

Forecasting for climate policy: CO₂, global temperatures, and alarms

J. Scott Armstrong

The Wharton School, U. of Pennsylvania, USA
armstrong@wharton.upenn.edu

Kesten C. Green

Business and Economic Forecasting, Monash University, Australia.
kesten@me.com

Andreas Graefe

Karlsruhe Institute of Technology, Germany
graefe@kit.edu

Willie Soon

Harvard-Smithsonian Center for Astrophysics, USA
wsoon@cfa.harvard.edu

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“We must . . . stop tolerating the rejection and distortion of science.”

Al Gore, *The Assault on Reason*, 2007

What information would change your opinion that we face “dangerous manmade global warming”?

How many skeptical scientists would there need to be to persuade you that “the science” is *not* settled; that there is no “scientific consensus”?

10 scientists? 100? 1,000? 10,000?

How long would a flat or cooling trend in temperatures need to be to persuade you that the globe is not warming dangerously?

1 year? 2? 5? 10? 20? 100?

Your beliefs about recent history

Extent of warming in past decade?

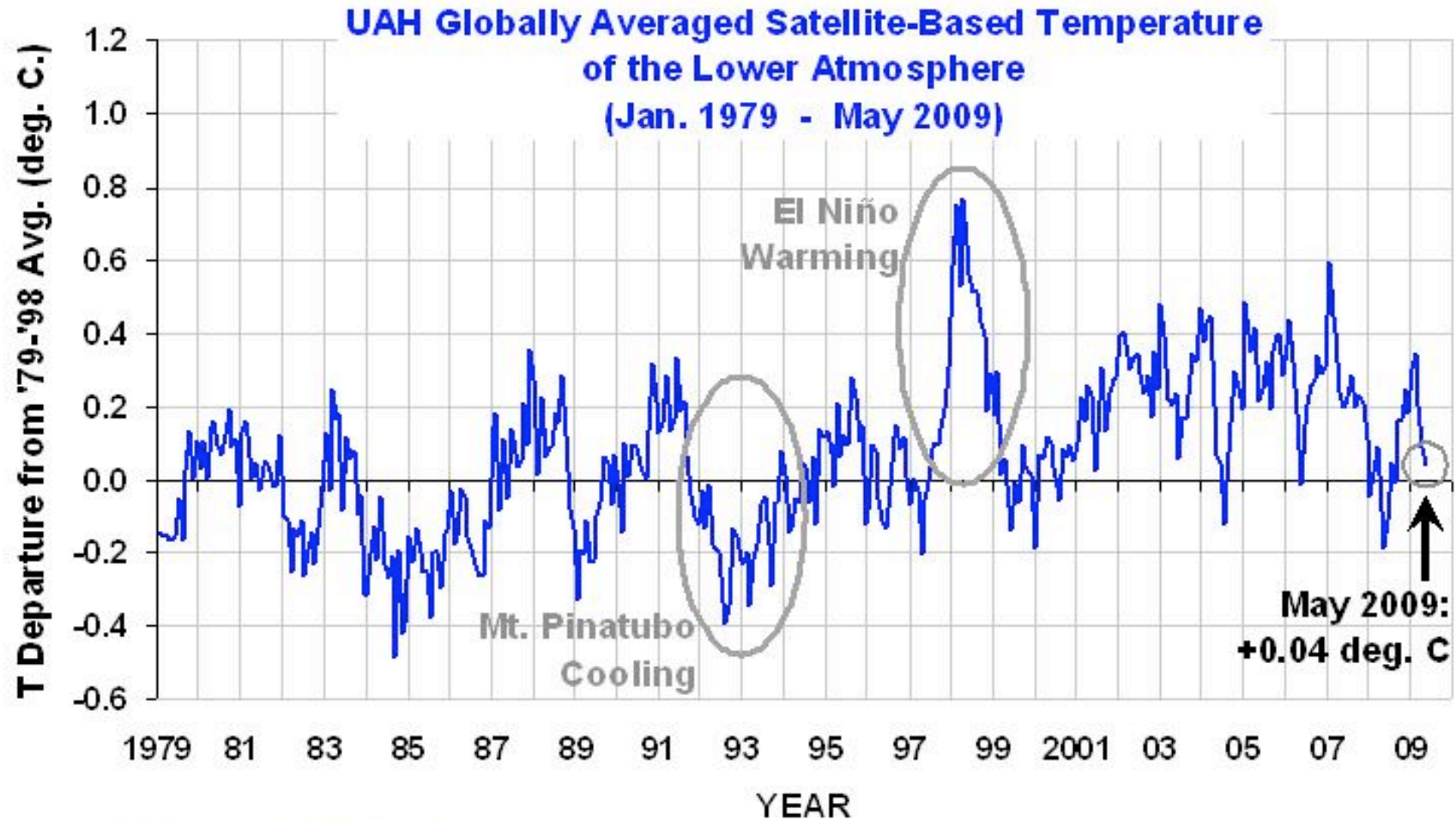
[___] +2 Up substantially

[___] +1 Up slightly

[___] 0 Negligible change

[___] -1 Down slightly

[___] -2 Down substantially



www.drroyspencer.com

Change (per month) over:	All satellite history	0.001
	Last 10 years	0.001
	Last 5 years	-0.002

Armstrong, Green Graefe, & Soon 2009:
Forecasting for climate policy

Do almost all scientists believe that manmade global warming poses a threat?

Climate scientists from a 27 country survey were not confident that scientists can make reasonable predictions of climate for 10 years (68%) or 100 years (73%)

(Bray & von Storch 2007)

U.S. Senator Inhofe's 700+ list of dissenters

Manhattan Declaration: 1,000+ scientists skeptical

Robinson Petition: 31,000+ scientists dispute dangerous AGW

Are scientists' opinions based on studies?

- *The Claim*: Published journal articles on climate show that almost all climate scientists believe in dangerous manmade global warming (Oreskes 2004 claimed none of 928 “global climate change” abstracts rejected AGW).
- Oreskes survey was found wanting by Peiser (2005), and
- Schulte (2008) found 6% of 539 papers rejected AGW while 7% explicitly endorsed AGW.

Does it matter what scientists believe?

Research over nearly 80 years has shown that scientists' *opinions* are irrelevant for forecasting in situations such as this... high uncertainty, complex situation, poor feedback

Can experts make useful climate forecasts?

Armstrong (1978) summarized studies: people with much expertise are no better at forecasting than those with little expertise.

Tetlock (2005): evaluated

- 82,361 forecasts
- made over 20 years
- by 284 professional commentators and advisors on politics and economics

and found that expertise did not lead to better forecasts.

Yet, global warming *is* a forecasting problem

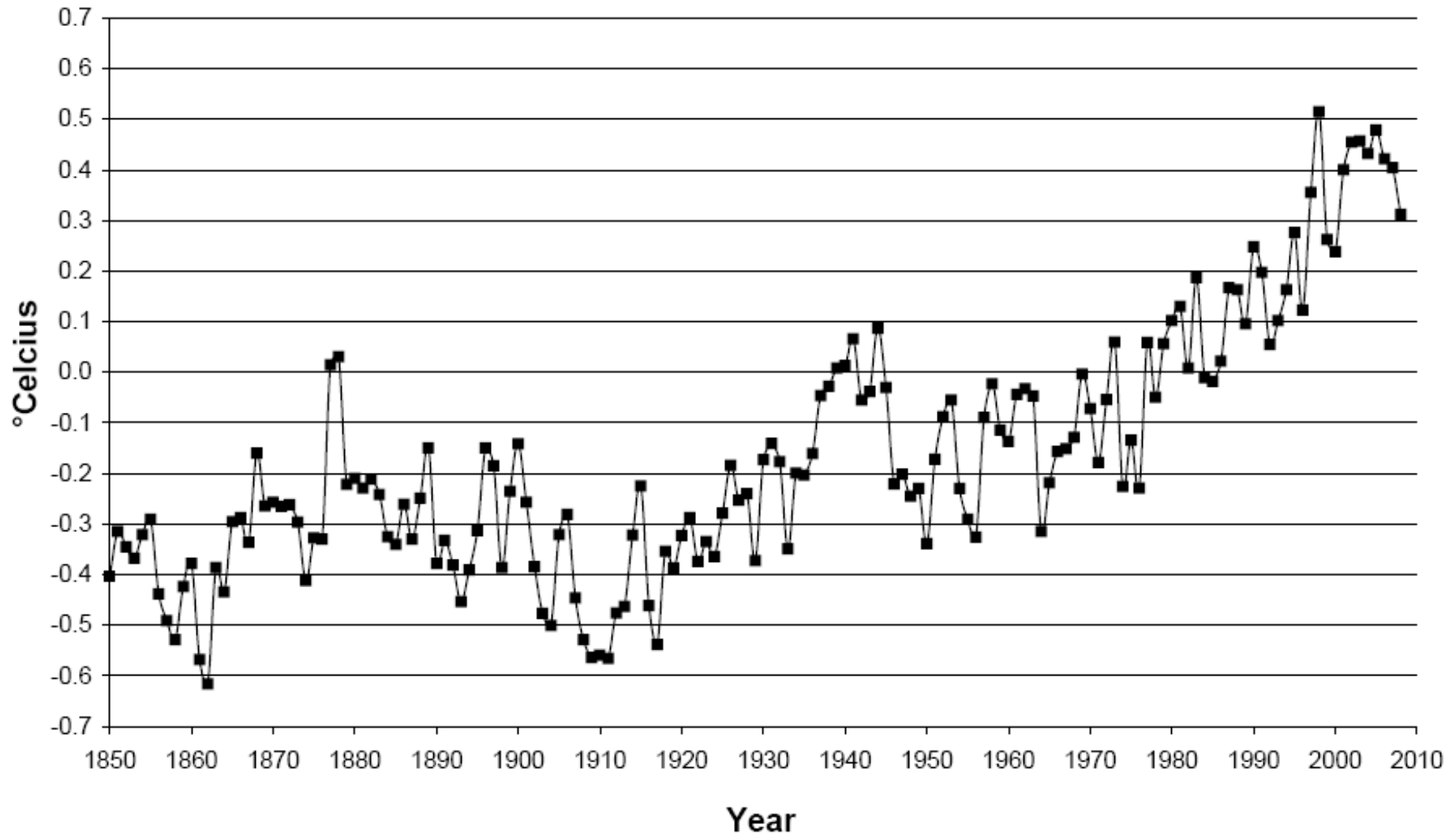
The climate has changed and will continue to change.

The 20th Century went through two “ice-age” scares and two “warming” scares.

Overall, some gradual warming over past 160 years.

Hadley annual temperature 1850-2008

Global surface temperature deviation from 1961-1990 average



The question is, can we forecast what will happen over the 21st Century?

“A trend is a trend is a trend
But the question is, will it bend?
Will it alter its course
Through some unforeseen force
And come to a premature end?”

Cairncross (1969)

Audit of IPCC forecasts

IPCC “projections” of global temperature change used improper procedures.

Green & Armstrong (2007) audit showed:

1. IPCC authors violated 72 forecasting principles.
2. Forecasts by scientists, not scientific forecasts.
3. No proper evidence on predictive validity

No scientific forecasts to date

Climate is complex.

Much uncertainty:

- causes of changes are disputed,
- causal factors are difficult to forecast,
- data are subject to error.

In such conditions, climate models, *even if properly developed as forecasting models*, are likely to be inferior to the simple naïve models, which assumes complete ignorance about climate.

Conditions favor conservatism

Many opinions by experts, but no *evidence* that the climate is different now.

Thus, the naïve method would be the preferred method based on the conditions. We suggest this as the benchmark model.

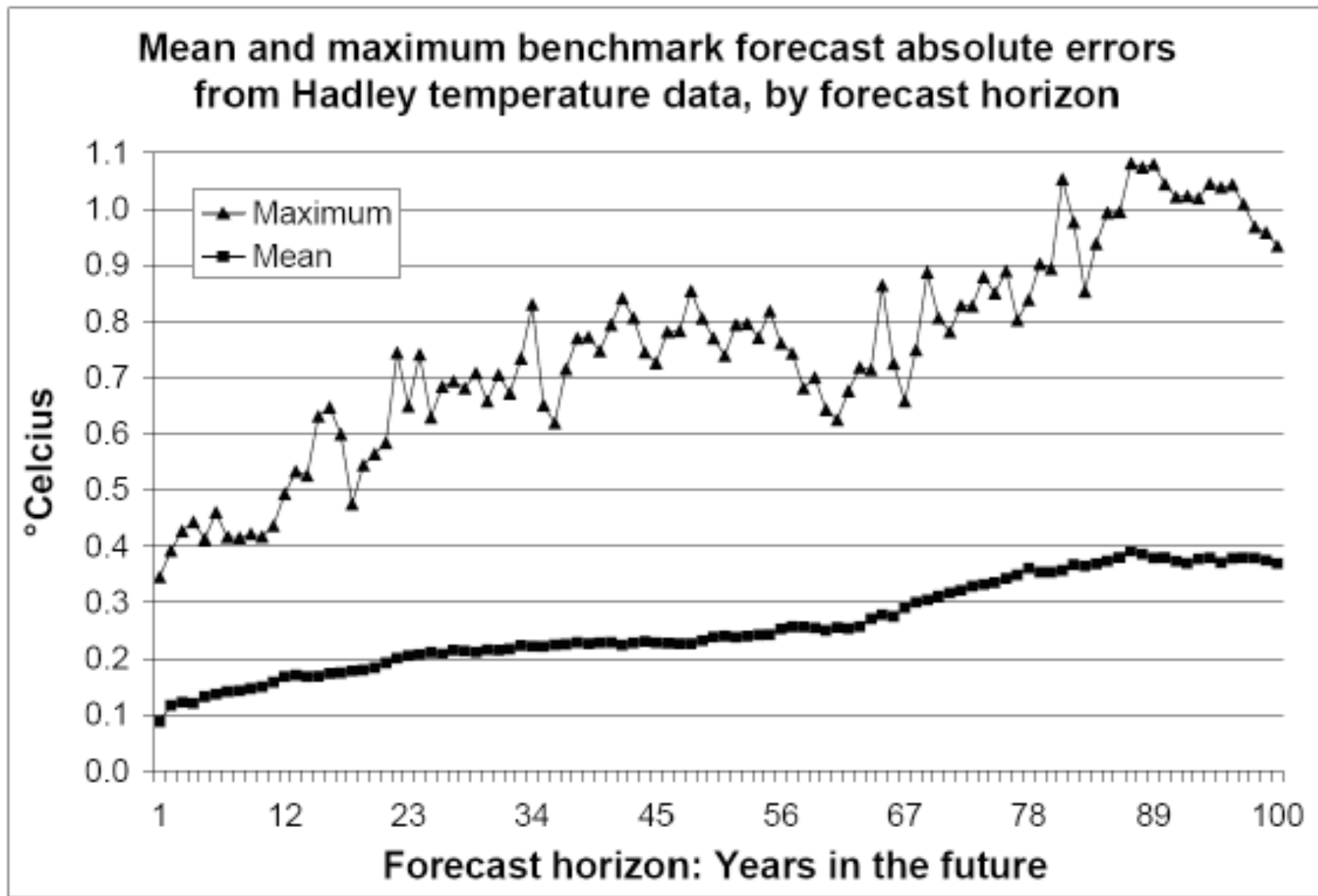
Test of the benchmark

- Used UK Hadley Centre's "best estimate" of global mean temperatures from 1850 to 2007 (HadCRUt3)
- Forecast for up to 100 subsequent years on rolling horizon
 - 157 one-year-ahead forecasts...
 - 58 hundred-year-ahead forecasts
 - 10,750 forecasts across all horizons
- Absolute errors calculated vs actual (HadCRUt3)

Expectations about the benchmark model

Assume that it is 1850 and you make a forecast that global temperature will be the same 50 years later (i.e., 1900). In 1851 you make another such forecast for the year 1801 . . . And so on up to 1958 when you forecast to 2008. You then compare the forecasts against HadCRUT3 and calculate the errors (ignore the signs). What would be the average error for the 108 50-year-forecasts in degrees centigrade? _____

Naïve (no-change) benchmark model forecast errors



Validity of IPCC projection

1992 IPCC report's 0.03°C/year linear projection

- Test vs benchmark for
 - 1992 to 2008 pure *ex ante*
 - 1851 to 1975 simulated *ex ante**

** advantage to IPCC vs benchmark model*

Mean errors 1992-2008

- Using UAH satellite data and rolling forecasts,
- Averaging the mean absolute errors for all 17 horizons...

Benchmark	0.215 °C
<u>IPCC projection</u>	<u>0.203 °C</u>
Difference	0.012 °C

IPCC performance 1851-1975 (long range; *ex post* warming trend)

CumRAE* of IPCC/Benchmark Ratio

	<u>Ratio</u>	<u>n</u>
From 1850 only	10.1	125
Rolling (1-100 years)	7.7	7,550
1-10 years	1.5	1,205
41-50 years	6.8	805
91-100 years	12.6	305

* CumRAE < 1 means forecast errors smaller than benchmark errors

The Global Warming Challenge

"The Climate Bet"

Predict global mean temp over 10 years.

- Al Gore ("An Inconvenient Truth") to select any current climate model
- Scott Armstrong will forecast *no change*

Each deposits \$10,000 in a trust fund in Dec. 2007. Value to winner's charity in 2018.

1. Proposed June 19, 2007 with Dec. 1, 2007 deadline
2. Mr. Gore replied -- too busy.
3. Armstrong simplified – check one box & sign name -- & extended deadline to March 26, 2008.
4. Mr. Gore replied – he does not make financial bets.
5. Armstrong dropped the financial part and suggested that the challenge be done simply in the interests of science.

Details at theclimatebet.com

Armstrong-Gore bet expectations

Based on the Hadley data for 1850 through 2008...*

Assuming Gore followed IPCC forecast of 3⁰C per century, Armstrong has a probability of winning bets against the 0.03⁰C/year trend of

0.54 for one-year-ahead forecasts; n=158

0.57 for three-year-ahead forecasts; n=156

0.68 for ten-year-ahead forecasts; n=149

** which, as we know, was a warming period*

Armstrong leads on *monthly* results

Armstrong more accurate than “Gore/IPCC” for
16 out of 17 months so far.

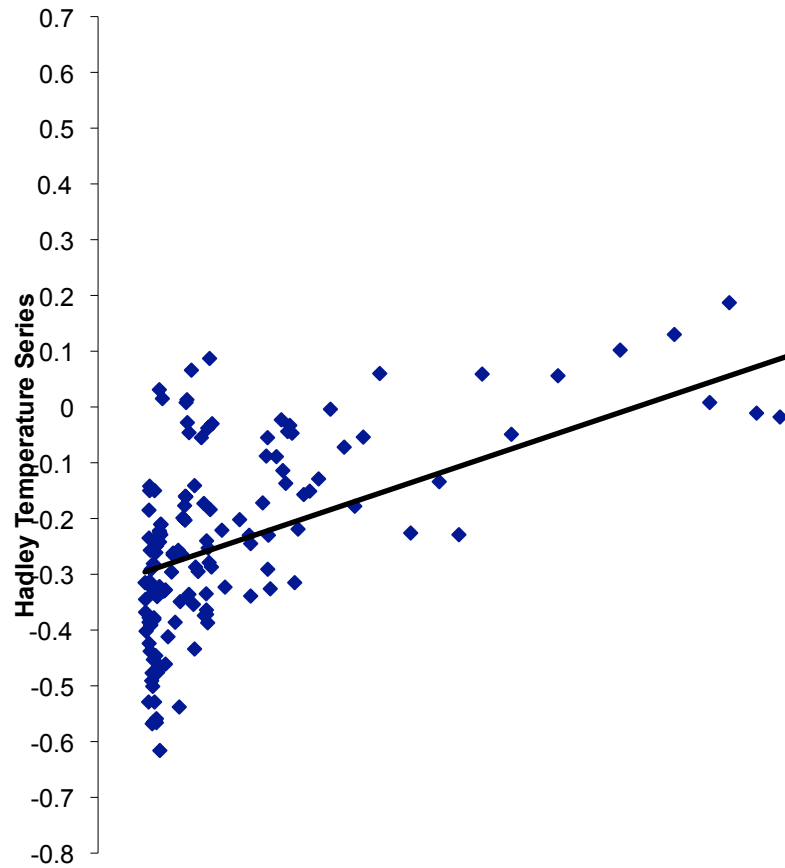
Will post month-by-month results on
theclimatebet.com

Alternatives to the benchmark

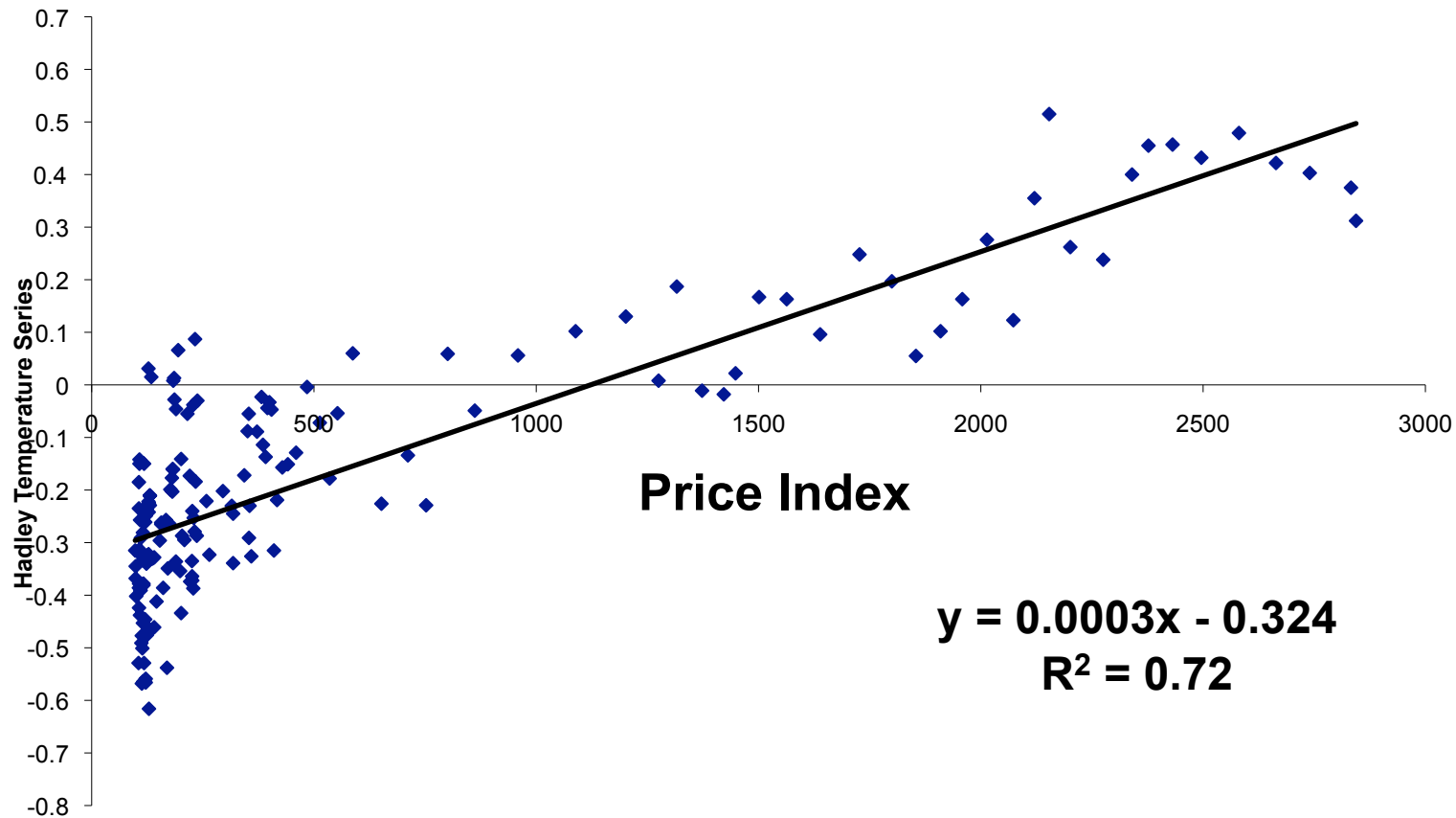
1. Causal model with atmospheric CO₂*;
alternative variables?
2. Prediction markets
3. Predictions about global warming alarm
from outcomes of analogies

*CO₂: concentration of carbon dioxide in the atmosphere in parts per million (ppm); also referred to as the CO₂ mixing ratio.

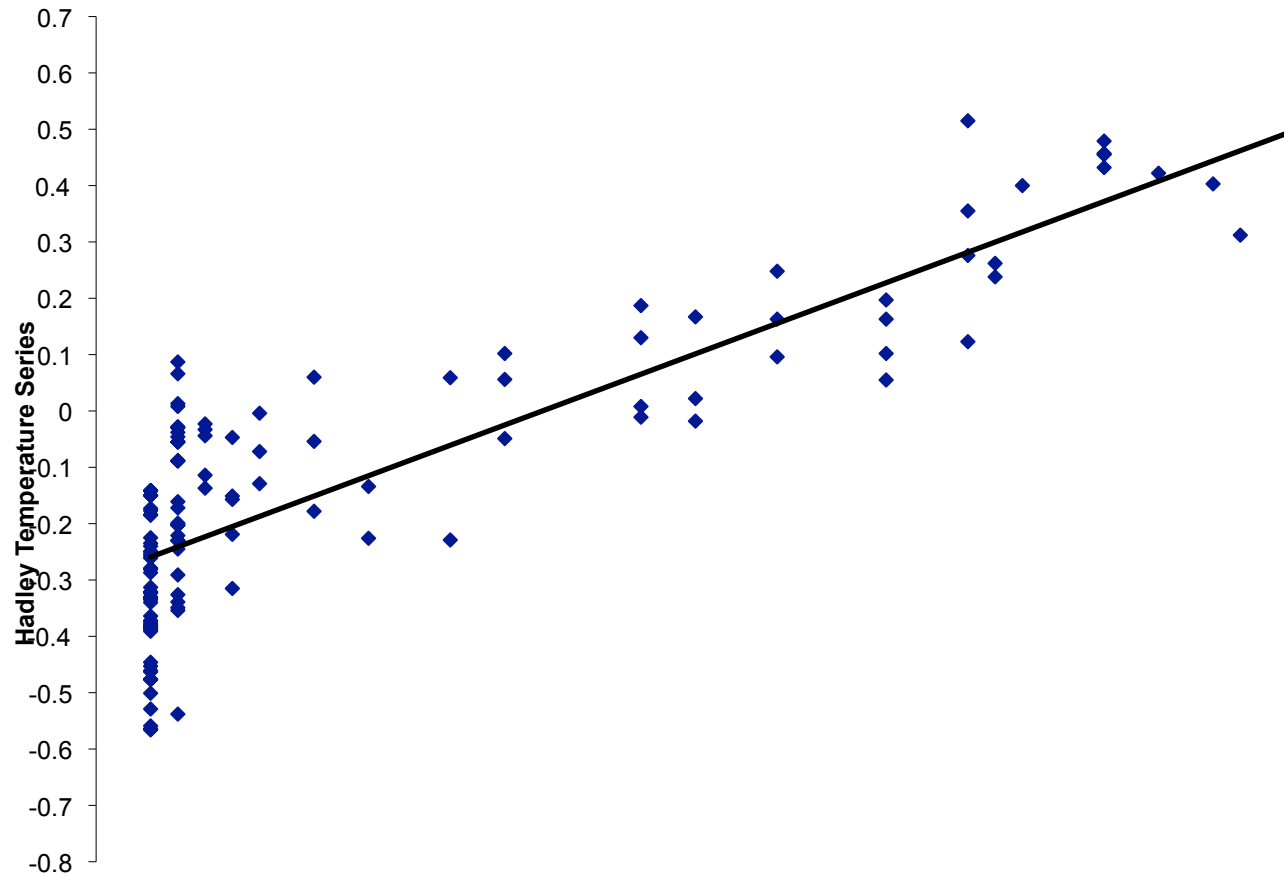
What causes temperature change?



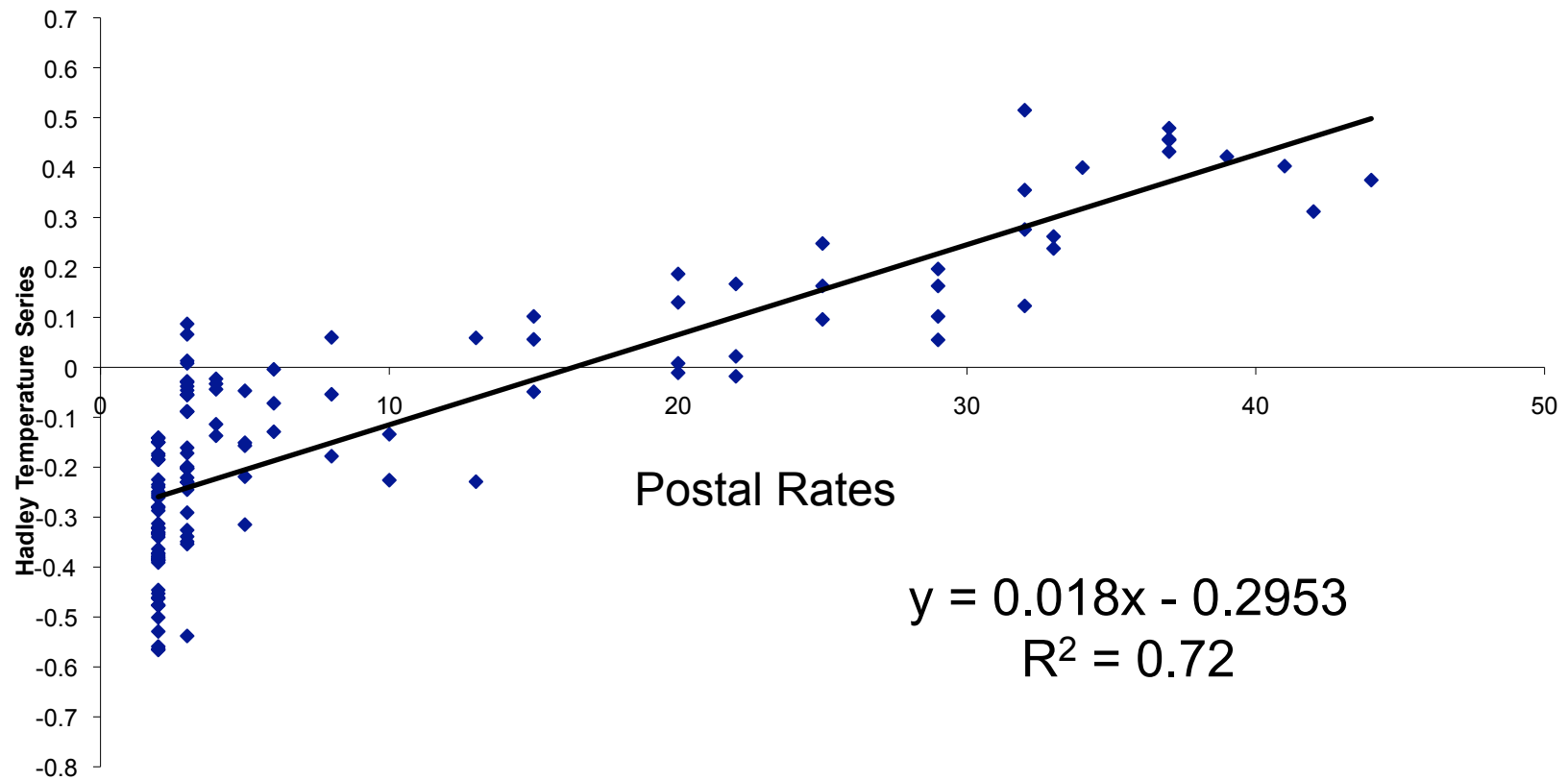
Does the increase in consumer price index causes global temperatures to rise?



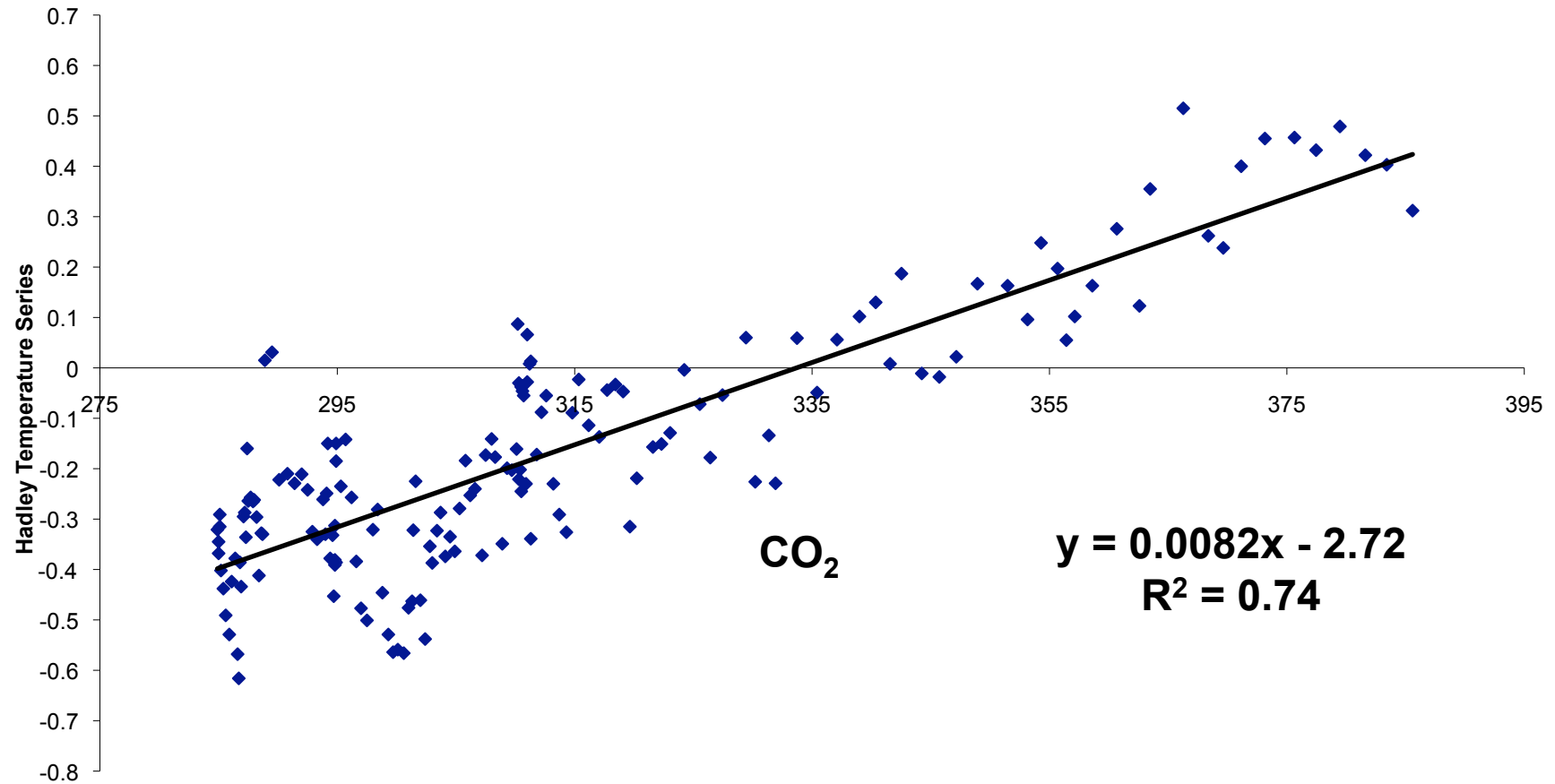
What causes temperature change? II



Do U.S. Postal Rates cause global temperatures to rise?



Does CO₂ cause global temperatures to rise?



Correlations between global temperatures and upwardly mobile time series

Series	Correlation
Atmospheric CO ₂ 1850-2008	0.86
U.S. Postal rates 1885-2009	0.85
U.S. Price Index 1850-2009	0.85
NOAA* expenditure 1970-2006	0.82
Books published in U.S. 1881-2008	0.73
[No change (naïve model)]	0.00]

*National Oceanic and Atmospheric Administration

Causal model out-of-sample* forecasting performance

<u>“Causal” variable</u>	<u>WtdCumRAE**</u>
U.S. Price Index 1850-2009	0.6
Naïve Model	1.0
NOAA expenditure 1970-2006	1.1
Atmospheric CO₂ 1850-2008	1.9
Books published in U.S. 1881-2008	2.1
U.S. Postal rates 1885-2009	14.0

*Models estimated using 1st half of data series (e.g. 1850-1929 for the U.S. Price Index series), then models used to forecast the 2nd half temperatures (e.g. 1930-2009 for the U.S. Price Index series) using actual values of the “causal” variable.

**Weighted Cumulative Relative Absolute Error; relative to no-change benchmark, weighted so that errors for each forecasting horizon are counted equally. (Note: WtdCumRAE < 1 means more accurate than benchmark.)

Fit not related to forecast accuracy

Results from this validation study consistent with research on time-series forecasting.

Causal model testing procedures

Data: Global mean temperature: HadCRUt3 1850- 2008
CO₂: Total global atmospheric concentration, NASA

Models: **First differences***; **levels****
Estimated initially using 1850-1899 data

Forecasts: **Annual**
Rolling forecasts for up to 100 years
Updated estimate of relationship each roll
Conditional on knowing CO₂

$$*\text{Temp}_t - \text{Temp}_{t-1} \sim \text{CO}_{2\ t-1} - \text{CO}_{2\ t-2}$$

$$**\text{Temp}_t \sim \text{CO}_{2\ t}$$

CO₂ policy implications? Or not?

Our tentative first round results, show little relationship between CO₂ and global mean temperature.

E.g. Forecast of the effect of stopping man-made CO₂ emissions altogether for the next 100 years:

Model	Effect on temp by end of 100 years
1 st differences	<i>increase</i> mean temperature by 0.40°C
Levels	decrease mean temperature by 0.24°C

As noted, these are only a rough first go. Additional studies are warranted, given the uncertainty.

Prediction Markets

Unlike polls, prediction markets do not ask for opinions.

They motivate self-selected, anonymous participants to

- reflect on the problem
- actively search for information

They might be useful for solving complex, controversial problems

Contribution of prediction markets

A way to assess whether there is a consensus about a specific prediction (for what it is worth)

Who are the participants?

No control over who is participating

Decision-makers fear the involvement of non-informed participants

But:

Experts have limited value in forecasting in this situation of high uncertainty and complexity.

Can the markets be manipulated?

Manipulation not successful

historically (Rhode & Strumpf 2004),
in the laboratory (Hanson et al. 2006),
or in the field (Camerer 1998).

Only one study reports successful short-term
manipulation of IEM prices (Hansen et al. 2004)

Can play-money work?

Mixed evidence on the relative accuracy of play-money and real-money (Servan-Schreiber et al. 2004, Rosenbloom & Notz 2006).

Potential problems with real-money:

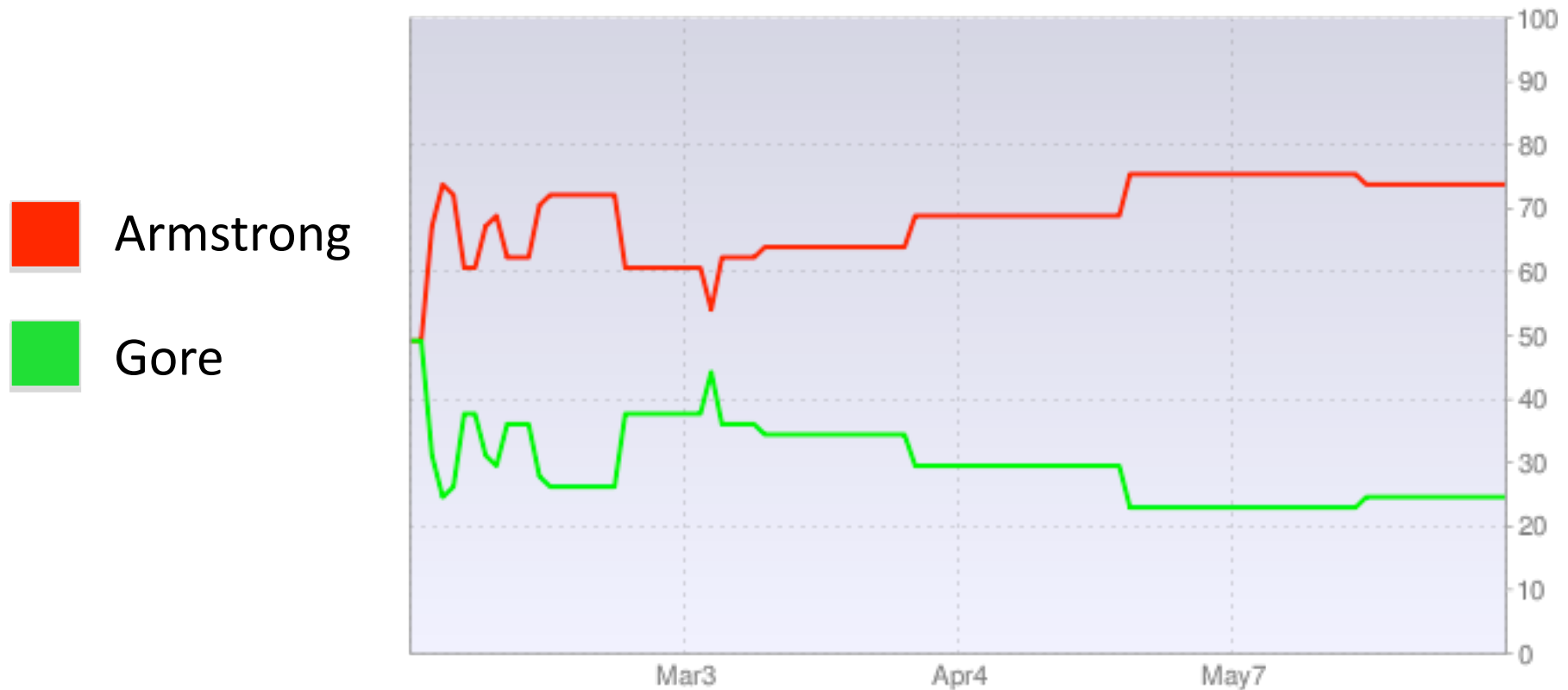
1. Manipulation still worthy of consideration
2. Investors might be reluctant to put money in long-term contracts

Who will win the Climate Bet?

Validation study estimated Armstrong at 68%

Hubdub.com (play-money): Armstrong 75%, Gore 25%

112 predictions since Jan. 29, 2009



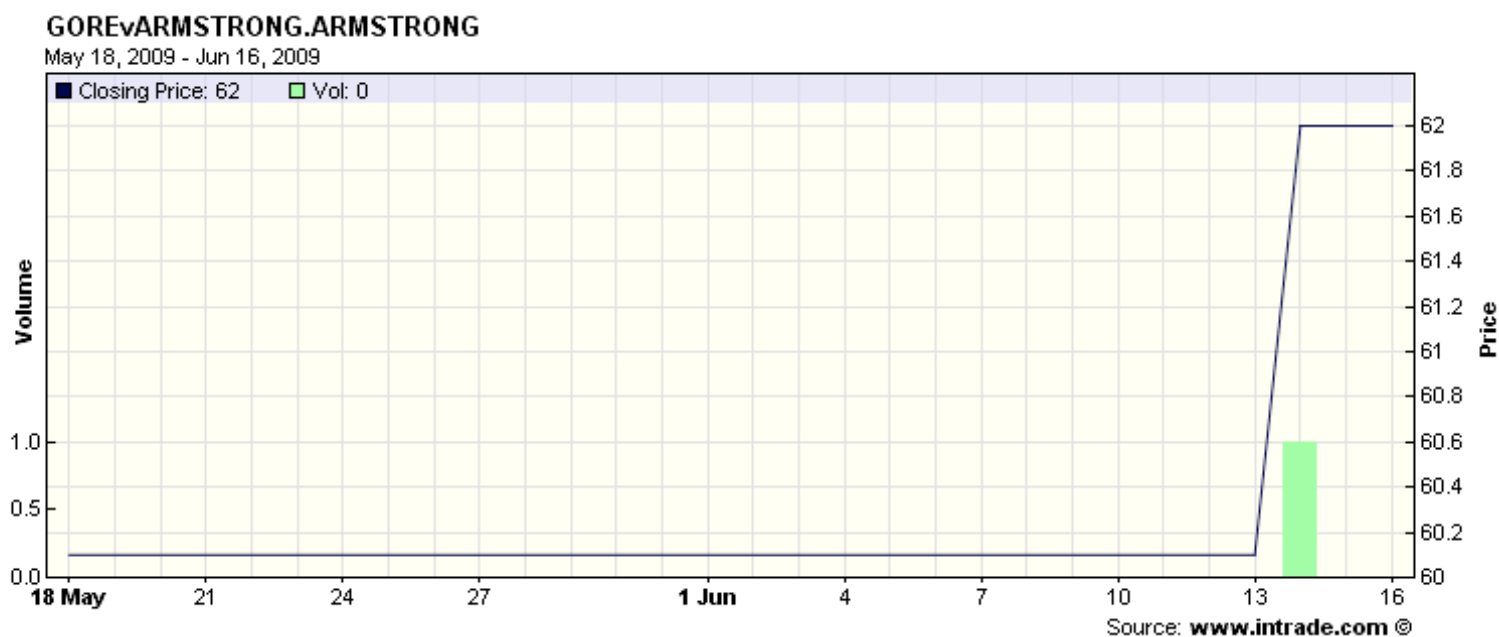
Who will win the Climate Bet? (To three years)

Validation study estimates Armstrong at 57%

Intrade.com (real-money): Armstrong 62%, Gore 38%

Problem: Very little activity (→ high uncertainty?)

If one thinks this prediction is wrong, go there, “fix it”,
and make money



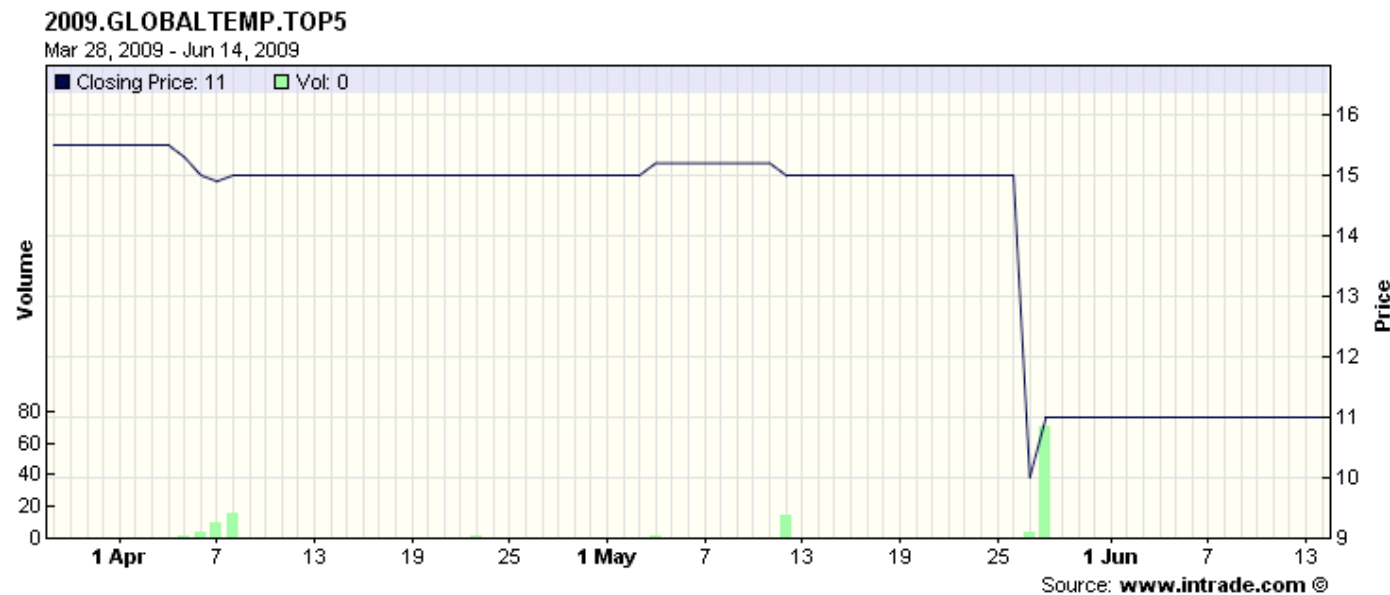
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Related prediction market

“British climate scientists have predicted that 2009 will be one of the top five warmest on record”

(Reuters, December 30, 2008)

Currently, Intrade forecasts a probability of 11% for that event to happen (all-time high was 19%; launched on March 28)



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Forecasting by Structured Analogies

Analogies commonly used to “sell” forecasts. They do not aid accuracy when used in this way.

Structured analogies produce better forecasts by overcoming biases. They help learning from history and thereby improve accuracy.

Armstrong & Green, (2007), "Structured Analogies in Forecasting", *International Journal of Forecasting*, 23 (2007) 365-376.

Structured analogies procedures

1. Ask heterogeneous group* of experts to individually describe as many analogies as they can for the current AGW situation.
2. Experts then rate analogies for similarity to the AGW situation.
3. Mechanical summary based on what happened in the analogous situations: (Forecasts based on the set of “most similar” analogies).

* Recruit warmers, skeptics, and others.

Structured analogies exercise on alarms

Please take the brief description of the 1960s alarm over DDT with you, and answer the questions to compare that alarm with the current alarm over predictions of dangerous manmade global warming.

You can return your completed questionnaire to the conference reception desk.

Rate the alarm analogies in the questionnaire

Please give your ratings on how similar (analogous) the ten alarm situations, listed in the other questionnaire you have been given, are to the current alarm over dangerous manmade global warming...

Structured analogies process

Please describe, below

- a Situations that are analogous to the current alarm over manmade global warming
- b The source of your knowledge about them (e.g. academic research, general knowledge, personal experience...)
- c Similarities and differences between your analogies and the manmade global warming alarm
- d How similar to manmade global warming? (*1 = Slight similarity... 10 = Great similarity*)
- e Was the warning justified? (*0 = No, not at all... 10 = Yes, entirely*)
- f Were recommended actions taken? (*0 = No, not at all... 10 = Yes, entirely*)
- g How did the benefits of the actions that were taken compare with the costs of those actions?

Analogies	d. Rate similarity	e. Warning justified	f. Action taken	g. Net Benefit
a. Description:				
b. Source:				
c. Similarities and differences:				

10 of the 40 analogies suggested to date

1. 1970s cooling and fear of consequences of a new Ice Age
2. Ehrlich's "The Population Bomb" fear of resource shortages
3. Calls to avoid eating fish due to presence of mercury
4. 2nd-hand tobacco smoke and lung-cancer and heart disease
5. Alarm over effects of alcohol and calls for abolition
6. Recreational drug taking concerns and resulting criminalization
7. Cancer from breast implants
8. Fear that "acid rain" would destroy the World's forests
9. Concern about economy and Roosevelt's New Deal response
10. Natural radon in homes and lung cancer

First impression from analogies

- Another story for “*Extraordinary popular delusions and the Madness of Crowds*”?

[Charles MacKay 1841]

A Forecaster's Summary

1. Policy decisions require scientific long-term forecasts of temperature, the impacts of temperature changes, and effects of policies
 - No scientific forecasts exist
2. Climate data and knowledge are uncertain, and climate is complex
 - The situation calls for simple methods and conservative forecasts
3. The no-change benchmark performs well
 - IPCC projection errors are 12 times higher for long-term.
4. Causal policy models with CO₂ have low credibility and poor validation.
5. AGW alarm analogous to many failed predictions.

Forecasters can make contributions

- Forecasting on climate change for public policy decision makers is dominated by people who have no knowledge of how to forecast.
- Nor do they care to learn, as alarm over dangerous manmade global warming is a political movement.
- Need for audits and proper forecasting (e.g., for sea levels.)
- What can you do to contribute?

When beliefs are strong, only *self-*persuasion is possible

Schopenhauer:

There is no opinion, however absurd, which men will not readily embrace as soon as they can be brought to the conviction that it is generally adopted.

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“The Precautionary Principle”

It is a political principle. . . if the government is persuaded that there is a risk with a high possible cost, there is no need for a rational analysis.

Contrary to scientific analyses of costs and benefits.

Brings to mind the slogan on the Ministry of Truth building in George Orwell’s 1984: “Ignorance is Strength.”

Scientific forecasting suggests appropriate policy decision is “don’t just do something, stand there!”

For more see “Evidence-based forecasting for climate change: Uncertainty, the Precautionary Principle, and Climate Change” on theclimatebet.com Sept 1, 2008