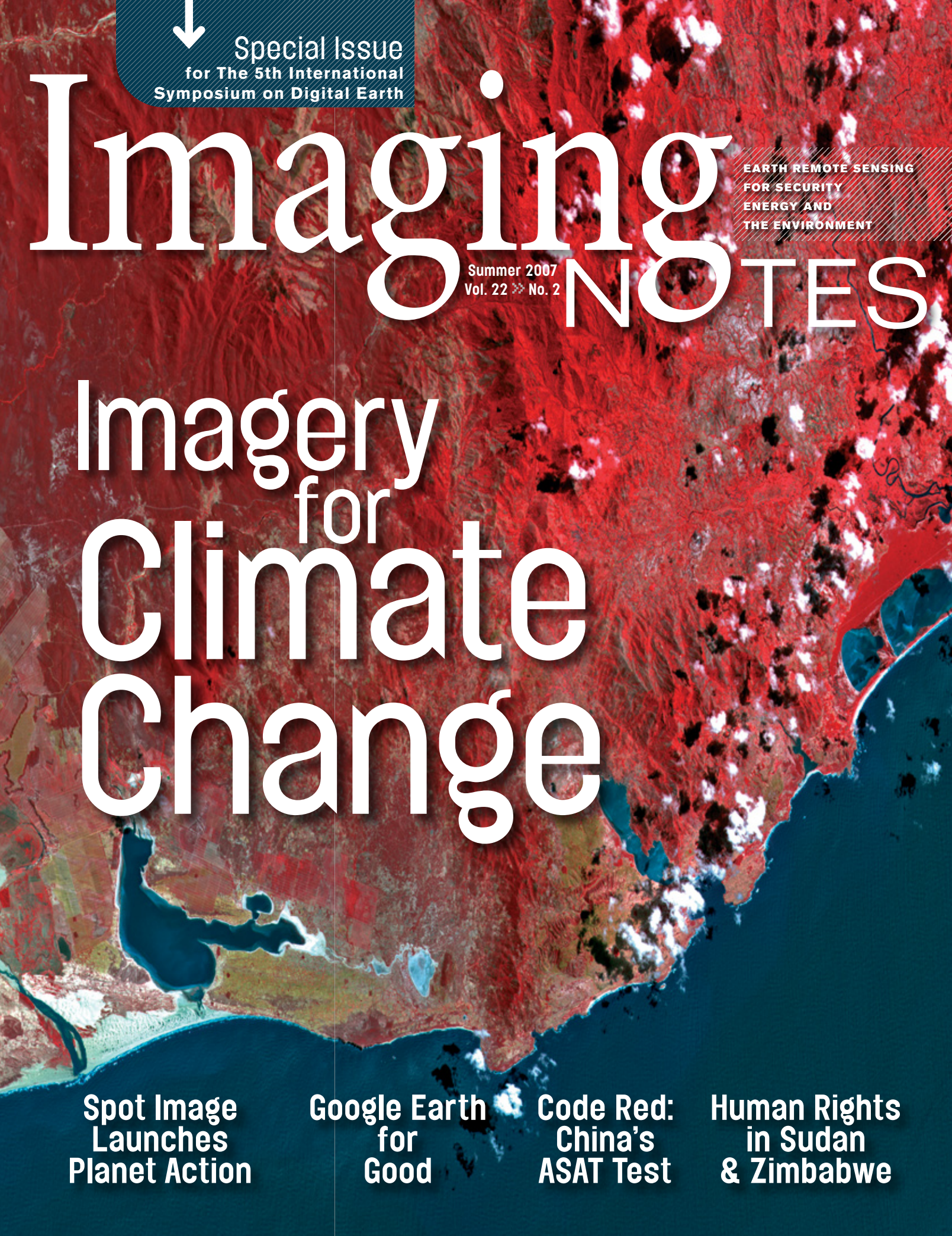


Special Issue
for The 5th International Symposium on Digital Earth

Imaging NOTES

EARTH REMOTE SENSING
FOR SECURITY
ENERGY AND
THE ENVIRONMENT

Summer 2007
Vol. 22 >> No. 2

Imagery for Climate Change

Spot Image Launches Planet Action

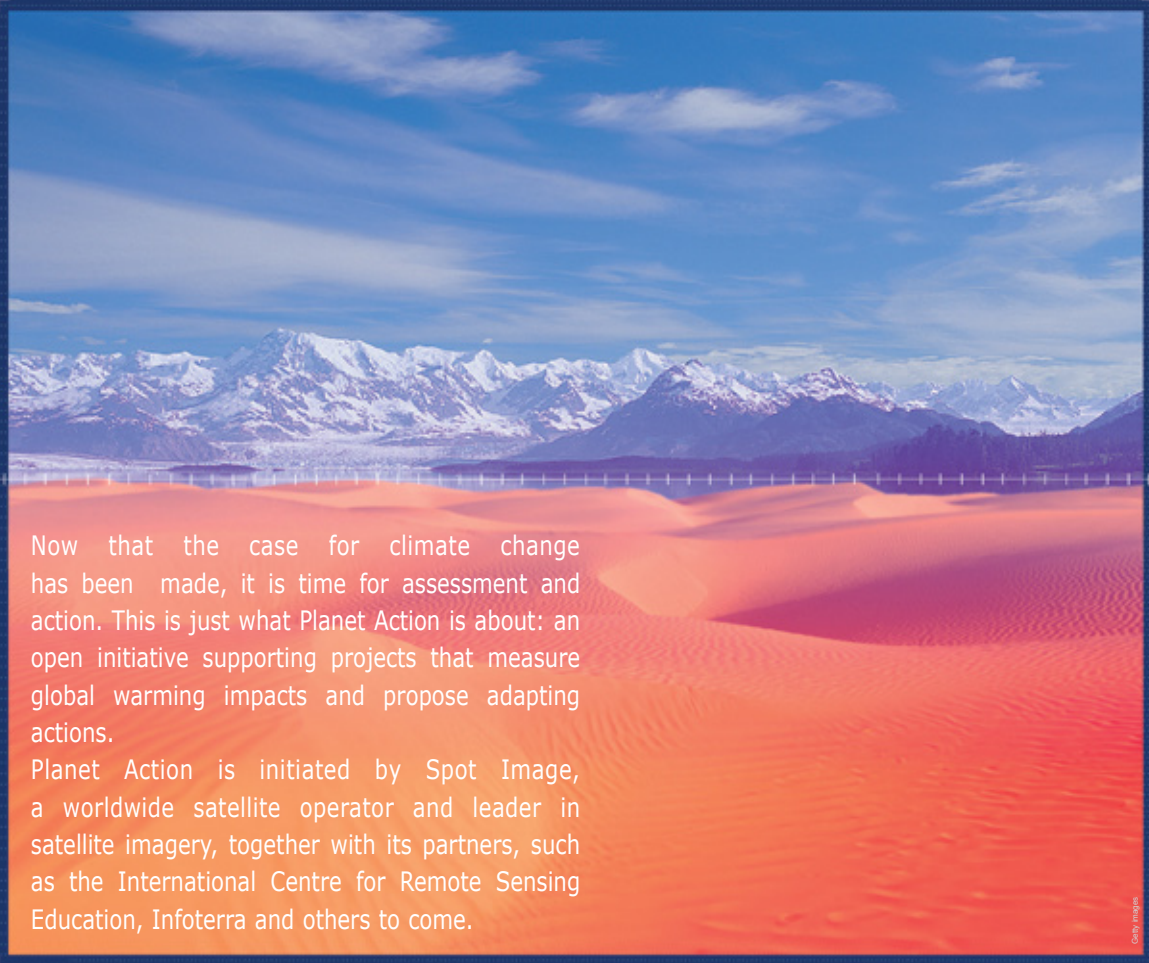
Google Earth for Good

Code Red: China's ASAT Test

Human Rights in Sudan & Zimbabwe

Climate Change

Spot the impacts, engage in action



Now that the case for climate change has been made, it is time for assessment and action. This is just what Planet Action is about: an open initiative supporting projects that measure global warming impacts and propose adapting actions.

Planet Action is initiated by Spot Image, a worldwide satellite operator and leader in satellite imagery, together with its partners, such as the International Centre for Remote Sensing Education, Infoterra and others to come.

The Planet Action purpose is threefold:

- support projects originating in scientific or civilian communities worldwide,
- set up an open internet platform to provide these projects with extensive visibility and collaboration tools,
- promote these projects as a vehicle for educational programs and communication outreach.

PLANET ACTION
An initiative from
Spot Image and ICRSEd
to tackle climate change

ICRSE SPOT IMAGE

Become a partner
www.planet-action.org

PLANET ACTION
Spot the impacts, engage in action

Imaging NOTES

Summer 2007

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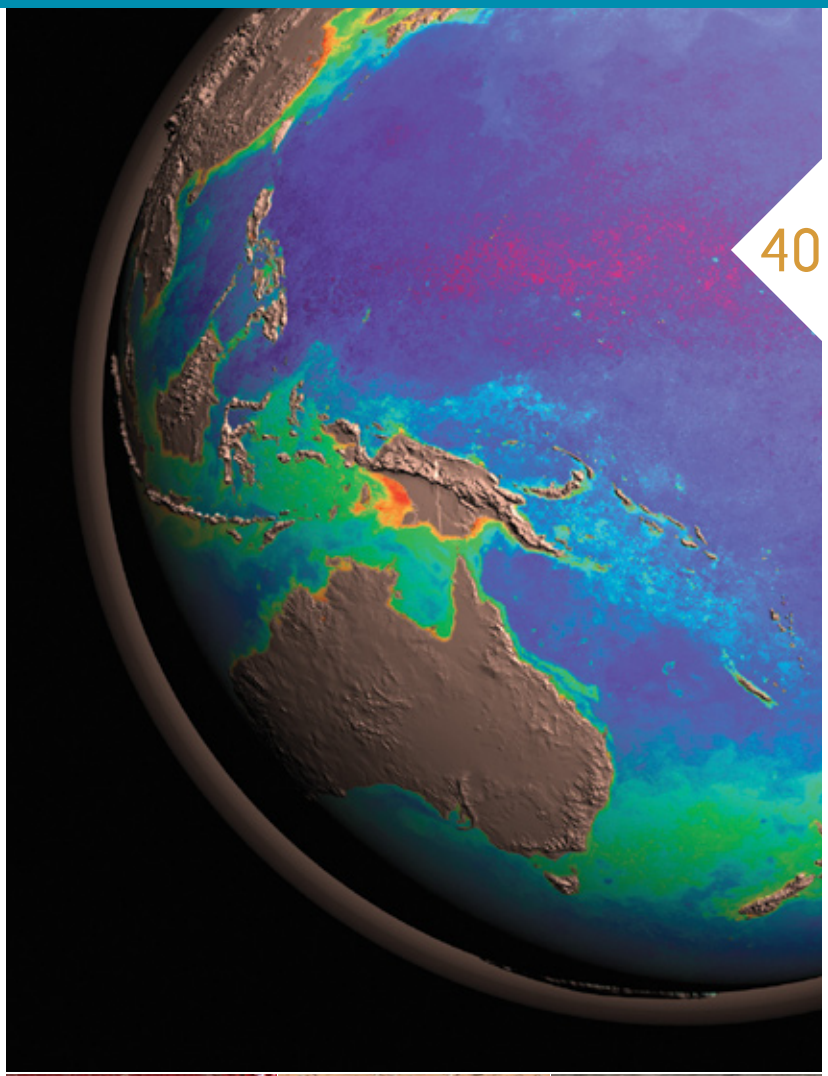

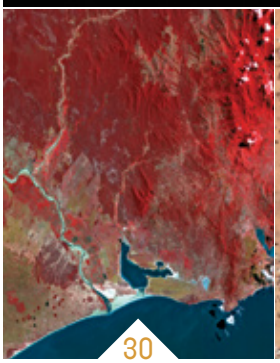

Madagascar

COVER IMAGE

Madagascar is an island located to the east of mainland Africa. This image shows the southeast coastline, located near Tolanaro (or Telagnaro, formerly Fort Dauphin), Madagascar. Shown in the image is Lake Anony near Monkey Bay. This area was affected by the 2006-07 cyclone season, which was one of the worst in the country's history.

This image is a classic false-color image where red indicates vegetation on the image because the near-infrared band is assigned with the red color of the color composite.

Spot Image is using images like this one to contrast with archived images for climate change assessment. See page 30 and the back cover for the 1993 image of this area.

Spot Image is also launching an open collaborative initiative to address climate change called "Planet Action." An interview with Spot CEO Hervé Buchwalter about their plans, and calling for partners, begins on page 30.

The image was taken Mar. 3, 2006, by Spot 4, a satellite owned by CNES, the French Space Agency, and the image was distributed by Spot Image (Toulouse, France). ≪

Imaging NOTES

Summer 2007 / Vol. 22 / No. 2

OUR MISSION

Imaging Notes is the premier publication for commercial, government and academic remote sensing professionals around the world. It provides objective exclusive in-depth reporting that demonstrates how remote sensing technologies and spatial information illuminate the urgent interrelated issues of the environment, energy and security.

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Digital Earth Provides Solid Platform for Various Significant Projects

Dear Reader,

This issue is particularly special for the *Imaging Notes* team; its publication coincides with the 5th International Symposium on Digital Earth (ISDE5). As a major sponsor of this conference, *Imaging Notes* signals its strong support of the goals of the conference—that "any citizen of the planet, linked through the Internet, should be able to freely access a virtual world of information and knowledge resources."

The following three articles are on topics that will be presented at ISDE5. The first is publisher Myrna Yoo's interview with Hervé Buchwalter, CEO of Spot Image about Spot's "Planet Action" initiative. The goal of the initiative is to create an online "Planet Action Exchange" to address climate change. Spot is actively seeking other partners in this exciting venture.

Similarly, Dan Stillman's article on climate change reminds us about the critical role that high-resolution satellites play in documenting and understanding those changes.

The second subject to be presented at ISDE5 deals with one of the biggest problems that has faced the remote sensing community in the past: How to get useful data to the end user, the individual or organization that would take the imagery and make something more out of it than simply an observable backdrop. As Rebecca Moore illustrates, the advent of Google Earth truly has brought the data to millions of new users who would never have gone near an image-processing or GIS program. Her article shows how Google Earth can be put to use to assist humanitarian, environmental, and biodiversity interests around the world.

Lars Bromley explores these themes in additional detail in his penetrating article about the program of the American Association for the Advancement of Science (AAAS) to assist human rights organizations in making effective use of the powerful high-resolution data that are now available from commercial satellites in this third story from ISDE5. He is working with Amnesty International, which is also launching a new effort, "Eyes on Darfur" at ISDE5.

Theresa Hitchens' article highlights the concern many of us feel about the increasing amount of orbital debris circling our planet Earth. It is of particular concern to all who depend upon data from low Earth orbit satellites, which is most of us. I also address this in my *Policy Watch* column on the next page.

In other columns, Tim Foresman offers a view "through the looking glass," uniting his own prophetic vision of the future with those of other creative thinkers in the Digital Earth orbit. Creative thinking continues in Craig Bachmann & Natasha Lèger's *NextGen Mapping* column on digital mashups that are creating new ways to assist customers of Earth observations data.

Finally, in the guest editorial spot, three of the authors of the famed "Decadal Survey," Bill Gail, Neal Lane and Molly Macauley make a plea for a new U.S. information strategy—one that energizes the civil community to do some serious strategic planning and coordination for ensuring the future of our Earth observation capabilities. ⋘

–Ray Williamson

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LETTERS TO THE EDITOR

This is the most useful information source of its kind anywhere. Keep up the great work!

–ROY SMITH, MELODY FARMS IN HAWAII

I have found your issues of Imaging Notes to be very clear and wide in scope. They are useful to a diversity of readers and agricultural scientists in research and applied areas dealing with regional development.

–JULIO HENAO, IFDC

Having worked for the government for 35 years in geospatial, imagery, and mapping areas, and then moving to the commercial sector, I firmly believe that the private sector needs to be educated about how commercial imagery can enhance their decision making processes and be used to increase bottom line profits.

–DONALD SMITH, PROGRAM MANAGER, COMPUTER SCIENCE CORPORATION

This note is a call to all "Earth doctors" who may have missed Dr. Timothy Foresman's column in the Summer 2006 edition. In medical education, physicians learn that the skin is the largest organ. "It is closely associated with the underlying structures, from which and through which it receives its nutrition, and because of its location, it is in intimate relation with the external environment" (Robbins, 1974).

In his article, "Udo's World: The Remote Sensing Community's Transgenerational Responsibility," Dr. Foresman leads us to this important and revolutionary analogy. While the dermatologist has long employed direct and total view of our body's skin, it is only now that we can enjoy analogous access to Earth's surface. Like our physicians, we investigate the total body Earth, gauging her health by the observed condition of her skin. If you believe the health of your own body is important, would you consider addressing the distress of your mother Earth? We now have the capability to do so.

–JOHN R. SCHMIDT, M.S., PRESIDENT, NCAD CORPORATION

Orbital Debris and Governance

POLICY WATCH

After more than three decades of promising advances in satellite remote sensing that never quite gained market traction outside of defense applications, remote sensing has started to take off commercially. Over the last five years, several companies and at least a dozen additional governments have either launched remote sensing satellites into orbit or announced plans to do so this year. As the quality and quantity of available data have increased, so has the timeliness of delivery after acquisition.

The value-added sector, which focuses on making satellite and other remotely sensed data useful in commercial and governmental applications, has grown right along with the proliferation of satellite systems. Aided by the extensive use of GPS for location and GIS for display and analysis, value-added companies have brought the power of satellite remote sensing to a broad variety of customers.

RAY A. WILLIAMSON, ***Imaging Notes*** *editor, is research professor of space policy and international relations at the Space Policy Institute of The George Washington University (Washington, D.C.) and a faculty member of the International Space University (Strasbourg, France).*

Yes, the future looks brighter than ever for satellite remote sensing. Yet, in addition to the risks of launch or equipment failure in orbit, satellite data providers face one increasingly worrisome threat to space operations–orbital debris.

Debris left in space by launch and deployment procedures, or by unintended satellite breakup, has always posed a definite risk to working satellites. However, until the last decade the risk has been quite acceptable. As Theresa Hitchens writes in this issue on page 36, not only has the number of trackable debris objects generated by normal space operations grown to worrisome proportions, the Chinese test of an antisatellite (ASAT) weapon, which destroyed a Chinese polar-orbiting weather satellite, has added significantly to the debris cloud in sun-synchronous low Earth orbit (LEO). Those orbits include nearly all satellites with remote sensing payloads.

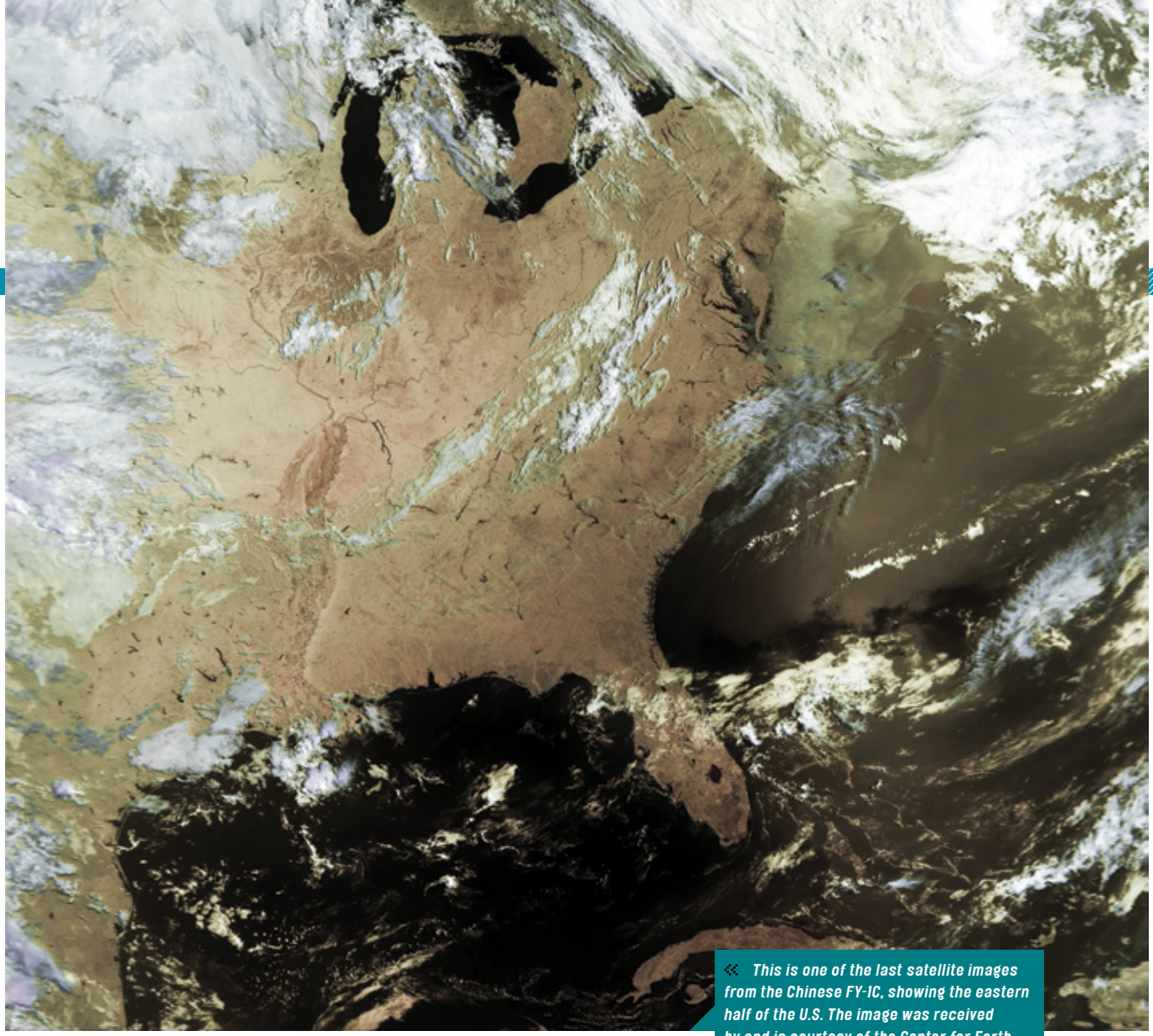
"THE CHINESE ASAT TEST GENERALLY INCREASES THE INCENTIVE TO CRAFT AND ADOPT INTERNATIONALLY ACCEPTABLE 'RULES OF THE ROAD' FOR SPACE."

The concern is not so much for the potential of satellites being destroyed in some future conflict between nations, but in its encountering one of the many thousands of pieces of debris left behind by the test. Even small bits of debris like fasteners can cause great damage to spacecraft because the average impact velocities of debris with other space objects approaches 10 km/sec.

We value satellite systems because they provide the global perspective that aerial systems cannot. Not only can they cover wide areas in a synoptic view, they can observe any territory in the world regardless of national boundary. The legal basis of this capability comes about as a result of the 1967 Outer Space Treaty, which states in Article I, "Outer space... shall be free for exploration and use by all States without discrimination of any kind." This provision is what makes satellite observations so valuable as reconnaissance tools. Unlike aircraft, satellites are not bound by the sovereignty laws of countries they overfly. This treaty also makes satellite images valuable for treaty verification, cross-border environmental monitoring, heritage conservation, and a host of other applications where national laws might impede the ability to gather information. In other words, satellite observations provide a level of global transparency not achievable by aircraft.

This year, the world celebrates its first 50 years in space; the Chinese test is a very poor way to celebrate this milestone. The 300 or so functioning satellites in LEO are at much greater risk of failure than prior to the test.

For more than a decade, space-faring nations, including China, have banded together in the Inter-Agency Space Debris Coordination Committee (IADC) to find ways to reduce the production of debris in space, which is a natural consequence of space activities. Yet, this single test has added some 1500 pieces 10 cm and



This is one of the last satellite images from the Chinese FY-1C, showing the eastern half of the U.S. The image was received by and is courtesy of the Center for Earth Observing and Space Research at George Mason University. Images processed by Dr. Guido Cervone, Jacek Radzikowski, and Dr. Menas Kafatos.

greater in size, to the 11,000 or so already in space. I find the decision to perform this test both puzzling and sad.

U.S. officials have tended to respond to the test by renewing calls for increased U.S. investment in countermeasures and in a revived U.S. ASAT development effort. Both the United States and the Soviet Union tested ASAT weapons in the 1970s and '80s, also leaving long-lived debris in orbit. However, both countries soon reckoned that their space funds would be better spent elsewhere. In my view that was the right decision. Space systems have become too important to world commerce and peacekeeping to risk further pollution of space by space debris.

Despite the problems the Chinese test has created for satellites in orbit, perhaps something good can come out of the test in the form of an increased awareness of the threat to space systems from orbital debris and the need to reduce that threat. In fact, in my view, the Chinese test generally increases the incentive to craft and adopt internationally acceptable "rules of the road" for space, with the goals of not only reducing the threat of damage from orbital debris, but also assisting all countries in establishing and maintaining relatively safe access to space.

Countries of the world long ago banded together to establish rules of the road for international civil air traffic, governed by the International Civil Aviation Organization (ICAO). It is not too far-fetched an idea to believe that space-faring nations could reach agreement on some basic rules of space traffic control and pollution avoidance to govern activities in outer space–in other words, to move toward a regime of orbital governance. «

Through the Looking Glass

A 21ST CENTURY VISION

EARTH SCOPE

The 19th century experience of Alice, in passing through the looking glass, placed her in an environment of the absurd, with nonsensical politics and with life based on an illogical game of chess. We seem to have passed through the same mirror in the 21st Century as we gaze upon our reflections of senseless violence and ineffectual leadership, coupled with fearful threats to our environment and to our lives on this planet. We are confronted by a question that accompanies our increasing use of the modern looking glass: Will the new viewing technologies improve life in this illogical world?

DR. TIMOTHY W. FORESMAN

is President of the International Centre for Remote Sensing Education. He has been director of United Nations Environment Programme's Division of Early Warning and Assessment (Nairobi, Kenya) and national program manager for NASA's Digital Earth (Washington, D.C.). He is editor of The History of Geographic Information Systems, 1998, Prentice Hall. Dr. Foresman is currently the Director-General for the 5th International Symposium on Digital Earth (www.isde5.org).

Digital Earth geobrowsers are capable of radically changing the public's ability to view the world by whetting their appetites for wondrous applications and entertainment. Unfortunately, at one end of the spectrum, the mainstream media have joined with the public's questionable taste by pandering heinous video clips of criminal actions, which then take on a life of their own through YouTube and other Web outlets.

On the other end of the spectrum, selfless advocate groups are harnessing 3D visualization to expose corporate destruction of the planet's ecological goods and services and to give evidence of genocidal assaults on innocent villagers in far-off lands. Our 21st Century Looking Glass is indeed a phenomenal invention.

Recently, the Intergovernmental Panel on Climate Change presented the science-consensus view that the Earth is warming as a result of increased carbon dioxide and other greenhouse gases, a symptom of our addiction to burning fossil fuels. Developed and developing countries alike are being tarred and feathered as the culprits. Walt Kelly's Pogo said it best: "We have met the enemy and he is us."

In a bizarre twist, China and the United States have united politically to dilute these scientific findings as "inconvenient truths" that act against their perceived economic interests. Meanwhile, the Earth heats up and the weather patterns are going berserk in the midst of the planet's 6th major episode of mass species extinction, the most recent of which involved the demise of the dinosaurs. Maybe we can look our children in the eyes and claim to be doing something. It's time to use Alice's looking glass to reflect the absurdities of our own time.

The role of remote sensing, along with that of its geospatial cohorts (GIS, GPS, and Digital Earth) is rising again to the top as a primary technology and medium for addressing many of the ills of climate change. But the technology cannot drive itself. The 21st Century Looking Glass must be held up properly and must be driven by leadership in the community.

That leadership is showing signs of emanating from the midst of our corporate community and is demonstrating promise for catalyzing action by the necessary coalitions of industry, NGOs, and academia, in partnership with governments.

The French satellite company Spot Image, for example, is shepherding a call for collaboration of key members in the geobrowser/Digital Earth, GIS, and climate change communities. Spot's initiative for a Planet Action Exchange (PAX) is designed to provide focus, technical assistance, and resources for local communities to understand and take action on the impacts and challenges of climate change. While this initiative is nascent, the coalition is targeting January 2008 for the operational kick-off. Spot Image will be announcing the details of the Planet Action Exchange at the 5th International Symposium on Digital Earth in Berkeley, California on June 5th.

Spot Image plans to promote a cooperative Web facility that will provide for the access and distribution of many historic satellite images and much data to be used by certified research and action groups (think researchers and NGOs). The build-out of this innovative initiative

will enable communities to construct time-series, detailed, and comprehensive visualization decision-support systems–a true 21st Century Looking Glass. Villages and communities will be empowered to consider climate change adaptation, coping strategies, and actions for their survival and for the sustainable continuity of their cultures for generations. Communities around the world will very soon have the capacity to "spot the impacts and engage in action."

Direct benefit can easily be imagined from extension of the Planet Action Exchange to other sectors than climate change. Recently, a report by Goodman and Finn detailed the expansive network of illegal logging from Burma, Siberia, Indonesia and Africa that feeds the voracious global wood-processing industry along the coast of China ("Corruption Stains Timber Trade: Forests Destroyed in China's Race to Feed Global Wood-Processing Industry," *Washington Post Foreign Service*, April 1, 2007). The World Bank calculates losses of $10 billion annually among the poorest nations from this silvicultural raping of their ecological goods and services.

In the United States, retail shoppers pick up these "price-smart" illegally logged wood products from Ikea, Home Depot, and Lowes. The Forest Stewardship Council and these aforementioned businesses admit to being able to account for only around 5% of their wood products as being legal and/or based on best forest-management practices. In the meantime, we can sit at our spinning globe browsers and see exactly where these rapacious and environmentally egregious acts are occurring in the world's tropical jungles, evidenced by gaping scars on the landscape.

Along the human dimensions, an initiative by Michael Graham and colleagues at the Holocaust Museum has poignantly demonstrated the power of the 21st Century Looking Glass with their multimedia experience for monitoring the atrocities in Darfur ("Museum, Google Zoom In on Darfur," Nora Boustany, *Washington Post Foreign Service*, April 14, 2007).

> "IT IS DAVID VERSUS GOLIATH, AND GOOGLE EARTH JUST GAVE DAVID A STONE FOR HIS SLINGSHOT."
>
> **JOHN PRENDERGAST**

We can now assuredly switch channels to watch, in almost real-time, the various pogroms offered for our viewing pleasure from the safety of our living rooms.

"No one can any longer say they don't know. This tool will bring a spotlight to a very dark corner of the earth, a torch that will indirectly help protect the victims," said John Prendergast, a senior adviser to the International Crisis Group. "It is David versus Goliath, and Google Earth just gave David a stone for his slingshot."

Our industry should accept these milestones as wake-up calls to recognize that we now have the capacity to give all the Davids of the world the ammunition needed, in terms of visualized information, to proactively stem the tides of genocide, ameliorate ecological destruction, and take charge of the destinies of every village and town. Questions posed under these realities are:

- Do we have the leadership capacity to begin collaboratively addressing the technical side of the 21st Century Looking Glass?
- Is there political will by the citizens and agencies to make use of the Looking Glass perspectives? I'll paraphrase an old adage: "You can lead a horse to data, but you can't make him think."
- Can we take the actions we need to take, in time to make a difference?

The Digital Earth community, represented by many nationalities and all walks of life, will be convening on the grassy hillside of the U.C. Berkeley campus on June 5-9, 2007, to consider the issues related to the 21st Century Looking Glass. We hope to see some real partnerships and action come from this 5th symposium in the series of international meetings. We believe that we can make a difference and we desperately want to celebrate hope. «

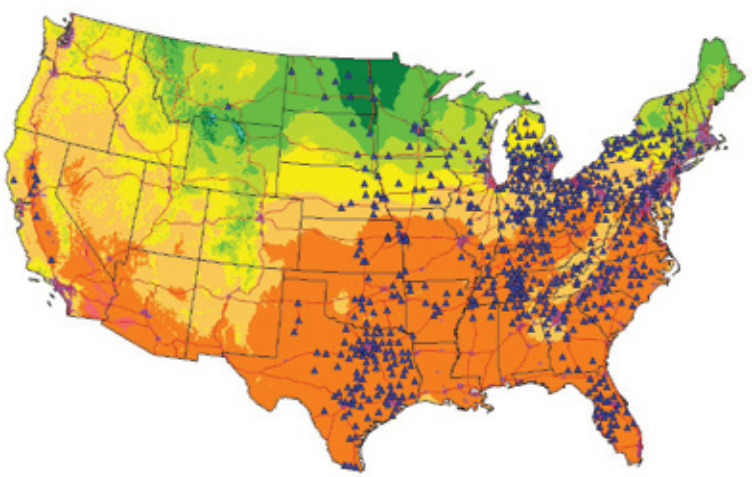
NOTES *The Spot Image initiative "Planet Action" is detailed in an interview with CEO Hervé Buckwalter on page 30.*

Our Guest Editorial on page 46 asks additional relevant questions regarding political will in the U.S. for Earth observations, without which the geobrowsers would not be possible.

Monetizing the Spatial Mashup

Convergence innovations of next-gen mapping inherently challenge the conventional I/RS (imaging and remote sensing) business models. Next-gen mapping is evolving where spatial data, visualization tools and public/private data are aggregated in "mashups." In our Fall column, we discussed early-adopter ProAm mashups. Like many things Web 2.0, monetizing the mashups has become the next step.

In this column we look at how two innovative companies have partnered to bring a new dimension of spatial imaging information to a set of users that have never touched a GIS. AWhere Inc., a mapping software company, and Planalytics, a weather analytics company, are providing a value chain link between I/RS and business users who never thought of I/RS as a source of business-critical data.



1

WEATHER ANALYTICS AS RISK MANAGEMENT

What do companies that span the spectrum of consumer products, retail, food and beverage, and utilities such as Campbell's Soup, Kaiser Aluminum, Sara Lee, Tractor Supply, and True Value have in common? Their business operations and decisions are impacted by weather, and they are using a new set of business weather intelligence tools marketed by Planalytics. For ten years, Planalytics has been using I/RS in their weather forecasting models (much as does Dr. Steve Lyons of The Weather Channel, as discussed in our last column) and has been delivering "actionable" weather data that helps businesses and organizations proactively address the impact that weather will have on business performance–in particular the financial impacts.

Because weather impacts supply, demand, and prices for products and services, such information as proximity forecasts, real-time weather conditions, and a customized hierarchy of integrated and overlaid business-related data are critical to reducing costs, optimizing inventory, protecting agricultural investments and much more. A business can develop a common operating picture of its entire operation, as illustrated in ***Figure 1***.

ENTER WEB 2.0 AND A NEW MARKET

When Planalytics teams discovered the AWhere SIS (Spatial Information System) capabilities, they began to understand the power of new media I/RS. This realization led to a partnership between Planalytics and AWhere, Inc., and to the development of a web-based business connected to a desktop application business, enabling the user to visualize and then integrate a series of weather and business-related data into compelling presentations that improve business decisions. The ability of AWhere SIS to pull together a variety of information–whether census data, inventory data, store locations, free Internet information, scientific studies, geographic and spatial data, or weather data–into information-rich, visually appealing and meaningful maps, charts, and tables, was viewed by Planalytics as the missing piece in turning their weather impact products and services into a truly ubiquitous business application.

What makes AWhere SIS such a powerful engine is its ability not only to create mission-critical information maps but to keep all of that information intact and share it with others across the organization. GIS is no longer relegated to use by the 'experts.' It's now available to anyone.

CRAIG BACHMANN & NATASHA LÉGER *are partners in ITF Advisors, LLC, an independent consulting firm with a focus on next-generation strategy and on translating the increasingly complex new media business environment's impact on business models, markets and users.*

With the AWhere SIS software, "GIS lite—mapping for everyone—has become a reality," said John Corbett, CEO of AWhere, Inc. ***Figure 2*** presents WeatherPin, an application that shows location-based weather data. By clicking 'download this map as an AWhere Exchange (aMap) file,' a business user can now "mashup" business data and discover seasonal supply and demand impacted, for example, by drought.

Planalytics has traditionally focused on serving the retail, manufacturing and energy industries. The company has recently launched a new Life Sciences solution that includes Malaria Mapper and Pest Monitor, which are direct results of these Web 2.0 applications.

THE SPATIAL DATA MASHUP

The weather conditions that lead to turf disease and crop failure are critical to land-use managers and farmers in deploying preventative measures. Here's how Pest Monitor and WeatherPin, which are Web-based, and AWhere SIS desktop mashup tools work.

SCENARIO 1:

A golf course is concerned about the impact of turf diseases, and the supplier of turf chemicals wants a better understanding of the supply and demand issues associated with the golf course maintenance needs. *Poa annua* germination (PAG), for example, is of concern because *poa annua* is a bluegrass that overruns quality turfgrass. Many *poa annua* control strategies fail because they are applied before the *poa annua* germinates. Accurate determination of the germination period is therefore critical. Pest Monitor identifies the weather conditions (sourced from Planalytics business meteorologists) that lead to the emergence of pests based on predictive models that Planalytics has developed.

With this application, the golf course superintendent can pick a location and drill into the maps, tables and charts that present the risk level for germination. ***Figure 3*** presents a set of PAG data for the U.S., color-coded to indicate risk area conditions. ***Figure 4*** presents PAG data for the Glenn Mills, Penn. golf course against a Microsoft Virtual Earth satellite image backdrop. As you can see, the PAG risk is high for the course relative to the prior week, as are the 5-year and 30-year averages for that time-frame, indicating that the manager should take action. Fortunately, the chemical supplier also monitors the situation and can begin to increase production and rearrange inventory to address the need. "This type of information has the potential to eliminate a billion dollars of excess inventory of crop and turf protection products," said Jed Lafferty, Managing Director of Planalytics Life Sciences Group.

SCENARIO 2:

A hay broker who sells quality feed to horse owners needs to forecast inventory and determine how much hay can be sourced from local growers versus other suppliers. The cost of transporting hay is significant. Precipitation impacts the supply of hay, while the number of horses in the surrounding counties impacts the demand. WeatherPin enables the supplier to see the precipitation data and view it with the county horse population data. At this point, specific business decisions can to be made.

Both data are downloaded as AWhere SIS aMap files. Within AWhere SIS, a model of the supply and demand for hay is quickly built, as seen in ***Figures 5 and 6***. This easily-made desktop map

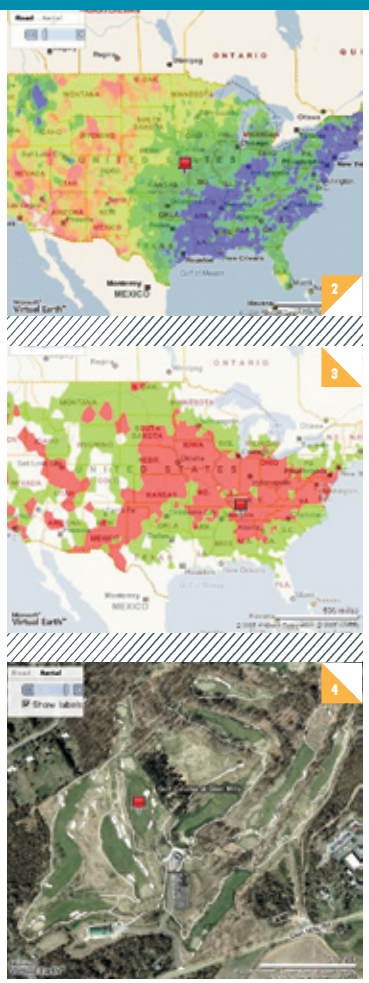


FIGURE 1 *A common operating picture of a retail business across all of its locations incorporates retail census data and private actual sales data.*

FIGURE 2 *The Planalytics "WeatherPin" application presents specific seasonal precipitation data.*

FIGURE 3 *Planalytics Pest Monitor application presents* poa annua *germination data for the U.S.*

FIGURE 4 *Planalytics Pest Monitor application presents* poa annua *germination data for the Glenn Mills, Penn. golf course showing that the risk is high for PAG relative to the week prior.*

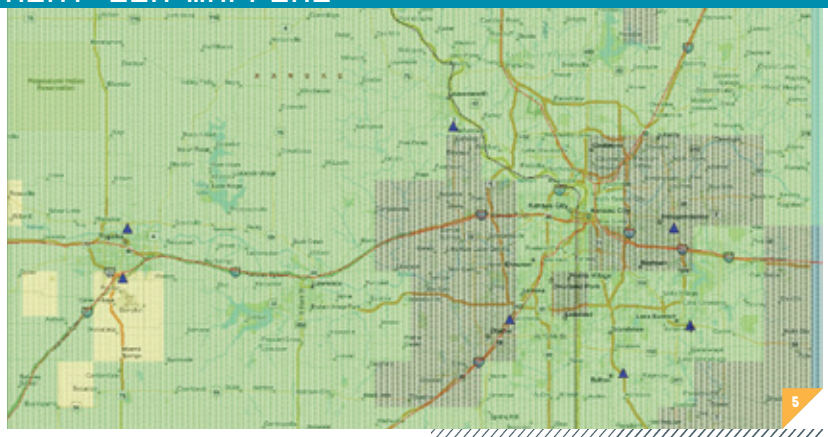


FIGURE 5 *An AWhere SIS view presents a section of Eastern Kansas, some customer locations, and the precipitation data on a Microsoft Virtual Earth backdrop.*

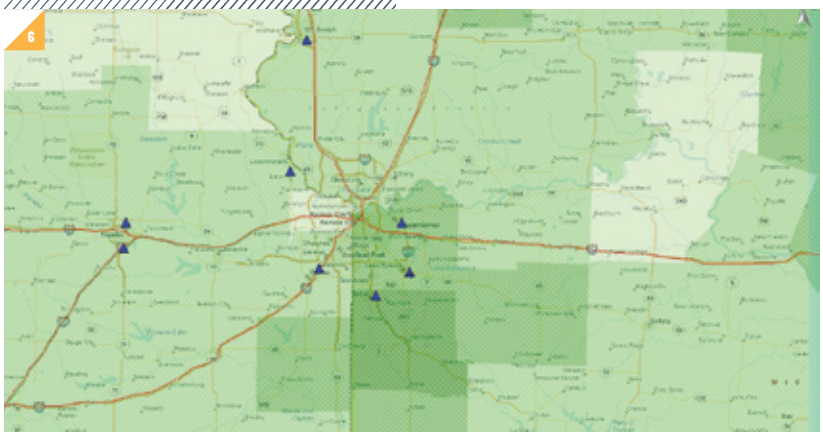


FIGURE 6 *AWhere SIS presents an overlay of the county horse population data from the agricultural department, with a customer location selected showing Planalytics weather data.*

mashup is due to patent-pending software that enables data of all types, including I/RS, to be aggregated and analyzed as easily as putting together a PowerPoint or a spreadsheet. "The user can interact with the data and access specific geographical and time-specific data that are actionable," said Jed Lafferty.

THE I/RS VALUE CHAIN

Next-gen mapping is about data integration to save lives, effectively use capital and resources, optimize supply and demand, and improve risk management and decision-making. As Dr. Corbett says, "I want to enable users to integrate the silos of data to create actionable decisions."

Web 2.0 offers an excellent opportunity to begin to explore the new ways that this can happen. It also challenges the I/RS industry to become more than a backdrop on GIS presentations. These two companies represent the next-gen opportunities to monetize I/RS and put spatial tools in the hands of action-minded people. The Spatial Mashup is here, and clearly the ability to aggregate public and private data in new ways will drive a new set of I/RS opportunities. ≪

POLITICS AND GLOBALISM

Global warming has led to erratic weather patterns that distort historical trends. Increased variability in weather makes access to specific or local weather data even more important. Dr. John Corbett, CEO of AWhere, Inc., told *Imaging Notes*, "preventative versus curative actions is a big issue because of the cost differential involved. Getting the weather wrong has a direct impact on everything from the cost of food to the risk of malaria." He explained that, based on historical trends, farmers might think that a pest will arrive in late June. However, Planalytics real-time weather data and prediction models might indicate that the pest will emerge earlier in May. The uninformed farmer will incur the higher curative costs that will be passed on to the consumer if he doesn't end up with crop failure. Malaria Mapper, a forecasting tool jointly developed by AWhere and Planalytics, results in the ability to predict a day-by-day (and three-week forecast) risk assessment of this mosquito-borne disease. "This tool can help optimize the supply chain and health service infrastructure that are needed to address this risk."

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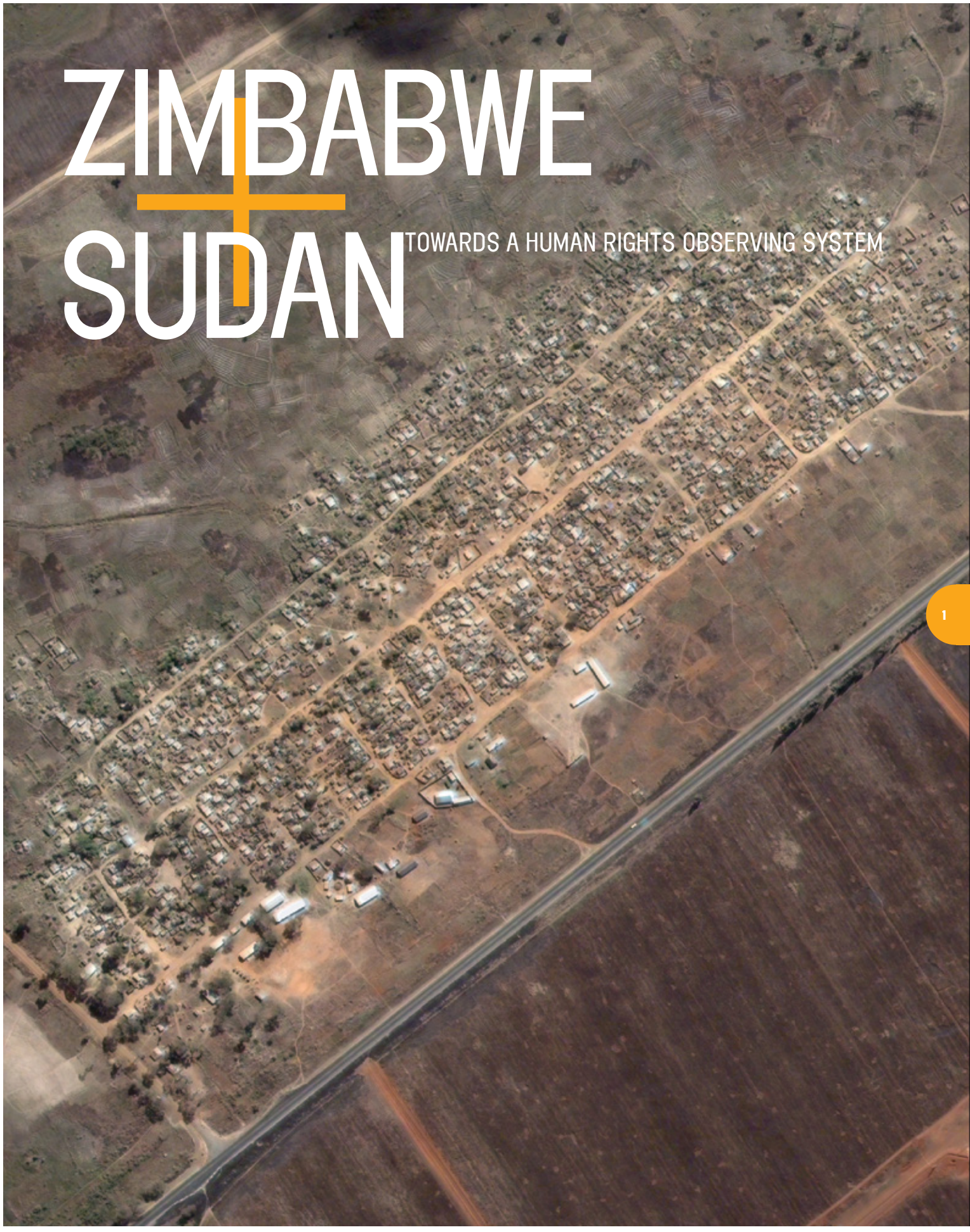
ZIMBABWE + SUDAN

TOWARDS A HUMAN RIGHTS OBSERVING SYSTEM



DEVELOPMENTS WITHIN THE REMOTE SENSING AND GEOSPATIAL TECHNOLOGIES FIELDS HAVE ENABLED HUMAN RIGHTS organizations more effectively to investigate, monitor and contest atrocities and other human rights violations around the world. Notably, the establishment of a constellation of high-resolution observation platforms are allowing non-governmental organizations (NGOs) the ability to detect and respond to human rights violations as never before. Properly equipped, NGOs can complement formal responses from national governments and international bodies to the full range of human rights violations.

Since late 2005, the Science and Human Rights Program of the American Association for the Advancement of Science (AAAS) has been funded by the John D. and Catherine T. MacArthur Foundation to explore and develop applications of geospatial technologies for human rights organizations. Over the next two years, AAAS will collaborate on this project with well-known entities such as Amnesty International and Human Rights Watch, more specialized bodies such as the U.S. Holocaust Memorial Museum, and locally based and smaller organizations such as the Zimbabwe Lawyers for Human Rights or the Karen Human Rights Group (in Burma).

This complex array of NGOs work to address specific and broad trends of genocide, crimes against humanity, atrocities, persecution, and violation of the gamut of civil, political, economic, social, and cultural rights. Embodied in internationally adopted treaties, such as the Geneva Conventions and the United Nations Universal Declaration of Human Rights, these rights also are addressed explicitly within such regional bodies as the African Union Human and Peoples Rights Court, but are often most effectively defined and protected—or denied—by national and local laws and institutions. Certain bodies such as the International Criminal Court address egregious atrocities when no other body will, though the majority of human rights work plays out at the local, national, and regional levels within a variety of legal and advocacy frameworks.

In order to empower these organizations, AAAS is developing applications of geospatial technologies for human rights NGOs. Such groups often are engaged in some form of monitoring, advocacy, and litigation efforts designed to halt transgressions, or provide remedy or repatriation. Depressingly, human rights violations occur with absolute regularity and include the range of human barbarism: wholesale massacre, mass rape, torture, destruction of livelihoods, and terrorization of innocent peoples based on many possible ethnic, religious, economic, and/or historical reasons. More subtle political, economic, and environmental oppressions join the more heinous acts, including denying specific groups of people access to homes, farmland, fisheries, roads, power grids, and other state-funded infrastructure.

FIGURE 1 *Porta Farm, Zimbabwe before image, taken June 22, 2002.*

FIGURE 2 *Porta Farm after image, taken April 6, 2006.*

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FIGURE 3 *Killarney settlement in Zimbabwe shown before and after Operation Murambatsvina. Some of the more than 465 Killarney structures are visible in the before image (Aug. 22, 2004 – top), most of which are absent from the after image (Sept. 7, 2005).*

FIGURE 4 *In the Chitungwiza settlement in Zimbabwe, backyard homes are visible in the left-hand image (Aug. 25, 2004), and are absent from the right-hand image (June 22, 2005). In addition, the possible marketplace seen in the before image is absent from the after image.*

Human rights NGOs operate under constrained resources, and oftentimes face difficulties effectively accessing specific regions. Even in situations where information is relatively easy to obtain, verifying, reporting and separating fact from rumor, or relating rapidly developing local events to regional and global trends, present unique challenges. As such groups are focused overwhelmingly on seemingly desperate battles with minimal resources, they often simply cannot afford to evaluate advanced technologies. However, they often make stunningly effective use of technologies as they become more available, including cellular and satellite phones, digital cameras, and free or low-cost e-mail and Web hosting services.

Human rights NGOs, by forming alliances around common issues of concern and by communicating on a global scale, represent a distributed, decentralized information network. It is this characteristic that the AAAS project is initially seeking to exploit by connecting these organizations with assets such as commercial high-resolution imaging satellites. None of the work undertaken by AAAS is necessarily new in this regard; aspects have been pioneered in the past several years by national governments, intergovernmental organizations, and individuals such as Dr. Matthew McKinzie (Dr. McKinzie is a physicist and consultant for the Natural Resources Defense Council, who undertook several studies based on high-resolution imagery for groups such as the U.S. Committee for Human Rights in North Korea, as reported in *Imaging Notes*' Summer 2005 issue). The focus of the AAAS work is to make the use of high-resolution imaging satellites the norm within the international human rights community, furthering the creation of an integrated human rights observation system.

APPLYING HIGH-RESOLUTION IMAGING TO HUMAN RIGHTS ISSUES

Several high-resolution platforms are being exploited for human rights purposes, oftentimes providing imagery within a week of ordering. In addition to the use of these satellites for rapid image acquisition, the archives of previously collected imagery from each satellite can be enormously helpful to human rights work. Obviously, the longer a satellite has been imaging, the more potentially useful its archives can be. Likewise, the higher the resolution of the satellite, the more applications can be posited for it within ongoing human rights work. AAAS has found that satellites with resolutions of one meter or better are the best-suited for human rights work. Violations that affect infrastructure and housing, in particular, or that require large build-ups of military, paramilitary, and police forces, are especially visible to such satellites. At present, AAAS is drawing from several satellites:

- IKONOS, operated by GeoEye (Dulles, Va.), has 1-m panchromatic and 4-m multispectral resolution. It has been in operation since 1999.

- QuickBird, operated by Digital Globe (Longmont, Colo.), has 0.6-m panchromatic resolution and 3-m multispectral resolution. It has been in operation since 2001..

- EROS-B, operated by ImageSat International, has 0.7-m panchromatic resolution. It was launched in 2006.

In addition to this array of satellites, other platforms are of possible use. AAAS has yet to test the Resurs DK-1, operated by Sovinformsputnik (Russia), which has 1-m panchromatic resolution. Likewise, the Korean KOMPSAT (1-m resolution), and the Indian IRS Cartosat-2 (1-m resolution), have not yet been utilized. Most important, two new highly anticipated satellites from DigitalGlobe and GeoEye, scheduled for operation in 2007, will provide 0.5-m resolution imagery to non-governmental clients.

Google Earth provides for many parts of the world, both urban and remote, a recently acquired QuickBird basemap. Users can upload GPS coordinates, e-mail waypoints acquired from work in the field and survey satphotos overlaid with annotations often supplied by local people, experiencing the situation on the ground.

CASE STUDIES

To further its goals, AAAS undertakes focused activities in response to specific human rights violations in close partnership with human rights organizations. Such case studies allow AAAS staff to understand the challenges to be faced, the needs of the human rights community, and the impact of the imagery if and when it is delivered. Conversely, human rights organizations are exposed to the information needed for guiding image acquisition, to the complexities and challenges of operational use of imagery, and to the specific limitations of satellite imagery and related technologies.

Since early 2006, AAAS has addressed several situations of concern to human rights organizations, including Zimbabwe and Darfur. Primary partners in this regard include Amnesty International, the Zimbabwe Lawyers for Human Rights, and other NGOs. In addition, the U.S. Holocaust Memorial Museum recently produced Google Earth layers on Darfur with information from many sources. The project has been extremely well-received with specific attention from U.S. President George Bush. *(Editor's note: See related story about Google Earth on page 24.)*

ZIMBABWE

In AAAS efforts regarding Zimbabwe, imagery was sought to document the 2005 home demolition campaign by the Government of Zimbabwe, Operation Murambatsvina ("Clean out the Trash"). Reporting was provided to AAAS regarding four specific towns where the homes of opposition supporters were destroyed. While Mugabe's government was not denying demolishing some un-permitted structures in a few areas, the scale of the devastation had not adequately been conveyed to the African Union or other bodies. AAAS staff worked to identify the demolished housing in the towns of Porta Farm, Hatcliffe, Chitungwiza, and Killarney.

While locating towns in many countries is as simple as finding a road atlas, in Zimbabwe—as in much of the world—finding locations is relatively difficult because of poorly mapped local areas. Further, the issue was complicated by the fact that Hatcliffe and Killarney shared town names with nearby and officially

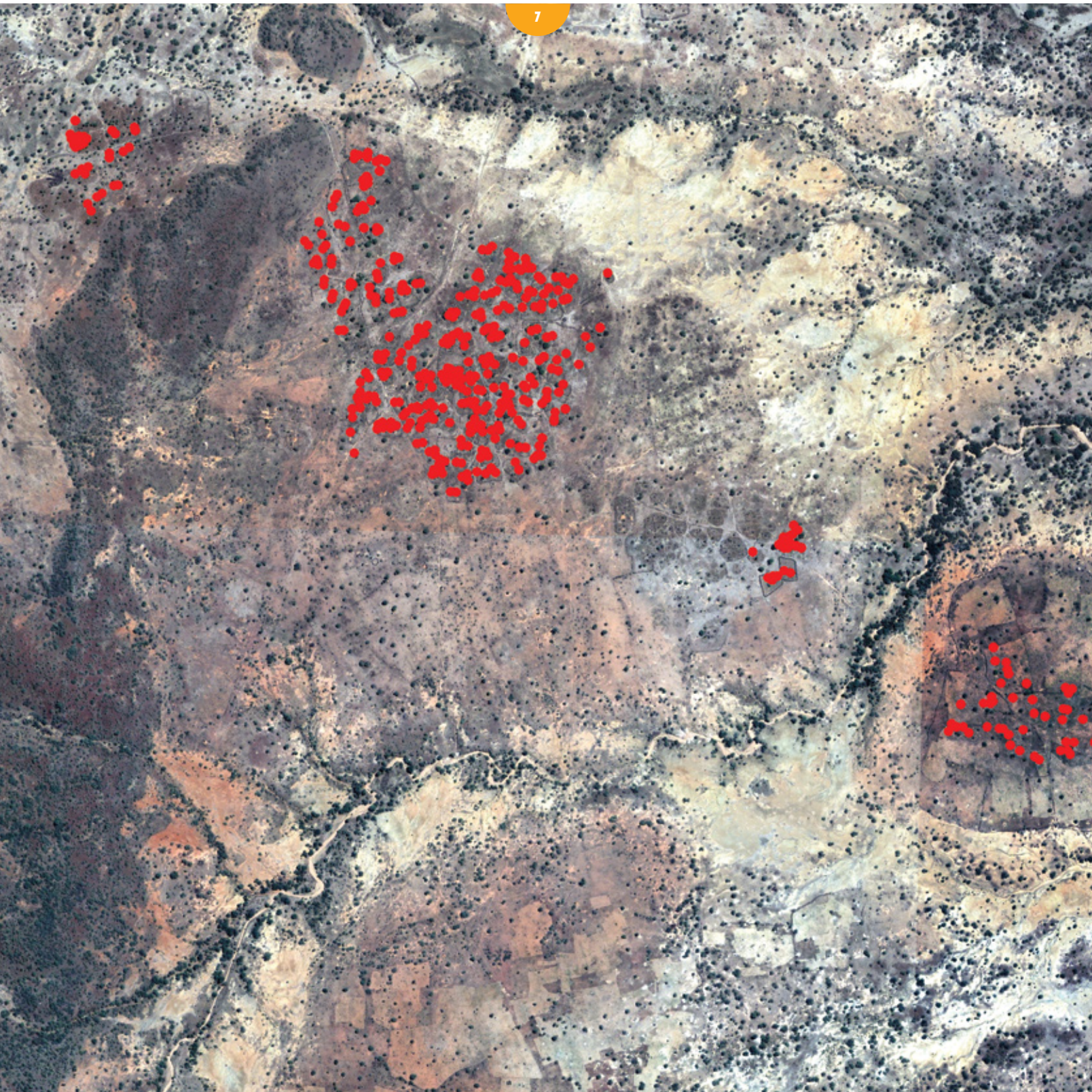
FIGURE 5 *Hatcliffe settlement before (May 14, 2004) and after (September 2, 2005) Operation Murambatsvina, where more than 700 structures were removed.*

FIGURE 6 *Madoua settlement in eastern Chad, along the Chad/Sudan border. All structures of this town were destroyed in the after image (November 4, 2006). Before image taken March 2, 2006.*

FIGURE 7 *Destroyed structures in Madoua, after the attack Nov. 4, 2006 (schematic of the 452 removed structures in Madoua).*

FIGURE 8 *Burned and Destroyed Homes in Bir Kedous, Chad.*

FIGURE 9 *Burned area of Bir Kedouas – The top image shows a sample set of homes, outbuildings, and fences in October 24, 2004. The bottom image shows the remains of those same homes and fenced areas on January 7, 2007, after the reported attack.*

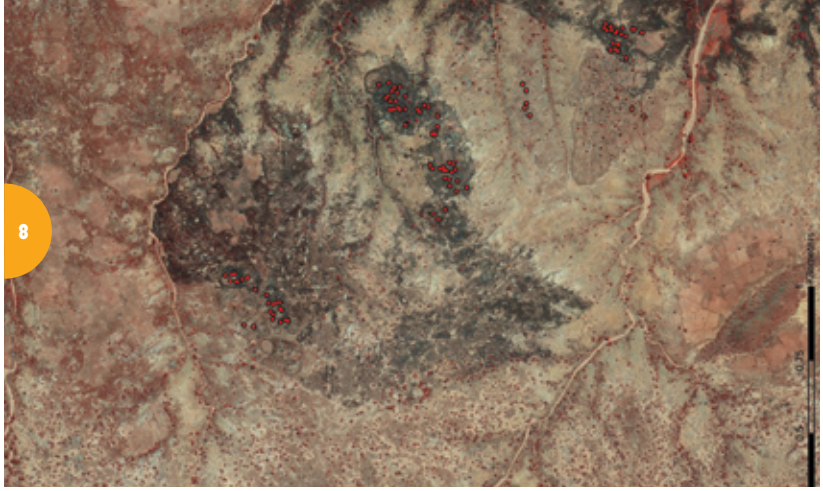


recognized towns. Only the demolitions in Chitungwiza proved easy to locate.

To locate the towns besides Chitungwiza, information from Amnesty International and Zimbabwe Lawyers for Human Rights was combined with place names from the National Geospatial-Intelligence Agency GeoNet Names database and with background imagery from the LandSat GeoCover product downloaded from the Global Land Cover Facility at the University of Maryland. Using such data, simple maps of the areas around the cities of Harare and Bullawayo were created and e-mailed to partners. Using these maps, partners precisely identified the location of the former settlements, thus providing AAAS staff with the geographic coordinates. The town of Porta Farm was found with driving directions from Harare, allowing staff to locate the precise area on Google Earth.

With precise locations in-hand, AAAS staff searched for images that would document both the presence of the settlements prior to their June, 2005 demolition, and any later imagery that would show their absence. Luckily, the QuickBird satellite had acquired images for all areas, and only one new image of the Porta Farm area needed tasking. AAAS staff analyzed and evaluated the four image sets, producing a report detailing findings (see ***Figures 1-5***).

Amnesty International then launched an advocacy campaign, with a report of their own including imagery samples provided by AAAS, a press release, and other activities. The result was unprecedented attention to the issue, with 24 hours of media interviews conducted by Amnesty staff in London. Further, the Zimbabwe Lawyers for Human Rights submitted the imagery to the African Union as part of their case against the Government of Zimbabwe. That case has been recessed



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as the government tries to refute the validity of the imagery—a development that AAAS sees as promising.

DARFUR

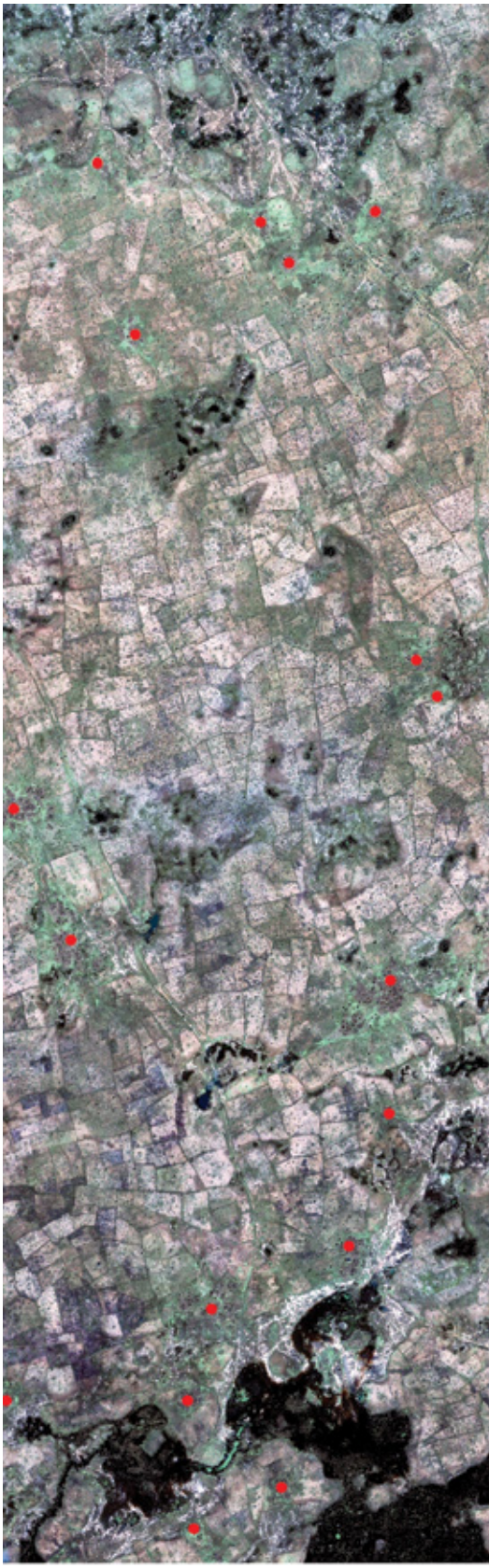
The case of Darfur presents different characteristics and challenges as AAAS works closely with Amnesty International and others to document aspects of the conflict. AAAS uses most of the same tools as in the Zimbabwe case, but the huge scale of the conflict significantly alters the process. Darfur is a vast, remote, and poorly mapped area, and the conflict dynamics and policies of the Government of Sudan make outside access and reporting extremely difficult. However, given the level of humanitarian interest in the area, a wide range of data products has been developed in recent years, including place names, roads, airfield locations, conflict events, extensive Google Earth layers, and more.

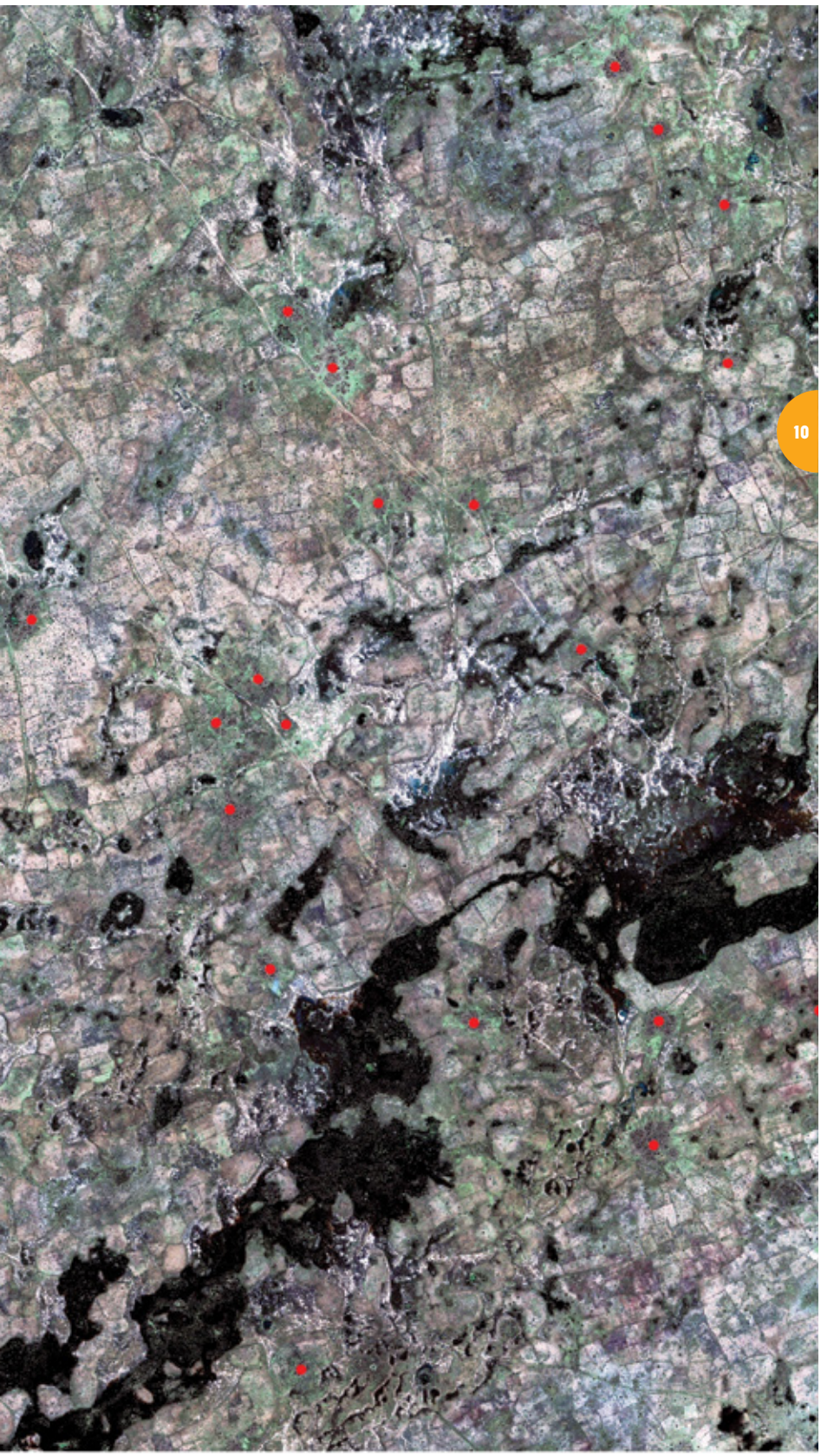
A key challenge is the variability found in town and place designations, both among different local peoples and among the differing nationalities providing humanitarian relief. Transliteration and transcription of place names morphs their spellings, and the same process among media and NGO reporting outlets causes significant difficulty in locating reported events. A custom "fuzzy" matching system using the Levenshtein Distance algorithm helps overcome some of this problem, along with a great deal of standard geographic research. AAAS staff therefore are presented with a classic data-mining experience. A great many place names are reviewed from U.N. and NGO reporting, and a small subset (about 30%) of these are located. Of this subset, an even smaller number has the before and after image pairs already available, identified as a key asset to advocacy work and, ideally, to future legal efforts.

Using this method, AAAS has produced compelling imagery of specific events in Darfur and eastern Chad, based on reporting from Amnesty International, the U.N., the media, and other sources. These imagery sets include Quickbird documentation of an initial cattle raid and subsequent destruction of Madoua, Chad (see ***Figures 6 and 7***) in 2006, and likewise the town of Bir Kedouas, Chad (see ***Figures 8 and 9***). Strikingly, an IKONOS imagery set reveals an area of South Darfur where every single one of the 41 villages within the "before" image footprint was razed prior to acquisition of the "after" image (see ***Figures 10 and 11***).

CONCLUSION

Within the next few months, AAAS will seek to provide effective Web-based documentation for human rights organizations seeking to make use of high-resolution imagery, from Burma to Russia to New Orleans in the U.S. Subsequently, AAAS will continue to provide some services in that regard as staff members proceed to evaluate and explore other remote sensing and geospatial information solutions. At the same time, significant information provision on crisis areas from governmental, intergovernmental, and NGO sources, together with tools from major corporations such as Google and Microsoft, will enable unprecedented response to and mitigation of human rights violations. It is important that this emerging information distribution system develop in a manner that recognizes the disparities in information access around the world and seeks to capitalize on the full range of information technology resources being made available. ≪





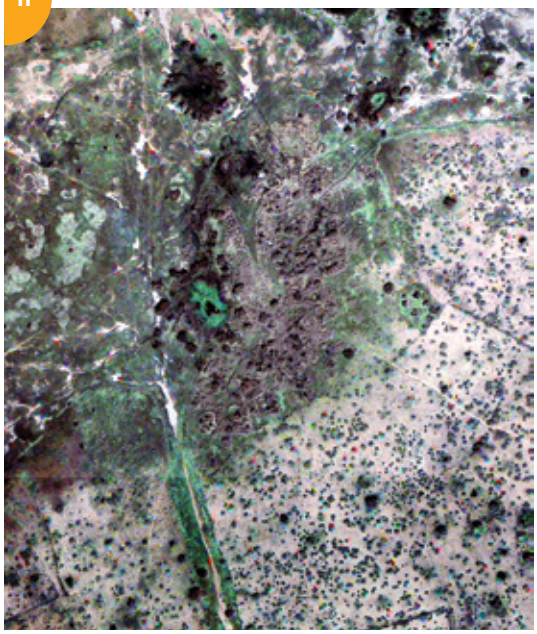
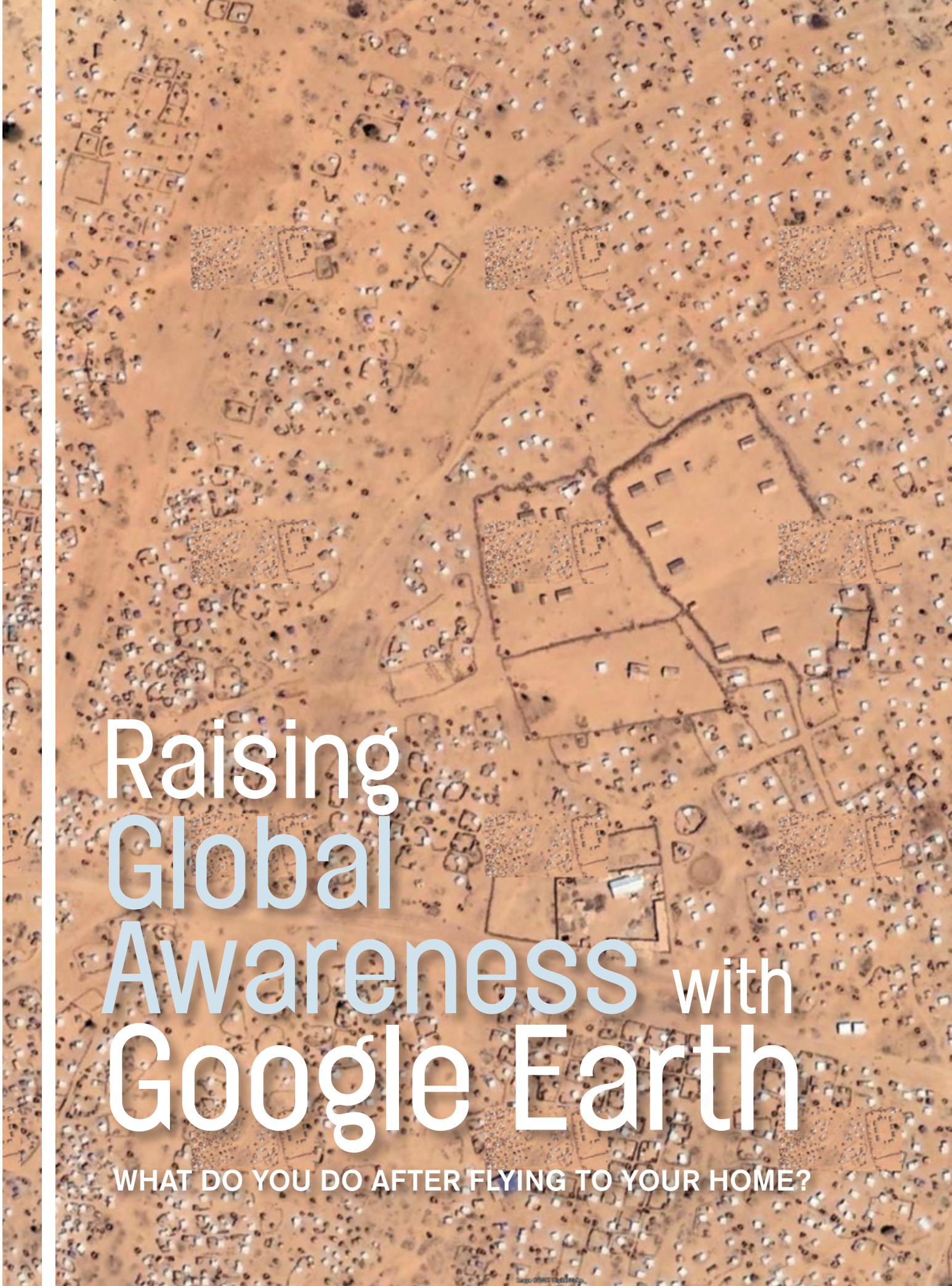


FIGURE 10 *Locations of destroyed settlements in the Tigla region on Sept. 8, 2006.*

FIGURE 11 *One of the villages in the Tigla area which was completely destroyed following attacks. Before image (top) is from September 30, 2004. After image is September 8, 2006.*

NOTE *Figures 1-9 are QuickBird imagery from DigitalGlobe. Figures 10-11 are IKONOS imagery from GeoEye.*

EDITOR'S NOTE *The newly announced GeoEye Foundation and separately, Spot Image's collaborative "Planet Action" are specifically designed to provide imagery for NGOs for human rights, climate change and education. See related stories beginning on pages 30 and 40.*



Raising Global Awareness with Google Earth

WHAT DO YOU DO AFTER FLYING TO YOUR HOME?

What is the first thing most users do in Google Earth?

Typically they fly to their homes, navigate around their neighborhoods and perhaps explore potential travel and vacation spots.

While this is a wonderful introduction to the power, utility and even pleasure of using Google Earth, increasingly there are much more interesting applications being launched that leverage the power of Google Earth to help the people, animals and plants of our planet.

As of this writing, Google Earth includes high-resolution imagery (sub-meter accuracy) for more than 30% of the world's landmass and 50% of the world's population. The 3D terrain model is also steadily increasing in accuracy all over the world. Try flying around Switzerland or Hawaii (10-meter horizontal accuracy) or Mount St. Helens (3-meter accuracy). In Africa, we have blended in extremely high resolution (2.5cm/pixel) aerial photographs taken by National Geographic explorer Michael Fay, allowing users to fly in seconds from outer space to see the eyelashes on a camel. Google continues to publish frequent updates to the imagery, terrain and vector databases, increasing our global high-resolution coverage, spatial accuracy and data freshness.

The power and reach of this technology have now been discovered by many non-profit groups, NGO's, governmental agencies, scientists, concerned citizens and indigenous peoples who are engaged in efforts to raise awareness and inspire action on a range of

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FIGURE 4 *Abdul and his family's journey ends at the Kalma Camp, current population 90,000; white tents are visible in the satellite imagery.*

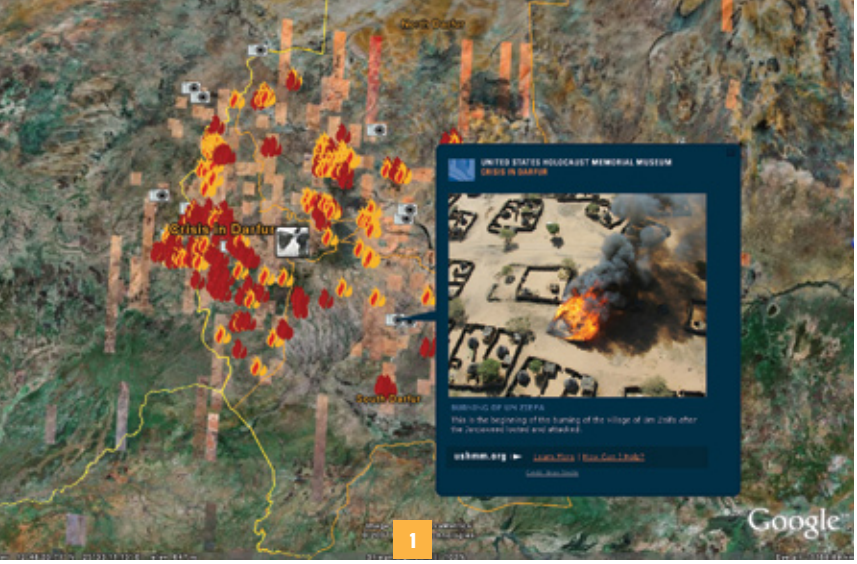

FIGURE 1 *"Crisis in Darfur" by the U.S. Holocaust Memorial Museum; each flame marks a damaged or destroyed village.*

FIGURE 2 *One of more than 1,600 damaged or destroyed villages in Darfur; more than 100,000 homes have been destroyed.*

FIGURE 3 *The blue line marks the 73-mile journey of Abdul's family across the sub-Sahara desert, from their destroyed village of Shattay (marked with a flame in the foreground) to the displaced persons camp at Kalma, shown on page 24.*

issues: environmental, humanitarian, cultural, educational and disaster relief/response, among others.

Many users have found that by publishing their data and telling their stories within the vivid geospatial context of Google Earth, they've been more effective at reaching the broader public and influencing policy at every level of government. Some already have achieved success at tangibly impacting what is happening "on the ground." At Google, we believe that technology can be a positive catalyst for education and action, and have committed resources to supporting these groups and efforts in a variety of ways. The following are a few examples of public-benefit Google Earth projects launched over the past year.

UNITED STATES HOLOCAUST MEMORIAL MUSEUM: *CRISIS IN DARFUR*

On April 10, 2007, the U.S. Holocaust Memorial Museum (USHMM) joined with Google in unveiling an unprecedented online mapping initiative aimed at furthering awareness and action in the Darfur region of Sudan. The goal was to enable Google Earth users worldwide to visualize and better understand the genocide currently unfolding in Darfur. Museum staff assembled content—photographs, data and eyewitness testimony—from a number of sources that were brought together for the first time in Google Earth. This information was (and still is) published as a Global Awareness layer in Google Earth, and the content is turned on by default—that is, users of Google Earth will see the collection of "Crisis in Darfur" icons simply by opening Google Earth and flying over Africa (see ***Figure 1***).

The "Crisis in Darfur" content comes from a range of sources—the U.S. State Department, NGOs, the United Nations, individual photographers, and the museum. Also, Google arranged to publish high-resolution imagery for many affected areas in Sudan and neighboring Chad. The high-resolution imagery in Google Earth enables users to zoom into the region to view more than 1,600 damaged and destroyed villages (see ***Figure 2***), providing visual, compelling evidence of the scope of destruction. The remnants of more than 100,000 homes, schools, mosques and other structures destroyed by the *janjaweed* militia and Sudanese forces are clearly visible. Humanitarian organizations and others now have a readily accessible tool for better understanding the situation on the ground in Darfur.

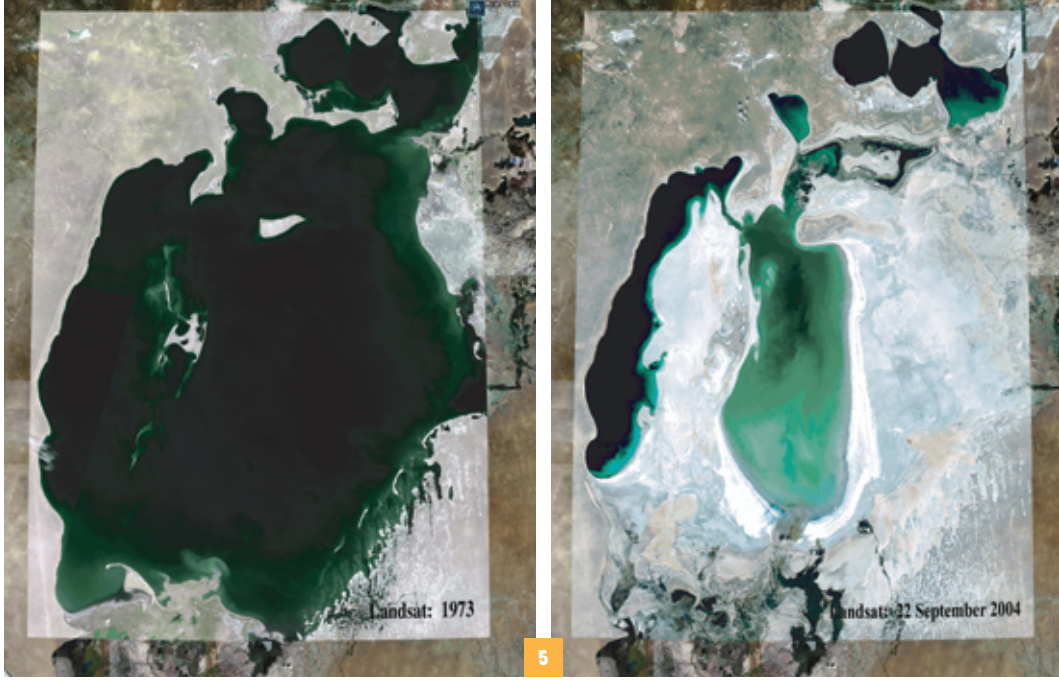

FIGURE 5 *The Aral Sea has dropped to one-quarter of its former size (50 years ago), due to diversion of water for cotton cultivation. These images are included in the UNEP layer on Google Earth.*

Also worth noting is that this project was started and substantially developed by a group of volunteers who donated their time and KML skills (Keyhole Markup Language, the file format used to display geographic data in Google Earth). The "BrightEarth" project included Michael Graham (of USHMM, who conceived the idea and led the team) and volunteers Lars Bromley, Declan Butler, Stefan Geens, Mikel Maron, Tim Caro-Bruce and Brian Timoney. (*Editor's note: See detailed story on page 16.*)

During their Google Earth presentation to assembled government officials and the media on April 10, the museum told and showed the story of one particular displaced family, from a report by BBC correspondent Hillary Anderson. Abdul and his mother lived in the village of Shattay. One morning before dawn, the attack on Shattay began. The next day Abdul and his family began their arduous three-day walk of 73 miles across the sub-Saharan desert to the displaced persons camp of Kalma (see ***Figure 3***). Due to the extreme difficulties of the journey, one member of the family died along the way. The dangerous conditions of these camps are portrayed in ***Figure 4*** on page 24.

The reaction to this project has been immediate: it has stimulated extensive worldwide media coverage, traffic to the USHMM website has quadrupled, and reporters and human rights organizations have used the information in these layers to ask more pointed questions.

As President George Bush noted when he spoke at the U.S. Holocaust Memorial Museum on April 18, 2007, "This museum cannot stop the violence. But through your good work, you're making it impossible for the world to turn a blind eye. Earlier I saw an exhibit that puts faces on the millions of men, women, and children who have been killed or driven into the desert. I also saw an interesting new venture that you've arranged with Google Earth. As a result of this partnership, millions of Internet users around the world will be able to zoom in and see satellite images of the burnt-out villages and mosques and schools. No one who sees these pictures can doubt that genocide is the only word for what is happening in Darfur—and that we have a moral obligation to stop it."

"No one who sees these pictures can doubt that genocide is the only word for what is happening in Darfur—and that we have a moral obligation to stop it."

- President George Bush

UNITED NATIONS ENVIRONMENT PROGRAMME: *ATLAS OF OUR CHANGING ENVIRONMENT*

UNEP's "Atlas of Our Changing Environment" was first published in hardback in 2005, featuring high-resolution images of areas around the world that have undergone dramatic change over the past thirty years, from receding Arctic glaciers and the vanishing snows of Mount Kilimanjaro to extensive deforestation in the Amazon.

In September 2006, UNEP and Google teamed up to publish this atlas online as a layer in Google Earth. There are now 177 sites around the world portrayed with before-and-after image overlays and explanatory text. The transparency slider feature in Google Earth allows users to morph the imagery back and forth in time, vividly conveying the dramatic changes (see ***Figure 5***).

The project has garnered considerable global media attention. For example, on Nov. 7, 2006, French TV Channel 2 allocated several minutes of their prime-time news program to a series of these before-and-after site visualizations

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FIGURE 6 *Flirt's biography as part of the Jane Goodall Institute "Gombe Chimpanzee Blog." Flirt is a daughter of Fifi, who was the last surviving chimpanzee from Jane's early days as a researcher. Fifi had infants from 1971 to 2002. Flirt was her second-youngest. Sadly, Fifi disappeared in 2004.*

FIGURE 7 *High-resolution imagery of Gombe National Park and environs; the deforestation outside the park boundary is readily apparent.*

FIGURE 8 *Mud River, West Virginia, before and after mountaintop removal coal mining.*

FIGURE 9 *Illustration of the mountaintop removal blasting process; dynamite holes visible in the imagery.*

FIGURE 10 *Representation of the Santa Cruz Mountain logging plan that proposes helicopter logging within several hundred yards of schools and a daycare center.*

and to an interview with project coordinator Ashbindu Singh. The project has also served as an inspiring example and technical demonstration to other non-profit groups interested in showing before-and-after imagery overlays in Google Earth.

JANE GOODALL INSTITUTE: *GOMBE CHIMPANZEE BLOG*

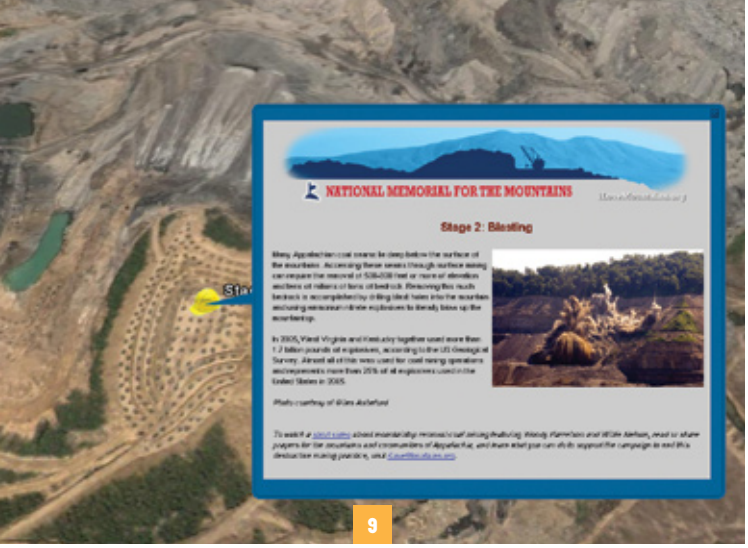
Also in September 2006, the Jane Goodall Institute (JGI) and Google teamed up to publish the first "geo-blog," a georeferenced Web log of updates about the lives of the famous chimpanzees living in Gombe National Park in Tanzania.

The "Gombe Chimpanzee Blog" is authored by field researcher Emily Wroblewshi, who is studying paternity among the chimpanzees. Her entries allow Google Earth users everywhere to understand current research findings in the program begun by Dr. Jane Goodall in 1960. Emily is trying to determine if paternal relatives treat each other in special ways.

JGI also created compelling biographies for the chimpanzees, with photographs and video clips that are included in the JGI layer in Google Earth (see ***Figure 6***).

In order to support this project, Google published new 0.61-m satellite imagery provided by DigitalGlobe (Longmont, Colo.). The new high-resolution imagery clearly shows the extent of deforestation in the Gombe region—lush and green inside the park and dry and brown outside (see ***Figure 7***). The deforestation is a serious problem for the Gombe chimps, as their feeding range outside the park has diminished. It has also led to flooding, landslides and loss of life in villages below the deforested slopes, as reported by Lilian Pintea in the Winter 2005-06 issue of *Imaging Notes*.

JGI is using Google Earth in concert with other technologies to portray these issues to the Tanzanian government, as well as to work with local communities to develop land use plans that will es-



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tablish a network of village-protected forest reserves outside the park.

APPALACHIAN VOICES: MOUNTAINTOP REMOVAL COAL MINING

In March 2007, the environmental advocacy group Appalachian Voices joined with Google in publishing a layer illustrating the effects of mountaintop removal mining in Appalachia.

This layer tells the stories of more than 470 mountains that have been dynamited in order to extract coal. Before-and-after image overlays are included (see ***Figure 8***), along with a detailed site tour which annotates the stages of a specific mountaintop removal operation (see ***figure 9***). In the Google Earth high-resolution imagery, users can see dynamited areas, the giant dragline machine which digs out the blasted material, drinking-water streams blocked by the mining debris, and neighboring communities affected by the mining.

Within the first week after the release of this layer, the Appalachian Voices online petition grew from two signatures to more than 12,000, including signatures and commentary by concerned individuals from all over the United States and the world.

NEIGHBORS AGAINST IRRESPONSIBLE LOGGING: COMMUNITY ACTION IN THE SANTA CRUZ MOUNTAINS

In the fall of 2005, a Silicon Valley water company announced plans to log more than 1000 acres of towering redwood trees in the Los Gatos Creek watershed of Northern California—the largest stand of coastal redwoods left in Santa Clara County—in a watershed that supplies drinking water to more than 100,000 people. The logging plan map provided to local residents was a black-and-white, low-resolution sketch that did not convey what was at stake. It was difficult to decipher and the local citizens did not understand it.

On behalf of Neighbors Against Irresponsible Logging, I remapped the plan instead in Google Earth, showing in vivid 3D imagery how close the logging trucks and chainsaws and heli-copters would be to schools, daycare centers and public open space (see ***Figure 10***). The annotation also depicted where endangered red-legged frogs had been spotted and specific locations of magnificent old-growth trees that would be cut.

When this "virtual flyover" was presented at a community meeting, the local residents gasped with recognition. The issues were much more clear. It galvanized opposition to the plan by the community, local policy makers and even Al Gore. The flyover has been featured on TV and radio news programs. As a result of the "organized and informed community opposition," the plan was withdrawn.

Although it has now been revised and resubmitted, a second Google Earth project has now been published, which demonstrates that the revised plan is invalid. For more information, see http://www.mountainresource.org/nail.


11

ADDITIONAL PROJECTS

Google Earth currently includes additional projects and layers, which can be seen by clicking on "Global Awareness" (see ***Figure 11***):

- ***Amazon Conservation Team and Amazon Indians Protecting their Land***
- ***WWF Global Conservation Projects***
- ***National Geographic - Elephant Poaching in Africa***
- ***New Snow and Ice Information***
- ***International Polar Year***
- ***Arctic and Antarctic Ice Floes***
- ***Wyoming Gas Drilling***

CONCLUSION

Google Earth is freely available to everyone around the globe as a canvas on which to portray compelling public-benefit information in a vivid geospatial context. It's not difficult to get started. Just explore KML files created by others. Many groups and individuals have already used Google Earth successfully to raise awareness, inspire action and affect positive change in the world. There are now more than 200 million Google Earth users around the world. «

NOTE *Rebecca will present this information at the 5th International Symposium on Digital Earth on June 6, 2007. (www.isde5.org).*

Planet Action Collaboration to Provide Climate Change Tools

HERVÉ BUCHWALTER, CEO OF THE FRENCH SATELLITE COMPANY SPOT IMAGE SHARES PLANS FOR PLANET ACTION WITH *IMAGING NOTES* PUBLISHER MYRNA JAMES YOO.

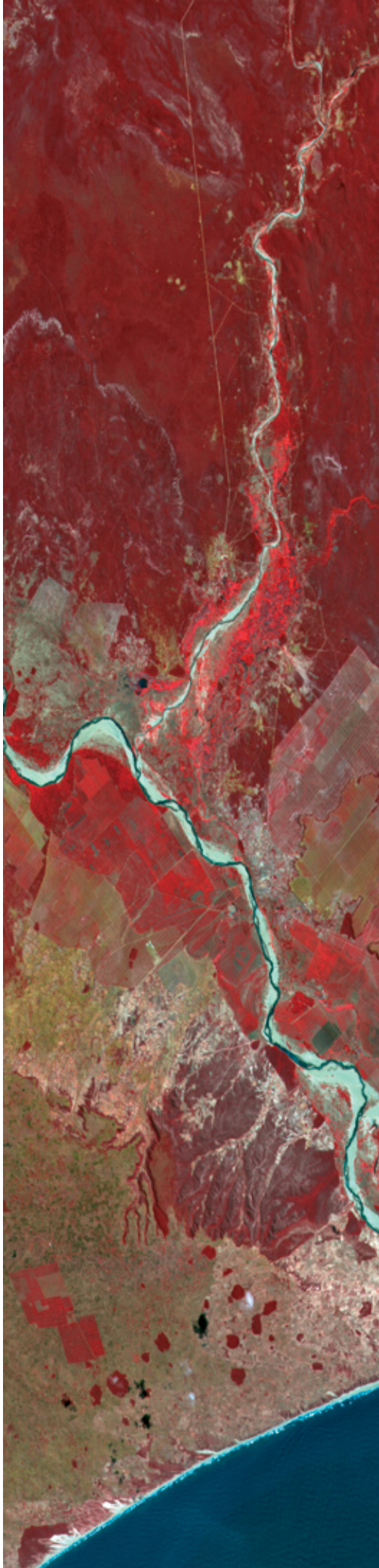

HERVÉ BUCHWALTER


MYRNA JAMES YOO

MYRNA JAMES YOO We understand that you originated Planet Action, an initiative about global warming. What was your inspiration for this idea?

HERVÉ BUCHWALTER If you remember, when space exploration started with the Mercury and Vostok programs in 1961, our perception of our planet Earth was radically changed, because we were at last able to contemplate it from a distance. Well, we at Spot Image have been in the remote sensing business for more than 20 years, and as such have developed an acute sense of responsibility about what happens on Earth.

When the case of global warming was so widely made in 2006, we immediately felt the need to engage in action. Can you cite any other industry which would be better placed than the field of Earth Observation to support projects and action on global warming? I'd like to point out that a very timely article in the Summer 2006 issue of Imaging Notes, titled "Udo's World" by Dr. Tim Foresman, helped us to make the "go" decision about the project.



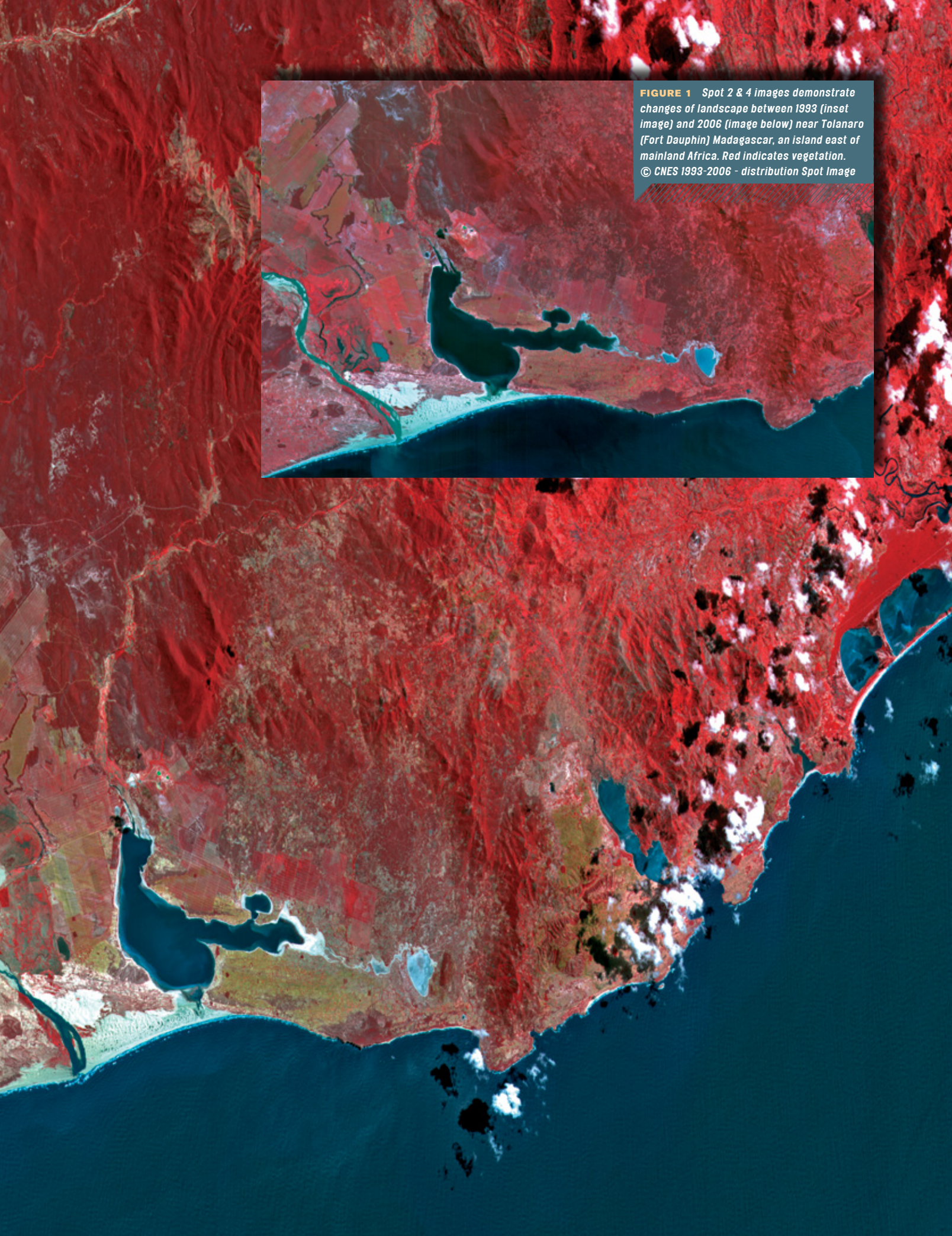


FIGURE 1 *Spot 2 & 4 images demonstrate changes of landscape between 1993 (inset image) and 2006 (image below) near Tolanaro (Fort Dauphin) Madagascar, an island east of mainland Africa. Red indicates vegetation.*
© CNES 1993-2006 - distribution Spot Image

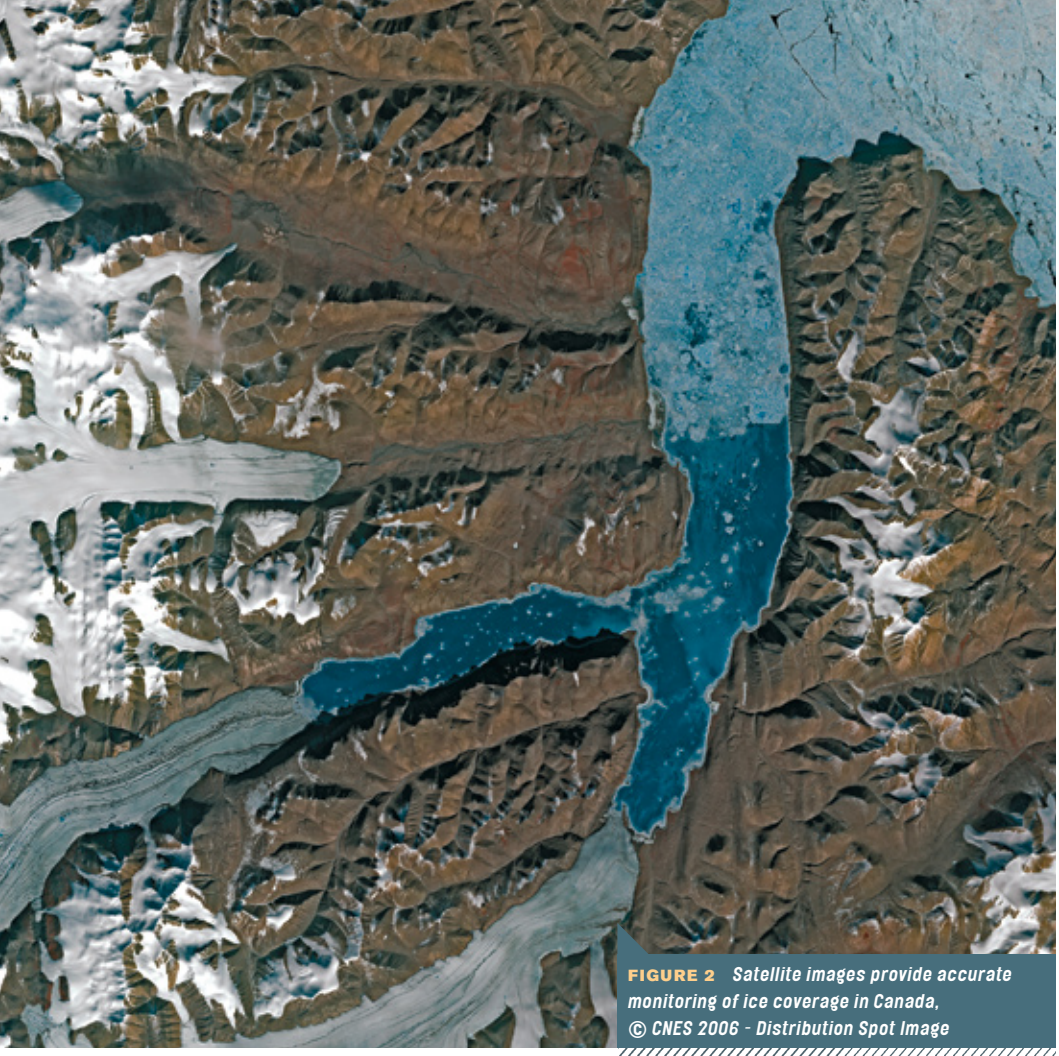


FIGURE 2 *Satellite images provide accurate monitoring of ice coverage in Canada, © CNES 2006 - Distribution Spot Image*

FIGURE 3 *Aerial view of the French Dumont d'Urville base, Terre Adélie, Antarctica, © CNRS Photothèque/IPEV/P. Katell/UPS 2928 - Institut polaire - Plouzane*

YOO What is Planet Action and what is its purpose?

BUCHWALTER Planet Action comes at the crossroads of three ideas: First and foremost, we want to support with imagery the initiatives that deal with global warming, whether big or small, whether they come from the scientific community, which they usually do, or from civil society, which they increasingly do. Our intention here is to bring these communities together, to use the remote sensing imagery as the link between global programs and local projects, between measures and actions.

Earth imagery has a very powerful effect in visualizing what really happens, even more so when you bring in time series on any location. Just consider, as an example, the real success of the "Atlas of a Changing Environment" published by UNEP (United Nations Environment Programme) a couple of years ago. Spot Image is among the few to be able to help do this, thanks to its huge archives, and this is a very good opportunity for us to put this legacy to use as a contribution. We'd like the Planet Action platform to be a kind of hub where big science meets village projects, where you can envision climate change at both a global and a local scale.

The second idea is to provide a kind of common depository of all the knowledge created by these projects. In his article mentioned earlier, Dr. Foresman envisioned an Earth Scope that would provide a transformational vision of what happens on Earth. We hope that the Planet Action Internet platform will become one of the starting blocks that activates this vision. We see it as an open platform for projects as well as for various participating actors, with a combination of content management and visualization tools. We would like it to be a place where anybody from anywhere in the world, whatever his or her background, can retrieve information, share and spread

awareness and feel impelled to action. Google Earth is already doing a tremendous job in this respect.

The third idea is to provide materials that raise awareness and support educational programs about climate change. It is our hope that Planet Action will stimulate schools and youth because their generation will ultimately be the most directly concerned. We are designing Planet Action as a means to bring together scientists and NGOs, international institutions and local organizations, industries and citizens. There is something new to invent here and there are boundaries to cross.

YOO What will Spot Image's specific role and contribution be?

BUCHWALTER There is no ownership of such an initiative, as we hope it will reach far beyond our means. We see our role as catalysts of a dynamic that we will help to grow and thrive. We can do this only with partners, existing ones and new ones. We've already identified and contacted like-minded companies and organizations, both within and outside our industry who are slated to play a significant role. Spot Image will contribute free satellite images, whether from our archives or from acquisition. To this, we will add our connections and relationships with both the industrial and scientific communities, plus a contribution in images sold at cost, something comparable to the French Isis or European Oasis programs to which we contribute via CNES (Centre National d'Etudes Spatiales), the French Space Agency.

YOO What is the scale of Spot Image's contribution?

BUCHWALTER This year is serving as a "proof of concept" phase where we experiment with the idea and check how it fits with our internal processes. We plan to donate some 700,000 km^2 of imagery for some 15 to 20 projects that we'll support in 2007. Most have been identified, a few have already started, and others will be brought by our partners.

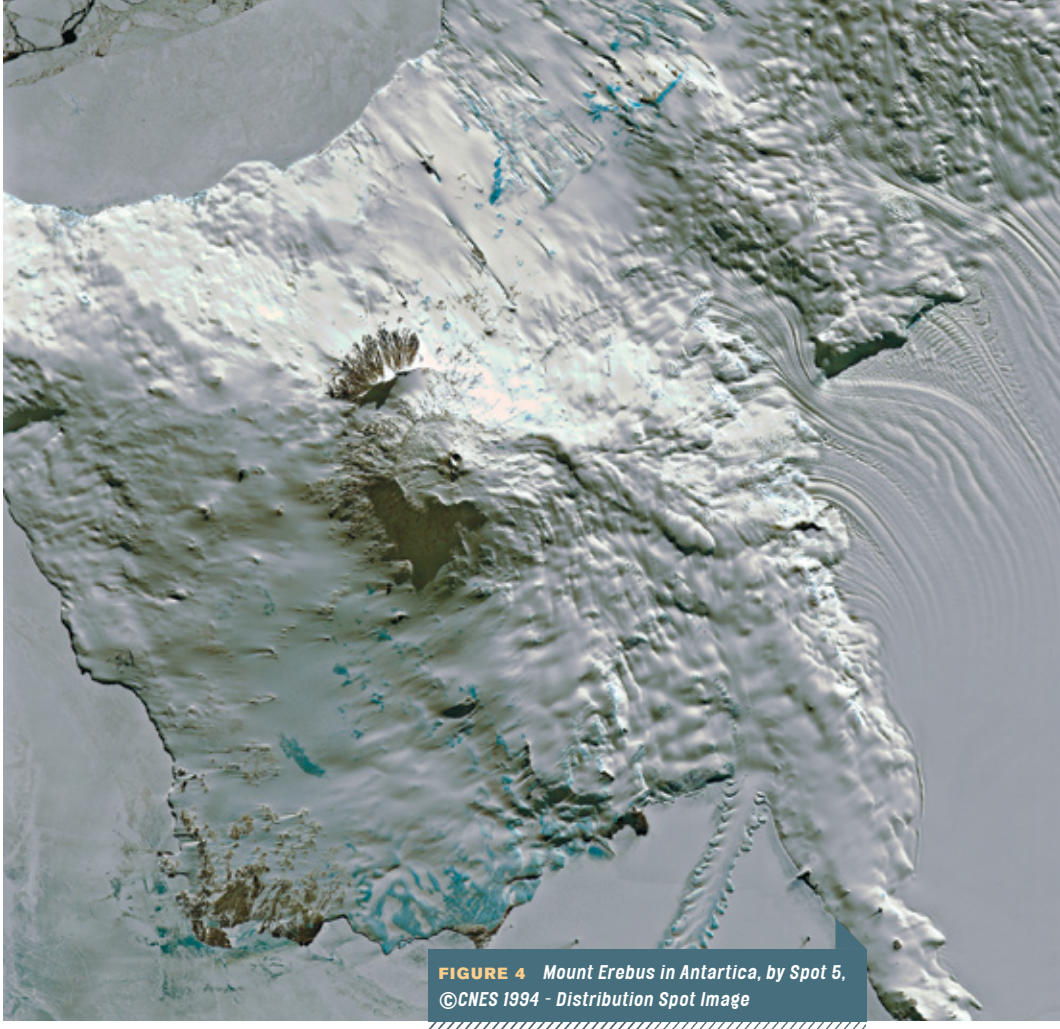


FIGURE 4 *Mount Erebus in Antartica, by Spot 5, ©CNES 1994 - Distribution Spot Image*

YOO Under what kind of license will these images be available?

BUCHWALTER You touch on a rather important and sensitive issue. The Planet Action purpose is to disseminate Earth imagery to people and communities who are not necessarily familiar with it. We are in the process of researching various license options to fulfil this objective without jeopardizing the profitability of our company. Licensing will enable a large exchange and access to data while keeping our business safe. Here again, we may experiment with new ideas. Another dimension attached to this is to train and educate new users on how properly to select the kind of data they need, how to understand what can be available and what cannot, how best to use this imagery and so on.

YOO Could you provide any detail about some projects?

BUCHWALTER Well, let's talk for instance about the International Polar Year, in which CNES, the French Space Agency, is very involved. This is a huge project, not only because of its size, but because of its potential implications. After the recent IPCC (Intergovernmental Panel for Climate Change) meeting in Paris, the 4th IPY (International Polar Year) was launched in March 2007, with 210 projects that will deal with melting ice, thawing permafrost, threatened populations and wildlife. Among these projects, 58 will have a French component, with several to be supported by satellite imagery. Planet Action will bring an additional dimension to existing community projects. For instance, we are currently consid-

ering a project in the Svalbard area of Norway, where a satellite reception station stands. *(Editor's note: The cover story of our Spring 2007 issue was a report from Svalbard.)*

Planet Action is also paying attention to projects that relate global warming to a human health element. For example, we are accompanying a project in Senegal that is monitoring environment and early warning systems about vector-borne diseases such as Dengue Fever or Rift Valley Fever.

As another example, a small NGO came to us to get support to study the changes in vegetation in Madagascar, due to the appearance of invasive plants that may relate to climate change. *(See **Figure 1** on page 31.)* All these are reference projects, which we are working with now in order to see how best we can support them, what kind of data they need, and how we can provide them with useful scientific support. For this scientific support, we have engaged talks with the USGS and France's IRD (Institut de Recherche pour le Développement). In order for Planet Action to scale up, we plan to launch an international call for projects in 2008, according to criteria and qualification processes that we will have fine-tuned during this early phase.

YOO How will you select these projects?

BUCHWALTER I don't think it is appropriate to speak of a selection process. The intention here is to set up a very open support protocol with clear and simple qualification criteria. As you would easily understand, in this matter the more projects the better. This being said, we have limited means and, as a start, we plan to support them on a first-come, first-served basis. This is another reason why partnerships and extra funding are needed to expand progressively the scope of projects as much as possible and gain momentum.

YOO What would these qualification criteria be?

BUCHWALTER Well, to qualify for support from Planet Action, the projects will have to address one of the following five fields: water resources and hydrology, ice and snow cover, drought and desertification, human issues and coping strategies, or agriculture and forestry. The project teams are expected to be international and to have at least one representative from the country where the project takes place. The projects should have a scientific dimension, of course, but should encompass a proposal or recommendation for action, in order to cope with the human impact of their findings. We would like the projects to have support from a university or a research lab to ensure their scientific validity.

There will not be subsidiary relationships in Planet Action, meaning that if there is already a support program for which the project qualifies that would provide a similar support to the project as the Planet Action one, then our support would not replace the original support program. These criteria will be finalized together with our partners.

YOO Why are you doing this?

BUCHWALTER As I mentioned before, this is a matter of corporate responsibility for us. So much so that, together with launching the Planet Action initiative, we are in the process of initializing a "Carbon Plan" within Spot Image to evaluate and compensate our carbon imprint. And there are a couple of other reasons. We see here an opportunity to add value to our archives, which are quite under-used, given their huge potential. Furthermore, Planet Action is a way for us to reinforce our existing partnerships. I'm thinking here of our Direct Receiving Stations (DRS) network, which spreads all over the world. Should they wish to, the DRS can be at the forefront of local initiatives to help assess the climate change impact in their region and to stimulate coping and adapting strategies within the population.

Last but not least, we'd be happy to see Planet Action as a way to start and

grow new partnerships, within and beyond our industry, because we think that our business, as well as climate change, is at a turning point and that extended partnerships will be part of the solutions. It may very well be that Planet Action teaches us new ways of doing business, brings in a new business culture to Spot Image and reaches out to new constituencies.

YOO Where will the funding come from?

BUCHWALTER First from the various Planet Action partners that will contribute either in cash or in kind to fund the Internet platform, the communication and education actions, and coordination. Next, the intention is to set up a foundation, possibly in 2008, which will become the proper vehicle to receive more significant funding from corporations, organizations and other foundations, and to extend support to other related projects.

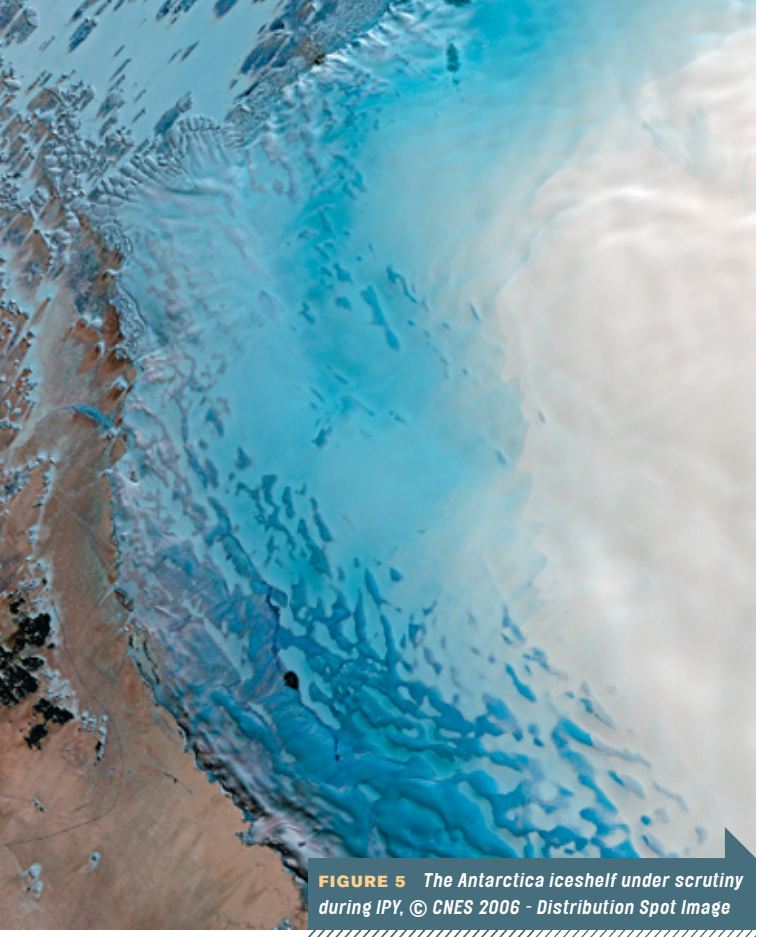


FIGURE 5 *The Antarctica iceshelf under scrutiny during IPY, © CNES 2006 - Distribution Spot Image*

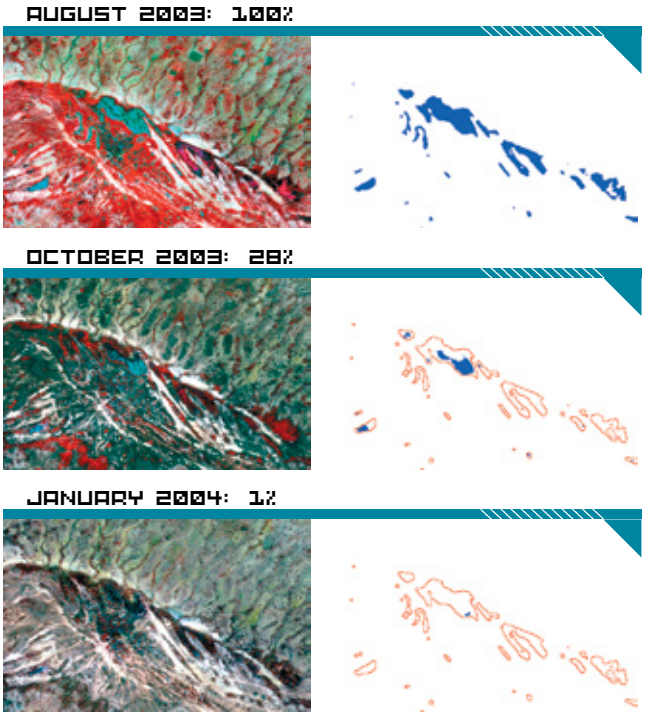
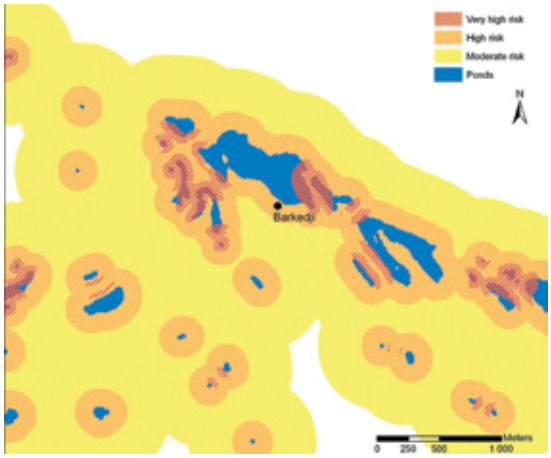


FIGURE 6 *Monthly satellite images monitor ponds' evolution in Barkedji area of Senegal for viral vectors risk analysis. Upper left: "Classic" false color composite from SPOT 5 images over Barkedji's zone. Upper Right: Detailed detection of ponds in the Barkedji's zone, with rate of draining expressed in %. The red line is for the pond's contour during the peak of rainy season. © Medias product, CNES 2004 - Distribution Spot Image.*

Below is an example of the brand-new ZPOM index with its 3-level RVF risks mapping. Clusters of ponds can be easily identified in blue, on Aug. 26, 2003 during the peak of the rainy season.



YOO How many partners have already joined?

BUCHWALTER Three Direct Receiving Stations in Asia, North America, and South America plan to join at this early stage. They did so with an enthusiasm that is a real support for us. We expect ten to twelve others to join by the end of the year. Infoterra, our sister company within the EADS Astrium group, recently joined us. We found a great partner in Dr. Tim Foresman. He has significant scientific and environmental expertise, and his commitment to the Digital Earth movement and his International Centre for Remote Sensing Education are key assets for Planet Action. (*Editor's note: Tim Foresman's column, Earth Scope, on page 10 discusses this subject.*) Dr. Bob Correll, who chaired the Arctic Impact Assessment supports the initiative as well. The USGS has shown interest in Planet Action and, as we talk, things seem well-engaged with them too.

As the Planet Action initiative gains momentum, we believe other companies and organizations will join. I take the occasion of this interview to appeal to any reader of your magazine: Whether big or small companies, whether in the remote sensing business or not, we would welcome any contribution to this project, whatever it may be!

As a final word, I'd like to quote a phrase from the United Nations Foundation and Sigma Xi (the Scientific Research Society) in their report, "Confronting Climate Change" (prepared for the 1st Session of the Commission on Sustainable Development): "There is still time to avoid the unmanageable and manage the unavoidable." ⁂

NOTE *For more details about Planet Action, go to www.planet-action.org.*

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Code Red?

CHINESE ASAT TEST RAISES DEBRIS THREAT TO EO SATS

AS OF MARCH 9, THE TOTAL SPACE DEBRIS CREATED BY CHINA'S JAN. 11 TEST OF AN ANTI-SATELLITE (ASAT) WEAPON had leapt to 1,500 pieces[1] and counting—and those are just the larger bits that can be seen. According to Nicholas Johnson, chief scientist for NASA's Orbital Debris Program Office at Johnson Space Center in Houston, Texas, the Chinese test "represents the most prolific and serious fragmentation in the course of 50 years of space operations."[2]

Unfortunately for operators of Earth observation (EO) satellites, China's destruction of the aging Fengyun-1C (FY-1C) weather satellite happened right smack in the middle of their neighborhood at an altitude of 860 kilometers in the highly popular sun-synchronous, polar orbit. Not only does the new debris represent an increased near- and mid-term threat to today's satellites, the specter of further tests—or wartime use—of destructive, direct-ascent ASATs poses an even greater threat to the existence of all EO operations. Even more unfortunately, there are no easy options for eluding those threats.

CODE RED FOR LEO?

The Chinese space debris now being tracked by the U.S. Space Surveillance Network has migrated from the FY-1C impact point to become a cloud stretching from 3,850 kilometers high down to about 200 kilometers, in essence polluting all of low Earth orbit (LEO). Again, this is only what can be seen: debris chunks larger than 10 centimeters in diameter, about the size of a baseball. NASA is estimating that at least 35,000 smaller pieces of FY-1C (between one and 10 centimeters in diameter) are also floating in the same general vicinity. Such debris may be small, but it can be deadly. Traveling at 10 times the speed of a rifle bullet, even flecks of paint can be hazardous to a satellite's health. According to Johnson, any of the Chinese debris bits "has the potential for seriously disrupting or terminating the mission of operational spacecraft in low Earth orbit."[3]

Owned and/or operated by 33 countries plus the European Space Agency, 130 known Earth imaging satellites (commercial, civil and military) are active today. Of that total, at least 102 will routinely pass through the new debris cloud.[4]

The new Chinese debris adds to an already worrisome problem. LEO currently is the most polluted orbit, with significant concentrations of space junk in the 800-kilometer band frequented by EO and weather satellites.[5] According to T.S. Kelso, technical program manager for the Center for Space Standards & Innovation (Colorado Springs, Colo.), of the 10,453 space objects for which the U.S. releases orbital data, 7,636 of them are in LEO, defined as 2,000 kilometers and below. (Most, but not all, of those objects are debris, but that figure also includes the some 389 working satellites in LEO and a handful of satellites with elliptical orbits that pass through LEO.)

Prior to the Chinese test, debris experts put the aggregate chances of a destructive collision in LEO at about one in a decade—the approximate lifetime of a satellite in LEO—although the chances of any one satellite being hit by a piece of debris was shown to be significantly smaller, with the meantime between impact with a debris piece larger than 10 centimeters something like 15,000 years.[6] Assessing collision risk is so complicated as to sometimes appear a "black art" rather than a science, and experts have yet to get a handle on how much the Chinese test might have raised the odds of a destructive impact in LEO. However, Kelso has calculated that the Chinese test has raised the likely number of "close conjunctions" between space objects larger than 10

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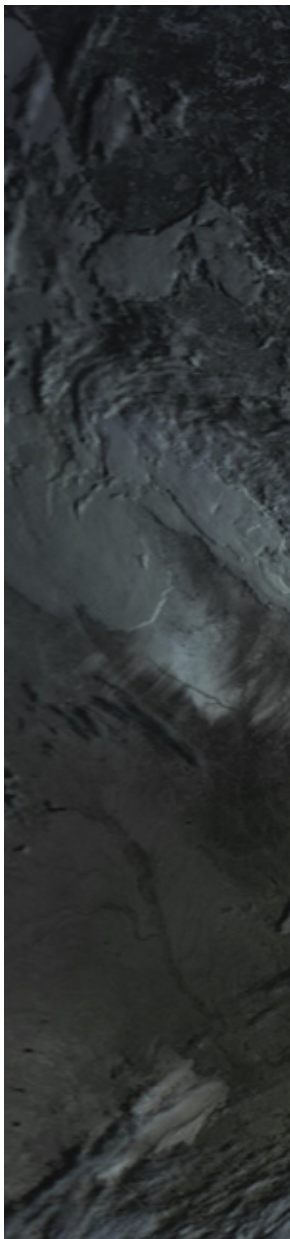


centimeters (when objects pass within five kilometers of each other) by 19.47 percent. "Not insignificant," he said.

The UN Committee on the Peaceful Uses of Outer Space offers hope in the pending agreement on a voluntary debris-mitigation regimen that includes a pledge by nations to refrain from deliberate creation of space debris. Still, it is starkly clear that if debris threats in LEO increase significantly, at some point the question of costs versus benefits for operators will arise, not only in insurance but also in viable life-span of assets.

LONG-TERM ASAT THREAT?

Beyond the near- and mid-term ramifications of the debris threat, the Chinese ASAT test raises long-term cause for concern about the safety of EO satellites: the possible introduction of destructive ASATs into future arsenals. The Chinese test was the first dedicated ASAT-weapons test in more than 20 years, highlighting the growing tensions in space caused largely by the increased reliance on space assets by the world's militaries, especially that of the United States. In addition, some developing nations have begun to question the legitimacy of satellites for Earth observation and "spying" that were established by the former Soviet Union and the United States during the Cold War as a means of reducing nuclear tensions. Indian leaders, for example, have complained that Google Earth is enabling a potential threat from terrorism or arch-rival Pakistan.[7]

> "THE CHINESE TEST 'REPRESENTS THE MOST PROLIFIC AND SERIOUS FRAGMENTATION IN THE COURSE OF 50 YEARS OF SPACE OPERATIONS.'" – NICHOLAS JOHNSON

While the Chinese are the first to break the unspoken taboo against ASATs that has existed for the past two decades, other nations—including the United States, India and Israel—are known to be considering satellite attack methods as part of their military strategies for the future. And although the U.S. military continues to shy away from destructive ASAT

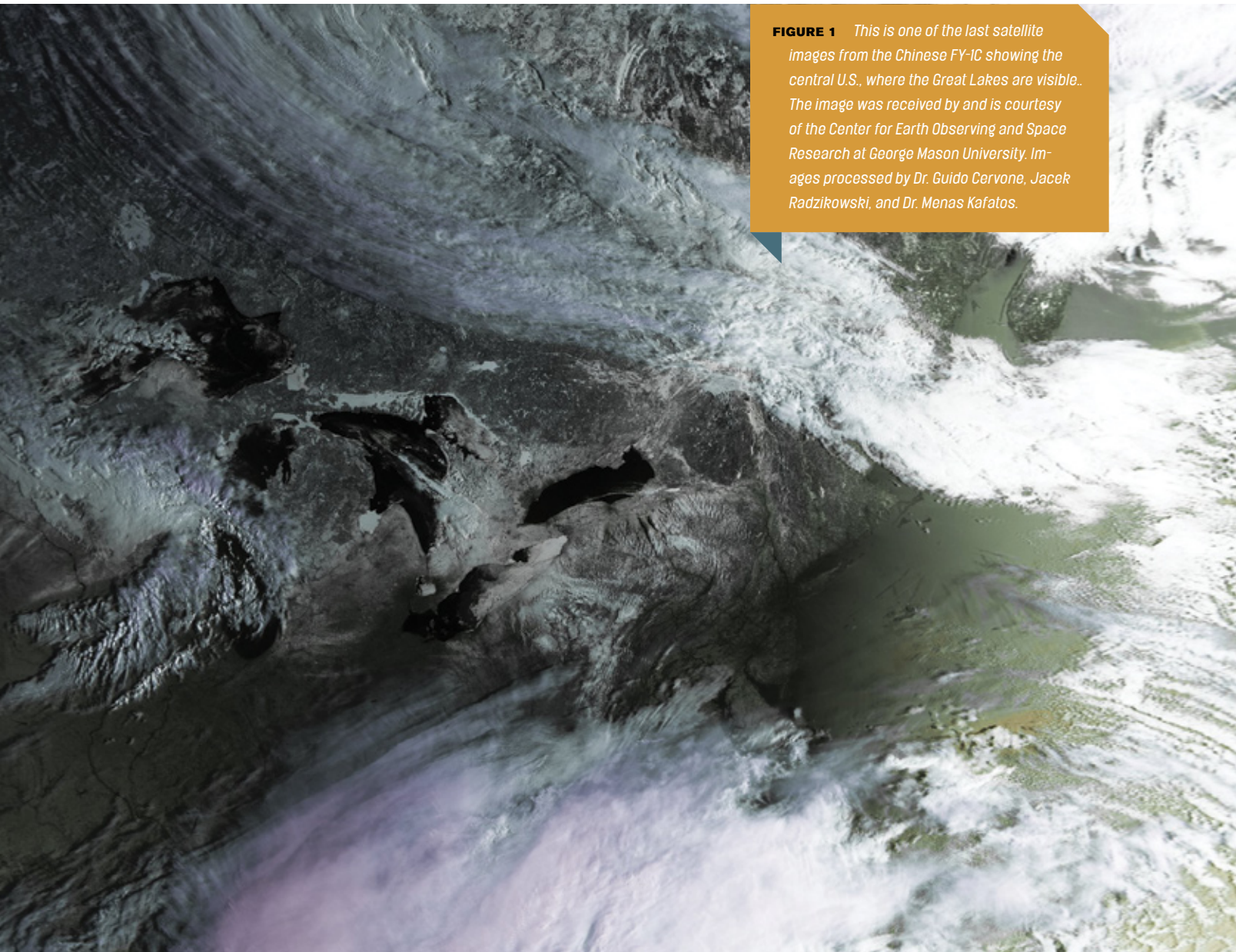


FIGURE 1 *This is one of the last satellite images from the Chinese FY-1C showing the central U.S., where the Great Lakes are visible.. The image was received by and is courtesy of the Center for Earth Observing and Space Research at George Mason University. Images processed by Dr. Guido Cervone, Jacek Radzikowski, and Dr. Menas Kafatos.*

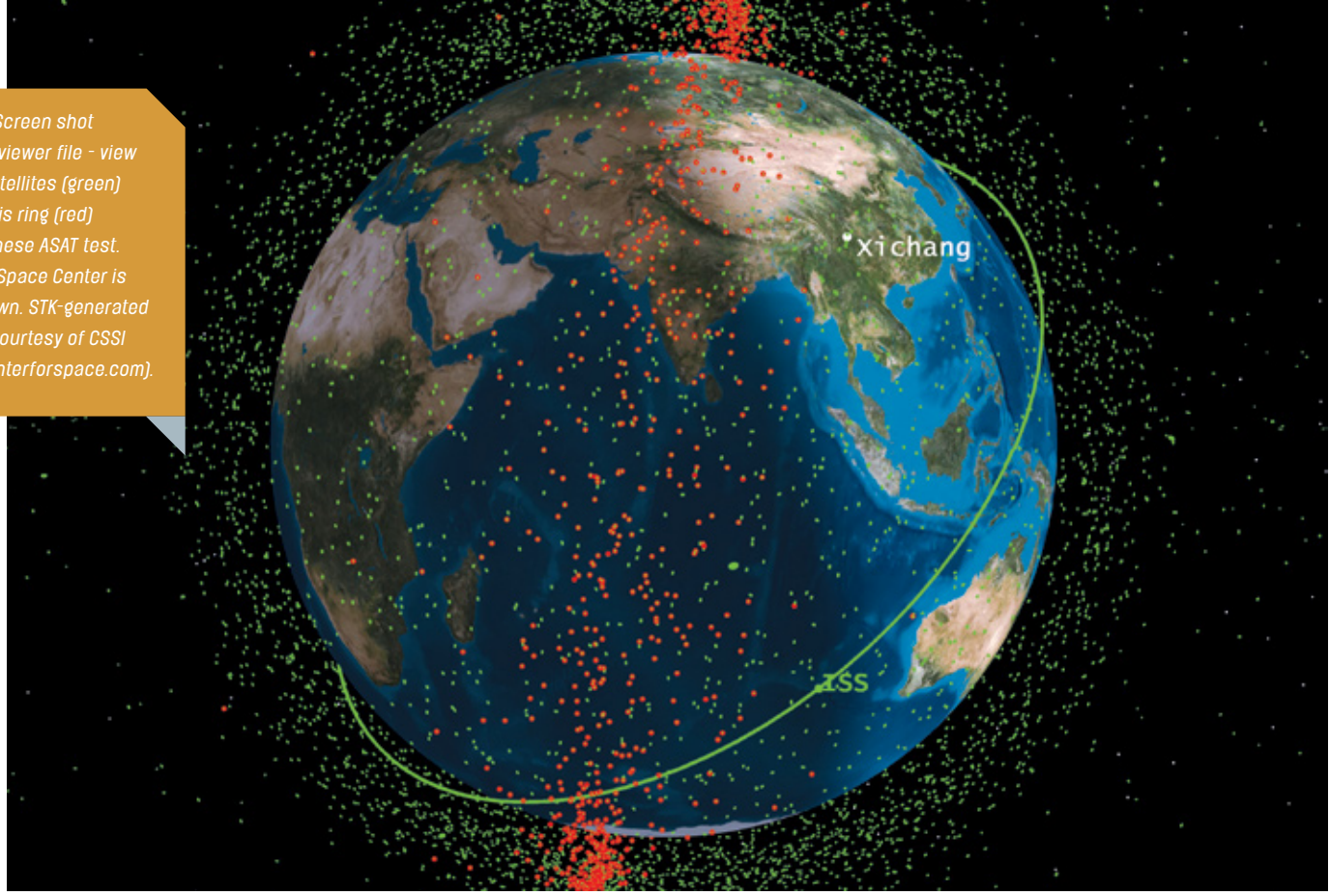


FIGURE 2 *Screen shot from AGI viewer file - view of LEO satellites (green) and debris ring (red) from Chinese ASAT test. Xichang Space Center is also shown. STK-generated images courtesy of CSSI (www.centerforspace.com).*

weapons in favor of what the Air Force terms "temporary and reversible means" such as jamming, it is highly unclear (as witnessed by the Chinese test) that others would follow that high-technology route in the event of an ASAT competition.

This possible future use of ASATs is doubly bad news for EO operators. While jamming (or possible laser blinding) attempts can be thwarted or at least made more difficult with technological protections, there aren't really any escape routes from a direct ascent attack for LEO-based satellites. Enabling the capability for rapid and significant maneuvering is simply too costly.

While one future solution might be the replacement of today's constellations of a few large satellites with more numerous small or micro-satellites (a capability proven feasible by the five-nation Disaster Monitoring Constellation),[8] the current reality is that a world where ASAT warfare is possible is a world in which EO satellites are in grave danger. While EO operators up to now have largely been ignoring the growing international debate about the wisdom of ASATs, it is apparent that they now are no longer able to do so. «

FOOTNOTES

1. The number of pieces being tracked, according to NASA; the number entered into the official catalog on Mar. 9, 2007 was 1,117.

2. Leonard David, "China"s Anti-Satellite Test: Worrisome Debris Cloud Circles Earth," Space.com, Feb. 2, 2007, www.space.com/news/070202_china_spaced-ebris.html

3. Ibid

4. Data from the Union of Concerned Scientists' Satellite Database, www.ucsusa.org/global_security/space weapons/satellite_database.html

5. "Orbital Debris Frequently Asked Questions," NASA Orbital Debris Program Office website, http://orbitaldebris.jsc.nasa.gov/faqs.html

6. "Space Debris: Assessing the Risk," European Space Agency, March 16, 2005, www.esa.int/esaCP/SEMZL0P256E_FeatureWeek_0.html

7. Elizabeth Svoboda, "Google"s open skies raise cries," The Christian Science Monitor, Dec. 1, 2005, www.csmonitor.com/2005/1201/p13s01-stct.html

8. The project involves Algeria, China, Nigeria, Turkey and the United Kingdom, and provides medium-resolution capability based on a micro-satellite design by Surrey Satellite Technology, Ltd. of the United Kingdom.

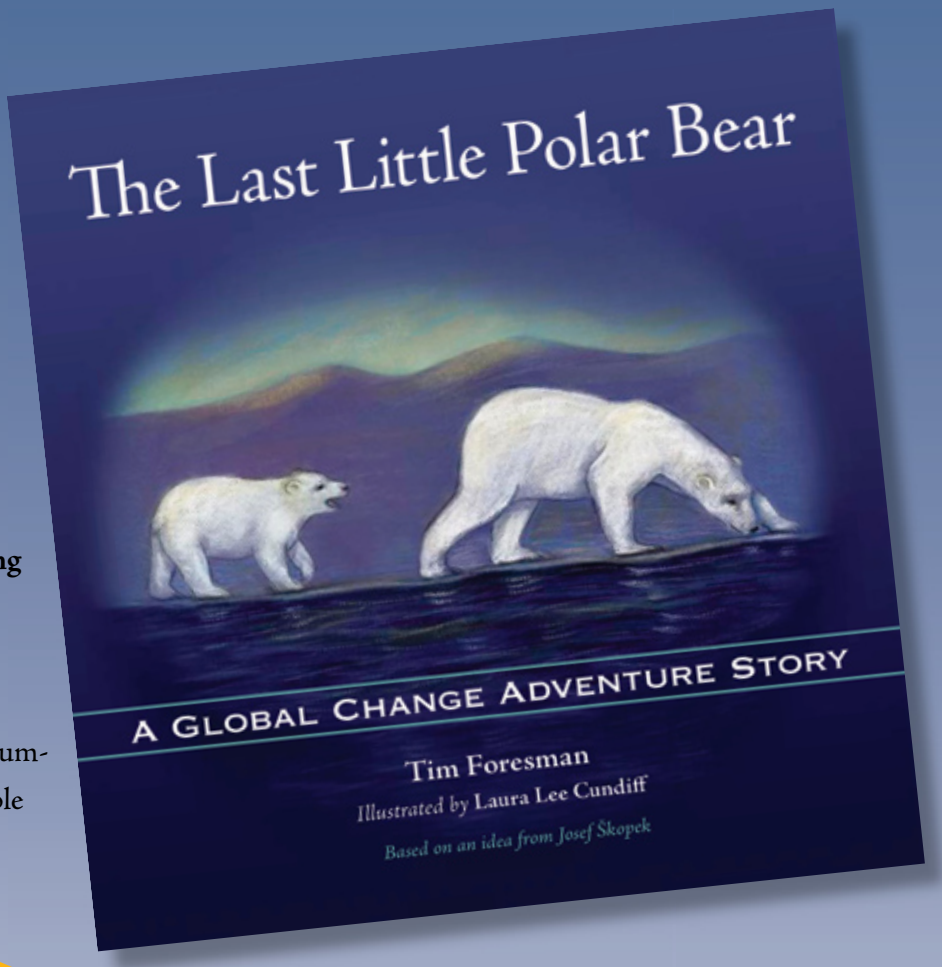
THERESA HITCHENS *is Director of the Center for Defense Information, and a consultant for Secure World Foundation, which works towards efforts to establish the secure and sustainable use of space through enforceable, law-based global systems.*

NOTE *Editor Ray Williamson also writes about orbital debris in Policy Watch on page 8.*

The Last Little Polar Bear

A Global Change Adventure Story for Children

"This book is a brilliant conveyance to engage our youth into the compelling learning experience about science issues now being discovered that are forging the fate of both polar bears and the polar environments."
– Robert W. Corell, Chairman, Arctic Climate Impact Assessment



The Last Little Polar Bear

is a thoughtfully written and beautifully illustrated children's book for ages 8-14. It was written out of deep concern for the future of our environment and the Earth by scientist **Dr. Timothy W. Foresman**, illustrated by artist and environmentalist **Laura Lee Cundiff**, and published by globally aware publisher **Blueline Publishing** of Denver, Colorado.

The book is a lavishly illustrated 64-page, hardcover book printed on 100% post-consumer waste recycled paper. First edition available in June 2007.

Author Dr. Tim Foresman will sign books at the Digital Earth Symposium on June 5 and at the ESRI User Conference on June 19, 2007

Order online:
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A portion of proceeds from this book will be donated to indigenous tribal cultural centers.

Zooming in on Climate Change

THANKS TO THE ROUTINE DISPLAY OF cloud cover during TV weather forecasts and the incorporation of satellite imagery into mapping platforms, including Google Earth and Microsoft Virtual Earth, the value of satellite technology has never been more apparent. However, such applications do not come close to demonstrating the full potential of satellites to serve society, especially those of high-resolution commercial satellites in the increasingly important area of climate change.

Two recent reports by the Intergovernmental Panel on Climate Change have elevated the urgency of climate change research. The panel said in February 2007 that "warming of the climate system is unequivocal," and then in April warned that "many natural systems are being affected by regional climate changes, particularly temperature increases."

Citing cost concerns and a need to view broad geographic areas, scientists have traditionally gravitated toward publicly available, lower-resolution satellite imagery for the purposes of studying climate change signals and impacts. But Mark Brender, vice president of marketing and corporate communications at GeoEye (Dulles, Va.), a major producer of satellite, aerial and geospatial information, says that evolving technology is turning up a growing number of uses for commercial imagery in climate-related research.

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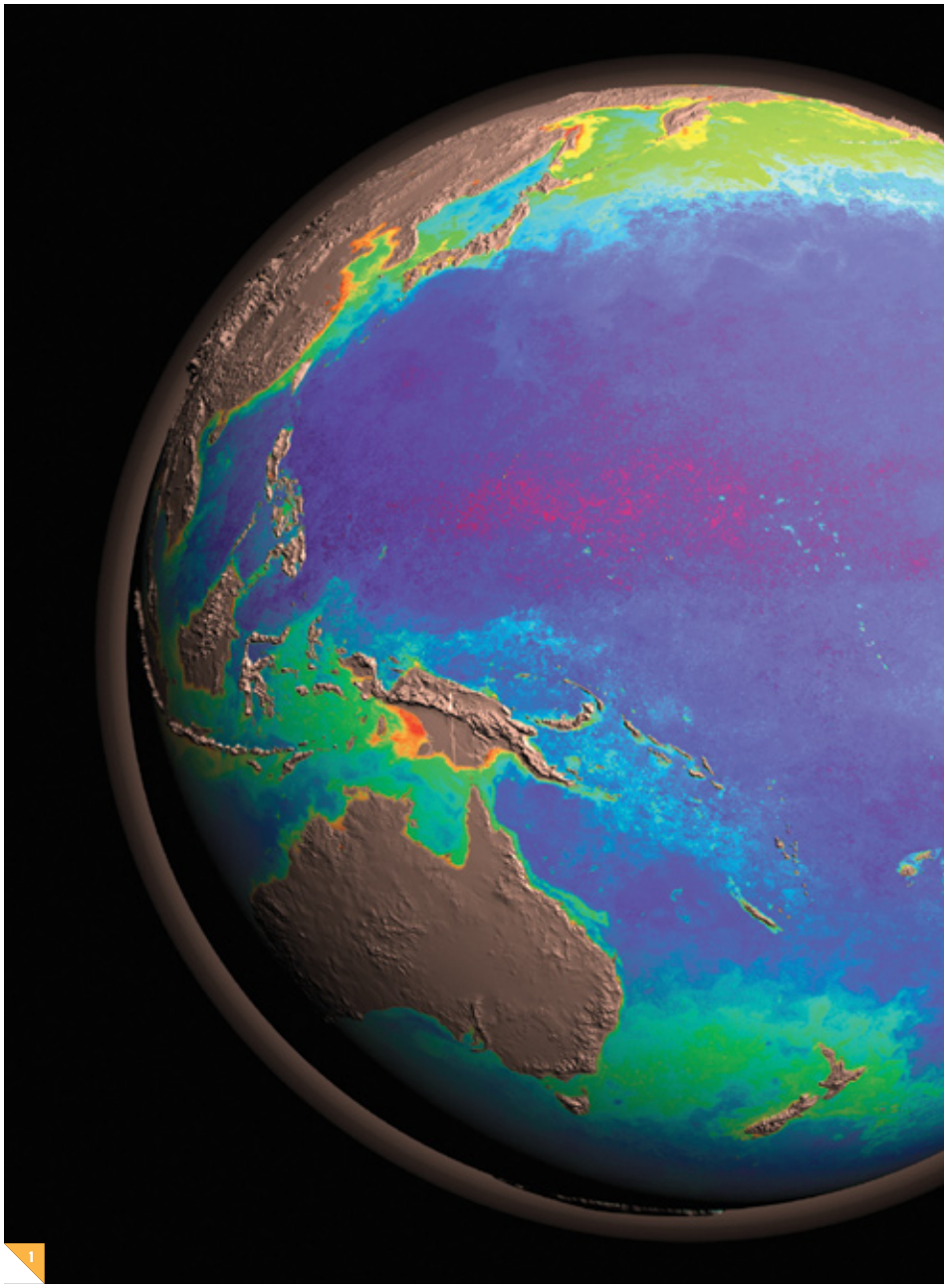
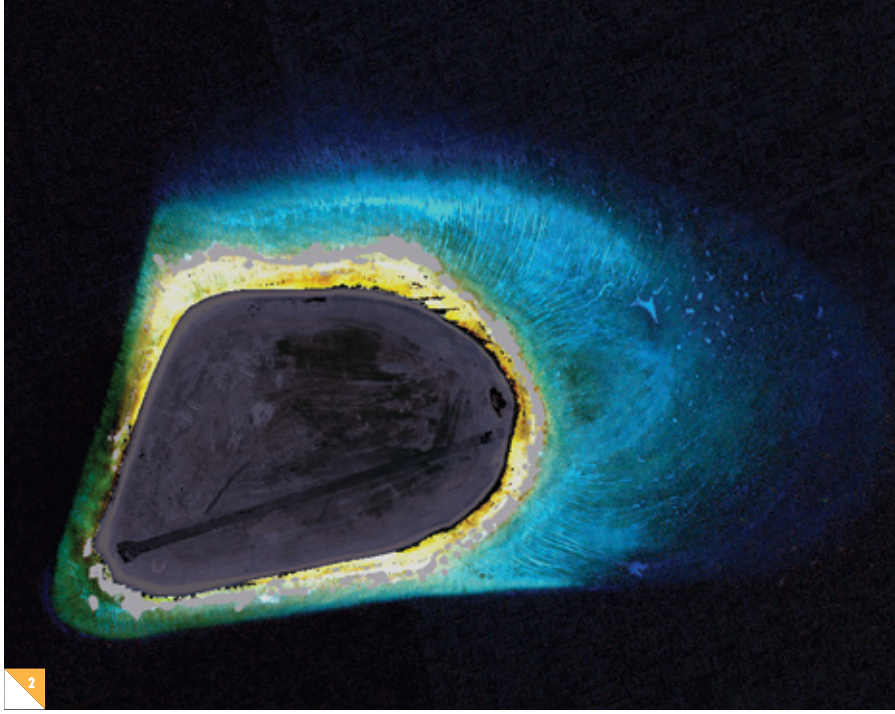
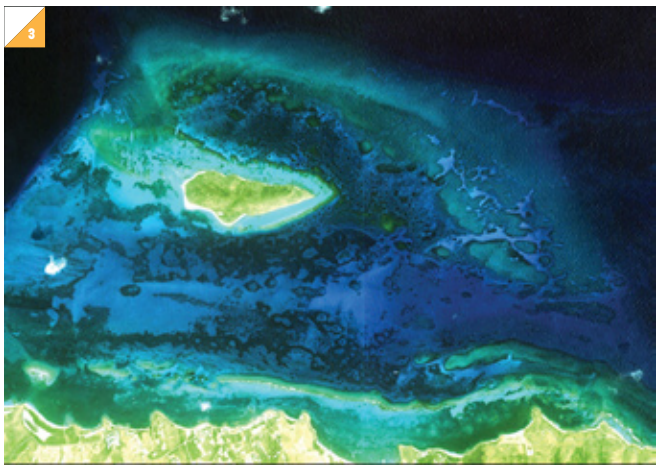


FIGURE 1 *SeaWiFS data over the Pacific Ocean, including a 32-day average from September 22, 2006 to October 23, 2006. Dark blue represents warmer areas where there is little plant life due to lack of nutrients, and greens and reds represent cooler nutrient-rich areas with more abundant plant life.*

"The commercial remote sensing industry is an extra set of eyes in the sky that can be utilized in looking at a host of climate change indicators, including glaciers and coral reefs, and in the verification and monitoring of carbon sequestration efforts," Brender said. "While high-resolution imaging satellites can't see climate change, they can certainly see the impact climate change has over the long term."

That sentiment is echoed by Chuck Herring, director of corporate communications at DigitalGlobe (Longmont, Colo.), also a major provider of commercial satellite imagery and geospatial information. The resolution, accuracy and coverage of high-resolution commercial satellite imagery "makes it a perfect fit for documenting changes in the Earth for many different applications, from coastal monitoring to glacier melting to wildlife habitat mapping," Herring said. Spot Image (Toulouse, France) also supplies imagery for a variety of climate change applications.





OBSERVING OCEANS

One discipline already benefiting from commercial satellites is the monitoring of oceans. The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on the OrbView-2 satellite, owned by GeoEye, has led to a better understanding of the ocean's role in the carbon cycle.

By comparing climate records with SeaWiFS measurements of ocean plant life, as indicated by ocean color, NASA scientists found that as Earth's climate warms, ocean plant life is decreased. This reduction in ocean plant life has

FIGURE 2 *This four-meter IKONOS satellite image of Baker Island, located approximately 1,650 miles southwest of Honolulu, Hawaii, is being used by NOAA to monitor the coral reef ecosystem surrounding the island. Baker Island is about 1.6 square kilometers in size with the highest elevation of only 20 feet above sea level, and is a national wildlife refuge under the authority of the U.S. Fish and Wildlife Service. NOAA research has shown that IKONOS imagery has been found to have a depth penetration of up to 30 meters in clear water. Visible on the island is an abandoned airstrip.*

Baker Island is a national wildlife refuge, with sparsely scattered vegetation and no trees. It is not within the jurisdiction of any specific state of the U.S. Administrative authority was transferred from the Office of Territorial Affairs to U.S. Fish and Wildlife Service in 1974. The island has remained unoccupied since 1942 when it was attacked by the Japanese during World War II. At this time, public use is restricted to scientists and educators by special permit. IKONOS satellite image courtesy of GeoEye.

FIGURE 3 *Buck Island Reef National Monument is located 1.5 miles off the northeast side of the island of St. Croix in the U.S. Virgin Islands. This image clearly shows an extensive underwater coral reef ecosystem. The reef is being studied and monitored by NOAA. Six thousand feet long and a half-mile wide, uninhabited Buck Island rises to 340 feet above sea level. The 880-acre National Monument includes 176 acres of land and 704 acres of water and coral reef system.*

First protected in 1948, the area was proclaimed a national monument in 1961. Many endangered species nest on the island, including the brown pelican, hawksbill, leatherback and green sea turtles. Buck Island is not volcanic in origin: its sedimentary rocks were uplifted by tectonic pressures. Two thirds of this largely tropical dry forest island are surrounded by an Elkhorn coral reef, which includes the Marine Garden area, closed to fishing and collecting activities. Resembling haystacks, Elkhorn coral patch reefs are scattered along the outside of the forereef and rise nearly to the water's surface from the seabed as much as 40 feet below. IKONOS satellite image courtesy of GeoEye.

FIGURE 4 *Pearl and Hermes Atoll, Northwestern Hawaiian Islands. The islands and atolls in the Hawaiian Archipelago are moving west at a rate of approximately 9 centimeters a year from the geologic "hotspot" from which all were formed. IKONOS image courtesy of GeoEye.*

negative impacts not only on fisheries and ecosystems, but also on the ocean's capacity to store carbon dioxide from the atmosphere, thus potentially producing a feedback effect of further warming. See ***Figure 1*** on page 40.

"SeaWiFS has been instrumental in increasing our understanding of the ocean's role in the carbon cycle, which affects what happens to all the carbon dioxide emitted by human activity," said Greg Hammann, a senior director and chief oceanographer at GeoEye.

One of the ocean's most precious victims of warming may be coral reefs. A vital natural resource, coral reefs provide a safe habitat for about one million species of fish, act as a natural barrier in protecting tropical coasts from high waves and storm surges, and generate billions of dollars per year for local economies through recreational and commercial fishing. Warmer waters can lead to coral bleaching—the whitening of coral reefs due to the loss of microscopic algae—and the eventual death of coral. See ***Figures 2-6***.

Measurements of sea-surface temperatures by the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer (NOAA's AVHRR), onboard its polar-orbiting satellites, are used to identify areas at risk for coral bleaching. High-resolution commercial satellites, like GeoEye's IKONOS and DigitalGlobe's QuickBird, can then penetrate 30 to 40 meters deep in clear water to detect features on the seafloor as small as a few meters in size. NOAA scientists are using data from these instruments to map every shallow-water coral reef within U.S. waters.

Tim Battista, a biological oceanographer for NOAA's Center for Coastal Monitoring and Assessment, explains that, for this purpose, satellite imagery is less expensive than airborne methods.

"A satellite allows us the flexibility to repeatedly shoot an area until we get an optimal scene, whereas the alternative is that you put an airborne platform over there, and you're kind of dictated on where you go based on where the clouds are on a given day, or the sea state," Battista said. "It's much more cost-effective for us to shoot with a commercial satellite and wait the additional time for a good collection, than to put a plane on the ground somewhere with a limited time window."

In the future, Battista expects commercial satellites to help coastal managers regularly monitor the distribution and health of coral reefs and their ecosystems, including the progress of reef restoration projects. "In order to do that, we have to have the imagery and methodologies that are cost-effective and efficient, and the commercial satellite imagery certainly plays a big part in that," he said.

Commercial imagery has a role to play along the coast as well. In its effort to map shoreline change, NOAA augments medium-resolution data from Landsat with images from IKONOS and QuickBird.

"When you get down to right along the coast, the Landsat data fall apart—they're too coarse," said Nicholas Schmidt, chief of NOAA's Coastal Geospatial Services. "When we start noticing trends or rapid development in certain areas, our plan is to use the high-resolution imagery to concentrate on those areas of high change."

IMAGING ICE

Even more than coral reefs and shorelines, ice can provide some of the most telling and dramatic signs of climate change. In this area, too, commercial satellites are proving to be an important monitoring and mapping tool.

A recent study by scientists at Texas A&M University used 1-meter IKONOS imagery to measure the retreat of tropical glaciers on New Guinea's Mount Jaya. The researchers found that from 2000 to 2002, the total area covered by ice on the mountain decreased by 7.5 percent, continuing a trend that began in the mid-1800s.

The increasingly small size of these glaciers makes high-resolution imagery all the more critical. According to Texas A&M researcher Joni Kincaid, in 2000 the largest of the Mount Jaya glaciers occupied an area slightly larger than one square kilometer. With IKONOS, Kincaid was able to measure glacial changes to within one square meter, whereas lower-resolution imagery may not have captured changes on such a small scale.

"There are thousands of tropical glaciers. Unlike large glaciers, these small glaciers respond quickly to climate changes, and therefore it's important to be able to determine change over small time periods," Kincaid said.

While Kincaid concentrates on tropical land ice, Burcu Cicek is focused on Antarctic sea ice. Late last year, the University of Texas, San Antonio researcher sailed with an international team of scientists on a Swedish icebreaker as it chiseled a channel through frozen McMurdo Sound, clearing the way for supply and fuel ships to reach McMurdo Station. Us-

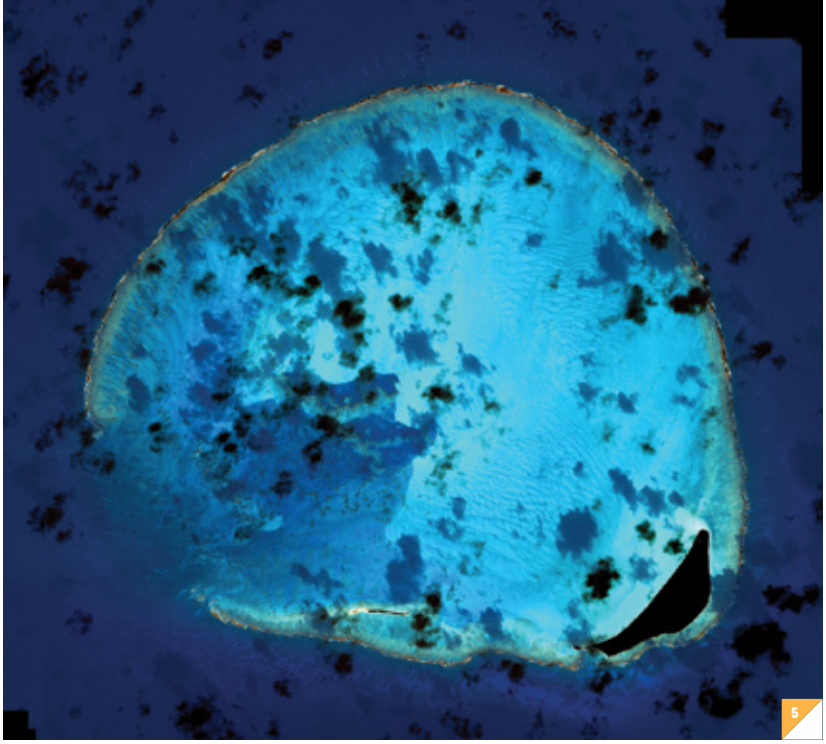


FIGURE 5 *Kure Atoll in the Northwest Hawaiian Islands is located approximately 2,200 km west-northwest of Honolulu, and is the oldest emergent land area in the Hawaiian archipelago (approximately 30 million years). IKONOS image courtesy of GeoEye.*

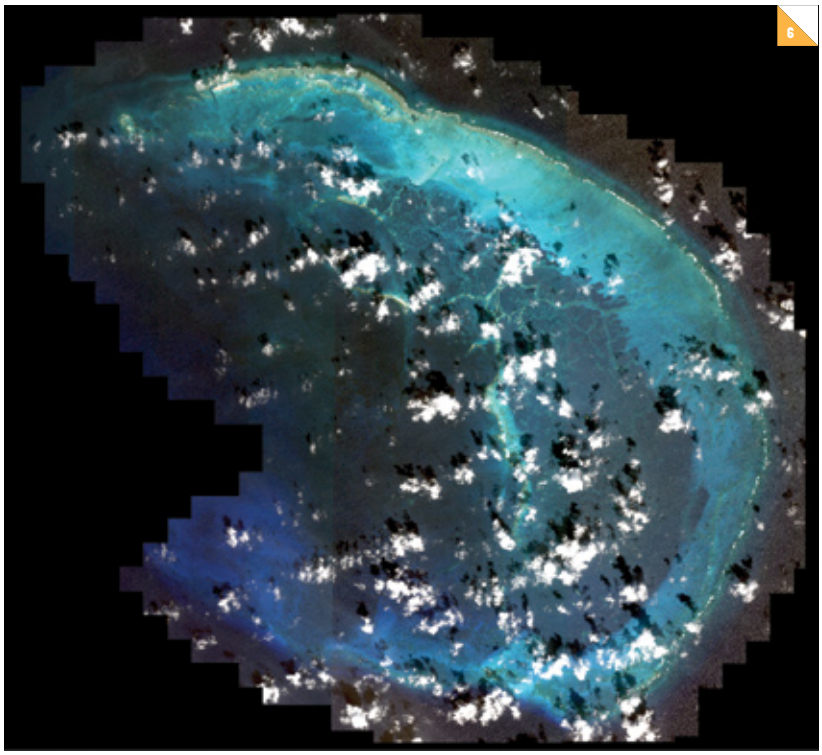
FIGURE 6 *This image of the French Frigate Shoals in the Northwest Hawaiian Islands covers approximately 690 square km. IKONOS image courtesy of GeoEye.*

ing IKONOS imagery, Cicek now plans to map the channel's length, its width, and the amount of ice inside it.

IKONOS will also aid Cicek in the mapping and detection of change in Antarctic melt ponds, areas of water that form as snow melts on top of ice. As these ponds absorb more sunlight than surrounding ice, they gradually grow in area and depth. The resulting imbalance between absorbed and reflected energy can impact regional and global climate. Therefore, knowing when and where melt ponds form could lead to improved climate projections.

"High resolution means more detail," Cicek said. "We especially need better resolution for the remote areas such as Antarctica, since we have limited access to the region."

Melting ice is more than just a signal of a warming climate—it can disrupt wildlife and entire ecosystems. For example, melting sea ice is stranding Pacific walrus in the Arctic Ocean, threatening the stability of a species that native Alaskans rely on for food, clothing and shelter. Biologists with the U.S. Fish and Wildlife Service have been testing the usefulness of IKONOS and QuickBird to assist them in reliably estimating walrus counts.



Satellite imagery has long been a valuable tool for monitoring general characteristics, such as sea surface temperatures and water circulation, of marine mammal habitats. Now, with the advance of commercial high-resolution satellites, detailed population information can be collected in remote areas that are otherwise difficult to access.

"Earlier-generation satellites with lower spatial resolution were useful for imaging habitat features," said Douglas Burn, a biologist at the U.S. Fish and Wildlife Service. "The advantage of high-resolu-

tion satellite imagery is that it allows us to image the animals themselves."

CAPTURING CARBON

The capacity of high-resolution satellites to collect detailed, small-scale information may also play an important role as Europe and many U.S. states work to limit and reduce carbon emissions through carbon-trading programs. Some of these programs allow carbon emitters to gain carbon "credits" by paying farmers to maintain their land in a way that stores more carbon in soil, trees and grass, instead of releasing it to the atmosphere.

William Pickles, a physicist at the Lawrence Livermore National Laboratory, has tested the ability of airborne hyperspectral imagery to detect increases in soil carbon dioxide levels by observing resulting changes in plant life, and he says there's the potential to do the same from satellites. "Suppose you had a thousand sites over the whole world where CO_2 was being sequestered, and you had a satellite that could measure one part per million CO_2 and it could revisit all these sites every week or two."

Another way carbon producers can earn credits is by agreeing to plant a certain amount of trees to store enough carbon to make up for that which they emit. Here again, Brender suggests, high-resolution commercial satellites may help to zoom in on specific locations to monitor and verify that trees were planted, and not subsequently damaged or lost.

"If, for example, a big oil company plants 1,000 trees in Laos in exchange for being able to build a plant in South Korea, who verifies the trees were planted, and not logged or destroyed by a storm?" Brender said. "High-resolution satellites are an ideal tool for verification and monitoring."

As for cost, a factor that many government and university scientists say deters them from using commercial imagery, Brender says that it's not as expensive as some might think at $7.70/square km (minimum order of 49 square km). He also mentions the recently announced GeoEye Foundation, which awards imagery to university students and faculty, and to nongovernmental organizations, to advance research in GIS, environmental studies and humanitarian efforts.

"In the grand scheme of things, given the seriousness and impact of climate change, commercial satellite imagery should be considered another tool in the tool kit to help us better understand how changes in climate impact the environment," Brender said.

Such tools are expected to become even more powerful with the next generation of commercial satellites scheduled to launch this year. GeoEye's GeoEye-1 and DigitalGlobe's WorldView I will boast resolutions of a half-meter or better, enabling even more detailed observations to support studies of Earth's changing climate.

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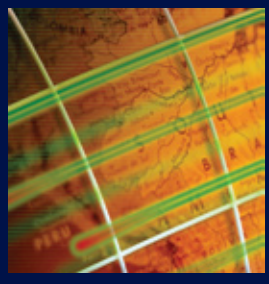

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(continued from page 46) both government and non-government leaders, will be appointed to recommend how the U.S. should restructure its end-to-end approach to Earth information—starting with scientific research and ending with the societal uses of Earth information. The panel will complete its work by 2010.

A subsequent letter to the editor of *Space News* from NOAA Administrator Lautenbacher (April 30) concurred with the value of the initiative but suggested that the Global Earth Observation System of Systems (GEOSS) fulfills this role.

GEOSS arose from the 2003 Earth Observation Summit where 34 nations agreed to develop a "comprehensive, coordinated, and sustained" international Earth observation system. Today, this effort has evolved into the 66-nation Group on Earth Observation (GEO), headquartered in Geneva, which leads the GEOSS effort. The U.S. contribution falls under the auspices of a 15-agency U.S. Group on Earth Observations (USGEO) reporting to the White House.

We believe that GEOSS and the USGEO activities fall short of the objectives of the National Earth-Information Initiative for several reasons.

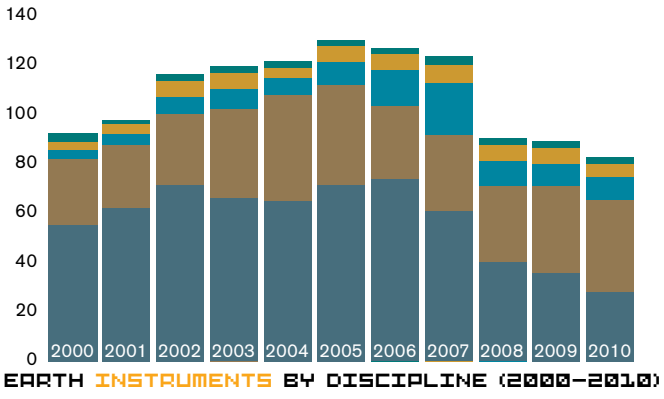
First, GEOSS is an international framework with formal obligations. The primary purpose of the USGEO is to ensure that the nation's Earth observing system meets GEOSS obligations. It is not to enhance or improve the U.S. system, except as required to satisfy these obligations.

Second, our op-ed noted deep problems with the overarching U.S. approach to Earth information. In contrast, GEOSS presumes that the U.S. system is structurally and fundamentally sound—that what is needed is simply to "connect the scientific dots" (language from the USGEO). GEOSS is thus grounded in a different set of assumptions from those of the initiative.

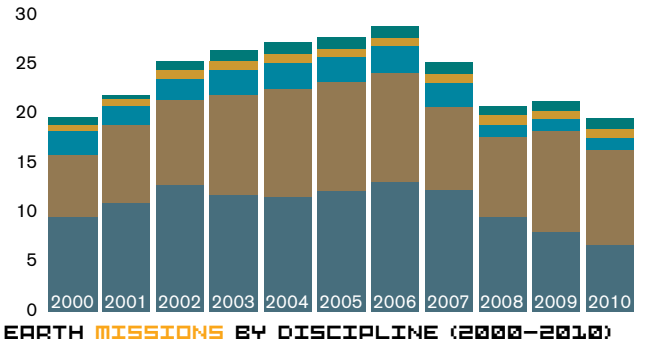
Third, GEOSS is predicated on doing more with existing resources. While an admirable goal, this certainly constrains what can be proposed or accomplished, and does not allow any recourse for the dramatic decline in NASA's Earth observing budget over the last five to seven years.

Fourth, whereas the USGEO strategic plan does envision much of what an initiative would accomplish, the actual implementation appears to be much more constrained. USGEO has limited influence on the direction of NASA's Earth science program and has not been able to ensure a robust U.S. climate observation program. The natural workings of U.S. government agencies make GEOSS an afterthought—an effort to shoehorn previously established agency plans into the GEOSS structure.

The decadal survey made a critical point that both our op-ed and Administrator Lautenbacher's letter echoed: "the aggressive pursuit of understanding the Earth as a system—and the effective application of that knowledge for society's benefit—will increasingly distinguish those nations that achieve and sustain prosperity from those that do not." Other nations have developed national strategies. The U.S. must do the same. ≪



EARTH INSTRUMENTS BY DISCIPLINE (2000–2010)



EARTH MISSIONS BY DISCIPLINE (2000–2010)

Number of U.S. space-based Earth observations missions and instruments in the current decade. Emphasis on climate and weather is evident as is the decline in number of instruments near the end of the decade. SOURCE: Information from NASA and NOAA websites for mission durations. For the period from 2007 to 2010, missions were generally assumed to operate for four years past their nominal lifetimes. Most of the missions were deemed to contribute at least slightly to human health issues and so health is not presented as a separate category.

A U.S. Earth Information Strategy?

THESE AUTHORS OF THE 'DECADAL SURVEY' SEEK TO FORM NATIONAL EARTH-INFORMATION INITIATIVE

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Photo of Molly Macauley unavailable.

For both developed and developing nations, the high ground for national security and economic progress is increasingly built on effective use of information. Earth information plays a particularly important role in this mix. For the readers of *Imaging Notes*, this point probably needs little elaboration.

When it comes to defense and intelligence, the U.S. gets the point. The National Imagery and Mapping Agency (NIMA) was formed from previously independent agencies and offices in 1996 and renamed the National Geospatial-Intelligence Agency (NGA) in 2003—all to address the strategic importance of coordinated Earth information.

On the civil side, however, there is no such strategic planning or coordination. If you want to know what's happening with weather, you go to NOAA. If the weather is pushing around polluted air, you ask EPA. For information about the land surface, check with USGS—unless it concerns agricultural soils, in which case you work with USDA. However, if your land surface interests address the global ecosystem, then go to NASA.

When asked where NOAA's observing responsibility for biological systems starts and ends, NOAA Administrator Vice Admiral Conrad Lautenbacher once quipped, "If it crawls out of the ocean onto the beach, it's probably still ours."

In 2004, NASA, NOAA, and USGS began to address this strategic gap. They asked the National Research Council (NRC) to recommend a 10-year plan for U.S. Earth science and applications. That "decadal survey," in which all three of us participated, was released in January of this year.

In establishing its recommended program of 17 new missions over the next ten years, the survey noted that decisive action is needed or a third of the nation's civil Earth observing system will be non-operational by 2010.

Following the release of the decadal survey, we wrote an op-ed in *Space News* (April 2) suggesting that the scientific recommendations of the survey need to be complemented by "an equally aggressive political and community vision if the observing program is to succeed."

The need for this vision is grounded in the lack of a national civil Earth information strategy. As our op-ed noted, responsibilities of our institutions "are in many cases mismatched with their authority and resources, mandates are inconsistent with their charters, and shared responsibilities are poorly supported by mechanisms for cooperation."

Evidence for these inconsistencies comes from the ongoing delays in establishing a real governmental home for Landsat, the failure of NASA to develop a viable Earth Observing System (EOS) follow-on, the loss of critical climate measurements from NPOESS, recent funding woes for both NPOESS and GOES, and more.

We proposed that the nation commit to a National Earth-Information Initiative to re-evaluate the national process of collecting and using civil Earth information, including the effectiveness of governmental organizations, the relationship between government functions and private sector activities, and the ability to effectively connect scientific developments to societal uses.

The initiative itself is simple in concept. A blue-ribbon panel, including

(continued on page 45)

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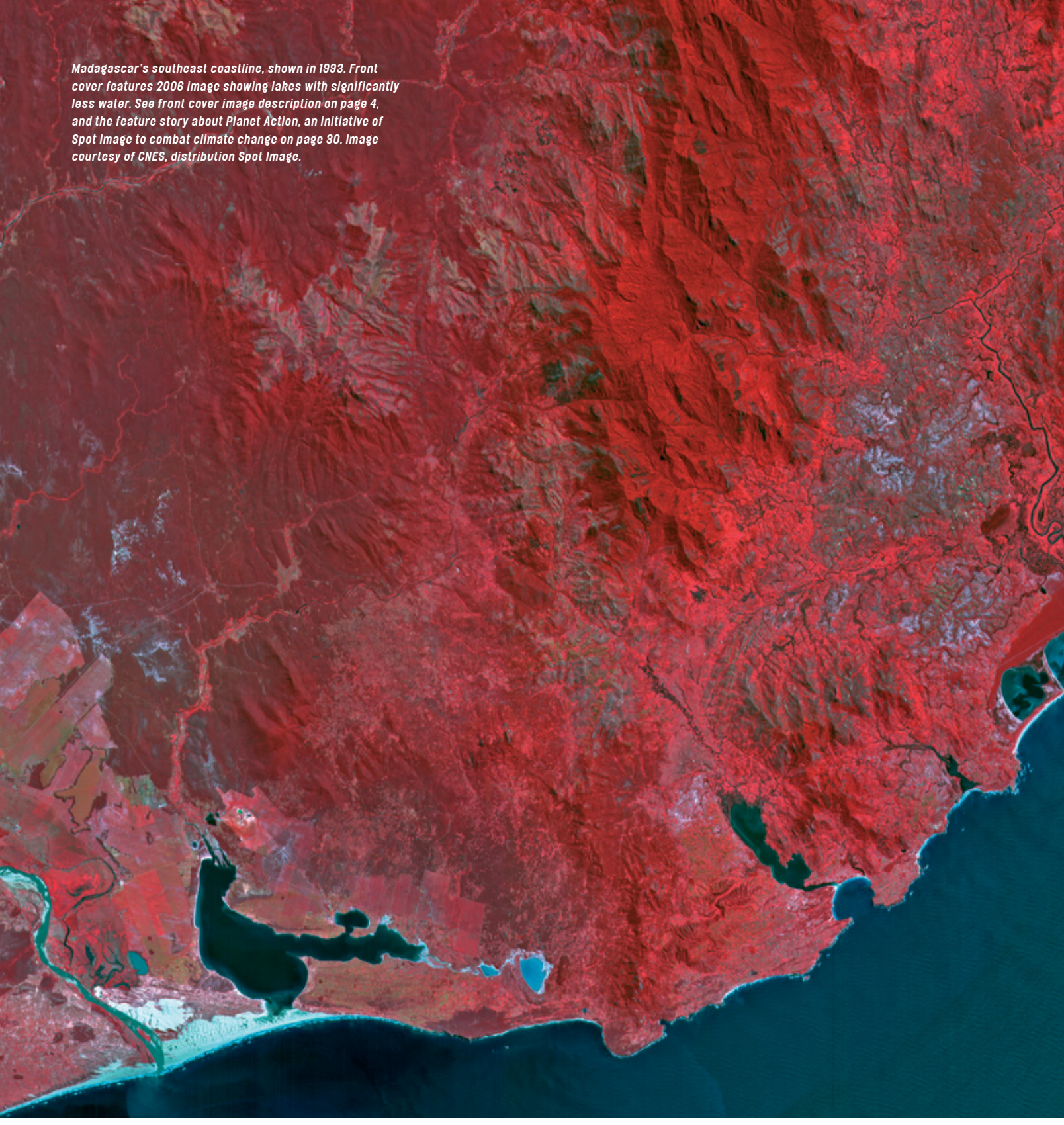

Madagascar's southeast coastline, shown in 1993. Front cover features 2006 image showing lakes with significantly less water. See front cover image description on page 4, and the feature story about Planet Action, an initiative of Spot Image to combat climate change on page 30. Image courtesy of CNES, distribution Spot Image.

Imaging NOTES

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