Climate Impacts on the Newport News Shipyard

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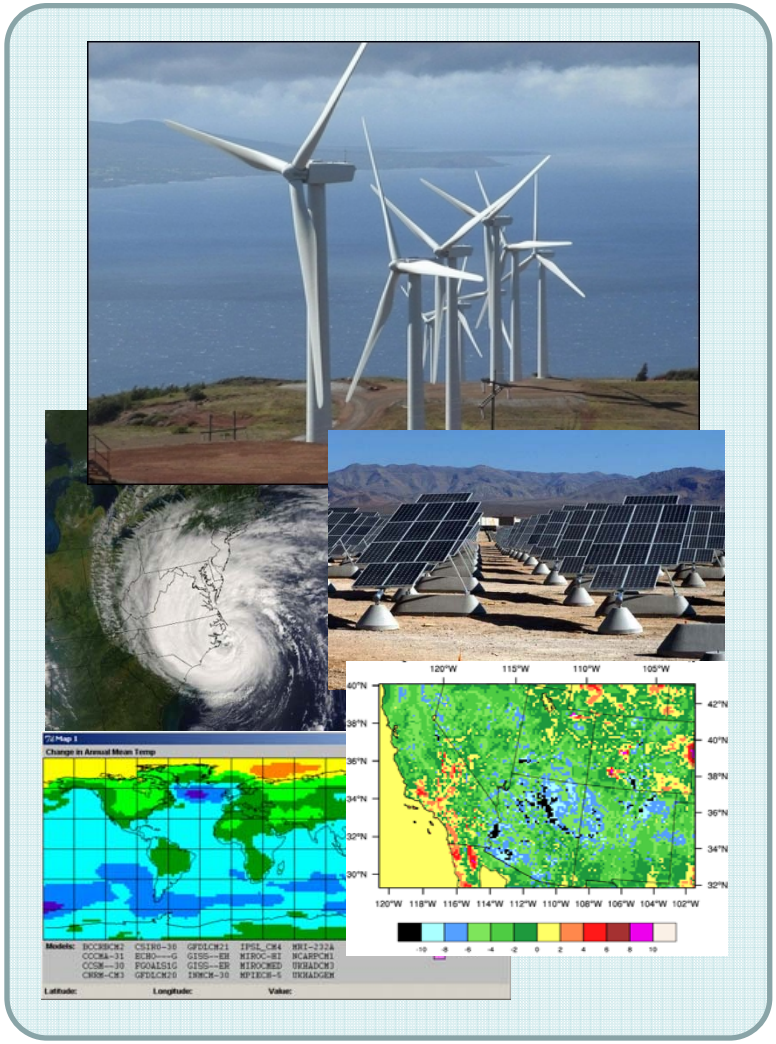
Climate Change Issues Overview

- Examples of Climate Change Impact Areas
  - Department of Defense – Readiness, Sustainment, Energy, Water
  - Infrastructure – Planning, Operations, Maintenance, Insurance, Energy, Water
  - Economic Activities –Manufacturing, Recreation, Agriculture, Transportation
  - Health & Safety – Preparedness and mitigation, disease vectors, heat stress
- Northrop Grumman's Initiative:

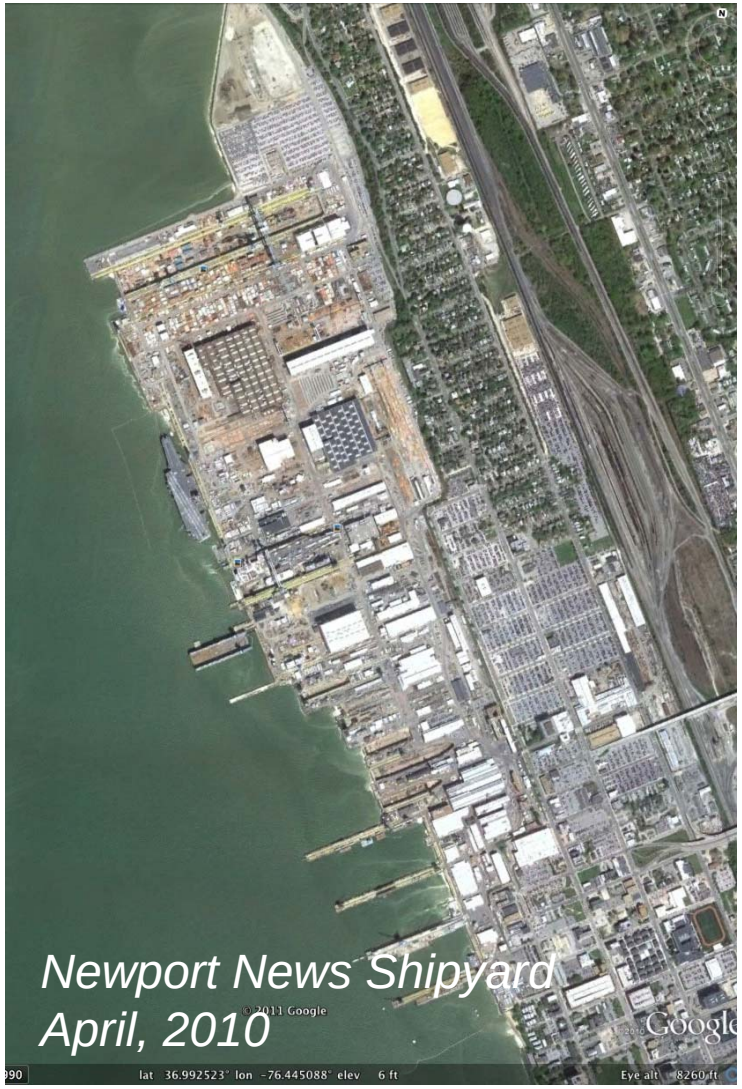
  Long-term program to develop and productize climate decision aids to support needs outside and inside the company



Climate Change Issues: Newport News

- Newport News Shipyard
  - Nation's sole Nuclear Aircraft Carrier construction and maintenance capability
  - In Existence since early 1800's
  - A Northrop Grumman Sector until March, 2011
- Major industrial facility with associated supporting economy
  - 20,000 Employees in Virginia
  - Largest Dry-dock and Crane in Western Hemisphere
  - Historical responsibility for over 800 Ships, including 30 Aircraft Carriers

Dry-dock doors were overtopped by storm surge and waves during Hurricane Isabel in 2003, highlighting sensitivity to Sea Level Rise



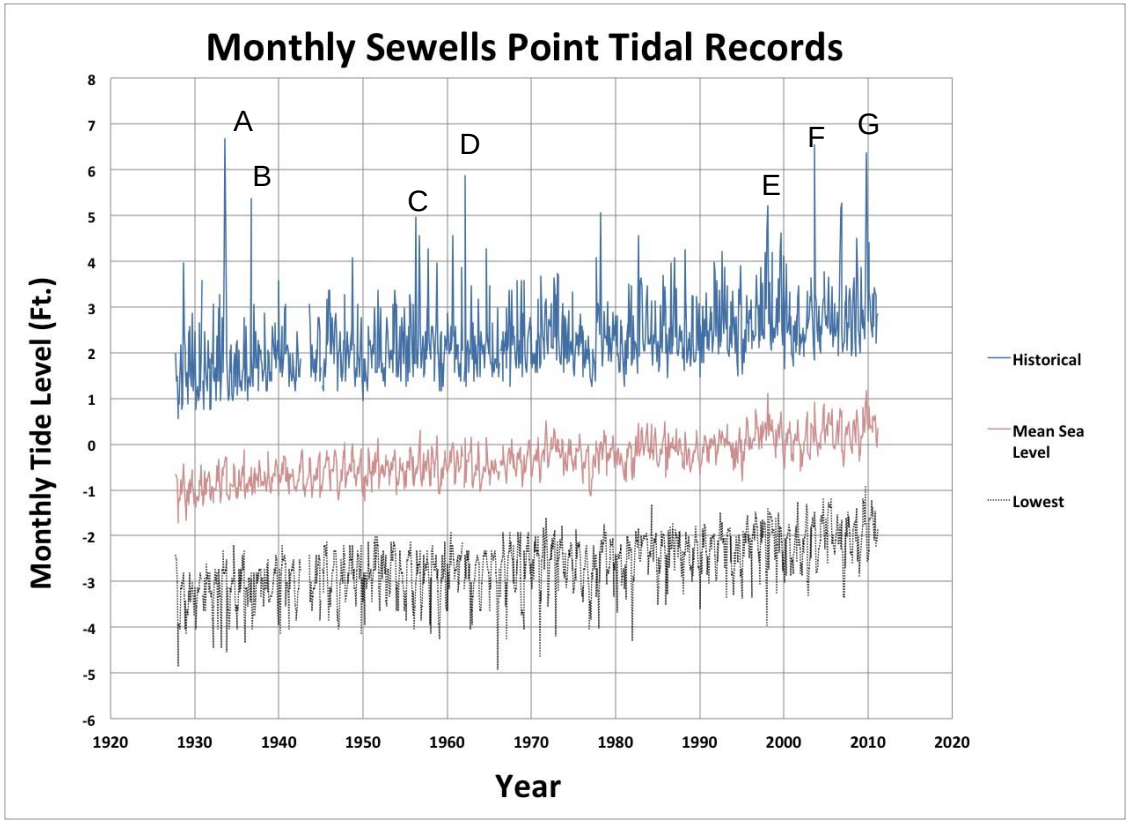
Hurricane Isabel

Record high water level at the Shipyard

James River spilling into dry dock #1

Sea Level at Sewell's Point

Sewell's Point is the NOAA Tidal Gauge Station at Norfolk , VA. It is nearby to both the Norfolk Naval Station and to the Newport News Shipyard



Trends show:

- Steadily increasing Mean Sea Level through the Century, carrying storm surges higher
- Well-known Tidal Peaks:
  - A. 1933 Cat 2 Hurricane
  - B. 1936 Cat 2 Hurricane
  - C. 1956 Nor'Easter
  - D. 1962 "Ash Wednesday" Storm
  - E. 1998 Nor'Easter
  - F. 2003 Hurricane Isabel
  - G. 2009 "Son of Ida" Nor'Easter

Tidal Record Modeling and Application of Extreme Value Theory

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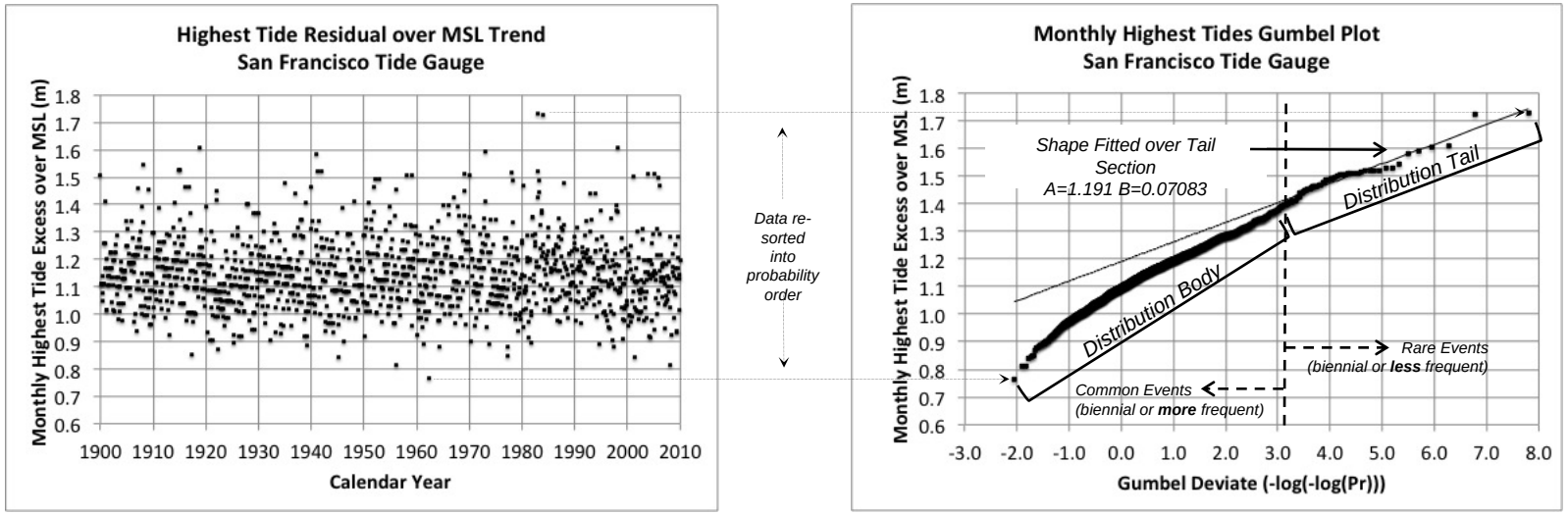
- *Extreme Value Theory* offers a distributional model of the tail of a distribution of specific types of statistics. These statistics generally follow the form of the single largest value out of an observed set of values – i.e., the extreme value of the set, such as the highest tide of the month or year.*

- *The Gumbel Distribution shows the probability p of observing at or above a given extreme value y is approximately linear w.r.t. the negative-logarithm of the negative-logarithm of the probability on the upper tail with two shape parameters, here given as intercept A and slope B.*

$$y = A + B(-\log(-\log(p)))$$

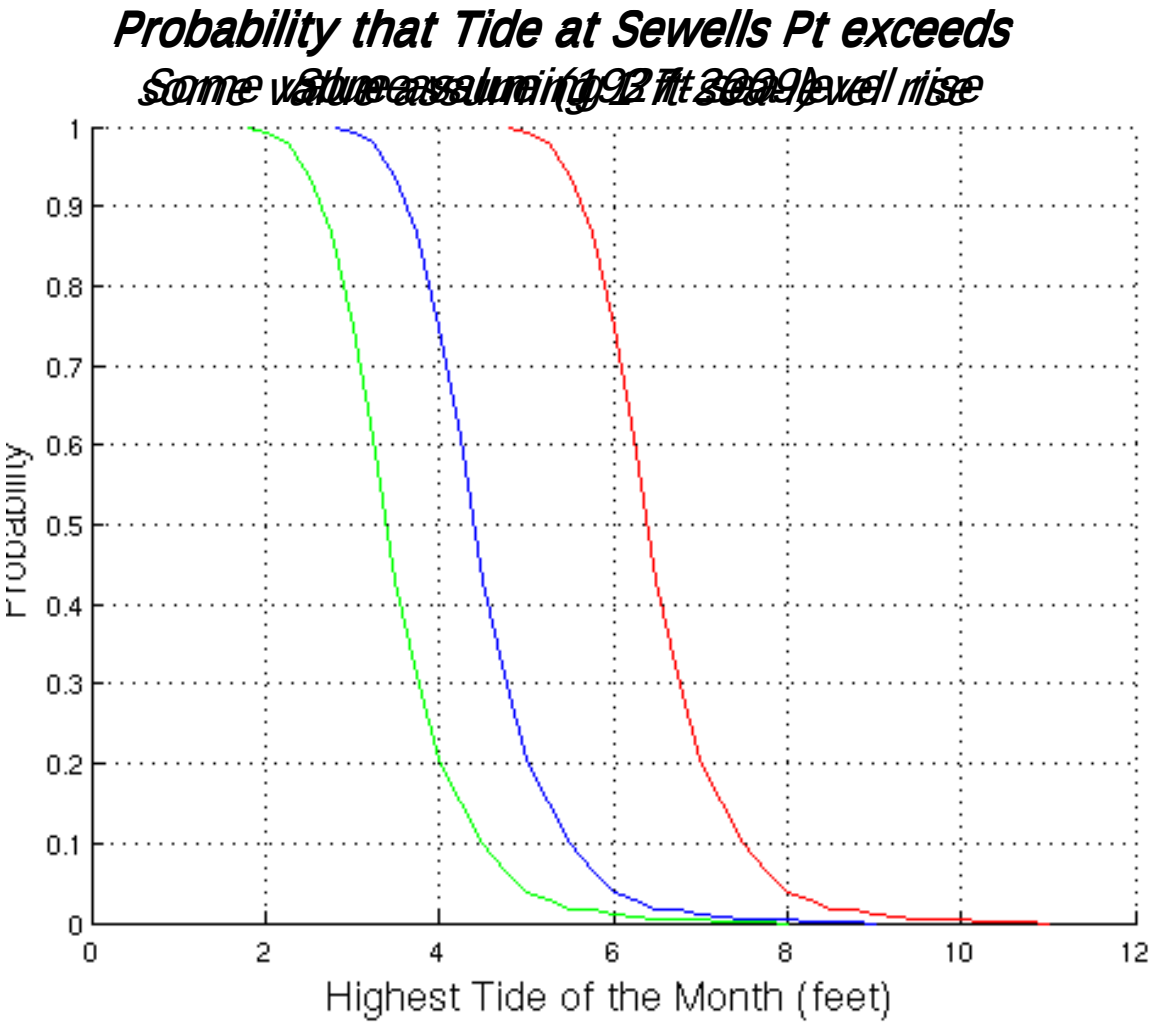
- *For tidal gauge data, the highest water level recorded in a month fits this form, and can be modeled using a linear-regression to recover the shape parameters A and B.*



San Francisco Bay Example

* Gumbel, E.J. 1954. Statistical Theory of Extreme Values and Some Practical Applications. Applied Mathematics Series 33. U.S. Department of Commerce, National Bureau of Standards.

Sea Level Rise Impacts



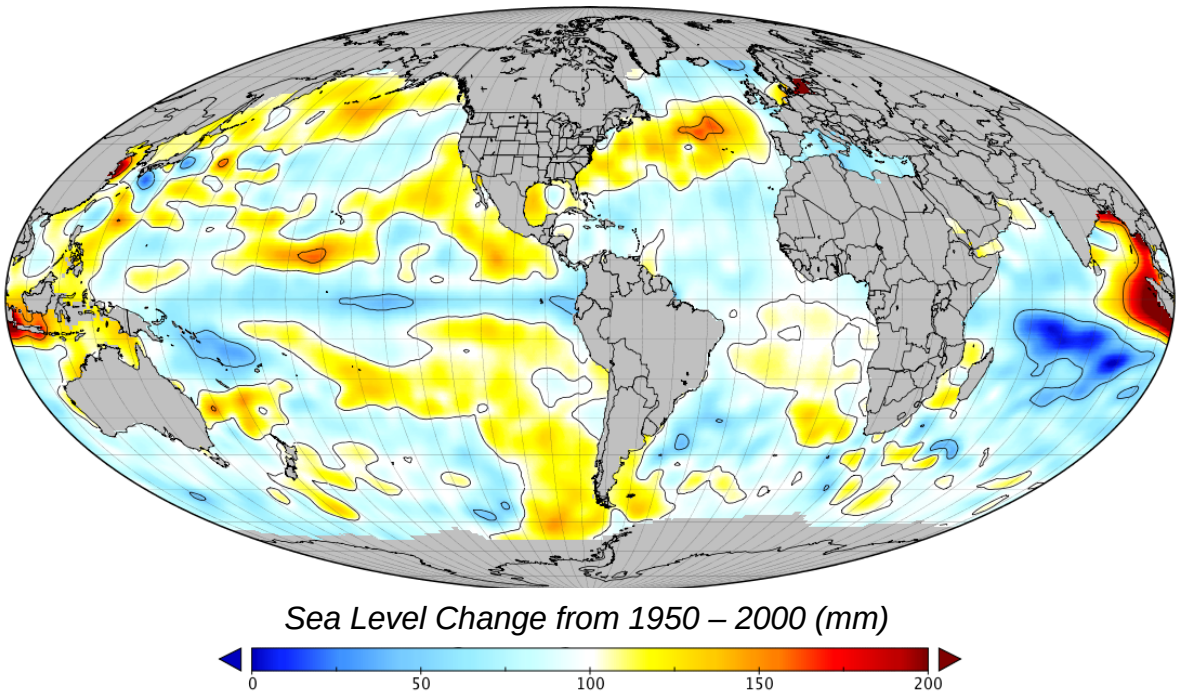
Fitting Gumbel Parameters allows us to estimate frequencies of extreme storm surges over and above the mean sea level

Modest levels of rise on the average increase the frequency of specific extreme events dramatically

Average Years Between Flooding Events					
Event Severity		Sea Level Rise (Ft)			
Flood Stage	Gauge Level	0	1	2	3
Action	4.50	0.70	0.15	0.09	0.08
Flood	5.00	1.71	0.33	0.10	0.08
Moderate	6.00	7.32	1.71	0.33	0.10
Major	7.00	26.83	7.32	1.71	0.33
Record	8.02	80.50	26.83	7.32	1.71
Disaster	9.00	~ 80.50		26.83	7.32

Global Sea Level Rise

Sea Level Rise is a Global Concern



- Oceanic Volume Increases from thermal expansion of the water column
- Post Glacial Rebound steadily lowering continental plate edges with the Ice-Age ice mass now removed
- Icecap melt increases total water content of Oceans – main Anthropogenic sea level driver

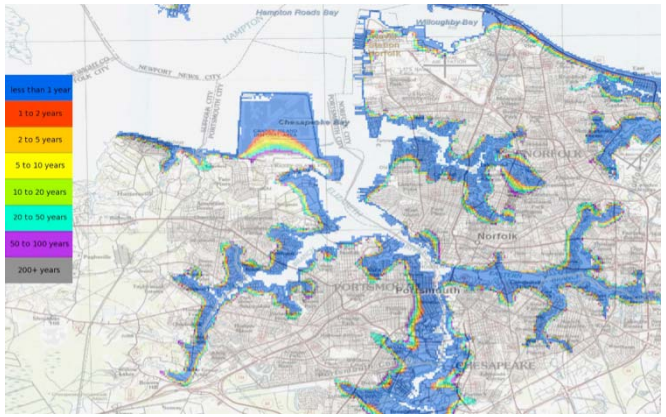
Norfolk Area Inundation Recurrence

The Hampton-Roads Economic Region supports the Newport News Shipyard and Norfolk Naval Station

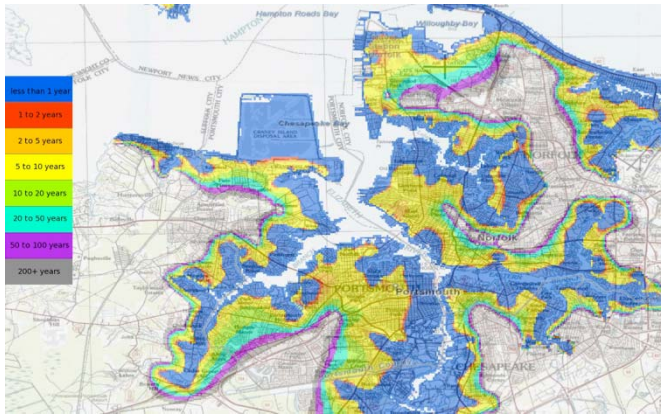
•Climate change impacts on the region affect the long term sustainability of the Shipyard beyond the direct flooding of the Dry-docks

•Inundation of local and regional residences, businesses, transportation facilities, and other supporting infrastructure impact the long term operational sustainment of this critical national asset

Inundation recurrence in the Norfolk Region overlaid on infrastructure base-maps



Year 2000 at Nominal Sea Level



2100 with One Meter of Sea Level Rise

Additional Material

Sea Level Rise
San Francisco Bay Area

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San Francisco Monthly Highest Tides

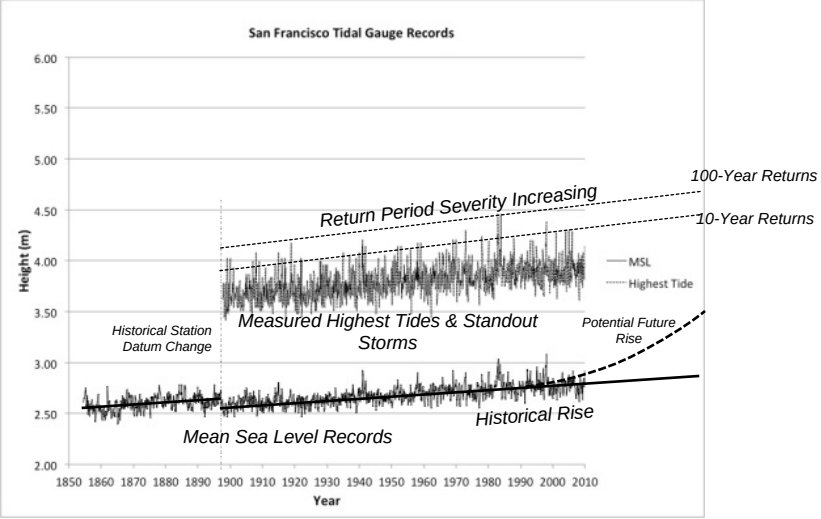
•Historical level steadily rising due to soil subsidence, post-glacial continental plate rebounding, and general oceanic volume increase

•Peaks Over Threshold technique shows trends in return periods of monthly highest tides

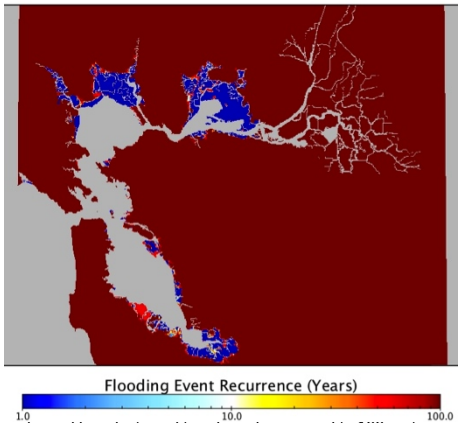
- *Storms of historical severity creating higher tides*
- *Historical high tides being regenerated by less severe storms*

•Possibility of significant additional anthropogenic forced rise compounds high-confidence historical sea level rise processes

Significant risks to established property and infrastructure

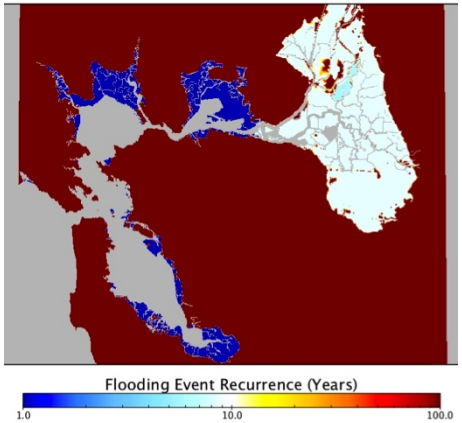


Return Period (Years) map for San Francisco Bay Area for Monthly Highest Tides



Current Case is derived from historical trends and compared to 100-meter resolution terrain

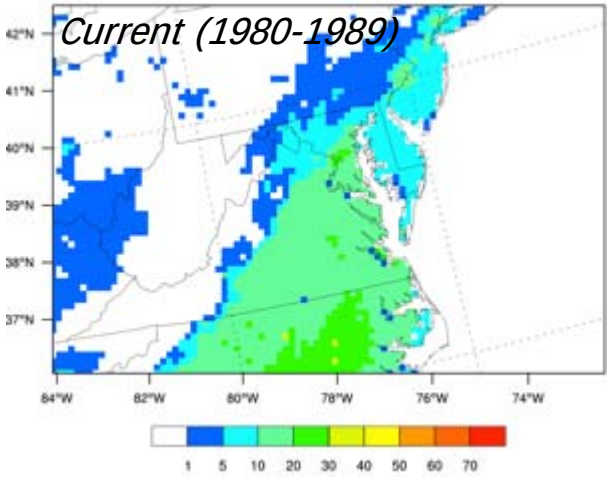
Historical Trend plus Half-meter Rise Effect to 2100

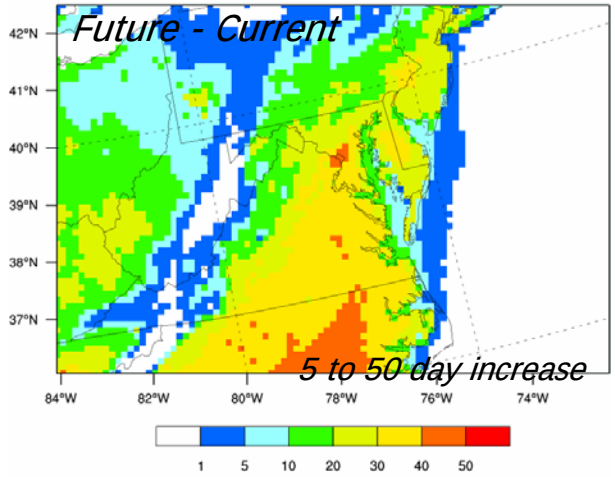


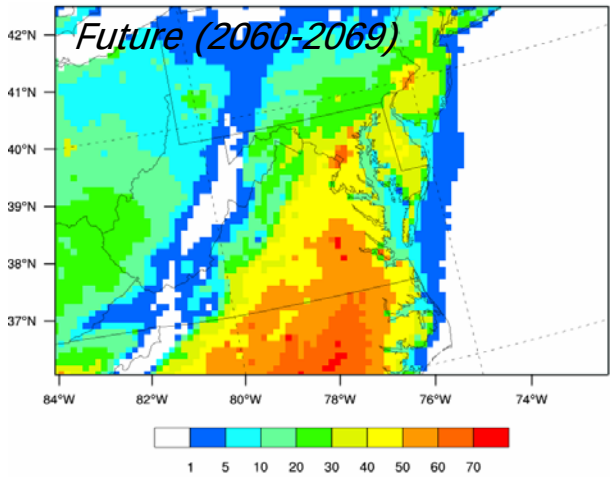
Illustrative Case is derived from historical trends and asserted one-half meter Sea Level Rise by 2100

Society and ecosystems indicators: Heat Stress and heat related deaths

Mean number of days per year with heat index > 105° F





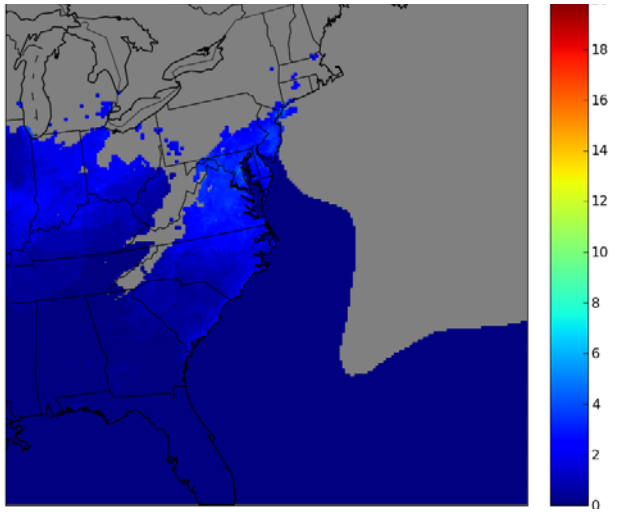


City	Metro Pop	Mean "Oppressive" Days Per Year (Models have monthly biases with respect to GHCN removed)			Change in Deaths due to Change in Oppressive Days	
		Current	Future	Change	Deaths per Million	Additional Deaths for Metro
Richmond	1.2 M	13.30	49.2	35.9	32.31	39
Lynchburg	246 K	5.7	32.8	27.1	24.39	6
Roanoke	296 K	5.9	30	24.1	40.97	12
Wash. DC	5.3 M	10.1	39.4	29.3	26.37	140
Norfolk	1.8 M	9.7	32	22.3	20.07	36
'Change' is Future value - Current value						

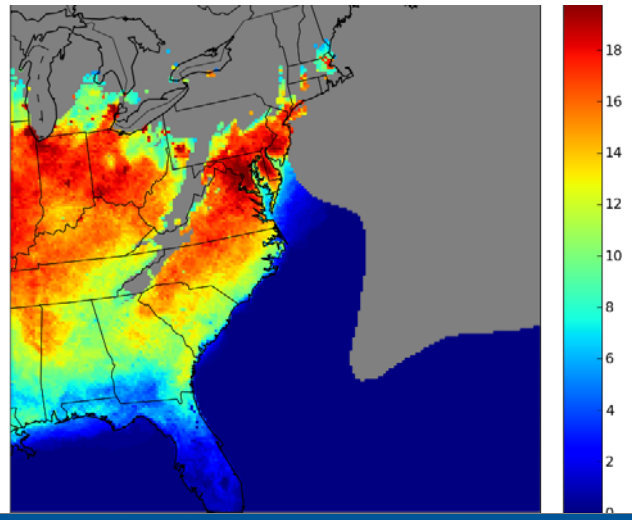
Use: City planning, emergency planning, public facility planning, HVAC planning

Weather and climate change indicators: Heat waves

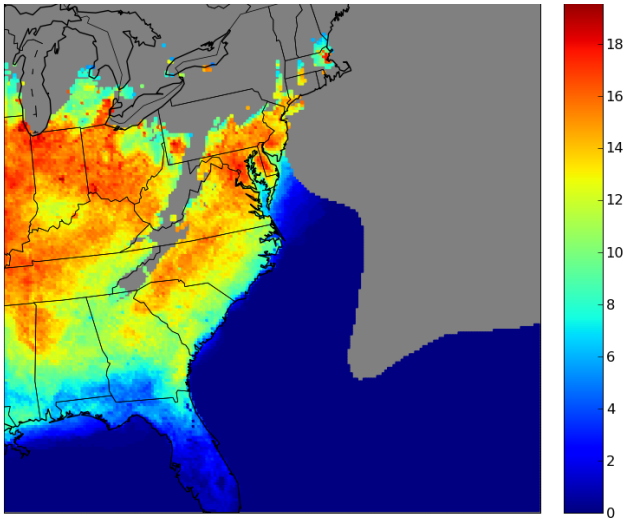
Mean summer days spent in a heat wave (1980s)



Mean summer days spent in a heat wave (2060s)



Mean summer days spent in a heat wave (future-current)



- Heat waves have caused more deaths than all other weather events.
- A heat wave is defined as 3+ consecutive days when the high temperature is 10+ degrees (Fahrenheit) higher than mean summer high temperature

Use: Urban planning, emergency planning