DRAFT: SUMMARY OF *AMERICAN CLIMATE PROSPECTUS* DATA DESCRIBING CLIMATE IMPACTS FOR MARYLAND

The *American Climate Prospectus* (ACP) served as the technical input to the Risky Business project, a broad-based effort to raise awareness about the potential costs of climate impacts in the United States during the 21st century.

In this paper, we summarize the information about the costs of climate impacts in ACP that are specific to the state of Maryland. The impacts examined include: increases in heat-related mortality, increases in the amount of coastal property exposed to flooding, declines in labor productivity, increases in energy expenditures, and declines in agricultural output. For the mortality impacts, annual costs could be several billion dollars by mid-century. Approximately $9 billion of Maryland's coastal property is likely to be below sea level in the coming decades; that estimate could exceed $20 billion for end-of-century sea levels. Other impacts are smaller in a monetary sense, generally on the order of millions of dollars annually. However, in all cases: 1) risks and costs grow with increasing warming, and 2) risks for substantial costs exist in the coming decades, even if significant reductions in global greenhouse gas emissions are achieved.

About the American Climate Prospectus

Overview and Methodology

The *American Climate Prospectus* (ACP; http://www.climateprospectus.org) is an assessment of the economic risks associated with climate change in the United States, completed by the Rhodium Group (http://rhg.com/). The assessment was completed in 2014 and served as the technical input to the Risky Business Project (http://riskybusiness.org/).

ACP is novel in that it uses a consistent methodology to estimate the potential costs of climate impacts in the 21st century across a range of sectors and regions (see Figure 1). It takes advantage of some of the most recent projections for future climate, using a risk-based framework of analysis. The ACP analysis draws upon econometric relationships, linking these climate variables to impacts on human health, labor productivity, and agriculture.[1] The analysis also employs a sector-specific approach for estimating future energy demands and expenditures (i.e., the analysis draws on a model that links climate to domestic energy use), and for estimating the exposure and potential damage to coastal property. All the data regarding future climate conditions, impacts, and costs are publicly available at http://rhg.com/wp-content/uploads/2015/06/ACP-Science-data-tables.zip. More in-depth descriptions of the methodology for each type of impact is provided in the ACP report, and its associated Technical Appendices, all available online (http://www.climateprospectus.org).

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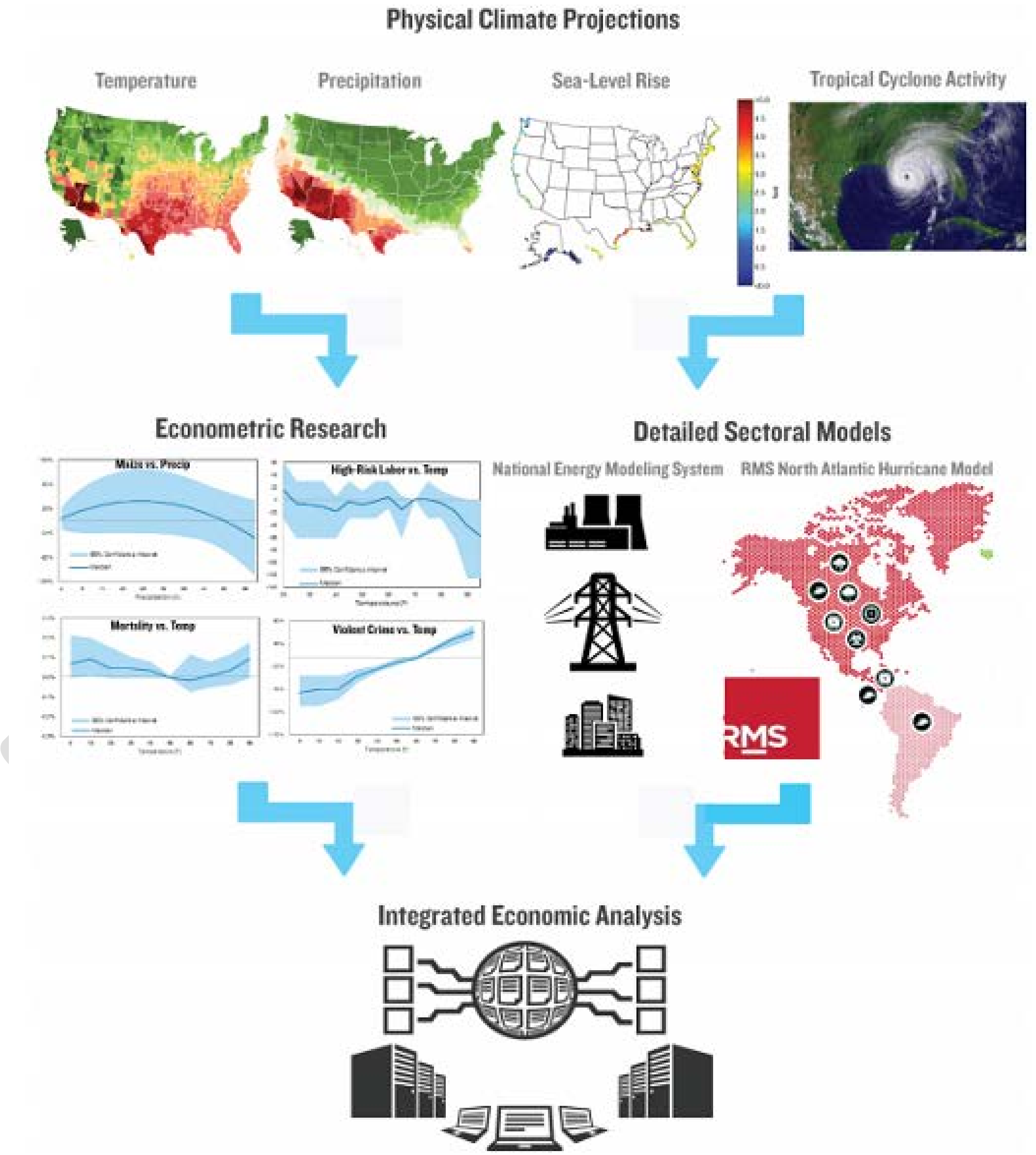
[1] The report also explores the relationship between climate and crime. However, given the number of non-climate factors that affect the incidence of crime, these impacts have not been included in this summary.

This report is an independent interpretation of the data analysis conducted by the ACP team. Any additional information and discussion of these data included in this report is separate from the findings of the ACP team.

Figure 1. A Schematic Depicting the Methodology Used in the American Climate Prospectus (SOURCE: ACP, Figure 1.1)



Time Periods, Scenarios, and Risk Framing

In this paper, we draw upon three scenarios and three time periods presented in ACP for estimates of future impacts and costs. These time periods and scenarios span a relatively wide range of potential future climate conditions, demonstrating the difficulty in precisely predicting future choices regarding greenhouse gas emissions, as well as the pace and magnitude of the climate system's response to those emissions. These uncertainties reinforce the need to think about future impacts from the standpoint of *risk* – despite the lack of a "crystal ball," we can generate a range of plausible climate futures and examine the probability of different consequences and costs that are associated with those future climate conditions.

The three time periods examined can be interpreted as **near-term**, **mid-century**, and **end-of-century**. The near-term results have been compiled from averages of the 2020-2039 climate conditions (labelled as "2030" on most graphs); the mid-century results correspond to 2040-2059 climate conditions (labelled as "2050"); the end-of-century results correspond to 2080-2099 climate conditions (labelled as "2090").

The three scenarios are the same that were developed for the Fifth Assessment Report (AR5) from Intergovernmental Panel on Climate Change (IPCC). A brief description of each is as follows:

RCP[2] 2.6 – This scenario assumes that the global community pursues immediate and significant action to reduce emissions, emissions peak in the first few decades of the 21st century, and that net emissions are close to zero during much of the second half of the 21st century. This scenario provides a likely chance (66 to 100 percent) of avoiding 2°C of warming[3], globally-averaged.

RCP 4.5 – This scenario assumes that the global community pursues policies to reduce greenhouse gas emissions in the early part of the 21st century, and that emissions peak around mid-century. It is somewhat comparable to the B1 scenario from previous IPCC reports, but defines different drivers in achieving emissions reductions (e.g. socio-economic and technological advancements versus direct climate mitigation initiatives). This scenario provides a chance (33 to 66 percent) of avoiding 2°C of warming by the end of the 21st century.

RCP 8.5 – This scenario can be loosely interpreted as "business as usual." Emissions continue to grow through most of the 21st century. Globally-averaged warming has a roughly 50-50 chance of exceeding 4°C by the end of the century.

Climate Impacts for Maryland from ACP

The following graphs identify a range of potential physical impacts that may affect the state of Maryland through the end of this century. The colored rectangles in these graphs show a "likely range" for each scenario and time period. Statistically speaking, these ranges correspond to the 17th and 83rd percentiles of the distributions generated in the ACP analysis (i.e., greater than two-thirds of the projected values lies within one standard deviation above and below the mean). The lines extend to the 5th and 95th percentiles – impacts at these levels can be considered a 1-in-20 chance.

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[2] Representative Concentration Pathways (RCP) are greenhouse gas concentration trajectories.

[3] The increase in warming is compared to the pre-industrial (1880) globally-averaged temperature.

It is important to note that the data presented within each graph result from a suite of 35 global climate models (GCM), downscaled to provide state-specific information on future trends in temperature, precipitation, and sea-level rise, and is interpreted within a framework that generates self-consistent probability distributions. These are the same GCMs used by the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Government in their latest assessment reports – the AR5 and the 3rd National Climate Assessment, respectively.

For many of the physical and subsequent economic impact categories, the differences among scenarios are small in the near-term and around mid-century. This reflects the long lifetime (decades to centuries) of majority of greenhouse gases, as well as the slow turnaround time for the energy system. Most impacts for the next several decades are essentially "baked into" the climate system, arising from emissions occurring in past decades. However, at the end of the 21st century, the choices made regarding the world's energy systems will have a significant influence on the severity of impacts.

Temperature

Under all RCP scenarios average seasonal temperatures rise throughout the course of the 21st century.

Figures 2 and 3 show the ranges for increases in the average summer and winter temperature during the 21st century compared to the 1981-2010 climatological average. A thirty-year average is used in place of a yearly average to minimize any potential effects of natural variation. In the early part of the 21st century, increases in the median average temperature range between 2°F and 3°F above the climatological average for both summer and winter. By mid-century, the median values begin to increase more sharply, especially for the RCP 8.5 scenario. By the end of the century, median temperatures range between 2.5°F and 9°F above the current average. The 1-in-20 chance associated with RCP 8.5 corresponds to an average summer temperature of 90.0°F and an average winter temperature of 48.1°F. This is 15.5°F and 12.6°F above the current climatological average, respectively.

Figure 2. Projected Changes in Average Summer Temperature in Maryland in the 21st Century

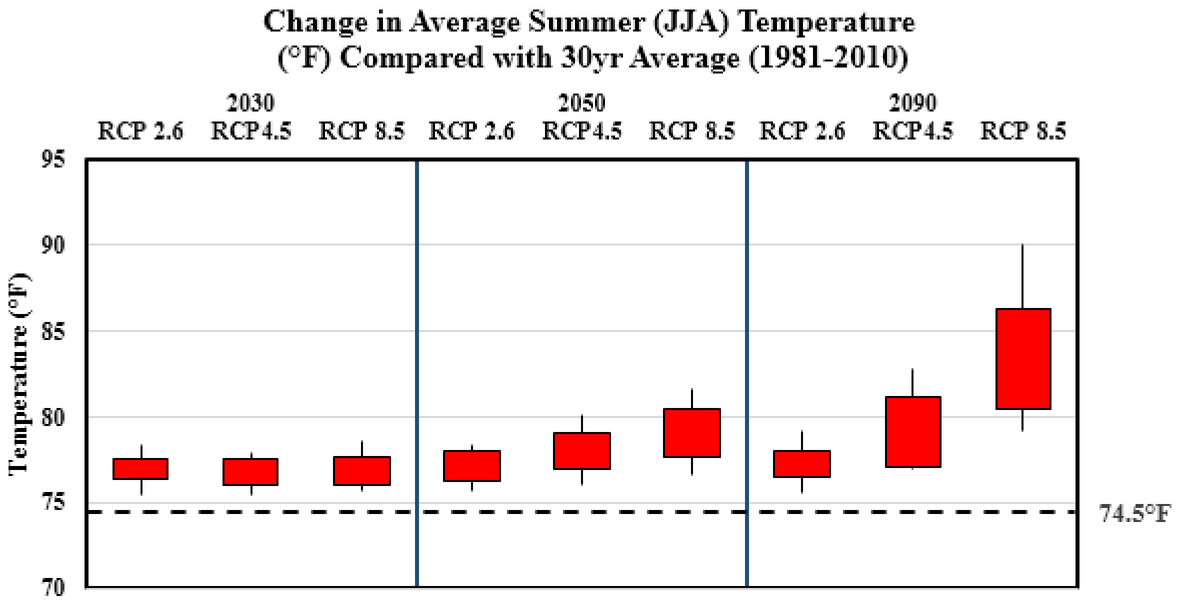


Figure 3. Projected Changes in Average Winter Temperature in Maryland in the 21st Century

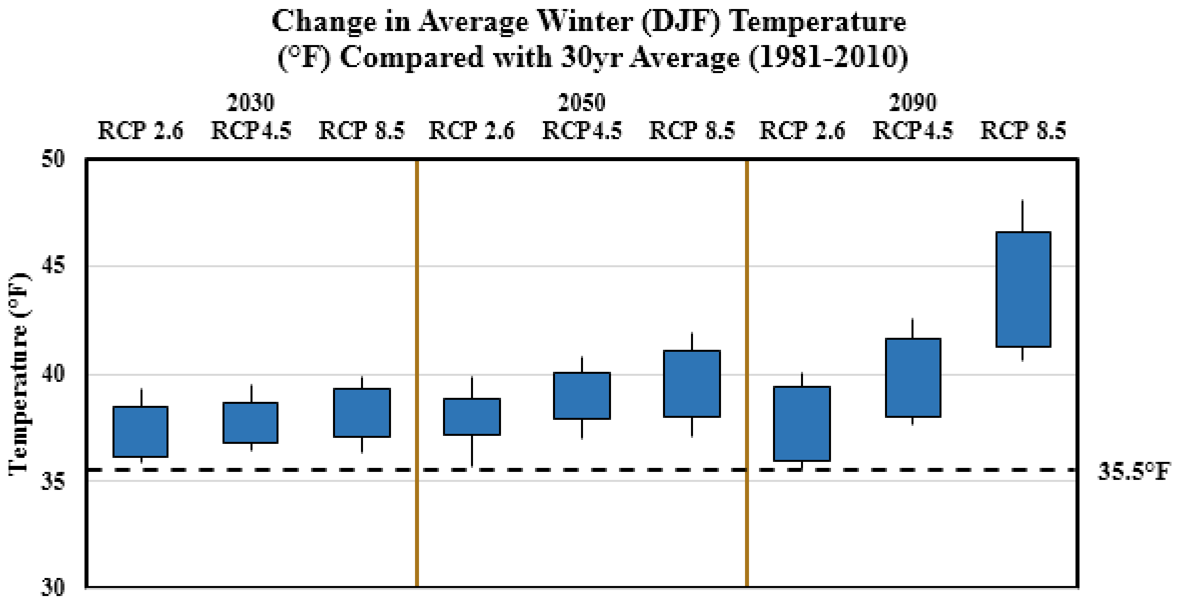


Figure 4 shows the ranges for increases in the number of days above 95°F compared to the 1981-2010 climatological average of 6.4 days. Under the RCP 8.5 scenario, the expected number of days above 95°F increases to 16 days by 2030, with a likely range of 11 to 17 days. By 2050, the expected number of days above 95°F increases to 27 days, with a likely range of 16 to 35 days. By the end of the century, this value increases to 62 days, with a likely range of 33 to 85 days. Also under the RCP 8.5 scenario, there is a 1-in-20 chance of 111 days above 95°F by the end of the century.

Figure 4. Projected Changes in Number of Days above 95°F in Maryland in the 21st Century

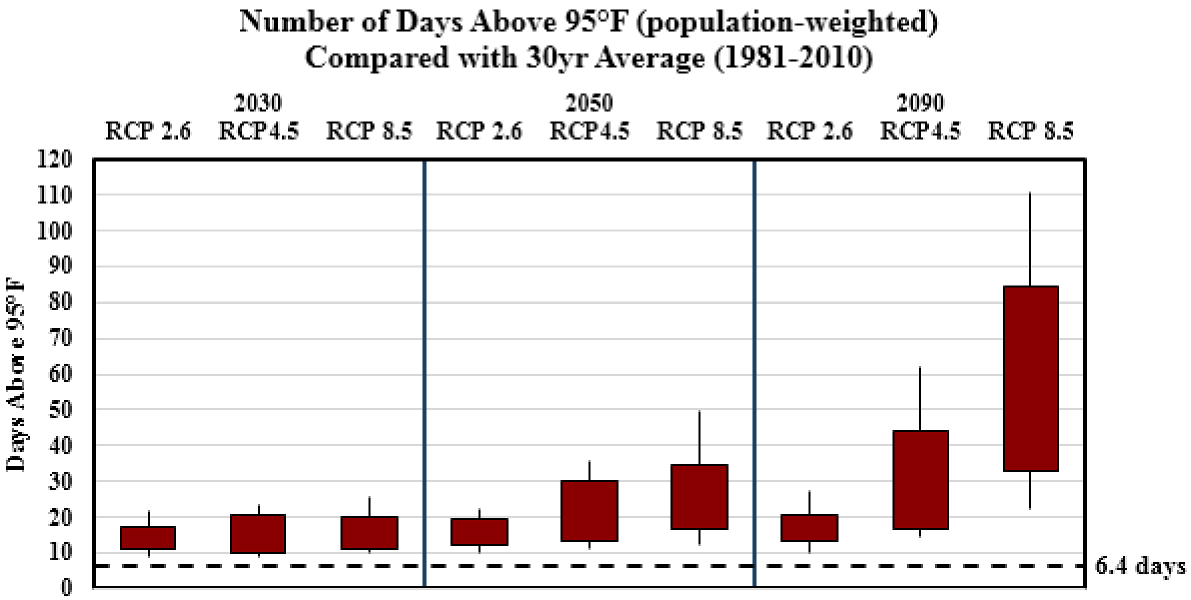
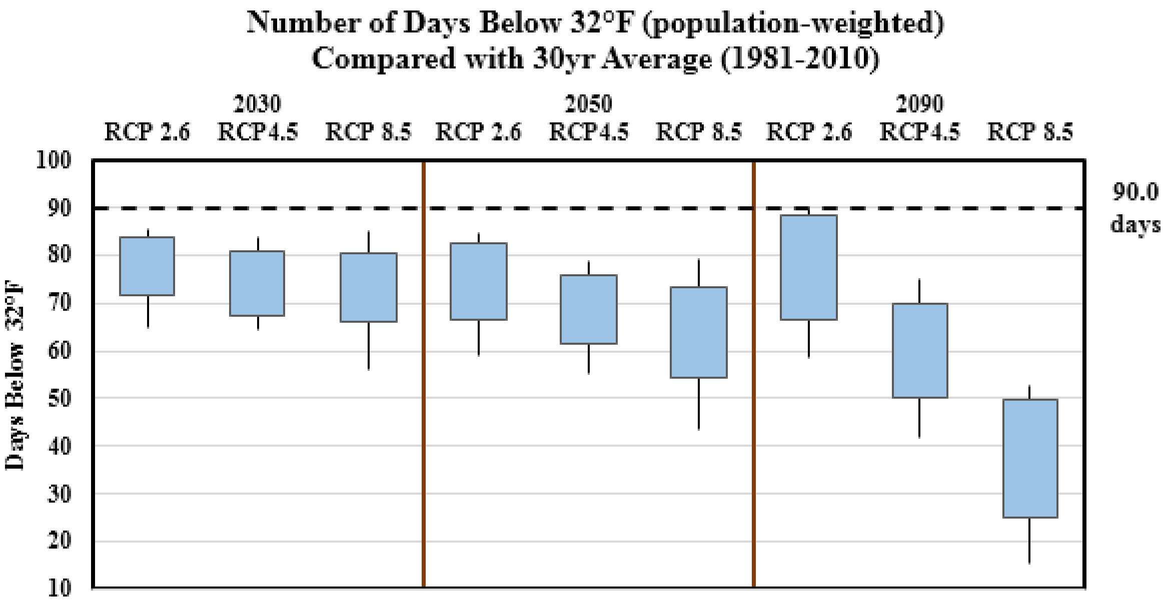


Figure 5 shows the ranges for increases in the number of days below 32°F compared to the 1981-2010 climatological average of 90 days. Under the RCP 8.5 scenario, the expected number of days below 32°F decreases to 56 days by 2030, with a likely range of 66 to 80 days. By 2050, the expected number of days below 32°F decreases to 43 days, with a likely range of 55 to 73 days. By the end of the century, this value increases to 38 days, with a likely range of 25 to 50 days. Also under the RCP 8.5 scenario, there is also a 1-in-20 chance of 15 days below 32°F by the end of the century.

Figure 5. Projected Changes in Number of Days below 32°F in Maryland in the 21st Century

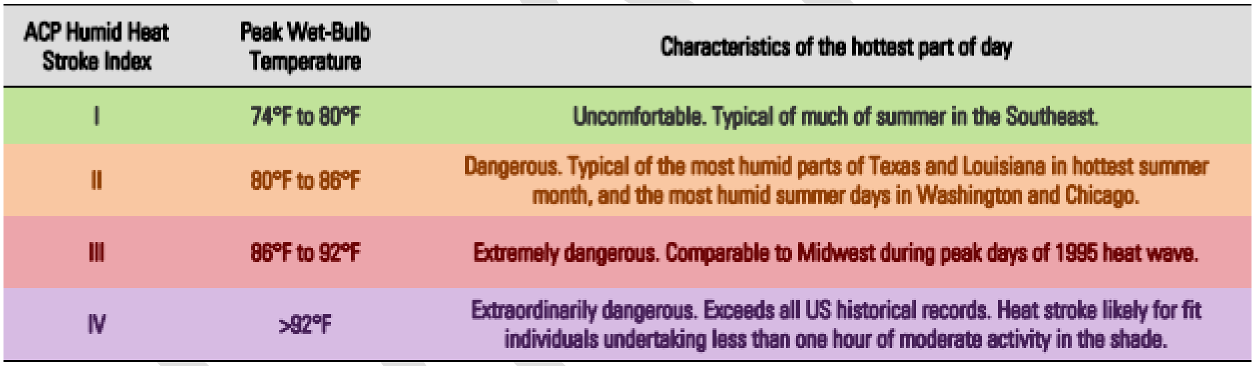


Heat and Humidity

Figures 6 and 7 identify the range of increases in the number of Humid Heat Stroke Index (HHSI) days compared to the 1981-2010 climatological average. The HHSI developed for the ACP takes into account not only ambient air temperature, but an evaporative measurement known as a wet-bulb temperature. This measurement is made by wrapping the bulb of a thermometer in wet cloth and allowing the moisture to evaporate. Evaporation is a cooling process, and as such the temperature of the cloth decreases. The wet-bulb temperature is the lowest temperature achieved by this process. The higher the wet-bulb temperature, the more moisture in the air. The more moisture in the air, the higher the humidity, and the more difficult it is to regulate body temperature by sweating.

ACP has defined four categories of HHSI (Table 1). Category I reflects the typical uncomfortable conditions experienced in the Southern U.S. during the summer months. Category II reflects the most humid conditions experienced in the Southern U.S. and expanding into the Midwest and along the East Coast during the hottest periods of the summer season. Category III reflects the most dangerous conditions experienced during record events such as the 1995 heatwave in the Midwest. Category IV reflects extreme events that have exceeded current U.S. records.

Table 1. Categories of ACP Humid Heat Stroke Index



ACP Humid Heat Stroke Index	Peak Wet-Bulb Temperature	Characteristics of the hottest part of day
I	74°F to 80°F	Uncomfortable. Typical of much of summer in the Southeast.
II	80°F to 86°F	Dangerous. Typical of the most humid parts of Texas and Louisiana in hottest summer month, and the most humid summer days in Washington and Chicago.
III	86°F to 92°F	Extremely dangerous. Comparable to Midwest during peak days of 1995 heat wave.
IV	>92°F	Extraordinarily dangerous. Exceeds all US historical records. Heat stroke likely for fit individuals undertaking less than one hour of moderate activity in the shade.

Under the RCP 8.5 scenario, the expected number of HHSI I days by the end of the century in Maryland increases from the climatological average of 37 days to 78 days, with a likely range of 69 to 84 days. The expected number of HHSI II days increases from the climatological average of 1 day to 43 days, with a likely range of 25 to 57 days. There is also a 1-in-20 chance of 88 HHSI I days and 71 HHSI II days. Although not graphed, the number of occurrences for category III and IV days also increases. By 2090, the expected number of HHSI III days increases from zero to 8. The number of HHSI IV days increases from zero to 1.

Figure 6. Projected Changes in the Number of HHSI I Days in Maryland in the 21st Century

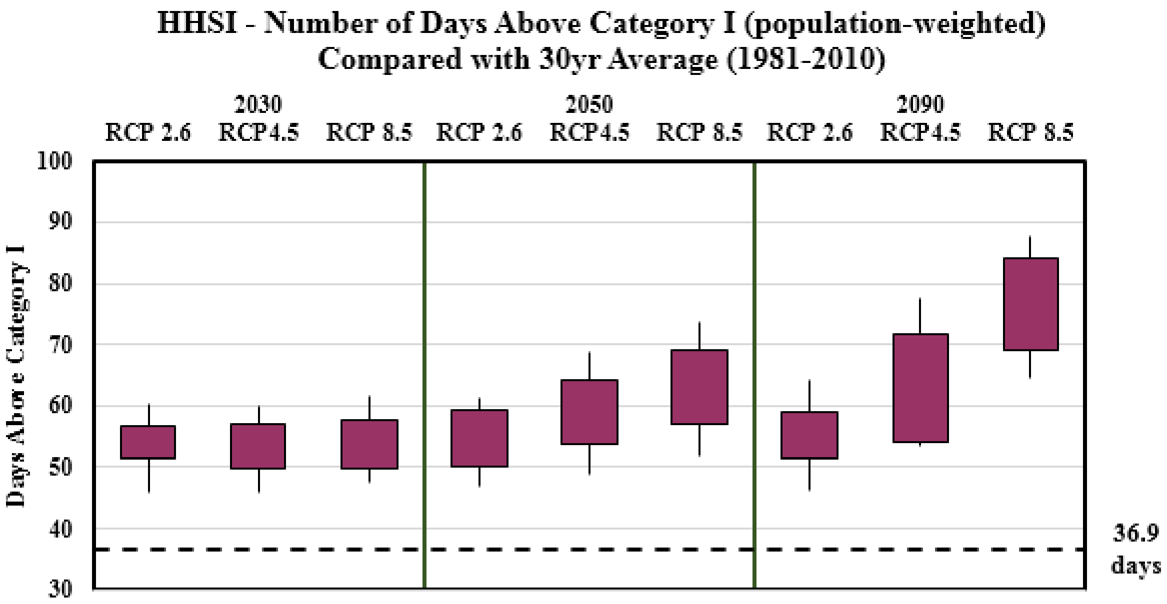
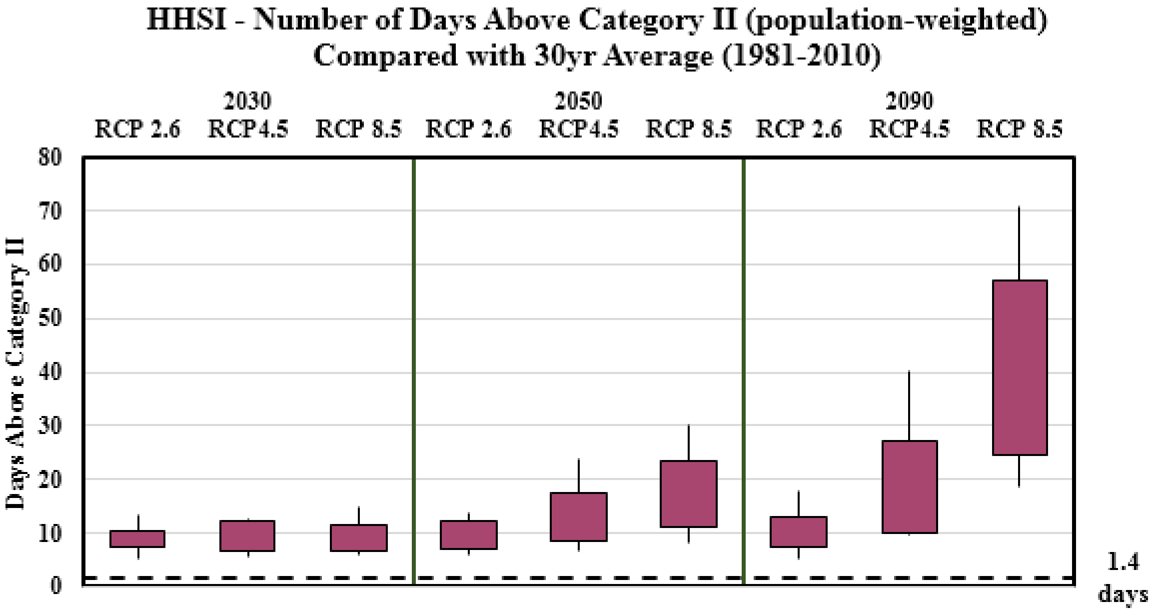


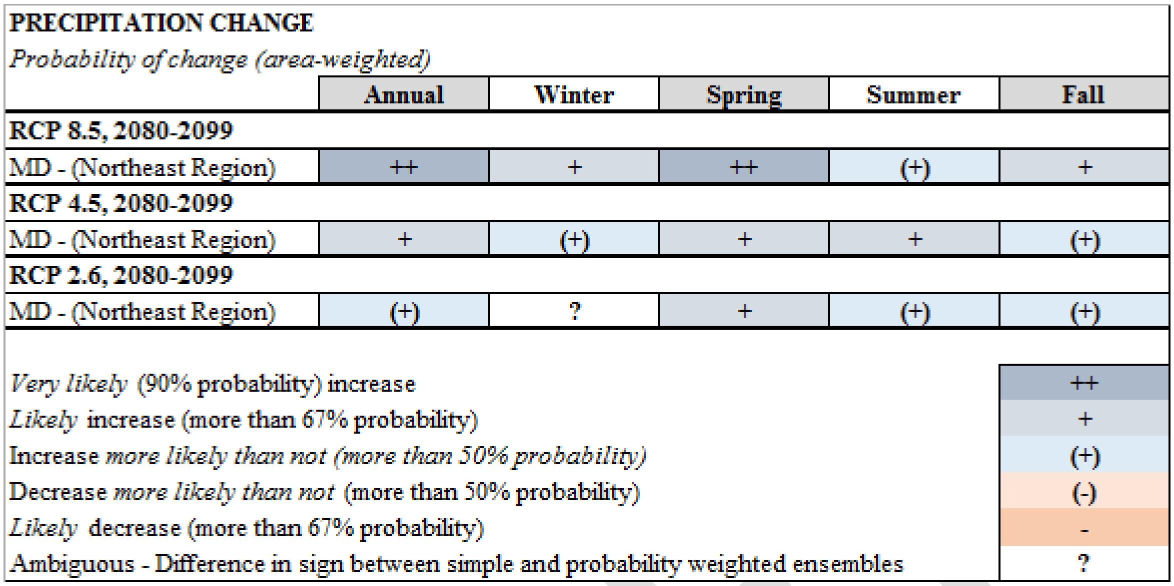
Figure 7. Projected Changes in the Number of HHSI II Days in Maryland in the 21st Century



Precipitation

Figure 8 shows the probability of change in precipitation when compared to the climatological average by the end of the 21st century. In Maryland, both seasonal and annual precipitation amounts are likely to increase under all three scenarios, with the highest likelihood of increased precipitation (>66%) occurring in the spring season and the RCP 8.5 scenario.

Figure 8. Projected Changes in Annual and Seasonal Precipitation in Maryland in the 21st Century



PRECIPITATION CHANGE
Probability of change (area-weighted)

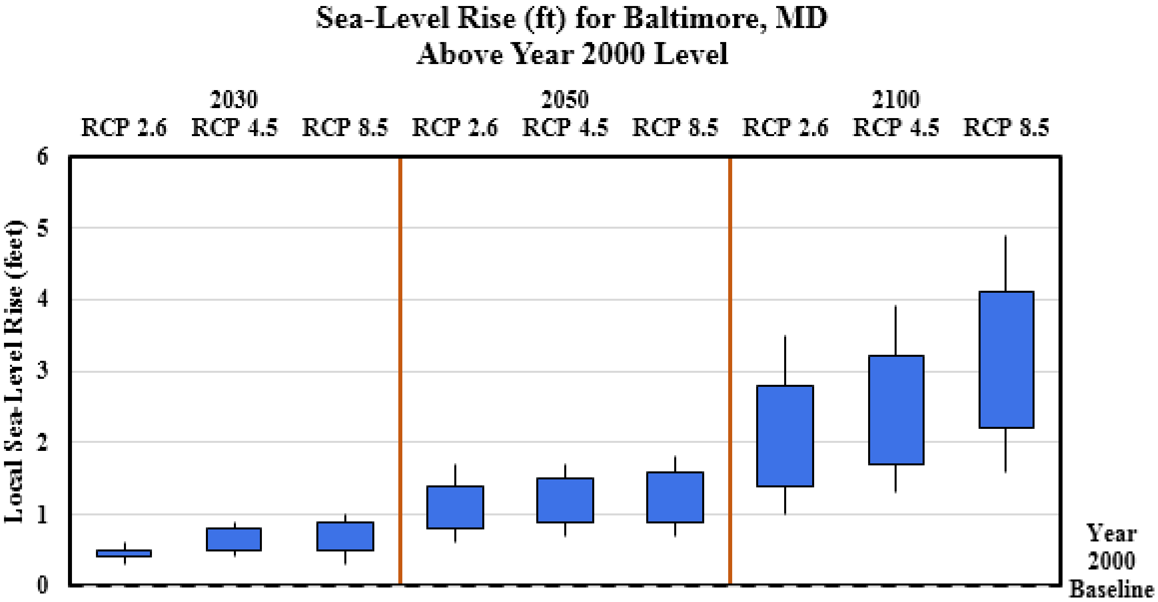
	Annual	Winter	Spring	Summer	Fall
RCP 8.5, 2080-2099					
MD - (Northeast Region)	++	+	++	(+)	+
RCP 4.5, 2080-2099					
MD - (Northeast Region)	+	(+)	+	+	(+)
RCP 2.6, 2080-2099					
MD - (Northeast Region)	(+)	?	+	(+)	(+)

Very likely (90% probability) increase	++
Likely increase (more than 67% probability)	+
Increase *more likely than not (more than 50% probability)*	(+)
Decrease *more likely than not* (more than 50% probability)	(-)
Likely decrease (more than 67% probability)	-
Ambiguous - Difference in sign between simple and probability weighted ensembles	?

Sea-Level Rise

Figure 9 shows ranges for increases in sea level above the 2000 level by 2100 for the city of Baltimore, MD. In the early part of the 21st century, increases in the median sea level range between 0.4ft and 0.9ft above the 2000 baseline. The median sea level range continues to increase to between 0.8ft and 1.6ft above the 2000 baseline, but displays little to no dependence on RCP scenario. However, by 2100 the range of sea level increases dramatically and is dependent on RCP scenario. Median values range from 1.4ft to 4.1ft, with an RCP 8.5 1-in-20 chance increase of 4.9ft and a 1-in-100 chance increase of 6.8ft.

Figure 9. Projected Changes in Sea-Level Rise for Baltimore, MD in the 21st Century



Combined Effects

In 2014, the total value of grain crops exceeded $680 million[4]. While a warming climate may increase the growing season and some crop yields, especially those harvested more than once per year, extended periods of extreme warmth above critical growth temperatures will limit yields (Porter et al., 2005). Additionally, increases in surface ozone levels due to warmer temperatures will also stunt crop growth and limit yields (Ainsworth et al., 2012). Furthermore, warmer temperatures may favor different crop varieties, causing farmers to switch less economically viable crops (Mercer & Perales, 2010).

Additionally, warmer air temperatures will translate to elevated surface water temperatures for the Chesapeake Bay region, affecting a fishing industry contributing over $600 million (2014) to the state's economy[5]. For some species – Brown shrimp, Spotted seatrout, and Black drum – warmer water may be more favorable. For others – Winter flounder, Soft-shelled clam, and Eastern oyster, the warmer temperatures could exceed their habitable range (Glick et al., 2007). Warmer water temperatures in the presence of an abundance of nutrients can also lead to harmful algal blooms (HAB) and hypoxia (Paerl & Huisman, 2009). A decrease in oxygen within the marine environment would prove detrimental to aquatic species.

Furthermore, likely increases in precipitation will affect the agricultural and fisheries sectors. Higher precipitation rates and amounts will likely lead to increased agricultural runoff, including fertilizers. This may result in increased amounts of fertilizer use by farmers and increased fertilizer in coast waterways, providing a favorable ingredient for the development of HABs.

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[4] MD State Archives – Agriculture 2014.
[5] MD State Archives – Seafood 2014.

Impacts on public health are also contingent on these climatological factors. Heat-related and respiratory illness will increase due to warmer temperatures and resultant increased pollution (Shea et al., 2008). Rates of vector- borne and waterborne disease will also increase as warmer winter temperatures and increased spring and summer precipitation produce optimal breeding conditions for mosquitos and bacteria such as cryptosporidium and giardia (Hunter, 2003). In Maryland, asthma rates have increased 5.5% in Baltimore and 1.8% throughout the state between 2000 and 2009[6]. Eighty-eight cases of West-Nile Virus have been reported since 2011[7].

Coastal regions are not immune to climate change impacts. Maryland's coastal counties account for over two thirds of the state's population and attract two thirds the state's tourists. In 2013, Maryland's tourist sector was valued at $15.4 billion, bringing in over $2.1 in tax revenue for the state[8]. Rising sea-levels place the coastal infrastructure in jeopardy, potentially reducing residential and tourist traffic and adversely affecting valuable coastal communities.

These climatological impacts are multi-faceted and inter-connected, and will significantly affect Maryland's agricultural resources, coastal environment, and air quality – all factors intimately tied to the state's economic well-being.

Impacts and Costs for Maryland from ACP

The following graphs show how climate change may affect health, coastal property, energy expenditures, labor productivity, and agriculture in Maryland. These categories represent a starting point for understanding the economic magnitude of *some* potential impacts. For example, no estimates are provided in ACP of how climate change might affect water resources, ecosystems, or aspects of human health beyond heat-related mortality (e.g., respiratory ailments associated with lower air quality, changes in the ranges of disease vectors).[9]

It is also critical to understand that the ACP modelling applies no assumptions about future changes in the economy. In other words, the estimates of impacts assume that the future climate conditions are affecting the population and economy of today. In the "real world," there will certainly be changes in many factors that are economically important between now and 2100 (e.g., patterns of land use; age-distribution of the population; location of communities; new technologies that affect labor, energy, agriculture, and health). As such, the impact estimates can be viewed as an indication of what is at stake if our economy was suddenly subject to a future climate, or what might happen if communities did nothing to prepare for the increases in risk over the coming decades.

All cost estimates are in 2011 U.S. Dollars.

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[6] MD Dept. of Health and Mental Hygiene Baltimore City Asthma Report, August 2011. Asthma and other respiratory ailments are not solely dependent on air quality.

[7] MD Dept. of Health and Mental Hygiene Arbovirus Surveillance Reports 2011-2014. The spread of water- and vector-borne illnesses are not limited to the degree of climate change impacts presented in this report.

[8] MD Dept. of Tourism 2014 Annual Report.

[9] We will explore available information for these other impacts in a subsequent paper. But it is unlikely that precise, comparable ranges for future costs will be available for many of these other types of impacts.

Increases in Heat-Related Mortality

Figure 10 shows the ranges for increases in the mortality rate during the 21st century. In the early part of the 21st century, decreases in cold-related deaths may potentially offset increases in heat-related mortality, as the "likely" ranges include both positive and negative values. However, by mid-century, the median values for each of the three scenarios are all positive, indicating that it is more likely that increases in heat-related deaths would exceed reductions in cold-related deaths. By the end of the century, benefits become less likely. The 1-in-20 chance associated with RCP 8.5 corresponds to an increase in mortality of over 30 deaths per 100,000 people.

Costs associated with heat-related mortality are shown in two different ways (Figures 11 and 12). In Figure 11, the costs are based on the "Value of a Statistical Life" (VSL), which is commonly used in economic analysis to estimate potential costs and benefits related to mortality. The VSL estimate ($7.9 million per person) used in ACP[10] is based on values used by U.S. the Environmental Protection Agency (EPA). These estimates track the changes in mortality – costs or benefits may be on the order of several billion dollars per year in the early part of the century. The likely range for near-term and mid-century impacts range from approximately $2 billion in benefits to $3.4 billion in costs. At the end of the century, costs are projected to exceed benefits – the median values for all scenarios are all greater than zero. And all scenarios have increasingly large "tail risks." For example, with the RCP 8.5 scenario there is a 1-in-20 chance for additional annual costs to exceed $15 billion.

"Market" costs (Figure 12) reflect the changes in labor productivity related to the loss of workers and their income. These costs are much smaller than the VSL estimates; in the near-term and at mid-century, the likely ranges begin around $20-50 million in annual benefits and go up to nearly $200 million in annual costs (note the difference in scale of the y-axis). However, unlike the VSL estimates, in all time periods the median cost estimates are greater than zero. At the end-of-century, the RCP 8.5 scenario has a 1-in-20 chance for additional annual costs to exceed $1 billion.

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[10] ACP, p. 108

Figure 10. Projected Changes in Mortality in Maryland in the 21st Century

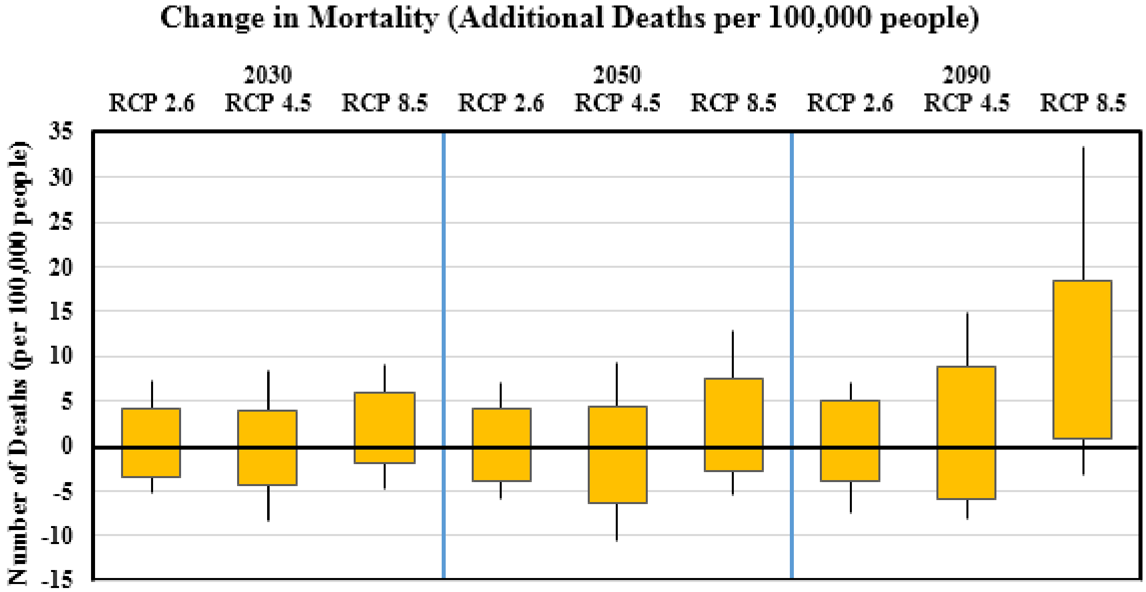


Figure 11. Costs Associated with Changes in Mortality in Maryland in the 21st Century

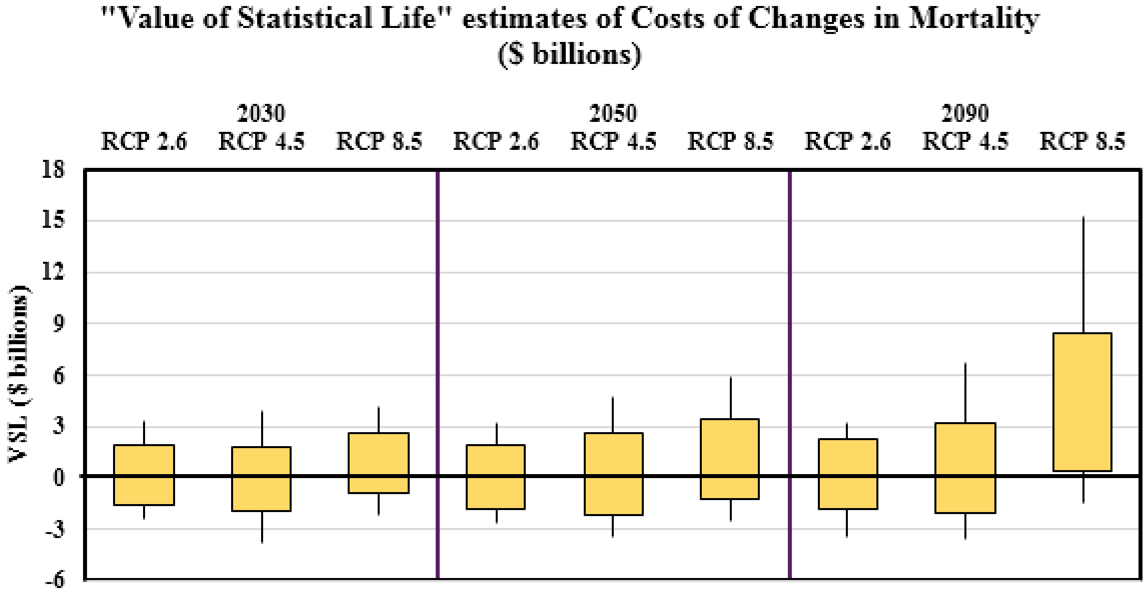
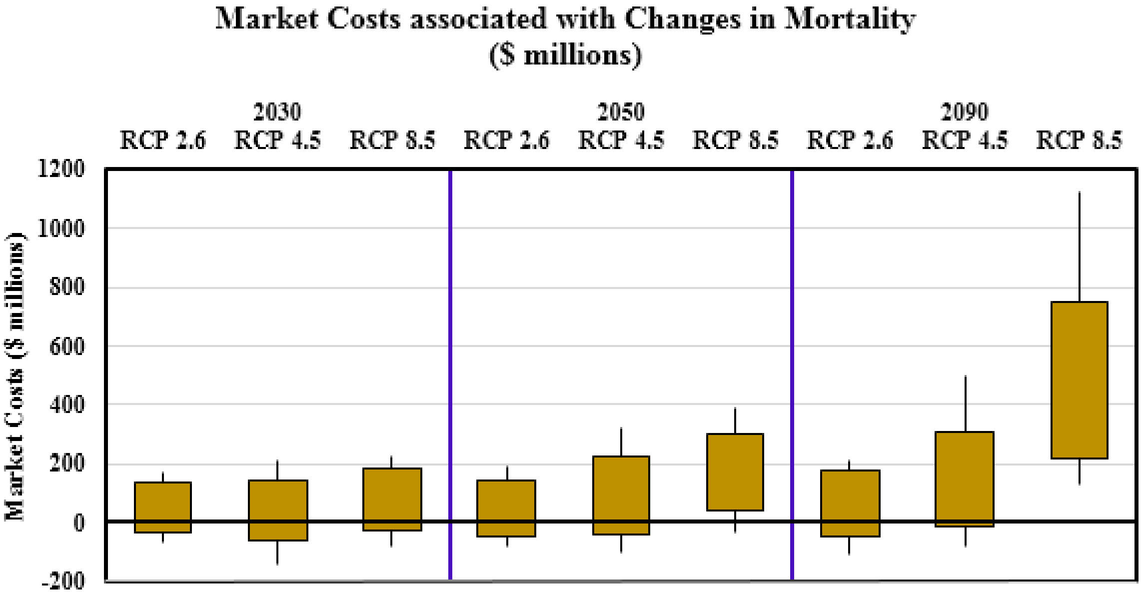


Figure 12. "Market" Costs Associated with Changes in Mortality in Maryland in the 21st Century



Increases in Risks to Coastal Property

Anticipated increases in sea level will expose a significant number of homes and businesses to more frequent flooding. Much of the newly exposed area will be on the east side of the Chesapeake Bay, in Queen Anne and Talbot counties[11]. As shown in Figure 13, in the near-term, an additional $9 billion in property value[12] is likely to be below sea level. For mid-century, this range grows to $9 to $13 billion. For the end-of-century, the likely range for the RCP 8.5 scenario extends to over $23 billion. Throughout the 21st century, only 4 states exhibit a greater increase in coastal property: Florida, Louisiana, California, and Texas. Unlike other impact estimates discussed in this paper, the future coastal exposure information is not based on a two decade average of future sea levels, but rather a "snapshot" of future sea level in 2030, 2050, and 2100.

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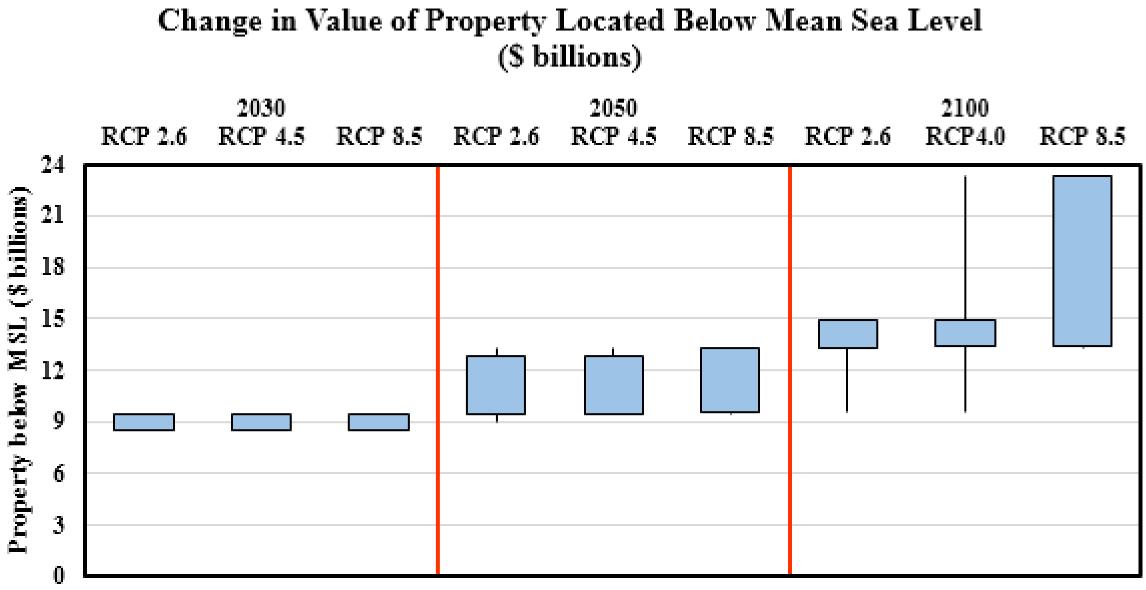
[11] ACP, p.89

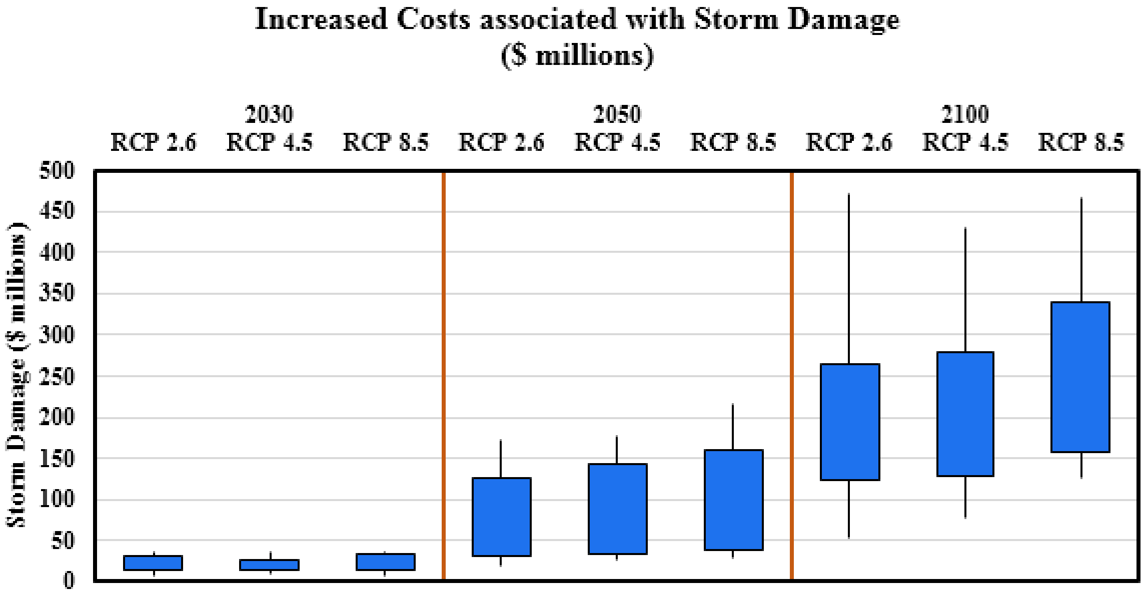
[12] Risk to coastal property is based on current (2014) distribution of property and economic activity.

Figure 13. Increases in Coastal Property at Risk of Inundation in Maryland for 2030, 2050, and 2100



Current damages from coastal storms in Maryland average approximately $200 million annually. As shown in figure 14, future damages estimated in ACP exhibit modest increases prior to mid-century (likely ranges for 2030 are increases of $7-30 million annually; for 2050, increases of $20-160 million annually). By 2100, the median damage estimates are approximately double current damages, and the likely range extends to around $340 million in additional annual damages.

Figure 14. Increases in Costs associated with Storm Damage in Maryland for 2030, 2050, and 2100

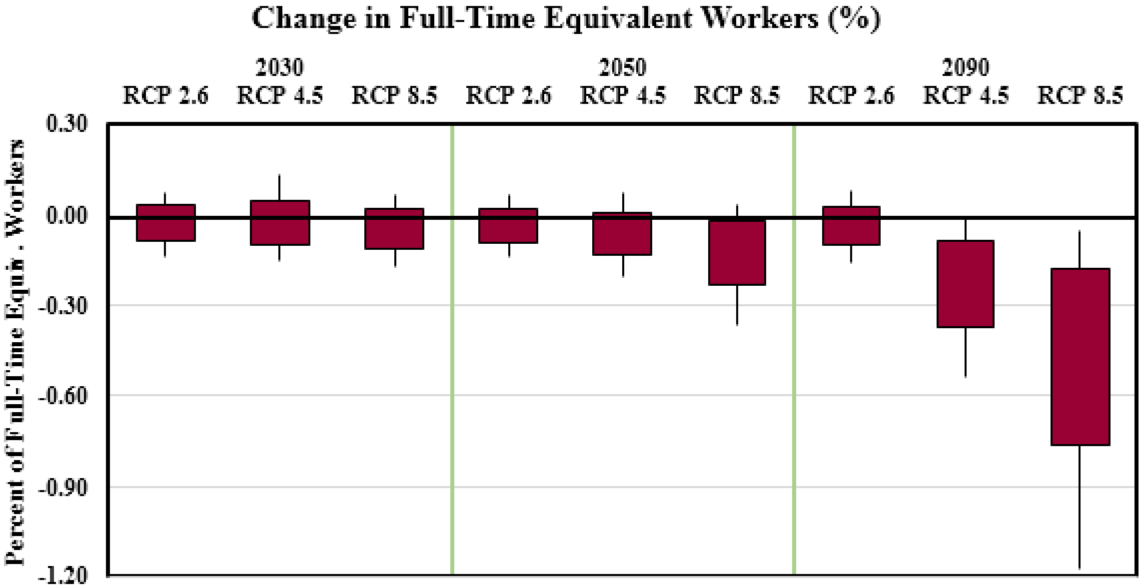


It should also be noted that the ACP scenarios draw upon sea level rise estimates that may be conservative. ACP sea level data situated within the likely range is in agreement with IPCC's sea level rise projections, which have a likely range of 2-3.3 feet through 2100. By comparison, the National Climate Assessment (NCA) (http://nca2014.globalchange.gov/) has a likely range for future global sea level extending up to 4 feet by 2100.

Decreases in Labor Productivity

Temperature can influence labor productivity, especially in sectors where outdoor work is required, such as agriculture, construction, utilities, and manufacturing.[13] ACP's estimates for changes in labor productivity are predominantly negative through the 21st century, with the likely range for lost productivity equivalent to about 0.2% to nearly 0.8% of all full-time equivalent workers in the state (Figure 15).

Figure 15. Changes in Labor Productivity in Maryland in the 21st Century



Although the likely ranges for the costs associated with changes in labor productivity show the potential for net benefits prior to mid-century, all the median estimates are greater than zero and correspond to costs (Figure 16). In the near-term, the median costs associated with the decline in labor productivity range between $70-110 million annually. This grows to $110-360 million by mid-century. By the end-of-century, the median estimate for RCP 8.5 is approximately $1.3 billion, with a 1-in-20 chance for costs to reach $4 billion annually.

Figure 16. Costs Associated with Changes in Labor Productivity in Maryland in the 21st Century

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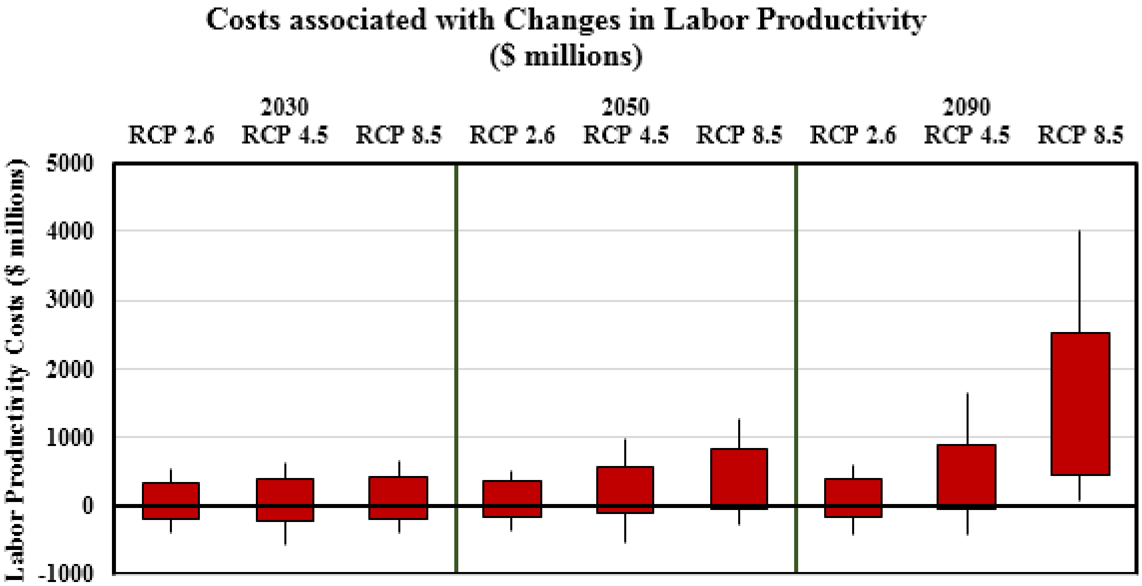
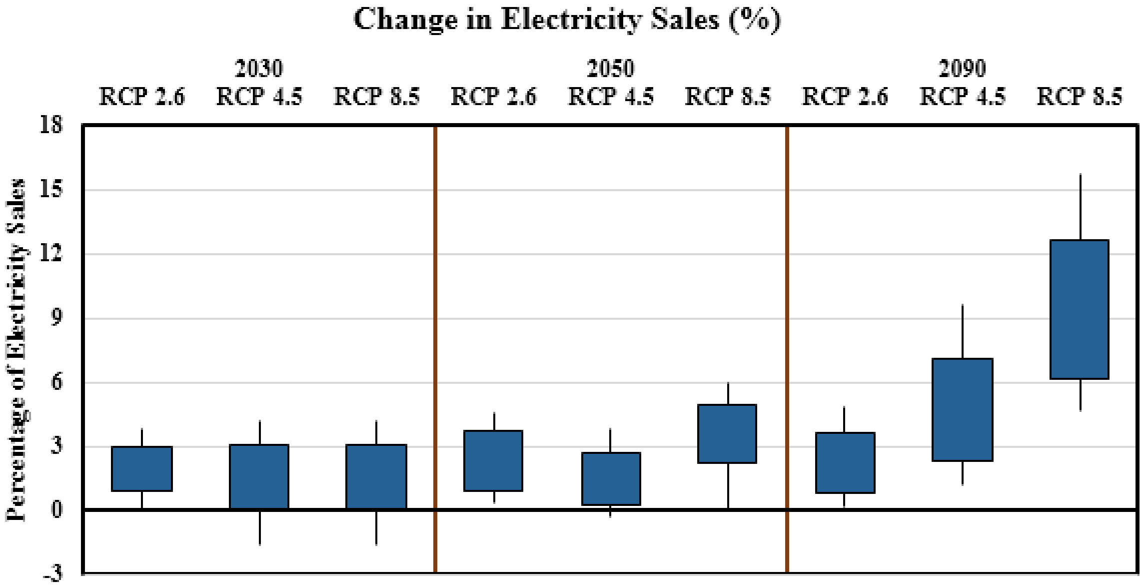
[13] ACP, p.54


Costs associated with Changes in Labor Productivity
($ millions)
2030
2050
2090
RCP 2.6
RCP 4.5
RCP 8.5
RCP 2.6
RCP 4.5
RCP 8.5
RCP 2.6
RCP 4.5
RCP 8.5
Labor Productivity Costs ($ millions)
5000
4000
3000
2000
1000
0
-1000

Increases in Energy Expenditures

Warming is likely to reduce energy required for heating in the winter, but boost energy demands in the summer for cooling. As the 21st century progresses, the increases in summer demands are likely to outpace reduced demands in the winter. More importantly, increases in the cost of energy are likely to accompany this shift. The increase in summer energy demands will drive up peak electricity demand (Figure 17), which is often a key factor in determining electricity prices, since it is connected to large capital investments associated with building and maintaining generation capacity[14].

Figure 17. Changes in Electricity Sales in Maryland in the 21st Century



ACP provides estimates for future energy expenditures. In the near-term, the likely ranges for impacts span zero, beginning at approximately $300 million in benefits and extending to $400 million in additional costs (Figure 18). By mid-century, the chances for a net benefit shrinks and the range for likely costs grow to approximately nearly $600 million for the RCP 8.5 scenario. By the end-of-century, costs grow: median costs for even the most optimistic emissions scenario (RCP 2.6) exceed $160 million. For RCP 8.5, the likely range extends to $1.3 billion in additional costs, with a 1-in-20 chance for costs of $1.8 billion.

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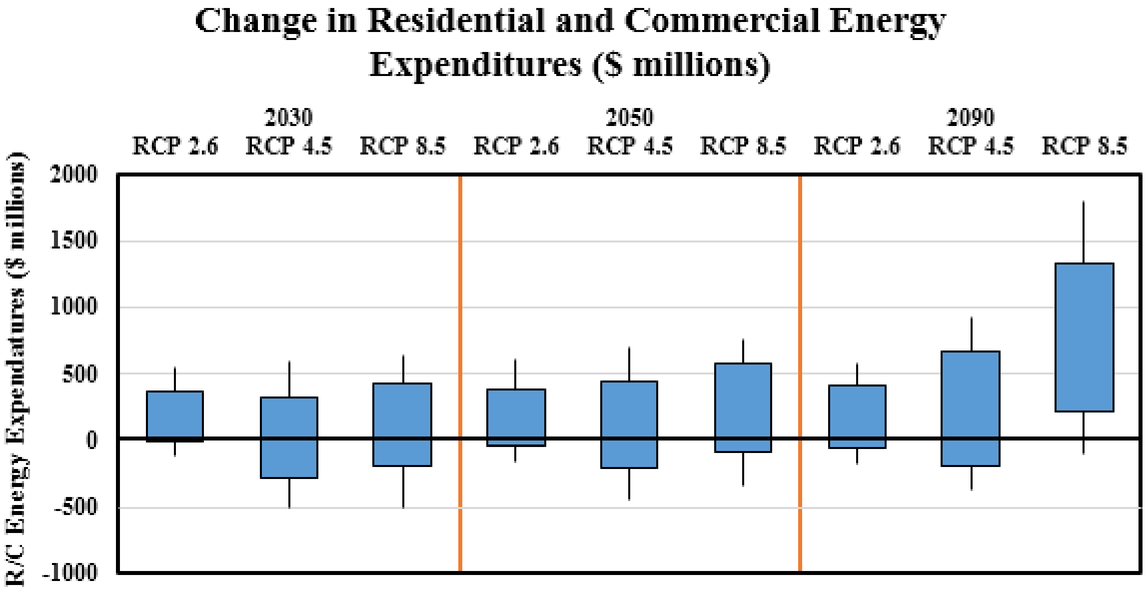
[14] ACP, p.80-81

Figure 18. Changes in Energy Expenditures in Maryland in the 21st Century



Declines in Agricultural Output

ACP provides estimates of the impacts of future temperature and precipitation on the yields of maize, wheat, and soybeans.[15] We have included the combined estimates for all three crops in the following figures. The estimates shown here also include the potential for carbon dioxide fertilization (that increases in concentrations of carbon dioxide facilitate crop growth), and can be thought of as conservative.

In Maryland, it is likely that yields for wheat would improve, while yields for maize and soybean would decline. The net effect of these changes are likely to lead to modest declines in agricultural yield prior to mid-century (Figure 19). Likely ranges for the near-term range from a 9% decline to a 7% improvement; all the median estimates indicate a decline of 2-4%. For mid-century, the likely ranges extend from a 17% decline to a 5% improvement. At the end-of-century, the potential exists for significant declines in crop yields – for the RCP 8.5 scenario, the likely range extends from a 50% decline to a 5% improvement, with a median estimate of a nearly 25% decline.

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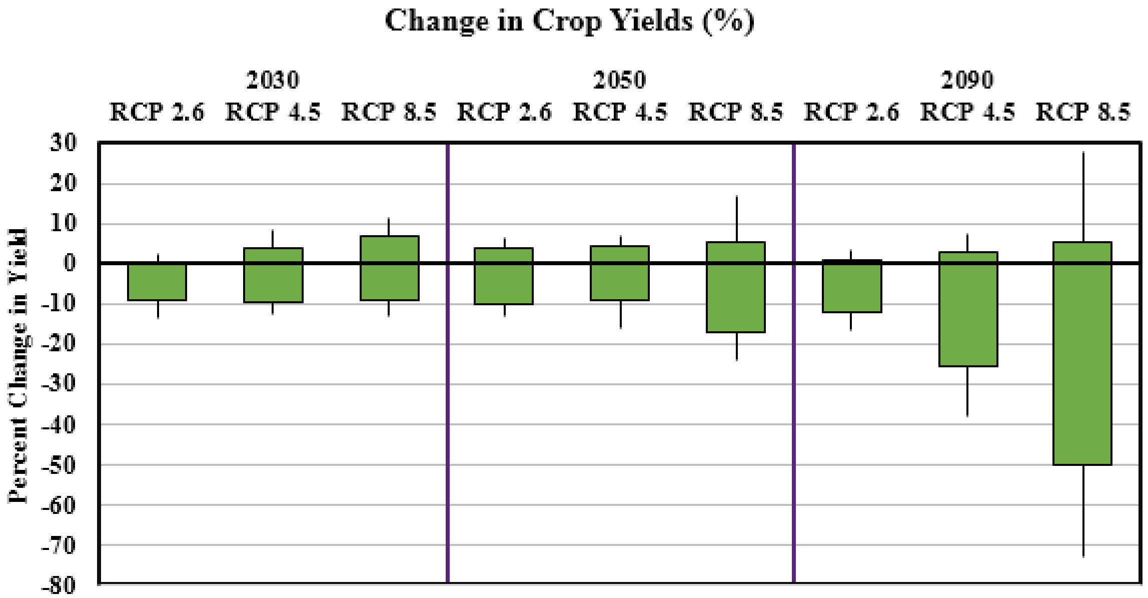
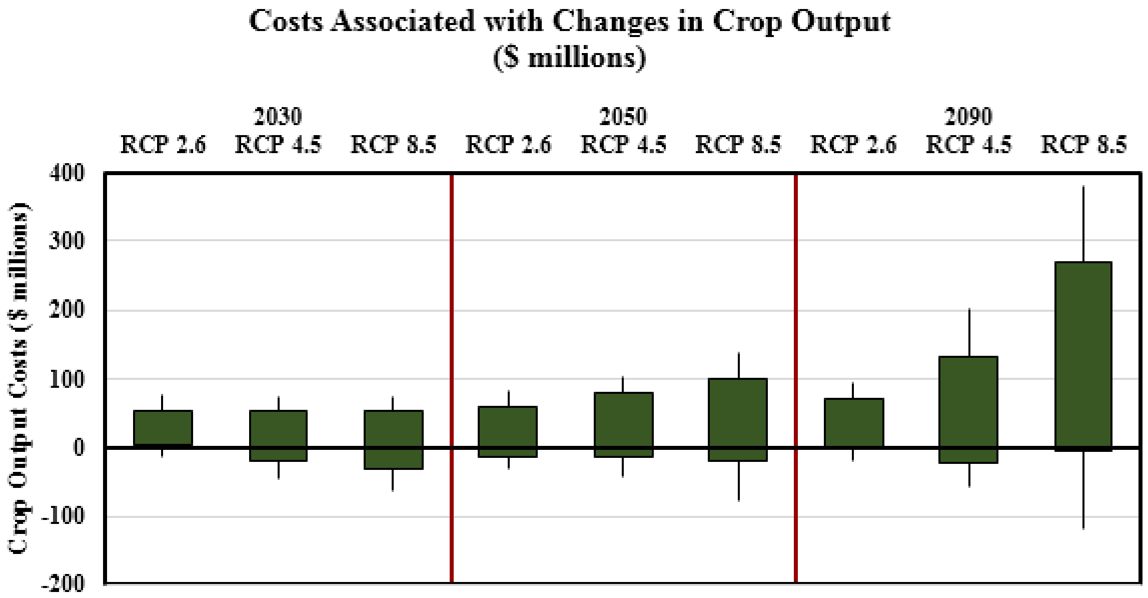
[15] ACP also includes estimates for cotton, but these estimates were not applicable to Maryland.

Figure 19. Changes in Crop Yields in Maryland in the 21st Century



Relative to the other impact categories, the costs associated with future declines in crop yields are relatively small (Figure 20). Costs or benefits are unlikely to exceed $50 million in the near-term, and are unlikely to exceed $100 million at mid-century. For the end-of-century, the likely range for costs extends from near zero to just over $260 million. The 1-in-20 chance for impacts equates to costs of approximately $380 million annually.

Figure 20. Costs Associated with Changes in Crop Yields in Maryland in the 21st Century



Adaptation Efforts

Given the extent of potential risks due to climate change, it is clear that remaining on a path of increased greenhouse gas emissions will only increase Maryland's exposure. While reducing emissions can mitigate much of the climate risk to Maryland, some climatic changes are already "baked in" as result of past business decisions that increased the level of greenhouse gas emissions. Furthermore, decision-makers at all levels may have limited ability to directly influence attempts to limit or reduce emissions. Understanding the limitations of action toward mitigation, decision-makers can instead choose to focus on reducing risk through behavioral change and "defensive investments" – two general forms of adaptation practice[16].

Potential gains from adaptation measures, however, are generally unknown and are not included in the Risky Business Project report or incorporated into the ACP cost analyses. Farmers benefiting from longer growing seasons due to increased temperatures may have to invest in improved irrigation infrastructure or crop varieties better suited for warmer climates. People opting to utilize air conditioning will reduce heat-related risks, but at the consequence of higher energy costs. Utilities may be forced to invest in infrastructure upgrades to keep up with changes in demand. Governments may be forced to invest in developing or improving infrastructure to protect economic interests.

Decision-makers may also choose not to partake in adaptive measures. This may be due to high investment costs, scale of action, and a general lack of information and awareness of the climate change issue. Because of these non-quantifiable variables and uncertainty in future changes in behavior, adaptation should not be seen as a substitute for mitigation efforts, but rather as a complement to mitigation polices focusing on reducing greenhouse gas emissions and minimizing risks associated with climate change.

Summary

The physical and economic impact data supplied by ACP identify not only the potential risks associated with climate change, but also the costs of climate change to specific sectors of Maryland's economy through the 21st century. These data examine not only the most likely physical and economic scenarios, given all three future emissions reduction tracks, but also the scenarios that, while less likely, could have greater impacts. Notably, no estimates are provided in the ACP of how climate change might affect water resources, ecosystems, or aspects of human health beyond heat-related mortality. And, potential gains from adaptation measures are not included in the Risky Business Project report or incorporated into the ACP cost analyses.

By continuing down the BAU path, it is likely that the number of days above 95°F will increase tenfold, the number of days below 32°F will decrease by half, and sea-level in the Chesapeake Bay region will increase an additional 3 feet. Moreover, there is a 90% likelihood of increased precipitation, especially during the spring and summer months. These climatological impacts translate to likely annual economic costs of over $5.5 billion dollars within the labor, health, and energy sectors by 2100 with an additional $15 billion dollars in property value at risk due to rising sea levels. However, opting for a scenario that

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[16] ACP, p. 163

incorporates a mix of policy and technology to reduce greenhouse gas emissions would significantly limit the costs associated with climate change. A significant increase in sea level rise by 2100 under all three climate scenarios limits the reduction of economic risk to coastal property from BAU by 7 to 10 percent ($1 to $1.5 billion). Projected annual economic costs within the labor, health, and energy sectors decreases 79 to 89 percent or between $600 million to $1.1 billion by the end of this century. The magnitude of cost and risk reductions is directly dependent on the speed of policy and technology implementation.

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