

## Final Technical Report

Title: Vertical air motions over the Tropical Western Pacific for validating cloud resolving and regional models

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### *Introduction*

The objective of this project was to estimate the vertical air motion using Doppler velocity spectra from two side-by-side vertically pointing radars. The retrieval technique was applied to two different sets of radars. This first set was 50- and 920-MHz vertically pointing radars near Darwin, Australia. The second set was 449-MHz and 2.8-GHz vertically pointing radars deployed at SGP for MC3E. The retrieval technique uses the longer wavelength radar (50 or 449 MHz) to observe both the vertical air motion and precipitation motion while the shorter wavelength radar (920 MHz or 2.8 GHz) observes just the precipitation motion. By analyzing their Doppler velocity spectra, the precipitation signal in the 920 MHz or 2.8 GHz radar is used to mask-out the precipitation signal in the 50 or 449 MHz radar spectra, leaving just the vertical air motion signal.

A second vertical air motion technique was developed using differential Doppler velocity (DDV) produced when two radars operating at different frequencies are observing the same raindrop size distribution. One radar needs to operate in the Rayleigh regime with the signal not being attenuated as it passes through precipitation. And the other radar needs to be in the non-Rayleigh regime and its signal needs to attenuate as it passes through the rain. This technique was developed for S-band (2.8 GHz) and KAZR (35 GHz) radars operating at SGP during MC3E. The results of this retrieval technique were presented at IGARSS 2014 and a manuscript has been submitted for peer-review publication.

During this DOE-funded research, the PI was an active member (and still is an active member) of the DOE Atmospheric System Research (ASR) Vertical Velocity Focus Group.

This project allowed collaborations with other ASR scientists resulting in 10 peer-reviewed publications (9 published and 1 still in the review process) and presentations at 3 scientific conferences.

*Peer-reviewed publications*

1. **Williams, C.R.**, 2015: Vertical structure of raindrop size distribution parameters retrieved from vertically pointing Doppler radars during MC3E. *J. Atmos. and Oceanic Technol.*, submitted.
2. Kumar, V.V., C. Jakob, A. Protat, **C.R. Williams**, and P.T. May, 2015: Mass-flux characteristics of tropical cumulus clouds from wind profiler observations at Darwin, Australia. *J. Atmos. Sci.*, in press, <http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-14-0259.1>.
3. Schumacher, C., S. N. Stevenson, and **C.R. Williams**, 2015: Vertical motions of the tropical convective cloud spectrum over Darwin, Australia. *Q. J. Roy. Meteor. Soc.*, in press, <http://onlinelibrary.wiley.com/doi/10.1002/qj.2520/abstract>.
4. Varble, A., E.J. Zipser, A.M. Fridlind, P. Zhu, A.S. Ackerman, J.-P. Chaboureaud, J. Fan, A. Hill, B. Shipway, and **C.R. Williams**, 2014: Evaluation of cloud-resolving and limited area model intercomparison simulations using TWP-ICE observations. Part 2: Rain microphysics. *J. Geophys. Res.*, doi/10.1002/2013JD021372.
5. Giangrande, S. E., S. Collis, J. Straka, A. Protat, **C.R. Williams**, and S. Krueger, 2013: A summary of convective core vertical velocity properties using ARM UHF wind profilers in Oklahoma. *J. Appl. Meteor. Climatol.*, **52**, 2278-2295, doi: 10.1175/JAMC-D-12-0185.1.
6. Collis, S., A. Protat, P.T. May, and **C.R. Williams**, 2013: Statistics of storm updraft velocities from TWP-ICE including verification with profiling measurements. *J. Appl. Meteor. and Climatol.*, **52**, 1909-1922, doi: 10.1175/JAMC-D-12-0230.1
7. Tridon, F., A. Battaglia, P. Kollias, E. Luke, and **C.R. Williams**, 2013: Signal Post-processing and Reflectivity Calibration of the Atmospheric Radiation Measurement Program 915 MHz Wind Profilers. *J. Atmos. Oceanic Technol.*, **30**, 1038-1054, doi: 10.1175/JTECH-D-12-00146.1.
8. Han, M., S.A. Braun, T. Matsui, and **C.R. Williams**, 2013: Evaluation of cloud microphysics schemes in simulations of a winter storm using radar and radiometer measurements. *J. Geophys. Res. Atmos.*, **118**, 1401-1419, doi:10.1002/jgrd.50115.
9. **Williams, C.R.**, 2012: Vertical air motion retrieved from dual-frequency profiler observations. *J. Atmos. Oceanic Technol.*, **29**, 1471-1480, doi: <http://dx.doi.org/10.1175/JTECH-D-11-00176.1>.
10. Protat, A., and **C.R. Williams**, 2011: The accuracy of radar estimates of ice terminal fall speed from vertically pointing Doppler radar measurements. *J. Appl. Meteor. and Climate*, **50**, 2120-2138, doi:10.1175/JAMC-D-10-05031.1.

*Conferences*

1. **Williams, C.R.**, 2014: Estimating raindrop size distributions and vertical air motion using S- and Ka-band vertically pointing radars. IEEE International Geophysical and Atmospheric Remote Sensing Symposium (IGARSS), 14-18 July 2014, Quebec City, Canada.
2. **Williams, C.R.**, 2013: Estimating vertical air motions using S-band and Ku-band Vertically pointing radars during MC3E. American Geophysical Union (AGU) Fall Meeting, 9-13 Dec. 2013, San Francisco, CA.
3. **Williams, C.R.** 2012: Vertical correlation of raindrop size distribution parameters retrieved from vertically pointing multi-frequency profiling radars. 9<sup>th</sup> International Symposium on Tropospheric Profiling, 3-7 Sept. 2012, L'Aquila, Italy.