Dynamic Logic

A personal perspective

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Stanford University

Slides downloadable from the top of my home page

Many theorems

I promise you many theorems

Many theorems

I promise you many theorems in this conference.

But not in this talk.

Please humour me with just one.

Disclaimer

Theorem IANAL

Disclaimer

Theorem   IANAL (I Am Not A Logician)

Proof   *Education and Career*

1962	Entered University of Sydney
1965	Pure Maths honours degree (thesis on knot theory)
1966	Physics honours degree (thesis on tunnel diodes)
1969	Finished NLP master's thesis; started PhD at UC Berkeley
1970	Transferred to Stanford
1971	Finished PhD thesis on sorting; postdoc under Knuth
1972-1980	Teaching & Research in TCS & AI at MIT
1980	Sabbatical at Stanford
1981-2000	Teaching & Research at MIT
2001-now	Tiqit, autonomous cars, climate, FCVs, H2@home

1972 Fall: Taught F. Hennie's groups-rings-fields-for-EEs
Spring: Founded 6.043, taught 6 times, then $\rightarrow$ Rivest *et al*

1973 Inherited Stoy's functional programming semantics course

1974 Added logics of imperative programs: Floyd, Hoare (FH)
Definition 1: $P\{a\}Q \equiv \forall\tau\in a.[\tau \vDash (P, Q)]$
where $\tau\ (= (\mathcal{I}, \mathcal{J})) \vDash (P, Q) \equiv \mathcal{I} \vDash P \rightarrow \mathcal{J} \vDash Q$
Definition 2 (afterthought): $P\{a\}Q \equiv P \rightarrow [a]Q$

1976 FOCS'76: "Semantical Considerations on FH Logic"

1977 STOC'77: Fischer and Ladner: Introduced PDL
Open: (i) gap: EXPTIME$\subseteq$PDL$\subseteq$NEXPTIME (ii) Axioms

1978 VP: Closed gap by reducing NEXPTIME to EXPTIME
Segerberg: PDL Axioms. Open: completeness, exciting!

1979 VP: Completeness via Kozen's dynamic algebras

1980 Sabbatical at Stanford. Derek Oppen's Abdication (DOA)

Sun Microsystems Inc

1981 Directed Sun workstation project;
     Supervised Andy Bechtolsheim's Ph.D.

1982 Helped found Sun Microsystems c. 4 employees

1983 My new focus: Computer graphics $+$ digital typography

1984 250 Sun employees

1985 I returned to Stanford

1986 Sun goes public @ $15 (a share)

2000 Sun stock splits many times, goes to $130

2006 38,600 Sun employees

2009 Oracle offers $9.50 for Sun, encounters much resistance

2010 Oracle completes purchase, adds hardware to its software

Stanford

1980-2003 Taught Universal Algebra & Category Theory

1981 FOCS'81: First modal μ-calculus—superseded by Kozen's

1983-1985 Leave of absence from Stanford (Sun)

1986 Coined "pomset" for Grabowski's "partial language"

1988 Manchester: Temporal structures (V-enriched cats)

1990 POPL'90: Higher dimensional automata

1991 Adopted Barr's Chu spaces for concurrency

1992 LATIN'92; quintuple CABG; LICS'92; LFCS'92 (Tver)

1994 Pentium FDIV bug: bruised integers (just scooped IBM)

1999 Matchbox PC: Guinness Records 2001-2003

Retirement ("Professor Emeritus")

2000-2010 Tiqit Computers Inc.

    2002 Tiqit exhibits the Tiqit 83 at CeBIT

    2003 Tiqit lays off everyone and reboots

    2005 DARPA Grand Challenge: Stanley (us) beats CMU (2)

    2006 Tiqit builds the T2 to DEVGRU specifications

    2007 DARPA Urban Challenge: Boss (CMU) beats Junior (us)

    2010 Closed Tiqit, started studying modern climate

2011-2016 Six presentations at the Annual AGU Fall Meeting

    2015 Junior team spins off as Zoox

    2016 Acquired a fuel cell vehicle (Toyota Mirai)

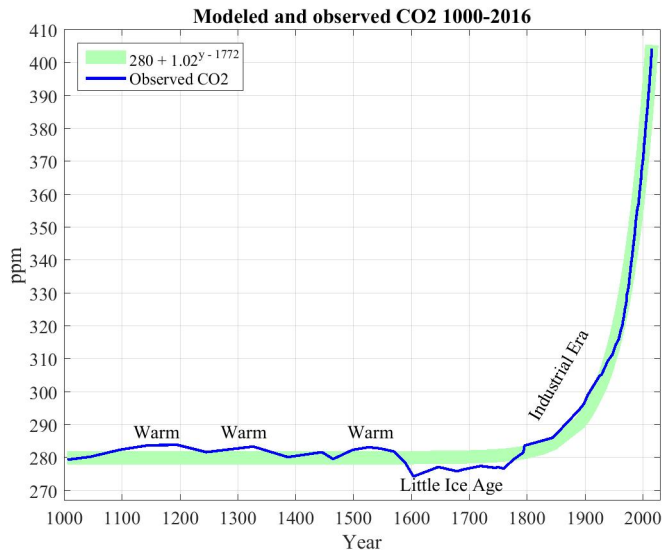   2017 Researching home hydrogen synthesis

Is CO2 responsible for climate change?

Proposition CO2 cannot be responsible for climate change.

Proof Whereas climate fluctuates up and down, CO2 climbs steadily.

In fact CO2−280 ppm has been climbing at 2% a year, but only since 1800.

Modeled and observed CO2 1000-2016

Legend:
- $280 + 1.02^{y-1772}$
- Observed CO2

Labels within figure: Warm, Warm, Warm, Industrial Era, Little Ice Age

Axis labels: ppm (y-axis), Year (x-axis)

Parsing modern climate – last two centuries

Proposition   Modern climate, defined as global mean surface temperature since 1860, can be parsed as a sum of five components.
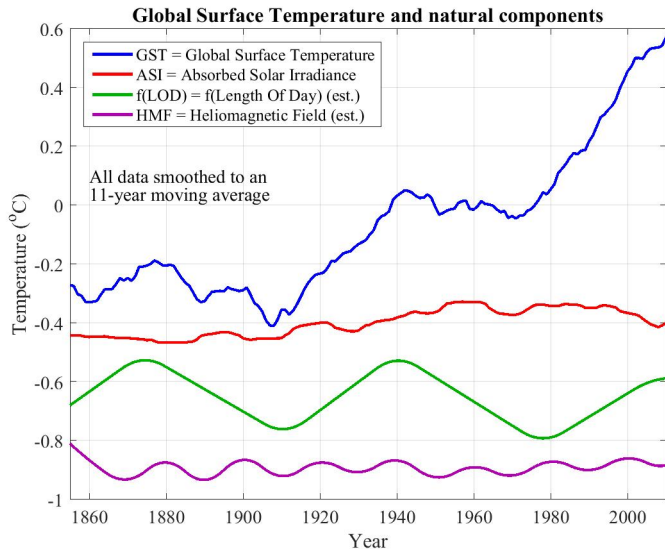
1. Fluctuations removable with an 11-year moving average filter.
2. A pervasive 21-year cycle extending back to the 16th C.
3. A chaotically excited 63-year resonance
4. Total Solar Irradiance (TSI).
5. Radiative Forcing (RF) attributable to CO_2.

We don't care whether the first is of natural or anthropogenic origin.

The next three are all of natural origin.

Strategy: We shall remove the first four from climate and compare with the fifth. What we would like to see is a good linear relationship.

Climate and the three natural components

Global Surface Temperature and natural components

All data smoothed to an 11-year moving average

Legend:
- GST = Global Surface Temperature
- ASI = Absorbed Solar Irradiance
- f(LOD) = f(Length Of Day) (est.)
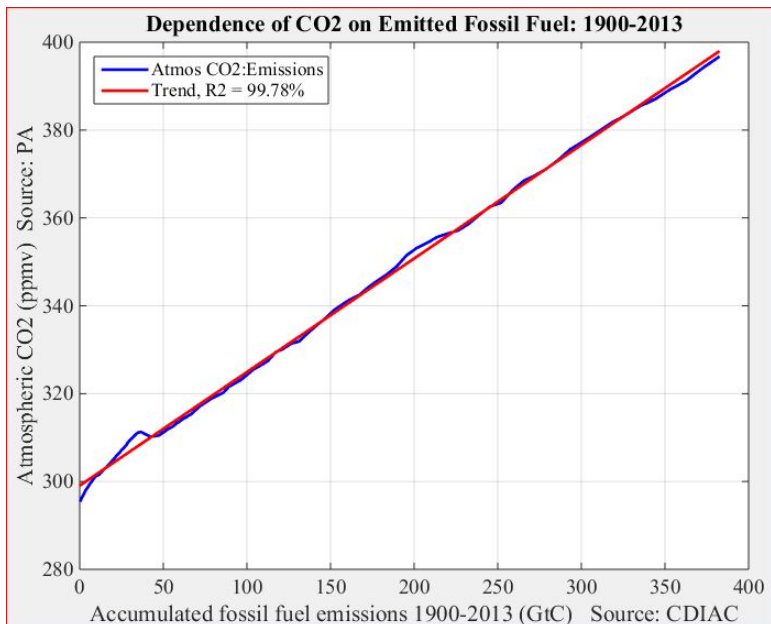- HMF = Heliomagnetic Field (est.)

The Residual, and Radiative Forcing

The residual is what remains of climate after filtering (to remove the first component) and subtracting the three natural components.

Here we shall define Radiative Forcing (RF) as $\log_2(CO2/280)$. This definition makes RF relative to preindustrial CO2 (280 ppm). The choice of preindustrial CO2 is only for convenience as any other index would lead to the same conclusion.

We also wish to make a connection between atmospheric CO2 and known human influences on CO2.
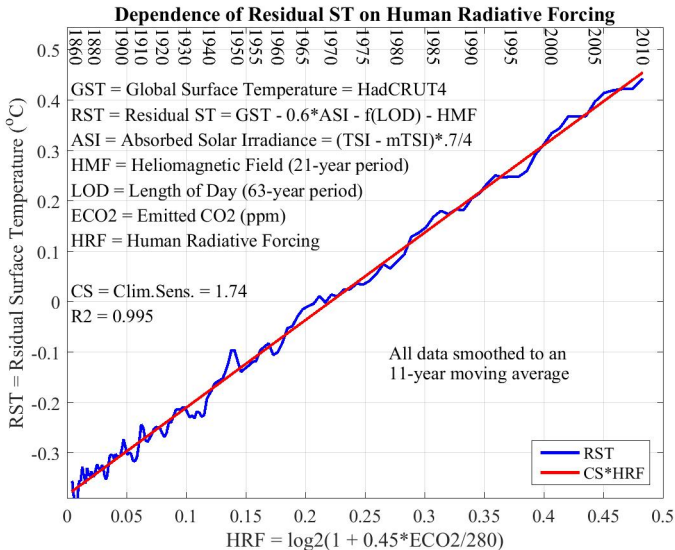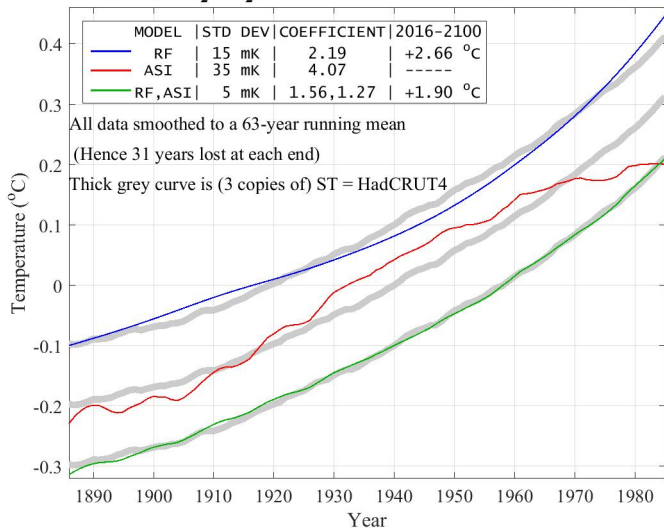
Because of this connection, in comparing the residual with CO2 it suffices to compare it with human influences. We therefore reconstruct atmospheric CO2 as 280 + 45% of human-influence CO2, and refer to the log of this reconstructed value as HRF (H for human).

Dependence of Residual ST on Human Radiative Forcing

GST = Global Surface Temperature = HadCRUT4
RST = Residual ST = GST - 0.6*ASI - f(LOD) - HMF
ASI = Absorbed Solar Irradiance = (TSI - mTSI)*.7/4
HMF = Heliomagnetic Field (21-year period)
LOD = Length of Day (63-year period)
ECO2 = Emitted CO2 (ppm)
HRF = Human Radiative Forcing

CS = Clim.Sens. = 1.74
R2 = 0.995

All data smoothed to an
11-year moving average

RST
CS*HRF
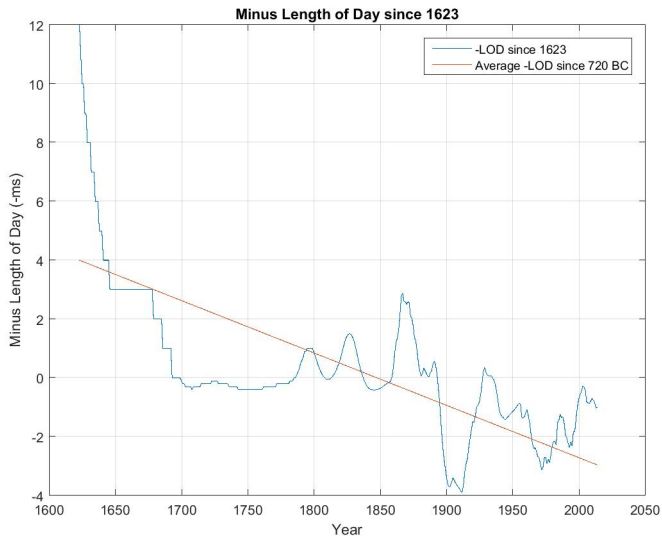
RST = Residual Surface Temperature (°C)

HRF = log2(1 + 0.45*ECO2/280)

Why do we need to include the solar constant (TSI)?

Fitting RF (= $\log_2(CO_2)$) and ASI to HadCRUT4 separately and together

MODEL	STD DEV	COEFFICIENT	2016–2100
RF	15 mK	2.19	+2.66 °C
ASI	35 mK	4.07	-----
RF,ASI	5 mK	1.56,1.27	+1.90 °C

All data smoothed to a 63-year running mean

(Hence 31 years lost at each end)

Thick grey curve is (3 copies of) ST = HadCRUT4