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NEWS

Online Interactive U.S. Reservoir Sedimentation Survey Database

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In April 2009, the U.S. Geological Survey and the Natural Resources Conservation Service (prior to 1994, the Soil Conservation Service) created the Reservoir Sedimentation Survey Database (RESSED) and Web site, the most comprehensive compilation of data from reservoir bathymetric and dry basin surveys in the United States. RESSED data can be useful for a number of purposes, including calculating changes in reservoir storage characteristics, quantifying rates of sediment delivery to reservoirs, and estimating erosion rates in a reservoir's watershed.

The database contains results from 6616 surveys at 1823 reservoirs in the conterminous United States and two surveys at one reservoir in Puerto Rico (Figure 1). The data span the period 1755–1993, with 95% of the surveys performed between 1930 and 1990. Reservoir surface areas range from subhectare-scale farm ponds to 658-square-kilometer Lake Powell in the southwestern United States. There are 214 RESSED-documented reservoirs in California, the most in any state.

The database project, sponsored by the U.S. federal interagency Advisory Committee on Water Information's Subcommittee on Sedimentation (SOS), is a work in progress. No post-1993 data currently reside in the database, nor does RESSED currently include any data for Alaska, Delaware, Florida, Hawaii, Rhode Island, Vermont, and the District of Columbia. Some RESSED-documented reservoirs lack precise location coordinates. Additionally, the database structure, heretofore solely compatible with 1953 Soil Conservation Service bathymetric data acquisition requirements, is archaic and unsuitable for capturing all types of data produced by modern bathymetric surveys. For example, RESSED currently cannot store raw bathymetric transect data collected using a sonic sounder and the Global Positioning System, nor can it store survey uncertainty or quality assurance data.

The project aims to obtain more precise coordinates for reservoirs as needed, add additional extant survey data for RESSED and other reservoirs, and initiate the development of a RESSED database structure capable of capturing all relevant information produced by modern reservoir bathymetric surveys.

Pending the development of an SOS-sponsored data entry interface and modernization of the RESSED database structure, the SOS seeks the cooperation of managers, scientists, and others with access to reservoir survey information. Interim guidelines and an online form for submitting additional or revised reservoir survey information are available at http://ida.water.usgs.gov/ressed/. The Web site also enables an interactive review of selected reservoir characteristics nationally and by state, and allows for the RESSED database to be downloaded in its entirety.

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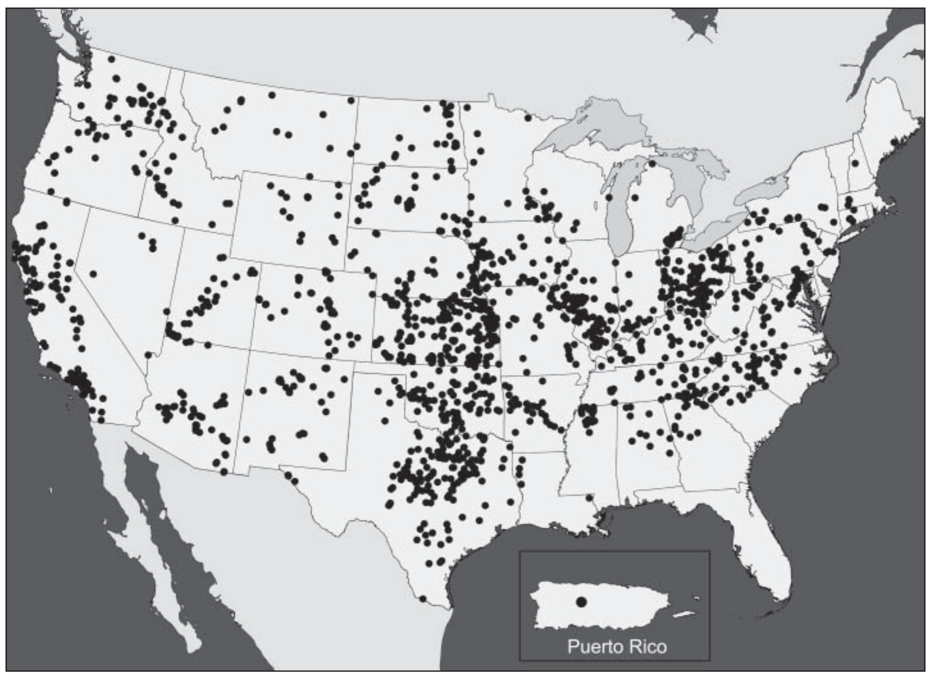

Fig. 1. Map of reservoir locations documented by the Reservoir Sedimentation Survey Database (June 2009).

FORUM

Critical Steps for the Continuing Advancement of Hydrogeophysics

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Special hydrogeophysics issues published by hydrology and geophysics journals, special sessions and workshops at conferences, and an increasing number of short courses demonstrate the growing interest in the use of geophysics for hydrologic investigations. The formation of the hydrogeophysics technical subcommittee of AGU's Hydrology section adds further evidence of the recognized significance of this growing interdisciplinary field. Given the clear value of nondestructive and nonintrusive imaging for subsurface investigations, we believe the advances in the adoption of existing geophysical methods, the development of novel methods, and the merging of geophysical and other data made in hydrogeophysics could be applied to a wide range of geological, environmental, and engineering applications.

During the past year, a group of hydrologists, geophysicists, and applied mathematicians has been discussing how geophysics can be used more quantitatively for hydrologic studies. To promote further discussion of this idea, we propose a set of working definitions and a framework for the integration of geophysics in hydrogeologic investigations.

We refer to the process of integrating geophysical and other data into a hydrologic assessment as hydrogeophysical inversion. Currently, there is significant disagreement regarding the differences among approaches to hydrogeophysical inversion, often stemming from a lack of common terminology. To clarify discussions among hydrologists and geophysicists, we propose the following definitions:

Independent hydrogeophysical inversion is the simplest and often the most practical approach, wherein hydrologic interpretations are based on hydrogeologic properties and states that are inferred from independent interpretations of geophysical surveys. While some of the choices made during inversion (e.g., norm or regularization) may be informed by hydrologic knowledge, the geophysical inversion is identical to that used in classical geophysics.

Joint hydrogeophysical inversion includes additional information about the relationships among different measurement types to interpret forward models of instrument responses simultaneously. This includes joint inversion of multiple geophysical methods but carried out in a manner that is essentially identical to classical geophysical methods with subsequent use of the inverted geophysical image for hydrologic investigations.

Coupled hydrogeophysical inversion uses a hydrologic model to relate geophysical and hydrologic measurements in time and space. In some cases, especially when monitoring transient hydrologic processes, coupled hydrogeophysical inversion approaches make direct use of a hydrologic process model as part of the geophysical inversion. Often, coupled hydrogeophysical inversion can eliminate the need to construct images of geophysical property distributions, which underlies independent and joint inversion. Whereas joint hydrogeophysical inversion combines multiple measurement types through empirical, physical, or statistical relationships between the hydraulic properties of interest and the properties that are inferred from the geophysical measurements, coupled inversion integrates multiple measurements in the context of the hydrologic process models.

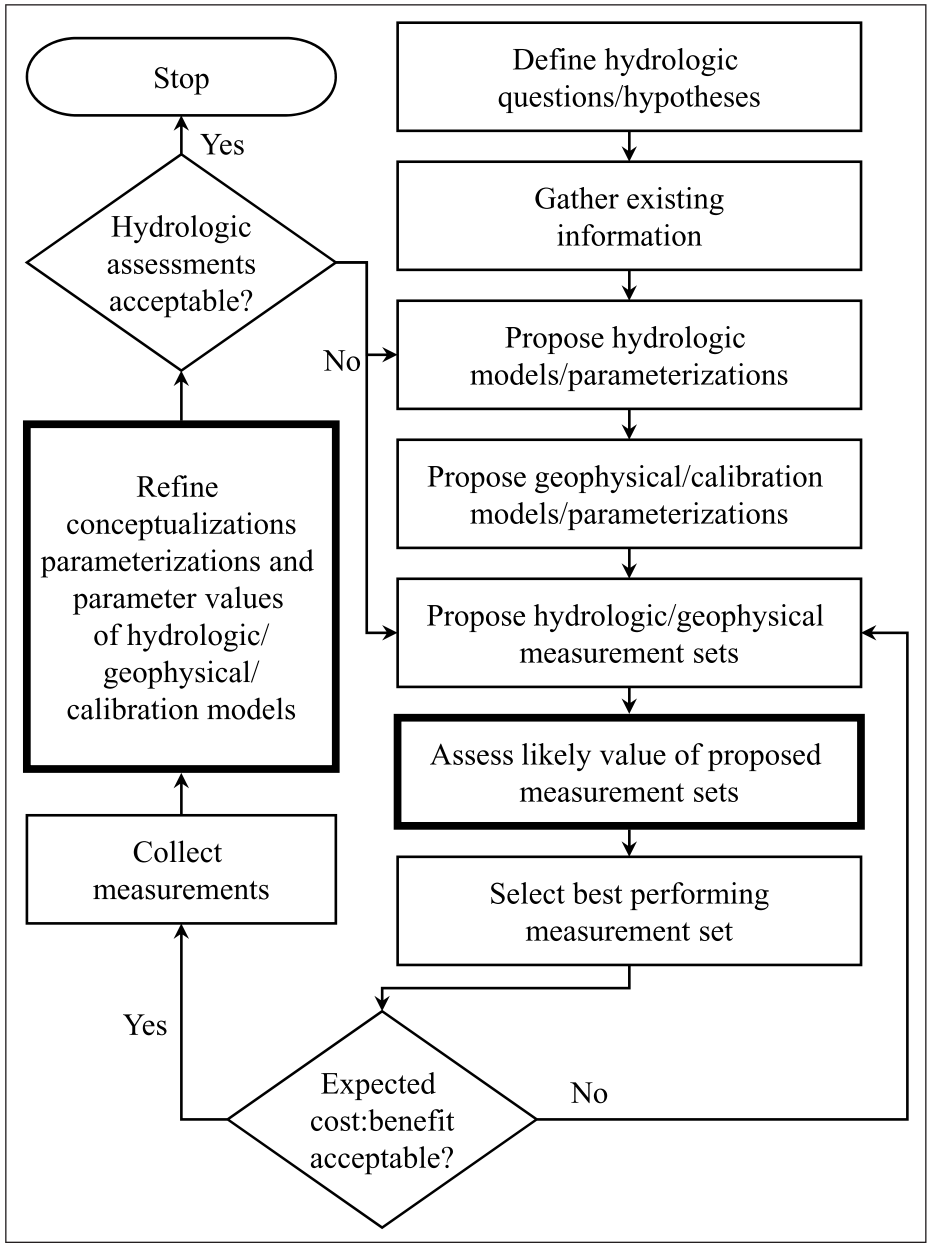

Fig. 1. Hydrogeophysical workflow based on a multimodel approach to hydrologic analysis. Coupled hydrogeophysical interpretation can improve the use of geophysics in survey planning and measurement interpretation (bold frames).

Hydrogeophysical Workflow

One of the key conclusions drawn from the group's discussions is that geophysics can be used effectively in hydrologic studies only if it is integrated in the entire hydrologic analysis. We propose a hydrogeophysical workflow based on a multimodel approach to hydrologic analysis (Figure 1). The models describe hydrologic processes (e.g., flow and transport), geophysical processes (e.g., electromagnetic or seismic responses to controlled or natural sources), and relationships among rock and fluid properties and measurable geophysical properties. Multimodel approaches allow for ranges of conceptualizations, parameterizations, and parameter values for each of these models. Within this workflow, the purpose of hydrogeophysics is to provide information that allows for discrimination among the proposed models. At the conclusion of the hydrologic investigation, the ensemble of models that are plausible, based on all observations, can be used to make probabilistic predictions to support scientific analysis and/or decision making.

There are two key steps that should include a hydrogeophysical analysis, which are highlighted in the proposed workflow diagram (Figure 1, bold frames). First, efficient hydrogeophysical characterization and monitoring requires quantitative assessment of the likely contribution of proposed measurement sets to discriminate among conceptual models and to refine the numerical or analytical model calibrations. This assessment is most effective if it is performed in the context of the specific hydrologic questions of interest and with the proposed numerical or analytical hydrologic, geophysical, and calibration models that will be used for the analysis. Ideally, this assessment should be made in a quantitative framework that allows for the comparison of multiple proposed measurement sets with different spatial and temporal resolutions and densities including satellite imagery, geophysical surveys, boreholes or drive points, and point measurements.

Second, once the geophysical data have been collected, they should be used together with other data to reject conceptual models that are not consistent with all of the data, and to refine the remaining numerical or analytical representations of these conceptual models. The choice of the most appropriate hydrogeophysical inversion approach depends on the complexity of the problem, the availability of supporting relationships, and whether the process of interest is steady state or transient.

Three Areas for Substantial Progress

As a group, we agreed that geophysics must be integrated within hydrologic analyses to realize the fullest potential of geophysical measurements. Further, we identified three primary areas in which substantial progress can be made in hydrogeophysics in the next 5 years:

1. Hydrologists currently are working to develop effective methods to generate ensembles of models that capture the range of possible hydrologic conceptualizations and parameterizations. Hydrogeophysicists can adopt some of these approaches to incorporate different conceptualizations of the responses of geophysical instruments to property distributions (geophysical forward models) in their interpretations. This is particularly important for relationships between physical and geophysical properties, which are often poorly understood and rarely characterized at the field scale.

2. In the past, some hydrologists have had negative experiences with geophysics, in part because of the inappropriate application of geophysical methods to hydrologic problems. Hydrogeophysics would benefit greatly if objective screening methods were available to guide the design of measurement sets that consider the spatial sensitivity patterns of geophysical measurement methods, the spatial resolution of imaging methods, the magnitude and characteristics of the measurement uncertainties (noise), the effects of uncertainty in field-scale rock physics relationships, the resultant uncertainty in inverted geophysical parameters, and the complementarity of different measurement types.

3. The likely value of geophysical (or other) measurements must be defined on the basis of the likely improvement they will provide for specific hydrologic questions. We need to develop quantitative approaches to compare proposed measurement sets to consistently identify high-value geophysical measurement sets that add to existing information and improve specific hydrologic analyses.

There are tremendous opportunities to advance hydrologic science through the thoughtful use of geophysics. However, to achieve this, we must find ways to increase and improve the dialogue between hydrologists and geophysicists throughout a hydrologic investigation.

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MEETING

Modeling Hazardous Mass Flows

Geoflows09: Mathematical and Computational Aspects of Modeling Hazardous Geophysical Mass Flows; Seattle, Washington, 9–11 March 2009

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A recent workshop at the University of Washington focused on mathematical and computational aspects of modeling the dynamics of dense, gravity-driven mass movements such as rock avalanches and debris flows. About 30 participants came from seven countries and brought diverse backgrounds in geophysics; geology; physics; applied and computational mathematics; and civil, mechanical, and geotechnical engineering. The workshop was cosponsored by the U.S. Geological Survey Volcano Hazards Program, by the U.S. National Science Foundation through a Vertical Integration of Research and Education (VIGRE) in the Mathematical Sciences grant to the University of Washington, and by the Pacific Institute for the Mathematical Sciences. It began with a day of lectures open to the academic community at large and concluded with 2 days of focused discussions and collaborative work among the participants.

A central goal of the workshop was to identify the present status and remaining challenges in the rapidly advancing field of computational modeling of hazardous mass flows, particularly through use of depth-integrated equations of motion. These hyperbolic partial differential equations are similar to those of classical shallow-water theory, but are complicated by the presence of complex dissipative terms representing the effects of granular friction and grain-fluid interactions. Additional complications arise from the need to compute motion across steep, irregular terrain and from lack of a priori knowledge of flow path boundaries.

Workshop participants agreed that some of the most important modeling advances now under way are (1) representation of evolving solid and fluid volume fractions and coupled pore-fluid pressure; (2) evaluation of grain-size segregation that influences intergranular friction and natural levee formation; (3) generalization of intergranular Coulomb friction to account for shear-rate effects that depend on flow thickness; (4) numerical estimation of nonlithostatic basal stresses associated with vertical components of flow acceleration; (5) modification of shock-capturing numerical methods to enable accurate computation of static as well as dynamic states; and (6) implementations of adaptive mesh refinement that can greatly speed computation. Some of the biggest remaining hurdles result from poor constraints on initial conditions (especially the volumes of potentially mobile material), and poor ability to anticipate rates of entrainment of erodible sediment along flow paths (despite the ease of including entrainment terms in the model equations). As a result of such difficulties, a continuing need exists for a range of models, from those that are most sophisticated to those that are simplest and most readily understood and implemented.

Workshop participants concluded that several steps can be taken to facilitate progress. More effort can be made to quantify causes and effects of uncertainty in model input and output. More sharing of data sets and computational codes can build better understanding of differences in model performance. Efforts to develop graphical interfaces with a standardized look and feel can broaden the community of model users and testers. To promote continuing information exchange among the participants as well as a broader scientific community, the workshop established a wiki site for posting links to resources such as data sets, computer codes, and publications. A pointer to this wiki, along with slides from some of the presentations given during the workshop, can be found at http://www.amath.washington.edu/events/geoflows09.

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