CHAPTER 16

Polymath Profile #6: National Hurricane Center

James Franklin has science, not finance, degrees from MIT. He is much more comfortable talking in engineering and military terms than about dollars and cents. His language includes “platforms,” and acronyms such as AMSU, which he kindly expands for the uninitiated as “Advanced Microwave Sounding Unit.”

Franklin is the branch chief at the National Hurricane Center (NHC) in Miami, Florida, part of the National Oceanic and Atmospheric Administration (NOAA). “We are forecasters, of course—but not the financial kind,” he explains. Nonetheless, he should be a role model to every financial analyst because his forecasts keep improving year on year, while the recent economic “hurricane” caught most business forecasters off by miles.

Another reason that he should be emulated is because his team’s forecasts provide significant return on investment. Although most of the attention goes to hurricanes when they make landfall and cause chaos, his team’s contribution is even more valuable: They help reduce the “false positives,” so that at-risk areas do not have to be evacuated unless absolutely necessary.

The NHC updates on its Web site every six hours a “cone of uncertainty” for every major storm it is tracking. The narrow end of the cone shows where the storm is now; the wide end of the cone shows where it will likely be in five days. The track is created based on the past five years of forecast data and error rates.

And most years, the track path accuracy improves. The track forecast error in the 1980s, 48 hours out, was 225 nautical miles. Today, that error is a little less than 100 nautical miles. The track forecast is used by the NHC to declare hurricane watches and warnings depending on likely time and location of landfall. Those guidelines are interpreted by state and local authorities to announce evacuations, and that triggers a series of emergency civic and security services. Low-lying areas and those expected to get dangerous storm surges usually receive mandatory evacuation notices. If evacuations can be minimized, so can emergency services, not to mention panic shopping, and other community disruption. Over the years, the improvements in track forecasts have amounted to hundreds of miles of coastline not evacuated and millions of dollars saved in emergency services.

Of course, the savings to local communities vary dramatically depending on location. Compare an evacuation of a neighborhood in Miami with one in a less populated area, for example, in rural Texas. Franklin would rather accountants worry about those financial numbers around savings in emergency services; he focuses more on human numbers and their safety. Better forecasts translate to earlier warnings so that people have more time to respond or evacuate.

Data Sources and Models

To deliver those forecasts, the NHC team takes an invasive approach to collecting a wide variety of external, real-time data. Too much business forecasting today is based on internal and historical data or looks at Google or external sources, such as Bloomberg and Gartner for its primary data.

Franklin's team, however, goes to the source and utilizes several platforms:

- *Satellites.* Geostationary satellites that are always in the same position with respect to the rotating Earth give a big-picture view of storms. The team supplements this information with data from lower polar-orbiting satellites
- *Data buoys.* Buoys in waters around the world collect data on wind speed and direction, wave information, air/water temperature, and sea-level pressure. They communicate the collected data via the geostationary satellites. The NHC uses information from the buoys throughout the year; individual sailors access the buoys to ascertain local conditions.
- *Dropsondes.* Dropsondes are weather reconnaissance devices that are parachuted from planes. They have a short life as they descend at 2,500 feet a minute through a storm. But at $750 each, they are a bargain; their sensors transmit pressure, temperature, and humidity data. As the storm batters them mercilessly in their downward paths, the data relayed by their GPS chips also allows for calculation of wind information.
- *"Hurricane Hunters."* Brave men and women fly the "Hunters" into storms to collect data. The U.S. Air Force maintains a fleet of 10 WC-130

> planes—modified and fortified cargo planes, which account for the bulk of the sorties. NOAA's P-3 Orions and Gulfstream IV are used mostly for research but also help on forecasting as storms threaten to make landfall. These planes carry Doppler radars to provide a three-dimensional description of a storm, from sea level to the storm's top.

The air pressure, humidity, temperature, wind, and other data collected from each platform needs to be scrubbed for historical error rates. Then the information is processed using multiple forecast models, both for redundancy and for validation.

Some of the models are three-dimensional. Since storms change course by the minute, the higher resolution the grids on the models, the better the accuracy. Like high-resolution TV screens, high-resolution grids require more computing power. And that is *super*computing power based on IBM Power 575 Systems, rated at 69.7 trillion calculations per second. These computers are 30 times as fast as those available just a decade ago. And yet the accuracy could be even better.[1]

Data Products

The NHC next synthesizes the conflicting and complex data from its models into usable data for average citizens. It packages its reports (in Franklin's words, its "products") in the 11 text and 7 graphical formats shown in Table 16.1.

These reports have a wide range of users. The text-based ones are handy for reporters to read on radio and TV weather bulletins. Citizens in the likely path of the storms avidly follow the graphic products on the NHC Web site. In addition, Web sites such as Stormpulse.com and TV meteorologists take raw data from the NHC and present it with their own layer of visualization, some of which makes for stunning graphics.

Take the Public Advisory text product shown in Figure 16.1. Issued every six hours for active cyclones (intense storm systems), it gives the cyclone position in latitude and longitude coordinates, its distance from a well-known reference point, and its current direction and speed of motion. Each advisory includes the maximum sustained winds and the estimated or measured minimum central pressure. It also provides a general description of the predicted track and intensity of the cyclone over the next 24 to 48 hours. When warnings are in effect, the advisory also includes information on potential storm tides, rainfall or tornadoes associated with the cyclone, and any pertinent weather observations.

The bulletin in Figure 16.1 was advisory 19 for a September 2009 system named Fred, which reached hurricane speeds at sea, then

TABLE 16.1 August 2009 National Hurricane Center Product Description

Text Products	
a	Tropical Cyclone Public Advisory
b	Tropical Cyclone Forecast Advisory
c	Tropical Cyclone Discussion
d	Tropical Cyclone Surface Wind Speed Probabilities
e	Tropical Cyclone Update
f	Tropical Cyclone Position Estimate
g	Tropical Cyclone Watch Warning Product
h	Aviation Tropical Cyclone Advisory
i	Tropical Weather Outlook
j	Special Tropical Weather Outlook
k	Monthly Weather Summary

Graphical Products	
a	Tropical Cyclone Track Forecast Cone and Watch/Warning Graphic
b	Tropical Cyclone Surface Wind Speed Probabilities
c	Cumulative Wind History
d	Maximum 1-minute Wind Speed Probability Table
e	Tropical Cyclone Wind Field Graphic
f	Tropical Cyclone Storm Surge Probabilities
g	Experimental Graphical Tropical Weather Outlook

Source: National Hurricane Center.

progressively weakened and never threatened land. Hurricanes are assigned short, distinctive, human names like Fred. The World Meteorological Organization maintains pre-assigned names for each hurricane season for 10 global zones—the Atlantic Region being one zone. The names start with A, B, C, etc. and they are assigned to storms in that zone in the order of their first reaching hurricane speeds. There are regional sensitivities—in the Atlantic, there are several Hispanic names. Also names which start with Q, U, X, Y, Z are avoided in the Atlantic. Until 1978, all names were female. The names are rotated every six years unless a named hurricane was devastating in which case the name is retired.

The corresponding product called Track Forecast Cone and Watch/Warning in Figure 16.2 shows advisory 19 in graphic detail. The cone represents the probable track of the center of a tropical cyclone over the next five days and is formed by enclosing the area swept out by a set of

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ZCZC MIATCPAT2 ALL
TTAA00   KNHC   DDHHMM
BULLETIN
TROPICAL STORM FRED ADVISORY NUMBER 19
NWS TPC/NATIONAL HURRICAN CENTER MIAMI FL    AL072009

...FRED MOVING LITTLE AND WEAKENING...

AT 500 AM AST...0900 UTC...THE CENTER OF TROPICAL STORM FRED WAS
LOCATED NEAR LATITUDE 17.8 NORTH...LONGITUDE 33.6 WEST OR ABOUT
645 MILES...1040 KM...WEST-NORTHWEST OF THE CAPE VERDE ISLANDS.

FRED IS NEARLY STATIONARY. A TURN AROUND THE NORTH AND THEN THE
NORTH-NORTHWEST WITH A CONTINUED SLOW MOTION IS EXPECTED LATER
TODAY...FOLLOWED BY A TURN TOWARD THE NORTHWEST WITH AN INCREASE
IN FORWARD SPEED ON SUNDAY.

MAXIMUM SUSTAINED WINDS HAVE DECREASED TO NEAR 45 MPH...75
KM/HR...WITH HIGHER GUSTS. ADDITIONAL WEAKENING IS FORECAST
DURING THE NEXT 48 HOURS AND FRED COULD DEGENERATE INTO A REMNANT
LOW BY SUNDAY NIGHT.

TROPICAL STORM FORCE WINDS EXTEND OUTWARD UP TO 105 MILES...165
KM FROM THE CENTER.

THE ESTIMATED MINIMUM CENTRAL PRESSURE IS 1002 MB...29.59 INCHES.

...SUMMARY OF 500 AM AST INFORMATION...
LOCATION...17.9N  33.6W
MAXIMUM SUSTAINED WINDS...45 MPH
PRESENT MOVEMENT...STATIONARY
MINIMUM CENTRAL PRESSURE...1002 MB

THE NEXT ADVISORY WILL BE ISSUED BY THE NATIONAL HURRICANE CENTER
AT 1100 AM AST.

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FORECASTER BLAKE

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FIGURE 16.1 Hurricane Advisory
Source: National Hurricane Center.

circles (not shown) along the forecast track (at 12, 24, 36 hours, etc.). The size of each circle is defined to include two-thirds of historical official forecast errors over a five-year sample.

If Fred had been close to land (and the graph was in color), the associated coastal areas on the map would show color bands: red for hurricane warning, pink for hurricane watch, blue for tropical storm warning, and yellow for tropical storm watch. The black dots show the NHC forecast

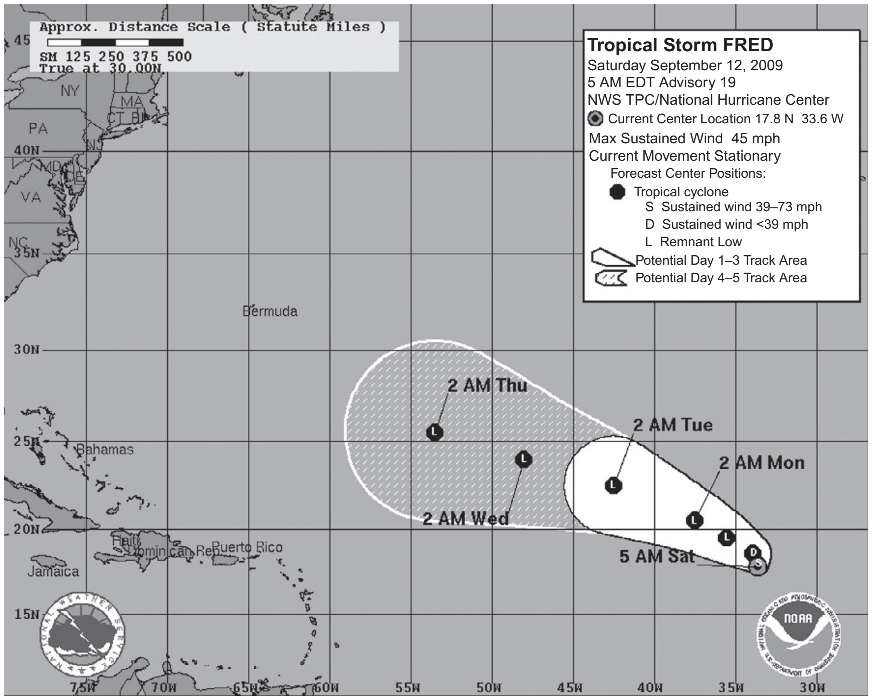

FIGURE 16.2 Tropical Storm Fred
Source: National Hurricane Center.

position of the center at the times indicated. The letter inside the dot indicates the forecast strength of the cyclone category: *D* for depression; *S* for storm; *H* for hurricane; *M* for major hurricane; or remnant *L* for low.

Continuous Improvement

Even as storm tracking and reporting have become better, the ability to predict storm intensity (using what is called the Saffir-Simpson Scale, with its 1 to 5 categorization based on the hurricane's intensity. Category 5 is the most intense, with sustained winds greater than 155 mph) has not improved as quickly. Since wind speed can vary by tens of miles and storm surges by several feet depending on storm intensity, that information would allow even more-accurate evacuation guidance.

This is where Franklin invokes the AMSU acronym. Microwaves are promising to help in that forecasting since they can penetrate clouds that infrared satellites cannot. They can provide a picture of the structure of the hurricane: more detail on the eyewall and rain bands. Forecasters can use knowledge of this structure to make better intensity forecasts.

How about using unmanned aircraft? Someday, says Franklin. Now it is still more efficient to have manned flights. Aren't those flights hairy? Earlier in his career, Franklin flew on close to 100 hurricane-penetrating missions. On the way to the hurricanes, most flights are calm and boring. However, once you approach them, Franklin can tell stories that would make most of us cancel our next commercial flight and the one after that. As the crews who fly the "Hunters" like to say in understated fashion: "Air sickness is just part of flying."

Although most businesses cannot afford the supercomputers and the satellites Franklin's team has access to, they can increasingly leverage powerful enough analytical computing resources, such as Oracle's Exadata, discussed in Chapter 15.

And how the hurricane team works provides lessons for every business forecaster: they relentlessly (and bravely) pursue primary, external data; they drive to measure and improve on errors in forecasting and they build plenty of redundancy into models in their estimating process.

Recap

The NHC reaches out to a wide range of data sources in hostile circumstances. It apples multiple, conflicting models to interpret the data. The data is presented in multiple formats, depending on audience sophistication. The forecasts keep improving year after year.

For all these reasons, Franklin and his team at the NHC have earned the right to be called polymaths around analytics.