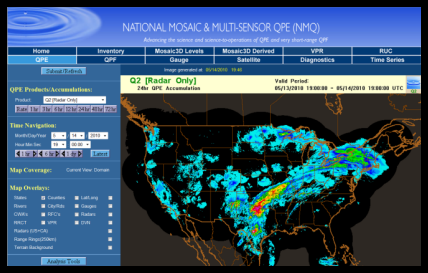
Ground Validation Status/ MC3E

Walt Petersen, NASA GSFC/WFF and Matt Schwaller, NASA GSFC

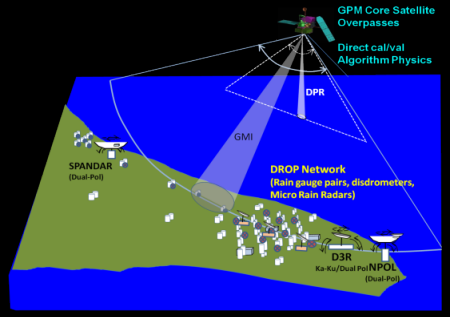


NMQ in Direct Val.

GCPEX Update

LPVEX

MC3E Summary



WFF Facility

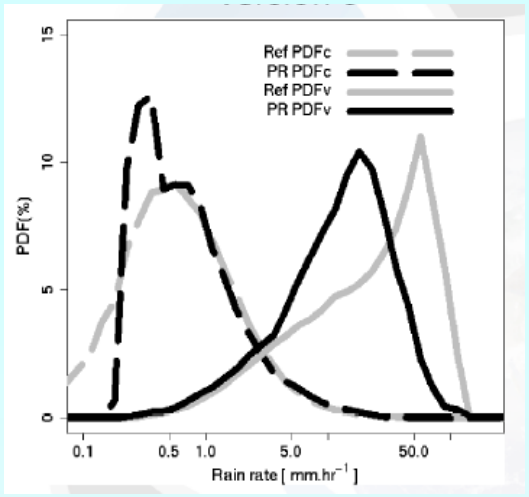
GPM Direct Validation Tool Development with NOAA NMQ Group

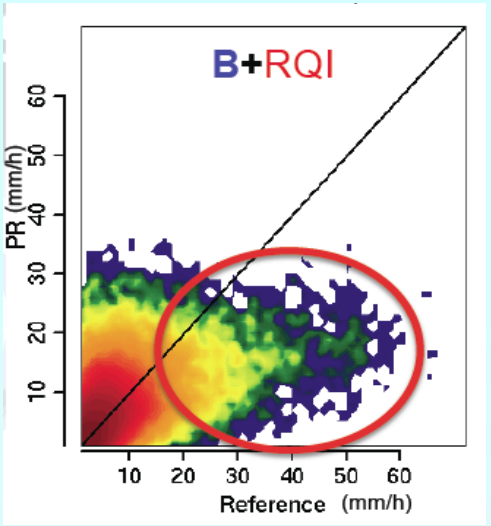
(OU/NSSL: Kirstetter, Hong, Gourley,; PMM: Morris, Wolff, Amitai, Petersen,Schwaller)

Compare March-May 2011

Reference Q2 matched to PR

- **V7.0 improved bias and correlation**
- **Slight shift of V7.0 rain volume PDF toward heavier rain (right direction)**



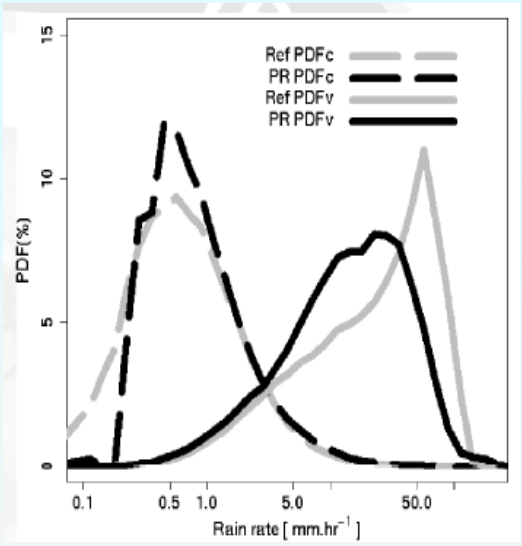


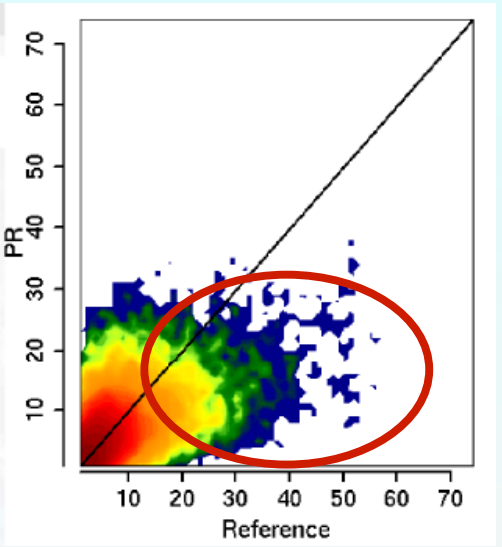
Ongoing Work

- Error by rain type, topography, scan angle, NUBF etc.
- Integrate TMI (2A12)

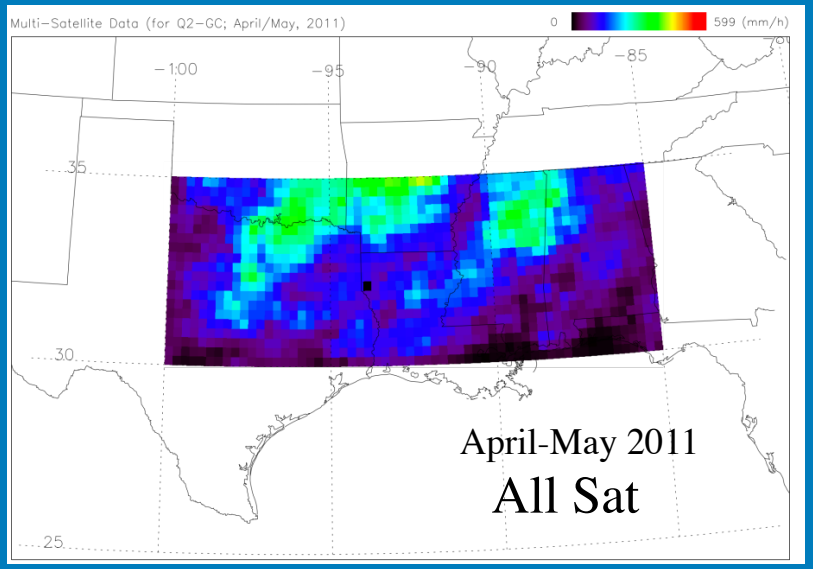
Planned Work

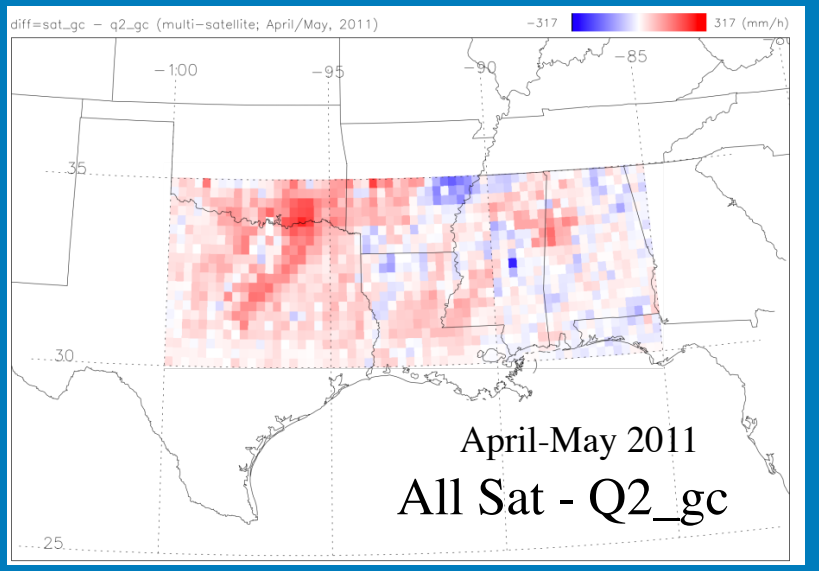
- Operational server /web site
- 1-Year Q2 rain rate, reflectivity, ancillary parms database (Dec 2011)

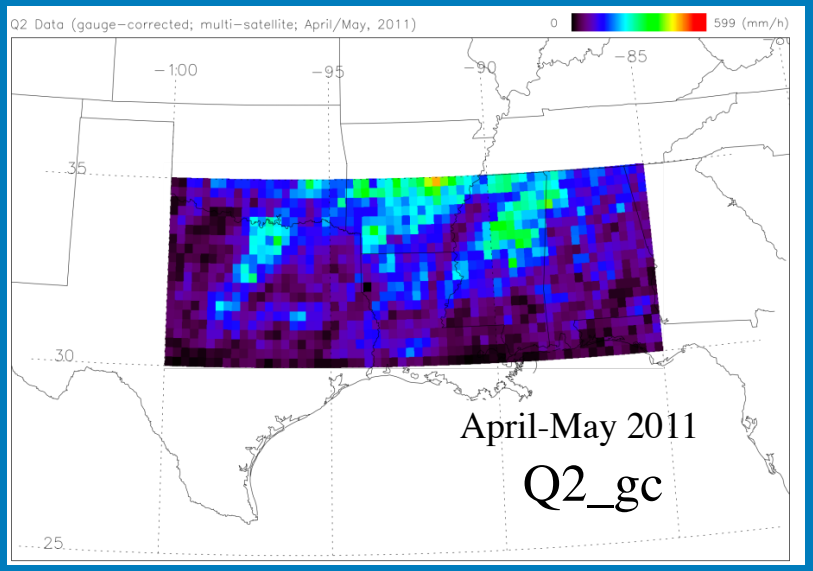




Multi-Satellite/Q2 Snapshot Comparisons







Sat/Q2 Area Average Rain Rate Ratio

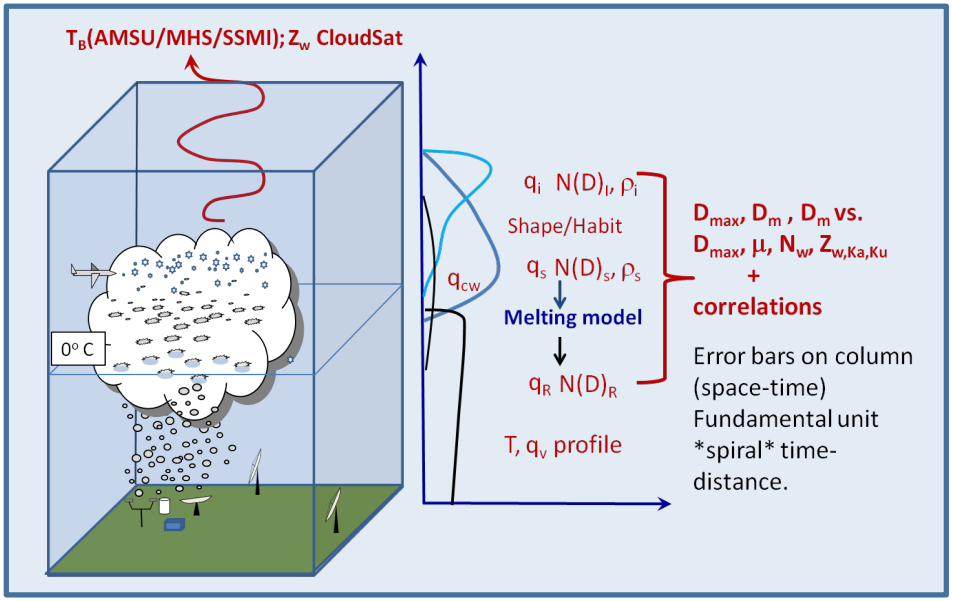
Satellite	$\Sigma R_{SAT} / \Sigma R_{Q2}$		$\Sigma R_{SAT} / \Sigma R_{Q2\_gc}$	
	April	May	April	May
All	1.11	1.08	1.26	1.22
METOP2A/MHS	1.46	1.29	1.69	1.43
NOAA19/MHS	1.29	1.08	1.54	1.23
NOAA18/MHS	1.22	1.23	1.35	1.37
TMI	0.90	0.97	1.02	1.12
AQUA/AMSRE	0.85	0.84	0.92	0.95
NOAA16/AMSUB	0.44	N/A	0.50	N/A

Rain rate retrievals from individual satellites are being used to construct multi-satellite rainfall products (like IMERGE) these are compared with Q2 ground-based obs *at overpass time*

Amitai et al.

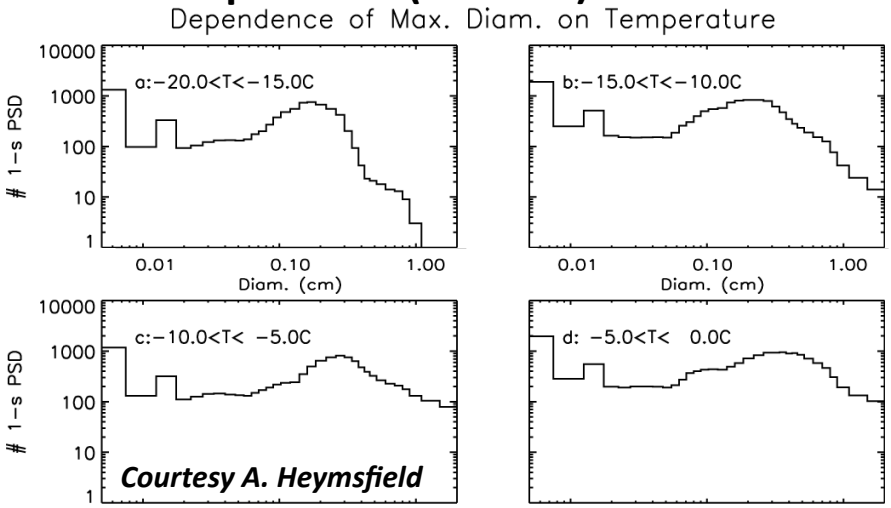
LPVEX Data Meeting (October 13-14, 2011)

- Data QC completing(ed)
- Formal release Dec. 2011
- Characterize column- ground to top

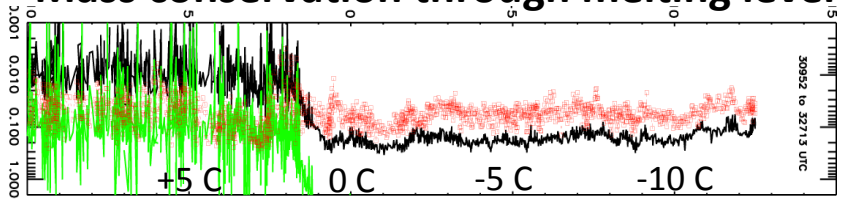


"Building" the Column

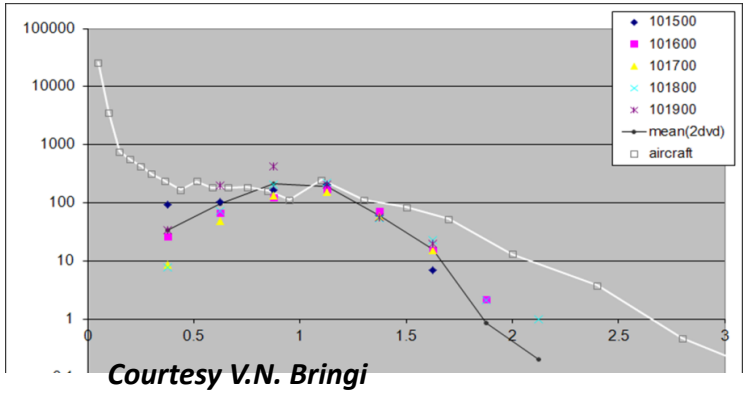
Increased D_{max} (decreasing PSD slope) in ice with temperature (altitude)



Mass conservation through melting level



DSD at ground vs that of Aircraft at low altitude- difference on tail?



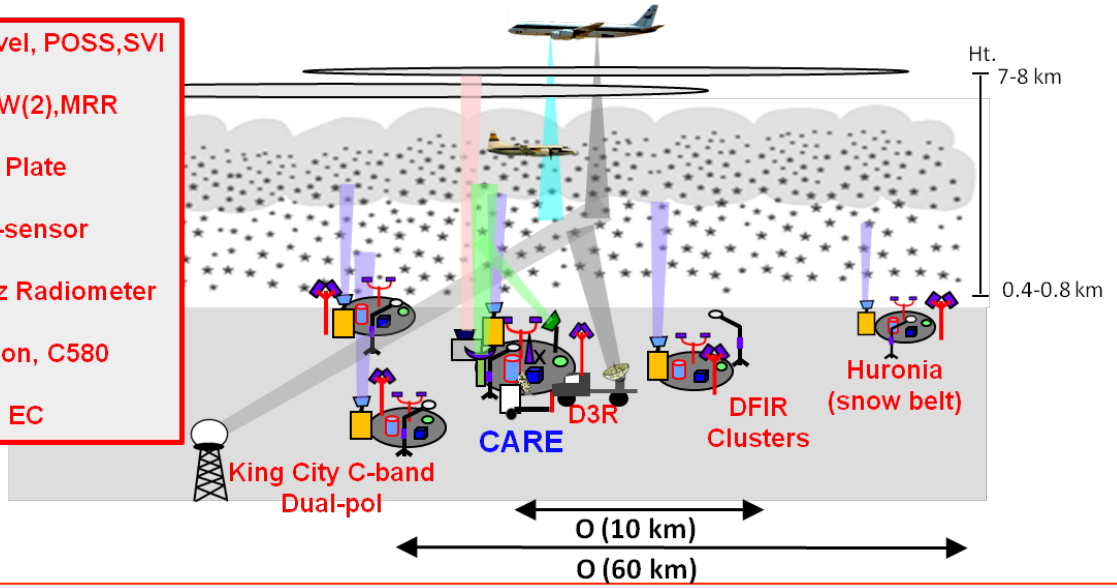
GCPEX (Jan. 17-Feb. 29)

GPM Overarching Objectives:

1. Quantify retrieval sensitivities to: a) snow physical characteristics (particle, bulk, regime); b) Definition of environment: e.g., land surface/snowpack, tropospheric T/Q; c) spatial heterogeneity
2. Build forward model databases for retrieval development.

Ground in situ → W,Ka,Ku,X,C Radar → Airborne in situ → High alt. GPM "Proxy"

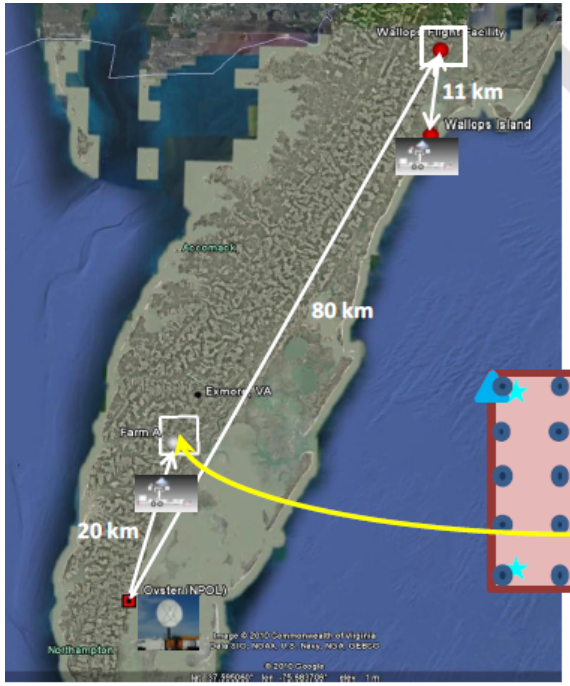
PSD:		2DVD, Parsivel, POSS,SVI
Radar:		Ka/Ku,X,W(2),MRR
SWER:		Pluvio, Hot Plate
SWE/Depth		L-Band + γ-sensor
ε: (Land/Snow)	x	1.4-150 GHz Radiometer
Aircraft:		DC-8, Citation, C580
Radiometer:		ADMIRARI, EC



Status

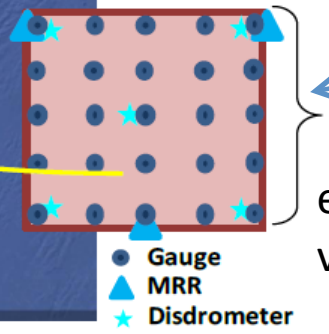
- Ground DSD/gauge instrument decks, power, and network installs underway
- Aircraft plans developed, discussed, approved by NavCanada
- Daily operations schedule, forecasting plan moving forward in earnest
- Personnel scheduling and site logistics work underway

Wallops Radar, Dense Gauge, and Disdrometer Network Facility

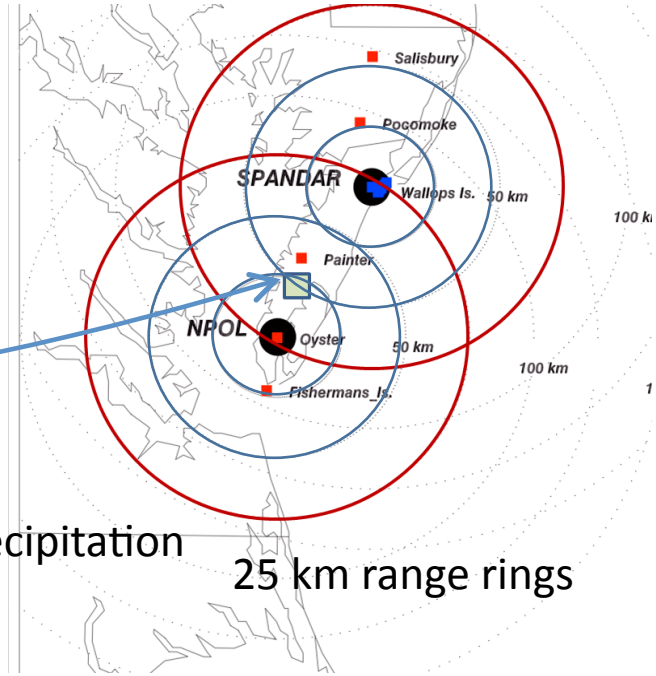


Objective(s)

GV "home base" extended *error characterization* coupled to physics in a coastal environment



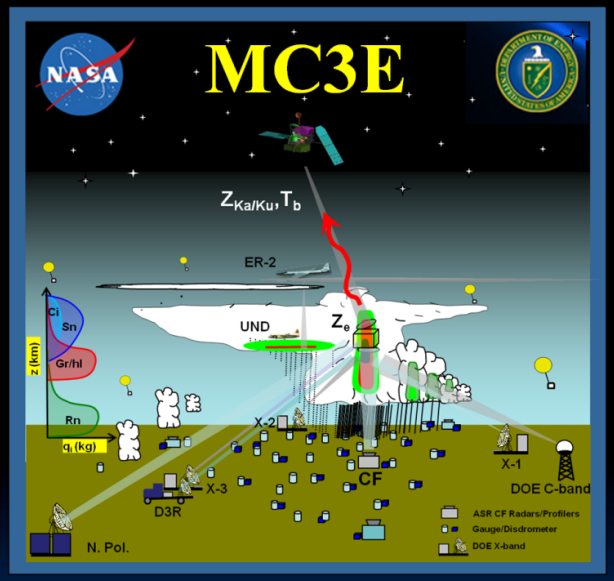
e.g., Dense network precipitation variance studies



25 km range rings

- **WFF long-term dense gauge/disdrometer network under radar coverage**
  - 25-50 gauge pairs, 25 km^2 – 100 km^2
    Spatial decorrelation of rain rate and point-to-area representativeness errors
  - NPOL (S-band) , SPANDAR (S-band) , WSR-88D (S-band), *Quantify GV radar rain rate error structure as f(scale, measurement type/method);*
  - **Add** D3R, Disdrometer network and MRR's
    DSD variability related to vertical structure and regime type; Implementation/testing of targeted DPR "centric" validation scanning/sampling strategy
- **Sample precipitation regime diversity:** WFF land/coast/ocean/bay

Mid-latitude Continental Convective Clouds Experiment
April 22 – June 6, 2011



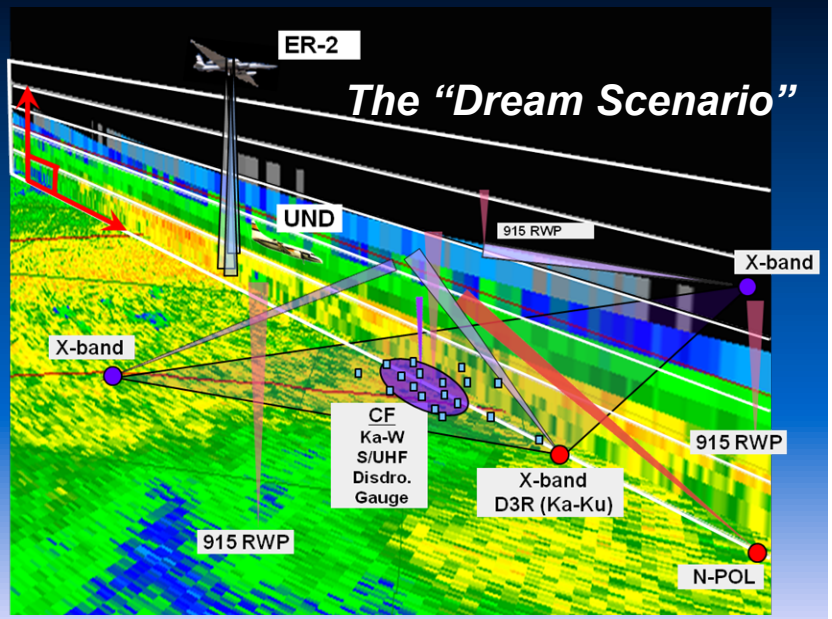
Location: DOE-ARM SGP Central Facility, N. Oklahoma and NE Colorado (CSU CHILL)

Overarching Objectives:

- GPM: Improved physically-based rainfall retrieval algorithms over mid-latitude land surfaces
- DOE: Improved simulation of convective cloud properties (initiation, dynamics, microphysics)

Sampling Strategy:

- ER-2 (satellite "proxy"; HIWRAP, CoSMIR, AMPR) stacked over UND-Citation (in situ microphysics)
- Coincident and targeted ground-based multi-frequency/dual-pol radar (S/C/X/Ku-Ka/W), profiler, disdrometer/gauges
- Column precipitation physics for a variety of precipitation types



Nature's response……

Oklahoma sees driest 4 months since Dust Bowl

(AP) – 8 hours ago

COYLE, Okla. (AP) — In most years, the dark clouds over western Oklahoma in the spring would be bringing rain. This year, they're more likely to be smoke from wildfires that have burned thousands of acres in the past month as the state and its farmers struggle with a severe drought.

Oklahoma was drier in the four months following Thanksgiving than it has been in any similar period since 1921. That's saying a lot in the state known for the 1930s Dust Bowl, when drought and high winds generated severe dust storms that stripped the land of its topsoil.

Neighboring states are in similar shape as the drought stretches from the Louisiana Gulf coast to Colorado, and conditions are getting worse, according to the U.S. Drought Monitor. The area in Texas covered by an extreme drought has tripled in the past month to 40 percent, and in Oklahoma it nearly doubled in one week to 16 percent, according to the monitor's March 29 update.

An extreme drought is declared when there's major damage to crops or pasture and widespread water shortages or restrictions.

While dozens of people in Kansas, Oklahoma and Texas have lost homes to the hundreds of grassfires that have torn through the parched landscape in the past month, Oklahoma officials said more fires caused more damage as recently as 2009. This year, the biggest losses are likely to come from the drought's effect on the wheat farmers planted last fall and hoped to harvest in June, they said.

Almost all of Oklahoma is covered in some degree of drought. Only the far northeastern corner has escaped, thanks to a few big winter snowstorms.

AP Associated Press

Photo 1 of 2

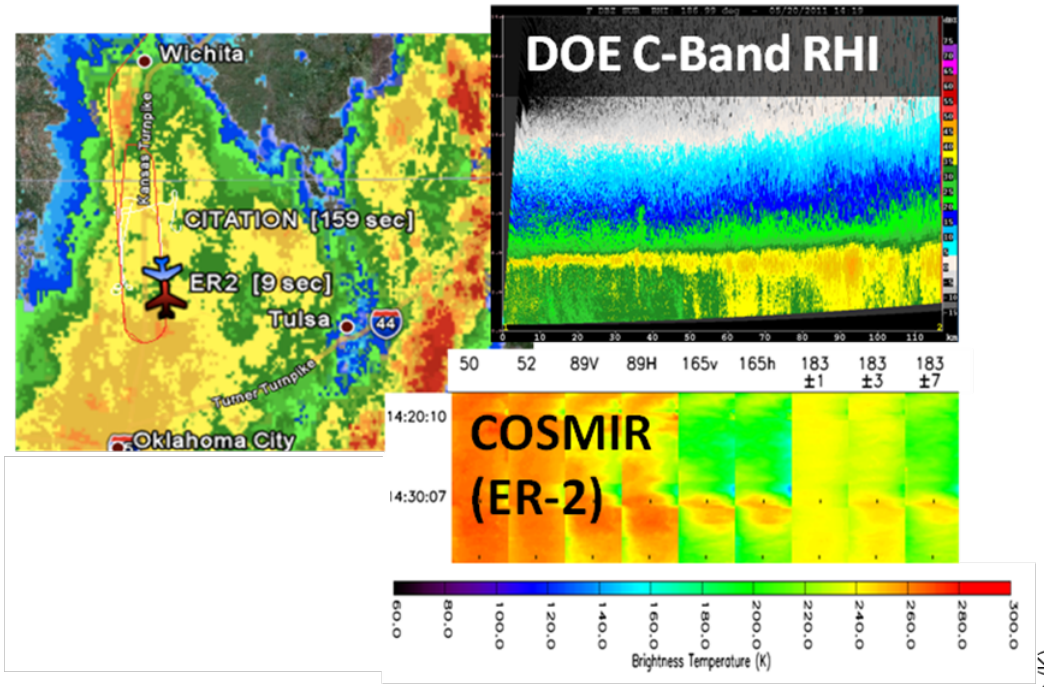
In this March 14, 2011 photo, farmer Jim Freudenberger surveys his wheat crop in Coyle, Okla. Freudenberger is among thousands of farmers in the South dealing with a severe drought that has choked back crops, forcing some to plow up what won't grow months before harvest. (AP Photo/Justin Juozapavicius)

MC3E : Case/Sampling "Round Up"

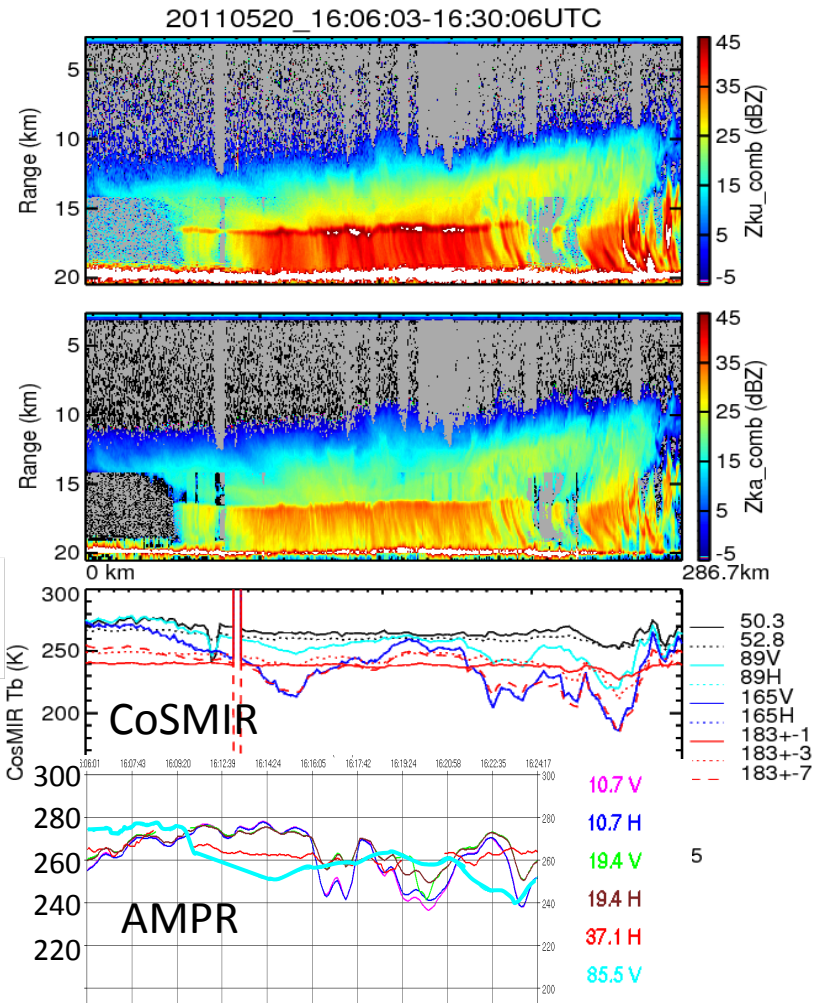
- **Flight hours ER-2:** ~70 Hours **Flight hours Citation**: ~45 Hours
- **Case summary dates for GPM**
  - **ER-2/Citation coordinated missions near SGP-CF**
    - **20 May** Severe convection, severe t-storm anvil, stratiform
    - 25 April Multi-cell MCS and stratiform
    - 23 May Severe convection, t-storm anvil
    - **11 May** Multi-cell MCS stratiform (mixed/convective stratiform)
  - **ER-2/Citation out of CF range (NE Kansas)**
    - 1 June eight-hour "marathon" of ER-2 sampling of severe storms (Citation spiral in anvil precip)
  - **ER-2-only mission with CSU-CHILL (NE Colorado upslope)**
    - **24 May** NE Colorado upslope stratiform, plains deep convection, severe t-storm anvil
  - **ER-2/Citation Coordinated but without CoSMIR**
    - 18 May; deep convection and precipitating anvil
  - **Citation only "microphysics" missions**
    - 1 May cold season profiling (sleet, frozen rain) over CF
    - 27 April (over CF and also AMPR data from ER-2)
    - 10 May light stratiform profiling spiral and 176 km long melting layer porpoising leg.
    - 24 May precipitating anvil spiral over CF
  - **Citation Cloud missions**
    - 02 June Persistent cirrus advecting over Central Facility
    - 27 May Shallow cumulus and stratocumulus
  - **Priority Surface ε missions, coordinated with Aqua, NOAA 18 and NOAA 19**
    - 29 May ER-2 and MAPIR L-band over Land-surface transect
    - 8 May ER-2 Land-surface transect
    - 25 April ER-2 Land-surface transect
- **Six weeks of ground Instrument cases**:
  - NASA NPOL, DOE C-band /X-bands, NASA D3R (after May 25),DOE Ka-W, NOAA S/UHF profiler, ADMIRARI (after May 18). GPM DROP network (disdrometers/gauges)
  - Network sector volume scanning, high temporal res. rain rate/DSD variability measurements

Example Operations and Observations
"Dream Scenario" Event: May 20

Early: Citation-ER-2 "Dream Scenario" stacks over/near SGP



A little later: ER-2- Only (HIWRAP, COSMIR, AMPR)

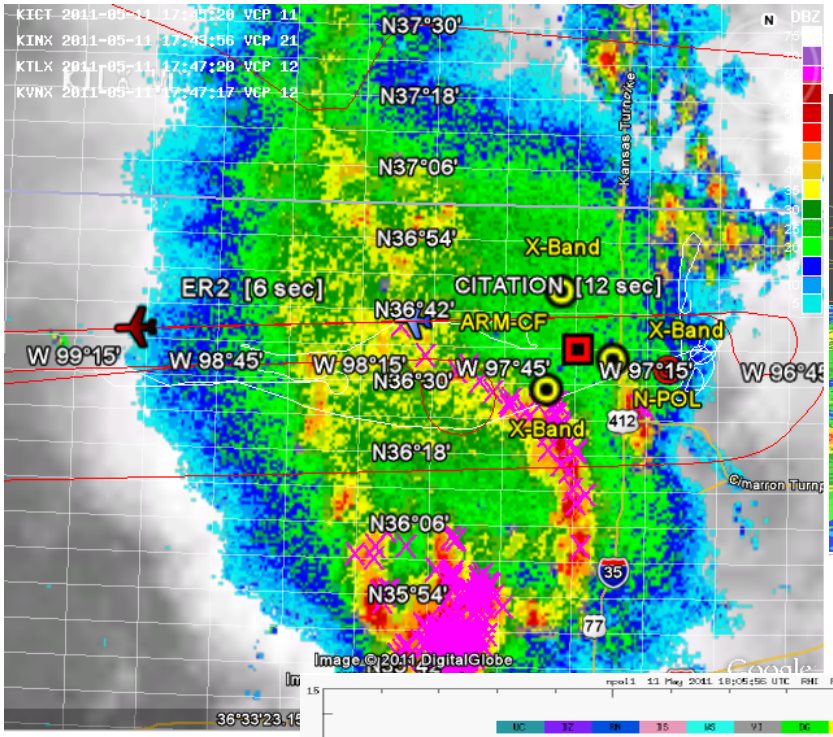


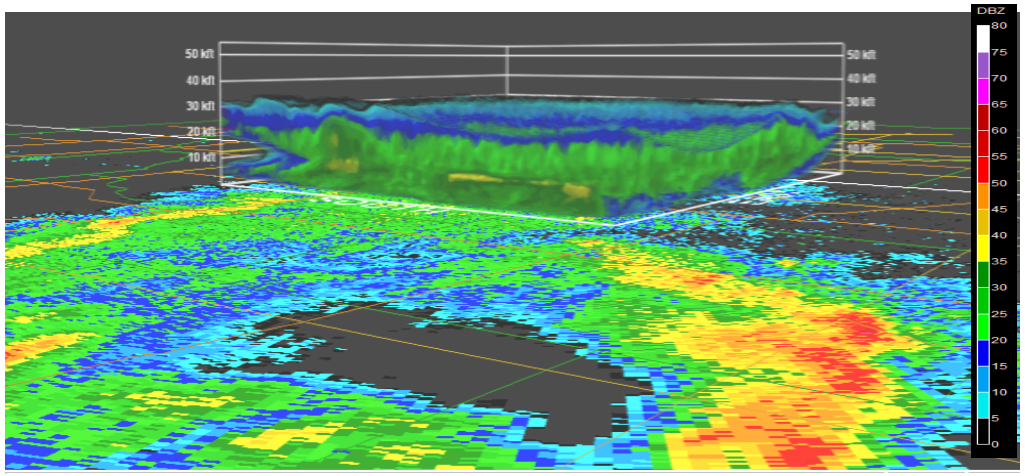
Variety:

- **Early sampling focused on stratiform**
- **Later sampling- ER-2 on deep convective line with trailing stratiform well east of Central Facility.**

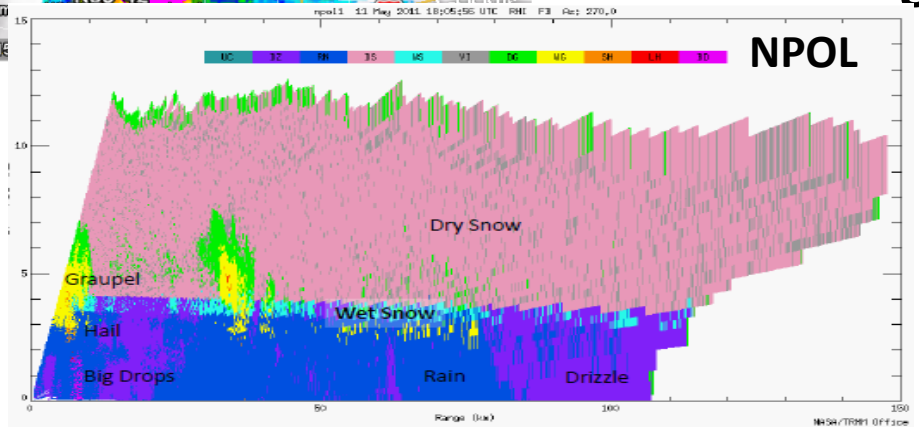
Example Operations and Observations: 11 May 2011

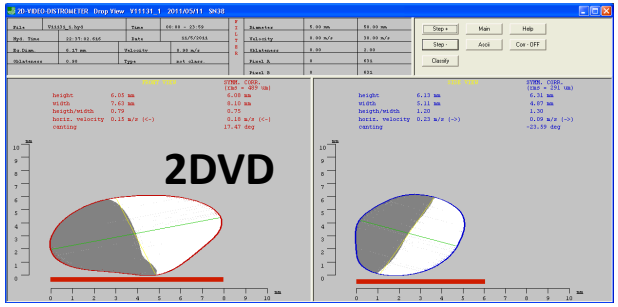
"Lumpy" mixed stratiform-convective sampling……





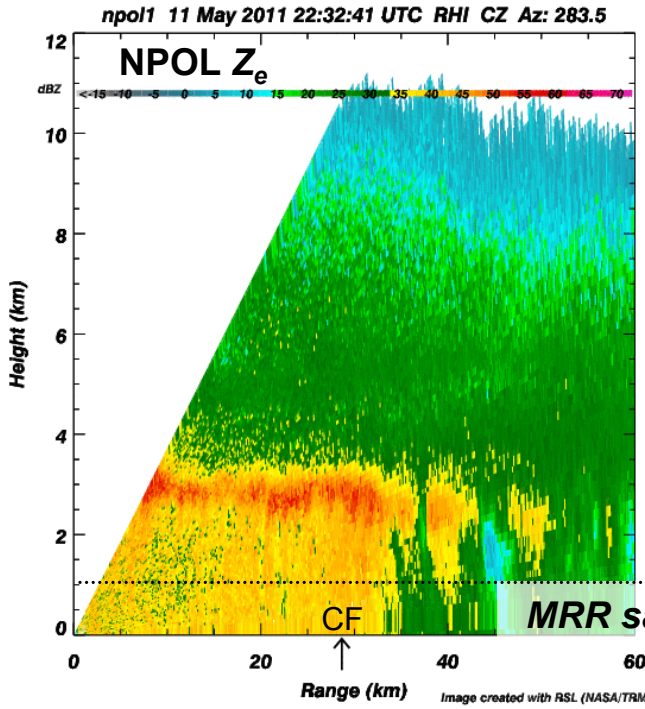
And large-drop microphysics

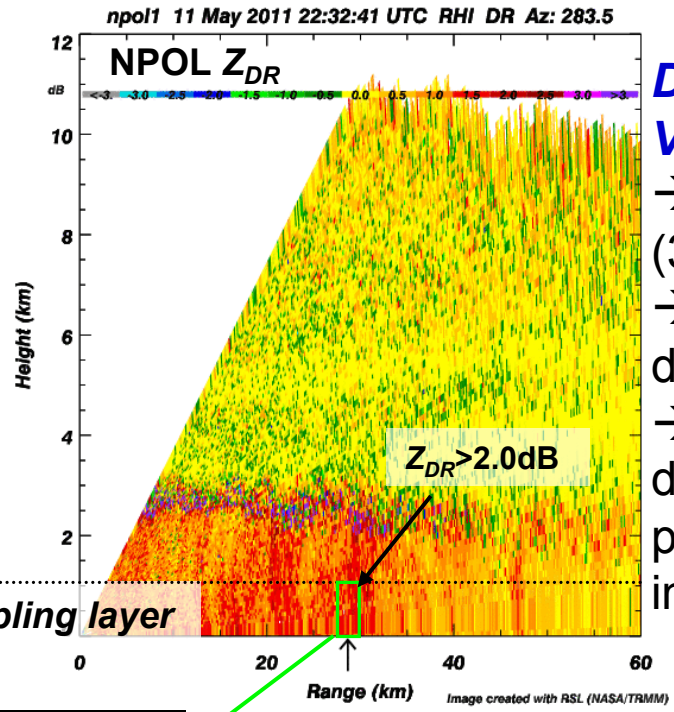




8mm 6 mm

Regime physics and D_{max}?



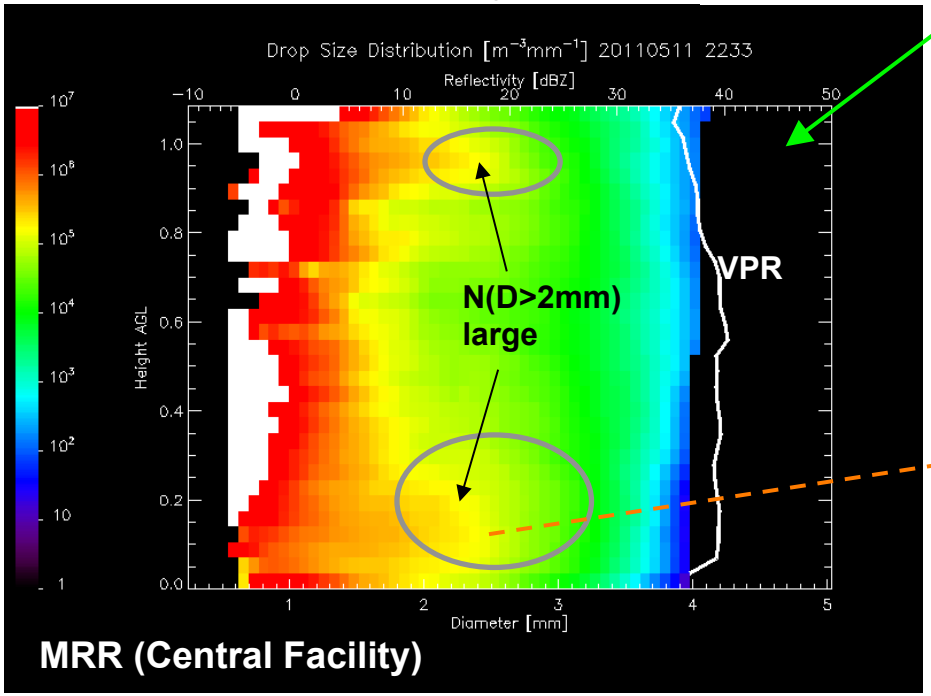


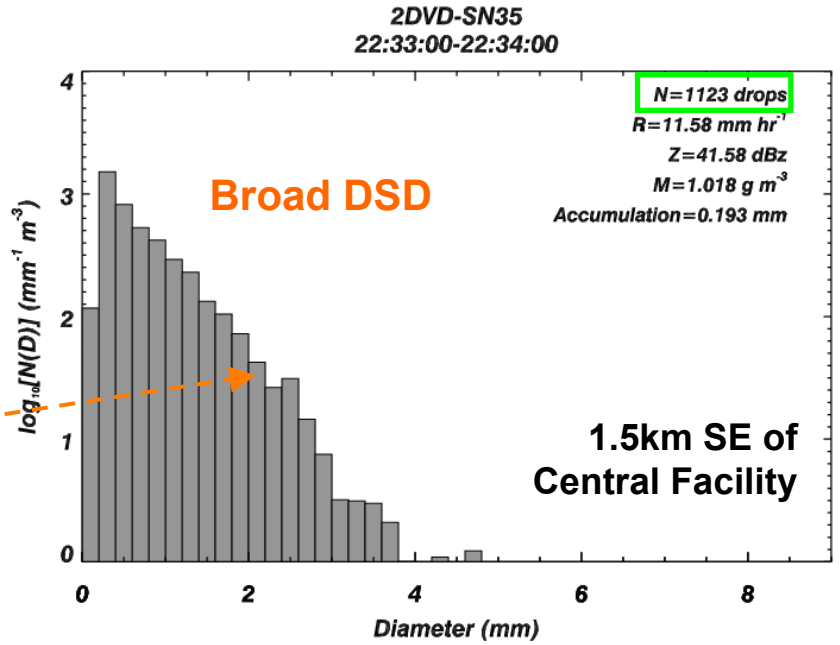
DSD Profile Variability

→Numerous mid-size (3-5 mm) drops

→Not uniformly distributed in vertical

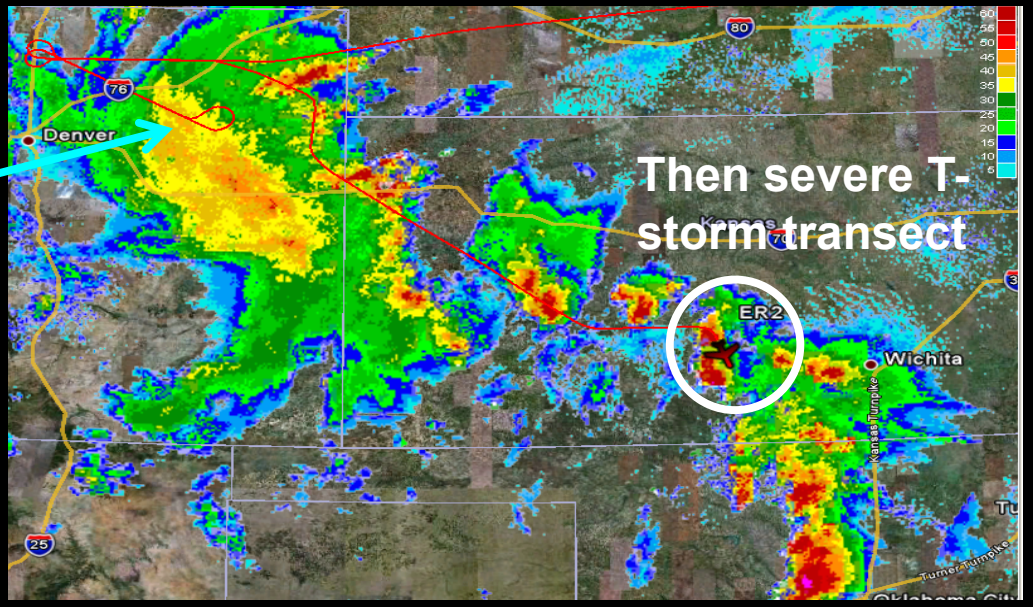
→ Cycles of descending N(D) peaks seen at ground in MRR and 2DVD





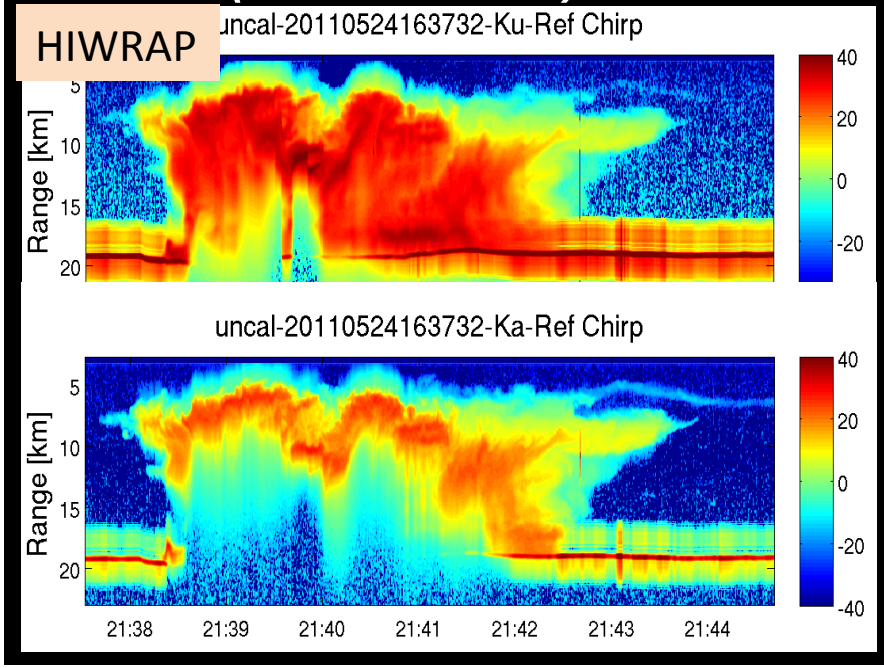
Variety: ER-2 over Distinct storm types(NECO and KS: 5/24)

First NE Colorado Upslope…….cf. Rutledge talk

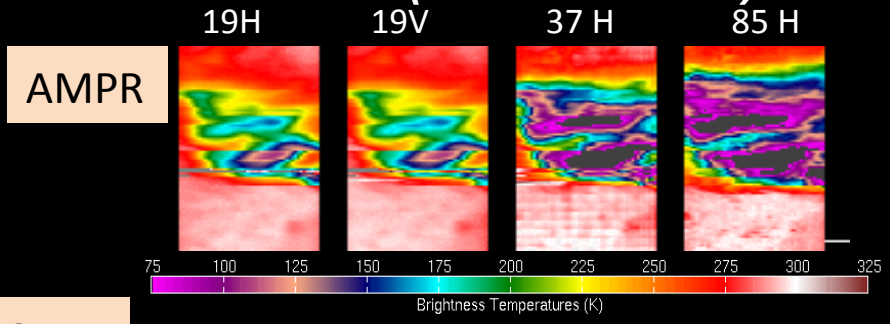


PIA (Ku-Ka Radar)……and .....Cold (Radiometers)

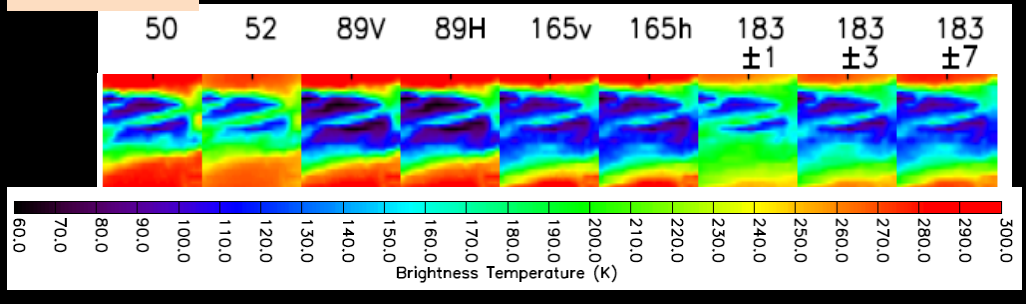
HIWRAP



AMPR



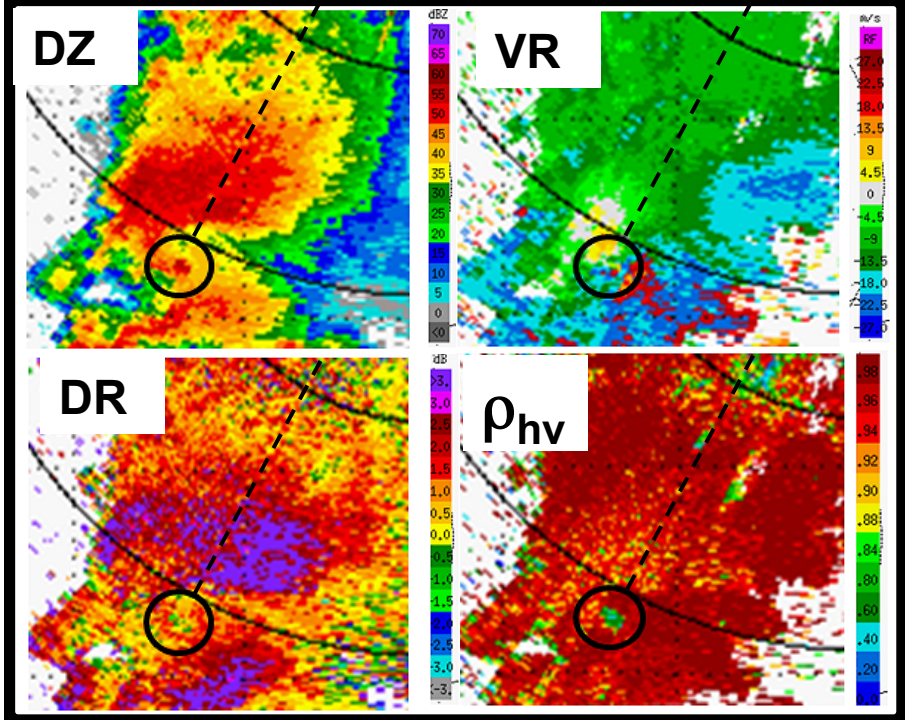
CoSMIR



NPOL sampling of Tornadic Storm: 24 May 2011

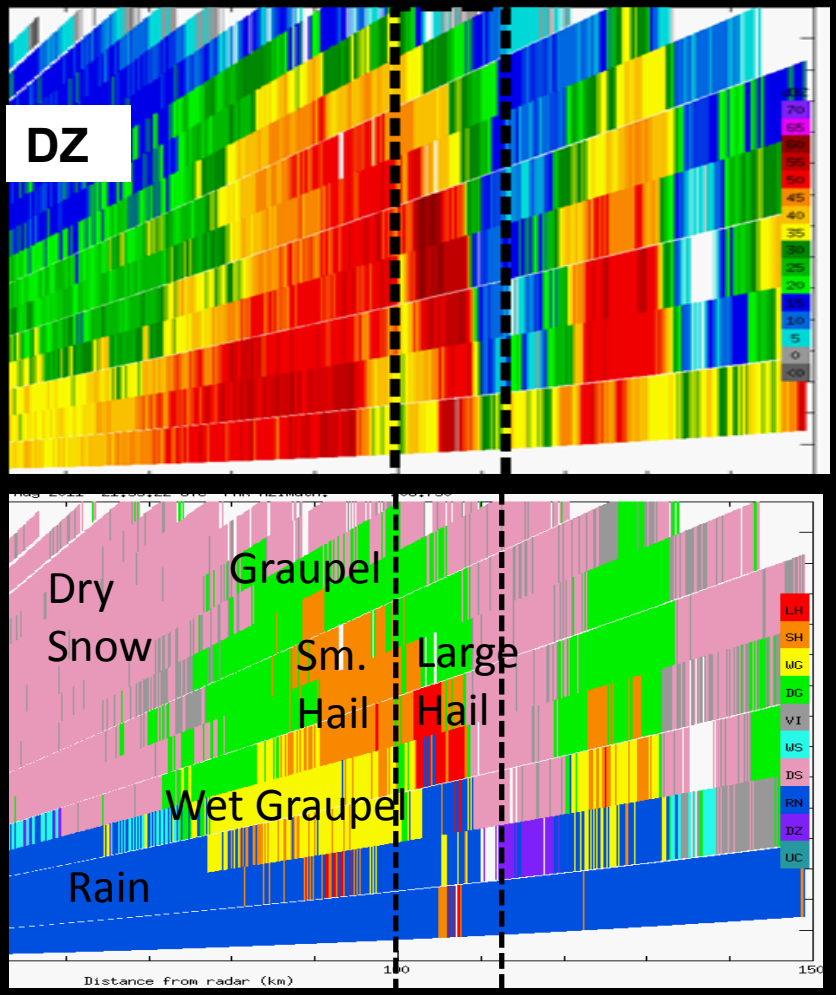
Tornadoes not the target but….

24 May 2011: MC3E Sampling deep (tornadic) storms with NPOL



Well defined debris signature
Can map mixed phase and liquid hydrometeors

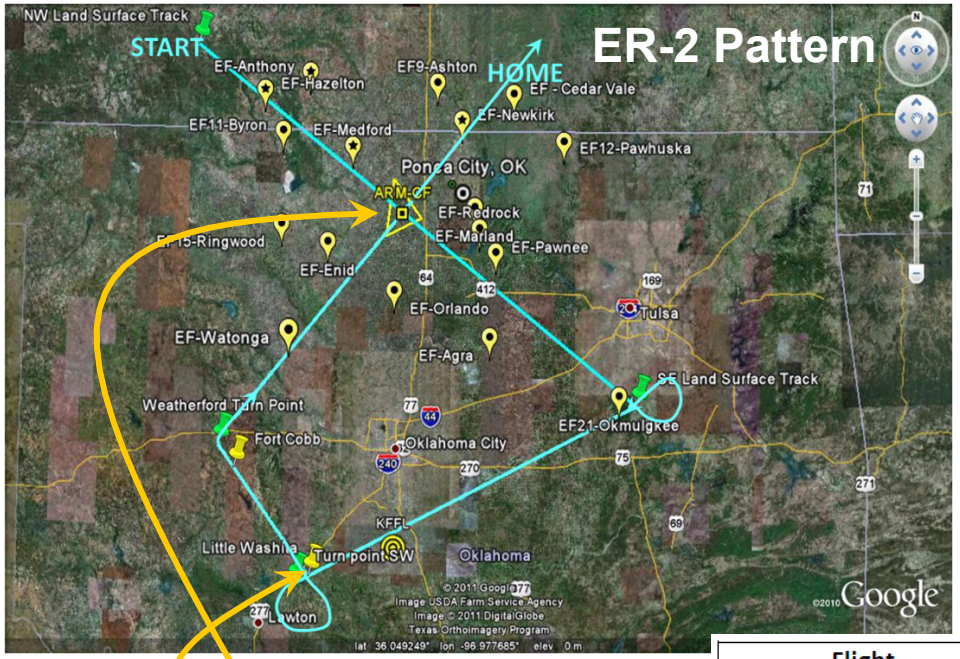
NPOL multi-parameter structure delineates microphysical characteristics



Hydrometeor classification separates ice and liquid particle types

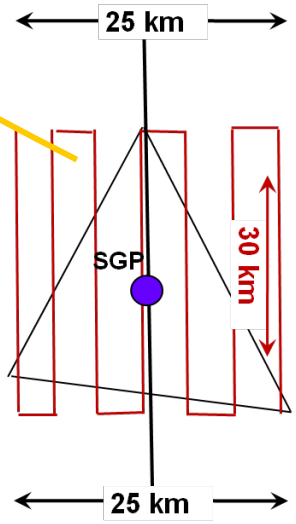
walt.petersen@nasa.gov

Several Dedicated Land Surface Modeling/Emission Flights



- Clear skies with NOAA 18 and Aqua afternoon overpass
- ER-2 intercepting soil moisture gradient, ARS/DOE soil moisture sites
- MAPIR L-Band over CF and Little Washita (1 km soil moisture)
- One coordinated ER-2 and MAPIR L-band mission (29 May)

MAPIR Pattern

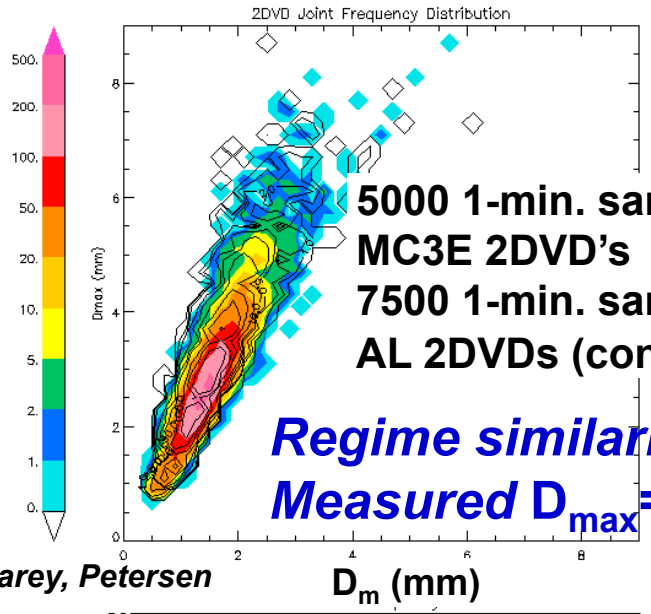


Flight	Date	Flight #	Time of Day	Duration (hr)	Remaining Hours
Total Allocated					30.0*
FCF	18 May	0		1.3	------
Transit to KPNC	19 May			4.7	------
Data Primary Site#	21 May	1	AM	3.2	26.8
Data Primary Site	23 May	2	AM	3.3	23.5
Data Primary Site	26 May	3	AM	3.5	20.0
Data Primary Site	28 May	4	AM	3.1	16.9
Data Primary Site	29 May	5a	PM	3.5	13.4
Data Secondary Site@	29 May	5b	PM	3.4	10.0
Data Primary Site	31 May	6	AM	2.9	7.1
Data Primary Site	1 June	7	PM	2.1	5.0
Data Primary Site	2 June	8	AM	3.7	1.3
Transit to KTHA	2 June				------

**Total hours allocated*
#Primary site is SGP area around the ARM Central Facility
@Secondary site is the Little Washita watershed

Disdrometer Networks: DSD Behavior and Parameter Correlations

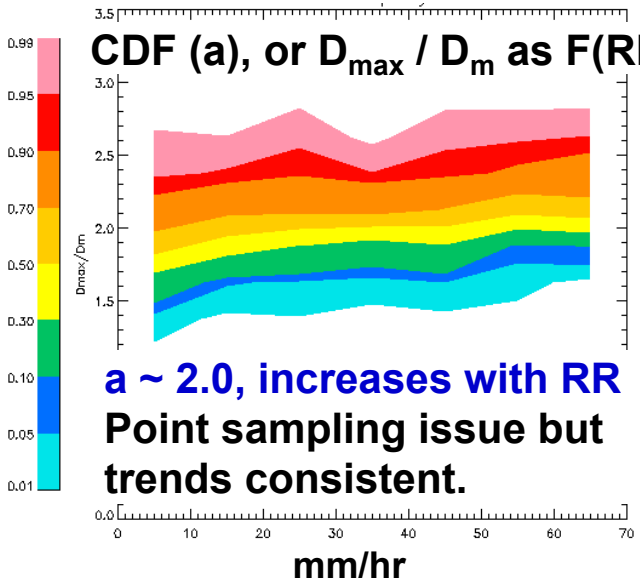
Integral Constraints: D_{max} vs D_m



5000 1-min. samples, 5 MC3E 2DVD's
7500 1-min. samples N. AL 2DVDs (contour)

Regime similarity in Measured D_{max}=a*D_m

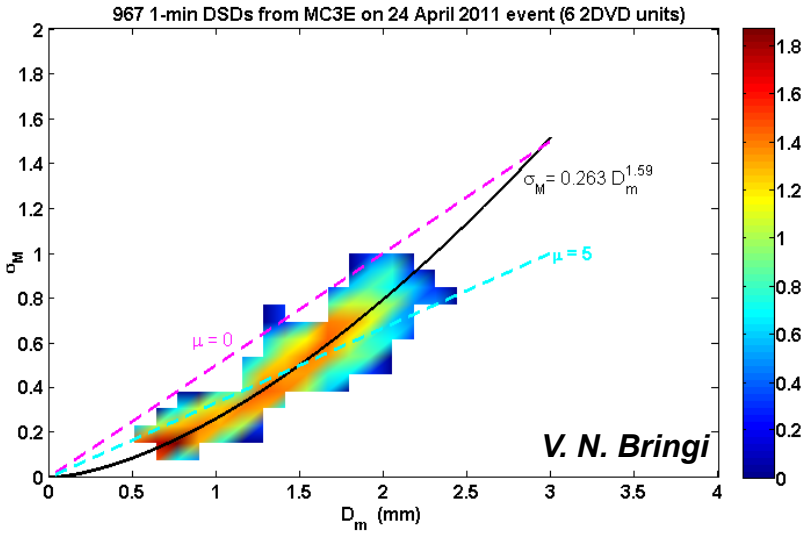
Carey, Petersen



a ~ 2.0, increases with RR
Point sampling issue but trends consistent.

Looking for μ constrained by D_m, σ_m…….

4/24/2011



Similarity found for σ_m vs. D_m in GV datasets in Huntsville, Darwin, Finland, MC3E……

$$\sigma_m \sim 0.3 * D_m^{1.5}$$

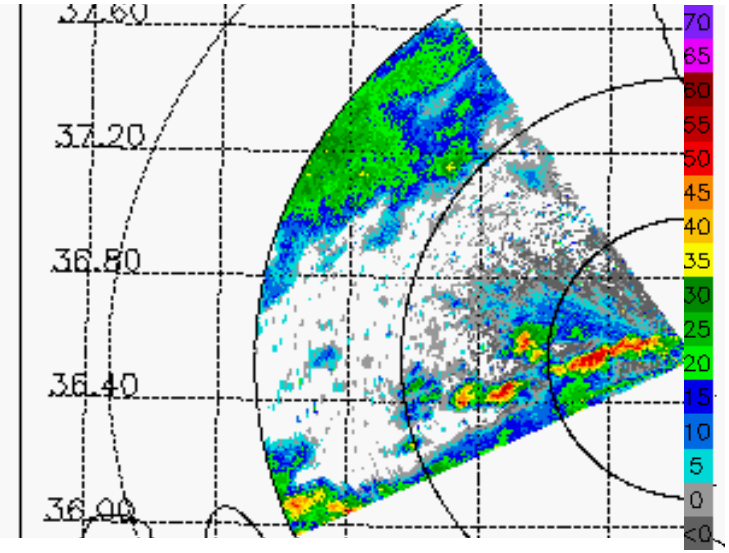
and $$(\sigma_m/D_m)^2 = 1/(4+\mu)$$

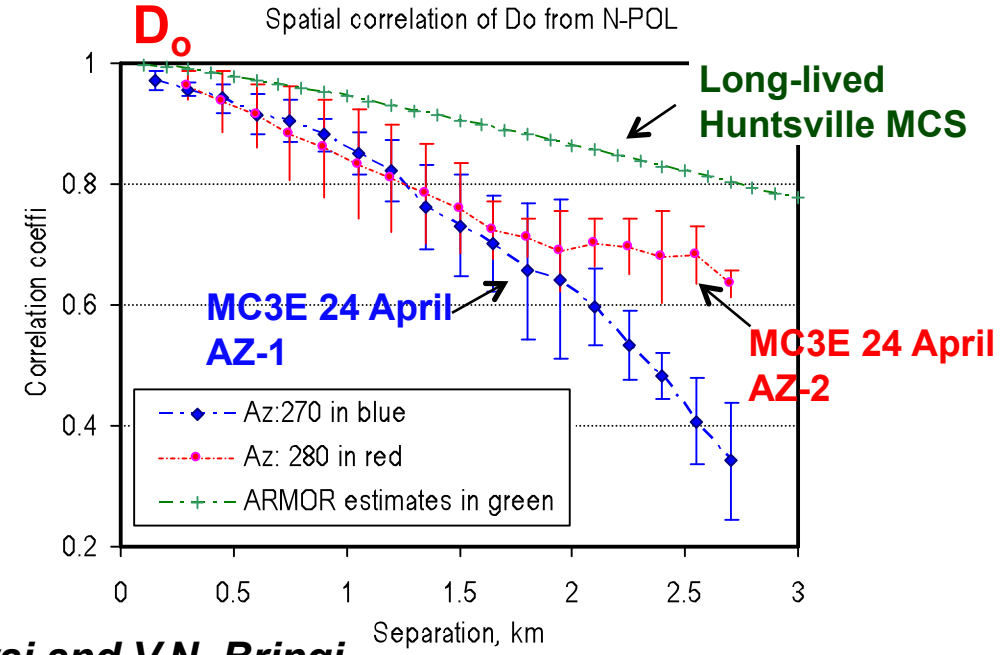
μ, σ_m and D_m are related for a gamma distribution. Use ($\sigma_m D_m^b$) in retrievals, or more simply, solve to give μ as f(D_m)?

Cf. C. Williams and DSD WG for more info

MC3E: NPOL+ 2DVD: Radar-Diagnosed DSD Spatial Correlation

High temporal res. (45 second cycle) PPI sector and RHI enables use of radar to examine 3-D correlative properties of the DSD





Courtesy M. Thurai and V.N. Bringi

- **Directional and rainfall system dependence of decorrelation**

Next *vertical profile* of DSD and *correlations*- compare to profiler, aircraft

MC3E Science Targets and Algorithm "Traceability"

Algorithm component, assumptions, or issue addressed	Applicable Measured and/or Diagnosed Parameters																
	Z	Z_{DFR}	R	PSD_{sfc}	PSD_{col}	PID	ρ_b	ρ_p	T	Q_v	Q_{soil}	CN_{CCN}	TW_c	CW	IW	ε/α_{sfc}	T_B
Path integrated attenuation approach(es)	◆	◆	◆	◆	◆	◆				◆			◆	◆		◆	
Rain/no rain discrimination	◆	◆	◆	◆	◆	◆			◆	◆			◆	◆	◆	◆	◆
Hydrometeor Identification (3D)	◆	◆	◆	◆	◆	◆	◆		◆				◆	◆	◆		
Melting layer identification/Models	◆	◆			◆	◆	◆	◆	◆				◆		◆	◆	
Convective/Stratiform partitioning	◆	◆	◆	◆	◆	◆											◆
DSD/rain profile, horizontal variability (correlation, beam filling, ε-adjustment)	◆	◆	◆	◆	◆	◆											◆
DSD Gamma parameter correlations	◆	◆	◆	◆	◆	◆											
Cloud water profiles	◆	◆	◆						◆	◆		◆	◆	◆	◆		◆
Column/land surface properties (ε_{sfc})	◆	◆	◆						◆	◆	◆					◆	◆
Ice water profiles of content, PSD, density, habit	◆	◆			◆	◆	◆	◆	◆	◆			◆		◆		◆
Ice particle vs. volume extinction	◆	◆			◆	◆	◆	◆	◆	◆					◆		◆
Ice process/profile coupled to scattering and rain profile	◆	◆	◆	◆	◆	◆	◆	◆					◆	◆	◆		◆
Regime controls on precipitation	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
CRM/LSM SSM Physics	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

- The experiment was challenging…….But, the collected data will make a contribution to algorithm physical validation over land.
- Further data QC, careful analysis/use/application will refine this assessment.
- Targeted December 2011 Version 1 QC Dataset releases (GHRC DAAC)

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Summary

- **NMQ/VN Direct Validation *Taking Shape***
  - **Data, processing infrastructure, PR and multi-satellite analysis**
  - **Radiometer algorithm database**
- **LPVEX: Fall 2010, Helsinki Finland, light rain in low melting layer environment**
  - **Data release December 2011**
  - **Team approach to building "column" data base archetypes.**
- **WFF GV Home-base" network measurements**
  - **WFF Polarimetric Radar, gauge, disdrometer facility (mid-lat coastal) for rain rate and DSD error characterization**
- **GCPEX: Jan-Feb. 2012. EC CARE, Egbert, Ontario, *Snowfall Algorithms*;**
  - **instrument deployments, final ops/site logistics underway**
- **MC3E: April-June, 2011 N. Oklahoma. Improving estimation over land.**
  - **Variety of Mid-lat. continental precipitation events sampled**
  - **Several priority events identified**
  - **Will support algorithm physical val**
  - **December version1 QC data on GHRC DAAC**