of 2009. Plans for 2011 are designed "to be completely complementary with what we have been doing in the past year or two," he said, adding that the directorate's new strategic plan, *GeoVision Report: Unraveling Earth's Complexities Through the Geosciences*, has been well received and has had an impact on thinking at NSF and on the budget. "If you want to know where we are going, that's the best place to look," he said.

Killeen highlighted some NSF and GEO themes, including OOI, SEES, and Dynamic Earth, a new GEO initiative that would receive $28 million over 2 years to look at the changing planet. He said the budget also ramps up several education programs that are consistent with the Obama administration's priorities. Graduate research fellowships would increase to $2.74 million from $1 million, and the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE) program would increase to $4.28 million from $3.46 million.

The budget also would provide $8 million to support high-risk and high-return "transformative" research. "We really want to send a signal to the community," he said, noting that NSF is "putting real money" into identifying and funding high-risk, high-return research.

The administration's proposed FY 2011 budget "says to the community that there is a real commitment to science and technology in the country and to geosciences at NSF," Killeen told *Eos*.

He emphasized the need for the science community "to help us ensure that we support the best research that can be done." He said scientists could help in a number of ways, including by serving on advisory committees. Killeen also indicated the importance of scientists providing their best critical judgment in the peer-review process to ensure scientific integrity, particularly at a time when the public is questioning some scientific reports from other organizations.

Killeen said NSF needs the best ideas from the community and also needs the community to be "sufficiently daring" and to have "aspirational thinking," adding, "We need to be at the frontier, at the cutting edge of knowledge."

Future issues of *Eos* will detail the Obama administration's federal budget request for FY 2011 for other geophysics-related agencies, including the National Oceanic and Atmospheric Administration. For more information, visit http://www.whitehouse.gov/omb/ and individual federal agency Web sites. For details on the NASA and Department of Energy proposed budgets for FY 2011, see *Eos, 91*(7), 16 February 2010; for details on the U.S. Geological Survey proposed budget, see *Eos*, *91*(8), 23 February 2010.

—Randy Showstack, Staff Writer

FORUM

Why Permafrost Is Thawing, Not Melting

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As global climate change is becoming an increasingly important political and social issue, it is essential for the cryospheric and global change research communities to speak with a single voice when using basic terminology to communicate research results and describe underlying physical processes. Experienced science communicators have highlighted the importance of using the correct terms to communicate research results to the media and general public [e.g., *Akasofu,* 2008; *Hassol,* 2008]. The consequences of scientists using improper terminology are at best oversimplification, but they more likely involve misunderstandings of the facts by the public.

A glaring example of scientifically incorrect terminology appearing frequently in scientific and public communication relates to reports on the degradation of permafrost. Numerous research papers have appeared in recent years, broadly echoed in the news media, describing the "melting of permafrost," its effects in the Arctic, and its feedbacks on climate through the carbon cycle. Although permafrost researchers have attempted to distinguish between the appropriate term "permafrost thawing" and the erroneous "permafrost melting" [e.g., *van Everdingen,* 2005; *French,* 2002], the latter is still used widely. A Web-based search using the phrase "permafrost melting" reveals hundreds of occurrences, many from highly regarded news and scientific organizations, including Reuters, *New Scientist,* ABC, *The Guardian,* Discovery News, *Smithsonian* magazine, the National Science Foundation, and others.

"Permafrost melting" is incorrect terminology that results from a misinterpretation of the physical process of permafrost degradation. "Melting" describes a physical phase change during a temperature increase when a solid substance is transformed into a liquid state. Hence, the term "permafrost melting" suggests the transition of solidly frozen permafrost terrain into a liquid. However, permafrost is properly defined as "all ground (earth material) that remains below 0° Celsius for at least two consecutive years" [*van Everdingen,* 2005]. As such, it is composed of soils, sediments, bedrock, and organic materials, which may or may not include water in the form of ice. Some of these substrates contain ice in pore space and cracks, or include larger bodies of almost pure ice, while others are completely ice-free. Ice-rich permafrost, like the Siberian Yedoma-type deposits, contains more than 70% ice by volume in its upper 30 meters. Warming this ground above 0°C will have dramatic effects on the terrain due to the volume loss from melting ice and subsequent differential subsidence of the land surface, a process often referred to as thermokarst. But even in such ice-rich permafrost types, only that 70% or so of the ground volume constituting the ice melts—not the mineral and organic component of the permafrost. To speak of "melting permafrost" implies that all components of permafrost are turning into a liquid, which is erroneous. In terrain types with much less ground ice, which are widespread in the Arctic and in alpine mountain regions [*Brown et al.,* 1998], warming above 0°C will have virtually no direct impact on the land surface.

Use of the term "permafrost melting" not only indicates misunderstanding of permafrost properties and the processes involved in permafrost degradation, but also leads to misinterpretation of the potential consequences of this process. Because melting of ice—a physically valid phrase—is common knowledge, the inappropriate phrase "permafrost melting" conveys an image of permafrost as a form of underground ice, undergoing a complete solid-to-liquid transition much like glaciers and ice sheets. Defrosting food is a much better analogy for communicating about permafrost thaw to the general public. Like most foodstuffs, permafrost does not liquefy completely when its temperature exceeds 0°C. Similarly, during permafrost thaw, only the ground ice melts, while mineral and organic particles, which represent the majority in many permafrost types by volume, remain solid.

Although some individuals may regard "permafrost melting" as an acceptable simplification, we advocate a different view. "Permafrost melting" is partly an oversimplification that ignores basic geophysical processes and partly sloppy science communication, both with unwanted implications for communicating scientific information and educating students and the public about climate change.

This example from permafrost research has equivalents in other geophysical research fields—for example, some writers refer to sea ice on the Arctic Ocean as an "ice cap," although that term properly applies to bodies of glacial ice of particular dimensions and morphology. Sometimes scientific writers unknowingly neglect or oversimplify basic physical, biological, or chemical processes, especially when working across disciplines. We strongly encourage authors working on cross-disciplinary topics or reaching outside their own research fields to ensure that they use basic terminology accurately. We also encourage reviewers and editors of scientific journals receiving manuscripts to be more rigorous in following up on the use of appropriate scientific terminology for basic physical processes.

References

Akasofu, S.-I. (2008), A suggestion to climate scientists and the Intergovernmental Panel on Climate Change, *Eos Trans. AGU, 89*(11), 108, doi:10.1029/2008EO110005.

Brown, J., O. J. Ferrians Jr., J. A. Heginbottom, and E. Melnikov (1998), Circum-Arctic map of permafrost and ground-ice conditions, in *Circumpolar Active-Layer Permafrost System, Version 2.0* [CD-ROM], edited by M. Parsons and T. Zhang, Natl. Snow and Ice Data Cent./World Data Cent. for Glaciol., Boulder, Colo.

French, H. (2002), Thaw vs melt: An editorial, *Frozen Ground, 26*, 6–7.

Hassol, S. J. (2008), Improving how scientists communicate about climate change, *Eos Trans. AGU, 89*(11), 106–107, doi:10.1029/2008EO110002.

van Everdingen, R. O. (Ed.) (2005), Multi-language glossary of permafrost and related ground-ice terms, World Data Cent. for Glaciol., Boulder, Colo. (Available at http://nsidc.org/fgdc/glossary)

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MEETING

New Concepts and Tools for Geological Mapping of Mars

Geological Mapping of Mars: A Workshop on New Concepts and Tools; Tuscany, Italy, 12–14 October 2009

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Geological mapping is a key tool for understanding the evolution of any planetary surface. The availability of ever growing data sets (e.g., multispectral and hyperspectral imaging and subsurface radar sounding) requires increasing effort in analyzing, integrating, and exploiting them for mapping purposes.

To discuss these issues, about 80 planetary geoscientists gathered in Italy at a workshop co-organized by the Italian Space Agency (ASI), the International Research School of Planetary Sciences (IRSPS), and the U.S. Geological Survey (USGS). The workshop focused on both data and concepts and covered a range of scientific and technical topics.

At the workshop, the importance of new data sets acquired by recent and currently orbiting Mars missions as the basis for revising previous geological mapping was stressed. Participants agreed that new mapping should involve the use and integration of hyperspectrally based surface compositional data, radar sounding–based subsurface data, topography, and imagery at multiple resolutions for describing and defining mappable geological units and other features and their relations in space and time.

Participants also pointed out that methodology, standards, and symbolization should be periodically updated to match the scientific and technical state of the art, keeping in balance standardization and scientific freedom and flexibility in mapping. Moreover, the long-standing issue of geomorphic versus geologic mapping should be tackled: How much geomorphology should be allowed in planetary maps and in the definition of geological units?

Geological mapping also provides important information for landing-site selection and characterization for current and future missions. Participants noted that diverse data sets can be integrated via thorough mapping, providing constraints on landing-site settings and potential risks. The importance of terrestrial analog mapping (from the scientific, technical, engineering, and procedural points of view) was also pointed out during the workshop.

Finally, a strong recommendation of the workshop is the need for coordination between current and future USGS mapping programs and newly emerging European geological mapping efforts, such as the ongoing Planetary Geographic Information System (PAGIS) program of the Italian Space Agency. The creation, implementation, and availability of mapping infrastructures and services can greatly improve the scientific exploitation of mission data. Participants noted several areas that would benefit by coordinated work, including cartographic and technical standards, symbology, and scientific outcome. Renewed efforts in geological mapping using state-of-the-art data sets, tools, and concepts will constitute the foundation for future international exploration of Mars.

A more extended summary of the plenary discussion, compiled by chairpersons, along with a list of sessions and session chairs, is available on the workshop wiki (http://www.irsps.unich.it/education/mapping09/wiki).

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