



## IN FOCUS

# THE IMPACT OF CLIMATE CHANGE ON HAMPTON ROADS

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## Climate Change is Happening, Now

In the late 1980s the World Meteorological Organization and the United Nations Environment Program created the Intergovernmental Panel on Climate Change (IPCC) to evaluate the risk of widespread climate modification triggered by human activity. The impetus for IPCC formation was the scientific speculation that human-induced transformation of the composition of the atmosphere primarily caused by fossil fuel burning could increase the risk of rapid climate change. The fourth assessment report (AR4) of the IPCC was published in 2007. The main conclusion of AR4 is highlighted below.

**Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (see Figure SPM.3). {3.2, 4.2, 5.5}**

The AR4 further concluded that, **“Most of the observed increase in global average temperatures since the mid-20<sup>th</sup> century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.”** The IPCC also warned that continued emission of greenhouse gases at or above current rates would cause a profound metamorphosis in the climate system in the 21<sup>st</sup> century unlike anything observed or experienced in the 20<sup>th</sup> century. Further, anthropogenic global warming and sea-level rise would continue for centuries even if atmospheric concentrations of greenhouse gases were stabilized.

Such unambiguous warnings make it clear that our civilization must develop strategies for dealing with this unfolding process: not only from the standpoint of controlling greenhouse gas emissions, but also from the standpoint of adapting to the inevitable changes that are coming.

The writing, editorial and publication cycle of the AR4 was based on peer-reviewed scientific literature dating back several years before the publication date. Since that time, global temperature and precipitation anomalies have continued to proliferate, even as the scientific community continues to refine its understanding of such changes.

This paper summarizes the best information available from AR4 and the related scientific literature to make the general IPCC warnings specific to Hampton Roads. The conclusions drawn herein suggest remediation strategies that officials could adapt and adopt regionally to address a potentially dire situation.

# Climate Change Projections for the 21<sup>st</sup> Century

AR4 projects that by 2100 Earth's average surface temperature will increase between 1.5° and 4° C (roughly 3° and 7° F) depending on the greenhouse-gas-emission scenario. The report predicts between a 0.2 and 0.5 meter (8 to 19 inches) of sea-level rise in the same period. This latter projection is based on models that account only for sea-level rise caused by thermal expansion of the oceans, as waters warm in response to excess heat trapped in the atmosphere-ocean system. A significant uncertainty that potentially will have a major impact on global sea-level rise is the melting of the planet's cryosphere, particularly parts of the world's great ice sheets in Greenland and Antarctica. If thawed, these now-frozen expanses contain 99% of the ice capable of raising sea level.

However, since initial AR4 publication, a number of recent studies have revealed that, since 2003, the ice sheets have responded to planetary warming by liquefying nearly two trillion tons of their mass, and that the rate of melting continues to accelerate substantially. The latest estimates that account for ice-sheet melting project a far greater sea-level rise of 1 to 2 meters (3 to 6.5 feet) by the end of this century.

It is very important to understand the nature of the time scales and responses of the climate system when trying to understand the situation for Hampton Roads. Human activity is changing the composition of the atmosphere at rates never before experienced in geologic history. The climate systems response to this massive change in atmospheric composition is now on a course that will be difficult, if not impossible, to reverse.

The most aggressive global response strategy yet developed is the Kyoto Agreement of 1992. This concord proposed to reduce greenhouse gas emissions to the 1990 level by 2012. Nevertheless, even the Kyoto strategy is fundamentally flawed from a climate-change point of view because targeted levels of greenhouse gas concentrations would still increase, further boosting global temperatures and sea levels.

To stabilize the climate system in the long term, reductions of greenhouse gas emissions of more than 80% will be required. The longer it takes to achieve such reductions the warmer it will be when the system stabilizes. Even with a rapid, radical reduction in greenhouse gas emissions, stabilization of atmospheric temperatures would occur over several centuries, whereas sea-level rise would continue for millennia, and could potentially rise by another 10 meters (33 feet) or more. Once greenhouse gases are emitted into the atmosphere it takes hundreds of years for natural processes to remove them.

# Hampton Roads Climate in 2100

The estimates of temperature and sea-level rise cited above represent global averages. AR4 also provided more localized projections of temperature change. For eastern North America the estimates are between a 2° and 5° C (4° and 9° F) temperature increase. Additionally the projections are for little change in annual precipitation for this region.

To translate global sea-level rise estimates into Hampton Roads tidal increases one must understand a bit of the local geography of the region. For various reasons, most of Hampton Roads is located on subsiding ground, with the ground sinking between 0.15 and 0.23 m (5 and 7.5 inches) per century. Combining this subsidence with the sea-level projections leads to a range of 1.15 to 2.23 meters (3.77 to 7.32 feet) of net tidal increase by 2100.

These projections lead to the conclusion that Hampton Roads in 2100 will be very different than it is today. By that time most of the land east of highway US 17 could be inundated. This would mean, from north to south, vast areas of Mathews, Gloucester, and York counties, most of Poquoson, much of Hampton, Norfolk, Chesapeake and the Virginia Beach oceanfront would either be under water or protected by a massive levy system.

The beautiful waterfront views we so cherish today would either be blocked by the levies or be views of neighborhoods or commercial areas devastated by inundation. Major regional economic engines such as the port, the shipyards and several military facilities will have to deal with mitigating the effect of the surging waters, face the need for major relocation and reconstruction, or simply be shut down.

With the continued rise of sea levels at a rapid rate (several meters per century for many centuries) it is critical that this region begin to consider adaptation strategies. Such strategies fall into two categories. The first category of adaptation is that of radically changing our own patterns of greenhouse gas emissions, becoming an example for the rest of the nation and the world. Since we have so much to lose, we should set the standard for the changes that must be made.

Second, we must begin to plan for the inevitable. We must develop an approach for deciding what assets to protect in the short term and begin the decades-long process of developing our levy system, fully recognizing that over the longer term even the idea of levies makes no sense when facing millennia of rapid sea-level rise.

Furthermore, and more realistically, we must develop a strategy of retreat from the waterfront, removing our human artifacts along the way. Otherwise the new shoreline and near-shore waters will be strewn with inundated buildings, roads, sewer systems and other infrastructure. The result would be a new waterfront unsuitable for human use, and massive pollution of the Chesapeake Bay and coastal ocean waters.

Bluntly put, the impact of climate change on our region will be a complete disaster. Our only viable strategy for the future is a bold plan of adaptation that can serve as a model for other coastal communities, the nation and the world.

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*Four NASA Langley Research Center scientists were among the recipients of the shared 2007 Nobel Peace Prize, which recognized the efforts of former U.S. Vice President Al Gore and the United Nations Intergovernmental Panel on Climate Change in assessing and predicting Earth's changing climate.*