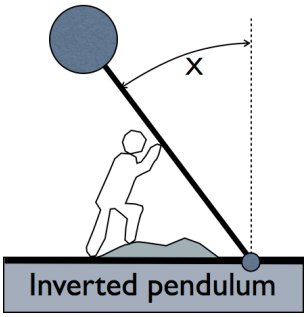
Gulf Stream's death forecasted between 2025 and 2095

By Warren D. Smith, July 2024.

ABSTRACT: This is an op-ed I wrote in July 2024 unfortunately rejected by several major newspapers. Its goal was to summarize/redo, in a concise way hopefully understandable by and convincing to people with pre-college education, a much longer and harder to read 2023 scientific paper by P.&S.Ditlevsen forecasting the imminent end of the "AMOC" – Atlantic Meridional Overturning Circulation. The cause is human-caused "climate change"; the consequences for our civilization might be devastating. I have now also appended a short postscript (not present in the original op-ed) asking important questions.

Why is Northern Europe habitable? The "Gulf Stream," transporting 30000 tonnes per second of warm Caribbean water up America's E.coast, then toward N.Europe, is a big reason, especially in winter. Although Paris is more North than Montreal, its winters are 26°F warmer. Dublin Ireland has the same latitude as Edmonton Canada, but 32°F warmer winters. With no Gulf Stream, presumably Britain, France, Germany, and Scandinavia's winters would be 5-16°F, and Reykjavic's 33°F, colder, while the Caribbean, Texas, and Florida would get hotter, perhaps with more or worse hurricanes.

So it's alarming that Peter & Susanne Ditlevsen recently forecast (claiming 95% confidence, and contradicting the IPCC 2021 report) that the Gulf Stream will *switch off* sometime between 2025 and 2095. Its flow has already shrunk about 15%; but they forecast a sudden drop to zero. I believe them for reasons I will explain simply.



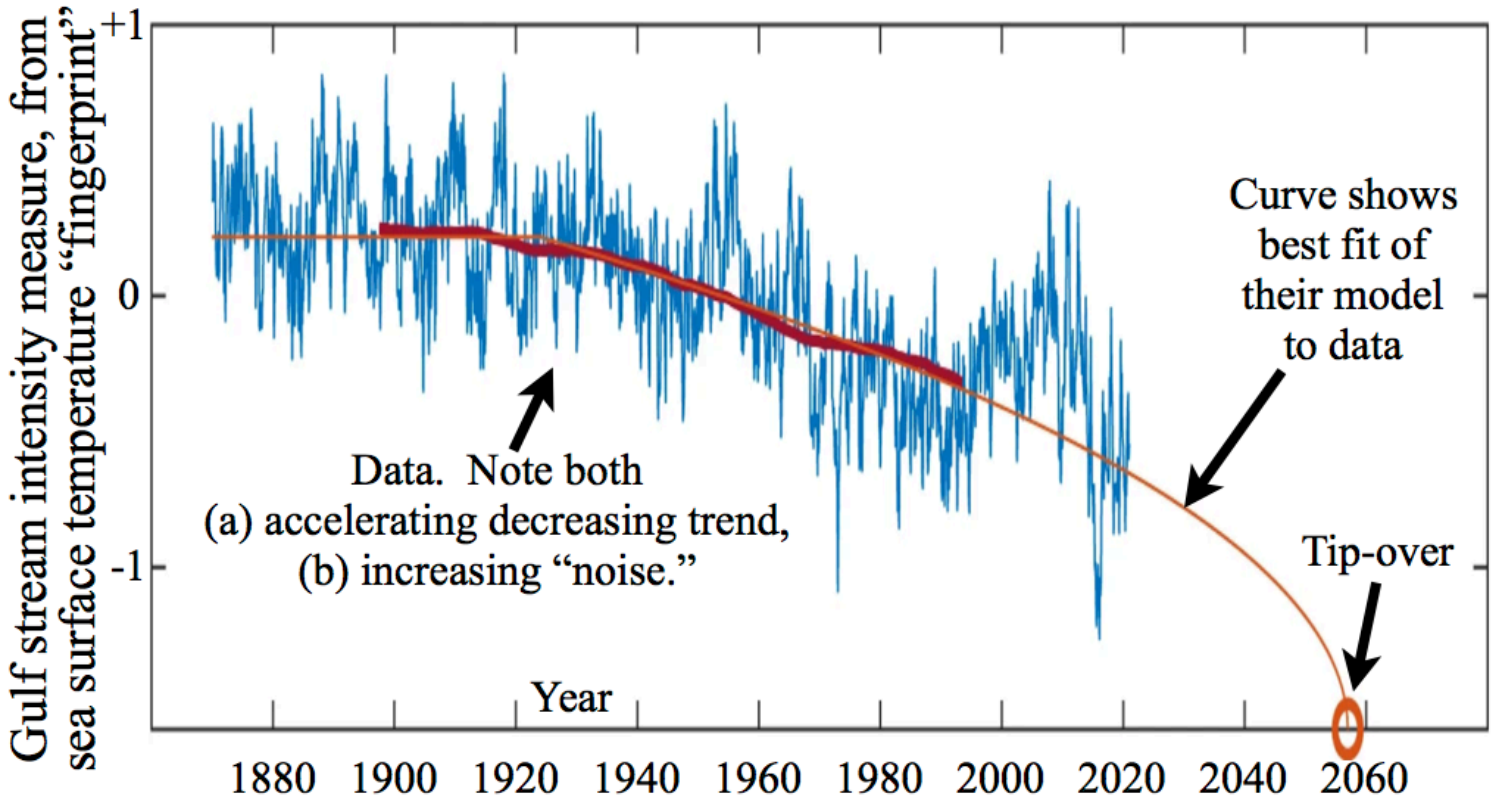
This is a "tip-over" effect triggered by "pushing" from human-caused "climate change." The key to predicting it is "universality": essentially all tip-over ("bifurcation") effects in virtually every noisy dynamical system – i.e, essentially *everything* – behave the same. Therefore we can consider the *simplest*: pushing a heavy **upside-down pendulum** (fig.1). You could push it upwards gradually all day, seeing little change – although your angular pushing keeps getting easier, the nearer vertical it gets. But once it reaches vertical, it *suddenly* falls down the other side, reaching positions never seen before. Once the Earth's climate reaches a tip-over point, there will be *rapid* changes, reaching new climate states never seen before by humanity.

What makes the Ditlevsens think there will be a sudden tip-over, rather than mere mild decrease? At least six computerized mathematical *models* of the Gulf Stream exhibit *two* stable states, "on" and "off," the latter having 0-8% of on-state flow. So mathematically, the tip-over is there. Switch-off is triggered by increasing glacial meltwater, which the Gulf Stream is very sensitive to.

The Gulf Stream is the crankshaft of the huge, but delicate, heat engine which is the main bottom/top mixer of all world oceans. The sun heats the wide shallow Gulf of Mexico, making its

water both *lighter*, and saltier (from evaporation). When that water reaches the N.Atlantic, it cools. It then, since saltier, becomes *heavier* than normal seawater, hence sinks to the bottom. It then flows down to Antarctica and all over the world along the seafloor where we don't notice it. This process self-organizes and self-reinforces, taking somewhere between 10 and 5000 years to attain full strength. *Small* density-differences drive all this: Seawater is only 3% denser than fresh, with the saltiest (Red Sea) only 20% saltier than the least-salty (Arctic Ocean). And heating water 10°C only makes it 0.3% lighter. That smallness is *why* the Gulf Stream is easily disrupted by cold non-salty meltwater.

But more important than theoretical models, is **measured reality** (fig.2). How do the Ditlevsens know when tip-over will happen? Simple. Imagine measuring your inverted pendulum's position once each minute. Those measurements show a *trend* (pendulum approaching vertical, thanks to your pushing) plus random and nonrandom *noise* (from, e.g, vibrations, turbulence, seasons, Brownian motion). The signature of approaching tip-over is: the noise *grows* and the trend *speeds up*. For an inverted pendulum, tip-over occurs at distance X=0. With constant-power slow pushing and small constant-energy noise: As a function of time T until tipping, the noise level and pushing speed both grow proportionally to $T^{-½}$, while the distance X shrinks proportional to $T^{½}$. (Need math-refresher on exponents? $T^{-½}$ is the reciprocal of $T^{½}=\sqrt{T}$=squareroot of T.) So with tiny noise, the noise- and speed-enlargement factors would approach *infinity* as X approaches 0, both in a manner inversely proportional to the distance X to tip-over – *easily-observed* signatures applicable *universally*.



Plotted measurements of the Ditlevsens' "AMOC fingerprint" Gulf Stream intensity measure versus year from 1870-2020, indeed show statistically significant (i) accelerating downward trend, (ii) growing noise. From that, they try to deduce the tip-over date, and try to estimate how confident

they are via Monte Carlo simulations. Their forecast is 2025-2095 with 95% confidence, with best guess 2057.

You don't need fancy models and curve-fits to make a simple "back of the envelope" estimate. You only need two truths:

A. Your eyeballs: the noise-amplitude roughly *doubled* during the 150 years 1870-2020, while "pushing speed" roughly *tripled* during the 90-year shift from 1910-1930 to 2000-2020.
B. For our simple pendulum model, noise and speed both are proportional to $T^{-½}$. So doubled noise means 4× sooner time-before-tip, while tripled speed means 9× shorter wait.

Combine A & B. Deduce: based on noise, switch-off will occur in 2070, but based on speed 2030. Your eyeballs should yield roughly the same answers as mine. And the noise already is large enough that it might trigger tip-over decades before the noiseless smooth curve.

This is an imminent global emergency. We need to do something massive about it. What? One idea: http://vixra.org/abs/2110.0016.

Warren D. Smith has a PhD in mathematics from Princeton. Text & data based mainly on P.&S.Ditlevsen: Warning of a forthcoming collapse of the Atlantic meridional overturning circulation, *Nature Communications* 14 (25 July 2023) #4254.

Postscript. What will happen after the AMOC shuts down? I think "nobody knows." I would like to see (but have not seen) model-based forecasted answers. One possibility is that the Gulf Stream will be replaced by a weaker current which instead of flowing NE from the Gulf, instead flows SEE then drops into the depths of the S.Atlantic, in which case the whole system of AMOC-ancillary currents will still happen, but in a weaker altered form which no longer will warm Europe and Eastern N.America. In this scenario, there might be a new induced current flowing S. from the Arctic Ocean along the W.Coast of Europe, in which case Europe will be *chilled* rather than warmed by ocean currents – presumably devastating their agriculture. Another possibility is that the Gulf Stream, despite being deprived of its "thermohaline" power source, still will be powered by the combined effects of the "trade winds" which blow Westward in the tropical region N. of the Equator, and weaker prevalent East-going winds at more Northern latitudes. In that case we might still get a Gulf Stream like the present one, but weaker, and not descending into the depths and thus no longer causing bottom-top ocean mixing. The shutoff of bottom-top ocean mixing would likely devastate fisheries worldwide and especially in the N.Atlantic; this paper presents evidence that has happened in the past: Jean Lynch-Stieglitz, T.D.Vollmer, S.G.Valley, E.Blackmon, S.Gu, T.M.Marchitto: A diminished North Atlantic nutrient stream during Younger Dryas climate reversal, Science 384,6696 (9 May 2024) 693-696. Finally, a third possibility is the entire AMOC system, including its most prominent component, the Gulf Stream, will simply end with nothing replacing them.