P13B.3 A 449MHZ MODULAR WIND PROFILER DEVELOPMENT STUDY

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1. INTRODUCTION

A new wind profiler radar using a modular design and operating at 449MHz has been proposed for development at the National Center for Atmospheric Research (NCAR) / Earth Observing Lab (EOL) and the University of Oklahoma School of Meteorology in collaboration with engineers from NOAA/ESRL. The system aims to meet the need in the NCAR user community for wind profilers with improved range, spatial and temporal resolution, flexibility, and ease of deployment. It is proposed to use a modular design so that radars of varying sizes can be deployed, depending on the needs of a particular experiment.

2. BACKGROUND

Wind profilers have been used to study a wide array of phenomena ranging from surface-atmosphere exchange, precipitation, boundary layer evolution, air quality, airflow in complex terrain, and many other topics. The four NCAR/EOL wind profilers alone have been involved in more than 30 projects ranging from TOGA-COARE, FASTEX, ACE, CASES, IMPROVE, NAME, IHOP, VTMX, T-REX, and many others. The radars are usually deployed with Integrated Sounding Systems (ISS, Parsons, et.al.,1994).

Currently the ISS use three DBS (Doppler Beam Swinging) boundary layer 915 MHz profilers of the classic NOAA Aeronomy Lab design, (Ecklund et.al. 1988). The ISS do use one advanced wind profiler, MAPR (Multiple Antenna Profiler Radar; Cohn et.al, 2001), however even this radar uses the same antenna as the 3 DBS wind profilers.

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MAPR was developed at NCAR/EOL and is capable of much faster wind measurements (1–5 minutes) than the DBS profilers (15–30 minutes), but otherwise has a similar performance to the older systems (e.g. the altitude range is often limited to around 3 or 4 km).

A variety of technological advances enable the development of much more capable wind profilers that will enable a greater range of deployment strategies to better meet the needs of the very diverse range of experiments. For example, some projects would benefit from a wind profiler capable of penetrating deep into the troposphere whereas others would use a wider network of small boundary layer capable systems.

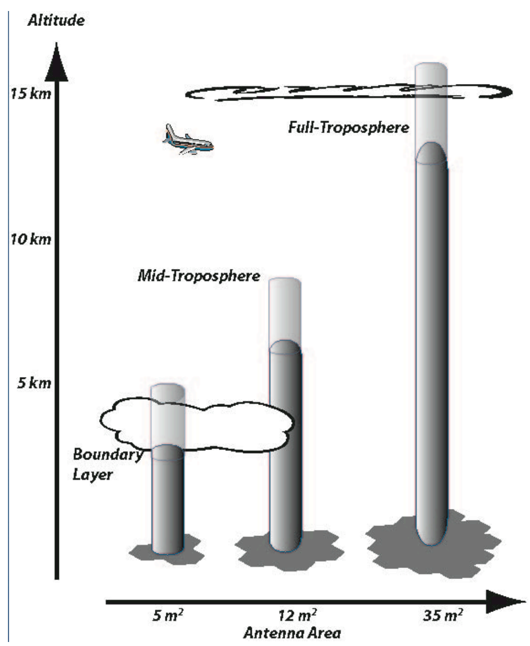

Figure 1: Potential configurations and approximate altitude coverage (the grayed columns indicate variability) for three configurations (see Fig. 2) of the modular wind profilers.

3. DESIGN OVERVIEW

A key feature of the proposed wind profiler system is modularity. The system would consist of a number of panels each of which is largely self-contained with a transmitter, receiver, antenna, and data acquisition and processing unit. These modules would be assembled together to produce wind profilers of varying sizes. Possible configurations are illustrated in figures 1 and 2. This modularity and other key features of the radar bring together design elements from a number of very successful atmospheric radars:

Modularity: A modular antenna and distributed receiver concept has been used in AMISR (Advanced Modular Incoherent Scatter Radar), a very large radar used for ionospheric research, and in the University of Massachusetts Turbulent Eddy Profiler (TEP, Mead, et.al., 1998) radars allowing the systems to be readily reconfigured depending on the application. Each panel would be around 2 meters across, include a transmitter and receiver and could operate independently or together with other panels.

449 MHz (67 cm wavelength): Profilers in this frequency band are used by the NWS in the NOAA Profiler Network and by NOAA-ESRL for their superior range and high sensitivity.

Multiple Receivers: MAPR and TEP, as well as Australian Bureau of Meteorology wind profilers use multiple receiver spaced antenna techniques to measure wind much more rapidly than traditional Doppler Beam Swinging wind profilers.

Hexagonal Antenna Panels: This shape is used in VHF radar such as the large MU radar in Japan, and in UHF radar such as the wind profiler on NOAAs *R/V Ronald H Brown*, (Law, et.al. 2002) The panels can be fitted together as in a honeycomb, yet retain the basic uniform outline producing an even antenna pattern with reduced sidelobes.

Solid state transmitter modules: Each panel would use one or more 500W solid state transmitter module. Similar transmitters are used behind each antenna element in AMISR, and are also used in the NOAA/ESRL quarter-scale 449 MHz radars.

Digital Receivers with Software Defined Radio (SDR): These FPGA (Field Programmable Gate Array) receivers are used in a number of radars (e.g., Applied Technologies 449 MHz Aerostat profilers) for their superior signal processing capabilities.

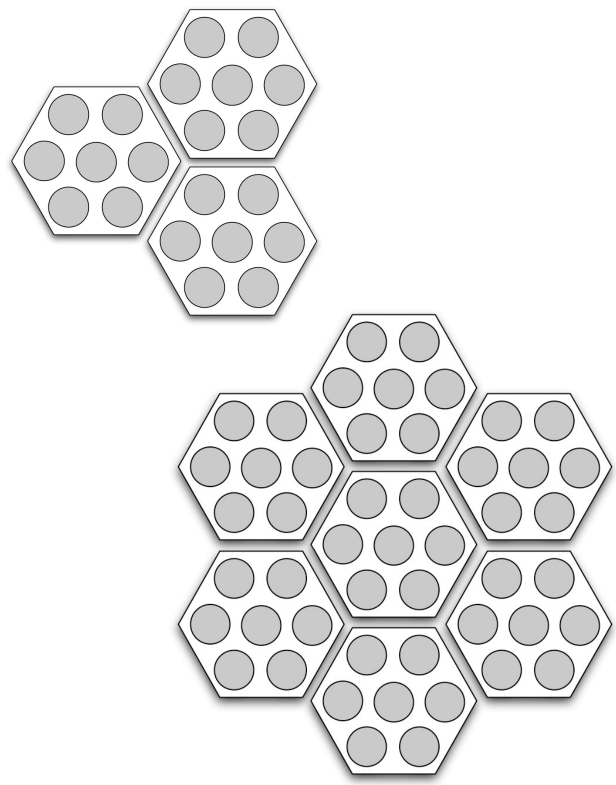

Figure 2: Possible arrangements of the wind profiler modules for boundary layer operations (upper left) and mid-troposphere operations (lower right).

Other features being investigated are Range IMaging (RIM, Palmer et.al., 1999) to improve the range resolution of the radars; adaptive clutter filtering using additional wide field-of-view antenna modules (Le et.al 2007); and RASS (Radio Acoustic Sounding System) for virtual temperature profiling.

Currently a preliminary design study is being carried out. The tentative performance goals of the system are summarized in table 1, however these and other aspects of the design may change as the study progresses and we receive input from the research community.

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TABLE 1: Tentative performance targets and modes of operation for the modular profilers.

	Configuration-1 Boundary Layer	**Configuration-2 Mid-Troposphere**	**Configuration-3 Full-Troposphere**	**Current 915 MHz BL Profiler (DBS)**
Number of Stations[1]	~6	~2	1	3
Expected Altitudes[2]	0.15 to 4 km	0.20 to 7 km	0.30 to 15 km	0.15 to 4 km
Altitude Resolution[3]	30-m	30-m to 200-m	100-m to 200-m	60-m to 100-m
Time resolution	~1-min	~1-min	~5-min	30-min
T_V coverage (RASS)[4]	~1 km	~2 km	~4 km	~1 km

[1] Proposed number of wind profilers that NCAR/EOL will be able to deploy
[2] A Doppler lidar will fill in winds down to 30-m AGL with good time resolution
[3] High-resolution is achieved in the boundary layer through the RIM technique, with lower resolution required at higher altitudes.
[4] Radio Acoustic Sounding System (RASS) is an add-on to wind profilers which measures virtual temperature through radar measurement of the speed-of-sound.