LLS2024 Part 4 — A Brief Primer on Global Warming

Undelivered End of the Prepared Talk

By Vincent S. Cronin, revised October 10, 2024

SLIDE 97 Federal agencies report that nearly 30% of the US population lives in a coastal area that might be vulnerable to sea level rise. Coastal communities are already vulnerable to tidal flooding and flooding due to storm surge.

There is an enormous amount of work to be done in the US and worldwide in the coming decades and centuries by folks who are expert in coastal engineering and engineering geology. We will need to replace and relocate or raise infrastructure like roads, utility lines, water-treatment plants, port facilities, and power plants along all of our low-lying coastlines, and build anew above the expected future maximum sea level. And everything we build will need to be more resilient to the weather extremes in a warming climate.

SLIDE 98 One of the clearest recent examples of our vulnerability to rising seas is the impact of Hurricane Sandy on New York City in 2012.

SLIDE 99 This map shows the depth of flooding measured in feet above the local ground surface, where purple areas were flooded by more than 10 feet, darker blue areas had 3-10 feet of flooding, and light blue was less than 3 feet.

Dozens of people died because of Sandy. Patients in flooded hospitals and nursing homes had to be evacuated. Sandy flooded tens of thousands of buildings, causing at least $19 billion in damage.

SLIDE 100 While flooding from previous storms was certainly significant in the New York area, only Sandy flooded the subway system, causing extraordinary damage.

Rising seas and more intense storms will affect engineered works worldwide during the coming centuries, on coastlines and along river systems. Engineering geologists will need to help society anticipate, avoid, design against, and ultimately mitigate and rebuild after disasters made worse by a warming climate.

SLIDE 101 We can model future flooding along our coastlines due to rising sea level. In the US, these projections are developed using digital elevation models of the coastal area that, in many instances, extend below sea level for a short distance. The first model we will use is NOAA's Sea Level Rise Viewer, which is a freely available web app.

SLIDE 102 This aerial photo shows some of the very expensive (if somewhat scruffy) beach houses along Broad Beach at Malibu in 2002. Beach houses here were built right on the beach, below Pacific Coast Highway. These folks just walked out their back doors and directly onto the beach. The edge of the vegetation is at the high high tide line.

SLIDE 103 The area that is currently flooded at high high tide (when the Moon is full or new) is shown in red and includes the upper beach face and the mouth of Trancas Creek.

SLIDE 104 In this more recent photograph along the beach, you can see that a boulder berm has been built on the beach to protect the houses from storm surge. Of course, the boulder berm destroys the recreational and real-estate value of the beach houses. Who wants an expensive ocean-front house whose view is the back side of a boulder berm!?!

SLIDE 105 Sometime in the 22nd century (depending on the fate of glacial ice on Greenland and Antarctica), it is probable that sea level will rise to 10 feet (about 3 meters) above current levels. By then, winter storms will have bashed the houses on Broad Beach to pieces and what's left of them will be fish habitat.

SLIDE 106 The Sea Level Rise Viewer provides part of the story, but not the whole tamale. It does not include local uplift or subsidence of the land surface, or any allowance for storm surge that could add over 2 meters to the local sea level.

SLIDE 107 Another free online resource for modeling coastal flooding has been posted by Climate Central: the Coastal Risk Screening Tool. This web app allows the user to incorporate various levels of storm surges, different carbon-emissions scenarios, and whether we experience the low, mean, or high probability outcomes for a given scenario.

I'm telling you about this because someday you might need a quick impression of the vulnerability of a given coastal area to sea-level rise so that you can help to engineer possible mitigation or avoidance strategies. The Coastal Risk Screening Tool helps you do this at no cost.

Let's look at some examples modeled for the year 2100 by the staff of Earth.com. With luck, my grandchildren and great-grandchildren will be alive in 2100, so it is not so very far away.

SLIDE 108 Here's a map of predicted coastal flooding in New York, modeled in the year 2100 with light blue areas inundated by a 2 meter rise, and the dark blue areas inundated by a 5 meter rise in sea level. Every-day flooding in 2100 will be about the same as during the worst of Hurricane Sandy. An estimated 15% of the population (1 million people) would be displaced from the blue inundated area.

SLIDE 109 New Orleans. By the year 2100, 97% of its population or 280,000 people could be displaced by a 2 to 5 meter rise in sea level.

SLIDE 110 Miami. 94% or 2 million people are displaced by a 1 to 3 meter rise in sea level by 2100.

SLIDE 111 This coastal inundation problem will occur worldwide, of course. Here's the model prediction for Rotterdam, in The Netherlands. 98% or 650,000 persons are displaced as their former homes become part of the North Sea after a 3 to 6 meter rise in sea level by 2100.

SLIDE 112 This impressive bit of engineering has been installed at the front of the access channel to the port of Rotterdam. While this has been successful in providing protection from storms and high tides, it will not ultimately be able to handle global sea-level rise into the next century. We will need engineered solutions at all scales that are flexible enough to respond to rising seas.

SLIDE 113 Higher local temperatures affect humans as well as the rest of the biosphere.

Higher temperatures result in drought, loss of alpine glaciers, reduced potable water supplies, wildfires and subsequent debris flows, heat-related illnesses, crop stress and loss, impacts on structures, damage to ecosystems, and so on.

SLIDE 114 Today, some places on Earth are functionally uninhabitable because their mean annual temperature exceeds 29°Celsius or just over 84°F. That's the average temperature of each day used to compute the average temperature over the entire year.

In India, which will probably become the most populous country in the world soon, the next 50 years of global warming could place significant parts of the land surface above that critical temperature threshold. The results will include increased heat-related illnesses, deaths, and migration.

By 2070, given a plausible increase in average temperature, as much as 73% of the Indian population will be exposed to extreme heat that might render their hometowns "too hot to live in" during summer months.

SLIDE 115 A recent review article by Javier Fluixa-Sanmartin and others discusses the impacts of climate change on dam safety. They observe that large dams as well as protective dikes and levees are critical facilities whose failure results in major damage and, often, loss of life. The risk impacts of climate change are rarely included in dam safety assessments.

Risks associated with high heat include heat stress on critical components of the dam structure. They wrote, "...The structural integrity of concrete dams is strongly affected by temperature and solar exposure".

In Texas with a 4°Celsius rise in mean global temperature, relative to the pre-industrial baseline temperature, 50 of these dams could experience maximum summer temperatures above 50°C (122°F) while 142 could experience temperatures that are only slightly lower. Many of the older dams at high risk are in the Dallas-Fort Worth area -- the state's largest population center.

SLIDE 116 Global warming can also affect the intensity and frequency of major storms like atmospheric rivers and tropical cyclones, drawing from the increased thermal energy stored in the ocean and atmosphere. The process of producing FEMA flood maps will need to be revised to be useful in a warming world.

SLIDE 117 Rapid filling of reservoirs during major storms, coupled with thermal stress from extreme summer high temperatures, pose a danger to the aging inventory of dams, dikes, levees and aqueducts in the US and elsewhere.

The lack of sufficient attention to maintaining, decommissioning, and replacing the aging dam infrastructure of the US has been a problem for decades, and it is now a critical need that will involve engineering geologists for a long time to come.

As temperature rises, the risks to dam safety increase.

SLIDE 118 A substantial increase in the human population of Earth and their expanding need for food, energy, shelter, and other necessities has driven greenhouse-gas emissions that have changed Earth's climate in ways that are likely to persist for centuries.

Specifically, the practice of excavating naturally sequestered carbon to use for thermal energy generation has produced an unprecedented increase in $CO2$ and methane in the atmosphere, to concentrations not seen on Earth for millions of years.

SLIDE 119 In short, geoscientists will play many essential roles helping society navigate the effects of a warming climate. We will be most effective when we set aside old assumptions about a static climate and learn to plan to meet the challenges of a warming climate, with geoscience practiced in the public interest.