Forecasters expect below-normal East Pacific hurricane activity despite likely El Niño development this season

by Melanie Lenart

When it comes to social impacts of climate, few phenomena can top hurricanes. Charley's visit to Florida earlier this month left at least 25 people dead as it flattened a 10-mile wide area north of Fort Myers. The damage is still being tallied.

Here in the West, we may be landlocked, but we're not immune to the effects of hurricanes. In fact, the remnants of tropical storm Norma killed 23 people in Arizona in 1970, a relatively dry year in the Southwest, when more than 11 inches of rainfall flooded a high-elevation campground about 60 miles northeast of Phoenix.

Still, most hurricanes that form off western North America travel westward, heading harmlessly across the Pacific. As a result, they have not received the attention given their Atlantic brethren, which regularly batter East Coast towns from Texas to New England. It wasn't until 1965 or so that reliable hurricane data became available for researchers who monitor East Pacific hurricanes, while Atlantic hurricane data was considered reliable a couple of decades earlier.

A growing awareness of the importance of hurricanes and tropical storms for potential rainfall in the Southwest and Mexico when they do turn landward, however, helped inspire researchers at the National Oceanic and Atmospheric Administration (NOAA) to release an experimental East Pacific Hurricane Outlook this year and last year.

The 2004 Hurricane Outlook calls for a below-average to normal season for the East Pacific, with only about a 10 percent chance of activity being greater than the average, explained Muthuvel Chelliah, the Climate Prediction Center (CPC) scientist who led the effort to produce the East Pacific forecasts. The experimental outlook, a collaborative effort among NOAA scientists working for the CPC, the National Hurricane Center, and the Hurricane Research Division, will go operational next year.

The 2004 outlook projects the formation of 13 to 15 East Pacific tropical storms, with about six to eight of these becoming hurricanes. Two to four of the latter are expected to become major hurricanes. The average since 1970 is 15 storms, with nine becoming hurricanes (winds of 74 miles per hour or greater) and four reaching major hurricane status (winds of 111 mph or greater). As of August 20, five of the seven tropical depressions that formed in the East Pacific became named tropical storms by reaching speeds of 39 miles per hour or greater, and two of these intensified to hurricane strength.

Arizona gets hit directly from a named tropical storm about twice every nine years, and receives rainfall from systems that started their existence as tropical depression or greater about every two years, according to calculations by Tucson National Weather Service meteorologist Erik Pytlak.

The resulting rainfall generally is welcome in the Southwest, outside of dangerous floods. For instance, the remnants of Tropical Storm Olivia dropped 3 to 5 inches of rain around the southern border of Arizona and New Mexico in mid-October of 2000, buffering the area from some of the widespread drought impacts for about a year, U.S. Drought Monitor archives state.

At this point, at least, the forecasts do not attempt to predict the number of storms that might turn landward, so desirable rainfall or even devastation could occur even during a below-normal year if one particular hurricane moved inland, Chelliah noted. Also, he cautioned that the numbers are rough estimates based upon the more accurate Accumulated Cyclonic Energy (ACE) index, which is similar to the Hurricane Destruction Potential used by Colorado State Professor William Gray and his colleagues who forecast Atlantic hurricane activity. These indices are more accurate than hurricane counts because their values encompass tropical storm systems as well, and take into account variations in intensity and duration of storms.

"It's fairly difficult to predict the exact number of storms or hurricanes because a couple of 6- or 12-hour storms that soon fizzle out will throw off the numbers," Chelliah explained. "How would one of those compare to a storm that lasted for three days and battered the shores and wouldn't go away?"

The destruction in Florida from Charley was in some ways foreseen by CPC climate forecasters, who had predicted an above-normal hurricane season in the Atlantic. But the last minute veering of the hurricane into Punta Gorda defied expectations by weather forecasters that it would strike Tampa Bay, which illustrates the erratic nature of individual hurricanes.

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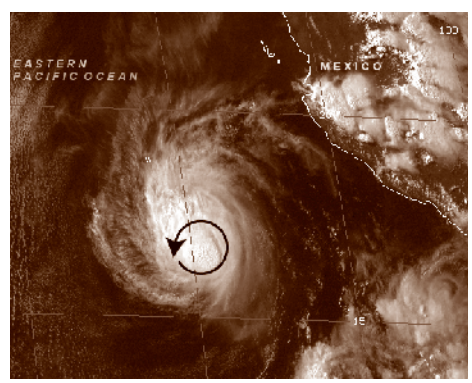

The cyclonic nature of tropical storms and hurricanes is illustrated here by a satellite image of Tropical Storm Agatha on May 22 of this year in the East Pacific. In the northern hemisphere, winds circulate counter-clockwise at the surface. Image courtesy of the National Oceanic and Atmospheric Administration.

Hurricanes, continued

Although the Atlantic hurricane outlook is updated during the season, the East Pacific outlook team does not plan to update their forecast, originally released in mid-June. In part, this is because the East Pacific season peak runs July–September, about a month earlier than the Atlantic season peak of August–October. Also, the June forecast ranges already took into consideration the likelihood that an El Niño might develop later this summer, Chelliah said.

If the ongoing trend continues, the start of an El Niño could be made official by the end of August, perhaps in time to affect the tail-end of the peak Pacific hurricane season in September. The CPC identifies an El Niño based on a three-month running mean of above-average sea surface temperature in a specific region of the equatorial central Pacific, an index that Chelliah was involved in devising with colleagues. (For more on the index they developed, Niño-3.4, see their 1997 paper in the journal *Atmosphere-Ocean*).

"El Niño and its counterpart La Niña definitely have a signature on the Atlantic and Pacific hurricane activity," Chelliah noted.

Chelliah and his colleague Gerald Bell, who heads the Atlantic hurricane forecast team, developed a global spatial model allowing them to depict when conditions are favorable for hurricane activity based on two dominant predictors. One has an El Niño/La Niña signature that can change from year to year, and the other reflects a longer-term pattern they dubbed the tropical multidecadal mode.

The multidecadal mode captures spatial patterns of atmospheric activity in the tropics that can hold for a couple of decades or more, and which appear related to a variety of factors, including sea surface temperatures in the tropical

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Hurricanes vs. Monsoons

by Melanie Lenart

The cyclonic precipitation that comes from hurricanes differs slightly from two other types of precipitation, namely the convective precipitation that is most dramatically represented by thunderstorms and monsoon systems, and the orographic precipitation promoted by mountains. These categories overlap and intermingle. Still, it can be useful to differentiate these three basic ways of initiating snow and rain.

Convective forces fuel the North American monsoon and its more famous Asian counterpart commonly known as the Indian monsoon. The monsoon season starts after the land surface has become warmer than surrounding water bodies. The change in heat gradient launches a change in wind direction, so prevailing winds transport moisture from the sea to land during the summer monsoons. The ongoing heating of the land also promotes the convective lifting of clouds, as heat rises.

Convective precipitation also occurs when clouds are lifted up by a warm front colliding with a cold front, and within a hurricane system. However, the collision of two frontal systems often sets in motion a pattern known as cyclonic precipitation, so named because the winds circle a low-pressure zone in the center.

Hurricanes, the most powerful form of cyclonic precipitation, do not have fronts. They have warm, low-pressure cores. The more dramatic the air pressure difference between the center of the storm and the encircling air, the greater the wind strength and therefore potential destructive force of the storm. Hurricanes themselves don't survive the inland trek into the Southwest—a hurricane's eye soon collapses once it leaves the energy-providing warmth of high sea surface temperatures. But the cyclonic storms they generate can survive to influence rainfall patterns here, particularly during the fall.

The relevant (East Pacific) hurricane season and the monsoon season both tend to peak around August in the Southwest. The hurricane season potentially stretches from mid-May through November, while the monsoon season typically extends from mid-July through mid-September depending on location in the Southwest, although stronger monsoons tend to start earlier and last longer.

On its own, convective precipitation tends to spawn relatively short-lived thunderstorms in spotty local events at a scale that is difficult to predict, especially in space. Cyclonic precipitation, which typically contains bands of thunderclouds, tends to operate at larger scales in space and time. An average hurricane measures about 350 miles across. Cyclonic storms may take days to pass over a region, with rainfall occurring continuously or least sporadically during their passage.

Orographic precipitation tends to be fairly predictable in space because it is associated with a specific mountain range or plateau. Orographic influences come in a variety of forms, all of them associated with changes in topography on the landscape. Mountains can mechanically force precipitation by channeling air and cloud parcels upward over its bulk, and differential heating of mountainsides facing the sun can contribute to convection. Mountain ranges can also shape precipitation events by slowing the movement of cyclonic systems and fronts.

Hurricanes, continued

northern Atlantic (see their article in the *Journal of Climate*, May 2004).

Many researchers have noted a strong tendency for East Pacific hurricane formation rates to be higher when Atlantic hurricane formation rates are lower, as during a multidecadal phase from about 1970 through 1995. That phase seems to have reversed, starting with a strong Atlantic season in 1995.

Similarly, El Niño conditions tend to suppress the formation of Atlantic hurricanes, and in the most recent decades a reduction in Atlantic hurricane activity tends to be associated with an increase in Pacific hurricane action and vice versa, Chelliah said. La Niña conditions, the opposite of El Niño, do the approximate reverse, he said.

In the Southwest, El Niño's effect on tropical storms is not clear-cut, although CLIMAS Program Manager Gregg Garfin found evidence that tropical storms in Arizona and New Mexico tend to last longer during strong El Niño years than during La Niña years.

CPC Director Jim Laver noted that stronger storms and hurricanes are more likely to survive the long trek to the Southwest from the birthing ground off Baja California, the most prolific spawning ground for hurricanes in the world.

"The air is already laden with moisture, having come in off the ocean, so for some period of time you have a chance of getting it into the Southwest," he said.

Garfin's finding of longer lasting tropical storms in the Southwest during strong El Niño years fits in well with the expectation for more Pacific hurricane activity during such years. However, the El Niño currently developing might not be strong, Laver cautioned.

"This one we're starting will most likely be a garden variety – either a weak or moderate El Niño," he said. It might impact this year's East Pacific hurricane season, which extends from about mid-May through November, but probably only in a comparatively weak or moderate way, he indicated.

Other influences on hurricane activity remain more mysterious at this time. Unfortunately, the reliable record for Pacific hurricanes is too short when it comes to clearly distinguishing the many potential climatic influences on hurricane formation rates, particularly when some of them have phases that can span several decades.

In more general terms, though, sea surface temperature, wind shear, and location on the globe are the most important factors influencing hurricane formation. Sea surface temperatures must reach at least 26 degrees Celsius (roughly 79 degrees Fahrenheit) in order to yield hurricanes. In addition, the system must be in the right place at the right time.

Hurricanes can form only in certain regions, between about 6 degrees and 30 degrees latitude in either hemisphere. Nearer the equator, there's not enough Coriolis force generated from the Earth's spin to maintain their required motion. Further north than about 30 degrees latitude, wind shear becomes an issue.

The timing, too, depends largely on wind shear, which relates to how surface winds are behaving in relation to those higher in the troposphere. If there's a lot of vertical wind shear, which gets more pronounced as upper and lower winds move in different directions, potential storms will not be able to launch or maintain the prerequisite cyclonic motion.

To illustrate, Laver likened hurricane action to a spinning top. Wind shear, in this metaphor, would act as pressure that tips the top in one direction, reducing its ability to maintain its structure.

Other factors that affect the hurricane's ability to maintain its internal spin include the temperature and humidity in the higher reaches of its vertical span, and the smoothness of the surface over which they travel. Hurricanes generally deteriorate rapidly once they hit land.

"When a system hits land, several things can happen," Laver explained. "The source of moisture becomes more limited. Also the friction of the land, and the unevenness of the terrain, breaks up the eye of the hurricane. The system doesn't maintain an eye very long once it hits land. The instability continues enough to create the rain and showers, but it no longer has the look of an organized circular system."

Unfortunately for those who happen to live in the path of an incoming hurricane, the disintegration of the system takes time, and the resisting friction that eventually disrupts its passage can come from homes and trees as well as terrain. One hurricane can contain enough energy to light up the continent for a year, if its power could be tapped.

So in the Southwest, we can count ourselves lucky for rarely having to face the wrath of hurricanes directly – even though it comes at the cost of not having as much information on the hurricanes that can affect us.

Melanie Lenart is a postdoctoral research associate with the Climate Assessment for the Southwest.

Resources on the Web

For more information on the East Pacific hurricane forecast, visit:
http://www.cpc.ncep.noaa.gov/products/Epac_hurr/Epac_hurricane.html

For information on how tropical storms have affected the Southwest, see
http://www.ispe.arizona.edu/climas/forecasts/articles/tropical_Aug2002.pdf