

# Sea Level Rise Flooding Pilot With Impacts & Timelines for the Built Environment at South Miami with Implications Globally

## Summary for Policy Makers

Jan. 28, 2020

**Background.** This is a science and technology policy Pilot Document containing relevant data and conclusions on the timing of the U.S. Climate Assessment Report's 2'–6' of sea level rise flooding in the pipeline, for setting compliance deadlines for buildings, homes, and infrastructure.

The Pilot Document shows 2015 -2017 NASA JPL ice-penetrating radar aerial imagery of W. Antarctic accelerating, and as stated by NASA, "*explosive and disturbing*" melt of 9 miles in two years that is likely increasing global sea level rise by 10 times from current levels. NASA states that these data have not been incorporated in any global models. The geologic record indicates that sea level rise tends to be sudden and episodic. IPCC states that the timing of rise will be much sooner than model predictions if new empirical data from Antarctica show accelerating melting. Although the onset of such saltatory rise periods cannot be determined exactly at this time, not being prepared for a sea level rise episode of this nature, with a margin of safety to maintain commerce and national security, is an unacceptable risk to society.

**Implications for coastal communities.** There is a consensus that models have historically underpredicted the pace of climate change and sea level rise due to complexity of the global climate system, which IPCC recognized primarily operates under chaos theory, thus substantially limiting the ability to accurately model impacts. The possibility exists that the 2'–6' of rise calculated by the U.S. Climate Assessment Report has already begun. Accelerated rise of this nature, not predicted by current models, could occur faster than resilient infrastructure could be financed and built if we wait until the rise is fully evidenced to the standards of scientific peer-review. Thus, prudence dictates that resilience financing be provided now.

### **Key requirements raised by the Pilot include:**

- **Preventing well documented risk of financial contagion** triggered from rapid bursts of sea level rise flooding similar to those occurring historically, that can overwhelm commerce and national security without sufficient lead times to finance and execute protections.
- **Providing notice to localities and the design / engineering community** of required protections for existing structures that have a low tolerance for sea level rise flooding risk because they have high sunk capital costs, in order to avoid liability from the need to stamp and seal final engineering / design drawings. Such structures are not amenable to flexible adaptive pathways with higher tolerance for sea level rise flooding risk.
- **Providing protections now** to required military operations' support functions of government and the private sector, to allow military facilities to continuously operate to maintain national security.
- **Ensuring critical infrastructure support facilities operate continuously** so regions and metropolitan areas are not shut down: water supply, wastewater treatment, transportation, electrical supply, communications. This prevents cascading risk where (1) a regional service / function if disabled like wastewater treatment, can shut down critical facilities like hospitals, (2) power failures without backup non-grid power and communications can cause injury and death including to the infirm, and (3) key facilities that supply food can be prevented from operating.

**National consensus resilience standard sea level rise flooding deadline** for buildings, homes and infrastructure must be amended to reflect these requirements. The graph on page 12 shows 2' of rise predicted by 2039 *without* taking the NASA findings into account. The Pilot also includes the need to incorporate a margin of safety. Accordingly, at this time for planned national public meetings and national consensus voting, the deadline for compliance is adjusted to 2030-35 to protect for 2'-6' of rise.

# Summary of Peer Review

Dec. 6, 2019 – Jan. 24, 2020

Over 100 experts in sea level rise including Antarctic melt were sent the 9<sup>th</sup> Draft Pilot Document three times and were called requesting comments.

In response to comments, a number of non-substantive changes were made.

Minor substantive changes were made in response to comments from Dr. George Sugihara of Scripps Institute, University of California. His comments concur with evidence in the Pilot Document stating that historically, most quantitative models of the natural world including climate change and sea level rise flooding, have underpredicted accelerating impacts due to the complexity of natural systems and nonlinear impacts / positive feedback loops that greatly accelerate change, and that actual empirical data should be given priority. These points were already part of the Pilot Document.

Sugihara is an expert in analyzing complex systems for precision and accuracy including developing empirical dynamic modeling and other data-enabled approaches for extracting information from observational data on complex systems. His work is described in

Nature: <https://www.nature.com/articles/437473a>.

Another substantive comment from a Thwaites Glacier researcher agreed with the Pilot Document conclusion that financing and construction for the 2' – 6' of sea level rise flooding in the pipeline should occur now due to the reasons stated in the Document, but disagreed that the timing of rise is in the near term. Sea level rise flooding protections require long lead times in order to prevent unacceptable risks to commerce and national security.

In the face of recognized historical underprediction of the pace of sea level rise, and without providing a factual or rational basis, a number of modelers adamantly disagreed with the Pilot Document's citations to evidence that sea level rise flooding is greatly accelerating including NASA data. Their rationale was that the Pilot Document should simply conform with the position of sea level rise modelers. Several commenters recently completed sea level rise projects for key very large east coast jurisdictions with timing of rise predicted much farther out, that omitted the NASA data of Thwaites Glacier accelerating melt, and refused to recognize it or take it into account without stating why. Responses were made to these commenters to ensure their position was clearly understood.

Importantly, several leading modelers stated they agree with the Pilot Document conclusions that in order to prevent unacceptable risks to commerce and national security, protections for the 2'-6' in the pipeline need to be financed and constructed now.

The nature of the comments received, support the facts that climate change and sea level rise have uniquely placed scientists in the unfamiliar position of making science policy judgments having potential \$trillion impacts. Thus, they are subject to intense economic, legal, and political criticisms.

It appears that this combination of substantial complexity not well suited to quantitative models, and intense attacks on and criticism of scientists due to unprecedented economic impacts, likely resulted in their well-recognized long term under-prediction of the accelerating pace of climate impacts as documented in the Pilot Document, especially in Appendix 2 showing evidence of "dangerous scientific reticence" presenting unacceptable risks to society. Comments from modelers disagreed with the facts presented on "dangerous scientific reticence," but provided no factual or rational basis for their conclusion.

# Sea Level Rise Pilot

*Sea Level Rise Impacts & Timelines for the Built Environment at South Miami with Implications Globally*

This Pilot Document is comprised of:

- City of South Miami Leading Climate Achievements & Commitment to Resilience
- Pilot Background
- Pilot Purpose
- Key Data for Determining the 2' of Rise Date of Compliance
- Documented Unreliable Precision & Accuracy of Most Sea Level Rise Models & Projections
- Abrupt Sea Level Rise Actual Empirical Data
- Suggested 2' of Rise Compliance Date for Discussion & Pilot Evaluation
- Financing Options Being Pursued

Figure 1 – NASA Antarctic Map of Velocity of Accelerating Ice Losses / Flow Into the Ocean, Including From West Antarctic Ice Sheet Probably in Response to Ocean Warming

Figure 2 – Map of Antarctic Glacier Locations

Figure 3 – Thickness, Shape & Surface Topography of Thwaites Glacier "Ice Tongue" That May Be Undergoing Irreversible Collapse

Figure 4 – Size of Rapidly Growing Very Large Cavity 10 Miles in Length & 300 Meters in Diameter at Thwaites Glacier's Grounding Line, 2011 to 2017

Figure 5 – Red Areas Show 3 Kilometers / yr. Velocity of Thwaites Glacier Irreversible Collapse into the Ocean

Figure 6.– Time Lapsed Satellite Imagery from 2015 – 2019 Showing Rapid Thwaites Glacier Ice Shelf Possible Irreversible Collapse

Figure 7 – Thwaites Cross Section Showing Grounding Line Near Downsloping Ridge That Will Greatly Accelerate Collapse

Figure 8 – Photo of Thwaites Glacier Undergoing Irreversible Collapse

Figure 9 – Photo of Miami Sunny Day Manmade Sea Level Rise Flooding

Figure 10 – Antarctica Size Superimposed on U.S by NASA satellite imagery

Appendix 1 on Dangerous Scientific Reticence and its Widespread Influence on Sea Level Rise Timing / Projections

Appendix 2 on Needed Precision & Accuracy Adjustment Factor for ~30 Years of Substantial Underprediction of the Pace of Climate Impacts Including Manmade Sea Level Rise Flooding Timing

*"There are three classes of people: those who see. Those who see when they are shown. Those who do not see."*  
— Leonardo da Vinci

*"Insensible before the wave so soon released by callous fate. Affected most, they understand the least, and understanding, when it comes, invariably arrives too late."* — Alan Moore, V for Vendetta 1990

*"Arctic ice is fun for children and other living things."* – name withheld of overworked Swedish glacial researcher 2019

**Executive Summary.** This is a Pilot to ascertain the state of science on sea level rise flooding for the City of South Miami with global implications, to update the timing of the 2' – 6' of rise *in the pipeline* as determined by the U.S. Climate Assessment Report, so communities have sufficient time to raise the financing to maintain commerce and national security. Based on historical data, increased levels of rise are likely to come in large pulses, and not gradually. And according to NASA 2019 published data based on interferometry (complex high resolution, ice- penetrating satellite radar), there was *"explosive & disturbing"* W. Antarctic melt of 9 miles from 2015 – 2017 that is likely increasing the contribution to global rise from this region from the current 4% level to 40% (*see also note 31 below*). NASA states that this new accelerated rise was not been predicted by any models *"which most likely underestimate how fast Thwaites is losing ice."*

The possibility exists that the 2'–6' of rise calculated by the U.S. Climate Assessment Report has already begun. We are concerned that accelerated rise of this nature, could occur faster than resilient infrastructure could be financed and built if we wait until the rise is fully evidenced to the

standards of scientific peer-review. Thus, prudence dictates that resilience financing be provided now.

Since current empirical data do not allow greater precision and accuracy of the timing of rise, and intense research is underway for this W. Antarctic region, NASA and this Pilot recommend updating the findings herein every three years. Simply, precision is the ability to competently replicate test results and accuracy is how close to the truth are tests, models, and observations.

For the City of South Miami this means that the estimated \$75 million to connect the septic tanks to sewers in the lower elevation canal areas must be procured now due to the rising water table from sea level rise that is incapacitating septic systems causing contamination and health hazards. Miami-Dade County has the same challenge but of a much greater magnitude estimated at \$3 billion to install sewers for ~50,000 systems that are being incapacitated annually of increasing duration. This contamination is releasing nutrients that have been linked to regional algae blooms in surface waters preventing fishing, swimming and recreation due to toxicity of the blooms.

This is a Pilot by determining results for one location that can also be applied to modify the national resilience consensus underwriting standard sea level rise performance requirement deadlines for buildings, homes, and infrastructure, to facilitate needed and timely financing for all coastal communities on or impacted by ocean tidal waters, and maintain commerce and national security.

**City of South Miami Leading Climate Achievements & Commitment to Resilience.** South Miami is a leader in addressing the Climate Crisis including as the only Florida City to mandate solar for homes, which is documented nationally as statistically increasing home value by 9% - 12%, reducing home defaults by 32%, and reducing insurance losses.<sup>1</sup> In addition to this pilot, South Miami continues to play resilience leadership roles including by supporting national and regional resilience financing.

**Pilot Background.** This Pilot covers sea level rise flooding for the City of South Miami with global implications. Since 2015, Florida cities are required by State building code to protect against increased flooding. Since certification of specific resilience attributes increase bond cash flow, a professional engineer can certify that a structure within the zone of projected rise is protected, which will facilitate acquisition of needed financing. Ideally, peer-reviewed sea level rise dates of compliance would be set to allow adequate lead time for design and construction. The actual rates of sea level rise may push the schedule.

A margin of safety should be set to maintain commerce and national security as raised during peer-review of Green Bond Business Case climate data on unmanageable dangerous climate.<sup>2</sup> Also, localities should account for increased or compounded flooding beyond sea level rise, from storm

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<sup>1</sup> Documented in higher green property credit ratings secured with major investment bank and credit rating agency based on consensus underwriting

<sup>2</sup> *Green Bond Business Case* released in 2009 at NYSE by JPMorgan, Sierra Club and Capital Markets Partnership, and updated by leading economists in 2014 led by Nobel Prize Winner Dr. Gary Yohe, IPCC, Vice Chairman, U.S. Climate Assessment Reports.

surge, high tides, any subsidence, average water table elevation, expected rainfall, and key geologic factors like South Florida's porous bedrock promoting rapid subsurface ocean salt water intrusion.

## **Pilot Purpose.** For South Florida coastal communities

*"The ocean is now at the brim, clogging storm water systems and routinely flooding local coastal communities with sea water with no storm in sight. The impacts are here and now."* (NOAA Oceanographer William Sweet, *Climate Change: More High-Tide Flooding Is On Its Way For South Florida*, Coastal News Today Southeast Jan. 2019).

Nearby Miami Beach with 5' of elevation, the same as land immediately adjacent to South Miami's canals, experiences diurnal sunny day sea level rise flooding:

*"Twice a day the water will come through the storm drainage network into the streets. All the roads are flooded, and the skies are blue. It's what we call sunny day flooding. ... [with the] compounding effect [in South Florida] of rainfall, sea-level rise, ... storm surge [and] the groundwater table coming up at the surface."* (Jayantha Obeysekera, FIU in *Rising to the Sea Level Rise Challenge*, ASCE News June 9, 2019).

See Figure 9 photo below of Miami manmade sunny day sea level rise flooding.

South Miami needs to define required protections for 2' of rise, to validate the date for compliance based on actual data and best professional estimates, and to identify management solutions, cost, and financing options. Initial assessment expects that areas near the canals must be protected, and about \$75 million in financing needs to be secured to install sewer systems to replace septic tanks that will otherwise become saturated or inundated, causing exfiltration to fail and plumbing to backup in turn creating health hazards and property devaluation.

Some areas with structures may need to be vacated so the land can be turned into green space or parks that can better accommodate accelerating sea level rise flooding. Also, cascading / correlative risk will be evaluated to determine if protections need to be on an areawide basis involving other jurisdictions in order to be effective and financed. In contrast to long term resilience design timeframes, where there are uncertainties in timing of impacts, "dynamic adaptive pathways" can be used for phased adaptation / resilience for low design life structures and areas that can tolerate high flooding risk. However, for the many large capital intensive structures with long design lives like large buildings and infrastructure, dynamic adaptive pathways will not work and they must be protected for much nearer term and higher level of sea level rise flooding.<sup>3</sup>

The Pilot takes into account that due to porous South Florida bedrock, sea level rise is occurring both at tidal surfaces and up from below ground, eliminating many engineering remedies due to excessive cost.<sup>4</sup>

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<sup>3</sup> See *Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world*, Haasnoot et al., *Global Environmental Change* 23 (2013) 485–498 497. Email communication with Jayantha Obeysekera, Ph.D., P.E., Florida Inter. U. Oct. 29, 2019.

<sup>4</sup> Miami Beach Sea Level Rise Preliminary Engineering Study 2015 & presentation at White House Resilience Financing Summit, Oct. 2016, determined that the only possible effective engineering remedy would be raised sea walls with horizontal and vertical subsurface barriers beneath the Miami Beach barrier island that would cost about \$1 trillion and in effect turn Miami Beach into a leaky bathtub.

Geotechnical consultants hired by the City of South Miami determined that rising water tables extending inland from sea level rise are already compromising septic systems in low areas near the canals. Miami-Dade County issued a 2019 report detailing the same problem countywide.<sup>5</sup>

## Key Data for Determining the 2' of Rise Date of

**Compliance.** Since the 1990's, the only certainty with climate change is that it is accelerating faster than predicted with ineffective efforts to bound uncertainty, e.g., IPCC's sea level rise projections were over 60% underestimated based on satellite verifications.<sup>6</sup> Emphasizing the importance of ongoing rapid, extensive, and very high volume Antarctic glacial melt, IPCC concludes:

*"[T]he collapse of the marine-based sectors of the Antarctic ice sheet, if initiated, could cause [global mean sea level] to rise substantially above the likely range during the 21st century."*  
Chapter 13 Sea Level Change at 1140 (2013).

\* \* \*

*"Global mean sea level (GMSL) is rising, with acceleration in recent decades due to increasing rates of ice loss from the Greenland and Antarctic ice sheets (very high confidence), as well as continued glacier mass loss and ocean thermal expansion. Increases in tropical cyclone winds and rainfall, and increases in extreme waves, combined with relative sea level rise, exacerbate extreme sea level events and coastal hazards (high confidence)."*  
*The Ocean and Cryosphere in a Changing Climate, Summary for Policy Makers at 10 (2019).*

IPCC also concludes that manmade sea level rise flooding is being worsened by more intense storms thus increasing coastal hazards, and that time is of the essence for resilience financing:

*"Rising mean sea levels will contribute to higher extreme sea levels associated with tropical cyclones (very high confidence). Coastal hazards will be exacerbated by an increase in the average intensity, magnitude of storm surge and precipitation rates of tropical cyclones." Id. at 24. "Increased mean and extreme sea level, alongside ocean warming and acidification, are projected to exacerbate risks for human communities in low-lying coastal areas (high confidence)." Id. at 31. "This assessment of the ocean and cryosphere in a changing climate reveals the benefits of ambitious mitigation and effective adaptation for sustainable development and, conversely, the escalating costs and risks of delayed action." Id. at 42.*

Greenland ice melt is a rapidly growing major contributor to sea level rise with the highest production of meltwater in 7,000 – 8,000 yrs. now occurring: *"The melting is not just increasing — it's accelerating,"* says a lead researcher.<sup>7</sup>

Thwaites Antarctic Glacier is one of five unstable Antarctic glaciers, that doubled its rate of ice loss in the last six years,<sup>8</sup> with many more than five that are vulnerable and Thwaites likely changing the

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<sup>5</sup> "A \$3 billion problem: Miami-Dade's septic tanks are already failing due to sea rise," Phys Org (Jan. 11, 2019): "That's a huge deal for a developed country in 2019 to have half of the septic tanks [50,000] not functioning for part of the year," said Miami Waterkeeper Executive Director Rachel Silverstein. "That is not acceptable." This contamination releases nutrients that has been linked to regional algae blooms in surface waters preventing fishing, swimming and recreation due to toxicity of the blooms.

<sup>6</sup> Rahmstorf et al 2012 Environ. Res. Lett. 7 044035); *Climate Science Predictions Prove Too Conservative*, Scien. Amer. Dec. 6, 2012.

<sup>7</sup> *Greenland is losing ice at fastest rate* [based on 350 yrs. of ice core samples] Nature Dec. 5, 2018.

fastest. Thwaites runs roughly 350 miles inland, growing deeper and taller, with its 100 mile long wall / floating ice shelf at the ocean, extending as much as 1,500 feet below the sea surface.<sup>9</sup> NASA recently discovered in Thwaites, a subsurface 1000' diameter cavity about 2/3 the size of Manhattan (9 miles long) with the cavity melting at –

*“an explosive growth rate ... over the last three years ... [losing] 14 billion tons of ice, ... a disturbing discovery. ... About the size of Florida, Thwaites Glacier is currently responsible for approximately 4 percent of global sea level rise. It holds enough ice to raise the world ocean a little over 2 feet (65 centimeters) and backstops neighboring glaciers that would raise sea levels an additional 8 feet (2.4 meters) if all the ice were lost. (Huge Cavity in Antarctic Glacier Signals Rapid Decay, NASA JPL Jan. 30, 2019. NASA high resolution and precision satellite and aerial radar were used.)*

NASA stated that this new accelerated rise was not been predicted by any models *“which most likely underestimate how fast Thwaites is losing ice.”*<sup>10</sup> Thwaites is rapidly collapsing, possibly irreversibly moving toward complete collapse at the highest of 3 km / yr.<sup>11</sup> Glacier velocity is a normal occurrence, but significantly, accelerated velocity is most likely in response to subsurface warming ocean water and associated melt. Thwaites connects to the inherently unstable West Antarctic ice sheet which has also lost ice at an unprecedented pace.<sup>12</sup> See NASA Figure 1 below showing rapid Antarctic melt velocity and very large extent. Most melt is from warmer ocean water especially underneath the ice sheets. See also Thwaites photo and maps of rapid possible irreversible collapse in Figures 2 - 6 below. These glaciers have been the largest contributors to global sea level rise for many years.<sup>13</sup>

Thwaites contribution of 4% of global sea-level rise is an amount that has doubled since the mid-1990s primarily caused by subsurface melt increasing ice discharge due to the presence of warmer water (Circumpolar Deep Water) in the ice shelf cavity, glacial hydro-fracture, warmer, denser lower ocean water – ice interaction, and elevation rise from the release of glacial weight from melt to the sea. Thwaites marine ice sheet instability is highly significant due to (1) large volumes of water released from subsurface cavities, (2) a very deep basin, (3) a downward subsurface ice-bedrock interface that accelerates glacial flow and collapse, (4) large potential for additional rapid collapse from tall marine ice cliffs' instability leading to runaway calving, which is a cause of current rapid Greenland ice sheet collapse, and (5) its key location that can trigger release of other glaciers. *“No glacier is more susceptible to the combination of marine ice sheet instability and marine ice cliff instability, and no glacier threatens the center of West Antarctica more.”*<sup>14</sup>

Thwaites' is likely the most important glacier in the World, given (1) its accelerating and potential irreversible collapse, (2) Its current large scale contribution to sea level rise, (3) its very large potential for very abrupt large scale sea level rise flooding, (4) the preceding extensive historical documentation of repeated large bursts of sea level rise of 10' or more in 10 – 20 yrs.

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<sup>8</sup> *Instability in Antarctic ice projected to make sea level rise rapidly*, GEORGIA INSTITUTE OF TECHNOLOGY, AAAS EurekAlert! (July 8, 2019) (NSF Data).

<sup>9</sup> *Here's what Antarctica's calving glaciers look like up close*, National Geographic (March 12, 2019).

<sup>10</sup> *Huge Cavity in Antarctic Glacier Signals Rapid Decay*, NASA JPL (Jan. 30, 2019) based on NASA led and NASA funded study: Milillo et al., Science Advances, "Heterogeneous retreat and ice melt of Thwaites Glacier, West Antarctica" (Jan. 30, 2019).

<sup>11</sup> *Collapse of Antarctic glaciers seems to be unstoppable*, New Scientist (May 14, 2014); European Space Agency (Aug. 17, 2017).

<sup>12</sup> *Increased West Antarctic and unchanged East Antarctic ice discharge over the last 7 years*, Cryosphere (Feb. 13, 2018).

<sup>13</sup> Rignot et al., Widespread, rapid grounding line retreat of Pine Island, Thwaites, Smith, and Kohler glaciers, West Antarctica, from 1992 to 2011, Geophysical Res. Letters, May 12, 2014)

<sup>14</sup> Statement of International Thwaites Glacier Collaboration, British Antarctic Survey & Press Conference (April 1, 2018).

Thwaites Glacier “*marine ice sheet instability greatly amplifies and skews uncertainty in sea-level projections with worst-case scenarios of rapid sea-level rise being more likely than best-case scenarios of slower sea-level rise. ... Thwaites Glacier rests on a reverse-sloping bed and is currently retreating rapidly, which is argued to be the result of the marine ice sheet instability. ... When the bedrock beneath the grounding line is reverse sloping (i.e., deepens toward the ice sheet interior), a small retreat of the grounding line onto deeper bed leads to greater ice flux and therefore more retreat. This positive flux feedback leads to the potential for rapid and irreversible retreat wherever the bed is reverse sloping, which has been termed the ‘marine ice sheet instability.’*” (Marine ice sheet instability amplifies and skews uncertainty in projections of future sea-level rise, Robel et al., PNAS July 23, 2019 116 (30) 14887-14892.)

A six-fold increase in Antarctic glacial melt occurred over 40 years from 1979-2017 as determined by grounding line ice discharge of 176 basins draining the Antarctic Ice Sheet from precise satellite records and models: “*The total mass loss increased from  $40 \pm 9$  Gt/y in 1979–1990 to  $50 \pm 14$  Gt/y in 1989–2000,  $166 \pm 18$  Gt/y in 1999–2009, and  $252 \pm 26$  Gt/y in 2009–2017.*”<sup>15</sup>

In 2019, researchers determined from historical plant remains revealed from fast retreating mountain glaciers on Baffin Island Canada, that the last century is as warm as any century in the last 115,000 years, at which time oceans were 20 - 30 ft. higher. Some melt could have come from Greenland, but researchers suspect there was the collapse of the West Antarctic ice sheet which could have easily provided 10’ of rise or more. “*There’s no way to get tens of meters of sea level rise without getting tens of meters of sea level rise from Antarctica,*” said Rob DeConto, an IPCC Antarctic expert at the University of Massachusetts. “*Today’s Earth looks a lot like it did 115,000 years ago. All we’re missing is massive sea level rise.*”<sup>16</sup> Based on DeConto’s and the preceding data, a total Thwaites and contiguous glaciers’ collapse likely occurred before when we were experiencing a period of rapid glacial melt like today. For the Last Interglacial Period (Eemian) ~125,000 yrs. ago which is as close historically as glacial melt today, there were 6 - 9 meters / 20’ – 30’ of rise above today’s levels.<sup>17</sup> Hansen states global temperature then was only about 1°C above the pre-industrial level, i.e., similar to today’s global temperature, even though seas were much higher.<sup>18</sup>

Further, over 13 positive feedback loops or accelerators like substantial upper latitude methane releases from melting and CO2 from massive, accelerating wildfires, are primarily not accounted for by IPCC and U.S. Climate Assessment Report (USCAR).<sup>19</sup> Unacceptable risks are greater from shorter timeframe abrupt sea level rise contributed by unprecedented and accelerating atmospheric climate pollution / CO2 currently at the dangerous level of 412 parts per million (ppm) and rapidly rising, which is the highest level in the one million yrs. of data analyzed.<sup>20</sup> The accepted safe level is 350 ppm.

See Appendix 1 below on this dangerous scientific reticence underestimating abrupt sea level rise timing documented by Jim Hansen, one of the World’s leading climate scientists according to the President of the National Academy of Sciences, calling for additional sea level rise analyses like

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<sup>15</sup> Four decades of Antarctic Ice Sheet mass balance from 1979–2017, Rignot et al., PNAS January 22, 2019 116 (4) 1095-1103

<sup>16</sup> Wash. Post Feb. 6, 2019, referencing *Rapidly receding Arctic Canada glaciers revealing landscapes continuously ice-covered for more than 40,000 years*, Nature Communications, 10 445 (2019)).

<sup>17</sup> Rob DeConto, personal communication (Sept. 5, 2019).

<sup>18</sup> Climate Change in a Nutshell: The Gathering Storm (Dec. 18, 2018).

<sup>19</sup> “*Very high confidence in the potential for state shifts and in the incompleteness of knowledge about feedbacks and potential state shifts,*” USCAR Ch. 15).

<sup>20</sup> CO2.earth (Sept. 2019).

IPCC ongoing special report and this Pilot. Hansen updated “scientific reticence” to “*dangerous scientific reticence*” due to scientists’ ignoring growing unacceptable risks to society as shown in the Appendix 1.

About 3” of sea level rise has occurred since 1995, progressing at an exponential rate due to rapid ice sheet melt.<sup>21</sup> “*Southeast Florida Regional Compact on Climate Change stresses that South Florida’s sea-level rise could be faster than the global rate because of changes in the Gulf Stream current.*”<sup>22</sup> Recent South Florida sea level rise flooding data show a 320% non-linear / approaching geometric rise in sea level rise flooding incidence.<sup>23</sup> Miami sea level rise flooding: (1) exceeds that of “passing” hurricanes, (2) combined with King and other high tides also causes health hazards for residents with salt water mixed with raw sewage that are code violations, (3) “*Some areas in the Keys are no longer offering permits to build. ... Parts of Miami are no longer offering long term mortgages.*” The Town of Cutler Bay approved a six-month building moratorium to evaluate on how to deal with sea level rise.<sup>24</sup>

The LA Times Special Report on sea level rise flooding documents similar California experience where localities are being forced to condemn or purchase homes along the waterfront.<sup>25</sup> Similarly, Moody’s is micromanaging Norfolk sea level rise capital improvements to prevent a credit rating downgrade so services can be provided for the World’s largest naval base.<sup>26</sup>

**Documented Unreliable Precision & Accuracy of Most Sea Level Rise Models & Projections.** Dr. George Sugihara, a leading researcher at Scripps Institute on assessing complex natural systems and employed by the capital markets to assess the complexity of trading, concurred during peer-review of this Document, that historically, climate models have inaccurately underpredicted the accelerating impacts of climate by not representing the complex, accelerating nonlinear systems, and underestimated the priority value of actual empirical data. Further, models unvalidated / uncalibrated *in situ* are unreliable as recognized for sea level rise, which is the case for most sea level rise models and projections.<sup>27</sup> This is why Jim Hansen and other leading scientists primarily uses actual data and models validated *in situ*. In addition to IPCC and USCAR sea level rise models not being validated / calibrated, they ignore ongoing acceleration from positive feedback loops:

*“There are two or three reasons that the ice melt accelerating feedbacks are not in the models that are being use for ice melt an sea level rise. First, we are just becoming aware of many of*

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<sup>21</sup> Jim Hansen, Climate Nutshell, Dec. 18, 2018 at 29)

<sup>22</sup> K. Miller, *Climate Change: More High-Tide Flooding Is On Its Way For South Florida*, Coastal News Today Southeast (Jan. 2019).

<sup>23</sup> Brian McNoldy, Senior Research Associate at Univ. of Miami’s Rosenstiel School *reported in Wash. Post.*, (Aug. 6, 2019).

<sup>24</sup> *Id.*

<sup>25</sup> *California Coast is Disappearing Fast Under Rising Seas* (July, 7, 2019).

<sup>26</sup> *Ratings agency turns attention to Hampton Roads flooding*, May 6, 2015 Va. Daily Press; *Moody’s Warns Cities to Address Climate Risks or Face Downgrades*, Bloomberg Nov. 29, 2017; *Moody’s Va. Beach Credit Opinion, “Credit challenges » Exposure to impacts of sea level rise and recurring flooding.”* Dec. 14, 2017; *Norfolk Wants to Remake Itself as Sea Level Rises, but Who Will Be Left Behind?* Virginia Pilot May 21, 2018. Leading sea level rise expert Jeff Goodell, author of the book *The Water Will Come*, on expedition to Thwaites, Rolling Stone sea level rise contributor, and expert on Norfolk Naval Base sea level rise, announced at a Jan. 2017 presentation at Richmond Law School, that the military secured funding for Norfolk base sea level rise protections, but is prepared to move to protected locations if the required City of Norfolk and Commonwealth of Virginia supported infrastructure protections are not financed soon. Norfolk base complex provides \$65 billion / yr. to the Commonwealth’s economy which comprises 10% of its GDP. National Resilience Cost Recovery Coalition data (2017).

<sup>27</sup> IPCC §5.5.2 Observations of Sea Level Changes: “*Although there has been some model validation, especially for (glacial isostatic adjustment (GIA) models, systematic problems with such techniques, including short data spans, have yet to be fully resolved (2007).*”

*them. Second, we do not have the understanding or capability to put many of them into a model yet. And third, most of the modelers, if they do not know how to input an influence (accelerating feedback) into their numerical model or if it is too complicated to input, they tend to ignore it.”* H.R. Wanless email on abrupt sea level rise to P. Stoddard, M. Italiano & D. Pierce, Nov. 7, 2017).

**Abrupt Sea Level Rise Actual Empirical Data.** Contrary to IPCC and USCAR models showing slow gradual rise, during the last period of glacial melt like today, sea level rise likely came in bursts of about six feet in 10 - 20 yrs.<sup>28</sup> Actual data show that abrupt sea level rise from glacial melt has been the norm, like now from Greenland and Antarctica:

*“Most of the models projecting future global sea level rise assume a gradual acceleration of sea level rise through this century and beyond as Greenland and Antarctic ice melt gradually accelerates. Our knowledge of how sea level rose out of the past ice age paints a very different picture of sea level response to climate change. At the depth of the last ice age, about 18,000 years ago, sea level was some 134 meters (440 feet) below present level as ice was taken up by large continental ice sheets (Lambeck et al., 2014).”* (H.R. Wanless, Professor & Chairman, U. of Miami Geology Dept., *The Coming Reality of Sea Level Rise: Too Fast Too Soon* (Sept. 13, 2017), & *Our Coming Inundation* June 25, 2019).

*“Subsequent ice melt and sea level rise was not a gradual acceleration and then deceleration. Rather it was a series of very rapid pulses of sea level rise followed by pauses (Figure 2). These rapid pulses of rise, from one to ten meters (3.3 to 33 feet) probably within a century, were fast enough to leave drowned reefs, sandy barrier islands, tidal-inlet and bay-head deltas, and other coastal deposits abandoned across the continental shelves of the world (Dominguez and Wanless, 1991; Locker et al., 1996; Vlaswinkel and Wanless, 2009; Anderson et al., 2016; Pretorius et al., 2016; Khanna et al., 2017; Webster et al., 2018). That is what happens when the climate warms. It destabilizes some ice sheet sector which rapidly disintegrates, resulting in a rapid pulse of global sea level rise.”* (Wanless, *Our Coming Inundation* June 25, 2019).

\* \* \*

*“The beginnings of this polar Ice Sheet melt are showing numerous positive reinforcing feedbacks, which are rapidly accelerating the rate of melt far beyond anything being projected in current models. For example, because water on the melting ice surface absorbs more heat, surface melt is accelerated; this melt water percolates down through the ice and lubricates the base permitting faster motion, which results in more extensive fracturing. Melt and rain water percolating through the fractured ice accelerates ice melt and warms the ice, which results in the softening of the ice causing even further acceleration of flow. With the rapid melting of the Arctic Ocean pack ice (floating ice) and warming of the Arctic Ocean, release of additional carbon dioxide and methane from decaying organics in the melted permafrost, and melting of methane hydrates on the Arctic continental shelf, the accelerating melt of the adjacent Greenland Ice Sheet seems irreversible. We are most certainly witnessing the onset of a new rapid pulse of global sea level rise.”* (Wanless, *Our Coming Inundation* June 25, 2019).

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<sup>28</sup> Oceans can rise in sudden bursts, Scientific American (Oct. 20, 2017), (“Fossilized corals off Texas show that in the past, sea level rose several meters in just decades, probably due to collapsing glaciers”), reviewing Khanna et al., *Coralgal reef morphology records punctuated sea-level rise during the last deglaciation*, Nature Communications (Oct. 19, 2017). Khanna et al. state in Nature Communications: “These systematic and common terraces are interpreted to record punctuated sea-level rise events over timescales of decades to centuries during the last deglaciation, previously recognized only during the late Holocene.”

Similar results were found in drowned coral beds in Hawaii where data support that a sudden rise in global sea level occurred between 14,200 and 14,700 years ago. *“These findings echo previous studies, which showed rapid rises in sea level between 14,200 and 14,700 year ago in locations as far apart as Barbados and Southeast Asia.”*<sup>29</sup> University of Florida Geology Professor, paleoclimate expert, and MacArthur Prize-winner Andrea Dutton confirms the historical record of abrupt sea level rise:

*“We’ve known for quite some time that there was at least one very rapid pulse of sea-level rise during the deglaciation between the last ice age and the present — we’ve known for a very long time that sea level can rise with a sudden jump related to the dynamics of the ice sheet,”* (Scientific American, *Oceans Can Rise in Sudden Bursts* (Oct. 20, 2017)

Abrupt sea level rise is occurring now:

*“The models and resulting projections by the U.S. government, IPCC and such do not have the philosophy of rapid ice sheet disintegration / collapse, though we see evidence for these rapid pulses of sea level rise (resulting from rapid ice sheet disintegration / collapse) all across the continental shelves of the world – sandy barrier island, tidal inlet deltas, reefs, coastal peri-tidal flats and coastal marshes / swamps suddenly drowned out and abandoned. Each one of these is a pulse of rise from the rapid disintegration of an ice sheet sector. ...*

*We are most certainly seeing the onset of one of these pulses of rapid rise. Beginning in about 1990, we saw the beginning of accelerating ice melt of the ice sheets of both Greenland and Antarctica (see attached “The Coming Reality of Sea Level Rise: Too Fast Too Soon”). The accelerating feedbacks which we are now observing that are dramatically speeding up ice sheet melt and weakening, are the visible evidence that a pulse of ice sheet disintegration / collapse is now underway. Most of these accelerating ice melt feedbacks are not in the current models, so they do not begin to capture the rate and extent of sea level rise that we are in for.”* (H.R. Wanless email on abrupt sea level rise to M. Italiano & P. Stoddard, Nov. 6, 2017).

**Thwaites observed deterioration from NASA aerial images is much faster than predicted by the models** including discovery of the cavity 2/3 size of Manhattan (9 miles long) and 1,000’ deep at Thwaites’ grounding line (current intersection of ice, land and ocean).<sup>30</sup> The cavity grew to this size in six years (2011 - 2017) with most of the growth from 2015 – 2017, about 9 miles of growth in two years. If growth continues at that rate or higher, that would be 18 miles in four years. The growth is *“explosive”* and this discovery *“disturbing”* according to NASA. See progressive aerial images over time, of growth from melt at figure at NASA website: <https://www.jpl.nasa.gov/images/earth/20190130/thwaitessupp20190130-16.gif><sup>31</sup> In contrast, Thwaites’ retreat at the grounding line was only 9 miles from 1992-2011 from satellite radar

<sup>29</sup> *Hawaii’s drowned coral reefs—victims of sudden climate change?* Monterey Bay Aquarium Research Institute (Feb. 26, 2004). See also J. T. Overpeck *et al.*, Paleoclimatic Evidence for Future Ice-Sheet Instability and Rapid Sea-Level Rise, *Science* **311** (2006) no. 5768 pp. 1747-1750.)

<sup>30</sup> *Huge Cavity in Antarctic Glacier Signals Rapid Decay*, NASA (Jan. 30, 2019) and time-elapsd 2011-2017 radar interferometry images at NASA website as a result of “NASA-led” and NASA funded study: Milillo *et al.*, Science Advances, “Heterogeneous retreat and ice melt of Thwaites Glacier, West Antarctica” (Jan. 30, 2019).

<sup>31</sup> Sept. 3, 2019 personal communications with Eric Rignot, NASA expert on Thwaites, coauthor of 2019 study on Thwaites rapid deterioration <https://www.jpl.nasa.gov/news/news.php?feature=7322> (“Huge Cavity in Antarctic Glacier Signals Rapid Decay”). The “NASA-led” and funded study cited at this preceding NASA link where Rignot is a quoted author, is Milillo *et al.*, Science Advances, “Heterogeneous retreat and ice melt of Thwaites Glacier, West Antarctica” (Jan. 30, 2019).

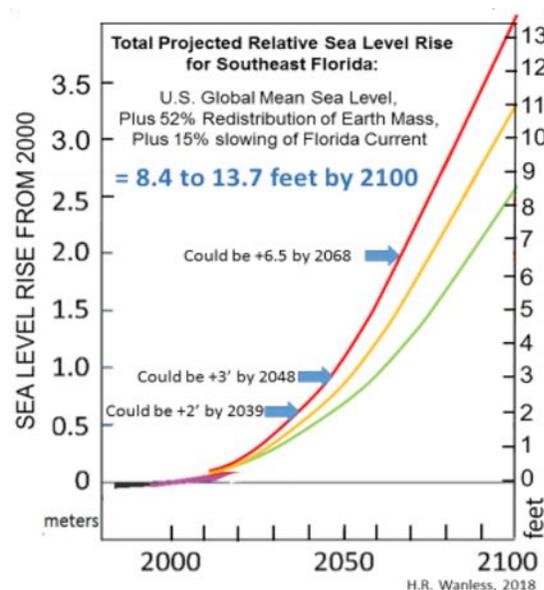
interferometry.<sup>32</sup> Significantly, “Upstream of the 2011 grounding line positions, we find no major bed obstacle that would prevent the glaciers [including Thwaites] from further retreat and draw down the entire basin [Amundsen Sea Sector].”<sup>33</sup>

**At its accelerating pace consistent with aerial radar observations of most recent cavity “explosive” growth at grounding line, West Antarctica (Amundsen Sea Embayment) potential runaway collapse, can raise its contribution to global sea level rise from 4% to 40%.** Thwaites grounding line is 19 miles away from the ridge (2017 NASA data), where the steep downslope is located that very likely causes runaway collapse.<sup>34</sup> Based on cavity growth, Thwaites observed maximum retreat to the ridge assuming continued accelerating growth after 2017 when last data were available, is about 2 mi. / yr. Since Thwaites’ retreat past the ridge very likely will start a rapid runaway collapse of Thwaites and contiguous glaciers, Rignot expects at that time, the global contribution to sea level rise from Thwaites and contiguous glaciers will increase from the current 4% to 40%.

Given this new NASA data on accelerated rise, the following graph by Wanless of South Florida sea level rise projections is relevant.

## Suggested 2’ of Rise Compliance Date for Discussion & Pilot Evaluation.

The military is financing protections and not taking any chances and solved this problem by securing resilience appropriations, e.g., recommending 14’ sea wall around the Washington, D.C. Naval Yard.<sup>35</sup> However, localities must finance their appurtenant infrastructure improvements to allow the military bases to operate. The world’s largest advanced treatment plant Blue Plains on the Potomac in D.C. is constructing 17’ sea walls.<sup>36</sup>



from “Our Coming Inundation” H.R. Wanless, Professor, U. of Miami (Nov. 8, 2019) at 5.

Key preceding identified factors to be considered in setting the 2’ rise deadline are:

1. The incidence of Miami sunny day sea level rise flooding is growing exponentially (high relevance)
2. South Miami’s existing high water table from sea level rise up through porous bedrock, making any additional rise significant for proper functioning of septic tanks in lower elevations near the

<sup>32</sup> Rignot et al., Widespread, rapid grounding line retreat of Pine Island, Thwaites, Smith, and Kohler glaciers, West Antarctica, from 1992 to 2011, *Geophysical Res. Letters*, May 12, 2014.

<sup>33</sup> *Id.*

<sup>34</sup> *Id.*

<sup>35</sup> Military Engineers Propose 14’ Sea Wall Around Wash. Naval Yard, *WTOP* (Feb. 11, 2019).

<sup>36</sup> D.C. Water’s Treatment Plant Makes Strides When it Comes to Preparing for Climate Change, *City Paper* (Sept. 19, 2019).

canals. Affect of average yearly rainfall on water table elevation should be considered. (high relevance)

3. Sea level rise fingerprint data show Florida's rise is 52% faster from Antarctic land mass upward adjustment from the release of ice mass melt to the sea.<sup>37</sup> Fingerprint data are also called gravitational rotation dynamic (GRD) percent increase. In contrast, Boston's fingerprint increase from Antarctica is 127%.<sup>38</sup> (high relevance)
4. The Gulf Stream is slowing thus increasing the pace of sea level rise in Florida. (high relevance)
5. Many substantial nonlinear positive feedback loops / accelerators like Arctic methane releases are not or are poorly accounted for by U.S. Climate Assessment Report and IPCC and models. This contributes to the significant underprediction of the accelerating pace of manmade sea level rise flooding. (high relevance)
6. Documented unreliable precision & accuracy of most sea Level rise models & projections including lack of calibration / validation *in situ* as recognized by IPCC. (high relevance)
7. Substantial historical data show sea level rise has come in large bursts of likely 6' – 10' in 10 – 20 yrs., not gradually as models and IPCC predicts. Thwaites glacier potential runaway collapse triggering similar collapse of contiguous glaciers supports this conclusion. (high relevance)
8. Thwaites and contiguous glaciers runaway, accelerated collapse could occur in about 10-15 yrs, based on NASA aerial radar images of recent explosive melt at the grounding line. Once that occurs, it is expected that melt from Thwaites' and glaciers it backstops, will likely rise from current 4% of global rise, to 40%. Current models do not predict this, and no one knows for sure, but it may be too late if we wait for certainty and the risks of not being protected are unacceptable to commerce and national security. (high relevance)
9. Margin of safety to avoid unacceptable risks from flooding to commerce and national security. Policy decisions on abrupt sea level rise flooding should include a margin of safety: *"Consider that cost of total destruction is infinite, and total destruction from catastrophic events may happen only once in very many years.*

*Infinity divided by a large number is still infinity.*"<sup>39</sup> (community determined relevance)

10. Adjustment Factor for ~30 yrs. of consistent underprediction of the pace of sea level rise. See Appendix 2 for the basis of the consistent underprediction. This repeated, long term, substantial underprediction of the pace of climate impacts including sea level rise without an accurate and precise scientific basis, and without adjustment, fits Rita Mae Brown's 1983 definition of insanity repeatedly but inaccurately attributed to Einstein due to its powerful logic: *'Insanity is doing the same thing over and over again, but expecting different*

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<sup>37</sup> Global fingerprints of sea-level rise revealed by satellites – Geological processes send more meltwater from glaciers and ice sheets to Earth's mid-latitudes, *Nature News* (Sept. 11, 2017).

<sup>38</sup> Personal communication with Rob DeConto, sea level rise expert, U. of Mass., (Sept. 5, 2019).

<sup>39</sup> P. Stoddard email to M. Italiano, H. Wanless & D. Pierce on abrupt sea level rise, (Nov. 7, 2017).

*results.*" This factor is an option and is concurred with by Rob DeConto, IPCC Sea Level Rise expert, U. of Mass, and lead author of the sea level rise component of IPCC's 2019, *Special Report on the Ocean & Cryosphere in a Changing Climate*.<sup>40</sup> (community determined relevance)

Given the scientific consensus on the uncertainty on the timing of rise as opposed to the likely amount of rise, and the consistent underprediction by models, many invalid due to lack of *in situ* validation / calibration, expert "*elicitations*" are now accepted.<sup>41</sup> Accordingly, a science policy decision must be made at this time based on expert and best professional judgment. Simply relying on a model cited in a resilience report is risky.

*"The inclusion of expert judgments along with other forms of data in science, engineering, and decision making is inevitable. Expert elicitation refers to formal procedures for obtaining and combining expert judgments. Expert elicitation is required when existing data and models cannot provide needed information. This makes validating expert judgments a challenge because they are used when other data do not exist and thus measuring their accuracy is difficult."* (Id.)

Drs. Hal Wanless and Jim Hansen, and the California Coastal Commission, project at least 10' of rise by 2100 / in the next 80 years.<sup>42</sup>

*Hansen states: "Ice sheet mass loss will not grow linearly, simply proportional to the temperature increase. The existence of amplifying feedbacks implies that mass loss from the most vulnerable portions of the ice sheets is likely to be a very nonlinear process that can be approximated by a doubling time for the rate of mass loss. [Hansen Nutshell at 27]. ... [Warmer ocean water] stratification and precipitation [are] amplifying feedbacks that affect ice sheet mass loss. at 23. ...*

*[T]he doubling time for ice sheet mass loss, assuming continued growth of fossil fuel emissions, may be as short as 10-20 years, based on evidence from the combination of paleoclimate data, modern observations, and ocean-atmosphere modeling. In that case, multi-meter sea level rise would occur on a time scale of 50-150 years."* (Hansen Nutshell at 30.)

Results of this Pilot will be used in adjusting 2' – 6' of rise compliance dates. As part of this Pilot document development, manmade sea level rise flooding deadlines should be updated every two years due to the scientific consensus on uncertainty on timing of rise, and accelerating increase in knowledge.<sup>43</sup>

**Financing Options Being Pursued.** Coastal cities are in the conundrum where massive manmade sea level rise flooding costs to maintain commerce and national security are required now due to long financing, design, and construction lead times, yet in most cases, local

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<sup>40</sup> Personal communication (Sept. 11, 2109).

<sup>41</sup> Expert Elicitation: Using the Classical Model to Validate Experts' Judgments, *Review of Envir. Economics & Policy* (Feb. 2, 2018).

<sup>42</sup> Wanless Aug. 21 email to P. Stoddard & M. Italiano, Wanless, *Our coming Inundation* June 25, 2019; Hansen communication to sea level rise expert Jeff Goodell in *What's Another Way to Say 'We're F-cked'?*, Rolling Stone Oct. 12, 2018; Hansen, *Climate Nutshell* at 30, Dec. 18, 2019; *Sea level rise: California's new reality*, Capitol Weekly, (Aug. 19, 2019).

<sup>43</sup> Communication with NASA sea level rise expert Eric Rignot (Sept. 3, 2019).

bonding capacity is exceeded even for short term protections, and State and federal financial support almost nonexistent. South Florida's need is more acute and expensive due to compounded flooding from:

- Accelerating sea level rise flooding
- Porous bedrock eliminating many effective solutions and causing subsurface rise in addition to tidal surface water rise
- Rainfall, storm surge & tidal added flooding impacts
- Very high water table now from sea level rise constituting a health hazard mixture of increasing ocean water, raw sewage from flooded septic tanks and likely leaking sewers submerged in groundwater, and in certain locations, hazardous substances from leaking underground gasoline storage tanks and uncontrolled waste sites.
- Resulting increasing incidence of this hazardous water flooding and upwelling in sinks and bathtubs in homes with similar adverse impacts on businesses
- Adverse economic effect to housing and community vitality depressing real estate values which also exists nationally in coastal areas due to sea level rise flooding, with recent published peer-reviewed data showing a 7% decrease in low elevation property values immediately adjacent to tidal coasts, all other factors removed.

Public and political support for solutions was severely hampered and greatly delayed by:

- Over 40 years of well-financed, extensive and unlawful fraud intentionally masking the actual impacts, that was publicly documented in comprehensive Pulitzer Prize nominated journalism with actual extensive industry documents showing the fraud on its face.
- Absent this fraud, the current crisis would have been obviated.
- Well documented extensive Federal and State denial of climate science which are plenary federal and state violations on prohibition of fraud and scientific fraud

City policy decisions must be made now and financing assistance pursued from multiple options. Investors with over \$70 trillion in assets can front resilience financing with demonstrated cheaper capital through Green + Resilient Bonds. Consensus underwriting standards identify resilience attributes increasing bond cash flow that are the basis of higher credit ratings and can protect and improve city credit ratings and be the basis for discounted insurance like that available for green buildings due to improved Fireman's Fund's loss ratios for green properties . For example, D.C. Water's \$300 million combined sewer overflow green bond received orders for \$1.1 billion and thus received cheaper capital, more bond proceeds raising the bond issue amount to \$350 billion, increased investor diversity, and reduced reputational risk.<sup>44</sup>

South Miami is working with State and other leaders to aggressively secure financing assistance including for debt service, and this Pilot is intended to accelerate much needed financing.

Finally and importantly, there is well-documented unacceptable risk of systemic, permanent financial contagion arising from South Florida's especially challenging geology.

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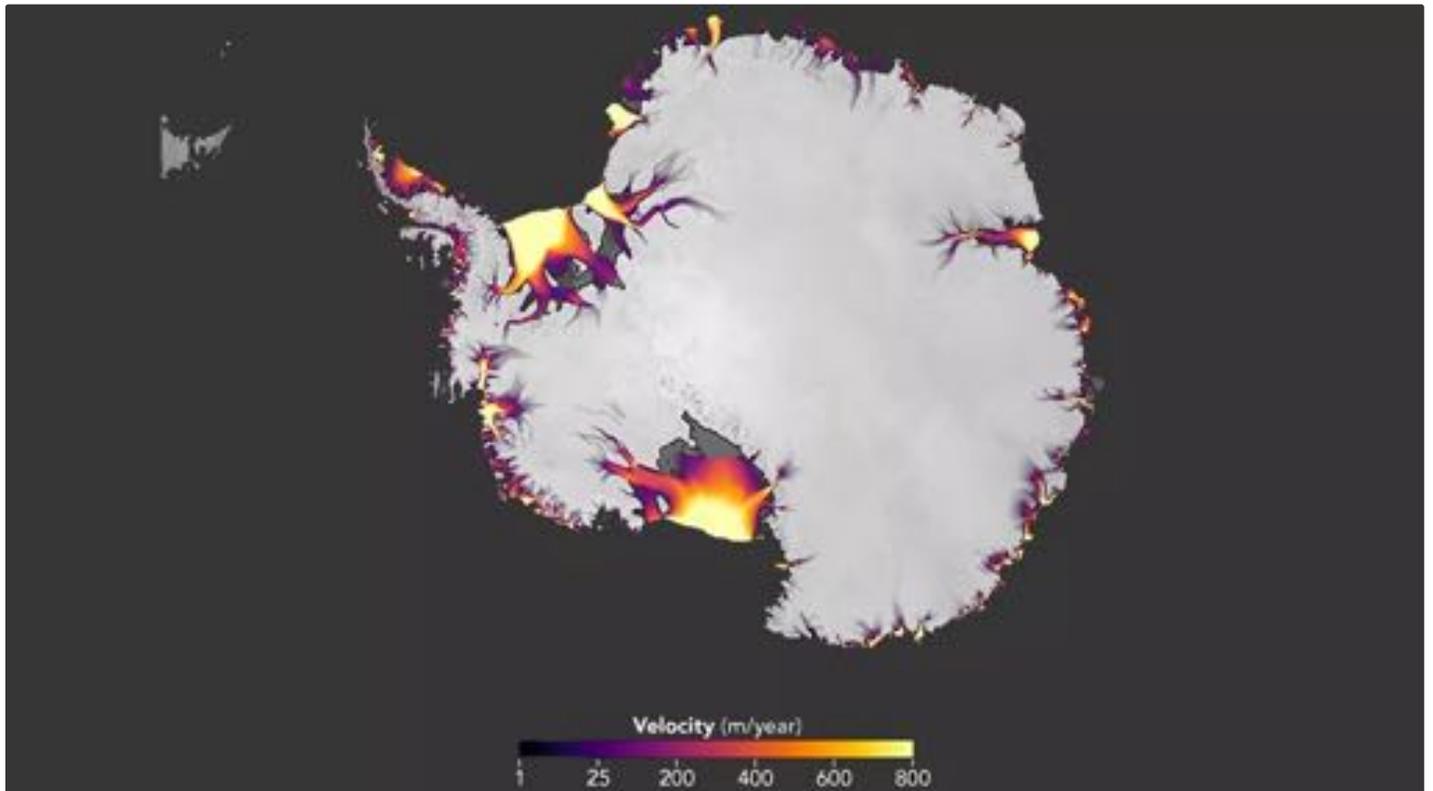
<sup>44</sup> *Green Bond Business Case* released at NYSE 2009 by JPMorgan Sierra Club & CMP & updated by leading economists & CMP in 2014 led by Dr. Gary Yohe, IPCC, Vice Chairman U.S. Climate Assessment Reports & Dr. Kristen Sheeran, Climate Advisor to Oregon Governor Kate Brown. Presentation by DC Water CFO Mark Kim at Ballard Spahr Green Infrastructure Conference (Oct. 2016).

The contagion can be triggered by litigation / liability risk from potential fraud on permanent mortgage holders including lenders with security interests, from the devaluation of trillions of dollars of South Florida's coastal built environment.

This litigation / liability risk extends to local and state governments, and state institutions since they are all required to act in the public interest, and developers, all with knowledge who failed and fail to warn / disclose.

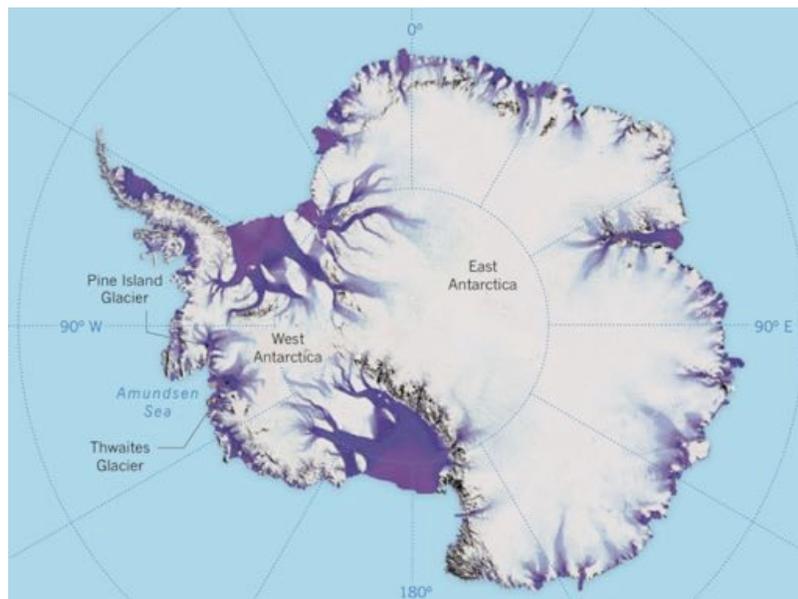
The Defense Department and credit rating agencies recognize this very real risk based on extensive briefings, and it's detailed in the peer reviewed *Green Bond Business Case* released at the NYSE by JPMorgan and updated by leading economists led by Dr. Gary Yohe, IPCC, Vice Chairman, U.S. Climate Assessment Reports.

The City of South Miami made an extensive effort and informed numerous key U.S. Senate staff as well as former Senator Bill Nelson of this risk.

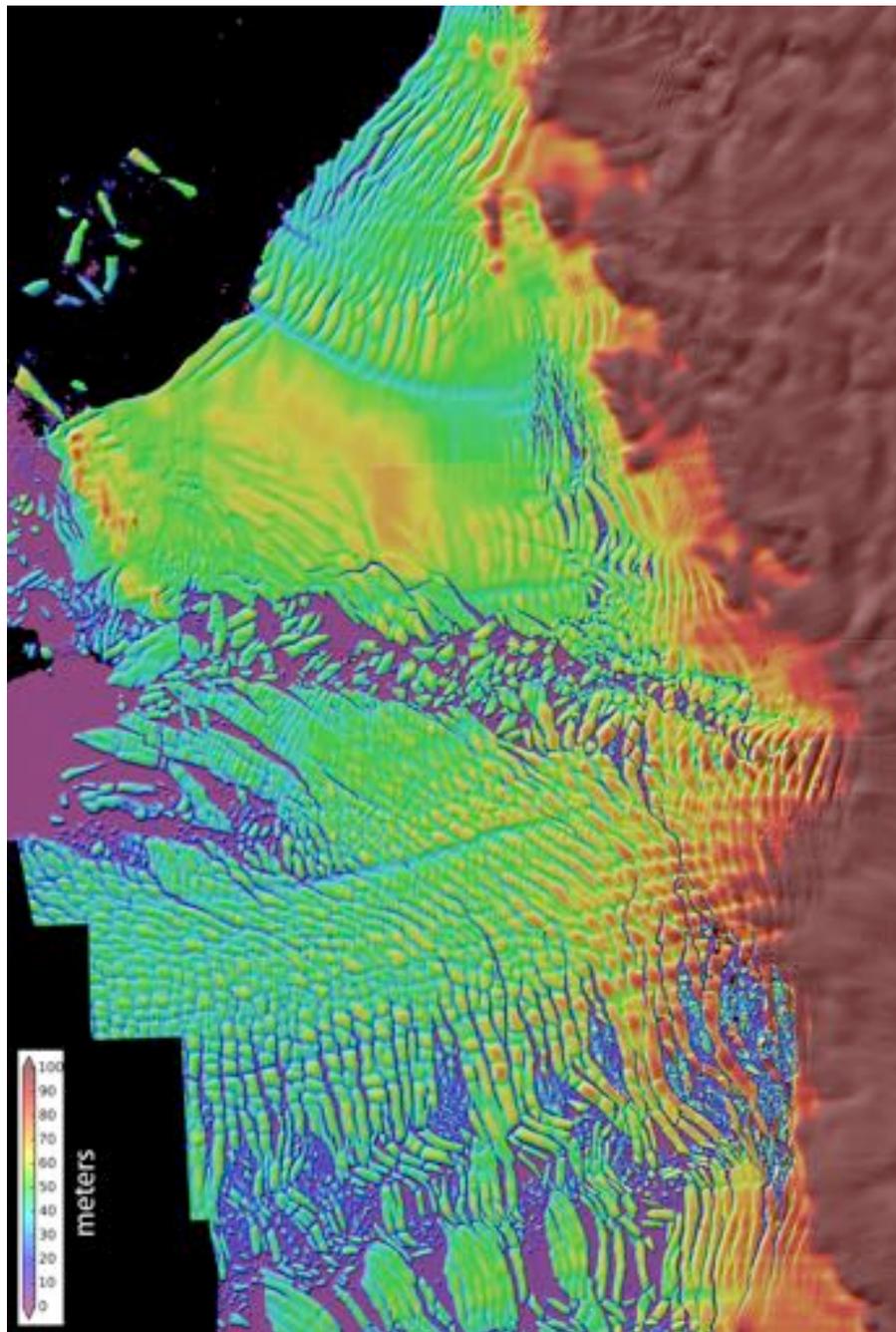


**Figure 1. Velocity of Accelerating Ice Losses / Flow Into the Ocean, Including From West Antarctic Ice Sheet Probably in Response to Ocean Warming**  
 NASA Earth Observatory (Feb, 20, 2018)

This image of the flow of Antarctic ice into the sea came from processing hundreds of thousands of images from NASA-U.S. Geological Survey satellites. The result is a picture of changes in ice-sheet motion with a higher precision than was previously possible.



**Figure 2. Antarctic Glacier Locations.** (from *Small glacier [Thwaites] has big effect on sea-level rise*, Nature, Oct. 22, 2015).



**Figure 3. Thickness, Shape & Surface Topography of Thwaites Glacier Ice Tongue that May Be Undergoing Irreversible Collapse.** David Sheen, U. of Washington circa 2018, from Arctic Sea Ice Forum, Thwaites Glacier Discussion Feb. 4, 2019.

"Thwaites Ice tongue" has been named iceberg B22A for several years, since it is not connected to the main glacier anymore. *Ibid* Feb. 1, 2019.

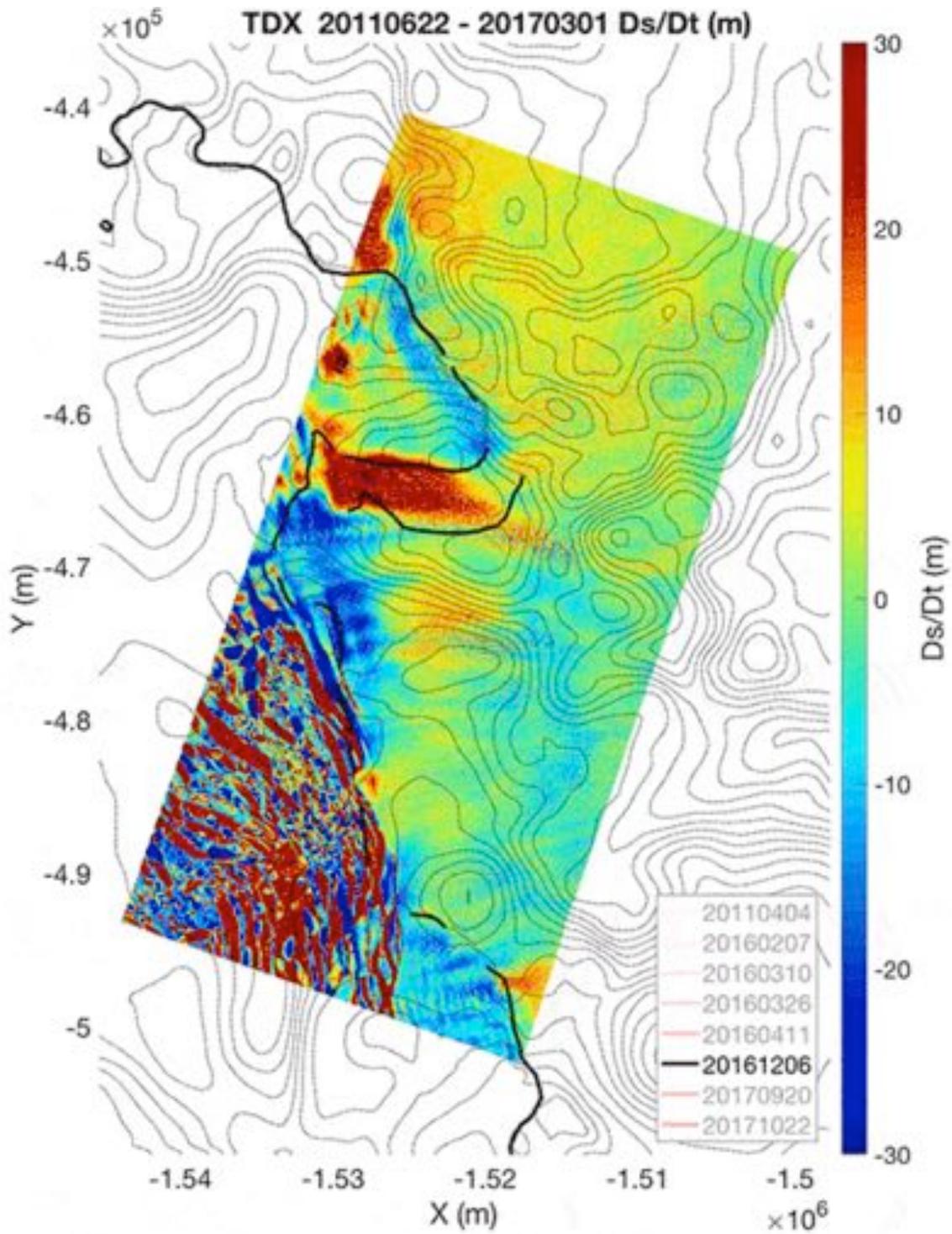
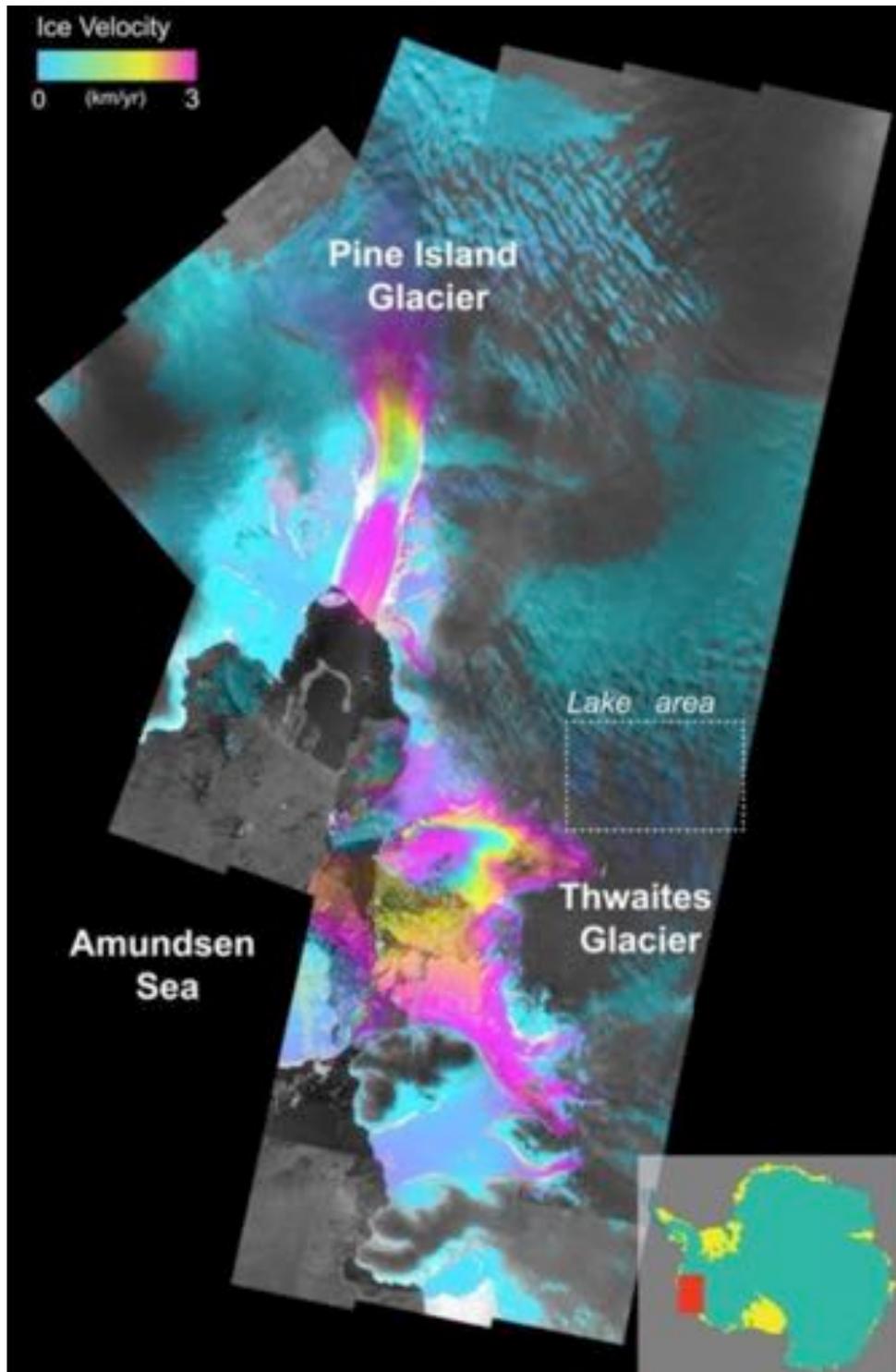


Figure 4. Size of Rapidly Growing Very Large Cavity 10 miles in Length & 300 Meters in Diameter at Thwaites Glacier's Grounding Line, 2011 to 2017.

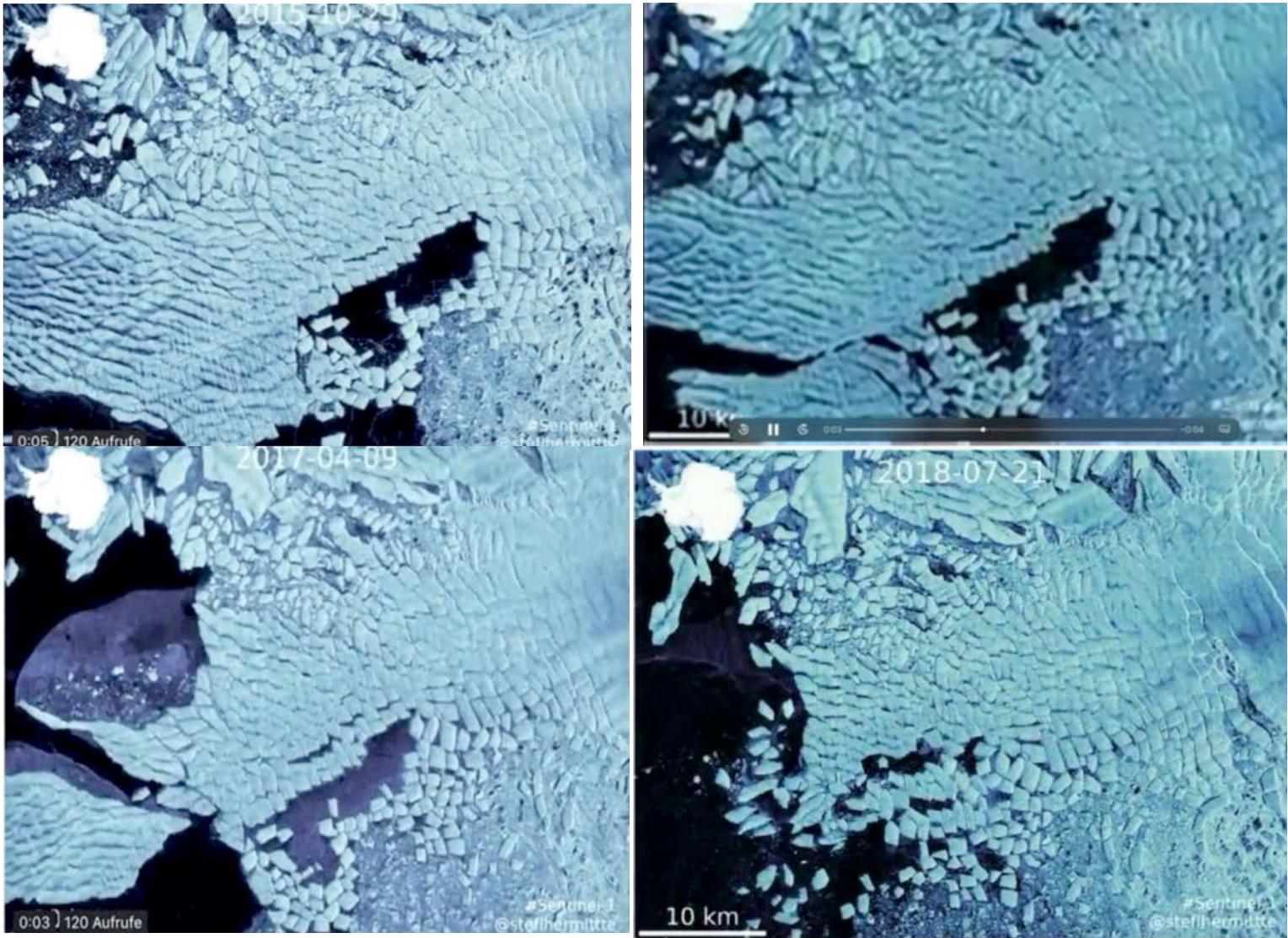
Sinking areas in red and rising areas in blue. The recently discovered growing cavity (red mass, center) is shown as in 2016, caused the greatest sinking. The mottled area (bottom left) is the site of extensive calving. Contours show bedrock topography.



**Figure 5. Red Areas Show 3 Kilometers / yr. Velocity of Thwaites Glacier for West Antarctic Glacial Speed**

Reaching speeds of over 3 km per year, Thwaites and Pine Island are two of the fastest receding glaciers on the Western Antarctic Ice Sheet. Applying interferometric synthetic aperture swath processing techniques to CryoSat data revealed that four large lakes beneath Thwaites drained into the Amundsen Sea correlating with about a 10% increase in Thwaites' receding discharge to the sea. Subsurface meltwater drainage is estimated to have peaked at about 240 m<sup>3</sup> per second, possibly the largest outflow of meltwater ever reported from subglacial lakes in this region.

European Space Agency, Universities of Leeds & Edinburgh (Aug. 2, 2017). CryoSat-2 (Earth Explorer Opportunity Mission-2) is the follow-on Earth Explorer Opportunity Mission in European Space Agency's (ESA) Living Planet Program. Figure 5 is Figure 32 from Earth Observation Portal Directory. Categorized from A to Z and by **Space Agency**, there are over 1000 in-depth articles of satellite missions at the Portal from 1959 to 2025). <https://directory.eoportal.org/web/eoportal/satellite-missions/content/-/article/cryosat2>

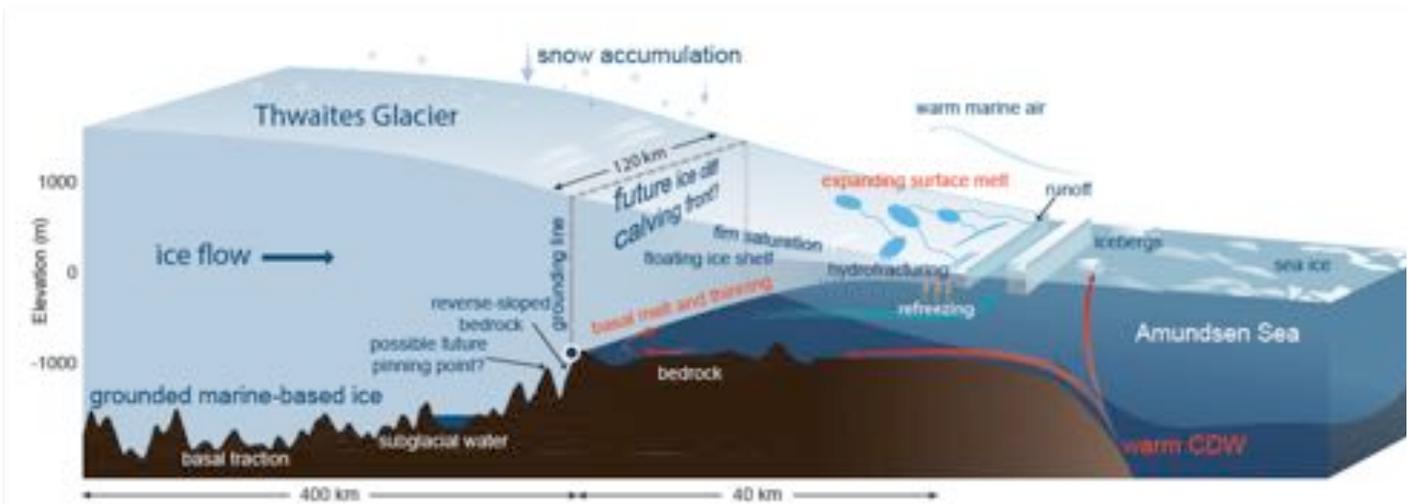


**Figure 6. Time Lapsed Satellite Imagery from 2015 – 2019 Showing Thwaites Glacier Possible Irreversible Collapse**  
 Copernicus EU Satellite, Stef Lhermitte, Assistant Professor GRS, Delft University of Technology

These images were taken from Video available on Vimeo showing large scale collapse with rapid outflow to the ocean:  
<https://vimeo.com/337729891>



**Figure 7. Thwaites Glacier Undergoing Irreversible Collapse.**  
 Photo credit: National Science Foundation U.S. Antarctic Program.



**Figure 8. Processes affecting the Thwaites Glacier in the Amundsen Sea sector of Antarctica.**

*“The grounding line is currently retreating on reverse-sloped bedrock at a water depth of ~600 m (Joughin et al., 2014; Mouginot et al., 2014). The glacier terminus is ~120 km wide, widens upstream, and is minimally buttressed by a laterally discontinuous ~40 km long ice shelf. The remaining shelf is thinning in response to warm, sub-shelf incursions of circumpolar deep water. . . . The bathymetry upstream of the grounding zone is complex, but it generally slopes downward into a deep basin, up to 2,000 m below sea level under the center of the WAIS (far left), making the glacier vulnerable to marine ice sheet instabilities.” IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, Full Report at 4-36 including this figure (Sept. 25, 2019).*

This cross section shows the current grounding line intersection of the ocean – ice – bedrock interface, almost at the reverse steep sloping bedrock ridge. Once the glacier grounding line recedes past the ridge, Thwaites’ already permanent collapse will greatly accelerate, triggering collapse of contiguous glaciers, increasing the contribution of Thwaites’ area glaciers to global sea level rise from the current 4%, to 40% (E. Rignot, NASA JPL, personal conversation Sept. 3, 2019). NASA ice-penetrating aerial imagery in Fig. 4 above shows that the grounding line was 19 miles from the ridge in 2017, with 9 miles of “explosive and disturbing” melt at the grounding line from 2015 – 2017. *Id.*



**Figure 9. Miami King Tide Sunny Day Manmade Sea Level Rise Flooding**, from *Business Insider* July 16, 2019



**Figure 10. Antarctica Size.**

Antarctica is the fifth largest continent, much larger than the U.S. as depicted in this NASA superimposed satellite image.

# Appendix 1

## Dangerous Scientific Reticence and its Widespread Influence on Sea Level Rise Timing / Projections

James Hansen description of reticence evolved to “*dangerous*” reticence due to the unacceptable risks presented to society especially accelerating sea level rise.<sup>45</sup>

Hansen’s earlier original paper *Scientific Reticence* is explained at the Ice Apocalypse - MULTIPLE METERS SEA LEVEL RISE scientific blog post:<sup>46</sup>

*‘While this thread goes well beyond Hansen’s ice-climate feedback mechanisms; nevertheless, Hansen’s basic position on this matter lies at the heart of this thread. Therefore, I note that it is a clear example of scientific reticence that consensus climate science has not highly cited Hansen et al. (2016), “Ice Melt, Sea Level Rise, and Superstorms”, as discussed in the first linked documents (also see the attached image showing Hansen’s illustration of both the ocean stratification and precipitation feedback mechanisms):*

*James Hansen (October 26, 2017), “Scientific Reticence: a DRAFT Discussion” and “Scientific Reticence and the Fate of Humanity”*

[http://www.columbia.edu/~jeh1/mailings/2017/20171026\\_ScientificReticence.pdf](http://www.columbia.edu/~jeh1/mailings/2017/20171026_ScientificReticence.pdf)  
<https://unfccc.int/event/abibimman-foundation-james-hansen-scientific-reticence-a-threat-to-humanity-and-nature>

*Extract: “Frank Dentener, an editor of Atmospheric Chemistry and Physics, in a recent note to me observed that Ice Melt, Sea Level Rise, and Superstorms, hereafter Ice Melt, was not highly cited or mainstream in climate impact discussions.”*

*Furthermore, the second linked reference indicates that consensus climate science has been largely ignoring Hansen’s warnings about fat-tail climate risks since well before 2007, and I note that the longer we wait to take effective action the worse our climate situation becomes:*

*Hansen (2007), “Scientific Reticence and Sea Level Rise”, Environmental Research Letters, Volume 2, Number 2, doi:10.1088/1748-9326/2/2/024002*

<http://iopscience.iop.org/article/10.1088/1748-9326/2/2/024002>  
<https://arxiv.org/abs/physics/0703220>

*Hansen Scientific Reticence Abstract: “I suggest that a “scientific reticence” is inhibiting communication of a threat of potentially large sea level rise. Delay is dangerous because of system inertias that could create a situation with future sea level changes out of our control. I argue for calling together a panel of scientific leaders to hear evidence and issue a prompt plain-written report on current understanding of the sea level change issue.”*

Hansen’s emphasis on fat-tailed higher probability, unacceptable risks was validated by JPMorgan’s published study that unmanageable dangerous climate is a high probability Black Swan statistical event.<sup>47</sup>

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<sup>45</sup> (Dangerous Scientific Reticence Mar. 24, 2016: <http://csas.ei.columbia.edu/2016/03/24/dangerous-scientific-reticence/>)

<sup>46</sup> From Re: Ice Apocalypse - MULTIPLE METERS SEA LEVEL RISE (narrated video) « Reply #248 on: November 30, 2018, 05:09:41 PM

## Appendix 2

### Need for Scientific Precision & Accuracy Adjustment Factor to Correct for ~30 Years of Consistent, Substantial Underprediction of the Pace of Adverse Climate Impacts Including Manmade Sea Level Rise Flooding.

There are many scientific and political factors contributing to the underprediction, *all* of which led to the long term decrease in precision and accuracy:

- **Dangerous scientific reticence** published by Hansen identifies the conservative nature of climate scientists and more frequent than normal “*climate contrarians*.”<sup>48</sup>
- **As recognized by IPCC, Climate change operates under chaos theory since innumerable air, land, water / ocean, ice sheet, and biota interactions determine climate change** reducing our ability to make accurate predictions / reducing the aspects of climate change that we can make accurate predictions of.<sup>49</sup>
- **Numerous unaccounted nonlinear positive feedback loops / accelerators that have a substantial impact** like growing arctic methane releases and CO2 from wildfires.<sup>50</sup>
- **Material / substantial impact of many unknown key factors due to great global complexity & uncertainty**
- **Concomitant difficulty of effectively validating / calibrating sea level rise models *in situ*.** In 2001 IPCC stated: “*An important question is whether a multi-model ensemble made by pooling the world climate community’s stock of global models adequately spans the uncertainty in our ability to represent faithfully the evolution of climate.*”<sup>51</sup> The subsequent satellite validation of the models shows IPCC and models likely acted “*faithfully.*” Unfortunately, the global stock of models was still unable to accurately represent the evolution of climate change.
- **Significant documented history of frequent use of unvalidated / uncalibrated models questioning a rational scientific basis of their use** in contrast to use of more accurate actual empirical data, e.g., the given priority by Hansen. Long term accepted scientific practice is to calibrate / validate models *in situ* for them to be usable let alone effective.

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<sup>47</sup> Green Bond Business Case released at NYSE by JPMorgan, Sierra Club & CMP and updated in 2014 by leading economists & CMP. This risk and recognized existing 6% loss to all investments from climate documented by CalPERs, Mercer and 16 other leading institutional investors, is what’s driving the enormous and unprecedented investor demand for green bonds and stocks.

<sup>48</sup> Hansen, “Dangerous Scientific Reticence – Climate Science Awareness,” Columbia University Earth Science Institute (March 23, 2016). [http://www.columbia.edu/~jeh1/mailings/2016/20160323\\_DangerousReticence.pdf](http://www.columbia.edu/~jeh1/mailings/2016/20160323_DangerousReticence.pdf)

<sup>49</sup> Lorenz at MIT was apparently the first to publish that climate from an atmospheric perspective alone, is chaotic followed by IPCC and others (The Index Cycle is Alive & Well 1963. Concurring is “A voyage through scales, a missing quadrillion and why the climate is not what you expect,” *Climate Dynamics* June 2015. Also concurring are IPCC Third Assessment Report (TAR), The Scientific Basis, § 7.1.3 Predictability of the Climate System at 422, “*The Earth’s atmosphere-ocean dynamics is chaotic: its evolution is sensitive to small perturbations in initial conditions.*” Also concurring is IPCC Third Assessment Report (TAR) Chapter 14, 2001 at 771, “*Advancing Our Understanding:*” “*The climate system is a coupled non-linear chaotic system, and therefore the long-term prediction of future climate states is not possible.*”)

<sup>50</sup> Thirteen positive feedback loops are documented in 5th Draft Legal Opinion Finding Criminal Liability for Dangerous Climate (2018), National Resilience Cost Recovery Coalition. There are very likely many more significant ones.

<sup>51</sup> IPCC Third Assessment Report (TAR), The Scientific Basis, § 7.1.3 Predictability of the Climate System at 422.

- **Over 40 years of big oil / front groups climate fraud**, the purpose of which successfully caused doubt and uncertainty on climate change, which was publicly documented with actual industry records in Pulitzer Prize nominated reporting. Absent the fraud, the current Climate Crisis would have been obviated. This well-financed long term disinformation campaign adversely influenced the World's governments including IPCC, and placed a *chill* on scientists' published objectivity for fear of higher than normal criticisms, threats to their funding, frivolous and unlawful legal attacks, and in some cases threats of personal harm.
- **Denial of & attack on manmade climate change & science by the Federal and many State Governments** in violation of plenary prohibitions on fraud and scientific fraud
- **Powerful elected officials frivolously prosecuting scientists** for scientists' accurate, peer-reviewed publications like former and discredited Virginia Attorney General Cuccinelli's fraudulent and unsuccessful prosecution of Michael Mann.
- **Death threats on climate scientists** including Michael Mann and attorneys

This repeated, long term, substantial underprediction of the pace of climate impacts without an accurate and precise scientific basis, and without adjustment, fits Rita Mae Brown's 1983 definition of insanity repeatedly but inaccurately attributed to Einstein due to its powerful logic:

*"Insanity is doing the same thing over and over again, but expecting different results."*

The enormous effect on society of the substantial underprediction on the pace of impacts without adjustment, jeopardizes commerce, national security, and a habitable Planet since:

- Resilience finance, design & construction have long lead times
- Resilience finance now is essential to maintain commerce, national security & a habitable Planet. Resilience is adaptation plus climate pollution reduction.
- Many coastal communities are using timing of projection by unvalidated / uncalibrated models with dates of timing of sea level rise that may be too far out in the future.
- City and state elected officials are not aware of this unvalidated prediction by their resilience studies of the timing of sea level rise too far out.
- U.S. resilience costs in the pipeline based on the U.S. Climate Assessment Reports as reported to S&P, the world's largest credit rating agency, are ~\$100 trillion based on SPECIAL REPORTS documenting Massachusetts and Pennsylvania's *existing* resilience costs at \$6.8 trillion.