Climate change: threats, challenges, and opportunities
Climate science: framing thoughts

Some thoughts to frame your thinking around:

a) I am not here to convince you!

b) Climate change is nuanced with simple messages, and complex detail

c) Uncertainty is intrinsic in a quasi deterministic coupled system

d) Context is paramount, especially as regards scales and sectoral interests

e) Warming of the last century is “unequivocal”
Sampling the “threat-space”

Research:
- Diversion of research foci / application driven research agenda
- Politicization of science (e.g. USA Virginia state attorney general)

Society:
- Exceeding societal design thresholds (e.g. storm water systems)
- Increased frequency of event-based disasters (e.g. Moscow, Pakistan)
- Changes in resource availability (e.g. shrinking glaciers for Asia water)
- Polarization / conflict (e.g. resource availability, trade conflicts)
- Tensions in the plurality of value systems (e.g. China vs USA vs SA)

Economic:
- Business as usual becoming unsustainable (e.g. agricultural systems)
- Shifting and fluid economics (e.g. realignment in investments)
- New centers of power (e.g. China, Brazil)
What’s happening? (the evidence basis)

In general:
- Warming
- Wetter and drier
- More extreme events
- Ocean acidification
- Glacier melt
- Increased drought and flood
- etc …
A metaphor for climate science

Learning to read

The challenge of bridging the science-society divide

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A unique context

10 Indicators of a Human Fingerprint on Climate Change

- Less heat escaping to space
- Cooling stratosphere
- Rising tropopause
- Less oxygen in the air
- More fossil fuel carbon in the air
- More heat returning to Earth
- 30 billion tonnes of CO2 per year
- More fossil fuel carbon in coral
- Nights warming faster than days

NOAA State of the Climate 2009 report
A unique context

These indicators all **increase** in a warming world

- Air Temperature Near Surface (Troposphere)
- Sea Level
- Sea-Surface Temperature
- Temperature Over Oceans
- Ocean Heat Content
- Land Surface Air Temperature Over Land

NOAA State of the Climate 2009 report
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These indicators all decrease in a warming world

NOAA State of the Climate 2009 report
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Where is global warming going?

- Ocean: 93.4%
- Atmosphere: 2.3%
- Continents: 2.1%
- Glaciers and ice caps: 0.9%
- Arctic sea ice: 0.8%
- Greenland Ice Sheet: 0.2%
- Antarctic Ice Sheet: 0.2%

Data from IPCC 2007

NOAA State of the Climate 2009 report
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Ocean Heat Content

The graph shows changes in ocean heat content in joules (a measure of energy) compared to the 1955-2002 average. The different colored lines represent various independently produced analyses of ocean heat content data. The most recent studies, in which recently discovered data errors have been corrected, show the strongest warming.

NOAA State of the Climate 2009 report
Global temperature is not the optimal metric.
Arctic Sea Ice Volume Anomaly and Trend from PIOMAS

Anomaly Trend: -3.4 [1000 km$^3$/Decade]
Last Day: 2010-05-30
A unique context

Global Temperature Change
Decade Averages

2000s even warmer. Every year warmer than 1990s average.

1990s even warmer. Every year warmer than 1980s average.

1980s warmest decade on record at the time.

The sun’s output at a current extended minimum
A unique context

Velicogna (2009)

Antarctic Ice Mass

Greenland Ice Mass

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Historical temperature trends
Adapted from Kruger and Shongwe (2004)
“Reconstructions for the last 1000 years indicate that this warming was unusual and unlikely to be entirely natural in origin” (IPCC)

There is no identified physical process, other than human induced change in greenhouse gas concentrations, that can credibly account for the recent warming!
With …

Simulate the climate without the human contribution, and then with human contribution. Compare to observed

From Stott et al, 2005.

So: can we make attribution of the change:

Model based studies
A unique response

*There has never before been seen in science:*

- Such a scale of multi-disciplinary research on one theme
- The magnitude of international collaboration as is now occurring
- The rapidity of release of new findings directly to society
- An urgency of demand from society as we now see
- The inadequacy of scientists to communicate, or society to adopt

A global challenge of such importance
Compounded by the diversity of information needs for adaptation, policy, and mitigation

- Articulation of relevant thresholds
- Understanding natural variability
- Effective communication between knowledge provider and user
- Tailored information products
- Quantified uncertainty
- Iterative and sustained re-examination
- Synergy between process change and local change
- Accommodation of feedbacks and tipping points
- Balancing multi-stressor factors
- Assessment of error

Etc …
Obs & past trend
Circulation changes
GCM regional deltas
Downscaling

Global and regional Integration and Understanding

Data products with articulated uncertainty
Storylines of descriptive change

Communication around real world questions

The foundation of understanding

The foundation of understanding

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Looking to the future

There is an unavoidable level of commitment

Current emissions scenarios put us on course for 4 degree global mean warming by 2100

Mitigation can at best cap the magnitude
Adaptation is (context dependent) an essential

The worlds nations are making exceptionally large funding commitments
Using and abusing projections to reach a range of variable outcomes

**Quadrant of Quandary**

**Credible**
- Can regional projections be

**Defensible**
- Awareness

**Actionable**
- Data
- Information
- Knowledge
- Wisdom of action

**Knowledge**

**Value Response**
- Risk management
- Reducing vulnerability
- Win-win solutions
- Short term pain and long term gain

**Apathy or Resistance?**
- Political pressures
- Economic constraints
- Fear of costs
- Saving face

**Dangerous?**
- Questionable foundations
- Possibility of mal-adaptation
- Knee-jerk responses
- Well-intentioned but misguided

Adapted from F. Zermoglio & Downing
The computational simulation basis of climate projections

First order response is a robust determination largely unchanged since the late 1800s!

\(~1.5°–4.5°C\) for 2 x CO\(_2\)
Data
Climate models, historical observations, trends, downscaling, projections, event frequency, …

Information
Measures of change and metrics of relevance, time-evolution, uncertainty, scale dependencies, secondary attributes, …

Knowledge
Assessing impacts & options, understanding consequences, evaluating responses, informing decision making, …

A basis for action
Policy development to balance competing priorities, strategic investments in adaptation and mitigation, new research avenues, coordination of response frameworks, …

Science of the physical system
(with internal disciplinary barriers)

Critical / Priority Interface

VIA / Policy / Mitigation
(with internal disciplinary barriers)
Difficulties of IPCC-type aggregated presentations of information (including many portals)

a) Un-stated limitations of low resolution information
b) Hides the range of uncertainty
c) Suggests detail, implies confidence
Current projections for South Africa: Temperature

75th percentile

Median

“Best estimate?”

25th percentile
Downscaled rainfall change

75\textsuperscript{th} percentile

Median

“Best estimate?”

25\textsuperscript{th} percentile
Sampling the “opportunity-space”

**Research:**
- New multi-disciplinary frontiers
- Innovation of applications (e.g. GRACE satellite)
- Capacity building in developing nations
- Enhanced understanding of the coupled system dynamics

**Society:**
- Changes towards sustainable living (30 planets needed for USA lifestyle)
- Investment in poverty alleviation and development
- Realignment of values and political power
- Leap-frog technology

**Economic:**
- New markets with different technologies
- Changing frameworks for improved resilience
Adapting to “climate change” … means adapting to what?

Pick as role as a stakeholder trying to accommodate climate change

What has already changed?
Is that any different from variability?
What is the future?
When is the future?
How do you know that?
Where do you get your information?
Do you “believe” it?
How do you know how good it is?
Would you spend your own money based on this information?

At the root of the issue, do you know threshold of vulnerability?
New developments: changing the game plan of information
Going further: starting points

Main reference:
The IPCC 4th assessment report: http://www.ipcc.ch

Summaries:
The Copenhagen diagnosis: http://www.copenhagendiagnosis.org


Web sources:
a) Climateprogress (http://www.climateprogress.com)
See esp: http://climateprogress.org/2010/04/14/the-complete-guide-to-modern-day-climate-change

b) Realclimate (www.realclimate.org)

The skeptics arguments:
Skeptical science (www.skepticalscience.com)
Also: iPhone and Android app of answers to skeptics arguments

Example of sceptical writing and the science rebuttal: Ian Plimer’s book “Heaven and Earth”