OVERVIEW OF “DANGEROUS” CLIMATE CHANGE

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UK Met Office

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Munich Re:

"We need to stop this dangerous experiment humankind is conducting on the Earth's atmosphere."

Article 2 of the UN Framework Convention on Climate Change (UNFCCC) states that: “The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference [DAI] with the climate system”. The Framework Convention on Climate Change further suggests that “Such a level should be achieved within a time frame sufficient

- to allow ecosystems to adapt naturally to climate change,
- to ensure that food production is not threatened and
- to enable economic development to proceed in a sustainable manner.”

Working Group 2’s working draft on Chapter 19 for the forthcoming IPCC Fourth Assessment Report (AR4)*, “key vulnerabilities” are defined as:

(a) a valued property of the coupled human-natural system that is associated with large impact risks (such as the sensitivity of the thermohaline ocean circulation to anthropogenic climate change), or *(b)* an impact risk that is considered salient to specific sectors, regions or social groups (such as increased flood risks in coastal regions or the extinction of species). Key vulnerabilities describe those interactions between elements of the climate system, climate-sensitive resources and the services provided by them that may involve significant adverse outcomes that are considered in the literature to be significant enough in terms of their ecological, social, and economic implications to be relevant to the determination of DAI.

*(*Please note, that all references to the current text or perspectives of Zero Order Drafts of the AR4 do not necessarily represent what will emerge from the many rounds in the next few years of review and governmental approvals of content. They cannot be quoted as IPCC results, and are only useful here to illustrate conceptual issues.)*

AR4, WG 2, Chapter 19, ZOD*:

While scientists have many ideas about what vulnerabilities may be considered dangerous, it is a common view of most natural and social scientists that it is not the direct role of the scientific community to define what "dangerous" means. Rather, it is ultimately a political question because it depends on *value judgments* about the relative salience of various impacts and how to face climate change-related risks and form norms for defining what is "acceptable."

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“Type 1” versus “Type 2" errors and their consequences

Decision	Forecast proves false	Forecast proves true
Accept forecast—policy response follows	**Type I error**	Correct decision
Reject or ignore forecast (e.g., “too much” uncertainty)—no policy response	Correct Decision	**Type 2 error**

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Role of Scientists: Assess Risk (= Consequence **X** Probability of Occurrence) as function of alternative policy choices ; confidence in the assessment of risks; distribution of risks and benefits; traceable account of aggregations.

Role of Decision-makers: Negotiate acceptability of risks and policies that alter risks; make policy choices; guide assessment process.

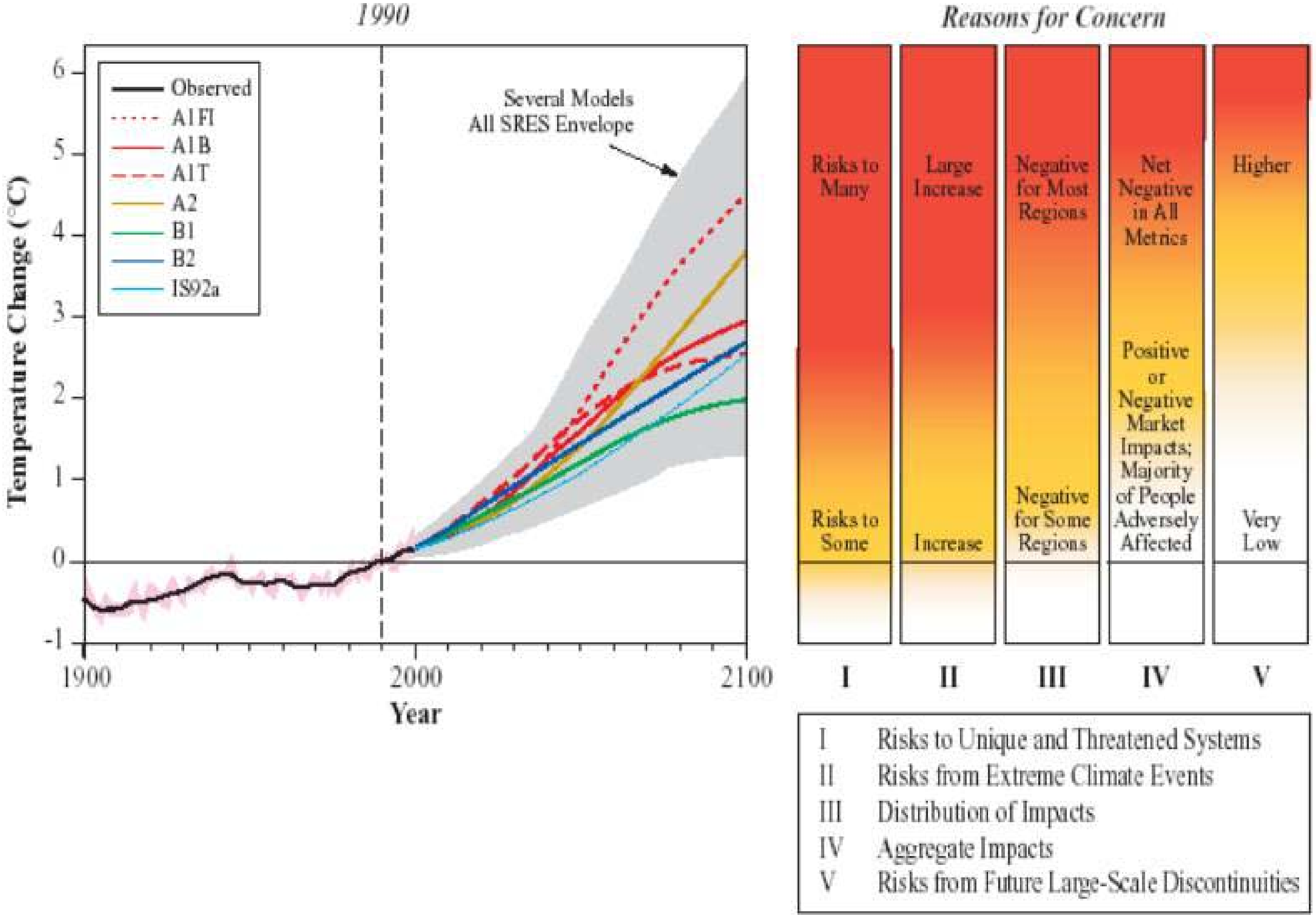
*Dessai et al, 2004:

External risks are defined via scientific risk analysis of system characteristics prevalent in the physical or social worlds. Internal risk, on the other hand, defines risk based on the individual or communal perception of insecurity. In the case of internal risk, in order for the risk to be "real," it must be experienced. Of course, these two definitions are intertwined in complex ways.

*(Actual words above from: AR4, WG2, Chapter 19, ZOD same caveats as earlier quotes)

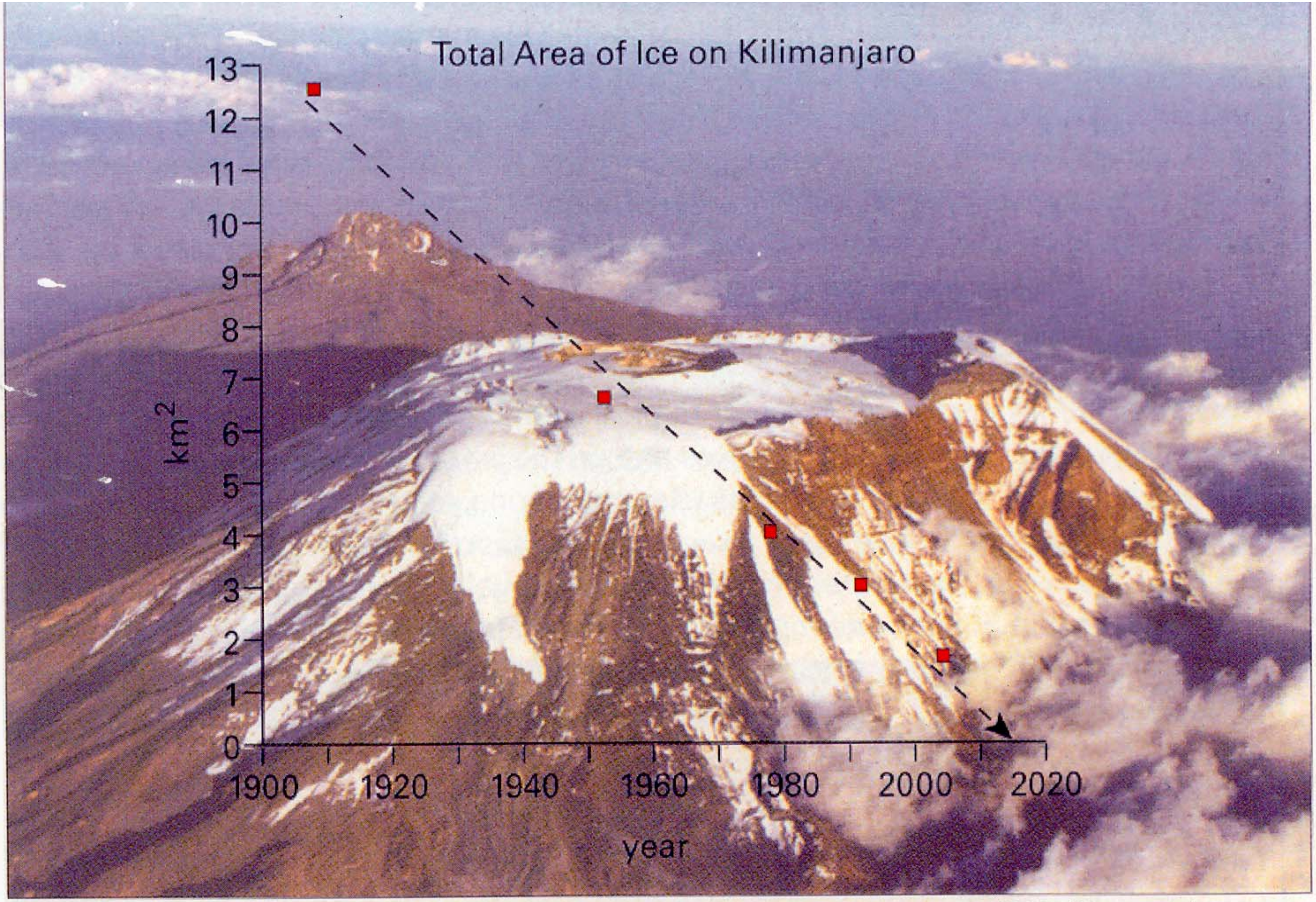
IPCC assessment could evaluate the range of possible climate change outcomes and the uncertainty associated with these outcomes corresponding to different adaptation and mitigation policies, without attempting to evaluate acceptability of such outcomes. This process has already been represented by IPCC WG 2 TAR as five “reasons for concern”: see “burning embers” diagram.

Reasons for Concern About Climate Change Impacts.

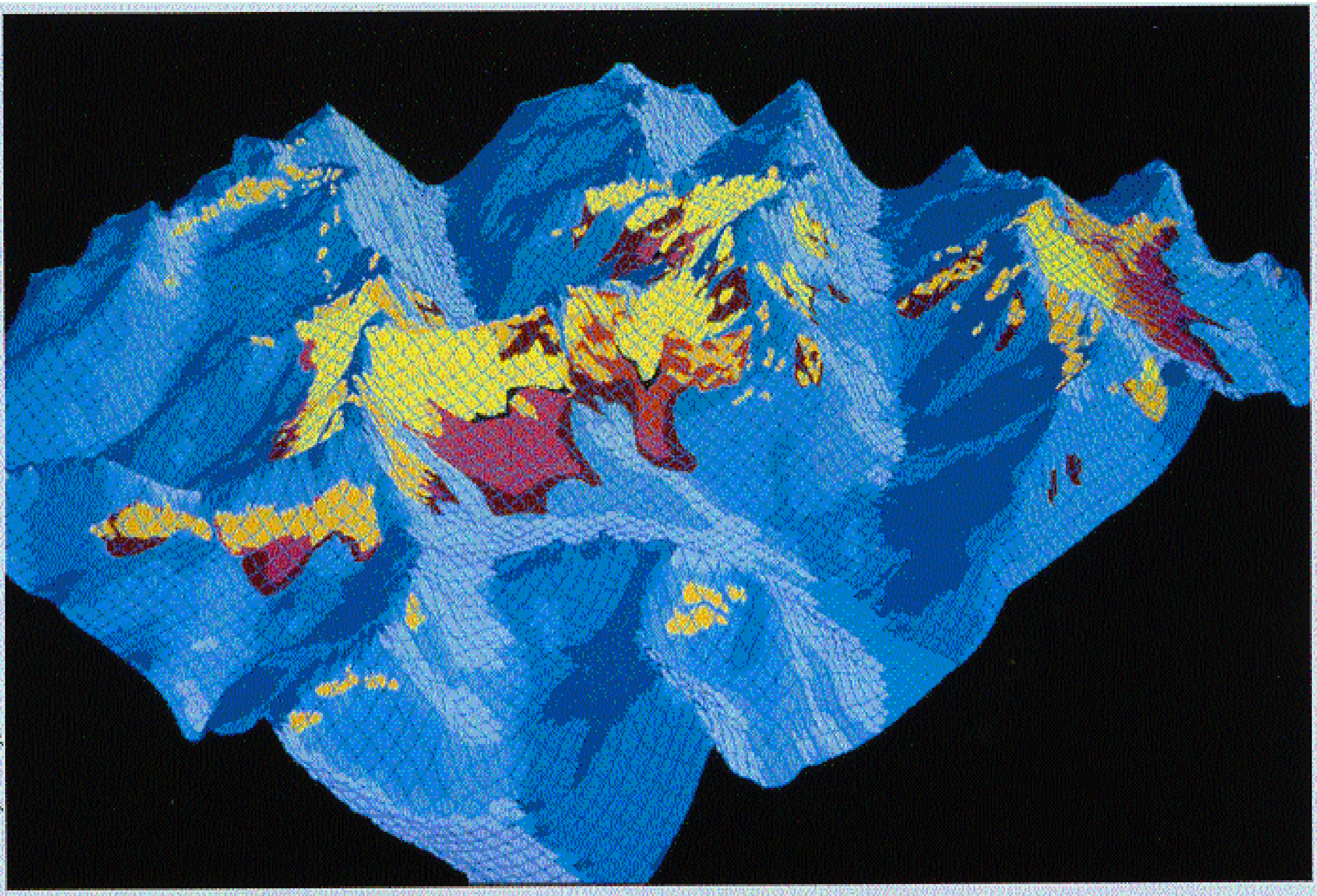


The WEHAB framework identified a number of areas that would be considered as essential for human well-being and development: Water, Energy, Health, Agriculture and Biodiversity, which map well into the umbrella HWB concept. Thus it may be useful to focus on the WEHAB framework and its components, due to the widespread recognition of these components as being key for short- and long-term development goals. The WEHAB framework also encompasses the original three criteria identified in Article 2 of the UNFCCC

The concept of critical impacts on the WEHAB components may be examined using notions of thresholds (or boundaries). For example, at the simplest case one could think of two types of thresholds. Thresholds of type I are simply target values of linear or other "smooth" changes that after some point would lead to damages that might be considered “unacceptable” by particular policy-makers. It is likely that such thresholds would be determined as the outcome of a socio-political process that weighs the relative risks to different sectors and regions. For example, a certain amount of sea level rise might be considered “unacceptable” for particular small island states, although the same amount of sea level rise falls within a coping range for another country.



The extent of ice cover on Mt. Kilimanjaro decreased by 81% between 1912 and 2000. Disappearing paleoclimate archives such as this are a priority target of the Global Paleoclimate Observing System currently being proposed by PAGES scientists. For more information see the editorial in this issue of PAGES News. Photo: Captain G. Mazula, Data: Lonnie Thompson.



Courtesy C. Key, USGS and R. Menicke, National Park Service

Fig. 7. A geographic information system representation of glacier shrinkage from 1850 to 1993 in Glacier National Park. The Blackfeet–Jackson glaciers are in the center. The yellow areas reflect the current area of each glacier; other colors represent the extent of the glaciers at various times in the past.

Thresholds of type II might be those that are linked directly to the key intrinsic processes of the climate system itself and might be related to maintaining stability of those processes or some of the elements of the climate system discussed earlier. Some thresholds that all would consider dangerous have no support in the literature as having a non-negligible chance of occurring. For instance, a "runaway greenhouse effect"—analogous to Venus--appears to have virtually no chance of being induced by anthropogenic activities. So our focus will be on those events that the literature suggests have a non-negligible chance of being induced by anthropogenic activities. For example, stability of thermohaline circulation or of the West Antarctic Ice Sheet (WAIS), or the mobilization of biospheric CO_2 stocks, or changes in the Asian summer monsoons and ENSO all appear to be of global or regional significance, respectively, and thus these are some of the natural bounds, which if exceeded, would lead to major potentially irreversible impacts.

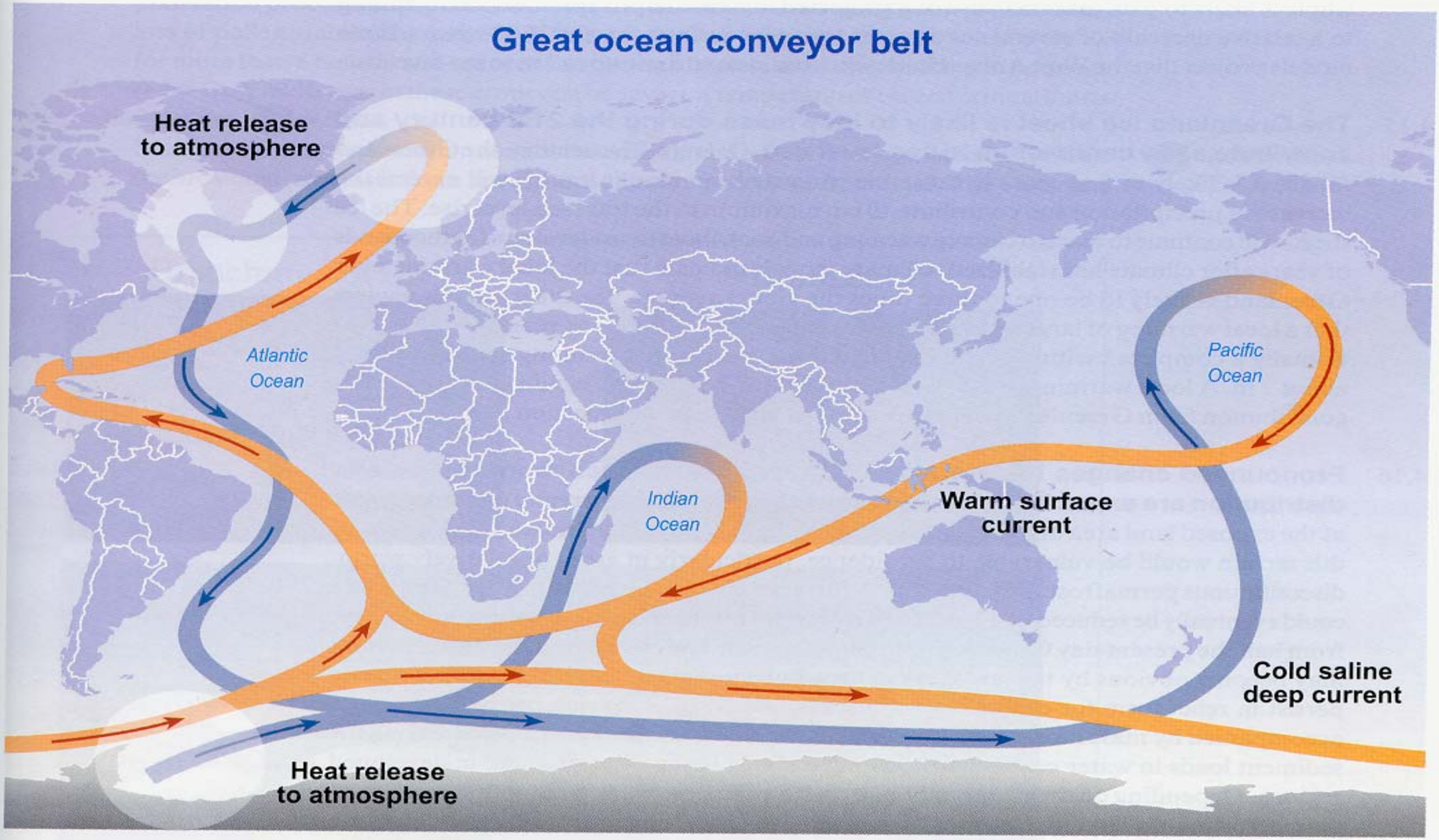


Figure 4-2: Schematic illustration of the global circulation system in the world ocean consisting of major north-south thermohaline circulation routes in each ocean basin joining in the Antarctic circumpolar circulation. Warm surface currents and cold deep currents are connected in the few areas of deepwater formation in the high latitudes of the Atlantic and around Antarctica (blue), where the major ocean-to-atmosphere heat transfer occurs. This current system contributes substantially to the transport and redistribution of heat (e.g., the poleward flowing currents in the North Atlantic warm northwestern Europe by up to 10°C). Model simulations indicate that the North Atlantic branch of this circulation system is particularly vulnerable to changes in atmospheric temperature and in the hydrological cycle. Such perturbations caused by global warming could disrupt the current system, which would have a strong impact on regional-to-hemispheric climate. Note that this is a schematic diagram and it does not give the exact locations of the water currents that form part of the THC.

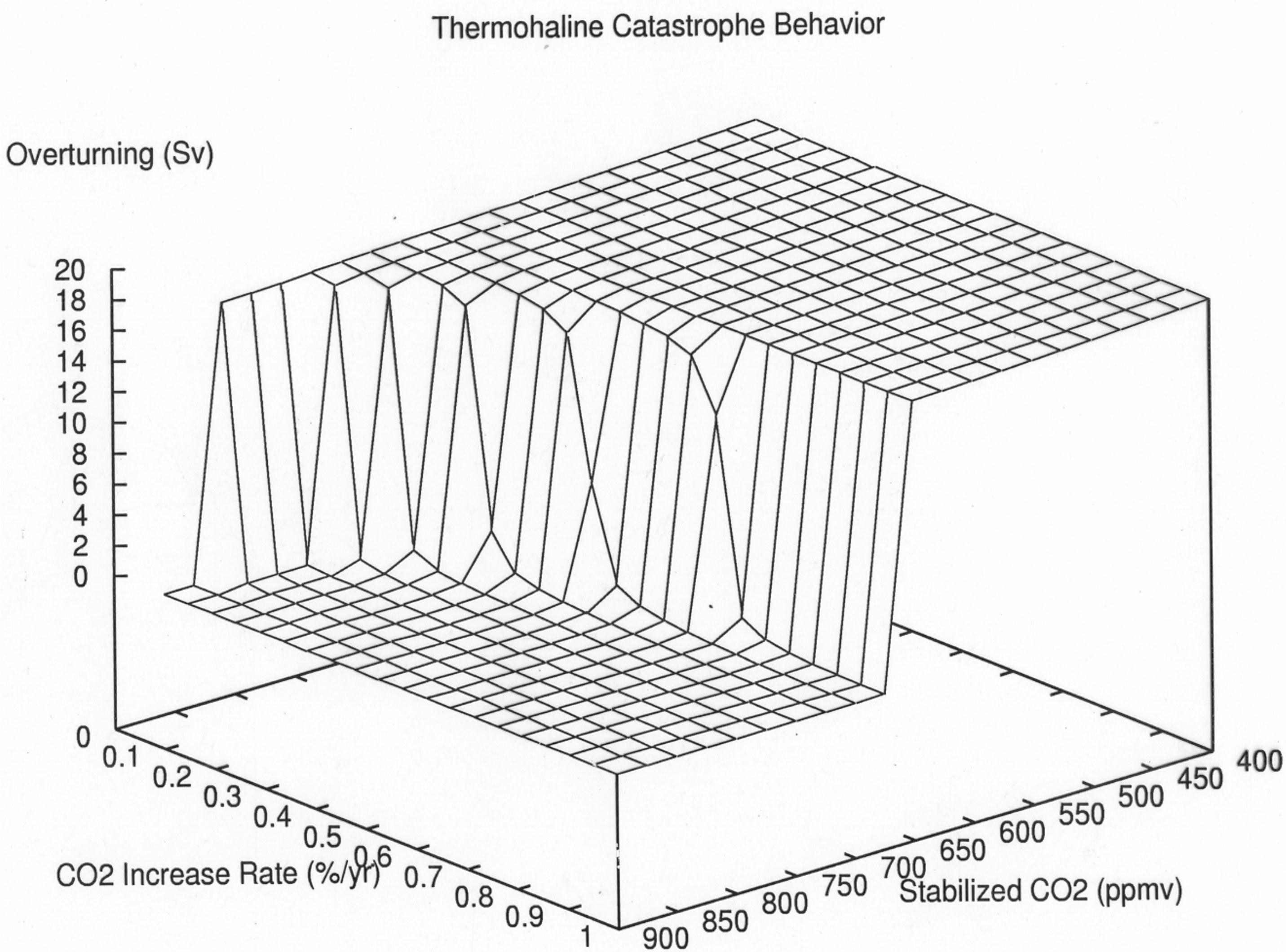

Thermohaline Catastrophe Behavior
Overturning (Sv)
20
18
16
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
CO2 Increase Rate (%/yr)
400
450
500
550
600
650
700
750
800
850
900
Stabilized CO2 (ppmv)

Figure 11

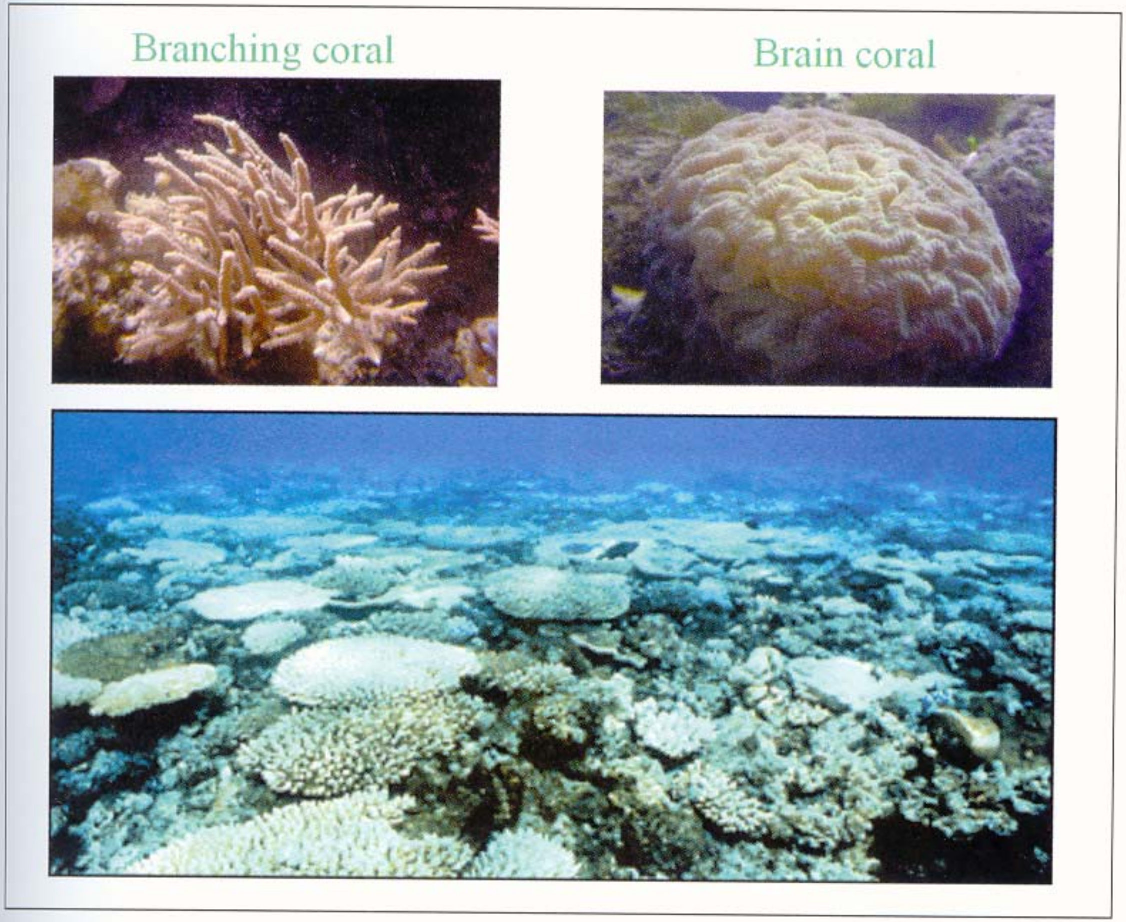
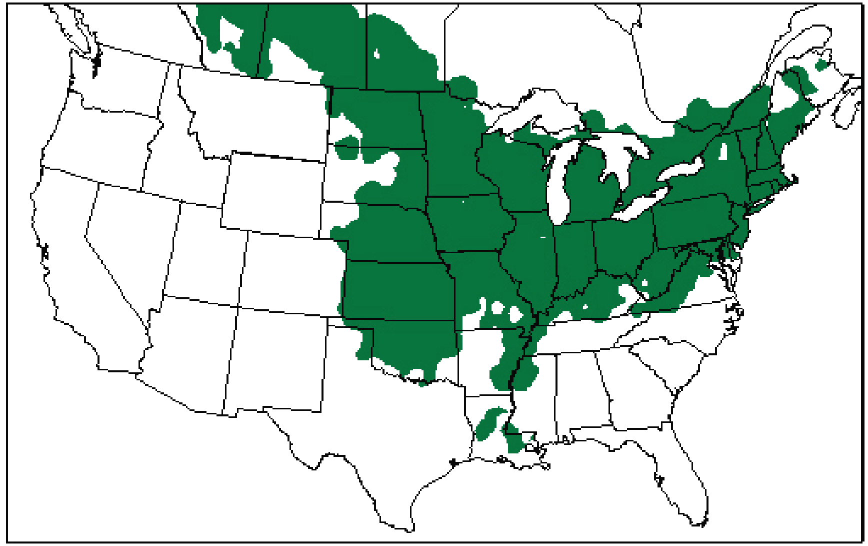


Figure 4-3: **The diversity of corals could be affected** with the branching corals (e.g., staghorn coral) decreasing or becoming locally extinct as they tend to be more severely affected by increases in sea surface temperatures, and the massive corals (e.g., brain corals) increasing.

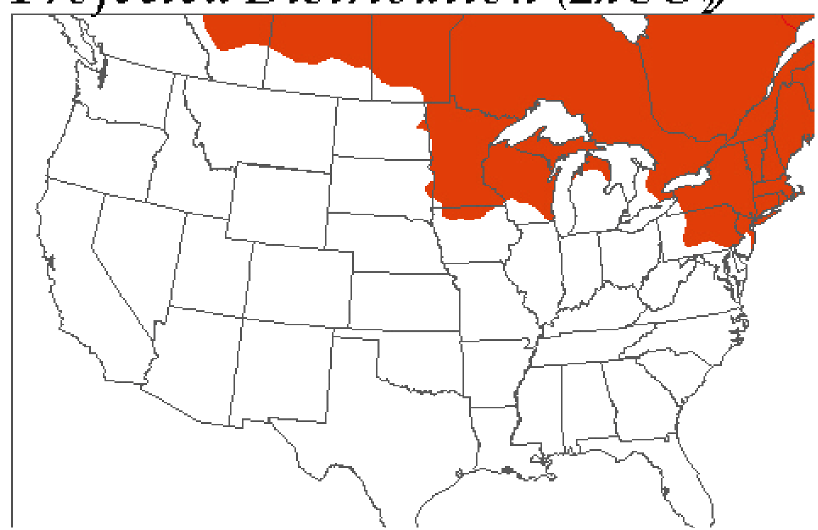
Current Distribution



Baltimore Oriole

(Icterus galbula)

Projected Distribution ($2xCO_2$)



Vulnerability	Global Mean Limit	References
Shutdown of thermohaline circulation	3 °C in 100 yr 700ppm CO_2	O'Neill and Oppenheimer (2002) Keller et al. (2004)
Disintegration of West Antarctic ice sheet (WAIS)	2 °C, 450ppm CO_2 2-4 °C, <550ppm CO_2	O'Neill and Oppenheimer (2002) Oppenheimer and Alley (2004, 2005)
Disintegration of Greenland ice sheet	1 °C	Hansen (2004)
Widespread bleaching of coral reefs	>1 °C	Smith et al. (2001) O'Neill and Oppenheimer (2002)
Broad ecosystem impacts with limited adaptive capacity (many examples)	1-2°C	Leemans and Eickhout (2004), Hare (2003), Smith et al. (2001)
Large increase of persons-at-risk of water shortage in vulnerable regions	450-650ppm	Parry et al. (2001)
Increasingly adverse impacts, most economic sectors	>3-4°C	Hitz and Smith (2004)
Source: IPCC Fourth Assessment Report, Chapter 19, Zero Order Draft. **[Usual caveat]**		

The WEHAB elements include market as well as non-market dimensions. While economic theory provides a number of approaches for valuing changes in market goods and services, there is little agreement on how to value and monetize changes in the non-market goods and services that form a part of HWB. It is clear that any comprehensive attempt to evaluate the societal value of climate change should include market as well as non-market goods and services, as well as aspects of intergenerational and distributional equity. Some of the end-points could include, for example, loss of species diversity, loss of coastline from increasing sea level, environmentally-induced displacement of persons, change in income distributions and regional differences in agricultural losses.

The Five Numeraires*

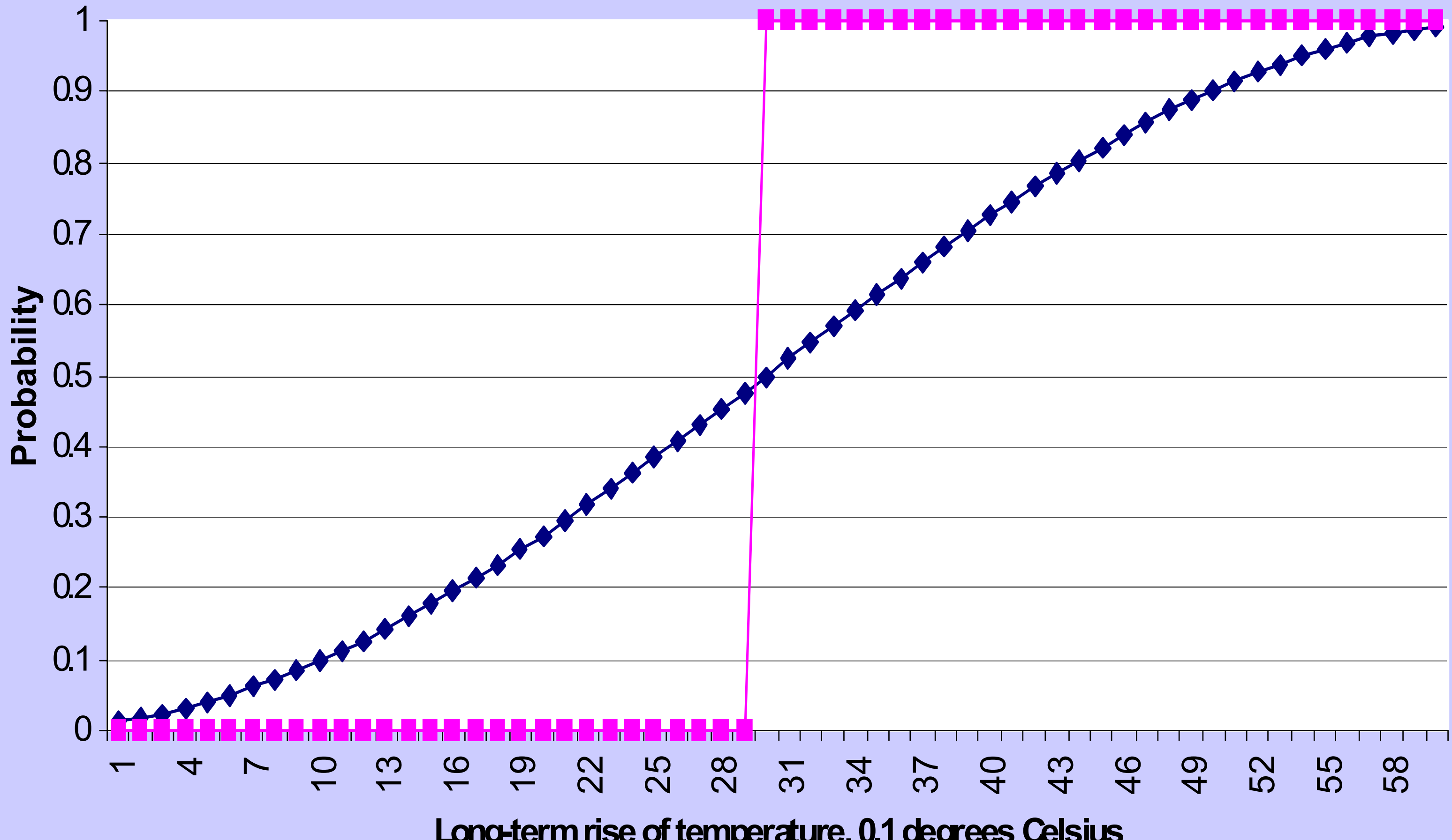
{Vulnerabilities to Climate Changes}

- Market Impacts {$ per ton C}
- Human Lives Lost {persons per ton C}
- Biodiversity Loss {species per ton C}
- Distributional Impacts {Income redistribution per ton C}
- Quality of Life {loss of heritage sites; forced migration; disturbed cultural amenities; etc. per ton C}

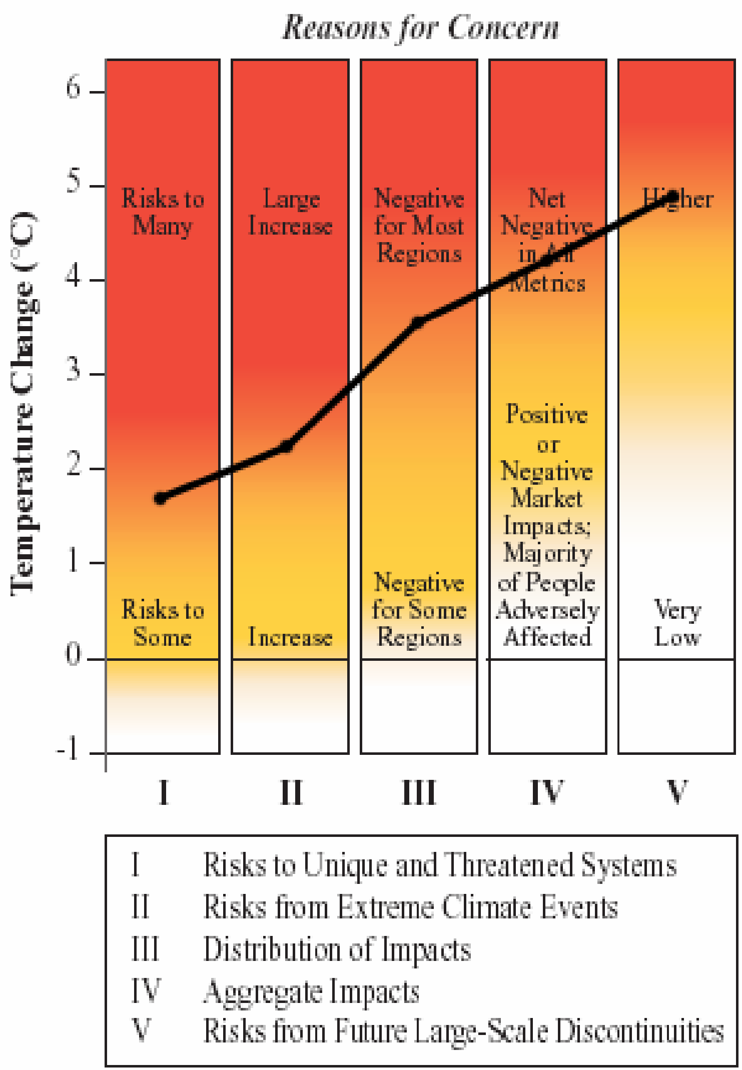
*Disaggregate by value differences—provide traceable account of re-aggregations to make value differences transparent

Source: Schneider, Kuntz-Duriseti & Azar, 2000 in reality we usually must formulate a probabilistic distribution, and thus define a certain level of risk for quantifying any critical limits. Moreover, there will be uncertainty in the very probability distribution assessed.

Fig. 2. Probability of damage vs. temperature increase: deterministic (stair) and stochastic (smooth curve) cases



Source: Semenov, 2004



"Dangerous" CDF

20th ‰: 1.8°C
50th ‰: 2.85°C
80th ‰: 4.2°C

"Burning embers": (IPCC TAR, WG 2, 2001)
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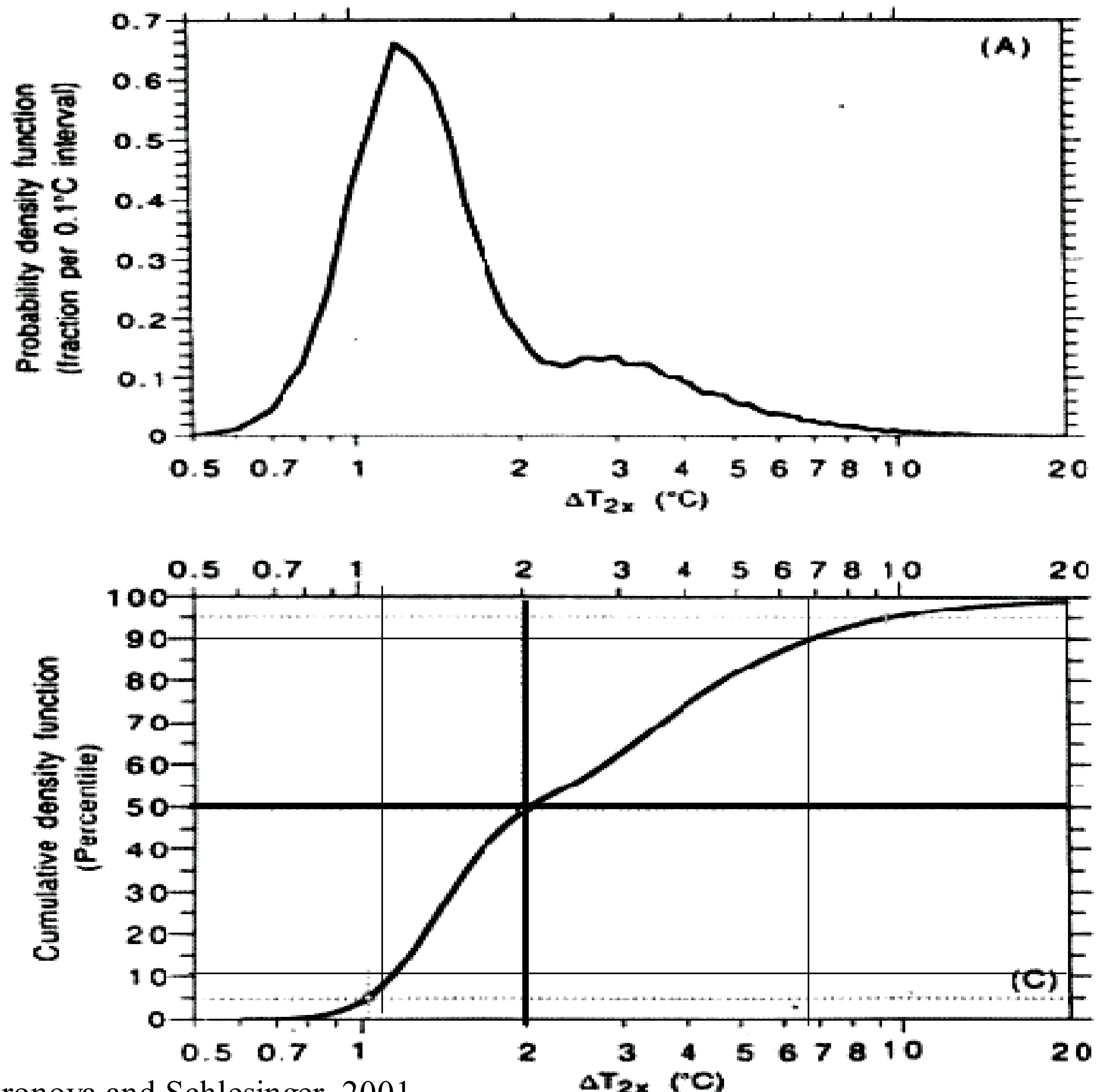
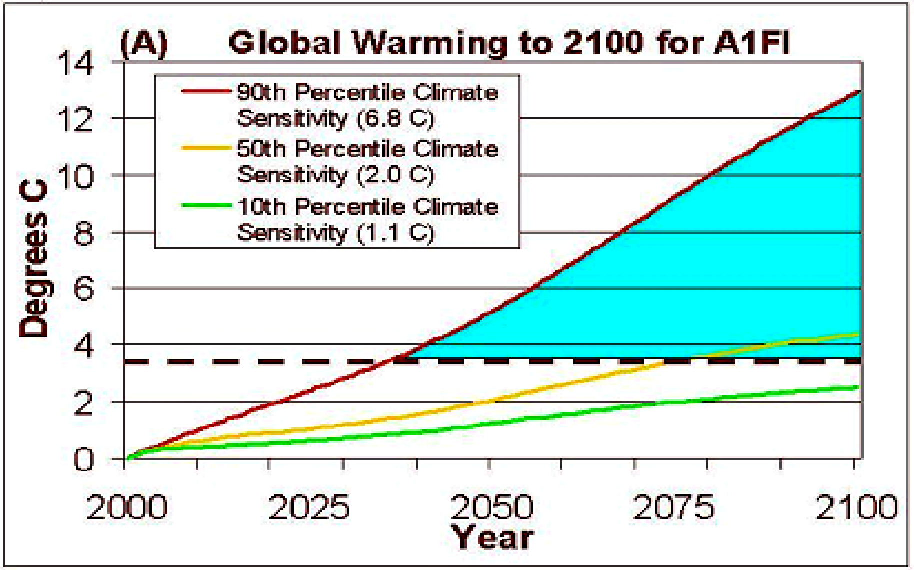
CDF: Mastrandrea and Schneider, **Science**, 2004

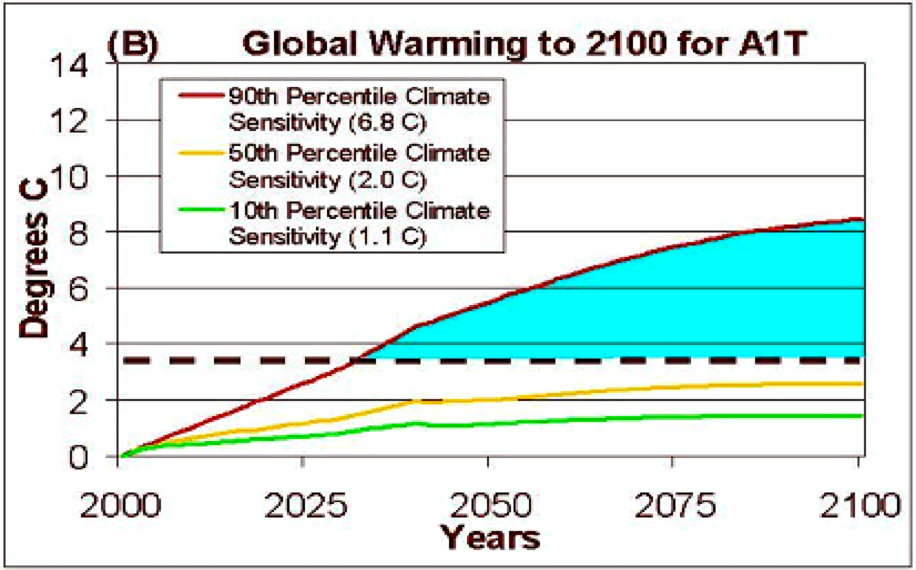
Of particular importance is a frank and open discussion of the subjective probabilities that might be attached both to SRES storylines and the climate sensitivity results of models and semi-empirical studies that have emerged in the past few years—many since the TAR. Moreover, illumination of the joint probability of scenarios and sensitivities needs to be explicitly considered, again in the light of recent debates in the literature.



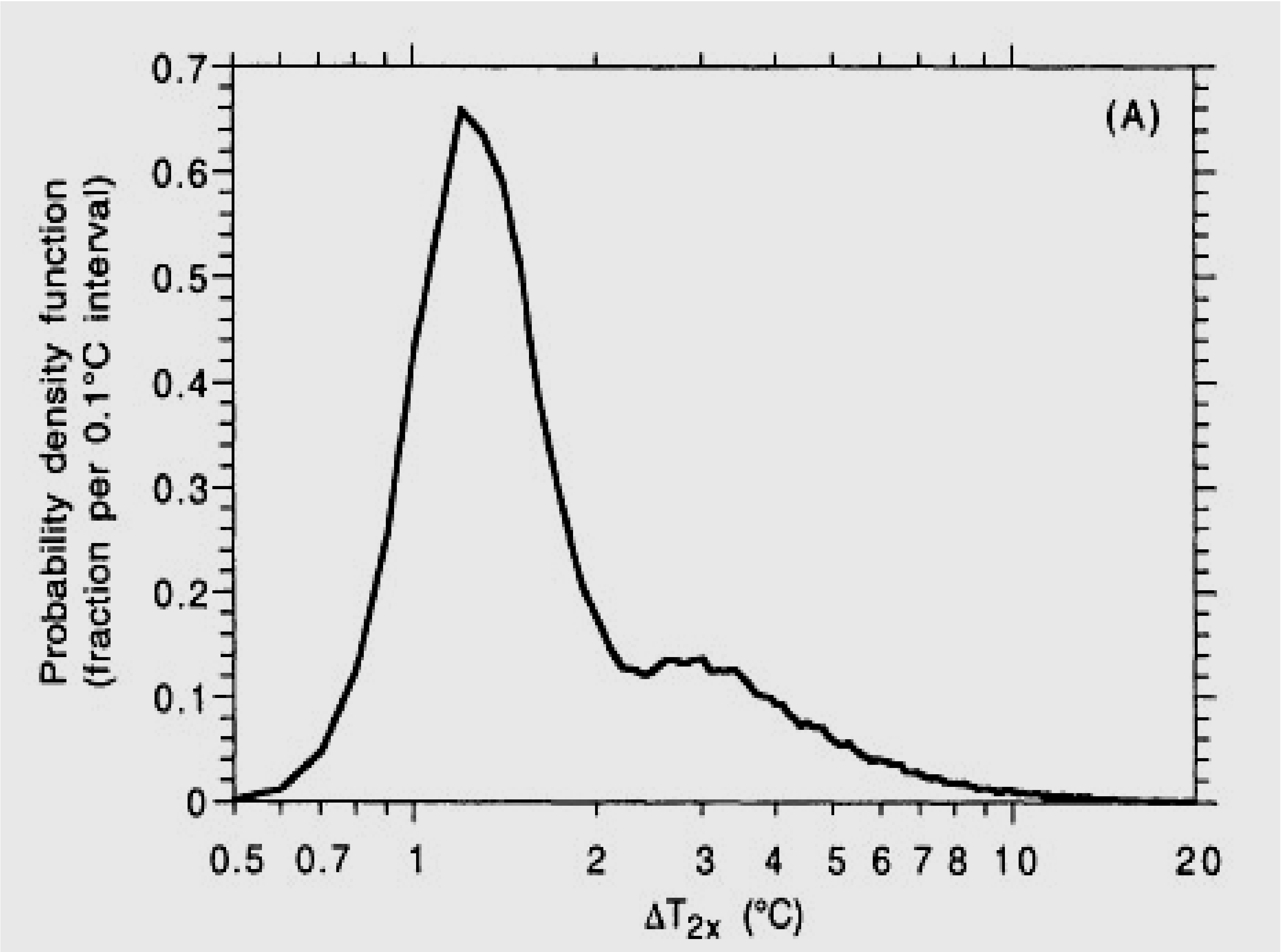
Source: Andronova and Schlesinger, 2001



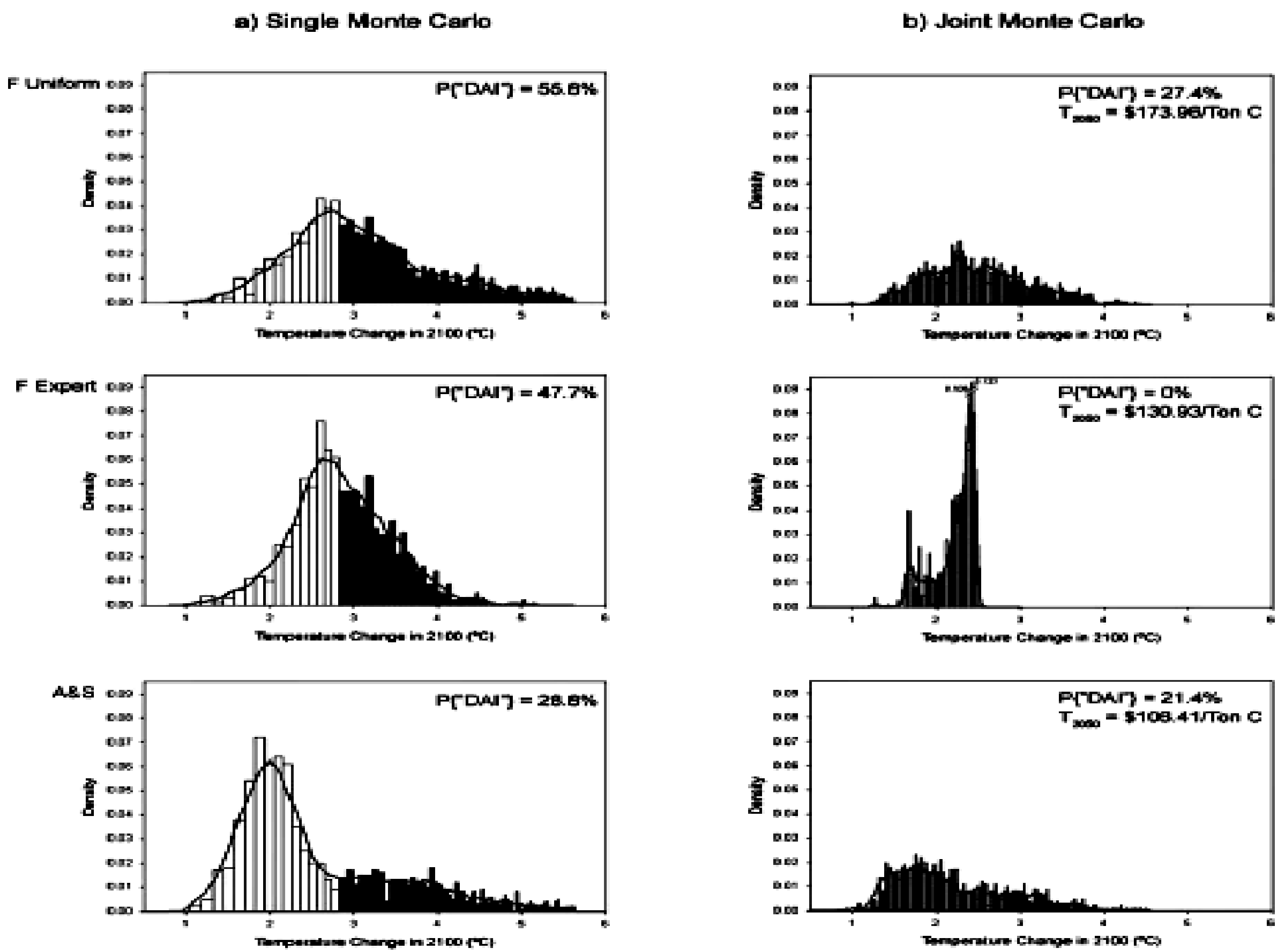
(A) Global Warming to 2100 for A1FI
90th Percentile Climate Sensitivity (6.8 C)
50th Percentile Climate Sensitivity (2.0 C)
10th Percentile Climate Sensitivity (1.1 C)
Degrees C
0
2
4
6
8
10
12
14
2000
2025
2050
2075
2100
Year



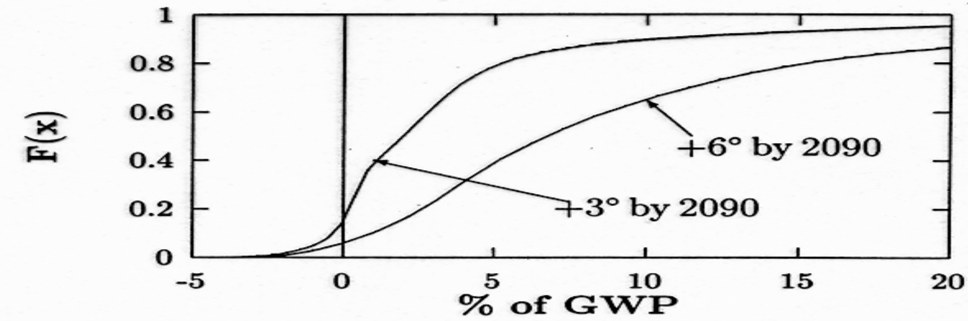
(B) Global Warming to 2100 for A1T
90th Percentile Climate Sensitivity (6.8 C)
50th Percentile Climate Sensitivity (2.0 C)
10th Percentile Climate Sensitivity (1.1 C)
Degrees C
0
2
4
6
8
10
12
14
2000
2025
2050
2075
2100
Years



0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
(A)
Probability density function
(fraction per 0.1°C interval)
0.5
0.7
1
2
3
4
5
6
7
8
10
20
ΔT2x (°C)

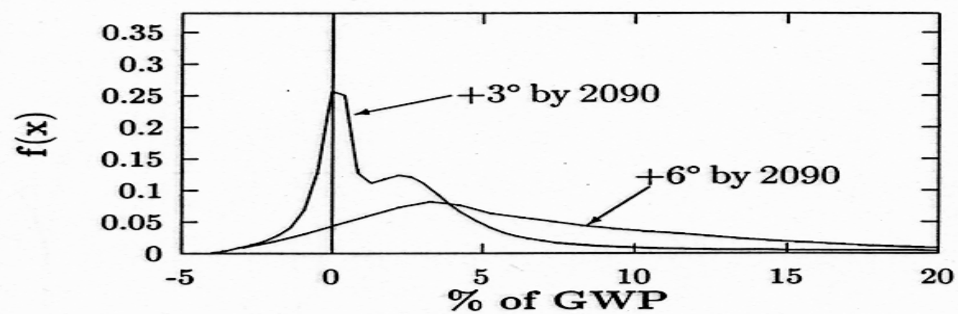


Source: Mastrandrea & Schneider, **Science**, 2004



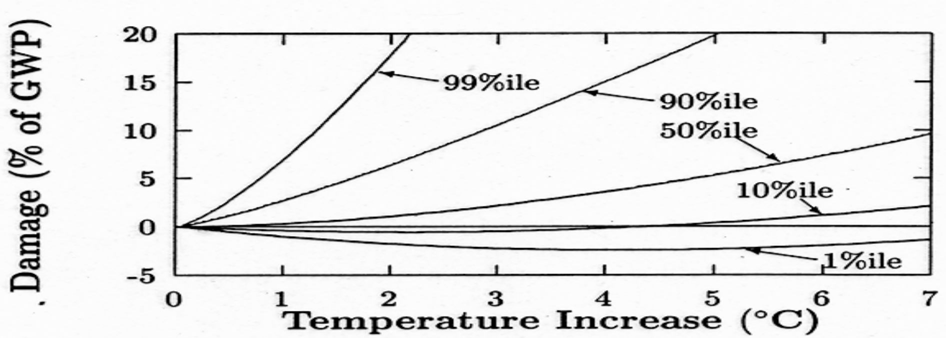
F(x)
1
0.8
0.6
0.4
0.2
0
-5
0
5
10
15
20
% of GWP
+6° by 2090
+3° by 2090

(a)



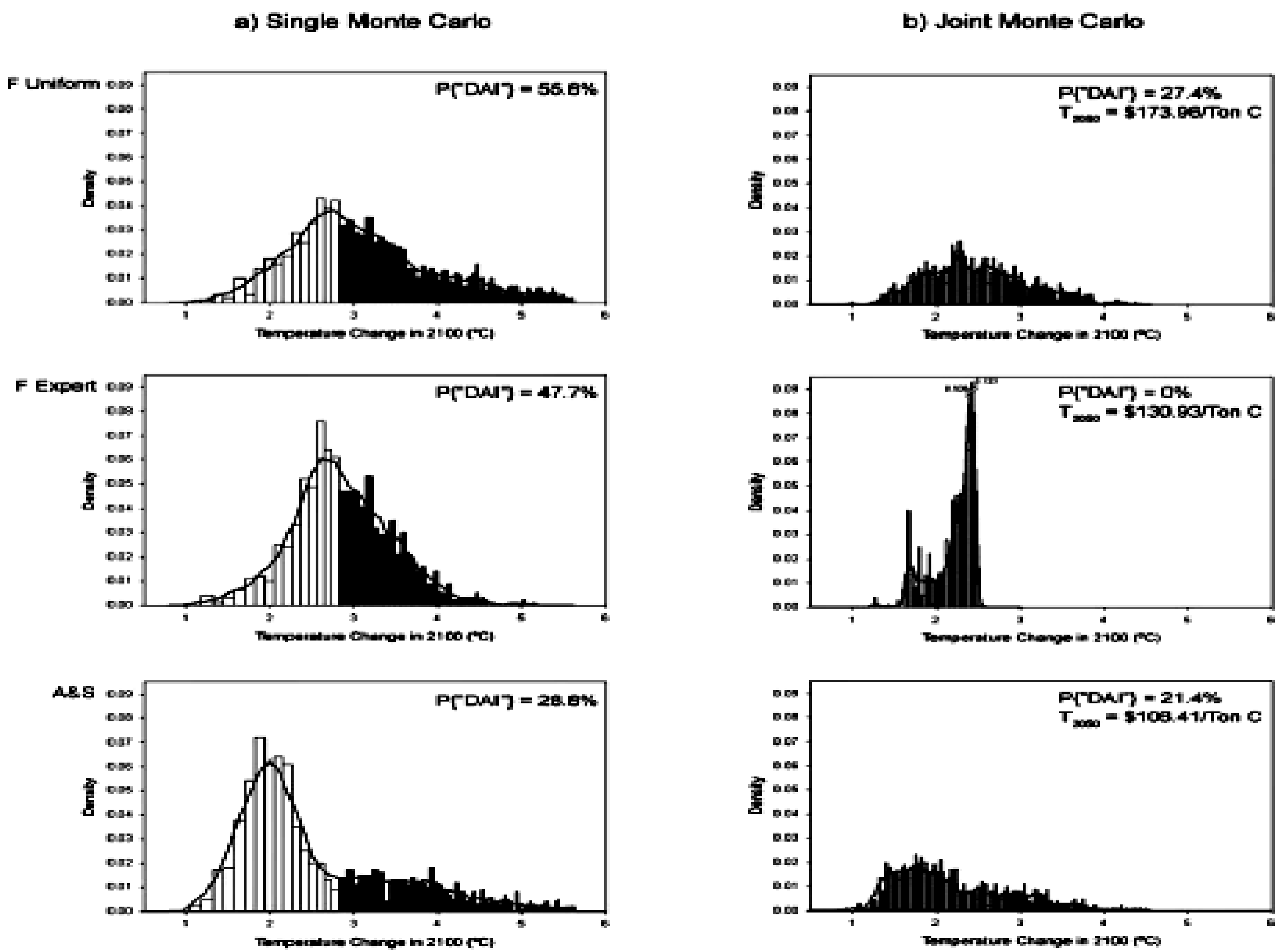
f(x)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-5
0
5
10
15
20
% of GWP
+3° by 2090
+6° by 2090

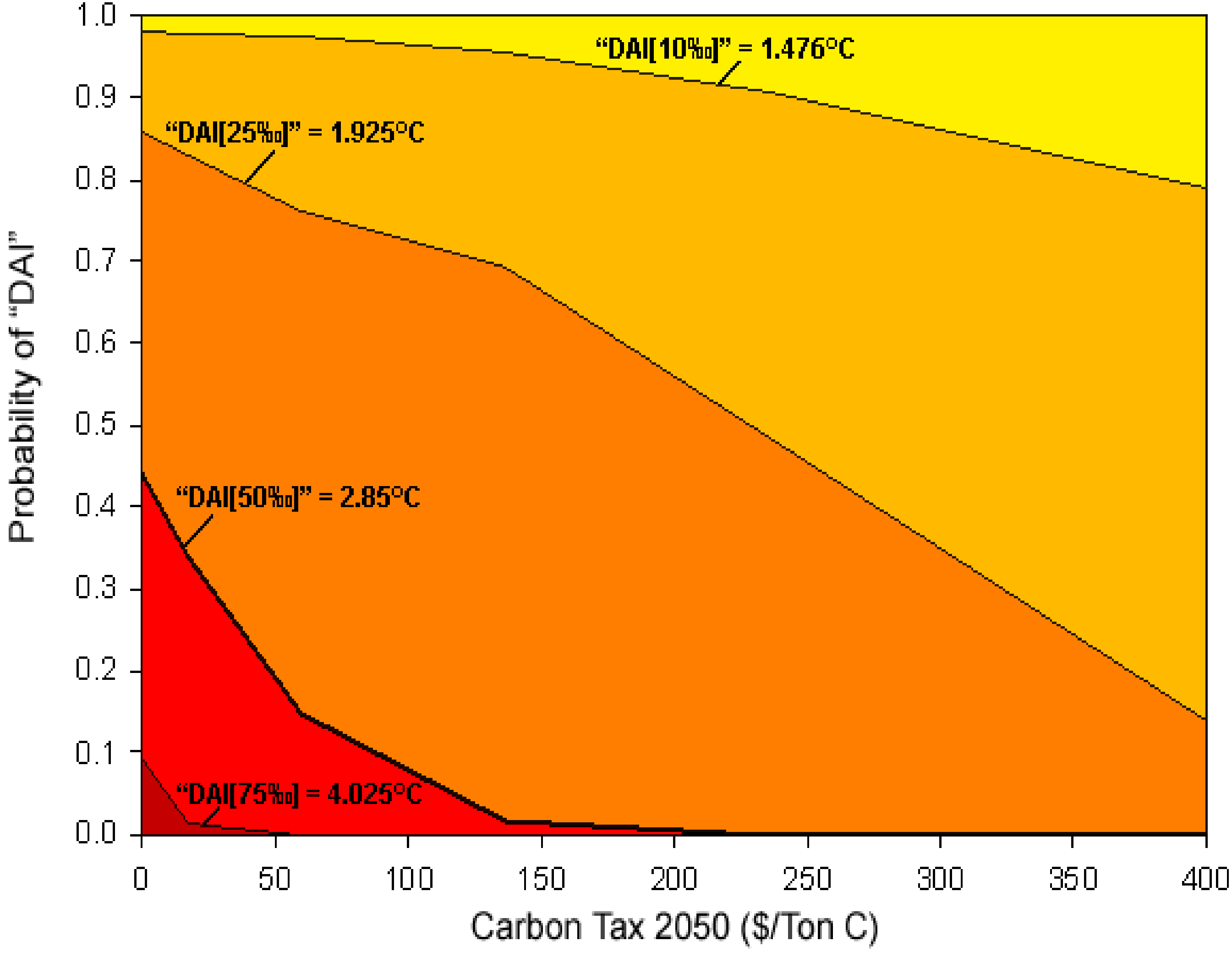
(b)



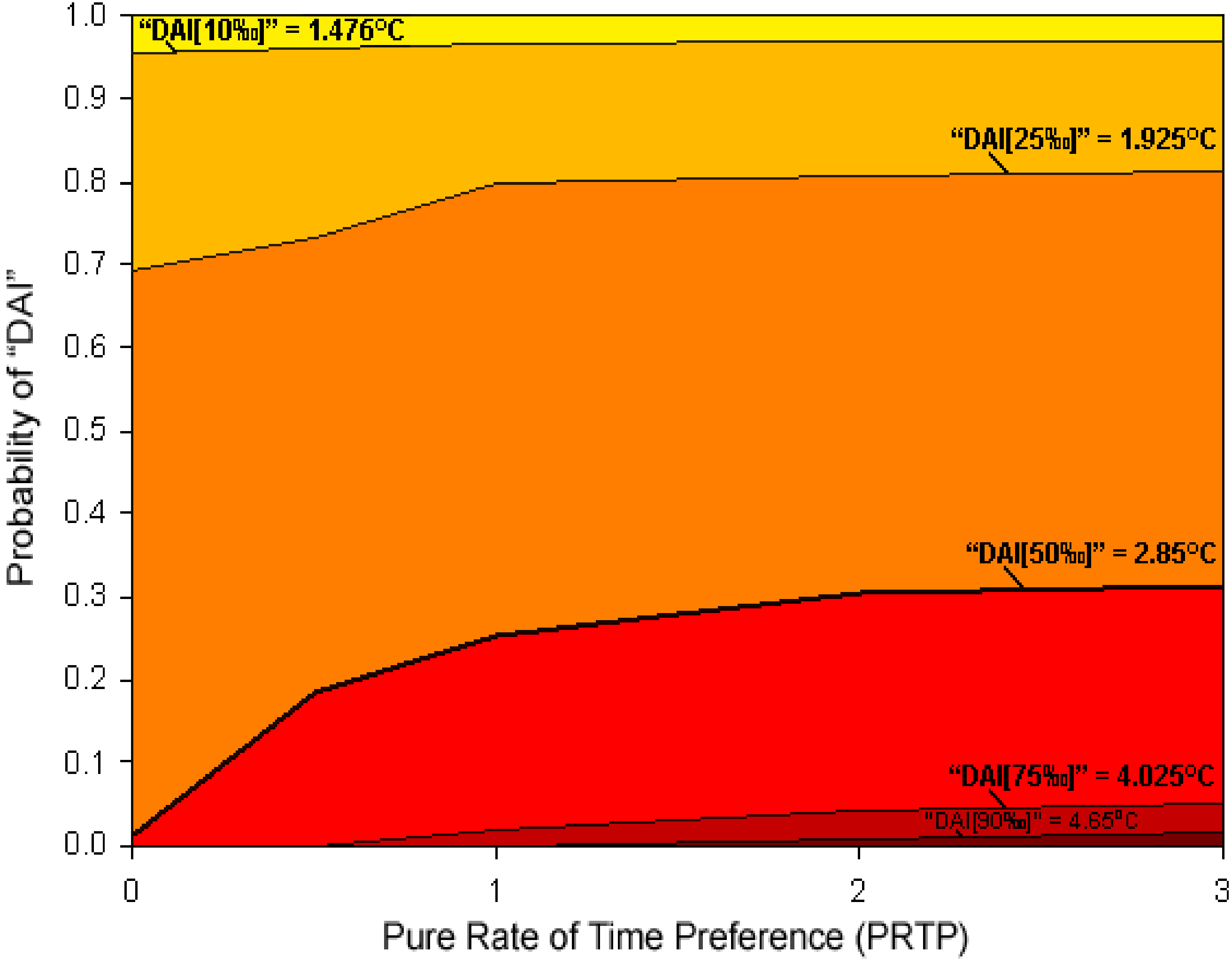
Damage (% of GWP)
20
15
10
5
0
-5
0
1
2
3
4
5
6
7
Temperature Increase (°C)
99%ile
90%ile
50%ile
10%ile
1%ile

(c)


a) Single Monte Carlo
b) Joint Monte Carlo
F Uniform
F Expert
A&S
P("DAI") = 55.8%
P("DAI") = 47.7%
P("DAI") = 28.6%
P("DAI") = 27.4%
T = $173.96/Ton C
P("DAI") = 0%
T = $130.93/Ton C
P("DAI") = 21.4%
T = $108.41/Ton C
Density
Temperature Change in 2100 (°C)



"DAI[10%ₒ]" = 1.476°C
"DAI[25%ₒ]" = 1.925°C
"DAI[50%ₒ]" = 2.85°C
"DAI[75%ₒ] = 4.025°C
Probability of "DAI"
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
350
400
Carbon Tax 2050 ($/Ton C)


"DAI[10%o]" = 1.476°C
"DAI[25%o]" = 1.925°C
"DAI[50%o]" = 2.85°C
"DAI[75%o]" = 4.025°C
"DAI[90%o]" = 4.65°C
Probability of "DAI"
Pure Rate of Time Preference (PRTP)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1
2
3

QUESTIONS AND COMMENTS PLEASE