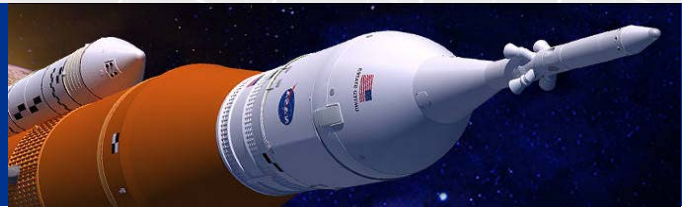
Quality Assurance Processes on KSC and ER Meteorological Tower Data Archived at MSFC



Jacobs Space Exploration Group
NASA MSFC, Natural Environments
Spring 2019 Natural Environments Day-of-Launch Working Group
Kennedy Space Center
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Agenda

1. Review of Data Received
2. Plan for QC'ed Archive
3. Tower QC Checks and Methodology
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   - Thermodynamic Checks
   - Wind Speed and Direction Checks
   - Sensor-to-Sensor Checks
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4. Manual verification of QC Flags with GUI
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Review of Data Received

- Marshall Space Flight Center (MSFC) Natural Environments (EV44) receives meteorological data from Kennedy Space Center (KSC) and the Eastern Range (ER) :
  - Balloon
  - Tropospheric Doppler Radar Wind Profiler (TDRWP)
  - 915 MHz DRWP
  - Weather Information Network Display System (WINDS) Towers
- EV44 has previously built QC'ed databases as needed for analysis, but now has a plan to develop a QC process for each system.
- This presentation will outline the wind tower QC processes.

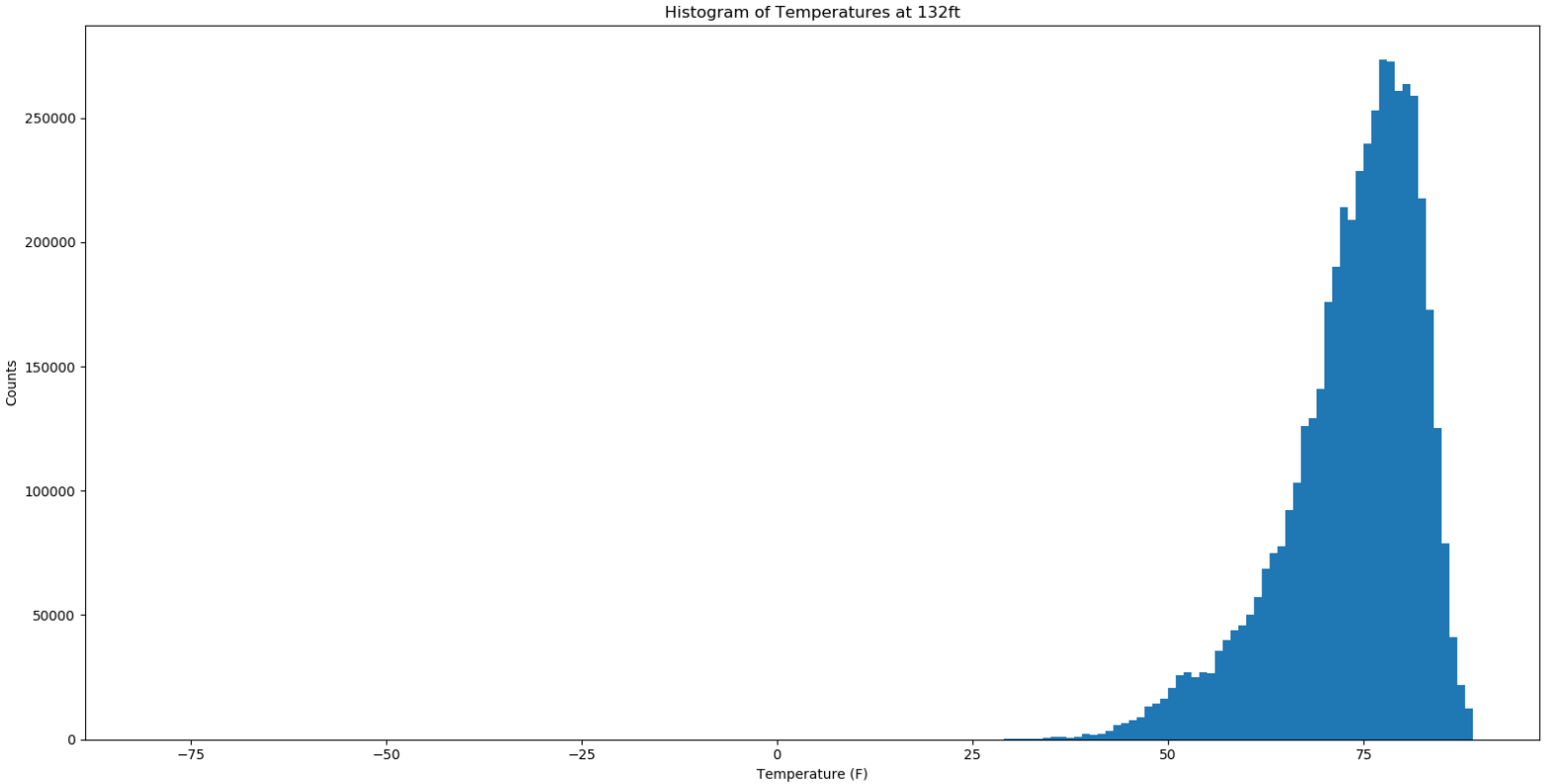
Plan for QC’ed Archive

1. Each variable needs to be assigned QC checks. To efficiently develop and assign checks, towers were grouped together based on similar structure.
2. Identify thresholds for the statistically driven QC checks. By implementing the QC checks, flags are written out with the data in EV44’s archive.
3. The flags are manually verified via a GUI. The GUI also gives the user the option to flag any erroneous data that was missed by the QC checks.
4. Once a month the data and QC flags are used to create two monthly NetCDF files: one with the as-received data with all QC flags and one with no QC flags but all flagged data that failed the manual verification removed.

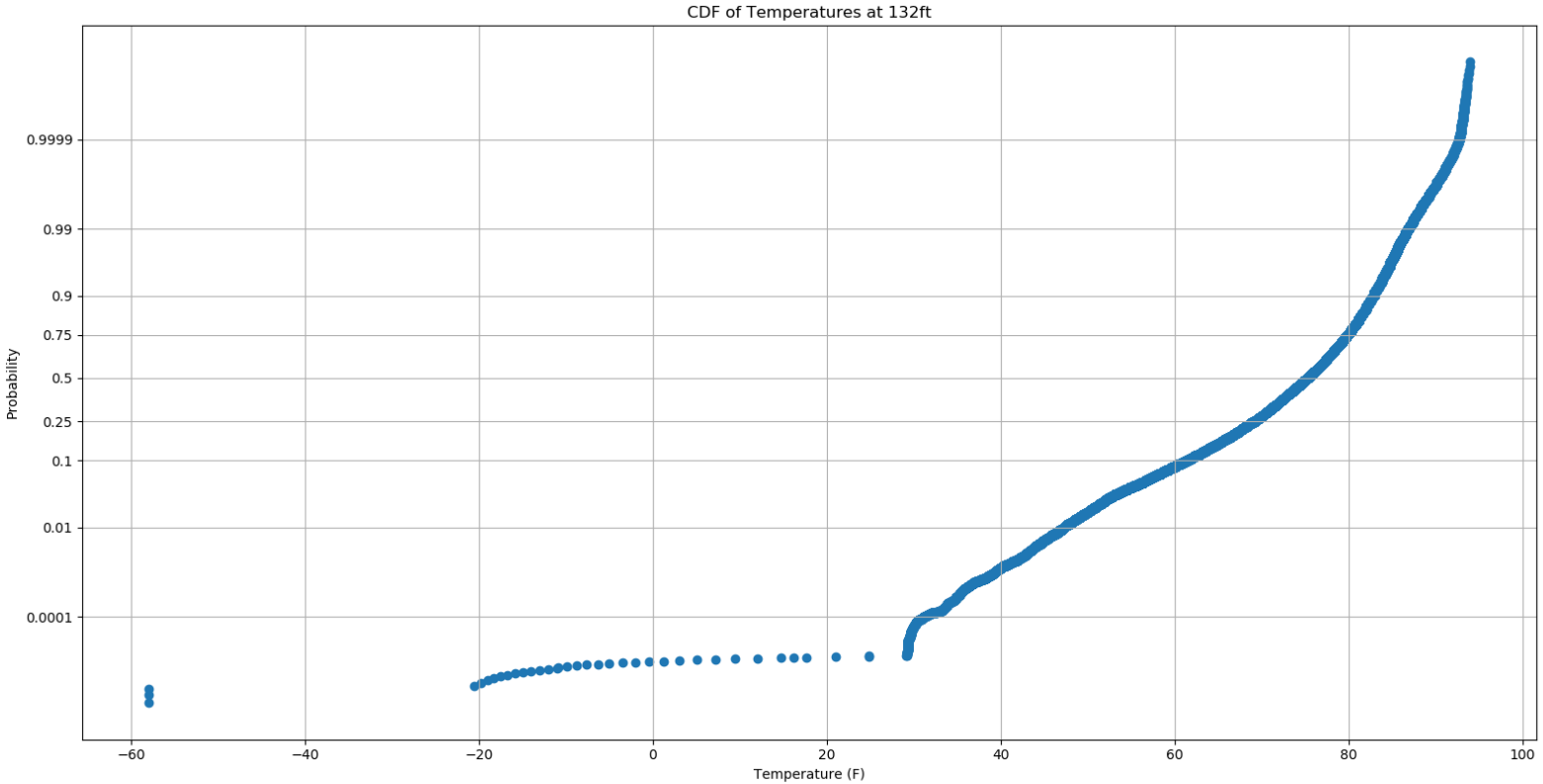
How the WT QC Checks Were Determined

1. Based on previous work
   - Barbré, R. E., “Quality Control Algorithms Used for the KSC Tower 313 Database.” Jacobs ESTS Group Analysis Report. ESTSG-FY08-1481. 2008.
   - Decker, R. K., “Kennedy Space Center Launch Complex 39 Meteorological Databases.” NASA/MSFC/EV44. Presentation to the Space Shuttle Program Natural Environments Panel. 28 February 2008.
   - Lambert, W.C. 2002. “Statistical Short-Range Guidance for Peak Wind Speed Forecasts on Kennedy Space Center / Cape Canaveral Air Force Station: Phase I Results.” NASA / Applied Meteorological Unit. NASA Contractor Report NASA/CR-2002-21180.
   - Orcutt, J. M. “The Quality Control Algorithms Used in the Process of Creating the NASA Kennedy Space Center Lighting Protection System Towers Meteorological Database.” Jacobs ESSSA Group Analysis Report. ESSSA-FY15-2550. 2015.
2. From this work, four types of QC checks were developed:
   - Thermodynamic checks for individual sensors.
   - Wind Speed and Direction checks for individual sensors.
   - Sensor-to-Sensor Checks
   - Upwind Sensor selection
3. Data from 2008 to 2017 were used for determining thresholds in checks. This provides a sample of multiple seasons.

Example of Histogram of a Dataset



Example of Cumulative Distribution of a Dataset



Thermodynamic Checks

1. Calculate Dew Point check (T_d)
   - Check if only Temperature and Relative Humidity are available, and calculate Dew Point.
2. Realistic data check (T, T_d, RH)
   - Thresholds for realistic data were based off of Histograms and CDFs of each variable.
   - Relative Humidity is set by physical limitations. (0 to 100%).
3. Temperature and Dew Point check (T_d)
   - Check that Temperature is greater than or equal to Dew Point.
4. Difference from Daily Median check (T, T_d)
   - The difference between all data points and the respective daily medians were found. This check protects against a sensor malfunctioning for several hours, where the values exceed or are below the expected diurnal variations.
5. Hourly Temporal Consistency Check (T, T_d, RH)
   - The surrounding hour for each data point was calculated and then the difference between the specific data point and the mean was found. This check protects against erroneous spikes in values.

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Wind Speed and Direction Checks

1. Realistic data check (W_S, W_D, P_S, P_D)
   - For Mean and Peak Wind Speed, the same methodology that was used for Temperature and Dew Point were applied.
   - Wind directions bounds are set by mathematical limitations. (0^o to 360^o).
2. Mean and Peak Wind Speed check ($W_S,\ P_S$)
   - Check that Peak Wind Speed is greater than or equal to Mean Wind Speed.
3. Light Wind Check ($W_S,\ P_S$)
   - Check instances where Mean Wind Speed and Peak Wind Speed are equal and greater than 1 knot.
4. Hourly Temporal Consistency Check (W_S, P_S)
   - The same methodology as the Hourly Temporal Consistency Check for Thermodynamic variables is applied to Mean Wind Speed and Peak Wind Speed
5. Mean Vector Consistency Check (W_S, W_D, P_S, P_D)
   - $\Delta\overline{U} = \frac{U_{i-1}+U_{i+1}}{2} - U_i,\ \Delta\overline{V} = \frac{V_{i-1}+V_{i+1}}{2} - V_i,\ \Delta V = \sqrt{\Delta\overline{U}^2 + \Delta\overline{V}^2}$

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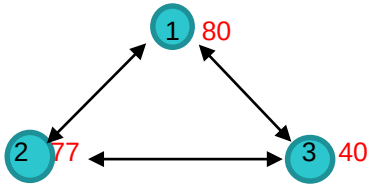
Sensor-to-Sensor Checks

1. Sensor-to-Sensor check
   - Check for “data hang-ups.” Data is flagged if data remain constant for at least 30 minutes and the difference between data at adjacent sensors exceeds a threshold for a given parameter.
   - For towers with multiple sensors at each height, direct sensor comparison will check and flag data that exceed a threshold based on a CDF of data deltas.



2. Vertical check
   - Temperature and Mean Wind Speed are the only variables checked due to inherent high vertical variability of other values. Also, this check will only be performed on sensors on the same side or tower.
   - Thresholds for differences will be based upon CDF of differences.

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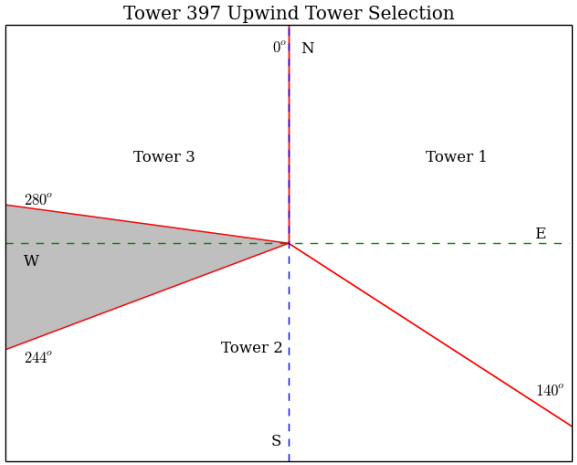
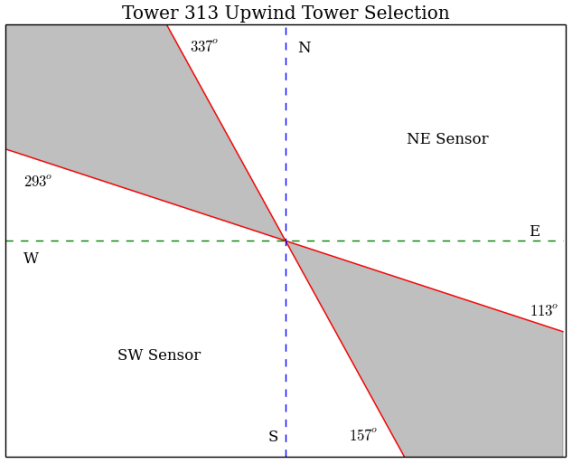
Upwind Tower Selection

- Upwind tower is determined by Mean Wind.
- If a wind is observed from one of the white regions in the graphs, that sensor or tower is selected as the upwind tower. If a wind is observed from one of the gray overlap regions, more scrutiny is applied to the upwind tower selection.
- The 200 ft towers, Tower 313, and Tower 397 will include QC flags indicating which sensor or tower was selected as the upwind sensor/tower.





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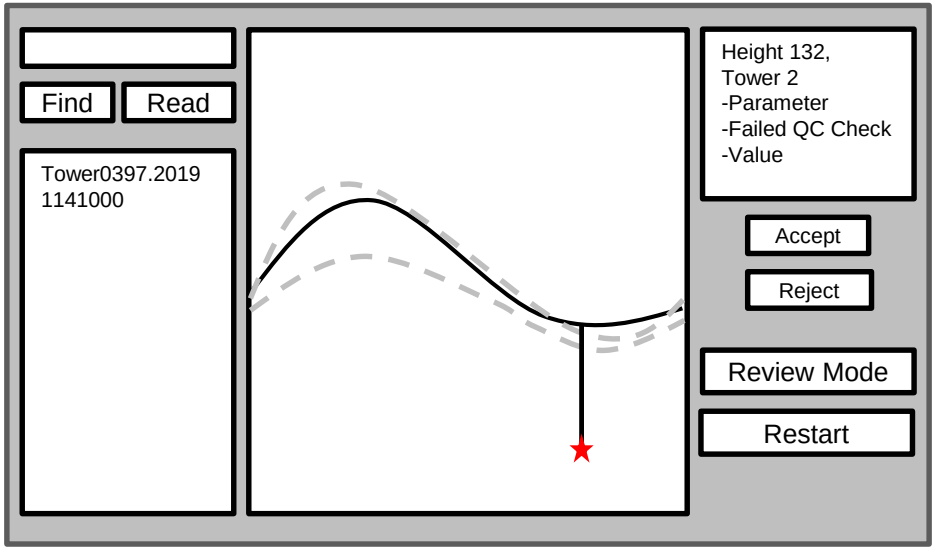
Manual Verification of QC Flags with GUI

- The previous checks will be part of an automated process to generate QC flags.
- A manual process will be implemented to confirm or reject QC flags. This process will use a Graphical User Interface (GUI) program constructed in Python to visualize the QC flags.



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QC Products and Future Work

- This process is built to begin building a database from the date of implementation, but have the versatility to backfill the database with prior data.
- The current plan is for WINDS Tower QC flags to be generated for all towers, however, only Tower 313 and 397 are planned to be manually verified.
- The process to begin generating QC flags for Tower 397 is nearing completion and other towers will follow.

Backup

Wind Towers Received

0001	0003	0019	0002 (NW)	0002 (SE)	0022
SLC 40	SLC 41	0006 (NW)	0006 (SE)	0108	0211
0300	0303	0311	0397 (LPS)	0403	0412
0415	0418	0421	0506	0509	0714
0803	0819	1000	1007	1012	110 (NW)
110 (SE)	1204	313 (NE)	313 (SW)	9404	

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