

## New Doppler Spectral Processing Technique for Identifying Atmospheric Signals from Radar Wind Profilers

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# The ARM Climate Research Facility

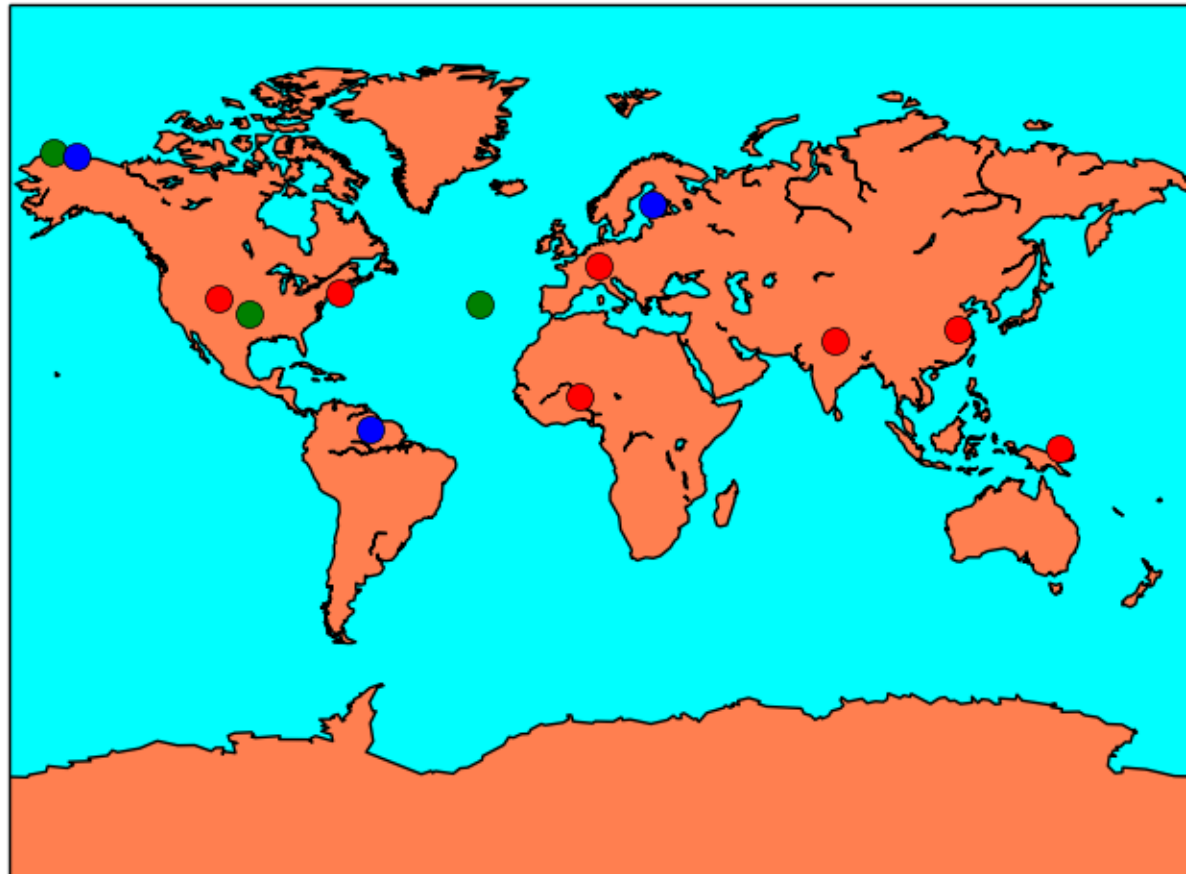
- The U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Climate Research facility provides *in situ* and remote sensing data with a mission to **improve climate and earth systems models**.
- The program operates a **large number of instruments**. Many of these instruments are **deployed together** to provide a more complete description of the system being measured.
- Instruments are located at three **fixed sites** as well as two **mobile facilities** that can be deployed in support of field campaigns around the globe.
- Many of the programs dataset covers an **extended time period** with continuous operation for more than a decade.

# Introduction to the ARM Radar Wind Profiler (RWP)

- ARM operates a number of Radar Wind Profiles (RWP) at both fixed sites and mobile facilities.
- The profilers provide **Doppler spectra, radar moments**, and a **consensus** profile of wind speed and direction.
- Instruments operate in 2 modes:
  - “wind” for obtaining wind profiles.
  - “precip” for radar moments with a high time resolution.



# Locations of ARM RWP instruments

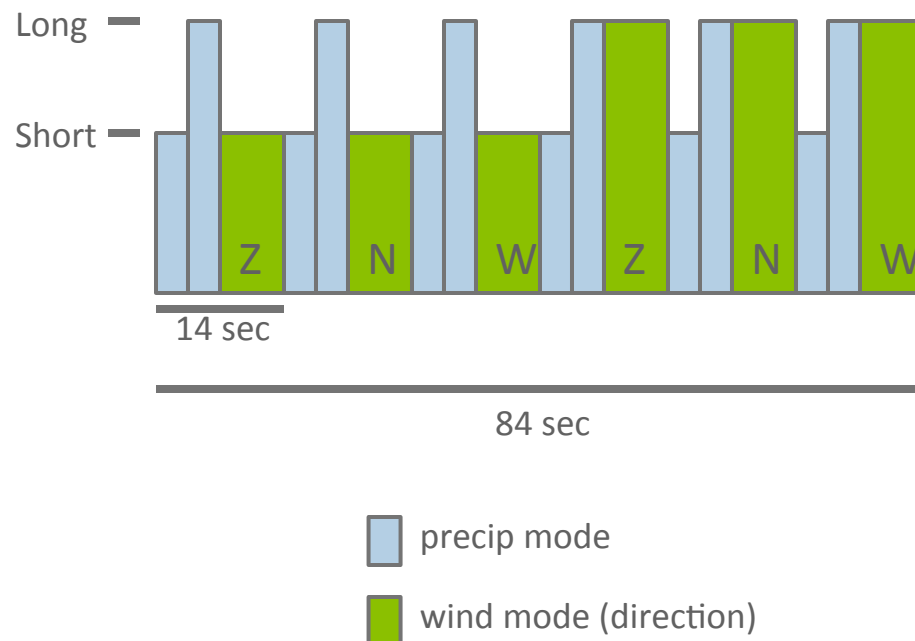


- : Fixed site
- : Mobile facility
- : Past mobile facility

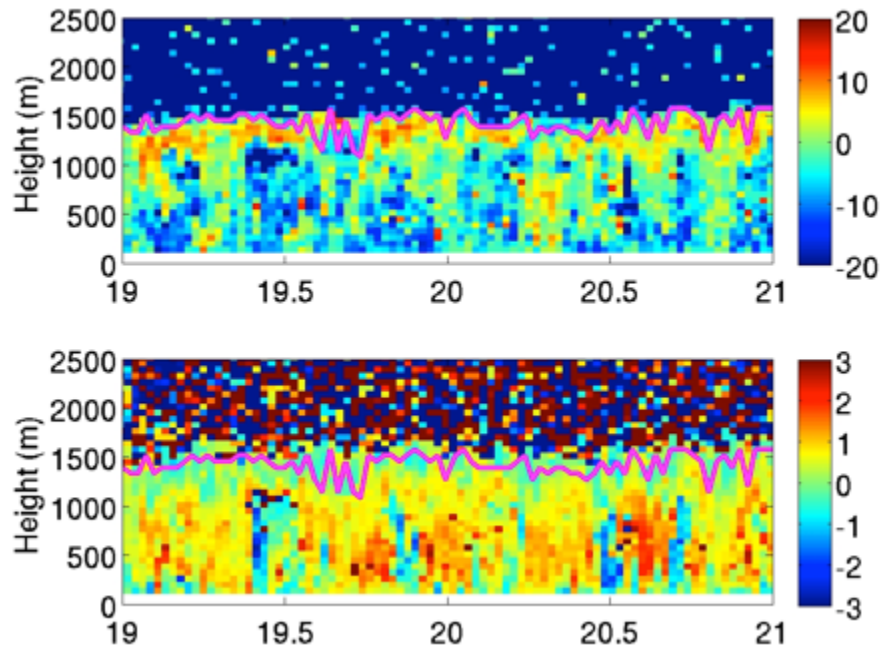
# Operational Modes and Specification

## Operating parameters of the ARM RWP

Parameter	Wind Mode	Precip Mode
Frequency	915 MHz	915 MHz
Beam width	8 degrees	8 degrees
Pulse width	417/2833 ns	417/2833 ns
FFT bins	64/64	128/128
Range gates	40/30	75/75
Range spacing	61/200 meters	120/206 meters
Min height	.136/.284 km	.327/.327 km
Max height	2.5/6.2 km	9.2 / 15.6 km
Time resolution	~84 seconds	~ 14 seconds



# Atmospheric parameters from RWP data

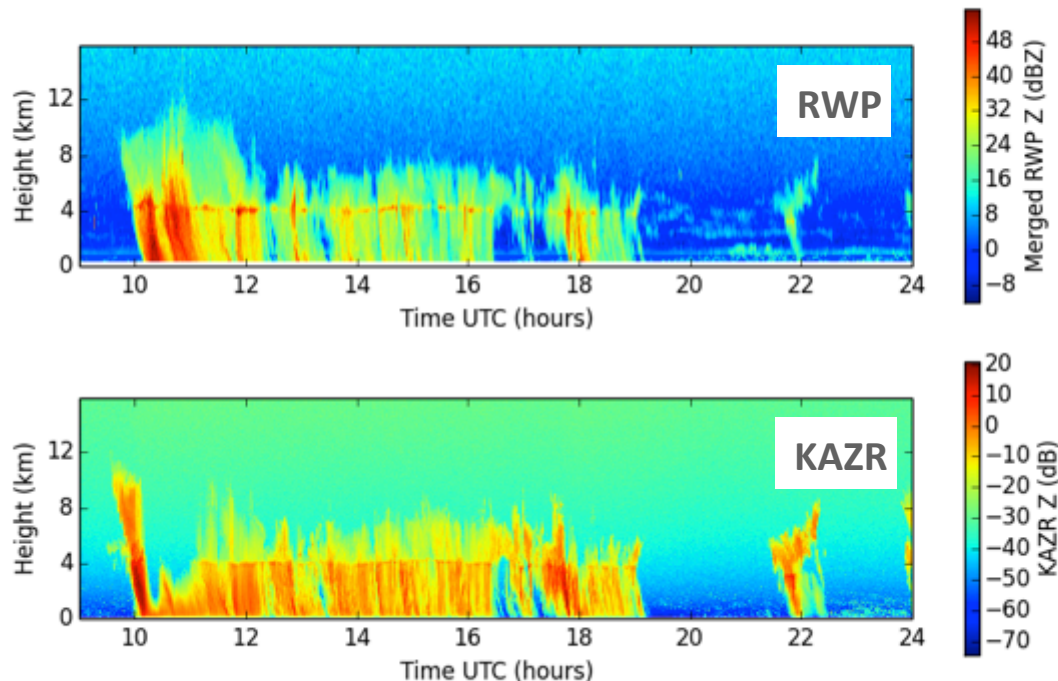


PBL height derived from RWP moments.

- Currently only the spectra, radar moments, and consensus winds, are available from the ARM RWP.
- A number of atmospheric parameters may be determined from RWP measurements:
  - Planetary boundary layer height
  - Cloud top height
  - Vertical wind speed and direction
  - TKE dissipation rates
  - Index of refraction
  - Rain rate

# Previous work with RWP spectra and moments

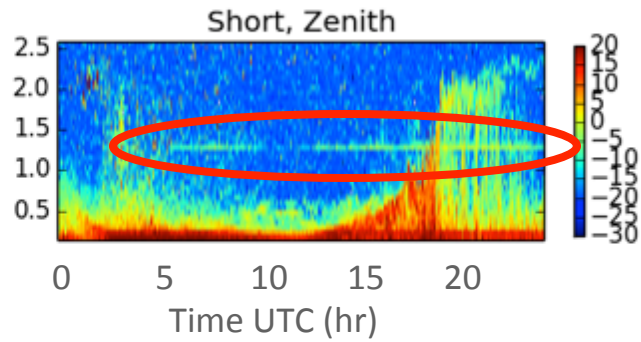
Previous work focused on the “precip” mode data. Expanding on the method of Tridon *et al*<sup>1</sup>, moments were calculated from Doppler spectra, pulse modes merged and a reflectivity value calculated using data from a co-located disdrometer. Data available for summer 2012, 2013.



[1] Tridon *et al*. Journal of Atmospheric and Oceanic Technology, 2013, 30, 1038.

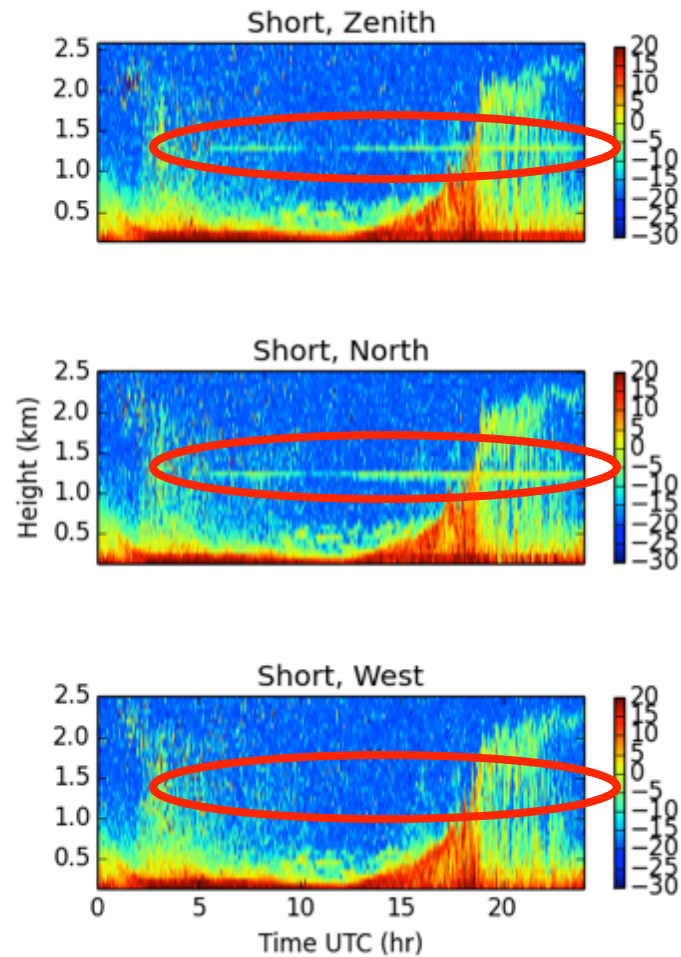


# Clutter in the ARM RWP Moments

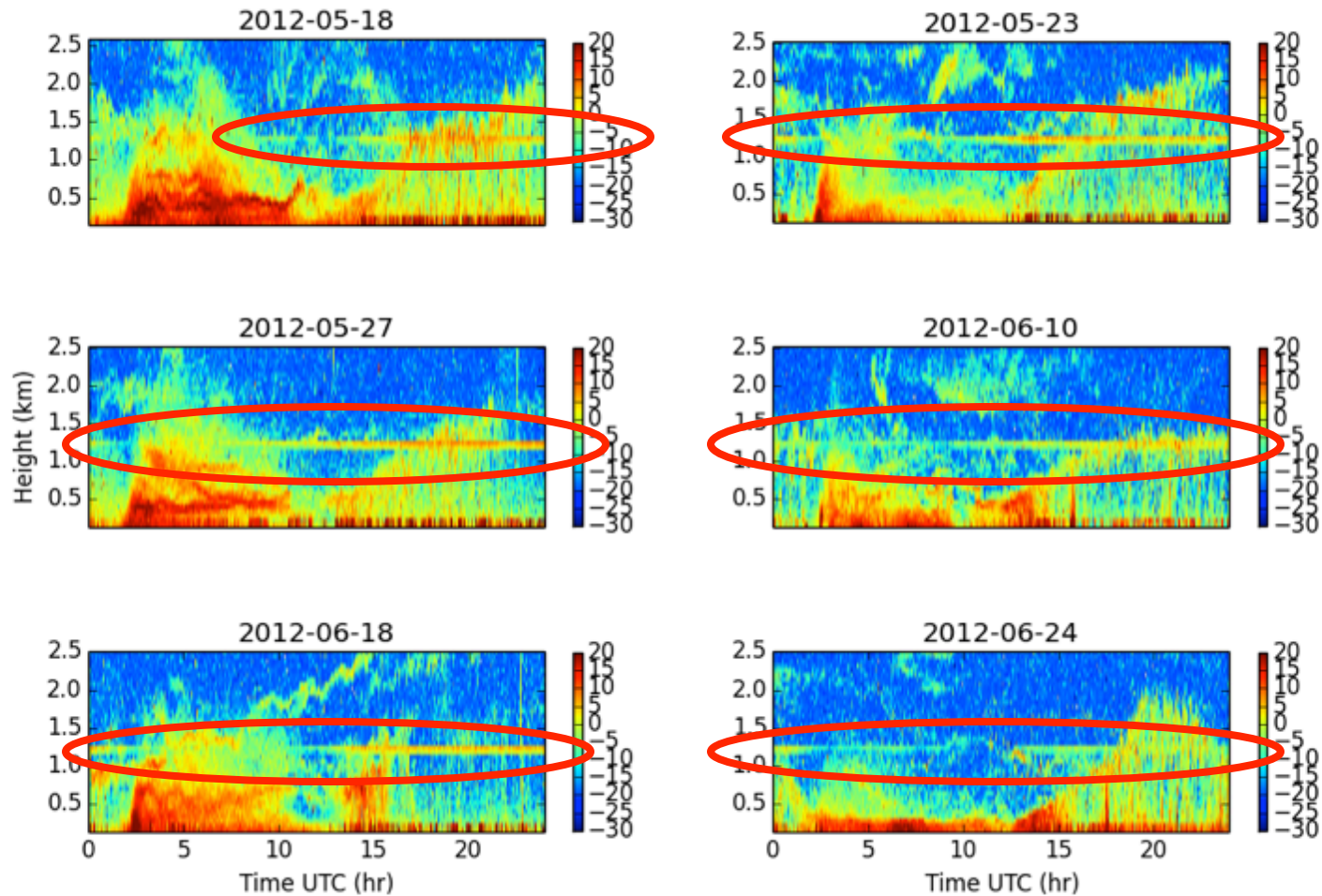




# Clutter in the ARM RWP Moments

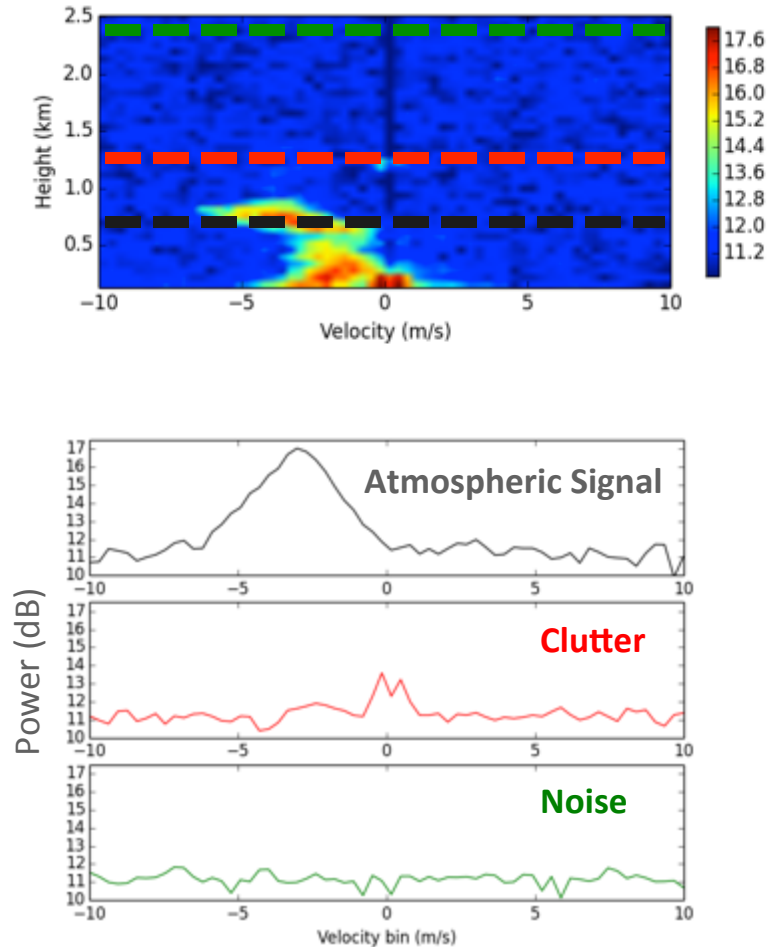
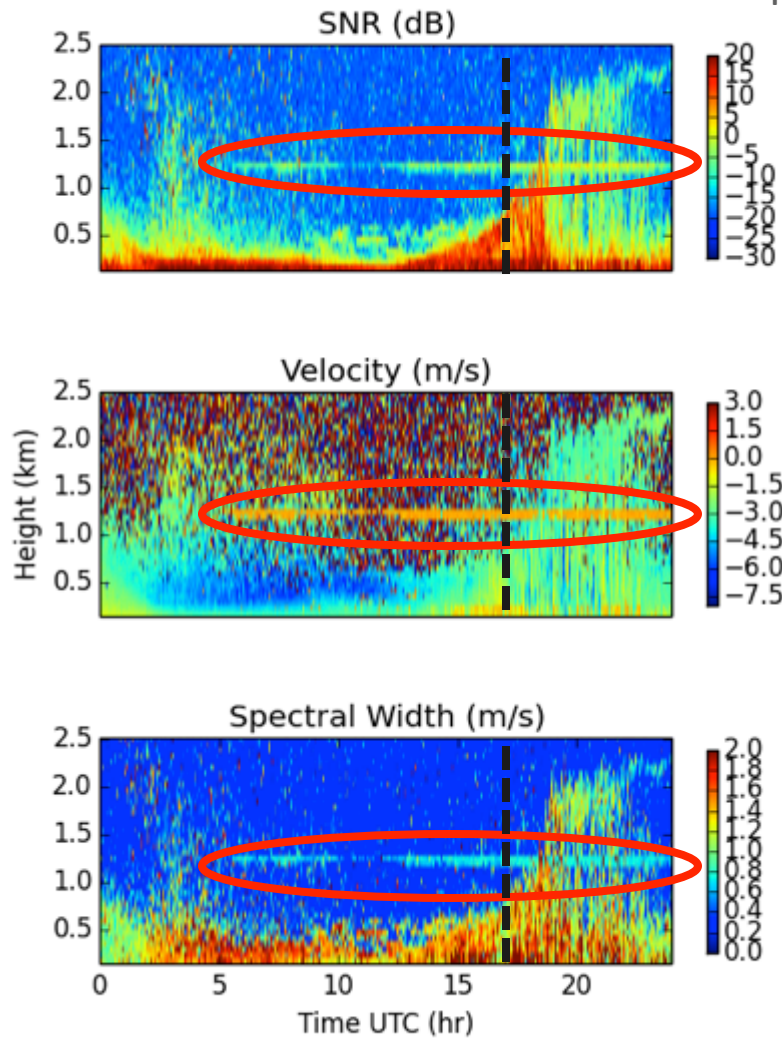


# Clutter in the ARM RWP Moments

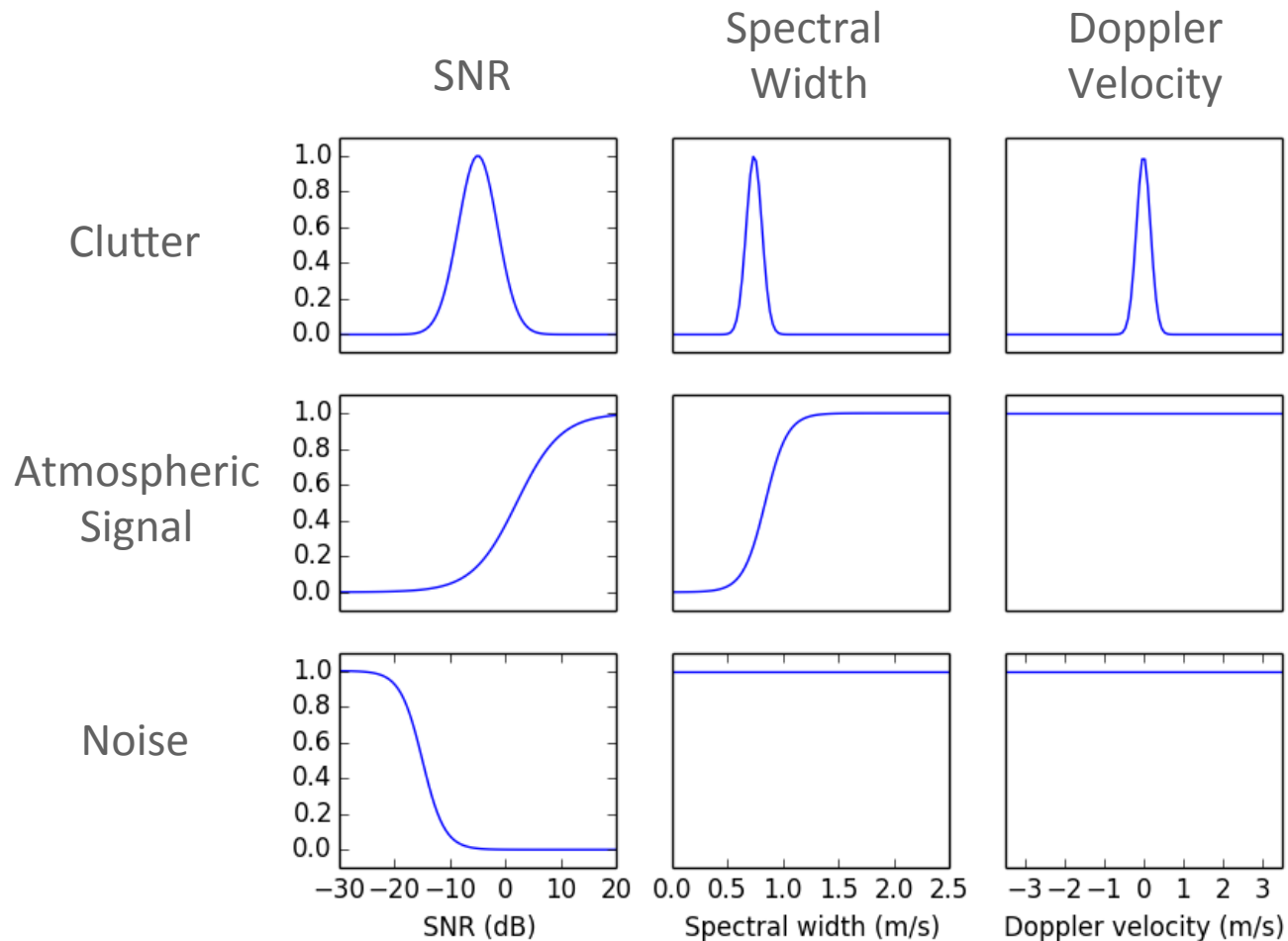


# Clutter in the ARM RWP Doppler Spectra

Short pulse, North beam



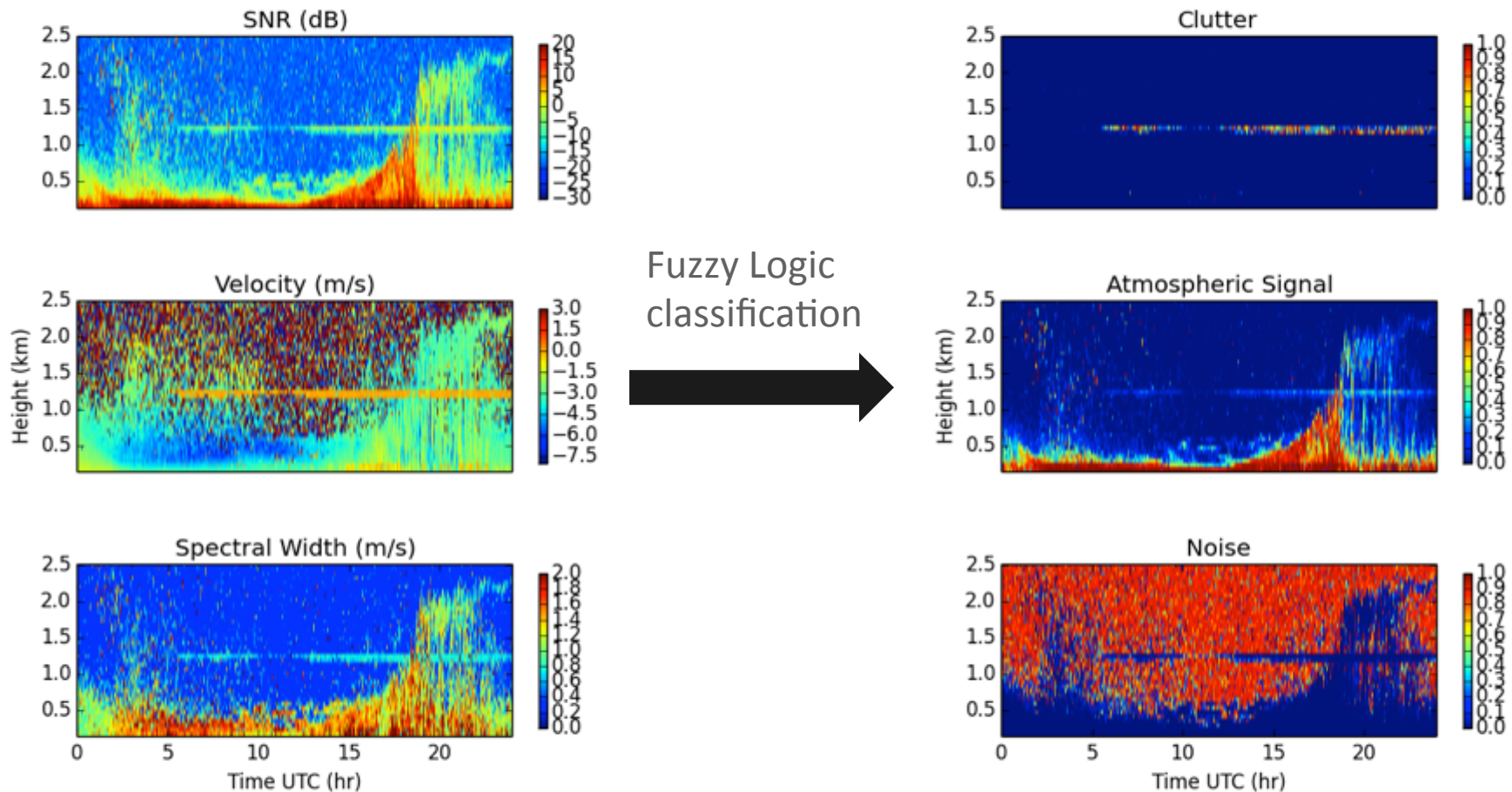
# RWP clutter classification using fuzzy logic



- Membership functions developed to model the character of each classification.
- Inspired by techniques in Bianco and Wilczak, 2002. *J. Tech.*, **19**, 1745–1758.

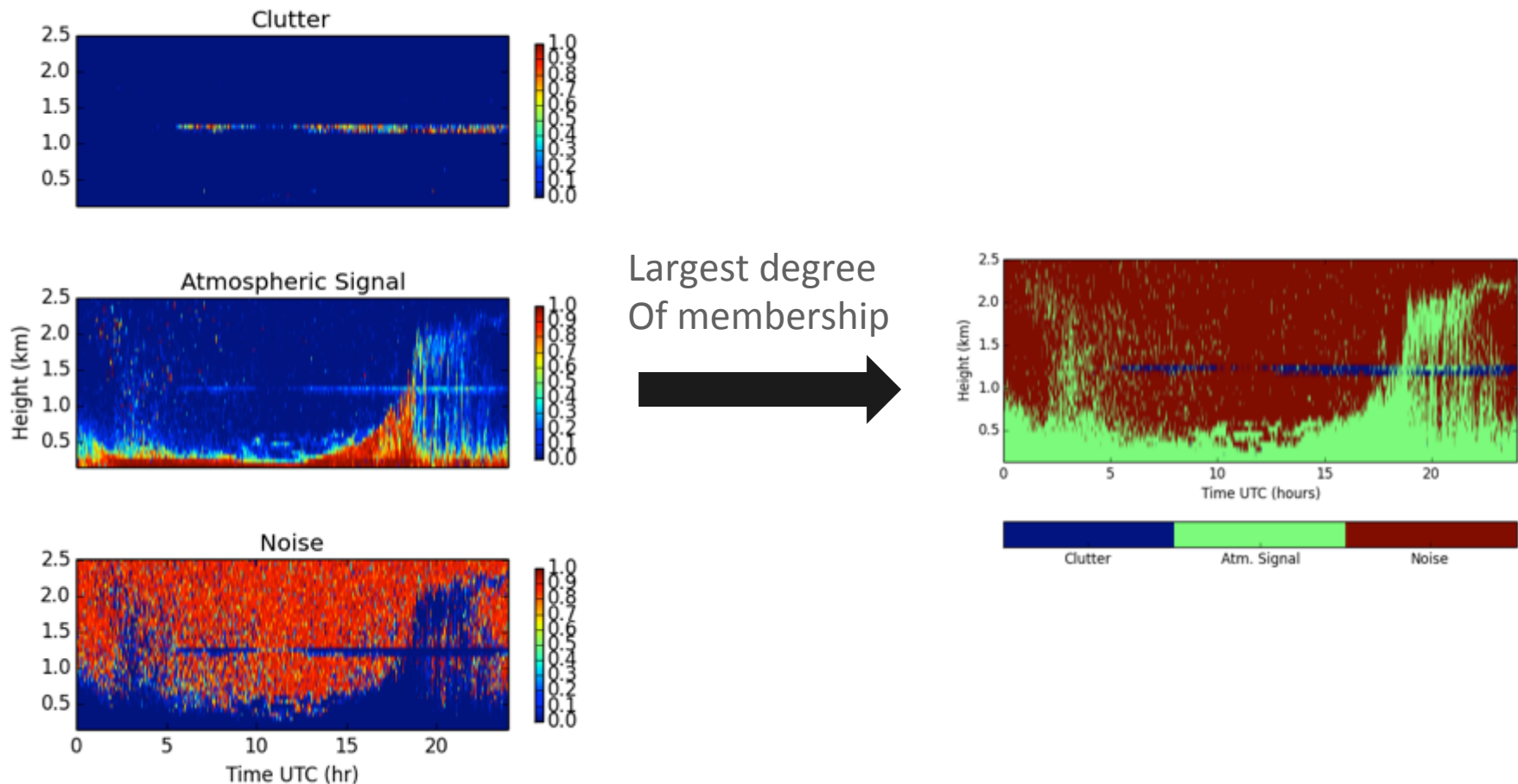


# Gate Classification



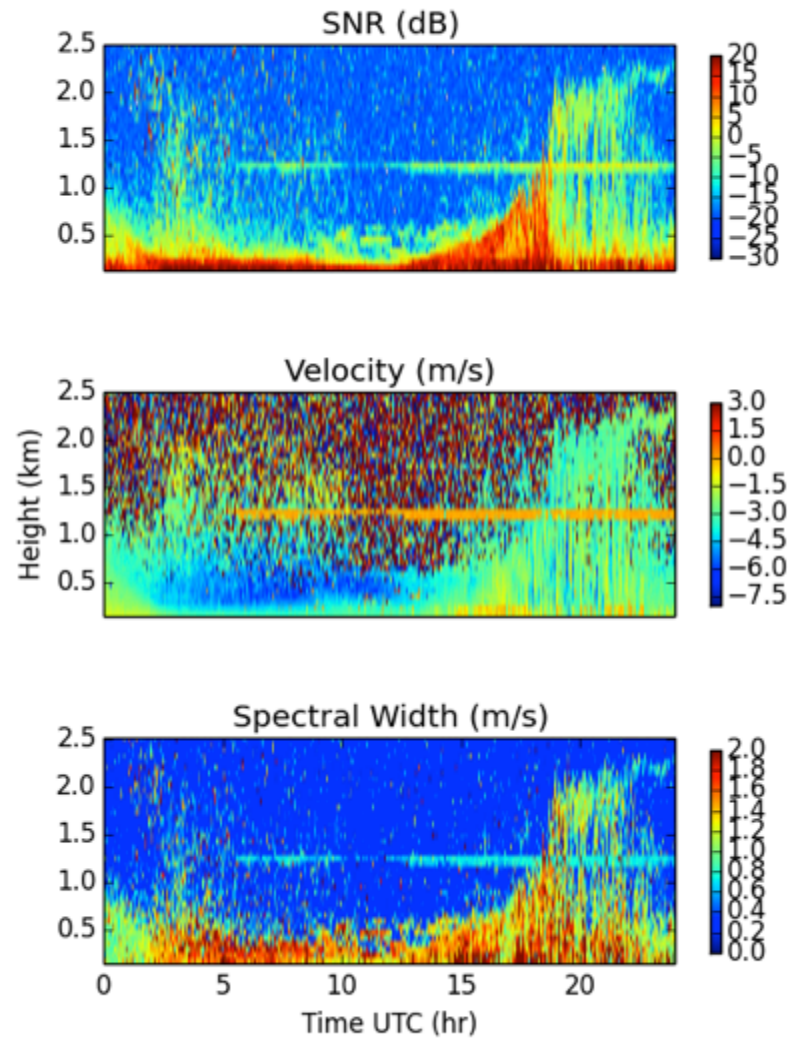
- Degree of membership is calculated using the membership function for each radar moment.
- Each gate calculated independently.

# Gate Classification



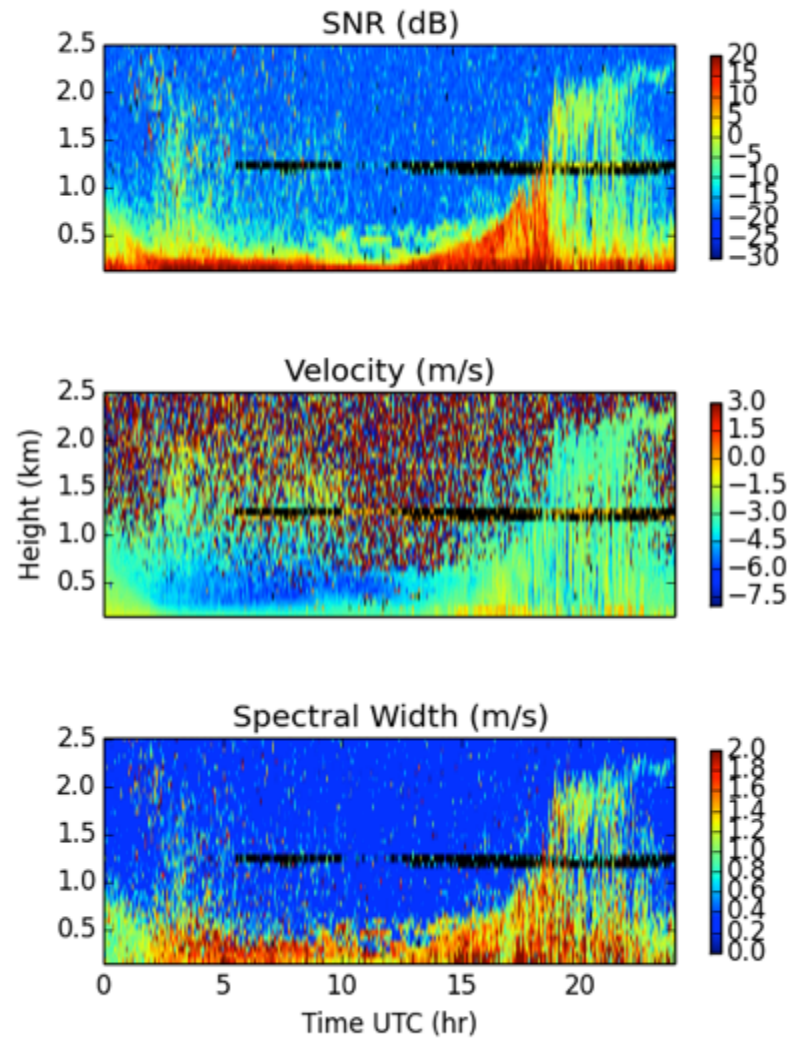
- Each gate is assigned the classification with the largest degree of membership.
- Other flexible assignments can be made by comparing the three membership metrics.

# Improving moments: Original Moments

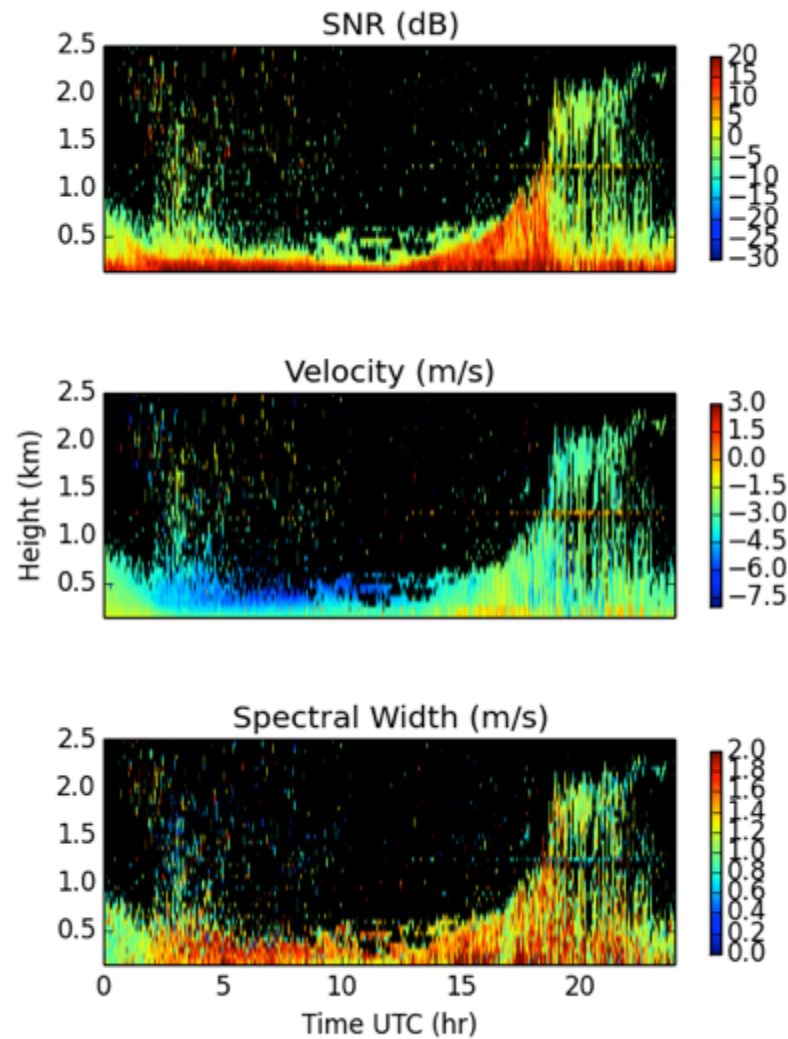




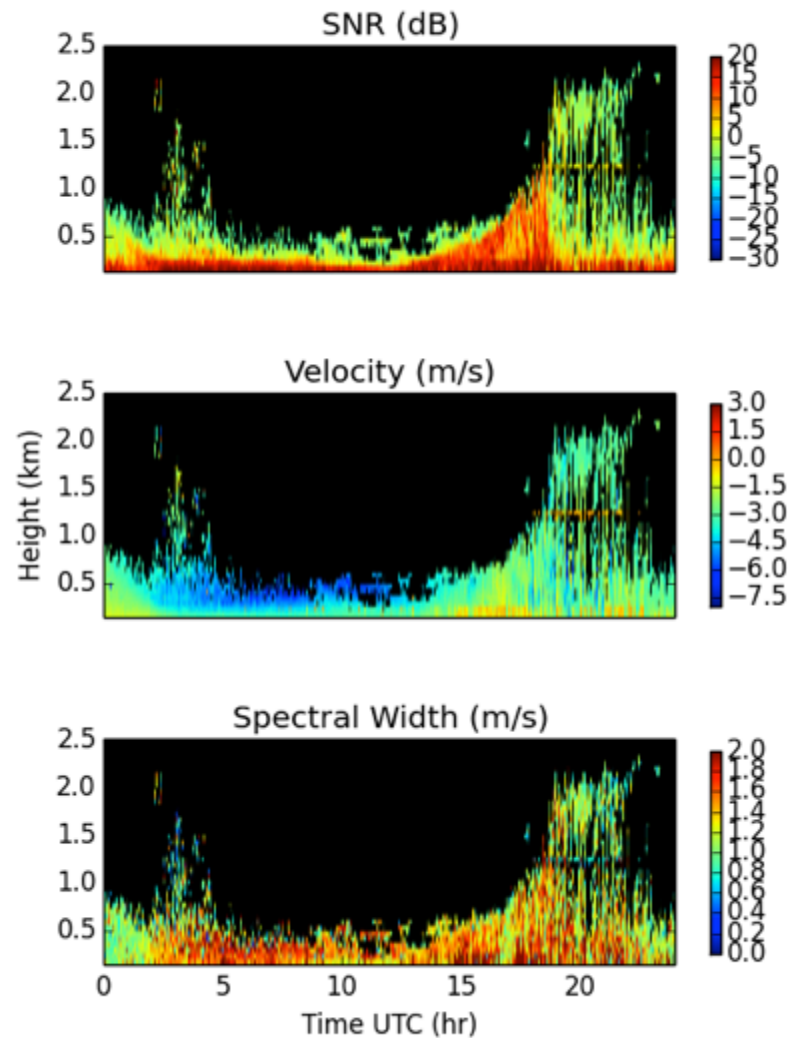
# Improving moments: Remove Clutter



# Improving moments: Remove Clutter + Noise



# Improving moments: ... and De-speckle



# Conclusion and future work

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- Fuzzy logic can be used **to classify** ARM RWP data as noise, clutter or atmospheric signal using only data from the moments.
- Removal of clutter and noise combined with a de-speckling algorithm leads **significant improvements to the RWP moments**.
- Future work:
  - Investigate improvements by including other moment based parameters, spectral data and measurement and from co-located instruments.
  - Attempt to recover any underlying atmospheric signal from gates in which clutter has been detected, re-calculate moments.
  - Determine if removal of clutter improves derived atmospheric parameters such as wind profiles and PBL height.