Model Verification and Documentation Are Needed

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Trust, but verify—this is what editors ask for, and what readers expect, from reviewers of technical articles. As a reviewer, I am growing concerned with the level of trust requested by authors of submitted manuscripts, and the frequent lack of verifiable data and methods. Negative reports in the press [e.g., *New York Times,* 2005] attest to the worst-case outcomes of such shortcomings.

Certainly novelty and merit must be present in a manuscript, but authors should also include the empirical and theoretical technical bases used to support their findings and conclusions. Where fundamental elements of the scientific analysis are alluded to but are not included either explicitly or by reference, the reviewer should recommend that the article be accepted for publication only after those shortcomings have been remedied.

A particular concern is the lack of documentation of computer model methods and analyses. Increasingly, scientists incorporate computational analyses as a part of their evaluation of either hypotheses or observational data, or to make predictions. Widely used codes, such as the U.S. Geological Survey groundwater flow model MODFLOW [*McDonald and Harbaugh,* 1988], have been subjected to extensive testing for suitability to purpose and are well documented. On the other hand, for many codes written to support a specific research area, published documentation of code methods and tests does not exist, leaving no basis for reviewers to assess the methods and the results of the research paper.

As the use of digital computers and numerical models rounds the half-century mark, the literature documenting model errors, both conceptual and numerical, has steadily grown. Of 29 numerical modeling studies reviewed by *Bredehoeft* [2005], between seven and 10 included 'surprises' where natural phenomena and model predictions of those phenomena diverged. *Konikow et al.* [1997] found that six different groups of modeling experts all made fundamental errors in implementing the same numerical boundary condition for a model test case. *Oreskes and Belitz* [2001] identified three factors—nonuniqueness, temporal and spatial divergence, and subjectivity of model assessment—inherent in contemporary numerical model predictions of natural systems that they argue make such predictions unreliable. These cautions should be taken seriously.

Reviewers and readers alike must be provided a sufficient technical basis to assess the methods, results, and interpretations described in scientific papers. Concern for such control in the field of biogeochemical dynamics has been previously remarked upon [*Thornton et al.,* 2005]. Model suitability for a particular application can be demonstrated in part by model tests, and documentation of such tests is required.

Furthermore, because reproducibility is a fundamental element of the scientific method, model documentation should be sufficiently detailed so that other researchers in the field could reproduce the published results. In the main, documentation can be sufficiently detailed to allow for these assessments of the science without revealing sensitive or proprietary information. Where scientific findings are based on computational analyses, documentation of computer model methods and analyses ought to be a required element of publication. The trust of the public in scientists and our methods depends upon this.

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ABOUT AGU

Near-Surface Geophysics: A New Focus Group

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AGU has established the new Near-Surface Geophysics (NS) focus group in response to rapidly growing scientific studies of the 'critical zone,' the near-surface environment where complex interactions exist between processes in hydrogeology, geochemistry, and geobiology, among other disciplines.

This new focus group will concentrate on processes occurring in the top 100 meters of the critical zone, which supports human infrastructure, provides water and mineral resources, is the disposal zone for much of the population's waste, represents a key component of many hazards assessments, and is the interface between land and atmosphere for many of the biogeochemical cycles that sustain life.

Following the inception of the NS executive committee at the 2005 AGU Fall Meeting, committee members have focused on developing short- and long-term goals for the focus group, which are described in this article.

The NS focus group will draw together scientists who are using geophysical methods to improve the understanding of Earth processes within the near-surface region, and will provide a forum for advancing the use of techniques unique to the near-surface realm. Geophysical technologies generate data sets from the near surface that are spatially continuous, densely sampled, and of minimal invasive impact. NS will promote the science required to improve the ability of geophysical technologies to extract useful information from this part of the Earth.

The NS focus group will thus promote research to address improvements in (1) geophysical image reconstruction/inversion of the near surface, (2) new sensor technologies to capture the complexity of natural systems, (3) rock physics relationships between geophysical properties and processes of interest, and (4) scale-dependent processes, among other goals. NS also will seek to understand the strengths and limitations of geophysical methods for investigating the near surface and how these affect the ability to predict near-surface processes and parameters.

The formation of the NS focus group was driven by the vast opportunities to improve the understanding of the dynamics of this complex region through geophysical investigation. The focus group will accelerate previous efforts made by the scientific community to take advantage of the unique information extractable from geophysical data by enhancing interaction with existing AGU sections and focus groups.

A recent National Research Council (NRC) report [*National Research Council*, 2005] made specific mention of the need for geophysical methods in hydrology to provide spatially continuous data to improve hydrostratigraphy, and called for studies to better understand sensitivity/noise limitations, methods for signal enhancement, controlled experiments to validate geophysical measurements, work to address issues of upscaling, and long-term geophysical monitoring studies.

An earlier report [*National Research Council*, 2000] emphasized the connections between biology and geophysics, noting that "there is

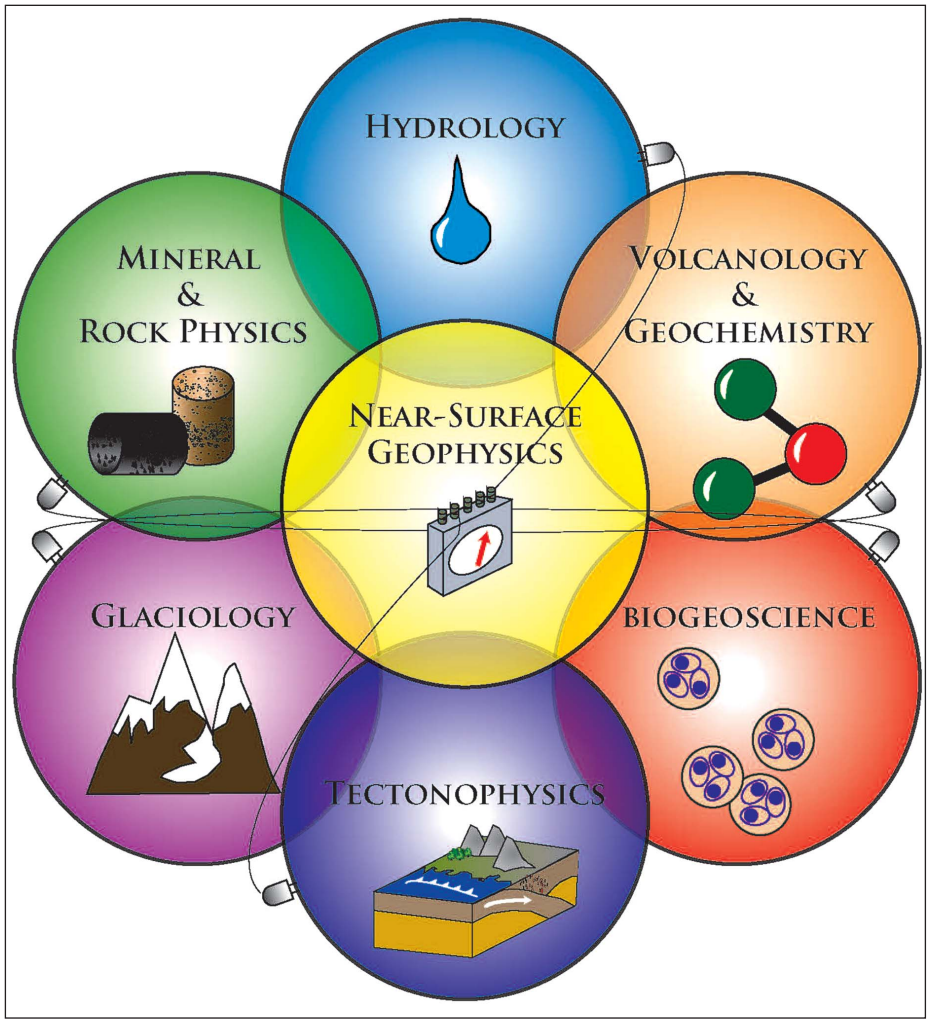

Fig. 1. Illustration of perceived interactions between Near-Surface Geophysics (NS) and other AGU sections and focus groups.

a possibility that some biologically mediated environmental properties might be detected by non-invasive or minimally invasive geophysical techniques." The report also stated that "these properties could be targeted to indicate near-surface biological activities." While some of these issues are addressed by other sections of AGU (e.g., hydrogeophysics as part of the Hydrology section), it is clear that better progress can be made by developments in geophysics that are more comprehensive in nature and that encourage knowledge transfer across subject boundaries.

Thus, a fundamental aim of the NS focus group is to interact with the broader AGU community concerned with studying processes in the near surface (Figure 1), and to support existing efforts made by other sections to promote geophysical research within the near-surface region. The most significant of these efforts is the series of hydrogeophysics sessions that the Hydrology section has organized at the past four fall meetings. These sessions have drawn the attention of the broad hydrology community to the opportunities that exist for obtaining unique, spatially rich data on hydrologic parameters and processes within the critical zone.

The NS focus group hopes to coordinate with the hydrogeophysics committee within the Hydrology section in order to elevate the visibility of these sessions at AGU and to promote appropriate sessions to complement them. NS hopes to highlight hydrogeophysics sessions as an example of how this new focus group could help to support long-term initiatives, within other AGU sections, that would promote geophysical research of key processes in the near surface.

The NS focus group will also reach out to other organizations [e.g., the Environmental and Engineering Geophysical Society (EEGS) and the Society of Exploration Geophysicists (SEG)] that have members interested in advancing geophysical studies of the near surface. For the past two years, SEG has participated in the spring Joint Assembly. This year, SEG partnered with the NS focus group to convene 13 NS special sessions. True to the spirit of NS interaction within AGU, as conceptualized in Figure 1, most of these sessions were cosponsored by other sections and focus groups (including Hydrology, Biogeosciences, Mineral and Rock Physics, and Tectonophysics).

The NS focus group also is reaching out to the Asian AGU community by cosponsoring sessions at the 2006 Western Pacific Geophysics Meeting in Beijing, China, and interacting with the Consortium of Universities for the Advancement of Hydrologic Science, Inc., to assist with plans for the Hydrologic Measurement Facility–Geophysics efforts to promote long-term research in hydrology (http://hmfgeophysics.stanford.edu/).

Short-term objectives of the NS focus group include efforts to broaden the understanding of the scientific opportunities that exist when geophysical methods are applied to study the near surface. Members of the NS committee plan to submit a proposal soon to the U.S. National Science Foundation to organize a workshop to draw the community together to examine common scientific issues within this emerging field. As a precursor to this workshop, NS convened a town hall meeting at 2006 Joint Assembly in Baltimore, Md., in order to solicit input on this matter from the broad scientific community using geophysical methods to study the near surface. At the Joint Assembly, the group also cosponsored a special Union Tutorial Lecture where distinguished scientists working in the fields of glaciology, volcanology, and biogeosciences offered their visions of how geophysical methods can advance studies of near-surface processes.

Interested individuals are encouraged to contact the NS focus group officers with ideas and thoughts about how the new group can promote geophysical imaging of near-surface process and parameters throughout the world. Near-surface geophysicists within the AGU membership community are encouraged to consider making NS their new primary AGU affiliation, which can be done through the AGU Web site (http://www.agu.org).

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