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DATELINE LOS ALAMOS

U.S. DEPARTMENT OF ENERGY
UNIVERSITY OF CALIFORNIA

BUBBLE SCIENCE BENEFITS DEEP DIVERS

Nitrogen, that colorless, odorless gas that makes up 80 percent of our air, is perfectly harmless as it's breathed in and out on land, but for underwater divers, it's the enemy.

Pressures exerted by water are formidable, each 30 feet in depth is equal to an added atmosphere of pressure, about 14 pounds per square inch. At high pressure, nitrogen is dissolved in the blood and tissues very easily and the deeper a diver goes and the longer they stay down, the more nitrogen is absorbed. Absorb too much nitrogen and it actually becomes toxic, causing a very dangerous condition known as nitrogen narcosis.

But more important is how the nitrogen comes out of solution in the body as a diver returns to the surface. If there is too much dissolved nitrogen in the body, or pressure is reduced too quickly, the gas can begin to form bubbles, causing a host of problems collectively known as decompression sickness. That's where bubble science comes into play and where Los Alamos National Laboratory physicist and master diver Bruce Wienke goes to work.

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FROM THE DIRECTOR

This month's Dateline features science that at first glance seems outside the normal responsibilities for an institution devoted to national security, but on closer inspection illuminates how our mission-related work can find beneficial applications in other areas.

A member of our weapons design division, who is also an underwater diving expert, has developed a new algorithm for calculation of safe dive times. This effort could replace the nearly 100-year-old table that currently guides diving plans, and has applications in sport, technical and military diving. The Los Alamos scientist, using his knowledge of both diving and physics, developed the new algorithm.

Another algorithm of note offers a means for compressing a high-definition television signal. Applied to HDTV, the work offers the prospect of transmitting digital and analog signals in the same broadcast channels and perhaps easing the transition to HDTV. Members of the broadcast industry will have to decide if the method has application for them, but offering new technological tools has long been part of Los Alamos' tradition.

Finally, I'm delighted we can present you information about the impressive successes of New Mexico mid school and high school children. A project called the Supercomputer Challenge hosts students who solve complex problems using supercomputers at Los Alamos and Sandia. Some of these students may be members of the national laboratories' future workforce. I hope you enjoy reading about them and the Los Alamos' breakthrough science.

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EDITOR
Kathy DeLucas

MANAGING EDITOR
Judith Goldie

COORDINATING EDITOR
Denise Bjarke

SENIOR SCIENCE WRITER
Todd Hanson

E-Mail the Dateline staff at *dateline@lanl.gov*

CONTRIBUTING WRITERS
Kevin Roark • Steve Sandoval
Kay Roybal

CONTRIBUTING PHOTOGRAPHERS & ILLUSTRATORS
LeRoy N. Sanchez • Edwin Vigil

PRINTING COORDINATOR
G.D. Archuleta

LOS ALAMOS NATIONAL LABORATORY
PUBLIC AFFAIRS OFFICE IN THE COMMUNICATIONS & EXTERNAL RELATIONS DIVISION
MS C177
LOS ALAMOS, NM 87545

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"I became interested in diving procedures, training and safety during my time in special warfare in the 1960s," said Wienke. "And later, as a physicist, I became convinced that a realistic biophysical model that would increase the safety of deep diving could be created based on the physics of bubble formation."

How deep a diver can go, and how long they can stay at a given depth, are the cardinal rules of diving. Recreational sport divers use standard Self Contained Underwater Breathing Apparatus, or SCUBA equipment, to generally do what are known as non-decompression dives, meaning they only go as deep and stay as long is allowed to keep their nitrogen levels below the danger zone. SCUBA allows a diver to carry along a supply of compressed air that is delivered through a regulator system.

Technical, research, commercial and military divers usually go deeper and stay longer than sport divers, so they must slowly decompress while returning to the surface and usually do not breathe regular compressed air but a gas mixture that replaces most of the nitrogen with helium. All these divers sometimes use systems called rebreathers, allowing divers to recycle their breathing gases and regulate the pressures at which the gases are delivered.

Bruce Wienke of the Applied Physics Division has combined his scientific research with his deep divinng experience to develop a new dive algorithm that has participated a sea change for divers.

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Both sport- and technical-diving parameters have long been based on a dive table developed around 1908 and refined through the years by the U.S. Navy. The table, known as the Haldane Table, named for John S. Haldane, its developer, governs not only how long and deep a diver may go but also how many decompression stops must be made on the way back up and at what depth they are made. For instance, a diver who goes to 250 feet and stays there for an hour will have to spend five hours conducting decompression stops at various depths.

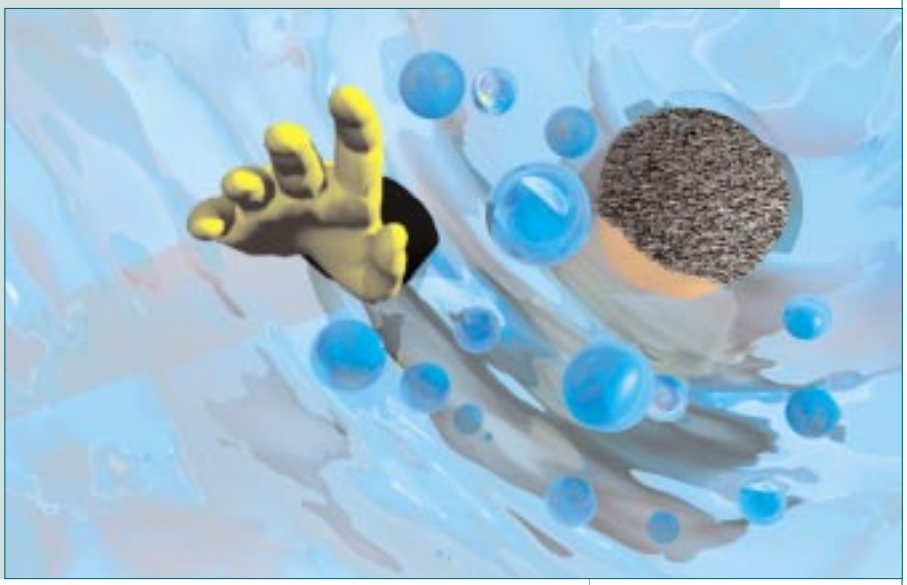
Wienke of Applied Physics Division, Materials Science Group, has developed a new dive algorithm based on the physics of bubble formation that is setting the diving community, both sport and technical, on its ear. The table, known as the Reduced Gradient Bubble Model, or RGBM, is already used in commercial diving and has applications in sport, cave, military and virtually every other diving situation. Wienke's research is in collaboration with the University of Rochester; the University of Trondheim, Norway; the National Aeronautics and Space Administration; the University of Wisconsin; and the University of Hawaii.

The benefits of the RGBM are that divers can go deeper, stay longer and spend less time decompressing than with the Haldane Table. Why? It's all about how bubbles are created.

"Bubbles begin as micronuclei, or tiny seed bubbles," said Wienke. "Micronuclei can be stable for up to two hours and can be coaxed into becoming bubbles by a variety of stimuli, like surface friction from muscle tissues rubbing together, called tribonucleation.

"If a newly forming bubble encounters high concentrations of inert gas, such as nitrogen or helium, in solution at high pressure, the lower pressure inside the bubble will cause the gas to diffuse into the bubble and it will grow."

Bubbles in the blood, tissue or nervous system cause a host of problems. Growing bubbles in joints, the spinal column or brain can cause mechanical pressure, nerve damage and severe pain. Bubbles in the blood can grow large enough to block blood flow, which in turn causes localized oxygen starvation and can trigger an immune system-like response to attack the blockage.



Keeping nitrogen and helium bubbles from forming is the goal of both the Haldane Table and RGBM. The advantages of RGBM stem from its use of various diving gas mixtures, the most common

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are called trimix, heliox, and nitrox and a different approach to determining the depth and timing of decompression stops upon ascent.

"Because of the physics of bubble formation and gas transfer, we determined that the staged decompression would start deeper, and the stops would not last as long as those called for in Haldane," said Wienke. "Plus we have the diver switching from mixed gas to pure oxygen on the shallowest decompression stops. These two factors can literally shave hours off of a typical decompression time."

The impact of RGBM has been huge in the commercial and technical diving communities and is now having a similar effect with sport diving, according to Wienke.

"It's a revolution," he said. "The algorithm is being built into dive computers and tables for the general consumer and has been adopted as the official model for the National Association of Underwater Instructors, one of the leading dive-training organizations."

A big part of the reason for RGBM's acceptance is Wienke's diving experience. Wienke has logged more than 3,000 hours underwater as deep as 400 feet and in locations all over the world, from under the ice of the arctic to the tropic waters of the South Pacific. Author of five technical diving books including "Basic Decompression Theory and Application," and "Basic Diving Physics and Application," Wienke credits RGBM's success to a common diving language.

"In the diving community, I'm not just a physicist, I'm a diver, too," he said. "I and many others have been diving using the RGBM table under a wide variety of conditions, so I have a connection to the technical divers, we speak the ssame language. So, it's not only the research but the diving experience as well that confirms the value of RGBM."

CONTACT: BRUCE WIENKE
MATERIALS SCIENCE GROUP
505-667-1358 • BRW@LANL.GOV

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HDTV: TO BE OR NOT TO BE

High definition television is coming – at least we hope so. For some television viewers the system is already in place and working well. For many more consumers, however, the technology may be a bit later in coming. The transition has proven troublesome for television broadcasters, television set manufacturers and government officials as technological, economic and even political issues have slowed the process.

The promise of HDTV is worth the wait, but only if you want the benefits of a higher-resolution picture – imagine doubling the resolution of today's analog television – coupled with a wider screen image close to the dimensions of a motion picture image. Add to that, Dolby digital sound with six separate audio tracks for detailed and realistic surround sound and you'll probably agree HDTV is a better way to see television.

HDTV sets are still pretty expensive and rare, so the programming is limited to a few major metropolitan areas. Since HDTV programming is not widely available, manufacturers are having a hard time generating significant revenues from HDTV sales to achieve economies-of-scale in manufacturing. Because of this, prices for HDTV sets remain relatively high. Since HDTV receivers are expensive and programming is limited,

The information content in the picture using the algorithm will approximate that of a dedicated HDTV transmission, giving slightly lower quality, but still far superior to analog television. The analog television picture would remain the same except for two bars of "static" on the top and bottom of the television screen.

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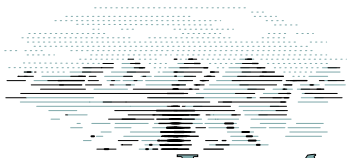

consumers are hesitant to adopt the new format. This knotty conundrum doesn't even begin to consider the problems of scrapping the entire nation's existing television infrastructure.

Many people involved in the transition are beginning to fear that when the federally mandated time comes in 2006 to convert broadcast formats, a large percentage of the population will not be ready. Nonetheless, at that time broadcasters will be required, for a while at least, to broadcast both analog and HDTV signal and manufacturers will be forced to produce HDTV sets simply to allow everyone to comply with the federal mandate. All this means the transition to HDTV may not happen the way planners had expected.

Anticipating this slowdown, a Los Alamos scientist has developed a technology that could make the ongoing transition from current analog television to HDTV easier. The technology is a new transmission algorithm capable of compressing a HDTV data stream to the point where both the HDTV and analog TV signals can be broadcast over the same channel.

The advantage of the Los Alamos transmission algorithm is that it allows broadcast television networks to avoid spending millions of dollars to maintain the two separate transmission systems required broadcasting both analog and HDTV signals during a transition period. Just as consumers will still need to eventually buy HDTV sets, television broadcasters will need to install HDTV transmission equipment.

However, the Los Alamos transmission technology would allow broadcasters with HDTV capability to transmit a signal compatible with both the new digital and the old analog sets without using two separate channels of the broadcast spectrum. The use of this algorithm would be compatible with the current HDTV format and could allow early expansion of HDTV availability during an interim period.

Since broadcasters could use a single channel for both signals they could then return unused portions of the broadcast spectrum back to the government for other uses such as wireless communications. At the end of a transition period, broadcasters would stop using the algorithm and HDTV receivers would then receive the purely digital signal. At that point, the old analog television in the basement would work no longer.

The technology is of particular importance to American consumers because although the deadline for HDTV to be the required format for broadcast television signals looms in 2006, many Americans are apparently still unaware of the pending change.

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Researchers estimate that only 30 percent of the U.S. population are familiar with HDTV. Given the fact that there are currently an estimated 120 million analog TV sets in use in the United States, that means that 84 million television owners don't know about the coming transition to HDTV. Since neither the television industry nor Congress wants the change to HDTV to be surprising or onerous to television owners, a transition technology like the Los Alamos algorithm could be useful by allowing people to continue using their old analog television sets a few more years until they purchase a new HDTV set. This interim solution would permit the continued broadcast of analog signals until both the awareness and acceptance of HDTV increases and the cost of HDTV sets decrease with improvements to the technology and increased sales volume.

The information content in the picture using the algorithm will approximate that of a dedicated HDTV transmission, giving slightly lower quality, but still far superior to analog television. The analog television picture would remain the same except for two bars of "static" on the top and bottom of the television screen. These bars are the result of differences in the shape, or format, between the analog and digital pictures, and the "static" is actually digital information containing finer details.

The Los Alamos algorithm is rapidly moving from theory to reality. A patent application has been filed for the HDTV technology and the project recently received critical financial support through the Laboratory's LDRD program. This Laboratory-Directed Research and Development funding will allow the HDTV computer coding to be completed and experimental transmission and reception devices to be built and tested.

KATHLEEN HERRERA
INDUSTRIAL BUSINESS DEVELOPMENT OFFICE
(505) 667-5844 OR KAHERRERA@LANL.GOV.

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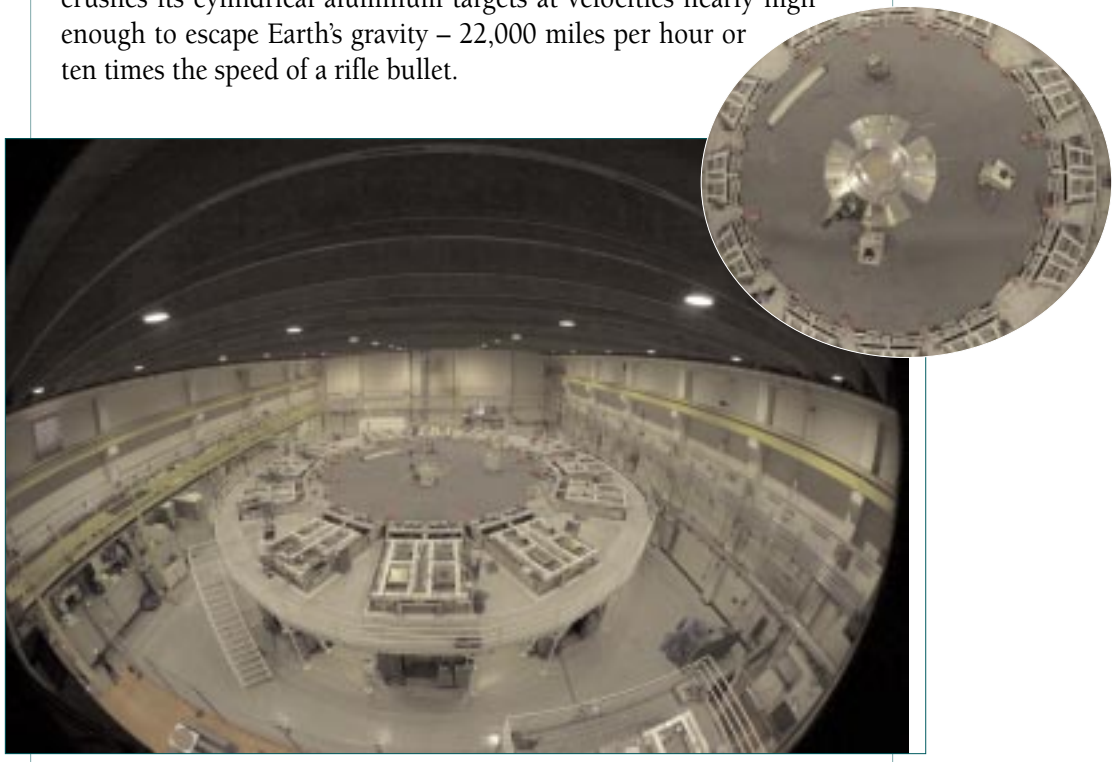
LABORATORY COMPLETES ATLAS MACHINE

Like its powerful namesake from Greek mythology whose strength allowed him to bear on his shoulders the earth and heavens, the Laboratory's Atlas machine is poised to become a powerful force in the world of experimental physics.

In December, the 650-ton Atlas pulsed-power generator successfully discharged 28.7 million amperes of current into a test load and completed its acceptance testing. The shot duplicated the world record for current produced by any fast capacitor bank.

Atlas uses enormous pulses of electrical energy to create the most uniform, symmetric and controllable implosions ever achieved. Atlas works like a giant capacitor using power that is accumulated slowly and stored in the machine capacitor banks for sudden release into a roughly three-inch-diameter target placed in the Atlas experiment chamber. As the electrical current surges through the Atlas machine, it crushes its cylindrical aluminum targets at velocities nearly high enough to escape Earth's gravity – 22,000 miles per hour or ten times the speed of a rifle bullet.



Atlas nears completion in September 2000; inset, same stage of construction, from above.

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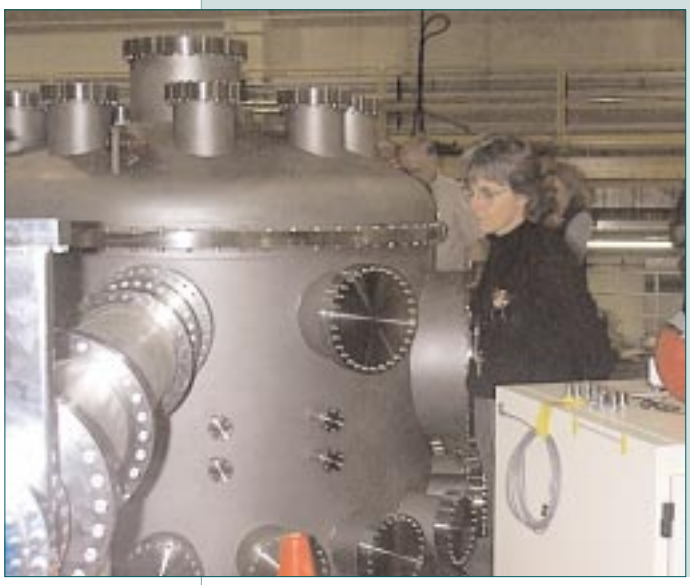
At the same time, Atlas compresses the target material to pressures several times that of the center of the earth or ten million times that of Earth's atmosphere. During the few fragments of a second that it is operating at full strength, the tremendous electrical output of Atlas is roughly equal to four times the world's total electric power consumption.

Since September 2000, Atlas operators have been firing incrementally more powerful test shots, first with one-twelfth of the machine, then one-third, two-thirds and most recently with the full machine. In the most recent test, the capacitor bank was discharged from only 75 percent of its design voltage and is likely to produce over 30 million amperes when used to accelerate imploding liners for weapon-physics experiments.

The Atlas machine is expected quickly to become a valuable tool for stockpile stewardship experimentation. The Atlas pulsed-power facility supports work relating to the certification of the nuclear weapons stockpile. It provides basic physics data to validate the computer codes used for weapon certification and helps scientists improve the models in those codes.

Atlas was conceived in 1993, as part of the Department of Energy's strategy to maintain the nuclear stockpile without underground nuclear testing. The Atlas construction project began in 1995 with engineering design and component tests. Full-scale assembly began in November 1999 and construction was completed in August 2000. Atlas has, so far, been an outstanding project management success for Los Alamos by meeting construction and safety requirements while remaining on schedule and within budget.

Physics Division Director Sue Seestrom examines the Atlas experimental chamber.



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Under the current plan, the powerful Atlas will conduct physics experiments for the Science-based Stockpile Stewardship Program for the next 18 months at Los Alamos before being disassembled and moved to the Nevada Test Site. After being reassembled, certified and prepared for continuous operation at the test site, Atlas will continue its mission supporting stockpile stewardship as a tri-lab (Lawrence Livermore, Sandia and Los Alamos national laboratories) resource and as a state-of-the-art research facility providing experimental opportunities to investigators from many laboratories and academic institutions.

Below is the bottom, or underside view, of Atlas' experimental chamber. ↓

CONTACT:
DAVE SCUDDER
ATLAS PROJECT
505-665-1892 • DWS@LANL.GOV

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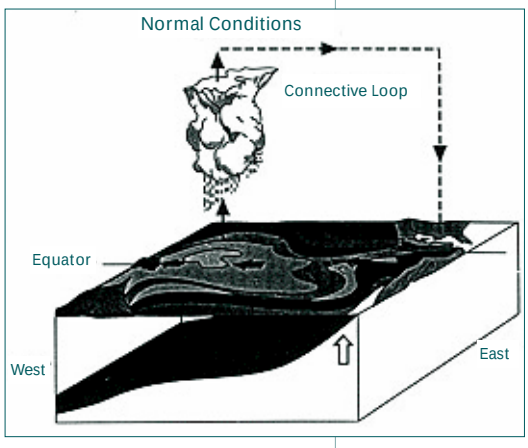
PREDICTING EL NIÑO: LAB RESEARCHERS HAVE SOME ANSWERS, MORE QUESTIONS

The Spanish term "El Niño" has been used for centuries by South American fishermen to describe the annual occurrence of warm, southward-flowing oceanic current waters off the coast of Ecuador and Peru around Christmas. El Niño, or the child, specifically refers to the Christ child.

In modern usage, the term refers to the oceanic and atmospheric condition in which the sea-surface temperature in the tropical eastern Pacific area becomes significantly warmer than normal by 2 degrees to 3 degrees Celsius, and the prevailing westward trade winds either disappear or reverse direction. The El Niño cycle consists of this warm phase. The cold phase is called La Niña. The combination occurs aperiodically, usually in a two- to nine-year time frame.

The largest sources of interannual climate variability on a global scale, El Niño effects have far-reaching societal consequences. While scientists know the sequence of phenomena once an El Niño event begins, they are still unable to predict when they will occur.

Two Los Alamos National Laboratory researchers have mapped the life cycles of El Niño events and identified categories of patterns that may lead to a model to predict occurrences up to a year in advance. Chung-Chieng "Aaron" Lai and Zhen Huang, both of the Lab's Atmospheric and Climate Sciences Group, have studied the El Niño/La Niña cycle with data analysis and modeling using patterns of anomalies in sea surface temperatures. By examining



The computer graphic shows numerous towering cumulus clouds that reach high into the atmosphere, creating an upward motion over the tropical western Pacific warm pool. The air in the upper atmosphere then spreads eastward and subsides over the cold (ocean) upwelling area in the eastern Pacific. The sea-surface temperature (SST) and sea-level pressure gradients maintain the westward trade winds to complete the circuit. However, the strength of circulation is weakened when some slightly warmer water mass comes into the tropical eastern Pacific. Scientists are trying to understand where that water mass comes from.

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these over a long period, 1871 to 1994, they found the cycle in all tropical and extratropical ocean basis.

"People have tried to forecast the regional weather based on the El Niño/La Niña cycle, but we have discovered that every one of these cycles is unique," Lai said. "We can't assume that the general weather patterns in two winters will be similar merely because they are both in El Niño years."

The key element of the El Niño phenomenon is the interaction between the winds in the atmosphere and the sea surface water. In normal years, when there is no El Niño, the trade winds tend to blow from east to west across the coastal waters of the eastern Pacific. They tend to drag the surface warm waters westward across the ocean and form a "warm pool" in the tropical western Pacific. This in turn causes deeper, colder waters to rise to the surface in the eastern Pacific.

Researchers found that the Antarctic Circumpolar Wave (ACW) in southern oceans can influence the occurrence of El Niño and La Niña in the tropics. In most cases, a warm sea-surface temperature anomaly associated with the ACW shows first near the southern tip of South America, the extends northward along the west coast of Chile — along the Humbolt Current. Eventually, the warm sea-surface temperature area reaches the tropical eastern Pacific and a full-blown El Niño develops.

National Nuclear Security Administration

At the beginning of an El Niño event, the westward trade winds weaken, causing the upwelling of deep, cold water to cease. One of the fundamental questions researchers must answer to understand the phenomenon is, "What causes the original weakening of the westward trade winds?"

"We have found El Niños, and subsequently La Niñas, appearing in the North Pacific, South Pacific, Indian Ocean, Equatorial Pacific, South Atlantic and North Atlantic," Lai said.

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"Sometimes they appear simultaneously over all world ocean basins except the Arctic and Southern Oceans. It's not uncommon for an El Niño to appear in one ocean basin while a La Niña appears in another ocean basin."

Lai believes the Antarctic Circumpolar Wave, a series of weather anomalies originating in the Southern Oceans, may hold a key to understanding the El Niño phenomenon. The Southern Oceans are the only oceanic domain encircling the globe, and they contain the strong eastward flow of the Antarctic Circumpolar Current, the unifying link for exchanges of water masses at all depths between the world's major ocean basins.

"Because these exchanges are an important control of mean global climate, the Southern Oceans are expected to play an important role in transmitting climate anomalies around the globe," Lai said.

Lai and Huang's report can be viewed on the World Wide Web at http://ees-www.lanl.gov/news/stories/elnino.html.

CONTACTS:

CHUNG-CHIENG "AARON" LAI

ATMOSPHERIC AND CLIMATE SCIENCES

505-665-6635 • CAL@LANL.GOV

ZHEN HUANG

ATMOSPHERIC AND CLIMATE SCIENCES

505-667-4579 • ZHEN_HUANG@LANL.GOV

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FUTURE SCIENTISTS FIND CHALLENGE REWARDING

Nearly 250 students competed in this year's Supercomputing Challenge. Students from 30 schools spent the last year researching scientific problems and writing programs to solve them using Los Alamos and Sandia national laboratories' computers.

The New Mexico High School Supercomputing Challenge is unique because it offers supercomputer access to students at every level of expertise and stresses student activity over work by teachers and coaches.

The goal of the Challenge is to increase knowledge of science and computing; expose students and teachers to computers and applied mathematics; and instill enthusiasm for science in high school students, their families and communities.

The student team of Joan Goldsworthy, Joelle Jones and Heather Wood each took home a $1,000 savings bond for their supercomputer program "Parallel Processing of Human Genomic Leukemia Data Using Neural Networks." Their teacher, Neil McBeth received a computer loaded with software for their classroom. The team also received the Cray High Performance Computing Award for their project, which used advanced computing techniques like Message Passing Interface to allow multiple processors to work on the same problem. The three students will split $1,000 in gift certificates to New Mexico bookstores.

The Judges Special Recognition award went to the Picacho Middle School team of Jordan Aday, Hector Cardona and Eddie Banda for their project "Gas Diffusion."

Many of the final Supercomputing Challenge teams' reports can be viewed online at http://www.challenge.nm.org.

Joelle Jones, center, congratulates teammate Joan Goldsworthy at an awards ceremony.They were named winners in the 11th annual New Mexico High School Supercomputing Challenge. Inset photo bottom: Jordan Aday, right, Eddie Banda, center, and Hector Cardona of Picacho Middle School in Las Cruces, N.M., received the Judges Special Recognition Award — the first mid school to win an award at the challenge.

J U N E I S S U E 2 0 0 1

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BRIEFLY

The recent completion of the first of five planned buildings in the Los Alamos County Research Park holds promise for commercial and Laboratory science. Sited adjacent to the central technical area of Los Alamos National Laboratory, it is in the best position, figuratively and literally, to take advantage of the cutting-edge science performed at the Lab.

Technology transfer, industrial partnerships and collaborative research will enhance the nation's significant scientific research and development advances by providing collaboration opportunities between Lab and private company researchers. A synergic boon to both the private and government sectors, researchers will be able to work closely on some of today's scientific challenges.

Motorola and Compaq are the first companies to take up residence in the modern structure, which was completed under budget and ahead of schedule, despite delays caused by last spring's Cerro Grand Fire.

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