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

Can We Expect to Predict Climate If We Cannot Shadow Weather?

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London School of Economics

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Can we expect to predict climate if we cannot shadow weather?

Leonard Smith (1,2)

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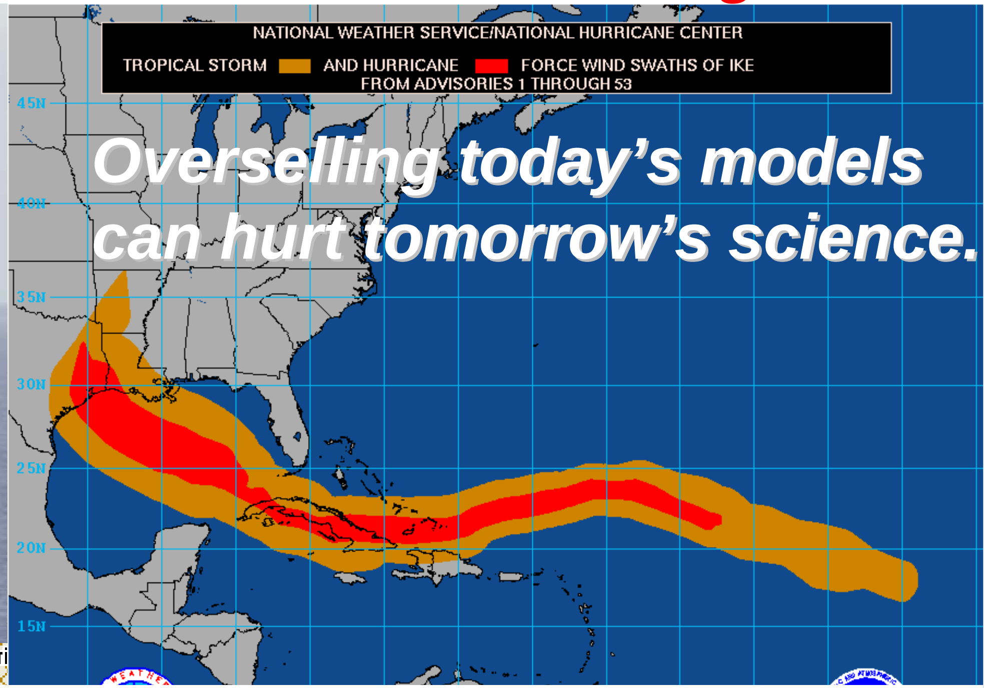
What limits our ability to predict (or project) useful statistics of future climate? And how might we quantify those limits? In the early 1960s, Ed Lorenz illustrated one constraint on point forecasts of the weather (chaos) while noting another (model imperfections). In the mid-sixties he went on to discuss climate prediction, noting that chaos, per se, need not limit accurate forecasts of averages and the distributions that define climate. In short, chaos might place draconian limits on what we can say about a particular summer day in 2010 (or 2040), but it need not limit our ability to make accurate and informative statements about the weather over this summer as a whole, or climate distributions of the 2040's. If not chaos, what limits our ability to produce decision relevant probability distribution functions (PDFs)? Is this just a question of technology (raw computer power) and uncertain boundary conditions (emission scenarios)?

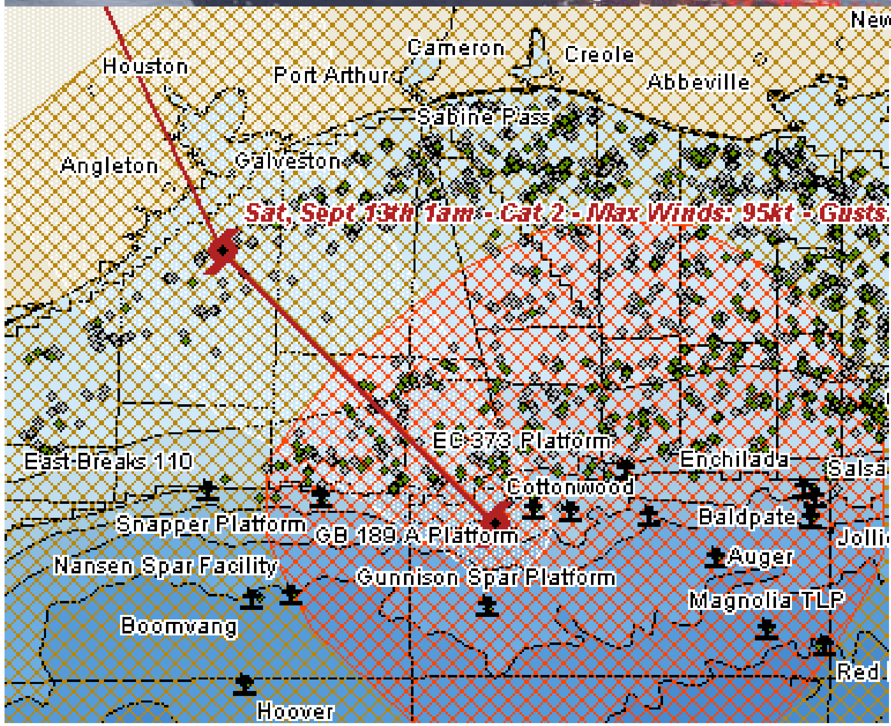
Arguably, current model simulations of the Earth's climate are limited by model inadequacy: not that the initial or boundary conditions are unknown but that state-of-the-art models would not yield decision-relevant probability distributions even if they were known. Or to place this statement in an empirically falsifiable format: that in 2100 when the boundary conditions are known and computer power is (hopefully) sufficient to allow exhaustive exploration of today's state-of-the-art models: we will find today's models do not admit a trajectory consistent with our knowledge of the state of the earth in 2009 which would prove of decision support relevance for, say, 25 km, hourly resolution. In short: today's models cannot shadow the weather of this century even after the fact. Restating this conjecture in a more positive frame: a 2100 historian of science will be able to determine the highest space and time scales on which 2009 models could have (i) produced trajectories plausibly consistent with the (by then) observed twenty-first century and (ii) produced probability distributions useful as such for decision support.

As it will be some time until such conjectures can be refuted, how might we best advise decision makers of the detail (specifically, space and time resolution of a quantity of interest as a function of lead-time) that it is rational to interpret model-based PDFs as decision-relevant probability distributions? Given the nonlinearities already incorporated in our models, how far into the future can one expect a simulation to get the temperature "right" given the simulation has precipitation badly "wrong"? When can biases in local temperature which melt model-ice no longer be dismissed, and neglected by presenting model-anomalies? At what lead times will feedbacks due to model inadequacies cause the 2007 model simulations to drift away from what today's basic science (and 2100 computer power) would suggest? How might one justify quantitative claims regarding "extreme events" (or NUMB weather)?

Models are unlikely to forecast things they cannot shadow, or at least track. There is no constraint on rational scientists to take model distributions as their subjective probabilities, unless they believe the model is empirically adequate. How then are we to use today's simulations to inform today's decisions? Two approaches are considered. The first augments the model-based PDF with an explicit subjective-probability of a "Big Surprise". The second is to look not for a PDF but, following Solvency II, consider the risk from any event that cannot be ruled out at, say, the one in 200 level. The fact that neither approach provides the simplicity and apparent confidence of interpreting model-based PDFs as if they were objective probabilities does not contradict the claim that either might lead to better decision-making.

Expensive Decisions now consider Climate Change





Wednesday, September 17, 2008

Offshore Rig Damage Caused by Hurricane Ike (Updated)

As companies evaluate their offshore assets and begin to report on their findings, it is quickly becoming apparent that Ike has dealt a harsh blow the Gulf of Mexico rig fleet. Thus far, 3 jackups and 1 platform rig have apparently been lost. In addition, another jackup has lost if drilling package and derrick, and two others suffered damages while in the shipyard. Four moored semisubmersibles sustained damage to their mooring systems and submersible rig was pushed off of its prestorm location.

Rig Name	Manager	Rig Type	Built	Cost	[illegible]
ENSCO 74	ENSCO	375' ILC jackup	[illegible]	$84 million	Rig missing - probable total loss
Pride Wyoming	Pride	250' MS jackup	1976	$26 million	Rig missing - probable total loss
Rowan Anchorage	Rowan	250' ILS jackup	[illegible]	$9 million	Rig missing - probable total loss
Ocean Tower	Diamond	350' ILC jackup	1972	$10 million	[illegible] derrick
Mad Dog	Pride / BP	Platform Rig	2004	n/a	Derrick collapsed & sunk
Transocean Marianas	Transocean	7,000' Semisub	1998	$224 million	Mooring system damaged, rig moved
Noble Amos Runner	Noble	8,000' Semisub	1999	$152 million	Broke moorings & set adrift
Noble Paul Romano	Noble	6,000' Semisub	1998	$118 million	Broke moorings & set adrift
Noble Lorris Bouzigard	Noble	4,000' Semisub	1975	$31 million	Mooring system damaged, maintained station
Hercules 78	Hercules	85' Submersible	1983	$34 million	Moved 600' during storm
Rowan Mississippi	Rowan	400' ILC jackup	2008	$165 million	Struck by vessel in shipyard, not expected to delay delivery
Blake 208	Blake Offshore	250' MC jackup	1977	n/a	damaged in shipyard, may delay avail.

For an overview of the locations of rigs affected by Hurricane Ike, take a look at our Offshore Damage Map.

Climate$_{1959}$ was not an average!

climate—"The synthesis of the weather" (C. S. Durst); the long-term manifestations of **weather,** however they may be expressed. More rigorously, the climate of a specified area is represented by the statistical collective of its weather conditions during a specified interval of time (usually several decades).

GLOSSARY
OF
METEOROLOGY

Edited by
RALPH E. HUSCHKE

Sponsored by
U. S. Department of Commerce
Weather Bureau
U. S. Air Force
Air Weather Service, MATS
and
Geophysics Research Directorate
AFCRC, ARDC
U. S. Army
Signal Corps
U. S. Navy
Office of Naval Research

AMERICAN METEOROLOGICAL SOCIETY
Boston, Massachusetts
1959

The critical question is whether or not model-PDFs are fit for purpose: are they decision support relevant?

PDFs of averages per se are not.

How might we decide if high resolution model-PDFs might be?

Reproducing the "statistical collective of weather conditions" would be sufficient.

That implies Φ-shadowing

On what space and times scales is real weather statistically indistinguishable from model output? Decision-support indistinguishable?

LA Smith (2000) 'Disentangling Uncertainty and Error: On the Predictability of Nonlinear Systems' in *Nonlinear Dynamics and Statistics*, ed. Alistair I. Mees, Boston: Birkhauser, 31.

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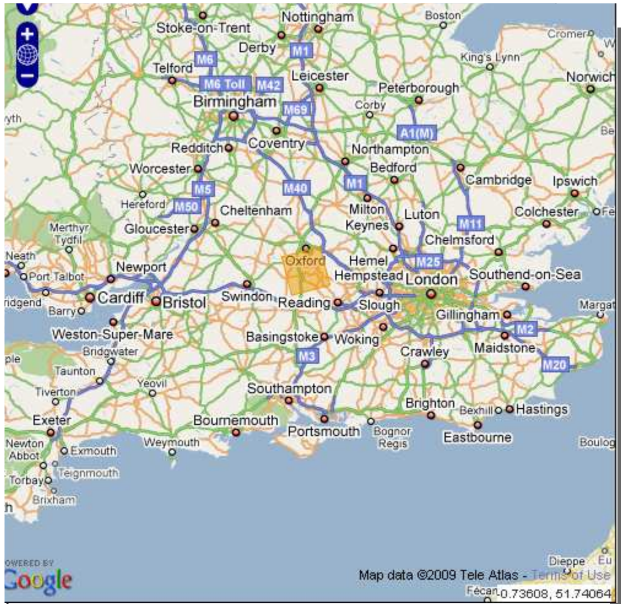
http://www.lse.ac.uk/collections/cats/publications.htm



Future Climate Change Only
Future Absolute Climate Values

Variable

- Change in mean temperature (°C)
- Change in mean daily maximum temperature (°C)
- Change in mean daily minimum temperature (°C)
- Change in temperature of the coolest day (°C)
- Change in temperature of the warmest day (°C)
- Change in temperature of the coldest night (°C)
- Change in temperature of the warmest night (°C)
- Change in precipitation (%)
- Change in precipitation on the wettest day (%)
- Change in mean sea level pressure (hPa)
- Change in total cloud (%)
- Change in relative humidity (%)
- Change in specific humidity (%)
- Change in net surface longwave flux (W m-2)
- Change in net surface shortwave flux (W m-2)
- Change in total downward surface shortwave flux (W m-2)

UK CLIMATE PROJECTIONS USER INTERFACE

http://www.ukcip.org.uk/

Start Page My Jobs My Details Using UKCP09 UI Manual Need help?

Logged in as: lenny@maths.ox...
Logout

Logged in users: 2

You have no pending jobs.
See **My Jobs** for previously run jobs.

Request Status:

Request Summary:

Selecting your UK location first

This page is intended for novice users of the UI who know what location they are interested in. This page should be used as follows:

Step 1: Click on a point on the map (or type in the latitude/longitude coordinates and click "Select".
Step 2: Select a data source of interest from the list that appears on the right.
Step 3: Select the variable you are interested in and click the "Next" button.

You can search by place name or postcode using the box on the right-hand side. Note that clicking a result re-centres and zooms the map to the new location but does make a selection.

Selections on this page are restricted in that only a single location may be selected. Weather Generator simulations and Marine Model Simulations are not available from this start point.

Read about starting your request by making spatial selections in the UI Manual.

Next

Search place name or postcode to re-centre map:
ox1 1dw Search Clear
Postcode: OX1 1DW

Select by Latitude / Longitude by:
Latitude: 52.0018
Longitude: -0.1044
Select

Step 2: Select a data source
At your chosen location, there is data for following data sources (clicking an option will highlight the selected location on the map adjacent):

- UK Probabilistic Projections of Climate Change over Land for the 25km Grid Box with the ID: **1551**
- UK Probabilistic Projections of Climate Change over Land for the Administrative Region: **East of England**
- UK Probabilistic Projections of Climate Change over Land for the River Basin: **Anglian**

Step 3: Select a variable
Please choose one of the following variables:

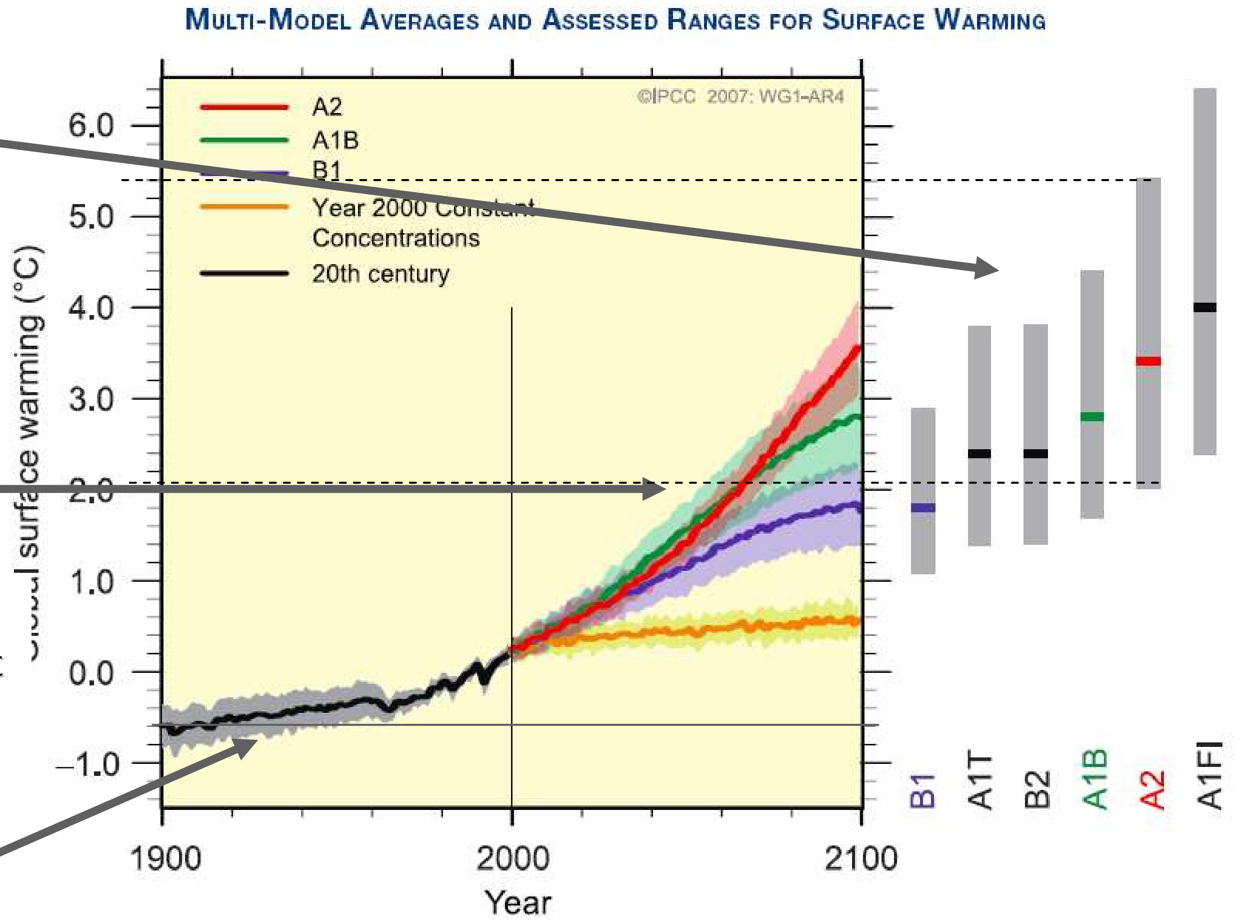
Next

Funded by: Provided by:

Service hosted at: Science & Technology Facilities Council, Rutherford Appleton Laboratory.

Scientific Uncertainty in GMT >> model range

Summary for Policymakers



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

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

Diversity NOT Uncertainty!
These distributions do not respect the law of large numbers!

The grey band represents traditional observational uncertainty.

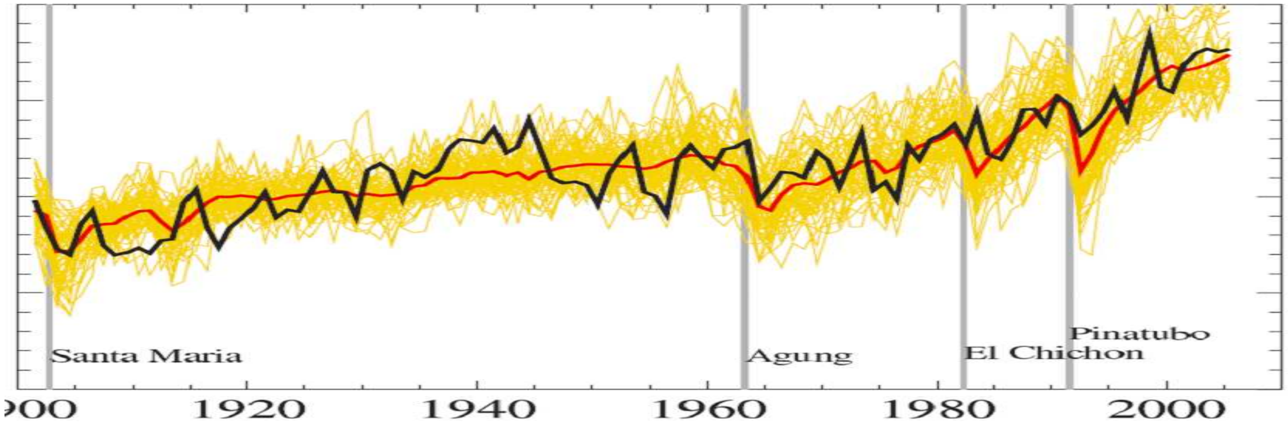
Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the 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}*

IPPC holds model range too narrow even in GMT!

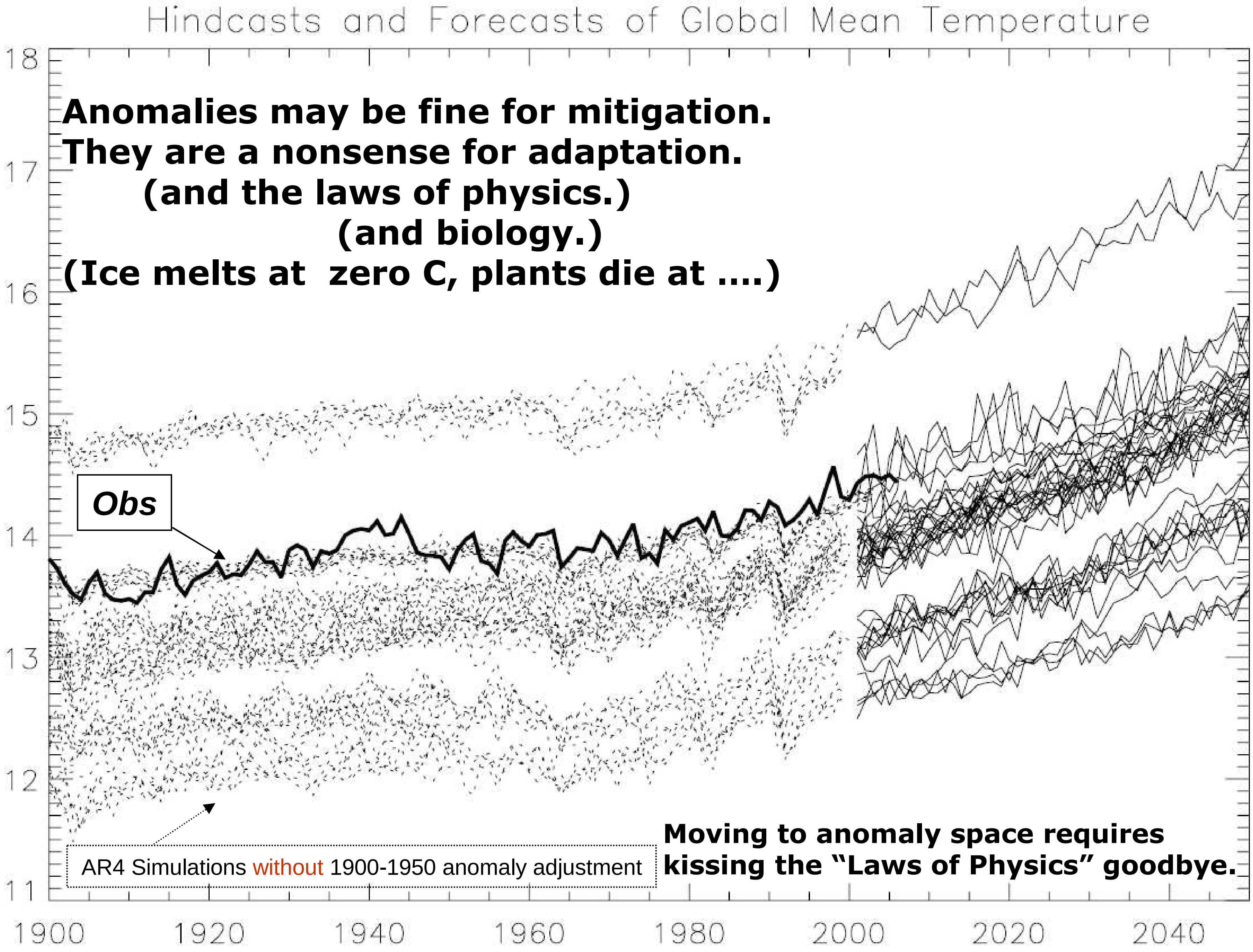
How big are systematic errors in global temp for the IPCC AR4 models?

IPCC AR4:

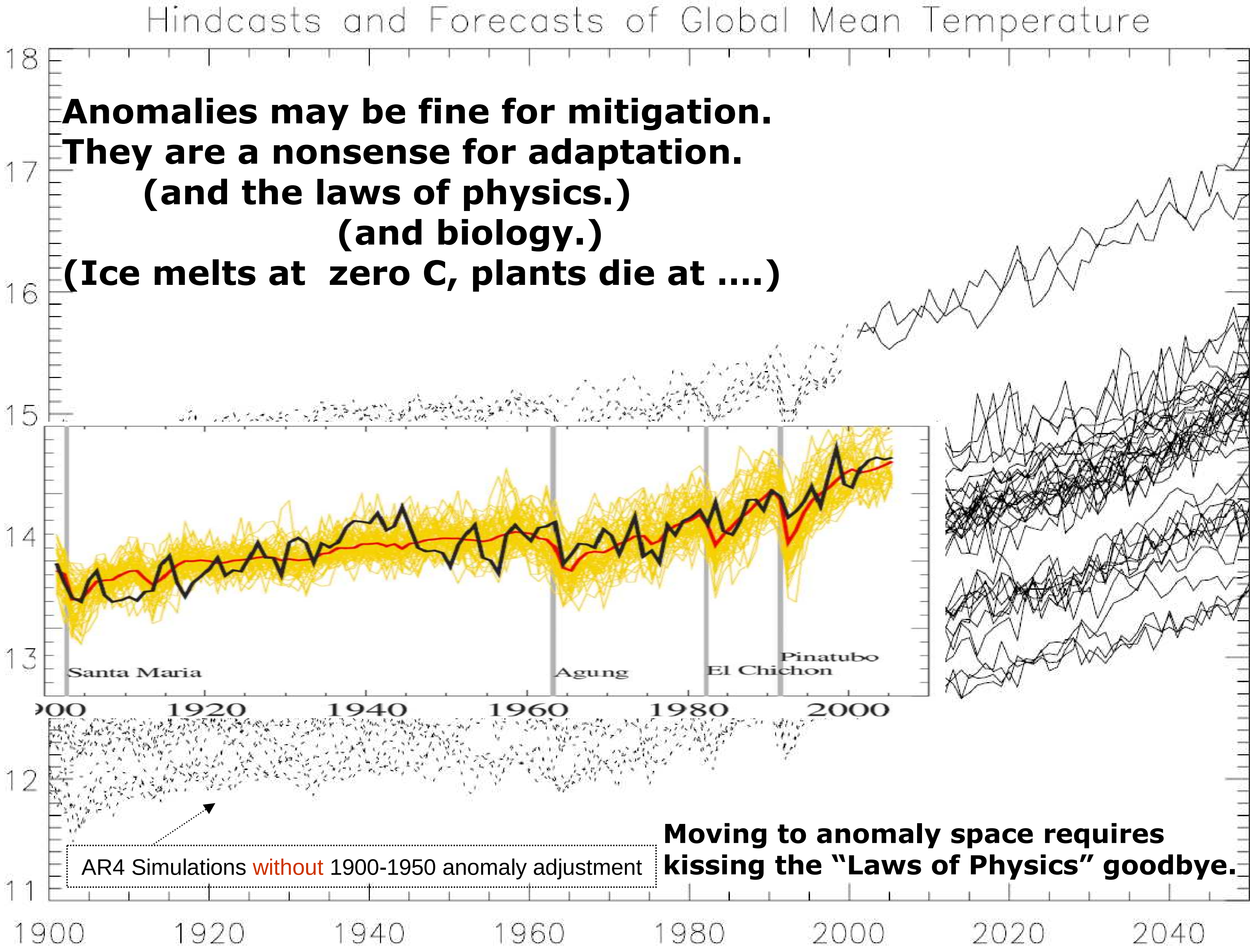
FAQ 8.1, Figure 1. *Global mean near-surface temperatures over the 20th century from observations (black) and as obtained from 58 simulations produced by 14 different climate models driven by both natural and human-caused factors*



Systematic errors are larger than the observed effect



Systematic errors are larger than the observed effect



Models are tools, not Miracles

"Best available" does not imply "fit for purpose"
Including a process does not mean it is realistically simulated.

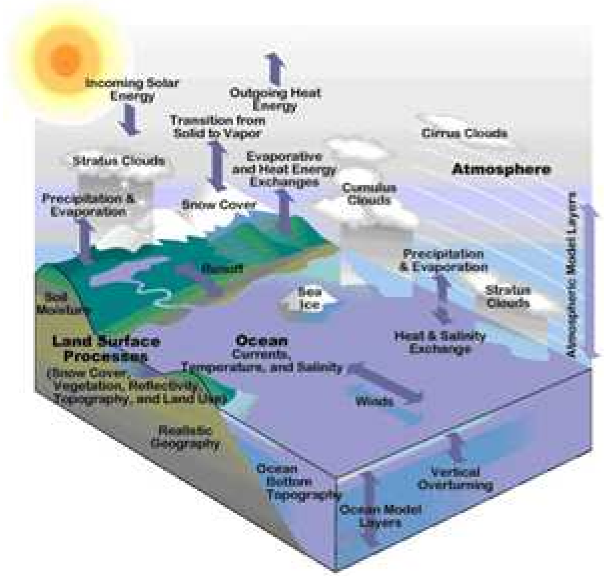
The plural of "simulation" is not "information."

Model diversity can not be translated into decision-relevant probability…

…the new spurious accuracy.

The significant value of Geophysical models may be ignored if oversold.
But how do we communicate uncertainty? And deep uncertainty?

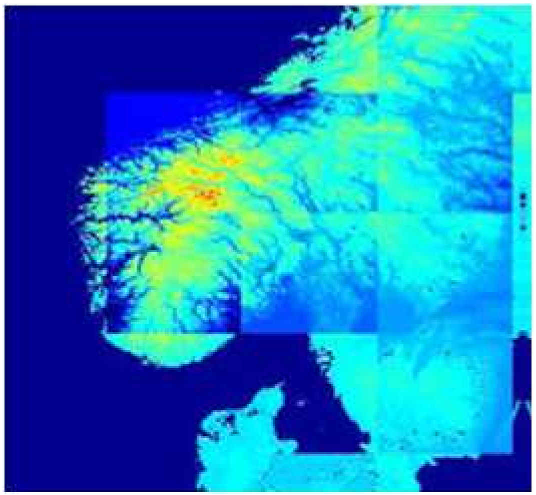
Climate Model Schematic



http://www.windows.ucar.edu/tour/link=/earth/climate/cli_models3.html

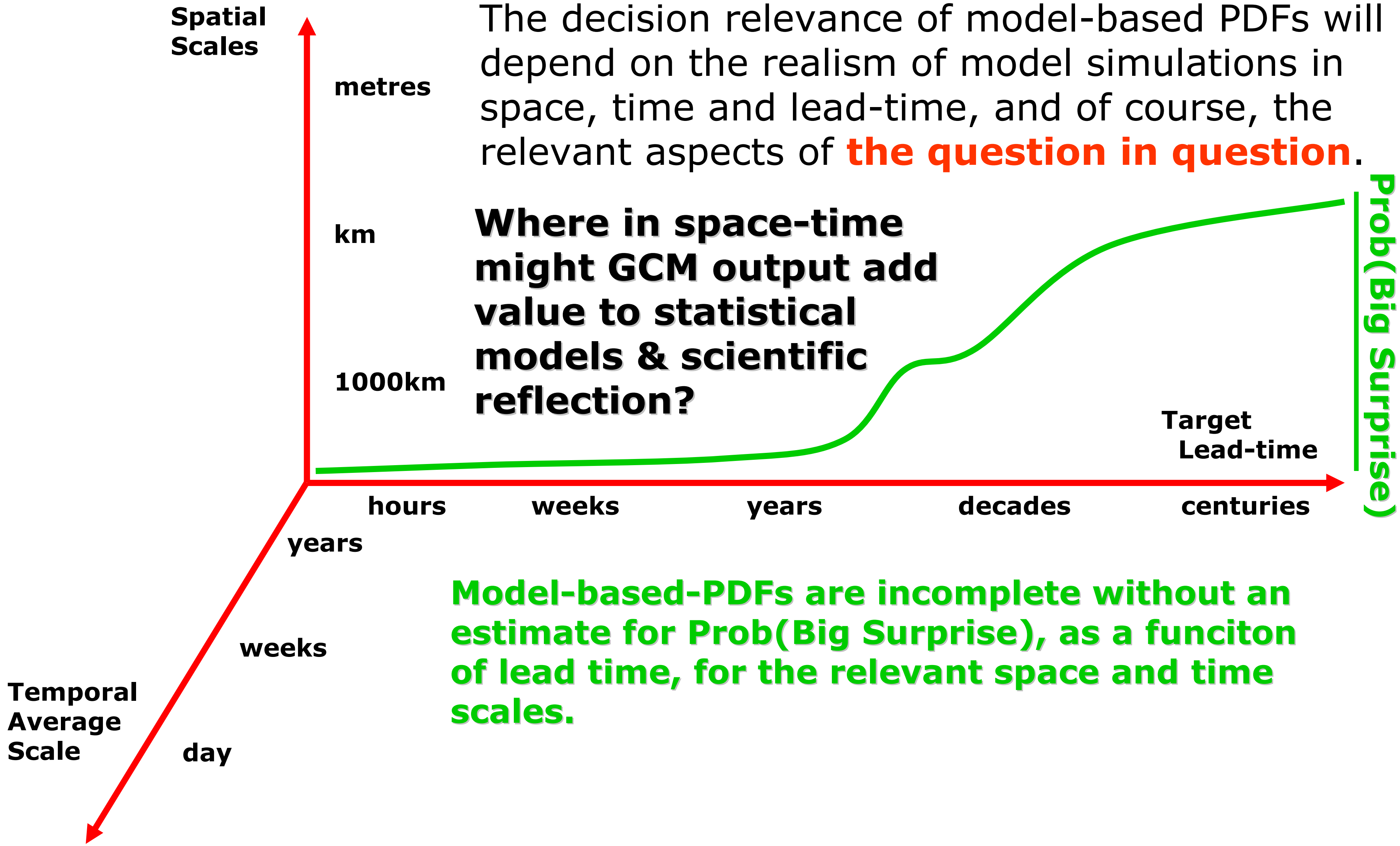
Model Reality (squares) Much Missing

HadCM3 missing elevation
2min x 2min obs – HadCM3



Model Relevance in Quantitative Decision Support

The decision relevance of model-based PDFs will depend on the realism of model simulations in space, time and lead-time, and of course, the relevant aspects of **the question in question**.



Where in space-time might GCM output add value to statistical models & scientific reflection?

Model-based-PDFs are incomplete without an estimate for Prob(Big Surprise), as a funciton of lead time, for the relevant space and time scales.

Very schematic schematic of Prob(Big Surprise) "surface".

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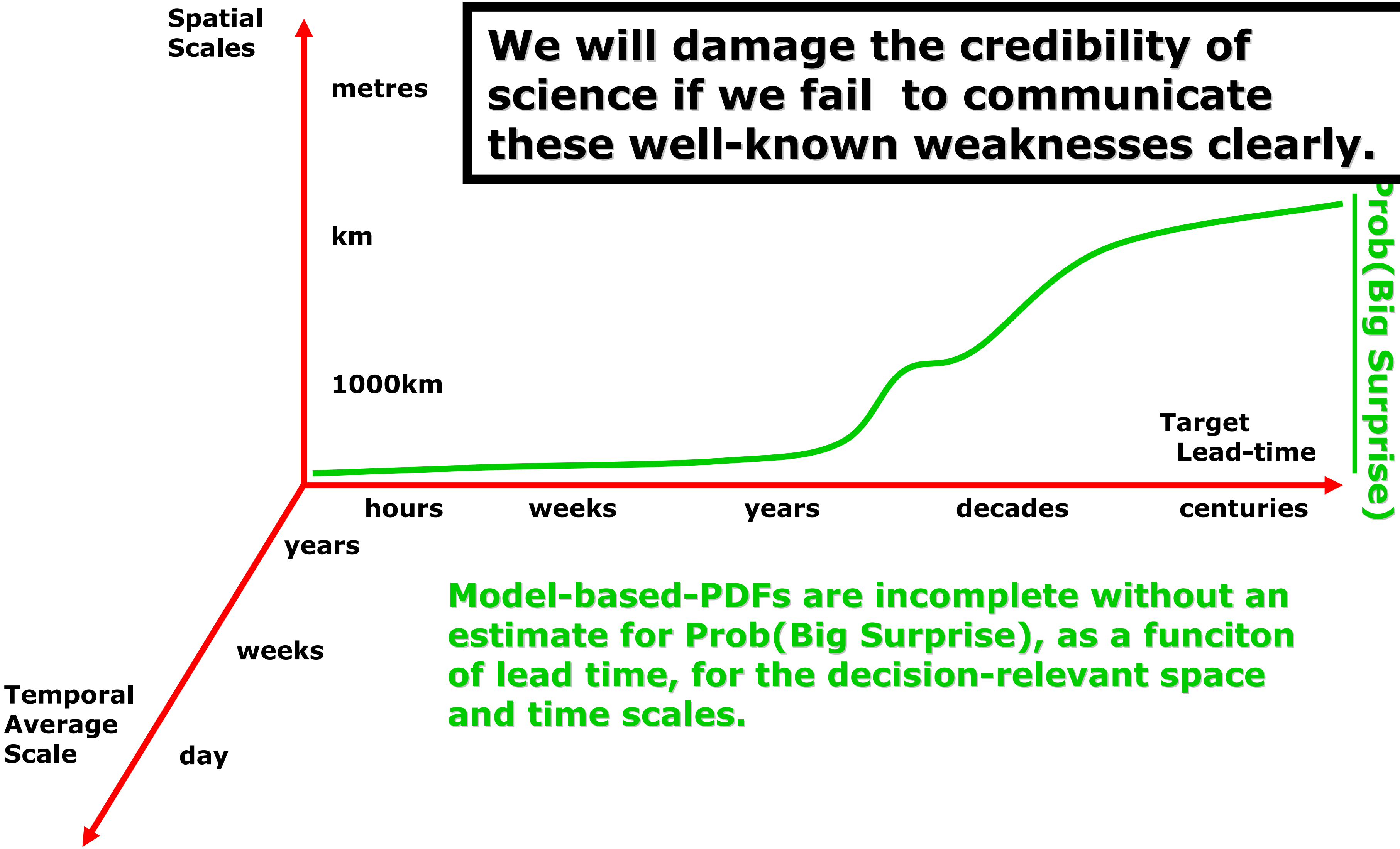
Model Relevance in Quantitative Decision Support

We will damage the credibility of science if we fail to communicate these well-known weaknesses clearly.

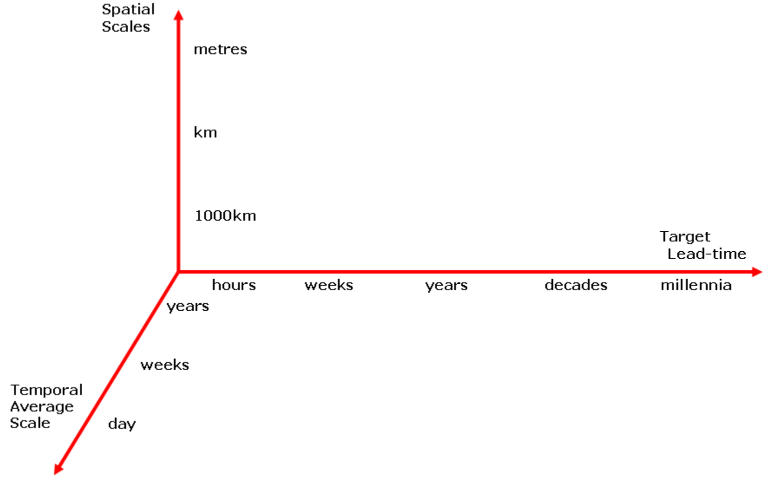


Model-based-PDFs are incomplete without an estimate for Prob(Big Surprise), as a funciton of lead time, for the decision-relevant space and time scales.

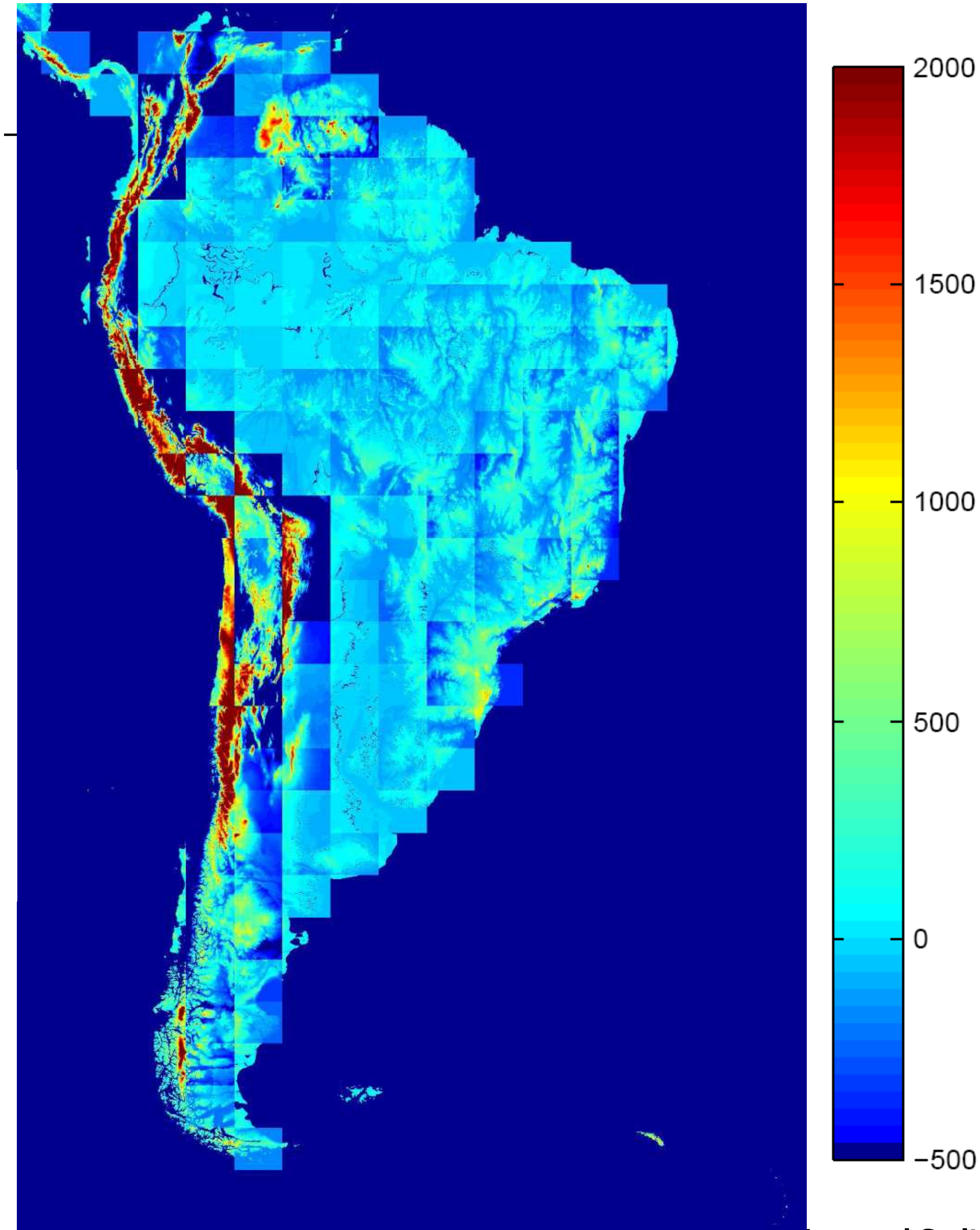
Missing mountain ridges:

And long term feedbacks (bio-feed backs, albedo, …)

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



One-way coupled regional models **cannot** account for missing physics or inactive feedbacks.



AR4 models given SSTs miss things as small as: The 1930's Dust 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

---

Decision makers should expect "Big Surprises" when using model-PDFs to anticipate future events similar to those our models do not capture well in the past.

If we misplace a decade long drought, can we claim P(Big Surprise) is small for the 2080's hottest day of the year in OX1 1DW?

When might Model-based PDFs be of value?

Arguably, we they must be:

Robust,
Representative
and Relevant

(My goal here is similar to
R. Cox's "Stable probabily" (AJP, 1946))

Because of the various simplifications of the model described above, it is not advisable to take too seriously the quantitative aspect of the results obtained in this study. Nevertheless, it is hoped that this study not only emphasizes some of the important mechanisms which control the response of the climate to the change of carbon dioxide.

The Effects of Doubling the CO_2 Concentration on the Climate of a General Circulation Model[1]

SYUKURO MANABE AND RICHARD T. WETHERALD

Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, N.J. 08540

(Manuscript received 6 June 1974, in revised form 8 August 1974)

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Robust, Representative and Relevant

Robust: not fragile, meteo PDFs are not expected to change substantially (a) as models undergo incremental development or (b) under slight changes in the analysis or (c) given the evidence suppressed. "Cox-Stable"

Where E = (EC U ES)

Representative: each meteo driver known to play a significant role in the question of interest is thought to be adequately represented (realistically simulated) to the extent that **each** simulation is fit to inform this question.

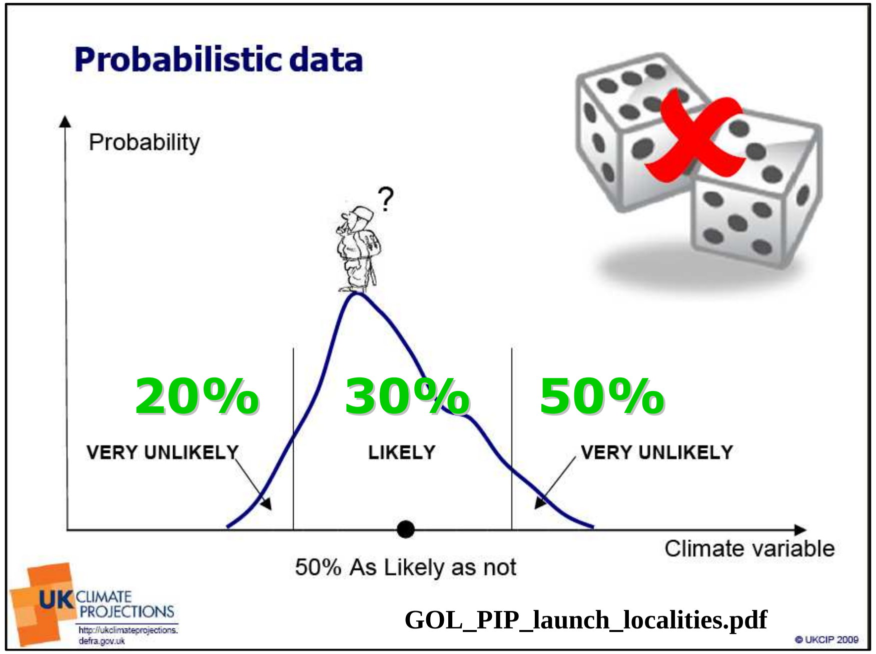
Relevant: in a form that users can use/exploit for the decision of interest using tools they like, spatial and temporal resolution and so on.

This is an ordered list:
First relax **relevant**, as other useful questions might be answered.
Impact PDFs are only decision-relevant if **robust** and **representative**.

Next relax **representative**: a set of simpler questions might still be addressed, given only a subset of the meteo drivers, as long as PDFs of those meteo phenomena were **robust**.

Without **Robust**, arguably the model-PDF is not a subjective PDF for the phenomena at all. (Recall Manabe and Wetherall, 1975)
(doesn't someone have to believe it for it a Bayesian to count it as a PDF?)

What is the chance of falling above the 90% line of model-PDFs?



A climate scientist can easily know that the probability of the real world falling above the 90% line of the UKCP PDF can be much **much** greater than 10%. Say > 50%

Traders in CAT bonds are already considering how this "information arbitrage" might be an opportunity…

It is irrational to base decisions on a model-based PDF when known model inadequacy dominates the model-PDF ("blocking")!

(Or for the Bayesians in the room: my subjective PDF is not constrained by any model-PDF when I know (aka believe) that the model is likely to be mis-informative!)

Diversity of My Models need not reflect Uncertainty in My Future

If I want a decision-relevant PDF I have to return to the Science

Sit and think <--------------> Simulate and Count

Publications http://www.lse.ac.uk/collections/cats/publications.htm

Papers

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K Judd, CA Reynolds, LA Smith & TE Rosmond (2008) The Geometry of Model Error (DRAFT). *Journal of Atmospheric Sciences* 65 (6), 1749--1772. Abstract
K Judd, LA Smith & A Weisheimer (2007) How good is an ensemble at capturing truth? Using bounding boxes for forecast evaluation. *Q. J. Royal Meteorological Society*, **133** (626), 1309-1325. Abstract
J Bröcker, LA Smith (2008) From Ensemble Forecasts to Predictive Distribution Functions *Tellus A* 60(4): 663. Abstract
J Bröcker, LA Smith (2007) Scoring Probabilistic Forecasts: On the Importance of Being Proper *Weather and Forecasting* 22 (2), 382-388. Abstract
J Bröcker & LA Smith (2007) Increasing the Reliability of Reliability Diagrams. *Weather and Forecasting,* 22(3), 651-661. Abstract
MS Roulston, J Ellepola & LA Smith (2005) Forecasting Wave Height Probabilities with Numerical Weather Prediction Models *Ocean Engineering,* 32 (14-15), 1841-1863. Abstract
A Weisheimer, LA Smith & K Judd (2004) A New View of Forecast Skill: Bounding Boxes from the DEMETER Ensemble Seasonal Forecasts, *Tellus* **57** (3): 265-279 MAY. Abstract
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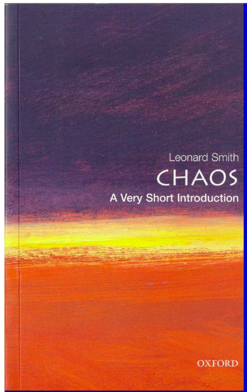
MS Roulston & LA Smith (2003) Combining Dynamical and Statistical Ensembles *Tellus 55 A*, 16-30. Abstract
MS Roulston, DT Kaplan, J Hardenberg & LA Smith (2003) Using medium-range weather forecasts to improve the value of wind energy production *Renewable Energy* 28 (4) April 585-602. Abstract
MS Roulston & LA Smith (2002) Evaluating probabilistic forecasts using information theory, *Monthly Weather Review* 130 6: 1653-1660. Abstract
LA Smith, (2002) What might we learn from climate forecasts? *Proc. National Acad. Sci.* USA 4 (99): 2487-2492. Abstract
D Orrell, LA Smith, T Palmer & J Barkmeijer (2001) Model Error in Weather Forecasting *Nonlinear Processes in Geophysics* 8: 357-371. Abstract
JA Hansen & LA Smith (2001) Probabilistic Noise Reduction. *Tellus 53 A* (5): 585-598. Abstract
I Gilmour, LA Smith & R Buizza (2001) Linear Regime Duration: Is 24 Hours a Long Time in Synoptic Weather Forecasting? *J. Atmos. Sci.* 58 (22): 3525-3539. Abstract
K Judd & LA Smith (2001) Indistinguishable states I: the perfect model scenario *Physica D* 151: 125-141. Abstract
LA Smith (2000) 'Disentangling Uncertainty and Error: On the Predictability of Nonlinear Systems' in *Nonlinear Dynamics and Statistics*, ed. Alistair I. Mees, Boston: Birkhauser, 31-64. Abstract



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

http://www.lse.ac.uk/collections/cats/publications.htm

www.cccep.ac.uk

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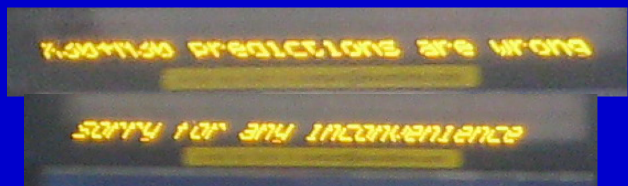

http://img97.imageshack.us/i/penguinpolar7ec.jpg/

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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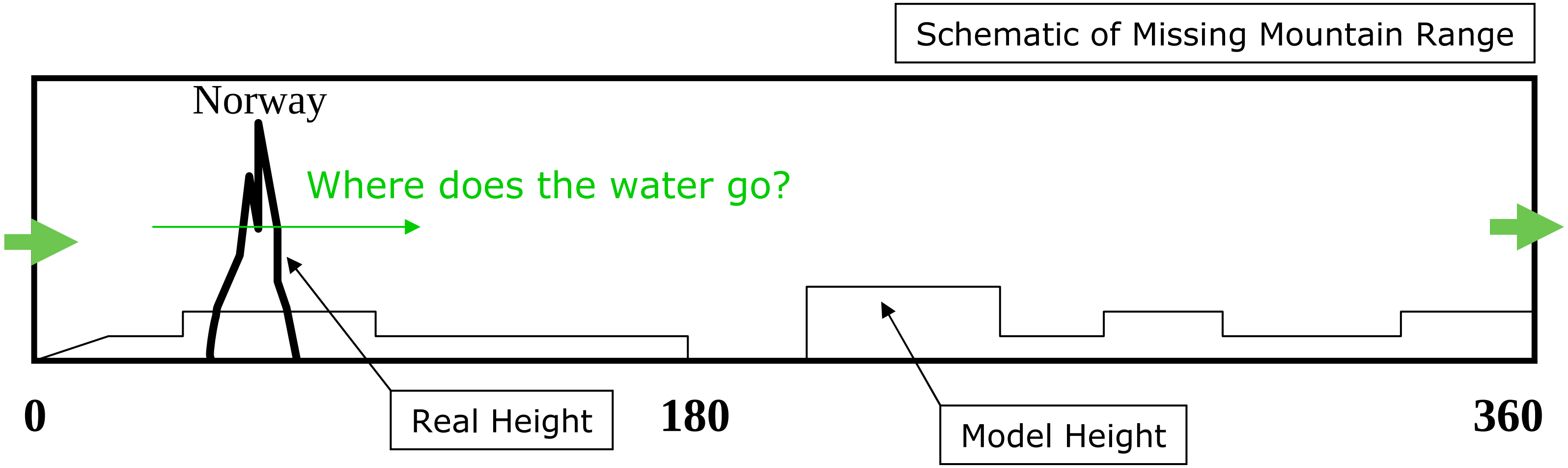
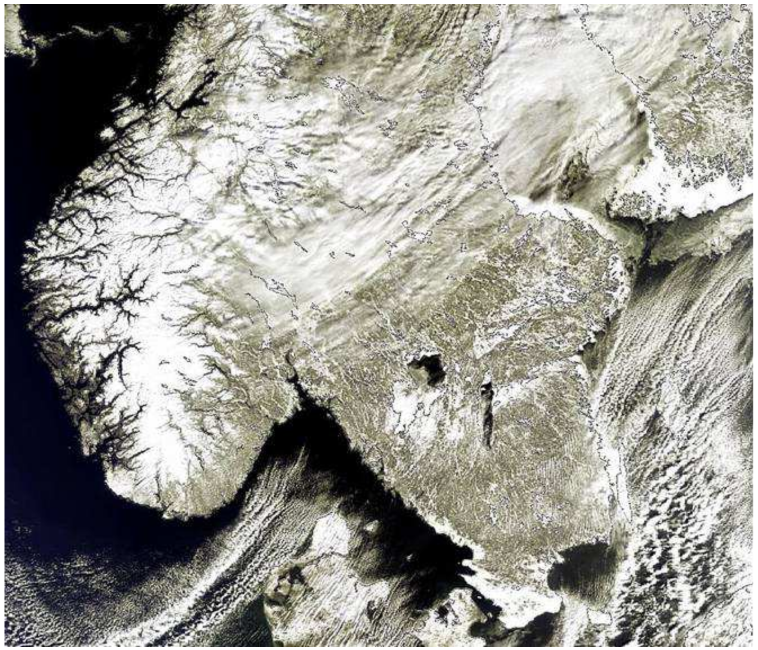
Sciences knows more than we can Model



If important, this leads to nonlocal effects.
(and the effective creation of water!)



Before we start using phrases like "Laws of Physics" in public, can we:
A) check for internal consistency
B) Find necessary (not sufficient) conditions for this model to contain decision relevant information?

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

A Schematic of a 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?**

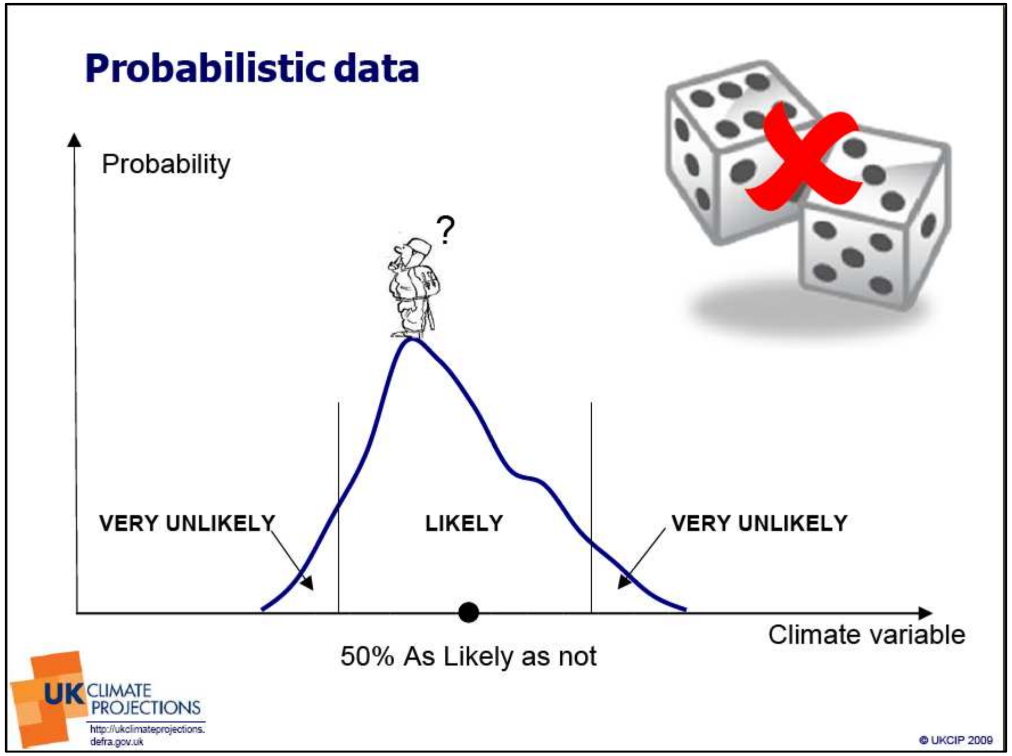
If one cannot clear these hurdles, the scientific value of the results does not make them of value to decision makers. They can be a detriment.

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

Sit and think will trump Simulate and Count

So what about UKCP probabilities?

What is the chance of falling above the 90% line of UKCP PDFs?



The shortcoming of climate models are more clearly acknowledged in the peer reviewed literature than in the UKCP user guidance.

It is important to stress that our approach to the specification of discrepancy can only be expected to capture a subset of possible structural modelling errors and should be regarded as a lower bound. This is because models tend to share certain common systematic biases, which can be found in diverse elements of climate including multiannual means of basic quantities such as surface temperature,

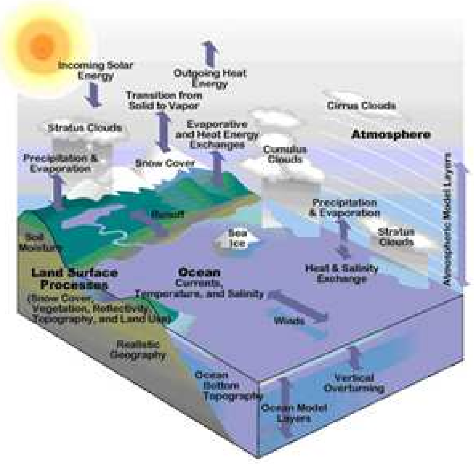
PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

A methodology for probabilistic predictions of regional climate change from perturbed physics ensembles

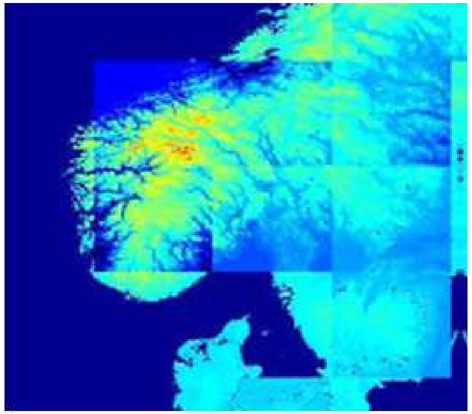
J.M Murphy, B.B.B Booth, M Collins, G.R Harris, D.M.H Sexton and M.J Webb

Phil. Trans. R. Soc. A 2007 **365**, 1993-2028
doi: 10.1098/rsta.2007.2077

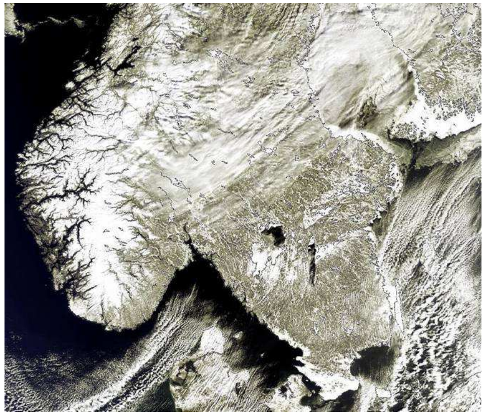
Plausible Planets or Implausible Earths?



The kitchen sink approach “includes” everything we can think of that might be important.
At best, this yields an implausible Earth, and parameter variation samples an empirically vacuous space of unphysical, unbiological, uninteresting & irrelevant model diversity. (**Unless the model is empirically adequate!**)



One alternative is to build plausible planets, while omitting any Earth-relevant process for which the model cannot provide coherent physical drivers on Earth-like scales. (no suggestion of linear superposition intended!)



Does water vapour come after mountains?
Does vegetation come after water vapour?
Do we avoid the penguin effect?
(until it is simulated realistically)

Centre for Climate Change Economics and Policy

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

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

UK CLIMATE PROJECTIONS

Reference: Probability level

Probability level

Describes the strength of evidence associated with a given value within a probabilistic climate projection. Probabilistic climate projections fall under subjective probability as the probabilities are a measure of the degree to which a particular level of future climate change is consistent with the evidence considered. In the case of UKCP09, the evidence comes from observations and outputs from a number of climate models, all with their associated uncertainties.

In detail

One of the main advances associated with UKCP09 is that it provides probabilistic climate projections. This means that different future climate outcomes described by a probabilistic projection have different strengths of evidence associated with them. As such, probability levels associated with a given change should be interpreted as indicating the relative likelihood of the projected change being at or less than the given change.

For example, if a projected temperature change of +4.5°C is associated with the 90% at a particular location in the 2080s for the UKCP09 medium emission scenario, this should be interpreted as it is projected that there is a 90% likelihood that temperatures at that location will be up to and including 4.5°C warmer than temperatures in the 1961–90 baseline period. Conversely, there is a 10% likelihood that those temperatures will be at or greater than 4.5°C warmer than the baseline period.

Probability level is associated with a cumulative probability. Another way of describing the probabilities in UKCP09 is to use a Probability Density Function.

Find out more

- UKCP09 Climate change projections report

Summary for Policymakers

PROJECTIONS OF SURFACE TEMPERATURES

This risk of overconfidence is well known and well founded.

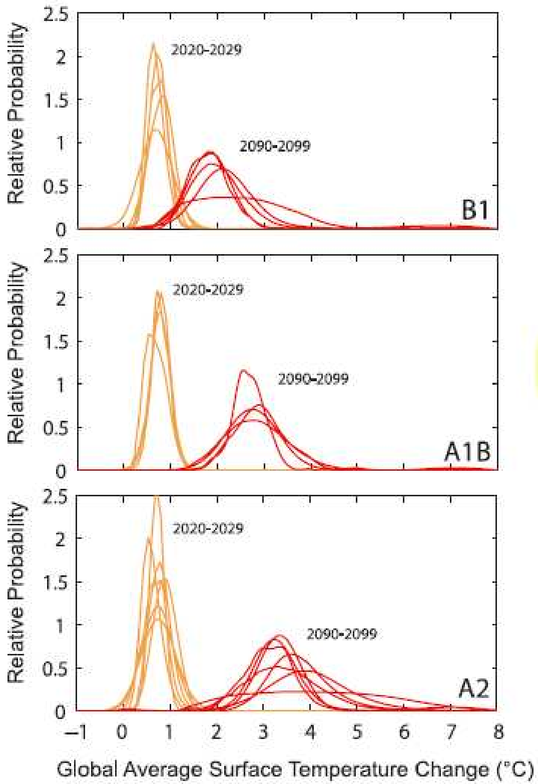


Figure SPM.6. *P[...] and right panels [...] averaged over the [...] probabilities of es[...] studies for the sa[...] Therefore the diff[...] {Figures 10.8 and[...]*

10

Global Climate Projections

The effects of uncertainty in the knowledge of Earth system processes can be partially quantified by constructing ensembles of models that sample different parametrizations of these processes. However, some processes may be missing from the set of available models, and alternative parametrizations of other processes may share common systematic biases. Such limitations imply that distributions of future climate responses from ensemble simulations are themselves subject to uncertainty (Smith, 2002), and would be wider were uncertainty due to structural model errors accounted for.

797

One would be exposed to significant losses/costs if distributions which are not decision-support relevant probabilities are interpreted as if they were.

The IPCC itself might say this a bit louder/earlier:

Of course, they do not face users breaking ground on powerplant in 6 years, which have been badly designed by overinterpreting UKCP PDFs…