

# Investigation of Sampling Low-Altitude Wind Profiles for Space Vehicle Applications

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# Background

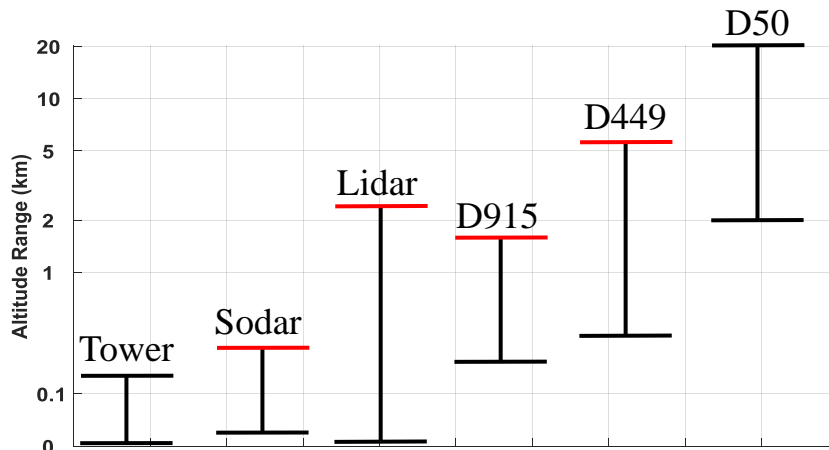
- Eastern Range (ER) and Western Range (WR) 915-MHz Doppler Radar Wind Profilers (D915s) are aging and their performance has been degrading.
- MSFC Natural Environments (NE) is investigating if there exists a better option to supplement the D50 (i.e., replace the D915s with something else).
- Based on known requirements for NASA's Space Launch System and for MSFC NE climatology development, the following is desired:
  - Lowest reliable measurement altitude of at most 300 m.
  - Continuous temporal sampling at least once every 5 minutes.
  - Vertical sampling interval of at most 150 m.
  - Maximum reliable measurement altitude of at least 3 km. \*
  - Cost efficient.
  - Others?

\* The new system must consistently reach 3 km to effectively splice with the D50. Higher maximum altitudes (e.g., 10 km) would provide redundant measurements to the D50.

# Current Status

- Different sources to supplement the D50:

Balloons	<ul style="list-style-type: none"> <li>• Miss temporal wind change over short (e.g., sub-hourly) time intervals.</li> <li>• Sample size of archive does not produce a robust climatology.</li> </ul>
D915	<ul style="list-style-type: none"> <li>• Do newer systems perform better than the current systems?</li> </ul>
D449	<ul style="list-style-type: none"> <li>• Good max altitude, altitude interval, and time interval.</li> <li>• Min altitude is higher than desired.</li> </ul>
Lidar	<ul style="list-style-type: none"> <li>• Highly configurable: Could be used to supplement a D449 / D50 combo, or the D50 alone.</li> <li>• Need to examine performance in cloudy conditions and feasibility of continuous operation.</li> </ul>
Sodar	<ul style="list-style-type: none"> <li>• Could be used for altitudes below the D449.</li> <li>• Need to examine for altitude coverage and data availability.</li> </ul>



- Examples of Technology advances
  - High Altitude Lidar for Atmospheric Sensing (HALAS)
  - National Center for Atmospheric Research Modular Profiler Network (<https://www.eol.ucar.edu/node/156>).

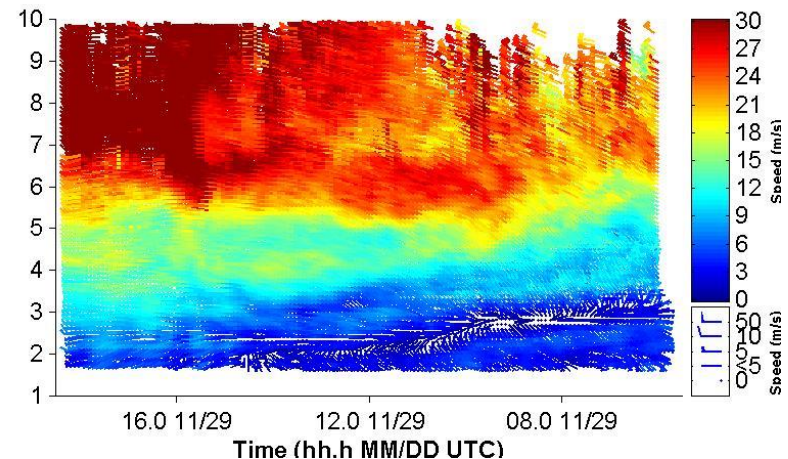
# Forward Work

- Soliciting feedback from the Ranges and launch vehicle programs.
  - Understanding requirements.
  - Knowledge of instrumentation and costs.
  - Timeline for replacing the D915s.
- MSFC NE intends to provide an update at the Autumn 2016 NEDOLWG.

# Backup

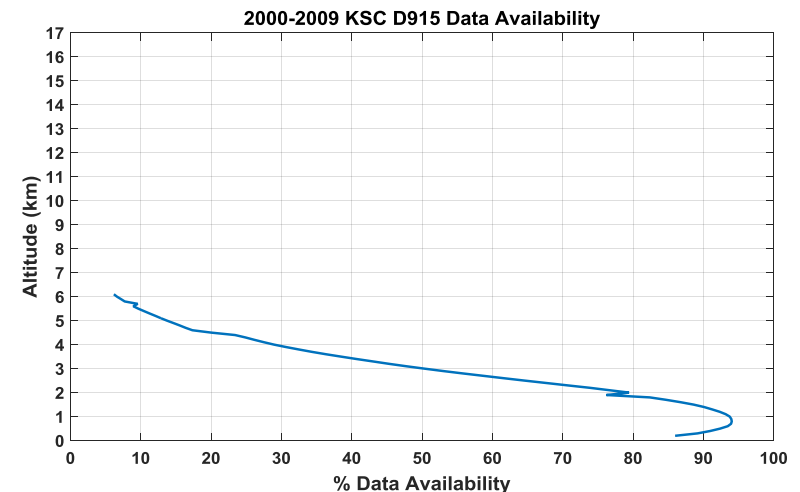
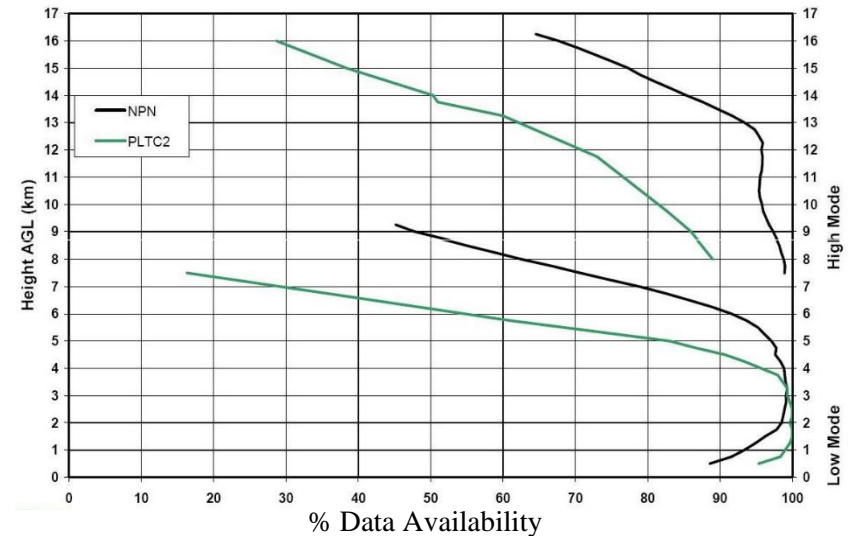
# Introduction to the D449

- Traditional systems have an aperture of  $\sim 28 \text{ m}^2$ .
- Detects signal through Bragg Scattering.
  - Turbulent fluctuations in the atmosphere of scales roughly half the radar's wavelength.
  - Wavelengths: D50, 6 m; D449: 0.7 m, D915: 0.3 m.
- Signal retrieval traits allow for the following versus the D915:
  - Greater penetration through the atmosphere.
  - Similar minimum reporting altitude.
- Plot from heritage D449 at Ft. Huachuca (near Sierra Vista, AZ).
  - Sampling interval of 100 m.
  - 15-min average wind profiles, updated every 5-min.



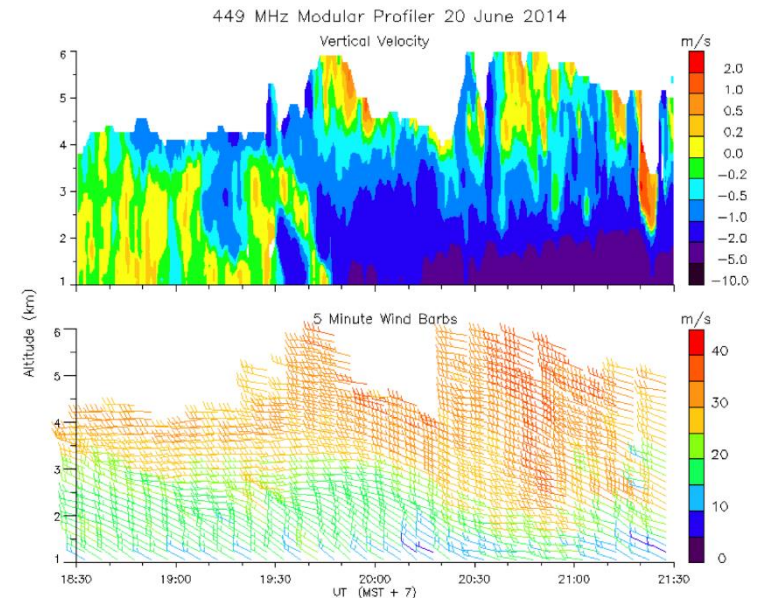
# D449 vs D915 Data Availability

- Top plot shows % data availability from:
  - NOAA Profiler Network (NPN), containing 35 D404s and D449s in the Central US.
  - PLTC2, an individual D449 located in Platteville, CO.
  - Period of record 2/1/04 - 4/30/04
- NPN low-mode availability is at least 90% from ~0.5-6.0 km.
  - Overlaps D50 from 2-6 km.
  - Redundant measurement capability.
- Bottom plot shows results from the same analysis using the KSC D915 archive.
  - Same scale.
  - 90% data availability from ~0.5-1.5 km.



# The NCAR Modular Profiling Network

- Developers
  - National Centers for Atmospheric Research (NCAR) / Earth Observing Lab (EOL)
  - University of Oklahoma's Atmospheric Radar Research Center (ARRC)
- Modular D449 with multiple module configuration options.
  - Each module has its own transmitter, receiver, and processing unit.
  - Arrangements consist of using one, three, or seven modules. Developers propose to use up to 19 modules.
- Modular Profiling Network (MPN) includes a mini-Lidar for low-level wind data collection.
- Working to improve lowest altitude and height resolution (currently 300 m and 150 m, respectively).





# Requirements versus System

	Balloon	D915	D449	Lidar	Sodar	Other?
<b>Minimum Altitude</b>	Yes	Yes	?	Yes	Yes	?
<b>Altitude Interval</b>	Yes	Yes	Yes	Yes	Yes	?
<b>Maximum Altitude</b>	Yes	?	Yes	?	?	?
<b>Temporal Interval</b>	No	Yes	Yes	?	?	?
<b>Qualitative Cost</b>	?	?	?	?	?	?
<b>Other?</b>	?	?	?	?	?	?