Abstract

The National Aeronautics and Space Administration’s (NASA) Marshall Space Flight Center (MSFC) Natural Environments Administration’s (NASA) Marshall Space Flight Center (KSC), located on the United States Air Force’s Eastern Range (ER) at the Cape Canaveral Air Force Station. The ER complex is one of the most heavily instrumented sites in the United States with over 31 towers measuring various atmospheric parameters on a continuous basis. An inherent challenge with large datasets consists of ensuring erroneous data are removed from databases, and thus excluded from launch vehicle design analyses. EV44 has put forth great effort in developing quality control (QC) procedures for individual meteorological instruments, however no standard QC procedures for all databases currently exists resulting in QC databases that have inconsistencies in variables, development methodologies, and periods of record. The goal of this activity is to use the previous efforts to develop a standardized set of QC procedures from which to build meteorological databases from KSC and the ER, while maintaining open communication with end users from the launch community to develop ways to improve, adapt and grow the QC database. Details of the QC procedures will be described. As the rate of launches increases with additional launch vehicle programs, it is becoming more important that weather databases are continually updated and checked for data quality before use in launch vehicle design and certification analyses.

Wind Towers QC

- Check that derived $T_d$ has supporting measured $T$ and RH values.
  
  $$T_d = 243.04 - \ln \left( \frac{RH}{100} \right) + \frac{17.625 + T}{293.04 + T}$$

  - Realistic value check for $T$, $T_o$, RH, $WS_{mean}$, $WD_{mean}$ $WS_{peak}$, $WD_{peak}$.
  - Check for instances where dew point was greater than temperature.
  - Check for instances where wind speed is not provided.
  - Check for values that exceed daily variability thresholds.
  - Check wind vector difference for mean and peak winds:
    $$\Delta U = U - \frac{1}{2} (U_{+1} + U_{+1}) - U$$
    $$\Delta V = V - \frac{1}{2} (V_{+1} + V_{+1}) - V$$
    $$\Delta V_i = (\Delta U_i)^2 + (\Delta V_i)^2$$
  - Checks against data from surrounding vertical sensors:
    $$T_{adjacent} - T > Tower \ defined \ threshold$$
    $$\Delta V_{mean} - \Delta V_{mean} > 3.0 \ m/s$$
    $$\Delta V_{peak} - \Delta V_{peak} > 3.0 \ m/s$$
    $$45^\circ < |W_{mean} - W_{mean}| < 315^\circ$$
    Missing wind report from adjacent sensor
  - Checks against multiple instruments at a given height:
    - Data reporting a constant value for greater than 30 minutes.
    - Differences of a given parameter at the same height that exceeded daily climatological thresholds.
    - For the three towers at LC39-B, a horizontal check comparing each value to the other two values at a given height is performed to flag data where:
      $$|\Delta T|, |\Delta U_1| < 4.0 \, ^\circ C$$
      $$|\Delta RH| < 10 \%$$
      $$|\Delta Mean \ Wind \ Speed| < 5.0 \, m/s$$

Cardinal Stage

- Data from 31 different towers at KSC and the ER are archived at MSFC.
- Several towers are associated with launch complexes (LC) such as Tower 397 at LC39-B (SLS), Tower 40 at LC40 (Falcon 9), and Tower 41 at LC41 (Atlas V).
- The towers vary in height and meteorological measurement capabilities, but almost all towers measure wind speed, wind direction, temperature, and relative humidity at various heights. From these values dew point, mean winds, and peak winds are derived.

Current and Future Work

- The efforts outlined here are still a work in progress. The QC checks for wind towers are written. The remaining QC checks are based upon the previously developed databases by EV44.
- These checks will flag data, allowing analysts to search for specific flagged sets of data.
- These efforts will be revisited as new instrumentation is introduced at KSC/ER.
- These efforts will need to be modified as the format of the data may be altered.

References