The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

1986-6

WCRP and ICTP Interpreting Climate Change Simulations: Capacity Building for Developing Nations Seminar

26 - 30 November 2007

Future of Climate Change Research: Beyond WCRP.

Ann Henderson-Sellers
World Climate Research Programme
Geneva
Switzerland

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Future of Climate Change Research: Beyond WCRP

Dr A. Henderson-Sellers Executive Director,
World Climate Research Programme

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Not to act is immoral

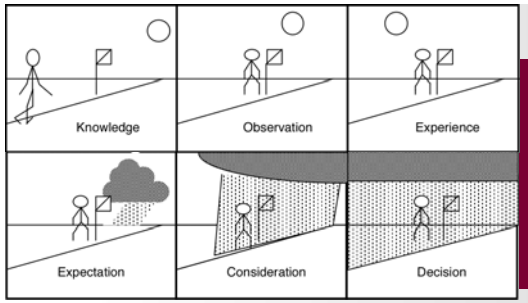
Climate Change Action Agenda

- Action is undoubtedly and urgently required to adapt to inevitable changes and mitigate further 'dangerous climate change' (UNFCCC Article 2); based on long history Villach 1985
- Challenge to separate (make coexist) 'objective' science and a new type of 'emergency' research: "important economic & social decisions made today … on assumption that past climatic data are a reliable guide to future.. no longer good"
  - Villach is seriously old news now
  - Greenhouse 2007 meeting discussed **"Not to act is immoral"**
- Action in 3 forms needed:
  - New technologies
  - Creative use of markets
  - Behavioural change

➢ Climate change priorities:

1. Calculate: do the science well
2. Advocate: explain impact; warn
3. Participate: become involved

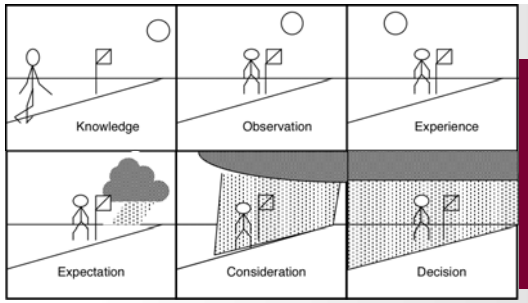
I argue for DOUBLE our funding so that climate science can maintain current research & also energise markets & people



Advocate: Bus Stop Parable

courteous reply to '*do you believe..*'

Knowledge
Observation
Experience
Expectation
Consideration
Decision



Greenhouse Advocate

courteous reply to '*do you believe..*'

Knowledge	Observations	Experience
Buses stops etc Rad^{n} theory & 150 years of expmtal evidence	Arrive early but no bus Mars & Venus temps right Earth +15^{o} -18^{o}C	No bus… review faith ? Temp up as we predicted + palaeoclimate
Expectation	**Consideration**	**Decision**
Still no bus! Hope? ….. Wins & losses IPCC etc: refugees, deaths	Other options important walk ? Action Policy on eg surprises or more assessment ?	Eventually give up or die Act! Options: More study debate, advocate

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WCRP Context: Our Objectives

- **Determine the predictability of climate**
- **Determine effect of human activities on climate**

Strategy: to facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society.

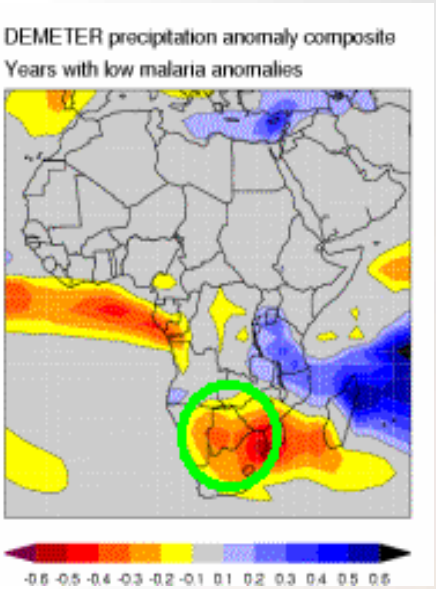
WCRP *central* to IPCC AR4: 75% of over 100 figures in WG1 Chapter 8-11 are CMIP3 based as are 4 of 7 in SPM

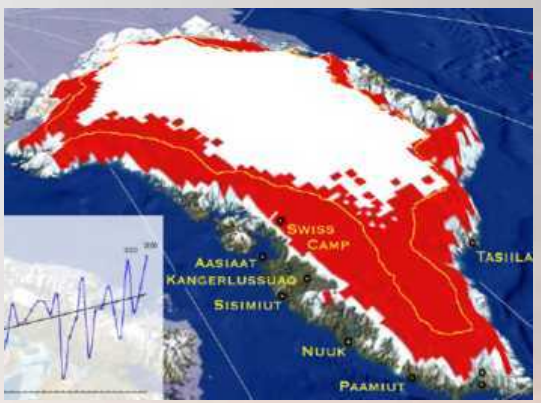
Target: focus on climate prediction

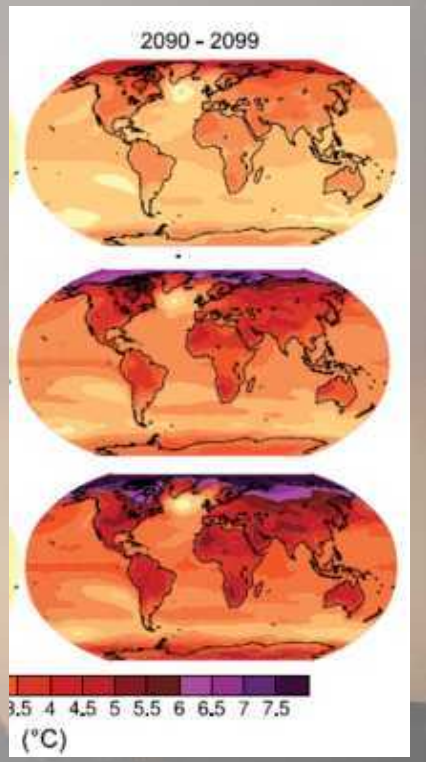
- Integration across WCRP (Anthropogenic Climate Change, Atmos. Chemistry & Climate, Tropical Convection & Monsoons, Decadal Prediction, Extremes, IPY, Sea level rise)
- Next generation weather and climate models (seamless prediction, thresholds, computing resources)
- Value delivery (user & sponsors needs, NWP)
- Strategic partners: WMO/WCP, ESSP & stakeholders

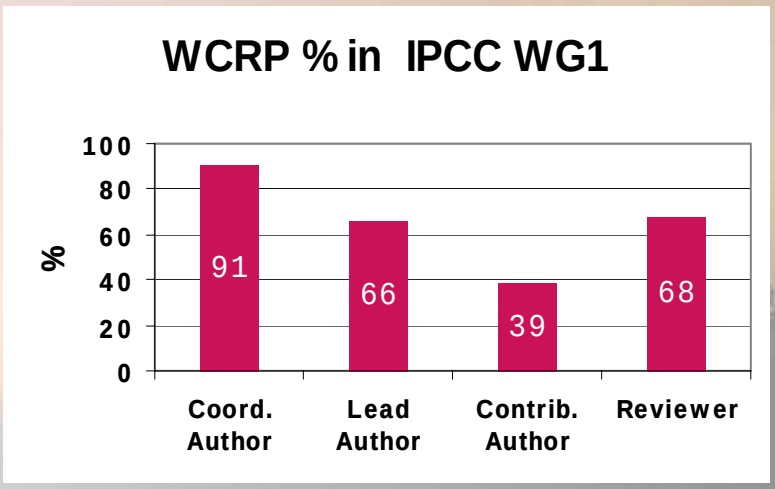
WCRP Context: Our Objectives

- Determine the predictability of climate
- Determine effect of human activities on climate









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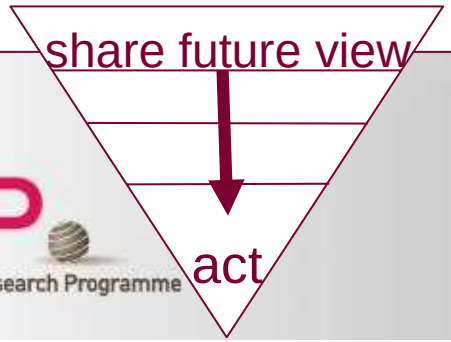
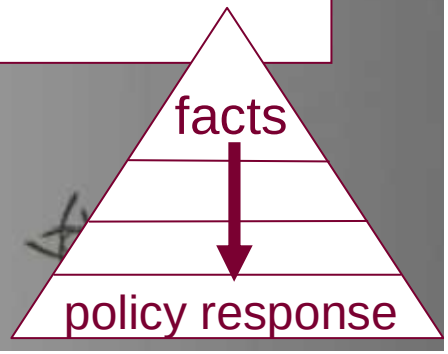
Calculate: Science Inputs to Society

- "Business-as-Usual scenarios by the end of the century produce basically another planet. How else can you describe climate change in which the Arctic becomes an open lake in the summer and fall, and most land areas on Earth experience mean warming this century that is 5-10 times larger than the standard deviation of the past century?" (Jim Hansen, AGU Lecture, Dec 2005)





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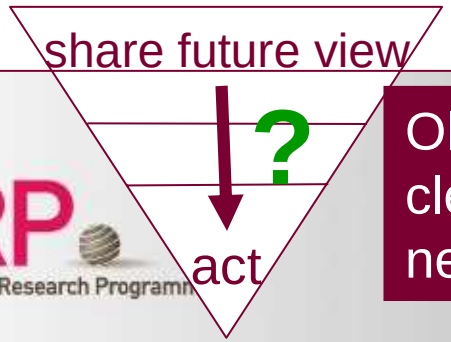
Calculate: Science Inputs to Society

- **Humanity must act collectively and urgently to change course through leadership at all levels of society**
- **There is no more time for delay**
- **The Time for Collective Action is NOW**

Source: report by the United Nations Foundation and SIGMA XI, Feb 2007 for 15th session of UN Commission on Sustainable Development



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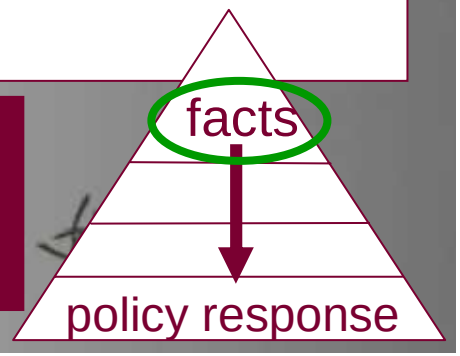
Old science input to RH process is clear but in LH process new ways needed: advocacy; business links



Post AR4 Priorities for Collaboration

- Response of models to a single transient 20th century forcing analyzing spread in the responses of the models over C20th. AR4 missed doing this
- Better reanalysis and data recovery/homogenization (organize in WCRP and work together with GCOS)
- More reliable social and economic data in order to understand the links between development and climate - preferably at a country level
- Socio-economic feedbacks linking forcing scenarios to plausible futures of population, fossil fuel use, technology etc. IPCC not yet best possible job.
- A framework presenting a unified picture of the future emissions' scenarios across the IPCC Working Groups I, II and III and thus the entire climate community has been defined in the 'Aspen Statement' (WCRP Informal Report No3/2007)
- Linking climate applications to socio-economic data e.g. answer 'how many Cat 4 tropical cyclones impacting the Gulf Coast in a year is climate change? 'How many over 40^{o}C periods of 20 days in Europe is due to increase in GHGs?' Posing topics this way relates better societal needs,
- Improve decadal predictability

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Post AR4 Priorities for Collaboration

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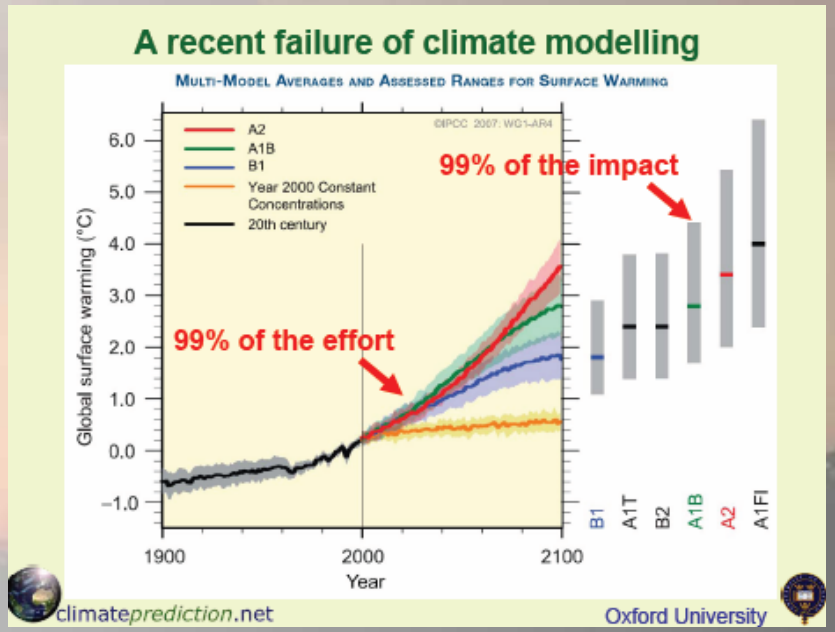

Make better model confidence relevant

Source: survey responses

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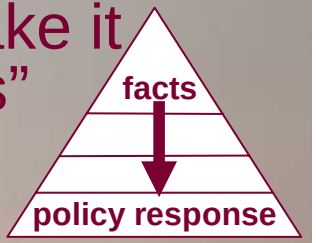
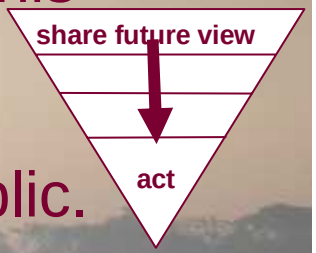
Science Participation Choices

- **Hands off:** "When risks cannot be well quantified, it is the job of policy to make decisions…. Scientists must make it clear where our job stops and the job of policy begins" (S.Solomon, 2007)



- **Recognise risk:** "Bottom line is how best to deal with risk & provide credible & defensible information to support this activity" (B.Hewitson, 2007)



- **Inform people:** "The ultimate policy-maker is the public. Unless the public is provided with unfiltered scientific information that accurately reflects the views of the scientific community, policymaking is likely to suffer." (J.Hansen, 2006)

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New parable: climate scientists as the medics advising cancer patient (society) on best treatment

Science Participation Choices

- Society is faced with a large number of problems of varying degrees of importance and urgency.
- Scientists can and must take the initiative in helping
- It is up to the scientific community to point out where they can help.
- Government cannot be expected to seek our advice and help because they are much more accustomed to solving problems by new legislation.
- Perhaps better solutions exist… (but) until we can make ourselves heard…. these problems are in danger of being grossly underestimated.

Who said this?

Atmos. & Oceanic Research Priorities

- Evaluate whether greatly increasing resolution does (as promised) solve many climate projection problems by single massive increment in computer resources
- Understand physics & dynamics of Greenland and Antarctic ice sheets, to predict sea level rise within 20% for a specified change in climate over the ice sheets
- Replicating relative changes over the past 50 years is essential and is an initial value problem for the oceans
- Simulate the main modes of variability in each of the main oceans: ENSO & PDO in Pacific, THC, MOC and AMO in Atlantic, monsoons in Indian Ocean.
- Re-evaluate projections for sea-level rise, reduction of uncertainties in sea-level change, aiming for a consensus rather than a lot of publications criticizing AR4.
- Constrain radiative forcing as much as possible: aerosols, clouds, land surface
- Reduce cloud feedback uncertainties: the cause of most of the uncertainty in forcing and model response and therefore a large chunk of projection uncertainty; mesh cloud-resolving models into AOGCM
- Improve understanding of global hydrological cycle under greenhouse (rainfall, evaporation and clouds), since a) the hydrological cycle is critical for estimating radiation budgets, but is poorly measured and b) rainfall and evaporation are so critical to human affairs

Improve prediction confidence

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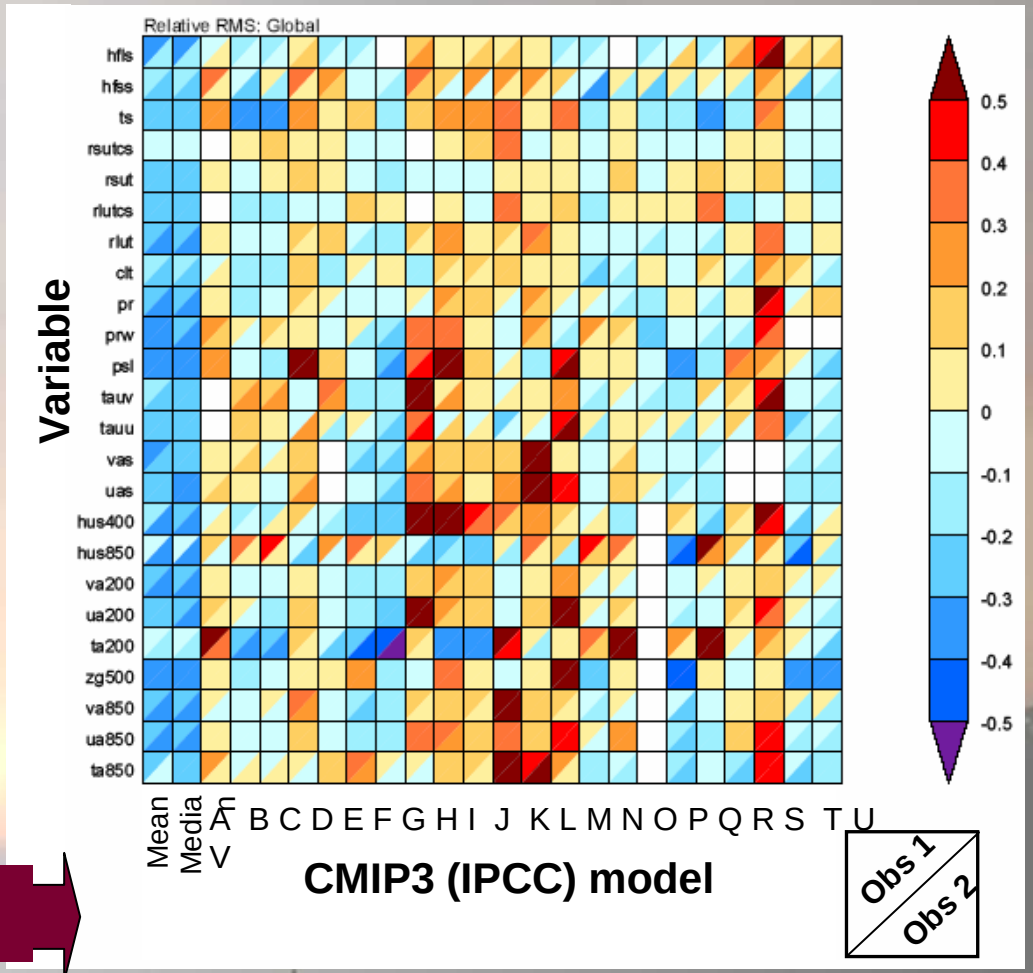
Atmos. & Oceanic Research Priorities

Source: survey responses

do this better



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The Climate Change Security Threat

In 2007 1990: climate change security threat rejected

accepted

AR4 Jan says yes

Aug UK ambassador says yes

Mick Keelty (Oz police) Sept yes

Independent 1 Feb 2007

Jeremy Leggett If climate change had been a military threat, we would have listened sooner

Mayday alert for the world

In last week's report from the UN Intergovernmental Panel on Climate Change (IPCC), we have a mayday alert. The fourth scientific assessment in 17 years from this expert group tells us that the first tank battalions have already broken through the border. Reading between the committee-written lines one can sense the panic.

In 1990 I listened to the scientists who had completed the IPCC's first assessment. At a press conference Margaret Thatcher, not otherwise known for eco-doom-mongering, warned the report would "change our way of life", and that we would cry out in the future not for oil, but water. The world seemed to be listening. The UN called for multilateral negotiations and most governments signed up. But these have run now for 16 years, and have done little to stem greenhouse gas emissions.

Many of the reasons for this failure sat with me in the room that day in 1990. The lobbyists from Exxon, Opec and the world's coal groups could not persuade the scientists to soften their language, though they tried. But ever since, the "carbon club" has spun a formidable web of obfuscation at best, lies at worst. Much slush money has been cast about trying to buy public confusion, as it had been by the tobacco industry. This, plus the carbon pushers' proxy ownership of key seats at the political table – not least in the current White House administration – has kept us addicted to the fuels that cause most of the greenhouse problem, and meant that the survival technologies remain pitifully neglected, despite their enormous potential.

The second and third assessments narrowed the uncertainties. By 1995 the IPCC's scientists – who must operate on consensus when writing their reports – were persuaded that they could see the first faint imprint of human enhancement of the greenhouse effect, in the pattern of rising temperatures around the globe. This, plus BP's farsighted defection from the carbon club's ranks, which split the vested interest for the first time, allowed the negotiation of the Kyoto protocol in 1997. The third report persuaded the rest of the world to keep the Kyoto process alive after Bush's US pulled out in 2001.

Back in December 1990, at the World Climate Conference – a UN event called to kick-start negotiations for a global climate treaty – colleagues from Greenpeace and I called for a worst-case analysis to be considered. If this were a military security exercise, we argued, we would be basing our policy response on worst-case analysis, not the best-guess consensus. We tabled a scenario wherein human greenhouse gas emissions stimulated huge emissions in nature, for example from melting permafrost and drying soils and forests, none of which were in the climate models of the day. Scientists call such amplifications positive feedbacks.

In the very worst case the amplifications could lead to a runaway effect, we argued, where feedbacks drown the potential to cut human emissions from fossil-fuel burning and other sources. Society needed to take out massive insurance against this horrific prospect, we argued. Billions needed to be invested in renewable and efficient-energy technologies, just as billions had been invested, rightly or wrongly, in taking out military insurance against a worst-case scenario of invasion during the cold war.

This was dismissed as scaremongering at the time. But today, checking the feedbacks in that 17-year-old scenario against emerging reality, almost every box has to be ticked.

Now the invasion is upon us, surely we can delay no longer. We need to go at the task as though we are mobilising for war. In an unnecessarily great hurry.

Jeremy Leggett is chief executive of solarcentury

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Asked worst case be considered as if a military threat

Almost every positive feedback in worst case now true

Science/Research is not "Done"

- Water infra-structure
  - expensive & long-lived
- UK in drought
  - national water grid

Does the UK need a national water grid?
Cost: £16 billion! Time-line: urgent!


THE INDEPENDENT

NEWSPAPER OF THE YEAR

Today .property

Drought Britain

Water shortages and wastage: how it affects you

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Science/Research is not "Done"

- Water infra-structure
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- UK in drought
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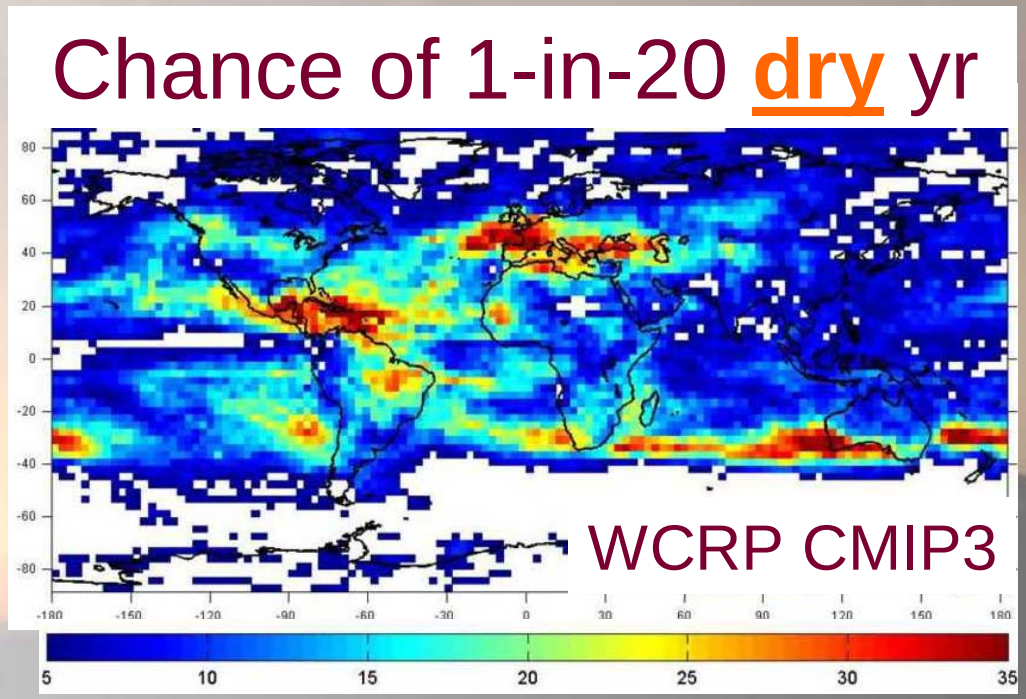
- European climate predictions –good?



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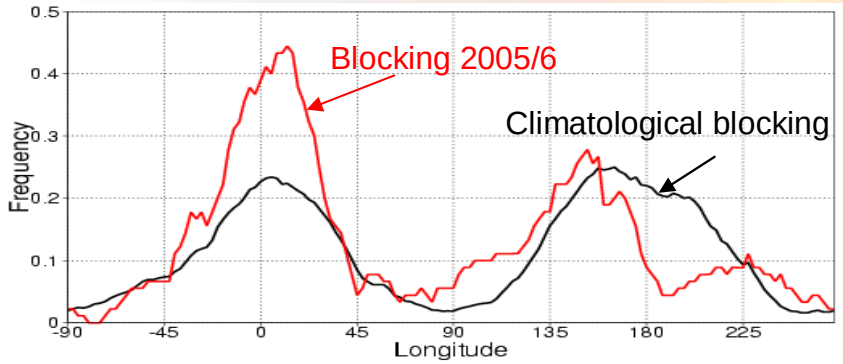
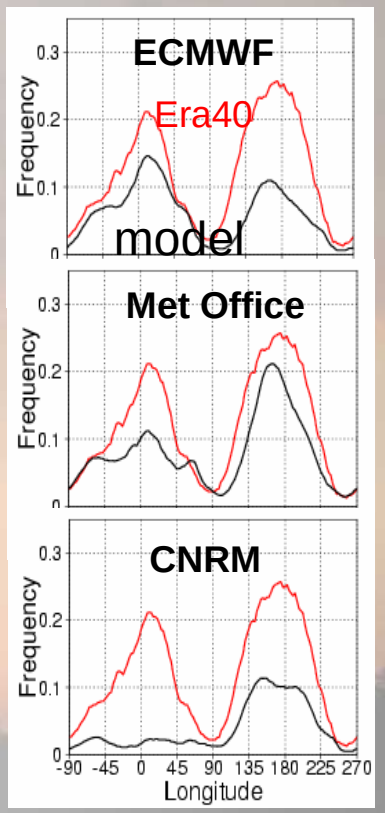
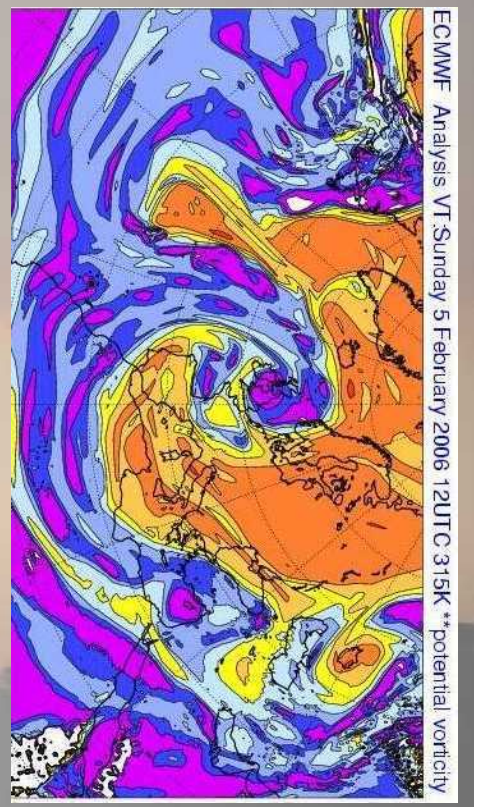
Science/Research is not "Done"

- Water infra-structure
  - expensive & long-lived
- UK in drought
  - national water grid
- European climate predictions –good? Low skill



Droughts: anomalous blocking





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Science/Research is not "Done"

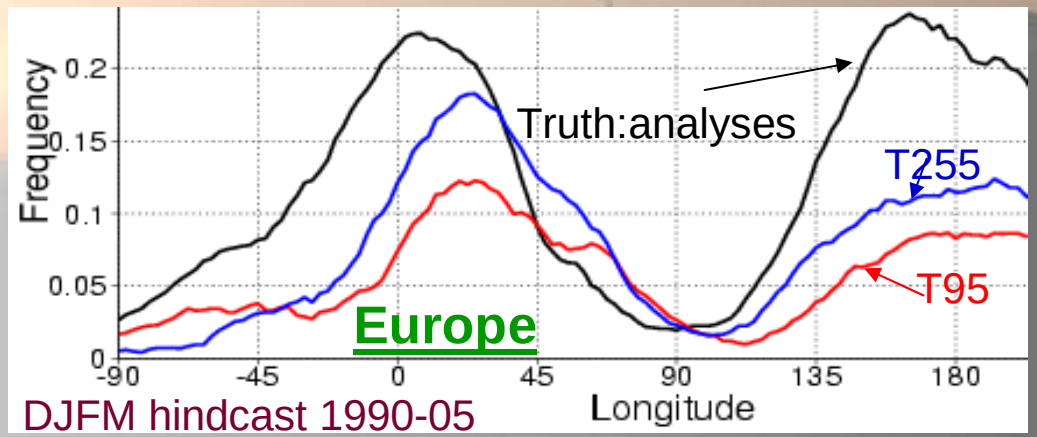
- Water infra-structure
  - expensive & long-lived
- UK in drought
  - national water grid
- European climate predictions –good?
- Model resolution greatly improves

Drought or flood?

Downscaling models now must fail

& floods: blocking

Low skill



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Revolution in Climate Research

Science MUST engage actively & do needed research:

- Calculate: do climate science well but not only this:
  - Traditional role e.g. clouds & convection in models but in
  - Security threat role e.g. thresholds for WAIS & Greenland; Amazon die back; N. Atlantic o'turn slowing; intenser TCs
- Advocate: explain impact & deliver useful warnings:
  - Traditional: hydrologic extremes e.g. droughts but as a real
  - Security threat: coastal deaths; virtual carbon & water trade
- Participate: actively combat a climate security threat
  - Argue for the use of ethical discount rates *and*
  - Business goal setting; better international governance

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Revolution in Climate Research

Case for DOUBLING funds for climate research but it will cost us

Science MUST engage actively & do

- Calculate: do climate science well
  - Traditional role e.g. clouds & c
  - Security threat role e.g. thresh
    Amazon die back; N. Atlantic o
- Advocate: explain impact & delive
  - Traditional: hydrologic extreme
  - Security threat: coastal deaths; virtual carbon &
- Participate: actively combat a climate security threa
  - Argue for the use of ethical discount rates *and*
  - Business goal setting; better international governance

"Much more must also be done by governments, business and civil society. The world needs a more coherent system of international environmental governance. We need to invest more in green technologies and smarter policies." UN SG Ban Ki-moon, 2/2/07

New funds for better story telling and creation of 'ordinary heroes'

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Emergency Climate Change Fund

- Climate research ~US $5 billion pa now
- Ask to double this for 10 years 2008-18:
  - retain $5bn for existing & objective
  - invest the SAME again in change research
    - Advocacy (stories) & emergency solutions
  - NOT a large funding increase cf.
  - ~ 50th of global govn. subsidies of fossil fuels
  - ~ 30th of US aircraft industry sales ($150bn)
  - ~ Typical IT firm's pa R&D investment
  - ~ UK urban air quality health care savings

High risk , low probability

New parable/ analogy: climate scientists acting like doctors advising on best cancer treatments

Market Action: Fix Carbon Poverty

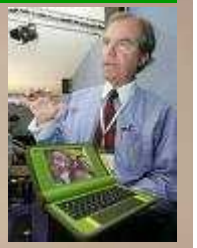
http://unfccc.int/cooperation_and_support/financial_mechanism

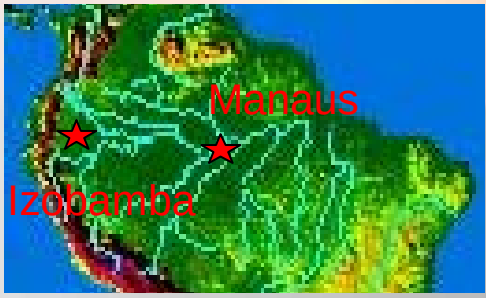
- **New market of 'carbon poverty reduction'**
- **Means of west investing $50 billion pa (NGOs)**

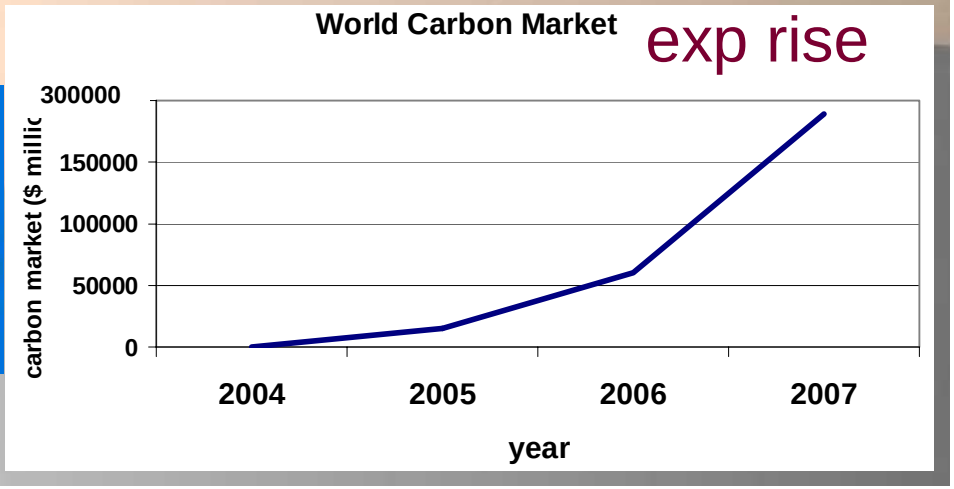
Climate research
act, assess or both?

Supply – from local	Transaction – who/how?	Market – west to do
land	Monitoring e.g. satellites	Educate
forest	Community gear e.g. PCs	Buy and support

Nic Negroponte (MIT) One Laptop @ ~$100 each or Intel's Classmate $250)







People Action: Change Behaviour

- Disparity between the enormity of climate change and small individual actions has to be admitted and tackled directly e.g.
  - Target ‘feels like what my people do’ behaviours
  - Exploit ‘esteem-driven’ achieved through what they do or buy NOT through what they do not do or do not buy.
  - Recognise that people trust other people much more than us (governments, business or other institutions)
  - Use non-rational approaches, like metaphor, to engage folks emotionally and make desired behaviours attractive.

Warm Words: Ereaut and Segnit (Aug 2006)

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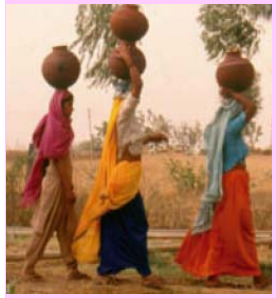
People Action: Change Behaviour

ordinary



most people:
cultural norm

ordinary hero

unheroic:
doing harm

heroic:
doing good

superman/woman:
beyond expectation

extraordinary

Joergen Randers, Norwegian economist: in cooler climates turn down thermostats 1 ^{o}C & wear a sweater to keep warm (Reuters, 23/8/07); Richard DeDear, Australian climate scientist: in warmer parts turn the air cond. down 5 ^{o}C & wear ‘cool biz’ (SMH 27/3/07)

Advocate: Ordinary Heroes Rise

Overcoming ‘smallness’

Al’s army (volunteers):

- Over 1000 citizens done 2-day training with Gore & staff to use his 330+ slide show seen in his movie
- US, UK and Australia
- Scientists helping include Mike McCracken and Richard Alley

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Nature, Vol 446, 12/4/07, p723

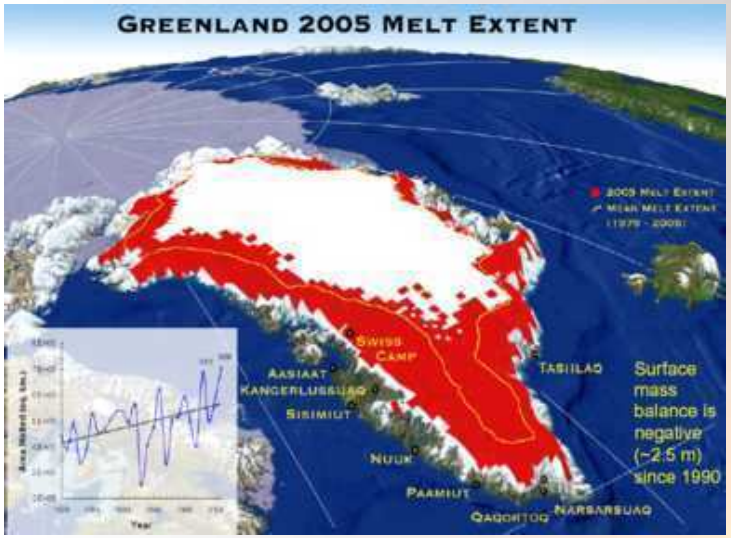
ICSU

Threat Research: Thresholds

- Extremes more uncertain than non-extreme variables
- Consensus policy input limited by strict literature view
  - sea-level rise: politicians 'trained' to believe that a few cms & gradual increase is most likely Rahmstorf *et al.* 2007
  - Schellnhuber *et al.* thresholds very near or will be passed if we fail to limit atmos. conc at ≤ 550ppm i.e. experts say:
    - Greenland disintegration (80%); Amazon dies (70%); W. Antarctica (60%), Atlantic merid. o'turn (50%); More intense tropical cyclones
  - major ice sheets collapse e.g.
    Steffen 2006; Fricker *et al.* 2007

Threat Research: Thresholds

Enough information now to make it a near certainty that business as usual will lead to disastrous multi-metre sea level rise on the century time scale Hansen, NS, 07



High risk , low probability

New science (as well as trad. climate research) be directed at Manhattan-type endeavour to quantify BAD risks & find behavioural solutions

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Hurricanes in the Greenhouse

- IWTC-6 Statement: A Consensus Nov 2006 (Costa Rica)
- Item 21: Thus it is possible that global warming may have affected the 2004-2005 group of events as a whole. The possibility that greenhouse gas induced global warming may have already caused a substantial increase in some tropical cyclone indices has been raised (e.g. Mann and Emanuel, 2006), but no consensus has been reached on this issue.
- Item 26: This recent international research is leading to major advances in understanding of the relationships between tropical cyclones and the large scale atmospheric state or “climate” as well as advances in the understanding of the observational record of tropical cyclones. Because of the rapid advances being made with this research, the findings in this statement may be soon superseded by new findings.

Hurricanes in the Greenhouse

Table TS-4. Recent trends, assessment of human influence on trend, and projections of extreme weather and climate events {Tables 3.7, 3.8, 9.4, Sections 3.8, 5.5, 9.7, 11.2-11.9}

IPCC WG1 SPM Jan 07

Phenomenon[a] and direction of trend	*Likelihood that trend occurred in late 20th century (typically post 1960)*	*Likelihood of discernible human influence on observed trend*	D	*Likelihood of continuation of trend based on projections for 21st century using SRES scenarios.*
Warmer/fewer cold days/nights over most land areas.	Very likely[b]	Likely[d]	*	Virtually certain[d]
Warmer/more hot days/nights over most land areas.	Very likely[c]	Likely (nights)[d]	*	Virtually certain[d]
Warm spells / heat waves. Frequency increases over most land areas.	Likely	More likely than not[c]		Very likely
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas.	Likely	More likely than not		Very likely
Area affected by droughts increases.	Likely in many regions since 1970s	More likely than not	*	Likely
Number of intense tropical cyclones increases.	Likely, since 1970	More likely than not		Likely
Increased incidence of extreme high sea level (excludes tsunamis).	Likely	More likely than not		Likely

No TC-CC link in Nov 06

but 'likely' link by Jan 07 Question: more science or immediate action/advocacy?

Participate: Greenhouse Wager

- Pascal asked: God exists? G'house true?

	no	yes
yes Act now Believe	pray/invest coastal benefits	saved $100s billions every year
no	no action incredibly lucky	damned many will die, more refugees

eg 0.7% USA GDP (Nordhaus)

Climate research act, assess or both?

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G'hs TC-CC link Cost: benefit evaluation

Wolf Warming Action Analogy

use a children's story

Wolf or Grandma?

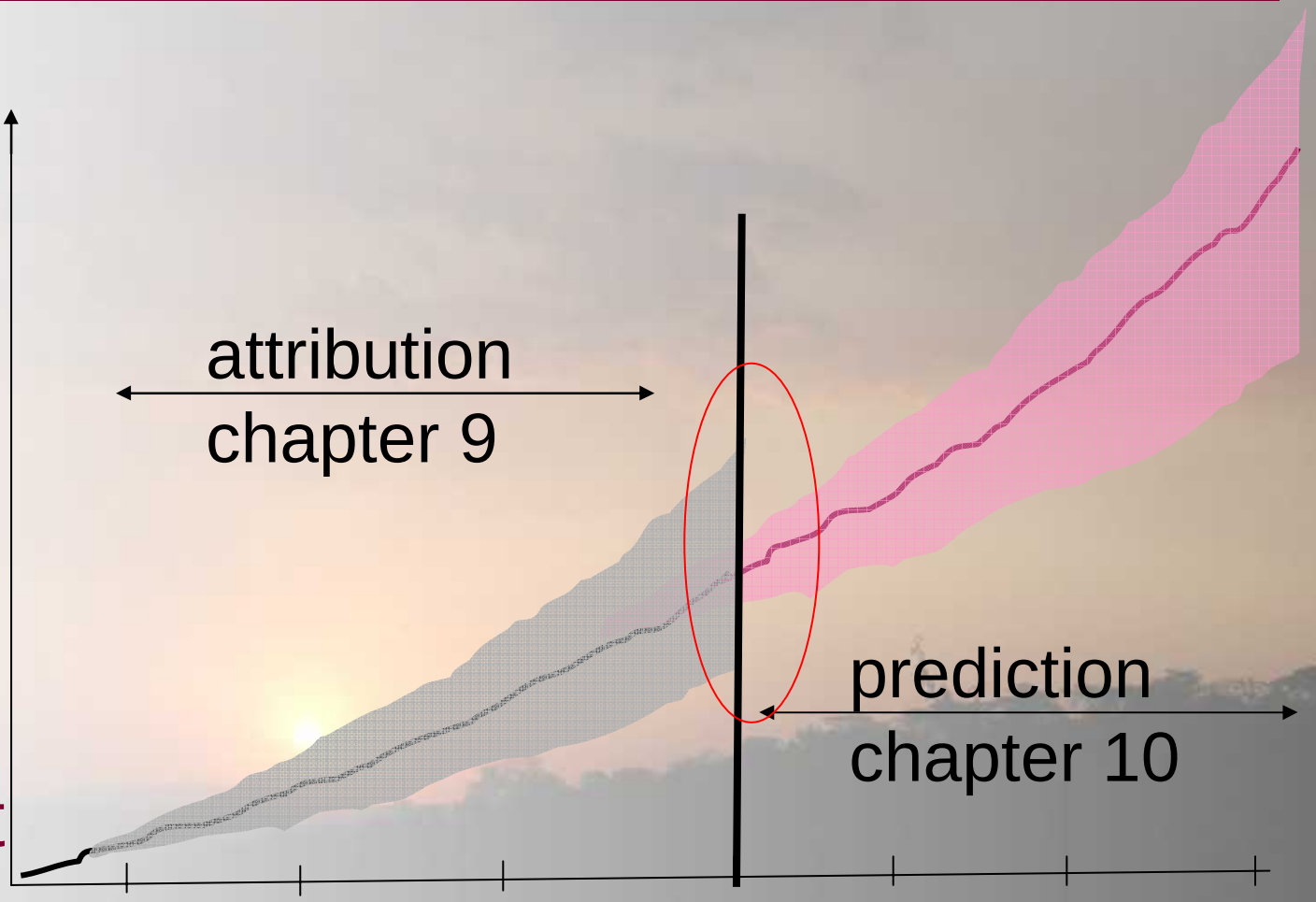
Ordinary hero Dad

Is climate research enabling separation between wolf's view (live now) & Granny's view (your best future)

Grandmama says because you will live your life 50 years after mine, I place far less value on your well-being than on mine and my neighbours. I am ready to take decisions with severe and irreversible implications for you. (Stern, 2006)

Climate Sensitivity Challenge

- AR4 could suggest we are more confident about future than about past



Myles Allen, 30/8/07

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WHO IOC ICSU

Provocative Climate Res. Priorities

- Adding complexity to models, when some basic elements are not working right (e.g. hydro. cycle) is not sound science. Use hierarchy of models
- Prioritize the models so that weaker ones do not confuse/dilute the signals
- More attention to basic model flaws: without this, future IPCC ARs will look very similar each time, resources wasted, & science & society ill-served
- Until and unless ENSO, PDO, NAO and AMO etc can be predicted to the extent that they are predictable, regional climate is not a well defined problem. It may never be. If that is the case then we should say so.
- Rush to emphasize regional climate is not scientifically sound
- Climate models need to be exercised for weather prediction: necessary but not sufficient things that can best be tested in this framework
- Climate change will remain a risk management problem for the foreseeable future. If we can constrain distribution functions of important process variables or outcomes like climate sensitivity or damages the chances of adaptation improve. The cleverer we are in the design, the sooner we constrain the potential for some really "dangerous" outcomes that cannot currently be ruled out with less than 10% chances

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Source: survey responses

Relevant & better model confidence applied to high risk, but low probability outcomes

Revolution in Climate Research

Asking to DOUBLE climate research funds to deliver solutions

- Calculate: do climate science well but no longer via:
  - Traditional role e.g. clouds & convection in models but in
  - Security threat role e.g. thresholds for WAIS & Greenland; Amazon die back; N. Atlantic o'turn slowing; intenser TCs
- Advocate: explain impact; deliver useful warnings not
  - Traditional: hydrologic extremes e.g. droughts but as a real
  - Security threat: coastal death; trade in virtual carbon/water
- Participate: actively combat a climate security threat
  - Argue for the use of ethical discount rates *and*
  - Business goal setting; better international governance

New funds: threat response, advocacy & creating ordinary heroes

World Climate Research Programme WMO IOC

Revolution in Climate Research

IUGG July 2007 Urges:

Nations to reduce sharply atmospheric emissions of g'house gases & aerosols;
International research to clarify urgency and extent of needed mitigation;
Scientists to freely & widely communicate with public & private decision-makers about consequences & risks of on-going climate change & actions to mitigate &

IUGG Resolves (July 2007)

To act to increase public understanding of the nature and implications of human-induced impacts on the Earth system and
To encourage governments and business to initiate mitigation activities directed at reducing the consequences and risks posed to society and the environment.

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Moral Climate Research Funding

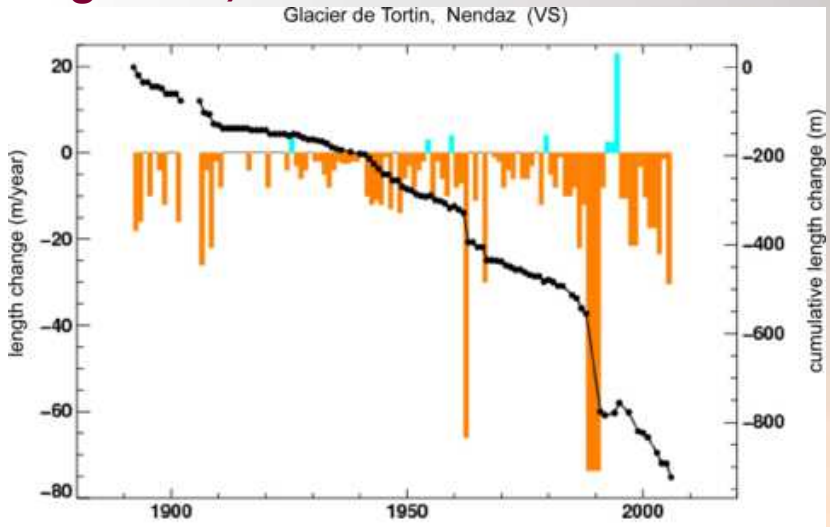
Not to act is immoral

- **$5 billion climate emergency research pa for 10 yr**
  - ~ **Madagascar GDP to help Malagasy**
    - ~ **Citi investment ($50b over decade) 9/07**

1994 flood from TC Geralda

Thank you

- **Decline of the Tortin - Montfort glacier, Switzerland**



Albert Crewe Argonne Nat. Lab, 3rd Director, Physics Today October 1967 (& July 2007)