Retrieving Raindrop Size Distribution Parameters and Vertical Air Motion from Micro Rain Radar (MRR) Observations

Christopher R. Williams — *University of Colorado Boulder*

Shoichi Shige — *Kyoto University*

Hiroyuki Hashiguchi — *Kyoto University*

Taro Shinoda — *Nagoya University*

Acknowledgments: NASA Precipitation Measurement Mission (PMM) Grant Number 80NSSC22K0605 and the Japan Society for the Promotion of Science (JSPS) International Fellowships for Research in Japan.

Motivation

Micro Rain Radars (MRRs) are small 24-GHz frequency modulated continuously wave (FMCW) commercial meteorological vertically pointing radars manufactured by Metek Meteorologische Messtechnik GmbH in Germany.

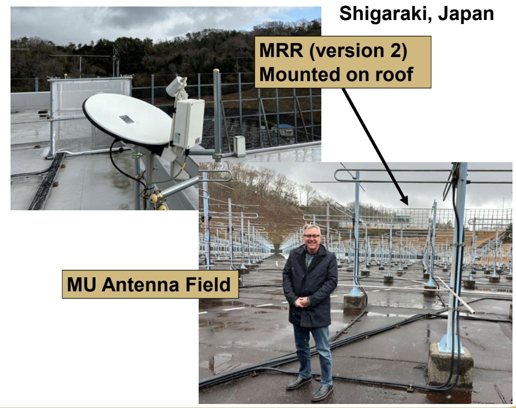
The MRR is a robust radar but the real-time Metek retrieval algorithms assume zero air motion, which is not a realistic assumption for rain rate estimates.

A new retrieval algorithm is being developed using MRR Doppler velocity power spectra profiles to estimate vertical air motion and raindrop size distributions (DSDs) below the melting layer.

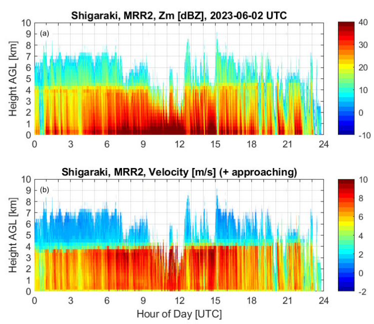
A MRR was deployed at the Middle and Upper atmosphere (MU) radar site in Shigaraki, Japan.

This study is using the direct measurement of vertical air motion by the MU radar (46 MHz) to evaluate and improve the MRR retrieval algorithm being developed.

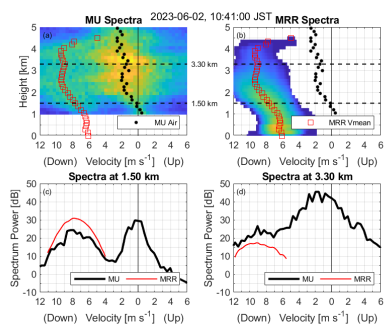
Middle & Upper (MU) Atmospheric Radar Site, Shigaraki, Japan



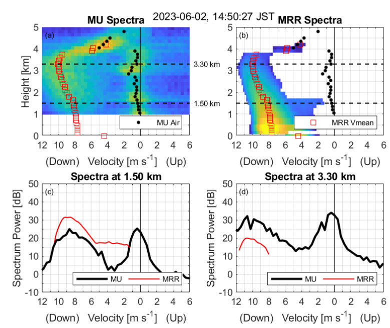
Raw Observations



Shallow Convection @ 10:41 JST



Stratiform Rain @ 14:50 JST



Retrieved Air Motions

Gamma distribution DSD model with parameters: N_w, D_m, μ

$$N(D) = N_w f(D; D_m, \mu) = N_w \left(\frac{6}{4^4}\frac{(\mu+4)^{\mu+4}}{\Gamma(\mu+4)}\right)\left(\frac{D}{D_m}\right)^{\mu}\exp\left(-(\mu+4)\left(\frac{D}{D_m}\right)\right)$$

scaling — shape

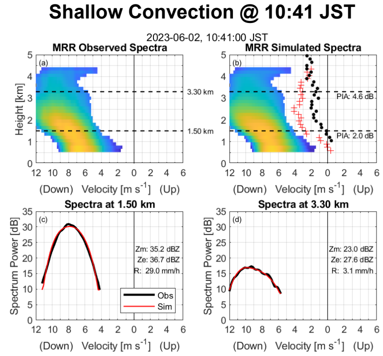
Reflectivity-weighted velocity power spectrum:

$$S_{obs}(v) = S_{broadening}(v+\omega) * S_{DSD}(v)$$

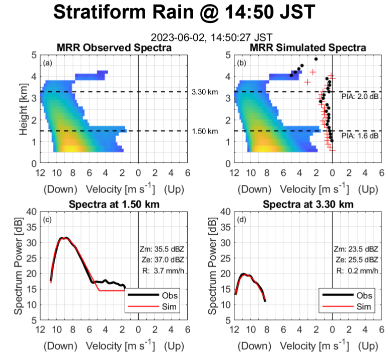
$$|S_{obs}(v)| = \left|\left(\frac{exp[-(v+\omega)^2]}{2\sigma^2_{broadening}}\right)\right| * g(D; D_m, \mu)\left(\frac{\lambda^4}{\pi^5|K|^2}\right)\sigma_s(D)\left(\frac{\Delta D}{\Delta v}\right)$$

Coarse solution over (D_m, μ, ω) is feed into an optimal estimation (OE) retrieval (Delanoë & Hogan (2008)). After a few iterations, the cost function is minimized.

Shallow Convection @ 10:41 JST



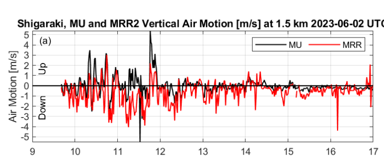
Stratiform Rain @ 14:50 JST



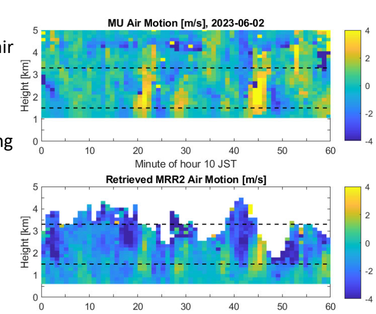
Comparisons

General Comments:

* The current MRR retrieval tends to produce more downward air motions than the observed MU Bragg scattering peak.
* The more downward air motion yields smaller mean drop size diameter (D_m), which leads to larger rain rates.
* This retrieval bias may be due to the fixed spectrum broadening term, which may be too small for the Shigaraki region.



Air Motions during Hour 10 JST



Air Motions during Hour 14 JST