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

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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.

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

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

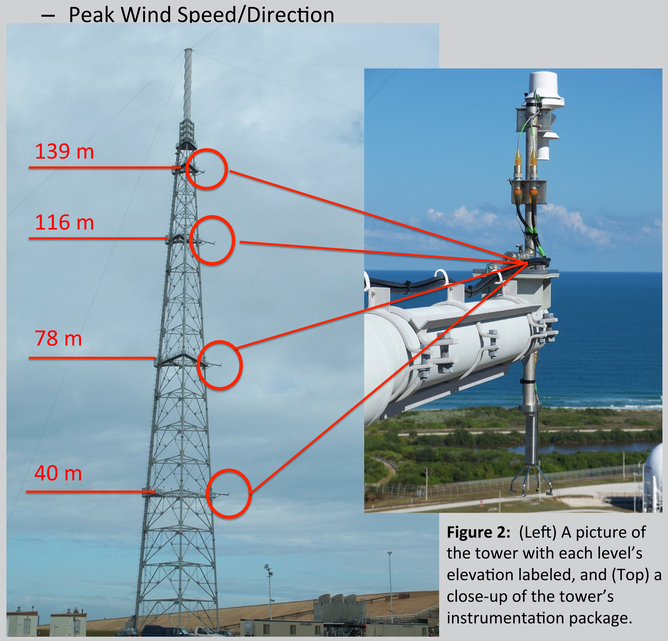

Figure 2: (Left) A picture of the tower with each level's elevation labeled, and (Top) a close-up of the tower's instrumentation package.

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 up-wind 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.

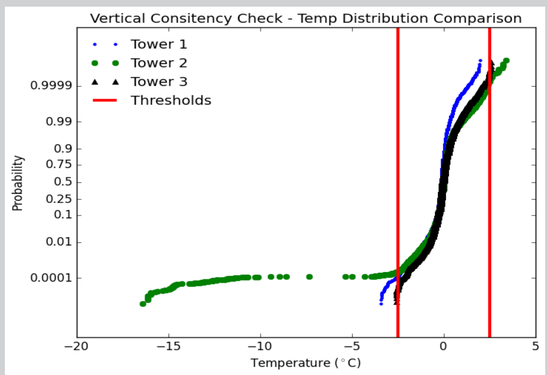

Figure 3: Example of a distribution comparison used to determine the thresholds used to remove data.

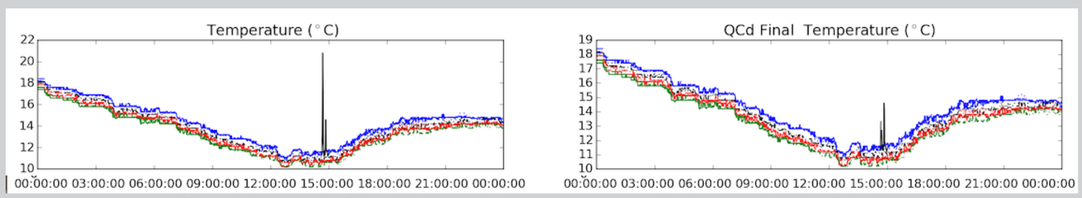

Figure 4: An example of the daily time series for temperature used in the manual QC'ing of the data.

Attributes of the QC'd Database

		T	Td	RH	WS	WD	PWS	PWD
	Initial # Available	10.44 M	9.64 M	10.39 M	8.84 M	8.94 M	9.06 M	9.54 M
Unrealistic Data Check	% Removed	0.03	0.01	7.2	3.5	4.6	5.8	10.6
Tower Obstruction	% Removed	0.00	0.00	0.00	0.02	0.02	0.02	0.02
Data Hang Up Check	% Removed	0.8	1.7	1.5	0.1	0.1	0.1	0.1
Climatological Check	% Removed	0.03	0.2	0.1	0.0	0.0	0.0	0.0
Horizontal Sensor-to-Sensor Check	% Removed	0.0	0.3	0.3	1.2	1.2	1.2	1.1
Vertical Sensor-to-Sensor Check	% Removed	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Available	# Available	10.35 M	9.44 M	9.44 M	8.41 M	8.41 M	8.41 M	8.41 M
	% Available	99.1	97.9	90.8	95.2	94.1	92.9	88.1

Conclusions

- A database of meteorological observations was created with data from the LPS tower network.
- Period of record of 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.

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References

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