Observations of the Diurnal Cycle of Marine Stratocumulus Clouds and Precipitation

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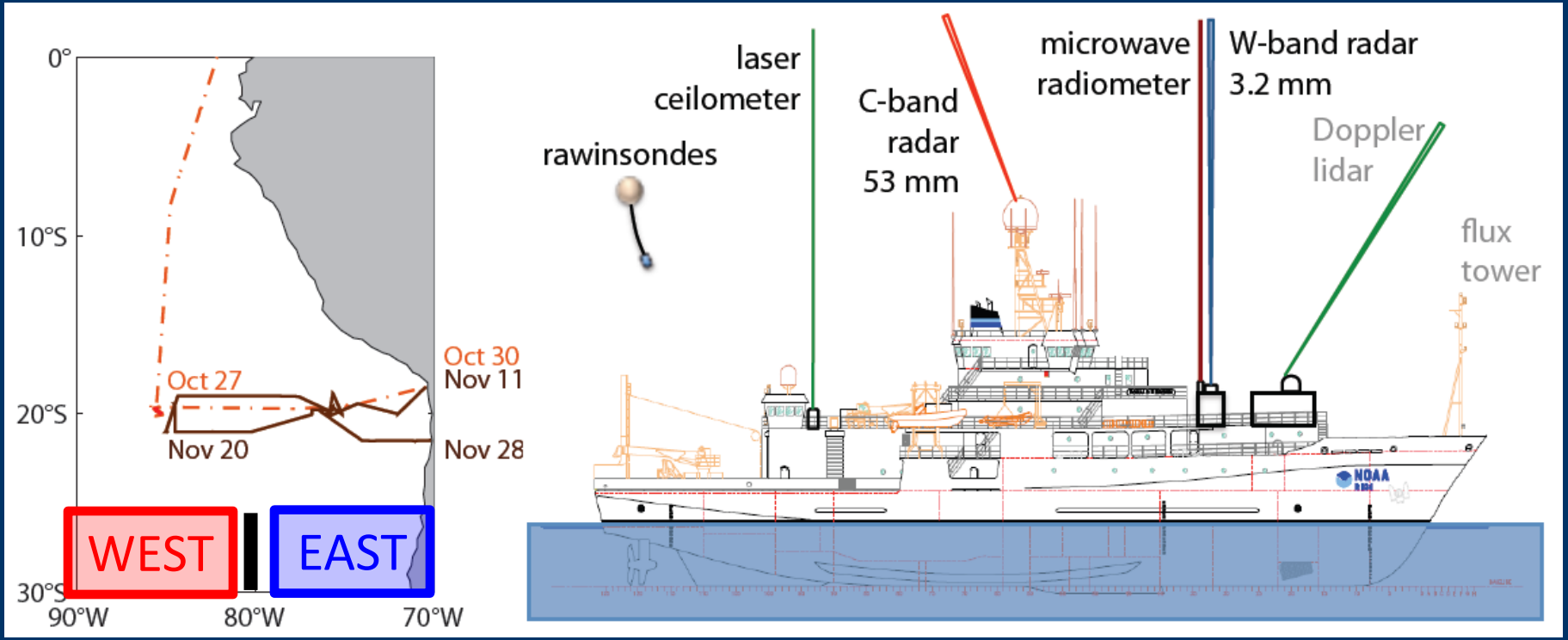
Goals

1) Document the diurnal variation of important features of the cloud deck to aid in validation of model output.

2) Examine to what degree drizzle varies in time and space.

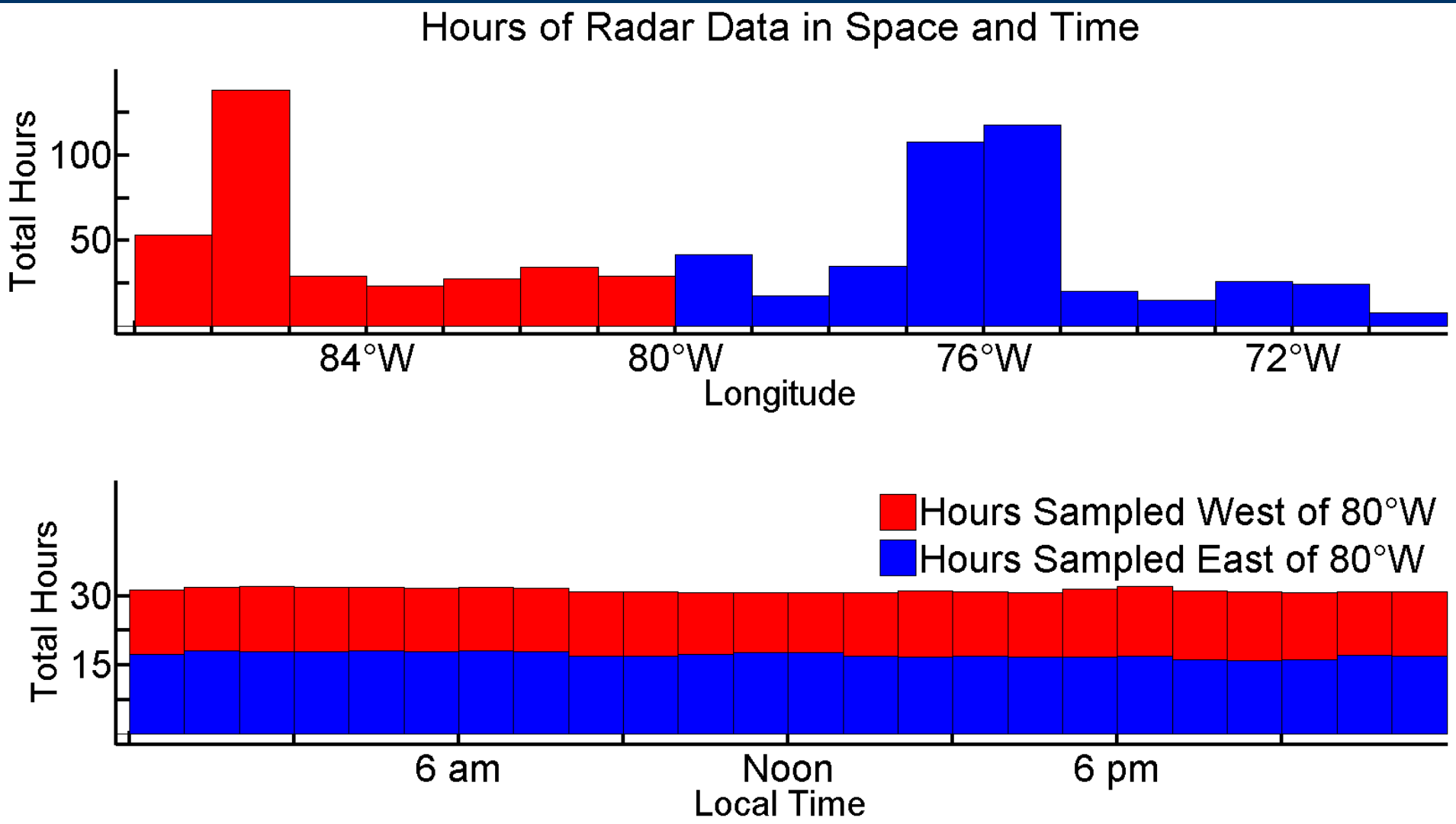
3) Begin to understand the controlling factors that cause drizzle to start and stop.

Data from the R.H. Brown

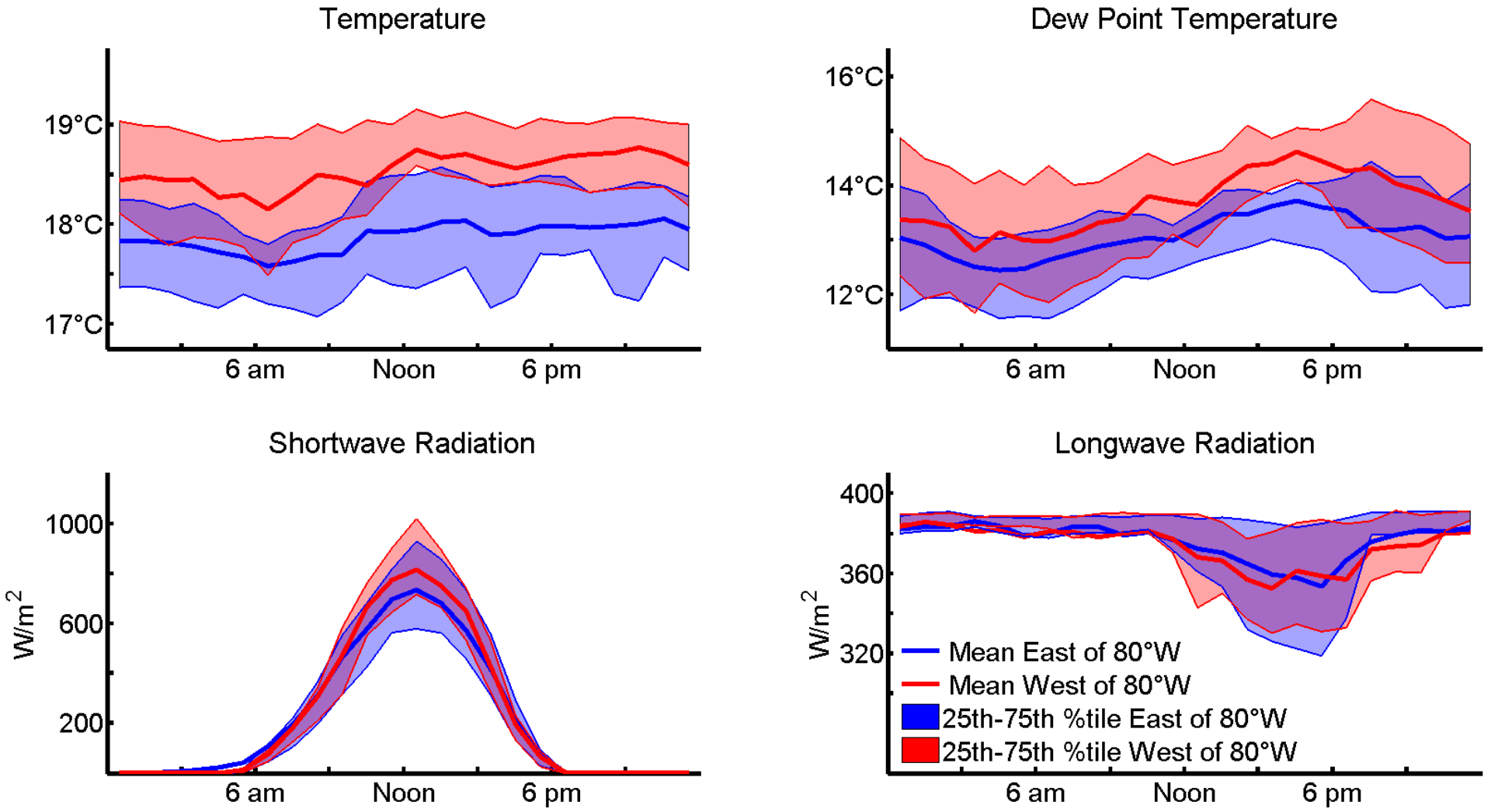


Data were divided into two regions, east and west of 80°W, to account for longitudinal changes to boundary layer characteristics.

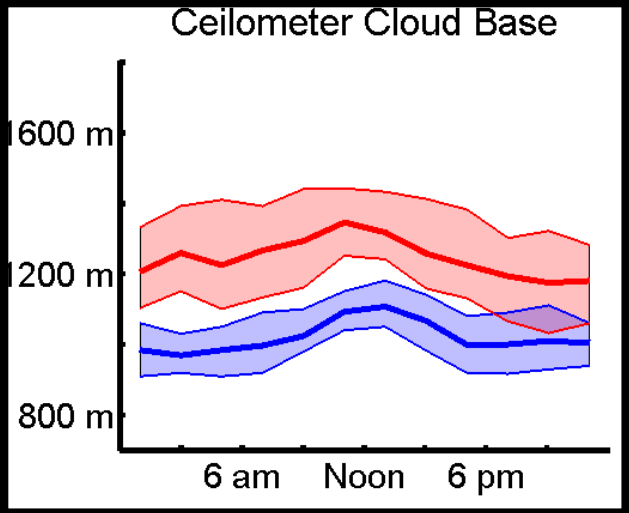
C-Band Radar Sampling

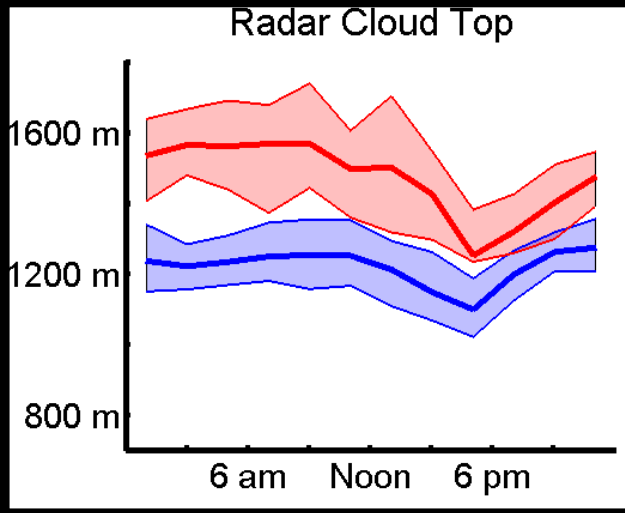


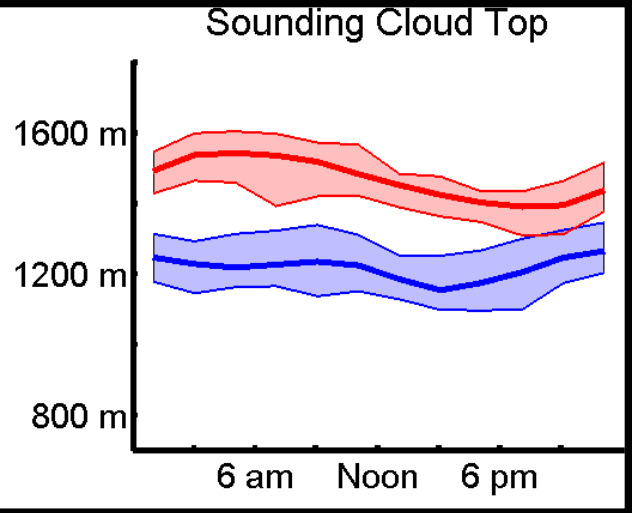
Surface Observations

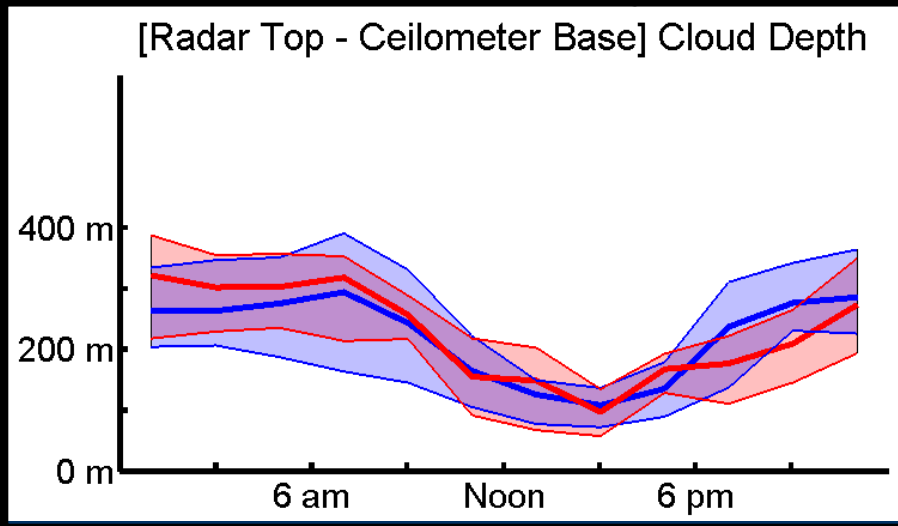


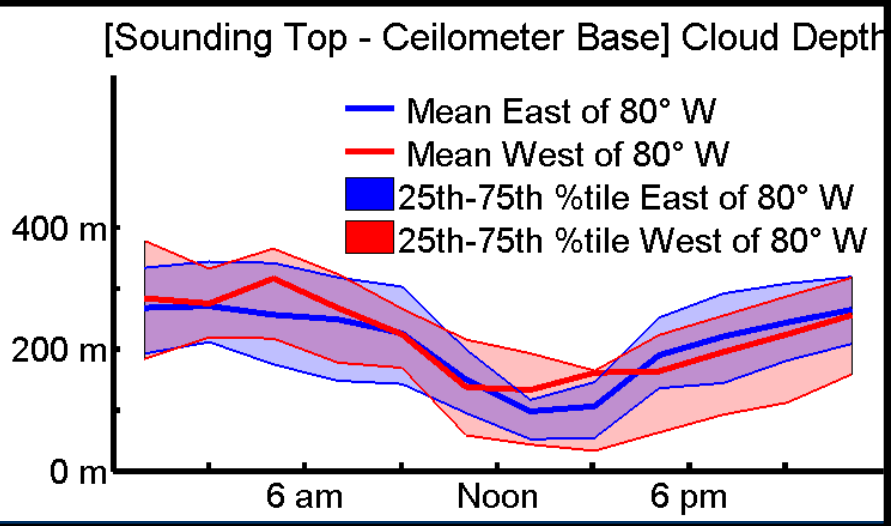
Cloud Observations



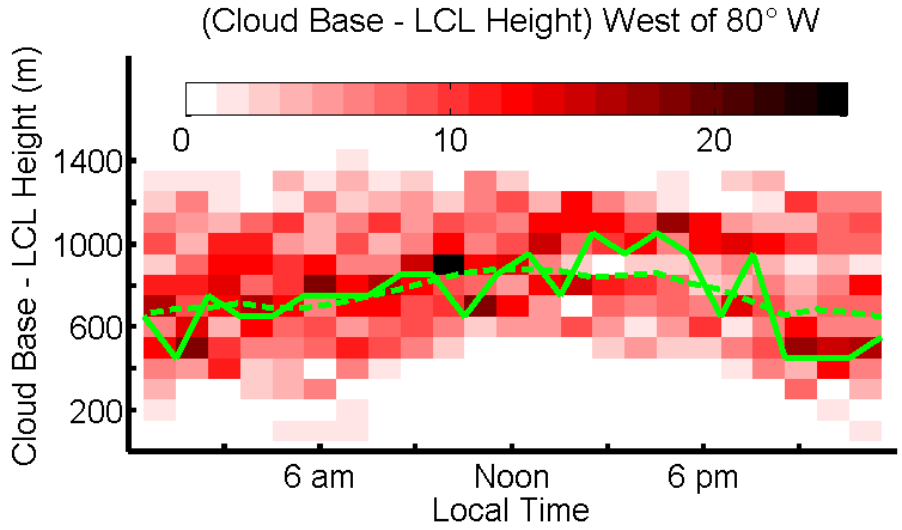


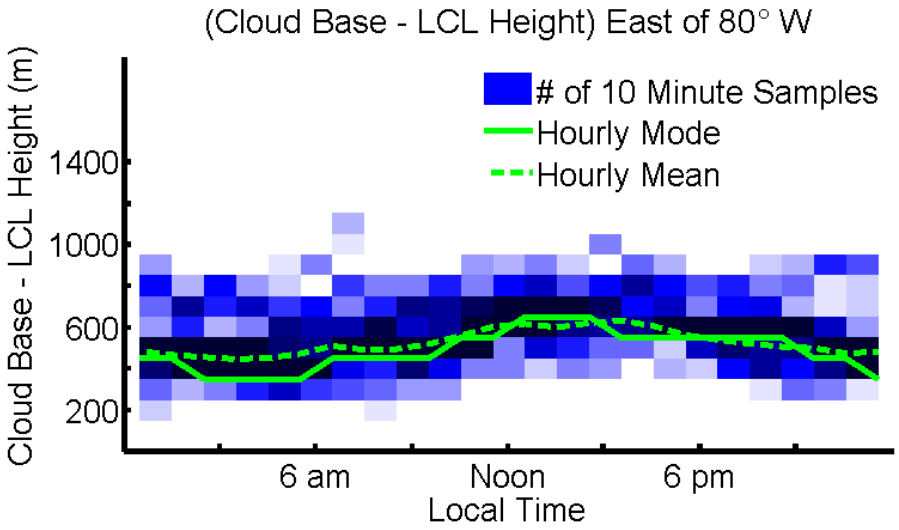


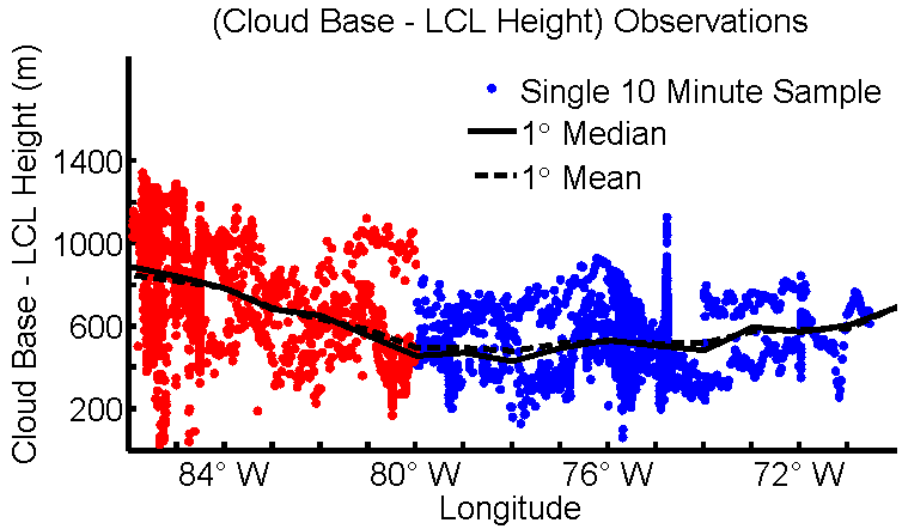


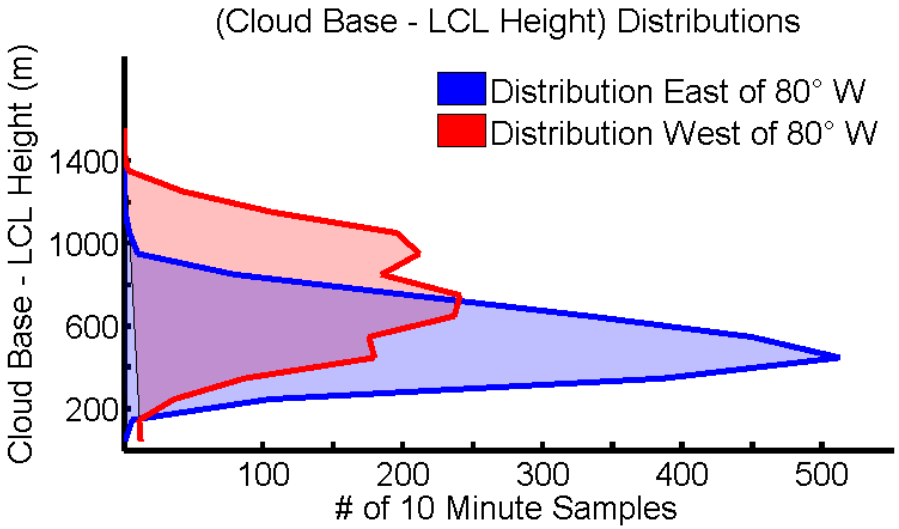


Boundary Layer Coupling

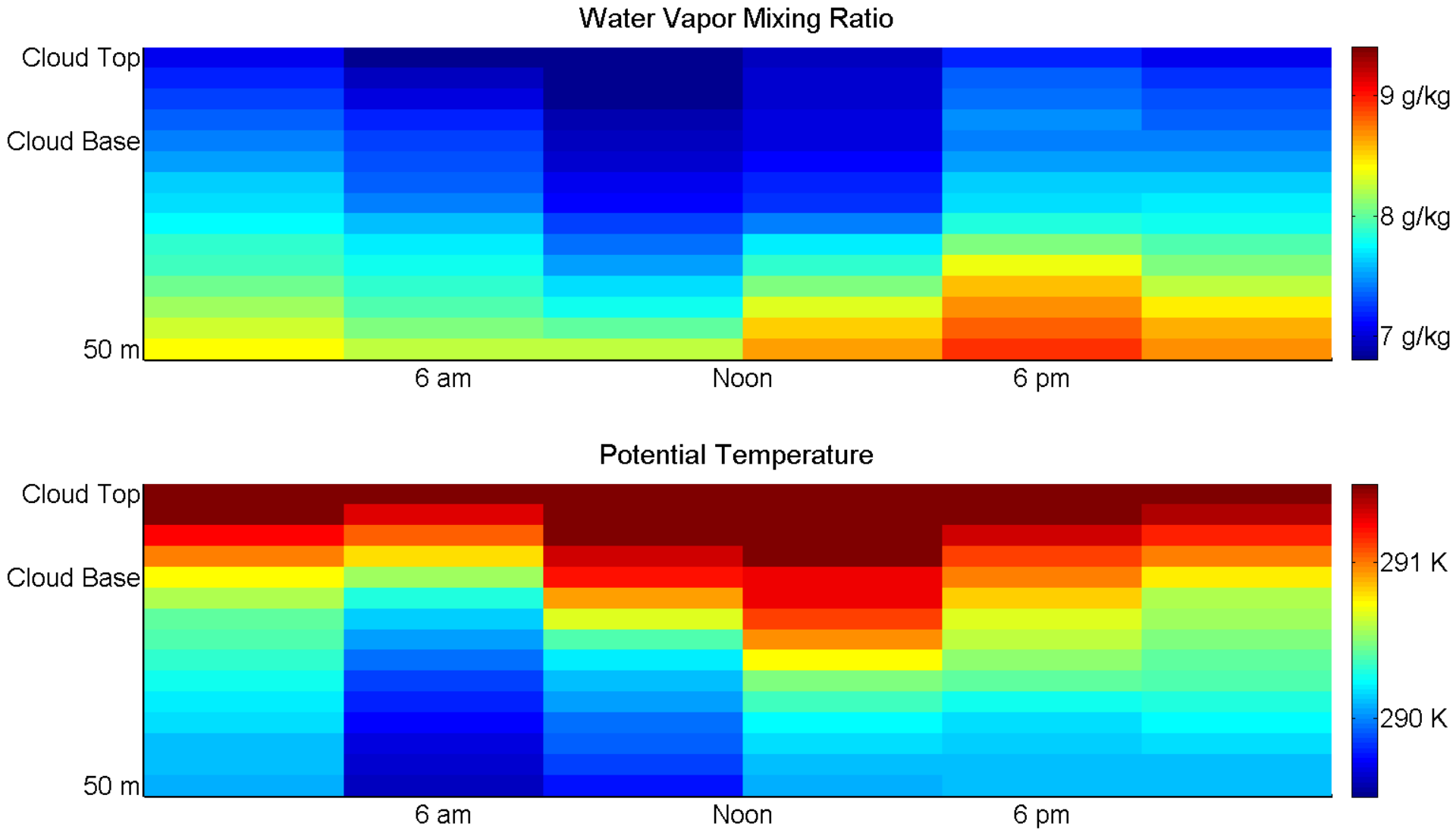




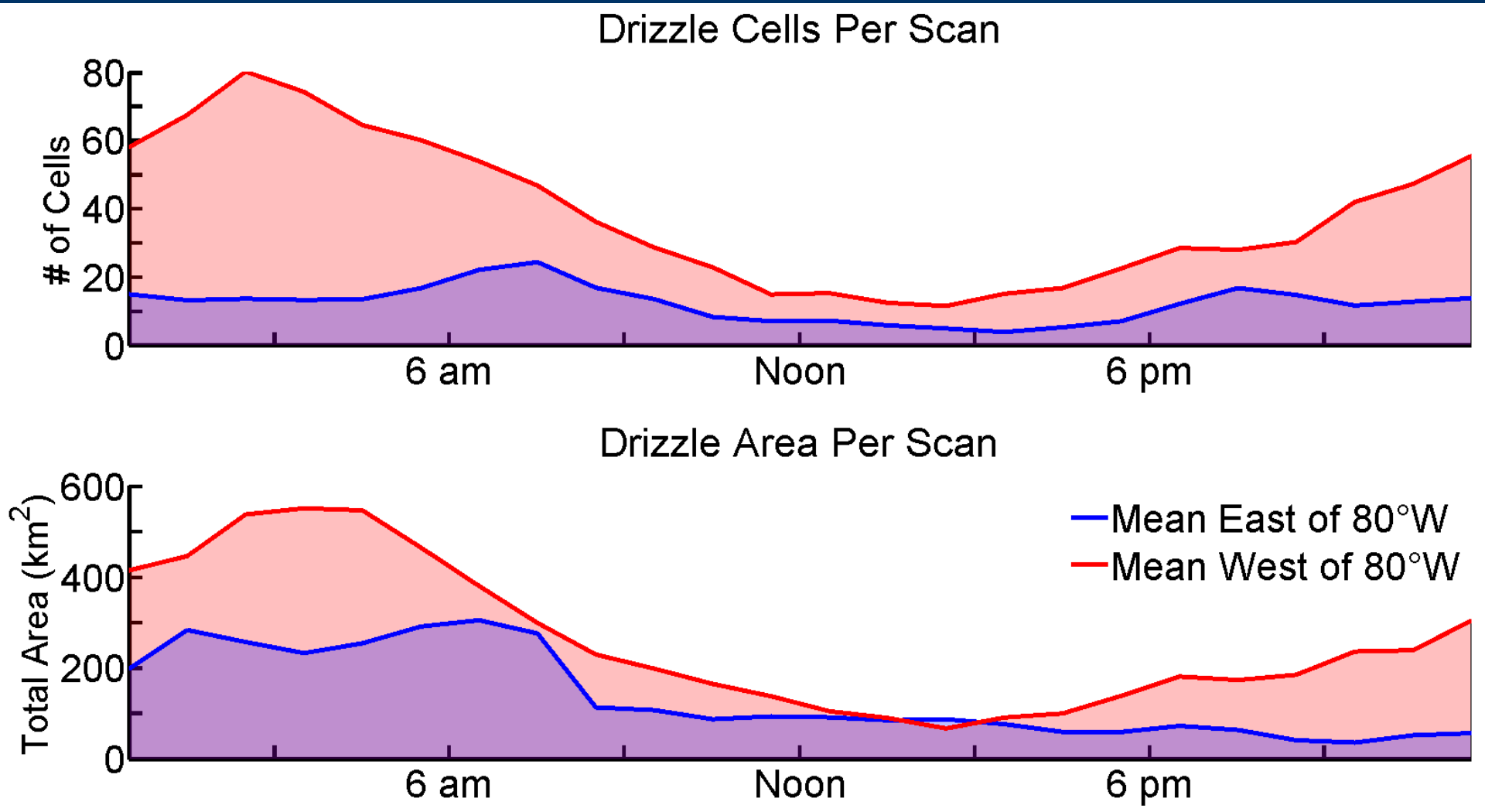




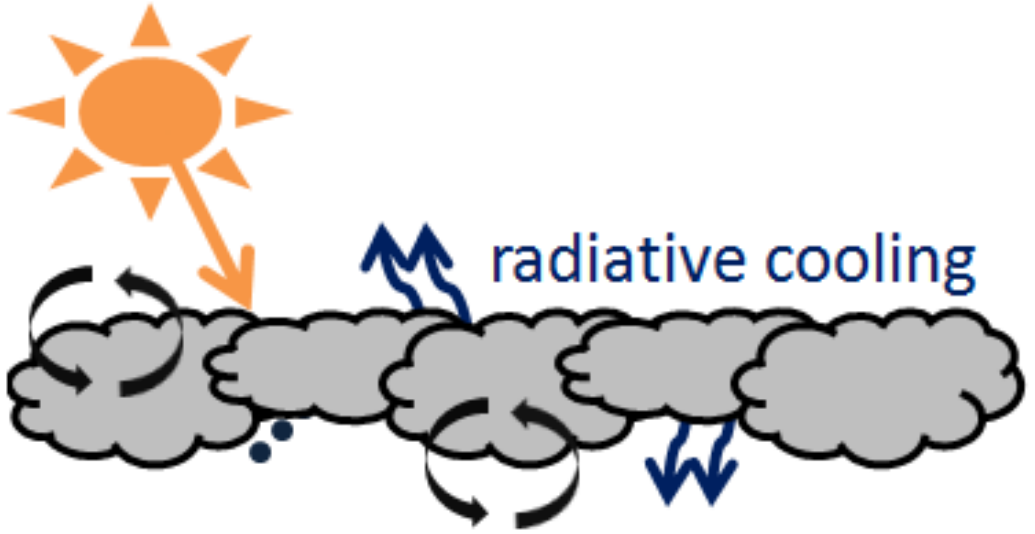
Boundary Layer Mixing



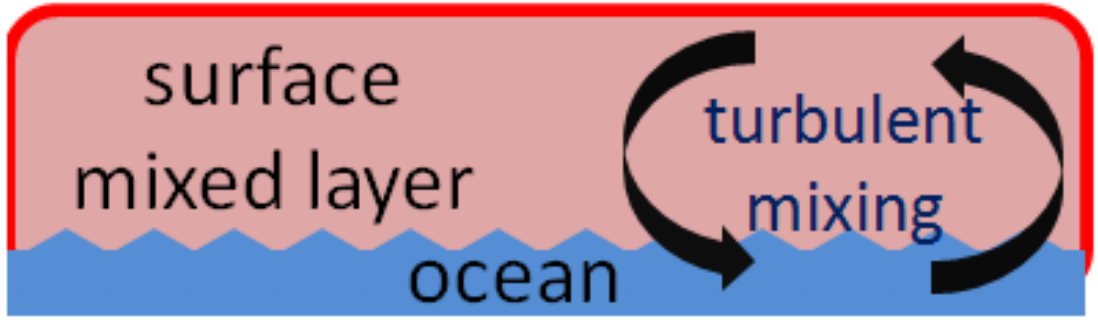
C-Band Radar Observed Drizzle



Noon



h_C = cloud depth



h_{ML} = mixed layer depth

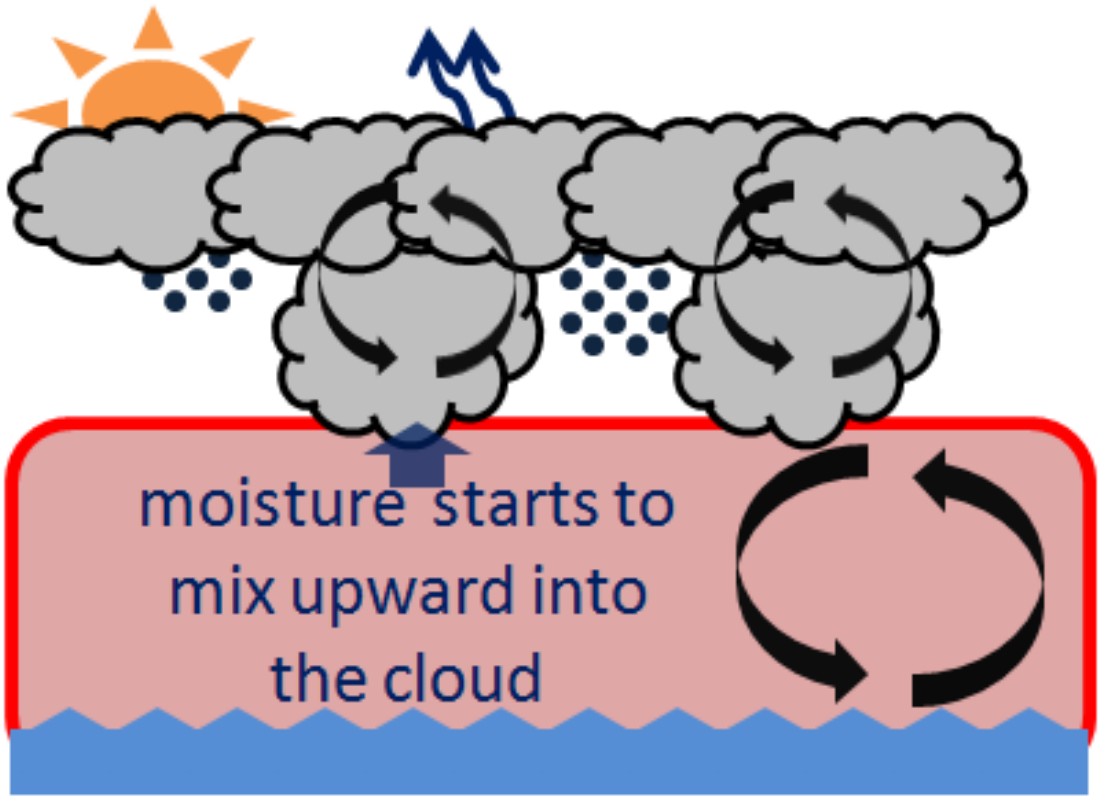
The surface mixed layer is decoupled from the cloud deck.

Sunset

$$\frac{d(h_C)}{dt} > 0$$

$$\frac{d(precip)}{dt} > 0$$

$$\frac{d(h_{ML})}{dt} > 0$$



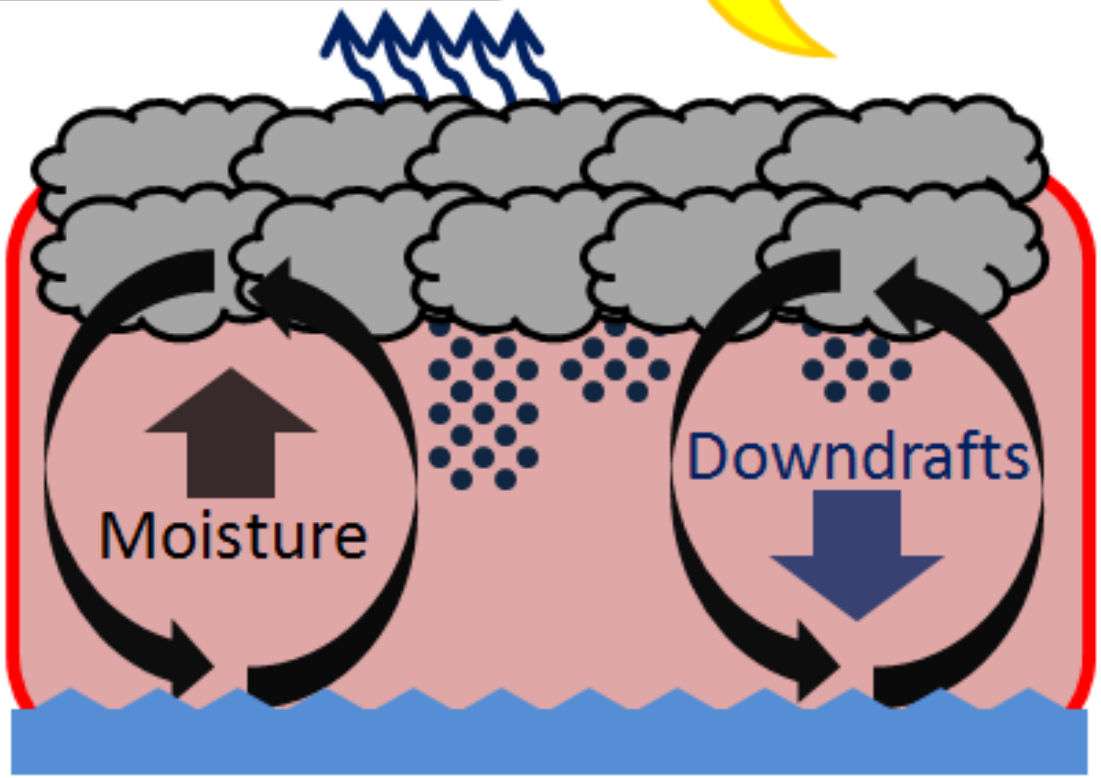
The mixed layer is deeper and may be coupled with the cloud deck via cumulus clouds.

9 pm -Midnight

$$\frac{d(h_C)}{dt} > 0$$

$$\frac{d(precip)}{dt} > 0$$

$$\frac{d(h_{ML})}{dt} > 0$$



The boundary layer is coupled through cloud top radiative cooling and cellular convection.

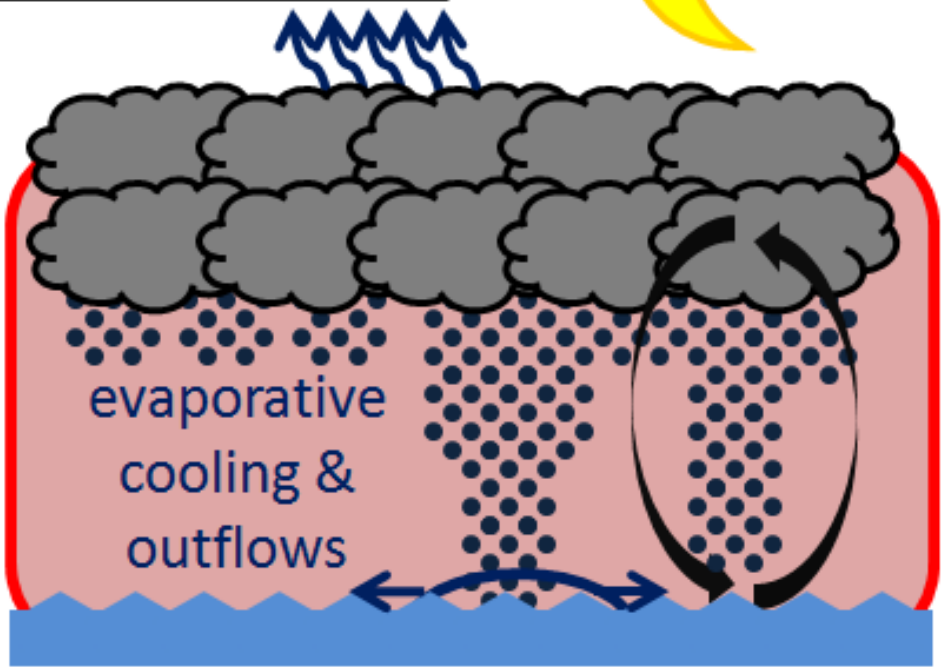
Heavy Drizzle (West)

Midnight - 3 am

$$\frac{d(h_C)}{dt} = 0$$

precip = max

$$\frac{d(h_{ML})}{dt} = 0$$



Diurnal maximum in precipitation and degree of coupling. Some drizzle evaporates.

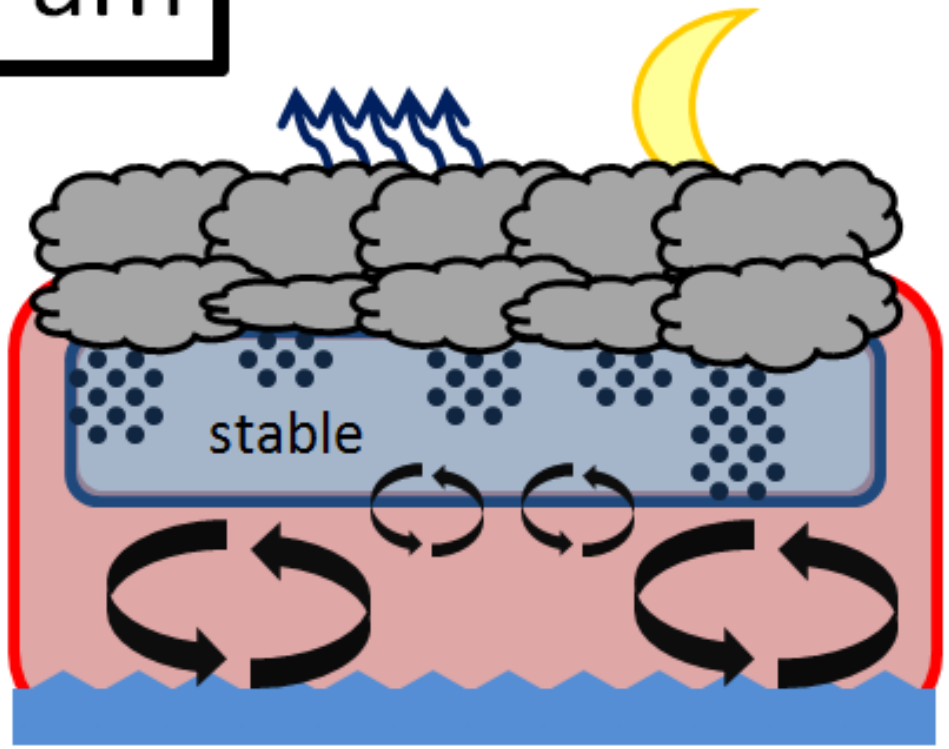
Heavy Drizzle (West)

3 am - 6 am

$$\frac{d(h_C)}{dt} \sim 0$$

$$\frac{d(precip)}{dt} < 0$$

$$\frac{d(h_{ML})}{dt} \sim 0$$



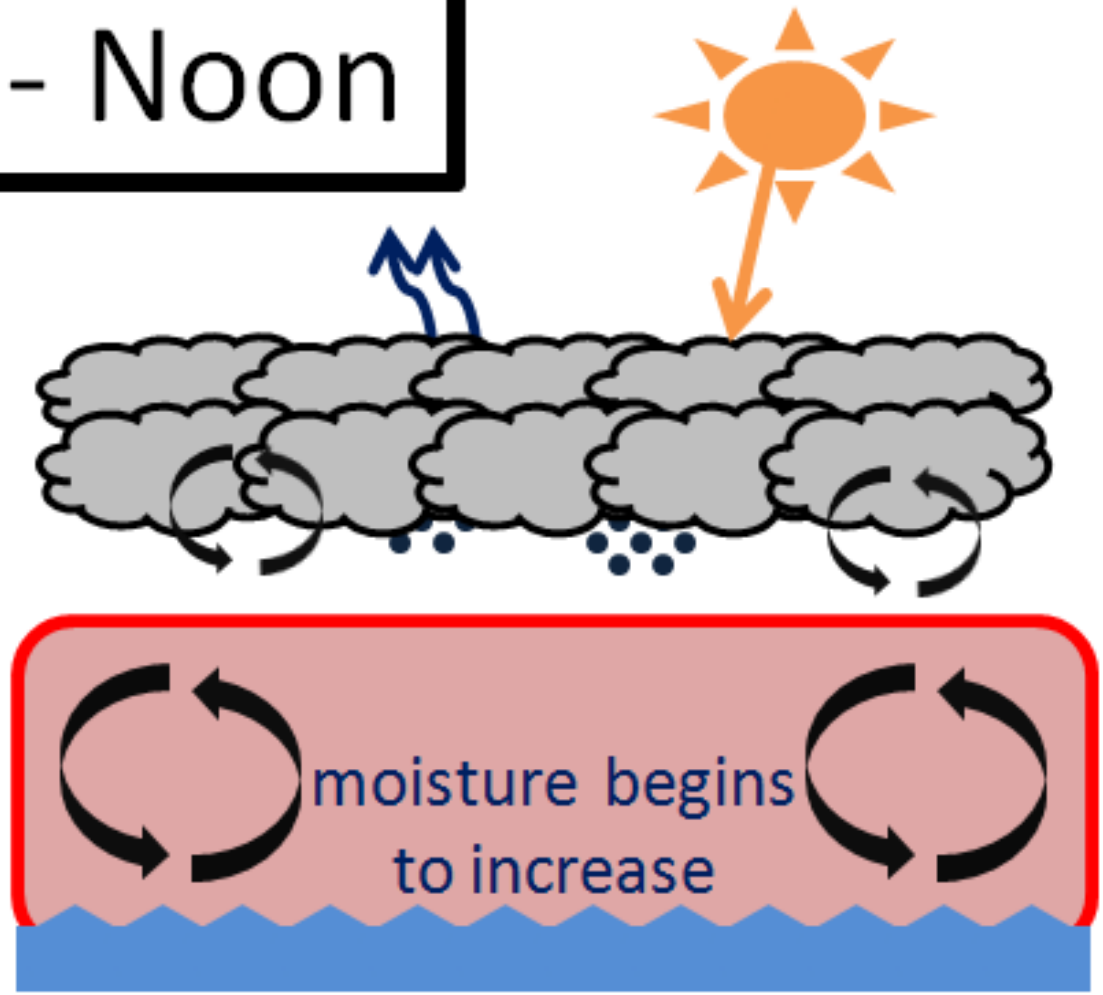
An evaporatively cooled stable layer develops and moisture flux into cloud is reduced.

Sunrise - Noon

$$\frac{d(h_C)}{dt} \ll 0$$

$$\frac{d(precip)}{dt} \ll 0$$

$$\frac{d(h_{ML})}{dt} < 0$$



Solar heating offsets radiative cooling and the boundary layer becomes less coupled.

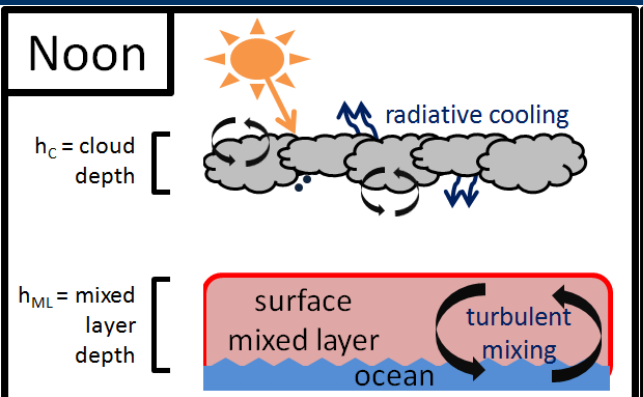
Conclusions

1) The diurnal cycle is clearly evident in every variable examined. Diurnal fluctuations in cloud depth, precipitation, and boundary layer mixing should be key features in simulations of STBLs.

2) Overnight the cloud depth is similar over all longitudes. The cloud deck thins rapidly after sunrise.

3) Heavy drizzle that occurs in the west is self-limiting, maximizing near 3 am. Lighter drizzle in the east only diminishes after the sun comes up.

Noon



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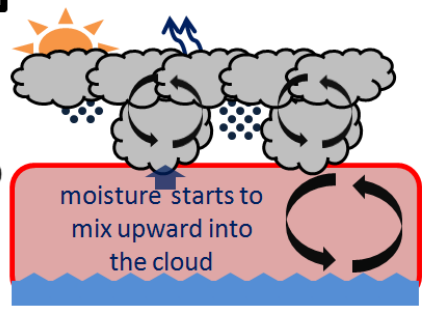

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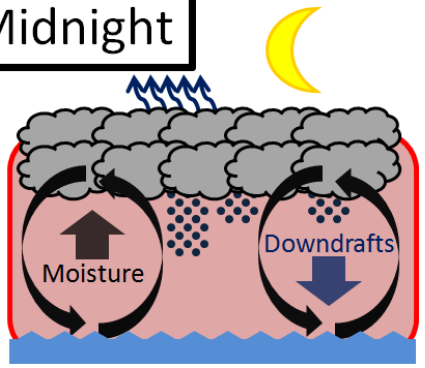

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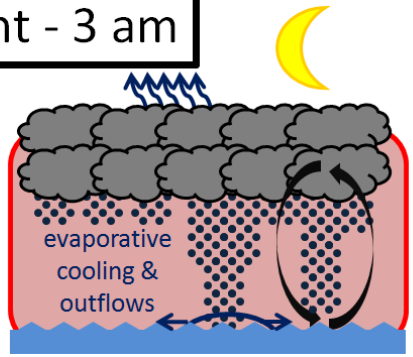

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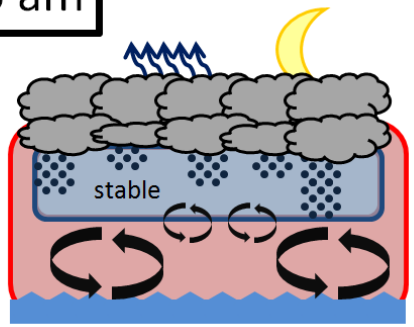

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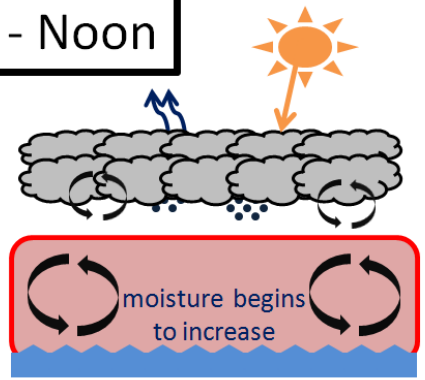

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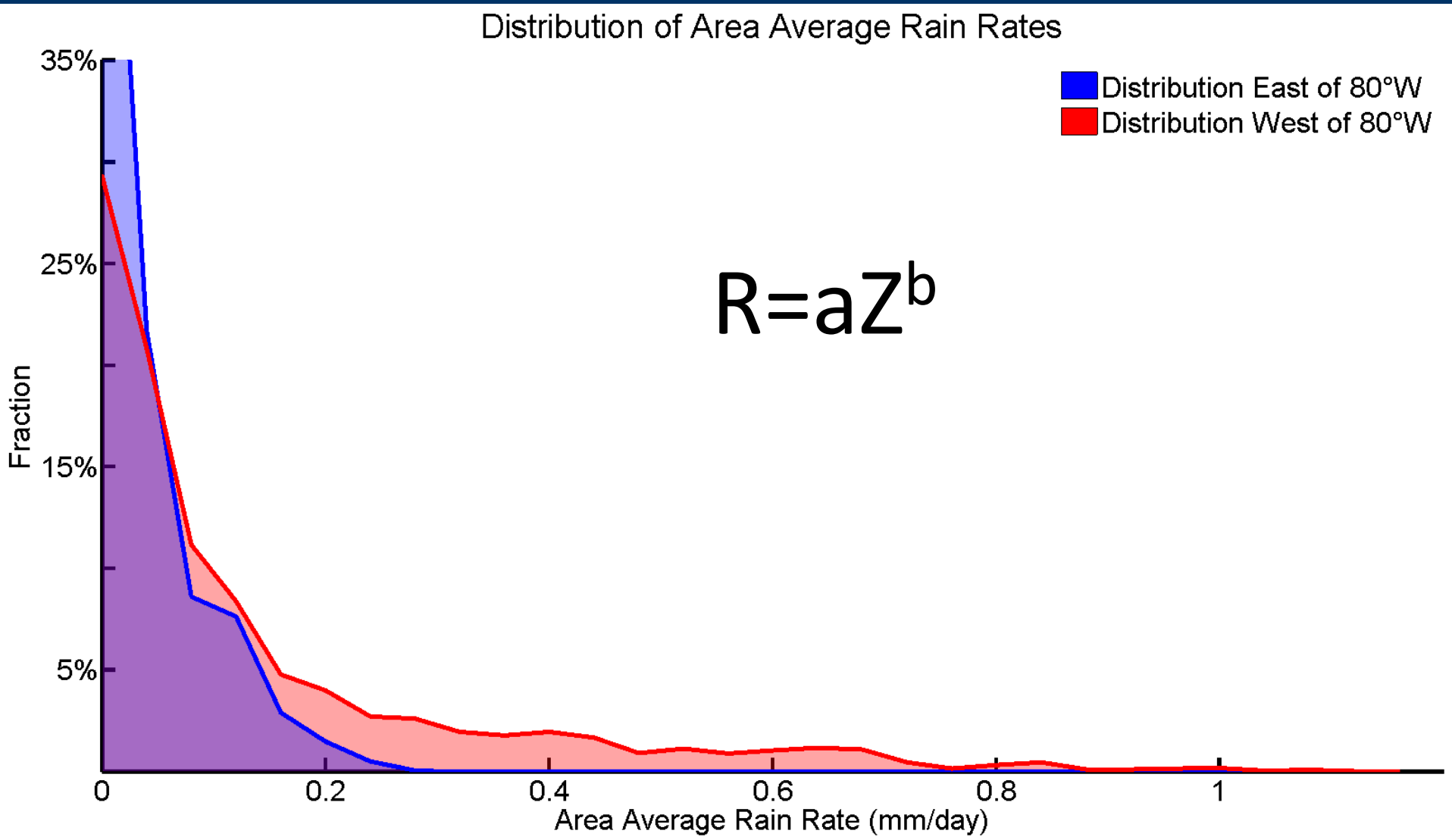
Drizzle Intensity Distributions



$$R=aZ^b$$