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Carbon dioxide from the burning of fossil fuels could cause climatic changes that would melt polar ice, raise oceans and create vast deserts

Scenario for disaster

Most of the United States is a desert; its people cling to the coastal fringes and huddle along the borders with Canada and Mexico, its rich neighbors.

Meeting in New Akkvik, heads of state of Canada, Russia and the Saharan Empire argue over whether to extend still more foreign aid to the desperate Americans. Even after a century there is resentment against the U.S. and the European nations most blamed for the climatic upheavals.

For the benefits were mixed. Canada, while richer, is shrunken. Wheat fields carpet the high Arctic. Freighters and cruise ships ply the Northwest Passage. But the old Akkvik and many other coastal communities lie under metres of water, flooded by oceans swollen with melt-water from polar ice.

There have been painful social upheavals. Famine and war have left scars.

Russia, which has shared many of America's problems, takes its side. Canada, strained by tides of immigration across its southern border and still suffering traces of a 20th century inferiority complex, opposes.

Statesmanship seems called for, however. Scientists believe the earth will remain unusually warm and the new order persist for a thousand years or more.

By TIM PADMORE

AS MAN FRENETICALLY consumes the last of his fossil fuels the world's atmosphere is being spiked with growing amounts of carbon dioxide. Profound climate changes will follow.

Exactly what will happen has been hotly debated, but in recent weeks the pieces of the puzzle seem to have been coming together. For parts of the world the change will be disastrous, but for Canada the future looks bright indeed.

The glimpse that introduces this article is an extreme view, based on an unsteady stack of assumptions. But there seems little doubt that Canada will benefit. And it is dead right on one count: the world of the 21st century will be vastly different from this one.

Carbon dioxide is an unlikely pollutant. In ordinary amounts it is harmless to life. In fact increased levels of the gas are mildly stimulating to plant growth. People can breathe it freely at much greater concentrations than it is ever likely to reach; we produce it in our lungs.

The hazard is in the architecture of the carbon dioxide molecule. The atoms are held together by springy bonds; if CO2 gets the proper sort of nudge it can be made to vibrate or spin like a top. Light at the proper wavelength can supply the nudges. It chances that the carbon dioxide molecule is especially sensitive to several wavelengths in the infra-red.

What happens is that sunlight falls on the earth, which warms up; the warm earth emits infra-red radiation, which would normally pass into space. The carbon dioxide intercepts some of that otherwise lost radiation, re-emits it, partly into space, but partly into the atmosphere and back to the earth.

The balance need be upset only a little to have an important effect. The sun maintains the planet at about 300 degrees above the cold of space; a one-half per cent change is 1.5 degrees, enough to precipitate a "little ice age" such as disrupted agriculture in Europe in the 16th and 17th centuries. At least that much change in the opposite direction — a warming change — now seems almost inevitable as a result of our burning of fossil fuels.

In the last hundred years the carbon dioxide content of the atmosphere has increased about 10 per cent. But that increase will be overshadowed by what is to come.

Rising oceans will inundate much of city, Fraser Valley

If present patterns of consumption of fossil fuel continue — that would mean continued under-utilization by developing nations — the CO2 concentration will double by early in the next century and reach a peak nearly 10 times the present level by the end of that century.

The global warming will approach 10 degrees; it will be twice as much at Canadian latitudes. The polar ice caps will probably melt, ultimately increasing sea levels by as much as 90 metres, which would inundate much of Vancouver, the Fraser Valley, parts of the Maritimes and Quebec and vast areas of Northern Canada.

The planet will become rainier, although some areas — such as the American Midwest — will become drier.

Until now these considerations have played little part in national energy policies. In the U.S., for example, major emphasis has been put on exploiting vast coal reserves to produce electricity and artificial liquid fuels; Canada would like nothing better than to convert its tarsands reserves into hundreds of billions of barrels of petroleum.

One reason is that scientists have been unable to agree on exactly what has been happening, and their predictions have been regarded with understandable suspicion.

The major debate has been over the Mystery of the Missing CO2. We know quite accurately how much of the gas has been produced by man since the industrial revolution: about 290 billion metric tons. We know how much extra CO2 there is in the atmosphere: about half that amount. The mystery is, why only half?

Two theories were offered: it has dissolved in the ocean, or it has been taken up by plants.

Both theories have been punctured.

Oceanographers calculated the ocean uptake and concluded that only about half the missing gas could have gone there. Biologists surveyed the world's plants and came up with an even more dismaying conclusion: forest clearing, which releases the carbon in plants, is dumping carbon dioxide into the atmosphere even faster than the burning of fossil fuels. Far from solving the dilemma, the biologists deepened it.

How can you convince a politician that carbon dioxide is increasing inexorably if some mysterious "sink" is soaking up most of it? Maybe the sink will soak up even more in future and eliminate the problem altogether. There was no good reply.

But now a paper, published in January in the journal Science, by University of Washington researcher Minze Stuiver seems to provide one.

"I don't see any missing carbon dioxide," he told me in a telephone conversation last week. "I think it can all be reasonably explained."

His analysis rests on the fate of three isotopes of carbon: carbon-12, the most common isotope; carbon-13, a slightly heavier form of carbon found in small quantities; and carbon-14, a radioactive carbon isotope produced when cosmic rays strike the atmosphere.

Stuiver realized that the burning of fossil fuels and clearing of forests affect the proportions of the isotopes in the atmosphere in different ways.

Fossil fuels have no carbon-14. They have lain in the earth for millions of years, and virtually all the radioactive atoms they once contained have long since decayed. Plants sort the other two isotopes. Photosynthesis works best with carbon-12, so plants are low in carbon-13.

Tree rings give a record of the changing amounts of all three isotopes, and provided the key for Stuiver to untangle the separate contributions of burning and clearing.

The result: forest clearing has indeed injected a lot of CO2 into the atmosphere — double what has come from fossil fuels — but most of that happened between 1860 and 1930. Since then almost all the increase has come from the burning of coal, petroleum and natural gas.

Where did the biologists go wrong? It may be that their tree counts, based on detailed data from only a few countries, were incomplete.

Stuiver also offers a solution to the oceanographer's problem. His Seattle laboratory has been analyzing ocean water samples for radioactive carbon-14 produced by nuclear bomb testing. The new measurements reveal that the carbon-14 has penetrated more deeply than expected, particularly in the region of ocean gyres, giant eddies that churn the water to a depth of several hundred metres.

The efficient mixing means, he says, that 88 per cent of the missing carbon dioxide can be accounted for.

"In this business that passes for 100 per cent," University of B.C. oceanographer Ron Burling said admiringly.

The mystery cleared up and credibility restored, researchers can start predicting again. The most up-to-date predictions are in another Science article that appeared only a week later. (Stuiver's article itself followed on the heels of the latest salvo by the biologists, who can be expected to reply. The dust may be clearing, but it hasn't all settled yet.)

We learn that if present trends continue, with economics the only limit on the exploitation of fossil fuels, the CO2 concentration will have doubled by 2030. Forty to 50 years after fuel burning peaks — that will come mid-century — the CO2 concentration will be five to 10 times its present level.

Computer models of the earth's atmosphere — which take into account the main forces driving the weather but omit many fine details — have been used to predict what that will mean.

Depending on whose computer calculation you believe and how much faith you put in it, each doubling of atmospheric carbon dioxide will result in a two- to three-degree global warming. An eight-fold increase amounts to three doublings, or six to eight degrees.

The warming could be double that at Canadian latitudes, and three to four times as much in the Arctic.

The reason, explained William Kellogg, a climate modeller at the National Centre for Atmospheric Research in Colorado, is the loss of snow and ice, which help keep the poles cold by reflecting sunlight back into space. As the snow-covered regions shrink, more sunlight is absorbed, reinforcing the change.

The melting of the Arctic sea ice will have no effect on ocean levels, since it is already afloat, but melting of the mile-thick ice sheets of Greenland and Antarctica will.

Each two degrees warming will ultimately raise sea levels by five metres (or maybe two, or 10), said Burling. The word "ultimately" is important, because it could take many centuries for the melting to take full effect.

But, says Burling, "much of what happens goes on in the first quarter of that period," and it's quite conceivable the sea will start creeping over the gardens of our great-grandchildren.

Precipitation patterns are certain to change as the climate warms. The computer models suggest that precipitation will drop in the middle latitudes — where much of the world's food is now grown — and increase elsewhere.

But the best guide available so far is probably the record of past climate. Kellogg has assembled the results of other researchers who have been studying pollen grains taken from lake-bottom sediments laid down in an unusually warm period that occurred between 4,000 and 8,000 years ago.

Species that thrive in wet conditions were found in Alaska, Mexico, the Sahara, China and Western Australia. Species that like dry climates predominated in the American West and Midwest.

Our introductory scenario is a projection of this pattern. Canada will not suffer inordinately. We have relatively little low land to be submerged and the climate changes will open up wilderness to agriculture. The North will become balmy and wet. Strains of wheat adapted to take advantage of the midnight sun could allow farming well past the Arctic circle.

While Richmond builds its dykes a little higher each decade, Vancouver will enjoy Miami-like weather.

Ships plying the Northwest Passage will be able to approximate the great circle routes of today's intercontinental jets and shave days off the transit time via the Panama canal.

"It looks pretty good for Canada," agreed Kellogg.

Still, there is a certain attraction in the status quo, particularly for the U.S. and other countries that will suffer undesirable changes.

'It looks pretty good for Canada' expert says

What are the prospects for avoiding the carbon-dioxide effect?

Not good, say U. Siegenthaler and H. Oeschger of the University of Bern, authors of the second Science article.

They ask what would be required to limit the CO2 rise to 50 per cent, which would mean only a one- or two-degree worldwide warming. (That would mean two to four degrees in Canada, and a month more in the growing season!)

Their answer: peak consumption of fossil fuels must be limited to 30 to 50 per cent above present rates. That rate will be reached soon after the year 2000. Consumption must then be cut back sharply, reaching 1970 levels by mid-century and dropping "for a very long time" to less than half the 1970 rate. No more than 10 per cent of economically exploitable fossil fuels could be used.

And that in a world with a population of 10 to 20 billion.

Of course one can hope that a natural cooling trend may cancel out the carbon dioxide effect.

Indeed, the earth has experienced a general cooling — now appearing to be slowing down — since 1940. It has come in the face of global increases in carbon dioxide that should already be having a measurable effect — perhaps half a degree of warming since the last century could be attributed to CO2.

But climate fluctuations that occur on a scale of centuries have historically not amounted to more than a degree or two. Any natural cooling will almost surely be swamped by the artificial warming.

What about dust, which man also makes? Whether dust warms (by absorbing or trapping sunlight) or cools (by reflecting it) has also been debated.

In November, a tentative answer was offered by Sherwood Idso of the U.S. Water Conservation Laboratory in Phoenix, who directed a study of solar radiation on dusty Arizona days. He reported that the dust warms, probably because it blocks outgoing radiation. Only at the highest dust levels — higher than man is likely to produce — was the warming trend reversed, a result of incoming sunlight not getting through.

Our doom seems increasingly certain. Although the scientists concerned are still cautious, there is some confidence where a year ago there was frustration. More tree rings will have to be measured to verify Stuiver's analysis. Satellites will be used to help the biologists count trees and to monitor sea level changes. Better climate models will be run through the computers.

Kellogg said NCAR, which just took delivery of the world's fastest computer, a Cray-1, built by computer genius Seymour Cray, will use several weeks of the machine's valuable time this year to run a climate model of unprecedented detail.

It will give climate predictions into the next century for regions as small as an American state.

It will, he said, finally make it possible to talk to politicians.

It is the cause of beautiful sunsets — and rain, dreams can turn to it, and to it we must all return

Dust: curiouser and curiouser

By DONALD ZOCHERT

DUST IS NOTHING to sneeze at. Without dust there would be no beautiful sunsets to write home about. Without dust no raindrops would fall on our heads.

Dust fell on the gladiators of ancient Rome, and on the ruined cities of Asia Minor. It blows from the Sahara in Africa to the Piedmont in South Carolina, and from Asia to blur the sky over northern Alaska some 12,000 kilometres away. More of Africa may be swept out to the Atlantic Ocean by wind than is carried out by a continent of mud-laden rivers.

All the stars and planets we see may have been created out of a gigantic cloud of interstellar dust, but dust is an embarrassment to astronomers — there's more of it left between the stars than there should be. But dust storms on Mars are providing new clues about dust storms on Earth.

Dust may be heating up the earth's atmosphere, or cooling it off. Meteorologists are still kicking up dust on that issue. But they feel it may help trigger tornadoes. And it does cause traffic accidents — 886 in eight years in Arizona alone, where the "haboob" winds whip dust into a wall of darkness.

Pea plants and pine seedlings "exhale" tiny particles of dust in the form of lead and zinc. Volcanoes belch millions of tons of dust into the atmosphere. Forests in Brazil exude thick clouds of dust.

All in all, it takes a long word to describe small dust: ubiquitous. Dust is everywhere. And because it's always with us, it deserves to join the pantheon of death and taxes.

Dust is, in fact, a metaphor for death: earth to earth, ashes to ashes, dust to dust. Dreams sometimes turn to dust. In the Old West, badmen bit the dust; the skateboarders of today eat concrete.

A boy named Rhodes can still expect to grow up to become a man called Dusty. Dorothy Parker's most memorable epitaph captured both the spirit of her times and intimations of mortality: she suggested a gravestone should be carved with the words "Excuse my dust."

Most of the dust in the atmosphere is broken out of the soil — chiefly by man in the practice of agriculture — and is carried away on the winds of the world. Perhaps 90 per cent.

About three per cent floats in the form of volcanic ash and an equal amount is made up of organic compounds called terpenes, which are emitted by plants — the smell you smell in a green forest. The rest is smog belched out by factory stacks and auto tailpipes.

Envelopes of dust rise to great heights — five kilometres and more — and are sometimes 1,000 kilometres wide, according to Joseph M. Prospero, who studies undersea dust deposits from the University of Miami's Rosenstiel School of Marine and Atmospheric Science.

An estimated 100 megatons of dust — 100 million tons — is picked up by the wind and blown off the western coast of Africa every year. Since the start of the long, disastrous drought in North Africa's Sahel region the concentration of aerosols or atmospheric dust over the Atlantic at the equator has increased by nearly three times, Prospero says.

"Back in 1943, when I was in Puerto Rico, we'd read in the paper about a big tank battle in North Africa, and then about 10 days later we'd see the dust come over — swept up by the trade winds," says Reid Bryson, director of the University of Wisconsin's Institute for Environmental Studies and a world-famous climatologist.

"During the Second World War, when the wind was blowing hard out of the interior of Asia, it carried so much dust that our bombers developed a static charge on their surface — they couldn't communicate by radio," Bryson adds.

Dust carried on westerly winds from Asia falls into the North Pacific and even in Hawaii. The great volcanic explosion of Krakatoa cast dust around the globe. During America's Dust Bowl years dust from the Great Plains darkened the noon sky over New York City.

Dust continues to fall today. As much as 150,000 tons of dust falls annually on the city of Phoenix estimates Troy L. Pewe, a geologist at Arizona State University. If you own a swimming pool in Phoenix, 30 pounds of dust will fall in your pool each year.

For Marion Jackson, a soil scientist in the University of Wisconsin's College of Agriculture and Life Sciences, the fascination in dust lies in determining where it came from and what it says about the climate past and the earth.

Like Alice in Wonderland, he works in a shrinking world where things get curiouser and curiouser. He works with tiny specks of fine dust so small it would take a thousand of them placed end to end to make a line one silly millimetre long. From these specks he extracts silica or quartz. And then he gets to the tricky part. He weighs the oxygen atoms.

This gives him a magic number — he calls it the oxygen isotope ratio — that tells him where and at what temperature the quartz was formed.

These magic numbers show, he reports, that the continents now in the northern hemisphere once "drifted" across the tropical and equatorial zones, and that the continents now in the southern hemisphere once were part of a supercontinent organized around the South Pole.

Jackson explores the past through a speck of dust, but many other scientists look at dust and worry about the future climate.

All things considered, there's no dust like house dust. Common house dust is composed of many things: animal hair, bacteria, insect parts, carpet fuzz, drapery thread, tiny litter mites, just to name a few.

M. W. Gibney doesn't see enough of it. "We use thousands of pounds of house dust a year," he says, "and we still rarely have enough."

Gibney heads Hollister-Stier Laboratories in Spokane, Wash., a firm that extracts allergenic compounds from house dust and purifies them for use by doctors in making skin tests and treating people with allergies.

Through its headquarters and its five regional offices the firm operates a non-profit fund-raising program by which community groups can organize door-to-door dust drives.

To prove there's at least one practical thing to say about dust, Gibney pays 90 cents for every pound of house dust turned in.

—*Chicago Daily News*

On the other hand, the sun's cooling

THE TEMPERATURE on the surface of the sun fell six degrees last year, enough to significantly affect the earth's climate, astronomers have found.

The change, which means a half per cent drop in solar energy reaching the earth, was measured using sensitive new observing equipment at the Kitt Peak National Observatory in Tucson, Ariz.

"We presume the changes we see are cyclic and that the temperatures will stop falling sometime in the near future," said Dr. William Livingston. "I can't imagine anything else happening."

The astronomers speculate that the drop in temperature may be associated with the 11-year cycle in the number of sunspots. The drawing of energy from the sun's atmosphere to generate sunspots would cause an over-all surface cooling, they believe.

The new observations provide a possible explanation for a previously observed link between the sunspot cycle and patterns of earth weather.

ULTRASHORT PULSES of laser light are unlocking the secrets of photosynthesis and other ultrahigh-speed chemical reactions.

Scientists at the annual meeting in Washington of the American Association for the Advancement of Science reported that bursts of laser light a trillionth of a second long are being used to "freeze" the reactions.

Better understanding of photosynthesis — the process by which plants use sunlight to manufacture carbohydrates — could lead to ways to use solar energy directly to produce liquid fuels and other valuable products, it was suggested.

In a typical experiment, a burst of light is used to start a chemical reaction. Further pulses are directed at the reaction area and the way the pulses change as they pass through the reacting materials yields clues to what is happening.

THE WORLD'S only nuclear-powered freighter may be mothballed soon because of rising fuel costs.

The West German vessel Otto Hahn, launched 10 years ago, needs refuelling for the third time and the government wants reluctant private industries to share the $50 million cost.

A decision on the fate of the vessel, which has been barred from a number of ports because of fears about radiation, is expected this month.

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