Arctic land ice is melting, sea ice is decreasing, and permafrost is thawing. Changes in these Arctic elements are interconnected, and most interactions accelerate the rate of change. The changes affect infrastructure, economics, and cultures of people inside and outside of the Arctic, including in temperate and tropical regions, through sea level rise, worsening storm and hurricane impacts, and enhanced warming. Coastal communities worldwide are already experiencing more regular flooding, drinking water contamination, and coastal erosion. We describe and summarize the nature of change for Arctic permafrost, land ice, and sea ice, and its influences on lower latitudes, particularly the United States. We emphasize that impacts will worsen in the future unless individuals, businesses, communities, and policy makers proactively engage in mitigation and adaptation activities to reduce the effects of Arctic changes and safeguard people and society.

Popular media articles commonly refer to the Arctic as a disappearing physical environment, using words like shrinking, melting, dissolving, thawing, and collapsing. These descriptors give the impression that the Arctic, which already feels distant to most people, is fading away and becoming a relic. It is easy then to consider these far-off events as only a scientific curiosity, with negligible influence on global environments and economies. But in fact, as permafrost, land ice, and sea ice in the Arctic (Figure 1) rapidly thaw, melt, and shrink, the Arctic has an increasing impact on societies and infrastructure across the globe. The effects show up as amplified climate change, rising sea level, coastal flooding and erosion, and more devastating storms (Figure 2; e.g., AMAP, 2017). As we will discuss here, the global footprint of infl

Permafrost, land ice, and sea ice are commonly discussed as separate features of the Arctic environment, although in fact they are closely interconnected. First, they are responding to common climate forcing across the Arctic, and second, each component is influencing changes in the other components. For example, sea ice loss is projected to continue, including periods of especially rapid change (e.g., Holland et al., 2006; rapid declines already occurred in 2007 and 2012; Stroeve et al., 2012). Rapid sea ice loss not only heightens atmospheric warming, but also early loss of sea ice locally near the Greenland Ice Sheet may increase heat transfer from the ocean to the atmosphere above the ice sheet and result in increased ice sheet melt (Stroeve et al., 2017). Rapid sea ice loss also has a significant effect on temperatures over land with implications for permalatitudes, the temperature gradient from the North Pole to the Equator is declining, weakening west to east jet stream winds, and contributing to a wavier jet stream (Francis & Vavrus, 2012). This derives in part from diminishing Arctic sea ice. Diminished sea ice allows the ocean north of Alaska to take up more summer heat. In autumn, the heat is released into the atmosphere causing stronger northward swings, or ridges, in the jet stream. This type of Arctic warming may have strengthened the atmospheric ridge that was largely responsible for California's recent extreme drought (Swain et al., 2016). The downstream effect of this northern ridge is also an intensified south dipping trough, which brought extreme cold to eastern U.S. states during the 2013/2014 and 2014/2015 winters. These large jet stream waves are more likely to remain in one place, bringing locally persistent warm and dry or cold and stormy weather (e.g., Mann et al., 2018).

As the flattest, most lowlying U.S. state, Florida is a stark example of the negative influence Arctic change is having and will have in lower latitudes. Key West has already experienced a threefold increase in coastal flooding since 1990, and St. Petersburg has seen a 40% increase. Future increases in sea level and storm damage will negatively affect major infrastructure. Across the state, ~5,500 km^2 of land lie less than 1 m above the high tide line. This includes 300,000 homes, 35 public schools, 4,112 km of road, and 978 U.S. Environmental Protection Agency listed hazardous waste dumps or sewage plants (Strauss et al., 2014). Within 2 m above high tide, the land area affected almost doubles, and overall property value rises from $145 billion (at 1 m) to $544 billion, including 14 power plants and 1.4 million homes. Within just the next 30 years, floods that rise up to 60 cm above the high tide line could occur every 1 to 5 years depending on location. Around the world, other low lying regions are experiencing similarly severe effects. Assuming global mean sea level rises of 0.2–2.0 m by 2100, 72 to 187 million people will be displaced if no protections are put into place (Wong et al., 2014). Some communities, for example, on the Torres Islands, Vanuatu, have already been displaced (Nurse et al., 2014).

5. Conclusions and a Call to Action

Unprecedented changes underway in Arctic permafrost, land ice, and sea ice have direct and indirect effects on the Continental United States and other temperate and tropical countries. The recent Intergovernmental Panel on Climate Change 2018 report on Global Warming of 1.5 °C underscores that every additional level of warming has far reaching consequences. With a global mean surface temperature change of 1.5 °C or more above preindustrial levels, relative to the 1.0 °C rise that we have already seen, the change in the Arctic, the occurrence of extreme events, and the interconnectedness of global impacts increase substantially (IPCC, 2018). Businesses, municipalities, state, and national decision makers must weigh the choice of reducing greenhouse gas emissions against spiraling upward costs of reactive adaptation and mitigation. At the same time, concerted planning efforts are needed to prepare for the impacts that are already inevitable due to

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