# Effects of Global Change on U.S. Urban Areas: Vulnerabilities, Impacts, and Adaptation

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## BACKGROUND OF THE U.S. GLOBAL CLIMATE CHANGE AS IT RELATES TO THIS PRESENTATION

- **The guiding vision for the U.S. Climate Change Science Program (CCSP) is "A nation and the global community empowered with the science-based knowledge to manage the risks and opportunities of change in the climate and related environmental systems".**
- **There are 5 principal goals that have been adopted to guide the CCSP.**
- **One of these goals (Goal 4) is to "Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes".**
- **The principal products of the CCSP are a series of more than 20 "Synthesis and Assessment Reports" (SAPs) during the next 4 years.**
- **These reports respond to the CCSP highest priority research, observation, and decision support needs.**

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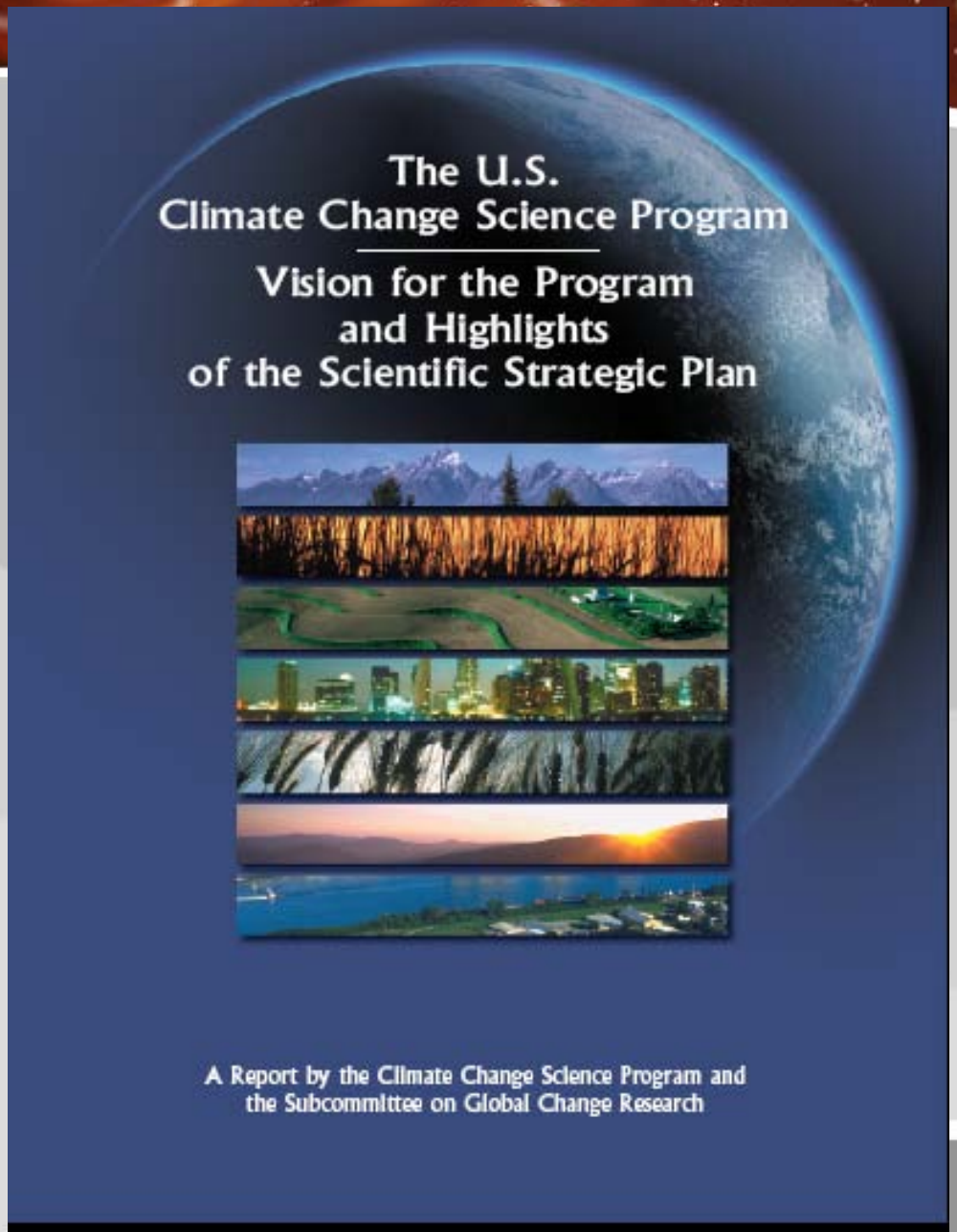

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**CCSP Goal 4: Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes.**

Seasonal to interannual variability in climate has been connected to impacts on almost every aspect of human life. Long time scale natural climate cycles and human-induced changes in climate may have additional effects. Improving the ability to assess potential implications of variations and future changes in climate and environmental conditions could enable governments, businesses, and communities to reduce potential negative impacts and to take advantage of opportunities by adapting infrastructure, activities, and plans.

CCSP research will examine the potential for multiple interacting effects (e.g., the carbon dioxide "fertilization effect," deposition of nitrogen and other nutrients, landscape changes that affect water resources and habitats, changes in frequency of fires or pests) in order to improve knowledge of sensitivity and adaptability to climate variability and change. CCSP research also will improve methods to advance our understanding of the potential effects of different atmospheric concentrations of greenhouse gases and to develop methods for comparing the potential impacts across different sectors.

Research focus areas are:

- Improve knowledge of the sensitivity of ecosystems and economic sectors to global climate variability and change
- Identify and provide scientific inputs for evaluating adaptation options, in cooperation with mission-oriented agencies and other resource managers
- Improve understanding of how changes in ecosystems (including managed ecosystems such as croplands) and human infrastructure interact over long periods of time.

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**We have developed working draft prospectus of a SAP for a subcategory of the CCSP Goal 4 on "Analysis of the effects of global change on human health and welfare and human systems".**

- **This is effectively referred to as SAP 4.6 – Effects of Global Change on Human Settlements.**

- **This is a draft prospectus will now undergo a 45 day invitation for public review for comment on its content beginning in June.**

- **The final prospectus after it has gone through public review, will be posted later this year.**

- **We see this overview presentation of the content of SAP 4.6 as a 1st stage of this public review and comment – Your comments are welcome!**

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## CLIMATE CHANGE VULNERABILITIES AND IMPACTS IN HUMAN SETTLEMENTS

### Determinants of Vulnerabilities/Impacts

**In many cases, it has been it has been difficult to project Impacts of climate**

**Climate change forecasts are not specific enough for decision-making at the human settlement/urban level**

**•Perhaps more profoundly, climate change is not the only change confronted by settlements**

**•More often, attention is paid to vulnerabilities to climate change**

**•At the current state of knowledge, vulnerabilities to possible impacts are easier**

**•to project than actual impacts**

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## Projected Impacts of Climate Change on Settlements in the U.S.

**Possible impacts of climate change on settlements in the U.S. are usually assessed by projecting climate change at a regional scale**

- **Factors such as temperature, precipitation, severe weather events, and sea level rise**

**Vulnerabilities of settlements to impacts of climate change vary regionally, but they generally include some or many of the following impact concerns:**

**Effects on health:**

- **Higher temperatures in urban areas related to higher levels of ozone**
- **Evidence shows combined effects of heat stress and air pollution may be greater than simple additive effects**
- **Other health concerns include vector-borne diseases, allergens, exposure to weather events such as storms floods and fires**

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Mission to Planet Earth
National Aeronautics and Space Administration

## Urban Remote Sensing and Air Quality Models

Volatile Organic Compounds
+ Nitrogen Oxides
+ Sunlight
→ Ozone

- Air pollution remains a National issue.
- Temperature increases the ozone levels.
- Urban heat island has major effect on temperature and height of mixing layer.
- Measurement program is defining land use patterns and relationship to heat production.
- Remote sensing data are being used to improve air quality modeling.

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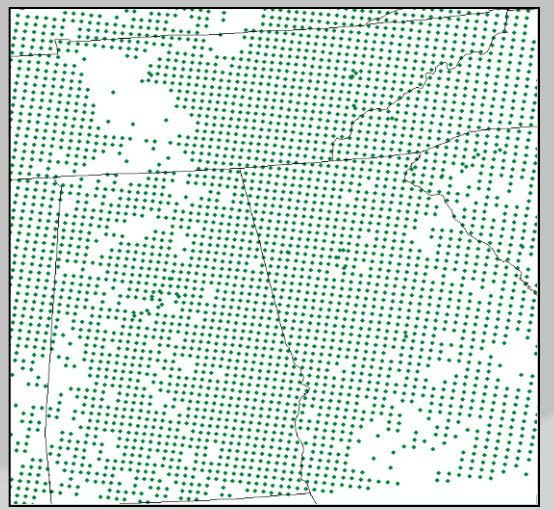
## MODIS Aerosol Optical Depth (AOD)

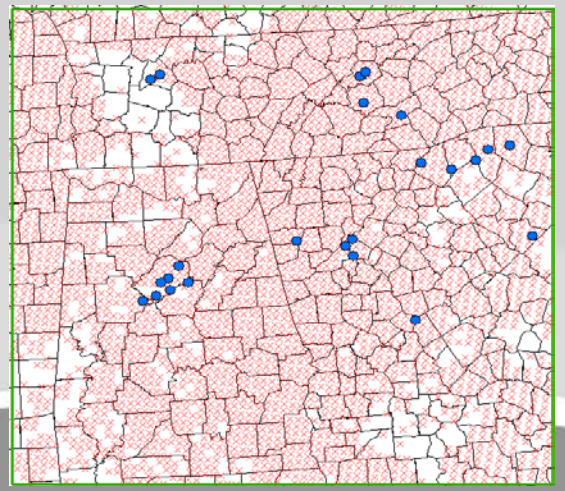
- AOD is a measure of the total particulate in the atmosphere
- If atmosphere is well mixed, AOD is a good indicator of surface $PM_{2.5}$
- Enhanced Spatial Coverage
- Provided on a 10x10 km grid
- Available twice per day

(Terra ~10:30 AM, Aqua ~1:30 PM)

- Clear-sky coverage only
- Available since spring 2000



MODIS



AQS

June 25, 2003

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## Effects on water and other urban infrastructures:

- Changes in precipitation patterns lead to reductions in meltwater, river flows, groundwater levels

- Storms, floods, and other severe weather events may affect other infrastructures such as sanitation, transportation, supply lines for food, energy and communication

## Effects of severe weather events:

- Urban areas in risk-prone regions must be concerned about severe weather events
- Severe storms (e.g., hurricanes, floods) combined with sea-level rise in coastal areas
- Risks of fire in drier arid areas
- Vulnerabilities may be especially great for rapidly-growing and large metropolitan areas

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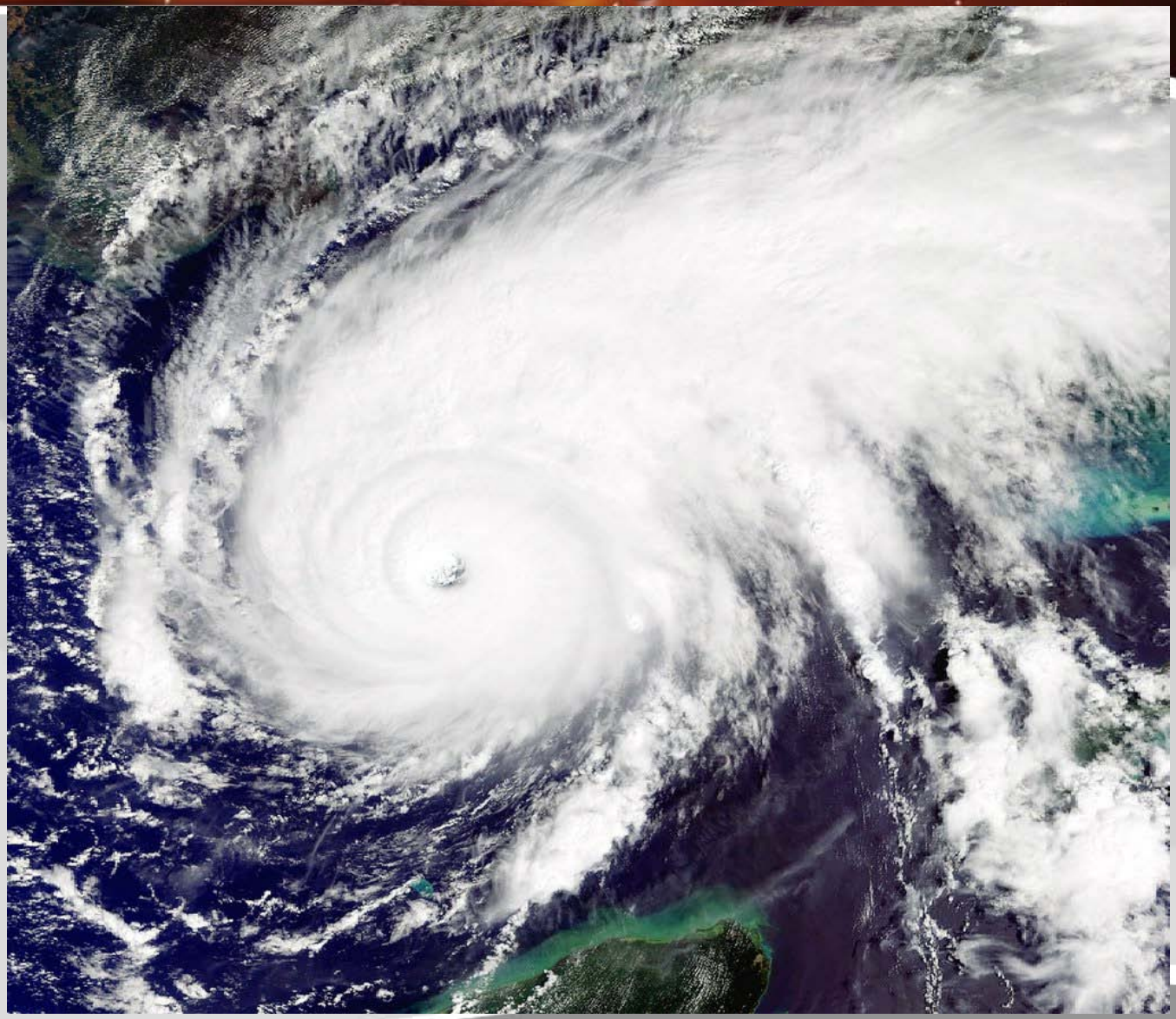

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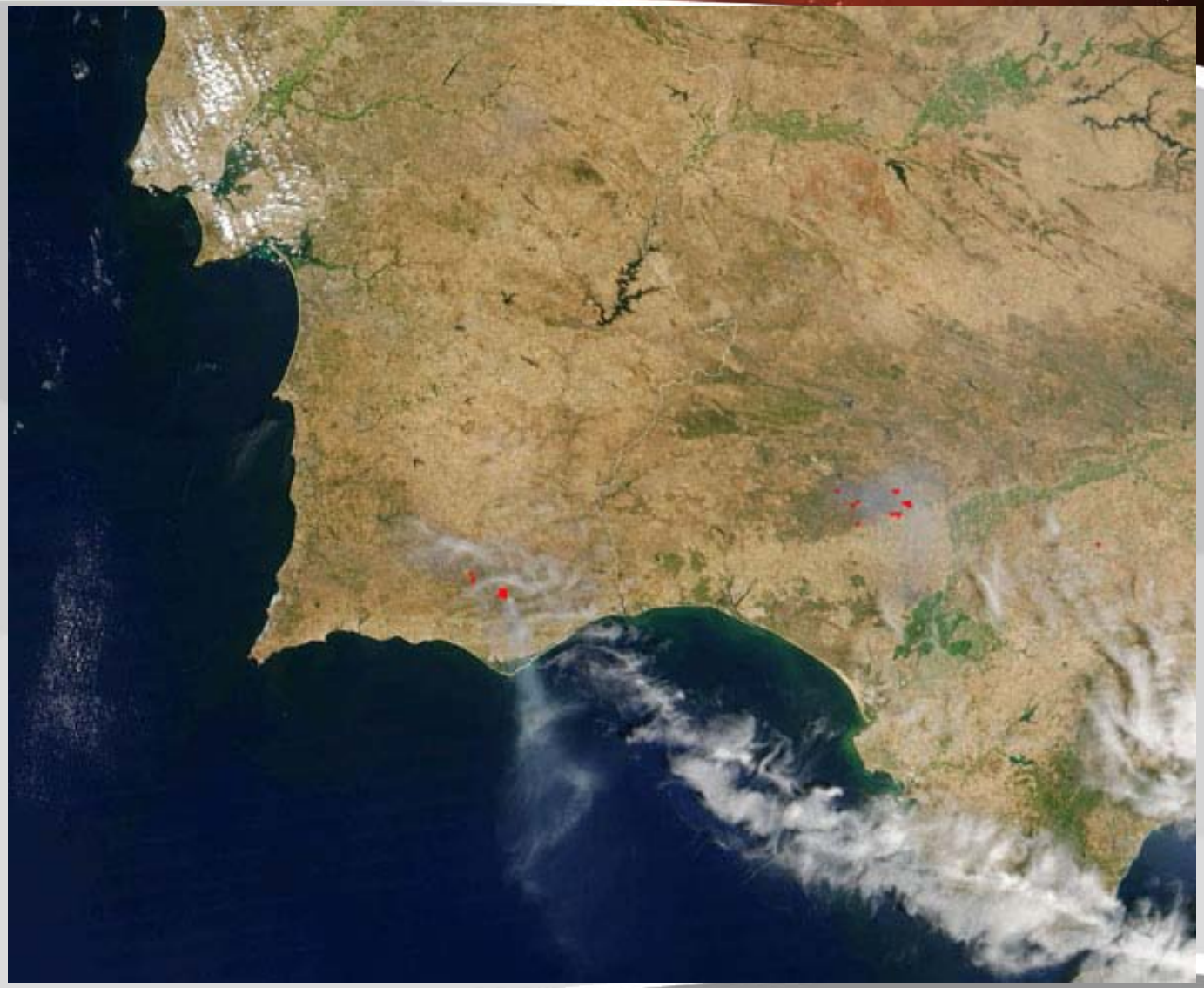

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## Effects on energy requirements:

•Warming is virtually certain to increase U.S. energy demand for cooling

## Effects on urban metabolism:

•Climate change will impact a host of inputs, transformations, and outputs such as heat, energy, materials

•An example is the Urban Heat Island (UHI) effect is expected to greatly Increase over cities as a function of urban growth and increased solar radiation and warmer surface temperatures

## Effects on economic competitiveness, opportunities and risks:

•Climate change has potential to affect settlements directly and indirectly Through impacts on other areas linked to their economies at the regional, national, and international scales

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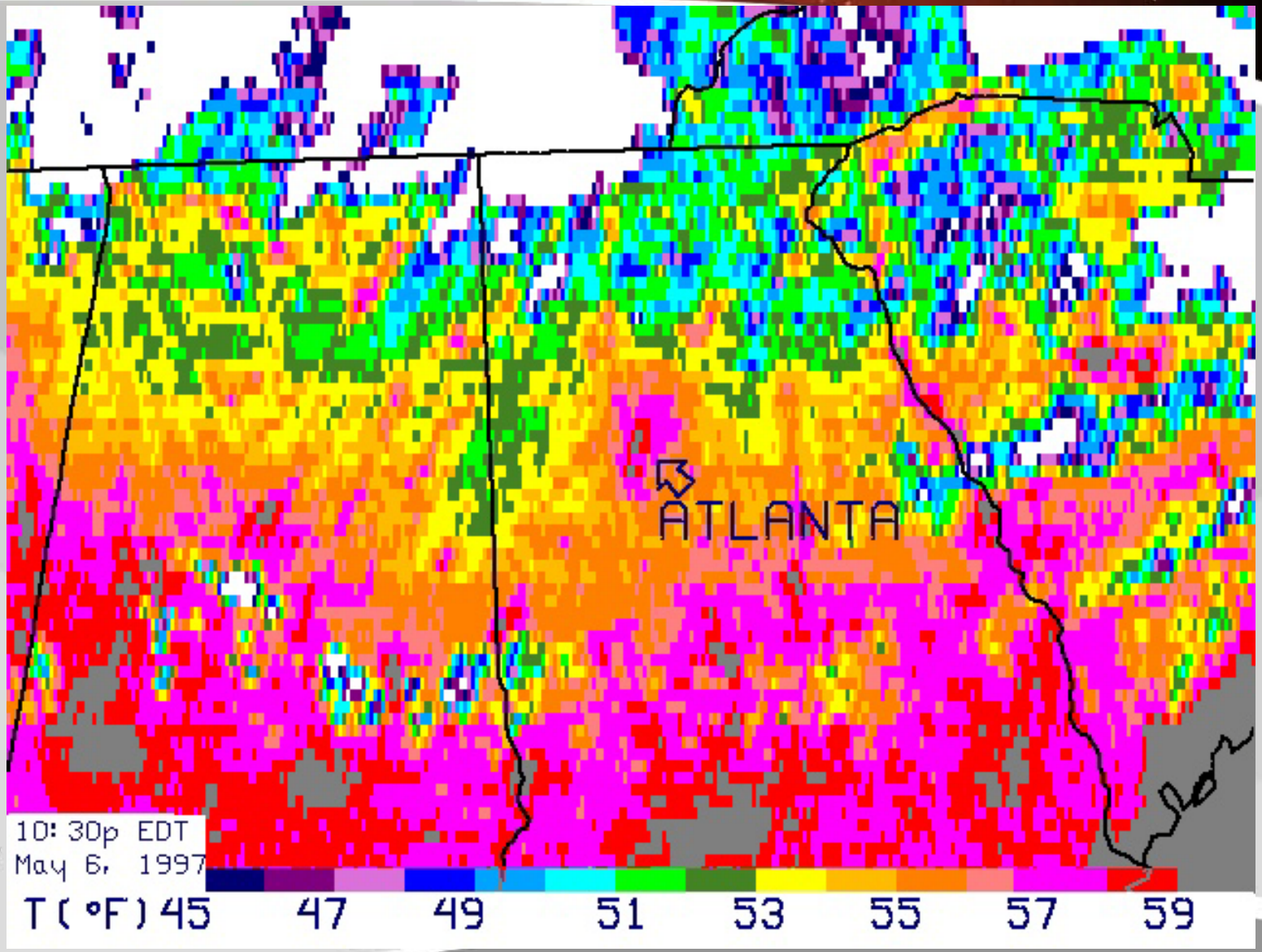

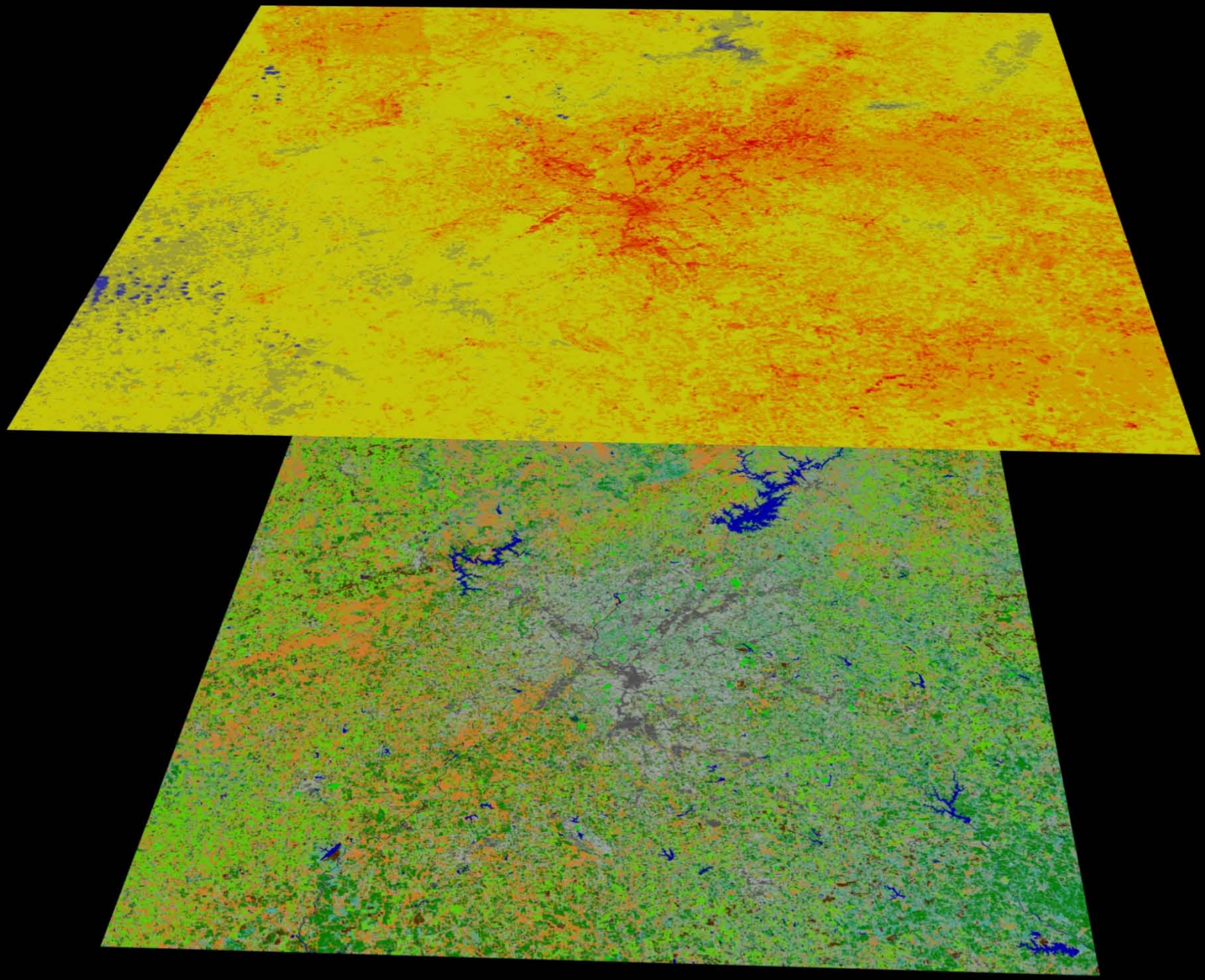


Temperature
°C ≤17 21.7 26.4 31.1 35.8 40.5 45.2 ≥50
°F ≤62.6 71.1 79.5 88.9 96.4 104.9 113.4 ≥122

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## Effects on social and political structures:

- Climate change can add stress on social and political structures
- Increasing management and budget requirements for public services such as public health care, disaster risk reduction, and public security
- Climate change will be especially problematic to vulnerable and disadvantaged parts of the population; e.g., poor, elderly, and those in poor health

## Effects of sea level rise:

- Approximately half of the U.S. population (~160 million people) will live in one of 673 coastal counties by 2008 as estimated by NOAA
- Concerns about sea level rise and increased hurricane activity are obviously justified

# Effects of Global Change on U.S. Urban Areas

**REGIONAL VULNERABILITIES OF SETTLEMENTS TO IMPACTS OF CLIMATE CHANGE**

| Region | Vulnerabilities | Major Uncertainties |
|---|---|---|
| Metro NE | Flooding, infrastructures, health, water supply, sea-level rise | Storm behavior, precipitation |
| Larger NE | Changes in local landscapes, tourism, water, energy needs | Ecosystem impacts |
| Mid-Atlantic | Multiple stresses | Ecosystem impacts |
| Coastal SE | More intense storms, sea-level rise, flooding, heat stress | Storm behavior, coastal land use, sea-level rise |
| Inland SE | Water shortages, heat stress, UH1, economic impacts | Precipitation change, development paths |
| Upper Midwest | Lake and river levels, extreme weather events, health | Precipitation change, storm behavior |
| Inner Midwest | Extreme weather events, health | Storm behavior |
| Appalachians | Ecological change, reduced demand for coal | Ecosystem impacts, energy policy impacts |
| Great Plains | Water supply, extreme events, stresses on communities | Precipitation changes, weather extremes |
| Mountain West | Reduced snow, water shortages, fire, tourism | Precipitation changes, effects on winter snowpack |
| Arid Southwest | Water shortages, fire | Development paths, precipitation changes |
| California | Water shortages, heat stress | Temperature and precipitation changes, infrastructure impacts |
| Northwest | Water shortages, ecosystem stresses, coastal effects | Precipitation changes, sea-level rise |
| Alaska | Effects of warming, vulnerable populations | Warming, sea-level rise |
| Hawaii | Storms and other weather extremes, freshwater supplies, health | Storm behavior, precipitation change |

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## Potentials for Adaptation to Climate Change in Human Settlements

**Where climate change might present risks of adverse impacts for U.S. settlements and their populations, there are two basic alternatives to respond to such concerns:**

1. **Mitigation strategies (i.e., by taking actions to reduce their greenhouse gas emissions and by showing leadership in encouraging others to support such actions)**
2. **Adaptation strategies (i.e., finding ways either to reduce sensitivity to Projected changes or to increase the settlement's coping capacities)**
3. **Combining both mitigation and adaptation strategies**

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## Mitigation Strategies

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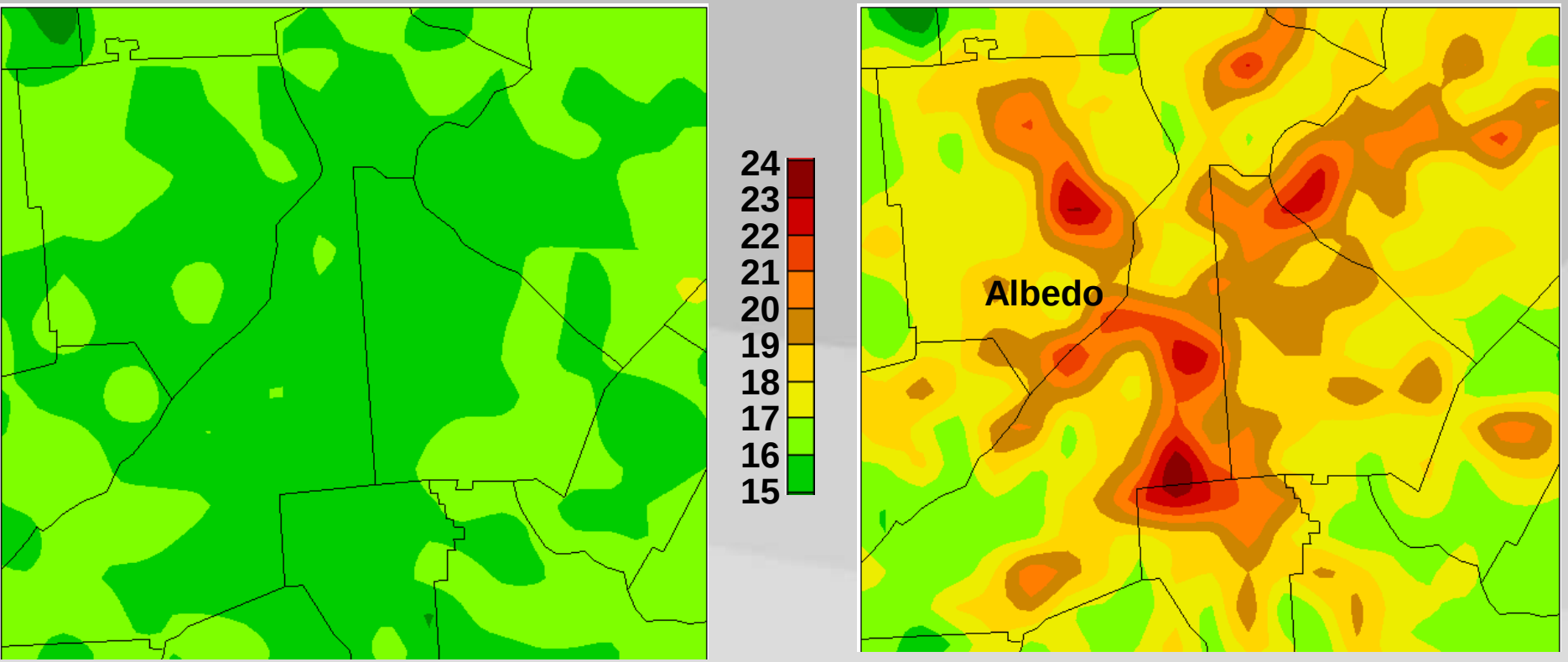
## Albedo Mitigation Simulation - 2030

### 2030 Business As Usual

### High Albedo



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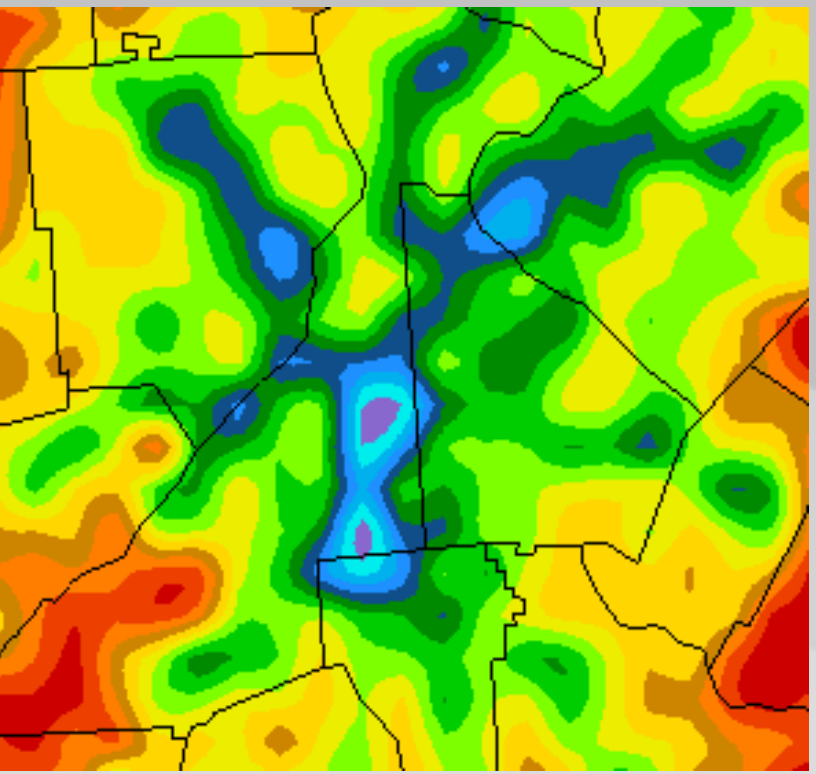
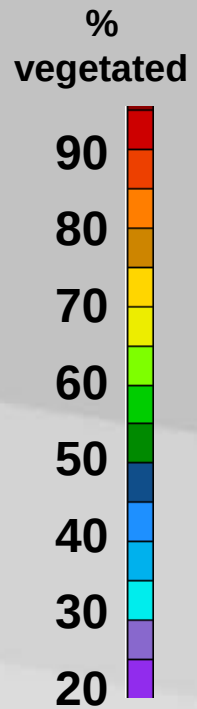
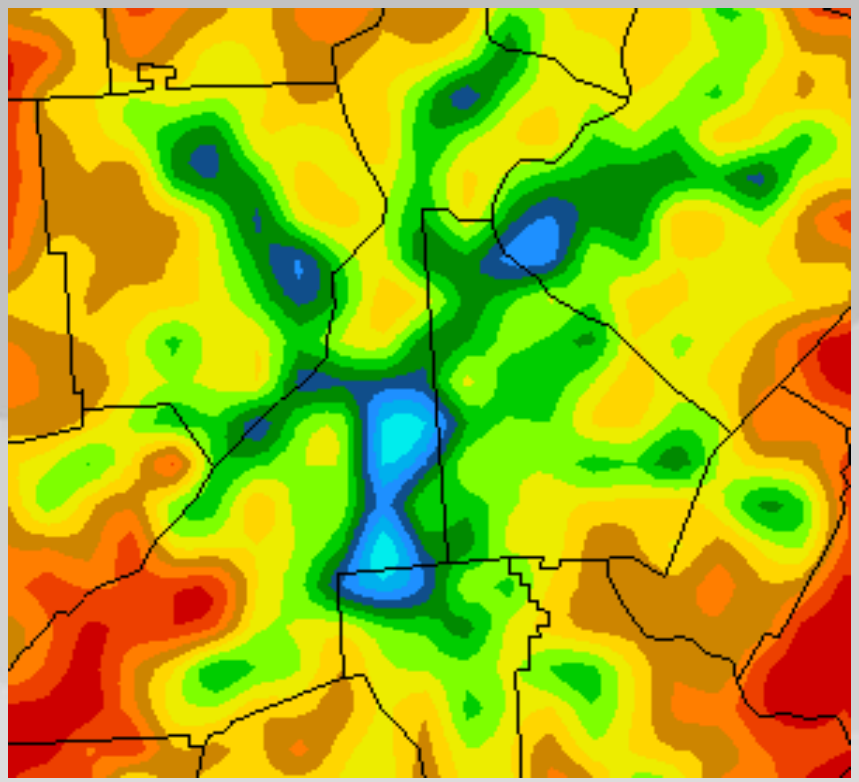
## Vegetation Mitigation Simulation - 2030

### 2030 Business As Usual






### 2030 Mitigation Scenario



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## Overview of Integrated Assessments of Climate Impacts and Adaptation In U.S. Cities

| | **Bloomfield et al. 1999** | **Kooten et al., 2001** | **Rosenzweig et al., 2000** | **Kirshen et al., 2004** | **Hoo and Sumitani, 2005** |
|---|---|---|---|---|---|
| **Location:** | Greater Los Los Angeles | New York | Metropolitan New York | Metropolitan Boston | Metropolitan Seattle |
| **Coverage:** | | | | | |
| Water supply | X | X | X | X | |
| Water Quality | | | | X | |
| Water Demand | | | | X | |
| Sea-level Rise | X | | X | X | X |
| Transportation | | | | X | X |
| Communication | | | | | |
| Energy | | | X | X | |
| Public Health | | | | | |
| Vector-borne Diseases | | | | | |
| Food-borne Diseases | | X | | | |
| Temperature-related Mortality | | | | X | |
| Temperature-related Morbidity | X | X | | | |
| Air-quality Related Mortality | | | | | |
| Air-quality Related Morbidity | | | X | | |
| Oher | X | X | X | | |
| Ecosystems | | | | | |
| Wetlands | | | | | |
| Other (Wldfires) | X | | X | | |
| Urban Forests (Trees and Vegetation) | | X | | | |
| Air Quality | | X | | | X |
| **Extent of:** | | | | | |
| Quantitative Analysis | Low | Medium | Medium | High | Low |
| Computer-based Modeling | None | Low | Low | High | None |
| Scenario Analysis | None | None | Medium | High | Medium |
| Explicit Risk Analysis | None | None | None | Medium | None |
| **Involvement of:** | | | | | |
| Local Planning Agencies | None | None | High | High | High |
| Local Government Agencies | None | None | High | High | High |
| Private Industry | None | None | None | Low | None |
| Non-profits | None | None | Low | High | None |
| Citizens | None | None | None | Medium | None |
| **Identification of:** | | | | | |
| Adaptation Options | X | X | X | X | X |
| Adaptation Cost | | | X | X | |
| Extent of Integration Across Systems | None | None | Low | Medium | Low |
| Attention to Differential Impacts (e.g., on individual types of businesses, specific sub-populations) | None | None | Low | Low | Low |

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## Conclusions

**Even from a current knowledge base that is very limited, it is possible to conclude several things about effects of climate change on human settlements in the United States:**

**1. Climate change will seldom be a primary factor in an area's development compared with other driving forces for development. It is likely to be a secondary factor, except in the case of major abrupt climate change**

**2. Effects of climate change will vary considerably according to location-specific vulnerabilities**

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## Conclusions (Cont'd.)

**3. The main impact concerns have to do with changes in the intensity, frequency, and location of extreme weather events and in some cases, water availability**

**4. Over time, the potential for adaptation through technological and institutional Development and behavioral changes**

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## Conclusions (Cont'd.)

**5. While uncertainties are very large about specific impacts, there is a higher level of confidence about the vulnerabilities to impacts for most settlements in most parts of the U.S.**

**6. Developing a better understanding of these vulnerabilities and reducing uncertainties about impacts will benefit from a higher level research on impact assessment**

**7. Promoting climate change mitigation and adaptation discussions at an urban/settlement scale will benefit from involvement of stakeholders**

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## Recommendations Based on This Preliminary Assessment

1. Research on climate change effects on human settlements in the U.S Should be given a much higher priority in order to provide better metropolitan-area scale decision-making

2. In-depth case studies of selected urban area impacts and responses should be performed as soon as possible, especially for:

   coastal areas in the Southeast

   arid areas of the Southwest

   coastal areas of the Northwest

   Great Lakes region of the Midwest

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## Recommendations (Cont'd.)

3. Stakeholders should be explicitly involved to access their knowledge bases and inform their responses

4. Organizations who represent urban area decision-making in the U.S. (e.g., NACO) need to be strongly encouraged to become actively engaged in discussions of climate change impact and response issues

5. One U.S. Government agency should have the responsibility to lead the national effort to improve information about climate change vulnerabilities, impacts, and responses for the nation's cities and smaller settlements

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## Recommendations (Cont'd.)

**6. A structure and process needs to be established for informing U.S. decision-makers about climate change effects, how to integrate climate change considerations into what they do with building codes, zoning, lending practices, etc.**

**7. Experiences with urban/settlement climate change responses need to be documented to provide this information to the decision-making, research, and stakeholder communities**

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**COMMENTS?** **QUESTIONS?**