RAINDROP SIZE DISTRIBUTION RETRIEVALS IN THE TROPICS AND MID LATITUDES

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Thesis
submitted for the degree of
DOCTOR OF PHILOSOPHY
at the
UNIVERSITY OF ADELAIDE
School of Chemistry and Physics
Discipline of Physics

May 2010

Dedicated to all students who paid the ultimate sacrifice in times of war, and never returned to complete their studies.





In their sacrifice was our shelter

Contents

Abstract

Weather radar capabilities have improved dramatically over the last 50 years. Following World War II, surplus military radars were turned to the study of weather. Since then, they have evolved to the modern standard of rainfall estimations available to the general public in real time. Forecasters rely on weather radars not only for routine forecasting, but also for tracking rapidly evolving, potentially hazardous, severe weather events. These storms have the potential to cause flash floods and hence loss of crops, livestock, and human life.

Most weather radars estimate rainfall by converting the measured reflectivity to a rainrate via an empirical relationship (Z-R relationship). There are limitations in the accuracy of the rainfall estimates derived from these scanning radars. Variations in the raindrop size distribution (DSD), that is, the spread of sizes of raindrops falling at a given location, affect the measured reflectivity, and thus the rain rate estimate. The DSD can vary both temporally and spatially, and also with latitude. Investigation of the DSD and its evolution can be used to investigate the effectiveness of Z-R relationships in varied meteorological conditions and locations.

Well-established techniques exist for retrieving the DSD using vertically pointing VHF Doppler radars. These radars can simultaneously detect a clear-air echo due to fluctuations in temperature and humidity, and a precipitation echo. Mean vertical air motion and spectral width are estimated from the clear air spectrum, and used to correct the precipitation spectrum through a deconvolution procedure. The corrected precipitation spectrum is then converted to a size spectrum, and the DSD calculated. The DSD and associated integral parameters such as rainrate and liquid water content can then be used to infer the microphysical processes dominating the cloud and precipitation structure. This knowledge can then be used to investigate various Z-R relationships.

This thesis presents DSD retrievals from VHF profilers located in Adelaide and Darwin. Each profiler is installed within the footprint of a scanning weather radar, allowing direct comparison of the same air space. These radars provide a unique opportunity to study the evolution of the DSD with the profiler, and use this to investigate variations in time and height of the Z-R relationship. The locations of the radars also permits investigation of the differing nature of DSD evolution in the tropics compared to the mid-latitudes.

The TWP-ICE field campaign was conducted in Darwin and surrounding areas in January and February 2006. The campaign involved many instruments, both in-situ and remote sensing, including a fleet of aircraft and ship. The University of Adelaide Atmospheric Physics Group installed a VHF wind profiler operating at 54.1 MHz near Darwin airport for the experiment. This radar sampled the same air space as a C-band polarimetric scanning radar (CPol), which performed horizontal scans at increasing elevations, along with vertical scans over the profiler site every 10 minutes. Results from 8 events, differing in age, type, dominant microphysical process and seasonal regime are presented in this thesis.

A VHF profiler permanently located near Adelaide airport provides an observational capability similar to Darwin, but in the mid-latitudes where the processes dictating rainfall are vastly different. This radar also operates at 54.1 MHz, and is installed within the footprint of an operational weather watch radar. Pseudo vertical scans can be constructed from the successive horizontal scans allowing direct comparisons. This profiler is the first generation of the profiler in Darwin. It is not as powerful and cannot detect low intensity rainfall. Due to this and the drought South Australia experienced between 2006 and 2008, data from Adelaide are limited. Two events are presented.

Seasonal trends in the tropics, that is break conditions as opposed to the monsoon, are compared and contrasted. These trends are then compared to the limited Adelaide data. By analysing the evolution in both time and height of the DSD, and the dependence on season and latitudinal location, this thesis leads to a better understanding of the microphysical processes dictating rainfall in the tropics and mid-latitudes.

Statement of Originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Bronwyn K. Dolman and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Acknowledgements

In any undertaking of this magnitude, there will be many people who have contributed in some way, either directly or indirectly, towards the ultimate realisation of the original goal. Practical limitations dictate that everyone can not be mentioned here but the contribution of those omitted is gratefully acknowledged.

Firstly, I need to thank my Dad, for albeit unknowingly, allowing me to plagiarise the opening paragraph of his own PhD thesis acknowledgements! Since the time I understood what that blue bound tome that sits amongst the photo albums on the bookshelf meant, it has been my ambition to do the same. It is a somewhat surreal feeling to be so close to achieving what feels like a life long goal. While the language of the opening statement is not what I would choose, the sentiment rings true, I would not have reached this final stage of writing the acknowledgements without the support of some wonderful people. This is my opportunity to thank those people.

Professor Bob Vincent has been an inspiration. Particularly in the final months, Bob has been an amazing source of knowledge, encouragement and support. His ability to know when to drop by just to say hi, or deliver his famous "your not trying to solve life, the universe and everything" speech is amazing. I finish my years as Bob's student not only with an instilled passion for science (and improved grammar!) but an all important appreciation of red wine! I remember my first Friday night drinks as a grad student when Bob informed me "if your going to be my student, your going to learn to drink red wine". It was certainly tough "learning", drinking a free glass or two of red every Friday night! Given all that Bob has taught me, I think its only fair I now make it my mission to teach him a love of brass bands!

I can't express my gratitude to Dr Peter (Petroneus) May enough. Despite being an incredibly busy external supervisor, Peter still found the time to have a profound impact on my candidature. Discounting the time he ignored my plea for help while stuck on a tiny tropical island with an approaching cyclone (claiming he never received the email!), he has been an amazing supervisor. His love and knowledge of science (and sport!) is infectious and one cannot help but be inspired to achieve when working with him.

The Atmospheric Physics Group has been a great place to "grow up" as a scientist. In no particular order, to Andrew Heitmann, Alex Dinovitser, Ray Oermann, Octavianus Cakra, Tran Trong, Sujata Kovalum, Daniel McIntosh, Andrew Dowdy - it has been a pleasure to work with you. A special thanks to those who have shared the "good or bad" lunch time routine, the beach volleyball extravaganza, and the occasional over indulgent usually sneaky drinking session, Peter Love, Chris Pietsch and Jens Lautenbach. I also thank Professor Iain Reid both for useful discussions, and for providing cake day comic relief! Two group members deserve special thanks. Joel Younger, an amazing knowledge on all topics, full of humorous stories, and exceptional drinking talent. Who could want more in a fellow grad student! Time spent plotting, conniving and mainly drinking has been awesome. In particular, our student years will forever be exemplified by "that poster session". Dr Andrew MacKinnon, not only an inspirational scientist, but also fulfilling the role of computer tech (even if we did lose all of my data!), gaming buddy and most importantly mentor. You have been a constant source of encouragement, advice, laughter, and proof that one can safely emerge on the other side of the write up process! Words cannot express how grateful I am that you were part of my PhD years.

While discussing encouragement, I am also indebted to Dr Christopher Williams. Despite only three face to face meetings, Chris has taught and inspired me far more than I'm sure he realises. It was Chris who taught me the foundations of the field, but more importantly the inner workings of the scientific community and how to cope with being a grad student. Chris is a brilliant scientist and genuine nice guy, and without his pep talks early on, I would not be writing my thanks to him.

The Australian Bureau of Meteorology supported this work both through an Australian Postgraduate Award scholarship, and through some fantastic people. Dr Chris Lucas provided the original code on which my work is based, and always made himself available to talk through problems. Alan Seed provided radar data, useful discussions, and inevitably a coffee or two when I was in Melbourne. Scott Collis has also been a source of knowledge and encouragement. Thanks to Ray Jones, Ken Glasson and particularly Brad Atkinson for their encouragement and support. Their dedication to drinking in Cairns is a highlight of my PhD years! At the local bureau office, thanks to Darren Ray for both data and useful discussions on the Adelaide rainfall climate, and John Nairn and Jenny Dickins for help in interpreting weather patterns. Their help has been invaluable.

Thanks must go to both the Atmos cake day team, and the Optics BBQ team, both an excellent source of procrastination on a Friday! In particular I would like to thank Dr Aidan Brooks, Dr David Hosken and the soon to be Dr Matthew Heintze, all of whom have been great friends over the years. The write up process is by necessity a lonely journey, made so much easier by travelling a parallel path to Matt, who shared the long hours, failures and triumphs. I have lost count of the number of times Bob caught one of us in the others office and the subsequent "get back to work" was heard throughout the department!

My candidature has in some ways been overshadowed by outside influences. The infamous ankle injury near the beginning of my time brought about an abrupt change in lifestyle, and a more depressed mind set than I care to admit. The realisation that I would probably never play sport again lead to some of the darkest days of my life, from which I didn't think I would recover. While it will never serve as a full replacement, a rediscovery of music gave me a new focus and outlook on life. I don't think it is any coincidence that many of my acknowledgements go to those in the band world. After all, banding is not a hobby, its a way of life!

To the members of Unley Concert Band, you have only known me as a PhD student, and have been supportive every step of the way. The band is filled with some wonderful people, who have shared some amazing experiences. Getting "the lay of the land" and "making the necessary adjustments" on the Anzac Tour of Belgium and France, as the dedication of this thesis suggests, was an incredible and inspiring experience, made so special by the people it was shared with. To the MD Dr Kevin Cameron, an inspiration both in life and music, I owe a heartfelt thanks. While we have in your own words a "love-hate" relationship, you always took the time to listen, encourage, support and mentor when you saw I needed it. In particular, for talking me into completing this degree, I will be forever in your debt.

To the members of the Hahndorf Town Band, being a small yet busy band its members become like a family. I can't thank this family enough for their support through my PhD years. Particularly during the final months of living and breathing thesis, the antics of Monday night rehearsals have been the highlight of my week. To the MD Philip Paine, I think my gratitude can be summed up with "thank you for the music"!!

To the other bands people I have gotten to know, Dp and TTB, Al and Holdfast, Unkie Brent and Payneham, and particularly Veronica and the many other wonderful people at MCB, thanks for making banding so special.

The person who started me on this banding journey many years ago deserves a special mention. Geoff Bradley has been an amazing source of inspiration, motivation and most importantly, humor. A man who will question why we can't just attach a low pressure system to a plane, and drag rain where we want it, and ask you to explain the concept of "nothing" but stop you after one word and explain that by defining it it is no longer nothing is a worthy adversary in the PhD process. Thanks for all those "lessons" where not a note was played, but the hysterical laughter brightened my week.

To my wonderful friends who have not only been supportive and encouraging, but patient and understanding when I declined invitations in favour of thesis writing. Mim, a great mate, adventures shared with you always bring a smile, including the aforementioned tropical cyclone! Gabrielle, a travel buddy and "crunch-time" specialist, you have supported and encouraged more than I am sure you will ever know. Skye, a great friend and great support, not to mention a damn fine drinker! Pip, Andy and Andy, probably the most patient in my disappearance from society, let the drinking team re-unite! The boys, lil bro Scott, Miller, Bernie, Ramsay and Cass, and also Steph and Val, you are like family and I thank you for your support. To all of my other wonderful friends, netball teams, tennis friends, kids I coach and their families, SABA friends, I can't thank you enough for kindness, encouragement and support.

A pizza loving massage therapist best mate, who is always ready to go drinking seems like a pre-requisite to a successful PhD candidature! Nads, you have been the most amazing understanding friend I could ask for, even when going through a rough time yourself. You took the time to email me almost every day just to say hi and brighten my day, drag me out when needed and understood when I wanted to work. You have been more support than I could ever have asked for, and the first person I turn to when things go wrong. You, and also Jd, listened and talked through every problem I had, and I cannot express how grateful I am for your love and support. I most definitely would not have achieved this goal if it wasn't for you mate.

To my partner Jon, who has been so supportive and put up with so much particularly in the last 12 months. Thank you for always being available to let me vent, sympathise, or just grab a coffee. Your face appearing in my doorway gasping for air because you once again forgot the lift was functional was always a highlight. Your patience, kindness and particularly the encouragement in your own very special "Thok" voice is greatly appreciated, and I cannot thank you enough. To the Whittall family, thank you for making me feel so welcome in your home and being

so supportive of these PhD adventures!
The biggest thanks of all of course goes to my family, without whose love and support I would not have been able to pursue education to this point. To my cousin Katie, with whom I share so many crazy memories, thanks for all those moments of hysterical laughter! To my Grandma, who is always there for a chat or a hug or a 3 course meal. Your ability to cope with whatever life throws at you is to be admired. Thanks for all of the Sunday night dinners, followed by a strong cup of tea to keep me going, made with water that we are all sure boils much higher than normal! A special note must also go to my Grandparents who are no longer with us, but have been no less influential. My brother Bean, a best mate, a drinking buddy, a taxi service, a source of computer advice, and so much more. I have missed hanging out with you and hope there are many years of lazy Saturdays drinking beer while playing games or watching footy. After all, lazy is what you do best! Finally, to my parents. The people who sacrificed so much to give us the best education and start in life possible. No words seem adequate to express my gratitude for your love and support, and allowing us to chase our every ambition. For being so patient, supportive, and mostly understanding, I will never be able to re-pay you. And I could never forget my puppy mate Maestro, as always curled up next to me as I write making the long hours not so lonely.
Finally, I thank my Dad, the man whose inspirational footsteps I walk in as I add my own tome to the shelves.

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