P1.27 RETRIEVAL AND VALIDATION OF THE REFRACTIVE INDEX STRUCTURE FUNCTION FROM 50MHZ RADAR DATA

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1. INTRODUCTION

The refractive index structure function (CN^2) is a measurement of atmospheric optical turbulence. Optical turbulence is defined as spatial or temporal fluctuations of refractive index. It is caused by the presence of adjacent parcels of air, at slightly different index of refraction, moving about in the path of propagating electromagnetic waves (Jumper et al. 1999). The Air Force has expanded research in directed energy and laser optics, and increased efforts to observe and understand optical turbulence.

The United States Air Force Research Laboratory Directed Energy Directorate (AFRL/DE) and the Airborne Laser (ABL) Program have developed a process to calculate CN^2 from 50MHz radar data. The ability to process radar data for CN^2 is useful to AFRL and the ABL program because it is automated and continuous. Until this process was developed, all CN^2 measurements required a human operator for each collection. One of the main uses for the radar CN^2 measurements will be to verify and validate numerical optical turbulence prediction models. These models produce hourly turbulence forecasts and the radar CN^2 data will allow for a more robust validation of the models than previous intermittent observations.

2. DATA

The process used to calculate CN^2 from radar data has been developed using the 50MHz radar at Vandenberg AFB, CA. The radar provides an excellent source of CN^2 data because of its reach into the lower stratosphere and because it provides a complete observation of optical turbulence patterns over hourly to yearly time scales.

The CN^2 data retrieved from the 50MHz radar was validated against thermosonde optical turbulence data taken during two field campaigns at Vandenberg AFB, CA. The Air Force Research Laboratory Space Vehicles Directorate (AFRL/VS), who designed the thermosonde, lead the collection campaigns and analyzed the data. Carried aloft by a balloon, the thermosonde ascend to a maximum of 100,000 ft. The thermosonde detects optical turbulence by measuring temperature differences using fine-wire probes that are one meter apart. This measurement system results in a temperature structure function, which is then translated into the refractive index structure function thru the Dale-Gladstone equation (Masson et al. 1996).

Comparisons were run between different radar processing and quality control codes to examine which processing code delivered the most useful and accurate optical turbulence data. The three codes that are being compared are Median Filter/First Guess (MFFG), Moments Processing (MOMPRO), and LAP-XM_CN2.

Vaisala, Boulder, CO designed LAP_XM_CN2 for the ABL program. The code ingests radar spectral data and outputs CN^2. The LAP_XM_CN2 program uses the CN^2 equation from Doviak and Zrnic (1993), "Doppler Radar and Weather Observations". The primary inputs into the CN^2 equation are noise, signal-to-noise and parameters specific to the radar system. There is no quality control in LAP_XM_CN2. The code outputs CN^2 profiles every three minutes. AFRL/DE and the ABL program ported the CN^2 calculation from LAP_XM_CN2 into MFFG and MOMPRO to leverage their quality control processes.

MFFG is used by Air Force Space Command. MFFG is designed to obtain high-

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resolution winds to support missile launches. MFFG allows for user interaction during both the initial phase of the algorithm and during the quality control process (Schumann et al. 1999) The main difference between MFFG and MOMPRO is that there is no missing data. The consensus-averaging quality control method in MFFG produces data at each height.

MOMPRO is designed by Bob Weber (NOAA, Air Resources Laboratory, Boulder, CO) and used by NOAA. MOMPRO is designed to run at remote radar sites without interaction. The quality control in MOMPRO checks Doppler velocities for temporal and special consistency and eliminates contaminated velocities.

The quality control in both MOMPRO and MFFG are performed on the winds. Then the associated CN^2 value is either eliminated or replaced with a consensus value.

3. ANALYSIS AND RESULTS

Preliminary CN^2 profiles from the three radar processing codes have been examined. The initial comparisons were done using hourly averaged profiles. The hourly averaged profiles were chosen to compensate for the balloon rise time and the fact that these results will be compared to numerical optical turbulence predictions in the future. The initial analysis shows good agreement between the LAP_XM_CN^2 and MOMPRO CN^2 profiles. There are some discrepancies between MFFG and LAP_XM_CN^2.

4. FUTURE WORK

AFRL/DE and the ABL program still have to complete an in-depth comparison between profiles from the three radar-processing methods and validate them against the thermsosonde profiles. In addition to comparing the four CN^2 profiles, the synoptic weather conditions during the campaigns will be examined. AFRL/DE has done extensive work relating synoptic features to optical turbulence, comparing profiles to the synoptic patterns will determine if the CN^2 values match well with what the synoptic patterns indicate or if the measurement systems are picking up artificial returns. Once the data and methodology are validated the radar CN^2 data will be used to anchor the optical turbulence models

5. REFERENCE

Doviak, R. J. and D. S. Zrnic, 1993: *Doppler Radar and Weather Observations*. Academic Press, 562pp.

Jumper, G.Y., R.R. Beland, J.R. Roadcap, and O.R. Cote, 1999: Effect of compressible flow on perceived temperature fluctuations measured by moving sensor. *AIAA* Journal. **37**, 1609-1616.

Masson, B., B. Scruggs, M. Hayes, J. Wissler, K. Bishop, and D. Kyrazis, 1996: Airborne measurement of tropopausal temperature fluctuations. *AIAA* paper 96-0265.

Schumann, R. S., G. E. Taylor; F.J. Merceret, and T. L. Wilfong, 1999: Performance Characteristics of the Kennedy Space Center 50-MHz Doppler Radar Wind Profiler Using the Median Filter/First Guess Data Reduction Algorithm. *J. Atmos Oceanic Technol*., **16**, 532-549.