Developing an Analysis Framework for Evaluating Boundary-Layer Clouds Associated with Midlatitude Synoptic Systems in NRL COAMPS

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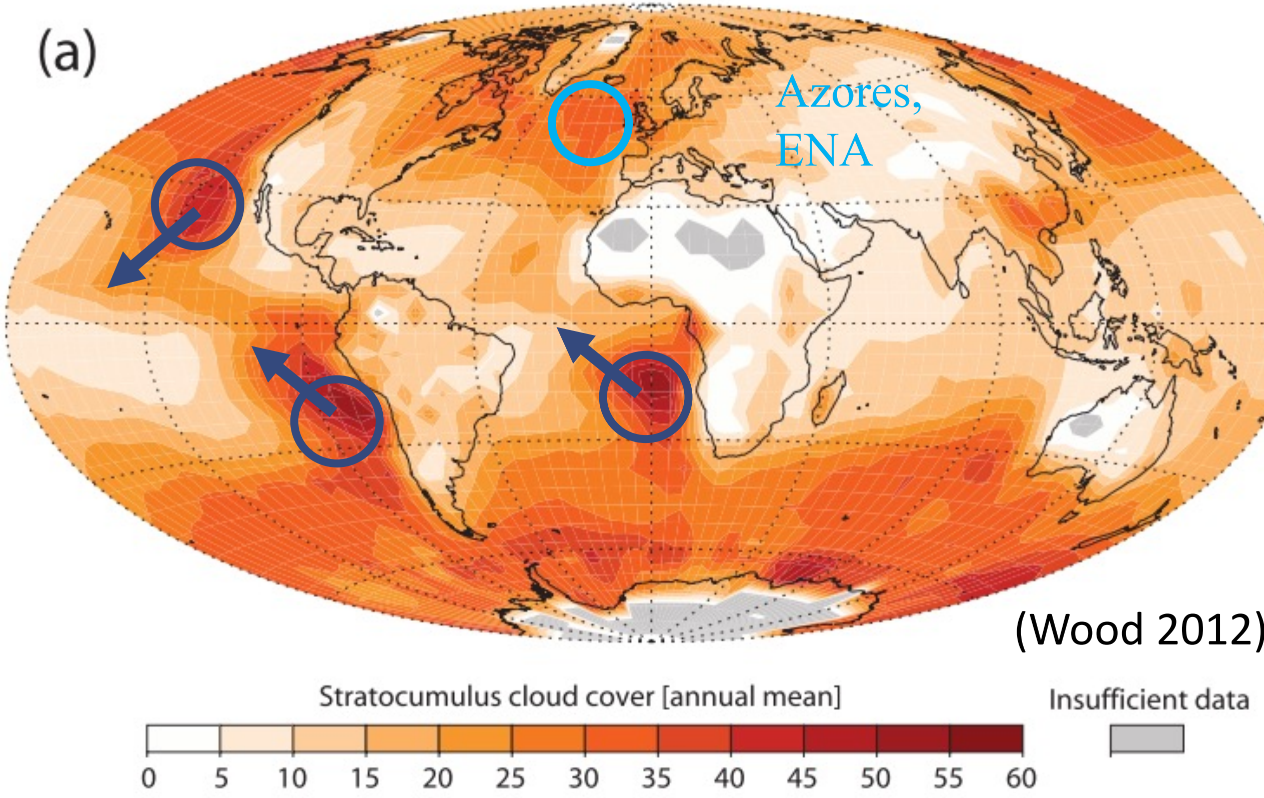
Marine low clouds and cloudiness transitions



(Wood 2012)

Warming–deepening mechanism
(Fig. 10, Wyant et al. 1997)

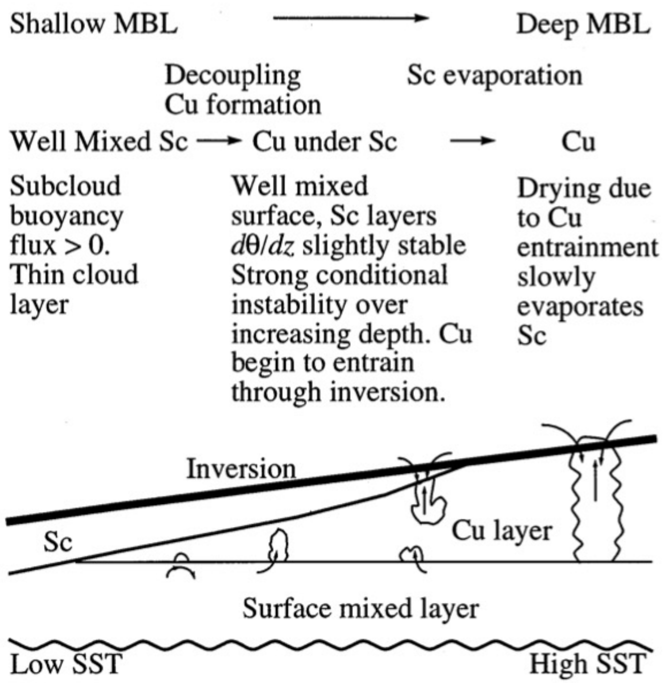
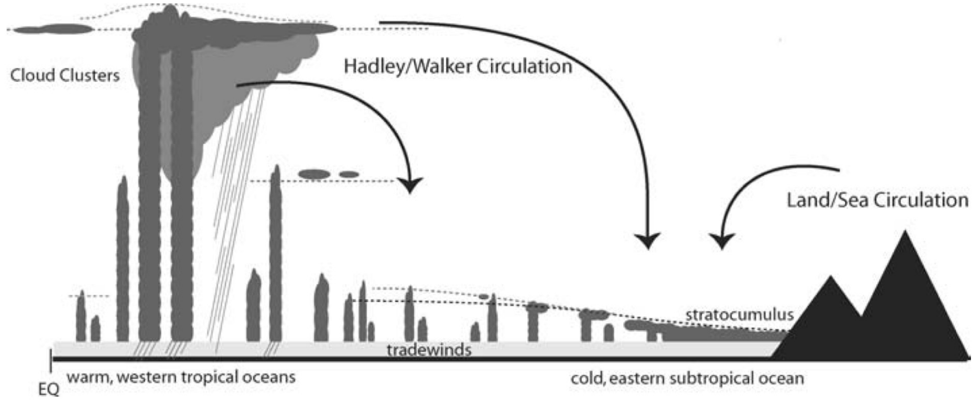
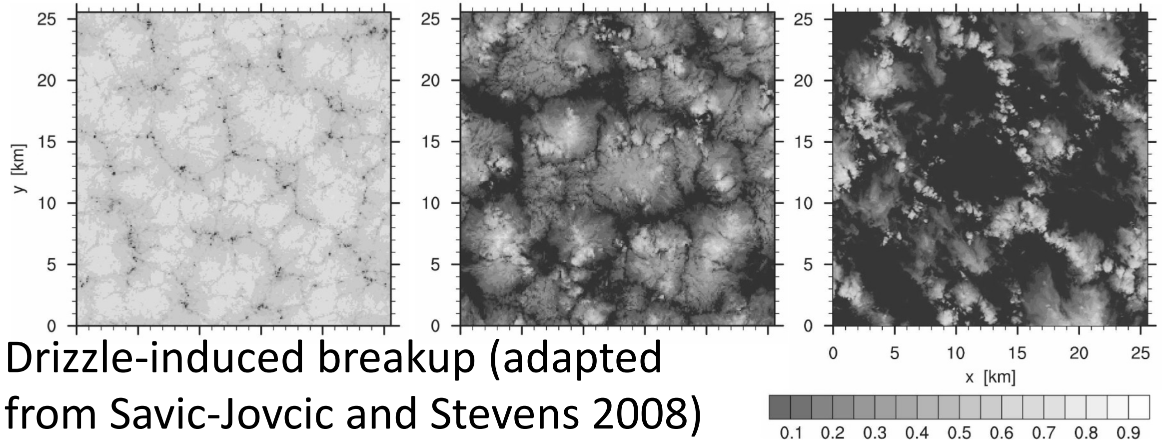


FIG. 10. A conceptual diagram of the STCT.

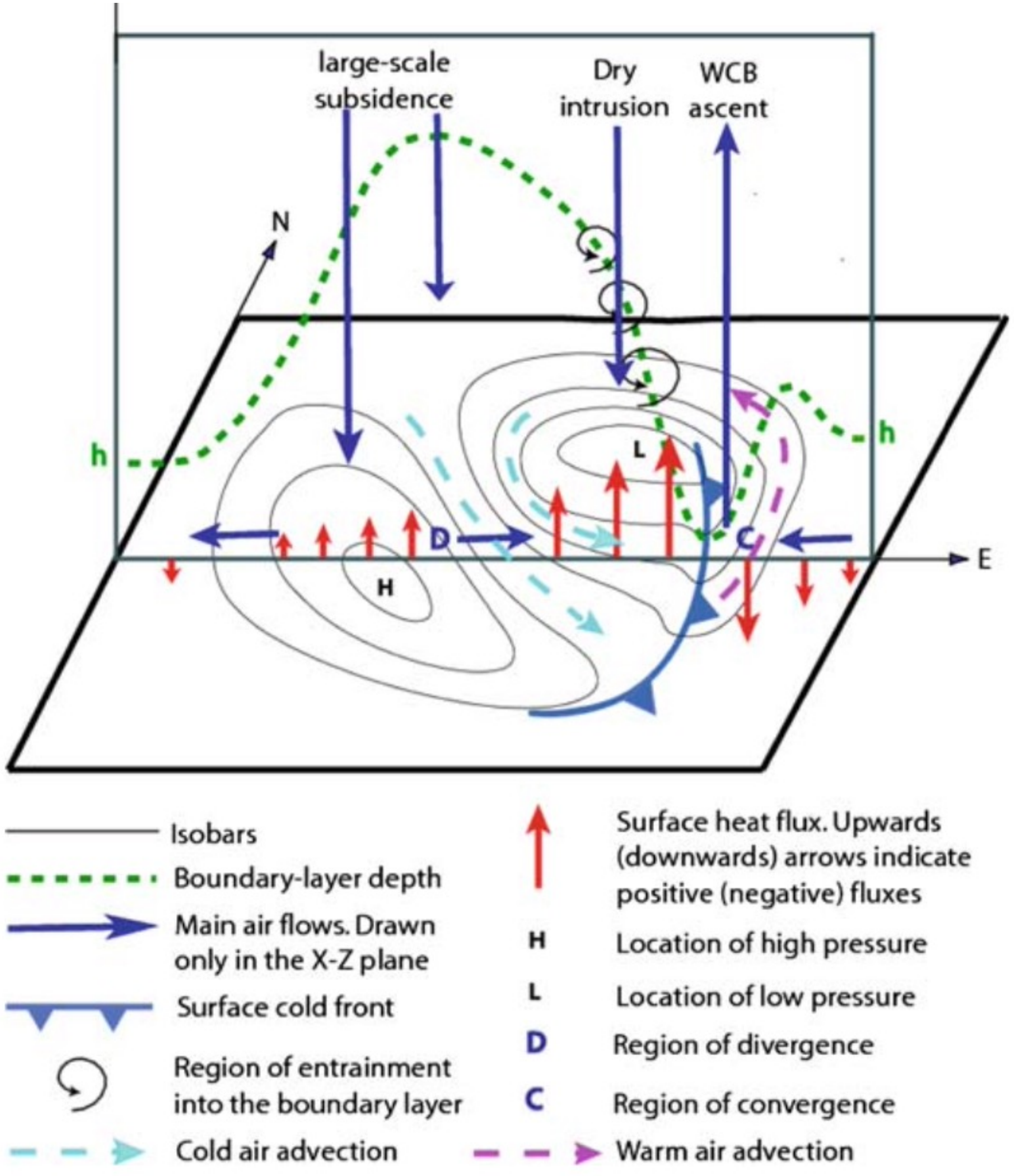


(Stevens 2005)

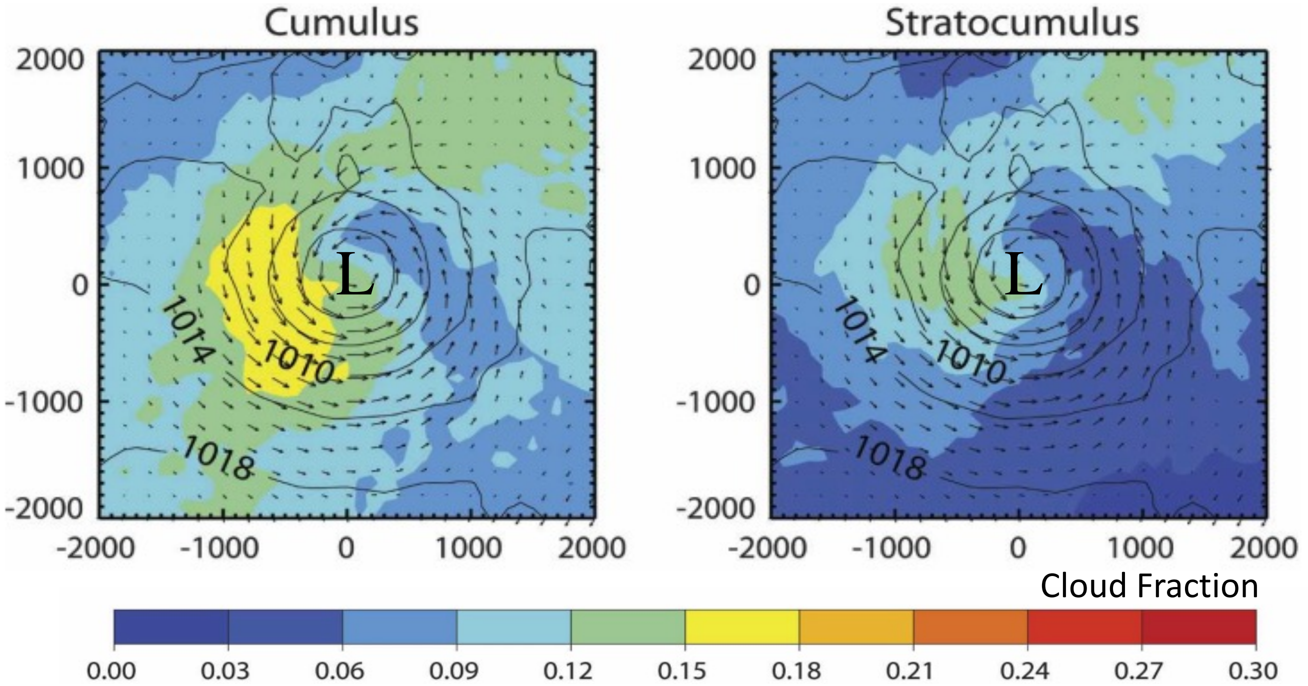


Drizzle-induced breakup (adapted from Savic-Jovcic and Stevens 2008)

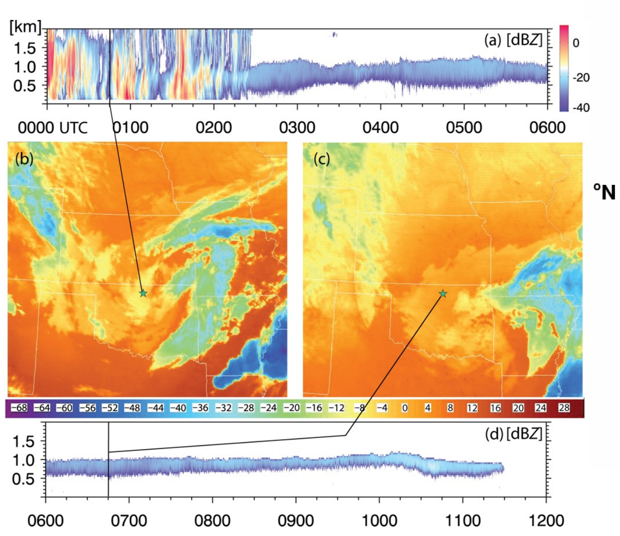
Cloudy boundary layers associated with synoptic systems

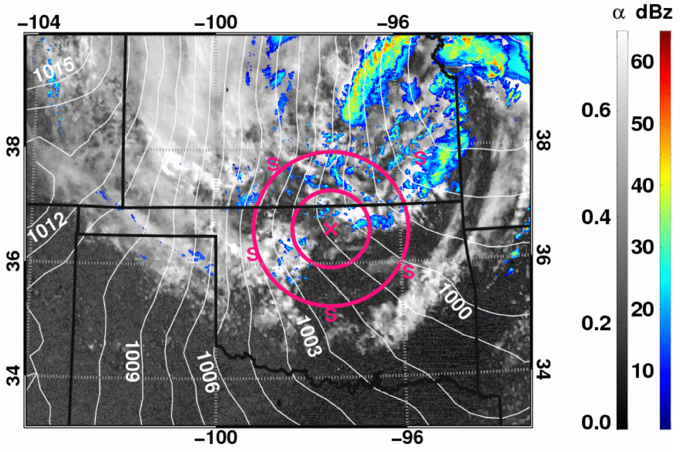


(Sinclair et al. 2010)



(Field and Wood 2007)





(Mechem et al. 2010; Mechem and Giangrande 2018)

In short,

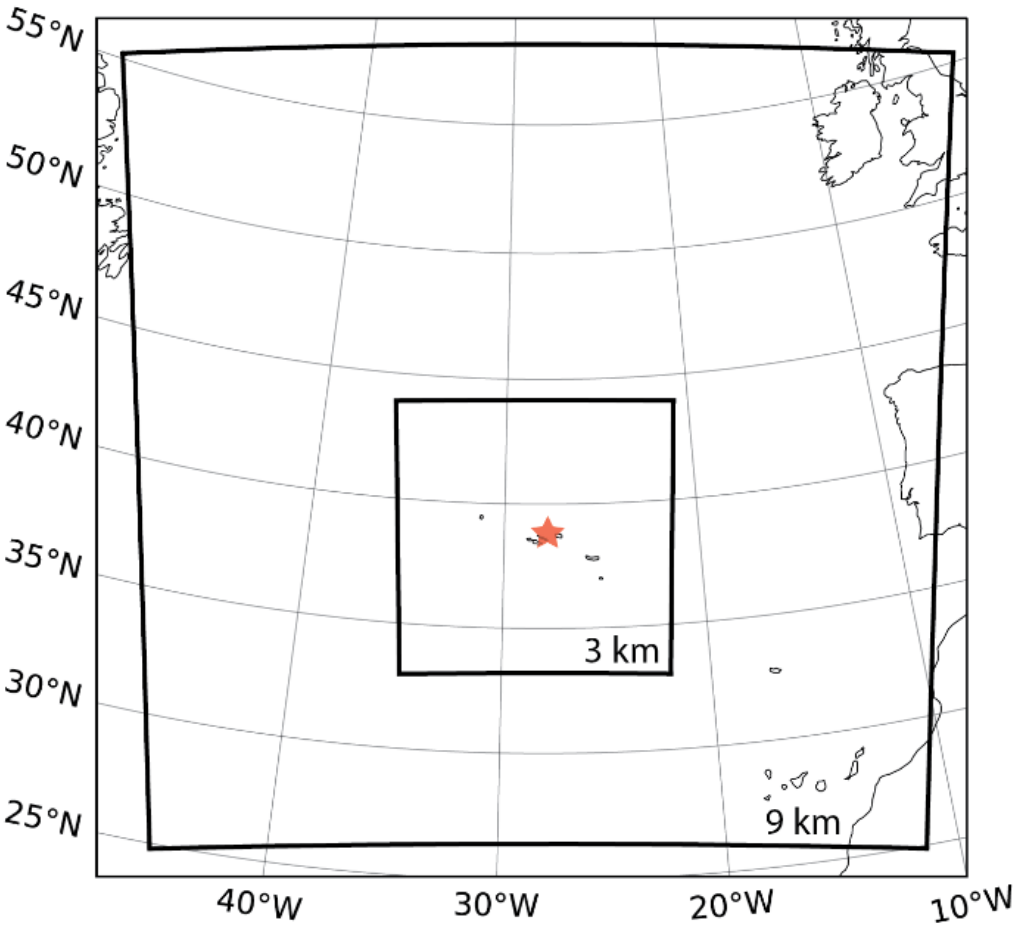
- We don’t have a good conceptual model of synoptically influenced boundary-layer clouds
- We don’t really know how well (or poorly) models handle them

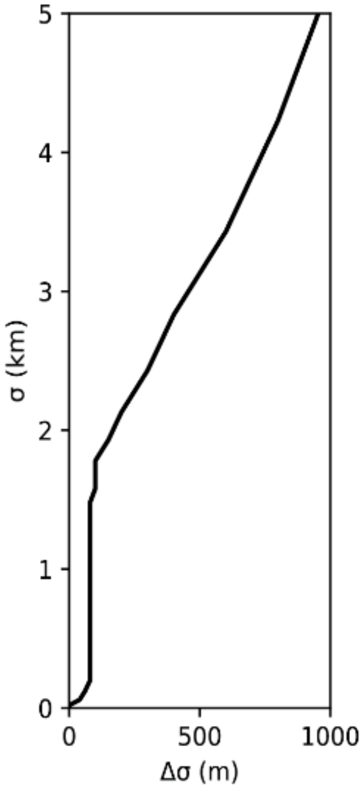
Project goals:

- Employ our knowledge base of MBL clouds and cloudiness transitions in idealized settings to improve fundamental understanding of synoptic low cloudiness and improve its representation in regional models
- Develop a synoptic-relative framework to evaluate models against observations
- Develop/evaluate parameterization improvements to better represent microphysical processes (subgrid-scale variability, aerosol load, small-droplet sedimentation) for improved operational forecasts

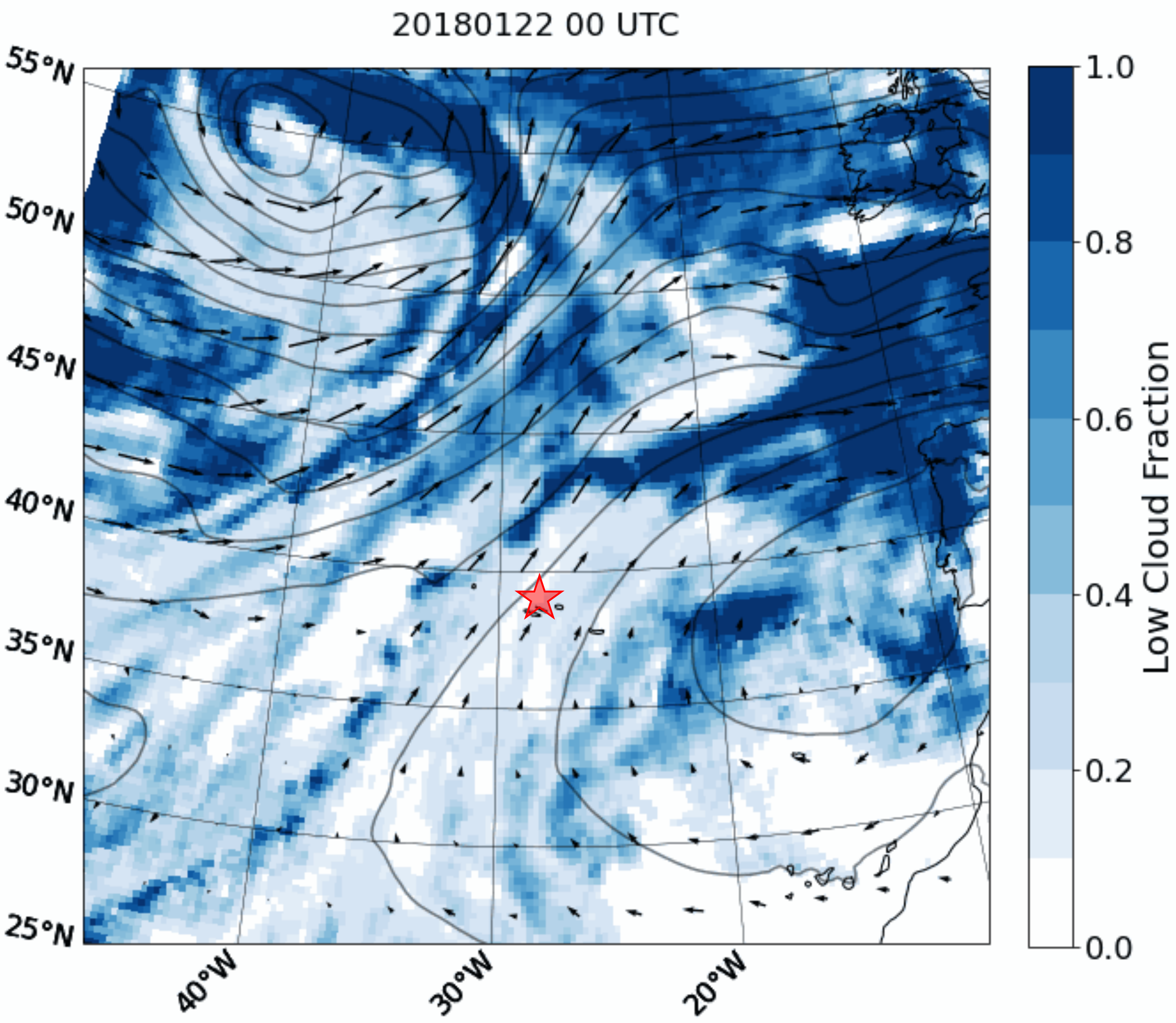
Baseline experimental configuration

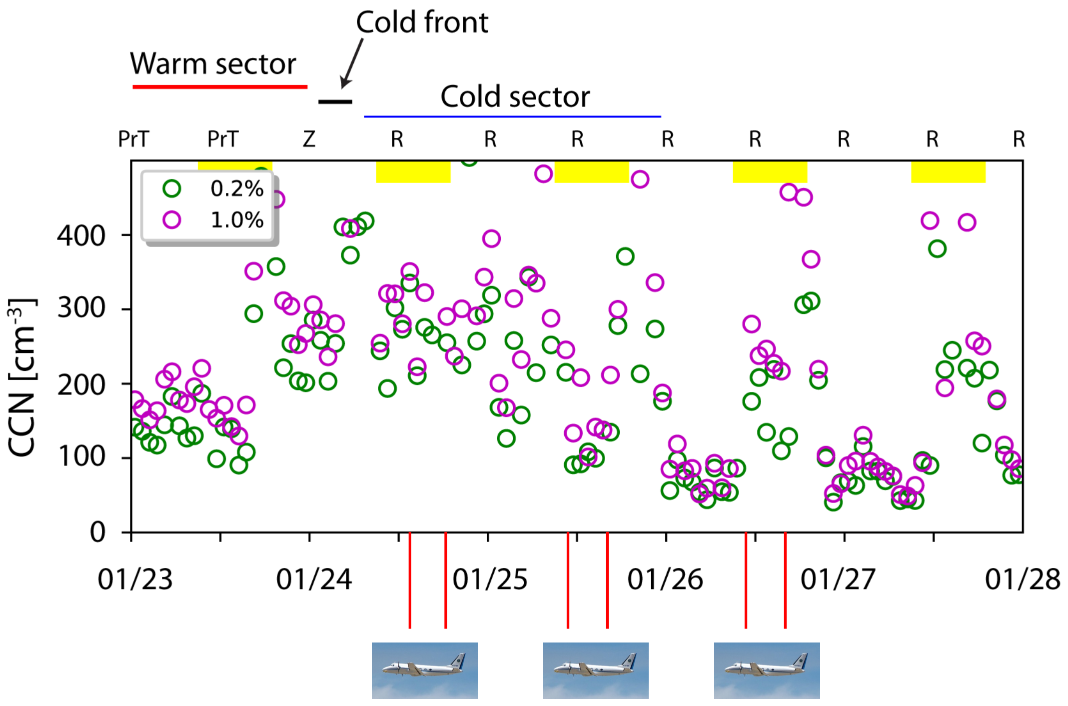
- Naval Research Laboratory's COAMPS (v5.2.2)
- Doubly nested domain over the Eastern North Atlantic:
  - 9 km, 384×384 points, 10 s
  - 3 km, 397×397 points, 3.33 s
- Δz=20–80 m in boundary layer and 100–1000 m above
- Mellor-Yamada level-2.5 PBL parameterization
- Single-moment microphysics (stock, KK2000 'lite')
- Tiedtke (1988) shallow cumulus





22-28 Jan 2018 period





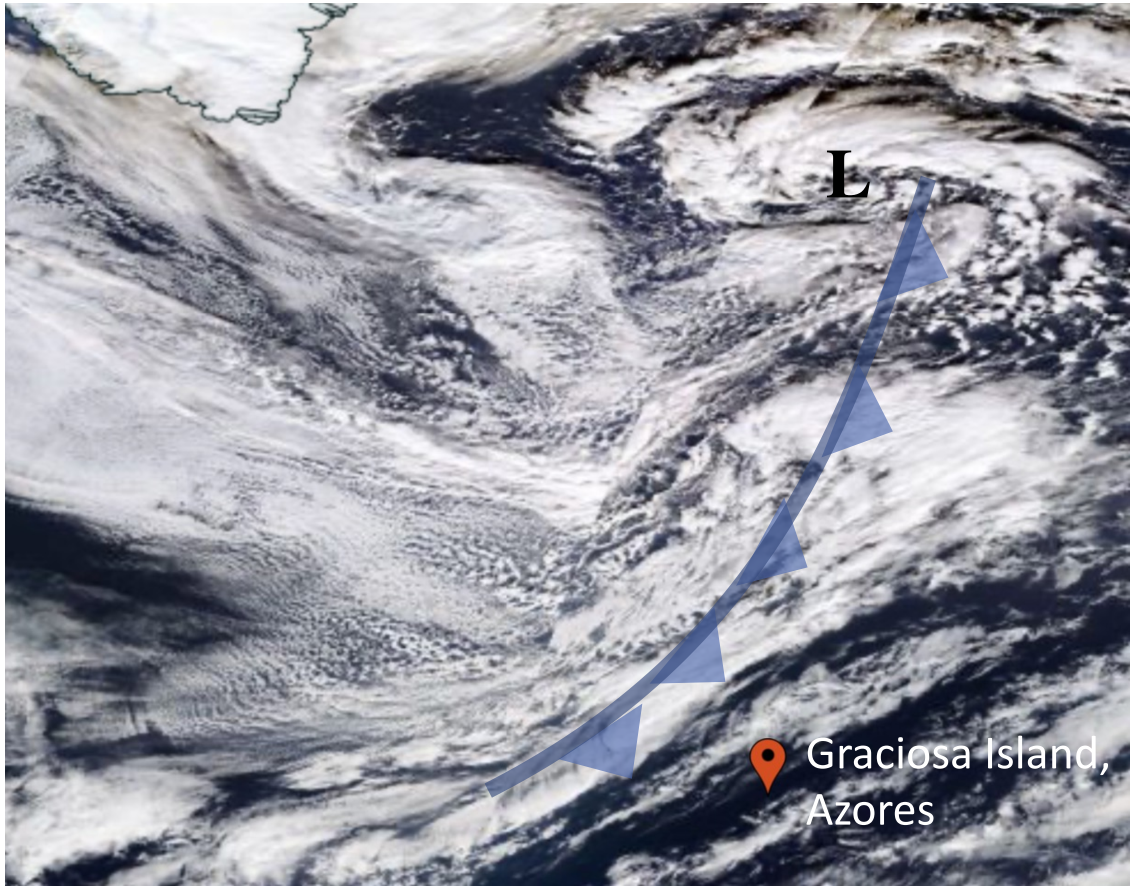
ACE–ENA IOP2 G-1 flights:

24 Jan 2018	1252–1654 UTC
25 Jan 2018	1100–1449 UTC
26 Jan 2018	1102–1504 UTC

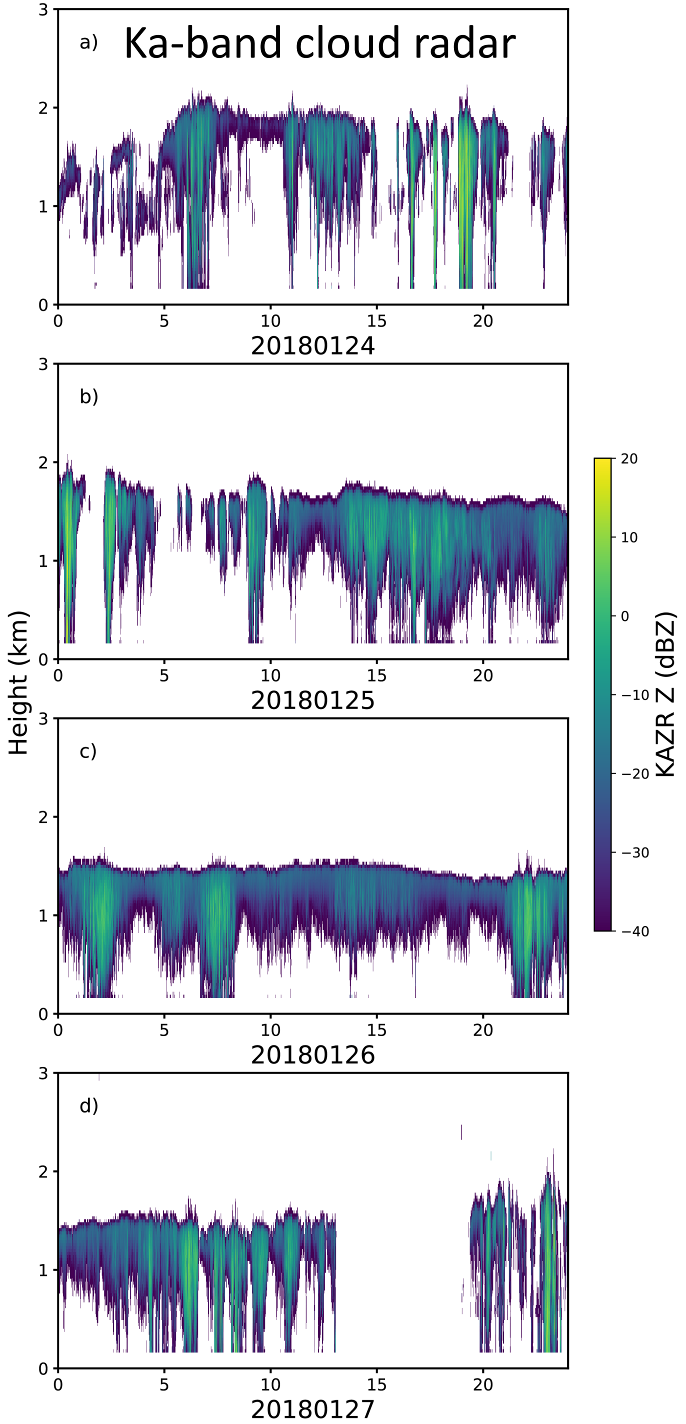
7 case-study periods (3 winter, 4 summer)

- Case 1: 144-h COAMPS simulation 22–29 Jan2018, with 24-h spin-up period and 2 DA cycles
- Wintertime cyclone impacting the Azores during ACE–ENA IOP2 field campaign

- Cold front passes Azores at 0600 UTC on 24 Jan 2018



2018–01–23, Terra/MODIS



Point-comparisons between COAMPS and Azores observations

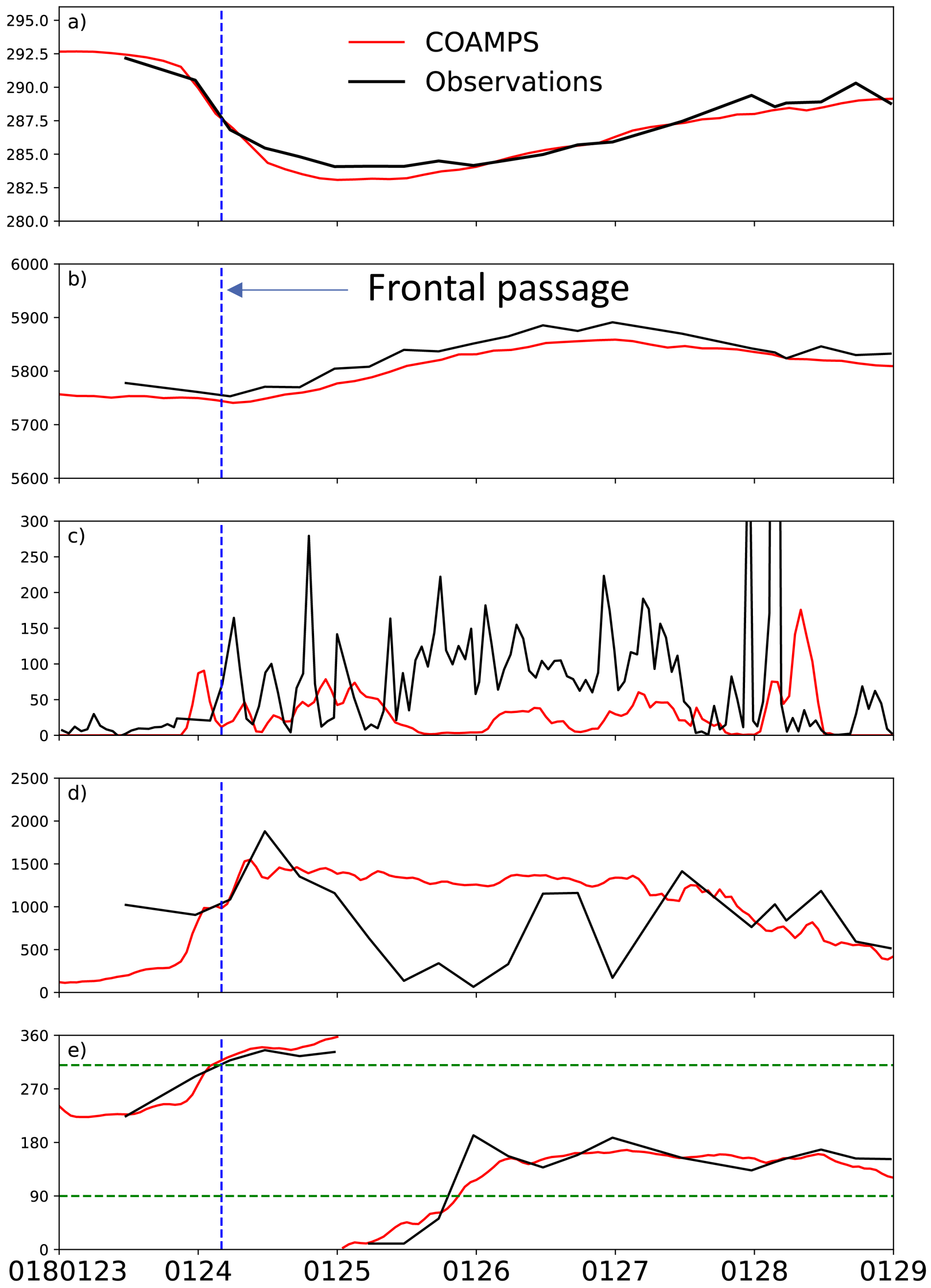
1000 m Potential Temperature (K)

500 hPa Height (m)

LWP (g m^{-2})

PBL Height (m)

1500 m Wind Direction (º)



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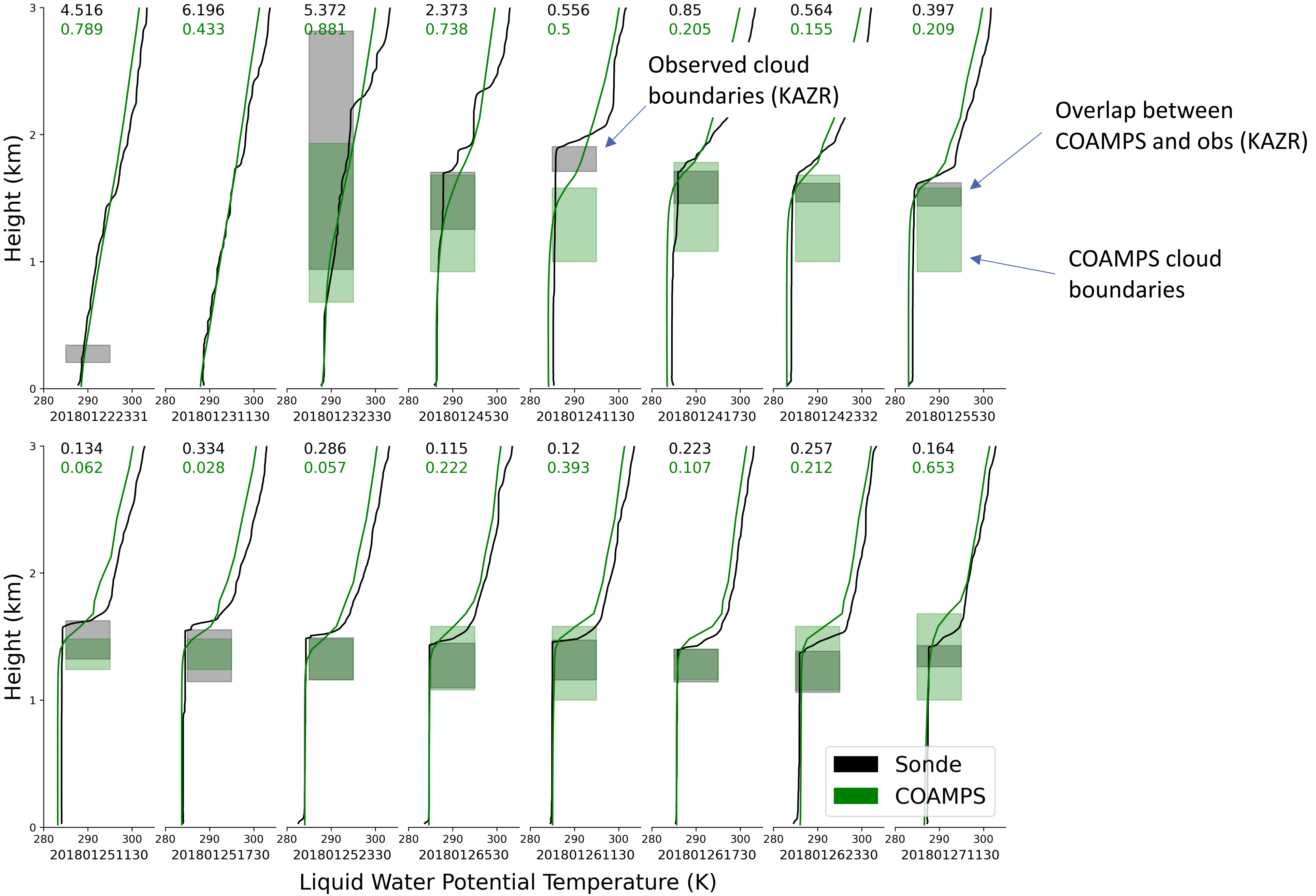
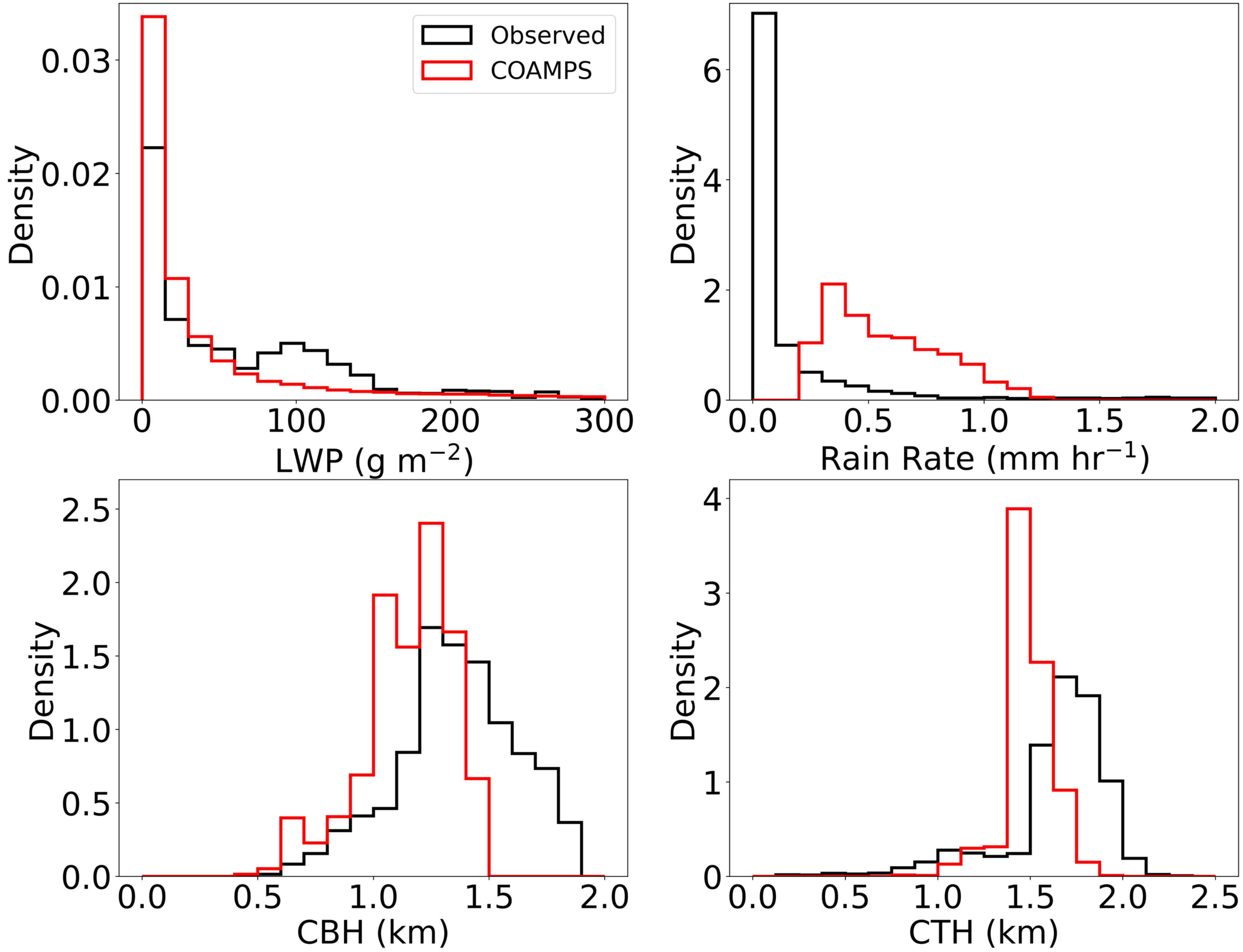


Distributions of MBL and cloud properties (COAMPS and Graciosa Island)



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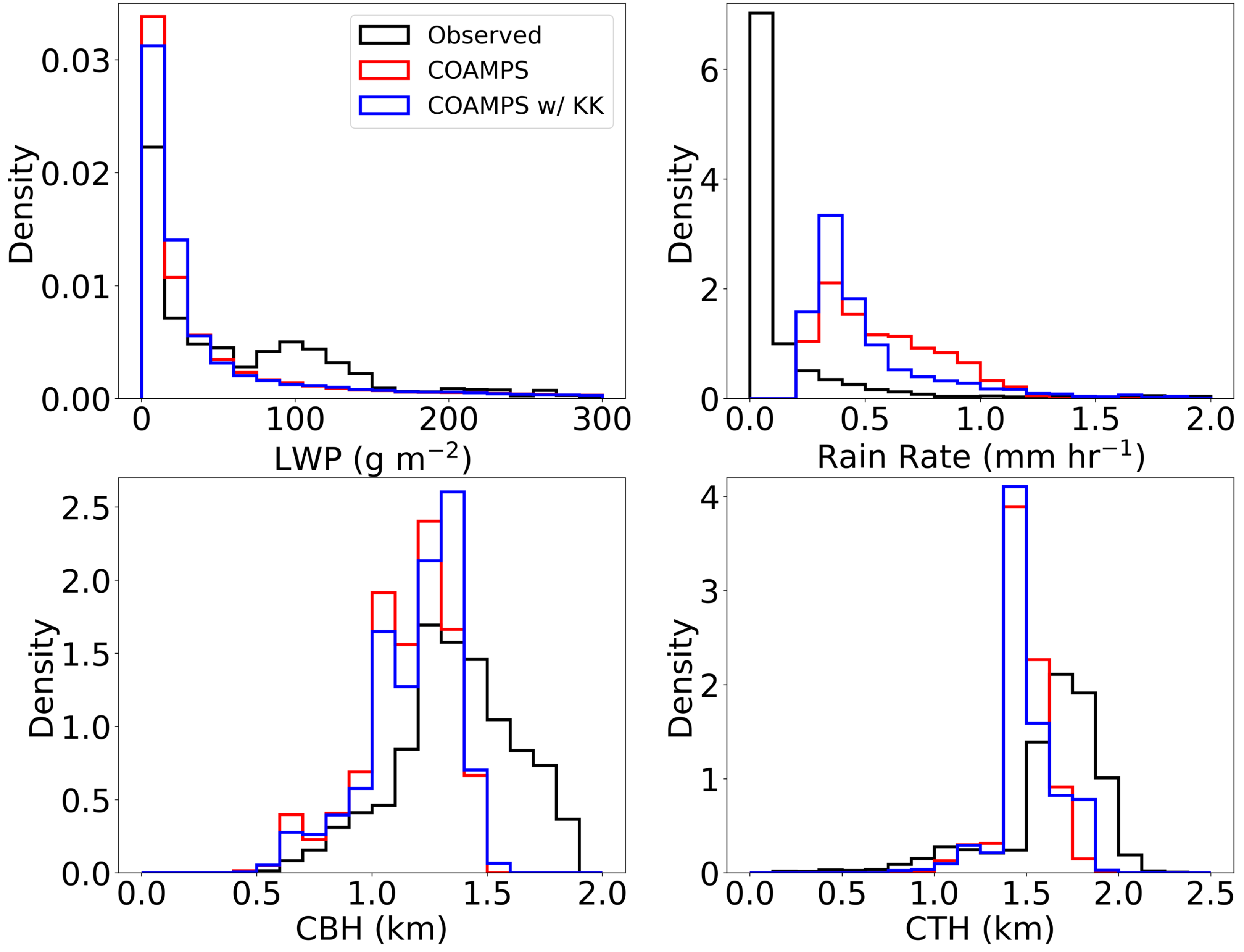
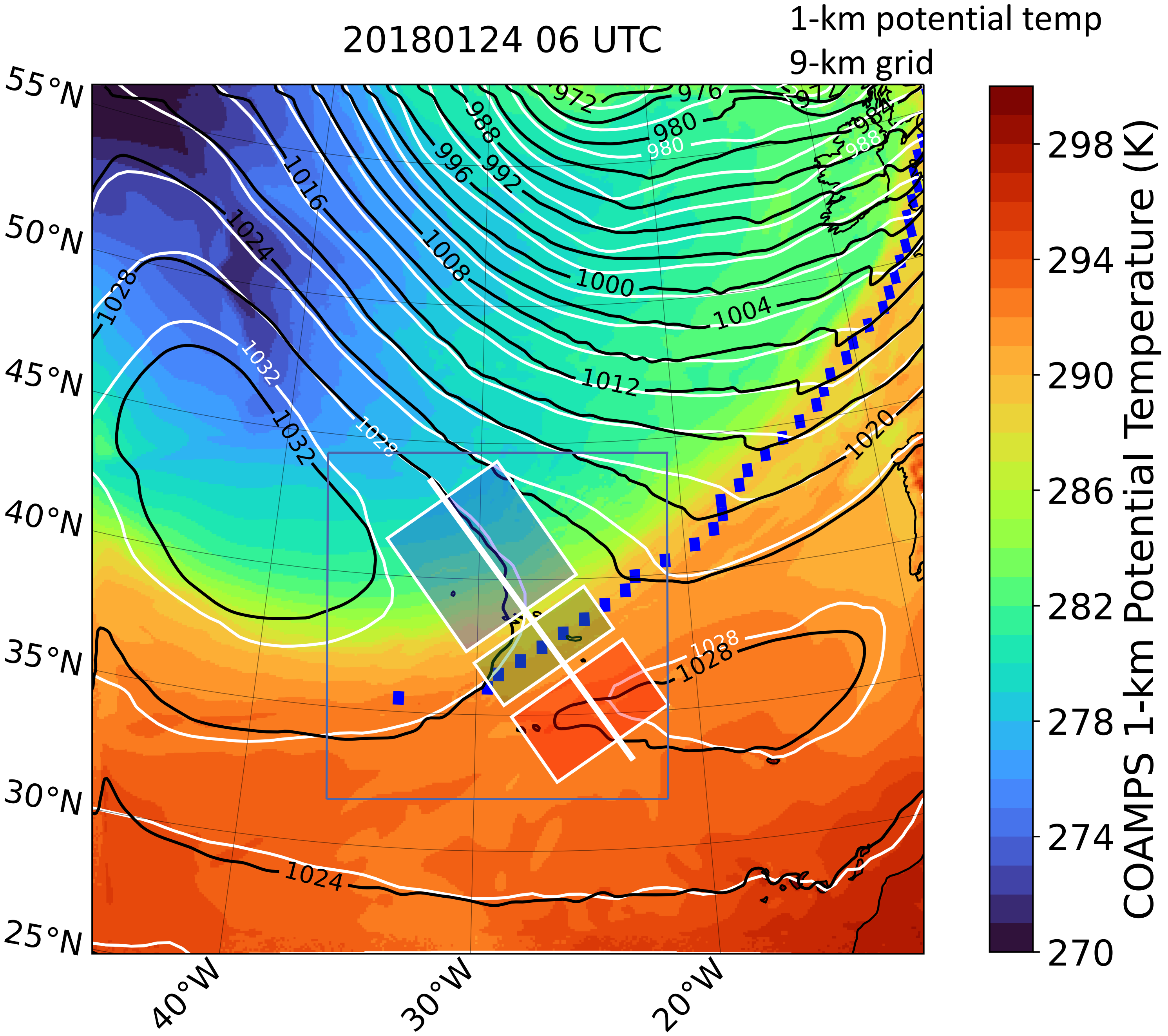
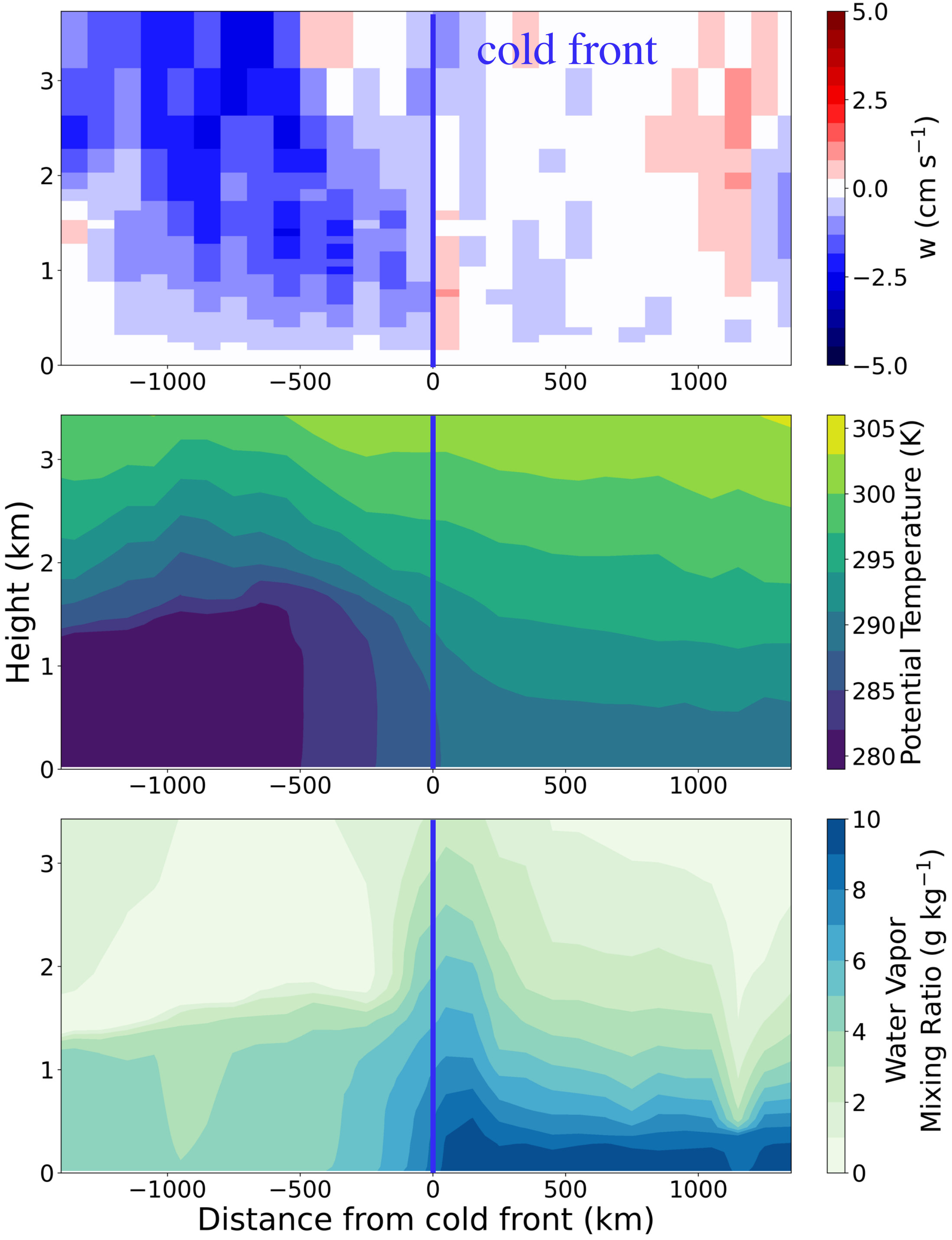


System-relative analysis framework

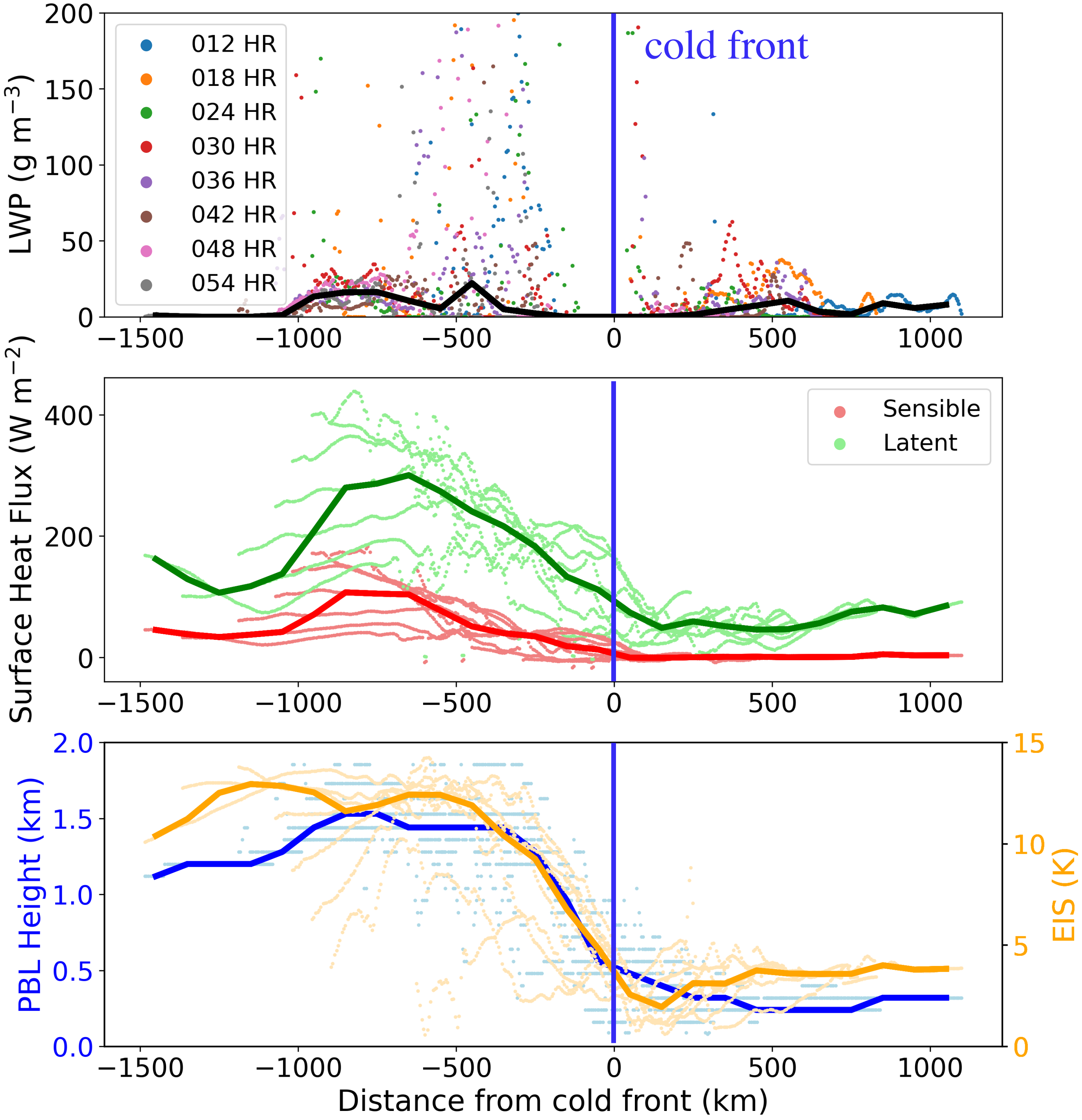
- Naud et al. (2016) frontal identification algorithm applied to COAMPS output
- COAMPS cold front compares well to ERA5
- COAMPS meteorology compares well with ERA5 (black and white SLP contours)



Composite of vertical cross-sections taken across the cold front

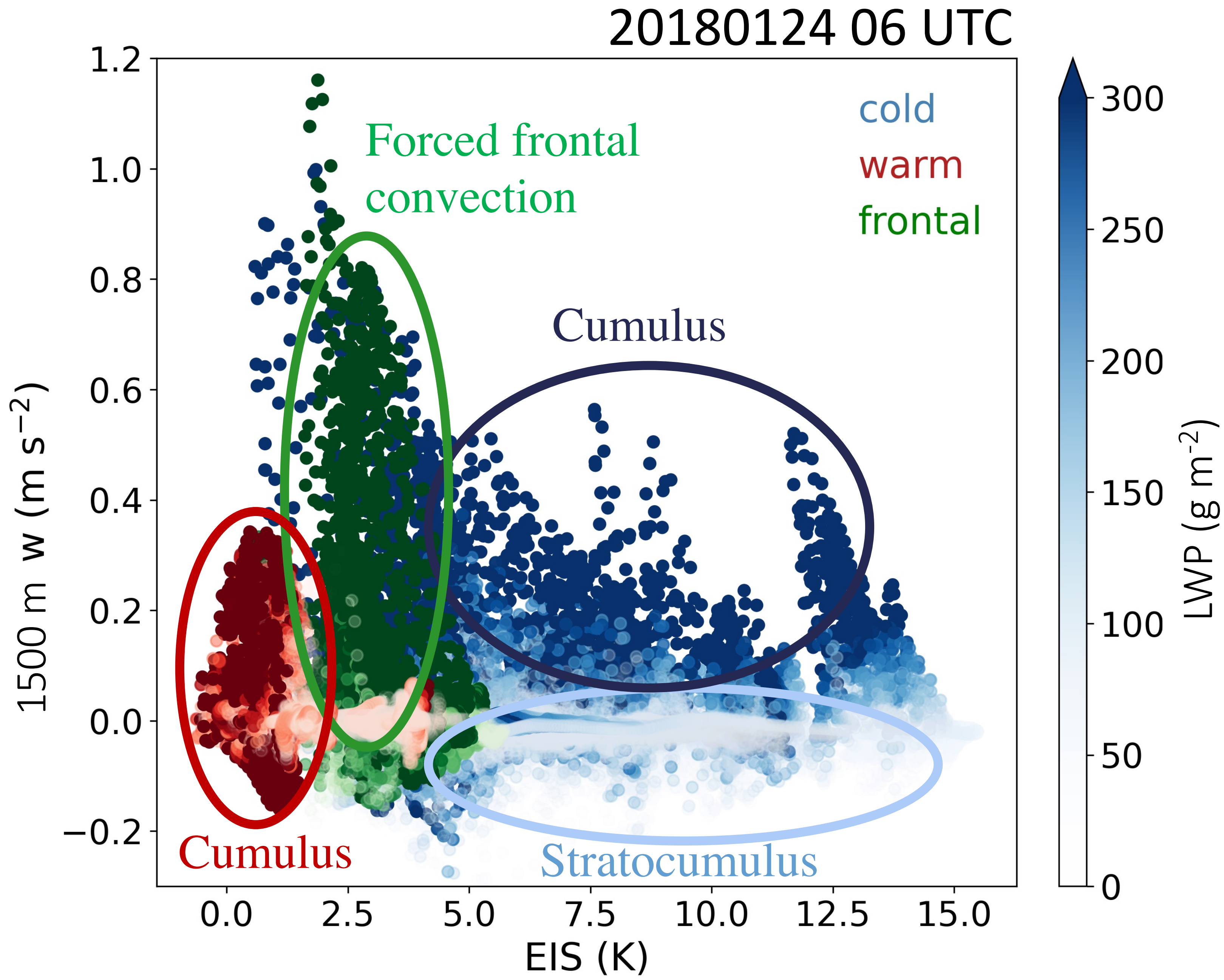


Composite transects across the cold front

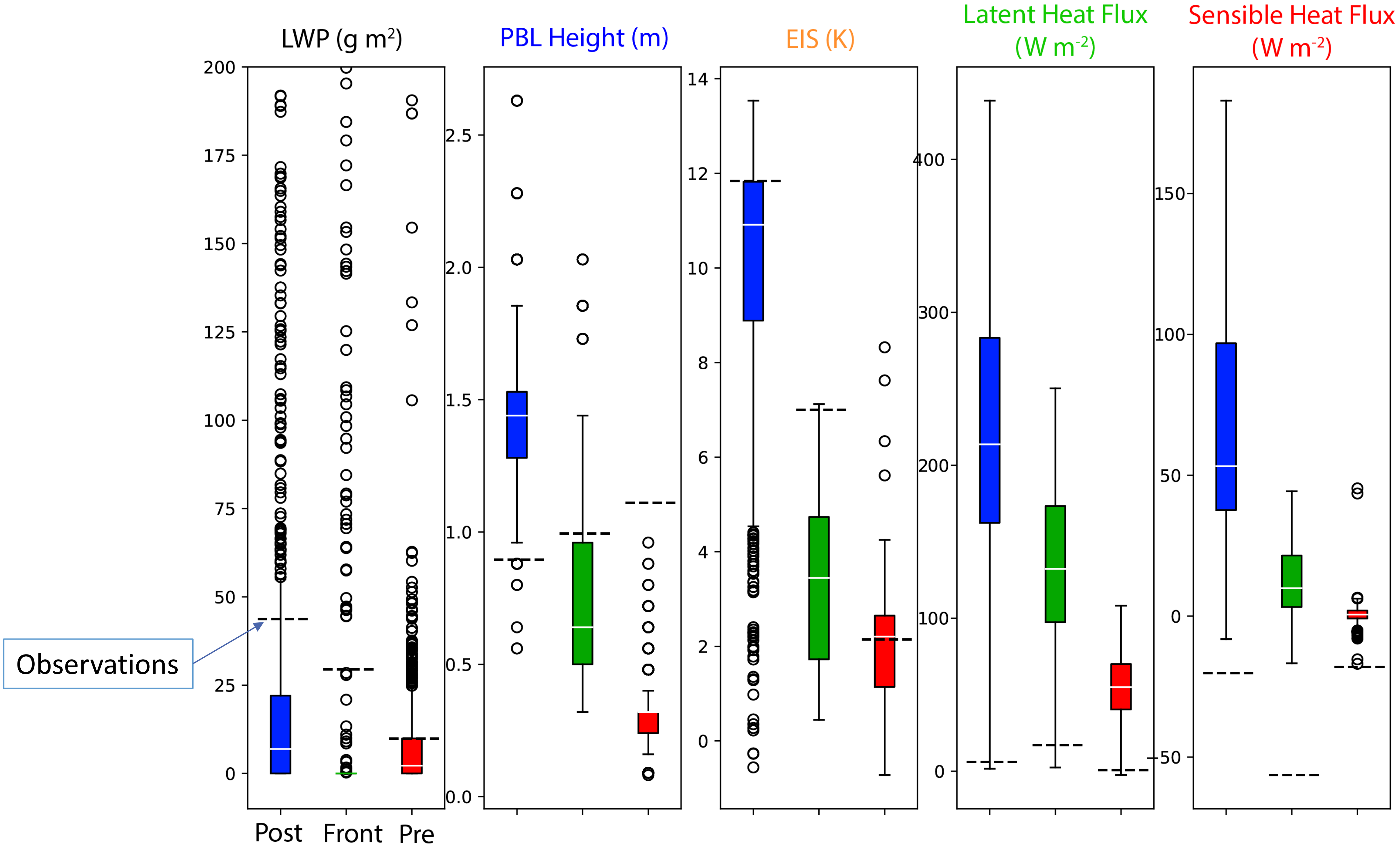


Conceptual model under development!

Cloud organization by region



Transects across the cold front



Summary and conclusions

- Compositing model output relative to synoptic structures (low center, cold front) provides a pathway to evaluate boundary-layer cloudiness forecasts in the context of the different structures of mid-latitude cyclones
- COAMPS meteorology — good! (didn’t show forecast stats)
- COAMPS cloud properties — not so good; however, COAMPS seems able to reproduce the different cloud regimes and synoptic relationships present in the observations
- Resolution vs. operational relevance
- Physics improvements to MBL clouds may not generalize to other physical regimes (ice, etc.)
- Ongoing work: 1. efforts to evaluate improvements to microphysics scheme (microphysics suite); 2. more attention to drizzle/precip; 3. production runs of the other simulation periods across seasons for more robust forecast stats