In Brief

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NSF Assistant Director for Geosciences announces resignation Margaret Leinen, assistant director for geosciences at the U.S. National Science Foundation, announced on 7 December that she will be leaving NSF in January 2007 to become the chief science officer and vice president of Climos, a new company based in San Francisco, Calif., that plans to develop solutions to reduce greenhouse gases. Leinen will oversee efforts to better understand the planet's carbon cycle to address global climate change issues.

Leinen has managed the Directorate for Geosciences since 2000. She also served as vice chair of the U.S. Climate Change Science Program, which coordinates federal climate change research, and as co-chair of the National Science and Technology Council's Joint Committee on Ocean Science and Technology.

Strategic approach needed for atmospheric research The Division of Atmospheric Sciences (ATM) within the U.S. National Science Foundation should develop a strategic plan in concert with the atmospheric science community and should regularly seek guidance from a panel of representatives of that community to ensure that the community's needs are met, according to a recent report from a committee of the U.S. National Research Council of the U.S. National Academies. ATM also should encourage and guide scientists participating in cross-disciplinary research and research that crosses federal agencies as well as increase support for high-risk, potentially transformative research. The committee also recommended the formation of a new graduate fellowship program. The report, "Strategic Guidance for the National Science Foundation's Support of the Academic Sciences," is available at http://www.nap.edu/catalog/ 11791.html

Indian Ocean tsunami detection buoy deployed The U.S. National Oceanic and Atmospheric Administration has deployed the first of two Deep-ocean Assessment and Reporting of Tsunami (DART) buoys in the Indian Ocean. This first buoy was placed about halfway between Thailand and Sri Lanka at the beginning of December 2006 and will be maintained by the Thai Meteorological Department and National Disaster Warning Center. Data from the buoy is available at http://www.ndbc.noaa.gov/station_page.php?station=23401

NOAA will deploy a second DART buoy farther south in spring 2007. The DART buoys are two of 22 tsunameters planned for the regional tsunami warning system in the Indian Ocean, which will provide warnings for Indonesia, India, Maldives, Sri Lanka, and Thailand. Other features of the final warning system will include tide gauges, modeling, and upgrades to communications.

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MEETINGS

Monitoring Global Vegetation Using Moderate-Resolution Satellites

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The international community long has recognized the need to coordinate observations of Earth from space. In 1984, this situation provided the impetus for creating the Committee on Earth Observation Satellites (CEOS), an international mechanism charged with coordinating international civil spaceborne missions designed to observe and study planet Earth. Currently, several international organizations, most prominently the Global Earth Observing System of Systems (GEOSS), are focusing on the requirements for Earth observation from space to address key science questions and societal benefits related to our terrestrial environment.

The recent CEOS-endorsed Long Term Global Monitoring of Vegetation Variables using Moderate Resolution Satellites Workshop was organized to establish a framework to understand the interrelationships among multiple global vegetation products and identify opportunities for (1) increasing knowledge through combined products, (2) realizing efficiency by avoiding redundancy, and (3) developing near- and long-term strategies to avoid gaps in our understanding of critical global vegetation information.

The three-day biennial workshop brought together 135 researchers from 25 states and 14 countries to advance these themes and to formulate recommendations for CEOS. Prior to the workshop was a one-day meeting about the validation of global vegetation indices (VI) and their time series. This report provides a summary of the workshop. Details about the VI meeting will be presented in *Morisette et al.* [2006].

A Framework for Long-Term Global Vegetation Monitoring

The workshop featured discussions about a number of global vegetation monitoring products available from several currently operating moderate-resolution (0.5–1.0km) sensors: Along Track Scanning Radiometer (ATSR)/Advanced ATSR, Advanced Very High Resolution Radiometer (AVHRR), Moderate Resolution Imaging Spectroradiometer (MODIS), Satellites Pour l'Observation de la Terre (SPOT) VEGETATION, Medium Resolution Imaging Spectrometer (MERIS), Multiangle Imaging SpectroRadiometer (MISR), and Polarization and Directionality of the Earth's Reflectance (POLDER). Two planned replacement sensors are the Global Monitoring for Environment and Security (GMES) Sentinel-3 and the Visible Infrared Imager/Radiometer Suite (VIIRS).

The presentations as well as the break-out sessions demonstrated that these sensors are providing critical information for monitoring the biosphere. They provide consistent spatial and temporal information on land cover type and change, as well as information on vegetation health and productivity, such as albedo, VIs, leaf area index (LAI); the fraction of absorbed photosynthetically active radiation (FPAR); and gross primary production (GPP) and net primary production (NPP). Use of data regarding fire location, intensity, and effects is increasing in both climate science and land management. As satellites provide the only global real-time tracking of fire-related biospheric changes, these products likewise are becoming increasingly important,

Workshop presentations and related discussions brought out several key issues. With the growing number of products, challenges include data access and uniformity, product accuracy assessment, and understanding the relationship between the multiple products. Currently, data accessibility varies widely by satellite. For example, MODIS near-real-time data are freely available after processing, normally 8–16 days after retrieval, and several fire products are sent to direct broadcast stations from the satellite daily. SPOT VEGETATION products are available in near real time to commercial users and freely accessible to the larger scientific community after three months.

At the meeting, participants working for those agencies responsible for sensors (e.g., European Space Agency, NASA, U.S. National Oceanic and Atmospheric Administration) and those working with international programs developing strategic plans (e.g., the Global Climate Observing System (GCOS) and the Global Observation of Forest Cover/Land Dynamics (GOFC/GOLD)), agreed that an assessment of the key issues needs to involve both of these groups.

CEOS is playing a role in this assessment through its working groups. The Working Group on Information Systems and Services (WGISS) is addressing issues of data format, access, and distribution (http://wgiss.ceos.org/). Issues of product accuracy are

addressed through the Working Group on Calibration and Validation (http://wgcv.ceos.org/). For example, the CEOS WGCV coordinated a special issue of *IEEE Transactions on Geoscience and Remote Sensing* (July 2006) on Global Land Product Validation; a copy of which was distributed to workshop participants. The special issue contains 29 articles focusing on validation of products from several of the sensors discussed during the workshop.

Calibration and validation issues become even more significant when using data from multiple sensors or products. At the meeting, at least five different global VI products and six different LAI products were demonstrated. These data sets differ in source sensor, as well as spatial and/or temporal resolution, atmospheric correction methodology, and other processing details.

Having multiple data products without a clear quantification of their accuracy or how they intercompare makes it difficult for users to know which product may be best for their particular needs. For example, what LAI product is best for global carbon monitoring studies? Addressing this overall concern requires a methodical, quantitative intercomparison of similar products, such as the pilot work by the CEOS WGCV on the intercomparison of global LAI products, presented at the workshop by Sebastien Garrigues, from the University of Maryland. The presentation and subsequent discussion suggested that such intercomparisons might enable users to employ the products with more confidence and develop better strategies for combining products.

Long-term data continuity necessitates the derivation of products from multiple satellites. Discussion at the meeting pointed to interagency and international coordination as a means to efficiently develop science-quality long-term data records from existing and planned international assets. To ensure a consistent record, products must be validated against independent data of known accuracy. Reports from the break out sessions indicated that the ground-based measurements from both the Aerosol Robotic Network (AERONET) and FluxNet have been vital to ongoing validation studies.

The AERONET (http://aeronet.gsfc.nasa.gov/) program is a federation of over 300 ground-based remote sensing instruments providing long-term measurements of aerosol properties used for validation of satellite estimates of albedo and the bidirectional reflectance distribution function (BRDF). FluxNet (http://www-eosdis.ornl.gov/FLUXNET/) is an international network of more than 200 eddy covariance flux tower sites that measure carbon dioxide, water vapor, and energy exchange between terrestrial ecosystems and the atmosphere. Measurements from FluxNet have been used to validate a number of satellite products, including MODIS LAI, GPP, and most recently, VI.

Given the importance of these networks to sensor validation, meeting participants agreed that CEOS WGCV should recommend to the CEOS plenary that these networks be maintained, enhanced, and expanded for continued validation needs into the future. Additionally, continuing and improved communication between ground-based measurement teams and satellite product validation teams also is vital to ensure that the needs of both groups are met.

Most of the global vegetation products discussed at the meeting derive from passive sensors operating predominantly in the visible and near-infrared wavelengths. However, meeting attendees also discussed the untapped potential of global radar and microwave sensors, possibly combining them with optical instruments to improve upon existing products.

The presentation on Global SAR and microwave sensors by Christiane Schmullius (Friedrich-Schiller-Universität, FSU) in Jena, Germany, made it clear that radar, and microwave sensors and their products, are now at a level of maturity to allow further consideration of how these products can be combined with data and products from passive sensors and how future sensors can take advantage of the lessons learned. All sensor-specific presentations and related discussion indicated that as satellite products mature, mechanisms should be put into place to transition proven research observations from global systems to the operational domain.

The Future of Biospheric Monitoring via Satellite

Many of the satellites discussed at the workshop are now in the middle to later stages of their life spans, and there is uncertainty as to what will be available throughout the next decade and beyond. Meeting attendees agreed that opportunities exist to coordinate future planned moderate-resolution missions, which potentially is a cost-saving measure for all involved. This indicates a need for the international community to work together (through CEOS) to resolve issues, such as potential data gaps, while concurrently resolving differences among satellite products, to develop satellites that are complementary and not redundant.

Discussions at the meeting suggested that CEOS initiate a pilot working group to study the efficacy of sensor constellations that could meet the spatial (<1 kilometer) and temporal (1–3 day) needs of the vegetation remote sensing community. This working group then would suggest methods for producing combined products and international mission planning to reduce associated costs for each cooperating country. Current sensors could be considered as a test bed for future sensors, but discussion at the meeting indicated that any degradation in current capability would represent a loss to the community. This concept of more coordination among CEOS members reinforces recent findings of the CEOS Strategic Implementation Team, whose constellation planning calls for such coordination.

Meeting attendees were encouraged by the current state of remote sensing science and the opportunities that it presents. Yet, there was concern about how best to meet the challenge of data continuity.

As a result of this meeting, representatives will be working within the international framework to continue developing validation and intercomparison protocols and to bring the needs of the moderate-resolution remote sensing community to the appropriate international entities, such as CEOS, GCOS, and GEOSS. Participants are planning to strengthen the lines of communication between this community and GEOSS, and simultaneously are seeking to reactivate the NPP demonstration product within the Global Terrestrial Observing System (GTOS, a program for observations, modeling, and analysis of terrestrial ecosystems to support sustainable development; http://www.fao.org/gtos/).

Many attendees are active or leading members in the various international programs, and they agreed to bring the recommendations from this meeting to those entities. In particular, the recommendations to CEOS were brought up at the 26th WGCV Plenary held in Chiang Mai, Thailand, 31 October–3 November 2006.

The Long Term Global Monitoring of Vegetation Variables using Moderate Resolution Satellites Workshop was held 8-10 August 2006 at the University of Montana, Missoula. Oral presentations and most of the posters presented at the meeting are available at http://www.ntsg.umt.edu/VEGMTG/

Reference

Morisette, J. T., J. E. Nickeson, S. Garrigues, F. Baret, A. Huete, K. Didan, T. Miura, W. van Leeuwen, and M. Friedl (2006), Report from the CEOS Land Product Validation topical workshop on the Validation of global vegetation indices and their time series, *Earth Obs., 18*(6).

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