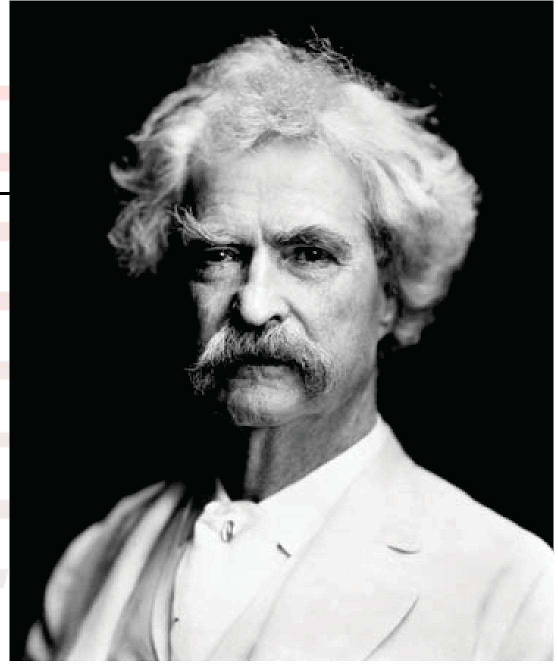
(with apologies to sam)

To the Physicist Sitting in Darkness



Probabilities are all well and good. And it is a fine thing to get in touch with your beliefs and feelings. Shall we bang ahead in our old-time, loud pious way, and commit new sciences to the game; or shall we sober up, sit down, and think it over first?

The Blessings-of-Subjective-Probability Trust, wisely and cautiously administered, is a Blue Chip. But Bayesians have been playing it badly of late, and must certainly suffer from it, in my opinion; they have been eager to solve every problem, especially the poorly posed ones, and the Physicists who sit in Darkness have begun to notice it – they have noticed it and have begun to show alarm. They have become suspicious of posteriors on empirically vacuous reals, not to mention function spaces; they have begun to resist the kindly extraction of priors. More – they have begun to examine them! This is not well. The Blessings of Bayesianism are all right, and a good RC commercial property; there could not be better, in a dim light. In the right kind of light, and at the proper distance, with the goods a little out of focus, they are a desirable enticement to the Physicists who sit in darkness.

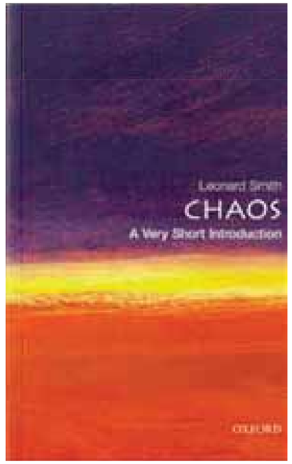
Probability theory eases the stress of decision making. And improves the outcome, but not if we adulterate it. For the Empirically Adequate and the Large Number Statistic, it is pie. But in cutting edge science, and in extrapolation, here the Physicist sitting in darkness is (almost) sure to say: “These is something curious about this – curious and unaccountable.” … There have been lies yes, but told in a good cause, it might have worked; yet we have passed on a Shadow from one who hadn’t it to sell, and long term infrastructure investments are being made.

LSE CATS CENTRE FOR THE ANALYSIS OF TIME SERIES

www.lsecats.ac.uk

Doing Science in the Dark

Predictability & Understanding of Our Climate Risk: Approximations, Bugs and Insight



Leonard A. Smith
London School of Economics &
Pembroke College, Oxford

EQUIP

Not Possible without: H Du, A. Jarman, D Stainforth & E Suckling

Centre for Climate Change Economics and Policy

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

Grantham Research Institute on Climate Change and the Environment

What I wish to avoid

An Oxford Bus Stop in the summer of 2010:

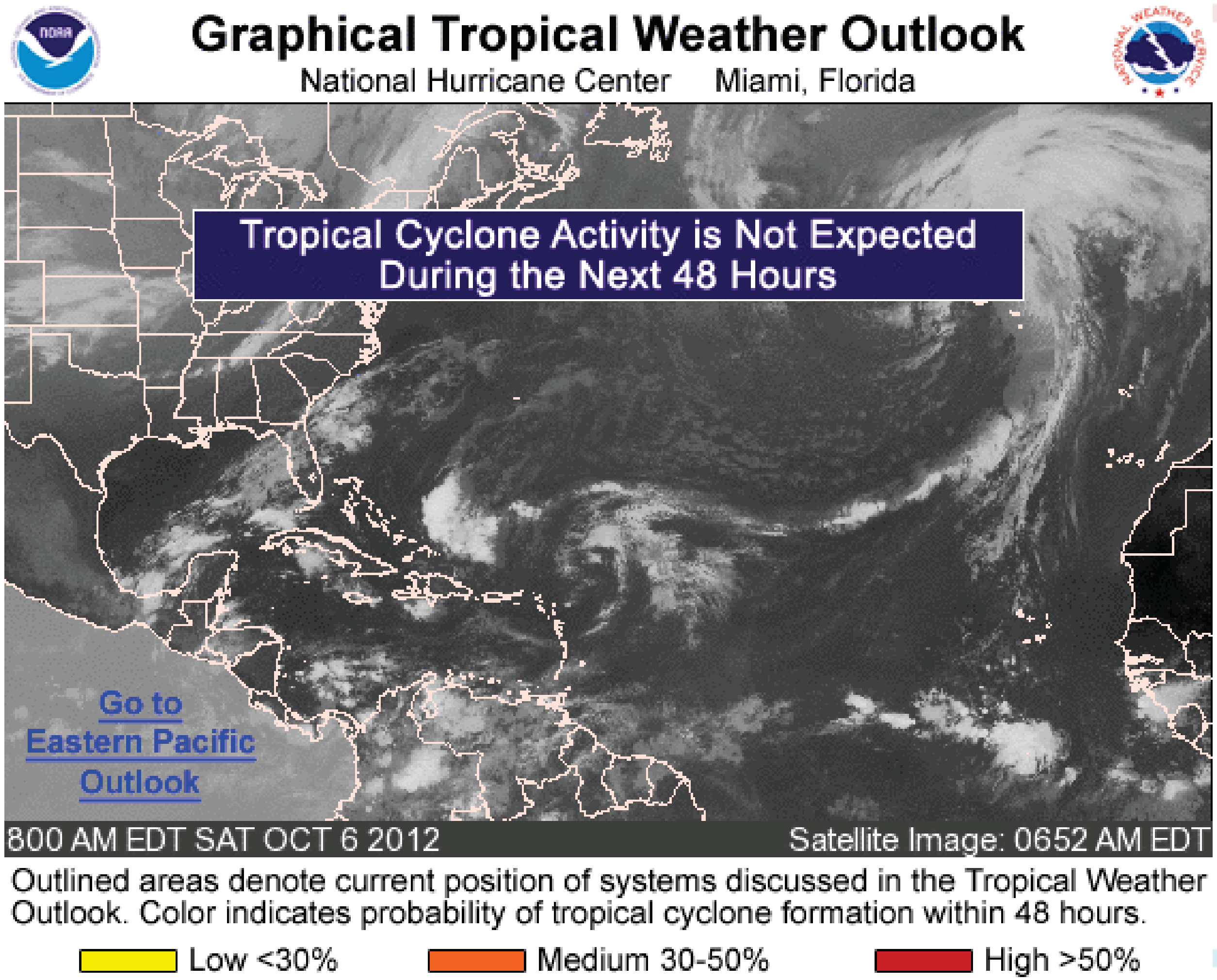
X30+N30 predictions are wrong
Sorry for any inconvenience

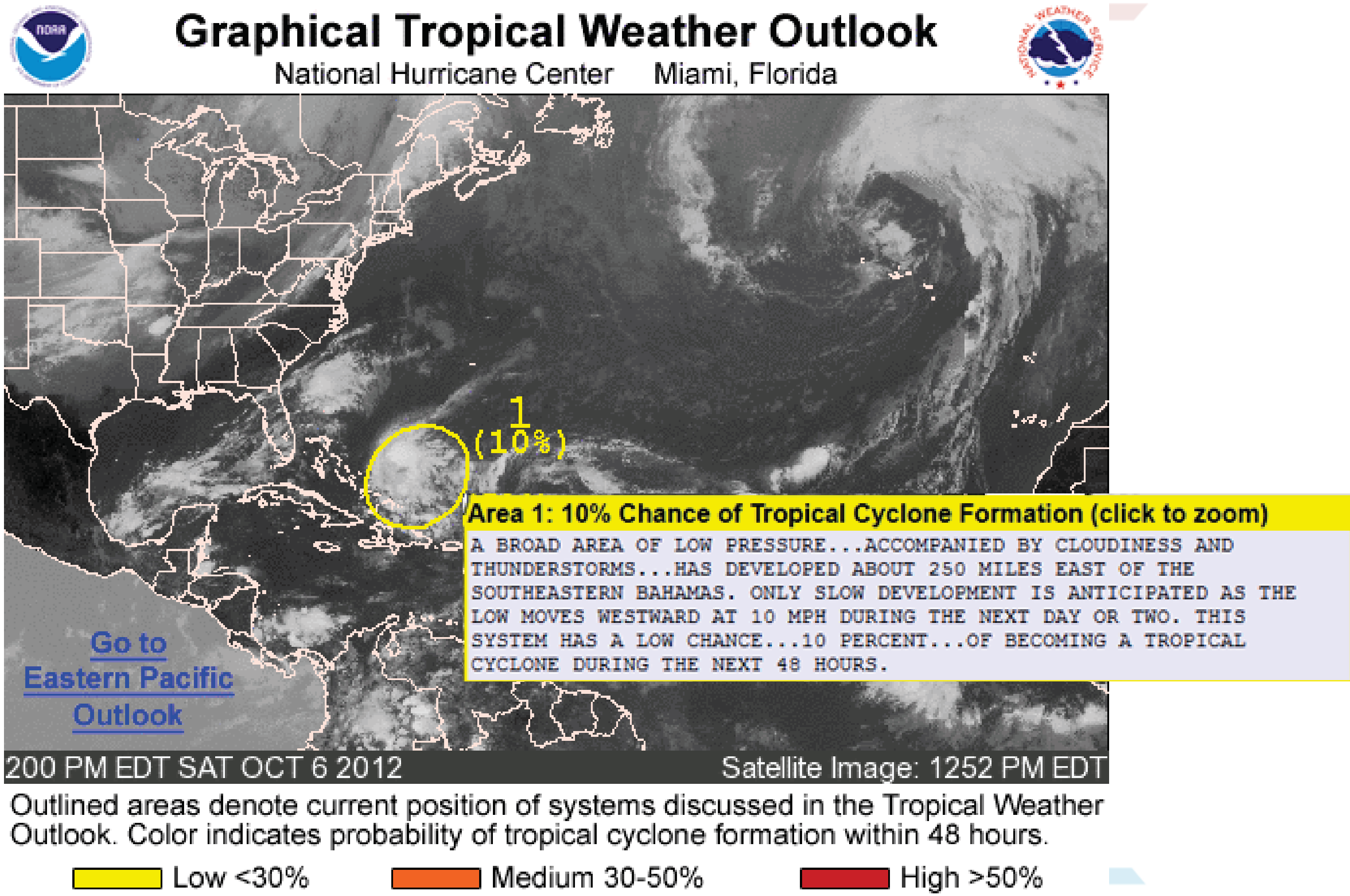
Why do Predictions go wrong?

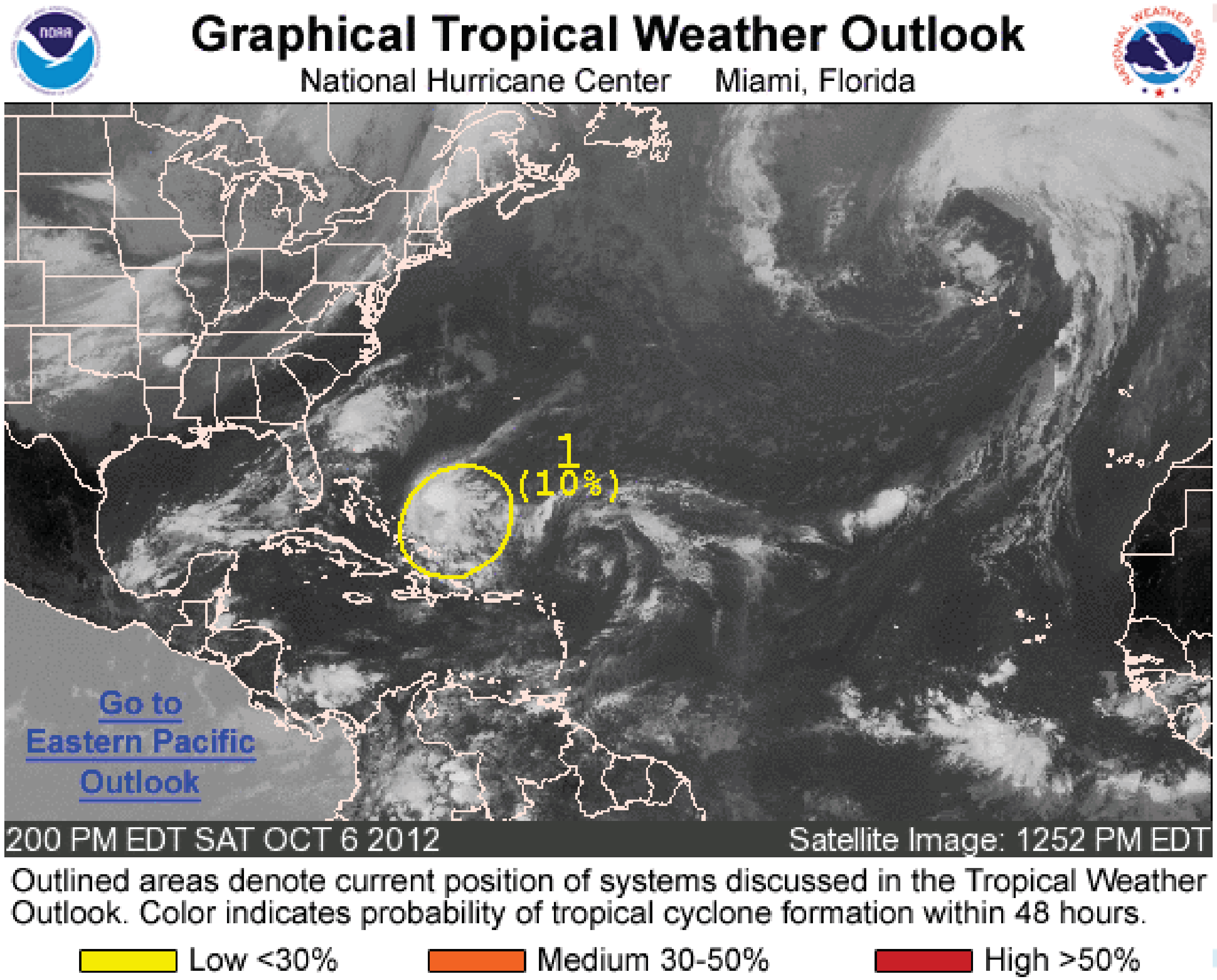
a) Technology is Lacking (Should we hide this?)
b) Science is Lacking (Can we know this?)
c) Political Shenanigans (Can we ignore this?)

Is it possible for Probabilistic Predictions to be “wrong”? (yes, sometimes)

But first… a timely example for those of you flying south:




Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
1
(10%)
Area 1: 10% Chance of Tropical Cyclone Formation (click to zoom)
A BROAD AREA OF LOW PRESSURE...ACCOMPANIED BY CLOUDINESS AND THUNDERSTORMS...HAS DEVELOPED ABOUT 250 MILES EAST OF THE SOUTHEASTERN BAHAMAS. ONLY SLOW DEVELOPMENT IS ANTICIPATED AS THE LOW MOVES WESTWARD AT 10 MPH DURING THE NEXT DAY OR TWO. THIS SYSTEM HAS A LOW CHANCE...10 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS.
Go to Eastern Pacific Outlook
200 PM EDT SAT OCT 6 2012
Satellite Image: 1252 PM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
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(10%)
Go to
Eastern Pacific
Outlook
200 PM EDT SAT OCT 6 2012
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Medium 30-50%
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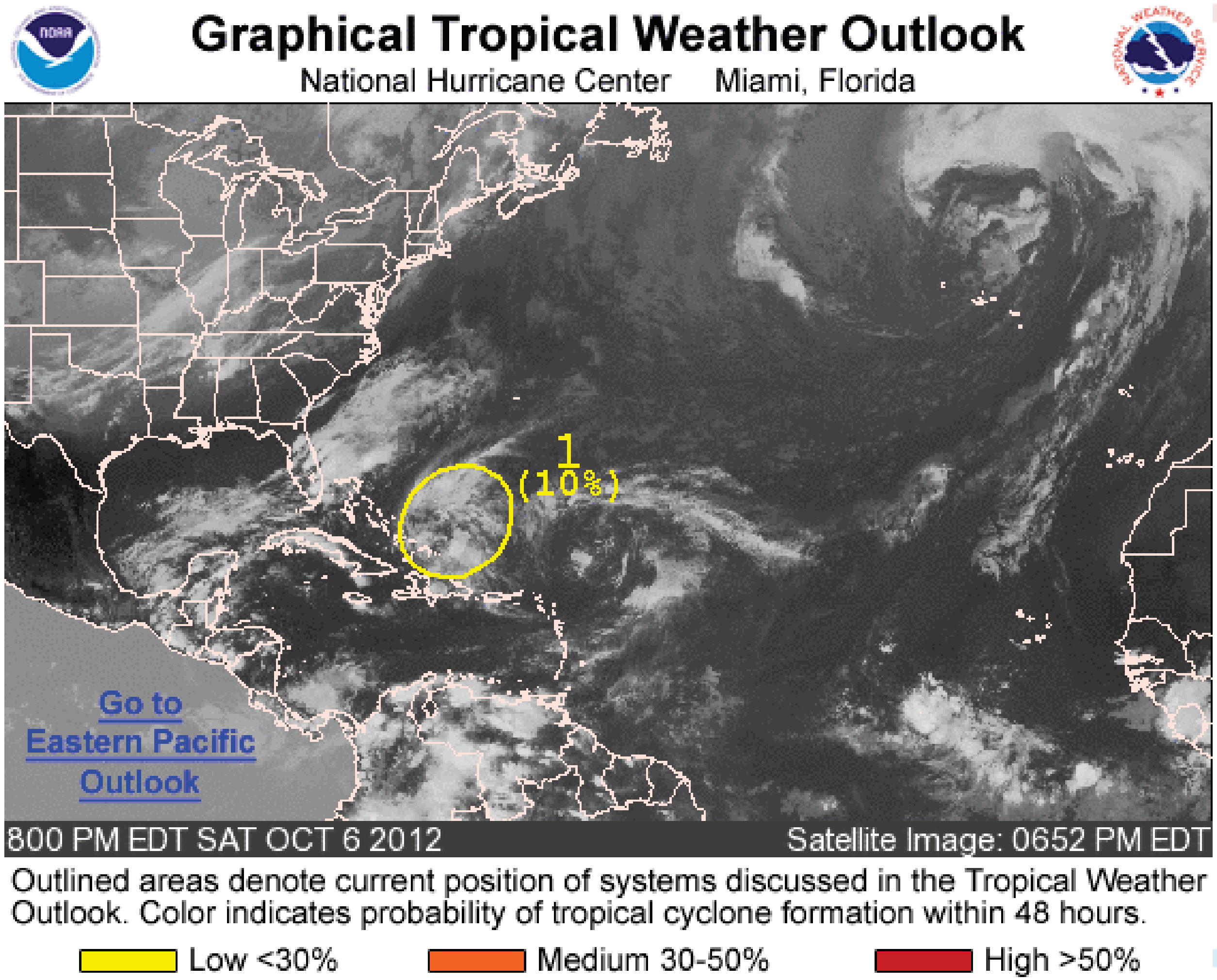
Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
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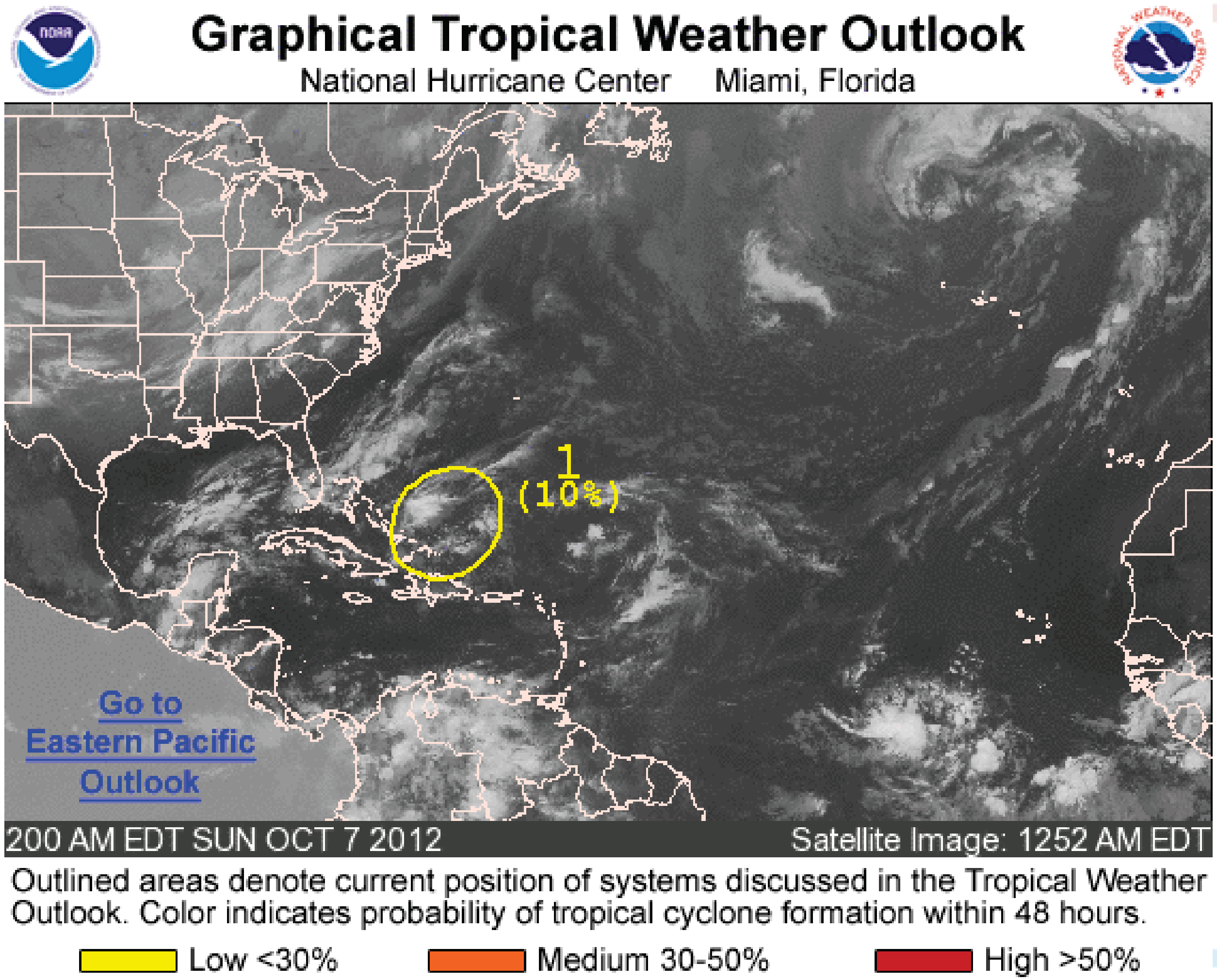
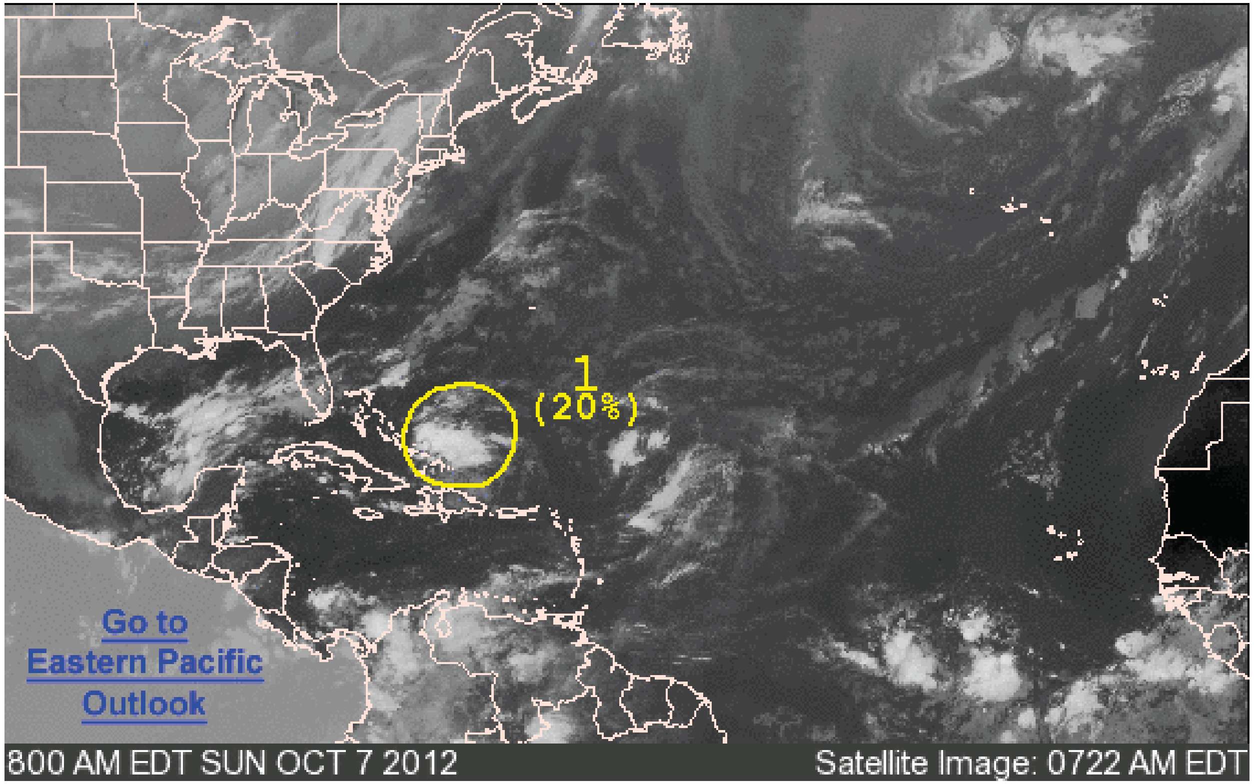
(10%)
Go to
Eastern Pacific
Outlook
800 PM EDT SAT OCT 6 2012
Satellite Image: 0652 PM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
1
(10%)
Go to Eastern Pacific Outlook
200 AM EDT SUN OCT 7 2012
Satellite Image: 1252 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%

Graphical Tropical Weather Outlook

National Hurricane Center   Miami, Florida



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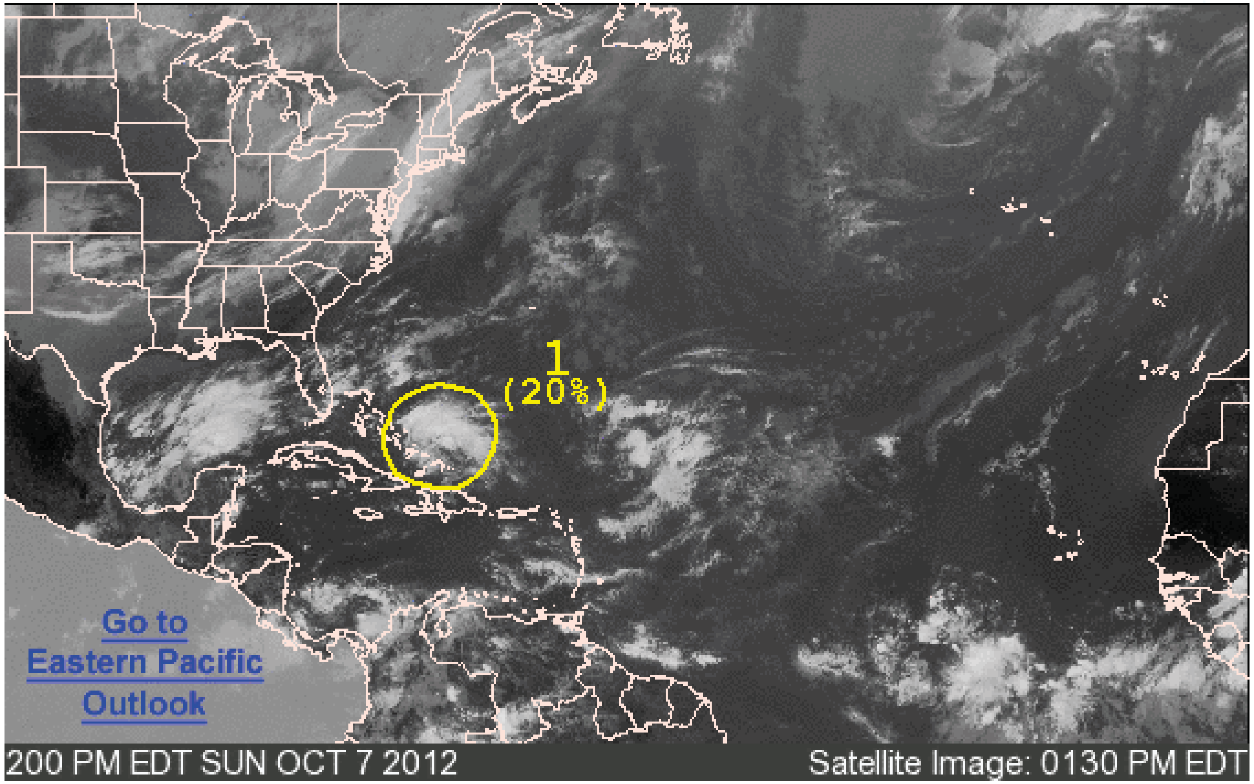
Graphical Tropical Weather Outlook

National Hurricane Center   Miami, Florida



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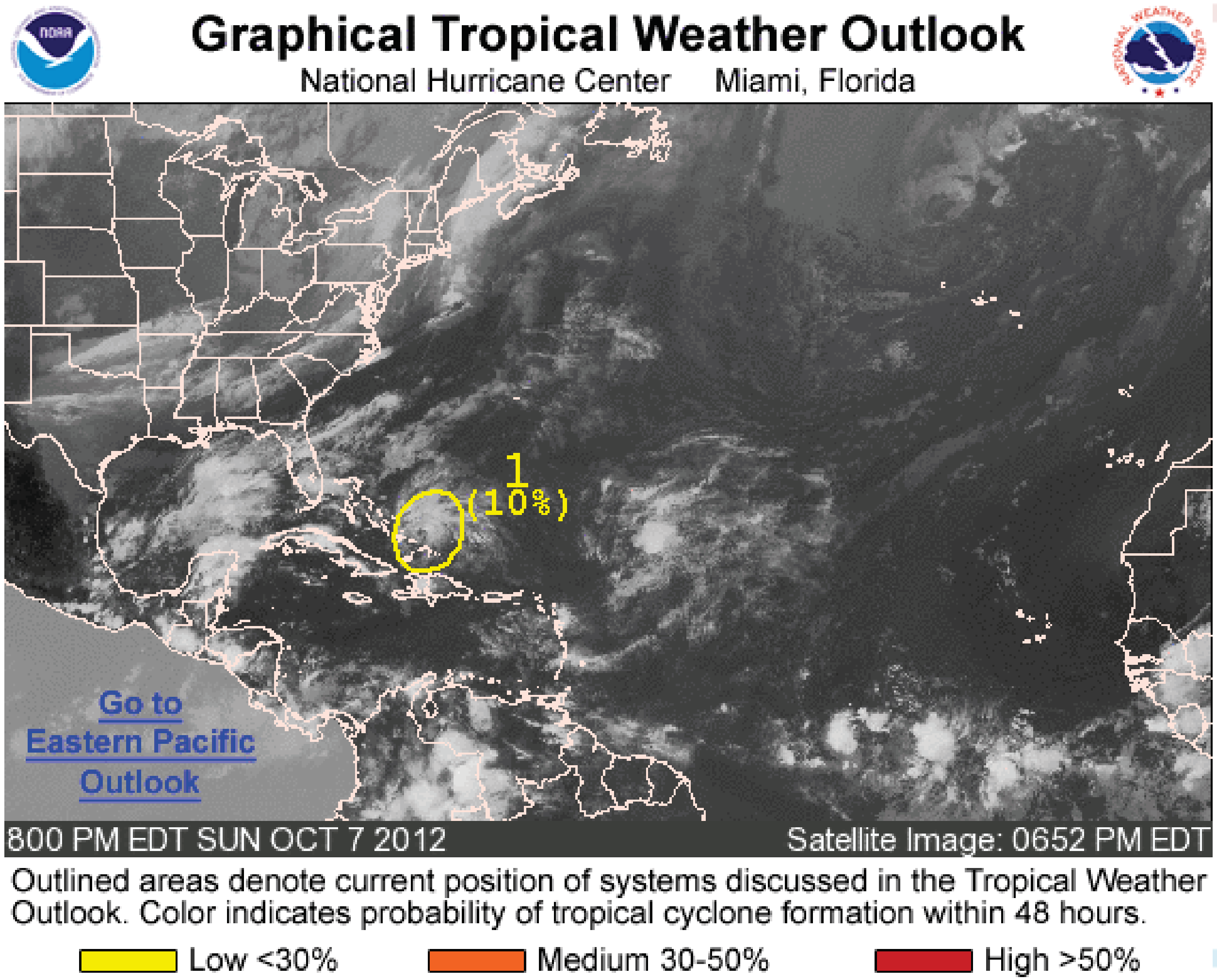
Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
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(10%)
Go to
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Outlook
800 PM EDT SUN OCT 7 2012
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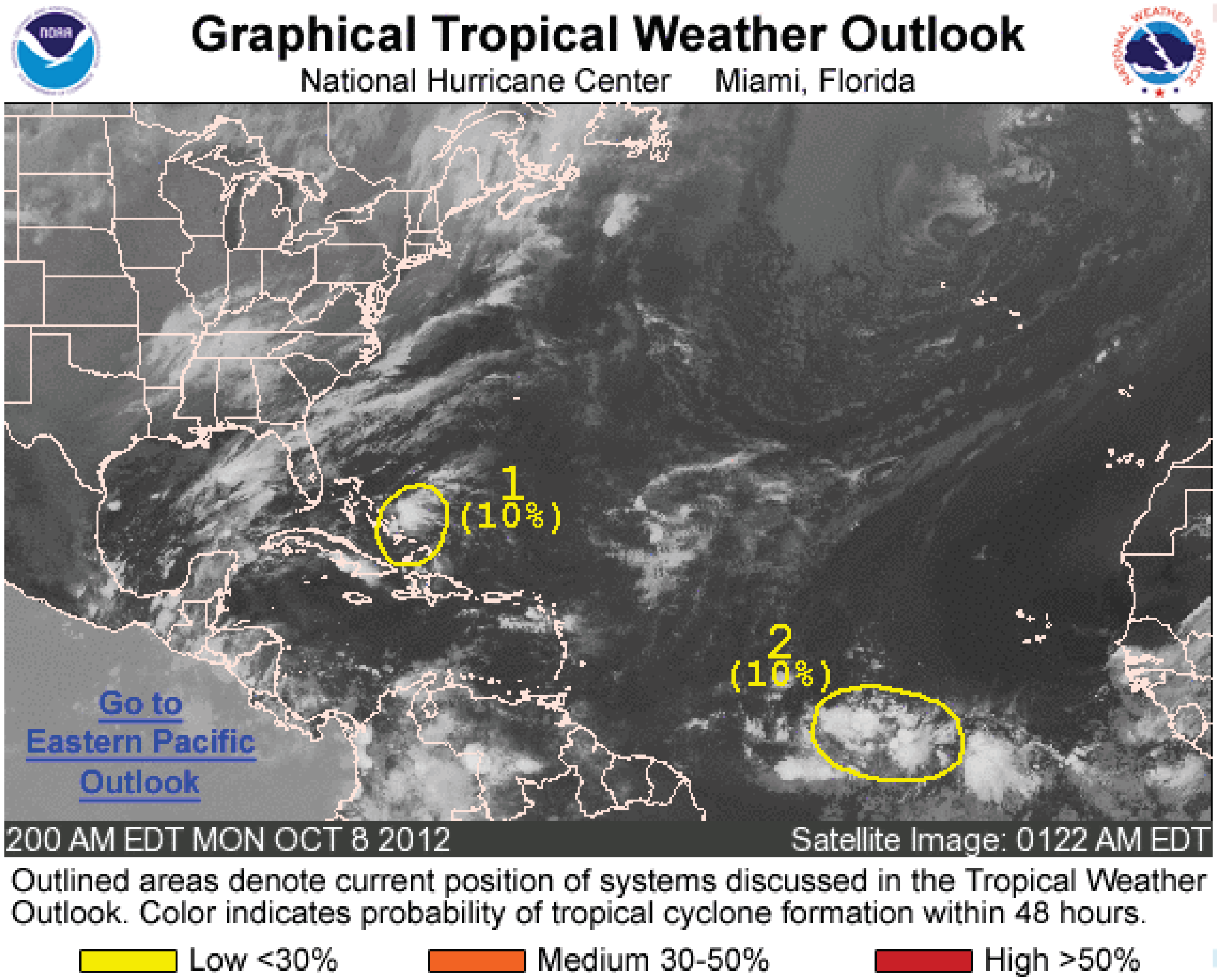
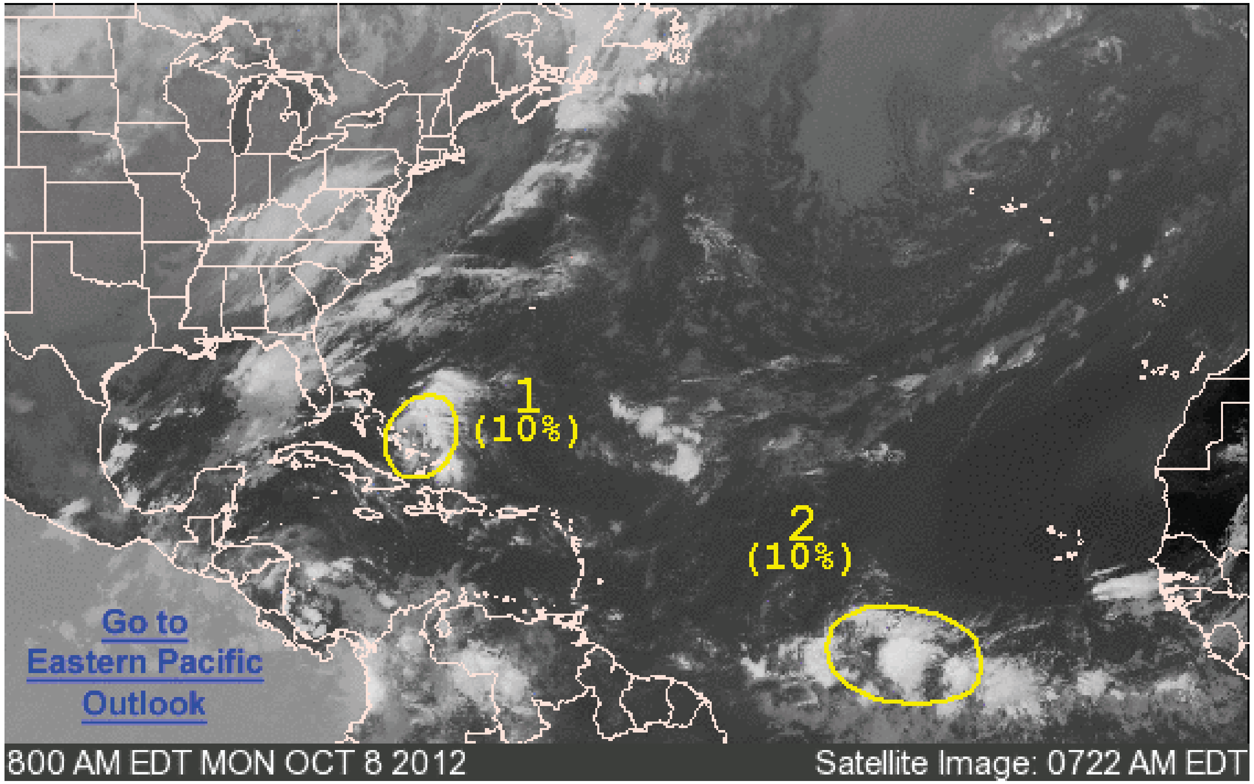


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
1 (10%)
2 (10%)
Go to Eastern Pacific Outlook
200 AM EDT MON OCT 8 2012
Satellite Image: 0122 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%

Graphical Tropical Weather Outlook

National Hurricane Center   Miami, Florida



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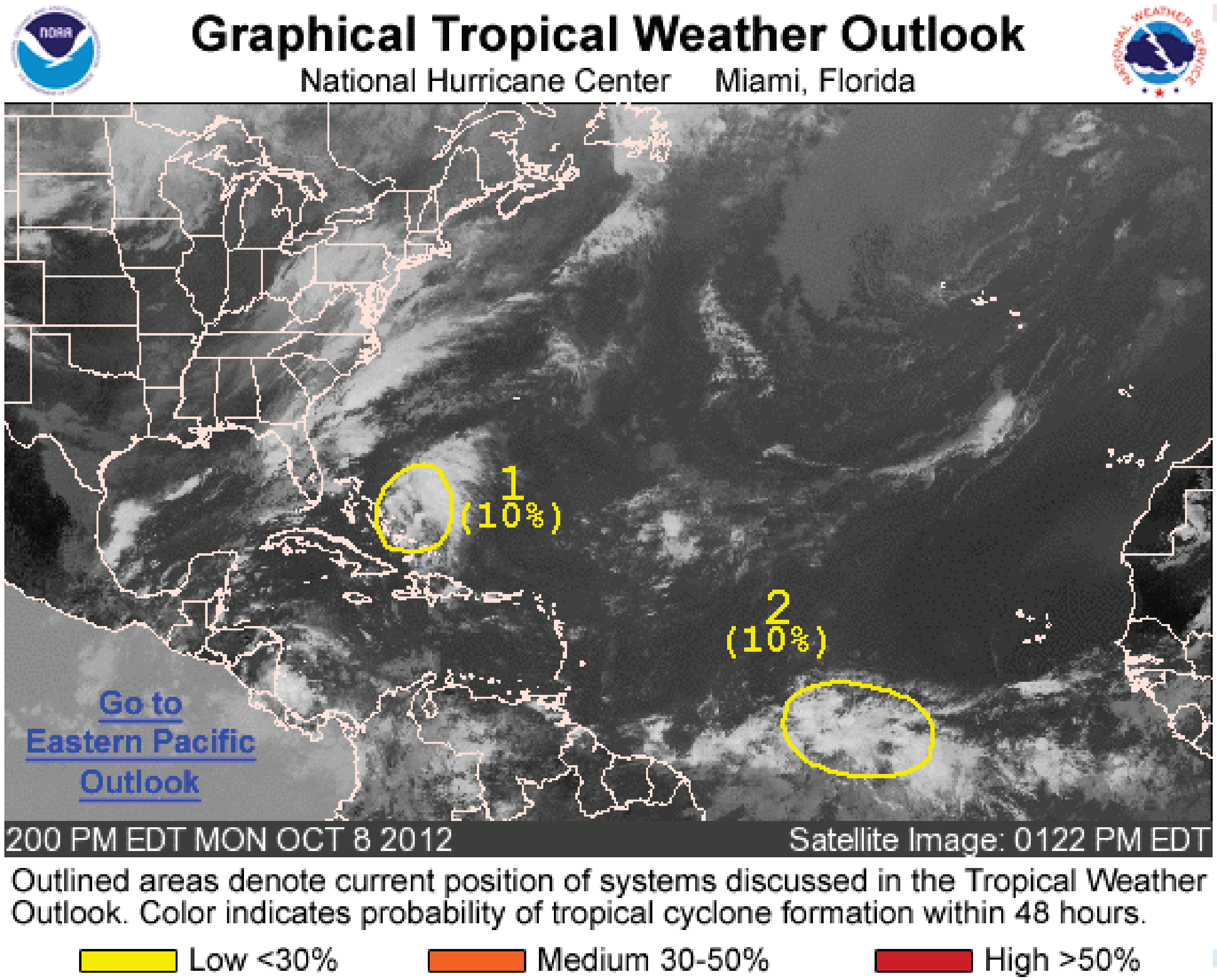
Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
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(10%)
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(10%)
Go to
Eastern Pacific
Outlook
200 PM EDT MON OCT 8 2012
Satellite Image: 0122 PM EDT
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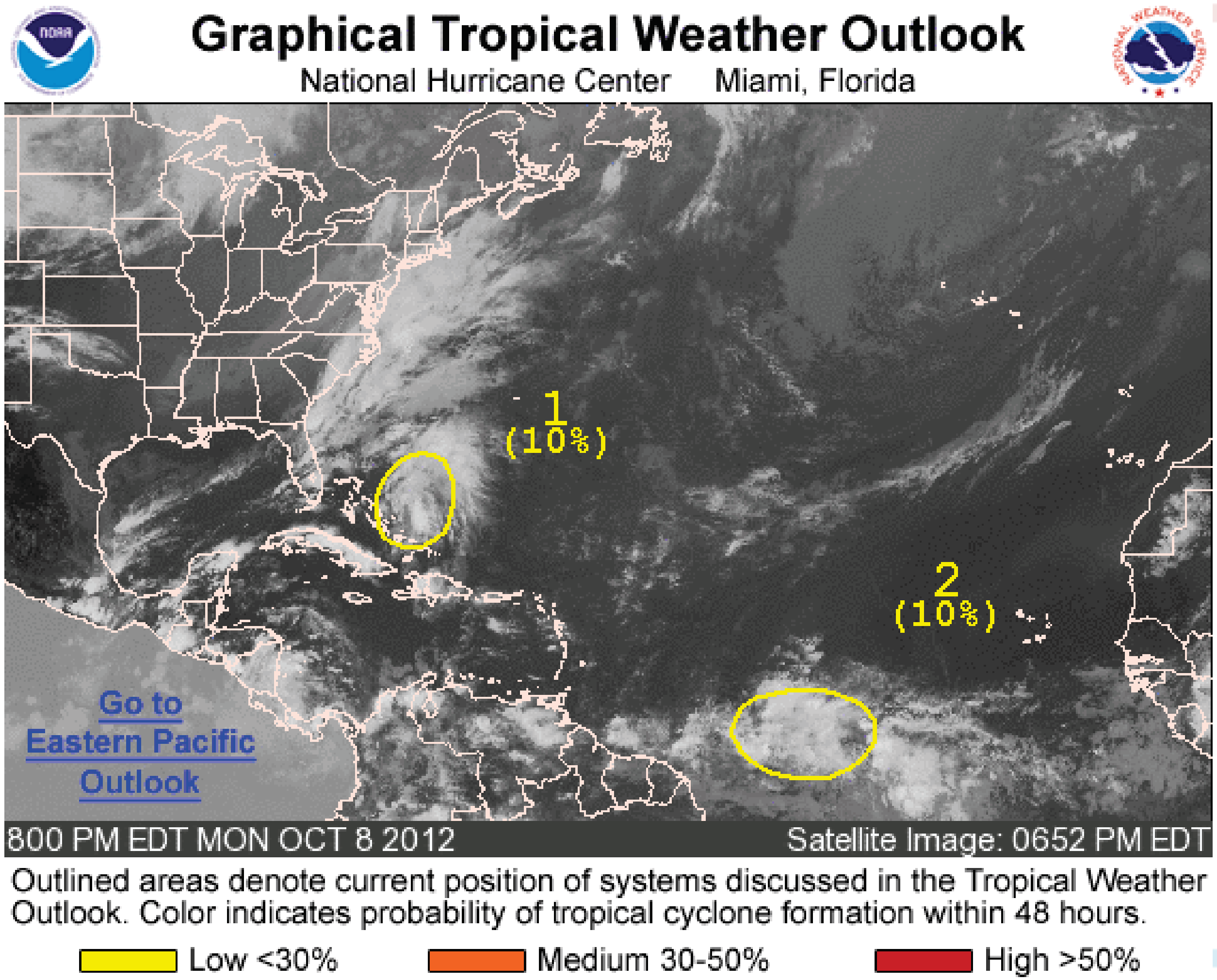
Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
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(10%)
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(10%)
Go to
Eastern Pacific
Outlook
800 PM EDT MON OCT 8 2012
Satellite Image: 0652 PM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
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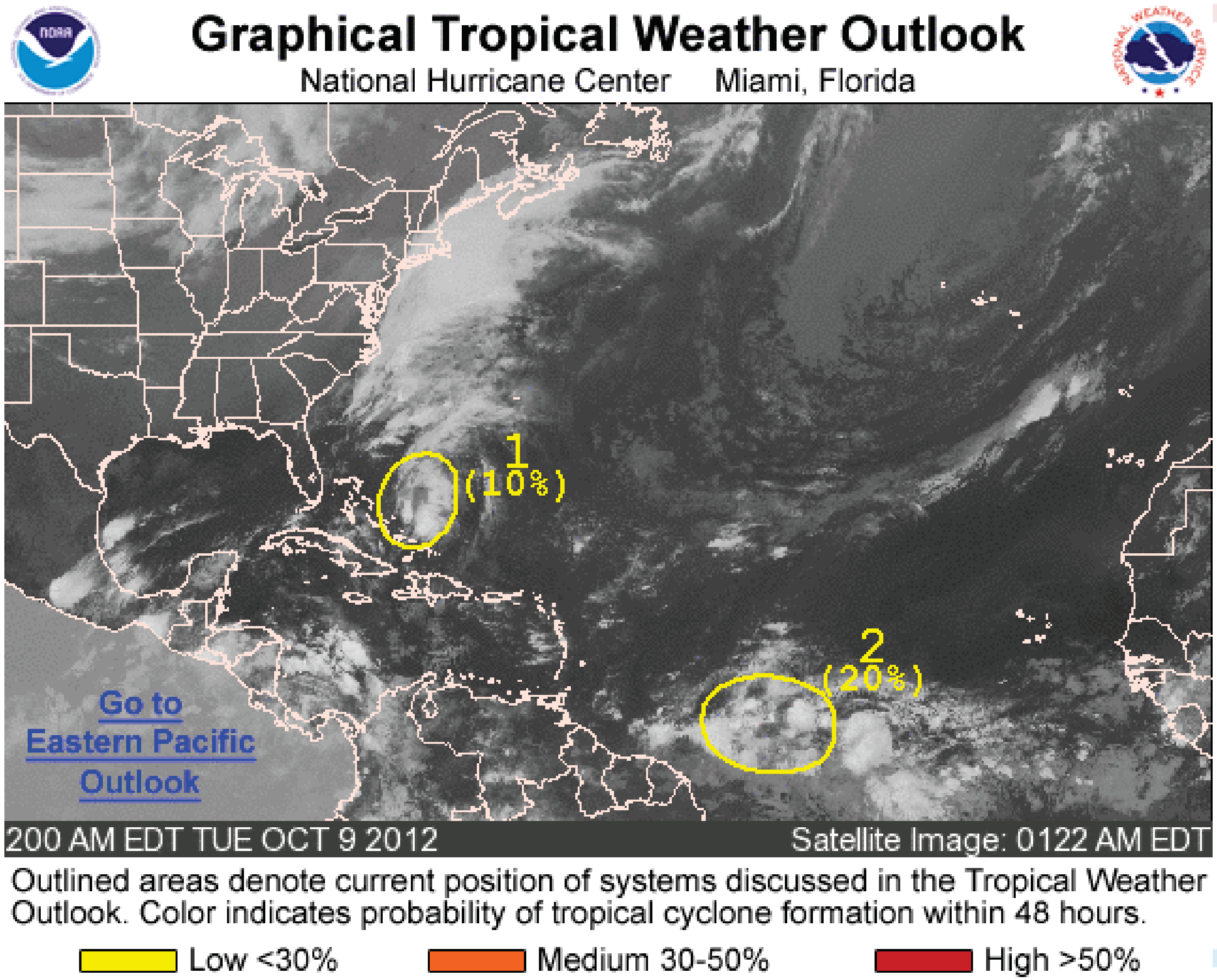
Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
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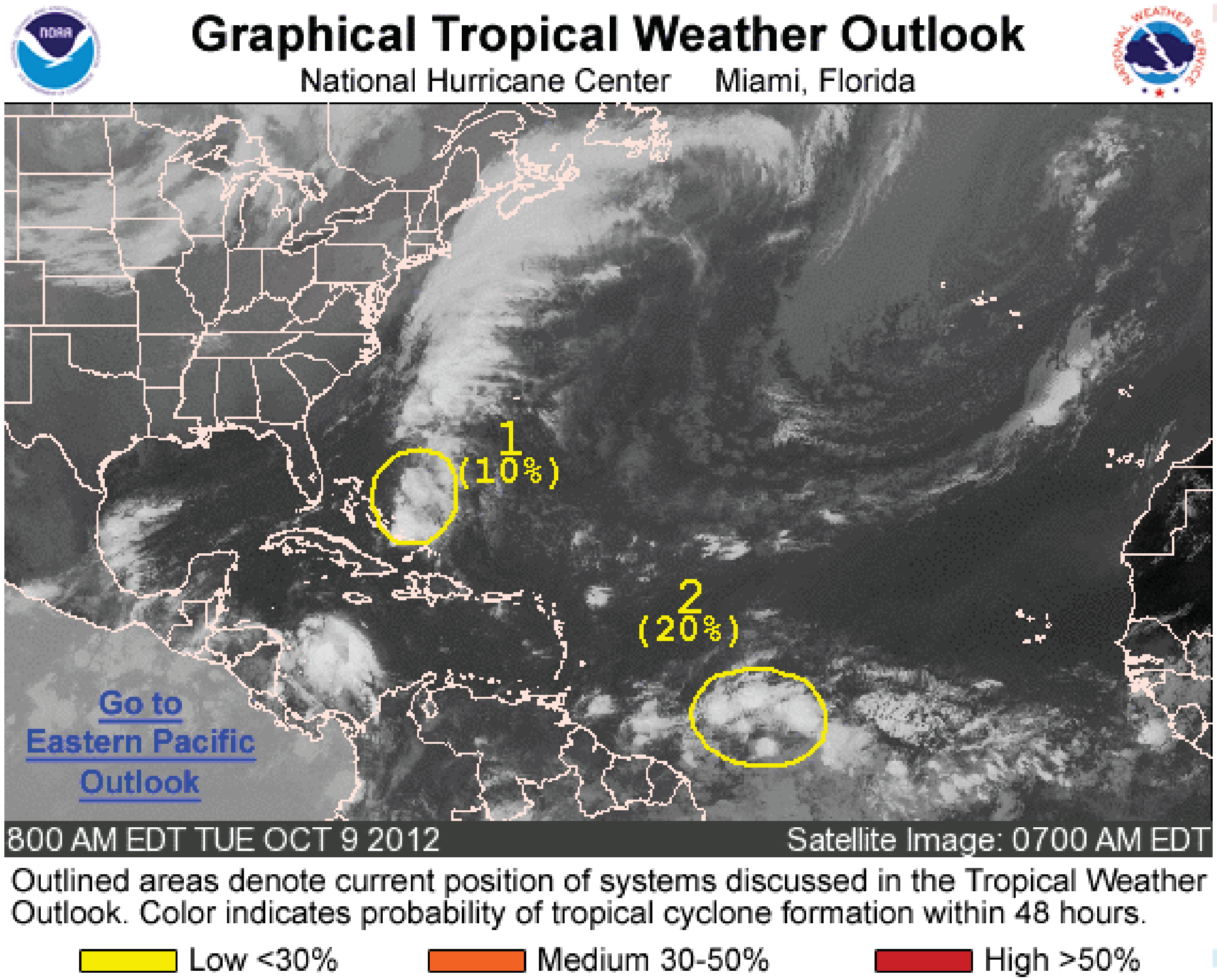
(20%)
Go to
Eastern Pacific
Outlook
200 AM EDT TUE OCT 9 2012
Satellite Image: 0122 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
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(10%)
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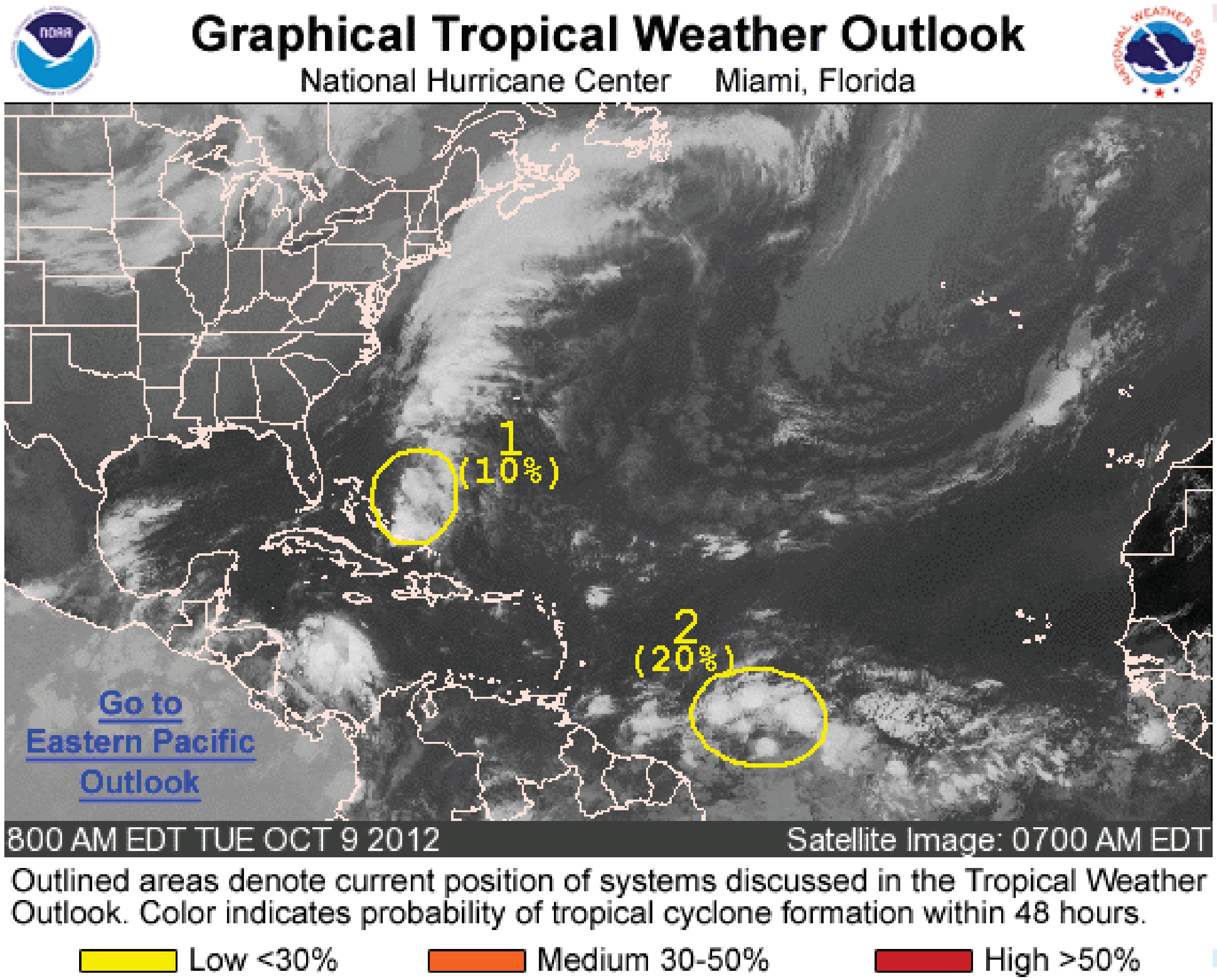
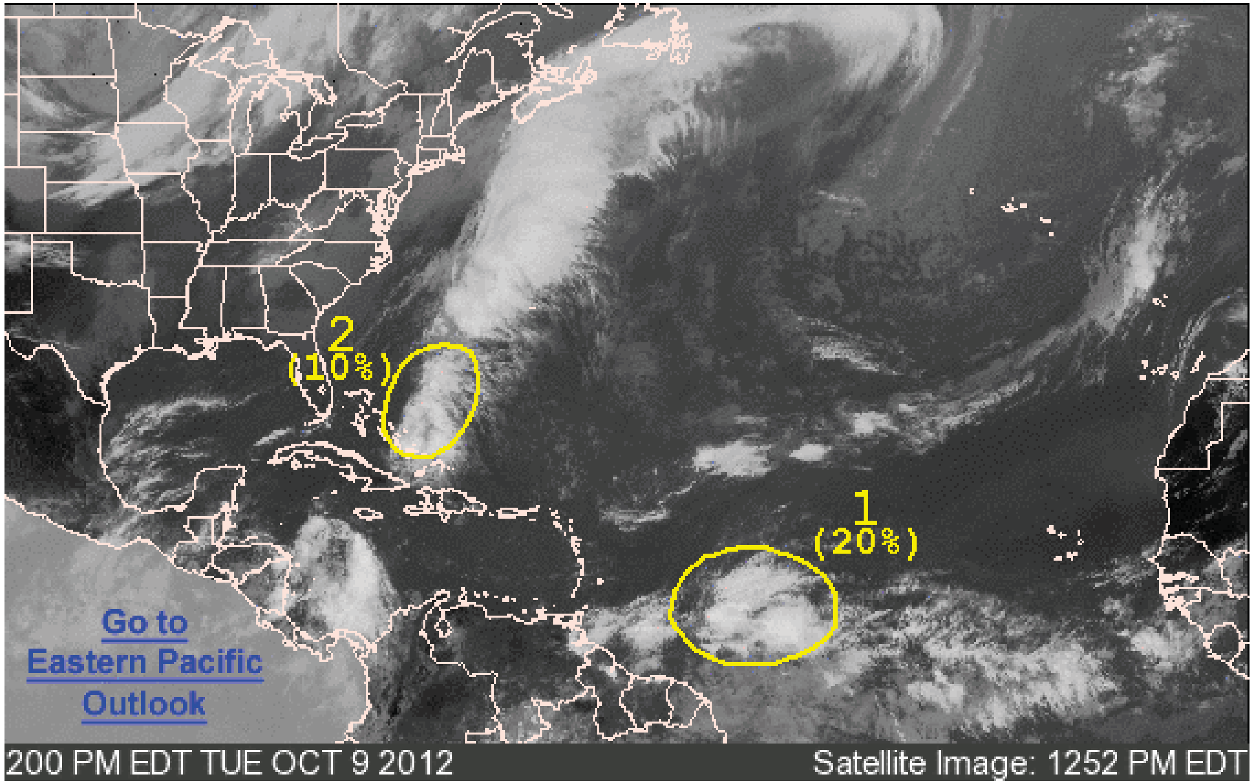
(20%)
Go to
Eastern Pacific
Outlook
800 AM EDT TUE OCT 9 2012
Satellite Image: 0700 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
1
(10%)
2
(20%)
Go to
Eastern Pacific
Outlook
800 AM EDT TUE OCT 9 2012
Satellite Image: 0700 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%

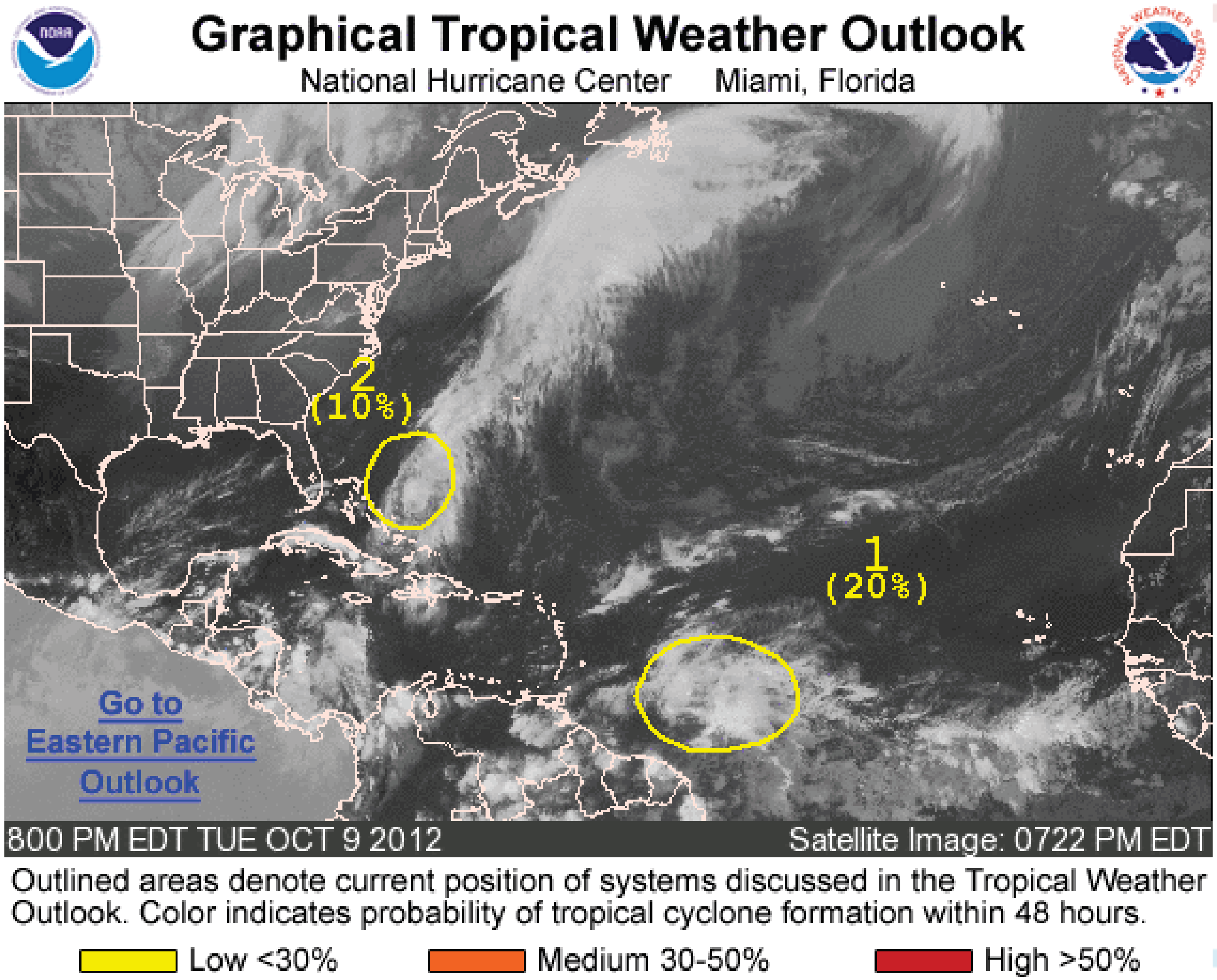
Graphical Tropical Weather Outlook

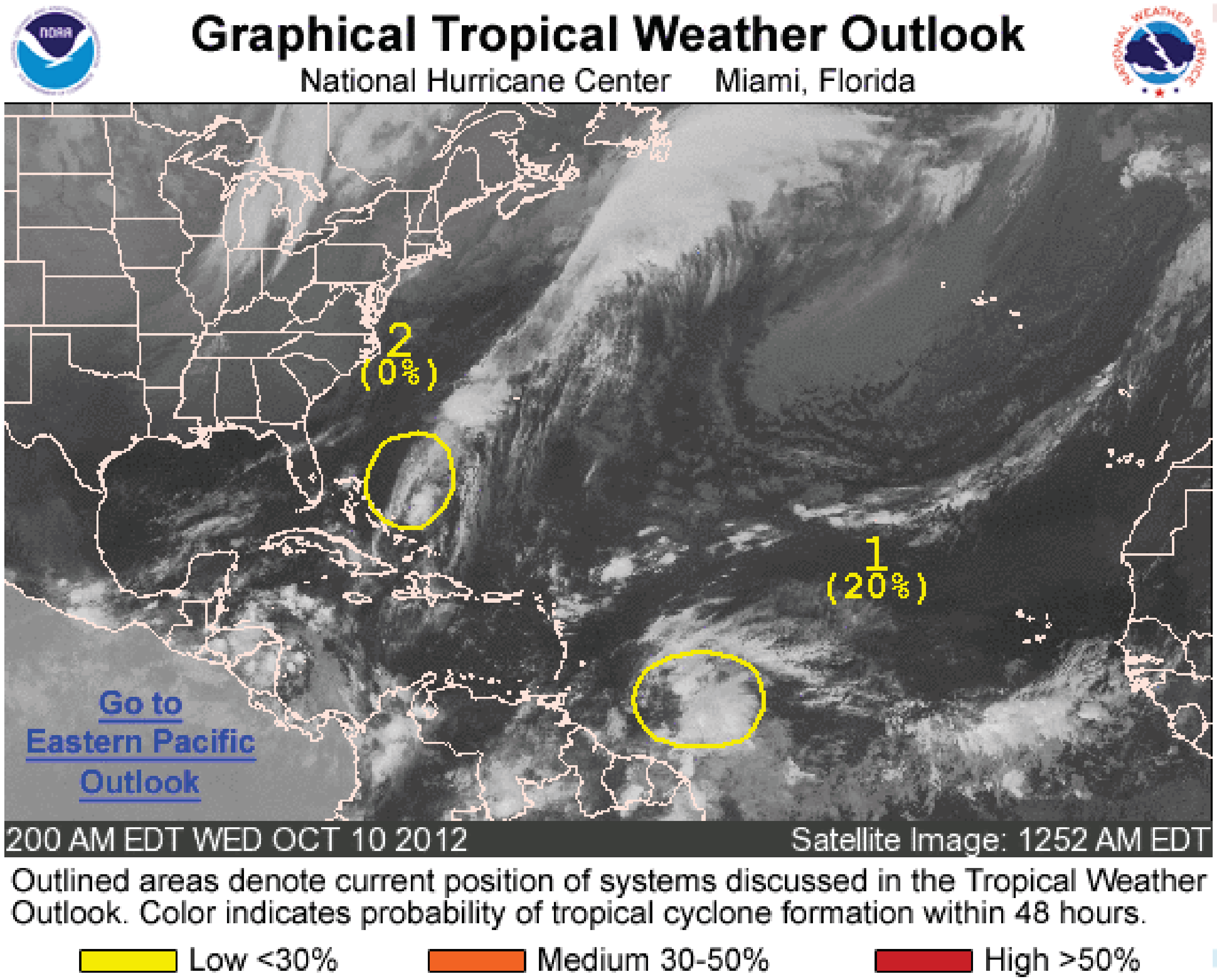
National Hurricane Center Miami, Florida



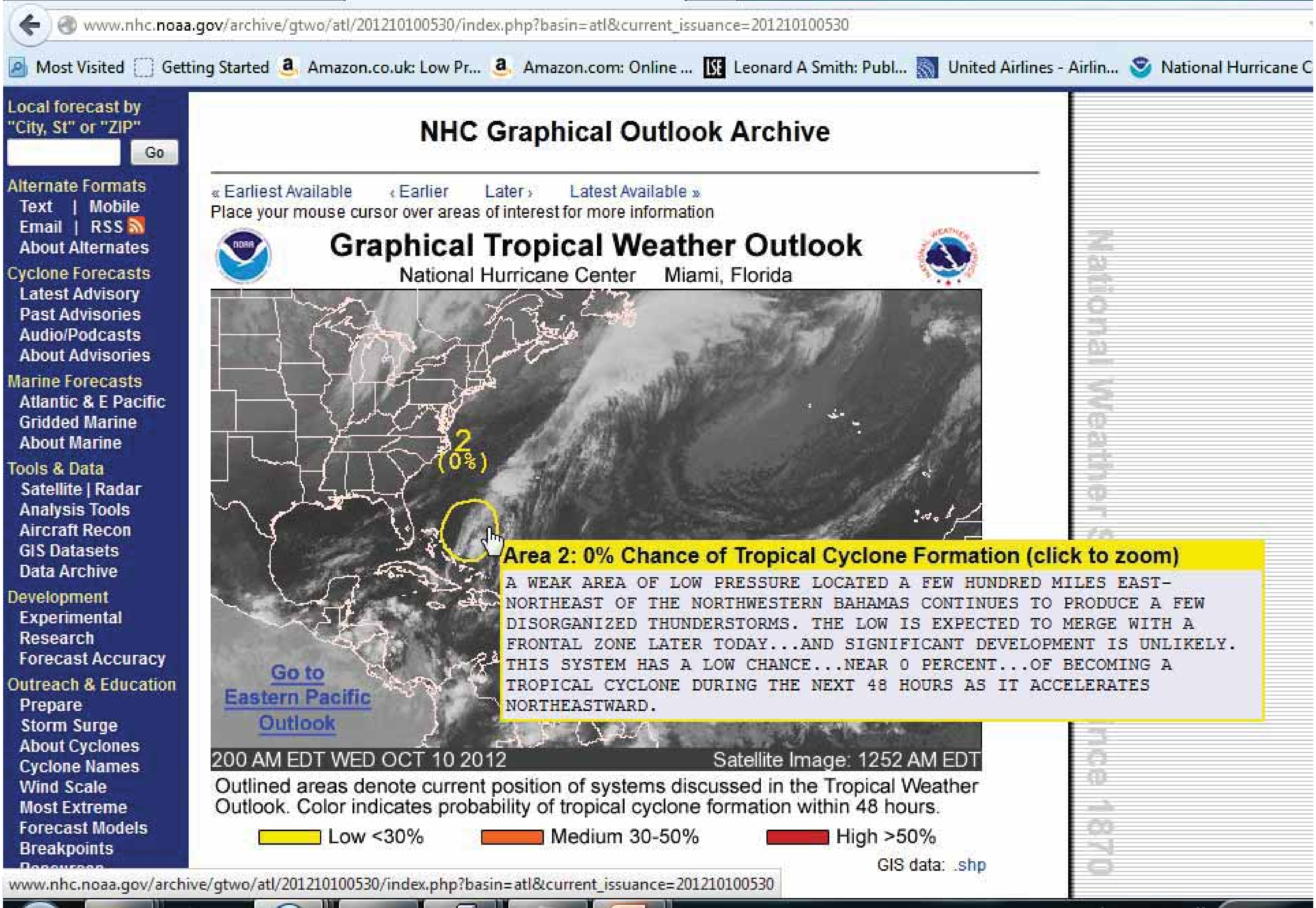
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.

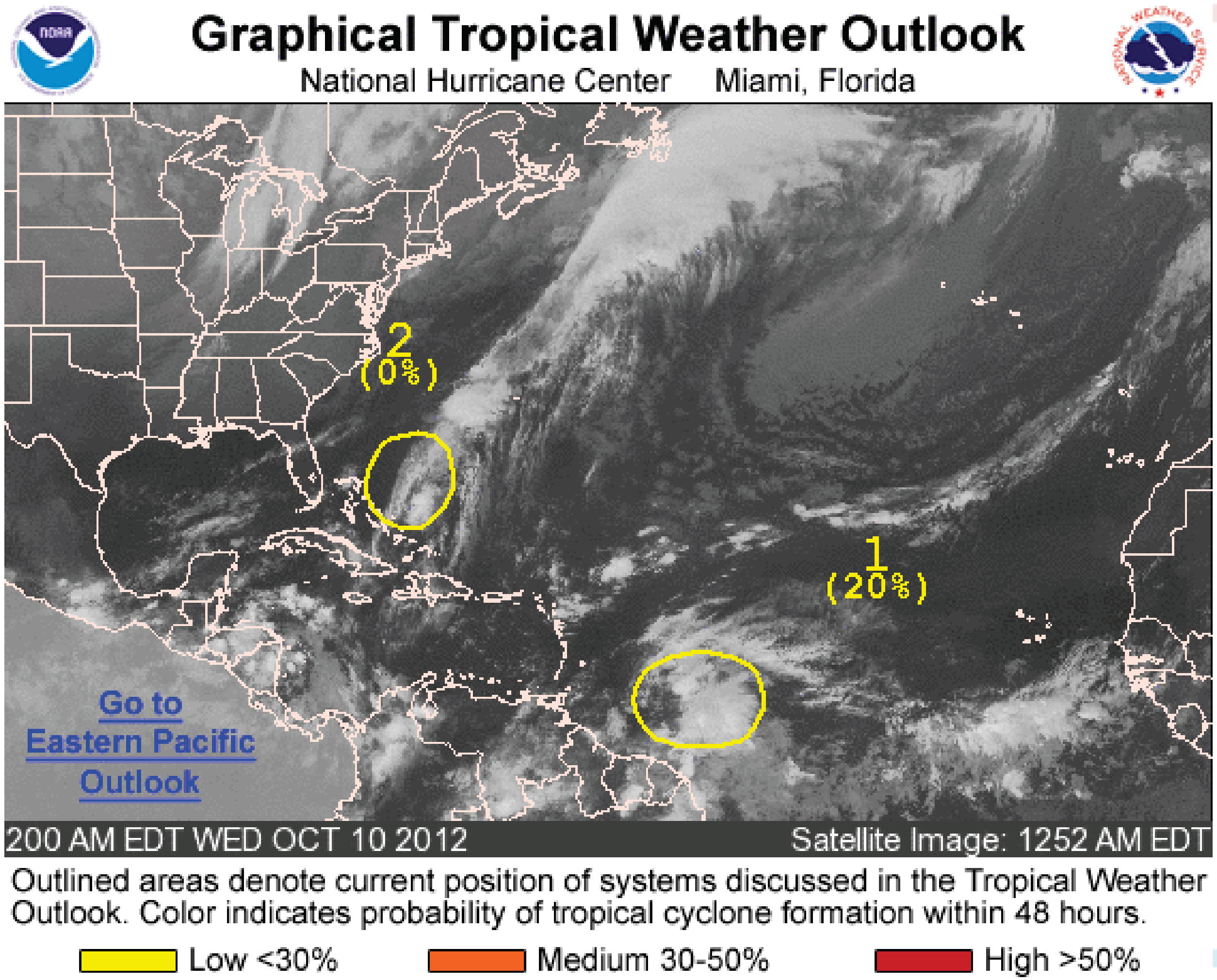
Low <30% Medium 30-50% High >50%

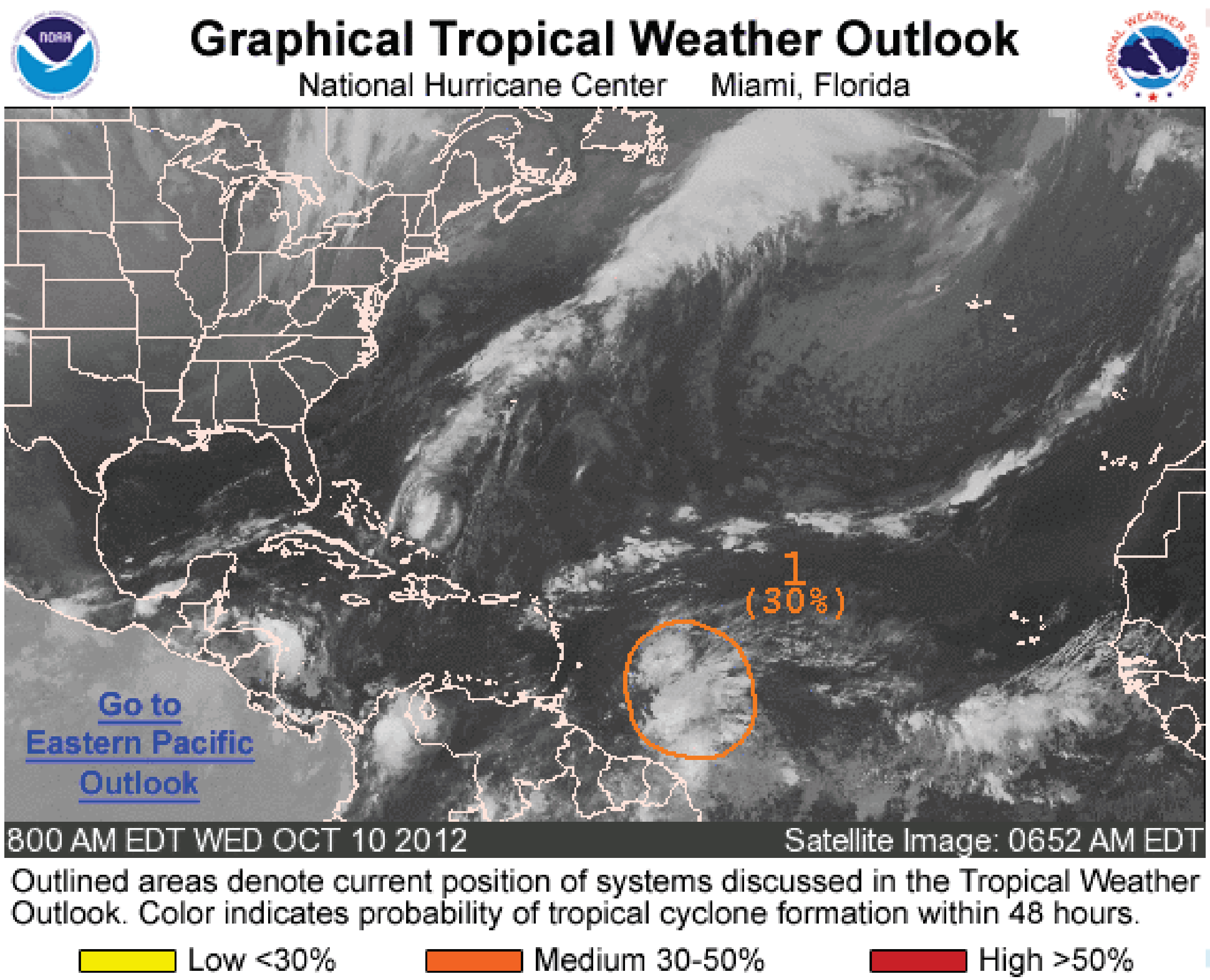

Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(10%)
1
(20%)
Go to
Eastern Pacific
Outlook
800 PM EDT TUE OCT 9 2012
Satellite Image: 0722 PM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%



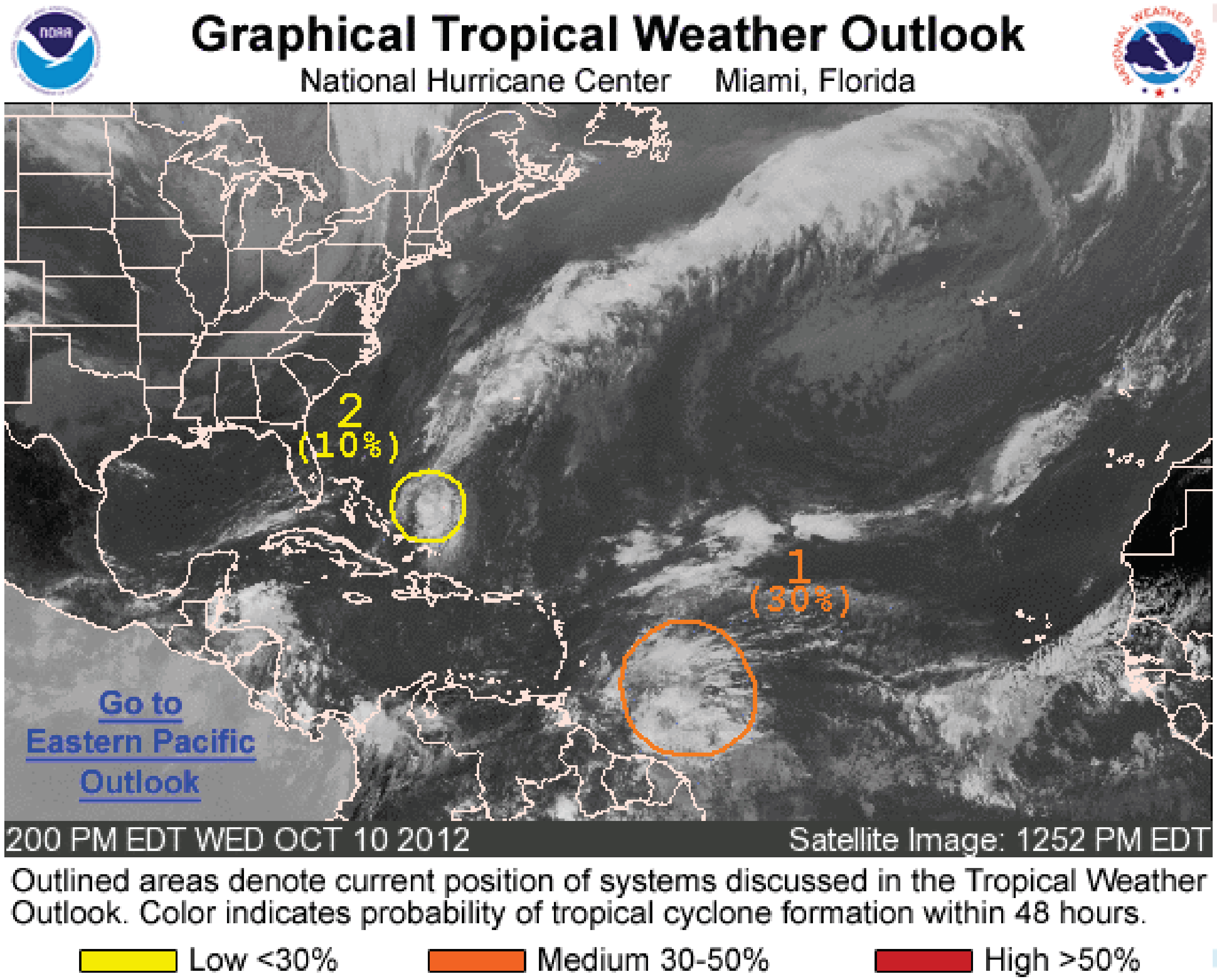
Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(0%)
1
(20%)
Go to Eastern Pacific Outlook
200 AM EDT WED OCT 10 2012
Satellite Image: 1252 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%


www.nhc.noaa.gov/archive/gtwo/atl/201210100530/index.php?basin=atl&current_issuance=201210100530
Most Visited
Getting Started
Amazon.co.uk: Low Pr...
Amazon.com: Online ...
Leonard A Smith: Publ...
United Airlines - Airlin...
National Hurricane C
Local forecast by "City, St" or "ZIP"
Go
Alternate Formats
Text | Mobile
Email | RSS
About Alternates
Cyclone Forecasts
Latest Advisory
Past Advisories
Audio/Podcasts
About Advisories
Marine Forecasts
Atlantic & E Pacific
Gridded Marine
About Marine
Tools & Data
Satellite | Radar
Analysis Tools
Aircraft Recon
GIS Datasets
Data Archive
Development
Experimental
Research
Forecast Accuracy
Outreach & Education
Prepare
Storm Surge
About Cyclones
Cyclone Names
Wind Scale
Most Extreme
Forecast Models
Breakpoints
NHC Graphical Outlook Archive
« Earliest Available
‹ Earlier
Later ›
Latest Available »
Place your mouse cursor over areas of interest for more information
Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(0%)
Go to Eastern Pacific Outlook
Area 2: 0% Chance of Tropical Cyclone Formation (click to zoom)
A WEAK AREA OF LOW PRESSURE LOCATED A FEW HUNDRED MILES EAST-NORTHEAST OF THE NORTHWESTERN BAHAMAS CONTINUES TO PRODUCE A FEW DISORGANIZED THUNDERSTORMS. THE LOW IS EXPECTED TO MERGE WITH A FRONTAL ZONE LATER TODAY...AND SIGNIFICANT DEVELOPMENT IS UNLIKELY. THIS SYSTEM HAS A LOW CHANCE...NEAR 0 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS AS IT ACCELERATES NORTHEASTWARD.
200 AM EDT WED OCT 10 2012
Satellite Image: 1252 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%
GIS data: .shp
www.nhc.noaa.gov/archive/gtwo/atl/201210100530/index.php?basin=atl&current_issuance=201210100530


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(0%)
1
(20%)
Go to Eastern Pacific Outlook
200 AM EDT WED OCT 10 2012
Satellite Image: 1252 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%



Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
1
(30%)
Go to Eastern Pacific Outlook
800 AM EDT WED OCT 10 2012
Satellite Image: 0652 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(10%)
1
(30%)
Go to
Eastern Pacific
Outlook
200 PM EDT WED OCT 10 2012
Satellite Image: 1252 PM EDT
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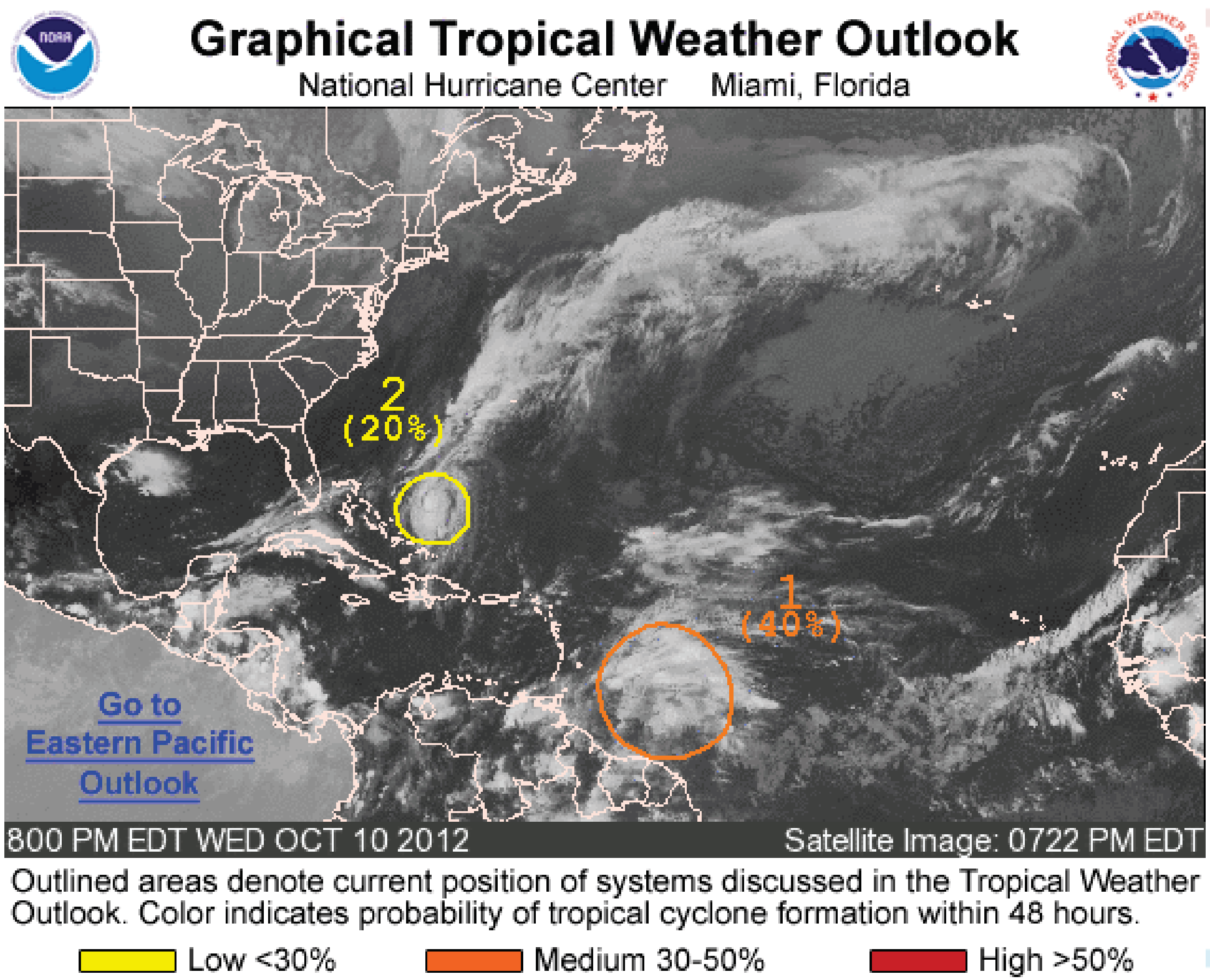
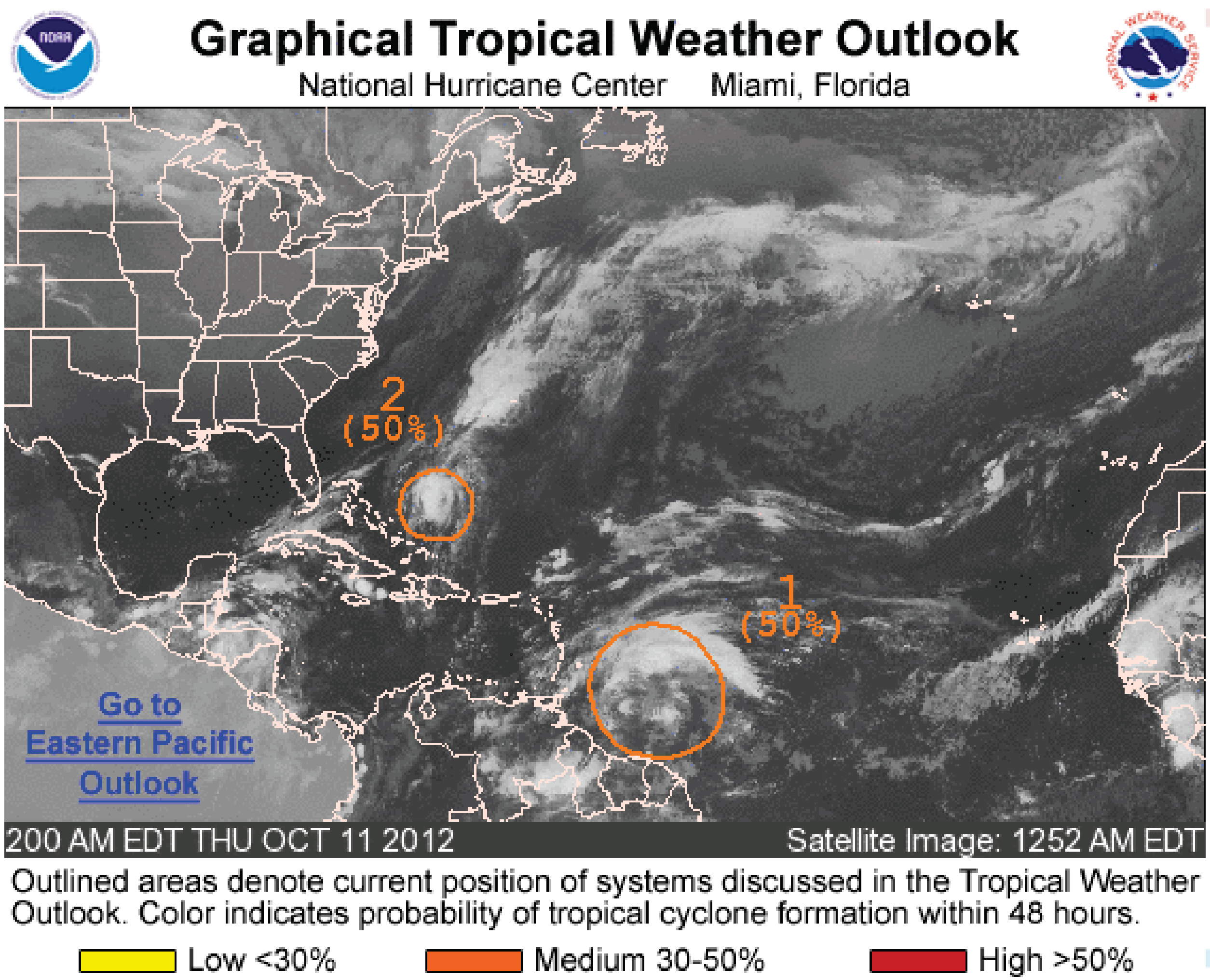

Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(20%)
1
(40%)
Go to
Eastern Pacific
Outlook
800 PM EDT WED OCT 10 2012
Satellite Image: 0722 PM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%



Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(50%)
1
(50%)
Go to
Eastern Pacific
Outlook
200 AM EDT THU OCT 11 2012
Satellite Image: 1252 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
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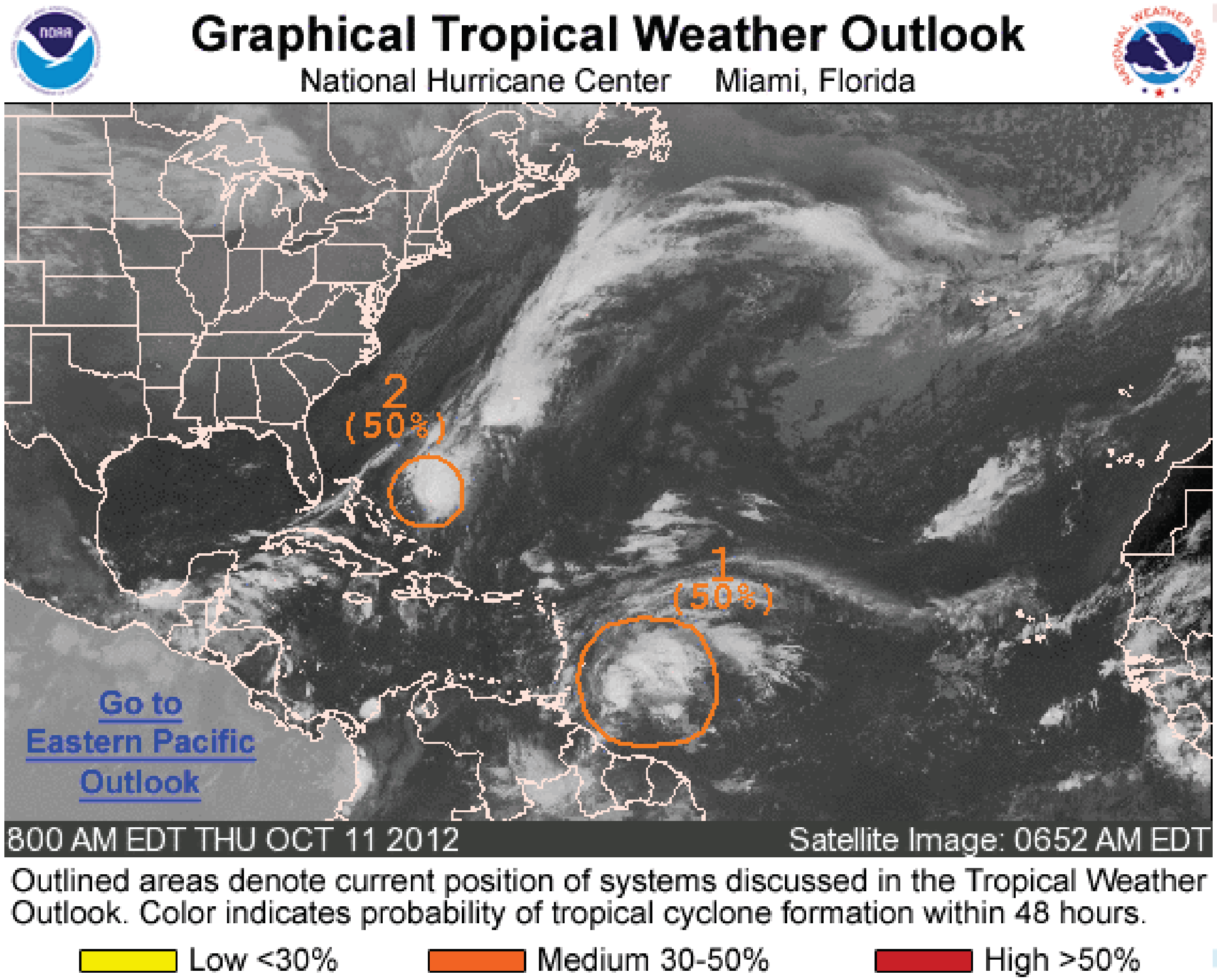
High >50%



Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
2
(50%)
1
(50%)
Go to
Eastern Pacific
Outlook
800 AM EDT THU OCT 11 2012
Satellite Image: 0652 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
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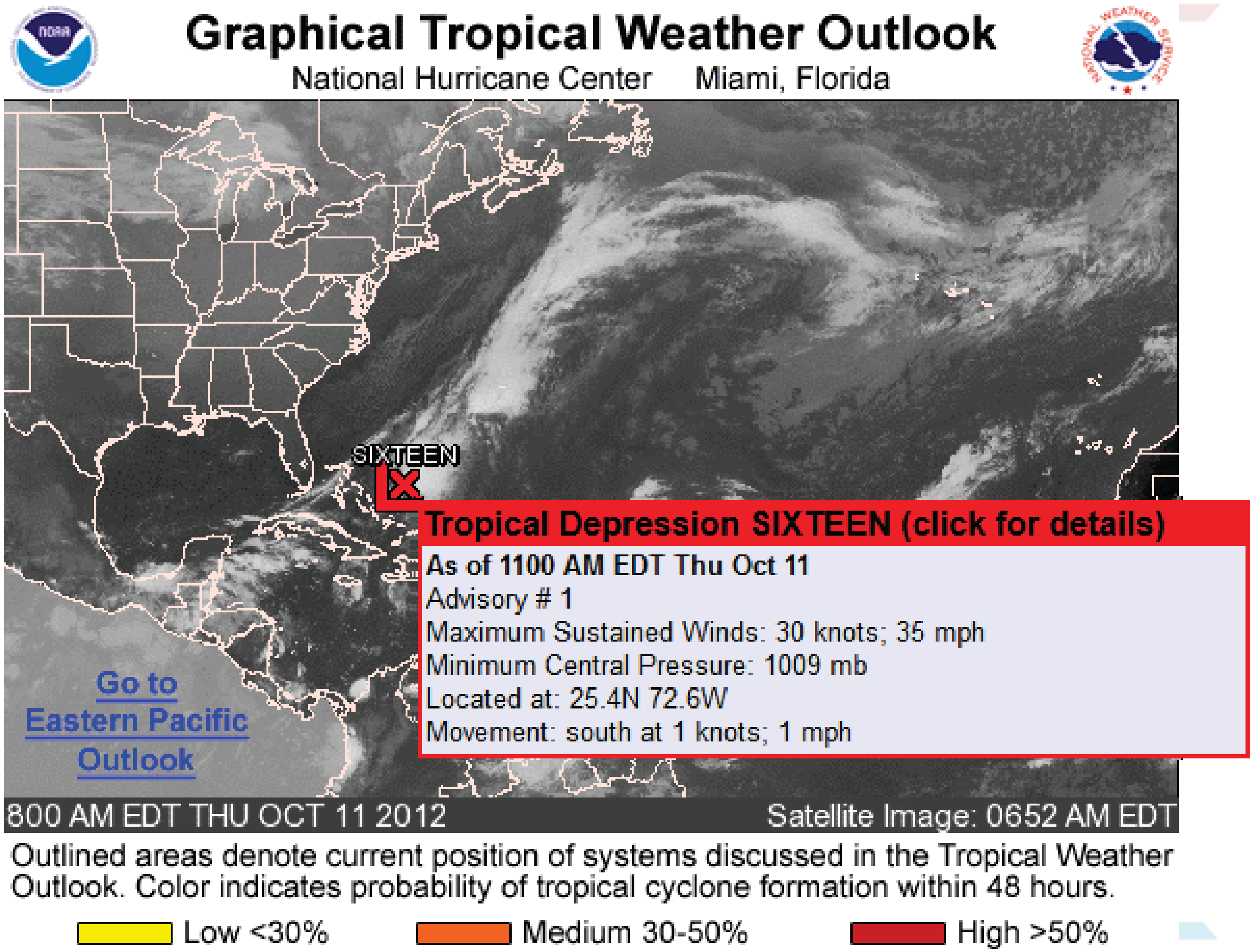
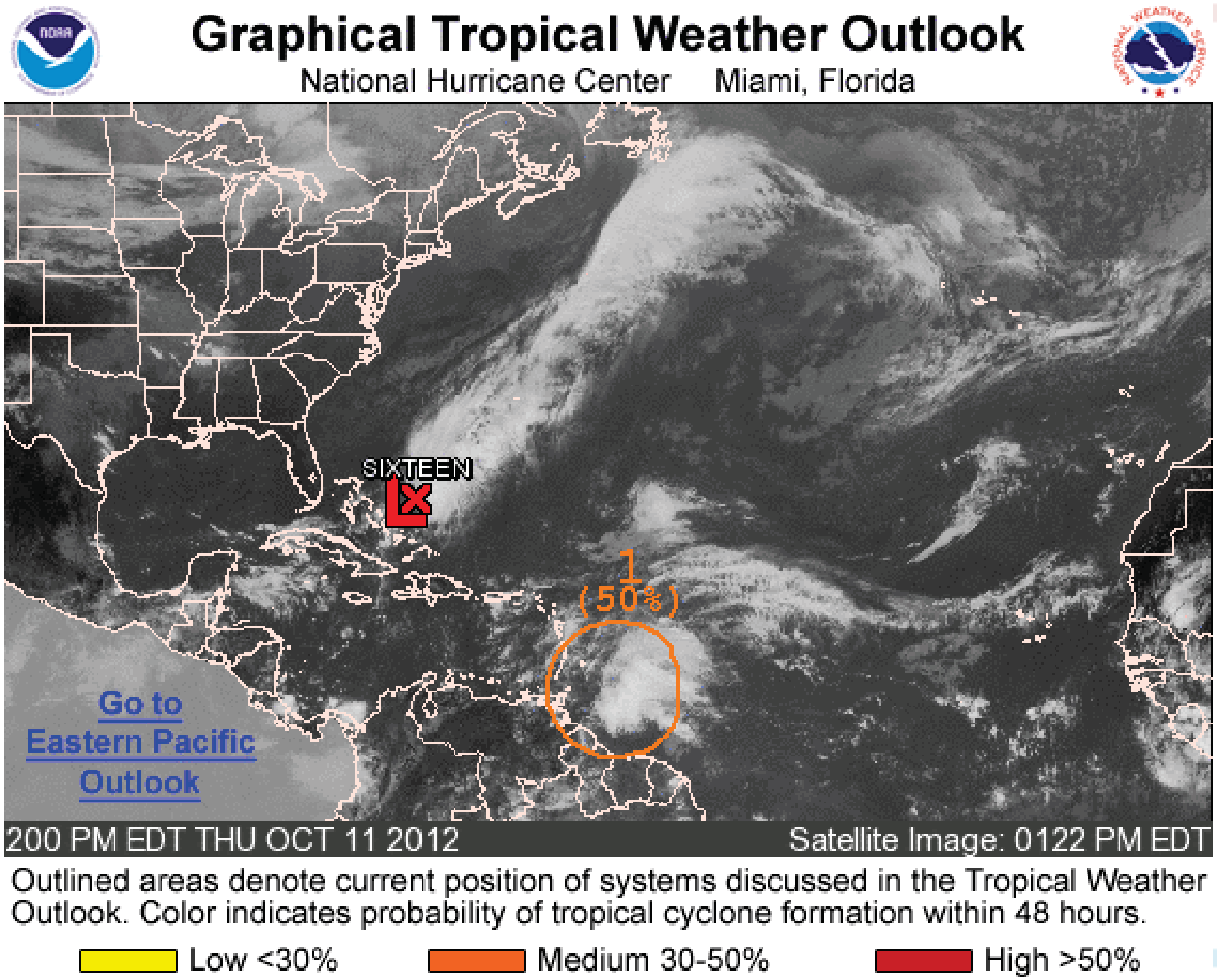
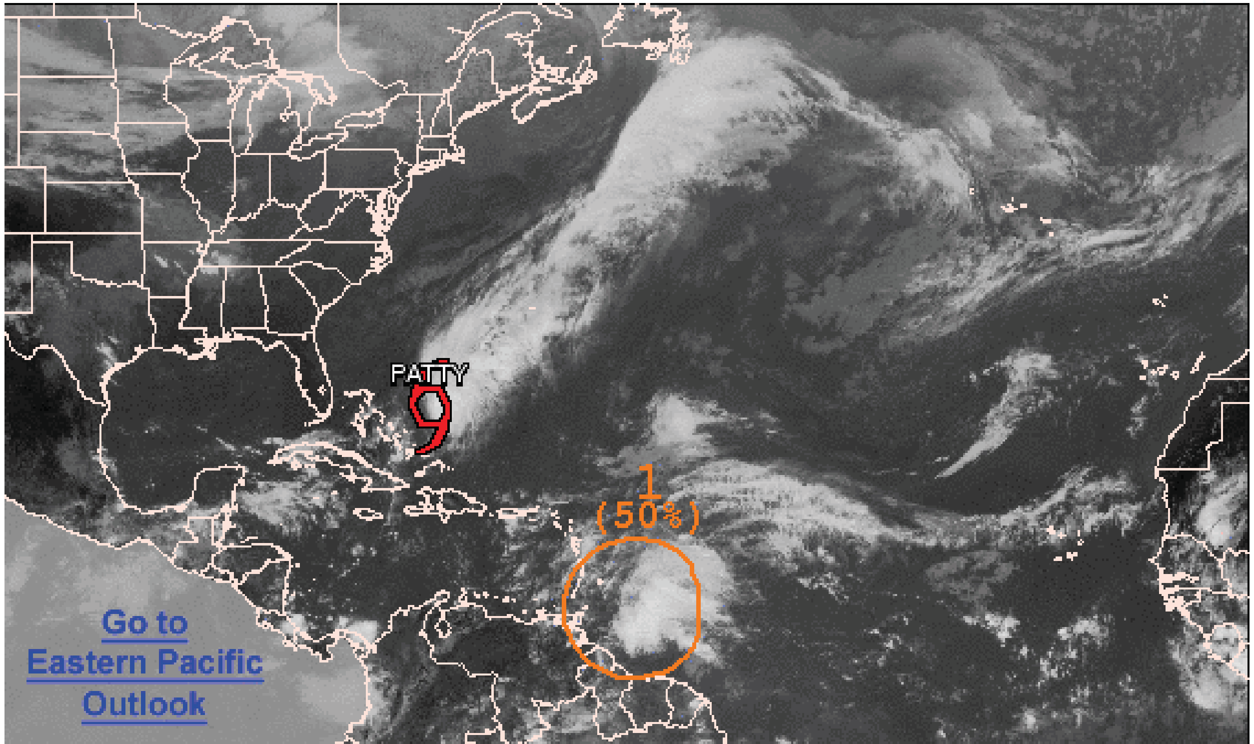

Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
SIXTEEN
Tropical Depression SIXTEEN (click for details)
As of 1100 AM EDT Thu Oct 11
Advisory # 1
Maximum Sustained Winds: 30 knots; 35 mph
Minimum Central Pressure: 1009 mb
Located at: 25.4N 72.6W
Movement: south at 1 knots; 1 mph
Go to Eastern Pacific Outlook
800 AM EDT THU OCT 11 2012
Satellite Image: 0652 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%



Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
SIXTEEN
1
(50%)
Go to
Eastern Pacific
Outlook
200 PM EDT THU OCT 11 2012
Satellite Image: 0122 PM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%

Graphical Tropical Weather Outlook

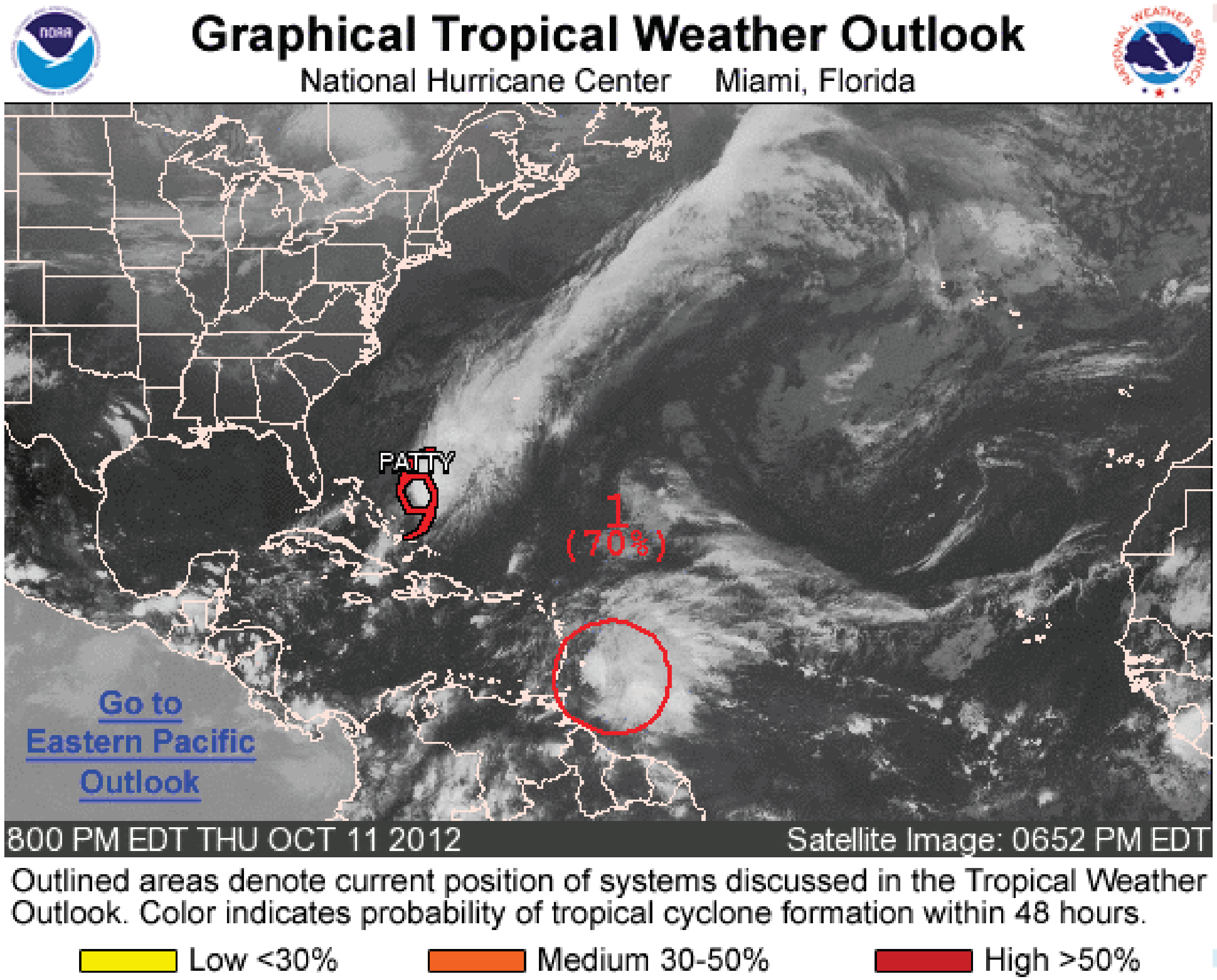
National Hurricane Center Miami, Florida



200 PM EDT THU OCT 11 2012 Satellite Image: 0122 PM EDT

Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.

Low <30% Medium 30-50% High >50%



Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
PATTY
1
(70%)
Go to
Eastern Pacific
Outlook
800 PM EDT THU OCT 11 2012
Satellite Image: 0652 PM EDT
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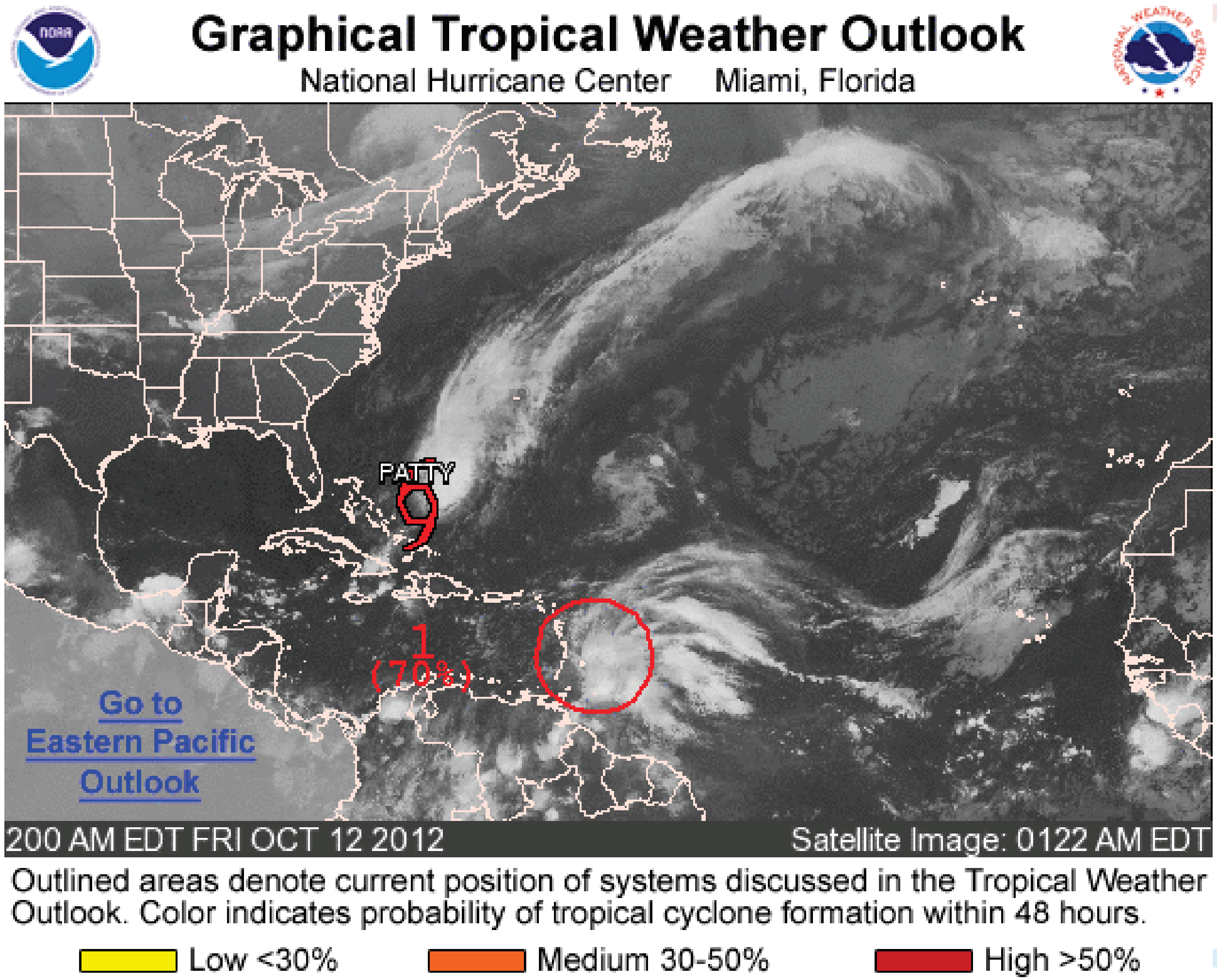
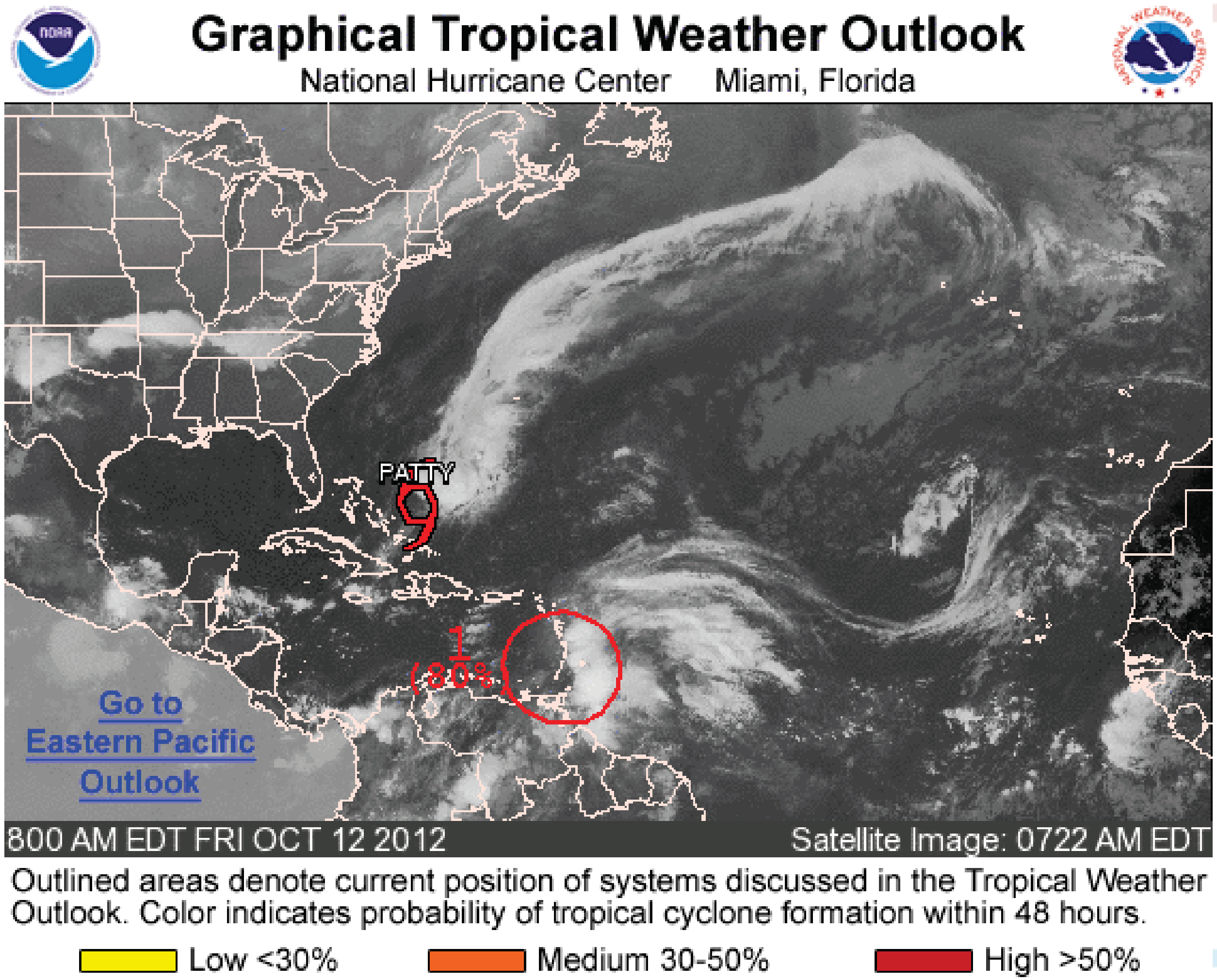
Low <30%
Medium 30-50%
High >50%


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
PATTY
9
1
(70%)
Go to
Eastern Pacific
Outlook
200 AM EDT FRI OCT 12 2012
Satellite Image: 0122 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%


Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
PATTY
9
1
(80%)
Go to
Eastern Pacific
Outlook
800 AM EDT FRI OCT 12 2012
Satellite Image: 0722 AM EDT
Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.
Low <30%
Medium 30-50%
High >50%

Probability Forecasting “in the Light”

Collect all the forecasts of 10% probability of an event, and compute the fraction of them in which the event occurred!

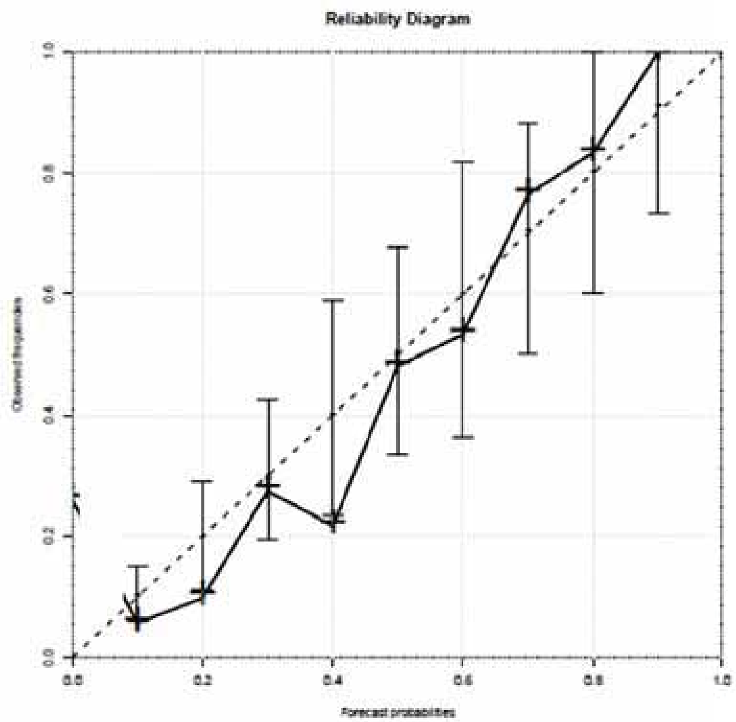
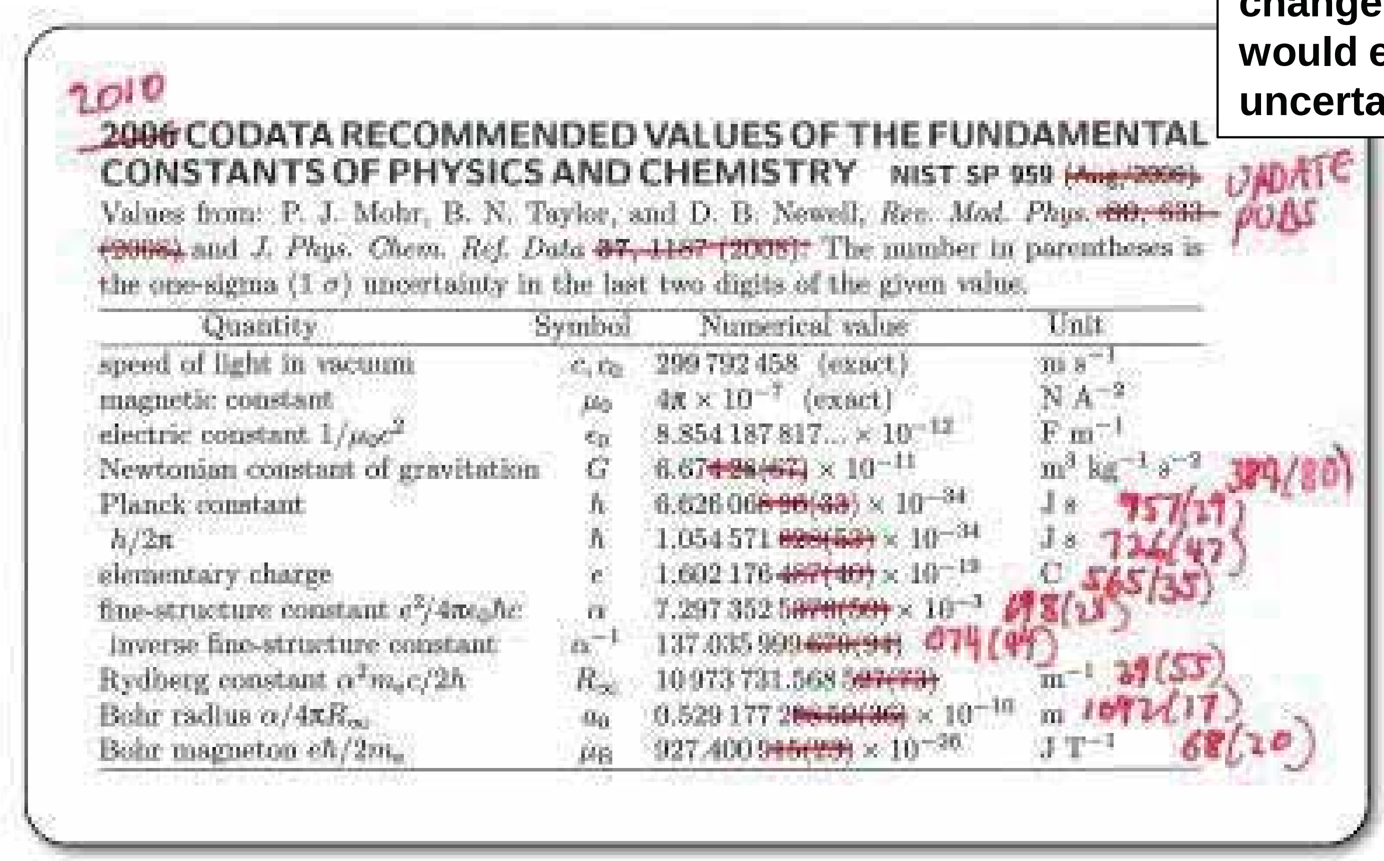


Figure 1: Reliability diagram for NOAA 2012 hurricane forecasts (48 hours lead time) with 5% - 95% consistency bars. The bin boundaries are taken as [0.05, 0.15, 0.25, 0.35, 0.45, 0.55, 0.65, 0.75, 0.85, 0.95].

This science is in the light not because the forecasts tend to be consistent: but merely because they can be evaluated with relevant observations!

The constants they are a chang’n (in the light)

Several of the 2006 values change by more than one would expect given the uncertainties stated in 2006…



2010
2006 CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL CONSTANTS OF PHYSICS AND CHEMISTRY   NIST SP 959 (Aug 2006) UPDATE PUBS

Values from: P. J. Mohr, B. N. Taylor, and D. B. Newell, *Rev. Mod. Phys.* 80, 633 (2008) and *J. Phys. Chem. Ref. Data* 37, 1187 (2008). The number in parentheses is the one-sigma (1σ) uncertainty in the last two digits of the given value.

Quantity	Symbol	Numerical value	Unit	2010
speed of light in vacuum	c, c_0	299 792 458 (exact)	$\mathrm{m\ s^{-1}}$	
magnetic constant	μ_0	$4\pi \times 10^{-7}$ (exact)	$\mathrm{N\ A^{-2}}$	
electric constant $1/\mu_0 c^2$	ϵ_0	$8.854\,187\,817... \times 10^{-12}$	$\mathrm{F\ m^{-1}}$	
Newtonian constant of gravitation	G	$6.674\,28(67) \times 10^{-11}$	$\mathrm{m^3\ kg^{-1}\ s^{-2}}$	384(80)
Planck constant	h	$6.626\,068\,96(33) \times 10^{-34}$	J s	757(29)
$h/2\pi$	$\hbar$	$1.054\,571\,628(53) \times 10^{-34}$	J s	726(47)
elementary charge	e	$1.602\,176\,487(40) \times 10^{-19}$	C	565(35)
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,5376(50) \times 10^{-3}$		698(24)
inverse fine-structure constant	α^{-1}	137.035 999 679(94)		074(44)
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	10 973 731.568 527(73)	$\mathrm{m^{-1}}$	39(55)
Bohr radius $\alpha/4\pi R_\infty$	a_0	$0.529\,177\,208\,59(36) \times 10^{-10}$	m	1092(17)
Bohr magneton $e\hbar/2m_e$	μ_B	$927.400\,915(23) \times 10^{-26}$	$\mathrm{J\ T^{-1}}$	68(20)

Science often underestimates its own uncertainty. Whether this is due to carelessness to intellectual phase locking, science in the light can advance when new evidence contradicts old belief.

Science in the Dark does not imply scientists have gone over to the dark side

Scientists are forced to "violate" traditional best practice guidance if such violations are imposed by the nature of the question being addressed.

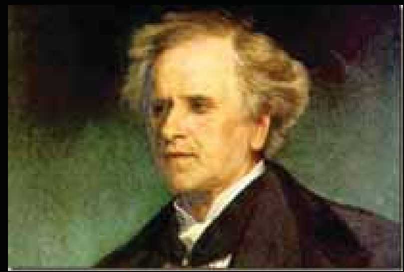
One cannot wait 50 years for out-of-sample observations.

It is a brute fact that a climate model's lifetime is less than its forecast lead-time!

The physics underlying CO_2 induced warming remains as solid as science gets.

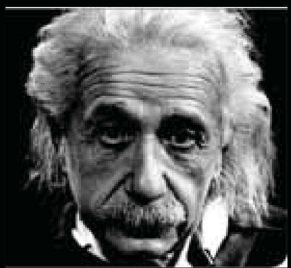
Cast of Characters

Fitzroy



Le Verrier

Galton



Einstein

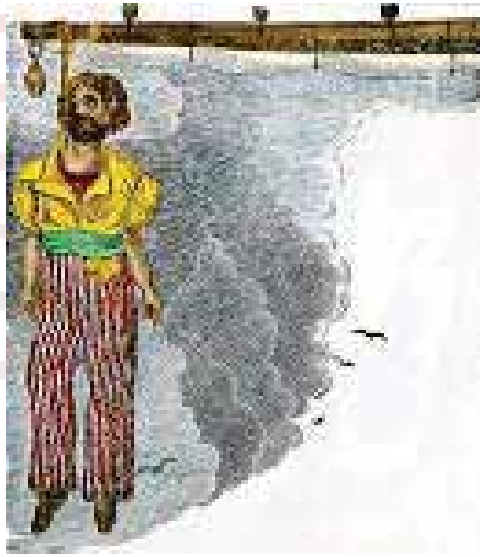
Whitehead

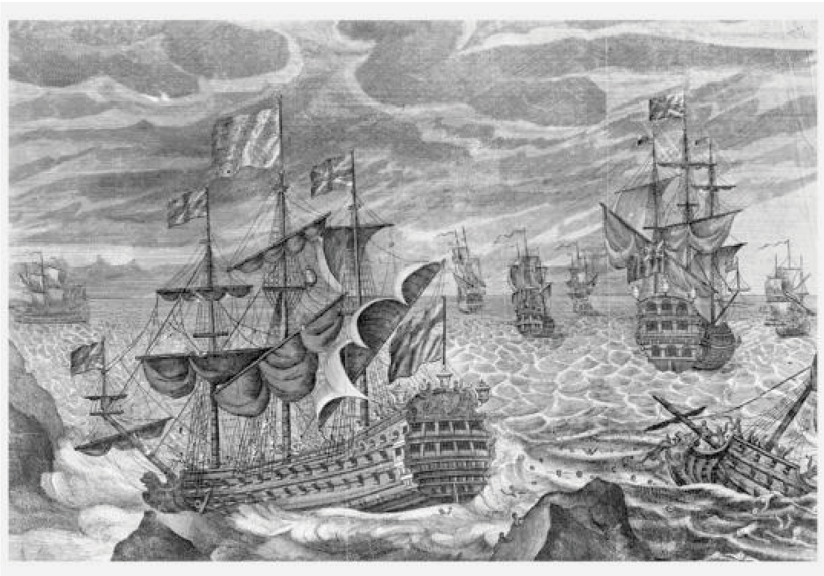
Lorenz

Richardson

It was a dark and stormy night…

…in 1707, when a dispute broke out between Sir Cloudesley Shovell, the master of HMS Association and his navigator regarding where they were and when they would reach land. Legend has it the sailor was hung, but no record survives, in part because…





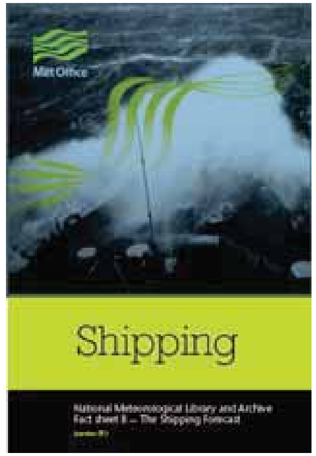
…on the Oct 22 the ships hit “unexpected” rocks; four ships and 1400 sailors were lost, including Sir Shovell, and the Association.

Dangers of Forecasting (c)
Political Shenanigans: The forecaster may be vulnerable

http://www.northwindpictures.com/results.asp?link=J405&co=NORPIC10

Fast-forward to 1859

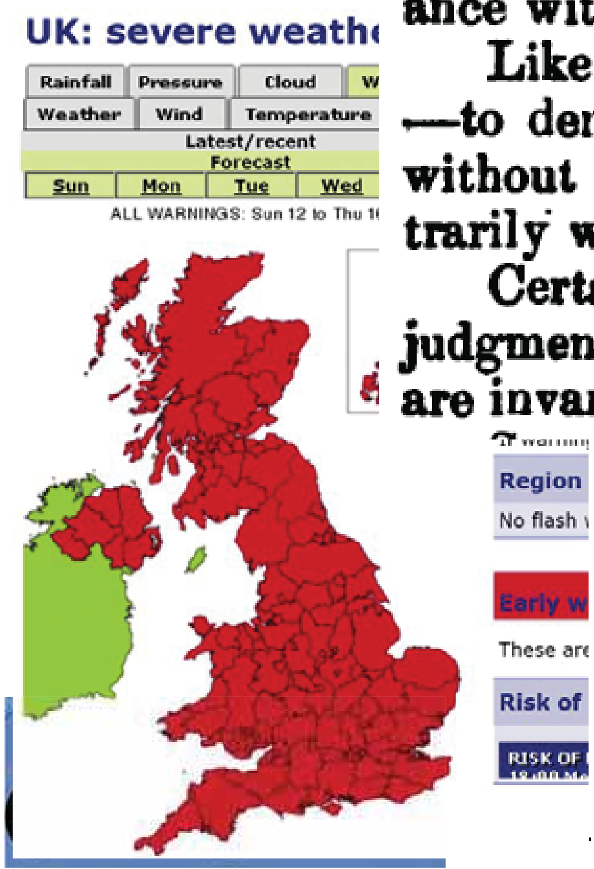
In October 1859, the steam clipper *Royal Charter* founded in a violent storm off the coast of Anglesey in North Wales with the loss of over 450 lives. As a direct result of this disaster, FitzRoy introduced the first British storm warning service for shipping in February 1861, making use of the electric telegraph. FitzRoy was the main influence in the early development of the Met Office, which was then primarily intended to improve safety at sea.



Fitzroy exploited new technology, the telegraph, to provide information on current meteorological conditions, but he was not allowed to “foretell” the future. (He coined the word “forecast” but was not allowed to issue them!)

He partnered with Le Verrier in France, who was famous for predicting the location (and existence) of the planet Neptune.

Fitzroy met resistance in the UK.



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.

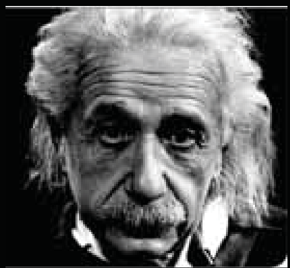
Fitzroy, 1862

Fitzroy aimed to provide decision makers with more information: not orders or decisions made.


Fitzroy


Le Verrier


Galton

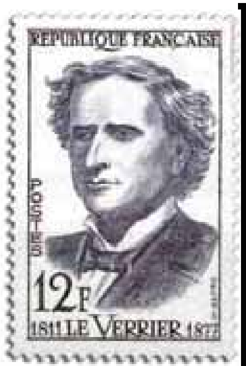

Einstein

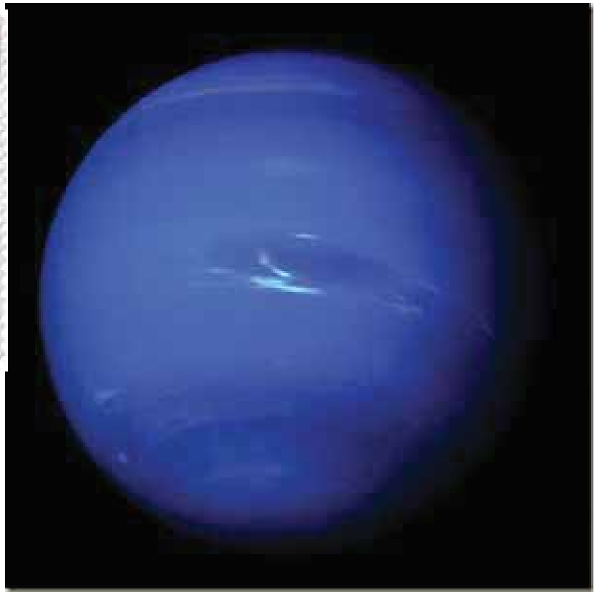

Whitehead


Lorenz

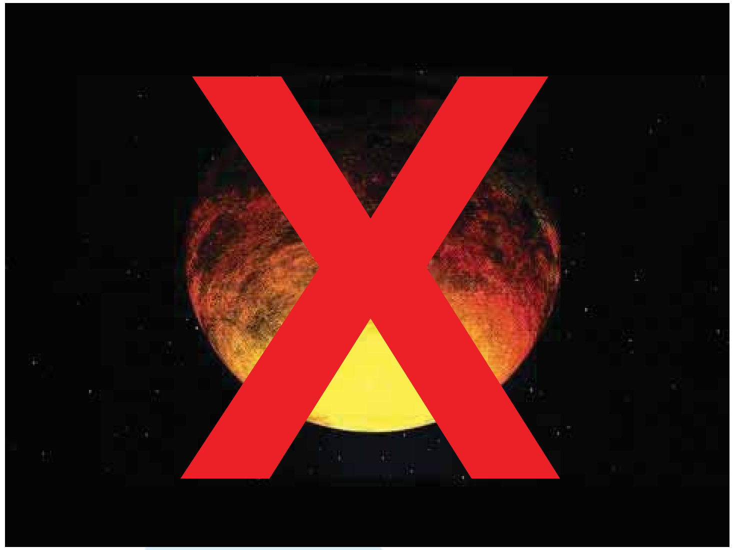

Richardson

Le Verrier & the "Discovery" of Neptune and Vulcan



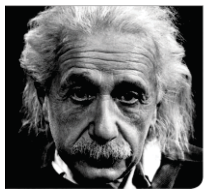


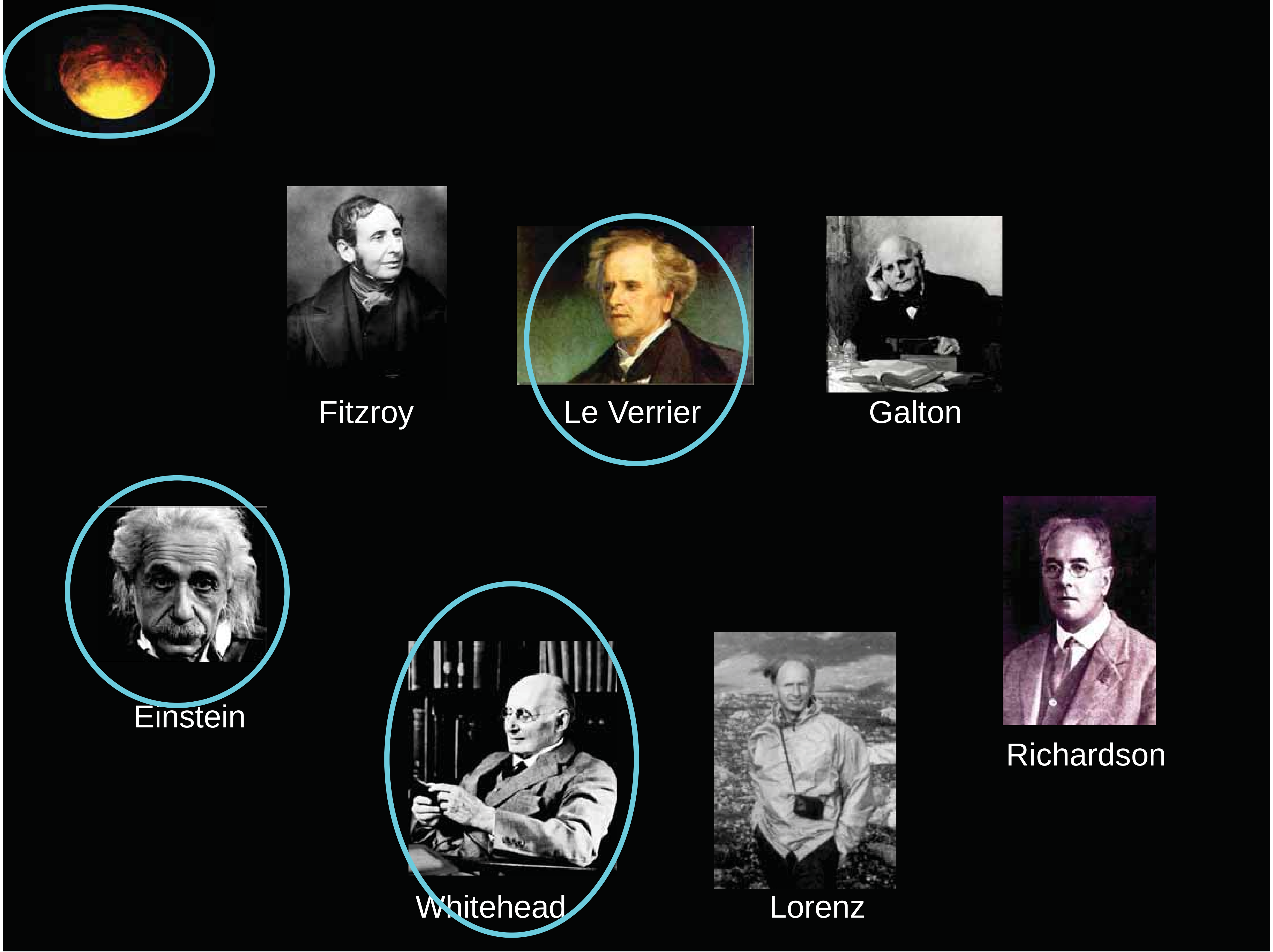
Le Verrier found discrepancies between the observations of Uranus and the workings of Newton's Laws; he knew these must be caused by a previously unknown planet, and in 1846 predicted where that planet should be, leading to the discovery of "Neptune".



In 1859 Le Verrier found discrepancies between the observations of Mercury and the workings of Newton's Laws; he knew these must be caused by a previously unknown planet, and predicted another new planet. This lead to the discovery of "Vulcan" by Lescarbault on 26 March 1859. Lescarbault was awarded the Légion d'honneur.

There is no planet Vulcan! Newton's Laws fail near the sun.




Fitzroy
Le Verrier
Galton
Einstein
Whitehead
Lorenz
Richardson

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.

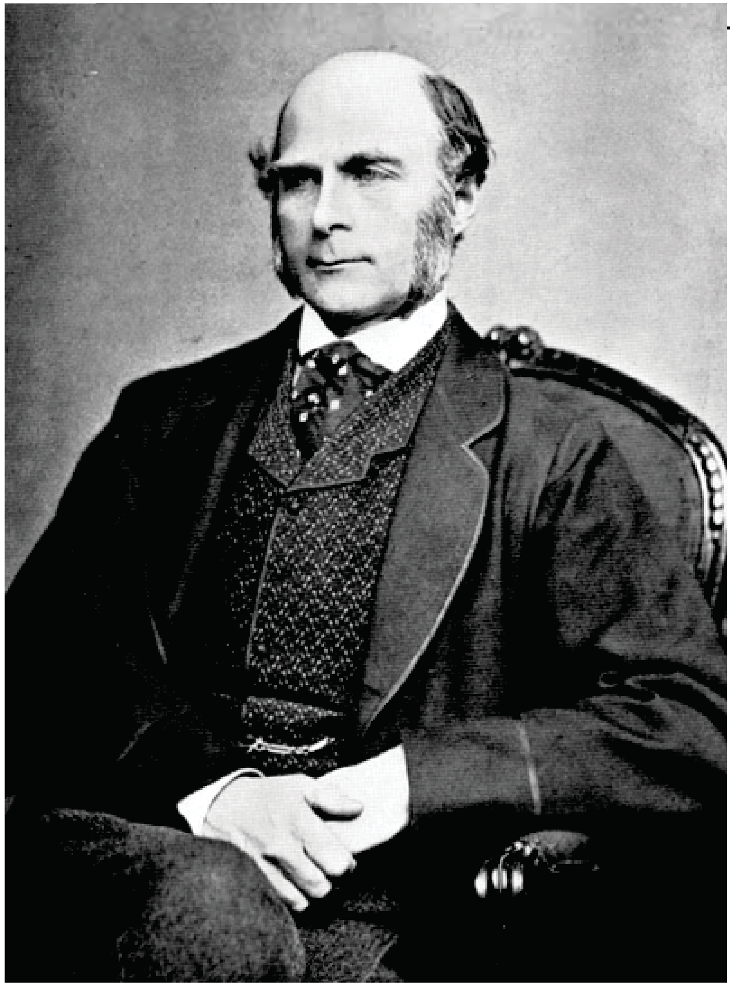
Sometimes it happens that the service rendered by philosophy is entirely obscured by the astonishing success of a scheme of abstractions in expressing the dominant interests of an epoch."

A N Whitehead. Science and the Modern World. Pg 58/9

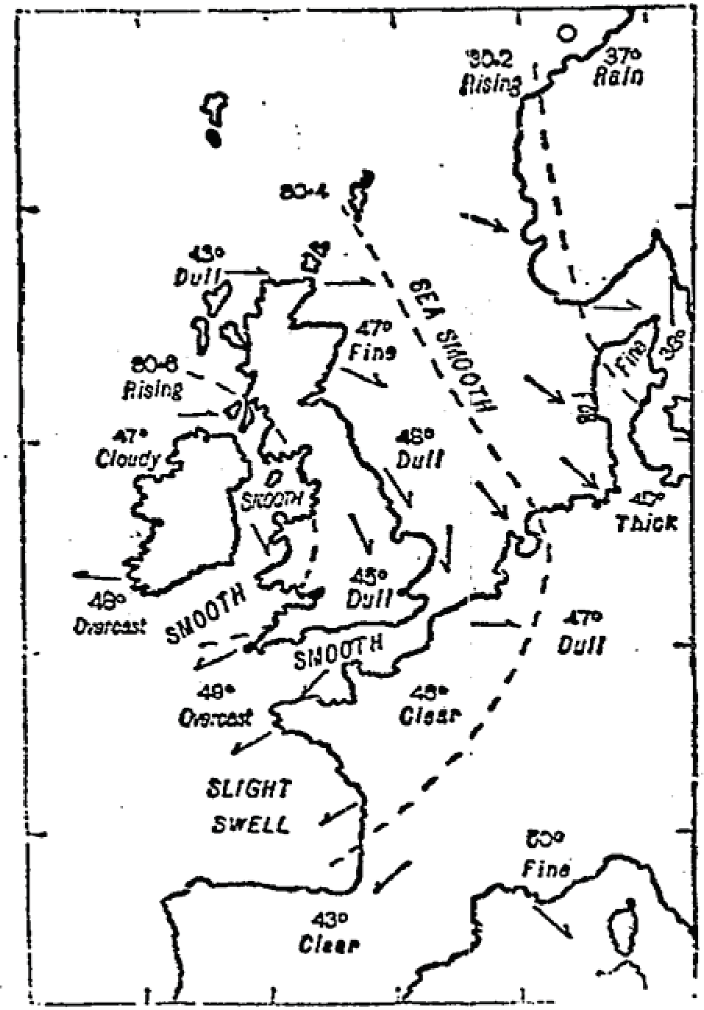
Whitehead was criticising straightjacket of Newtonian science; I will suggest that computer simulation may impede more than just the progress of science.

But first, lets bring in Galton…

Back to Galton



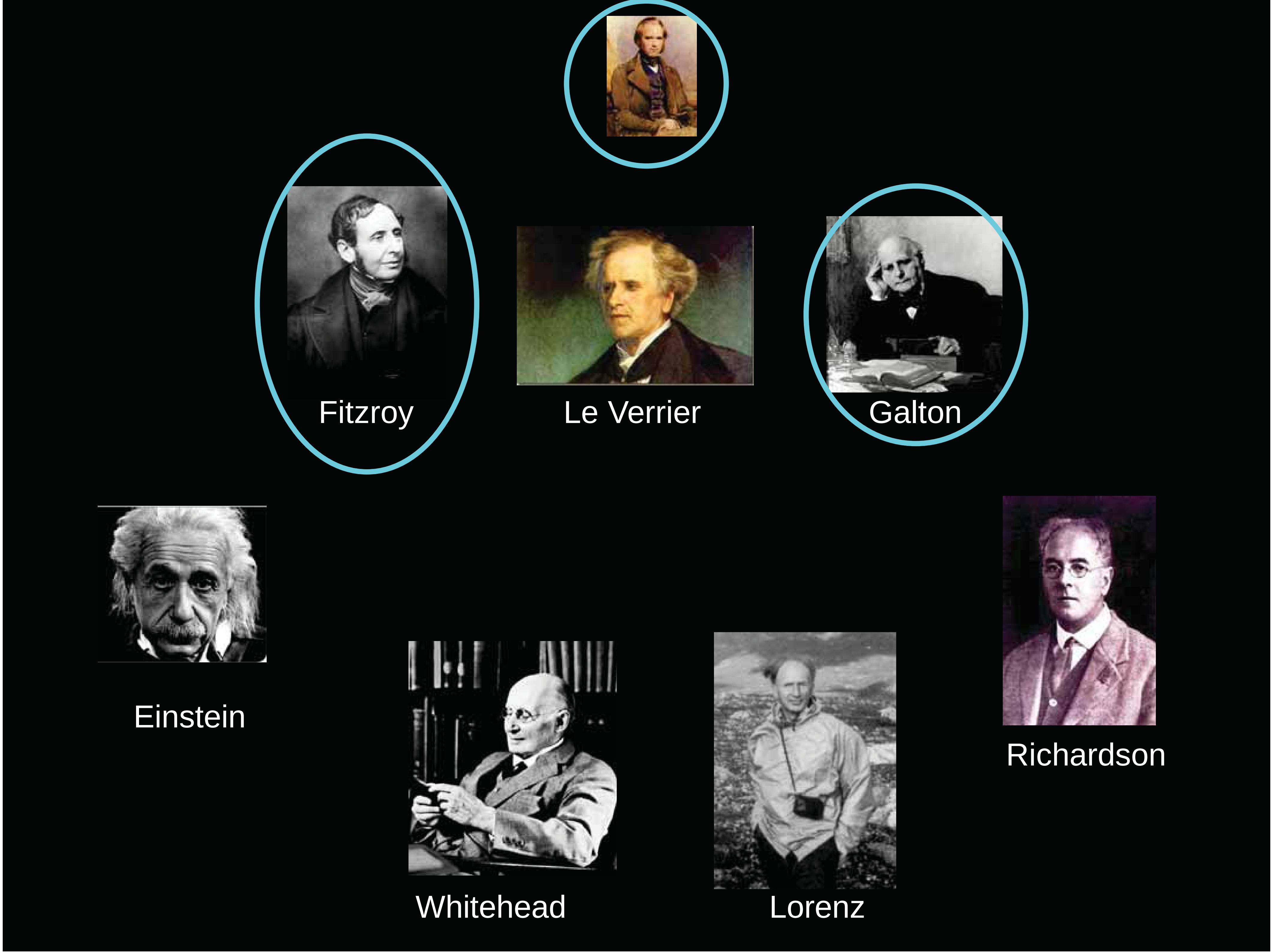
WEATHER CHART, MARCH 31, 1875.



The dotted lines indicate the gradations of barometric pressure The variations of the temperature are marked by figures, the state of the sea and sky by descriptive words, and the direction of the wind by arrows—barbed and feathered according to its force. ⊙ denotes calm.

Sir Francis Galton FRS (16 February 1822 – 17 January 1911), cousin of Douglas Strutt Galton**,** **cousin of Charles Darwin**, was an English Victorian polymath: anthropologist, eugenicist, tropical explorer, geographer, inventor, meteorologist, proto-geneticist, psychometrician, and statistician. He was knighted in 1909.

http://galton.org/meteorologist.html


Fitzroy
Le Verrier
Galton
Einstein
Whitehead
Lorenz
Richardson

The Galton Board (Galton 1889)

(quincunx)

FIG. 7.

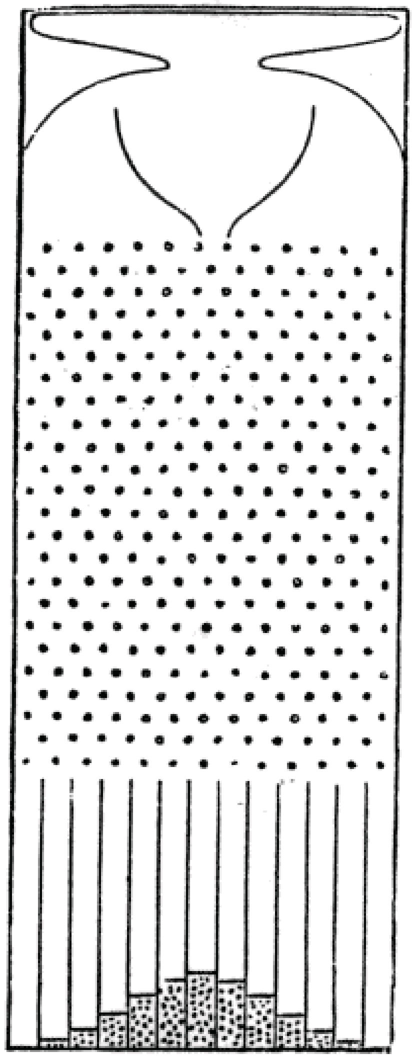


FIG. 8.

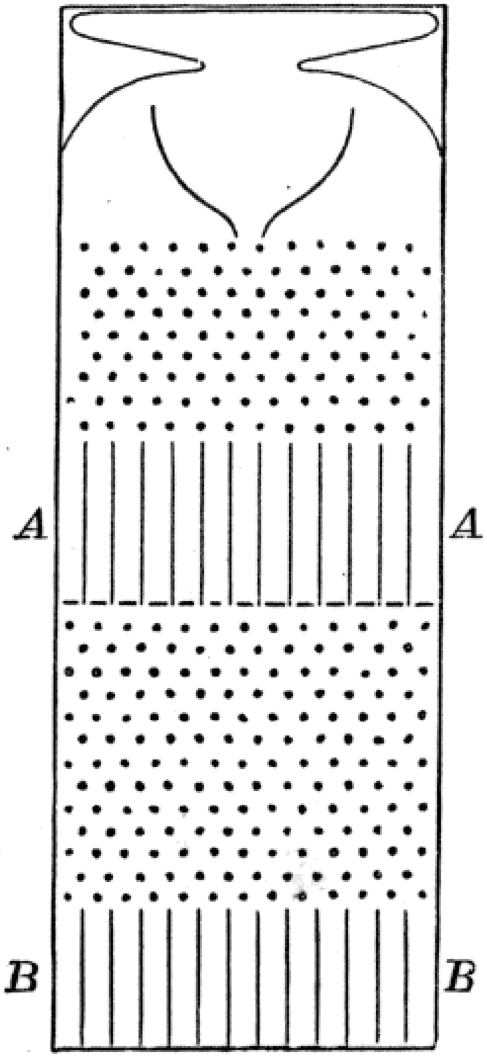
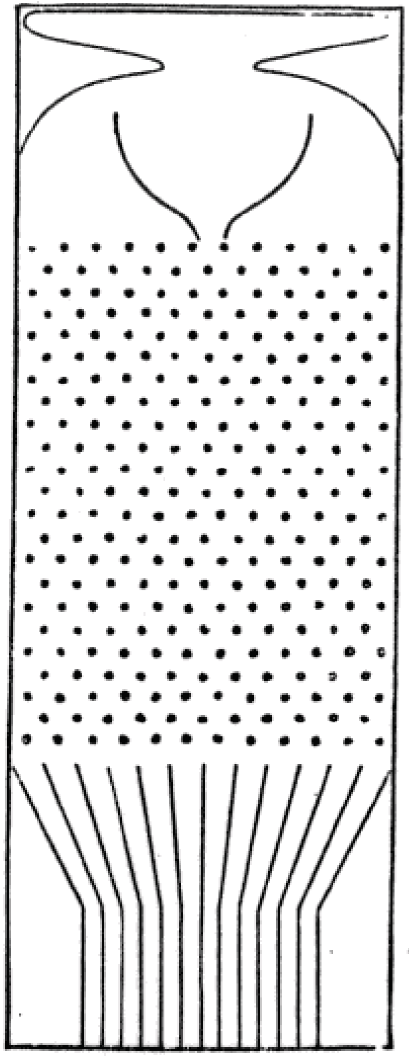


FIG. 9.



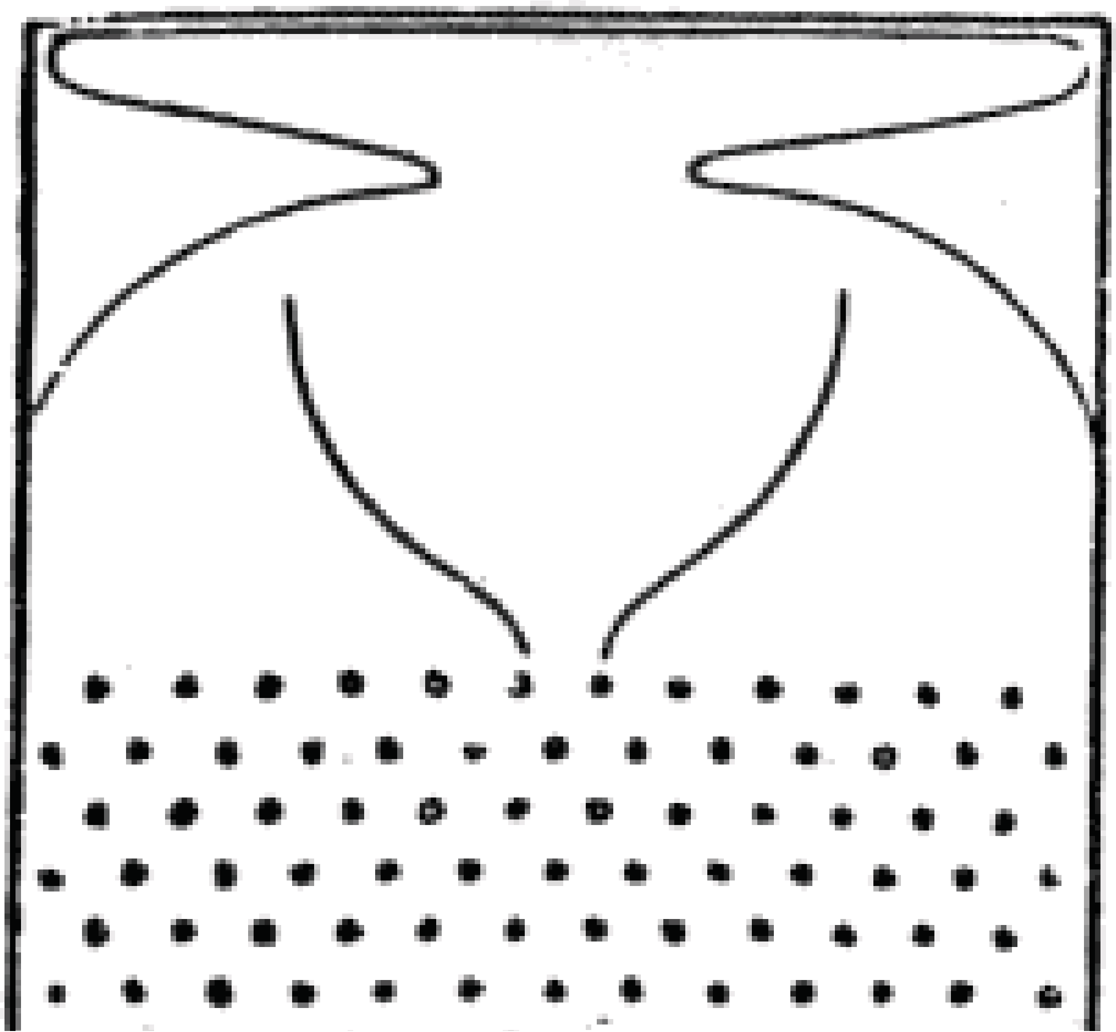
Each pellet has a 50/50 chance of going to the right (left) of each nail.

A mathematical result which is easier to match if you pour the shot in all at the same time…

The Galton Board (Galton 1889)

(quincunx)

FIG. 7.



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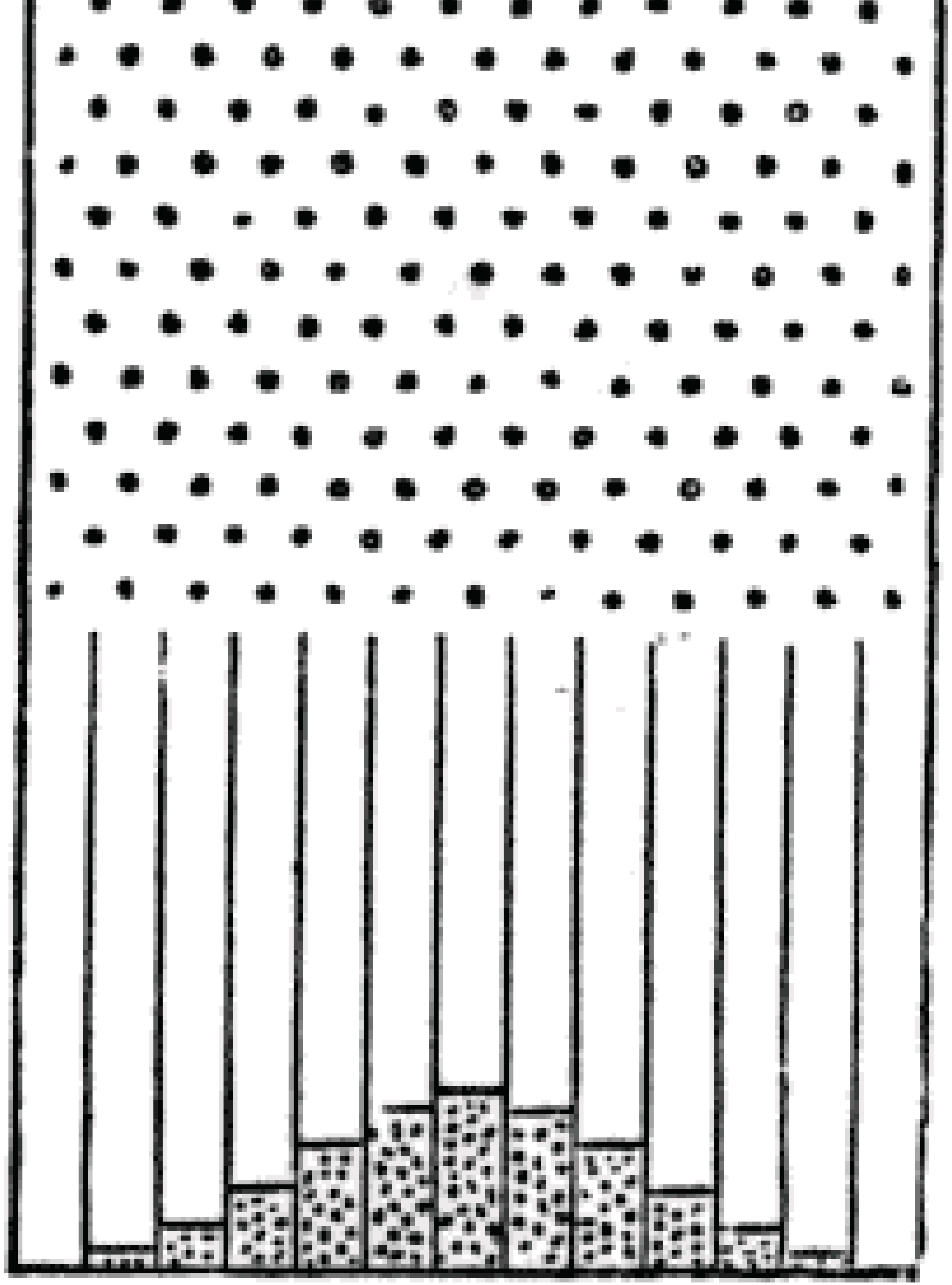

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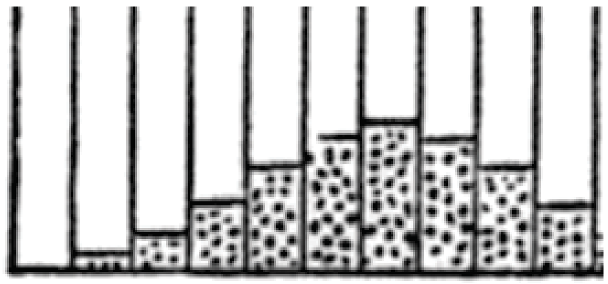

But would any randomness remain if we knew exactly where each pellet started?

Laplace's Demon (1814)

1) Perfect Equations of Motion (PMS)
2) Perfect noise-free observations
3) Unlimited computational power

Demon's Apprentice (2007)

1) Perfect Equations of Motion (PMS)
2) ~~Perfect noise-free observations~~
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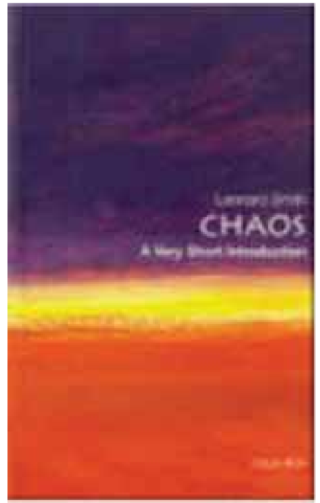


Apprentice's Novice (2012)

1) ~~Perfect Equations of Motion (PMS)~~
2) ~~Perfect noise-free observations~~
3) Unlimited computational power

http://2darts.com/2dtuts/articles/50-terrifying-creatures/

Lewis Fry Richardson's Successful Failure (in the light)

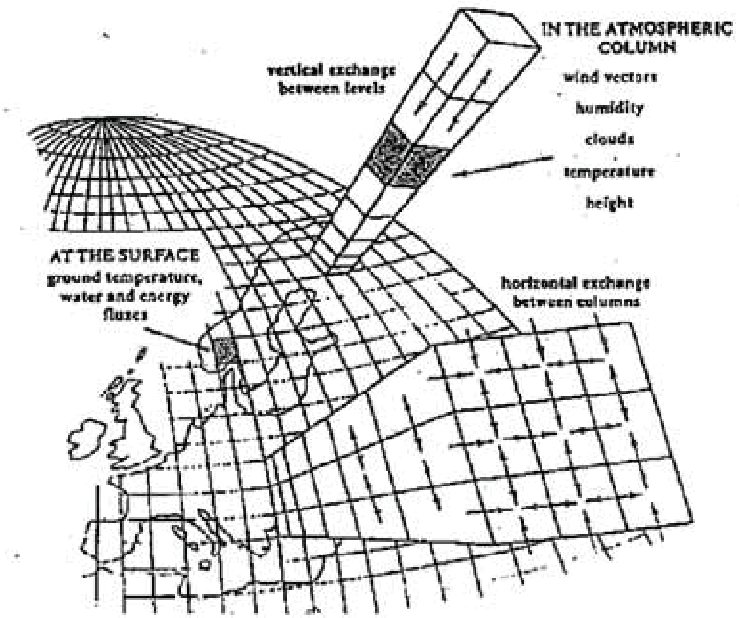
Given the equations and an initial condition, one can compute a forecast.

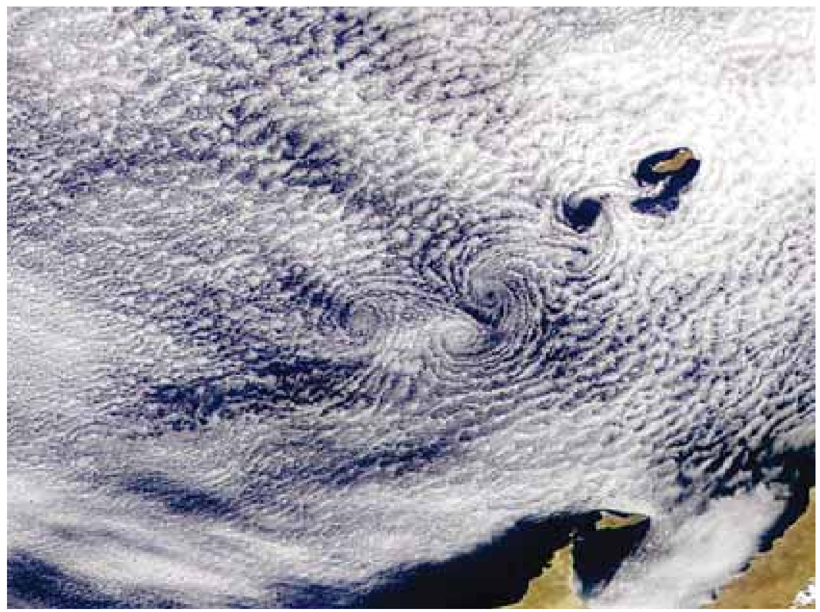
Richardson made the first numerical weather forecast for 20 May 1910. He did this by hand, while working as an ambulance driver in WWI.

While the forecast was wildly inaccurate, comparison with what actually had happened, it allowed progress leading to modern systems.

Of course, even todays best models do not resolve everything we see from space.

Lewis Fry Richardson in *Weather Prediction by Numerical Process*, 1922.

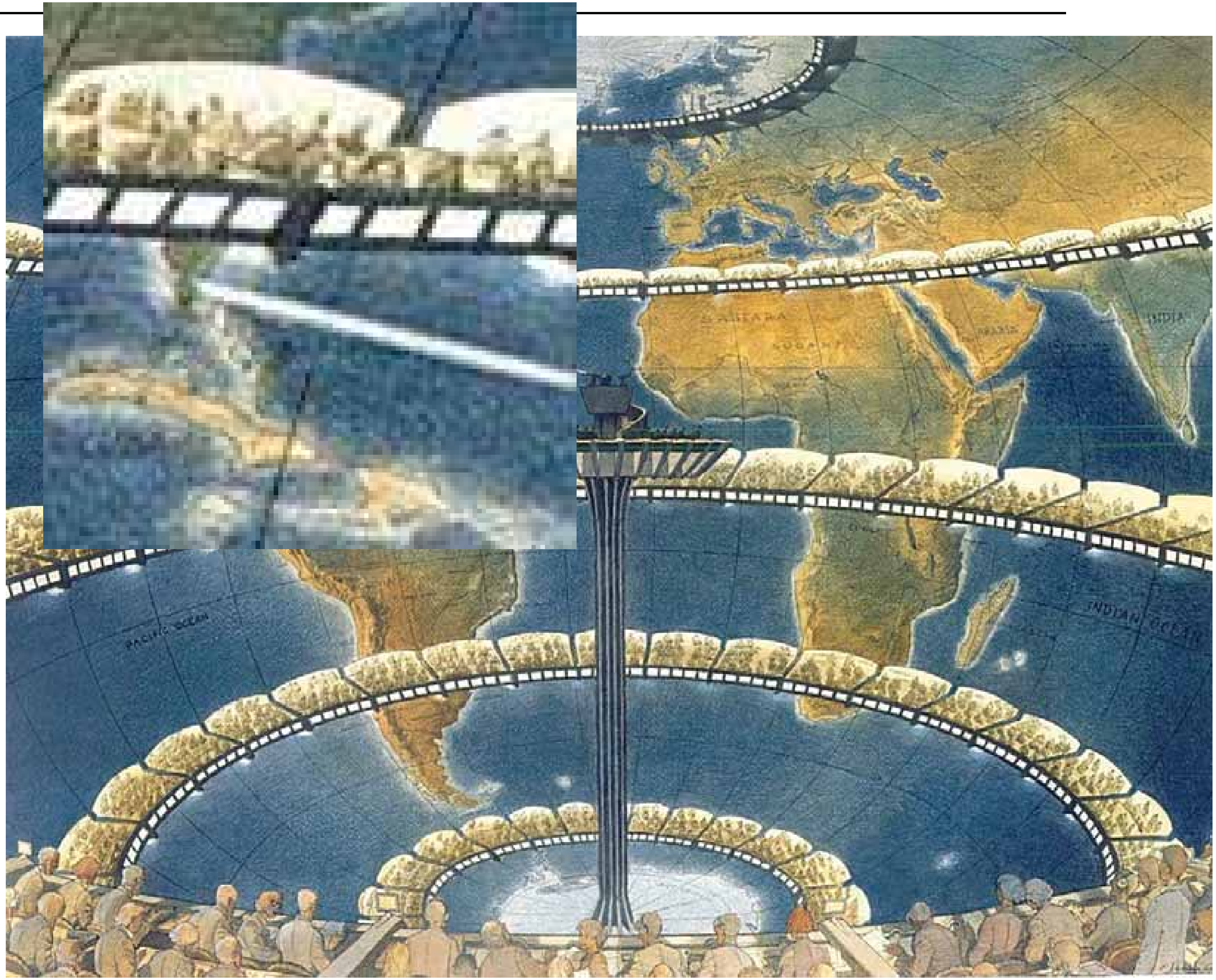




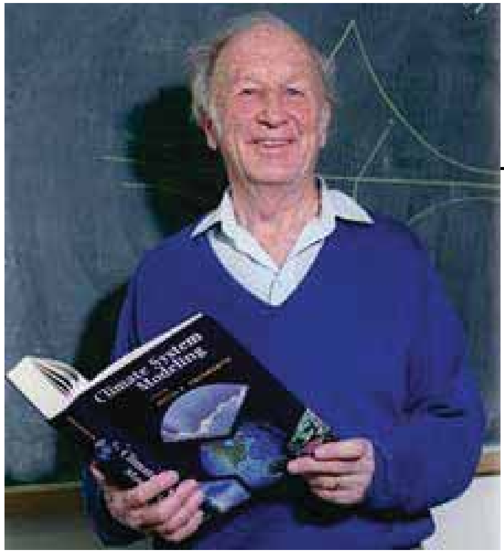
Richardson's Dream (1922)

Richardson realised that his algorithm could be run in parallel by a large number of "computers" sitting in a theatre…

He suggested that 64,000 computers could forecast the weather in real time.

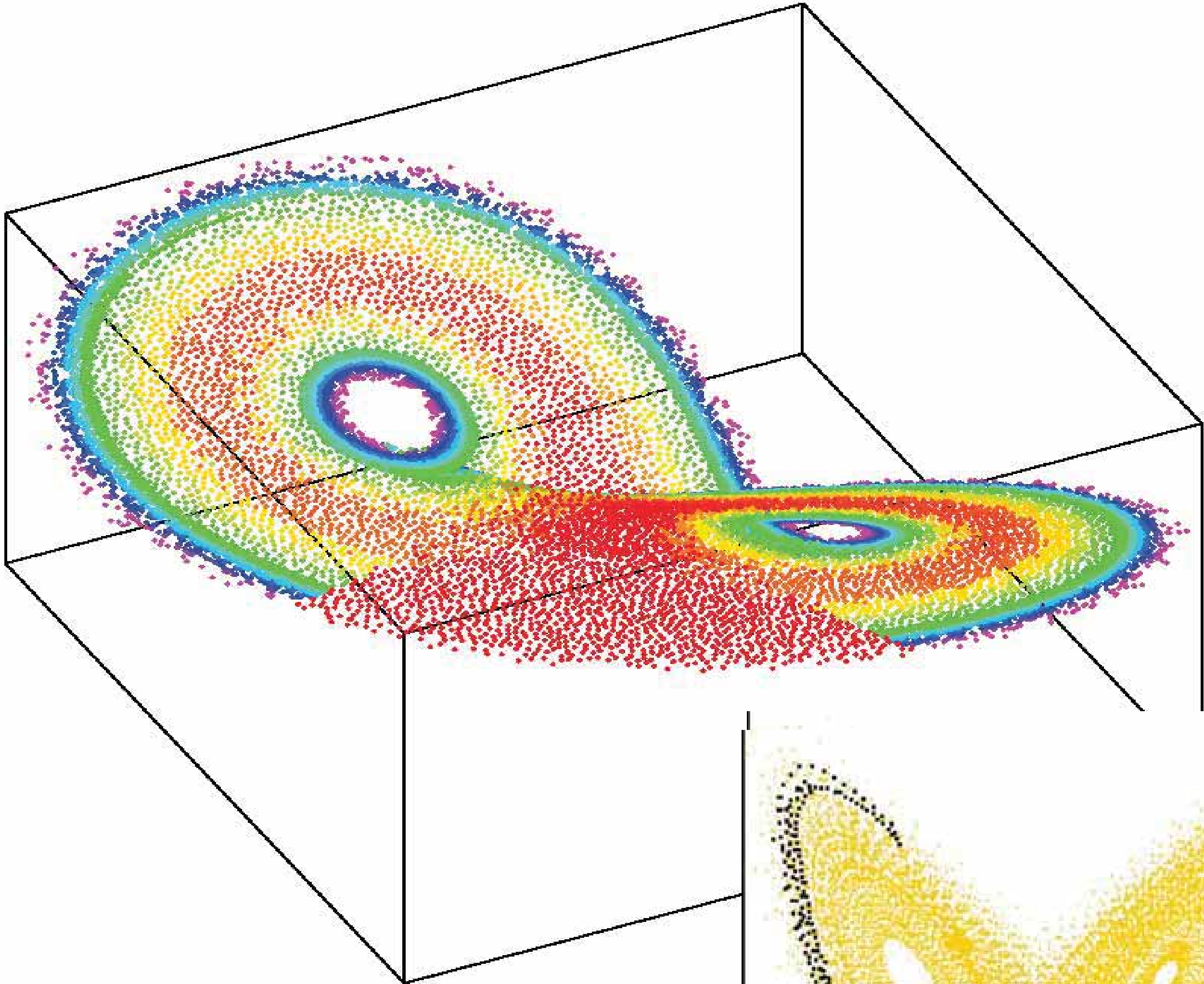


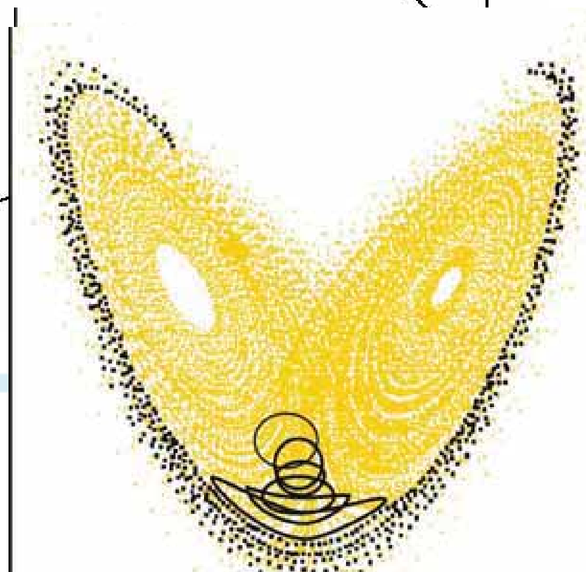
Ed Lorenz:
Weather and Chaos (and Error)



Lorenz realised that even for the Apprentice, small uncertainties could grow exponentially fast, leading to “chaos.”

He was also very concerned about the role of model error, which is much harder to solve than that of mere chaos.

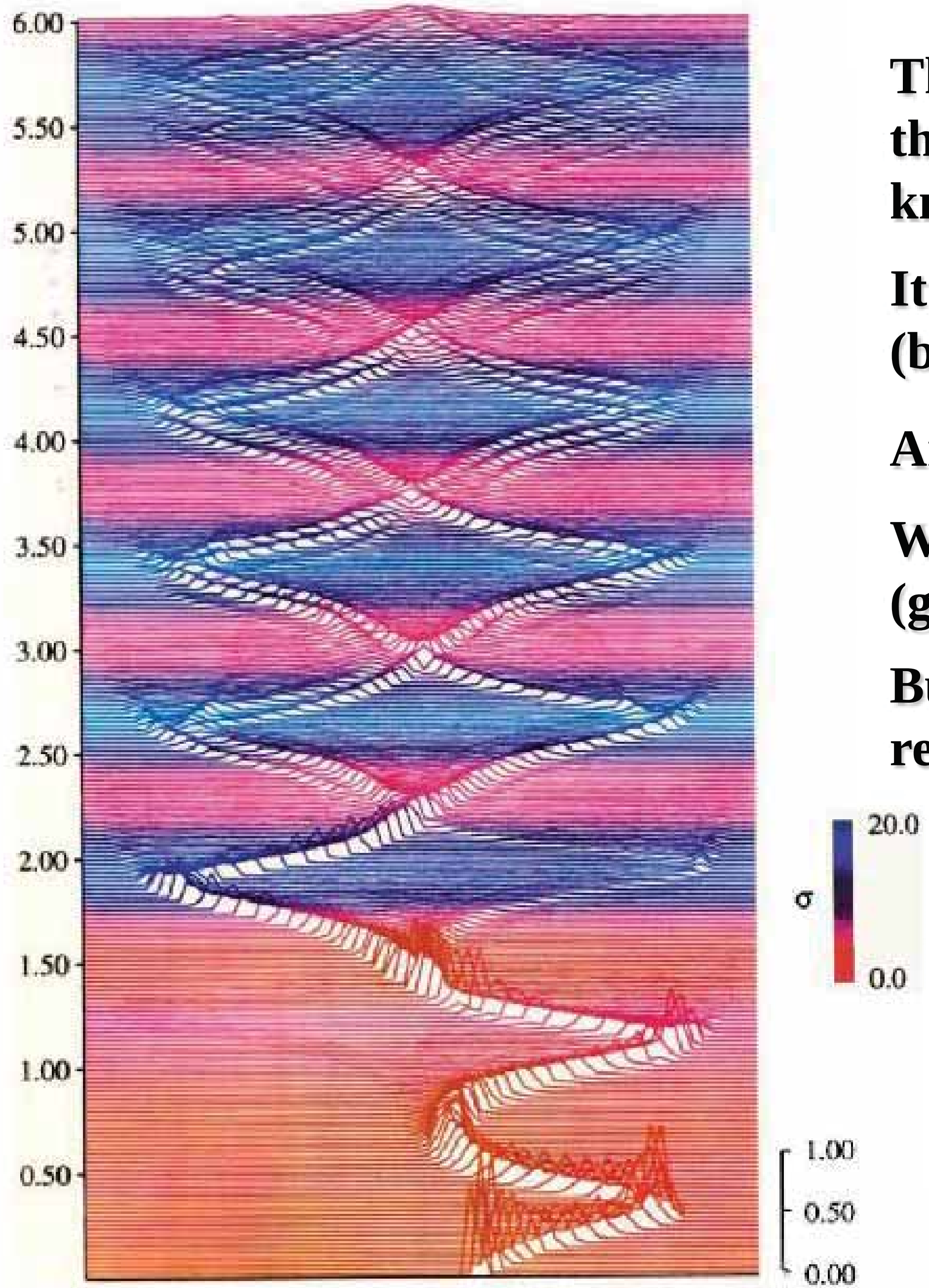




Thx to Tim Palmer

LA Smith (1994) Local Optimal Prediction: Exploiting strangeness and the variation of sensitivity to initial condition. *Phil. Trans. Royal Soc. Lond.* A, 348 (1688): 371-381.

Probability Forecasts: Chaos



Smith (2002) Chaos and Predictability in *Encyc Atmos Sci*

The evolution of this probability distribution for the chaotic Lorenz 1963 system tells us all we can know of the future, given what we know now.

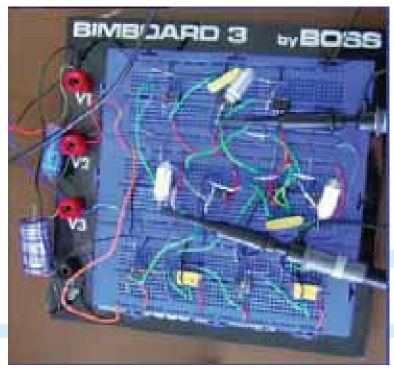
It allows prudent quantitative risk management (by brain-dead risk managers)

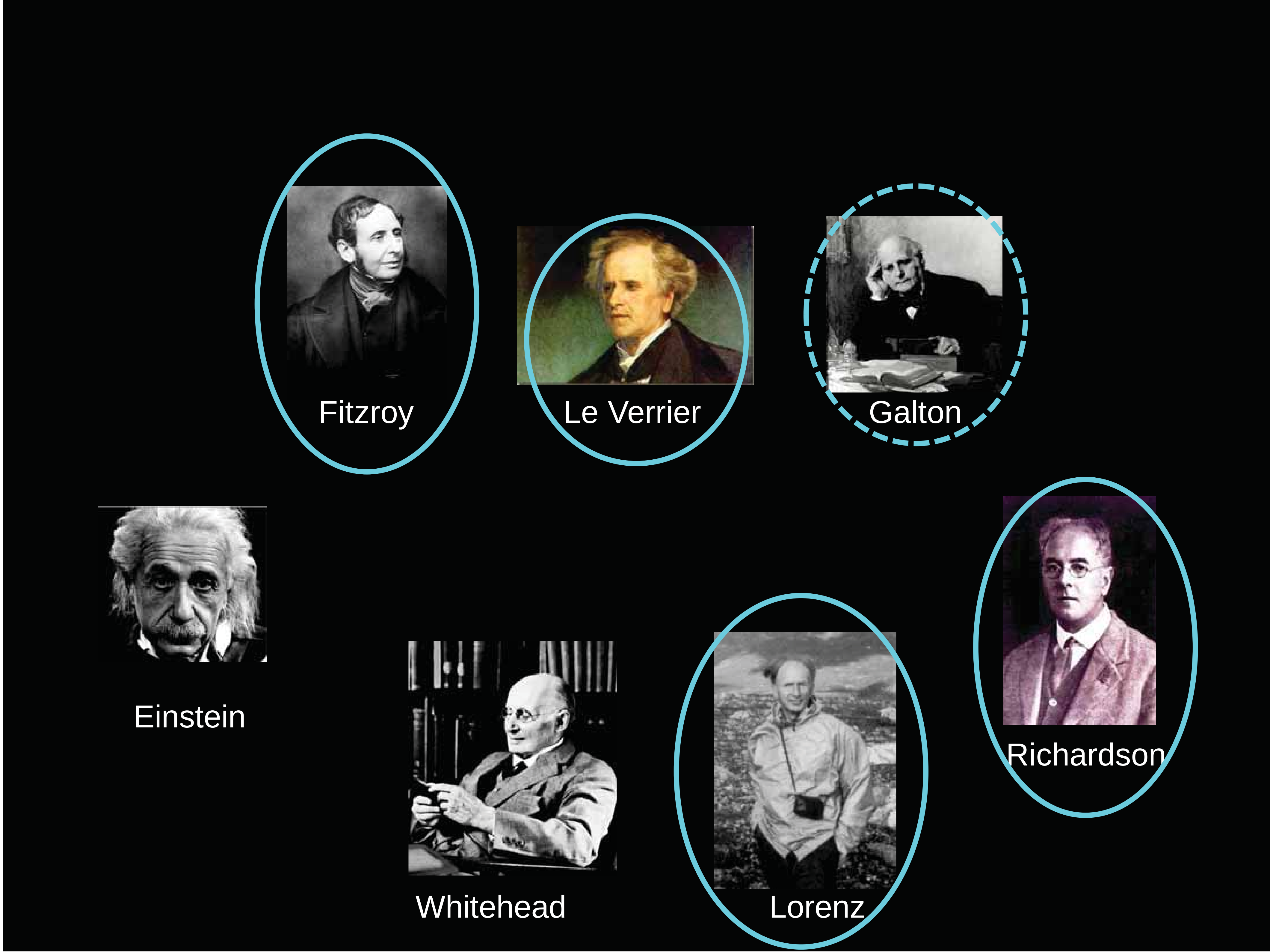
And sensible resource allocation.

We can manage uncertainty for chaotic systems (given a perfect model).

But how well do we manage uncertainty in the real world? For GDP? Weather? Climate?

Do we have a single example of a nontrivial system where anyone has succeeded (and willing to offer odds given their model-based PDFs?)




Fitzroy
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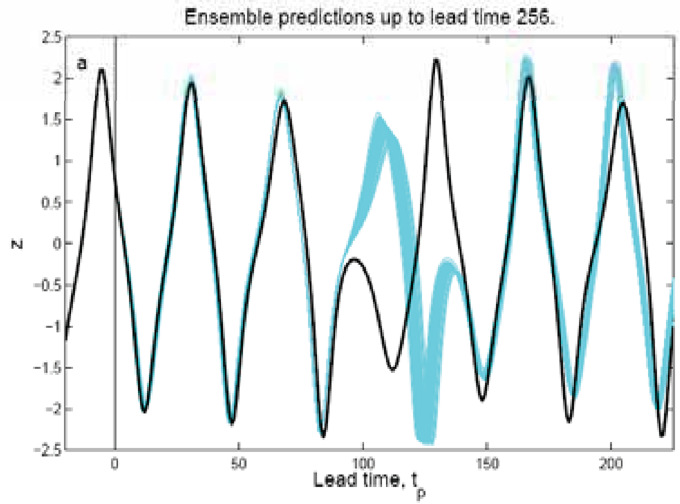
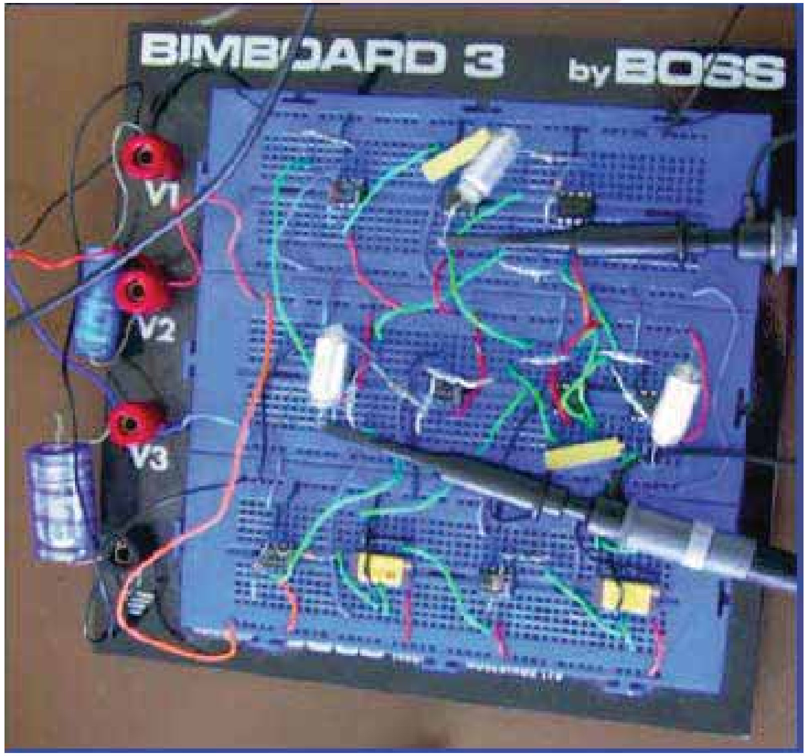
Richardson

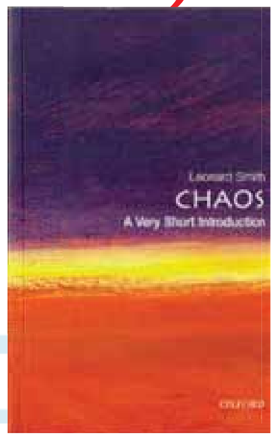
Probability Forecasts: “Simple” “chaotic” Physical System

Model 1





A Big Surprise in the Moore-Spiegel Circuit (by Reason Machette)



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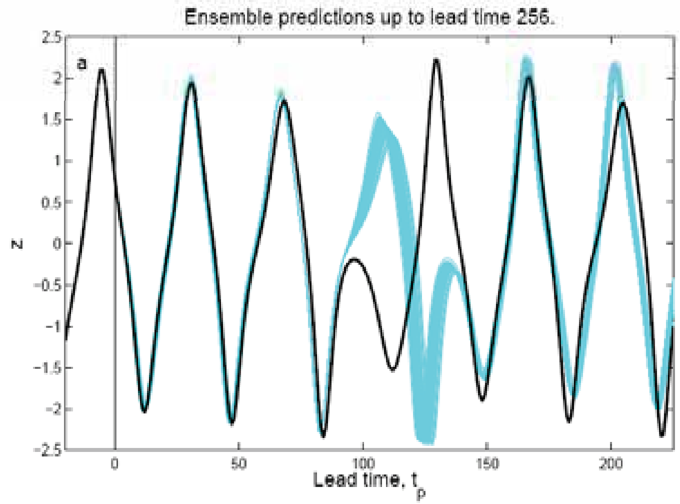


Model 2

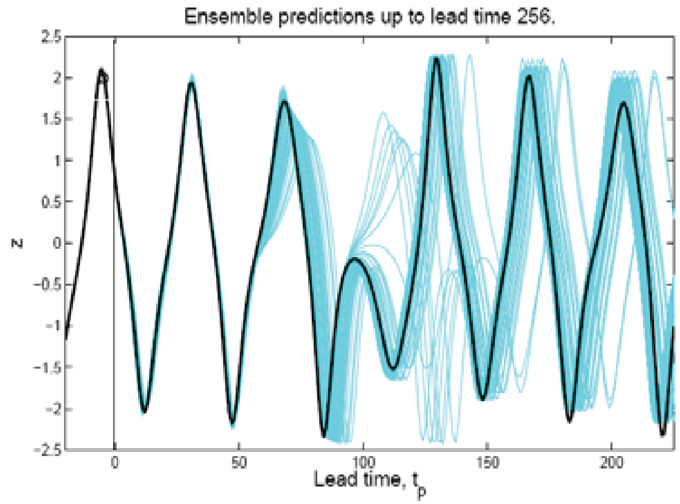
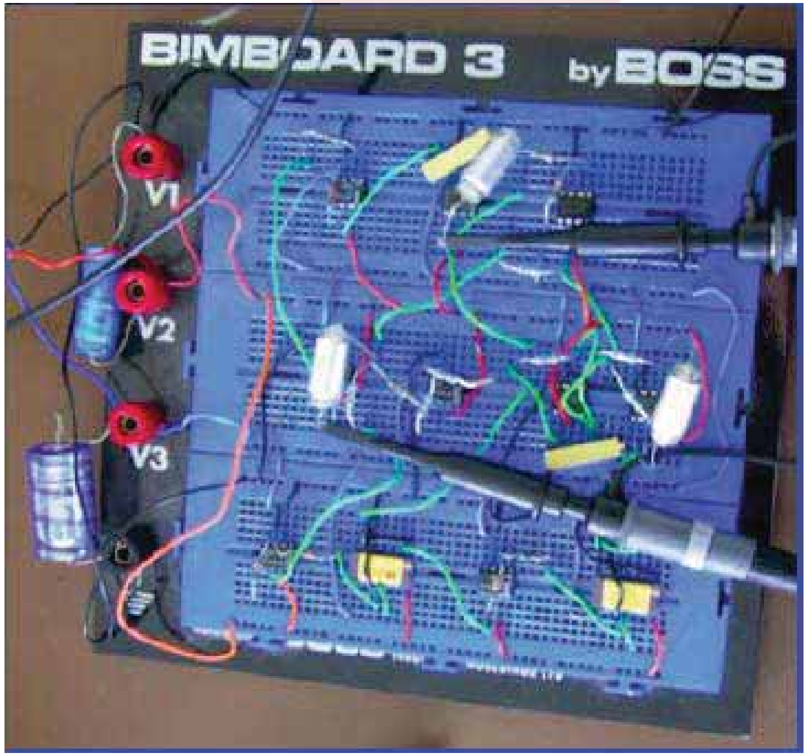
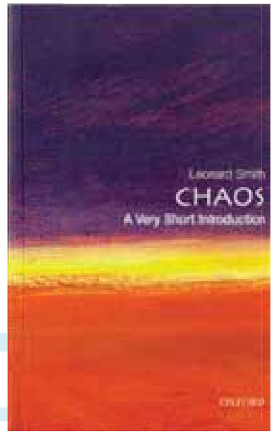


Figure 7: Ensemble predictions using (a) model 1 and (b) model 2. The



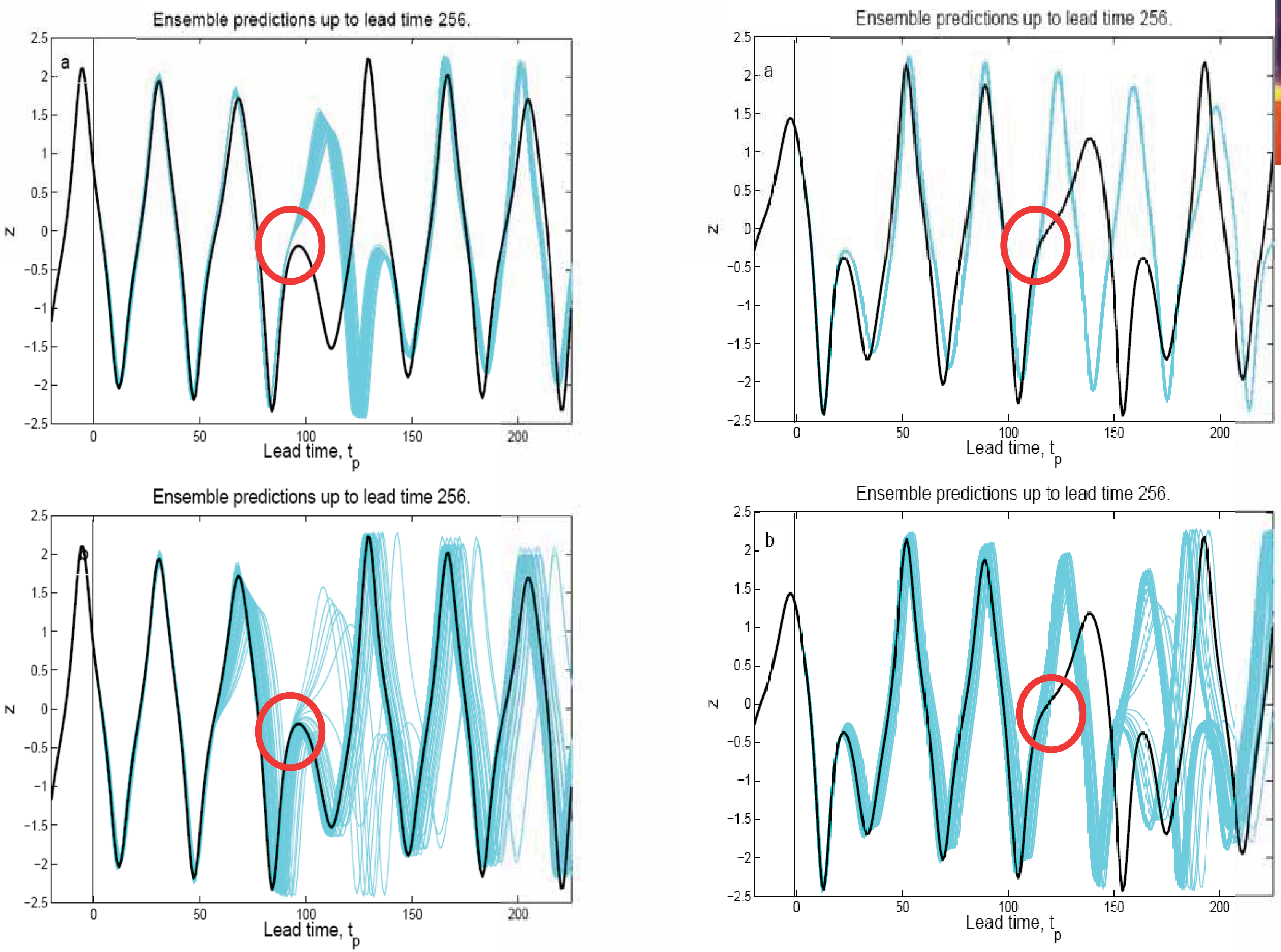


Big Surprise in the Moore-Spiegel Circuit (by Reason Machette)

One Initial State — Another Initial State

Model 1

Model 2



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Laplace's Demon (1814)

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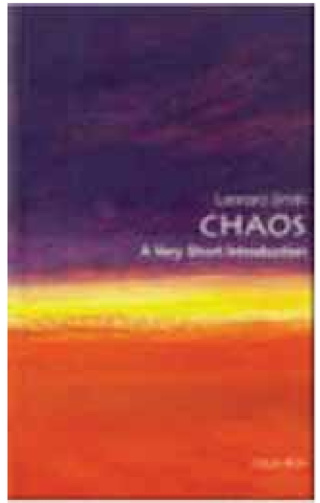

Do the pro's fare better?

Page last updated at 11:04 GMT, Friday, 5 March 2010

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Met Office seasonal forecasts to be scrapped

The Met Office is to stop publishing seasonal forecasts, after it came in for criticism for failing to predict extreme weather.

The Met Office says its short-term forecasts are "extremely accurate"

It was berated for not foreseeing that the UK would suffer this cold winter or the last three wet summers in its seasonal forecasts.

The forecasts, four times a year, will be replaced by monthly predictions.

The Met Office said it decided to change its forecasting approach after carrying out customer research.

Explaining its decision, the Met Office released a statement which said: "By their nature, forecasts become less accurate the further out we look.

SEE ALSO
- Met Office rethink on forecasts

http://news.bbc.co.uk/2/hi/uk_news/8551416.stm

Met Office document shows it only renamed its seasonal forecasts

Published 01/02/2011 Uncategorized 21 Comments
Tags: Abuse of Power, Dishonesty, Incompetence, Met Office, Our Tax £s, Spin, Weather

Met Office

A Freedom of Information request submitted to the Met Office by Autonomous Mind reveals the Met Office did not tell the truth when it said it had scrapped its seasonal forecast.

Despite repeatedly trailing the line that the Met Office no longer issues seasonal forecasts because the public says they are not of use (a separate blog post on that public view later today, with some new information that has come to light… *Update: part two can now be* read here), the reality is that the department's Chief Executive, John Hirst, engaged in a smoke and mirrors exercise in an attempt at reputation management.

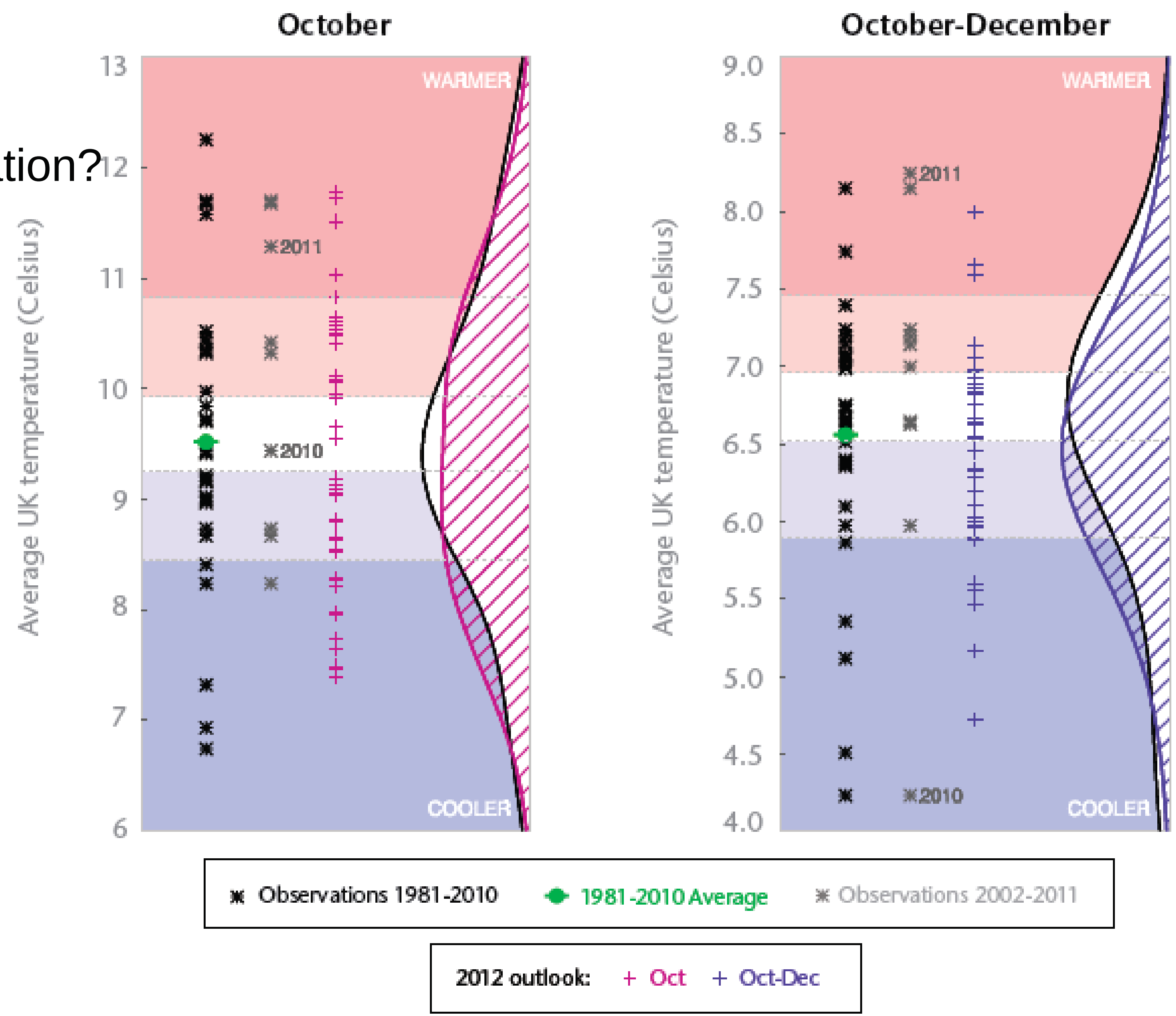
At a Board meeting of the Met Office on 26 January 2010, (original Minutes extract received under FOI: 0012014 AM Attachment) a recommendation was tabled by Hirst to *rename* the forecasts and locate them in a different part of the department's website, and that Hirst:

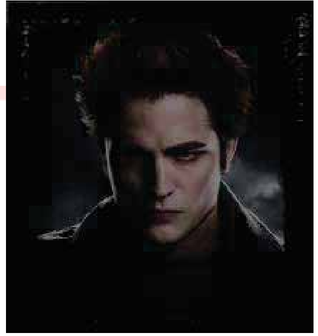
http://autonomousmind.wordpress.com/2011/02/01/met-office-document-shows-it-only-renamed-its-seasonal-forecasts/

These forecasts are not quite in the dark.

Skill?
Value?
Expectation?

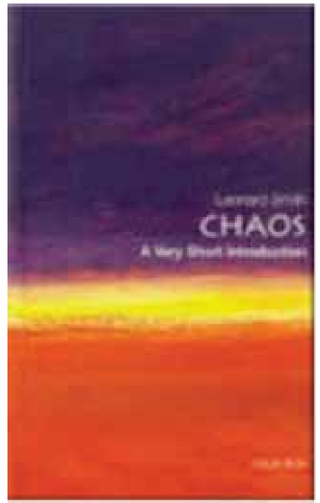
Time to
Value?





http://www.metoffice.gov.uk/media/pdf/n/3/A3-plots-temp-OND.pdf

Can we disentangle these “uncertainties”?



Demon’s Apprentice (2007)

1) Perfect Equations of Motion (PMS)
2) ~~Perfect noise-free observations~~
3) Unlimited computational power

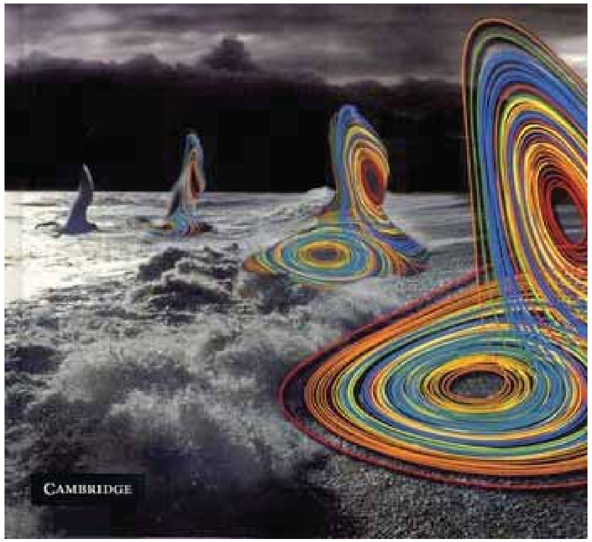
Apprentice’s Novice (2012)

1) ~~Perfect Equations of Motion (PMS)~~
2) ~~Perfect noise-free observations~~
3) Unlimited computational power

Enter the NAG Board

The NAG Board

(Not A Galton Board 2000)
150th Birthday of RMS



Enter Ensembles

How might ensembles help us understand uncertainty?
Consider the Not A Galton (NAG) Board.

In the NAG board, probability forecasting corresponds to predicting with a collection (ensemble) of golf balls…

Ensembles inform us of uncertainty growth within our model!
(Telling us about the next golf ball.)

Diversity is not Uncertainty

Ensembles inform us of uncertainty growth within our model(s)!

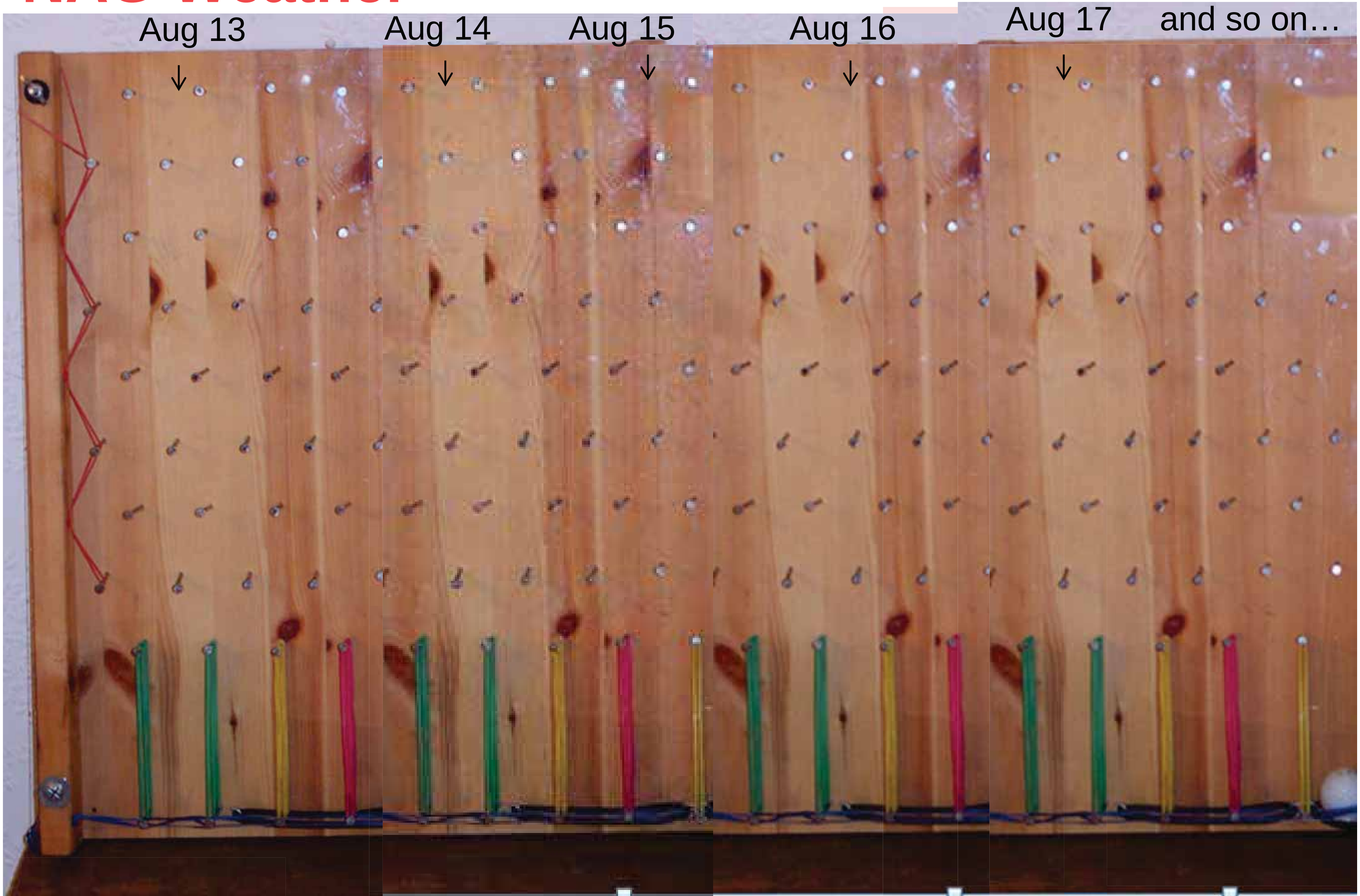
But ***reality*** is not a golf ball…

… ***reality*** is a red rubber ball.

What exactly does the distribution of 1024 golf balls tell us about the one (and only) red rubber ball?

While we never see similar initial states, we can still learn from our mistakes!(in this <u>weather-like</u> case)

NAG Weather



Science can anticipate surprises beyond model-land

Interpreting even weather-like distributions is a challenge!

Climate predictions require extrapolating out of the observed archive: into the known-to-be-different (?fluid?) unknown.

Scientific insight can help.

But the best we can hope for is sensible, consistency in distribution between our models ("the details do not matter").

And to anticipate "**Big Surprises**" (things are models cannot do)

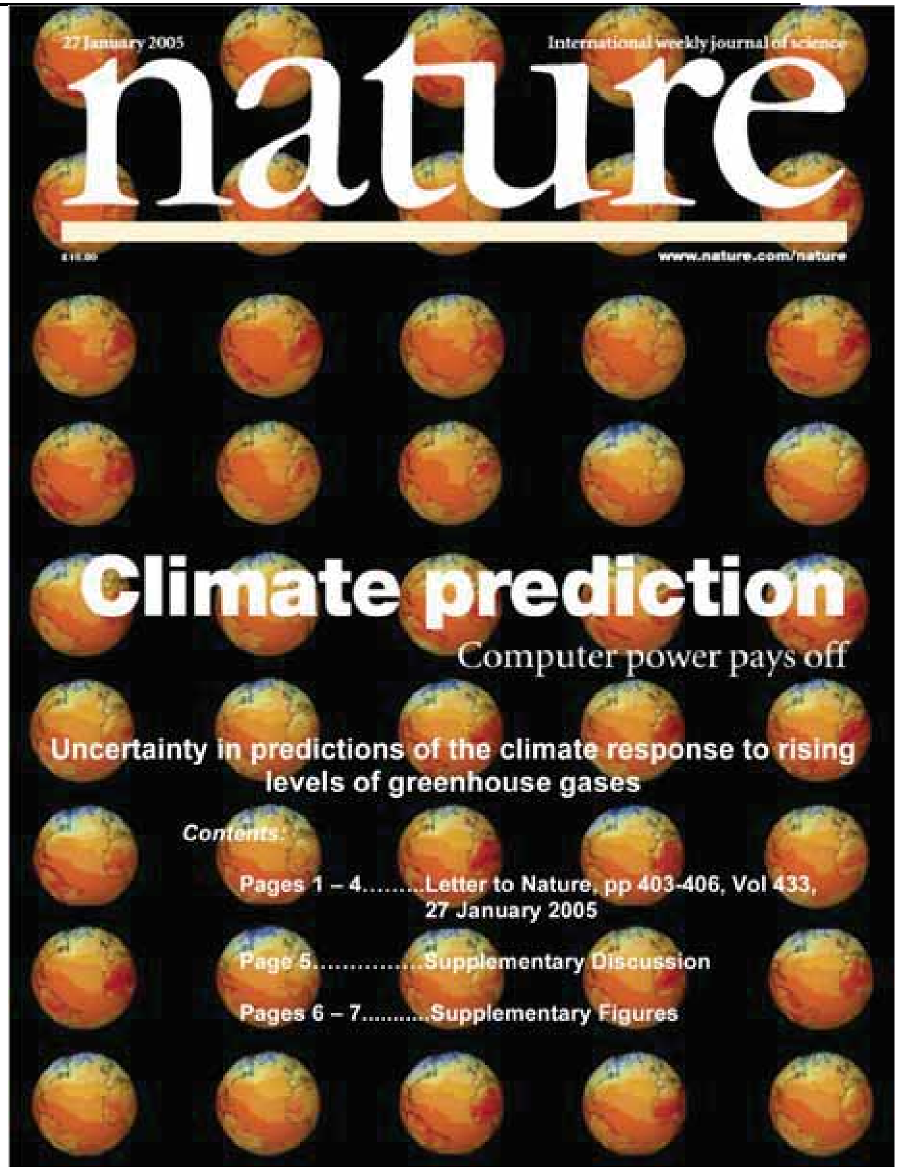
What is the aim of Climate Modelling?

It would be interesting to trace how the idea that climate models could provided quantitative insight came about.

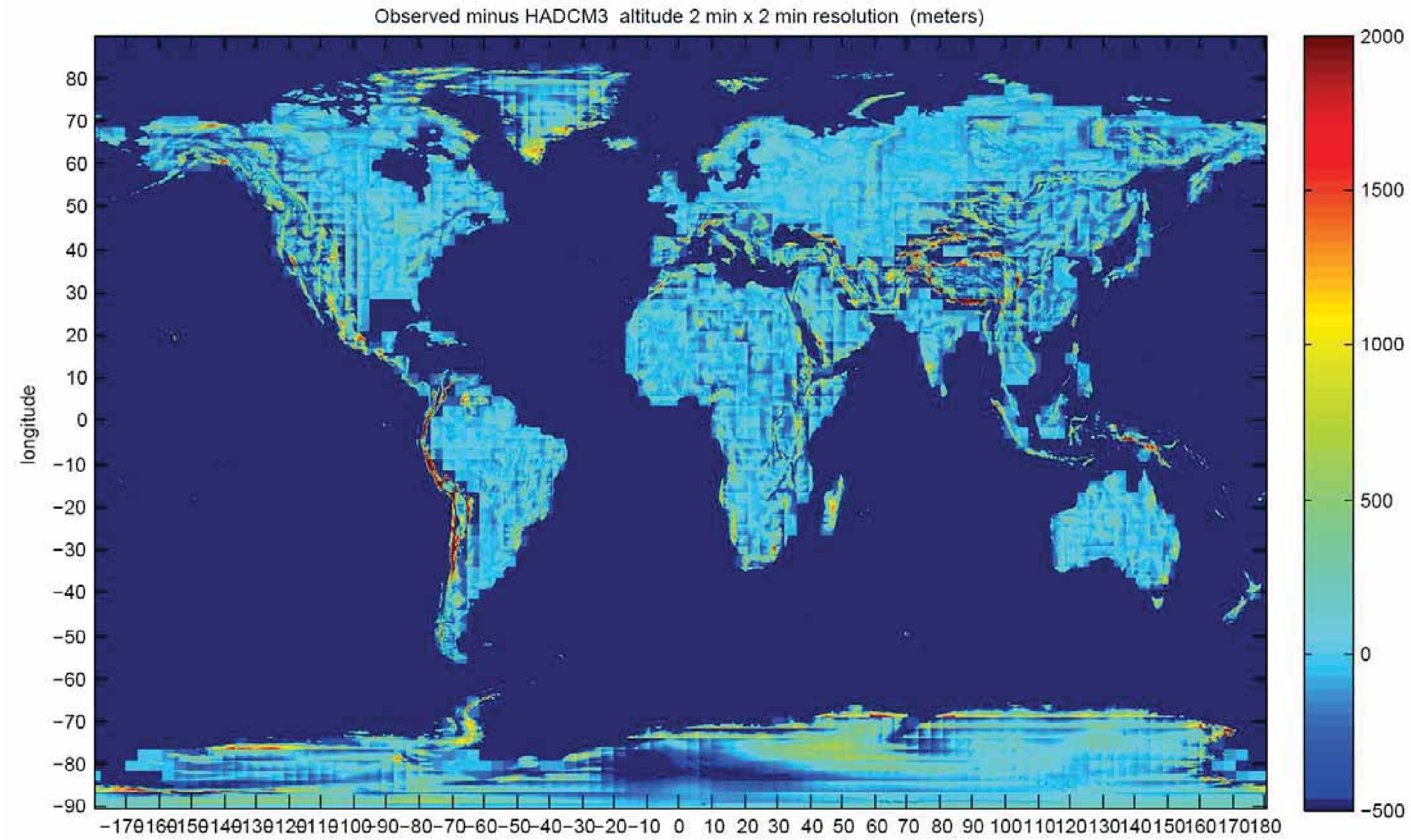
Weather models are simplified climate models: you need not turn on ocean currents in the first few days, or ice in the first few weeks, or forest in the first few years…

But climate models must run faster than real-time, and so are simplified in implementation:
do we have the technology to run high fidelity climate models?

Why do we hide behind clouds when we cannot realistically simulate rock?



DA Stainforth, T Aina, C Christensen, M Collins, DJ Frame, JA Kettleborough, S Knight, A Martin, J Murphy, C Piani, D Sexton, L Smith, RA Spicer, AJ Thorpe, M.J Webb, MR Allen (2005) Uncertainty in the Predictions of the Climate Response to Rising Levels of Greenhouse Gases *Nature* 433 (7024): 403-406.


Observed minus HADCM3 altitude 2 min x 2 min resolution (meters)
longitude
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
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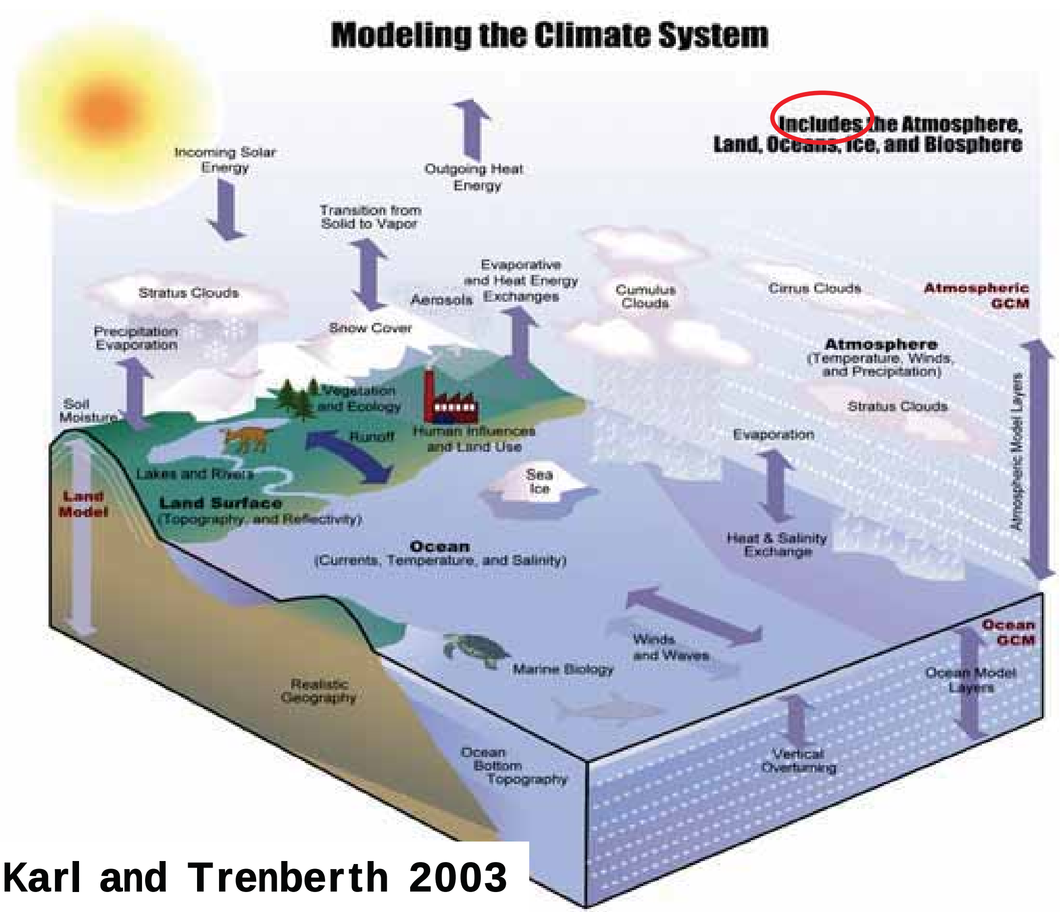
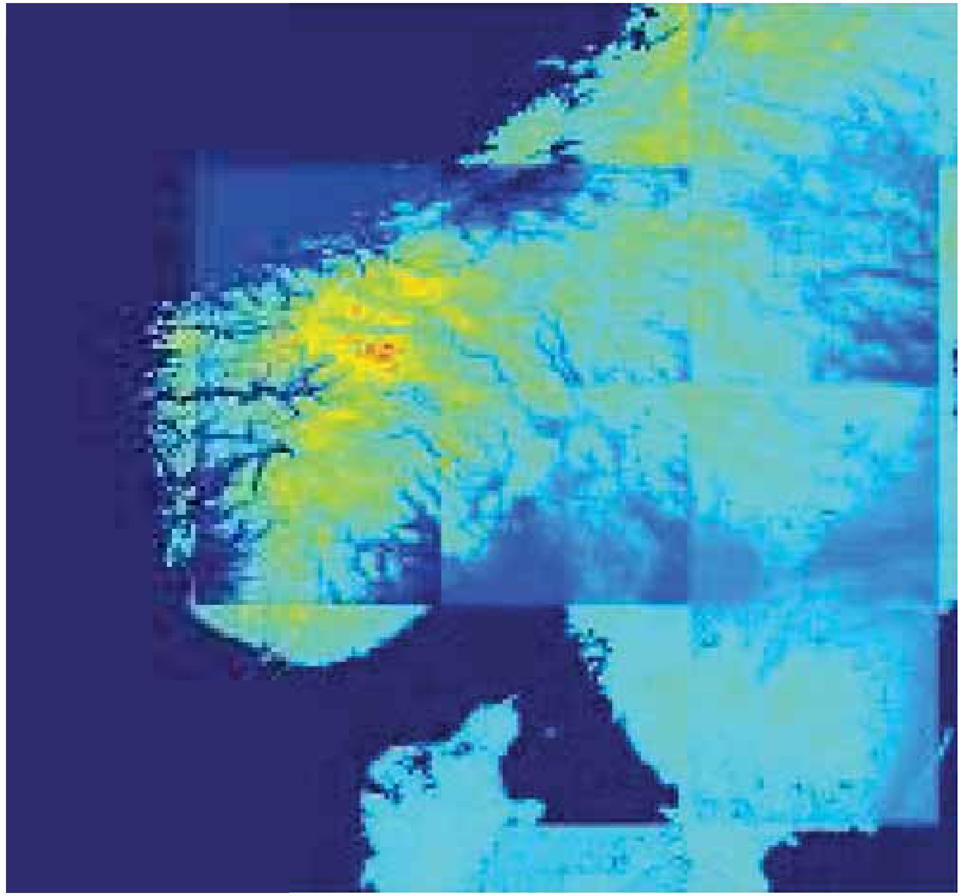
−90
−170 −160 −150 −140 −130 −120 −110 −100 −90 −80 −70 −60 −50 −40 −30 −20 −10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
2000
1500
1000
500
0
−500

Climate Models: “Included” vs “realistically simulated”



Karl and Trenberth 2003



A very schematic schematic reflecting phenomena the model “includes”. (Note the turtle)

The detail you see above is what is *missing* in HadCM3: the large squares reflect model grid resolution, the detail reflects the difference between the observed surface height and the model surface height, “constant” within a grid point,

Probabilistic Forecasts: IPCC Sixty-Forty Rule

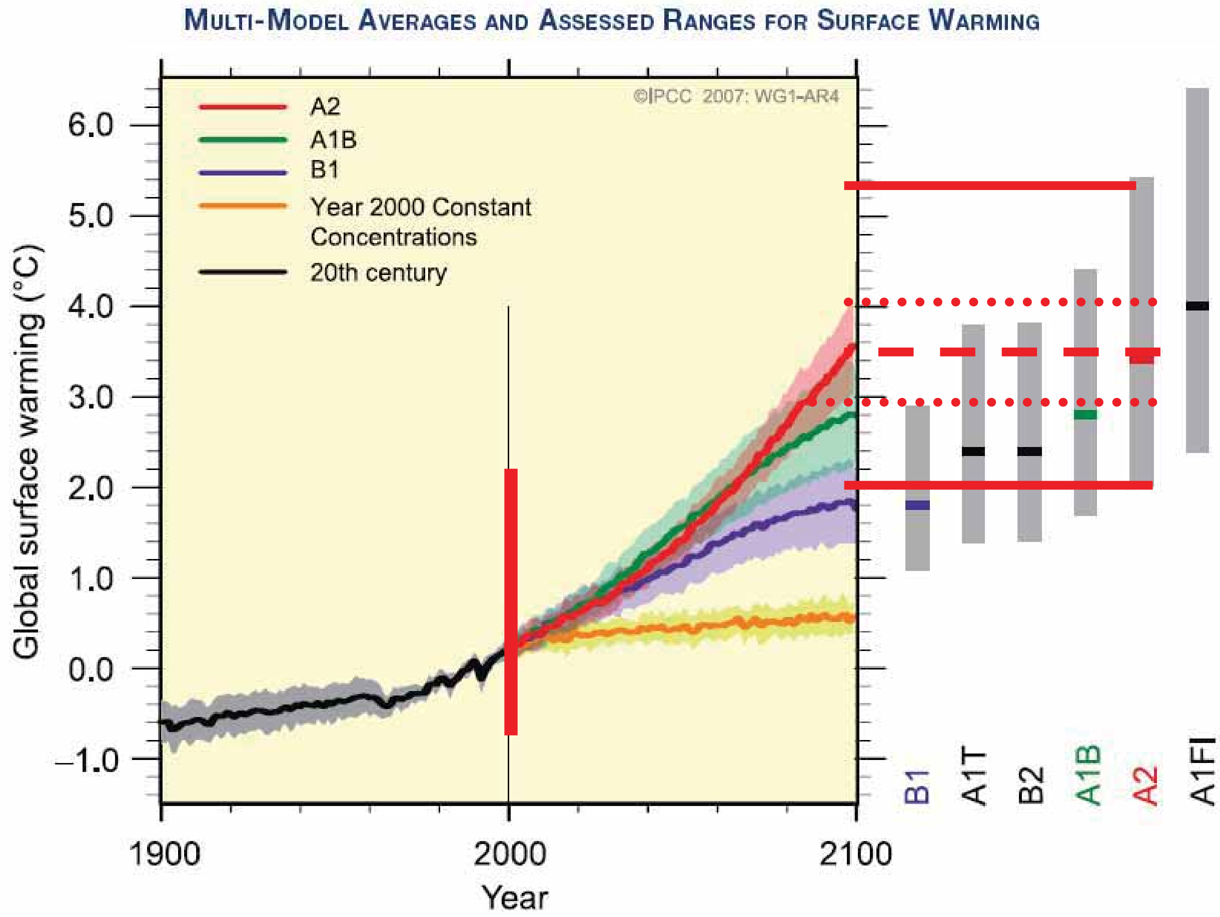
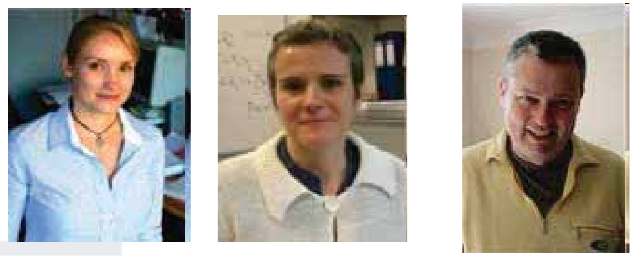


Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the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

– The conditional forecasts (projections) are the grey bars (right); they differ from the ensemble distributions left and centre.



The real concern is that an adequately parameterised process might significantly shift the range.

Discussions of broadening imply confidence in the location.

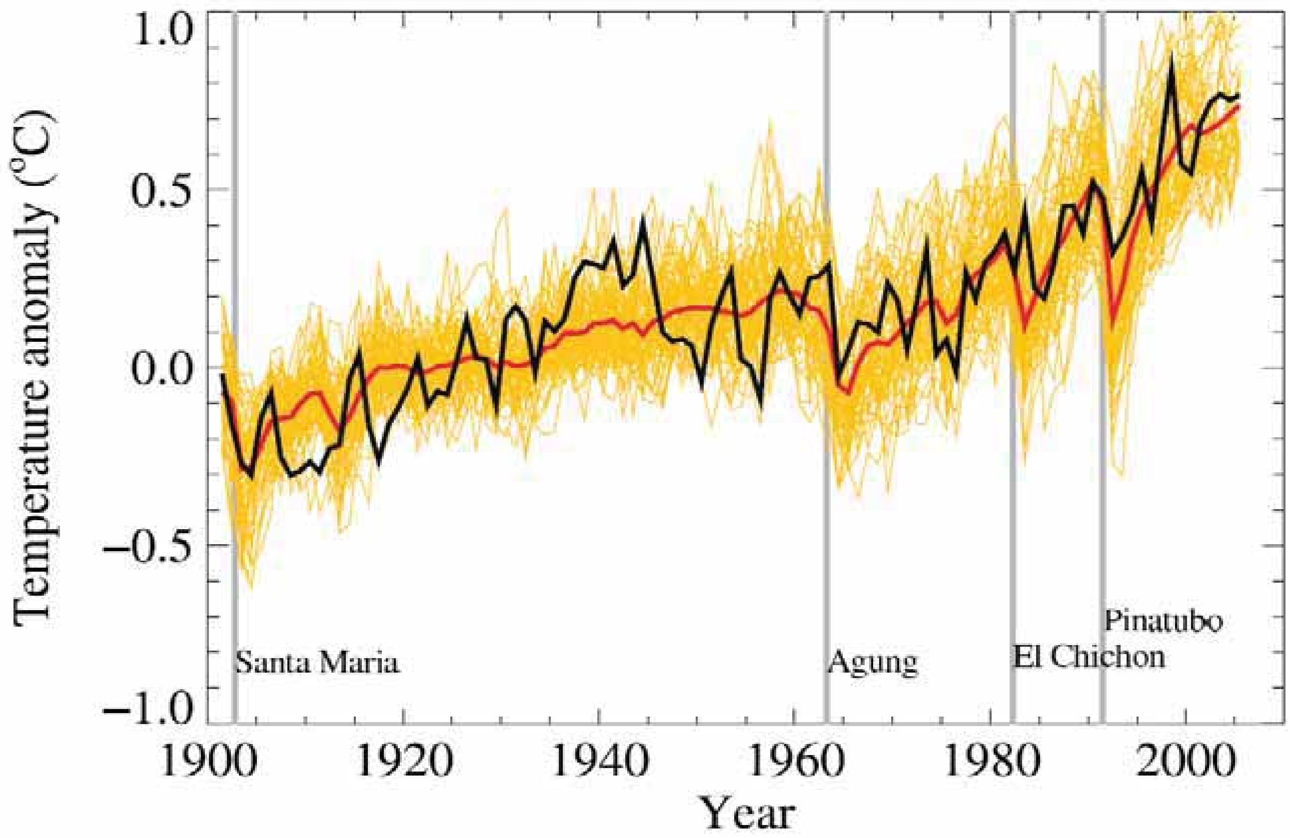
Do we have that confidence?

The IPCC rejects the diversity of ensembles directly reflecting the pdf of GMT, it follows that “downscaling” cannot provide local probabilities.

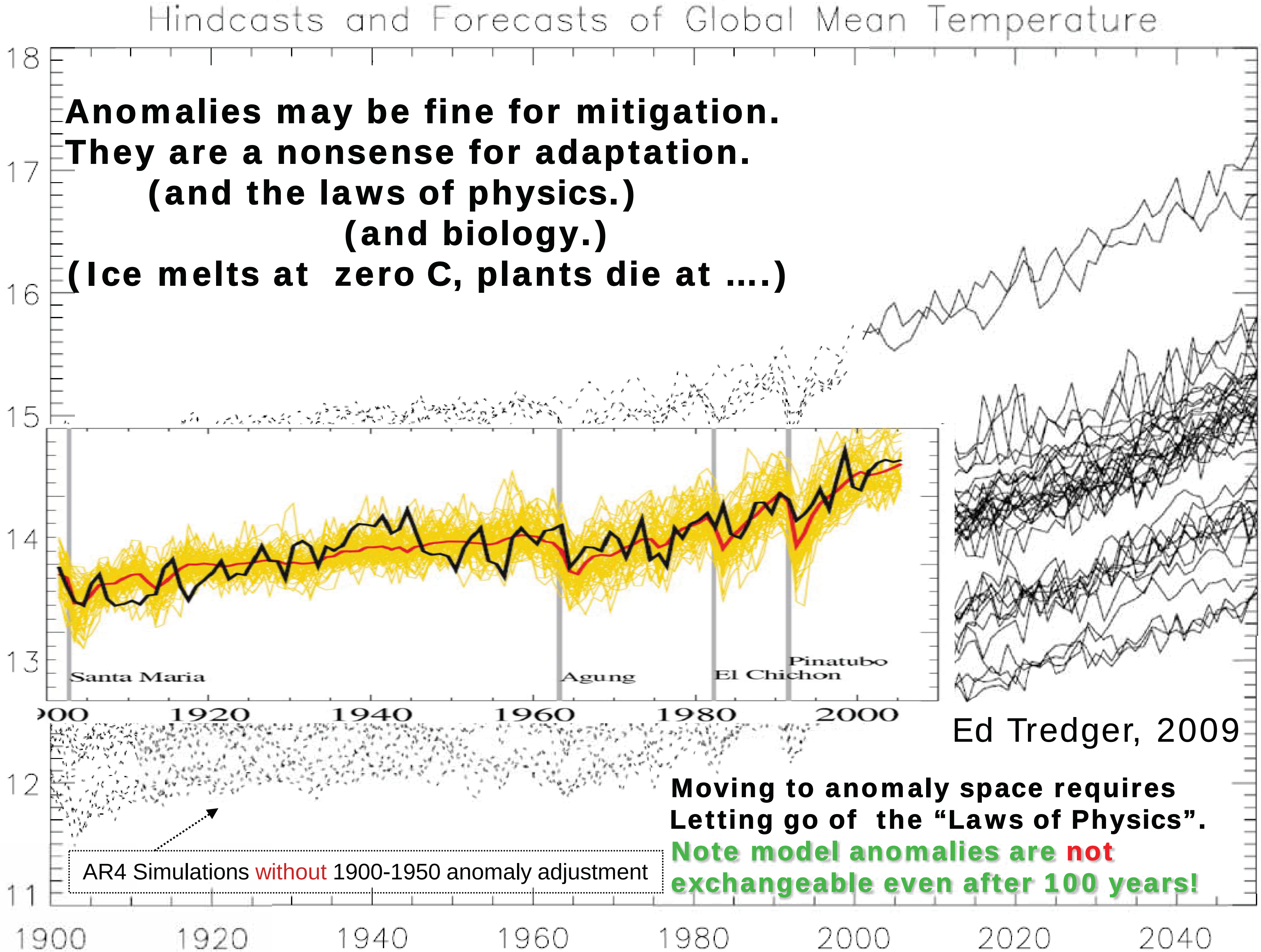
Climate in Practice: In-sample examples.

This graph tends to leave the impression GCMs do rather well.

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.)*



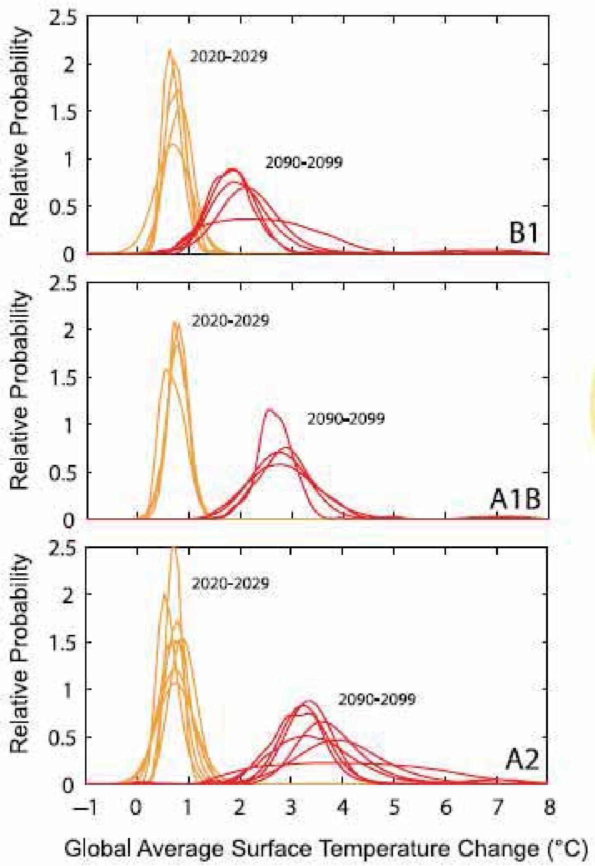
While systematic errors are larger than the observed effect



Summary for Policymakers

This risk of overconfidence is well known and well founded.

Projections of Surface Temperatures



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

Figure SPM.6. *Projected surface temperature changes for the early and late 21st century relative to the period 1980–1999. The central and right panels show the AOGCM multi-model average projections for the B1 (top), A1B (middle) and A2 (bottom) SRES scenarios averaged over ... probabilities o... studies for the... Therefore the ... {Figures 10.8 a...*

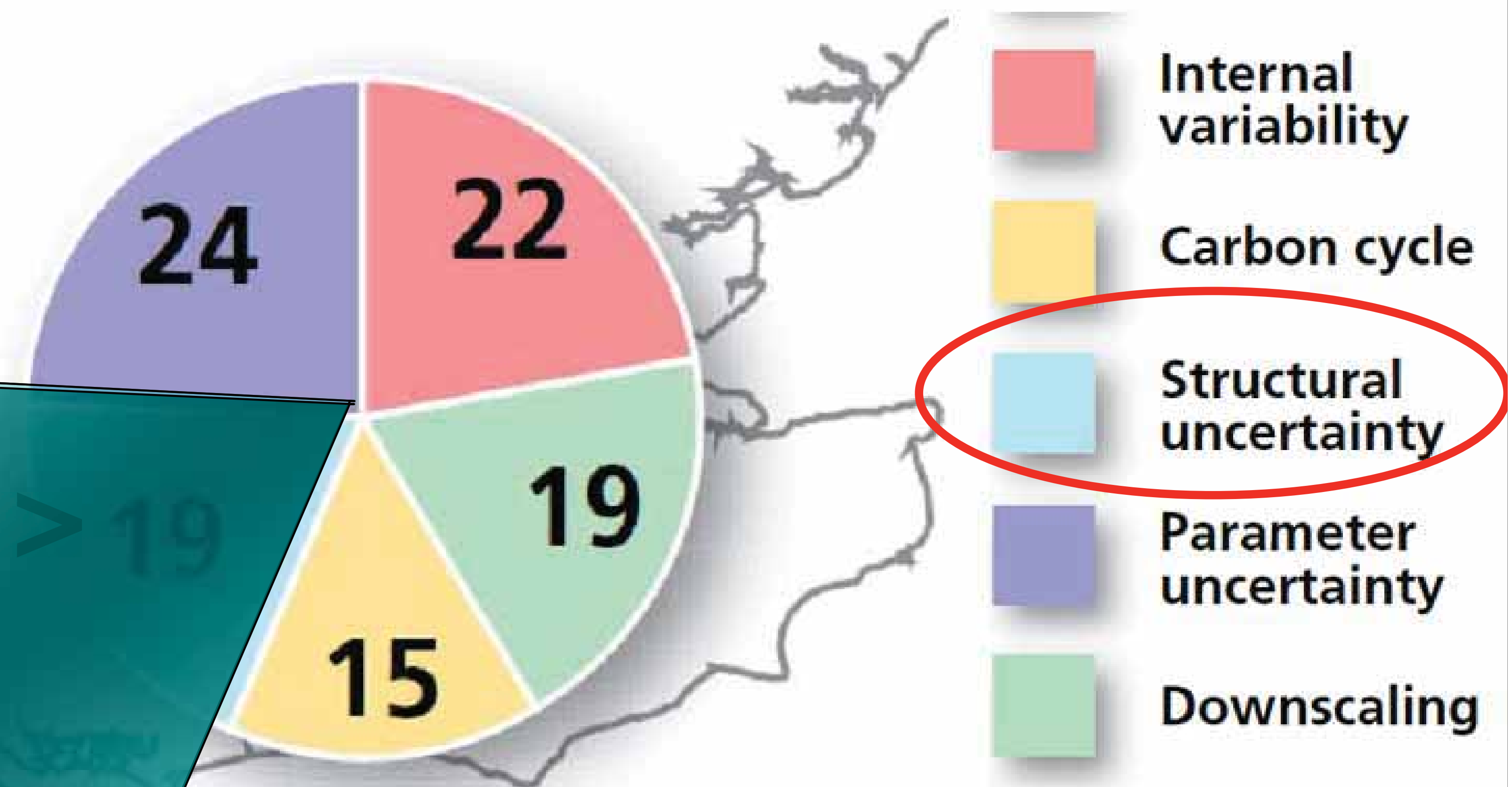
Not necessarily wider: they may narrow and shift under better models…

The IPCC itself might say this a bit louder/earlier: What space-time scales are realistic as a function of lead-time? (Focus on robust, but discuss inappropriate use.)

How important are different sources of uncertainty?

Dangers in the Dark: The value of qualitative insight is at risk of being discarded in favour of quantitative mis-information.

- Varies, but typically no single source dominates.



How might we avoid miscommunication in this case?

Uncertainties in winter precipitation changes for the 2080s relative to 1961-90, at a 25km box in SE England

Source: Met Office

How can we know our simulation models are inadequate?

Science is more than simulations

When does
"Sit and Think" trump
"Simulate and Count"?

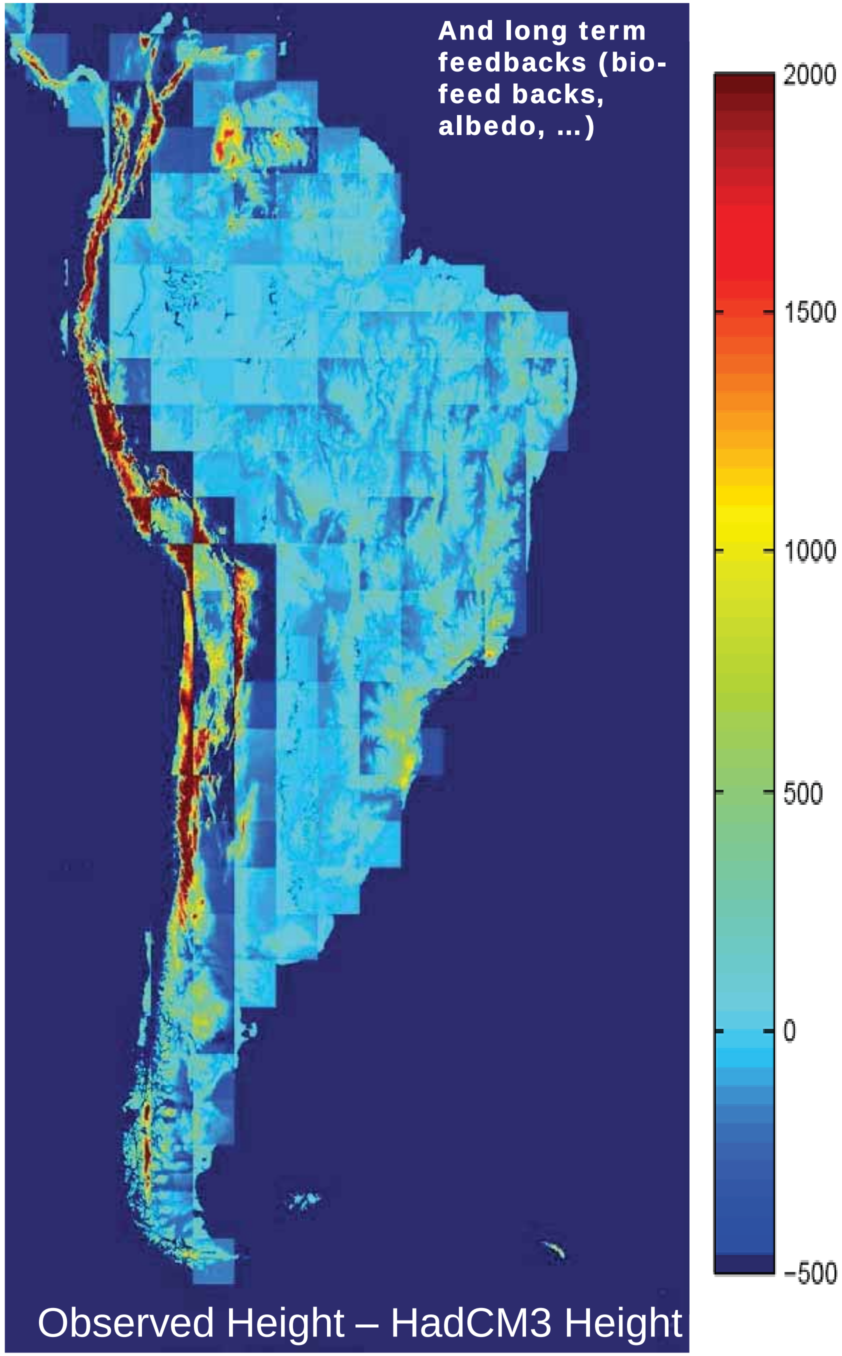
Example: When we know moist air must go over or around in (and only in) the real world!

If our models cannot reproduce today's driving meteorological phenomena, can we expect them to get second order feedbacks "well enough"?

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

Can we provide Prob(Big Surprise) with lead time?

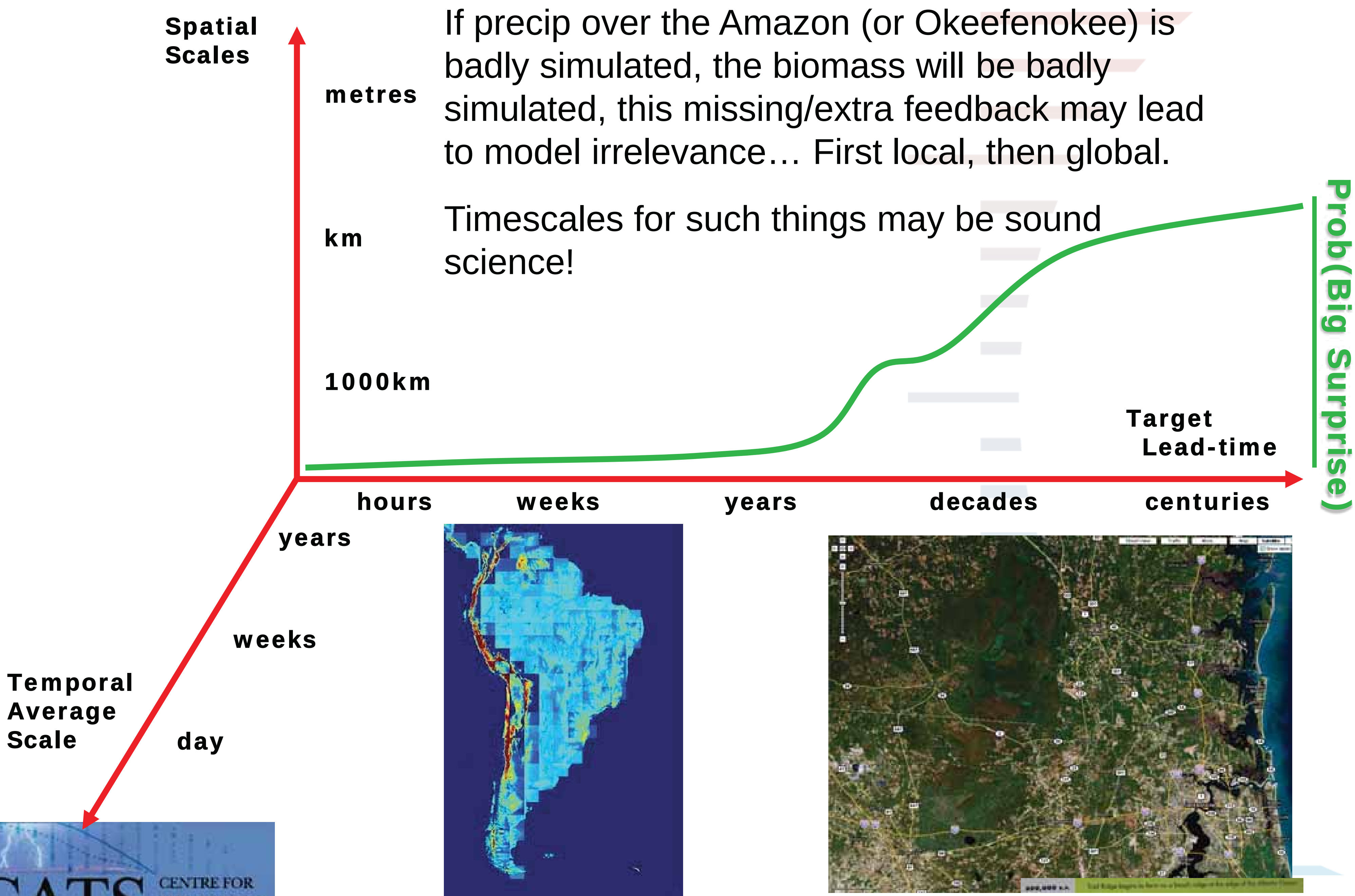
Missing 2km tall walls of rock!



Model-based probability forecasts are incomplete without a quantitative measure of the likelihood of model irrelevance.

If precip over the Amazon (or Okeefenokee) is badly simulated, the biomass will be badly simulated, this missing/extra feedback may lead to model irrelevance… First local, then global.

Timescales for such things may be sound science!



A genuine expert can always foretell a thing that is 500 years away easier than he can a thing that's only 500 seconds off.

- *A Connecticut Yankee in King Arthur's Court*

What is a "Big Surprise"?

Big Surprises arise when something our simulation models cannot mimic turns out to have important implications for us.

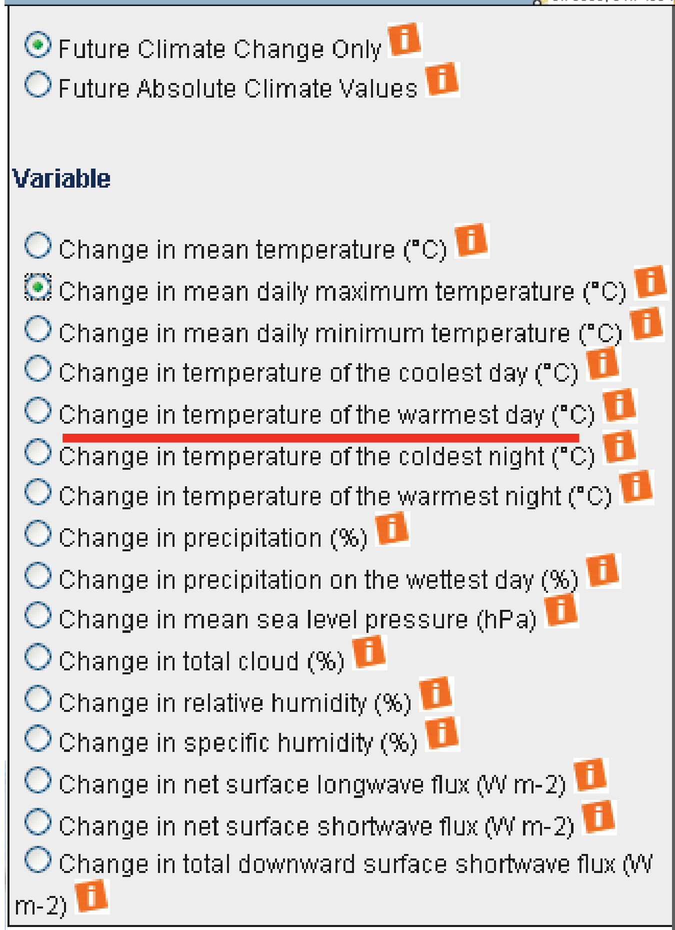
Often we can identify cases where we are "leaking probability" when a fraction of our model runs explore conditions which we know they cannot simulate realistically. (Science can warn of "known unknowns" even when the magnitude remains unknown)

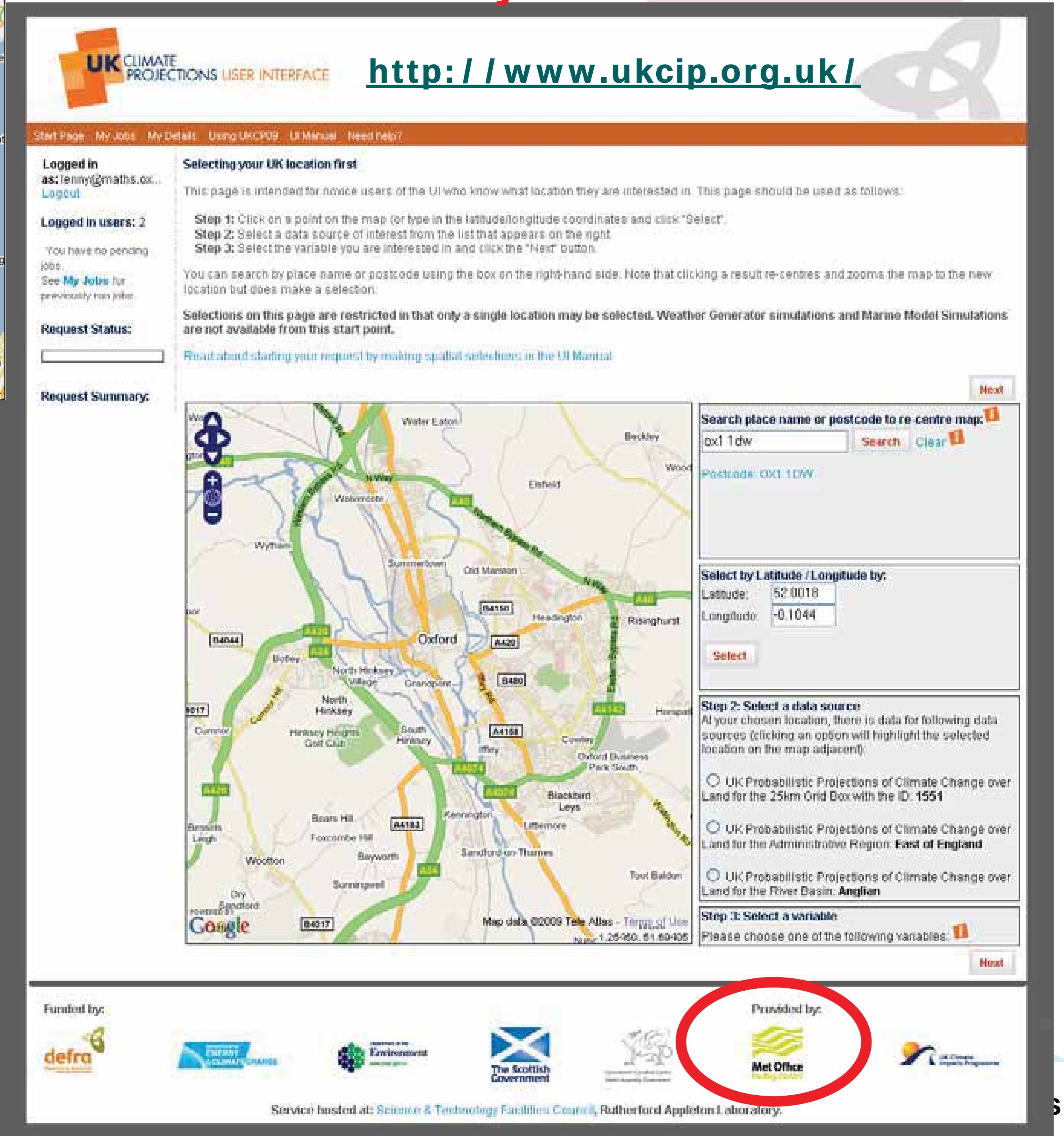
Big Surprises invalidate (not update) model-based probability forecasts, the I in $P(x|I)$. (Arguably "Bayes" does not apply: this is not a question of probability theory.)

In weather forecasting, we can see when are models become silly, but in climate forecasting we are in the dark.

If our models agreed (in distribution) we would we have more confidence?

Is it plausible to provide a PDF of hottest or stormiest summer day in 2080's Oxford???





Smith

Data Data Everywhere, and Not a Bit to Bank On

It seems we are surrounded by model output… but we know that the models are unlikely to be adequate to inform the questions we must answer.

What is the rational path forward when the best available model is known not to be adequate for purpose?

http://4umi.com/coleridge/rime/1

The basic insight here is not new

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

Dr. Platzman

I may add to this another point mentioned by Dr. Charney, a somewhat philosophical comment concerning model experiments. I think that I agree with Dr. Charney's suggestion that machines are suitable for replacing model experiments. But I think it is also necessary to remember that there are in general two types of physical systems which one can think of modeling. In one type of system one has a fairly good understanding of the dynamical workings of the system, involved. Under those conditions the machine modeling is not only practical but probably is more economical in a long run. Typical examples of this kind, I think, are problems where you are concerned, let's say, with wave action in harbors, in general a whole class of engineering problems of that kind. But there is another class of problem where we are still far from a good understanding of the dynamical properties of the system. In that case laboratory models, I think, are very effective and have a very important place in the scheme of things.

PROCEEDINGS
OF
THE INTERNATIONAL SYMPOSIUM
ON NUMERICAL WEATHER
PREDICTION IN TOKYO

NOVEMBER 7–13, 1960

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, but also identifies the various requirements that have to be satisfied for the study of climate sensitivity with a general circulation model.

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)

Political Shenanigans

Senator Inhofe's List

U. S. Senate Report
Over 400 Prominent Scientists Disputed
Man-Made Global Warming Claims in 2007
Scientists Debunk "Consensus"

cyclopedia

nhofe (/ˈɪnhɒf/; born
senior United States
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the science of

to

Jim Inhofe

United States Senator
from Oklahoma

Statistician Lenny Smith of the London School of Economics, who co-authored a study on the uncertainties of climate models for the Tyndall Centre for Climate Change Research in Oxford, dubbed climate modeling "naive realism." "Our models are being over-interpreted and misinterpreted," Smith said, according to a New Scientist article from August 16, 2007. "They are getting better; I don't want to trash them per se. But as we change our predictions, how do we maintain the credibility of the science?" Smith explained. "We need to drop the pretence that they are nearly perfect," he added. The article noted that Smith believes that the "over-interpretation of models is already leading to poor financial decision-making." The article continued: "[Smith] singled out for criticism the British government's UK Climate Impacts Programme and Met Office. He accused both of making detailed climate projections for regions of the UK when global climate models disagree strongly about how climate change will affect the British Isles." (LINK)

Derailing Science Ourselves: The Penguin Effect

The challenge of climate change will be with us for some time.

Can we maintain parallel streams: pure research to apply in 2050, and applied research to improve the modelling position we are in when we get there?

When selecting a thesis problem: do you suggest something important, like understanding cloud dynamics (better)?

Or to be the first person in the world to include the penguin effect in a global model? (and thereby all but assured a job at a rival modelling centre?)

(Similar effects plague economics and statistics)

THERE IS NO PENGUIN EFFECT

(My prior on this effect is zero)

It is a joke regarding climate,

but sadly not career paths!

Science in the Dark does not imply scientists have gone over to the dark side

Scientists must "violate" traditional best practice guidance if such violations are imposed by the nature of the question being addressed.

One cannot wait 50 years for out-of-sample observations.

It is a brute fact that a climate model's lifetime is less than its forecast leadtime!

The physics underlying CO_2 induced warming is as solid as science gets.

Science in the Dark does not imply scientists have gone over to the dark side

But science done without the benefit of out-of-sample evaluation cannot call on the unreasonable effectiveness of science done in the light.

Science which cannot be falsified without risking catastrophe needs to communicate clearly the limits of its (current) insights, or it risks the credibility of all science.

When the best available model is not adequate for purpose

Accept (for a moment) that Model Inadequacy may make probability forecasting irrelevant in just the same way that chaos made the RMS/least-squares error of point forecasts irrelevant.

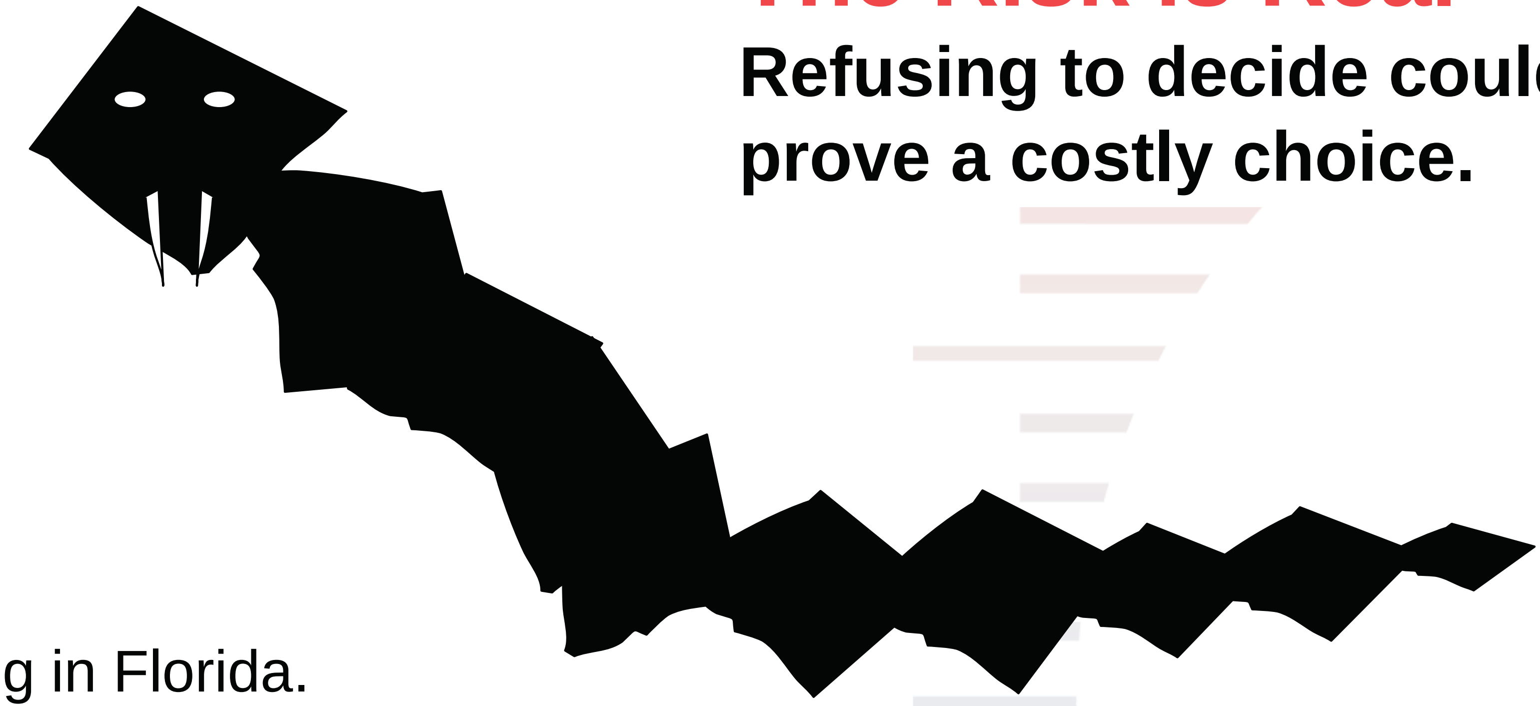
When the best model we have is not adequate from quantitative prediction: What is the role of quantitative modelling & simulation in decision support? In explanation?

How can we better extract insight and information from big models and ensemble forecasts without taking them too seriously?

Might this lead to better decision making?

The Risk is Real

Refusing to decide could prove a costly choice.



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.

How can eScience help?

Publications http://www2.lse.ac.uk/CATS/publications/Publications_Smith.aspx

LA Smith, (2002) What Might We Learn from Climate Forecasts? *Proc. National Acad. Sci.* USA 4 (99): 2487-2492.

Smith, LA and Stern, N (2011) Uncertainty in science and its role in climate policy *Phil. Trans. R. Soc. A (2011)*, **369**, 1-24

K Bevan, W Buytaert & L A Smith (2012) On virtual observatories and modelled realities *Hydrol. Process.*, 26: 1905–1908

R Hagedorn and LA Smith (2009) Communicating the value of probabilistic forecasts with weather roulette. *Meteorological Appl* 16 (2): 143-155.

K Judd, CA Reynolds, LA Smith & TE Rosmond (2008) The Geometry of Model Error. *Journal of Atmospheric Sciences* 65 (6), 1749-1772.

J Bröcker & LA Smith (2008) From Ensemble Forecasts to Predictive Distribution Functions *Tellus A* 60(4): 663. Abstract

DA Stainforth, MR Allen, ER Tredger & LA Smith (2007) Confidence, uncertainty and decision-support relevance in climate predictions, *Phil. Trans. R. Soc. A*, **365**, 2145-2161. Abstract

LA Smith (2006) Predictability past predictability present. MS Roulston, J Ellepola & LA Smith (2005) Forecasting Wave Height Probabilities with Numerical Weather Prediction Models, *Ocean Engineering* **32** (14-15), 1841-1863. Abstract

DA Stainforth, T Aina, C Christensen, M Collins, DJ Frame, JA Kettleborough, S Knight, A Martin, J Murphy, C Piani, D Sexton, L Smith, RA Spicer, AJ Thorpe, M.J Webb, MR Allen (2005) Uncertainty in the Predictions of the Climate Response to Rising Levels of Greenhouse Gases *Nature* 433 (7024): 403-406.

A Weisheimer, LA Smith & K Judd (2005) A New View of Forecast Skill: Bounding Boxes from Seasonal Forecasts, *Tellus* **57** (3) 265-279 MAY.

K Judd & LA Smith (2004) Indistinguishable States II: The Imperfect Model Scenario. *Physica D* **196**: 224-242.

MG Altalo & LA Smith (2004) Using ensemble weather forecasts to manage utilities risk, *Environmental Finance* October 2004, 20: 8-9.

MS Roulston & LA Smith (2004) The Boy Who Cried Wolf Revisited: The Impact of False Alarm Intolerance on Cost-Loss Scenarios, *Weather and Forecasting* 19 (2): 391-397.

LA Smith (2003) Predictability Past Predictability Present. In 2002 ECMWF Seminar on Predictability. pg 219-242. ECMWF, Reading, UK.
also now: Chapter 9 of *Predictability of Weather and Climate* (eds T. Palmer and R Hagedorn). Cambridge, UK. Cambridge University Press.

MS Roulston, DT Kaplan, J Hardenberg & LA Smith (2003) Using Medium Range Weather Forecasts to Improve the Value of Wind Energy Production, *Renewable Energy* 29 (4) April 585-602.

MS Roulston and LA Smith (2002) 'Weather and Seasonal Forecasting' in *Climate Risk and the Weather Market* pg 115-126. Risk Books, London.

MS Roulston & LA Smith (2002) Evaluating probabilistic forecasts using information theory, *Monthly Weather Review* 130 6: 1653-1660.

D Orrell, LA Smith, T Palmer & J Barkmeijer (2001) Model Error in Weather Forecasting, *Nonlinear Processes in Geophysics* 8: 357-371.


Mind the gap between
the training and reality.

Thank you


predictions are wrong
sorry for any inconvenience

Publications http://www2.lse.ac.uk/CATS/publications/Publications_Smith.aspx

LA Smith, (2002) What Might We Learn from Climate Forecasts? *Proc. National Acad. Sci.* USA 4 (99): 2487-2492.

Smith, LA and Stern, N (2011) Uncertainty in science and its role in climate policy *Phil. Trans. R. Soc. A (2011)*, **369**, 1-24

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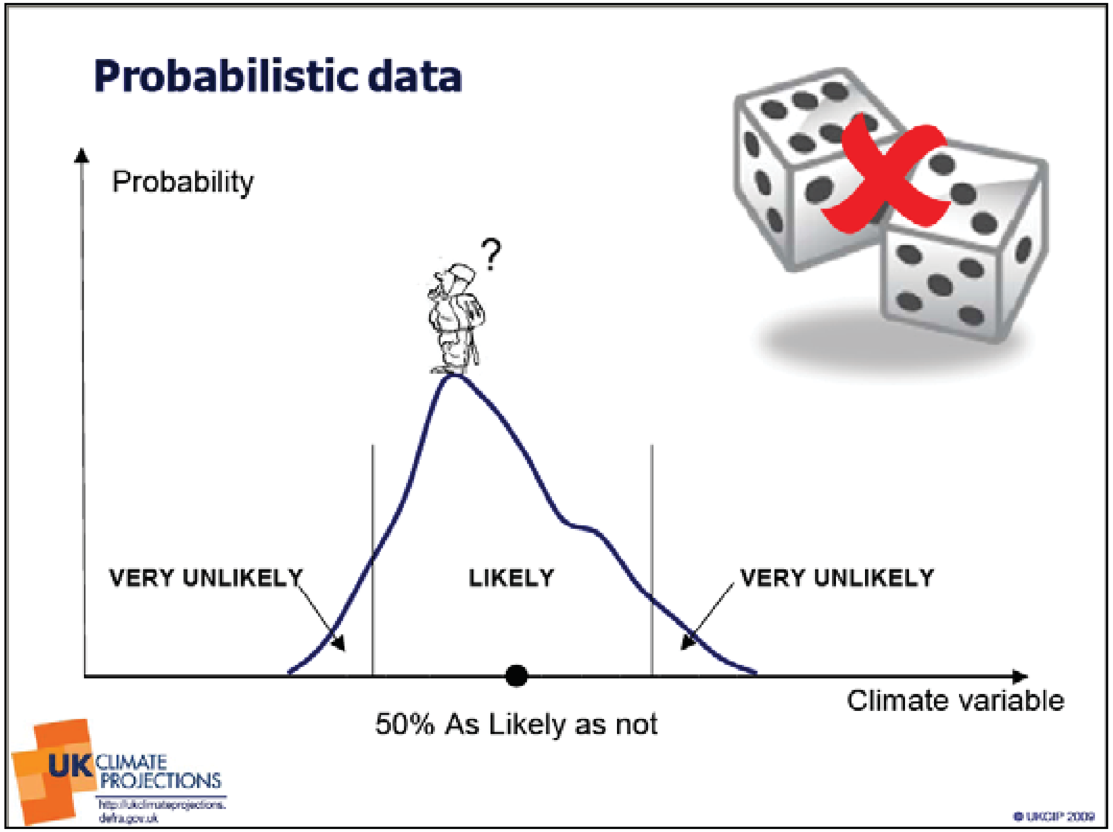
D Orrell, LA Smith, T Palmer & J Barkmeijer (2001) Model Error in Weather Forecasting, *Nonlinear Processes in Geophysics* 8: 357-371.

So what about UKCP probabilities?

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



The probability of the real world falling above the 90% line of the UKCP PDF can be much **much** greater than 10%.

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

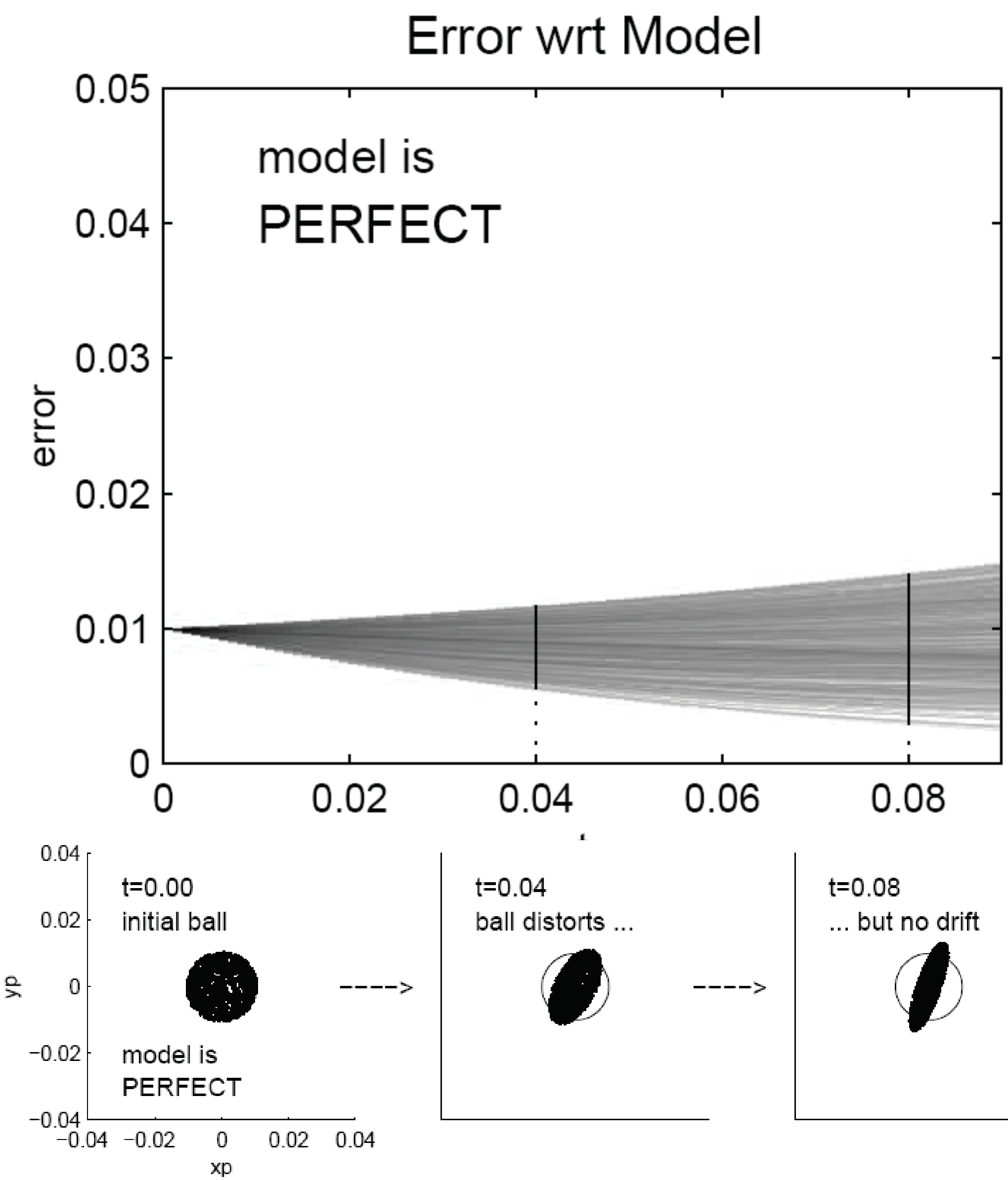
A methodology for probabilistic predictions of regional climate change from perturbed physics ensembles

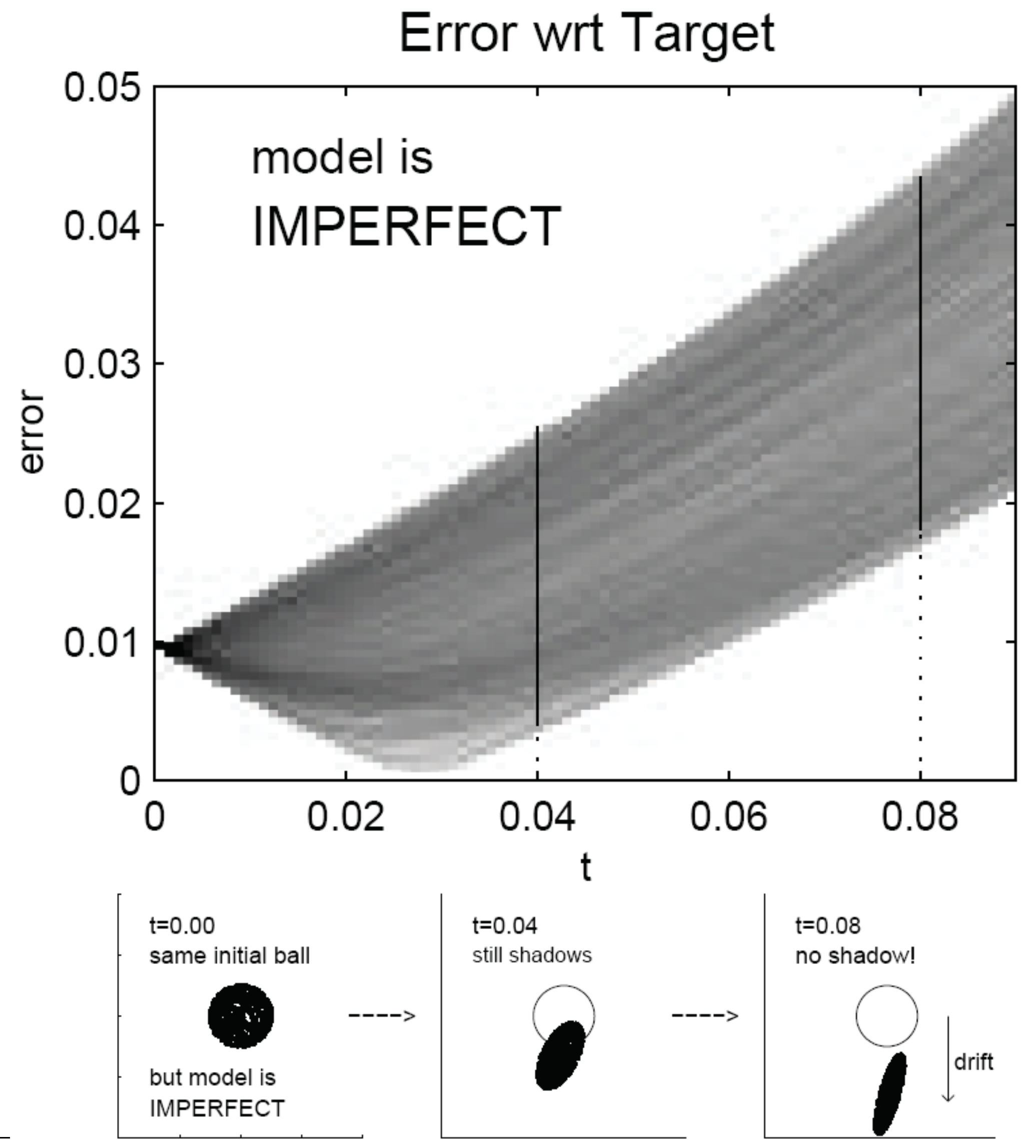
J M Murphy, B B B Booth, M Collins, G R Harris, D M H Sexton and M J Webb

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

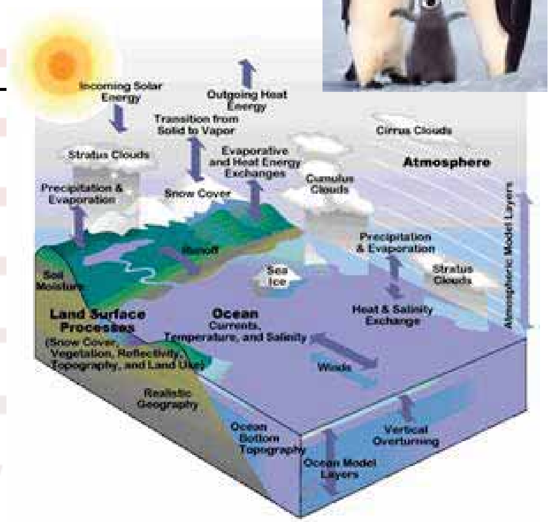
Model Imperfections

D Orrell, LA Smith, T Palmer & J Barkmeijer (2001) Model Error in Weather Forecasting, Nonlinear Processes in Geophysics 8: 357-371.





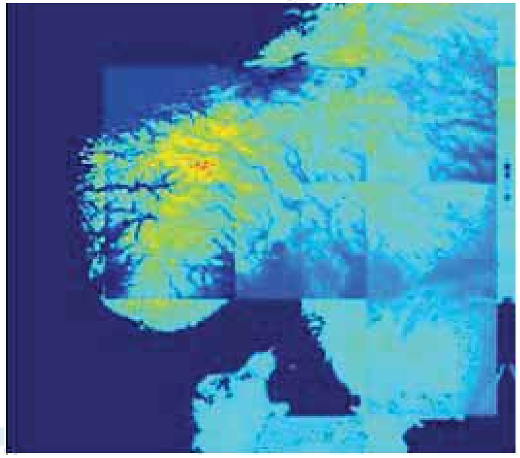
Moving Forward:
Plausible Planets or Implausible Earths?



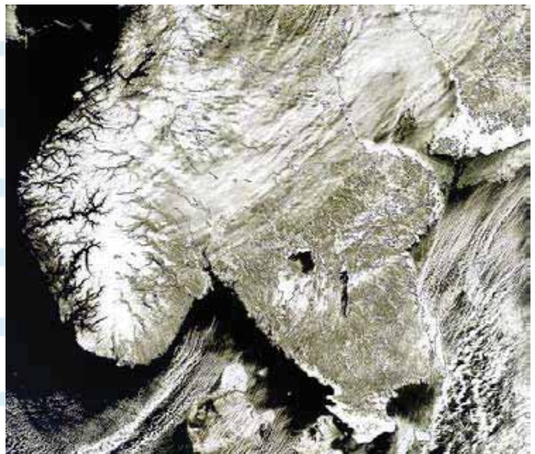
How can we best develop our models as the available computational power increases?

A) Simulate potentially real planets that get more and more Earth-like 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!)

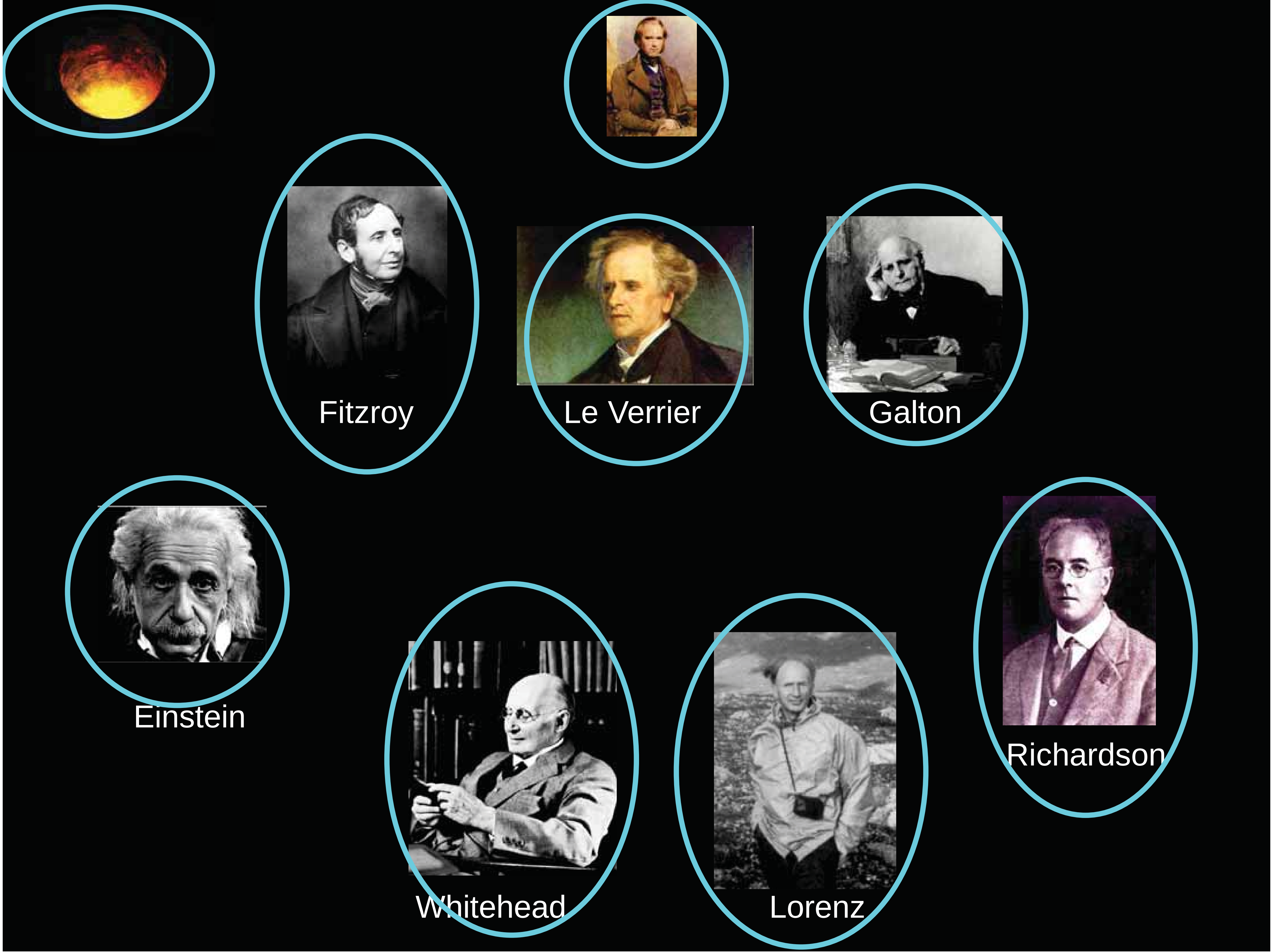
Does water vapour come after mountains?
Does vegetation come after water vapour?
Do we avoid the penguin effect? (until it is simulated realistically)



B) Via an hodgepodge of unphysical/unbiological simulations resembling no planet that could possibly exist, but "including" every phenomena we can think of that might be important (including penguins), and hoping the simulated planets will suddenly become Earth-like at some resolution in an ill-defined higgledy-piggledy way.



One might argue physical intuition is more effective in evaluating plausible planets, as there is physics to intuit in that case. (and at least a few examples.)


Fitzroy
Le Verrier
Galton
Einstein
Richardson
Whitehead
Lorenz

Take home questions

How might we **better communicate model diversity** given the possibility that we cannot get probabilities useful as such!

Do we have a single example of a nontrivial system where anyone has succeeded (and **willing to bet** on their model-based probabilities?)

At what lead times do inadequacies drive (or fail to drive) feedbacks yielding local impacts? extremes? **global impacts**?
How far to one go with a simulation model (when to stop: in time? space?)

How can we best deal with models behaving badly?

What prevents the provision of **Prob(Big Surprise)** with lead time?

How can we improve the communication of insights from simulations without falling afoul of **forecasting good practice**?

How to distinguish the value of improvement from the utility of prediction?

Might the provision of probability be maladaptive?

How might we better **communicate** the inadequacy as well as imprecision

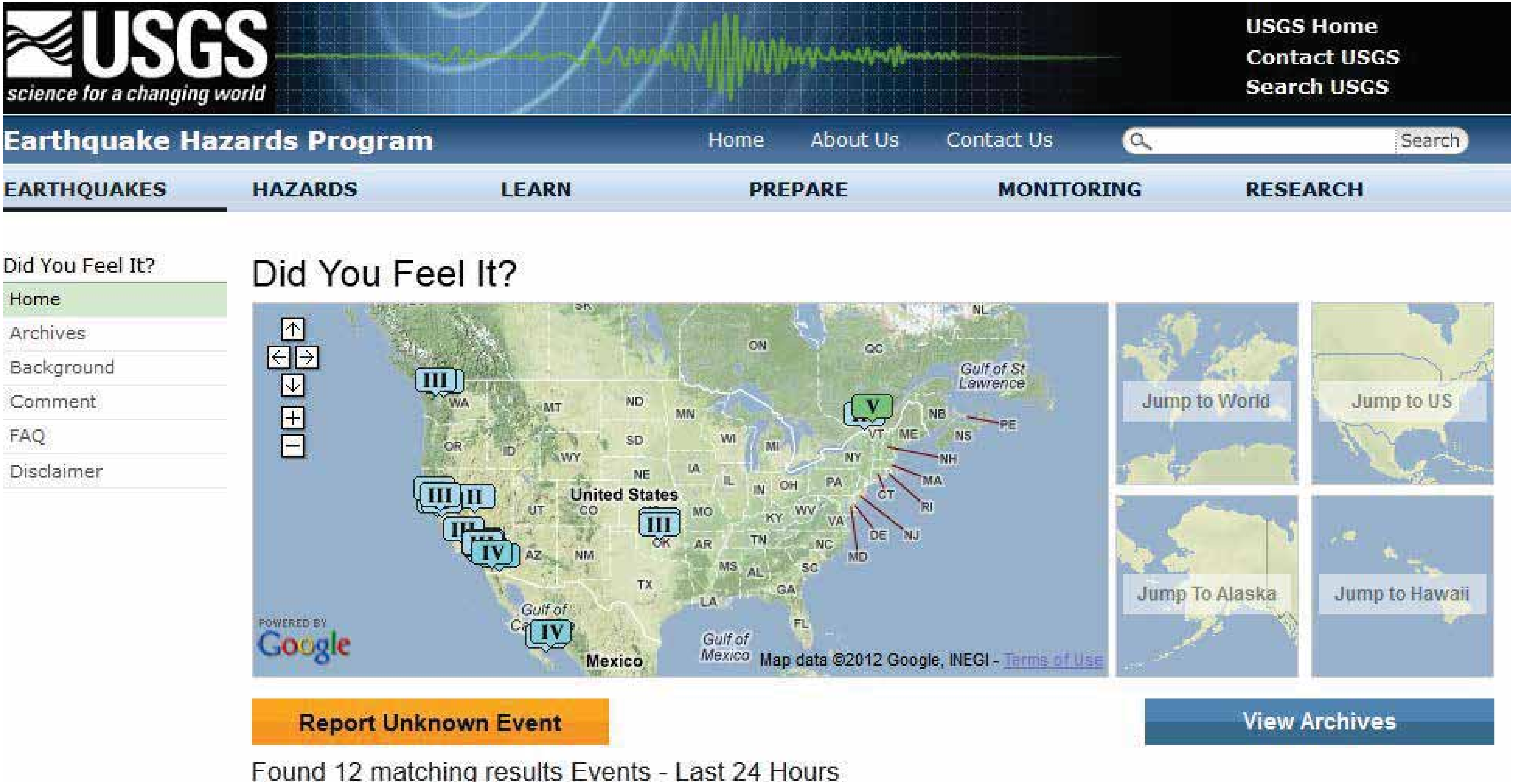
Is the **value of qualitative insight** at risk of being discarded in favour of quantitative mis-information?

Precision or Early Warning an Event is Likely?

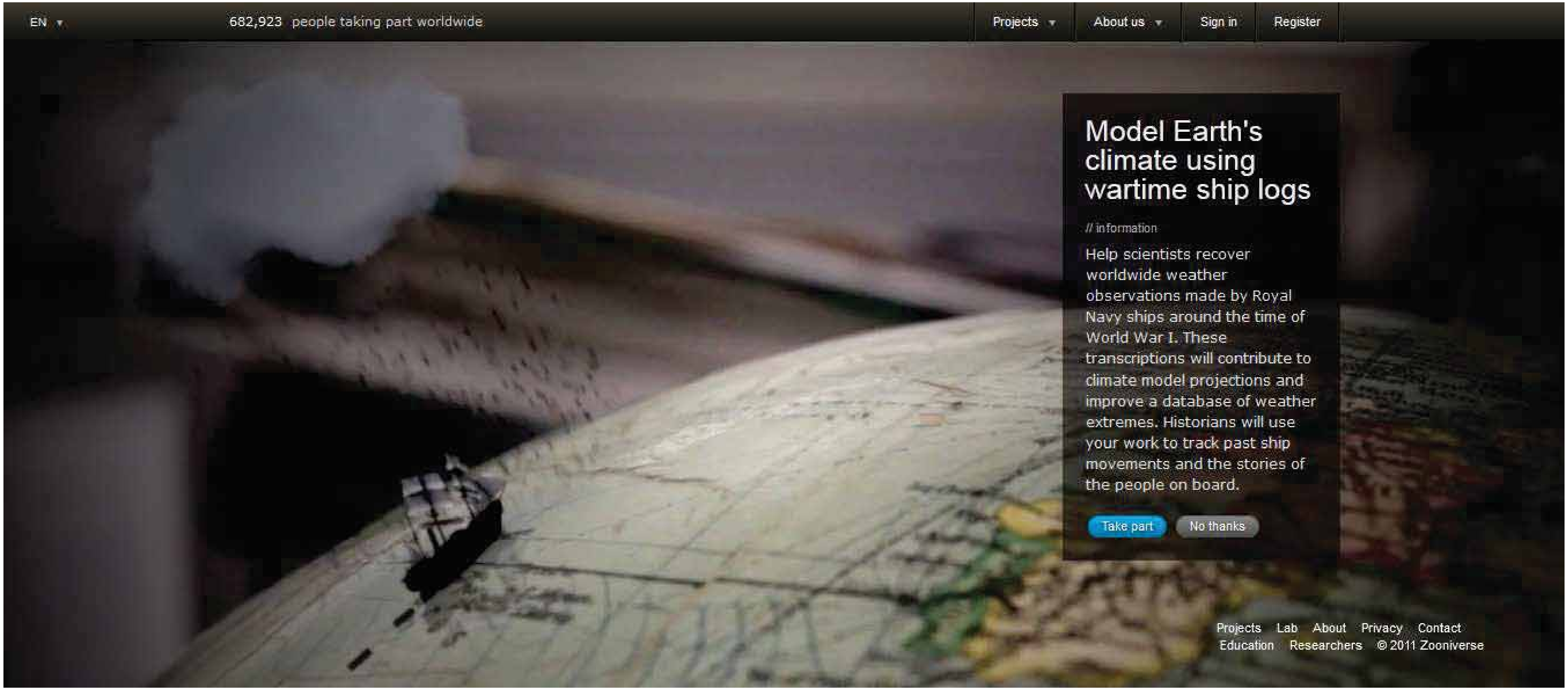
Smoothing out the highs and lows of running a business
As in daily life, one of the unruliest factors in running a business can be the weather. It can bring a highly functioning organization to a dead stop in a matter of seconds. Rack up billions in costs, in the blink of an eye. It's completely uncontrollable. And relentless. It is not, however, unpredictable.
Increasingly, precise, short-term, extremely local forecasts can help companies sidestep major disasters as well as plan for the more routine weather events that haemorrhage energy and resources.

http://www.ibm.com/ibm/ideasfromibm/science/092506/

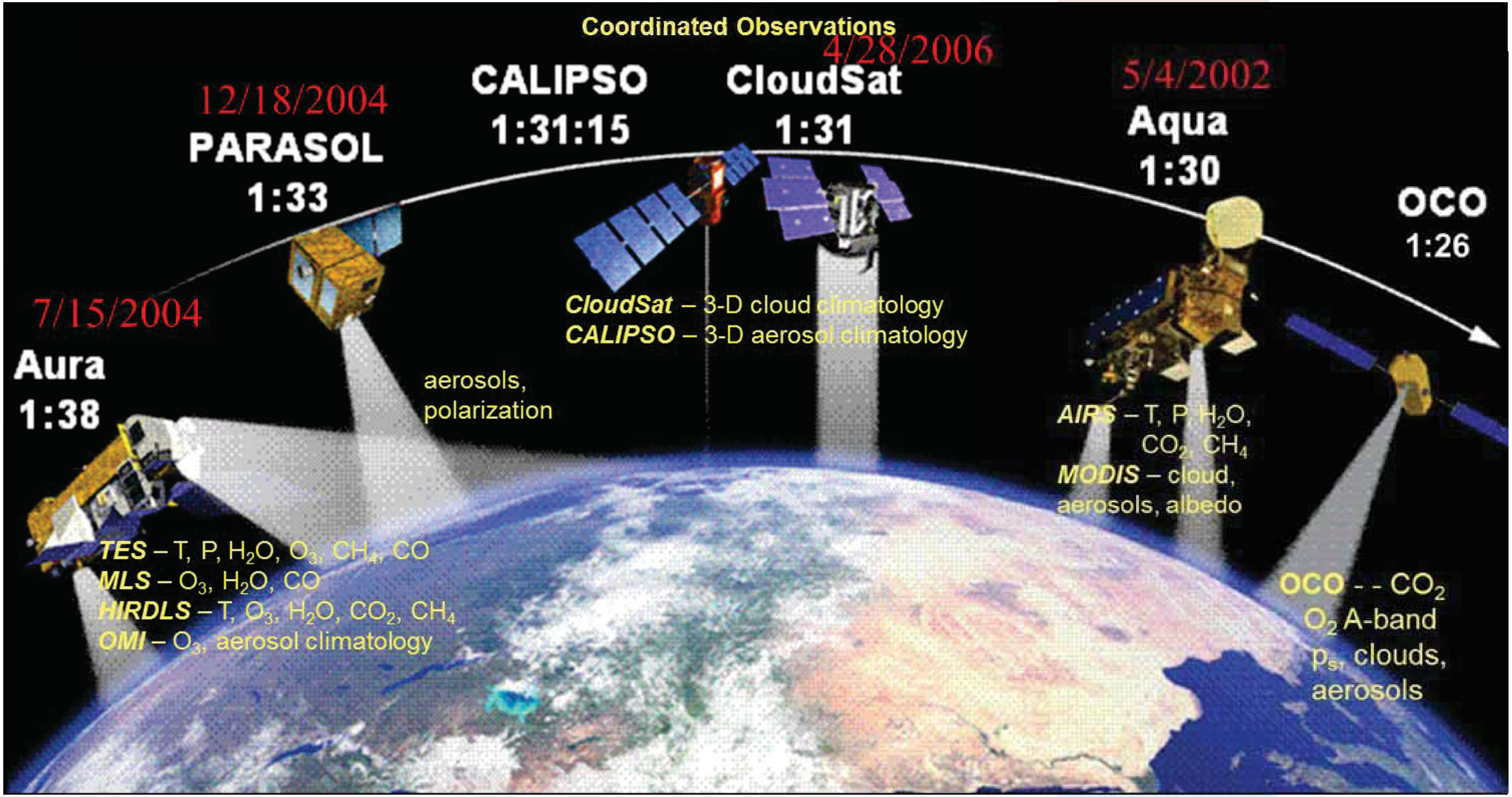
http://earthquake.usgs.gov/earthquakes/dyfi/



Where Might Climate Science Better Use eScience?



Better Handling of Data Streams



LA Smith & N Stern (2011) Uncertainty in science and its role in climate olicy
Phil. Trans. R. Soc. A (2011), 369, 1-24. **An**

An Oxford Bus Stop, Summer 2010:

How did we get to zipcode PDFs from here?

(It would be interesting to trace how the idea that climate models could provided quantitative insight came about.)

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)

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

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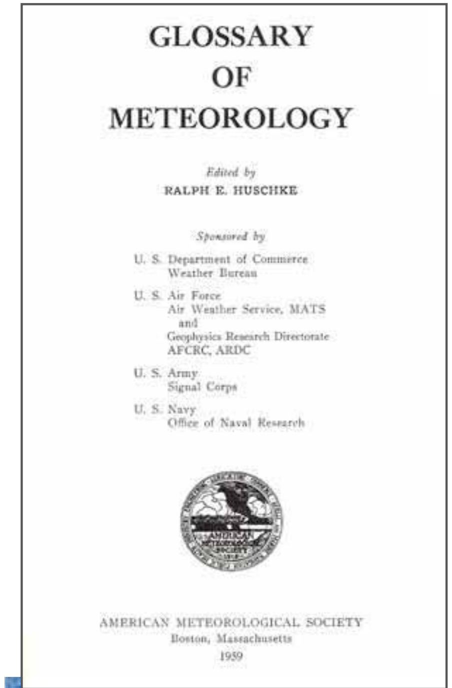
Why do these words get lost in the graphics?

What is climate?

Climate is what you expect,   Weather is what you get.

Robert Heinlein (1973)

The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. The atmospheric component of the climate system most obviously characterises climate; climate is often defined as 'average weather'. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (the classical period is 30 years).

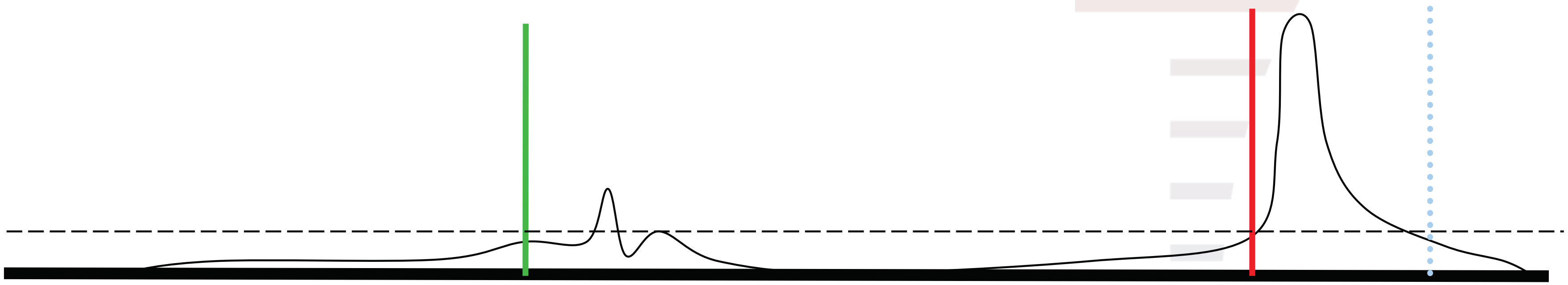


climate—"The synthesis of the weather" (C. S. Durst); the long-term manifestations of **weather,** however they may be expressed. More rigorously, the climate of a specified area is represented by the statistical collective of its weather conditions during a specified interval of time (usually several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

Climate is a distribution of multivariate time series!
(It's not just a number or two)
And for policy and (most) decision support:
"All Climate is Local"

The Advantage of being Local

While there is a common desire for non-locality, I know of no examples where a nonlocal score can be expected to have any advantages in probability forecasting.



“Should” this probability forecast score more highly for the red verification than the green (because there is more probability mass “near” the red verification)?

Is this not merely a case of trying to evaluate a single probability forecast in isolation?

Is there an example where this can happen repeatedly, which is not a case where smoothing the forecast pdf and using a local score would be advantageous?

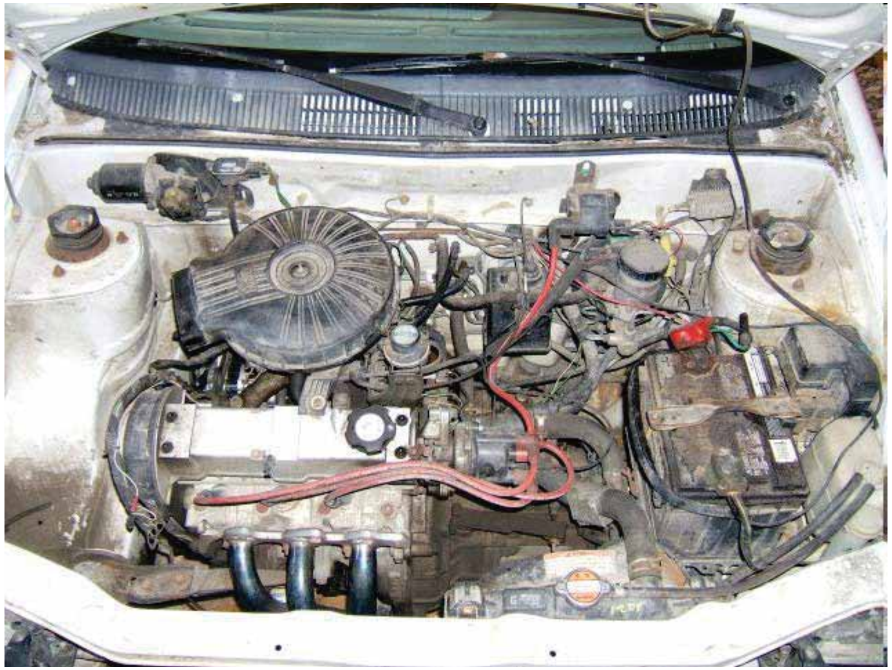
Parameter Estimation via Probability Forecasts

Consider parameter estimation in the case of the logistic map $F(x) = a\,x\,(1-x)$

We can evaluate the skill of our entire ensemble prediction system as a whole by examining the skill of out forecast as a function of a.

Unless the prediction system is perfect, this need not return the true value of a.

If the model is structurally in error, there is no True value of a.



Where should decision makers draw the line?

Climate models are based on well-established physical principles and have been demonstrated to reproduce observed features of recent climate (see Chapters 8 and 9) and past climate changes (see Chapter 6). There is considerable confidence that Atmosphere-Ocean General Circulation Models (AOGCMs) provide credible quantitative estimates of future climate change, particularly at continental and larger scales. Confidence in these estimates is higher for some climate variables (e.g., temperature) than for others (e.g., precipitation). This summary highlights areas of progress since the TAR:

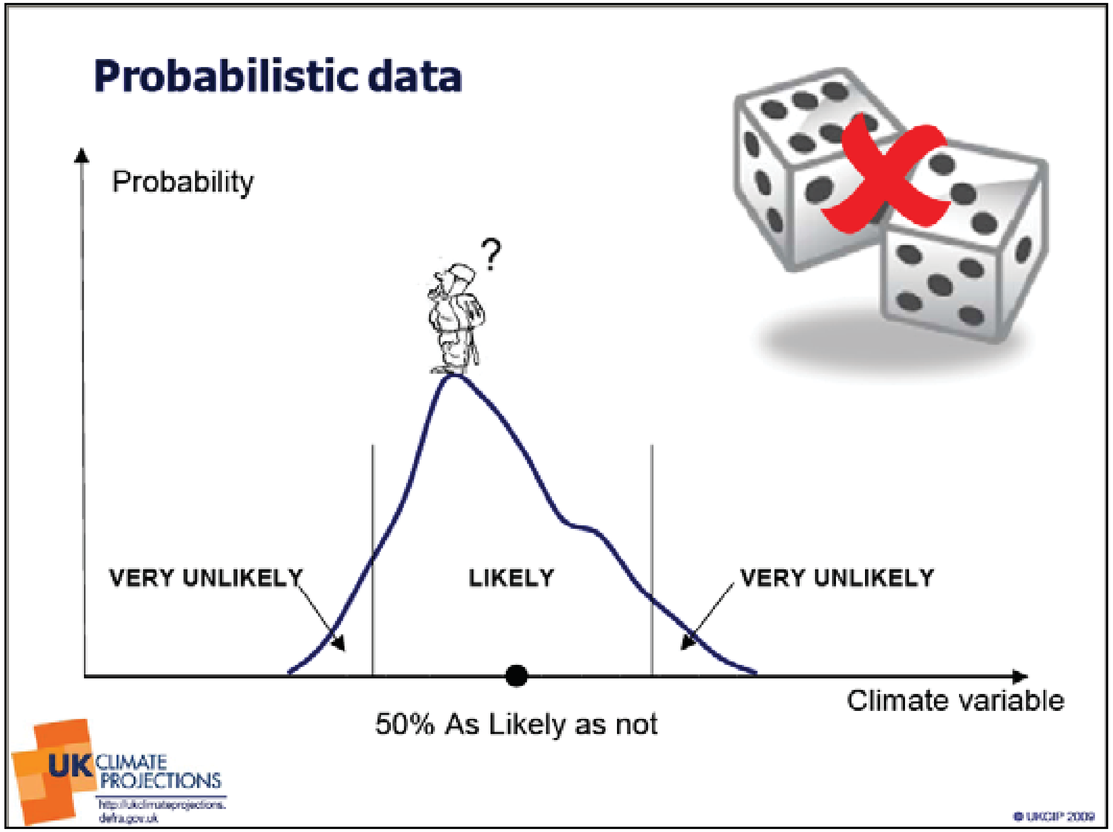
Page 591

A report of Working Group I of the Intergovernmental Panel on Climate Change

Clear, plain spoken discussion of what today's models cannot capture quantitatively would be of great value.

So what about UKCP probabilities?

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



The probability of the real world falling above the 90% line of the UKCP PDF can be much **much** greater than 10%.

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,

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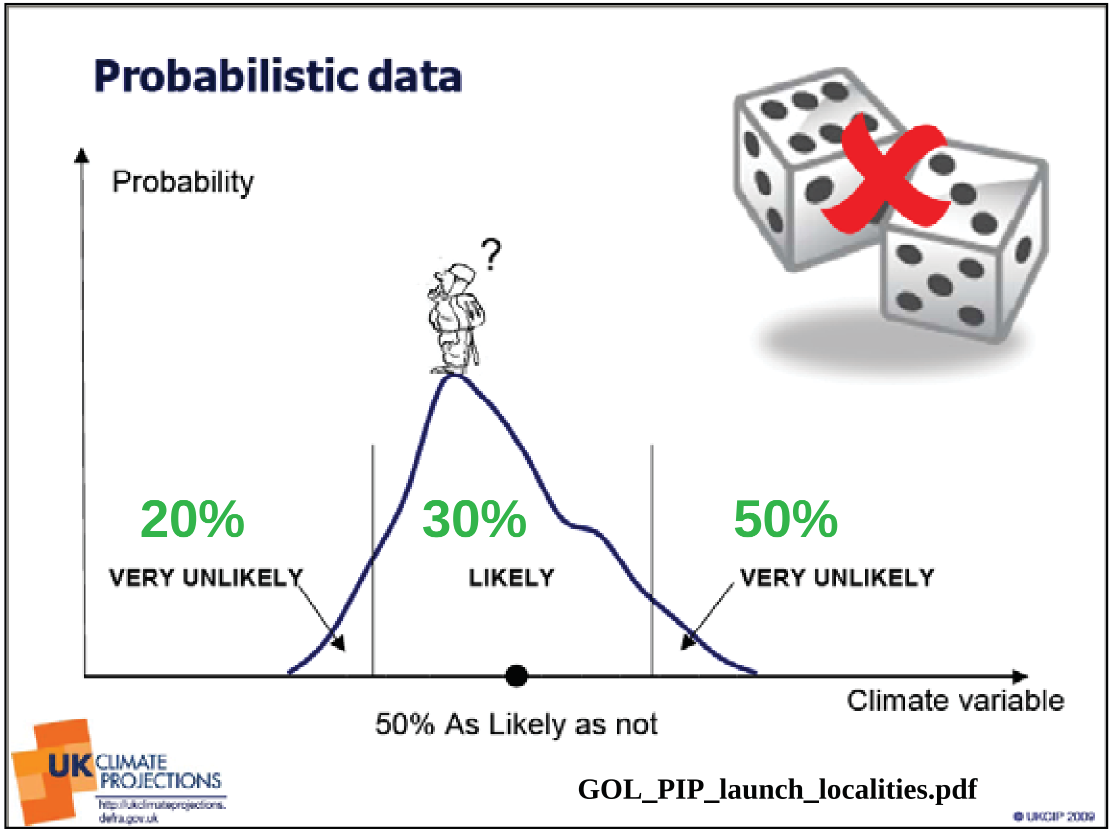

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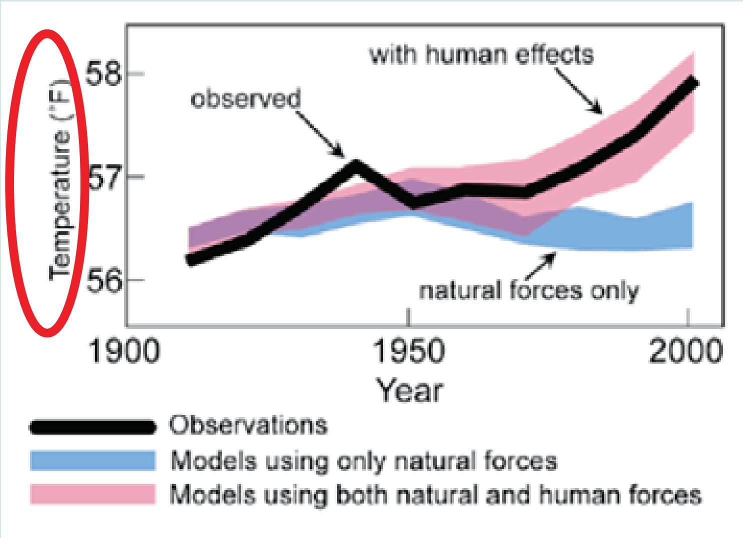
United States Global Change Research Program

Separating Human and Natural Influences on Climate



As the blue band indicates, without human influences, global average temperature would actually have cooled slightly over recent decades. With human influences, it has risen strongly (black line), consistent with expectations from climate models (pink band).

http://www.globalchange.gov/images/cir/pdf/20page-highlights-brochure.pdf

ipcc INTERGOVERNMENTAL PANEL ON climate change WMO UNEP

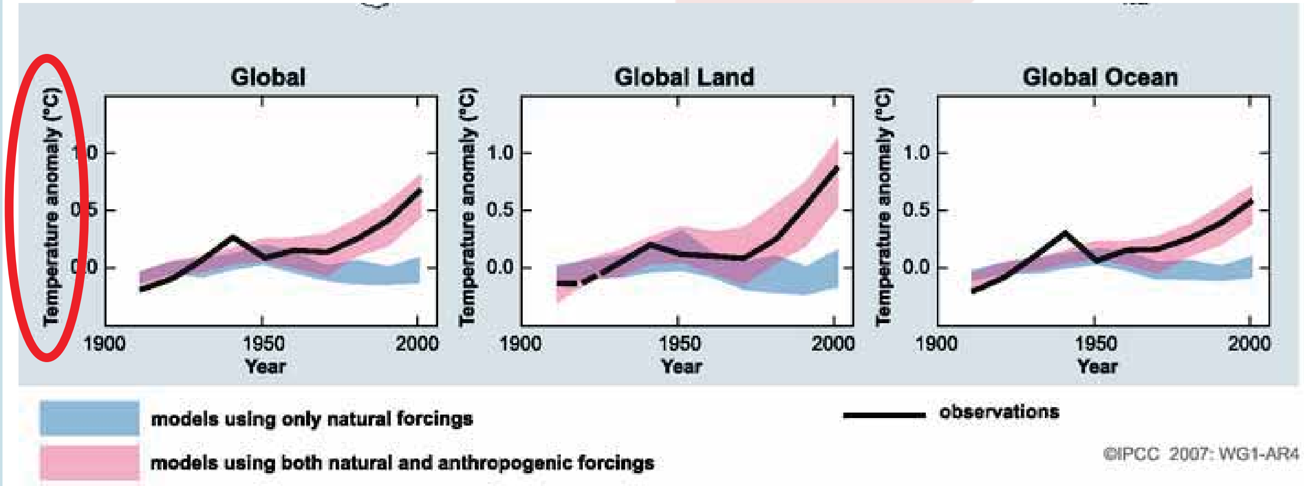
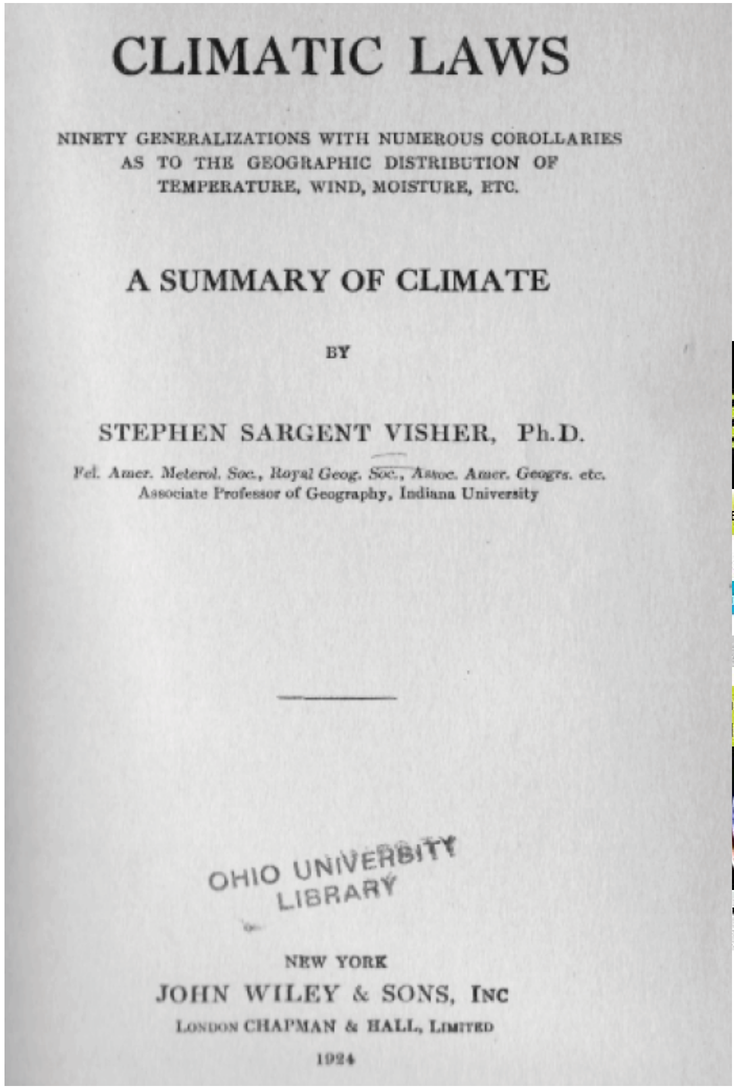


Figure SPM.4. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {FAQ 9.2 Figure 1}

http://www.ipcc.ch/publications_and_data/ar4/wg1/en/figure-spm-4.html

Statistical post-processing: These are anomalies, not temperatures. Parameterization of cloud formation is a bit of a distraction when we are missing two kilometre tall walls of rock…

Does a big model add?



CLIMATIC LAWS

NINETY GENERALIZATIONS WITH NUMEROUS COROLLARIES AS TO THE GEOGRAPHIC DISTRIBUTION OF TEMPERATURE, WIND, MOISTURE, ETC.

A SUMMARY OF CLIMATE

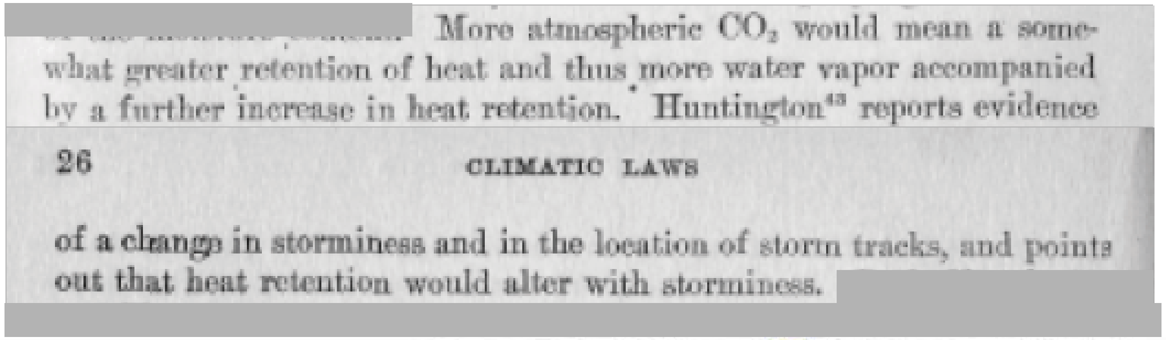
BY

STEPHEN SARGENT VISHER, Ph.D.

Fel. Amer. Meterol. Soc., Royal Geog. Soc., Assoc. Amer. Geogrs. etc.
Associate Professor of Geography, Indiana University

NEW YORK
JOHN WILEY & SONS, INC
LONDON CHAPMAN & HALL, LIMITED
1924

1924



More atmospheric CO_2 would mean a somewhat greater retention of heat and thus more water vapor accompanied by a further increase in heat retention. Huntington[43] reports evidence

26 CLIMATIC LAWS

of a change in storminess and in the location of storm tracks, and points out that heat retention would alter with storminess.

?Confidence?

?Insight?

?Numbers?

http://www.metoffice.gov.uk/climatechange/guide/what/

Probability and Weather-like Simulations

Here we usually have a “unconditioned distribution” called “climatology”

$$P_{clim}(x|\ archive)$$

It is “unconditioned” inasmuch as it does not take into account our knowledge of the current state of the system.

In addition we have a number of model simulations that are conditioned on current observations, s, and of course on the model used.

$$P_i(x|\ s,\ M_i)$$

the subscript i denotes the model used

Given that we know the model is inadequate, this notation is already odd…

But in the weather case, we use the forecast-verification archive to determine when the model has less skill than climatology, and thereby cope with model inadequacy.

Probability in Climate-like Simulations

Here the problem is one of extrapolation, we have no relevant forecast-verification archive and we do not know the climatology (that being our aim!)

Arguably, the best we can hope for is agreement between our models (in distribution) which suggests the details do not (better: did not) matter.

LA Smith, (2002) What might we learn from climate forecasts? *Proc. National Acad. Sci.* USA 4 (99): 2487

We do not have that sort of agreement today, even for the planet's temperature.

And we have a hodge-podge of various types of "uncertainties" mixed together and shown to policy makers on the same graph:

The Bayesian Way (UKCIP)

UK CLIMATE PROJECTIONS

What is UKCP09? UKCP09 Guidance Key findings Published material Customisable output About UKCP09 Downloads Need help? search this site...

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.

http://royalsociety.org/page.asp?tip=1&id=6232

Misleading argument 5: 'Global warming computer models which predict the future climate are unreliable'

CLIMATE CHANGE
controversies
a simple guide

Computer models which predict the future climate are unreliable and based on a series of assumptions

What does the science say?

Modern climate models have become increasingly accurate in reproducing how the real climate 'works'. They are based on our understanding of basic scientific principles, observations of the climate and our understanding of how it functions.

By creating computer simulations of how different components of the climate system - clouds, the Sun, oceans, the living world, pollutants in the atmosphere and so on - behave and interact, scientists have been able to reproduce the overall course of the climate in the last century. Using this understanding of the climate system, scientists are then able to project what is likely to happen in the future, based on various assumptions about human activities.

It is important to note that computer models cannot exactly predict the future, since there are so many unknowns concerning what might happen. Scientists model a range of future possible climates using different scenarios of what the world will 'look like'. Each scenario makes different assumptions about important factors such as how the world's population may increase, what policies might be introduced to deal with climate change and how much carbon dioxide and other greenhouse gases humans will pump into the atmosphere. The resulting projection of the future climate for each scenario, gives various possibilities for the temperature but within a defined range.

While climate models are now able to reproduce past and present changes in the global climate rather well, they are not, as yet, sufficiently well-developed to project accurately all the detail of the impacts we might see at regional or local levels. They do, however, give us a reliable guide to the direction of future climate change. The reliability also continues to be improved through the use of new techniques and technologies.

The Bayesian Way

Bayesian probability calculus

[edit]

Main article: Bayes' Theorem

Given some data and some hypothesis, the posterior probability that the hypothesis is true is proportional to the product of the likelihood multiplied by the prior probability. For simplicity, the "prior probability" is often abbreviated as the "*prior*" and the "posterior probability" as the "posterior". The likelihood brings in the effect of the data, while the prior specifies the belief in the hypothesis before the data was observed.

More formally, Bayesian inference uses Bayes' formula for conditional probability:

$$P(H|D) = \frac{P(D|H)\ P(H)}{P(D)}$$

where

- H is a hypothesis, and D is the data.
- $P(H)$ is the *prior probability* of H: the probability that H is correct before the data D was seen.
- $P(D \mid H)$ is the conditional probability of seeing the data D given that the hypothesis H is true. $P(D \mid H)$ is called the *likelihood*.
- $P(D)$ is the marginal probability of D.
- $P(H \mid D)$ is the *posterior probability*: the probability that the hypothesis is true, given the data and the previous state of belief about the hypothesis.

$P(D)$ is the prior probability of witnessing the data D under all possible hypotheses. Given any exhaustive set of mutually exclusive hypotheses H_i, we have:

$$P(D) = \sum_i P(D, H_i) = \sum_i P(D|H_i)P(H_i).$$

We can consider i here to index alternative worlds, of which there is exactly one which we inhabit, and H_i is the hypothesis that we are in the world i. $P(D,H_i)$ is then the probability that we are in the world i and witness the data. Since the set of alternative worlds was assumed to be mutually exclusive and exhaustive, the above formula is a case of the law of total probablility.

$P(D)$ is the normalizing constant, which in many cases need not be evaluated. As a result, Bayes' formula is often simplified to:

$$P(H|D) \propto P(D|H)\ P(H)$$

where $\propto$ denotes proportionality.