DOWNLOAD PDF WHETHER THE WEATHER : AN ABRUPT CLIMATE CHANGE SCENARIO AND ITS MEANING(S FOR SECURITY

Chapter 1 : Space Weather: Its Effect on Human Health & Behavior â€“ Abrupt Earth Changes

ONA's decision to commission a scenario on abrupt climate change suggests that the military is aware of a need to expand its understanding of national security. Schwartz and Randall's study makes a contribution toward meeting that need.

Subscribe to Fortune Though triggered by warming, such change would probably cause cooling in the Northern Hemisphere, leading to longer, harsher winters in much of the U. Worse, it would cause massive droughts, turning farmland to dust bowls and forests to ashes. Climate researchers began getting seriously concerned about it a decade ago, after studying temperature indicators embedded in ancient layers of Arctic ice. The data show that a number of dramatic shifts in average temperature took place in the past with shocking speed--in some cases, just a few years. The case for angst was buttressed by a theory regarded as the most likely explanation for the abrupt changes. Pumping out warm, moist air, this "great conveyor" current gets cooler and denser as it moves north. That causes the current to sink in the North Atlantic, where it heads south again in the ocean depths. The sinking process draws more water from the south, keeping the roughly circular current on the go. A warmer climate also increases rainfall and runoff into the current, further lowering its saltiness. As a result, the conveyor loses its main motive force and can rapidly collapse, turning off the huge heat pump and altering the climate over much of the Northern Hemisphere. As the Ice Age began drawing to a close about 13, years ago, for example, temperatures in Greenland rose to levels near those of recent decades. Then they abruptly plunged as the conveyor apparently shut down, ushering in the "Younger Dryas" period, a 1,year reversion to ice-age conditions. A dryas is an Arctic flower that flourished in Europe at the time. Though Mother Nature caused past abrupt climate changes, the one that may be shaping up today probably has more to do with us. In an international panel of climate experts concluded that there is increasingly strong evidence that most of the global warming observed over the past 50 years is attributable to human activities--mainly the burning of fossil fuels such as oil and coal, which release heat-trapping carbon dioxide. Indicators of the warming include shrinking Arctic ice, melting alpine glaciers, and markedly earlier springs at northerly latitudes. A few years ago such changes seemed signs of possible trouble for our kids or grandkids. Accordingly, the spotlight in climate research is shifting from gradual to rapid change. In the National Academy of Sciences issued a report concluding that human activities could trigger abrupt change. Last year the World Economic Forum in Davos, Switzerland, included a session at which Robert Gagosian, director of the Woods Hole Oceanographic Institution in Massachusetts, urged policymakers to consider the implications of possible abrupt climate change within two decades. Such jeremiads are beginning to reverberate more widely. Hollywood has also discovered the issue--next summer 20th Century Fox is expected to release The Day After Tomorrow, a big-budget disaster movie starring Dennis Quaid as a scientist trying to save the world from an ice age precipitated by global warming. But what would abrupt climate change really be like? Scientists generally refuse to say much about that, citing a data deficit. But recently, renowned Department of Defense planner Andrew Marshall sponsored a groundbreaking effort to come to grips with the question. Since he has headed a secretive think tank whose role is to envision future threats to national security. Three years ago Defense Secretary Donald Rumsfeld picked him to lead a sweeping review on military "transformation," the shift toward nimble forces and smart weapons. Rather, it sketches a dramatic but plausible scenario to help planners think about coping strategies. Here is an abridged version: Or the conveyor might only temporarily slow down, potentially causing an era like the "Little Ice Age," a time of hard winters, violent storms, and droughts between and For planning purposes, it makes sense to focus on a midrange case of abrupt change. A century of cold, dry, windy weather across the Northern Hemisphere that suddenly came on 8, years ago fits the bill--its severity fell between that of the Younger Dryas and the Little Ice Age. Suppose it recurred, beginning in Here are some of the things that might happen by At first the changes are easily mistaken for normal weather variation--allowing skeptics to dismiss them as a "blip" of little importance and

leaving policymakers and the public paralyzed with uncertainty. But by there is little doubt that something drastic is happening. The average temperature has fallen by up to five degrees Fahrenheit in some regions of North America and Asia and up to six degrees in parts of Europe. By comparison, the average temperature over the North Atlantic during the last ice age was ten to 15 degrees lower than it is today. Massive droughts have begun in key agricultural regions. Violent storms are increasingly common as the conveyor becomes wobbly on its way to collapse. A particularly severe storm causes the ocean to break through levees in the Netherlands, making coastal cities such as the Hague unlivable. In California the delta island levees in the Sacramento River area are breached, disrupting the aqueduct system transporting water from north to south. Megadroughts afflict the U. That has a downside, though: It magnifies the haves-vs. Turning inward, the U. Borders are strengthened to hold back starving immigrants from Mexico, South America, and the Caribbean islands--waves of boat people pose especially grim problems. Tension between the U. America is forced to meet its rising energy demand with options that are costly both economically and politically, including nuclear power and onerous Middle Eastern contracts. Yet it survives without catastrophic losses. Europe, hardest hit by its temperature drop, struggles to deal with immigrants from Scandinavia seeking warmer climes to the south. Southern Europe is beleaguered by refugees from hard-hit countries in Africa and elsewhere. Japan has fewer resources but is able to draw on its social cohesion to cope--its government is able to induce population-wide behavior changes to conserve resources. It is hit by increasingly unpredictable monsoon rains, which cause devastating floods in drought-denuded areas. Other parts of Asia and East Africa are similarly stressed. Much of Bangladesh becomes nearly uninhabitable because of a rising sea level, which contaminates inland water supplies. Countries whose diversity already produces conflict, such as India and Indonesia, are hard-pressed to maintain internal order while coping with the unfolding changes. As the decade progresses, pressures to act become irresistible --history shows that whenever humans have faced a choice between starving or raiding, they raid. Imagine Eastern European countries, struggling to feed their populations, invading Russia--which is weakened by a population that is already in decline--for access to its minerals and energy supplies. Or picture Japan eyeing nearby Russian oil and gas reserves to power desalination plants and energy-intensive farming. Envision nuclear-armed Pakistan, India, and China skirmishing at their borders over refugees, access to shared rivers, and arable land. Or Spain and Portugal fighting over fishing rights--fisheries are disrupted around the world as water temperatures change, causing fish to migrate to new habitats. Growing tensions engender novel alliances. Canada joins fortress America in a North American bloc. Alternatively, Canada may seek to keep its abundant hydropower for itself, straining its ties with the energy-hungry U. North and South Korea align to create a technically savvy, nuclear-armed entity. Europe forms a truly unified bloc to curb its immigration problems and protect against aggressors. Russia, threatened by impoverished neighbors in dire straits, may join the European bloc. Nuclear arms proliferation is inevitable. Oil supplies are stretched thin as climate cooling drives up demand. Many countries seek to shore up their energy supplies with nuclear energy, accelerating nuclear proliferation. Israel, China, India, and Pakistan also are poised to use the bomb. As Harvard archeologist Steven LeBlanc has noted, wars over resources were the norm until about three centuries ago. As abrupt climate change hits home, warfare may again come to define human life. Over the past decade, data have accumulated suggesting that the plausibility of abrupt climate change is higher than most of the scientific community, and perhaps all of the political community, are prepared to accept. In light of such findings, we should be asking when abrupt change will happen, what the impacts will be, and how we can prepare--not whether it will really happen. In fact, the climate record suggests that abrupt change is inevitable at some point, regardless of human activity. Among other things, we should: In sum, the risk of abrupt climate change remains uncertain, and it is quite possibly small. But given its dire consequences, it should be elevated beyond a scientific debate. Action now matters, because we may be able to reduce its likelihood of happening, and we can certainly be better prepared if it does. It is time to recognize it as a national security concern. At least some federal thought leaders may be starting to perceive climate change less as a political annoyance and more as an issue demanding action. If so, the case for acting now to address

climate change, long a hard sell in Washington, may be gaining influential support, if only behind the scenes.

Chapter 2 : What Will Climate Change Do to the U.S.-Mexico Border? by Todd Miller â€" YES! Magazine

An Abrupt Climate Change Scenario and Its Implications for United States National Security October By Peter Schwartz and Doug Randall Imagining the Unthinkable.

Cloud seeding Cloud seeding is a common technique to enhance precipitation. Cloud seeding entails spraying small particles, such as silver iodide , onto clouds to affect their development, usually with the goal of increasing precipitation. Cloud seeding only works to the extent that there is already water vapor present in the air. Critics generally contend that claimed successes occur in conditions which were going to lead to rain anyway. In mountainous areas of the United States such as the Rocky Mountains and Sierra Nevada, [5] cloud seeding has been employed since the s. Storm prevention[edit] Hail cannons at an international congress on hail shooting held in Project Stormfury was an attempt to weaken tropical cyclones by flying aircraft into storms and seeding the eyewall with silver iodide. The project was run by the United States Government from to A similar project using soot was run in , with inconclusive results. Moshe Alamaro of the Massachusetts Institute of Technology [7] proposed using barges with upward-pointing jet engines to trigger smaller storms to disrupt the progress of an incoming hurricane; critics doubt the jets would be powerful enough to make any noticeable difference. The substance is a polymer in powder form a polyacrylic acid derivative which reportedly has the ability to absorb 1, times its own weight in water. The theory is that the polymer is dropped into clouds to remove their moisture and force the storm to use more energy to move the heavier water drops, thus helping to dissipate the storm. When the gel reaches the ocean surface, it is reportedly dissolved. Peter Cordani teamed up with Mark Daniels and Victor Miller, the owners of a government contracting aviation firm AeroGroup which operated ex-military aircraft commercially. The tests were documented on film and made international news showing the storms were successfully removed on monitored Doppler radar. In , the program was shut down because of political pressure through NOAA. NOAA published a page addressing various ideas in regards to tropical cyclone manipulation. In , "How to stop a hurricane" [13] explored various ideas such as: Using lasers to discharge lightning in storms which are likely to become hurricanes Pouring liquid nitrogen onto the sea to deprive the hurricane of heat energy. Creating soot to absorb sunlight and change air temperature and create convection currents in the outer wall. If enough power was used then it might be enough combined with computer modeling to form an interference pattern able to inhibit a hurricane or significantly reduce its strength by depriving it of heat energy. The first scientifically controlled and monitored effort generally recognized by the meteorological community as constituting weather modification occurred in Irving Langmuir first experimented with artificially seeding clouds to produce rain, his experiments showed positive results â€" sparking tremendous interest in the field nearly overnight. The Russians have long been interested in using weather modification as a way to control hail. Fogleman was issued to examine the concepts, capabilities, and technologies the United States would require to remain the dominant air and space force in the future. In law[edit] US and Canada agreement[edit] In , the US and Canada entered into an agreement under the auspices of the United Nations for the exchange of information on weather modification activity. President Jimmy Carter on December 13, ; and the U. Senate Bill and U. House Bill U. Senate Bill [24] and U. House Bill [25] were two bills proposed in that would have expanded experimental weather modification, to establish a Weather Modification Operations and Research Board , and implemented a national weather modification policy. Neither were made into law. Leedom was the key lobbyist on behalf of the weather modification bills. House Bill Senate Bill and House Bill , identical bills introduced July 17, , proposed to establish a Weather Mitigation Advisory and Research Board to fund weather modification research [26] [27] In religion and mythology[edit] Witches concoct a brew to summon a hailstorm. Magical and religious practices to control the weather are attested in a variety of cultures. In ancient India it is said that yajna or vedic rituals of chanting manthras and offering were performed by rishis to bring sudden bursts of rain fall in rain starved regions. Some Indigenous Americans , like some Europeans,

had rituals which they believed could induce rain. The Finnish people , on the other hand, were believed by others to be able to control weather. As a result, Vikings refused to take Finns on their oceangoing raids. Remnants of this superstition lasted into the twentieth century, with some ship crews being reluctant to accept Finnish sailors. The early modern era saw people observe that during battles the firing of cannons and other firearms often initiated precipitation. In Greek mythology , Iphigenia was offered as a human sacrifice to appease the wrath of the goddess Artemis , who had becalmed the Achaean fleet at Aulis at the beginning of the Trojan War. However, the sailors opened the bag while Odysseus slept, looking for booty money , and as a result were blown off course by the resulting gale. When Rome suffered from drought, the stone was dragged into the city. If the rain was not forthcoming, the statue of St Peter was removed from the church and tossed into a river.

Chapter 3 : Weather modification - Wikipedia

The report 'An Abrupt Climate Change Scenario and Its Implications for United States National Security' (Schwartz and Randall,) offers speculations on the potential devastating effects of.

Attribution of recent climate change In this article, " climate change " means a change in climate that persists over a sustained period of time. Changes in climate may be due to natural causes, e. Detection does not imply attribution of the detected change to a particular cause. NASA GISS The graph above shows the average of a set of temperature simulations for the 20th century black line , followed by projected temperatures for the 21st century based on three greenhouse gas emissions scenarios colored lines. This projection is relative to global temperatures at the end of the 20th century. Global surface temperature for the past 5. The last , years are expanded in the lower half of the figure image credit: Physical impacts of climate change Seven of these indicators would be expected to increase in a warming world and observations show that they are, in fact, increasing. Three would be expected to decrease and they are, in fact, decreasing. Each of the different colored lines in each panel represents an independently analyzed set of data. The data come from many different technologies including weather stations , satellites , weather balloons , ships and buoys. Some of the graphs show a positive trend , e. Other graphs show a negative trend, e. Evidence of warming is also apparent in living biological systems. With medium confidence see footnote 1 , IPCC [58] concluded that human influences had contributed to an increase in heavy precipitation events at the global scale. Projections of future changes in precipitation show overall increases in the global average, but with substantial shifts in where and how precipitation falls. Extremely hot nights have doubled in frequency. The area in which extremely hot summers are observed, has increased fold. These changes are not explained by natural variability, and attributed by climate scientists to the influence of anthropogenic climate change. Heat waves with high humidity pose a big risk to human health while heat waves with low humidity lead to dry conditions that increase wildfires. The mortality from extreme heat is larger than the mortality from hurricanes, lightning, tornadoes, floods, and earthquakes together [65] See also heat wave. Tropical cyclones At the global scale, the frequency of tropical cyclones will probably decrease or be unchanged. Some impacts will be beneficialâ€”e. Retreat of glaciers since A map of the change in thickness of mountain glaciers since Thinning in orange and red, thickening in blue. A map that shows ice concentration on 16 September , along with the extent of the previous record low yellow line and the mid-September median extent black line setting a new record low that was 18 percent smaller than the previous record and nearly 50 percent smaller than the long-term â€” average. The cryosphere is made up of areas of the Earth which are covered by snow or ice. Assuming high growth in greenhouse gas emissions SRES A2 , some models projected that Arctic sea ice in the summer could largely disappear by the end of the 21st century. Effects of global warming on oceans The role of the oceans in global warming is complex. The oceans serve as a sink for carbon dioxide, taking up much that would otherwise remain in the atmosphere, but increased levels of CO 2 have led to ocean acidification. Furthermore, as the temperature of the oceans increases, they become less able to absorb excess CO 2. The ocean have also acted as a sink in absorbing extra heat from the atmosphere. Ongoing effects include rising sea levels due to thermal expansion and melting of glaciers and ice sheets, and warming of the ocean surface, leading to increased temperature stratification. Other possible effects include large-scale changes in ocean circulation. Ocean acidification This map shows changes in the amount of aragonite dissolved in ocean surface waters between the s and the most recent decade â€” The uptake of human carbon emissions since the year has led to an average decrease in pH of 0. The effects of ocean acidification on the marine biosphere have yet to be documented. Oxygen depletion The amount of oxygen dissolved in the oceans may decline, with adverse consequences for ocean life. Future sea level Trends in global average absolute sea level, â€” Between and , the rate increased above the previous period to 3. Authors of IPCC AR4 SYR [24] were uncertain whether the increase in rate from to was due to natural variations in sea level over the time period, or whether it reflected

an increase in the underlying long-term trend. There are two main factors that have contributed to observed sea level rise. The major store of water on land is found in glaciers and ice sheets. Cited studies suggested a great deal of uncertainty in projections. There is variability both year-to-year and over longer time scales, with global ocean heat content observations showing high rates of warming for â€", but some cooling from to Regional effects of global warming Temperatures across the world in the s left and the s right , as compared to average temperatures from to Some are the result of a generalised global change, such as rising temperature, resulting in local effects, such as melting ice. In other cases, a change may be related to a change in a particular ocean current or weather system. In such cases, the regional effect may be disproportionate and will not necessarily follow the global trend. There are three major ways in which global warming will make changes to regional climate: The coast can also be considered a region, and will suffer severe impacts from sea level rise. The Arctic , Africa , small islands and Asian megadeltas are regions that are likely to be especially affected by climate change. Climate change and gender The impacts of climate change can be thought of in terms of sensitivity and vulnerability. Sectors sensitive to climate change include water resources, coastal zones, human settlements, and human health. Industries sensitive to climate change include agriculture , fisheries , forestry , energy , construction , insurance , financial services , tourism , and recreation. Food security , Food vs fuel , and â€" world food price crisis Graph of net crop production worldwide and in selected tropical countries. Raw data from the United Nations. This graph is based on several studies. With medium confidence, global production potential was projected to: Most of the studies on global agriculture assessed by Schneider et al. Studies had also not considered the development of specific practices or technologies to aid adaptation to climate change. Food security Easterling et al. It was noted that these projections were highly uncertain and had limitations. However, the assessed studies suggested a number of fairly robust findings. The first was that climate change would likely increase the number of people at risk of hunger compared with reference scenarios with no climate change. Climate change impacts depended strongly on projected future social and economic development. Additionally, the magnitude of climate change impacts was projected to be smaller compared to the impact of social and economic development. In , the global estimate for the number of people undernourished was million. By contrast, the SRES A2 scenario showed only a small decrease in the risk of hunger from levels. The smaller reduction under A2 was attributed to the higher projected future population level in this scenario. Droughts and agriculture Some evidence suggests that droughts have been occurring more frequently because of global warming and they are expected to become more frequent and intense in Africa, southern Europe, the Middle East, most of the Americas, Australia, and Southeast Asia. Effects of global warming on human health Human beings are exposed to climate change through changing weather patterns temperature, precipitation, sea-level rise and more frequent extreme events and indirectly through changes in water, air and food quality and changes in ecosystems, agriculture, industry and settlements and the economy Confalonieri et al.

Chapter 4 : Abrupt Climate Change: Should We Be Worried? -- Earth Changes -- calendrierdelascience.co

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Say Hollywood and, Yes, the Pentagon â€"New York Times, February 29, Abrupt climate change has been a growing topic of concern for about a decade for climate scientists, who fear that global warming could shut down the ocean conveyer that warms the North Atlantic, plunging Europe and parts of North America into Siberian-like conditions within a few decades or even years. But it was only with the recent appearance of a Pentagon report on the possible social effectsâ€"in terms of instability and warâ€"of abrupt climate change that it riveted public attention. To answer this question it is necessary to approach the issue in stages, by first addressing global warming, then abrupt climate change and its inherent social dangers, and finally how the present system of production constitutes a barrier to any ready solution. How Bad Is It? As carbon dioxide, methane, and other greenhouse gases accumulate in the atmosphere they trap heat that would otherwise radiate off into space. This natural greenhouse effect along with proximity to the sun serves to warm the earth making it habitable to diverse species. But now, as a result of enhanced greenhouse gas emissions from human production, most notably the burning of fossil fuels, this same life-supporting greenhouse effect is pushing average global temperatures higher and higher. Carbon dioxide concentration in the atmosphere is now at its highest point in the last , years and likely in the last 20 million years. Rising sea levels, heat waves, crop failures, worsening floods and droughts, and more extreme weather conditions in general are all to be expected as a result of such increases in average global temperature. Some of the warming to be experienced in coming decades is already locked-in. Greenhouse gases have atmospheric lifetimes of decades to centuries. Even if societies were to cease fossil fuel use and end all other forms of greenhouse gas emissions today the accumulation of such gases in the atmosphere would likely generate further warming on the order of 0. While if we do nothing to limit such emissions global average surface temperature could conceivably rise as much as 5. The main fear at present is that the rise in global temperature will be two or three times as large if human society is unable to act decisively. In mountainous regions all around the earth plant and animal species are ascending higher and higher as warming occurs. But mountains only reach so far. Still, the ruling economic and political interests and their attendant elites tell us not to be worried. Never mind the threats to other species. Human society, we are frequently told, is different. What is often projected for global society then is increased discomfort rather than massive social upheaval and dislocation. Orthodox economists generally caution that we should do nothing that might limit economic growth. Instead they see the only answer as lying in a bigger economy, which will give us more means of addressing future contingencies. Abrupt Climate Change Nevertheless, there is every reason to believe that placing so much faith in economic growth and technological change as answers to global warming is short-sighted and naive. But the problem does not stop there. Scientists are now raising the even more alarming question of abrupt climate change, i. Abrupt climate change is usually seen as change arising from gradual causes that lead to the crossing of a threshold, triggering a sudden shift to a new stateâ€"with the shift determined by the climate system itself and occurring at a rate much faster than the initial cause. A lesser instance of abrupt climate change occurred 8, years ago and lasted around a century. Abrupt climate change is believed to result from disruption of the thermohaline circulation, a global ocean conveyor that moves warm, saline tropical waters northward in the Atlantic with the Gulf Stream as its northern arm, and then loops south. This draws additional warmer, saline water from the south, helping to keep the conveyor going. Differences in the density of ocean waters associated with the saline content thus drive this ocean conveyor. Abrupt climate change arises from a lessening or collapse of the thermohaline circulation due to increased river runoff, melting ice, and changes in precipitationâ€"all of which serve to increase the amount of freshwater supplied to the North Atlantic. As the salinity of the ocean waters

decreases a dramatic lessening or complete collapse of the North Atlantic conveyor circulation can occur. The current global warming is seen as potentially triggering this effect. Two basic scenarios are worth considering. The second of these two scenarios is viewed as much more likely. Seeming to confirm these fears, a report in Nature in concluded that the North Atlantic has been freshening dramatically for 40 years; while a report a year earlier suggested that the ocean conveyor may already be slowing down. The end of humanity? An uncomfortable time for humanity? That this did not happen is due to the fact that the issue was taken up and dramatized in the Pentagon report. The Pentagon Elevates the Threat The story behind the Pentagon report on abrupt climate change is almost as remarkable as the contents of the report itself. When they need someone to think about big things, the Department of Defense turns to Marshall. His most famous achievement was the promotion of missile defense. The intent was obviously to have economic futurologists visualize the possible effects of such abrupt climate change, since they would be in the best position to speculate on the economic and social fallout of such a catastrophic development, and thus upgrade it to a major Pentagon concern. Schwartz was a surprising choice for such a task since he was best known previously for his book The Long Boom In the s he was a contributing writer to Wired magazine. Their first version of this thesis in their Wired article on the long boom came out in July and created a stir. The article together with the book that followed two years later, constituted the most extreme version of the great millennial celebration. According to Schwartz and his coauthors, who grossly misunderstood the main economic tendencies of the time, the U. All such New Economy mythology was put to an end, however, by the bursting of the speculative bubble and the dramatic stock market decline of , followed by recession in and slow growth and employment stagnation ever since. Nevertheless, it was to Schwartz, the failed prophet of a long New Economy boom, to whom Marshall turned to dramatize the consequences of abrupt climate change. When most people think about climate change, they imagine gradual increases in temperature and only marginal changes in other climatic conditions, continuing indefinitely or even leveling off at some time in the future. The conventional wisdom is that modern civilization will either adapt to whatever weather conditions we face and that the pace of climate change will not overwhelm the adaptive capacity of society, or that our efforts such as those embodied in the Kyoto protocol will be sufficient to mitigate the impacts. The IPCC documents the threat of gradual climate change and its impact to food supplies and other resources of importance to humans will not be so severe as to create security threats. Optimists assert that the benefits from technological innovation will be able to outpace the negative effects of climate change. Climatically, the gradual view of the future assumes that agriculture will continue to thrive and growing seasons will lengthen. Northern Europe, Russia, and North America will prosper agriculturally while southern Europe, Africa, and Central and South America will suffer from increased dryness, heat, water shortages, and reduced production. Overall, global food production under many typical climate scenarios increases p. Schwartz and Randall argue against such complacent views of global warming, insisting that they do not take sufficient account of the discontinuities that may arise as warming causes various thresholds to be crossed. More frequent droughts, for example, could have disastrous and cumulative effects. Still, the worst effects from such gradual warming are seen as applying mainly to the poorer countries of the global South rather than the richer countries of the global Northâ€”the main source of carbon dioxide emissions. All of this encourages a do-nothing or do-little attitude in the northern centers of world power. Abrupt climate change alters this picture dramatically. Such change would create catastrophic conditions for human society; and rather than falling first and foremost on the global South the direct effects of a shutdown of the thermohaline conveyor would bear down on the global Northâ€”specifically those countries bordering the North Atlantic. Schwartz and Randall are clear that they are not actually predicting such abrupt climate change in the near future though it is certain to occur in the long-term future. They model their scenario on the event of 8, years ago rather than on the much worse Younger Dryas. Colder temperatures, wind and dryness in the global North are accompanied by increased warmth and drought in much of the rest of the world. The picture they paint is one of agricultural decline and extreme weather conditions, stretching energy resources, throughout the globe. Military confrontation may be triggered by a desperate need for

natural resources such as energy, food and water rather than by conflicts over ideology, religion, or national honor. For Schwartz and Randall the lesson is clear. If the scenario that they depict is actually in the cards, it is already too late to do anything to stop it. What can be done under these circumstances is to make sure that the necessary security measures are in place to stave off the most disastrous consequences resulting from social instability. Such information will make it possible for the United States to act in its own security interest. The narrow objective is thus to safeguard fortress America at all cost. Although the ecological repercussions are supposed to hit the global North the hardest, the scenario provided by the Pentagon report with respect to instability and war follows conventional ideological paths, focusing mostly on the global South. The possibility that the United States itself might in such circumstances attempt to seize world oil supplies and other natural resources is not raised by the report. Given the contents of this report it is not surprising that it initially generated dismay and widespread fears when it was made public in February. At that point the Pentagon quickly stepped in to quiet the alarm that the report had set off. Yet the real importance of An Abrupt Climate Change Scenario does not lie in its impact on the top brass in the Pentagon much less their environmentally-challenged superiors in the White House. It is a small step from this view to one that insists that the nature of the threat demands that we begin to consider other, radical social alternatives to business as usual, which must be elevated to the forefront of public discussions. Accelerated Climate Change Here it is crucial to recognize that abrupt climate change as currently modeled by scientists, though the most dramatic, is not the only nongradual outcome possible as a result of global warming. Scientists are even more concerned at present about the potential for positive feedbacks that will greatly amplify global warming, increasing the rate of its advance and the speed with which it crosses various ecological thresholds. The hydrological cycle evaporation, precipitation, and runoff could accelerate as a result of global warming, driving temperatures higher faster. Water vapor, the most potent natural greenhouse gas, could trap additional heat increasing the rate at which average surface temperatures rise. The melting of highly reflective ice and snow could result in further absorbtion of sunlight, leading to additional global warming. The capacity of both forests and oceans to absorb carbon dioxide could decrease, creating a positive feedback loop that accelerates climate change. All of this is taken into account to some extent in the IPCC reports. But given the level of uncertainty the possibility of surprising developments under these circumstances is very great. The grim reality is that the more threatening scenarios with respect to global warming are becoming increasingly plausible as the data keeps coming in. Carbon dioxide levels in the atmosphere increased at an accelerated level over the past year. The increase of 3 parts per million was well above the 1. Although it is too soon to be sure if this means anything or not it may reflect mere annual variance , this kind of evidence is leading scientists to worry that positive feedbacks may already be at work, serving to accelerate the whole problem New York Times, March 21, Capitalism and Carbon Dioxide Both the capitalist economy and the world climate represent complex, dynamic systems. The uncertainty with respect to climate change and its economic effects has to do with the interaction of these two complex systems. To make matters worse, both the climate system and the human economy are subsets of the biosphere and are inseparably interconnected in extremely complex ways with innumerable other biogeochemical processes. Many of these other biospheric processes are also being transformed by human action. It is not uncommon for analyses of climate change to assume that the world economy is essentially healthy except for disturbances that could result from the climate. This, however, is in error and underestimates the economic vulnerability of populations and whole societies. Many have no access to clean water 1 billion , electricity 2 billion , or sanitation 2. Economic growth is slowing in ways that have deepened the economic crisis for human populations.

Chapter 5 : Thermohaline Circulation - Fact Sheet by Stefan Rahmstorf

Whether the weather: comments on 'an abrupt climate change scenario and its implications for United States national security' Shearer, Allan W View online Borrow.

August 10th, Personal Blog of Doug Snedden The severe climate change impacts will continue to occur as trends toward a warming planet increase. More air pollution, biodiversity loss, and water scarcity will fuel escalating economic and social upheaval from here on in, resulting in far-reaching global disruptions and conflicts around the world. Tipping points and other thresholds, including all known unknowns, now point directly at an apocalyptic transition for all life on Earth due to abrupt climate change. The G-7 have known since that the escalating natural disasters and global catastrophes due to abrupt climate change would peak sometime over the next twenty years And with that knowledge, and without much fanfare, they have been preparing for the end-times and perpetual conflict while the general public stay out of touch and continue on with their everyday lives, unaware of the dire climate change reality that is clearly now upon us all. What will lead up to this edge of anarchy is nuclear conflict , mega-droughts, famine and widespread rioting across the world. Many countries are secretly developing a nuclear threat to defend and secure dwindling food, water and energy supplies. Disruption and conflict are now becoming endemic features of life while escalating warfare re-defines human life in these last few years of human civilization as we know it. Final thoughts There is no more charts or graphs or conflicting climate change studies needed for the general public. We know that this past century has been the warmest period in the history of modern civilization and the trend is clearly going to continue as the global temperature rises until the end of human civilization. According to a US Government Pentagon Paper , , or sooner, will be the year we fully understand the complete spectrum and path ahead for the end of human civilization due to abrupt climate change. An Abrupt Climate Change Scenario Its Implications for United States National Security By Peter Schwartz and Doug Randall October Imagining the Unthinkable The purpose of this report is to imagine the unthinkable â€” to push the boundaries of current research on climate change so we may better understand the potential implications on United States national security. We have interviewed leading climate change scientists, conducted additional research, and reviewed several iterations of the scenario with these experts. The scientists support this project, but caution that the scenario depicted is extreme in two fundamental ways. First, they suggest the occurrences we outline would most likely happen in a few regions, rather than globally. Second, they say the magnitude of the event may be considerably smaller. We have created a climate change scenario that although not the most likely, is plausible, and would challenge United States national security in ways that should be considered immediately. Executive Summary There is substantial evidence to indicate that significant global warming will occur during the 21st century. Because changes have been gradual so far, and are projected to be similarly gradual in the future, the effects of global warming have the potential to be manageable for most nations. The research suggests that once temperature rises above some threshold, adverse weather conditions could develop relatively abruptly, with persistent changes in the atmospheric circulation causing drops in some regions of degrees Fahrenheit in a single decade. Paleoclimatic evidence suggests that altered climatic patterns could last for as much as a century, as they did when the ocean conveyor collapsed 8, years ago, or, at the extreme, could last as long as 1, years as they did during the Younger Dryas, which began about 12, years ago. In this report, as an alternative to the scenarios of gradual climatic warming that are so common, we outline an abrupt climate change scenario patterned after the year event that occurred about 8, years ago. This abrupt change scenario is characterized by the following conditions: Western Europe and the North Pacific experience enhanced winds. The report explores how such an abrupt climate change scenario could potentially de-stabilize the geo-political environment, leading to skirmishes, battles, and even war due to resource constraints such as: As global and local carrying capacities are reduced, tensions could mount around the world, leading to two fundamental strategies: Nations with the resources to do so may build virtual fortresses

around their countries, preserving resources for themselves. Less fortunate nations especially those with ancient enmities with their neighbors, may initiate in struggles for access to food, clean water, or energy. Unlikely alliances could be formed as defense priorities shift and the goal is resources for survival rather than religion, ideology, or national honor. This scenario poses new challenges for the United States, and suggests several steps to be taken: There are some indications today that global warming has reached the threshold where the thermohaline circulation could start to be significantly impacted. These indications include observations documenting that the North Atlantic is increasingly being freshened by melting glaciers, increased precipitation, and fresh water runoff making it substantially less salty over the past 40 years. This report suggests that, because of the potentially dire consequences, the risk of abrupt climate change, although uncertain and quite possibly small, should be elevated beyond a scientific debate to a U. The conventional wisdom is that modern civilization will either adapt to whatever weather conditions we face and that the pace of climate change will not overwhelm the adaptive capacity of society, or that our efforts such as those embodied in the Kyoto protocol will be sufficient to mitigate the impacts. The IPCC documents the threat of gradual climate change and its impact to food supplies and other resources of importance to humans will not be so severe as to create security threats. Optimists assert that the benefits from technological innovation will be able to outpace the negative effects of climate change. Climatically, the gradual change view of the future assumes that agriculture will continue to thrive and growing seasons will lengthen. Northern Europe, Russia, and North America will prosper agriculturally while southern Europe, Africa, and Central and South America will suffer from increased dryness, heat, water shortages, and reduced production. Overall, global food production under many typical climate scenarios increases. This view of climate change may be a dangerous act of self-deception, as increasingly we are facing weather related disasters -- more hurricanes, monsoons, floods, and dry-spells â€" in regions around the world. Weather-related events have an enormous impact on society, as they influence food supply, conditions in cities and communities, as well as access to clean water and energy. For example, a recent report by the Climate Action Network of Australia projects that climate change is likely to reduce rainfall in the rangelands, which could lead to a 15 per cent drop in grass productivity. This, in turn, could lead to reductions in the average weight of cattle by 12 per cent, significantly reducing beef supply. With over million people living in drier, subtropical, often over-populated and economically poor regions today, climate change and its follow-on effects pose a severe risk to political, economic, and social stability. In less prosperous regions, where countries lack the resources and capabilities required to adapt quickly to more severe conditions, the problem is very likely to be exacerbated. For some countries, climate change could become such a challenge that mass emigration results as desperate people seek better lives in regions such as the United States that have the resources to adaptation. Because the prevailing scenarios of gradual global warming could cause effects like the ones described above, an increasing number of business leaders, economists, policy makers, and politicians are concerned about the projections for further change and are working to limit human influences on the climate. But, these efforts may not be sufficient or be implemented soon enough. Rather than decades or even centuries of gradual warming, recent evidence suggests the possibility that a more dire climate scenario may actually be unfolding. This is why GBN is working with OSD to develop a plausible scenario for abrupt climate change that can be used to explore implications for food supply, health and disease, commerce and trade, and their consequences for national security. While future weather patterns and the specific details of abrupt climate change cannot be predicted accurately or with great assurance, the actual history of climate change provides some useful guides. Our goal is merely to portray a plausible scenario, similar to one which has already occurred in human experieince, for which there is reasonable evidence so that we may further explore potential implications for United States national security. Reviewing History Sampling of an ice core in Greenland, shows a historical tendency for particular regions to experience periods of abrupt cooling within periods of general warming. The Cooling Event 8, Years Ago The climate change scenario outlined in this report is modeled on a century-long climate event that records from an ice core in Greenland indicate occurred 8, years ago. Immediately following an

extended period of warming, much like the phase we appear to be in today, there was a sudden cooling. Average annual temperatures in Greenland dropped by roughly 5 degrees Fahrenheit, and temperature decreases nearly this large are likely to have occurred throughout the North Atlantic region. During the 8, event severe winters in Europe and some other areas caused glaciers to advance, rivers to freeze, and agricultural lands to be less productive. Longer ice core and oceanic records suggest that there may have been as many as eight rapid cooling episodes in the past , years, and sharp reductions in the ocean conveyer--a phenomenon that may well be on the horizon â€" are a likely suspect in causing such shifts in climate. The Younger Dryas About 12, years ago, also associated with an apparent collapse of the thermohaline circulation, there was a cooling of at least 27 degrees Fahrenheit in Greenland, and substantial change throughout the North Atlantic region as well, this time lasting 1, years. The remarkable feature of the Younger Dryas event was that it happened in a series of decadal drops of around 5 degrees, and then the cold, dry weather persisted for over 1, years. While this event had an enormous effect on the ocean and land surrounding Europe causing icebergs to be found as far south as the coast of Portugal , its impact would be more severe today â€" in our densely populated society. It is the more recent periods of cooling that appear to be intimately connected with changes to civilization, unrest, inhabitability of once desirable land, and even the demise of certain populations. The Little Ice Age Beginning in the 14th century, the North Atlantic region experienced a cooling that lasted until the midth century. This period, often referred to as the Little Ice Age, which lasted from to , brought severe winters, sudden climatic shifts, and profound agricultural, economic, and political impacts to Europe. The period was marked by persistent crop failures, famine, disease, and population migration, perhaps most dramatically felt by the Norse, also known as the Vikings, who inhabited Iceland and later Greenland. Ice formations along the coast of Greenland prevented merchants from getting their boats to Greenland and fisherman from getting fish for entire winters. As a result, farmers were forced to slaughter their poorly fed livestock -- because of a lack of food both for the animals and themselves -- but without fish, vegetables, and grains, there was not enough food to feed the population. Famine, caused in part by the more severe climatic conditions, is reported to have caused tens of thousands of deaths between and alone. It has been less than years since 1 million people died due to the Irish Potato famine, which also was induced in part by climate change. A Climate Change Scenario For the Future The past examples of abrupt climate change suggest that it is prudent to consider an abrupt climate change scenario for the future as plausible, especially because some recent scientific findings suggest that we could be on the cusp of such an event. The future scenario that we have constructed is based on the 8, years before present event, which was much warmer and far briefer than the Younger Dryas, but more severe than the Little Ice Age. This scenario makes plausible assumptions about which parts of the globe are likely to be colder, drier, and windier. Although intensified research could help to refine the assumptions, there is no way to confirm the assumptions on the basis of present models. Rather than predicting how climate change will happen, our intent is to dramatize the impact climate change could have on society if we are unprepared for it. Where we describe concrete weather conditions and implications, our aim is to further the strategic conversation rather than to accurately forecast what is likely to happen with a high degree of certainty. Even the most sophisticated models cannot predict the details of how the climate change will unfold, which regions will be impacted in which ways, and how governments and society might respond. However, there appears to be general agreement in the scientific community that an extreme case like the one depicted below is not implausible. Many scientists would regard this scenario as extreme both in how soon it develops, how large, rapid and ubiquitous the climate changes are. In the climate change disruption scenario proposed here, we consider a period of gradual warming leading to and then outline the following ten years, when like in the 8, event, an abrupt change toward cooling in the pattern of weather conditions change is assumed to occur. Warming Up to Following the most rapid century of warming experienced by modern civilization, the first ten years of the 21st century see an acceleration of atmospheric warming, as average temperatures worldwide rise by. Such temperature changes would vary both by region and by season over the globe, with these finer scale variations being larger or smaller than the average change. What would be very

clear is that the planet is continuing the warming trend of the late 20th century. In addition to the warming, there are erratic weather patterns: In general, the climate shift is an economic nuisance, generally affecting local areas as storms, droughts, and hot spells impact agriculture and other climate-dependent activities. More French doctors remain on duty in August, for example. The weather pattern, though, is not yet severe enough or widespread enough to threaten the interconnected global society or United States national security. Warming Feedback Loops As temperatures rise throughout the 20th century and into the early s potent positive feedback loops kick-in, accelerating the warming from. As the surface warms, the hydrologic cycle evaporation, precipitation, and runoff accelerates causing temperatures to rise even higher. Water vapor, the most powerful natural greenhouse gas, traps additional heat and brings average surface air temperatures up. As evaporation increases, higher surface air temperatures cause drying in forests and grasslands, where animals graze and farmers grow grain. As trees die and burn, forests absorb less carbon dioxide, again leading to higher surface air temperatures as well as fierce and uncontrollable forest fires Further, warmer temperatures melt snow cover in mountains, open fields, high-latitude tundra areas, and permafrost throughout forests in cold-weather areas. By the climatic impact of the shift is felt more intensely in certain regions around the world. More severe storms and typhoons bring about higher storm surges and floods in low-lying islands such as Tarawa and Tuvalu near New Zealand. In , a particularly severe storm causes the ocean to break through levees in the Netherlands making a few key coastal cities such as The Hague unlivable. Failures of the delta island levees in the Sacramento River region in the Central Valley of California creates an inland sea and disrupts the aqueduct system transporting water from northern to southern California because salt water can no longer be kept out of the area during the dry season. Melting along the Himalayan glaciers accelerates, causing some Tibetan people to relocate. As glacial ice melts, sea levels rise and as wintertime sea extent decreases, ocean waves increase in intensity, damaging coastal cities. Additionally millions of people are put at risk of flooding around the globe roughly 4 times levels , and fisheries are disrupted as water temperature changes cause fish to migrate to new locations and habitats, increasing tensions over fishing rights. Each of these local disasters caused by severe weather impacts surrounding areas whose natural, human, and economic resources are tapped to aid in recovery.

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Chapter 6 : Effects of global warming - Wikipedia

This chapter will examine an abrupt climate change scenario from an environmental security perspective and present a regional framework to demonstrate the spatial pattern of potential threats.

Rather than continue on a path to militarize the border, we should consider the alternatives. Soil deposits covered it, as did countless spiders, and purple flowers grew from it. The scene telegraphed that, if left alone, nature would consume the border apparatus, erase it, devour its technologies and infrastructure of exclusion, and clear the way for something new. The impact of climate change on migration in the future will be dramatic, according to some projections. The border wall deteriorating was the first of three possible glimpses into the future of the U. The second was the status quo: But a third possibility also presented itself on that November morning from where I stood at the intersection of borders and climate change. Right before my eyes, on this small piece of the U. Building something else at the border was possible. Alternatives to a militarized border are obscured by 25 years of U. Over that time, miles of walls and barriers were built, and the U. Border Patrol increased fivefold. When I visited, there were about 21, armed agents, such as the ones watching us in Silver Creek from behind the reconstructed border barrier in an idling F truck with a green stripe. From where we stood, I could see that one agent had binoculars and was, presumably, checking us out. Behind the agents, about a half-mile inland, was a new Customs and Border Protection surveillance tower. It was an Integrated Fixed Tower, equipped with long-distance, thermal imaging, and night-vision cameras, as well as ground-sweeping radar. I wondered whether agents in a command and control center in Douglas, Arizona, could view us kneeling before the broken ruins of the border wall. This was ramped up considerably in the early summer of when the Trump administration forcibly removed children from their parents and imprisoned them separately behind coiling razor wire. And scientists predict the severity and frequency of superstorms, megadroughts, and inundating sea level rise to increase. In this future, a science-fictive borderscape bolstering against and profiting from climate migration may be what is in store for humanity. Borders will be strengthened around the country to hold back unwanted starving immigrants from the Caribbean islands an especially severe problem , Mexico, and South America. Many Honduran asylum seekers are already traveling to the U. One of those reasons, as Honduran climate scientist Leonardo Lenin Banegas Barahona put it to me, is climate disruption. In Honduras, droughts are intensifying to the point that parts of the country are being converted into deserts in a process known as desertification. As hydrologist Chris Castro, who has been doing climate modeling in Central America for many years, told me: Everything gets more extreme. As stated in the U. Which brings me to the third future glimpse of the borderâ€”the alternative vision. They were placed there by Cuenca Los Ojos beginning in the s. To me, the gabions looked like an intricately carved stone wall. But this wall was not used to repel people: It was used to harvest water. This part of northern Sonora and southern Arizona is in a drought of more than 15 years, an event expected to occur with greater frequency and severity in this region as the planet warms. The rocks in the gabions act like a large sponge, slowing rainwater so it seeps into the earth rather than rushing over it. Juan Manuel Perez and David Hodges from Cuenca Los Ojos pointed to native grasses growing in the stream bed near the gabionsâ€”and to desert willows and cottonwoods, too. They said animals, especially birds, were returning to the area. But the most miraculous thing of all, they said, was that the water table had risen by 30 feet. All this, during a drought. The Pentagon and DHS have been saying that water scarcity could displace people in places such as northern Mexico, and here an apparatus at the border was helping capture and store water. What if the billions that went to border and immigration enforcement went to this instead? The drones, the fixed-wing jets, the Blackhawk helicopters, or the more than 50, vehicles that DHS has in its fleet will do no battle with climate change. They will not be able to shoot it down, nor stop it, but only exacerbate it. There is another future possible for the border, and the tangible, pragmatic examplesâ€”like this one at Rancho San Bernardinoâ€”are already here. Just Readers Like You. You can help fund powerful stories to light the way forward. Todd Miller wrote this

article for YES! Todd is a journalist and the author of another book, "Border Patrol Nation.

Chapter 7 : The day before yesterday: when abrupt climate change came to the Chesapeake Bay | NOAA

In the U.S., Senator Susan Collins (R-Maine) sponsored bill S to authorize $60 million for the National Oceanic and Atmospheric Administration (NOAA) to study abrupt climate change. On March.

He found that revolutions and periods of intense fighting seemed to occur during Solar Maxima â€" the period of greatest activity in the year solar cycle of the Sun â€" while cultural flourishing and social cohesion tended to occur during Solar Minima. It was in this paper that Tchijevsky wrote: The Sun is an enormous generator of electric energy and emits it in the form of radiation and induction. Newton, Professor Bechtereff, Lombroso. He refused, was arrested and spent eight years in a forced labour gulag in the Ural mountains. In this space, charged ions are all flowing along electromagnetic currents, tethers that are connecting each planet to the Sun. Known as the Interplanetary Magnetic Field, this dynamo of sphere magnets planets revolving around one central, powerful sphere magnet the Sun makes up the protective shell of our Solar System known as the Heliosphere. The Earth has its own protective interface from the various effects of Space Weather, called the Magnetosphere. This decline in Magnetospheric strength on Earth has also been accompanied by a weakening in Solar Magnetics,5 as a Sunspot Grand Minima is quite possibly knocking at our door. Reduced solar irradiance such as during the MM and Dalton Minimum, is correlated with the negative shift of the North Atlantic Oscillation NAO index leading to enhance north easterly wind which results into cooling of Europe, whereas enhanced solar irradiance is correlated with positive NAO index Singh et al. The year Solar Cycle and year Magnetic Cycle will continue to unfold, unhindered, into the foreseeable future; this periodicity was first discovered by H. Cosmic Rays are thought to induce cloud formation in the lower atmosphere8 and charge-up lightning strikes, thereby impacting regional temperatures. An important aspect of geoeffective CMEs is how large of a Forbush decrease drop in galactic cosmic radiation they produce. Tony Phillips wrote that Magnetic fields deflect charged particles, so when a CME sweeps past Earth, it also sweeps away many of the electrically-charged cosmic rays that would otherwise strike our planet. A geomagnetic storm induced blackout was the case in , after a large Earth-directed solar flare occurred on Friday, 10 March, which reached the Earth on Monday, 13 March We know for a fact that extreme geomagnetic storms can induce ground currents that will affect all of sorts of sensitive electronics. Effects on the Human Body There are a wide variety of effects that Space Weather exerts on the electricity of the brain, heart and central nervous system inside of our own bodies. The Schumann Resonances are easily detectable on any planet on which lightning takes place, and so far the SR signals have been detected on Venus, Mars, Titan, Jupiter and Saturn. It is apparent that disruptions in the Schumann Resonances via external factors, such as natural variations in Space Weather intensity, can have a profound impact on the physiological and psychological health of an organism. The primary EEG bands are: Cherry had collected and conducted research showing that the effects to human health via solar and geomagnetic activity S-GMA are biophysically possible through changes in Schumann Resonance intensity. The effects include, altered blood pressure and melatonin, increased cancer, reproductive, cardiac and neurological disease and death. Many occupational studies have found that exposure to ELF fields between Melatonin is a potent anti-oxidant with receptors in every major organ, and it is released from the pineal gland when the natural boundary of light is missing. Previous research shows that geomagnetic variations of a solar origin have been correlated with enhanced anxiety, sleep disturbances, altered moods, and greater incidences of psychiatric admissions Persinger, Infant mortality, suicide, traffic accidents, crime rates, and numerous other significant events and human conditions have been statistically matched with fluxes in solar and cosmic energy. Although this field of study is by no means new, it is just now becoming accepted, understood, and investigated in a serious manner. For more information on the work of Ben Davidson and David Hyde, go to www. Singh, Devendraa Siingh, R. Ben was classically trained in law and legal research, before taking up independent research in diverse sciences. His focus is on the daily solar environment and the electromagnetic interactions between the Sun, Earth, and the galaxy. He also examines the connection between

space weather, the natural environment and human condition.

Chapter 8 : Abrupt climate change - Wikipedia

The report bases its abrupt climate change scenario on the collapse of Thermohaline Circulation in the Atlantic Ocean. The probability of this taking place is a very real scenario and tests have shown that a certain collapse has already begun in the polar regions.

Food The spectrum of abrupt disruptions to ecosystem services as a result of climate change is broad, but of particular concern are those that would impact essential provisioning services such as food production and water availability. The potential disruptions of food and water, see below supplies could be one of the most serious manifestations of abrupt climate change, especially when put in the context of the changing global food system. The challenges of food security today are driven mainly by poverty, the lack of access to food, and poor institutions Godfray et al. Even a slight added impact from climate change, therefore, could lead to significant, abrupt, and problematic food shortages. This challenge is made more cogent by realizing that even without potential impacts of climate change, providing food security, meeting growing demands for agricultural products, and ensuring the environmental sustainability of agricultural systems worldwide will require a multi-faceted approach Foley et al. Such an approach will need to concentrate on boosting yields especially in places where yields are low today , improving the resource efficiency of agriculture especially the water, nutrients, and energy used per calorie of food delivered , avoiding further deforestation and land degradation, shifting diets and biofuels to more sustainable trajectories, and reducing food waste across the entire supply chain Foley et al. To date, investigations of how climate change will affect crop production and food systems have mainly focused on long-term changes in the mean climate e. Mainly, these studies have split into two broad categories: One of the first studies to consider the impacts of climate change on agriculture was conducted by Rosenzweig and Parry Abrupt Impacts of Climate Change: The National Academies Press. Typical increases in production for the developed world range from 3 to 8 percent, and typical decreases for the developing world range from 2 to 7 percent. More recently, Deryng et al used the PEGASUS process-based crop model and found that global maize production for , under a climate change scenario based on rapid economic growth A1B; see IPCC, , changes by â€”15 percent, and under a scenario based on more modest economic growth B1 changes by -8 percent, if farmlevel adaptation especially changing planting dates is taken into account. However, without farm-level adaptation of planting dates, the yields decreases are estimated 30 percent and 20 percent respectively. A new study 1 uses a cross-sectional method based on the shifting climate zones and find that global maize production in under and A1B scenario could decrease by 7 percent and under a B1 scenario will decrease by 3. In short, it is clear that changes in climate will have profound impacts on global food production and, in turn, food security Easterling et al. Modeling and statistical analyses consistently show that climate change could introduce substantial changes to global food production some positive, many strongly negative. However, the exact magnitude of these changes depends on the assumptions made about the adaptation of farmers to climate change Easterling et al. This presents a particular challenge in the face of abrupt climate change compared to slower changes in climate that may occur over many decades. Will abrupt changes in climate cause more severe dislocations in agriculture, because it leaves less time for farmers and agricultural markets to adapt? This remains a critical area for future research. Therefore, climate changes, mainly through changes in precipitation and evapotranspiration over watersheds that people depend upon, can cause serious, abrupt yearly to decadal changes to critical freshwater resources. As with other ecosystem services, it is necessary to interpret potential climatic impacts on freshwater resources within the broader context of how water resources are already stressed around the world. Freshwater resources are already reaching limits under the increasing demands of a growing population, rising incomes, and increasing per capita consumption particularly through food. Furthermore, increasing demands on water estimated from population growth and economic development will greatly exceed expected changes from climate change. Groundwater is critical for farmers to ride out droughts, and if that safety net reaches an

abrupt end, the impact of droughts on the food supply will be even larger. Satellites measuring gravity now reveal that groundwater supplies have decreased rapidly around the world over the past decade, including key aquifers in California, the High Plains, and the southeastern United States Famiglietti et al. Groundwater is a key part of successful adaptation to periodic drought, which in turn is a key aspect of maintaining stable food supplies. In many cases it is unknown how long this situation could continue without water availability reaching an end, possibly an abrupt end, although history is clear in showing that groundwater supplies can indeed be depleted, parts of the Ogallala Aquifer un- Page Share Cite Suggested Citation: Questions remain about the future of this potential abrupt change, but the potential impact, especially on national and global food supplies, is substantial. On a larger scale, changes in atmospheric circulation e. In the United States, key cropgrowing areas, such as California, which provides half of the fruits, nuts, and vegetables for the United States, will experience uneven effects across crops, requiring farmers to adapt rapidly to changing what they plant Kahrl and Roland-Holst, ; Lobell et al. Fisheries Degradation of coral reefs by ocean warming and acidification will negatively affect fisheries, because reefs are required as habitat for many important food species, especially in poor parts of the world. For example, in the poorest countries of Africa and south Asia, fisheries largely associated with coral reefs provide more than half of the protein and mineral intake for more than million people Hughes et al. On a broader scale, many fisheries around the world can be expected to experience changes as ocean temperatures, acidity, and currents change Allison et al. One study suggests climate change, combined with other pressures on fisheries, may result in a 30â€”60 percent reduction in fish production by in areas such as the eastern Indo-Pacific, and those areas fed by the northern Humboldt and the North Canary Currents Blanchard et al. Because other pressures, notably over-fishing, already stress fisheries, a small climatic stressor can contribute strongly to hastening collapse Hidalgo et al. Other Provisioning Services Outside the food and water sector, abrupt changes to other provisioning services also are very likely as a result of in-progress climate change Reid et al. Page Share Cite Suggested Citation: Such is already the case for millions of square miles of beetle-killed forests throughout the American West. In several documented cases the efficacy of provisioning services correlates positively with the biodiversity of an ecosystem Cardinale et al. Among the provisioning services that have been shown to increase with biodiversity are: Some studies suggest that increased biodiversity also increases the following ecosystem services: However, the efficacy of higher biodiversity in promoting these services still is under study, with conflicting results for different studies clouding the generality of the relationship Cardinale et al. Regulatory Services Also of concern is the potential loss of regulatory services, which buffer the effects of environmental change Reid et al. For example, tropical forest ecosystems slow the rate of global warming both by absorbing atmospheric carbon dioxide and through latent heat flux Anderson-Teixeira et al. Coastal saltmarsh and mangrove wetlands buffer shorelines against storm surge and wave damage Gedan et al. Grassland biodiversity stabilizes ecosystem productivity in response to climate variation see Cardinale et al. Climate change has the clear potential to exacerbate losses of these critical ecosystem services for instance, decrease in rainforests, desertification and attendant impacts on human societies. Direct Economic Impacts Some species currently at risk of extinction, and some of those which will be further imperiled by ongoing climate change, provide significant economic benefits to people Page Share Cite Suggested Citation: Yet in a single year, , an extreme drought decimated the elephant population and populations of many other large animals in Amboseli Park, Kenya. Increased frequency of such extreme weather events could erode the ecotourism base on which the local economies depend. Other international examples include ecotourism in the Galapagos Islandsâ€”driven in a large part to view unique, threatened speciesâ€”which contributed 68 percent of the 78 percent growth in GDP of the Galapagos that took place from â€” Taylor et al. Wildlife in Yellowstone is undergoing substantial changes, as evidenced by the clear amphibian decline as a result of drying up of breeding ponds McMenamin et al. Recent work there demonstrates that many of the small mammals are shifting their geographic ranges, with as yet unknown consequences to the overall ecosystem, as a result of climate change over the last century Moritz et al. Examples near coasts include infrastructure such as roads,

power lines, sewage treatment plants, and subway systems located close enough to the ocean and at a low enough elevation to be subject to the direct and indirect e. Other examples from northern latitudes include roads built on permafrost in Alaska, where that permafrost is now melting causing the roads to buckle and heave. Less obviously, there are also systems whose useful lifetimes are cut short by gradual changes in baseline climate. Such systems are experiencing abrupt impacts if they are built to last a certain period Page Share Cite Suggested Citation: One example would be a large air conditioning system for computer server rooms. If maximum high temperatures rise faster than planned for, the lifetime of such systems would be cut short, and new systems would need to be installed at added cost to the owner of the servers. Another example is storm runoff drains in cities and towns. These systems are sized to handle large storms that precipitate a certain amount of water in a certain period of time. Rare storms, such as a year event, are typically not considered when choosing the size of pipes and drains, but the largest storms that occur annually up to once per decade or so are considered. As the atmosphere warms and can hold more moisture, the amount of rain per event is increasing Westra et al. Another type of infrastructure problem associated with abrupt change is the infrastructure that does not exist, but will need to after an abrupt change. The most glaring example today is the lack of US infrastructure in the Arctic as the Arctic Ocean becomes more and more ice free in the summer. For example, the United States lacks sufficient ice breakers that can patrol waters that, while seasonally open in many places, will still have extensive wintertime ice cover. Servicing and protecting our activities in this resource-rich region is now a challenge, one that only recently, and abruptly, emerged. This challenge has illustrated a time scale issue associated with abrupt change. While complete inventories are lacking, the accompanying infrastructureâ€”from the obvious, such as roads and buildings, to the less obvious but no less critical, such as underground services e. In , 39 percent of the US population lived in Coastal Shoreline Counties less than 10 percent of the total land area excluding Alaska. The population density of Coastal Shoreline Counties is over six times greater than the corresponding inland counties. Consequently, the United States has a large amount of physical assets located near coasts and currently vulnerable to sea level rise and storm surges exacerbated by rising seas See Chapter 3 and especially Box 2. Overall, there is a need to shift to more holistic planning, investment, and operation for global sea ports Becker et al. For human transportation systems, these trends have both positive and negative impacts, with rising maritime access in seasonally frozen rivers and seas but declining overland access to seasonally frozen ground Smith, ; Stephenson et al. As such, it is a substrate upon which numerous pipelines, buildings, roads and other infrastructure have or could be built, so long as these structures are properly designed to not thaw the underlying permafrost. For areas underlain by ice-rich permafrost, severe damage to permanent infrastructure can result from settlement of the ground surface as the permafrost thaws Nelson et al. Numerous engineering problems are associated with thawing of ground permafrost, including loss of soil bearing strength, increased soil permeability, and increased potential for thermokarsting, differential thaw settlement, and heave Shiklomanov and Streletskiy, Numerous structures have become unsafe in Siberian cities, where the percentage of dangerous buildings ranges from at least 10 percent to as high as 80 percent of building stock in Norilsk, Dikson, Amderma, Pevek, Dudina, Tiksi, Magadan, Chita, and Vorkuta ACIA, Problems are also apparent on the Tibetan Plateau, where mean annual ground temperatures have risen as much as 0. However, the geographic range of their use is much larger, extending to seasonally frozen land and water surfaces well south of the permafrost limit. They are most important in Alaska, Canada, Russia, and Sweden, but also used to a lesser extent mainly river and lake crossings in Finland, Estonia, Norway, and the northern US states. They are critically important for trucking, construction, resource exploration, community resupply and other human activities in remote areas. In the Arctic Ocean, climate model projections of thinning sea ice thickness, lower sea ice concentration, lower multi-year ice MYI fraction, and shorter ice-covered season all enable increased accessibility to ships. In general, the Russian Federation is projected to experience the greatest increase both in percent change and total marine-accessible area in accessibility to its offshore Exclusive Economic Zone EEZ , followed by Greenland and Norway. Offshore accessibility increases for Canada and the United States are projected to be

less than for the Russian EEZ, owing to greater ice persistence in the Canadian Archipelago and already high accessibility off the North Slope of Alaska today. The timing and magnitude of these projected marine accessibility increases are likely conservative, both because most GCM projections of sea ice loss generally lag behind observations and the CCSM4 model in particular has weaker Arctic climate amplification than previous versions e. When compared to other GCMs, the CCSM4 model also tends to project greater sea ice cover throughout the 21st century relative to other models Massonnet et al. A second impact of declining sea ice thickness and concentration is decreased shipping distance and travel time through summer trans-polar routes linking the Atlantic and Pacific oceans Figure 3. Although the prospect of such trans-Arctic routes materializing has attracted considerable media attention and indeed, 46 vessels transited the Northern Sea Route during the season , it is important to point out that these routes would Page Share Cite Suggested Citation: Green indicates where new maritime access to moderately ice-strengthened ships Canadian Type A icebreaker will become enabled. Red indicates where conditions presently suitable for building temporary winter roads assuming kg weight vehicles will be lost. All eight Arctic states are projected to suffer steep declines 11 to 82 percent in winter road potential, caused by by milder winters and deeper snow accumulation from Stephenson et al. Johns, Newfoundland and the Pacific Bering Strait. Red lines indicate fastest available routes for Polar Class 6 icebreakers; blue lines indicate fastest available routes for common open-water ships. Where overlap occurs, line weights indicate the number of successful transits using the same navigation route. Dashed lines indicate national nautical mile Exclusive Economic Zone EEZ boundaries; white backdrops indicate period-averaged sea ice concentrations figure adapted from Smith and Stephenson, Related issues of food and water security have been discussed in previous sections.

Chapter 9 : Global Warming - Climate Change: Abrupt Climate Change â€“ The Smoking Gun

An abrupt climate change occurs when the climate system is forced to transition to a new climate state at a rate that is determined by the climate system energy-balance, and which is more rapid than the rate of change of the external forcing.

Mon, 27 Jan Most of the studies and debates on potential climate change, along with its ecological and economic impacts, have focused on the ongoing buildup of industrial greenhouse gases in the atmosphere and a gradual increase in global temperatures. This line of thinking, however, fails to consider another potentially disruptive climate scenario. In addition, these climate shifts do not necessarily have universal, global effects. They can generate a counterintuitive scenario: Even as the earth as a whole continues to warm gradually, large regions may experience a precipitous and disruptive shift into colder climates. This new paradigm of abrupt climate change has been well established over the last decade by research of ocean, earth and atmosphere scientists at many institutions worldwide. But the concept remains little known and scarcely appreciated in the wider community of scientists, economists, policy makers, and world political and business leaders. Thus, world leaders may be planning for climate scenarios of global warming that are opposite to what might actually occur. Rather, abrupt regional cooling and gradual global warming can unfold simultaneously. Indeed, greenhouse warming is a destabilizing factor that makes abrupt climate change more probable. A report by the US National Academy of Sciences NAS said, "available evidence suggests that abrupt climate changes are not only possible but likely in the future, potentially with large impacts on ecosystems and societies. An abrupt cooling that happens within the next two decades would produce different climate effects than one that occurs after another century of continuing greenhouse warming. Each mode produces different climate patterns. Pushed past a threshold, the system can jump quickly from one stable operating mode to a completely different one - "just as the slowly increasing pressure of a finger eventually flips a switch and turns on a light," the NAS report said. Scientists have so far identified only one viable mechanism to induce large, global, abrupt climate changes: The oceans also play a pivotal role in the distribution and availability of life-sustaining water throughout our planet. Evaporation from the ocean transfers huge amounts of water vapor to the atmosphere, where it travels aloft until it cools, condenses, and eventually precipitates in the form of rain or snow. Changes in ocean circulation or water properties can disrupt this hydrological cycle on a global scale, causing flooding and long-term droughts in various regions. But our present knowledge of ocean dynamics does not match our knowledge of atmospheric processes. The equatorial sun warms the ocean surface and enhances evaporation in the tropics. This leaves the tropical ocean saltier. The Gulf Stream, a limb of the Ocean Conveyor, carries an enormous volume of heat-laden, salty water up the East Coast of the United States, and then northeast toward Europe. This oceanic heat pump is an important mechanism for reducing equator-to-pole temperature differences. Conveyor circulation increases the northward transport of warmer waters in the Gulf Stream by about 50 percent. At colder northern latitudes, the ocean releases this heat to the atmosphere - especially in winter when the atmosphere is colder than the ocean and ocean-atmosphere temperature gradients increase. But records of past climates - from a variety of sources such as deep-sea sediments and ice-sheet cores - show that the Conveyor has slowed and shut down several times in the past. This shutdown curtailed heat delivery to the North Atlantic and caused substantial cooling throughout the region. Solving this puzzle requires an understanding of what launches and drives the Conveyor in the first place. The answer, to a large degree, is salt. For a variety of reasons, North Atlantic waters are relatively salty compared with other parts of the world ocean. Salty water is denser than fresh water. Cold water is denser than warm water. When the warm, salty waters of the North Atlantic release heat to the atmosphere, they become colder and begin to sink. In the seas that ring the northern fringe of the Atlantic - the Labrador, Irminger, and Greenland Seas - the ocean releases large amounts of heat to the atmosphere and then a great volume of cold, salty water sinks to the abyss. Thus, the North Atlantic is the source of the deep limb of the Ocean Conveyor.

It also helps draw warm, salty tropical surface waters northward to replace the sinking waters. This process is called "thermohaline circulation," from the Greek words "thermos" heat and "halos" salt. If cold, salty North Atlantic waters did not sink, a primary force driving global ocean circulation could slacken and cease. Existing currents could weaken or be redirected. It would produce winters twice as cold as the worst winters on record in the eastern United States in the past century. In addition, previous Conveyor shutdowns have been linked with widespread droughts throughout the globe. It is crucial to remember two points: Are worrisome signals developing in the ocean? At a critical but unknown threshold, when North Atlantic waters are no longer sufficiently salty and dense, they may stop sinking. An important force driving the Conveyor could quickly diminish, with climate impacts resulting within a decade. In an important paper published in in Nature, oceanographers monitoring and analyzing conditions in the North Atlantic concluded that the North Atlantic has been freshening dramatically - continuously for the past 40 years but especially in the past decade. This is the largest and most dramatic oceanic change ever measured in the era of modern instruments. At present the influx of fresher water has been distributed throughout the water column. But at some point, fresh water may begin to pile up at the surface of the North Atlantic. When that occurs, the Conveyor could slow down or cease operating. Signs of a possible slowdown already exist. A report in Nature indicates that the flow of cold, dense water from the Norwegian and Greenland Seas into the North Atlantic has diminished by at least 20 percent since The short answer is: We do not know. Nor have scientists determined the relative contributions of a variety of sources that may be adding fresh water to the North Atlantic. Among the suspects are melting glaciers or Arctic sea ice, or increased precipitation falling directly into the ocean or entering via the great rivers that discharge into the Arctic Ocean. Though we have invested in, and now rely on, a global network of meteorological stations to monitor fast-changing atmospheric conditions, at present we do not have a system in place for monitoring slower-developing, but critical, ocean circulation changes. The great majority of oceanographic measurements was taken throughout the years by research ships and ships of opportunity - especially during the Cold War era for anti-submarine warfare purposes. Many were taken incidentally by Ocean Weather Stations - a network of ships stationed in the ocean after World War II, whose primary duty was to guide transoceanic airplane flights. Starting in the s, satellite technology superseded these weather ships. The demise of the OWS network and the end of the Cold War have left oceanographers with access to far fewer data in recent years. Initial efforts to remedy this deficit are under way,7 but these efforts are nascent and time is of the essence. Satellites can measure wind stress and ocean circulation globally, but only at the ocean surface. Also recently launched but not nearly fully funded is the Argo program - an international program to seed the global ocean with an armada of some 3, free-floating buoys that measure upper ocean temperature and salinity. Measuring deep ocean currents is critical for observing Conveyor behavior, but it is more difficult. Efforts have just begun to measure deep ocean water properties and currents at strategic locations with long-term moored buoy arrays, but vast ocean voids remain unmonitored. Global warming affects the hydrological cycle because a warmer atmosphere carries more water. This, in turn, has implications for greenhouse warming, since water vapor itself is the most abundant, and often overlooked, greenhouse gas. What can the past teach us about the future? Geological records confirm the potential for abrupt thermohaline-induced climate transitions that would generate severe winters in the North Atlantic region. A bad winter or two brings inconvenience that societies can adapt to with small, temporary adjustments. But a persistent string of severe winters, lasting decades to a century, can cause glaciers to advance, rivers to freeze, and sea ice to grow and spread. It can render prime agricultural lands unfarmable. About 12, years ago, as Earth emerged from the most recent ice age and began to warm, the Conveyor was disrupted. This cold period, known as the Younger Dryas, lasted 1, years. It is named after an Arctic wildflower. Scientists have found substantial evidence that cold-loving dryas plants thrived during this era in European and US regions that today are too warm. Deep-sea sediment cores show that icebergs extended as far south as the coast of Portugal. The Younger Dryas ended as abruptly as it began. Within a decade, North Atlantic waters and the regional climate warmed again to pre-Younger Dryas levels. A similar cooling occurred 8, years ago. It lasted

only about a century - a blip in geological time, but a catastrophe if such a cooling occurred today. Scientists are investigating whether changes in ocean circulation may have played a role in causing or amplifying the "Little Ice Age" between and This period of abruptly shifting climate regimes and more severe winters had profound agricultural, economic, and political impacts in Europe and North America and changed the course of history. During this era, the Norse abruptly abandoned their settlements in Greenland. But the era is also marked by persistent crop failures, famine, disease, and mass migrations. A growing body of evidence from joint archaeological and paleoclimatological studies is demonstrating linkages among ocean-related climate shifts, "megadroughts," and precipitous collapses of civilizations, including the Akkadian empire in Mesopotamia 4, years ago, the Mayan empire in central America 1, years ago, and the Anasazi in the American Southwest in the late 13th century. Our current speculations about future climate and its impacts have focused on the Intergovernmental Panel on Climate Change, which has forecast gradual global warming of 1. It is prudent to superimpose on this forecast the potential for abrupt climate change induced by thermohaline shutdown. These climate changes would occur quickly, even as other regions continue to warm slowly. It is critical to consider the economic and political ramifications of this geographically selective climate change. The key component of this analysis is when a shutdown of the Conveyor occurs. Two scenarios are useful to contemplate: Conveyor slows down within next two decades. Such a scenario could quickly and markedly cool the North Atlantic region, causing disruptions in global economic activity. These disruptions may be exacerbated because the climate changes occur in a direction opposite to what is commonly expected, and they occur at a pace that makes adaptation difficult. Conveyor slows down a century from now. In such a scenario, cooling of the North Atlantic region may partially or totally offset the major effects of global warming in this region.