National Climate Assessment Health Sector Workshop

Southeast Region

February 13-14, 2012

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OVERVIEW

The U.S. Global Change Research Program (USGCRP) Climate Change and Human Health Working Group (CCHHG) convened two regional climate change and human health workshops in February 2012 as part of the National Climate Assessment (NCA) process. The workshops were supported by the National Oceanic and Atmospheric Administration (NOAA) Oceans and Human Health Initiative, the Centers for Disease Control and Prevention (CDC) National Center for Environmental Health, and the National Institutes of Health (NIH) National Institute for Environmental Health Sciences, with participant contribution of time and travel. This synthesis white paper summarizes the findings from the Southeast regional workshop.

Context

Section 106 of the 1990 Global Change Research Act requires that the United States develop an NCA every four years. The NCA tracks the status of climate change in the nation by tracking the state of the science across seven sectors, including human health and welfare. To forward this objective, the interagency cross-cutting CCHHG was chartered in December 2009 and became the first group to assess societal and sector impacts as part of the NCA process. CCHHG is divided into several workstreams, including adaptation, assessment and indicators, education and engagement, joint research and application, international, and data integration.

Purpose

CCHHG organized the Southeast and Northwest regional workshops to help inform its contribution to the 2013 NCA. More specifically, the workshops are intended to help provide a more nuanced representation of regional climate change impacts on human health, since impacts in the health sector are place-specific and path-dependent. The workshops also provided an important venue for dialogue among regional climate change experts, public health experts, and other stakeholders.

The Southeast region includes Florida, Georgia, Alabama, Mississippi, Louisiana, Tennessee, Kentucky, Arkansas, South Carolina, North Carolina, Virginia, and the U.S. Caribbean Islands. The Southeast was chosen as one of the two regions because it is considered a nexus of climate information and relevant climate and health activities. The workshop was intended to build off of the region's existing momentum by leveraging existing capacity, efforts, and discussions.

The goals of the Southeast workshop were to:

- Inform the 2013 U.S. NCA report;
- Increase the level of understanding of climate and health science in the region;
- Raise awareness of ongoing climate and health activities in the region;
- Improve tools for public health decision making by providing a forum for scientists and decision makers to share information and develop new or improve existing partnerships ; and
- Serve as a pilot for how to sustain an ongoing assessment process for understanding, predicting and adapting to the human health impacts of climate change across time scales.

This synthesis white paper serves as one of the products from the workshops and will be provided as technical input for the NCA. The paper documents participant input in the following six areas, which serve as the organizing structure for the *Summary of Input in Key Areas* section, below.

1. Current Regional Health Impacts of Climate Change
2. Regional Adaptation Efforts
3. Key Risks and Vulnerabilities
4. Future Projections of Health Impacts
5. Relevant Indicator Research and Tracking
6. Identification of Research and Monitoring Needs

Additional products from the workshops include:

- A survey of existing projects, research, publications, and decision-support tools on health effects of climate change in the region;
- A plan for building sustained collaborations needed to support ongoing assessment efforts including roles for different institutions; and
- Draft Monitoring, Early Warning, Data and Surveillance (MEDS) metadatabase, summarizing federal information related to climate change and health.

Format

The Southeast workshop took place over one full and one half day, February 13-14, 2012 in Charleston, South Carolina. The workshop was attended by approximately 50 individuals, including biological, physical, and social scientists as well as public health and natural resource decision-makers working on human health effects of climate change within the Southeast region.

The first (full) day of the workshop was devoted to plenary sessions, including presentations and discussion. Several plenary presenters have given permission for their presentations to be posted to the workshop website. These presentations are available at: http://www.joss.ucar.edu/ohhi/se_nca_health_sector_feb12/presentations/.

To initiate the proceedings, three introductory presentations provided background for the participants. First, July Trtanj and George Luber provided the background and objectives for the workshop, as laid out above. Second, Ralph Cantral provided an overview of the NCA process and divisions, emphasizing the current focus on: a sustained and interactive assessment process, integrated studies instead of sectoral studies, consistent methodologies, stakeholder engagement, and developing a product that is useful to decision-makers. Third, Chip Konrad presented a summary of current and projected climate change impacts in the Southeast region. He focused on weather and climate extremes, including the geographic pattern of occurrence across the region, variability and trends over the last 50-100 years, societal and public health impacts, and future projections. His presentation of climate conditions is outlined in the *Summary of Southeast Climate Conditions* section, below.

Following the introductory presentations, a panel discussion with four speakers and a moderator presented a regional health perspective on climate change. Representatives from North Carolina, South Carolina, and Puerto Rico presented and discussed the key impacts, vulnerabilities, and adaptation actions in their state or territory, while an EPA representative provided the federal perspective. Their key points are included in the *Summary of Input in Key Areas* section, below.

During lunch, Chris Portier presented the keynote address on *Priority Actions for Climate Change Adaptation: Perspectives from the Health Sector.* He emphasized the importance of effectively communicating climate change issues to key stakeholder groups, including the general public, policy makers, and the scientific community that identifies and funds priorities. He recommended that communications separate the mitigation and adaptation conversations so that adaptation-related communications are not affected by the controversial nature of mitigation. He also recommended that climate change communications capitalize on social media tools to disseminate information. He emphasized the need for anticipatory adaptation. After his address, the workshop participants engaged in a collaborative discussion exchanging information, resources, and needs.

During the afternoon of Day One, five speakers provided case study presentations highlighting ongoing research in the Southeast region. The titles of their presentations are noted in the workshop agenda included in the appendix. Their research, as well as the gaps and needs they identified, are included in the *Summary of Input in Key Areas* section, below.

The second (half) day of the workshop was devoted primarily to breakout sessions. After a brief overview of Public Health considerations in the 2013 NCA and the NCA writing process, participants were divided into two groups and given their charge for the two breakout sessions. Both groups considered the same questions during the breakout sessions. During the first breakout session on vulnerabilities and health impacts, participants were asked:

- What regional impacts are you already seeing?
- What key vulnerabilities have you identified?
- Which vulnerabilities are you worried about for the future?
- What are key health impacts you have identified or already seen?
- What health impacts are you worried about for the future?
- What existing indicators or tracking/monitoring efforts do you know of? (as time is available)

In response to these questions, breakout session participants provided largely anecdotal input on:

- Current public health impacts of climate change
- Current vulnerabilities to climate change
- Potential future public health impacts of climate change
- Potential future vulnerabilities to climate change
- Useful indicators

During the second breakout session on needs, collaborations, and next steps, participants were asked to identify:

- Research and monitoring needs
- Opportunities for collaboration
- Next steps

After the breakout sessions, representatives from each group reported out to plenary on their group's discussion. While the discussion in the two groups differed somewhat based on participant make-up, there was a lot of overlap between the two groups' input. The groups both suggested that it was difficult to distinguish impacts that are being seen now from impacts that are expected in the future, as future impacts will likely be extension of those impacts seen now. In fact, one group opted to treat them as one – discussing current and future impacts together and current and future vulnerabilities together. Input gathered during the breakout discussions are summarized in the *Summary of Input in Key Areas* section, below.

UNIQUE CHARACTERISTICS OF SOUTHEAST REGION

This section summarizes the participant-identified characteristics that make the Southeast unique, as compared to other U.S. regions. The following characteristics tend to increase the region's vulnerability to climate change impacts and are elaborated on in the *Summary of Input in Key Areas* section, below.

- Large and **diverse geography**
- Exposure to a wide range of **extreme weather** events including hurricanes, tornados, wildfire, drought, heat, and ice
- Extensive **coastlines**, coastal populations, and coastal assets
- Exposure to **"tropical" issues**
- High **urban sprawl rates** and therefore significant urban heat island effect
- Significant reliance on **mobile homes and substandard housing**
- **Ample trees and vegetation** that can become projectiles during storms
- High proportion of **older populations and retirees**
- High proportion of **poor and disadvantaged** populations
- High rates of **chronic disease**, including asthma and obesity
- Highest regional **production, use, and waste of energy**
- Greatest source of ***Vibrio* infections** in the United States

SUMMARY OF SOUTHEAST CLIMATE CONDITIONS

This section summarizes Chip Konrad's presentation of historical, current, and projected climate conditions in the Southeast.

Southeast Climate Conditions

The Southeast climate is influenced by a wide variety of factors. Both tropical cyclones (e.g., tropical storms and hurricanes) and extratropical cyclones impact the region. Meteorological conditions in the region lead to the development and intensification of storms. These conditions include warm moist air

moving into the region from the Gulf of Mexico and Atlantic and continental dry air moving in from the West.

Dr. Konrad discussed nine different weather and climate extremes affecting the Southeast: flooding, droughts, extreme cold, heat waves, heavy snow, ice storms, hurricanes, tornadoes, and severe thunderstorms. He noted a number of historical events that have significantly impacted human health in the region (e.g., 2002 ice storm, 2007 heat wave, 2011 flooding), due partially to the region's unique vulnerability.

Projected Climate Changes

Dr. Konrad then presented climate projections based on the North American Regional Climate Change Assessment Program (NARCCAP), focusing on those scenarios on which most models agree. (Note that this dataset is different from the projections being developed for the NCA.) Dr. Konrad noted that projected changes in the Southeast are not as great as those in other parts of the world. As a result, he suggested that past climate variability and weather extremes in the region serve as a good analog of the future.

Climate change projections for the Southeast include:

- **Temperature increases,** especially in the summer and especially in northern areas of the region.
- **More and more intense heat waves** (days above 95^{o}F), particularly in the southern and western portions of the region.
- **Increases in annual precipitation**, except for Arkansas and Louisiana.
- **Increases in heavy rainfall**, particularly in the Southern Appalachians.
- **No clear drought trend**. However, the vulnerability of the region is increasing due to population growth and other factors.
- **Increases in ground-level ozone**, particularly in urban and industrial areas.
- Slightly **fewer tropical storms and hurricanes, but stronger hurricanes.**
- **Sea level rise of 1 to 3 feet by 2100**, with large uncertainty due to uncertainty about carbon dioxide emissions and melting of polar ice.

SUMMARY OF INPUT IN SIX KEY AREAS

This section summarizes participant input in six areas:

1. Current Regional Health Impacts of Climate Change
2. Regional Adaptation Efforts
3. Key Risks and Vulnerabilities
4. Future Projections of Health Impacts
5. Relevant Indicator Research and Tracking
6. Identification of Research and Monitoring Needs

Current Regional Health Impacts of Climate Change

Participants identified a wide range of climate impacts on health that are already being seen. Participants noted that while these climate-related health impacts have been observed, in almost all cases, it is not possible to directly attribute the impacts to climate change. One breakout group described this category as one that identifies impacts already experienced that will become more extreme due to climate changes.

This list of participant-identified impacts draws primarily on the input gathered during the first breakout session, with some additions from the Day One presentations.

- **Issues with water quality and availability** affecting drinking water, agriculture, and water infrastructure.
    - Increased **contamination loading** due to drought. Drought can increase dry deposition, lead to higher concentrations in runoff (particularly if rain events become more extreme and lead to flooding), and result in a greater propensity for acute loadings. This process is suspected to be the cause of observed increases in arsenic levels (above maximum contaminant levels (MCLs)) in drilled wells in Southern Georgia.
    - A **need to drill wells deeper** due to drought (in Northern Georgia). By forcing wells into bedrock, this practice is resulting in uranium and radon issues.
    - **Saltwater intrusion** and contamination of aquifers. These impacts can also compound water shortages from drought.
    - **Algal bloom impacts** on freshwater supply and recreation. Raleigh is already spending $20 million per year to treat drinking water. Georgia is receiving call complaints.
- Increased intensity of heat waves resulting in **heat-related illnesses and death**. In North Carolina, heat-related deaths are concentrated in middle-aged males, ages 19 to 44. Participants suggested that this group includes both rural farm workers and student-athletes participating in summer training programs. Increased temperatures might also contribute to obesity, cardio-vascular disease, and diabetes due to decreased activity and increased time spent in air-conditioned indoor spaces.
- Increased frequency of short- and long-term **injury, illness, and behavioral and mental health issues as a consequence of extreme weather events** (e.g., floods, major storms). Mental health issues associated with extreme weather events include secondary impacts such as coping with relocation.
- Shifts in the type and distribution of **vector-borne, food-borne, water-borne, and zoonotic diseases**. This includes diseases such as dengue, Rocky Mountain spotted fever, and *Vibrio* infections.
    - Globally and nationally, ***Vibrio* illness** rates are rising, in part due to changes in sea surface temperatures and circulation. In the Southeast, where temperatures are already high enough to support *Vibrio* populations, there have been shifts in the types,

seasonality, and range of disease-causing species, as well as the presentation of symptoms. Increasingly, exposure to *Vibrio* is by direct contact, as opposed to oyster and seafood consumption. While 75% of *Vibrio* cases historically occur between May and September, this period has lengthened into April and November.

  - Incidences of **dengue fever** have increased in Puerto Rico related to changes in temperature and precipitation.
  - Increased water temperatures increase the potential for exposure to **water-borne diseases**. Increases in water-borne disease have also been observed during drought periods.

- Increased **asthma and allergy rates** due to changes in the pollen season, particularly in younger age groups.
- Epidemic outbreak of **skin cancer** believed to be due to increases in ozone.
- **Food safety and supply issues**. According to the USDA, 14% of the population in South Carolina is already food insecure. These populations are impacted as agricultural lands are taken out of production due to droughts, floods, or other climate-related factors. These impacts also affect family income making food purchases more difficult.
- **Respiratory and cardio-vascular issues due to decreased air quality**, particularly in urban areas. This includes respiratory and cardiovascular impacts from wildfires, peat bog fires, and ozone.
- Severe droughts leading to **wildfire** that can affect tourism and the economy, with trickle-down effects to people's health.

Participants also noted a number of climate change impacts that are not specifically health-related.

- Increased **sea level rise** and **erosion of shores and beaches**.
- Changes in the frequency, type, severity, and duration of **extreme weather events**. This includes precipitation, drought, flooding, hurricanes, and tornados. For example, participants mentioned an increase in the frequency and duration of rain events; flooding in areas where there has never been flooding before; and increased tornado frequency, frequency of major hurricanes, and intensity of hurricanes in Florida.
- Increased **heat**.
- Increased **wildfires**.
- **Shifting of plants and organisms**, including aquaculture, due to a lack of cold weather. For example, "stink bug" populations have increased and become prevalent in the Southeast and there have been well-documented ecosystem shifts in Florida, including significant losses of forest.

Regional Adaptation Efforts

During the presentations and discussion on Day One, participants mentioned a number of adaptation efforts underway in the Southeast region. In addition, all of the participants reviewed the *Inventory of Climate Change and Health Activities: Southeast Region* and added any activities missing from the spreadsheet. This *Inventory* will be provided as a separate technical input to the NCA. During the workshop discussion, participants noted the following activities:

REGIONAL

- Brian Stone is conducting research on the effects of land use and urban sprawl on the urban heat island effect and urban warming. His presentation at this workshop teased out the portions of urban warming that are impacted by the heat island effect (i.e., changes in land use) compared to changes in climate, suggesting changes in the urban landscape could significantly assist in reducing urban extreme heat events. His research shows that cities are warming faster than rural areas, with warming correlated with urban sprawl. According to his research, 70% of Southeast cities are implementing strategies (e.g., albedo enhancement, vegetation enhancement, energy efficiency) that reduce the urban heat island effect. However, only 15% of Southeast cities are implementing these strategies *with the intention* of reducing the urban heat island effect. Dr. Stone noted three available strategies to manage the urban heat island effect: sunscreening (integrating vegetation into the building envelope and increasing reflectivity), greenbelting (preserving vegetation proximal to cities), and carbon cooling (mitigation strategies that also have cooling benefits).
- Research is being conducted to investigate trends associated with *Vibrio* populations and infections. In particular, research is investigating the effect of changing temperatures, salinity, and water flows on *Vibrio* populations and human exposure.
- Research is being conducted in 55 tidal creeks throughout the Southeast to investigate the effects of coastal development and climate change (e.g., changes in precipitation and soil moisture) on coastal ecosystems and human health and well-being. The research models runoff volume and the loading of *Enterococci*, a type of indicator bacteria, in surface water discharges. The project is working to determine what percentages of impervious cover result in physical-chemical changes, living resources impacts, and health and well-being impacts.
- A Southeast Tidal Creek Summit was held to promote collaboration between different estuarine and tidal creek assessments.

CARIBBEAN

- Integrated research is being conducted in the U.S. Virgin Islands on ciguatera fish poisoning. Ciguatera fish poisoning is regarded by some as a "sentinel" disease—one that can foreshadow the impact of environmental change in coral reef systems. A CDC-funded project is investigating relationships among environmental stresses to coral reefs, population dynamics of *Gambierdiscus* dinoflagellates, and associated cases of ciguatera. The research is collecting time-series data on *Gambierdiscus* abundance and population structure, changes to reef health at

these locations (e.g., extent of coral bleaching, coral disease), toxicity of dinoflagellates and fish, and incidence of human poisonings from ciguatera in hospitals and clinics.

North Carolina

- A North Carolina Climate & Health Workshop was held in August 2011.
- North Carolina developed an Interagency Climate Change Adaptation Plan.
- North Carolina is conducting an assessment for a strategic plan to address health impacts.
- There are climate change adaptation projects underway in New Bern and Wilmington, funded by the EPA-FEMA Sustainable Communities work.
- North Carolina Emergency Management has drafted a new heat response plan.

Puerto Rico

- Emergency management systems have been effective at preventing mortality during extreme events.

South Carolina

- The South Carolina Department of Health and Environmental Control (DHEC) Environmental Public Health Tracking system (http://www.scdhec.gov/administration/epht/) monitors key indicators and communicates information to the public. Their website provides access to environmental and health data, maps, charts, and GIS layers.
- South Carolina emergency management efforts (part of DHEC) respond to health and medical needs during and after extreme weather events, track a number of diseases as well as oil and hazardous material spills, and have developed emergency plans for the full range of extreme weather events.

Key Risks and Vulnerabilities

Participants were asked to identify key regional risks and vulnerabilities related to climate change impacts on human health. This list of participant-identified risks and vulnerabilities draws primarily on the input gathered during the first breakout session, with some additions from the presentations on Day One.

Infrastructure-Related Vulnerabilities

- **Urban sprawl** is particularly prevalent in the Southeast. Sprawl increases vulnerability primarily by increasing the urban heat island effect and urban warming, as well as by increasing exposure to wildfire, increasing the use of inefficient transportation such as cars, increasing runoff, and generally decreasing community resiliency and self-sufficiency. Brian Stone's research shows that Southeast cities tend to rate very high on the urban sprawl index, compared to other U.S. cities, and are expected to experience a significant increase in the number of extreme heat days. According to his presentation, the urban heat island effect is the dominant driver of warming trends in large U.S. cities and a rising threat to public health.
- **Waste water and water treatment facilities** have largely been poorly maintained, are damaged, and/or are in need of replacement. They are also often located in vulnerable locations. A

number of waste water treatment plants are already having trouble meeting their water quality standards because of changes in stream flow.

- The **energy grid** is already vulnerable to outages. With increased population and hotter summers, there will likely be an increase in energy outages. Outages limit the ability to provide emergency information to farmers and migrant workers, among other things.
- Much of the Southeast's physical infrastructure (e.g., waste water facilities, ports, airports, power plants, transportation infrastructure) is **coastally located,** making it particularly vulnerable to sea level rise, storm surge, coastal erosion, and coastal storms.
- **Transportation and communication infrastructure** is also vulnerable to climate change, and serves as a critical component of health care and information delivery systems.
- **Chemical stockpiles and Superfund sites** could pose a significant health challenge.

Public Health Capacity-Related Vulnerabilities

- **Public health infrastructure** is generally developed on an as-needed basis (just enough, just in time), without a lot of reserve.
- The **public health workforce is unprepared** for climate change issues. People are good at what they do now and may not be prepared for climate change-related changes such as new diseases. Training on climate change issues is inadequate.
- **Public health funding** is inadequate to deal with climate change public health impacts. The recent loss of state and local funding for public health has resulted in a renewed focus on core programs and reduced attention given to evolving climate change-related issues. The people and capacity available to serve as public health resources are generally inadequate.
- **Access to care and delivery systems** are inadequate in many areas of the Southeast.
- Many hospitals and health care facilities are **located in vulnerable areas,** such as on the coast or in the path of tornadoes.
- There are generally **not enough people working in public health**. For example, there is a need for more people to monitor vulnerable populations in the field and check on program implementation. Moreover, many public health workers have additional responsibilities during extreme events that impede their capability to respond (e.g., 20-30% of the workforce is not available for the people that need their support). Public health personnel will likely remain constant or decrease.
- **Supply chain issues** can restrict resource movement during extreme events.

People-Related Vulnerabilities

- There have been significant increases in the Southeast's **coastal population**, placing more people at risk of illness, injury, and mental health impacts from sea level rise, storm surge, and coastal storms. Retirees make up a significant number of the coastal population, with a growing number over the age of 85. In Puerto Rico, 70% of the population lives on the coasts.
- The Southeast has a disproportionate number of retirees. **Older adult populations** are more vulnerable to infectious disease, cardiovascular disease, heat-related illness, and other climate-related health issues. To compound vulnerability, these older populations are often located in

coastal areas. In Puerto Rico, 13% of the population is over 65 years old and this proportion is increasing.

- A lot of people in the Southeast live in **mobile homes and manufactured housing**, which are generally less resilient.
- Increasing **socio-economic inequity** in the Southeast will put an increasing number of disadvantaged populations at risk. According to the participants, the Southeast has the highest regional poverty rate, which increases health vulnerability. For example, there was a breakout of West Nile Virus in Jacksonville in 2011, where 20% of the cases were among the homeless concentrated in the central part of the city, where poverty is greatest.
- The Southeast population is already characterized by **high rates of chronic disease** and the rates are increasing. For example, according to the participants, the Southeast has the highest regional obesity rate, 10% of the Puerto Rican population has heart disease, and Puerto Rico has the highest prevalence of asthma in the United States. People with chronic disease are more vulnerable to other health impacts and less able to evacuate during extreme events.
- The **outdoor workforce** in the Southeast is especially exposed to climate change-related health impacts, including heat and insect-borne diseases. From 2008-2011, the highest incidence of heat-related emergency department visits was among 19-44 year old males.
- Rural populations often have reduced **access to care.** For example, from 1977-2001, 40% of occupational heat-related fatalities in North Carolina were among farm workers, many of whom died unnoticed and without medical attention.
- During extreme events, the **left-behind population** is particularly vulnerable. This includes individuals that are physically unable to evacuate, the socio-economically disadvantaged, migrant workers, those without vehicle access, and those unwilling to abandon their pets. In addition, the livestock left behind often do not survive, resulting in carcasses that require clean-up and are associated with the spread of diseases.
- The Southeast region has experienced significant **population growth** in recent history which will further stress resources affected by climate change.

Economic Vulnerabilities

- **Federal and private insurance programs** will likely increase in cost, particularly for weather-related issues. Insurance could become prohibitively expensive for people to afford privately or for the government to support. In some cases, insurance may no longer be offered.
- Climate change impacts on **agriculture production and tourism** could economically hurt the Southeast, reducing both the ability to afford food and general resiliency, including to health impacts.

Programmatic Vulnerabilities

- Given the Southeast's vulnerability to extreme storms such as hurricanes and tornados, **evacuation** could become an issue.
- There is a lot of competition in the Southeast over **water rights**, between humans and agriculture, between states and cities, and between different states.

- **Communication gaps** result in people not receiving and understanding the information they need. Cultural sensitivities resulting from the Southeast's cultural diversity impede communication and trust.
- The **political climate** is reducing resiliency. Political structures often prevent effective management of vulnerabilities and risks. Regulatory compliance issues often do not account for climate change, instead relying on the "stationarity" of climate. Shifts in local and state public health funding have adversely impacted the management of vulnerabilities and risks.
- The **geographic diversity** of the Southeast region will be a challenge in effectively addressing impacts in the different regions. The Southeast is exposed to a large number of different extremes, including ice, drought, heat, hurricanes, wildfires, and tornados. In addition, the Southeast is vulnerable to "tropical" issues (e.g., harmful algal blooms, coral-related issues).
- **Public health is often left out** of climate change-related discussions.
- There is **inadequate structure, regulation, and knowledge** to deal with climate change issues in many areas, such as Puerto Rico.

Future Projections of Health Impacts

Participants discussed a wide range of public health impacts from climate change that they are concerned about for the future. Due to the anecdotal nature of participant input, the future impacts they noted were very similar to the current regional impacts summarized in the *Current Regional Health Impacts of Climate Change* section, above. In fact, one breakout group combined current and future impacts and discussed them together. As a result, all impacts discussed in the current impacts section should also be considered when characterizing future impacts.

This list of participant-identified projected impacts draws primarily on the input gathered during the first breakout session, with some additions from the Day One presentations.

- **Mental health** effects. While these impacts are uncertain, they will likely be compounded by a lack of resources.
- **Shifts in the human and agricultural disease burden** from habitat, range, and phenology shifts of animals, insects, and plants.
    - **Emerging diseases, emerging pests, and invasive species**. Participants noted examples such as shifting plant pathogens, fire ants moving north, dying bees and bats, and amoebas in warmer waters.
    - Increased pollution from **increased pesticide, insecticide, and herbicide use**. Changes in plant hardiness zones could change the types of pesticides and herbicides needed and used. Invasive species and emerging pests could cause increased use of these chemicals and an increased number of emergency pesticide use exemptions. Similarly, in carbon dioxide-enriched environments, weeds tend to outgrow crops, which could lead to increased herbicide use. Changes and increases in the use of these chemicals could cause health problems for those affected by runoff, for people who live near areas of application, and for workers applying the chemicals and unable to understand the proper application directions (e.g., non-English speaking migrant workers).

    - Increases in **vector-borne diseases** such as Dengue fever, Chikungunya fever, Yellow fever, West Nile virus, Eastern Equine Encephalitis (EEE), St. Louis Encephalitis, and Malaria. According to one participant, there is epidemic potential for mosquito-borne disease in the Southeast given the region's mosquito-friendly ecology and the speed with which vectors can spread.
- Worsening **ciguatera fish poisoning** both in Puerto Rico and in more northern areas. Ciguatera fish poisoning incidence is strongly correlated with sea surface temperatures (optimal temperature regime for the underlying dinoflagellates is 25-29°C). In addition, coral bleaching promotes ciguatera fish poisoning because the toxic dinoflagellates live attached to seaweed that opportunistically colonize dead or diseased coral.
- **Water quality and availability** issues.
    - Increased **diarrheal and gastrointestinal diseases** such as S*almonella* and *E. coli*.
    - Increasing issues from **Harmful Algal Blooms (HABs)**, such as **cyanobacteria blooms** in freshwater aquifers and recreational water.
- Increases in **antibiotic-resistant infective agents.** This includes antibiotic-resistant *Vibrio* infections and MRSA (Methicillin-resistant Staphylococcus aureus), among others.
- Shifts in ***Vibrio* infections** due to the synergistic impact of changes in temperature and precipitation, altered water salinity and chemistry, distribution shifts of commensals and reservoirs, altered water flows and transport, changing seasonality, and sea level rise and storm surge. Other factors may affect the species, such as increased ocean warming due to El Niño events, making it challenging to isolate the impact of climate change.
- Issues caused by **behavioral changes.**
    - If worsening asthma or increasing temperatures decreases outdoor physical activities, there could be **increases in cholesterol-related heart disease**.
    - If climate changes cause people to spend more time outside, issues could arise from **increased sun exposure**.
- Increases in **chronic diseases**, including asthma.
- Changes in **allergies** including shifts in location and prevalence. For example, ragweed is expected to increase in response to increasing levels of atmospheric carbon dioxide.
- Public health problems from the non-human "**left-behind population**" following extreme events. During events requiring evacuation, agricultural animals and pets are often left behind resulting in the accumulation of dead carcasses.
- Issues with **food safety and security**, with trickle-down health effects.
- **Decreased air quality** due to increased energy use for more frequent heat waves and cold periods. Air quality may be further degraded by increasing temperatures, limiting the relevance of air quality modeling that is based on the assumption of stationarity.
- Increases in the proportion of **vulnerable populations** due to increasing energy costs and damage to housing from extreme events.
- **Economic effects** resulting from many climate change impacts. Since economics is a key determinant of health, these effects will in turn affect human health.

Participants also noted a number of climate change impacts that are not specifically health-related, but that could impact health.

- Changes in the **intensity and frequency of extreme weather**, including hurricanes, tornados, droughts, and floods.
- Increased **sea level rise** with important impacts for the Southeast's extensive coastline.
- **Population displacement** from coastal areas.
- Increased **environmental justice** issues.
- Changes in **stormwater runoff** leading to erosion, sedimentation, flooding, and pollution.
- Magnified issues from **compounded extremes**. For example, more extreme precipitation events could combine with sea level rise and increased runoff from urbanization to create very flashy environmental conditions.

Relevant Indicator Research and Tracking

During the first breakout session, participants were asked to identify existing indicators, tracking and monitoring systems, resources that would help monitor or track indicators, and ongoing monitoring efforts. One of the groups opted to introduce themselves by naming the indicator that is most important to their work. In this context, the participants identified the following.

- Changing patterns of extreme weather. E.g., hurricanes, major rainfall events, droughts.
    - Changing patterns of precipitation (drier dry periods, wetter wet periods), especially as they relate to the hydrological cycle and more specifically stormwater runoff.
    - Injuries related to extreme weather events.
    - Precipitation frequency, more specifically, return frequency for major storms.
    - Drought, as it relates to wells and the need to sink them deeper.
- Infectious disease.
    - Harmful algal blooms (HABs), more specifically, ciguatera fish poisoning.
    - Emerging vector-borne and zoonotic diseases.
- Indicators that affect all other indicators.
    - Community resiliency.
    - Socioeconomic status.
    - Level of poverty.
- Vulnerable populations.
- Substandard housing.
- Urban heat island effect risk factors and mitigation strategies.
- Shellfish production.
- Increased salinity.
- Heat-related deaths, especially as they relate to rural communities and access to health care.
- Coastal distribution.
- Access to care.

In addition, during the presentations and discussions on Day One, participants discussed the following efforts.

- The South Carolina Department of Health and Environmental Control (DHEC) Environmental Public Health Tracking (EPHT) system (http://www.scdhec.gov/administration/epht/) tracks key health and environmental indicators. The EPHT website is consistent with the national CDC EPHT program in the specific indicators that are included, but the DHEC site also expands access to other sources of information. The climate change portion of the website, when fully developed, will include the national indicators selected by the CDC EPHT program. Max Learner of South Carolina DHEC suggested that public health can play a key role in surveillance and assessment, including: daily monitoring and response to disease outbreaks, hazardous material releases, and climate-related illness; sustaining surveillance, epidemiology, and laboratory capabilities; and analyzing data and identifying trends and relationships between climate, environment, and health.
- The Council of State and Territorial Epidemiologists (CSTE) is developing a set of health indicators with climate change as one of the considerations.
- North Carolina was one of the states that tested the 26 indicators developed by CSTE. North Carolina's efforts were focused on establishing baselines for the indicators, to be used in the future to evaluate trends.
- The following list constitutes North Carolina's Climate Ready NC Indicators, which they are collecting for 2000-2010.
    - Air pollution
        - Asthma incidence
        - Number of wildfires, acres affected
        - Number of respiratory hospitalizations
    - Water-borne disease
        - Number of maximum contaminant level (MCL) violations
        - Public health infrastructure at-risk for sea level rise inundation
        - *Vibrio* skin wounds
    - Food-borne disease
        - *Campylobacter*
        - *Salmonella*
    - Vector-borne disease
        - La Crosse encephalitis
        - Rocky Mountain spotted fever
        - Malaria, dengue (imported)
        - West Nile virus
    - Cardiovascular disease and stroke
        - Number of strokes on days above 90°F
        - Number of cardiovascular hospitalizations
    - Extreme weather
        - Number of heat waves by season

        - Number of heat-related emergency department visits, hospitalizations, deaths
        - Number of storms, other types of severe weather
        - Number of extreme weather fatalities
    - Mental health
        - Number of severe persistent mentally ill
    - Developmental effects
        - Number of birth defects
        - Number of births to mothers receiving WIC
    - Cancer
        - Number of colorectal cancer cases
        - Number of non-melanoma skin cancer cases
    - Other
        - Top concerns on local health directors' community health assessments
        - Greenhouse gas policy and adaptation actions
- CDC's National Environmental Public Health Tracking Network is developing environmental modules that link to climate change. The modules will be available in the next build. Meanwhile, a portion of the dataset is already available. CDC is looking to the tracking portal to gather success stories from states about how they are using the tracking network to promote change.

Identification of Research and Monitoring Needs

Throughout the workshop, participants identified a number of research and monitoring needs to better understand the effects of climate change on public health. Participants were directly asked to identify needs during the second breakout session, however, research needs were identified throughout the workshop proceedings.

In particular, participants identified a need for:

- **Long-term time series data**. Participants emphasized the criticality of having long-term datasets (e.g., 20-30 years or more) to tease out climate-related trends. This kind of data is needed for a wide variety of climate and public health factors and indicators, from urban temperatures to ciguatera fish poisoning incidence. Key to gathering long time series data is implementing long-term monitoring capacity.
- **Coastal ocean observing capabilities and projections**. Participants emphasized the need for climate observations and projections that are not just land-based. Offshore projections in and over coastal waters are critical for understanding hurricane and storm development, effects on fisheries, HABs, and other ocean-based phenomenon. The ocean observing system should monitor time series of variables such as ocean stratification, temperature changes, water layering, ocean circulation, currents, salinity, and acidity.
- More useful **climate scenarios**. This includes higher resolution scenarios with finer downscaling. It would be beneficial for the scenarios to conform to the boundaries at which health data are collected (e.g., at the census tract or county level), so that data could be trained on current patterns and then extrapolated forward.

- Research, observations, and monitoring of **mental health impacts**, particularly those impacts following extreme weather events. For example, it would be beneficial to monitor the pattern of requests for mental health services during and after extreme events.

Participants also discussed the need for greater collaboration. This might involve:

- Better knowledge of, collaboration between, and **combination of efforts**. Regional meetings and workshops could encourage people to discuss their ongoing work and facilitate effort integration.
- Continued multi-state, **regional meetings,** organized around different commonalities (e.g., by watershed, by scarce resource).
- Collaborations **between researchers and applied implementers** (as at this workshop). These collaborations are very important to prioritize research and to develop and improve stakeholder-driven messaging about the evolving science. Collaborations could include public health officials, researchers, and climate experts.
- **Intra-state roundtables** that engage the various agencies (e.g., emergency managers, environmental departments, public health officials) within the state to think about cross-collaborations and develop a unified voice from the state. This could take the form of a state-level climate change task force in some states, but may need to be less official in others.
- Compilation of **research needs from the environmental health directors** in each state. These compiled needs could be brought to researchers to better shape the research agenda or could serve as a practicum catalogue of research topics for interested universities.
- A **national research agenda** for specific areas such as health effects of drought.
- Involvement and education of the **medical community** on basic climate science and the health impacts of climate change. This includes major medical societies and physicians.
- Connection with **One Health groups**.
- Getting climate change issues on the agenda of **public health organizations, NGOs, state environmental agencies, and environmental health directors** to educate new health officials, gain their support, and support all ongoing efforts. Groups might include the National Association of County and City Health Officials (NACCHO), the Association of State and Territorial Health Officials (ASTHO), and the American Public Health Association (APHA), among others.
- **State-to-local collaborations** where states interact with localities in more meaningful, productive ways (e.g., by sharing state-gathered data).
- **Local-to-local collaborations** that take advantage of the trust among local communities to share information between those localities that have tools, resources, and experience with those that do not.
- Partnerships with **non-traditional partners** such as planners, insurance companies, and builders.
- Taking advantage of resources that are funneled into the **ocean observing system** for reasons other than climate to add sensors to existing buoys and observing stations.
- Better **understanding the role of the state climatologist**.

In addition, participants identified the following list of research and monitoring needs:

- Better **integration of climate data and public health outcomes**. For example, it would be helpful to have a standard, formal method and accompanying guidance on how to integrate public health data (e.g., as collected by state and public health departments) into climate models and emissions scenario development. This lack of integration knowledge proves to be a bottleneck limiting collaboration. Additionally, public health data and climate data should match each other temporally and spatially to facilitate integration.
- Better **quality and quantity of data** including better, more consistent reporting of more health outcomes, better methods to monitor exposure, and data collection on a more regular basis.
- **Continued funding of public health data collection**. This surveillance is under scrutiny and threat. It is critical that this surveillance is protected from budget cuts, as long time series of data (e.g., 30-50 years) are much more valuable than short time series (e.g., 4-7 years).
- Identification of **health surrogates**. Public health data could be gathered by monitoring social media platforms and internet searches or by using pharmacy data.
- Increased labor capacity devoted to **working with data**. While a lot of data has been collected, people are not adequately mining, analyzing, and using it.
- **Integration of the veterinary and zoonotic disease monitoring** with climate change and human health tracking. For example, integrating ArboNET with the public health tracking network.
- Better **monitoring of runoff** to detect chemical loads (such as pesticides) that might affect oceans and fisheries. This might be supplemented by better monitoring of pesticide use, including tracking of pesticide purchases.
- Formal **tracking of emerging disease occurrences**, such as vector-borne disease, as well as monitoring of pests and disease vectors.
- Improved models for **forecasting HABs and other pathogens**.
- Research on **factors affecting *Vibrio* populations and exposure risks**. This includes interactions between *Vibrio* species and plankton groups; concentrations of nutrients, dissolved organic matter (DOM), and trace metal; and changes in demographics and vulnerable populations.
- Continued **coral reef monitoring programs**, tied in with human health surveillance. More specifically, since ciguatera fish poisoning may be a sentinel disease of the impact of environmental change in coral reef systems, it would be beneficial to invest resources into understanding its dynamics. This includes the dynamics of source dinoflagellates, as well as human exposure and infection.
- Understanding of the ecological conditions and dynamics that promote ***Aedes aegypti*** which could pose a serious vector-borne disease threat.
- Understanding and **quantifying the benefits** of mitigation and adaptation actions, **including economic evaluations** such as the cost-effectiveness of actions, health impact assessments, estimations of monetized impact, the direct health care costs of climate change impacts, and the costs of action versus the costs of inaction.

- Understanding the **communication needs and expectations** of different socio-cultural groups, as well as policy makers. It is critical to identify effective communication methods, messaging, and ways to target each key audience.
- Understanding the **public's awareness** of climate change and its health implications. Similar to studies conducted by Ed Maibach, researchers need to better understand shifts in public opinion and policy issues. In particular, it would be helpful to study the awareness and concern of state public health officials and state policy makers.
- **Community-level vulnerability and needs assessment**.
- Understanding the differences between the various **geographic areas** of the region.
- Understanding **indirect effects of extreme events**. For example, the ramifications of bottlenecks in evacuation, the clean-up following extreme events, the coordination of extreme event response.
- Development of relatively short-term **health warning systems** for specific outcomes, such as HABs.
- Development of **long-range planning for infrastructure**, including water, wastewater, and transportation.
- Tracking of the **migration** of affected people.
- Identification of **locations for temporary housing** following natural disasters. Communities should pre-identify where temporary housing can be located and acquire the necessary permitting before disasters occur. Communities should also pre-identify what resources will be available and what organizations can provide assistance.

Participants also requested better quantification of observed and projected changes in a number of climate variables, including:

- **Extreme weather** patterns such as the 100-year flood.
- **Precipitation** patterns.
- **Sea level rise** and the potential impacts on soil saturation.
- Changes in **runoff.**
- **Growing degree days, cooling degree days.**
- **Days above 90°F.**
- **Frost-free days.**
- **Length of frost season.**

APPENDIX

This appendix includes the following workshop materials:

1. Workshop Agenda
2. Participant List
3. Workshop Overview

Note: several presenters have given permission for their presentations to be posted to the workshop website. These presentations are available at: http://www.joss.ucar.edu/ohhi/se_nca_health_sector_feb12/presentations/.

U.S. Global Change Research Program

National Climate Assessment

National Climate Assessment Health Sector Workshop
Southeast Region
February 13th and 14th, 2012
Francis Marion Hotel, 387 King Street,
Charleston, South Carolina

Monday, Feb 13th

8:00 AM	Coffee and continental breakfast
8:30	**Welcome** - Juli Trtanj, Director, NOAA Oceans and Human Health Program; and George Luber, Associate Director for Climate Change, Climate and Health Program, CDC
8:45	**Brief overview of the National Climate Assessment** - Ralph Cantral, Sectoral Coordinator, National Climate Assessment
9:15	**State of regional climate, downscaling impacts / scenarios** - Chip Konrad, Southeast Regional Climate Center
10:00	*Break*
10:15	**Panel discussion: A Regional Health Perspective on Climate Change** Moderator: Margaret Davidson, Director, NOAA Coastal Services Center • Max Learner, Director, Office of Public Health Preparedness, South Carolina Department of Health and Environmental Control • Mina Shehee, Branch Head, Occupational & Environmental Epidemiology, Division of Public Health, North Carolina Department of Health & Human Services • Ken Mitchell, Senior Climate Change Advisor, U.S. EPA Region 4 • Susan Pacheco, Puerto Rico Coastal Zone Program
12:00 PM	Lunch and keynote address - Christopher Portier, Director, National Center for Environmental Health, Centers for Disease Control and Prevention

2:00 – 4:50	**Case study presentations: synthesis of current efforts in the Southeast including surveillance gaps and future needs**
2:00	*Extreme Heat and Health: Warming Trends and Climate Action Planning in Large U.S. Cities.* Brian Stone, Associate Professor of City and Regional Planning, School of City and Regional Planning, Georgia Institute of Technology
2:25	*Shifting dynamics in Vibrio populations and human exposure risk with changing climate in the southeast.* Erin Lipp, Associate Professor, College of Public Health, University of Georgia
2:50	*Tidal Creek Ecosystems: Sentinel Habitats for Assessing and Predicting the Consequences of Coastal Development and Climate Change.* Denise M. Sanger, Center of Excellence in Oceans and Human Health at the Hollings Marine Laboratory and SC Sea Grant Consortium
3:15	*Break*
3:30	*Climate and Vector-borne Disease in the Southeast.* Carina Blackmore, Adjunct Professor, Department of Environmental and Global Health, University of Florida
3:55	*Impact of climate on ciguatera poisoning and marine toxins.* Don Anderson, Woods Hole Oceanographic Institution
4:30	**Summary and Conclusions**
5:00	**Adjourn to Reception**
6:15	Joint reception with the NCA Rural Communities Workshop. Charleston Place Hotel, 205 Meeting Street (approximately ½ South of the Francis Marion Hotel)

Tuesday, Feb 14th

8:30 AM	Coffee and continental breakfast
9:00	**Welcome**, health input into the NCA, and instructions for breakouts - Juli Trtanj, Director, NOAA Oceans and Human Health Program; and George Luber, Associate Director for Climate Change, Climate and Health Program, CDC
9:15	**Breakout session one:** discussion for input to the National Climate Assessment
10:30	*Break and compilation of input*
10:45	**Breakout session two**
11:30	*Break and compilation of input*

11:45 **Report outs.** Next steps, summary and moving forward

12:30 PM **Adjourn**

Breakout topics and questions:

- Current regional health impacts of climate change
- Key risks and vulnerabilities (vulnerable populations, infrastructure, etc.)
- Potential health impacts in the future (what are you worried about?)
- Regional adaptation efforts underway or being planned
- Identification of existing indicators or tracking/monitoring
- Identification of research and monitoring needs
- Collaboration and steps forward

U.S. Global Change Research Program

National Climate Assessment

National Climate Assessment
Health Sector Workshop
Southeast Region
February 13-14, 2012
Charleston, South Carolina

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On National Climate Assessment Health Sector Workshop
Southeast Region
February 13th and 14th, 2012
Francis Marion Hotel, Charleston, South Carolina

This workshop is held under the auspices of the U.S. Global Change Research Program, Climate Change and Human Health Working Group and is designed to**:**

1) Inform the US National Climate Assessment;
2) Increase the level of understanding of climate and health science in the region
3) Raise awareness of ongoing climate and health activities in the region
4) Improve tools for public health decision making by providing a forum for scientists and decision makers to share information and develop new or improve existing partnerships; and
5) Serve as a pilot for how to sustain an ongoing assessment process for understanding, predicting and adapting to the human health impacts of climate change across time scales.

This workshop will bring together biological, physical and social scientists, with public health and natural resource decision-makers working on human health effects of climate change such as ocean and coastal related health risks, vector-borne and water-borne disease, heat and weather-related effects, and cardiovascular and respiratory diseases. Integrated adaptation efforts and a One Health approach will be stressed.

Products:
Products from these workshops will include

- A survey of existing projects, research, publication and decision-support tools on health effects of climate change in the region,
- Synthesis white papers that document inputs from participants in six areas:
    - current regional health impacts of climate change
    - regional adaptation efforts
    - key risks and vulnerabilities
    - future projections of health impacts
    - relevant indicator research and tracking
    - identification of research and monitoring needs
- A plan for building sustained collaborations, needed to support ongoing assessment efforts including roles for different institutions.
- Draft Monitoring, Early Warning, Data and Surveillance (MEDS) metadatabase, summarizing Federal information related to climate change and health.

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