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Quality Control Algorithms and Proposed Integration Process for Wind Profilers Used by Launch Vehicle Systems

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Outline

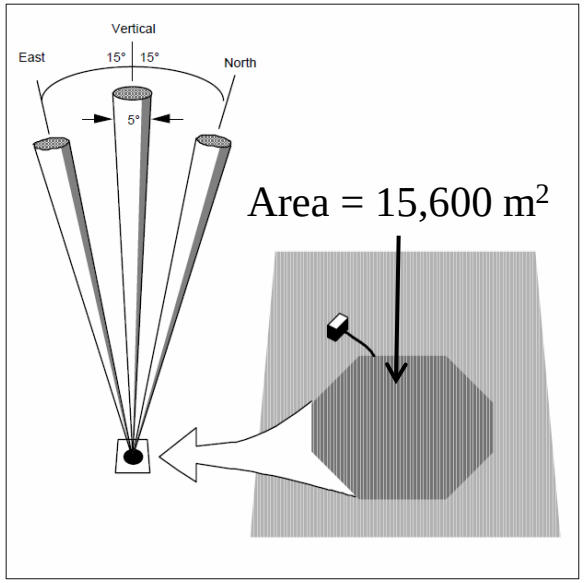
- Introduction
- 50-MHz Doppler Radar Wind Profiler (DRWP) description
- 50-MHz DRWP quality control (QC) process
- Resulting database
- Forward work

Introduction

- Impact of winds to space launch vehicle
  - Design
  - Certification
  - Day-of-launch (DOL) steering commands
    - Develop “knockdowns” of load indicators
    - Temporal uncertainty of flight winds
- Currently use databases from weather balloons
  - Discrete profiles and profile pair datasets
  - Issues
    - Larger vehicles operate near design limits during ascent
    - 150 discrete profiles per month
    - 110-217 seasonal 2.0 and 3.5-hour pairs
    - Balloon rise time (one hour) and drift (up to 100 n mi)
- Alternative approach using DRWP
  - Obtain larger sample size
  - Provide flexibility for assessing trajectory changes due to winds
  - Better representation of flight winds

50-MHz DRWP Description

- Identical systems at Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB)
- Clear air return via Bragg scatter
  - Signal obtained through temperature and humidity fluctuations in the atmosphere that are small compared to DRWP wavelength (6.0 m)
- Doppler return signal at each beam converted to an estimate of radial velocity at each range gate
  - Median filter first guess (MFFG) algorithm



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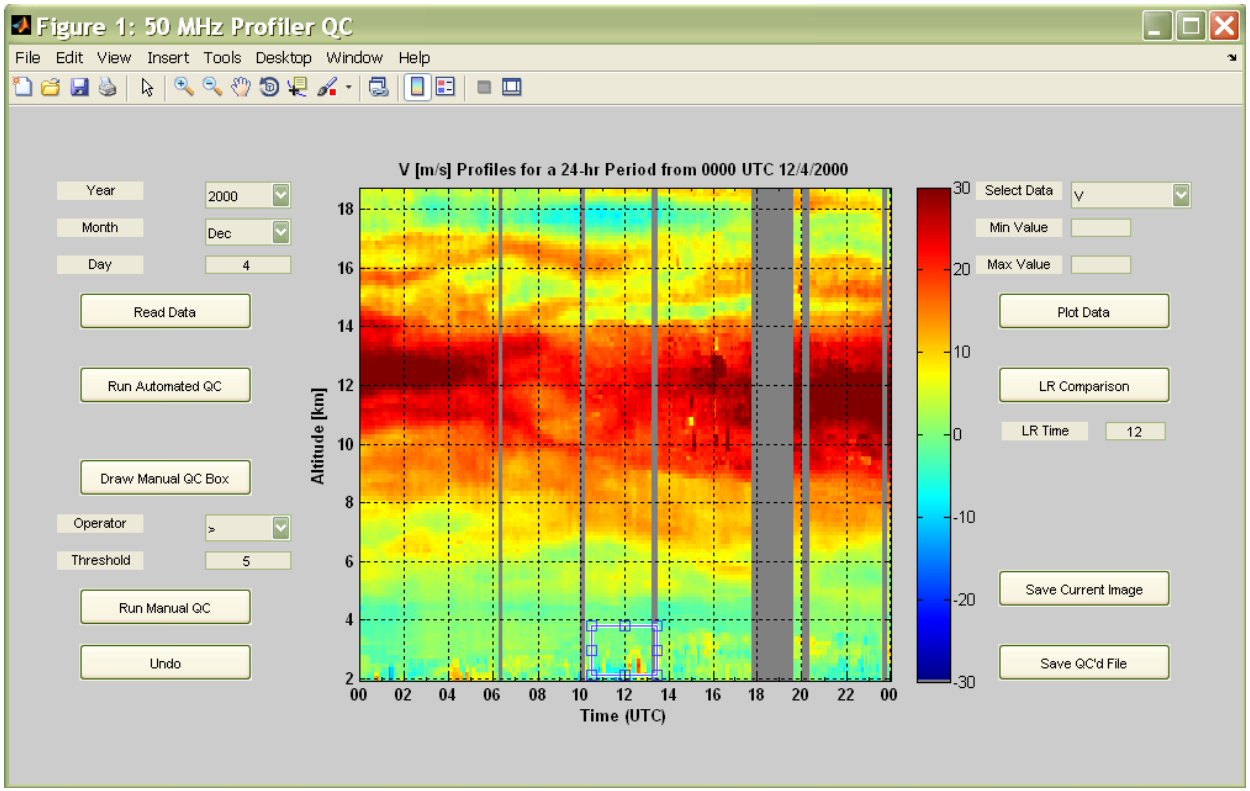
50-MHz DRWP Description

- Temporal and spatial coverage
  - 111 (or 112) gates within altitudes from ~ 2500 m (8200 ft) to ~ 18,500 m (60700 ft)
  - 150 m (492 ft) sampling interval
  - Data reported approximately every five minutes
  - Changed since DRWP's installation in 1990
    - Instrument upgrade in summer 2004
- Fields:
  - Wind speed (*WS*) [m/s], wind direction [deg], spectral width (*SW*) [m/s], signal power [dB], noise power [dB], vertical velocity (*w*) [m/s], # first-guess propagations, internal shear value [s^{-1}] at each altitude (*z*) [m]
  - Calculate east-west (*u*), and north-south (*v*) wind components
- Daily files from Aug 1997 to present archived at MSFC, but not routinely QC'd
  - Objects in atmosphere, Ground clutter
  - Rain, False signal from sidelobes
  - Weak signal, others…

QC Process

- Developed automated checks based on Carr et al (1995), Merceret (1997), and data examination
  - Filled in time gaps with missing data
  - Initial screening of vertical beam
  - DRWP internal shear and meteorological shear
  - Vertical velocity, spectral width
  - “Unrealistic” values
  - First Guess Propagations
  - Small-median test, Isolated datum
  - Rain / convection flags
  - Missing signal or noise from oblique beams
- Developed manual QC process
  - Side lobes, ground clutter, convection-contaminated data removal
  - Removed data based on user-specified thresholds of a variable
  - Graphical User Interface

QC Process



- Examine and QC data quickly
- Automated saving of images and logs
- Compare to Rawinsonde data
- Scrutinize QC process and add data

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QC Results

- Complete profiles
  - Approximately 30,000 profiles per month
  - Subsets selected for vehicle loads and trajectory assessments
- Complete pairs
  - Roughly 15,000 pairs per month and time separation
  - Different time intervals available
    - Not limited to 2.0 and 3.5 hours
    - Enhanced flexibility in knockdown calculations and DOL procedures
- ~100x sample size increase from balloon datasets

50-MHz DRWP Uses

- Provided subsets to the MSFC loads and trajectory community
  - Discrete profile sets
    - January (n = 28,200 profiles)
    - February (n = 30,059 profiles)
    - March (n = 34,649 profiles)
  - Temporal wind sequences
    - 3.0-hour pairs for January (n = 14,080 pairs), February (n = 15,314 pairs), and March (n = 17,746 pairs)
    - 3.0 and 1.0 hour February triplets (n = 9,259 triplets)
    - 4.0, 3.0, 2.0, 1.0, and 0.5 hour February sextuplets (n = 7,194 sextuplets)
- Issue
  - Boundary layer winds of interest to end user
  - 50-MHz DRWP does not sample altitudes below 2.7 km

Forward Work

- Generate vertically complete DRWP-generated wind profiles for use in vehicle design cycles and on day-of-launch

- QC 915-MHz DRWP data from KSC
- Combine 915-MHz DRWP and 50-MHz DRWP profiles
  - Vertically complete profiles over extensive POR
  - Same spectral resolution
  - Fare / interpolate 915-MHz DRWP data to 50-MHz DRWP data
- Repeat process for VAFB
  - One 50-MHz and six 915-MHz DRWPs
  - POR: December 2007 – June 2008, and October 2009
- Transition algorithms for operational use
  - Reduced uncertainty in DOL loads and trajectory assessments due to winds
  - Allow for go / no-go decision making closer to launch (e.g., Atlas launch scrub)
  - Winds used in DOL assessments will be more representative of vehicle ascent environments