Hurricanes in disguise.

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Meteorologists have discovered a hybrid type of storm that combines the characteristics of tropical and nontropical storms. Such a storm hit the eastern US coast in Dec 1994, while another one in Oct 1991 caused heavy damages in New England.

Some winter storms sport a tropical look:

Youngsters in western Massachusetts enjoyed a treat on Halloween Eve 1991: crisp and pleasant weather. Nature was playing all of its tricks on people along the New England coast. A storm of surprising intensity the day before had brought waves of 25 feet crashing onto the shore and swells of more than 100 feet at sea. Thousands of coastal homes were seriously damaged, and Atlantic City recorded its second highest tide of record. Damage costs soared into the hundreds of millions, approaching the levels inflicted by Hurricane Bob only weeks earlier.

Though powerful like a hurricane, the storm off New England initially was very clearly not of tropical origins. Instead it had the structure of an extratropical storm, the conflagration of atmospheric temperature contrasts common to midlatitudes.

But then the powerhouse assumed a masterful disguise for one final Halloween trick. After weakening most of the day, the storm drifted south in the evening and came upon the Gulf Stream, where ocean temperatures hovered near 78 [degrees] F (26 [degrees] C), a threshold for tropical-storm development. Thunderstorms began to blossom near the storm's center overnight. By 10 a.m. EST on the 1st, satellite imagery showed an eye forming - a sign that the storm was developing a tropical structure and nearing hurricane intensity.

Special advisories from U.S. and Canadian weather service offices and the Navy treated the system as a typical (albeit strong) North Atlantic cyclone. Still, the National Hurricane Center was curious. As luck would have it, a routine hurricane-hunter training flight had been scheduled for November 1 by the U.S. Air Force Reserves. The trainees were hastily redirected into the Halloween storm, where they unmasked a tropical cyclone. At 7 p.m. on the 1st, they found a cluster of hurricane hallmarks: winds of nearly 100 m.p.h. at flight level (3,000 feet), a temperature increase of seven degrees in the storm's core, and an extrapolated surface pressure of 981 millibars. The radius of maximum winds was about 30 nautical miles, whereas a day before, the storm had been far more diffuse, with no well-defined center and with gale-force winds spanning over 600 nautical miles.

The Halloween storm had donned a masterful disguise that has been tantalizing forecasters with its surprising frequency and uncharacteristic form: an extratropical storm that acquires tropical characteristics. Such hybrid storms are stretching the conventions of meteorology, putting forecasters in a delicate bind when clear warnings are urgently needed.

For most of meteorological history, scientists have had their hands full simply constructing the major categories of weather systems and working with them. Advances in observing tools, particularly weather balloons in the 1930s and satellites in the 1960s, strengthened the case for tropical cyclones as a well-defined class. These storms tend to form in very distinct regions and at predictable times of the year. They have a symmetric structure with

inflow bands feeding into the low-level circulation from all directions and a compensating outflow structure at high levels. A compact, deep warm core is surrounded by intense bands of showers and thunderstorms, fueled by the oceanic heat from which the system draws most of its energy. At their strongest, they wreak far more havoc than higher-latitude storms.

Initially the Halloween storm was a classic case of another class of storms, the midlatitude systems called extratropical cyclones. These storms are caused by an upper-level trough (often seen as a dip in the jet stream) that tends to focus regions of temperature contrast and create low-pressure areas through a combination of dynamic and thermal processes. With rain and storms developing on the north and east flanks and drier descending air wrapping in from the south and west, the familiar, asymmetric "comma cloud" pattern of extratropical systems is unmistakable on satellite photos.

Yet the satellite era also opened a Pandora's box of storms that didn't fall neatly into a single category - or that demanded a new one. Take the polar low, first discussed in the scientific literature in 1969. A few of these small, intense spin-ups are observed each year across such regions as the Arctic Ocean north of Norway and the far North Atlantic near Labrador. They behave much like tropical storms in their size, intensity, and appearance on satellites. Occasionally a polar low will sport a clearly defined eye. These hurricane-like features might seem drastically out of place in the frigid north. The common link, however, seems to be intense convection. Showers, and sometimes even thunderstorms, develop in bands around a polar low, just as with hurricanes. The catalyst is often a deep, cold low-pressure center passing over relatively warmer waters, thus providing enough vertical temperature contrast to fire up thunderstorms. As the bands of convection feed into the storm's center, latent heat release (the energy produced by water-vapor condensation) helps to create a warm core and sometimes an eye.

Differences are evident on top. A hurricane's outflow is usually directed by an upper-level high directly above the surface low. In contrast, polar lows usually develop beneath deep upper-level lows. However, the strongest polar lows can produce enough of a warm core to cause a "mini-high" aloft that helps the air to diverge in an outflow pattern, even inside a surrounding upper low.

Recent analyses show that the polar low itself has a variety of faces. While many develop in the fashion described above, others seem to be small-scale versions of a classic extratropical cyclone, where the energy is drawn from temperature contrasts and from progressing upper-level features. Some polar-low specialists now like to think of a spectrum extending across the various modes of development.

The idea of a spectrum with extratropical systems on one end and tropical ones on the other appeals to Jack Beven. A forecaster at the NHC, Beven is one of a small number of researchers looking intently at cases where cyclones adopt a new persona. The progression from tropical to extratropical is well-documented; it's the fate of most hurricanes as they recurve northward into existing frontal zones. The reverse process, though, is still a question mark.

The East Coast of the United States is proving to be fertile territory for Beven's work. Only three years after its Halloween surprise, New England was battered on Christmas Eve 1994 by what appeared to be a troublesome hybrid storm. This one brought winds close to 100 m.p.h. on Cape Cod, beach erosion along the coast, and 30-foot seas offshore. This fall Beven completed a study designed to help the NHC decide whether to retroactively add the Yuletide storm to the year's tropical pantheon.

The cyclone was born over the Florida Keys on December 21 along an east-west frontal zone separating mid-50- from mid-70-degree air. Pushed eastward across the mainland by an approaching upper-level trough, the storm remained extratropical until that evening.

“Then, as it moved out into the Bahamas, it appeared to take on the characteristics of a tropical storm,” Beven recalled. “We didn’t issue any advisories at the time because we weren’t absolutely sure of its nature.”

Even as temperature contrasts associated with the front weakened, the storm tightened into a 985-millibar low off the Carolinas by Thursday evening, December 22. Instead of pushing the low along, the upper-level trough had passed to the north, allowing the system to generate the high pressure aloft that it needed for tropical-style development. Meanwhile, the Gulf Stream was pumping 80 [degree] F water northward beneath the low. The next two days - the 23rd and 24th - saw the cyclone deepen further to 970 millibars as it moved northward along the Gulf Stream and eventually north-westward to a point just south of Cape Cod, giving millions of New Englanders a very stormy Christmas Eve. Finally, the system took a holiday on the 25th, moving toward Nova Scotia as it weakened rapidly.

Could this have been just a super-intense, extratropical nor’easter? The satellite photos suggest a hybrid storm, but other evidence is sparse. “This one is a judgment call,” says Beven, “because we just don’t have the data. We didn’t have any really good observations near the center - there weren’t many ships passing through.” Hurricane-hunting operations had ceased for the season. An Air Force plane on routine winter-storm patrol took measurements around the storm’s periphery, but “they were trying to cover as much ocean as possible. They were rarely any closer than 100 miles of the center.”

Another puzzling case analyzed by Beven was an unnamed storm in the eastern Gulf of Mexico during September and October 1994. Buoys off the Florida coast were tossed by sustained winds of more than 45 m.p.h., well above tropical-storm criteria of 39 m.p.h. “This system was very strange,” notes Beven. “There was no front associated with it and it had a warm core, but the radius of maximum winds was more than 150 nautical miles, so under the standard NHC criteria it didn’t qualify as a tropical storm.”

Louis Uccellini, an extratropical-cyclone specialist at the National Centers for Environmental Prediction in Camp Springs, Maryland, says he thinks there could be another process, disguised as tropical development, taking place in some or all hybrid storms. Uccellini has joined several colleagues, including Melvyn Shapiro (National Oceanic and Atmospheric Administration), in arguing for a “seclusion” process that creates a pseudo-tropical system in the midst of an extratropical one.

In this model, an intense winter-type storm draws in warm air from the south and adds to that warmth throughcondensation from intense rainfall. The warm air wraps around to the west of the low, toward the back end of an occluded front, and is eventually pinched off. The result is an isolated pocket of air warmer than its surroundings, ringed by showers and thunderstorms and fed by latent heat release. “It’s a bit different from the tropical cyclone, where you have upper-level subsidence [sinking air] creating an eye,” says Uccellini. “In this case, the upper-level anticyclone is displaced to the north and east, downwind of where the [surface] cyclone is.”

Whether they bear names and are truly tropical or are just strange extratropical systems, hybrid storms appear to be raking the East Coast with unsettling frequency. One in 1992 ripped up a beach-front boardwalk in Delaware and dumped two inches of rain on an NFL playoff game in Washington, D.C.

“Some of these systems have more unusual characteristics than we observed in years past,” says Beven, who recently analyzed “a couple of lows that moved by Cape Hatteras

with tight pressure patterns [as with tropical systems], but were clearly frontal lows and seemed to have the typical upper features of wintertime lows."

These unclassifiable storms are also appearing elsewhere. The Mediterranean, a tranquil sea not monitored by any tropical forecasting agencies, has now recorded several bona fide hybrid storms since the early 1980s. Perhaps the most dramatic occurred last January. A small, intense low formed between Greece and Sicily on January 16 and moved southward to the Libyan coast the next day. Despite sea-surface temperatures no warmer than 61 [degrees] F and air temperatures below 50 [degrees] F, the storm grew into something resembling a minimal hurricane: thunderstorms circling the center, sustained winds measured by a German ship at 84 m.p.h., and a clearly formed eye.

"The system had all the satellite appearances of a hurricane," says Beven.

One reason hybrid storms may seem to be on the upswing is that we're able to observe them more closely. The Hatteras lows were mapped in detail by offshore data buoys as well as the Coastal Marine Automated Network, which has provided detailed data within 60 miles of the eastern seaboard since the 1980s.

"All of the geostationary satellite data has helped," Beven added. "The photo availability has improved dramatically over the last five to 10 years. Twenty years ago, a hybrid storm might not have been recognized for what it was. In the pre-satellite days, some of them might actually have been labeled as tropical storms, depending on where they occurred."

Recognizing a hybrid doesn't necessarily make forecasting its progress any easier. The warm-core structure within such lows is normally too small to be analyzed and followed by the computer models that are used for routine U.S. weather predictions. Uccellini thinks there's hope on the horizon.

"As we increase the resolution and physical processes that these models can deal with, we're getting better forecasts of rapidly developing storms in general. For example, we're starting to get better simulations of hurricanes in operational models that aren't specifically designed for hurricanes."

As proof that computers can deal with hybrids, Uccellini points to Australian meteorologists who have successfully used a high-resolution model to reproduce the severe cyclones that hammer that continent's east coast. Some of these storms have the unmistakable marks of hybrids: short but intense lives, winds above hurricane force, warm cores within larger-scale cyclones. One, in 1974, drove a 57,000-ton freighter aground. Uccellini called the Australians' modeling success "an eye-opening experience. I had doubts about the ability to do this until I read their papers."

Despite this success, Uccellini says forecasters still have a ways to go before hybrid development can be reliably modeled in a forecast mode. "But, we do know the kinds of areas where we need to make improvements in the models," he added. As an example, he cites the importance of accurately depicting latent heat release, which seems to be a key ingredient in creating and maintaining a hybrid's warm core.

Meanwhile, no matter how good the models, the uncertain origins and status of a hybrid can leave forecasters in a quandary when they need to issue warnings. For now, the National Hurricane Center handles hybrids on a case-by-case basis, giving them a name only if they carry a critical mass of full-fledged tropical characteristics and pose a significant threat to land or marine interests.

Hurricane specialist Richard Pasch recalls the Halloween storm dilemma: "By the time the tropical system had formed, the [encompassing] extratropical system was on the wane with conditions improving on the coasts. The damage that had been created by the extratropical

system was continuing to receive major media attention at that stage and it was felt that naming the system (which clearly met all of the meteorological criteria to be designated as a hurricane) at that time would cause major confusion on the part of the media, emergency management officials and the public."

Fortunately, the new hurricane was swept northeast after only a few hours by an upper-level trough. Away from its oceanic fuel - the Gulf Stream - the storms winds fell below 40 m.p.h. by noon on the 2nd, and by that evening a center could not be identified. For an unnamed hurricane, however, the Halloween storm had made quite a name for itself and the uncertain cyclones like it.