Comparisons of VHF Meteor Radar Observations in the Middle Atmosphere With Multiple Independent Remote Sensing Techniques.

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Abstract

This thesis describes the development, modification and refinement of a high-powered hybrid Stratospheric Tropospheric (ST)/meteor radar at the University of Adelaide's Buckland Park (BP) field station. This thesis also describes the process of statistically comparing results obtained from multiple co-located independent measurement sources. Also included are statistical comparisons made between meteor radars at BP, Darwin, Northern Territory, and Davis Station, Antarctica, with other independent sources of measurement.

Previous meteor radar systems have generally been low powered (∼8 kW peak) and as such could only afford low count rates at frequencies of the order of 50 MHz. While it has been shown that the echo detection rate is inversely proportional to frequency to the power of 1.5, the use of lower VHF frequencies within Australia is restricted by government regulations. As such, this has lead to the development of a high powered meteor radar system at 55 MHz which has served to facilitate higher echo rates at this frequency. The aim of improving the echo rate is to improve the statistical accuracy of results generated by the meteor technique. Also presented are descriptions of the meteor radar systems used to provide the data for this study and the basic principles of the meteor technique. Basic descriptions of the other systems and the techniques used to provide data for comparison are also presented.

Two key components in the development of the high-powered meteor system are the high-powered all-sky crossed-dipole transmit antenna and the high-powered 1:2 splitter-combiner required to drive the antenna. The antenna was designed using standard equations for Yagi-Uda antenna design found in literature and modeled using the EZNEC modeling programe. After successful modeling, the antenna was prototyped and refined into a low powered version to investigate the antenna's performance characteristics. Once the performance of the antenna was verified, the process of upgrading the antenna to handle the full output power from a VTX transmitter was performed. This upgrade also spawned the design and development of the high-powered 1:2 splitter-combiner which would be used to feed the high-powered version of the antenna.

The successful operation of the high-powered system over several periods of observation has allowed for a more in-depth investigation into the statistical reliability of the meteor technique. Along with the comparison of standard atmospheric parameters, i.e. temperatures and wind velocity, the high-powered system has allowed for the verification of the relationship between echo rate and radar parameters found by McKinley, which is frequently referred to in many papers dealing with meteor observations.

Along with the comparisons made with the results from the high-powered meteor radar system at BP, comparisons of atmospheric parameters derived from meteor observations and other techniques were made at Davis Station and Darwin. Of particular interest is the unique comparison of atmospheric winds made at Davis between two independent meteor radar systems and a Medium Frequency (MF) radar. Previous comparison studies have only enjoyed the benefit of having two independent sources of measurement to compare and as such have not allowed for a unique solution to be obtained for the uncertainties of the techniques using the method of Hocking et al. [2001]. Davis Station is unique in that it has two independent meteor radars in addition to a MF radar. This has enabled for the reduction in the number of degrees of freedom in the statistical comparison process, and as such has allowed for unique solutions to be determined for the uncertainties when comparing two independent techniques; i.e. meteor and MF wind comparisons.

Atmospheric temperatures in the Mesospheric and Lower Thermospheric (MLT) region were determined through the use of meteor diffusion coefficients and derived atmospheric pressure models at Davis Station, BP and Darwin. Comparisons are made between the meteor technique and other co-located independent measurements. These include; airglow, satellite and falling sphere measurements at Davis Station, airglow and two independent satellite measurements at BP and two independent satellite observations at Darwin.

This thesis as a whole demonstrates the successful operation of the high-powered ST/meteor hybrid radar at BP. It also demonstrates the successful comparisons of MLT winds and temperatures made between meteor radar and other independent sources of MLT measurements. The validation of using the high-powered meteor radar at BP coupled with the successful comparison of atmospheric parameters derived using the meteor technique and other forms of MLT observations serves to re-affirm the statistical accuracy

and benefit of the meteor technique in observations of the MLT region.

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 to Daniel L. McIntosh 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 made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library catalogue, the Australasian Digital Theses Program (ADTP) and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Signed: ..... Dated: .....

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Acknowledgements

Well finally, I have arrived. Not that long ago it seemed like a dream that I could complete such an enormous feat in my life, but finally I am here! At last, writing the very last section of this thesis. A section that in all likeliness those who have been with me along this journey will read to see if they have made the cut. They say that every journey begins with a single step and that the journey, not the destination, is the most important part. I think that through these tired eyes I would begrudgingly agree... As refreshing as it is to have finally arrived at this point, it is not as refreshing as the thought of how the journey has prepared me for what lies ahead! From the outset I believed that this would be one accomplishment that I and I alone could achieve. Was I wrong! Although ultimately it has been my blood, sweat and tears (I kid you not) that has gotten me to this point, if it were not for an unbelievable group of people who have supported me along the way, I would not have reached this far. There are so many people that deserve thanks that I could probably write another thesis, however I will attempt to avoid the cliché actors fall into with the never ending speech thanking everyone including the goldfish!

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One's own sanity through all this can only be balanced by those they have in their personal lives outside the office, the lab and the field site. To my family who have been there every step of the way and in particular my Mum and Dad. Thanks Mum for taking me back in upon your return home, all the home cooked meals and of course the washing and ironing. I know at the time it seemed like it would never end and I would never leave but it worked out in the end. Thanks Dad for all the help, advice and the friendly ear over the years. At times when the going got tough I knew he was but a phone call away! Neither of my parents had the same educational opportunities that I had, so I hope deep down that I have made them proud and that they feel that all their efforts over the years have not been in vain.

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support through those undergraduate years and since has been unwavering and just what the doctor ordered. All the thanks and praise I can give to you and more. I hope all the good times we have had are only a mere sample of what is yet to come!

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> *"So many of our Dreams at first seem impossible, then they seem improbable, and then, when we Summon the Will, they soon become Inevitable."*
>
> *- Christopher Reeve*
> *(1952-2004)*

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