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Not My Fault: Bombogenesis, two cyclones and an atmospheric river – what next?

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Geology 308 students learning sandbagging techniques at the Eureka NWS Office in 2015. Keep the bag low and fill 1/3 full. Don't tie the bags, fold over the end in the direction of the water flow (shown by white arrow). Stack each layer to overlap the one below.

It's been a week for weather. On Monday, a large cyclonic storm system developed in the northeastern Pacific off the coast of British Columbia. Over the next day pressure in the storm's center dropped so quickly, that it reached "bomb cyclone" status. On Thursday, a second cyclonic system emerged off the Northern California coast. And all the while an atmospheric river pumped intense rainfall upon us.

Some rain continues to fall and it's too early to know the full impacts of our triple whammy, but early assessments are we ducked disaster. I will attempt to parse out what I've learned so far about this wild week.

Large, counterclockwise rotating storms are no surprise. All storms rolling into us from the Pacific exhibit this same behavior and we experience many each winter. The rotation direction is a result of two factors: the propensity of air to move from areas of high pressures to lows and the rotation of the earth. Called the Coriolis force, in the northern hemisphere air currents will always be twisted to the right as they move from north to south or vice versa, coalescing into a counterclockwise spiral.

What was unusual this last week was how rapidly this storm developed and the size of the pressure change. Air pressure is something we tend to think about in terms of tires, not the air all around us. But our atmosphere has mass and is affected by the tug of gravity, keeping us cocooned in a pressure of roughly 14.7 pounds per square inch (psi). All living beings on the planet have evolved to thrive in this environment and we would quickly succumb to any major deviation from that norm.

The National Weather Service (NWS) uses millibars (mb) to measure air pressure. 14.7 psi translates to 1013 mb, the average sea level value. Average does not mean constant. Air pressure decreases with elevation and changes with temperature and other ambient conditions. Hot areas expand and become less dense (low pressure), and relatively colder areas are more dense (high pressure). Highest surface pressures are found in Siberia where 1050 mb is not unusual. The lowest pressures are in the eyes of cyclones – Typhoon Tip in the western Pacific plummeted to 870 mb in 1979.

The "bomb cyclone" concept dates back to the 1940s but wasn't formalized in weather terminology until the 1980s. It describes a phenomenon in some mid-latitude storms where the central pressure drops in a short time span – the technical definition is 24 mb pressure decrease in a 24-hour period. The Tuesday storm crushed the bar by plummeting 27 millibars in six hours and tied the record for the lowest bomb cyclone pressure recorded to date.

At first glance, a bomb cyclone looks a lot like a hurricane. Both form over water and become large rotating storm system with a central low-pressure zone, capable of producing very strong winds. Both have "seasons" when they typically occur. The main difference is in what causes them to form and the energy that sustains them.

Hurricanes are late summer/fall events fueled by warm ocean waters. That low-pressure zone causes moist air to rise, creating a positive feedback loop with clouds, thunderstorms, and rainfall intensifying the disturbance. A fully developed hurricane becomes well-organized with an eye and vertical eyewall. Ambient weather patterns propel the hurricane on predictable tracks. The main foe of hurricanes is wind shear, changes in wind speed/direction that can dampen the energy flow.

Bomb cyclones in contrast are a winter phenomenon that thrive on wind shear. Most commonly observed off the east coast and in the western Pacific, they need wind shear to form. Strongly contrasting temperature gradients produce what meteorologists call a "cold core low," which boosted by a strong jet stream and a sharp contrast between the relatively warmer ocean waters and the cold air can quickly intensify. Called bombogenesis, they form very quickly and don't track in the way hurricanes do.

Tuesday's cyclone made headlines all over the world, but it wasn't the only one of the week. By Thursday, a second cyclonic storm formed offshore of the California – Oregon border. It's rapidly dropping core pressure also brought it into the bomb cyclone category and provided a second jolt of strong winds along the coast.

A bomb cyclone by itself doesn't necessarily bring heavy rainfall. At the same time Tuesday's bomb cyclone was developing, a broad band of moisture was forming in the central and eastern Pacific, coalescing into an atmospheric river. Atmospheric rivers (ARs) account for more than half of California's annual rainfall.

To be classified as an AR, a storm must meet criteria based on the amount of water vapor it carries and the wind that propels it (IVT Integrated Vapor Transport). Quantified into an AR scale only last year, IVT can be measured from satellite data and is the basis of a five-step scale for Atmospheric Rivers. This week's AR landed us at category 4 (Extreme).

The bomb cyclones and atmospheric river had impacts on the West Coast. Two deaths were reported in Washington related to strong winds. Power outages and economic impacts were felt from San Francisco to British Columbia. But as bad as the headlines made it appear, Humboldt and Del Norte counties appear to have escaped major damage.

I won't downplay impacts. As I write, nearly 3000 customers in Humboldt County are still without power, several structures suffered significant wind damage, and ponds of water still saturate some yards and pastures. But the rivers didn't rise quite as high as first forecast, most of our roads escaped with little damage, and prepositioning of response supplies by both the county and PG&E limited damage. But the triple whammy has given us a powerful teachable moment.

At the top of my lessons learned list is reducing confusion about evacuation orders, warnings, and zones. Each county is divided into geographic units that typically have dimensions of several miles. These emergency management zones are used when wildfire, flood, or other hazardous incident requires potential evacuation.

On Thursday, Humboldt County issued evacuation ORDERS for several zones at risk of Eel River flooding and evacuation WARNINGS for other areas near the Eel, Van Duzen, and Mad River. ORDER is the highest level of alert – it means GET OUT NOW. Hazardous conditions are imminent. An evacuation warning means BE PREPARED TO EVACUATE; conditions are uncertain, and the warning may be upgraded to an evacuation order at any time. People who need more time to evacuate – those with medical conditions, animals, or little road access should use the warning as a signal to evacuate.

Everyone who was signed up for emergency notifications in these zones received a phone call, email, or text message about the potential hazard. No messages were sent to other areas where no alerts were in place. There was a flurry of confused posts on social media about who was affected. People living in fire-prone areas have a pretty good idea of the difference between orders and warnings and their zone name, but most of the rest of us haven't a clue.

Here's an easy way to find out. Sign up for the free Genasys App. Enter your address and voila – I'm in HUM-E042 and I had nothing to worry about in this storm. If my zone ever is alerted, the App will let me know. You can also visit https://humboldtgov.org/3219/Evacuation-Mapping and enter any address in the interactive map.

The second lesson is about sandbags. I never thought much about sandbagging until I started taking my Natural Disasters class to NWS field trips. Troy Nicolini put on a show for my students demonstrating dos and don'ts. Number one no-no is spare your back and don't overfill. A filled sandbag becomes a sausage and when stacked leaves gaping holes. Filling the bag only a third of the way makes much better handling. Don't tie the bag, just lay it flat, fold over the corner in the direction of flow, stomp it flat, overlap the next bag and repeat. Build a wall by offsetting the next row so that no gaps are left. Afterwards, empty the sand, dry the bags and store for future use.

To make an effective sandbag barrier, you need lots of bags. This week too many people didn't think about potential flooding until the waters began to rise. Sandbags are not something you can easily obtain at the last moment, nor are they easy to fill when the sand is already wet. If you are a longtime North Coast resident, you should have an idea of how vulnerable your home/workplace is to flooding. Have bags and a sand supply on hand. New to the area? Talk to your neighbors or call the Eureka NWS (707-443-6484) to learn more about your risk. The Eureka office is also happy to give you sandbagging advice or demonstrate the how-tos like they did for my class. Visit https://news.caloes.ca.gov/using-sandbags-safely/ - just ignore the photo on the cover which illustrates the wrong way to fill and stack.

All counties affected by these storms are compiling damage assessments. These assessments are critical to determining whether a State of Emergency will be declared by the governor or if California is eligible to receive federal assistance is a disaster declaration is made at the federal level. In Humboldt County, please report damages to OES@co.humboldt.ca.us, in Del Norte the contact is delnorteoes@co.del-norte.ca.us.

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