GHSC Pre-AGU Presentation Symposium

Talks & On-Screen Posters—10:00–11:15am

Time:	Presenter:	Title:
10:00am	Anna Kelbert	Extended ModEM 3D forward modelling capabilities for space weather applications
10:15am	Benjamin Murphy	The Importance of Geology for Space Weather: An Example from the Colorado Front Range Urban Corridor
10:30am	Benjamin Mirus	More than skin-deep: subsurface properties and processes control streamflow across spatial and temporal scales (Invited)
10:45am	Nick Mathews	Evaluating the Regional-Scale Influence of Antecedent Soil Moisture and Shear Strength Uncertainty on Rainfall-Induced Landsliding Using a Deterministic Susceptibility Framework
11:00am	Benjamin Mirus	The U.S. Landslide Inventory Compilation and Updated National-Scale Assessment of Landslide Occurrence and Susceptibility

Pre-recorded talks and posters can be found at:
https://doimspp.sharepoint.com/:f:/s/gs-ghsc-seminars2/Em3MZywKKUxAlc3vu8VIteEB7twhucJBX3wbPTQwvaPViA?e=sCyvlX

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Extended ModEM 3D forward modelling capabilities for space weather applications

GP21A-07: Tuesday, 14 December 2021, 7:35–7:40
Convention Center—Room 352

Authors: Anna Kelbert, Gary Egbert, Hao Dong, and Naser Meqbel

Abstract: ModEM 3D is a parallelized Fortran magnetotelluric (MT) modeling and inversion code [Egbert and Kelbert, 2012; Kelbert et al., 2014] that is freely available for academic use, and has been widely used for 3D MT modeling and inversion by the global MT community. Some inherent approximations of ModEM 3D software are based on the traditional formulation of the MT method, and include the use of plane-wave external sources and a Cartesian approximation for regional Earth modeling. However, realistic ground-level natural geoelectric fields of consequence for space weather applications are induced in the Earth by large-scale spatially and temporally complicated ionospheric currents that intensify during geomagnetic storms. These processes can be modeled within ModEM 3D by relaxing traditional MT approximations to include the use of arbitrary external source current geometry, flexible boundary conditions, and a spherical coordinate system. Other relevant developments include computational improvements that allow for high-resolution forward modeling of large spatial domains. Here, we report on our progress towards a versatile version of ModEM 3D suitable for the modeling of electromagnetic induction in the Earth in the context of large-scale space weather applications. These extensions will allow for the modeling of realistic, spatially and temporally complicated storm-time geoelectric fields. In the United States, these developments will also be used for high-resolution continental-scale forward modeling of MT impedances to create a gridded national impedance map, as detailed in the U.S. Geological Survey Geomagnetism Program Research Plan.

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The Importance of Geology for Space Weather: An Example from the Colorado Front Range Urban Corridor

SM35B-1972: Wednesday, 15 December 2021, 15:00–17:00
Convention Center—Poster Hall, D–F

Authors: Benjamin S. Murphy, Anna Kelbert, Paul A. Bedrosian, Jeffrey J. Love, Greg M. Lucas, E. Joshua Rigler

Abstract: The characteristics of storm-induced geoelectric fields, and therefore geomagnetically induced currents (GICs), depend upon the three-dimensional distribution of solid-Earth electrical conductivity. However, the treatment of the solid Earth's influence on GICs in critical infrastructure varies widely in the literature; in particular, the degree to which geologic information is utilized in guiding analyses differs significantly between various methodologies. Here, using recently acquired magnetotelluric (MT) data from the Colorado Front Range Urban Corridor (COFRUC), we demonstrate the importance of regional geology, which dictates three-dimensional solid-Earth electrical conductivity structure, in the estimation of GICs. Along the COFRUC, uplift of the Rocky Mountains has created a strong, sharp contrast in solid-Earth electrical properties between the topographically high mountains and the topographically low plains. In the mountains, variably deformed crystalline basement rocks with highly variable electrical properties yield high and highly variable surface impedances, which produce large, heterogeneous surface geoelectric fields (~3-30 [mV/km]/[nT] at 100 s). In contrast, in the plains, thick accumulations of electrically conductive sedimentary rocks yield low and comparatively uniform surface impedance, which gives rise to small, relatively homogeneous surface geoelectric fields (~0.8 [mV/km]/[nT] at 100 s). The transition between these strongly differing geoelectric structural domains occurs over a distance of less than 10 km at the break in topography. The ultimate impact of this major contrast in Earth properties upon grounded infrastructure, and the degree to which simplifying assumptions about Earth structure will be valid, depends crucially on the exact path of integration. Along the COFRUC, regional geology exerts a substantial control on anticipated GICs and, consequently, must be appropriately taken into account when assessing hazards for critical infrastructure.

GHSC Pre-AGU Presentation Symposium

More than skin-deep: subsurface properties and processes control streamflow across spatial and temporal scales (Invited)

H13E-01: Monday, 13 December 2021, 11:45–11:55
Convention Center—Room 271–273

Authors: Benjamin B. Mirus

Abstract: Streamflow is the combined result of rainfall that does not infiltrate and groundwater that is forced to emerge from the subsurface. While groundwater maintains the steady baseflow in streams, stormflow can be generated by infiltration-excess overland flow, saturation-excess overland flow, or interflow within the variably saturated subsurface. Thus, the geometry and hydraulic properties of soil horizons and weathered bedrock in the near surface play a critical role in governing the timing, location, and magnitude of both the slow and fast components of streamflow, which in turn controls the hydrogeomorphic evolution of landscapes. Recent advances in computational resources and numerical methods have enhanced our capacity to simultaneously simulate the coupled surface and variably saturated subsurface processes that control streamflow and erosion. Regrettably, characterization of the subsurface will likely never be sufficient to fully inform robust parameterization of hydrologic or land surface models to accurately predict integrated water fluxes across hillslope, catchment, and regional scales, due to the intricacies of subsurface processes. However, long-term hydrologic monitoring provides valuable insights into the non-linear controls on subsurface storage dynamics, from individual storm events to seasonal and long-term trends, and from single hillslopes to groundwater basins. Furthermore, monitoring reveals nuances in how disturbances such as wildfire, landslides, and extreme weather events impact hillslope hydrological processes, and also provides clues as to how these may shift with increasing frequency and magnitude of such disturbances. Insights gleaned from long-term hydrologic monitoring and comparison to modeled hydrological processes and properties highlight some of the greatest needs for future data acquisition and model development to improve quantitative characterization of runoff generation.

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Evaluating the Regional-Scale Influence of Antecedent Soil Moisture and Shear Strength Uncertainty on Rainfall-Induced Landsliding Using a Deterministic Susceptibility Framework

NH13B-04: Monday, 13 December 2021, 11:56–11:59
Convention Center—eLightning Theater VII

Authors: Nicolas Mathews, Ben Leshchinsky, Benjamin Mirus, Michael Olsen, and Adam Booth

Abstract: Shallow landslides are a destructive natural hazard that claim lives and infrastructure worldwide, and regional-scale characterization of landslide hazards is paramount for reducing their impact on society. Landslide hazards are commonly characterized by (1) their location and likelihood through susceptibility maps, (2) their size and frequency through geomorphic scaling laws, and (3) the magnitude of disturbance required to cause them through landslide initiation thresholds. This is typically accomplished by assessing inventories that document the location of previous landslides. In the absence of comprehensive landslide inventories, "synthetic inventories" may be computed using physically based slope stability models, providing landslide distributions tied to a wide range of modeled conditions. However, these models are limited in their ability to (1) capture key mechanisms tied to discrete, three-dimensional landslide mechanics, and (2) quantify the uncertainty of model inputs, such as soil shear strength, while remaining sufficiently computationally expedient for broad scale application. We developed RegionGrow3D (RG3D) to simulate the area, volume, and location of landslides on a broad regional scale through three-dimensional (3D), limit-equilibrium (LE) based slope stability modeling. Further, we incorporated RG3D into a susceptibility framework, which quantifies landsliding uncertainty using a distribution of soil shear strengths and their associated probabilities, back-calculated from inventoried landslides using 3D LE-based landslide forensics. Through a case study in the Oregon Coast Range, USA, we use this RG3D susceptibility framework, to evaluate the influence of (1) shear strength uncertainty, (2) remotely sensed antecedent soil moisture, and (3) extreme rainfall on potential landsliding. Through modeling susceptibility for a wide range of potential hydroclimatic conditions, we find that antecedent soil moisture and soil shear strength uncertainty are important factors that may considerably alter landslide susceptibility maps, geomorphic scaling laws, and rainfall thresholds.

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The U.S. Landslide Inventory Compilation and Updated National-Scale Assessment of Landslide Occurrence and Susceptibility

NH22B-03: Tuesday, 14 December 2021, 9:00–9:06
Convention Center—eLightning Theater VI

Authors: Benjamin B Mirus, Gina Belair, Eric S Jones, Jeanne M Jones, Maciej Obryk, Stephen L Slaughter, Jacob Woodard, and Nathan J Wood

Abstract: The U.S. Geological Survey (USGS) has partnered with other federal agencies and state geological surveys to gather and combine many geodatabases of landslide occurrence across the U.S. and Territories to work towards creating a national landslide inventory. In 2019, we published the first version of this compilation that included nearly 300,000 points and polygons of landslides and landslide-related features. However, this effort highlighted the vast disparity in the availability, documentation, and confidence levels of landslide information across different regions of the country. This facilitated both qualitative and quantitative re-evaluation of previous landslide susceptibility assessments for the conterminous U.S., which revealed that approaches relying primarily on coarse resolution geologic information and topography may under-estimate landslide potential in moderately sloping terrain. These important revelations about landslide data availability and prior susceptibility maps have motivated a recent update to ingest more landslide data, including revised, new, and newly identified inventories, increasing the total number of points and polygons to over 570,000. We are also developing an updated, higher-resolution landslide hazard zonation for the entire country, revising our initial criteria for assessing confidence in landslide information to account for differences between discrete landslides and other polygons that map landslide-related features, and exploring new approaches to assess landslide inventory completeness for improved susceptibility mapping. The national landslide inventory database provides a centralized portal for land managers, emergency planners, researchers, and the public to access landslide occurrence information from numerous states, the USGS, and other agencies. The national landslide inventory has prompted a broader community-wide discussion about developing future standards for landslide inventories, and it has also generated increased sharing of landslide data; it will continue to be updated as landslide inventories are revised, created, or identified.