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Consequences of Climate Change in Louisiana

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Climate variability and change his been the norm rather than the exception on our planet. In fact modern Louisiana owes much of its existence to climatic events that produced floods bringing the vast quantities of sediments down the Mississippi River that built the southeastern part of the state. But, southeastern Louisiana also owes its existence to an exceptional period of climatic stability over the past 7,000 years or so. Only 12,000 years ago the vast ice sheets that covered the northern part of the U.S. began to melt as a result of a rapidly warming climate. Sea level was about 300 feet lower than it is today—Louisiana extended to the edge of the continued to warm. It finally stopped when temperature stabilized, with the Gulf lapping shores near present day Lafayette, Baton Rouge and Covington. Only during this last 7000 years of relatively stable global climate and sea level was Old Man River able to take over and build the bountiful and populous lands of south Louisiana. As a fifth generation New Orleanian, I am profoundly grateful for that.

It is now increasingly evident that we have entered another period of rapid climate change—this one caused by humankind itself, rather than the wobble of Earth or some other natural phenomenon that has caused the planet's climate to change periodically. In this brief essay I will explore the potential consequences of climate changes to Louisiana during the 21st century, not only to the delta and coastal regions, but also to the rest of the state and its habitability and resources. I base my perspectives on several recent scientific assessments that have evaluated the potential extent of human-induced climate change and its consequences on global, national and regional sales. These reports, websites for which are listed at the end, were published just in the last two years and have greatly contributed to our ability to foresee the future. They provide a sobering basis for reflection by our society on our options to deal with these changes.

Global Climate Change Has Already Begun

It has been understood in theory for over a century that releases of carbon dioxide by Earth's growing and increasingly industrialized population would likely lead to warming of the planet due to the greenhouse effect. Although there have been debates over whether the Earth has indeed begun to warm, these are mainly now in the news media and political arena rather than the scientific community. As demonstrated in the latest report of the Intergovernmental Panel on Climate Change (IPCC) there is strong scientific consensus that the Earth's

climate has already begun to change in ways very consistent with the build-up of CO_2 in the atmosphere. Over the 20th century, the average U.S. temperature rose by 1^0F and precipitation increased by 5-10%, most of this occurring over the past few decades. Globally and in the U.S., the 1990s was the warmest and most rapidly warming decade ever measured and perhaps the warmest in the last 1000 years, based on measurements of tree rings, ice cores and coral growth.

Like many aspects of climate, there was local variability in these trends, as was shown in the recent report of the U.S. National Assessment of the Consequences of Climate Variability and Change. For example, the Deep South, including much of Louisiana, actually became slightly cooler and Louisiana became slightly drier over the 20th century (although the winters became somewhat wetter and extreme rainfall events more important). However, it is a mistake to blame every dry spell, hurricane or mild winter on global warming, or even El Niño for that matter. But, the well-documented warming of the ocean's surface waters provides additional weight to the conclusion drawn from more variable air temperature measurements that global warming has begun.

Changes Ahead

We know that CO_2 in the atmosphere is increasing at a rapid rate due to human activities, mainly from burning of fossil fuels, but also by deforestation. Furthermore, humans are also releasing large quantities of other gases such as methane (CH_4) and nitrous oxide (N_2O) that produce an even more potent greenhouse effect than CO_2. While we can say that in general terms the increased concentration of these "greenhouse gases" will mean warmer temperatures, increased precipitation (simply because more water will evaporate), and rising sea levels (because of thermal expansion of the ocean and melting of glaciers), predicting the degree and rate of these changes is more challenging. As mentioned before, although these trends may apply for the world as a whole, their regional manifestations may be very different. Much effort has been spent in the development of general circulation models of the atmosphere and oceans in order to project future trends. These supercomputer-based models have improved over the years and have been used to make projections on regional scales. Nonetheless, these predictions may differ considerably among models because of different assumptions regarding the rate of releases of greenhouse gases and key physical and biogeochemical processes involved in the Earth's climate system, for example whether increased cloud cover that may moderate warming.

Overall, the models have been very successful in explaining 20th century climate variability as a function of both natural climate forces and human effects, thus confidence has grown in their use in forecasting. According to the IPCC the following climate changes are very likely (90-99% probability) over most areas during the 21st century: higher maximum temperatures and more hot days; higher minimum temperatures, fewer cold days and frost days; reduced diurnal

temperature range; increase in the heat index (combining temperature and humidity); and more intense precipitation events. Likely (66-90% chance) changes include: increased summer drying and associated risk of drought; increase in tropical cyclone peak wind intensities; and increase in tropical cyclone intensities. Based on the models, the average global temperature is projected to increase by 2 to 10^0F by the end of the 21st century, with a most probable increase of 4-8^0F. Temperatures are projected to rise more rapidly after about 2040. Global sea level is projected to rise between 8 and 28 inches, with the most probable rise between 12-19 inches. Using two different models, the U.S. National Assessment projected temperatures in the U.S. to increase by about 4-7^0F during the century. While the degree of warming is projected to be greater in the Plains states, the increase in the heat index should be greatest in the Southeast and South Central states—not good news!

The use of late 21st century scenarios is somewhat misleading in that the changes in temperature and other associated aspects of climate will be gradual over the course of the century and subject to various advances and reversals rather than abrupt. Most of the change is likely to come in the latter half of the century, when many of us will not be around. However, focus on the late 21st century also obscures the even higher temperatures that will be experienced into the following century even if we are successful in significantly reducing greenhouse gas emissions. Stabilization of Earth's temperature will take centuries.

Uncertainties about the Details

There are, of course, uncertainties regarding these projections of future climate. While the confidence in projections of overall warming is great, other climate related factors that are driven by temperature changes can be less confidently predicted, especially on regional scales. This is particularly the case, for example, for precipitation—the patterns of changes predicted over the U.S. vary greatly among climate models. The Canadian Climate Center model projects significant decreases in precipitation over the southeastern U.S., while most other models project modest increases. Of course, the interaction of changes in precipitation with those in temperature, which influences evapotransportation, will have a major influence on stream flow, groundwater recharge, and availability of water resources in the future.

Other uncertainties particularly important to Louisiana concern the rate of sea-level rise, which could increase dramatically if polar ice caps melt more rapidly than assumed in the models, and the frequency, intensity and behavior of tropical storms. Although basic considerations would suggest more frequent and energetic storms will result from kicking up Earth's heat engine a notch, tropical storm behavior is greatly affected by multi-year climate cycles such as El Niño-

La-Niña. The effects of long-term global warming on El Niño and other decadal-scale ocean variability will be very important in determining future storminess.

Louisiana's Climate Later This Century

It looks like Louisiana is in for both hotter summers (3-7^{o}F warmer) and milder (3-10^{o}F warmer) winters through the end of the 21st century. A significant increase (10-25^{o}F!) in the heat index could mean greater heat-related health risks. Both models used in the National Assessment also project that the trend toward decreased precipitation observed over the 20th century in Louisiana will continue through the 21st century, particularly in southeastern Louisiana. However, rainfall events are likely to be more extreme, with heavy downpours separated by long dry spells. As a result of the warmer conditions and decreased precipitation, soil moisture is projected to decline by 20-40% in south Louisiana by the end of the century.

Water: Too Little, Too Much?

Sitting at the funnel spout of one of the world's largest drainage basins, Louisiana is blessed with plentiful water resources—sometimes too plentiful! While the Mississippi River is not likely to run dry as a result of global climate change—it fact as discussed below it s discharge may well increase—the dryer summer conditions that are projected by the climate models would tax the water resources in many of the state's other surface waters and in groundwater. Although we cannot say that severe drought would become more common, the extended La Nina drought experienced in south Louisiana during 1998-2000 provides an example of the kinds of consequences that could be experienced: reduced production of agricultural crops, the "brown marsh" phenomenon witnessed in the coastal wetlands; and reduced crawfish production. On the other hand, most climate models predict increased precipitation and runoff in the northern and eastern portions of the Mississippi Basin, as well as the increased importance of extreme rainfall events. Already flood peaks have become higher as a result of artificial drainage and constriction of the Mississippi flood plain. On top of this, climate change may pose even greater flooding risks downriver. Louisiana oceanographers have demonstrated that increased flow of the Mississippi, particularly in the spring and early summer, would increase both the delivery of nutrients and stratification of Gulf waters, thereby increasing the extent and intensity of hypoxia (the so called "dead zone") in the Gulf.

Forests and Fields

Climate models have been linked to plant succession models to project the potential changes in forest vegetation in the U.S. as a result of climate change. The most dramatic changes would be in the northern states, including the retreat to the north of forests dominated by maple, beech and birch and even the loss of the colorful sugar maples from New England. Joining many other plants and animals in the move north is the Baltimore Oriole—it's already extremely scare around my present home in the Free State now. In the southeast, including Louisiana, loblolly and shortleaf pine forests are projected to be converted to oak-pine forests. Forestry is a significant economic sector in Louisiana and it is mainly based on managed pine forests, which could become more vulnerable to drought and fire.

The National Assessment estimated that crop production in the U.S. as a whole would actually increase under warmer climate scenarios during the 21st century, but there would be regional winners and losers, with agricultural production increasing in the Midwest and Plains states and possibly decreasing in the Southeast. The assessment projected that conditions for corn and soybean production in Louisiana would worsen without irrigation. The shortage of surface water resources or saline intrusion may also limit rice production.

Sea Level Rise, Hurricanes and the Future of South Louisiana

Some regions in the northern part of the U.S. or in Canada may see significant benefits of climate change in term of less severe winters and greater agricultural productivity. Although there has been little to be optimistic about in the hotter climate with more variable rainfall that seems to be in Louisiana's future, the most serious threats the state faces are probably along its low lying, fragile coasts. The coastal zone has already experienced rapid environmental change as a result of human activities, which have greatly altered the natural hydrology, both through preventing river inflows and canalizing wetlands. Rapid wetland loss has occurred because of the altered hydrology and the inability of wetlands to build up soil fast enough to keep pace with local sea-level rise. Salinity has supplies, and threatening population centers with stronger storm surges. And now, will they face a return to an era of rapid global sea-level rise such as experienced after glaciation?

To the approximately 12 to 19 inch rise in the level of the world's oceans likely to occur over this century, one must add an additional 8 to 31 inches of land subsidence depending on where one is along the Louisiana coast. So, the locally realized rise in sea level relative to some fixed feature on the land will probably be 20 to 48 inches. This will not mean that all of the interidal marsh land will be

submerged under 2-4 feet of water, however, because these marshes can, within limits, build up the soil with peat and mineral sediments to keep up with relative sea-level rise. Given the present debilitated nature of most of these coastal wetlands, the prospects of their survival are rather bleak without major human intervention to restore them and provide large quantities of riverine sediments to promote soil building.

While, in general, an increase in tropical cyclone peak wind intensities is expected on a warmer Earth, it is uncertain whether this will mean more or more violent hurricanes for the Louisiana coast. As mentioned before, any effects of climate change on the El Niño-La Niña cycle would be critical in this regard. Even if hurricanes do not intensify, the damages from coastal flooding and erosion will increase with sea-level rise.

Further loss of coastal wetlands, together with additional salt-water intrusion, would impair the high fisheries productivity of the estuarine ecosystem of coastal Louisiana. Higher sea levels, coupled with the diminished ability of wetlands to attenuate storm surges will present a severe test to flood protection levees in coastal communities ranging from bayouside villages to the city of New Orleans. Either the levees or houses will have to be raised or the communities abandoned. Some very difficult decisions will have to be made as to where to expend efforts and resources and which regions will have to be abandoned to the sea. Where there are warranted, large scale restoration projects, such as river diversions, will require relinquishing of private rights for the greater public good—the very survival of these coastal regions.

The crisis of the Louisiana coastal zone has been well recognized by the public and in government for over 20 years now. Still relatively little has been done strategically to protect coastal regions, much less reverse wetland loss trends. If another 20 years goes by before major action is taken, I fear that we will be simply overtaken by events and our options narrowed ever more if not eliminated.

What Can Louisiana Do?

I sometimes think that future generations of Louisianians will condemn my generation and that of my parents for our gluttonous extraction of Louisiana's energy resources and careless stewardship of its delicate coastal fringe. After all, in just two generations we tore up the wetlands to extract oil and gas as fast as we could just so that we could burn it, thus contributing to global warming and accelerated sea-level rise, or make nitrogen fertilizer, much of which was washed back down the river creating an extensive "dead zone." But, for most of these two generations we really did not fully understand the ramifications of our actions. Now we do, so can we do something to reduce the burden of this awful legacy we have set in motion?

I think Louisiana can play a significant role in slowing down climate change and should be aggressively filling this role—after all it has a lot more to lose than most regions of the U.S., so it should be a leader in climate change abatement. There are many things that we will all have to do to become more energy-efficient and reduce greenhouse gas emissions. A number of these are discussed in the *Danger and Opportunity* report submitted to the Louisiana Legislature a few years ago. Here are my three suggestions of particular relevance to Louisiana:

1. Substantially reduce industrial greenhouse gas emissions. Louisiana makes a disproportionately large contribution to U.S. greenhouse gas emissions on a per capita basis because of large emissions from industry. Energy and chemical manufacturing companies such as BP and DuPont have been able to meet or exceed reduction targets for greenhouse gas emissions and save money in the process. With so much to lose, Louisiana industries should be in the vanguard of this new industrial revolution.

2. Use the state's abundant natural gas as a key resource in the transitional energy economy. Not only does natural gas release half as much CO_2 per energy production unit as coal or gas, but it is also the bridge to the hydrogen economy, as it will be used as the principal source of hydrogen for fuel cells.

3. Manage the environment to enhance carbon sequestration and minimize N_2O and CH_4 fluxes to the atmosphere. The warm, wet climate of Louisiana provides opportunities to integrate reduction in greenhouse gas emissions with other environmental management goals. For example, expanding Mississippi River flood plains would reduce flooding risks while increasing excessive fertilizer use in the Midwest would not only help alleviate hypoxia in the Gulf, but also reduce the emissions of N_2O during eventual denitrification.

Internet Resources and Downloadable Reports

- Intergovernmental Panel on Climate Change: downloadable Summaries for Policymakers and Technical Summaries for The Third Assessment Report, *Climate Change 2001* http://www.ipcc.ch/
- U.S. National Assessment of the Consequences of Climate Variabiltiy and Change: http://www.usgcrp.gov/usgcrp/nacc/default.htm
    - *Climate Change Impacts on the United States: The Potential Consequences of Climate Variablity and Change Overview* http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overview.htm
- U.S. Global Climate Change Research Program http://www.usgcrp.gov/

    - *Our Changing Planet: The FY 2002 U.S. Global Change Research Program* http://www.gcrio.org/ocp2002/
- Pew Center on Global Climate Change http://www.pewclimate.org/ has published a number of reports on environmental effects, solutions, economics and policy
    - Sea-level rise & global climate change: a review of impacts on U.S. coasts http://www.pewclimate.org/projects/env_sealevel.cfm
    - The science of climate change: global and U.S. perspectives http://www.pewclimate.org/projects/env_science.cfm
    - Aquatic ecosystem and global climate change (co-authored by LSU scientists John W. Day, Jr.) http://www.pewclimate.org/projects/aquatic.cfm
    - Facts and figures chapter of *Climate Change: Science, Strategies, and Solutions* (co-edited by Louisiana native Vicki Arroyo-Cochran, Director of Policy Analysis at the Pew Center) http://www.pewclimate.org/book/index_chapter.cfm
- Union of Concerned Scientists http://www.ucsusa.org/index.html
    - *Confronting Climate Change in the Gulf Coast Region: Prospects for Sustaining our Ecological Heritage* (report by group of scientists led by Robert Twilley of the University of Louisiana, Lafayette, and including Denise Reed of University of New Orleans) http://www.ucsaction.org/downloads/gulf_coast.pdf
    - Louisiana Summary http://www.ucsusa.gov/environment/Louisiana.pdf
    - Louisiana Teacher's Supplement http://www.ucsusa.org/enviroment/la_supplement.pdf
- *Danger and Opportunity: Implications for Climate Change for Louisiana* (report for the Louisiana State Legislature) http://www.goca.state.la.us/crcl.html
- *Coast 2050: Toward a Sustainable Coastal Louisiana* http://www.coast2050.gov/reports.htm

About the Author

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