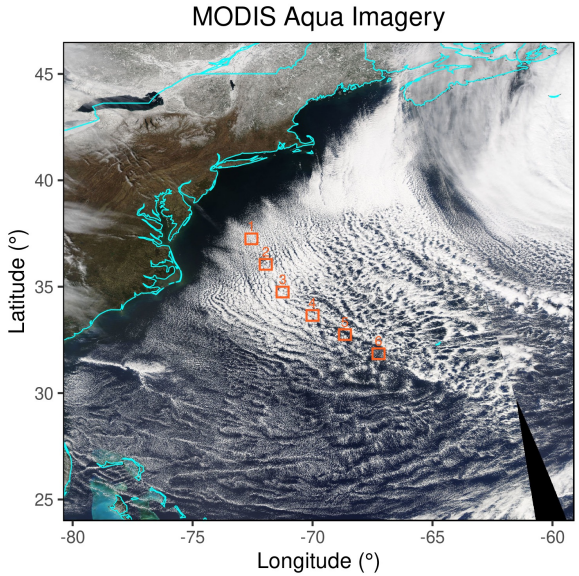
Conditions	Case study	Aerosol aware?
dry convective boundary layer	idealized [Bretherton and Park 2009]	—
dry stable boundary layer	GABLS1 [Cuxart et al. 2006]	—
marine stratocumulus	DYCOMS-II RF02 [Ackerman et al. 2009]	observed (2 modes)
marine trade cumulus (shallow)	BOMEX [Siebesma et al. 2003]	no
marine trade cumulus (deep, raining)	RICO [van Zanten et al. 2011]	no
marine stratocumulus-to-cumulus *	SCT [Sandu and Stevens 2011]	no
continental cumulus ^	RACORO [Vogelmann et al. 2015]	observed profile (3 modes)
Arctic mixed-phase stratus	M-PACE [Klein et al. 2009]	observed (2 modes)
Antarctic mixed-phase stratus *	AWARE [Silber et al. 2019, 2021, 2022]	estimated (1 mode)
tropical deep convection	TWP-ICE [Fridlind et al. 2012]	observed profile (3 modes)
mid-latitude synoptic cirrus *	SPARTICUS [cf. Mühlbauer et al. 2014]	no
mid-latitude cold-air outbreak *^	ACTIVATE [Tornow et al., 2021, 2022, in prep.]	observed profile (3 modes)
high-latitude cold-air outbreak *^	COMBLE [Tornow et al., in prep.]	observed/estimated profiles (3 modes w/INP)
marine cumulus and congestus *^	CAMP2Ex [Stanford et al., in prep.]	observed profiles (3 modes)
subtropical marine deep convection *^	SEAC4RS [Stanford et al., in prep.]	observed profiles (TBD)
continental sea breeze convection *^	TRACER [Matsui et al., in prep.]	observed profiles (TBD)

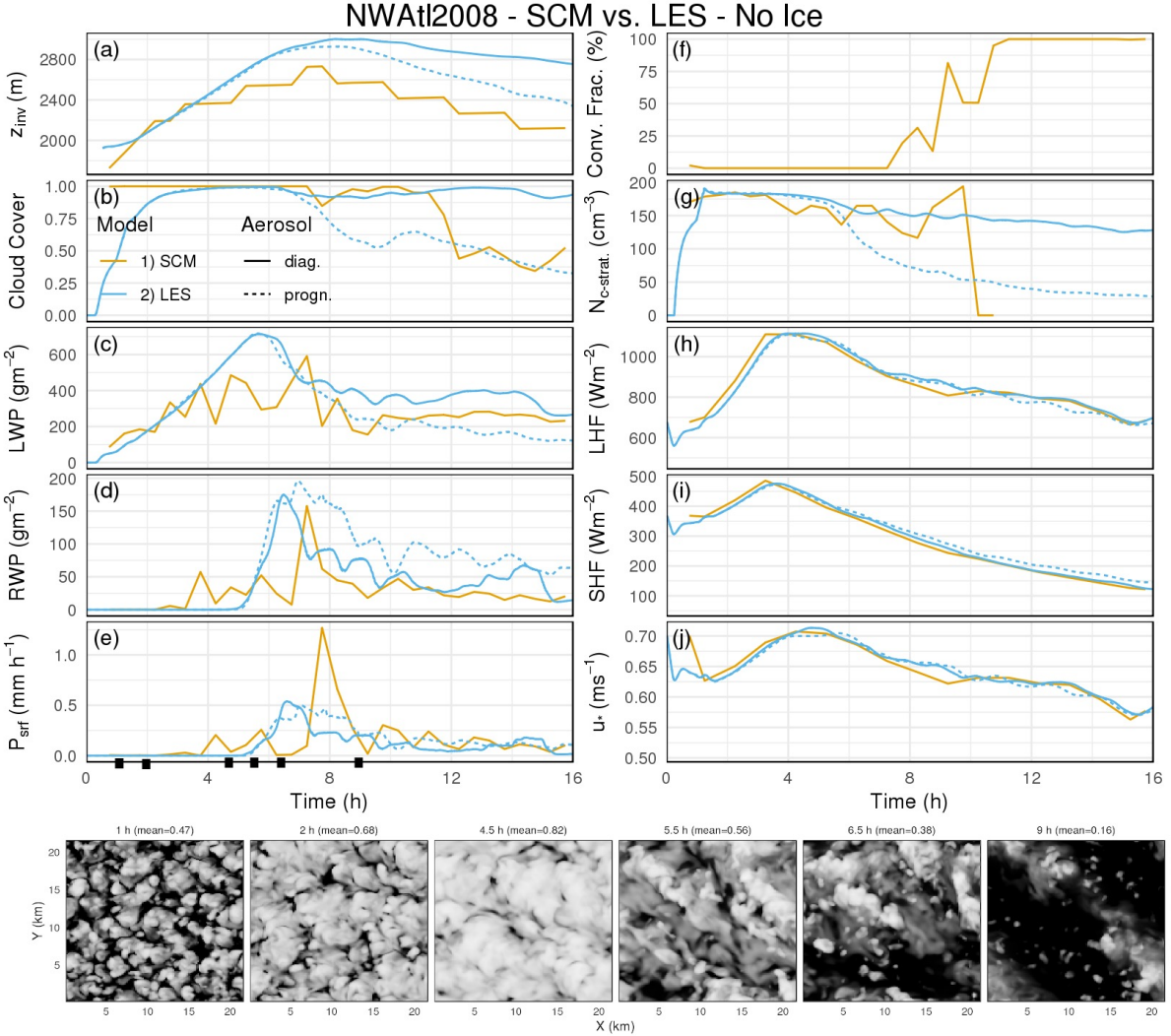
*Lagrangian (cf. Neggers JAMES 2015, Pithan et al. NatGeo 2019)

^ensemble (cf. Neggers et al. JAMES 2019)

NASA ACTIVATE

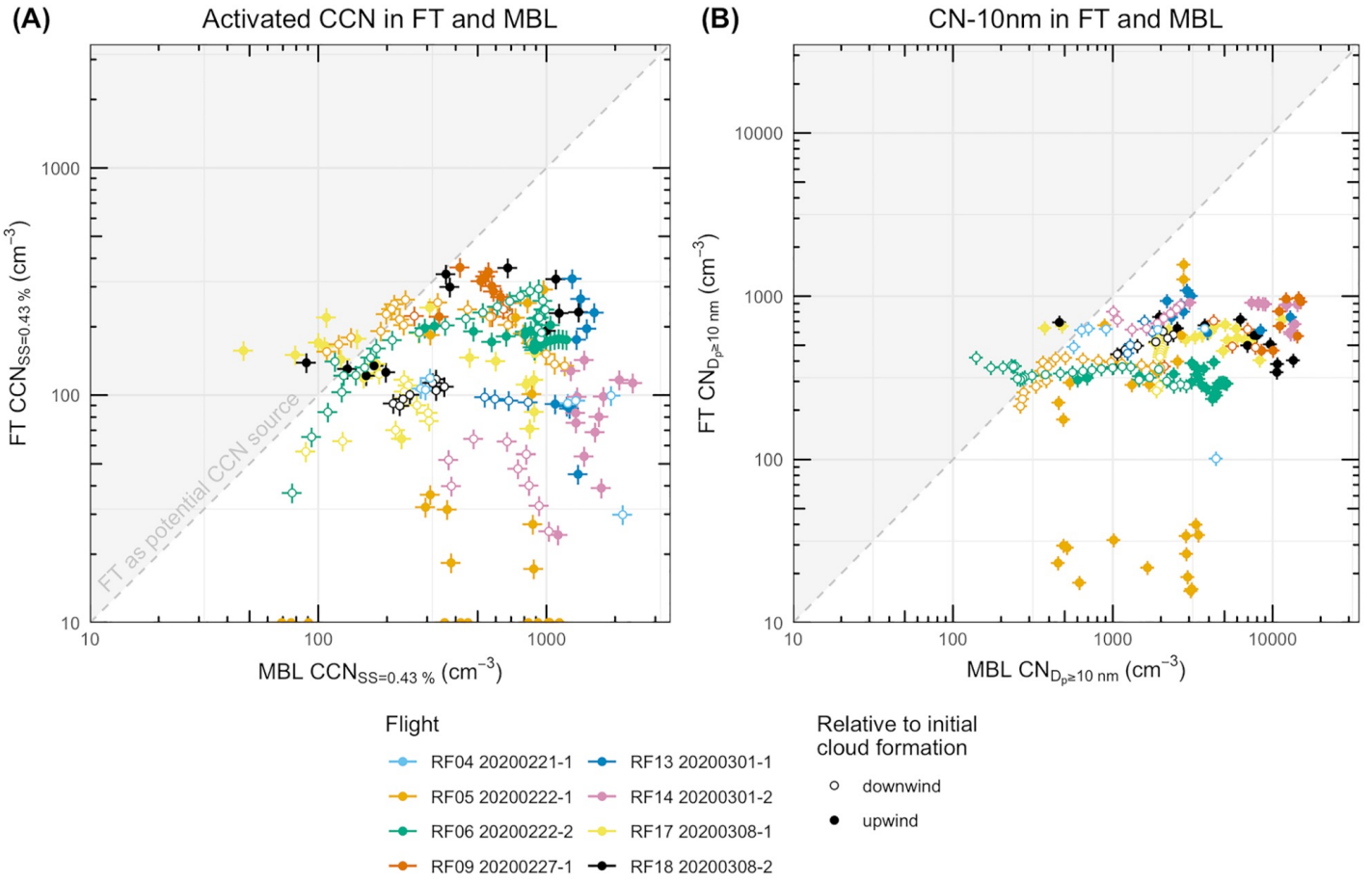
- riming consumes CCN [Tornow et al. ACP 2021]
- applicable to grey zone [de Roode et al. 2019]





ACTIVATE

- entrainment of FT air reduces CCN in the MBL [Tornow et al. GRL 2021]



Stony Brook University
School of Marine and Atmospheric Sciences

1 2 3 4 5 6

AEROICESTUDY: An ARM Southern Great Plains Pilot Study to Assess a Field-Observational Approach to Conduct Aerosol-Ice Formation Closure

Knopf, D. A., Barry, K. R., Brubaker, T. A., Jahl, L. G., Jankowski, K. A., Li, J., Lu, Y., Monroe, L. W., Moore, K. A., Rivera-Adorno, F. A., Sauceda, K. A., Shi, Y., Tomlin, J. M., Vepuri, H. S. K., Wang, P., Lata, N. N., Levin, E. J. T., Creamean, J. M., Hill, T. C. J., China, S., Alpert, P. A., Moffet, R. C., Hiranuma, N., Sullivan, R. C., Fridlind, A. M., West, M., Riemer, N., Laskin, A., DeMott, P. J., Liu, X.

U.S. DEPARTMENT OF ENERGY

Knopf et al. (BAMS 2021)

ASR Atmospheric System Research

Goals and Objectives

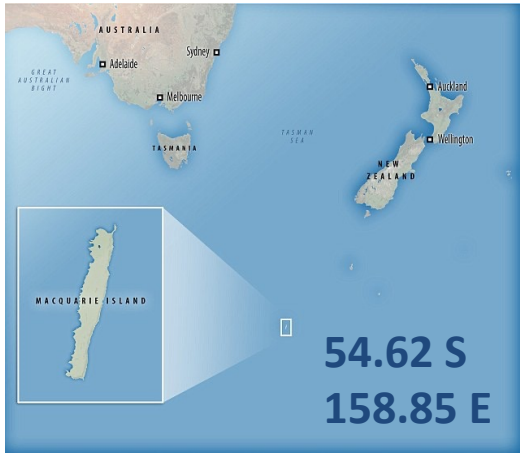
- ***Identify ice nucleation parameterizations that produce the most robust predictions of INP number concentrations.***
- ***What are the crucial aerosol physicochemical properties to guide ice nucleation representations in models and long-term INP measurements?***
- ***What level of parameter details needs to be known to achieve aerosol-INP closure?***
- ***What are the leading causes for climate model bias in INP predictions?***

➡ **Apply ambient aerosol to evaluate the aerosol composition-INP relationship.**

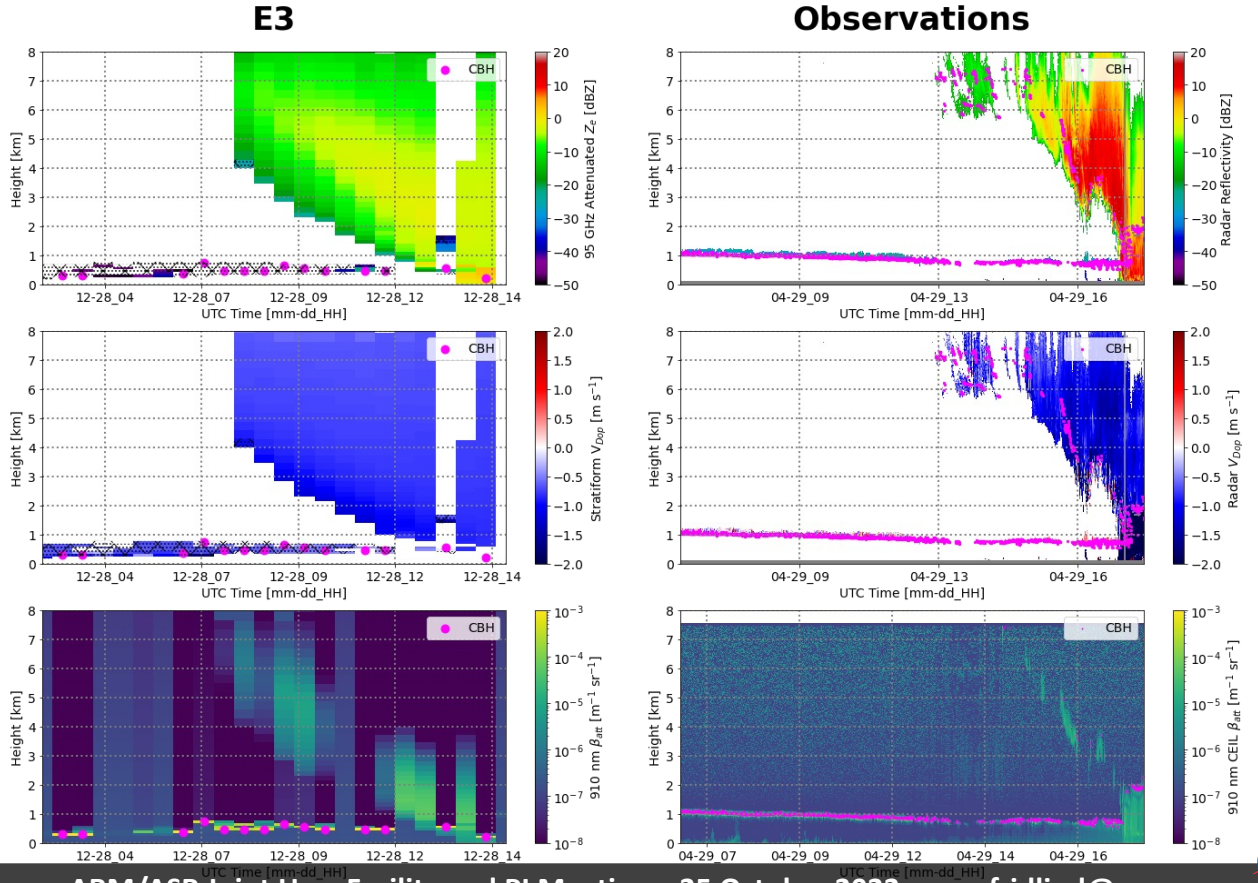
A feasible integrated data set for model development?

- a survey of <post-frontal clouds> suitable for an aerosol-aware Lagrangian ensemble of case studies (cf. ACTIVATE and COMBLE)
  - explicit focus on unconstrained processes that limit confidence in all models
  - rain and ice formation mechanisms in well-defined aerosol/cloud regimes, ...
  - long enough to attract aircraft participation? EVS-4? (cf. CAMP2Ex RSP)
- simultaneous constraints on thermodynamics, aerosol, cloud
  - frequent soundings (MBL stability, entrained air properties)
  - liquid water path (including raining conditions; arguably most important?)
  - cloud base droplet number concentration (Leipzig group lidar approach?)
  - full aerosol PSD (supermicron, modal kappa, composition, lidar closure?)
    - within MBL and above MBL (several size cuts with UAV?)
  - ice nucleating particle measurements and INP composition via filter
    - suitable for closure analysis (cf. AEROICESTUDY)
  - radar with Doppler spectra, HSRL, ice crystal properties (UAV imagery? MASC-like?)

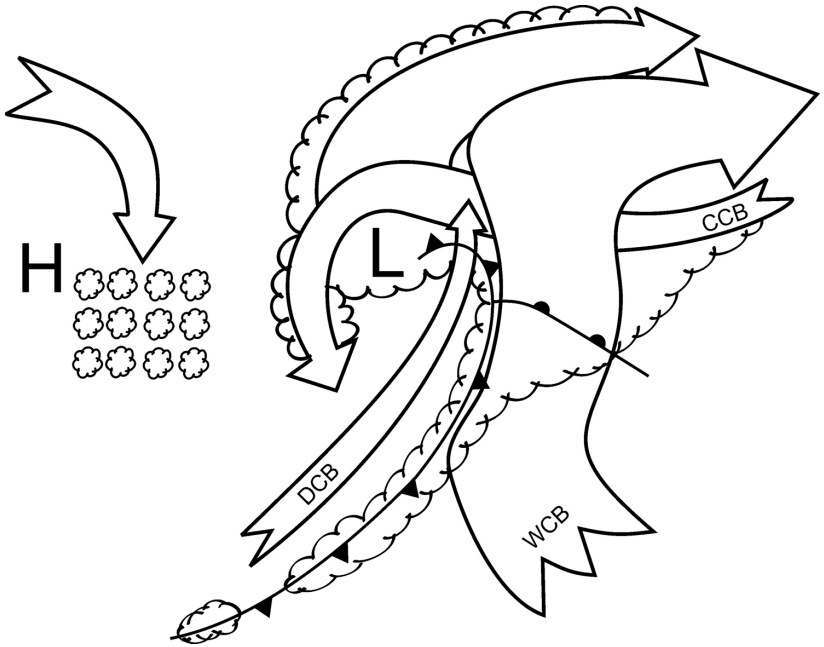
ModelE3 vs obs using EMC² [Silber et al. GMD 2022]



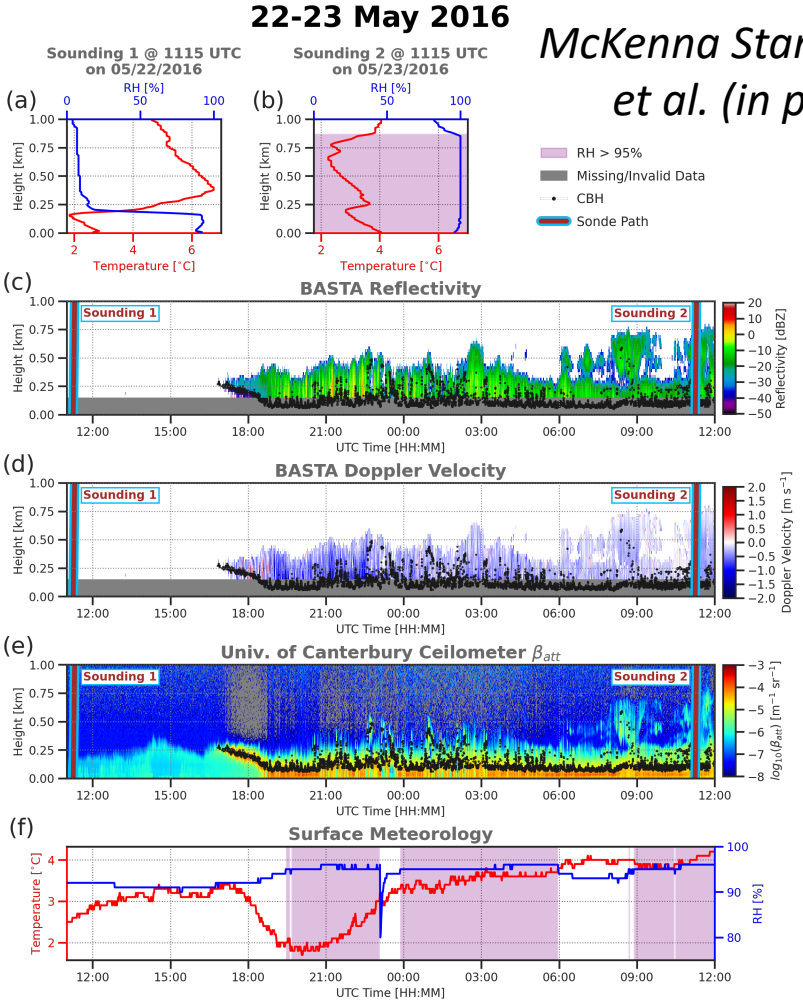
source:
McKenna Stanford et al. (in prep.)



Fog during MICRE



Tselioudis and Grise (2020)



McKenna Stanford et al. (in prep.)