Modeling Natural Surface Motion Mitigates Risk

By Dr. David B.

Many people view the natural environment as essentially unchanging, giving deference only to seasonal differences and periodic meteorological events. However, those who interact with the Earth by studying rocks, soil and vegetation understand that the natural environment is constantly in motion, at times shifting and adjusting with potentially deadly outcomes.

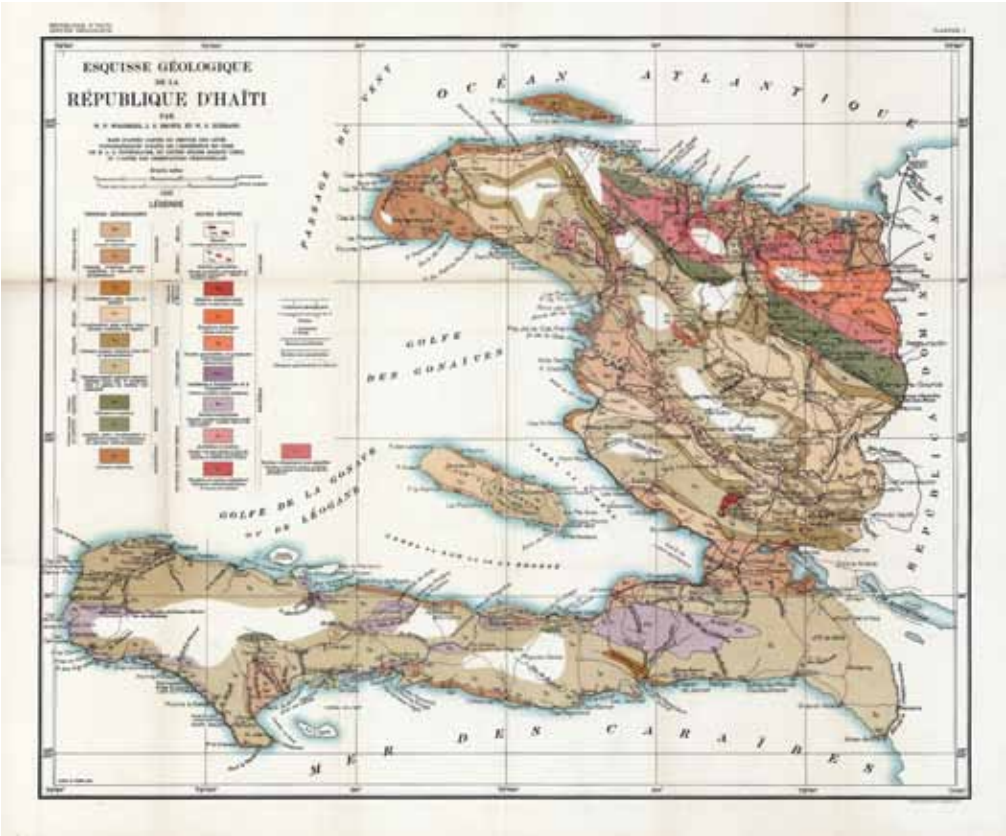
Such an outcome was witnessed recently in Haiti, where the devastating environmental effects of the January earthquake are still being assessed. A National Geospatial-Intelligence Agency team has been modeling changes in the Earth's surface to enable more rapid responses to potential crises in the Caribbean and elsewhere. By 2012, the agency plans to have modeled the entire globe.

Depicting Haiti's Environmental Vulnerabilities

In response to NGA's support to the ongoing relief efforts in Haiti, a team of geodetic scientists from the agency's Source Operations and Management Directorate, Office of GEOINT Sciences, used geotechnical modeling to depict environmental situations that could compound problems in the region. The team provided soil data, used for engineering and agriculture, for the island of Hispaniola, and products characterizing the terrain by flood potential and the percentages of sand, silt, clay and gravel.

Using scientific methods and mathematical models to predict the behavior of the Earth, the team's geotechnical modeling helped organizations planning relief efforts to determine population mobility patterns, locate makeshift camps and analyze natural and environmental hazards. For example, the team assisted the National Center for Medical Intelligence and other NGA analysts to identify areas vulnerable to erosion, landslides and floods during the approaching rainy season. Camps identified as vulnerable could then be moved to other locations to mitigate risk.

Understanding the value of geotechnical modeling for predicting, preventing or mitigating damage caused by natural hazards associated with the Earth's terrain and movement, the NGA team equipped decision makers with geospatial intelligence tools to determine current and future needs to assist in relief efforts.

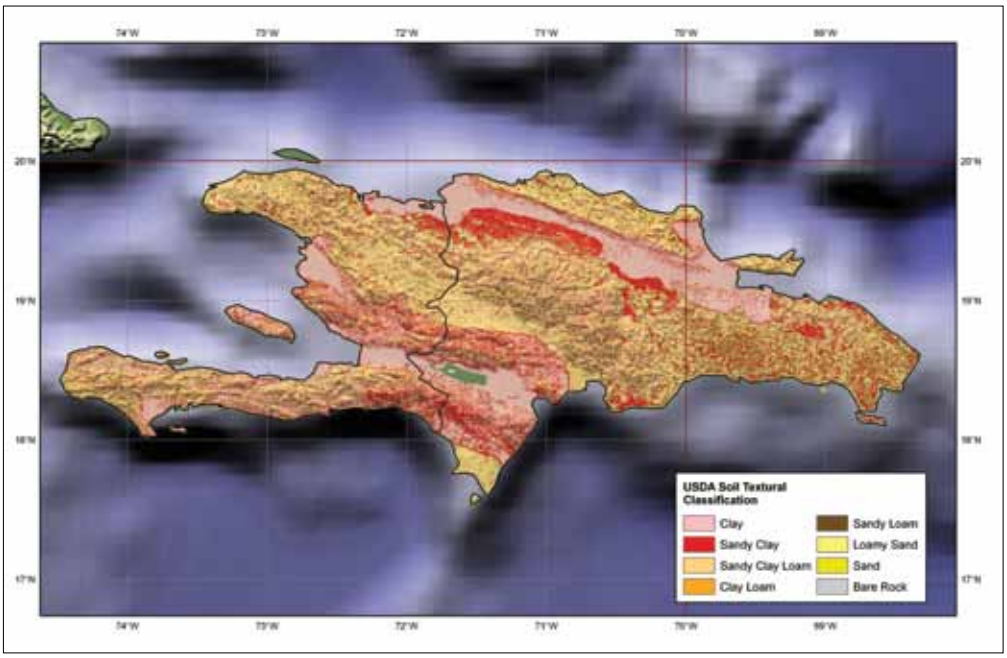


Geological Survey of the Republic of Haiti.
From Geology of the Republic of Haiti by the Geological Service of the Republic of Haiti, 1924

Creating Effective Geotechnical Models

While maps depict a geographic area at a single moment, crisis operations demand current, in-depth data that account for dynamic environments, making imagery and other remote platforms ideal for monitoring the changing ground conditions over a sequence of time. The team took these capabilities and fused them with all-source information and spatial elements to create a multidimensional understanding of what was taking place on the ground.

For example, looking individually at an area's sedimentation, local temperature, precipitation trends and vegetation limits the overall perspective of what changes are occurring as well as what could occur. However, combining those elements with imagery and complementary all-source information results in a geotechnical model that allows for a more in-depth analysis and greater understanding of what the future needs of an area might be.



Geotechnical soil modeling based on the U.S. Department of Agriculture soil textural classification.
NGA graphic

Effective geotechnical models assess what is known about an area as well as what can be inferred. The team uses all available resources, including open-source data, to describe the environment. These resources are combined with other information, such as elevation data, imagery and terrestrial geophysics, to form a mathematical model. Global data sets, which represent climate, soils, geology and vegetation, are then established as a base from which products are developed.

To create a model, the data used must first be evaluated and translated into the universal language of mathematics. The resulting data sets are applied to an X, Y, Z data series where the Z component consists of the data of interest, with X and Y representing geographic coordinates. Using this process, hardcopy data can be readily converted into any desired format and reprocessed to conform to fundamental principles of physics and natural systems.

The fusion of all-source data within a spatial domain is both flexible in application and adaptable in scope. The process can be tailored to the GEOINT objective for any given area or mission, effectively contributing to the knowledge base necessary to address an issue through a geographic information system and provide a comprehensive GEOINT solution.

Demonstrating the power of geophysical surface modeling through GEOINT has proven invaluable to many of NGA's partners over the past two years. In addition to models for those operating in Haiti, the NGA team has built and enhanced geotechnical models of Afghanistan, Iraq, the Korean Peninsula and other areas.

Understanding the effects of changing environmental patterns helps NGA to prepare its partners to meet global humanitarian needs and address potential operational issues related to the Earth's surface. NGA stands ready to help, whether the need is predicting or responding to natural disasters or answering related GEOINT questions for those in theater.

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