The Quality Control Algorithms used in the Creation of NASA Kennedy Space Center Lightning Protection System Towers Meteorological Database

John M. Orcutt
Jacobs ESSSA Group / MSFC

James C. Brenton
Jacobs ESSSA Group / MSFC

Introduction
- An accurate database of meteorological observations is essential for designing any aerospace vehicle.
- Kennedy Space Center (KSC) Launch Complex 39B (LC-39B) Meteorological instrumentation.
  - Provides a unique dataset over an extensive altitude range.
  - Systems measure temperature, dew point, relative humidity, wind speed, and wind direction.
- Marshall Space Flight Center Natural Environments (MSFC NE) applied a broad quality control (QC) process to an archive of observations from January 2011 to April 2015.

LPS Tower Network
- Network consists of three towers at KSC LC-39B.
- Each tower has instrumentation at four levels.
- Observations are reported in 1-minute intervals.
- The following are measured at each level:
  - Temperature
  - Humidity
  - Dew point Temperature
  - Mean Wind Speed/Direction
  - Peak Wind Speed/Direction

The QC Process
- The methodology used is similar to QC procedures implemented on other tower databases by both the Applied Meteorological Unit (AMU) [3] and MSFC NE [1, 2].
- QC process consists of individual sensor checks, sensor-to-sensor checks, selection of an upwind tower, and a manual QC check.
- Automated individual sensor checks are performed first and include:
  - Unrealistic data check: Removes data that either physically cannot exist. Thresholds were determined from [3].
  - Tower obstruction check: Removes any wind observations that are obstructed by the tower.
- Automated sensor-to-sensor checks are then performed
  - Data hang-up check: Removes any data that are constant for more than 30 minutes.
  - Climatological check: Checks each observation against the standard deviation of the given parameter for the given month and hour.
  - Horizontal sensor-to-sensor check: Compares each sensor to the other two sensors at the same level.
  - Vertical sensor-to-sensor check: Compares each sensor to the one below and above. Is only performed on the middle two sensors.
- Automated up-wind tower selection
  - Selected to remove any outside influence on wind observations.
- A manual QC check is performed last
  - Distributions of data are examined to check validity of thresholds (Figure 3).
  - Daily time series of each variable are examined (Figure 4).
  - Any erroneous data that are found are removed.

Conclusions
- A database of meteorological observations was created with data from the LPS tower network.
- Period of record from January 2011 – April 2015.
- Between 88% and 99% of available data remained after QC procedure.
- Percentages remaining vary per month, sensor and tower.
  - Most sensors have approximately 85% availability during all months
- Database is regularly updated by MSFC NE.

Acknowledgements
The authors would like to thank Bill Barbré (Jacobs ESSSA / MSFC NE) and Ryan Decker (NASA / MSFC NE) for their help with gathering data that was missing from MSFC NE archives. Also, thanks must be given to the rest of the MSFC NE Terrestrial and Planetary Environments team for their contributions to this paper.

References

Attributes of the QC’d Database

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Initial # Available</th>
<th>% Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrealistic Data</td>
<td>0.44 M</td>
<td>0.01</td>
</tr>
<tr>
<td>Tower Obstruction</td>
<td>0.44 M</td>
<td>0.00</td>
</tr>
<tr>
<td>Data Hang Up Check</td>
<td>0.44 M</td>
<td>0.00</td>
</tr>
<tr>
<td>Climatological Check</td>
<td>0.44 M</td>
<td>0.03</td>
</tr>
<tr>
<td>Horizontal Sensor-to-Sensor Check</td>
<td>0.44 M</td>
<td>0.03</td>
</tr>
<tr>
<td>Vertical Sensor-to-Sensor Check</td>
<td>0.44 M</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Total Available % Available
- 99.1
- 97.9
- 90.8
- 95.2
- 94.1
- 92.9
- 88.1

Figure 1: Image of the lightning protection system (LPS) tower network.

Figure 2: (Left) A picture of the tower with each level’s elevation labeled, and (Top) a close-up of the tower’s instrumentation package.

Figure 3: Example of a distribution comparison used to determine the thresholds used to remove data.

Figure 4: An example of the daily time series for temperature used in the manual QC’ing of the data.