Earth Science

Looking far ahead into the greenhouse

Most forecasts of greenhouse warming take a relatively shortsighted view by focusing on how the climate will react to a doubling of atmospheric carbon dioxide – an increase expected sometime in the middle of the next century under current emission rates. But unless nations drastically curtail their use of fossil fuels, carbon dioxide will continue to accumulate even after doubling. That raises the question of how greater amounts of carbon dioxide will affect the climate.

A new computer simulation of quadruple carbon concentrations suggests that major climate changes could lie ahead.

At the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory in Princeton, N.J., Syukuro Manabe and Ronald J. Stouffer used a general circulation model to compare how a computerized climate evolves under three different scenarios. In one run, carbon dioxide concentrations increase 1 percent per year until they double in 70 years, and then remain constant. In a second run, concentrations climb until they quadruple in 140 years. A "control" simulation lets the climate develop with constant carbon dioxide levels.

The double and quadruple cases show similar behavior up to a point. As global temperatures rise, both show a weakening in the conveyer-belt system of ocean currents that transports heat around the globe. In the doubling simulation, the currents gradually regain strength over several centuries. But they remain weak in the case of quadrupled carbon dioxide.

"This is a fundamental change in the ocean circulation," says Manabe. The diminished circulation would reduce mixing between the deep ocean and surface waters, he and Stouffer report in the July 15 NATURE. This would limit the amount of nutrients brought up from the depths. It would also curtail the supply of life-sustaining oxygen to the deep ocean.

By the end of the 500 years, the quadruple-carbon simulation shows temperatures over the continents reaching 7°C to 10°C warmer than today. The last time Earth saw such warmth was during the Cretaceous period, more than 65 million years ago.

Sulfur hazard in the deep

While boring into the seafloor off the coast of Oregon, marine scientists pulled up a nasty surprise late last year. Several cores of rock collected during the drilling held extremely high concentrations of dangerous hydrogen sulfide gas.

"Ever since the beginning of scientific ocean drilling, which goes back to the 1960s, I don't think anybody's recovered a core that's so rich in hydrogen sulfide as this stuff was," says Timothy J. G. Francis, deputy director of the Ocean Drilling Program (ODP) in College Station, Texas.

When the crew brought the cores up to the ship, the rock gave off potentially lethal doses of gas, forcing the workers to don special breathing equipment, Francis and Robert E. Olivas note in the July 13 Eos. The ODP team encountered the hazardous rocks while drilling into a thick accumulation of sediments in 674 meters of water. The researchers believe the sediments contained hydrogen sulfide in the form of a gas hydrate, an ice-like structure kept solid by the tremendous pressures and cold temperatures of the deep ocean.

Although they could not make direct measurements, the ODP scientists believe the water near the seafloor also contained dangerous concentrations of hydrogen sulfide. Francis says the drilling operation itself probably melted some of the gas hydrates, releasing hydrogen sulfide into the water. But if the deep ocean in this region normally holds significant concentrations of this gas, it could damage submersibles or other equipment visiting the site, he says. Because the area has geologic importance, submersibles have explored near there in the past.

Technology

NASA X-ray device to inspect aircraft

With aging planes infesting the U.S. carrier fleet, potential crashes due to structural failures are now a modern nightmare.

In response, NASA is testing a portable X-ray system to look for structural defects in the hard-to-reach nooks and crannies of airplane bodies and engines. The new system, developed under NASA contract by the Digiray Corp., can inspect fuselages, wings, joints, and even jet engine turbine blades.

Unlike conventional, bulky X-ray methods – which use film, require dissembling of the plane, and produce fuzzy pictures – this system employs small probes placed into or behind the material, without taking the plane apart. Using intensities comparable to a chest X-ray, the machine creates a sharp, digital image of a material's physical structure, says Richard D. Albert, president of Digiray. With multiple probes, a computer fashions a three-dimensional view, revealing a sample's integrity or highlighting its defects.

The resolution is high enough to spot cracks in composite materials – heavily used in such craft as the space shuttle and stealth bomber – and corrosion on metal, Albert says. "We can see cracks and defects early on, when they're forming, not just when they've advanced. Individual layers of material stand out, so defects show up before they're out of control," he says.

NASA believes these new diagnostic systems will prove useful in other areas as well. "This technology, along with others we're developing, will have a major impact on the cost of maintaining and extending the life of large structures that are very costly to replace," says Joseph S. Heyman, a senior researcher at NASA's Langley (Va.) Research Center. He cites, for example, chemical storage tanks, roads, bridges, and other big objects whose useful life is curtailed by an inability to measure their soundness.

Radar distorts light-based electronics

For years, engineers puzzled over a problem: How to build machines with sensitive electronic components that will not suffer distortion when operated in an electromagnetic field. Such fields show up around radar and radio transmitters, causing unwanted currents to flow in metal wires and cables.

Then, an answer emerged: Use photonic devices, which send signals through fiberoptic cables or free space, media unaffected by electromagnetism.

Not so fast, say John K. Daher and his colleagues at the Georgia Tech Research Institute in Atlanta. Their new study shows that electrical connections in photonic devices suffer the same troubles as the electronic components themselves. "It's a myth to say that installing a photonic system means you don't have to worry about electromagnetic interference," says Daher, who described the study at a July symposium at NASA's Jet Propulsion Laboratory in Pasadena, Calif.

The researchers tested four types of photonic devices – electro-optic, acousto-optic, magneto-optic, and charge-coupled devices – all of which use light as the primary means of information transmission. These devices sense energy in one form (sound, magnetic pulses, etc.) and convert it into another (light, electrical pulses, etc.). Yet, when exposed to radio frequency or microwave fields, they all experienced interference, in some cases disrupting equipment. The magneto-optic device, used in aircraft instrument panels, showed inadvertent switching. In charge-coupled devices, commonly used in videocameras, even 1 microwatt of energy distorted the video signal. With the electro-optic device, used to modulate a laser, the beam stopped shining entirely.

Both military and civilian systems share these weaknesses, the researchers explain, so engineers must shield photonic devices from hazardous fields. "You can't let down your guard," says Daher, "just because you're using an optical system."