Effect of Environment on Marine Boundary Layer Cloud-Drizzle Process

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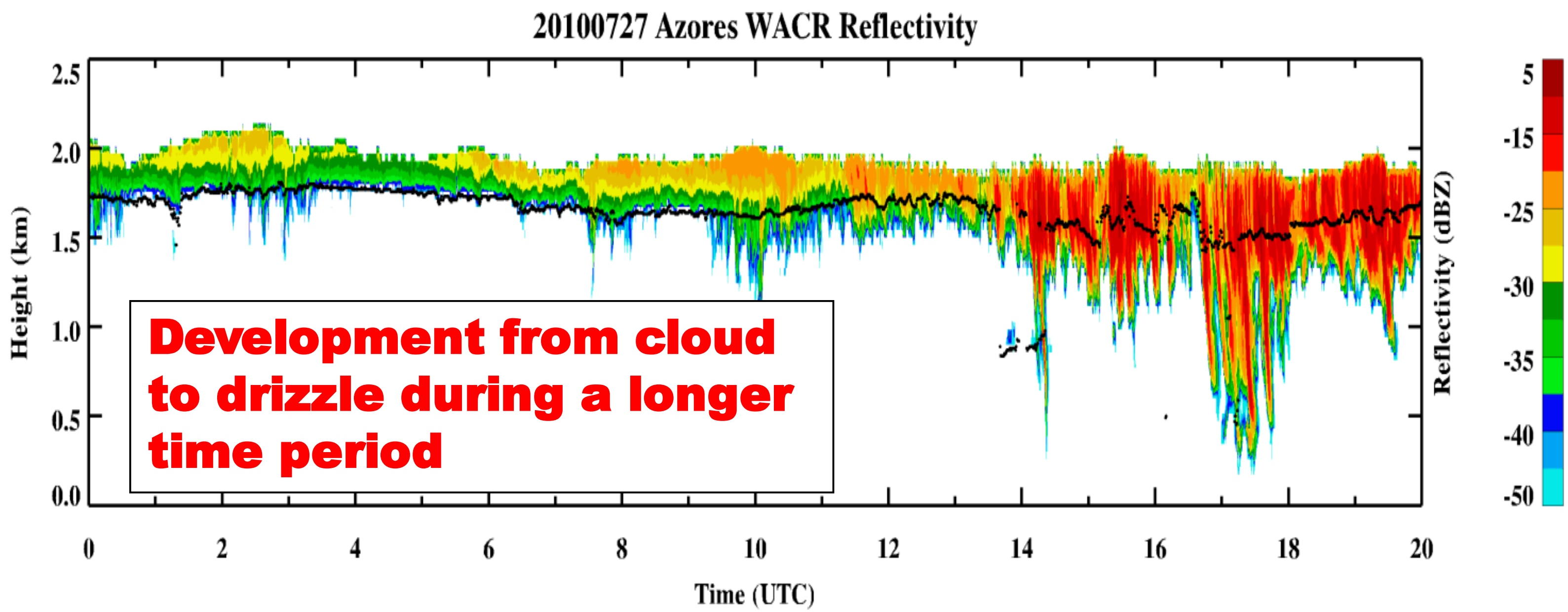
Introduction

- MBL clouds frequently produce drizzle,
- Cloud to drizzle processes are still unclear,
- This study investigates the role of vertical wind shear and large-scale forcing in cloud-drizzle formation process.

Two types of Cloud-drizzle processes

TYPE I



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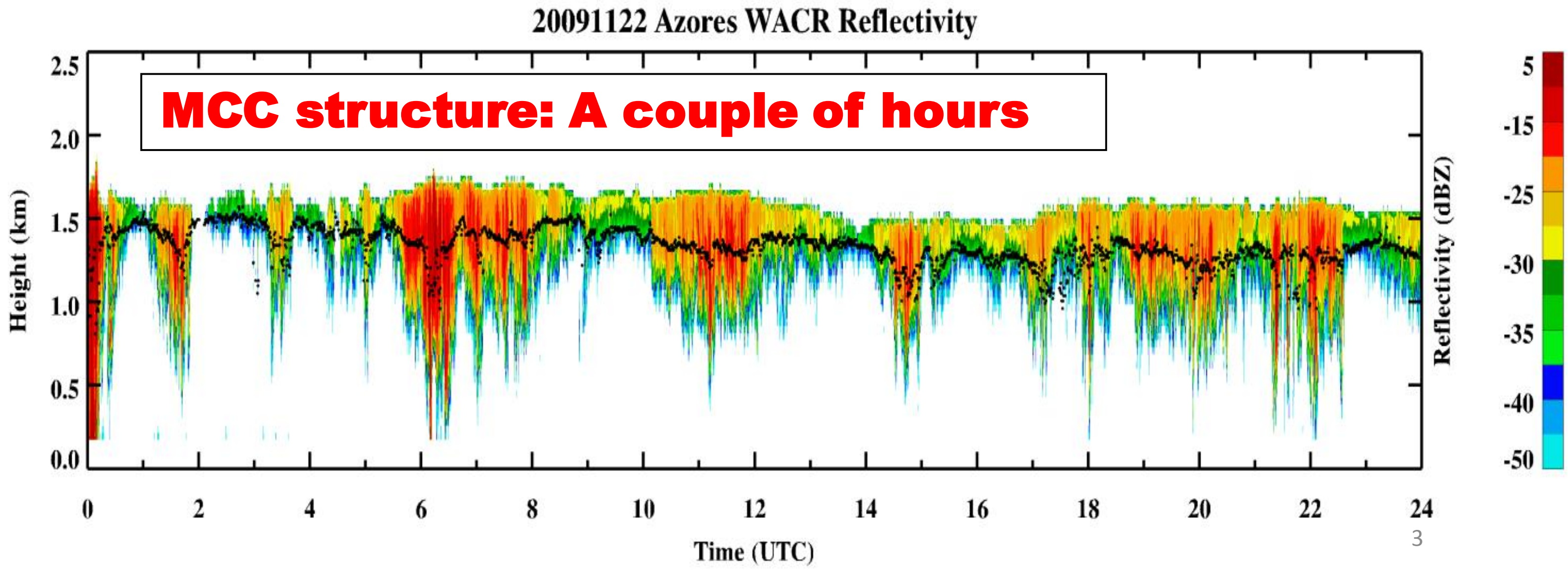
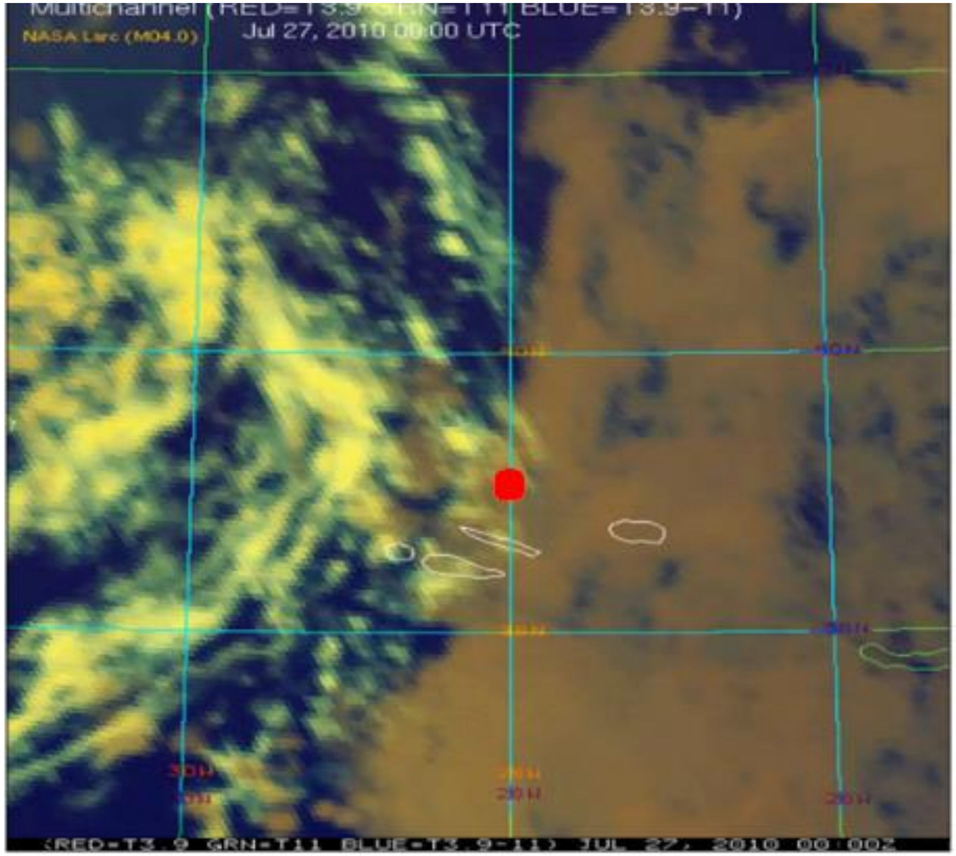
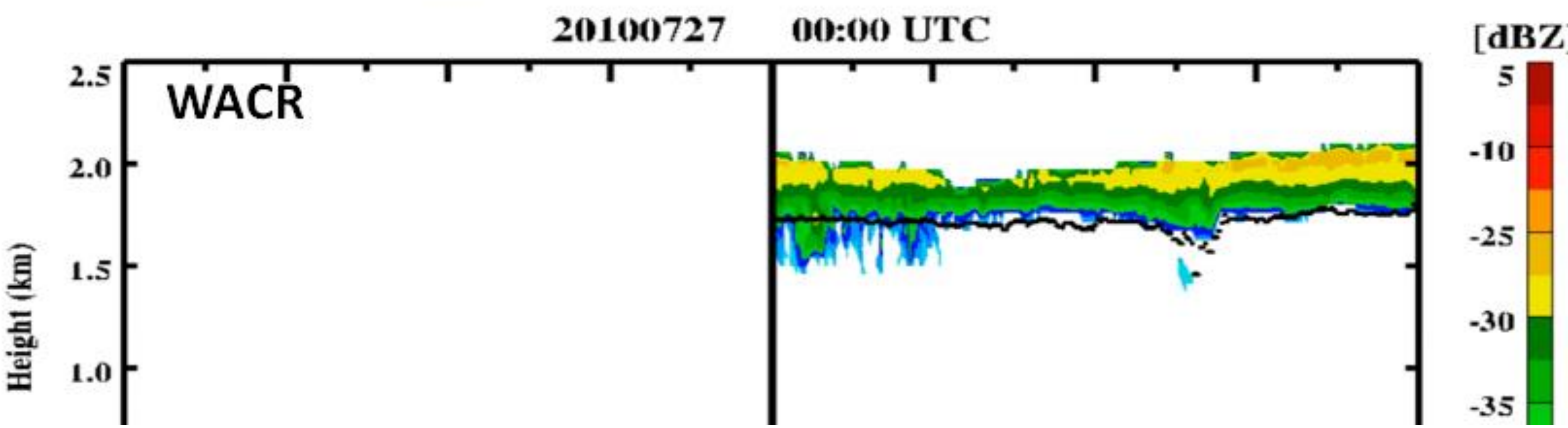


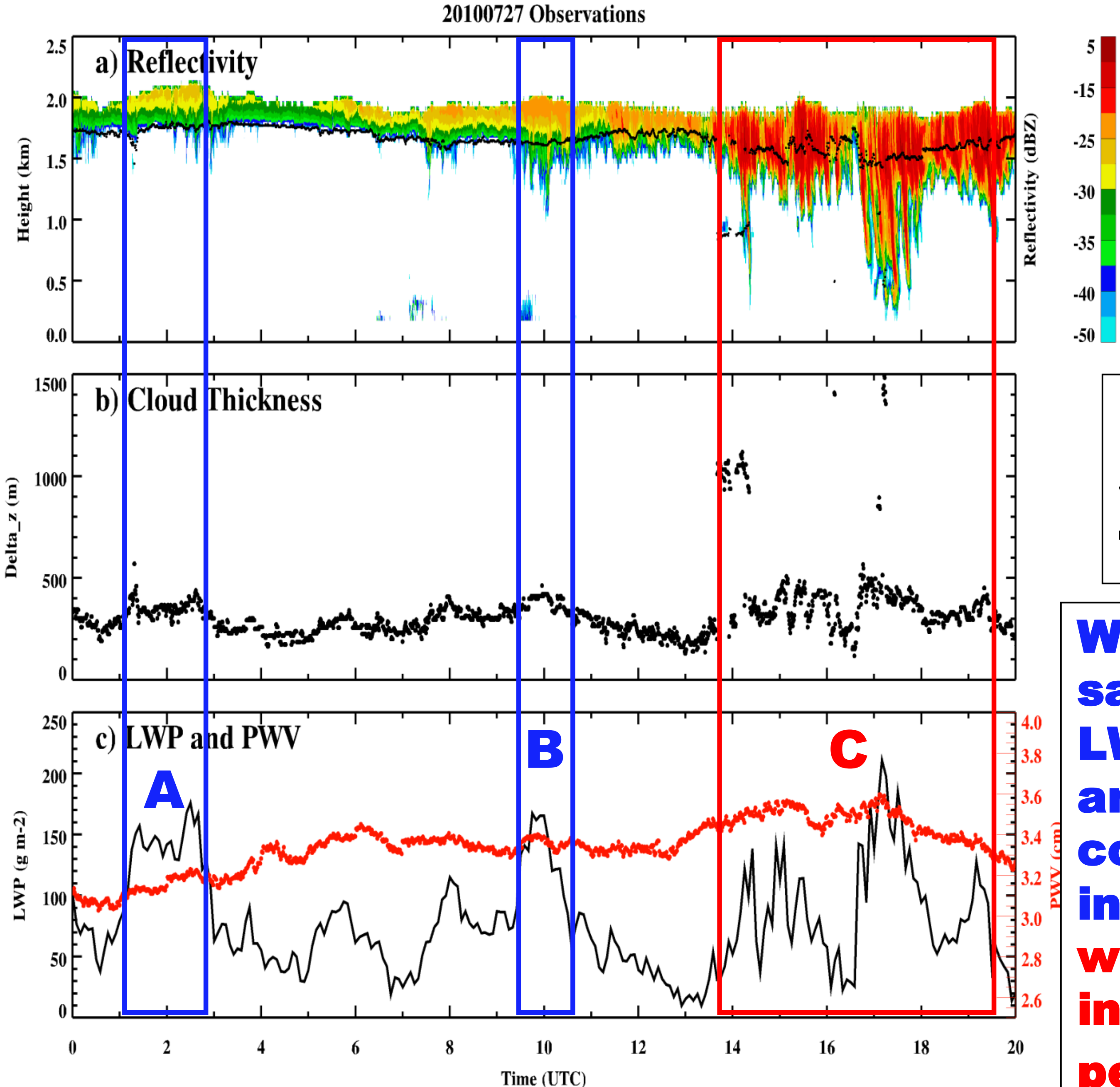
TYPE I



METEOSAT- 9
RGB IMAGE

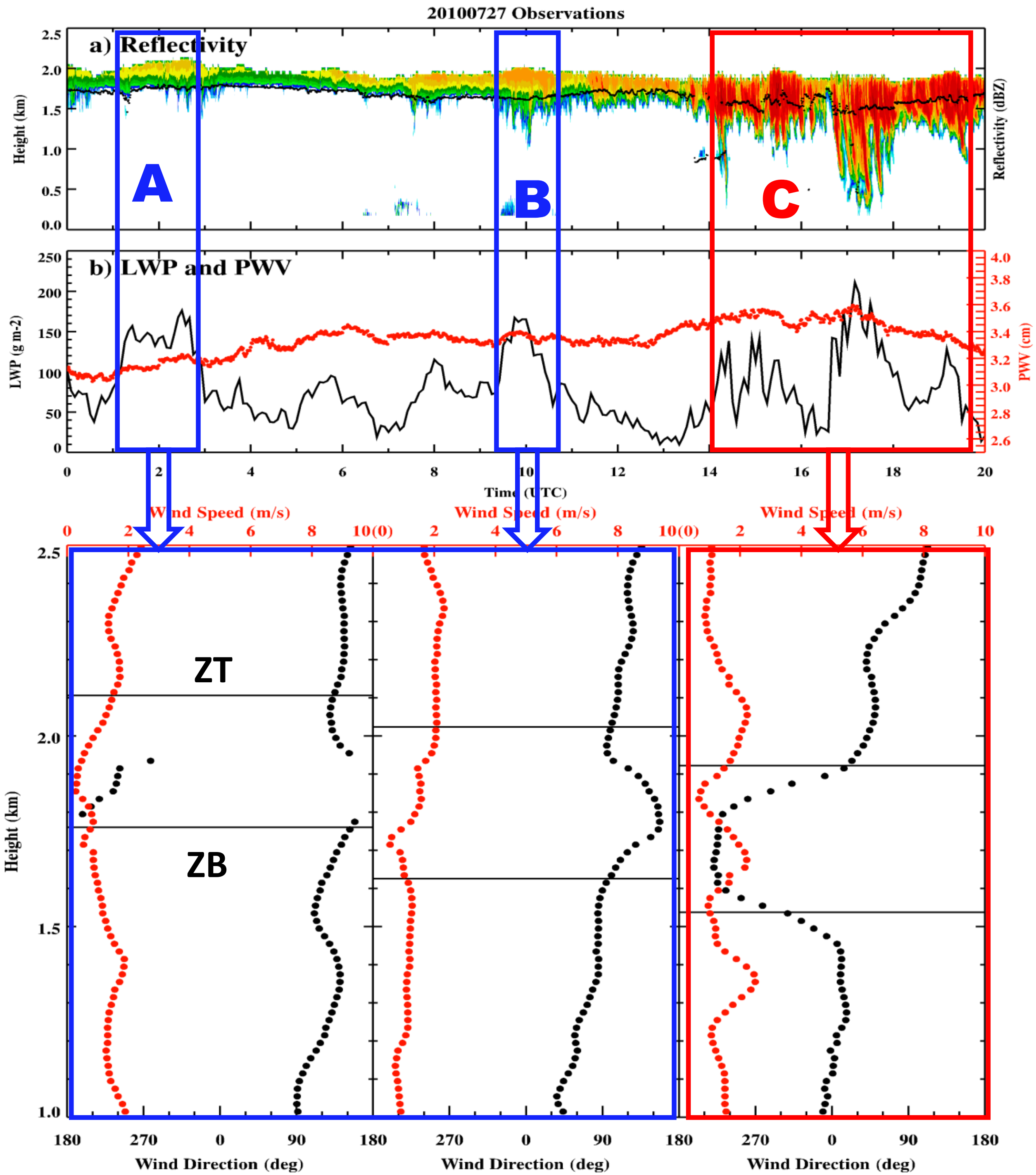


TYPE I Observations



Nearly the same cloud thicknesses

With nearly the same PWV, the LWPs in Periods A and B are comparable to that in Period C, but why there are intense drizzle in period C?



Role of Wind Shear

→Wind speed in all three time periods are less than 3 m/s.

→Weak wind shear during Periods A and B, but strong wind shear exists in Period C which generates more collision-coallescence processes within clouds→ generating drizzle.

Recent Model Study

Magaritz-Ronen, L., M. Pinsky, and A. Khain, 2016: **Drizzle formation in stratocumulus clouds: effects of turbulent mixing**. *Atmos. Chem. Phys.*, 16, 1849–1862. **Fig. 12**

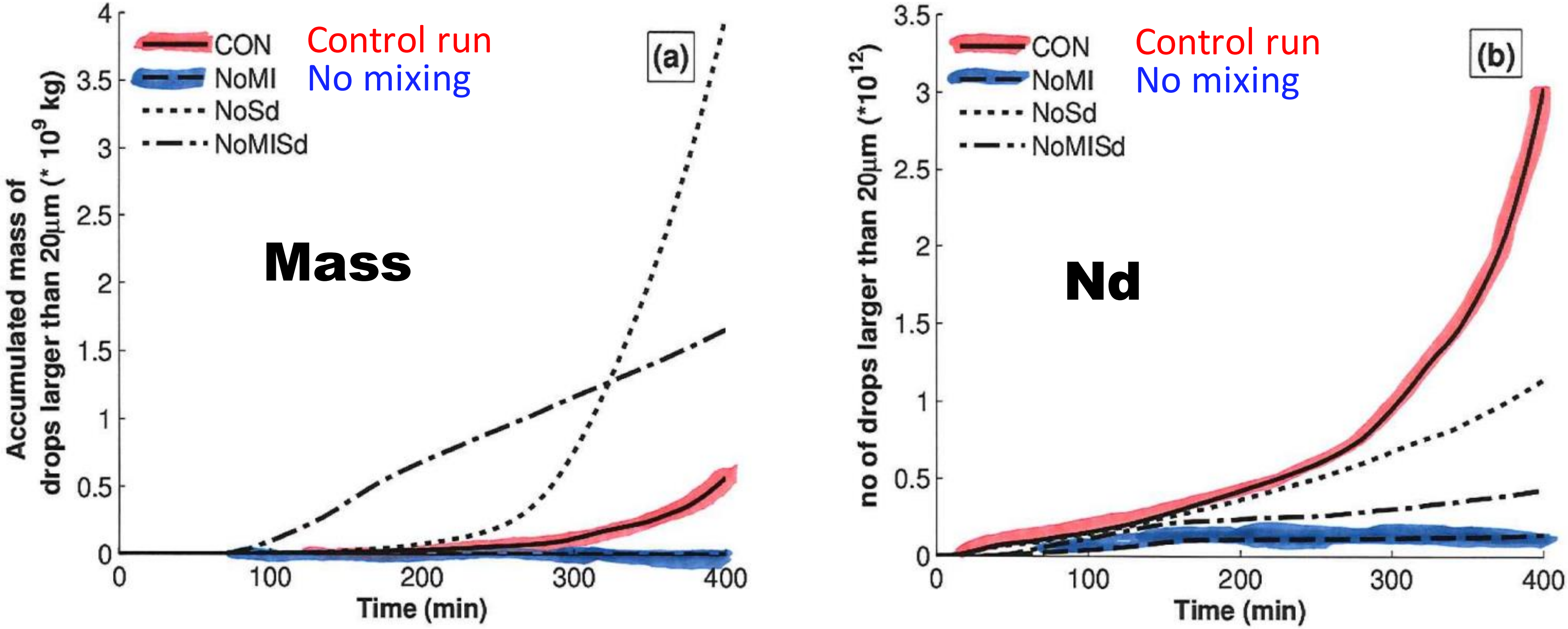
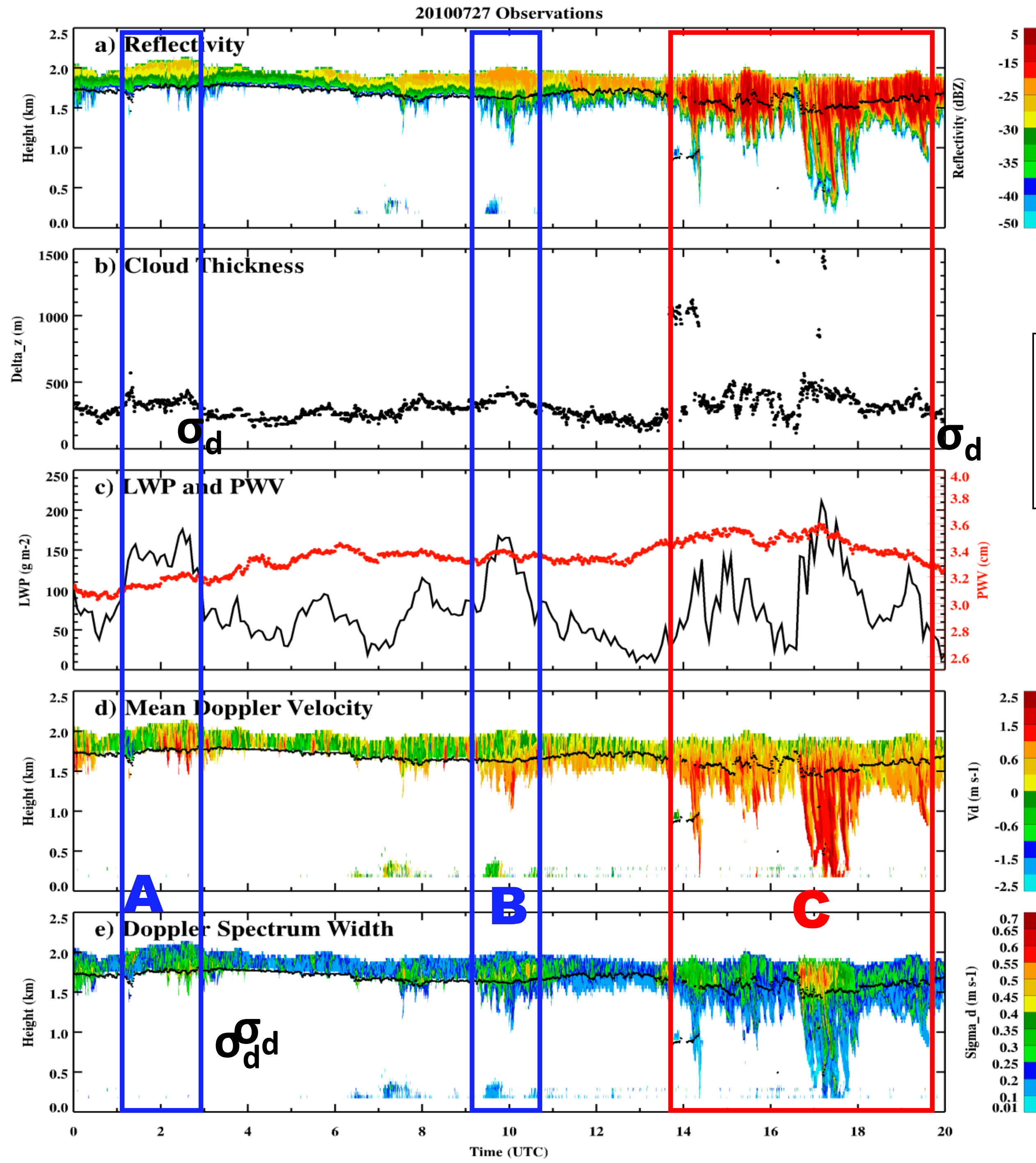


Fig. 12 shows main phases of drizzle formation in Sc.

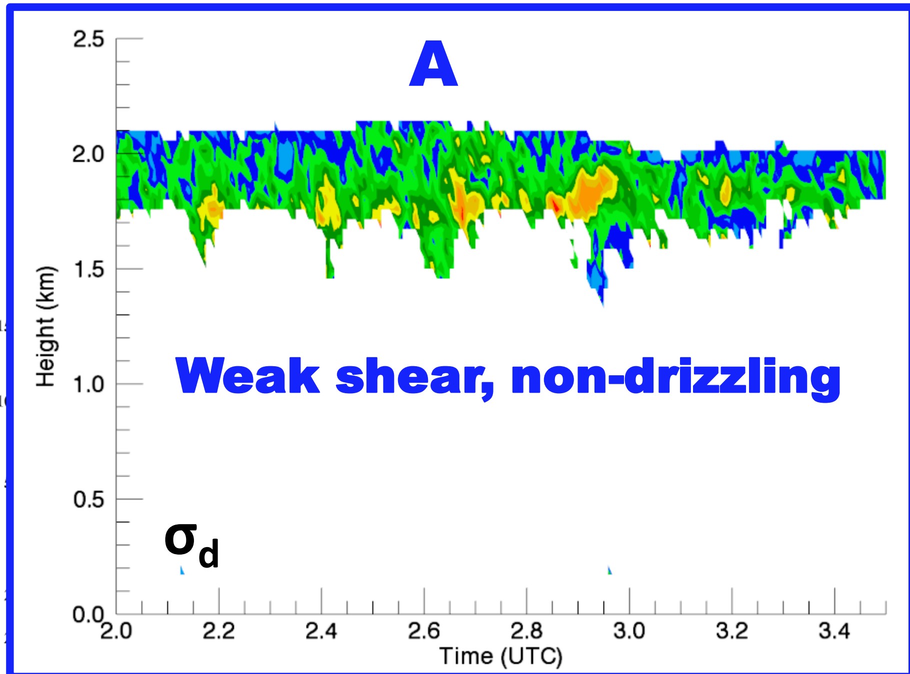
1) NO MIxing: No significant increase in mass and Nd

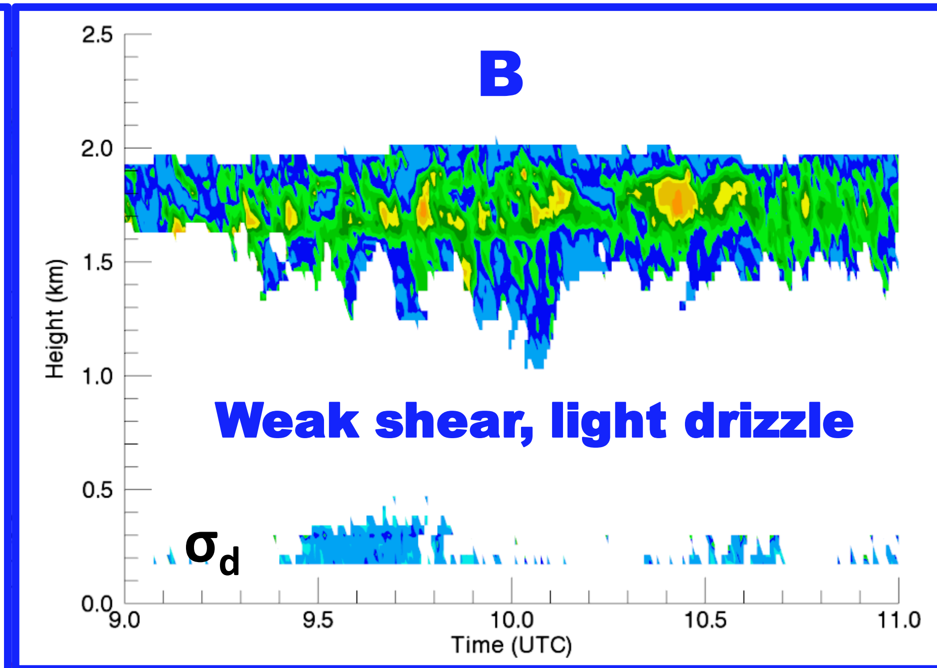
2) CONtrol run: Turbulent mixing leads to further formation of more large droplets and drizzle-sized drops

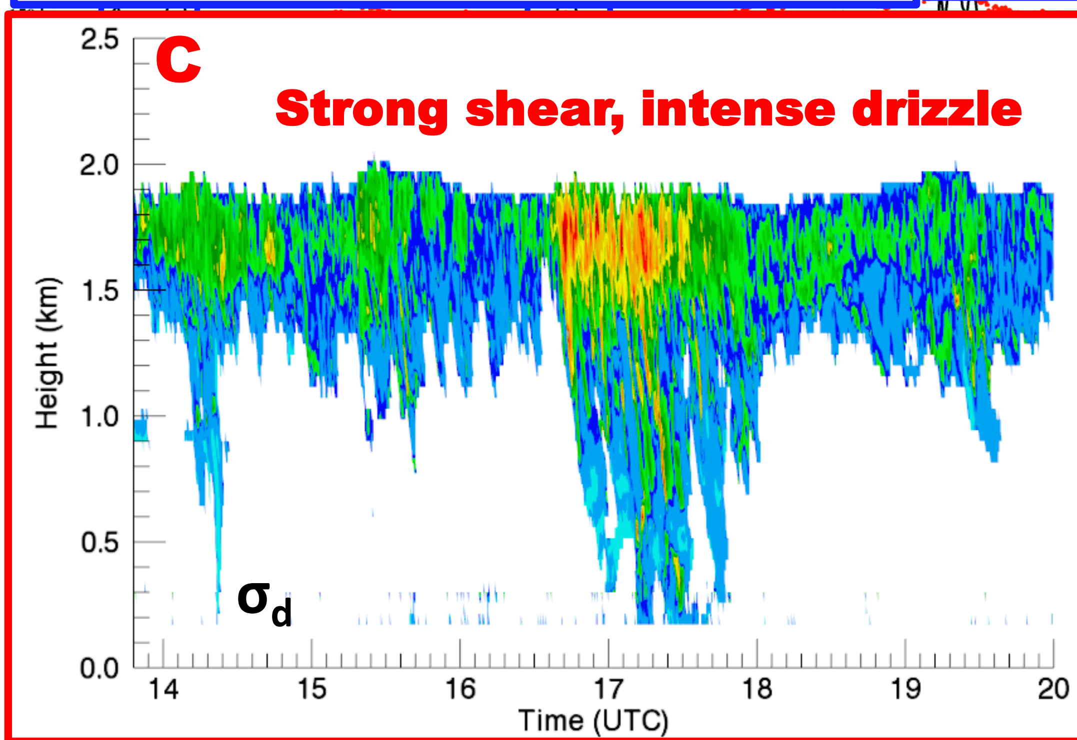
Existence of large drops revealed by v_d, σ_d



Assuming same vertical air motion, large V_d indicate large particles.





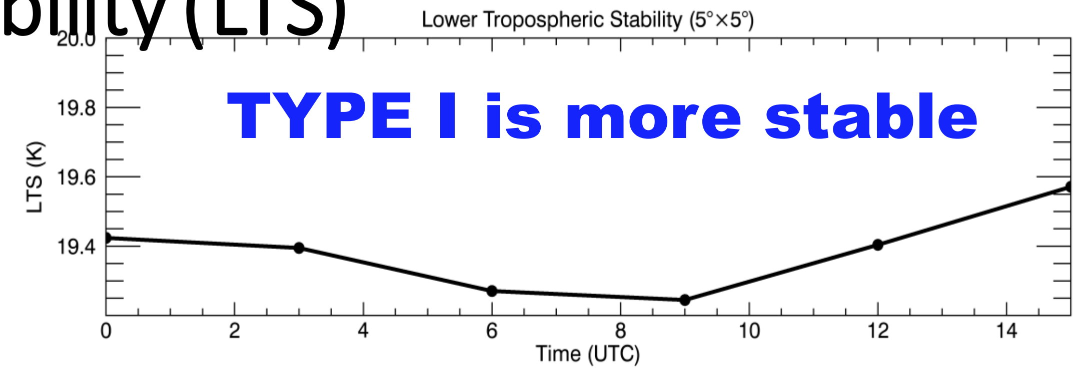


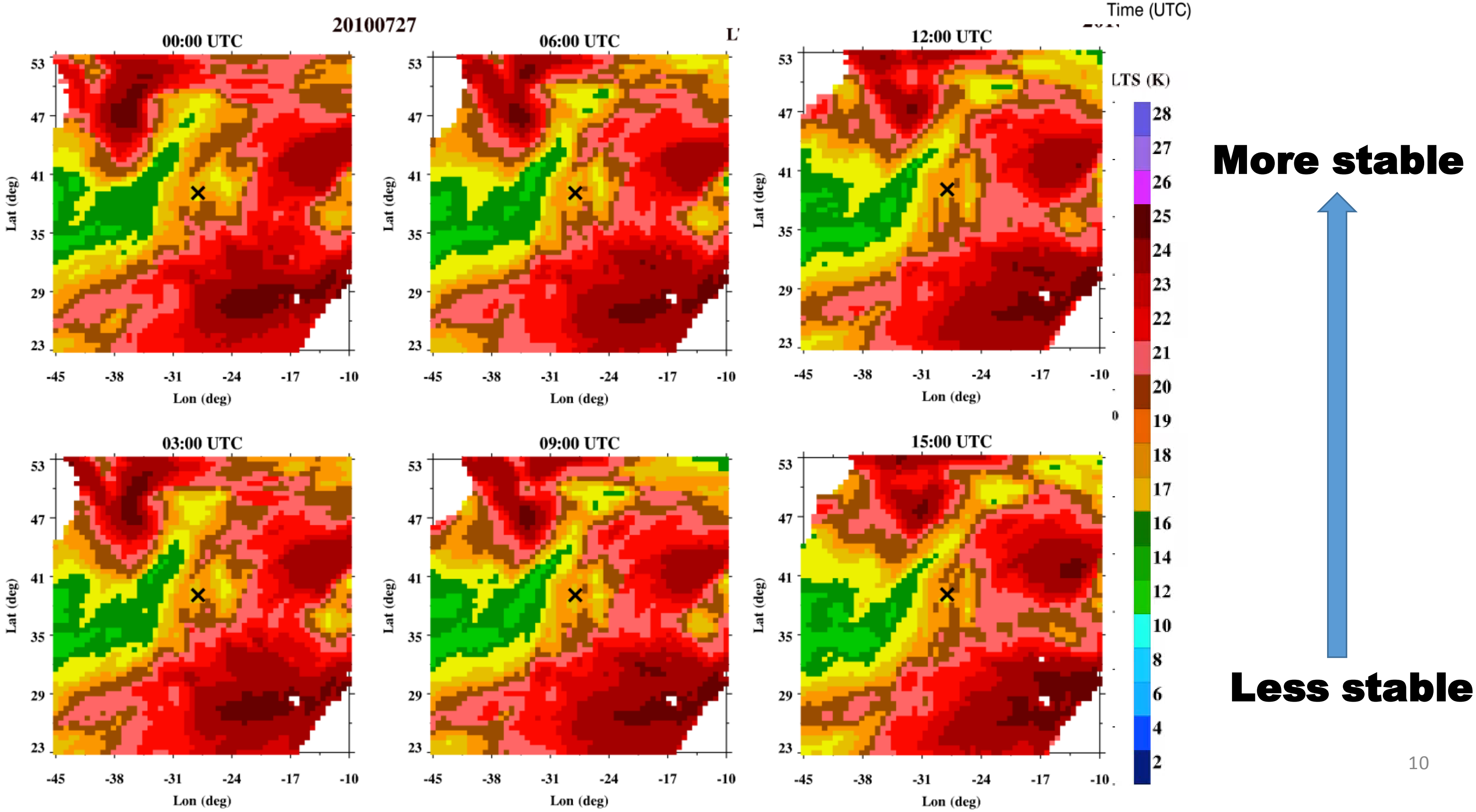
Spectral broadening due to the existence of several large drops. No intense drizzle production afterwards due to weak shear.

Large droplets form via enhanced wind shear→ generating more collision-coalescence processes.

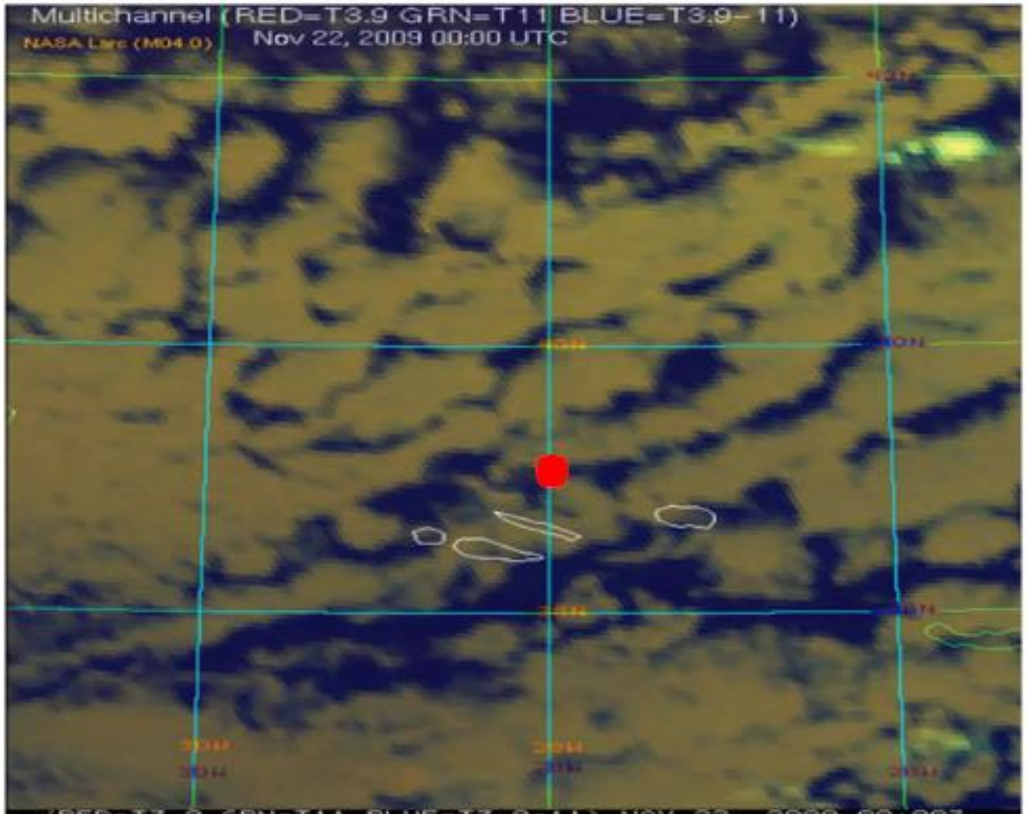
Lower Tropospheric Stability (LTS)

- $LTS = \theta_{700hPa} - \theta_{sfc}$
- MERRA-2 data (0.5°×0.625°)

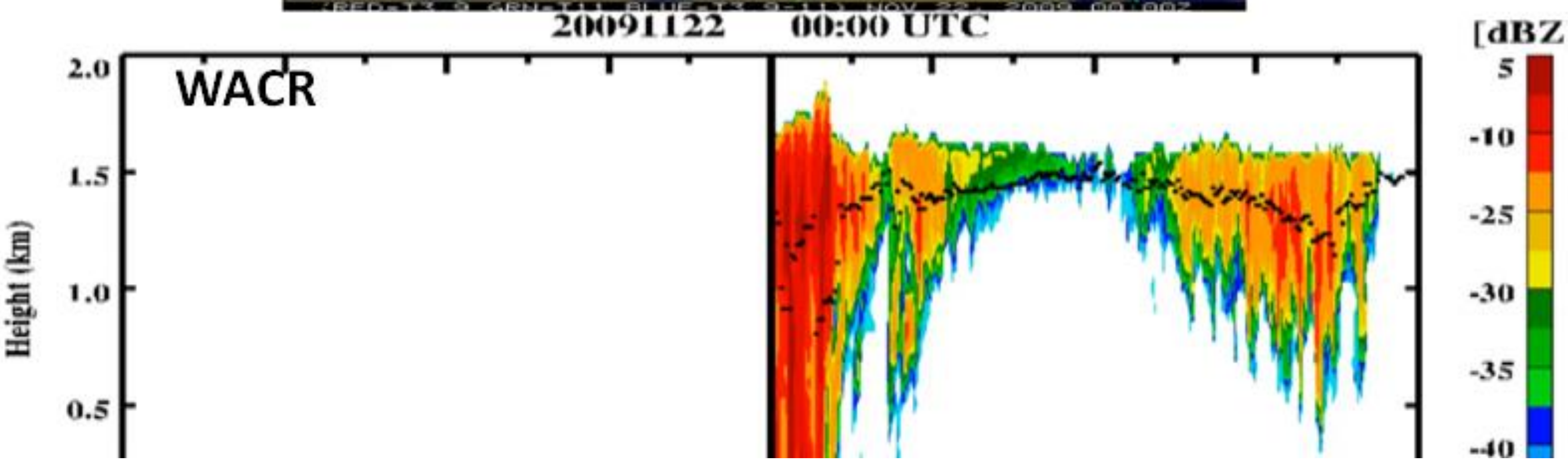


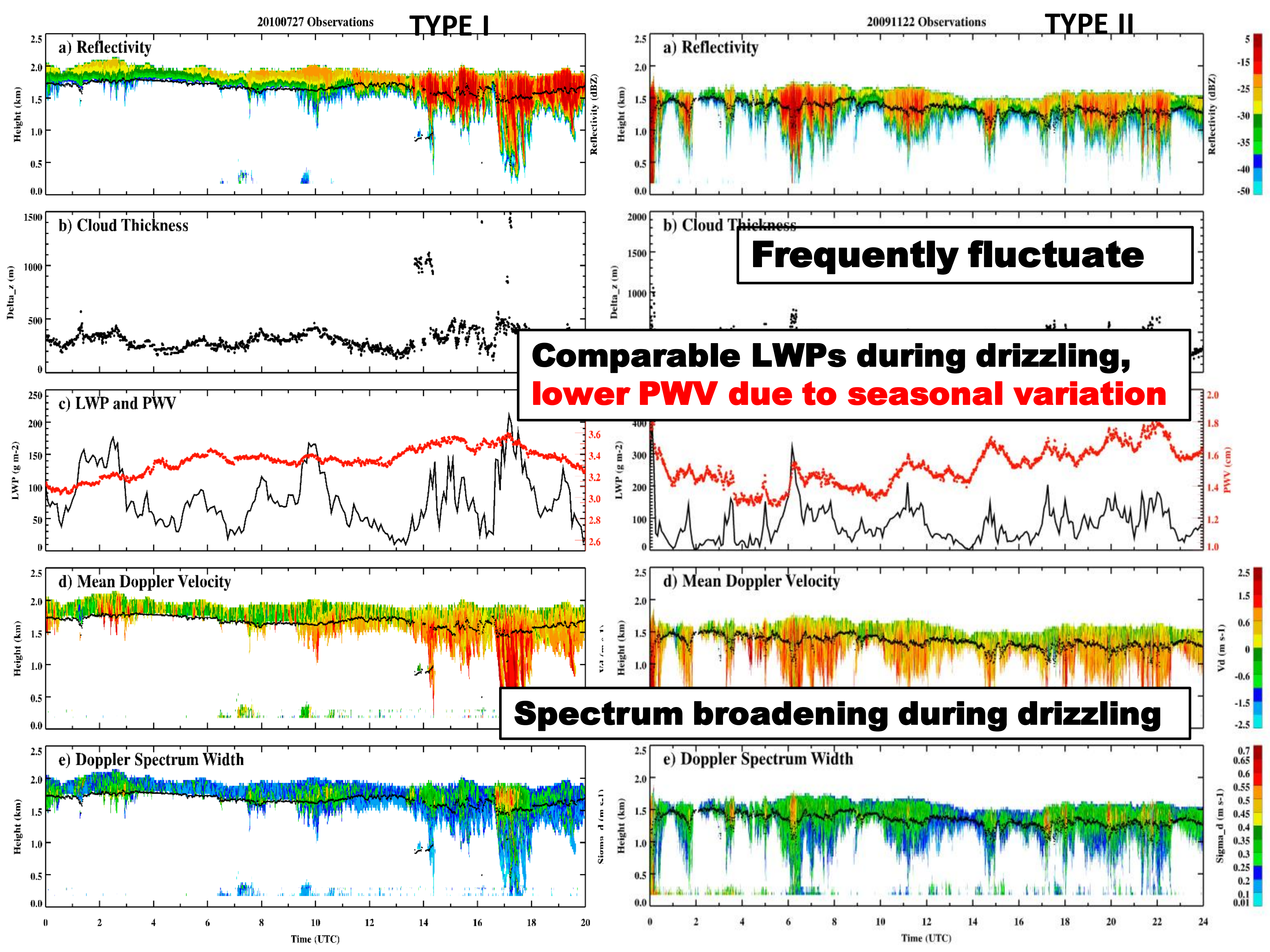


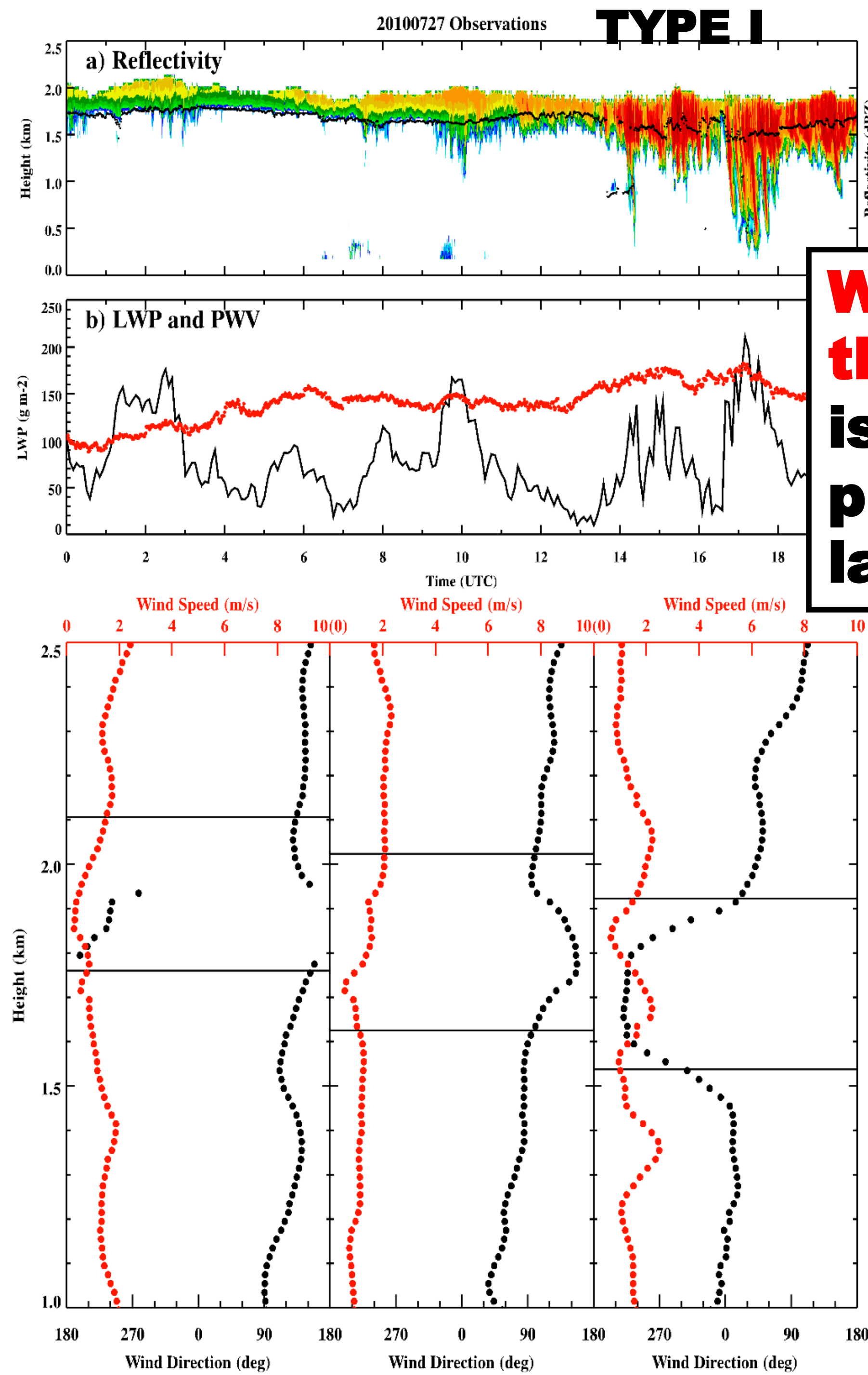
TYPE II

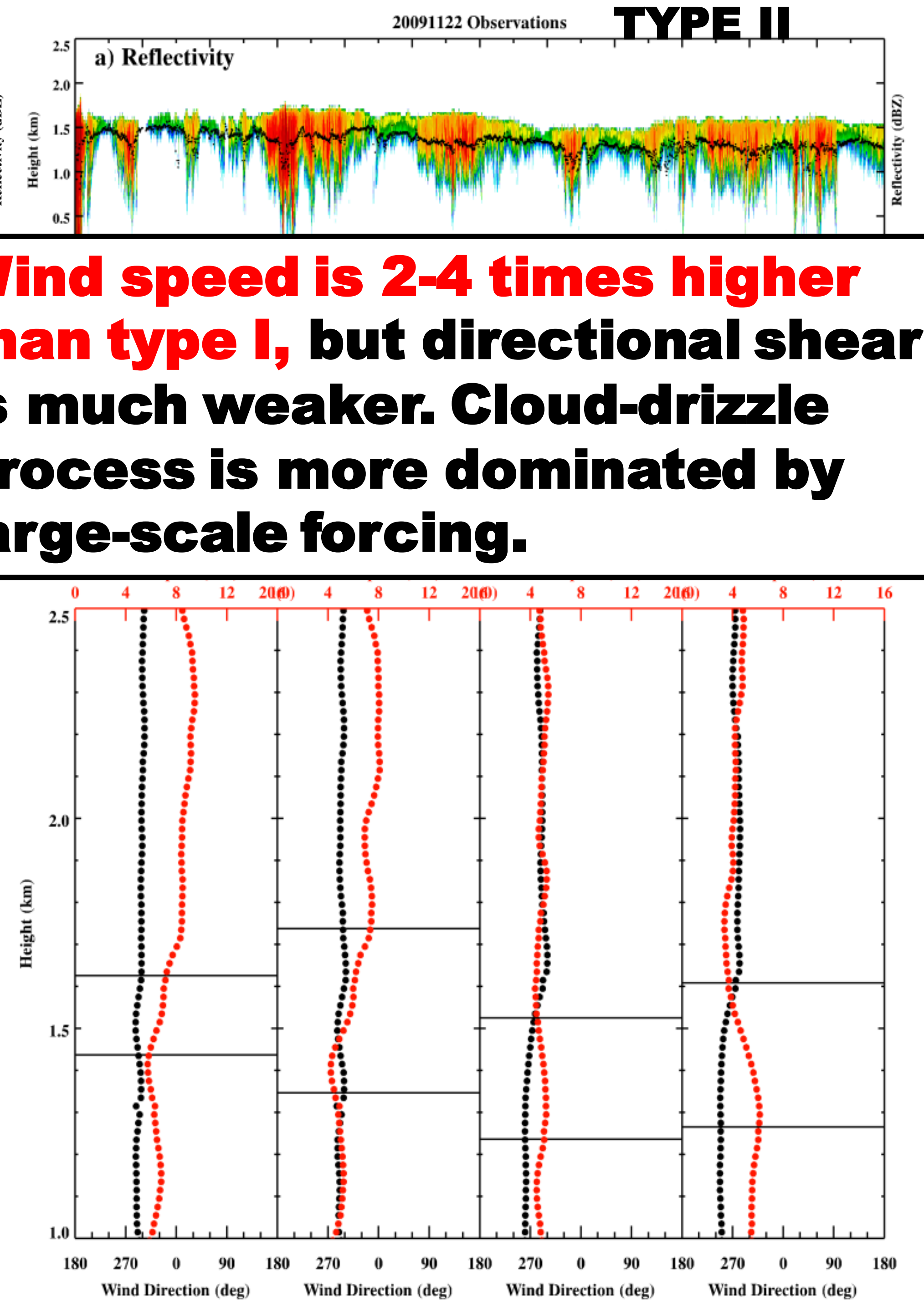


METEOSAT- 9
RGB IMAGE




20100727 Observations
TYPE I
20091122 Observations
TYPE II
a) Reflectivity
b) Cloud Thickness
c) LWP and PWV
d) Mean Doppler Velocity
e) Doppler Spectrum Width
Height (km)
Delta_z (m)
LWP (g m-2)
PWV (cm)
Reflectivity (dBZ)
Vd (m s-1)
Sigma_d (m s-1)
Time (UTC)
Frequently fluctuate
Comparable LWPs during drizzling,
lower PWV due to seasonal variation
Spectrum broadening during drizzling



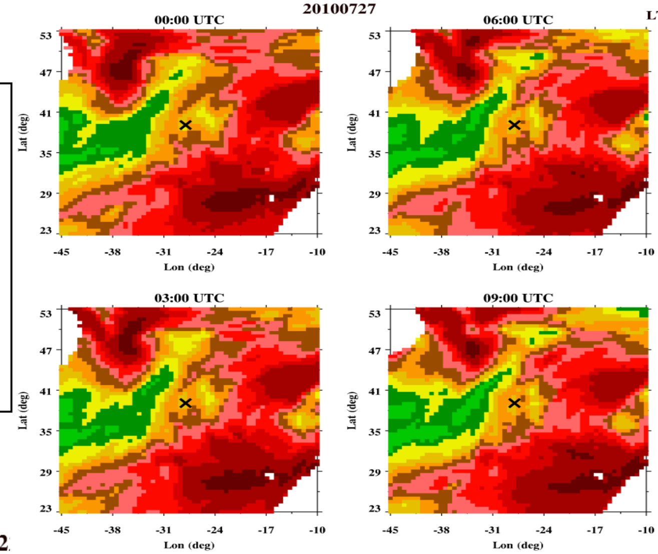


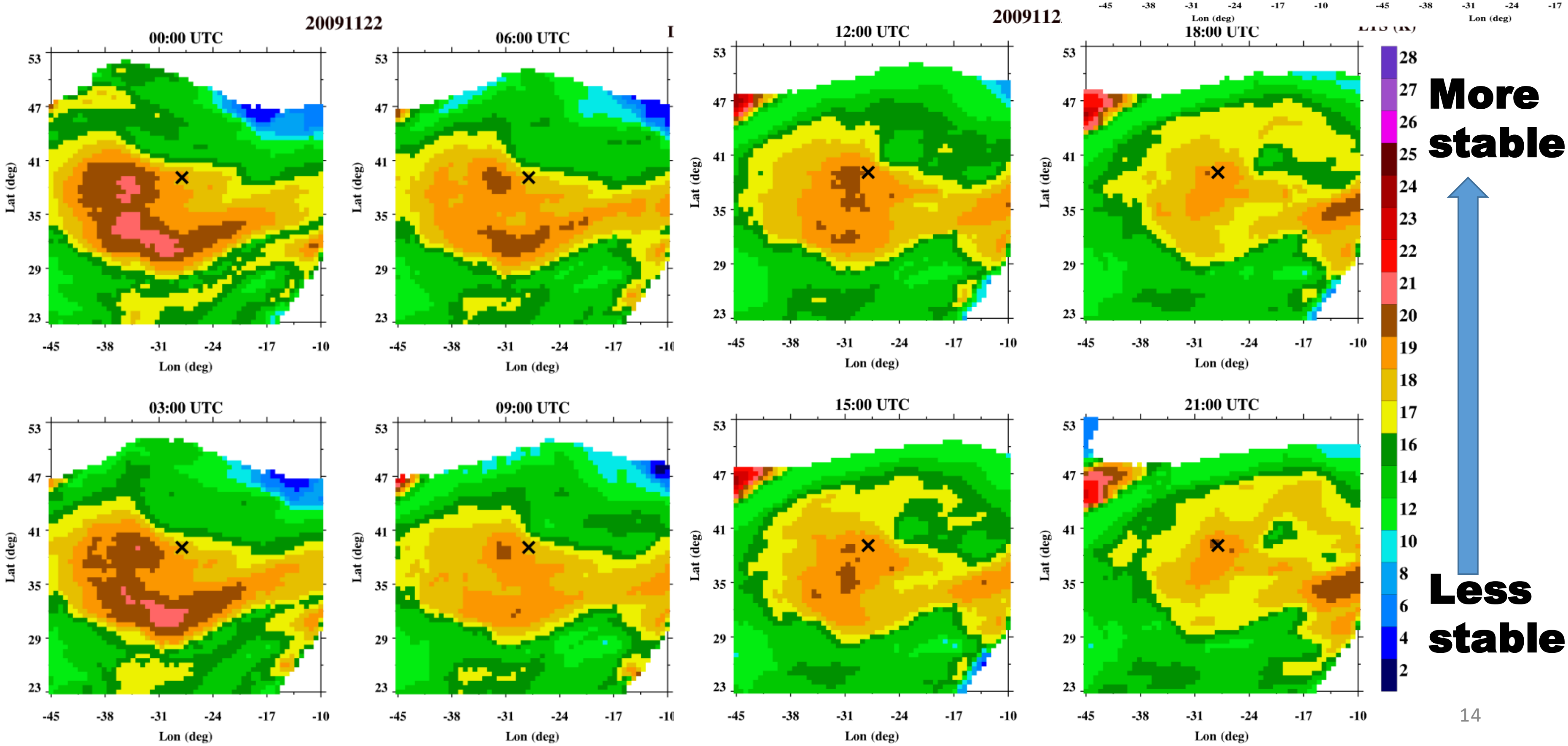
Wind speed is 2-4 times higher than type I, but directional shear is much weaker. Cloud-drizzle process is more dominated by large-scale forcing.

LTS

Type II is more convectively active, resulting in the MCC structures as shown in radar reflectivity.

TYPE II is less stable





Summary

- **(Type I) In a stable MBL, cloud can persist for more than 10 hrs before intense drizzle occurs,**
- **(Type I) Vertical wind shear plays an essential role in enhancing cloud-drizzle process,**
- **(Type II) Vertical wind shear is weak,**
- **(Type II) Relatively lower LTS results in less stable MBL and thus MCC structure, in which large-scale forcing becomes more important,**
- **In-depth study of the cloud-drizzle process for type II will be conducted.**

THANK YOU!

Welcome Questions and Comments