Assessment of Saildrone extreme wind measurements in Hurricane Sam using MW satellite sensors

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Acknowledgment: This analysis was supported by NASA OVWST
Saildrone (SD) mission in Hurricane SAM

- **NOAA/SD project** (summer 2021): 5 unmanned solar/wind powered Saildrones to monitor Tropical Atlantic/Caribbean, deployed in areas with high probabilities of storms.
- **SAM**: long lasting major Atlantic hurricane, Cat. 3-4 for 8 days (Sep/Oct 2021)
- **On Sep 30, 2021, SD-1045 was in the core of Hurricane Sam**
- Unprecedented observations of ocean surface variables within a major hurricane: winds, SLP, SHW, SST, RH, currents

Objective

Assess accuracy of SD extreme wind measurements, using many datasets:

- MW Satellite Sensors: radiometers (SMAP, AMSR2), scatterometers (ASCAT), SAR
- NDBC Buoy 41044
- HWRF model.

Methodology

Homogenize the observations to common height (10m) and account for differences in observed spatial/temporal scales

Approach:
1. Conversion to 10 m reference height in unusually extreme conditions: Use COARE 3.5 algorithm for 10 m adjustment (Fairall et al, 2003; Edson et al, 2013); adjust for tilting.
2. Time average SD to 10-min when comparing to low resolution (25-40 km) satellite
3. Tight co-location between SD, Buoy, and satellites: 10 minutes, 25 km
4. Apply similar adjustments to buoy data
5. Not possible to compare SD and Buoy directly □ use Sat and HWRF for cross-comparisons.
SD-1045 vs Satellite Winds

Saildrone 1045 in Hurricane Sam (10-minute mean)

(Sep 22-Oct 5)

SD peak winds at ~15 UTC
Buoy 41044 vs Satellite Winds

Buoy 41044 in Hurricane Sam in Hurricane Sam

Buoy peak winds ~6 UTC
AMSR2 TC- wind product:
- Specifically trained for storm conditions and in rain
- 25 km grid; considered ~10-min winds
- ~10% uncertainty
- Processed at RSS in NRT: https://www.remss.com/tropical-cyclones/tc-winds/

(Meissner et al, 2021; Manaster et al, 2021)
**SAR wind products:**
- We used SAR winds from Ifremer
- Accurate in TCs up to Cat. 5
- 3 km grid, considered ~ 1-min winds
- Processed at Ifremer in NRT: https://cyclobs.ifremer.fr/app/tropical.

(Mouche et al, 2019; Combot et al, 2020)
HWRF wind products:
• We used 0-hour analyses at 0, 6, 12, 18Z and 3-hr forecast at 15Z
• 10 m winds
• 1.5 km grid, considered ~ 1-min winds
• Later resampled at Sat resolution
• Processed at NOAA/NWS/NCEP:

(Biswas, 2018)

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<tr>
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<th>Max HWRF Wind speed (m/s)</th>
<th>SD vs HWRF Wind speed (m/s)</th>
<th>Buoy vs HWRF Wind speed (m/s)</th>
<th>Max Resampled HWRF Wind speed (m/s)</th>
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Summary Scatterplot of SD vs Satellite, 30 Sep 2021
Saildrone SD-1045 mission in Hurricane Sam (Sep 2021) exceeded expectations
Great potential for monitoring storms in remote locations

- SD observed peak winds of 40.5 m/s at a nominal height of 3.4m
- When converted to 10 m $\text{SD}_{10m} \approx 50$ m/s
- Conversion to 10 m winds performed using sophisticated algorithm for atmospheric boundary layer: COARE 3.5
- SD winds here were compared to all available MW Satellite passes for Sep 30
- Remarkable agreement between SD-1045 and Satellite at all winds (0-46 m/s)
- Indirect comparisons with buoys using satellite and HWRF as third-party data
- First and only assessment so far in hurricane
- Here we developed a methodology for comparisons with satellite winds
- More missions are planned for 2022
- SD data simultaneous with SAR and SMAP would be an ideal configuration
- This analysis $\text{Ricciardulli et al}$, being submitted to Remote Sensing in April 2022
Extra slides
**SAR vs SMAP vs HWRF: 10-12 UTC**

**Homogenizing spatial scales:**
In order to compare high-resolution SAR (3 km) or HWRF (1.5 km) to low-resolution SMAP (25 km grid), we performed a resampling of the SAR and HWRF grids using a Gaussian weighted window (40 km half-power width) resembling the SMAP signal distribution within a satellite footprint. (methodology in Manaster et al, 2021)

The resampled SAR and HWRF wind fields are consistent with SMAP.
ASCAT-B and -C TC-Winds at 13-14 UTC

ASCAT-B and -C: Processed at RSS, latency ~ days

- Global winds (25 km grid), ASCAT-A,B,C developed as Climate Data Record (Ricciardulli and Manaster, 2021);
- Not significantly affected by rain in storms; Decreased signal sensitivity above 35 m/s, might be biased low > Cat 1

www.remss.com/ascat
Sharp wind gradients and even small inaccuracies in the storm center position in the HWRF model make a comparison with SD or buoy in-situ data very challenging.
High resolution data (solid lines)
- Small eye (~ 50 km)
- Very sharp eyewall
- SAR minimum winds ~ 14 m/s
- HWRF minimum winds ~ 1 m/s

Resampling to a low resolution:
- Challenging resampling due to very small size of eye and core of the storm
- Resampled SAR consistent with SMAP
- HWRF resampled minimum is much lower than satellite.