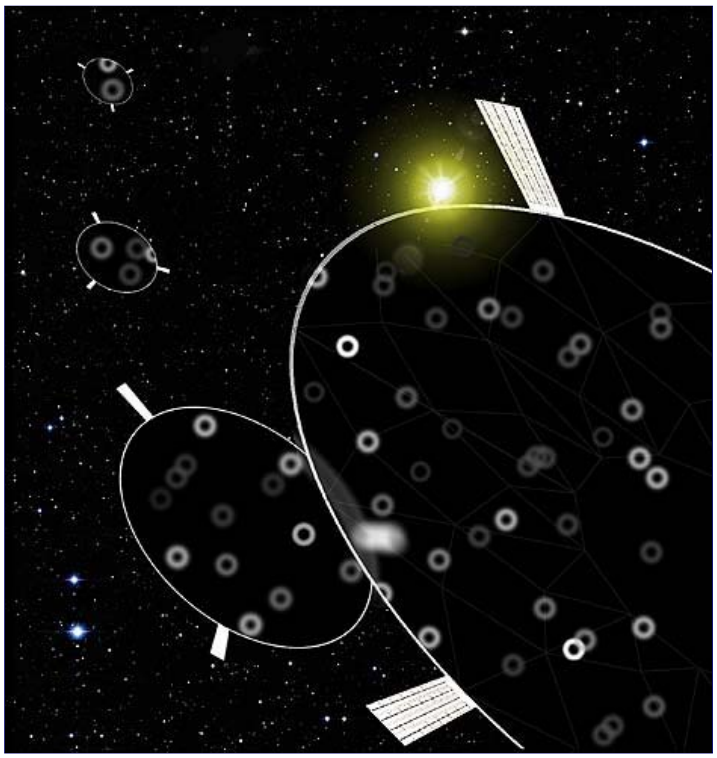
Outer Space Sunshade to Cool Earth in Global Warming?

"The scientific evidence is now overwhelming: climate change presents very serious global risks,
and it demands an urgent global response. … If no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could reach double its pre-industrial level as early as 2035."
- Sir Nicholas Stern, British Economist, November 10, 2006,
Report to U.K. Prime Minister and Chancellor of Exchequer



Graphic illustration of thin, 2-foot-diameter, transparent inscribed discs with small solar panels that could be launched by the trillions to form a large "cloud" between the sun and Earth in order to cool this planet in the grip of global warming. The little rings in the discs represent light from background stars that is blurred into the deflected ring shapes as an analogy for how a small percentage of the Sun's light could be deflected from reaching Earth. The goal: to keep the world's global temperature cooler. Illustration by University of Arizona Steward Observatory.

November 9, 2006 Tucson, Arizona - Even a year ago, I would not have reported about a sunshade in space to help cool off our planet in the grip of global warming because an outer space sunshade would have seemed too much like science fiction speculation - not news.

But Earth keeps warming. Greenland, the Arctic and Antarctic keep melting, sea levels are rising and finally the banking/business community is beginning to realize – and acknowledge – that global warming threatens people and economies around the world.

The most recent major player on the world economic scene to speak out is Sir Nicholas Stern in London, the former Chief Economist at the World Bank and head of the British Government Economic Service. Back in July, England's Chancellor of the Exchequer asked Sir Nicholas Stern to lead a major review of the economic challenges in this century of rapid global climate change and its impacts on Great Britain and the world.

On Friday, November 10, 2006, Sir Stern reported to both the Chancellor and Prime Minister that:

> "The scientific evidence is now overwhelming: climate change presents very serious global risks, and it demands an urgent global response. … If no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could reach *double* its pre-industrial level as early as 2035."

That means in the next quarter-century, the average mean global temperature could increase rapidly. For perspective, over the last one hundred years of the 20th Century, the average global temperature rose one degree Celsius. If, in the next twenty-nine years, it warms "over 2 degrees Celsius," a probability warned about in Sir Nicholas Stern's official report, the consequences could be catastrophic for regions of the planet that will be plunged into severe drought while other regions experience excessive rains and flooding.

Further, Sir Stern's report states:

> "In the longer term, there would be more than a 50% chance that the temperature rise would exceed 5 degrees Celsius. This rise would be very dangerous indeed; it is equivalent to the change in average temperatures from the last ice age to today. Such a radical change in the physical geography of the world must lead to major changes in the human geography – where people live and how they live their lives."

In short, global warming now, and for the foreseeable future, is going to cost governments huge amounts of money to cope with weather damage and relocation of people on inundated coastlines. Instead of figuring billions of dollars to cope, some are already beginning to talk in *trillions* of dollars. That's why a sunshade in outer space between the sun and the Earth is suddenly a serious subject.

In astrophysics, there is a name we will probably start hearing more about. It's the Lagrangian points, five positions in interplanetary space between the Earth and sun where a small object affected by the gravity of the Sun and Earth can theoretically stay in the same position between the two larger planet and solar bodies. Think of a satellite in geosynchronous orbit around Earth in a fixed position. But the distance to one of the Lagrangian points is a million miles beyond Earth. It's called "Lagrangian Point 1," or "L-1."

A physicist from Oxford University now teaching at the University of Arizona in Tucson, has proposed in the most recent issue of the *Proceedings of the National Academy of Sciences*, a plan to launch trillions of feather-light, very thin, transparent discs into space where they would form a "several million square kilometers cloud" at Lagrangian Point 1 between the Earth and the sun. Solar energy would be deflected by those trillions of discs into a ring that would bypass Earth and theoretically cool our planet by about 2%. The cost to produce trillions of discs and get them launched into outer space is projected to be "a few trillion dollars."

The lead scientist on this proposal is Roger Angel, Ph.D., Professor of Astronomy and Optical Sciences in the Steward Observatory at the University of Arizona in Tucson. I talked with him this week about the feasibility of his idea and how long it would take to execute.

Interview:

Roger Angel, Ph.D., Prof. of Astronomy and Optical Sciences, Steward Observatory, University of Arizona, Tucson, Arizona: "The idea of the sunshade – it's not an alternative to alternative energies or reducing carbon. That we have to do anyway. But the idea of the sunshade is that if we find ourselves in a position where the climate effects that are very serious seem to be otherwise inevitable. In other words, we already have got enough carbon in the atmosphere and we find that we are on a track to melt Greenland or something that raises the sea level, then the only thing you can do to prevent that would be to explicitly cool the planet.

There are ideas, for instance, to put aerosols in the atmosphere, which would mimic the effect of a big volcano like Pinatubo, which was known to cool the Earth.

> [Editor's Note:

Mt. Pinatubo, Philippines volcano spewed more than 5 billion cubic meters of ash and pyroclastic debris into the Earth's atmosphere in June 1991.

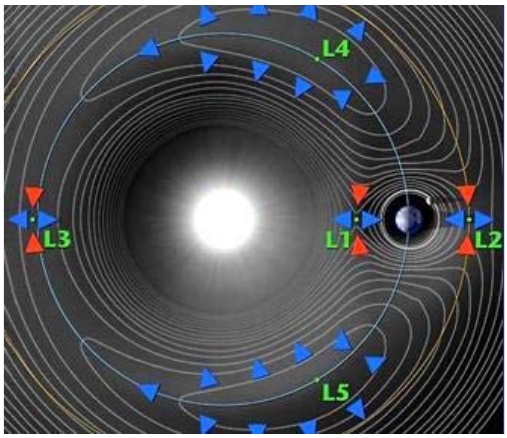
In June 1991, after more than four centuries of slumber, Pinatubo Volcano in the Philippines erupted so violently that more than 5 billion cubic meters of ash and pyroclastic debris were ejected from its fiery bowels producing eruption columns 18 kilometers wide at the base and heights reaching up to 30 kilometers above the volcano's vent.

For months, the ejected volcanic materials remained suspended in the atmosphere where the winds dispersed them to envelope the earth, reaching as far as Russia and North America. This phenomenon caused the world's temperature to fall by an average of 1 degree Celsius.]

But a cleaner way to cool the planet is to put a sunshade in space. There is a natural point, Lagrangian Point or L-1, which is a million miles toward the sun where if you set something orbiting there, then it will kind of stay in line between the Earth and the sun and can permanently cast a shadow on the Earth.

[Editor's Note: The Lagrangian points, also Lagrange point, L-point, or libration point, are the five positions in interplanetary space where a small object affected only by gravity can theoretically be stationary relative to two larger objects such as the Earth and Sun. The Lagrange Points mark positions where the combined gravitational pull of the two large masses provides precisely the centripetal force required to rotate with them. They are analogous to geosynchronous orbits in that they allow an object to be in a "fixed" position in space rather than an orbit in which its relative position changes continuously.

As seen in a frame of reference which rotates with the same period as the two co-orbiting bodies, the gravitational fields of two massive bodies combined with the centrifugal force are in balance at the Lagrangian points, allowing the third body to be stationary with respect to the first two bodies.]



Contour plot of the effective potential of five Lagrange points in relationship to the Earth and Sun. Image by *Wikipedia*.

Putting Sunshade in Outer Space Between Earth and Sun

The numbers that people (Sir Nicholas Stern; U. N.'s Intergovernmental Panel on Climate Change; other scientific research) have worked out say if there is a doubling of carbon dioxide (by the end of this 21st Century) - and that's a target *only* if we are fairly aggressive about switching to renewable energies - we might be able to hold the carbon dioxide increase to doubling. (It could go much higher). Then you would need to shade about 2% of the sunshine that arrives on the Earth. And so, you need a large area of 'stuff' at L-1 – something like 2% of the area of the Earth – and that's a few million square kilometers. So, the problem is – how light can you make this? How could you get this much material out there (a million miles from Earth)? I've figured out how light you could make it, but it would still weigh 20 million tons because there is so much area to fill.

What gets launched are the discs a couple of feet in diameter of very thin material in stacks, nearly a million discs at a time. I've also looked at how you could launch that much mass and this would be by magnetic acceleration in a technique that was developed at Sandia Labs in Albuquerque. When you get out there (at L-1), rather than building a great big structure, my idea is to deploy all this material in literally trillions of very small "space craft." Each one is a couple of feet in diameter and weighs about as much as a big butterfly.

IT WOULD BE ALMOST LIKE MAKING A BIG CLOUD THAT WOULD REFLECT BACK PHOTON ENERGY FROM THE SUN?

It's very much like a little cloud that sits in front of the sun and dims it down a little bit. It would dim it down by no more than thin cirrus clouds – just a very small amount. The light is not actually reflected back to the sun. It's just deviated by a small angle enough so that light that would have hit the Earth is just deviated a little bit away.

Each disc is a couple of feet in diameter. It's thinner than Saran wrap and it's imprinted with some small scale structure on the surface so it diffuses the sun a little bit. As shown in the graphic illustration, sunlight is diffused into a ring shape. So where the light, if it had been only clear material without inscribed patterns, had gone straight through, the light just gets bent a little bit into a donut – it's bent a couple of degrees off the original line. That's enough to make it miss the Earth.

WHAT EXACTLY HAPPENS TO THE SUNLIGHT?

The same as happens to the starlight that gets bent. Instead of heading straight towards the Earth, which is what it would have done if there were no discs there. When light goes through a disc, it gets bent by a couple of degrees in all directions. The sunlight spreads out into a donut shape and misses the Earth, which is in the middle of the donut.

Space Sunshade Is Movable

WHAT IF SOMETHING HAPPENS DURING GLOBAL WARMING, THERE ARE SUDDEN CHANGES AND WE NEED MORE SOLAR ENERGY?

Each of these discs is actually controlled. Unfortunately, this L-1 point in space – if you put something there and you don't control it, eventually it will wander away. It's not able to stay there indefinitely. So in each little 1-gram-disc are rectangular panels which contain some sensors and ways to reflect the sun and put pressure on the individual discs to hold each one in the right place. At any time, you could send out a signal, which says, 'Move to one side.' The discs have in them little solar reflecting panels, or sails, so each disc can move off to one side. The problem is much more keeping them in line (between the Earth and sun) than it is getting rid of them. Their natural tendency is to wander away.

How Urgent Is the Need for An Outer Space Sunshade?

HOW SERIOUS DO YOU THINK GLOBAL WARMING IN THIS CENTURY IS AND HOW MUCH WILL WE PERHAPS NEED SOMETHING LIKE THE SUNSHADE BETWEEN THE EARTH AND SUN?

I think there is a very strong consensus of scientists in the field that it is very serious and it's quite serious in particular for Arizona and New Mexico and the center of the United States because that looks like it's going to heat up more than the general average for the planet.

So, it's a very dire future. If we go on with business as usual, then the normal conditions of Arizona and New Mexico could be more extreme drought than we've ever experienced.

On top of that, snow melt in the Rockies is going to get a lot less because it will melt much earlier. So, the Colorado River and other rivers that supply us might dry out. It's pretty grim. That's not an extremist picture. That's a generally accepted picture.

The largest of the Colorado River-Big Thompson Project's reservoirs, Lake Granby was reduced in parts to mud flats by the ongoing 2004-2006 severe drought, which significantly cut normal spring runoff. Image © 2004 Mark Henle, *The Arizona Republic*.

The question of the speed with which this happens and whether we get into irreversible things like Greenland melting and sea level rising by 20 feet – this we don't understand well enough how quickly that might happen or whether it would happen. But there's a *probability* of it happening.

So, the sunshade idea is like insurance. It's not something you would implement unless you knew that some fairly dire and otherwise uncontrollable consequences were going to happen. Then, if you could reverse what seems to be an inevitable ocean rise and this sunshade gadget would do it, you might think it worth paying for and doing it.

Cost and Time Line to Get Outer Space Sunshade at L-1

HOW MUCH WOULD IT COST AND HOW LONG WOULD IT TAKE TO GET OUT INTO THAT L-1 AREA BETWEEN THE EARTH AND THE SUN?

Actually getting there is like a year or something, so that's not so long. The cost would be a few trillion bucks, the best I can estimate it. The time to do it depends a little bit on how urgently you want to do it. I scaled a time after you get all the launching facilities built, and it would take ten years to get everything up there.

TEN YEARS. I KNOW IN SOME OF THE PROJECTIONS RIGHT NOW FOR TEN YEARS IN THE FUTURE SHOW THE ARCTIC ICE IN THE SUMMER IS EXPECTED TO BE OPEN WATER AND GREENLAND IS MELTING FASTER THAN ANYONE HAD PREDICTED.

GIVEN THE FACT THAT EVERY YEAR WE SEEM TO BE GETTING SCIENTIFIC REPORTS THAT SAY GLOBAL WARMING IS ACCELERATING, WHEN DO YOU THINK WE HAVE TO DO THE SUNSHADE NOW OR WE WILL BE TOO LATE? WHAT IS YOUR OWN PROJECTED DEADLINE AS TO WHEN THIS MIGHT HAVE TO BE DONE?

I can't say that, but I agree with you. Things are speeding up. But you could not attempt a very high tech project like this sunshade without much more research and experimentation to understand the best way to do it. So, what I would advocate is spending some money now.

Nasa spends $15 billion a year and it seems to me they should spend a few percent of that looking at how they might do constructive things to help the global warming problem. My present grant from NASA is $70,000 to look at this a bit more. I would like to see hundreds of millions of dollars go into it – that kind of money could really start to answer the questions. So whereas I'm guessing it might cost a few trillion dollars, if we put some money into research, we would know more exactly.

WHAT IS NASA'S RESPONSE?

At the moment, they are too busy with other things. And as you know, the national priority set by the Administration is not very high in this area of global warming challenges.

IF THE SUNSHADE DOESN'T GET FUNDED AND DOESN'T GET LAUNCHED, WHAT IS YOUR GREATEST WORRY?

My worry at the moment is that we *need* to study ways to cool the planet, like the sunshade and sulfur in the atmosphere or increasing clouds or making more ice on the

oceans. There are many possible alternatives to reducing the heat input from the sun. I think we need to look at them all very hard now and invest money in the research, along with a big effort in renewable energy and ways to cut carbon. These are complementary. We have to cut carbon anyway. But these ideas like the sunshade are in case we just can't move fast enough. We've already put a huge amount of carbon in the atmosphere and we're just beginning to see the effects of that. And if it turns out those effects are very bad already, then for the coming hotter future, we need something like the sunshade.

IS THERE ANYBODY WHO IS STANDING BY AND IS READY TO MAKE THESE MANY TRILLIONS OF SUNSHADES THAT COULD BE LAUNCHED?

The technique of mass production would have to be increased even more than anything we mass produce now. I think we could mass produce now in quantities of millions. We would have to learn how to mass produce in quantities trillions. That's a new level of mass production.

WHEN YOU SAY THAT, IS ONE OF THE BIG STUMBLING BLOCKS THAT A LOT OF PEOPLE WOULD SAY IT'S AN INTERESTING IDEA, BUT IT'S NOT FEASIBLE TO DO?

I think at the moment we don't know how to bring the costs down enough. I quoted in the *Proceedings of the National Academy of Sciences* paper that mass production of high tech things like laptop computers is presently about $100 per kilogram if you bought laptops by the pound! (laughs) We have to get the price of these little discs down to about $20/pound. They are comparable in complexity to a laptop – maybe a bit simpler.

Similarly for the launching, we have to learn a lot. At least I can show that the energy needed to do this electro-magnetic launch is quite affordable. This is how I came up with my cost estimate of a few trillion dollars.

How Long to Produce and Launch Sunshade to L-1?

BUT IF YOU WERE FUNDED TO DO THIS AND THE WORLD SAID, 'YES, WE NEED TO DO THIS,' IT MIGHT TAKE AT LEAST 20 YEARS TO GET ALL OF THIS PRODUCED, LAUNCHED AND IN PLACE?

Yes, it would take at least that long. In the meantime, other techniques like putting sulfur in the atmosphere are sort of quicker fixes for cooling the planet. So, sulfur would probably be the first line of defense, such as creating artificial volcanoes. But they are fairly short-lived. So, the space sunshade would be a longer term fix that would give us more time to cut CO2 levels and so on.

IF WE PUT SULFUR IN THE ATMOSPHERE AS A FIRST STEP TO REDUCING THE IMPACT OF GLOBAL WARMING, WOULDN'T WE THEN HAVE ANOTHER PROBLEM OF ACID RAIN?

It turns out that already far more sulfur is being put into the atmosphere than you need to control global warming. It's just that it doesn't go into the stratosphere where it's useful. So you could actually produce acid rain and the amounts of sulfur in the higher parts of the atmosphere where they would do the cooling job.

MEANING THERE MIGHT BE AN ATMOSPHERIC LEVEL WHERE THE SULFUR IS NOT GOING TO PRECIPITATE DOWN IN RAIN?

Yes, if you go high in the stratosphere, it does a better job of scattering back sunlight. And it also precipitates out much more slowly than from the lower part of the atmosphere. So, you can actually have your cake and eat it, too. You can produce acid rain and increase the scattering in the high atmosphere.

Natural Variability of Earth's Warming and Cooling

WHAT DO YOU SAY TO PEOPLE WHO MAKE THE ARGUMENT THAT THE EARTH HAS BEEN GOING INTO GLOBAL WARMING, AS FAR BACK AS THE DINOSAURS, IN CYCLIC PERIODS AS WELL AS ICE AGES? WHATEVER WE ARE ENTERING NOW MIGHT BE SOME NORMAL CYCLE OF THE EARTH AND WE BETTER NOT TAMPER WITH IT?

No serious scientist, I think, is saying that. The evidence that this is manmade by fossil fuel burning is overwhelming.

AND THE CONSEQUENCES BY THE END OF THIS 21ST CENTURY COULD BE WHAT?

Pretty severe in places on the planet where it goes hotter than average. It's extremely unpleasant. And people who live near the present sea level – there are hundreds of millions of them. If the sea rises 20 or 30 feet, that's the end of their cities. The level of damage is potentially enormous. On that scale, the space sunshade, I believe, would last 50 years. If it costs $5 trillion bucks, that's $100 billion/year. This is much less than 1% of world GDP (gross domestic product). So, even though in absolute terms, the sunshade is very expensive, in terms of cost savings to the planet, it's almost negligible."

More Information:

For further information about global warming, please see reports below in the **Earthfiles Archives:**

• 09/09/2006 -- Methane - Another Threat in Global Warming
• 08/23/2006 -- Solar Cycle 24 - Headed for Intense X Flares by 2010-2012?
• 08/19/2006 -- Repair of Earth's Ozone Layer Has Slowed
• 07/18/2006 -- 2006 - Hottest Year So Far in U. S. History
• 06/24/2006 -- "High Confidence" Earth Is Warmest in 400 Years - Maybe Even 2,000 Years
• 04/08/2006 -- Recent Caribbean Coral Reef Die-Off Biggest Ever Seen
• 03/17/2006 -- Planet Earth's Ice Melt
• 02/20/2006 -- Mysterious Deaths of Whales in Mexico
• 11/18/2005 -- Is the Sun Heating Up?
• 10/07/2005 -- Warmer Sea Surfaces and Increased Wind Power Are Making Hurricanes Stronger
• 09/29/2005 -- 2005 Arctic Summer Ice Melt - Largest On Record
• 09/23/2005 -- 9 X-Class Solar Flares Between September 7 - 19, 2005.
• 09/23/2005 -- Phenomenon of "Instant" Hurricanes in 2005
• 08/26/2005 -- What Is Killing Amphibians Around the World?
• 08/18/2005 -- Unusual Summer Swarm of Arkansas Copperheads
• 08/05/2005 -- Scientists Puzzled by "Bizarre" Pacific Coast Die-offs in 2005
• 05/11/2005 -- Greenland Sea Cold Water Re-Cycling Has Nearly Stopped. Britain Expected to Become Cooler.
• 05/07/2005 -- Did Milky Way Gas and Dust Turn Earth Into Icy Snowball Four Times?
• 02/26/2005 -- Collapse of Societies: From Easter Island to Iraq - to Western World?
• 02/03/2005 -- Kyoto Protocol Goes Into Effect February 16, 2005. British Scientists Warn Global Temperatures Could Climb Higher Than Earlier Estimates.
• 01/22/2005 -- From U. S. to Arctic - A Sea Change in the Weather
• 12/31/2004 -- Abrupt Climate Change Occurred Worldwide 5,200 Years Ago
• 11/02/2004 -- North Pole Summers Without Ice?
• 10/15/2004 -- Ever-Increasing Carbon Dioxide Build-Up in Atmosphere Since 1958
• 09/17/2004 -- Cat 4 and 5 Hurricanes Charley, Frances and Ivan in Four Weeks -Unprecedented in American Recorded Weather History
• 08/27/2004 -- Global Warming Impact On Birds - More Extinctions Expected
• 08/14/2004 -- Oceans Are Absorbing A Lot of Greenhouse CO2. As Chemistry Changes, What Happens to Sea Life?
• 08/01/2004 -- Sixth Straight Year Hundreds of Birds Die at Roestler Lake, North Dakota.
• 02/27/2004 -- Abrupt Climate Change: Scenario from A Pentagon-Commissioned Report
• 11/29/2003 -- Glaciers Are Melting Around the World So Fast That Water Supplies Could Be Threatened
• 10/29/2003 -- Fifth Intense Solar X-Flare - What's Happening On the Sun?
• 05/30/2003 -- Scientists Surprised by Common House Fly Fossils in Antarctica
• 01/05/2003 -- What Are the Grooves in the Martian South Pole?
• 12/14/2002 -- Arctic Rivers' Fresh Water Flows Could Change Atlantic Ocean Current
• 11/14/2002 -- What Happened 12,000 Years Ago That Killed So Many Animals?
• 10/21/2002 -- Mt. Kilimanjaro's Ice Cap Is Melting Fast
• 08/27/2002 -- August 2002: Severe to Moderate Drought in 37 States
• 07/20/2002 -- Extinctions of Earth Life Are Accelerating Rapidly
• 06/04/2002 -- EPA Admits Humans Burning Fossil Fuels A Big Factor in Global Warming
• 03/30/2002 -- Drought Worsens in United States
• 03/21/2002 -- Antarctic Peninsula Is Melting - And So Is Arctic Ice
• 02/13/2002 -- January 2002 Warmest On Record For Whole World
• 01/30/2002 -- Latest Satellite Data Shows Surprisingly Thicker Ross Ice Shelf in Antarctica
• 01/05/2002 -- Global Warming - Could Increasing Carbon Dioxide Gas Be Transformed Into Limestone?
• 12/22/2001 -- Scientists Warn That Climate and Earth Life Can Change Rapidly
• 04/18/2001 -- April Environmental Updates
• 03/24/2001 -- Alps Permafrost Melting
• 03/21/2001 -- Earth Hasn't Been This Warm Since the Pliocene 3 Million Years Ago
• 03/04/2001 -- Disappearing Glaciers - Evidence of A Rapidly Warming Earth
• 02/25/2001 -- Environmental Updates
• 02/18/2001 -- Environmental Updates and Mysterious Deaths of 2000 Atlantic Brant Geese
• 02/07/2001 -- 94% Decline In Aleutian Islands Sea Otter Population
• 01/28/2001 -- U. N. Global Warming Forecast: Up to 10.5 Degrees F. Hotter At End of 21st Century
• 11/26/2000 -- Environmental Updates
• 09/10/2000 -- Arctic Ice Melt Threatens Polar Bears
• 09/10/2000 -- Largest-Ever Antarctic Ozone Hole
• 07/09/2000 -- The "Cell from Hell" Is Back in North Carolina Estuaries
• 07/02/2000 -- Brown Tide Devastating Long Island's Great South Bay Shellfish
• 06/17/2000 -- Spring 2000 - Hottest On Record in U. S.
• 05/07/2000 -- Serious Drought in the Great Lakes
• 04/20/2000 -- Severe Arctic Ozone Loss and Deep Ocean Warming
• 03/12/2000 -- Environmental Updates and Mysterious Fires Near Scott, Arkansas
• 01/13/2000 -- Computer Projections About Earth Weather 2000-2100

• 01/09/2000 -- Global Warming Alert from NOAA and U.K.
• 12/25/1999 -- Y2K Nuclear Concern and Global Warming Update
• 07/25/1999 -- Maryland Fish Kills; Global Warming; and Warm Oceans and Disease
• 06/04/1999 -- Global Warming Linked to Increasingly Warmer and Wetter Winters in Europe & Western North America
• 05/05/1999 -- Two Antarctic Ice Shelves Almost Gone
• 02/28/1999 -- Chickadee Beak Deformities in Alaska

Websites:

Stern Review On Economics of Global Warming: http://www.hm-treasury.gov.uk /independent_reviews/stern_review_economics_climate_change /sternreview_index.cfm

Intergovernmental Panel on Climate Change: http://www.ipcc.ch/

Proceedings of the National Academy of Sciences: http://www.pnas.org/

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