Status of the KSC 50-MHz Doppler Radar Wind Profiler Operational Acceptance Test

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Outline

- Background
- OAT Criteria
- Data
- Methodology
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- Summary and Forward Work

Background

- The new 50-MHz Doppler Radar Wind Profiler (DRWP) shall undergo full certification testing prior to NASA acceptance.
  - Evaluates DRWP performance over multiple seasons.
  - Time-consuming.
- Desire exists amongst the launch vehicle community to use the DRWP before certification is complete.
- Operational Acceptance Test (OAT)
  - Goal: Evaluate the functional performance of the new DRWP so end users can use data during mission operations.
  - Short-term test to verify that the new DRWP's data quality compares well with the previous DRWP.
- Charts contain the data and methodology that MSFC Natural Environments (NE) is currently using for the OAT.

OAT 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

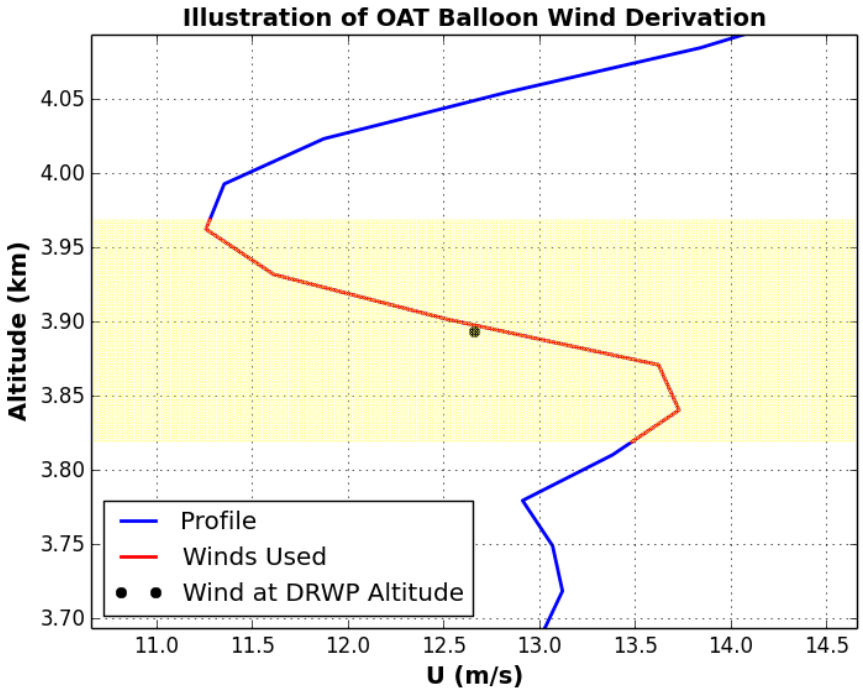
- OAT Test Plan specifies expectations of different parameters.
- Root-mean-square (RMS) and effective vertical resolution (EVR) values are baselines for DRWP examination based on results from previous tests (Pinter et al. 2006, Merceret 1999).
- Specifies that MSFC NE will compare simultaneous DRWP and balloon data.
- Does not define specific methodology.

Data

- Automated Meteorological Profiling System (AMPS) balloons.
  - Low-Resolution (LR) and High-Resolution (HR) Flight Element (FE).
  - 30.5-m (100.0 ft) wind components, interpolated from 1-s measurements.
- DRWP
  - Winds and radar parameters reported every 150-m (492 ft) from 1798-19465 m (5899-63862 ft) at ~5-min temporal intervals.
  - Meets the OAT's "required data", "time interval", "altitude", and "vertical interval" criteria.
  - Signal, Noise, spectral width, first-guess propagations are a function of four-beam system.
- Data collected from 6 Jan 2015 to 19 Feb 2015.
- A total of 5504 concurrent winds from 48 profiles exist.

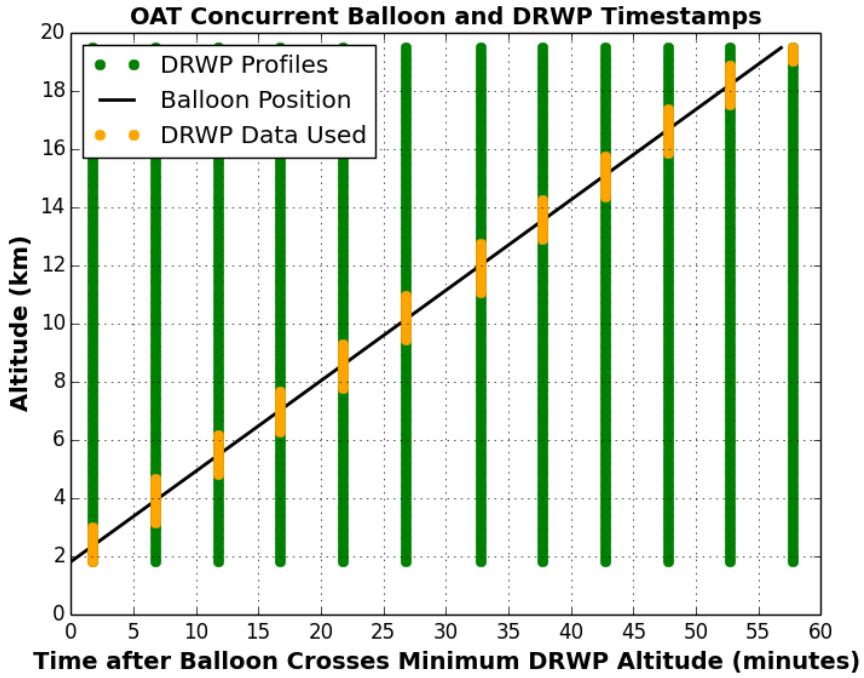
Methodology-Vertical Matching

- Addresses discrepancies from each source sampling at different altitudes and altitude intervals.
- Extracted balloon data at each DRWP altitude.
- Interpolated balloon wind components to 0.35-m (1.0-ft) intervals.
- Averaged wind component existing within 75 m (246 ft) of each DRWP altitude.

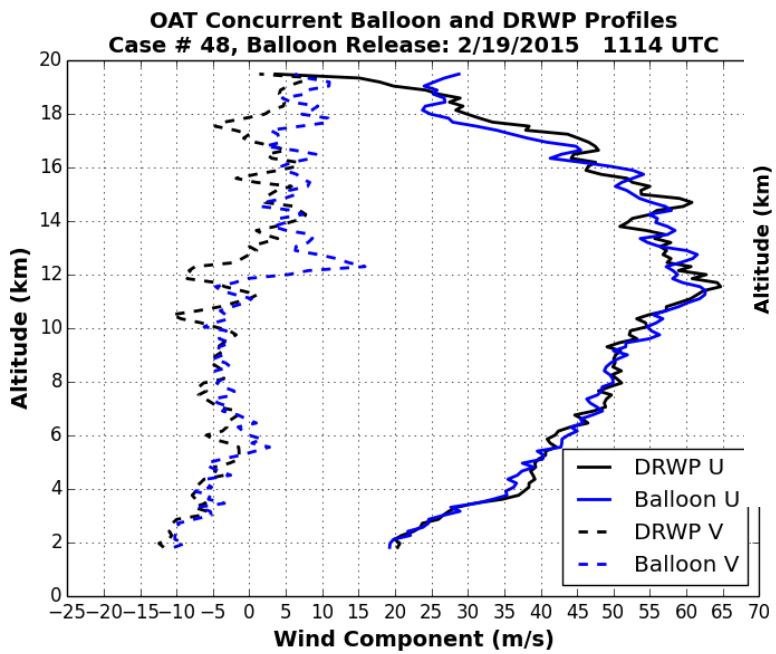


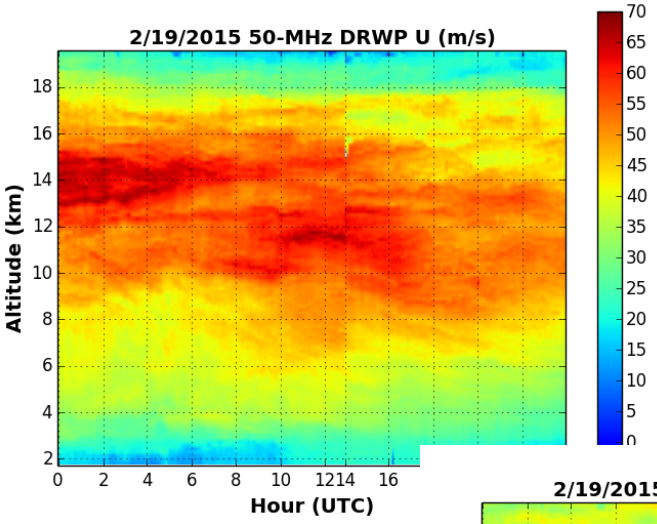
Methodology-Temporal Matching

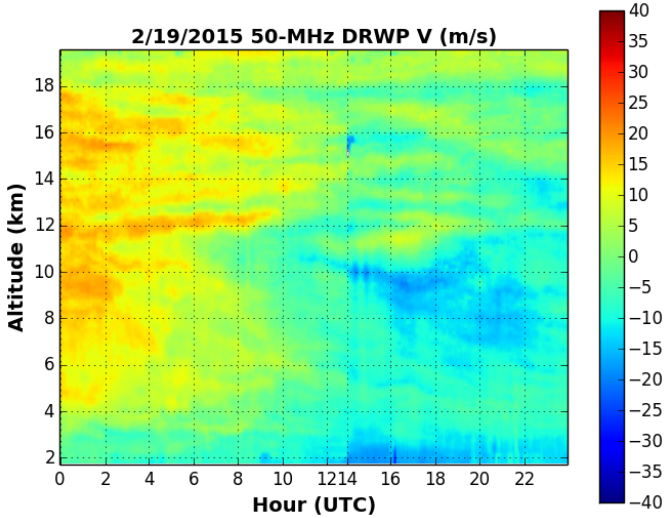
- Addresses each source's temporal sampling characteristics.
- Extracted DRWP data at timestamp corresponding to balloon's altitude.
- Derived balloon's altitude versus time after release using rise rate.
  - LRFE: Assumed rise rate of 5.2 m/s (17.0 ft/s).
  - HRFE: rise rate exists in data.
- Extracted DRWP data at the closest timestamp to the balloon's timestamp at the given altitude.
- Only used DRWP data if closest timestamp was within 10 minutes of balloon timestamp at the same altitude.
- Accepted concurrent profile if at least 75% of data exist below 15240 m (50000 ft).



Methodology-QC of Concurrent Profiles

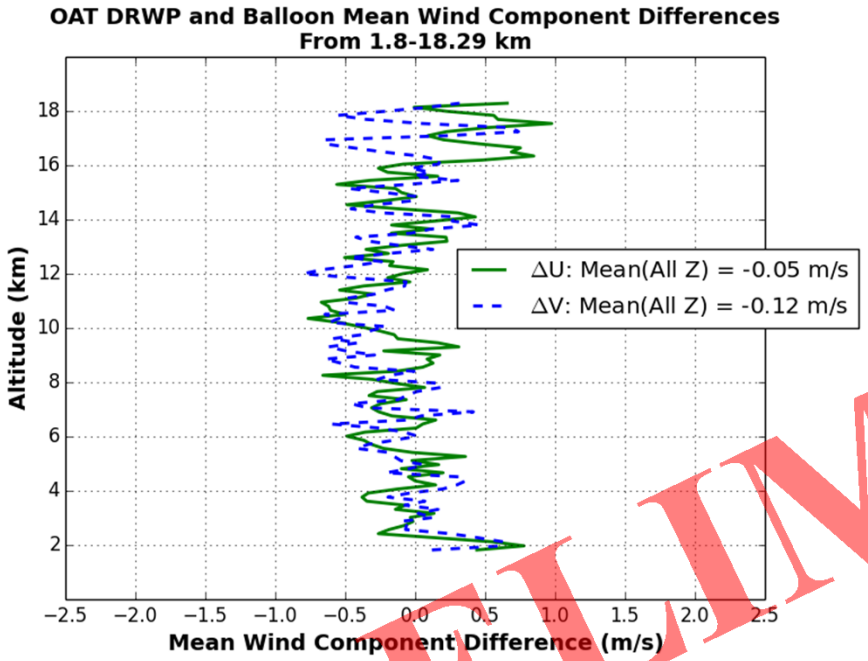


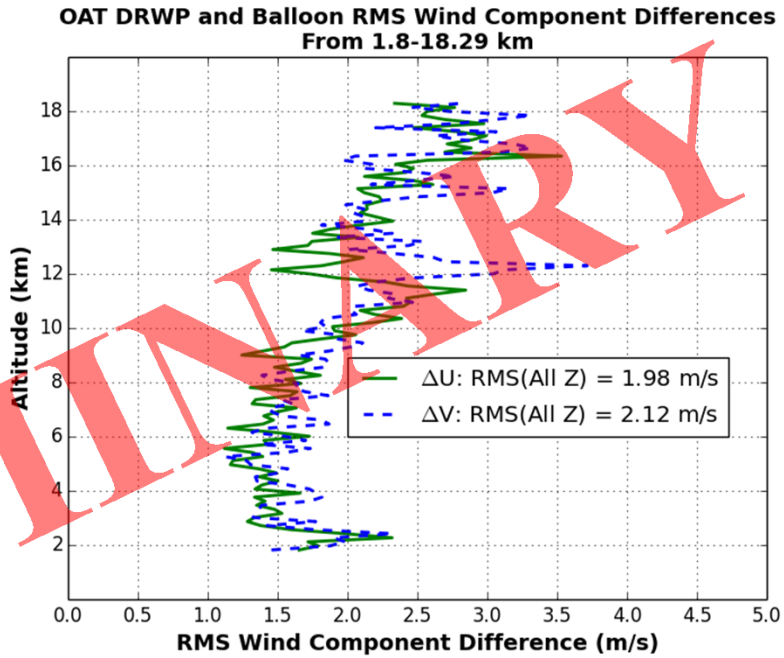




- Examined all comparisons, heavily scrutinizing cases with vector wind differences greater than 15 m/s (49 ft/s).
- Manually removed data only within suspect regions of flagged profiles.
- Illustrated case removes winds around 18500 m (60696 ft), but retains V near 12000-13000 m (39370-42651 ft).

Preliminary Results – Wind Differences





- From 1798-18288 m (5899-60000 ft), DRWP wind component bias approximates -0.1 m/s (0.3 ft/s) and RMS near 2.0 m/s (6.6 ft/s).
- Additional analysis necessary to determine causes of RMS results.
  - System noise
  - Seasonal effects (downrange drift)
  - Sample Size

Summary and Forward Work

- Preliminary results suggest DRWP wind component bias of approximately -0.1 m/s (-0.3 ft/s) and RMS of near 2.0 m/s (6.6 ft/s).
- Forward work
  - Examine DRWP EVR through spectral analysis.
  - Finalize wind difference results.
  - Release OAT final report 1 May 2015.

References

Barbré, R.E.: 2012. Quality Control Algorithms for the Kennedy Space Center 50-MHz Doppler Radar Wind Profiler Winds Database. J. Atmos. Oceanic Technol., 29, 1731–1743.

Marshall Space Flight Center Natural Environments. Operational Acceptance Test Plan for Qualification of Functional Performance of the New NASA/KSC 50 MHz Doppler Radar Wind Profiler (DRWP). 6 Nov 2014.

Merceret, F.J.: 1999. The Vertical Resolution of the Kennedy Space Center 50 MHz Wind Profiler. J. Atmos. Oceanic Technol., 16, 1273-1278.

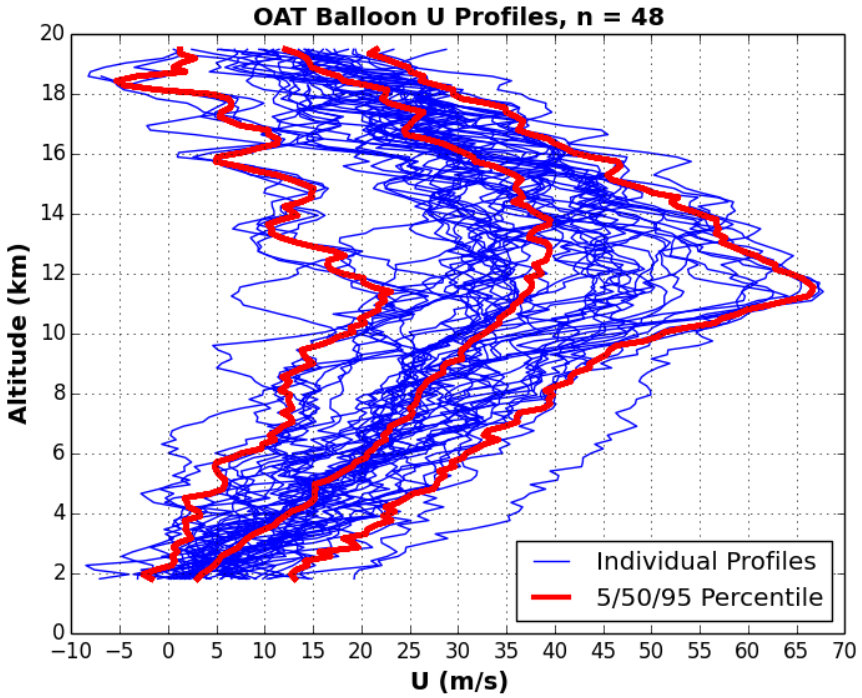
Pinter, D. J., F. J. Merceret, and C. V. Hatley: 2006. Performance Validation of Upgraded Eastern Range 50-Megahertz Doppler Radar Wind Profiler. J. Spacecr. Rockets, 43, 693–695.

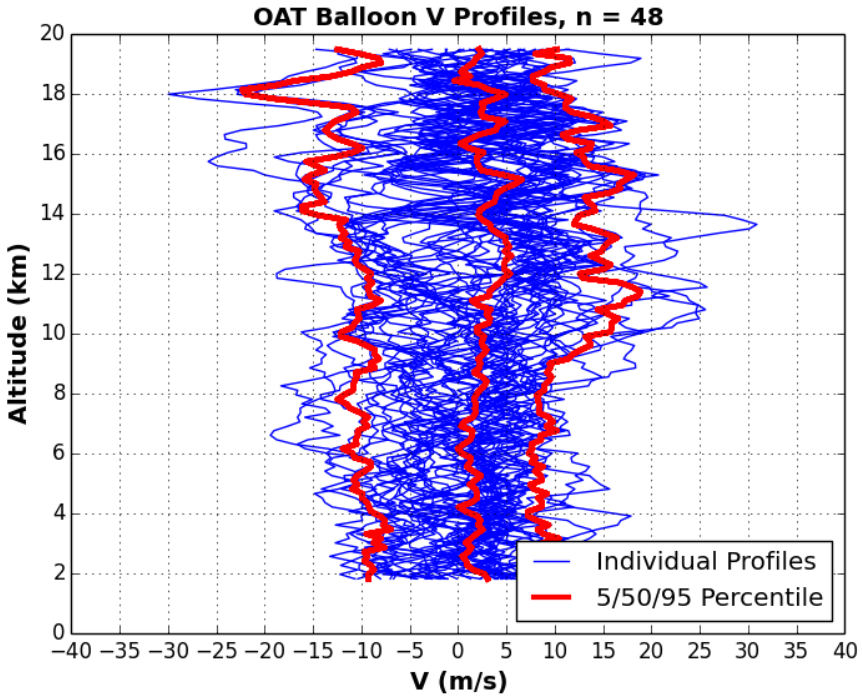
DeTect: 2015. NASA 50 MHz Wind Profiler Performance Acceptance Test Procedure and Test Results. DeTect document number 9001307.

Backup-Initial Processing

- Initial Balloon processing
  - Sorted all balloon data (LRFE and HRFE) chronologically.
  - Balloon must reach at least 15240 m (50000 ft) and report at 30.5-m (100.0-ft) intervals.
  - Balloon release times must be at least five minutes apart.
  - Check that a DRWP file exists for the day of balloon release.
  - A total of 56 balloon profiles are available after this step.
- Initial DRWP processing
  - Read DRWP data for the day(s) of each balloon release.
  - Removed DRWP data during convective events using algorithm from Barbre' (2012) and synoptic observations provided by the Cape Canaveral Air Force Base Weather Station.
- Implemented a shear check at each individual report.
  - Removed data if vector shear exceeded 0.15 s^{-1}.
  - Retained the rest of the profile.
  - Check removed small amount of balloon and DRWP data, respectively.

Backup – Initial Wind Examination





- A total of 48 profiles are available after aforementioned QC.
- Median U approaches 40 m/s (131 ft/s) from 12000-14000 m (39370-45932 ft).
- Median V is ranges from 0-5 m/s (0-16 ft/s) throughout profile.
- U is as large as 60-70 m/s (197-230 ft/s), which implies significant downrange drift.

Backup: Previous DRWP Study (Pinter et al. 2006)

- Comparisons of DRWP and balloons after DRWP upgrade in 2004.
- Data collected between Oct 2004 and Jan 2005.
- Compared DRWP to HR using DRWP profile 30 minutes after balloon release.
- Negligible bias and wind component root mean square (RMS) of approximately 1.5-2.0 m/s (4.9-6.6 ft/s).
- RMS reduced to roughly 1.6 m/s (5.2 ft/s) after removal of comparisons associated with large horizontal wind gradients.
- LR statistics from simultaneous releases:
  - Bias roughly 1.0 m/s (3.3 ft/s)
  - Standard deviation near 1.5 m/s (4.9 ft/s)
  - Implies RMS of approximately 1.8 m/s (5.9 ft/s).
- Acceptance criteria of 1.0 m/s (3.3 ft/s) mean and 3.0 m/s (9.8 ft/s) RMS component difference.

Backup: Comparison to Previous Study

- Table compares the mean and RMS wind component differences from Pinter et al. (2006) and the OAT at given altitude ranges.
- OAT mean differences are comparable to Pinter et al. (2006), and lower than LRFE mean (~1.0 m/s).
- RMS comparisons are all within 0.7 m/s (2.1 ft/s) of each other.
- OAT RMS differences are lower than Pinter et al. (2006) at altitudes from 2-6 km (6096-18288 ft).

	mean(du)		mean(dv)		RMS(du)		RMS(dv)	
	Pinter	**OAT**	**Pinter**	**OAT**	**Pinter**	**OAT**	**Pinter**	**OAT**
All Altitudes	-0.12	-0.05	0.01	-0.12	1.70	1.98	1.65	2.12
2-6 km	N/A	-0.07	N/A	0.03	1.85	1.49	1.78	1.60
6-14 km	N/A	-0.19	N/A	-0.25	1.40	1.86	1.40	2.06
14-18 km	N/A	0.19	N/A	-0.08	2.16	2.54	2.09	2.62

- Notable differences between OAT and Pinter et al. (2006) methodology.
  - Use of LRFE versus HRFE.
  - Maximum wind component magnitudes of ~70 m/s (230 ft/s) versus ~40 m/s (131 ft/s).
  - Temporal and vertical matching differences.
  - Different seasons (winter versus autumn and winter)