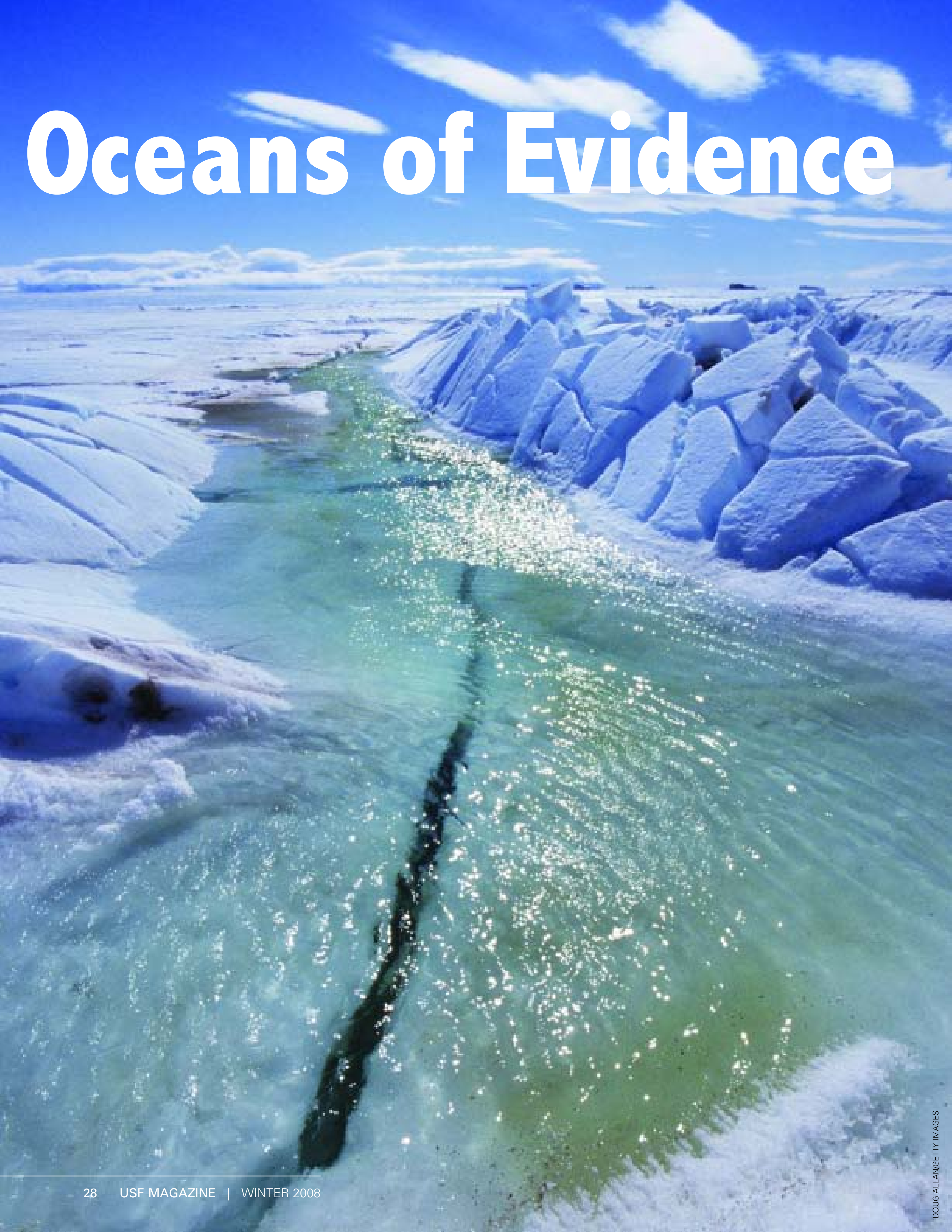
Oceans of Evidence



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USF ocean scientists weigh in on global warming.

BY RANDOLPH FILLMORE

CLIMATE CHANGE IS nothing new.

Mother Earth has been through some drastic changes in her 4.6 billion-year history. In the late stages of the pre-Cambrian era, about 1.6 billion years ago, the sun was not as strong as it is now and the atmosphere contained more carbon dioxide than present. Oxygen in the atmosphere was "toxic."

Much more recently, thanks to climate change, the semi-tropical forests where dinosaurs roamed 200 million years ago are today's rocky deserts. Significant climate fluctuations, long and short term, have killed off species and helped foster new ones, including Homo sapiens. Us.

Paleoanthropologists say that five or six million years ago, when a tropical ecosystem slowly became a grassland in Africa, the change contributed to the development of bi-pedalism—walking on two legs—among some primates way down our family tree.

Sea levels have fluctuated wildly over the millennia. Ice Ages have repeatedly come and gone over the past three million years, paced by regularly occuring Earth orbit changes. Only about 12,000 years ago did the modern climate stabilize and warm enough to foster the beginnings of plant domestication and agriculture in some locations. Then, about 300 years ago, the "Little Ice Age" made people miserable for several generations.

Now, scientists, environmentalists, politicians, elementary school students, former Vice President Al Gore, you and I, know that the climate is warming further because of carbon emissions, green house gasses. Carbon dioxide is streaking into the atmosphere in explosive quantities and trapping heat. And, most agree, for the first time the climate is changing because of us. The carbon dioxide generated by human activities is junking up the atmosphere and threatening life as we know it.

CO_2 and you

"With each breath, we inhale 25 percent more CO_2 than our great grandparents did," says Pam Hallock, a marine biologist at the USF College of Marine Science. "The atmospheric preindustrial level of CO_2 was about 280 parts per million. By the 1950s the CO_2 levels were at 315 parts per million. Now, it's at 380 parts per million."

Most scientists agree that a CO_2 atmospheric score of 450 would be calamitous for the atmosphere and us. Talked about less, however, is the effect carbon dioxide has as it enters into the oceans.

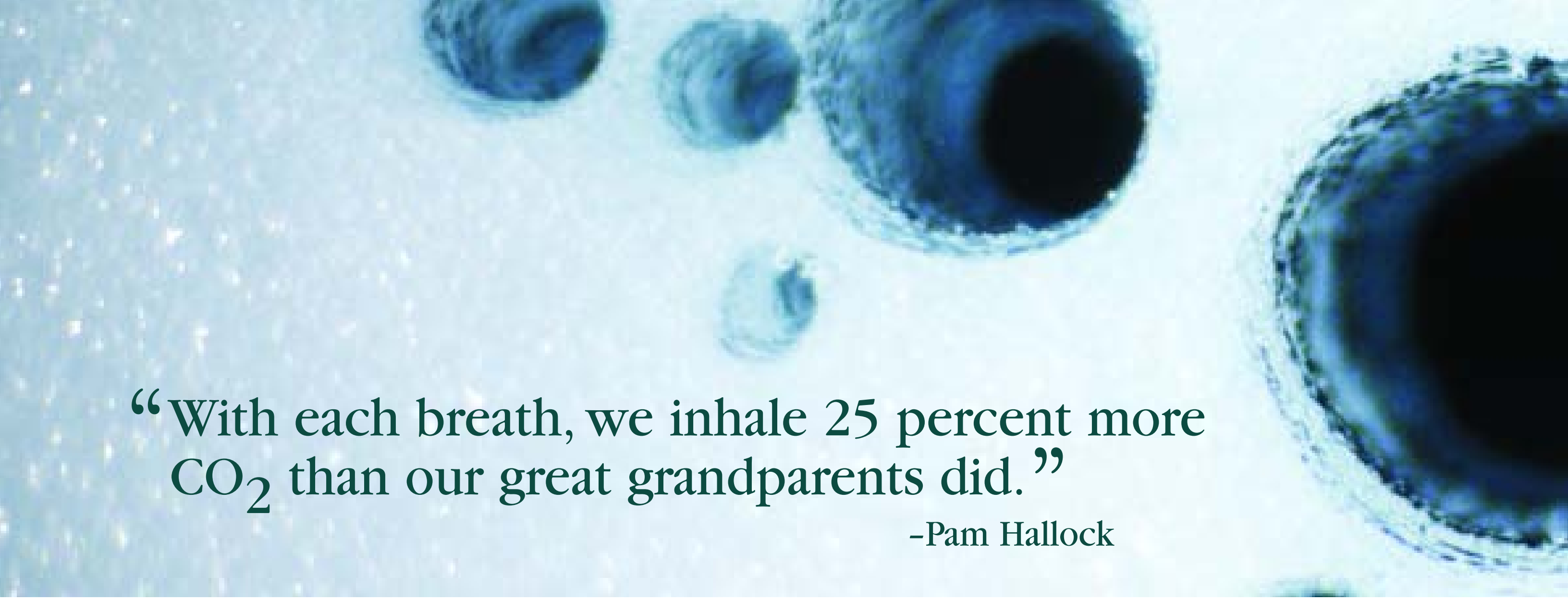
"Increasing concentration of atmospheric CO_2 entering into the oceans is already changing the pH balance significantly," says Hallock.

She is quick to point out that the balance between acid and base (pH measured as 0-14 with 7.0 neutral) in the oceans is tilted more to the acidic than it was just a generation ago.

"As the pH lowers toward acidic, all organisms will have difficulty," says Hallock.

One serious effect is already documented. As the oceans become more acidic, shellfish are not forming their shells properly. Calcium carbonate, used by shellfish to manufacture their shells, does not form as readily in a more acidic environment. Acidification of the oceans also means that coral reef formation will be retarded.

"Human activities that produce green house gasses are seriously impacting coral reefs—physically, biologically and chemically," she says.



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> –Pam Hallock

For decades, measuring acidification in the oceans has been a focus for USF chemical oceanographer Bob Byrne. Recent work conducted by his research group in the North Pacific Ocean shows that a huge patch of the Pacific, between Hawaii and Alaska, has had up to a six percent rise in acidity in just 15 years.

"There are big changes in the upper parts of the ocean where CO_2 has entered the water," says Byrne. "Organisms are already under stress, and this means a major impact for fisheries."

Byrne points out that when CO_2 in the atmosphere enters the oceans it endangers not only shellfish, but also affects organisms such as pteropods, food items for fish. It's not just a theoretical issue, he says; this may have a big impact on what is not on your future dinner plate.

"Loading up the atmosphere with CO_2 results in a significant penetration of CO_2 into the Pacific in the upper 200 meters," says Byrne. "On the one hand, it's good that the oceans can absorb some of the anthropogenic CO_2; but on the other hand, it's very bad for some important organisms in the oceans."

Bigger, badder storms?

Then there is the issue of whether global warming due to the greenhouse effect is churning up more disastrous weather patterns that will create bigger, badder hurricanes, beefed up on warming oceans. According to USF geological oceanographer Ben Flower, this question must be answered taking into account natural hurricane patterns and the Atlantic multidecadal oscillation (AMO) where North Atlantic sea temperatures fluctuate from high to low and back on the multidecadal scale. Records on AMO fluctuations date back to 1860, when atmospheric carbon levels had not yet spiked because of industry.

"Natural changes in the AMO should be included in models of climate change," insists Flower, who has generated AMO proxy data from deep-sea sediment cores in the Gulf of Mexico. "We found significant oscillations throughout the past 3,000 years, including during the Little Ice Age. In addition, the amplitude (or temperature range) of the AMO appears to increase during warm intervals."

USF College of Marine Science graduate student Julie Richey, lead author on a recent paper that looks at 1,400 years of climate variation in the Northern Gulf of Mexico using ocean sediment cores, found that sea surface temperatures (SSTs) between 1,000 and 1,400 years ago were as warm or warmer than modern SSTs and 2-3°C lower during the Little Ice Age. (Interestingly, that range falls into line with predictions for global warming's effect on global surface temperatures.)

While that was a natural cycle, a fear is that anthropogenic global warming could amplify the effects of natural variability, inflicting unnatural climate change as a nightmare scenario.

A period of tranquility?

If global warming is going to create more killer hurricanes in the North Atlantic and Gulf of Mexico, why have we had two years of relatively light activity in 2006-2007 after two years of being battered in 2004-2005?

USF physical oceanographers Robert Weisberg and Jyotika Virmani looked at the devastating 2004-2005 hurricane seasons in the Atlantic and Gulf and found them "odd but explainable."

"The seasonally warm SSTs that developed in the Atlantic Ocean through the fall of 2004 did not decrease as much as usual the next winter," says Weisberg. "So, SSTs were higher than normal going into the spring of 2005."

Warmer than normal SSTs have had an impact before. "Stronger and more frequent hurricanes have been


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spawned by warmer SSTs in 1958, 1969, 1980, 1995 and 1998," says Virmani.

"Hurricane frequency is generally greater when the AMO is in its positive stage," explains Virmani. "But you can get devastating hurricane years in the negative stage as well.

According to Weisberg, anthropogenic greenhouse gasses such as CO_2 are not the only condition that can stoke a warming atmosphere. Atmospheric water vapor is actually the Earth's primary greenhouse gas, and just how water vapor distributions are modified by warming due to increasing CO_2 is the unknown issue.

"An increasing temperature trend through global warming and the warm AMO were not necessarily the drivers of the unusually active 2004-2005 hurricane season," Weisberg says. "The controls on sea surface temperature and atmospheric moisture distributions are much more complicated than that."

And what contributed to the quieter 2006-2007 hurricane seasons if global warming may be a factor in brewing bigger storms? Local conditions trump the global warming card, Weisberg and Virmani agree.

"In 2006, the winds were stronger, leading to cooler SSTs," explains Virmani. "But, SSTs are just part of the story, along with greater wind shear."

The global warming story is not just a natural story, nor is it a story only humans are writing.

"Because of subtle trade-offs between naturally occurring and man-induced changes, coupled with the complexity of hurricane generation and intensification, further research is needed to understand and predict these processes of great societal importance," Weisberg explains.

Sea levels on the rise

Sea-level rise because of global warming may be a disaster in the making.

"Measurements of sea-level rise are consistent with the data on global warming," says USF physical oceanographer Gary Mitchum. "We're running out of other explanations."

According to Mitchum, we need to fear two things—ice melting on Greenland and Antarctica (ground ice melt) and the increase in water volume as waters warm and their density decreases.

"Coastal flooding, flooded sewers, salt water intrusion into aquifers are all consequences," says Mitchum. "We already see these problems in some developing countries."

To gauge the progression and impact of global warming, Mitchum recommends looking to the oceans rather than the atmosphere.

"The atmosphere is not a good system for inquiry," says Mitchum. "There is too much noise. The oceans are quieter and have better memories."

Likely the oceans are today thinking back to better times.

IPCC in a nutshell

In its 2007 report, the Intergovernmental Panel on Climate Change (IPCC) said that:

- Temperatures at the top of the permafrost layer in the Arctic have increased since the 1980s.
- Increasing atmospheric $C0_2$ concentrations will acidify the oceans.
- Snow cover will contract, sea ice and ground ice will shrink.
- Future tropical storms will likely be more intense.
- Average atmospheric water vapor content has increased since the 1980s.
- Hot days and hot nights have become more frequent.