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Imaging NOTES

EARTH REMOTE SENSING
FOR SECURITY
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Spring 2007
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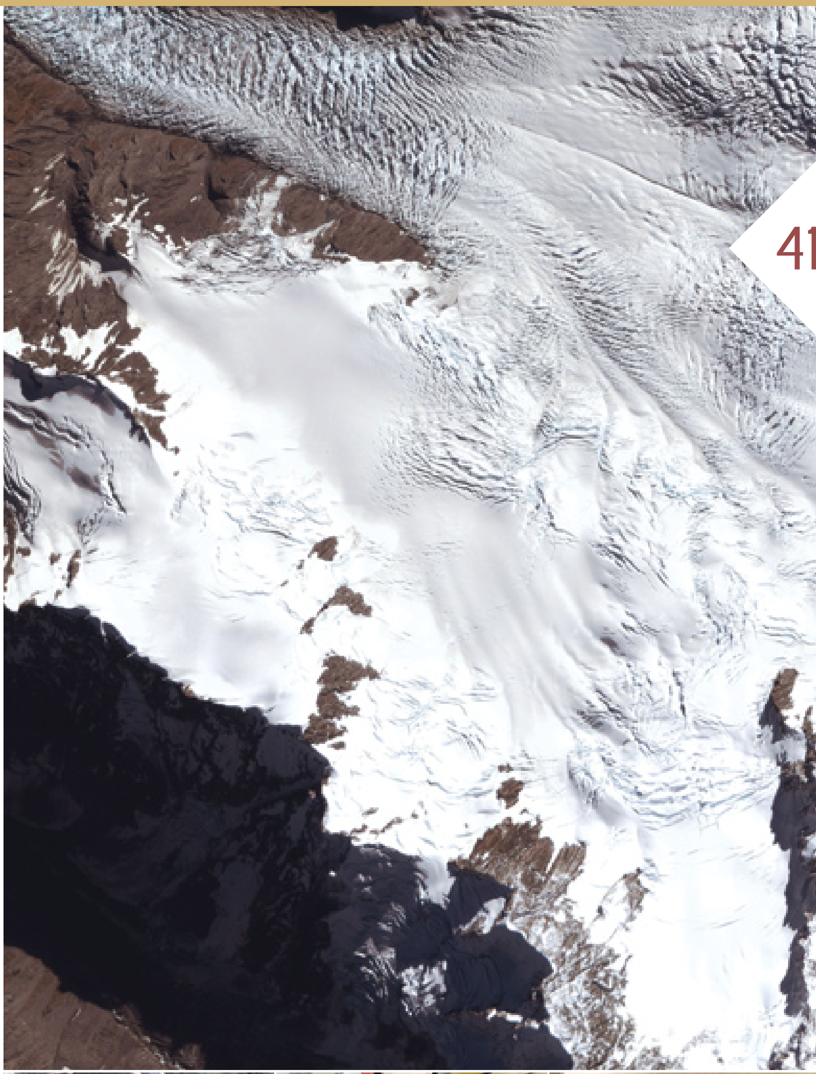

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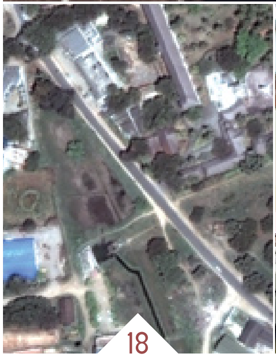

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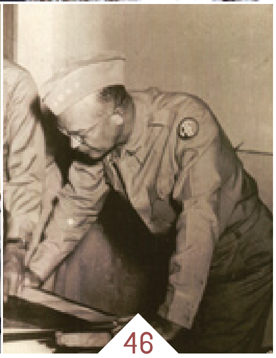

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Longyearbyen, Norway

COVER IMAGE

The town of Longyearbyen

(Longyear Town) on the frozen fjord, on the main island of Spitsbergen, is located among the islands called Svalbard, several hundred miles north of Norway's mainland.

Scientists from Swansea University's School of the Environment and Society are doing a research project called SLICES (sea level rise from ice in Svalbard), and our report on this research begins on page 24.

Featured in the article are small glaciers Slakbreen (Slak Glacier) and Lovénbreen (Lovén Glacier). Small glaciers like these in the Svalbard archipelago represent only four percent of the world's total land ice, but account for an estimated 20 to 30 percent of sea level rise predicted for the 20th century. The amount of melt since 1988 has increased substantially, and these glaciers around Svalbard could make the largest contribution to sea level rise of any Arctic Region outside of Greenland.

Image captured by QuickBird on April 26, 2003, courtesy of DigitalGlobe.

Imaging NOTES

Spring 2007 / Vol. 22 / No. 1

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.

Imaging Notes is affiliated with the Alliance for Earth Observations, a program of The Institute for Global Environmental Strategies (www.strategies.org).

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From Norway to Kenya to San Francisco

In this 50th anniversary year of the world's first artificial satellite, Sputnik, several countries will join the orbital remote sensing club, after a very exciting year in 2006.

This year has already demonstrated increasing momentum in Earth observations with the publication of the National Academy of Science's first Decadal study of Earth science. The report lays out the priorities considered most important by the Earth science community, but NASA's budget has not allocated nearly enough funding to support the Academy's agenda. If we are to tackle the many unanswered questions about climate change and other major environmental problems, we will need funding for the best analytical tools we can muster for the task.

Ray Williamson is the editor of Imaging Notes

Our March eNewsletter* describes one of the Senate hearings on the subject and notes that we are seeing an important shift in thinking by the authors of this report, going beyond fundamental science to consider "increased applications to serve the nation and people of the world." This larger view is extremely important and comes none too soon.

Fortunately, the satellites already in orbit are providing important data to further this process. Features in this issue include Carolyn Gordon's article about melting Norwegian glaciers, which addresses global sea level rise and the crucial role that powerful software has in such studies. Ben Jacobs' piece on the use of remote sensing to assist in reducing the impact of malaria on tropical populations is a potent reminder that we don't always have to be able to see the causes of diseases in order to control them.

Monica Hale summarizes the economic value of weather forecasts to the electric energy industry, illustrating just how important forecasts are to that industry's bottom line. Satellite data from NOAA's fleet provide 90 percent of the data fed into weather models.

As Robert Mott reminds us in his article, the display of remotely sensed imagery has a lot to do with conveying its meaning. In particular, 3D modeling helps military officials make much more effective use of remotely sensed data than ever before.

Tim Foresman's piece summarizing the Digital Earth Summit on Sustainability in New Zealand highlights how important sustainability has become to that island nation. Officials in this land of flightless birds and hobbits have an incredible environment to sustain and they are looking to Digital Earth technologies to help them do it.

Foresman's article also reminds us of the exciting 5th International Symposium on Digital Earth to be held in San Francisco this June (www.isde5.org). We will be joined by top representatives from China, Japan, Canada, New Zealand and other countries for this truly global discussion. Imaging Notes is a partner of the conference; we hope to see you there. Foresman's column on page 10 provides background and details.

Watch the Summer issue for exciting announcements of partnerships currently forming for the greater good!

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LETTERS TO THE EDITOR

I was with the 14th Space Force and I have enjoyed your publication for all these years. I have shared it with colleagues at the Aerospace College and many others. I consider it to be the best in the trade. Keep up the good work.

From an old space guy,

—BOYD "JOE" BALDAUF, COL. USAF RET., PHD, PUEBLO, COLO.

Imaging Notes has essential information to keep updated in Remote Sensing Technologies.

—CESAR SANTISTEBAN, CEO, GEOMAP CONSULTING, PERU

I just received the Fall 2006 issue of *Imaging Notes* and fully agree with your comments in Policy Watch, "NASA: No Longer Understanding and Protecting Our Home Planet?" Why NASA would drop the phrase, "to understand and protect our home planet," with its potential for favorable public support, is beyond me.

Also, anyone associated with the Max Planck Institute for Astronomy will be disheartened to read their name as given in the cover caption on page 4 of the same issue.

—JOHN WESTFALL

I like your publication, but the story about Heidelberg on the title page includes mention of the "Max Planck Institute of Astrology." ASTROLOGY? Max Planck was a physicist, a Nobel Prize winner, no less, who undoubtedly would have screwed his head through the ceiling over being associated with astrology. Please don't let Liberal Arts majors affect the credibility of your magazine.

—HARRY PARKER PE

EDITOR'S REPLY

Thanks for your note, and thanks for finding that mistake... Even educated people slip up and use the term astrology instead of astronomy commonly. Believe me, I know, as I am a PhD astronomer. We apologize for the error.

MetOp-A from Europe
The Newest Weather and Climate Tool

On October 19, 2006, MetOp-A, Europe's first polar-orbiting, operational environmental satellite, was launched aboard a Russian Soyuz launch vehicle from Kazakhstan's Baikonur Cosmodrome. This substantial new Earth observation satellite was built by the European Space Agency (ESA) and is now operated by EUMETSAT, Europe's meteorological satellite agency. It is the first of a series of three MetOp satellites to be built in the next few years, which will supplement the data from EUMETSAT's Meteosat series of geosynchronous weather satellites.

MetOp-A is crammed with a variety of European and U.S. remote sensing instruments to measure surface temperature, cloud cover, humidity, space weather parameters, and many other weather and climate components.

After checkout of the satellite's various subsystems, ESA turned the satellite over to EUMETSAT, where it is now part of the U.S. - European fleet of polar orbiting operational environmental satellites, which includes NOAA's Polar-orbiting Operational Environmental Satellites (POES) and the Air Force's Defense Meteorological Satellite Program (DMSP) birds. The U.S. will have access to all of the data sets from the new satellite.

This launch is highly significant for Europe and the United States. First, it signifies that EUMETSAT will now be able to gather high quality global atmospheric, land, and ocean data and will not be limited solely to a dependence on U.S. sources for them. Global data are needed to develop and validate EUMETSAT's weather forecast models. These data will significantly improve global environmental coverage and also cement EUMETSAT's role as a major player in the global collection and exploitation of weather climate data.

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).*

Weather affects virtually everything we do daily, and advance warning of potential weather patterns can help us prepare for changes. Though we often take these forecasts for granted, weather forecasts help to mitigate risk, and as such, provide a daily benefit in our lives. Industries as diverse as agriculture, electricity generation, transportation, and recreation use weather forecasts daily, even hourly, as shifts in upcoming weather can sharply affect the bottom line. As several studies have shown, including those cited by the SAIC in a story on page 34, weather forecasts can deliver substantial economic and social benefits to those who use them in their operational decision making processes.

Forecasts of extreme weather such as hurricanes, drought, and snow are especially important, since such weather can affect industry and the general population severely and may even cause loss of life. As coastal population density has increased, property damage from severe storms has increased right along with it, making accurate forecasts even more important.

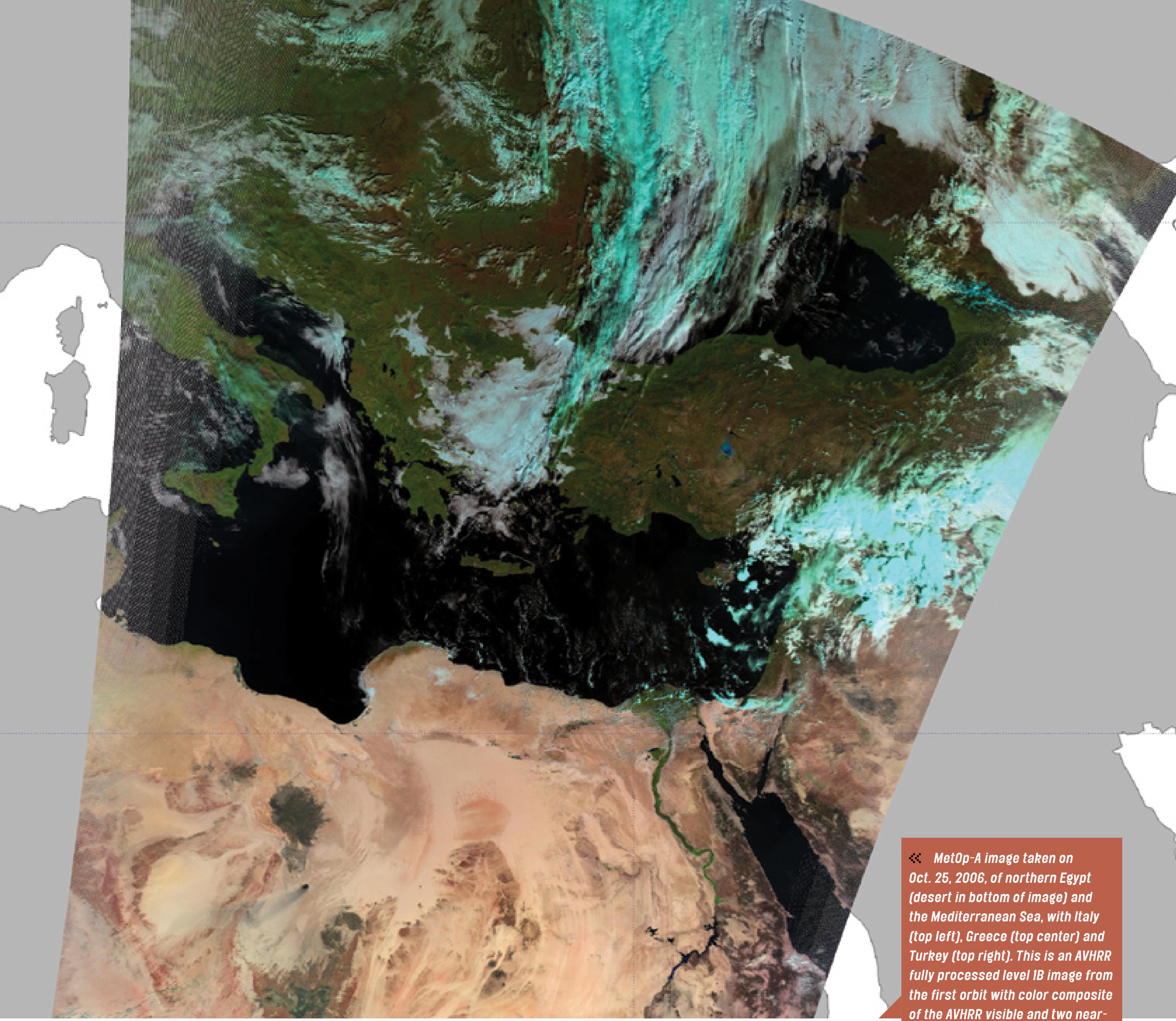
Some 90 percent of the data in U.S. and European forecast weather models now derive from satellite sensors, so the relative importance of these satellite collectors of weather data is clear. MetOp-A data, when combined with data from Europe's new Meteosat Second Generation geostationary satellite, and from the U.S. geostationary GOES and polar-orbiting POES satellites, will contribute significantly to forecasting accuracy. U.S. and European forecast modelers will make considerable use of these new data sets.

Over the long term, EUMETSAT's plan to collect and archive MetOp-A data sets for assessing and interpreting climate change may be the most important contribution that the new satellite makes. Climate forecasting is in its infancy, and these data sets will contribute to improvements in our ability to predict future climate change.

> EUMETSAT's plan for assessing and interpreting climate change may be the most important contribution that the new satellite makes.

As Tim Foresman argued in his last column for *Imaging Notes*, climate change, especially the rate of change, is becoming one of the most contested environmental issues of our day, in large part because of the potentially large economic and social effects of climate change and the difficulties of regulating reductions in harmful greenhouse gases effectively. These instruments will provide the additional data that policymakers say they need to make critical budgetary and regulatory decisions in attempts to mitigate the effects of climate change.

So far, U.S. policymakers have a mixed record (some say a poor one) of using the information already available to them. Europe is far ahead of the United States in this realm, and has already developed a number of technological and policy solutions to global warming. Yet, even if government officials fail



MetOp-A image taken on Oct. 25, 2006, of northern Egypt (desert in bottom of image) and the Mediterranean Sea, with Italy (top left), Greece (top center) and Turkey (top right). This is an AVHRR fully processed level 1B image from the first orbit with color composite of the AVHRR visible and two near-infrared channels, rendered from the CalVal Facility. Courtesy and copyright of EUMETSAT.

to make good use of the information that this and other satellites provide, the instruments aboard will daily provide useful information for a wide variety of purposes.

MetOp-A's launch has been a long time in coming, held up in part by differences in policy between the United States and Europe. The United States wants to be able to withhold distribution of certain satellite data from its instruments during times of armed conflict or serious tension. EUMETSAT, however, is a strictly civilian agency supported by 20 European countries, so it was reluctant to grant such rights. After long negotiations, the two entities resolved the issue by agreeing on the terms by which data delivery might be restricted or delayed. It is not likely that such restrictions will occur very often.

Despite the delays, the launch of MetOp-A is a fine example of the continuing excellent U.S.-European cooperation in Earth observations. Such cooperation is becoming ever more important as we discover the many benefits of satellite Earth observations for managing our fragile planet.

NOTE: *Related story by SAIC about the economic implications of more accurate weather forecasting begins on page 34, and a look at The Weather Channel's reliance on satellite data is on page 14.*

Digital Earth as an Operating System for a Troubled Planet

SYMPOSIUM IN JUNE OFFERS OPPORTUNITY AND INSPIRATION

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).*

When this article reaches you, we will be only a few weeks away from the June 5 kick-off of the 5th International Symposium on Digital Earth (ISDE5), hosted for the first time in the United States. Participants from around the world will be gathering on the U.C. Berkeley campus to gain a clear perspective regarding how technology and active community networks can make a meaningful impact towards improving life on our planet for as many living beings as possible.

Often, we find ourselves conversing within our various communities (whether environmental, peace, climate, water, fair trade, sustainable communities, indigenous peoples, green investments, etc.) and retreating towards the negative elements of our realities only to witness paralysis of progress and mental psychosis. A delightful tonic for all souls can be realized better by witnessing the debut of some remarkable initiatives and stellar actions by a variety of communities that are indeed taking hold of their destinies and effectively using technology in these dynamic and challenging times with Digital Earth (a term encompassing all online spinning virtual globes).

China has taken the lead with Digital Earth, which is perhaps not that surprising given the ambitious nature of their society today. Not only did they host the first Symposium in 1999 (held every other year), but they also founded the International Society for Digital Earth in Summer 2006 (see Figures 1-2). Many Chinese leaders will attend this gathering in June.

One key thread throughout the series of Digital Earth Symposia, which began in Beijing in 1999, has been to embrace the prowess of technology to provide an accurate and objective view of the Earth and its life support systems, a legacy of the Symposia's remote sensing origins.

The second thread is to capture the potential of the Earth observation technologies to enhance communications and exchange of intellectual and financial resources among the many types of communities that comprise the fabric of our societies.

These combinations of watch, think, communicate, and act are just beginning to become visible as viable constructs or mainstays in societal policies and politics. Coming from an eight-year international forum, this is worthy of attention.

In 1968, visionary and engineering genius Buckminster Fuller submitted his thesis for an "Operating Manual for Spaceship Earth." He recognized the increasing stresses of overpopulation on life-sustaining resources and the need to understand better and to manage the life-cycle processes related to the international commerce and commodities. He suggested the GeoScope, forerunner of our satellite systems and virtual globe geobrowsers, as a way to maintain a constant awareness of the planet's conditions. He further recognized that we would need the application of vast networks of computers to provide us with the cybernetic framework for addressing our greatest challenges ahead. His extensive writings remain valuable today as we attempt to get our collective minds around the multiple systems that operate on "Spaceship Earth."

Digital Earth, as an articulated vision, is credited to former Vice President Al

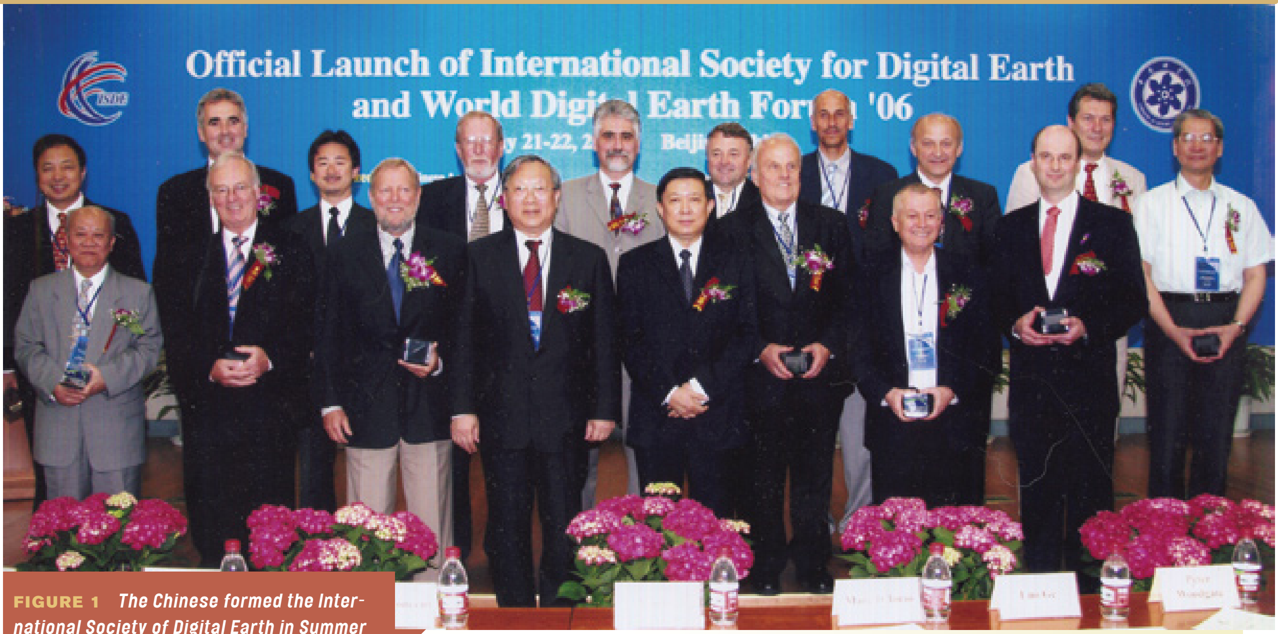


FIGURE 1 ***The Chinese formed the International Society of Digital Earth in Summer 2006. Founding members are pictured, including author of this article, Dr. Tim Foresman (front row, 3rd from left).***

Official Launch of International Society for Digital Earth
May 21, 2006 Beijing, China

FOUNDING MEMBERS ARE PICTURED

FIRST ROW LEFT TO RIGHT:

Chen Shupeng, Professor of Geoinformatics, Chinese Academy of Sciences, China
David Rhind, Vice-Chancellor and Principal, The City University, London, U.K.
Tim Foresman, President of International Centre for Remote Sensing Education, U.S.
Lu Yongxiang, President of Chinese Academy of Sciences, China
Xu Guanhua, Minister of Ministry of Science and Technology, China
Werner Alpers, Institute of Oceanography, University of Hamburg, Germany
John van Genderen, Department of Earth Observation Science, ITC, Netherlands
Peter Woodgate, CEO, Cooperative Research Center for Spatial Information, Australia

BACK ROW LEFT TO RIGHT:

Guo Huadong, Professor, Institute for Remote Sensing Applications, China
Richard Simpson, University of Auckland, New Zealand
Hiromichi Fukui, Director Geoinformatics and Remote Sensing, Keio University, Japan
Fred Campbell, International Program Consultant, Canada
Marc D'Iorio, Director General, Canada Centre for Remote Sensing, Canada
Milan Konecny, Professor, Masaryk University, Czech Republic
Mario Hernandez, Chief Information Management & Remote Sensing Unit, UNESCO
Armin Gruen, Institute of Geodesy and Photogrammetry, Switzerland
Jean Sequeira, Remote Sensing Laboratory, University of Marseille, France
Chen Yuntai, Professor, Institute of Geophysics, State Seismological Bureau, China

Gore in a 1998 speech (www.isde5.org). Gore's elegant vision portrayed a future where a young girl would sit before a three-dimensional virtual globe and access all forms of information about art, science, history, literature, and more, in a compelling and entertaining manner. Information would be derived from digital libraries, government agencies, commercial and non-profit organizations, and other data networks connected through means of interoperability over the web.

We have witnessed the sparkling birth of the Digital Earth vision with the debut of Google Earth, the ramping up of Microsoft's Virtual Earth, NASA's World Wind, SkylineGlobe, GeoFusion, and a host of other promising 3D geobrowsers coming of age on the web. ***Figure 3*** shows one of the first, from Keyhole, Inc. (which is now

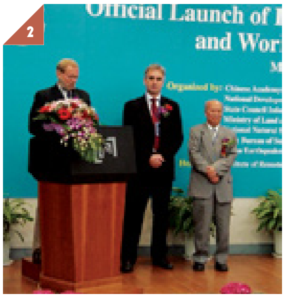


FIGURE 2 *Dr. Tim Foresman with Richard Simpson of New Zealand and Chen Shupeng, Chinese "Father of GIS."*

FIGURE 3 *Keyhole, Inc., predecessor of Google Earth, presented this early 'earthviewer' demonstration in 2001 at the 5th African GIS conference in Nairobi, Kenya, symbolizing the birth of Digital Earth to an international community. Photo courtesy of the author.*

Google Earth) as demonstrated to the United Nations Environment Programme in 2001. Digital Earth appears, therefore, to be arriving, whether by design or serendipitous actions, as we are crossing the threshold of the 21st century.

A legitimate question can be raised as to the value of any conference, meeting, or workshop when the market forces and world events increase in momentum and complexity. Perhaps it may be said that what the growing number of those in the Digital Earth community are doing is putting a face on the real applications for our future technology and its uses, in full harmony with the original vision. "Bringing Digital Earth Down to Earth" is the central theme of the 5th Digital Earth gathering and will serve to keep our collective focus grounded to real issues for real people. And so it only seems fitting that the ISDE5 will be launched on World Environment Day amid salutations by its host country, Norway.

Joining us will be these accomplished visionaries and others:

- **Apollo Astronaut Ed Mitchell** will begin the conference with his unique perspective, gained from his moon walk and its impact on his life's work.
- **Ambassador John McDonald** will share his views from his days as the U.S. initiator of the 1972 U.N. Conference on the Human Environment (called the 1972 Stockholm Conference, from which the United Nations Environment Programme was founded in 1973) and his subsequent work in water and peace throughout the world.
- **Doug Engelbart**, inventor of the computer mouse, will address the motives for his technology push to improve humankind's conditions.

An excellent cast will follow, representing global and national leaders in deep philosophy, community networks, technology, Earth observation systems, and effective strategies for sustainability to bring more solutions to the collective table for consideration. Bold suggestions will be offered for follow-on initiatives towards a Digital Earth Exchange (or "Digital Commons") and community empowerment through activism and collaboration with the leading virtual globes. Finally, grassroots, youth, and sustainability communities (Planetwork, Bioneers, and others) will address how to harness the best initiatives for directed actions resulting from this conference.

A principal component needed for the Digital Earth vision and Buckminster Fuller's concept of an Operating Manual for Spaceship Earth is an operating system. An Earth Operating System (EOS) is a collective concept for enabling all citizens of the planet to become more aware of their current conditions and to participate in improving these conditions while coping with vagaries of global change impacts. An EOS represents the next phase in providing everyone with an objective view of the planetary current events and in holding people and nations responsible for collective behaviors impacting the welfare of others.

Digital Earth technology can provide a 'glass house' view of the planet, but we need an EOS to effectively encourage the full exchange of talent and resources necessary to meet the demands of our future. Fortunately, many of the people and organizations that can move us along on this common journey will be gathering in June on the Berkeley campus to help us understand the next pragmatic steps needed for humankind's survival.

Register now to attend the 5th International Symposium on Digital Earth (www.isde5.org).

NOTE *A summary of the 2006 Digital Earth Conference on Sustainability in New Zealand appears on page 40.*


The 5th International Symposium on Digital Earth
June 5-9, 2007
San Francisco Bay Area, California
www.isde5.org
International Symposium on Digital Earth
ISDE
Bringing Digital Earth Down to Earth

From Missions to "My" Weather.com

NEXT-GEN MAPPING

In our exploration of next-generation mapping we have been focused on the impact of Internet distribution of imaging and remote sensing (I/RS). In our last column we looked at the different users of I/RS–legacy niche users, convergence users, and ProAm users in "Where's the Killer App in Satellite Imagery?" (See archive at www.ImagingNotes.com.) In this column we look at the impact of Internet distribution and NASA's change in mission on two companies at the polar extremes of the I/RS supply chain–Ball Aerospace and The Weather Channel. One builds the satellites that collect the data and the other transforms the data into information that saves lives and allows you to plan picnics.

Ball Aerospace has been manufacturing satellites for over 50 years and focuses on the most difficult of missions to deliver the best land imaging of the earth. The Weather Channel has been in business for 25 years and takes the I/RS data and transforms it into TV and Internet presentations that educate over 89 million U.S. subscribers on storms and weather patterns.

Internet distribution of satellite imagery impacts the two companies differently: for one it means understanding a new user profile; for the other it means access to more free information. NASA's change in mission impacts the business model of one, while potentially compromising the service of the other. (See Sidebar on page 16.) Let's begin with The Weather Channel, which integrates some of the I/RS data that is powered by Ball's land imaging satellites.

3

FIGURE 3 *DigitalGlobe's WorldView 1 rendering.*

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.*

NOTE: *An interview with Dr. Steve Lyons was featured in our February eNewsletter, which is posted at www.imagingnotes.com.*

THE WEATHER CHANNEL

An innovative cable TV network, The Weather Channel, has successfully commercialized weather forecasting and brought weather, science, and education programming to TV viewers. In addition, the Weather Channel is one of the most innovative media companies on the Web. On the weatherchannel.com, users can download weather tool bars, create their own weather web site ("my" weather), and click on related topics, helpful hints, information on global warming, and of course – ads! For the readers of this magazine, the site features satellite imagery and

You can take away anything but my satellite imagery!

DR. LYONS OF THE WEATHER CHANNEL

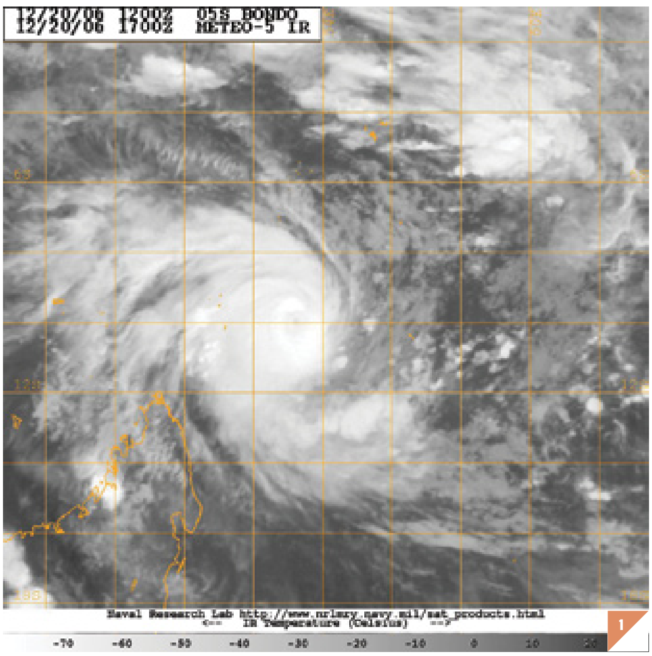


FIGURE 1 *Naval Research Lab image of tropical cyclone "Bondo" on Dec. 20, 2006, in the southwest Indian Ocean.*

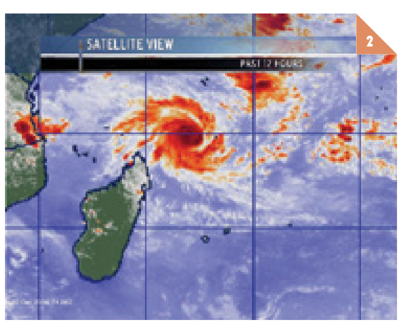
FIGURE 2 *A Weather Channel enhancement of the satellite imagery of tropical cyclone "Bondo" for on-air presentation.*

FIGURE 4 *WorldView 1 under construction in December 2006 at the Ball Aerospace facility in Boulder, Colo. Technicians perform integration of the focal plane into the telescope.*

remote sensing presentations on a variety of views of weather patterns.

Behind the scenes are some "power users" of I/RS, including Dr. Steve Lyons of The Weather Channel. As an expert in tropical storm and hurricane forecasting, Dr. Lyons watches the oceans. According to Dr. Lyons, although the world is three-quarters water, there aren't enough aerial observation networks around the oceans and icebergs. Without up-to-date information on ocean activity, weather prediction models are inherently inaccurate. Satellite imagery fills the void in ocean data.

Dr. Lyons has been using I/RS in



forecasting for over 35 years, and has found Internet distribution of I/RS to fill many data gaps. In addition, Internet use enables him to be mobile and have all of the data and models available to him 24/7. Every day Dr. Lyons analyzes 50-60 satellite images that

he integrates into his forecasting models, including wind intensity, tropical wave, and water vapor models. Dr. Lyons analyzes data purchased by The Weather Channel as well as free imagery available from over 10 trusted Internet sites. This free imagery is what fills the data gaps.

Despite the growing use of numerical models in weather forecasting, Dr. Lyons believes that interpreting the satellite imagery is by far the most insightful way of developing forecasts. "You can take away anything but my satellite imagery," said Dr. Lyons in an interview with *Imaging Notes* (see our in-depth interview online at www.imagingnotes.com/newsletter-2007-02 including images direct from Dr. Lyons to share with *Imaging Notes* readers). These images are transformed into presentations that even the most casual observer of The Weather Channel can recognize as storms, dangerous weather, or a nice weekend to go outdoors. See ***Figure 1*** for example of imagery used in the forecast analysis, and ***Figure 2*** for an example of the on-air presentation.

I/RS results in improved weather forecasting, better understanding of climate change, life-saving information, and cost savings of billions of dollars to governments, organizations, and individuals. "If the government doesn't launch other land imaging satellites, we have a big problem," said Dr. Lyons.

POWERED BY BALL AEROSPACE

With 60-80% of the commercial satellite industry business in the hands of the government, Ball Aerospace's major customers are NASA and DigitalGlobe. Ball is currently building DigitalGlobe's next satellite, WorldView 1, due to launch this summer with resolution of 50-centimeter panchromatic images. (See ***Figures 3-4***.) As a provider of satellites for science, defense, commercial missions, with 2-3 launches a year and an average building time of 2.5 years for a spacecraft, Ball must be aware of changes in the business of missions as well as changes with end users. With NASA budgets flat, Ball sees the growth in the satellite imagery business coming from the commercial sector, including new Internet users and applications, and international demand.

In the past, understanding I/RS users meant talking to NASA and DigitalGlobe and their end customers, which include government agencies, academic research organizations, and large engineering firms. With the rise of Google Earth and Microsoft Virtual Earth as consumers of I/RS, Ball recognizes that these companies have a different business model and that a new generation of users requires a different product. "The Internet has changed our behavior and the people we talk to," said Jim Good, Director of Program Development for Operational Space at Ball Aerospace. To better understand this growing new user profile, Ball has begun focus groups to determine the types of data and rendering that will be acceptable to these new consumers of I/RS data. Timeliness of data (more revisits) and low cost are important to all users, but "pretty pictures is what sells advertising for Google Earth and Microsoft Virtual Earth, and that's a different product," he commented.

Ball is optimistic that new uses for I/RS, including linking metadata to remote sensing data (driven by Internet users), agricultural applications (including crop health monitoring), and various weather forecasting applications will drive future growth. As on-board storage has increased, data downlinks have become the "long pole in the tent," according to Jim Good. This long pole creates opportunity for innovation in communications over the next 2-3 years that should address the increased demand for real-time data by new Internet users.

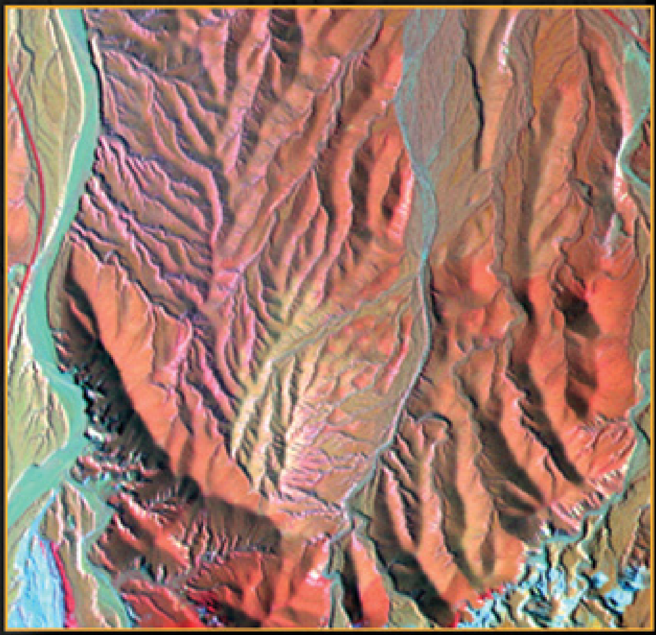
A COMPLEX ECOSYSTEM

"New media" distribution is impacting companies throughout the I/RS supply chain. Ball and The Weather Channel are just two examples. Ball relies on taxpayer dollars to build the majority of its satellites, so that data can be purchased by government agencies and academic research centers that make the data available for free on the Internet, and by a company like Google that makes money selling advertising. The Weather Channel is cleverly making use of all this free information to make better weather predictions and sell more advertising. In order for Ball to stay on the cutting edge of satellite technology, and for all of these anticipated new I/RS applications to flourish, it needs government funding. If NASA continues to diminish its role in I/RS funding, who will fill the void? The stakes are high for next-generation mapping.

POLITICS AND GLOBALISM

The U.S. government remains the single largest purchaser of remote sensing data. As such, NASA's change of mission as pointed out by *Imaging Notes* editor Ray Williamson in his last column, "NASA: No Longer Protecting Our Home Planet?" (see archive at www.imagingnotes.com) will have serious impacts on the demand for earth observation as the focus moves to deep space exploration. Jim Good of Ball Aerospace says the impact on Ball's I/RS business is that growth from NASA will remain flat. In the meantime, the international satellite business is experiencing high growth fueled by the quest for more data, faster revisits, and overall timeliness. As other countries develop their own satellite capabilities through government funding and subsidies, and as they seek to reduce reliance on U.S. data, the U.S. satellite manufacturers find themselves increasingly challenged in the international marketplace. As the U.S. continues to balance technology transfer and competitiveness in an increasingly global market, the Internet continues to deliver "data without borders."

Will we see a Google Satellite in the not-so-far future?



Using Imaging Technologies to Control Malaria

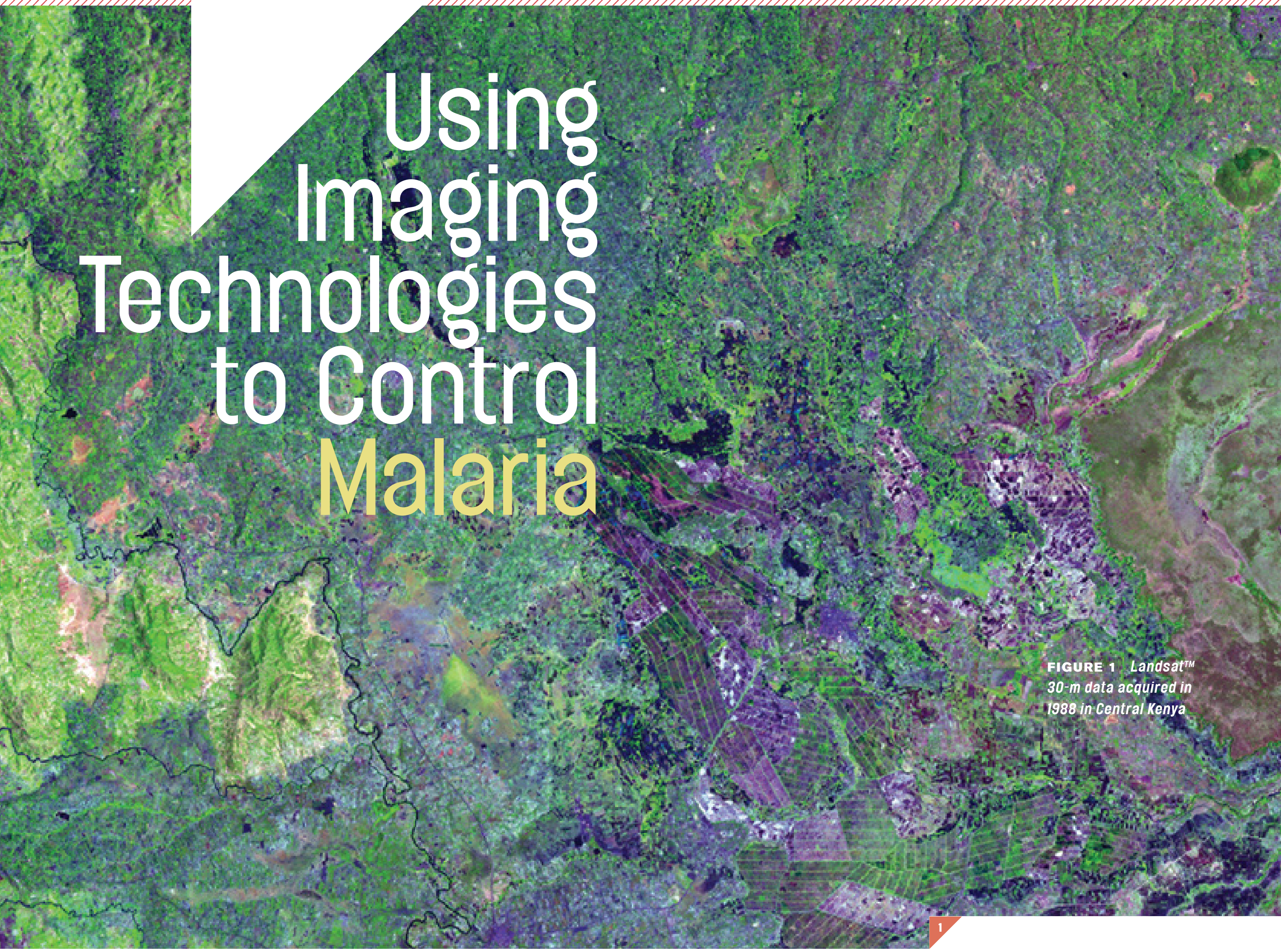


FIGURE 1 *Landsat TM 30-m data acquired in 1988 in Central Kenya*

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FIGURE 2 *QuickBird 0.61-m spatial resolution of urban and vegetation land cover in Malindi, Kenya*

2

MALARIA, virtually unknown in developed countries, exacts a horrific toll in terms of human health throughout the developing regions of the world. One to three million deaths occur from the disease each year, and most of the global burden falls on sub-Saharan Africa.

To place the impact on sub-Saharan Africa in perspective, 300 to 500 million cases of malaria are reported annually there – more than the total number of people living in the United States. In some areas people receive 200 to 300 infective bites per year, and those who die are overwhelmingly children under five years of age.

Efforts during the 20th century demonstrated that reducing the abundance of larval habitats for Anopheline mosquitoes is a key tool for malaria control. Because suppressing mosquito densities is one of the critical factors in reducing the transmission of the malaria parasite, identification of the distribution of viable habitats is important.

3

Remote sensing (RS) imaging technologies offer cost-effective means for identifying habitats, estimating densities of mosquito species, and predicting disease incidence to support vector control programs. Typically, multispectral information from visible and near-infrared (NIR) light wavelengths covering a range from 0.45 to 0.96 *µm* can distinguish between high and low mosquito-producing areas. These, in turn, are correlated with vector distributions as well as malaria incidence and prevalence. Imaging provides an effective way to identify likely mosquito habitats for implementing various strategies to control the spread of malaria.

MAPPING HABITATS WITH IMAGERY DATA

Most studies have used data from Landsat or the National Oceanic and Atmospheric Administration's (NOAA) Advanced Very High Resolution Radiometer (AVHRR), although those systems have limited spatial resolution for characterizing and monitoring the spatial and temporal patterns of mosquito habitats (see ***Figure 1***). In recent years, however, there has been a significant advance in high-resolution polarimetric satellite platforms.

The best-known of the fine spatial resolution satellite sensors, and regarded widely as the first of this new "era" of remote sensing, is IKONOS, launched in 1999 (GeoEye, Dulles, Va.). The IKONOS satellite uses a multispectral sensor to collect blue, green, red, and NIR bands with 4.0-m resolution, providing natural-color imagery for visual interpretation and color-infrared applications. The IKONOS satellite also collects panchromatic imagery at 1-m resolution.

The launch of the QuickBird satellite in 2001 provided even more refined spatial resolution imagery (0.6-m and 2.4-m spatial resolution panchromatic and multispectral imagery, respectively). IKONOS and QuickBird imagery can be used to generate geographic coverages (representative shapes) at a spatial scale equivalent to larval habitats (see ***Figures 2*** and ***3***).

Employing geographic information systems (GIS) to digitally overlay higher spatial resolution satellite data with older, lower resolution Thematic Mapper data spanning back several decades offers a way to fuse data from multiple platforms. Data fusion with GIS makes possible systematic delineation of seasonal entomologic habitats using remotely sensed data. Thus, it is possible to map significant land use variation, and to identify factors that can affect mosquito larval ecology (***Figure 4***). GIS can also provide relevant information that focuses control on the immature stages of vector Anopheles species to reduce the transmission of malaria.

Climatic factors associated with malaria risks in sub-Saharan Africa can also be identified using meteorological data obtained from satellites along with malaria transmission distribution maps. Malaria transmission maps can be developed by taking into account biological constraints of climate on urban and rice land Anopheline habitat development. Widely used environmental proxies for determining the occurrence and distribution of Anopheline aquatic habitats include vegetation indices such as the normalized difference vegetation index (NDVI). NDVI expresses the abundance of actively photosynthesizing vegetation, or "greenness," and has been of particular interest in mapping both spatial and temporal relationships between the environment and disease incidence (***Figure 5***).

The Image Analysis extension of ArcView 9.1 was used to perform the NDVI calculations using ERDAS IMAGINE and ENVI software. ERDAS IMAGINE and ENVI are broad collections of software tools designed specifically to pro-

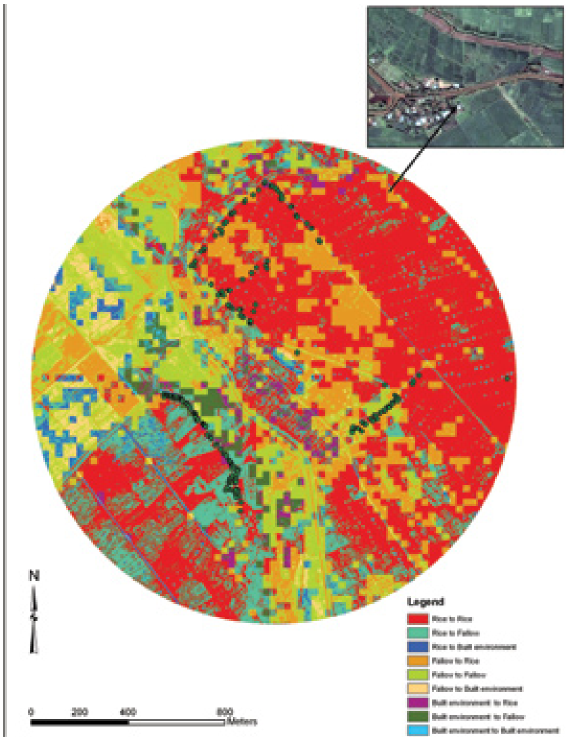


FIGURE 3 *IKONOS 4-m spatial resolution of Kangichiri agro-village complex in the Mwea Rice Scheme, Kenya*

FIGURE 4 *Land use land cover change (LULC) and non-LULC change areas mapped in GIS using July 1988 Thematic Mapper 30-m data and July 2005 IKONOS 4.0-m for Kangichiri village in the Mwea Rice Scheme, Kenya*

FIGURE 5 *NDVI using QuickBird red band and NIR data for Kangichiri village in the Mwea Rice Scheme, Kenya*

cess satellite imagery. NDVI is calculated using the red channel (band 3) and the NIR channel (band 4). The NDVI is calculated from these band measurements as follows: (NIR band - red band) / (NIR band + red band). The NDVI calculation provides index values ranging from -1 to 1. NDVI values typically range from 0.1 up to 0.6 for vegetation, with higher values associated with greater density and greenness of the plant canopy. Surrounding soil and rock values are close to zero while the index values for water bodies such as rivers and dams have the opposite trend to vegetation and are negative.

SAMPLING USING SATELLITE IMAGERY

Both increased computing power and spatial modeling capabilities of GIS extend the use of remote sensing beyond the research community into operational disease surveillance and control. For example, overlaying a GIS sampling scheme on high resolution remotely sensed data helps organize and characterize mosquito larval habitats. A GIS sampling scheme is constructed by applying a mathematical algorithm to generate geometric cells (square, hexagonal, triangular) with a continuous and bounded surface consisting of equidistant cells that define an area to be sampled in the field to quantify attributes of interest. For instance, cells may be selected from the GIS sampling scheme in which the number, type, and area of larval habitats may be measured, or the number of larva and the proportion infected with the malaria parasite may be quantified.

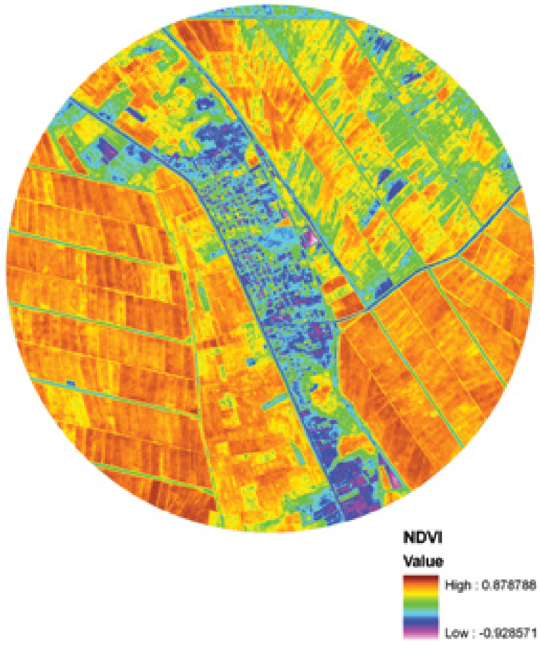
GIS sampling scheme data files consist of columns and rows of uniform cells coded according to data values. Each cell within a matrix contains an attribute value as well as location coordinates and can be joined relationally to other databases. The spatial location of each cell may be implicitly contained within the ordering of the matrix (see ***Figure 6***).

Digitally tracing a rice land habitat in ArcInfo 9.1 generates polygons which can conform to rice land Anopheline aquatic habitat boundaries. The larval habitats can then be characterized in relation to ecological attributes of an aquatic habitat such as water temperature, flow, turbidity, or acidity (see ***Figure 7***). Like the sampling scheme data files described earlier, each polygon is assigned an identifying number and the attributes sampled at each rice field can be added to the database.

INTEGRATING GPS TECHNOLOGY

One critical aspect that is often overlooked is the accuracy of global positioning system (GPS) coordinates. Accuracy in GPS/GIS is the degree of conformance between the estimated or measured position, time, and/or velocity of a GPS receiver and its true time, position, and/or velocity as compared with a constant standard. Developing an integrated vector management (IVM) program for control interventions requires relatively precise knowledge of the geographic location and ecological characteristics of habitats.

Members of this team recently compared the accuracy of location data collected from five handheld units (Trimble Geoexplorer 3, Garmin GPSMAP 76, Magellan 2000 XL, Garmin GPS 2PLUS and a highly precise CSI Wireless Max receiver) using real-time differentially corrected OmniStar L-Band satellite signal at the Illinois Natural History Survey (Champaign, Ill.). The coordinates gener-



ated from each of these were compared to five geodetic markers and the positional accuracy for each unit was determined. A histogram showing the distribution of the number of points in relation to the distance from the actual test location is shown in ***Figure 8***.

The real-time CSI Wireless differentially-corrected global positioning system (DGPS) Max receiver, using real-time Omni Star L-Band satellite signal, mapped the geodetic sites with greater repeatable positional accuracy and higher distance accuracy than the other units. The repeatable positional accuracy improved by an average of 37.5 meters, and distance accuracy improved by an average of 31.5 meters through employing newer, more advanced CSI Wireless DGPS unit.

Terrestrial DGPS and public access systems improves GPS position accuracy but are dependent on range and transmission interference and are proven to be less reliable than satellite-based systems. The CSI Wireless DGPS Max is a high-accuracy GPS receiver that incorporates internal sensors capable of receiving corrections from Space Based Augmentation Systems (SBAS), the worldwide OmniSTAR service, and DGPS beacon stations. OmniSTAR operates a network of 19 base stations that constantly communicate with available GPS satellites and calculate correction values. The OmniStar subscription service has the benefit of supplying fast and accurate GPS coordinate data without the added steps, inconvenience and processing time associated with other GPS acquisition systems. When using any of these services, the DGPS CSI Max receiver provides locational accuracy at position update rates of up to five times per second (5 Hz). With the growing demand for accurate and reliable GPS positioning, there has been a significant move towards the use of real-time GPS augmentation systems with wide area differential positioning capabilities for ecologically based field surveillance.

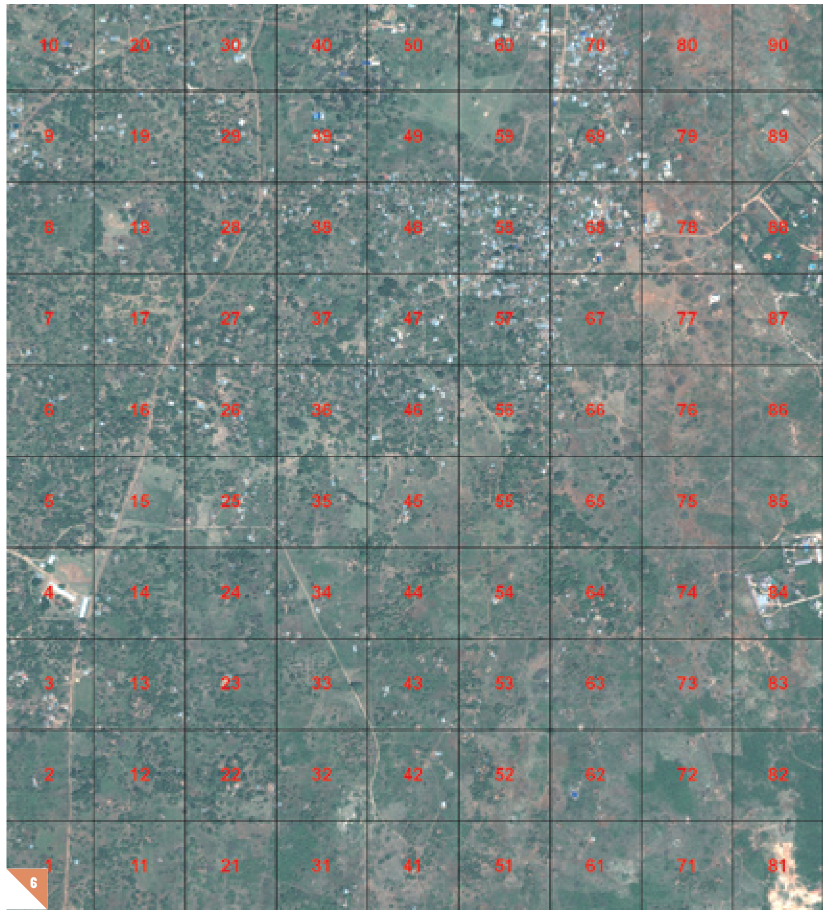


FIGURE 6 *A 250-m square urban grid for Malindi, Kenya*

FIGURE 7 *Digitized grid with a unique identifier with each grid cell/paddy overlaid on Karima village complex in the Mwea Rice Scheme*

CREATING EFFECTIVE CONTROL PROGRAMS

Because malaria is still increasing in sub-Saharan Africa, it is crucial to identify accurate site-specific information to determine areas which maintain the zoonotic cycle. Determining remote heterogeneity in larval habitat distribution can have important operational significance. Evaluating the spatial-temporal distribution of larval habitats by integrating high-resolution satellite data and highly accurate ground coordinates in malaria-prone areas provides the foundation for implementing control measures based on habitat productivity.

Base maps were created from IKONOS and QuickBird data using ArcInfo 9.1 from DGPS ground coordinates. Each aquatic habitat, with associated land cover attributes from a study site, can be entered into a Vector Control Management System (VCMS) database, Advanced Computer Resources Corp. (ACR, Nashua, N.H.). VCMS can support mobile field data acquisition in a study site through a Microsoft PocketPC. All two-way, remote synchronizing of mosquito data, geocoding, and spatial display can be processed using the embedded GIS Interface Kit, which can be built using ESRI's MapObjects 2 technology. The VCMS database can plot and update DGPS ground coordinates of urban and rice land Anopheline aquatic larval habitat seasonal information and can support exporting data to a spatial format in which any combination of larval habitats and supporting data are exported in GIS as a shapefile. Such information makes possible the design and implementation of vector control operations that target zones where high larval densities occur (***Figure 9***).

The current generation of imaging technology was applied to assess the effectiveness of control measures, including using new formulations of insecticides, at representative sites. Time series imagery acquired from field sites combined with laboratory analysis of Bacillus thuringiensis ssp. israelensis (Bti), Bacillus sphaericus (Neide) (Bsph), and Bti:Bsph ratios can be used for preliminary determination of lethal dose (LD) parameters. Follow-up confirmation of LD50 and LD95 values using village-scale tests for final candidate formulations can evaluate efficacy (based on feeding behavior and susceptibility to bacteria toxins), impact of ultraviolet radiation on efficacy, ease of use through conventional application equipment, and cost profile relative to other larvicides. Imagery data also can be used to assess the impact of any control measure on agricultural productivity.

The evolving state-of-the-art in imaging technologies and the expanding scope for applications offer tremendous promise for controlling malaria. These technologies can help transform the vision of eradicating malaria as a major public health threat into a reality. Furthermore, the techniques summarized here can also be applied to other vector-borne infectious diseases to promote other advances in public health. «

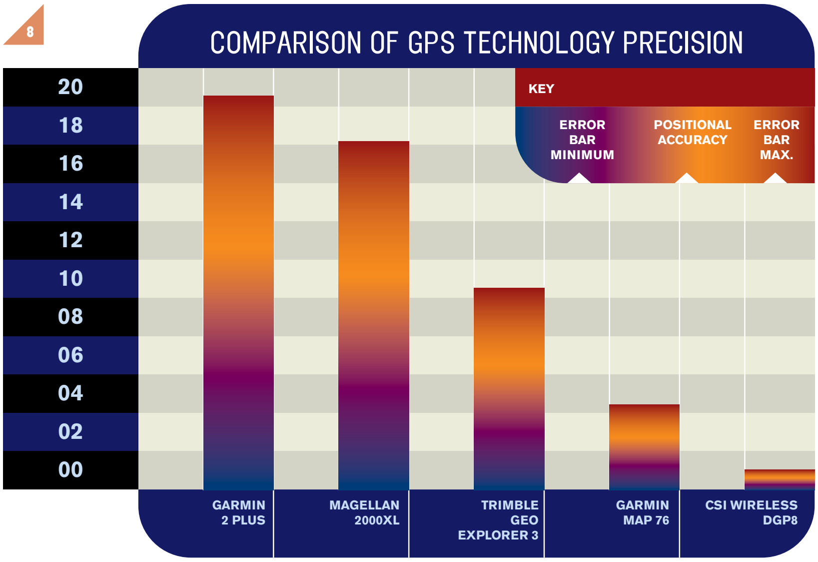


FIGURE 8 *The CSI Wireless Max receiver had the best positional accuracy. A total of 15 test points were collected. The Garmin 2 Plus had a positional accuracy of 15.0m (+/- 5.39m); Magellan 2000XL = 12.03m (+/- 4.17m); Trimble GeoExplorer 3 = 8.03m (+/- 2.43m); Garmin Map 76 = 3.34m (+/- .989m); the CSI Max receiver = .179 (+/- .392).*

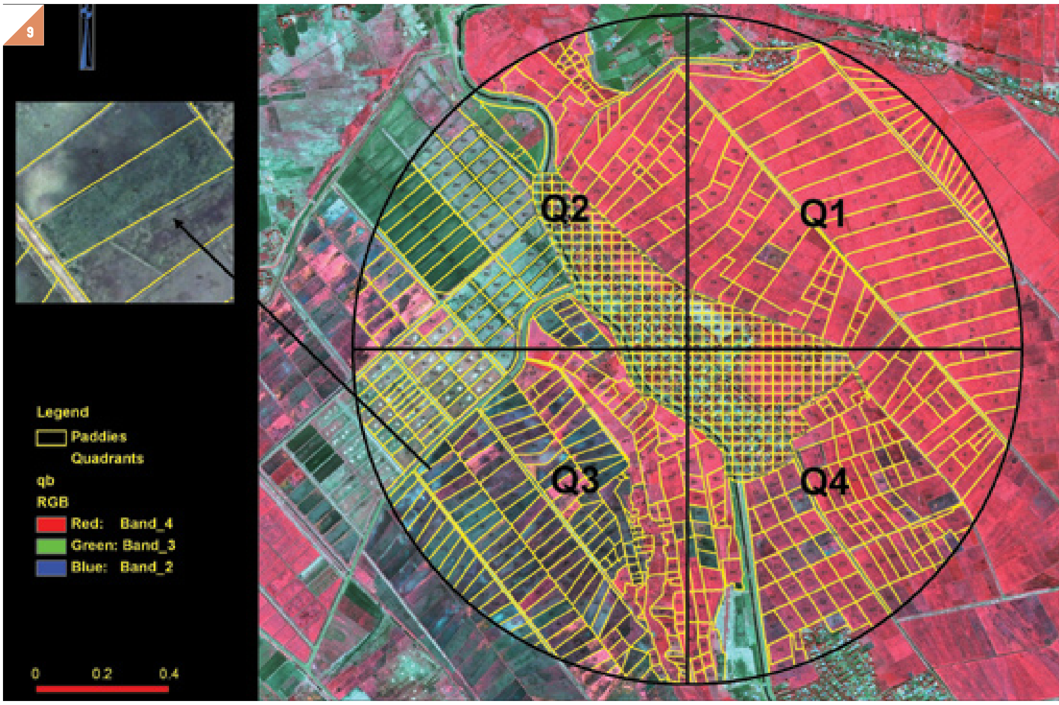


FIGURE 9
Spatially targeting An.arabiensis aquatic habitat using a digitized grid algorithm and QuickBird visible and NIR data within a 1-km buffer divided by quadrants in Kangichiri agro-village complex in the Mwea Rice Scheme, Kenya

ACKNOWLEDGEMENTS

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PHOT

TRACKING GLACIAL ACTIVITY IN NORWAY WITH OGRAMMETRY SOFTWARE

Vertical aerial photo of the north shore of the Brøgger Peninsula in northwest Svalbard taken in 1990. Photo is subset of aerial photograph S90 6526. © Norwegian Polar Institute.

BASED ON HISTORICAL TIDAL RECORDS, GLOBAL SEA LEVELS HAVE risen by approximately 0.17 meters since 1900, and recent predictions estimate that this trend will continue. Excluding thermal expansion, it is believed that 20 to 30 percent of this increase was caused by the melting of small glaciers, such as those in Svalbard, Norway, an area expected to make a disproportionate contribution to future sea-level rise because of its sensitivity to climate change.

In 2003, a group of researchers, led by a team of scientists from Swansea University, U.K. launched a field study named the Sea Level Rise from ICE in Svalbard (SLICES) project, designed to measure and calculate past and future sea-level rise among the archipelago called Svalbard. The purpose of the study was to gather historic topographic data sets for comparison with current records of the same area.

Because of logistical difficulties and a lack of knowledge pertaining to how the world's glaciers are changing, measuring and forecasting global sea-level rise is no small task — and there are few long-term mass balance studies for historical comparison. However, while it is impossible to pinpoint exact timetables, advanced tools for collecting and analyzing information give researchers renewed optimism to expect more precise results than ever before.

The SLICES team, led by Professor Tavi Murray from the School of the Environment and Society, Swansea University, includes a host of prestigious co-investigators and partners such as the Universities of Bristol and Newcastle upon Tyne, the Norwegian Polar Institute, British Antarctic Survey, NASA, University of Silesia, and the Russian Academy of Sciences.

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Between 2003 and 2005, the team collected accurate GPS control data, aerial photography, LIDAR, and optical data of nine benchmark glaciers around the Svalbard archipelago. Statistics from other expeditions, collected during the same timeframe, were also available.

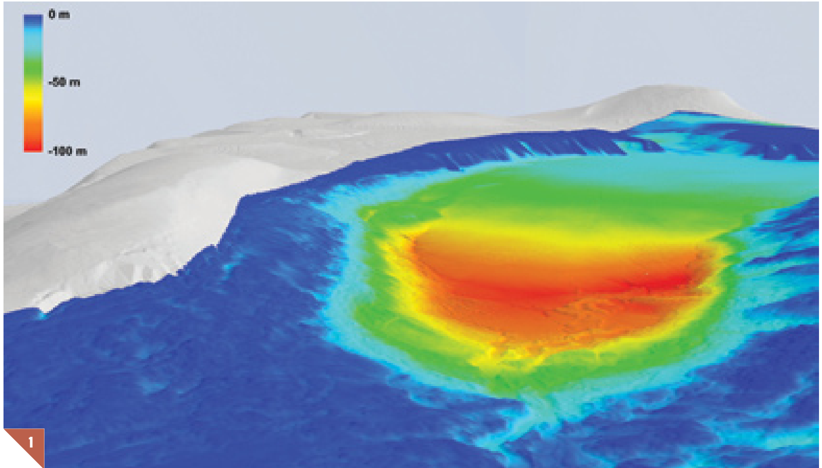
The primary goal was to measure volume changes of the benchmark Svalbard glaciers, using LIDAR and photogrammetrically derived digital elevation models (DEMs), to provide a strong baseline for continued monitoring in the area. The findings were applied to the entire archipelago with a regional mass balance model, which was used to derive 20th and 21st century contributions to global sea-level rise in Svalbard.

THERE WERE FOUR MAIN OBJECTIVES:

1. Address the baseline length limitation of LIDAR collection – the decay in the accuracy of post-processed data caused by the distance between the aircraft and the nearest GPS reference station – and overcome the logistical limitations of working in remote areas.

2. Derive estimates of historical mass balance for the 20th century for a representative sample of Svalbard glaciers.

3. Scale the results to arrive at an estimate of sea-level rise contribution for the archipelago.



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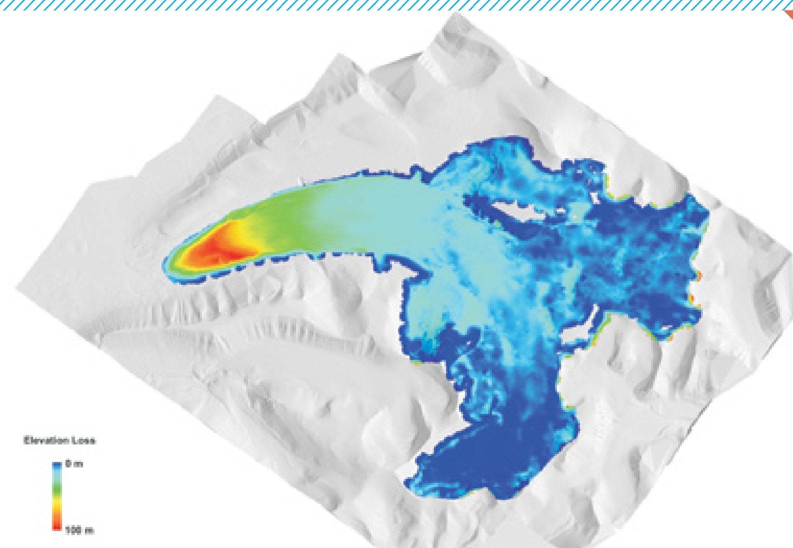

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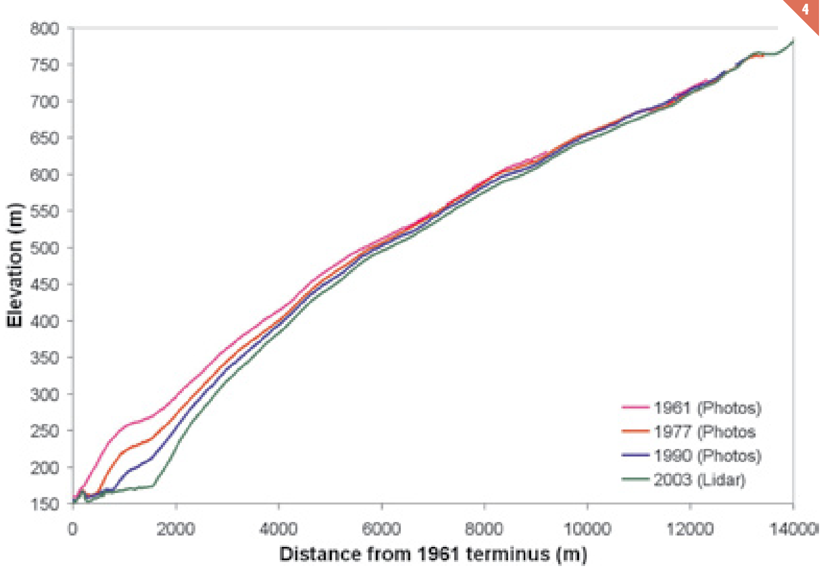


4. Forecast sea-level rise contributions for the 21st century under different climatic scenarios.

The glaciers around Svalbard could make the largest contribution to sea-level rise of any arctic region outside of Greenland. According to Dr. Timothy James, scientist at Swansea University, "Ice masses around the world are changing rapidly. The Glaciology Group within the School of the Environment and Society at Swansea is using advanced digital terrain modeling techniques with SOCET SET as our key photogrammetric data capture package to improve the quantification and our understanding of these changes."

For the SLICES project, there were many large images that had been captured at 1:50,000 scale and scanned at a high resolution to maximize DEM resolution. SOCET SET's flexibility with large images, input file formats and ASCII files was a major advantage. SOCET SET's Automatic Terrain Extraction (ATE) and Interactive Terrain Editing (ITE) modules offer a combination of automated and manual tools for building terrain and surface models, and work equally well with new and century-old data.

Stereo matching on surfaces such as glaciers with repeating patterns and a lack of texture is notoriously difficult. Through the use of back-matching algorithms in ATE, the scientists have been able to eliminate many of the blunders that are normally associated with stereo matching on such surfaces, and thus obtain a better automated DEM with far less manual correction required.

Occasionally, in extremely steep areas, or areas where fresh snow cover makes stereo matching difficult, the team implements a hybrid approach, which involves measuring DEM points or breaklines manually in ITE, then using these as seed points in ATE. If stereo matching is unreliable, for example in areas of fresh snow with little texture, it is preferable to have a hole in the data, as opposed to blunders. A TIN (Triangulated Irregular

THE SCALE SHOWS SURFACE LOWERING OF OVER 100 METERS. SINCE 1961, THE SNOUT (FRONT OR TERMINUS) OF SLAKBREEN HAS RETREATED 1.4 KM, WITH A SIGNIFICANT PORTION OF THE MELT OCCURRING IN THE PAST 10 YEARS.

FIGURE 1 *Perspective view (looking northeast) of a glacier in Svalbard, Norway called Slakbreen. The image, from 2003, shows a shaded-relief, LIDAR DEM interpolated to 2 meter overlaid with a change map relative to a 1961 DEM. The figure was created in QT Modeler from Applied Imagery.*

FIGURE 2 *Another LIDAR DEM of Slakbreen Glacier, illustrating the decrease in elevation over the 42-year period. Note that red areas show decrease of over 100 meters.*

FIGURE 3 *Vertical aerial photograph of Slakbreen in 1990. Photo is subset of aerial photograph S90 1987, © Norwegian Polar Institute*

FIGURE 4 *Graph shows centerline profiles of Slakbreen for each of the four years for which topographic data are available. Data for 1961, 1977, and 1990 were all derived from aerial photographs using photogrammetry, and 2003 data is from a LIDAR DEM. These results showing rapid decay are typical in the west of Svalbard.*

FIGURE 5 *2005 photo of Midre Lovénbreen in northwest Svalbard.*

FIGURE 6 *2005 shaded-relief LIDAR DEM of Midre Lovénbreen in perspective view shaded by elevation.*

FIGURE 7 *1990 aerial photo of Midre Lovénbreen with GPS checkpoints overlaid. Photo is subset of aerial photograph S90 6526, © Norwegian Polar Institute.*

FIGURE 8 *Calving (fracturing) front of Monacobreen in northwest Svalbard (in 2004) with zodiac for scale (small inflatable boat for short trips).*

Network) DEM, produced in ATE with back-matching, yields much better results; it will identify such points as blunders and discard them.

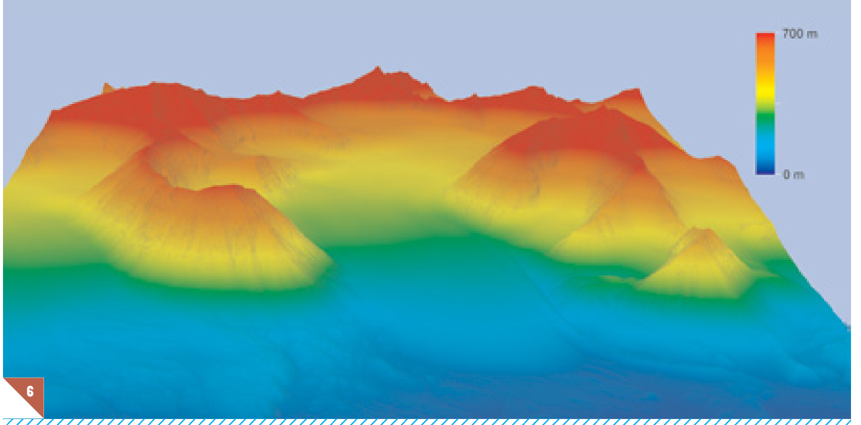
Results from study of the Slakbreen glacier (The Slak Glacier) are illustrated in ***Figures 1–4***. ***Figures 1*** and ***2*** show 2003 shaded-relief LIDAR DEMs. The image of Slakbreen is overlaid with a color-coded illustration that depicts elevation change of the glacier surface since 1961 which was calculated using the 1961 DEM generated photogrammetrically in SOCET SET. The scale shows surface lowering of over 100 meters. Since 1961, the snout (front or terminus) of Slakbreen has retreated 1.4 km, with a significant portion of the melt occurring in the past 10 years. Evidence suggests that this is characteristic at least on the west side of the Svalbard archipelago. Mass balance measurements of selected benchmark glaciers in Svalbard were made using contemporary and historical aerial photographs controlled using contemporary LIDAR DEMs. This approach provides both well distributed and long-term mass balance measurements.

Figures 5-7 show the Midre Lovénbreen glacier in photos, in LIDAR and with GPS checkpoints overlaid. The glacier, like Slakbreen, has experienced significant melting over the last 40 years. Between 1961 and 2005, the average rate of melt was found to be about 0.47 meters vertically per year, with more melt occurring in recent years.

Climate change is a cause for concern to the scientific community and the general public. Small glaciers like those in Svalbard represent only four percent of the world's total land ice, but account for an estimated 20 to 30 percent of 20th century sea-level rise — and the melt has increased substantially since 1988. This work is extremely important for improving predictions of sea-level rise due to the density of population along the world's coastlines. To appreciate the scale of these glaciers, note ***Figure 8*** and cover of this magazine.

Looking ahead, the Swansea Glaciology Group is turning their attention to Greenland, an area that has been identified as crucial for predicting future sea-level rise. Their new project, Greenland Ice Margin Prediction, Stability and Evolution (GLIMPSE) aims to examine the Greenland ice sheet through collaborative research using fieldwork, remote sensing, and modeling studies. To help make this project possible, GLIMPSE will provide an exciting opportunity for private sector organizations to become involved in groundbreaking Greenland research. For details on these and other projects underway within the Swansea Glaciology Group, please visit: http://geography.swan.ac.uk/glaciology/ «

***NOTE** LIDAR data courtesy of the Natural Environment Research Council Airborne Remote Survey Facility in the U.K. Aerial photographs were provided by the Norwegian Polar Institute. The SLICES project would like to thank BAE Systems for their support with SOCET SET (www.baesystems.com/gxp) and Applied Imagery (www.appliedimagery.com) for providing their Quick Terrain Modeler software.*



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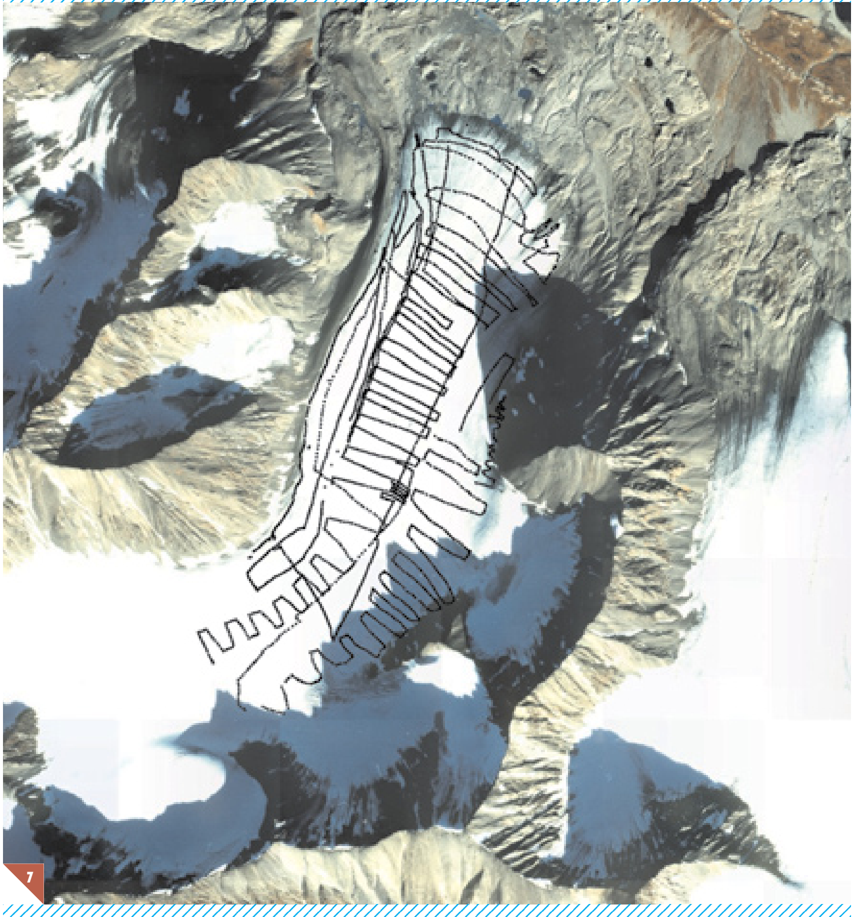

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Taking 3D Visualization to New Heights

MILITARY USE AND BEYOND

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THE POPULARITY OF INTERNET-BASED 3D visualization applications is clearly on the rise. Tools such as Google Earth and Microsoft Virtual Earth provide easy and intuitive access to a wealth of satellite imagery, aerial photos, mapping data and other location-based information that combine to generate a synthetic environment that models the real world in some way. Google, Microsoft and others are opening up this geospatial browsing experience to everyone, allowing users of all ages essentially to "spin the globe" and visit any number of locations for further exploration.

Some of these synthetic environments support sophisticated representations of real-world objects, such as using photorealistic textures, real-time video, and integration of other forms of complex information. Another feature that offers top performance and a continuous experience is the support for multi-resolution image and multi-resolution terrain data that enable multiple levels of detail.

Many organizations within the military, intelligence, and homeland security industries are considering, or already have embarked upon, deployment of these capabilities within their enterprises. However, initial deployment of 3D visualization technology can fall short of expectations for some of these agencies. As users in these organizations employ these geospatial browsers to fly to their area of interest for a particular task, they of course need to see their own in-house imagery and other information assets directly within that environment.

This is important so that the operators and analysts can perform required analysis; however, these users are finding out that achieving this goal may not be so straightforward or cost effective. Additionally, military and intelligence organizations require their own mission data in their original format to appear in these systems, and they require the use of military symbology when representing related mapping information in that context.

In the military and intelligence context, it is extremely important that all of the imagery, aerial photos, and other information be quickly integrated and accurately placed, since decisions need to be made rapidly. However, some geospatial browsers do not support direct connections to dynamic online imagery archives, and require conversion of the imagery into specified formats in order to appear in the visualization environment. In addition to causing delays in the overall decision cycle, this conversion introduces administrative overhead costs. As imagery is constantly collected and updated, it is essential that the visualization environment be fed with a constant stream of updated imagery automatically, and to do so while limiting data conversions that introduce delays in the process.

Skyline Software's suite of 3D modeling and visualization products deliv-

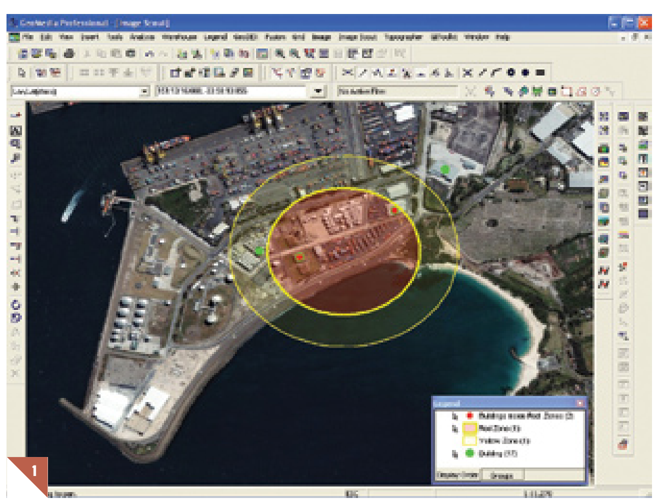
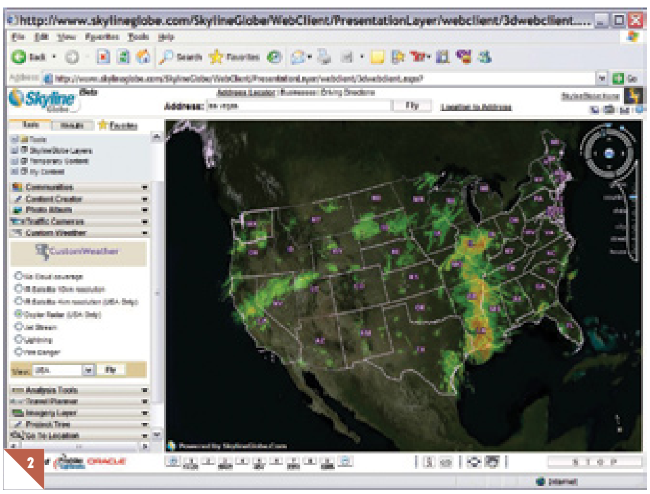


FIGURE 1
Image Scout provides today's intelligence analysts with advanced visualization and data fusion capabilities

ers a rich and intuitive experience, and is built on an architecture that provides dynamic updates of imagery from online archives and offers support for direct connections to online web services. Whereas other systems may require preprocessing and manufacturing of the data prior to display, Skyline's model enables dynamic updating on-the-fly, thus ensuring the most up-to-date representation possible.

An additional concern is that these geospatial browsers offer seamless integration into tools and systems that already exist within these enterprises and not merely as stand-alone interfaces, or "stovepiped" tools. Many tools, such as Intergraph's advanced image exploitation application, Image Scout, are in widespread use within military and intelligence agencies around the world and use the same data that feeds the geospatial browsers. However, if geospatial browsers do not directly integrate with these applications, users must switch between systems and manually correlate information, thus causing delays in the overall decision-making process. See ***Figure 1***.

Intergraph has directly incorporated the Skyline 3D visualization environment into Image Scout and other applications as a "3D engine." This seamless integration provides a rich and rewarding experience, and further compresses the overall decision cycle. The integration between Intergraph and Skyline brings together key technologies that combine to solve many of the problems facing today's analysts.



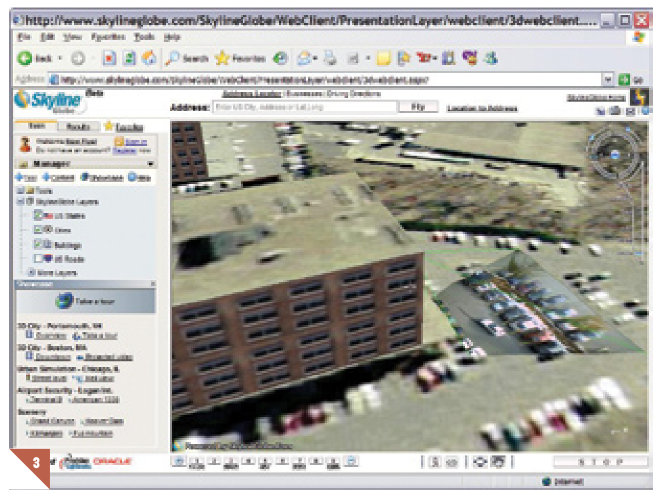


FIGURE 2 *Direct integration with OGC web services provides up-to-date data feeds of dynamic information, such as weather*

FIGURE 3 *SkylineGlobe provides real-time integration of motion imagery directly into the 3D environment*

THE IMPORTANCE OF AUTOMATED IMAGERY MANAGEMENT AND INGEST

There is no doubt that the sheer amount of digital information in the world today is rapidly increasing. As network bandwidths increase, disk storage becomes less expensive, and as all types of systems from camera phones to orbiting satellites collect information in higher and higher resolutions, we are faced with the growing need to manage all of these data. Military and intelligence organizations are finding themselves spending more and more time finding, accessing and transmitting these digital files.

A similar comparison outside of the geospatial industry is the rapidly increasing popularity of digital music. In the digital music consumer market, Apple provides a digital music management system, iTunes, that accompanies every iPod digital music player sold. iTunes provides a user-friendly and powerful interface for managing tens of thousands of digital music files, as well as photos and videos, while removing users from the burden of navigating folders and files with Windows Explorer to find those files. iTunes makes the music and other files easily discoverable and also provides direct uploads to the digital music players themselves.

In a similar manner, Intergraph has tackled the problem of collecting, managing, and disseminating vast amounts of digital imagery that can directly feed into a 3D visualization environment. This solution, TerraShare, automates the management of vast amounts of satellite imagery, aerial photos, elevation data, and other digital files that are essential to the 3D visualization experience. The imagery is indexed and cataloged, making that imagery automatically discoverable by the 3D visualization applications, thereby improving efficiency, reliability, and quality.

Organizations are also faced with the burden of finding, preparing and uploading data into these archives, activities that can consume a significant amount of time. Today's fast-paced environment also demands around-the-clock monitoring and processing of new data. Intergraph's Auto Terra Ingest tool automates the ingest and preprocessing, and uploads new imagery to TerraShare the instant it becomes available. This maximizes the effectiveness and productivity of the entire organization, and also raises the confidence level of the analysts, as they know beyond any doubt that they are working with the most recent and relevant data possible.

INTEROPERABILITY AND COLLABORATION

Providing the user with a high degree of flexibility regarding the selection of data sources is important for 3D visualization systems. Users across an organization have differing requirements and may require different renditions of a common area of interest, and may even need to link in new sources of information at the time of fly-through. Some remote information may be very dynamic in nature, such as real-time sensor feeds, weather patterns, or highway traffic conditions, so it is essential for the 3D visualization tool to create persistent links to these data feeds.

The Open Geospatial Consortium (OGC) provides open web services that allow users to discover and link to a variety of geospatial data feeds, including imagery. Some 3D visualization systems, such as Microsoft Virtual Earth, NASA's World Wind, and SkylineGlobe, support these OGC web services and provide the most up-to-date experience possible. Users have the flexibility to discover new sources of web services and can then fuse and correlate many disparate sources of information to help the analyst visualize and understand information in new and improved ways.

Three-dimensional visualization technology can also be a uniting force. Mapping and imagery information provide a common, global language. Whereas many 3D visualization systems allow individual users to conduct their own fly-throughs and explore areas of interest with this common set of information, Skyline's 3D environment supports real-time collaboration among users across the organization. This powerful capability allows one user to conduct a fly-through, possibly a mission rehearsal, and then invite remote observers to "go along for the ride." Each remote participant experiences the environment in the same manner, and can communicate real-time with the mission leader. If desired, the leader can pass flight control to another participant during the session ***(Figure 2)***.

INTEGRATION WITH MOTION IMAGERY

Motion imagery is playing an increasingly larger role in modern warfare. Unmanned aerial vehicles (UAVs) have become instrumental in real-time surveillance and operational support. The use of this collected video can provide a powerful analytical advantage and can serve to make future planning activities more effective.

Integration of these collected video streams in the 3D environment is essential. Whereas some systems allow for pop-up windows to display video, this feature requires the analyst to transition between views and windows and limits the assimilation of information. However, Skyline's integration of UAV feeds directly into the 3D environment providing for a more optimal experience. The background imagery and geospatial features add context to the video and help the analyst to understand better the video content as well as the environment that surrounds the field of vision of the camera or sensor.

For example, an analyst may be able to determine that a street intersection is visible in a stand-alone UAV feed, but he may not immediately realize which exact streets are intersecting. By fusing this video directly into the 3D fly-through, satellite imagery and mapping information provide that additional surrounding information, such as street names, and quickly orient the analyst. See ***Figure 3***.

CONCLUSION

A key goal of these 3D visualization environments is to model and represent our environment in a rich and intuitive manner. For military and intelligence organizations, this modeling must be done quickly and accurately and must make complete use of existing imagery and other information in a variety of formats and locations. Such modeling should also do so without requiring conversion of the imagery or data. To be truly useful, these 3D visualization applications must integrate with existing applications that provide ongoing analysis and decision support. They need to provide flexibility for users to incorporate additional data sources at the time of fly-through as needs dictate. While some of these systems may provide a very rich fly-through experience, if the data are not accurate or relevant, then their use as a true decision support tool is greatly diminished.

Imagery management systems are critical to establishing a reliable foundation from which to generate an accurate and truly representative 3D environment, since they automate the search and dissemination of vast amounts of digital information. As military organizations face the need to collect, manage and share more and more data, imagery management solutions such as TerraShare will be the key to doing so reliably, securely and cost efficiently. Just as iTunes automatically delivers digital music to an iPod, TerraShare delivers digital imagery to the analyst's 3D visualization environment.

As we deal with the ever-increasing volume and variety of imagery and other digital information, we must be prudent about how we present that information to the analysts and operators. Consolidation of windows and views, and effective blending of all kinds of information into one seamless environment, are essential for rapid understanding and assessment. We must strive to make the complex simple, to consolidate information delivery so that analysts can be more effective than ever before in our complex world. Three-dimensional visualization technology can be instrumental in achieving this goal. «

economic significance of improved environmental forecasting

ENERGY AND INSURANCE SECTORS

Weather conditions and climatic factors affect virtually all economic sectors. Continuous enhancement in accuracy, coverage and resolution of Earth-observing systems by NASA and NOAA will lead to better-informed decisions by end users, thus reducing risk and improving operations.

Some industries are better prepared to utilize enhanced data than others. The energy and financial services sectors—in particular, the insurance industry—use sophisticated forecast models for a range of decision making. The cost of decisions that are based on limited, incomplete or inaccurate data is compounded by errors resulting from deficiencies in the applications or models through which the data are processed. Better understanding of the needs of customers in these industries is imperative.

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USE OF ENVIRONMENTAL INFORMATION IN THE ENERGY SECTOR

Accurate forecasts of power demand are directly reflected in the profitability and commercial competitiveness of energy suppliers and distributors. Better anticipation of power demand—through load forecasting techniques based on weather forecast and market data—is essential to the operations of energy suppliers. Such a capability assists them in matching supply to demand, complying with environmental and other regulatory requirements, and operating in a socially responsible manner.

Load forecasting models assimilate weather forecast data and other information to predict power demand and to mitigate operational risk. However, the accuracy of load forecasting systems is limited by errors in weather data and is compounded by deficiencies in weather and load forecast models and by human error. Reducing load forecasting errors is critical to cost-sensitive areas.

Since deregulation of the energy market, power providers are even more conscious of factors affecting their operations and efficiency. Power generation, transmission and distribution companies increasingly have to deal with issues related to reliability and cost effectiveness. At the same time, they are becoming more and more aware of the overall risks to capital posed by weather conditions and, over the longer term, by climate change.

In fact, weather is often cited as the "tipping point" causing unreliability in the system, decreasing the efficient supply of power and leading to substantial costs. Unpredicted sea breezes, back-door fronts, afternoon thunder-

FIGURE 4 *Winds blow from the mountains down to the coast around Boston, driving temperatures up. Image of Boston Harbor taken Aug. 2, 2005 by IKONOS, courtesy of GeoEye.*

FIGURE 1 *Time scales and operational functions within each timescale.*

FIGURE 2 *Map of the U.S. Regional Transmission Organizations (RTO) showing the California (2) and New England (7) Transmission Territories relevant to these case studies.*

1

TIME SCALES/OPERATIONAL FUNCTIONS

REAL-TIME – SITE-SPECIFIC WEATHER INFORMATION

A. DYNAMIC LINE LOADING
B. EMISSIONS CONTROL

SHORT-TERM LOAD FORECASTS – 4 HOURS TO 7 DAYS

A. GENERATION COMMITMENT
B. TARIFF SCHEDULING
C. COMMITMENT OF EXPENSIVE MUST-RUN GENERATION

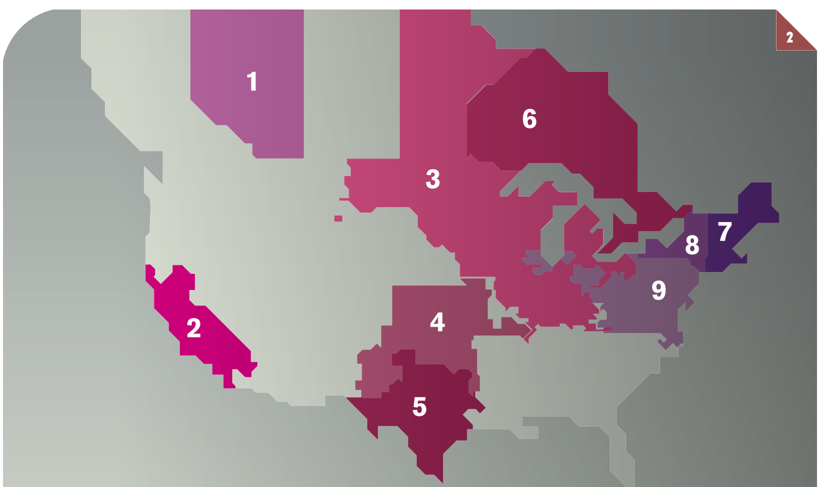
SEASONAL

A. IRRIGATION PUMP LOAD
B. DEFERRING CAPITAL INVESTMENT ASSET MANAGEMENT DECISIONS
C. FUEL PURCHASING

DECADAL

A. INFRASTRUCTURE SITING AND UPGRADING

2



U.S. REGIONAL TRANSMISSION ORGANIZATIONS

1 ALBERTA ELECTRIC SYSTEM OPERATOR
2 CALIFORNIA ISO
3 MISO RTO
4 SPP RTO
5 ERCOT ISO
6 ONTARIO INDEPENDENT ELECTRICITY SYSTEM OPERATOR
7 NEW ENGLAND ISO
8 NY ISO
9 PJM INTERCONNECTION

Note: Other RTO's exist.

storms and other environmental factors tend to result in overestimated forecast demand. Under-forecasting summer temperature extremes can cause load swings that might cost as much as $75-200 per megawatt hour.[1]

Heightened power demand is largely driven by high summer temperatures, and to a lesser extent by low winter temperatures. Temperature also acts as a constraint on transmission systems, which are rated to carry specific power loads at defined temperature intervals. Wind, too, has an impact on the system, as it modifies temperature. Hence, weather conditions impact not only overall power usage, but also the carrying capacity of the transmission system.

Energy companies need to know what weather information is available, how to access it and use it to inform operational decision making, and how to employ it for strategic planning. They also need to know which decision support tools are most appropriate and effective. The value of environmental information can be demonstrated by its impact on pricing, scheduling, risk management and, ultimately, the company's bottom line of profitability.

The energy industry utilizes forecast data on different time scales depending on the operational function (see ***Figure 1***).

A series of benchmarking energy sector studies showed these deficiencies:

A. Error in weather forecast data;

B. Inadequate incorporation of environmental data into load forecast models;

C. Load forecast model error;

D. Misapplication of load forecast output in business transactions.

FIGURE 3 *Wind blows from inland westward, funneling through the Golden Gate strait, just north of San Francisco proper. Image taken Aug. 28, 2004 by IKONOS, courtesy of GeoEye.*

The economic benefits of environmental observations to the U.S. energy and financial services sectors, and the potential of improved observing systems to increase such benefits, are illustrated primarily by two energy sector case studies.[2] The U.S. energy transmission system is divided into distinct areas, each run by its own independent system operator (see ***Figure 2***.)

CALIFORNIA DELTA BREEZE PREDICTABILITY

During the summer, northwest winds are drawn into California's Central Valley over the Golden Gate strait and into the lower portions of the San Francisco peninsula. To the south of Mount Tamalpais, the northwesterly winds accelerate considerably as they stream through the Golden Gate (see ***Figure 3***). This channeling of the flow through the Golden Gate produces a jet that sweeps eastward but widens downstream, producing southwest winds at Berkeley and northwest winds at San Jose; a branch of this air stream curves eastward through the Carquinez Straits and into the Central Valley. The result of this "delta breeze" is a massive decrease in power demand that can result in a 4,000 megawatt shift in just a few hours. Few energy systems experience such extreme weather phenomena.[3] The delta breeze is strongly influenced by large-scale synoptic weather patterns that move into California from the northern Pacific Ocean.[4]

NEW ENGLAND WEATHER CONDITIONS

A similar study was carried out looking at weather conditions impacting the Independent System Operator for New England (ISO-NE). A case-by-case analysis was completed to identify the standard synoptic weather events that are correlat-

FIGURE 5 *Load model errors due to weather forecast errors were found in 27 of 30 cases studied.*

ed with high weather forecast errors. In 27 of the 30 cases examined, the load model errors could be explained by weather forecast errors associated with recurring weather features, the key ones being:

A. A frontal boundary moving through the area slower or faster than expected.

B. Easterly or northeasterly maritime winds resulting in temperatures below those that were forecast.

C. Strong westerly winds flowing downhill from the mountains to the coastal plain around Boston, Mass. and Providence, R.I., resulting in compression of the air and, thus, temperatures higher than forecast. (See ***Figure 4*** on page 35.)

D. Unexpected afternoon thunder-showers resulting in temperatures lower than forecast.

A summary of these results is presented in ***Figure 5***.

A review of forecast errors and associated market prices during summer 2002 shows that significant forecast errors occurred during periods of high market prices. This relationship suggests that marketers may be able to pinpoint key load and temperature events, and that there is a need to reduce load forecast errors.

Further investigation indicated that the weather forecast component in the model was responsible for only approximately 40 percent of the overall load error. A subsequent test of the 30 days with the highest load error revealed that when the load error was high, forecast error was responsible for a substantially larger percentage of the load model error. The forecast improvement was only 6.41 percent for the entire model run. This improvement more than doubled to 15.76 percent when the analysis was conducted on the 30 days with the highest error.

These results indicate the potential to improve the load model forecast by improving the weather forecast. It is difficult to estimate the total cost to ISO-NE, or a true social cost, for these errors. However, during some of the highest-error days, including one in which an outage at a major base load plant necessitated expensive imports from Quebec, costs approached $1,000 per megawatt hour.

The weather forecast component and the total load error exhibit minimal correlation (r2 = 0.1900). This means that under-forecasting of the temperature profile does not necessarily imply under-forecasting of the load, and vice versa. The model component and the total load error possessed a high degree of correlation (r2 = 0.8564). This means that the more accurate the temperature forecast, the more likely the power load requirements will be.

Overall, the case studies above suggest that environmental conditions, particularly weather, can have significant impacts on the bottom line of energy supply and delivery organizations. The trend toward real-time pricing and sub-hourly markets makes load forecast accuracy even more critical.

The benefits of improving the day-ahead weather forecast by one degree Fahrenheit include the following:

A. Approximately $20-25 million per year in cost avoidance for a major Northeast regional transmission authority.

B. About $1-2 million per year cost avoidance for a large regional distribution company.

5

WEATHER EVENT	TEMPERATURE FORECASE	NUMBER OF EVENTS
FRONTAL BOUNDARY	TOO HIGH OR LOW	10
MARITIME FLOW	TOO HIGH	6
STRONG WEST WINDS	TOO LOW	6
UNEXPECTED AFTERNOON SHOWERS	TOO HIGH	5
UNEXPLAINED	TOO HIGH OR LOW	3

THIS ALTERNATIVE STRATEGY ESSENTIALLY REPRESENTS A CHANGE IN PARADIGM FROM UTILIZING ENVIRONMENTAL INFORMATION FOR REGULATORY COMPLIANCE TO USING IT FOR COMPETITIVE ADVANTAGE THROUGH OPERATIONAL APPLICATION.

Effects on private energy companies' earnings per share (EPS) can be dramatic. One of the large generators in the Northeast reported that its earnings per share in 2003 versus 2002 were positively affected by $+.15/share. In an earlier report, it noted a negative result of $-.05/EPS due to adverse weather effects. Thus, over a short period of time, earnings can swing from a loss of $11 million to a profit of $36 million—a $47 million swing—primarily the result of seasonal weather patterns such as a colder-than-average winter.

Weather forecast error costs suppliers, transporters and consumers. Despite improvements in weather forecasting, load forecast errors still average in the range of 1 to 2 percent per year, and these errors add up to significant annual costs. In addition, extreme weather events often occur during periods when energy costs are normally high.

THE FINANCIAL SERVICES SECTOR AS RELATED TO THE ENERGY INDUSTRY

The financial services sector is closely tied to the energy industry, as it influences the way in which energy companies operate their underwriting investment. The energy sector must respond to pressure from the financial services sector to manage weather-related risk. Improved management would minimize unanticipated costs, reduce high generation costs, meet environmental and supply regulatory requirements, and optimize capital investment, all of which impact profitability.[5]

The key to achieving these objectives is the enhanced use of weather forecast information to transform weather-related risk into probabilistic terms, a concept that is understood by the financial services sector and that facilitates improved management and mitigation of financial risk.

Power companies are continually developing strategic plans to manage and mitigate their diverse risks. While the use of weather derivatives to manage risk has gained considerable momentum in the energy industry over the past five years, there is an alternative mitigation strategy available, namely, to use environmental forecast information more effectively as a supplement to, or replacement of, weather derivatives. This alternative strategy essentially represents a change in paradigm from utilizing environmental information for regulatory compliance to using it for competitive advantage through operational application. Hedging risk with information is the goal.

CONCLUSIONS

The case studies indicate that forecast information is now of sufficient accuracy to be incorporated into decision-making processes and models with greater effectiveness. New methods are facilitating the creation of probability trends, which the energy industry will be able to incorporate into its forecast and financial models. The challenge is to shift away from the statistical forecast methods used currently to the probabilistic data. The Northeast case study confirmed the need for this shift, as significant levels of error in both weather forecasting and load forecasting were found.

It is important that the information that is generated from the enhanced observing systems be rapidly assimilated into society to enhance economic competitiveness, improve public safety and address policy imperatives. While it is commendable to produce information that is "capable" of enhancing various industry operations and decision making, it is important that the providers, such as NASA and NOAA, help to prepare users to receive the information and maximize its utility. An investment in understanding the customers' needs is essential to transferring observing systems research to practical operations. «

FOOTNOTES

1. *Mary Altalo and Monica Hale, 2004. "Turning Weather Forecasts into Business Forecasts,"* Environmental Finance, *May 2004.*

2. *Science Applications International Corporation (SAIC) undertook a series of regional and industry-specific studies sponsored by NOAA from 1999 to 2005.*

3. *T. D. Davis, D. Gaushell, D. W. Pierce, and M. Altalo, 2005. "Guessing Mother Nature's Next Move: What Can Be Done to Improve Weather Prediction and Load Forecasts?"* Public Utilities Fortnightly, *August, 2005.*

4. *Mary Altalo, Todd D. Davis, and Monica Hale, 2004. "The Economic Benefit of Incorporating Weather and Climate Forecasts into Western Energy Production Management, Final Report," a project sponsored by the National Oceanographic and Atmospheric Administration (NOAA).*

5. *Monica Hale, 2003. "Environment, Weather and Climate Information in the Financial Services Sector"* In Practice, Bulletin of the Institute of Ecology and Environmental Management (IEEM), *No. 42, p. 9-12, Dec. 2003.*

A Summit Stop in Middle Earth on the Way to the Digital Earth Symposium

NEW ZEALAND TAKES SUSTAINABILITY SERIOUSLY

WHAT DO YOU GET WHEN A BUNCH OF KIWIS traveling along on an unsustainable pathway meets an entourage of international Digital Earth enthusiasts? In Auckland, New Zealand, last August, this experiment unfolded before several hundred participants, yielding many striking results at the Digital Earth Summit on Sustainability (www.digitalearth.org.nz/). The summit focused on recognizing a wave of innovative technological means to enable citizens and governments to view the complexity of our planet for any specific place on the Earth's surface. Digital Earth was presented as a global initiative aimed at harnessing the world's data and information resources to develop a virtual 3-D model of Earth in order to monitor, measure, and forecast natural and human activity on the planet.

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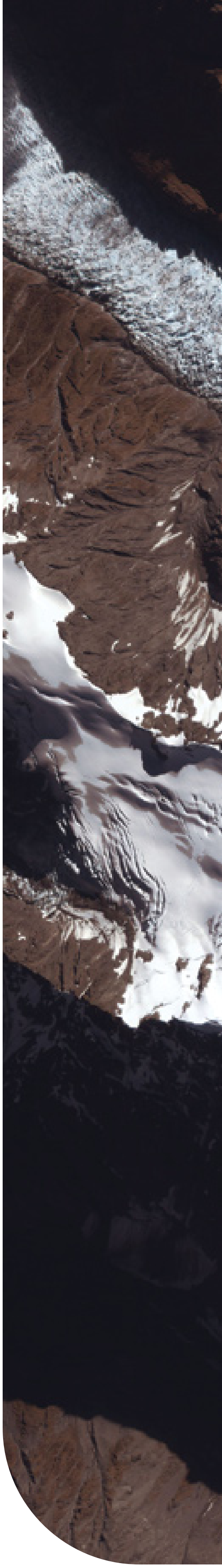
For an isolated island nation with four million citizens and an abundance of natural resources, New Zealand might not be expected to be so keenly interested in the ubiquitous but fuzzily defined topic of sustainability. Prime Minister Helen Clark, however, quickly pointed out in her keynote speech that this is not the case for her nation. She noted that the government, universities, industry, and citizen groups are acutely aware of the looming threats to their quality of life from global climate change, decreasing biodiversity, dependence upon a fossil-fuel economy, and the myriad impacts of these dynamics on social harmony and quality of life. Prime Minister Clark noted,

> *"If we are able to manage our resources wisely from now on and build on modern technology and innovation, we will be able to forge a path that will enable New Zealanders to maintain our high quality of life.*
>
> *Information and social engagement are a key to that. Working collaboratively across central government, local government, business, and non-governmental organizations, we can build a sustainable future for New Zealand.*



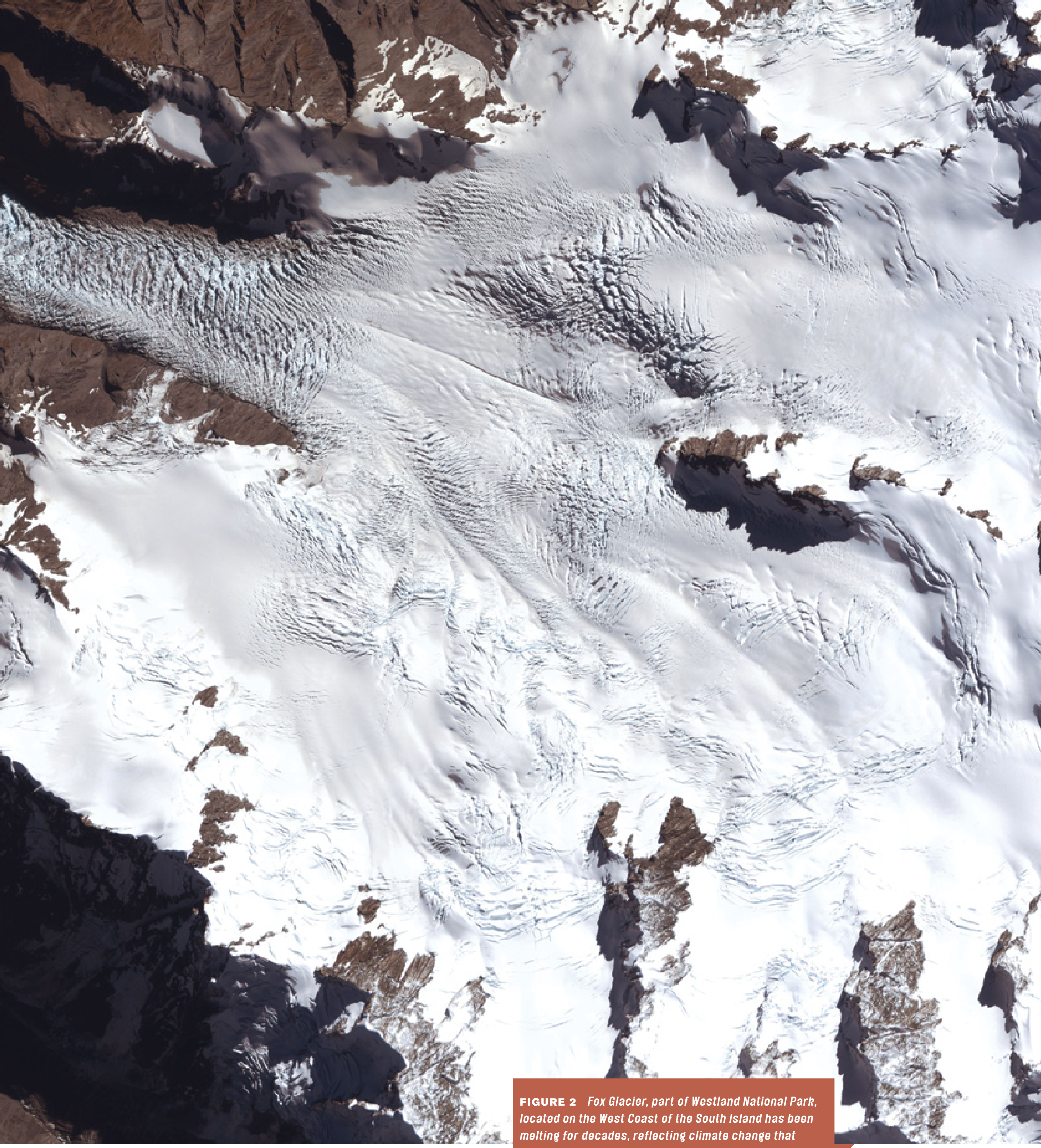


FIGURE 2 *Fox Glacier, part of Westland National Park, located on the West Coast of the South Island has been melting for decades, reflecting climate change that will affect these tiny islands more quickly than larger land masses. Image captured April 11, 2003 by IKONOS, courtesy of GeoEye.*

FIGURE 1 *Auckland, capital of New Zealand and location of the sustainability summit. Satellite image captured August 15, 2001 by IKONOS, courtesy of GeoEye.*

The place we can look to learn how to be a global community, is in our own community. The school, the marae (Maori meeting house), the workplace, the council chamber, the country hall, all are places where we can learn how to work together as a community. Increasingly, the way we find out about what is going on in our neighbourhood, our catchment, our city, is by digital means.

Using tools like these with other digital data and information, we can look to our past, analyze our current situation, and plan for a sustainable future."

The prowess and promise of the Digital Earth vision and technology were well covered at the summit in a series of engaging talks that investigated and assessed a great variety of compounding issues facing all nations and all people. Internationally recognized intellectuals explored various themes associated with contemporary understanding of sustainability, including energy and transportation, climate change, urban housing retrofitting, land reform, and community welfare.

Auckland Councilman Richard Simpson provided an enthusiastic presentation that emphasized the fundamental biological imperative contained within all living species to survive. His survival-based thesis pointed out the various organizational constructs that are needed in complex societal systems, and the need to harness technology to maintain the pulse of system components in assuming 'governance' functions for cities and the nation.

Maslow's Hierarchy of Needs and the confounding feedback and relationships of ecological goods and services can be construed, according to Simpson, to impose critical reliance on automated spatial systems. Digital Earth represents the philosophical and technical umbrella for forging forth into an uncertain world of dwindling resources and increased meteorological variability. He suggested that the need to have citizens and government working with a shared view of the landscape can best be envisioned using Digital Earth technologies that allow for community decision making to be integrated with complex models for hydrology, transportation, taxation, and other relevant data.

Auckland's Mayor, Dick Hubbard, harmonized with the other New Zealand elected officials in recognizing that good governance requires good communications with the citizens. Equally important, in his view, is mastering understanding of the complex underpinnings of municipal operations from health services to education, and from housing needs to more sustainable and green business innovation. He echoed the sentiments of other New Zealanders who wish to see their nation as a leading example, or "living laboratory," for the movement towards sustainable living.

Mayor Hubbard noted that New Zealand's capacity for excellence in technology, including winning the America's Cup in sailing, and their strong sense of connection with the land provides the right mix for leading the world's thinking on sustainable development. The Maori legacy adds an important element to the great challenge of balancing all things to include indigenous peoples and their cultures along with e-commerce and renewable energy.

Other delightful contributions to the summit potpourri of intellectual wealth included the work of Beacon Industries as presented by Nick Collins, who described the company's retrofitting of 50,000 homes in New Zealand as part of a strategy to reduce the ecological footprint (the resource demands for water and energy). These and other impressive pilot projects are being studied by academic-industry-government partnerships of the Land Environments of New Zealand. Dr. Maggie Lawton shared with the summit attendees the impressive efforts of her team as they collect, analyze, and organize the fundamental information layers for New Zealand as prerequisite components of their "Digital New Zealand."

All in all, the New Zealand speakers presented a positive image of a country that recognizes and treasures the gifts of natural and cultural resources within the island nation. They also readily acknowledge the challenging struggles to address the oil-addicted elements of their society, as epitomized by the ranking as number two in car ownership per capita in the world. Real estate sales of the old railroad lines and right-of-ways are making the news as citizens are wondering how to maintain transportation and standards of living in a greener and more sustainable set of circumstances. A ubiquitous challenge remains in how to communicate with and educate the majority of citizens to enable them to understand the necessary changes in lifestyle behaviors that would accompany societal shifts towards sustainability.

A chorus of energetic and articulate young Kiwis added a much needed balance to the Auckland Summit by placing focus on the life journeys of one hundred representatives (17-25 years of age), therein transferring the abstract notions of future events into concrete dimensions of their lives. This coming-of-age generation is acutely aware that environmental scientists are not trying to scare them with reports of sea-level rise and global warming. They recognize that corporate interests in the bottom line are often lacking in moral fortitude and are simply based on short-term financial gains, even if that means consuming the seeds for tomorrow's harvest.

These one hundred youth helped to remind everyone that the value of the Digital Earth vision is ever more important as more and more trend analysis points to an extremely variable and risky future for all elements of economic, environmental, and social variables. But they also recognize the myriad opportunities for research, green-industry development, and social revitalization that are paragons of progressive movements away from doom and gloom.

Throughout the three-day event, an international gallery of visiting speakers added details and anecdotes, and increased the dimensions of the science to the overall summit understanding of where we are and where we are going. Technologies that enable citizens to see what is on the ground and what is going on day by day were viewed as essential to the community decision support systems being developed.

Remote sensing data, GIS, and other geo-enabled technologies all play a crucial role in the aggregated synthesis of information needed to implement the envisioned Digital Earth of the near future. Three-dimensional spinning globes linked to vast amounts of information about commerce, impacts of policies, environmental conditions, and social well-being are rapidly being developed by industry, academia, and government. What the Auckland Summit provided was a clear vision and determined consensus that the path for survival of the country and the planet is one that includes Digital Earth.

Digital Earth advocates have entered a new phase of the world's awareness as people all over casually "google" (search) the Earth for directions to anywhere with an address. People now spend hours on recreational reconnaissance as they investigate honeymoon getaways or adventure vacations. The learning and entertainment value for 3D virtual Digital Earth is just beginning to be appreciated against a backdrop of apathy, ignorance, and denial.

The Auckland Summit proved to be an excellent testing ground for the relevance of the Digital Earth vision and community to the pragmatic and often mundane operations of daily Kiwi life.

Youth recognize that corporate interests in the bottom line are often lacking in moral fortitude and are simply based on short-term financial gains, even if that means consuming the seeds for tomorrow's harvest.

From the setting in New Zealand, the group gained a veritable wealth of understanding that forms the catalyst for the follow-on event, the 5th International Symposium on Digital Earth on June 5-9, in Berkeley, California.

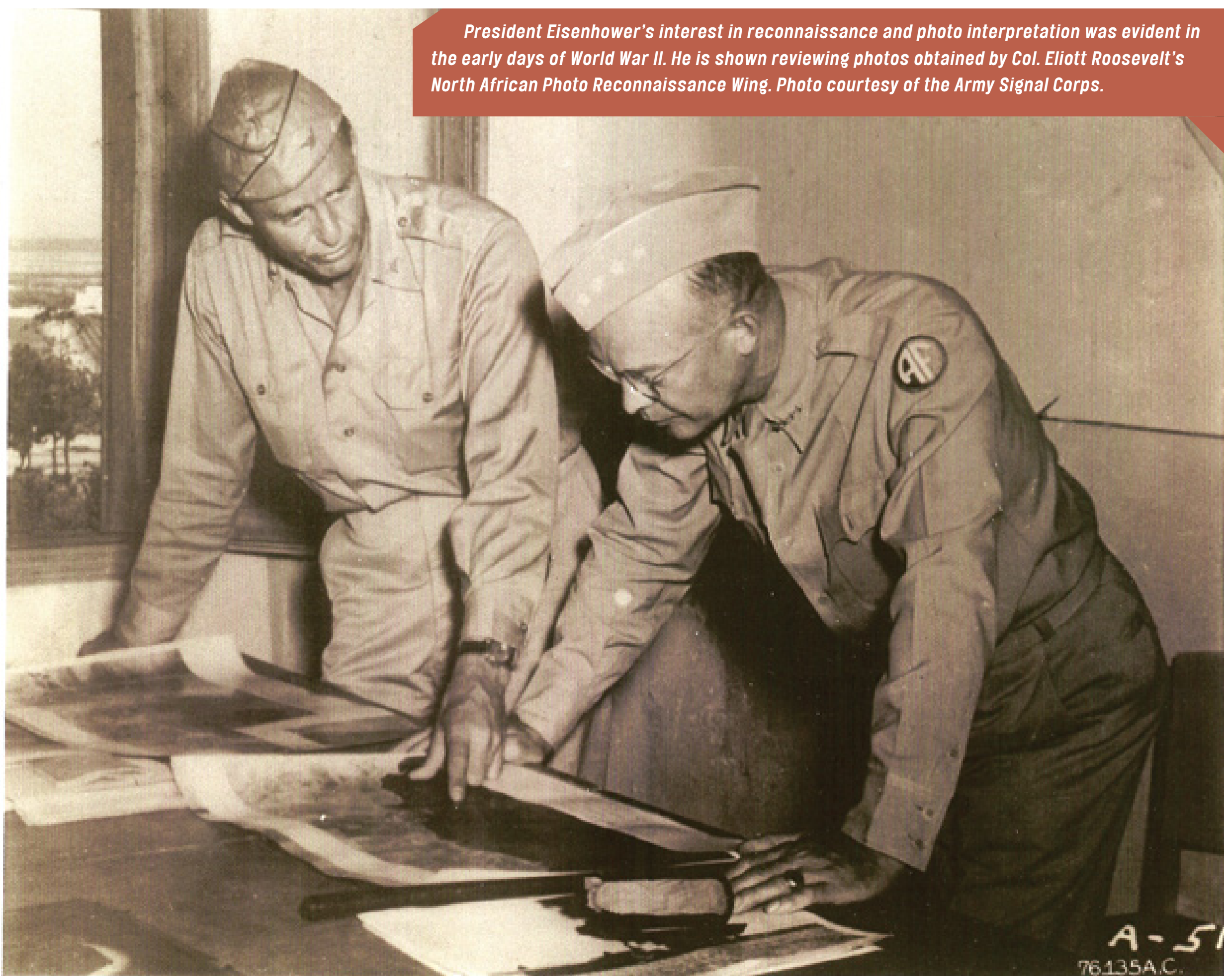
We now have the Digital Earth tools in hand, along with the creators of the tools, and we have the students and practitioners of the tools gathering. It is time to stop and ask some pointed questions and to ponder our future. We now know that at least some of our world leaders understand what we need to do and where we need to focus our attention. «

FIGURE 3 *Fiordland National Park (on the southwest corner of the South Island) includes the famed Milford Trek along Milford Sound, shown here, offering a coveted 4-day hike along the river, with waterfalls and dramatic peaks. This natural habitat will benefit from being monitored for environmental change. Image captured on Feb. 5, 2006 by QuickBird, courtesy of DigitalGlobe.*

(continued from page 46) Reconnaissance Office to monitor development and operation of reconnaissance and surveillance satellites. These systems had a major role in keeping the peace by providing critical information about the Soviet threat. The Panel continued to function throughout Eisenhower's administration and members were often called for advice by succeeding presidents.

It is time for a new TCP. Just as the TCP of 1956 led to many innovations, a new panel would also find scientific and technological pursuits to be fertile ground to plow. A new TCP-like panel would define the major security problems and opportunities that will challenge the U.S. over the next 10 to 15 years so presidential decisions can be soundly based. The technology exists to solve these security problems. Geospatial technologies have been and will continue to be a major part of intelligence gathering and analysis.

Too often the organizational aspects of inserting new technologies into the country's response to a threat is given too little attention. Yet, organization in the use of technologies is one of the most critical and important factors for making and executing national security policy; it is time too for competent scientific and technical personnel to review both U.S. policies and technologies and to adopt clear institutional guidelines for carrying out such policies.



President Eisenhower's interest in reconnaissance and photo interpretation was evident in the early days of World War II. He is shown reviewing photos obtained by Col. Eliott Roosevelt's North African Photo Reconnaissance Wing. Photo courtesy of the Army Signal Corps.

Focusing Attention on Geospatial Security Needs

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Dino Brugioni, senior officer at the National Photographic Interpretation Center, circa 1963.

The task of ensuring the national and global security of the United States has assumed a much different character than it did during the Cold War. Today, the world is dealing with more mobile, diverse adversaries and targets than the stationary ones of the Cold War. Such adversaries present a significant challenge to security analysts and policy makers.

Because a significant proportion of future U.S. economic resources will be devoted to meeting national and global security issues, the United States must make the best possible use of these resources. Hence, it should review the opportunities that specific technical solutions offer for identifying and monitoring the movements of potential adversaries. Where does the United States become vulnerable to penetration? How can attempts to penetrate be countered? Today's situation calls for a new approach to gathering and analyzing information and to forming U.S. responses.

The information networks now controlled by many different agencies need to provide for persistent surveillance, time-critical targeting, and rapid movements of forces. Adversaries create paths in their operations that are subject to discovery and counteraction. The United States currently has a capability to gather by electronic ears and eyes information that can be screened, processed, and analyzed by giant computers working at the rate of billions of bits per second. Future developments could increase that capability dramatically.

To make the best use of U.S. current and future technology resources, a highly focused effort is needed to assess the role of technology within the total range of U.S. security problems. The United States needs a structure or mechanism to recognize and discern those technologies that could improve its means of discovering and responding to threats to national security. Because technologies provide only part of the solution, it also needs to recognize the important role that national policy considerations play in the equation and to develop policies that make effective use of the needed technologies.

Most of all, presidential commitment to such an enterprise is essential. Similar problems confronted President Eisenhower during the early years of the Cold War. In the face of the threat from the Soviet Union, confusion reigned among his cabinet departments, which failed to employ new scientific discoveries adequately. Duplication of efforts, lack of coordination, bickering, and turf protection were prevalent at all levels of government.

In response to this confusion, President Eisenhower asked Dr. James Killian, president of MIT, to see if a solution could be found that would set the U.S. science and technology effort on a firmer course. Killian brought together scientists, engineers, and military and communications experts with members of military and civilian agencies to discuss the nation's security problems and to seek solutions in three important areas: defense, offense, and intelligence.

Among other critical intelligence gathering technologies, this secret Technology Capabilities Panel (TCP) created the intellectual framework for developing the U-2 and SR-71 reconnaissance aircraft and the Corona film-return photographic satellite. The world's first meteorological satellite, TIROS, derived in part from this work as well. In addition, the TCP recommended the creation of the National Indications Center, set up expressly to prevent strategic surprise, and the secret National

(continued on page 45)

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