Results of the Kennedy Space Center 50-MHz Doppler Radar Wind Profiler Operational Acceptance Test

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Background

- NASA's 50-MHz Doppler Radar Wind Profiler (DRWP) at Kennedy Space Center (KSC).
  - Vertically-pointing radar that collects wind profiles every five minutes from near 2-18 km.
  - Identifies short-term wind changes.
  - Situational awareness asset for launch operations.
  - NASA replaced the original instrument in autumn 2014.
- Full certification required prior to acceptance.
  - Evaluates DRWP over multiple seasons.
  - Time-consuming process.
  - Vehicle programs desire to use the DRWP conditionally prior to certification.
- Operational Acceptance Test (OAT)
  - Short-term test to assess the new DRWP's data quality against the previous DRWP.
  - Verify DRWP data quality for Eastern Range launch support.

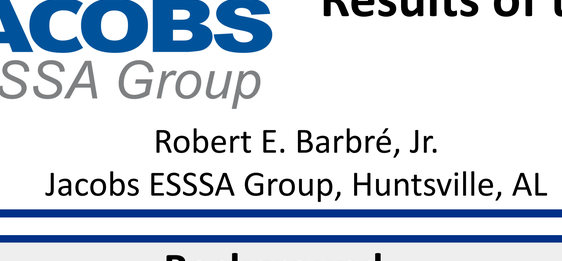


Figure 1: View of the new DRWP during installation.

OAT Criteria

Table1: OAT parameters and criteria.

OAT Test Plan Specifications	
Required Data	Wind Speed and Direction, Altitude, Shear, Radial Velocities, Signal Power, Noise Power, Spectral Width.
Time Interval	5 min
Vertical Data Interval	150 m
Altitude	2-18.6 km
Wind Accuracy	1.5 m/s RMS component difference
Effective Vertical Resolution	500 m

- OAT Test Plan [1] specifies parameters' acceptance criteria.
- Wind accuracy and effective vertical resolution (EVR) criteria are based on [2] and [3].
- Analysis methodology:
  - Required data, time interval, vertical data interval, and altitude: Data examination
  - Wind accuracy: Examine root mean square (RMS) wind component differences between DRWP and balloon data.
  - EVR: Spectral analysis of DRWP wind profiles.

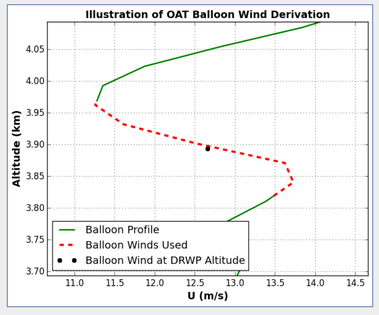
Data

- Automated Meteorological Profiling System (AMPS) balloons.
  - Low-Resolution (LR) and High-Resolution (HR) Flight Element (FE).
  - 30.5-m (100.0 ft) wind component profiles.
- DRWP
  - Winds and radar parameters reported every 150 m (492 ft) from 1798-19465 m (5899-63862 ft) at ~5 minute intervals.
  - Meets the OAT's criteria for required data, time interval, altitude, and vertical data interval.
- Data collected from 6 Jan 2015 to 19 Feb 2015.
- Quality control
  - Removed convective periods from DRWP archive.
  - Removed vector shears exceeding 0.15 s^{-1}.
- A total of 5426 concurrent winds from 49 profiles exist.

DRWP and Balloon Comparison

Preprocessing

- Extracted balloon data at each DRWP altitude.
- Extracted DRWP data at the timestamp corresponding to the balloon's altitude.
- Computed the wind component difference at each altitude.
- Scrutinized cases where vector differences exceeded 15 m/s.



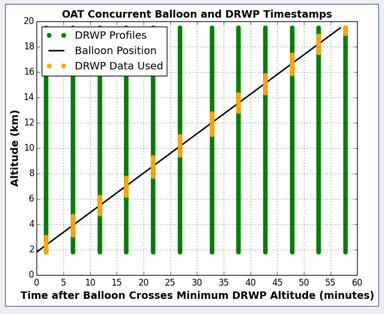


Figure 2: Illustration of OAT balloon (left) and DRWP (right) wind profile derivation.

Results

- RMS ΔU = 2.02 m/s and RMS ΔV = 2.14 m/s exceed criteria.
- Adjustments for system noise changed results by less than 0.03 m/s.
- Balloon drift has significant effect on results.
  - RMS ΔU, ΔV below 1.6 m/s, which is near the LRFE error.
  - Sample size artifact at close ranges.

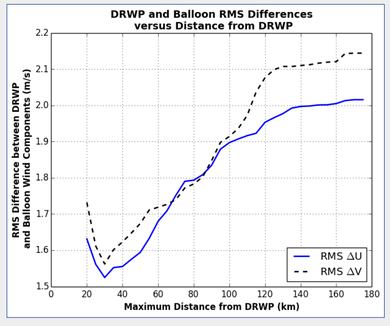


Figure 3: RMS ΔU and ΔV versus balloon's distance from the DRWP.

DRWP EVR Assessment

- Magnitude Coherence Squared (Coh^2) [3].
  - Quantifies correlation versus wavelength.
  - EVR defined at wavelength where Coh^2 equals 0.25.
- Computed daily mean power and cross spectral density and Coh^2.
- Sample-weighted mean Coh^2 exceeds 0.25 at all wavelengths.

$$Coh^2 = \frac{|\langle CSD \rangle|^2}{\langle PSD_1 \rangle \langle PSD_2 \rangle}$$

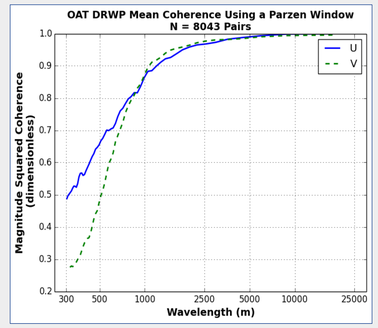


Figure 4: U and V Coh^2 versus wavelength.

Vertical Data Coverage Analysis

- DRWP reports a wind at all altitudes.
  - Median Filter First Guess algorithm [4].
  - Implements a first-guess propagation (FGP) if the signal to noise ratio is less than -30 dB.
- Examined FGPs versus altitude for awareness.

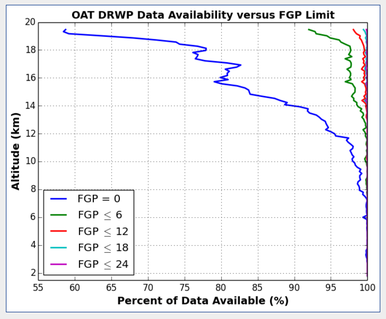


Figure 5: FGP limit versus altitude.

Conclusion

- Results pass all criteria except wind accuracy. However, data is good enough to use for its short-term purpose based on the OAT's intent and through experience.
- Individual vehicle programs decide if and how to use the DRWP.
- Intend to use the OAT methodology for DRWP full certification.

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References

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[2] Pinter, D.J., F.J. Merceret and C.V. Hatley, 2006: Performance Validation of the Upgraded Eastern Range 50 MHz Wind Profiler, *J. Spacecr. Rockets*, **43(3)**, 693 - 695.
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