In-Cloud Velocity Product Breakout Session (Christopher Williams)

Presented this morning by Sally McFarlane

ARM Mission Statement

The Atmospheric Radiation Measurement (ARM) user facility, a DOE Office of Science user facility managed by the Office of Biological and Environmental Research, provides the climate research community with strategically located atmospheric observatories to improve the understanding and representation in earth system models of clouds and aerosols and their interactions with the Earth's surface.

ARM Vision Statement

To provide the research community with the best array of field observations and **supporting state-of-the-art data analytics** to significantly improve the representation of challenging atmospheric processes in earth system models.

In-Cloud Velocity Product Breakout Session (Christopher Williams)

Presented this morning by Shaima Nasiri

ASR Goal Statement

The goal of the Atmospheric System Research (ASR) program is to improve understanding of the key cloud, aerosol, precipitation, and radiation processes that affect the Earth's radiative balance and hydrological cycle, particularly processes that limit the predictive ability of regional and global earth system models.

ASR Objective Statement

To achieve this goal, ASR supports research that uses observations to improve understanding of atmospheric processes. ASR works closely with the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) user facility, using ARM's measurements of radiation, aerosols, clouds, precipitation, thermodynamics, turbulence, and state variables. ARM's continuous observational data sets are supplemented with process models, laboratory studies, and shorter-duration ground-based and airborne field campaigns to target specific atmospheric processes in different locations and across a range of spatial and temporal scales.

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Background

- Aim of 2022 ARM/ASR in-Cloud Velocity Product breakout session
  1. Solicit community feedback on the **scientific needs** of in-cloud velocity for **process understanding** and **model evaluation**.
  2. Discuss issues in developing in-cloud velocity retrieval methodologies.

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Background

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  2. Discuss issues in developing in-cloud velocity retrieval methodologies.

- Key results – *Scientific Needs and Interests*

  1. To **understand cloud evolution**, spatial organization, and aerosol loading, it is important to link in-cloud velocity with air motions below the cloud.
  2. To **investigate entrainment**, it is important to estimate in-cloud air motions near cloud top.

Roadblocks with Developing Vertical Velocity Retrievals

Key Issues Identified

1. Vertical velocity cannot be estimated in all places at all time.
   a) Need to identify science questions, then identify ARM measurements that can be used to estimate air motion.

2. Developing retrievals (and b1 products) is hard. It takes time to QC data, develop the retrieval, and evaluate the output.
   a) PI Products are often viewed as being more reliable than routinely processed VAPs because they are focused on the PI's science question.
   b) Once retrieval is developed, it is 'easy' to process data from other sites. But, difficult and time consuming to validate output at new site.

3. Cloud & precipitation vertical velocities are usually not analyzed in isolation.
   a) Need other data products like water vapor flux or precipitation retrieval to interpret cloud dynamics.
   b) Some cloud regimes require multiple sensors to estimate air motion outside and within cloud (i.e., lidar & radar)

4. ARM has the capability to collect both short- and long-term datasets.
   a) Some science questions need many cases (aka long-term datasets) to build up statistics.
   b) Some science questions require calibrated b1 products for short-term studies for detailed analysis.
   c) ARM data will be used to address unknown future science questions.

Survey Results from 2022 ARM/ASR Breakout (1/4)

There were 21 survey responses.

In-Cloud Vertical Velocity Survey Questions

updated: 16-Nov-2022

For these survey questions, use these four radar centric categories:

Clouds

The radar pulse volume is filled only with cloud particles.

Definition: Cloud particles remain suspended due to atmospheric dynamics

Precipitation

The radar pulse volume is filled only with precipitating particles.

Definition: Precipitating particles are large enough to overcome cloud dynamic motions and precipitate out of clouds.

Cloud and Precipitation

The radar pulse volume contains both cloud and precipitation particles.

Survey Results from 2022 ARM/ASR Breakout (2/4)

- Survey Results (2/3)

Question #1

If you had $100, how much money would you donate to each category to advance vertical air motion retrievals in that category?

	$0	$25	$50	$75	$100	Total #	Total $
Clouds	7	8	4	2	0	21	$550
Precipitation	5	14	1	1	0	21	$475
Clouds & Precipitation	3	7	5	2	4	21	**$975**
No Donation. I want to keep my money	19	1	0	1	0	21	$100
							$2,100

Question #2

You have another $100 to donate. Focusing only on radar volumes containing just clouds, how much money would you donate to estimate vertical air motion in:

	$0	$25	$50	$75	$100	Total #	Total $
Clouds with only warm processes (only liquid particles)	2	6	6	6	1	21	**$1,000**
Clouds with ice processes (frozen and liquid particles)	3	6	4	6	2	21	**$1,000**
No donation. I want to keep my money.	19	0	2	0	0	21	$100
							$2,100

Survey Results from 2022 ARM/ASR Breakout (3/4)

- Survey Results (3/3)

Question #3

You have another $100 to donate. Focusing only on radar volumes containing just precipitation, how much money would you donate to estimate vertical air motions in:

	$0	$25	$50	$75	$100	Total #	Total $
Liquid raindrop precipitation during convective processes (air motion magnitude greater than 1 m/s)	4	8	4	3	2	21	**$825**
Liquid raindrop precipitation during stratiform or frontal systems (air motion magnitudes less than 1 m/s)	6	12	3	0	0	21	$450
Frozen particle precipitation that reaches the ground as frozen particles	10	8	1	2	0	21	$400
Frozen particle precipitation above the freezing level that will melt into raindrops before reaching the ground	9	11	1	0	0	21	$325
No donation. I want to keep my money.	20	0	0	0	1	21	$100
							$2,100

Question #4

You have another $100 to donate (you broke the piggy bank for this $100). Focusing only on radar volumes containing both clouds and precipitation, how much money would donate to estimate vertical air motions in:

	$0	$25	$50	$75	$100	Total #	Total $
Clouds with **warm processes** that produce drizzle	3	6	6	6	0	21	$900
Clouds with **ice processes** that produce frozen precipitation	1	6	6	5	3	21	**$1,125**
No donation. I want to keep my money.	20	0	0	1	0	21	$75
							$2,100

Survey Results from 2022 ARM/ASR Breakout (4/4)

- Recommendations
  1. Equal support to focus on **warm cloud processes** (with liquid precipitation) and **ice cloud processes** (with frozen precipitation).
  2. Community may consider **cloud only** cases to be simplifications of the harder mixed cloud and precipitating particle cases, but they are different retrievals with different assumptions.
  3. Community suggested **ARM provide calibrated and QC'd data** and let the **community produce in-cloud velocity products**.

Next Steps?

Key take-a-ways that are driving our next steps

- Equal weight to study warm clouds and ice clouds
- Retrievals are hard to develop and usually need a dedicated person to perform the QC
- Key ingredients include **Calibration**, **QC**, and **Retrieval Algorithms**

ARM is focusing energy towards radar **Calibration**

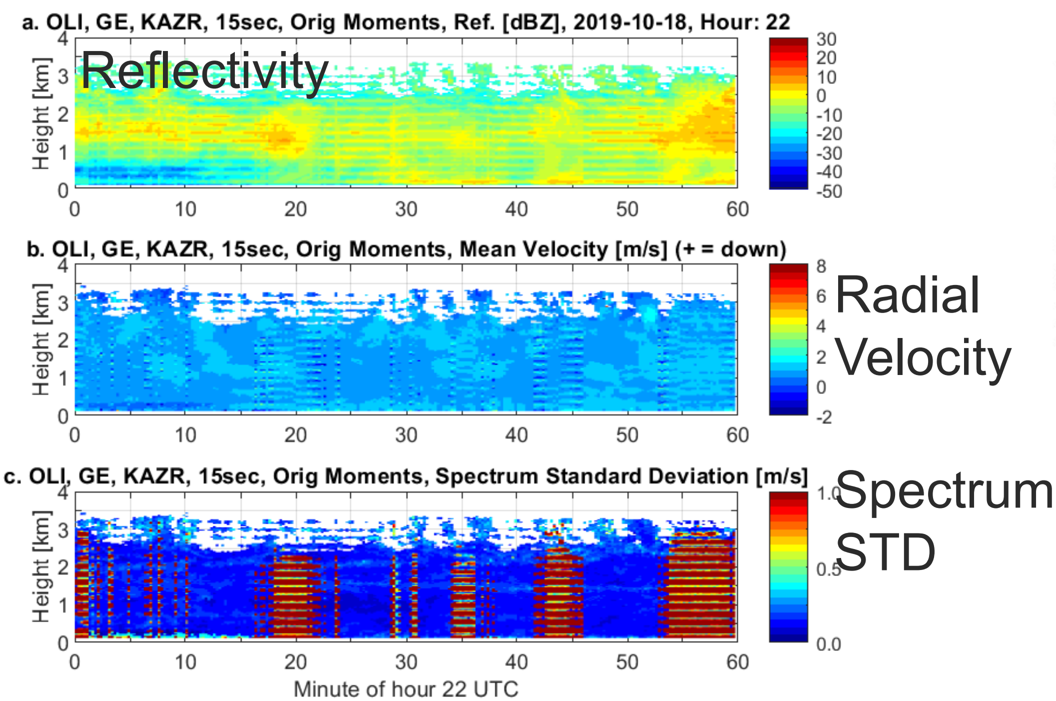
What do we do about **QC** and **Retrieval Algorithms**?

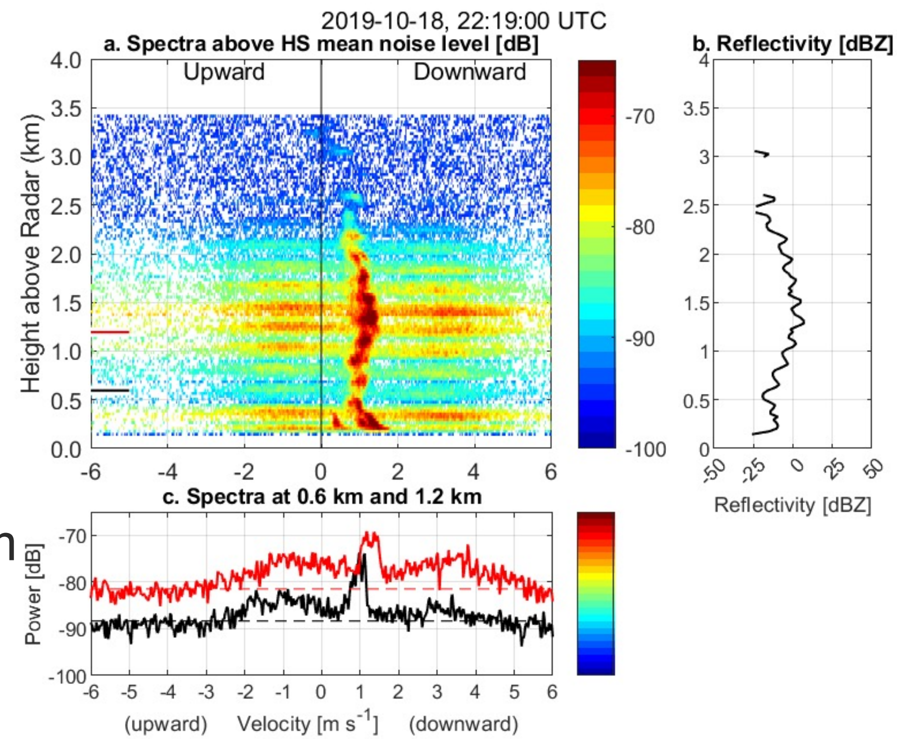
Remaining slides include:

1. Examples of radar data needing **QC**
2. Path forward for **QC**: Open-source codes, PI Products, or ARM Products?
3. Path forward for **Retrieval Algorithms**: Community coding effort?

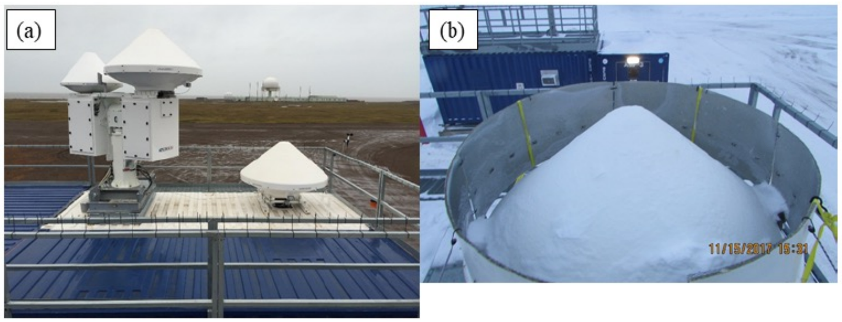
MOSAiC – Internal Interference

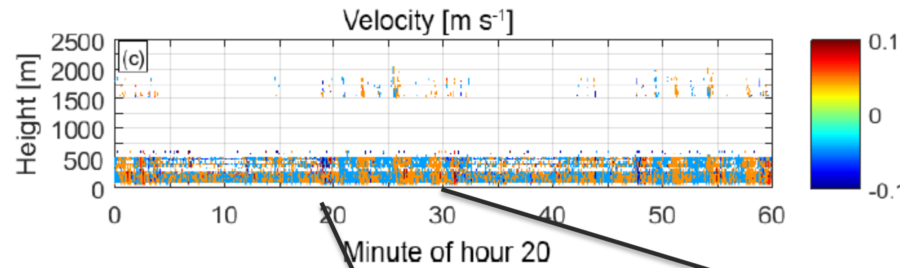
Spectrum Moments

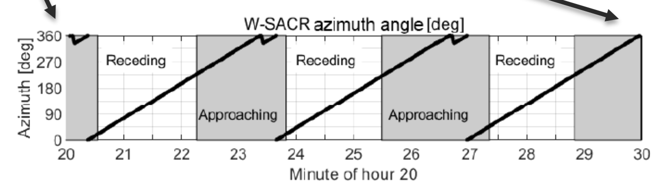




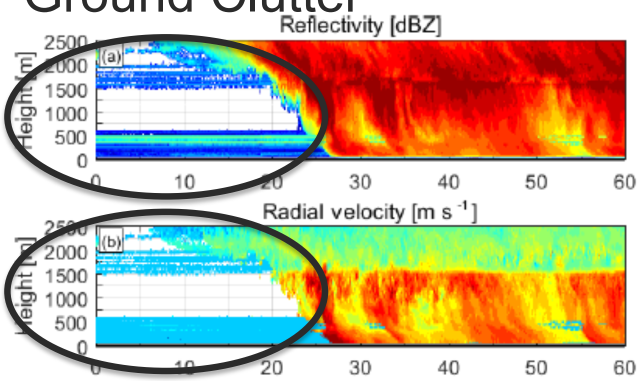
Oliktok Point – Ground Clutter with & w/out Radial Motion

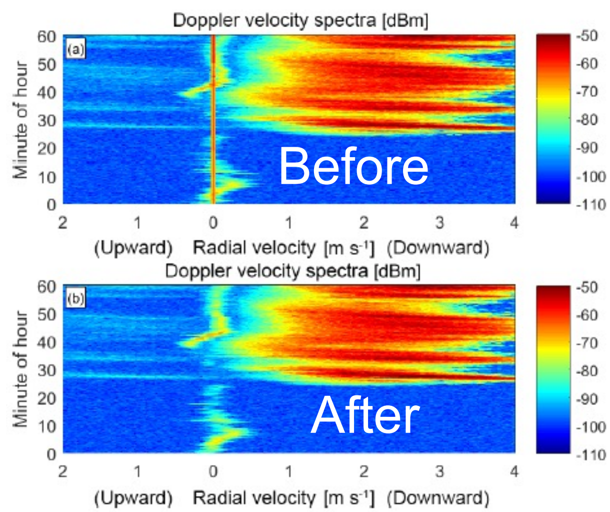




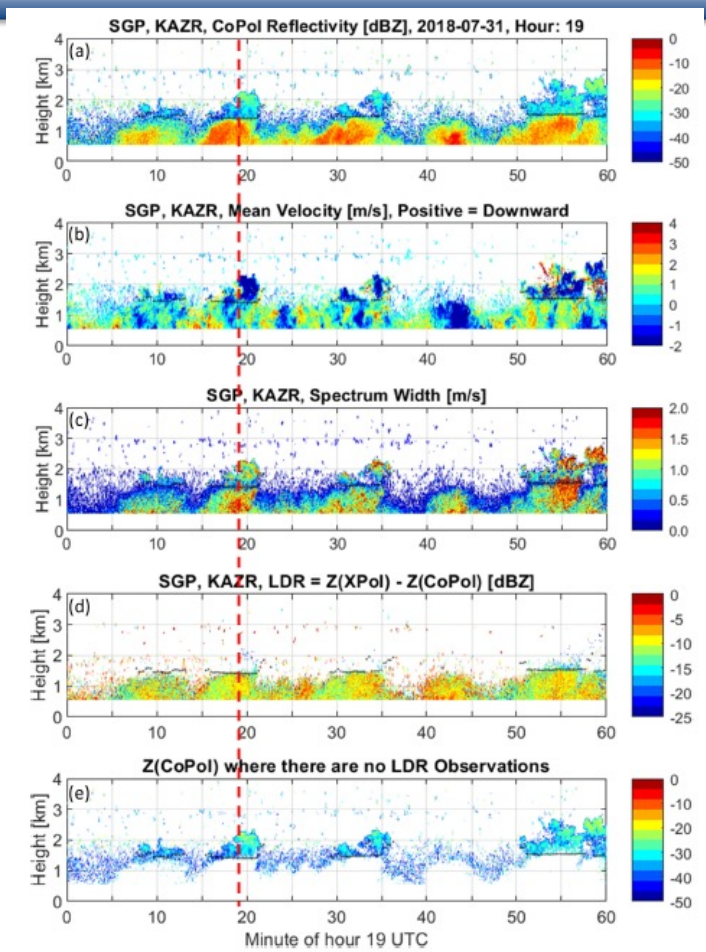


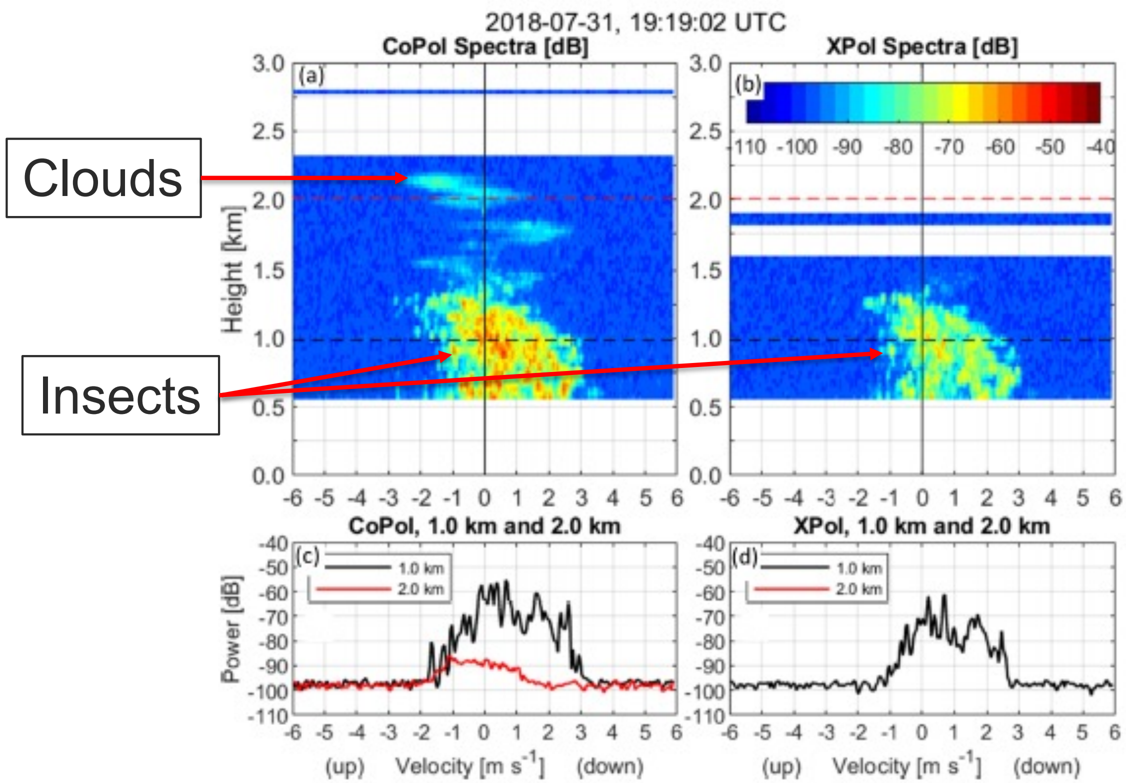
Ground Clutter



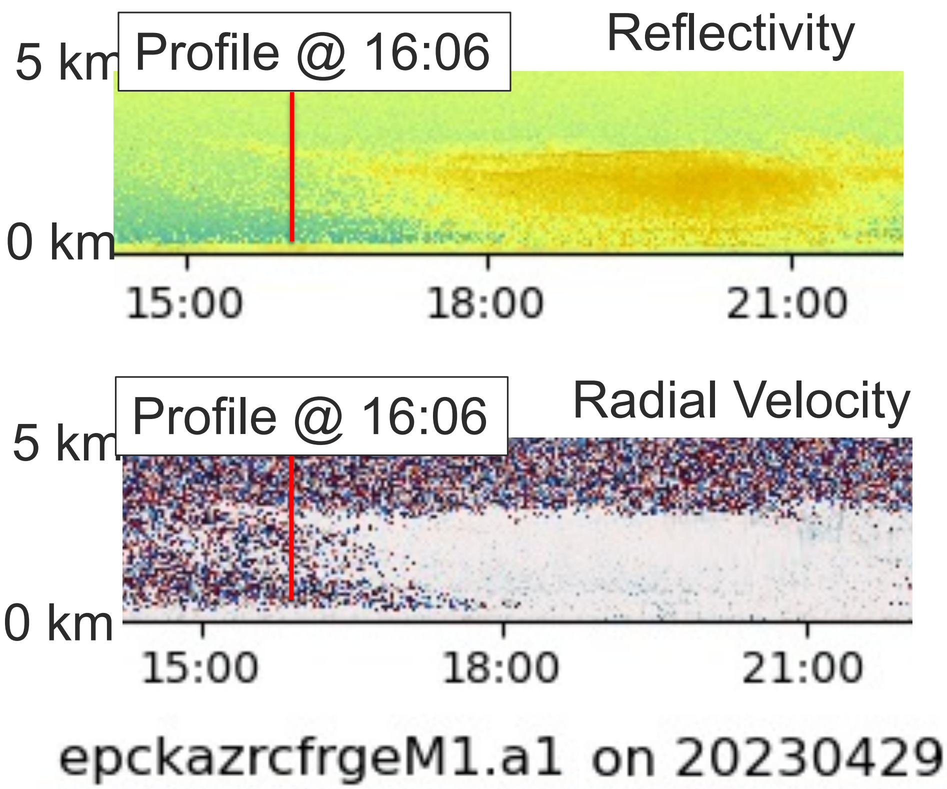


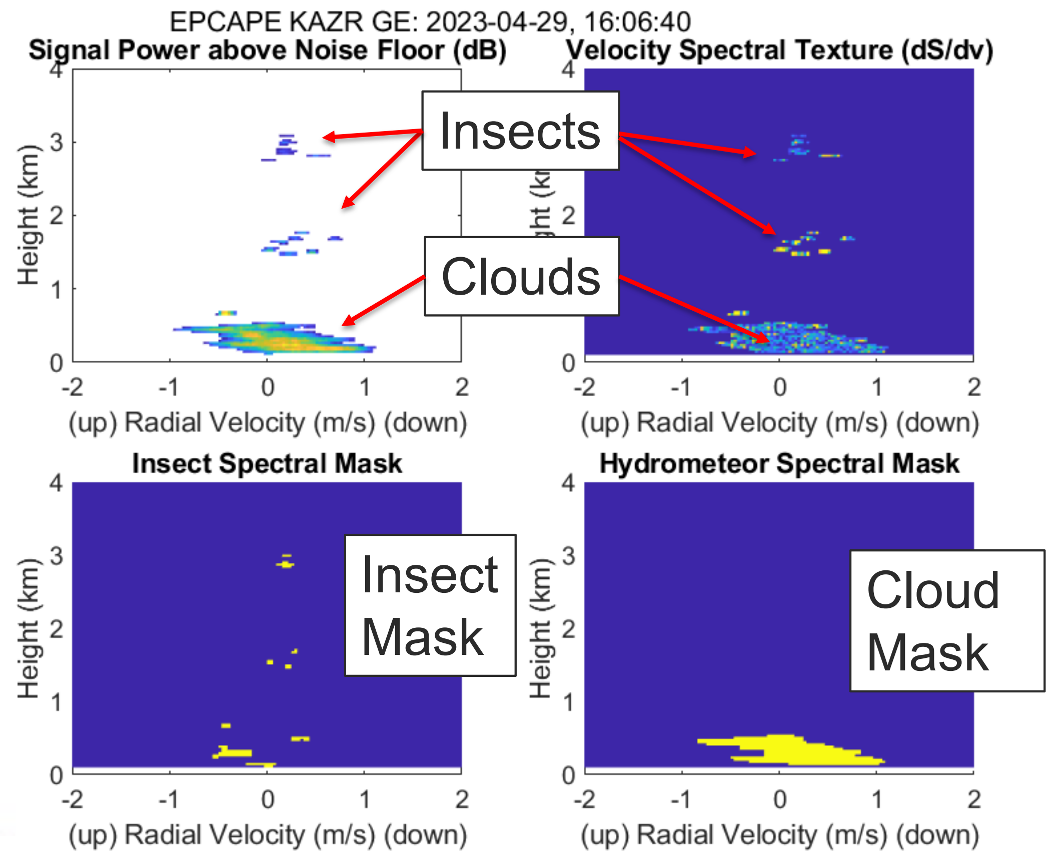
SGP – Insects – LDR helps, but not the solution





EPCAPE – Insects / Chaff / Other Filers





Path Forward for Data QC

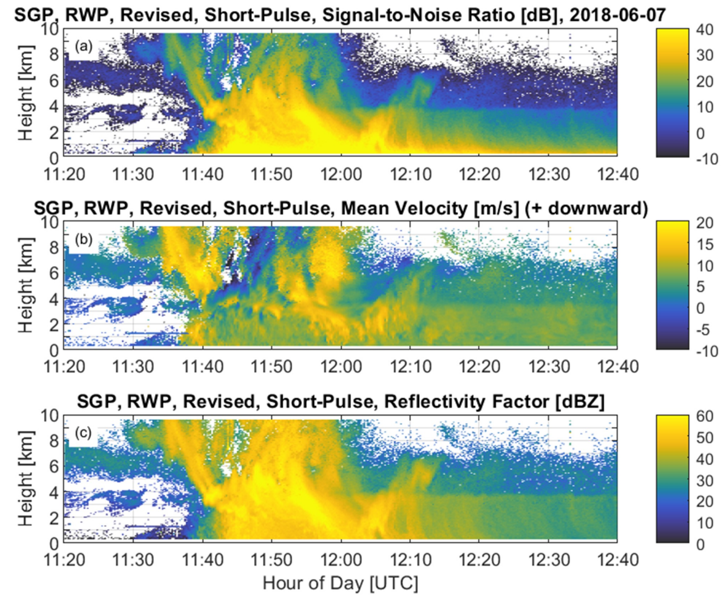
Need to identify and remove non-atmospheric returns before performing atmospheric retrievals.

Options Include:
1. Open-source code (ASR scientists do their own QC)
2. PI Product stored on ARM Archive
3. ARM Product (b1 or c1 level product)

ASR Radar Wind Profiler (RWP) Data Product Project

Spectra processing to estimate unbiased moments and calibrate against surface disdrometer.

1. Open-source code: Python code on Github
2. PI Product: 10-years calibrated SGP data on ARM Archive
3. ARM Product: Python code integrated into ARM ADI



Request for your Advice

Regarding **QC**, which path do you recommend ARM pursue?

(show of hands – Vote for only one!)

1. Open-source code (ASR scientists do their own QC)
2. PI Product stored on ARM Archive
3. ARM Product (b1 or c1 level product)

What are the barriers preventing your contribution?

(open discussion)

Regarding **Retrieval Algorithms**, is there interest in forming a community effort to develop community codes to retrieve in-cloud velocities in different regimes?

(open discussion)