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GEOINT HOLDS PROMISE FOR UNDERSTANDING CLIMATE

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CHANGE THROUGH THE LENS OF NATIONAL SECURITY.

On a sunny afternoon in May, President Barack Obama stood before a class of U.S. Coast Guard graduates and unequivocally made the case for climate change as a national security issue.

"I'm here today to say that climate change constitutes a serious threat to global security, an immediate risk to our national security, and make no mistake, it will impact how our military defends our country," he said.

The same day, the White House released a new report, "The National Security Implications of a Changing Climate," which chronicles the national security implications of climate change and stresses that its impacts increase the "frequency, scale, and complexity of future defense missions."

For days, the Internet was abuzz with reactions. Some applauded President Obama's strategy; some questioned whether national security is the best lens through which to frame climate change. In short order, headlines returned to crises that demanded immediate attention: torrential downpours in Texas, record-breaking heat in Alaska, drought in California, a deadly heat wave in India.

In his speech, President Obama said terrorist group Boko Haram exploited the instability partially created by severe drought in Nigeria, and that drought and crop failures helped fuel the early unrest in Syria. Regardless of the causes of climate change, the U.S. now faces increasingly volatile environmental conditions on American soil as well as in politically fragile parts of the world that can't be ignored. The resounding call is to arm our defense, intelligence, and homeland security communities with environmental intelligence in order to better anticipate climate-related security threats.

The GEOINT Community plays a critical role in leading the effort to better understand climate change and mitigate damage. From imaging and measuring the Earth to mapping environmental and human risks, GEOINT can provide increasingly accurate and timely information about a changing planet to yield better decision-making.

Yet there are many uncertainties: How can the dots be better connected with current data? How can warnings be improved? What is the best way to graphically represent the second and third order national security effects such as changes to growing seasons and water security? How is a changing climate tied to extreme weather events?

"The question that many policymakers have is, when an extreme event happens, can it be scientifically tied to the fact that we've changed the climate?" said Rear Adm. (ret.) David Titley professor of practice at Pennsylvania State University's Department of Meteorology and director of the Center for Solutions to Weather and Climate Risk. "For millennia we've had storms and droughts, but the data shows that we're having more severe heat waves. When it rains, it rains harder." Connecting these events with climate change, he said, requires adequate monitoring. "Having long-term time series is very important. "If you can do that long enough, the signal comes out of the noise."

Retired Air Force Maj. Gen. Richard Engel, director of the National Intelligence Council's (NIC) Environment and Natural Resources Program, said he's not surprised certain weather phenomena, such as an increase in the number of extreme weather events, are occurring as a result of climate change; however, the rate at which this is happening is disconcerting.

"If these really are fundamental changes we're seeing, and not just the normal statistical variation in weather," he said, "we're in for one whale of a rough ride."

A 2013 Harvard report, "Climate Extremes: Recent Trends with Implications for National Security" details the security risks of extreme weather and climate change, finding that higher temperatures, stronger tropical cyclones, wider areas of drought, increased precipitation, Arctic warming, and continued sea level rise will affect water and food availability, energy decisions, and the design of critical infrastructure. The report stressed the U.S. government is not prepared for the "new climate normal" and must better observe key indicators, monitor unfolding events, and forewarn of impending security threats.

The biggest environmental threats to national security are threefold: changes in the Arctic, sea level rise, and extreme weather, which includes dangerous heat, drought, and flooding.

STATE DEPARTMENT PHOTO/PUBLIC DOMAIN

EXPERTS BELIEVE CLIMATE CHANGE can lead to political unrest and civil wars. In July 2013, the Za'atari refugee camp in Jordan had grown to the country's fourth largest city in the aftermath of the Syrian Civil War.

WHEN WEATHER FUELS THE FIRE

The United Nations Intergovernmental Panel on Climate Change (IPCC) projects sea level could increase up to 23 inches this century. Satellite data collected over a 23-year period beginning with the TOPEX/Poseidon launch in 1992 shows a steady global sea level rise of about three millimeters per year, nearly 50 percent faster than the rate in the previous century.

Although the Arctic is changing faster than anywhere else on Earth thus far, nations have been working together

to keep the region peaceful. Russia and the U.S., for example, recently agreed to regulate trawling in newly melted waters. However, rising temperatures and melting permafrost means reduced military vehicle access, degraded infrastructure, and uncharted waters for commercial activity. Most significantly, the melting Arctic is a major factor in sea level rise around the globe.

Sea level rise has led to more frequent "nuisance flooding"—whether at the Tidal Basin a mile south of the White House or in the streets of Miami—but the potential for greater flooding has prompted the U.S. Navy to carefully examine its coastal bases in conjunction with geospatial data such as tidal gauges and LiDAR to ensure the service is prepared for long-term operations.

Bordering India's east coast, Bangladesh—a country the size of Iowa with a population of 157 million—is often cited in sea-level rise scenarios. As heights increase, millions of people will be dislocated from the country's coastal flood plains. A flood may drive the people of Bangladesh to move into areas or across borders where they're not wanted, causing food and water shortages, or worse—violence.

Christine Parthemore, a senior research and policy fellow at the Center for Climate and Security, who previously worked at the Department of Defense (DoD) and teaches a class on climate change and national security at Johns Hopkins University, said her biggest worry is we're too focused on the Arctic, where it's easy to see ice melting. According to her, the most serious geopolitical hotspots lie between 20 degrees north and south of the equator.

"We need to look at North Africa and a lot of places in Southeast Asia that are both important to U.S. security interests and strategy," she said. "I think climate change is going to wreak havoc in these parts of the world, and we have the knowledge to put these pieces together and mitigate the potential security risks."

The unknown destabilizing potential of extreme weather is what defense experts are calling a "threat multiplier"—weather events are not causing wars, infectious disease, or terrorism, but they are a contributing factor.

Marc Levy, deputy director of Columbia University's Center for International Earth Science Information Network and an author of the IPCC report, said he's never seen anything more serious in security terms than climate change. Levy added it's easy to imagine how a political hotspot layered with a climate hotspot could result in disaster, citing examples of regions where preexisting grievances coupled with an unprecedented drought or flood has led to unrest.

The Syrian Civil War is the latest candidate for what Levy calls a "climate war," given the unprecedented, widespread drought, massive relocation, and violence, leading to 3.3 million refugees and a death toll of 220,000.

"I think the easiest thing the Pentagon deals with is the operations stuff—trucking in water because local supplies have run out," Levy said. "Harder to handle are the effects from a climate shock that trigger a breakdown of order—political events like the Arab Spring, a severe food crisis, or refugee camps in Europe with people crossing the Mediterranean."

FROM THEORY TO APPLICATION

In addition to the IPCC and White House reports, the climate change-national security connection is the subject of numerous reports from a number of organizations, including the NIC, G7, National Research Council (NRC), and CNA Military Advisory Board. Climate change has also been addressed in the DoD's Quadrennial Defense Review and the Director of National Intelligence's Worldwide Threat Assessment.

While the DoD and Intelligence Community have said publically climate is a threat to be taken seriously, the question remains: What are they doing about it?

"It's one thing to mention in a report, another to take action," Levy said.

Lt. Gen. (ret.) Mike Flynn, former director of the Defense Intelligence Agency, said thinking about chronic, long-term threats such as climate change is difficult for Americans, versus threats in front of us today, such as extreme weather or ISIS.

For starters, the government needs a clear message and plan, and neither has

GEOINT & Forecasting

The defense and intelligence communities have an increasing need for the timeliest and most accurate information on cloud characterization, soil moisture, snow depth, cyclone intensity, and ocean winds.

Throughout history, weather information has been sourced from balloons, ships, airplanes, and radar. Today, satellites provide the backbone for global coverage and weather models, and the new generation of satellites will help us better understand storms and weather patterns. Their effectiveness depends on each satellite's orbit, instruments, and technologies, as well as the time lag between data capture and availability.

The National Oceanic and Atmospheric Administration (NOAA) operates two types of satellites: polar operational environmental satellites (POES), which fly 540 miles above Earth's surface and provide full global coverage and weather predictions for up to a week in the future; and geostationary operational environmental satellites (GOES), which remain stationary above the equator at an altitude of 22,300 miles and provide near-continuous observation of a fixed region. POES help predict the intensity and location of severe weather events several days in advance, such as in the case of the infamous "left hook" track of Hurricane Sandy.

NOAA is working with NASA to develop the next generation of POES, called the Joint Polar Satellite System (JPSS), which is planned for

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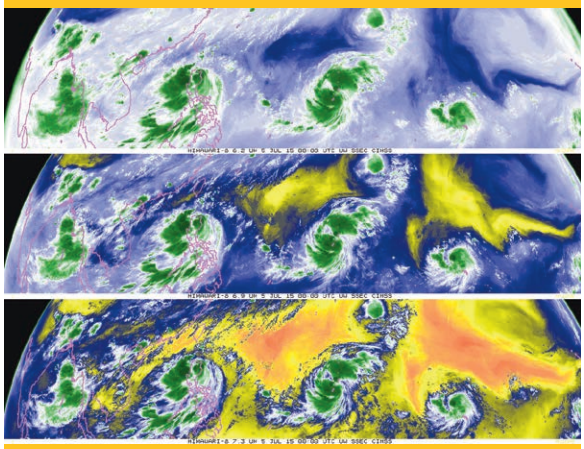

THE IMAGES ABOVE show two days of water vapor imagery from Himawari-8 over the tropical Pacific, revealing a train of three tropical cyclones moving westward toward Asia.

IMAGE COURTESY OF HARRIS

launch in 2017. Offering full global coverage twice a day, the system will increase timeliness and accuracy of public warnings. JPSS includes a Cross-track Infrared Sounder to measure atmospheric temperature and water vapor, which will improve both short-term weather "nowcasting," long-term forecasting, and our understanding of major shifts like El Niño.

The GOES-R Series, also a collaboration between NOAA and NASA, is the next generation of geostationary systems. It is expected to launch in 2016 with Harris' Advanced Baseline Imager and Lockheed Martin's lightning mapper, both of which will provide more advanced imaging of environmental phenomena that directly affect public safety.

NASA's ISS-RapidScat, which launched in 2014 and sits outside the International Space Station, provides data about wind speed and direction over the ocean. The scatterometer plays a critical role in producing weather forecasts that inform ship deployments and rerouting. NASA's Soil Moisture Active Passive (SMAP) satellite was launched into a polar orbit this year and uses a radiometer and spinning antenna to measure the water in the top two inches of soil, offering high-resolution data for local weather forecasts, drought early warnings, and flood warnings. Further, SMAP provides operational benefits for DoD with its ability to assess terrain and ice characteristics as well as forecast dust and fog.

The U.S. also uses satellite data from other countries. For example, data from Japan's new Himawari-8 weather satellite may be factored into U.S. weather models.

However, not every country that shares weather information is a U.S. ally, and recent discussions have brought to the forefront the question of how much the U.S. should depend on certain nations for this data. As some satellites retire, specifically, Meteosat-7—a European satellite that provides Indian Ocean and Middle East coverage—the U.S. may find a gap in weather coverage in a critical area of the world.

been communicated well to Americans, Flynn said. Those having a hard time putting bread on the table need a "crystal clear explanation" as to why climate change matters.

"I don't think the Intelligence Community has done it well, I don't think the administration has done it well, I don't think the international community has done it well, and the presidential candidates aren't talking about it," Flynn said.

Muddying the White House's message, the CIA shut down Medea, its decades-old, off-and-on climate study program in May, just days after the administration released its "National Security Implications of a Changing Climate" report. The program had provided civilian scientists with environmental data collected by submarines and satellites to help study the connection between security and climate change.

Meanwhile, the U.S. Geological Survey's Civil Applications Committee (CAC) allows civilian agencies access to classified satellite imagery for non-military, non-classified purposes such as monitoring climate change. CAC activities include remote sensing applications such as monitoring sea ice, glaciers, and volcanoes; detecting and tracking wildfires; coordinating emergency response to natural disasters; and monitoring ecosystems.

The consensus among experts is a lack of information sharing and no central authority hinders analytic capabilities.

Rear Adm. Jonathan White, director of the Navy's Task Force on Climate Change, said the U.S. needs to better fuse and synchronize observations of what's happening at ground level with the ability to predict what is coming in terms of a changing climate.

For example, we can zoom into Google Maps to see a restaurant, but in the future, White said, could we pull up a map and see what a flash flood would do to the same block?

"Then we could start making decisions," White said. "That granularity is something we should be striving for. We're not there yet, but it starts with GEOINT."

The National Geospatial-Intelligence Agency (NGA) has taken a large step in this direction, recently awarding Arizona State University a $20 million, multi-year grant to fund the Foresight Initiative. The initiative examines how to anticipate and visualize global environmental change, specifically as it relates to national security.

Ted Cope, NGA's director for Basic and Applied Research, described climate change as a "wicked problem with no solution," but with a set of continual tradeoffs. For example, he described the tradeoff of increasing the amount of water released from a hydroelectric dam during an extended drought to sustain agricultural needs while diminishing the electrical production of the dam, which would cause widespread economic impacts. He said Foresight, when fully realized, will allow multi-discipline government experts, planners, and decision-makers to collectively "see projected outcomes of their decisions and policies" leveraging models, simulations, and supercomputer power to formulate mitigation and adaption strategies.

Cope said Foresight will also demonstrate how GEOINT can contribute authoritative data to serve as a credible "game board" to establish a foundation for launching anticipatory conjectures.

In June, NGA and the National Center for Atmospheric Research held a first of its kind Climate and Human Security–Geospatial Data and Mapping symposium at the University of Colorado at Boulder. The goal of the symposium was that it serve as a catalyst for a "broad community of purpose across the government," Cope said, "to explore how we collectively could get better synergy for tackling the complexities of climate change effects on national security-related issues." A conference paper published late this summer will capture the proceedings and recommended actions.

The European Space Agency (ESA) is taking steps to study climate change as well. Satellite data can be used to capture wavelengths of fluorescent light from vegetation and determine the level of photosynthetic activity in that vegetation. This practice has already been done using data from systems such as Japan's Greenhouse Gases Observing Satellite and Europe's Global Ozone Monitoring Experiment. However, ESA's Fluorescence Explorer (FLEX)

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satellite is expected to provide unprecedented capabilities in fluorescence observation and help scientists better understand the global carbon cycle, state of food security, and effects of climate change on crops. FLEX is a candidate for ESA's eighth Earth Explorer mission in competition with CarbonSat, which intends to study levels of carbon dioxide and methane in the atmosphere to understand how they are linked to climate change. ESA and the Earth observation community will select in September which mission will launch under Earth Explorer.

GAPS REMAIN

For the amount of scientific data we have on the world's changing climate, we still lack the ability to predict its effects, said Jim Baker, director of Forest and Land-Use Measurement for the Clinton Foundation. The ability to answer the queries of the Intelligence Community (How much will it rain? What will this volcano do?), he said, requires a stronger understanding of the atmosphere, as well as faster computers to crunch the data.

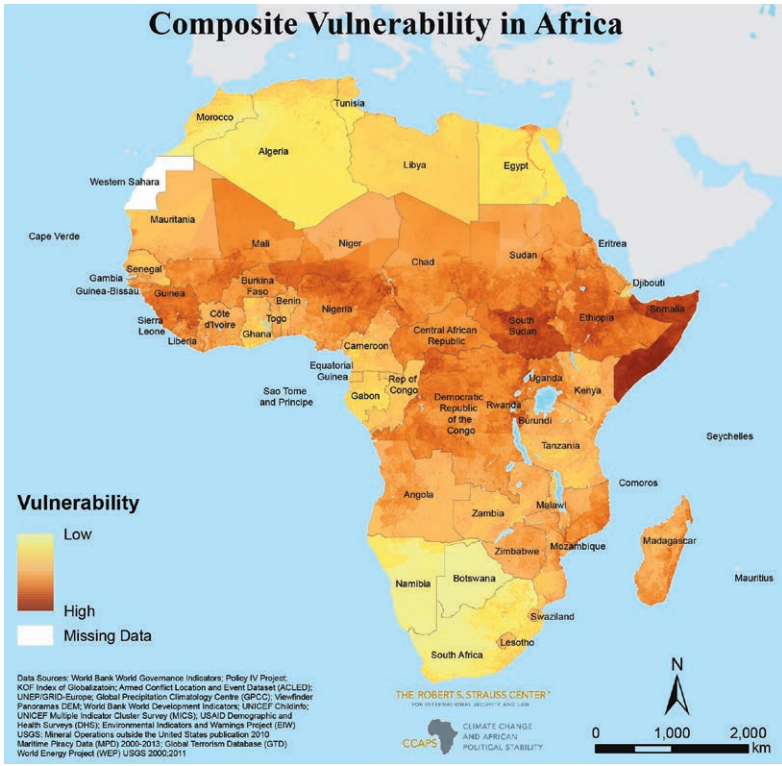
"We know the overall trends, but knowing when a drought or storm will start or end is very tough, and that's exactly what national security wants," Baker said. "If you have an area of conflict—Syria or Iraq—and there's a big change in climate there, do you know what the weather impacts are? Other than broad predictions, I'd say no."

Security experts say the only thing harder than predicting the climate is predicting human behavior. Climate change is largely a human geography problem, rather than one of physical geography. When a region is hit with a climate shock, one community may come together and become more resilient while the other deteriorates and becomes violent. How will any one population react?

Currently, the Intelligence Community addresses such questions by gathering multidisciplinary subject matter experts on a particular region, Engel said.

"If the climate scientists tell us in 2040 [a particular] country will experience [a predicted] kind of stress, you ask the experts, 'how will people

THIS COMPOSITE MAP factors four variables to determine climate change vulnerability: physical exposure, population density, household and community resilience, and governance.



react?'" he said. "In a part of the world that has high Internet connectivity and an existing grievance against the government, a stress from climate change may put people in the streets and result in social disruption, if not political disruption."

However, the Intelligence Community is working toward visualizing such intelligence. That's exactly what the Climate Change and African Political Stability Program (CCAPS) at the University of Texas at Austin's Robert S. Strauss Center is doing. Funded by DoD's Minerva Initiative, CCAPS' online tool enables policymakers to visualize data sets on climate change vulnerability, conflict, and aid in any combination over set time periods for any African country. The tool uses historic and real-time data to depict chronic hotspots and relative vulnerability levels, and is intended to be a point of departure for further dialogue.

With a $1.9 million grant from the Pentagon that began in September 2014, the center is developing a similar tool for South and Southeast Asia that is expected to be available next year. The center is also starting work on a Middle East mapping project to explore the nexus of water, energy, and human security. Finally, they're looking at adding the ability to explore different scenarios, i.e., if health care quality or sanitation were improved one percent, how would that change overall vulnerability? Ashley Moran, associate director of the center, said the idea is to create plug-and-play tools that can interface with existing DoD systems and allow decision-makers to explore intervention strategies.

The Air Force's 14th Weather Squadron is also exploring how to overlay maps with public health data that would be useful in better preparing for situations such as Haiti, where a devastating earthquake was followed by a hurricane and a cholera outbreak. In addition, the squadron is working on creating a global version of the U.S. Drought Monitor so the DoD and Intelligence Community can improve six-month outlooks. This would inform them when a country is 90 days from running out of water, and enable them to visualize reservoir levels and local unrest as a drought becomes imminent.

Levy said connecting the dots in these ways is more important than any one initiative. He noted that an NRC report, which recommended the Intelligence Community establish a system of periodic "stress testing" for countries to better manage potentially disruptive climate events, made an important suggestion, but the government hasn't yet acted on the recommendations.

The Intelligence Community wants to know how to determine risk, said Roger-Mark DeSouza, the Wilson Center's director of Population, Environmental Security and Resilience.

"How do you assign a value for risk that you can use for decision-making?" he said. "You try to be objective, but it's a little bit of an art. If there's a way to do that in terms of technology, it would be very compelling."

Cope said at NGA, the bigger challenge is not the technology, but rather educating a new generation to think about these multidimensional problems and to reason spatially, temporally, and contextually. He said the next level of capabilities would enable users to see connections and interdependencies as well as consequences of their decisions before they're made.

"How can we enable people to make these good resource decisions and help them visualize the outcome?" Cope said. "Having a keen grasp of the near present, having insights to connections, and observing that something has changed—that's what gives us that magic anticipatory power." ■

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— Ted Cope, director for Basic and Applied Research, NGA

IMAGE COURTESY OF THE UNIVERSITY OF TEXAS AT AUSTIN