Climate Change in New Jersey: Trends in Temperature and Sea Level

Background

There is good evidence that as a result of ever increasing carbon dioxide (CO_2) emissions to the atmosphere from human activity, the Earth's surface has warmed by over 1.3 degrees Fahrenheit (0.7 degrees Celsius) during the past century.[1] These increased temperatures have contributed to an overall rise in sea level. Continued GHG emissions at or above current rates are expected to cause further warming and induce many changes in the global climate system during the 21st century that will very likely be larger than those observed during the 20th century.[2]

In July 2007, the Northeast Climate Impacts Assessment (NECIA) released a report detailing the projected impacts of climate change on the Northeast Region of the United States.[3] This research echoed the global findings of the United Nations Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report and also pointed out that states in the Northeastern United States are especially vulnerable to the impacts of climate change and that the potential ecological, economic and public health impacts to New Jersey may be devastating.

Precipitation and runoff are likely to increase in the Northeast (and Midwest) in both the winter and spring. According to the State Climatologist, New Jersey is getting wetter.[4] The additional atmospheric moisture contributes to more overall precipitation in some areas, especially in much of the Northeast. Such areas, where total precipitation is expected to increase the most, would also experience the largest increase in heavy precipitation events. For the Northeast, projections indicate spring runoff will advance by up to 14 days. Earlier runoff produces lower late-summer streamflows, which stress human and environmental systems through less water availability and higher water temperatures. Over the last 50 years, the Northeast has experienced snow pack reductions, and observations indicate a transition to more rain and less snow in both the Northeast and the Western regions of the country.

Sea level rise is documented throughout the world, and it is a trustworthy indicator of the Earth's heat balance.[5] Although there are local and regional influences on sea level that are not related to climate change, such as geological subsidence (which exists in New Jersey), globally, the sea level rises for two main reasons: ice melting on land and the expansion of the ocean as it warms.

Other factors also can influence regional and local temperature and climate besides greenhouse gas emissions. One significant factor is increasing urbanization. The large expanses of asphalt and concrete associated with urban and suburban sprawl and the resulting decreased coverage of the land by forests, fields and other open space, are exerting a warming effect. This effect is especially pronounced in densely populated urban areas, which can exhibit what is called a heat island effect.

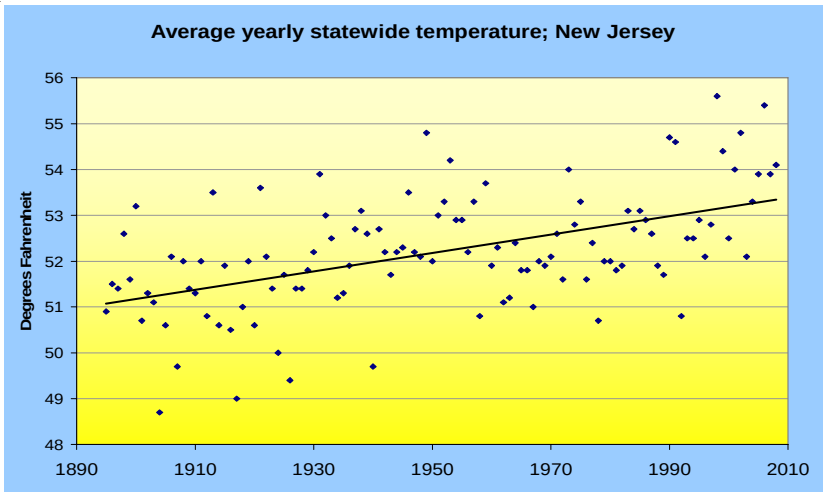
In New Jersey, long-term data document a significant increase in average temperature, a significant increase in precipitation, and a significant rise in sea level that are consistent with observed and predicted global trends.

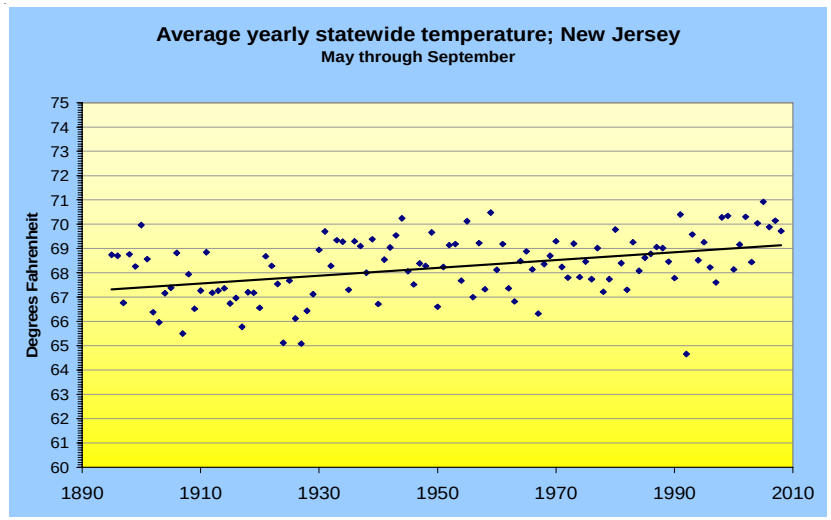
Status and Trends: Temperature

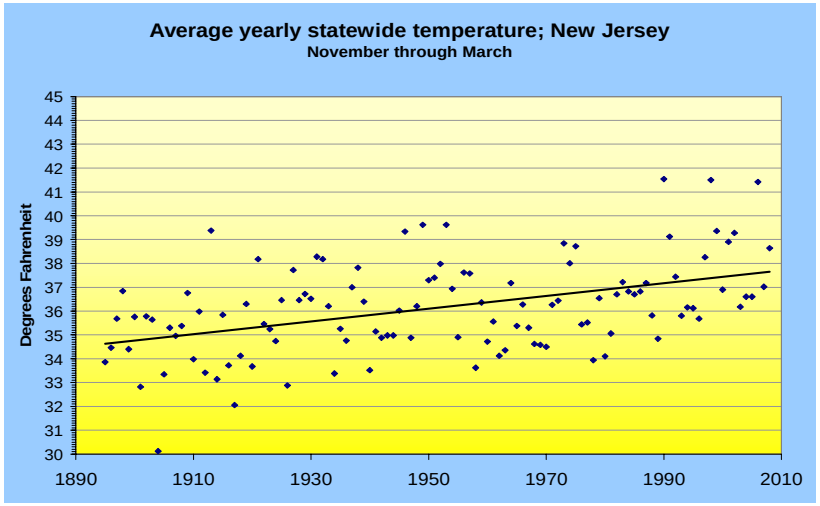
The Office of the New Jersey State Climatologist has gathered and quality-checked New Jersey statewide temperature and precipitation records going back to 1895, and has made these data available on-line.[6] These data, as summarized and charted by the Department, show a statistically significant rise in average statewide temperature over the last 113 years. Although there is much variation from year to year, overall both the normally cooler season (November through March) and the normally warmer season (May through September) are warmer now than formerly. The rise in temperature appears to be especially pronounced during the November through March period. See the three "Average yearly statewide temperature…" figures on page 2.

One important aspect of temperature is the effect it has on heating and cooling needs. This effect is often estimated by translating temperature readings into heating degree days or cooling degree days. Heating degree days are calculated as the difference between a day's average temperature and 65° F, if that day's average was below 65° F. Cooling degrees are the difference between a day's average temperature and 65° F if the

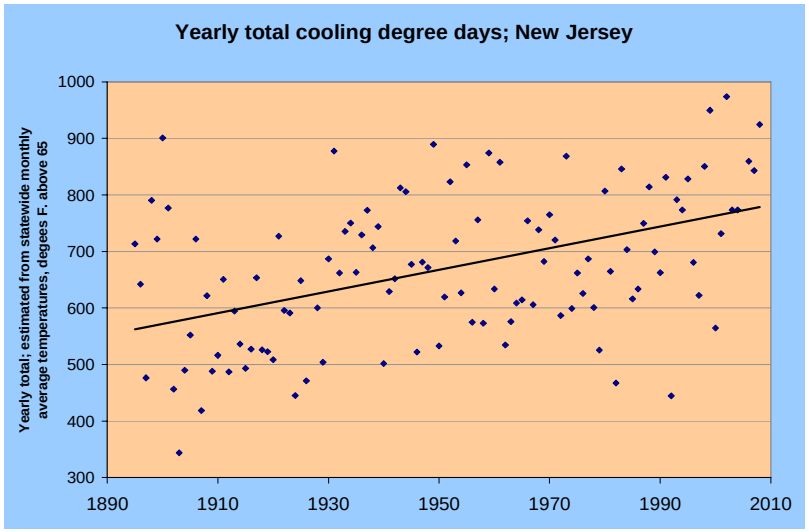
average temperature was above 65° F.[7] More heating and cooling degree days generally translate to more energy expenditure for heating and cooling, respectively. However, other factors, such as the amount of insulation, the amount of space that is heated or cooled, and the efficiency of the heating or cooling equipment also play a role in heating and cooling energy requirements.

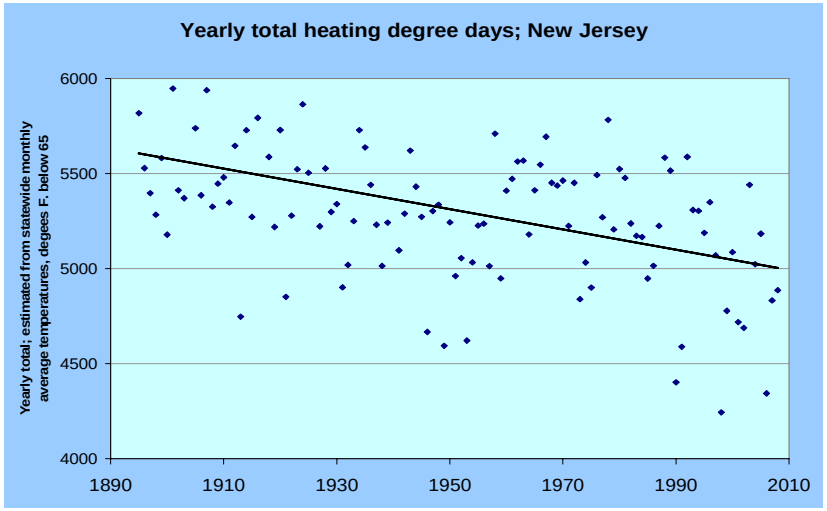




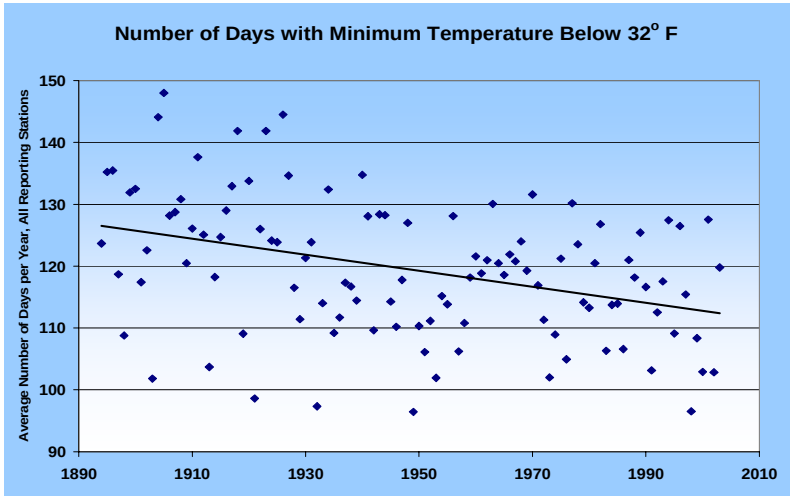


Yearly total heating and cooling degree days were calculated by the Department based on yearly average temperatures for each month[8] as provided by the State Climatologist. These values are plotted by year in the figures "Yearly total cooling degree days.." and "Yearly total heating degree days.." below.



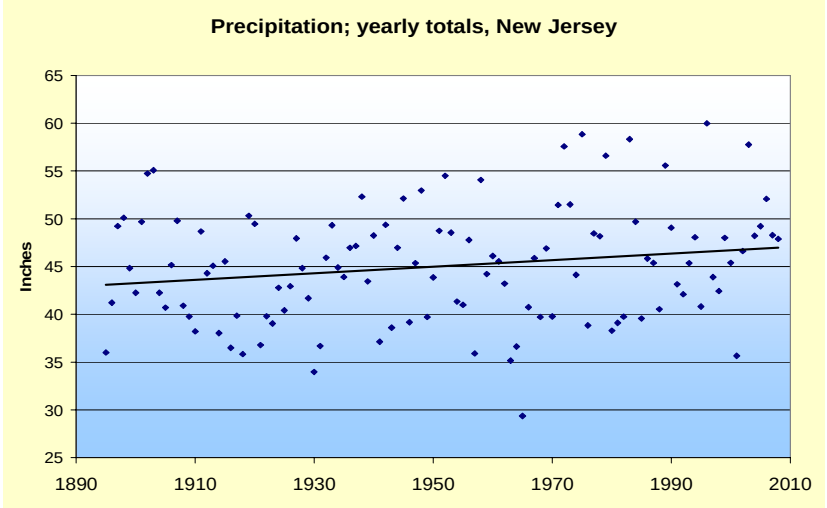


It is clear from both temperature and heating and cooling degree data as shown above that both winters and summers have become warmer in New Jersey during the period. It appears that there has been relatively more warming during winter. The trend in summer temperatures indicates there is a likelihood of several more days above 90° F each year; the winter trend shows that on average there are nearly 14 fewer days per year when the temperature can be expected to reach 32° F or lower than there were 100 years ago. See the chart "Number of Days with Minimum Temperature Lower than 32° F" below.



Status and Trends: Precipitation

Yearly average precipitation data are also available from the State Climatologist. These data show a statistically significant[9] increasing trend. The best-fitting linear regression of these data indicates that, on average, there are nearly four more inches total precipitation each year now than in 1895. As with temperature, there is a pronounced year-to-year variation. See the chart "Precipitation; yearly totals, New Jersey." below.

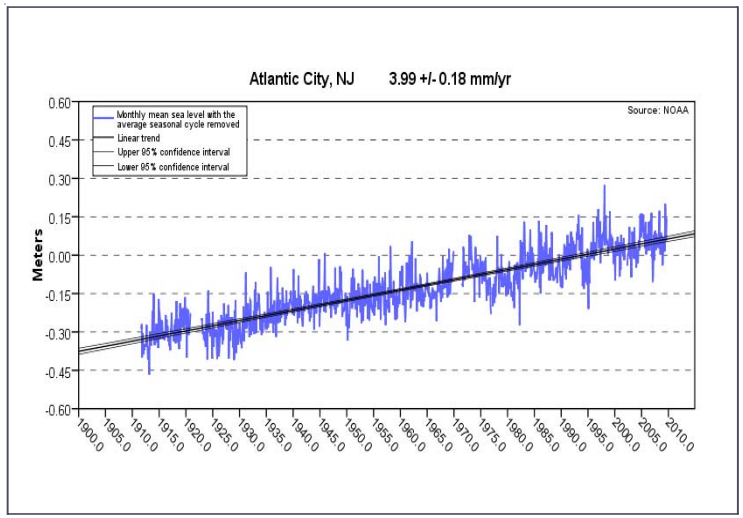


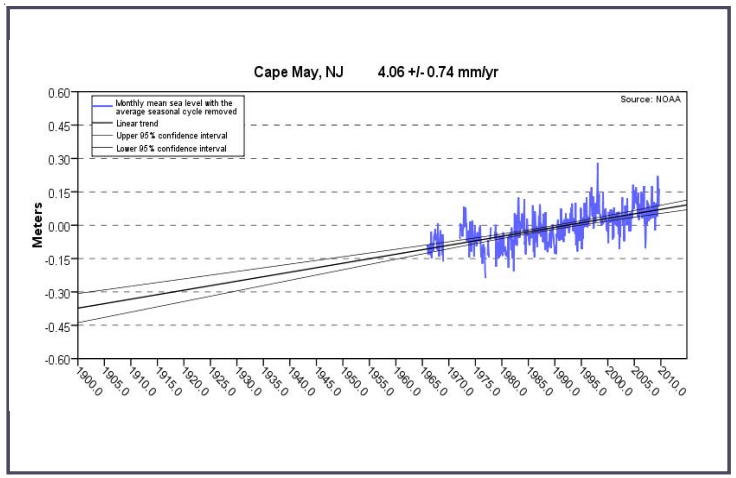
Status and Trends: Precipitation

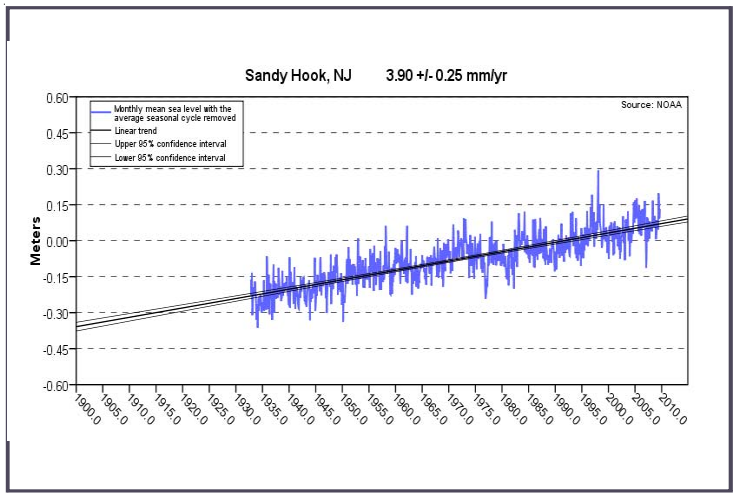
Tide gauge data made available by the National Oceanic and Atmospheric Administration (NOAA)[10] show that the sea level at the New Jersey coast sites of Atlantic City, Cape May, and Sandy Hook has risen at a rate of approximately 4 mm/y since recording began in the early- to mid-1900s. Recent research completed for the Department shows that the preanthropogenic sea-level rise in New Jersey was approximately 2 mm/y, due to geological factors.[11] This suggests that the anthropogenic contribution to the recent higher rate of rise is approximately 2 mm/y, approximately one-half of the total observed rate of rise, which is in line with recent estimates of the global rate. Some of the

anthropogenic rise is believed due to land subsidence caused by groundwater withdrawal; this is believed to be especially significant at the Atlantic City site.

See the figures “Atlantic City, NJ”, “Cape May, NJ”, and “Sandy Hook, NJ” below. Each shows the best-fitting linear sea level trend line and the yearly average rate of increase as determined by NOAA. Values shown represent the deviation from the mean sea level for the 1983 through 2001 period.







Outlook and Implications

Rising temperatures are expected to have human health impacts, including increased heat stress, increased levels of ground-level ozone, accelerated secondary fine particle formation, and possibly facilitate the northern spread of insects carrying diseases such as West Nile virus, particularly in the winter season. Heat stress is of special concern for vulnerable urban populations such as the elderly and urban poor. Climate models predict an increase in the number of days per year with temperatures above 90° F in the New York City metro area, with a potentially significant impact on human health due to heat stress.[12] By the 2020s, climate change could result in an increase in summer heat-related mortality of 55% and a more than doubling in mortality by the 2050s.[13]

Natural ecosystems in New Jersey will also be impacted by warmer temperatures and associated changes in the water cycle. These changes could lead to loss of critical habitat and further stresses on some already threatened and endangered species, impacts on water supply and agriculture, more intense rain events, more frequent periods of extended dryness, and continued increases in fires, pest, disease pathogens, and invasive weed species.[14]

Sea level rise is a major concern for New Jersey. Sea level in the Northeast region is projected to rise more than the global average.[15] The State is especially vulnerable to

significant impacts due to geologic subsidence, the topography of its coastline, current coastal erosion, and a high density of coastal development.[16] A sea level rise in line with median projections would threaten the majority of New Jersey's coastline. These effects will be magnified during storm events, increasing the severity of storm-related flooding in coastal and bay areas. Atlantic City is predicted to experience floods as severe as those that today happen only once a century every year or two by the end of the century.[17] In addition, if the recent measures showing a dramatic increased rate of melting of the Greenland ice sheet[18,19] are substantiated by further data, and if the melting continues at this rate or accelerates further, the rate of sea level rise throughout the world will increase significantly, and the severity and frequency of coastal flooding in New Jersey will be even greater.

Currently, responses to rising sea levels and increasing erosion along the NJ coast have been the construction of sea walls and bulkheads, raising land elevation with beach nourishment projects, and the building of jetties to capture sand. All of these approaches are expensive, and the costs can be expected to increase as sea level rises further. The additional impact of anticipated more intense storms and floods when coupled with higher sea levels will likely compound the growth in costs. (See the report, Beach Replenishment, in this Environmental Trends series.)

More Information

More information on climate change and its causes and effects, and on efforts to reduce greenhouse gas emissions in New Jersey, can be obtained from New Jersey's website on global warming, http://www.state.nj.us/globalwarming/index.shtml, and linked documents and sites. The U.S. Environmental Protection Agency also has much information on climate change available. See http://www.epa.gov/climatechange/. New Jersey temperature and other climate data are available from the New Jersey State Climatologist; see http://climate.rutgers.edu/stateclim.

References

[1] Intergovernmental Panel on Climate Change (IPCC), 2007, Climate Change 2007: Synthesis Report, Summary for Policymakers, Fourth Assessment Report, November 2007

[2] IPCC, 2007

[3] Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

[4] O'Neill, James, 2009. How could climate change affect New Jersey (interview with the State Climatologist) in *The Record* (North Jersey Media Group), June 19, 2009.

[5] Lovelock, James, 2009, *The Vanishing Face of Gaia*, Basic Books, NY

[6] New Jersey State Climatologist, 2009, downloaded from http://climate.rutgers.edu/stateclim_v1/data/njhisttemp.html, 11/19/09

[7] For example, if a day's average temperature was 30° F, it would represent 65-30, or 35, heating degree days. If a day's average temperature was 75° F, it would represent 75-65, or 10, cooling degree days.

[8] Heating and cooling degree days can be estimated from monthly average temperatures by multiplying the difference between the average temperature and the desired temperature by the number of days in that month

[9] An analysis of variance test shows that the slope of the best-fitting linear regression line is non-zero with a P value of 0.0459. This means that based on these data we can be more than 95% confident that the trend is increasing; there is less than a 5% chance that the actual rate of increase is zero or less.

[10] Downloaded from http://co-ops.nos.noaa.gov/sltrends/sltrends.shtml, 11/19/09.

[11] Stanley, Alissa, Kenneth Miller, and Peter Sugarman, 2004, *Holocene sea-level rise in New Jersey: An Interim Report,* DEP Grant Final Report, Submitted to New Jersey Department of Environmental Protection Division of Science, Research & Technology, September 15, 2004.

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[13] New York Climate & Health Project, Assessing Potential Public Health and Air Quality Impacts of Changing Climate and Land Use, Columbia University, 2000.

[14] Karl, Tomas, J.M. Melillo, and T.C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press...

[15] Karl, Thomas, et al, 2009.

[16] U.S. Department of State, 2002, U.S. Climate Action Report, p. 103, U.S. Department of State, Washington, DC.

[17] Frumhoff, et al., 2007.

[18] Velicogna, Isabella, and John Wahr, 2006, Acceleration of Greenland ice mass loss in spring 2004, Nature, 443, 329-331.

[19] Pritchard, H., R. Arthern, D. Vaughan, and L. Edwards, 2009, Extensive dynamic thinning on the margins of the Greenland and Antartic ice sheets, *Nature*, 461, 971-975.