NG12D MCC: 3005 Monday 1600h

Visualization, Analysis, and Distributed Computing in Nonlinear Geosciences III *(joint with OS, V, AE, DI)*

Presiding: **G Erlebacher,** Florida State University**; B Travis,** Los Alamos National Laboratory

NG12D-01 1600h INVITED

Visualization of a 3-D Simulation of the K-T Boundary Impact

Galen Gisler[1] (505-667-1375; grg@lanl.gov)

Robert Greene[2] (505-665-0340; greene@lanl.gov)

Robert Weaver[1] (505-667-4756; rpw@lanl.gov)

Michael Gittings[1] (505-667-1453; gittings@lanl.gov)

[1]Los Alamos National Laboratory, X-2/MS-T087, Los Alamos, NM 87545, United States

[2]Los Alamos National Laboratory, CCN-8/MS-T080, Los Alamos, NM 87545, United States

Sixty-five million years ago, late Cretaceous life came to an abrupt end with the impact of a large bolide in the shallow water off the coast of modern Mexico. Effects of this catastrophic event were felt worldwide, and dramatically changed the course of biological evolution on this planet. Understanding the dynamics of this event, and guiding further exploration of the crater and proximal and distal deposits, are goals of a simulation project we have recently undertaken at Los Alamos. We performed the simulations with the Adaptive Mesh Refinement code SAGE and followed the development of the crater out to two minutes past impact. Visualization and analysis of the results were performed mainly using the CEI Ensight package. We will present our results and discuss how the visualization informs the scientific interpretation.

NG12D-02 1620h INVITED

Using Subdivision Surfaces and Adaptive Surface Simplification Algorithms for Modeling Chemical Heterogeneities in Geophysical Flows

Joerg Schmalzl[1] (++49-251-8334703; joergs@uni-muenster.de)

Alexander Loddoch[1] (loddoch@uni-muenster.de)

[1]Muenster University, Inst. of Geophysics, Corrensstr. 24, Muenster 48149, Germany

Convective flows govern much of the dynamics of the Earth. Examples of such flows are convection in the Earth's mantle, convection in magma chambers and much of the dynamics of the world oceans. Nowadays these time-dependent flows are often studied by means of three dimensional (3D) numerical models which solve the equations for the transport of heat and momentum alternatingly. These flows are often driven by a temperature difference. But for many flows there is also an active or passive chemical component that has to be considered. One characteristics of these flows is that the chemical diffusivity is very small. Implementing such a chemical field with a very low diffusivity into a numerical model using a field approach is difficult due to numerical diffusion introduced by the Eulerian schemes. Using Lagrangian tracers is also difficult in 3D flow since a massive amount of tracers is needed. We therefore have implemented a tracer-mesh method which tracks only the position of the interface between the two different components. Compared to a 2D tracer-line the insertion of new 3D surface-elements in highly deformed regions is however more complex. This is due to the topology of the mesh which changes because of the adaptive refinement. Luckily the refinement of polygonal meshes is a very active field of research in computer graphics and has been termed "Subdivision Surfaces". There is a wealth of different subdivision schemes with different properties. We applied the Butterfly scheme and the Loop scheme for the refinement of tracer meshes. When a density difference is connected to a chemical component it often acts as a restoring force. In many cases, the governing flow is spatially heterogenous and the spatial location of the heterogeneities is varying in time (e.g. the location of an upwelling plume). The restoring force of the density contrast may result in a situation where a highly deformed, and therefore highly refined region, returns to a simple geometry. In order to limit the computational expenses we also need a surface simplification algorithm which removes excess tracers. In this talk we want to show how these techniques can be successfully applied in geophysical fluid dynamics and will give application examples.

NG12D-03 1640h INVITED

Amira: Multi-Dimensional Scientific Visualization for the GeoSciences in the 21st Century

Hauke Bartsch[1] (858-457-5359; hauke@tgs.com)

Gordon Erlebacher[2] (+49 (30) 84185 - 354; erlebach@csit.fsu.edu)

[1]TGS Inc., 5330 Carroll Canyon Rd., Suite 201, San Diego, CA 92121, United States

[2]Florida State University, 489 Dirac Science Library, Tallahassee, FL 32309-4120, United States

amira (www.amiravis.com) is a general purpose framework for 3D scientific visualization that meets the needs of the non-programmer, the script writer, and the advanced programmer alike. Provided modules may be visually assembled in an interactive manner to create complex visual displays. These modules and their associated user interfaces are controlled either via a mouse, or via an interactive scripting mechanism based on Tcl. Finally, an advanced API is made available, which enables the development of specialized modules. Its standard configuration includes many of the current visualization algorithms that operate on curves, surfaces and volumes, over a range of grid types. Amira uses a combination of efficient data structures, fast algorithms and hardware support not only to produce stunning visualizations, but to analyze and extract features from the data. Examples of available capabilities include scalar and vector field visualizations, geometry reconstruction, image segmentation, and direct volume rendering. Amira runs on both laptop and supercomputers on most existing operating systems. The user interface has the same functionality on all platforms. One extension to Amira, of relevance to the geosciences, is the VR component, which enables Amira scripts to run unmodified on big tiled displaces, in a cave-like environment, or in a dome. Ongoing research to provide Amira with features of direct relevance to the Geosciences community includes tools for remote and collaborative visualization. In this talk, we will present an overview of the above features, with an emphasis on the Earth Sciences community.

URL: http://www.amiravis.com

NG12D-04 1700h

Data-mining Analysis and Multi-dimensional Visualization of Earthquake Clusters in a GRID-Like Interactive Environment

David A. Yuen[1] (612 6249801; davey@krissy.geo.umn.edu); Witold Dzwinel[2] (011 48 12 617 3497; dzwinel@uci.agh.edu.pl); Evan F. Bollig[1] (612 6246730; bollig@msi.umn.edu); Benjamin F. Kadlec[1] (612 6246730; kadlec@msi.umn.edu); Yehuda Ben-Zion[3] (benzion@usc.edu); Shoichi Yoshioka[4] (yoshioka@geo.kyushu-u.ac.jp)

[1]Minnesota Supercomputing Instiute and Dept. of Geology and Geophysics, University of Minnesota, Minneapolis, MN 55455, United States

[2]A.G.H., Computer Science Institute, Krakow 30-159, Poland

[3]Dept. of Earth Sciences, University of Southern California, Los Angeles, CA 98809, United States

[4]Dept. of Earth and Planetary Sciences, Kyushu University, Fukuoka 813, Japan

We have developed an interactive web-based scheme for data-mining the spatio-temporal patterns of many earthquakes. This novel technique is based on cluster analysis of the multi-resolutional structures of earthquakes. The interactive scheme is based on a client-server paradigm in which we have used the off-screen rendering technique to facilitate the visual interrogation. A powerful 3-D visualization package Amira (www.amiravis.com) is also used to visualize the complex clusteral patte nrs in a reduced dimensional space. We have applied our method to observed and synthetic tic seismic catalogs. The observed data represent seismic activities situated around the Japanese islands in the 1997-2003 time interval. The synthetic data were generated by numerical simulations for various cases of a heterogeneous fault governed by quasi-analytical 3-D elastic dislocation models .At the highest resolution, we analyze the local cluster structure in the data space of seismic events for the two types of catalogs by using an agglomerative clustering algorithm. We demonstrate that small magnitude events produce local spatio-temporal patches corresponding to neighboring large events. Seismic events, quantized in space and time, generate the multi-dimensional feature space of the earthquake parameters. Using a non-hierarchical clustering algorithm and multi-dimensional scaling, we explore the multitudinous earthquakes by real-time 3-D visualization and inspection of multivariate clusters. At the resolutions characteristic of the earthquake parameters, all of the ongoing seismicity before and after largest events accumulate to a global structure consisting of a few separate clusters in the feature space . We show that by combining the clustering results from low and high resolution spaces, we can recognize precursory events more precisely. We will discuss how this WEB-IS (Web-Interrrogative system) would work. One can also access this by going to the URL http://boy.msi.umn.edu/web-is/. Its implementation and deployment in light of future GRID-computing will be discussed in terms of the recently developed Narada-Brokering (distributed messaging) system of publishing and subscribing . This will provide a scalable infrastructure for several applications involving a set of nodes communicating with each other. .

URL: http://boy.msi.umn.edu/web-is

NG12D-05 1720h INVITED

The Future of Computational Mineral Physics

Ronald E Cohen (2024788937; cohen@gl.ciw.edu)

Geophysical Laboratory Carnegie Institution of Washington, 5251 Broad Branch Rd., N.W., Washington, DC 20015

Great strides have been made in developing generally applicable methods to study Earth materials from first-principles, and the future will see great increases in accuracy and applications to more and more materials problems relevant to solid Earth geophysics. Two major hurdles which are slowly being overcome and (1) the computational and methodological demands for studying complex minerals and (2) insufficient accuracy in the most commonly used density functionals. Minerals important in the Earth pose a number of challenges to theory. For instance, they are complex solid solutions, and they usually contain troublesome transition metal ions, especially ferrous and ferric iron. Secondly, though some geophysically important properties are straightforward, if involved to compute, such as equations of state and elasticity, others are more difficult, such as transport properties including diffusivity, thermal and electrical conductivity, and anelasticity. These properties may also be dependent on defects and mesoscopic structure. The immediate future of computational mineral physics can be seen by looking at advances in theoretical materials research. Future prospects will be discussed.

NG12D-06 1740h INVITED

GeoFramework: A Modeling Framework for Solid Earth Geophysics

M Gurnis[1] (1-626-395-6979; gurnis@caltech.edu); M Aivazis[1]; J Tromp[1]; E Tan[1]; P Thoutireddy[1]; Q Liu[1]; E.-s. Choi[1]; C. Dicaprio[1]; M Chen[1]; M Simons[1]; S. Quenette[2]; Bill Appelbe[2]; B Aagaard[3]; C Williams[4]; L Lavier[5]; L Moresi[6]; H Law[7]

[1]Seismo. Lab. & Center for Advanced Computer Research, Caltech, Pasadena, CA 91125, United States

[2]VPAC, RMIT, Melbourne, VIC 3053, United States

[3]USGS, So. Wilson Blvd., Pasadena, CA 91125, United States

[4]Earth & Enviromental Sci., RPI, Troy, NY 12180, United States

[5]UTIG, Univ. of Texas, Austin, TX 78759, United States

[6]School of Mathematical Sci., Monash Univ., Clayton, VIC 3800, Australia

[7]School of Geosciences, Sydney University, Sydney, NSA 2006, Australia

As data sets in geophysics become larger and of greater relevance to other earth science disciplines, and as earth science becomes more interdisciplinary in general, modeling tools are being driven in new directions. There is now a greater need to link modeling codes to one another, link modeling codes to multiple datasets, and to make modeling software available to non modeling specialists. Coupled with rapid progress in computer hardware (including the computational speed afforded by massively parallel computers), progress in numerical algorithms, and the introduction of software frameworks, these lofty goals of merging software in geophysics are now possible. The GeoFramework project, a collaboration between computer scientists and geoscientists, is a response to these needs and opportunities. GeoFramework is based on and extends Pyre, a Python-based modeling framework, recently developed to link solid (Lagrangian) and fluid (Eulerian) models, as well as mesh generators, visualization packages, and databases, with one another for engineering applications. The utility and generality of Pyre as a general purpose framework in science is now being recognized. Besides its use in engineering and geophysics,

it is also being used in particle physics and astronomy. Geology and geophysics impose their own unique requirements on software frameworks which are not generally available in existing frameworks and so there is a need for research in this area. One of the special requirements is the way Lagrangian and Eulerian codes will need to be linked in time and space within a plate tectonics context. GeoFramework has grown beyond its initial goal of linking a limited number of exiting codes together. The following codes are now being reengineered within the context of Pyre: Tecton, 3-D FE Visco-elastic code for lithospheric relaxation; CitComS, a code for spherical mantle convection; SpecFEM3D, a SEM code for global and regional seismic waves; eqsim, a FE code for dynamic earthquake rupture; SNAC, a developing 3-D coded based on the FLAC method for visco-elastoplastic deformation; SNARK, a 3-D FE-PIC method for viscoplastic deformation; and gPLATES an open source paleogeographic/plate tectonics modeling package. We will demonstrate how codes can be linked with themselves, such as a regional and global model of mantle convection and a visco-elastoplastic representation of the crust within viscous mantle flow. Finally, we will describe how http://GeoFramework.org has become a distribution site for a suite of modeling software in geophysics.

URL: http://GeoFramework.org

NG31A MCC: Level 1 Wednesday 0830h

Nonlinear Processes in Geomorphologic Organization and Natural Hazards II Posters *(joint with B, H, OS, AE)*

Presiding: **E Foufoula,** St. Anthony Falls Laboratory, University of Minnesota**; I Rodriguez-Iturbe,** Princeton University**; S F Tebbens,** University of South Florida

NG31A-0596 0830h POSTER

Dissipation, Entropy and Geomorphological structures

Ralph D Lorenz (rlorenz@lpl.arizona.edu)

Lunar and Planetary Laboratory, University of Arizona 1629 E. University Blvd, Tucson, AZ 85721, United States

A wide variety of landforms can be viewed as dissipative structures. These persistent, organized structures (including river networks, sand dunes, sorted stone circles, etc.) exploit some driving energy source, whether potential energy in the case of hydrology, kinetic energy from wind, or heat flows into and out of the ground. It is instructive to compare the mechanical work required to construct these landforms with the energy available. A natural question is whether these structures seek some extremum, such as maximum dissipation or Maximum Entropy Production. Such principles appear to be supported by theoretical considerations, as well as the empirical observation of planetary climates. Dissipative properties of river networks have been extensively explored ; it has also been suggested that sand dunes may organize to maximize the sand transport normal to the dune crest, which is equivalent to maximizing frictional dissipation.

NG31A-0597 0830h POSTER

Channel Patterns as the Result of Self-Organization Within the Flow-Sediment-Vegetation System

Michal Tal[1] (612-624-4675; talx0001@umn.edu)

Chris Paola[1] (612-624-8025; cpaola@umn.edu)

[1]University of Minnesota, St. Anthony Falls Laboratory, 2 3rd Ave. SE, Minneapolis, MN 55414, United States

The familiar patterns of braided and meandering rivers can be thought of as the result of self-organization within a "three-phase" system comprising fluid, sediment, and vegetation. Interactions between these three components are also largely responsible for the organization of river systems into separate and distinguishable channels and floodplains. Key elements of the self organization include the space and time characteristics of seed dispersal and plant growth as well as the statistics of occupation, abandonment, and reworking of the bed by the flow. Seeds are transported and dispersed readily by wind and water and opportunistically colonize areas of the channel that are abandoned or exposed at low flows. Vegetation increases bank stability through root reinforcement of the sediment and increases the threshold shear stress needed for erosion. In addition, vegetation offers resistance to the flow by increasing the drag and reducing the velocity, thus decreasing the stream power available for erosion and transport. Vegetation that is not removed while young will become stronger and increasingly resistant to erosion and removal by the flow. Thus a key organizing parameter in the flow-sediment-vegetation system is the time scale for establishment of the vegetation relative to a characteristic channel or bed mobility time. Experiments at the St. Anthony Falls Laboratory demonstrate how repeated cycling of vegetation seeding and water discharge changes an unvegetated braided channel morphology: the flow is gradually corralled into a single sinuous channel that largely tracks the thread of maximum velocity in the original braided network. The experiments are carried out in a large unconsolidated sand bed flume in which alfalfa sprouts are used to simulate riparian vegetation and offer the only form of cohesion in the system. An initial braided pattern is allowed to evolve freely in conjunction with alternating high and low discharges and repeated seedings. As the vegetation density and age increase with time, smaller and weaker channels are choked off leaving a single relatively narrow channel with a sinuous thalweg. This channel develops its own internal bar forms with smaller length scales than the original braid bars.

URL: http://www.geo.umn.edu/orgs/seds/

NG31A-0598 0830h POSTER

PHYSICAL INSIGHTS INTO THE SCALING OF AT-SITE HYDRAULIC GEOMETRY AND SCALING OF FLOOD PEAKS

Boyko A Dodov[1] (dodo0001@tc.umn.edu)

Efi Foufoula-Georgiou[1] (efi@tc.umn.edu)

[1]St. Anthony Falls Laboratory, University of Minnesota, Mississippi River at 3rd Avenue SE, Minneapolis, MN 55414, United States

The dependencies between channel properties and river flows known for a long time as at-station hydraulic geometry (HG: power laws connecting discharge to stream geometry) have been recently shown to systematically vary with scale (contributing area), and a model based on the multiscaling framework has been proposed to statistically describe this scale-dependence (Dodov and Foufoula Georgiou, AGU Fall meeting 2002). In this paper, we attempt to provide a physical explanation for the scale-dependence of at-station HG. Namely, we postulate that it arises from the scale-dependence of river sinuosity and, thus, channel cross-sectional asymmetry and we use observations and physical theories (channel stability analysis and linear theory of river meandering) to test this hypothesis. Also, physical insight to the multiscaling of flood peaks is offered. In particular, it is argued that the empirically observed break in variability of flood peaks with scale relates to the scale-dependent frequency of transition from below-bankfull to overbank flow, controlled by the systematic and interrelated variations of channel and flood plain geometries with contributing area.

NG31A-0599 0830h POSTER

Dynamic Bedrock Fluvial Channel Networks: Analytic Model and Field Evidence

Michael Oskin

Department of Geological Sciences, University of North Carolina, Chapel Hill, NC 27599-3315, United States

Fundamental processes in landscape evolution are the establishment and elaboration of stream channel networks. Network geometry, and in particular efficient concentration of discharge to incise channels, controls the first-order distribution of mountain range relief. This study explores the mechanisms that organize a pre-existing channel network into a series of regularly-spaced drainages that dissect a linear mountain range. The elevation of the channel network is approximated analytically using a stream power law. Channel elevations are minimized to produce an optimal channel network simulating competition between adjacent incising stream channels. Solving for the minimum range crest elevation predicts the position of the principle tributary junction point - where two tributaries join to form the main stream channel. For reasonable values of channel concavity of 0.4 to 0.7, the junction point resides at 3/4 to 5/6 the catchment length as defined by the distance from the outlet to the divide. Solving for the ridge line elevation between catchments predicts a catchment length / width ratio between 1.8 and 2.1, also consistent with published numerical models and studies of natural landscapes. Field investigations of the tectonically active Kyrgyz Range of the western Tien Shan reveal evidence for natural processes that optimize stream networks. Comparisons of youthful, intermediate, and mature catchments define a pattern of tributary junction points that migrate upstream to maximize concentration of discharge. Differential incision of adjacent tributary catchments leads to upstream drainage capture and formation of under-fit parallel paleo-valleys. The extent of evidence for dynamic bedrock fluvial channel networks in the Kyrgyz Range suggests that these networks undergo significant reorganization over several million years before reaching an optimal topology. Complete understanding of the time scale of drainage network evolution and response to changing tectonic boundary conditions will thus require calibration of processes that contribute to lateral bedrock channel migration and capture. Processes observed to be occurring in the Kyrgyz Range include differential channel incision rates, deep-seated landslides, and the effects of debris loading from tributaries

NG31A-0600 0830h POSTER

Patterns in tidal environments: salt-marsh channel networks and vegetation

Marco Marani[1] (+39 0498275449; marani@idra.unipd.it); Sonia Silvestri[2] (sonia@unive.it); Enrica Belluco[1] (belluco@idra.unipd.it); Monica Camuffo[3] (camonic@unive.it); Andrea D'Alpaos[1] (adalpaos@idra.unipd.it); Stefano Lanzoni[1] (lanzo@idra.unipd.it); Alessandro Marani[3] (marani@unive.it); Andrea Rinaldo[1] (rinaldo@idra.unipd.it)

[1]University of Padova - Centro Internazionale di Idrologia D. Tonini, via Loredan 20, Padova I-35131, Italy

[2]Servizio Informativo - CVN, Campo S. Stefano, Venezia I-35120, Italy

[3]University of Venice - Dept. SA, S. Marta, Venezia I-35120, Italy

Salt marshes in tidal environments are characterised by complex patterns both in their geomorphic and ecological features. Such patterns arise through the elaboration of a network structure driven by the tidal forcing and through the interaction between hydrodynamical, geophysical and ecological components (e.g. microphytobenthos and vegetation). This contribution introduces observations of tidal environments from remote sensing and ancillary data collected in the field. In particular CASI, MIVIS and LiDar airborne data and IKONOS and Quick-Bird satellite data on the lagoon of Venice (Italy) have been acquired in the period 2001-2002Salt marshes in tidal environments are characterised by complex patterns both in their geomorphic and ecological features. Such patterns arise through the elaboration of a network structure driven by the tidal forcing and through the interaction between hydrodynamical, geophysical and ecological components (e.g. microphytobenthos and vegetation). This contribution introduces observations of tidal environments from remote sensing and ancillary data collected in the field. In particular CASI, MIVIS and LiDar airborne data and IKONOS and Quick-Bird satellite data on the lagoon of Venice (Italy) have been acquired in the period 2001-2002, within the European RTD project TIDE. The remotely sensed data have been radiometrically calibrated, atmospherically corrected and accurately georeferenced to allow the comparison with ground truth observations. Classification and unmixing techniques are then used to derive the spatial distribution of salt marsh vegetation species, which are also characterised through the use of vegetation indexes (e.g. NDVI), allowing an objective and quantitative analysis of vegetation patterns. The set of observations available are further used, together with mathematical models, to describe channel meandering characteristics and branching properties yielding an accurate and spatially distributed description of the tidal network. . The remotely sensed data have been radiometrically calibrated, atmospherically corrected and accurately georeferenced to allow the comparison with ground truth observations. Classification and unmixing techniques are then used to derive the spatial distribution of salt marsh vegetation species, which are also characterised through the use of vegetation indexes (e.g. NDVI), allowing an objective and quantitative analysis of vegetation patterns. The set of observations available are further used, together with mathematical models, to describe channel meandering characteristics and branching properties yielding an accurate and spatially distributed description of the tidal network.

NG31A-0601 0830h POSTER

Ground Penetrating Radar Technique to Locate Coal Mine Subsidence Features at Malakoff, Texas

Neelambari Save[1] (979-324-8232; nsave@geo.tamu.edu)

Mark E. Everett[1] (979- 862-2129; everett@geo.tamu.edu)