Sea level, the Moon, and Frankenstein

Aslak Grinsted, J.P. Steffensen, B. M. Vinther, Centre for Ice and Climate, Niels Bohr Institute, Copenhagen

A haunting tale

A recent study argued that moon cycles are to blame for recent sea level rise. This gave rise to these hair-rising headlines:

"Scientific censorship in the name of climate"
"Humans not to blame for higher sea levels"
"Moon-cycle gives exaggerated numbers for sea level rise"
"The effect of the moon on sea level"
"No detectable effect on sea levels from global warming"

Sources for headlines: Forskeren, Berlingske, Ingeniøren, Weekendavisen, og Aktuel Naturvidenskab.

Chapter 1

JM Hansen et al. (2015; JMH) used sine-regression to fit five oscillations plus a linear trend to a 160-year sea level record from waters near Denmark (a stack of local GIA corrected tide gauge records). They then observe that the sines-plus-trend model correlates highly with the record it was fitted to, after applying a 19-year moving average. This should be unsurprising as the procedure guarantees high correlation, regardless of input data (see figure 1). This result is clearly not significant in any meaningful sense of the word. They proceed to post-rationalize the fitted model frequencies in terms of the nearest half-multiples of the lunar nodal cycle (18.6 years). But you can postulate any similar set of frequencies, and you would still get high correlation. This is illustrated in the figure where we show how sea level can be 'predicted' using the orbital periods of five exoplanets.

Chapter 2

We demonstrate, by example, the non-significance of the model fit as you get high correlations regardless of data set, and periods used. Figure 1 shows how we can fit pretty much any time series using the exact same lunar frequencies they used in their study. We illustrate this using data for the population in Denmark over time, and the frequency of the words "Frankenstein", and "Hamlet" in books over time. We can also predict sea level using the orbital periods of exoplanets. The point is that high-correlations are guaranteed even when there clearly is no causal link. This means you cannot conclude anything at all from a high correlation using this methodology.

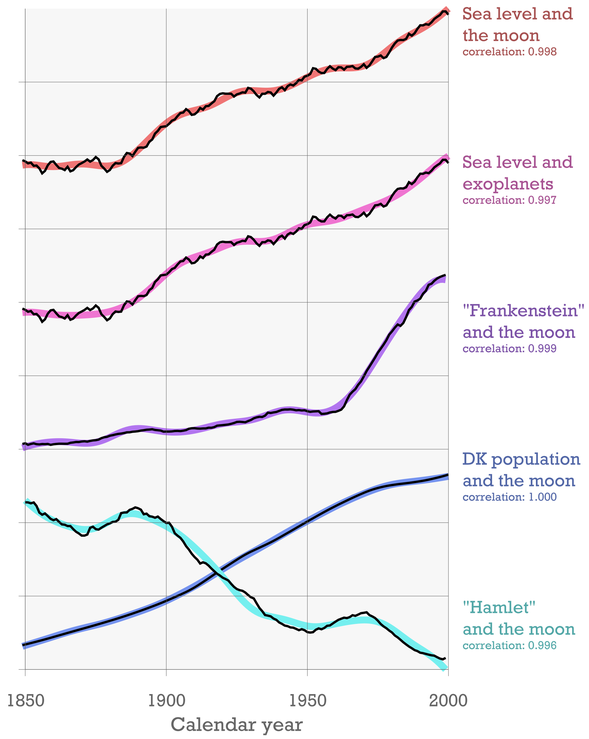

Figure 1 (right): The sea level series can be fitted using a sum of five lunar nodal cycle multiples plus a trend, but that does not mean there is a causal relationship. Virtually any time series can be fitted using the exact same set of frequencies, and that any similar set can fit the sea level series. We illustrate this by 'predicting' time series of frequencies of the words "Frankenstein" and "hamlet" in books and the population in Denmark using the nodal cycle, and by predicting sea level using the periods of five exoplanets.

Chapter 3

The basic issue is over-fitting: The statistical model has 17 degrees of freedom (5 periods, 5 phases, 5 amplitudes, 1 trend, 1 constant). They test the quality of the resulting fit against 19-year moving averages of a 160-year series. There is effectively 8-9 independent points in the smoothed series.

"With four parameters I can fit an elephant, and with five I can make him wiggle his trunk". – John von Neumann.

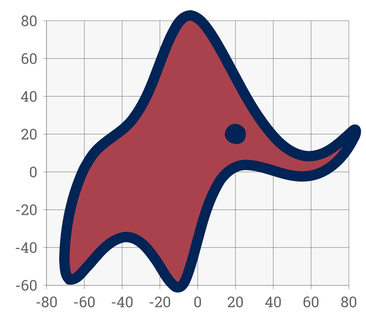

Figure 2: Mayer et al. (2010) put Neumann's statement to the test and fit a cycle model to a drawing of an elephant. The model is remarkably similar to JMHs sea level moon model, albeit with fewer free parameters and with additional periodicity constraints.

Chapter 20

"I sat one evening in my laboratory; the sun had set, and the moon was just rising from the sea; I had not sufficient light for my employment, and I remained idle, in a pause of consideration of whether I should leave my labour for the night or hasten its conclusion by an unremitting attention to it." – Mary Shelley (1818)

JMH et al. (2015) were struck by the high correlation between sea level and a model with five cycles, and felt they needed a causal explanation. Our examples show that there is absolutely no need for an explanation as their procedure guarantees high correlations even when there is no causal link. They propose what I call the lunar nodal resonance hypothesis, where all sea level variability is explained by the moon. I see this as a post-hoc rationalization of a (very) insignificant correlation, and we are not convinced.

Armed with their new nodal resonance hypothesis, they reformulate their model with the frequencies rounded to nearest half-multiple of the nodal cycle. They then re-optimize all the remaining parameters and 'test' whether the nodal resonance model also can fit the data. We show that this is a poor test as it is guaranteed to give an apparent positive result.

The nodal resonance hypothesis is also physically far-fetched. The nodal cycle may have a detectable effect on sea levels, but they are arguing that multiples thereof have a large significant effect on winds (and AMO / NAO). That is quite a mental leap.

Chapter 24

"I darted towards the spot from which the sound proceeded, but the devil eluded my grasp. Suddenly the broad disk of the moon arose and shone full upon his ghastly and distorted shape as he fled with more than mortal speed."

"I pursued him, and for many months this has been my task. Guided by a slight clue, I followed the windings of the Rhone, but vainly. The blue Mediterranean appeared, and by a strange chance, I saw the fiend enter by night and hide himself in a vessel bound for the Black Sea. I took my passage in the same ship, but he escaped, I know not how."
– Mary Shelley (1818)

My blog: https://debris.glaciology.net/
J.M. Hansen, Aagaard, Kuijpers (2015), J. Coast. Res: 31, 5
Mary Shelley 1818, Frankenstein
Mayer, Khairy, Howard, (2010), Drawing an elephant with four complex parameters, Am J. Phys., 78
A critical comment : T. Schmith, P. Thejll, and J.W. Nielsen (2016) J. Coast. Res: 32, Issue 2 (poster EGU2016-7128)
Reply: Hansen, Aagaard, Kuijpers (2016) J. Coast. Res: 32, 2
Data sources: google ngrams. statistikbanken.dk. openexoplanetcatalogue.com
contact: ag@glaciology.net