Hurricane Juan Storm Summary

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See also the NovaWeather feature website on this event:
http://www.novaweather.net/Hurricane_Juan.html

At 12:10 a.m. ADT, Monday September 29, 2003, Hurricane Juan made landfall between Shad Bay and Prospect, Nova Scotia, Canada, as a category-two hurricane with maximum sustained winds of 85 knots (157 km/h). Juan's eastern eyewall battered the Halifax region with extreme winds, driving rains, storm surge and huge waves. The hurricane tore a path across Nova Scotia as it traveled rapidly northward hitting Prince Edward Island (PEI) as a marginal category-one hurricane then exited the island as a strong tropical storm.

Juan claimed the lives of eight individuals: two when trees fell on their vehicle, two fishermen when their boat capsized near Anticosti Island in the Gulf of St. Lawrence, three in a house fire speculated to have been started by candles used during the power outage, and one involved in relief work weeks after the storm. Hurricane Juan will be recorded as the most damaging storm in modern history for Halifax, as measured by the widespread tree blow-downs (100 million trees lost), power outages, and damaged homes. An estimated 800 to 900 thousand residents in Nova Scotia and PEI lost power at one point as the storm tore through the area. The Nova Scotia Power Corporation reported that the last of their affected customers had power restored by the morning of Sunday October 12 - just short of 2 weeks after the storm.

Synoptic Summary

The **storm track** and **track data** for Hurricane Juan show the history of this dangerous storm along an almost due-northward track through Nova Scotia.

Hurricane Juan formed in a weakly baroclinic environment to the southeast of Bermuda on 23 and 24 September, 2003. An upper-level low induced the formation of a surface frontal wave (as appeared on satellite imagery) north of the Bahamas. That wave moved to the northeast and became the seedling for Juan. Tropical cyclogenesis was not instant, and the system had an almost subtropical-type development initially. Tropical depression status was declared at 12 UTC 24 September then tropical storm strength shortly thereafter at 00 UTC 25 September. This system was not declared subtropical, although one could certainly argue for that classification initially. Juan became a hurricane around 12 UTC 26 September.

Juan moved slowly northward over a large upper ocean heat content anomaly that most certainly helped intensify the storm to 90 kts (166 km/h) by the evening of 27 September. The storm was moving northwestward by that time as it was being deflected by a strong high pressure system to the northeast. On 28 September Juan accelerated along a northward track on a bee-line for Nova Scotia. Although Juan was weakening during that accelerating period, the surface wind speeds remained at or above 85 kts (157 km/h) up until landfall just west of Halifax, Nova Scotia. This was due to the large translational speed of the storm. Juan maintained hurricane status as it crossed Nova Scotia in just under 3 hours and became tropical storm strength as it was exiting PEI. The storm then continued rapidly north-northeastward through the Gulf of St. Lawrence with strong tropical storm force winds.

Landfall statistics:

Juan made landfall while moving northward at close to 30 kts (55 km/h) at 12:10 AM local time (0310 UTC) 29 September near the community of Prospect, Nova Scotia. Maximum sustained winds of 85 kts (157 km/h) were experienced about 30 km to the east with surface gusts near 100 kts (185 km/h). The highest reported gust was from the Canadian Coast Guard vessel "Earl Grey" in the Halifax Harbour "Narrows" of 125 kts (231 km/h) at a height of 20 m above the water. The estimated landfall minimum sea level pressure was 973 mb (28.74"). The eye radius was about 25 km at landfall and the radius of maximum winds was estimated to be 30 km. The highest sustained wind (2-minute mean) recorded by a land station near landfall was 82 kts (152 km/h) with gusts to 95 kts (176 km/h) at McNab's Island, in Halifax Harbour, at 12:24 am local time. The storm surge was estimated to be a maximum of 2 m (7 feet) in the vicinity of Cole Harbour.

Meteorological Imagery

An **animation of infrared satellite images** shows the rapidly-moving Hurricane Juan striking Nova Scotia and PEI. The cloud-top eye disappears yet radar imagery suggests partial maintenance of the eye up till landfall. A **colorized infrared satellite image** at landfall is also shown. An **animation of radar imagery** from Mechanic Settlement, New Brunswick shows the evolution of Juan's rain field. Note that there was very little rain on the south side of the storm. Normally the rain pattern is somewhat symmetric. This is a consequence of atmospheric wind shear on a hurricane. A **doppler radar image** of Juan indicates extreme winds from the southeast and parallel jets of stronger winds showing up as striations in the image, believed to be "boundary layer rolls." Also, a **QuikSCAT analysis** courtesy of Roger Edson (personal communication) shows the highly-asymmetric wind field before the hurricane made landfall.

Rainfall Data

Hurricane Juan did not bring substantial rainfall. There were two reasons for this. One, the storm was moving very quickly (30-35 kts) northward so there was less time for rain to fall. Second, the southern half of the hurricane generally dried-out, leaving a void in precipitation on that side of the storm. A **table of rainfall data** and a **subjective analysis** of that rainfall are provided.

Wind Data

Juan will be remembered for its extreme wind and damage. The force of the wind caused large sections of forest to be completely flattened. A tabular **summary of wind data** and a subjectively-analyzed **map of that data** and characteristic damage are provided. One striking feature of the wind pattern was that the hurricane-force speeds were confined to the east side of the storm, and almost all wind-related damage occurred everywhere east of the track. The **time series of wind data** from McNab's Island where the highest land-based winds were reported shows the classic hurricane-like spike in the wind. A **photograph of the station** (atop the lighthouse) looking directly upwind shows that the station has a true marine exposure from that direction.

Surface analyses

Surface analyses for **03 UTC** and **06 UTC** 29 September show the change in the pressure field during Juan's trip across Nova Scotia. During this time, Juan went from a marginal category-two hurricane to weak category-one. The pressure had filled by about 9 mb, but winds were still howling at Charlottetown, PEI and at the Confederation Bridge linking PEI with New Brunswick. Note the change in the tight inner pressure pattern during the 3-hour period. The pattern of isobars at landfall was also estimated from aircraft **dropsonde data** just prior to landfall.

Marine Data

There were several interesting factors associated with this storm including the large 2-m (7-foot) storm surge, towering waves and associated shoreline erosion. The surge set a new record high water level for Halifax Harbour. Given the damage at the head of Bedford Basin (innermost part of the harbour) the surge may have been 2 m there. A **time series of water levels** from the naval base dockside tide gauge in Halifax Harbour were prepared by Lorne Ketch (Canadian Hurricane Centre). Ketch has also plotted data showing **huge waves** reported outside the harbour at buoy 44258. The maximum significant wave height was ~10 m (33 feet) and the tallest wave reported at this site was ~20 m (66 feet). Another important report was from buoy 44142 located about 250 km south-southwest of Halifax. This site was located just outside the eye of the storm. Based on one-hourly data, the lowest sea level pressure reported by the buoy was 974.7 mb and the highest significant wave heights were around 14 m (Bowyer and MacAfee, 2004). Maximum winds were 54 kts (100 km/h) gusting to 68 kts (126 km/h) but only based on hourly sampling intervals. The station data were helpful for estimating the storm's intensity before hitting Nova Scotia.

Many observations were made by ships, oil rigs and buoys in and around Halifax Harbour. These data were analyzed carefully in the days after Juan to determine the hurricane category (one or two?). After close inspection of the **data** (courtesy of Bridget Thomas and Doug Mercer), it was decided that Juan was indeed a category two hurricane. The **data** from McNab's Island proved to be the most telling piece of information.

Damage and Impacts

There was an estimated 200 million dollars in damage from Hurricane Juan. The storm was responsible for 8 deaths, millions of destroyed trees, heavy shoreline damage to piers and fishing vessels. Countless pleasure craft were grounded or capsized during the storm – not only in Nova Scotia but in the Hillsborough Bay area near Charlottetown, PEI. There were also widespread power outages from downed trees that last up to two weeks. Many homes and structures suffered minor to extensive damage including roof failure on several homes and particularly multi-unit dwellings. There were even a few cases of external wall damage. Some storage silos and large barns were destroyed or damaged as far north as PEI. Many signs were broken or blown-out completely including some large steel-supported billboards that twisted over and touched the ground. Many vehicles were crushed by fallen trees throughout the streets of Halifax. Flooding from rainfall was minor and mostly occurred 8 to 10 hours after the storm when another convective system dumped about 30 to 45 mm of rain on Halifax creating many problems for those who had lost their roof or shingles. Many photographs of the damage can be found at the source website for this document: **http://www.novaweather.net/Hurricane_Juan.html**.

Convair Research Flight

The Convair-580 aircraft owned and operated by the National Research Council was flown into Hurricane Juan just prior to landfall. The project to study hurricanes and tropical storms affecting Canada is funded by Search and Rescue Canada through the Meteorological Research Branch headed by Jim Abraham.

Data collected during the flight included 25 GPS dropsondes and radar data that provided a vertical cross-sectional view through the storm. The track flown by the research team and **location of dropsondes** is provided. A **cross section of radar data** shows the remains of the tilted eyewall of hurricane Juan and lack of rain on the southern side of the storm. Analyses of meteorological data displaying cross-sectional views of the storm include the striking **asymmetric wind pattern** along the Nova Scotia coast. Additional storm cross sections are available at **http://www.novaweather.net/Hurricane_Juan.html** near the bottom on the right hand side of the web page. A hand-drawn **surface analysis** of sea level pressure and wind data from the dropsonde data reveals the very tight pressure pattern of Hurricane Juan responsible for the extreme winds and surge.

Special Reports

A handful of "spin-off" reports were written in the wake of the storm – mainly to address intense media interest and questioning. The **first of these reports** was written to address the false reports of people seeing the eye of the hurricane. Since Juan's eye was filled with cloud, the stars and calm winds people witnessed well to the west of the storm centre was not associated with the true eye of the storm, but from a notch of clear sky on the west side of the storm. The other big question that had arisen concerned the **intensity of the storm**. This had a lot to do with the abnormally warm water temperatures south of Nova Scotia during September 2003, which kept the storm going a little longer than usual. Also, since the storm was moving so fast, there was an additional component to the wind owing to the storm motion. An **animation of sea surface temperatures** during September shows the atypical warming trend. This is also reflected in the 27-day, **pre-storm sea surface temperature change analysis**. It is interesting to note that normally the water would be cooling during this period.

Additional reports and anecdotes have been collected and appear on the Canadian Hurricane Centre website:
http://www.ns.ec.gc.ca/weather/hurricane/juan/index.html

The complete series of forecast bulletins can be found at:
http://www.ns.ec.gc.ca/weather/hurricane/juan/bulletins_e.html

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Bowyer, P. J., and A. W. MacAfee, 2004: The theory of trapped-fetch waves with tropical cyclones – an operational perspective. *Manuscript submitted to Wea. and Forecasting.*