VHF BOUNDARY LAYER RADAR AND RASS

By

Andrew D. MacKinnon, B.Sc (Hons)

Thesis

submitted for the degree of

DOCTOR OF PHILOSOPHY

at the

UNIVERSITY OF ADELAIDE

(Department of Physics and Mathematical Physics)

February 2001

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 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.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed: ..... dated: .....

Andrew D. MacKinnon, B.Sc (Hons)

Abstract

This thesis describes the refinements, modifications and additions to a prototype Very High Frequency (VHF) Boundary Layer (BL) Spaced Antenna (SA) radar initially installed at the University of Adelaide's Buckland Park field site in 1997.

Previous radar observations of the lowest few kilometres of the atmosphere, in particular the Atmospheric Boundary Layer, have used Ultra-High Frequency (UHF) radars. Unlike VHF radars, UHF radars are extremely sensitive to hydro-meteors and have difficulty in distinguishing clear-air echoes from precipitation returns. The advantages and requirements of using a VHF radar to observe the lowest heights is discussed in conjunction with some of the limitations.

The successful operation of the system over long periods has enabled in-depth investigation of the performance of the system in a variety of conditions and locations. Observations were made from as low as 300m and as high as 8 km, dependent upon conditions. Comparisons between the radar and alternative wind measuring devices were carried out and examined.

The antenna system of the radar is a critical component which was analysed in depth and subsequently re-designed. Through the use of numerical models and measurements, evaluation of different designs was accomplished. Further calibration of the remaining components of the full system has enabled estimations of the absolute received power. Additional parameters which can be derived with a calibrated radar were compared with values obtained by other authors, giving favourable results.

Full Correlation Analysis (FCA) is the predominant technique used in this work. A brief discussion of the background theory and parameters which can be measured

is described. A simple one-dimensional model was developed and combined with a "radar backscatter model" to investigate potential sources of errors in the parameters determined using FCA with the VHF Boundary Layer Radar. In particular, underestimations in the wind velocity were examined.

The integration of a Radio Acoustic Sounding System (RASS) to obtain temperature profiles is discussed. The theory of RASS measurements including the limitations and considerations which are required for the VHF BL radar are given. The difficulties encountered trying to implement such a system and the subsequent success using a Stratospheric Tropospheric (ST) Profiler in place of the BL radar is presented.

Taken as a whole this thesis shows the success of the VHF BL to obtain measurements from as low as 300m. The validation of this prototype radar provides an alternative and, in certain situations, a superior device with which to study the lower troposphere.

Acknowledgements

Inevitably the acknowledgements is the last thing written and often the first thing (and in many case the only thing) people will read. The light at the end of the tunnel is suddenly a lot brighter and everything looks...well the same, albeit through tired eyes. Its a strange feeling to think that something that has completely dominated my life for the last few months is suddenly gone, (and I think it has taken a fair old chunk of my hair with it). There are so many people that are deserving of thanks, that an appendix could be added. However, I will try to thank as many of those people as I can.

Firstly I would like to thank my supervisors Dr. Bob Vincent and Dr. Iain Reid. I would particularly like to thank Bob for all the help he has given, especially in the last few months. His advice, knowledge, proof-reading and willingness to be, but a phone call away have been very much appreciated. Thanks is extended to Dr. David Holdsworth for providing the code for the backscatter model and in all respects, other than name, being an additional supervisor.

The members of the Atmospheric Physics group have, to the most part, been a great bunch of people to work with and their assistance and help is acknowledged. Of the (many) years the group has consisted of Alireza Kazempour, Andrew Dowdy, Andrew Taylor, Brenton Vandepeer, Bridget Hobbs, Chris Lucas, Daniel Badger, David Low, David Holdsworth, Deepak Rajopadhyaya, Dorothy Gibson-Wilde, Florian Zink, Graham Elford, Jonathan Woithe, Karen Berkefeld, Laurie Campbell, Manuel Cervera, Minh Nguyen, Pham Nga, Rupa Vuthaluru, Scott Dullaway, Simon Allen, Stephen Grant and Sujata Kovalam.

For helping keep the radar working, I would like to thank Scott, Brian Fuller and the rest of the Genesis team, Florian, Alex Didenko and Malcolm Kirby. I would like to thank the guys at ATRAD, for help with the RASS sound card and for providing a great working environment.

Thanks is extended to Dr. Chris Coleman for his help with NEC and the measuring of the antenna coupling. I would like to thank Jon Barnes for his help with the antenna ("black magic") side of things.

Field campaigns are always fun exciting things, until everything goes wrong, it starts to rain, a hundred flies decided to take a personal interest or you find yourself in fog at 3 o'clock in the morning struggling to stay awake as you launch yet another balloon. Luckily the people who I shared these experiences with were all a great bunch of people. Thanks must be given to the the following: the CAFE 98 crew, Michael Reader (for giving me the opportunity in the first place), Roger Smith, Todd Lane, Zsuzsanna Racz and Maria Peristeri; Florian, Bob and Chris for helping drag the RASS speakers around. Bob and Richard McMahon for the Sydney trials; Steve, Bridget, Florian, Laurie, and Harold Richter for the sonde launching and the staff at the Bureau of Meteorology's stations at Adelaide airport, Kent Town, Alice Springs, Mt. Gambier and Sydney's Mascot airport.

Peter May's helpful comments, suggestions and knowledge was highly appreciated. I would like to thank Dallas Kirby for being a wonderful source of information and Donna Riordan for her access to Adelaide airport sonde data.

My sanity has been maintained through my Ph.D by a great group of friends and family. I would like to thank Florian, (the most tolerate person I've ever met), and Vic 'Luigi' Pisani for being two wonderful people to live with. Thanks must be extended to Pete Murenu, who was always happy to go for a spin not matter what time and is a great friend as he made the mistake of offering to proof-read my thesis. A great deal of gratitude must be given to Ma, Ba and Eilin who helped keep me feed and made me feel part of their family. The support of my Mum and Dad was without bounds, I only hope when I beome a father I can be as great a parent as they have been to me.

The last person and the most important person that I want to thank is my partner ('buddy') Linda. She maintained my grip and link to the outside world in so many ways during these last final months. For this, and so many other reasons I love her dearly. To both my parents and Linda I thank you for reading through my thesis even though it was not the most interesting things to read.

A brief anti-acknowledgement is extend to the bastard who stole my motorbike while I was writing up and Western QBE who verified all the preconceived ideas I had about insurance companies.

Contents

List of Tables

List of Figures