Characterizing the joint variability of MBL cloud properties over the northeast Atlantic

David B. Mechem[1], Sandra E. Yuter[2], Simon P. de Szoeke[3]

[1]*Atmospheric Science Program*
Department of Geography
University of Kansas

[2]*Department of Marine, Earth, and Atmospheric Sciences*
North Carolina State University

[3]*College of Oceanic and Atmospheric Sciences*
Oregon State University

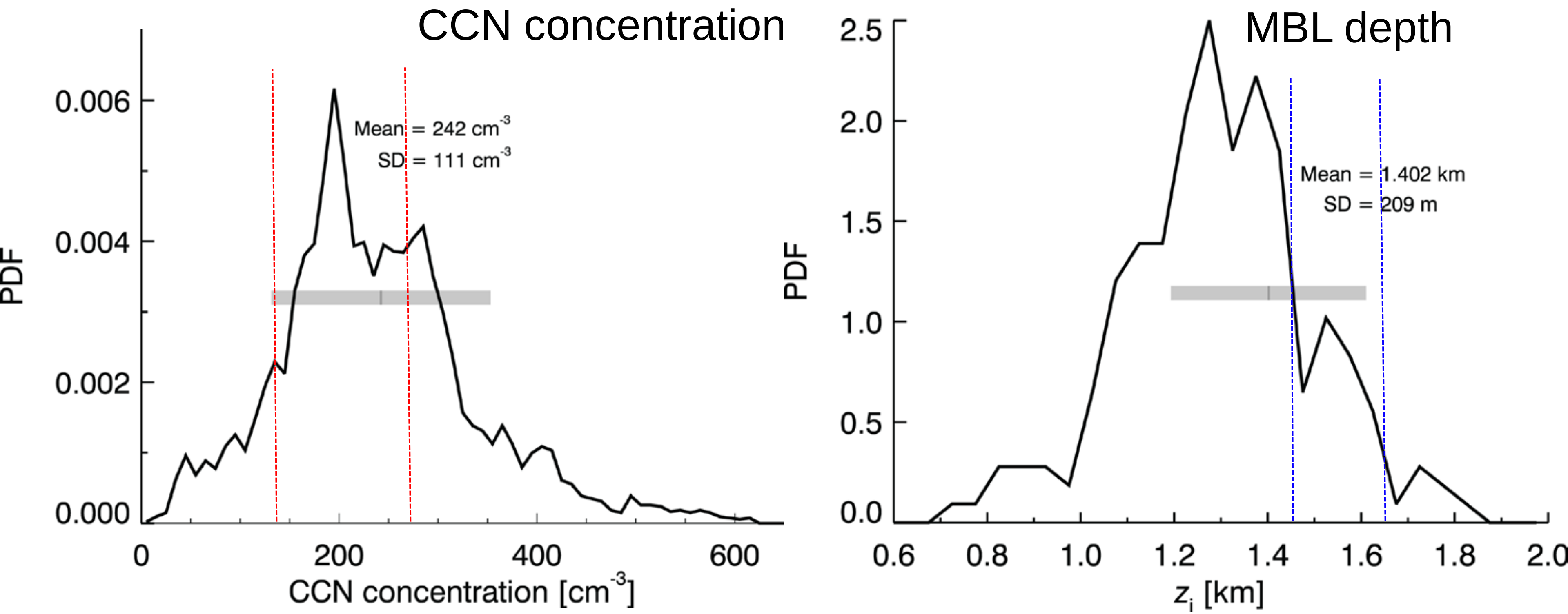
DOE ASR — Azores Breakout
13 March 2012

What factors determine cloud properties and precipitation outcomes over the northeast Atlantic (NEA)?

- Determine joint PDFs of thermodynamic, aerosol, cloud, precipitation, and synoptic factors
- Employ the joint PDFs as observational constraints to formulate LES cases to evaluate mechanisms that determine cloud system outcomes

Factor separation technique — MBL depth and CCN in V

Mechem/Yuter/deSzoeke (2012)

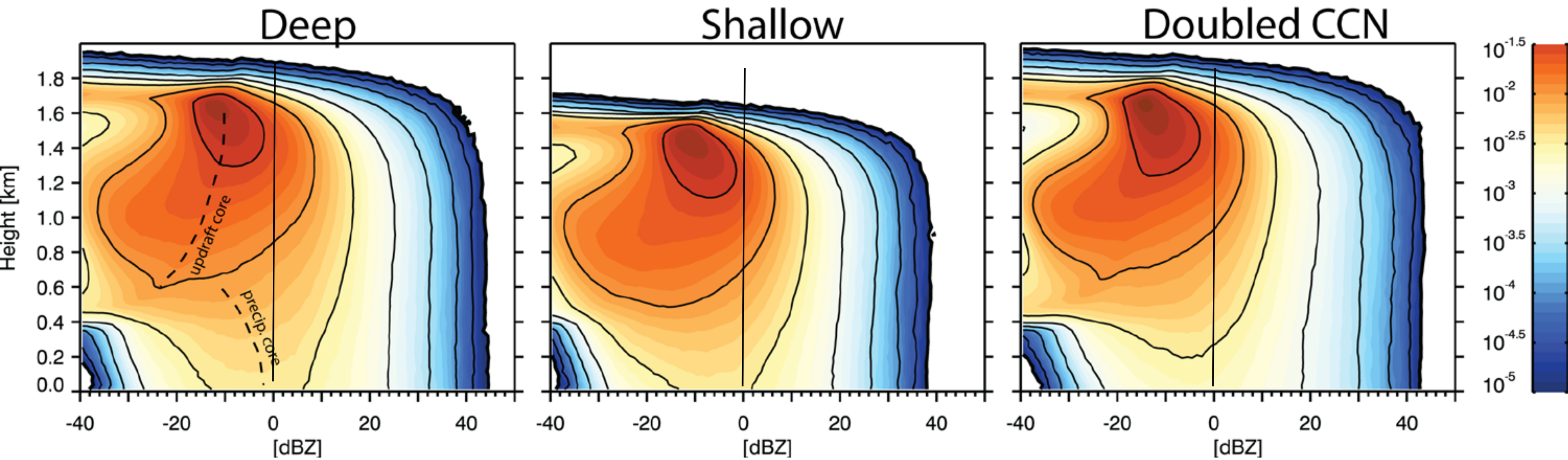


Simulation	MBL depth [m]	CCN concentration [cm^{-3}]
Deep (control simulation)	1650	135
Shallow	1450	135
Doubled CCN	1650	270
Shallow + Doubled CCN	1450	270

Cloud and precipitation outcomes from factor separation

VOCALS (simulated) reflectivity CFADs

Mechem/Yuter/deSzoeke (201

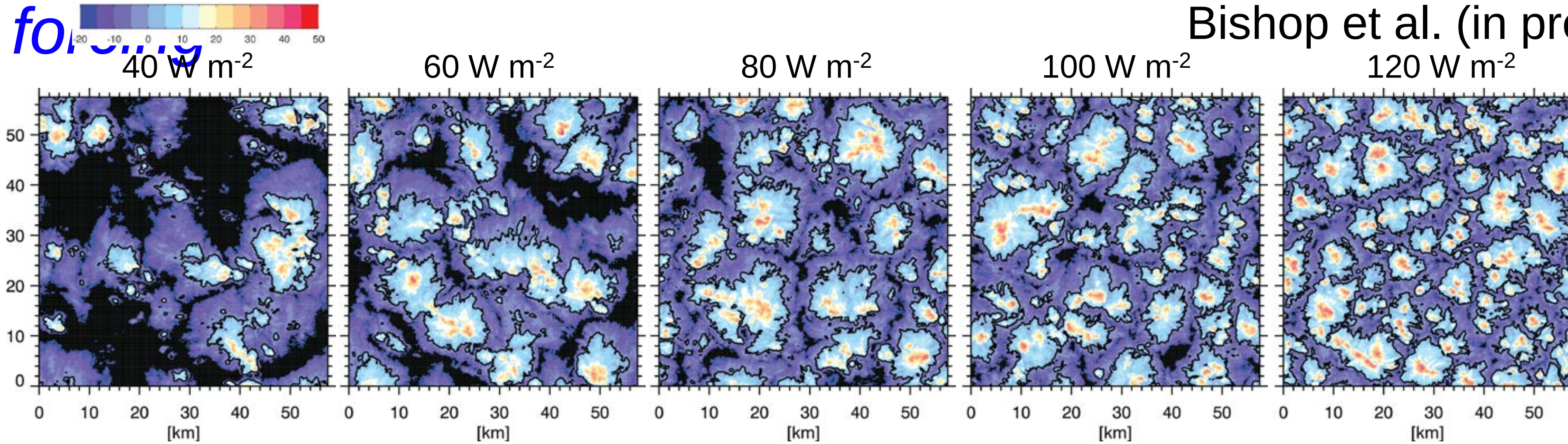


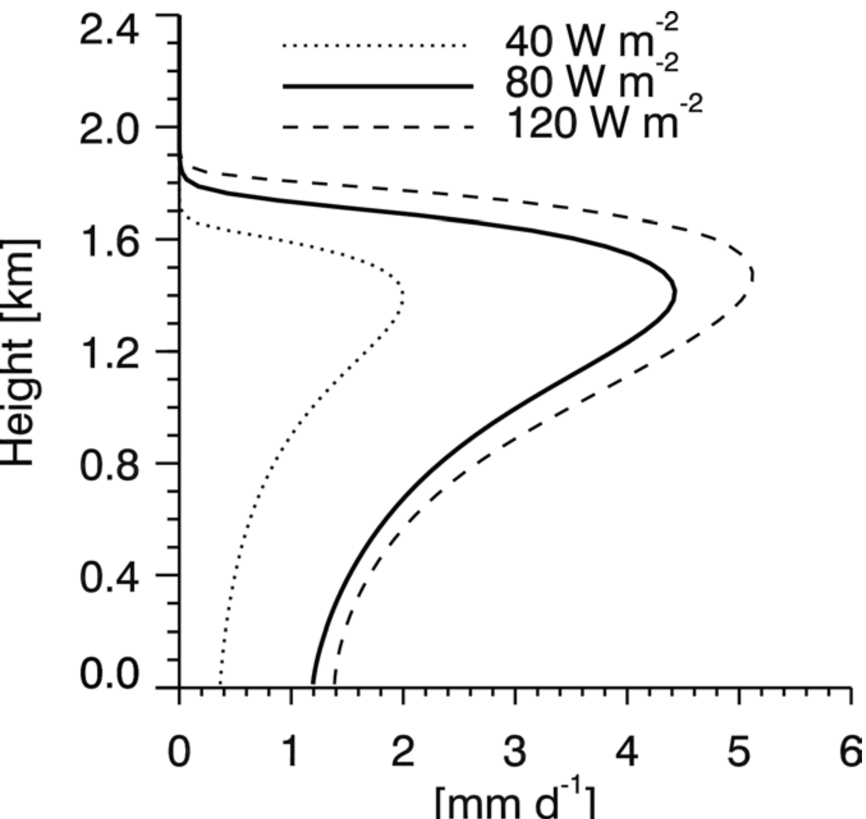
Average quantities from 8–12 h

Simulation	***R* [mm d^{-1}]**	**w_e [cm s^{-1}]**
Deep (control simulation)	0.98	0.76
Shallow	0.44 (–55%)	0.58
Doubled CCN	0.57 (–42%)	0.85
Shallow + Doubled CCN	0.28	0.72

Sensitivity of mesoscale organization to longwave forcing

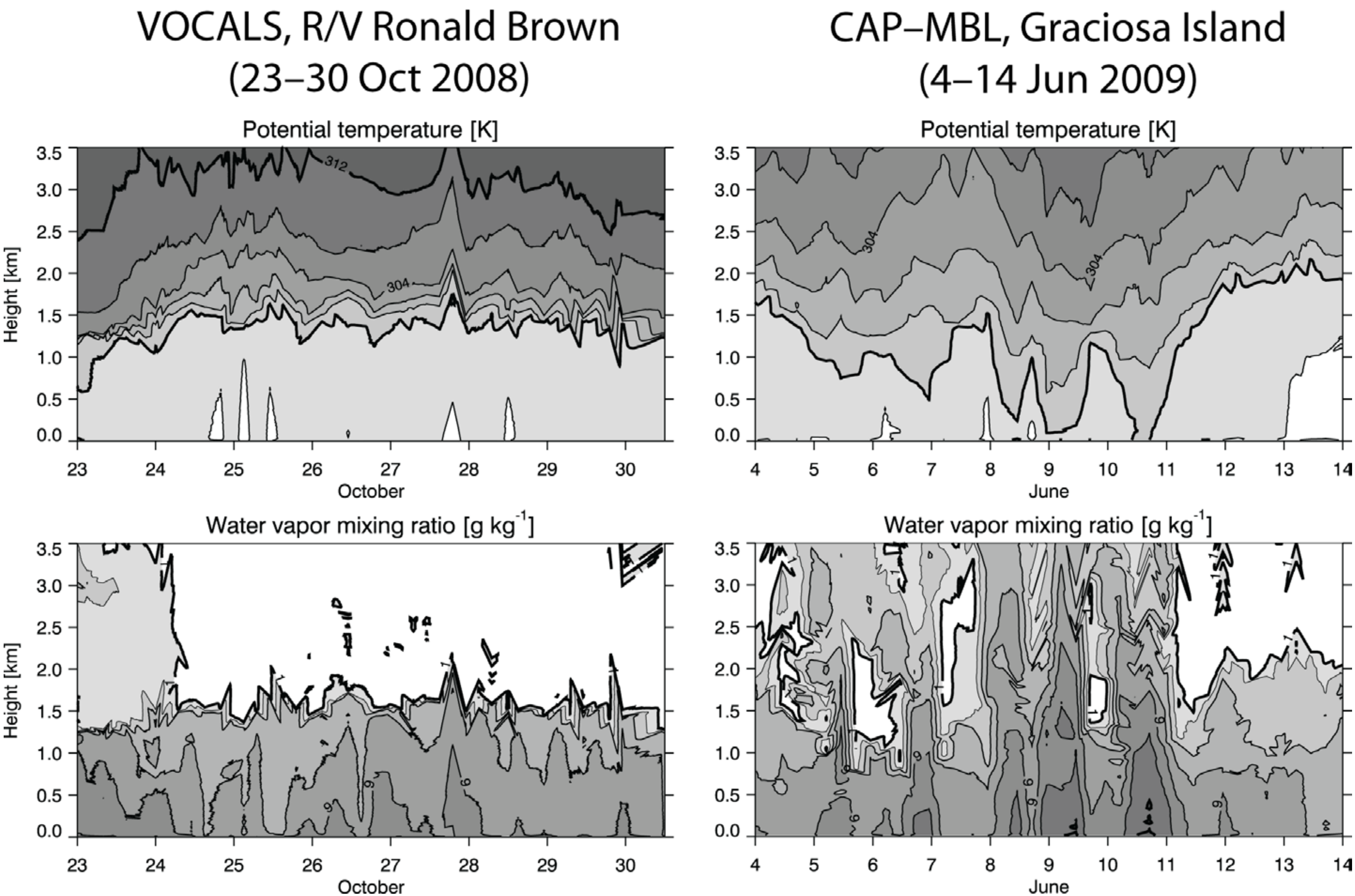
Bishop et al. (in prep)





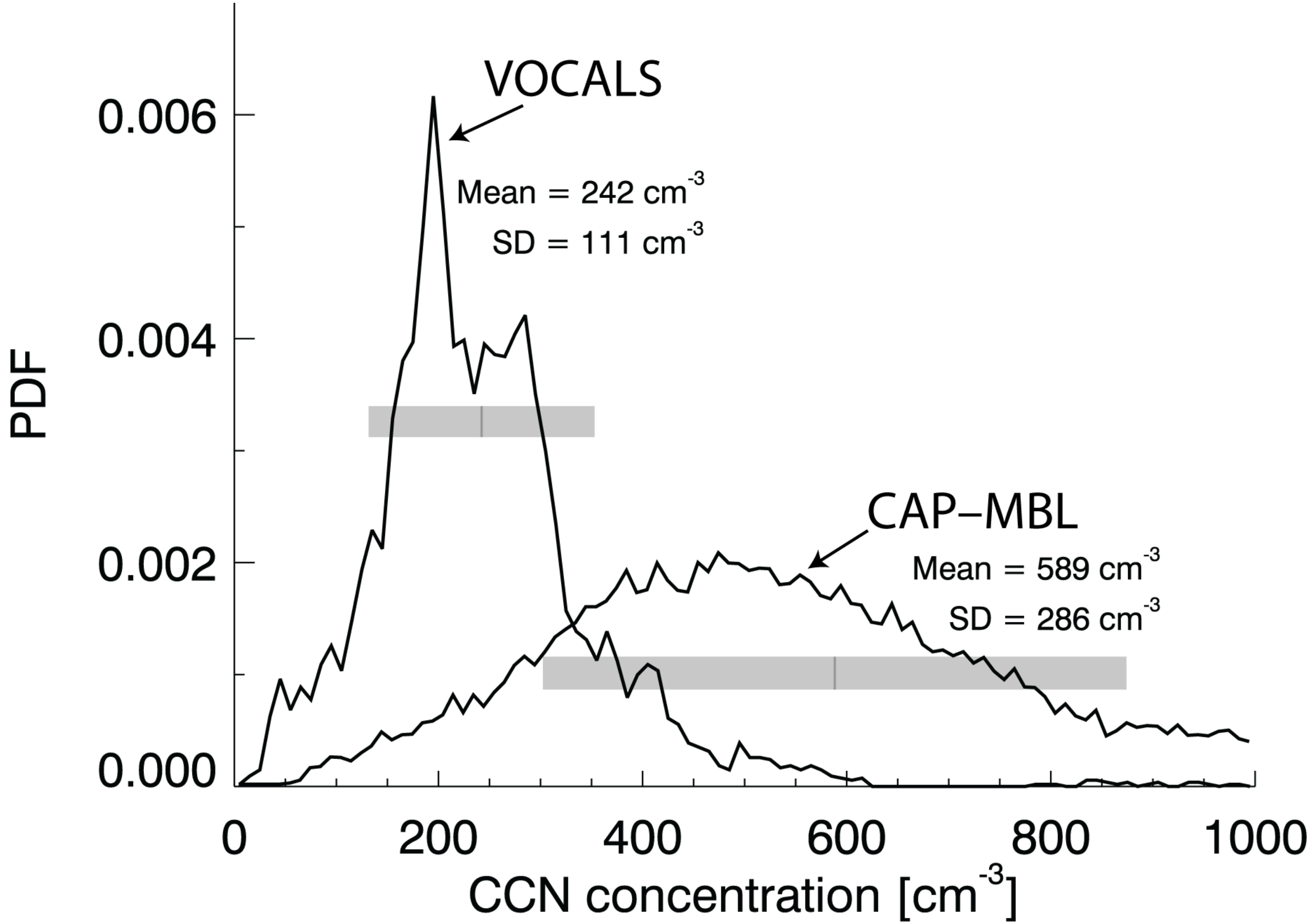
- •Stronger LW forcing leads to more precipitation and stronger MBL turbulence
- •Stronger mean turbulence is not a result of greater updraft buoyancy
- •Stronger LW forcing results in greater updraft area fraction

Southeast Pacific and Northeast Atlantic — very differen



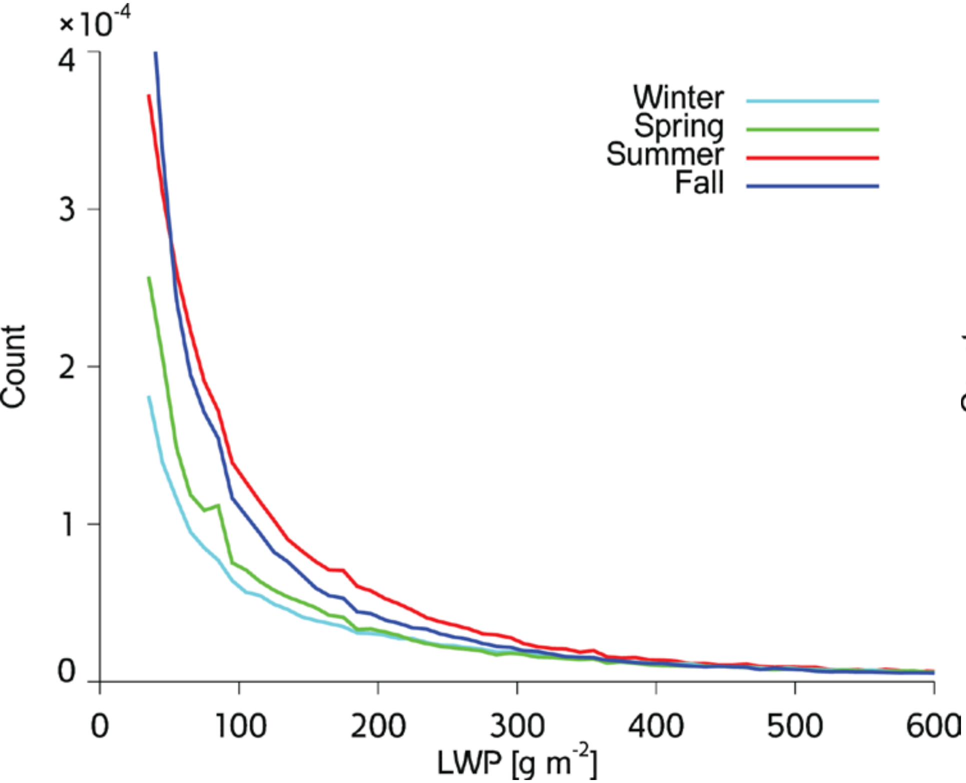
Southeast Pacific and Northeast Atlantic — very different

CCN concentration at the surface

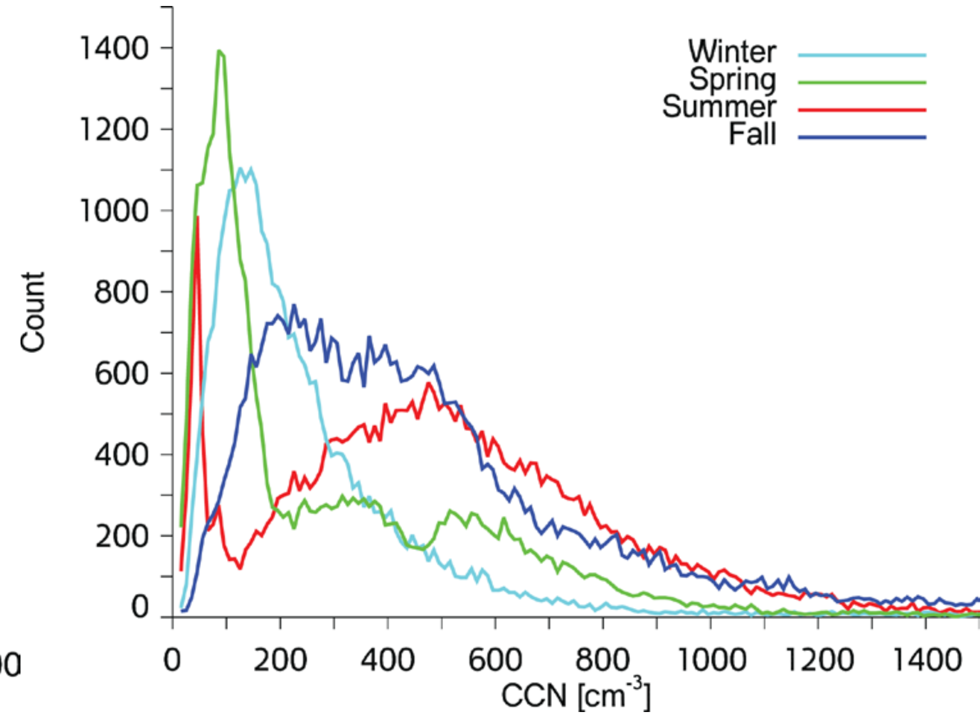


PDFs of LWP and CCN over the NEA (by season)

LWP from microwave radiometer

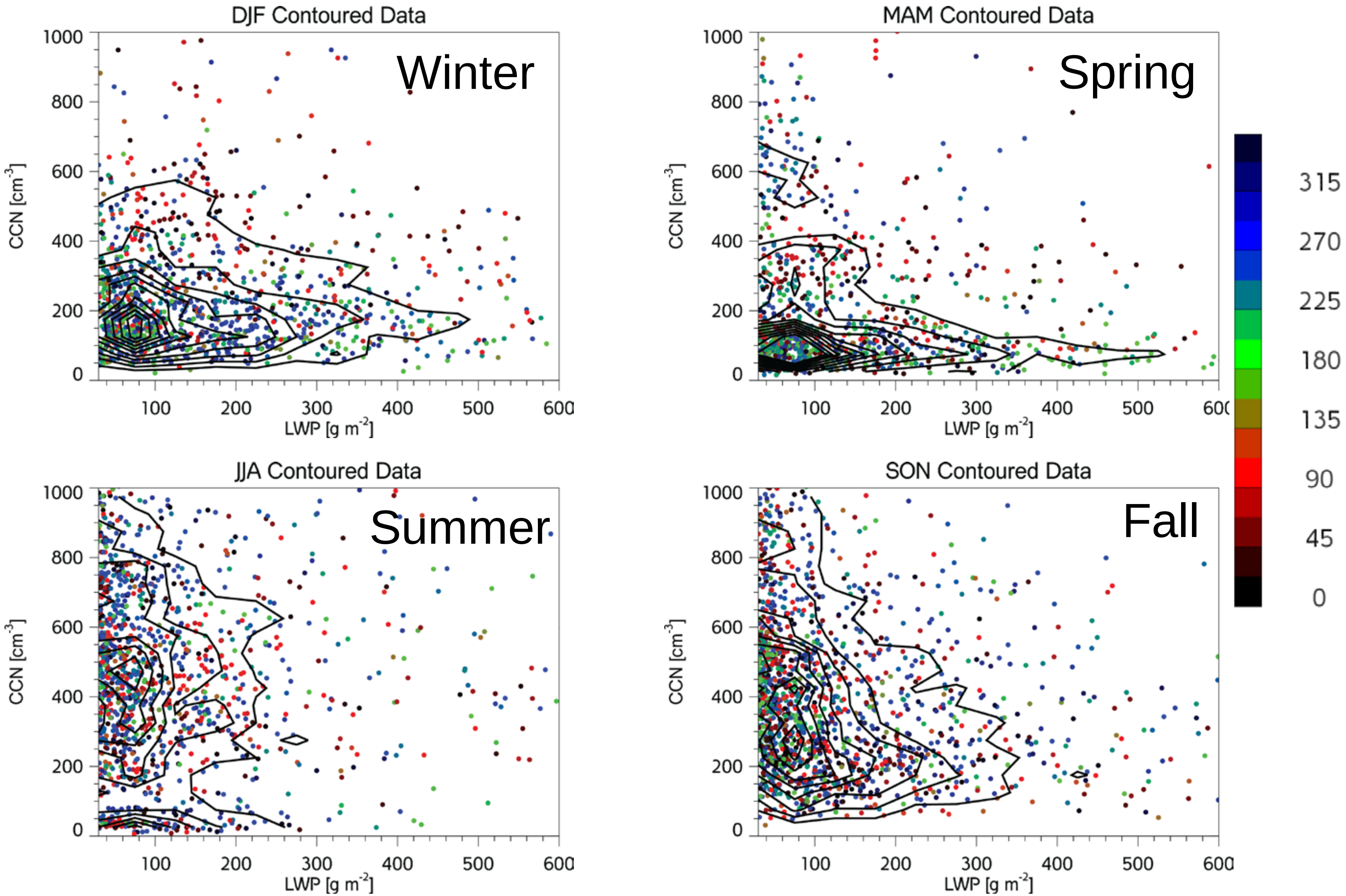


CCN concentration at the surface



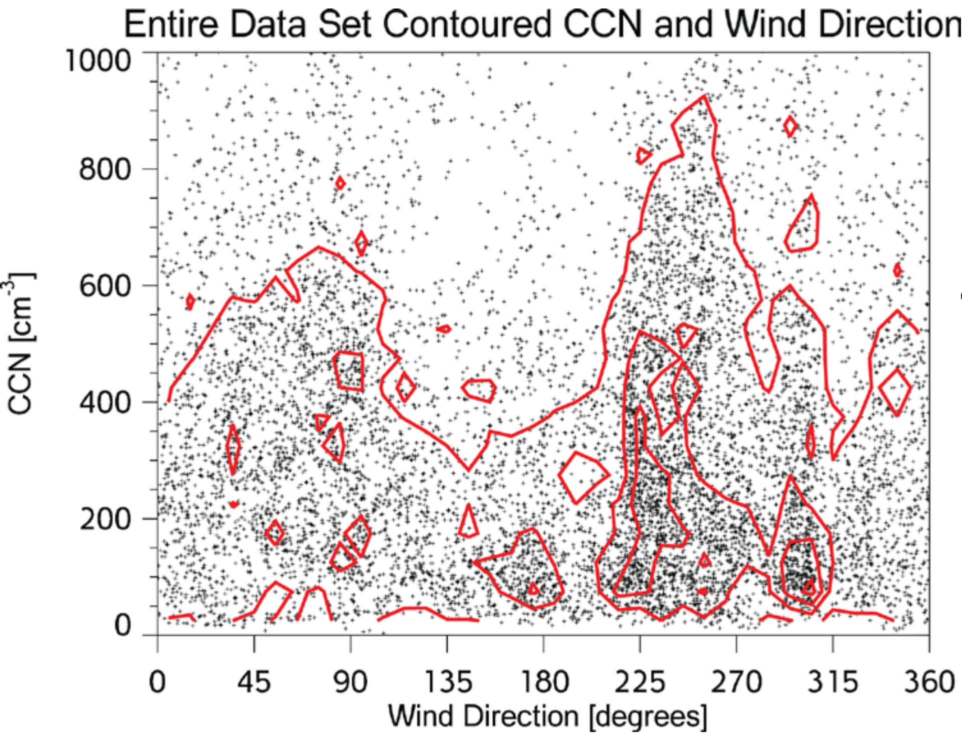
But are they jointly variable?

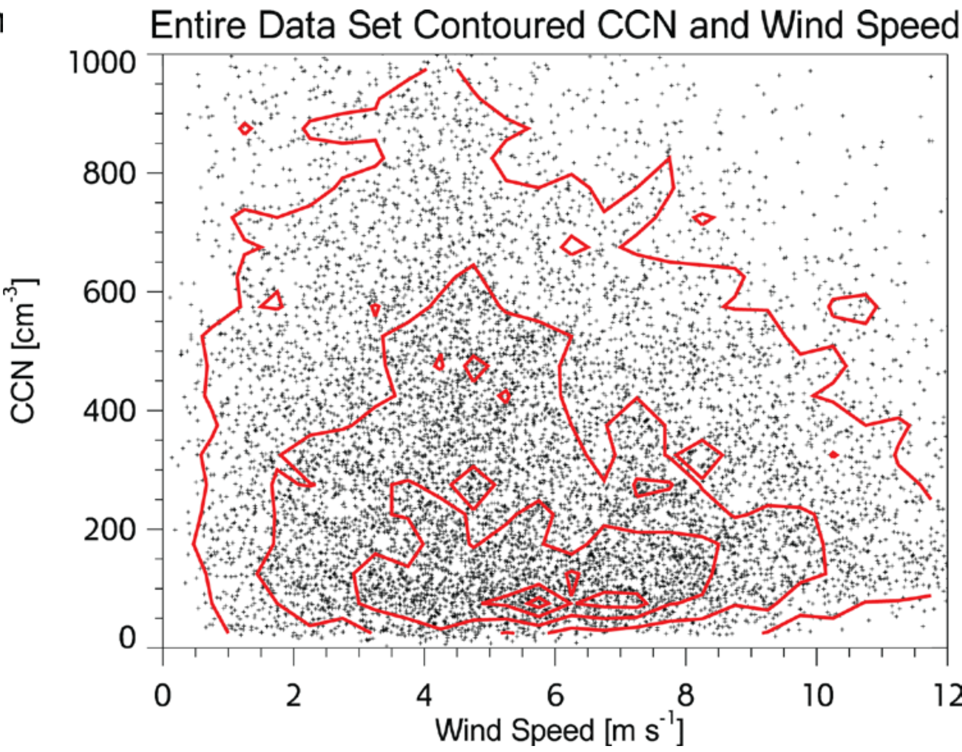
Joint PDFs of LWP and CCN by season



CCN dependence on wind speed and direction

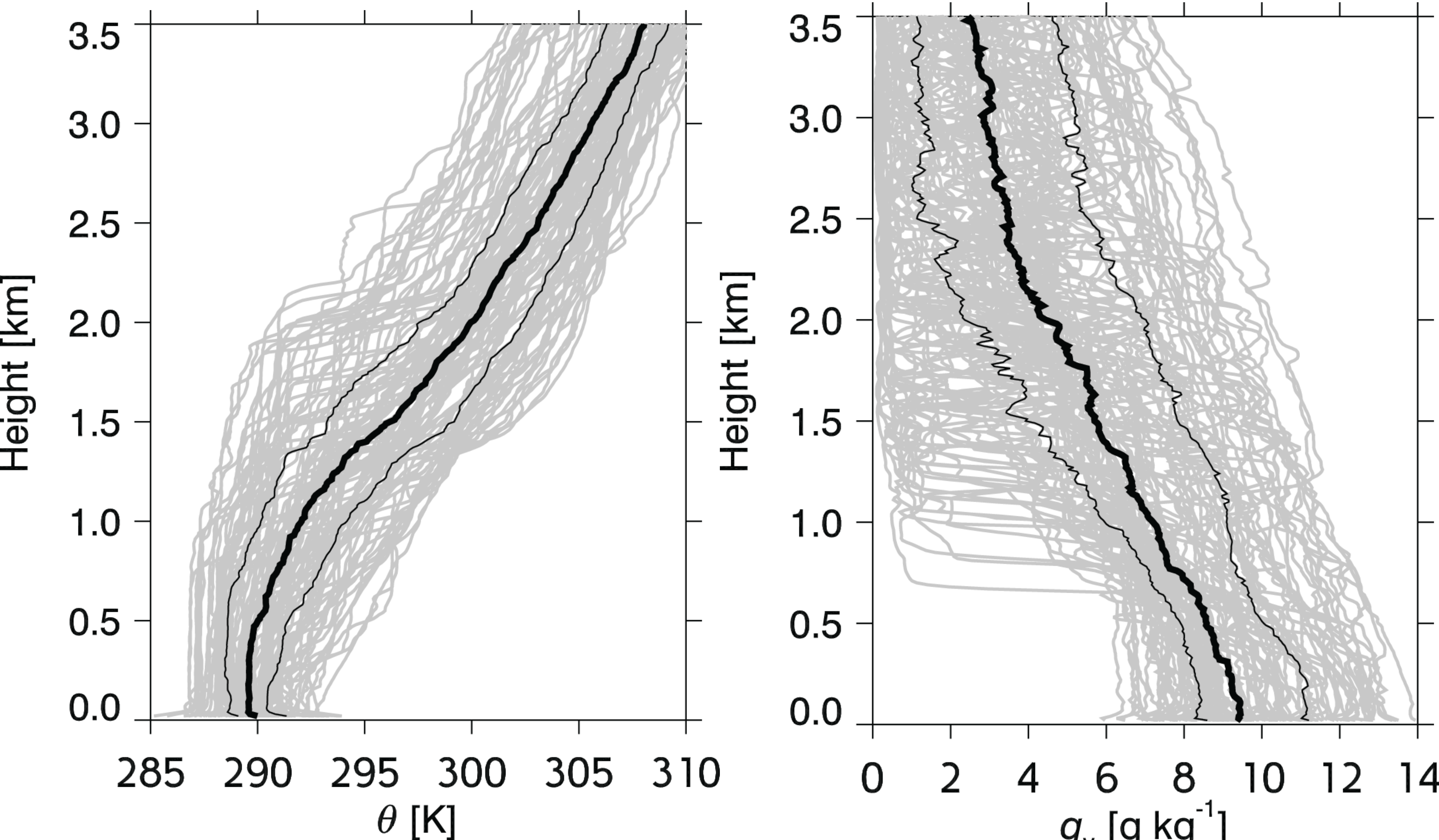
Joint PDFs of CCN and wind (speed and direction)





Variability in MBL vertical profiles

June 2009 only



Final comments and outstanding issues

- Determine the factors that dictate NEA cloud properties and precipitation outcomes
- Clouds over the NEA are messy! Is it even fair to call this a “stratocumulus region?”
- With the large array of variability, how do we formulate (control) cases for idealized large-eddy simulation?
- Stratify by stability?
- What is a “factor” and what is an “outcome?”
- Do we incorporate multi-day simulations, which may permit a more natural separation between factor and outcome?