What datasets and results we can provide from MC3E

Xiquan Dong
University of North Dakota

Jingjin Tian, Jingyu Wang, Ning Zhou, Ron Stenz, Baike Xi, Tony Grainger, Uni. of North Dakota
Zhe Feng, DOE PNNL
Pat Minnis and Mandy Khaiyer, NASA Langley
Scott Giangrande and Tami Toto, DOE BNL

MC3E results we can provide

1. 2D and time-height NEXRAD over SGP and its classified DCS components (Convective core, Stratiform region, and Anvil clouds).
2. Surface precipitation from NEXRAD Q2 and OK mesonet measurements
3. Time series of NEXRAD and corrected KAZR reflectivity, fall speed, LWP, rain rate, and surface rain drop diameter (disdrometer)
4. UND citation aircraft in situ measurements
5. GOES retrieved cloud properties

These datasets will be used to study the DCS cloud properties, life cycle, precipitation, and to provide a ground truth for modelers to validate their simulations.

There are 15 flights during MC3E

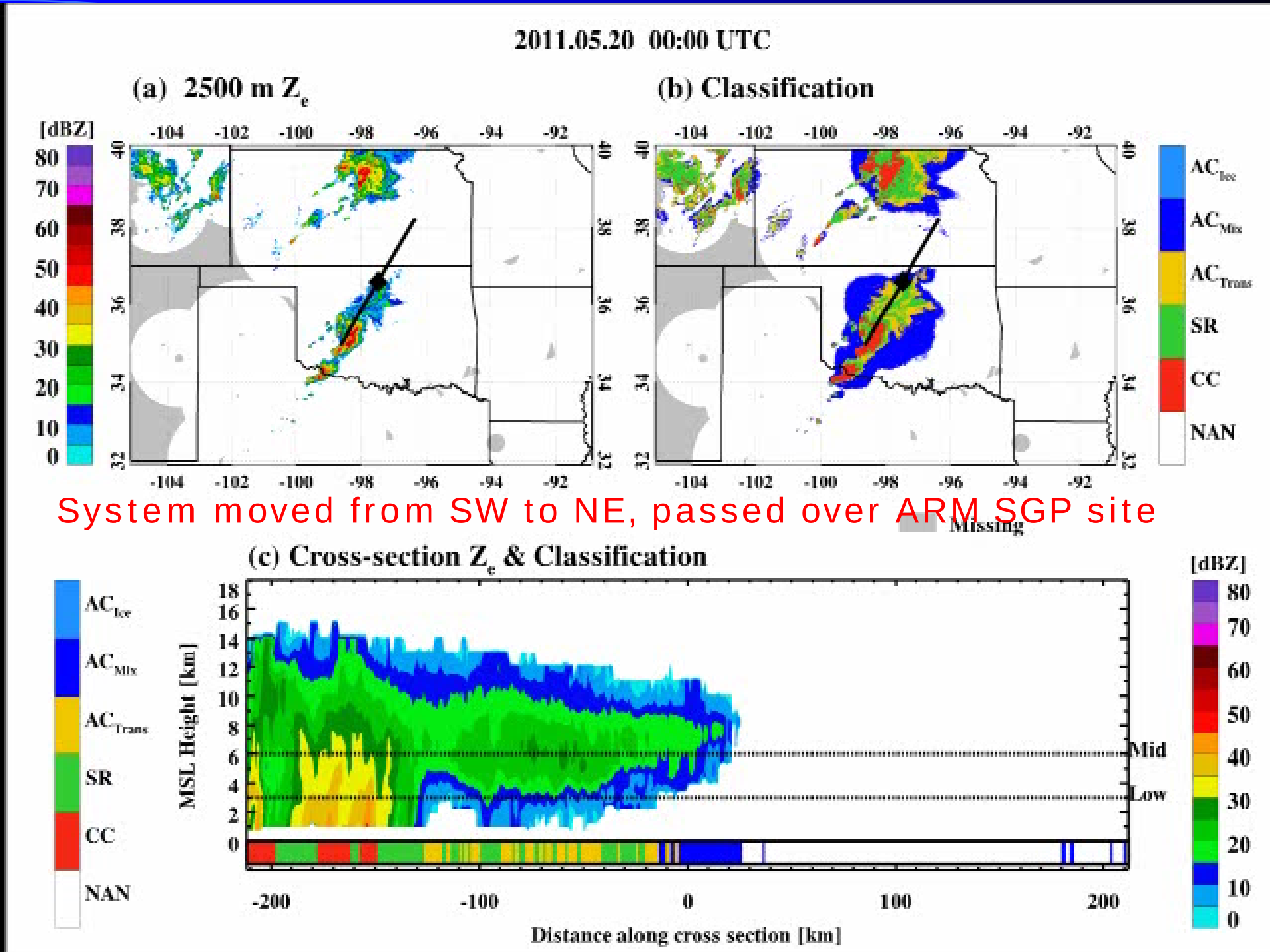
Date	Sortie	Takeoff	Landing	Hours	Notes
4/22	MC3E-1	223337	005710	2.4	Severe convection, anvil; legs
4/25	MC3E-2	092119	122229	3.0	MCS and stratiform; steps
4/27	MC3E-3	080207	112245	3.4	Stratiform; spiral
5/1	MC3E-4	162839	184213	2.2	Cold season stratiform; spiral
5/10	MC3E-5	214937	001048	2.4	Stratiform; spiral & porpoise
5/11	MC3E-6	160209	192706	3.4	Stratiform; steps
5/18	MC3E-7	072010	092156	2.0	Deep convection, precipitating anvil;
5/20	MC3E-8	130539	170204	4.0	Severe convection, stratiform; steps, spiral over ARM SGP
5/23	MC3E-9	212942	004129	3.2	Severe convection; anvil
5/24	MC3E-10	201825	222750	2.1	Precipitating anvil; spiral
5/27	MC3E-11	210309	000405	3.1	Shallow cumulus;
5/30	MC3E-12	122204	160034	3.6	
6/1	MC3E-13	163000	174429	1.3	Shallow cumulus;
6/1	MC3E-14	190636	220246	2.9	Precipitating anvil; spiral
6/2	MC3E-15	144124	181847	3.6	Cirrus; steps, spiral

Now we focus on three cases

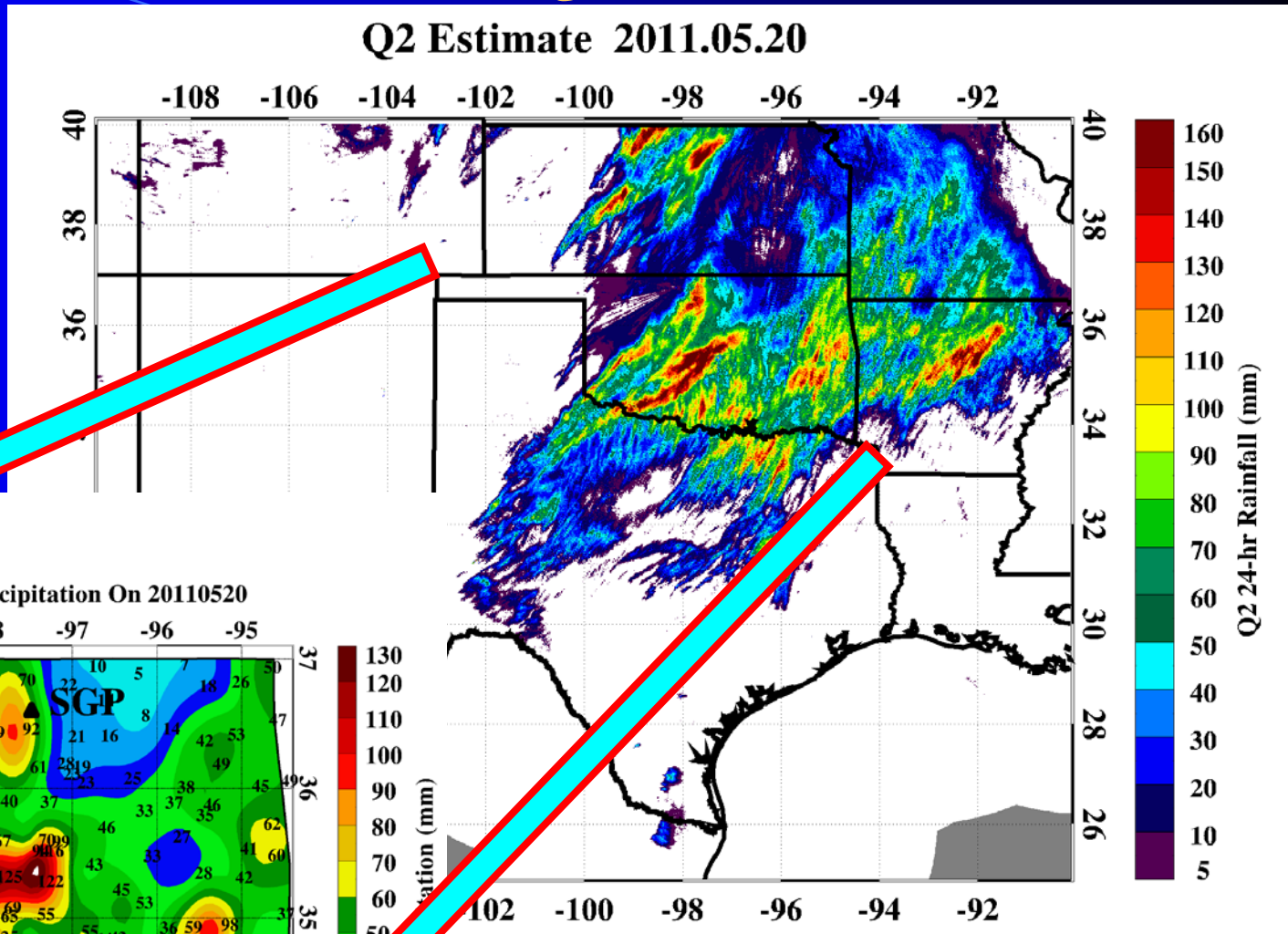
Date	Sortie	Takeoff	Landing	Hours	Notes
4/25	MC3E-2	092119	122229	3.0	MCS and stratiform; steps ➔Lower radar reflectivity associated with clean airmass, AOD~ 0.2 ➔Higher LWP~ 4000-5000 gm^{-2}, ➔Huge rain rates= 10-20 mm/hr, ➔Larger max rain drop Diameter~ 4-5 mm at surface ➔Higher IWC~ 1 gm^{-3}, and re~ 400 um
5/20	MC3E-8	130539	170204	4.0	Severe convection, stratiform; steps, spiral over ARM SGP A classic DCS case
5/23	MC3E-9	212942	004129	3.2	Severe convection; anvil ➔Higher radar reflectivity associated with polluted airmass, AOD~ 0.4 ➔Lower LWP~ 1000-2000 gm^{-2}, ➔Rain rates < 10 mm/hr, ➔Max rain drop Diameter< 5 mm at surface ➔Higher IWC~ 0.9 gm^{-3}, and re~ 800 um

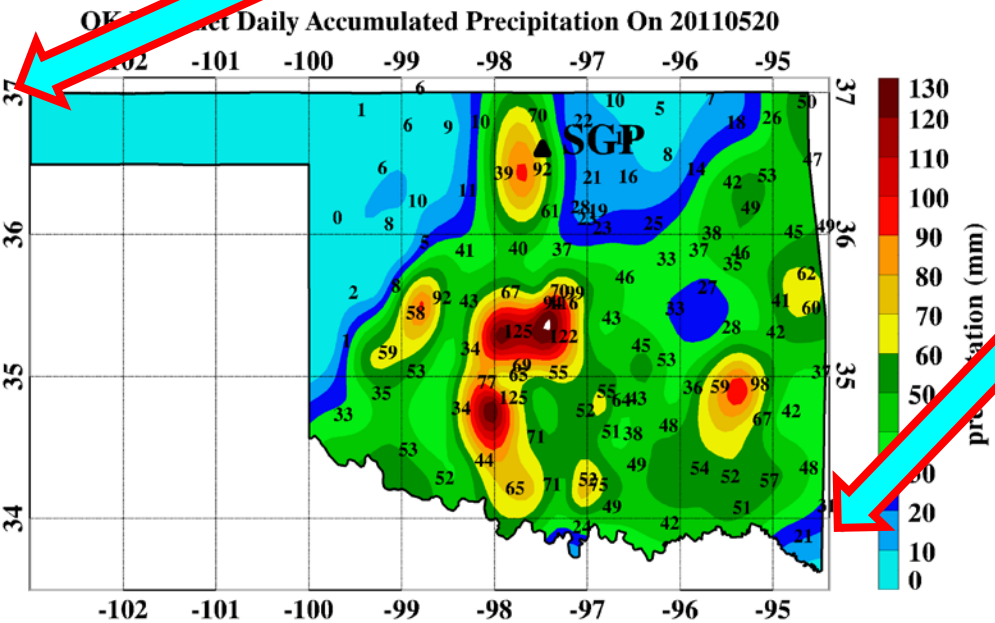
A Case Study: May 20

- From Surface, aircraft and satellite observations and retrievals


2011.05.20 00:00 UTC
(a) 2500 m Z_e
(b) Classification
[dBZ]
80
70
60
50
40
30
20
10
0
-104
-102
-100
-98
-96
-94
-92
40
38
36
34
32
AC_{Ice}
AC_{Mix}
AC_{Trans}
SR
CC
NAN
Missing
System moved from SW to NE, passed over ARM SGP site
(c) Cross-section Z_e & Classification
MSL Height [km]
18
16
14
12
10
8
6
4
2
0
Mid
Low
-200
-100
0
100
200
Distance along cross section [km]

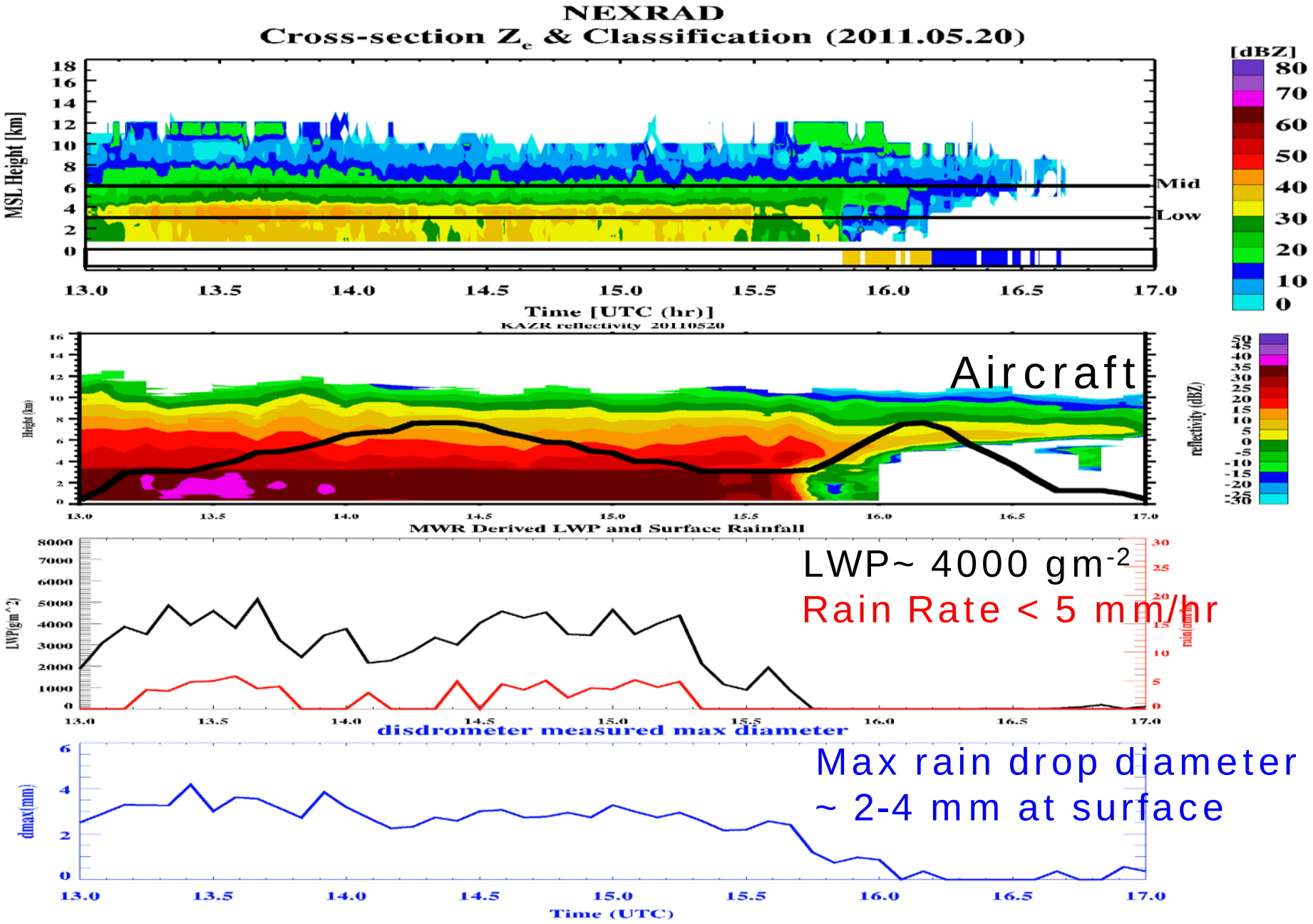
Daily Precip from NEXRD Q2 and OK Mesonet

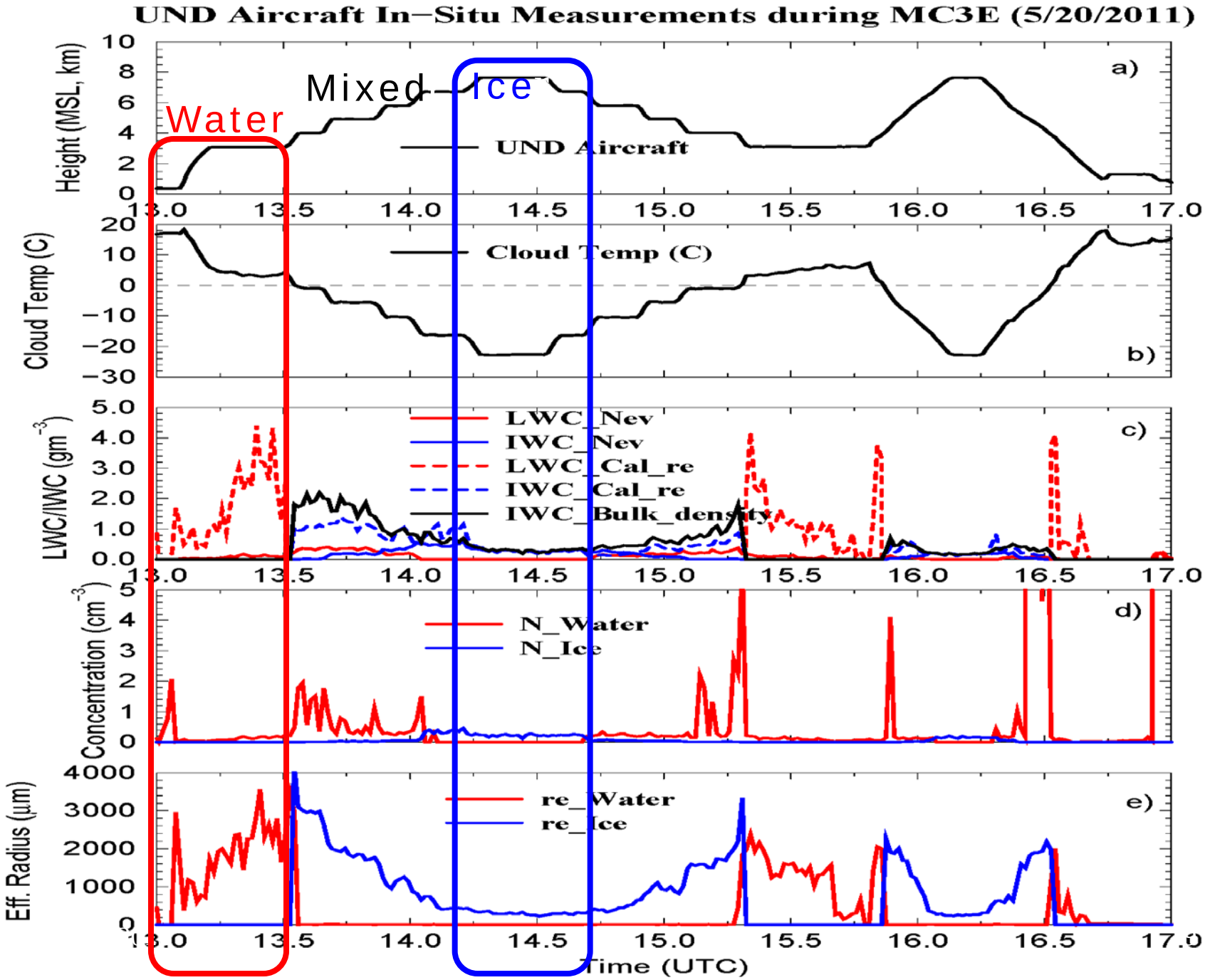




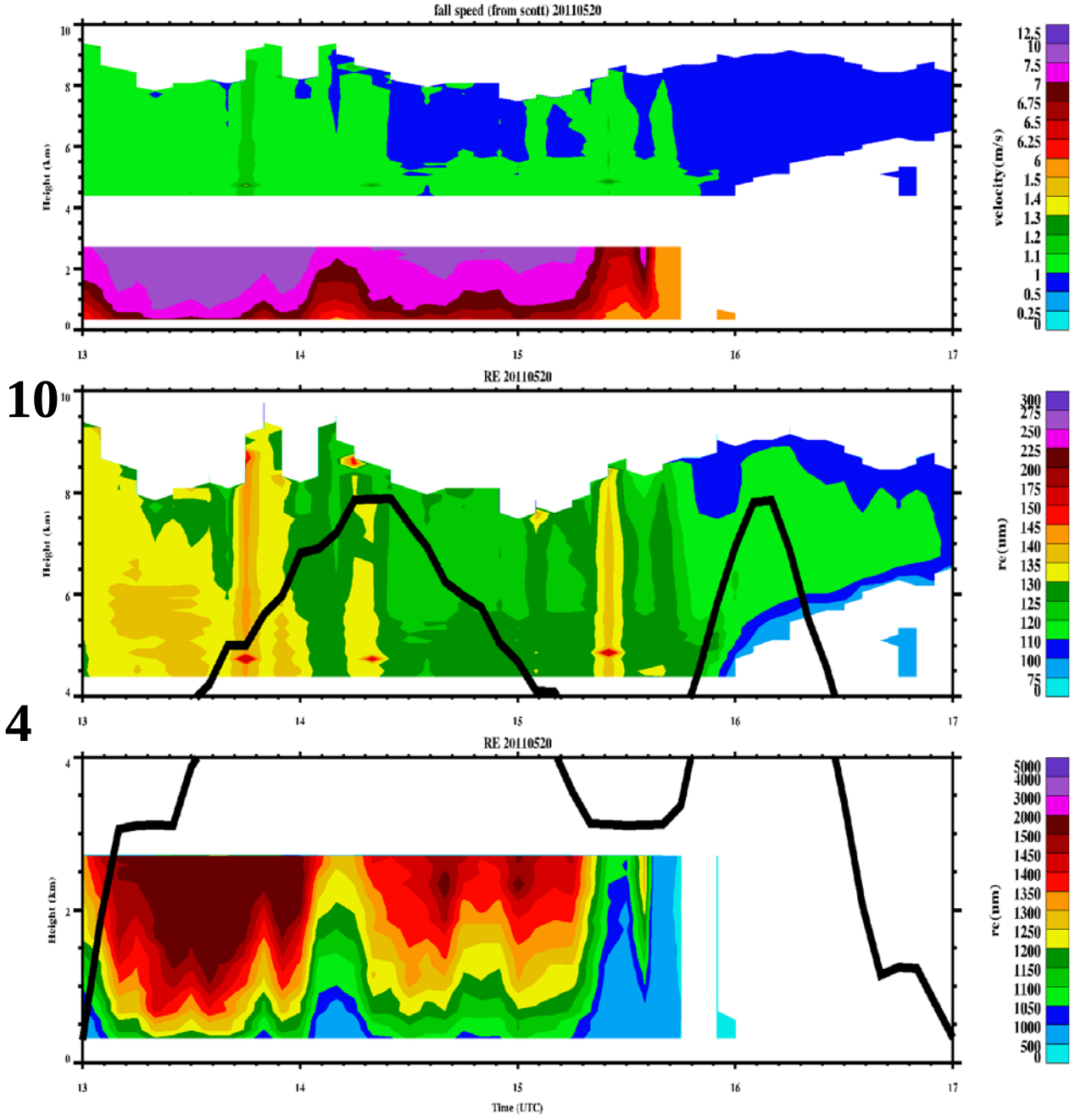
Max daily precipitation can reach up to 120 mm over central OK.

Time series of Surface Radar and other obs




UND Aircraft In−Situ Measurements during MC3E (5/20/2011)
Water
Mixed
Ice
Height (MSL, km)
UND Aircraft
a)
Cloud Temp (C)
Cloud Temp (C)
b)
LWC/IWC (gm-3)
LWC_Nev
IWC_Nev
LWC_Cal_re
IWC_Cal_re
IWC_Bulk_density
c)
Concentration (cm-3)
N_Water
N_Ice
d)
Eff. Radius (μm)
re_Water
re_Ice
e)
Time (UTC)

DCS microphysical retrievals using fall speed



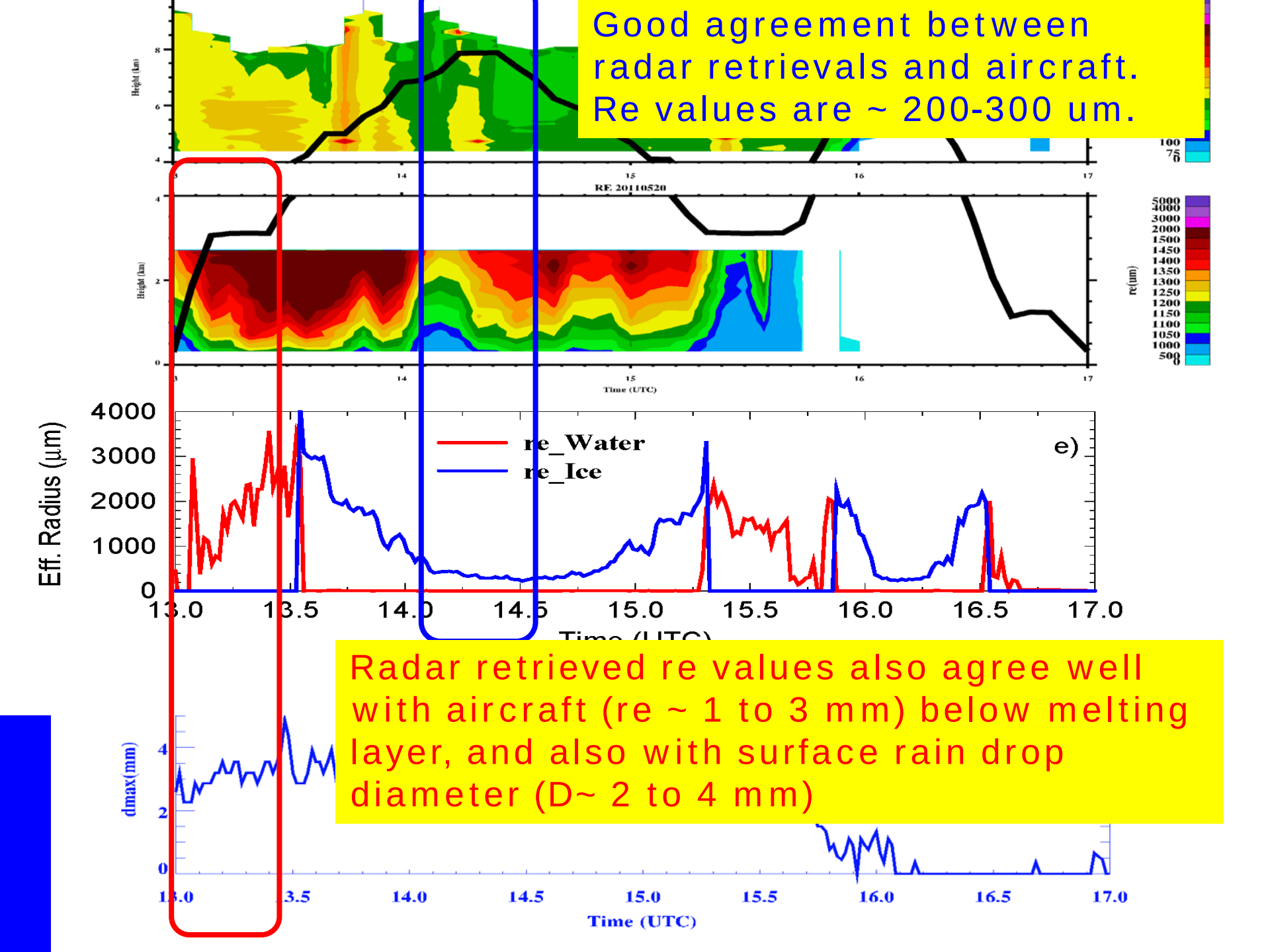
10

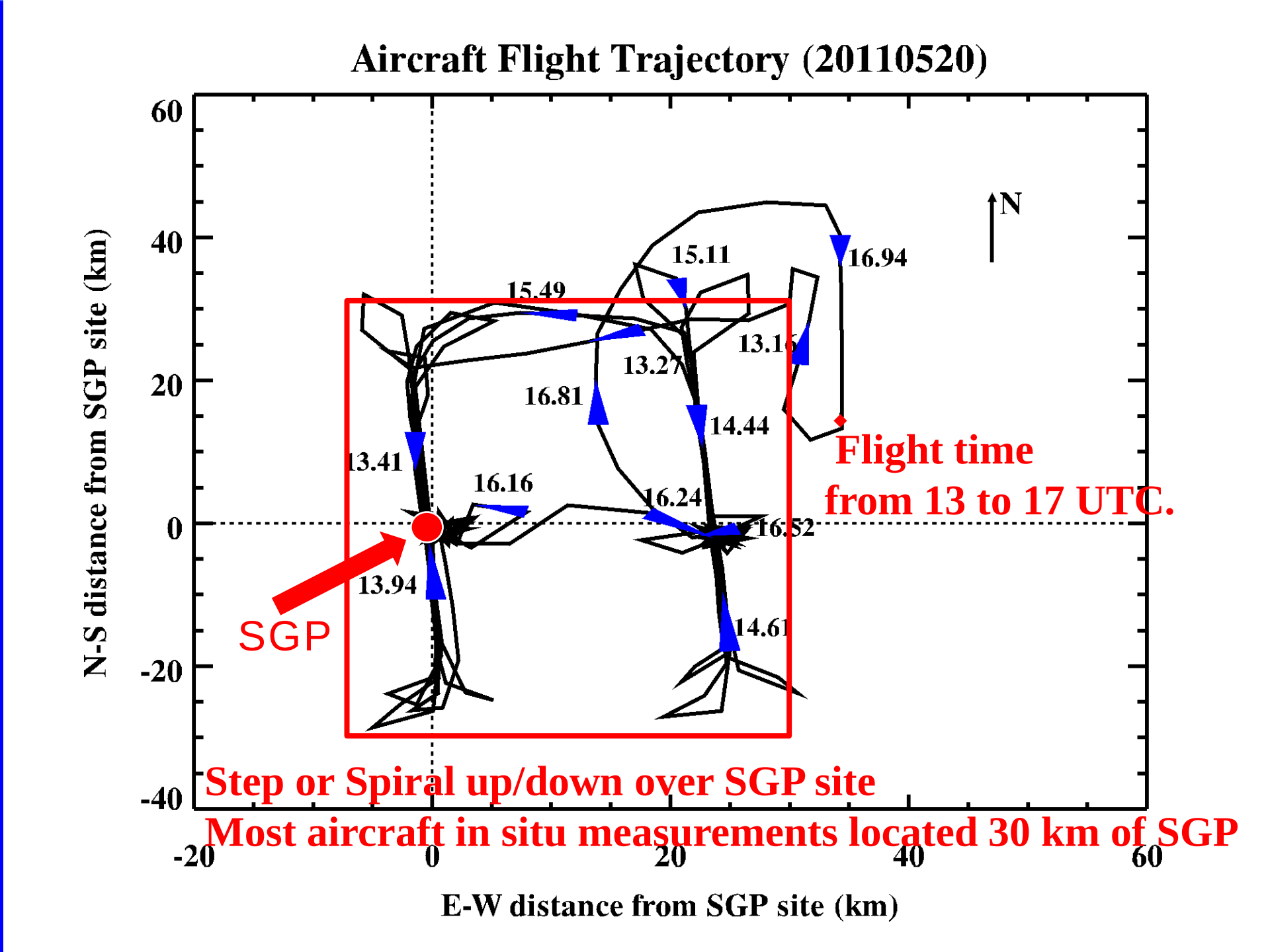
4

➔Fall Speed derived from KAZR reflectivity Above 4 km, Fall speed~ 1 m/s Below melting layer, FS ~ 10 m/s

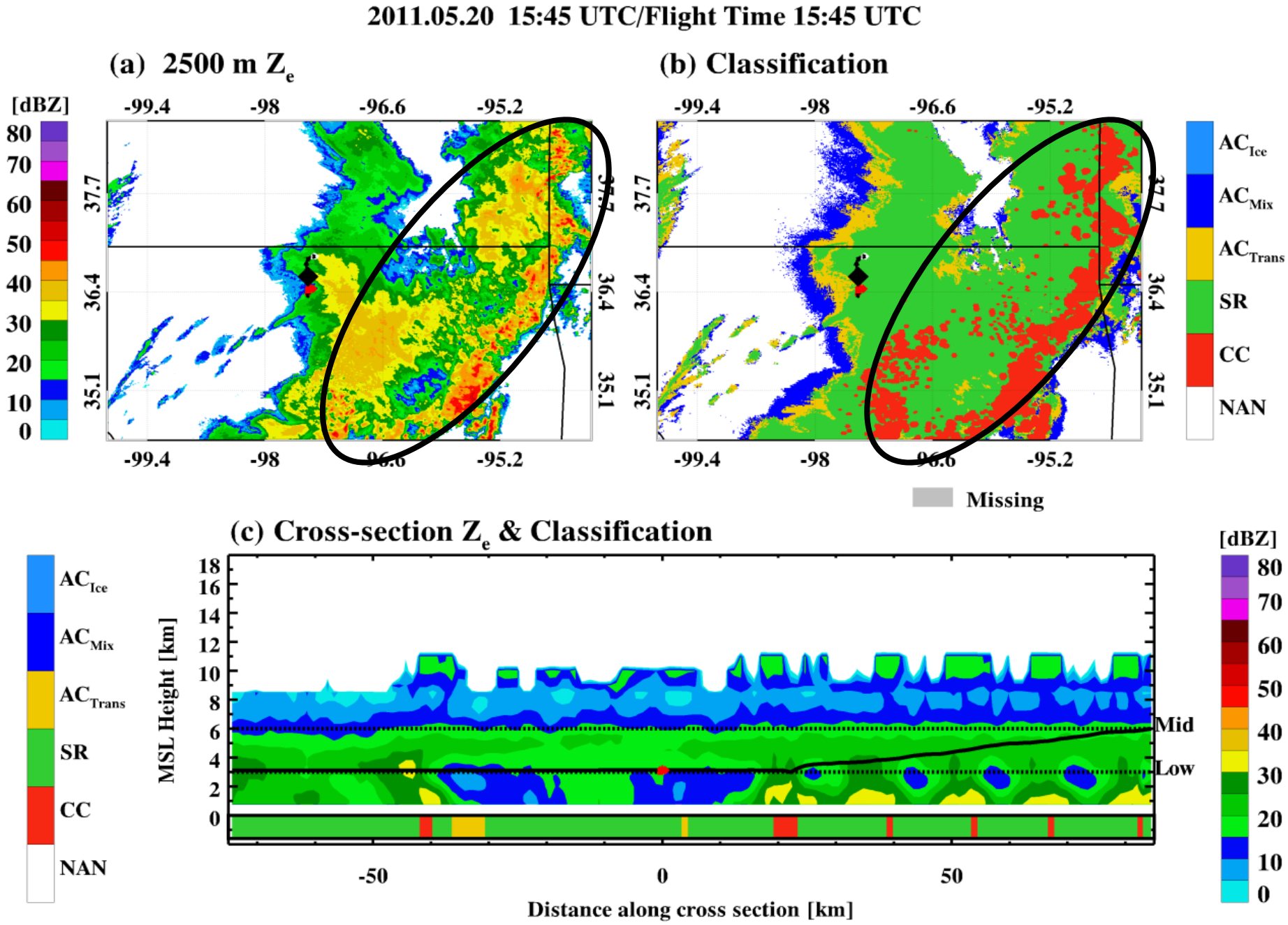
Based on V~ r Above 4 km, water droplet radii are **110 to 150 um (≈** r_{ice}=240-340 um)

Below melting layer, rain drop radii range from 1 to 2 mm,consistent to Disdrometer measurements (D ~ 2-4 mm)

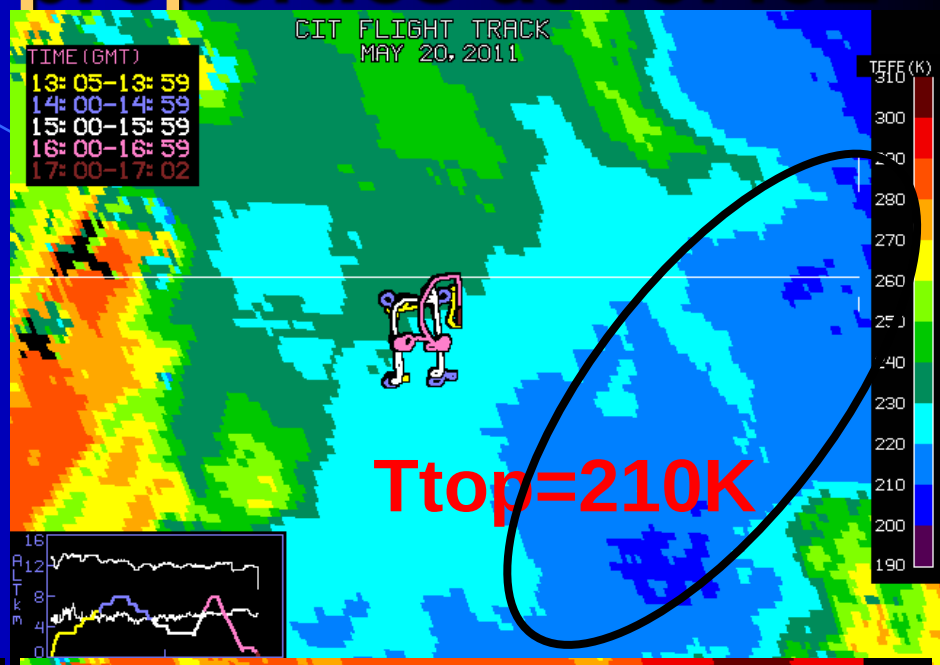

Good agreement between radar retrievals and aircraft. Re values are ~ 200-300 um.
RE 20110520
Height (km)
Time (UTC)
re(um)
Eff. Radius (μm)
re_Water
re_Ice
e)
Radar retrieved re values also agree well with aircraft (re ~ 1 to 3 mm) below melting layer, and also with surface rain drop diameter (D~ 2 to 4 mm)
dmax(mm)
Time (UTC)

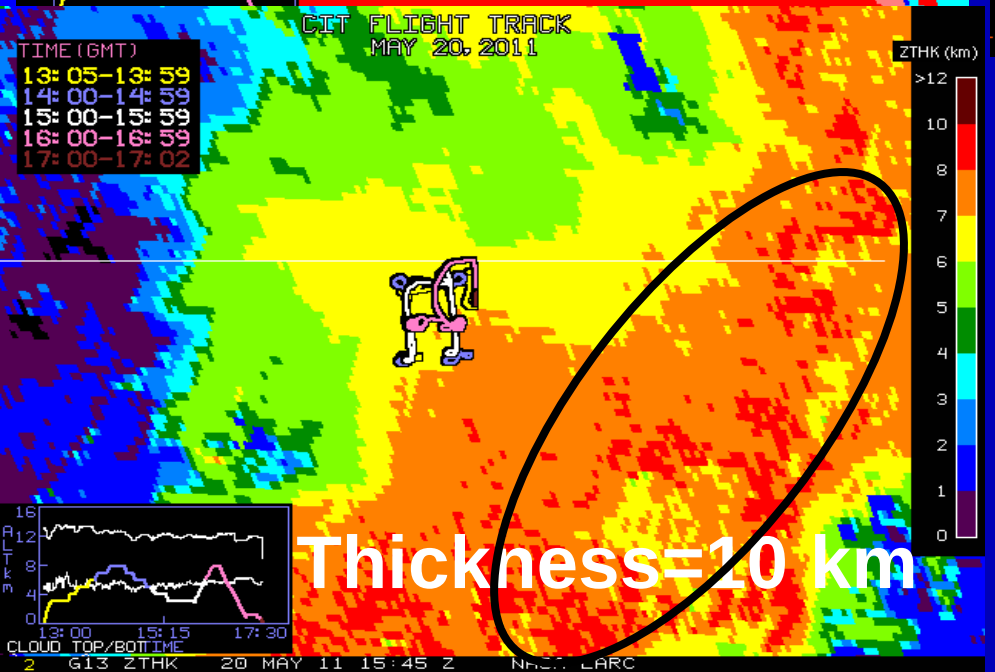

Aircraft Flight Trajectory (20110520)
N-S distance from SGP site (km)
E-W distance from SGP site (km)
60
40
20
0
-20
-40
-20
0
20
40
60
N
15.11
16.94
15.49
13.16
13.27
16.81
14.44
13.41
16.16
16.24
16.52
13.94
14.61
SGP
Flight time
from 13 to 17 UTC.
Step or Spiral up/down over SGP site
Most aircraft in situ measurements located 30 km of SGP

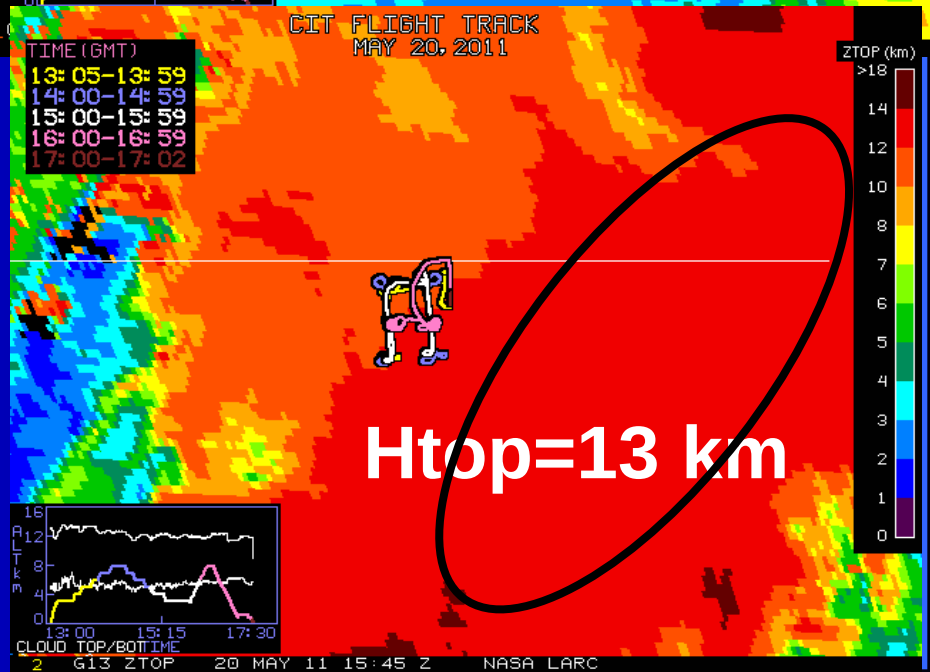
Comparing NEXRAD and its classification with GOES results



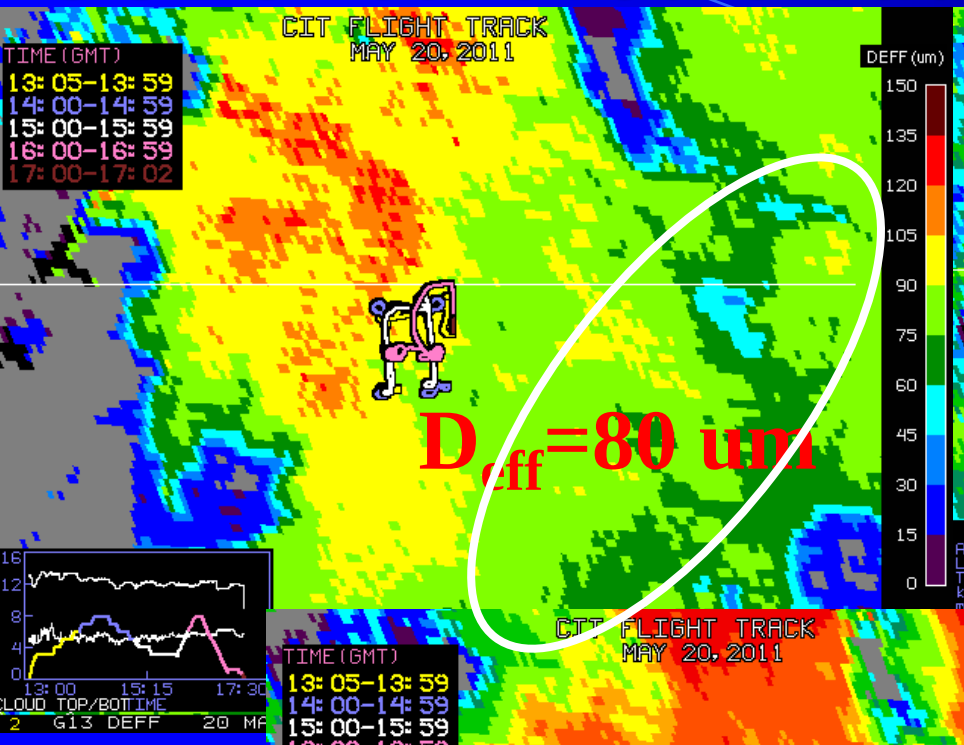
GOES retrieved cloud properties at 15:45Z

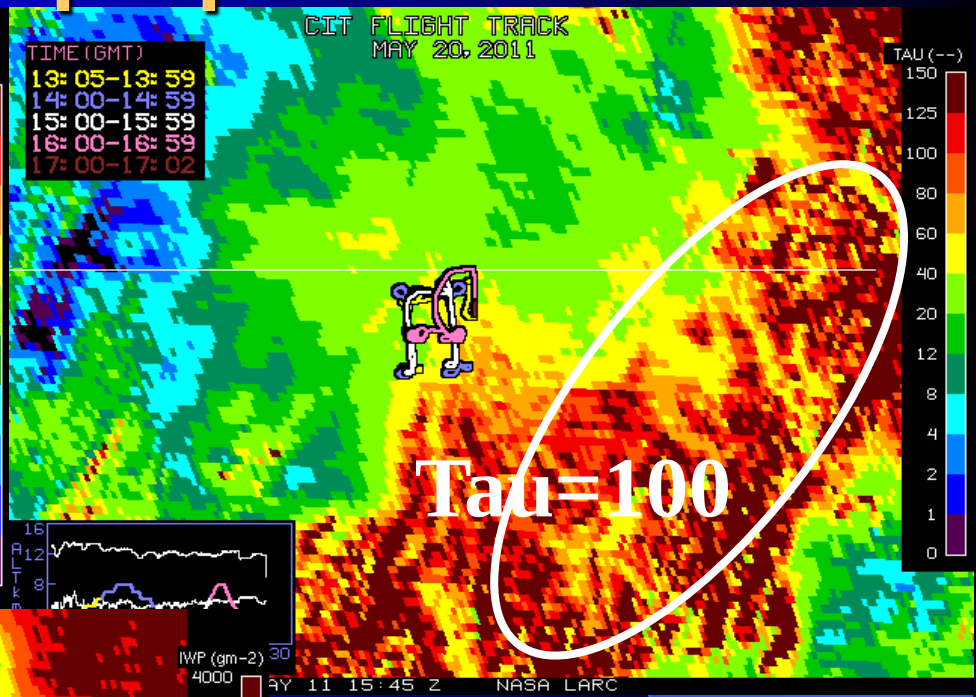


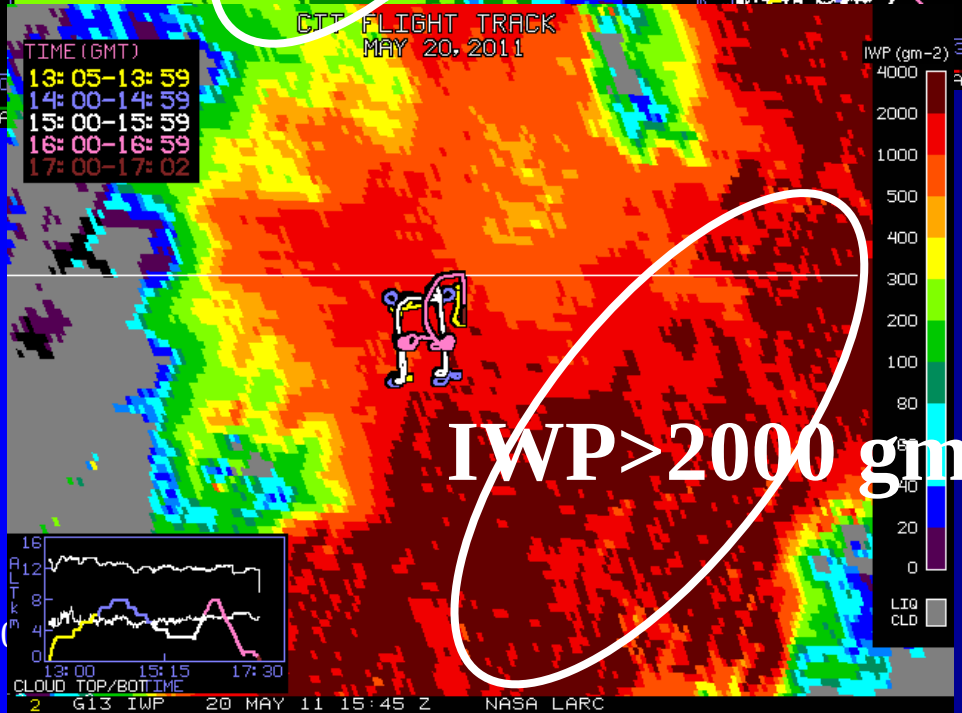




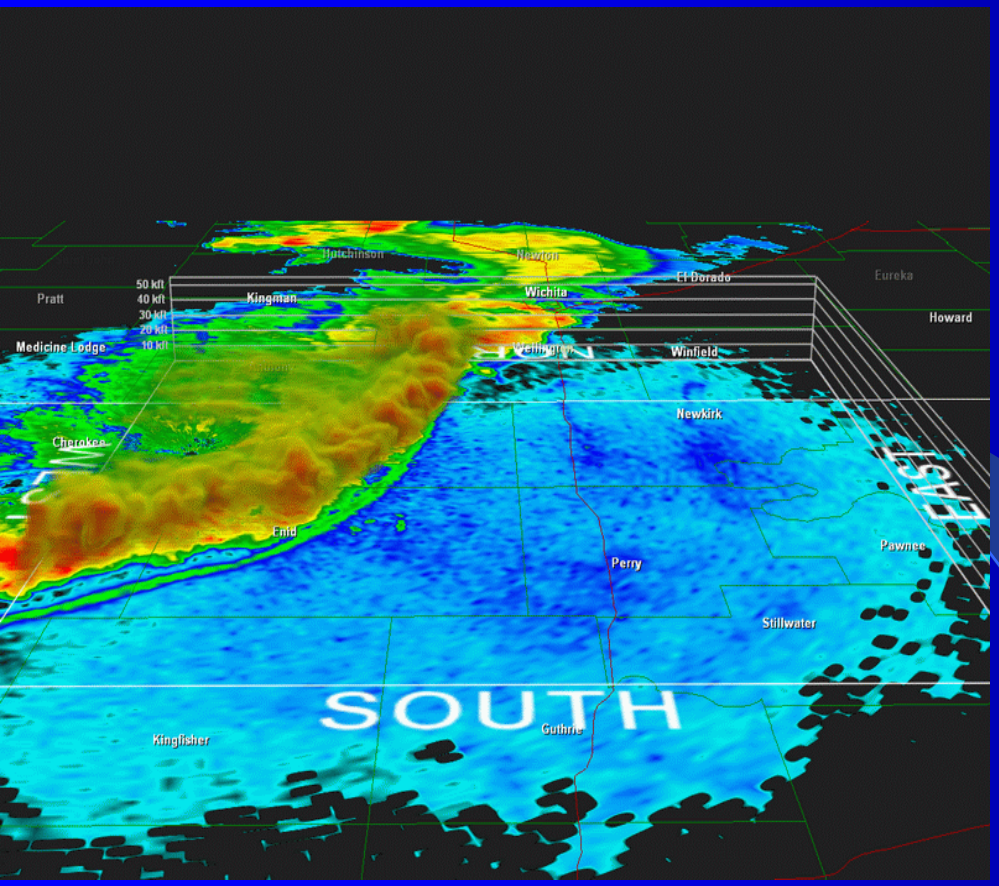
GOES retrieved cloud properties at 15:45Z

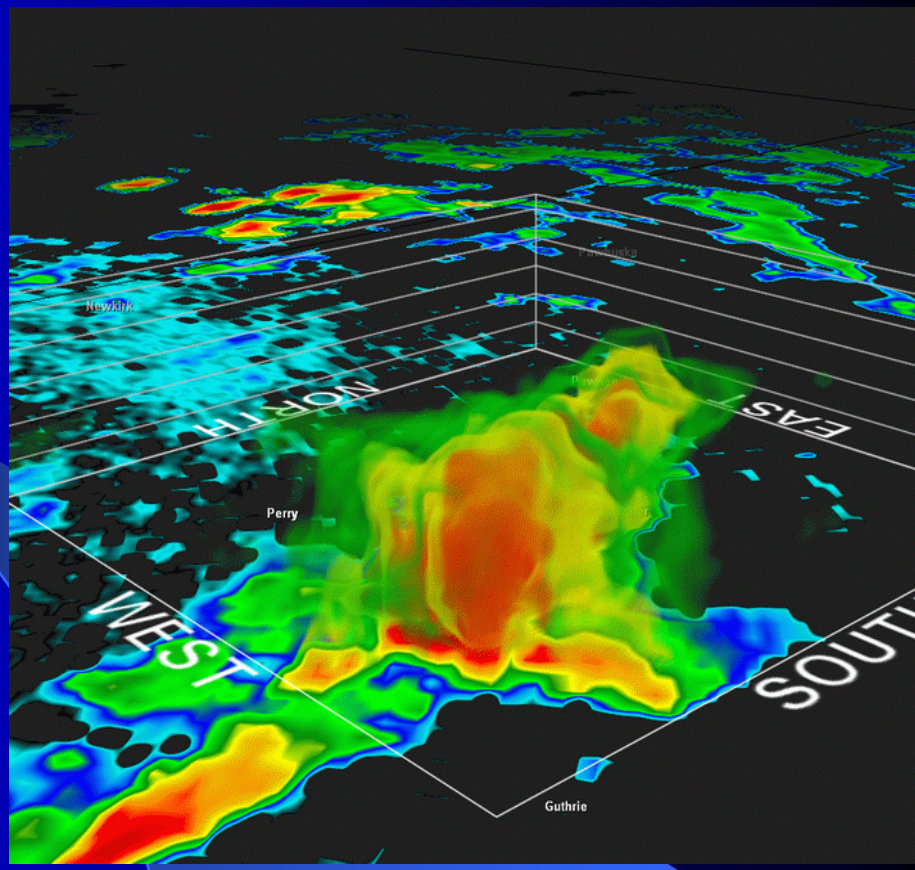






Challenge and difficulty for modeling DCS clouds

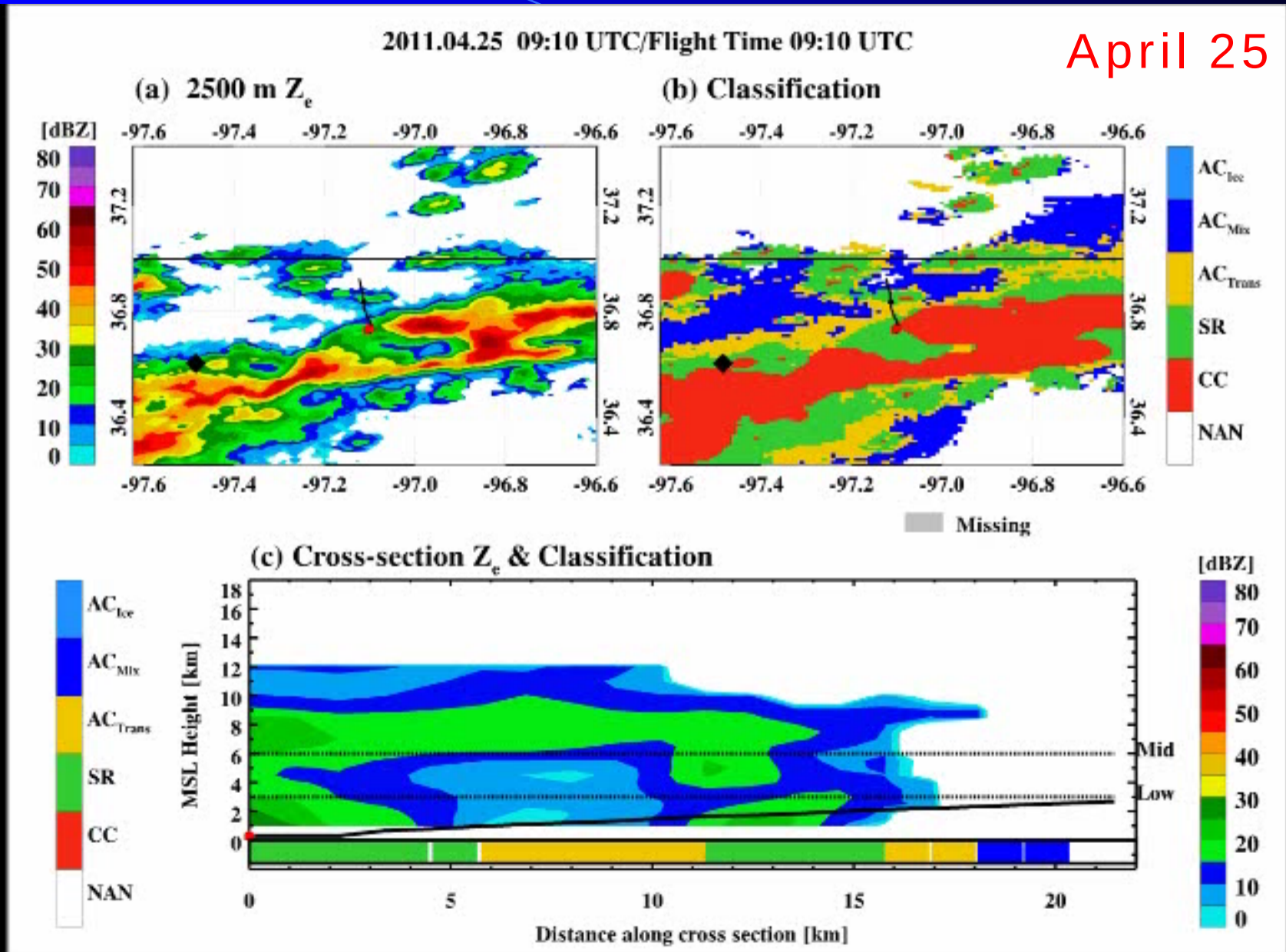




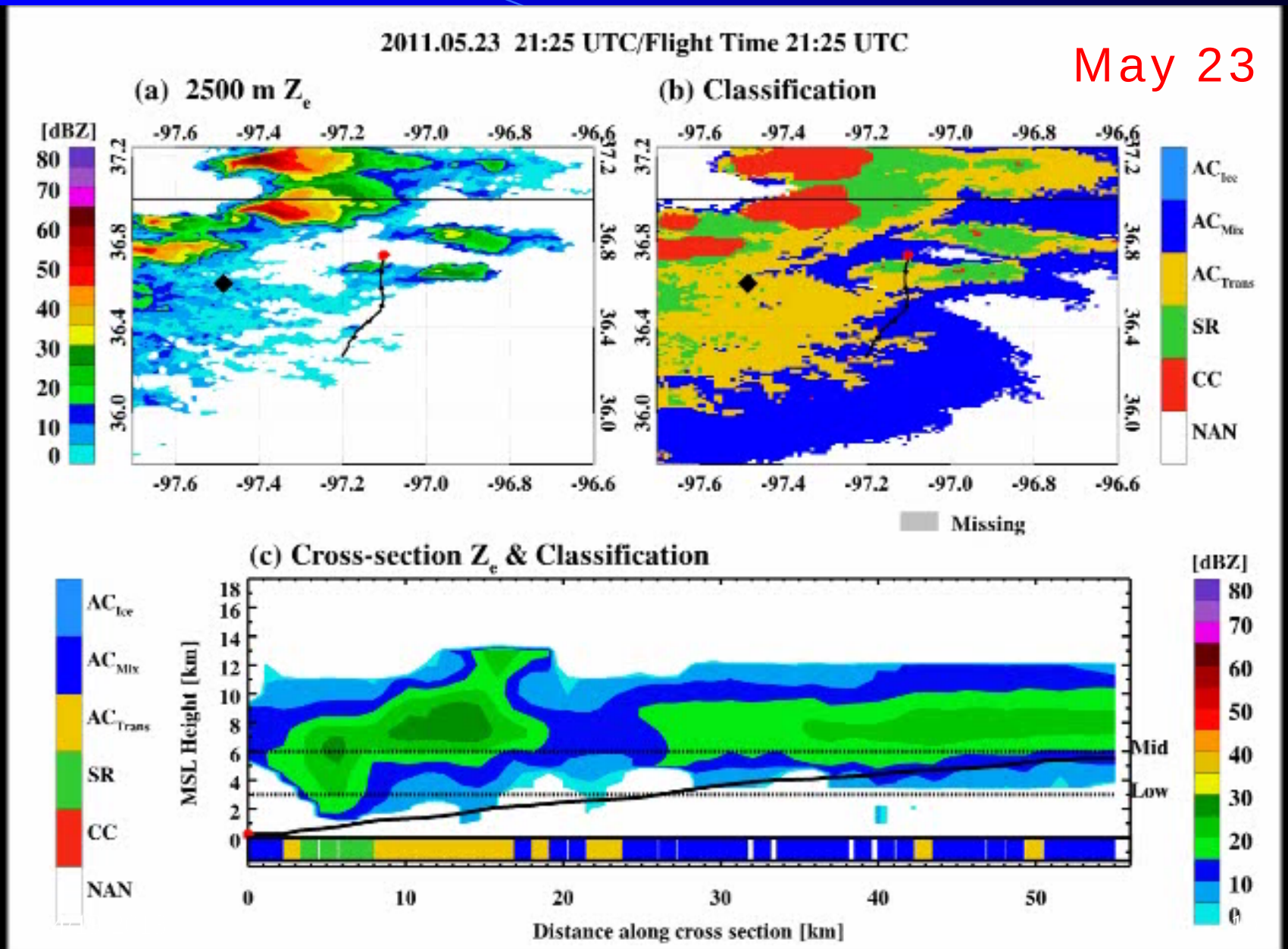
Quite often, models can simulate large-scale frontal systems, but not for local systems

Thanks for your attention

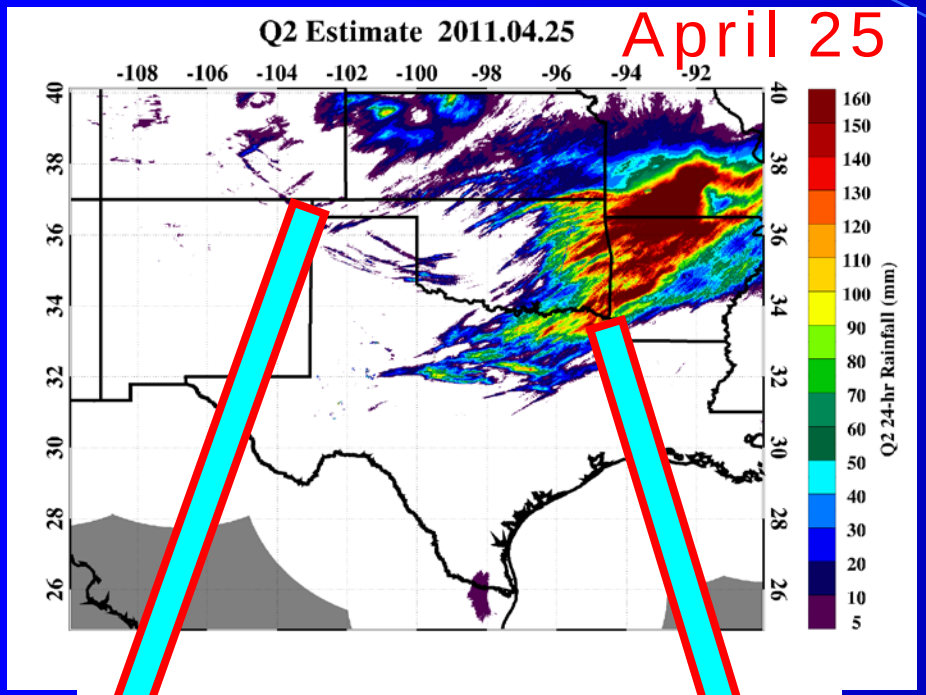
1. NEXRAD 3D structure and classification

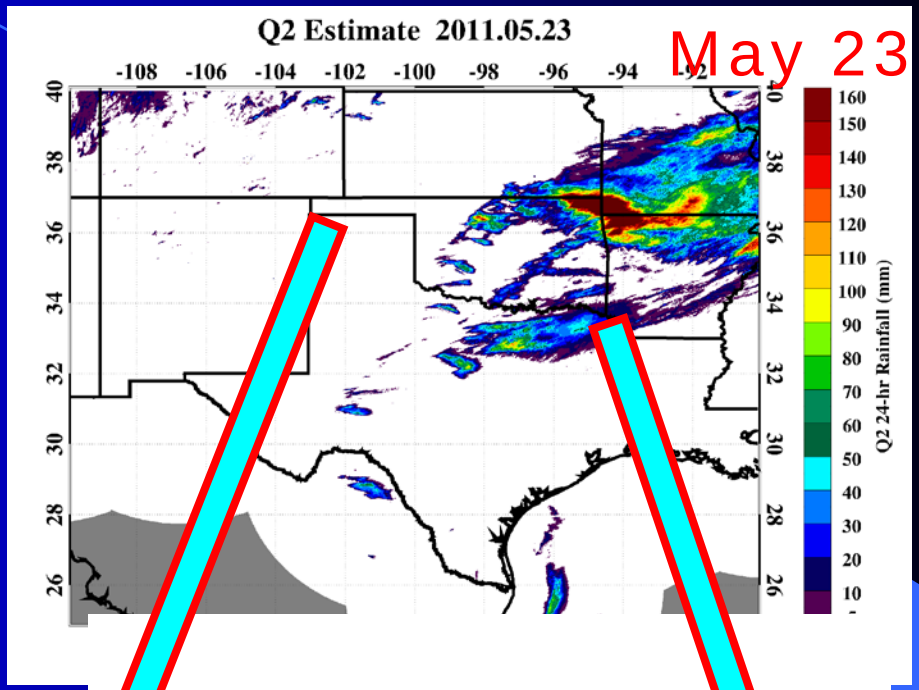


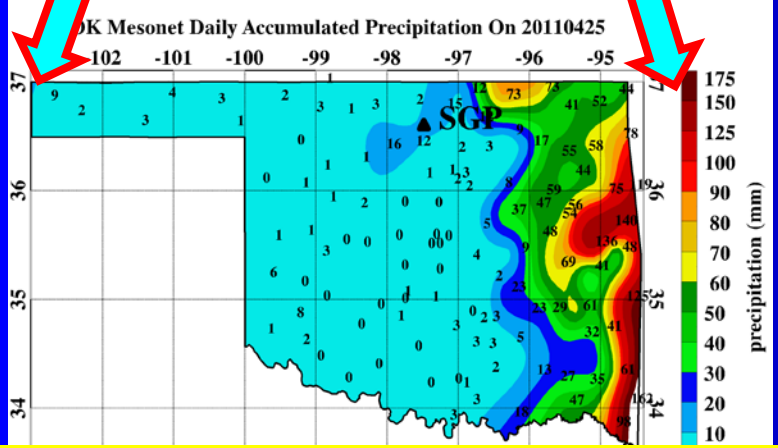
1. NEXRAD 3D structure and classification

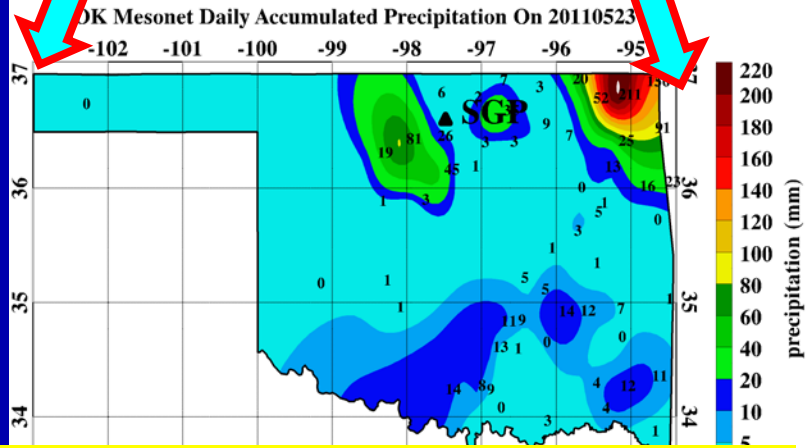


2. Surface precipitation from NEXRAD Q2 and OK mesonet measurements



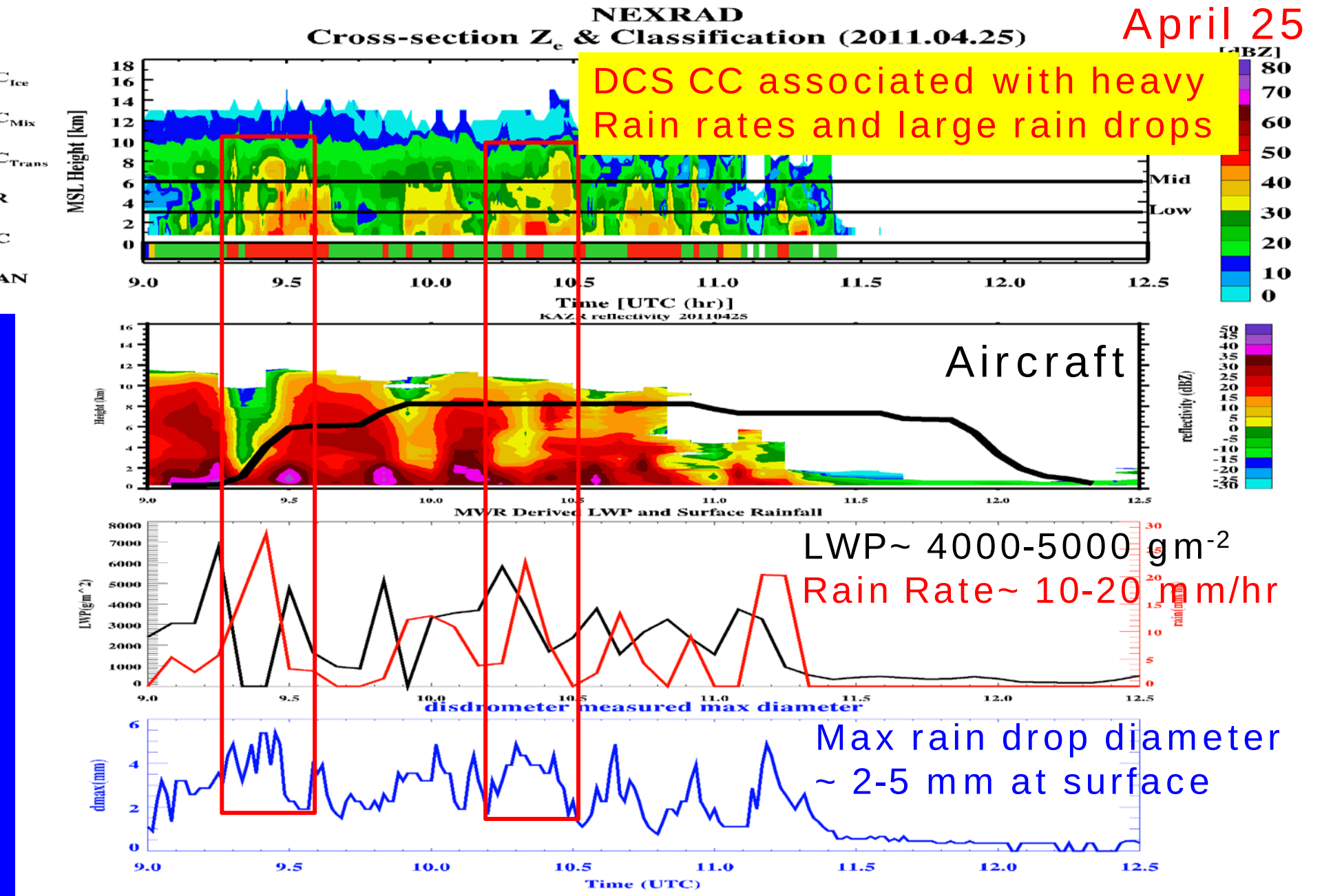






Daily Precip up to 150 mm on April 25 over East OK and MO/AR

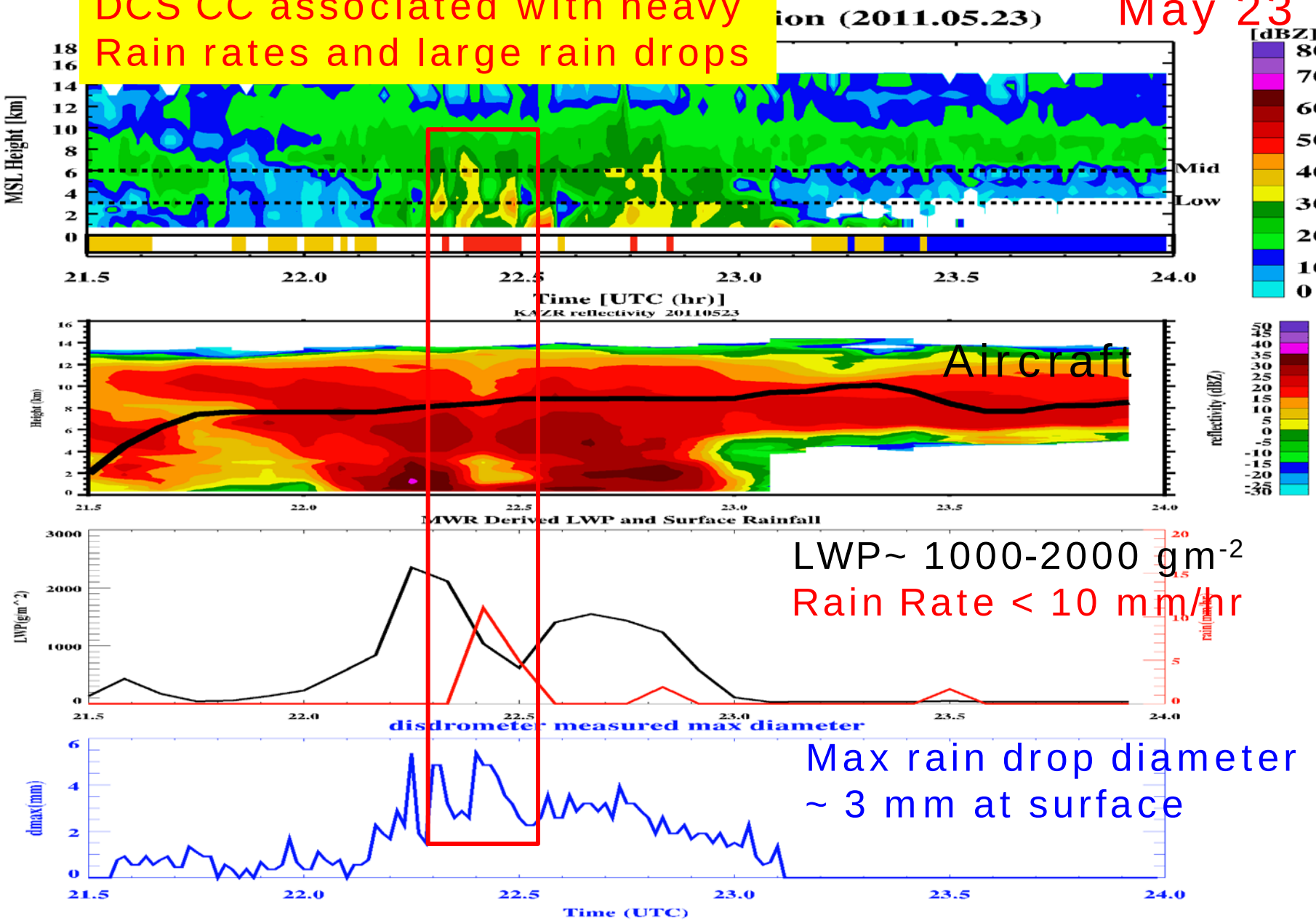
3. Time series of Surface Radar and other obs



3. Time series of Surface Radar and other obs

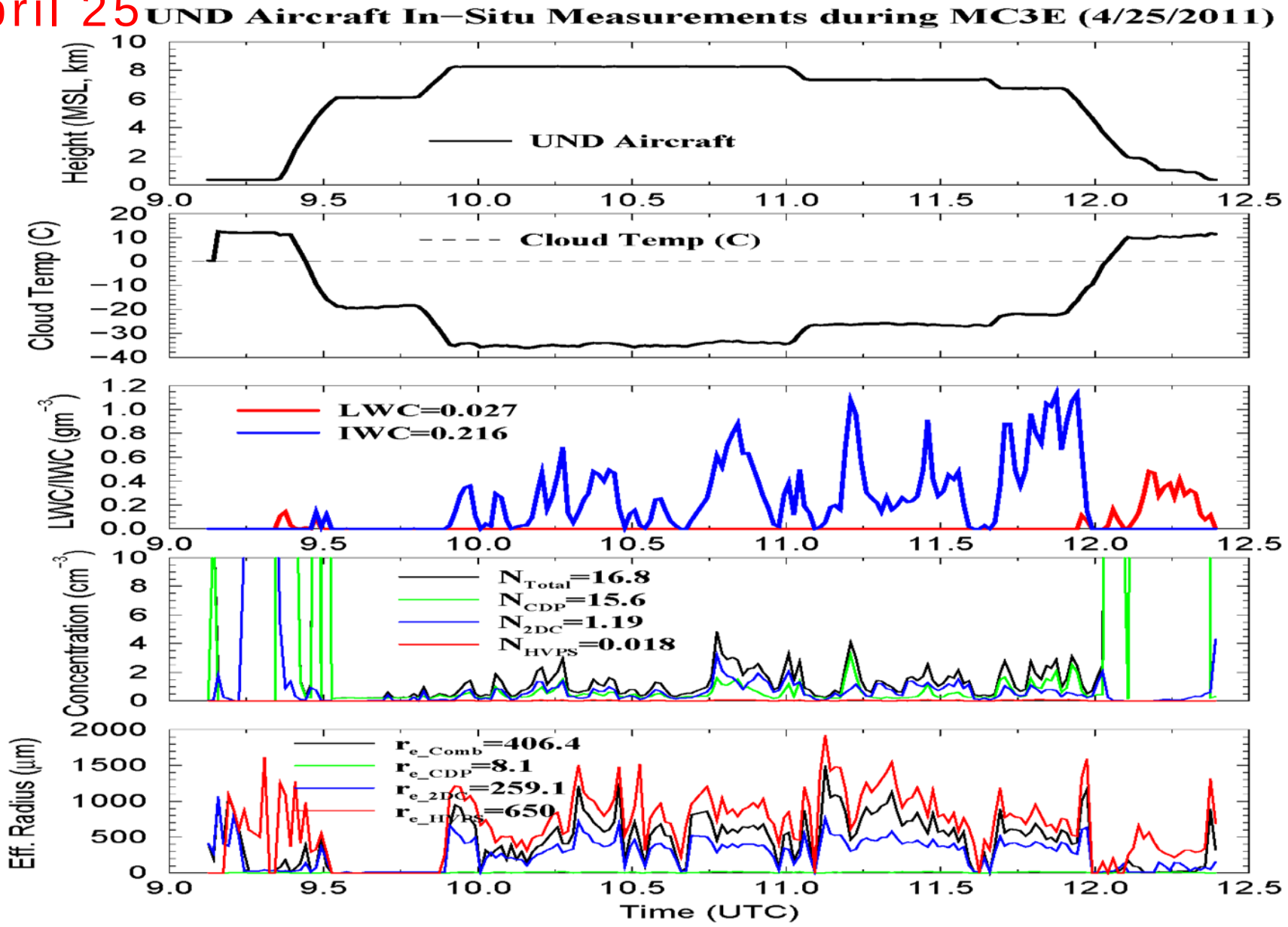
DCS CC associated with heavy
Rain rates and large rain drops

May 23



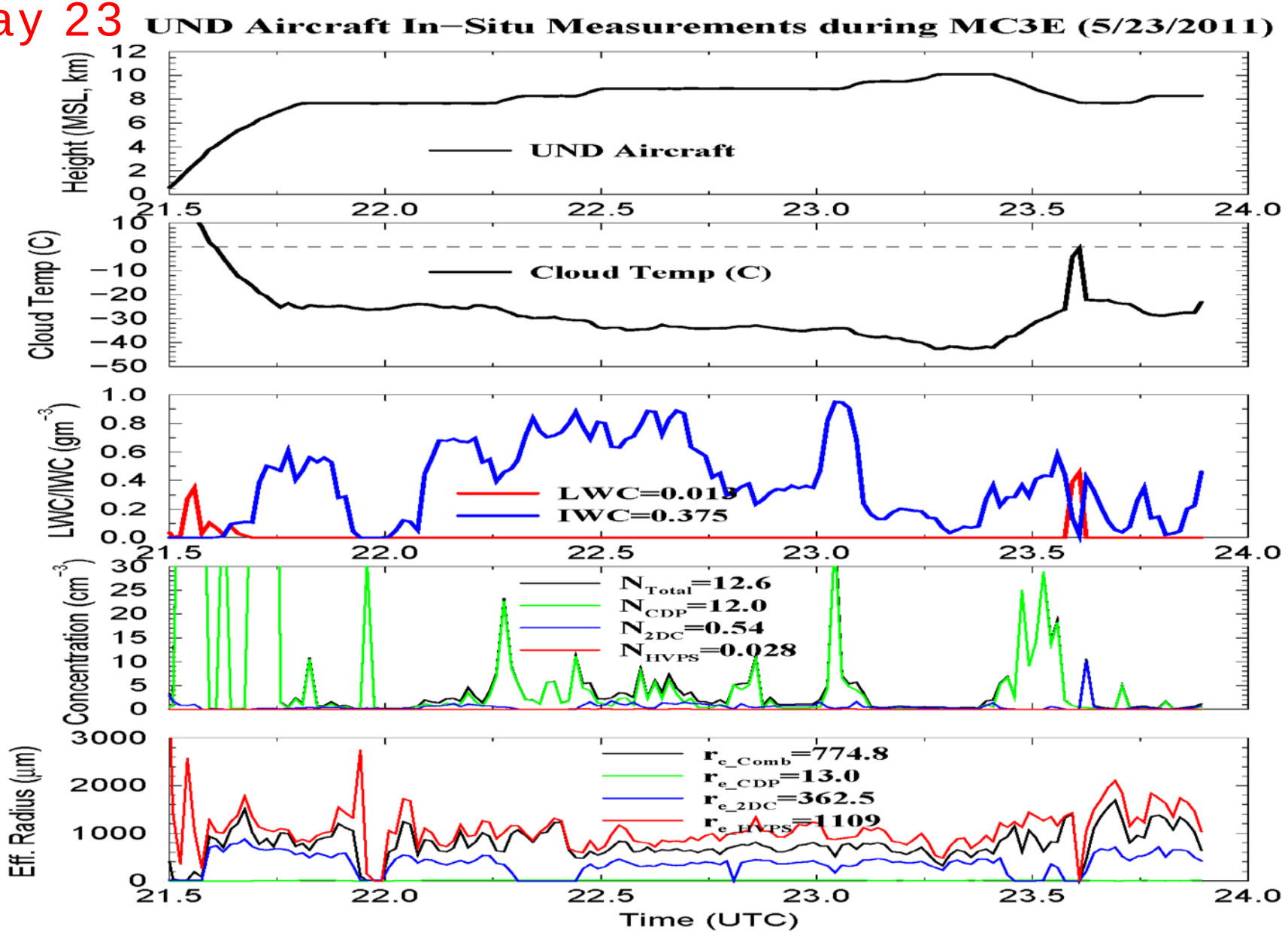
4. UND citation aircraft in situ measurements

April 25



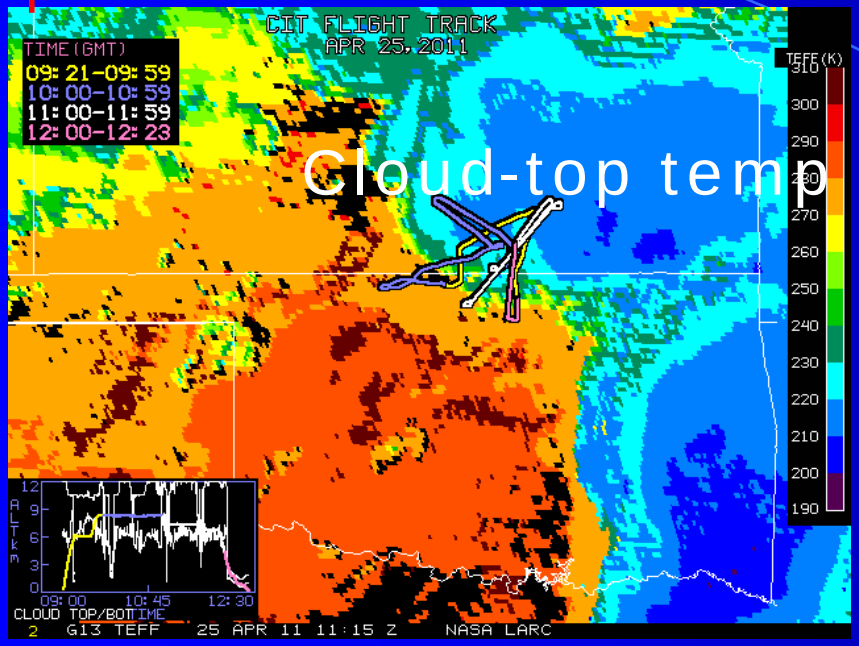
4. UND citation aircraft in situ measurements

May 23

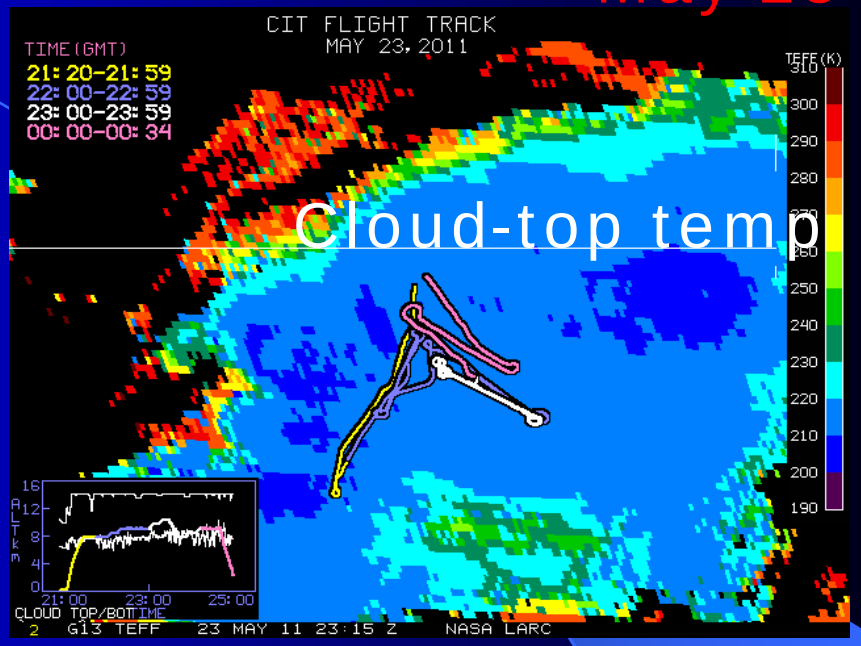


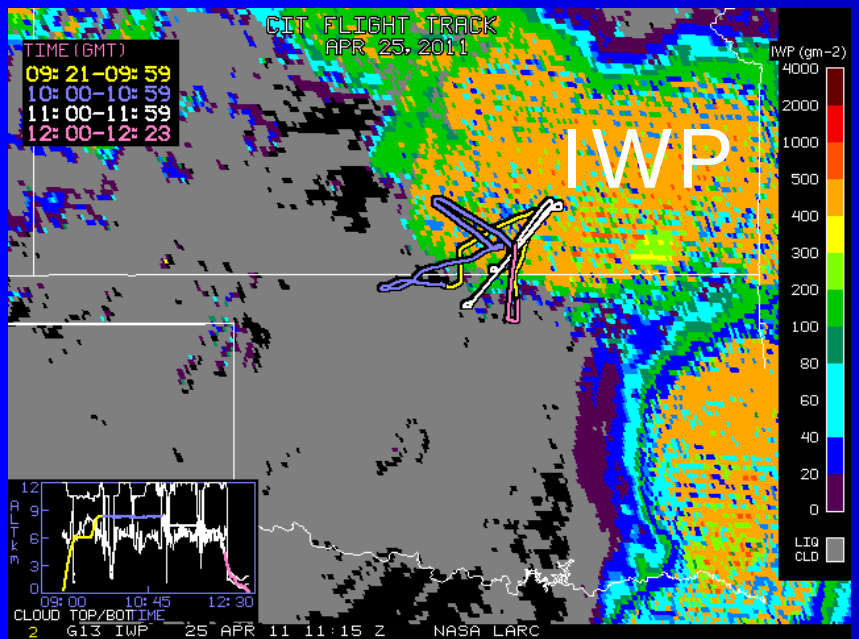
5. GOES retrieved cloud properties

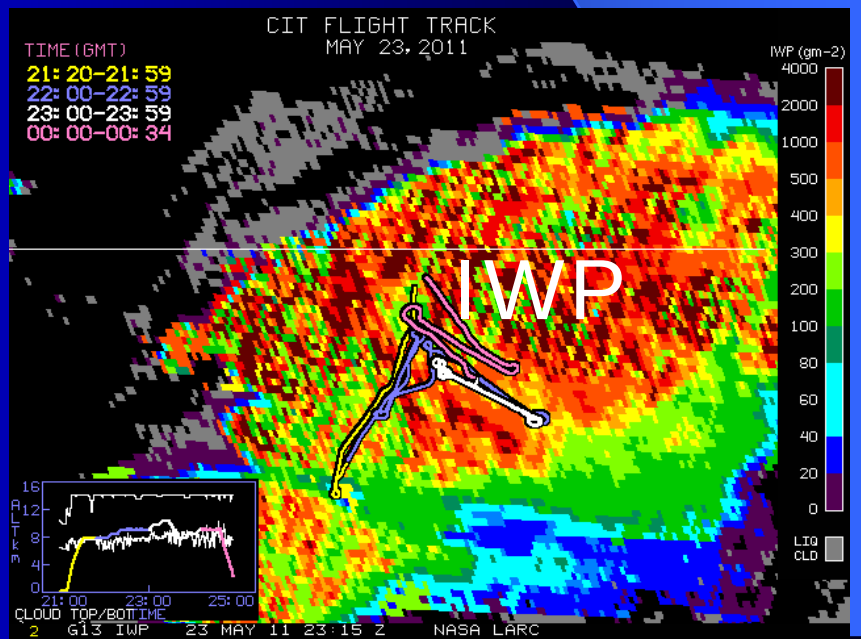
April 25



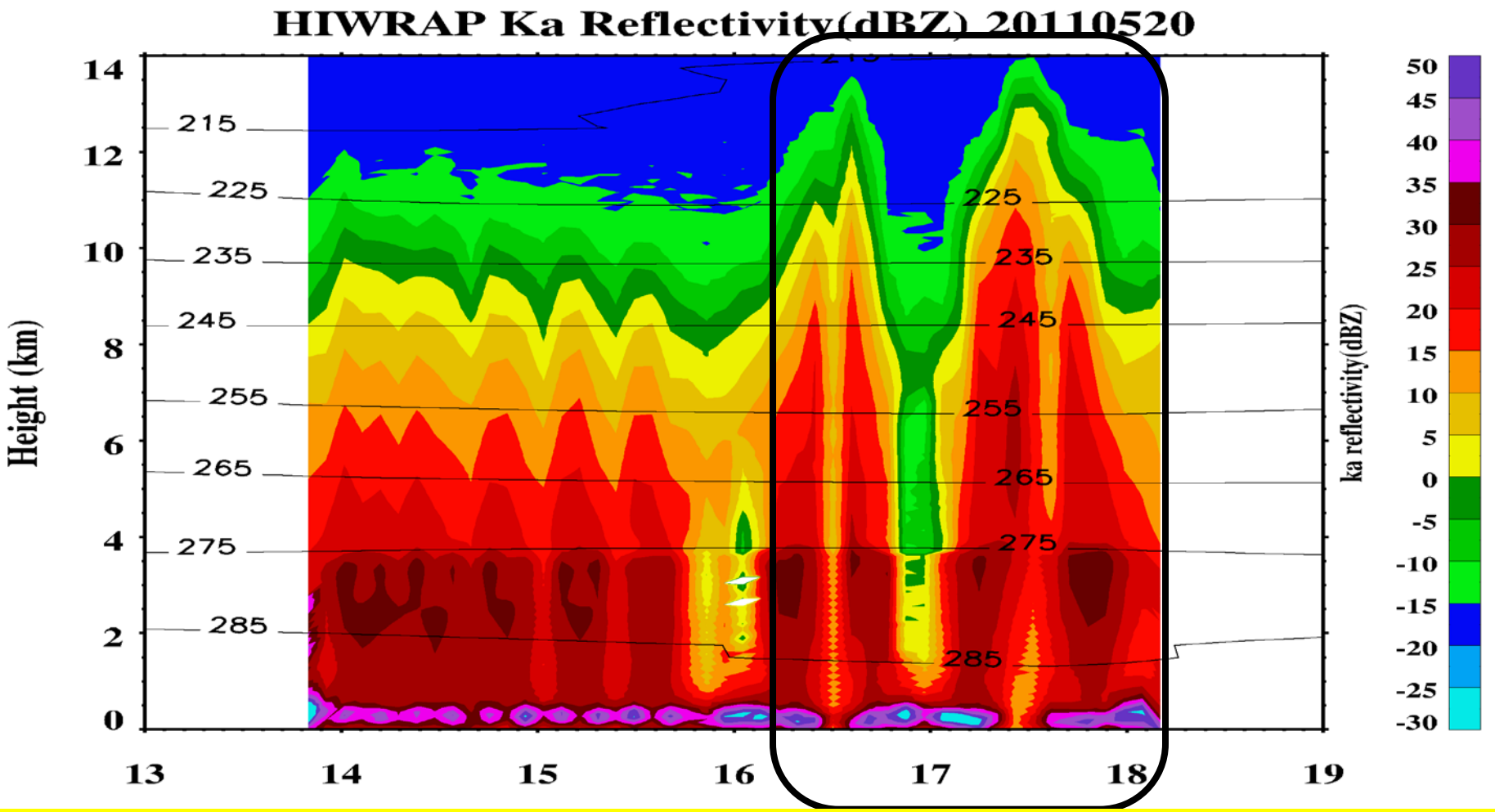
May 23





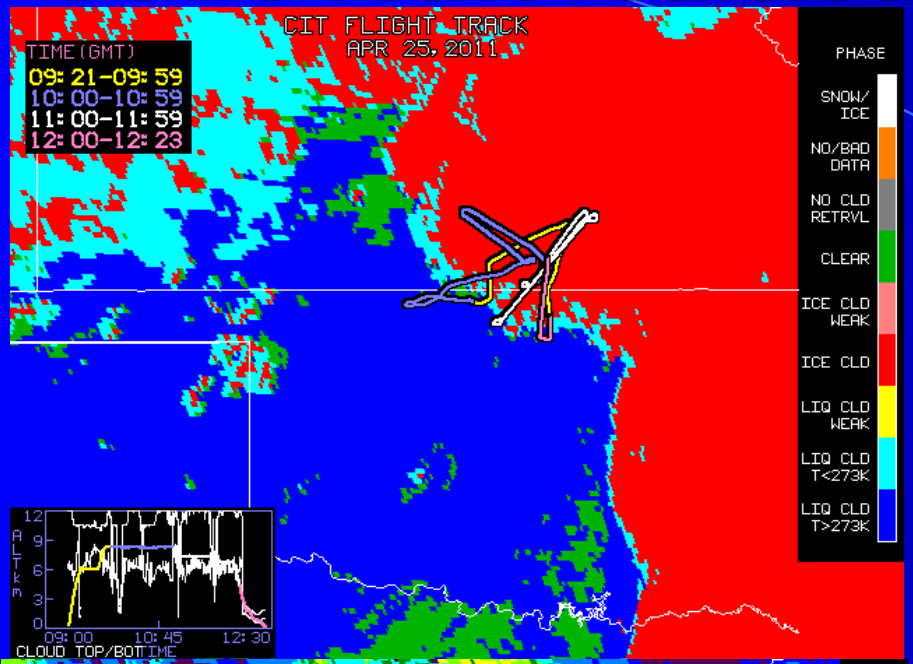


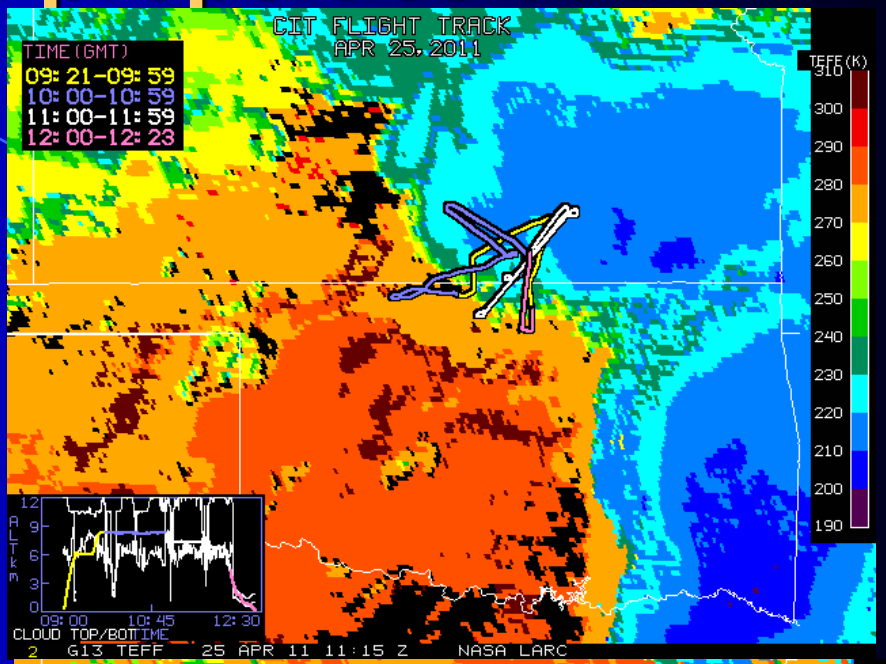
ER2 Ka Radar Image

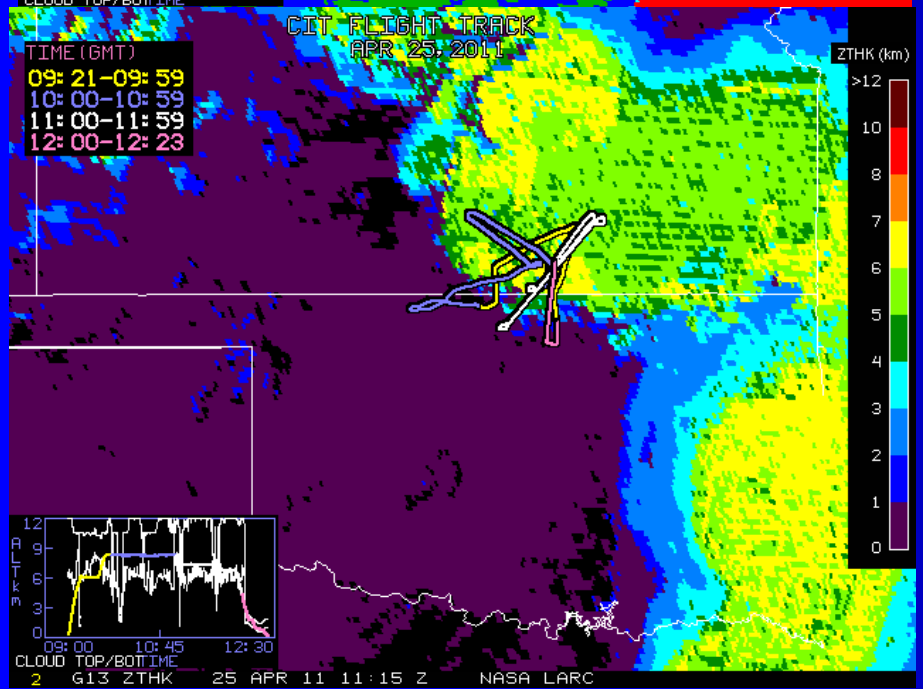


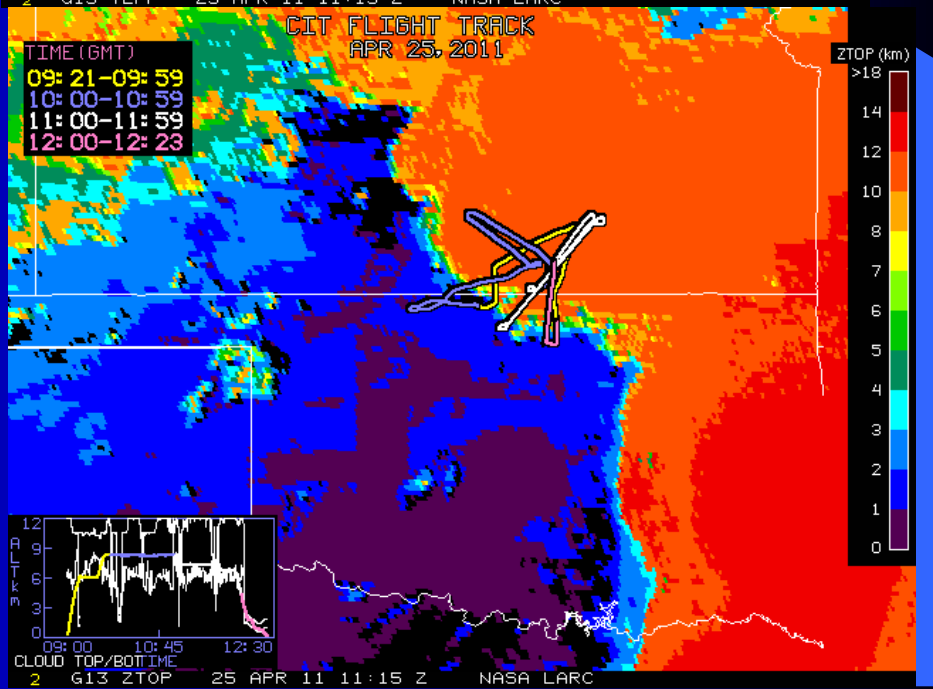
Higher cloud-top heights (~ 14 km) from ER2 Radar are consistent to GOES retrievals, indicating KAZR ARSCL signals were attenuated out at that level.

GOES retrieved cloud properties at 23:15Z

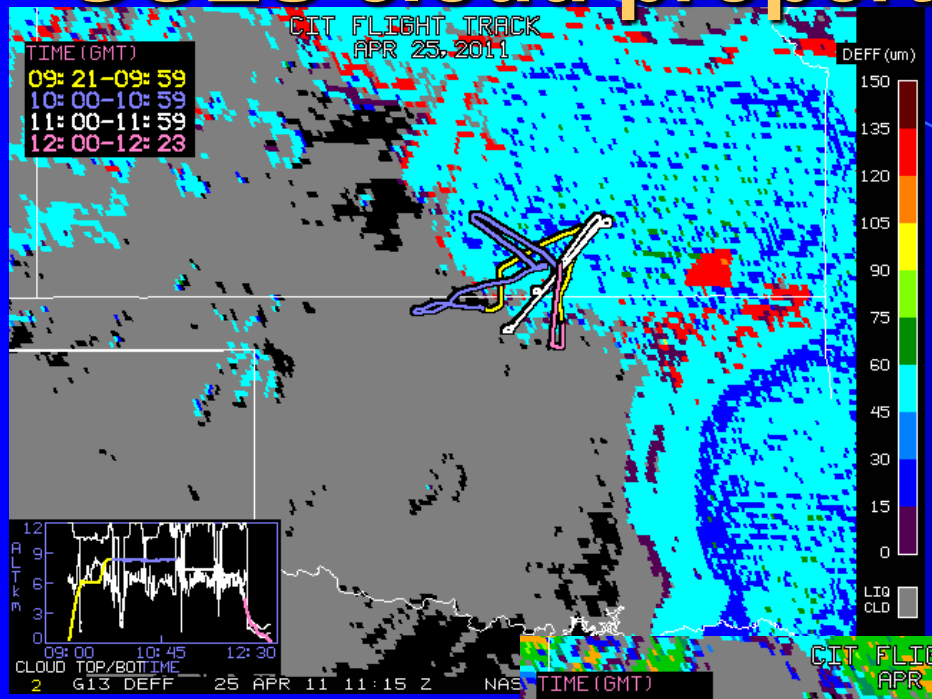


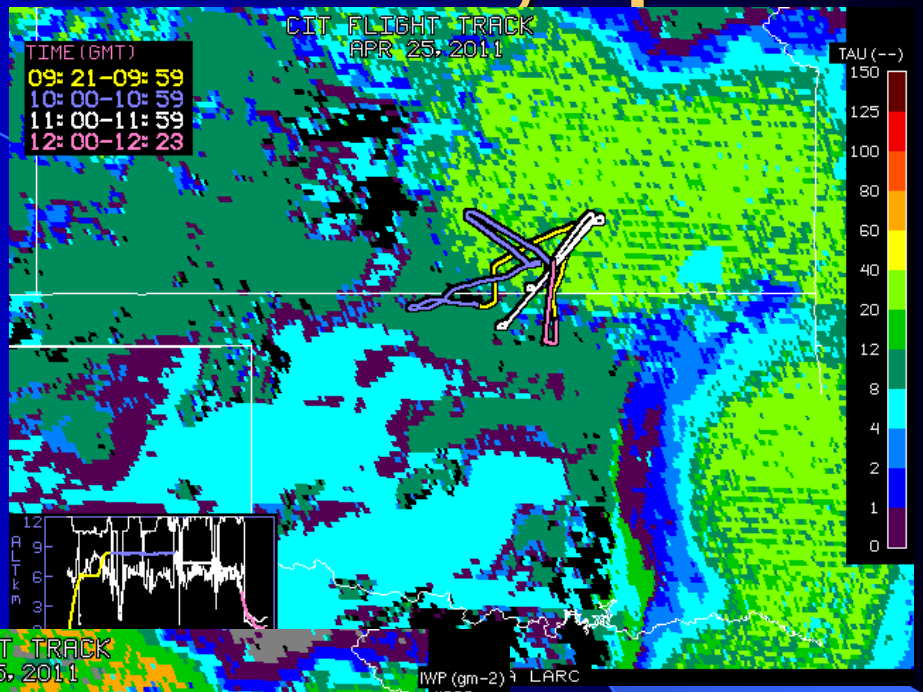


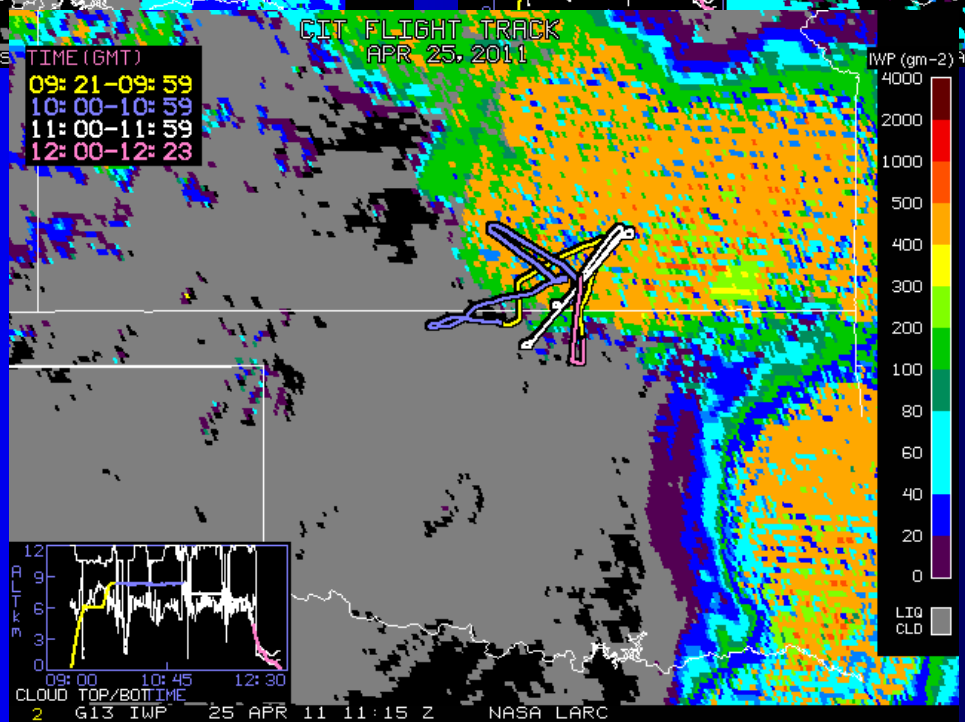




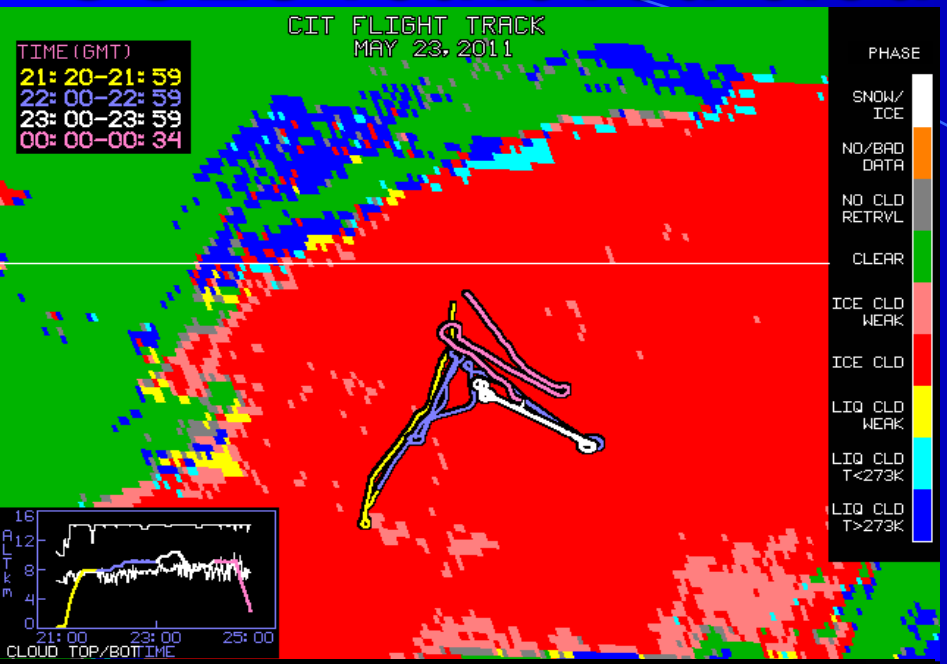
GOES cloud properties at 11:15Z, April 25

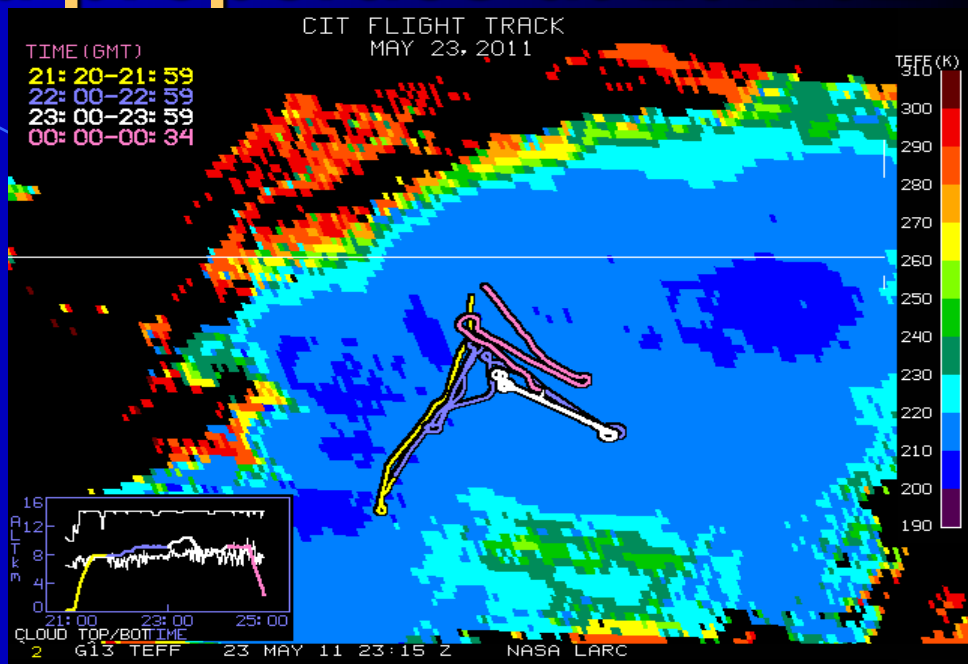


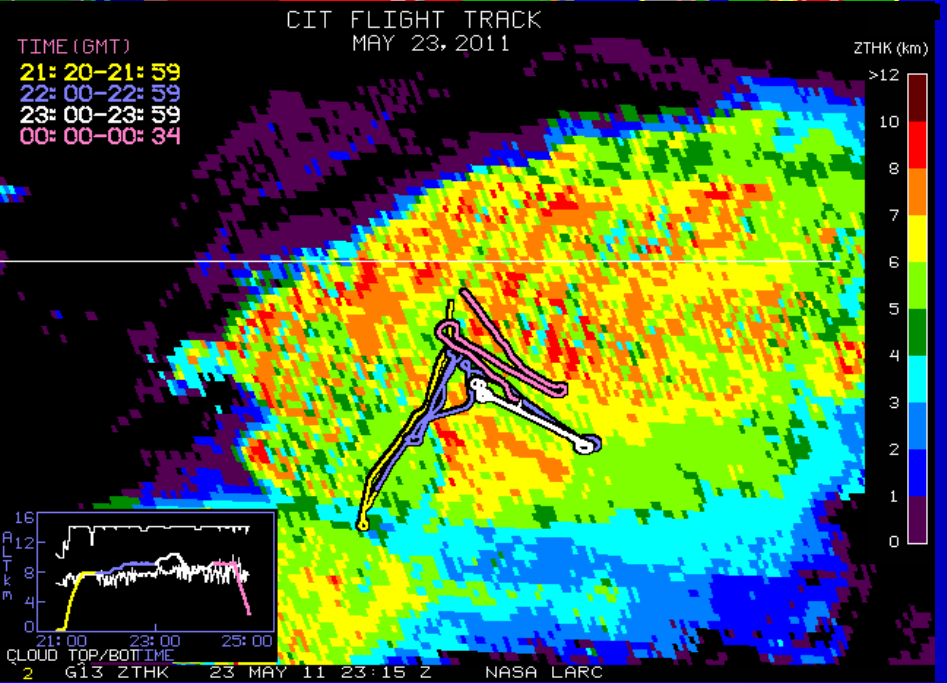


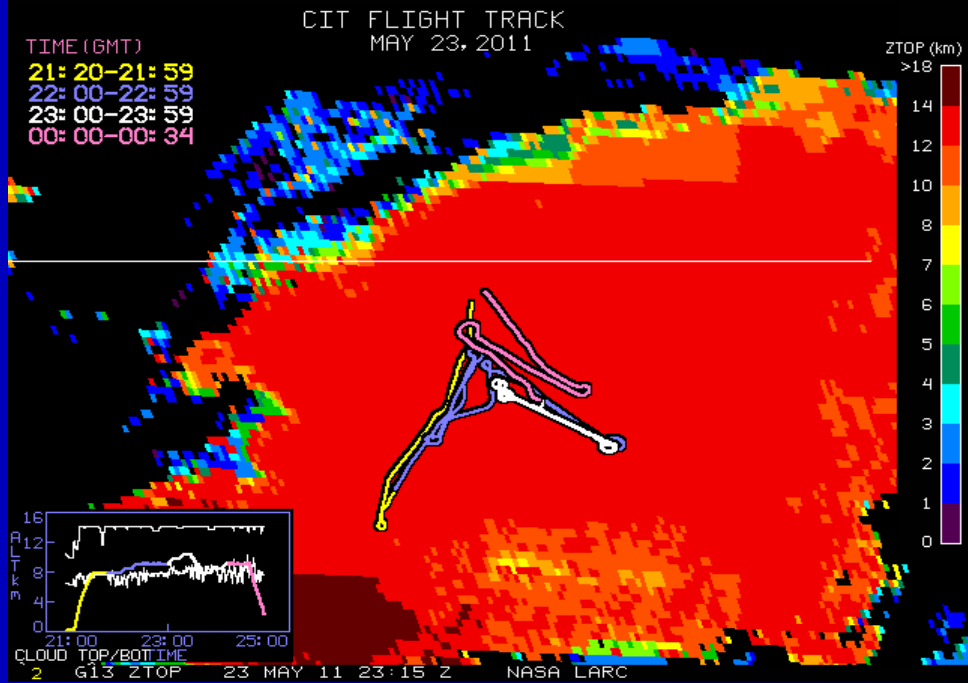


GOES retrieved cloud properties at 23:15Z

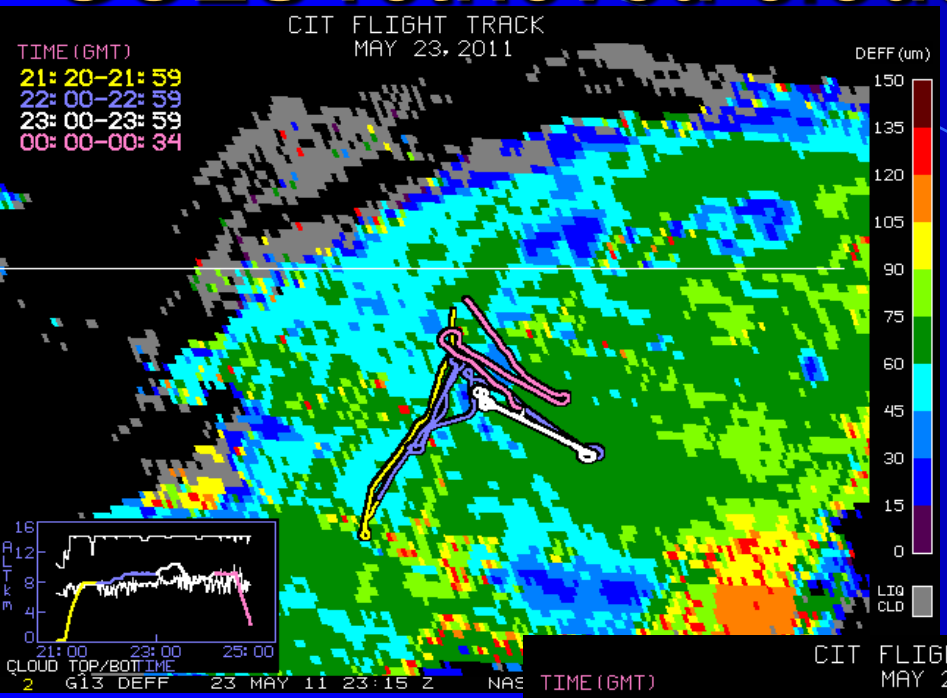


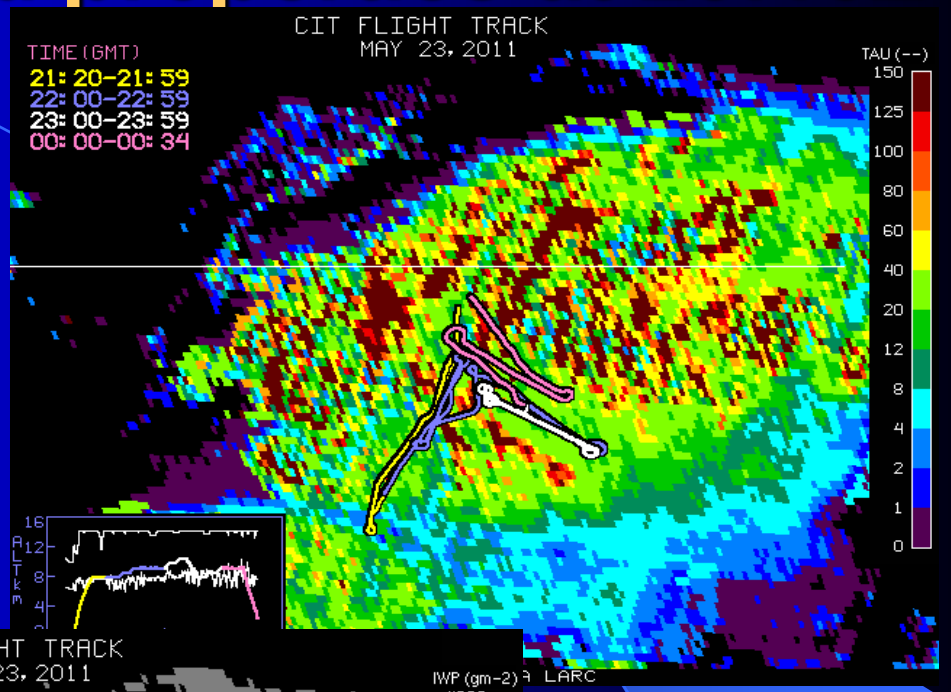


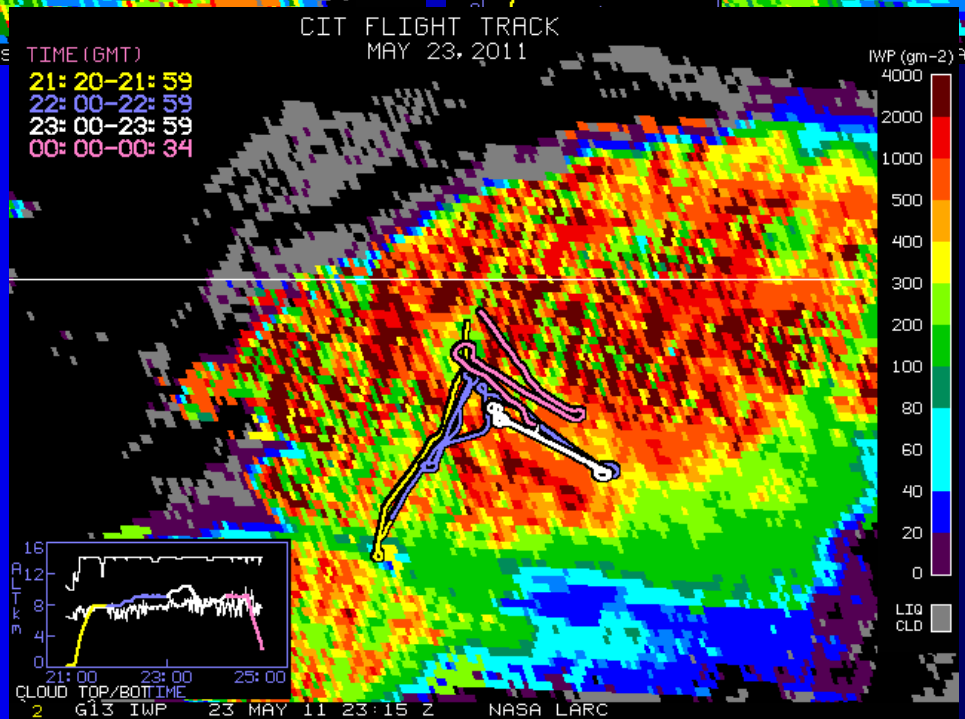




GOES retrieved cloud properties at 23:15Z







Cloud droplet terminal fall speed

TABLE 8.1. *Terminal Fall Speed as a Function of Drop Size (equivalent spherical diameter) (From Gunn and Kinzer, 1949)*

Diam. (mm)	Fall speed (m/s)	Diam. (mm)	Fall speed (m/s)
0.1	0.27	2.6	7.57
0.2	0.72	2.8	7.82
0.3	1.17	3.0	8.06
0.4	1.62	3.2	8.26
0.5	2.06	3.4	8.44
0.6	2.47	3.6	8.60
0.7	2.87	3.8	8.72
0.8	3.27	4.0	8.83
0.9	3.67	4.2	8.92
1.0	4.03	4.4	8.98
1.2	4.64	4.6	9.03
1.4	5.17	4.8	9.07
1.6	5.65	5.0	9.09
1.8	6.09	5.2	9.12
2.0	6.49	5.4	9.14
2.2	6.90	5.6	9.16
2.4	7.27	5.8	9.17

1) $0 < r < 40$ um, $V_f = K_1 r^2$, Stokes' law, $K_1 = 1.19 * 10^6$ cm^{-1} S^{-1}
2) $40 < r < 0.6$ mm, $V_f = K_2 r$, linear law, $K2 = 8 * 10^3$ S^{-1}
3) $0.6 < r < 2$ mm, $V_f = K_3 r^{1/2}$, Square root law, $K_3 = 2.2 * 10^3$ $(\rho/\rho 0)^{1/2}$ cm^{-1} S^{-1}. ρ is air density, $\rho 0$ is a reference density of 1.2 kg/m3. (Rogers and Yau book, P124-126)