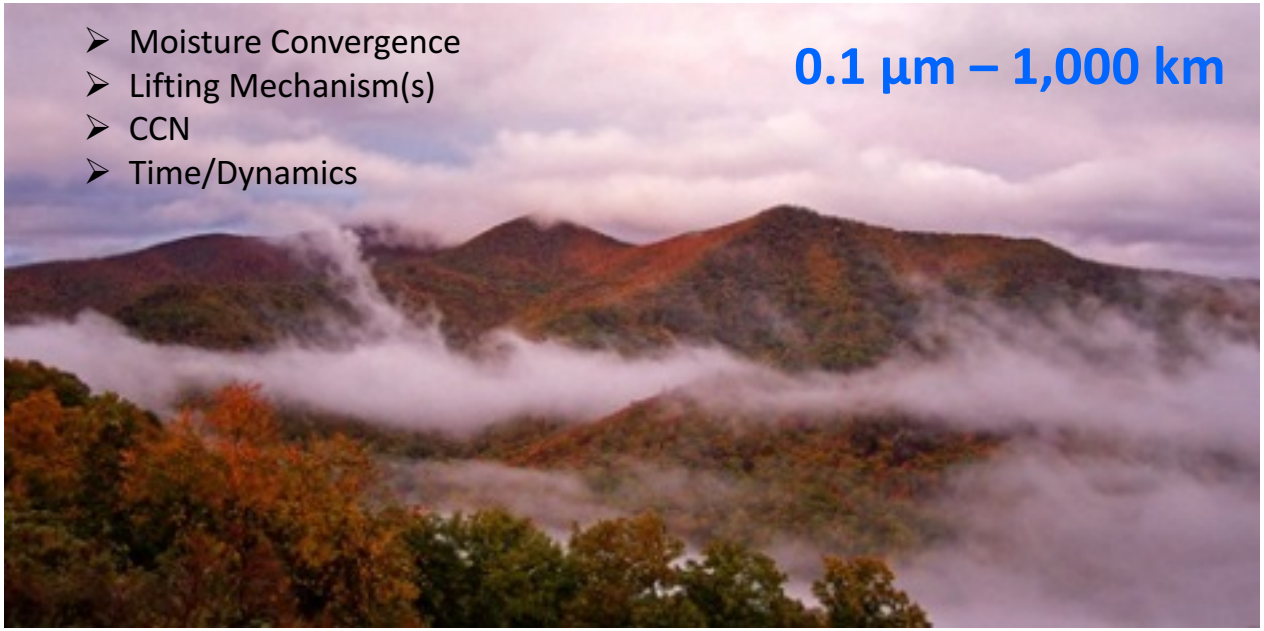
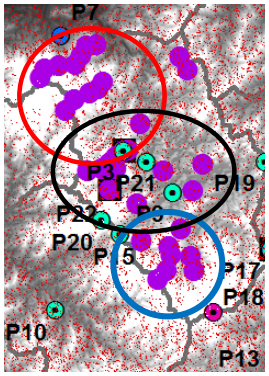
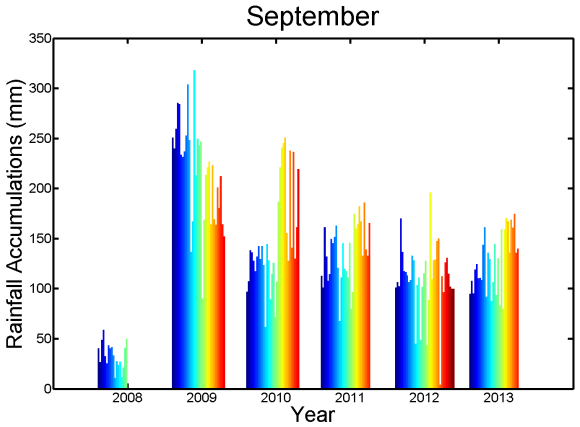
Improving orographic precipitation estimation by linking measurements to processes



Ana P. Barros, Yajuan Duan, Anna Wilson, Malarvizhi Arulraj, and many others

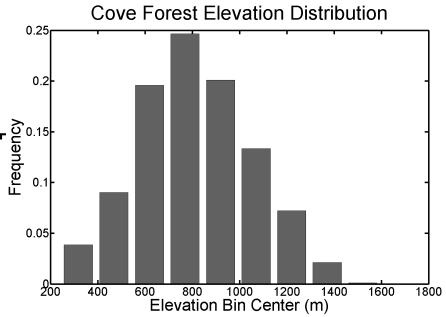
Rain Gauge Network Observations

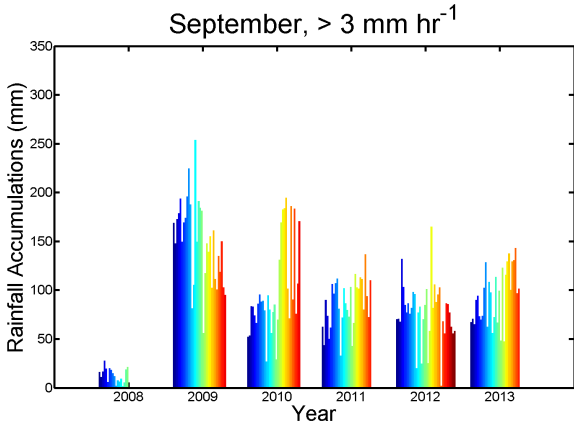


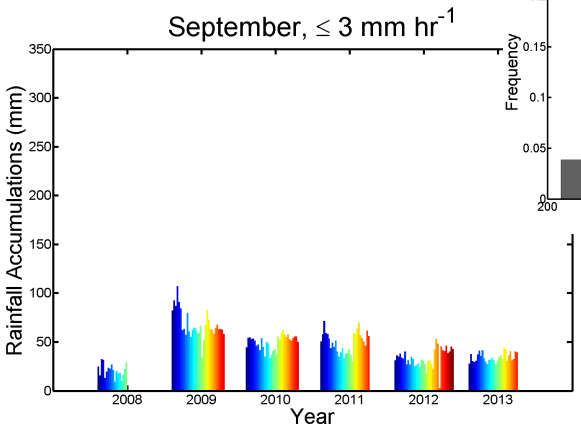


2008: drought year –
Light rainfall exceeds heavy

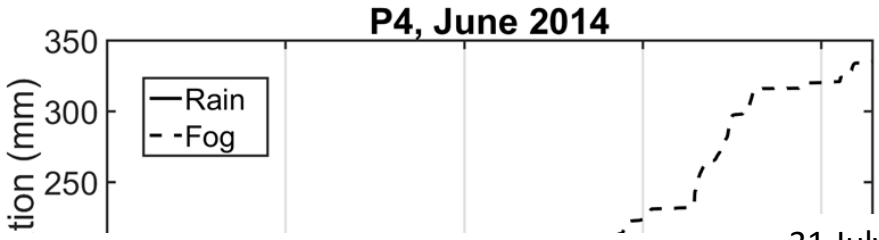
Much higher inter-ridge variability in heavier rainfall

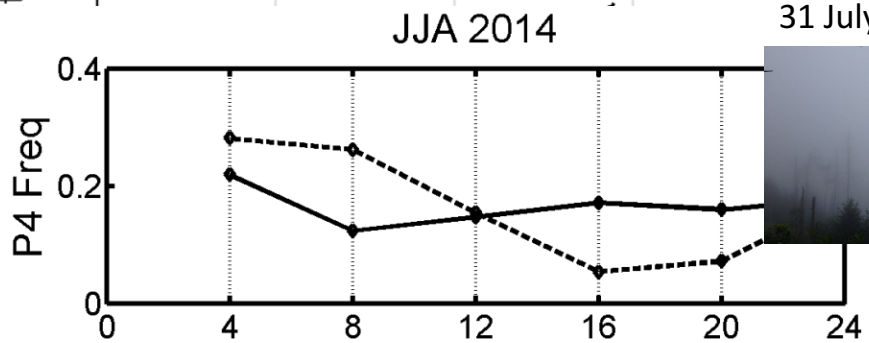




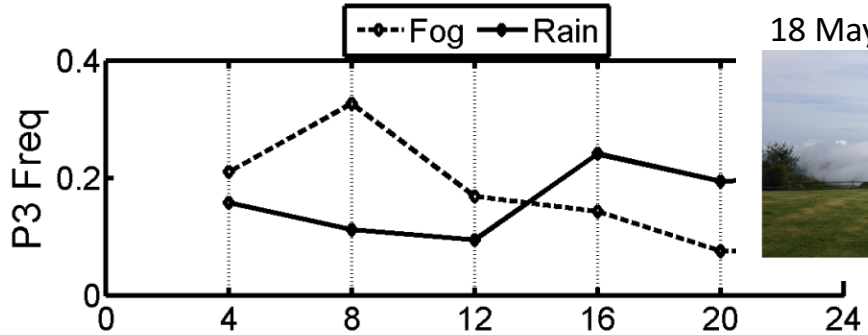


Cloud Immersion



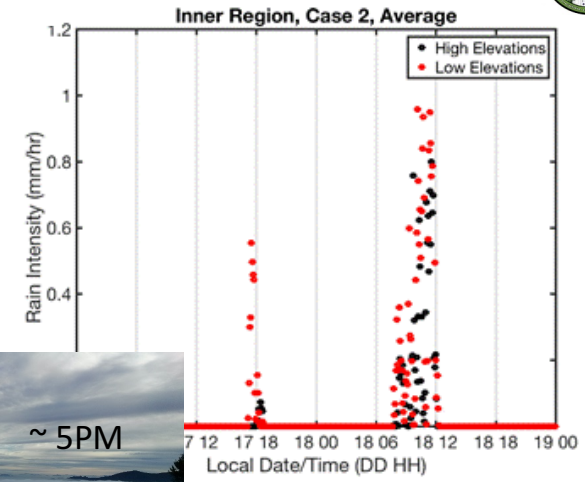


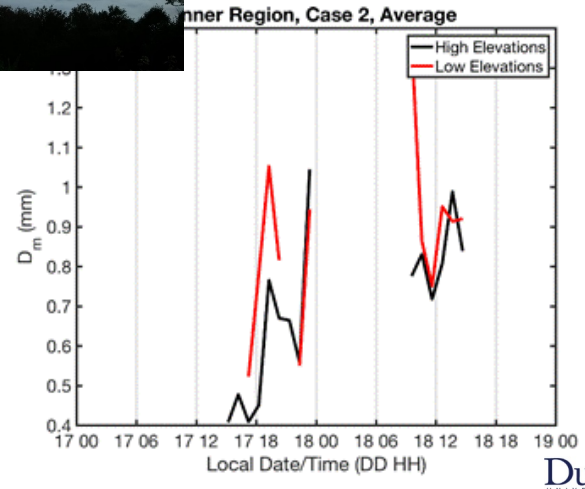
31 July, ~4:30 PM

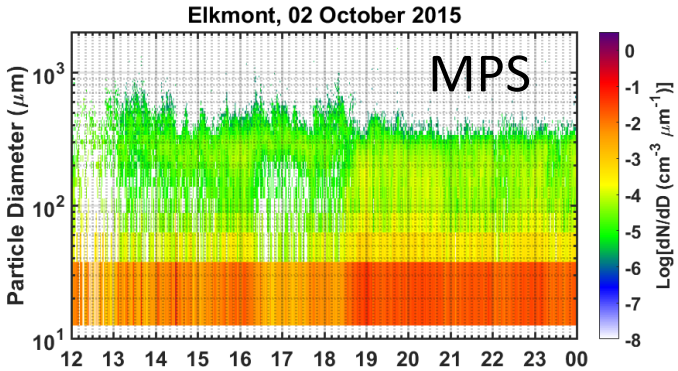


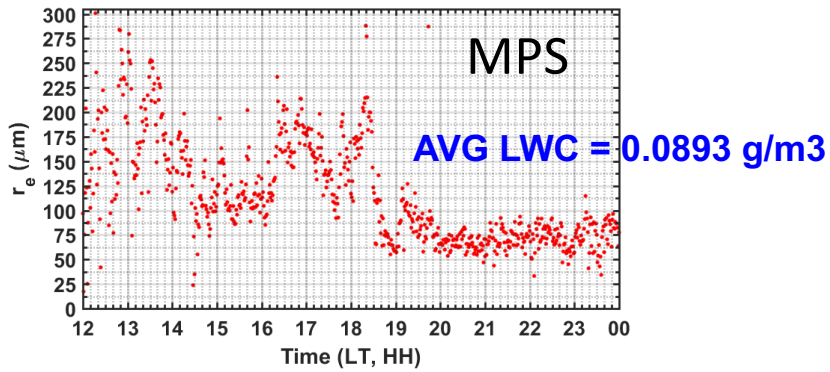
18 May, ~10 AM

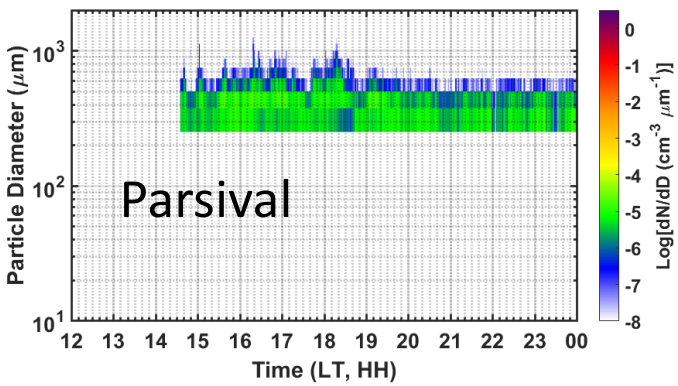
LLCF Banks

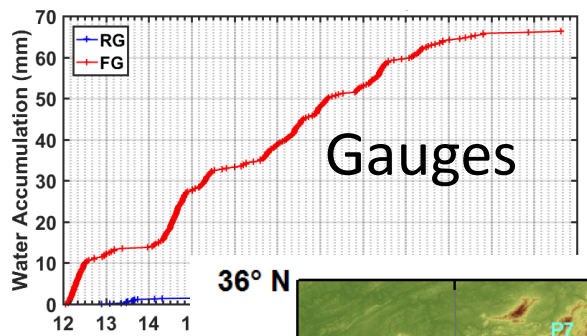


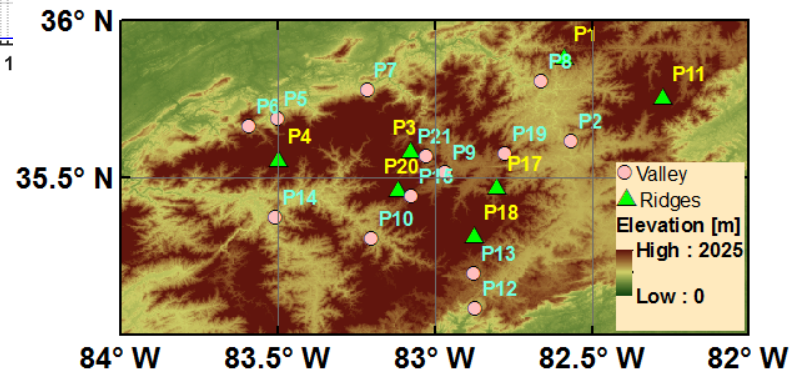


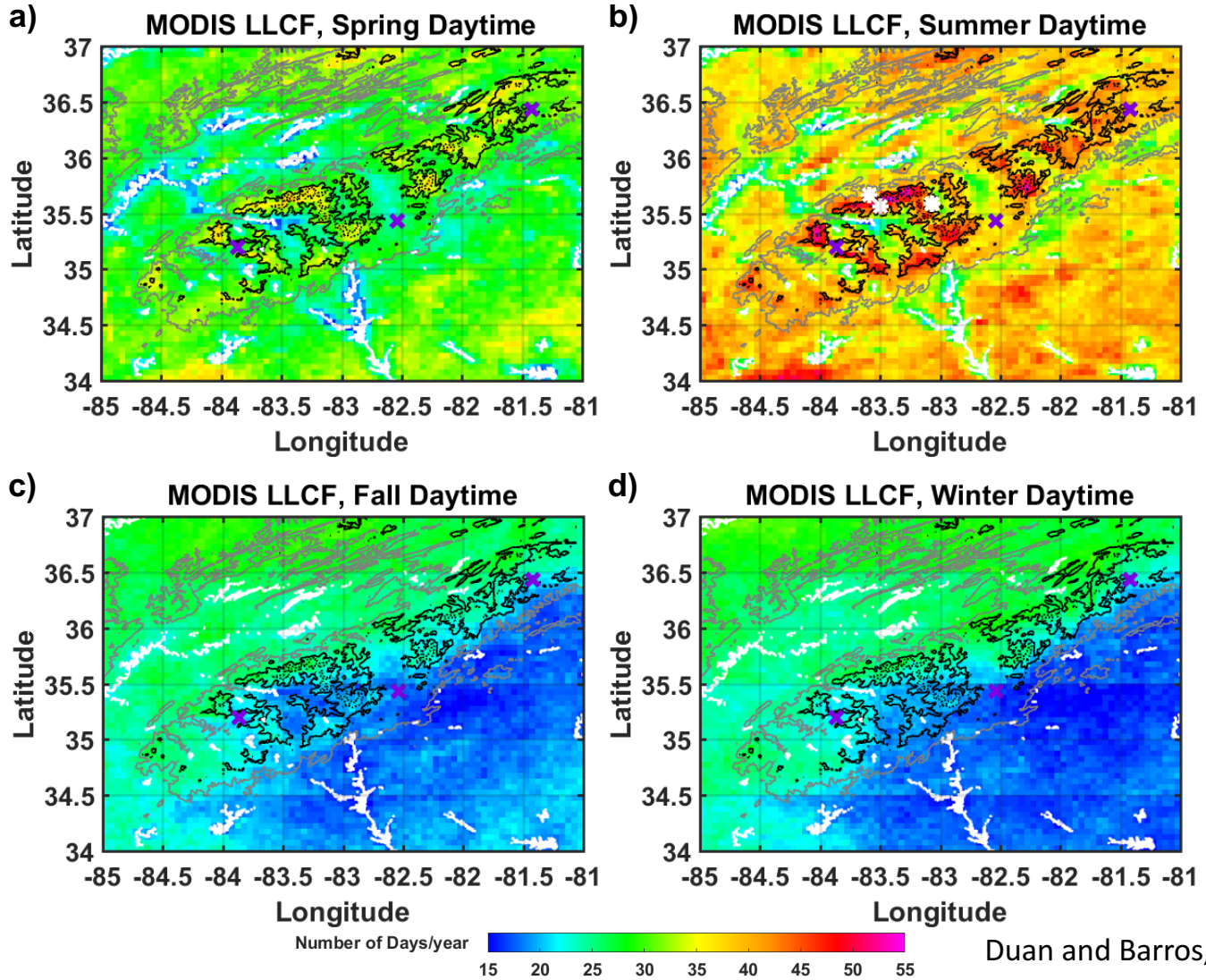

Elkmont, 02 October 2015
MPS
Particle Diameter (μm)
Log[dN/dD (cm-3 μm-1)]


MPS
AVG LWC = 0.0893 g/m3
re (μm)
Time (LT, HH)

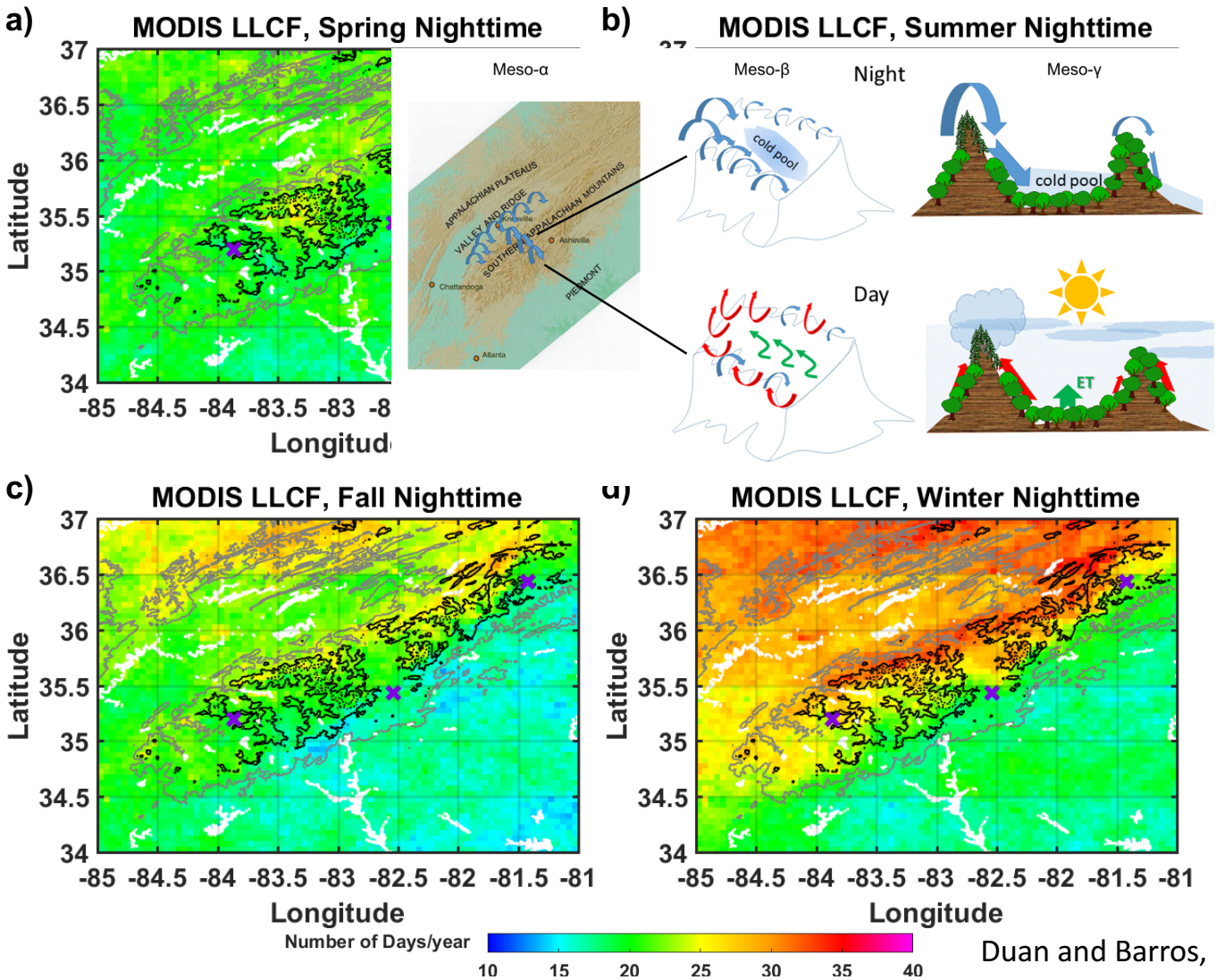

Parsival
Particle Diameter (μm)
Log[dN/dD (cm-3 μm-1)]
Time (LT, HH)


Gauges
RG
FG
Water Accumulation (mm)

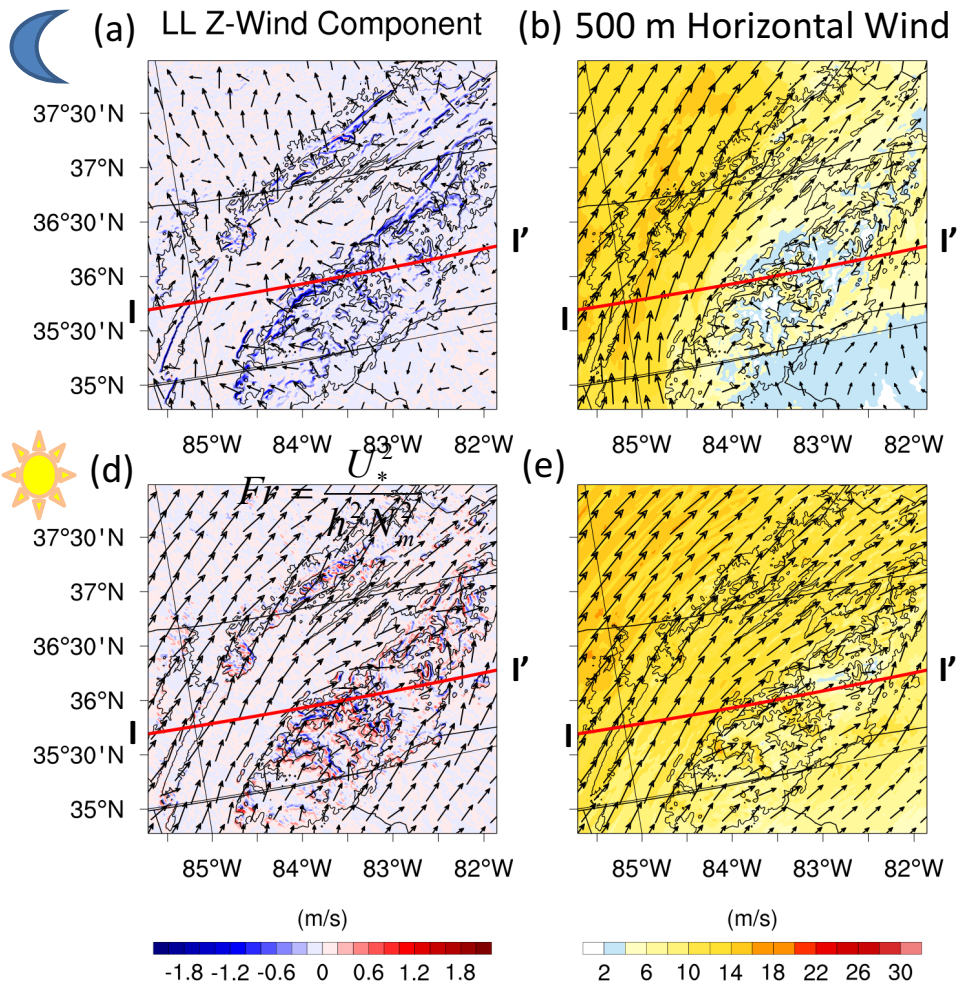

36° N
35.5° N
84° W
83.5° W
83° W
82.5° W
82° W
Valley
Ridges
Elevation [m]
High : 2025
Low : 0

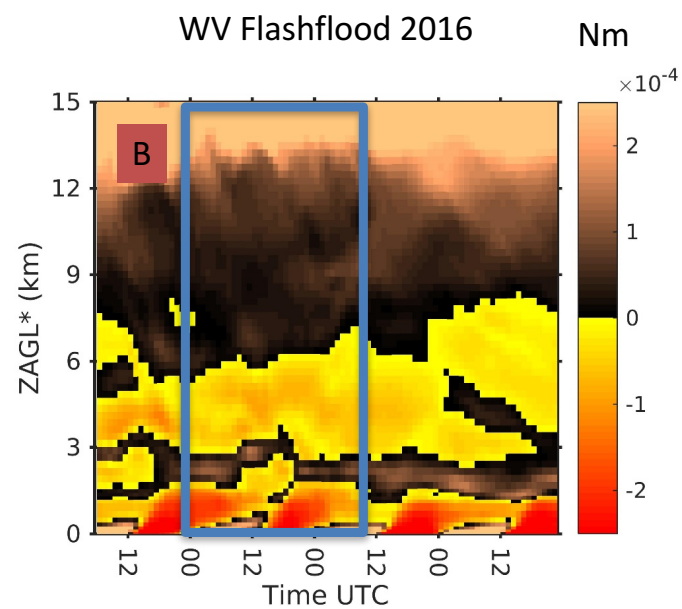


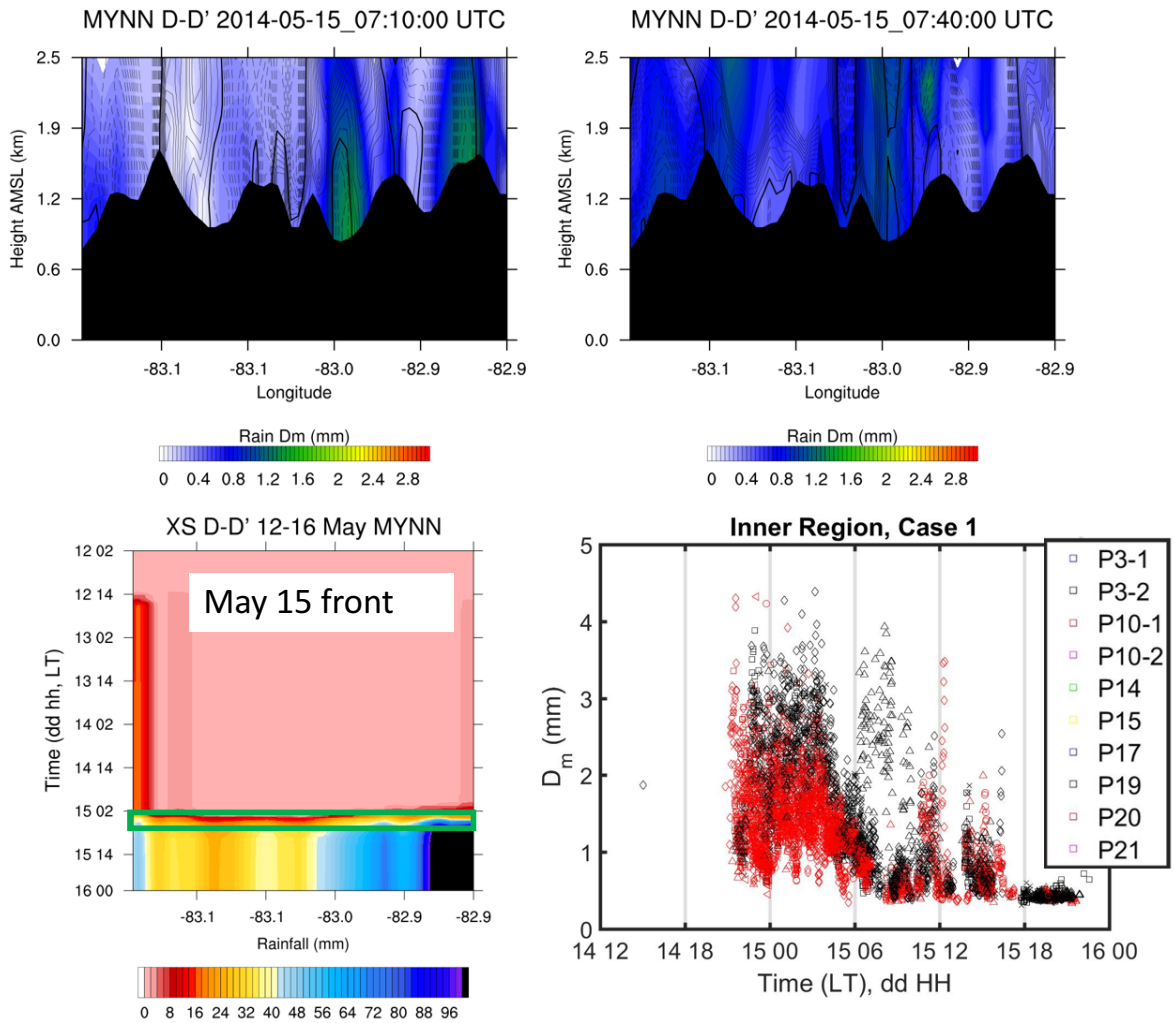
Duan and Barros, 2017



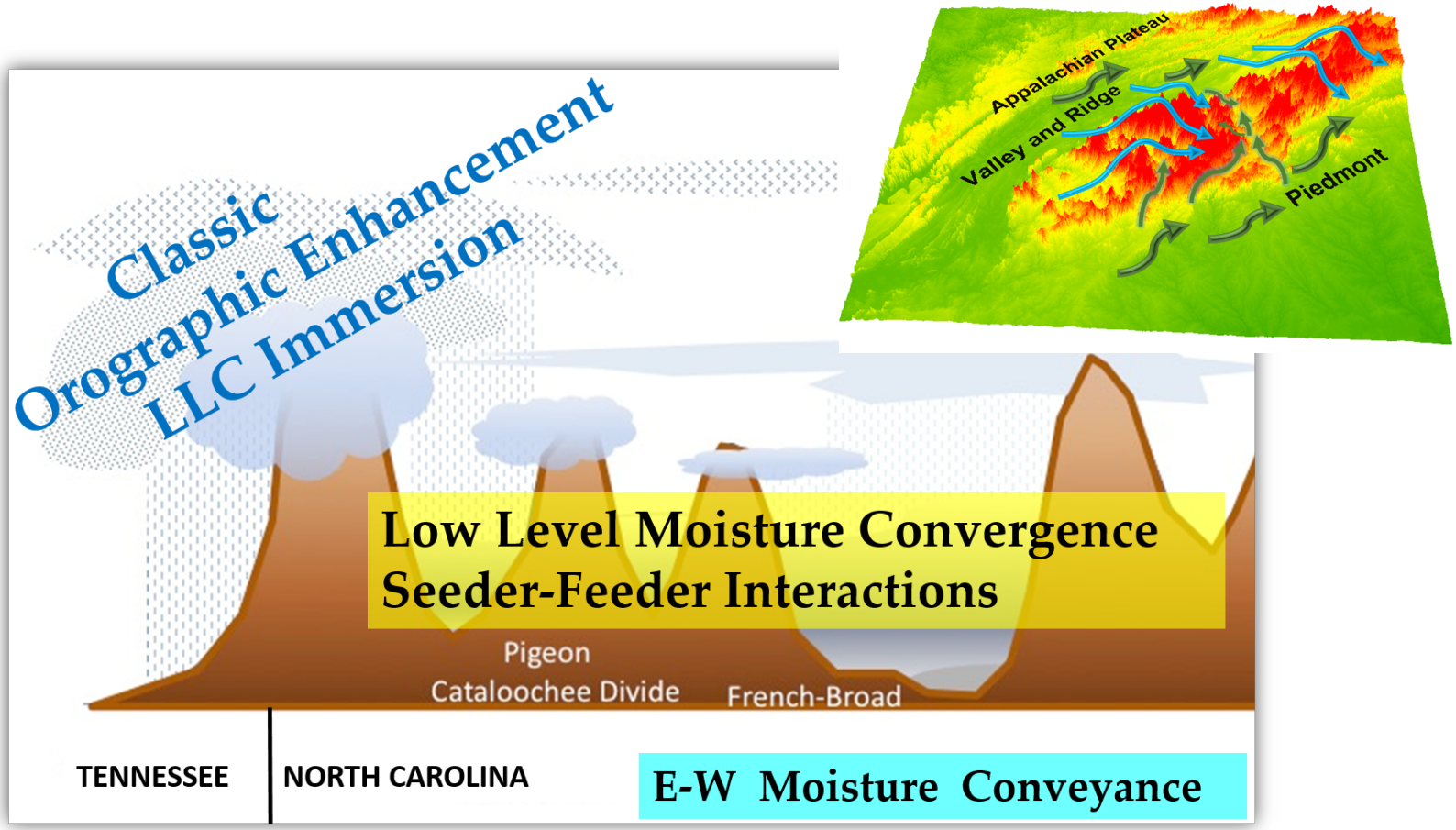
Duan and Barros, 2017


(a) LL Z-Wind Component
(b) 500 m Horizontal Wind
(d)
(e)
37°30'N
37°N
36°30'N
36°N
35°30'N
35°N
85°W
84°W
83°W
82°W
I
I'
$Fr = \frac{U_*^2}{h^2 N_m^2}$
(m/s)
-1.8 -1.2 -0.6 0 0.6 1.2 1.8
2 6 10 14 18 22 26 30

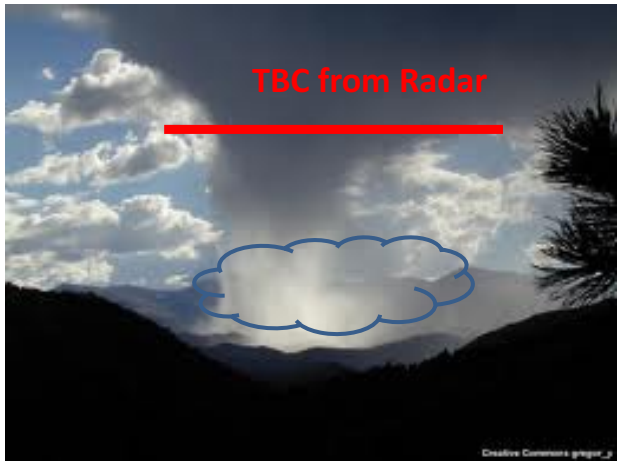

WV Flashflood 2016
Nm
$\times 10^{-4}$
B
ZAGL* (km)
15
12
9
6
3
0
12
00
12
00
12
00
12
Time UTC
2
1
0
-1
-2

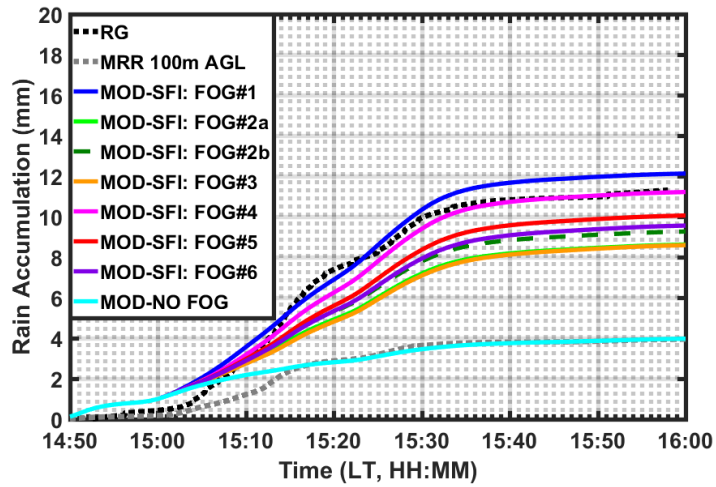

MYNN D-D' 2014-05-15_07:10:00 UTC
MYNN D-D' 2014-05-15_07:40:00 UTC
Height AMSL (km)
Longitude
Rain Dm (mm)
XS D-D' 12-16 May MYNN
May 15 front
Time (dd hh, LT)
Rainfall (mm)
Inner Region, Case 1
D_m (mm)
Time (LT), dd HH
P3-1
P3-2
P10-1
P10-2
P14
P15
P17
P19
P20
P21

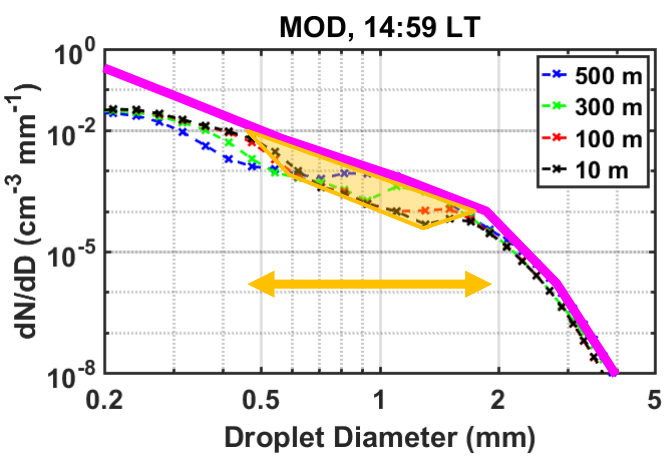
WARM SEASON REGIME CHARACTERIZATION

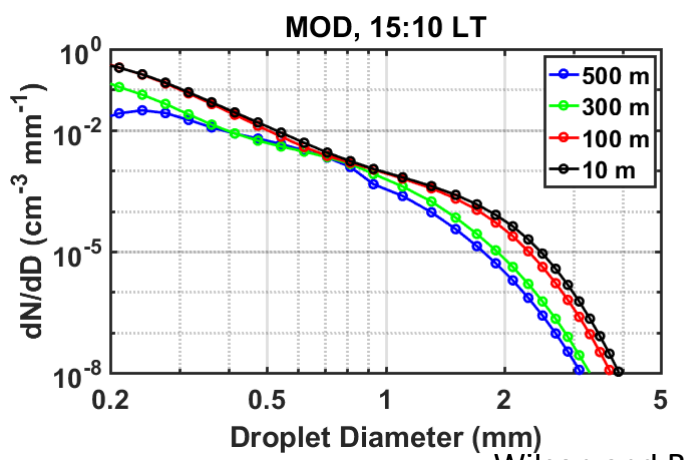


Wilson and Barros, 2015, 2017; Eghdami and Barros, 2017 in prep



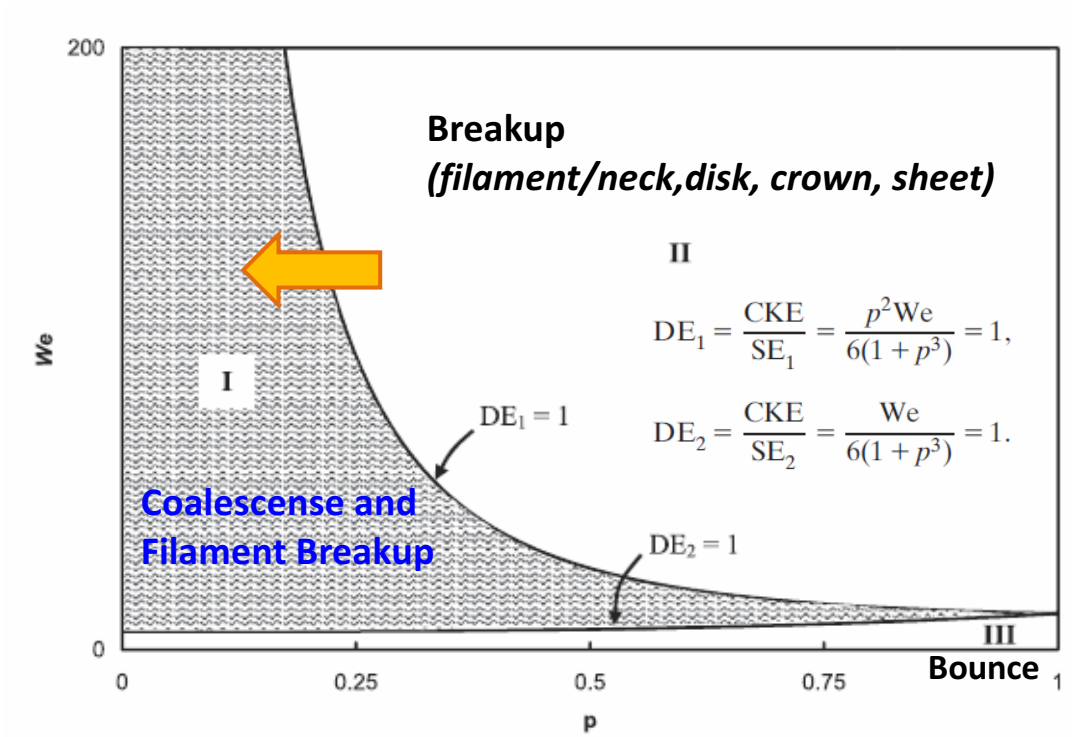






Wilson and Barros, 2014
Duan and Barros, 2017

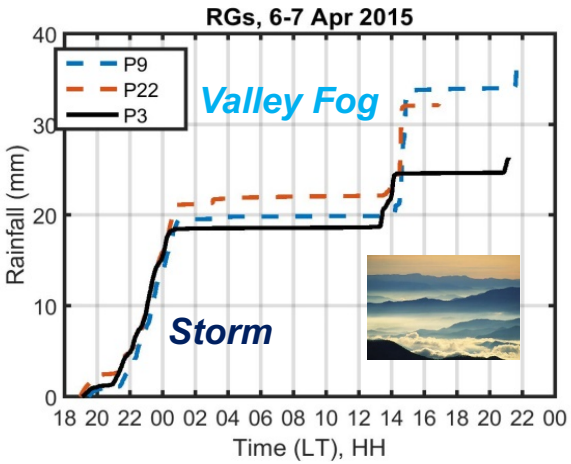
Parameterization of Regimes of Drop Collision Outcomes (I-III)

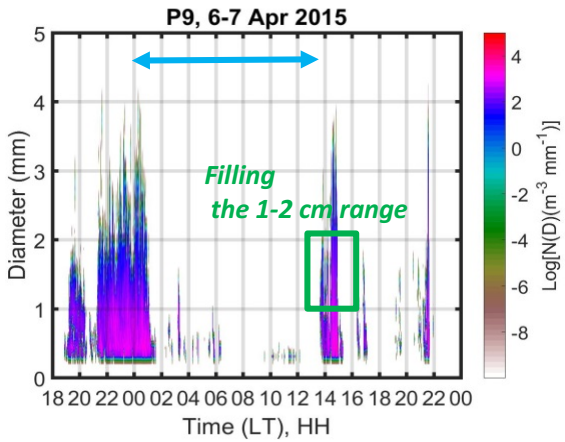


SE surface tension energy neglecting viscosity, CKE is the collision kinetic energy,
p is the diameter ratio between the small and larger diameters of two colliding hydrometeors,
and We is the Webber number. For details see Testik 2009, Testik et al. 2011, Prat et all. 2013

Seeder-Feeder Interactions

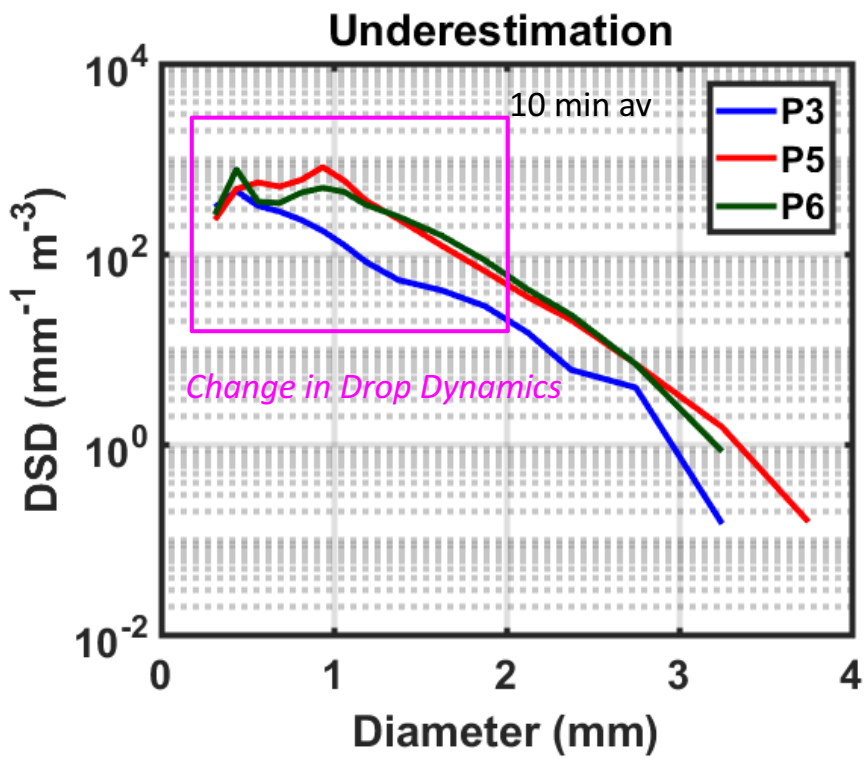
same terminal properties
different physical process
different DSD



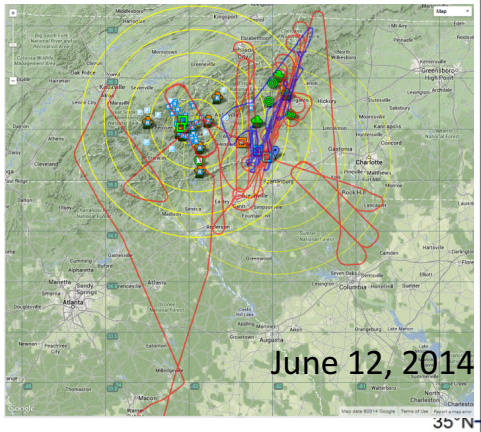


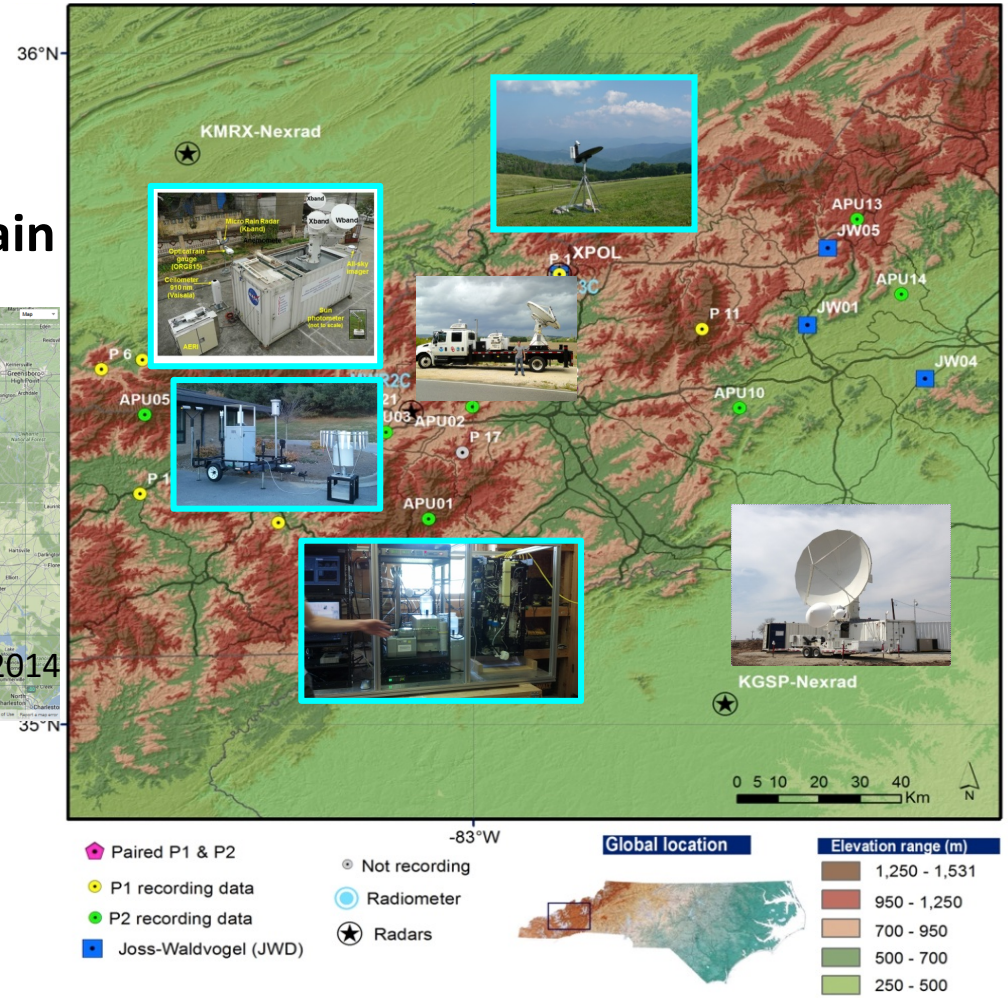
Wilson and Barros, JAS (2014), JHYDR (2015), JHM (2017)

Parsivel	Time UTC	GPM-DPR v5 (mm/h)	Parsivel (mm/h)
P3	June 16, 2014 16:31:02	1.25	8.8
P5	August 9, 2014 00:55:21	3.40	12.39
P6	September 3, 2014, 02:59:37	1.37	9.75



Mapping Precipitation Processes in Complex Terrain





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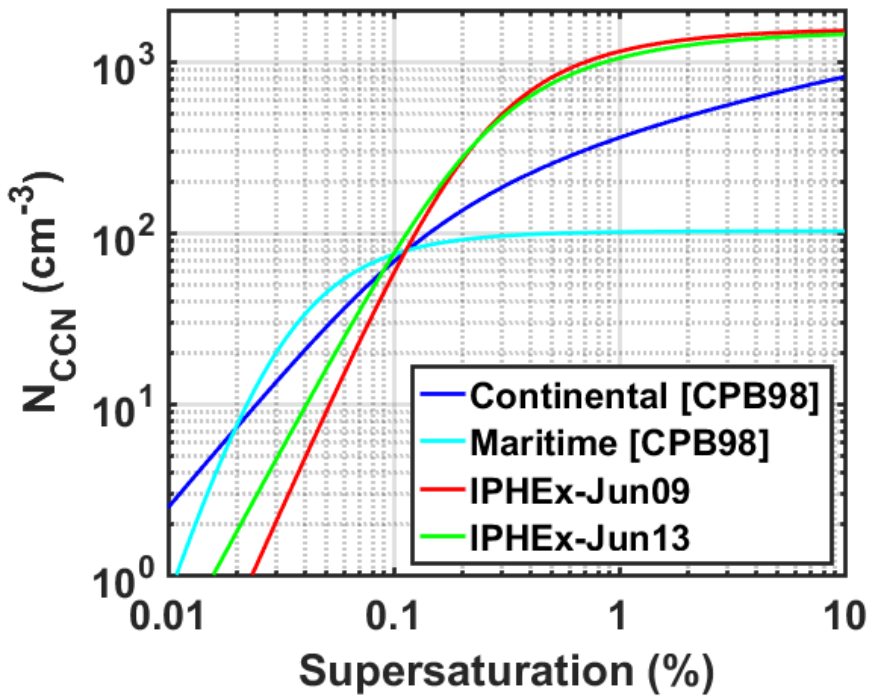
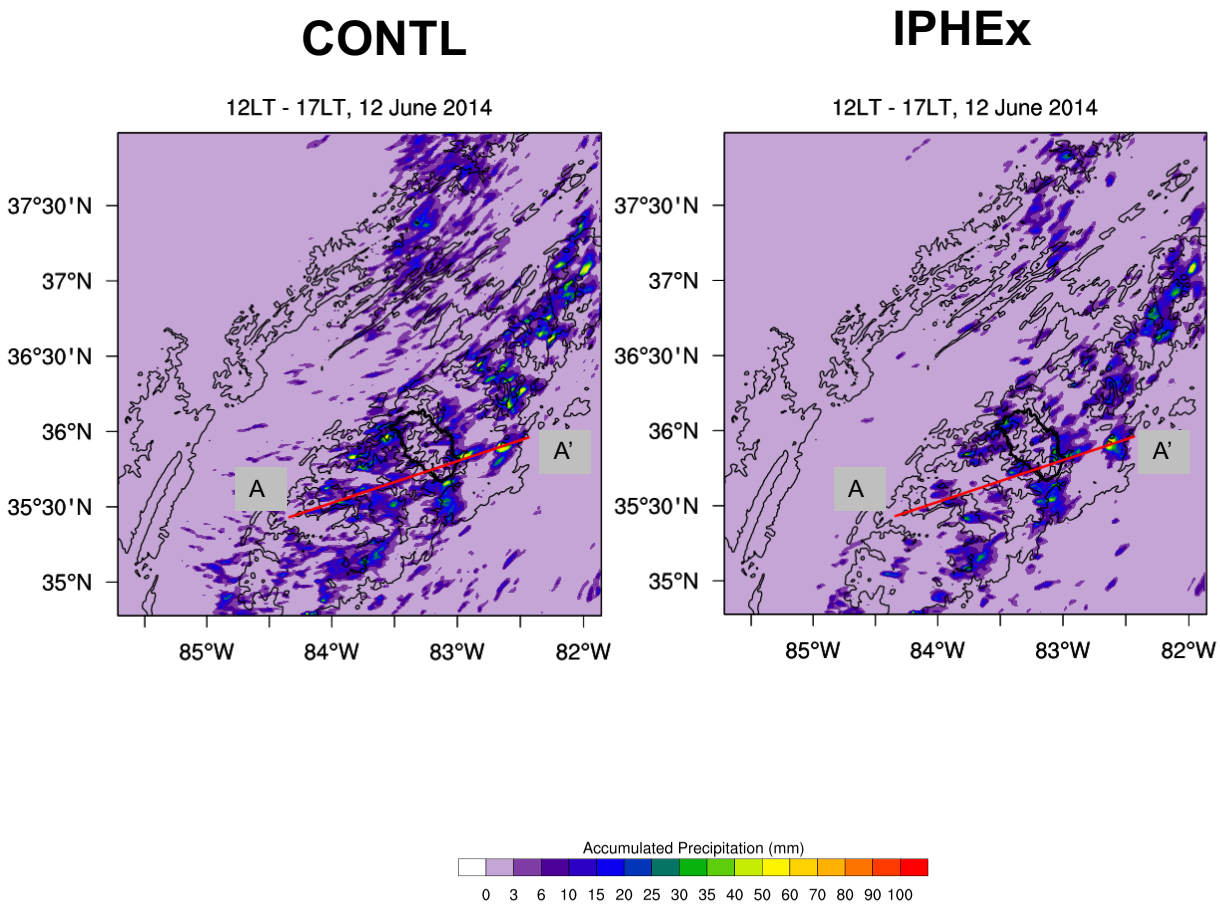
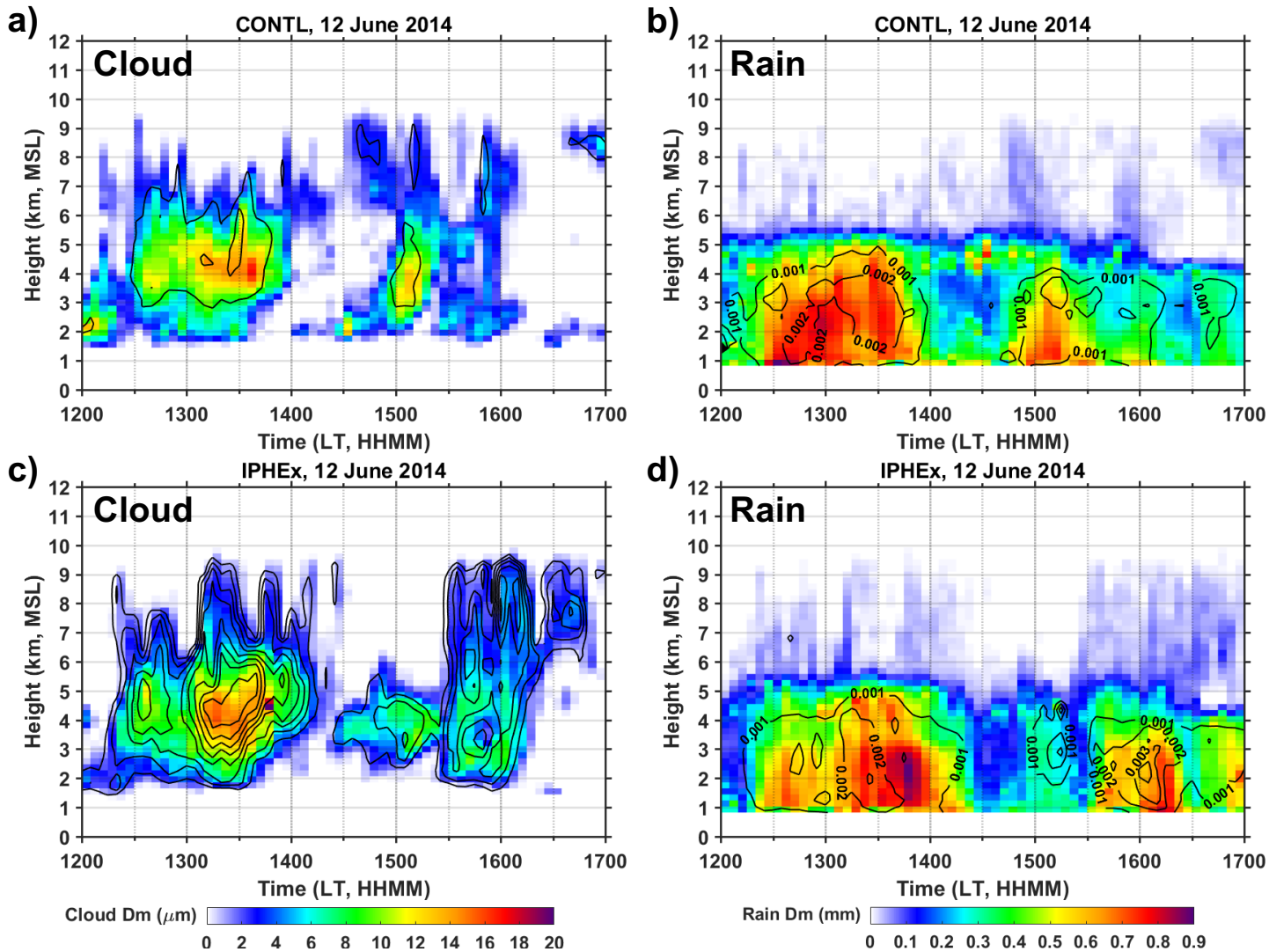
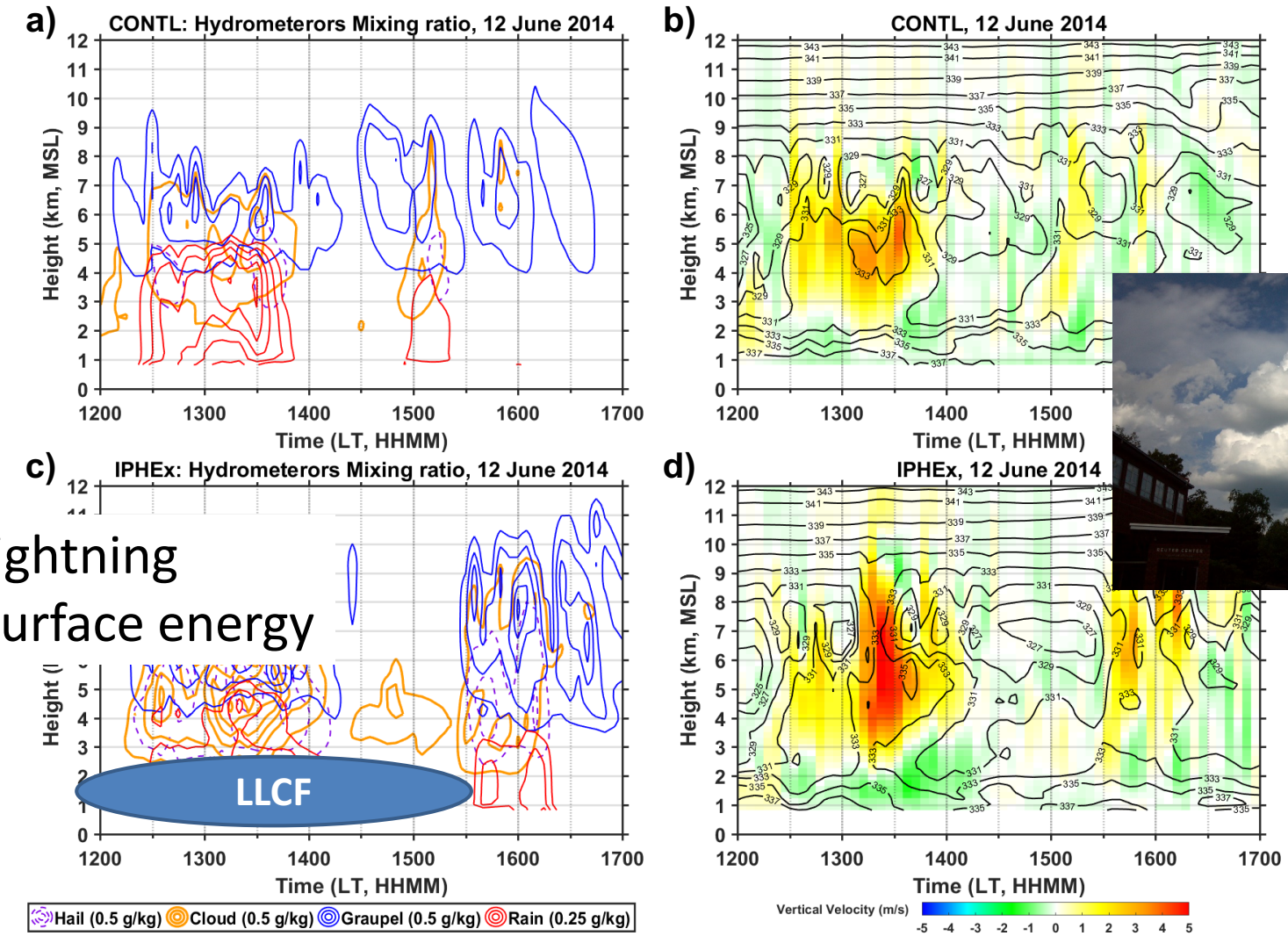


	C (cm-3)	k	β	μ
Continental [CPB98]	3270	1.56	136	0.7
Maritime [CPB98]	1.93×10^8	4.16	1370	2.76
IPHEx-Jun09	68824	2.97	23.46	1.96
IPHEx-Jun13	24935	2.44	22.66	1.62

Duan et al., 2017a
Duan and Barros, 2017b


CONTL
IPHEx
12LT - 17LT, 12 June 2014
12LT - 17LT, 12 June 2014
37°30'N
37°N
36°30'N
36°N
35°30'N
35°N
85°W
84°W
83°W
82°W
A
A'
Accumulated Precipitation (mm)
0 3 6 10 15 20 25 30 35 40 50 60 70 80 90 100

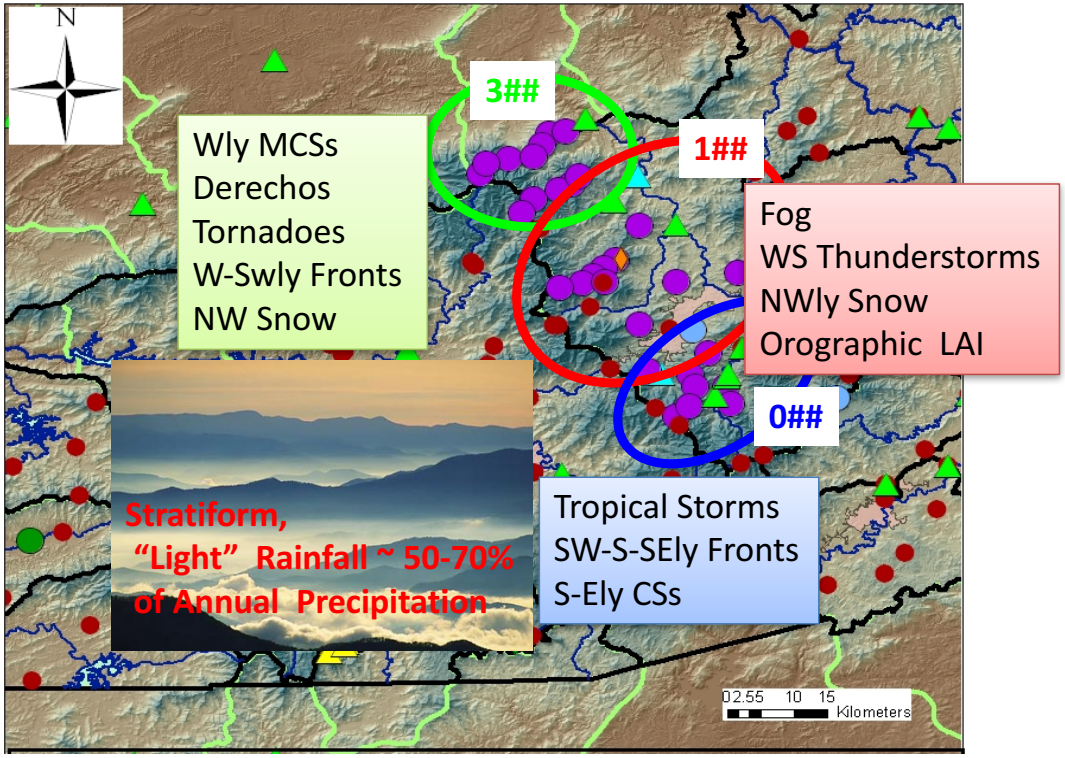

a)
CONTL, 12 June 2014
Cloud
b)
CONTL, 12 June 2014
Rain
c)
IPHEx, 12 June 2014
Cloud
d)
IPHEx, 12 June 2014
Rain
Height (km, MSL)
Time (LT, HHMM)
Cloud Dm (μm)
0 2 4 6 8 10 12 14 16 18 20
Rain Dm (mm)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9



lightning

surface energy

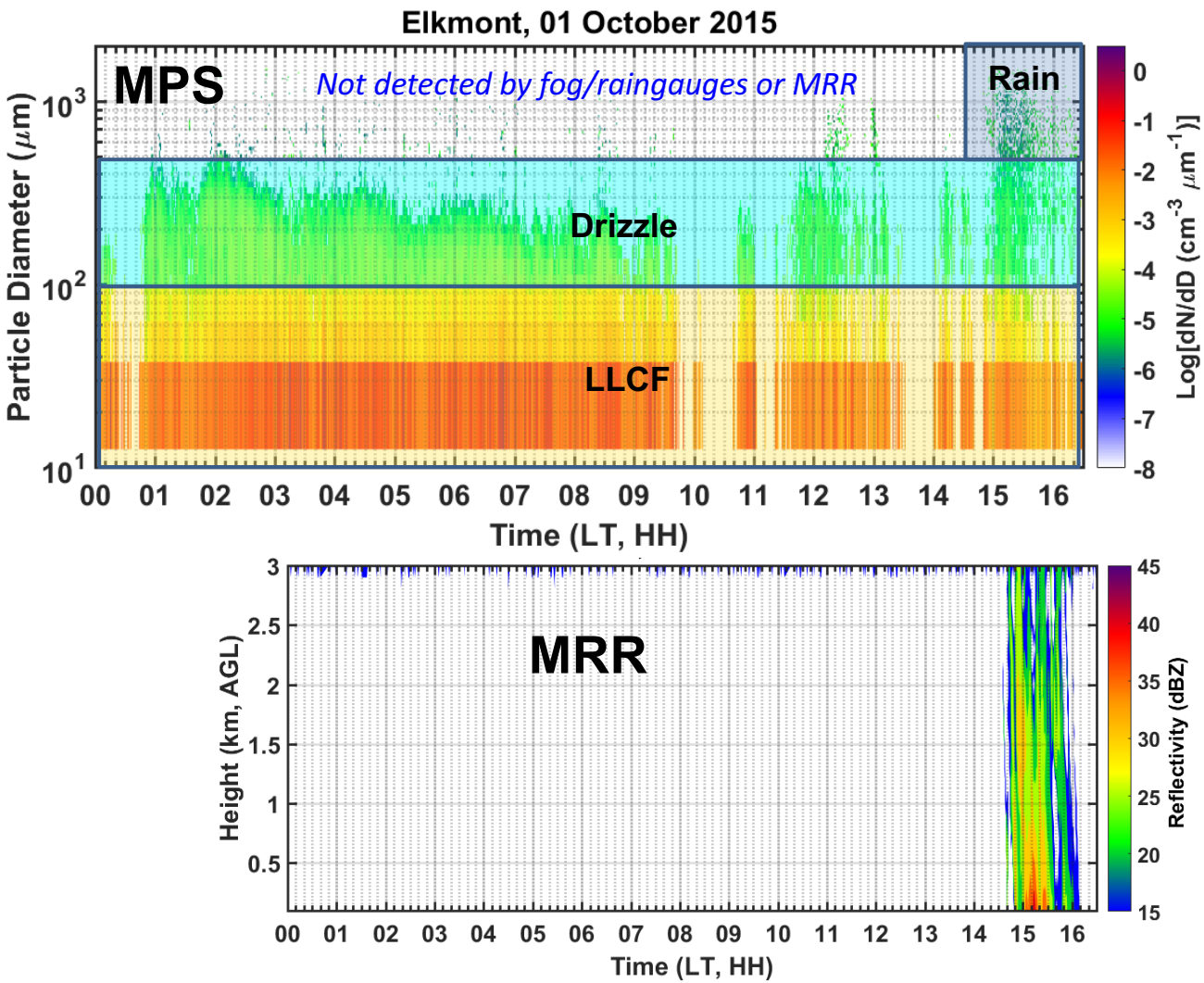
LLCF

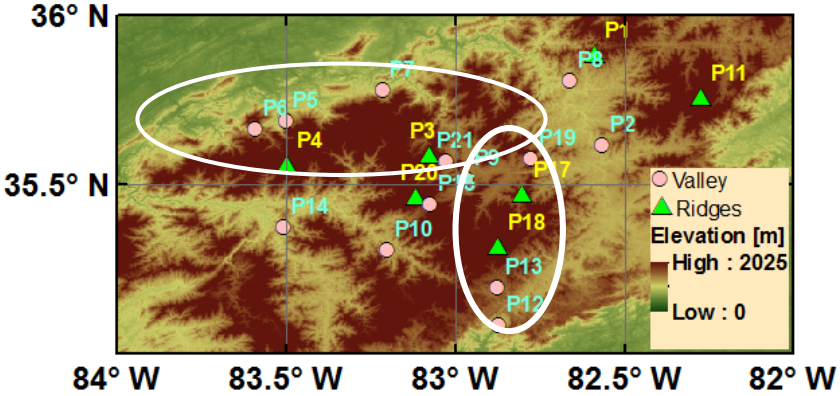


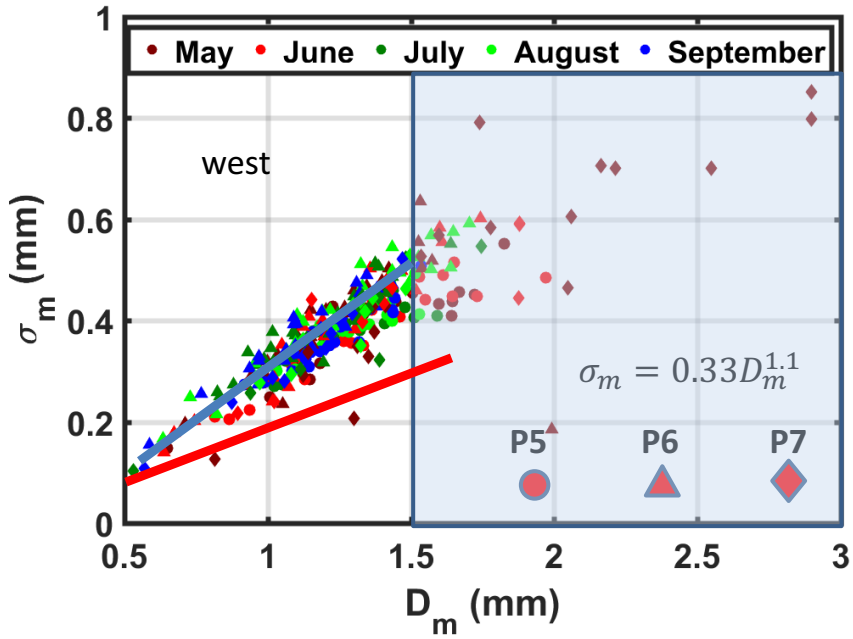
Aircraft

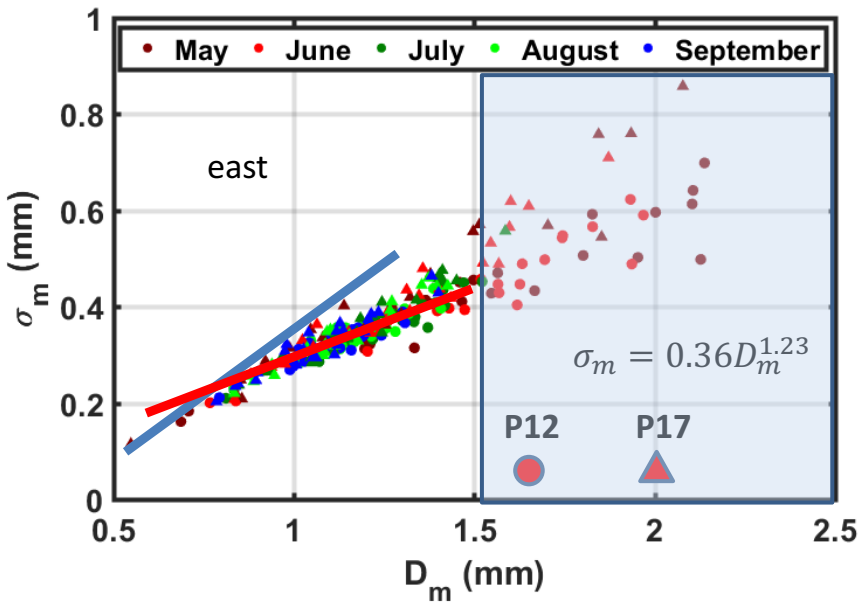
Comprehensive,multi-disciplinary, integrated, long-term quality Ground Validation

Duke
UNIVERSITY


Elkmont, 01 October 2015
MPS
Not detected by fog/raingauges or MRR
Rain
Drizzle
LLCF
Particle Diameter (μm)
Log[dN/dD (cm-3 μm-1)]
Time (LT, HH)
MRR
Height (km, AGL)
Reflectivity (dBZ)
Time (LT, HH)


36° N
35.5° N
84° W
83.5° W
83° W
82.5° W
82° W
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P17
P18
P19
P20
P21
Valley
Ridges
Elevation [m]
High : 2025
Low : 0


May
June
July
August
September
west
$\sigma_m = 0.33D_m^{1.1}$
P5
P6
P7
σ_m (mm)
D_m (mm)


May
June
July
August
September
east
$\sigma_m = 0.36D_m^{1.23}$
P12
P17
σ_m (mm)
D_m (mm)