CYGNSS Preliminary L2 Winds

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CYGNSS L2 Products

- Preliminary L2 product development complete
  - L2 products:
    - Winds: DDMA, LES, MV
      - MV winds: optimal combination of DDMA and LES winds based on covariance of DDMA, LES errors with respect to truth; used for gridded L3 winds
    - Mean square slope (MSS)
    - Uncertainty estimates from each
    - At native resolution in time/space
      - Gridded product at L3
    - QC flags

- MSS algorithm: see talk from Valery Zavorotny on Wednesday

- L2 algorithm: summary of development and initial results …

GMF Overview

- Key to wind retrievals is geophysical model functions (GMFs)
  - Empirically developed mapping from observables to winds
    - Observables:
      - DDMA – NBRCS over 3x5 area in DDM around specular point (SP)
      - LES – leading edge slope from 3x5 area in DDM around SP
    - Winds: variety of L1 wind matchups from NOAA
      - Passive, active microwave, model
      - Using ECMWF as truth to develop GMFs
  - Data filtered to ensure quality data and smooth GMF

CYGNSS Observed BRCS

- DDM of observed BRCS (left) summed over 3x5 area (white box) around specular point (x)

- BRCS normalized by scattering area (right) to give NBRCS

- Example shown from CYGNSS overpass of TC Enawo

- Leading edge slope also computed from DDM of BRCS

BRCS

Scattering Area

Delay

Doppler
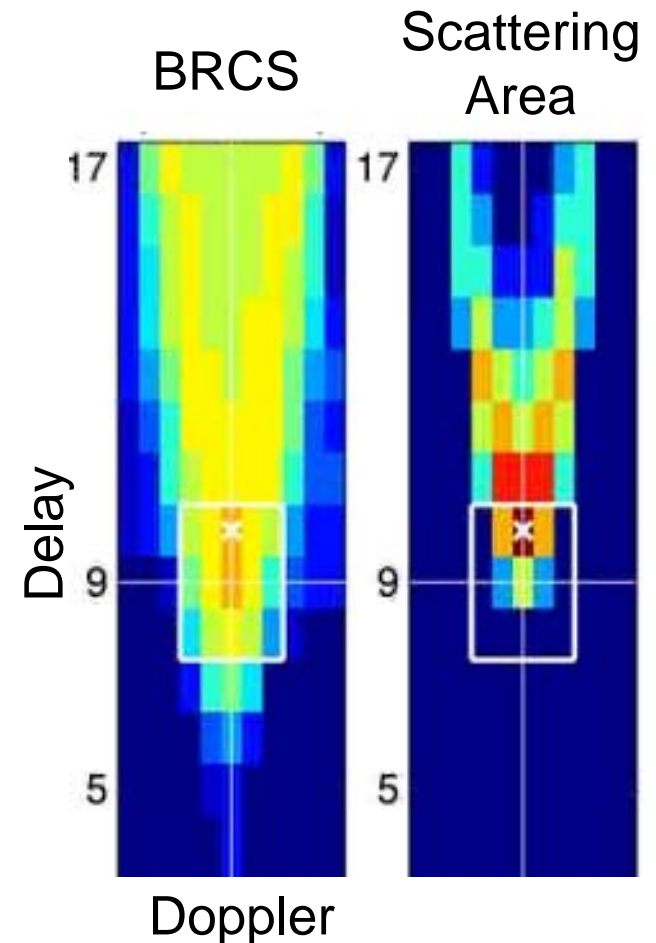
GMF Specifics (1 of 2)

- GMFs developed from early on-orbit data for initial release products
  - GMFs trained on V1.10 Data for DOY 44-101
  - GMFs a function of Incidence Angle and Wind Speed
  - GMF LUT filters to ensure stable, high SNR data:
    - RCG > 3
    - DDMA between 25 and 1000
    - LES between 15 and 1000
    - $|ECMWF\ WS - GDAS\ WS| <= 1.0$ m/s
  - Wind speed bins from 0 to 27 m/s (maximum in training set) in variable averaging widths

    +/- 2 m/s for wind speed < 5 m/s

    +/- 3 m/s for 5 < wind speed < 10 m/s

    +/- 4 m/s for 10 < wind speed < 14 m/s

   +/- 5 m/s for 14 m/s < wind speed

GMF Specifics (2 of 2)

- Inc. angle bins from 0 to 89 degrees with +/- 2 degree averaging width
  - Entries above incidence angle of 70 degrees are repeats of entry at 70
    - Very little data above 70 degrees = very noisy GMFs
- DDMA, LES GMFs forced to monotonic
  - Non-monotonic entries interpolated from nearest monotonic pair
- Bins with fewer than 100 observations removed
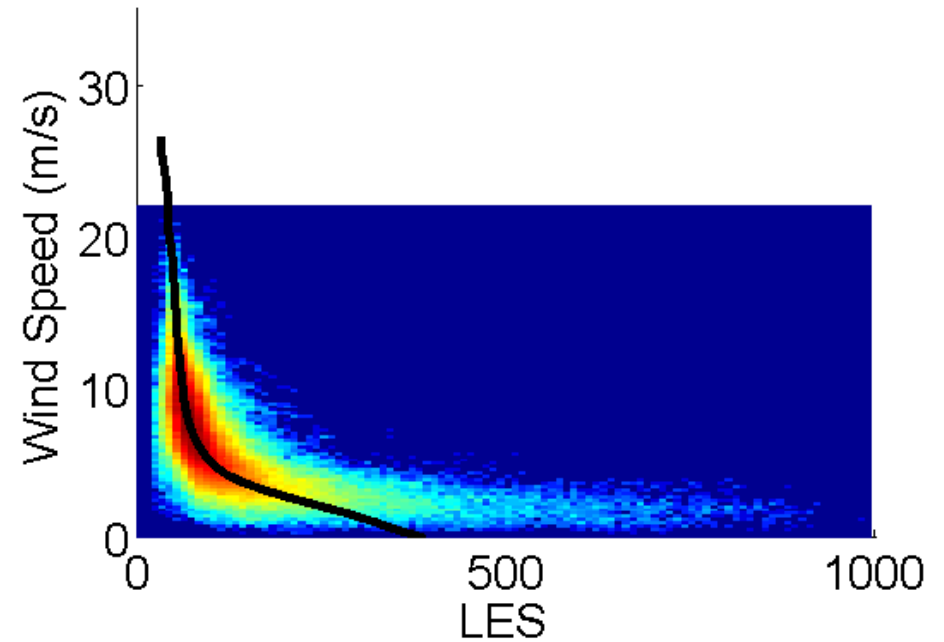 - Results interpolated from neighboring bins

Example DDMA and LES GMFs
Incidence Angles 28-29 Degrees

DDMA Training Data and LUT Curve
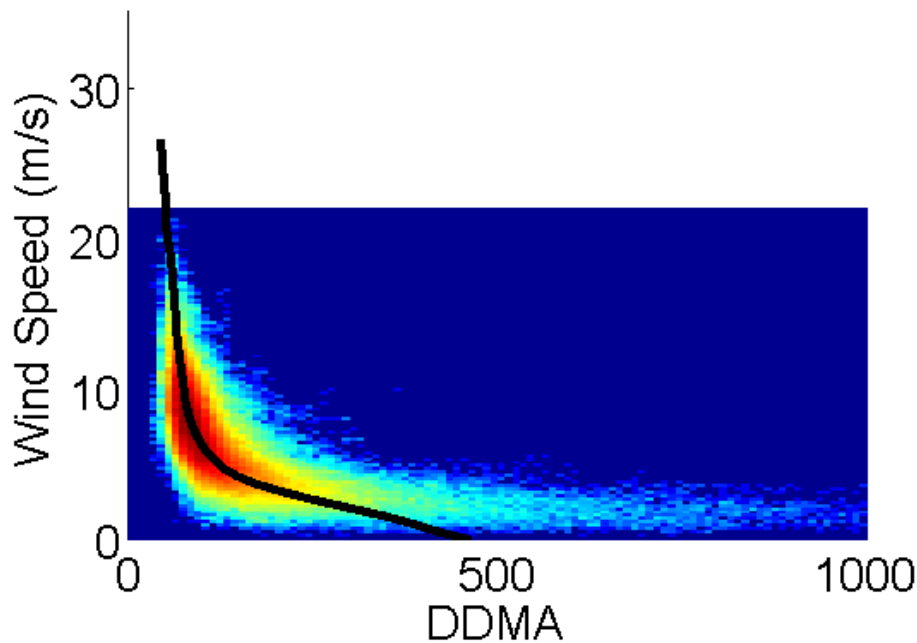
LES Training Data and LUT Curve

Wind Retrieval Preliminary Assessment

- These GMFs used to retrieve winds, compare to truth
  - Will reassess as new data over wider range are validated
- Performance assessment data filters:
  - |ECMWF WS – GDAS WS| <= 1.0 m/s
  - RCG > 3
  - LES > 0
- Minimum variance (MV) coefficients computed as function of RCG
  - Computed from covariance of DDMA and LES errors with respect to truth
    - Combination of DDMA and LES to minimize error, optimize information content
  - Coefficients binned by range corrected gain (RCG):

$$RCG = \frac{G_{Rx}}{(R_{Rx}R_{Tx})^2} * 10^{27}$$

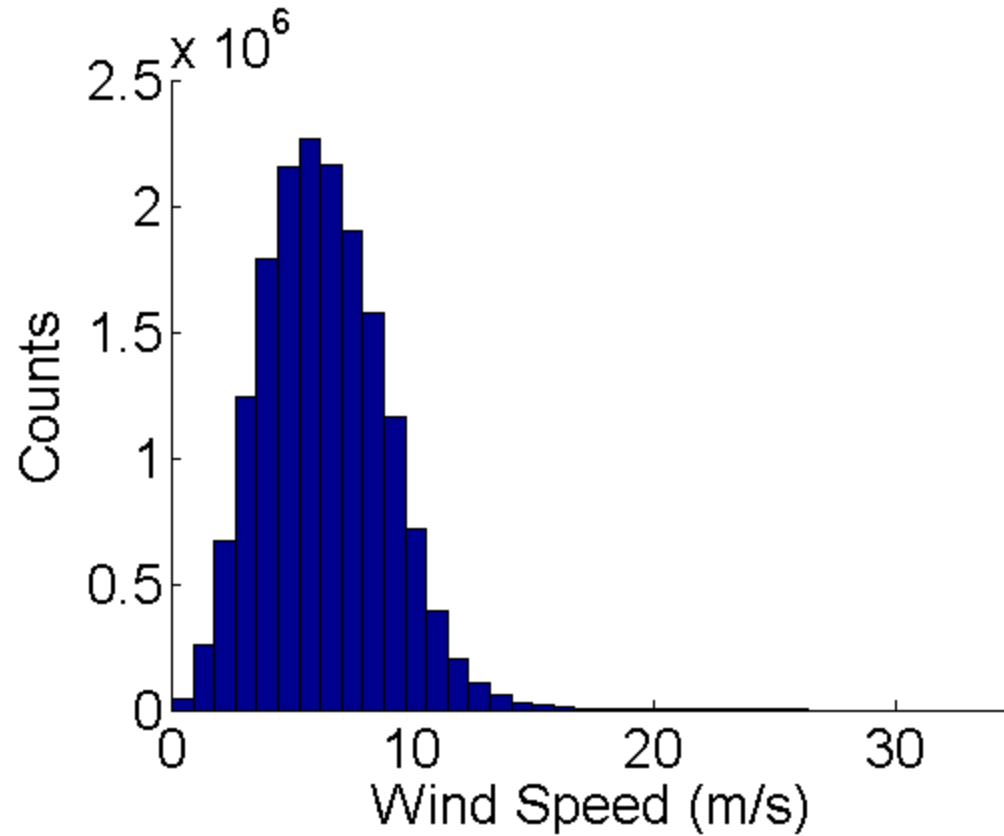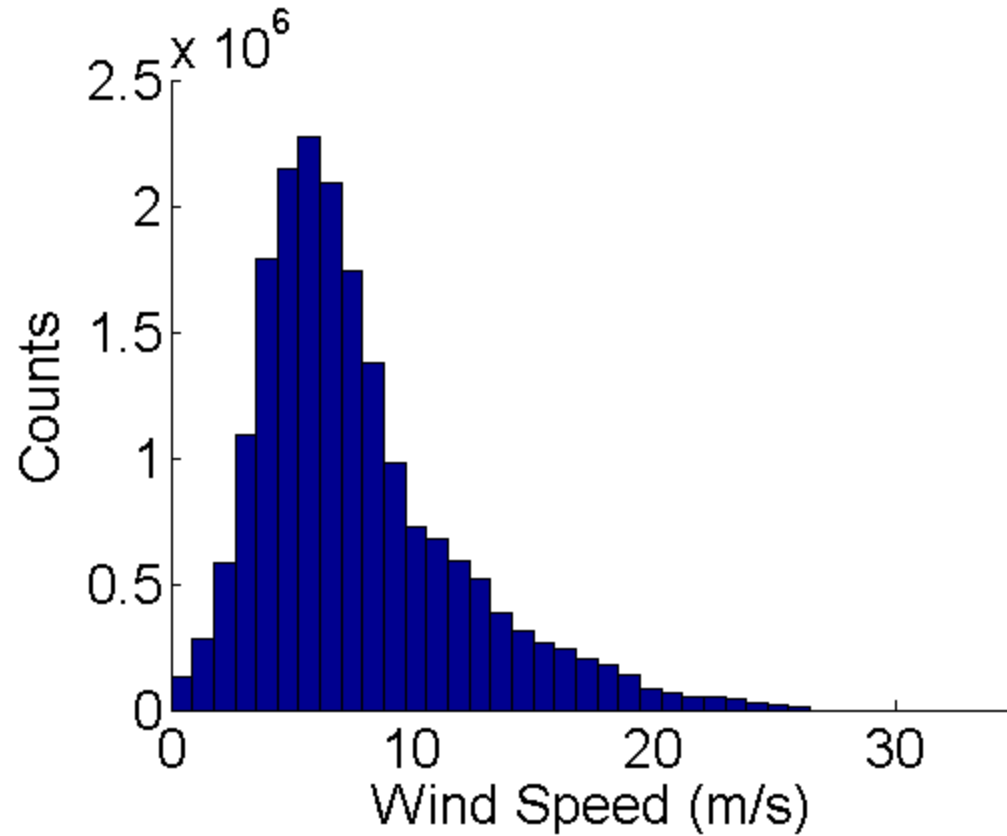# RMS Wind Speed Difference (Truth-Retrieved)
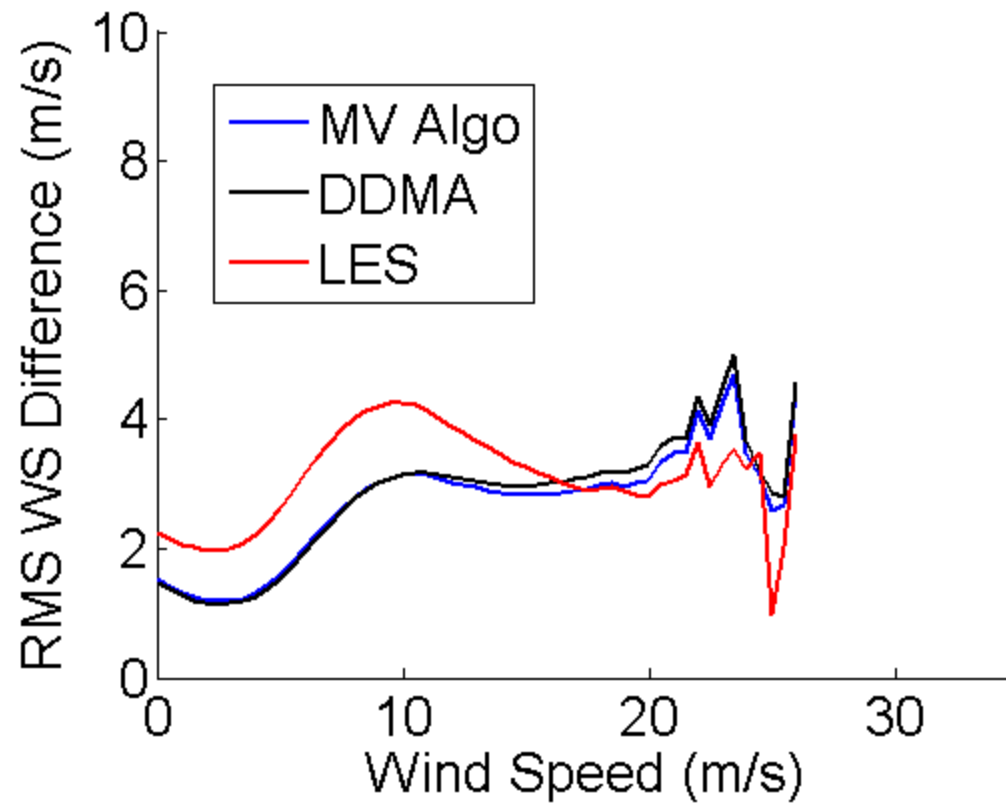
Histogram of Truth Winds

Histogram of MV Winds

- Above results are from off-line processing
- GMFs integrated into SOC processing to produce official L2 products with associated QC
    - Notes on QC: adjustments made to high wind flags
        - Non-fatal high threshold: 30-35 m/s (previously 70-100 m/s)
        - Fatal high threshold: >35 m/s
        - Limited to max winds in training and validation set
        - Will extend as get reliable high wind validation
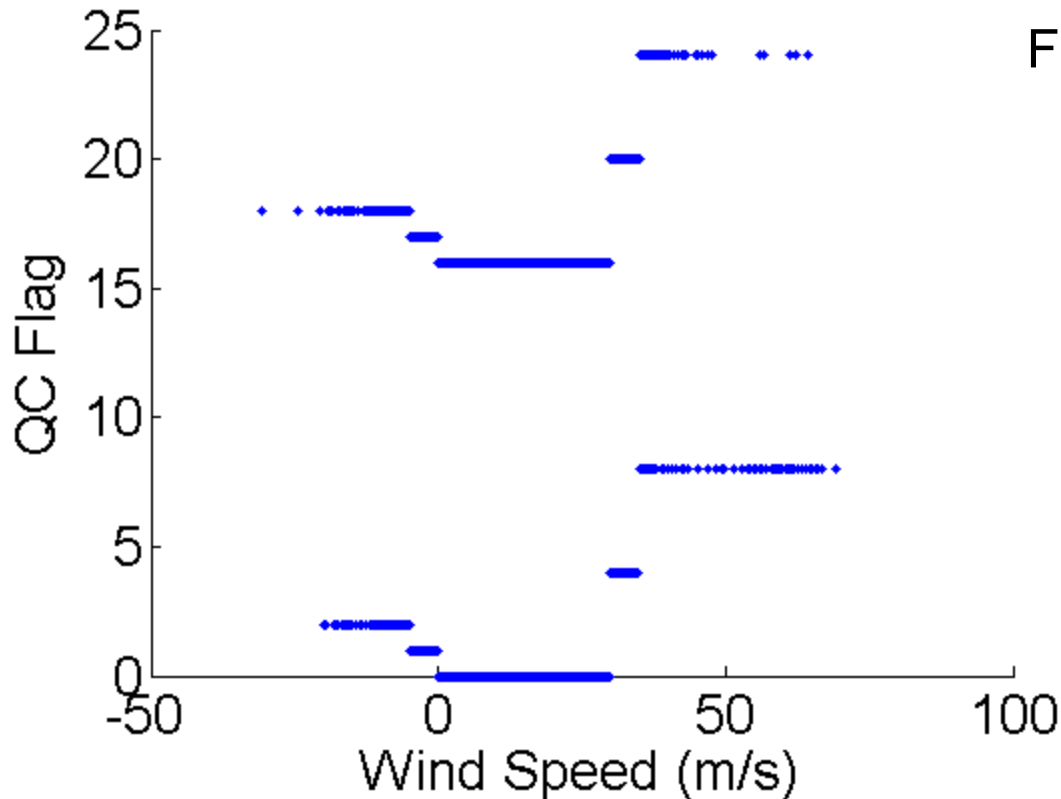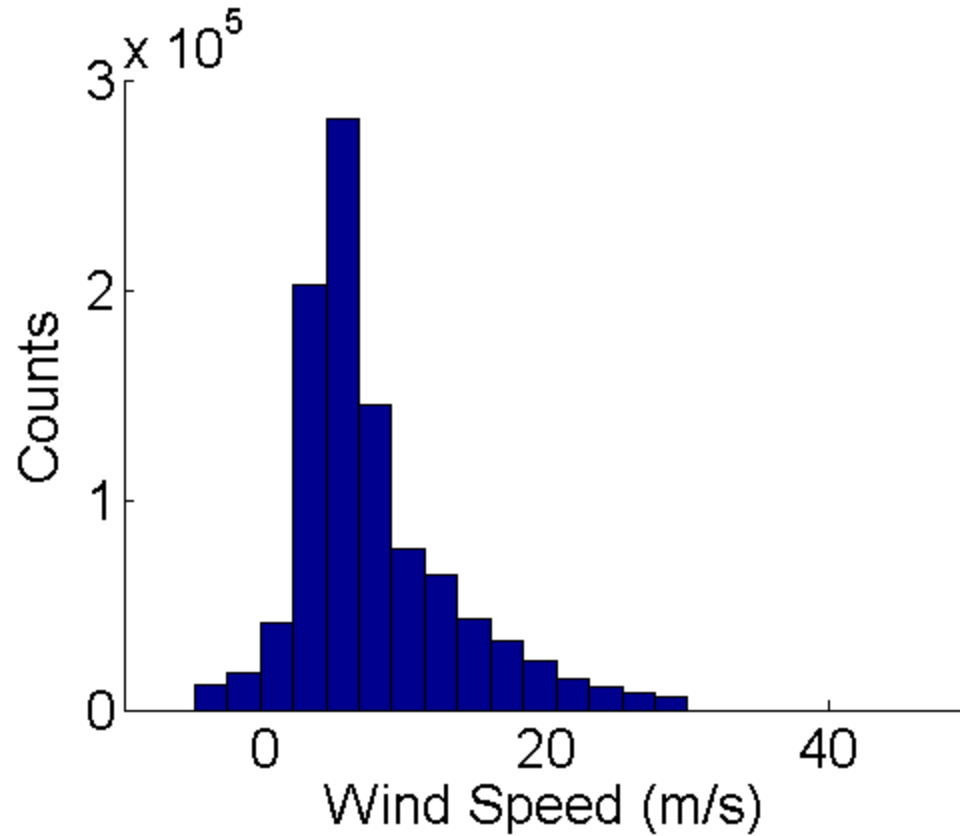
Histogram of L2 MV winds, No QC
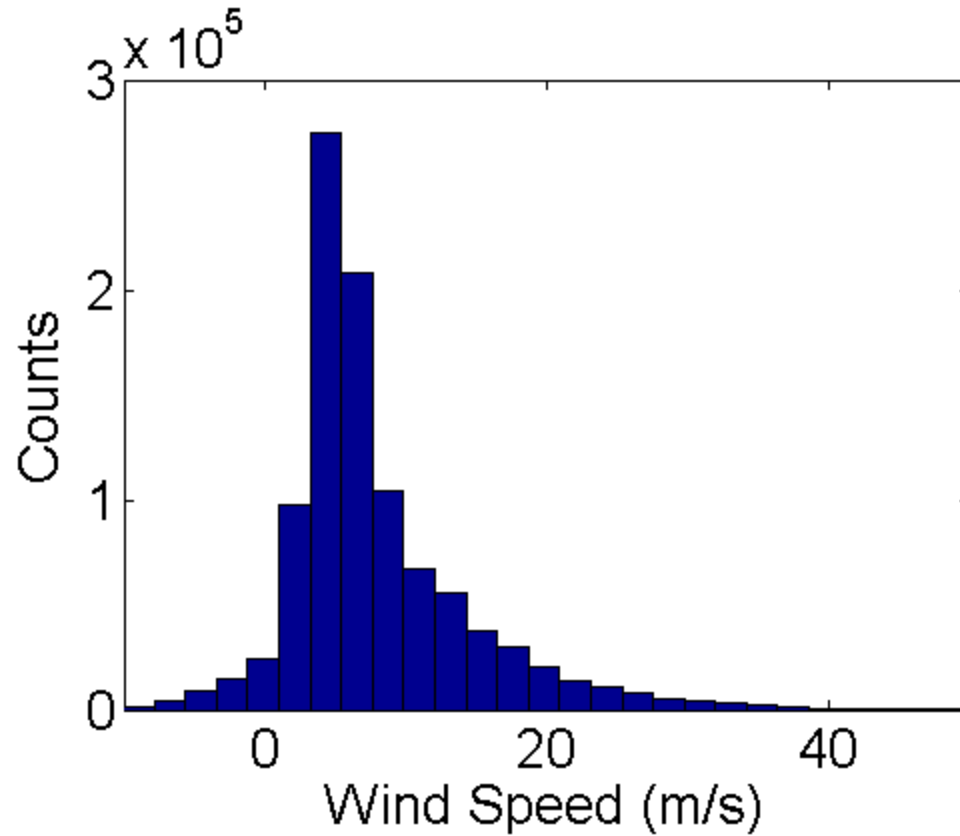
Example L2 QC flags

Flags:

0=good, descending pass
1=non-fatal neg, descend.
2=fatal neg, descend.
4=non-fatal high, descend.
8=fatal high, descend.

16=good, ascending pass
17=non-fatal neg, ascend.
18=fatal neg, ascend
20=non-fatal high, ascend
24=fatal high, ascen

Histogram of L2 MV winds, with QC

CYGNSS L2 Winds Summary

- Based on first ~60 days of on-orbit data, GMFs have been empirically developed to derive winds from CYGNSS observations
  - GMFs used to compute winds from DDMA and LES observables
  - These winds combined to provide optimized wind retrieval based on comparison to truth winds
  - Truth winds for initial development are from ECMWF
    - Checked for consistency against GDAS estimates
    - Limited in range to ensure validity
- CYGNSS L2 winds now in production at SOC
  - Due to limits of validation data, no retrievals beyond 35 m/s at this point
  - Future updates will improve performance of winds and extend range to TC strength winds as training and validation data become available