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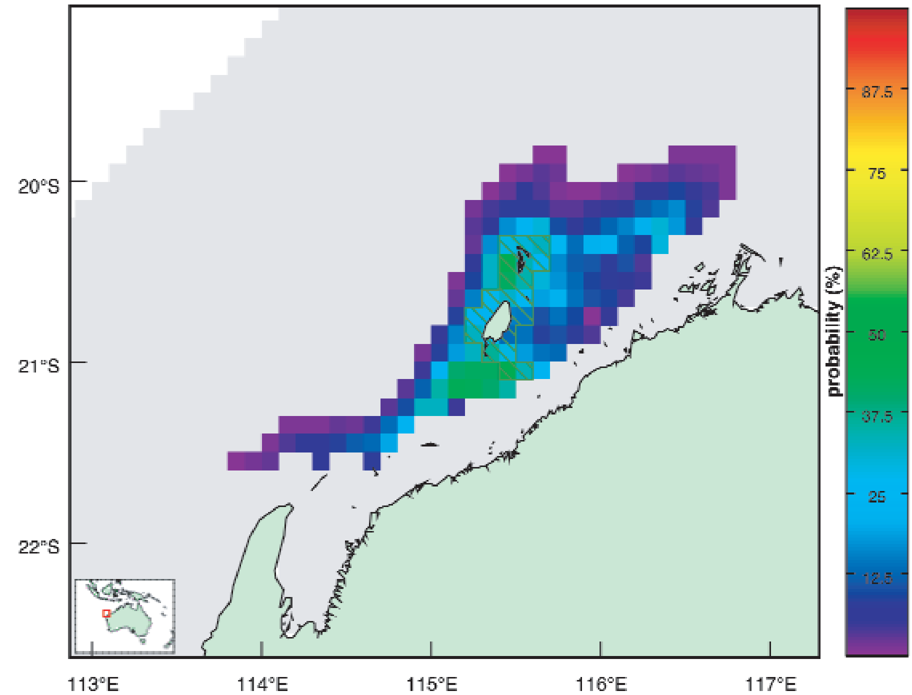

Fig. 3. Probability that water from the region around the Monte Bellow and Barrow Islands (marked by cross-hatching) will reach other areas within a 21-day period. The distribution is based on a single month of particle outputs from the hydrodynamic model (January 1999). The image is taken from Web-based graphical-user-interface, which allows the user to select the source region of interest (e.g., a proposed marine reserve or an oil platform), the period of interest (specific months and years or seasonal composites), and the dispersion time (e.g., larval lifetime or time for chemical biodegradation).

Integrating Complexity of Social Systems in Natural Hazards Planning: An Example from Caracas, Venezuela

PAGES 55–56

In December 1999, days of heavy rain on steep slopes north of Caracas, Venezuela triggered massive mud and debris flows, killing tens of thousands. Partly in response to this disaster, a multidisciplinary team of urban planners and Earth scientists from Columbia University recently developed a framework plan for building disaster resilience into the Venezuelan capital region. After assessing the complex intersection of urban geography with severe seismic and hydrologic hazards, substantial recommendations were made to local and regional authorities on future hazards mitigation.

Areas found most at risk in the Caracas region include the transportation and utility infrastructure and the friable building stock of squatter settlements. Recognizing realistic economic and socio-political constraints on implementing change, a prioritized list of goals and activities was constructed, and recommendations made along various time scales. Immediate disaster-avoidance goals (to be completed within 1 to 5 years) include strengthening critical infrastructure nodes, housing stock, and emergency services. More intermediate goals (5 to 10 years) focus on upgrading fragile housing units, creating detailed hazard maps across the city, and incorporating disaster education into cultural activities. Recommended activities for the long term (beyond 10 years) include creating a fully redundant transportation and water delivery network, establishing legitimate land title for squatters, and re-locating critical facilities currently in high-risk areas.

These recommendations were presented to government officials in Caracas, the Andean Parliament, representatives from Venezuelan academic institutions, the United Nations Development Programme, and the Venezuelan Red Cross.

This article presents a pedagogic approach to developing urban planning and design principles that are sensitive to hazard and risk issues.

Studio Implementation

At Columbia University in New York, the Graduate School of Architecture, Planning and Preservation offers a studio in urban planning and design. This provides degree candidates the opportunity to work in a collaborative setting to solve problems for a particular urban client, usually a civil municipality. In January 2001, such a studio was organized to also include faculty and Ph.D. students from Columbia's Lamont-Doherty Earth Observatory and Department of Earth and Environmental Sciences. The purpose was primarily to perform an academic experiment attempting to incorporate knowledge about natural hazards and mitigation into the urban planning and design process. Participants worked with the realistic goal of providing the citizens of Caracas with a solid planning document that could be used as a starting point as they build disaster resilience into their city.

The final 125-page report is available at http://www.arch.columbia.edu/Studio/Spring2001/Caracas/.

The Caracas Urban and Environmental Context

Natural hazards. Located on the intersection of the South American and Caribbean Plates, northern Venezuela faces extreme seismological hazards. *Perez et al.* [2001] report a 2 cm/yr rate of plate motion at the offshore boundary; half of which is accommodated by the San Sebastian fault, which likely comes ashore under the Simon Bolivar International Airport in Vargas State [*Audemard et al.*, 2000]. The fault zone is diffuse, containing the Tacagua-El Ávila and La Victoria fault systems that surround the city to the north and south. Major earthquakes have destroyed

Caracas three times in the last 400 years. The last large earthquake (M_w=6.5) came in 1967, killing an estimated 300 people and destroying four modern structures built for earthquake resistance [*Papageorgiou and Kim*, 1990].

The natural hazards faced by northern Venezuela are not limited to earthquakes. The position of the northern coast near 10°N ensures frequent heavy rainfall events with strong erosion potential. In December 1999, a month of rain on the north central coast of Venezuela—including over 900 mm of rain in a 72-hour period between 15 and 17 December—triggered landslides, mudflows, and debris flows on the north face of the El Ávila range that killed an estimated 25,000–250,000 residents of the coastal state of Vargas. (Estimates of this number vary by one order of magnitude within the Venezuelan government and non-governmental organizations.) The heavy rains also caused fatalities in the Caracas basin.

High slope angles along El Ávila (some up to 80%) allow for immediate acceleration of surface fluids. The December 1999 event saw evidence of hyper-concentrated flows, alluvial fan re-activation, and some evidence of prior, larger flows [*Salcedo*, 2000, 2001]. The Vargas coast is lined with extensive alluvial fans, nine of which re-activated during the December 1999 event [*Larsen et al.*, 2001]. The Caracas basin contains at least three alluvial fans with clear signs of Earth movement in the past 100 years. In an article in *Eos*, *Larsen et al.* [2001] present an excellent overview of El Ávila geology and mud flow processes during the December 1999 disaster.

Although rainfall data is sparse, historical records compiled by *Salcedo* [2000] show that either the Caracas or Vargas area has been severely affected by debris flows roughly every 25 years since recorded history. Previous empirical work by local geologists illustrates that any rainfall exceeding 100 mm in 24 hours will cause damaging mud and debris flows; any rainfall exceeding 300 mm in 72 hours is considered catastrophic. An analysis of 25 years of regional rainfall data produced during the Columbia studio extrapolates a frequency of recurrence of 100 mm/24 hours to once every 5 to 10 years; the probability of 300 mm/24 hours is once in 25 years.

Built environment. Since the last major earthquake in 1967, the population of Caracas has doubled to 5 million people, with a population density of 12,000 persons/km^2 and growth of 3.1% per year. Eighty-six percent of the Venezuelan population is urban, making it the seventh most urbanized country in the world.

The valley floor is well developed, with high-rise buildings and densely packed apartment blocks scattered unevenly throughout the city. These buildings are generally concentrated in the deepest part of the basin (where shaking is expected to be highest during an earthquake). Barrios, or informal squatter settlements, dominate the landscape on the low-lying, rugged mountains to the east and west of the city center, where rainfall-induced debris flows are expected to be greatest. To the south exists a mixture of urbanazacions (similar to suburbs) and barrios. The individual building blocks of the barrios,

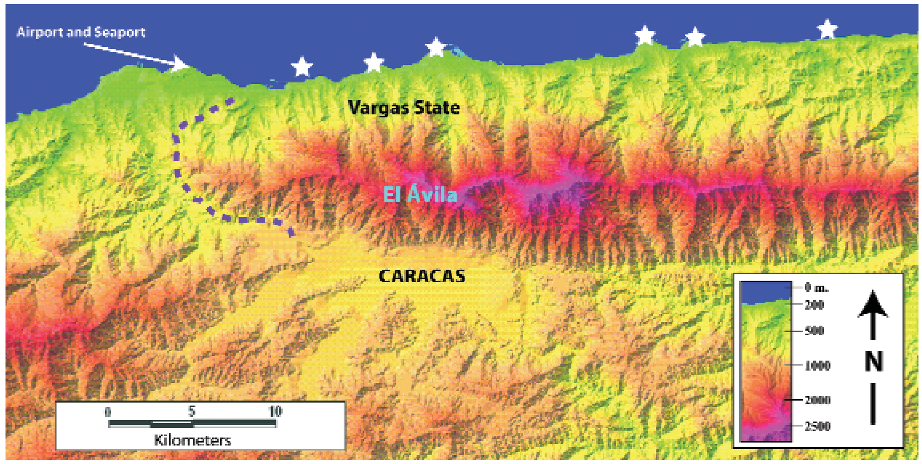

Fig. 1. Regional elevation map of Caracas, Venezuela and Vargas State. Stars indicate major mud flow and alluvial fan re-activation during the December 1999 catastrophe. Dashed line denotes approximate path of the single road and water link between Caracas and Vargas. Caracas relies upon this link for transportation of people and goods; Vargas relies on this link for fresh water. A major bridge along the highway is being compressed by an active landslide. (Basemap credit: F. Urbani, Universidad Central de Venezuela.)

Fig. 2. Map of the Petare barrio of Caracas, Venezuela, illustrating dual nature of city. On left is the open spacing of the planned, "formal" city. On right is the densely packed squatter barrios of the "informal" city. This diversity in housing quality and density creates large challenges in planning for natural hazards mitigation. A vast majority of informal housing stock on the right is constructed of un-reinforced masonry.

known as ranchos, are constructed of un-reinforced masonry, making them particularly vulnerable to earthquakes. The ranchos are highly visible from every point in the city as they carpet the hills, creating a starkly contrasting landscape of a dual urban fabric (Figure 2).

While the formal city averages 6,000 persons/km^2, similar to the world average urban density, the barrios approach 25,000 persons/km^2.

Vargas State is isolated physically from the Caracas basin by El Ávila (Figure 1). However, Vargas is inextricably linked to Caracas. It serves as Caracas' economic connection to the rest of the Caribbean, and acts as the social "relief valve" for the city, by offering weekend recreation for residents. Although separated geographically, Vargas and Caracas are economically and culturally intertwined.

Collision of the Built Environment and Natural Hazards

Centuries ago, Caracas was purposefully built away from the coast and through steep terrain to deter sea-borne attacks on the city. However, this removal creates major transportation and utility infrastructure problems which are exacerbated by natural hazards. Caracas is linked to the world through its airport and seaport, both of which are located across El Ávila on the Vargas coast (Figure 1). The only road between Caracas and the airport and seaport is a single highway that travels through steep, landslide-prone valleys crossing secondary faults of the active San Sebastian fault.

Uncontrolled building and lack of enforcement of building and zoning codes in this hazardous environment have led to human disasters and potential problems of great magnitude.

A lack of building code and enforcement allowed Vargas residents to build on active (but quiescent for the previous 50 years) alluvial fans, which re-activated during December 1999. Although various groups are working to repair and rebuild Vargas State with new housing built in safe locations, a general lack of planning and enforcement are allowing squatters to return to the alluvial fans and stream beds where most of the December 1999 destruction was concentrated.

Results of the Studio

The main threats to the future health of the Caracas urban landscape were identified (Figure 3) during a one-week field reconnaissance in Caracas and Vargas State in January and February 2001, and during further collaborative investigation from February to May 2001. On-site visits included meetings with local academic and professional geologists, hydrologists, engineers, urban planners, sociologists, disaster-relief workers, and political officials, as well as touring areas affected by the disaster. With the goal of making hazards-related recommendations in the context of the current socio-political and economic situation, we attempted to determine both the natural and social magnitude of the problem. It was a surprising revelation during the visit to learn that neither Caracas nor Venezuela currently has any urban planning projects or studies that incorporate or discuss natural hazards and disasters. It became readily apparent that our project could help to fill those large planning, policy, and administrative gaps.

Critical areas classified as at highest risk in Caracas include the utility infrastructure (water, sewage, and power), the emergency response system (medical, police, and fire), and the highway system (both within and the one connecting the city to Vargas).

For example, more than 95% of the water supply to the Caracas basin comes from three lines originating from southern reservoirs in the Tuy Valley, with all lines crossing seismic faults. Less than a one-day supply of water is stored within the city, and the state of Vargas receives all of its water from one line along the vulnerable Caracas-Vargas highway. The water system is therefore considered extremely fragile, and it is likely that firefighting and medical operations will be severely hampered in the event of a major earthquake.

The only direct road link between Caracas and its airport and seaport crosses a bridge threatened by an active landslide into its northern abutment. While the current slip rate has recently slowed from 2 cm/month to 1 cm/year, local engineers have estimated that the bridge can tolerate less than 23 cm of further slip [*Salcedo and Ortas*, 1992; *Salcedo*, pers. comm., 2002].

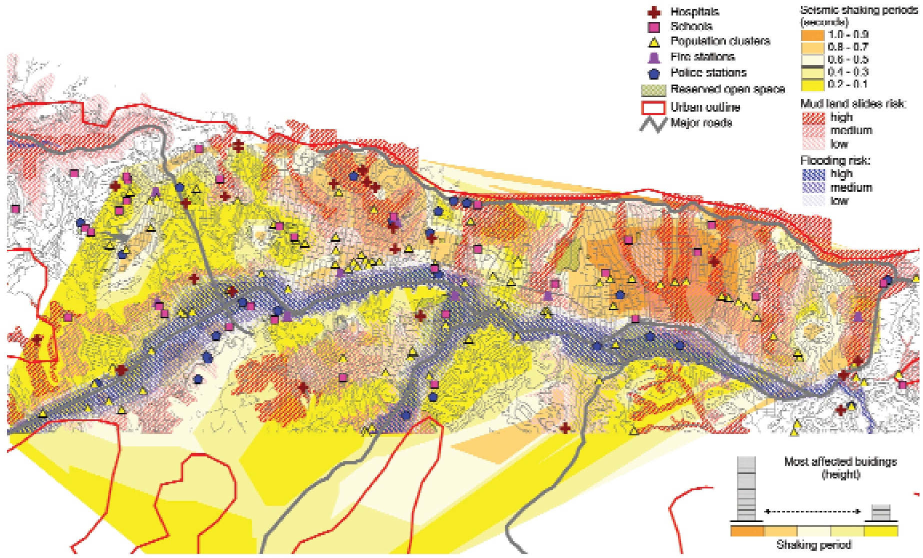

Fig. 3. An example of a studio-produced hazard map of urbanized Caracas. The map is a compilation of urban facilities research and natural hazards research, and is the type of presentation provided to local government officials. This map relied upon existing estimates of ground-shaking period from FUNVISIS and estimated flooding extent, based on local topography, produced during the Columbia studio.

Losing the bridge would mean losing Caracas' commerce and transport link to the world.

This threatened bridge is emblematic of the regional road system, which is neither redundant nor strengthened. Illustrating the unstable confluence of hazards and politics, in the past century, the typical tenure of the Venezuelan transportation minister has been six months. Many changes recommended by the studio require continuity and stability within the government; mitigation projects are difficult to achieve without consistent leadership.

Intermediate-term recommendations include establishing constitutional and legal legitimacy for disaster management; fostering international exchange among scientists, professionals, and technicians; and starting public outreach programs in schools and communities. Creating a redundant utility infrastructure, developing a hazards-based zoning code, and enforcing no-build zones in highly hazardous areas for the reservation of open space are also important goals.

A strong lesson of the field reconnaissance was the general ignorance of the public to natural disasters. We recommended educating barrio residents about safer building techniques, recognizing that unregulated building will continue into the future. Hazards intersect with population realities in Caracas: half of the population live in unplanned, unzoned, and unofficial squatter settlements, built of non-reinforced masonry.

Long-term recommendations include the realization of open spaces and resilient structures. Open spaces are considered critical dual-use facilities: they have obvious cultural value and historical context for daily activities; and during natural disasters, they provide important gathering and distribution locations for critical services. Establishing legitimate land-title for ranchos built on a squatter basis and the creation of a working real estate market are crucial property issues that will contribute to disaster mitigation through planned building and location.

Finally, a clearly organized hazards and disaster management system that incorporates government officials, the military, the scientific community, non-governmental organizations (NGOs), and the public is critical to effectively respond to inevitable disasters.

Before any changes are to begin, one very important activity must be undertaken: our planning exercise must be duplicated on a grander and more detailed scale by those with intimate knowledge of local issues. The obstacles to implementing these goals by Venezuelans parallel our obstacles in researching this project: lack of observational data, lack of clear channels in government, and an overwhelming array of issues to be tackled.

Future of Caracas and Other Regions

While the recommendations summarized here were well received by local government and NGOs, they represent only the first of many steps required to construct a viable multi-hazards mitigation plan for Caracas. Data collection, assimilation, and integration leading to quantitative risk assessments are high-priority needs. Effective risk reduction strategies and appropriate mitigation policies can be designed only once risks are assessed. Given our interactions with Venezuelans currently engaged in hazards-related research throughout government, academic, and private institutions, we remain confident that natural hazards mitigation will return to its high priority once the current political crisis is resolved.

Since this project was undertaken, a similar international hazards studio has been repeated for seismic hazards in Istanbul, Turkey, and another will soon examine flooding and public health issues in Ghana.

Comparatively, the Caracas studio was important in providing an original first-step plan to a region currently lacking in any adaptive, integrated planning to ameliorate such an immediate risk.

Acknowledgments

Interaction with and assistance from IREU, FUNVISIS, and numerous other Venezuelan academic and government groups was greatly appreciated. Financial support for this project came from the Graduate School of Architecture, Planning and Preservation, the Lamont-Doherty Earth Observatory, and the Columbia Earth Institute through the Center for Hazards and Risk Research. Lamont-Doherty Contribution Number 6410.

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Learning More about Antarctic Geoscience

PAGE 49

Windy, cold, remote, hostile, barren, extreme. These are just some of the words that come to mind when describing Antarctica.

Antarctica is the highest, coldest, and windiest continent on Earth. Less than 3% of Antarctica is free of ice, and the continent contains some of the most spectacular mountain ranges in the world. The most extensive are in the Antarctic Peninsula, 1700 km in length, and the Transantarctic Mountains, which are more than 3000 km long. The highest mountain, Vinson Massif in the Ellsworth Mountains, peaks at 4897 m.

For the explorers of 100 years ago, Antarctica was the ultimate survival contest. For today's scientists, it remains a place of intellectual challenge that is of key importance to our understanding of how the world works. Scientific research in Antarctica is coordinated by the Scientific Committee on Antarctic Research (SCAR), an interdisciplinary committee of the International Council for Science (ICSU). SCAR initiates, promotes, and coordinates scientific research in Antarctica and provides scientific advice to the Antarctic Treaty System.

Recently, an organizational restructuring of SCAR resulted in three large scientific groups being formed to examine the areas of geo-science, life science, and physical science. The Geoscience Standing Scientific Group (GSSG) is charged with sharing information on disciplinary scientific research being conducted by national Antarctic programs, identifying research areas or fields where current research is lacking, and promoting geoscientific research activities within SCAR, and to the broader geoscience community.

The GSSG coordinates the research being conducted in such disciplines as geology, geophysics, geodesy, geographic information, permafrost, climate change and evolution, neotectonics, geochronological evolution, and subglacial lake exploration. The group is also the provider of a number of key data bases and products that are assisting not only scientists with their research, but logistics personnel as well. The Antarctic Digital Database, a digital vector topographic representation of the continent, is the group's flagship product. Other very important data sets available online include a gazetteer of Antarctic place names, a map catalogue for all Antarctic maps known to SCAR, an Antarctic Seismic Data Library, details on permanent geoscientific observatories, and a geodetic control data base.

If you are interested in learning more about Antarctic geoscience research and GSSG activities, see www.geoscience.scar.org.

Links for additional information about Antarctica: SCAR Web site: www.scar.org; Antarctic Treaty Consultative Meeting: www.25atcm.gov.pl; ICSU Web site: www.icsu.org; Antarctic Digital Database: www.nerc-bas.ac.uk/public/magic/add_main.html; Composite Gazetteer of Antarctica: www.pnra.it/SCAR_GAZE; SCAR Map Catalogue: www-aadc.aad.gov.au/mapping/scarmaps.asp; Antarctic Seismic Data Library System: walrus. wr.usgs.gov/sdls/; SCAR Geological Map Catalogue: www.nerc-bas.ac.uk/geosci/geomapcat/geomapcat.html.

—GLENN JOHNSTONE, Scientific Committee on Antarctic Research, Geoscience Standing Scientific Group, Belconnen, Australia

New Immigration Requirements for Students in U.S. Who Are Not U.S. Citizens

PAGE 50

The U.S. Immigration and Naturalization Service (INS) has delayed the date by which universities and colleges who enroll non-U.S. citizens holding non-immigrant visas must decide whether or not they are going to participate in the INS' new Student and Exchange Visitor Information System (SEVIS). The new deadline is 15 February.

The initial deadline was 30 January. However, it has been delayed "to accommodate schools and visitors centers that are new users" of the Internet-based SEVIS system, according to a statement released by the INS.

SEVIS-participating schools will be required to enter certain information about such students in this new data base. The information will be provided by students on SEVIS Form I-20, which will be distributed to them by the schools in which they are enrolled. For currently enrolled students, schools are required to have the requisite data entered in SEVIS no later than 15 August 2003.

In addition, a prospective student not already in the United States will be required to complete Form I-20 at the time he or she applies for a visa at a U.S. embassy or consulate. The INS will formally notify the university at which the student has been accepted; if the student fails to register, the school is required to report this to the INS.

Schools are also required to update SEVIS with any change of a student's status, such as a change in home or work address, program extensions, changes in program of study, etc.

Also, students in the U.S. who are citizens of certain countries are now required to register directly with the INS so that various personal data, such as home address and school registration, can be entered in another new data base, the National Security Entry-Exit Register System (NSEERS).

All citizens of Iran, Iraq, Libya, Sudan, and Syria were required to report to their local INS offices for this purpose by 16 December 2002. Male citizens of Afghanistan, Algeria, Bahrain, Eritrea, Lebanon, Morocco, North Korea, Oman, Qatar, Somalia, Tunisia, the United Arab Emirates, and Yemen were required to report by 10 January 2003. Male citizens of Pakistan and Saudi Arabia have until 21 February to register.

Individuals registered in NSEERS will also be required to periodically verify their location and activities with the INS—for example, whether they are still attending school—and to confirm their departure dates when they leave the United States.

—EMILY CRUM, AGU Staff Writer; AND JUDY JACOBS, Assistant Managing Editor, *Eos*