MEASUREMENTS OF TROPOSPHERIC SCATTER WITH A NEW MULTI-BEAM, MULTI-RECEIVER VHF DOPPLER RADAR

By

Bridget Hobbs, B.Sc. (Hons)

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Contents

Abstract

This thesis discusses the work done by the author to upgrade the Buckland Park (BP) VHF stratosphere-troposphere (ST) radar, verify the data from the new system, plan and run new experiments, and analyse the resultant data in order to study the scattering and aspect sensitivity of the troposphere.

Between 1995-1998 the system was upgraded to enable Doppler beam-swinging (DBS) measurements at a wide range of angles, and spaced antenna (SA) measurements in a variety of antenna configurations. The upgraded system is discussed, with emphasis on the tests that were conducted in order to estimate the various phase errors in the system, including the antenna arrays, the new beam steering hardware and receivers, and tests to ensure the correct operation of the system as a whole in both multiple beam DBS and SA modes

The new DBS capabilities of the system, in particular, required that new data analysis algorithms be developed. These algorithms were necessary to perform the analysis in the frequency domain and to cope with various new contaminants observed with the new system due to the increased number of pointing directions relative to the old system. These algorithms are discussed in detail with various examples of the resultant improvement in data quality.

The primary aims of the work in this thesis were to use SA and DBS techniques together and to examine DBS data at many off-zenith angles, in order to study the scattering and aspect sensitivity of the troposphere. Two joint DBS/SA experiments were run, an approach which for the most part is not taken in VHF ST studies. The first deals with a comparison between SA full correlation analysis (FCA) and DBS data. The main result of this experiment was that in aspect sensitive conditions, θ_s values using DBS beams at 3.6° off-zenith and 0.0° were in excellent agreement with FCA estimates of θ_s, suggesting that the same scattering structures were affecting both angles.

The second DBS/SA experiment deals with a comparison between SA angle of arrival (AOA) measurements and DBS data. The main results of this experiment indicated that the aspect sensitive structures at small off-zenith angles were tilted

layers. This was seen in a comparison of the AOA on a vertical beam with power differences in off-zenith beams at 3.6°.

With respect to multiple off-zenith beam DBS measurements, most of the similar studies have their emphasis on examining the behaviour at small, aspect sensitive off-zenith angles, in relatively short data sets. Instead of this approach, the emphasis of the multiple off-zenith beam experiments discussed in this thesis was to examine the scattering over the full angle range from 0.0° to 22.0° over a large period of time to quantify the variation in the decrease in power as a function of off-zenith angle, and to identify the isotropic scattering level. The main result of this experiment was that the isotropic scattering level occurred at a minimum off-zenith angle of approximately 14.5°.

This thesis represents the first use of the upgraded system for atmospheric studies in the ST region. As such it is a study of the new capabilities of the radar. In addition, the experiments now possible with the system have provided new information on the nature of the aspect sensitivity and scattering of the troposphere.