

Typhoons, Hurricanes, and Cyclones



Hurricane Elsa (July 2, 2021) was the first cyclonic event in this year's Atlantic **hurricane** season. **Typhoon** Imogene (January 1, 2021) was the first cyclonic event in the Pacific region, near Australia. There are **cyclones** as well.

1. Do some research to find the differences between typhoons, hurricanes, and cyclones?

All of these storms are measured and compared with their ACE score (Accumulated Cyclone Energy). The ACE score measures the storm's intensity and duration.

ACE uses an approximation of the wind energy used by tropical systems over each of their lifetimes. A wind velocity measurement is taken every 6 hours. The data of velocities that are greater than or equal to 35 knots are then squared, summed, and divided by 10,000 to reach a measure of the storm's intensity and duration.

This is the formula for finding the ACE score of each storm: $ACE = 10^{-4} \sum (v_{\max})^2$

Below are the every 6-hour measurements from Hurricane Ida. We've left the first 6 calculations blank so that you can do a little math to get the feel of how the formula is used.

2. In the table below, fill in the calculations for velocity² and Velocity squared divided by 10,000 only for wind speeds **greater than or equal to 35 knots (40mph)**.

Hurricane Ida				
Date of Activity	Time of reading	Storm intensity in knots	Velocity ²	Velocity squared and divided by 10,000
2021-08-30	12:00	40		
2021-08-30	06:00	65		
2021-08-30	00:00	105		
2021-08-29	18:00	125		
2021-08-29	12:00	130	16900	1.69
2021-08-29	06:00	115	13225	1.3225
2021-08-29	00:00	90	8100	0.81
2021-08-28	18:00	90	8100	0.81
2021-08-28	12:00	75	5625	0.5625
2021-08-28	06:00	70	4900	0.49
2021-08-28	00:00	70	4900	0.49
2021-08-27	18:00	70	4900	0.49
2021-08-27	12:00	50	2500	0.25
2021-08-27	06:00	40	1600	0.16
2021-08-27	00:00	35	1225	0.1225
2021-08-26	18:00	35	1225	0.1225
2021-08-26	12:00	30		

The sum of that last column = IDA's ACE measurement = 10.5675

3. How many days of the storm's appearance were measured?
4. How many of those days will be counted in the calculation of its ACE measurement?
5. How many times per day was the data collected?
6. How do you suppose this ACE calculation takes into account the duration of a storm?
7. Why do you believe that the velocities are squared before being added together to reach an ACE measurement? What was accomplished by squaring these velocities?
8. Why do you suppose the sum of the squared velocities was divided by 10,000?

Here is the data on Typhoon Mangkhut, a very powerful and catastrophic tropical cyclone that caused extensive damage in Guam, the Philippines and South China in September 2018.

Typhoon Mangkhut			
Date time	Velocity in knots	Velocity squared	Velocity squared divided by 10,000
20:00 HKT 17 September 2018	21.60		
17:00 HKT 17 September 2018	24.30		
14:00 HKT 17 September 2018	29.70		
11:00 HKT 17 September 2018	40.50	1639.99	0.16
08:00 HKT 17 September 2018	45.90	2106.47	0.21
05:00 HKT 17 September 2018	59.40	3527.80	0.35
02:00 HKT 17 September 2018	59.40	3527.80	0.35
23:00 HKT 16 September 2018	64.79	4198.37	0.42
20:00 HKT 16 September 2018	78.29	6129.91	0.61
17:00 HKT 16 September 2018	94.49	8928.83	0.89
14:00 HKT 16 September 2018	94.49	8928.83	0.89
11:00 HKT 16 September 2018	94.49	8928.83	0.89
08:00 HKT 16 September 2018	94.49	8928.83	0.89
05:00 HKT 16 September 2018	99.89	9978.42	1.00
02:00 HKT 16 September 2018	105.29	11086.32	1.11
23:00 HKT 15 September 2018	105.29	11086.32	1.11
20:00 HKT 15 September 2018	105.29	11086.32	1.11
17:00 HKT 15 September 2018	105.29	11086.32	1.11
14:00 HKT 15 September 2018	105.29	11086.32	1.11
11:00 HKT 15 September 2018	105.29	11086.32	1.11
08:00 HKT 15 September 2018	118.79	14111.19	1.41
05:00 HKT 15 September 2018	124.19	15423.18	1.54
02:00 HKT 15 September 2018	134.99	18222.10	1.82
23:00 HKT 14 September 2018	134.99	18222.10	1.82
20:00 HKT 14 September 2018	129.59	16793.49	1.68
17:00 HKT 14 September 2018	129.59	16793.49	1.68
14:00 HKT 14 September 2018	129.59	16793.49	1.68
08:00 HKT 14 September 2018	129.59	16793.49	1.68
02:00 HKT 14 September 2018	129.59	16793.49	1.68
20:00 HKT 13 September 2018	129.59	16793.49	1.68
14:00 HKT 13 September 2018	129.59	16793.49	1.68
08:00 HKT 13 September 2018	129.59	16793.49	1.68
02:00 HKT 13 September 2018	129.59	16793.49	1.68
20:00 HKT 12 September 2018	129.59	16793.49	1.68
14:00 HKT 12 September 2018	129.59	16793.49	1.68
08:00 HKT 12 September 2018	129.59	16793.49	1.68
02:00 HKT 12 September 2018	124.19	15423.18	1.54

20:00 HKT 11 September 2018	118.79	14111.19	1.41
14:00 HKT 11 September 2018	110.69	12252.54	1.23
08:00 HKT 11 September 2018	99.89	9978.42	1.00
02:00 HKT 11 September 2018	89.09	7937.55	0.79
20:00 HKT 10 September 2018	83.69	7004.57	0.70
14:00 HKT 10 September 2018	78.29	6129.91	0.61
08:00 HKT 10 September 2018	78.29	6129.91	0.61
02:00 HKT 10 September 2018	65.33	4268.64	0.43
20:00 HKT 09 September 2018	45.90	2106.47	0.21
14:00 HKT 09 September 2018	43.20	1865.94	0.19
08:00 HKT 09 September 2018	40.50	1639.99	0.16
02:00 HKT 09 September 2018	35.10	1231.81	0.12
20:00 HKT 08 September 2018	27.00		
	Sum of Velocity squared divided by 10,000		47.98

9. What is Mangkhut's ACE score?

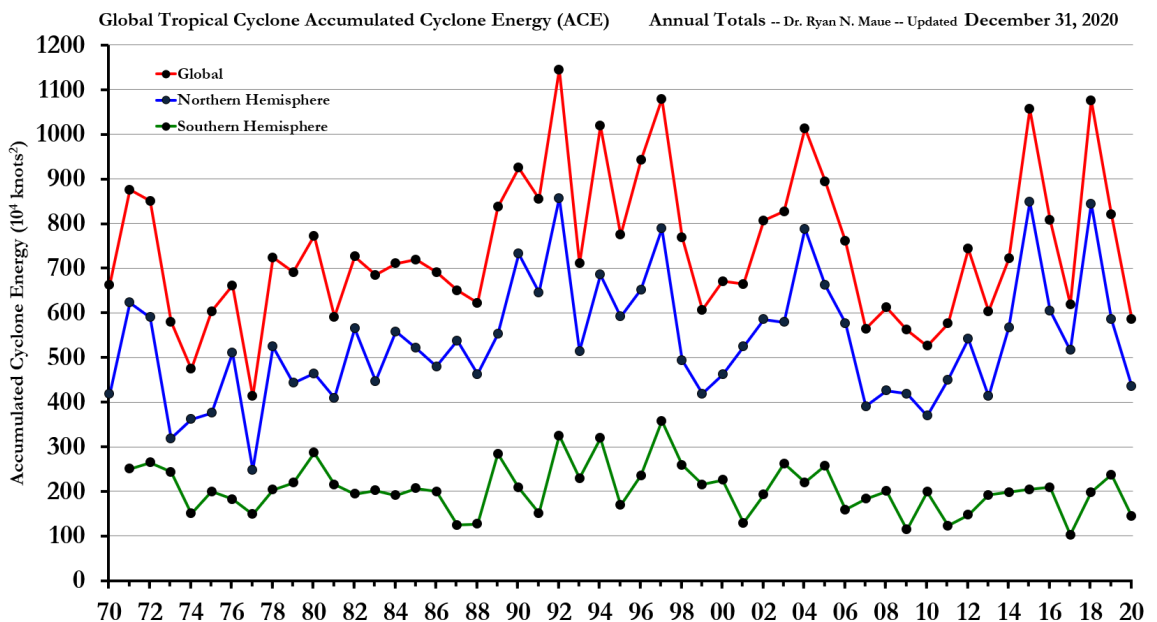
10. According to their ACE scores, which was the more intense storm Ida or Mangkhut?

11. From what you've calculated and observed about these two storms does the ACE measurement seem correctly identify which was a more severe storm? Please explain.

12. What storm ramifications does the ACE measurement not account for?

We found the following chart that shows the sum of the ACE scores from all of hurricane basins of the world, historically.

Last 4-decades of Global Tropical Storm and Hurricane Accumulated Cyclone Energy -- Annual totals. The Southern Hemisphere tropical cyclone season occurs from July-June each calendar year. The graph is constructed such that SH annual value for July 2014 - July 2015 is positioned in 2015. Adapted from [Dr. Ryan Maue](#).



13. Do you notice any historical trends in this chart of ACE scores? Please explain.

Sources: <http://beachchairschemist.com/2017/06/01/hurricane-vs-cyclone-vs-typhoon/>
<https://www.bbc.com/news/world-us-canada-42251921>
https://en.wikipedia.org/wiki/Accumulated_cyclone_energy
<https://oceanservice.noaa.gov/facts/cyclone.html>
https://www.casact.org/pubs/forum/18spforumv2/05_Collins.pdf
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<https://maps.wunderground.com/tropical/tracking/wp201826.html>