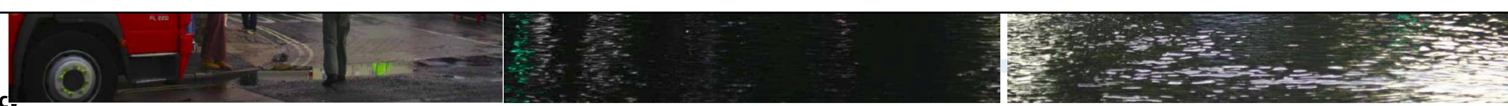
Can today's science tell John what +4 degrees would be like for his pub?
Or his insurer? (or their reinsurer?) Or better still "climate-proof" his business?
Is it a question of mere probabilities? Or might models see a "Big Surprise"?
How to best manage Expectations (Theirs) and Credibility (Ours) ?
Why is this so hard? Should Michel care about global mean temperature?



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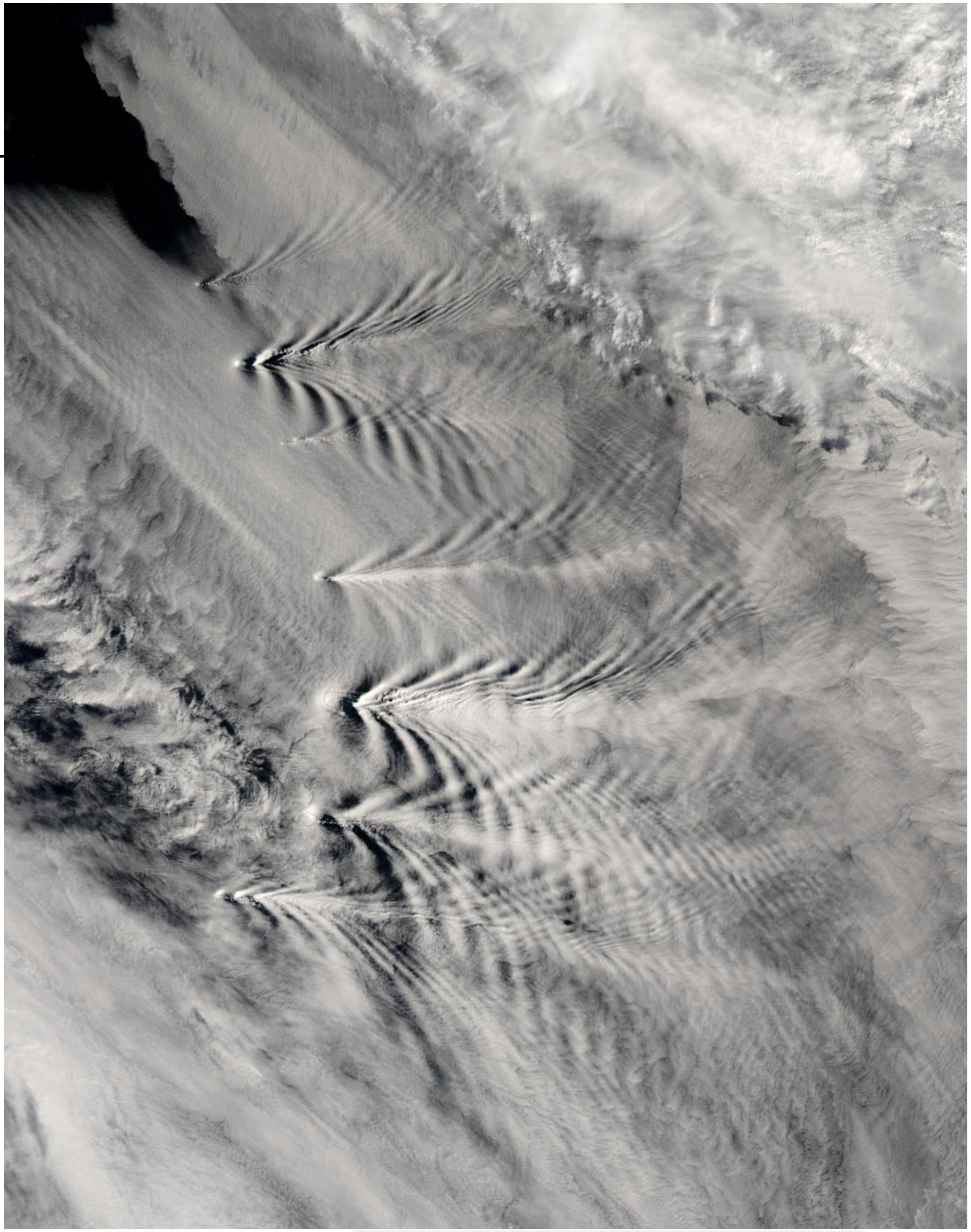
How many physical details can our models miss and still yield useful quantitative decision-relevant information downstream?

How can we tell in the case of a given decision?

What do 4 degree warmer GCMs tell us about a 4 degree warmer Earth?

The islands' peaks range in elevation between 1,807 feet (551 m) and 3,600 feet (1,100 m), and stand in about 8,500 feet (2,600 m) of water.
As is apparent in this true-color image, the islands are tall enough to disrupt the cloud patterns forming and flowing around them. Most of this scene is dominated by a large formation of low-level stratiform clouds that appears to be flowing in a southeasterly direction

This scene was acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS), flying aboard NASA's Aqua satellite, on January 27, 2004.



http://earthobservatory.nasa.gov/images/imagerecords/4000/4174/SouthSandwich_lrg.jpg

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The Munich Re Programme: *Evaluating the Economics of Climate Risks and Opportunities in the Insurance Sector*

www.cccep.ac.uk

One Two Three More:

Challenges to describing a Warmer World

Challenges in Adaptation-Relevant Modelling of a Zero Degree Warmer World

Leonard Smith

With Ana Lopez,

Falk Niehoerster,

Dave Stainforth & Ed Tredger

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Living With Environmental Change LWEC

Münchener Rück Munich Re Group

LSE The London School of Economics and Political Science

University of Leeds

Overview

- There are many many different 4 degree worlds.
- Today's models appear unlikely to provides quantitative decision-relevant probabilities about them, evidence is required for each decision (and would be welcome!)
- Climate science and climate models make it very clear exploring a 4+ degree world empirically would carry huge ecological, human and economic costs.
- The credibility of science is at risk if we fail to communicate our deep uncertainty quantitative results provided to decision makers.
- Honestly lowering the bar makes applied science more useful, less volatile, and much much easier to advance.

The original plan

As a model warms, parameterizations are more and more likely to break down (and yield physically misleading results).

The story-line was to discuss how to communicate this type of model inadequacy to decision makers, especially for 4+ degree worlds.

For real decision support questions, when might model-based probability distributions be dominated by spurious accuracy?

How might we outline a test for decision-support relevant probabilities from models? And communicate the result to decision makers (and impacts modellers!)?

Schematic of Test For Quantitative Decision Relevance

- Specify the Decision Question in terms of local environmental phenomena that impact it.
  ("hot dry periods")
- Determine the larger scale "meteorological" phenomena that impact the local.
  ("blocking")
- Identify all relevant drivers (which are known).

  ("mountains")
- Pose necessary (*NEVER SUFFICIENT*) conditions for model output to quantitatively inform prior subjective science based reflection.
- Are local phenomena of today realistically simulated in the model?
  - (If not: Are relevant larger scale (to allow "prefect prog")).
- Are all drivers represented? (to allow "laws-of-physics" "extrapolation")
- **Are these conditions likely to hold given the end-of-run model-climate?**

If one cannot clear these hurdles, the scientific value of the results does not make them of value to decision makers. They can be a detriment.

And claiming they are the "Best Available Information" is both false and misleading.

How clear is our vision of 4 degree worlds?

Our models sample an ill-defined mathematical space of bland worlds, similar to the Earth but systematically less rich: mere abstractions.

Where implimentation details matter (in distribution) in those models-worlds, we have no rational way to interpret ensembles as probabilities.

Can climate **science** suggest the space and time scales, as a function of lead time, on which we can make arguably robust statements or "decision-relevant probabilities" ?

How do we communicate this insight to decision makers?

? Is there a better approach than quantifying Prob(Big Surprise) ?

How do we explore methodologies without misleading decision makers?

Expecting Surprises before 4+

Avoiding Surprises for Users in reality and as science advances:

- Often, very well established science suggests we are over-interpreting the model output, and even suggests the sign of a likely surprise. Can we quantifying subjective probabilities here?
- Can we lower the bar of expectation from models and clarify the limits of seeing a zero degree warmer world in today's GCMs.
- We will look briefly at mountain ridges and the 1930's dustbowl to get an idea what our current models cannot do "accurately"
- But first we need to distinguish uncertainty and diversity in the AR4.

The grey bands on the far right "the likely range."
SUBJECTIVE PROBABILITY

The coloured bands represent the widths of multi-model ensembles.

These distributions violate the law of large numbers!
DIVERISITY

The grey band represents traditional observational uncertainty.
NOISE

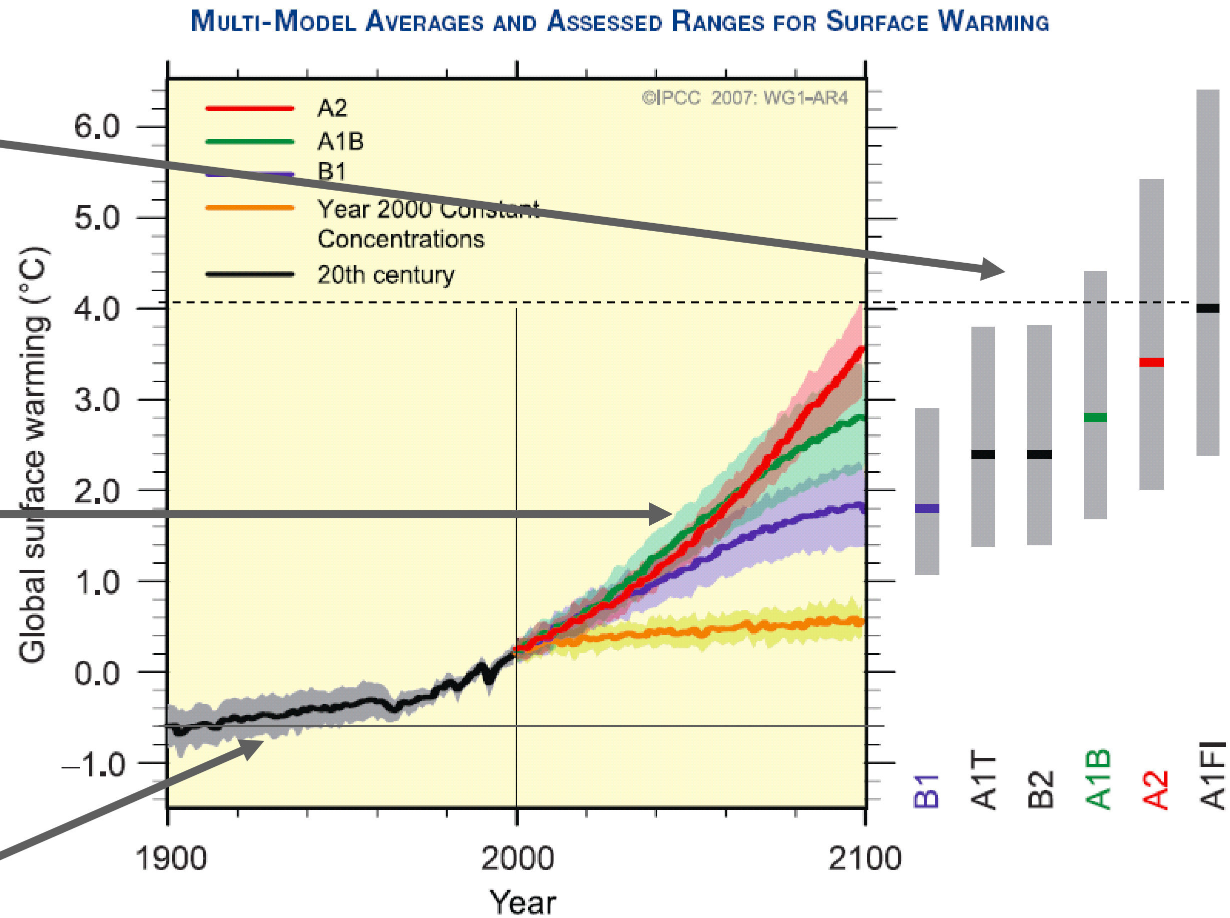

Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the* ***likely*** *range assessed for the six SRES marker scenarios. The assessment of the best estimate and* ***likely*** *ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints. {Figures 10.4 and 10.29}*

These are very different kinds of uncertainty(s).

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This one would, but we do not need GCMs to know that!

Would this count as a Big Surprise at 2100?

Model diversity plays out differently in mitigation and adaptation.

How well would today's models have informed decision for the previous century?

To what extent do the models agree with each other?

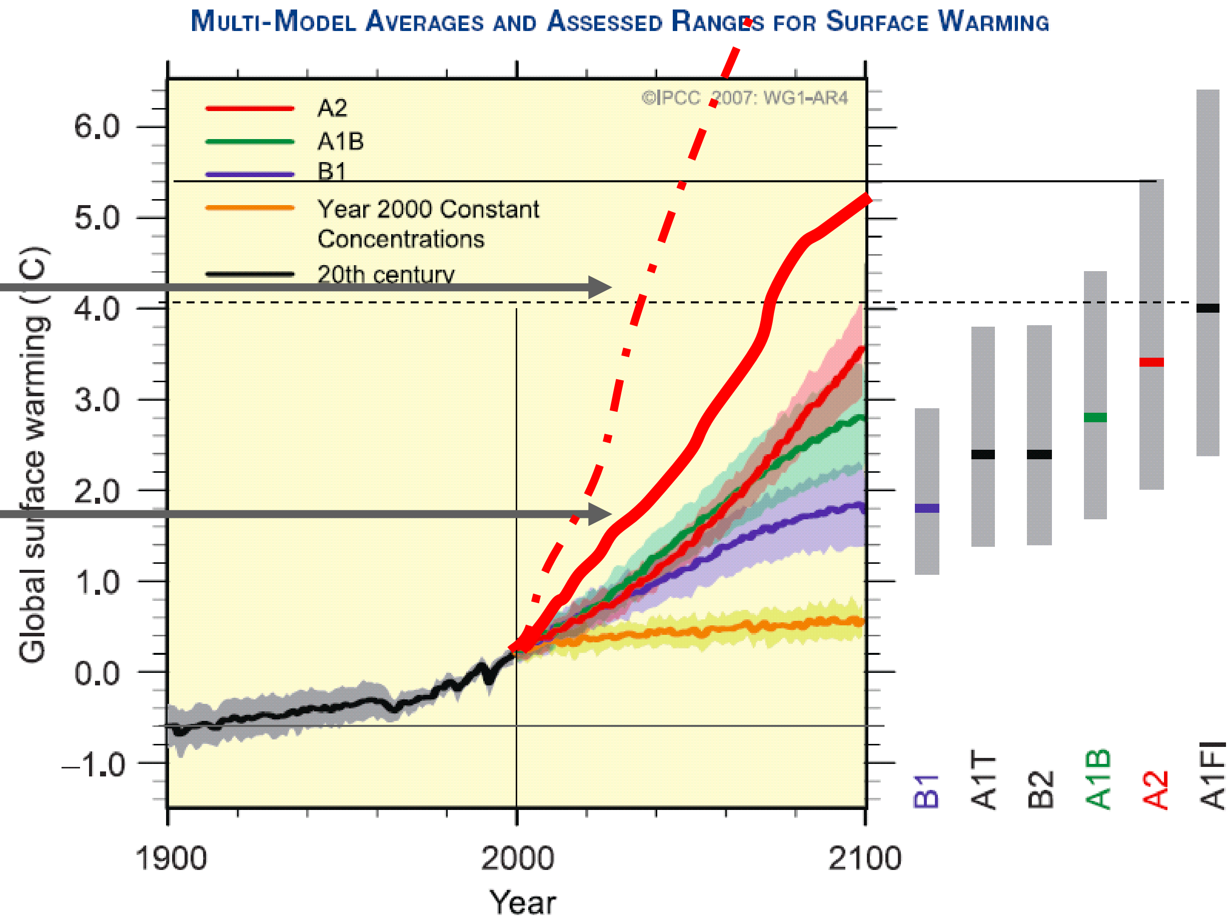

Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the* ***likely*** *range assessed for the six SRES marker scenarios. The assessment of the best estimate and* ***likely*** *ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints. {Figures 10.4 and 10.29}*

What is the value added of simulation models?

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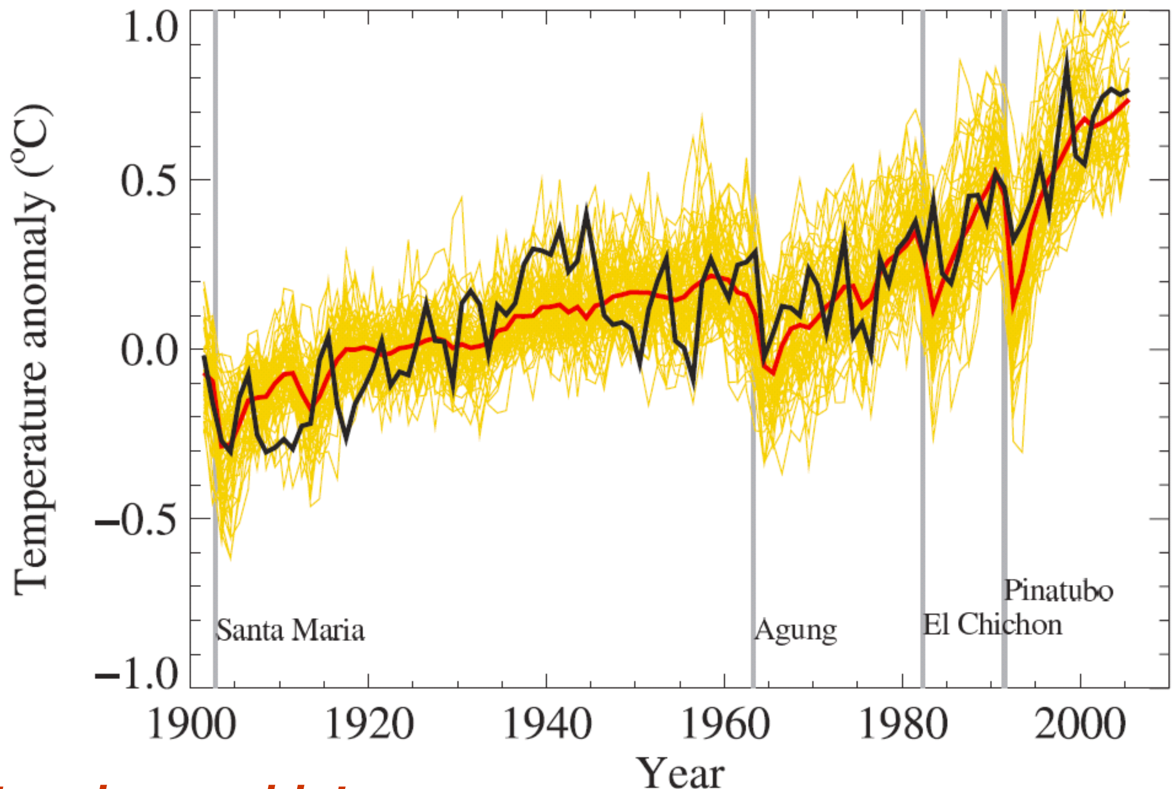
models to simulate important aspects of the current climate. Models are routinely and extensively assessed by comparing their simulations with observations of the atmosphere, ocean, cryosphere and land surface. Unprecedented levels of evaluation have taken place over the last decade in the form of organised multi-model 'intercomparisons'. Models show significant and

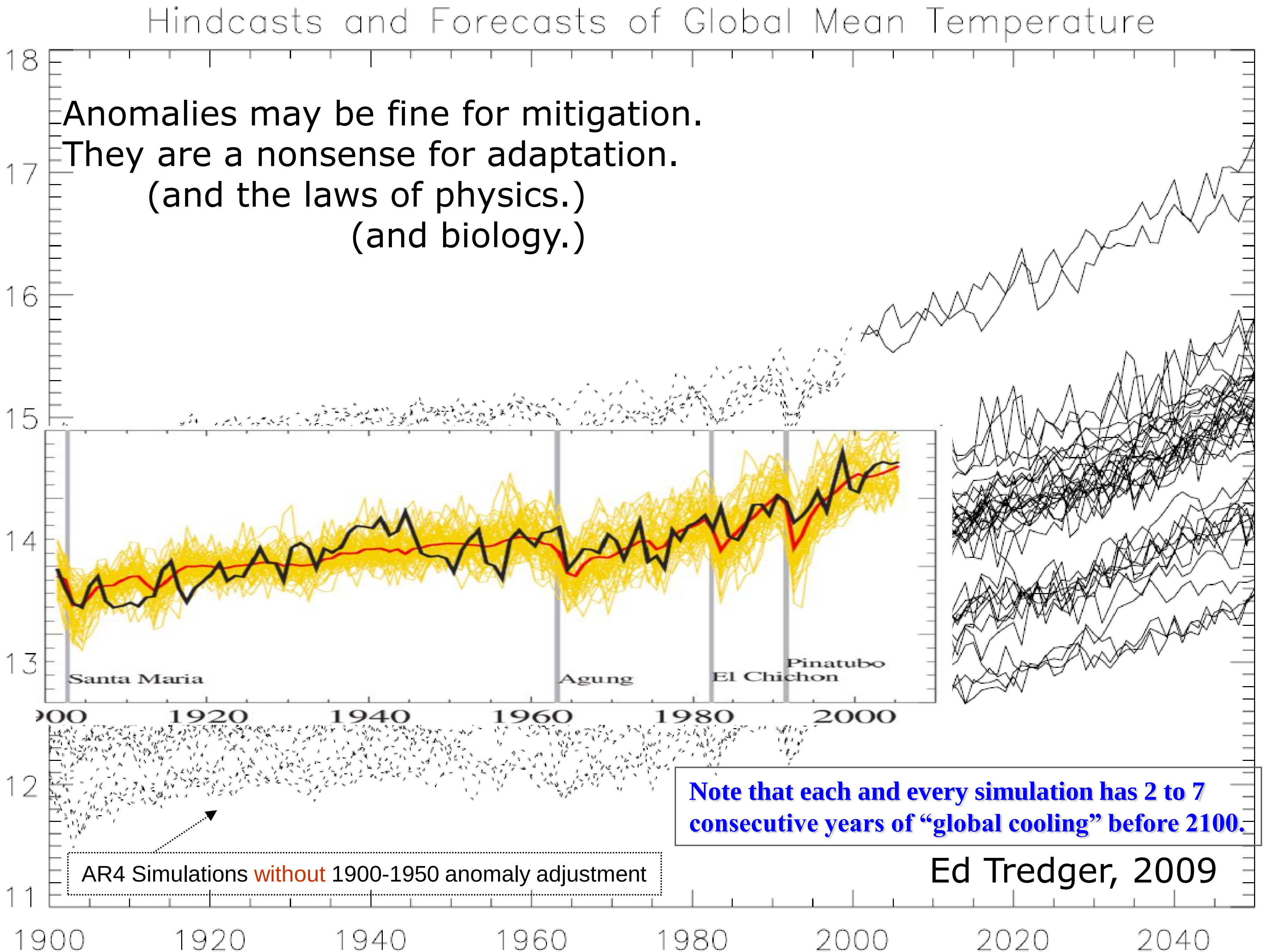
they represent the essential physical processes important for the simulation of future climate change. (Note that the limitations in climate models' ability to forecast weather beyond a few days do not limit their ability to predict long-term climate changes, as these are very different types of prediction – see FAQ 1.2.)

(continued)

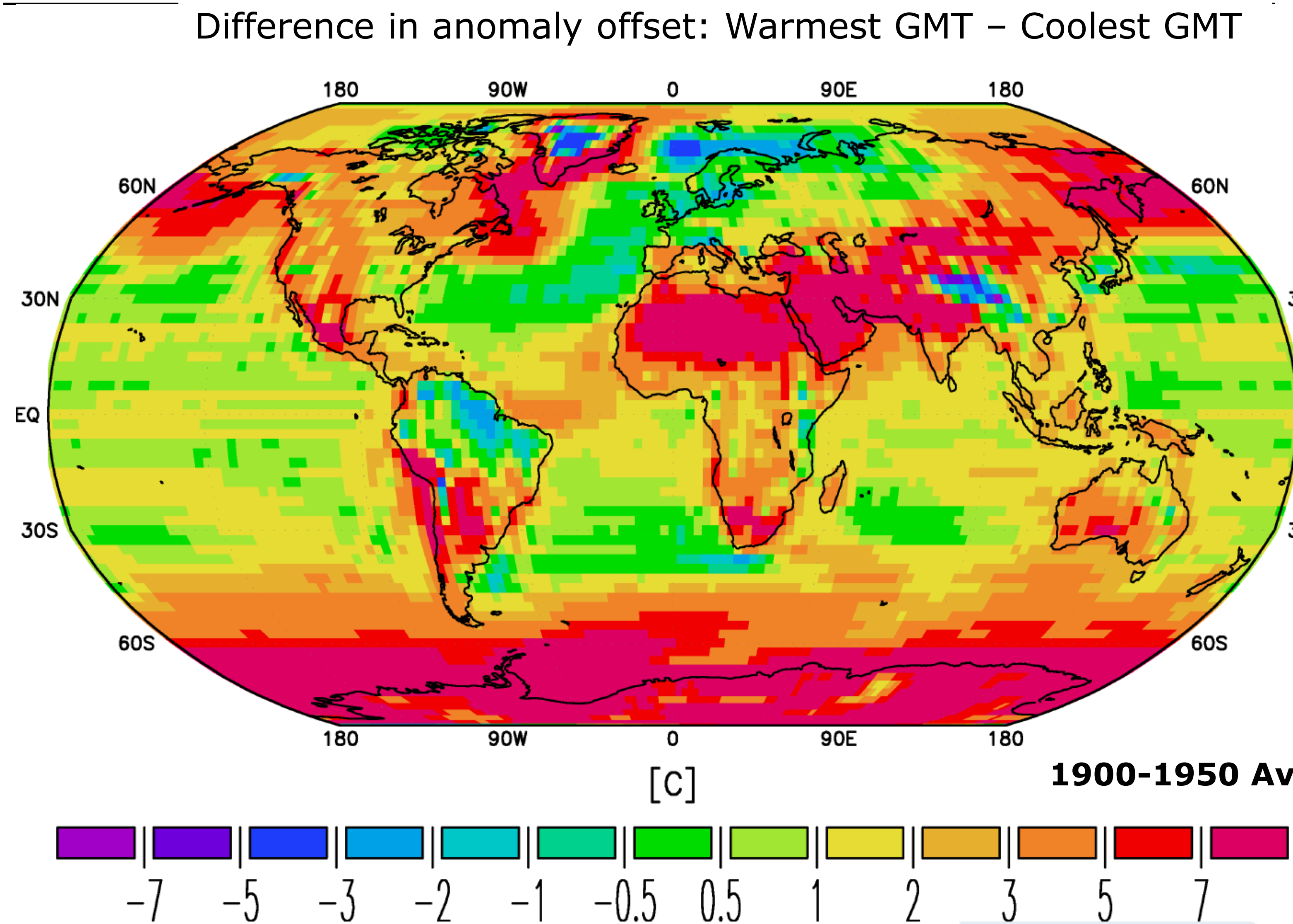
FAQ 8.1, Figure 1. *Global mean near-surface temperatures over the 20th century from observations (black) and as obtained from 58 simulations produced by 14 different climate models driven by both natural and human-caused factors that influence climate (yellow). The mean of all these runs is also shown (thick red line). Temperature anomalies are shown relative to the 1901 to 1950 mean. Vertical grey lines indicate the timing of major volcanic eruptions. (Figure adapted from Chapter 9, Figure 9.5. Refer to corresponding caption for further details.)*



All yellow yet NOT exchangeable!


Hindcasts and Forecasts of Global Mean Temperature
Anomalies may be fine for mitigation.
They are a nonsense for adaptation.
(and the laws of physics.)
(and biology.)
Santa Maria
Agung
El Chichon
Pinatubo
1920
1940
1960
1980
2000
Note that each and every simulation has 2 to 7 consecutive years of "global cooling" before 2100.
AR4 Simulations without 1900-1950 anomaly adjustment
Ed Tredger, 2009
18
17
16
15
14
13
12
11
1900
1920
1940
1960
1980
2000
2020
2040

How clear is our vision of a zero-degree warmer model-world?



1900-1950 Averages

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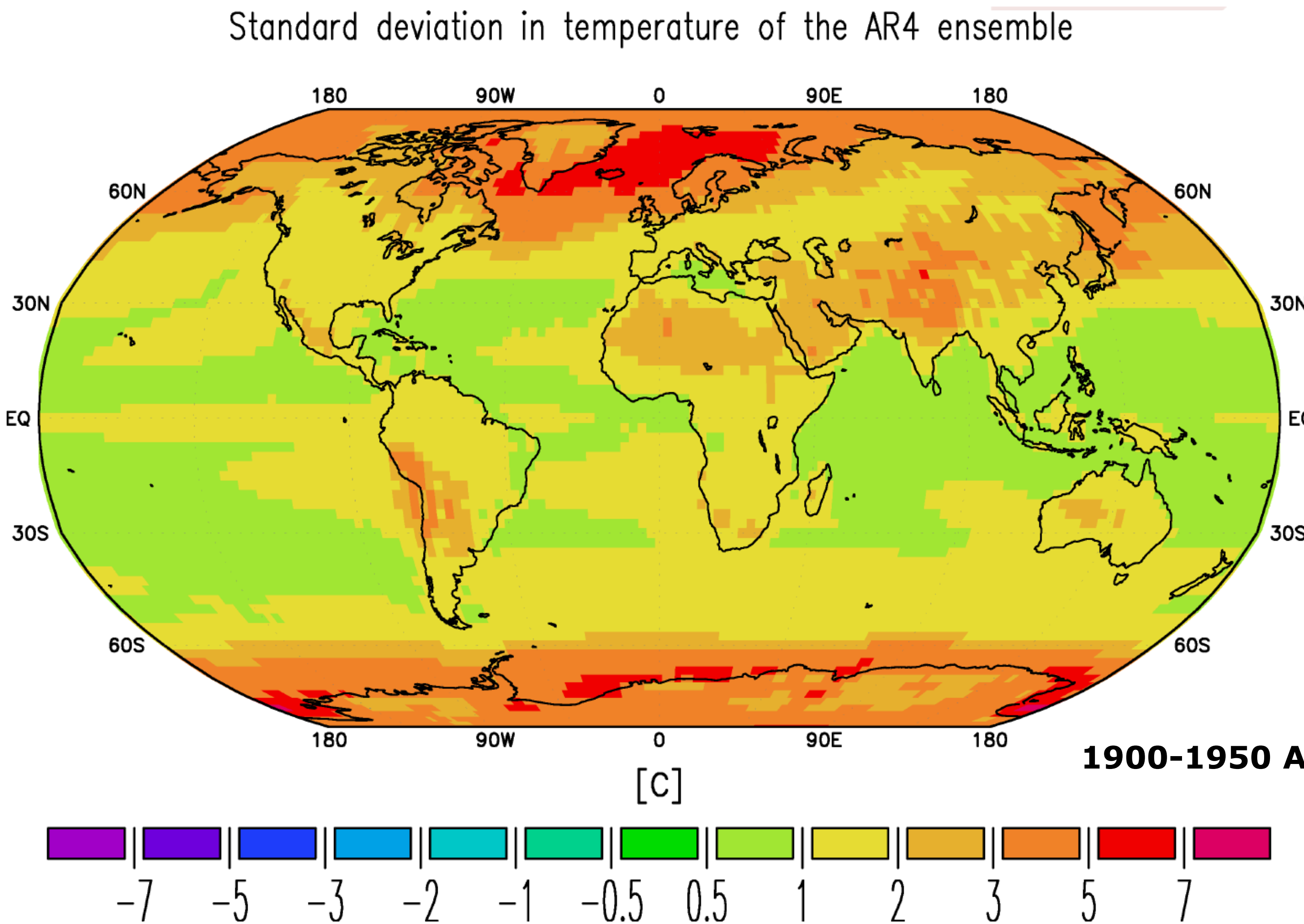
Impacts and physical processes are functions of temperature (not temperature anomaly).

How clear is our vision of a zero-degree warmer model-world?



1900-1950 Averages

Impacts and physical processes are functions of temperature (not temperature anomaly).

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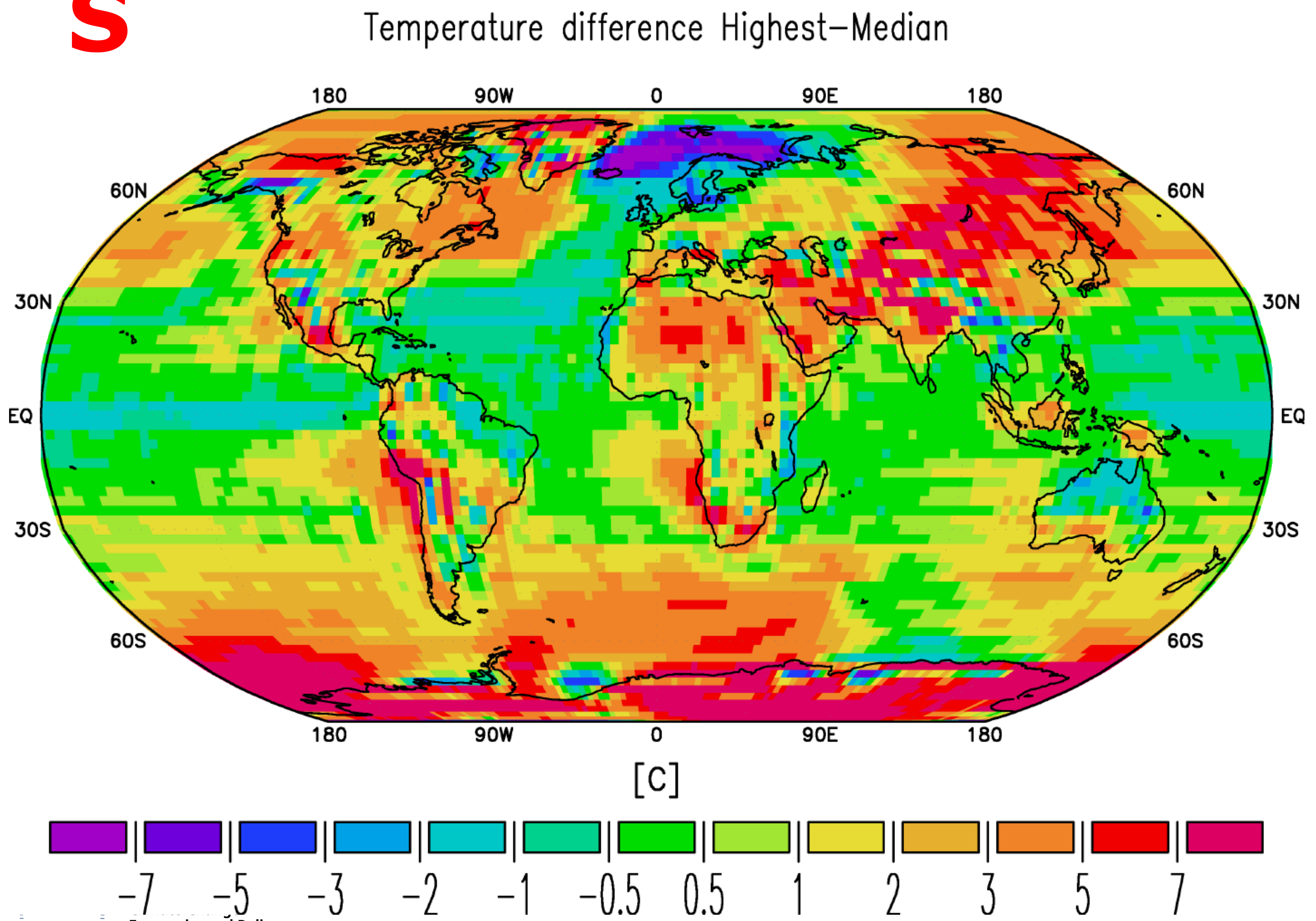
S



Economics and Policy

4+ degree Worlds, Oxford

Diversity of Freezing Locations

How clear is our vision of a zero-degree warmer model-world?

1900-1950 Averages

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Impacts and physical processes are functions of temperature (not temperature anomaly).

All Climate is Local

Anomalies may be OK for global changes, but they are a nonsense locally, both for adaptation and claims involving "the laws of physics".

Impacts and physical processes are functions of temperature (not temperature anomaly).

Ice melts at zero degrees,
Water boils at 100 degrees (at sea level)
Crops die at ….

Do you want to bet on robustness of:

Political reality, Physical reality, Model "reality"?
Can we avoid suggesting others bet on details our models are known to miss?

Things we know we cannot model: The 1930'sDust bowl

Would Advance Knowledge of 1930s SSTs Have Allowed Prediction of the Dust Bowl Drought?*

Richard Seager, Yochanan Kushnir, Mingfang Ting, Mark Cane, Naomi Naik, and Jennifer Miller

Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York

This hypothetical drought prediction would have been of limited success because of differences in the modeled and observed patterns.

We should expect Big Surprises when using model-probabilities to anticipate future events similar to those our models do not capture well in the past (where the models have the historical Sea Surface Temperatures!)

Why is decision support here hard?

The question requires information on exceeding user-defined thresholds.

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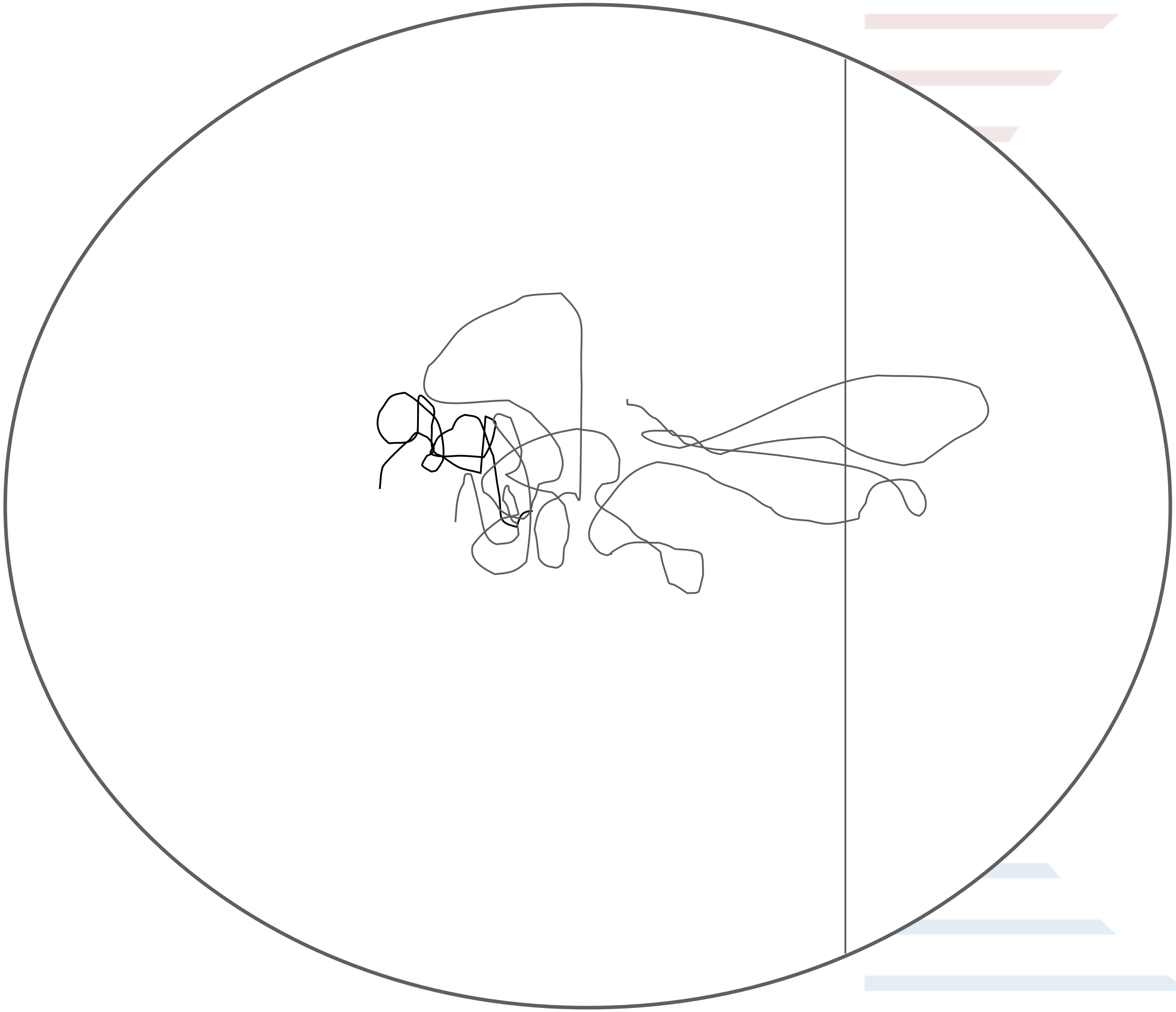
Most decisions depend neither on ***"average meteorological variables"*** nor ***"standard deviation of the average weather"*** they depend on the trajectory.



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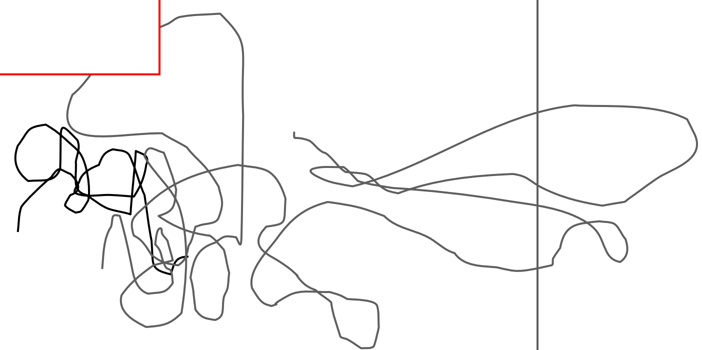
As they are nonlinear we have to evaluate them along trajectories. Crops, cables, wind energy and system failures depend on what and even when weather events unfold.

We need to communicate whether or not we believe current models can provide robust, relevant and informative quantitative information on decision relevant distributions:
Prob(Big Surprise)



Loss of pub kitchen
Crop loss/Power-plant shutdown
Two Cat 5 hurricane US landfalls
Cable overload London brownouts

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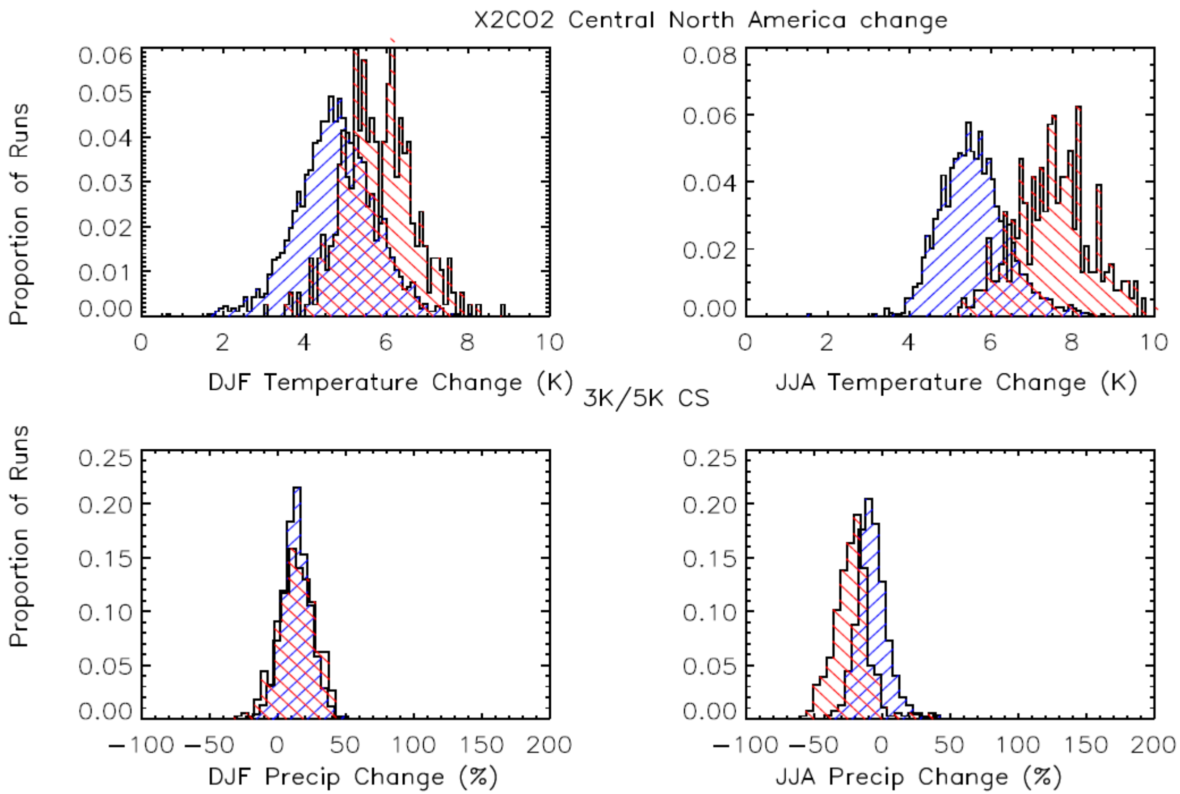
Acknowledges the limits, examine model diversity:

Look at the range of local temperatures for a given model-GMT?

Is downscaling sensible?

For Policy and Decision Support: All climate change in local!

What's the chance a 3 degree globally is "worse" than 5 degrees?



For Central North America, for instance, there is about a one in five chance that a random draw from CS=3 is hotter than one from CS=5

Assuming the model is relevant!

Distributions for Giorgi regions
CS = 3 +/- 0.1 runs (1835) in blue
CS = 5 +/- 0.1 runs (385) in red
Final 8 year means (years 8-15), Phase 3 – Phase 2.

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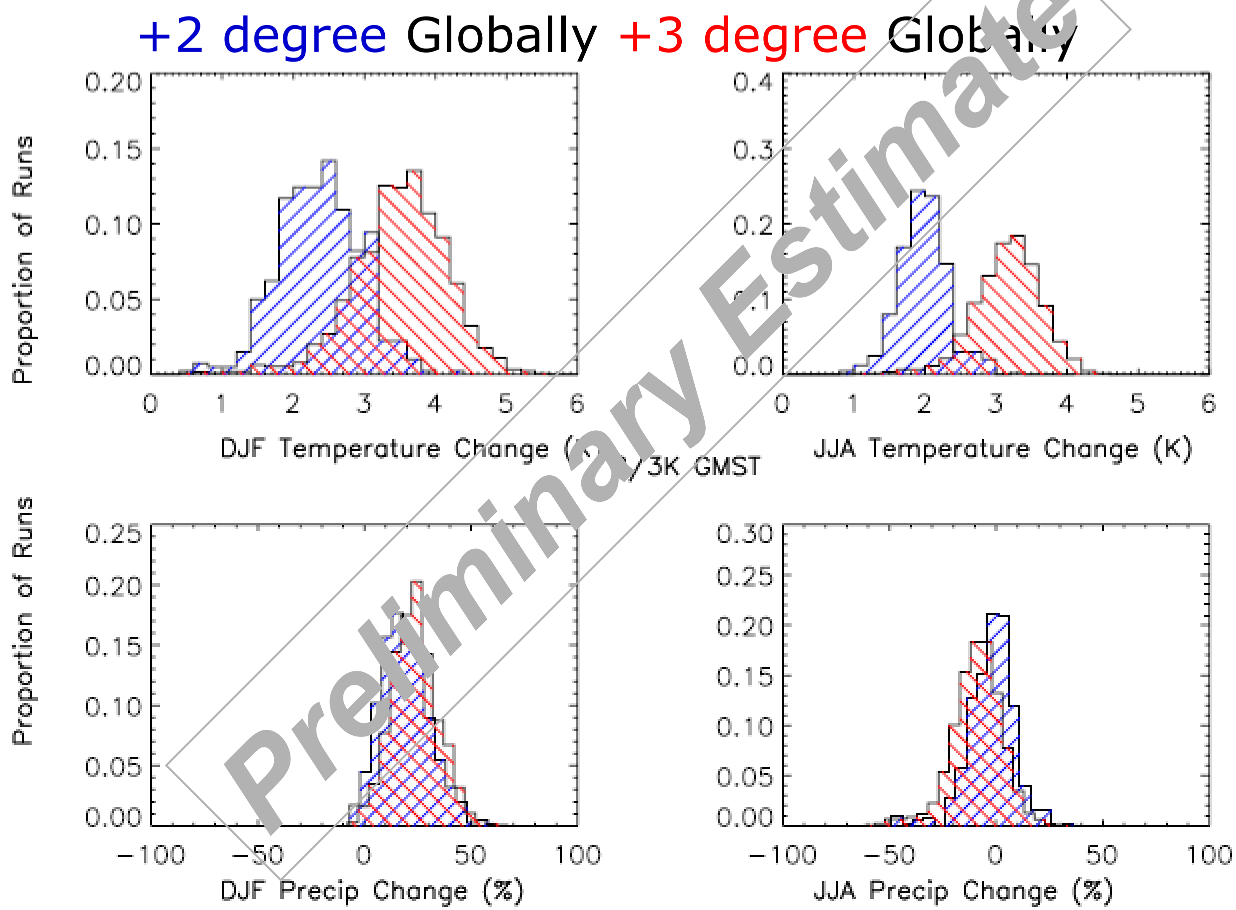
climateprediction.net

Mapping global temperature to local impacts

Variations in UK seasonal temperature For fixed change in global mean temperature.



Here is the UK figure. 8 year mean seasonal p3-p2 uk temp and precip change for UK region (mean over 6 grid boxes as shown in uk_map.ps).

The overlap probabilities are :
DJF temp - 9%
JJA temp - 2%
DJF pr - 37%
JJA pr - 67%

Assuming the model is relevant!

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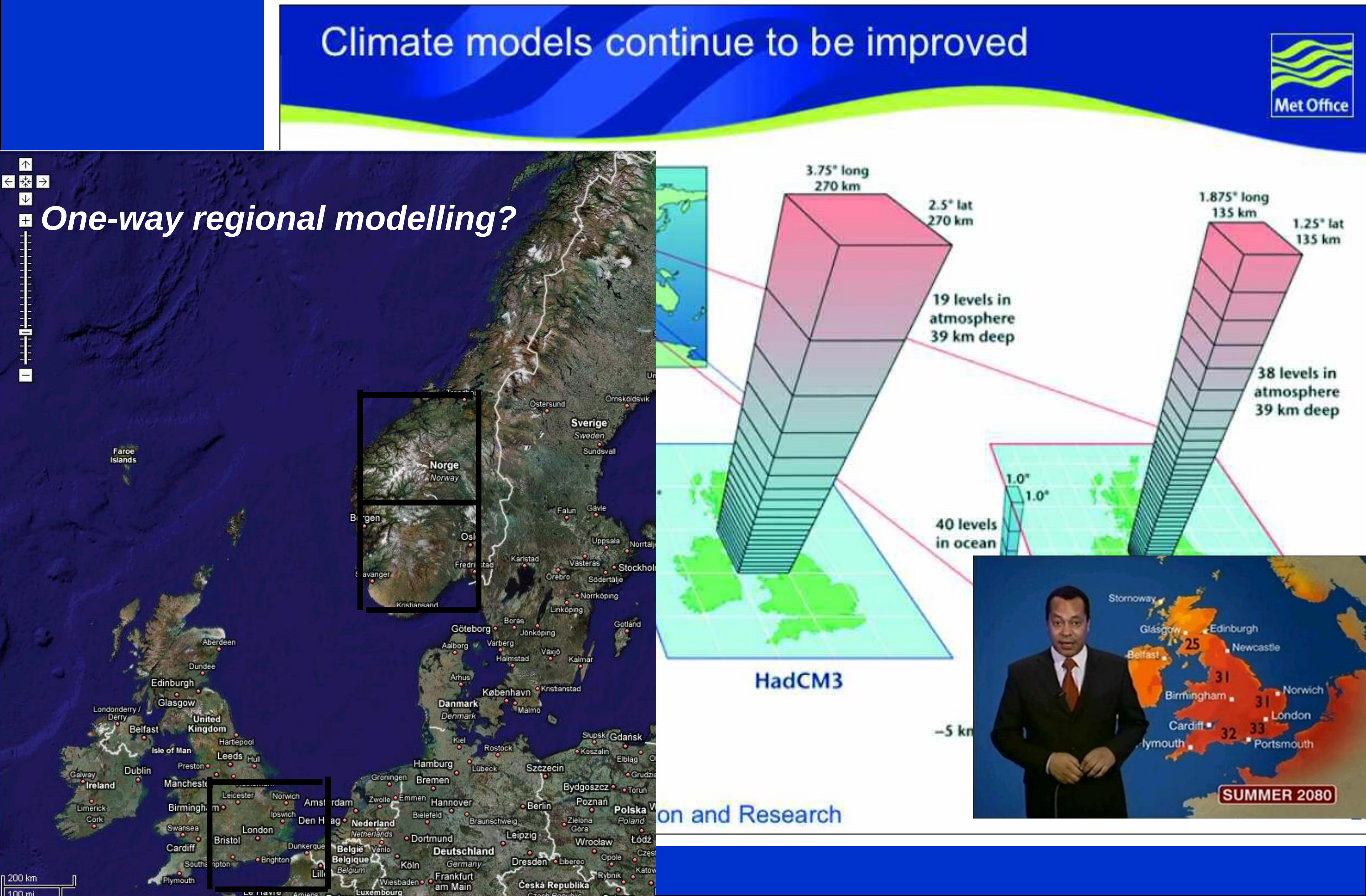
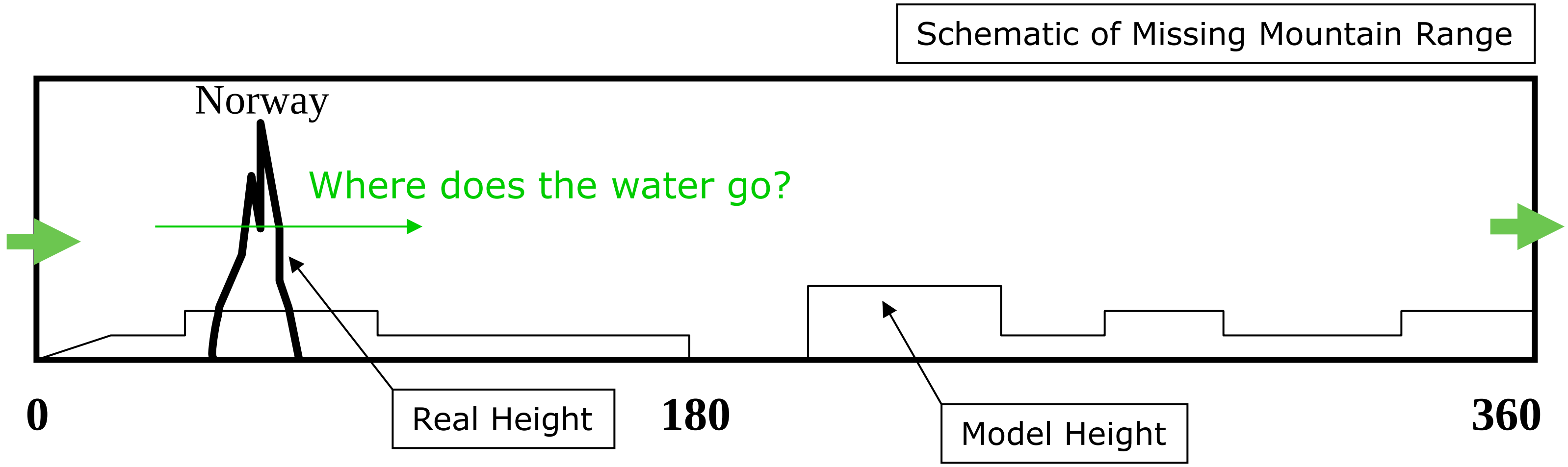
climateprediction.net

On what space and time scales *do* we have (robust) climate information?
(The usual numerical arguments require much larger scales than the model's grid, at least!)



Sciences knows more than we can Model

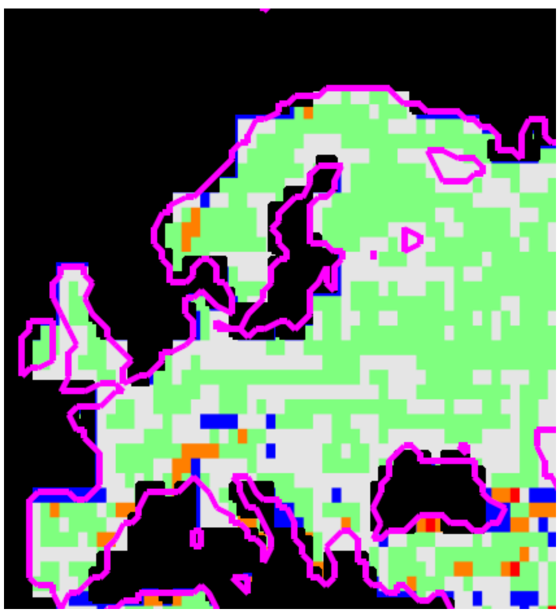


Before using phrases like "based on the Laws of Physics" to defend hi-resolution predictions, we might check for internal consistency (quantitative).

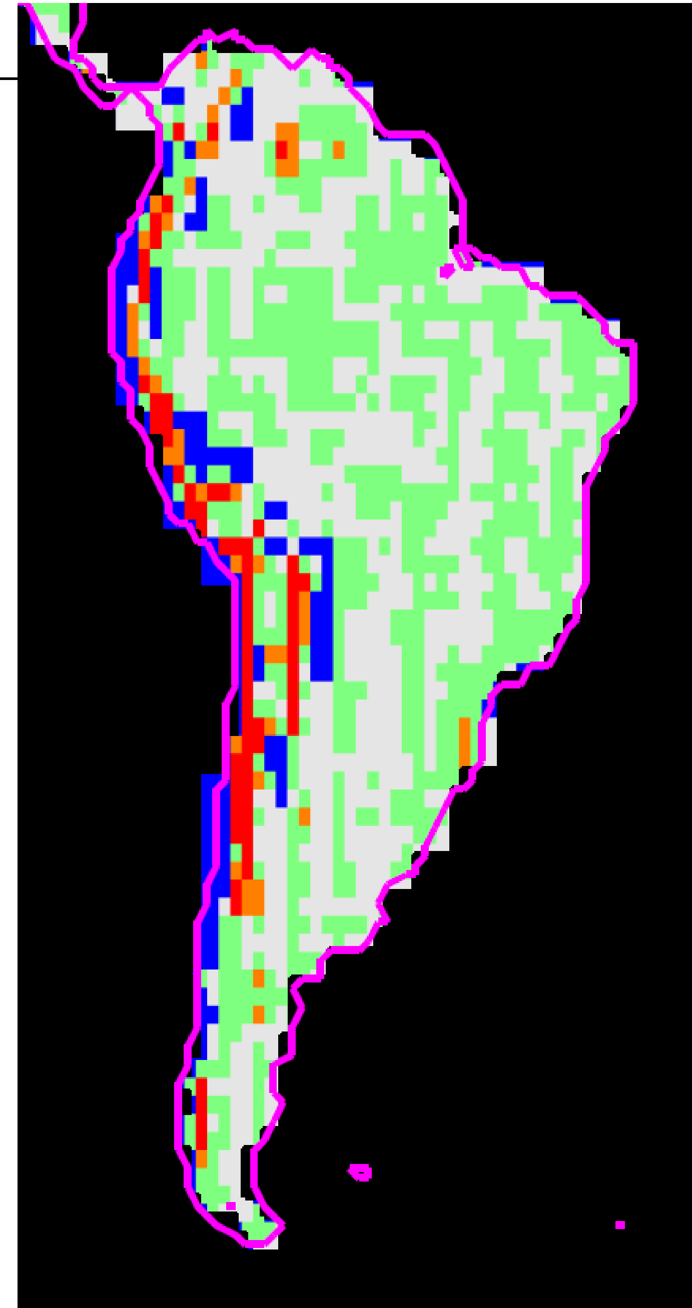
Or better: find necessary (not sufficient) conditions for this model to contain decision relevant information.

Not "how to downscale?" but "whether to downscale?"

Missing Mountain Ridges



Observed minus HADCM3 Height



Blue < -500m
Grey > -500m
Green > 250m
Orange > 500m
Red > 1 km

Orange and red lines correspond to walls which water vapour must go over or around, walls which are missing in this climate model.

(Walls > 500m and > 1km!)

Resulting changes in the downstream dynamics cannot be “fixed” statistically.

Continent outlines: National Geophysical Data Center,NOAA 88-MGG-02.via matlab
Hadcm3 model topography http://www.ipcc-data.org/sres/hadcm3_topo.html
1x1 topography: http://www.ngdc.noaa.gov/mgg/topo/globe.html.

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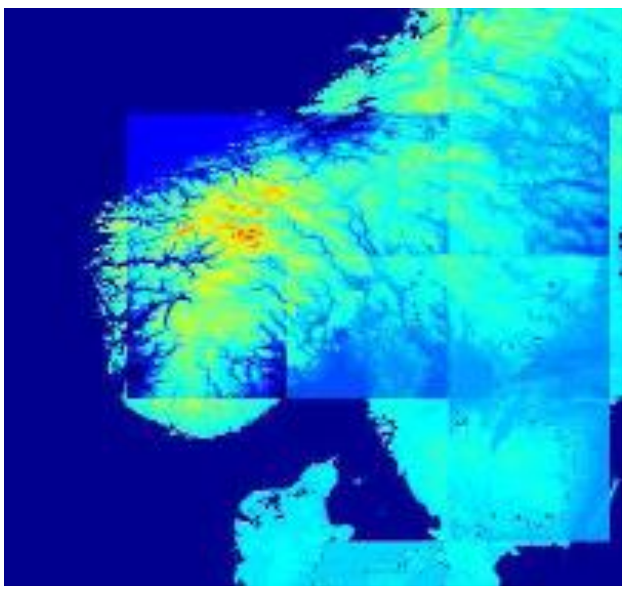
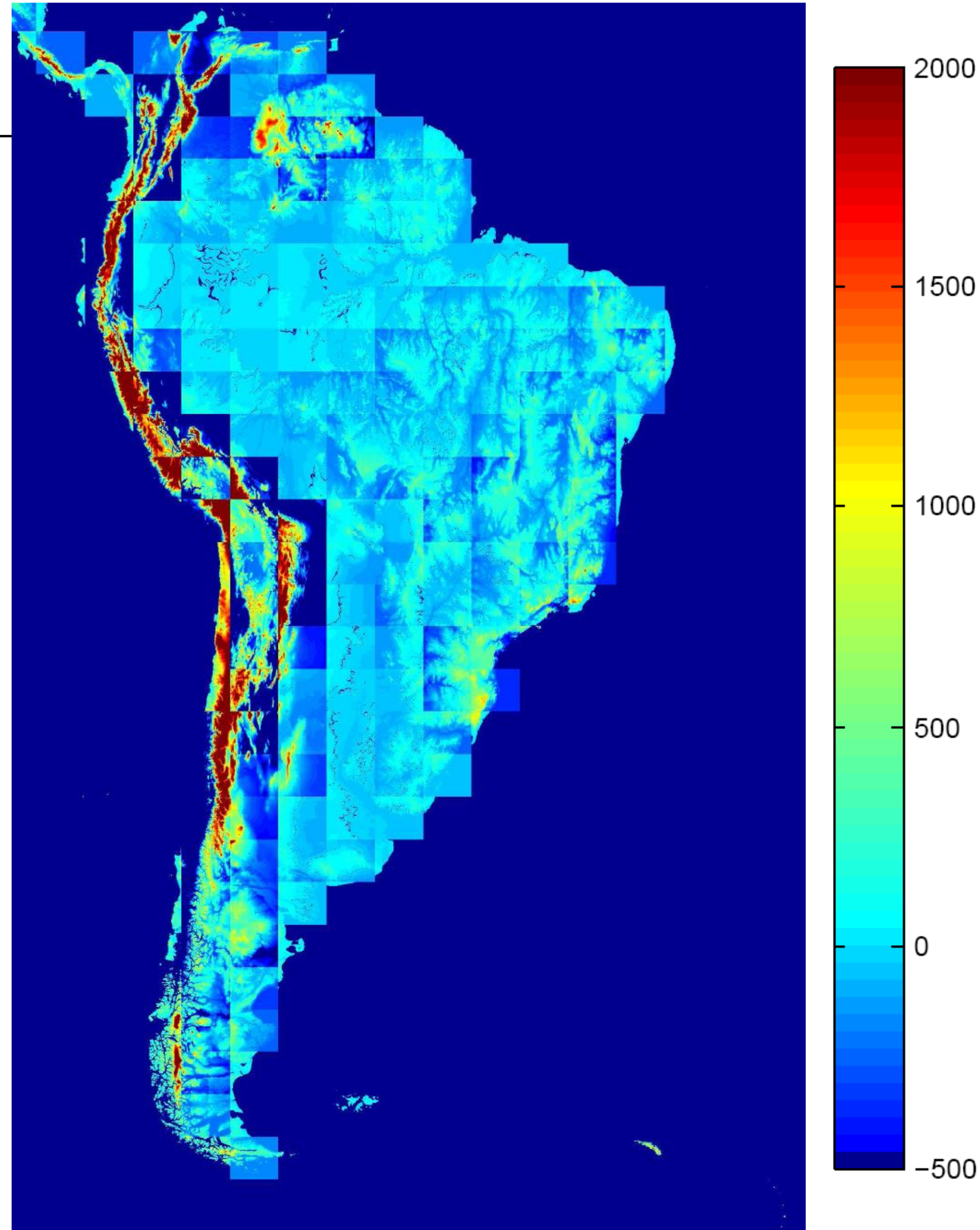
These are not small errors.

At what lead times do inadequacies in downstream flow (or precipitation) result in feedbacks with beyond local impacts?





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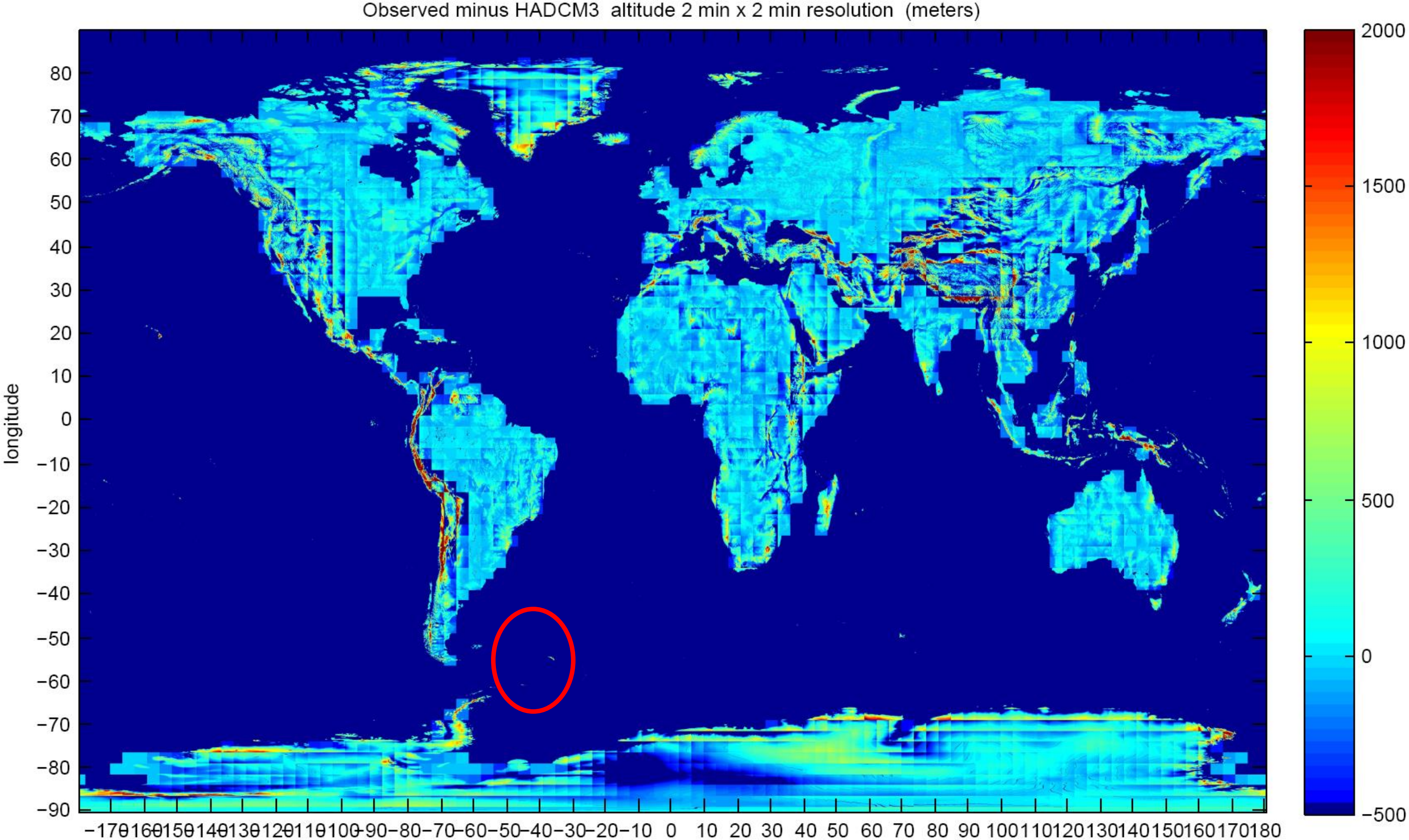
Common, nontrivial, systematic errors



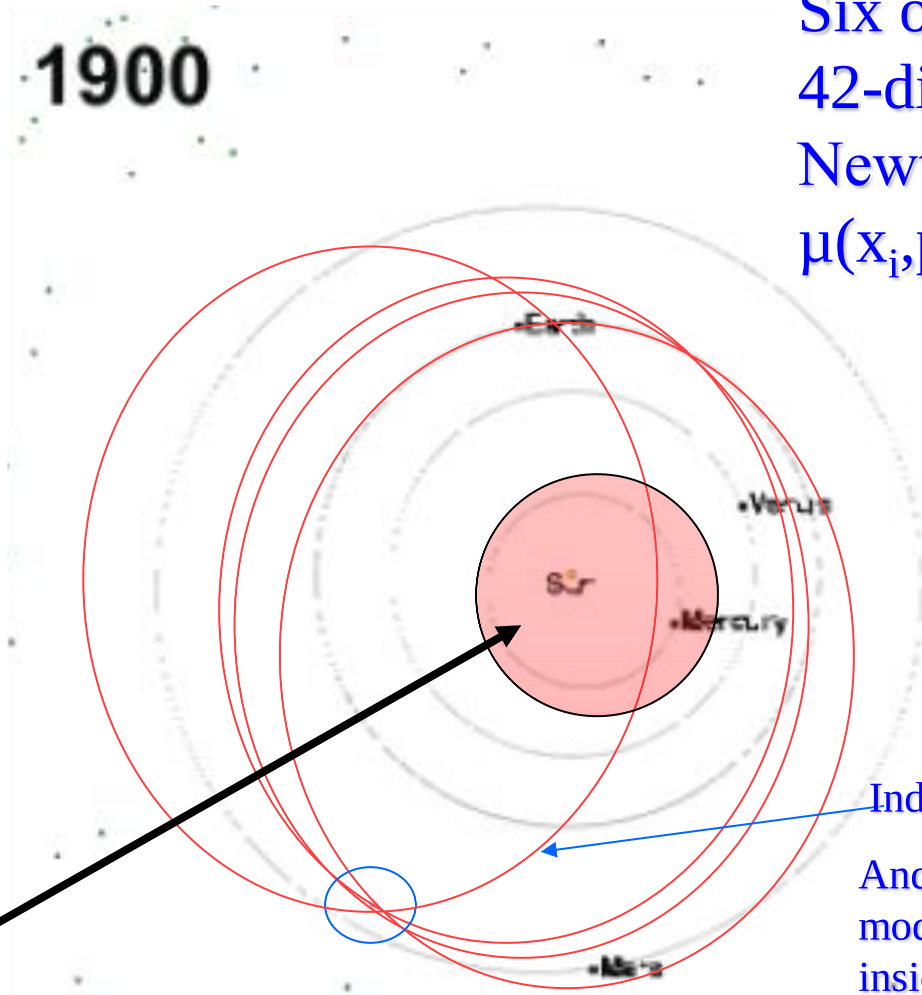
The probability of Earth impacts in 10000 years

The question of quantitative model relevance is a generic problem.

We can Newton's laws to generate orbits based on uncertainties.

Is Prob(Big Surprise) ~ 0?

Newton fails too close to the sun or where mercury might be!



Six objects,
42-dimensional space,
Newton's Laws
$\mu(x_i, p_i, m_i, G)$

Individual model trajectories can fail!

And **discrepancy** based on Newtonian models **will not help** (at least not inside the simulation approach)

What do I do if I lose 12% of my simulations this way?

I can easily know my model (class) is inadequate here, without knowing how/being able/ to improve it: what value do ensemble simulations add in this case?

Advantages of unleashing the "Big Surprise"?

- Big Surprises arise when something our models cannot mimic turns out to have important implications for us.
- Climate science can (sometimes) warn us of where those who use naïve (if complicated) model-based probabilities will suffer from a Big Surprise.

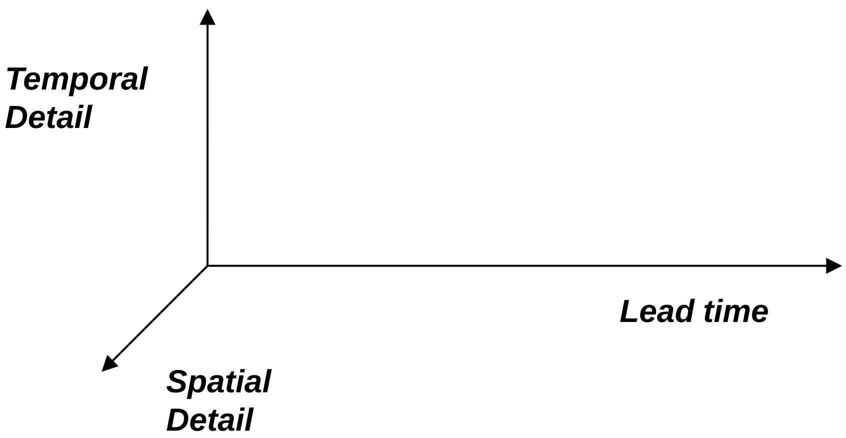
  (Science can warn of "known unknowns" even when the magnitude is not known)
- Big Surprises invalidate (not update) the foundations of model-based probability forecasts. (Arguably "Bayes" does not apply, nor the probability calculus.)

(Failing to highlight model inadequacy can lead to likely credibility loss)

Including information on the Prob(BS) in every case study allows use of probabilities conditioned on the model (class) being fit for purpose without believing it is.

(or appearing to suggest others should act as if they do!)

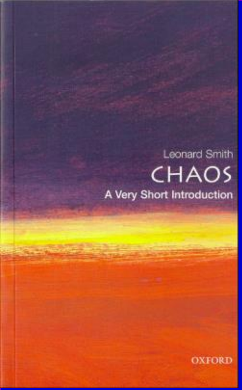
Questions



What do contours of Prob(BS) look like?
Where does 100 km, weekly, rainfall fall?
Near which contour does the most robust 4 degree model-world fall?

"When you have eliminated all which is impossible, then whatever remains, however improbable, must be the truth."
Sherlock Holmes, The Blanched Soldier
"Whenever you have eliminated the impossible, whatever remains, however improbable, must be true."
Spock

(or there was something we left out: what is P(missed something)?



Background Reading:

LA Smith(2002) *What might we learn from climate forecasts?* P. Nat. Acad. Sci (99)

LA Smith (2003) *Predictability Past Predictability Present. Predictability and Weather Forecasting* (ed. Tim Palmer, CUP).

LA Smith (2000) *Disentangling Uncertainty and Error*, in Nonlinear Dynamics and Statistics (ed A.Mees) Birkhauser.

Stainforth et al (2005) *Uncertainties in Prediction of Climate response*. Nature.

Stainforth et al (2007) *Uncertainty & Decision Support*. Phil Trans Roy. Soc. A,1098

LA Smith (2007) *A Very Short Introduction to Chaos*. OUP

Nancy Cartwright (1983) *How the Laws of Physics Lie*. OUP

www.cccep.ac.uk

L.Smith@lse.ac.uk

When in doubt, distrusting the indications, or inferences from them (duly considered on purely scientific principles, and checked by experience), the words "*Uncertain*," or "*Doubtful*," may be used, without hesitation.

Fitzroy, 1862

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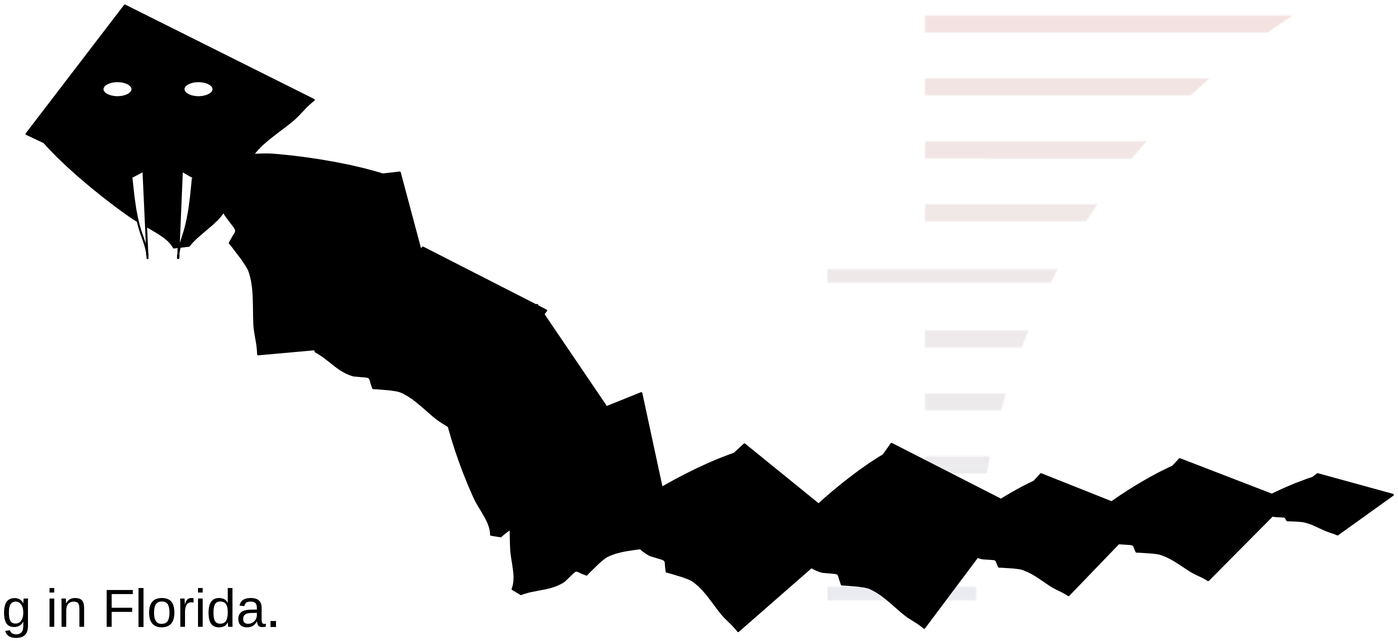

We are walking in Florida.
You find you have just been bitten on the hand by a snake.
We did not see the snake.
If it was the deadly carbonblack snake, the bite will kill you in a painful way, unless you cut off your hand within 15 secs.
I have a hatchet.
You have 5 seconds left.
Did you cut off your hand?

How would a society learn to make such decisions?

Luckily with climate change we have more than 15 seconds.
Without knowing exactly how much more…

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Overview

- Today's models share systematic er

- appear unlikely to provides quantitative decision-relevant probabilities regarding what we might see, evidence is required for each decision (and would be welcome!)

Things we know we cannot model: The 1930'sDust bowl

Would Advance Knowledge of 1930s SSTs Have Allowed Prediction of the Dust Bowl Drought?*

RICHARD SEAGER, YOCHANAN KUSHNIR, MINGFANG TING, MARK CANE, NAOMI NAIK, AND JENNIFER MILLER

Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York

As noted earlier, the overestimate of intensity of the modeled Dust Bowl drought in the southern plains and northern Mexico is attributable to model error. Errors in the temperature simulations are consistent with being the result of errors in the precipitation simulation.

It is extremely valuable for scientists to be this blunt about model error!

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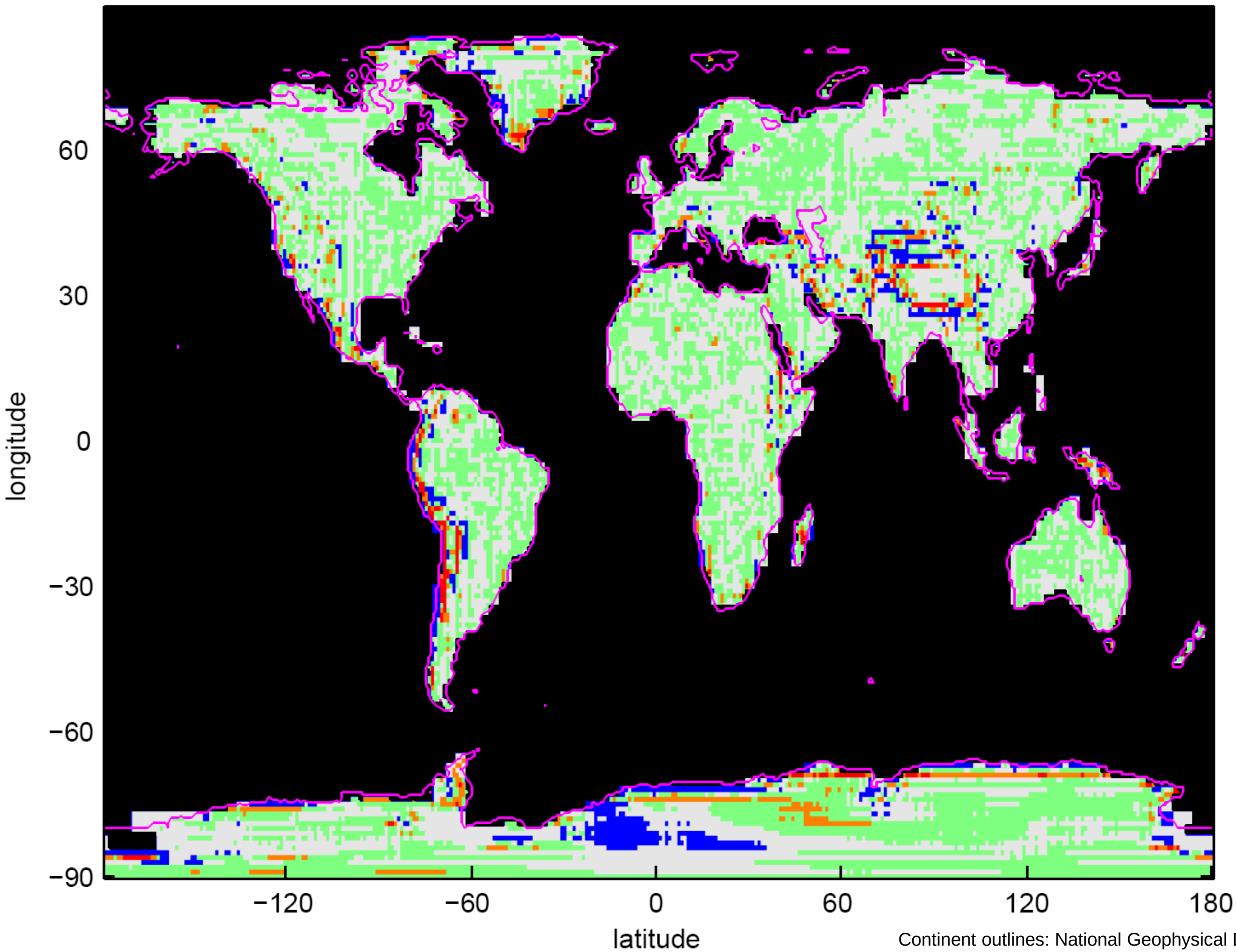
Missing Mountain Ridges

Observed Height minus HADCM3 Height



Blue < -500m
Grey > -500m
Green > 250m
Orange > 500m
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Continent outlines: National Geophysical Data Center,NOAA 88-MGG-02.via matlab
Hadcm3 model topography http://www.ipcc-data.org/sres/hadcm3_topo.html
1x1 topography: http://www.ngdc.noaa.gov/mgg/topo/globe.html.

For mitigation, do I always need to know the probability?

I am flying to the Germany next week..
If an engineer says my plane will fall out the say over Europe,
I do not ask her “where exactly”.
And I certainly do not plan to fly if she cannot tell me where!!
I plan not to fly.

And if I must fly?
If she tells me that at a cost of twice my ticket, she can cut the probability from 10% to 1%,
or from 1% to 0.1%
or from 0.0000000001% to 0.00000000001% ?

Do I care if she is not sure whether it is from 50% to 5%, or if it is from 10% to 1%?

No, as long as the chance is not vanishingly small already!

And there are huge costs (to me) associated with waiting:
The Cost (to me) of doing something once my plane has taken off is much higher than doing something now.

These facts ease mitigation decisions.

The risk of an irrelevant Discrepancy:

The Climate-Bayesians reply is to take several models and compute the discrepancy:

- Runge-Kutta 6th order
- Runge-Kutta 4th order (smaller time step)
- Predictor-corrector
- Hamiltonian (numerically exact energy conservation scheme)

In the case of Newton's Laws, this is a misleading lower bound.
And was known to be so in 1920!

Might one rationally believe:
"relationships between *model errors* for different climate variables can reasonably be expected to follow relationships between *inter-model differences* for different variables." Murphy et al 2007
"are unlikely to be fundamentally compromised"
?@ 5 km, hourly extremes of precip in 2080? In Y2007 models?

I will next argue "no", first generically for Physics, then for Y2007 GCMs, and then suggest question areas for the SAMSI working group.

The Diversity of our models does not reflect the uncertainty in our future.

This does not imply climate change is not happening.
(It may well be worse than today's models suggest!)

This is not an attack on Bayesian methodology.
Prob(Moon made of Swiss Cheese | Moon is made of cheese)
[NOT a question of probability calculus –or- a frequentist bias]
more a question of interpreting model noise as if it were signal.

This does not imply ensembles are uninteresting!
I am in part responsible for the largest ensemble of climate models ever run (and I just launched 512 more last week!)

This has nothing to do with a need/desire for "perfect models"!

This does not imply that there is nothing to do!
(But it does suggests care in designing the questions.)

I am flying to the UK tomorrow.
If an engineer says my plane will fall out the say over the Atlantic tomorrow, I do not ask her "where exactly".
And I certainly do not plan to fly unless she can tell me!
I plan not to fly.

And if I must fly?
If she tell me that at a cost of twice my ticket, she can cut the probability from 10% to 1%,
or from 1% to 0.1%
or from 0.0000000001% to 0.00000000001% ?

Do I care if she is not sure whether it is from 50 to 5, or if it is from 10 to 1?

No, as long as the chance is not vanishingly small already!
And there are huge costs (to me) associated with waiting:
The Cost (to me) of doing something once my plane has taken off is much higher than doing something now.

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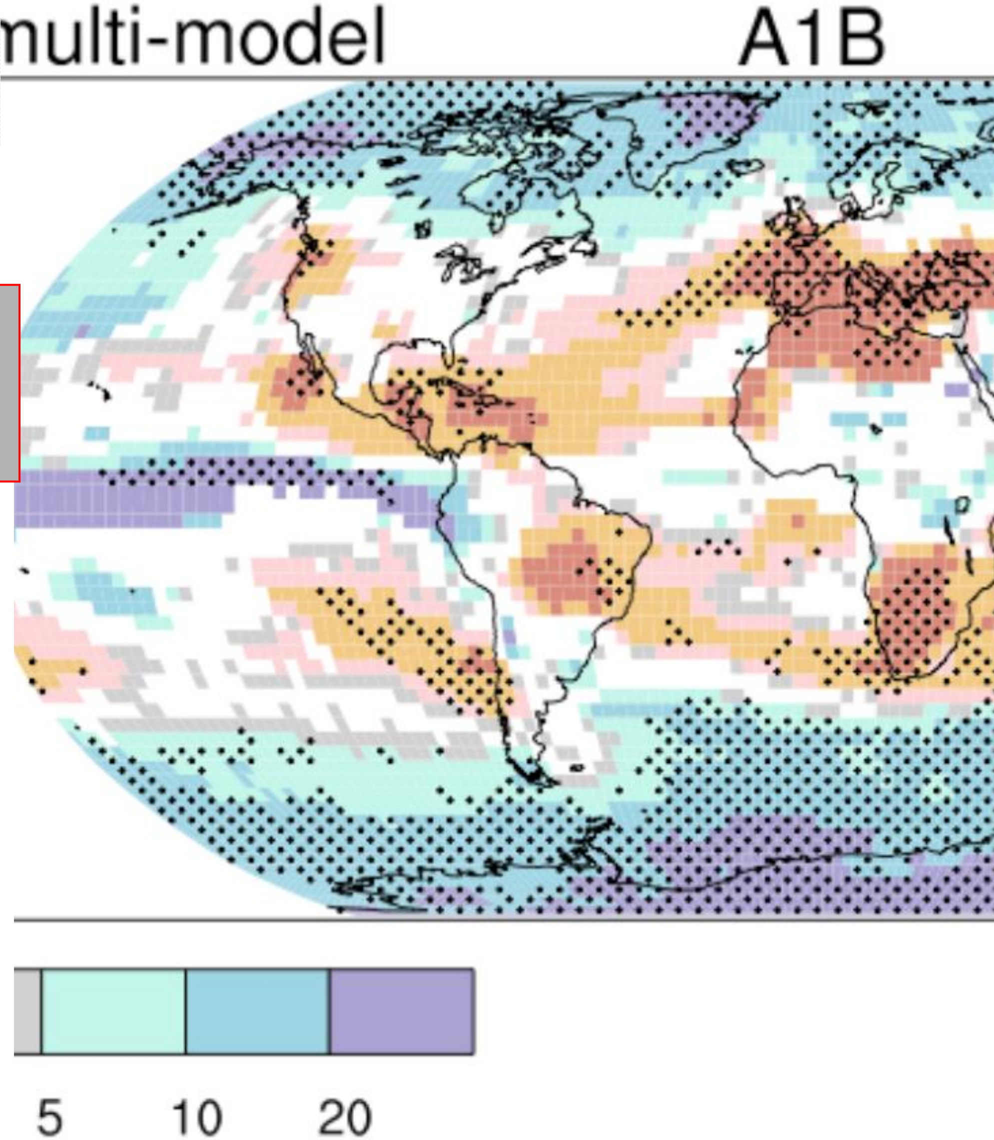


UK Climate Impacts Programme

UKCIP08 will provide climate change scenarios for the UK :

- for 25 x 25 km grid squares, plus some aggregated results for administrative regions and river catchments

- The weather generator will allow future time daily (and sub-daily) time-series to be simulated, which will be of use to any user who is interested in daily weather variables, thresholds and sequences or extreme events.

events.

- relative to a baseline period of 1961–1990
- including extra information such as marine scenarios and changes to river flows

UKCIP02

FIGURE SPM-7. Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}

So what does a physical model tell me?

(In what sense can we "get the average" right?)

Consider this case:

Physical simulation models do not tell us about our Earth, (they are far too simple), rather they tell us about properties the "average planet"; average over those even remotely like Earth are likely to share.

So the energy balance model applies equally well to the Mars, and very well to the Moon: the parameter values that change are not "fit" but specified.

Similarly: The robust properties of GCMs are those shared with planets like Earth but, say, without Iceland, or the Andes, or a highly variable ocean… or where ice is less interesting/more viscous…

The "better" the model, the more Earth-like the class of planets are; but it would be a fundamental mistake to take the diversity of these "planets" to reflect the uncertainty in our's in any detailed quantity. Especially as we know a priori that our Earth is an outlier in that set. (without knowing exactly how/why)

What is a "Big Surprise"?

Suppose there is an SAMSI meeting in 2109 to discuss the IPCC AR21

We have 2100 hardware, and knowledge of the "emission scenario"

We can reproduce (shadow) climate change from 1900 till 2100 with good fidelity relevant to the insurance sector (using 2100 hardware)

We contrast our 2100 results with climate models available in 2009: What is the chance that events of high impact on the insurance sector happened? Things that we then understand, but which UKCP09 simply could not have foreseen using the model **structures** available on the hardware available in 2009?

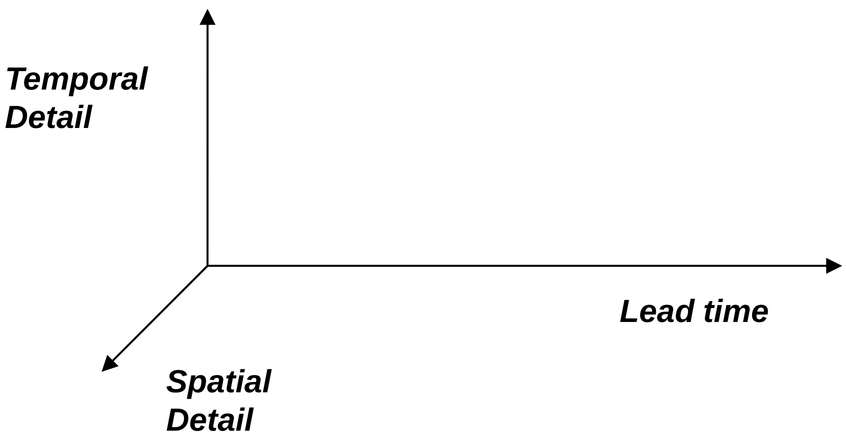
In short:

What is the probability of a Big Surprise (in 2012? 2040? 2090?) for UKCP users?

How is one to use UKCP numbers for quantitative decision support when Prob(BS) is not small?

(First note: climate scientists in 2009 can often say Prob(BS) is **not** small).

Questions



What do contours of P(BS) look like?
Where does 100 km, weekly, rainfall in 2030 fall?

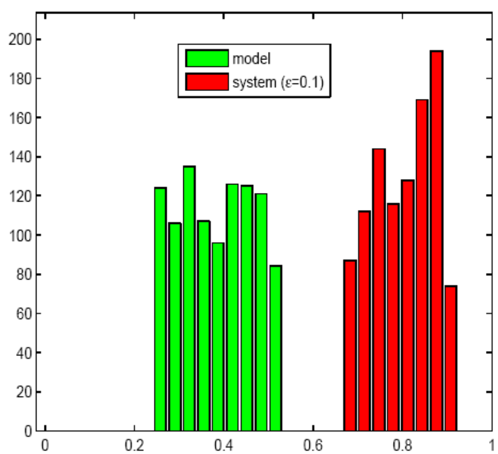


Figure 5: 8-step forecast using system and model, 1024 initial condition ensemble is constructed by random draw around 0.759 using $U(0, 2^{-10})$

Model Logistic Map: $l(x) = 4x(1-x)$
Quartic Map: $q(x) = \frac{16}{5}x(1-2x^2+x^3)$
System: $F(x) = (1-\epsilon)l(x) + \epsilon q(x)$ with $\epsilon = 0.1$

Please accept for a moment that Model Inadequacy makes probability forecasting irrelevant in just the same way that Chaos made RMS error irrelevant. If so:

How might we guide progress?

How might we inform society?

444 *Admiral Fitz-Roy* [March 28,

Are these just old unfair criticisms?

WEEKLY EVENING MEETING,

Friday, March 28, 1862.

John Peter Gassiot, Esq. F.R.S. Vice-President, in the Chair.

Rear-Admiral Fitz-Roy, F.R.S.

An Explanation of the Meteorological Telegraphy, and its Basis, now under trial at the Board of Trade.

an idea of the kind of weather thought *probable* cannot be otherwise than acceptable, provided that he is in no way *bound* to act in accordance with any such views, against his own judgment.

No! (In fact I fall on Fitzroy's side of the "Storm warning" debate, as did Lloyd's).
The case against detailed 2007 "climate-proofing" differs in that:

(a) one can learn how to use storm warning, day after day.
(b) storm warning did in fact reflect the weather "thought probable."
(c) Fitzroy argued captains to be left entirely to their own judgement.

Overview

- Models as a basis for evidence-based decision making
- Complex models interpreted within the understanding of science
  - Detailed example of a simple (and amazingly useful) climate model
- What are ensembles?
  - How do they aid our insight?
  - Where can we expect "surprises"?
- What is a "Big Surprise"?
- Challenges to interpreting today's state-of-the-art models

Political reality, Physical reality, Model "reality"

Having acknowledges the limits, can we work within model reality?

Ensembles show the range of conditions our models propose we might observe, a "non-discountable envelope" of outcomes which the models suggest must be considered.

Assuming the red ball is very much like a golf ball, what range of temperatures would the US or UK see in a model-world 2 degrees warmer, compared with a model-world 3 degrees warmer?

Expectations and Goals of Munich Re Program 5a

- To improve the mix between Science and Modelling in informing decisions
- To better propagate uncertainty to and through post-climate modelling (economics and impacts)
- Clarify the assumptions underlying popular climate products (Like assuming the climate changes and the weather stays the same)
- To "close the loop" with modelling, leading to experiments designed to be more informative to decision makers (rather than informative to modellers)
- To inform other programs across Grantham, the LSE, and beyond, with model output and insights on what is robust reliable information. (And ideally case dependent estimates of the probability and direction of the most likely "Big Surprise"!)

We know details of our planet are omitted from the models.
We know at some level details of the model output have no information, no connection, to our Earth.
We believe that models reflect properties of any planet "like" the Earth, "in some way".

For chaotic (perhaps generically for nonlinear) models, the better the model the worse the PDF! (I have a nice simple example of this…)

Should we have more faith in those model outputs which are robust across models, and deprecate attempts to combine over model structure?

Mathematically, we lack evidence that relevant PDEs are robust to infinitesimal perturbations (Clay Prize: Finite time blow up)

And how can we interpret graphs like:

Change in precip over a three month period (June, July, Aug)

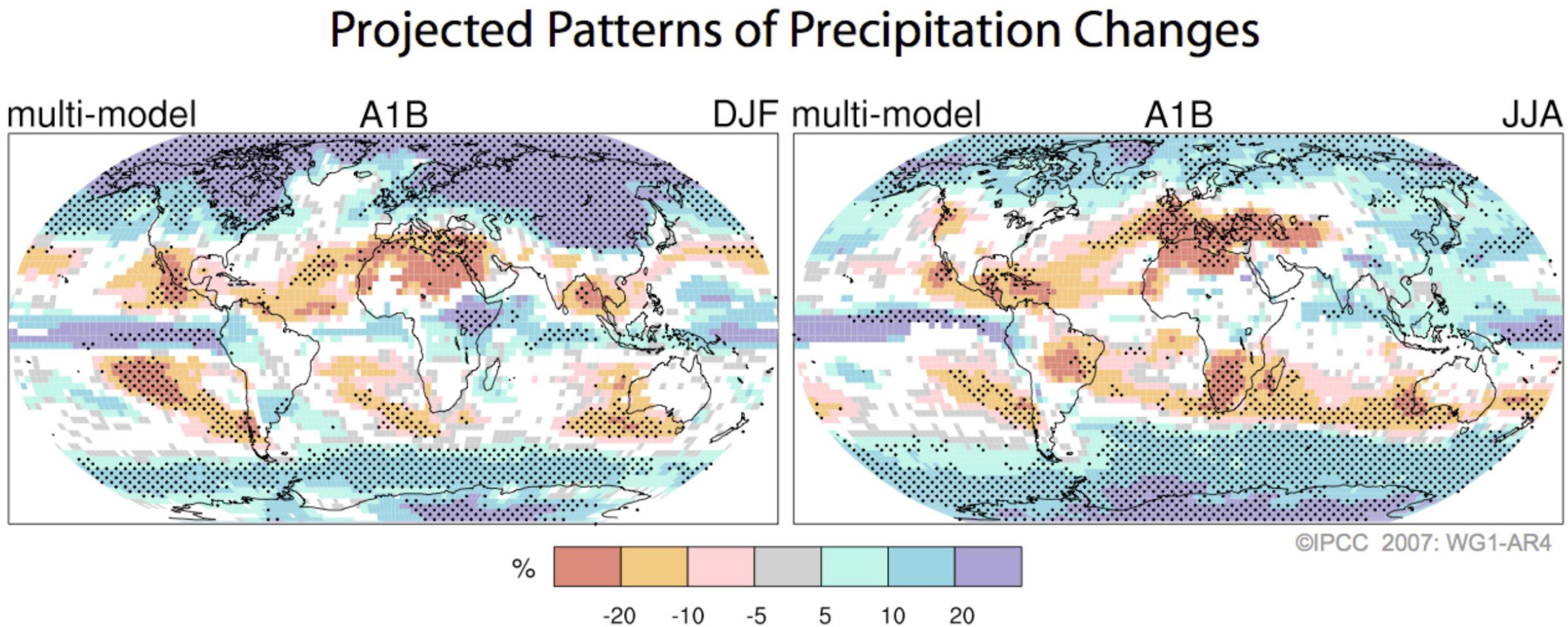


FIGURE SPM-6. Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}

Whitehead's Fallacy of Misplaced Concreteness

"The advantage of confining attention to a definite group of abstractions, is that you confine your thoughts to clear-cut definite things, with clear-cut definite relations. …

The disadvantage of exclusive attention to a group of abstractions, however well-founded, is that, by the nature of the case, you have abstracted from the remainder of things.

... it is of the utmost importance to be vigilant in critically revising your *modes* of abstraction.

Science and the Modern World. Pg 58/9

You don't have to believe everything you compute!

Or in terms of "trust":
We might "trust" our models in the way a parent trusts a child,
but never in the way a child trusts a parent!
This holds for all models, and does not damn climate models!

Science allows for "big surprises"!

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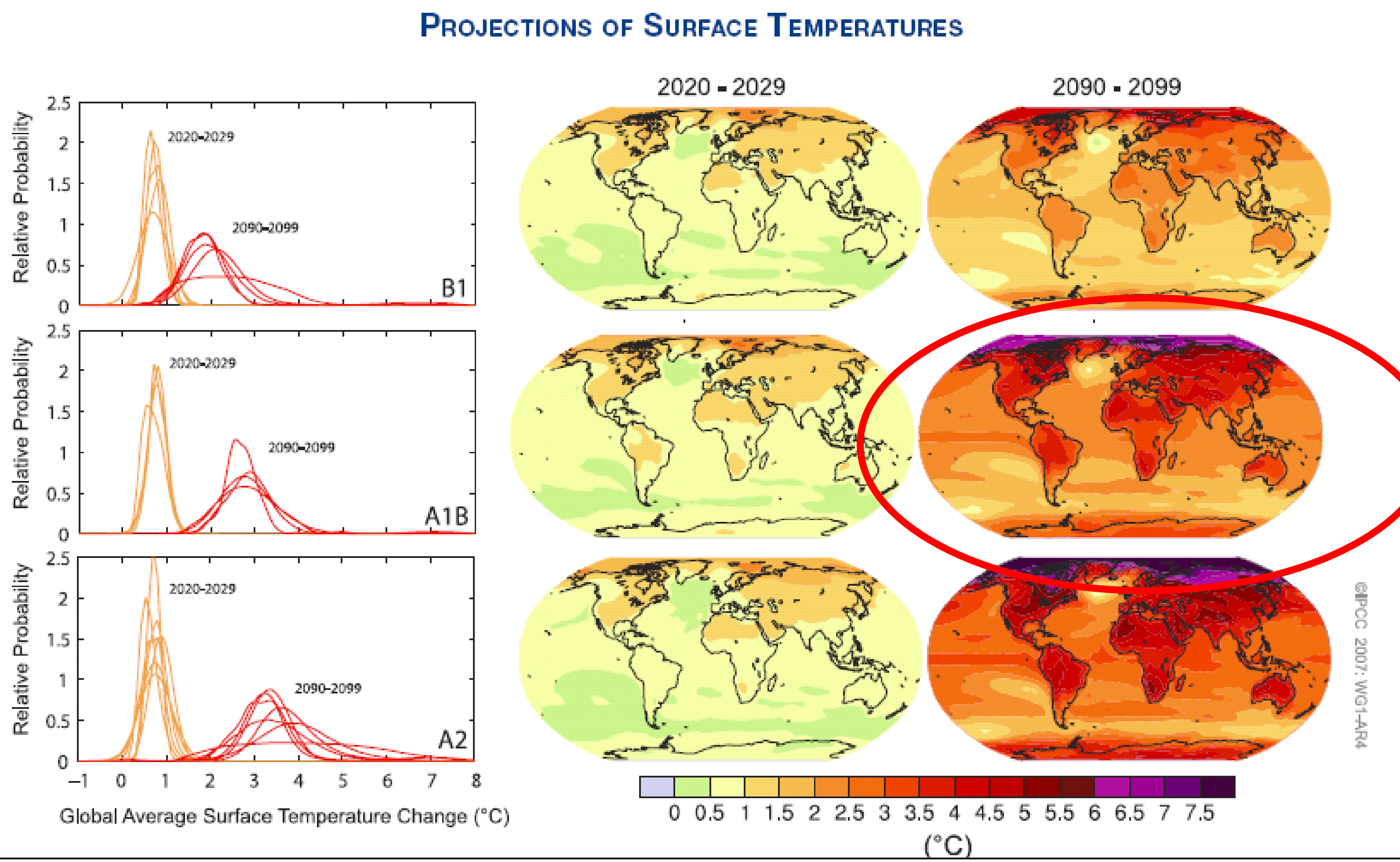
What does a (model) mean mean? For hurricanes?

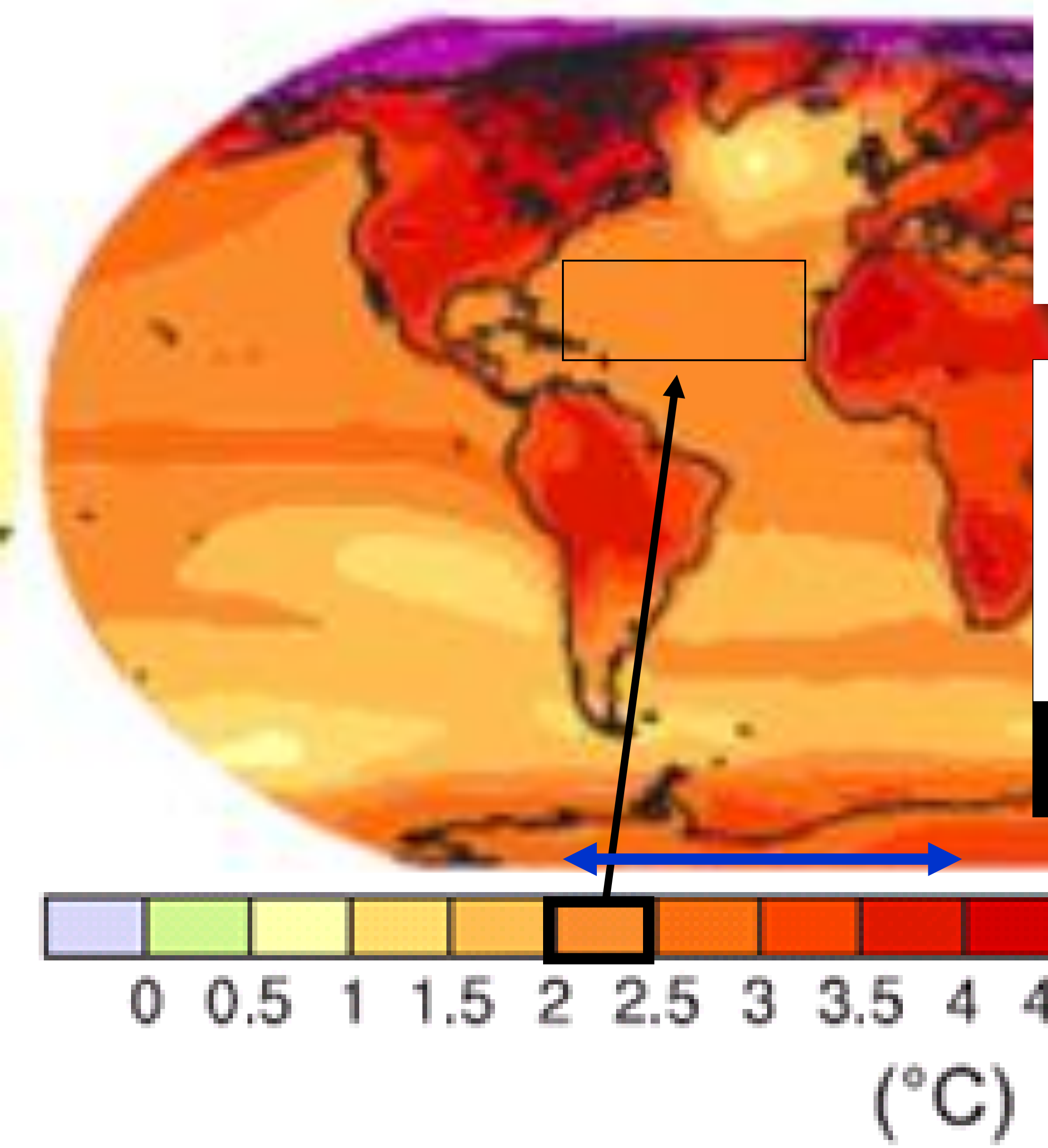


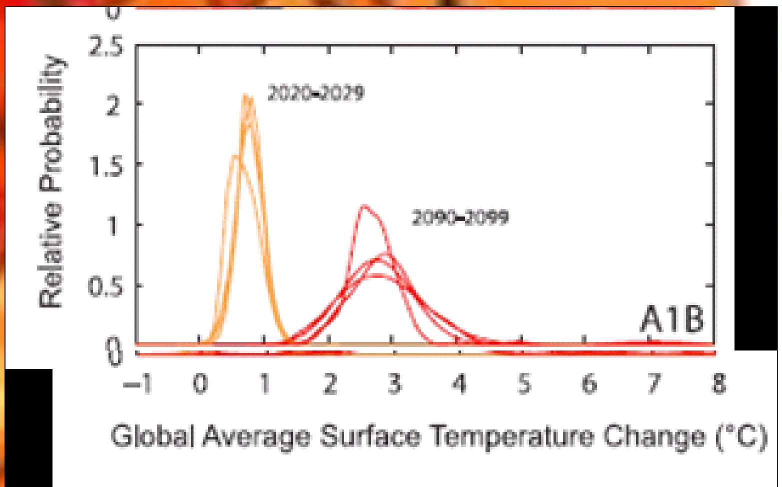
Today's state of the art climate models do not resolve things as small as a hurricane, but if the model temperatures were thought to be decision-support relevant, we could look at projected temperatures in the Atlantic and apply some experimental statistics…

studies for the same periods. Some studies present results only for a subset of the SRES scenarios, or for various model versions. Therefore the difference in the number of curves shown in the left-hand panels is due only to differences in the availability of results. {Figures 10.8 and 10.28}

What does a mean mean?
Say, for changes in Atlantic hurricanes?

As in the case of the three statisticians, rather than averaging first and then computing the impact on hurricane numbers, one should first compute hurricane numbers, and then (if you must) average. (or better still look at the distribution).





Prior to complicated statistical analysis, it would be useful if domain scientists believe these SSTs are robust, given that the GLOBAL ***model***-temperature range is >> 2 degrees…

Objection has been taken to such forecasts, because they cannot be always exactly correct,—for all places in one district. It is, however, considered by most persons that general, comprehensive expressions, in aid of local observers, who can form independent judgments from the tables and *their own instruments*, respecting their immediate vicinity, *though not so well for distant places*, may be very useful, as well as interesting: while to an unprovided or otherwise uninformed person, an idea of the kind of weather thought *probable* cannot be otherwise than acceptable, provided that he is in no way *bound* to act in accordance with any such views, against his own judgment.

Like the storm signals, such notices should be merely *cautionary*—to denote anticipated disturbance *somewhere* over these islands,—without being in the least degree compulsory, or interfering arbitrarily with the movements of vessels or individuals.

Certain it is, that although our conclusions may be incorrect—our judgment erroneous—the laws of nature, and the signs afforded to man, are invariably true. Accurate interpretation is the real deficiency.

Fitzroy, 1862

Temperature Observations

Model Ensemble means with misc observed Sea Temperatures

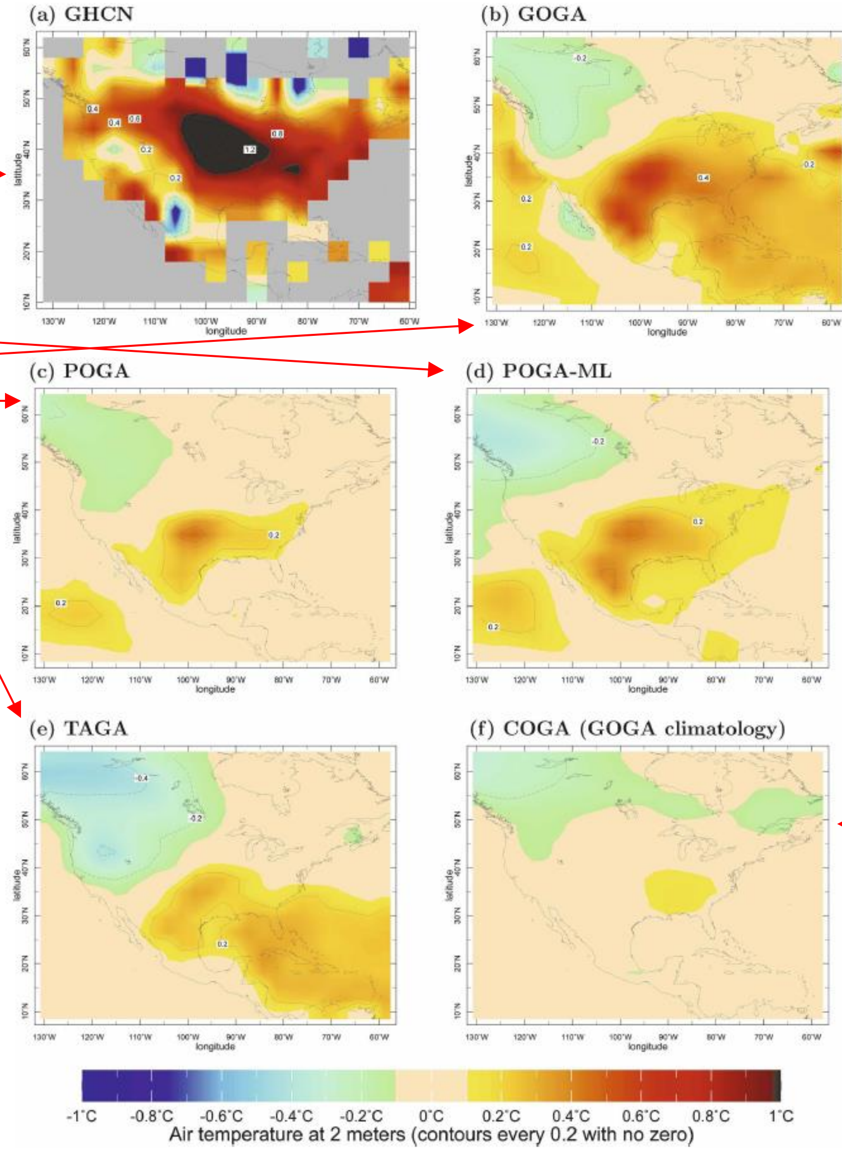


Fig. 4. Same as Fig. 2, but for temperature. The contour interval is 0.2 K.

Model with Average Sea Temperatures

Even given the SSTs, the drought is too weak and in the "wrong place."

Fig. 2. The (a) observed and (b)–(f) modeled precipitation anomalies (mm month^{-1}) during the Dust Bowl (1932–39) relative to an 1856–1928 climatology. Observations are from GHCN. The modeled values are ensemble means from the ensembles with (b) global SST forcing (GOGA), (c) tropical Pacific forcing (POGA), (d) tropical Pacific forcing and a mixed layer ocean elsewhere (POGA-ML), (e) tropical Atlantic forcing (TAGA), and (f) with land and atmosphere initialized in January 1929 from the GOGA run and integrated forward with the 1856–1928 climatological SST (COGA). The uneven contour interval is given at the base of the figure.

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