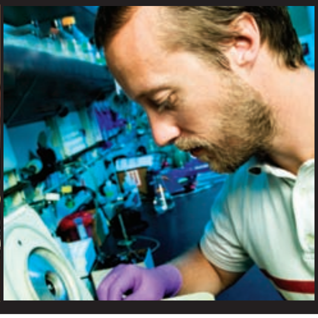
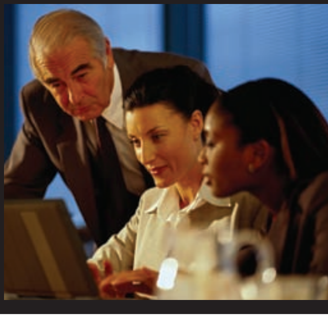
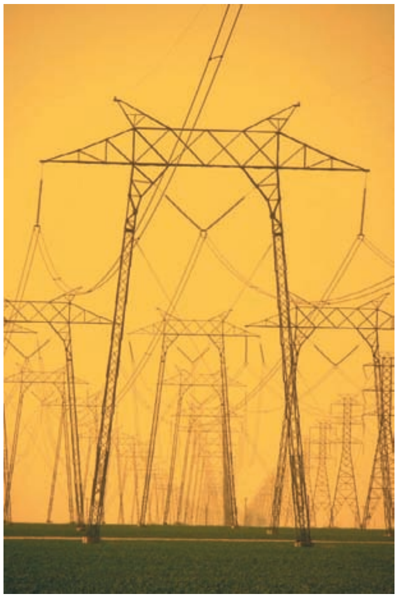
# Bridging Scripps Science and Industry



SCRIPPS INSTITUTION OF OCEANOGRAPHY UC San Diego

**ON HOT SUMMER AFTERNOONS**, residents of California's Central Valley sometimes find relief from a wind known as the Delta Breeze. Some days they're not so lucky. To the state's Independent System Operator (ISO), the difference translates to 500 megawatts of increased air conditioner use and an additional $250,000 in energy production costs. If the ISO knew not to expect the breeze, it could substantially reduce those costs by enacting voluntary or mandatory power saving measures.



This was one of many issues that formed the basis for a study involving a consortium of industrial and academic partners including the California Energy Commission. Scripps Institution of Oceanography at UC San Diego scientists worked together with other stakeholders on a project called CalEnergy to leverage advances in climate science. It was an effort to supply knowledge to help energy officials more efficiently plan for electricity demand, such as in hot summer months when power needs surge, or when variations in local weather conditions affect electrical loads.

Based on Scripps-operated climate models and applied climate research, Scripps scientists created forecasting tools tailored to the needs of water, electric, and natural gas industries. CalEnergy became viable when advances in climate forecasting achieved a level of reliability useful in management decisions. This program was a part of a larger Scripps effort to incorporate climate science into the everyday routine of resource managers

Long-term prediction has been viewed skeptically in the war rooms of power providers, who are accustomed to seeing only one to two weeks into the future, the limit of weather forecasts. Yet longer time scales can be predictable when phenomena such as the Pacific Decadel Oscillation are considered. For example, this climate pattern can evolve in summer or fall then tend to bring frequent Arctic winds to the western United States the following winter. This climate pattern also leads to linkages between spring temperatures and summer irrigation pump use in the Pacific Northwest.

In the past decade, climate forecasting has achieved a level of reliability that enables its use as a management tool. Climate prediction tools give probabilistic, season-ahead forecasts of phenomena such as El Niño and the Pacific Decadal Oscillation, both of which affect summer and winter energy use. Besides forecasting phenomena like the Delta Breeze, Scripps

researchers have also created prediction tools to help energy officials plan for nighttime heatwave episodes and better control rates at which California's dams release water.

CalEnergy featured many individual deliverables and resulted in a significant number of publications in respected academic journals. A few of the results and conclusions from the study were:

- **A set of statistical models** that demonstrated significant skill for predicting summertime cooling degree days, average temperature and number of maximum temperature extremes based on Pacific Ocean sea surface temperatures.
- **A catalog of conditional probabilities** for summer temperatures across dozens of California zones based upon the springtime pattern of the Pacific Decadal Oscillation. For example, when the Pacific Decadal Oscillation is below normal in March, April and May, the subsequent June, July, and August period only has a 12 percent chance of being warmer than normal in the San Diego zone.
- **The Pacific Decadal Oscillation's impact** on wintertime temperatures was quantified through statistical modeling as well as dynamic atmospheric simulation. This technique was simultaneously used to test El Niño's impact on both summer and winter weather regimes. The Pacific Decadal Oscillation was found to have a stronger impact than El Niño on temperature patterns and warm California winters are more likely in "positive" phases of the Pacific Decadal Oscillation while colder winters are likely in "negative" phases.
- **Irrigation pump loads** in parts of the rural western states make up a large part of their electrical load, and vary widely from year to year. A method of predicting summer pump loads was based on spring conditions, along with a characterization of the skill and uncertainty in the forecast. This allowed one energy utility to factor the forecast information into it's springtime planning for whether to obtain long-term energy supply contracts ahead of time, or to buy energy on the spot market as the summer progressed.

The CalEnergy deliverables themselves can lead to breakthroughs in energy risk management but this study also discovered an equally important outcome. Products from academic research, such as those above, must be made useful to non-scientist decision-makers. Communications between scientists and industry participants have traditionally been hampered because the two professions often use different methodologies and terminology. In addition, it has not been common for university-based scientists to interact directly with utility executives or water district officials.

CalEnergy established vehicles between climate research academics and industry. Industry representatives identify key decisions that can be influenced by weather and climate, and the climate scientists in return develop appropriate forecasts and associated estimates of uncertainty. The two groups come together in the end to establish an ongoing rapport and educational network through which industry professionals learn to best utilize the products from research scientists.

For a full report including links to further reading, please see scripps.ucsd.edu/special/business/news.

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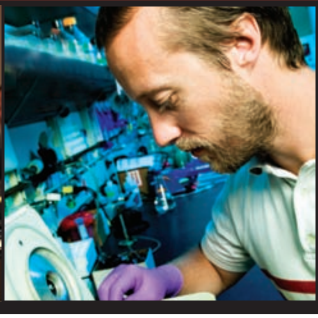
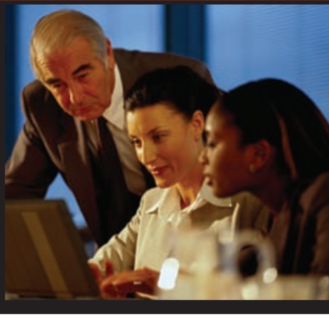
# Understanding Heat Waves in California



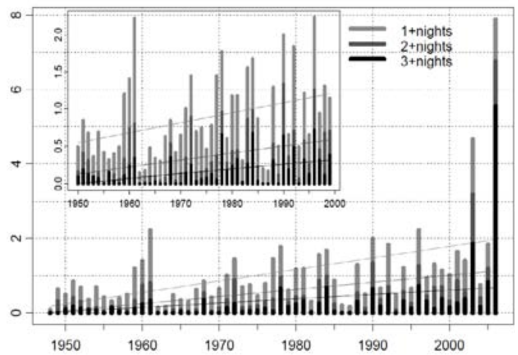
SCRIPPS INSTITUTION OF OCEANOGRAPHY *UC San Diego*

**DEADLY HEAT WAVES ARE BECOMING MORE FREQUENT IN CALIFORNIA. FROM MID JULY TO EARLY AUGUST 2006, A HEAT WAVE SWEPT THROUGH THE SOUTHWESTERN UNITED STATES. TEMPERATURE RECORDS WERE BROKEN AT MANY LOCATIONS AND UNUSUALLY HIGH HUMIDITY LEVELS FOR THIS TYPICALLY ARID REGION LED TO THE DEATHS OF MORE THAN 600 PEOPLE, 25,000 CATTLE, AND 70,000 POULTRY IN CALIFORNIA ALONE.**

An analysis of this extreme episode carried out by researchers at Scripps Institution of Oceanography, UC San Diego, put this heat wave in the context of six decades of observed heat waves. Their results suggest that such regional extremes are becoming more and more likely as climate change trends continue.

The team, led by climate scientist Alexander Gershunov, examined meteorological conditions that lead to this and other recorded heat waves, when temperatures rose into the hottest one percent of historical summertime daily and nightly temperatures recorded in California and Nevada since 1948. The scientists found that heat waves in the region often fall into either of two types: the typical "daytime" events characterized by dry daytime heat and rejuvenating nighttime cooling, or the less typical "nighttime" heat waves characterized additionally by high humidity and hot muggy days and nights. Since the early 1990s, nighttime heat wave events in California, which historically had been less common, have become more prevalent, increasing in both frequency and intensity. The pinnacle of nighttime heat waves occurred in a 17-day episode during July 2006 when a persistent warm pattern was aggravated by unusually humid conditions, associated with warm ocean waters off Baja California, Mexico.

"Water vapor is the main greenhouse gas. During the night in humid environments, air doesn't cool nearly as much as it does in dry conditions," said Gershunov. "Elevated humidity also causes heat waves to last longer. Hotter nights pre-condition hotter days and the cycle feeds on itself until the winds change. The weather pattern that traditionally causes heat waves in California is tending to bring with it more humidity, changing the character of heat waves from the dry daytime heat and cool nights typical for this region, to the muggy heat around the clock that locals are simply not accustomed to."




*An index of regional summertime heat wave activity that reflects intensity, duration and spatial extent of heat waves over California and Nevada. The index is computed using nighttime (minimum) temperatures for local durations of at least one, two and three consecutive days/nights.*

A preliminary version of the study, co-authored by Scripps climate researchers Dan Cayan and Sam Iacobellis, appeared July 27 in the online edition of the American Meteorological Society's Journal of Climate.

The 2006 event caused a wide variety of systemic impacts. One percent of the state's dairy cows succumbed, milk production was reduced by 10 percent, agriculture took a heavy toll, and energy and water delivery infrastructure was stressed almost to the breaking point. Electrical blackouts were avoided, but only barely through a series of heroic measures by California's electrical power managers. Additionally, the heat wave impacted emergency and social service networks as well as natural ecosystems.

The 2006 pattern of extreme muggy heat is actually part of a trend of increasing nighttime heat wave activity observed over the last six decades. This trend has accelerated since the 1980s and has become especially prevalent in this decade. The nighttime heat waves of 2001, 2003, and 2006 were each unprecedented on record when they occurred. The source of the moisture that propelled the heat wave was an area of the eastern Pacific Ocean where a strong increase in sea surface temperatures has been observed and linked to global-scale trends of human-induced warming of the upper oceans.

Humidity is the key ingredient forming muggy nighttime heat waves. That same humidity usually provides some daytime relief by stoking afternoon cloud formation. The authors note that in the 2006 event, however, and to a lesser degree in the next largest 2003 event, the convection that usually triggers afternoon cooling was stifled.

"This conspicuous relative absence of convection in the presence of so much moisture led to intense daytime warming which in turn promoted more intense and extensive nighttime heat, without any observed precedent," the researchers wrote.

While mechanisms driving this regional anomaly are still under investigation, the researchers concluded that the trend towards more frequent and larger-scale muggy heat waves should be expected to continue in the region as climate change evolves over the next decades.

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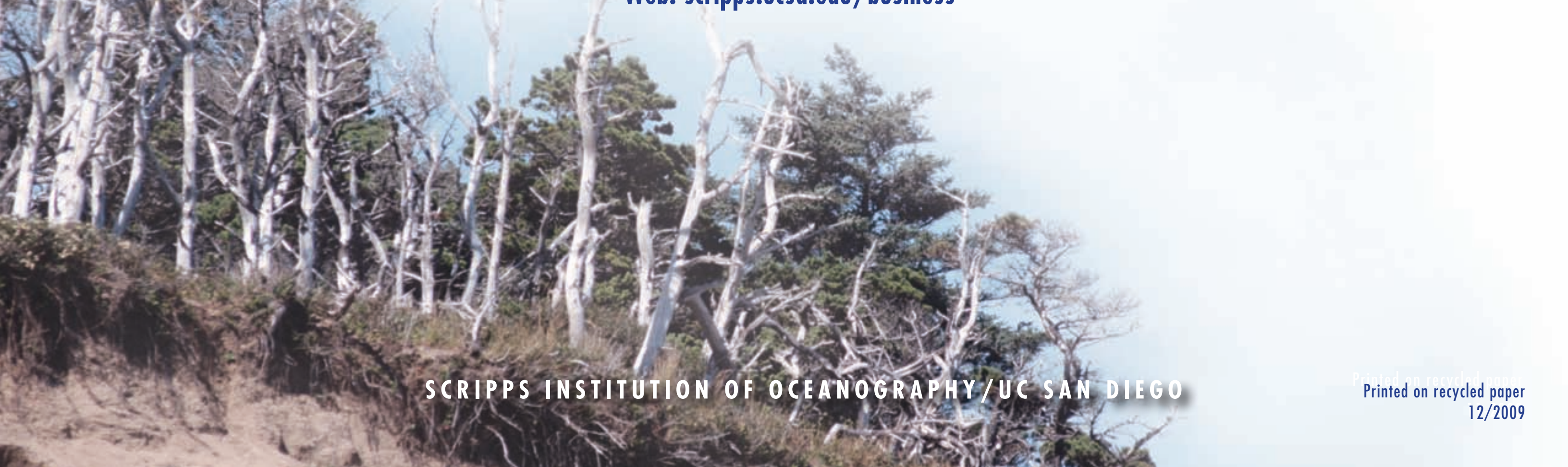



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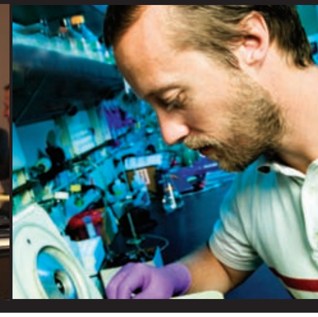
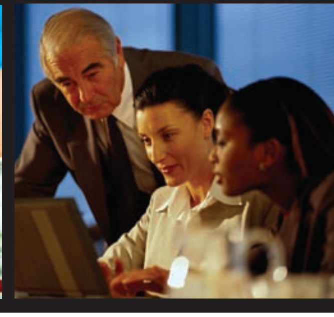

SCRIPPS INSTITUTION OF OCEANOGRAPHY UC San Diego

SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO IS WORKING IN COLLABORATION WITH SEVERAL COMPANIES WHO INVEST IN ENERGY COMMODITY FUTURES TO DELIVER INSIGHTS ON WEATHER EXTREMES AS APPLIED TO ENERGY DEMAND AND FUTURES PRICES.

## Midwest and Northeast Severe Cold Events: Climatology, Causality, and Predictability

Extreme cold spikes in wintertime temperature increase demand for heating which, in turn, leads to greater usage for commodities such as oil and natural gas. Large-scale climate information can be used to condition medium-range weather forecasts in order to gain skill predicting these extreme temperature events.

This joint project between Scripps and the three industry collaborators is part of the Scripps Partnership for Hazards and Environmental Applied Research (SPHEAR). The study focuses on cold weather outbreaks and their impact to the energy market. Dr. Alexander Gershunov is the lead scientist on the project, which has developed statistical and empirical frameworks to improve the lead-time and skill of extended range weather forecasts. SPHEAR Executive Director Stephen Bennett heads the team consisting of Gershunov and Scripps postdoctoral researcher Dr. Kristen Guirguis.

This pilot project: (1) uses a comprehensive definition to examine the variability of regional cold extremes; (2) uses powerful statistical tools to investigate causality and begin a framework to develop models for skillful seasonal-to-interannual predictability, on a probabilistic basis, for regional cold outbreaks; and (3) examines synoptic causes and precursors of individual regional cold events.

Short-term temperature extremes, both hot and cold, are highly sensitive to climate time scales. Climate variability and climate change affect both the mean and variance structure of daily temperatures as they evolve over a season.

The project considers wintertime cold snaps over a large region of the Northeastern and Midwestern United States according to how local cold temperature thresholds have been exceeded on daily timescales. A regional magnitude index, called the "Severe Cold Index (SCI)" was derived to reflect the temperature intensity, duration, and spatial extent of extreme cold spells for 61

winters from 1948/1949 to 2008/2009 and for each day of each event. Observed variability of regional cold spells was then examined on timescales ranging from daily to interdecadal and scrutinized with respect to the climatic controls on their synoptic causes.

Relationships with known climate modes as well as other relevant objectively derived circulation and land-surface patterns were then used to develop simple rule-of-thumb techniques for seasonal and improved medium-range probabilistic prediction of cold snap magnitude. Further extension of this project can lead to development of sophisticated models designed for straightforward operational application by practicing meteorologists working to predict energy demand.

The project also examined the synoptic causes and precursors to individual cold extremes. Cold outbreaks are typically caused by extensive rotating polar masses of cold dense air whose trajectories over land are steered by topography. These anticyclones interact in complex ways with storm tracks and cyclonic activity and can even be forced by distant phenomena such as large masses of thunderstorm activity in the tropical South Pacific. Their behavior is regionally specific, and statistical models similar those used for seasonal-to-interannual prediction can also be used to enhance medium-range weather forecasts of individual extremes by utilizing all relevant antecedent weather and contemporary climate information.

Industrial collaborators will use this information to improve the lead-time and skill of their extended-range energy demand forecasts by tapping into relevant precursor weather information and conditioning their weather forecasts with contemporaneous large-scale climate information. Scripps Institution of Oceanography supported this project in conjunction with Chesapeake Energy, Citadel Investment Group, and Susquehanna International Group.

Commercialization and technology transfer are pivotal to SPHEAR's mission. As such, industry collaborators have exclusive commercial licensing opportunities for the primary project deliverables. Deliverables include: (1) detailed synoptic catalogs that compare each individual winter against a series of user-defined atmospheric variables such as northern hemisphere temperature and tropical thunderstorm activity (2) composite map products highlighting preceding weather phenomena and (3) significance plots that provide snapshots of research conclusions for operational users. UC San Diego is also investigating various patents on SPHEAR research methods to encourage long-term relationships with firms wishing to develop additional commercial products.

With this pilot project now complete, SPHEAR is currently seeking additional industry collaborators for the next research cycle, which will begin in the first half of 2010. SPHEAR collaborations may represent multiple industries such as energy, recreation, insurance and reinsurance, agriculture, technology, and financial services and trading.  SPHEAR is designed to help corporate collaborators enhance their risk management practices, investing strategies, product lines, product pipelines, and corporate governance practices by applying Scripps research findings.

For more information and links to further reading, please see scripps.ucsd.edu/special/sphear

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