COMMUNICATING CLIMATE SCIENCE

KIM GOTWALS
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

TWO TYPES OF PRODUCTS TO REVIEW – WHY TWO?

1. **Climate Science Slide Presentation**

2. **Climate Information Handouts for Workshop Participants**

DIFFERENT COMMUNICATION NEEDS

	Briefing	Handout
Who?	A group	Individual readers
What?	The minimum facts	Enriched with context and details
When?	In the workshop	Before, during, and after workshop
How?	Spoken	Printed
Why?	Shared focus/ Consistency in understanding	Depth fosters confidence; reference in workshop breakouts

IT TAKES A TEAM!

Project Manager
Training Instructor & Project Coordinator
Science Information Expert
Climate Scientists
Risk Communication Expert
Communication Specialist
Visual Communication Expert
Graphic Designer

WHY DO WE NEED TO THINK ABOUT THIS?

- **Communication is surprisingly important AND takes time**
- **Provide lessons learned during the evolution of these two products so that…**
- **You can help with this effort in your own agency (EVERY agency must communicate climate information)**

"The problem with communication is the illusion that it has occurred."

- George Bernard Shaw

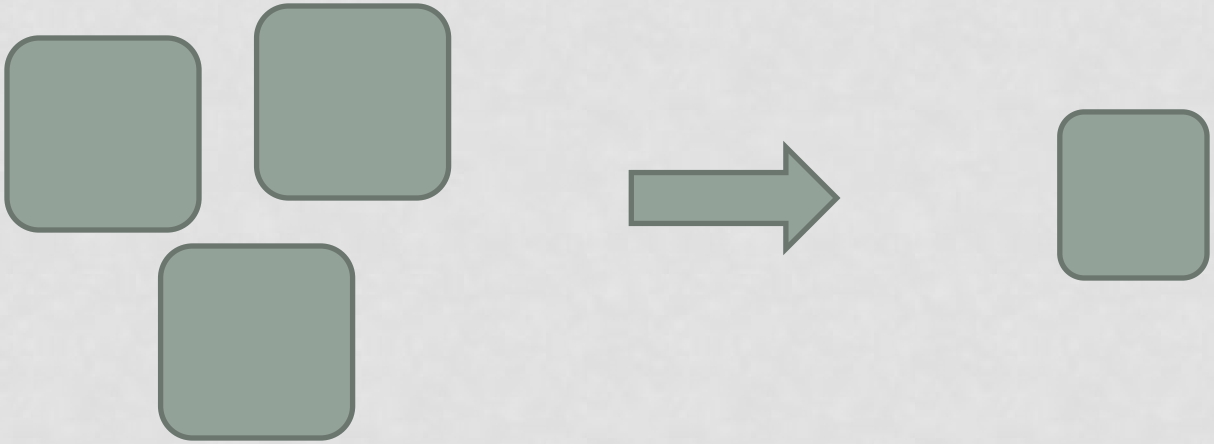
PRODUCT I

Climate Science Slide Presentation

WHAT MAKES THE CLIMATE TALK WORK? PART 1 - STREAMLINING

- Its Length (or rather, lack thereof)

  - Presentation evolved from 3 separate presentations on Global, Regional, and Local Climate Science



Climate Information Sharing – 1st Attempt

We went from paper handouts with lots of numbers….

Table 3.1. Baseline climate and mean annual changes[a]

	Baseline 1971–2000	2020s	2050s	2080s
Air temperature				
Central range[b]	55° F	+ 1.5 to 3.0° F	+ 3.0 to 5.0° F	+ 4.0 to 7.5° F
Precipitation				
Central range[b]	46.5 in[3]	+ 0 to 5%	+ 0 to 10%	+ 5 to 10%
Sea level rise[c]				
Central range[b]	NA	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Rapid ice-melt scenario[d]	NA	∼ 5 to 10 in	∼ 19 to 29 in	∼ 41 to 55 in

Source: Columbia University Center for Climate Systems Research.

[a]Based on 16 GCMs (7 GCMs for sea level rise) and 3 emissions scenarios. Baseline is 1971–2000 for temperature and precipitation and 2000–04 for sea level rise. Data from National Weather Service (NWS) and National Oceanic and Atmospheric Administration (NOAA). Temperature data are from Central Park; precipitation data are the mean of the Central Park and La Guardia Airport values; and sea level data are from the Battery at the southern tip of Manhattan (the only location in New York City for which comprehensive historic sea level rise data are available).

[b]Central range = middle 67% of values from model-based probabilities; temperatures ranges are rounded to the nearest half-degree, precipitation to the nearest 5%, and sea level rise to the nearest inch.

[c]The model-based, sea level rise projections may represent the range of possible outcomes less completely than the temperature and precipitation projections.

[d]"Rapid ice-melt scenario" is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic ice sheets and paleoclimate studies.

R Horton, V Gornitz & M Bowman (2010) "Chapter 3: Climate Observations and Projections;" *In* New York City Panel on Climate Change (2010) Annals of the New York Academy of Sciences

Table 3.2. Quantitative changes in extreme events

	Extreme event	Baseline (1971–2000)	2020s	2050s	2080s
Heat waves and cold events	# of days/year with maximum temperature exceeding:				
	90°F	14	23 to 29	29 to 45	37 to 64
	100°F	0.4[a]	0.6 to 1	1 to 4	2 to 9
	# of heat waves/year[b]	2	3 to 4	4 to 6	5 to 8
	Average duration (in days)	4	4 to 5	5	5 to 7
	# of days/year with minimum temperature at or below 32°F	72	53 to 61	45 to 54	36 to 45
Intense precipitation and droughts	# of days per year with rainfall exceeding:				
	1 inch	13	13 to 14	13 to 15	14 to 16
	2 inches	3	3 to 4	3 to 4	4
	4 inches	0.3	0.2 to 0.4	0.3 to 0.4	0.3 to 0.5
	Drought to occur, on average[c]	∼once every 100 yrs	∼once every 100 yrs	∼once every 50 to 100 yrs	∼once every 8 to 100 yrs
Coastal floods and storms[d]	1-in-10 yr flood to occur, on average	∼once every 10 yrs	∼once every 8 to 10 yrs	∼once every 3 to 6 yrs	∼once every 1 to 3 yrs
	Flood heights (in ft) associated with 1-in-10 yr flood	6.3	6.5 to 6.8	7.0 to 7.3	7.4 to 8.2
	1-in-100 yr flood to occur, on average	∼once every 100 yrs	∼once every 65 to 80 yrs	∼once every 35 to 55 yrs	∼once every 15 to 35 yrs
	Flood heights (in ft) associated with 1-in-100 yr flood	8.6	8.8 to 9.0	9.2 to 9.6	9.6 to 10.5
	1-in-500 yr flood to occur, on average	∼once every 500 yrs	∼once every 380 to 450 yrs	∼once every 200 to 330 yrs	∼once every 120 to 250 yrs
	Flood heights (in ft) associated with 1-in-500 yr flood	10.7	10.9 to 11.2	11.4 to 11.7	11.8 to 12.6

Source: Columbia University Center for Climate Systems Research.

Note: Extreme events are characterized by higher uncertainty than mean annual changes. The central range (middle 67% of values from model-based probabilities) across the GCMs and GHG emissions scenarios is shown.

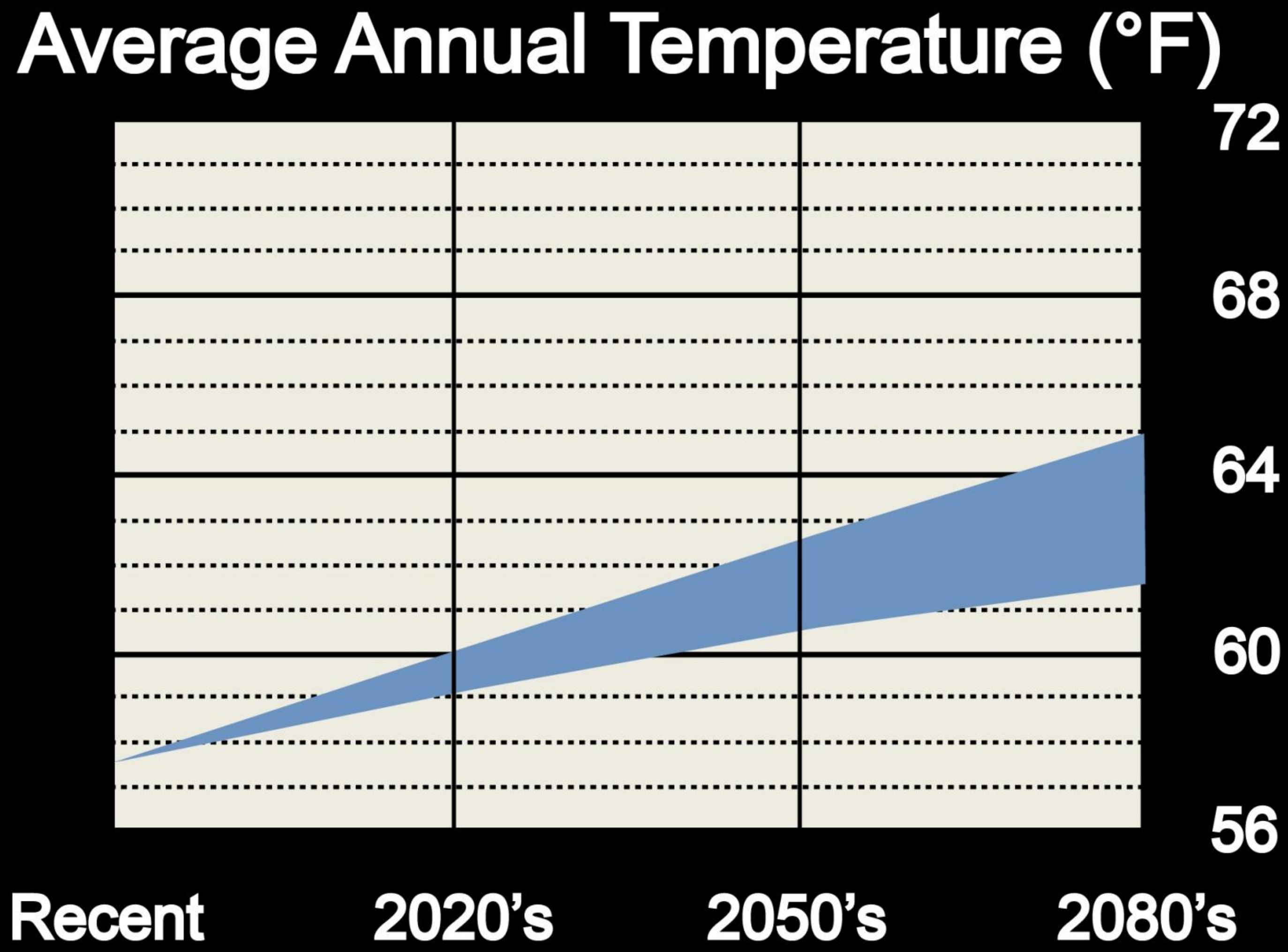
[a]Decimal places shown for values less than 1 (and for all flood heights), although this does not indicate higher accuracy/certainty. More generally, the high precision and narrow range shown here are due to the fact that these results are model based. Owing to multiple uncertainties, actual values and range are not known to the level of precision shown in this table.

[b]Defined as three or more consecutive days with maximum temperature exceeding 90°F.

[c]Based on minima of the Palmer Drought Severity Index (PDSI) over any 12 consecutive months. More information on the PDSI and the drought methods can be found in the CRI.

[d]Does not include the rapid ice-melt scenario.

What is projected locally?



Average temperatures are projected to rise

TIPS FOR SUCCESS

- **Attention to What the Participants Can Absorb, and What They *Need* to do Their Jobs**

- **Engaging Graphics to Convey the Chief Points**

- **Text to Reinforce the Take-Home Messages**

- **NOT "Dumbing Down", but Focusing the Information**

"Data" is not necessarily the same thing as "Information"

GETTING DOWN TO SPECIFICS

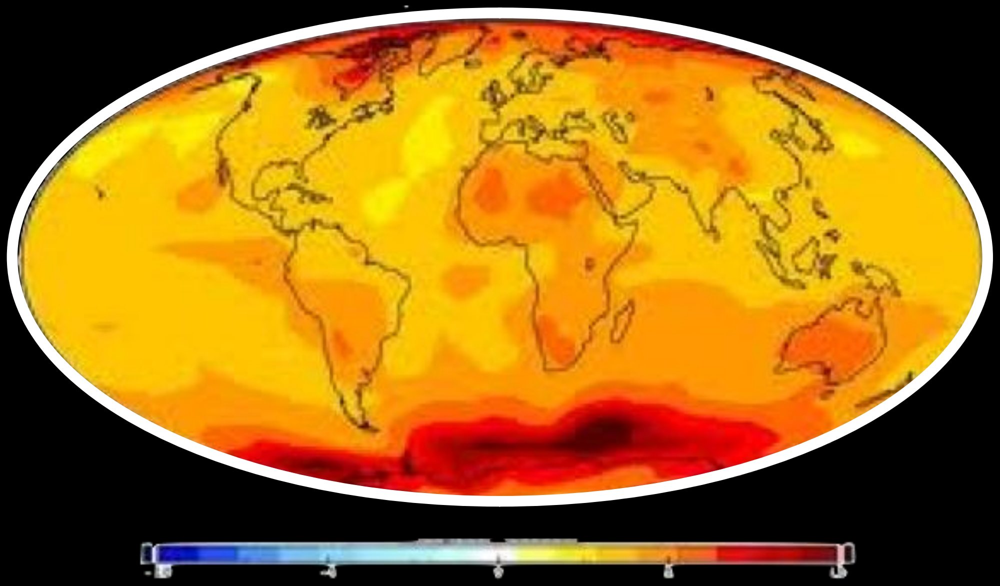
With regard to length, we narrowed down the talk to answer a few primary questions:

What’s the difference between weather and climate?

An important distinction

Weather describes current and near-term conditions

Climate describes weather patterns over a longer term



"Weather is what you get; climate is what you expect."

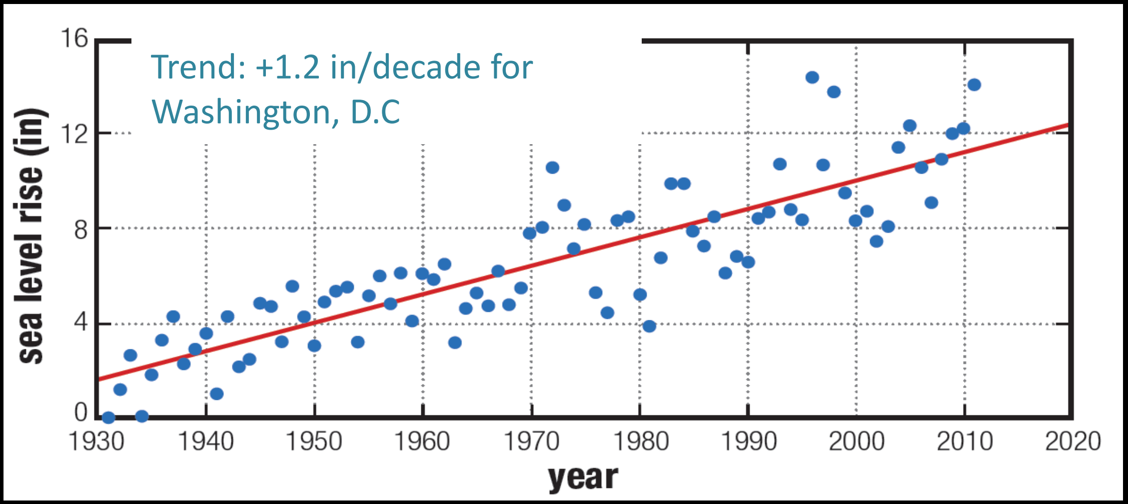
CLIMATE QUESTIONS, CONT.

What is already happening locally?

What's already happened ***locally***?

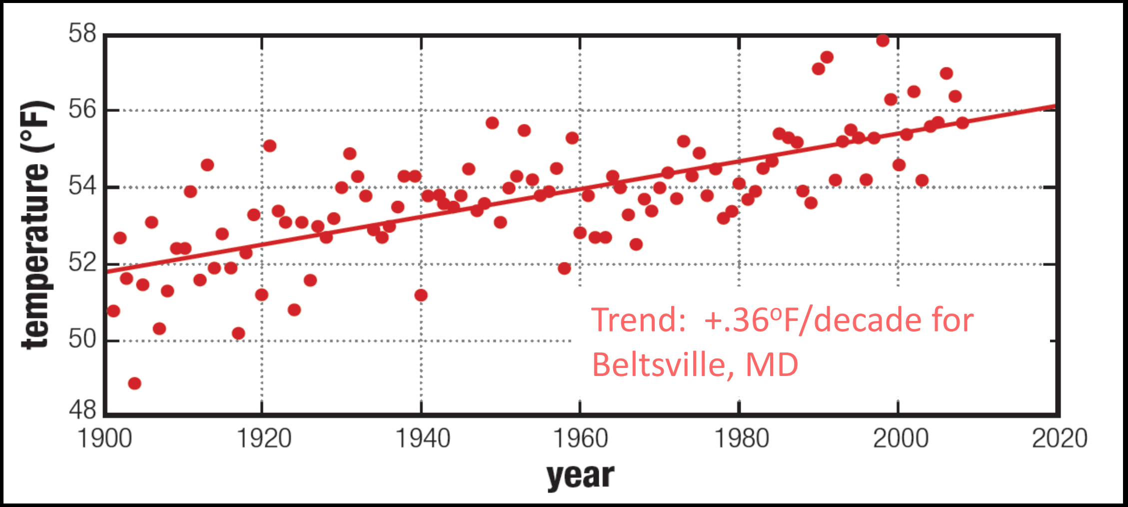
Sea Level

has risen over decades, though individual years vary somewhat



Temperature

has risen too, but the trend varies more year-to-year

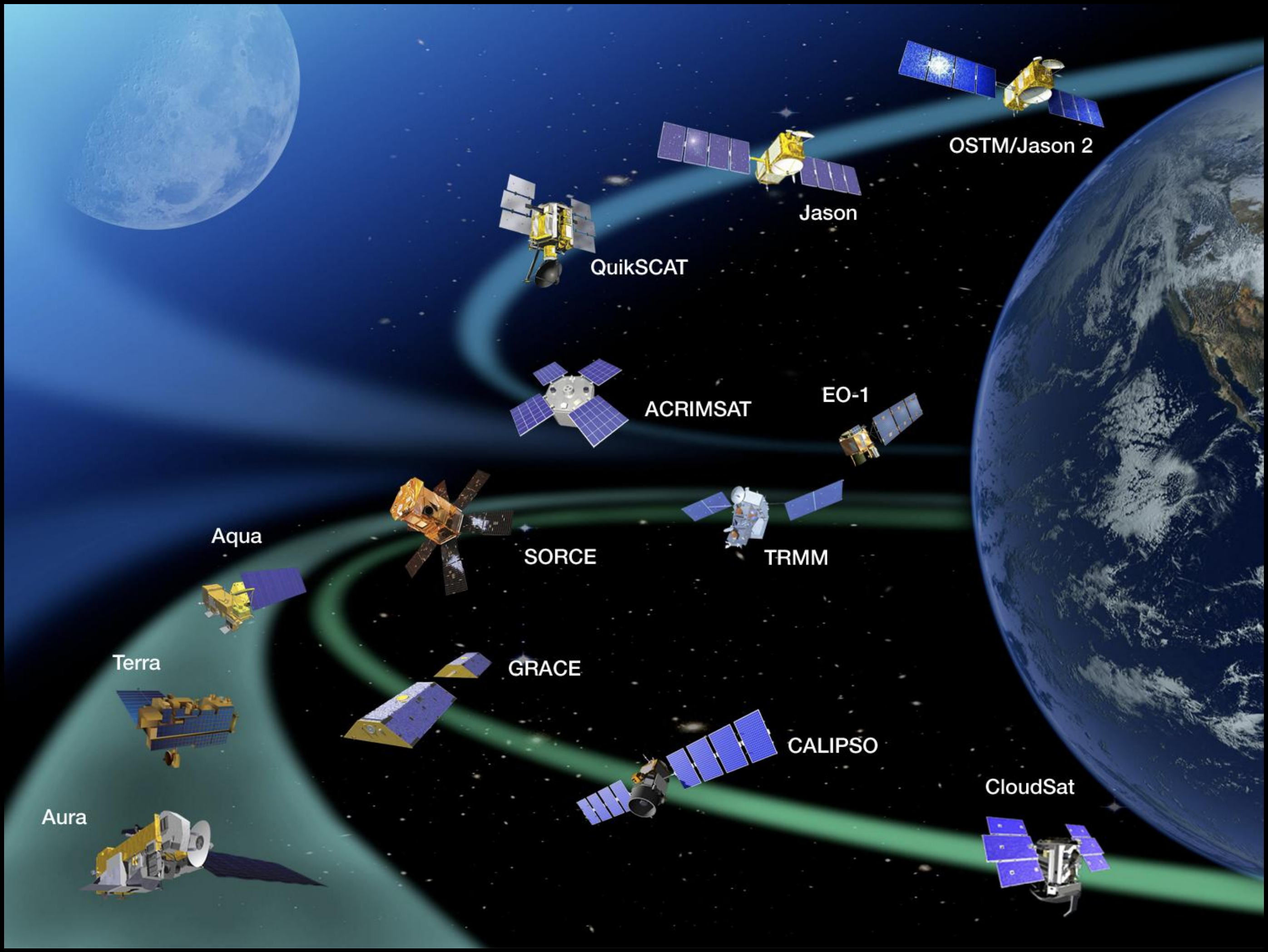


A century of local data tells us <u>the climate is changing</u>

CLIMATE QUESTIONS, CONTINUED

What is the basis for climate projections?

Gathering better data

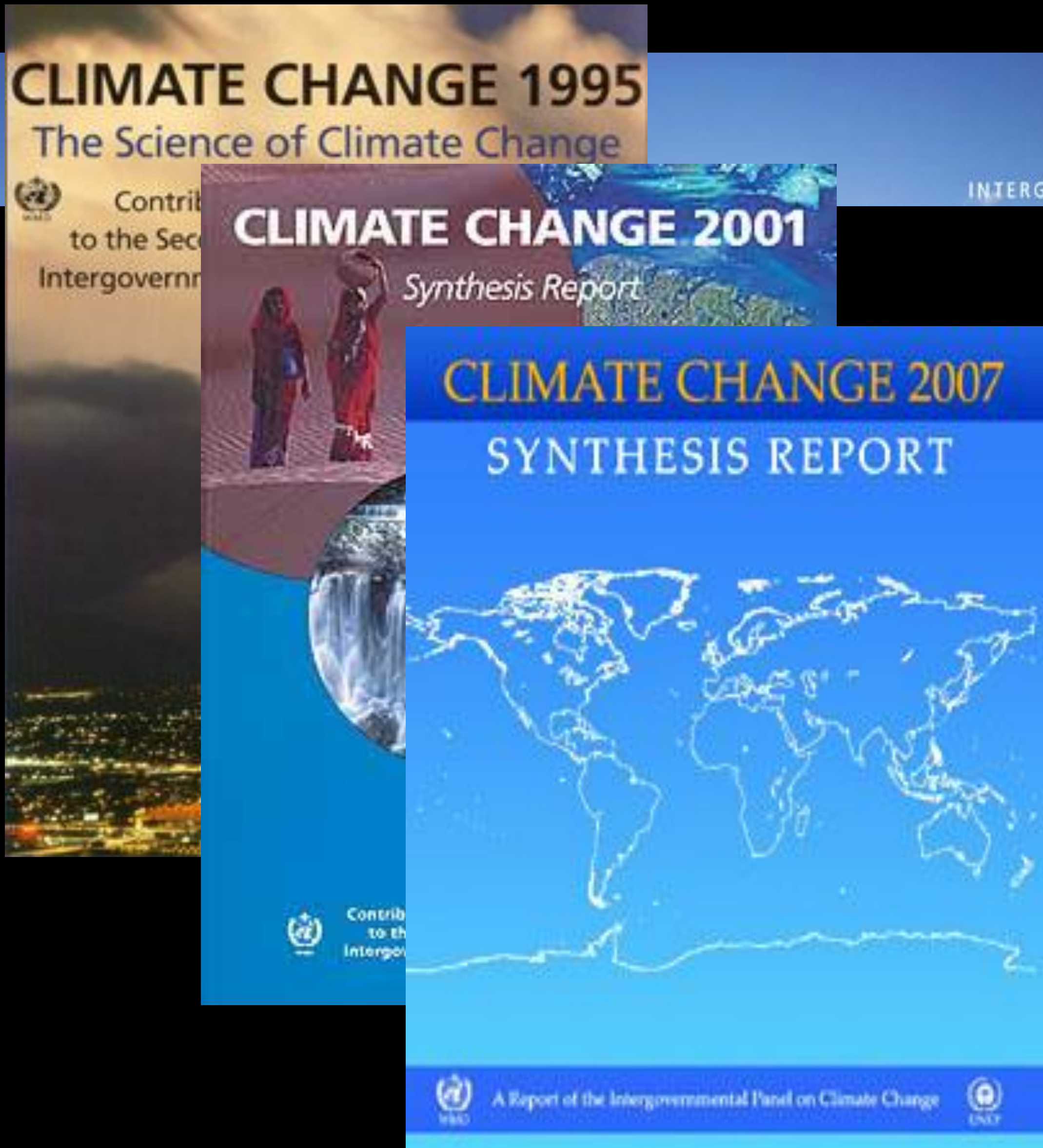


NASA's orbital perspective is a critical vantage-point

Building on a strong foundation

Powerful computer models let us test and refine hypotheses

Intergovernmental Panel on Climate Change

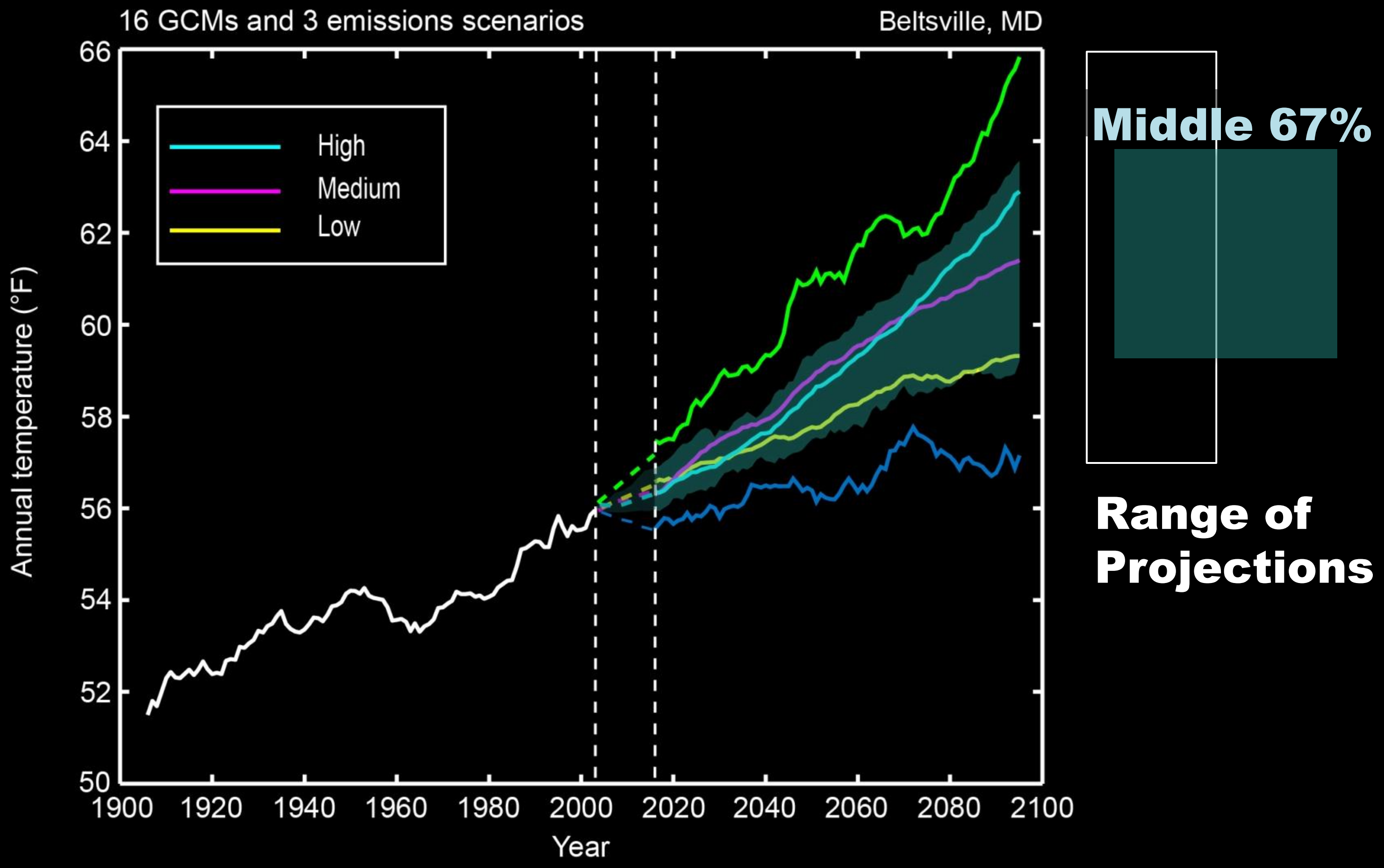


Consensus-based projections using
- Several models
- Several future greenhouse gas emission scenarios

Updated as the science advances

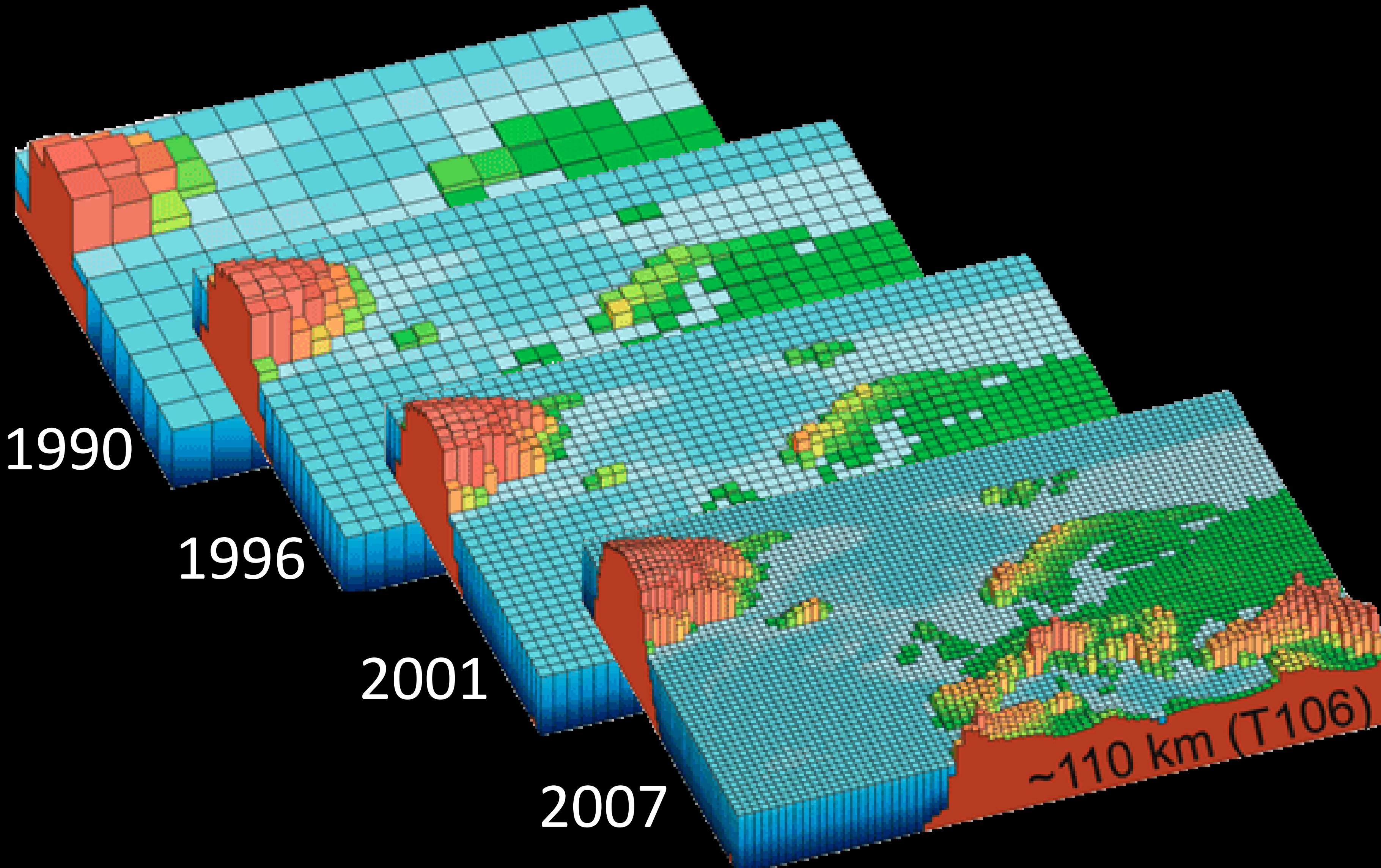
NASA contributes to a worldwide consensus

IPCC Models



Central range of models is basis for NASA's projections

Rising precision/resolution over time

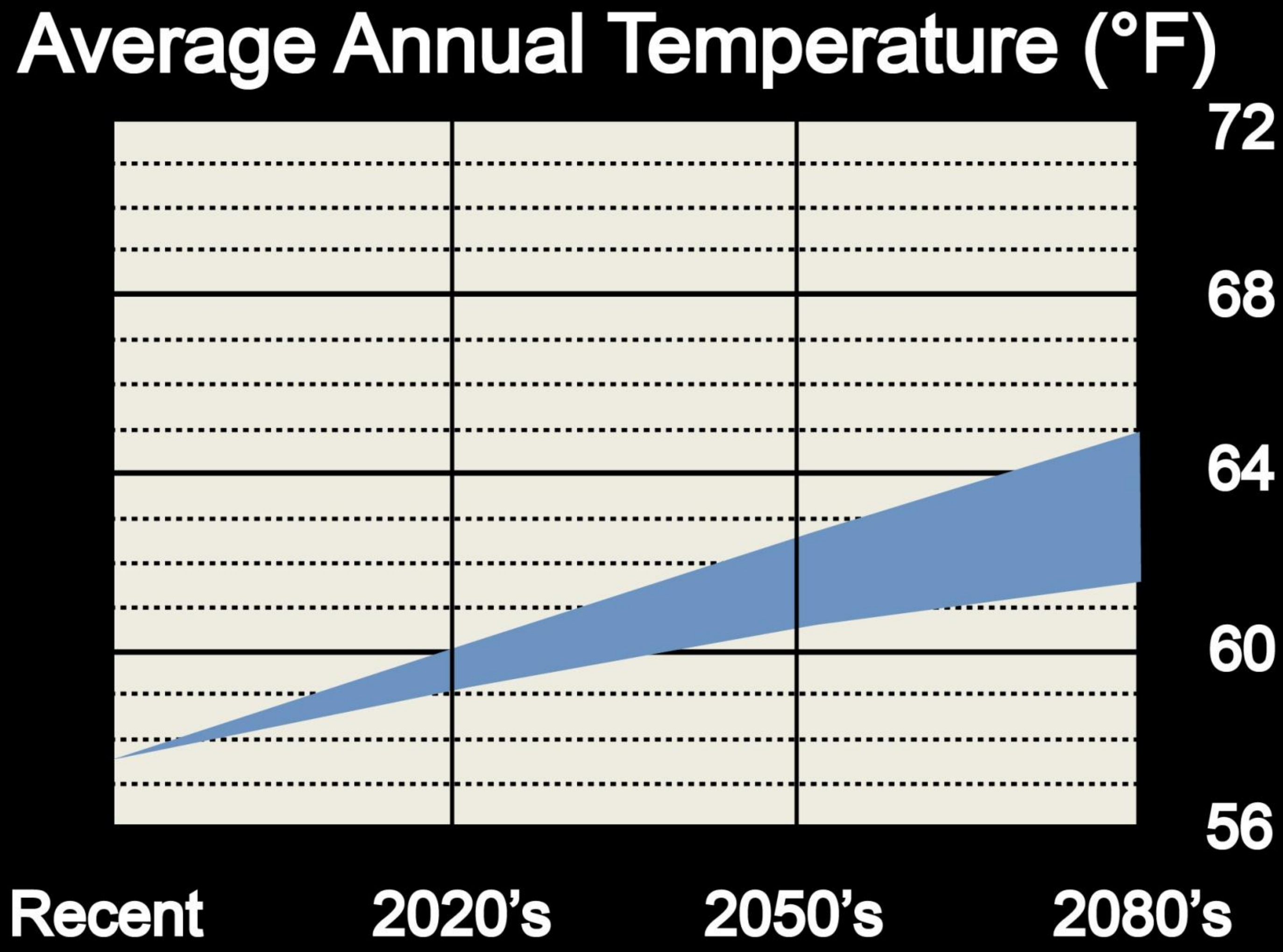


New models + better data = more specific projections

CLIMATE QUESTIONS, CONT.

What is projected to happen locally?

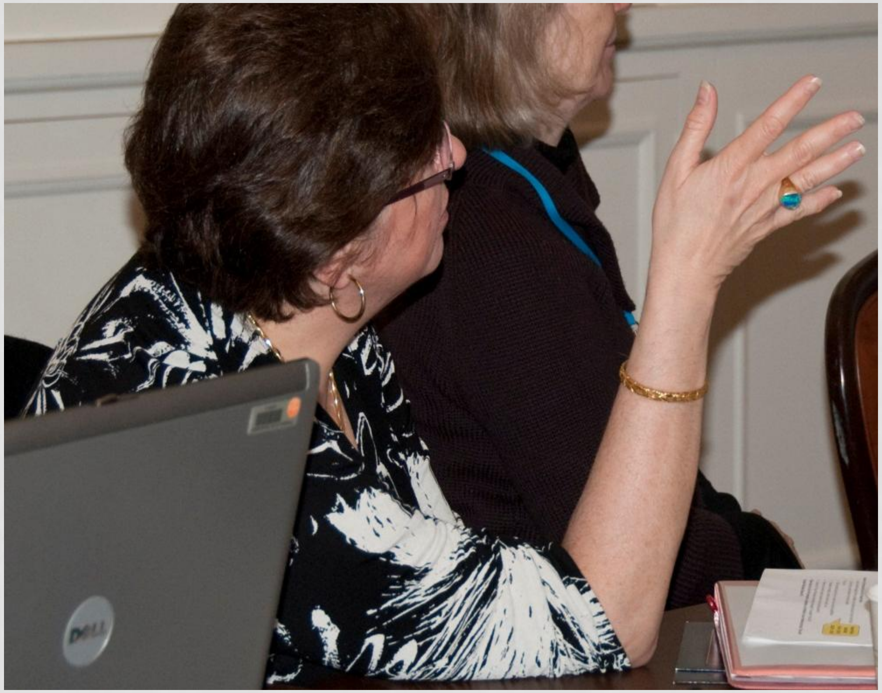
What is projected locally?



Average temperatures are projected to rise

WHAT MAKES THE CLIMATE TALK WORK?
PART 2 - TALKING DURING CLASS

- **Slides evolved into a "climate conversation" between institutional steward and climate scientist**



GO AHEAD – ASK THE CLIMATE SCIENTIST A QUESTION

Participants used post-it notes to ask questions

BREAKING THE ICE, IN A GOOD WAY

- Allowed for some breaks in the presentation
- Clarified how the institutional side “heard” the climate message
- Reinforced how to use climate data to improve resiliency of the Center
- Broke down barriers by encouraging table conversation

SUMMARY: WHY THE SCIENCE PRESENTATION ROCKS!

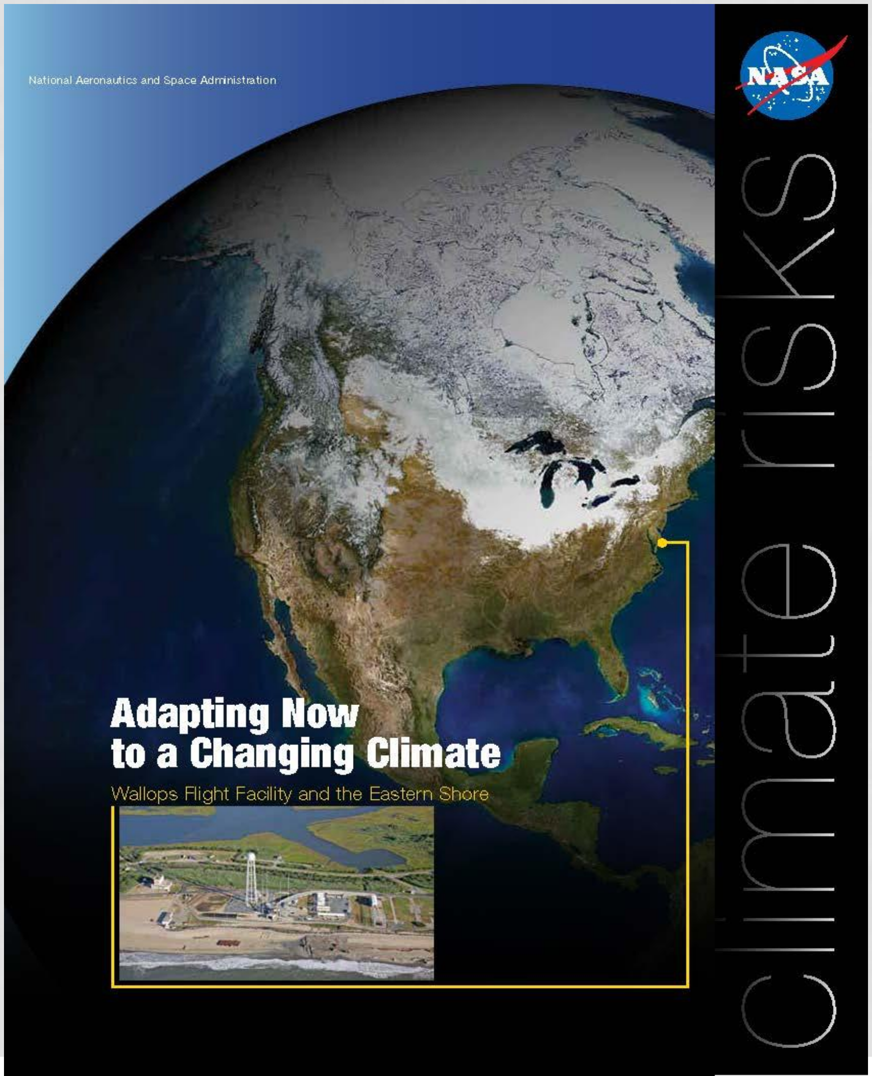
- Short – fewer than 20 slides
- Engaging, simple graphics with no need to read and interpret complex graphs
- Reinforced message with tag lines
- "Conversation" technique, with questions from participants, more interactive

PRODUCT II

Climate Information Handout

INFORMATIONAL, CENTER-SPECIFIC HANDOUTS

FRONT PANEL PIQUES INTEREST

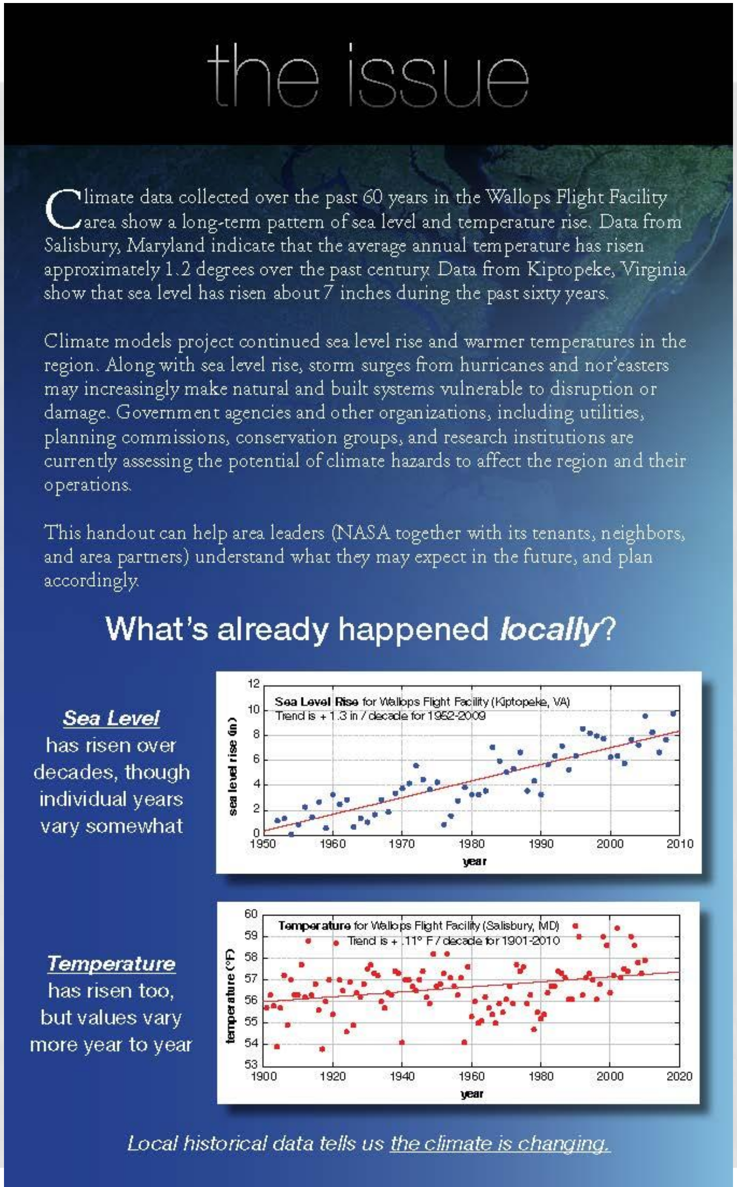


"Hmmm. Attractive photo, not too intimidating. Maybe I'll open it and see what this climate change thing is about."

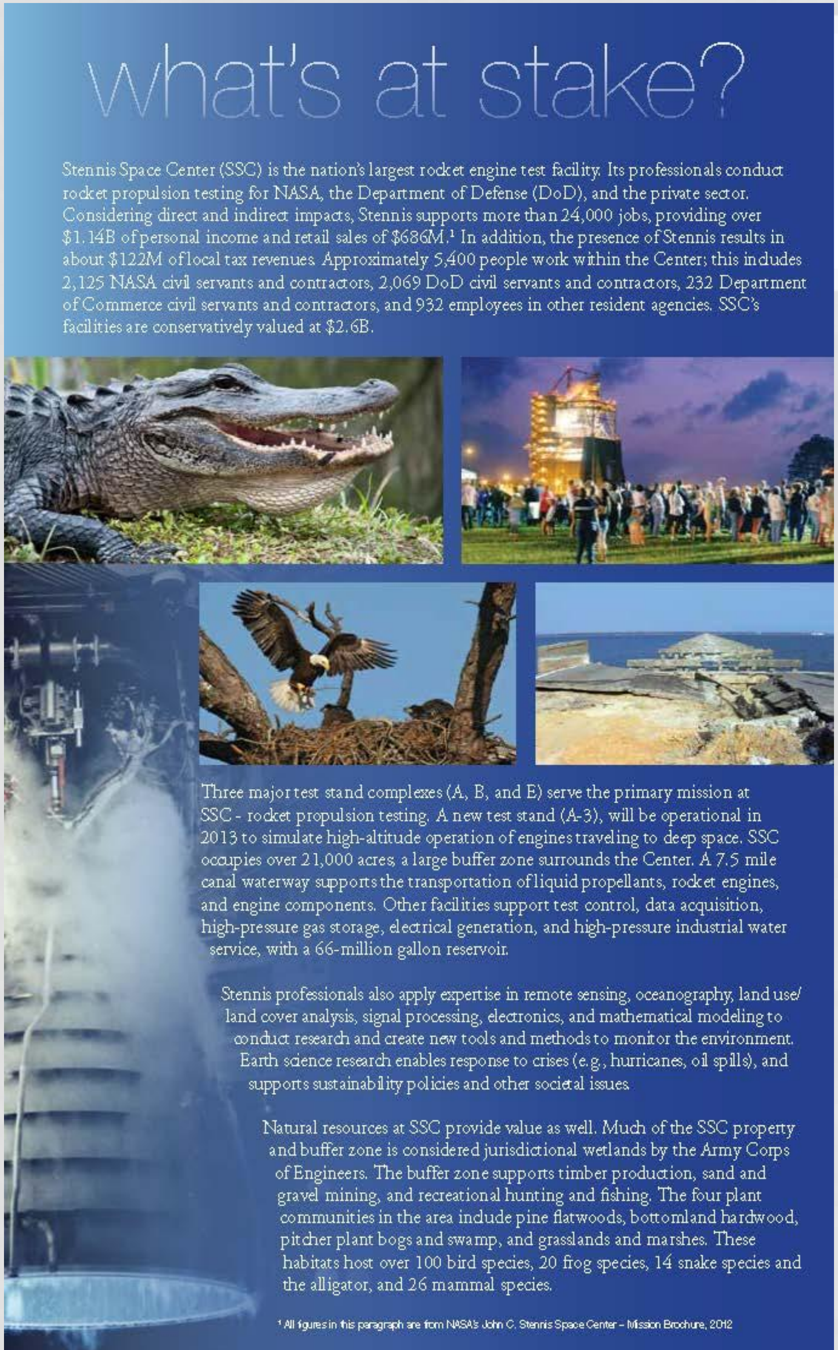
AN "ISSUE" PANEL SETS THE STAGE

Two simple graphs demonstrate historic temperature and sea level rise.

One clear message – your area has already experienced climate change.



A "WHAT'S AT STAKE" PANEL TELLS WHY IT'S IMPORTANT


what's at stake?

Stennis Space Center (SSC) is the nation's largest rocket engine test facility. Its professionals conduct rocket propulsion testing for NASA, the Department of Defense (DoD), and the private sector. Considering direct and indirect impacts, Stennis supports more than 24,000 jobs, providing over $1.14B of personal income and retail sales of $686M.[1] In addition, the presence of Stennis results in about $122M of local tax revenues. Approximately 5,400 people work within the Center; this includes 2,125 NASA civil servants and contractors, 2,069 DoD civil servants and contractors, 232 Department of Commerce civil servants and contractors, and 932 employees in other resident agencies. SSC's facilities are conservatively valued at $2.6B.

Three major test stand complexes (A, B, and E) serve the primary mission at SSC - rocket propulsion testing. A new test stand (A-3), will be operational in 2013 to simulate high-altitude operation of engines traveling to deep space. SSC occupies over 21,000 acres; a large buffer zone surrounds the Center. A 7.5 mile canal waterway supports the transportation of liquid propellants, rocket engines, and engine components. Other facilities support test control, data acquisition, high-pressure gas storage, electrical generation, and high-pressure industrial water service, with a 66-million gallon reservoir.

Stennis professionals also apply expertise in remote sensing, oceanography, land use/land cover analysis, signal processing, electronics, and mathematical modeling to conduct research and create new tools and methods to monitor the environment. Earth science research enables response to crises (e.g., hurricanes, oil spills), and supports sustainability policies and other societal issues.

Natural resources at SSC provide value as well. Much of the SSC property and buffer zone is considered jurisdictional wetlands by the Army Corps of Engineers. The buffer zone supports timber production, sand and gravel mining, and recreational hunting and fishing. The four plant communities in the area include pine flatwoods, bottomland hardwood, pitcher plant bogs and swamp, and grasslands and marshes. These habitats host over 100 bird species, 20 frog species, 14 snake species and the alligator, and 26 mammal species.

[1] All figures in this paragraph are from NASA's John C. Stennis Space Center – Mission Brochure, 2012

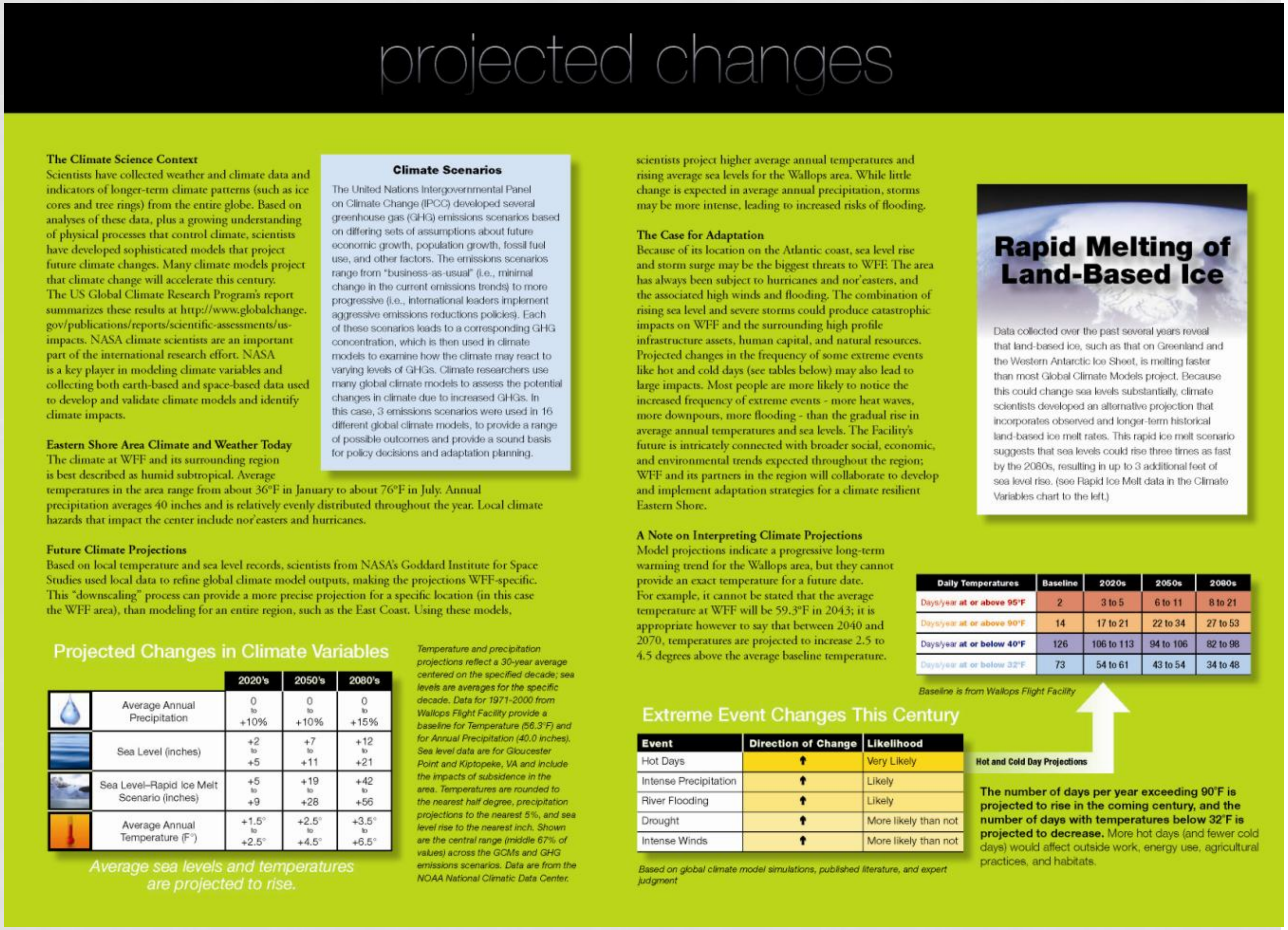
Reference the mission, the community, the natural setting, the jobs supported by the area, etc.

Find something they care about and use photos!

PROJECTIONS DATA INFORM THEIR DECISIONS

Mixture of Text and Data tells them what to expect in the future.

Factual, neutral language tells it straight.



projected changes

The Climate Science Context
Scientists have collected weather and climate data and indicators of longer-term climate patterns (such as ice cores and tree rings) from the entire globe. Based on analyses of these data, plus a growing understanding of physical processes that control climate, scientists have developed sophisticated models that project future climate changes. Many climate models project that climate change will accelerate this century.
The US Global Climate Research Program's report summarizes these results at http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts. NASA climate scientists are an important part of the international research effort. NASA is a key player in modeling climate variables and collecting both earth-based and space-based data used to develop and validate climate models and identify climate impacts.

Climate Scenarios

The United Nations Intergovernmental Panel on Climate Change (IPCC) developed several greenhouse gas (GHG) emissions scenarios based on differing sets of assumptions about future economic growth, population growth, fossil fuel use, and other factors. The emissions scenarios range from "business-as-usual" (i.e., minimal change in the current emissions trends) to more progressive (i.e., international leaders implement aggressive emissions reductions policies). Each of these scenarios leads to a corresponding GHG concentration, which is then used in climate models to examine how the climate may react to varying levels of GHGs. Climate researchers use many global climate models to assess the potential changes in climate due to increased GHGs. In this case, 3 emissions scenarios were used in 16 different global climate models, to provide a range of possible outcomes and provide a sound basis for policy decisions and adaptation planning.

Eastern Shore Area Climate and Weather Today
The climate at WFF and its surrounding region is best described as humid subtropical. Average temperatures in the area range from about 36°F in January to about 76°F in July. Annual precipitation averages 40 inches and is relatively evenly distributed throughout the year. Local climate hazards that impact the center include nor'easters and hurricanes.

Future Climate Projections
Based on local temperature and sea level records, scientists from NASA's Goddard Institute for Space Studies used local data to refine global climate model outputs, making the projections WFF-specific. This "downscaling" process can provide a more precise projection for a specific location (in this case the WFF area), than modeling for an entire region, such as the East Coast. Using these models, scientists project higher average annual temperatures and rising average sea levels for the Wallops area. While little change is expected in average annual precipitation, storms may be more intense, leading to increased risks of flooding.

Projected Changes in Climate Variables

	2020's	2050's	2080's
Average Annual Precipitation	0 to +10%	0 to +10%	0 to +15%
Sea Level (inches)	+2 to +5	+7 to +11	+12 to +21
Sea Level–Rapid Ice Melt Scenario (inches)	+5 to +9	+19 to +28	+42 to +56
Average Annual Temperature (F°)	+1.5° to +2.5°	+2.5° to +4.5°	+3.5° to +6.5°

Average sea levels and temperatures are projected to rise.

Temperature and precipitation projections reflect a 30-year average centered on the specified decade; sea levels are averages for the specific decade. Data for 1971-2000 from Wallops Flight Facility provide a baseline for Temperature (56.3°F) and for Annual Precipitation (40.0 inches). Sea level data are for Gloucester Point and Kiptopeke, VA and include the impacts of subsidence in the area. Temperatures are rounded to the nearest half degree, precipitation projections to the nearest 5%, and sea level rise to the nearest inch. Shown are the central range (middle 67% of values) across the GCMs and GHG emissions scenarios. Data are from the NOAA National Climatic Data Center.

The Case for Adaptation
Because of its location on the Atlantic coast, sea level rise and storm surge may be the biggest threats to WFF. The area has always been subject to hurricanes and nor'easters, and the associated high winds and flooding. The combination of rising sea level and severe storms could produce catastrophic impacts on WFF and the surrounding high profile infrastructure assets, human capital, and natural resources. Projected changes in the frequency of some extreme events like hot and cold days (see tables below) may also lead to large impacts. Most people are more likely to notice the increased frequency of extreme events - more heat waves, more downpours, more flooding - than the gradual rise in average annual temperatures and sea levels. The Facility's future is intricately connected with broader social, economic, and environmental trends expected throughout the region; WFF and its partners in the region will collaborate to develop and implement adaptation strategies for a climate resilient Eastern Shore.

A Note on Interpreting Climate Projections
Model projections indicate a progressive long-term warming trend for the Wallops area, but they cannot provide an exact temperature for a future date. For example, it cannot be stated that the average temperature at WFF will be 59.3°F in 2043; it is appropriate however to say that between 2040 and 2070, temperatures are projected to increase 2.5 to 4.5 degrees above the average baseline temperature.

Rapid Melting of Land-Based Ice

Data collected over the past several years reveal that land-based ice, such as that on Greenland and the Western Antarctic Ice Sheet, is melting faster than most Global Climate Models project. Because this could change sea levels substantially, climate scientists developed an alternative projection that incorporates observed and longer-term historical land-based ice melt rates. This rapid ice melt scenario suggests that sea levels could rise three times as fast by the 2080s, resulting in up to 3 additional feet of sea level rise. (see Rapid Ice Melt data in the Climate Variables chart to the left.)

Daily Temperatures	Baseline	2020s	2050s	2080s
Days/year at or above 95°F	2	3 to 5	6 to 11	8 to 21
Days/year at or above 90°F	14	17 to 21	22 to 34	27 to 53
Days/year at or below 40°F	126	106 to 113	94 to 106	82 to 98
Days/year at or below 32°F	73	54 to 61	43 to 54	34 to 48

Baseline is from Wallops Flight Facility

Extreme Event Changes This Century

Event	Direction of Change	Likelihood
Hot Days	↑	Very Likely
Intense Precipitation	↑	Likely
River Flooding	↑	Likely
Drought	↑	More likely than not
Intense Winds	↑	More likely than not

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

Hot and Cold Day Projections

The number of days per year exceeding 90°F is projected to rise in the coming century, and the number of days with temperatures below 32°F is projected to decrease. More hot days (and fewer cold days) would affect outside work, energy use, agricultural practices, and habitats.

"OUR RESPONSIBILITY" PANEL INSPIRES AND ADVISES

our responsibility

The time to develop and implement adaptation strategies is now. Executive Order 13514 directs federal agencies to assess and manage the effects of climate variables on operations and mission in both the short and long term. A changing climate in the Wallops area will affect facility operations (e.g., water and energy management), natural resources (e.g., new invasive species control), infrastructure that is vital to mission success (e.g., increased cost of protection against flooding), quality of life in the community (e.g., additional heat stress management), and the regions' economy (e.g., increased public expenditures on utilities). By considering these impacts during existing planning and decision-making cycles at Wallops Flight Facility and in collaboration with area partners, impacts to their missions may be abated or reduced. The recent construction of the new beach in front of the launch range, at considerable expense, provides an example of an adaptation measure taken to protect valuable national assets. Adaptation strategies developed for WFF may also prove beneficial to the local community as planners implement short-term tactical changes now, while simultaneously planning for longer-term strategic adaptation measures. Some potential impacts are listed in the chart below.

A new beach built by pumping sand from dredges offshore in 2012 will help protect more than $1 billion in federal and state government assets located here. The Wallops Island facility is home to NASA, the US Navy Surface Combat Systems Center, and the Mid-Atlantic Regional Spaceport. (upper photo - U.S. Army photo/Patrick Bloodgood)

Climate Trends	Potential Impacts
Rising Sea Level	Exacerbated flooding from storm surges; reduced emergency response capabilities. Increased salinity impacts to drinking water resources and habitats
Increased Coastal Flooding	Impacts to wastewater treatment plants on the coast; damage to infrastructure; changes in shoreline habitats; overloading of stormwater management systems
Overall Increased Temperature	Increased cooling costs in the summer; decreased heating costs in the winter. Changes in plant and animal cycles, including pest and disease vector species
Increased Number of High Temperature Days	Potential for damage to infrastructure materials; potential for limiting work and recreation outdoors; increased health problems related to heat stress
Precipitation Changes	Increased flooding from extreme precipitation events; increased risk of drought as temperatures rise; habitats affected by fluctuating groundwater levels

Often features a photo that shows adaptation measure in place, such as a green building.

Advises action now rather than delaying.

"FINE PRINT" PANEL HAS ALL THE SCIENCE YOU NEED TO KNOW

....and probably more.

Provides more details on the modeling approach and associated uncertainty.

Contains web links for academic references.

A Note about Downscaling Climate Data Specifically for Individual NASA Centers

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-disaggregated climate projections derived from CMIP3 data. Results provide a more refined projection for a smaller geographic area. This information is maintained at: **http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections** and described by Maurer, et al. (2007)[1].

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, see a paper and references at **http://www.nature.com/climate/2010/1004/pdf/climate.2010.29.pdf**.

Key Uncertainties Associated with Climate Projections

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) Levels of future greenhouse gas concentrations and other radiatively important gases and aerosols,

2) Sensitivity of the climate system to greenhouse gas concentrations and other radiatively important gases and aerosols,

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 variability/climate change and the assets in their care.

[1]Maurer, E.P., L. Brekke, T. Pruitt, and P.B. Duffy (2007), 'Fine-resolution climate projections enhance regional climate change impact studies', Eos Trans. AGU, 88(47), 504.

Authorization for NASA's climate risk management efforts, which began in 2005, includes:
- Federal Managers' Financial Integrity Act of 1982, supported by:
  - GAO (1999) Standards of Internal Control in the Federal Government
  - OMB Circular A-123 (2004) Management's Responsibility for Internal Control
- National Security Directive 51 and Homeland Security Presidential Directive 20: National Continuity Policy (9 May 2007) on localized acts of nature
- Presidential Policy Directive 8 – National Preparedness (30 March 2011) for catastrophic natural disasters
- Executive Order 13514 (8 October 2009) Leadership in Environmental, Energy and Economic Performance
- 2010 National Aeronautics and Space Act (51 USC Sec 20101 et seq)
- 2010 National Space Policy of the United States of America

Members of NASA's Climate Adaptation Science Investigator (CASI) Work Group contributed to this document.

Fall 2012
www.nasa.gov
NP-2012-10-909-HQ

SUMMARY: WHY THESE HANDOUTS WORK

- They're colorful
- Hard copy (they are refrigerator worthy!)
- Data clearly displayed for all audiences
- Language is straightforward and factual
- "Fine print" on the back panel provides the scientific basis for information
- "Story Board" reveals information to the reader in a deliberate order

TIPS FOR CLIMATE COMMUNICATION PRODUCTS

- Make the graphs as simple as possible AND be true to the science and interests of intended audience
- Engage multiple reviewers
- Acknowledge uncertainty, but do not let it derail progress
- Use factual language to create a sense of urgency for some, but not all, aspects

QUESTIONS?

Kim Gotwals

Science Applications International Corporation

Kimberly.b.gotwals@saic.com

919-724-3471