

Confronting Climate Change Over the Next Three Decades



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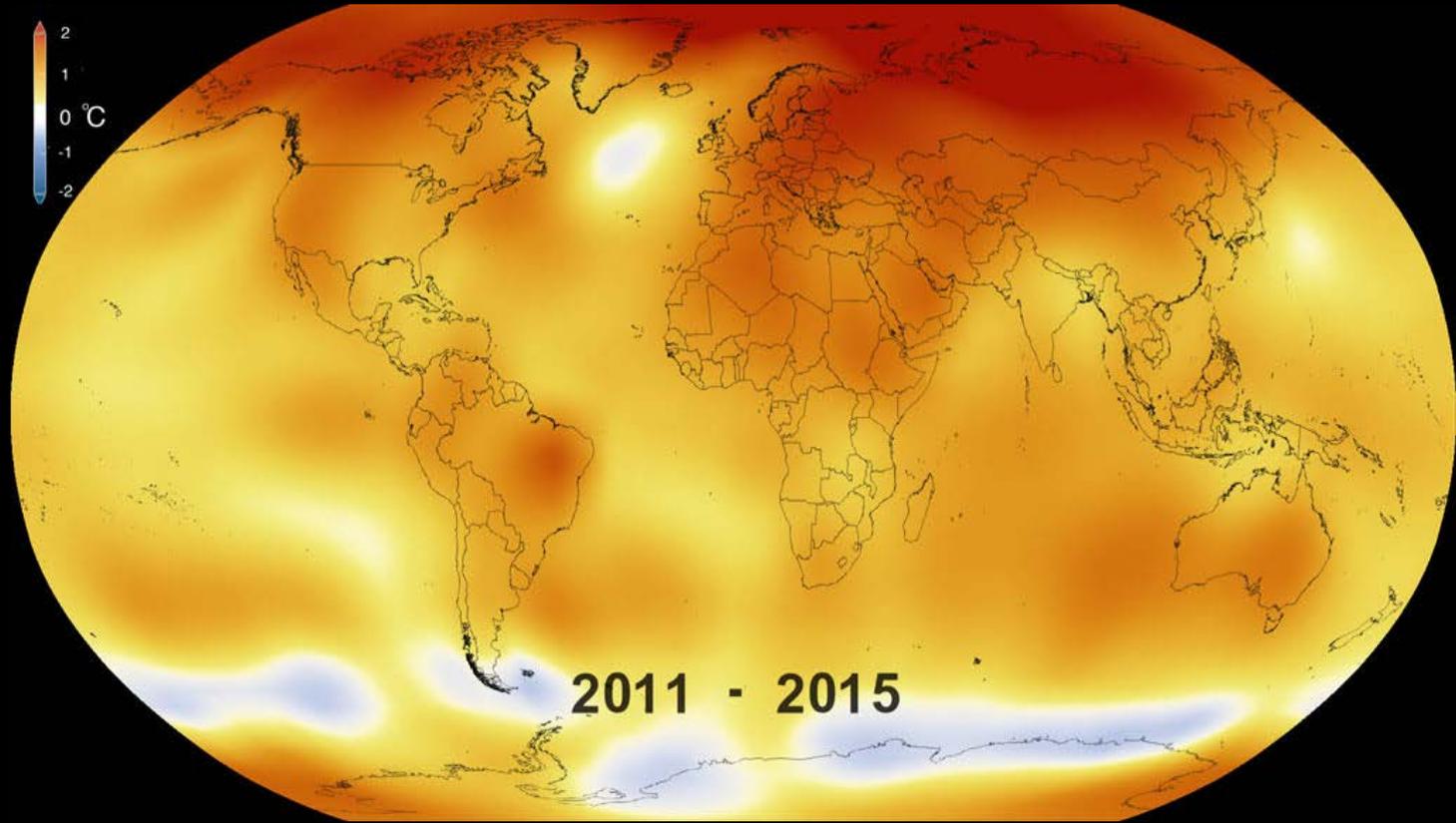
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Climate change is a *super-hard* problem for two simple reasons.

1. Climate change is a *collective action* problem that is truly *global*.

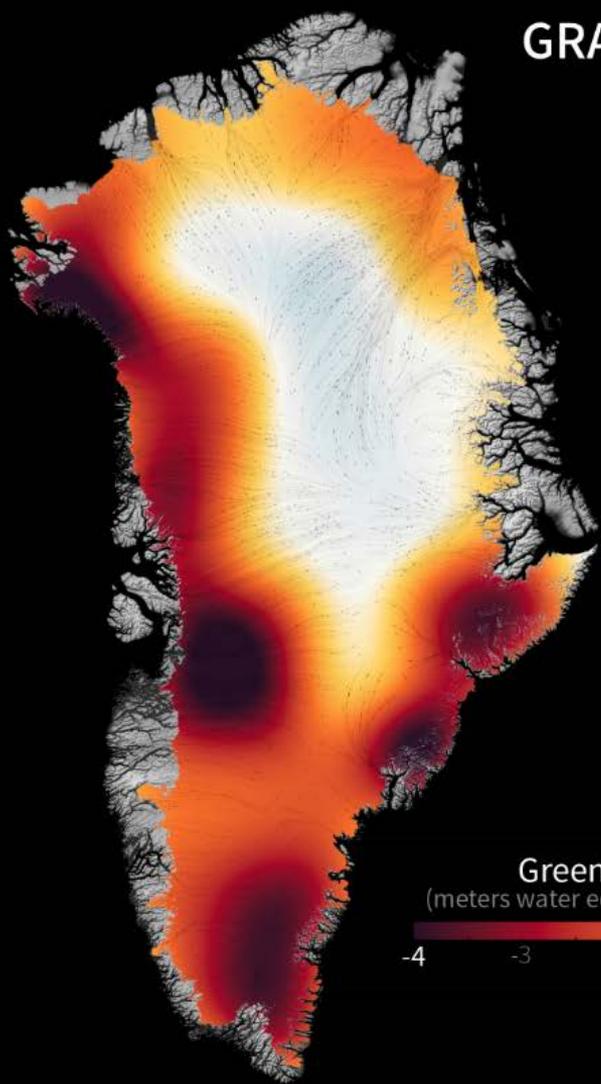
2. Almost all aspects of climate change have *long* timescales.

The spatial pattern of climate change



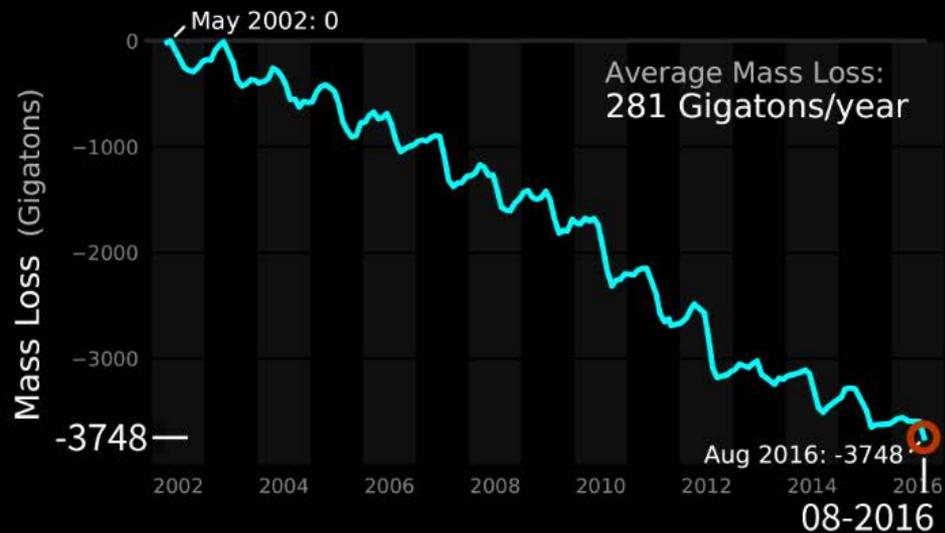
Average temperature (2011-2015) minus average temperature (1911-1915)

GRACE Observations of Greenland Ice Mass Changes

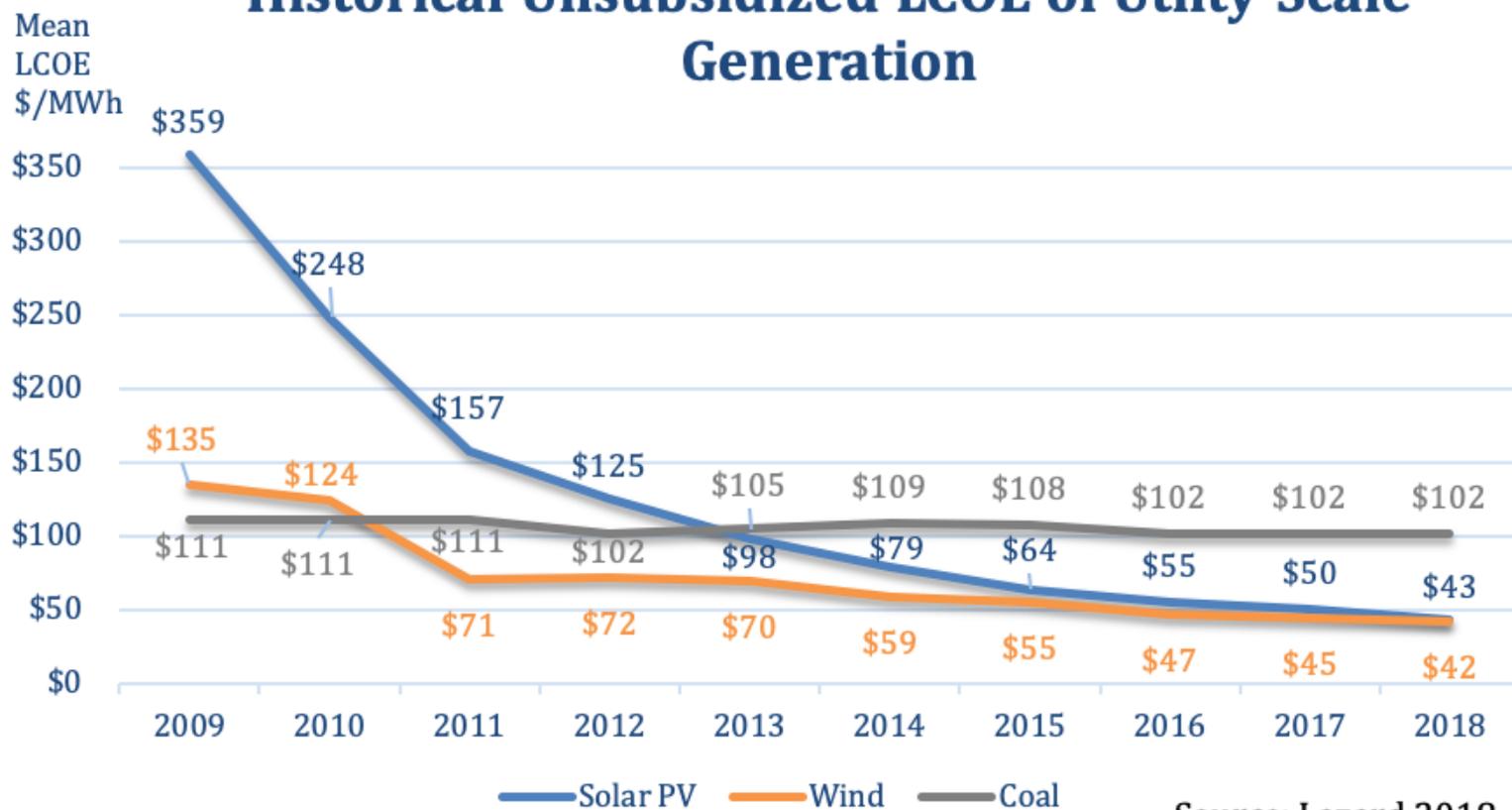


Greenland Ice Loss
(meters water equivalent relative to 2002)

-4 -3 -2 -1 0 0.5

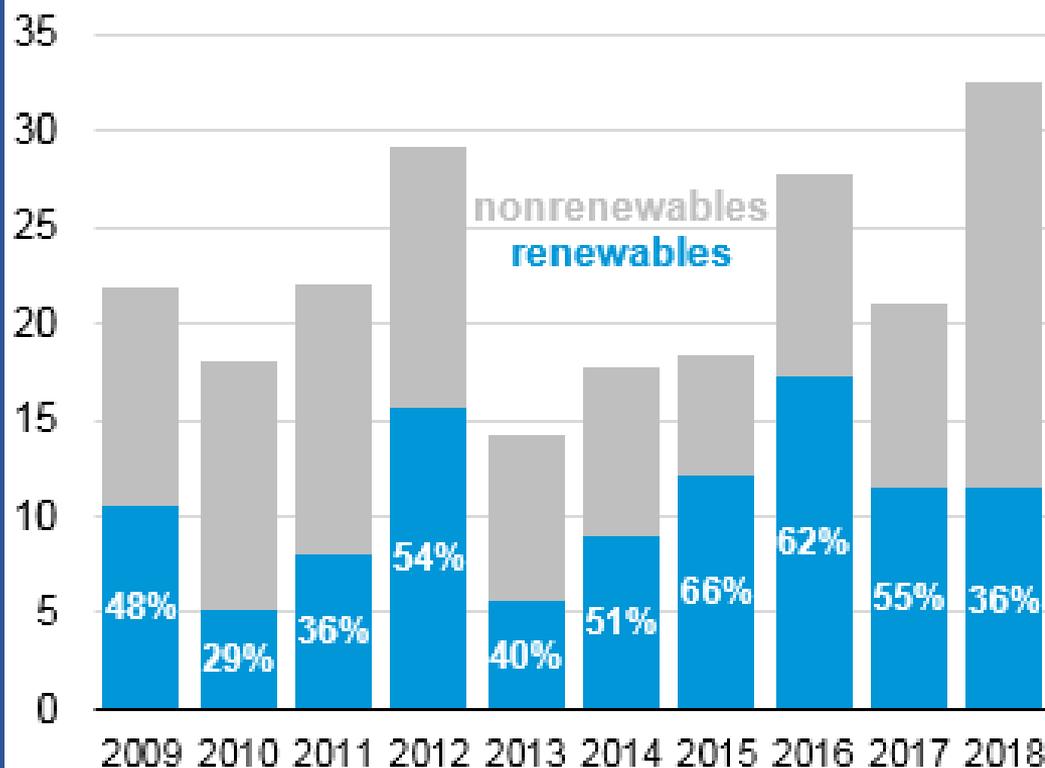


Historical Unsubsidized LCOE of Utility-Scale Generation

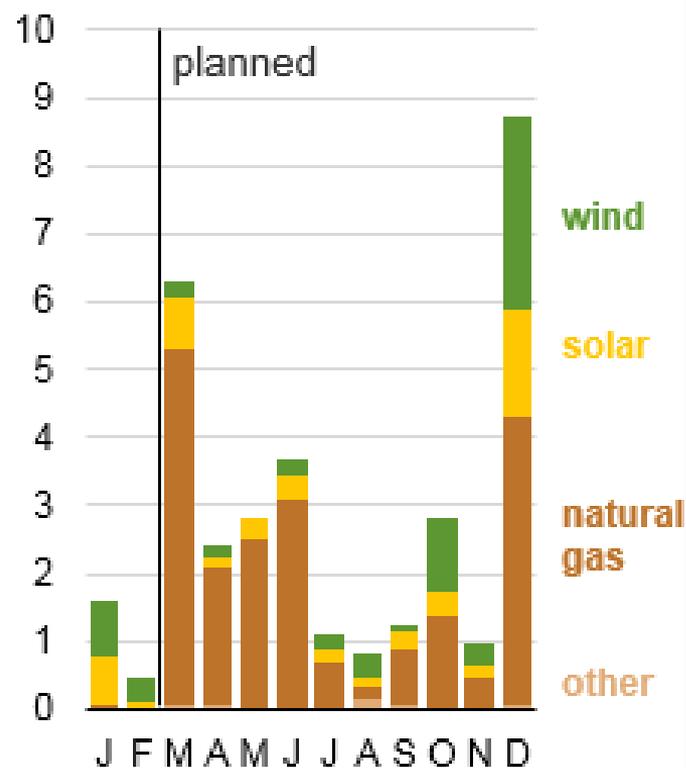


Source: Lazard 2018

Utility-scale capacity additions, 2009-2018
gigawatts

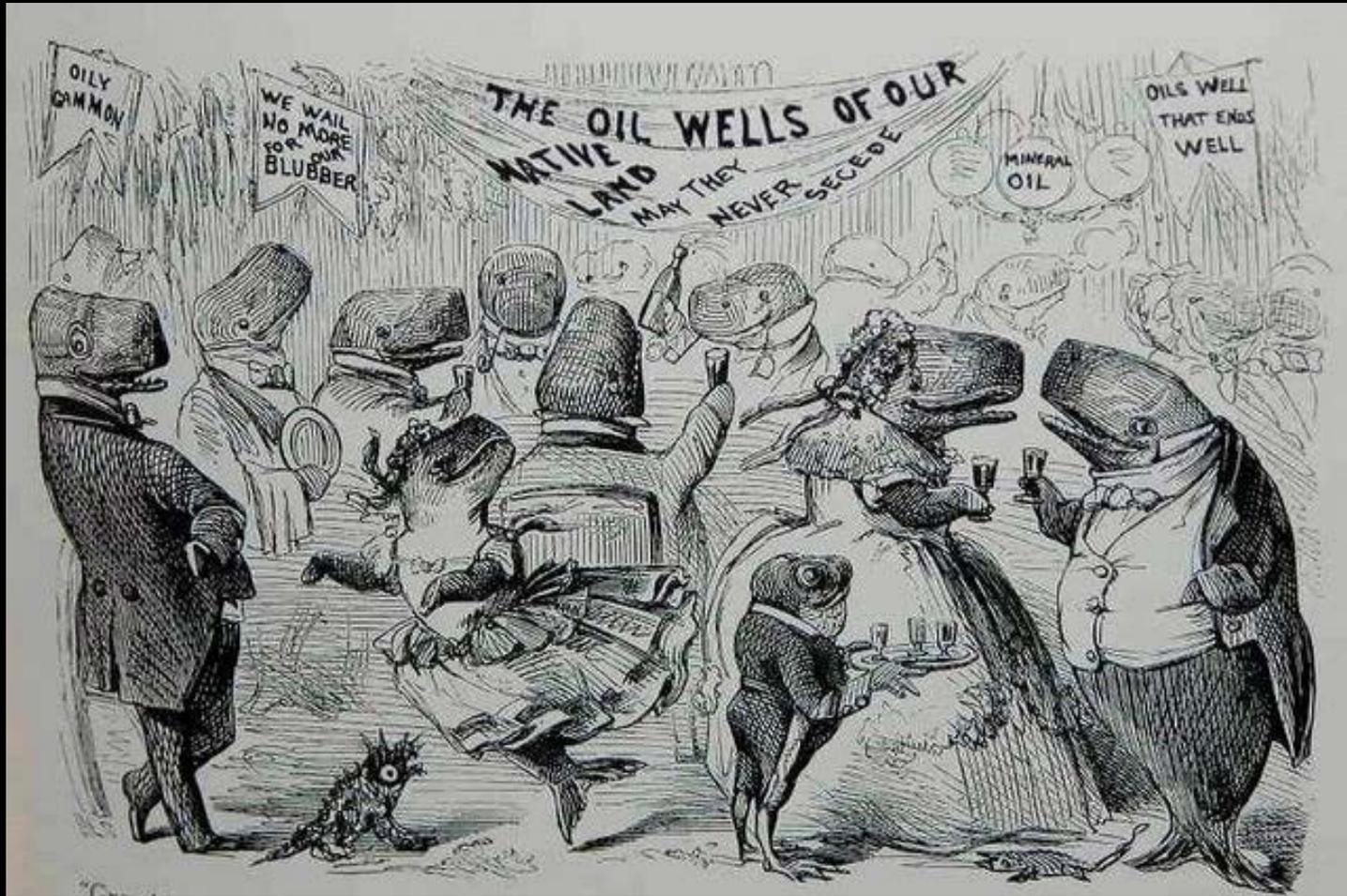


2018 monthly additions
gigawatts



Four categories of investment risks and opportunities:

- Infrastructure related to decarbonization
- Disruptions related to climate change impacts
- Infrastructure needed to prepare and/or respond to climate change impacts
- Interactions with social/political systems



Cartoon from an 1861 *Vanity Fair*: "Grand ball given by the whales in honor of the discovery of the oil wells in Pennsylvania."

Technology is critical to any solution. Global demand for electric vehicles (for example) will happen when electric vehicles are a better choice than internal combustion engine vehicles. Global demand for wind and solar power will happen when wind and solar power are better choices than coal power.

“It is very hard to predict, especially the future.”

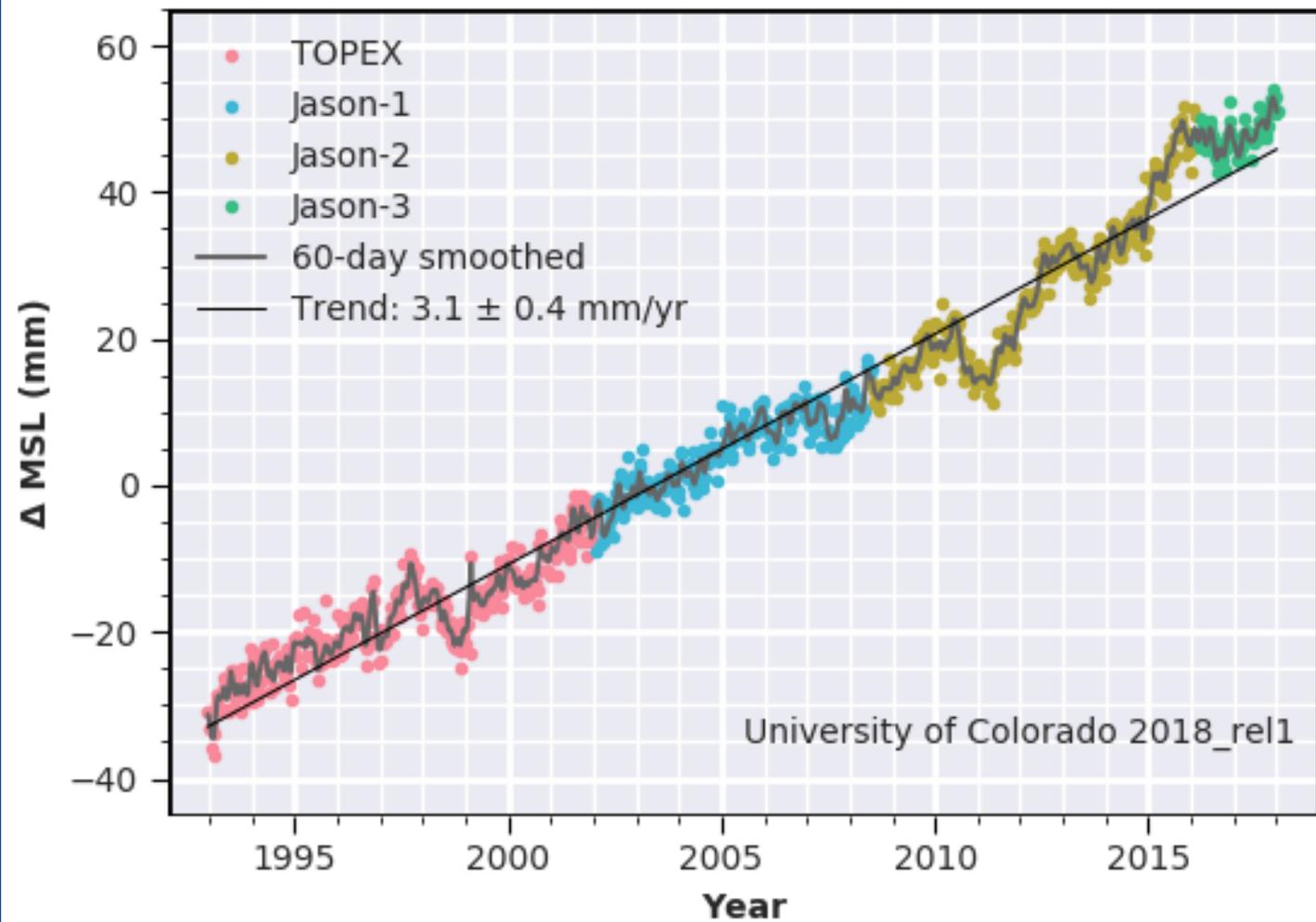
(attributed to Niels Bohr but apparently an old Danish proverb)

Phase 1 (until 2030 to 2050): Increasing penetration of wind and solar (backed by natural gas); substitution of natural gas for coal; efficiency in all sectors.

Phase 2 (2040 to 2070): Continued expansion of renewables; deployment of storage to manage intermittency of renewables; electrification of passenger vehicles, heating, industry.

Phase 3: (post-2070?) Carbon capture and storage for natural gas plants, industrial sources; biofuels or synthetic fuels; advanced nuclear.

If global decarbonization takes longer than current rhetoric among the U.N. climate discussions, then people's experience of climate impacts will grow substantially over the coming decades.



Tide Gauges

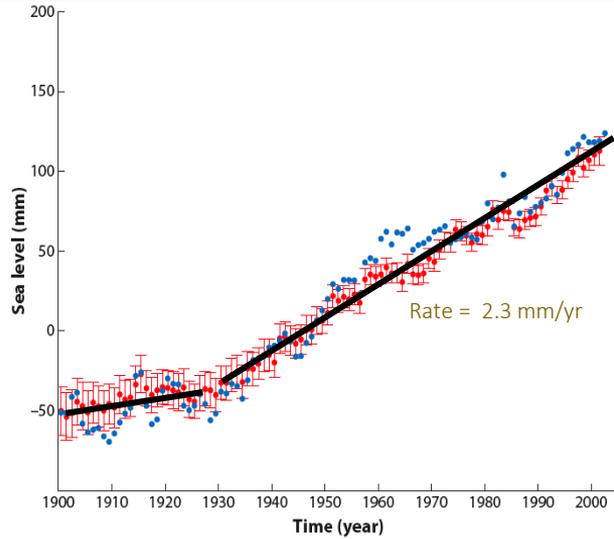


Figure 1

Observed global mean sea level (from tide gauges) between 1900 and 2001. Red dots are from Church et al. (2004). Blue dots are from Jevrejeva et al. (2006).

Satellites

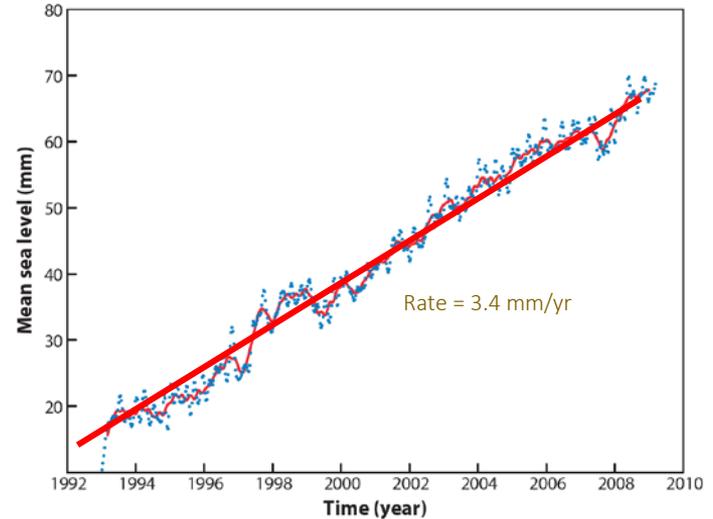
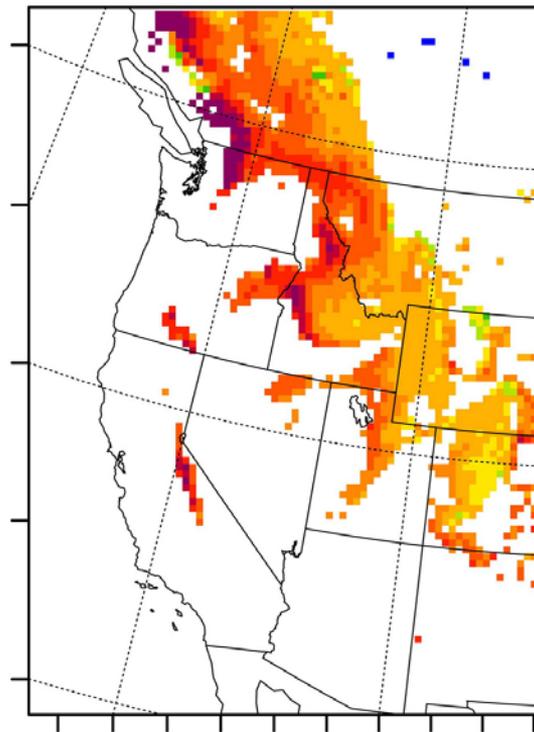


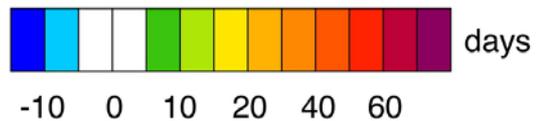
Figure 2

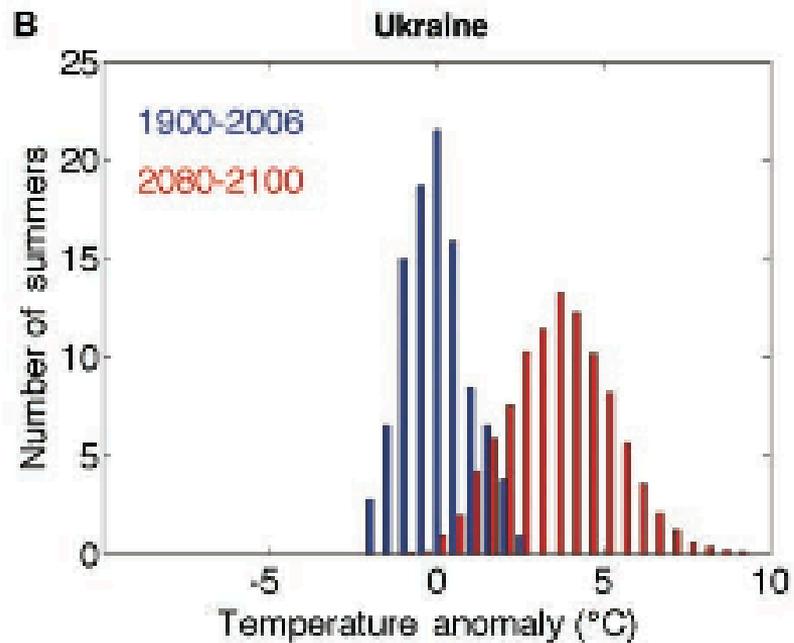
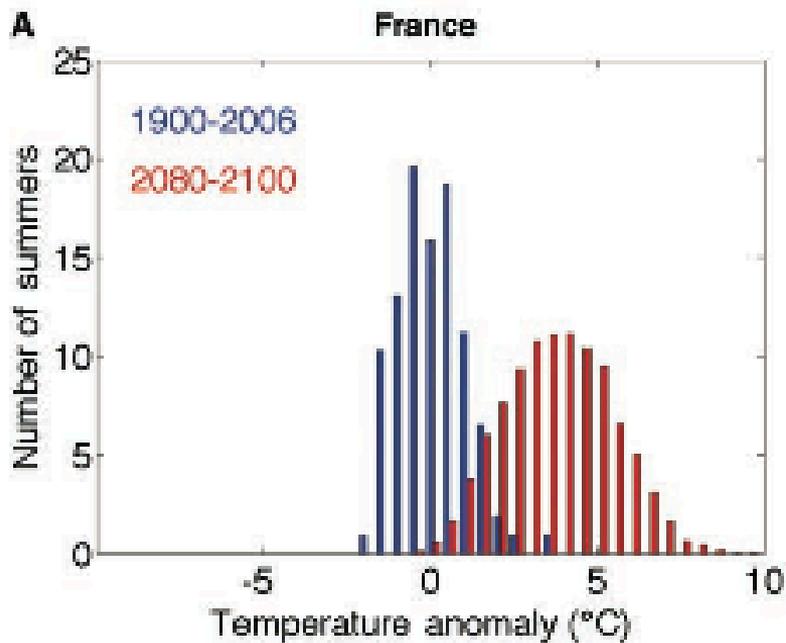
Global mean sea level from satellite altimetry between January 1993 and December 2008. Annual cycle has been removed. Blue dots are raw 10-day data. Red line corresponds to a 90-day smoothing of the raw data. The $-0.3 \text{ mm year}^{-1}$ GIA correction has been removed.

Snow-Dominated Runoff



Late 21st Century Change







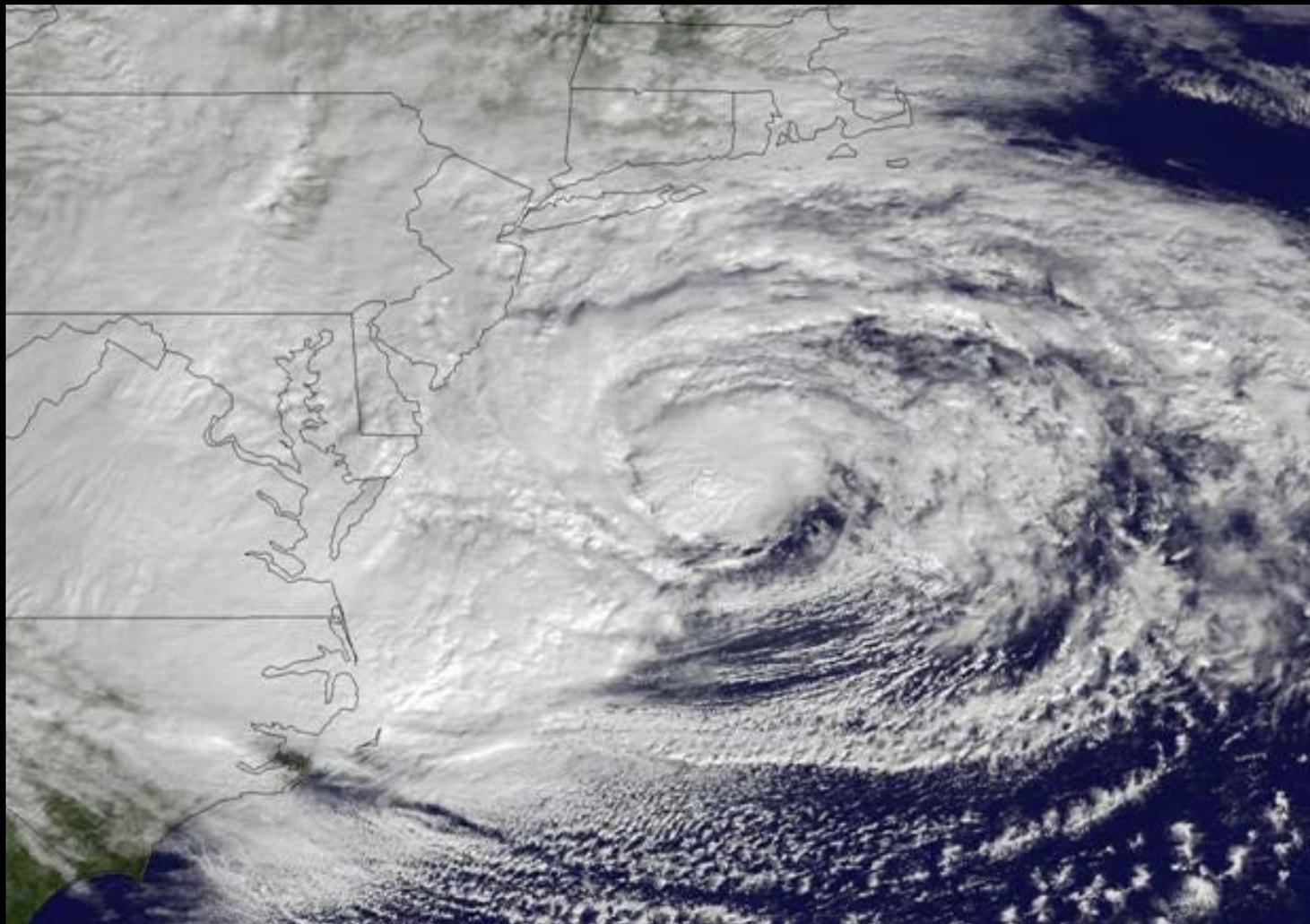






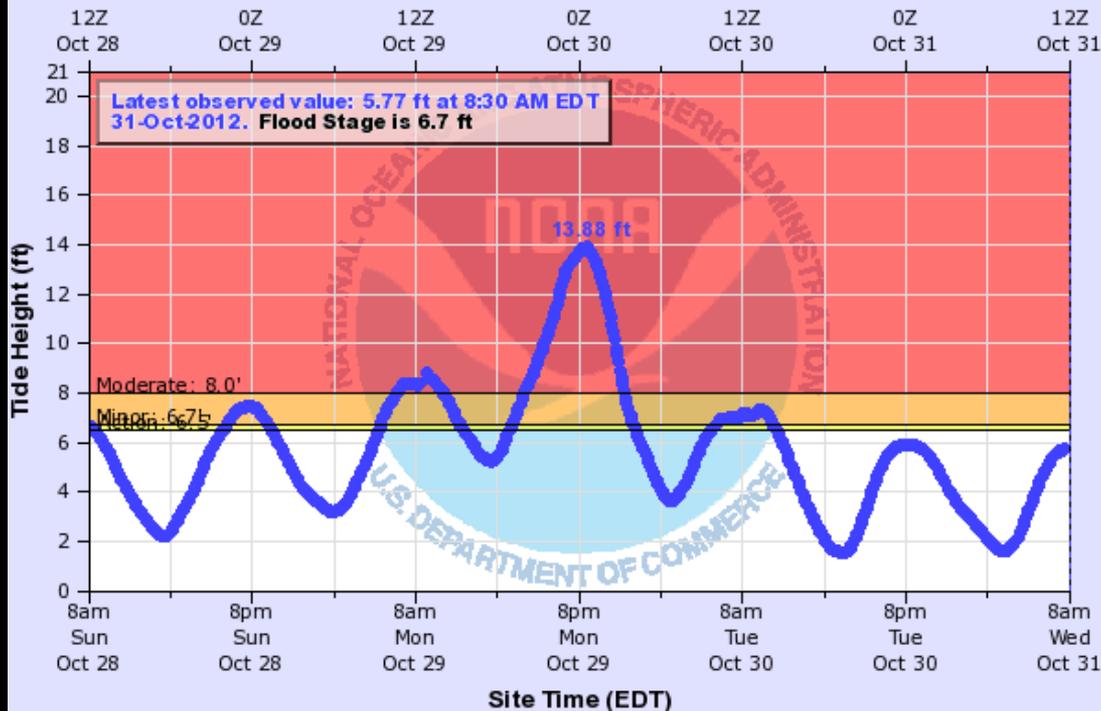






NEW YORK HARBOR AT THE BATTERY

Universal Time (UTC)



BATN6(plotting HMIRG) "Gage 0" Datum: n/a

Observations courtesy of NOAA's National Ocean Service









The elevated house that the owners call the Sand Palace, on 36th Street in Mexico Beach, Fla., came through Hurricane Michael almost unscathed.
Credit: Johnny Milano for The New York Times

“We are kept keen on the grindstone of pain and necessity.”

— H.G. Wells, [The Time Machine](#)

“It is not the strongest of the species that survives,
not the most intelligent that survives.

It is the one that is the most adaptable to change.”

— Charles Darwin

Are we on the verge of a new age of innovation?

Energy?

Architecture?

Agriculture?

Transportation?

Government?

What is the relationship between technology, economics, and social and political attitudes?

How will our perception of the climate problem change as new technologies are developed?

How will the politics of climate change shift as the experience of climate impacts grows?