RADAR AND OPTICAL STUDIES OF THE ATMOSPHERE

A Thesis Submitted for the degree of
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by

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Acknowledgments

It is a pleasure to acknowledge the contribution of my colleagues to the work presented herein. My career started under the supervision of Basil Briggs and Bob Vincent in Adelaide, and continued in Canada, working with Alan Manson and Chris Meek. There I met Adolf Ebel, who was instrumental in my next appointment, at the Max Planck Institute for Aeronomy in Germany. Adolf taught me a great deal about science and about being a good citizen in science. At the Max Planck Institute, I worked with the SOUSY Group, most closely with the very professional Rüdiger Rüster and Peter Czechowsky.

Since my return to Adelaide, I have had the privilege of supervising a number of Honours and PhD students, many of whom I have continued working with subsequent to their graduations. David Holdsworth and Jonathan Woithe stand out in this context. My colleagues in ATRAD have always presented a counterpoint to the academic worldview and I have particularly enjoyed this part of my career to date.

In terms of encouraging me to pursue an education, I start by thanking my parents, Mabel and Robert, for whom achievement was always expected; my grandmother Margaret Murray, for whom education was a natural and expected form of advancement; and her son Bill Murray, who provided an early model for me.

Finally, I wish to acknowledge my wife Holly's support and encouragement throughout my career, without which, I wouldn't have achieved much at all. Thank you Holly.

Abstract

The research described in this thesis can be categorized into three main areas. The first area concerns the interpretation of observations of various atmospheric processes and phenomena. The focus here has been on internal atmospheric gravity waves and their manifestation in radar winds and in airglow intensities, but also includes investigation of atmospheric tides and planetary scale waves, *D-region* electron densities and collision frequencies, the aspect sensitivity of backscattering and partially reflecting regions of the atmosphere, Polar Mesosphere Summer Echoes and Mesosphere Summer Echoes, meteor trails, mesospheric temperatures, long period variations in airglow intensities, and Kelvin Helmholtz Instabilities.

The second major area has been in the development of new experimental techniques and the validation of existing techniques for investigating the atmosphere. New techniques have included the dual–beam radar technique for measuring momentum fluxes, and radar Time Domain Interferometry and Hybrid Doppler Interferometry for use with multi-receiver channel Doppler radars. The Doppler Beam Steering technique in the presence of non-uniform and periodically varying wind fields has been investigated analytically, and various spaced sensor techniques have been investigated using a numerical model of atmospheric radar backscattering and by direct comparison with other techniques. The Sodium Lidar technique has been investigated through numerical model calculations and a solid state system is currently being developed.

Finally, a major activity has been the development of new radars and radar sub-systems. This has included the development of a modular Medium Frequency Doppler radar and a Medium Frequency Spaced Antenna radar, a variety of Stratosphere Troposphere / Mesosphere Stratosphere Troposphere radars, an Ionospheric radar, a Boundary Layer Tropospheric radar and an All-Sky meteor radar.

Declaration

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.

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Signed: Dated: April 18, 2008

Organization of the Thesis

The body of this thesis begins with a brief overview of my research career. This is followed by my *CV*, and a complete publication list, including un-refereed articles and reports, invited presentations, and contributed oral presentations. Next there is a list of my research students and then my grant record. The main part of the thesis follows, and here I present a commentary on each refereed journal publication. When taken together these form a narrative providing the context and significance of my research. A commentary is provided for all papers, but copies of only *35* are included here. The last part of the thesis is concerned with my contribution to the design and development of radar systems. This represents a major contribution to the field and I have provided a brief commentary for each major radar type. This follows as closely as possible the format used in the first part of the thesis for refereed journal publications. A complete summary of radars produced by *Atmospheric Radar Systems Pty Ltd* and its precursor *Adelaide Radar Systems* is included in Chapter 7.