

# Sustainability Leadership





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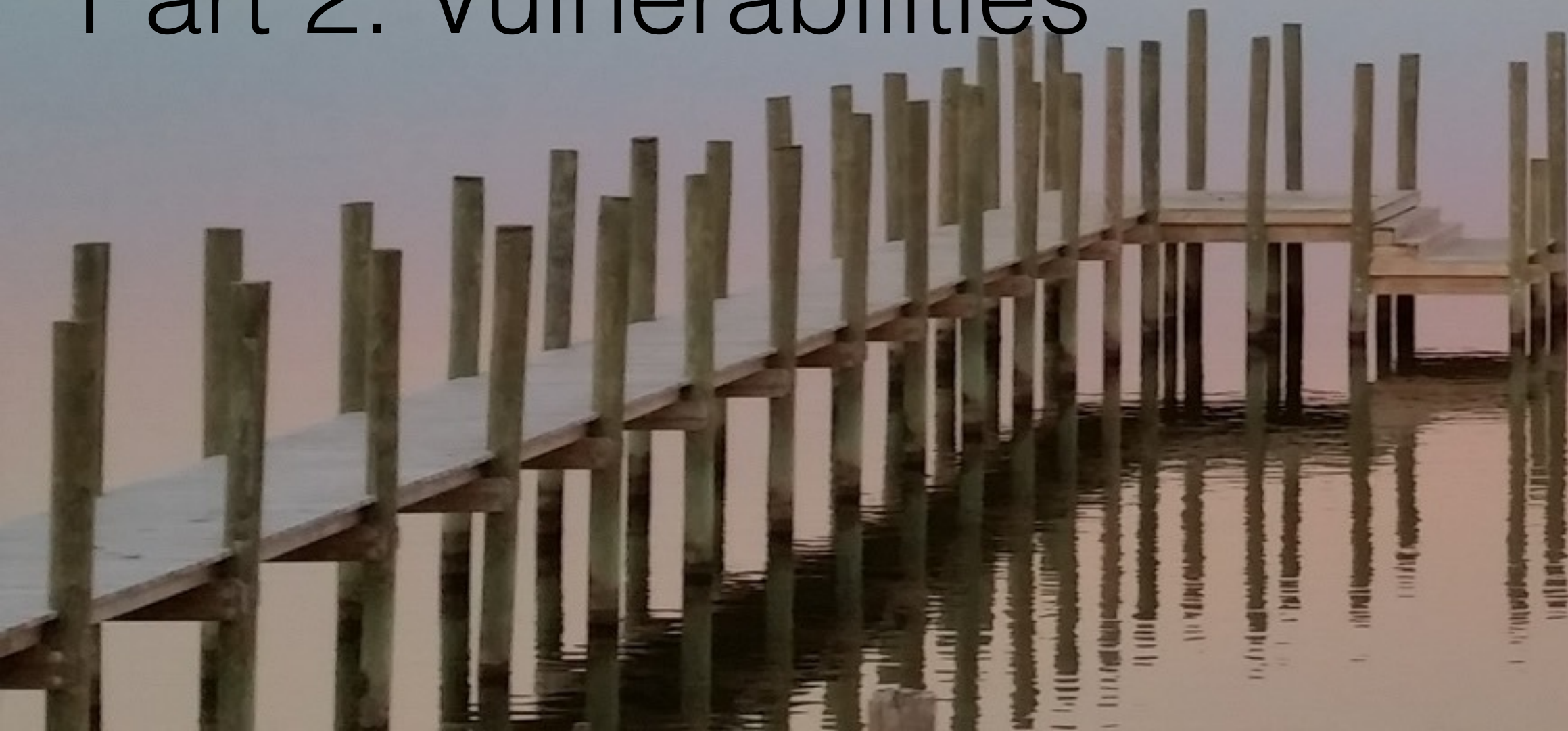
Class 5:

Prologue: Biases

Part 1: Risk Assessment

- Risk (hazards, vulnerability, value)
- Probability
- Risk assessments

Part 2: Vulnerabilities





Cognitive biases are mistakes made in evaluating situations due to one's preference or believe.

Cognitive bias is a mistake in reasoning, evaluating, or remembering as a result of holding onto one's preferences and beliefs regardless of conflicting information.

A cognitive bias is a systematic pattern of deviation from norm to rationality in judgement.

Cognitive biases result when an individual adopts a belief that is not a result of logically sound evidence.

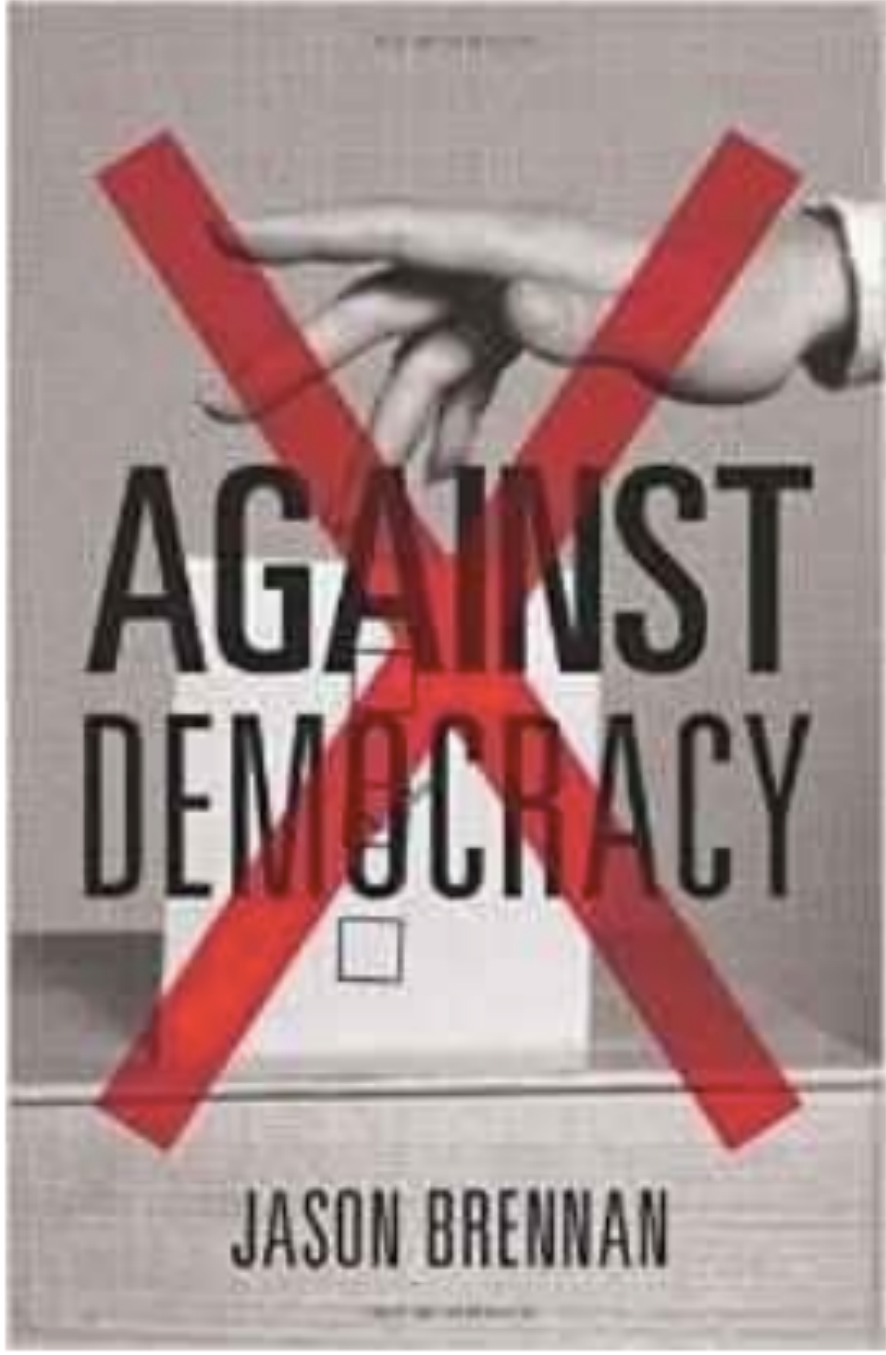
Cognitive biases help make every decision humans make every day.

... describe cognitive bases as affecting the behavior of individuals, and that they can prevent persons from acting in their own best interests.

The Volokh Conspiracy • Opinion

# Democracy vs. Epistocracy

By Ilya Somin September 3, 2016 [Email the author](#)



Georgetown political philosopher Jason Brennan’s important new book [Against Democracy](#) challenges a basic precept that most people take for granted: the morality of democracy. Dominant conventional wisdom on both

The Washington Post



The long read

## Why replacing politicians with experts is a reckless idea

In the age of Trump and Brexit, some people say that democracy is fatally flawed and we should be ruled by ‘those who know best’. Here’s why that’s not very clever. By [David Runciman](#)

|||  
4 2 |

**D**emocracy is tired, vindictive, self-deceiving, paranoid, clumsy and frequently ineffectual. Much of the time it is living on past glories. This sorry state of affairs reflects what we have become. But current democracy is not who we are. It is just a system of government, which we built, and which we could replace. So why don’t we replace it with something better?

The Guardian, May 1, 2018

## Epistocracy

The ruling of those who know  
Find the “right” answer

## Democracy

Have all participate and  
live with the  
consequences

“What we want is more  
important than what is right”

## Philosocracy

The ruling of ethics and  
religions

Value-based governance

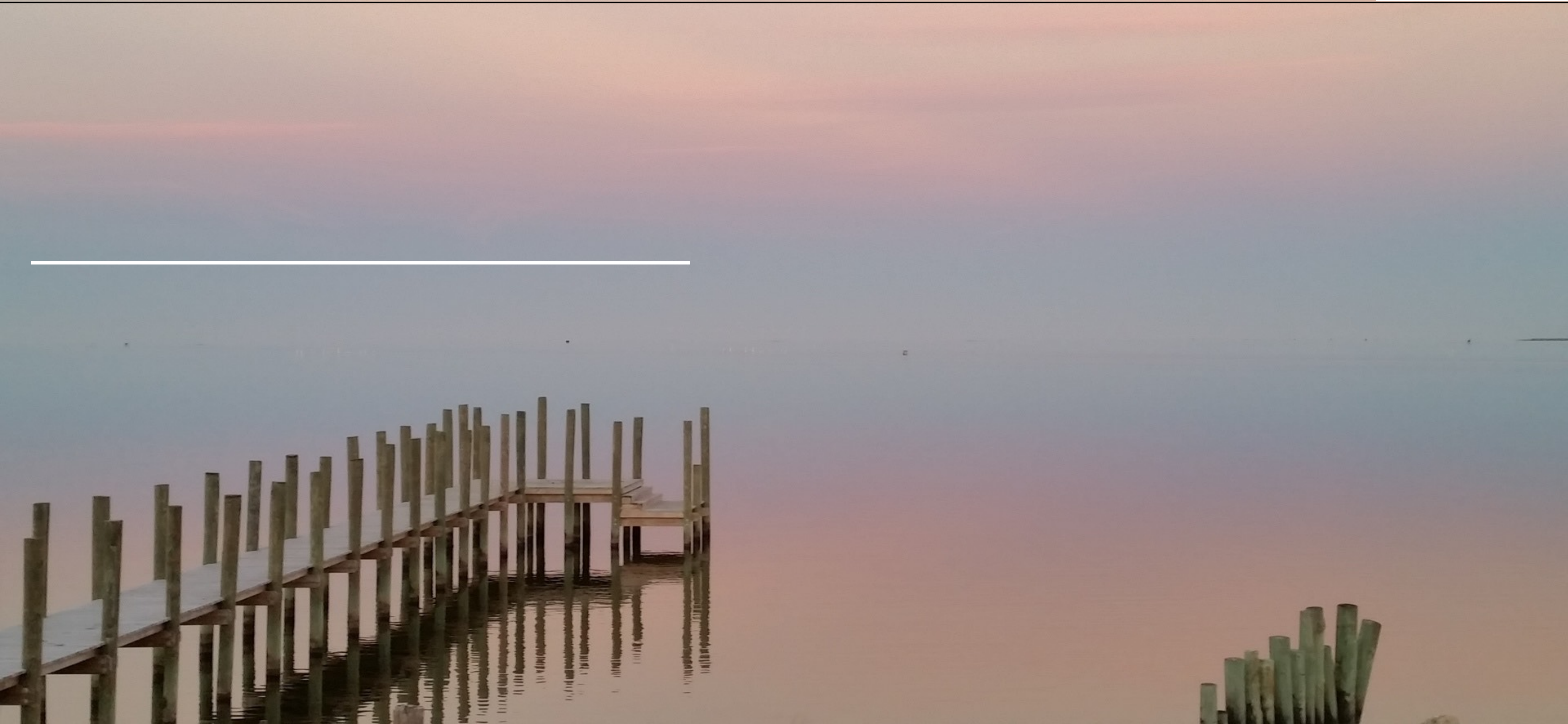
## Technocracy

The operators are the rulers

Keep the machine working



# Sustainability Leadership





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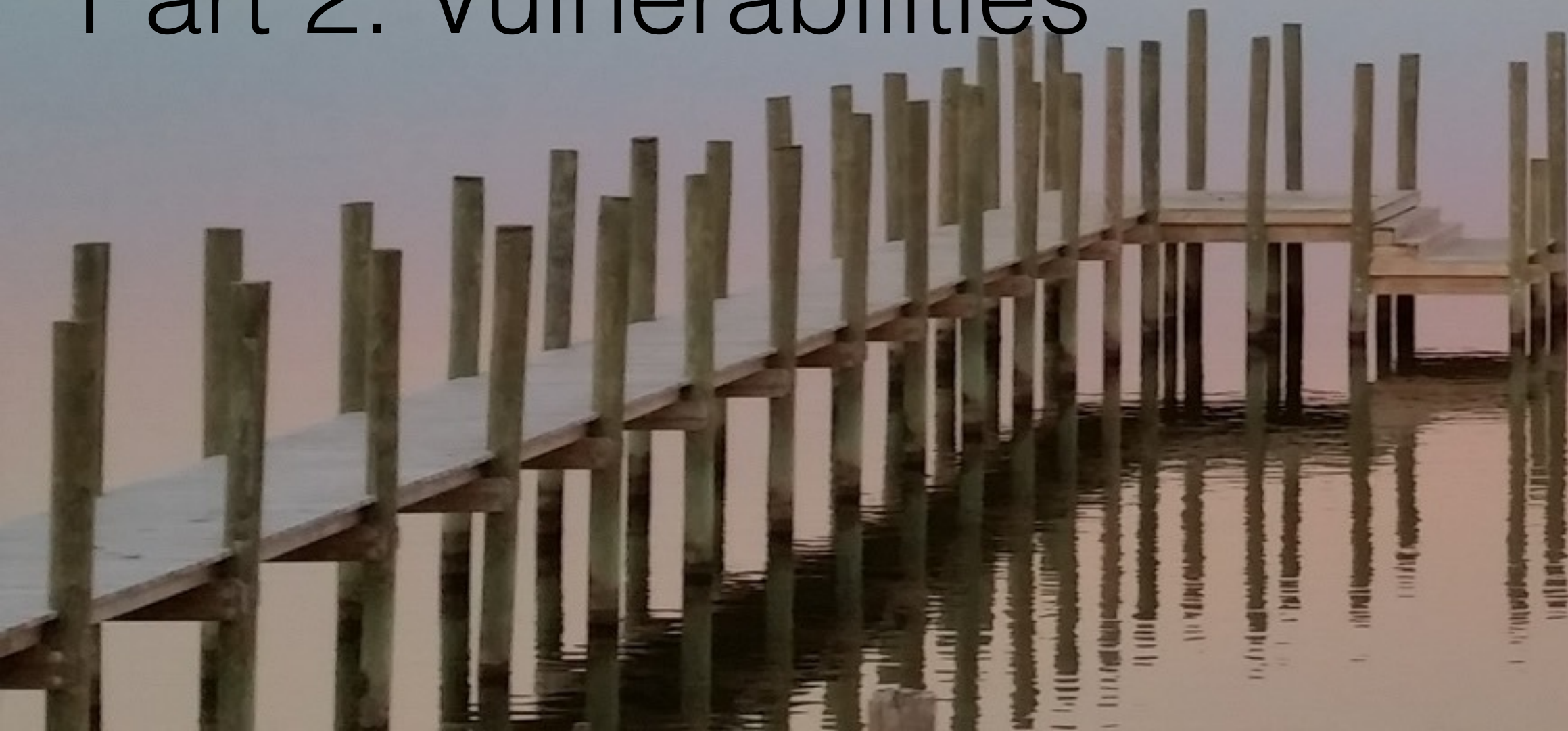
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Risk is a word that has various meanings to people of various fields.



Merriam-Webster

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risk

DICTIONARY | THESAURUS

# <sup>1</sup> risk

*noun* | \ˈrisk\


Popularity: Top 10% of words

**Examples:** RISK in a Sentence ▼

## Definition of RISK

- 1 : possibility of loss or injury : **PERIL**
- 2 : someone or something that creates or suggests a hazard
- 3
  - a : the chance of loss or the perils to the subject matter of an insurance contract; *also* : the degree of probability of such loss
  - b : a person or thing that is a specified hazard to an insurer
  - c : an insurance hazard from a specified cause or source • war *risk*
- 4 : the chance that an investment (such as a stock or commodity) will lose value






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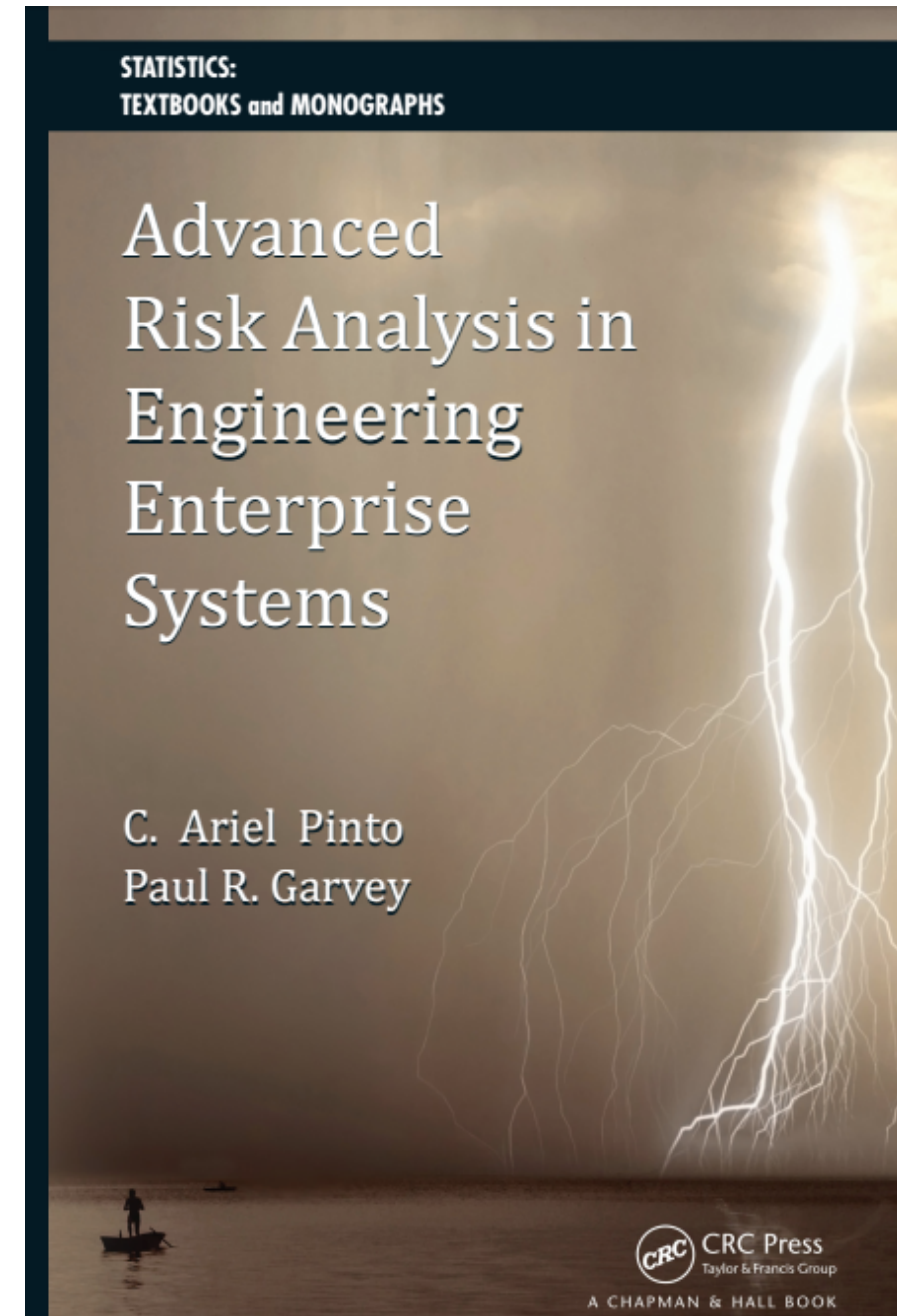






“In general, risk means the possibility of loss or injury. Risk is an event that, if it occurs, has unwanted consequences.”

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## U.K. CCC in CCRA 2017:

In this report, 'risk' is taken to mean 'the potential for consequences where something of value is at stake and where the outcome is uncertain'.



UK  
2017 | Climate  
Change  
Risk  
Assessment

## UK Climate Change Risk Assessment 2017

Synthesis report: priorities for the next five years





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How can we measure risk?



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Risk = hazard probability x vulnerability x value of exposed assets

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$\text{Risk} = \text{hazard probability} \times \text{vulnerability} \times \text{value of exposed assets}$

Hazard: ?

Hazard probability: ?

Vulnerability: ?

Value of assets: ?



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$\text{Risk} = \text{hazard probability} \times \text{vulnerability} \times \text{value of exposed assets}$

Hazard: ?

Hazard probability: ?

Vulnerability: ?

Value of assets: ?

Knowing the probability density function of a hazard

Knowing the vulnerabilities of the assets/system

Assessing the value of the assets

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hazard

DICTIONARY | **THESAURUS**

<sup>1</sup>hazard   
*noun* | haz·ard | \ˈha-zərd\  
Popularity: Top 30% of words

Examples: HAZARD in a Sentence ▼

Editor's Note: Did You Know? ▼

## Definition of HAZARD

- 1 : a game of chance like craps played with two dice
- 2 : a source of danger • *hazards* on the roadway
- 3 a : the effect of unpredictable and unanalyzable forces in determining events : **CHANCE**, **RISK**
  - the *hazards* involved in owning your own business
    - men and women danced together, women danced together, men danced together, as *hazard* had brought them together — Charles Dickens
- b : a chance event : **ACCIDENT**
  - looked like a fugitive, who had escaped from something in clothes caught up at *hazard* — Willa Cather
- 4 *obsolete* : **STAKE** 3a
- 5 : a golf-course obstacle (such as a bunker or a pond)





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A hazard can be:

- a short event (e.g., an earthquake),
- a longer process (e.g., extinction), or
- a slow trend (e.g., sea level rise).



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## Synonyms and Antonyms of VULNERABILITY

- the quality or state of having little resistance to some outside agent**
  - vulnerability* to infection

**Synonyms of VULNERABILITY**  
[defenselessness](#), [susceptibility](#), [weakness](#)

**Words Related to VULNERABILITY**  
[helplessness](#), [powerlessness](#)  
[passiveness](#), [passivity](#)  
[feebleness](#), [frailness](#), [frailty](#), [infirmity](#)  
[exposure](#), [liability](#), [openness](#), [predisposition](#), [proneness](#), [sensitivity](#)  
[receptiveness](#), [receptivity](#)

**Near Antonyms of VULNERABILITY**  
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[impenetrability](#), [indomitability](#), [indomitableness](#), [invincibility](#)

**Antonyms of VULNERABILITY**  
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  - the *vulnerability* of the car to the elements when it's parked outside


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Risk

**Insurance:**

Risk (in \$) = Hazard Probability \* Vulnerability \* Exposed Assets

## Risk

### Insurance:

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### Engineering:

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## **Social vulnerability:**

The extent to which a community could be affected by stress, change or a hazard.

# Risk

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## Hazard:

a change of the system state that can lead to system degradation and/or a reduction of the system's capability to function.

Here we take a risk-based approach that is commonly used for natural hazards and particularly geohazards. For a given hazard  $h$ , a given recurrence time interval  $T$ , and for a prescribed intensity  $I$ , the associated risk  $r(I)$  expressed in currency is given by

$$r_h^T(I, x, t) = p_h^T(I, t) \cdot V_h^{a(x, t)}(I, t) \cdot a(x, t) \quad [1]$$

## Vulnerability:

Inability of a system to withstand the effects of a hostile environment or harmful system trends.

where  $x$  is the location,  $t$  time,  $p$  the hazard giving the probability that the hazard with intensity  $I$  will occur in the considered recurrence interval,  $V$  the vulnerability of an asset  $a$  for hazard  $h$  at intensity  $I$ , and  $a$  being the asset exposed at location  $x$ . To assess the total risk  $R$  associated with a hazard, we can use

## Social vulnerability:

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$$R_h^T(x, t) = \int_0^{I_{\max}} r_h^T(I, x, t) di. \quad [2]$$



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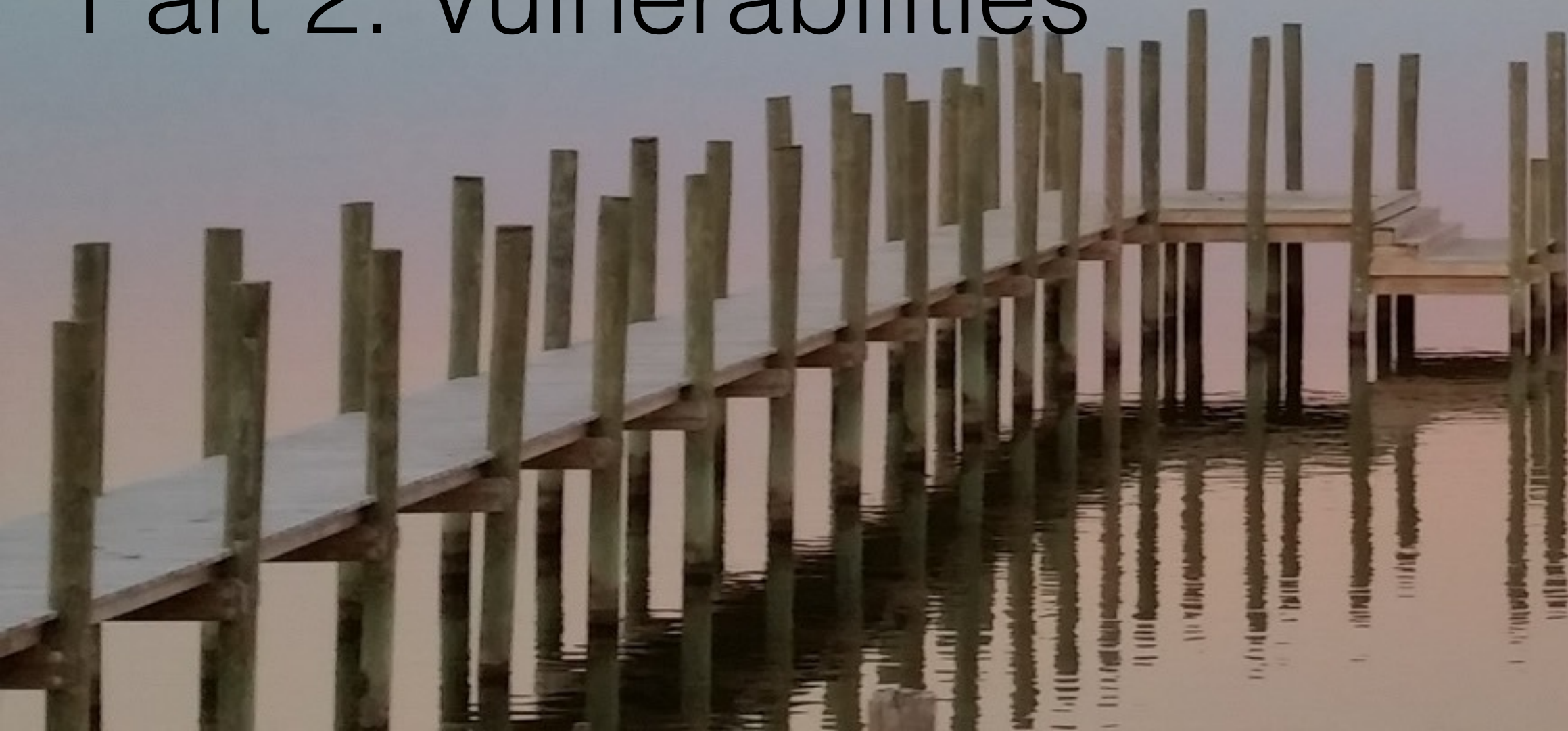
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A simple example is the tossing of an unbiased coin. Since the coin is unbiased, the two outcomes ("heads" and "tails") are both equally probable; the probability of "heads" equals the probability of "tails"; and since no other outcomes are possible, the probability of either "heads" or "tails" is  $1/2$  (which could also be written as 0.5 or 50%).

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Independent events:

$$P(A \text{ and } B) = P(A) * P(B)$$





## **Probability mass function:**

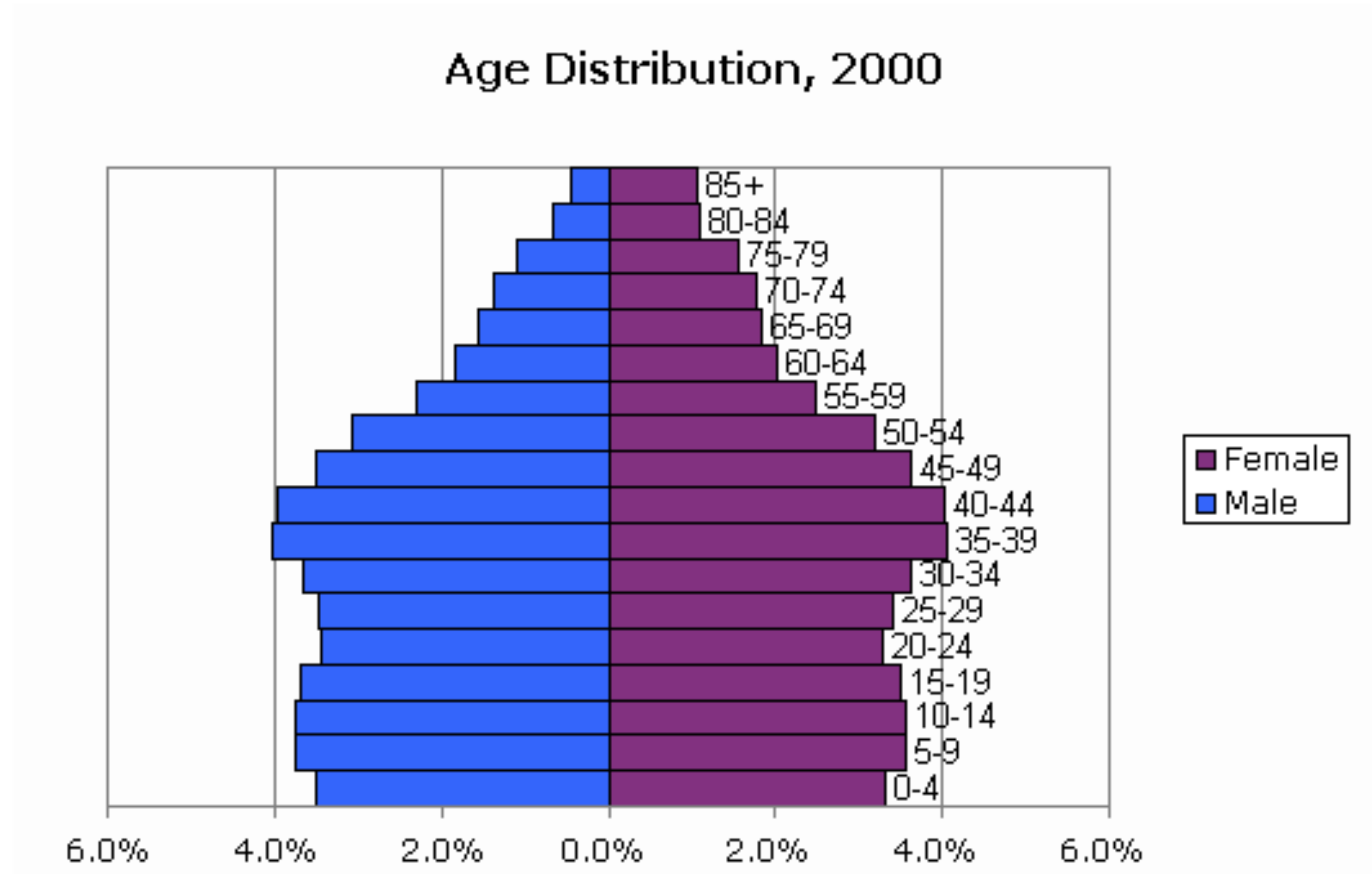
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$$P[a \leq X \leq b] = \int_a^b f_X(u) du$$



Question: What is the probability density function for sea level change per century?

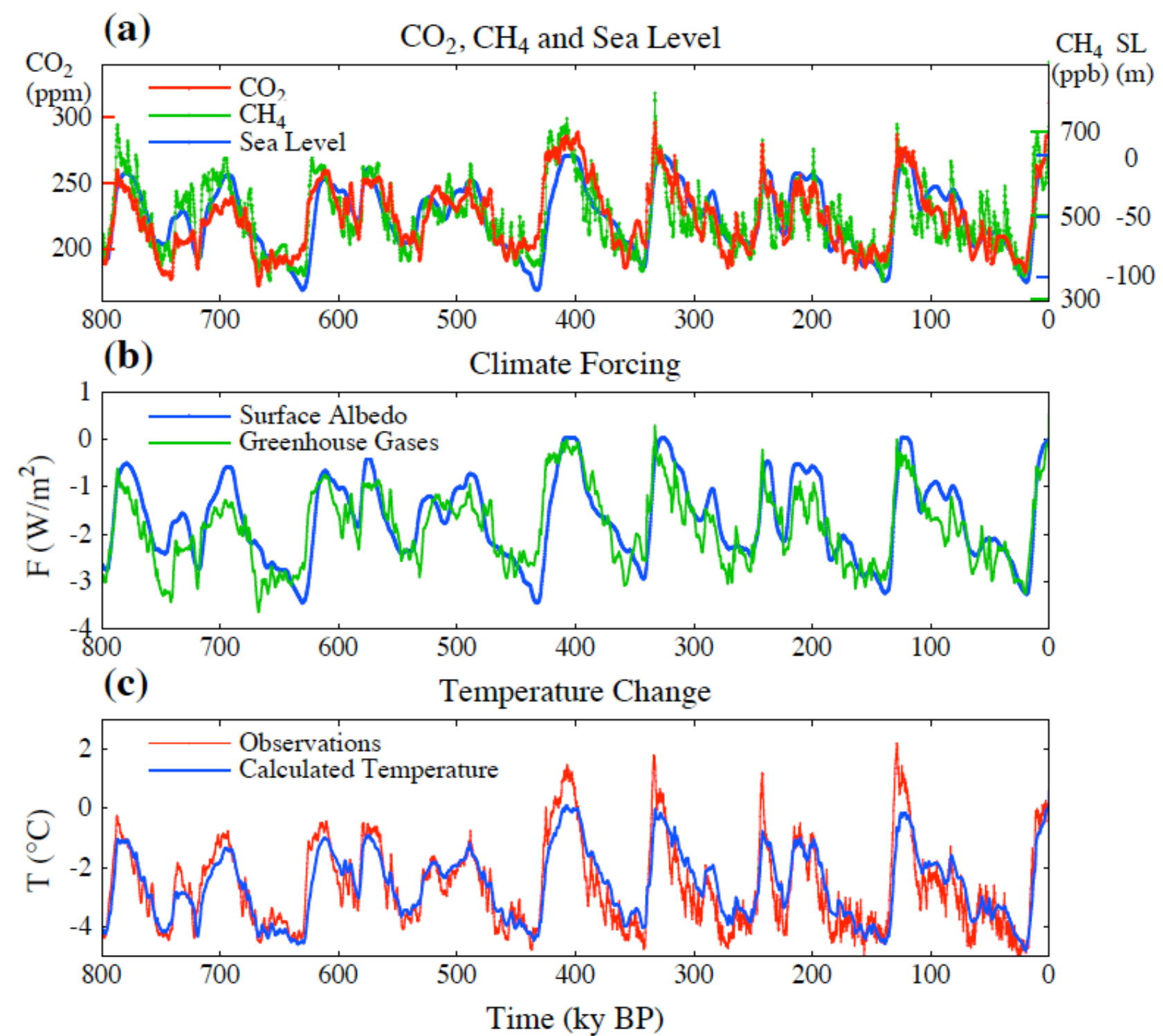


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Look at paleo-data ...

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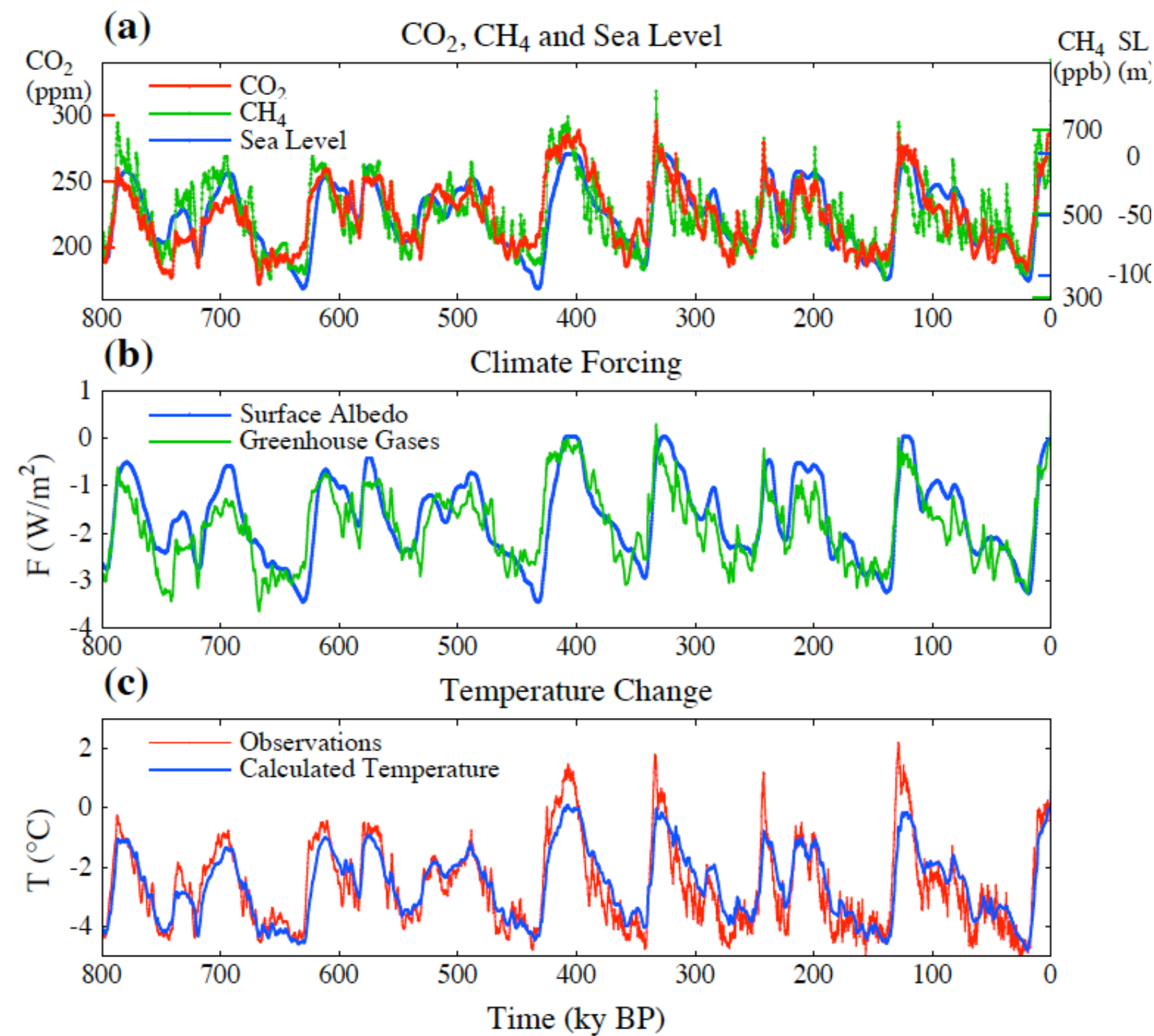


*Hansen et al. (2008)*

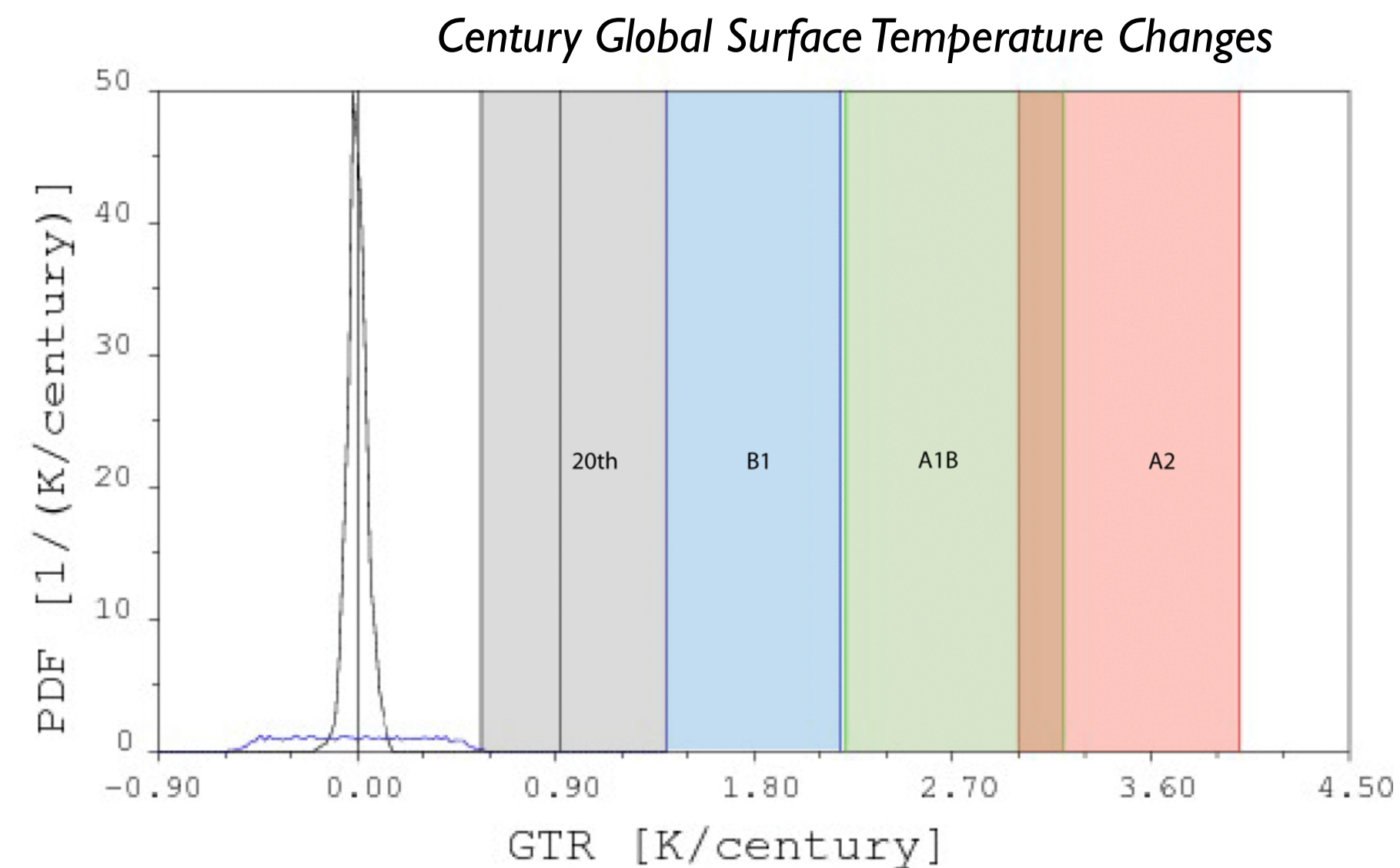
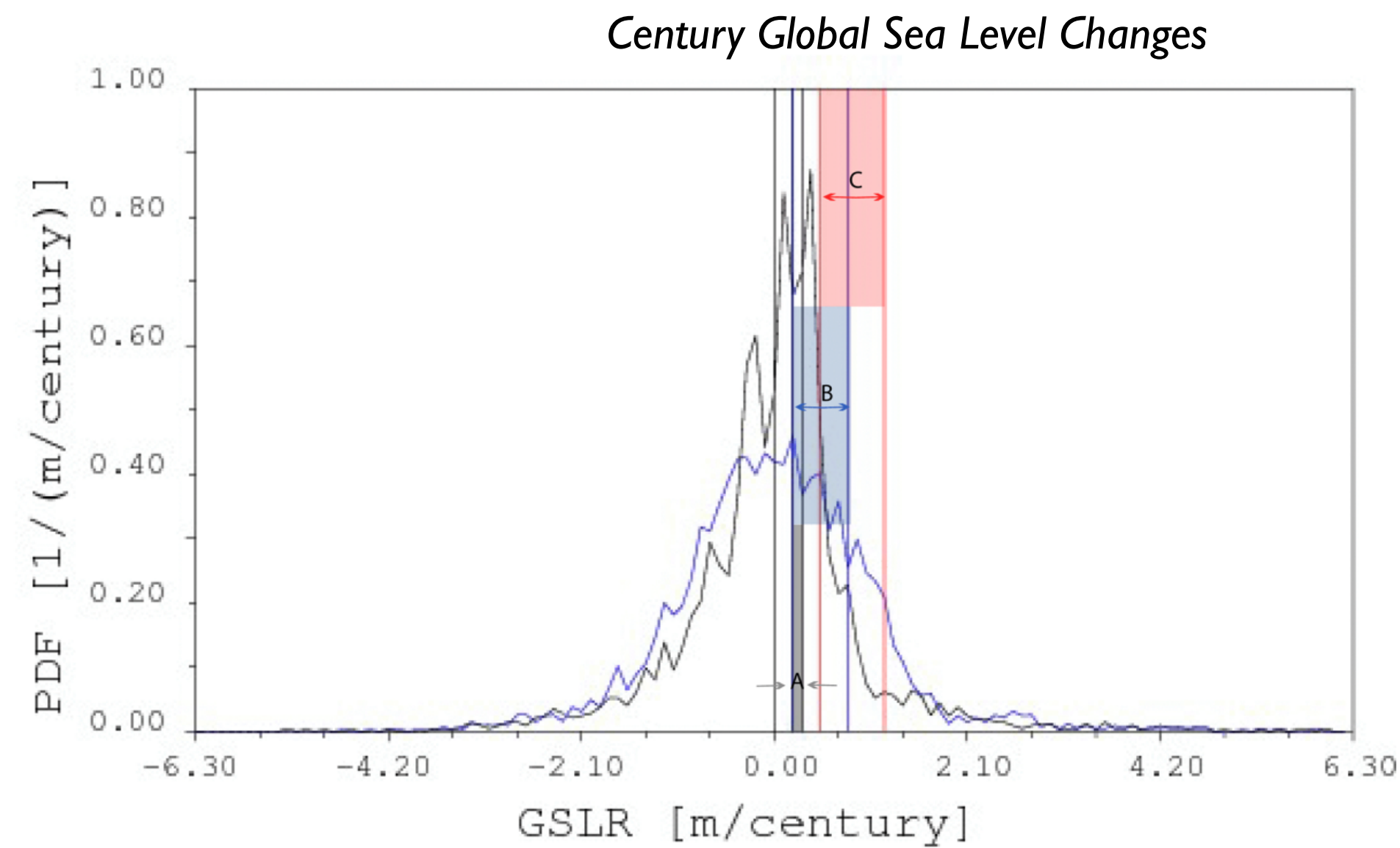
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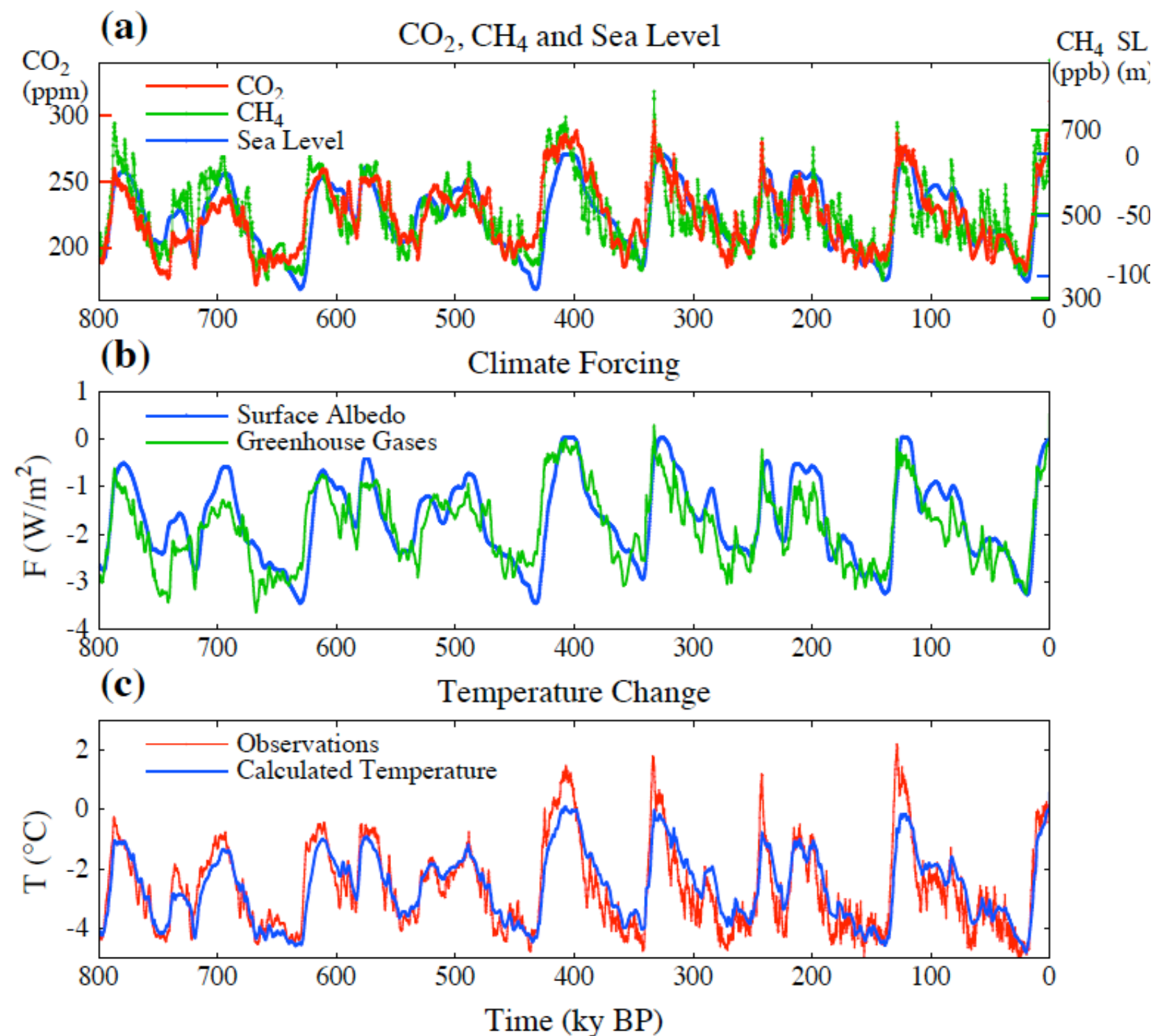
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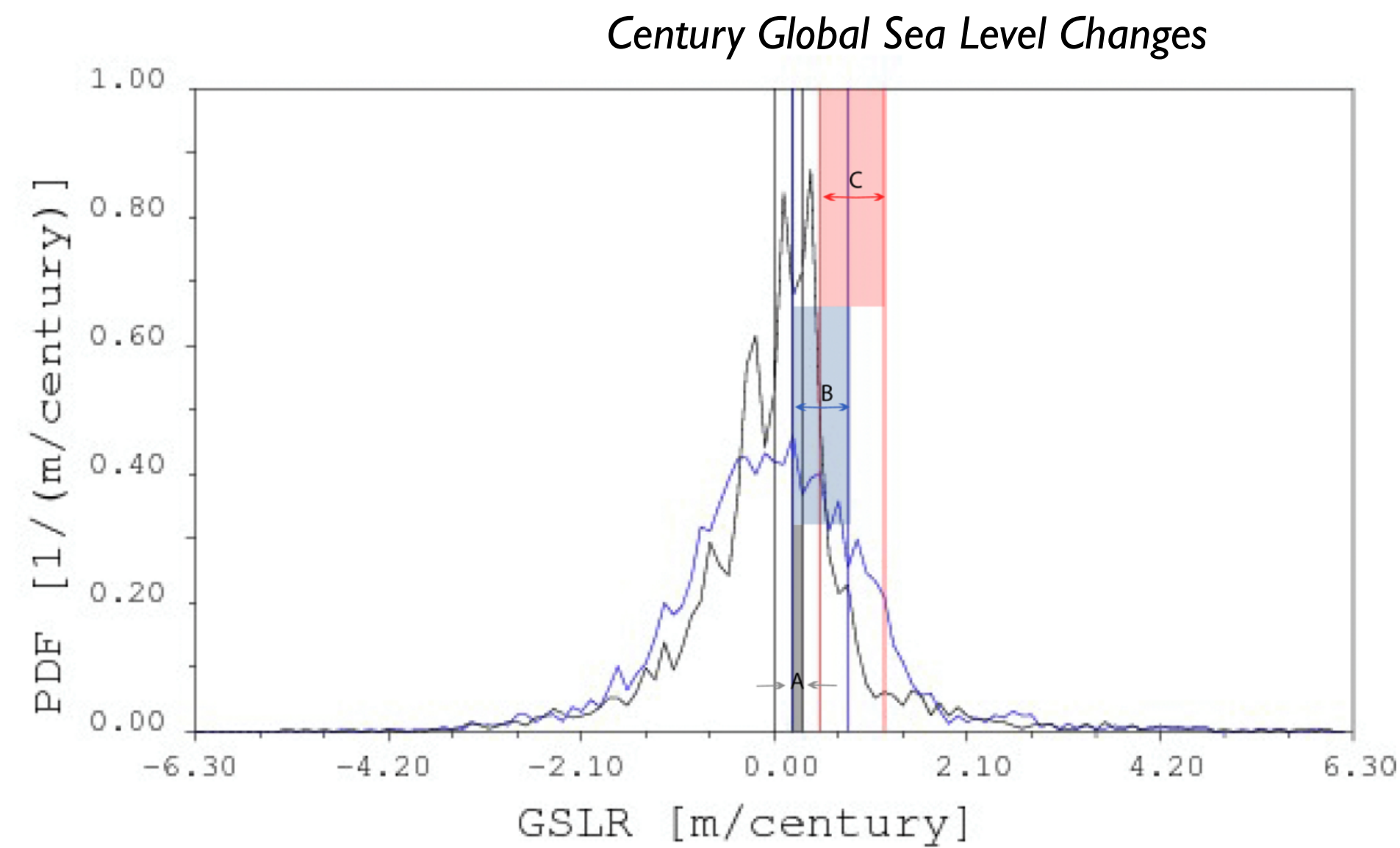
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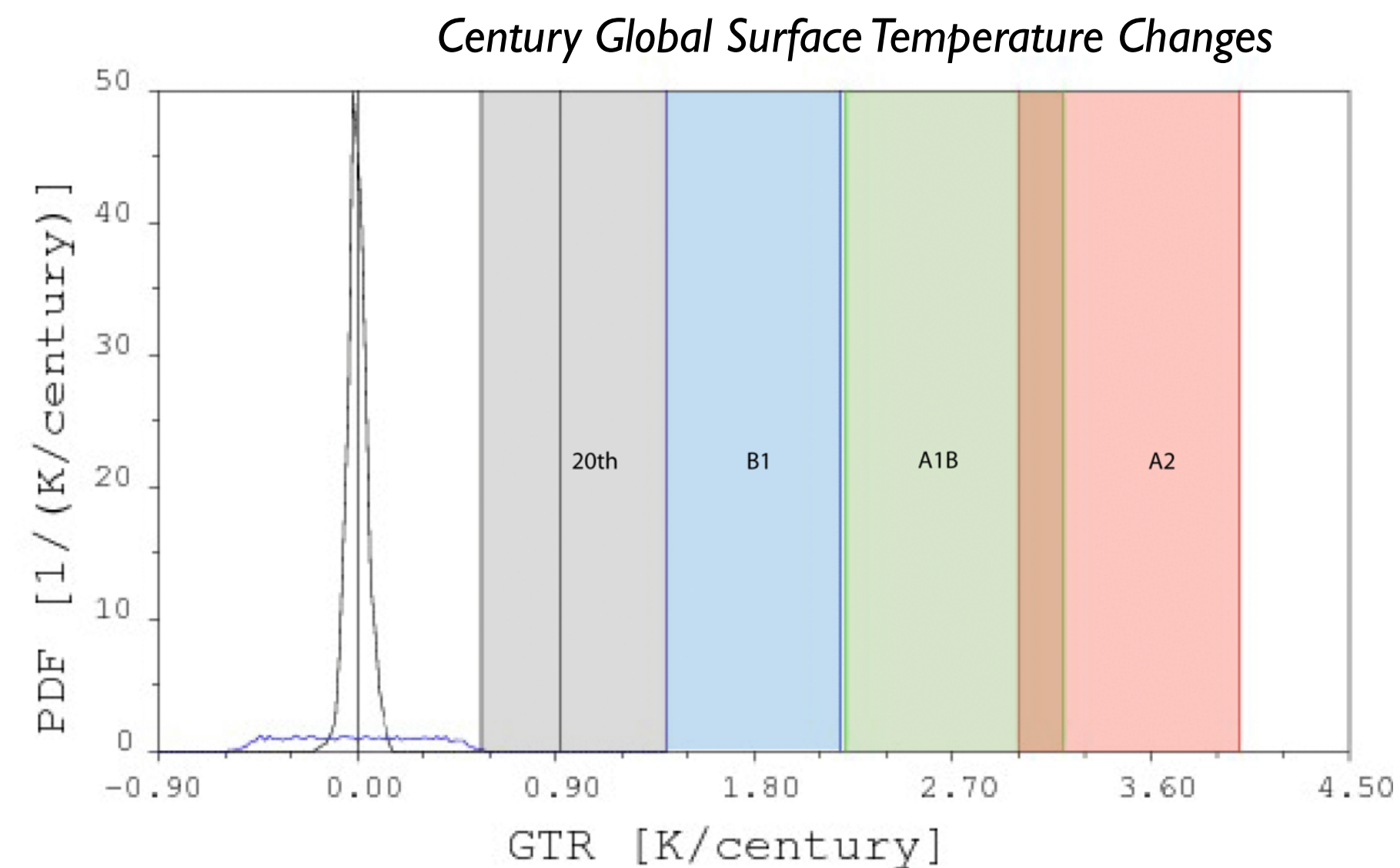
Question: What is the probability density function for sea level change per century?



*Hansen et al. (2008)*



Look at paleo-data ...



Scientifically, we cannot exclude a large, rapid global sea level rise with large spatial variability in local sea level rise.

*Plag and Jules-Plag (2013)*

Probability question in Risk assessments:

- How likely is it that a hazard of a certain magnitude occurs?
- How likely is it that one or more hazards exceeding a certain magnitude occur in a given time interval?
- How likely is it that a certain quantity exceeds a certain level?





## Poisson Distribution

## Poisson Distribution

Example: your e-mail

On average, you may get 14 e-mails per day with some variation.

What is the likelihood of a day where you get 0 e-mails/95 e-mails/more than 50 e-mails?

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What is the likelihood of a day where you get 0 e-mails/95 e-mails/more than 50 e-mails?

Conditions:

- the event is something that can be counted in whole numbers;
- occurrences are independent, so that one occurrence neither diminishes nor increases the chance of another;
- the average frequency of occurrence for the time period in question is known;
- it is possible to count how many events have occurred, but it meaningless to ask how many such events have not occurred.



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- it is possible to count how many events have occurred, but it is meaningless to ask how many such events have not occurred.

The last point sums up the contrast with the Binomial situation, where the probability of each of two mutually exclusive events ( $p$  and  $q$ ) is known.

## Poisson Distribution

The following notation is helpful, when we talk about the Poisson distribution.

$e$ : the base of the natural logarithm system, equal to approximately 2.71828.

$\mu$ : The mean number of successes that occur in a specified region.

$x$ : The actual number of successes that occur in a specified region.

$P(x; \mu)$ : The **Poisson probability** that exactly  $x$  successes occur in a Poisson experiment, when the mean number of successes is  $\mu$ .

**Poisson Formula.** In a Poisson experiment, in which the average number of successes within a given region is  $\mu$ , the Poisson probability is:

$$P(x=k; \mu) = (e^{-\mu}) (\mu^k) / k!$$

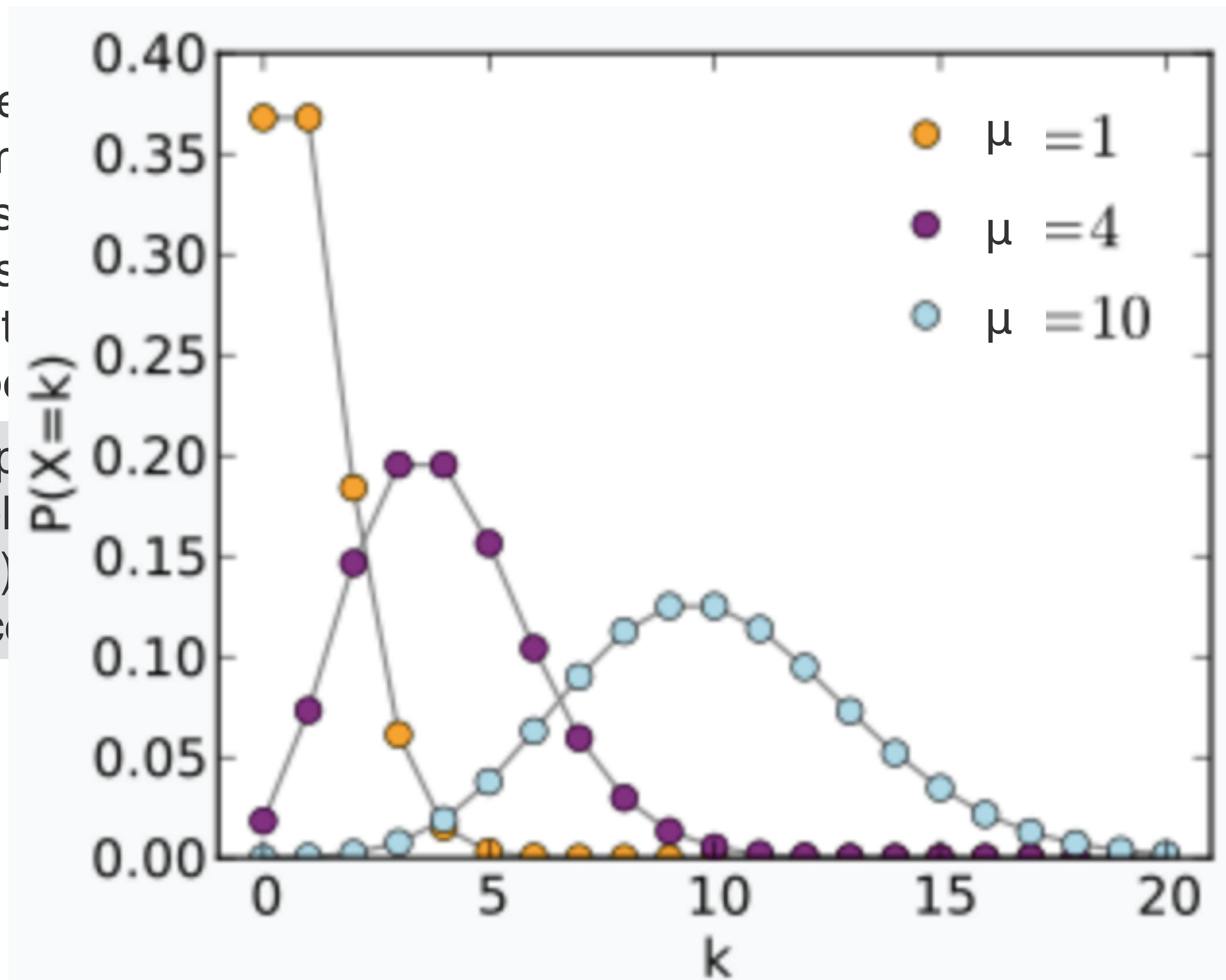
where  $x$  is the actual number of successes that result from the experiment.

## Poisson Distribution

The following notation is helpful, where  
 $e$ : the base of the natural logarithm  
 $\mu$ : The mean number of successes  
 $x$ : The actual number of successes  
 $P(x; \mu)$ : The **Poisson probability** of  $x$  successes in a fixed interval of an experiment, when the mean number of successes is  $\mu$

**Poisson Formula.** In a Poisson experiment, if the mean number of successes in a given region is  $\mu$ , the Poisson probability of  $x$  successes is given by  

$$P(x=k; \mu) = \frac{e^{-\mu} \mu^k}{k!}$$
 where  $x$  is the actual number of successes





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$$e \sim 2.71828$$

$$P(x=k; \mu) = \frac{\mu^k}{e^{\mu} * k!}$$

The factorial  $k!$  is:

$$0! = 1$$

$$1! = 1$$

$$2! = 1 * 2 = 2$$

$$3! = 1 * 2 * 3 = 6$$

$$4! = 1 * 2 * 3 * 4 = 24$$

...

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Probability of exactly one 100-year flood to occur in a specific century?

$\mu = 1$ ,  $k = 1$ ,  $P=?$

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Probability of exactly one 100-year flood to occur in a specific century?

$$\mu = 1, k = 1, P=?$$

Probability of no 100-year flood to occur in a specific century?

$$\mu = 1, k = 0, P=?$$

The factorial  $k!$  is:

$$0! = 1$$

$$1! = 1$$

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...

Probability of no 100-year flood to occur in a specific century?

$$\mu = 1, k = 0, P=?$$

Probability of one or more 100-year flood to occur in a specific century?

$$\mu = 1, k \geq 1, P=?$$



# Sustainability Leadership





# Sustainability Leadership

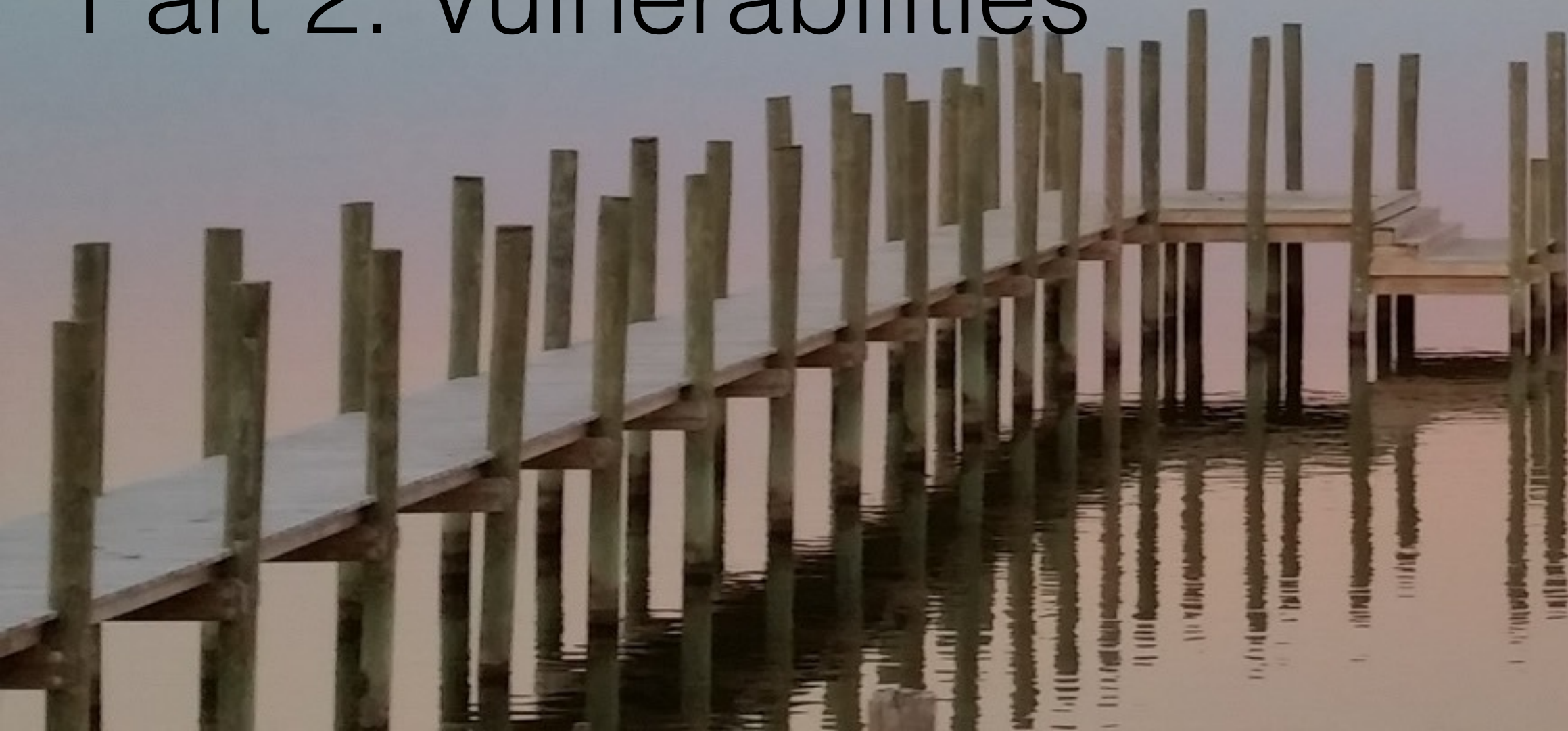
Class 5:

Prologue: Biases

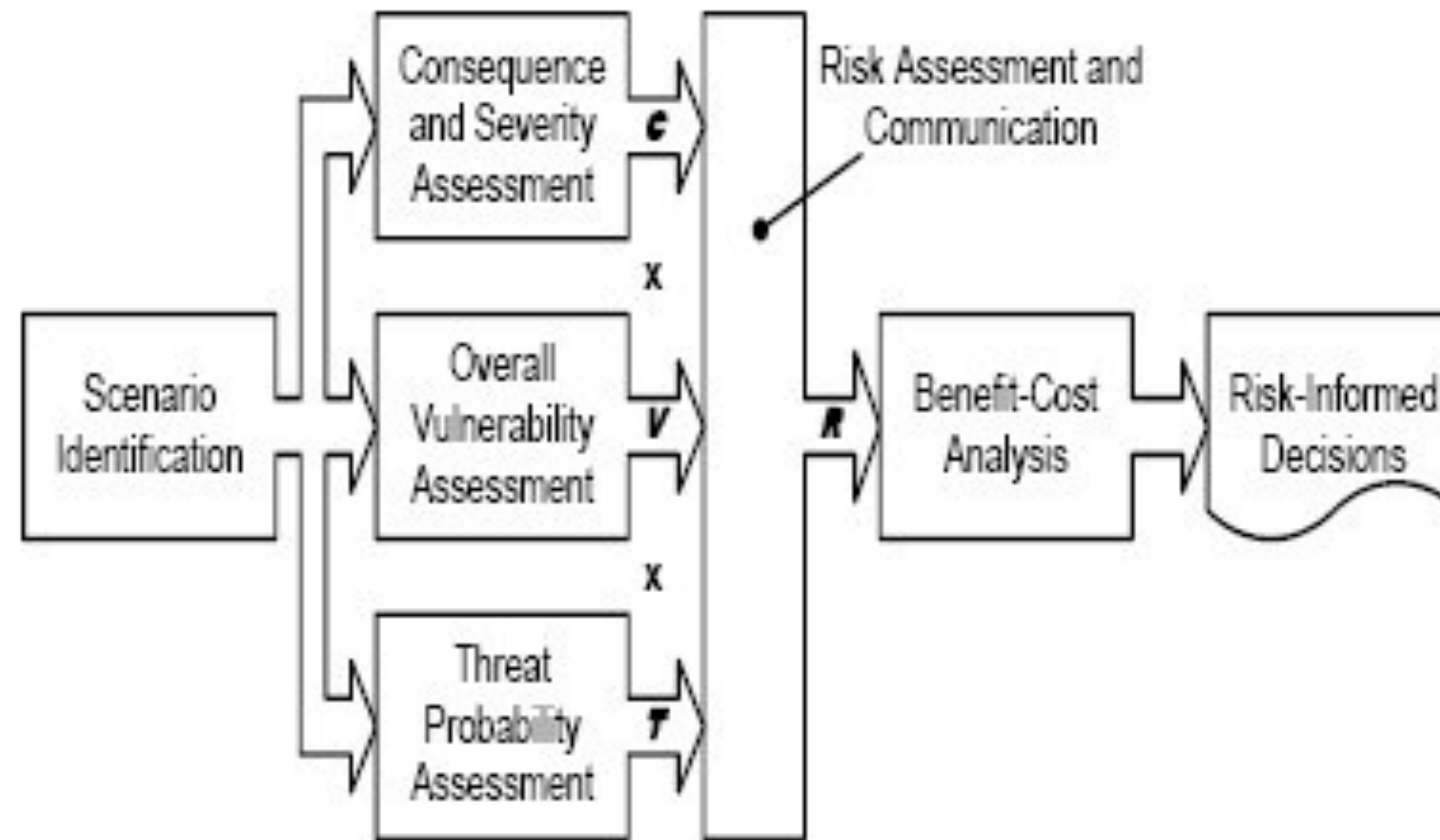
Part 1: Risk Assessment

- Risk (hazards, vulnerability, value)
- Probability
- Risk assessments

Part 2: Vulnerabilities





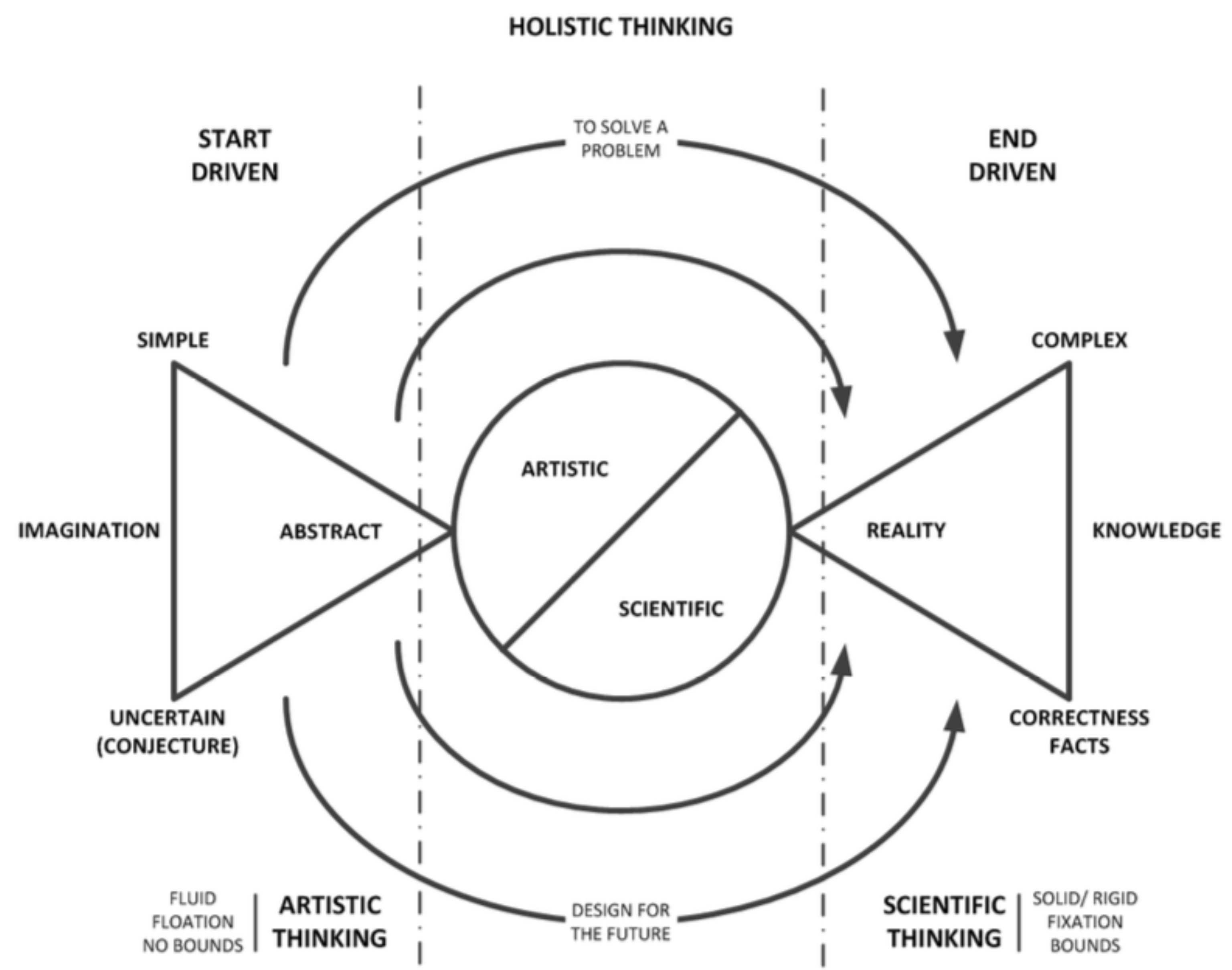


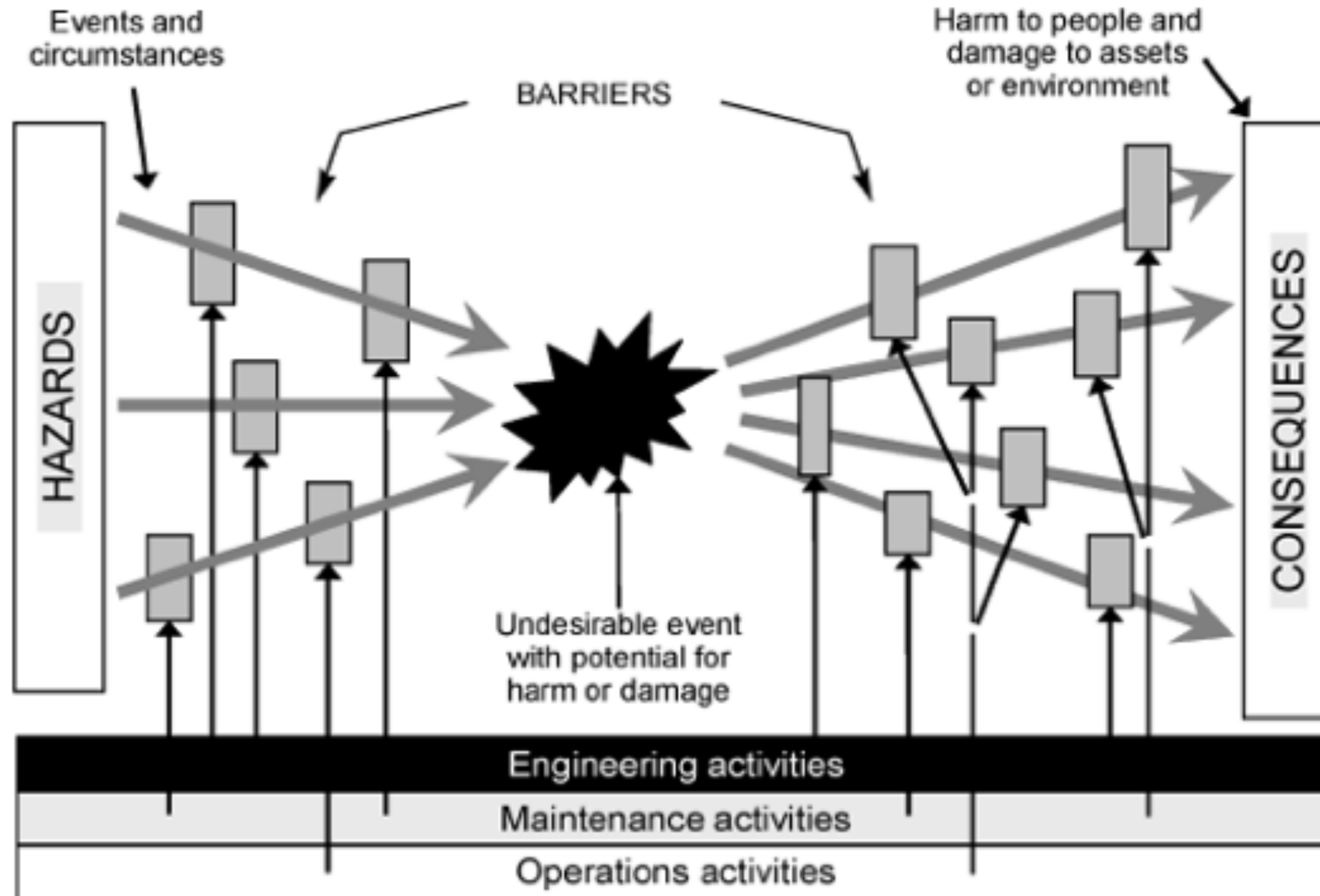
**Figure 1-1.** The critical asset and portfolio risk analysis (CARRA) methodology



Gaining a Better Understanding of How to Cope with Extreme  
Low Probability and High Impact Shock Events

*And What About Sea Level Rise?*





**Figure 3.2: Bowtie model**



## Definition:

A disaster is the loss of lives and property; often as the result of a hazardous event.



## Risk Analysis:

- Approach to develop foresight
- Assess potential of an event and its consequences

## Risk Analysis:

- Approach to develop foresight
- Assess potential of an event and its consequences

## Challenge:

- Include all possible types of events
- Understand the full spectrum a specific type of events
- Understand the possible consequences for the system and their impacts (cascading effects)
- Understand the possible events triggered by an event



## *Perspective*

# **The Challenge of Degraded Environments: How Common Biases Impair Effective Policy**

**Alan Berger,<sup>1</sup> Case Brown,<sup>2</sup> Carolyn Kousky,<sup>3,\*</sup> and Richard Zeckhauser<sup>4</sup>**

---

Economic activity can damage natural systems and reduce the flow of ecosystem services. The harms can be substantial, as our case studies vividly illustrate. Most degraded landscapes have at least some potential to be reclaimed. However, uncertainty plagues decision making regarding degradation and reclamation, in relation to the extent of the damage, the success of reclamation, and how exposure will change in the future. We examine how a range of observed decision biases can lead to far-from-optimal policies regarding how much degradation to allow and when, as well as how and how much, to reclaim degraded sites. Despite our focus on degraded landscapes, we believe these are generic biases present in a wide range of risk situations. Our three case studies show these biases at work. The first two studies are of mining operations in the United States and Canada, and the third is of climate change.





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## THE OTHER SIDE OF THE GLOBAL CRISIS: ENTROPY AND THE COLLAPSE OF CIVILIZATIONS

By [Jacopo Simonetta](#), originally published by [Cassandra's legacy](#)

March 7, 2016



1



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17



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1



When we discuss the impending crisis of our civilisation, we mainly look at the resources our economy need in a growing quantity. And we explain why the diminishing returns of resource exploitation pose a growing burden on the possibility of a further growing of the global economy. It is a very interesting topic, indeed, but here I suggest to turn 180 degrees around and take a look at the "other side;" that is to what happens where the used resources are discarded.

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Our planet is under threat.  
Our communities are struggling.**

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## Climate change

Keep it in the ground



🕒 This article is 2 years old



25,372



2,455

**Alan Rusbridger**

Friday 6 March 2015 07.32 EST

# Climate change: why the Guardian is putting threat to Earth front and centre

As global warming argument moves on to politics and business, Alan Rusbridger explains the thinking behind our major series on the climate crisis



 Connection by Antony Gormley. Illustration: Antony Gormley

Journalism tends to be a rear-view mirror. We prefer to deal with what has happened, not what lies ahead. We favour what is exceptional and in full view over what is ordinary and hidden.



## WORLD SCIENTISTS' WARNING TO HUMANITY

**INTRODUCTION** Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about.

**THE ENVIRONMENT** The environment is suffering critical stress:

**The Atmosphere** Stratospheric ozone depletion threatens us with enhanced ultraviolet radiation at the earth's surface, which can be damaging or lethal to many life forms. Air pollution near ground level, and acid precipitation, are already causing widespread injury to humans, forests, and crops.

**Water Resources** Heedless exploitation of depletable groundwater supplies endangers food production and other essential human systems. Heavy demands on the world's surface waters have resulted in serious shortages in some 80 countries, containing 40 percent of the world's population. Pollution of rivers, lakes, and groundwater further limits the supply.

**Oceans** Destructive pressure on the oceans is severe, particularly in the coastal regions which produce most of the world's food fish. The total marine catch is now at or above the estimated maximum sustainable yield. Some fisheries have already shown signs of collapse. Rivers carrying heavy burdens of eroded soil into the seas also carry industrial, municipal, agricultural, and livestock waste—some of it toxic.

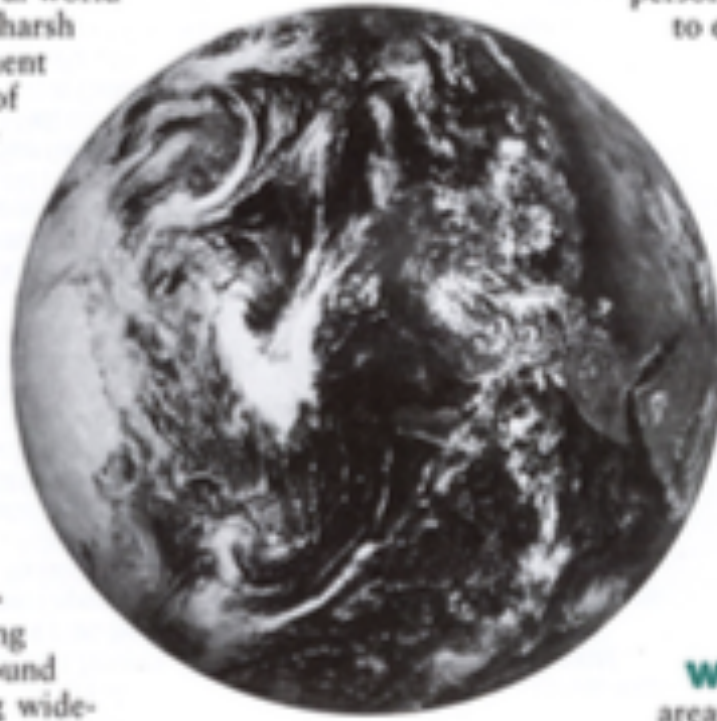
**Soil** Loss of soil productivity, which is causing extensive land abandonment, is a widespread by-product of current practices in agriculture and animal husbandry. Since 1945, 11 percent of the earth's vegetated surface has been degraded—an area larger than India and China combined—and per capita food production in many parts of the world is decreasing.

**Forests** Tropical rain forests, as well as tropical and temperate dry forests, are being destroyed. Some critical forest types will be gone in the next 10 years. Tropical rain forest will be gone before then. They will go large numbers of plant and animal species.

**Living Species** The irreversible loss of species, which by 2100 may reach one-third of all species now living, is especially serious. We are losing the potential they hold for providing medicinal and other benefits, and the contribution that genetic diversity of life forms gives to the robustness of the world's biological systems and to the astonishing beauty of the earth itself.

Much of this damage is irreversible on a scale of centuries, or permanent. Other processes appear to pose additional threats. Increasing levels of gases in the atmosphere from human activities, including carbon dioxide released from fossil fuel burning and from deforestation, may alter climate on a global scale. Predictions of global warming are still uncertain—with projected effects ranging from tolerable to very severe—but the potential risks are very great.

Our massive tampering with the world's interdependent web of life—coupled with the environmental damage inflicted by deforestation, species loss, and climate change—could trigger wide read adverse effects, including unpredictable collapses of critical biological systems whose interactions and dynamics we only imperfectly understand.



person in five lives in absolute poverty without enough to eat, and one in ten suffers serious malnutrition.

No more than one or a few decades remain before the chance to avert the threats we now confront will be lost and the prospects for humanity immeasurably diminished.

**WARNING** We the undersigned, senior members of the world's scientific community, hereby warn all humanity of what lies ahead. A great change in our stewardship of the earth and the life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated.

**WHAT WE MUST DO** Five inextricably linked areas must be addressed simultaneously:

1. We must bring environmentally damaging activities under control to restore and protect the integrity of the earth's systems we depend on. We must, for example, move away from fossil fuels to more benign, inexhaustible energy sources to cut greenhouse-gas emissions and the pollution of our air and water. Priority must be given to the development of energy sources matched to Third World needs—small-scale and relatively easy to implement.
2. We must manage resources crucial to human welfare more effectively. We must give high priority to efficient use of energy, water, and other materials, including expansion of conservation and recycling.
3. We must stabilize population. This will be possible only if all nations recognize that it requires improved social and economic conditions, and the adoption of effective, voluntary family planning.
4. We must reduce and eventually eliminate poverty.
5. We must ensure sexual equality, and guarantee women control over their own reproductive decisions.

The developed nations are the largest polluters in the world today. They must greatly reduce their overconsumption, if we are to reduce pressures on resources and the global environment. The developed nations have the obligation to provide aid and support to developing nations, because only the developed nations have the financial resources and the technical skills for these tasks.

Acting on this recognition is not altruism, but enlightened self-interest: whether industrialized or not, we all have but one lifeboat. No nation can escape from injury when global biological systems are damaged. No nation can escape from conflicts over increasingly scarce resources. In addition, environmental and economic instabilities will cause mass migrations with incalculable consequences for developed and undeveloped nations alike.

Developing nations must realize that environmental damage is one of the gravest threats they face, and that attempts to blunt it will be overwhelmed if their populations go unchecked. The greatest peril is to become trapped in spirals of environmental decline, poverty, and unrest, leading to social, economic, and environmental collapse.

Success in this global endeavor will require a great reduction in violence and war. Resources now devoted to the preparation and conduct of war—amounting to over \$1 trillion annually—will be badly needed in the new tasks and should be diverted to the new challenges.

Uncertainty over the extent of these effects cannot excuse complacency or delay in facing the threats.

**POPULATION** The earth is finite. Its ability to absorb wastes and destructive effluent is finite. Its ability to provide food and energy is finite. Its ability to provide for growing numbers of people is finite. And we are fast approaching many of the earth's limits. Current economic practices which damage the environment, in both developed and underdeveloped nations, cannot be continued without the risk that vital global systems will be damaged beyond repair.

Pressures resulting from unrestrained population growth put demands on the natural world that can overwhelm any efforts to achieve a sustainable future. If we are to halt the destruction of our environment, we must accept limits to that growth. A World Bank estimate indicates that world population will not stabilize at less than 12.4 billion, while the United Nations concludes that the eventual total could reach 14 billion, a near tripling of today's 5.4 billion. But, even at this moment, one

A new ethic is required—a new attitude towards discharging our responsibility for caring for ourselves and for the earth. We must recognize the earth's limited capacity to provide for us. We must recognize its fragility. We must no longer allow it to be ravaged. This ethic must motivate a great movement, convincing reluctant leaders and reluctant governments and reluctant peoples themselves to effect the needed changes.

The scientists issuing this warning hope that our message will reach and affect people everywhere. We need the help of many.

We require the help of the world community of scientists—natural, social, economic, political;

We require the help of the world's business and industrial leaders;

We require the help of the world's religious leaders; and

We require the help of the world's peoples.

We call on all to join us in this task.

SPONSORED BY THE UNION OF CONCERNED SCIENTISTS, TWO BRATTLE SQUARE, CAMBRIDGE, MA 02238-9105

### About the Union of Concerned Scientists

The Union of Concerned Scientists (UCS) is dedicated to advancing responsible public policies in areas where science and technology play a critical role. Established in 1969, UCS has created a unique alliance between many of the United States' leading scientists and thousands of committed citizens. This partnership addresses the most serious environmental and security threats facing humanity.

UCS is currently working to encourage responsible stewardship of the global environment and life-sustaining resources; promote energy technologies that are renewable, safe, and cost effective; reform transportation policy; promote sustainable agriculture; and curtail weapons proliferation. An independent nonprofit organization, UCS conducts technical studies and public education, and seeks to influence government policy at the local, state, federal, and international levels.

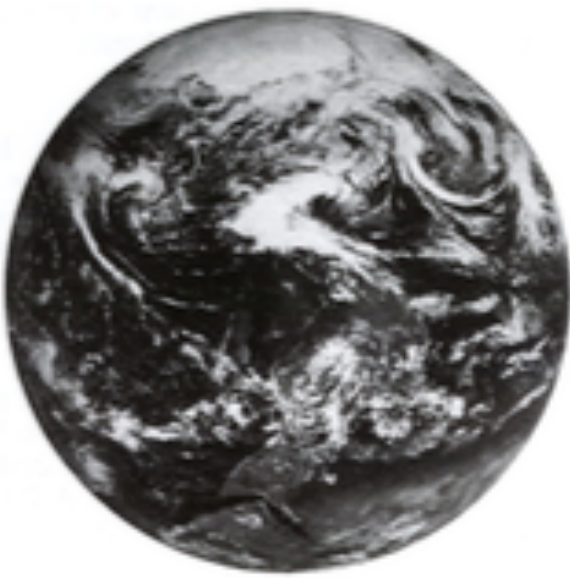
For information about UCS and our work, visit the UCS site on the World Wide Web at <http://www.ucsusa.org>. Or you may call us at 617-547-5552 or send us an e-mail at [ucs@ucsusa.org](mailto:ucs@ucsusa.org).

Union of Concerned Scientists  
Two Brattle Square  
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April 1997

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## WORLD SCIENTISTS' WARNING TO HUMANITY



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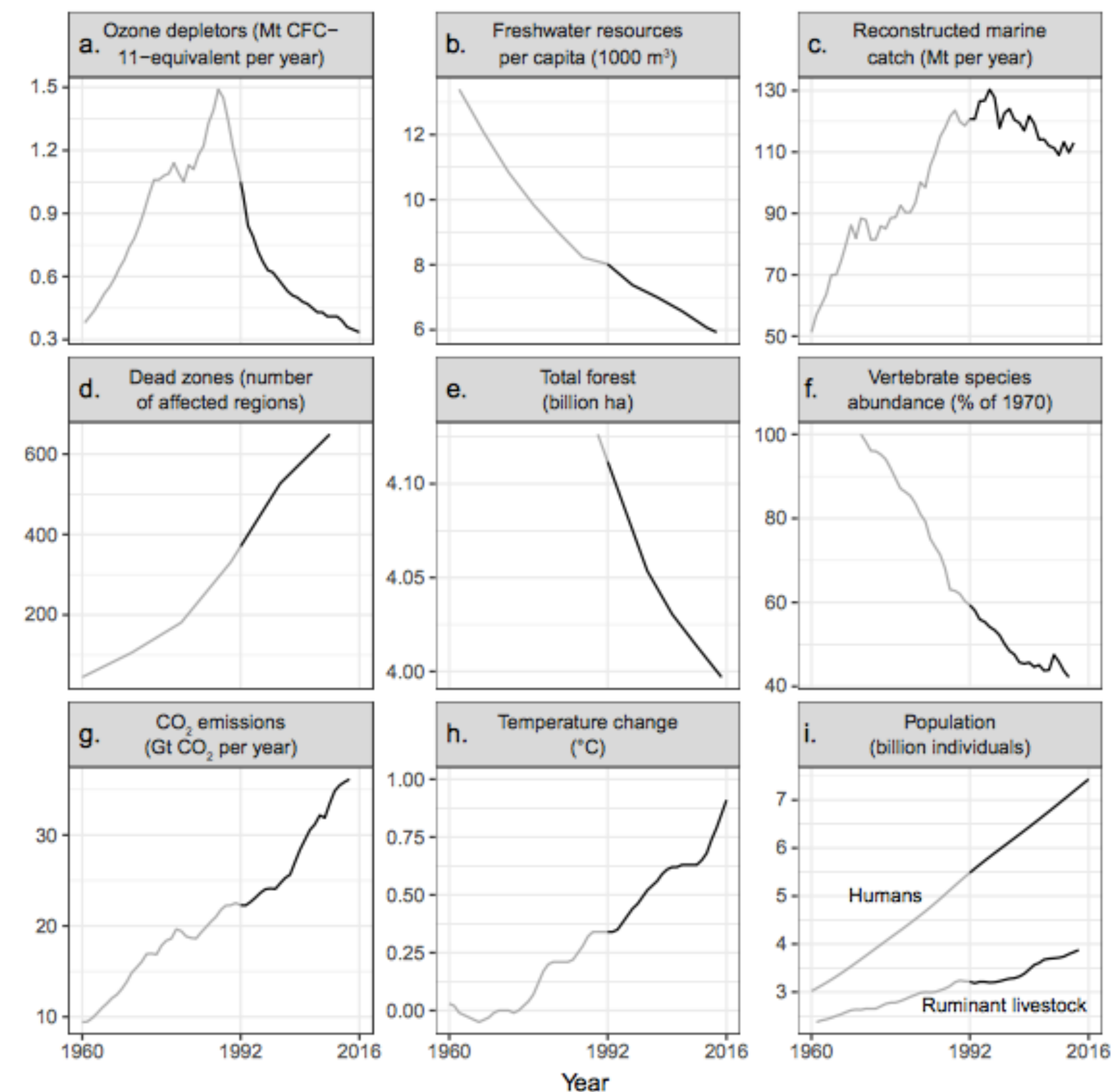


# Risk Assessments

## Viewpoint

## World Scientists' Warning to Humanity: A Second Notice

WILLIAM J. RIPPLE, CHRISTOPHER WOLF, THOMAS M. NEWSOME, MAURO GALETTI, MOHAMMED ALAMGIR, EILEEN CRIST, MAHMOUD I. MAHMOUD, WILLIAM F. LAURANCE, and 15,364 scientist signatories from 184 countries



**Figure 1.** Trends over time for environmental issues identified in the 1992 scientists' warning to humanity. The years before and after the 1992 scientists' warning are shown as gray and black lines, respectively. Panel (a) shows emissions of halogen source gases, which deplete stratospheric ozone, assuming a constant natural emission rate of 0.11 Mt CFC-11-equivalent per year. In panel (c), marine catch has been going down since the mid-1990s, but at the same time, fishing effort has been going up (supplemental file S1). The vertebrate abundance index in panel (f) has been adjusted for taxonomic and geographic bias but incorporates relatively little data from developing countries, where there are the fewest studies; between 1970 and 2012, vertebrates declined by 58 percent, with freshwater, marine, and terrestrial populations declining by 81, 36, and 35 percent, respectively (file S1). Five-year means are shown in panel (h). In panel (i), ruminant livestock consist of domestic cattle, sheep, goats, and buffaloes. Note that y-axes do not start at zero, and it is important to inspect the data range when interpreting each graph. Percentage change, since 1992, for the variables in each panel are as follows: (a) -68.1%; (b) -26.1%; (c) -6.4%; (d) +75.3%; (e) -2.8%; (f) -28.9%; (g) +62.1%; (h) +167.6%; and (i) humans: +35.5%, ruminant livestock: +20.5%. Additional descriptions of the variables and trends, as well as sources for figure 1, are included in file S1.



# Sustainability Leadership





# Sustainability Leadership

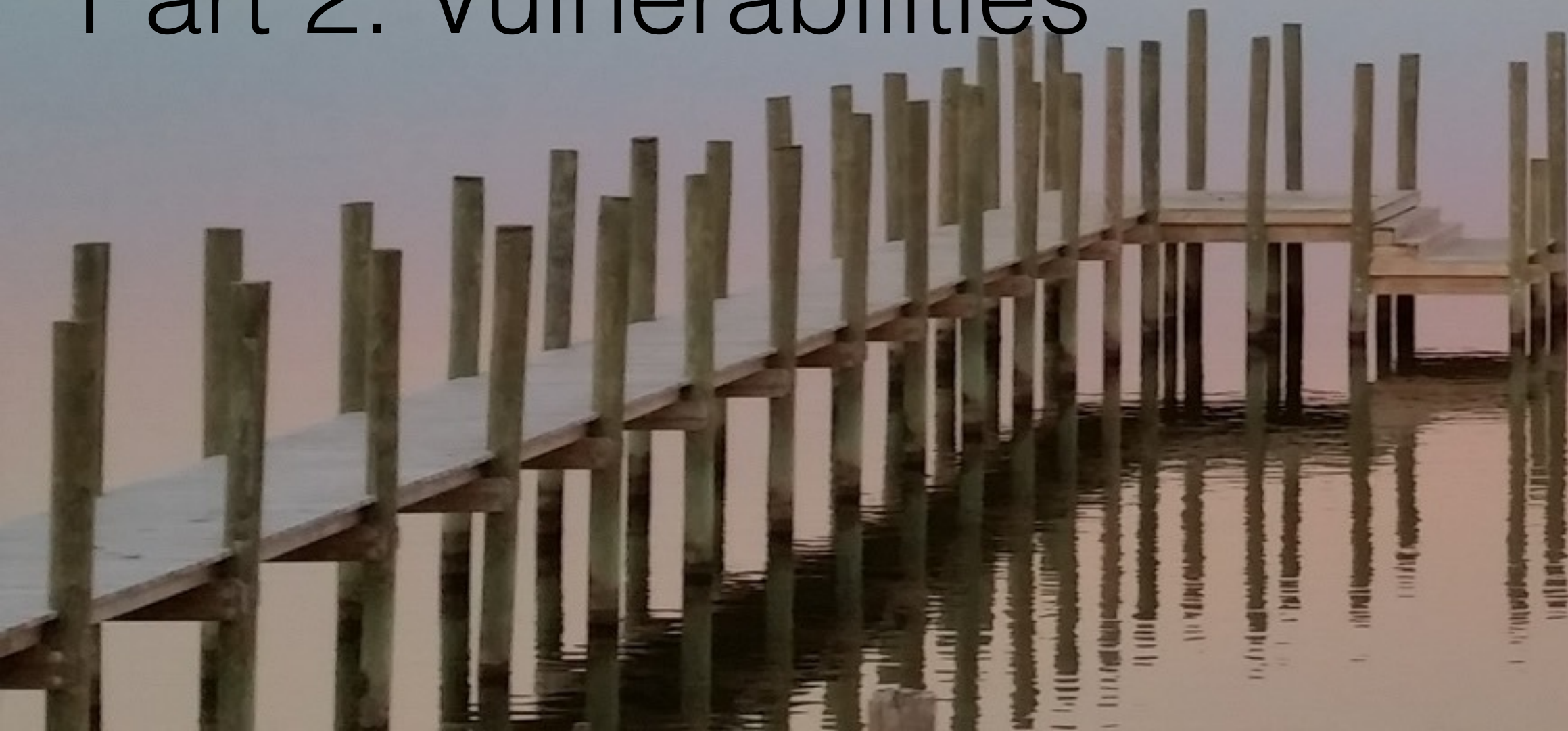
Class 5:

Prologue: Biases

Part 1: Risk Assessment

- Risk (hazards, vulnerability, value)
- Probability
- Risk assessments

Part 2: Vulnerabilities





## Questions for you:

- 1 What modeling approaches for different system classes are discussed by [Köhler et al. \(2018\)](#)?
- 2 What are the main advantages of taking a systems theory approach to sustainability?
- 3 Provide a simple sketch that explains risk assessment in a systems theory context.
- 4 Why are some low risks often overemphasized and high risks almost ignored? Use [Anderson \(2017\)](#) as a starting point.
- 5 Discuss the relevance of the “[normalcy bias](#)” for disasters and the recognition of trends that could pose threats. Use climate change, land use changes and/or extinction as examples.
- 6 Why do anthropogenic land-use changes constitute a threat to the Earth's life-support system? Use [Barnosky et al., 2012](#) as a starting point.
- 7 What are the main processes that determine local sea level changes? Which are the processes that introduce the largest uncertainties for future local sea level rise? Use [Plag and Jules-Plag \(2013\)](#) as starting point.





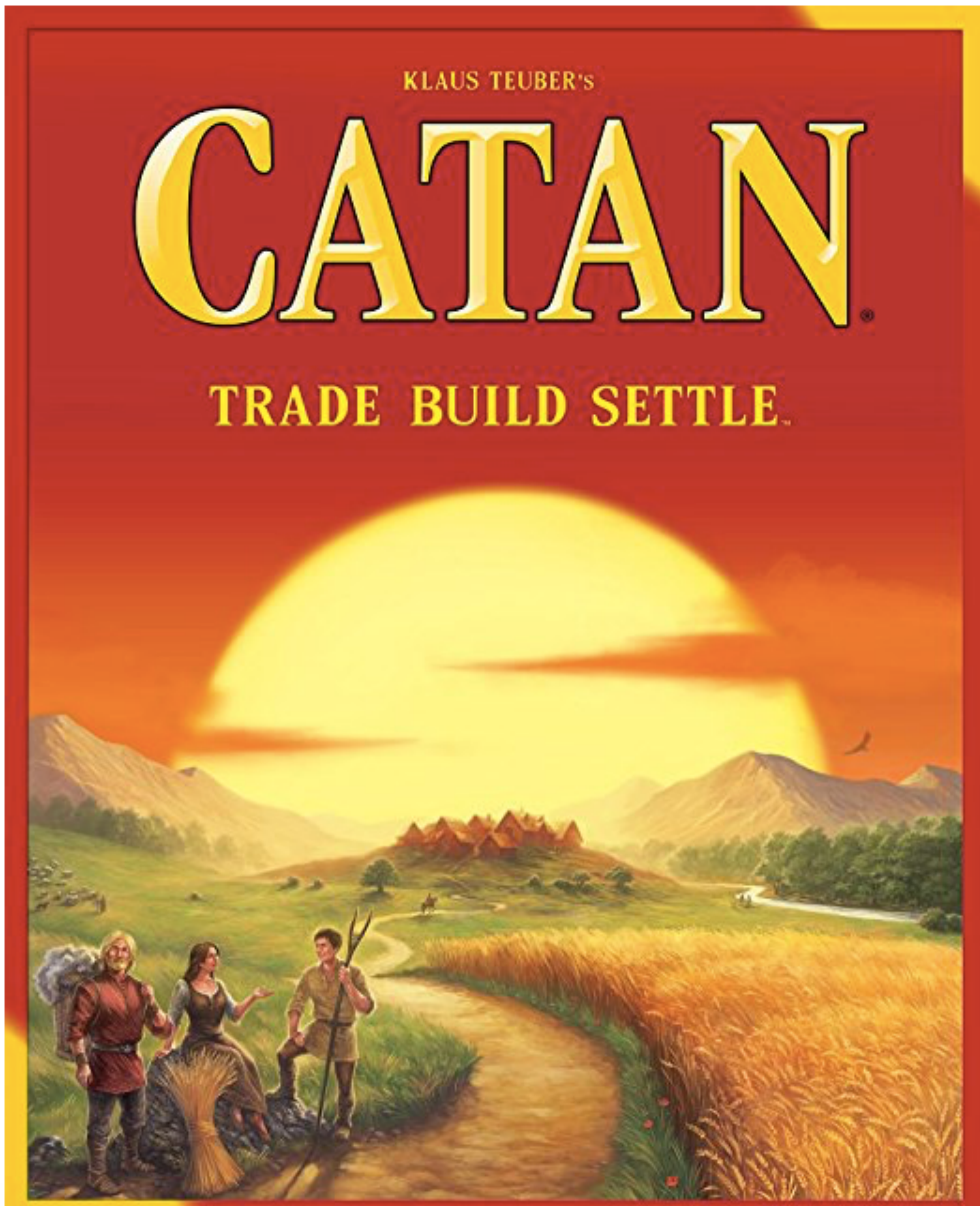
## Fieldwork Week

### Overview

The service learning requires a week of fieldwork in the Florida Keys and Everglades National Park area. The preliminary schedule for the week is:

- Saturday, June 9, 2018: Travel to Key Largo
- Sunday, June 10, 2018: Reconnaissance and preparation of fieldwork, shopping for material
- Monday, June 11, 2018: 8:00-5:00: Trip to Everglades
- Tuesday, June 12, 2018: 8:00-12:00: Service project at State Park; 12:00-1:00 lunch; 1:00-5:00 Snorkeling
- Wednesday, June 13, 2018: 8:00-10:00 Crocodile Lake NWR; From 10:00: in planning
- Thursday, June 14, 2018: Report, presentations and board game
- Friday, June 15, 2018: Stakeholder meeting
- Saturday, June 16, 2018: Travel back to Norfolk





KLAUS TEUBER'S

# CATAN

## TRADE BUILD SETTLE

Your adventurous settlers seek to tame the remote but rich isle of Catan. Start by revealing Catan's many harbors and regions: pastures, fields, mountains, hills, forests, and desert. The random mix creates a different board virtually every game. No two games are the same!

Embark on a quest to settle the isle of Catan! Guide your settlers to victory by clever trading and cunning development. Use resource combinations—grain, wool, ore, brick, and lumber—to buy handy development cards and build roads, settlements, and cities. Acquire your resources through trades, cards, or lucky dice (even outside your turn).

But beware! Someone might cut off your road or buy a monopoly. And you never know when the wily robber might steal some of your precious gains!

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Learn in only ~15 minutes.  
Play in only ~60 minutes.  
For 3-4 players. Enjoy hundreds of hours of fast-paced, interactive fun!

**Catan contains:**

- 19 unique hexagonal terrain tiles
- 6 coastal frame pieces
- 9 extra harbor pieces
- 20 wooden settlements
- 16 wooden cities
- 60 wooden roads
- 95 resource cards
- 25 development cards
- 4 building costs cards
- 2 special bonus cards
- 18 number tokens
- 2 six-sided dice
- 1 wooden robber pawn
- simple rules & almanac

**MADE IN USA**

**WARNING!**  
NOT A TOY!  
Not for children under age 5.

Art by Michael Menzel

EU: Editionen Catan, Unit 6, Westbrook Rd., Allen, Maryland, 20743-2133, EU Phone: +44 (0)1420 555555

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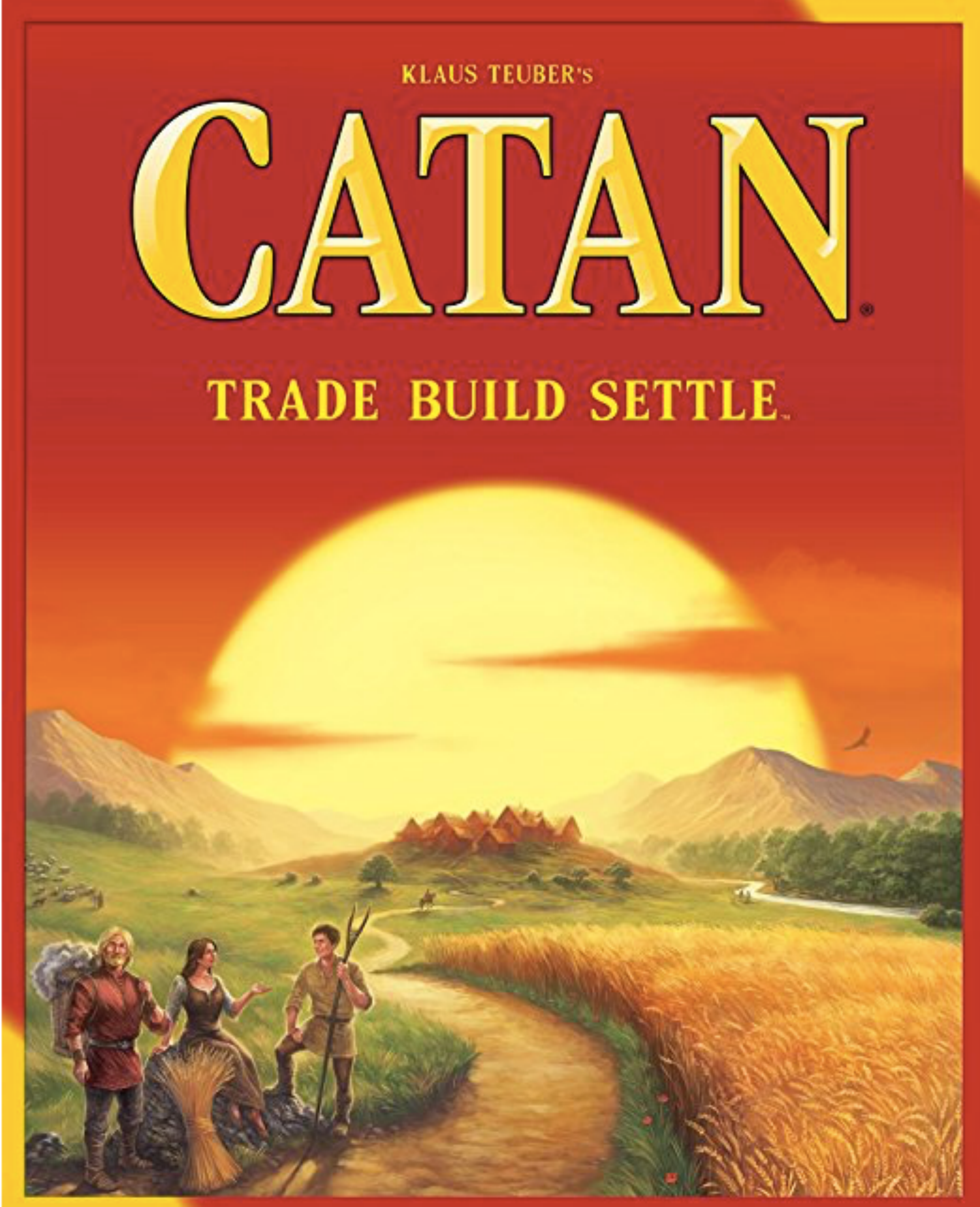
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Charlottesville, VA USA  
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**CATAN STUDIO**  
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# Practicalities

## Board game example



KLAUS TEUBER'S

# CATAN

TRADE BUILD SETTLE

Ages 10+  
 =60  
 3-4

*Catan, (aka The Settlers of Catan)* has been awarded with "Game of the Year," "Hall of Fame," and even "Game of the Century" honors in Germany, the United States, and a host of other countries worldwide. An international favorite, it's been called the "Perfect Social Game."

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MADE IN USA

WARNING! NOT A TOY! Not for children under age 5.

Art by Michael Menzel

CE

EU: Eubank Games, Unit 6, Westbrook Rd., Alton, Hampshire, GU14 2UD, UK. Phone: +44 (0)1420 555555

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## Contents:

- 1 Introduction
- 2 Hazards
- 3 Vulnerabilities
- 4 Foresight
- 5 Decision-Making & Stakeholders
- 6 Options
- 7 Discussion, Summary, Recommendations