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EARTH REMOTE SENSING
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IPY Project

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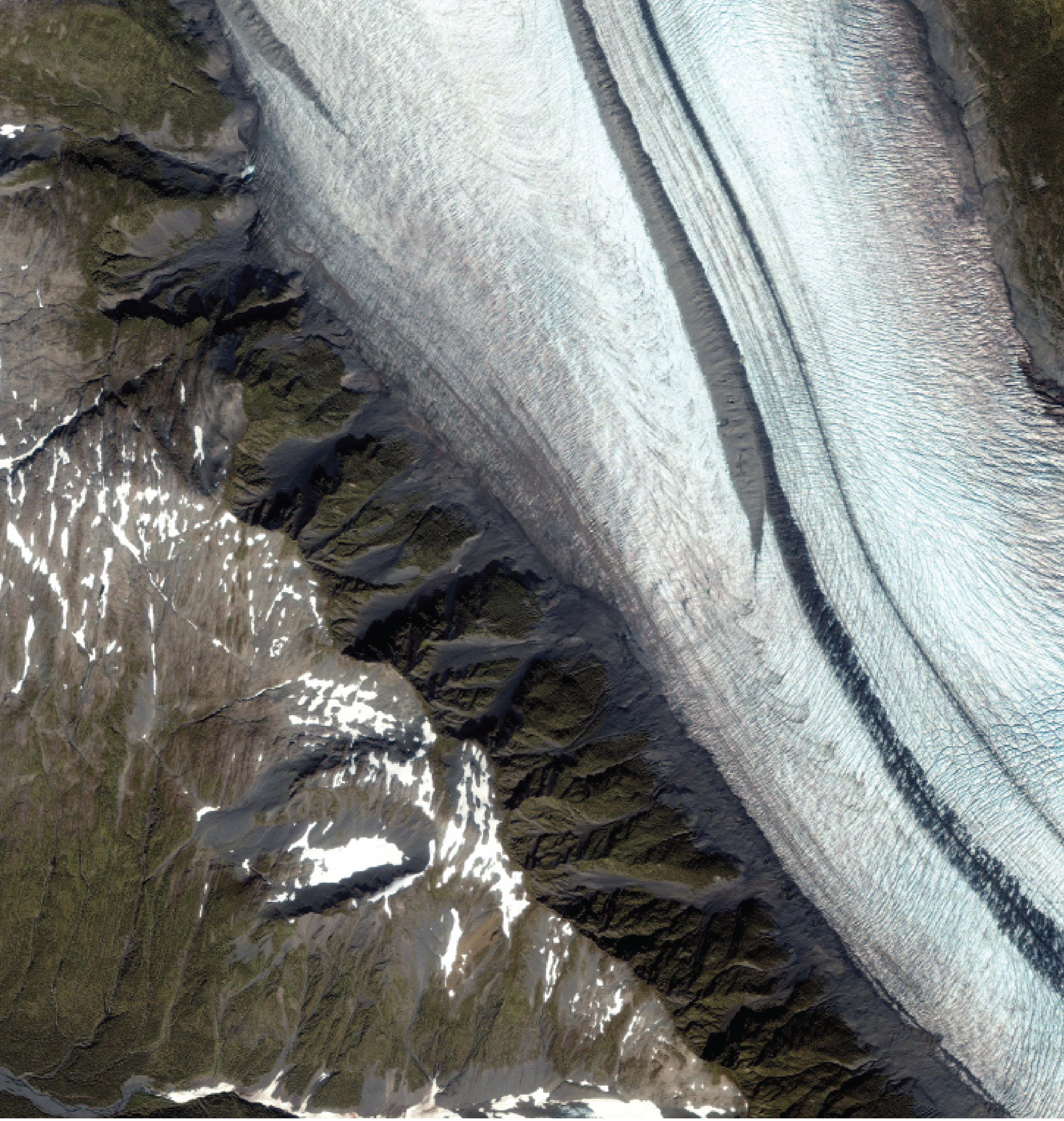

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GIIPSY:
A Flagship Project of the IPY

AND CONTRIBUTOR TO GEOSS

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The Global Interagency International Polar Snapshot Year (GIIPSY) is a flagship project in the 2007-08 roster of International Polar Year (IPY) earth science collaborations (see Figure 1 on page 22). GIIPSY could very well shake out as an epic of modern scientific discovery. It was conceived to analyze and model data collected at both poles with the hope of forestalling those climate change events which the best technical evidence has suggested will impact the planet over the next several generations. The project is a collaborative effort that will involve the tasking and coordination of a global network of Earth observation satellites for purposes of more completely understanding the current, historic, and anticipated dynamics of global warming.

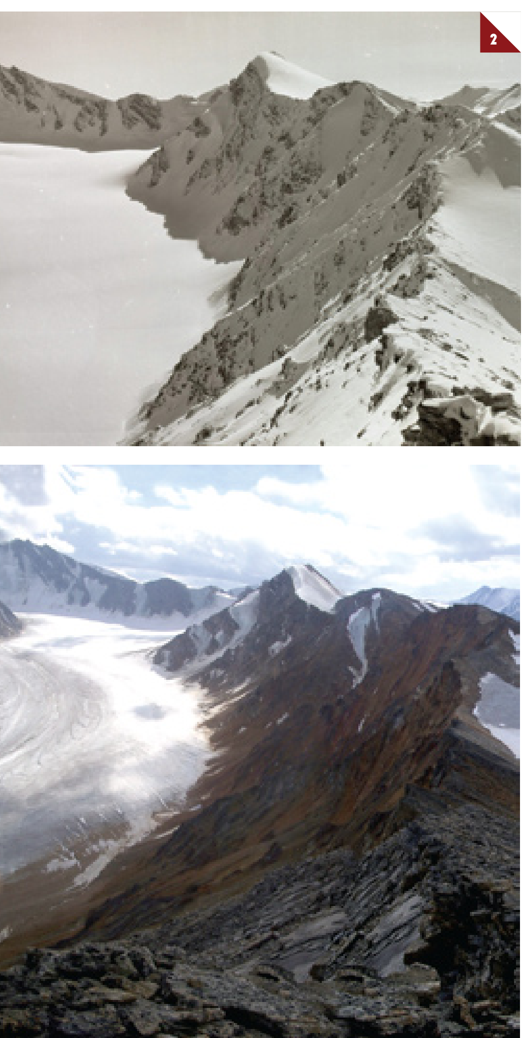
Inaugurated in March of 2007, GIIPSY has reached the halfway point in its mission. Eleven satellites with active or approved status are now passing through the two-year IPY tasking window. Data collection exercises focusing on the cryosphere include projects aimed at shedding light on sea level rise and hemispheric climate; ocean circulation and polar air-sea interactions (sea ice); regional climate, precipitation and hydrology; and changing permafrost and Arctic climate.

Interaction between GIIPSY and international space agencies and companies around the world is being coordinated by

FIGURE 2
McCall Glacier, located in what is now the Arctic National Wildlife Refuge in Alaska, has the longest history of scientific observation for any U.S. Arctic Glacier. It began as part of the International Geophysical Year in 1957-58. The field research here is geared towards measuring everything that may change over time, including mass balance, ice volume, ice temperature, ice velocities, bed properties, albedo, and local weather, and has been ongoing (with some major gaps) from IGY until now. The most recent period of retreat began about 1890, and the glacier has since been losing ice at a rate that is increasing with time. This is typical of glaciers in this region of Alaska. 1958 image copyright: Austin Post; 2004 image copyright: Matt Nolan and Bernhard Rabus, University of Alaska Fairbanks.

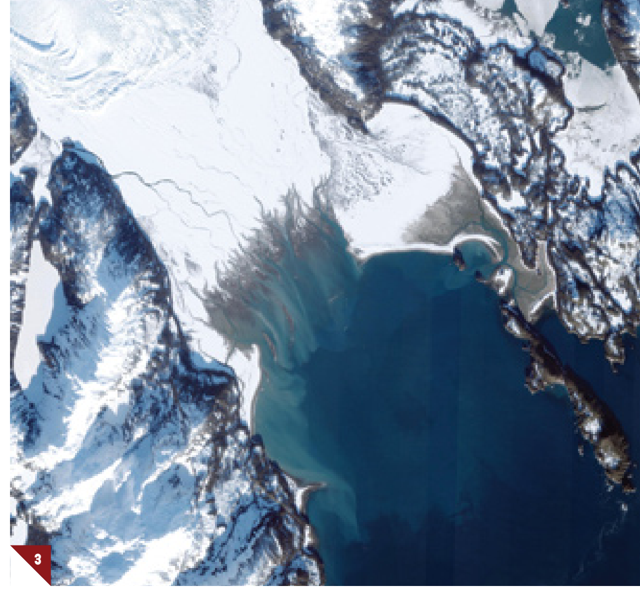
FIGURE 3
Image of Brady Glacier in Alaska was taken at 4-m rather than 1-m resolution to show a larger area. The glacier has been losing 2-3 meters per year at its base due to climate change. IKONOS satellite image taken Feb. 7, 2002; courtesy of GeoEye.

the IPY Space Task Group, which was initially convened by the World Meteorological Organization in Geneva in January of 2007. The GIIPSY project also has been endorsed by the International Council of Scientific Unions.



The current IPY is only the fourth since the ambitious program was initiated in an 11-nation agreement in 1892. A follow-on 40-country IPY was organized for 1932-33. In its third 1957-58 incarnation (one year prior to the launch of the first observational satellite), the IPY was re-dubbed the International Geophysical Year (IGY). That program witnessed the establishment of 50 new research stations in the Antarctic. The now 50-year-old datasets collected during the IGY are somewhat relevant to the current GIIPSY project and other IPY investigations. But leaders of the GIIPSY effort, including Ohio State University Professor Ken Jezek and Dr. Mark Drinkwater, head of the Mission Science Division at the European Space Agency, assert that IGY information will not be the most relevant data to consider for purposes of comparative benchmarking as the GIIPSY project moves forward; GIIPSY is the first big collaborative project in history designed to exploit fully the advantages of modern satellite imaging and ground-based remote sensing gear for purposes of climate change remediation. Analysts will thus compare GIIPSY data with those archived satellite readings that have been amassed since the early 1960s, when the United States and other countries began watching the planet from the near reaches of space.

"Space-borne observational technology (combined with) this sort of international collaboration in space is something new under the sun," said Jezek. "It is really one of the major steps in earth science beyond IGY. In my opinion, the best datasets for comparison come just after the IGY. Specifically, the U.S. and presumably other countries began space-borne reconnaissance in the early 1960s. Observations included the polar regions, and the resulting photographic data offer a unique glimpse of the earth as it was at the time,



and a benchmark for gauging change."

Drinkwater was specific in his acknowledgement of the technical advances that have been made since the IGY effort closed and international Earth observation programs began in earnest: "Survey data provides a source of extremely limited point measurement data, and thus does not provide anything but a historical context for things like snow accumulation patterns and ice shelf configurations of the past. The satellite era provided a dramatic change in the types of information available, because satellites give something that may be used in a comparative sense with today's sensors. Corona comparisons with RAMP (Radarsat Antarctic Mapping Project), compared with SAR mosaics from this IPY, will be of extremely high value in this sense. Moreover, present day interferometry will give us further essential information on the timescales on which dynamical adjustments in streaming ice flow regions can actually vary."

Recent and impending events promise to augment further the power of today's versatile technology platform. DigitalGlobe launched WorldView-1 last fall, introducing half-meter panchromatic imaging to the global warming research community. The bird's average revisit time is 1.7 days, and WorldView-1 is capable of gathering up to 750,000 square kilometers (290,000 square miles) of images per day. Things are advancing in the multispectral realm as well. Ball Aerospace &

Technologies Corp. and ITT Corporation are scheduled to complete later this year their WorldView-2 for DigitalGlobe—a satellite that will provide eight bands of multispectral imagery with a resolution of 1.8 meters at nadir. Also, GeoEye-1, after this summer's launch, will provide four bands of multispectral imagery at 1.65-meter resolution.

While imaging resolutions have been more or less fully optimized in terms of their practical uses, technological advances continue in the growing catalogue of ground-based sensing hardware being used to calibrate ice melt, snow volume and many other factors. These leading-edge devices will play a large role in defining the boundaries of GIIPSY as a legacy benchmark that scientists 30 years from now will use as a reference.

"Indeed, satellite remote sensing data represent one of the greatest technical measurement leaps beyond those which were available to IGY-era scientists," observed Jezek in a presentation on IPY satellite data legacy objectives. "We think this activity provides a unique and very interesting venue for collaboration between the world's space agencies. If successful, we think it can be a prototype for other and grander plans envisioned as part of the Global Earth Observation System of Systems (GEOSS)."

Jezek has stressed that the best data collection system for GIIPSY will be the one that utilizes the international constellation of observation satellites while balancing the burden of acquisition, processing, and data distribution across numerous international agencies. Drinkwater believes the operational standards that GIIPSY may be in a position to showcase for the larger GEOSS project have primarily to do with the various space agencies working in concert. "To have a GEOSS element for the effective monitoring of the cryosphere,

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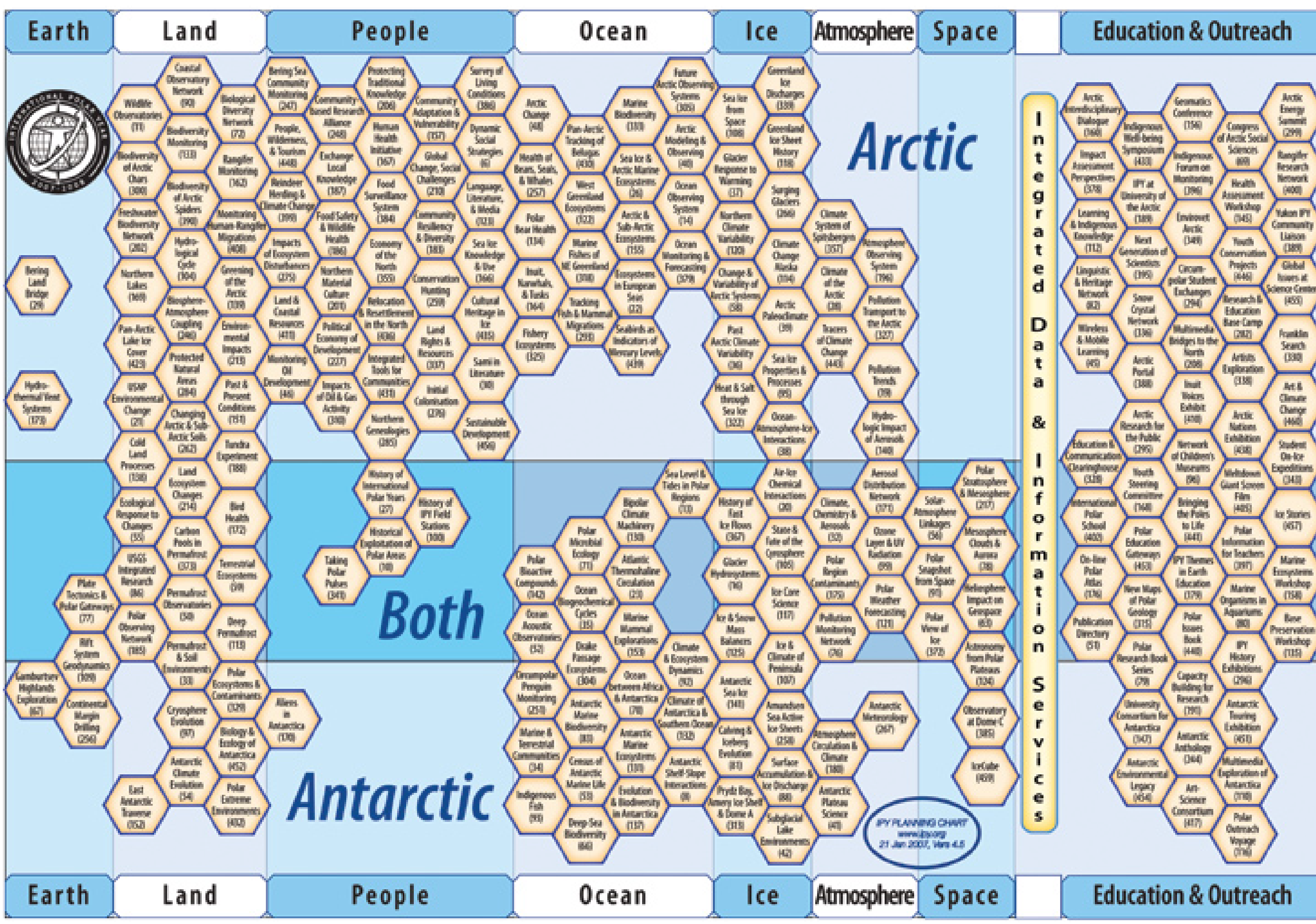


with the by-product of improved understanding of its climate feedbacks, requires first that one can effectively marshal existing satellite resources," he said. "The combined benefits of working together during IPY shall be apparent, and will clearly demonstrate why a sustained cryospheric observing system is critical to the success of GEOSS."

But GEOSS is still in development phase; GIIPSY is now. With its rich portfolio of imaging and sensing hardware, data processing software, and human expertise, the project endeavors to diagnose the measurable symptoms of climate change, including a litany of metrics related to fluctuations in water, ice, and snowpack. Five separate categories will be monitored over varying periods of time, and according to measurement matrices, tailored exclusively for each.

Satellites such as RADARSAT, GOCE, IceSAT and SMOS will be tasked for imaging in the microwave and visible spectrum frequencies. In addition, a number of concurrent areas of study have been identified, many of which are characterized by technical innovations.

FIGURE 1
IPY planning chart showing extensive reach and impact of IPY projects, in both the Arctic and the Antarctic.

FIGURE 4
The village of Shishmaref in Alaska, inhabited for 400 years, is facing evacuation due to rising temperatures that caused the infrastructure to fail. The reduction in sea ice allows higher storm surges to reach shore and thawing of permafrost along the coast makes the shoreline more vulnerable to erosion. From NOAA website with input from Dr. James W. Jordan, Antioch University, New England. See www.arctic.noaa.gov/detect/human-shishmaref.shtml. IKONOS satellite image collected June 23, 2006, courtesy GeoEye.

FIGURE 5
Scientists are currently studying life forms living in the alkaline-rich lake of Don Juan Pond in Antarctica. IKONOS satellite image collected Dec. 1, 2006, courtesy GeoEye.

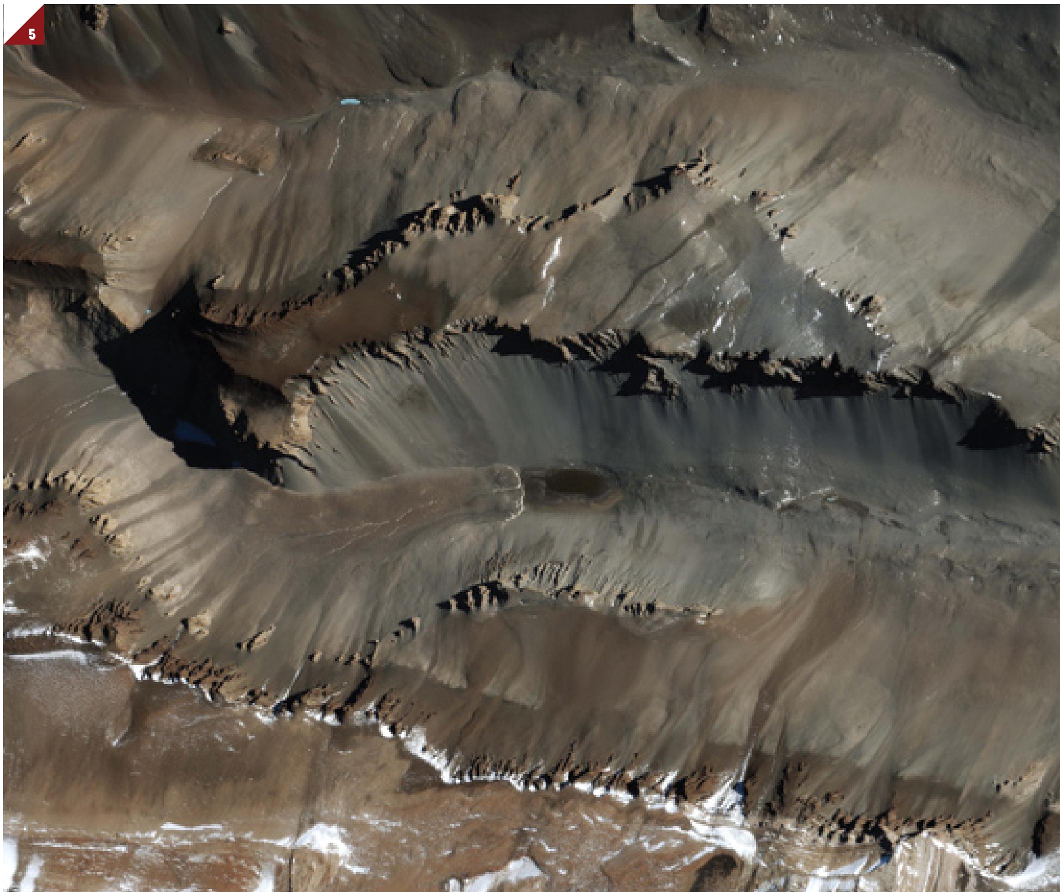
CONCURRENT AREAS OF STUDY

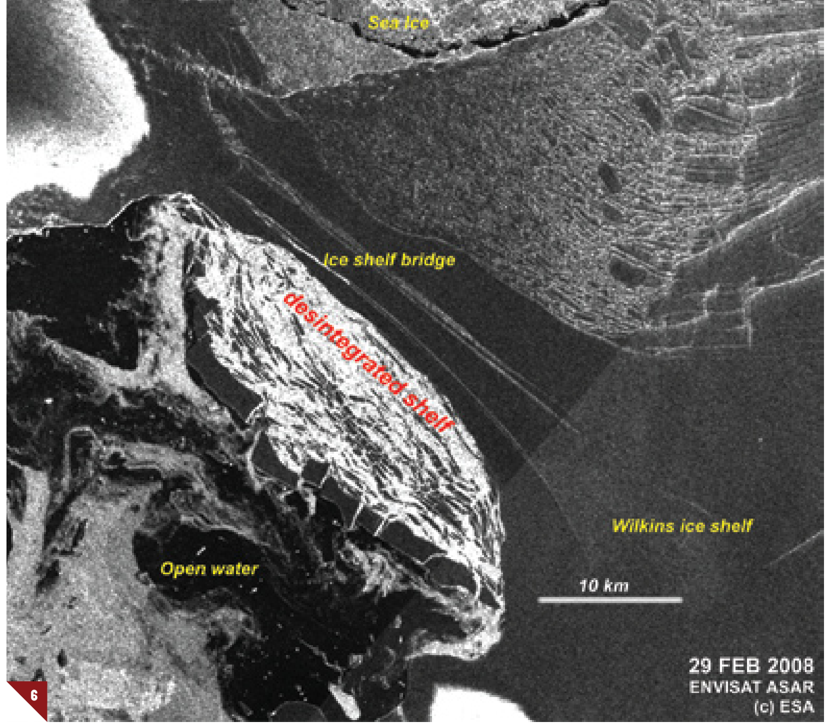
Greenland and Antarctic Ice Sheets:

Efforts will be made to understand polar ice sheets and predict their contribution to global sea level rise.

Technical firsts include:

- One summer and one winter SAR snapshot of the polar ice sheets, glaciers and ice caps, with near-simultaneous imagery at L, C, and X band and polarimetric quad pole for documenting ice surface physical parameters.
- Pole-to-coast multi-frequency InSAR measurements of ice surface velocity.
- Repeated X-band InSAR topography for detecting local changes in ice sheet elevation associated with movement of subglacial water.





- One summer and one winter high-resolution visible/near-IR and TIR snapshot of the polar ice sheets, glaciers and small ice caps, followed with bimonthly coverage of select glaciers for snow-zone mapping.

Arctic and Southern Ocean Sea Ice: Sea ice will be measured in an attempt to forecast its response to and influence on global climate change and biological processes.

Technical firsts include:

- L-band SAR mapping of the Arctic Ocean and marginal seas ice cover for leads and ridges.
- Fine-resolution SAR mapping of the entire southern ocean sea ice cover for ice motion.
- SAR and optical fine-resolution mappings of the entire Arctic Ocean.

Glaciers and Ice Caps: An examination of glaciers and ice caps within the context of hydrologic and biologic systems will increase human understanding of their contributions to global processes, including sea level rise.

Technical firsts include:

- Pan-arctic high- and medium-resolution microwave snapshots of fresh water breakup and freeze.
- Pan-arctic high- and medium-resolution visible, near-IR and TIR snapshots of fresh water breakup and freeze.

Ice and the Polar Atmosphere: Data will be collected to facilitate new knowledge regarding the interactions between the changing polar atmosphere and the changes in sea ice, glacial ice, snow extent, and surface melting.

Technical firsts include:

- One complete high-resolution snapshot of all polar permafrost terrain at L, C and X band.
- One complete high-resolution visible and thermal IR snapshot of all polar permafrost terrain.

High Latitude Seasonal Snow Cover: Scientists will measure how much water is stored in the form of seasonal snow, as well as its volumetric variabilities.

YEAR ONE ADVANCES

Advances have been made during Year One of the IPY. These are new contributions of the space agencies in support of the GIIPSY snapshot from space; they are not all-encompassing or all-inclusive:

- SPOT-4 VGT 1-km weekly summer Arctic and Antarctic mosaics from French space agency CNES;
- SPOT-5 HRS-derived DEMs of specific Arctic outlet glaciers and ice caps from CNES;
- TerraSAR-X stripmap mode InSAR of ice streams in Antarctica from German space agency DLR;
- L-band mosaics of Antarctica from ALOS PALSAR from JAXA;
- Envisat ASAR regular bipolar GMM and wide-swath mosaics and routine Arctic Basin-wide sea-ice motion, and Ross/Weddell Sea ice motion from European Space Agency;
- SAR measurements of fastest moving ice streams in Greenland using Envisat-ERS-2 inter-satellite interferometry (tandem configuration) from ESA;
- Inter-satellite InSAR of Siberian tundra-permafrost heave (using Envisat-ERS-2 tandem configuration) from ESA.

In addition to this, routine operational meteorological products at high latitudes are available from Eumetsat and NOAA, and routine atmospheric chemistry observations at high latitudes are available from ESA.

A major task in the GIIPSY enterprise will be the buildout of a cogent end-to-end data processing system capable of

FIGURE 6
Synthetic Aperture image of the Wilkins Ice Shelf, taken on February 29, 2008, courtesy of ESA, © 2008. The image was acquired in support of the International Polar Year by Envisat's Advanced Synthetic Aperture Radar (ASAR). Between February 28 and 29, an area of about 400 sq km disintegrated into large and small icebergs within 24 hours. As a result of the recent collapse, the remaining shelf, which totals about 14,000 sq km, is now only supported by a 6-km strip of ice.

The Wilkins Ice Shelf is a broad plate of floating ice south of South America on the western Antarctic Peninsula. Since the ice shelf is already floating, this event will not cause a rise in sea level. However, ice shelves on the Antarctic Peninsula are sandwiched by extraordinarily rising surface air temperatures and a warming ocean, making them important indicators for on-going climate change. Thousands of years of accumulated and compacted snow on the Antarctic central Plateau have formed a mighty ice sheet which flows under gravity towards the coastal plane.

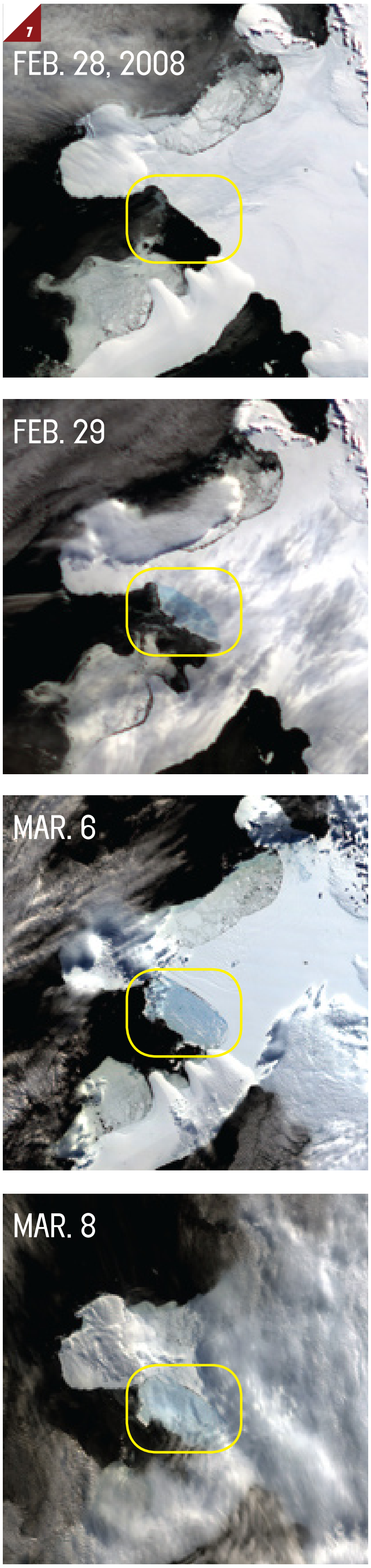


FIGURE 7
This series of the Wilkins Ice Shelf breaking over only ten days from Feb. 28 to March 8 is from the National Snow and Ice Data Center.

managing the hundreds of remote sensing data streams that will be pouring into whatever data repositories are established at the heart of the project. A collaborative and detailed solution to this challenge remains on the drawing boards at this writing, but the basic framework has been defined. The system is envisioned as an integration of hardware and software that will accommodate the sensors and various spacecraft, provide for data acquisition planning, and fulfill the technical requirements at the receiving ground stations. It will also provide for adequate processing facilities, calibration and validation, and distribution architecture.

As planning and data acquisition exercises move forward, administrators are looking for creative approaches to the realization of such a network. In an overview paper on the project, Jezek and Drinkwater predict that IPY investigations "will also identify new technical requirements and approaches. A recommendation to the flight agencies is to seed the most promising ideas so as to prepare for next-generation observations."

Mark Parsons has ownership of one piece in that overall system assembly effort. As manager of the IPY Data and Information Service at the National Snow and Ice Data Center in Boulder, Colorado, he is excited about the ways that data in the GIIPSY program will be visualized.

"One aspect of remote sensing data that may not be immediately obvious in the snapshot concept is the realization and importance of remote sensing time series and their indications of change," he said in a recent communication. "It's not just a snapshot but a movie, and that movie is showing significant change, especially in the polar regions. One high profile example of that is the nearly thirty-year remote-sensing record showing significant decrease in sea ice extent in the Arctic (http://nsidc.org/data/seaice_index/). Other examples, such as the greening of the Arctic and receding glaciers, exist too. It's an exciting subject. In many ways, IGY marked the beginning of the remote sensing era, and the latest IPY is illustrating and beginning to realize the long-term potential of remote sensing."

The most recent extensive example is the breaking of the Wilkins Ice Shelf in Antarctica in late February. See ***Figures 6-7***.

GIIPSY and the IPY represent an unprecedented confluence of international science programs and technical capabilities at a time when global warming and climate change have indisputably become fixtures within the public and political dialogue. These programs present a once-in-a-lifetime opportunity for gathering data essential to the understanding and rectification of the most serious Earth science threat yet to be faced by modern Man.

NOTE Url for this project is http://bprc.osu.edu/rsl/GIIPSY/.