Times Standard

Not My Fault: Tides, tsunamis, and earthquakes

Lori Dengler for the Times-Standard
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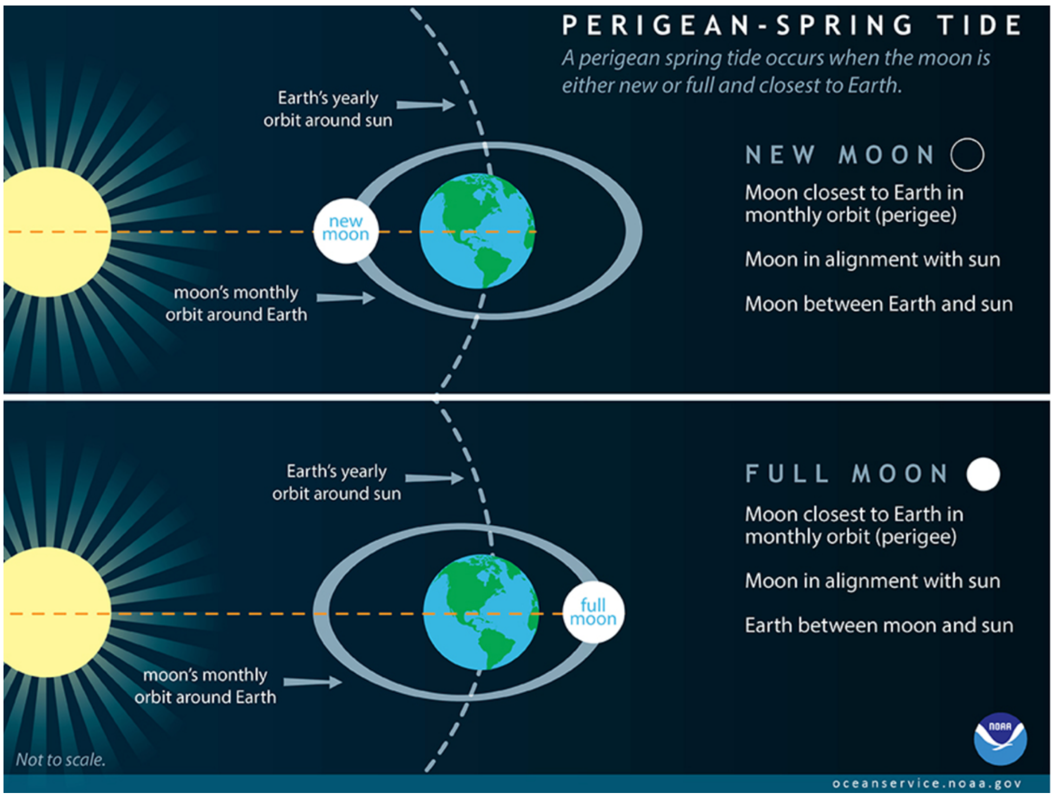

Last week, the North Coast experienced very high tides. King tides refer extreme tides that happen three or four times a year when the gravitational pull of the sun and moon are maximum. I've gotten many questions about king tides since Friday's article in this paper and realized there is confusion about tides, what causes them, and the hazards they pose.

Tides are caused by gravity. All masses attract one another and exert a pull that is proportional to the amount of mass and the square of the distance they are apart. Sir Isaac Newton worked out the fundamentals back in the late 17th century and his formulations still do a very good job explaining tides today.

The two main players in earth tides are the sun and the moon. While the masses of each are constant, distances and positions vary. The orbit of the earth around the sun is not a circle. The elliptical path defines the plane of the ecliptic. At its furthest (aphelion), the earth is more than 94.5 million miles away from the sun and at its closest (perihelion), only 91.4 million miles distant.

The moon has an elliptical orbit about the earth. There is a 26,000-mile difference between its farthest (apogee) and closest approaches (perigee). And to make matters more confusing, the plane of the moon's orbit is at an angle about 5° tilted to the plane of the ecliptic. The resulting gravitational pull is the combination of where the sun and the moon are relative to you on the earth's surface.

The biggest player is the moon. Far smaller than the sun, the moon is much closer, exerting more than twice as strong a pull. The moon tugs at anything with mass – the solid earth, oceans, and the atmosphere. The most visible result is our twice daily pattern of high and low tides. The earth makes a complete rotation once a day. One daily high tide is produced in areas positioned closest to the moon. The opposite side of the earth experiences a high tide at the same time. That's because the entire planet is pulled toward the moon. The less rigid ocean is not pulled as much, creating the second daily high.

Anyone looking at a tidal chart or graph will notice that the tidal highs and lows change throughout the month. The shape of the tides changes as well. It's not a simple function of latitude; the shape of the coastline and oceans play a role as well. On the West Coast, the range between high and low tides generally increases to the north. Typical highest tides in the San Diego area are just over 6 feet, 8 feet in the Humboldt Bay area, and nearly 10 feet in the Port Townsend area of Washington State.

On our coast, the two high and low tides are asymmetric. Each day there is a higher and a lower high tide, and the same for the low tides. Tide tables and online tidal charts in the US are measured relative to Mean Lower Low Water (MLLW). NOAA has official tide gauges installed along all US State and territorial coastlines – the North Coast ones are at Arena Cove in Mendocino County, just inside Humboldt Bay, and at Crescent City. MLLW for each site is determined by averaging all the daily low low tides over the past 19 years. If the tide height is zero, that means you are right at the low tide average. A negative tide means water level is below the average lowest tide level.

Twice a month (full and new moon), the sun and the moon are in alignment, causing spring tides, the highest and lowest tides of the month. Spring tides have nothing to do with the season; they occur twice a month all year round. The name derives from the ocean "springing forth" producing higher waters than average. When spring tides occur at the same time as the minimum distances between the earth, sun, and moon, we get king tides. The official name is perigean-spring tide.

Neap tides are the opposite of spring tides - when the positions of the sun and moon offset the gravitational pull of each other. They occur during the first and last quarter phase of the moon, producing lower high tides and the smallest range between the highest and lowest water levels.

The rocky mass of our planet also feels the gravitational pull resulting in solid-earth tides. Unlike ocean tides, they aren't visible, but gravimeters (instruments measuring gravitational acceleration) easily detect them and must be compensated for when conducting gravity surveys. Just like the ocean, the inexorable tug of the moon and the sun produce twice daily bulges. Solid-earth tides are far smaller, only inches in height. But if you had a sensitive enough scale, you could see miniscule twice-daily changes in your weight.

High tides cand be hazardous. The most obvious impacts are flooding and coastal erosion. They can also exacerbate the sneaker wave threat. Sneaker waves are the result of swells from distant areas of the Pacific interacting to produce 'constructive interference,' an adding up of wave amplitude and waves that suddenly are much larger.

Higher water also means a great tsunami threat. Tsunamis arriving at high tide inundate much further inland than those at low tides. We were lucky in 2011 that the largest tsunami surges produced by the Japan earthquake arrived at low tide along our coast. The peak was over 8 feet high at Crescent City, but arriving at low tide, no land above the high tide level was flooded. Had it occurred 18 hours later at the highest tide, it much of the Crescent City waterfront would have been affected. Crescent City wasn't as lucky in 1964 when the largest surge was 13 feet and arrived atop an 8-foot tide. The result was a water height of almost 21 feet and the flooding of 29 city blocks.

Whenever I work with emergency planners and responders, I always stress the importance of tides and tsunami duration. Everyone with a response role needs to be aware that the tsunami hazard period can last for 12 hours or longer and even if the largest surges occur within the first four or five hours, the tidal fluctuation may cause more flooding later on. The only on land flooding in Crescent City in 2011 occurred around 1 AM, more than 16 hours after the largest tsunami waves. An up-to-date tide table should be part of every responder's gear.

Since tides affect the solid earth, could they cause earthquakes? Despite the tabloid media, there is no correlation between large earthquakes and the strongest tides. Periodic alarms about the "Jupiter Effect," alignment of all the planets increasing the gravitational tug and triggering earthquakes, have no basis in fact. The planets have a far smaller gravitational pull than the moon and the sun and there has been no increase in earthquake activity at times of past alignments. Non-volcanic tremor (very small amplitude continuous vibrations) appears to be affected by tides, and some studies of tine earthquakes near the coast show a small correlation, but the triggering of larger earthquakes is unsubstantiated.

Update: The eruption threat continues on Iceland's Reykjanes Peninsula although seismicity rates have decreased, and the rate of surface deformation has slowed. Magma is still feeding the intrusion and the influx rate could change at any time.

Lori Dengler is an emeritus professor of geology at Humboldt State University, an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. All Not My Fault columns are archived online at https://kamome.humboldt.edu/taxonomy/term/5 and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column. Downloadable copies of the North Coast preparedness magazine "Living on Shaky Ground" are posted at https://rctwg.humboldt.edu/prepare/shaky-ground.