Climate Change in New Jersey: Temperature, Precipitation, Extreme Events and Sea Level

Background

There is good evidence that as a result of ever increasing atmospheric carbon dioxide (CO_2) and other greenhouse gas emissions from human activity, as well as natural climate variability, the Earth's surface has warmed by over 1.3° Fahrenheit (0.7° Celsius) during the past century.[1] These increased temperatures have contributed to an overall rise in sea level. Continued greenhouse gas 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 melts will begin up to 14 days earlier. Earlier runoff produces lower late-summer stream flows, 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.

Despite a trend toward more precipitation, the Northeast is seeing longer periods without rainfall and longer growing seasons. The result is a drier growing season, especially during the summer months, when temperatures and evapotranspiration are highest. This summer drying trend is exacerbated by reduced recharge from spring snowmelt. New Jersey has experienced one severe water-supply drought (2001-2002) and three minor ones (2005, 2006 and 2010) in the last decade. The state has a comprehensive drought monitoring system which allows assessment of drought conditions on a regular basis.

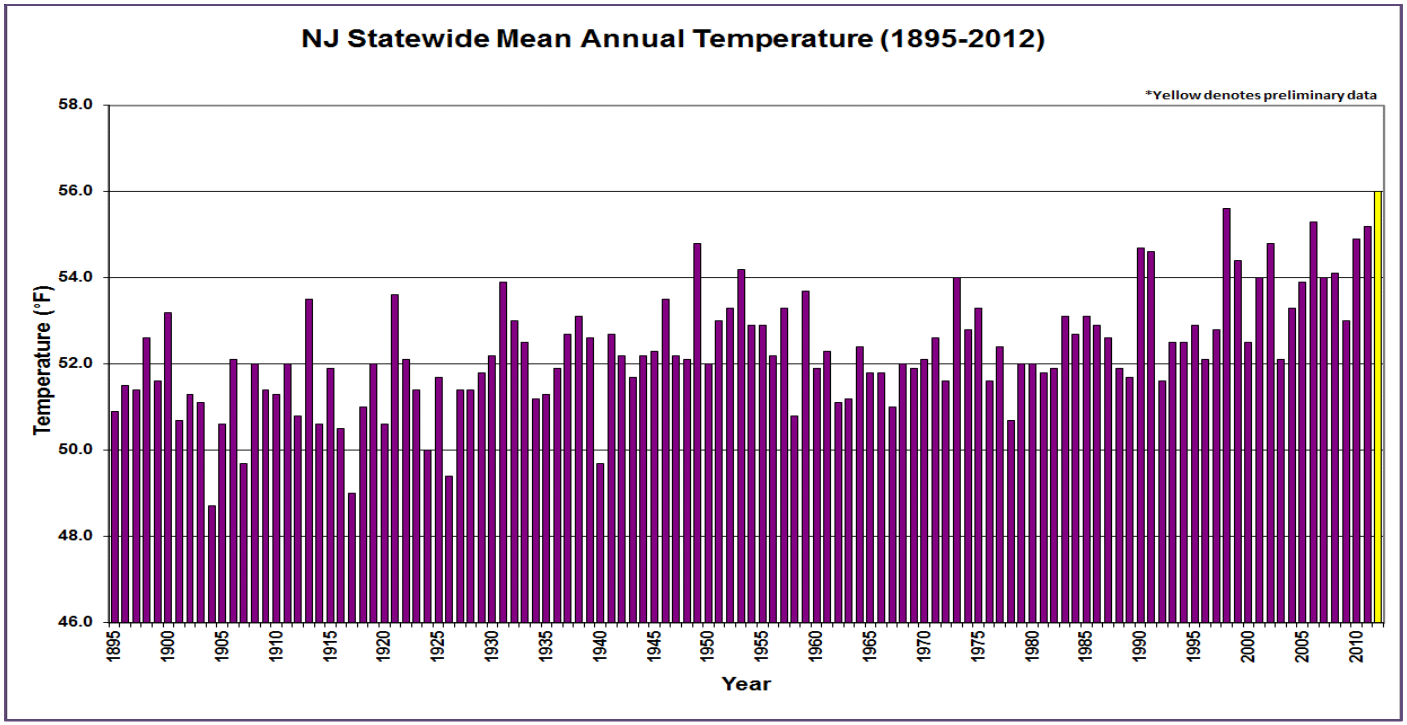
Sea level rise is documented throughout the world, and it is a trustworthy indicator of the Earth's heat balance.[5] Although there are local and regional influences on sea level that are not related to climate change, such as geological subsidence (which exists in New Jersey), globally, sea level rises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

Other factors can also 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 resultant loss of 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

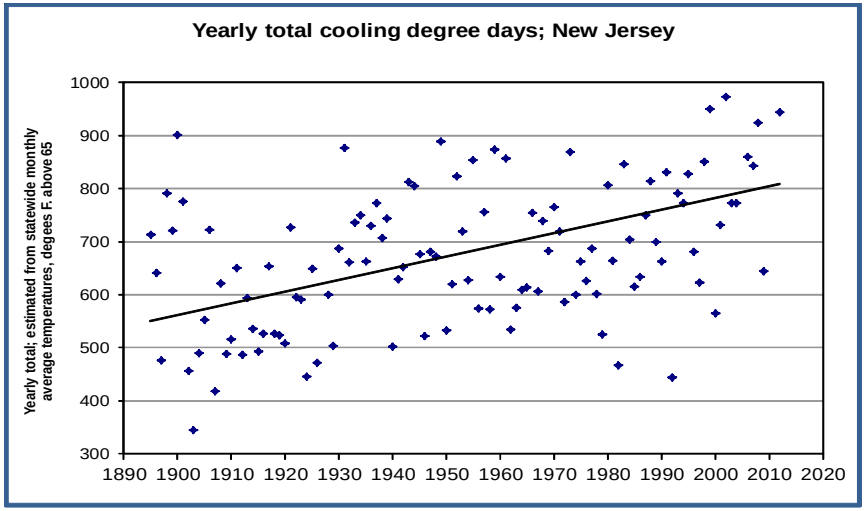
The Office of the New Jersey State Climatologist has gathered and quality checked statewide temperature and precipitation records back to 1895, and has made these data available on-line.[6] These data show a statistically significant rise in average statewide temperature over the last 118 years. The departure from normal has also significantly increased over the period indicating that average annual temperatures are consistently greater than the longer term average. The State's mean annual temperature from 1895 to 2012 is shown below in the figure "NJ Statewide Mean Annual Temperature (1895-2012)".

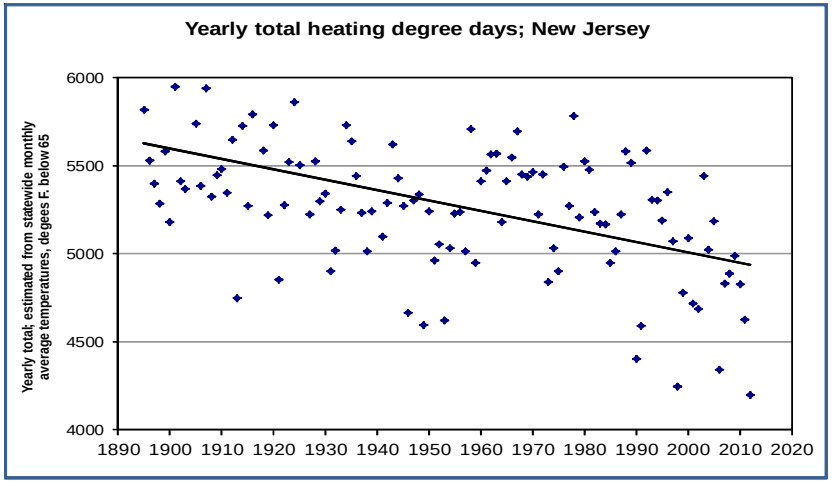


Yearly total heating and cooling degree days were calculated by the Department based on yearly average temperatures for each month[7] as provided by the State Climatologist. These annual values are plotted in the figures "Yearly total cooling degree days; New Jersey" and "Yearly total heating degree days; New Jersey".

It is clear from both temperature and heating and cooling degree data that both winters and summers have become warmer in New Jersey during the period.

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. 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.





Status and Trends: Extreme Events

Since 1998, the State has experienced a string of extreme events including Hurricane Sandy, which struck New Jersey in October 2012[8]. It is the latest in a line of recent weather and climate extremes including:

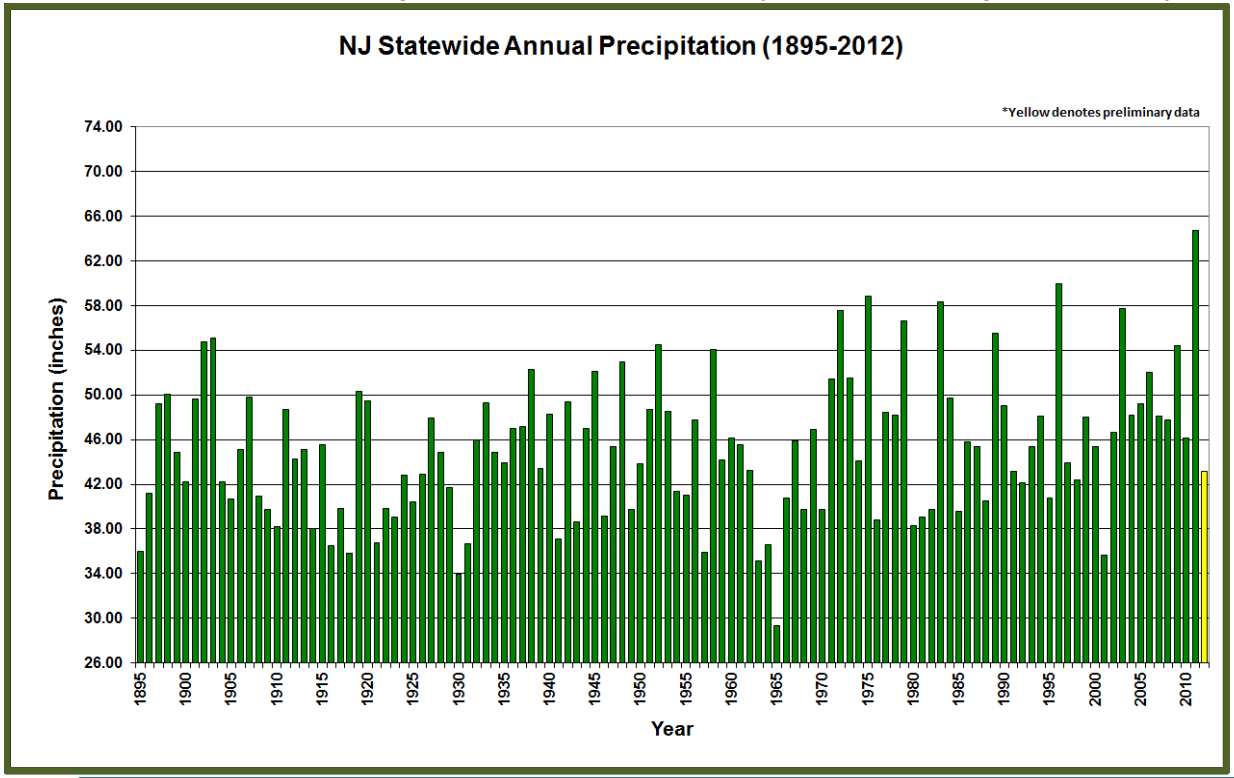
- Major floods in 1999, 2004, 2005, 2006, 2007, 2010, 2011,
- The snowiest February (2010), January (2011), October (2011) of record,
- Eight of the 10 warmest summers have occurred since 1999 based on the period of 1895 to present, and
- Thirty-seven of 51 months from July 1998 to September 2002 had below average precipitation.

While increasing variability and extremes are expected in the future, the nature and magnitudes of the extremes still represent an area of great uncertainty.

Status and Trends: Precipitation

Total annual precipitation data are also available from the State Climatologist. Analysis of the data shows a statistically significant increasing trend since 1895 in total annual precipitation and the departure from normal. There is a pronounced year-to-year variation. To date, 2011 was the wettest year on record. In August of 2011, Tropical Storm Irene dropped more than 17 inches of precipitation over the State. See the chart "Precipitation; yearly totals, New Jersey from 1895 to 2012" below.

Although steady or significant precipitation is projected for New Jersey's future climate, there is considerable uncertainty with respect to magnitude of change from the baseline as well as seasonality of the change that is a subject of active research.



Status and Trends: Sea Level

Tide gauge data made available by the National Oceanic and Atmospheric Administration (NOAA)[9] 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 pre-anthropogenic sea level rise in New Jersey was approximately 2 mm/y, due to geological factors.[10] 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.

Long-term (for years 2050 and 2100) projections of sea level rise for New Jersey are available. Researchers at Rutgers University developed these projections (with best, high, and low estimates) using the same procedures employed for the recent global estimates of the National Research Council (NRC).[11] The Table below shows the Rutgers projections.[12]

Total sea level rise for New Jersey. All values with are presented with respect to a year 2000 baseline.

Year	Total (centimeters)	Total (inches)	Total (feet)
2050			
Best estimate	44	17	1.4
Low estimate	33	13	1.1
High estimate	56	22	1.9
2100			
Best estimate	112	44	3.7
Low estimate	87	34	2.8
High estimate	141	56	4.6

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.[13] 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.[14]

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.[15]

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.[16] 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.[17] 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.[18] In addition, if the recent measures showing a dramatic increased rate of melting of the Greenland ice sheet[19, 20] 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, repsonses to rising sea levels and increasing erosion along the New Jersey coast have been to construct 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.)

A separate issue from sea level rise that needs to be monitored by the state is *ocean acidification*, the contribution made by higher levels of carbon dioxide in the atmosphere to the acidity of ocean surfaces. In some sea areas of the world there has been a 0.1 unit change in pH—corresponding to a 30% increase in acidity over levels in the mid-eighteenth century. Increased acidity is expected to affect the variety of marine organisms with shells of calcium or aragonite, decrease oxygen metabolism of animals, and modify nutrient availability.[21,22]

Given the year to year variability (in the frequency and intensity) of nor'easters and hurricanes and their associated storm surges, tracking over long time scales is necessary before a statistically significant trend can be documented. However, more recent extreme events that impacted the state and other areas in the country and the world (e.g., Hurricane Sandy and hurricane Irene) seem to indicate that the frequency of some of these phenomena is increasing. A shift away from the usual/familiar patterns of climate variability will be bringing changes in many aspects of climate. While it is quite difficult to attribute one particular extreme, such as a severe hurricane, to human induced climate change rather than to the natural range of variability, the increased probability of these changes occurring can be linked to changes in climate.

More Information

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.

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