Quality Control of Wind Data from 50-MHz Doppler Radar Wind Profiler

Author: Austin Vacek – University of Alabama in Huntsville
Mentor: Ryan Decker – MSFC Natural Environments Branch/EV44

Abstract

Upper-level wind profiles obtained from a 50-MHz Doppler Radar Wind Profiler (DRWP) instrument at Kennedy Space Center are incorporated in space launch vehicle design and day-of-launch operations to assess wind effects on the vehicle during ascent. Automated and manual quality control (QC) techniques are implemented to remove spurious data in the upper-level wind profiles caused from atmospheric and non-atmospheric artifacts over the 2010-2012 period of record (POR). By adding the new quality controlled profiles with older profiles from 1997-2009, a robust database will be constructed of upper-level wind characteristics. Statistical analysis will determine the maximum, minimum, and 95th percentile of the wind components from the DRWP profiles over recent POR and compare against the older database. Additionally, this study identifies specific QC flags triggered during the QC process to understand how much data is retained and removed from the profiles.

Background

• The DRWP is a vertically pointing radar which transmits radio pulses in three beams (vertical, and two 15° off zenith at azimuths of 45° and 135° East from North) to determine vertical and horizontal winds.
• Return signal is converted to a power spectra using a Fast Fourier Transform.
• Radial velocity is then obtained from Doppler Shift.
• Using triangulation, U (east-west) and V (north-south) components are calculated from the radial velocity assuming a homogeneous atmosphere.
• Wind data are reported at 111 gates in 150m increments from 2.666 to 18,166m.
• Advantages over traditionally used weather balloons:
  • Continuously produces profiles every 3-5 minutes vs. 1 hour for weather balloons.
  • Measures wind above DRWP eliminating effects of balloon drift.
• Provides an important asset for NASA to understand the effects of the wind environment on the structural integrity of launch vehicles during ascent. NASA’s Space Launch System program is currently using wind data from the DRWP in vehicle trajectory design analyses.

Methodology

Automated QC Process
• Fills data gaps if greater than six minutes exist between timestamps with the missing data flag.
• Evaluates vertical beam measurements to avoid flagging a valid wind calculation.
• Series of threshold checks include: unrealistic wind, isolated data, small median test, oblique beam spectrum width (SW), meteorological shear, vertical velocity, first-guess propagation (FGP), oblique beam signal power, and convection.

Manual QC Process
• Flag contaminated data that pass automated QC check.
• Data that appears to be contaminated by convection or ground clutter are assigned own QC flag.
• Wind components from time correlated weather balloons are compared with DRWP profiles as a third-party check.

Statistical Analysis
• Calculate the total number of QC flags that occur.
• Determine the number of complete vertical profiles that exist.
• Construct maximum, minimum, and 95th percentile profiles and compare against previous QC data.

Results

QC Data
• Interference signals from sidelobes (non-meteorological artifacts, radio-frequency interference, ground clutter) are removed from data profiles. Figure 1 shows a sidelobe feature being removed from the daily profile at 5 km between the times of 8 to 14 UTC.
• The January 2010 to August 2012 data set contained 43.3 million gates with a given month containing 2.5 to 4.1 million gates.
• A total of 136 days existed that contained no data.
• The missing data flag was tallied most accounting for 20.6% of the total gates.
• The new QCed database retained 73.2% of the possible wind observations.

Complete Profiles
• A total of 101,467 complete profiles exist in the new QCed database. The Winter season contains the most complete profiles (36,221), while the Summer season contained the least complete profiles (30,400).
• An average of 3,171 profiles exist per month, ranging from 80 profiles (June 2010) to 5,072 profiles (May 2012).
• By adding the new QCed data to the current database, the number of complete profiles increased by 24.3%.

Weather Patterns
• Larger values of easterly winds are noticeable during the Transition and Summer seasons due to sea breezes developing off the Florida coast.
• Slightly larger northerly winds can be observed during the Summer season as the Azores High intensifies over the Atlantic Ocean.
• Westerly winds are more predominant during the Winter season as the jet stream develops trough patterns in the lower part of the United States.

Conclusions

• Third-party comparisons also display sidelobe characteristics which can be used to assist with the manual QC process.
• Manual QC is essential to ensure that only valid profiles are used for the database.
• A larger sample size of wind measurements better represents the atmosphere that could be experienced by launch vehicles.
• Adding new maximum and minimum wind observations assists on the development of structural integrity that the launch vehicle may experience during ascent.
• New database will be implemented in design assessments of the Space Launch System and future launch vehicle designs.

Future Work

• Continue the QC process and recalculate the number of gates and complete profiles with the remaining unfinished QC data of September 2012 until the end of the POR.
• Determine the number of pairs for each month for multiple temporal separation that correspond with the profiles.

Acknowledgements

I would like to thank my mentor, Ryan Decker for his guidance and support, as well as Robert Barbé Jr. for his guidance and programming assistance. This project was funded by the Space Launch System Project Office.

References