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# AT: Transportation Infrastructure

#### C/I – transportation infrastructure includes pipelines

NDU Report 11 (National Defense University Fort McNair, Washington, D. C. – The Industrial College of the Armed Forces – Final Report: Transportation Industry – Spring 2011 – panelists include: Mrs. Stacy Cummings, Department of the Navy. Seminar Leader LtCol Anthony Barnes. U.S. Marine Coips Mr. William Boden, Computer Sciences Corporation, (CSC) LtCol Mike Brantley, U.S. Air Force Mr. Michael Breslin, Department of Homeland Security (DHS) Mr. Charles E. Brown, Defense Logistics Agency (DLA) Mr. Bart Merkley, Department of Homeland Security (DHS) – <http://www.ndu.edu/icaf/programs/academic/industry/reports/2011/pdf/icaf-is-report-transportation-2011.pdf>)

The United States has the largest transportation system in the world with an extensive physical infrastructure that moves both people and freight. As an industry it consists of five modes: aviation, highway, maritime, pipeline and rail. In 2009, transportation related goods and services contributed $1.2 trillion to the U.S. Gross Domestic Product and employed over 3.5 million people.3 The U.S. transportation infrastructure includes 4 million miles of public roads, 160,000 miles of railroad track, 25,000 miles of navigable waterways, 9,800 coastal and inland waterway facilities, nearly 400,000 miles of oil and fuel pipelines, and 5,200 public-use airports.5 The aviation industry provides for the movement of passengers and freight by both large and small air providers. In 2010, over 785 million passengers traveled by air.6 The economic downtiin had a significant impact on the airline industry; passenger miles are still down from their total of 81 million in 2008.7 In 2009. 27 percent of international freight, both imports and exports, moved by air.8 The U.S. National Highway System is made up of the Interstate Highway System, arterial roads that support commerce and trade, and the Strategic Highway Network (STRAHNET), which are highways important to military mobilization, and roads that connect inteimodal facilities.9 It handles a tremendous amount of vehicular traffic to include heavy equipment. The total vehicle miles traveled on all U.S. public roads increased from about 1.5 trillion miles in 1980 to more than 2.5 trillion miles in 2009. Based on current and historical trends, traffic congestion in metropolitan areas is expected to increase, due to population growth, urbanization, increasing freight traffic, and roadway maintenance activities.10 The U.S. water transportation industry serves the needs of both foreign and domestic commerce and includes companies that cany freight or passengers on the open seas or inland waterways, offer towing services, charter vessels, and operate canals and terminals. In 2009, U.S. water trades (foreign and domestic) amounted to 2.0 billion metric tons. In 2009, container trade accounted for 17 percent of U.S. waterbome foreign trade, up from 14 percent five years before. Ir 2009, 44 percent of U.S. foreign trade by value was moved by vessel, up from 42 percent five yean earlier. In 2009. 6,996 oceangoing vessels made 55,560 calls at U.S. ports. The pipeline infrastructure, comprised of over 168,000 miles of liquid pipelines and 217,000 miles of gas pipeline, carries over 71 percent of petroleum transported in the United States and is one of the most strategically important parts of the transportation network relative to energy distribution.13 Typically the oil or gas production company owns a significant share of the transportation pipeline system which is operated commercially. They transport oil and natural gas to and from refineries and for distribution to homes and businesses around the country.

#### Department of Transportation is the only fair brightline

USA Gov 12 (<http://www.usa.gov/Agencies/Federal/Executive/Transportation.shtml>)

The Department of Transportation establishes the nation's transportation policy. It oversees highways, mass transit, railroads, aviation, ports, pipelines, and more.

#### **That excludes energy infrastructure**

Monast 8 (PhD, Director of the Climate and Energy Program at Duke University’s Nicholas Institute for Environmental Policy Solutions Jonas, “From Carbon Capture to Storage: Designing an Effective Regulatory Structure for CO2 Pipelines,” <http://www.nicholas.duke.edu/ccpp/ccpp_pdfs/co2_pipeline.pdf>)

The Surface Transportation Board (STB) and the Federal Energy Regulatory Commission (FERC) are responsible for pipeline regulation on the federal level for issues other than pipeline safety. The STB has limited authority over interstate pipelines transporting “a commodity other than water, gas, or oil.” The FERC has authority over interstate pipelines carrying natural gas or oil, although the specific regulatory powers differ for the two types of pipelines. In each circumstance, post‐construction pipeline safety is governed by the Department of Transportation’s Office of Pipeline Safety (OPS). The OPS has specific jurisdiction over CO2 pipelines. Regulation of pipeline construction, transportation rates, and operation of CO2 pipelines—especially CO2 piped as a waste product destined for storage— falls into a gray area at the federal level. It is generally accepted that the STB has jurisdiction over CO2 pipelines, but that authority has not been tested. Furthermore, the limited regulatory regime covering CO2 pipelines occurred by default and not as a result of a deliberate congressional or administrative decision. Instead, the legal framework that granted jurisdiction over oil and natural gas pipelines to the FERC and jurisdiction over other pipelines carrying other commodities to the STB was established long before the concept of CCS existed. Given the rapid expansion of CO2 pipelines expected in the coming years as industry begins deploying CCS technologies to reduce GHG emissions, it is prudent for regulators to take a fresh look at the appropriate regulatory structure(s) to govern CO2 pipelines.

#### **CO2 pipelines are transportation infrastructure**

Svennson et al 5 (R and D analyst @ Vattenfall Rickard, Transportation Infrastructure for CCS – experiences and expected development, <http://uregina.ca/ghgt7/PDF/papers/poster/350.pdf>)

CO2 Capture and Storage (CCS), i.e. capture and storage of carbon dioxide (CO,) emitted from large point sources of emissions, has the potential of a significant and relatively quick response to climate change at reasonable cost. In order to reach widespread commercialization of CCS it is crucial to demonstrate the concept in large-scale projects, reduce costs, build infrastructures for transportation of C02, establish a legal framework and reach acceptance by the public. Most research on CCS deals with capture technologies and storage possibilities (e.g. in connection to Enhanced Oil Recovery (EOR) projects and in saline aquifers). This, since capture represents the highest cost and storage is critical with respect to long-time security and monitoring. Still, there is a need to identify and structure transportation alternatives in order to analyse and evaluate future paths comprising CCS. In a previous work on transportation of C02 [1] the costs and capacities have been investigated by means of analysing type scenarios for different means of transportation, i.e. truck, train, ship and pipeline. It was concluded that transportation by means of pipeline and ship gave feasible logistics and costs. Still, there were large variations in costs depending on the scenario studied (amount of CQ2 transported). The present paper continues the previous work with the aim to illustrate how a CCS transportation infrastructure can be developed applying pipeline and ship transportation. Pipeline transportation Previous Experiences CQ2 pipelines have been in use since the early 1970s in the linhanced Oil Recovery (EOR) industry. The first C02 pipeline construction was completed in 1972 when the Canyon Reef Carriers (CRQ built a 354 km C02 pipeline to the SACROC oilfield in Texas, USA. The largest existing CQ2 pipeline is the 808 km long Cortez pipeline from Cortez in Colorado to Denver City in Texas, which was put into operation in 1984. The Cortcz pipe line is made of API 5LX-65 carbon steel with a diameter of 762 mm [2], delivers about 20 Mt of C02 per year to the C02 hub in Denver and constitutes an important part of the C02 infrastructure that delivers C02 to the oilfields in Texas, Examples on other C02 pipelines in use arc the 330 km long Weybum pipeline, the 648-km long Sheep Mountain pipeline and the 338-km long Bravo pipeline. Design of a C02 pipeline Existing large-scale C02 pipelines are all designed for dense phase/supercritical conditions, i.e. a O02 pressure above 7.38 MPa. This gives a high density compared to gas transmission and material requirements for cryogenic conditions and frost heave arc avoided. When using C02 forliORthe miscibility pressure of O02in oil becomes important. The miscibility pressure of C02 in oil is usually above 8.3 MPa and often as high as 16-20 MPa and the delivery pressure of the C02 at the injection site is therefore often set at a relatively high level, i.e. a C02 pressure above 10 MPa. To maintain the O02 at this condition, typical operational intervals for temperature and pressure of the C02 are 15-30\*0 and 10-15 MPa, respectively [3], However, due to the special properties of CQ2 it is not easy to maintain the C02 within such intervals. Pipelines suffer from pressure drops and to maintain the pressure between 10-15 MPa, recompression stations must be installed along the route, further, the compressibility and density of O02 show strong, nonlinear dependence on the pressure and temperature, which make it difficult to fully predict the C02 flow. At the critical point of C02 (738 MPa and 31"C) a small change in temperature or pressure yields a large change in density, e.g. the density doubles with a change in temperature from 47 to 37\*0 at a constant pressure of 9.0 MPa. Thus, due to that the flow behaviour for C02 is complicated to predict, the calculations of the hydraulic characteristics for pipeline transportation of C02 is important Small amounts of impurities also affect the properties of C02, e.g. small additions of methane (CH4) affect the vapour pressure of C02 [5]. Other impurities which normally occur arc H2S, C2, N2 and water (H20), which all change the 002 properties and therefore need to be reduced to levels that can be handled. Among these impurities, water is most critical since C02 in equilibrium with liquid water form an acid gas that causes so called sweet corrosion, and that C02 in presence of water form hydrates (solid ice-like crystals), which can plug equipment and flow lines, fouling heat exchangers etc [6]. These problems make it necessary to dehydrate the C02 to low water contents. The maximum allowable water content in the C02 flow is typically 0.4x10-3 kg'm3n [5], although this figure depends on the amount of other impurities. Thus, it is recommended that the allowable water content at the proposed operating conditions is determined experimentally [6]. If possible, a common standard for levels of impurities in the C02 fluid should be established. The other main impurity that must be considered in EOR projects is H2S. This, since H2S is dangerous to life at concentrations as low as 300 ppm. In existing C02 pipelines, the H2S concentration has been limited to less than 100 ppm in the CQ2 flow [4]. Ship transportation Experiences Transportation of commodities by ship has always been very cost-effective due to the large loading capacity. Experiences of large-scale ship transportation of C02 are limited with previous applications mainly found in the food and brewery industry with amounts transported in the range of some 100,000 tons of CO, annually, i.e. much smaller quantities than the amounts associated with CCS [1]. Since the transportation conditions for C02 showr similarities with Liquefied Petroleum Gas (LPG) [8], which is transported by ship at a relatively large scale, experiences and design criterion for LPG shipping can be used in the establishment of a large-scale C02-transportation infrastructure. Ship transportation Experiences Transportation of commodities by ship has always been very cost-effective due to the large loading capacity. 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This capacity is too small to effectively transport the amounts of C02 that is associated with CCS. Lor LPG, there are three types of ship design: low temperature type, which is designed to keep LPG liquid at a low temperature and atmospheric pressure, the pressure type which is designed against the boiling point of LPG maintaining the LPG liquid at ambient temperature and, the scmi-ref type which is a combination of both, i.e. the ship is both pressurised and cooled. Seen from a bulk-transportation perspective, the low temperature type is preferable due to that this design does not require pressurised tankers. Existing low temperature ships have a capacity of up to 80,000 m3 [10]. This option is, however, not possible for 002 ships due to that 002 at atmospheric pressure only can exist in gaseous or solid phase, but not as a liquid. The best option for CQ2 for bulk transportation is the semi-ref type design, A standard semi-ref LPG ship has a capacity of 22,000 m3, i.e. 24,000 ton C02, and is designed for a pressure of 0.7 MPa and a temperature of -50°C. Such a ship should be suitable for C02 transportation. Since ship transportation does not allow a continuous flow from source to storage location, the logistics must include appropriate intermediate storage facilities to handle reloading of C02 (e.g. in harbours). There are two main technologies for intermediate storage of LPG, either underground in great rock and salt caverns, or in large steel tanks above ground. At present only the steel tank technology is used for C02, but also storage in cavern can be applied. Existing rock caverns for LPG have storage capacities of up to around 500,000 m3 LPG [11], which approximately correspond to 500,000 tons of C02. Steel tanks have storage capacities up to 3,000 tons of CQ2 [9]. Transportation scenarios Based on the technical criterions for C02 transportation by pipeline and ship, briefly outlined above, and the scenarios employed in the previous study [1], three scenarios have been further evaluated with respect to costs, capacity, distance, and means of transportation. The scenarios correspond to a small-scale "start-up" case of 1 Mt/y of C02 (Sl-1, Sl-2 and Sl-3), a large-scale single-source case of 10 Mt'y of C02 (S2-1, S2-2 and S3-2), and a fully developed and coordinated infrastructure with a capacity of 40 Mt'y (S3-1). Table 1 lists the different scenarios with respect to combinations of transportation modules, transportation distance and capacity. The cost calculations have assumed a depreciation time of 25 years at 5% interest rate. The resulting costs obtained from the scenario calculations are given in Figure 1. Discussion Commercialization of CCS will mean that a transportation infrastructure must be developed and built over time. Such a development will, however, mainly depend on the transportation cost, which in turn depends on transportation distance between source and storage site and if coordinated networks are possible to establish. Prom Kgurel it can be seen that from a cost perspective a short distance is obviously the best option for both large and relatively small power plants (-1 Mt/y of C02). Short distances may of course not always be an option. In addition. relocation of fossil-fuelled (especially lignite) power plants in order to achieve short transportation distances will probably not occur. Power plants are situated near the fuel reserves and/or electricity consumers in order to minimise freight and transmission costs and it is likely that also new power plants have to be located at such already developed sites. Still, if CCS is employed, there will be three commodities to be considered; C02, electricity and fuel. The complexity and cost of a C02 infrastructure arc lower than the infrastructure cost of solid-fuel and of electricity transmission. This, since C02 can be transported at steady-state flow in a pipeline whereas solid-fuel transportation is mostly carried out by railway and electricity transmission suffers from losses. Tor a large power station located far from the disposal site, a single pipeline from source to sink could be used. A single network is, however, believed to have an upper capacity limit This is not because of technical limitations but due to that single storage regions will have upper limits in receiving rate. If several power stations can use a coordinated network, the transportation costs are lowered. l;rom a European perspective, such networks will probably be established offshore to take advantage of early LX)R opportunities. A future large-scale vision of 300 Mt/y of CG2 will therefore be built up of several coordinated networks from suitable areas to neighbouring disposal sites, with capacity and infrastructure similar the case represented by scenario S3-1. This also means that the transportation cost per ton of C02 is expected to be similar to that of S3-1, i.e. about 2 €/ton. Such a coordinated network could also include ship transportation. Ships are more flexible than pipelines when it comes to adaptability of capacity and transportation route, and a transportation system including both ships and pipeline will therefore make the infrastructure more adaptable to variations in the infrastructure of the storage location. CoDclusions The development of an infrastructure for C02 transportation is expected to start with a small-scale demonstration plant. Tor such a case onshore disposal near the CQ2 source is the least expensive transportation alternative, with a cost of around l&ton of C02 (Sl-1). However, onshore storage may not be an option for a first demonstration project of this size and if so, the present analysis shows that the transportation costs to an offshore storage site would be 7€/ton of CQ2 when transported by ship (Sl-2). Obviously, coordinated networks must be established in order to bring down the transportation costs to the figures normally mentioned for CCS, i.e. to a cost of around 2€/ton as obtained in this study for the coordinated network (S3-1). The latter figure should also be valid for a large large-scale vision of 300 Mt/y of C02, and can be compared with the target of 20€7ton of C02 avoided, as set by the European Climate Change Programme (LCCP) [12].

# Carbon Isn’t Energy

#### **CO2 is a byproduct of energy, not energy itself**

National Academy of Sciences No Date (“What you need to know about energy: Glossary”, <http://needtoknow.nas.edu/energy/glossary/>)

Carbon Dioxide (CO2)

A colorless, odorless, non-poisonous gas consisting of one carbon and two oxygen atoms. A by-product of fossil fuel combustion and other industrial processes, it is considered a greenhouse gas because it traps heat (infrared energy) radiated from Earth within the atmosphere. For this reason, CO2 is believed to be a major contributor to human-induced climate change.

# Carbon = Commodity

#### It’s a good, not energy

Forbes et al 8 - senior associate at the World Resources Institute, former member of the National Energy Technology Laboratory

Sarah, CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage, World Resources Institute, http://pdf.wri.org/ccs\_guidelines.pdf

CO2 used for carbon dioxide capture and storage is typically in the supercritical stage, where the density resembles a liquid but it expands to fill space like a gas. Supercritical CO2 is purchased, as a commodity, for use in many industrial processes. In the climate change context CO2 is most often classified as an important greenhouse gas, an emission, or—in some countries—a waste. There is concern that the classification of CO2 under various U.S. regulatory programs (e.g., air, waste, drinking water protection) may trigger unintended requirements that impose increased cost without increasing project performance or safety.

# Contextual Evidence

#### CO2 pipelines are transportation infrastructure

Chrysostomidis et al 9 - Masters in Environmental Management and Sustainability from IIT Stuart Graduate School of Business

Ioannis, Assessing issues of financing a CO2 transportation pipeline infrastructure, January, http://www.co2captureproject.org/viewresult.php?downid=152

For carbon dioxide capture and geologic storage to be deployed commercially and in a widespread manner will require well thought out approaches for transporting the CO2 in a pipeline system from the capture facility to the injection site. Establishing a widespread CO2 transportation infrastructure will require strategic long-term planning, taking into account the potential magnitude of future deployment scenarios for CCS, up to a scale of infrastructure that could be comparable to the scale of oil & gas infrastructure. This paper outlines the results of a study, commissioned by the CO2 Capture Project (CCP) and completed by Environmental Resources Management (ERM) that evaluated the benefits and risks of two approaches to developing CO2 pipeline systems. The two basic approaches are described in the paper as: On a point-to-point basis, which matches a specific source to a specific storage location; or Via the development of pipeline networks, including backbone pipeline systems, which allow for common carriage of CO2 from multiple sources to multiple sinks.

#### They’re topical

ERM 10

Business group that asses different environmental policy options and then publishes papers about them, “The Economics of Transportation of CO2 in Common Carrier Network Pipeline Systems,” 4/9/12, http://www.erm.com/Analysis-and-Insight/ERM-Publications/Publications-Archive-2009---2010/The-Economics-of-Transportation-of-CO2-in-Common-Carrier-Network-Pipeline-Systems/]//SH

Establishing a widespread CO2 transportation infrastructure requires a strategic approach that takes into account the magnitude of potential deployment scenarios for CCS as hundreds of megatonnes (Mt) of CO2 are transported every year through pipeline systems. Transporting CO2 by pipeline is not a new technology; in the US almost 4,000 miles of CO2 pipeline for enhanced oil recovery (EOR) are in operation. However, the infrastructure for mass CCS could be on the scale of the current gas transmission infrastructure for Europe or North America, and will require significant investment to construct and operate.

# Some Pipelines Aren’t Energy

#### Beer is transported by pipelines

Upton 12 – Editor of Broken Secrets

Chad, There is a Beer Pipeline, http://brokensecrets.com/2012/04/26/there-is-a-beer-pipeline/

Today, some of our most valuable resources are carried by pipeline: water, oil, natural gas, and even beer. Yes, there is a beer pipeline. Actually, there are at least two beer pipelines.

#### So is salt

AA No Date

Austrian Attraction, “Salt Pipeline,” http://www.anaustriaattraction.com/austria-attractions-ah/salt-pipeline.htm

The Soleleitung, dating from the early 17th century, is the oldest industrial pipeline in the world. During construction, from 1597 to 1607, 13,000 spruce and fir tree trunks were used form a 40 kilometre long pipeline to convey brine from the salt works Hallstatt to Ebensee where it was refined and taken by barge to Gmunden. This method of conveyance superseded the excavation of salt rock and transport overland. The pipeline starts at the Rudolfsturm and the walk along its route takes in some of the most spectacular views of the Salzkammergut.

# \*\*\*WARMING\*\*\*

# Warming O/W

#### **Warming outweighs nuclear war**

Morgan 09 (Dennis Ray, Professor of Current Affairs at Hankuk University of Foreign Studies, Yongin Campus - South Korea, “World on fire: two scenarios of the destruction of human civilization and possible extinction of the human race”)

As horrifying as the scenario of human extinction by sudden, fast-burning nuclear fire may seem, the one consolation is that this future can be avoided within a relatively short period of time if responsible world leaders change Cold War thinking to move away from aggressive wars over natural resources and towards the eventual dismantlement of most if not all nuclear weapons. On the other hand, another scenario of human extinction by fire is one that may not so easily be reversed within a short period of time because it is not a fast-burning fire; rather, a slow burning fire is gradually heating up the planet as industrial civilization progresses and develops globally. This gradual process and course is long-lasting; thus it cannot easily be changed, even if responsible world leaders change their thinking about ‘‘progress’’ and industrial development based on the burning of fossil fuels. The way that global warming will impact humanity in the future has often been depicted through the analogy of the proverbial frog in a pot of water who does not realize that the temperature of the water is gradually rising. Instead of trying to escape, the frog tries to adjust to the gradual temperature change; finally, the heat of the water sneaks up on it until it is debilitated. Though it finally realizes its predicament and attempts to escape, it is too late; its feeble attempt is to no avail— and the frog dies. Whether this fable can actually be applied to frogs in heated water or not is irrelevant; it still serves as a comparable scenario of how the slow burning fire of global warming may eventually lead to a runaway condition and take humanity by surprise. Unfortunately, by the time the politicians finally all agree with the scientific consensus that global warming is indeed human caused, its development could be too advanced to arrest; the poor frog has become too weak and enfeebled to get himself out of hot water.

# Action Now Key

#### Only action now solves future catastrophe

**Antholis and Talbott 10 – Director and President @ Brookings**

William Antholis, managing director of the Brookings Institution and a senior fellow in Governance Studies, former director of studies at the German Marshall Fund of the United States, and Strobe Talbott, president of the Brookings Institution, deputy Sec. of State under Clinton, “The Global Warming Tipping Point,” The Globalist, http://www.theglobalist.com/storyid.aspx?StoryId=8523

Moreover, we need to start reductions now in order to slow temperature rise later. Even if we could flip a switch and shut down all emissions, gases that are already in the atmosphere will continue to trap heat for some time to come. Once emitted into the atmosphere, a molecule of carbon dioxide, or CO2, lingers for decades. So gases emitted today are added to ones that have been around for 50 years or more. The current concentration of CO2 in the atmosphere is about 385 parts per million (ppm) and growing by two ppm each year. If we continue with current warming trends, the globe could keep warming for millennia. Even if the human species is biologically resilient enough to survive for centuries, the human enterprise may well be hard to maintain in anything like its current form. Today, humanity is cumulatively emitting, on a yearly basis, around 30 gigatons of CO2. A gigaton is a billion tons. Thirty gigatons is about the weight of 8,000 Empire State Buildings, which, if stacked one on top of another, would reach almost 2,000 miles into space. Of those 30 gigatons of CO2 that will be emitted this year, just under six gigatons are from the United States. To keep CO2 concentrations below 400 ppm and thereby keep temperature rise below 3.6°F, we should use the next four decades to cut the current output of 30 gigatons a year approximately in half. Thirty gigatons is about the weight of 8,000 Empire State Buildings, which, if stacked one on top of another, would reach almost 2,000 miles into space. So that is another target for mitigation: a staged process that would bring the global annual output down to 15 gigatons a year by 2050. To reach that goal, we have to build a new worldwide system for generating and using energy. We have to begin quickly in order to achieve the bulk of the necessary cuts between 2020 and 2035 so that there is some hope that, by 2050, emissions will have come down to 15 gigatons, concentrations will have stabilized below the 400 ppm level — and temperature rise will have flattened out before hitting the 3.6°F mark. At the heart of this mammoth undertaking is a transition from a high-carbon to a low-carbon global economy — that is, one that is powered as much as possible by forms of energy that do not burn fossil fuels and therefore do not pump CO2 into the atmosphere.

# Warming Real

#### **Even the most ardent climate deniers now admit it’s real and anthropogenic**

Banerjee 12 (Neela, Tribune Washington Bureau, “Prominent climate change denier now says he was wrong”, July 30, <http://www.csmonitor.com/Science/2012/0730/Prominent-climate-change-denier-now-says-he-was-wrong>)

The verdict is in: Global warming is real and greenhouse-gas emissions from human activity are the main cause. This, according to Richard A. Muller, professor of physics at the University of California, Berkely, a MacArthur fellow and co-founder of the Berkeley Earth Surface Temperature project. The United Nations Intergovernmental Panel on Climate Change and hundreds of other climatologists around the world came to such conclusions years ago, but the difference now is the source: Muller is a long-standing, colorful critic of prevailing climate science, and the Berkeley project was heavily funded by the Charles Koch Charitable Foundation, which, along with its libertarian petrochemical billionaire founder Charles G. Koch, has a considerable history of backing groups that deny climate change. In an opinion piece in Saturday’s New York Times titled “The Conversion of a Climate-Change Skeptic,” Muller writes: “Three years ago I identified problems in previous climate studies that, in my mind, threw doubt on the very existence of global warming. Last year, following an intensive research effort involving a dozen scientists, I concluded that global warming was real and that the prior estimates of the rate of warming were correct. I’m now going a step further: Humans are almost entirely the cause.” The Berkeley project’s research has shown, Muller says, “that the average temperature of the earth’s land has risen by 2½ degrees Fahrenheit over the past 250 years, including an increase of 1½ degrees over the most recent 50 years. Moreover, it appears likely that essentially all of this increase results from the human emission of greenhouse gases.” He calls his current stance “a total turnaround.” Tonya Mullins, a spokeswoman for the Koch Foundation, said the support her foundation provided, along with others, has no bearing on results of the research. “Our grants are designed to promote independent research; as such, recipients hold full control over their findings,” Mullins said in an email. “In this support, we strive to benefit society by promoting discovery and informing public policy.” Some leading climate scientists said Muller’s comments show that the science is so strong that even those inclined to reject it cannot once they examine it carefully. Michael E. Mann, director of the Earth System Science Center at Pennsylvania State University, said Muller’s conversion might help shape the thinking of the “reasonable middle” of the population “who are genuinely confused and have been honestly taken in” by attacks on climate science. On his Facebook page, Mann wrote: “There is a certain ironic satisfaction in seeing a study funded by the Koch Brothers — the greatest funders of climate change denial and disinformation on the planet — demonstrate what scientists have known with some degree of confidence for nearly two decades: that the globe is indeed warming, and that this warming can only be explained by human-caused increases in greenhouse gas concentrations. I applaud Muller and his colleagues for acting as any good scientists would, following where their analyses led them, without regard for the possible political repercussions.”

#### Warming is real and human induced – drastic emissions reductions are key to avoid dangerous climate disruptions

**Somerville 11 –** Professor of Oceanography @ UCSD

Richard Somerville, Distinguished Professor Emeritus and Research Professor at Scripps Institution of Oceanography at the University of California, San Diego, Coordinating Lead Author in Working Group I for the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 3-8-2011, “CLIMATE SCIENCE AND EPA'S GREENHOUSE GAS REGULATIONS,” CQ Congressional Testimony, Lexis

1n early 2007, at the time of the publication of WG1 of AR4, the mainstream global community of climate scientists already understood from the most recent research that the latest observations of climate change were disquieting. In the words of a research paper published at the same time as the release of AR4 WG1, a paper for which I am a co-author, "observational data underscore the concerns about global climate change. Previous projections, as summarized by IPCC, have **not exaggerated** but may in some respects even have **underestimated the change**" (Rahmstorf et al. 2007). Now, in 2011, more recent research and newer observations have demonstrated that climate change continues to occur, and in several aspects the magnitude and rapidity of observed changes frequently **exceed the estimates of earlier projections**, including those of AR4. In addition, the case for attributing much observed recent climate change to human activities is **even stronger now** than at the time of AR4. Several recent examples, drawn from many aspects of climate science, but especially emphasizing atmospheric phenomena, support this conclusion. These include temperature, atmospheric moisture content, precipitation, and other aspects of the hydrological cycle. Motivated by the rapid progress in research, a recent scientific synthesis, The Copenhagen Diagnosis (Allison et al. 2009), has assessed recent climate research findings, including: -- Measurements show that the Greenland and Antarctic ice-sheets are losing mass and contributing to sea level rise. -- Arctic sea-ice has melted far beyond the expectations of climate models. -- Global sea level rise may attain or exceed 1 meter by 2100, with a rise of up to 2 meters considered possible. -- In 2008, global carbon dioxide emissions from fossil fuels were about 40% higher than those in 1990. -- At today's global emissions rates, if these rates were to be sustained unchanged, after only about 20 more years, the world will no **longer have a reasonable chance** of **limiting warming** to less than 2 degrees Celsius, or 3.6 degrees Fahrenheit, above 19th-century pre-industrial temperature levels, This is a much- discussed goal for a maximum allowable degree of climate change, and this aspirational target has now been formally adopted by the European Union and is supported by many other countries, as expressed, for example, in statements by both the G-8 and G-20 groups of nations. The Copenhagen Diagnosis also cites research supporting the position that, in order to have a reasonable likelihood of avoiding the risk of **dangerous climate disruption**, defined by this 2 degree Celsius (or 3.6 degree Fahrenheit) limit, global emissions of greenhouse gases such as carbon dioxide must peak and then start to **decline rapidly** within the next five to ten years, reaching near zero well within this century.

#### Warming is real, anthropogenic, and happening now.

**Braganza 6/14/11** (Karl, Manager, Climate Monitor at the Bureau of Meteorology in Australia, The Bureau presently operates under the authority of the Meteorology Act 1955, which requires it to report on the state of the atmosphere and oceans in support of Australia's social, economic, cultural and environmental goals. His salary is not funded from any external sources or dependent on specially funded government climate change projects. Karl Braganza does not consult to, own shares in or receive funding from any company or organisation that would benefit from this article, and has no relevant affiliations “The greenhouse effect is real: here’s why

,” http://theconversation.edu.au/the-greenhouse-effect-is-real-heres-why-1515, AM)

In public discussions of climate change, the full range and weight of evidence underpinning the current science can be difficult to find. A good example of this is the role of observations of the climate system over the past one hundred years or more. In the current public discourse, the focus has been mostly on changes in global mean temperature. It would be easy to form the opinion that everything we know about climate change is based upon the observed rise in global temperatures and observed increase in carbon dioxide emissions since the industrial revolution. In other words, one could have the mistaken impression that the entirety of climate science is based upon a single correlation study. In reality, the correlation between global mean temperature and carbon dioxide over the 20th century forms an important, **but very small part of the evidence for a human role in climate change.** Our assessment of the future risk from the continued build up of greenhouse gases in the atmosphere is even less informed by 20th century changes in global mean temperature. For example, our understanding of the greenhouse effect – the link between greenhouse gas concentrations and global surface air temperature – **is based primarily on our fundamental understanding of mathematics, physics, astronomy and chemistry.** **Much of this science is textbook material that is at least a century old and does not rely on the recent climate record**. For example, it is a scientific fact that Venus, the planet most similar to Earth in our solar system, experiences surface temperatures of nearly 500 degrees Celsius due to its atmosphere being heavily laden with greenhouse gases. Back on Earth, that fundamental understanding of the physics of radiation, combined with our understanding of climate change from the geological record, clearly demonstrates that increasing greenhouse gas concentrations will inevitably drive global warming. The observations we have taken since the start of 20th century have confirmed our fundamental understanding of the climate system. While the climate system is very complex, observations have shown that our formulation of the physics of the atmosphere and oceans is largely correct, and ever improving. Most importantly, the observations have confirmed that human activities, in particular a 40% increase in atmospheric carbon dioxide concentrations since the late 19th century, have had a discernible and significant impact on the climate system already. In the field known as detection and attribution of climate change, scientists use indicators known as of climate change. These fingerprints show the entire climate system has changed in ways that are consistent with increasing greenhouse gases and an enhanced greenhouse effect. They also show that recent, long term changes are inconsistent with a range of natural causes. A warming world is obviously the most profound piece of evidence. Here in Australia, the decade ending in 2010 has easily been the warmest since record keeping began, and continues a trend of each decade being warmer than the previous, that extends back 70 years. Globally, significant warming and other changes have been observed across a range of different indicators and through a number of different recording instruments, and a consistent picture has now emerged. Scientists have observed increases in continental temperatures and increases in the temperature of the lower atmosphere. In the oceans, we have seen increases in sea-surface temperatures as well as increases in deep-ocean heat content. That increased heat has expanded the volume of the oceans and has been recorded as a rise in sea-level. Scientists have also observed decreases in sea-ice, a general retreat of glaciers and decreases in snow cover. Changes in atmospheric pressure and rainfall have also occurred in patterns that we would expect due to increased greenhouse gases. There is also emerging evidence that some, though not all, types of extreme weather have become more frequent around the planet. These changes are again consistent with our expectations for increasing atmospheric carbon dioxide. Patterns of temperature change that are uniquely associated with the enhanced greenhouse effect, and which have been observed in the real world include: greater warming in polar regions than tropical regions greater warming over the continents than the oceans greater warming of night time temperatures than daytime temperatures greater warming in winter compared with summer a pattern of cooling in the high atmosphere (stratosphere) with simultaneous warming in the lower atmosphere (troposphere). By way of brief explanation, if the warming over the 20th century were due to some deep ocean process, we would not expect to see continents warming more rapidly than the oceans, or the oceans warming from the top down. For increases in solar radiation, we would expect to see warming of the stratosphere rather than the observed cooling trend. Similarly, greater global warming at night and during winter is more typical of increased greenhouse gases, rather than an increase in solar radiation. There is a range of other observations that show the enhanced greenhouse effect is real. The additional carbon dioxide in the atmosphere has been identified through its isotopic signature as being fossil fuel in origin. The increased carbon dioxide absorbed by the oceans is being recorded as a measured decrease in ocean alkalinity. Satellite measurements of outgoing long-wave radiation from the planet reveal increased absorption of energy in the spectral bands corresponding to carbon dioxide, exactly as expected from fundamental physics. It is important to remember that the enhanced greenhouse effect is not the only factor acting on the climate system. In the short term, the influence of greenhouse gases can be obscured by other competing forces. These include other anthropogenic factors such as increased industrial aerosols and ozone depletion, as well as natural changes in solar radiation and volcanic aerosols, and the cycle of El Niño and La Niña events. By choosing a range of indicators, by averaging over decades rather than years, and by looking at the pattern of change through the entire climate system, scientists are able to clearly discern the fingerprint of human-induced change. The climate of Earth is now a closely monitored thing; from instruments in space, in the deep ocean, in the atmosphere and across the surface of both land and sea. It’s now practically certain that increasing greenhouse gases have already warmed the climate system. That continued rapid increases in greenhouse gases will cause rapid future warming is irrefutable

#### Human-induced global warming happening now – it’s indisputable – deal with it

**Rahmstorf**, 200**8** Professor of Physics of the Oceans at Potsdam University [Richard, *Global Warming: Looking Beyond Kyoto*. Edited by Ernesto Zedillo. “Anthropogenic Climate Change?” Page 42-49]

It is time to turn to statement B: human activities are altering the climate. This can be broken into two parts. The first is as follows: global climate is warming. This is by now a generally **undisputed** point (except by novelist Michael Crichton), so we deal with it only briefly. The two leading compilations of data measured with thermometers are shown in figure 3-3, that of the National Aeronautics and Space Administration (NASA) and that of the British Hadley Centre for Climate Change. Although they differ in the details, due to the inclusion of different data sets and use of different spatial averaging and quality control procedures, they both show a consistent picture, with a global mean warming of 0.8°C since the late nineteenth century. Temperatures over the past ten years clearly were the warmest since measured records have been available. The year 1998 sticks out well above the longterm trend due to the occurrence of a major El Nino event that year (the last El Nino so far and one of the strongest on record). These events are examples of the largest natural climate variations on multiyear time scales and, by releasing heat from the ocean, generally cause positive anomalies in global mean temperature. It is remarkable that the year 2005 rivaled the heat of 1998 even though no El Nino event occurred that year. (A bizarre curiosity, perhaps worth mentioning, is that several prominent "climate skeptics" recently used the extreme year 1998 to claim in the media that global warming had ended. In Lindzen's words, "Indeed, the absence of any record breakers during the past seven years is statistical evidence that temperatures are not increasing.")33 In addition to the surface measurements, the more recent portion of the global warming trend (since 1979) is also documented by satellite data. It is not straightforward to derive a reliable surface temperature trend from satellites, as they measure radiation coming from throughout the atmosphere (not just near the surface), including the stratosphere, which has strongly cooled, and the records are not homogeneous' due to the short life span of individual satellites, the problem of orbital decay, observations at different times of day, and drifts in instrument calibration.' Current analyses of these satellite data show trends that are fully consistent with surface measurements and model simulations." If no reliable temperature measurements existed, could we be sure that the climate is warming? The "canaries in the coal mine" of climate change (as glaciologist Lonnie Thompson puts it) ~are mountain glaciers. We know, both from old photographs and from the position of the terminal moraines heaped up by the flowing ice, that mountain glaciers have been in retreat all over the world during the past century. There are precious few exceptions, and they are associated with a strong increase in precipitation or local cooling.36 I have inspected examples of shrinking glaciers myself in field trips to Switzerland, Norway, and New Zealand. As glaciers respond sensitively to temperature changes, data on the extent of glaciers have been used to reconstruct a history of Northern Hemisphere temperature over the past four centuries (see figure 3-4). Cores drilled in tropical glaciers show signs of recent melting that is unprecedented at least throughout the Holocene-the past 10,000 years. Another powerful sign of warming, visible clearly from satellites, is the shrinking Arctic sea ice cover (figure 3-5), which has declined 20 percent since satellite observations began in 1979. While climate clearly became warmer in the twentieth century, much discussion particularly in the popular media has focused on the question of how "unusual" this warming is in a longer-term context. While this is an interesting question, it has often been mixed incorrectly with the question of causation. Scientifically, how unusual recent warming is-say, compared to the past millennium-in itself contains little information about its cause. Even a highly unusual warming could have a natural cause (for example, an exceptional increase in solar activity). And even a warming within the bounds of past natural variations could have a predominantly anthropogenic cause. I come to the question of causation shortly, after briefly visiting the evidence for past natural climate variations. Records from the time before systematic temperature measurements were collected are based on "proxy data," coming from tree rings, ice cores, corals, and other sources. These proxy data are generally linked to local temperatures in some way, but they may be influenced by other parameters as well (for example, precipitation), they may have a seasonal bias (for example, the growth season for tree rings), and high-quality long records are difficult to obtain and therefore few in number and geographic coverage. Therefore, there is still substantial uncertainty in the evolution of past global or hemispheric temperatures. (Comparing only local or regional temperature; as in Europe, is of limited value for our purposes,' as regional variations can be much larger than global ones and can have many regional causes, unrelated to global-scale forcing and climate change.) The first quantitative reconstruction for the Northern Hemisphere temperature of the past millennium, including an error estimation, was presented by Mann, Bradley, and Hughes and rightly highlighted in the 2001 IPCC report as one of the major new findings since its 1995 report; it is shown in figure 3\_6.39 The analysis suggests that, despite the large error bars, twentieth-century warming is indeed highly unusual and probably was unprecedented during the past millennium. This result, presumably because of its symbolic power, has attracted much criticism, to some extent in scientific journals, but even more so in the popular media. The hockey stick-shaped curve became a symbol for the IPCC, .and criticizing this particular data analysis became an avenue for some to question the credibility of the IPCC. Three important things have been overlooked in much of the media coverage. First, even if the scientific critics had been right, this would not have called into question the very cautious conclusion drawn by the IPCC from the reconstruction by Mann, Bradley, and Hughes: "New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the twentieth century is likely to have been the largest of any century during the past 1,000 years." This conclusion has since been supported further by **every single** one of close to a dozen new reconstructions (two of which are shown in figure 3-6). Second, by far the most serious scientific criticism raised against Mann, Hughes, and Bradley was simply based on a mistake. 40 The prominent paper of von Storch and others, which claimed (based on a model test) that the method of Mann, Bradley, and Hughes systematically underestimated variability, "was [itself] based on incorrect implementation of the reconstruction procedure."41 With correct implementation, climate field reconstruction procedures such as the one used by Mann, Bradley, and Hughes have been shown to perform well in similar model tests. Third, whether their reconstruction is accurate or not has no bearing on policy. If their analysis underestimated past natural climate variability, this would certainly not argue for a smaller climate sensitivity and thus a lesser concern about the consequences of our emissions. Some have argued that, in contrast, it would point to a larger climate sensitivity. While this is a valid point in principle, it does not apply in practice to the climate sensitivity estimates discussed herein or to the range given by IPCC, since these did not use the reconstruction of Mann, Hughes, and Bradley or any other proxy records of the past millennium. Media claims that "a pillar of the Kyoto Protocol" had been called into question were therefore misinformed. As an aside, the protocol was agreed in 1997, before the reconstruction in question even existed. The overheated public debate on this topic has, at least, helped to attract more researchers and funding to this area of paleoclimatology; its methodology has advanced significantly, and a number of new reconstructions have been presented in recent years. While the science has moved forward, the first seminal reconstruction by Mann, Hughes, and Bradley has held up remarkably well, with its main features reproduced by more recent work. Further progress probably will require substantial amounts of new proxy data, rather than further refinement of the statistical techniques pioneered by Mann, Hughes, and Bradley. Developing these data sets will require time and substantial effort. It is time to address the final statement: most of the observed warming over the past fifty years is anthropogenic. A large number of studies exist that have taken different approaches to analyze this issue, which is generally called the "attribution problem." I do not discuss the exact share of the anthropogenic contribution (although this is an interesting question). By "most" I imply mean "more than 50 percent.” The first and crucial piece of evidence is, of course, that the magnitude of the warming is what is **expected** from the anthropogenic perturbation of the radiation balance, so anthropogenic forcing is able to explain all of the temperature rise. As discussed here, the rise in greenhouse gases alone corresponds to 2.6 W/tn2 of forcing. This by itself, after subtraction of the observed 0'.6 W/m2 of ocean heat uptake, would Cause 1.6°C of warming since preindustrial times for medium climate sensitivity (3"C). With a current "best guess'; aerosol forcing of 1 W/m2, the expected warming is O.8°c. The point here is not that it is possible to obtain the 'exact observed number-this is fortuitous because the amount of aerosol' forcing is still very' uncertain-but that the expected magnitude is roughly right. There can be little doubt that the anthropogenic forcing is large enough to explain most of the warming. Depending on aerosol forcing and climate sensitivity, it could explain a large fraction of the warming, or all of it, or even more warming than has been observed (leaving room for natural processes to counteract some of the warming). The second important piece of evidence is clear: there is no viable alternative explanation. In the scientific literature, **no serious alternative hypothesis has been proposed** to explain the observed global warming. Other possible causes, such as solar activity, volcanic activity, cosmic rays, or orbital cycles, are well observed, but they do not show trends capable of explaining the observed warming. Since 1978, solar irradiance has been measured directly from satellites and shows the well-known eleven-year solar cycle, but no trend. There are various estimates of solar variability before this time, based on sunspot numbers, solar cycle length, the geomagnetic AA index, neutron monitor data, and, carbon-14 data. These indicate that solar activity probably increased somewhat up to 1940. While there is disagreement about the variation in previous centuries, different authors agree that solar activity did not significantly increase during the last sixty-five years. Therefore, this cannot explain the warming, and neither can any of the other factors mentioned. Models driven by natural factors only, leaving the anthropogenic forcing aside, show a cooling in the second half of the twentieth century (for an example, See figure 2-2, panel a, in chapter 2 of this volume). The trend in the sum of natural forcings is downward. The only way out would be either some as yet undiscovered unknown forcing or a warming trend that arises by chance from an unforced internal variability in the climate system. The latter cannot be completely ruled out, but has to be considered highly unlikely. No evidence in the observed record, proxy data, or current models suggest that such internal variability could cause a sustained trend of global warming of the observed magnitude. As discussed, twentieth century warming is **unprecedented** over the past 1,000 years (or even 2,000 years, as the few longer reconstructions available now suggest), which does not 'support the idea of large internal fluctuations. Also, those past variations correlate well with past forcing (solar variability, volcanic activity) and thus appear to be largely forced rather than due to unforced internal variability." And indeed, it would be difficult for a large and sustained unforced variability to satisfy the fundamental physical law of energy conservation. Natural internal variability generally shifts heat around different parts of the climate system-for example, the large El Nino event of 1998, which warmed, the atmosphere by releasing heat stored in the ocean. This mechanism implies that the ocean heat content drops as the atmosphere warms. For past decades, as discussed, we observed the atmosphere warming and the ocean heat content increasing, which rules out heat release from the ocean as a cause of surface warming. The heat content of the whole climate system is increasing, and there is no plausible source of this heat other than the heat trapped by greenhouse gases. ' A completely different approach to attribution is to analyze the spatial patterns of climate change. This is done in so-called fingerprint studies, which associate particular patterns or "fingerprints" with different forcings. It is plausible that the pattern of a solar-forced climate change differs from the pattern of a change caused by greenhouse gases. For example, a characteristic of greenhouse gases is that heat is trapped closer to the Earth's surface and that, unlike solar variability, greenhouse gases tend to warm more in winter, and at night. Such studies have used different data sets and have been performed by different groups of researchers with different statistical methods. They **consistently conclude** that the observed spatial pattern of warming can only be explained by greenhouse gases.49 Overall, it has to be considered, highly likely' that the observed warming is indeed predominantly due to the human-caused increase in greenhouse gases. ' This paper discussed the evidence for the anthropogenic increase in atmospheric CO2 concentration and the effect of CO2 on climate, finding that this anthropogenic increase is proven **beyond reasonable doubt** and that a mass of evidence points to a CO2 effect on climate of 3C ± 1.59C global-warming for a doubling of concentration. (This is, the classic IPCC range; my personal assessment is that, in-the light of new studies since the IPCC Third Assessment Report, the uncertainty range can now be narrowed somewhat to 3°C ± 1.0C) This is based on consistent results from theory, models, and data analysis, and, even in the absence-of any computer models, the same result would still hold based on physics and on data from climate history alone. Considering the plethora of consistent evidence, the chance that these conclusions are wrong has to be considered minute. If the preceding is accepted, then it follows logically and **incontrovertibly** that a further increase in CO2 concentration will lead to further warming. The magnitude of our emissions depends on human behavior, but the climatic response to various emissions scenarios can be computed from the information presented here. The result is the famous range of future global temperature scenarios shown in figure 3\_6.50 Two additional steps are involved in these computations: the consideration of anthropogenic forcings other than CO2 (for example, other greenhouse gases and aerosols) and the computation of concentrations from the emissions. Other gases are not discussed here, although they are important to get quantitatively accurate results. CO2 is the largest and most important forcing. Concerning concentrations, the scenarios shown basically assume that ocean and biosphere take up a similar share of our emitted CO2 as in the past. This could turn out to be an optimistic assumption; some models indicate the possibility of a positive feedback, with the biosphere turning into a carbon source rather than a sink under growing climatic stress. It is clear that even in the more optimistic of the shown (non-mitigation) scenarios, global temperature would rise by 2-3°C above its preindustrial level by the end of this century. Even for a paleoclimatologist like myself, this is an extraordinarily high temperature, which is very likely unprecedented in at least the past 100,000 years. As far as the data show, we would have to go back about 3 million years, to the Pliocene, for comparable temperatures. The rate of this warming (which is important for the ability of ecosystems to cope) is also highly unusual and unprecedented probably for an even longer time. The last major global warming trend occurred when the last great Ice Age ended between 15,000 and 10,000 years ago: this was a warming of about 5°C over 5,000 years, that is, a rate of only 0.1 °C per century. 52 The expected magnitude and rate of planetary warming is highly likely to come with major risk and impacts in terms of sea level rise (Pliocene sea level was 25-35 meters higher than now due to smaller Greenland and Antarctic ice sheets), extreme events (for example, hurricane activity is expected to increase in a warmer climate), and ecosystem loss. The second part of this paper examined the evidence for the current warming of the planet and discussed what is known about its causes. This part showed that global warming is already a measured and-well-established fact, not a theory. Many different lines of evidence consistently show that most of the observed warming of the past fifty years was caused by human activity. Above all, this warming is exactly what would be expected given the anthropogenic rise in greenhouse gases, and no viable alternative explanation for this warming has been proposed in the scientific literature. Taken together., the very strong evidence accumulated from thousands of independent studies, has over the past decades convinced virtually **every climatologist** around the world (many of whom were initially quite skeptical, including myself) that anthropogenic global warming is a **reality with which we need to deal**.

# Warming = Systemic

#### Warming has a disproportionate effect on poor communities

Snyder and Brush 9 **(Jim and Silla, The Hill, “Civil rights groups join climate talks”, 10/27,** [**http://thehill.com/business-a-lobbying/64861-civil-rights-groups-join-climate-talks**](http://thehill.com/business-a-lobbying/64861-civil-rights-groups-join-climate-talks)**)**

Hurricane Katrina turned climate into an environmental justice issue for the NAACP, Shelton said. “We want to make sure our policymakers address the severe weather conditions like Katrina that are caused by major shifts in our climate,” Shelton said. That’s not only a risk to New Orleans and other coastal cities with large minority populations — areas that are among the “frontline” communities that could be the first and hardest-hit by the effects of climate change, supporters of capping carbon dioxide and other so-called greenhouse gases argue. Heat waves worsen air pollution in urban areas, where more than 40 percent of African-Americans live, compared to 20 percent of white people, according to an NWF report. Blacks are also twice as likely as whites to live in poverty and are therefore less likely to have air conditioning or proper insulation to minimize the effects of excessive heat, the report found. In July, the NAACP adopted a resolution noting the particularly severe impact global warming could have on countries in Africa. A climate bill would likely curb the use of coal as an energy source, which would have residual clean air benefits as well. The resolution also notes that 70 percent of African-Americans live in counties in violation of federal air pollution standards, and that blacks are nearly three times as likely to be hospitalized or killed by asthma.

#### Climate change has an acutely negative effect on the poor and minorities

Fischer 9 **(Douglas, Daily Climate editor, “Climate change hitting poor in U.S. hardest.”, May 29,** [**http://wwwp.dailyclimate.org/tdc-newsroom/2009/05/Climate-Change-hitting-poor-in-U.S.-hardest**](http://wwwp.dailyclimate.org/tdc-newsroom/2009/05/Climate-Change-hitting-poor-in-U.S.-hardest)**)**

Climate change is disproportionately affecting the poor and minorities in the United States – a "climate gap" that will grow in coming decades unless policymakers intervene, according to a University of California study. Everyone, the researchers say, is already starting to feel the effects of a warming planet, via heat waves, increased air pollution, drought, or more intense storms. But the impacts – on health, economics, and overall quality of life – are far more acute on society's disadvantaged, the researchers found. "Climate change does not affect everyone equally in the United States," said Rachel Morello-Frosch, associate professor at the School of Public Health at the University of California, Berkeley and lead author of The Climate Gap. "People of color and the poor will be hurt the most – unless elected officials and other policymakers intervene." Watching this unfold is akin to watching a movie where disparate and seemingly unrelated storylines converge to denouement that is "decidedly tragic,” the researchers wrote. For instance, the report finds that African Americans living in Los Angeles are almost twice as likely to die as other Los Angelenos during a heat wave. Segregated in the inner city, they're more susceptible to the "heat island" effect, where temperatures are magnified by concrete and asphalt. Yet they're less likely to have access to air conditioning or cars. Similarly, Latinos make up 77 percent of California's agricultural workforce and will likely see economic hardship as climate change reworks the state's highest-value farm products. The dairy industry brings in $3.8 billion of California's $30 billion agriculture income; grapes account for $3.2 billion. Yet climatic troubles are expected to decrease dairy production between 7 percent and 22 percent by century's end, while grapes will have trouble ripening, substantially reducing their value. Other impacts, according to the researchers: Households in the lowest income bracket spend twice the proportion of their income on electricity than those in the highest income bracket. Any policy that increases the cost of energy will hurt the poor the most. California industries considered heavy emitters of greenhouse gases have a workforce that is 60 percent minority. Any climate plan that fails to transition those workers to new "green energy" jobs threatens to widen the racial economic divide. Minorities and the poor already breathe dirtier air than other Americans and are more likely to lack health insurance. As higher temperatures hasten the chemical interactions that produce smog, they're going to feel the most impact. The findings, the researchers say, underscore the need for policymakers to consider environmental justice when addressing climate. Ignoring the climate gap, they warn, could reinforce and amplify current and future socioeconomic and racial disparities. "As America takes steps to prevent climate change, closing the climate gap must also be a top priority," said Manuel Pastor, a co-author and director of the Program for Environmental and Regional Equity at the University of Southern California's Center for Sustainable Cities.

#### **Climate change destroys value to life**

McInerney-Lankford et al 11 (Siobhan McInerney-Lankford, Mac Darrow, and Lavanya Rajamani, The World Bank, “Human Rights and Climate Change”, <http://siteresources.worldbank.org/INTLAWJUSTICE/Resources/HumanRightsAndClimateChange.pdf>)

Climate change has direct implications for the right to life. In its January 2009 report on climate change and human rights, the OHCHR states, on the basis of the 2007 IPCC assessment: A number of observed and projected eﬀ ects of climate change will pose direct and indirect threats to human lives. IPCC . . . projects with high conﬁ dence an increase in people suﬀ ering from death, disease and injury from heat waves, ﬂ oods, storms, ﬁ res and droughts. Equally, climate change will aﬀ ect the right to life through an increase in hunger and malnutrition and related disorders impacting on child growth and development, cardio-respiratory morbidity and mortality related to ground-level ozone. Climate change will exacerbate weather-related disasters which already have devastating eﬀ ects on people and their enjoyment of the right to life, particularly in the developing world. For example, an estimated 262 million people were aﬀ ected by climate disasters annually from 2000 to 2004, of whom over 98 per cent live in developing countries. 115 In keeping with this, the UN General Assembly recently adopted a resolution recognizing climate change as a possible threat to international peace and security. 116 Climate change – by redrawing the maps of water availability, food security, disease prevalence, population distribution and coastal boundaries – has the potential to exacerbate insecurity and violent conﬂ ict on a potentially large scale. 117 While the threats to life are more immediate in some countries and regions than others, a recent report by the Center for Naval Analyses in the U.S. argues that climate change acts as a threat multiplier in already fragile regions, exacerbating conditions that lead to failed states and breed terrorism and extremism, concluding that “projected climate change poses a serious threat to America’s national security.” 118 Some communities, such as those living in the Arctic and in coastal regions, are particularly at risk, and are already starting to experience the adverse eﬀ ects of climate change on their right to life. For example, in their December 2005 petition to the InterAmerican Commission on Human Rights (IACHR), the Inuit described the eﬀ ects of climate change on their right to life, saying: “[c]hanges in ice and snow jeopardize individual Inuit lives, critical food sources are threatened, and unpredictable weather makes travel more dangerous at all times of the year.” 119 The jeopardy to individual lives results from the changing climate: the sea ice on which the Inuit travel and hunt freezes later, thaws earlier, and is thinner; critical food sources are threatened because warming weather makes harvestable species scarcer and more diﬃ cult to reach; a greater number of sudden, unpredictable storms and less snow from which to construct emergency shelters have already contributed to death and injuries among hunters; and the decrease in summer ice causes rougher seas and more dangerous storms, making water travel more dangerous. 120

#### **Climate change causes widespread hunger – that’s a fundamental human right**

McInerney-Lankford et al 11 (Siobhan McInerney-Lankford, Mac Darrow, and Lavanya Rajamani, The World Bank, “Human Rights and Climate Change”, <http://siteresources.worldbank.org/INTLAWJUSTICE/Resources/HumanRightsAndClimateChange.pdf>)

The ICESCR includes the right to adequate food as an element of the right to an adequate standard of living. 125 The CESCR has argued that the right to food126 is fundamental to the inherent dignity of the human person and indispensable for the fulﬁ lment of other human rights enshrined in the International Bill of Rights. 127 It interprets the right to adequate food as encompassing both availability of and accessibility to food and has recognised the inter-dependence between the environment and the right to food, noting that the right to adequate food requires the adoption of “appropriate economic, environmental and social policies.” 128 The threats caused by climate change to the right to food have been apparent to the CESCR for some time. According to the CESCR, “even where a State faces severe resource constraints, whether caused by a process of economic adjustment, economic recession, climatic conditions or other factors, measures should be undertaken to ensure that the right to adequate food is especially fulﬁ lled for vulnerable population groups and individuals.” 129 In his 2008 annual report to the Human Rights Council, the Special Rapporteur on the right to food voiced caution about what he perceived as disproportionate reliance upon technology-driven solutions to agricultural production in response to the challenges facing food production systems due to climate change and population growth, and outlined a number of potential negative impacts of agrofuel development (intended to substitute for fossil fuels for transport) on the right to food. 130 The Special Rapporteur has speciﬁ cally encouraged sustainable agricultural practices which will improve the resilience of farming systems to climate change, 131 and has called upon the international community to encourage a diversity of resilient agricultural systems capable of coping with climate disruptions. 132 Article 2 of the UNFCCC underscores the importance of ensuring availability of food. It requires the stabilization of GHG in the atmosphere to be achieved within a time frame suﬃ cient to “ensure that food production is not threatened.” 133 Climate impacts, and possibly climate response measures may threaten both availability and accessibility to food. 134 The IPCC documents, across a range of temperature increases, complex, localized negative impacts on small holders, subsistence farmers and ﬁ shers. 135 For lower latitudes, even for small local temperature increases, crop productivity is projected to decrease, thereby increasing the risk of hunger. 136 Increases in extreme weather events, including droughts and ﬂ oods, will also negatively aﬀ ect crop production, 137 thereby placing both availability and accessibility at risk. The Stern Review refers to a study that pegs the increase in the number of people at risk of hunger at 30-200 million for a 2-3 degrees celcius increase, and 250-550 million beyond 3 degrees Celsius. Around 800 million people are already at risk of hunger. 138 The UNDP estimates that an additional 600 million people will face malnutrition due to climate change, with a particularly negative eﬀ ect on Sub-Saharan Africa. 139 Malnutrition was associated with 54% of child deaths in 2001. 140 Climate change is projected to exacerbate this vulnerability. The right to adequate food may also be placed at risk by policies and measures to mitigate climate change, namely, as the Special Rapporteur on the right to food has noted, the use of bio fuels as an alternative to high GHG emiĴ ing fossil fuels. 141 The use of food and feed crops for fuel increases the role of energy markets in determining the value of agricultural commodities which are direct or indirect substitutes for biofuel feed stocks. 142 Food prices, hitherto on a downward trend, could increase once more, thereby aﬀ ecting accessibility. 143

#### **Climate change exacerbates water inequality**

McInerney-Lankford et al 11 (Siobhan McInerney-Lankford, Mac Darrow, and Lavanya Rajamani, The World Bank, “Human Rights and Climate Change”, <http://siteresources.worldbank.org/INTLAWJUSTICE/Resources/HumanRightsAndClimateChange.pdf>)

The right to water, 163 as an essential condition for survival, is not just a self-standing right, 164 but is recognized as inextricably linked with other human rights such as the right to an adequate standard of living, the right to the highest aĴ ainable standard of health, and the rights to adequate housing and adequate food. 165 Climate change [is projected to seriously aﬀ ect the availability of water. The Stern Review records that even a 1 degree Celsius rise in temperature will threaten water supplies for 50 million people, and a 5 degrees Celsius rise in temperature will result in the disappearance of various Himalayan glaciers threatening water shortages for a quarter of China’s population, and hundreds of millions of Indians. 166 The OHCHR report on climate change and human rights relies on the 2007 IPCC assessment to state: “Loss of glaciers and reductions in snow cover are projected to increase and to negatively aﬀ ect water availability for more than one-sixth of the world’s population supplied by melt water from mountain ranges. Weather extremes, such as drought and ﬂ ooding, will also impact on water supplies. Climate change will thus exacerbate existing stresses on water resources and compound the problem of access to safe drinking water, currently denied to an estimated 1.1 billion people globally and a major cause of morbidity and disease.” 167

#### **Climate change threatens the fundamental human rights of disadvantaged communities**

McInerney-Lankford et al 11 (Siobhan McInerney-Lankford, Mac Darrow, and Lavanya Rajamani, The World Bank, “Human Rights and Climate Change”, <http://siteresources.worldbank.org/INTLAWJUSTICE/Resources/HumanRightsAndClimateChange.pdf>)

In addition to the rights discussed thus far, climate change may impact the progressive realization of a range of other rights as well. Climate change has been characterised as a “profound denier of freedom of action and a source of disempowerment.” 179 Climate impacts – extreme weather events, increased ﬂ ood and drought risk, changing weather and crop paĴ erns, among others – will likely hamper the realization of the rights to private and family life, 180 property, 181 means of subsistence, 182 freedom of residence 183 and movement. 184 For indigenous groups like the Inuit, climate impacts will fundamentally alter their way of life, aﬀ ecting a further set of protected rights and interests, 185 in particular the right to the beneﬁ ts of their culture, 186 and the right to freely dispose of natural resources. 187 There are concerns among certain groups that policies and measures to reduce emissions from deforestation, a signiﬁ cant contributor to climate change, may have direct relevance to indigenous peoples’ rights particularly in relation to traditional rights to forest produce. 188 For these and other communities whose very existence is threatened, such as those living in small island states, climate change threatens their right to self-determination, protected by both the ICCPR and the ICESCR. 189 Research indicates that inequalities within countries are a marker for vulnerability to climate shocks. 190 One recent quantitative assessment of the human impacts of disasters found that “countries with high levels of income inequality experience the eﬀ ects of climate disasters more profoundly than more equal societies.” 191 ‘The eﬀ ects of climate change will be felt most acutely by those segments of the population who are already in vulnerable situations due to factors such as poverty, gender, age, minority status, and disability.’ 192 For example, there is a growing body of scholarship that documents the gendered impacts of climate change and climate change policy and the disproportionate impacts on women’s rights. 193 The nature of that vulnerability varies widely, cautioning against generalisation. However, because women form a disproportionate share of the poor in developing countries and communities that are highly dependent on local natural resources, women will in many instances, be disproportionately vulnerable to the impacts of climate change. 194 The situation is further exacerbated by gender diﬀ erences in property rights, political participation, access to information and in economic, social and cultural roles. 195 [The CEDAW CommiĴ ee has issued a statement on Gender and Climate Change as a contribution to the COP 15 negotiations, drawing aĴ ention to the gender-diﬀ erentiated impacts of climate change and the need for equal participation of women and men in decision-making. 196 Another particularly vulnerable group is children. The OHCHR reports that: “[o]verall, the health burden of climate change will primarily be borne by children in the developing world.” 197 In 2007, Save the Children UK reported that within the next decade up to 175 million children are likely to be aﬀ ected every year by natural disasters brought about by climate change. 198 Recent research by the United Nations Children’s Fund (UNICEF) identiﬁ es a wide range of circumstances – ranging from physical aĴ ributes of children to structural factors determining the distribution of economic power and social roles, such as the gendered divisions of labour – that will render climate change especially threatening to children by exacerbating existing health risks; destroying clinics, homes and schools; disrupting the natural resource base sustaining community livelihoods and nutrition and water security; provoking population displacements; and undermining support structures that protect children from harm. 199 Extreme weather events and reduced quantity and quality of water already are leading causes of malnutrition and child death and illness. Climate change will again exacerbate these stresses.

# \*\*\*AT: CASE TURNS\*\*\*

# AT: Earthquake Turn

#### No risk of earthquakes

Reisinger 9 (JD, Attorney @ Ohio Environmental Council

Will, “RECONCILING KING COAL AND CLIMATE CHANGE: A REGULATORY FRAMEWORK FOR CARBON CAPTURE AND STORAGE,” Vermont Journal of Environmental Law, http://vjel.org/journal/pdf/VJEL10107.pdf)

Injecting large quantities of foreign substances deep underground, especially in earthquake-prone regions, could potentially trigger seismic activity. 101 Some fear that massive quantities of CO2 could expand within porous rock, increase pressure, and possibly lead to earthquakes. 102 Most geologists, however, have concluded that this type of harm is an improbable result of CCS injections. The risk of “induced seismicity” will not likely deter serious operators or investors, but is more likely to be used as a rallying cry by environmental groups and citizen activists who are opposed to CCS.

#### CCS stops fracking

Scientific American 12 (Science Magazine, “Can Fracking and Carbon Sequestration Coexist,” 3/16/12, http://www.scientificamerican.com/article.cfm?id=can-fracking-and-carbon-sequestration-co-exist)

Natural gas production and carbon sequestration may be headed for an underground collision course. That is the message from a new study finding that many of the same shale rock formations where companies want to extract gas also happen to sit above optimal sites envisioned for storing carbon dioxide underground that is captured from power plants and industrial facilities. The problem with this overlap, the researchers found, is that shale-gas extraction involves fracturing rock that could be needed as an impenetrable cover to hold CO2 underground permanently and prevent it from leaking back into the atmosphere. "Shale gas production through hydraulic fracturing can compromise future use of the shale as a caprock formation in a CO2 storage operation," said Michael Celia, a civil and environmental engineering professor at Princeton University and a co-author of the study. "There is an obvious conflict between the two uses," the study says. Celia's work with colleague Thomas Elliot, a postdoctoral research associate, will be published in an upcoming paper version of Environmental Science & Technology. The two reported that 80 percent of the potential area to store CO2 underground in the United States could be restrained by shale and tight gas development. The numbers held when they examined potential CO2 storage sites close to the nation's largest greenhouse gas emitters, such as coal plants. Natural gas is extracted from shale via hydraulic fracturing, in which rock is cracked so that injected fluids can flow through the rock more easily to extract gas. The process is designed to increase permeability of the rock over a long distance. That cracking of the shale rock is what could make it inappropriate for use as a stable, impervious rock layer blocking upper migration of injected CO2, the researchers said.

#### Fracking increases the rate of earthquakes more than the plan does

Bloomberg 12 (Mark Drajem, staff writer, "Fracking Tied To Unusual Rise In Earthquakes In U.S.", April 12, 2012, [www.bloomberg.com/news/2012-04-12/earthquake-outbreak-in-central-u-s-tied-to-drilling-wastewater.html](http://www.bloomberg.com/news/2012-04-12/earthquake-outbreak-in-central-u-s-tied-to-drilling-wastewater.html))

A spate of earthquakes across the middle of the U.S. is “almost certainly” man-made, and may be caused by wastewater from oil or gas drilling injected into the ground, U.S. government scientists said in a study. Researchers from the U.S. Geological Survey said that for the three decades until 2000, seismic events in the nation’s midsection averaged 21 a year. They jumped to 50 in 2009, 87 in 2010 and 134 in 2011. In northern California, engineers are drilling to great depths to force water into bedrock, a process that causes slippage and small earthquakes. Those statistics, included in the abstract of a research paper to be discussed at the Seismological Society of America conference next week in San Diego, will add pressure on an energy industry already confronting more regulation of the process of hydraulic fracturing. “Our scientists cite a series of examples for which an uptick in seismic activity is observed in areas where the disposal of wastewater through deep-well injection increased significantly,” David Hayes, the deputy secretary of the U.S. Department of Interior, said in a blog post yesterday, describing research by scientists at the U.S. Geological Survey. ‘Fairly Small’ Quakes The earthquakes were “fairly small,” and rarely caused damage, Hayes said. He said not all wastewater disposal wells induce earthquakes, and there is no way of knowing if a disposal well will cause a temblor. Last month, Ohio officials concluded that earthquakes there last year probably were caused by wastewater from hydraulic fracturing for natural gas injected into a disposal well. In hydraulic fracturing -- or fracking -- water, sand and chemicals are injected into deep shale formations to break apart underground rock and free natural gas trapped deep underground. Much of that water comes back up to the surface and must then be disposed of. There’s “a difference between disposal injection wells and hydraulically fractured wells,” Daniel Whitten, a spokesman for the America’s Natural Gas Alliance, which represents companies such as Chesapeake Energy Corp. (CHK) and Cabot Oil & Gas Corp. (COG), said in an e-mail. “There are over 140,000 disposal wells in America, with only a handful potentially linked to seismic activity.

#### Earthquakes inevitable

MTU 7(Michigan Tech University, April 3, 2007, “Where Do Earthquakes Happen?,” [http://www.geo.mtu.edu/UPSeis/where.html)](http://www.geo.mtu.edu/UPSeis/where.html%29//DR)

**Earthquakes occur all the time all over the world, both along plate edges and along faults.** Along Plate Edges **Most earthquakes occur along the edge of the oceanic and continental plates.** The earth's crust (the outer layer of the planet) is made up of several pieces, called plates. **The plates under the oceans are called oceanic plates and the rest are continental plates. The plates are moved around by the motion of a deeper part of the earth** (the mantle) **that lies underneath the crust. These plates are always bumping into each other, pulling away from each other, or past each other.** The plates usually move at about the same speed that your fingernails grow. **Earthquakes usually occur where two plates are running into each other or sliding past each other.**

#### Alt causes

Zoback and Gorelick 12(Mark D. Zoback Professor at the Department of Geophysics at Stanford University, and Steven M. Gorelick Professor of Environmental Earth System Sciences at Stanford University, “Earthquake triggering and large-scale geological storage of carbon dioxide” Found on the Proceedings of the National Academy of Sciences, May 4th, 2012)

Because of the critically stressed nature of the crust, ﬂuid injection in deep wells can trigger earthquakes when the injection increases pore pressure in the vicinity of preexisting potentially active faults. The increased pore pressure reduces the frictional resistance to fault slip, allowing elastic energy already stored in the surrounding rocks to be released in earthquakes that would occur someday as the result of natural geologic processes (8). This effect was first documented in the 1960s in Denver, Colorado when injection into a 3-km-deep well at the nearby Rocky Mountain Arsenal triggered earthquakes (9). Soon thereafter it was shown experimentally (10) at the Rangely oil field in western Colorado that earthquakes could be turned on and off by varying the rate at which water was injected and thus modulating reservoir pressure. In 2011 alone, a number of small to moderate earthquakes in the United States seem to have been triggered by injection of wastewater (11). These include earthquakes near Guy, Arkansas that occurred in February and March, where the largest earthquake was M 4.7. In the Trinidad/Raton area z near the border of Colorado and New Mexico, injection of produced water associated with coalbed methane production seems to have triggered a number of earthquakes, the largest being a M 5.3 event that occurred in August. Earthquakes seem to have been triggered by wastewater injection near Youngstown, Ohio on Christmas Eve and New Year’s Eve, the largest of which was M 4.0. Although the risks associated with wastewater injection are minimal and can be reduced even further with proper planning (11), the situation would be far more problematic if similar-sized earthquakes were triggered in formations intended to sequester CO2 for hundreds to thousands of years.

# AT: Leaks

#### No leaks

Stephenson 8 (Director, Natural Resources and Environment @ GAO

“Federal Actions Will Greatly Affect the Viability of Carbon Capture and Storage As a Key Mitigation Option,” GAO, <http://www.gao.gov/new.items/d081080.pdf>)

According to the preamble to EPA’s proposed rule, improperly operated injection activities or ineffective long-term storage could result in release of injected CO2 to the atmosphere, resulting in the potential to impact human health. EPA’s summaries of stakeholder workshops indicate that public health concerns have been expressed about such issues. One concern is the risk that improperly operated injections could result in the release of CO2 , and that at very high concentrations and with prolonged exposure, CO2 can lead to suffocation. Concerns have also been raised that improperly injected CO2 could raise the pressure in a geologic formation and, if it became too high, could cause otherwise dormant faults to trigger seismic events, such as earthquakes. The IPCC has noted, however, that 99 percent of the CO2 stored in appropriately selected and managed formations is very likely to be retained for over 100 years, 55 and EPA states in the preamble to its proposed rule that the risk of asphyxiation and other health effects from airborne exposure to CO2 resulting from injection activities is minimal.

#### No leaks or spikes

Reisinger 9 (JD, Attorney @ Ohio Environmental Council

Will, “RECONCILING KING COAL AND CLIMATE CHANGE: A REGULATORY FRAMEWORK FOR CARBON CAPTURE AND STORAGE,” Vermont Journal of Environmental Law, http://vjel.org/journal/pdf/VJEL10107.pdf)

Because CO2 is toxic at high concentrations, some fear that escaping CO2 from a non-performing sequestration site could poison surrounding air supplies, potentially harming humans and animals. 93 The threat of catastrophic escape is often cited as an argument against CCS demonstration projects. The Lake Nyos disaster of 1986, in which volcanic activity led to a massive release of naturally occurring CO2 from beneath an African lake, is often mentioned. 94 The Lake Nyos incident was an earth science anomaly and not analogous to commercial CCS storage. At Lake Nyos, volcanic activity beneath the lake led to a buildup of pure CO2, which was sequestered in the deepest waters of the lake and eventually escaped in a large poisonous cloud. 95 By contrast, any atmospheric releases of CO2 at a non-performing CCS site would be small and incremental, not likely to result in harm like that at Lake Nyos. Captured CO2 is injected while in a supercritical state (with both gaseous and liquid characteristics) and is stored as it permeates porous rock. 96 Thus, the stored CO2 is not sequestered in vast underground reservoirs, and it is unlikely that a massive cloud of CO2 could escape.

#### No leakage from pipelines or storage

CTA 11 (Carbon Tech Alliance, “Frequently Asked Questions,” <http://www.carbontechalliance.org/welcome/frequently-asked-questions>)

What safety measures are in place if something goes wrong, is it a case of once it happens it's too late? There are over 3,600 miles of existing CO2 pipelines in the United States. There are existing rigorous safety requirements that must be met for the construction and operation of CO2 pipelines. These requirements include specification of pipeline materials, plans for routine inspection and maintenance, continuous monitoring of pipeline operations to insure safety, and emergency response plans that address specific actions that would be taken in response to postulated accidents. There are also deep monitoring wells associated with storage areas. These wells are designed to detect any leakage long before it could ever migrate to the surface.

# AT CO2 Fertilization

#### Consensus is on our side – weeds, pests, invasive species, diseases, and droughts overwhelm CO2 fertilization

**Garber** 200**8** *US News and World Report* [Kent, “How Global Warming Will Hurt Crops,” *US News and World Report* 5/28/08, http://www.usnews.com/articles/news/2008/05/28/how-global-warming-will-hurt-crops.html]

The global food supply, as recent events have shown all too clearly, is threatened by many problems. Some of them are man-made; some are natural. The natural ones tend to be obvious—droughts, floods, hurricanes, earthquakes—and, in the past year alone, they have been notably devastating. Searing droughts in Australia and central Europe have squandered wheat supplies; more recently, Cyclone Nargis destroyed rice stocks for millions of people in Myanmar. Historically, the damage to food supplies by bad weather has been regarded as fleeting: catastrophic in the short term but ultimately remitting. Droughts ease, floodwaters recede, and farmers replant their crops. But as a new government report indicates, such views are increasingly narrow and outdated, in that they fail to acknowledge the creeping reach of global climate change. The report, released Tuesday, offers one of the **most comprehensive** looks yet at the impact that climate change is expected to have on U.S. agriculture over the next several decades. Not surprisingly, the prognosis is grim. Temperatures in the United States, scientists say, will rise on average by about 1.2 degrees Celsius by 2040, with carbon dioxide levels up more than 15 percent. The consequences for American-grown food, the report finds, will most likely be far-reaching: Some crop yields are predicted to drop; growing seasons will get longer and use more water; **weeds** and shrubs will grow faster and spread into new territory, some of it arable farmland; and **insect and** crop **disease** outbreaks will become more frequent. The new report, which was produced by more than a **dozen agencies** over multiple years and reflects the findings of **more than 1,000 scientific studies**, offers only predictions, but the predictions reflect a high degree of confidence. In a sense, there is a vein of fatalism among most scientists about what will happen in the next few decades. Government actions, they say, may alter the trajectory of climate change 50 to 100 years from now, but the fate of climate change in the short term has been largely shaped by past behavior, by carbon already released into the atmosphere. The question now is the extent of its impact.Some agricultural changes are already observable. In the central Great Plains, in states known for their grassy prairies and sprawling row crops, there are new neighbors: trees and large shrubs, often clustering in islands in the middle of fields. In the Southwest, perennial grasses have been largely pushed out by mesquite bushes, those long-rooted staples of the desert. And the invasive kudzu vine, formerly a nuisance only to the South, has advanced steadily northward, forming a staggered line stretching from Connecticut to Illinois. Human practices in all three cases have abetted the turnover, but climate change, scientists say, has been a primary driver, as invasive species reproduce more quickly and expand into areas once deemed too cold for their survival. In turn, high-quality pastureland, once ideal for livestock grazing, has become poor-quality brush, and farmland faces competitors for space. In the next 30 years these problems will very likely expand and multiply, as an already taxed food system faces threats on multiple fronts. A rise in temperature—even as little as 1 degree Celsius—could cause many plantings to fail, the report indicates, since pollen and seeds are sensitive to slight temperature changes. Yields of corn and rice are expected to decline slightly. Heat-sensitive fruits and vegetables, such as tomatoes, will most likely suffer. Some of the potential damage will be blunted by higher carbon dioxide levels; soybean yields, for instance, will probably improve, because soybeans (and several other crops) thrive from higher carbon inputs. But if temperatures keep rising, **the balance will ultimately tip**: At some extreme temperature, **cells stop dividing**, and pollen dies. High ozone levels, which have risen sixfold in the United States in the past century and are expected to rise further, will suppress yields as well. In fact, ozone levels are already extremely high in the eastern and midwestern regions of the country, rivaled globally only by eastern China (no model of air quality, to be sure) and parts of western Europe. One recent study, for instance, found that high ozone levels significantly suppress yields of soybean, wheat, and peanuts in the Midwest.Eventually, the effects of climate change, far from being limited to individual plants, could percolate throughout entire ecosystems. If springs become warmer, as predicted, the crop-growing season will expand. Insects and pests, thriving in warmer winters, will reproduce more frequently and spread more rapidly. Many, in fact, are proliferating already, as reflected in reports of abnormally high rates of disease outbreaks in the western half of the United States. Higher temperatures also are usually accompanied by declining rainfall, threatening to slowly transform once lush areas into arid expanses. At the same time, droughts and heavy isolated rainfalls could become more numerous.

#### We control uniqueness – food supplies sufficient now but on the brink

**Dupont** 200**8** Michael Hintze Professor of International Security and Director of the Centre for International Security Studies at the University of Sydney [Alan, “The Strategic Implications of Climate Change,” *Survival*, Vol. 50, Iss. 3 June 2008, pp. 29 – 54]

Weather extremes and greater fluctuations in rainfall and temperatures have the capacity to refashion the world’s productive landscape, especially at a time of rising populations in the developing world and concerns that the green revolution of the twentieth century may have largely run its course. Crop yield increases have levelled off since the 1990s and increases in the frequency of extreme weather events, such as cyclones, riverine flooding, hail and drought will disrupt agriculture and put pressure on prices. If the gap between global supply and demand for a range of primary foods narrows, price volatility on world markets is likely to increase and will be exacerbated by the reduction in food stockpiles mandated by the implementation of the 1994 World Trade Organisation’s Uruguay Round agreement. The world’s food stocks are already at historical lows due to a combination of rising demand and crop substitution. Much corn is now converted to ethanol for biofuels, rather than being used for human and animal consumption, and productive farmland is being lost due to environmental degradation and urbanisation. Without the moderating influence of **substantial grain stocks**, a confluence of unfavourable political and economic influences, aggravated by climate change, could create local scarcities, sparking food riots and domestic unrest. If sustained, reduced crop yields could seriously undermine political and economic stability, especially in the developing world. Of course, doomsayers have long warned of an approaching food deficit and been **proved wrong**. **Most food economists** believe that global supply will be **able to keep ahead of rising demand**. But their assumptions have not adequately factored in the impact of climate change, especially the shift in rainfall distribution, rising temperatures and the probable increase in extreme weather events. Nor have they accounted for the fact that agricultural yields are heavily dependent on high fertiliser use, which links food production to climate change through the energy cycle. The need to achieve greenhouse-gas reductions will increase energy costs, making it more difficult to maintain the per capita food yield gains of the previous century.

#### More atmospheric CO2 means less CO2 intake

**Strom** 200**7** Professor Emeritus of planetary sciences in the Department of Planetary Sciences at the University of Arizona [Robert, studied climate change for 15 years, the former Director of the Space Imagery Center, a NASA Regional Planetary Image Facility, *Hot House: Global Climate Change and the Human Condition*, p. 123]

It has been suggested that the increase in C02 will be at least partly offset by what is termed "C02 fertilization." The concept is that elevated levels of C02 would stimulate plant growth so that plants would take up excess C02 to produce carbohydrates, which are their stored energy source. However, contrary to predictions, increased C02 only accelerates plant growth to about **one-third** of what was expected. In fact, increased C02 may have a **positive feedback** in that C02 is absorbed less with increasing C02 levels (Young et al., 2006). The stomata of leaves are the parts of a plant that "breathe" in C02 and "exhale" oxygen. A new study shows that the level of C02 in the atmosphere controls the opening and closing of leaf stomata (Young et al., 2006); the higher the concentration of C02, the smaller the stomata opening and the less C02 intake. The lower the C02 abundance, the larger the opening and the more C02 intake. A doubling of the C02 abundance caused leaf stomata to close by about 20-40% in a variety of plant species, thus reducing the C02 intake. Therefore, the increasing atmospheric abundance of C02 will result in **less C02 uptake** by plants, not more.

#### CO2 depletes soil nutrients

**Körner et al**, 200**7** professor of botany at University Basel [Christian, also Jack Morgan, plant physiologist at USDA and faculty member in the Crops and Soils Department at Colorado State University, and Richard Norby, researcher in the Environmental Sciences Division at the Oak Ridge National Laboratory, *CO2 Fertilization: When, Where, How Much?*, p. 9-10]

It is obvious that these carbon investments also depend on resources other than CO2, in particular mineral nutrients. A common effect of short-term plant exposure to elevated CO2 is a **reduced consumption** of nutrients, but also water, per unit of biomass produced (Drake et al. 1997) or a constant consumption at greater biomass per unit land area (Niklaus and Körner 2004). In cases where total nutrient uptake is increased under elevated CO2 (Finzi et al. 2002) this will deplete soil resources in the long run. In cases where tissue nutrient concentrations are depleted, this will induce **cascades** of negative ecosystem level feedbacks, which eventually may also cause initial rates of carbon gain to diminish. In many cases, it became **questionable** whether carbon is a limiting resource at the whole plant or ecosystem level (Körner 2003a). It is worth recalling that all taxa of today’s biosphere grew and reproduced successfully with only 180–190 ppm, half the current CO2 concentration, 18 000 years before present (peak of last glaciation). Based on this reference period, current biota operate already in a double CO2 atmosphere. In addition, the observed reduction of water consumption per unit land area is likely to induce climatic feedbacks (through a drier atmosphere), not yet accounted for in experiments. Furthermore, any CO2 enrichment effect on plants will depend on their developmental stage, with younger plants more responsive than older ones (Loehle 1995). Most of the CO2-enrichment responses for woody species available to date are – for very practical reasons – for young, rapidly expanding life stages, during which carbon is more likely a limiting resource.

# AT: Ice Age

#### Warming will shut down the thermohaline current – negative feedbacks are overwhelmed – consensus goes aff.

Timothy Lenton 8 [et al.], School of Environmental Science, University of East Anglica, (Tipping elements in the Earth’s climate system, Proceedings of the National Academy of Sciences, Vol. 105)

Atlantic Thermohaline Circulation (THC). A shutoff in North Atlantic Deep Water formation and the associated Atlantic THC can occur if sufficient freshwater (and/or heat) enters the North Atlantic to halt density-driven North Atlantic Deep Water formation (41). Such THC reorganizations play an important part in rapid climate changes recorded in Greenland during the last glacial cycle (42, 43). Hysteresis of the THC has been found in all models that have been systematically tested thus far (44), from conceptual ‘‘box’’ representations of the ocean (45) to OAGCMs (46). The most complex models have yet to be systematically tested because of excessive computational cost. Under sufficient North Atlantic freshwater forcing, all models exhibit a collapse of convection. In some experiments, this collapse is reversible (47) (after the forcing is removed, convection resumes), whereas in others, it is irreversible (48)— indicating bistability. In either case, a tipping point has been passed according to condition 1. The proximity of the present climate to this tipping point varies considerably between models, corresponding to an additional North Atlantic freshwater input of 0.1–0.5 Sv (44). The sensitivity of North Atlantic freshwater input to anthropogenic forcing is also poorly known, but regional precipitation is predicted to increase (12) and the GIS could contribute significantly (e.g., GIS melt over 1,000 years is equivalent to 0.1 Sv). The North Atlantic is observed to be freshening (49), and estimates of recent increases in freshwater input yield 0.014 Sv from melting sea ice (18), 0.007 Sv from Greenland (29), and 0.005 Sv from Eurasian rivers (50), totaling 0.026 Sv, without considering precipitation over the oceans or Canadian river runoff. The IPCC (12) argues that an abrupt transition of the THC is ‘‘very unlikely’’ (probability 10%) to occur before 2100 and that any transition is likely to take a century or more. Our definition encompasses gradual transitions that appear continuous across the tipping point; hence, some of the IPCC runs (ref. 12, p. 773 ff) may yet meet our criteria (but would need to be run for longer to see if they reach a qualitatively different state). Furthermore, the IPCC does not include freshwater runoff from GIS melt. Subsequent OAGCM simulations clearly pass a THC tipping point this century and undergo a qualitative change before the next millennium (48). Both the timescale and the magnitude of forcing are important (51), because a more rapid forcing to a given level can more readily overwhelm the negative feedback that redistributes salt in a manner that maintains whatever is the current circulation state.

#### Warming causes an ice age-best evidence proves.

Leigh Dayton 4, Science Writer for the Australian (The Australian, Lexis)

IN the latest Hollywood blockbuster, The Day After Tomorrow, the world is plunged into a sudden and deadly ice age because humanity tossed too many "greenhouse gases" into the atmosphere. Now, new evidence from the longest ice core ever drilled from Antarctica provides compelling evidence that we're racing towards an icy future. And it's thanks to modern global warming and the climate instability it can trigger. A consortium of researchers from eight nations, led by Eric Wolff of the British Antarctic Survey in Cambridge, has retrieved a core from the 3km-thick ice at a site known as Dome C in East Antarctica. The core reveals in remarkable detail what the climate of Earth was like over the past 740,000 years. Writing in the journal Nature, Dr Wolff and his colleagues with the European Project for Ice Coring in Antarctica (EPICA) report they have discovered the telltale signs of eight ice ages in that period of time. The new work adds to studies of other Antarctic ice cores, finding that four climate cycles, glacial to inter-glacial to glacial, occurred over the past 430,000 years. According to the team, preliminary analysis of the core shows conditions at the end of one of those early ice ages were similar to conditions at the end of the last ice age, some 12,000 years ago. That earlier warm inter-glacia period lasted 28,000 years. Given the temperature and atmospheric similarities between that period and today, the EPICA scientists conclude we'd be headed for another balmy 16,000 years "without human intervention". Today, levels of the key greenhouse gases, carbon dioxide and methane, are escalating rapidly. The gases, produced mainly by burning fossil fuels and other industrial activities, reflect light back towards Earth, triggering global warming. Ironically, warming can set off a chain of atmospheric, oceanic and climatological changes that can trigger a sudden climate switch ... and a new ice age.

#### Tech can stop a natural ice age.

James Hansen 7, Prof. Environmental Sciences @Columbia University (http://arxiv.org/pdf/0706.3720)

Thus the natural tendency today, absent humans, would be toward the next ice age, albeit the tendency would not be very strong because the eccentricity of the Earth’s orbit is rather small (0.017). However, another ice age will never occur, unless humans go extinct. Although orbital changes are the ‘pacemaker’ of the ice ages, the two mechanisms by which the Earth becomes colder in an ice age are reduction of the long-lived GHGs and increase of ice sheet area. But these natural mechanisms are now overwhelmed by human-made emissions, so GHGs are skyrocketing and ice is melting all over the planet. Humans are now in control of global climate, for better or worse. An ice age will never be allowed to occur if humans exist, because it can be prevented by even a ‘thimbleful’ of CFCs (chlorofluorocarbons), which are easily produced.

#### Our turns outweigh on timeframe- natural ice age not coming for 70,000 years.

Berger and Loutre 2, Université catholique de Louvain, Institut d'Astronomie et de Géophysique, [André. and M.F., “An Exceptionally Long Interglacial Ahead?” Science 23 August, Vol. 297. no. 5585, pp. 1287 – 1288]

When paleoclimatologists gathered in 1972 to discuss how and when the present warm period would end (1), a slide into the next glacial seemed imminent. But more recent studies point toward a different future: a long interglacial that may last another 50,000 years. An interglacial is an uninterrupted warm interval during which global climate reaches at least the preindustrial level of warmth. Based on geological records available in 1972, the last two interglacials (including the Eemian, ~125,000 years ago) were believed to have lasted about 10,000 years. This is about the length of the current warm interval--the Holocene--to date. Assuming a similar duration for all interglacials, the scientists concluded that "it is likely that the present-day warm epoch will terminate relatively soon if man does not intervene" (1, p. 267). Some assumptions made 30 years ago have since been questioned. Past interglacials may have been longer than originally assumed (2). Some, including marine isotope stage 11 (MIS-11, 400,000 years ago), may have been warmer than at present (3). We are also increasingly aware of the intensification of the greenhouse effect by human activities (4). But even without human perturbation, future climate may not develop as in past interglacials (5) because the forcings and mechanisms that produced these earlier warm periods may have been quite different from today's. Most early attempts to predict future climate at the geological time scale (6, 7) prolonged the cooling that started at the peak of the Holocene some 6000 years ago, predicting a cold interval in about 25,000 years and a glaciation in about 55,000 years. These projections were based on statistical rules or simple models that did not include any CO2 forcing. They thus implicitly assumed a value equal to the average of the last glacial-interglacial cycles [~225 parts per million by volume (ppmv) (8)]. But some studies disagreed with these projections. With a simple ice-sheet model, Oerlemans and Van der Veen (9) predicted a long interglacial lasting another 50,000 years, followed by a first glacial maximum in about 65,000 years. Ledley also stated that an ice age is unlikely to begin in the next 70,000 years (10), based on the relation between the observed rate of change of ice volume and the summer solstice radiation. Other studies were more oriented toward modeling, including the possible effects of anthropogenic CO2 emissions on the dynamics of the ice-age cycles. For example, according to Saltzman et al. (11) an increase in atmospheric CO2, if maintained over a long period of time, could trigger the climatic system into a stable regime with small ice sheets, if any, in the Northern Hemisphere. Loutre (12) also showed that a CO2 concentration of 710 ppmv, returning to a present-day value within 5000 years, could lead to a collapse of the Greenland Ice Sheet in a few thousand years. On a geological time scale, climate cycles are believed to be driven by changes in insolation (solar radiation received at the top of the atmosphere) as a result of variations in Earth's orbit around the Sun. Over the next 100,000 years, the amplitude of insolation variations will be small (see the figure), much smaller than during the Eemian. For example, at 65ºN in June, insolation will vary by less than 25 Wm-2 over the next 25,000 years, compared with 110 Wm-2 between 125,000 and 115,000 years ago. From the standpoint of insolation, the Eemian can hardly be taken as an analog for the next millennia, as is often assumed. The small amplitude of future insolation variations is exceptional. One of the few past analogs (13) occurred at about 400,000 years before the present, overlapping part of MIS-11. Then and now, very low eccentricity values coincided with the minima of the 400,000-year eccentricity cycle. Eccentricity will reach almost zero within the next 25,000 years, damping the variations of precession considerably.

#### High CO2 levels prevent another ice age for at least another 50,000 years

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Several modeling studies provide outputs to support this progression. These studies show that with elevated levels of carbon dioxide, such as those that exist today, no permanent snow can exist over land in August (as temperatures are too warm), a necessary prerequisite for the growth of glaciers in the Northern Hemisphere [e.g., ( 6)]. These same models show that if the AMO were to be artificially shut down, there would be regions of substantial cooling in and around the North Atlantic. Berger and Loutre ( 7) specifically noted that "most CO[sub2] scenarios led to an exceptionally long interglacial from 5000 years before the present to 50,000 years from now . . . with the next glacial maximum in 100,000 years. Only for CO[sub2] concentrations less than 220 ppmv was an early entrance into glaciation simulated." They further argued that the next glaciation would be unlikely to occur for another 50,000 years.