

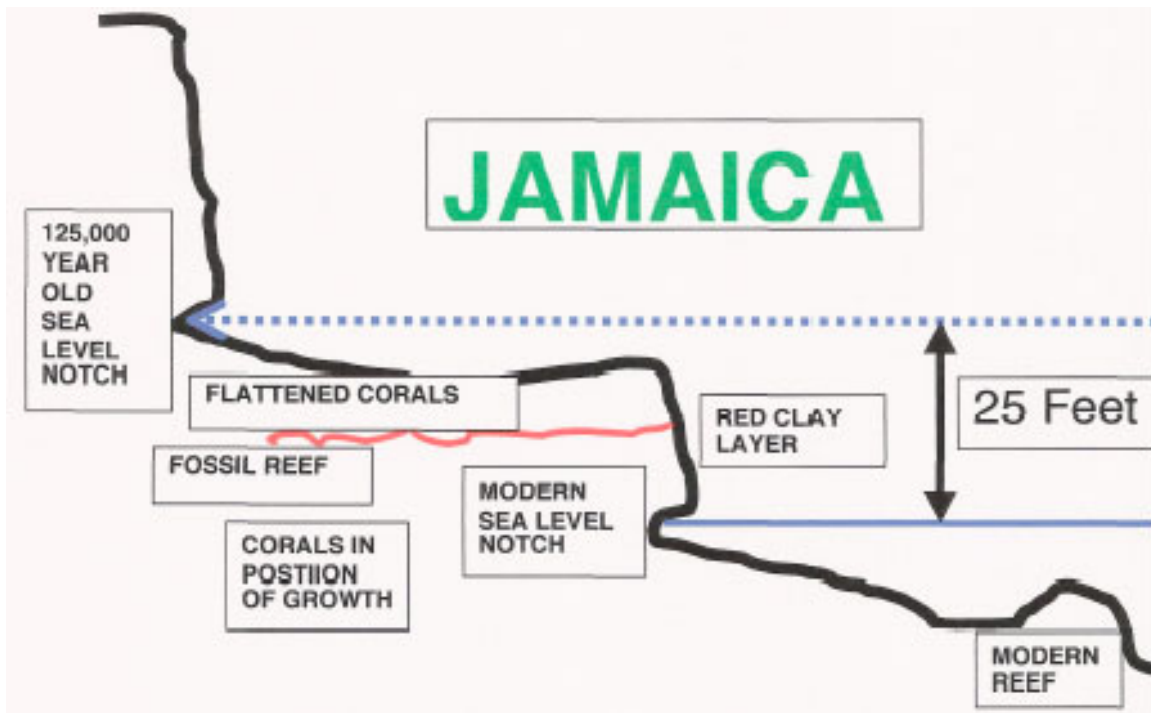
**WHAT IS THE RIGHT TARGET FOR CO<sub>2</sub>?:  
350 PPM IS A DEATH SENTENCE FOR  
CORAL REEFS AND LOW LYING ISLANDS,  
THE SAFE LEVEL OF CO<sub>2</sub> FOR SIDS IS  
AROUND 260 PARTS PER MILLION**

**T. Goreau, PhD  
Delegation of Jamaica**

**Scientific & Technical Briefing  
To the Association of Small Island States  
United Nations Climate Change Conference  
Copenhagen, Denmark, December 7-18 2009**

**SUMMARY**

**THE LONG-TERM SEA LEVEL THAT CORRESPONDS TO CURRENT CO<sub>2</sub> CONCENTRATION IS ABOUT 23 METERS ABOVE TODAY'S LEVELS, AND THE TEMPERATURES WILL BE 6 DEGREES C OR MORE HIGHER. THESE ESTIMATES ARE BASED ON REAL LONG TERM CLIMATE RECORDS, NOT ON MODELS. WE HAVE NOT YET FELT THE CLIMATE CHANGE IMPACTS OF THE CURRENT EXCESS OF GREENHOUSE GASES PRODUCED BY FOSSIL FUELS, AND THE DATA SHOWS THEY WILL IN THE LONG RUN BE MANY TIMES HIGHER THAN IPCC MODELS PROJECT. IN ORDER TO PREVENT THESE LONG TERM CHANGES CO<sub>2</sub> MUST BE STABILIZED AT LEVELS BELOW PREINDUSTRIAL VALUES, AROUND 260 PARTS PER MILLION. CO<sub>2</sub> BUILDUP MUST BE REVERSED, NOT ALLOWED TO INCREASE OR EVEN BE STABILIZED AT 350 PPM, WHICH WOULD AMOUNT TO A DEATH SENTENCE FOR CORAL REEFS, SMALL ISLAND DEVELOPING STATES, AND BILLIONS OF PEOPLE LIVING ALONG LOW LYING COASTLINES. THE GOOD NEWS IS THAT ALL THE TOOLS FOR REVERSING GLOBAL WARMING AND REDUCING CO<sub>2</sub> TO SAFE LEVELS ARE READY, PROVEN, AND COST EFFECTIVE, BUT ARE NOT BEING SERIOUSLY USED DUE TO LACK OF POLICIES AND FUNDING.**



After T. J. Goreau, 1965

A geological cross section of the central North Coast of Jamaica. The solid blue line shows today's sea level, the dashed blue line 7 meters higher (25 feet) is the sea level from 125,000 years ago, the last time global temperatures were 1 degree C warmer than today, and a significant part of the Greenland and Antarctic Ice caps had melted. At the same time London, England (and probably Copenhagen as well) was a tropical swamp with crocodiles and hippopotamuses. At that time modern humans had recently evolved, and had not yet spread out of Africa. The lower part of the fossil reefs has all the corals intact, in position of growth. Above them is thin red layer of clay washed in by large waves, and above it all of the corals were smashed to pieces by huge waves from hurricanes or tsunamis, and lie on their sides. Jamaica has not undergone significant geological uplift or sinking in this time period, the same ancient sea level can be found at sites all around Jamaica, and on many other stable oceanic islands around the world. Older sea level notches, dating from before the Ice Ages, can be seen much higher up on the cliff. If all the Antarctic Ice were to melt due to uncontrolled increases in CO<sub>2</sub>, global sea level would rise around 70-100 meters. That is where we are headed, in the long run, if we don't reduce greenhouse gas concentrations to safe levels.



**The ancient Sea Level Notch at Discovery Bay, Jamaica is 125,000 years old, and is 7 meters above modern sea levels. The sea is visible through the gap. The large rocks on the right are blocks of limestone that fell off the cliffs at that time (this can be shown by the fact that marine fossils grew on them after they fell into the water). 2009 Photo by T. Goreau showing Tracey Edwards, a marine science student at the University of the West Indies, for scale.**

## **WHAT DOES THE PAST SHOW THAT A ONE DEGREE C GLOBAL WARMING WILL MEAN IN THE LONG RUN?**

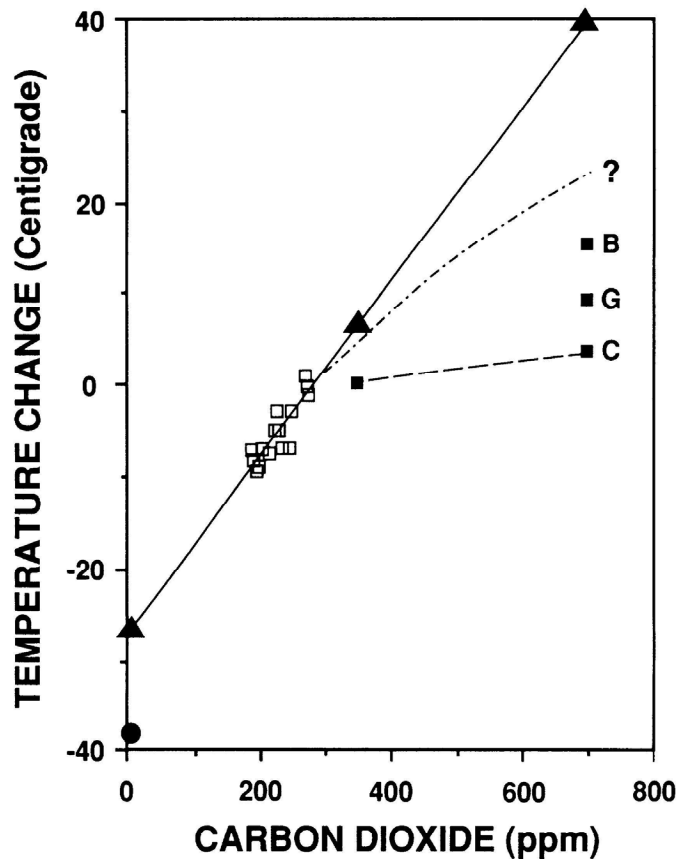
- **The last time it was 1 C warmer than today, 125,000 years ago, sea levels were 7 m higher**
- **Crocodiles and hippopotamuses lived in London, England**
- **Huge waves, bigger than anything we know, flattened coral reefs and created new sand islands**
- **CO<sub>2</sub> was then around 280 ppm, more than 30% lower than it is today**
- **Therefore conditions at that time underestimate long term changes for PRESENT levels of CO<sub>2</sub> (around 390 ppm) even if no more fossil fuels are ever used starting right now.**
- **When it was 4-5 C warmer, sea levels were 70-100 meters higher**
- **IPCC model projections from climate change models must be way too low**

**COMPARISON OF ACTUAL LONG TERM GLOBAL CLIMATE CHANGE RECORDS OVER THE LAST HALF MILLION YEARS WITH IPCC MODEL PROJECTIONS SHOW THAT IPCC MODELS HAVE UNDERESTIMATED THE SENSITIVITY OF TEMPERATURE TO CO<sub>2</sub> AROUND 10 TIMES, UNDERESTIMATED THE SENSITIVITY OF SEA LEVEL TO TEMPERATURE AROUND 100 TIMES, AND UNDERESTIMATED THE SENSITIVITY OF SEA LEVEL TO CO<sub>2</sub> AROUND 1000 TIMES.**

**THESE DISCREPANCIES RESULTS FROM 1) THE FACT THAT IPCC PROJECTIONS ARE BASED ON MODELS FOR A TIME PERIOD OF 20, 50, OR 100 YEARS, WHEN THE RESPONSE OF THE CLIMATE SYSTEM TO INCREASED CO<sub>2</sub> TAKES THOUSANDS OF YEARS, SO MODELS MISS MORE THAN 90% OF THE LONG TERM RESPONSE (AN ARTIFACT OF THE POLITICALLY MANDATED TIME FRAME, WHICH HAS NO RELATION TO THE PHYSICAL RESPONSE TIME SCALES OF THE CLIMATE SYSTEM), AND 2) THE FACT THAT THE MODELS DO NOT INCLUDE THE MAJORITY OF INTERNAL AMPLIFICATION MECHANISMS (POSITIVE FEEDBACKS) KNOWN TO EXIST IN THE CLIMATE SYSTEM.**

**T. J. Goreau, Briefing to AOSIS delegates at the Earth Summit, Rio de Janeiro, 1992**

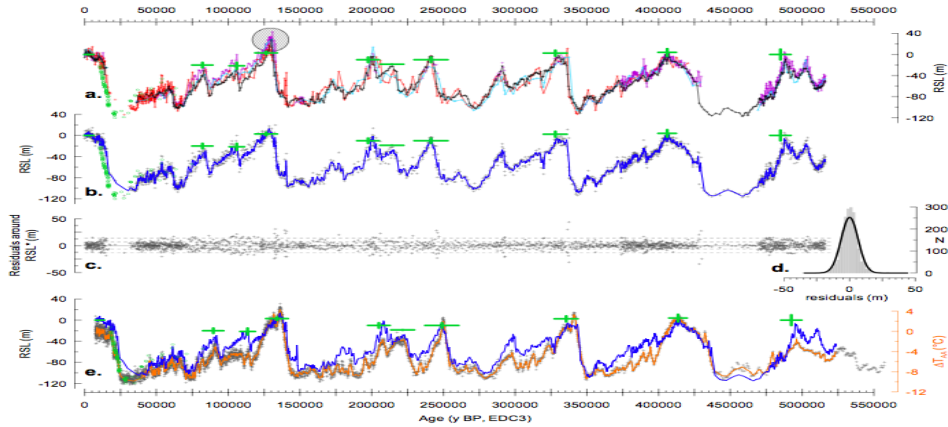
Figure 4. Antarctic ice temperature (centigrade difference from modern temperatures) versus atmospheric carbon dioxide (in parts per million) at 10 000-year intervals over the past 160 000 years (open squares). The straight line is the linear regression to the data. Upward pointing triangles indicate the values predicted from the regression at carbon dioxide concentrations of 0, present levels, and twice present levels. The filled square symbol at 350 ppm, which shows present day mean global temperature CO<sub>2</sub> concentrations, falls around 6 degrees centigrade below the regression line, indicating that global temperatures and current carbon dioxide levels have not yet reached their steady state values. The filled squares at 700 ppm show various predicted temperature increases due to CO<sub>2</sub> doubling. The dashed line indicates predicted 3 degree centigrade increase in global temperature for carbon dioxide doubling, using standard climate models (point C). For the global system to follow this trajectory, sensitivity of temperature to carbon dioxide would have to be 11 times less in the future than it has been over the past 160 000 years. Points marked G and B are based on a recent assessment of geophysical and biogeochemical feedbacks respectively (50), but do not include respiratory feedback mentioned in the text. The curved dot-dash line is a schematic fit to the ice-core data which estimates saturation of carbon dioxide feedback effects. The circular symbol shows the -38 degrees cooling of the Earth without atmosphere greenhouse gases (8). The regression line does not



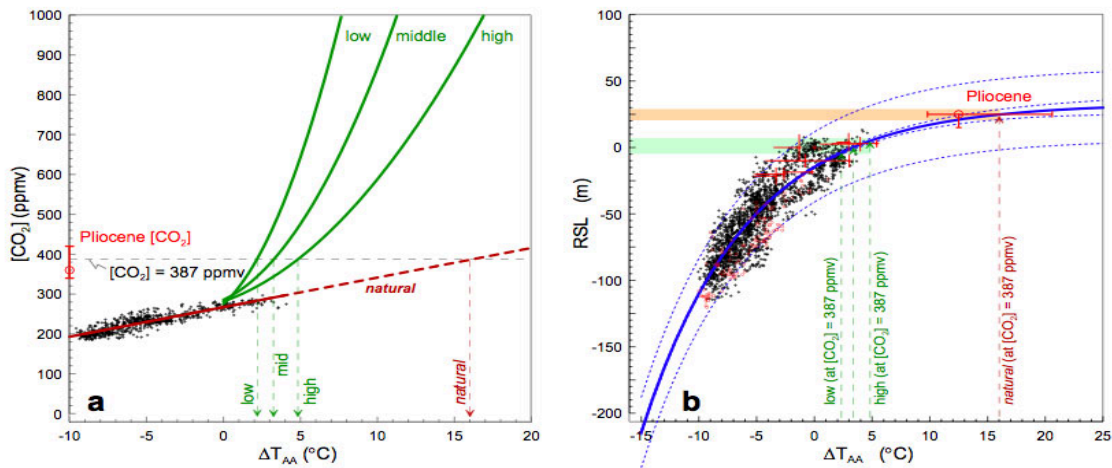
pass through it because without greenhouse gases the entire earth would be frozen, and the equator to pole temperature gradient would be reduced.

T. J. Goreau, 1990, Balancing Atmospheric Carbon Dioxide, *Ambio*, 19:230-236

This paper, written 20 years ago, was the first to show that IPCC had seriously UNDERESTIMATED long-term climate change and that the sensitivity of temperature and sea level to CO<sub>2</sub> in IPCC models was much lower than that actually recorded in ancient climate records. Present temperatures fall below the line because we have not yet experienced the warming caused by the existing excess of CO<sub>2</sub> in the atmosphere. Ignored then, and forgotten now, over the last year the conclusions that paper reached have increasingly become the consensus of most experts working on ancient climate changes. The data below, from a paper published in 2009, repeats the analysis with much more data, and comes to exactly the same conclusions, although not aware of the earlier work.

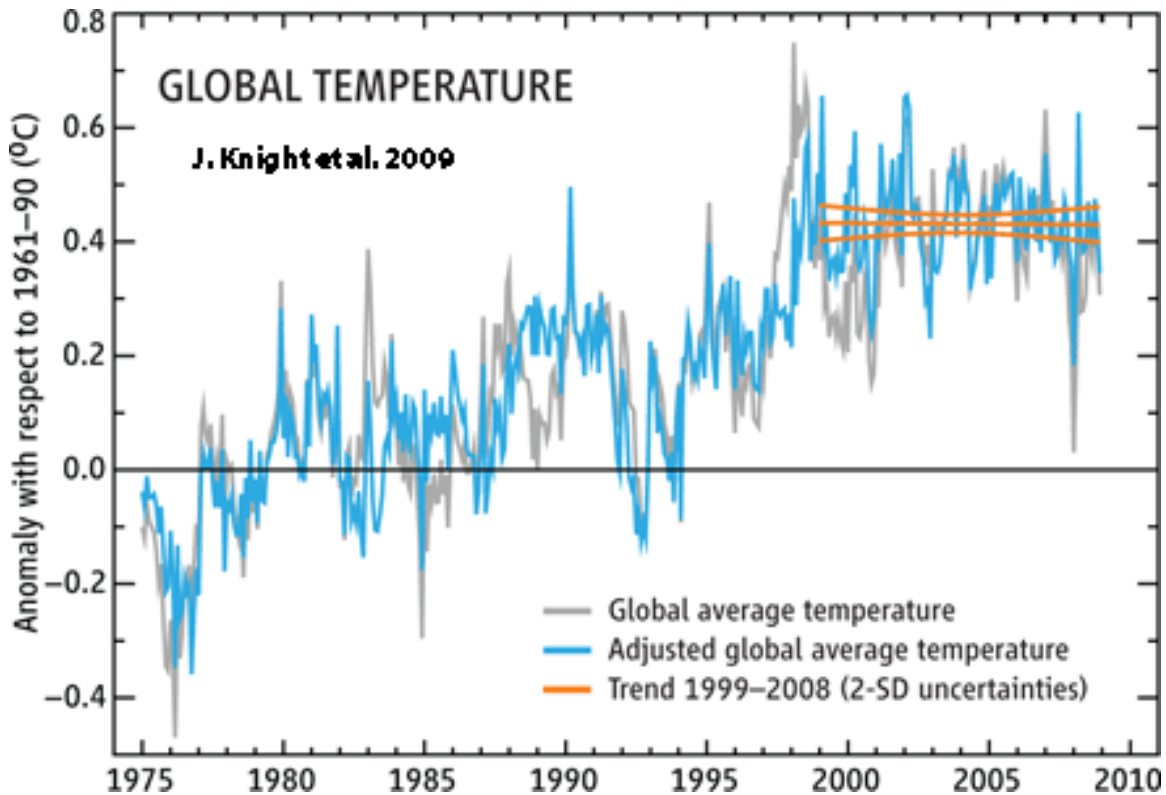


**GLOBAL SEA LEVEL DATA FOR THE LAST HALF MILLION YEARS. NOTE CHANGES OF UP TO 120 METERS AS GLOBAL TEMPERATURES CHANGED BY ABOUT 10 DEGREES C.**



**E. J. Rohling et al., 2009, Antarctic temperature and global sea level closely coupled over the past five glacial cycles, Nature Geoscience, DOI 10.1038/NCEO557**

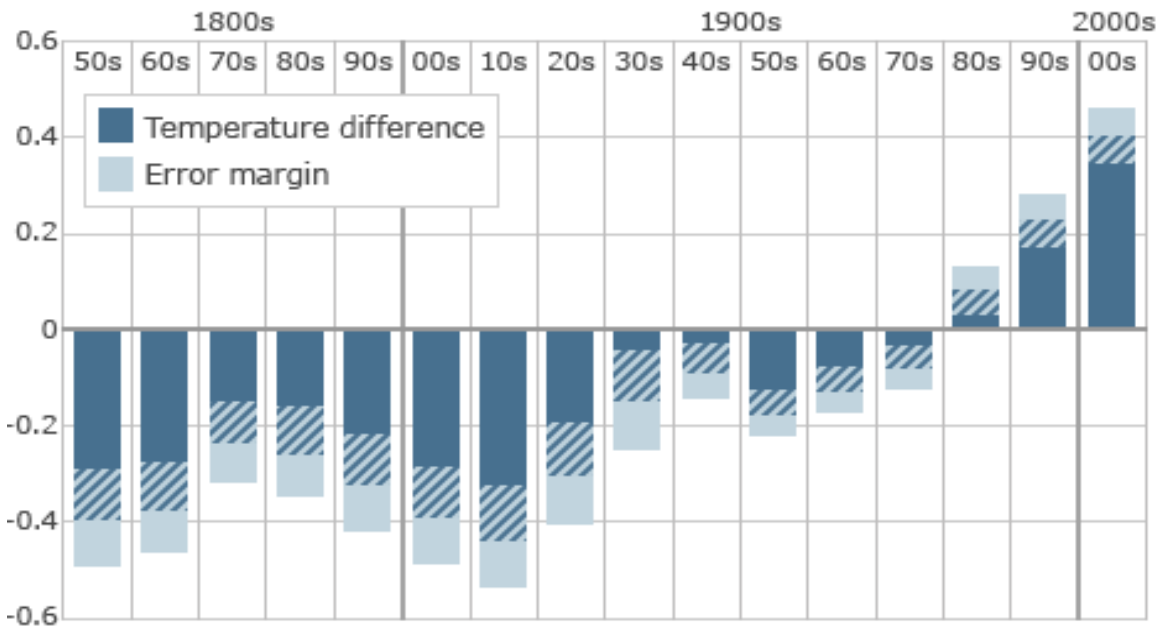
**GLOBAL SEA LEVEL IN EQUILIBRIUM WITH TODAY'S CO2 LEVEL (387 PPM) IS ABOUT 23 METERS (75 FEET) ABOVE TODAY'S LEVEL, AND TEMPERATURES ABOUT 15 DEGREES HIGHER, SIMILAR TO PRE ICE AGE CONDITIONS 5 MILLION YEARS AGO, INDICATING THAT IPCC PROJECTIONS (GREEN LINES) SERIOUSLY AND SYSTEMATICALLY UNDERESTIMATE LONG TERM CLIMATE CHANGE.**



Global surface temperatures have not increased in a smooth way, but by irregular and sudden jumps in 1977-1980 and in 1998, because most of the heat is absorbed by the ocean. The total amount of heat in the ocean is steadily and inexorably increasing, but most of it is now being mixed into the deep sea due to changes in ocean currents, and so is not building up at the surface. It will take about a thousand years for the ocean to fully mix, and only then will we feel the full impact of warming at the surface. The next sudden jump upwards will take place when currents slow down just a small bit (ocean circulation changes are not included in the climate models), and will cause record surface temperatures. Statistically this is likely in 2010, but could come at any time. The UK Met Office, the world's top climate modelers, predict above record temperatures for all of the coming decade.

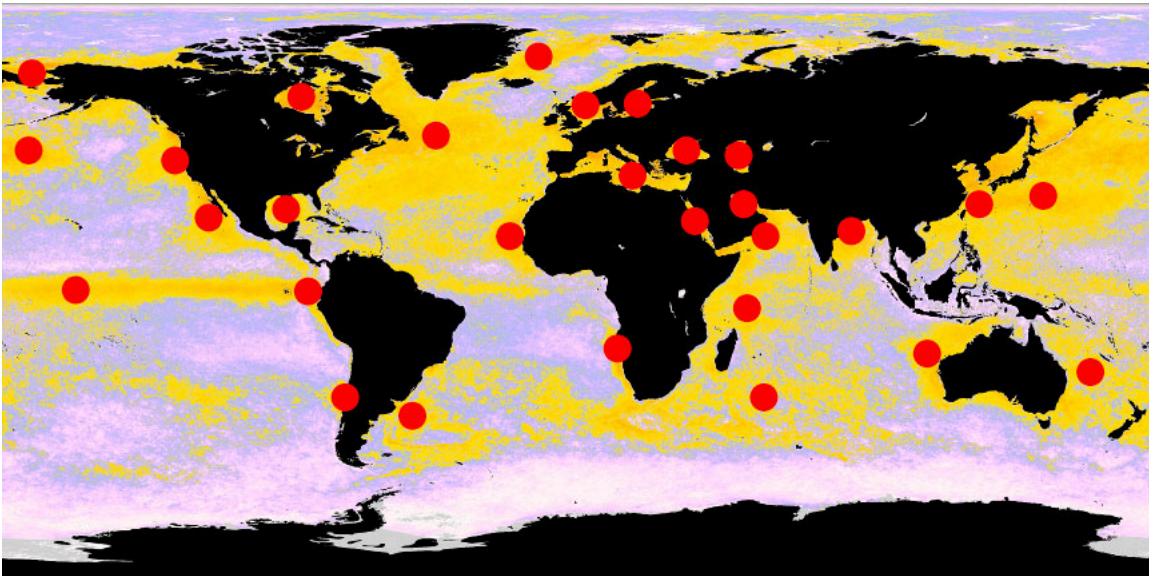
## Global average temperature 1850-2009

Temperature difference from 1961-1990 (°C)



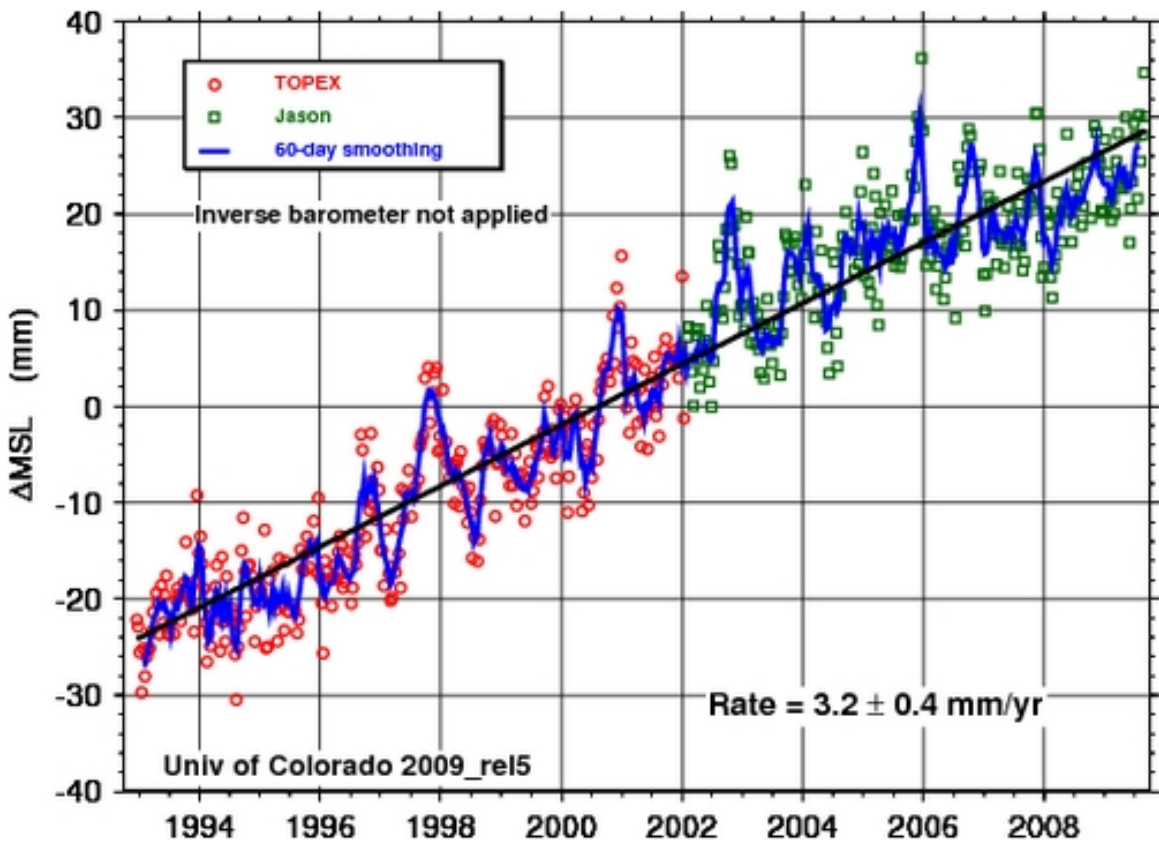
Source: Met Office

**WHEN AVERAGED BY DECADE, THE LONG TERM TRENDS ARE CLEAR!**

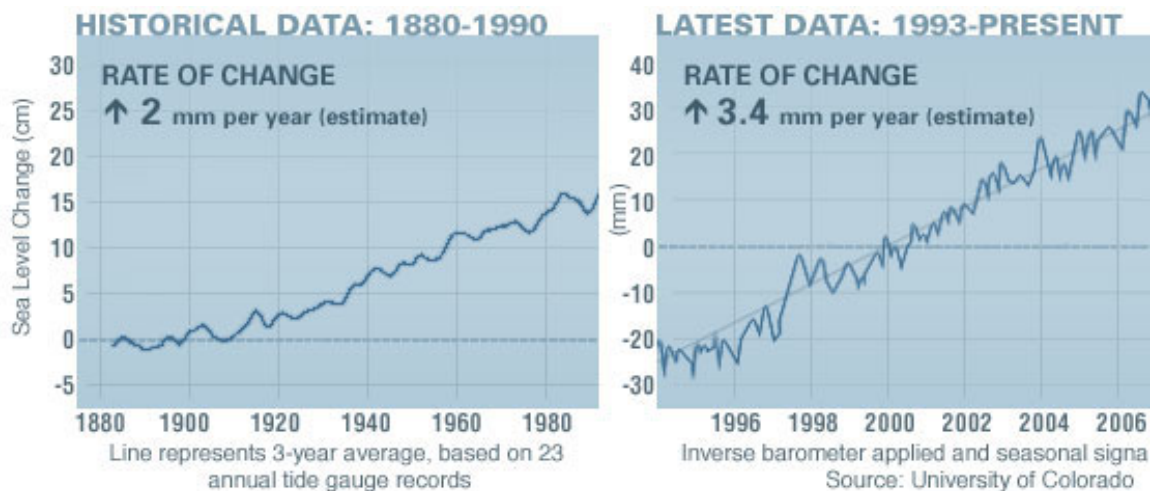


Global patterns of ocean warming, 1982-2003. Higher than average warming in yellow, lower than average warming in blue and white. Almost all SIDS are in the higher than average areas. From T. J. Goreau, R. L. Hayes, & D. McAllister, 2005, Regional patterns of sea surface temperature rise: Implications for global ocean circulation change and the future of coral reefs and fisheries, *World Resource Review*, 17:350-374



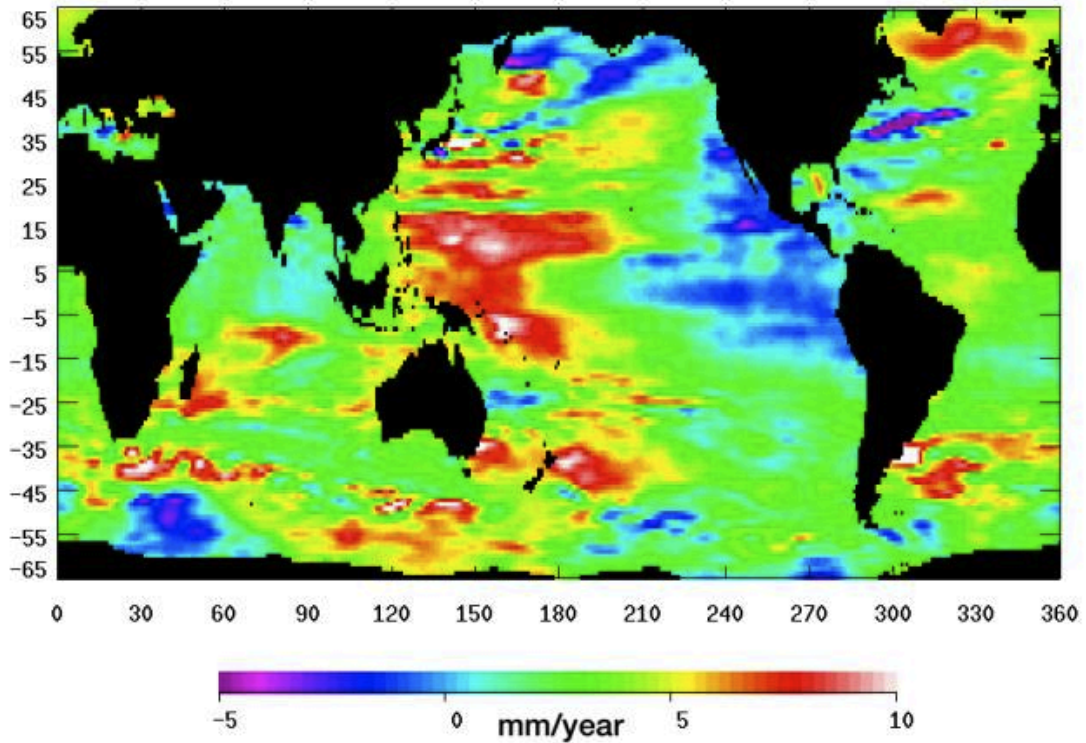


**GLOBAL SEA LEVEL RISE HAS BEEN ACCURATELY MEASURED BY SATELLITES SINCE 1993. IT IS EXPECTED TO INCREASE DRAMATICALLY IN COMING YEARS AS MELTING OF GLACIERS AND THE POLAR ICE CAPS ACCELERATE.**

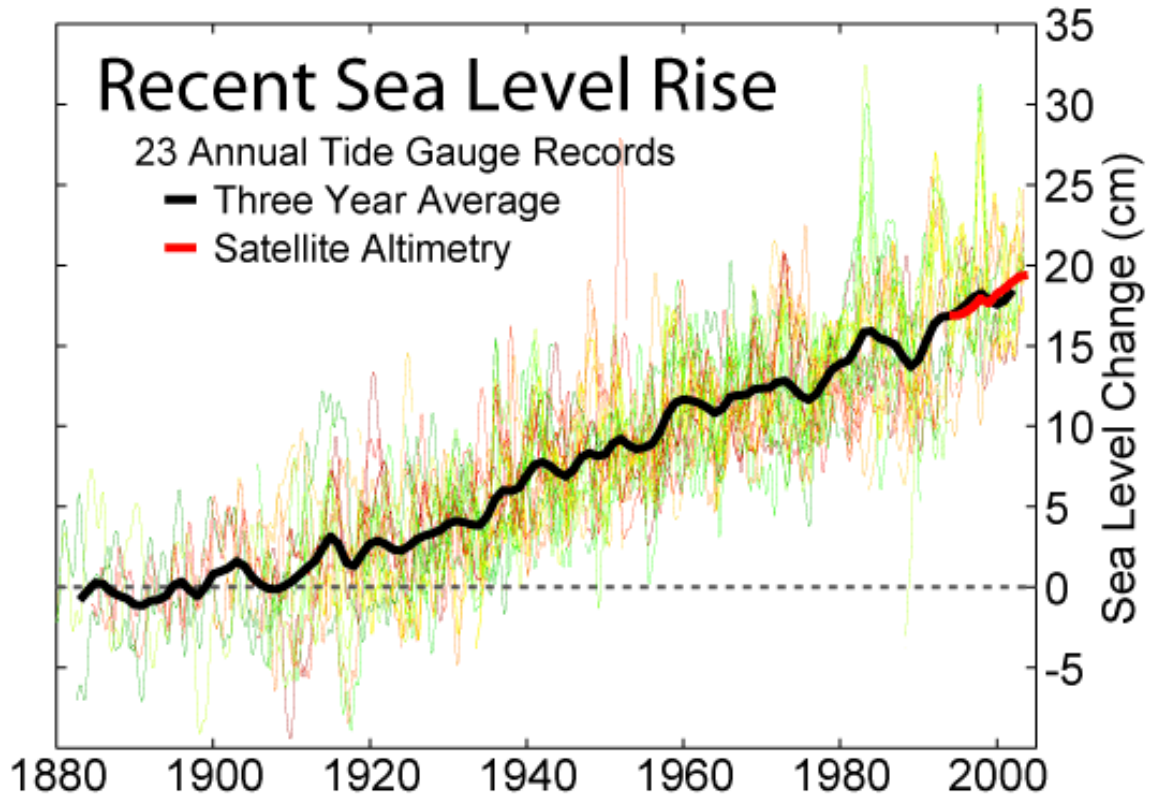


**Sea level rise has accelerated by more than 50% since 1990**

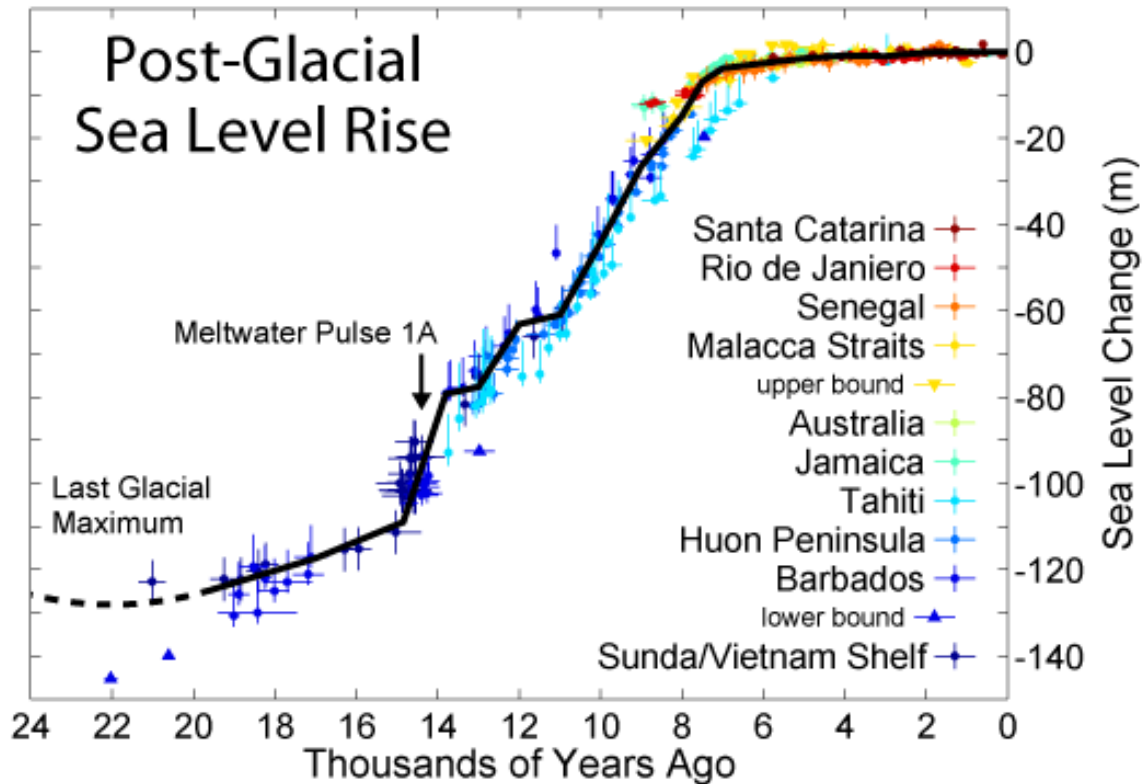
## Trend of Sea Level Change (1993-2008)



**Geographic patterns of global sea level rise, Based on satellite data. Note the extreme vulnerability of many West Pacific and Indian Ocean SIDS. The situation is even more severe for most atolls, which are located on areas of the ocean crust that are sinking by several millimeters per year. Volcanic islands that are undergoing geological uplift will be less affected.**



The satellite sea level data fits well with over 100 years of tide gauge records from ports, but provides coverage of the entire ocean. At the same time other satellite records show significant increases in wind speed, significant decreases in ocean phytoplankton, causing ocean food chains and fisheries to collapse from the bottom up (although usually blamed on the over-fishing that is collapsing fisheries from the top down at the same time), and large increases in atmospheric moisture, which acts to amplify the greenhouse effect many times because water vapor absorbs heat even more effectively than CO<sub>2</sub>.



Long term sea level changes show that sea level has been stable for the last 7000 years, and that the increases of the last 100 years (which do not show on this scale) are similar to those at the end of the last Ice Age when the Ice Caps of Europe, Asia, and North America melted. Note that there were sudden increases in sea level of tens of meters when ice melting surged. This could happen again if human-caused climate change is not brought under control.

THE SITUATION IS FAR WORSE THAN RECOGNIZED, AND THEREFORE CORRECTIVE ACTION IS FAR MORE URGENT. NEVERTHELESS INNOVATIVE, COST EFFECTIVE, PROVEN, BUT UNDERUTILIZED TECHNOLOGIES EXIST THAT COULD BE RAPIDLY RAMPED UP TO REVERSE GLOBAL WARMING. THESE WOULD PUT OUR PLANET, ECOSYSTEMS AND PEOPLE BACK ON A SAFE AND SUSTAINABLE PATH, BUT WE ARE NOT USING THEM DUE TO LACK OF POLICIES AND FUNDING. MANY OF THESE SOLUTIONS ARE INCLUDED IN A MULTIMEDIA DVD (THE GREEN DISC: NEW TECHNOLOGIES FOR A NEW FUTURE) THAT IS BEING LAUNCHED AT COP-15 OF UNCCC BY THE UNITED NATIONS COMMISSION ON SUSTAINABLE DEVELOPMENT PARTNERSHIP IN NEW TECHNOLOGIES FOR SMALL ISLAND DEVELOPING STATES. THAT DISC ACCOMPANIES THIS BRIEFING. THE SOONER THEY ARE IMPLEMENTED, THE LOWER THE COST WILL BE.

**SIDS' CORAL REEFS, FISHERIES, SAND SUPPLIES, BEACHES, TOURISM, SHORE PROTECTION, AND MARINE BIODIVERSITY ARE ALREADY AT THEIR UPPER TEMPERATURE LIMIT AND CAN TAKE NO FURTHER WARMING! SIDS HAVE ALREADY LOST MOST OF THEIR CORALS IN THE LAST 20 YEARS. LOW LYING ISLANDS AND COASTLINES CAN TAKE NO FURTHER SEA LEVEL RISE. THE "TARGETS" OF 1.5 DEGREES C RISE AND 350 PPM CO2 ARE A DEATH SENTENCE FOR CORAL REEFS AND A SUICIDE PACT FOR LOW LYING ISLANDS AND COASTS.**

**THESE TARGETS APPEAR TO BE PROGRESIVE ONLY WITH REGARD TO THE SMOKE-SCREEN PROPOSALS BEING OFFERED BY THE BIG FOSSIL FUEL CONSUMERS AND PRODUCERS, WHICH ARE DESIGNED TO ALLOW BUSINESS AS USAL TO CONTINUE, AND TO MINIMIZE DISRUPTION TO THEIR PLANET-DESTROYING, BUT HIGHLY PROFITABLE, PRACTICES. THE TARGETS BEING OFFERED BY SIDS MUST BE BASED ON THE BEST SCIENCE TO PROTECT OUR REAL LONG TERM INTERESTS. WHAT WE HAVE AT PRESENT IS SERIOUSLY INADEQUATE, UNREALISTIC IN THE LONG RUN FROM A SCIENTIFIC PERSPECTIVE, AND SO IS ULTIMATELY SELF-DEFEATING. WE CANNOT AFFORD TO FOOL OURSELVES AND SACRIFICE OUR LONG TERM FUTURE.**

**UNCCC NEEDS TO ADOPT SCIENTIFICALLY SOUND TARGETS THAT REVERSE CO2 BUILDUP IN ORDER TO AVERT THE WORST IMPACTS AND PRODUCE MEANINGFUL AND COST-EFFECTIVE SUSTAINABLE DEVELOPMENT. THE SOONER WE DO SO, THE LOWER THE COST WILL BE AND THE GREATER THE BENEFITS. THE SOLUTIONS ARE IN HAND IF ONLY WE CHOOSE TO GRASP THEM.**

## **CONCLUSION**

**Current “targets” for CO2 being discussed by UNCCC are way too high to prevent the extinction of coral reefs (which can take no further warming, since most corals have died in the last 20 years from heat shock) and the disappearance of all low lying islands and coastlines where billions of people live. Even a target of 350 ppm is UNACCEPTABLE if we are to avoid dangerous interference with the Earth climate system, causing inconceivable ecological, environmental, and economic disaster. Global warming must not be allowed to continue as would happen by stabilizing CO2 and temperature at present levels. Greenhouse gas buildup MUST BE REVERSED, and CO2 reduced to levels of around 260 ppm, below Pre-Industrial levels. The technologies to do so are proven, cost effective, and capable of being rapidly ramped up, but are not being used on the scale needed due to lack of serious policies and funding to reverse global warming and stabilize the climate system at safe levels. THAT IS WHAT AOSIS AND UNCCC MUST ACCOMPLISH IF WE ARE TO PRESERVE OUR PLANET’S LIFE SUPPORT SYSTEMS FOR FUTURE GENERATIONS. The solutions are already in hand. Let’s all get serious and stop stealing our children’s future!**

**The author is President of the Global Coral Reef Alliance, an international NGO for restoration of coral reefs, and a member of the Jamaican delegation to UNCCC. Previously he was Senior Scientific Affairs Officer at the United Nations Centre for Science and Technology for Development, in charge of Global Climate Change and Biodiversity issues, where he contributed to the original draft of the UN Framework Convention on Climate Change. Dr. Goreau developed the HotSpot method used for the last 20 years to predict coral bleaching from satellite data. He was educated in Jamaican schools, MIT (BSc in Planetary Physics), Caltech (MSc in Planetary Astronomy), and Harvard (PhD in Biogeochemistry). He has swum and dived on reefs around the world since he was a small child, including most SIDS. His father was the first marine scientist in the world to use diving as a research tool and founded the Marine Science Program at the University of the West Indies.**

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