UNIVERSITY OF CALIFORNIA RESEARCH INITIATIVES TO FIGHT GLOBAL WARMING

"California is not waiting for a clean-energy revolution. No – we are actually the leaders in the revolution."

– Gov. Arnold Schwarzenegger

The move to control greenhouse gas emissions

Global warming has taken center stage this past year, as policymakers and researchers consider strategies to address the enormous economic, environmental and health consequences of pollution. In September 2006, Governor Schwarzenegger signed the Global Warming Solutions Act that sets a statewide goal of cutting greenhouse gas emissions by 25% by 2020.

As the research arm for the state, the **University of California** is playing a large role in helping the state to reach that goal. UC has long been involved in studying climate change and exploring ways to curb global warming, and today is home to many of the world's top experts on greenhouse gases and environmental sustainability.

UC: The Power of Ten

The University of California system has 10 campuses – at Berkeley, Davis, Irvine, Los Angeles, Merced, Riverside, San Diego, San Francisco, Santa Barbara and Santa Cruz – and is also involved in managing three U.S. Department of Energy national laboratories at Berkeley, Livermore and Los Alamos.

For more than a half century, the **University of California** has studied the phenomena of global climate change from a wide range of scientific perspectives. Today, UC researchers are developing technological solutions to curb global warming and mitigate its environmental, economic and health impacts. This brochure highlights just some of these research achievements, ongoing efforts and recent news headlines.

UC wins international alternative energy research project

On February 1, 2007, UC Berkeley, in partnership with the Lawrence Berkeley National Laboratory and the University of Illinois, won an international competition sponsored by the global energy firm BP to lead the **Energy Biosciences Institute**, an unprecedented $500 million research effort to develop new sources of energy and reduce the impact of energy consumption on the environment.

The project will focus on renewable biofuels for road transport, along with three other key areas – conversion of hydrocarbons into clean fuels, improved recovery from existing oil and gas reservoirs, and carbon sequestration.

"Our generation's moonshot."

— UC Berkeley Chancellor Robert Birgeneau, describing the quest for new environmentally sustainable and economically viable energy sources.

California is a world leader in biotechnology, with much of the biotech industry's attention to date largely on biomedicine and the development of pharmaceuticals. Fewer applications have emerged for the chemical and agricultural industries, but the new biosciences institute will produce major advancements for both in the quest for new, more efficient biofuels. Read more: berkeley.edu/news/media/releases/2007/02/01_ebi.shtml

Helios: new research facility for sustainable energy

The Helios Project, a new sustainable, clean energy initiative at Lawrence Berkeley National Laboratory launched by lab director and Nobel laureate Steve Chu, has a most futuristic vision: vast fields of bioengineered plants designed to break down cellulose to make ethanol and other carbon-neutral fuels, thus eliminating America's need for foreign oil and creating a new market for sustainable agriculture.

"In 50 years, if everything goes on business as usual, CO_2 levels will be twice as high," said Paul Alivisatos, the project's co-leader. "That is a problem we have in society right now. It's not really a political issue. It's a technological issue that has a real solution if we decided to pursue it."

Helios will be a new type of research facility that targets the development of efficient processes to produce transportation fuel from biomass and solar energy-driven electrochemistry. The impact of Helios is expected to extend beyond the development of solar fuels to include fundamental developments in areas such as bioengineering of plants for optimal production and environmental impact, new routes to efficient and low-cost solar panels, production of energy-saving catalytic methods, and increasingly efficient separation processes.

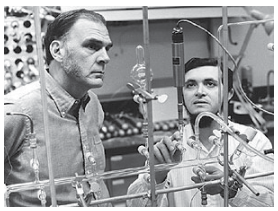
While the barriers to the development of efficient and scalable solar fuel generation have been known for decades, today's emergent techniques in synthetic biology [qb3.org, synBERC.org] and nanomaterials provide new ways to overcome the limitations faced in years past. Helios will bring together expertise in novel approaches to catalysis, electrochemistry, separations, and theory and reactions and transport in complex systems into a single large project. Read more: foundry.lbl.gov/facilities/Helios/index_helios.htm

UC pioneers in climate change research

Roger Revelle, a professor of Scripps Institution of Oceanography at UC San Diego, co-authored a paper with Hans Suess in 1957 that is considered to be the opening salvo in the global warming debate. They demonstrated that carbon dioxide had increased in the air as a result of the use of fossil fuels.

A few years after the now-famous Revelle-Suess article, Charles David Keeling became the first to confirm the rise of atmospheric carbon dioxide by very precise measurements producing a data set now known widely as the "Keeling Curve." He would go on to become the world's leading authority on atmospheric greenhouse gas accumulation and a pioneer in climate science.

UC Irvine professor Sherwood Rowland won the 1995 Nobel Prize in Chemistry with now-UCSD professor Mario Molina and P.J. Crutzen for discovering that CFCs damage the ozone layer. This research awakened the world to the dangers of a common industrial gas and would forecast the drastic depletion of the ozone layer over the Antarctic, called the "ozone hole." As the Royal Swedish Academy of Sciences noted, thanks largely to this research, "it has been possible to make far-reaching decisions on prohibiting the release of gases that destroy ozone."



GLOBAL WARMING REPORT

Scientists predict droughts, rise in temperatures, sea levels

Temperatures will increase by 3.2 to 7.2 degrees F. by 2100. Sea levels will rise by 7 to 23 inches. Many of the world's most populated regions will face severe water shortages. Scientists made these dire predictions in a report in February 2007 by the Intergovernmental Panel on Climate Change. This was the IPCC's fourth report since 1990. For the first time, it states with near-certainty that global warming is man-made.

"The planet is warming, land, atmosphere, ocean. This fact is unequivocal," said Tony Haymet, director of Scripps Institution of Oceanography at UC San Diego.

IPCC findings are based on an extensive three-year review of climate change research, including complex computer simulations modeling the impact of global warming. Scripps professor Richard Somerville and Mario Molina, a Nobel Prize winner and UCSD professor of chemistry and biochemistry, were two of the report's drafting authors.

Semi-arid tropical regions will face more severe droughts, with a 20% drop in rainfall under the IPCC mid-range forecast for a rise in greenhouse gas emissions.

Californians live in a semi-arid region where dry areas will probably get drier and wet areas wetter. "We may drown, but we'll probably burn first here," joked Lynne Talley, an IPCC author and Scripps expert on oceanic and atmospheric conditions.

The state's water supply also is at risk. Between 40% to 80% of the Sierra Nevada snow pack could disappear. Water shortages will hit California in a few decades.

> *"The science is really done now. We need to get on with mitigation."*
>
> — Tim Barnett, UCSD-Scripps marine geophysicist

"What we're headed for on a global basis is a catastrophe for water supplies," said Tim Barnett, a Scripps marine geophysicist.

The heat trapped by greenhouse gases is roughly equivalent to the heat generated by 25 trillion light bulbs burning constantly, or every person burning 4,000 light bulbs every second of every day and night.

What can we do about it? Today's concentration of CO_2 is 379 parts per million, according to the IPCC report. We would have to cut fossil fuel emissions by as much as 70 to 80% over the next 50 years just to stabilize CO_2 concentration to 450 to 550 parts per million. Read more: ucsdnews.ucsd.edu/thisweek/2007/02/05_ipcc.asp

Humans change climate and air quality: Michael Prather, a UC Irvine professor of Earth system science, has led international assessments of the impacts of aviation on the global atmosphere and wrote the chapters on atmospheric chemistry for the 1996 and 2001 IPCC assessments. For the 2007 report, he was a lead author on the historical overview chapter, and served as government reviewer on other chapters. His research includes predicting how human activities and natural phenomena such as volcanoes can alter the global distribution of trace gases in the atmosphere, changing the greenhouse forcing of climate and the quality of the air we breathe.

ENERGY USE, NEW MATERIALS

Energy represents one of the most important connections between the things people do and the environment they live in. UC researchers are studying the environmental impacts of our energy use – to light our homes, operate our workplaces and run our cars – and ways to conserve and use it more efficiently.

We have made significant gains in the past 40 years in energy productivity, as laws have encouraged more energy efficient lighting, air conditioners, refrigerators, water heaters and other appliances. But as the country's population continues to grow and business demand for energy climbs, more will have to be done to meet our long-term energy needs, while at the same time protecting the environment. The University of California is leading the efforts to produce gains in more efficient lighting and other energy efficiencies, pursue sustainable energy sources and explore the development of alternative fuels.

Energy efficiency: In April 2006, the Energy Efficiency Center at UC Davis was created to develop energy-saving products and services and then quickly move them into the marketplace. The center, whose research will focus on the three key areas of transportation, homes and buildings; agriculture; and food processing, joins the Institute of Transportation Studies, the Biomass Collaborative, the Wind Collaborative and the California Lighting Technology Center as prime examples of UC Davis-led public-private partnerships geared toward solving California's core energy challenges.

New materials for solar: Imagine a future in which the rooftops of residential homes and commercial buildings can be laminated with inexpensive, ultra-thin films of nano-sized semiconductors that will efficiently convert sunlight into electrical power and provide virtually all of our electricity needs. This future is a step closer to being realized. Researchers with Berkeley Lab and UC Berkeley have developed the first ultra-thin solar cells comprised entirely of inorganic nanocrystals and spin-cast from solution. These dual nanocrystal solar cells are as cheap and easy to make as solar cells made from organic polymers and offer the added advantage of being stable in air because they contain no organic materials. UC Berkeley materials engineers have developed a new technique to handle metal defects in low-grade silicon, an advance that could dramatically reduce the cost of solar cells. Elsewhere at Berkeley, chemists have found a way to make cheap plastic solar cells flexible enough to paint onto any surface. The discovery could lead to devices that provide electricity for wearable electronics or other low-power devices.

Investing in solutions: California's 'green tech' research initiative

One of the highlights of Gov. Arnold Schwarzenegger's proposed 2007-08 state budget is a $95-million research and innovation initiative that would help UC continue to support California in retaining its leadership in the field of "green" technology.

The proposal includes $40 million for the Energy Biosciences Institute, $30 million for Helios and $20 million for UC's multi-campus California Institutes for Science and Innovation. Read more: gov.ca.gov/index.php?/press-release/5004

Lighting and solar surfaces: UC Santa Barbara engineers are making significant contributions toward reducing energy requirements. The Solid State Lighting and Energy Center is involved in high-efficiency white lighting for residences, businesses and displays, solid power switching devices for hybrid cars, and, solar hydrogen production from wide-band-gap semiconductors, while the Center for Polymers and Organic Solids is reducing high capital costs of solar-panel installation by making paintable photovoltaic materials.

Better, less expensive solar cells: Generation of solar energy is being increasingly embraced as a viable, non-polluting alternative energy source. Silicon solar cells are still several times the cost of electrical energy, but a variety of different approaches are being explored at UC's California NanoSystems Institute to increase the efficiency and lower the cost of solar cell devices. New solar absorber materials formed from nanoscale building blocks are being incorporated into solar modules designed to achieve 50% efficiency by 2010. Use of 'plastic' materials for solar cells allows lower-cost manufacture and large area sheets of solar material. Novel chemical processes at the nanoscale promise greater photovoltaic efficiency.

photo by Jim MacKenzie

ECONOMIC IMPLICATIONS

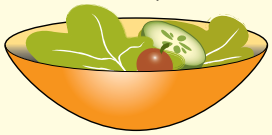
Last summer, a large group of UC economists took the lead in urging the governor and state legislators to move quickly to control greenhouse gas emissions. The risks of climate change to California's economy are significant, especially to our water system. California will face significant economic costs from global warming if we fail to take action.

Heating up the economy

"Climate action can be profitable." A new UC Berkeley report found that reducing California greenhouse gas emissions to 1990 levels by 2020, as envisioned by AB 32, can boost the state's economy by $60 billion and create 17,000 new jobs by 2020. The gains could be even larger – $74 billion and 89,000 new jobs – if climate policies are designed to create direct incentives for California companies to invest in new technology. > calclimate.berkeley.edu/Growth_Strategies_Full_Report.pdf

The multi-campus Center for Information Technology Research in the Interest of Society (CITRIS) sponsors collaborative information technology research that will ultimately provide solutions in such areas as energy efficiency, transportation and environmental monitoring. For example, a network of tiny, inexpensive sensors can make buildings vastly more energy-efficient, saving as much as $55 billion in energy costs nationally and 35 million tons of carbon emissions each year.

Food and climate



Increasing temperatures in California during the next 45 years could negatively affect the amount of almonds, walnuts, oranges, avocados and table grapes that Americans put on their tables. According to the Lawrence Livermore National Laboratory, production losses in some of California's most popular crops could be as high as 40% by mid-century. In the study, researchers evaluated the impact of climate change on six major perennial crops – wine grapes, almonds, table grapes, oranges, walnuts and avocados. Because each of these crops is typically planted only once every 25-40 years, climate can change considerably in the lifetime of individual vines or trees.

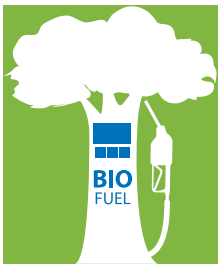
TRANSPORTATION: THE CAR-CLIMATE CONNECTION

The way we travel and use energy are the biggest sources of greenhouse gases. Energy represents one of the most important connections between the things people do and the environment they live in. Throughout UC's campuses and national labs, researchers are studying the environmental impacts of our energy use – to light our homes, operate our workplaces and run our cars – and ways to conserve and use it more efficiently.

Cars and trucks are one of the biggest drains on energy and the largest source of pollution. Nationally, one-third of all CO_2 emissions are emitted through the use of the personal automobile. This number is even higher in California. According to a 2006 report by the California State Department of Water Resources, California is the 12th-largest source of climate change emissions in the entire world, exceeding the amount emitted by many countries.

Addressing these environmental challenges also requires changes in our behavior and our transportation infrastructure – and UC researchers are finding solutions from these angles as well.

For example, UC researchers at the Berkeley Lab have pioneered the compact fluorescent light bulb, while UC Davis is designing more energy-efficient cars and fuel cells.



New fuels: UC Riverside's Center for Environmental Research and Technology (CE-CERT) is pursuing efforts to speed up large-scale processing of biomass for commercial use, and develop processes for converting problematic solid wastes into sustainable ethanol and diesel fuel. Last fall, CE-CERT and Viresco Energy LLC announced plans to build a plant that would convert wood, "green" waste, sewer sludge and trash into diesel fuel, implementing a new hydro-gasification process that uses high-temperature steam and hydrogen to convert biomass into a gas that, in turn, is made into diesel.

UC San Diego's new Center for Bioenergy Science and Technology (CBEST) will also create new technologies to help convert crops into biofuels and engineer plants that can produce high yields of these alternatives to fossil fuels.

Because transportation is responsible for a large portion of greenhouse gas emissions, creating fuels such as ethanol from biomass can virtually eliminate net greenhouse gas emissions.

Energy efficiency: Automobile engines are notoriously inefficient: Two-thirds of the energy produced from burning fuel in a car's engine is wasted as heat. But new technology for direct conversion of heat to electricity could change that and lead to increased energy efficiency far beyond the automobile industry. That's the goal of the Thermionic Energy Conversion Center led by UC Santa Cruz, where researchers are using advances in nanotechnology to develop efficient thermoelectric materials.

The hydrogen highway: By converting chemical energy into electrical energy without combustion, fuel cells represent perhaps the most efficient and clean technology for generating electricity. This is especially true for fuel cells designed to directly run off hydrogen, which produce only water as a byproduct.

Hydrogen is a clean and efficient fuel, but its environmental advantages are diminished if the energy used to generate it comes from burning fossil fuels. So UC Santa Cruz chemists are developing novel materials and devices to produce hydrogen from water using solar energy.

While eco-friendly hybrid automobiles gain popularity, UC researchers are already developing cars with no emissions at all, powered by hydrogen fuel cells. To help develop a safe and practical hydrogen storage system, UC Berkeley chemists are developing novel nanomaterials for tomorrow's hydrogen fuel tanks.

Researchers at Lawrence Berkeley National Laboratory have identified a new variation of a familiar platinum-nickel alloy that is far and away the most active oxygen-reducing catalyst ever reported. The hydrogen-powered fuel cells most talked about for use in vehicles are polymer electrolyte membrane (PEM) fuel cells because they can deliver high power in a relative small, light-weight device. Unlike batteries, PEM fuel cells do not require recharging, but rely on a supply of hydrogen and access to oxygen from the atmosphere.

UCLA's Hydrogen Engineering Research Consortium is working with private industry to make the hydrogen economy a reality. The consortium has one of the few hydrogen fuel-cell cars – a Mercedes Benz A-Class sedan.

First fuel cells: Dedicated by the U.S. Department of Energy and the California Energy Commission in 1998, the National Fuel Cell Research Center is the first university fuel cell research program established in the United States and recognized today as one of the foremost fuel cell systems research programs in the nation. Scott Samuelsen, UC Irvine professor of mechanical, aerospace and environmental engineering, directs the National Fuel Cell Research Center and the Advanced Power and Energy Program. He also directs research for DOE and serves on the implementation advisory panel for the California Hydrogen Highway Network.

Carbon standard: Transportation experts at UC Davis and UC Berkeley will draft California's new, groundbreaking air-quality standard to reduce carbon emissions from transportation fuels that Gov. Schwarzenegger announced on January 2007.

Engine technology: The UC Davis Institute of Transportation Studies is the world's largest academic center of research on future automobile engine technology and fuels. It helps governments and automakers develop and promote new cars, trucks and buses that run on clean energy.

Renewables research: Chevron Corp. will fund up to $25 million in research at UC Davis in the next five years to develop affordable, renewable transportation fuels from farm and forest residues, urban wastes and crops grown specifically for energy.

The UC Davis Bioenergy Research Group has more than 100 people working on making affordable, renewable transportation fuels from farm and forest residues, urban wastes and crops grown specifically for energy.

Traffic solutions, clean commutes: UC Irvine researchers are using a fleet of electric cars and tracking devices to put in motion a program that responds to transportation congestion and sustaining air quality. Another UCI transportation project combines rail, zero- and low-emission vehicles in a far-reaching public-private partnership for cleaner commute alternatives.

UC Riverside is exploring methods to promote vehicular traffic to move more efficiently, through the implementation of new transportation technology that reduces traffic congestion and the resulting greenhouse gases.

Climate change impacts wildlife and ecosystems

UC Santa Barbara is addressing climate change impacts upon wildlife, species extinction and ecosystem services through a PIER-funded project, in collaboration with Conservation International. The project is developing next-generation models of animals' various responses to climate change, including species dispersal and interactions with land use change.

BETTER HEALTH

At UC Davis, the U.S. EPA founded the $8-million San Joaquin Valley Aerosol Health Effects Center to study how air pollution triggers premature deaths, sends more sick people to the hospital and damages children's lungs.

At UC San Diego, chemists are working to better understand the atmospheric processes that could be giving our pollution-weary lungs more breathing room.

Cleaner air, health benefits in developing countries

UC has found cleaner, more efficient technologies for producing charcoal in Africa can save millions of lives, and have significant climate change and development benefits. In many developing nations in Africa, Asia and Latin America, many families are dependent on both wood and charcoal for cooking and heating homes. However, more than 1.6 million people, primarily women and children, die prematurely each year worldwide from respiratory diseases caused by the pollution from such fires.

More on UC and climate change

> universityofcalifornia.edu/everyday/globalwarming

> universityofcalifornia.edu/environment/energy.html

> universityofcalifornia.edu/environment/air.html

> energy.berkeley.edu/climate.shtml

> meteora.ucsd.edu/cap/pdffiles/CA_climate_Scenarios.pdf

WATER RESOURCES

Water, water … everywhere? Global warming will reduce glaciers and storage packs of snow in regions around the world, causing water shortages and other problems that will impact millions of people. In analyzing several scenarios, researchers at Scripps Institution of Oceanography at UC San Diego showed that human-produced greenhouse gases, and the resulting warmer climates they produce, will have a significant influence on ice- and snow-dependent regions and result in costly disruptions to water supply and resource management systems, potentially affecting the water resources of a substantial portion of the world's population.

Flood risk, water shortages: If the world continues to burn greenhouse gases, some regions may have an increased risk of winter floods and summer water shortages, even within the same year. New research by Lawrence Livermore National Laboratory scientists shows that global warming is likely to change river flows in ways that may result in both increased flood risk and water shortages. The predictions assume atmospheric CO_2 concentration doubles from pre-industrial levels. The research shows that this well-known scenario – in which global warming causes an increase in wintertime river flows and a reduction in spring and summer flows – is more robust than previously thought.

Aquatic ecosystems and wildfires: UC Riverside is studying how climate change impacts lakes and alters the abundance of plant and animal species in the lakes. Meanwhile, UC San Diego researchers have shown that rising temperatures expected in the years ahead will exacerbate the number of large and costly wildfires in the western U.S.

Regional climate and water resources: Berkeley Lab scientists contributed to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, which analyzed regional climate projections, temperature extremes and the impacts of snow pack on water resources. They found that, regardless of the emissions scenario, there are likely to be significant decreases in snow pack and available water resources in California, which has led researchers to develop a new water-energy model with surface water, groundwater and dynamic vegetation, and to apply this to a multi-decade drought study.

Ocean carbon cycle: Oceans contain more carbon than any other dynamic reservoir on earth. They pose a great observational challenge because the pulses of biological productivity are episodic and rapid, and the areas are so vast. Scientists at the Berkeley Lab have developed the Carbon Explorer, an autonomous float that uses satellite telemetry to report its observations from distant oceans. These 12 low-cost robots have achieved a data record not possible with conventional research ships. www-esd.lbl.gov/CLIMATE

Focus on California: At UC Santa Cruz, the Climate Change and Impacts Laboratory has developed regional climate models that allow scientists to take a close look at the implications of global warming for California. Their investigations provide more detail than studies based on global climate models, showing potential impacts on water supply, agriculture, and natural ecosystems throughout California's diverse landscape. Among other findings, their

How blue? Lake Tahoe heats up

The waters of Lake Tahoe are warming up at almost twice the rate of the world's oceans, probably as a consequence of global climate change, according to a 2004 study by UC Davis scientists. The higher warming rate could have major implications for public plans to keep the lake blue.

results show there could be profound changes in coastal waters due to effects on the seasonal upwelling that supports California's diverse marine life and productive fisheries.

Triggering ocean, climate changes: Using deep ocean historical records, new research by scientists at UCSD's Scripps Institution of Oceanography illustrates how global warming caused by greenhouse gases can quickly disrupt ocean processes and lead to drastic climatological, biological and other important changes around the world.

The California Water Resources Research and Applications Center [www-esd.lbl.gov/RCC] focuses on hydroclimate and impacts research based on modeling and analysis of regional climate, streamflow and water demand, water quality, and agriculture impact models.

Carbon cycle modeling: How will current terrestrial and marine carbon sinks respond as fossil fuel emissions increase and climate changes? UC scientists have added interactive land and ocean carbon cycles to the global Community Climate Simulation Model to study how diverse features of the environment, including plants, soil, precipitation, oceans, clouds and CO_2 emissions, interact to affect the strength of carbon sinks.

Energy, water and climate: The Climate Change and Carbon Management program at the Berkeley Lab conducts research to increase the scientific foundation for climate change prediction, impact assessment and mitigation. Its research on biogeochemical cycles and climate also addresses other pressing issues, such as stewardship of water resources and the environmental effects of energy use and land use [eetd.lbl.gov/ea/EA_C_I.html].

UC RESEARCH: GETTING THE FACTS ON CLIMATE CHANGE

Chlorine and ozone: Standard methods of predicting air pollution don't take atmospheric chlorine into account, but the chemical could be responsible for 10% or more of daily ozone production in local air, UC Irvine researchers have found. Chlorine salts are naturally present in coastal air in sea salt aerosols, and chlorine gas also is used to treat water in swimming pools, cooling towers and municipal water. Chlorine atoms react rapidly with hydrocarbons and nitrogen oxides from car and power-plant emissions, contributing to the complex chain of reactions that leads to ozone formation.

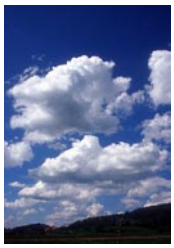
Waves, gas and videotape: Gas escaping from the ocean floor may provide some answers to understanding historical global warming cycles and provide information on current climate changes, according to UC Santa Barbara scientists. Remarkable and unexpected support for this idea occurred when the scientists observed and videotaped a massive blowout of methane from the ocean floor of the Santa Barbara channel. The most abundant organic compound in the atmosphere, atmospheric methane is at least 20 times more potent than CO_2. An important piece of the global climate puzzle may be explained by understanding bubble-plume processes during methane blowout events.

Climate studies: For the first time, new climate observations and computer models provide a consistent picture of recent warming of the earth's tropical atmosphere. Two studies, published in 2005, revisit temperature data obtained from satellites and weather balloons, and provide compelling evidence that the tropical troposphere has warmed since 1979. A third study, led by scientists at Lawrence Livermore National Laboratory, finds that these new estimates of temperature change are consistent with results from state-of-the-art climate models. The findings help remove a major stumbling block in the understanding of the nature and causes of climate change.

Humans and hurricanes: Rising sea surface temperatures (SSTs) in hurricane "breeding grounds" of the Atlantic and Pacific Oceans are likely linked to human activities. Targeting SST changes in hurricane formation regions, new research by the Lawrence Livermore National Laboratory shows that the warming of the tropical Atlantic and Pacific over the last century is directly linked to human activities. For 1906-2005, researchers found an 84% chance that external forcing such as human-caused increases in greenhouse gases, ozone and various aerosol particles accounts for at least 67% of the observed rise in SSTs in the Atlantic and Pacific hurricane formation regions. In both regions, human-caused increases in greenhouse gases were found to be the main driver of the 20th-century warming of SSTs.

Making policy: At UC, the California Climate Change Center is providing better climate information and forecasts for decision-makers. In August 2006, the center, with core research from UC San Diego's Scripps Institution of Oceanography and UC Berkeley, issued a sweeping report that predicted the state would become significantly hotter and drier by the end of the century, leading to severe air pollution and a drop in the water supply.

Carbon center: UC Irvine established the first accelerator mass spectrometry center in the United States dedicated exclusively to research on the carbon cycle, a global process that provides vital information on pressing environmental concerns such as air pollution and global warming. Through mass spectrometry, researchers measure a rare isotope of carbon, called radiocarbon, in materials such as plants, soils and ocean coral. These measurements are the best and at times the only way to determine the rates of carbon exchange on a global scale. The center helps scientists answer some of the most important scientific issues of our time — understanding how carbon flows through the air, oceans, soils and plants; and how carbon dioxide increases affect the Earth system.



Ozone formation: UC Riverside has developed a unique atmospheric chamber to better understand the formation of particulate matter and ozone. This "next generation" chamber is the only facility in the U.S., where leading-edge research on tropospheric ozone and aerosol formation at near-ambient conditions can be undertaken.

Crunching numbers: The Earth is a really big place, and pulling together the numbers to understand and solve the problems associated with global warming takes a really big computer. That's where the San Diego Supercomputer Center – in collaboration with the Lawrence Livermore National Laboratory– and Berkeley Lab's supercomputer, the National Energy Research Scientific Computing Center, apply their heavy-duty, number-crunching expertise.

Sky-high faculty: The latest Faculty Scholarly Productivity Index ranked atmospheric sciences research at UC Irvine first in the nation among large research universities for faculty productivity.

Lessons from ancient climates: Global warming is nothing new – there have been other periods in Earth's history when the climate was much warmer than it is now. UC Santa Cruz is studying these ancient climates to understand how the planet's climate system may behave in the future. They've found that the tropical Pacific was in a stable state of El Niño-like conditions during the most recent period in Earth's past when the climate was warmer than today.

Ocean life: Global warming is reducing ocean life and increasing atmospheric carbon dioxide, according to an ongoing NASA-funded satellite study by UC Santa Barbara. A vicious cycle has been identified: as phytoplankton growth rates go down with a warmer climate, the amount of CO_2 that these plants consume also goes down, allowing CO_2 to accumulate more rapidly in the atmosphere, producing more warming.

Although it is expected that populations of many organisms will move away from the equator and toward the poles to stay cool during global warming, UCSB researchers have found that the intertidal zone does not exactly fit this pattern. Because they live very close to their thermal tolerance limits, organisms inhabiting the intertidal zone have emerged as potential harbingers of global warming's effects on species distribution.

Past may predict future: Using evidence found in glacial deposits, fossils and sediments, a UC Santa Barbara geologist is studying how past climate change relates to modern global warming. New evidence from climate records of the past provides some of the strongest indications yet of a direct link between tropical warmth and higher greenhouse gas levels. The present steady rise in tropical temperatures due to global warming will have a major impact on global climate and could intensify destructive hurricanes like Katrina and Rita. His research suggests this shift is due to a change in the oscillation frequency of atmospheric CO_2 abundances.

Plants breathing: An important source of uncertainty in predictions about global warming is how plants will respond to increasing atmospheric carbon dioxide. Biologists at UC San Diego have made significant advances toward understanding the mechanism plants use to regulate their CO_2 intake. The study shows how the level of CO_2 in the atmosphere controls the opening and closing of leaf stomata – pores through which plants "breathe" in CO_2.

Adapting world: Countering Darwin's view that evolution occurs gradually, UC Irvine scientists recently discovered that plants with short life cycles can evolutionally adapt in just a few years to climate change. This finding suggests that quick-growing plants such as weeds may cope better with global warming than slower-growing plants such as redwood trees – a phenomenon that could lead to future changes in the Earth's plant life, as well as the make-up of our forests.

To make this discovery, researchers stored field mustard seeds, then later planted and grew the seeds to compare with contemporary versions of the weed. By growing ancestors and descendents at the same time, they determined not only that the plant's blooming pattern had changed, but that the change was an evolutionary shift.

Plant a tree? Can planting a tree stop the sea from rising, ice caps from melting and hurricanes from getting stronger? A new Lawrence Livermore National Laboratory study says it depends on where the trees are planted. New forests in mid- to high-latitude locations could actually create a net warming. Planting more trees in tropical rainforests could help slow down global warming worldwide. Global forests actually produce a net warming of the planet. Forests affect climate in three different ways: they absorb CO_2 from the atmosphere and help to keep the planet cool; they evaporate water to the atmosphere and increase cloudiness, which also helps keep the planet cool; and they are dark and absorb a lot of sunlight, warming the earth. Mitigation strategies that promote planting trees have taken only the first effect into account. By 2100, forests in mid- and high-latitudes will make some places up to 10 degrees F. warmer than if the forests did not exist.

Soils and greenhouse gases: What is the contribution of soils to climate change? In a 2001-06 study on "Soil Carbon and California's Terrestrial Ecosystems," UC's Kearney Foundation of Soil Science supported research to investigate soils as sources and sinks of greenhouse gases. Agricultural soils can sequester carbon as organic matter, particularly when carbon input is increased through manure additions or cover cropping. Though increases in soil carbon are sometimes small, these increases are often associated with other important benefits such as better soil physical properties, increased biodiversity and a reduction in dust production. A UC Davis integrated assessment of the biophysical and economic potential for greenhouse gas mitigation in California agricultural soils is underway to develop tools and protocols for assessing potential for carbon sequestration and greenhouse gas reduction in agricultural soils.

Snow keeps climate cooler: By taking a closer look at the effects of boreal fires, UC Irvine scientists recently upended one presumption about global climate warming – that forest fires in Alaska, Canada and Siberia may be a culprit. In fact, researchers discovered that cooling may occur in areas where charred trees expose more snow, as the snow reflects warming sunlight back into space. Sunlight absorbed by the Earth tends to cause warming, while heat reflected back into space tends to cause cooling.

This cooling effect cancels the impact of the greenhouse gases, so the net effect of fire is close to neutral when averaged globally, and in northern regions may lead to slightly colder temperatures.

UC campuses go green

UC Santa Cruz has been named the sixth-largest green power purchaser in the country by the U.S. EPA's College and University Green Power Partners. The EPA estimates the campus' purchase is equivalent to avoiding CO_2 emissions of nearly 7,000 cars a year.

Elsewhere around its 10-campus system, UC continues to lead the way in implementing environmental sustainability programs. UC's Santa Barbara and Merced campuses were recently chosen by the U.S. Green Building Council to participate in a program for the leading green building organizations in the country. UC Santa Cruz has undertaken purchasing 100% renewable energy for its campus, and eight UC campuses have become members of the California Climate Action Registry.

UC San Diego was the first university in the state to be recognized by the California Climate Action Registry as a "Climate Action Leader," and since 2002, has received no less than 15 awards and special recognitions for green practices. Last year, the San Diego campus was named one of the "Best Workplaces for Commuters" by the U.S. EPA and the Department of Transportation for its popular transportation alternatives. Nearly 45% of all UCSD commuters use some form of alternative transportation, including bikes, buses, vanpools, flexcar or train.

In January 2006, UC's green building and clean energy policy was expanded to address sustainable transportation practices and greenhouse gas emissions. There are currently 75 new construction projects that have set green building targets. UC is projecting annual operating savings from energy efficiency projects at over $2 million and growing.

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