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GLOBAL CHANGE

Roads, Ports, Rails Aren't Ready for Changing Climate, Says Report

A federal study released this month documents the significant impact that climate change is expected to have on the U.S. transportation system. Its conclusion, says Henry Schwartz, the former head of one of the country's largest highway engineering firms, is "a pretty damning tale of what could happen."

The 3-year effort, led by the U.S. Department of Transportation and including outside experts as well as climate scientists, focused on a roughly 80-km-wide strip along the Gulf Coast region from Mobile, Alabama, to Houston, Texas, that is home to 10 million people (climatescience.gov/Library/sap/sap4-7/final-report/). It found an expected sea-level rise of 122 centimeters over the next 50 to 100 years—an estimate reflecting the midrange of previous global forecasts that was tweaked to factor in as much as 81 cm in subsidence in some areas—would permanently flood nearly a third of the region's major roads. Some 72% of ports in the region would be at risk, the report concludes, and a majority of roads and 29 airports would likely experience major flooding during major storms. In addition, the report says that a temperature rise of between 0.5° and 2.5°C would cause railroad lines to buckle, require more sturdy driving surfaces, and boost the cost of road maintenance by increasing the strain on repair crews.

Scientists say the study is the most rigorous effort thus far to quantify how climate change could impact vulnerable U.S. infrastructure at the local level. "Transportation professionals ... by and large haven't looked very seriously at global warming," says Schwartz, a former president of engineering giant Sverdrup Civil (now Jacobs Engineering Group in Pasadena, California). Schwartz is also chair of a panel of the U.S. National Academies' National Research Council (NRC) that has tackled the same issue on a national scale. Its report, released last week, calls for similar partnerships between climate scientists and transportation planners in other regions (nap.edu/catalog/12179.html).

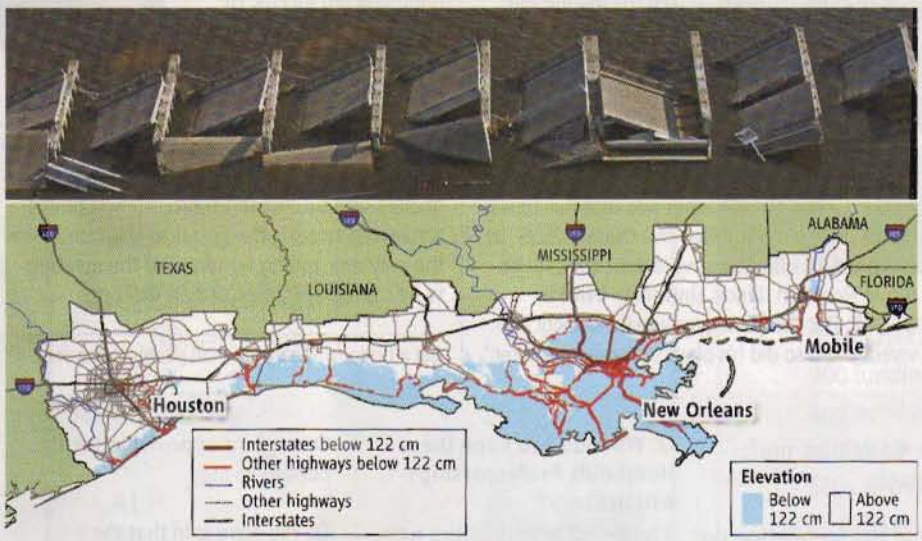
The Gulf Coast study examined how the region's climate might change over the expected life of major transportation facilities, a period that extends for the next half-century and beyond. The panel extracted data from 21 global climate models that project a temperature increase for the region of from 1° to 2°C by 2050. Researchers also took into account geologic data, global forecasts on sea-level rise, and ground subsidence of as much as 0.8 cm per year. Transportation planners then overlaid the forecasts onto thousands of kilometers of roads, ports, railways, and airports.

The results point to a looming disaster. "Based on these levels, an untenable portion of the region's road, rail, and port network is at risk of permanent flooding," the federal report says. Hurricanes and the rising ocean are already destroying barrier islands, which blunt the coastal impact of incoming storms. The Gulf Coast study also calls for more drainage and alternative traffic-handling schemes to cope with increasingly severe rain storms, as well as better evacuation routes for hurricanes expected to grow more intense.

The two reports acknowledge their limitations. The federal study admits that its precipitation projections are open to question and that more rapid polar melting could wreak greater havoc on transportation systems. To address such gaps in the research, the NRC study called for more regional climate studies, short-term prediction tools to foresee disruptions such as storm-flooded roads, and more help from the federal government to local planners trying to batten down the hatches.

Both reports recommend new approaches to infrastructure investments. In the past, says Schwartz, engineers decided how high to make a highway overpass or how deep to make a drainage ditch by using "some preset design standards" based on historic variations in rainfall, temperature, and other climate variables. The changing climate patterns now require planners to devise a standard for each project based on the probability of more severe weather events. Additional federal studies are expected to focus on how climate change would affect a particular Gulf Coast facility, be it a port, highway, or coastal city.

Alan Clark, a transportation planner for the greater Houston, Texas, area who participated in the study, plans to take shifting climate patterns into consideration in ▶



Road hazards. New study (*above*) shows what a 122-cm rise in sea level would do to the Gulf Coast's major roads, already vulnerable to major storms such as Hurricane Katrina in 2005 (*top*).

CREDITS (TOP TO BOTTOM): M. SPENCER GREEN/AP PHOTO; (SOURCE) CAMBRIDGE SYSTEMATICS ANALYSIS OF U.S. DOT DATA

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preparing a development plan for the Houston-Galveston area. In particular, says Clark, climate change should be factored into decisions on whether to build a proposed second bridge connecting the rapidly growing Galveston Island to the mainland. Aside from the usual factors such as cost, environmental impact, and the population to be served, Clark notes, officials also need to think about whether continued coastal development is prudent in the face of rising sea levels and worsening storms. "The real question is whether we should be going down this route at all," he says.

Transportation managers in several southern and western states say they would like to undertake similar studies of their regions but that money is an obstacle. John Zamurs of the New York State Department of Transportation, who advised on the Gulf Coast effort and has tried to launch an equivalent effort for his state, says, "We're still struggling to find the funding."

Putting the issue off would be a mistake, says Schwartz. The Missouri-based Sverdrup Civil he once headed has built billions of dollars' worth of water, highway, rail, and bridge projects across the country. But he says that the challenges to infrastructure will be more complex and the costs greater as both the seas and the mercury rise. **–ELI KINTISCH**

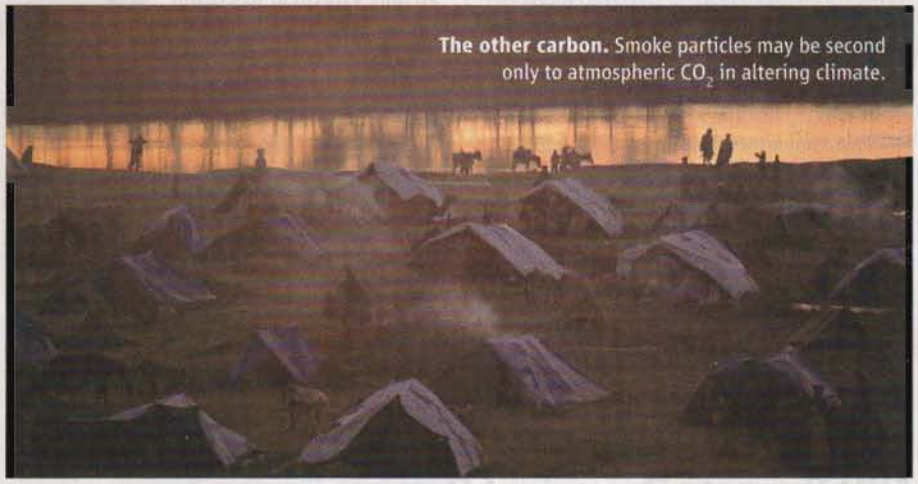
CLIMATE CHANGE

Study Fingers Soot as a Major Player in Global Warming

Climate-change authorities long ago tagged carbon dioxide public enemy number one. Now, there may be a new number two: tiny particles of black carbon, or soot. According to a new analysis reported online this week in *Nature Geoscience*, climate scientists are concluding that reports such as last November's assessment by the Intergovernmental Panel on Climate Change (IPCC) may seriously underestimate black carbon's role in global warming. The good news is that—unlike reductions in greenhouse gas emissions—reducing the release of large amounts of black carbon worldwide would have immediate effects.

Although the error bars on the new measurement are large, "the effects of black carbon are definitely stronger than what the IPCC estimates," says Mark Jacobson, an atmospheric scientist at Stanford University in Palo Alto, California, who was not involved in the study.

The IPCC report noted that black carbon is a strong absorber of sunlight but downplayed its impact because the haze it produces occurs regionally rather than globally. IPCC estimated that, at current levels, black carbon warms the atmosphere by 0.2 to 0.4 watts per square meter ($W\ m^{-2}$), considerably below the value of 1.66 $W\ m^{-2}$ for CO_2. But in their new analysis of a wide variety of recent data, Veerabhadran Ramanathan of the Scripps Institution of Oceanography in San Diego, California, and Gregory Carmichael of the University of Iowa in Iowa City suggest that black carbon warms the atmosphere by as much as 0.9 $W\ m^{-2}$—enough to vault it over the impact of other climate-warming gases such as methane, halocarbons, and tropospheric ozone.



The other carbon. Smoke particles may be second only to atmospheric CO_2 in altering climate.

CREDIT: REZA/WEBISTAN/CORBIS

Black carbon comes from sources as diverse as the burning of grasslands in Africa and the rainforest in Brazil, diesel emissions from trucks in North America, cooking fires burning coal in China, and cow dung in India. The soot wafts high into the atmosphere, often in thick brown clouds that block some sunlight and absorb significant solar radiation.

Ramanathan says previous conservative estimates of black carbon's warming effect overlooked key factors—most importantly, the interaction between black carbon and other particles in the atmosphere. "Black carbon doesn't exist by itself," says Ramanathan. "It's always mixed with other aerosols," such as sulfate particles, and other organic combustion byproducts. Many of those other aerosols reflect light, increasing the chances that it will be absorbed by nearby flecks of soot. Black carbon high in the atmosphere also absorbs light reflected by Earth's surface and clouds. Because most climate models don't adequately represent such effects, they often underestimate how much reflected light soot absorbs, Ramanathan says.

If studies by Ramanathan and others turn out to be right, that's both good and bad news for policymakers. On the downside, the plethora of sources of black carbon will make it hard to cut emissions. On the other hand, the particles circulate in the atmosphere for only about a week before falling back to Earth. So concerted efforts to reduce biomass burning in the Amazon, cut diesel emissions, or convert cooking stoves to biogas or even solar power could have a powerful impact far more quickly than changes in CO_2 emissions.

Public health researchers have long sought to curb black carbon because inhalation of smoke from wood fires is thought to contribute to as many as 400,000 deaths a year in India alone. Now, Jacobson says, climate change research "underscores the need to control black carbon even more." **–ROBERT F. SERVICE**