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What is a Virtual Field Campaign?

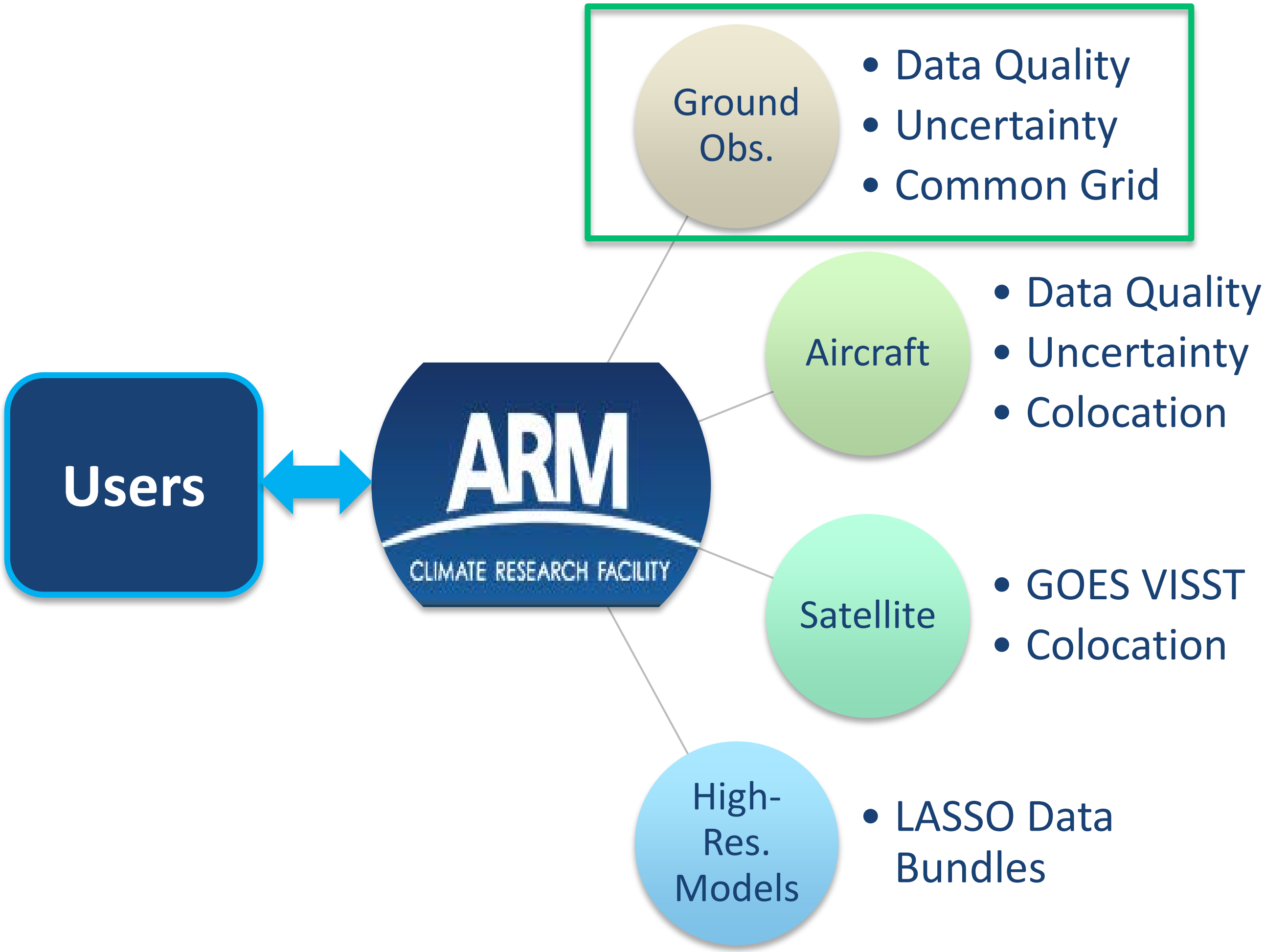
JENNIFER COMSTOCK

Pacific Northwest National Laboratory

Virtual Field Campaigns
A Few Definitions

- Virtual Global Field Campaign (Moncrieff et al. 2012) – focused around a specific set of science objectives, i.e. YOTC
  1. Global analysis, forecasts, and sub-grid tendencies
  2. Comprehensive measurements (satellite, field campaign, ground, in situ)
  3. Research programs focused on numerical modeling and analysis
- Making field campaign datasets more accessible
- 'Golden' datasets: a collection of high quality datasets
  - Quality controlled and flagged
  - Uncertainty estimates
  - Focused around time periods of interest to a set of science themes

Data Collections Concept Diagram



Building a Collection of High Quality Datasets

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- Identify time periods of interest and associated science themes
- Identify instruments/datastreams
  - Profiling instruments (radar/lidar)
  - Radiometers (MWR, broadband and/or spectral)
  - In situ (AOS)
  - Meteorology
  - Derived datasets (Model forcing datasets, cloud properties, aerosol properties)
- Define data products and quality requirements
- Package the data (i.e. LASSO data bundles)
- Disseminate the data (i.e. ways to browse, download, etc.)

Session Goals

1. Identify time periods and science themes
2. Key measurements and datastreams
3. Minimum quality control requirements
4. Discuss strategies for packaging and disseminating data

Agenda

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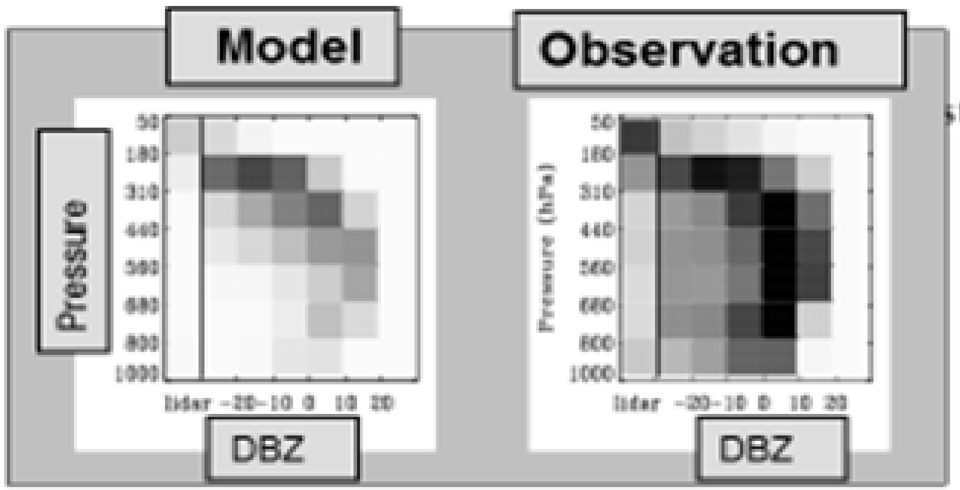
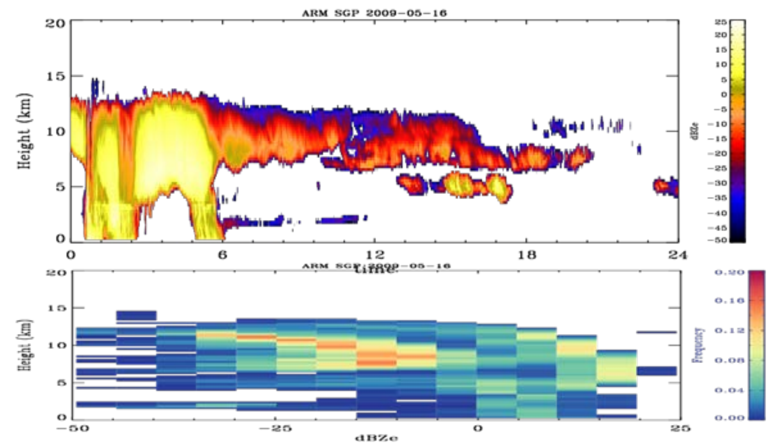
- Introduction - What is a virtual field campaign? (Jennifer Comstock) 10:45
- Identifying scientifically relevant time periods (Discussion lead: Eugene Clothiaux) 10:55 – 11:45
  - ARM Radar Simulator for GCMs (Shaocheng Xie & Yuying Zhang)
  - ENA Science Team (Rob Wood)
  - Oliktok Science Team (Sergey Matrosov)
  - Oliktok Science (Mariko Oue)
  - Barrow Science (Katia Lamer)
- Radar Characterization and Data Products (Discussion Lead: Scott Giangrande) 11:45 - 12:45
  - Historical datasets and past experiences with MMCR - (Karen Johnson)
  - Looking forward - current activities to characterize and QC radar data - (Nitin Bharadwaj)
  - Packaging and distributing data (Giri Prakash)
  - Discussion

Simulator Converts Model Variables to Pseudo-Instrument Observations

Shaocheng Xie
Yuying Zhang



Case: May 16th, 2009



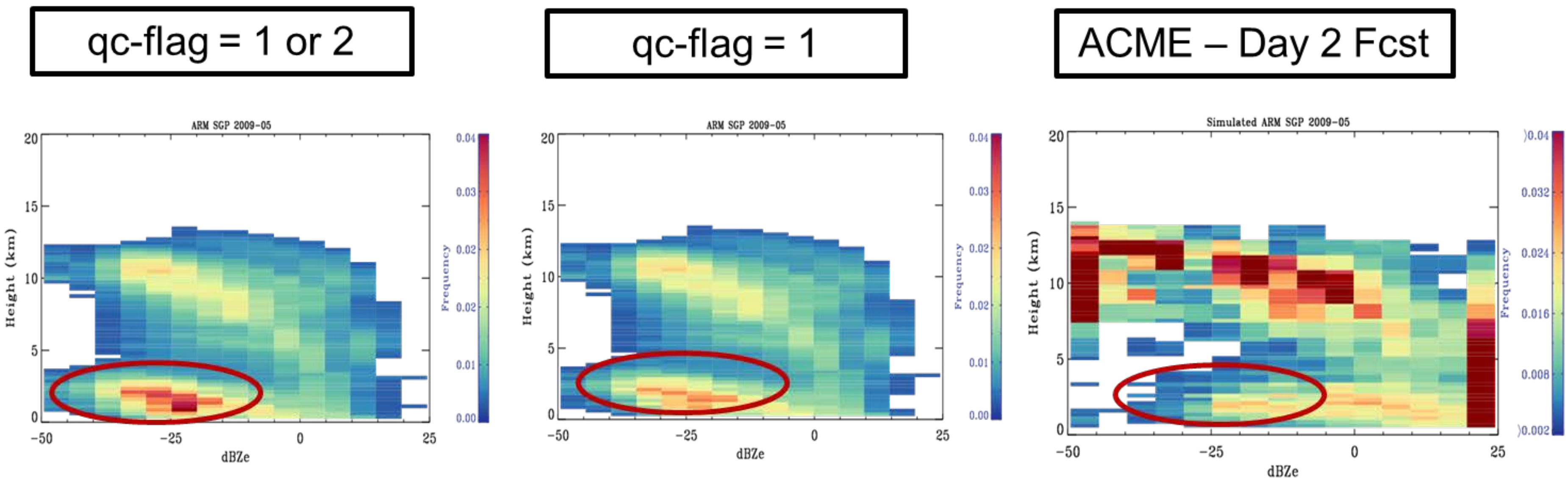
Data source: ARSCL

ARM Radar Reflectivity-Height Histogram (CFAD) Data Availability

ARM Site	Lamont, OK Southern Great Plains (SGP)	Barrow, North Slope of Alaska (NSA)	Manus Island, Tropical Western Pacific (TWPC1)	Nauru Island, Tropical Western Pacific (TWPC2)	Darwin, Australia, Tropical Western Pacific (TWPC3)
Available Period	2006~2010 2011~2013	2012~2013	2006~2010 2011~2013	2006~2008	2006~2008 2011~2013

Clutter has impact on low-level clouds

Shaocheng Xie
Yuying Zhang



MMCR reflectivity may be contaminated by clutter

MMCR reflectivity with clutter removed, but also lose some cloud information

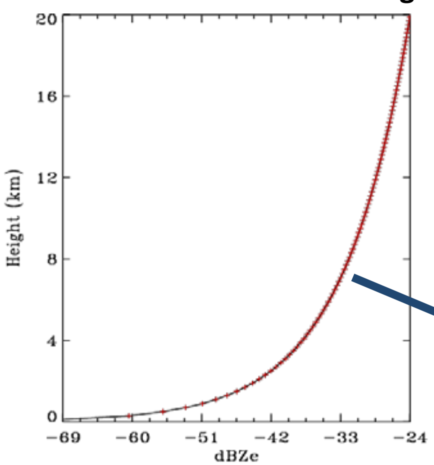
Impacts are seen below 5km

Model underestimates non-precipitating low clouds

Impact of Minimum Detectable Signal Threshold and Maximum Instrument Recording Signal

Summer Diurnal non-precipitating clouds at SGP (2009)

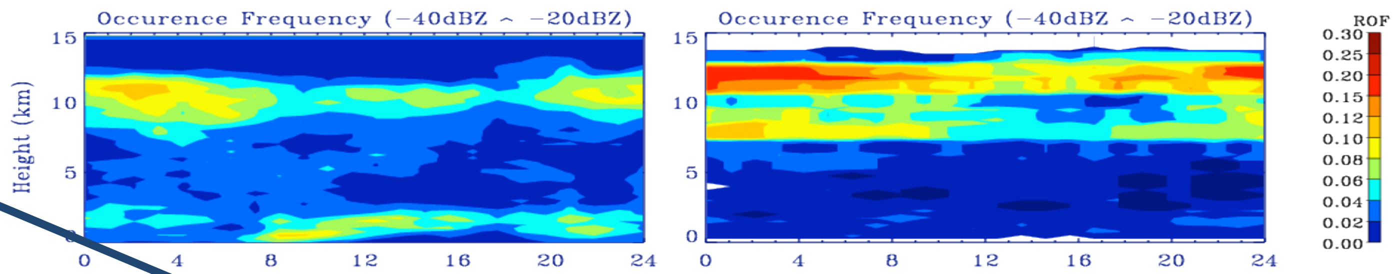
Minimum Detectable Signal



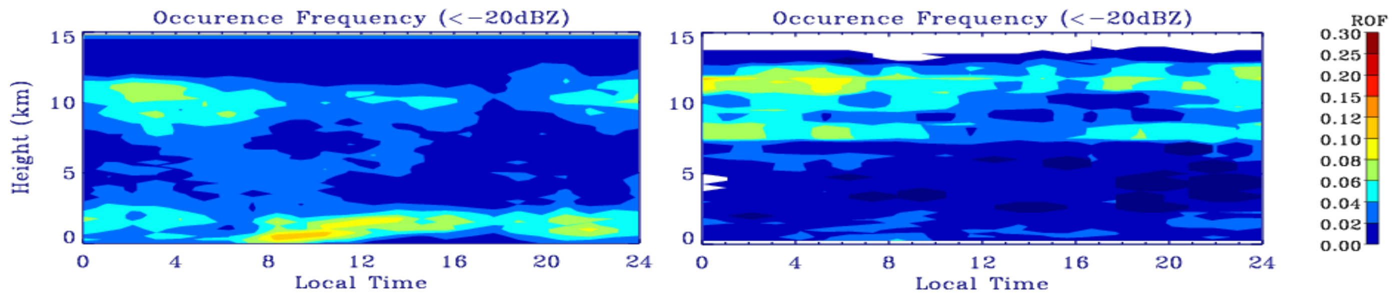
The MDS threshold and MIR signal were provided by Pavlos Kollias

Observation | **ACME**

Minimum detectable threshold set by -40 dBZ, constant with height



New minimum detectable profile suggested by Pavlos



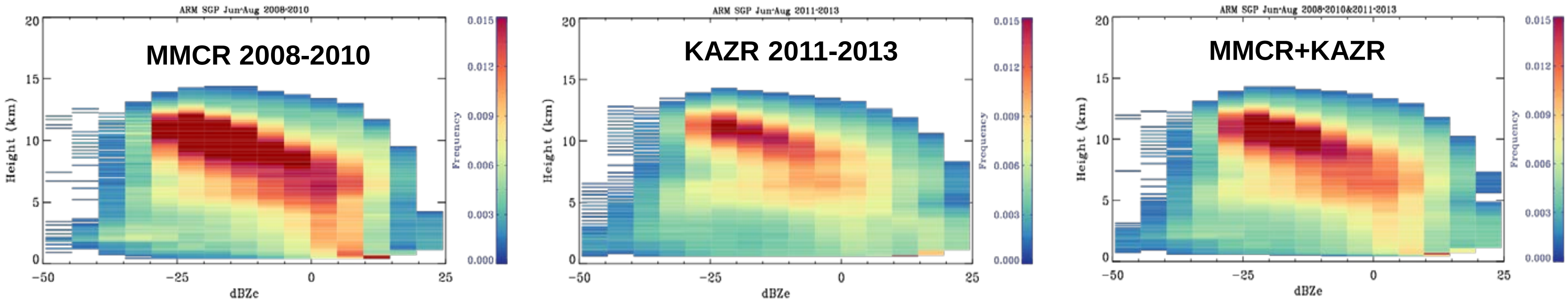
- The overestimation of high non-precipitating clouds in ACME is largely due to the limitation of Radar to detect weak signals

We also tested the saturation value of radar reflectivity as a function of height. The impact is insignificant.

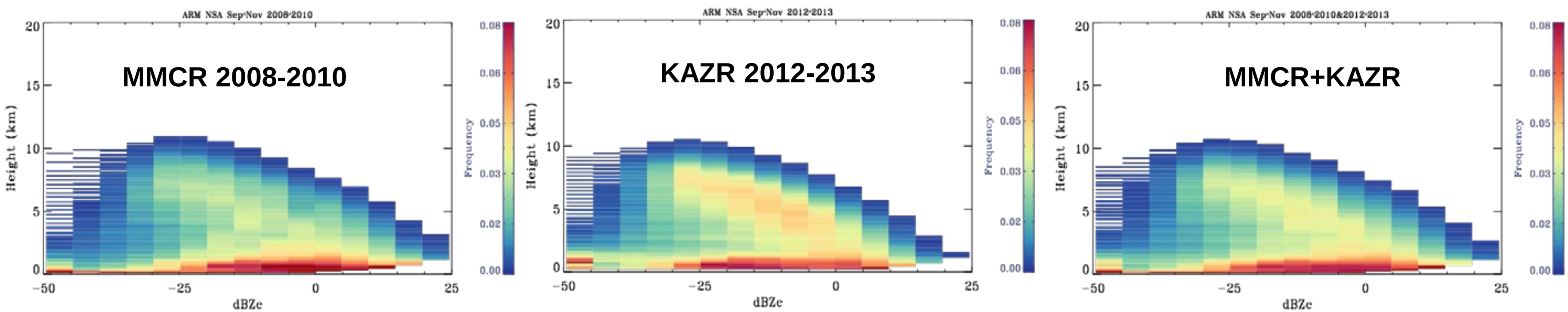
Any systematic changes between MMCR and KAZR?

Shaocheng Xie
Yuying Zhang

Summer SGP Climatology



Fall NSA Climatology



- MMCR show much higher frequency of occurrence in middle and upper levels at SGP and near surface at Barrow

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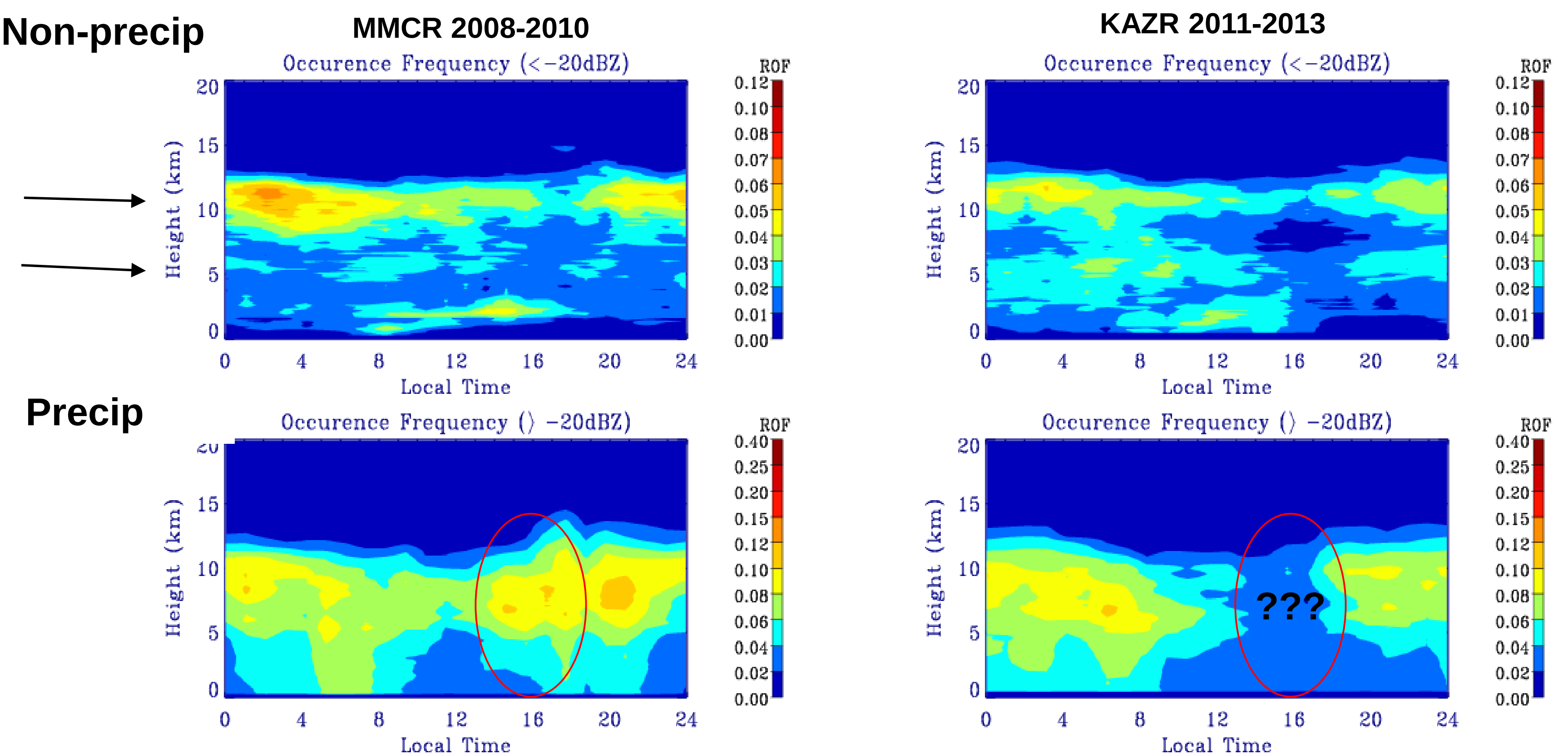
Any systematic changes between MMCR and KAZR?

Shaocheng Xie
Yuying Zhang

Summertime Diurnal Cycle of Cloud at SGP



- KAZR shows few high clouds and more mid-level clouds
- Missing convective clouds associated with afternoon precipitation in KAZR --- is this true???

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Research Activities with ARM Data

Shaocheng Xie
Yuying Zhang

SGP

- Summertime diurnal cycle of clouds at SGP
- CAUSES – *Cloud Above the United States and Errors at the Surface :* 4/1/2011-8/31/2011 (MC3E and beyond)
- Shallow Convection – 2015-2016, LASSO, CMDV
- Deep Convection – MC3E (2011) CMDV

NSA

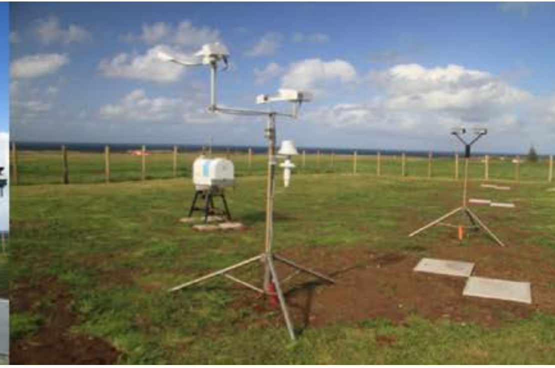
- ACME-Arctic – a new focus across DOE model programs (ACME and RGCM) and other modeling centers
  - Arctic clouds including mixed-phase clouds

TWP

- YOTC (Year of Tropical Convection) – 2008-2010

ENA

- Some golden cases selected for studying stratocumulus and cumulus clouds - 22 Nov 2009 and 30 Aug 2010 (Rob Wood)
- Stratocumulus and cumulus clouds by ACME and CMDV projects

Science themes, requirements and time periods for ENA

Robert Wood and Sam Pennypacker (U. Washington)

and the ENA Site Science Team

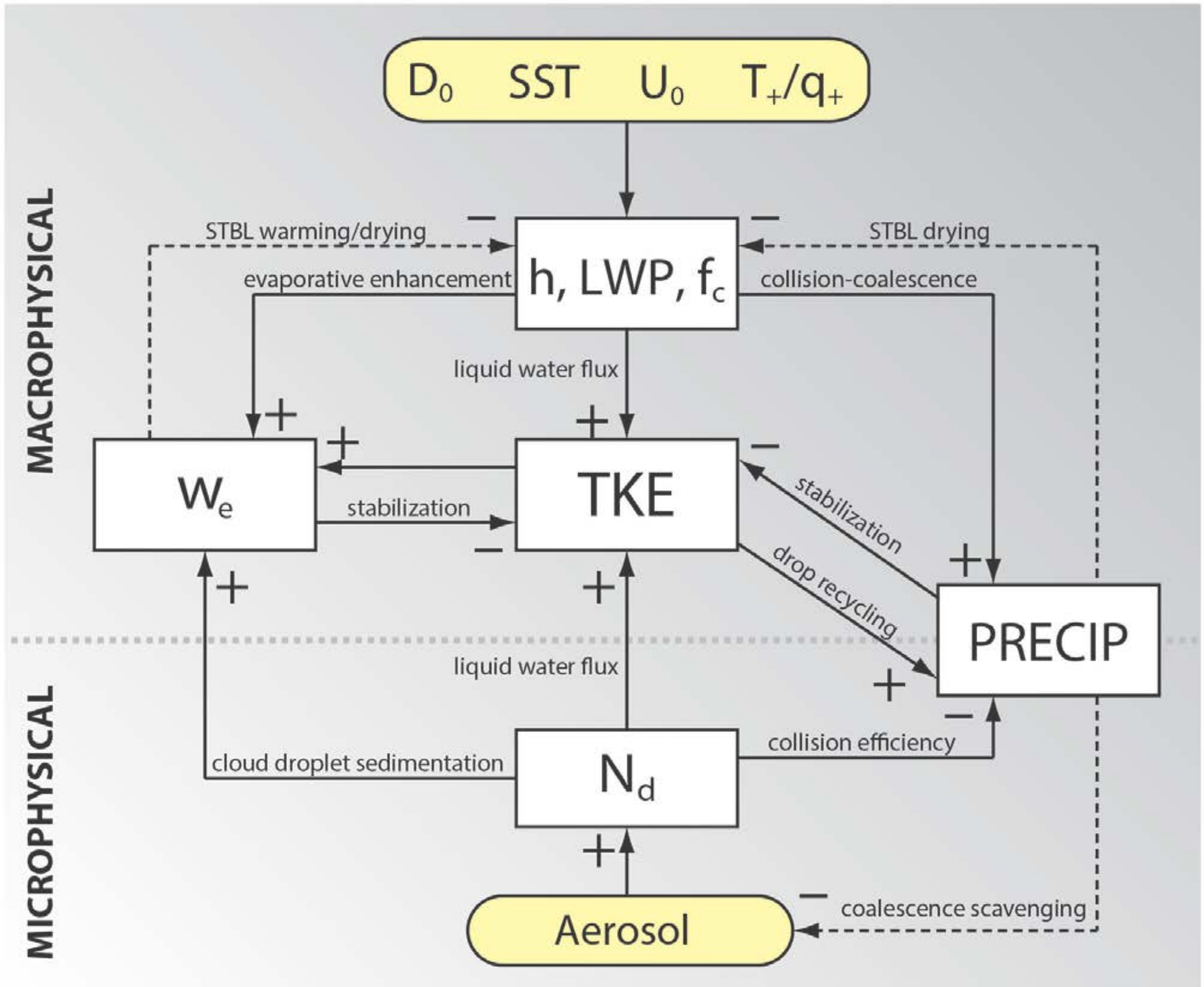



ENA Site Science:

Microphysical-macrophysical interactions in low cloud systems over the Eastern North Atlantic

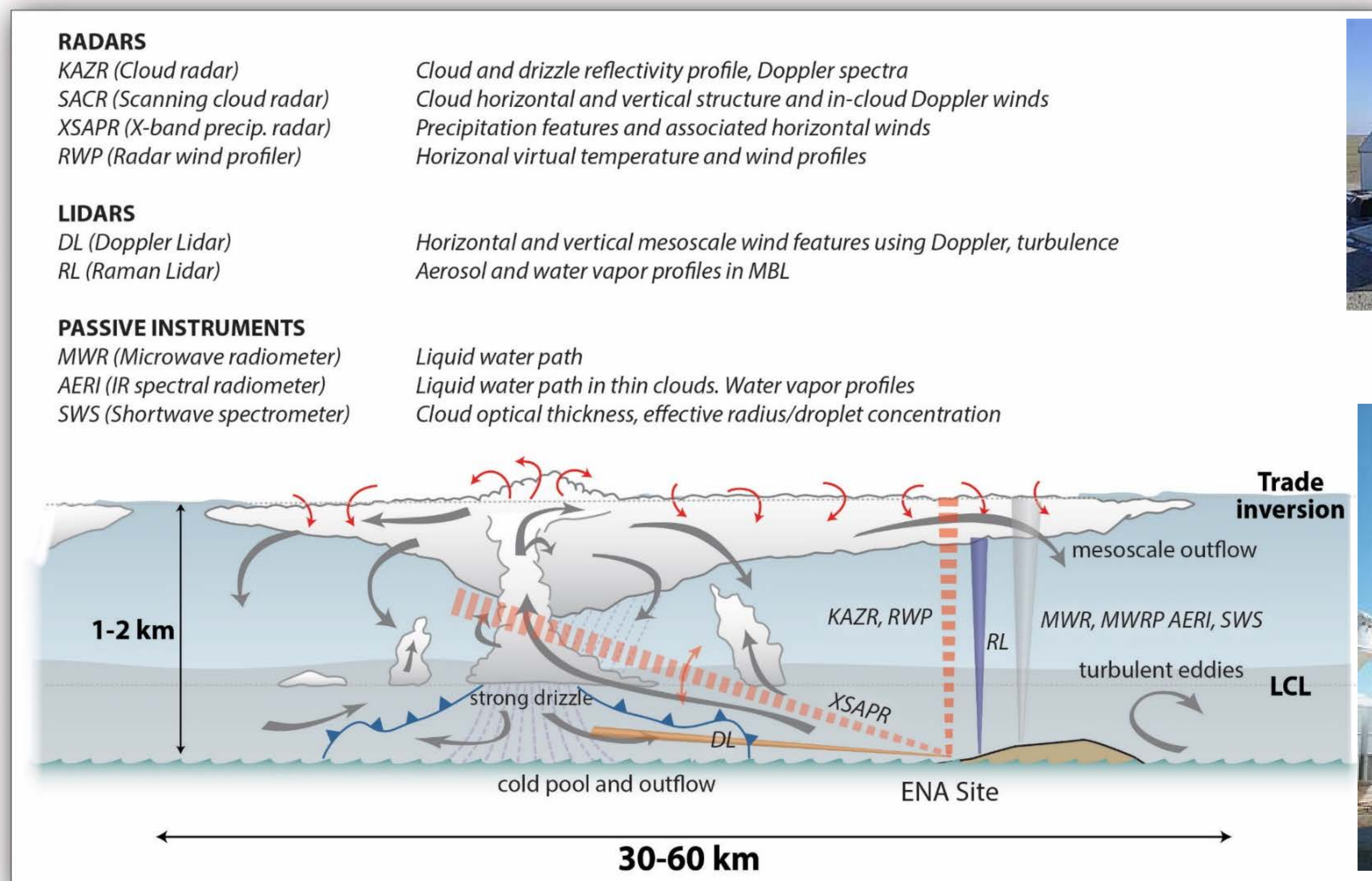
- Theme 1. Acquiring process-based understanding of cloud microphysical-macrophysical interactions across scales
- Theme 2. Understanding how microphysical-macrophysical interactions depend upon and influence the aerosol and meteorological environment
- Theme 3. Assessing and improving process and climate model representations of clouds, aerosols and their interactions.

Microphysical-macrophysical interactions: central to low cloud behavior



Adapted from Wood: *Stratocumulus Clouds*, MWR (2012)

Surface-based approaches for probing marine low clouds (esp. mesoscale organization)



Raman lidar

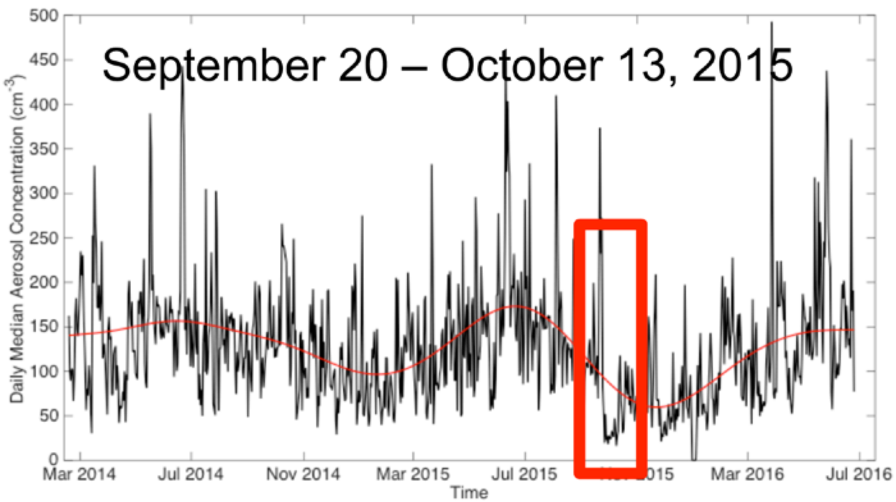
KaW SACR

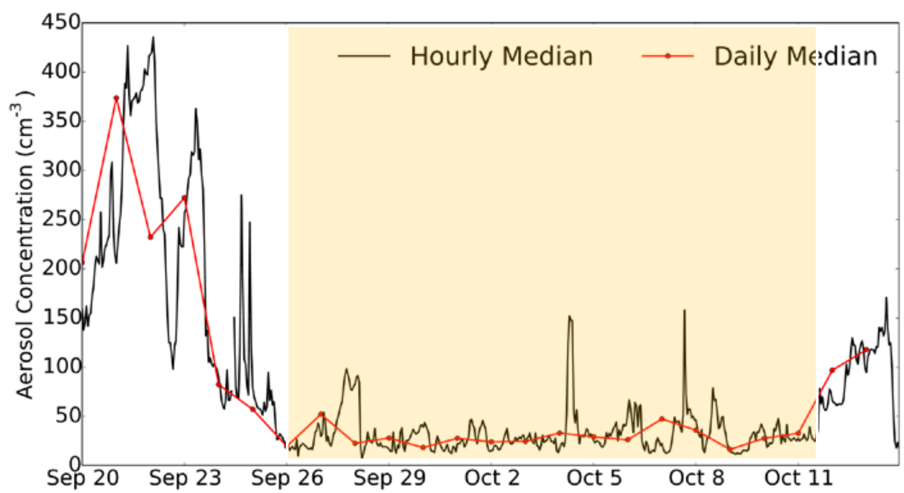
Periods of particular interest

- Warm season periods
  - Highest frequency of single layer low clouds
  - Focus on 2016 because of greatest availability of ENA datasets
- Low CCN/cold air outbreak cases
  - Currently analyzing 20th Sep-12th Oct 2015
  - Very low aerosol loadings

Low Aerosol Case Study

New: Ultra-High Sensitivity Aerosol Spectrometer (UHSAS)



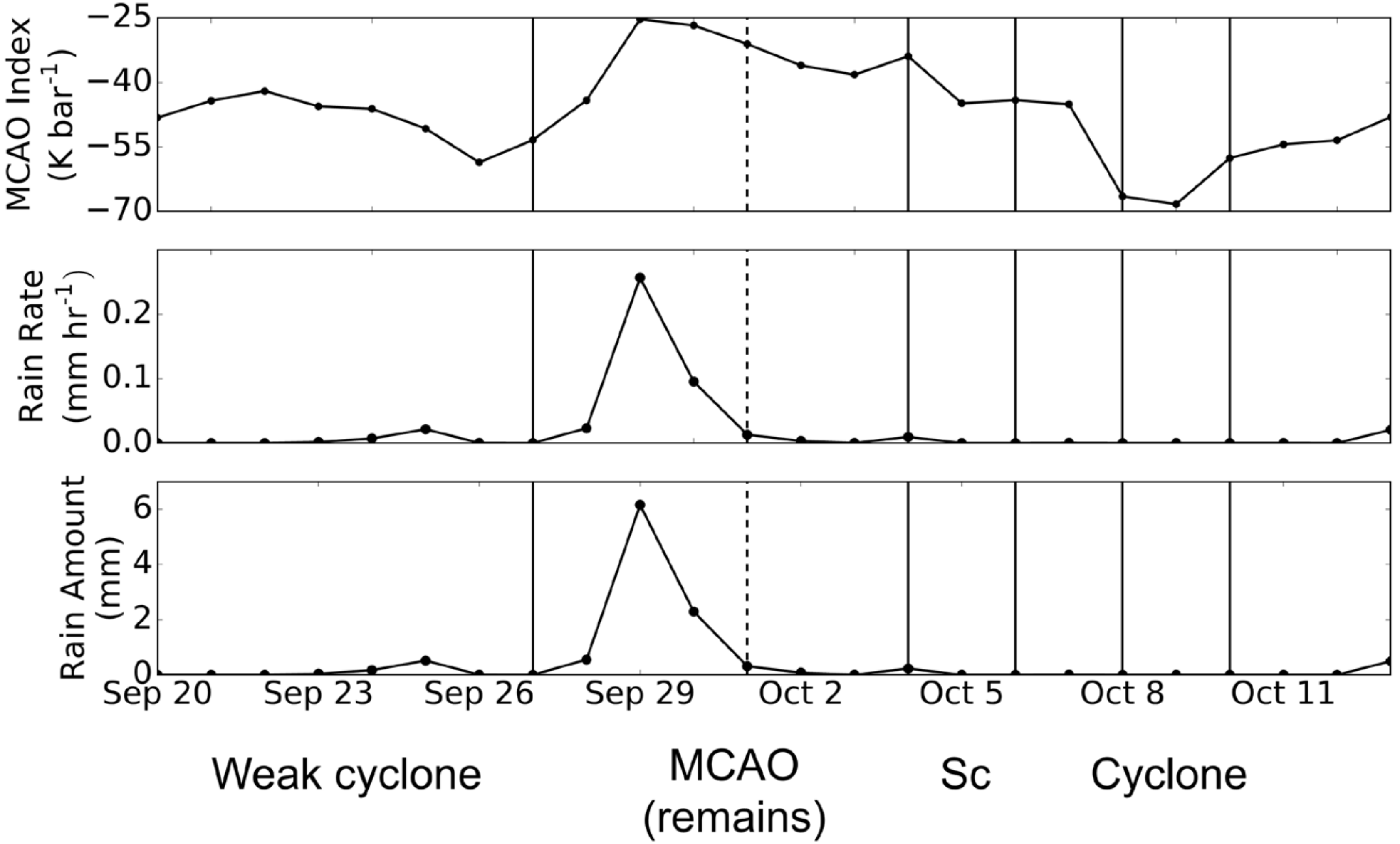


Daily accumulation mode (~ 100 nm – 1 μm) < 50 cm^{-3} for ~ 2 weeks

Can we see evidence for aerosol removal by precipitation?

What allowed very low CCN conditions to persist for 15 days?

Marine cold air outbreak (MCAO) Index

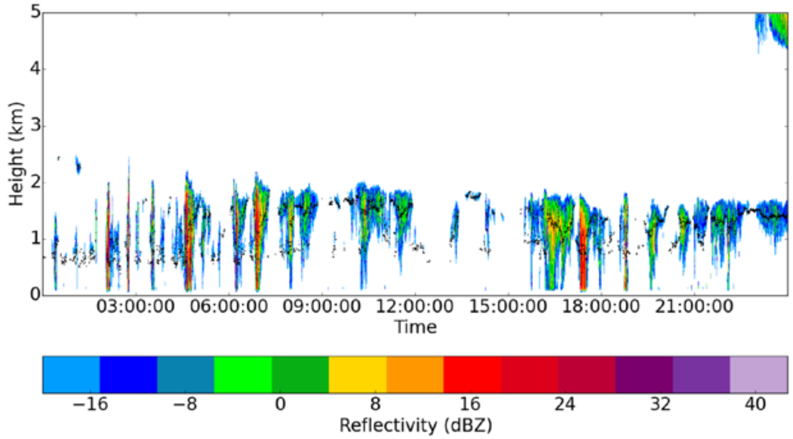


$$M = \frac{\theta_{sfc} - \theta_{700}}{p_{sfc} - p_{700}}$$

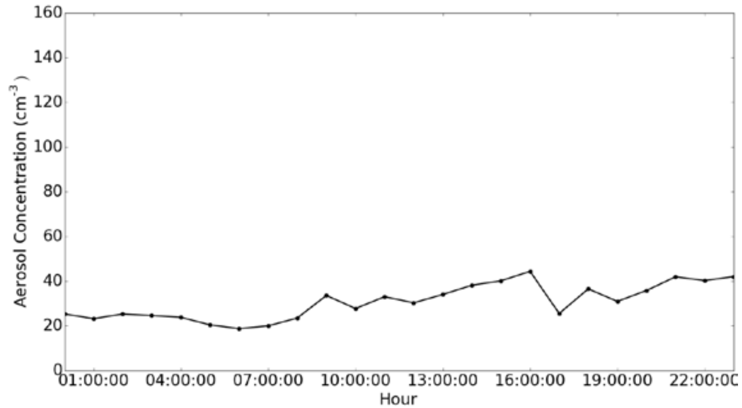
After Kolstad et al. (2009)

From MERRA 2 Reanalysis and QC'd ENA Video Disdrometer

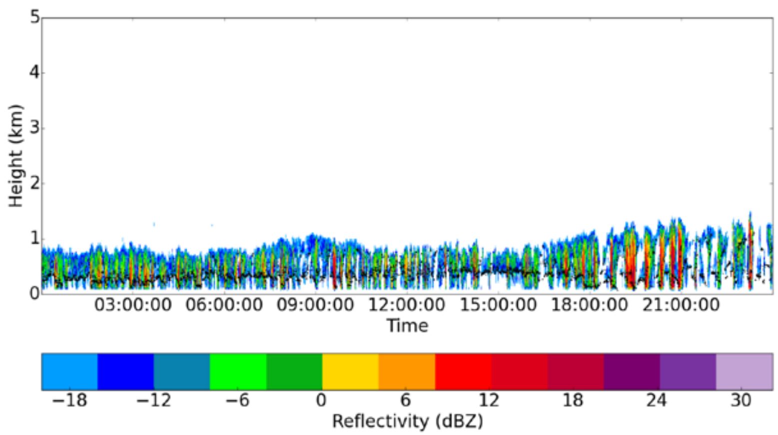
Aerosol concentrations remain low during periods of precipitating low clouds (open and closed cells)



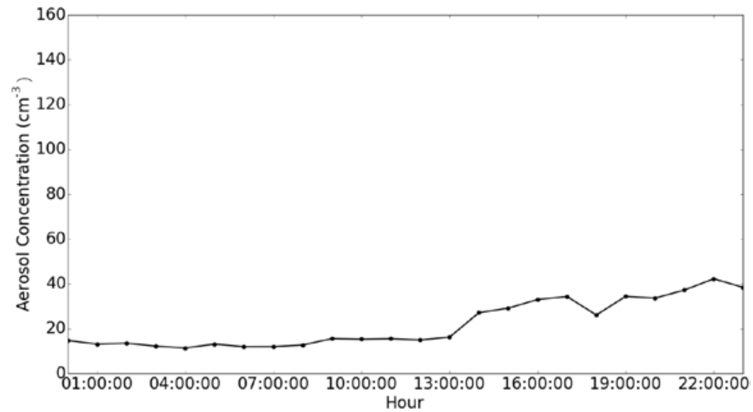
October 5- Open cell stratocumulus



Higher reflectivity but not persistent; aerosol remains low
Note deeper cloud height

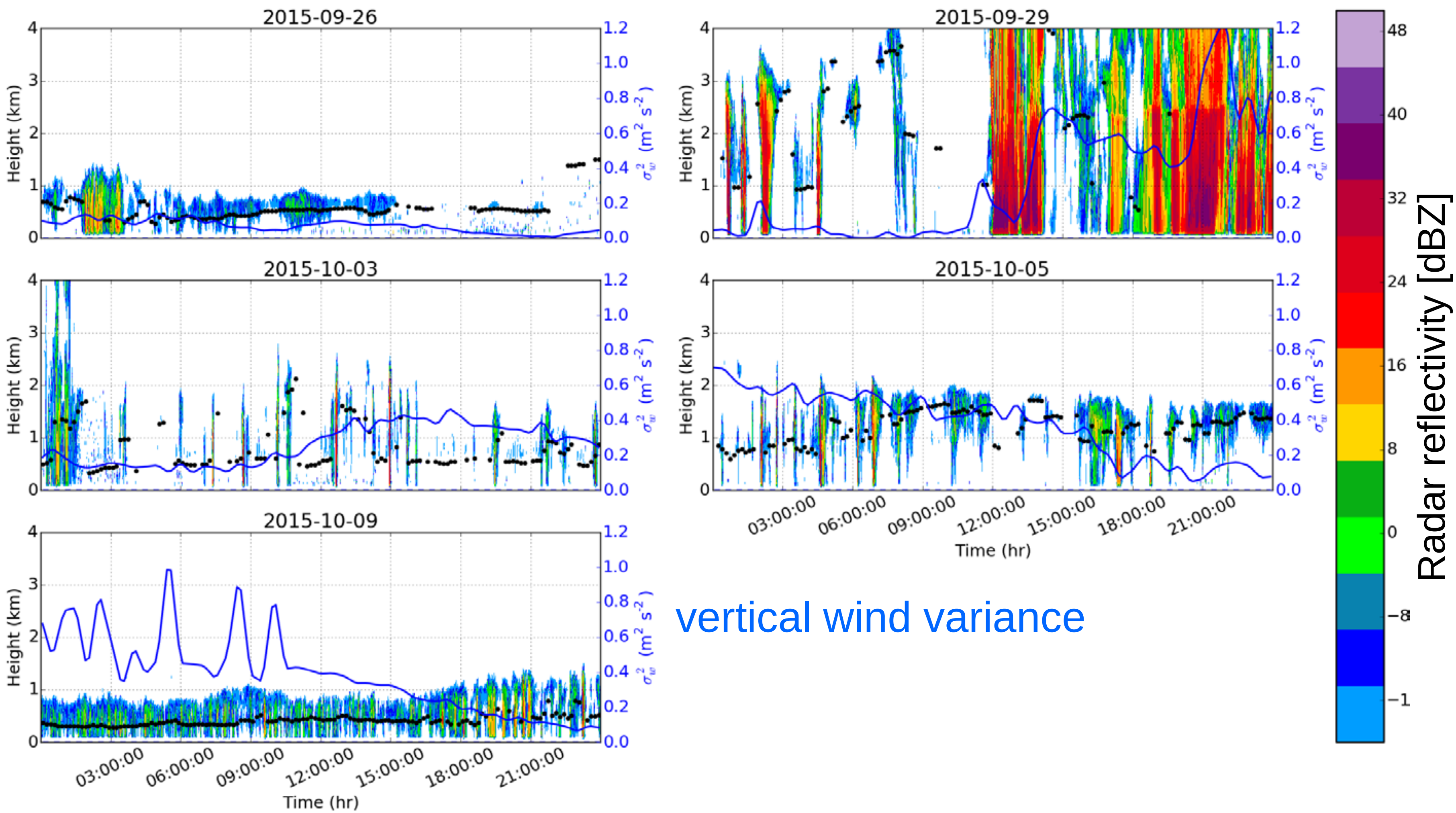


October 9- Stratocumulus behind cyclone

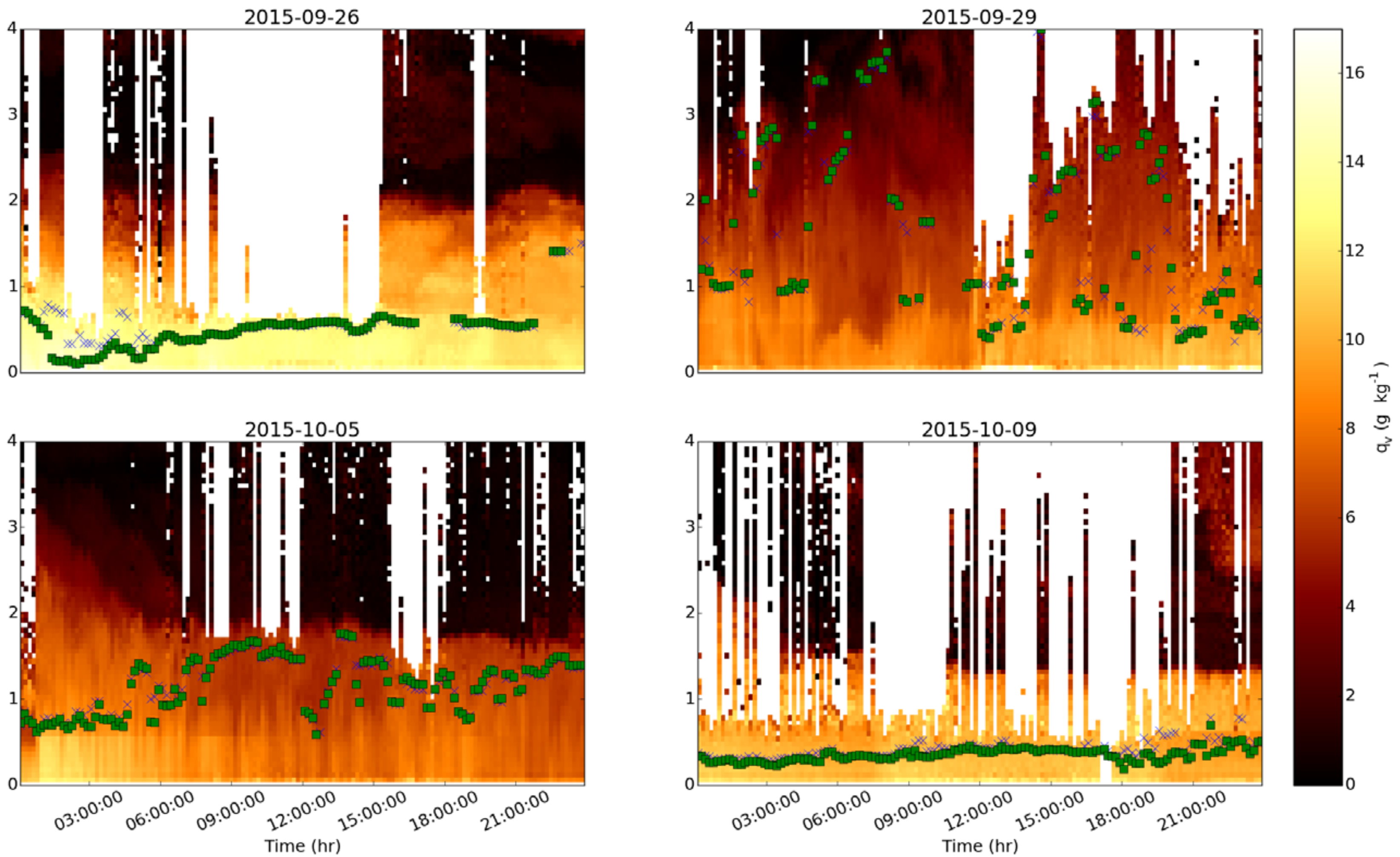


More cloud variability but higher reflectivity later in the day

Connecting radar and turbulence

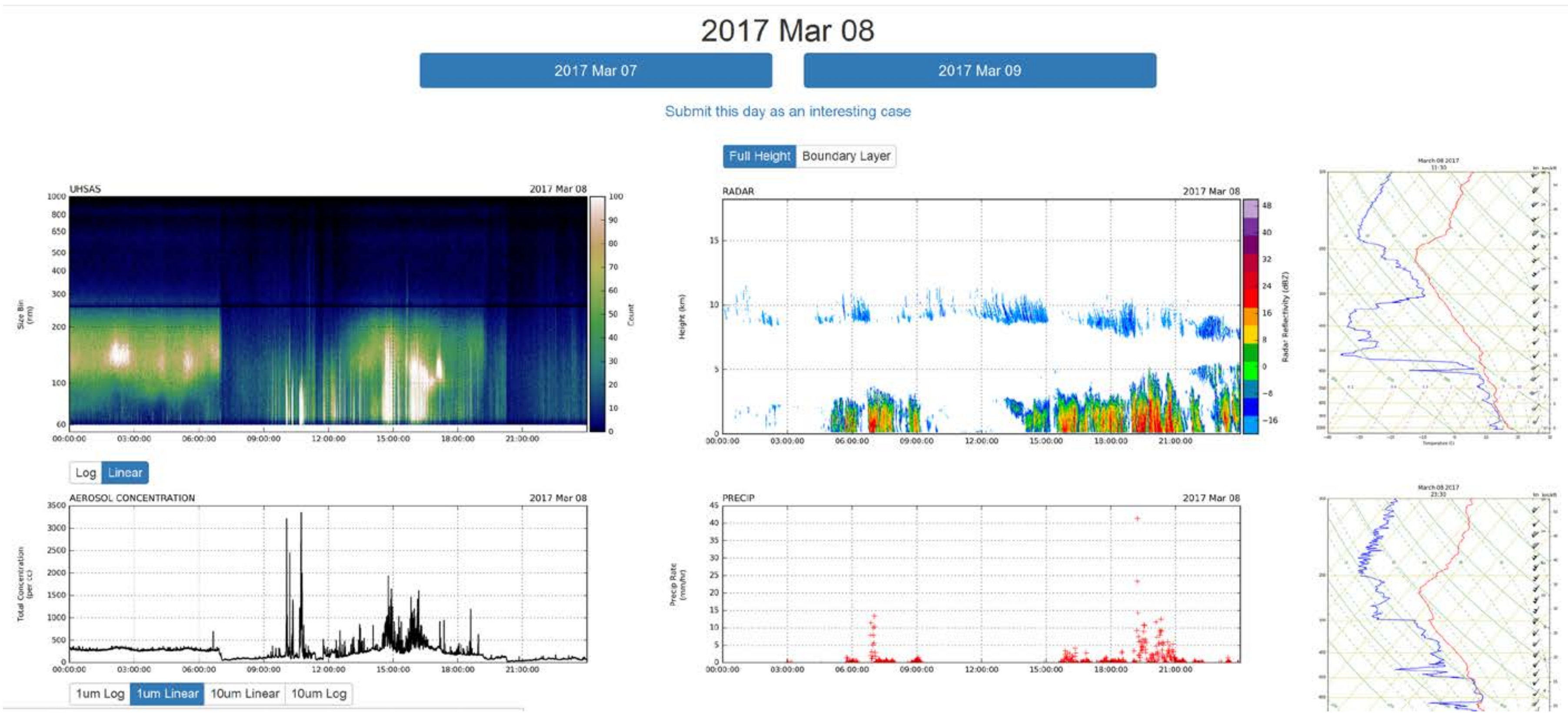


Raman Lidar



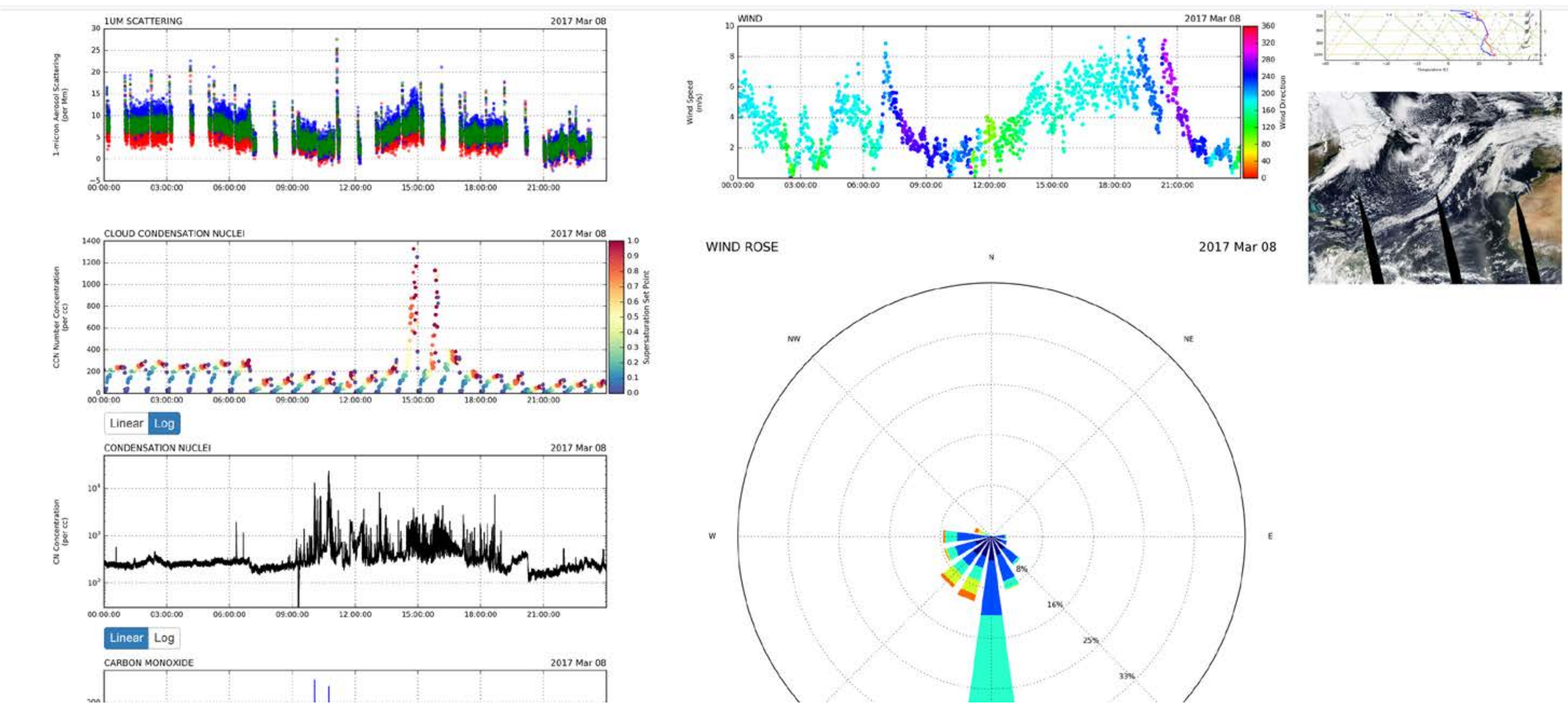
2015-09-26
2015-09-29
2015-10-05
2015-10-09
0
1
2
3
4
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
Time (hr)
Time (hr)
0
2
4
6
8
10
12
14
16
q_v (g kg^{-1})

ENA Data Browser: http://ena-data.site/



Latest data ~ 4 days old, so useful for reviewing data a few days after collection

ENA Data Browser: http://ena-data.site/



Remote sensing instrumentation

Instrument(s)		Key derived parameters
RADARS	Ka-band ARM Zenith Radar (KAZR)	(i) Cloud and precipitation vertical structure (iii) Drizzle drop size distribution using both Doppler spectral measurements and with lidar (O'Connor et al. 2005)
	Ka-band and W-band Scanning ARM Cloud Radar (KaW-SACR)	(i) 3D cloud and drizzle structure up to 20 km range (ii) Dual-wavelength observations (retrieval of LWC) (iii) 3D cloud dynamics and turbulence
	X-band Scanning ARM Precipitation Radar (X-SAPR2)	(i) Areal precipitation rate and hydrometeor type (ii) Doppler winds in precipitating systems
	Radar Wind Profiler (RWP)	(i) Horizontal wind profiles and virtual temperature profiles (ii) Unattenuated profiling radar moments of drizzle/precipitation (iii) Inversion height and strength
LIDARS	Ceilometer (VCEIL) and Micropulse Lidar (MPL)	(i) Cloud base height and cloud cover (ii) Precipitation profiling below cloud base (with radar)
	Raman Lidar (RL)	(i) Aerosol extinction profile (ii) Water vapor profe
	Doppler Lidar (DL)	(i) Vertical turbulent wind component (ii) Horizontal wind fields
MWR	Microwave Radiometer (MWR) – 23/31/90 GHz	Column liquid water and water vapor path
	Microwave Profiler	(i) Temperature and mixing ratio profiles
VISIBLE AND IR RADIOMETERS	MultiFilter Rotating Shadowband Radiometer (MFRSR); Sunphotometer	(i) Cloud visible optical thickness. Cloud microphysical properties (droplet concentration, effective radius) in combination with MWR (ii) Aerosol optical properties in clear skies
	Atmospheric Emitted Radiance Interferometer ("ASSIST")	Cloud liquid water path (LWP) estimates for thin clouds (combined with MWR, following Turner 2007)
	Broadband and Spectral Radiometers	SW and LW radiative fluxes used to constrain the surface energy budget; spectrally resolved radiances for microphysical and LWC retrievals
	Total Sky Imager (TSI)	Cloud coverage and type

In situ instrumentation

Instrument	Key derived parameters
Balloon-borne Sounding System (BBSS)	(i) Atmospheric profile of temperature, humidity and winds (ii) MBL depth (iii) Inversion strength
Eddy Correlation Systems (ECOR)	Surface turbulent fluxes of latent and sensible heat
Surface Meteorological Instruments	Surface temperature, humidity, pressure, winds, precipitation rate (optical and tipping bucket rain gauges, disdrometer)
Surface aerosol observing system	Total aerosol concentration > 10 nm diameter (CN counter);
	CCN spectra at seven supersaturations (nominally 0.1, 0.2, 0.3,0.5, 0.8, 1, 1.1%)
	Aerosol size distribution from 60-1000 nm (UHSAS)
	Dry (low RH) and wet (scanning RH from 40-90%) aerosol scattering (total and hemispheric backscattering) at three wavelengths (450, 550 and 700 nm) with 1 and 10 micron size cut-off;
	Aerosol absorption (PSAP) at three wavelengths (450, 550 and 700 nm) wavelength
	Hygroscopic aerosol size growth (TDMA)
	Aerosol chemical speciation (Aerosol Mass Spectrometer)
Gas tracers	Carbon monoxide/dioxide, nitrous oxide, methane

Oliktok Point Science Team

Some current science activities

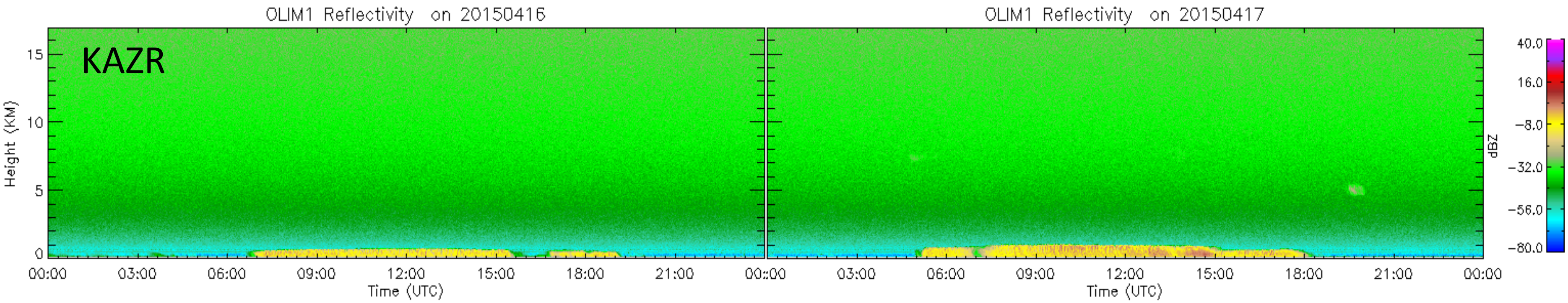
Evaluation of aerosol-cloud interactions using WRF model simulations and intercomparisons with observations (the primary period of interest: 16-17 April 2015)

Analyzing the open water - sea ice transition period (the primary period of interest: 9-21 October 2016)

Development and evaluation of techniques to retrieve quantitative information on Ice hydrometeor shapes (the primary period of interest: 15-21 October 2016)

Characterization of ABL thermodynamic and dynamic structure and comparisons with remote sensor retrievals (the primary period of interest: 15-21 October 2016)

16-17 April, 2015



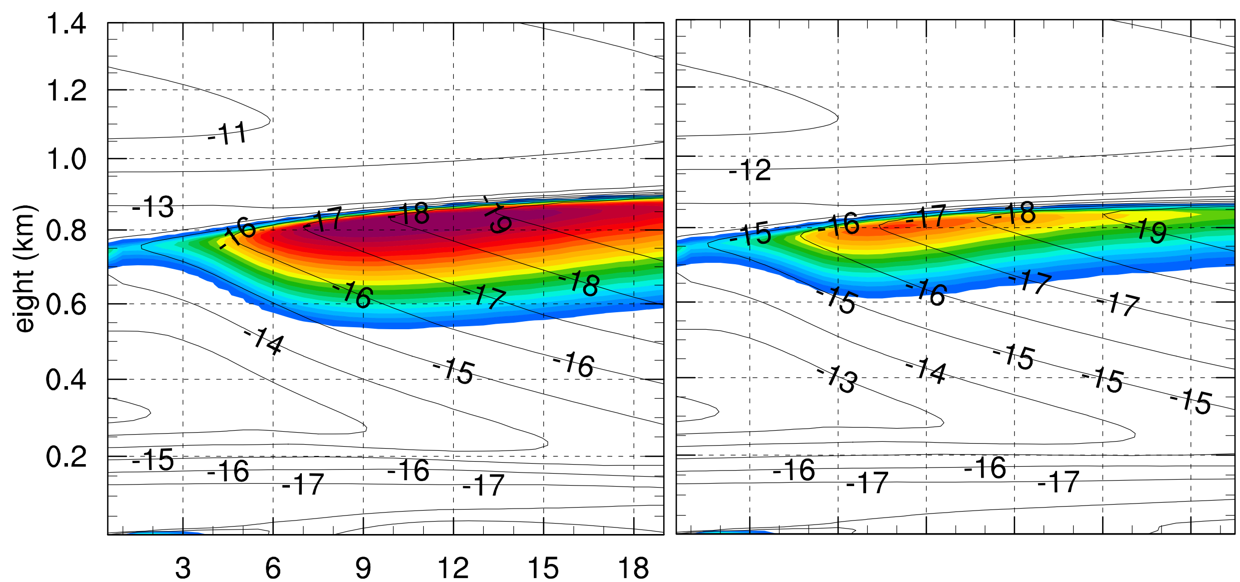
Oliktok Diurnal Cloud Case

- Used as test case for evaluating questions related to aerosol cloud interactions
- Completing WRF simulations to evaluate sensitivity to aerosol parameters
- Observational need:
  - Microphysics Info.
  - Dynamics/Turbulence
  - Cloud macrophysics
  - Thermo structure
- Potential problems:
  - Pre-CGA

WRF-LES

CCNx1.0, INx2.0

CCNx4, INx0.5

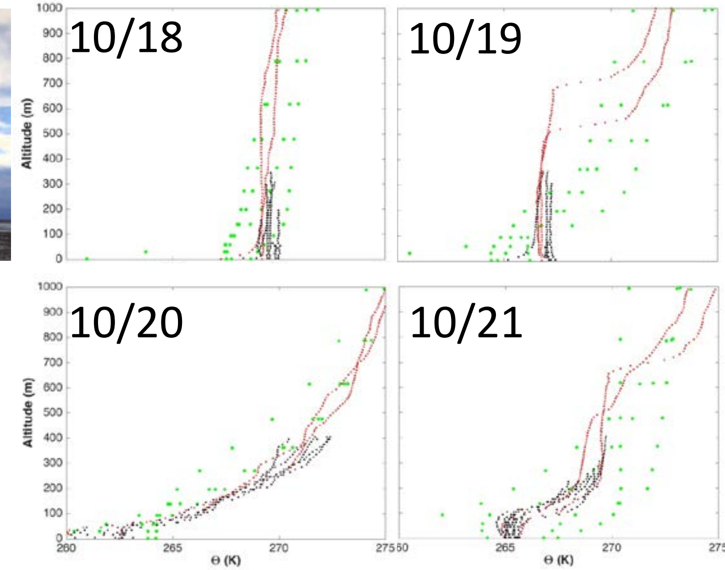


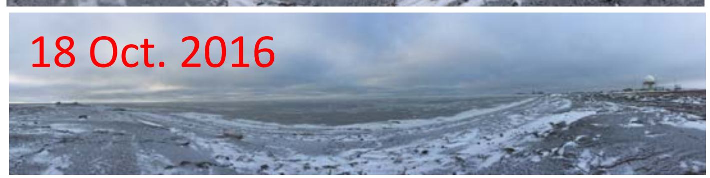
9-21 October, 2016

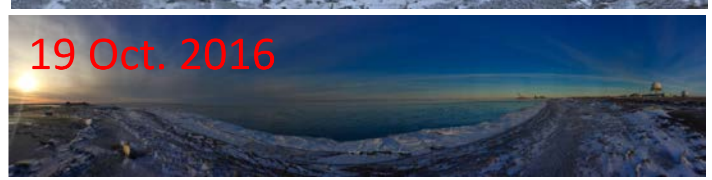
Sea Ice Transition Period

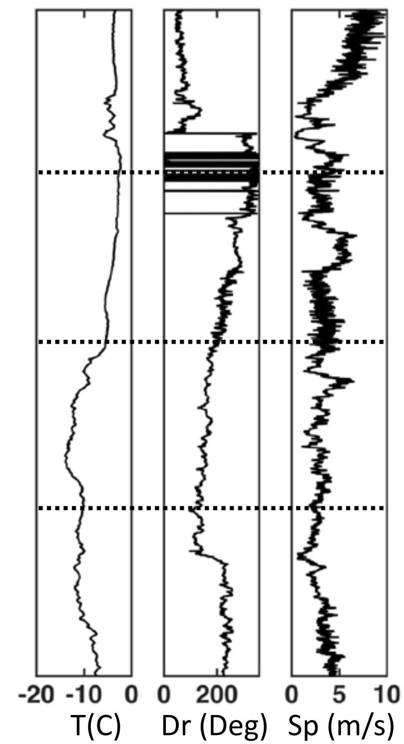
- Period with additional observations from ICARUS and ERASMUS – particular emphasis on 15-21 October
- AOS in place and operational
- Observational need:
    - Microphysics Info.
    - Dynamics/Turbulence
    - Cloud macrophysics
    - Thermo structure
    - Aerosol properties
    - Turbulent fluxes
    - Radiative fluxes
- Potential problems:
    - Radar operations were variable due to calibration activities

RASM-ESRL
ARM Radiosonde
CU DataHawks





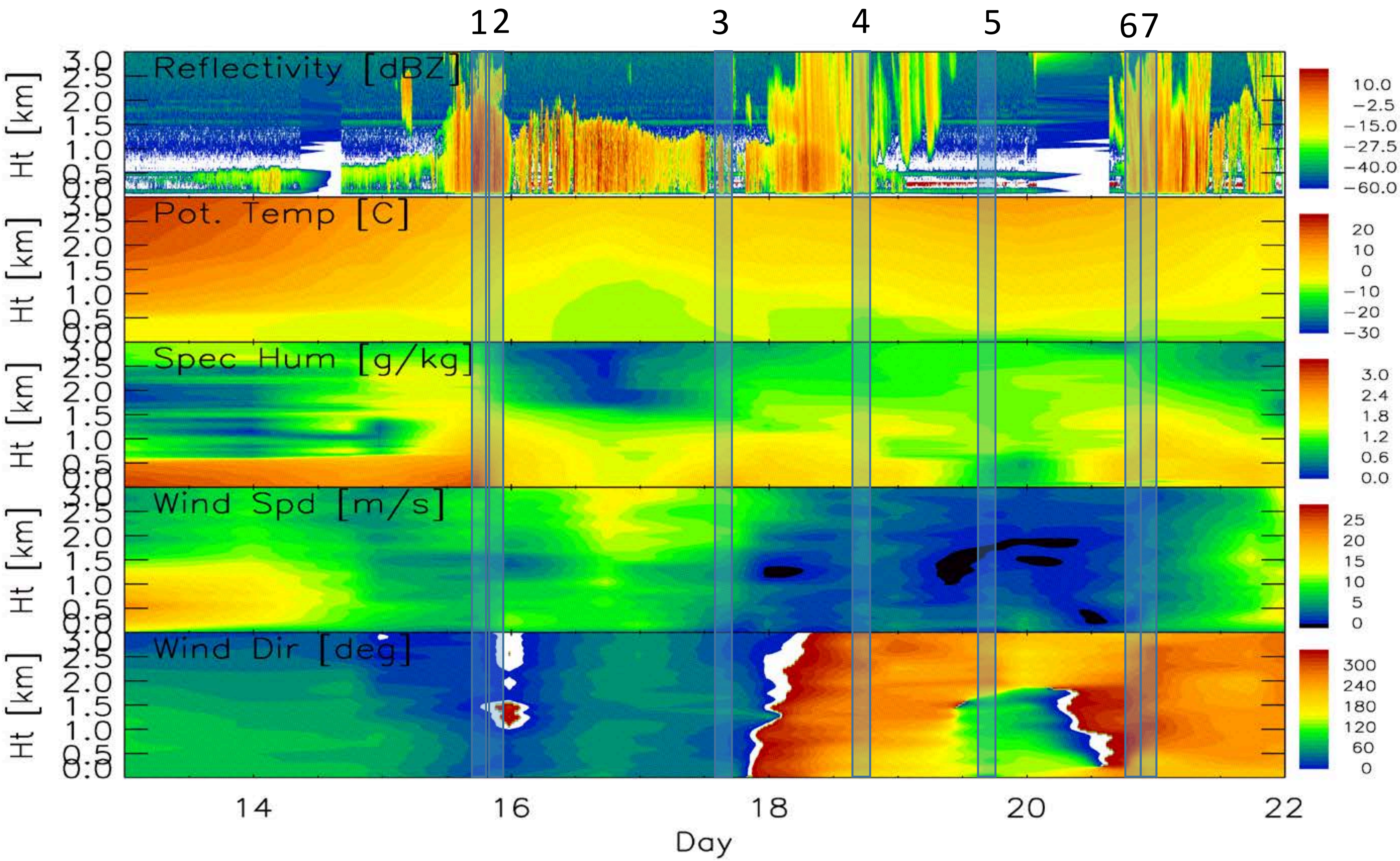




15-21 October, 2016

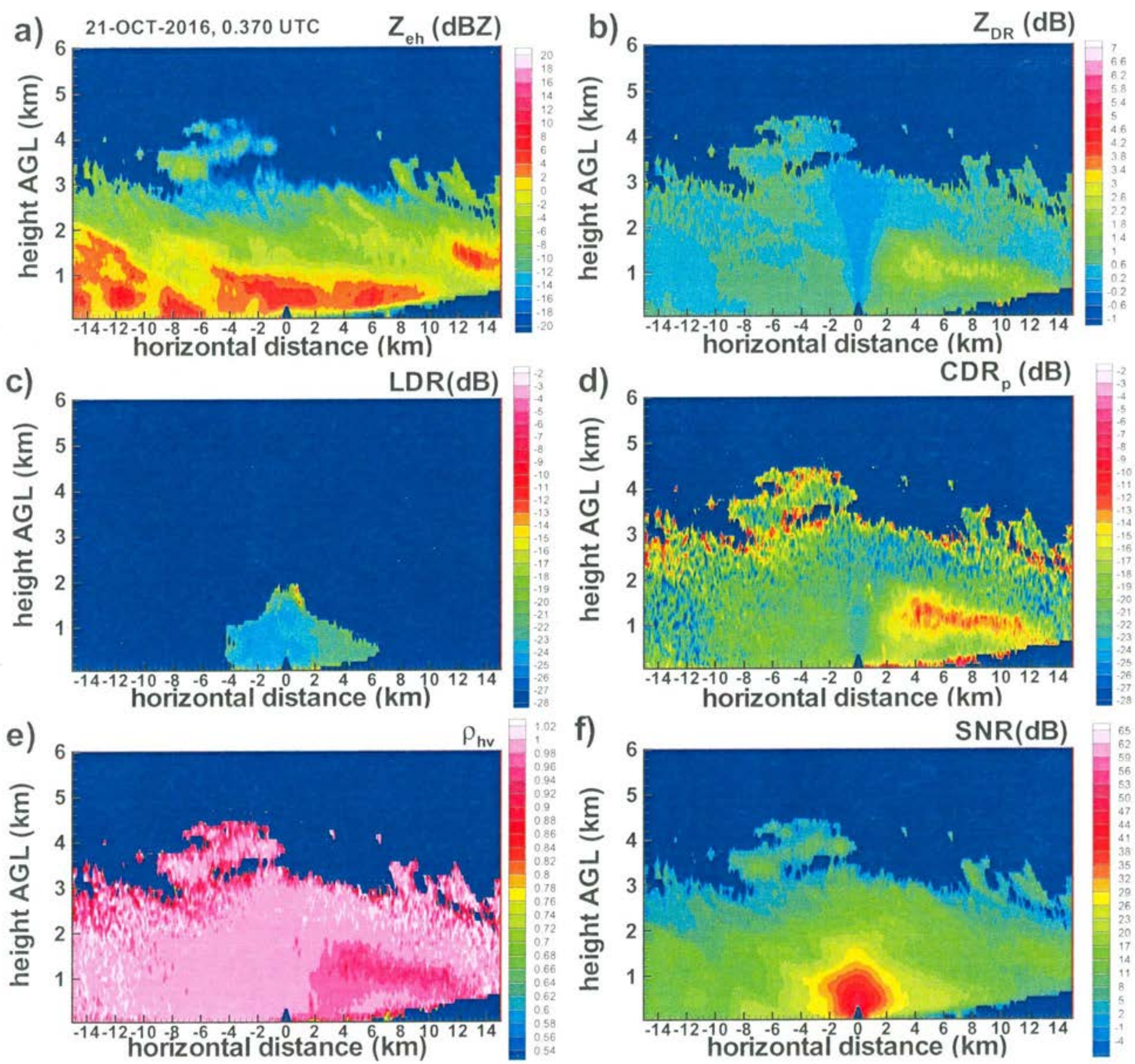
ICARUS TBS soundings

Guest instruments: VIPS (ice microphysics available during launches 1, 3, 6, and 7)
turbulence pod measurements available for the most launches



15-21 October, 2016

Validations of ice hydrometeor shape retrievals from SACR-2 measurements



HSRHI K_a-band SACR
21 October 2016
Time = 0.370 UTC

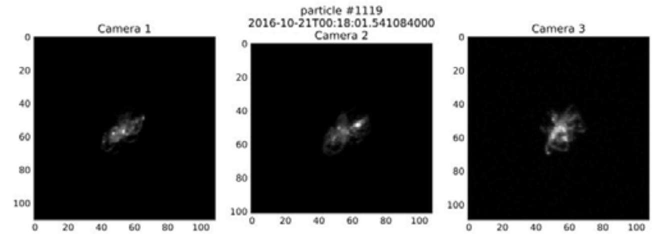
15-21 October, 2016

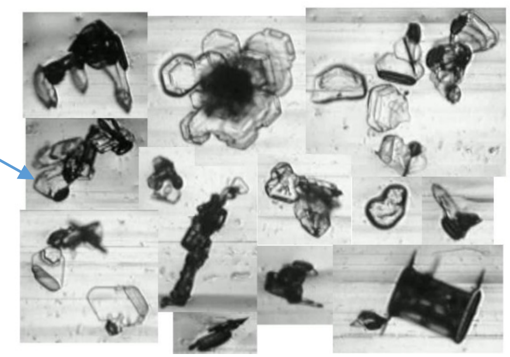
Validations of ice hydrometeor shape retrievals from SACR-2 measurements

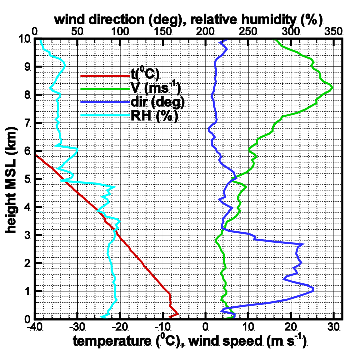
Primary observational needs:

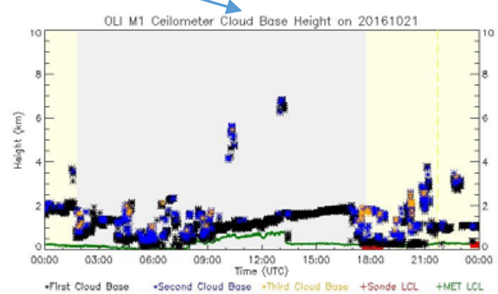
SACR-2 polarimetric measurements (HSRHIs, VPTs, PPIs)
MASC retrievals of particle sizes, shapes and fall velocities
VIPS measurements of cloud microphysics
MWR radiometer retrievals of LWP and IWV
Standard ARM retrievals of cloud microphysics
Surface meteorological measurements, ECOR
Radiosonde soundings, thermodynamic profiles
Ceilometer estimates of liquid cloud bases
KAZR measurements

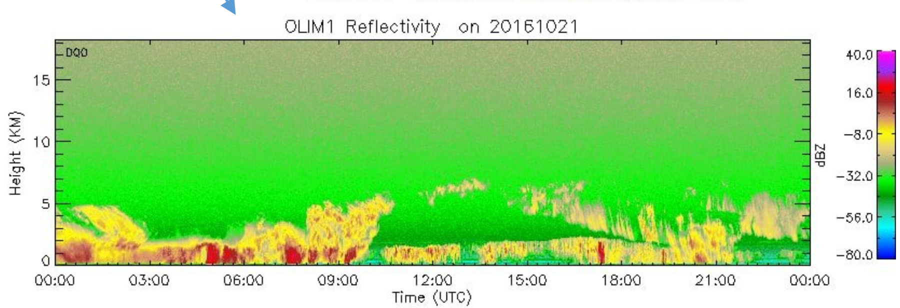
21 October 2016

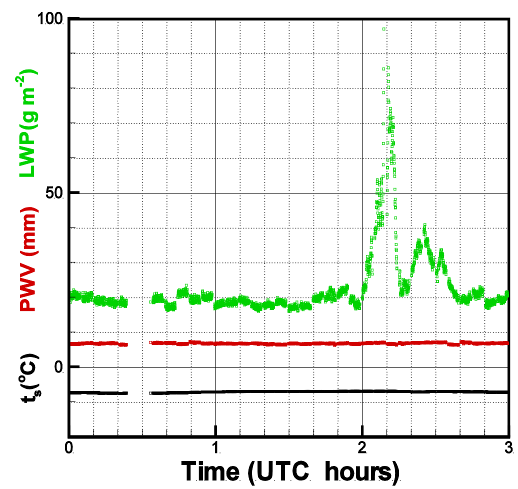








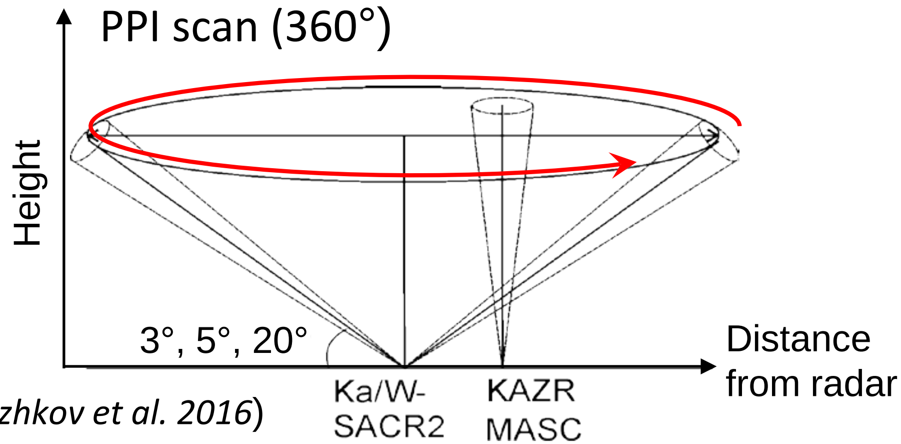




Oliktok Ka-SACR2 ADVance Quasi-Vertical Profile (SACR-ADV-QVP) product

Mariko Oue and Pavlos Kollias
Stony Brook University
Meng Wang and Scott Giangrande
Brookhaven National Laboratory

Ka-SACR2 Quasi Vertical Profiles (QVP)

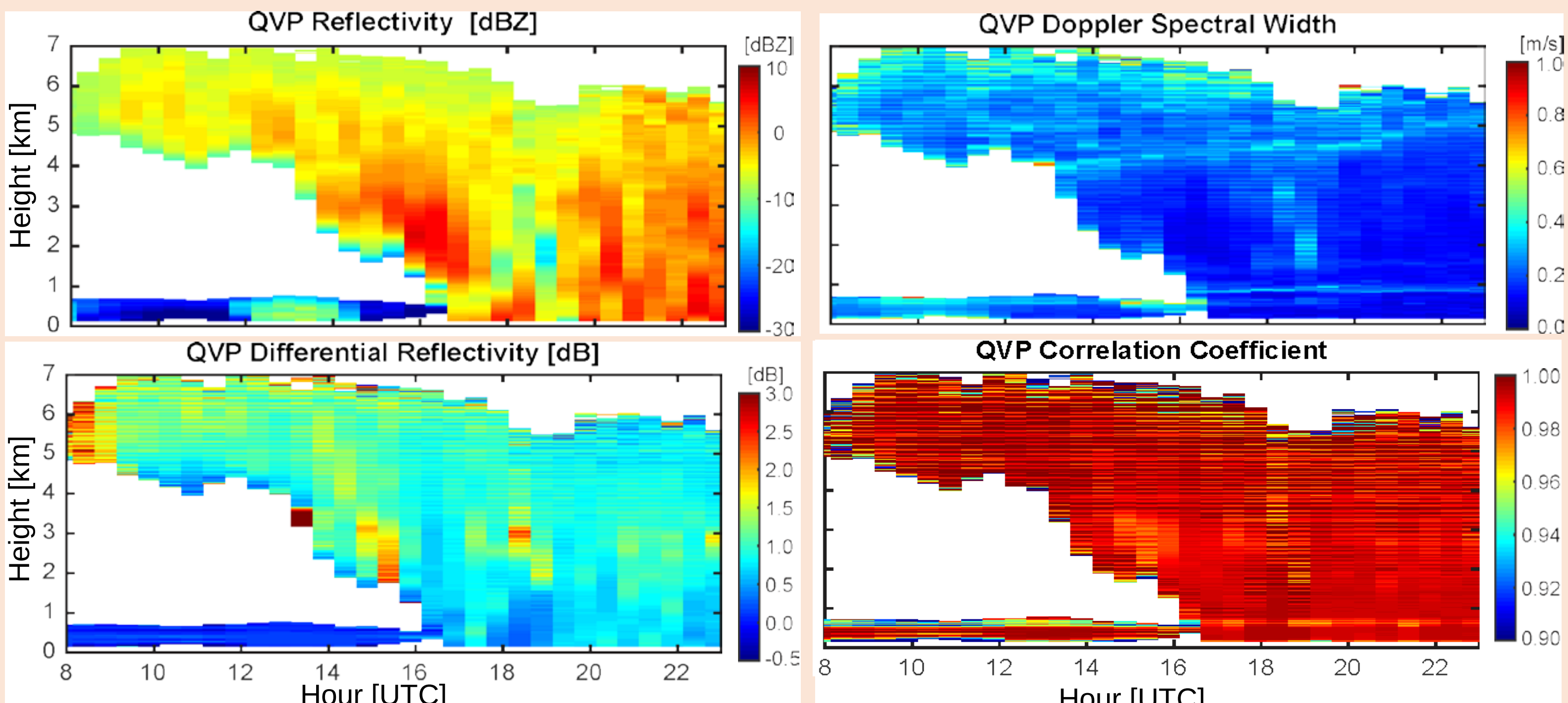


(*Ryzhkov et al. 2016*)

Azimuthal averages of polarimetric variables at each level from PPIs at three elevation angles (3°, 5°, 20°) every 30 min.

Available for horizontally homogeneous clouds.

QVP (Elevation angle: 20°)



Output Variables of SACR ADV QVP

Date range: From 2016/03/28 to 2016/09/10

Elevation angles	Variable name		
	Elevation angle	Height (maximum height, spacing)	Number of samples used for calculating qvp_reflectivity
3°	elevation_angle_1	elevation_height_1 (1062 m, 1.6 m)	number_of_points_used_1
5°	elevation_angle_2	elevation_height_2 (1771 m, 2.6 m)	number_of_points_used_2
20°	elevation_angle_3	elevation_height_3 (6956m, 10.3 m)	number_of_points_used_3

Variables	Variable name	
	Radar variables	Standard deviation
Reflectivity (Zhh)	qvp_reflectivity_1, 2, 3*	qvp_reflectivity_error_1, 2, 3
Differential reflectivity (Zdr)	qvp_diff_reflectivity_1, 2, 3	qvp_diff_reflectivity_error_1, 2, 3
Correlation coefficient (ρhv)	qvp_corr_coeff_1, 2, 3	qvp_corr_coeff_error_1 , 2, 3
Linear depolarization ratio (LDR)	qvp_ldr_h_1, 2, 3	qvp_ldr_h_error_1, 2, 3
Specific differential phase (Kdp)	qvp_specific_diff_phase_1, 2, 3	qvp_specific_diff_phase_error_1, 2, 3
Doppler spectral width (SW)	qvp_sw_1, 2, 3	qvp_sw_error_1, 2, 3

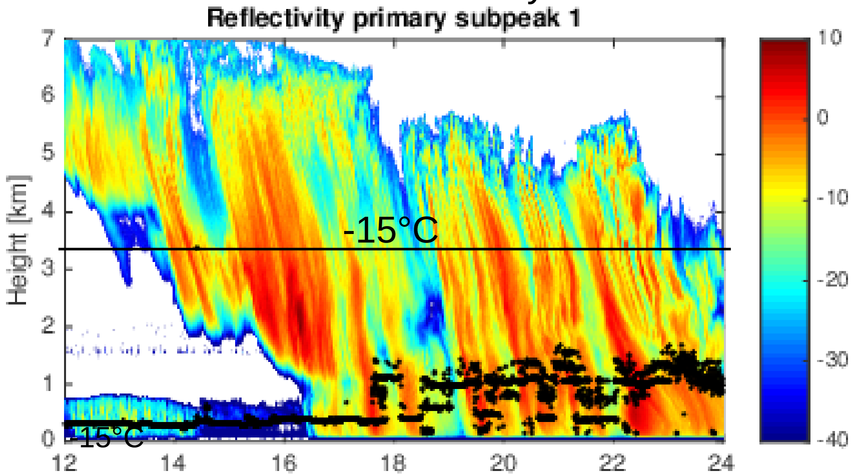
* 1, 2, and 3 in each variable name correspond to elevation angles of 3°, 5°, and 20°, respectively.

Precipitation cases with multi sensor datasets

- Complete dataset of Ka-/W-SACR, KAZR spectra, MWR, Ceilometer, and MASC.
- Shallow cloud cases
  20160416, 20160426, 20160503, 20160602
- Deep cloud cases
  20160328, 20160403, 20160417, 20160429, 20160524

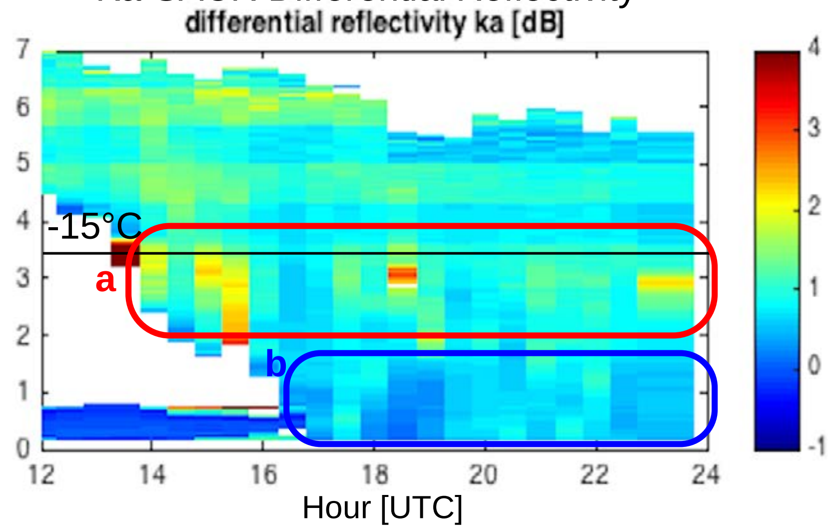
KAZR MicroARSCL & Ka-SACR QVP

KAZR Reflectivity



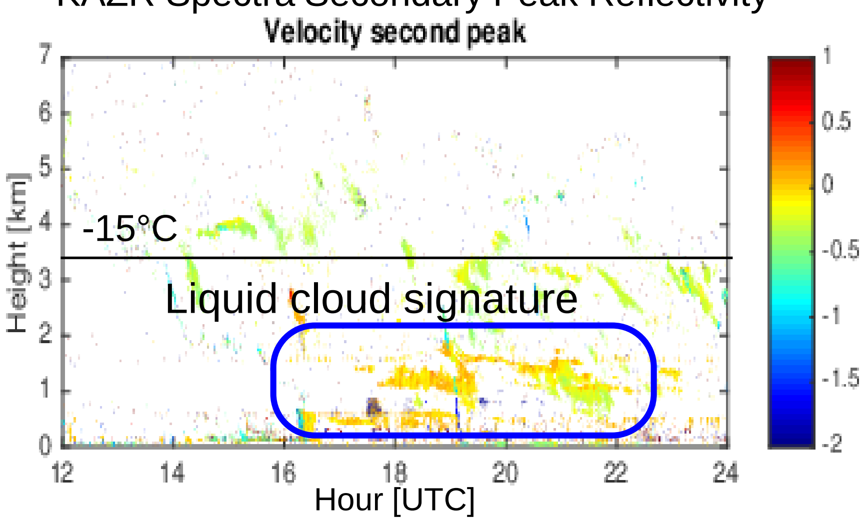
•: Ceilometer cloud base

Ka-SACR Differential Reflectivity

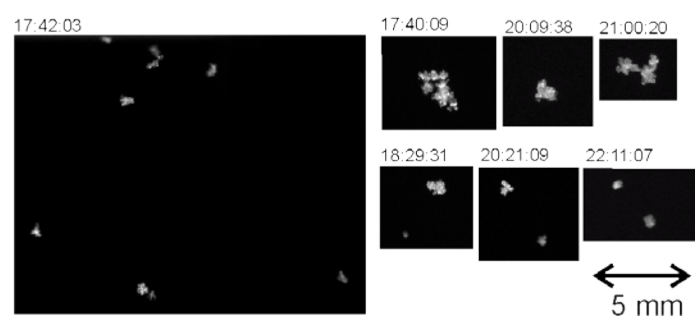


a. Plate-like crystal signature
b. Particles becoming spherical

KAZR Spectra Secondary Peak Reflectivity



Multi-Angle Snow Camera (MASC)



MASC observed rimed dendrites and compact rimed ice particles.

Summary

- ✓ Ka-SACR2 QVP datasets are prepared.
  - ➢ Provide polarimetric variables and Doppler spectral width, and their standard deviation.
  - ➢ At three elevation angles: 3°, 5°, and 20°.
  - ➢ Every 30 min.

- ✓ Synergy analysis between Ka-SACR2 QVP and KAZR Micro ARSCL can help to understand particle characteristics in mixed ice particle regions.
  - ➢ High Kdp values were frequently shown in multimodal spectra regions.
  - ➢ Zdr showed low values.

  → Aggregation and depositional growth processes dominated, and dendrites coexisted with larger aggregates.

MMCR / ARSCL Long-Term Records

Karen Johnson, Shannon Baxter, Michael Jensen

Brookhaven National Laboratory

2017 ARM/ASR PI Meeting

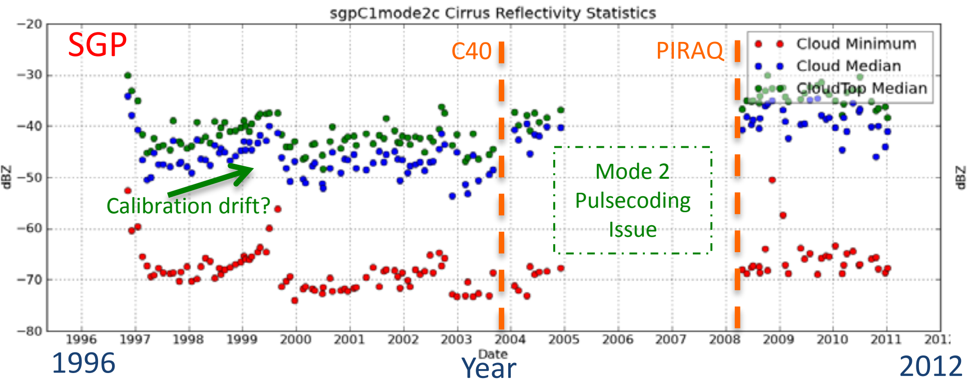
MMCR and ARSCL Data Records

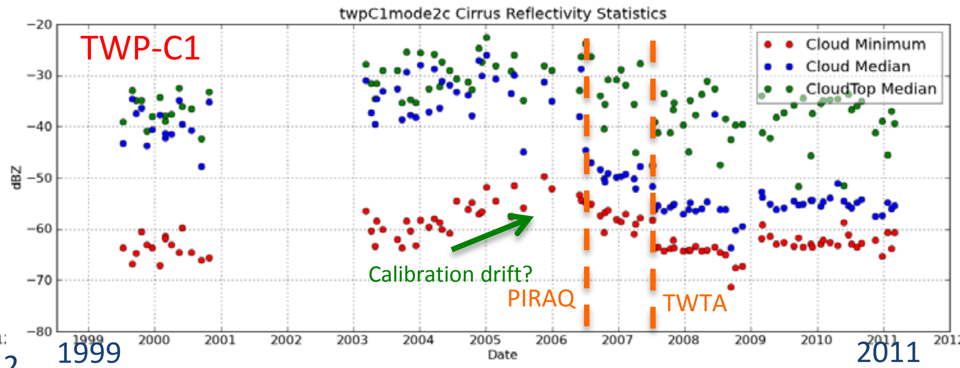
SGP	>14 years (1997 – 2010)
NSA	~13 years (1998 – 2011)
TWP-C1	>11 years (1999 – 2011)
TWP-C2	>10 years (1998 – 2009)
TWP-C3	> 5 years (2005 – 2011)

- How does data availability change over time and from site-to-site?
- How does data quality very over time?
- What can we say about calibration?

MMCR 'cirrus mode' Sensitivity

Selected dates with single-layer cirrus

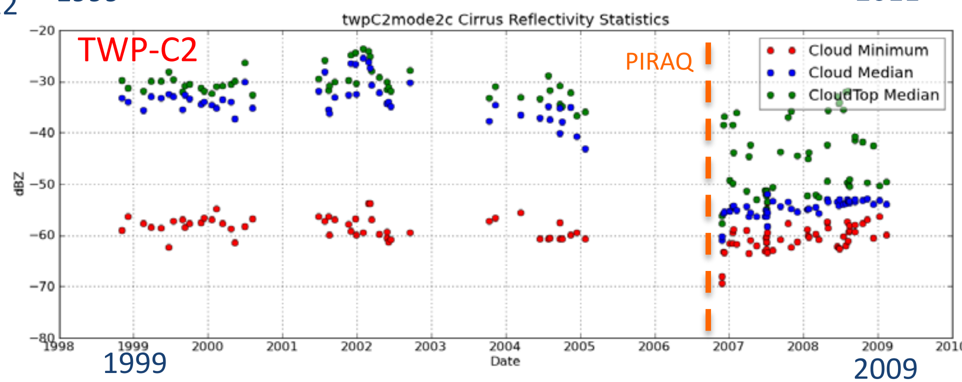


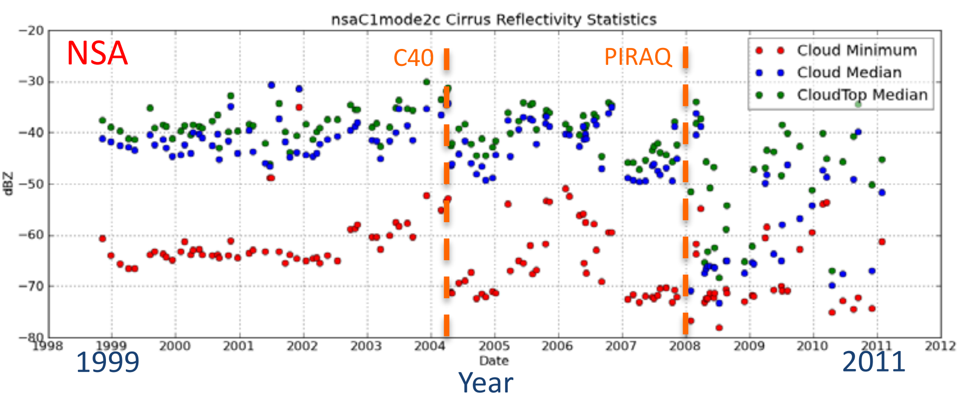


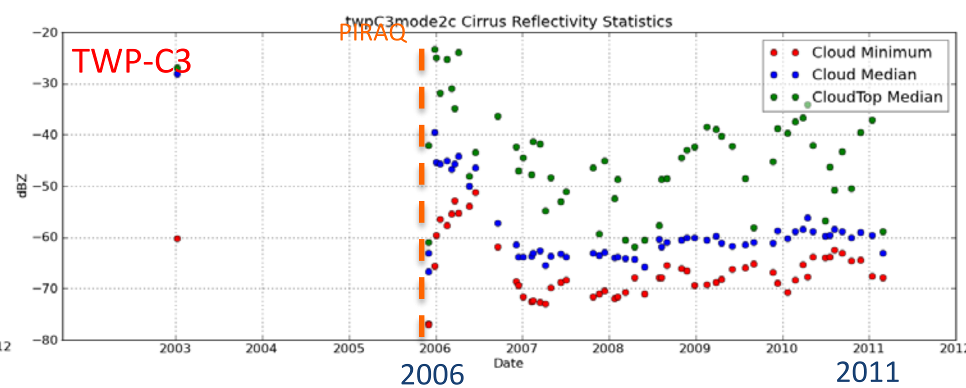
Lower observed minimum reflectivities → Higher Sensitivity

Key

- Minimum Cloud reflectivity (likely background noise)
- Median Cloud reflectivity for date
- Median Cloud Top reflectivity

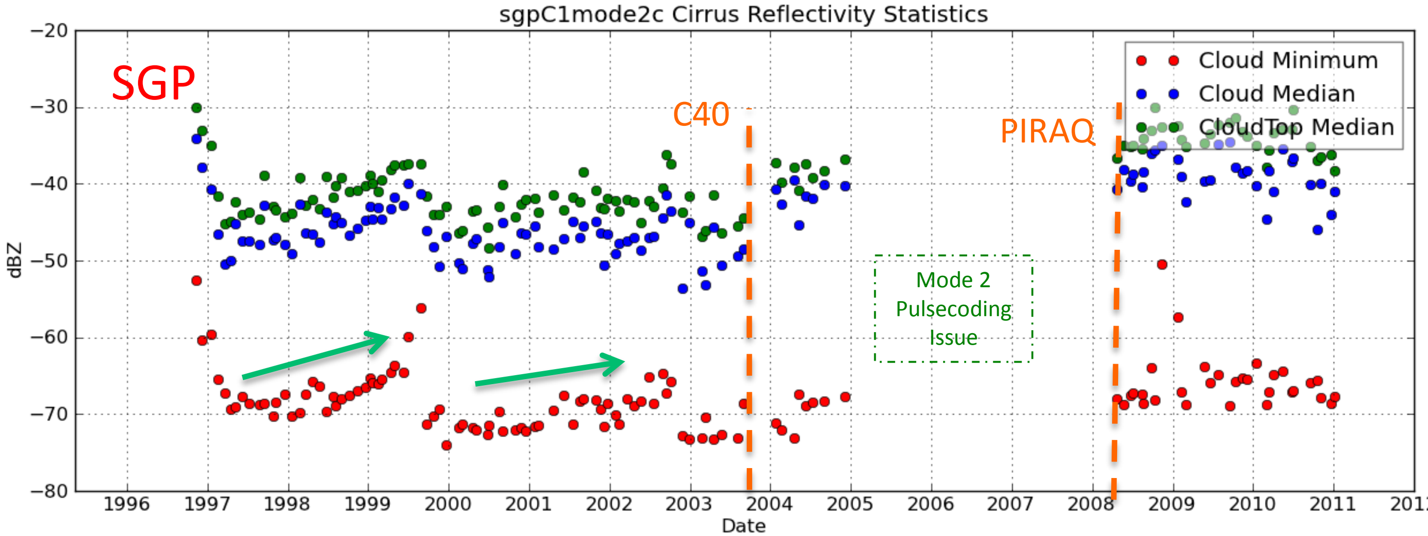






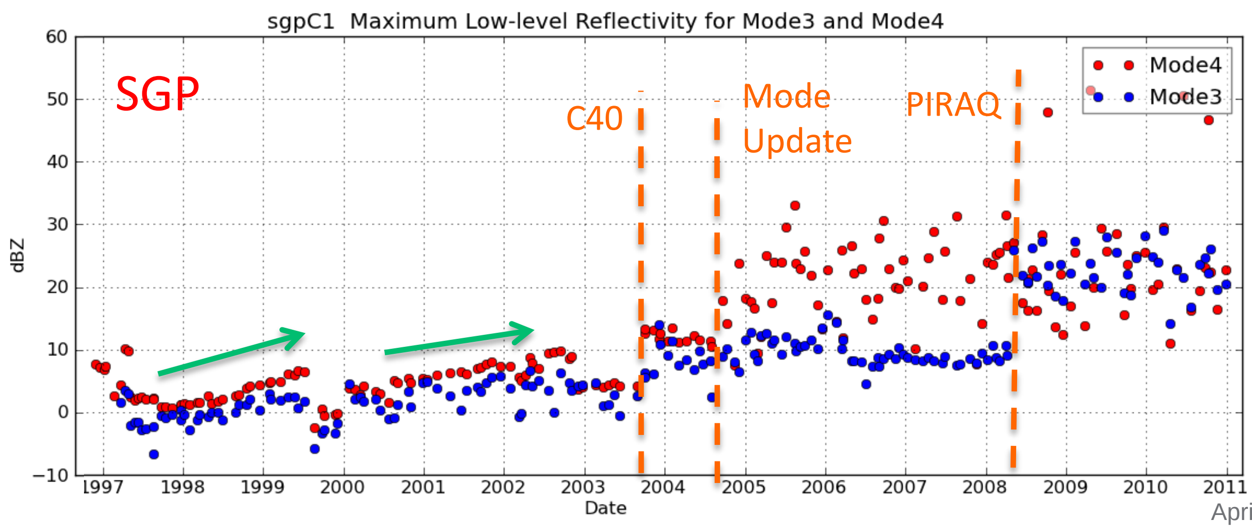
SGP Sensitivity and Saturation

Cirrus Sensitivity



Reflectivity Saturation in precipitation

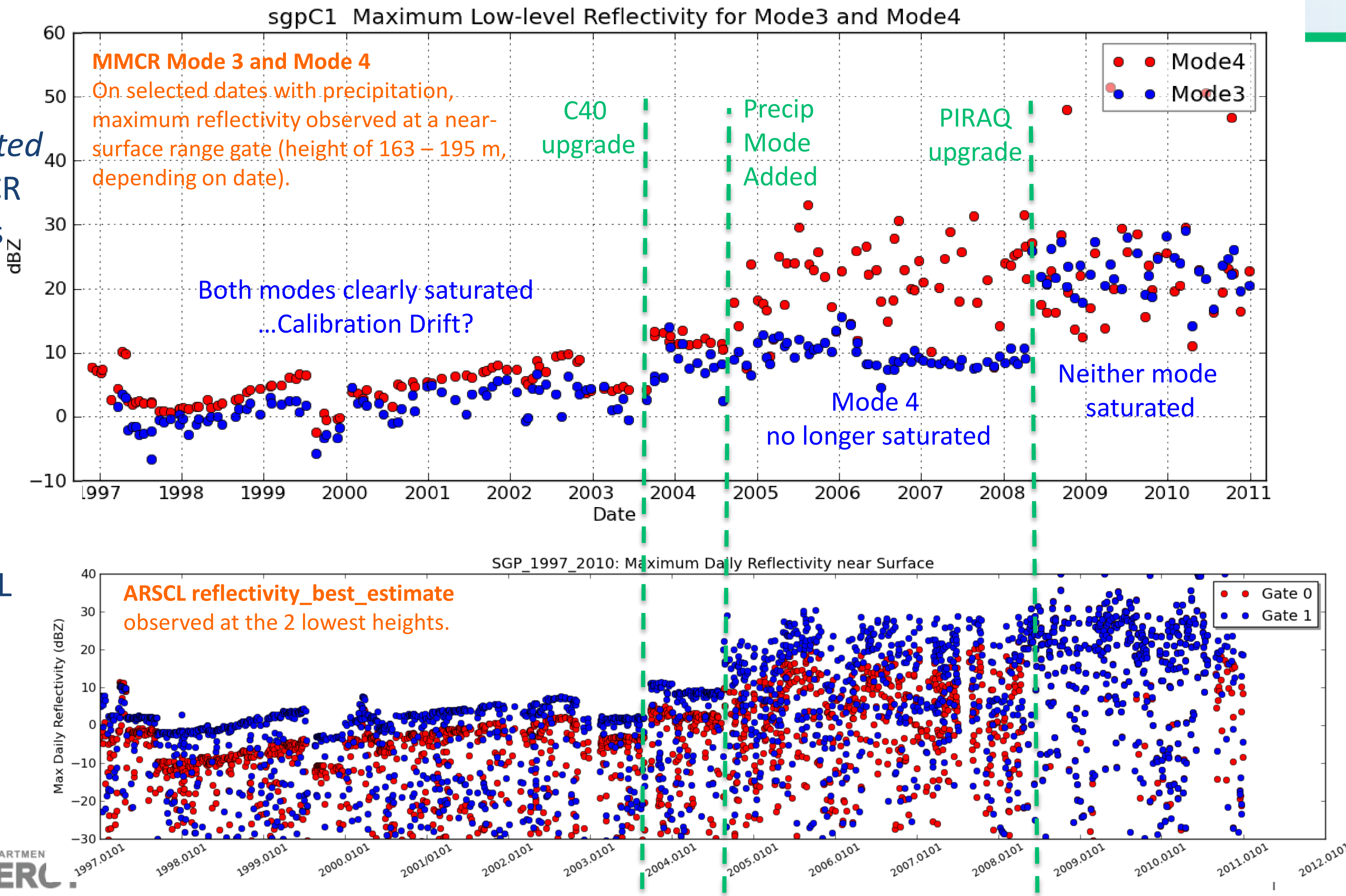
General mode 3 vs. Precip mode 4



Reflectivity Saturation at SGP site

Selected MMCR Cases

ARSCL RBE



Saturation based on ARSCL ReflectivityBestEstimate

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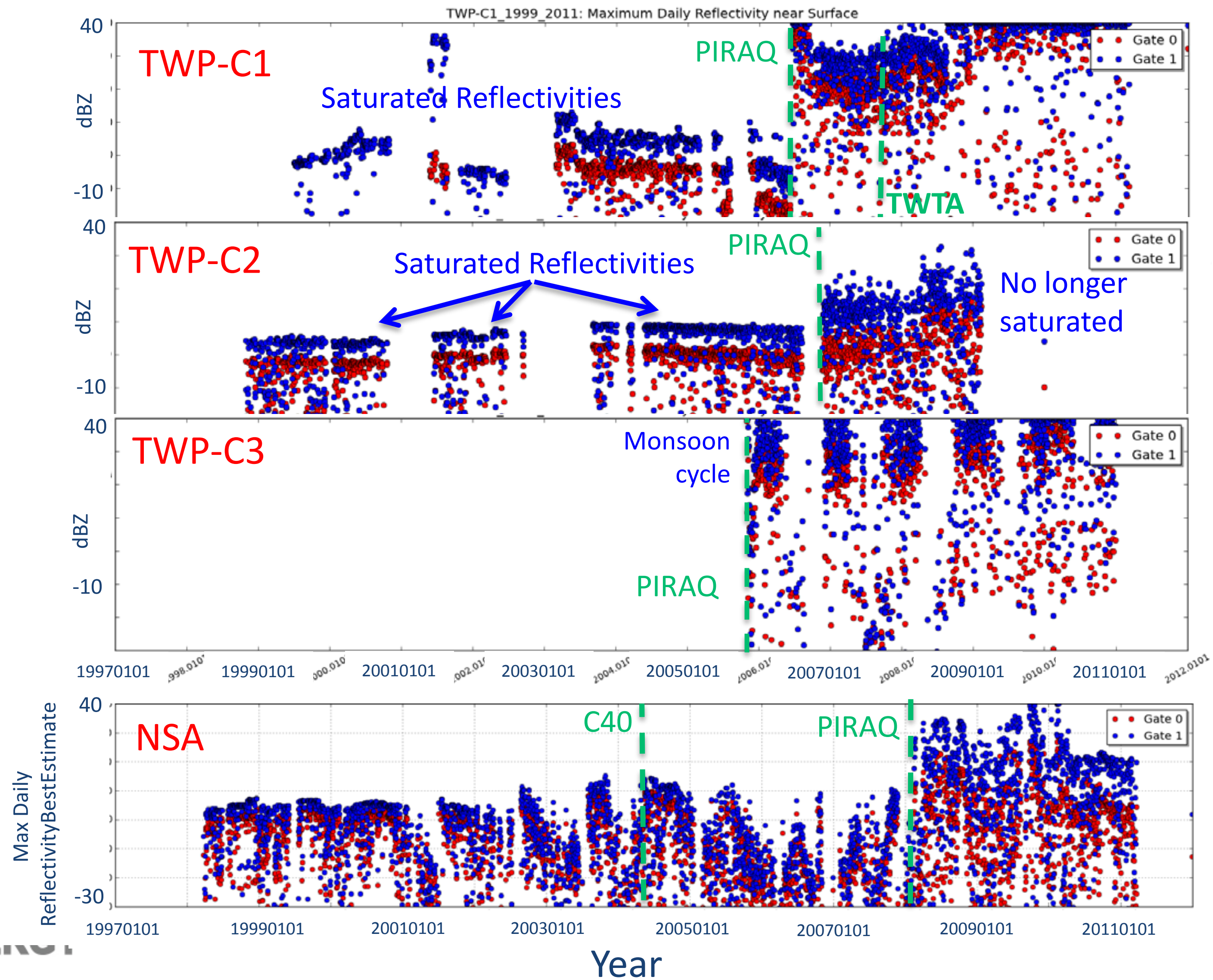

ARSCL Min/Max Clutter Returns

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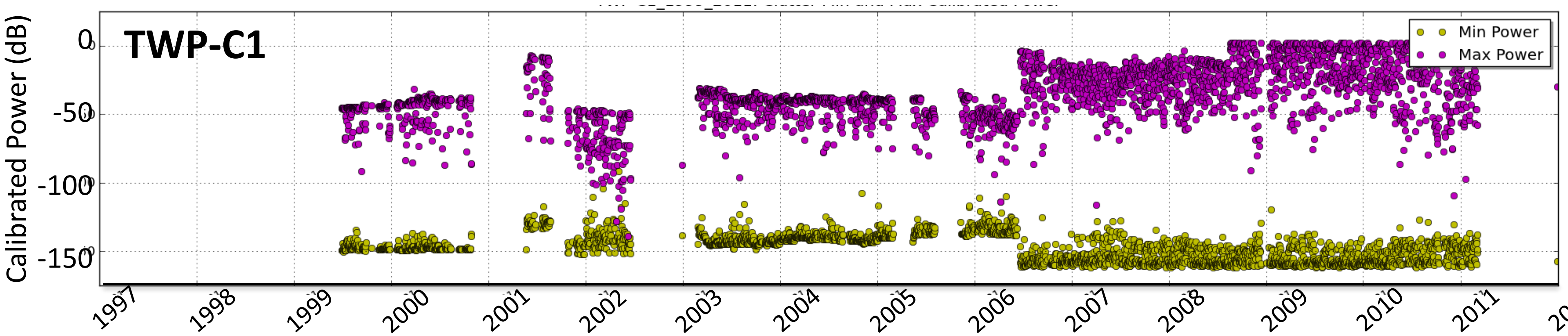
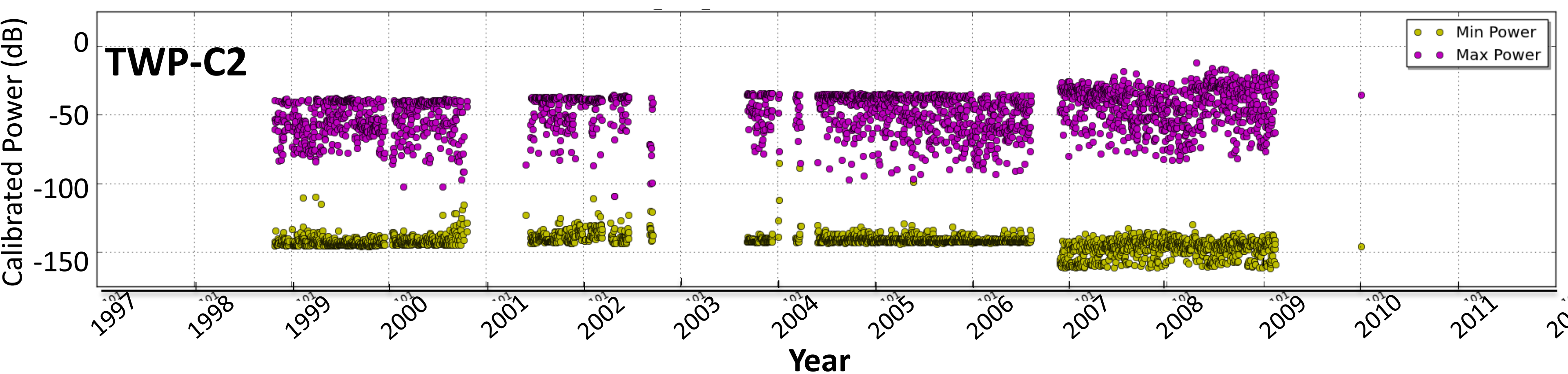
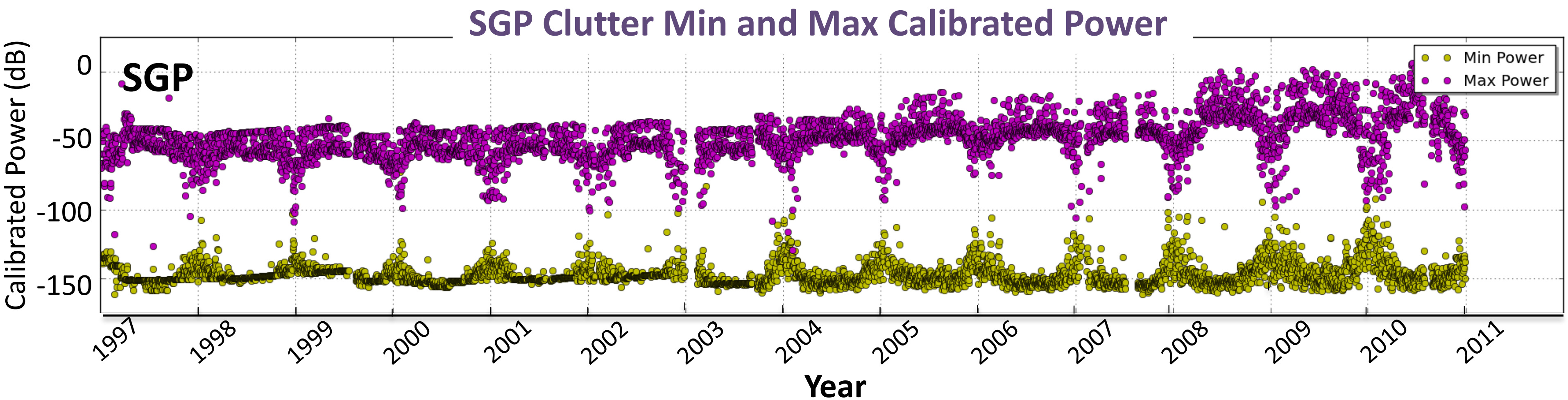
TWP-C1 Clutter Min and Max Calibrated Power

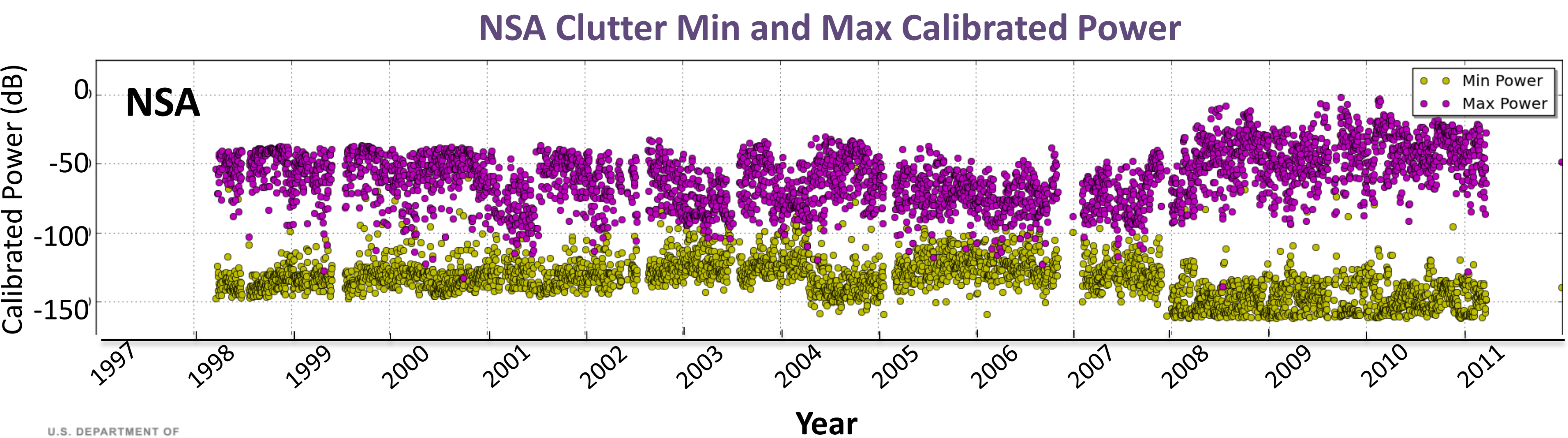


TWP-C2 Clutter Min and Max Calibrated Power



ARSCL Min/Max Clutter Reflectivity





Characterization and QC of Radar Data

Nitin Bharadwaj, Brad Isom, Joe Hardin, Andrei Lindenmaier, and Alyssa Matthews
ARM Radar Engineering and Operations Group

Pacific Northwest National Laboratory

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Characterization and QC of Radar Data

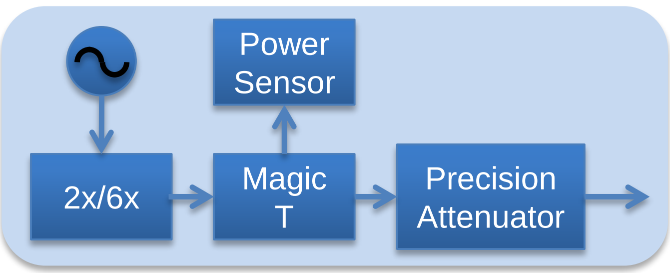
- Calibration and Characterization
  - Reflectivity
  - Differential reflectivity
  - Signal processing
  - Linear depolarization ratio
- QC
  - Signal detection mask
  - Clutter mask
  - Beam blockage mask
  - Blanking mask
  - Cloud mask

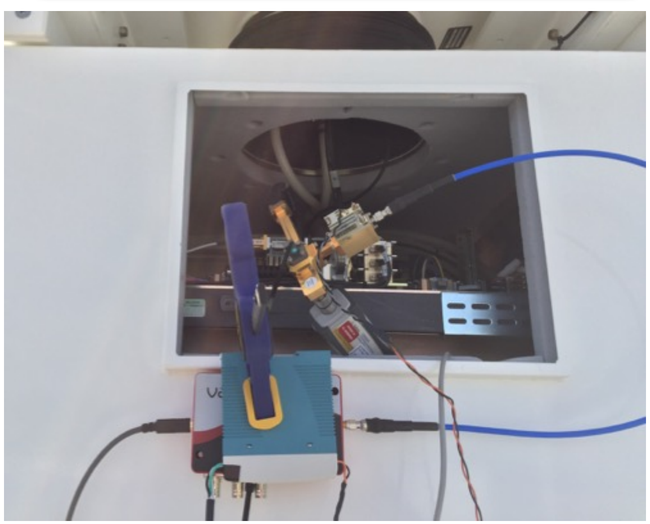
Reflectivity at ENA SACR

- Calibrations of co-located radars must be consistent with each other

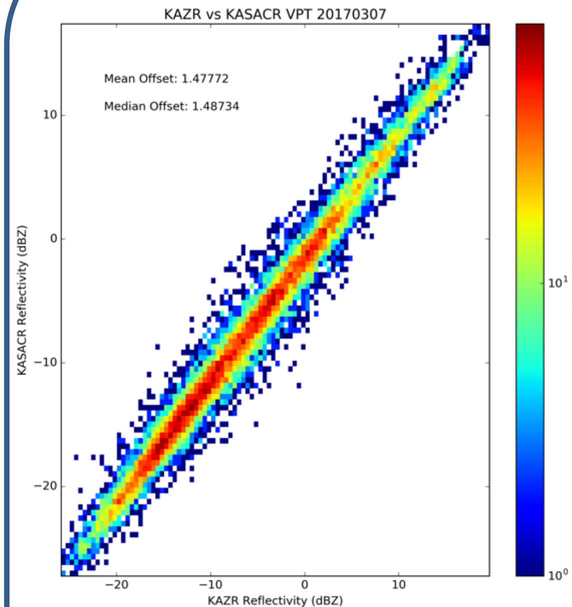
System measurements

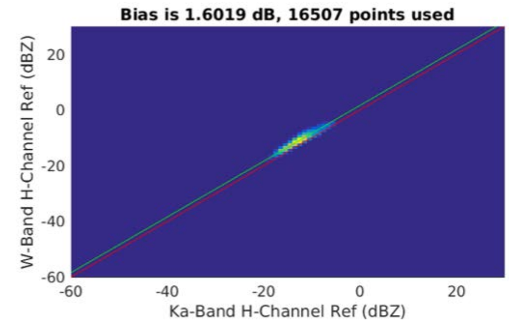
- Test equipment
- Built-in test equipment

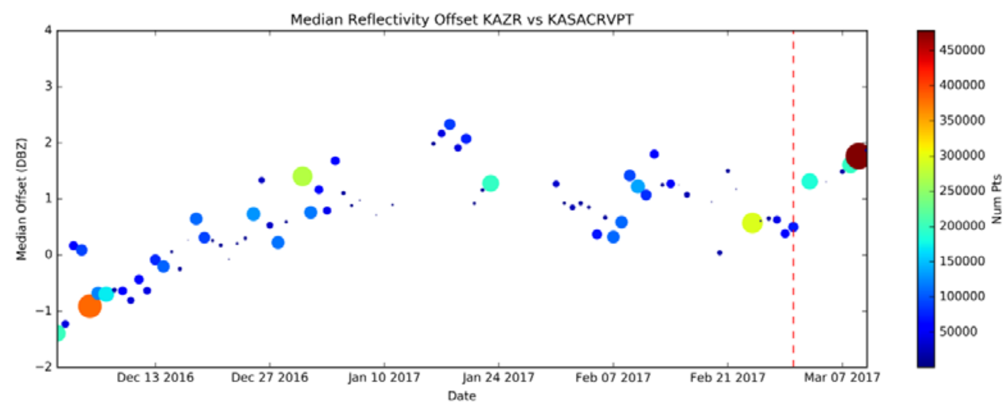




Relative Calibration

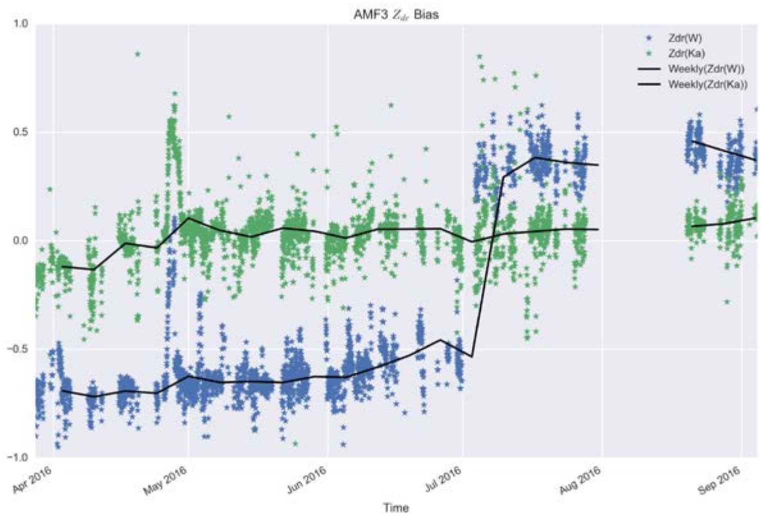


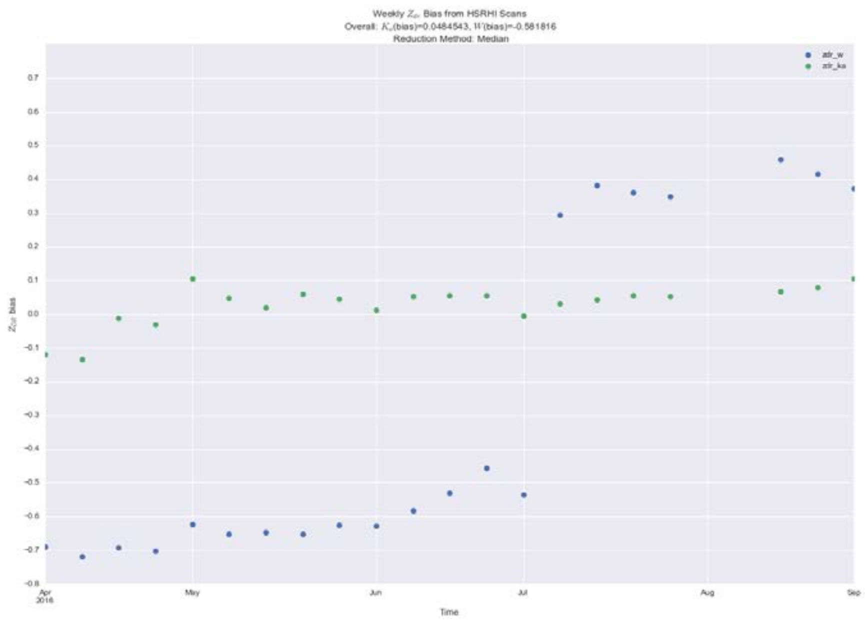




Differential Reflectivity at AMF3 SACR

- Routine ZDR system offset estimated from
  - Birdbath scans
  - HSRHI scans
- Tracking changes in ZDR system offset





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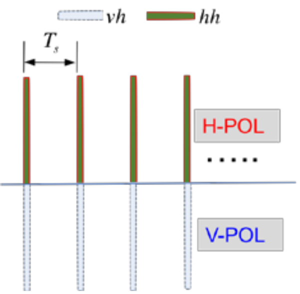
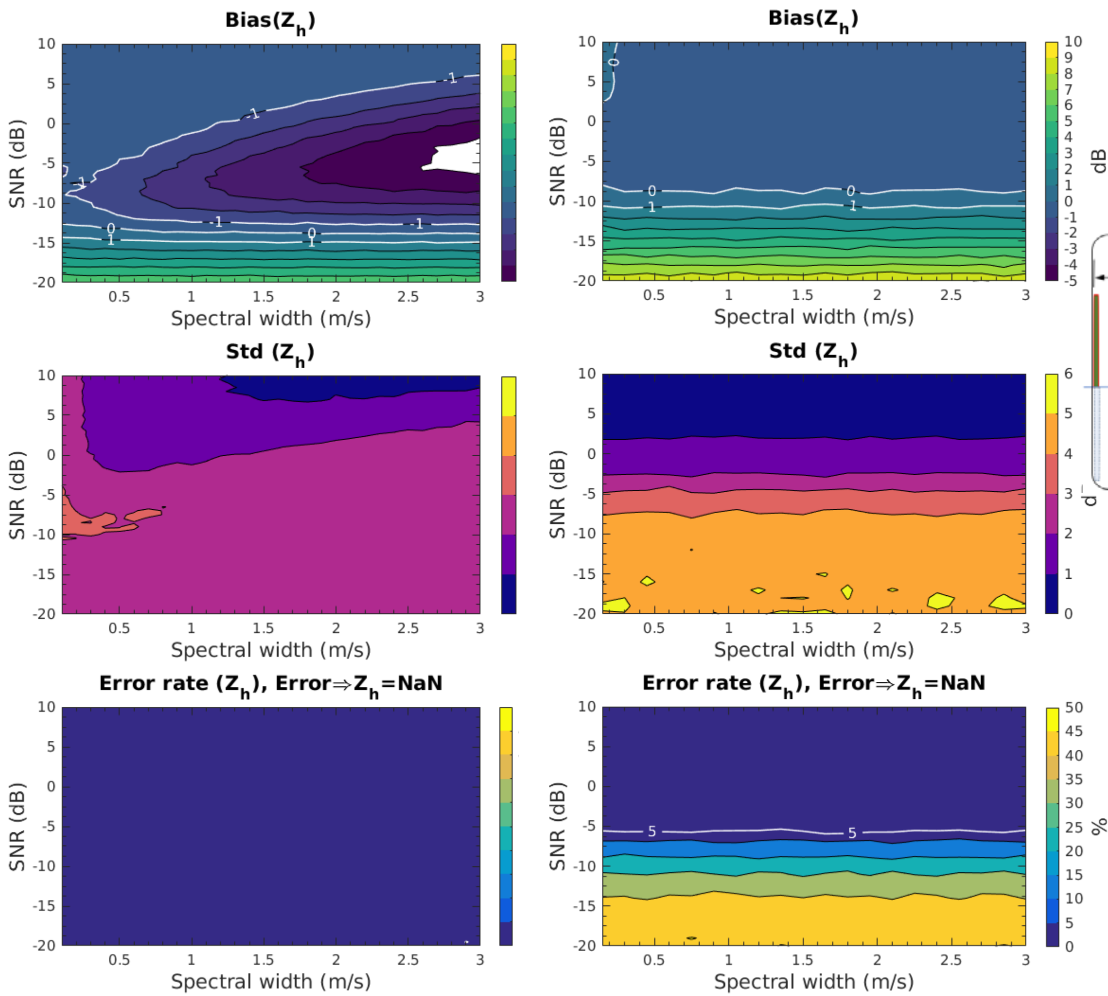
Signal Processing SACR

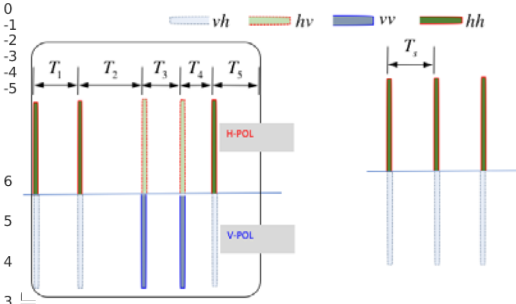
- Error characterization of the estimators

Uniform pulsing





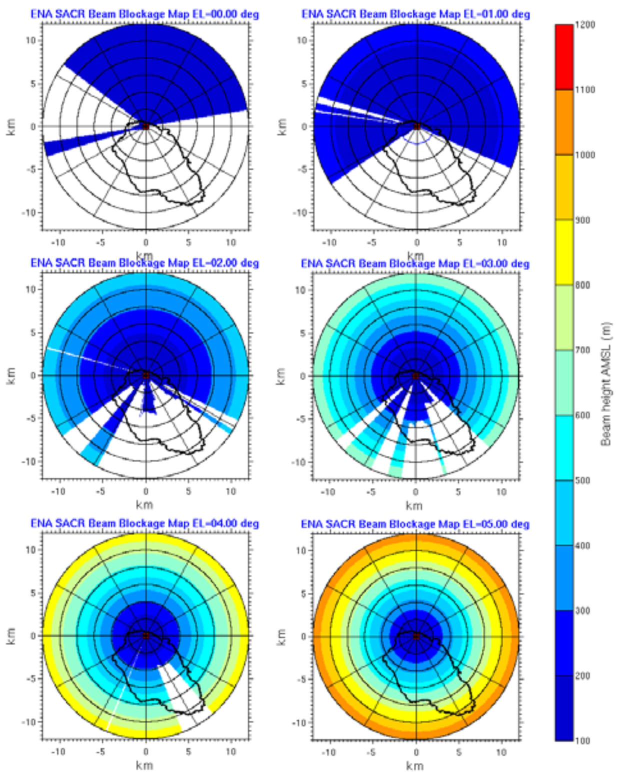
SACR2 pulsing



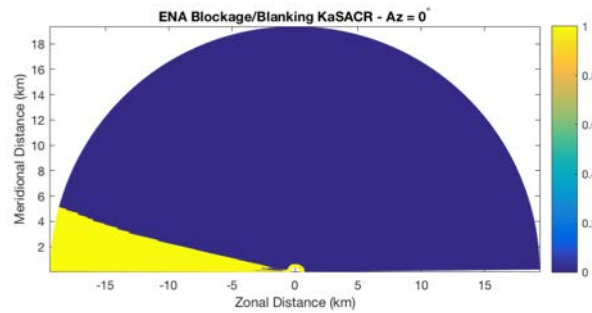
Beam blockage and blanking

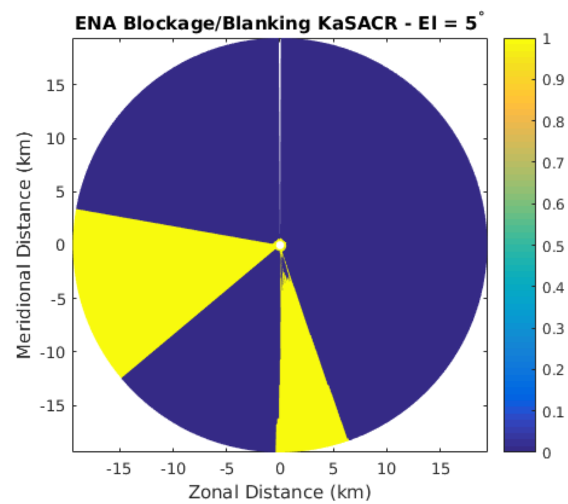
- Beam blockage mask estimated from data
- Blanking verified with data

DEM Only - Blockage



Data Only – Blockage and





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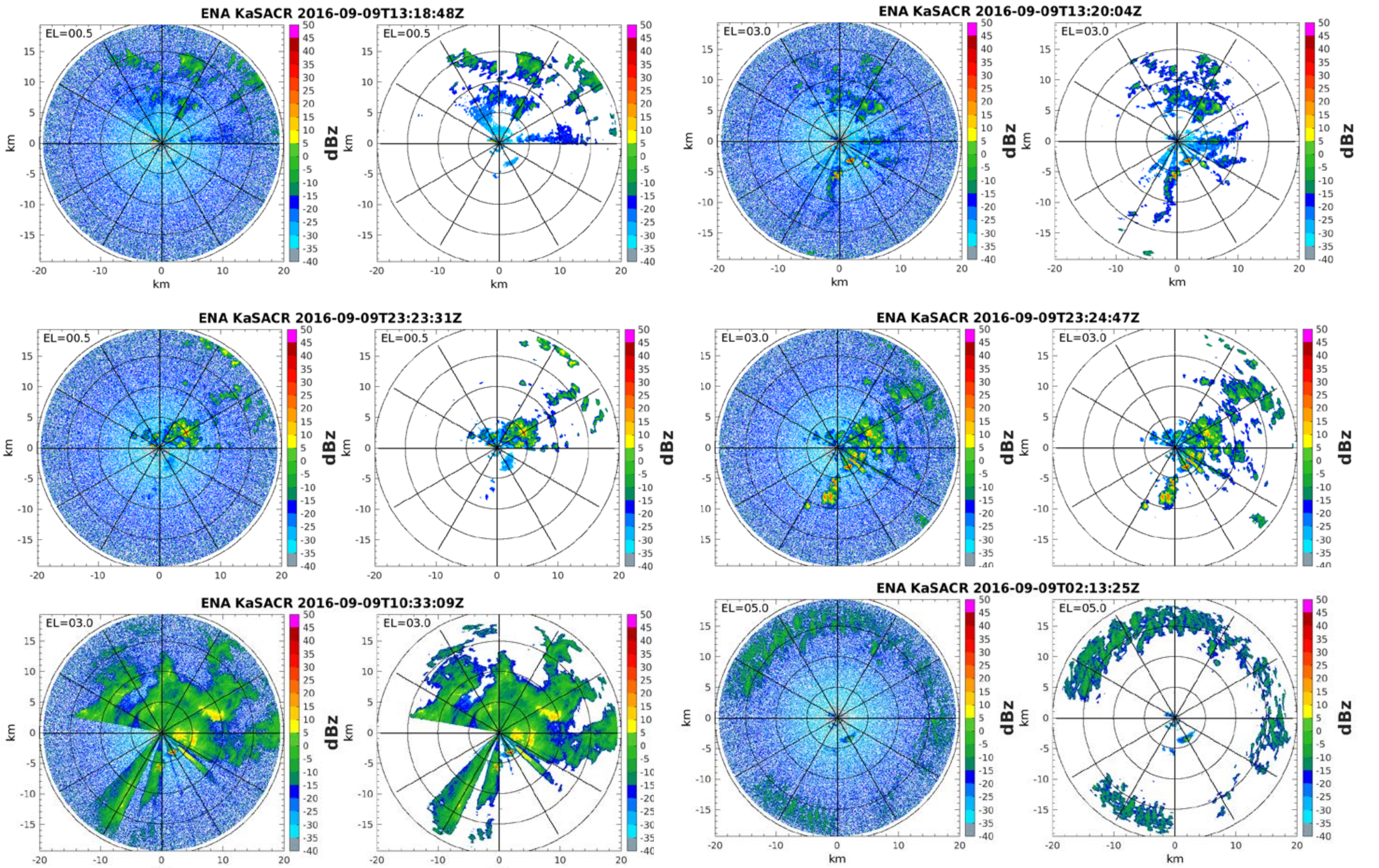
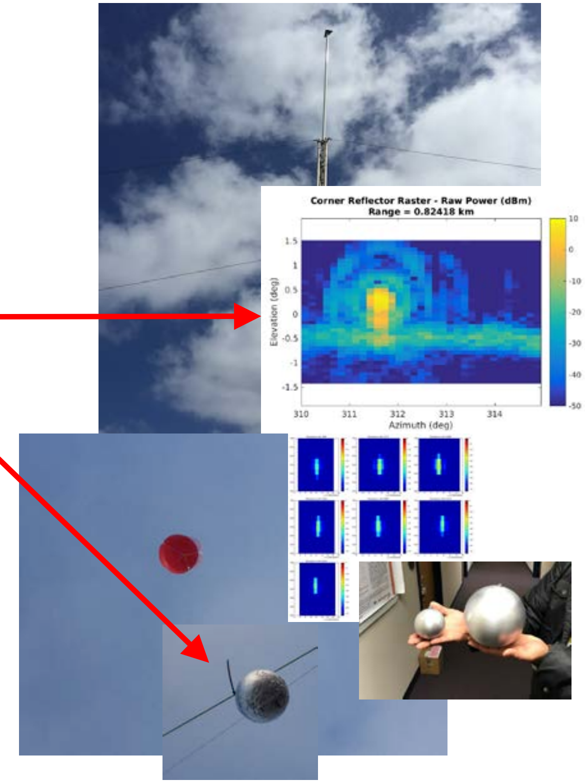
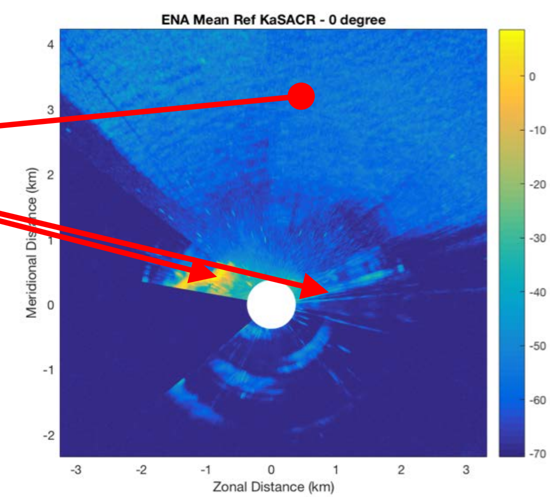
Signal detection



In Progress

- Calibration and Characterization
  - Reflectivity
    - Cross validation with calibration target
  - Differential reflectivity
  - Signal processing
  - Linear depolarization ratio
    - ICPR will be computed and bounds provided
- QC
  - Signal detection mask
  - Clutter mask
    - Ground clutter
    - Sea clutter
  - Beam blockage mask
  - Blanking mask
  - Cloud mask
    - Composite mask to categorize cloud





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Data Highlight and Packaging

Giri Prakash
ARM Data Services and Operations Manager

ARM/ASR Meeting 2017

Workflow

- Collection → Data highlight → Metadata database
- Dissemination → User discovery → download
- User Feedback → ServiceNow or Trello → Review and update

Data Highlights “Golden Period”

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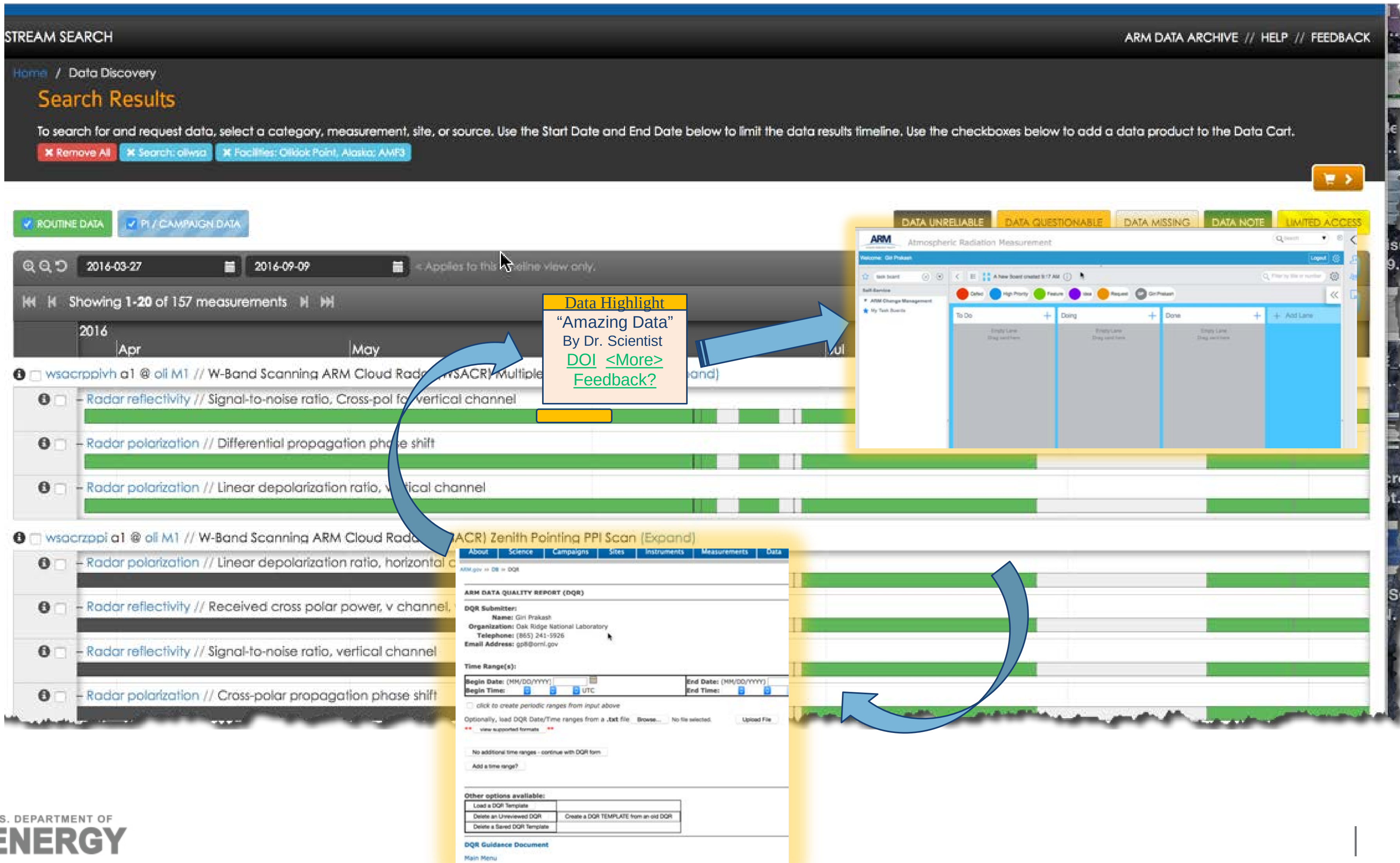
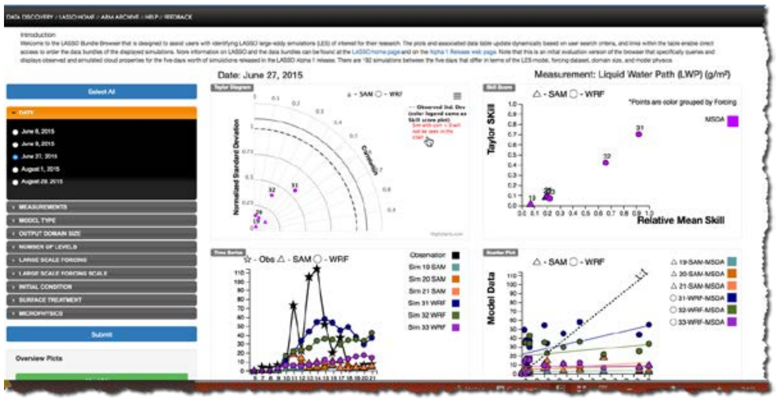
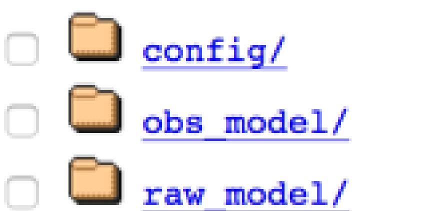


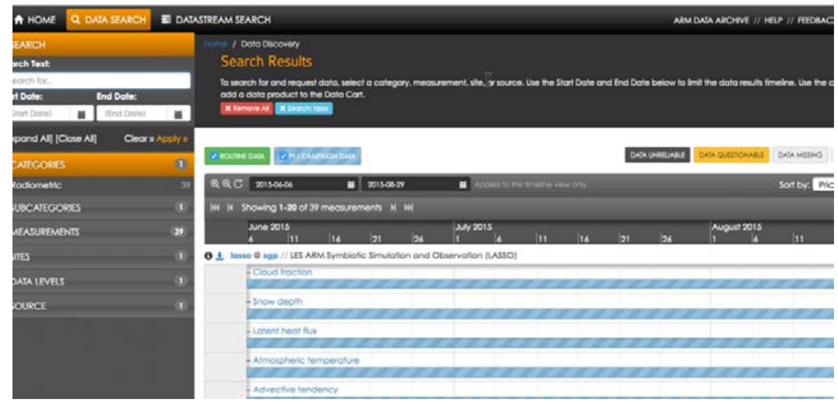
U.S. DEPARTMENT OF
ENERGY

LASSO Data Package and Access



http://www.archive.arm.gov/lassobrowser





Data selection, packaging and delivery