This map shows sea-surface temperatures averaged over eight days in September 2001, as measured by NASA's Terra satellite. Dark red represents warm water (32°C) and purple is cold (–2°C). The Gulf Stream can be seen as the orange strip extending from the eastern U.S. toward the Atlantic.

**PICTURE CREDITS**
2 — Ronald Vogel, SAIC for NASA GSFC; 3 — Genping "Roots" Liu; 4, 10 — Lance Hayashida; 5 — Charles Decker; 7 — Katie Neith; 9, 11 — Jenny Somerville

## WALL OF SOUND

Over 50 members of the Caltech Jazz Bands and the Caltech-Occidental Concert Band brought the sound of music to the Great Wall of China in March. Positioned in front of a fort on a portion of the wall near Beijing, the group played a concert featuring two new pieces written specifically for the occasion. One of the world premieres was written by Caltech alumnus Leslie Deutsch (BS '76, MS '77, PhD '80), chief technologist for the Interplanetary Network Directorate at JPL; the other was written by his son, Elliot, a jazz bandleader, composer, and trumpeter. The featured vocal soloist, Kjerstin Williams (BS '00, MS '02, PhD '06), lent her voice to the jazz tunes. The group also joined fellow musicians from Tsinghua University for a joint concert in Beijing. —*KN* E&S

"Playing on and climbing the Great Wall was definitely a highlight of the trip. It will be something that I will be able to talk about for decades after I graduate from Caltech, since it will always stand out from the everyday life of a Techer," said freshman clarinetist Hima Hassenruck-Gudipati.

## 'MID THESE DANCING ROCKS

The following real-world paradox comes to you courtesy of Assistant Professor of Geology Michael Lamb: "Say you're out hiking, and you come to a roaring stream plunging down the side of a mountain. It's full of rocks and boulders, all precariously balanced. You come back the next year, and you find that those same rocks are still there, just where they were. In fact, year after year you come back, and they never seem to move. Why is this?"

Don't know the answer? Neither does Lamb, and he's been thinking about it for a long time. Loose rocks on the bottom of lazy, low-sloping rivers migrate slowly downstream under nature's inexorable nudging. But in very steep channels, where it would seem that the collaboration between water and gravity should produce much more dramatic results, much of the stuff on the bottom stays put. And no one knows why.

A huge flume recently installed on the Caltech campus just might provide some answers. A flume is an artificial river—in this case, a tilted rectangular chute down which water cascades. Explains Lamb, "We can load our flume with various sediments, including fair-sized rocks, tilt it at any angle up to 15 degrees, and change the rate of flow of the water. That gives us a way to simulate all kinds of rivers."

Rocks, water, slope—surely there must be more to simulating a river than that? "Surprisingly, that's complicated enough," shrugs Lamb. "Water, on its own, we understand fairly well. We know the equations that describe how it flows in a smooth channel. But as soon as we start introducing sediment, the coupling between moving sediment, immobile sediment, and water becomes quite a complicated problem. We don't even know the equations to describe it."

The flume hulks in one corner of the Central Engineering Services building's machine shop, filling virtually every cubic inch of available space. It features a main section more than 15 meters long and, bone-dry, it weighs

15 tons—simply dwarfing most of the other laboratory flumes in the world capable of such steep slopes. Lamb didn't design it this way from a bigger-is-better mentality, but because he's interested in complexities that can't be modeled on smaller scales. "Imagine a steep mountain stream where the boulders have organized themselves into steps," he explains. "There's a boulder that makes a little waterfall, with a pool at the bottom, and below that there's another boulder making another waterfall with another pool, and so on. In order to understand how the sediment organizes itself into these structures, and how the structures then feed back into the system, we'd need to create three or four step-and-pool sequences in a row. You can't do that in a small flume."

A remotely controlled cart trundles back and forth atop the length of the flume, bearing high-precision instruments that map both the surface and the bottom of the artificial river with submillimeter accuracy. Water overflows into the flume's upstream end from the headbox, which is constantly refilled at whatever rate is needed in order to simulate anything from a trickling creek to a roaring cascade. The headbox is replenished from the tailbox at the flume's downstream end by a pair of pumps. "The larger one is the size of a Volkswagen," Lamb points out. "It can move 8,000 gallons of water a minute."

"Typical flume research," Lamb continues, "uses sand or even finer sediments, which can be pumped right through the pipes along with the water. But we're looking at the much coarser objects found in mountain channels." Rocks the size of softballs or soccer balls don't normally mix well with high-speed pumps, so a system of external conveyors collects the accumulation in the tailbox and returns it back to the head.

Lamb's plans range from studying issues of local concern, such as how debris rumbles down a denuded mountainside after a wildfire, to the global connection between erosion and climate change. "When you weather silicate rocks into clays, you're sucking carbon dioxide out of the atmosphere. But once the rock is covered by a layer of clay, the weathering process shuts down unless you physically transport that material away and expose fresh bedrock to more weathering. So the highest chemical weathering rates are tied to the highest erosion rates. In the Himalayas, for example, where rocks are uplifting rapidly and the rivers are eroding rapidly, weathering may be drawing enough $CO_2$ out of the atmosphere to affect global climate. But if I stood in front of a mountain river with the most knowledgeable people in the world, and asked them to tell me how fast that river was cutting, or how much sediment would come out of it in a year, they wouldn't be able to tell me within a factor of ten. We just don't have the observations yet to know how these systems work.

"A lot of research has been done on low-sloping, big channels: how to engineer them, how to dam them, and so forth. That makes sense, because we live in a world full of cities built on rivers. But small, steep mountain channels play a critical role in shaping our terrain and climate over long timescales, and we know very, very little about them." *—DZ* e&s

A look into the empty flume. The flume can be tilted as much as 15 degrees, allowing water and sediments—such as rocks, pebbles, and dirt—to flow down and simulate everything from a creek to a cascade.