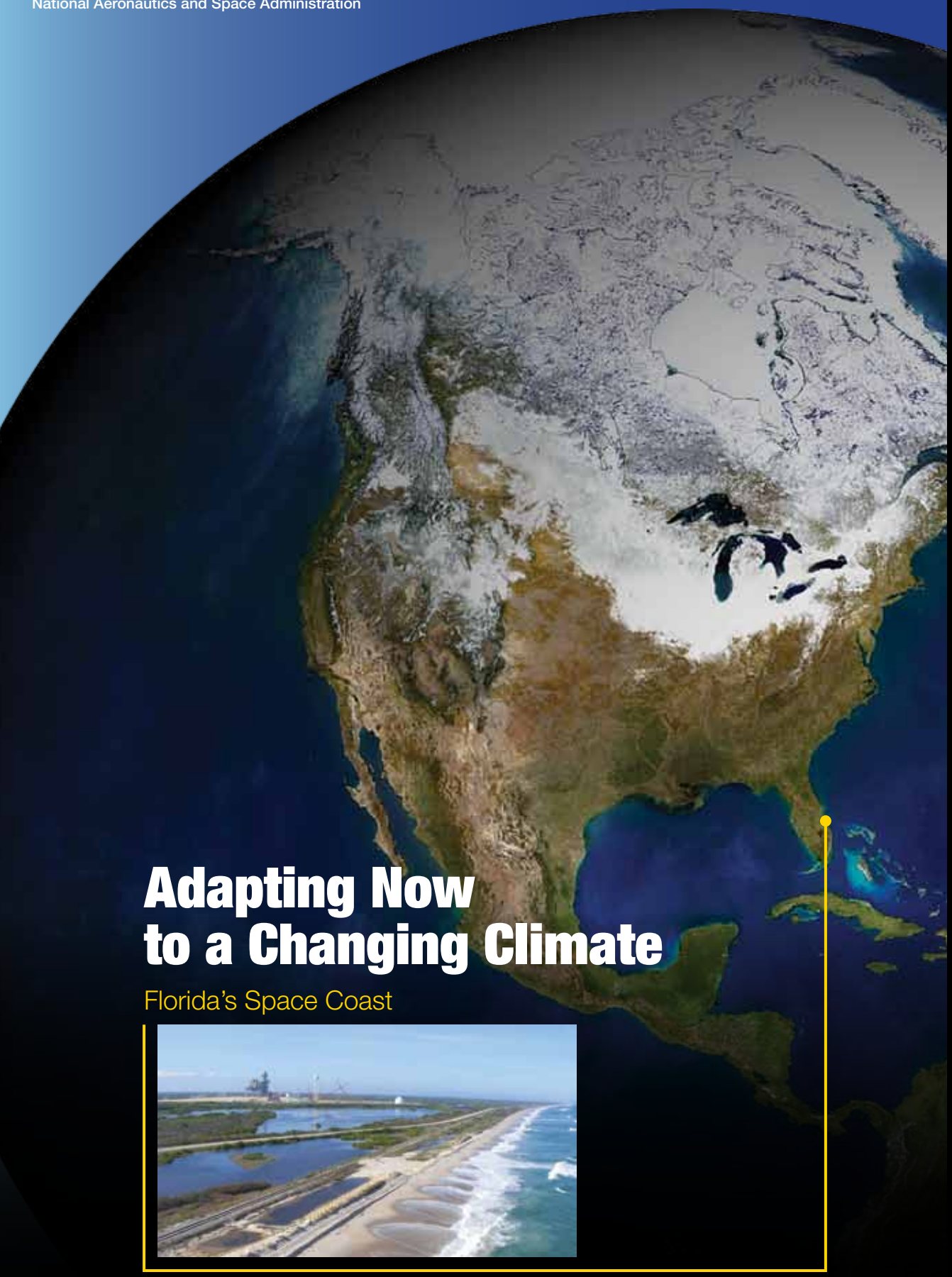
National Aeronautics and Space Administration



climate change

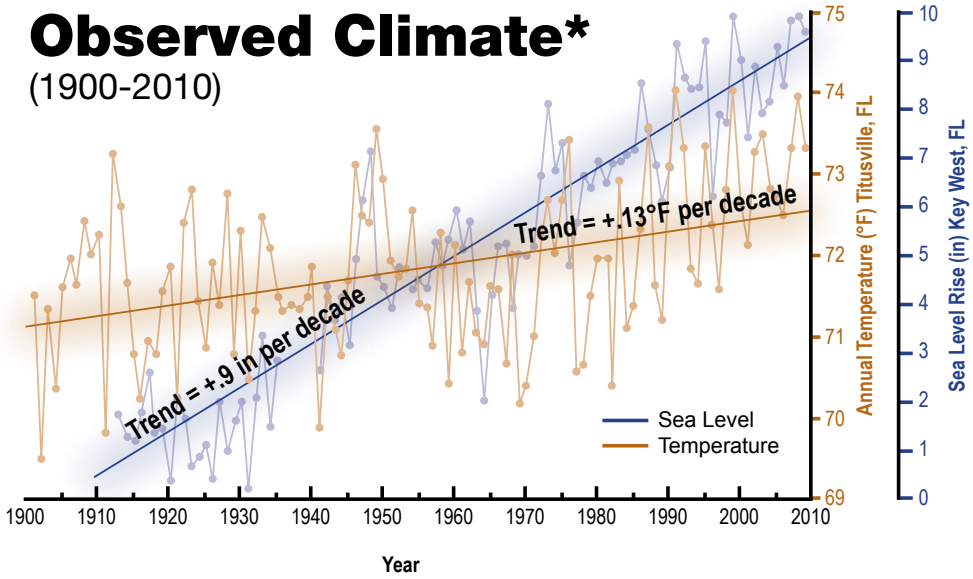
# Adapting Now to a Changing Climate

## Florida's Space Coast

# the issue

Actual weather data collected over the past 100 years in Florida point to one undeniable fact: ***average temperatures and sea level are rising***. In addition, climate models project accelerated temperature and sea level rise and an increase in extreme weather events – including heat waves, coastal flooding, and intense precipitation – for the Space Coast in the future. Already, the area shows signs of climate vulnerability: outdoor work schedules must accommodate increasing temperatures, storm surges regularly breach the dunes near the launch pads, and sea turtles were rescued during a January 2010 cold stun event.

Equipped with solid information about what to expect for the area, resource stewards on the Space Coast can ***plan and implement adaptation strategies now*** to protect the assets entrusted to their care.




*Data from National Oceanic and Atmospheric Administration:
Temperature: National Climatic Data Center
Sea level: Tides and Currents Web Portal

# the setting

Approximately 72 miles of coastal and inland habitat in the center of Florida's eastern coast comprise the area known as the Space Coast, which includes NASA's Kennedy Space Center and DoD's Cape Canaveral Air Force Station. The location provides a critical asset for the Nation – access to orbits that cannot be obtained from launches anywhere else in the US.


# what's at stake?

Classified as a humid subtropical climate, the Space Coast's mean annual temperature ranges from 60°F (in January) to 82°F (in August) and receives an average of 53 inches of rain per year. The area's three primary ecological zones are: coastal dune/strand, coastal scrub, and maritime and riverine hammocks. The area is home to several threatened or endangered species, including scrub jays and several types of sea turtles. The area's beautiful natural and cultural resources attract millions of visitors every year, supporting a robust tourism industry.

The aerospace industry is a key building block of the thriving local economy. In a report prepared for Space Florida, a state-chartered economic development organization focusing on aerospace interests, the total economic contribution of NASA to Florida in 2008 was estimated at $4.1B in output; the local impact of Patrick Air Force Base and Cape Canaveral Air Force Station was nearly $1.07B in salaries for military and civilian employees, indirect jobs created, and local contracts and construction.[1] The highly-trained aerospace workforce attracts additional high-tech industries to the region. The local economy gains significantly from the presence of NASA and DoD assets and operations. The whole community stands to benefit from adaptation planning that considers regional energy, water, human health, and sustainability factors.

[1]www.spaceflorida.gov (Spaceport Master Plan 2010)

# projected changes

Several national and international research organizations have collected weather data over the past century and studied other indicators of longer term climate patterns, such as ice cores and tree rings. Climate scientists are researching weather and climate systems to understand and predict how one change can cause other changes, such as the influence of ocean currents on the number and intensity of hurricanes. Using collected and calculated weather data, plus an understanding of physical processes that control climate, scientists have developed sophisticated models that project future climate changes. Climate scientists have reached a consensus that some climate changes will accelerate this century, leading to a range of corresponding impacts. A summary is provided in the US Global Climate Change Research Program's report at **www.globalchange.gov/publications/reports/scientific-assessments/us-impacts**.

### Climate Change Models

The United Nations Intergovernmental Panel on Climate Change (IPCC) developed three emissions scenarios based on differing sets of assumptions about economic growth, population growth, and greenhouse gas (GHG) emission reduction policies. The emissions scenarios range from very conservative (i.e., minimal change in the current emissions trends) to more progressive (i.e., international leaders implement aggressive emissions reductions policies). From each of these three scenarios, a corresponding GHG atmospheric concentration is calculated. The GHG levels are then used in each of 16 primary models to yield a total of 3 x 16 = 48 possible outcomes with regard to climate variables. Scientists assess the range of model results to forecast climate patterns. The models include atmosphere, land surface, ocean, and sea ice components.

NASA climate scientists are an important part of the international research effort. NASA is a key player in climate modeling and collection of both earth-based and space-based data used to develop and validate climate models. For purposes of this targeted study on Florida's Space Coast, NASA's Goddard Institute for Space Studies used site-specific data from Titusville and Daytona Beach to **downscale the climate models to yield projections for the central eastern coast of Florida**. The chart below presents model results. The color shading is intended to draw attention to the more dramatic projected changes.

**Key Climate Variables***

| Variable | Baseline[1] | 2020s | 2050s | 2080s |
|---|---|---|---|---|
| Air Temperature (°F) | 72°F | +1 to 2 | +2.5 to 3.5 | +3 to 6 |
| Annual Precipitation | 53 in | -5 to +5% | -5 to +5% | -5 to +5% |
| Sea Level Rise[2] | N/A | +2 to 3 in | +5 to 8 in | +9 to 15 in |
| Sea Level Rise *(See Rapid Ice Melt Scenario text box)* | N/A | +6 to 8 in | +21 to 24 in | +43 to 49 in |

** Temperatures reflect a 30-year average centered on the specified decade; sea levels are averages for the specified decade.*
*[1] Average over 1970-2000.*
*[2] A 1-inch rise in sea level can cause a shoreline retreat inward of about 100 inches (8.3 ft) if the coastal plane is relatively flat. (From 2004 Arctic Climate Impact Assessment)*

# projected changes

Does this information mean it is appropriate to say, "In 2043, the average temperature on the Space Coast will be 75°F."? No. Models do not provide this degree of absolute certainty. It is, however, appropriate to say that models suggest that between 2040 and 2070, temperatures may increase 2.5 to 3.5 degrees above the average temperature from 1970-2000.

**Overall, the projections for the Space Coast indicate higher temperatures and rising sea levels, but fairly consistent annual precipitation.** Besides the overall trends in temperature, precipitation, and sea level rise, the trends in **extreme events** must be considered in adaptation strategy planning. Of particular note in the chart below, while overall annual precipitation may remain consistent, **intense downpours** will become more likely. This has serious implications for water management, already a challenge in the relatively flat topography of central eastern Florida.

## Rapid Ice Melt Scenario

Because General Circulation Models do not capture all of the processes that may contribute to sea level rise, an alternative method that incorporates observed and longer-term historical ice-melt rates was developed. This "rapid-ice melt" approach includes the potential for rapid melting of some of the **land-based ice** in polar regions, such as that on Greenland or the Western Antarctic Ice Sheet. **This approach suggests that sea level could rise at the Space Coast by approximately 43 to 49 inches by the 2080s.** In a flat coastal area, this could have dramatic impacts.

Heat stress, downpours, storms, and high winds are projected to increase along the Space Coast in this century.

| Daily Temperatures | Baseline | 2020s | 2050s | 2080s |
|---|---|---|---|---|
| Days at or **above 95°F** | 12 | 21 to 28 | 31 to 57 | 45 to 101 |
| Days at or above 90°F | 82 | 99 to 114 | 118 to 142 | 125 to 173 |
| Days at or below 40°F | 20 | 13 to 15 | 10 to 14 | 7 to 11 |
| Days at or below 32°F | 4 | 2 to 3 | 2 | 1 to 2 |

**Extreme Events*: 2020-2090**

| Event | Trend | Likelihood |
|---|---|---|
| Heat Stress | ↑ | Very Likely (>90%) |
| Downpours | ↑ | Likely (>66%) |
| Intense Storms | ↑ | More likely than not (>50%) |
| Extreme Winds | ↑ | More likely than not (>50%) |

* Based on global climate simulations, published literature, and expert judgment

**The number of days in a year hotter than 95°F will rise dramatically in the coming century, and the number of days below freezing will decrease.** More hot days will affect outside work, energy use, agricultural practices and habitats. On the plus side, fewer days below 40°F may reduce launch delays due to cold weather.

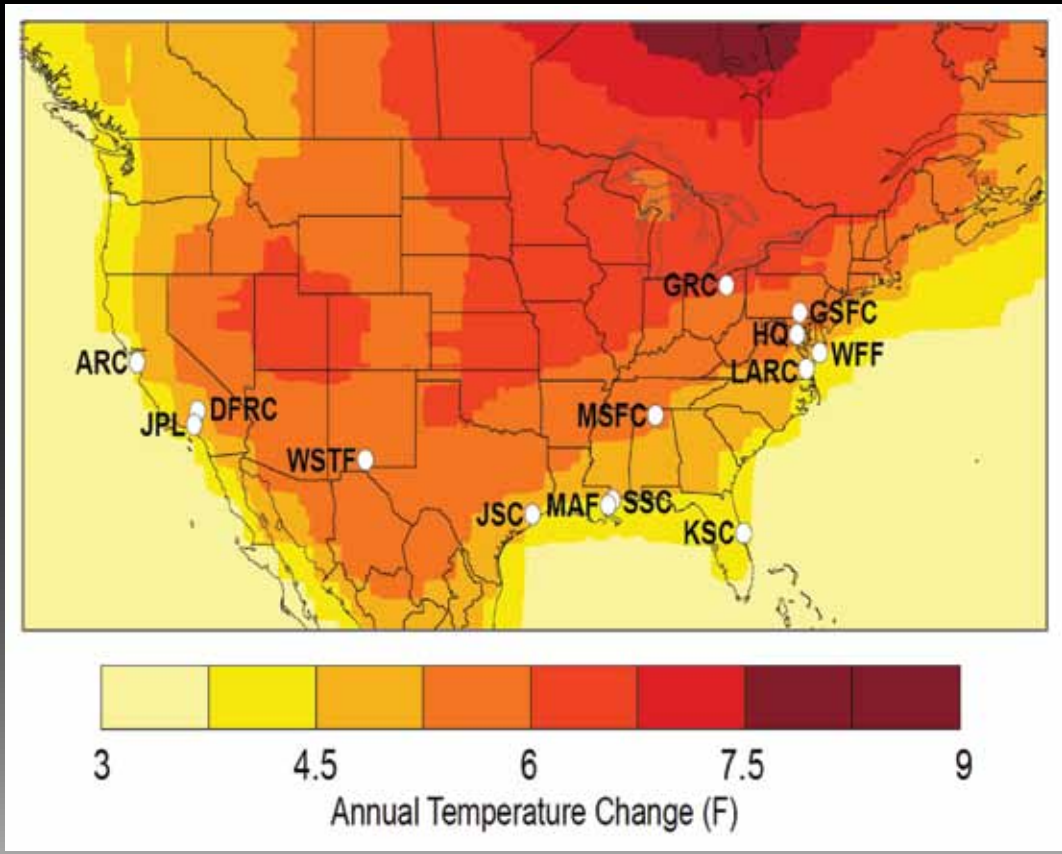
# our responsibility

While leaders around the world are deliberating about the best ways to slow the rate of climate change through greenhouse gas reduction, *the time to develop and implement adaptation strategies is now. Executive Order 13514 directs federal agencies to assess and manage the effects of climate change on their operations and mission in both the short and long term.* Climate changes on the Space Coast will impact facility operations (e.g., water management, energy demands), natural resource management (e.g., sea turtle habitat loss, increase in invasive species), mission infrastructure (e.g., launch pad assets), quality of life in the community (e.g., heat stress, potential for increased disease), and economic changes (e.g., increased percentage of public funds for utility costs). By considering these impacts in the normal planning cycles of the federal agencies on the Space Coast, impacts to mission may be abated. Agencies will need to implement short-term tactical changes now, while simultaneously planning for longer-term strategic adaptation measures. Some of the potential impacts are listed below in the chart.

The first group of hatchlings from endangered sea turtle eggs (relocated from northern U.S. Gulf Coast beaches affected by the April 2010 oil rig disaster) are being released into the Atlantic Ocean off NASA's Kennedy Space Center in Florida. Photo credit: NASA/ Kim Shiflett

| Climate Variable | Impacts |
|---|---|
| Sea Level Rise | Inundation of launch assets, mission-critical infrastructure, transportation corridors, and remediation sites |
| Increased Coastal Flooding | Coastal erosion; changes in shoreline habitats; challenges to stormwater and wastewater management; limited launch windows; public safety concerns |
| Increased Number of High Temperature Days | Increased cooling costs; increased restrictions on outdoor labor; damage to infrastructure materials |
| Overall Increased Temperature | Increased cooling costs; potential for increased invasive and exotic species; damage to infrastructure materials |
| Reduced Number of Days Below Freezing | Reduced heating costs; reduced freeze threat to agriculture operations; potential for increased invasive and exotic species |

## Projected Temperature Change (°F), 2080s minus 1980s, A1B Emissions Scenario*




* A1B scenario, one of several developed by the IPCC, assumes high CO2 levels for first half of the 21st century, followed by a gradual decrease in emissions after 2050 due to new technologies

**A Note about Downscaling Climate Data Specifically for the Space Coast:**

The quantitative climate projections in this document are based on global climate model simulations conducted for the IPCC Fourth Assessment Report (2007) from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project Phase 3 (CMIP3) multi-model dataset. The simulations provide results from sixteen global climate models that were run using three emissions scenarios of future greenhouse gas concentrations. The outputs are statistically downscaled to 1/8 degree resolution (~12 km by 12 km) based on outputs from the bias-corrected (to accurately reflect observed climate data) and spatially-downscaled climate projections derived from CMIP3 data. This information is maintained at: **http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections** and described by Maurer, et al. (2007).

The **rapid ice melt scenario** and qualitative projections reflect a blend of climate model output, historical information, and expert knowledge. For more information about rapid ice melt models, see a paper and references at **http://www.nature.com/climate/2010/1004/pdf/climate.2010.29.pdf**.

Climate projections and impacts, like other types of research about future conditions, are characterized by uncertainty. Climate projection uncertainties include but are not limited to:

1) Future greenhouse gas concentrations,
2) Sensitivity of the climate system to greenhouse gas concentrations,
3) Climate variability, and,
4) Changes in local physical processes (such as afternoon sea breezes) that are not captured by global climate models.

Even though precise quantitative climate projections at the local scale are characterized by uncertainties, the information provided here can guide resource stewards as they seek to identify and manage the risks and opportunities associated with climate change and the assets in their care.

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