

## Coastal Folk Lore

I very much enjoyed Alan Champneys' latest Westward Ho! article (August 2017), and would like to offer an alternative hypothesis to the origin of 'the every seventh wave is the biggest' lore. My discussions with coastal folk have indicated that this 'lore' is far from constrained to surfers, and is well-known amongst fishermen, beachcombers, sailors and many others.

First, it needs to be explained that coastal and marine engineers tend to use wave height rather than wave amplitude, and most design formulae are couched in terms of wave height. Wave height is simply the difference in level between the wave crest and the preceding wave trough, and will vary on a wave by wave basis. As waves are created by the action of wind they are generally taken to be random, or at least irregular, in height. A widely used measure of irregular wave heights is the significant wave height,  $H_s$ , defined as the average of the largest 1/3 of the waves in a record. Remarkably, the significant wave height determined in this way is very close to the 'typical' height of waves estimated by observers. The significant wave height may also be calculated directly from the first moment of the wave spectral density function if this information is available.

Second, the probability density function of wave heights is fairly well described by a Rayleigh distribution, (but see references below for some caveats and further details). Why this should be so can be hinted at by the observation that, for Airy waves, the sea surface excursion at a point at any time,  $\eta(t)$ , may be written as

$$\begin{aligned}\eta(t) &= \sum_{n=1}^N [a_n \cos(\omega_n t) + b_n \sin(\omega_n t)] \\ &= \sum_{n=1}^N [c_n \cos(\omega_n t + \theta_n)].\end{aligned}$$

For a particular  $\omega_n$  if  $a_n$  and  $b_n$  are normally distributed then  $c_n = \sqrt{(a_n^2 + b_n^2)}$  is Rayleigh distributed. The sum of a few Rayleigh distributed variables can be assumed to be approximately Rayleigh, with decreasing assuredness as  $N$  increases and/or the  $\omega_n$  vary. Assuming the observed wave heights follow a Rayleigh distribution, we can write the probability that the wave height,  $h$ , exceeds a value  $H$  as:

$$P(h \geq H) = e^{-2(\frac{H}{H_s})^2}.$$

If we take a 'big' wave to mean one that is larger than the significant wave, we can determine the probability that any particular wave is greater than the significant wave to be

$$P(h \geq H_s) = e^{-2} \approx 0.135 \approx 1/7,$$

indicating that we might expect one in seven waves to be large, but not necessarily every seventh wave; a semantic but mathematically important difference that could easily be lost amongst non-specialists.

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### REFERENCES

- 1 Forristal, G.Z. (1978) On the Statistical Distribution of Wave Heights in a Storm, *J. Geophys. Res.*, vol. 83, pp. 2353–2358.
- 2 Longuet-Higgins, M.S. (1952) On the Statistical Distribution of the Heights of Sea Waves, *J. Marine Research*, vol. 11, pp. 245–265.
- 3 Thornton, E.B. and Guza, R. (1983) Transformation of wave height distribution, *J. Geophys. Res.*, vol. 88, pp. 5925–5938.

## Climate Science

In response to Paul Williams' letter (*Mathematics Today*, August 2017), I would point out that for those of us not immersed in climate science, opinion of one form or another is about all that we have to go on when attempting to assess the reality or otherwise of Anthropogenic Global Warming. There may indeed be evidence that conclusively demonstrates climate change (and anthropogenically-induced climate change in particular), but it is not available to the general public in any digestible form. Instead, we are confidently told that 'the science is settled', that 'a consensus of scientists' supports the conclusions of the IPCC, and any people asserting the contrary are either 'in denial' or are funded by oil, gas and coal interests. The contents of the leaked emails from the University of East Anglia (see, for example [1]) have hardly improved academic standing on this issue.

Professor Williams asks for peer-reviewed opinion pieces, but given the current strongly polarised (and increasingly bad-tempered) nature of any discussions on climate change, I rather doubt that the peer-review process can remain sufficiently objective.

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### REFERENCES

- 1 House of Commons Science and Technology Committee (2010) *The disclosure of climate data from the Climatic Research Unit at the University of East Anglia*. Available at: <https://publications.parliament.uk/pa/cm200910/cmselect/cmsctech/387/38702.htm>

I thank Paul Easthope for contributing to the important discussion about the coverage of climate science in *Mathematics Today*. I would sympathise with any layperson who wants to assess for himself or herself the evidence for climate change without recourse to expert opinion. I am always mindful of the Royal Society's motto, *nullius in verba*, my favourite translation being *words are empty*. But I would argue that laypeople already have easy access to digestible evidence about climate change [1–3]. I often ask contrarians: Assuming there is an anthropogenic contribution to climate change, what evidence (that is not currently in existence) would it take to convince you of it? Invariably, they are unable to provide an answer.

I would fundamentally disagree that the peer-review process cannot remain sufficiently objective when dealing with climate change. I see this objectivity in action every day, as editor of *Geophysical Research Letters*, advisory board member of *Dynamics and Statistics of the Climate System*, and recent editorial board member of *Philosophical Transactions of the Royal Society*. That same objectivity of peer-review must be called upon by *Mathematics Today*, if erroneous and misleading content is to be eradicated from these pages.

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### REFERENCES

- 1 <https://climate.nasa.gov/evidence/>
- 2 The Royal Society (2014) *An introduction to climate change in 60 seconds*. Video available at <https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/>
- 3 Rennie, J. (2009) Seven Answers to Climate Contrarian Nonsense, *Scientific American*, <https://www.scientificamerican.com/article/seven-answers-to-climate-contrarian-nonsense/>