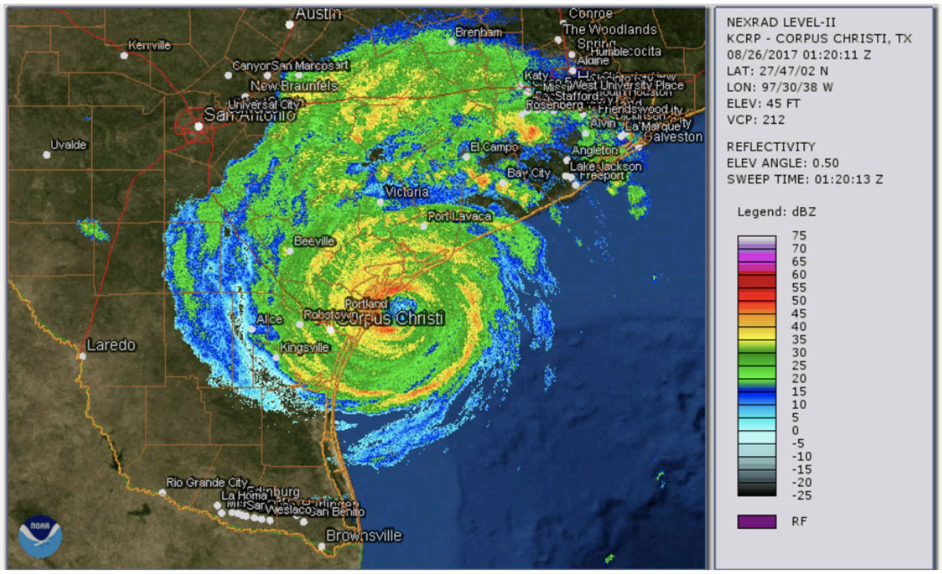
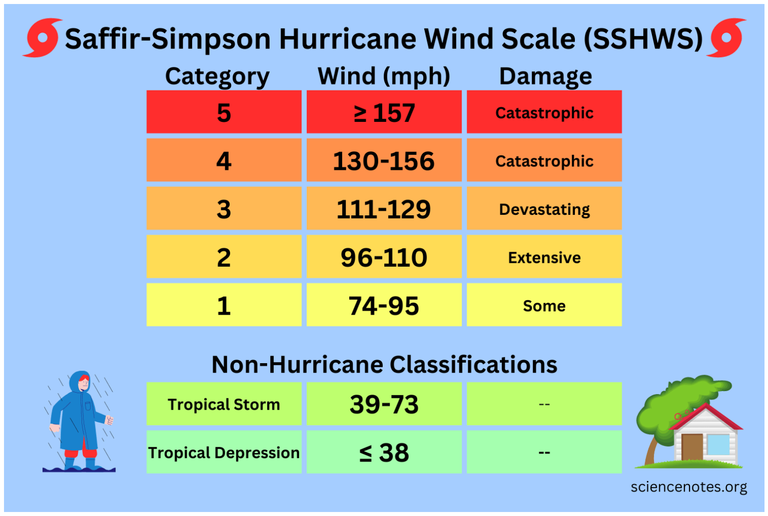
Hurricane Winds at Landfall: The Challenge of Accurate Measurement



Measuring hurricane winds at landfall presents significant challenges, often leading to discrepancies between a storm's official Saffir-Simpson rating and the wind speeds recorded on land. This issue was particularly evident during the hyperactive 2017 Atlantic hurricane season, which features 22 tropical cyclone landfalls.

This outbreak of tropical storm activity offered scientists an unprecedented opportunity to analyze and compare wind speeds recorded during hurricane landfalls against the storm ratings provided by the Saffir-Simpson Hurricane Wind Scale. Interestingly, direct land-based observations often fail to match the intensity associated with a storm’s official category.

The gap between estimated hurricane strength and ground-level wind measurements poses a significant scientific and practical challenge, with implications ranging from emergency planning and insurance policies to engineering and infrastructure.



Saffir-Simpson Hurricane Wind Scale (SSHWS)

Category	Wind (mph)	Damage
5	≥ 157	Catastrophic
4	130-156	Catastrophic
3	111-129	Devastating
2	96-110	Extensive
1	74-95	Some

Non-Hurricane Classifications

Tropical Storm	39-73	--
Tropical Depression	≤ 38	--

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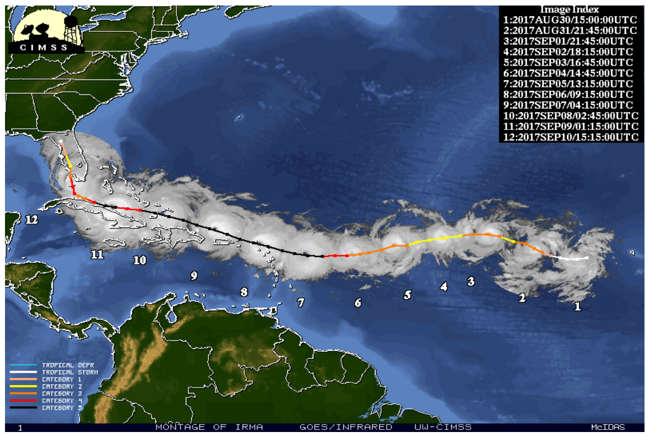
Reasons for Discrepancies

Several factors contribute to the mismatch between expected and observed wind speeds:

- **Rapid Wind Decay**: Hurricane winds diminish quickly after landfall thanks to friction. This dramatically reduces the optimal chance to capture peak speeds inland.
- **Sparse Instrumentation**: The strongest winds often occur in areas without weather stations, leading to underreporting.
- **Measurement Standards**: Wind speeds are standardized at 10 meters (33 feet) above ground. Since measurements taken at higher elevations may necessitate adjustments, this then introduces inaccuracies of such recordings.

- **Damage Indicators**: Structural damage assessments can suggest higher wind speeds than those recorded, but these are indirect measures and can be influenced by construction quality and other factors.

Case Study 1: Hurricane Irma's Dual U.S. Landfall



On September 10, 2017, Hurricane Irma made two landfalls in Florida:

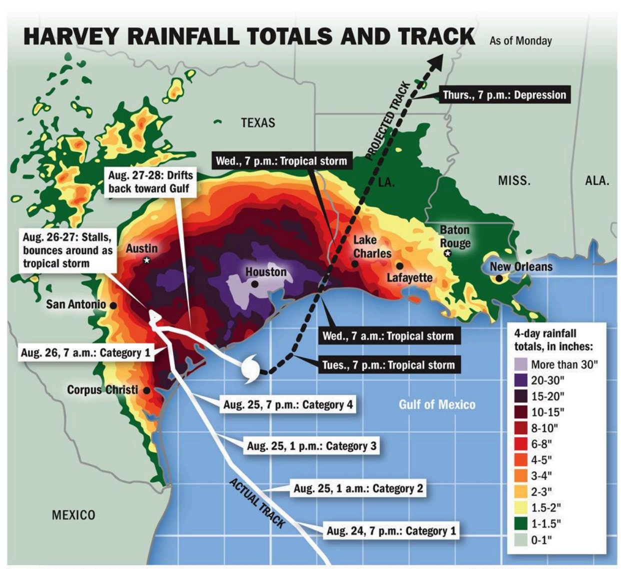
1. **Cudjoe Key at 9:00 a.m. EST**
   - Category 4
   - Estimated sustained winds: 130 mph (115 knots)
   - Central pressure: 931 mb
2. **Marco Island at 3:35 p.m. EST**
   - Category 3
   - Estimated sustained winds: 115 mph (100 knots)
   - Central pressure: 936 mb

Despite the high estimated intensities, direct wind measurements told a different story:

- A spotter reported sustained winds of **111 mph** on Marco Island.
- A U.S. Air Force tower in Cape Canaveral recorded **104 mph**—but at **459 feet** above the ground.

Adjusting those tower-based readings to the standard 10-meter height would yield significantly lower values due to frictional drag from land surfaces—trees, buildings, and topography.

Case Study 2: Hurricane Harvey



Source: National Weather Service

Advocate graphic by DAN SWENSON

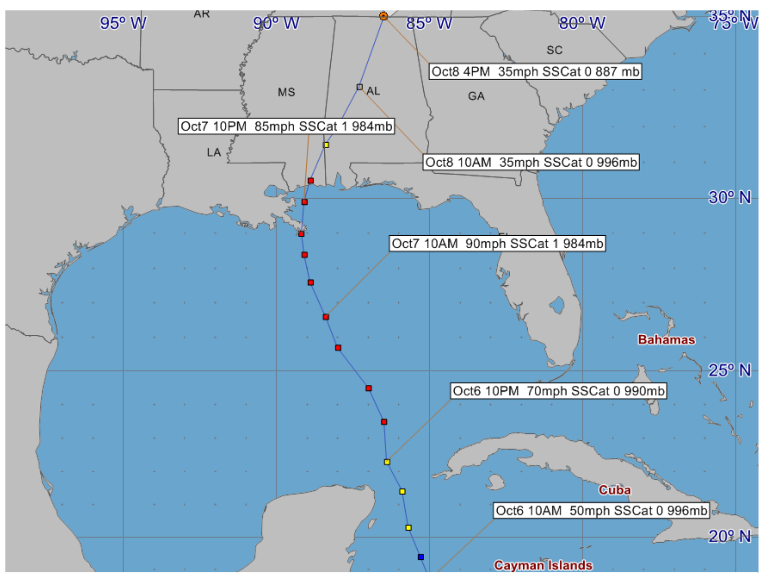
In August 2017, Hurricane Harvey rapidly intensified from Category 1 to 4 within 24 hours before striking the Texas coast near Rockport. The Center for Severe Weather Research (CSWR), using its Doppler on Wheels (DOW) mobile radar - captured rare, high-resolution wind data.

- Top 3-second gust: 134 mph at 26 feet above ground

- Top sustained wind: 103 mph
- These readings were taken just 1,000 feet from a destroyed building, likely impacted by a localized tornado or mesovortex that was embedded within the hurricane's eyewall.

Here's the point: even under optimal conditions— unobstructed, elevated, and just onshore—the mobile units failed to match the NHC's category 4 estimation of 135 mph sustained winds. This illustrates how localized extreme gusts may occur, but widespread category 4-level sustained winds are difficult to verify on land.

Case Study 3: Hurricane Nate



Hurricane Nate made two landfalls—first was near the mouth of the Mississippi in Louisiana (Oct. 7th) and then Biloxi, MS (Oct. 8th) both as a Category 1 storm. Flight-level winds recorded 102 mph at around a mile in altitude, while near-surface microwave instruments estimated 80 mph winds.

Despite the data, the strongest land-based wind gust registered only a 66 mph gust at Mobile Regional Airport. The South Alabama Mesonet, which is a regional network of 25 stations with high-quality 10-meter anemometers, measured even lower speeds—just 54 mph at Grand Bay.

The issue here is that placing these types of high accuracy instruments in even the most ideal open and unblocked terrain is a logistical problem. This is because it's littered with trees and also the environments are urbanized.

Networks and Collaboration: The National Mesonet Program

To improve land-based wind data, the National Mesonet Program (launched in 2009) connects thousands of public and private weather stations into a unified network. Over 35,000 sensors contribute to this "network of networks," including: State-run mesonets and private companies (i.e. WeatherFlow) contributes over 35,000 sensors that basically render a "hive" of networks operating hurricane stations.

Chief Science Office of WeatherFlow, Marty Bell, emphasized that rapid wind reduction upon landfall is largely due to friction. When this effect is accounted for, wind observations often fall within the expected range of NHC's estimated intensity. Bell stated that this distinction is important for public perception, building codes, insurance claims, and understanding risk.

Conclusion: Measuring Hurricane Winds Is Complicated

Accurately capturing the ferocity of a hurricane at landfall is incredibly difficult. Peak winds often occur in scarce monitored locations or at altitudes well above the surface. Frictional drag from land surfaces dramatically reduces wind speeds shortly after landfall, creating discrepancies between observed conditions and the storm’s official rating.

While mobile radar units, advanced mesoscale networks, and the National Mesonet have greatly improved our ability to gather high-quality data, challenges remain. Ultimately, translating over-ocean storm estimates into meaningful, location-specific wind forecasts will require continued innovation as this science continues to remain inexact.