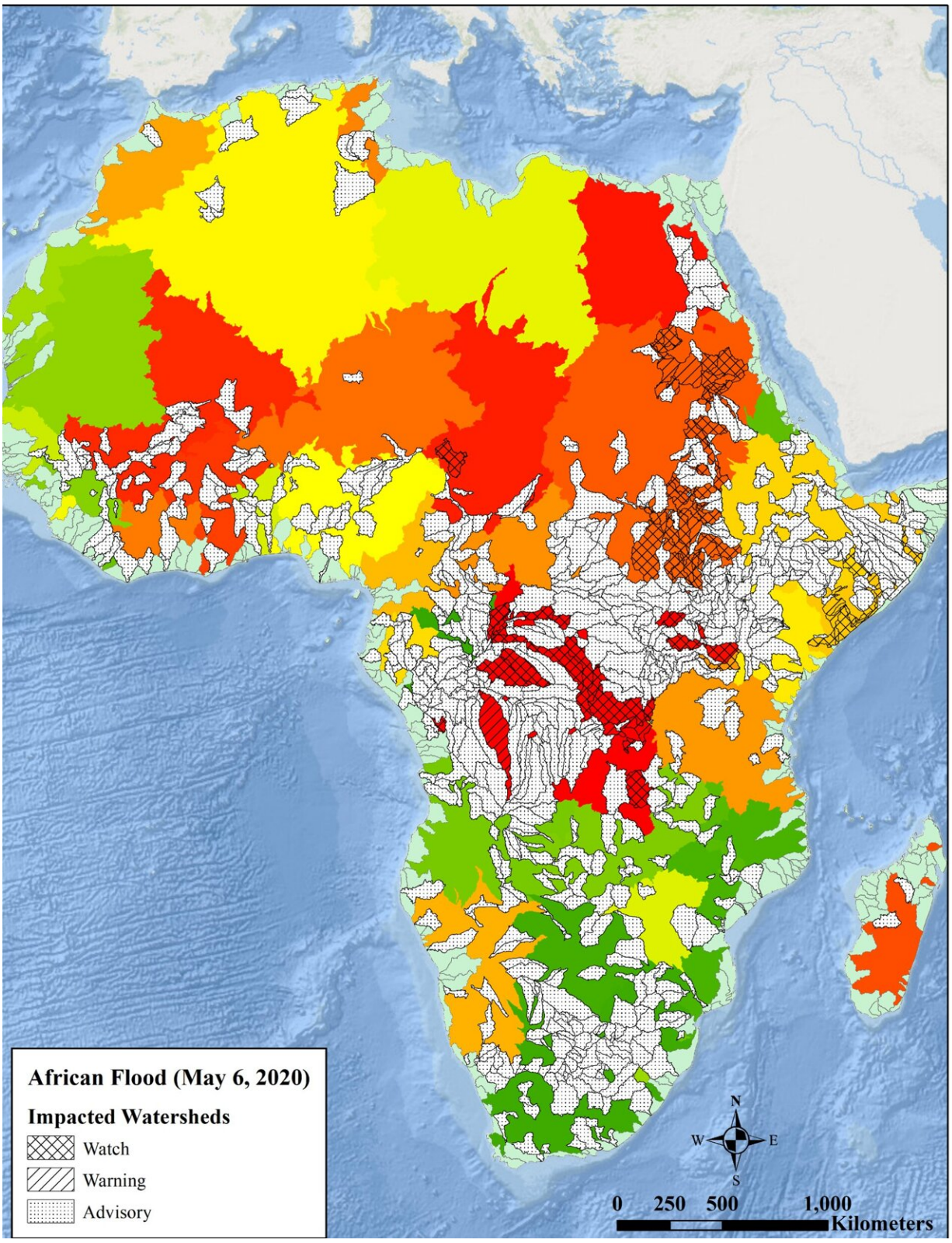
Researchers anticipate, help prevent national security consequences of climate crises

November 18 2021, by Elizabeth Rosenthal



Output from the Model of Models (an ensemble model) trained on near real-time

hydrological model and earth observation output revealed which regions in Africa were most likely to face severe flooding in 2020. Credit: NASA and Pacific Disaster Center

Using novel data sets and computing systems, researchers at the Department of Energy's Oak Ridge National Laboratory are simulating how climate change affects the safety and security of the country. This research can help policy and decision makers at federal, state and local levels quickly identify risk factors and develop real-world mitigation strategies.

For more than two decades, ORNL scientists have modeled environmental factors, such as temperature and precipitation, and population distribution. Currently, researchers are studying how climate change affects population density, critical infrastructure and security to better understand how extreme climate events can threaten physical safety and set off a domino effect of economic ramifications and other national security challenges.

In some cases, rising temperatures that reduce agricultural opportunities can lead to mass migrations away from struggling communities. In other cases, violent hurricanes and winter storms can disrupt electric grid operations, interrupting access to electricity and other utilities long after the initial climate threat has passed.

"We're interested in contextualizing the tangible consequences that phenomena like sea level rise and temperature and precipitation changes have on humans," said Carter Christopher, who leads ORNL's Human Dynamics Section in the National Security Sciences Directorate. "Human security is a function of the security and resilience of a community, whether that's a rural county, a small town or a major city,

domestically or internationally."

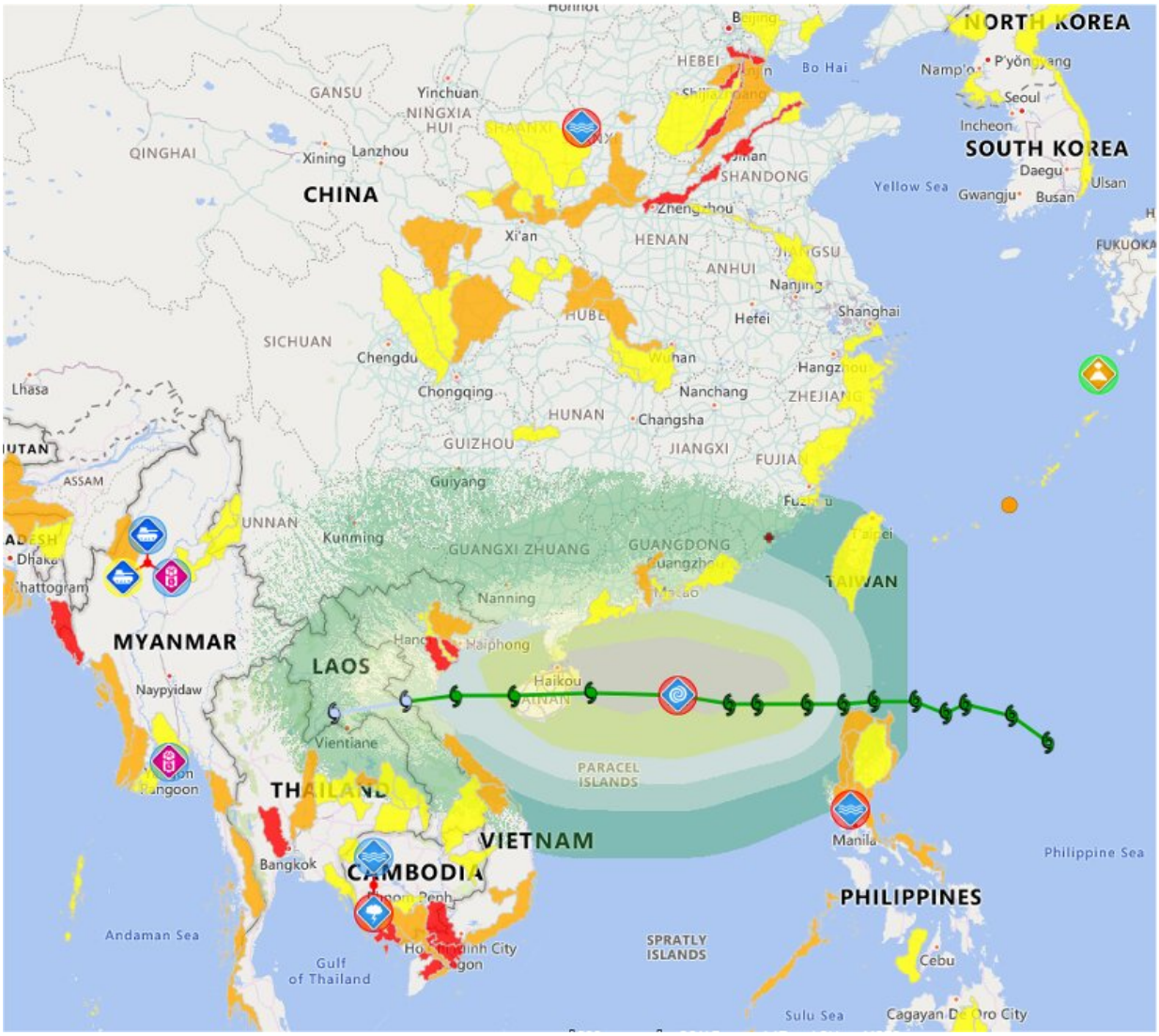
Researchers in the National Security Sciences Directorate and across the laboratory are studying the relationship between climate change and national security from multiple perspectives—yielding important results that decision makers can use to strategize how best to protect people before they end up in dangerous situations.

Modeling population at unprecedented scale

Bandana Kar, who leads ORNL's Built Environment Characterization, or BEC, Group, focuses on examining and forecasting the risk and resilience of the nation's critical infrastructure systems and cities. Using geographic information science concepts and technologies including satellite remote sensing, geospatial modeling and data sets, and computational science, Kar's team assesses and identifies the risk factors present in communities and cities, as well as access to resources such as energy in those areas, which is crucial for resiliency and disaster recovery.

Because the nation's critical infrastructure systems are interconnected, seemingly unrelated concerns, such as increased shipping costs and limited supplies of gasoline or other fuel sources, could affect supply chains and the communities that rely on them.

Having access to geospatial datasets and situational awareness information before disaster strikes enables emergency managers to plan evacuations or other mitigation measures as necessary. The BEC group generates critical infrastructure datasets and develops models and algorithms tailored to specific communities and scenarios to help forecast climate impacts and prevent economic losses, as well as injuries and fatalities.



The Global Flood Modeling and Alerting project provides insights into the areas of Asia that may need to prepare for disruptive floods in 2021, with risk levels ranging from an advisory (yellow) to a watch (orange) to a warning (red). Credit: NASA and Pacific Disaster Center

Scientists in ORNL's Human Geography Group apply geographic data science and computational methods to better understand the distribution and dynamics of populations around the world. Historical and current

population trends based on demographic distributions and behavior related to human mobility during daytime and nighttime hours provide a baseline for communities at risk of facing environmental hazards.

"The Human Geography Group is uniquely positioned to address global human security through our scalable population modeling and research to expose current and future inequities and vulnerabilities across the human landscape," said Group Leader Marie Urban. "Our goal is to continue leading population dynamics research, not only in support of DOE's national security mission, but also in support of the humanitarian community, policy makers and stakeholders in development of a more sustainable future."

ORNL's LandScan population modeling program, which is funded by the National Geospatial-Intelligence Agency, builds on U.S. Census data to provide a more granular picture of populations in residential areas, office buildings, schools and other common commuter destinations. LandScan researchers develop algorithms to evaluate population movements based on daily schedules, as well as long-term migration patterns.

These algorithms model human activity, accounting for different sociocultural, economic and demographic factors around the world that influence where people are located throughout the course of a day. The various patterns throughout the landscape, particularly changes that occur between daytime and nighttime, are captured in LandScan to provide a better understanding of population distributions. Analyzing these routines helps researchers study how unwarned populations at home, at work, in the classroom and elsewhere in a given city would fare against sudden security threats caused by the rapid onset of a climate disaster.

"LandScan was designed to help governments and scientists plan ahead

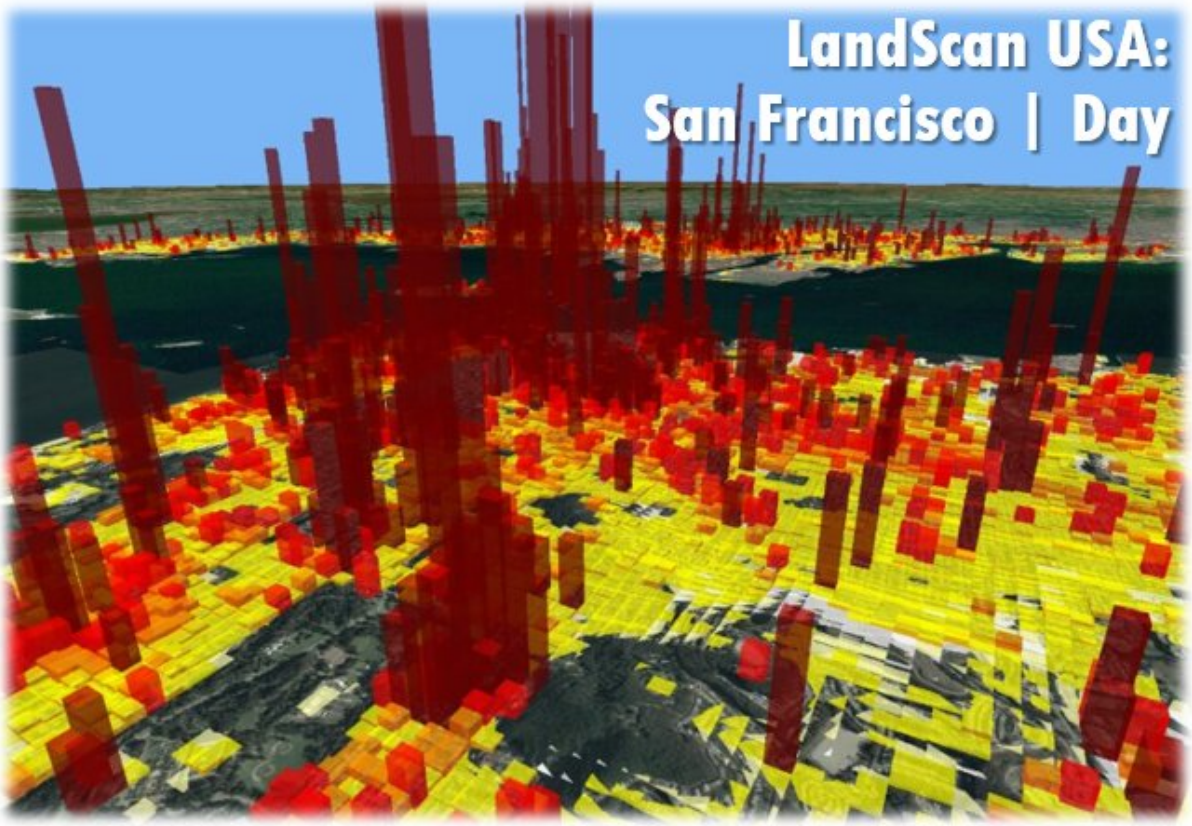
and study the potential impacts of natural disasters—such as hurricanes, tsunamis, earthquakes and landslides—and technological disasters, such as oil spills," said LandScan Program Director Amy Rose. "For example, some of our federal users integrate LandScan data sets with hurricane tracks and forecasts, as well as other critical infrastructure data, to provide policy makers with estimates of how the hurricane will affect the residential population and economy of a community."

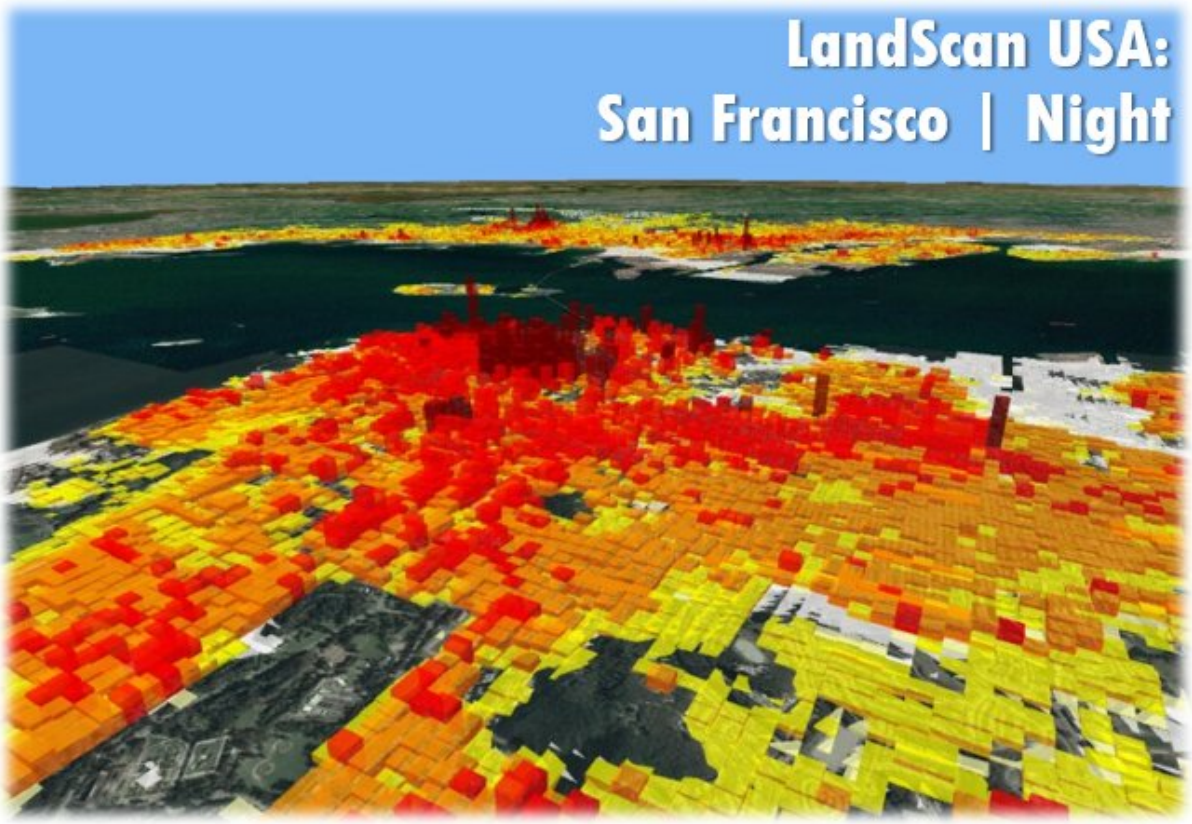
The LandScan team also examines how rising sea levels and other phenomena are likely to alter city growth and coastal topology in the long term.

Building toward energy and environmental justice

Using the UrbanPop framework, researcher Joe Tuccillo develops high-resolution recreations of the social makeup of Census block groups containing 600–3,000 people. This data can help proponents of energy and climate justice identify neighborhoods and communities that may lack access to clean energy sources or be disproportionately harmed by natural disasters and other environmental and national security consequences of climate change over time.

UrbanPop, which has received funding through ORNL's Laboratory Directed Research and Development program and DOE's National Virtual Biotechnology Laboratory, uses sample survey responses provided by the U.S. Census Bureau's American Community Survey to estimate the composition of these groups. This data enables researchers to study the general demographic characteristics and behavioral trends of people in different geographic areas—information that can be used to assess a group's risk and preparedness for climate-related threats—while preserving the privacy of individual respondents.


LandScan USA:
San Francisco | Day


LandScan USA:
San Francisco | Night

Through LandScan, ORNL researchers are using nighttime residential population distribution as a baseline to determine how many people are located at workplaces, schools, public spaces and at home during daytime hours. Credit: Eric Weber/ORNL, U.S. Dept. of Energy

The goal is to create aggregate representations of what communities are like in terms of individual demographics and behavior, which provide insights into collective activity patterns," Tuccillo said.

Research scientist Christa Brelsford focuses on human-environment interactions from another angle. She models how the location and arrangement of buildings in the year 2050 will affect environmental factors such as temperature, humidity and wind speed worldwide.

She is particularly interested in learning how these changes might influence daily life, especially for communities located in economically and physically disadvantaged areas that may be more susceptible to flooding, air pollution and other environmental hazards.

"It's important for us to consider that the worst implications of all these adverse climate effects are most likely to be felt by the people who are already the most vulnerable," Brelsford said.

In addition to developing new integrated modeling frameworks, Brelsford is examining existing population projections to determine the environmental footprint of major cities more than 30 years from now.

The expected influx of millions of new residents into cities around the world will have numerous consequences, including significant changes to each location's "microclimate." These small-scale but potentially

devastating phenomena could include heatwaves and urban heat islands, which occur when cities endure higher temperatures than the surrounding areas because of the prevalence of manufactured structures that absorb more heat than natural surfaces.

Through these research efforts, Christopher, Kar, Urban, Rose, Tuccillo, Brelsford and many others across ORNL aim to provide leaders at every level with the data and information they need to mitigate environmental threats and make informed national security decisions, both domestically and abroad.

More information: For more information, visit energy.gov/science

Provided by Oak Ridge National Laboratory