



## Frequently Asked Questions Regarding the New Jersey Science and Technical Advisory Panel (STAP) Study

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*Human-caused climate change is accelerating sea-level rise in New Jersey and driving increases in coastal flood hazards. In 2016, Rutgers University researchers convened a panel of scientists to assess projections of future sea-level and storm changes affecting the Garden State. To ensure the usability of their assessment, the scientists also consulted with state and local practitioners to discuss how they would integrate the science into their decisions to enhance the coastal resilience of New Jersey's people, places, and assets. In 2019 the New Jersey Department of Environmental Protection engaged Rutgers to conduct new consultations with panels of scientists and practitioners to update its 2016 work to reflect the most recent climate science. Key updates in the new report include: the addition of historical sea-level rise information for New Jersey; consideration of the latest information related to potential ice-sheet changes and their effect on sea-level rise; and assessment of increasing tidal flooding under sea-level rise. All of the reports can be found at: <https://njclimateresourcecenter.rutgers.edu/resources/nj-sea-level-rise-reports/><sup>1</sup>*

### **1. What are the New Jersey Science and Technical Advisory Panel (STAP) studies?**

The first New Jersey Science and Technical Advisory Panel (STAP) on Sea-Level Rise and Coastal Storms was convened by Rutgers University on behalf of the New Jersey Climate Change Alliance in 2015, culminating in a 2016 report that identified consensus science that can inform practitioners' efforts to enhance the resilience of New Jersey's people, places, and assets to sea-level rise, coastal storms, and the resulting flood risk (Kopp et al., 2016).

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<sup>1</sup> Citations for the 2019 and 2016 STAP reports are:

- Kopp, R.E., C. Andrews, A. Broccoli, A. Garner, D. Kreeger, R. Leichenko, N. Lin, C. Little, J.A. Miller, J.K. Miller, K.G. Miller, R. Moss, P. Orton, A. Parris, D. Robinson, W. Sweet, J. Walker, C.P. Weaver, K. White, M. Campo, M. Kaplan, J. Herb, and L. Auermuller. New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel. Rutgers, The State University of New Jersey. Prepared for the New Jersey Department of Environmental Protection. Trenton, New Jersey.
- Kopp, R.E., A. Broccoli, B. Horton, D. Kreeger, R. Leichenko, J.A. Miller, J.K. Miller, P. Orton, A. Parris, D. Robinson, C.P. Weaver, M. Campo, M. Kaplan, M. Buchanan, J. Herb, L. Auermuller and C. Andrews. 2016. Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel. Prepared for the New Jersey Climate Adaptation Alliance. New Brunswick, New Jersey.

Following the same process, the same team at Rutgers University was engaged by the State of New Jersey Department of Environmental Protection to update the 2016 report based on the most current scientific information. Similar to the inaugural work, the 2019 STAP was charged with identifying and evaluating the most current and authoritative science on sea-level rise projections and changing coastal storms, considering the implications for the practices and policies of local and regional stakeholders, and providing practical options for stakeholders to incorporate science into risk-based decision processes.

The scientists that participated in the STAP were nationally and internationally recognized experts from many institutions and organizations including Drexel University; Princeton University; Rutgers University; Stevens Institute of Technology; U.S. Army Corps of Engineers; U.S. Environmental Protection Agency; the National Oceanic and Atmospheric Administration; the New Jersey Association for Floodplain Management; the New York City Mayor's Office of Resiliency; and Atmospheric and Environmental Research.

## **2. What were the findings of the 2019 STAP study?**

- *Sea-level rise* - The 2019 STAP examined both the magnitude (amount) and rate (speed) of sea-level rise in New Jersey.
  - **Magnitude:**
    - Historical sea-level rise in New Jersey: sea level in New Jersey rose 17.6 inches (1.5 feet) along the New Jersey coast from 1911 to 2019, compared to a 7.6-inch (0.6 feet) total change in the global mean sea-level.
    - Near term future projections of sea-level rise: New Jersey coastal areas are likely to experience sea-level rise of 0.5 to 1.1 feet between the years 2000 and 2030, and 0.9 to 2.1 feet between 2000 and 2050.
    - Longer term projections of sea-level rise.
      - Under a high-emissions scenario, coastal areas of New Jersey are likely to see sea-level rise between 1.5 to 3.5 feet between the years 2000 and 2070, and 2.3 to 6.3 feet between the years 2000 and 2100.
      - Under a moderate-emissions scenario, coastal areas of New Jersey are likely to see sea-level rise 1.4 to 3.1 feet between the years 2000 and 2070, and 2.0 to 5.2 feet between 2000 and 2100.
      - Under a low-emissions scenario, coastal areas of New Jersey are likely to see sea-level rise between 1.3 to 2.7 feet between the years 2000 and 2070, and 1.7 to 4.0 feet between the years 2000 and 2100.
  - **Rate:**
    - Over the last forty years, from 1979 to 2019, sea-level rose at an average rate of 0.2 inches per year along the New Jersey coast, compared to an average rate of 0.1 inches per year globally.
    - Near-term future rates of sea-level rise: New Jersey coastal areas are likely to experience average sea-level rise rates of 0.2 to 0.5 inches per year over 2010 to 2050.
    - Longer term future rates of sea-level rise
      - Under a high-emissions scenario, coastal areas of New Jersey are likely to see sea-level rise rates of 0.3 to 1.1 inches per year over 2060 to 2100.

- Under a moderate-emissions scenario, coastal areas of New Jersey are likely to see sea-level rise rates of 0.2 to 0.8 inches per year over 2060 to 2100.
  - Under a low-emissions scenario, coastal areas of New Jersey are likely to see sea-level rise rates of 0.2 to 0.6 inches per year over 2060 to 2100.
- *Coastal storms* - Higher sea-levels will increase the baseline for flooding and impacts from high tides and coastal storms (i. e., hurricanes and nor'easters):
- Hurricanes: The 2019 STAP focused on three issues with respect to hurricanes (i.e., tropical cyclones): frequency, intensity and precipitation. While most studies do not project an increase in the global frequency of tropical cyclones, both maximum wind speeds and the rate of rainfall during tropical cyclones are likely to increase. Changes in the frequency, wind speed and tracks of tropical cyclones remain an area of active research, and there is no definitive consensus at this time regarding such changes specific to New Jersey.
  - Nor'easters: The 2019 STAP reviewed the science with regard to the global frequency of nor'easters (i.e., extratropical cyclones) indicates that such frequency is not likely to change substantially. While there is some evidence for a decrease in frequency of extratropical cyclones over the North Atlantic as a whole, this is not apparent near the coast. While some research points to the possibility of changes to extratropical storm tracks in the North Atlantic, this research is not reliably established. Changes in the frequency, wind speed, precipitation rate, and tracks of extratropical cyclones remain an area of active research; at this time, there is no definitive consensus regarding such changes.
- *Tidal flooding* – The 2019 STAP reviewed the science with regard to the frequency of high-tide flooding, also known as “nuisance” or “sunny day” flooding. Between 2007 to 2016, there was an average of 8 high-tide -flood events in Atlantic City, NJ, with annual event totals ranging between 4 events in 2007 and 18 events in 2009. This frequency has grown from an average of less than one high-tide flood event per year in the 1950s. The frequency of high tides exceeding the current high-tide flood threshold will continue to increase with sea-level rise. For example, based on the likely range of sea-level rise projections, Atlantic City will experience 17 to 75 days of expected high-tide flooding per year in 2030, and 45 to 255 days per year of expected high-tide flooding in 2050.

### **3. What is sea level and how is it measured in the STAP report?**

*Sea level* refers to the elevation of the ocean in reference to the shoreline. Land that is higher than the shoreline is above sea level and land that is lower than shoreline is below sea level. Sea level is measured by tide gauges around the world as well as by satellites.

Sea level is not changing at the same rate at all points around the world; in fact, sea level rise in the Mid-Atlantic region of the United States is greater than it is globally. When describing local or regional sea-level rise (SLR), the STAP refers specifically to relative sea-level rise.

Global mean sea-level (GMSL) and local relative sea-level (RSL) are determined by several factors (Gregory et al., 2019; Kopp et al., 2015).

- Global mean sea-level (GMSL) is determined by the volume of water in the ocean. The three major processes contributing to GMSL change on human timescales are thermal expansion, land ice mass loss, and changes in terrestrial water storage.
- The same three factors that contribute to GMSL also contribute to local relative sea-level (RSL). Additionally, RSL is also affected by factors that cause changes in landforms (e.g., Kopp et al., 2015). In New Jersey, these factors include:
  - The ongoing adjustment of the solid Earth to the loss of the North American ice sheet at the end of the last ice age, (known as glacial isostatic adjustment), leading to SLR of about 0.5 in/decade across the region;
  - Natural sediment compaction and groundwater withdrawal along the Coastal Plain and in the Meadowlands, reaching up to about 0.4 in/decade along the Coastal Plain;
  - Dynamic sea-level changes due to changes in ocean circulation, temperature, and salinity, which may add as much as 1 ft/century in the U.S. Northeast under high-emissions scenarios; and
  - Gravitational, rotational and deformational effects (changes in the shape of Earth's gravitational field and crust associated with the large shifts of mass from ice to the ocean), which diminish the effect of Greenland ice sheet and Arctic glacier melt and increase the effect of Antarctic ice sheet melt.

#### **4. How does the 2019 STAP report differ from the 2016 report?**

The projections in the 2016 report were produced using the Kopp et al. (2014) framework, which was designed to produce local estimates of sea-level probabilities fairly consistent with the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report. As with the Fifth Assessment Report, the *likely* sea-level projections in the 2016 report did not fully integrate the possible instabilities in the polar ice sheets. As the 2016 STAP noted:

*These results represent one consistent, scientifically justifiable way of estimating the probability of different levels of SLR. Alternative methods or new science may yield higher or lower estimates of the probability of high-end outcomes. For example, one recent study (Deconto & Pollard, 2016) suggested that physics involving ice cliffs and ice shelves, not previously incorporated into ice sheet models, could render the Antarctic ice sheet significantly more vulnerable to melt within the current century than ice sheet models had previously indicated. Taken at face value, the results of that paper would elevate likely sea-level rise for New Jersey in 2100 under high emissions (RCP 8.5) to about 4–8 ft., while having little effect by 2050 or under low emissions. While this is just one study, it highlights the dynamic nature of the scientific knowledge. Accordingly, the STAP advises that extra consideration be given to high-end outcomes when assessing highly vulnerable or highly consequential people, places and assets.*

One key new study since the 2016 report was a structured expert judgement study (Bamber et al., 2019) of potential ice-sheet contributions to sea-level rise over the next three centuries. Structured expert judgement is a formal risk analytic method used for estimating the likelihoods of different outcomes when formal models are inadequate; it has been used for a variety of topics, including nuclear reactor safety, particulate matter pollution, food-borne disease, volcanic hazards, and COVID-19 transmission in schools. It uses a formal method to combine the expertise of experts, weighting their relative contributions to the analysis based on tests of the

experts' ability to estimate their own uncertainties as well as correct values for relevant calibration questions to which the correct answers are knowable.

The STAP report combines the structured expert judgement study of Bamber et al. (2019) with the approach used by the 2016 STAP report. The two approaches complement each other: the 2016 STAP likely ranges capture what is represented in the models used by the ice-sheet modeling community, while the Bamber et al. (2019) study uses a formal risk analytic method to incorporate estimates of the factors not in these models.

Because the two approaches give different estimates of likelihoods, the 2019 STAP reports ranges of probabilities: for example, based on both approaches, in a 2°C world, there is a 3-5% chance of exceeding 5 ft of sea-level rise by 2100, while in a 5°C world, there is a 12-38% chance of exceeding 5 ft by 2100. The summary table presents bounded probabilities (e.g, less than a 17% chance) that represent the consensus of both approaches (e.g., both approaches agree that, by 2100, there is less than a 17% chance of exceeding 3.9 ft in a 2°C world, 5.1 ft in a 3.5°C world, and 6.3 ft in a 5°C world).

This choice of using ranges of probability is a fairly conservative one, and we expect that, as scientific knowledge, estimates of probability from individual future scenarios will vary within the range the STAP report presents.

Other differences from the 2016 report include:

- The use of climate scenarios based on warming levels (i.e., global mean warming by the end of the century of 2°C, 3.5°C or 5°C above pre-industrial levels) rather than Representative Concentration Pathways,
- Incorporation of information on historical sea-level rise in New Jersey, and
- A focused discussion of tidal flooding.

## **5. What do the low, high, and moderate emissions scenarios used in the STAP report represent?**

Both the 2016 and 2019 STAPs indicate that longer term (post 2050) projections of sea-level rise are dependent upon the amount of greenhouse gas emissions in the Earth's atmosphere.

- The low emissions scenario corresponds to a world in which global warming is limited to 2°C above late-nineteenth century levels, consistent with the aspirations of the 2016 Paris Agreement. According to a 2018 Intergovernmental Panel on Climate Change Special Report, limiting global warming to 2°C, consistent with the low scenario, would require a global decline of carbon dioxide emissions of about 25% by 2030 and global net-zero emissions by about 2070.
- The high emissions scenario corresponds to a future with growth in fossil fuel emissions, leading to global warming reaching 5°C by 2100.
- The moderate emissions scenario is halfway between the two and corresponds to a future experiencing warming of about 3.5°C by 2100.

At the time of the writing of the 2019 STAP report, Climate Action Tracker projected that current global climate policies set the planet on course for a warming of 3.1-3.5°C by 2100.

Additional policies enacted in 2020 lowered Climate Action Tracker's projection for 2100 to 2.7-3.1°C.

## **6. What does the STAP report mean when it discusses 'likely' sea-level rise?**

Following the terminology used by the Intergovernmental Panel on Climate Change, the STAP uses the term 'likely' to mean 'at least a 66% (i.e., two-in-three) chance.' Based on the STAP's assessment, there is at least a two-in-three chance that future sea level will fall within the projected likely range. There could be as much as a 17% chance that it could be above the likely range.

## **7. If sea level rose in NJ at 0.2 inches/year over the last 40 years (1979-2019), how can the STAP report project that sea-level in 2030 could be more than 0.5 feet?**

The STAP report measures relative sea-level change using 19-year averages (tidal epochs) centered on each decade. This approach accounts for the variability in sea-level change on a year-to-year basis ([See STAP figure 2a](#)) driven by regional variability in atmosphere and ocean circulation. To measure the trend in sea-level by 2030, scientists will need tide gauge observations from the 19-year period 2021 to 2039 to accurately reflect change over the 19-year period 1991 to 2009 that serves as the 2000 baseline.

Were the historic rate of sea-level change in New Jersey to continue without acceleration, it would indeed yield a projection in 2030 of 0.5 feet above the 2000 baseline. This constitutes the lower end of the likely range. However, there is strong evidence for a global acceleration of sea-level rise. The IPCC concluded in a 2019 report: "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."

This acceleration is not apparent in local tide gauges over 1979 to 2019 due to the temporary masking effect of regional variability in atmosphere and ocean circulation. The panel expects accelerating global sea-level rise to be apparent over the next two decades, trending toward the higher values in the likely range for the 19-year tidal epoch from 2021 to 2039 (reported as 2030).

## **8. How do sea-level rise projections in the STAP study compare with projections made by others such as the IPCC, NOAA, and the USACE?**

In a review of other states' policies to inform Rutgers' work, Herb et al. (2019) found that most studied states were relying on NOAA (2017) or Kopp et al. (2014) as the scientific basis for their work. In the STAP report, the Rutgers expert panel compared its projections to the NOAA 2017 projections. It is also worth noting that the *likely* range projections that emerged from the STAP's approach are consistent with NOAA's three most central projections scenario ([See Figure 7](#) in the 2019 report). Interested parties can also compare the STAP projections to USACE projections using the [USACE Sea-Level Calculator](#). The STAP projections account for local relative sea-level rise. One would need to regionalize IPCC projections of Global Mean Sea Level in order to generate a direct comparison in a manner similar to methods used by the

[Southeast Florida Regional Climate Change Compact](#) (SFRC) . However, the global *likely* projections of Kopp et al. (2014) are fairly similar to those of the IPCC Fifth Assessment Report (within 3 inches in 2100) and can provide an approximate basis for comparison.

## **9. Was the STAP study built upon peer-reviewed research?**

The STAP study is a consensus report in which a panel of experts used a deliberative process that relied on the peer-reviewed literature on sea-level rise projections. As was done in the 2016 STAP, the 2019 STAP vetted its preliminary findings with a panel of diverse practitioners to ensure the findings were provided in a manner that was useful and informative in their planning and decision making practices.

The STAP deliberated upon several peer reviewed studies that provide probabilistic SLR projections for sites around the world, including New Jersey. These studies differ in their treatment of the polar ice sheets, as well as (in some cases) the climate scenarios considered. Examples of studies consulted include:

- Kopp et al. (2014) – This study is the framework used by the 2016 STAP. It is based upon the Representative Concentration Pathway (RCP) emission scenarios (van Vuuren et al., 2011) and yields projections of *likely* GMSL changes broadly consistent with IPCC AR5.
- Rasmussen et al. (2018) – This study is consistent with the framework and basic set of assumptions of Kopp et al. (2014), but employs different climate scenarios. In particular, rather than the RCPs, it uses warming-level scenarios based upon temperature projections for 2100, so that projections are (for example) for 1.5°C and 2.0°C global mean warming scenarios rather than for the RCPs.
- Kopp et al. (2017) – This study replaced the original Antarctic ice-sheet mass loss projections of Kopp et al. (2014) with those from the Antarctic ice-sheet modeling study of DeConto and Pollard (2016). The ice-sheet model used incorporated (for the first time in a continental-scale model) the gravitational instability of ice cliffs and exhibited high sensitivity to increasing atmospheric temperatures. This study was considered by the STAP but not integrated into its projections.
- Bamber et al. (2019) – This study replaced the Greenland and Antarctic ice-sheet projections of K14 with projections based on a structured expert judgment (SEJ) study of ice-sheet changes associated with climate scenarios leading to 2°C and 5°C of warming by 2100, and it produced sea-level rise projections consistent with these scenarios.

## **10. Does the STAP study offer policy recommendations?**

No. The STAP report is intended to provide a consensus scientific basis on which policy makers can build their decisions. Discussion as to the use of the STAP report to reflect variable asset life cycles, uncertainty principles, and other applicable decision points are for illustrative purposes.

### **11. Are other states using the approach that the NJ STAP used?**

Yes. Several jurisdictions use an expert-panel-led process to evaluate and produce a determination of the best available science for that jurisdiction. Jurisdictions that have used a similar scientific framework, in part or wholly, as that used in the 2016 STAP and 2019 STAP efforts include: California, Delaware, Maryland, Oregon, Washington, and City of Boston.

### **12. What uncertainties are included in the STAP report?**

The word “uncertainty” itself has slightly different meanings when used in everyday speech versus a scientific context. In scientific discourse, it conveys the extent to which a measurement or projection may be affected by information that is known to be imperfect or incomplete. One can think of it as the range of possible values for that measurement or projection. The STAP communicates uncertainty in their projections using the likelihood and confidence terminologies adopted by the International Panel on Climate Change (IPCC) AR5 Report (Mastrandrea et al., 2010).

### **13. How often should the expert panel report be updated?**

The STAP recommends that SLR projections be revisited periodically not to exceed 5 years, as well as after the release of any relevant reports from the Intergovernmental Panel on Climate Change (IPCC) or the U.S. National Climate Assessment, to assure that the estimates remain consistent with scientific advances.

## **ADDITIONAL BACKGROUND**

### **14. Why is sea-level change in the report measured from the year 2000?**

At the time of publication, the National Tidal Datum Epoch is the 19-year tidal cycle centered on 1992 (i.e., 1983 to 2010). For consistency with the sea-level projection literature, including most recent federal and state sea-level assessments, the baseline tidal epoch for the projections in this report is different from the National Tidal Datum Epoch. It is instead centered on the year 2000; more specifically, it is the average sea-level over the 19-year tidal cycle from 1991 to 2009. Users can adjust the STAP projection to the 1983 to 2001 National Tidal Datum Epoch (centered on the year 1992) by adding 1.4 inches (0.1 ft). For example, the STAP central estimate projection for 2050 is 1.4 ft above the 2000 baseline. This is equivalent to 1.5 ft above the 1983 to 2001 National Tidal Datum Epoch (1992). Due to atmosphere and ocean dynamics, the annual average sea-level can vary by up to 0.2 ft around the 19-year average sea-level centered in the same year.

### **15. How long has sea-level rise been occurring in NJ?**

Twenty thousand years ago, a giant ice sheet covered much of North America, extending as far south as northern New Jersey. Between about 18,000 years ago and 7,000 years ago, this giant ice sheet disappeared, and other glaciers and ice sheets around the world shrunk considerably, leading to a rapid rise in global average sea-level that was also experienced here in New Jersey. Over the last 4,000 years, the dominant long-term driver of SLR in New Jersey has been the sinking of the land as part of the ongoing response to the disappearance of the North American ice sheet.

Geological data indicate that, primarily as a result of land subsidence, sea-level in New Jersey rose about 6 inches/century ( $1.6 \pm 0.1$  mm/yr) from 0-1900 CE (Kemp et al., 2013; Kopp, Kemp, et al., 2016). Rates in the 20<sup>th</sup> and 21<sup>st</sup> centuries recorded by tide gauges are significantly higher (roughly three times higher than before), reflecting a growing contribution from processes related to current, greenhouse gas-driven climate changes. SLR along the Jersey Shore has been consistently faster than at The Battery over this



period, a difference predominantly attributed to subsidence associated with groundwater withdrawal (See Figure 2b in the 2019 STAP report).

From 1911 (the start of the Atlantic City tide-gauge record) to 2019, sea-level rose 17.6 inches along the New Jersey coast (average rate of 1.7 in/decade [ $4.2 \pm 0.1$  mm/yr]) in New Jersey. Sea-level rose 13.3 inches at the Battery (average rate of 1.2 in/decade [ $3.1 \pm 0.1$  mm/yr]). Comparatively, GMSL rose 7.6 inches (average rate of 0.7 in/decade [ $1.8$  mm/yr]) (Dangendorf et al., 2019; WCRP Global Sea Level Budget Group, 2018).

Over the last forty years, from 1979 to 2019, sea-level rose 8.2 inches along the New Jersey coast (average rate of 2.0 in/decade [ $5.2 \pm 0.2$  mm/yr]). Sea-level rose 6.5 inches at the Battery over the same period (average rate of 1.6 in/decade [ $4.1 \pm 0.2$  mm/yr]). Comparatively, GMSL rose 4.3 inches (average rate of 1.1 in/decade [ $2.7$  mm/yr]) (Dangendorf et al., 2019; WCRP Global Sea Level Budget Group, 2018) (see Figure 2).

Between the 19-year period centered on the year 2000 (1991-2009) and the 19-year period centered on the year 2010 (2001-2019), sea level rose by 1.5 in (3.8 cm) at The Battery, 1.7 in (4.2 cm) at Atlantic City, 2.0 in (5.2 cm) at Cape May, and 2.1 in (5.4 cm) at Sandy Hook.

#### **16. How would the projections of the 2016 report translate into the framework of the 2019 report?**

The 2016 report used different emissions scenarios than the 2019 report. Rather than the warming level-based projections in the 2019 report, the 2016 report used the more obscurely labeled Representative Concentration Pathways (RCPs) that were the standard emissions scenarios used by the climate modeling community from about 2010 to 2018. However, it is possible to reconstruct what the 2019 STAP would have produced had they chosen to adopt warming level-based scenarios but not been able to draw upon the work of Bamber et al. (2019) to characterize uncertainties not well represented in ice-sheet models. Indeed, these projections were an input (alongside the projections using Bamber et al, 2019) into the 2019 STAP headline numbers.

Had the 2019 STAP chosen to retain the methodology of the 2016 report, which was consistent with the state of knowledge represented in the 2013 Intergovernmental Panel on Climate Change report, the STAP would have projected a *likely* rise in New Jersey by 2100 of 1.7-3.6 feet (instead of 1.7-3.9 ft) in a 2°C scenario, 2.0-4.1 feet (instead of 2.0-5.1 feet) in a 3.5°C scenario, and 2.3-4.7 feet (instead of 2.3-6.3 feet) in a 5°C scenario.

Such ranges would have come with the caveat similar to that the IPCC included with its projections of likely sea-level change in its 2013 report: “collapse of 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. This potential additional contribution cannot be precisely quantified but there is *medium confidence* that it would not exceed several tenths of a meter of sea level rise during the 21st century.” (A tenth of a meter is equal to about a third of a foot.) The approach used by the 2019 STAP allowed that hazard to be quantified and incorporated into key figures and tables using a formal risk analytic method.

#### **17. What critical research is underway to assess risk from sea-level rise in the future?**

While flood risks are often modeled as independent events, recent research is focusing on modeling compound events. The STAP panel and practitioners discussed the need to move toward models that can represent combined hazards from rainfall and flooding that can co-occur.