An Objective Look At The Global Warming Controversy

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The Right Climate Stuff Research Team

TRCS

- **Volunteer group** of primarily retired NASA scientists and engineers who are **veterans of the Apollo Program**.
- The group formed in February 2012 as **an independent, objective, research team** of **volunteers with no funding**
  - **INITIAL GOAL: Determine the extent to which burning fossil fuels can cause harmful global warming**
- **CONCLUSIONS:** Due to world-wide **rising energy demand** and **rising fossil fuel prices**, as proven **reserves are consumed**,
  - A **market-driven transition** to **alternative fuels** will be **required before any climate problems can occur**
  - A **national energy plan** is **needed** to **ensure our energy future**
  - **Climate alarm** is **causing irrational energy-related decisions**

The Right Climate Stuff Research Team

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- **We aren't climate scientists**
- We do have **education, training, and experience** in the **same scientific disciplines** that **climate scientists use**
- We have **expertise in identifying** and **solving Problems** from **exploring** the **unknowns** of **manned space flight**
  - We **define Problems** in terms of a **deviation from "normal"**
  - To be able **to determine root cause of defined Problems**
    - We **specify Problems** in terms of **What?, Where? When?** and **How Much?** has the **process deviated** from **a normal range**
    - **We seek data on the "Is Not" answers to the same questions**
    - **Important data for root cause within "IS" and "IS NOT" answers**

The Northern Hemisphere

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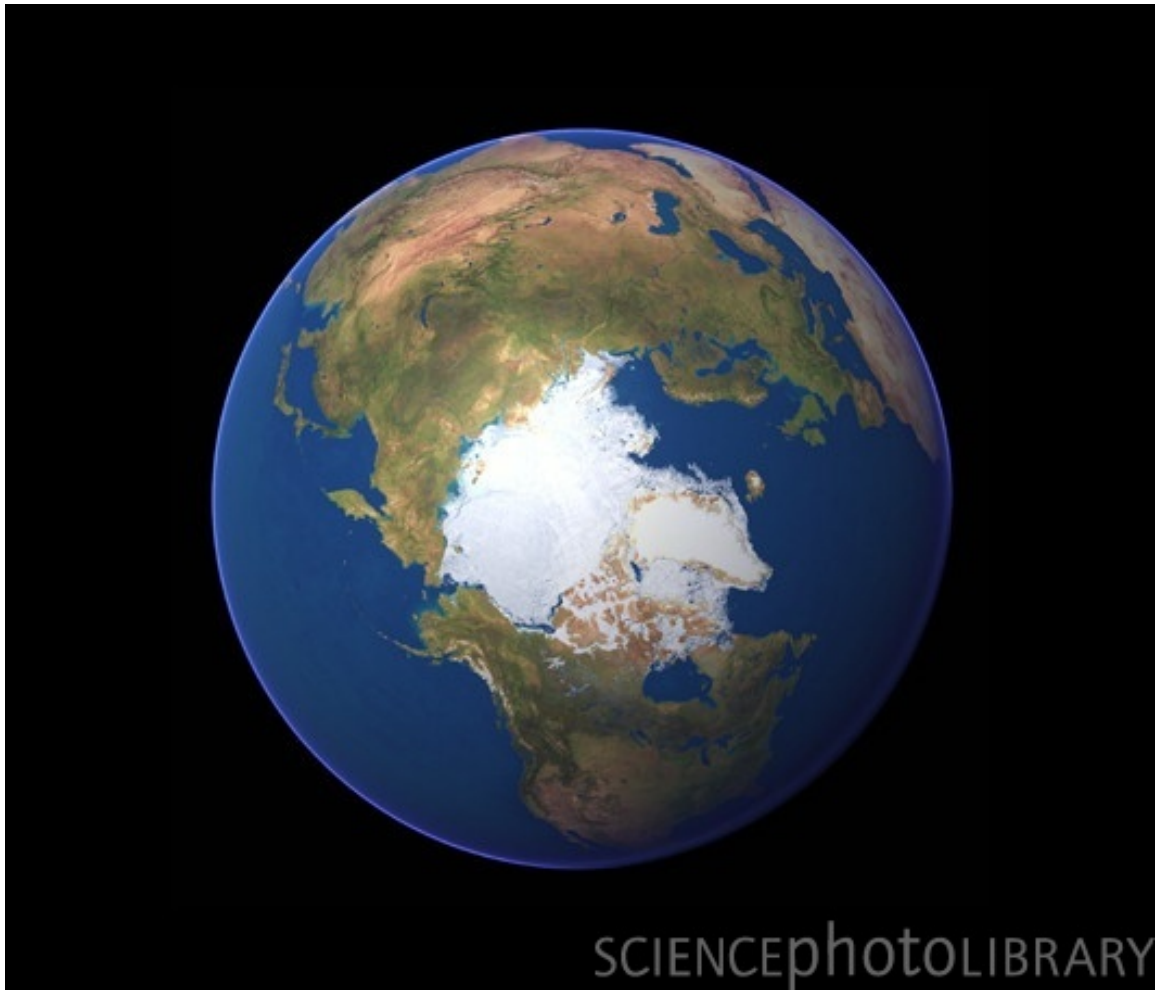
Photo from John Kehr's Book: The Inconvenient Skeptic
Earth has 71% ocean coverage total, but NH and SH markedly different



Northern Hemisphere (NH) has 41% land coverage

North Pole is ocean covered with ice and surrounded by land

NH heats up more quickly in Summer season compared to SH due to its higher % land coverage

The Southern Hemisphere

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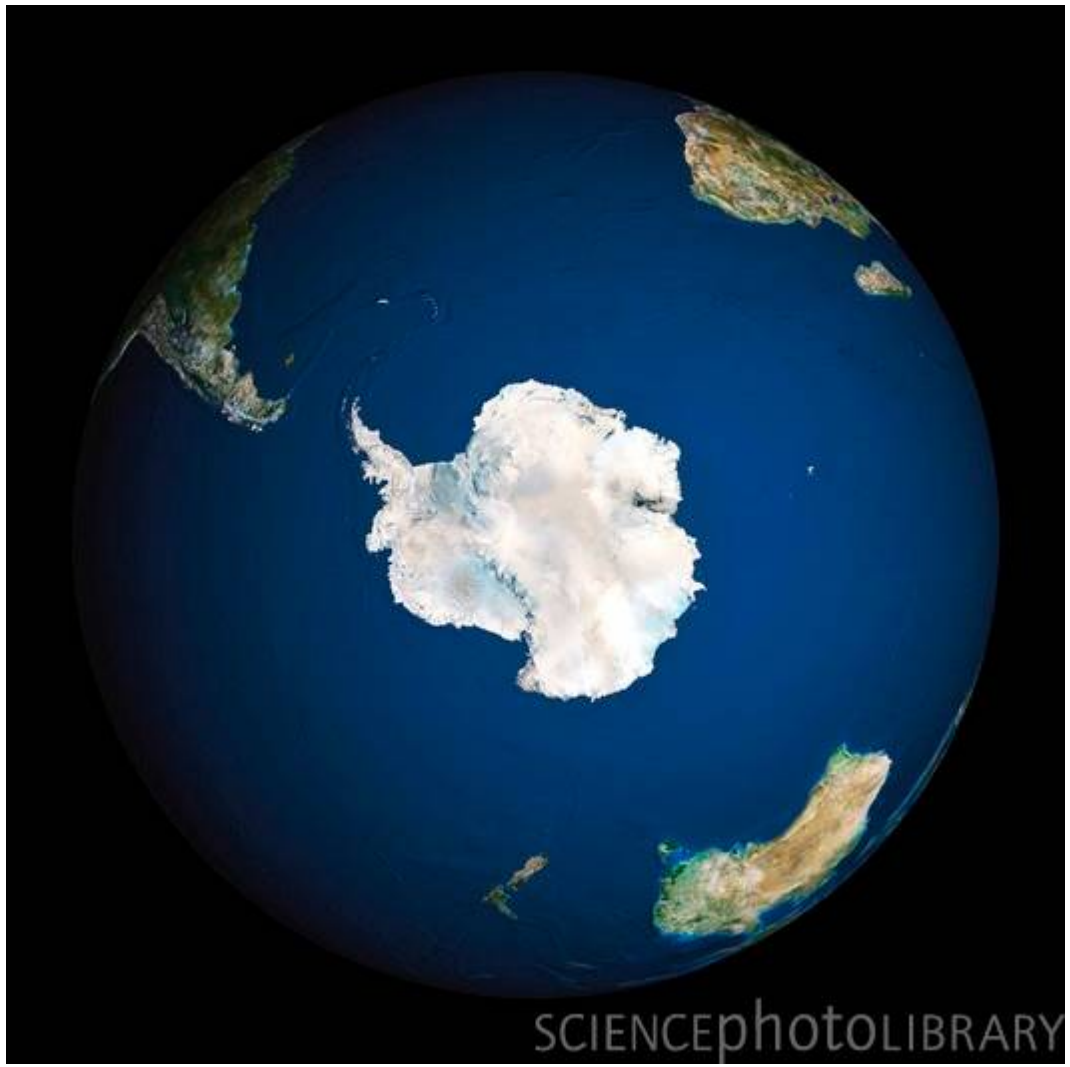
Photo from John Kehr's Book: The Inconvenient Skeptic



Southern Hemisphere only has 19% land coverage – much of that is Antarctica land mass covered with ice and always below 0 deg C

Southern Hemisphere responds much differently to its seasons than the NH because of its 81% ocean coverage

Key Historical Data from Greenland

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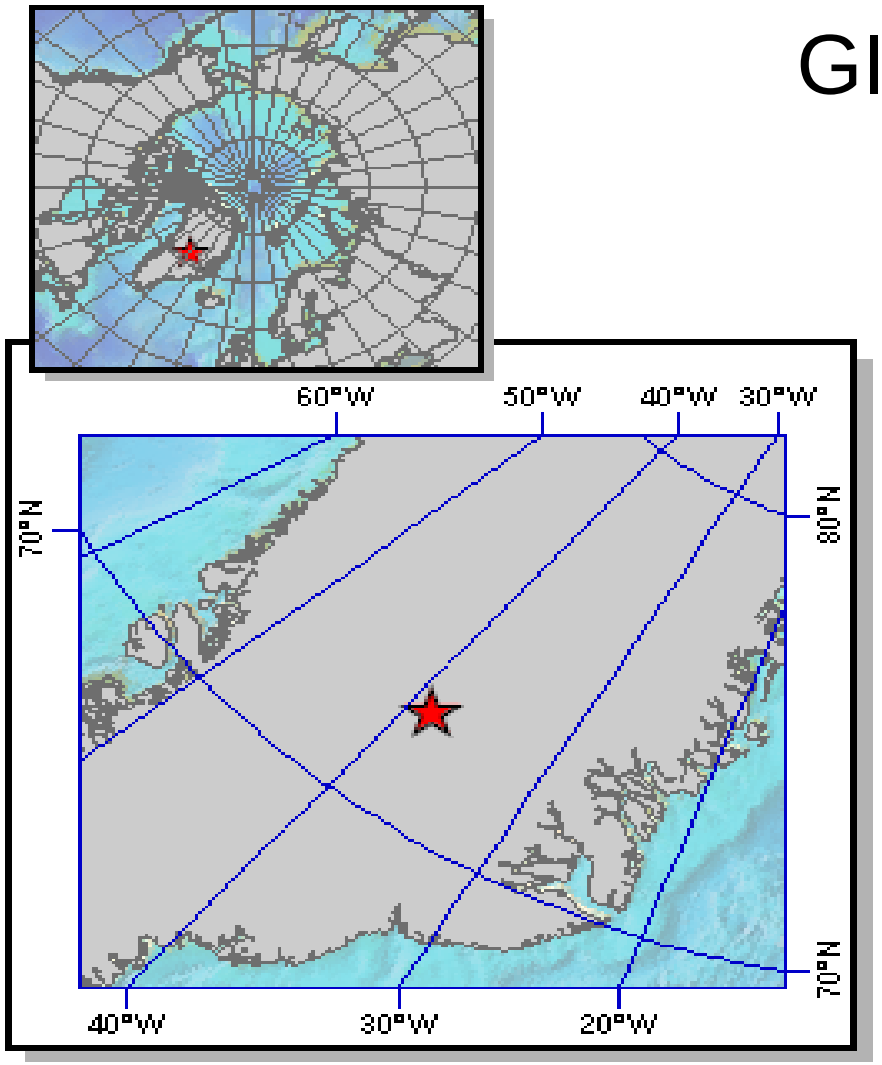

GISP2 ICE CORE DATA

Ref: Alley, R.B.. 2004.
GISP2 Ice Core Temperature and Accumulation Data.
IGBP PAGES/World Data Center for Paleoclimatology
Data Contribution Series #2004-013.
NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

Greenland - GISP2 Ice Core Data

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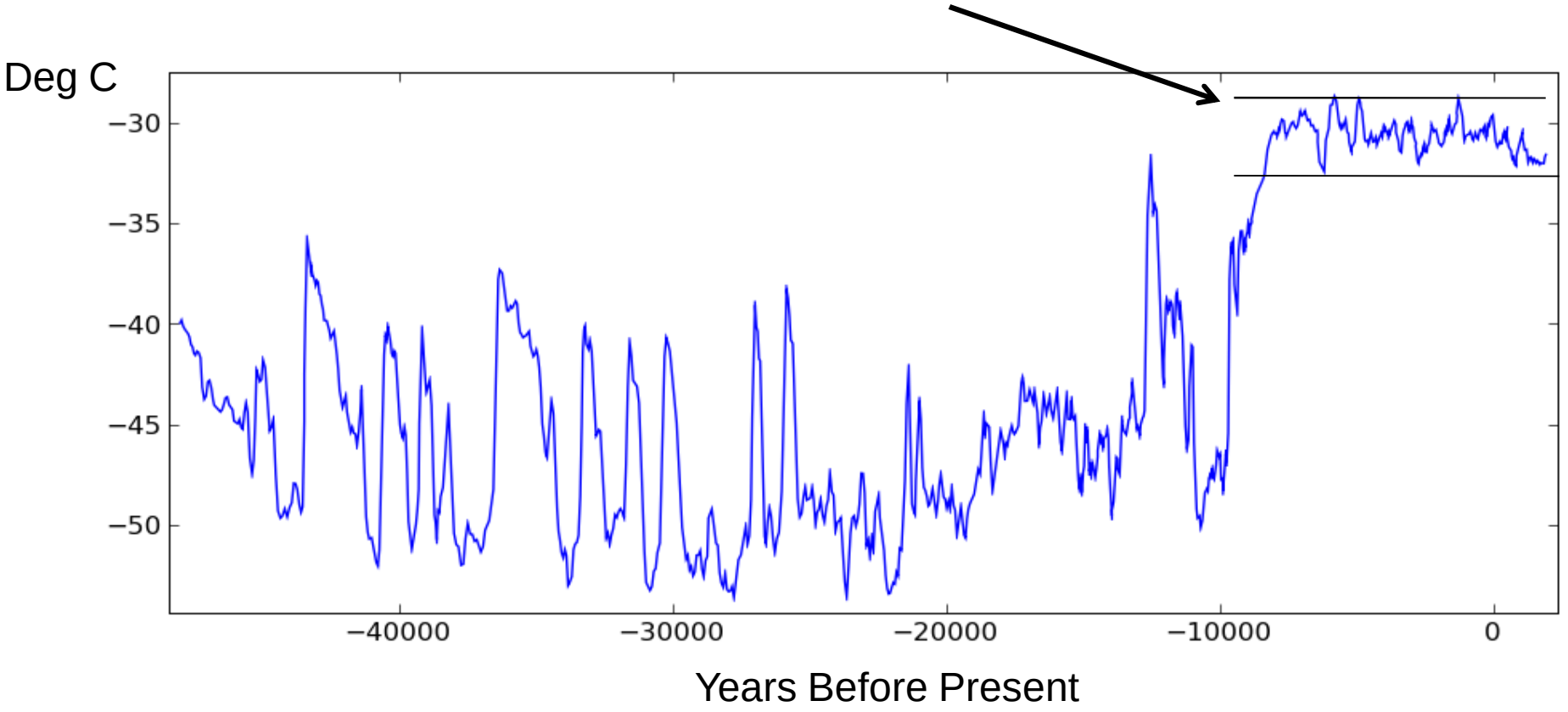
A major concern of a warming climate is melting of the Greenland Ice Sheet and resulting sea level rise

Last 10,000 years of stable climate data from GISP2



Proper Problem Specification

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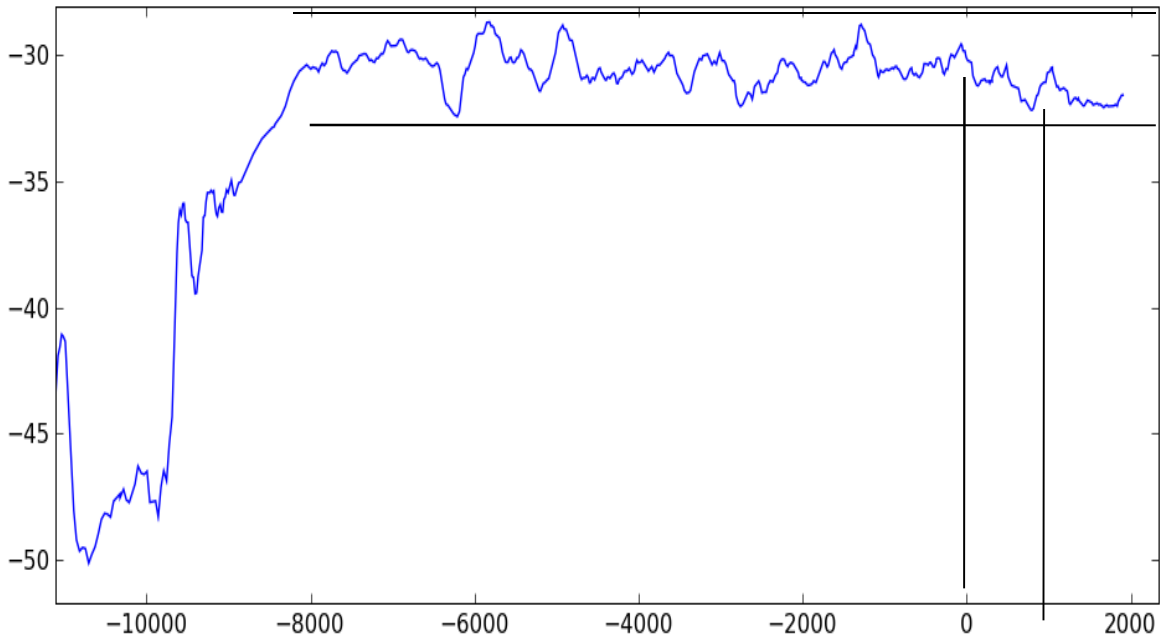
- Problem Definition
  - ➢ A **PROBLEM** must be defined in terms of a **HARMFUL DEVIATION** from **NORMAL**, expected behavior
    - o **SPECIFICS: What?, Where?, When?, How Much?, Is, Is Not**
  - ➢ GISP2 Ice Core Data: **PROBLEM? WHAT PROBLEM?**

Deg C

Determined from correlations with Oxygen stable isotope ratio $^{18}O/^{16}O$



Analysis of Other Ice Core Data

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- **Greenland** and **Antarctica** contain the Earth's major permanent ice sheets.
  - Antarctica's ice volume is much, much greater than Greenland's
  - Antarctica holds more than 90 percent of all fresh water on the planet and has been building ice volume for 34 million years
- The National Oceanic and Atmospheric Administration (NOAA) maintains data from ice cores taken in various locations in Greenland and Antarctica
  - All ice core data indicates current temperatures are not abnormal compared to the last 10,000 years of natural variation

Ljungqvist Temp Reconstruction

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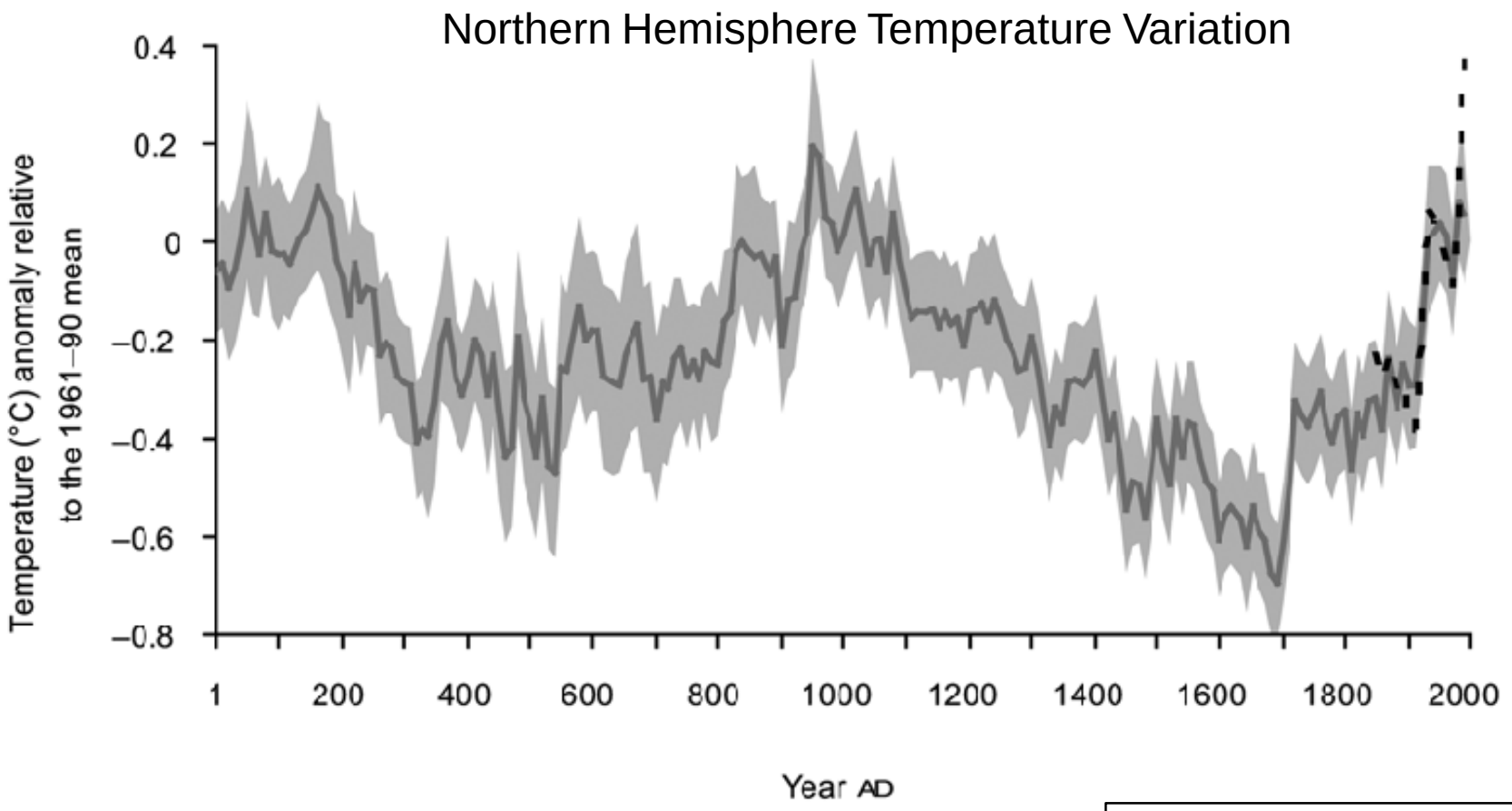

Ljungqvist (2010)

Recent Global Mean Temp Variation

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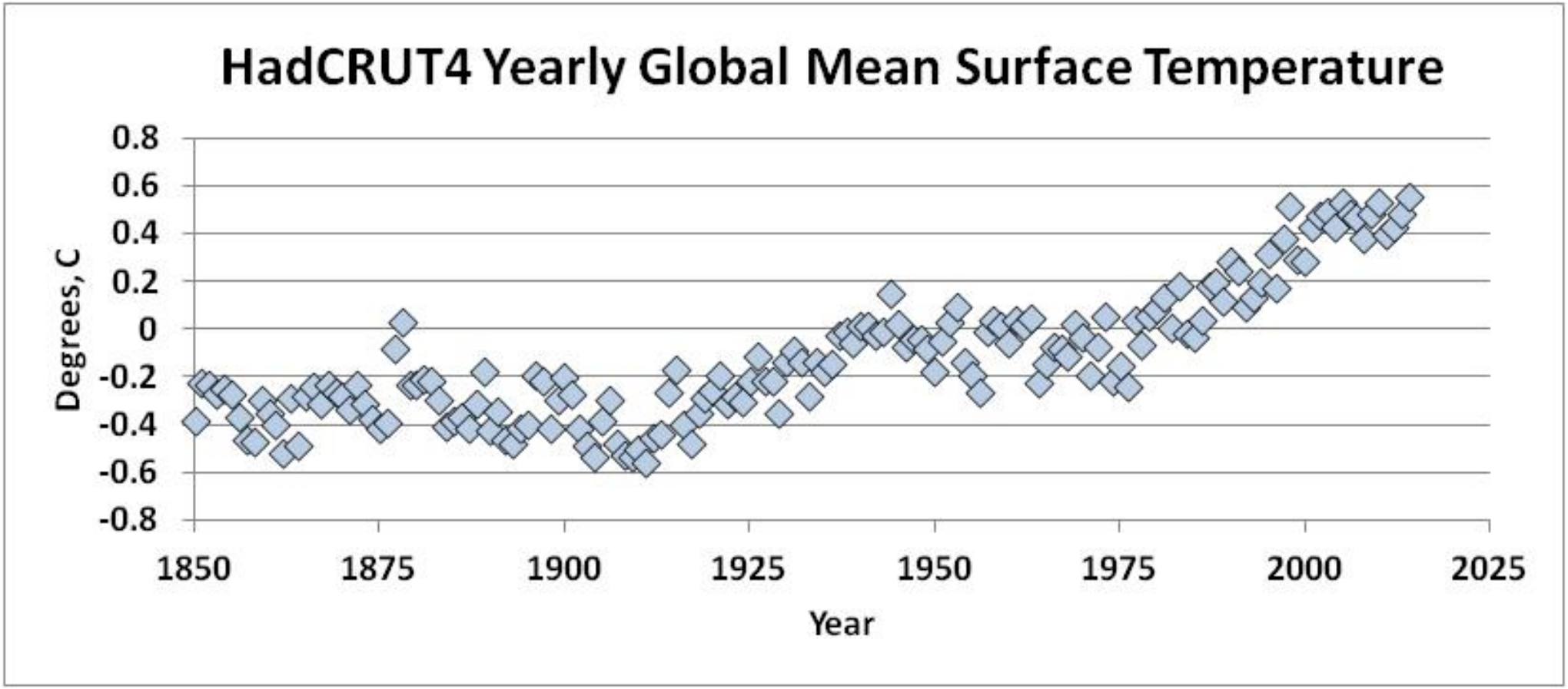

Un-Validated Climate Models Predict Future Global Warming Problems

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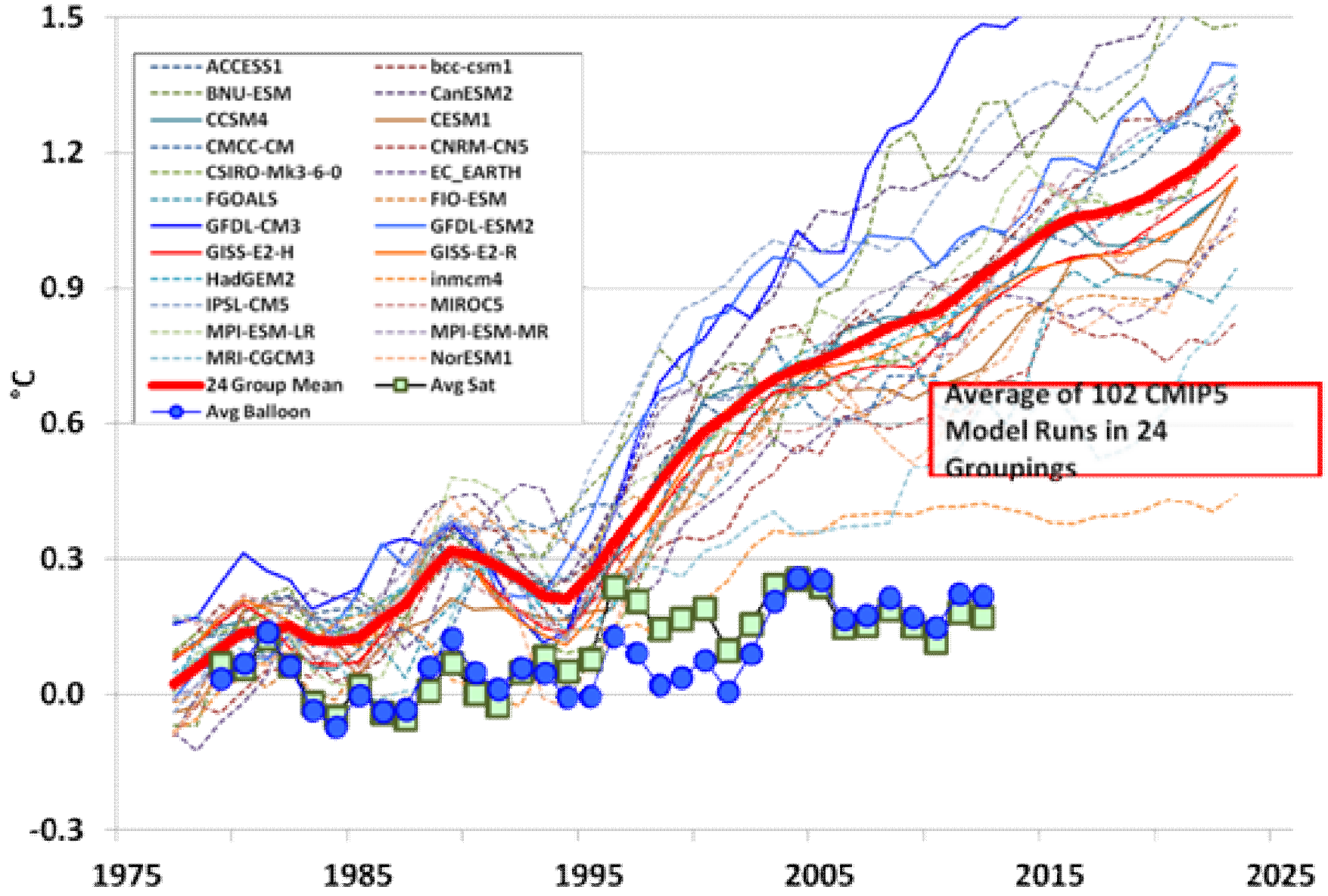

Root Cause Analysis of Defined Problems

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- By our strict definition, a **Global Warming Problem does not exist at the present time**
  - **A Problem must exist to determine Root Cause**
- **At present**, there is **only a concern** that **burning fossil fuels may cause harmful temperatures – Potential Problem**
  - **Concern is not supported by actual data; only un-validated models**
- **Potential Problems require monitoring, study and contingency plan development**
  - **Potential Problems don't require premature critical decisions with potentially severe adverse consequences - eg. EPA CO2 regulations!**
  - **Our nation needs an objective, scientific review of EPA Social Cost of Carbon (SCC) calculations used to justify CO2 emission regs.**

IPCC Metrics for GHG Climate Sensitivity

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- **Equilibrium Climate Sensitivity (ECS)**
  - **Loosely defined as global average temp rise that will eventually result from doubling CO2 level in the atmosphere**
  - **Computed by complex, un-validated computer model simulations**
  - **Doubled CO2 level is artificially held constant (Step Function Forcing) for more than 1000 years to achieve a new temp equilibrium between atmosphere and oceans**
  - **Totally unrealistic scenario, but most popular with researchers!!**

IPCC Metrics for GHG Climate Sensitivity

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- **Transient Climate Response (TCR)**
  - **Climate model simulation** of **Global Warming** that **would result** from
    - **Increasing atmospheric CO2 levels at a rate of 1% per year** until **doubled CO2 level is reached**
    - **Current rate of increase is about 0.5% per year**
  - **TCR** climate model simulation more realistic than an **ECS** simulation
    - **But still hypothetical!!**

Differences In ECS and TCR

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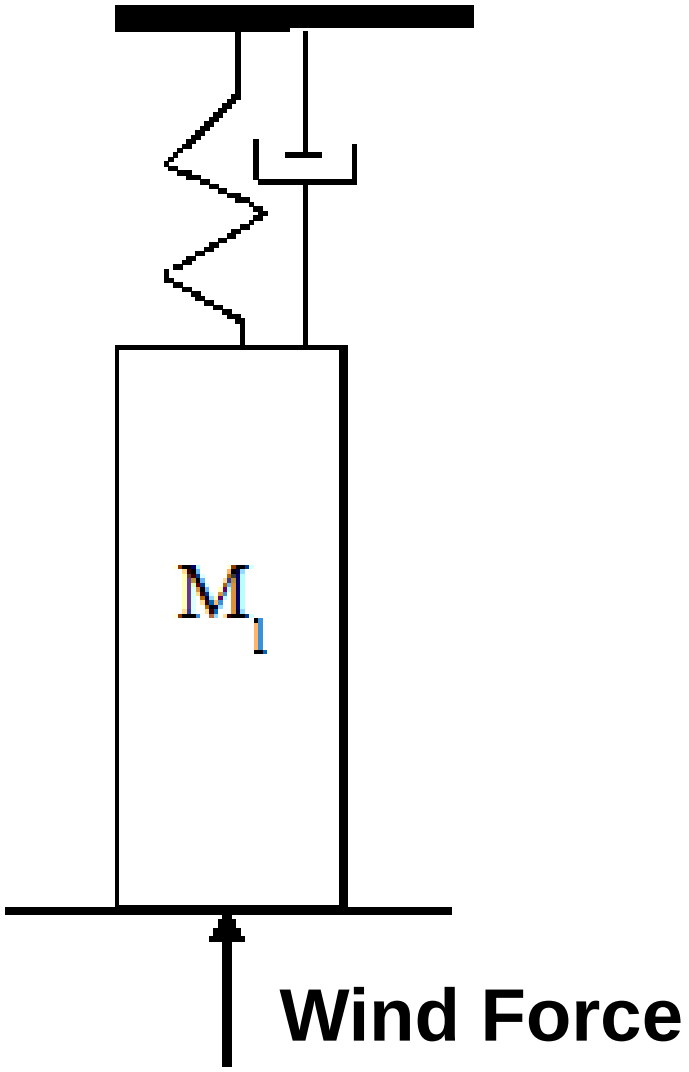
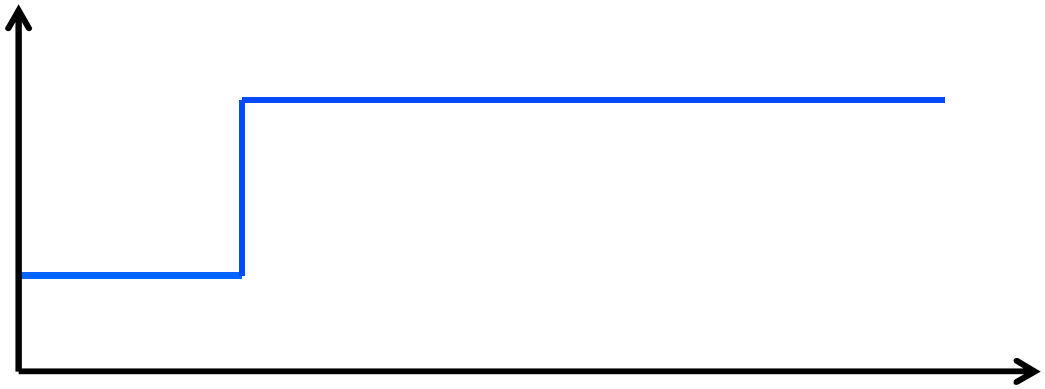
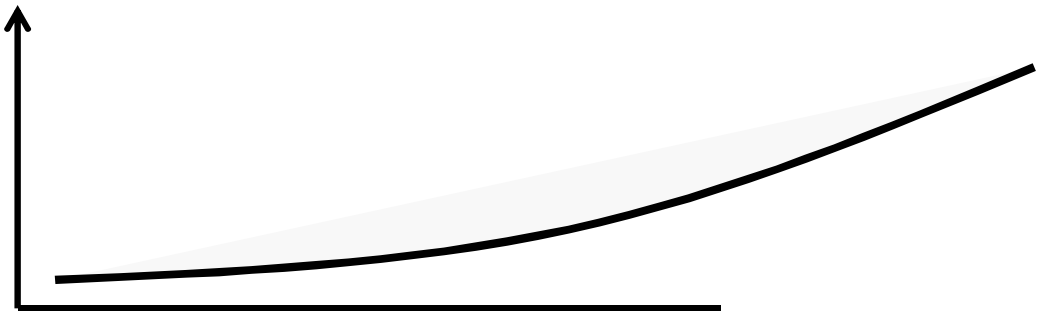


ECS FORCING FUNCTION



TCR FORCING FUNCTION



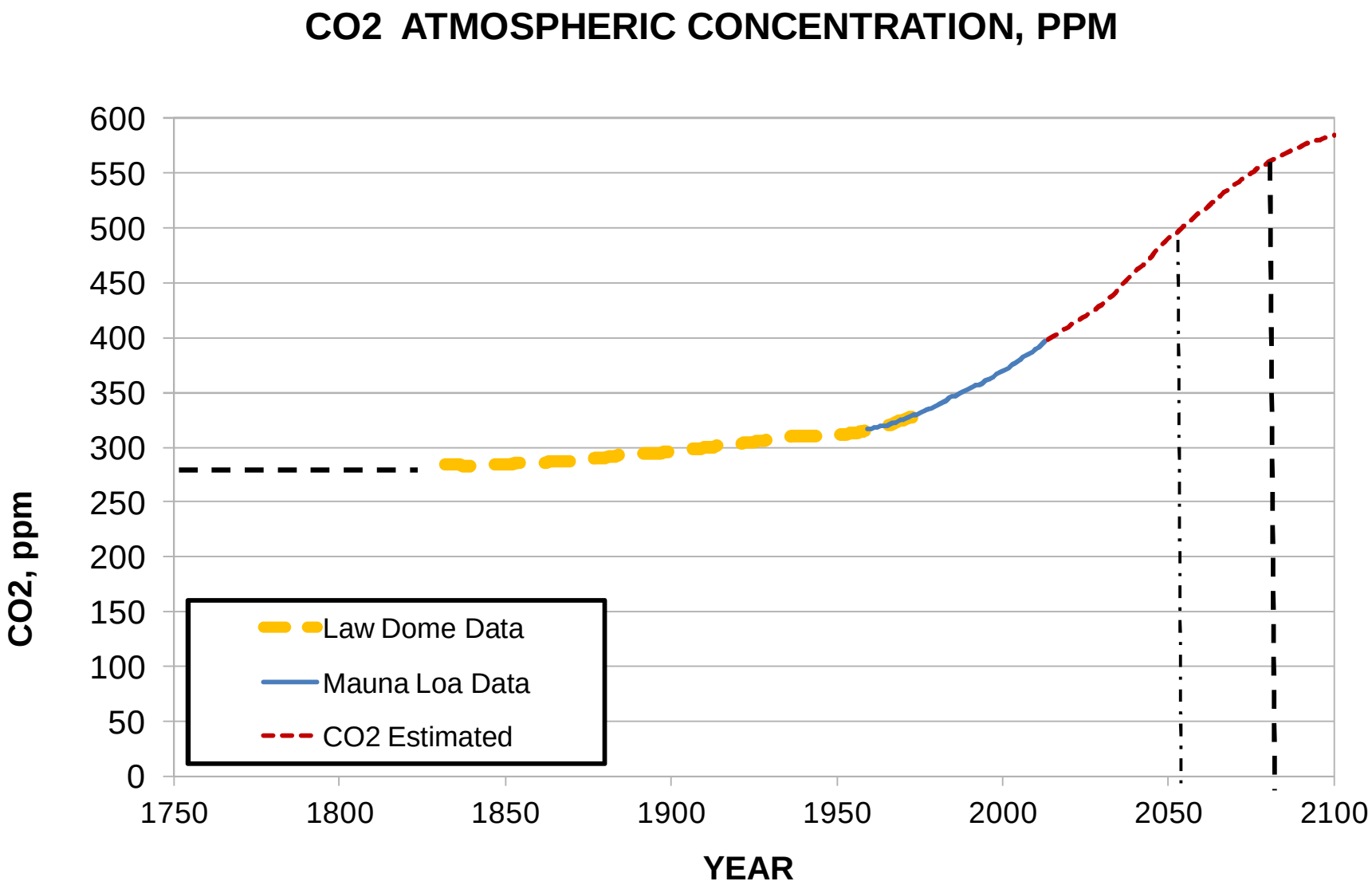
Transient Climate Sensitivity (TCS)

TRCS

- **To obtain a verifiable GHG climate sensitivity metric, our research team defined a new metric:**
  - **Transient Climate Sensitivity (TCS)** – The rise in global average surface temperature due to the actual gradual rise of CO2 in our atmosphere until CO2 levels are doubled
  - **Effects of all GHG are approx. = 1.5x(CO2-only effects)**
  - A **CO2-only TCS** value **is needed** to evaluate effects of **CO2 emissions regulations**
- **TCS is a verifiable quantity using actual data**

CO2 TRENDS IN ATMOSPHERE

TRCS



Differences In ECS, TCR & TCS

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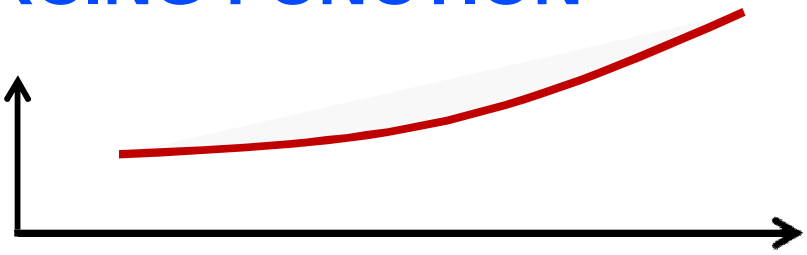
ECS FORCING FUNCTION

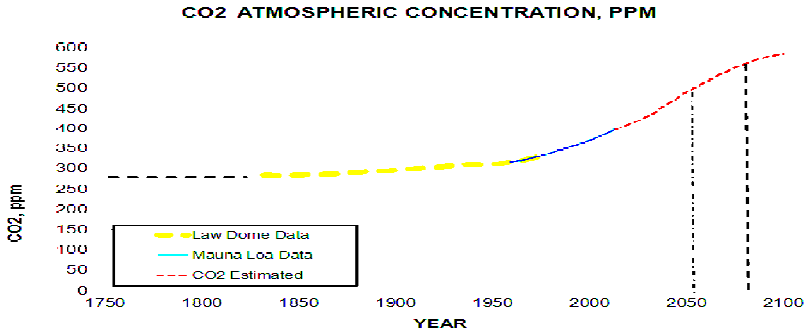
Step Function instantly doubles CO2 level and artificially holds it constant for > 1000 yr.

TCR FORCING FUNCTION



Atm. CO2 level Increased by 1%/yr.

TCS FORCING FUNCTION



Actual atm. CO2 rise History; currently < 0.5%/yr.

EPA Uses ECS For Regulatory Decisions

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- **Used by EPA to forecast future temperature change caused by atmospheric CO2 level change**
- **Uncertainty Range: 1.5 < ECS < 4.5 deg C (IPCC)**
  - **Lower value supported by actual data**
  - **Upper value results from un-validated climate model simulations – essentially speculation**
- **But, EPA arbitrarily increased its ECS uncertainty range to justify its CO2 emission regulations**
  - **1 < ECS < 10C; results in artificially high probability of high temperatures in future - Totally Speculative!**

Validated Model Developed to Determine TCS

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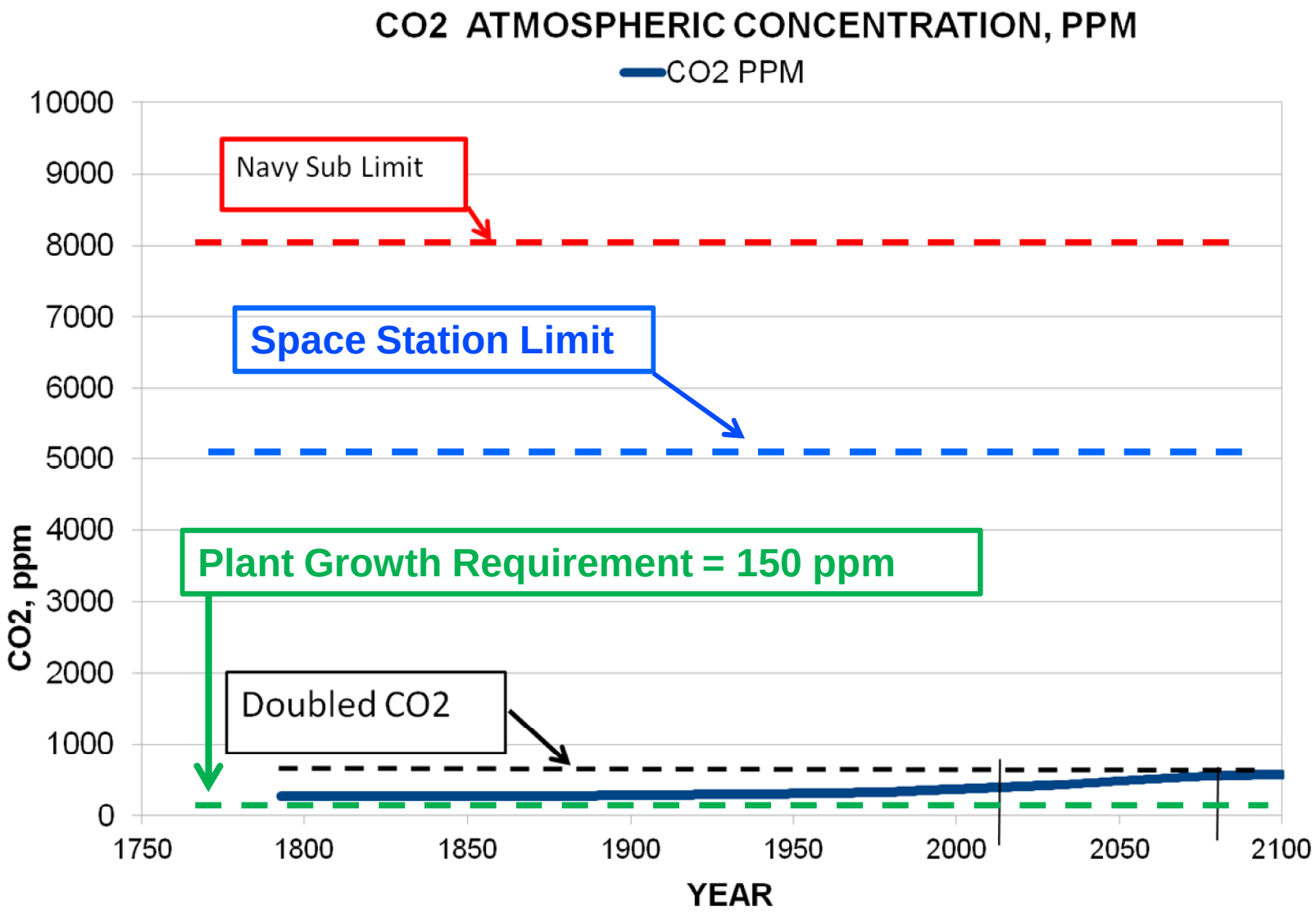
- **We determined a conservative value for TCS from climate data based on**
  - **A simple model derived from Conservation of Energy**
  - **40 percent rise in atmospheric CO2 since 1850**
  - **< 0.8K rise in Global Average Surface Temperature since 1850**
- **TCS(1+β) = 1.8K with low uncertainty, K = deg. Kelvin**
  - **β = fraction of CO2 rad. forcing caused by other GHG & aerosols**
  - **Low uncertainty limited only to temp rise uncertainty since 1850**
- **For a nominal value of β = 0.5, TCS = 1.2K**
- **β, and therefore TCS, is somewhat uncertain due to large uncertainty of historical cooling effects of atm. aerosols**
- **TCS(1+β) = 1.8K can be used for accurate forecasts**

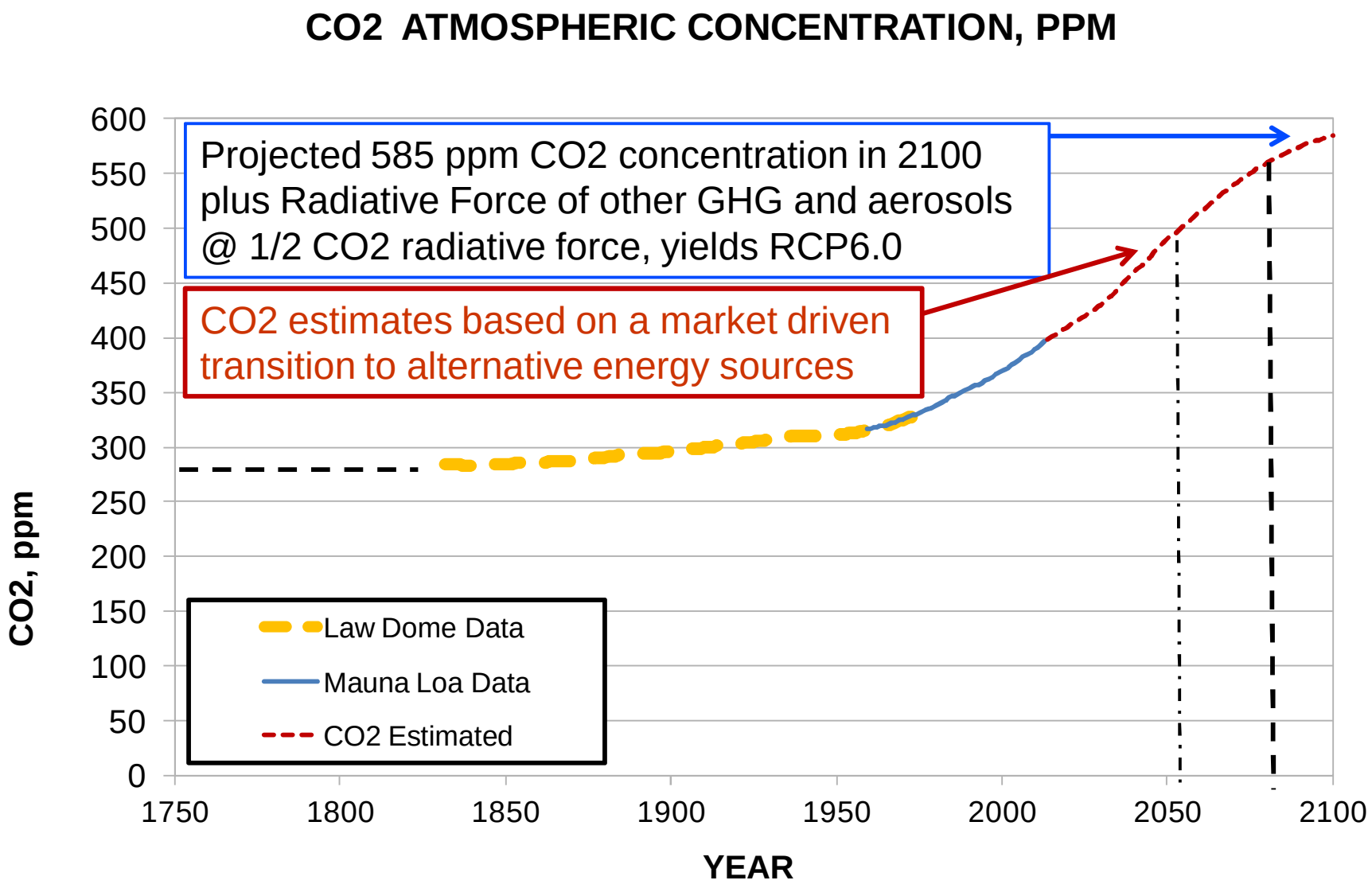
CO2 Level In Atmosphere

TRCS



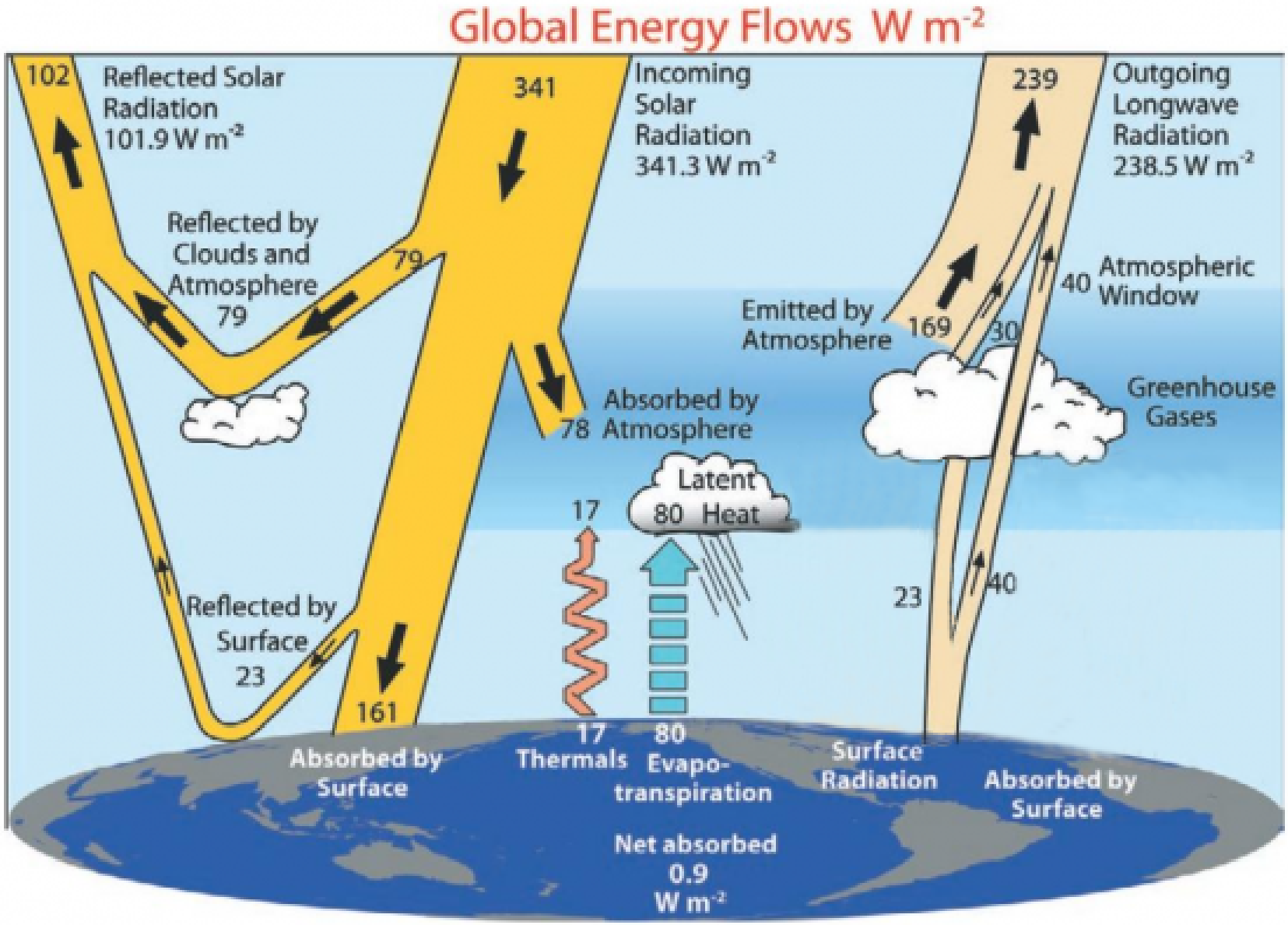
CO2 TRENDS IN ATMOSPHERE

TRCS



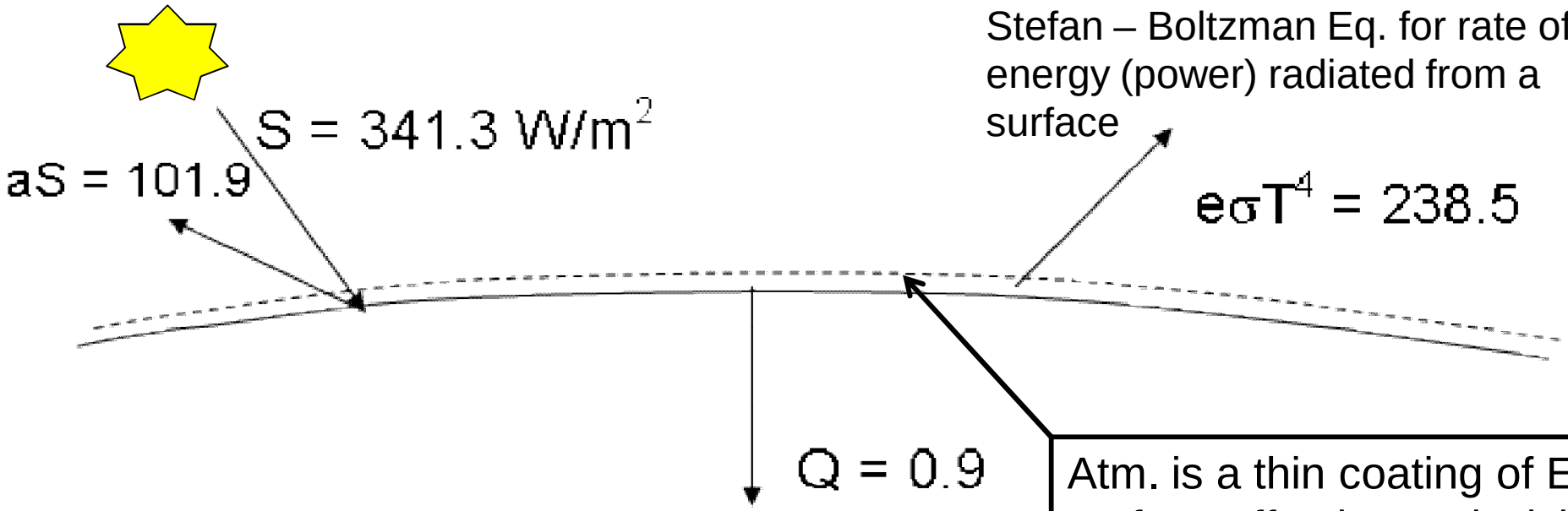
How Does Atm. CO2 Warm the Earth?

TRCS



Earth Surface Energy Balance

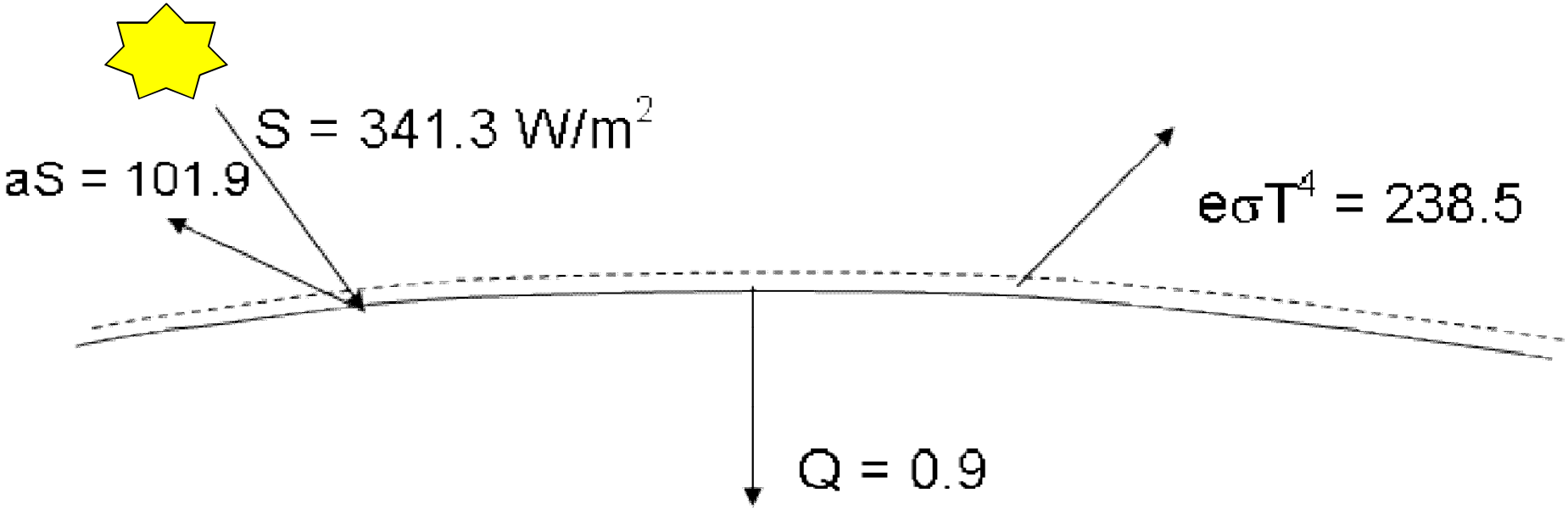
TRCS



S = incoming radiation from the Sun
a = the earth's albedo reflecting sunlight from atm. and earth surface
Q = heat transport below ocean surface

Earth Surface Energy Balance

TRCS



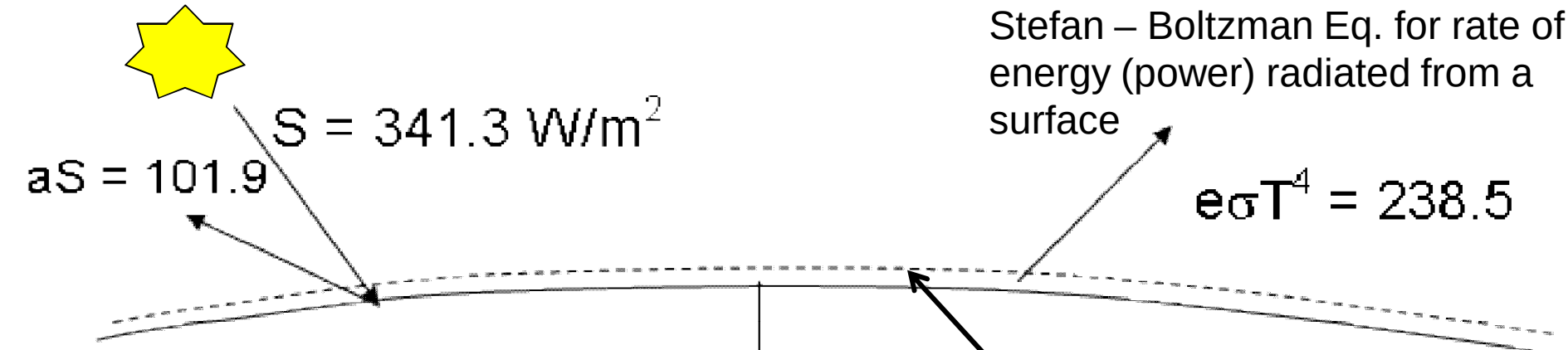
$$e(W, C, G)\sigma T^4 = (1 - a)S - Q$$

Negligible Contributors

- **Incoming radiation from stars other than our Sun**
- **Heat rising from Earth's molten core**
- **Heat generation processes on the Earth's surface**
  - **Forest fires, decaying organic matter, burning fuels**

Earth Surface Energy Balance

TRCS



S = incoming radiation from the Sun
a = the earth's albedo reflecting sunlight from atm. and earth surface
Q = heat transport below ocean surface

Atm. is a thin coating of Earth surface affecting emissivity (e) of the surface.

Conservation of Energy

$$e(W, C, G)\sigma T^4 = (1 - a)S - Q$$

W, C and G are atm. concentrations of water vapor, CO_2 and other GHG, respectively

A Simple Model For Temperature Changes

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- **Use calculus to form a differential of the Earth Surface Power Balance Equation to evaluate effects of changes in variables**

$$d\{e(W, C, G)\sigma T^4\} = d\{(1 - a)S - Q\}$$

$$[(\frac{\partial e}{\partial W}\frac{\partial W}{\partial C} + \frac{\partial e}{\partial C})dC + (\frac{\partial e}{\partial W}\frac{\partial W}{\partial G} + \frac{\partial e}{\partial G})dG\ ]\sigma T^4 + 4e(W,C,G)\sigma T^3 dT = (1-a)dS - Sda - dQ$$

$\sigma = 5.67(10)^{-8}\ W/m^2/K^4$ $\quad e\sigma T^4 = 238.5\ W/m^2$

For $T = 288K$ and $e = 238.5/(\sigma T^4) = 0.611$, $\quad 4e\sigma T^3 = 1/0.302$

$dT = [0.302]\{-$ [changes in $e(W, C, G)$] $\sigma T^4 + (1-a)dS - Sda - dQ\ \}$

[changes in $e(W, C, G)]\sigma T^4$ are called Radiative Forcing from GHG including water vapor (W) feedback effects

A Simple Model For Temperature Changes

TRCS

Radiative Forcing changes from rising atm. CO2 concentration relative to the 284.7 ppm concentration in 1850 can be modeled as:

$$\left[\frac{\partial e}{\partial C}\mathrm{dC(year)}\right]\sigma T^4 = 3.71\{\mathrm{LOG[C(year)/284.7]/LOG[2]}\} \quad W/m^2$$

Radiative Forcing changes from other GHG and aerosol concentration rise in atmosphere relative to 1850 can be modeled as a fraction, β, of CO2 radiative forcing

$$\left[\frac{\partial e}{\partial G}\mathrm{dG(year)}\right]\sigma T^4 = (\beta)3.71\{\mathrm{LOG[C(year)/284.7]/LOG[2]}\} \quad W/m^2$$

A Simple Model For Temperature Changes

TRCS

Radiative Force changes due to water vapor feedback effects can be modeled as a fraction, w, of CO2 and other GHG forcing

$$[(\frac{\partial e}{\partial W}\frac{\partial W}{\partial C})dC + (\frac{\partial e}{\partial W}\frac{\partial W}{\partial G})dG]\ \sigma T^4 = w(1+\beta)(3.71)LOG[C(year)/284.7]/LOG[2]$$

Other possible temperature feedbacks from GHG radiative forcing can also be expressed as a fraction, f, of GHG radiative forcing

$$\text{Other radiative force feedbacks} = f(1+\beta)(3.71)LOG[C(year)/284.7]/LOG[2]$$

Using our expressions for radiative force changes since 1850 due to CO2, other GHG, aerosols and all feedbacks from GHG forcing

$$dT(year) = [0.302]\{(1+w+f)(1+\beta)(3.71)LOG[C(year)/284.7]/LOG[2]+(1-a)dS–Sda–dQ\}$$

A Simple Model For Temperature Changes

TRCS

Repeating from previous slide:

$$dT(year) = [0.302]\{(1+w+f)(1+\beta)(3.71)LOG[C(year)/284.7]/LOG[2]+(1-a)dS–Sda–dQ\}$$

The RF for doubling atm. CO2 concentrations from 284.7 ppm in 1850 is 3.71 W/m^2 as computed from IR absorption bands of CO2

$$3.71\{LOG[569.4/284.7]/LOG[2]\} = 3.71\ W/m^2$$

Using our definition for TCS as temperature rise including all feedbacks from doubling atm. CO2,

TCS = [0.302](1+w+f)3.71 deg K

Therefore substituting with this definition for TCS,

$$dT(year) = TCS(1+\beta)LOG[C(year)/284.7]/LOG[2] + 0.302\{(1-a)dS – Sda – dQ\}$$

Recent Global Mean Temp Variation

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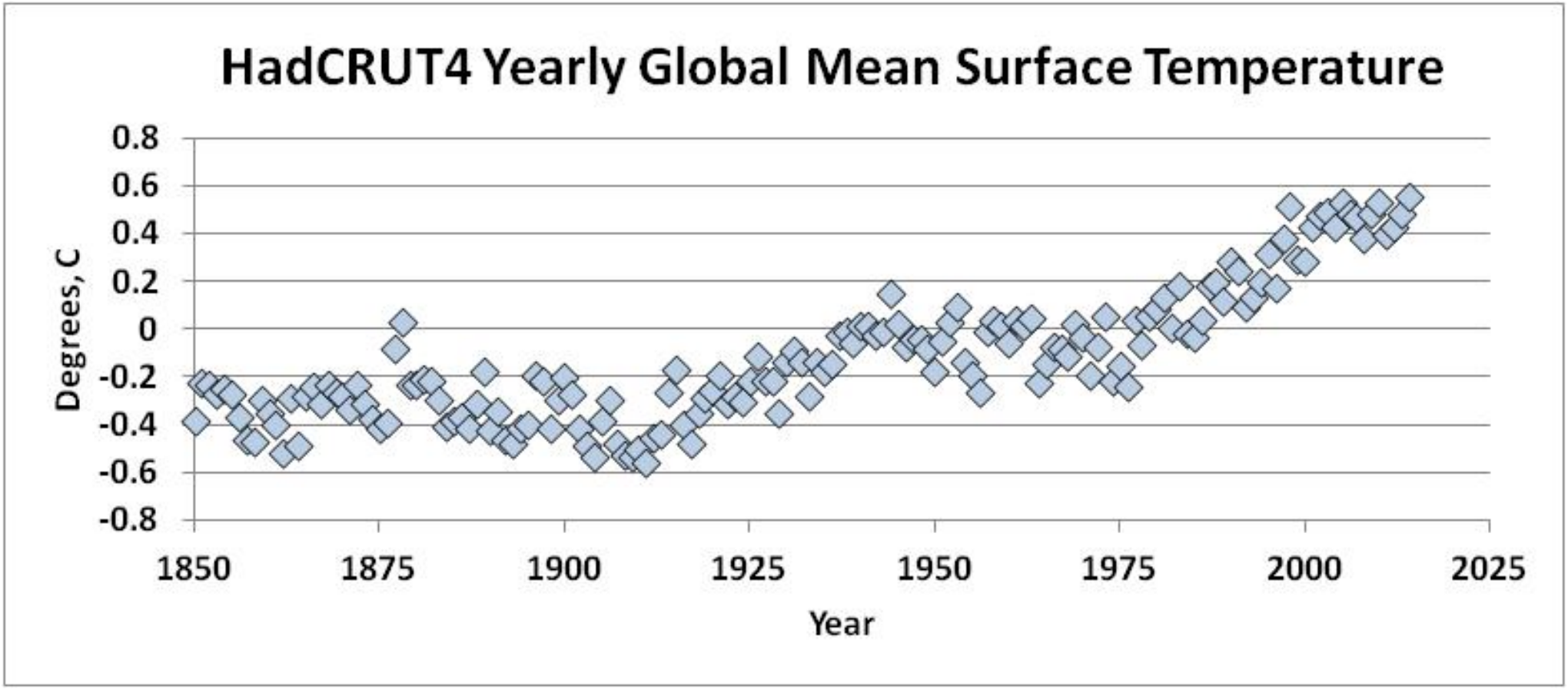
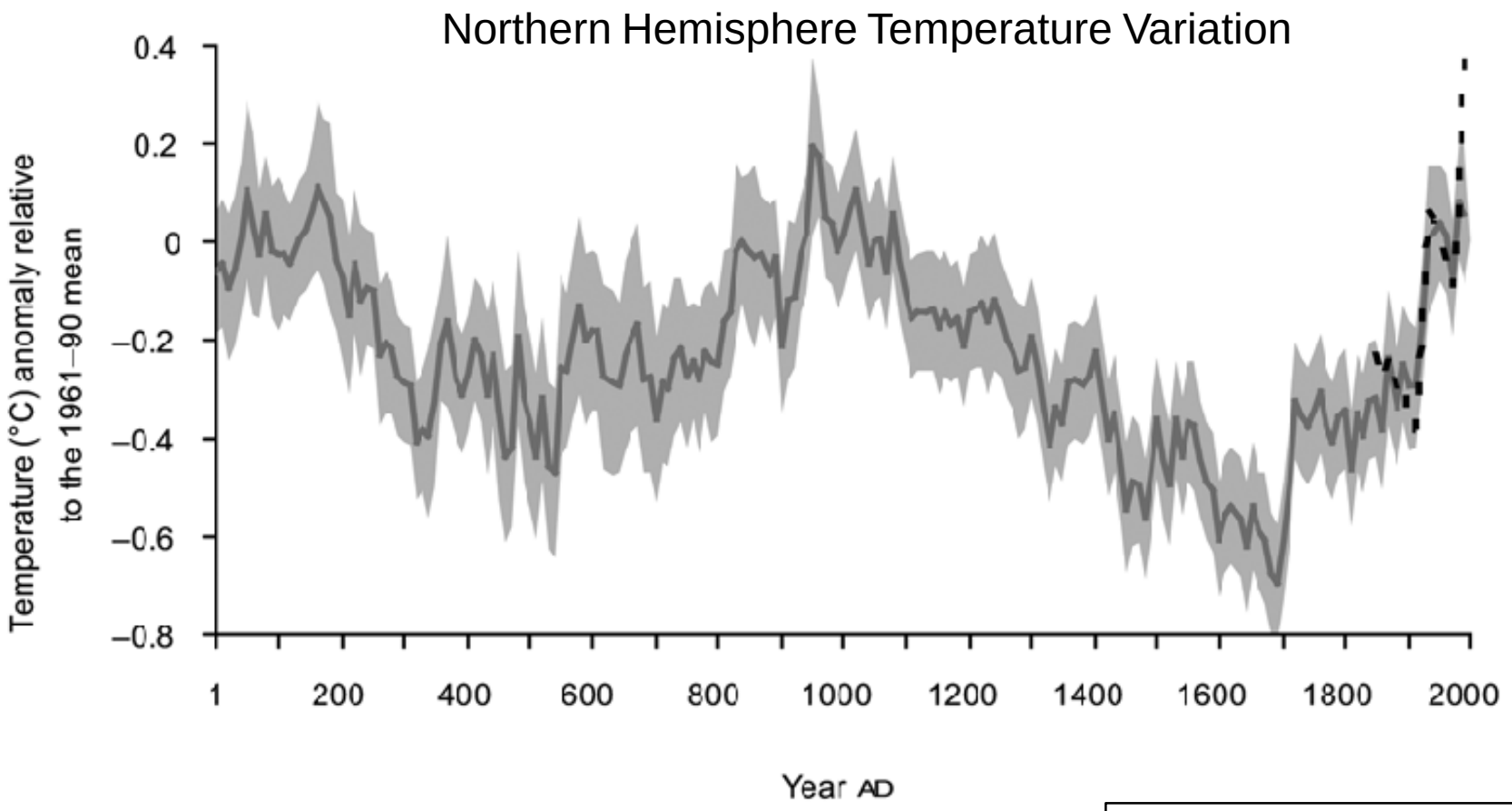


Ljungqvist Temp Reconstruction

TRCS



Ljungqvist (2010)

Simple Climate Model Fit To Temp Data

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$$dT(year) = TCS(1+\beta)LOG[C(year)/284.7]/LOG[2] + 0.302\{(1-a)dS - Sda - dQ\}$$

dT(year) = HadCRUT4 Temp(Year) - **(1850 value)** = **Models**

+ **(TCS)(1+β)**{Log[CO2(year)/284.7]/Log[2]} **(All GHG)**

+ 0.021(year – 1850)/155 **(Solar, dS)**

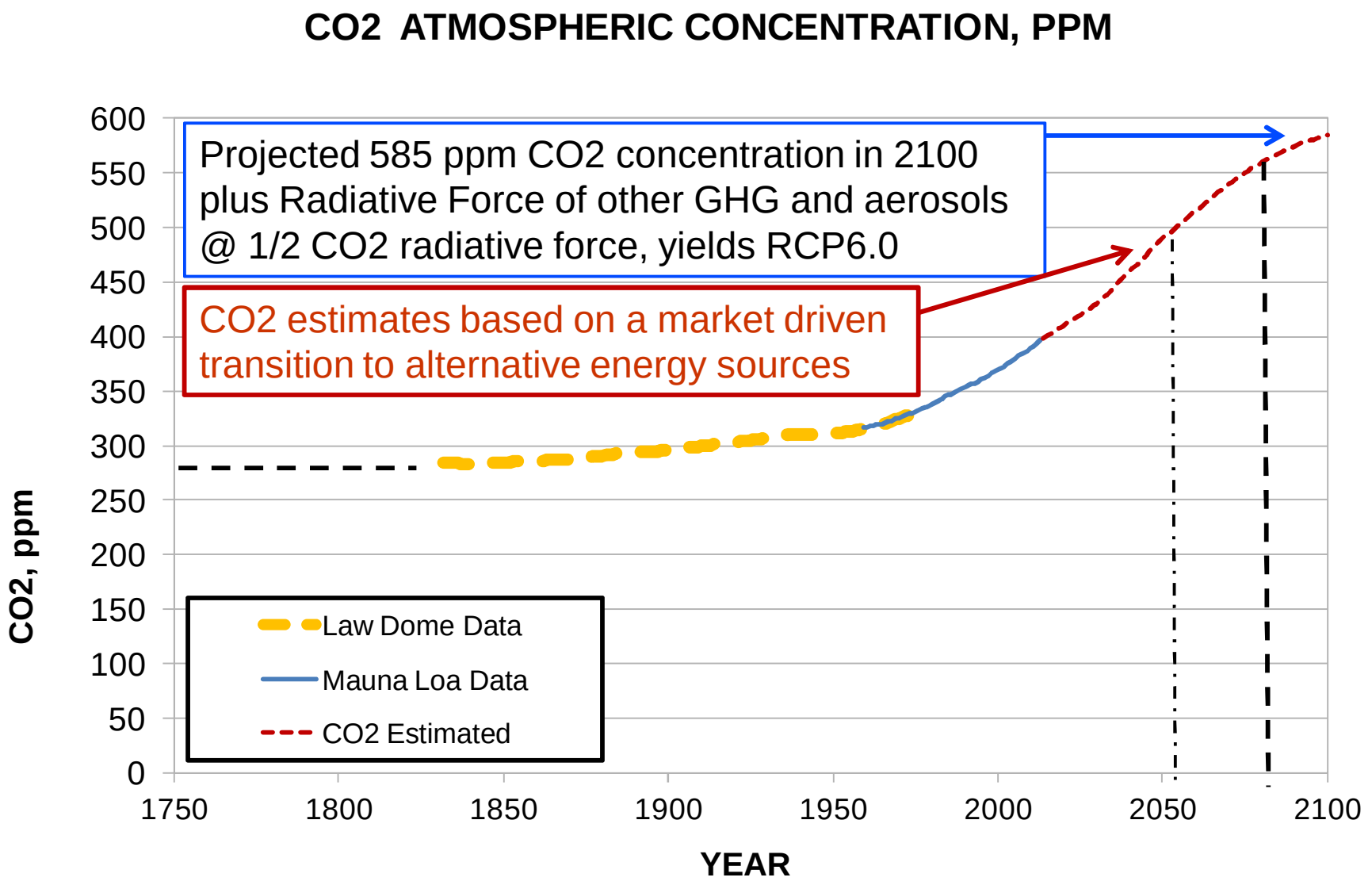
+ $\mathbf{A_L}$Sin[2π(Year-1850)/ **1000 yr.**] **(da, dQ)**

+ $\mathbf{A_S}$Sin[2π(Year-1988)/**62 yr.**] **(da, dQ)**

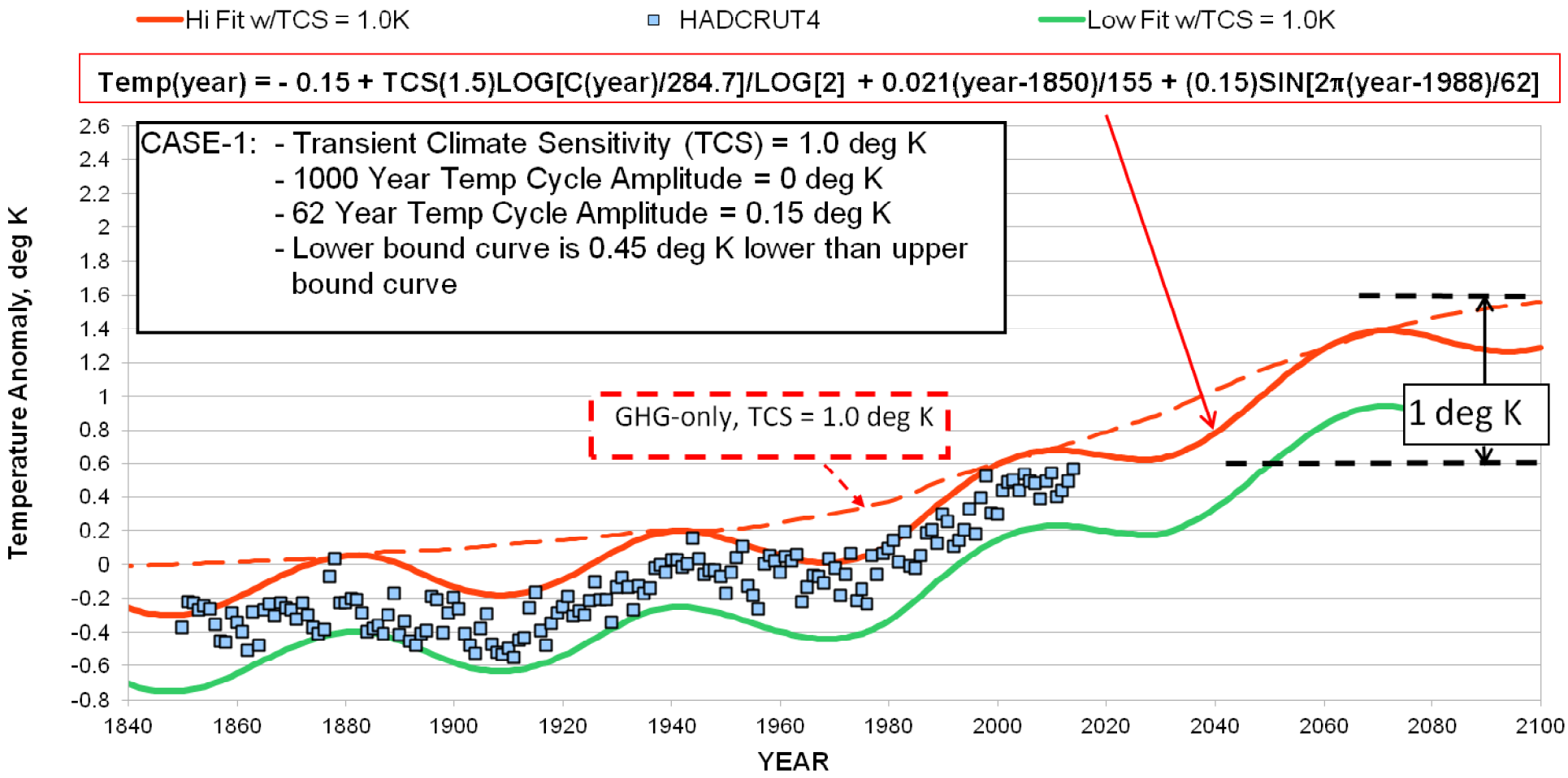
TCS(1+β) is a constant determined from function fit to temp time history data; Nominal value of **β = 0.5** used to determine **TCS**

CO2 TRENDS IN ATMOSPHERE

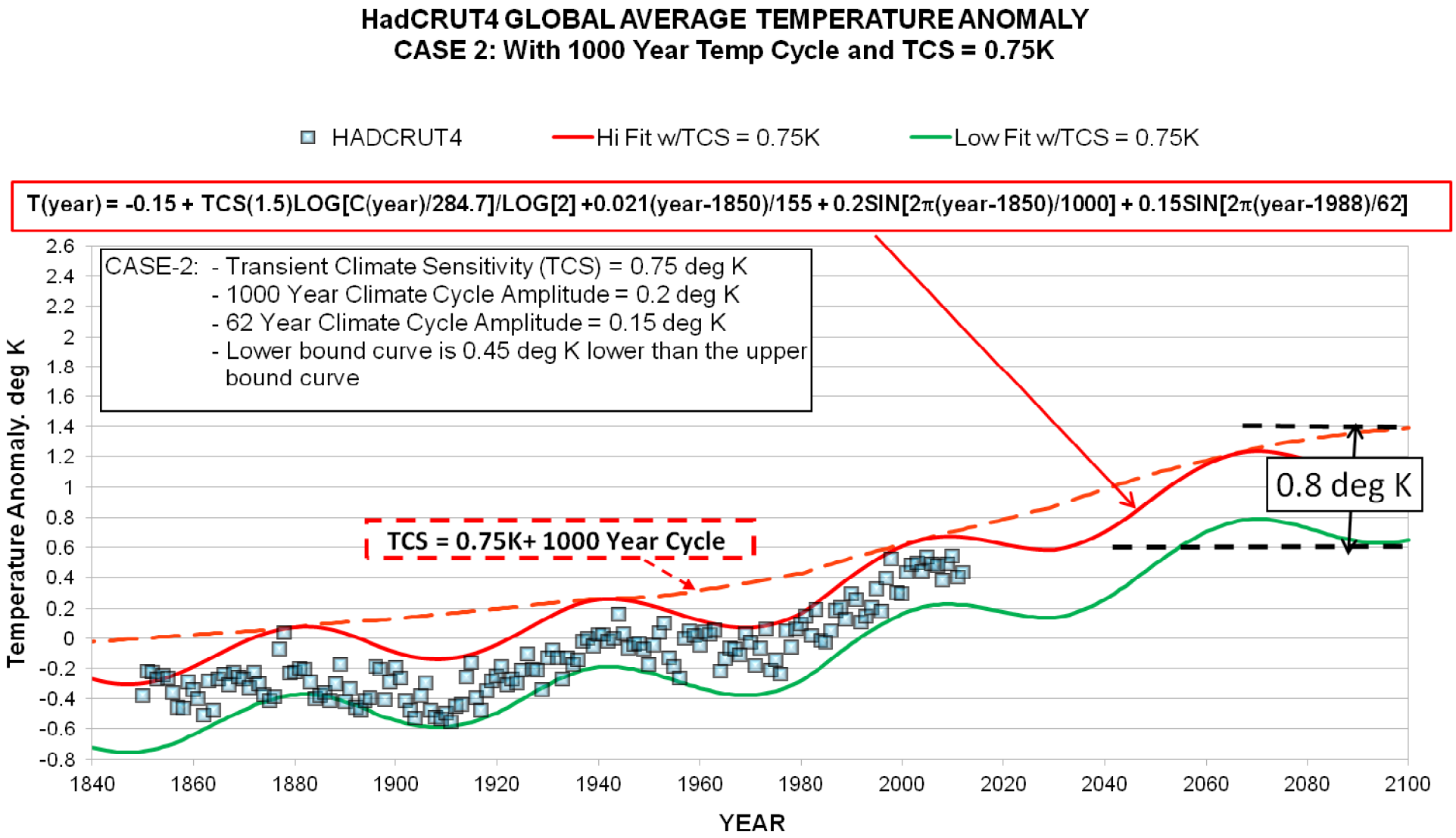
TRCS



HadCRUT4 GLOBAL AVERAGE TEMPERATURE ANOMALY
Case 1: No 1000 Year Temperature Cycle, TCS = 1.0 Deg K



With 1000 Year Climate Cycle – TCS = 0.75K



Extracting Most Conservative TCS Value

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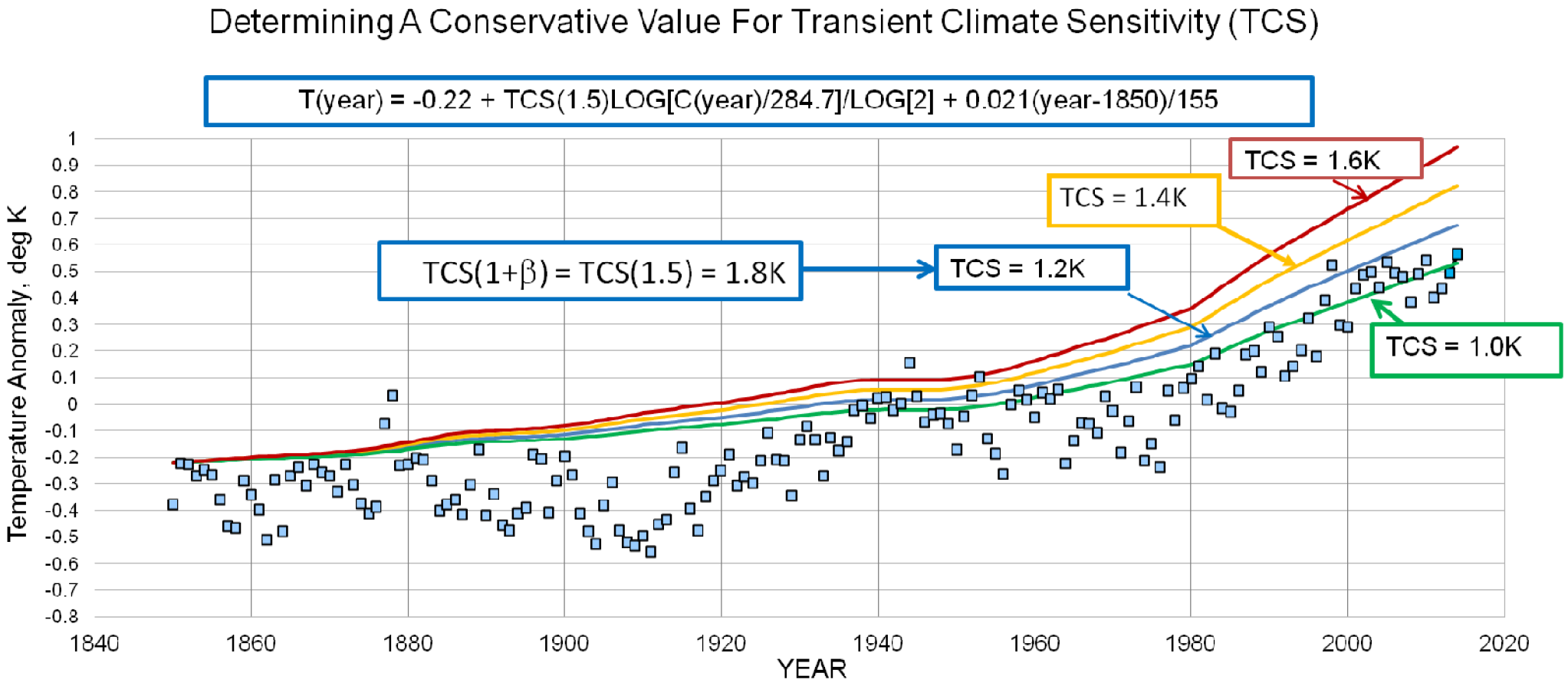

Note: Out of family "spurious" data points not bounded by **TCS = 1.2K blue** curve are known to be associated with strong, naturally occurring El Nino events such as in late 1870's and 1998. These events are noted to occur near peaks of the 62 year temperature cycle (see previous slide).

Bounding Future Warming

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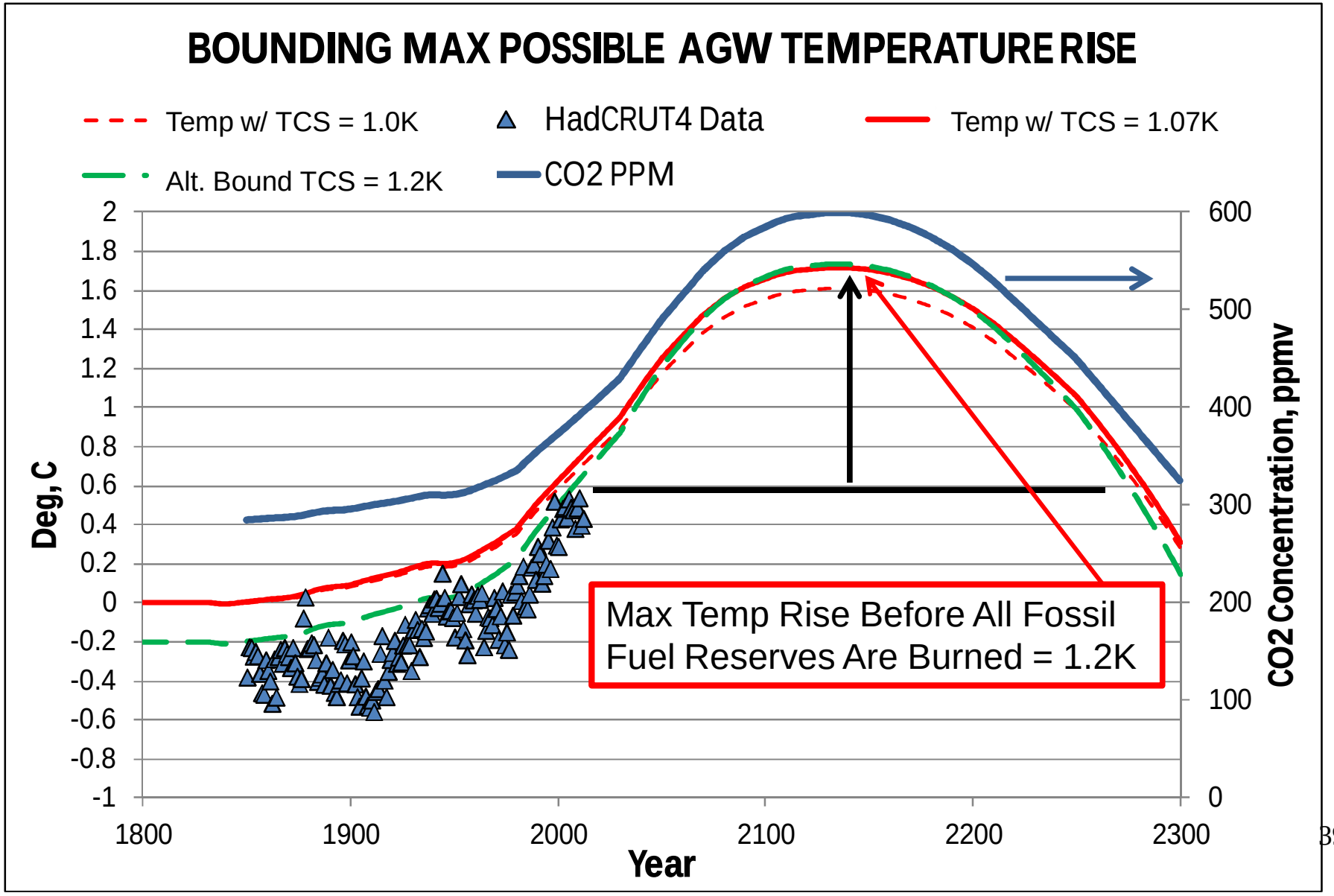

Our ECS Compared to Recent Research

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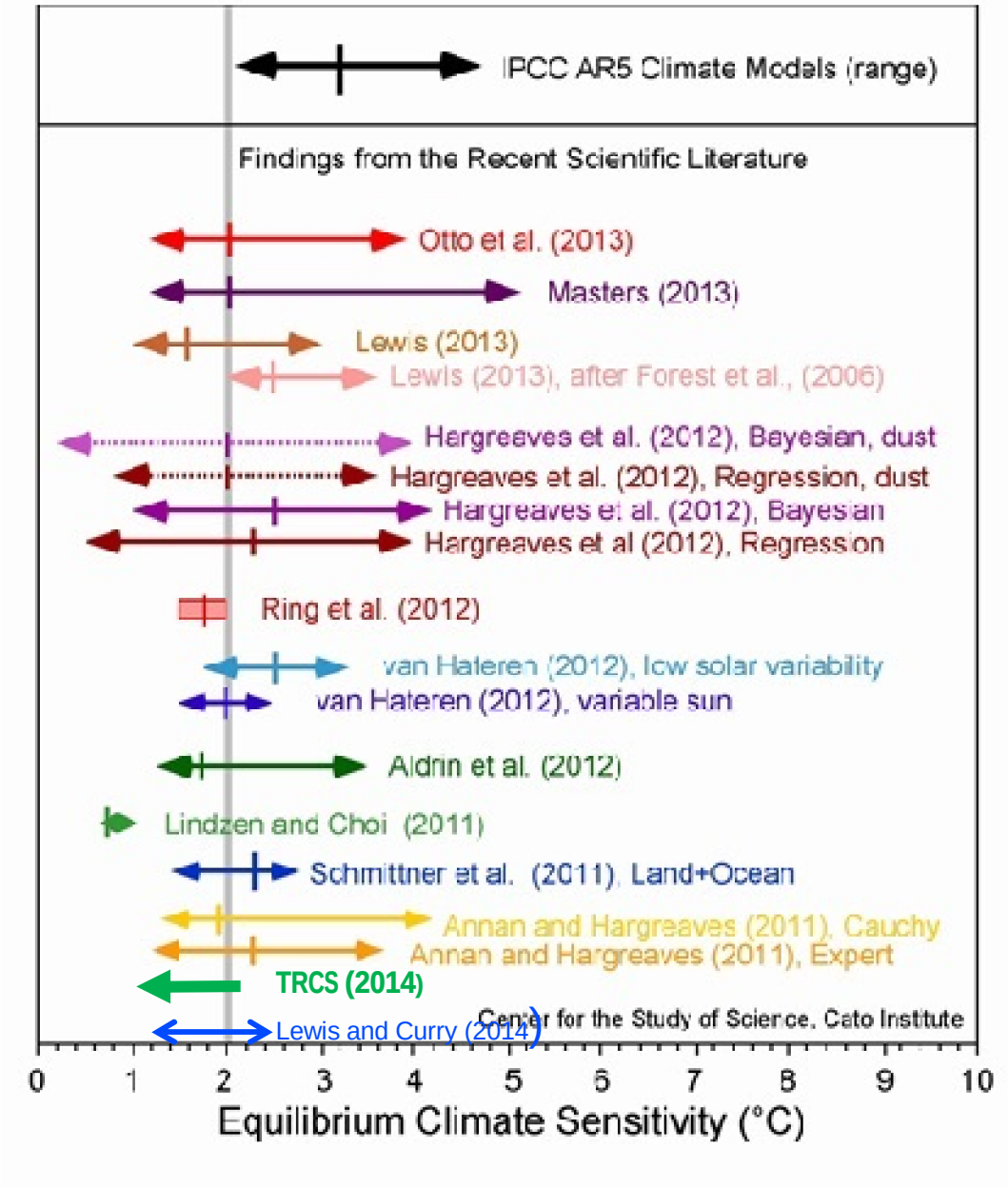

Our ECS Distribution Compared To EPA's

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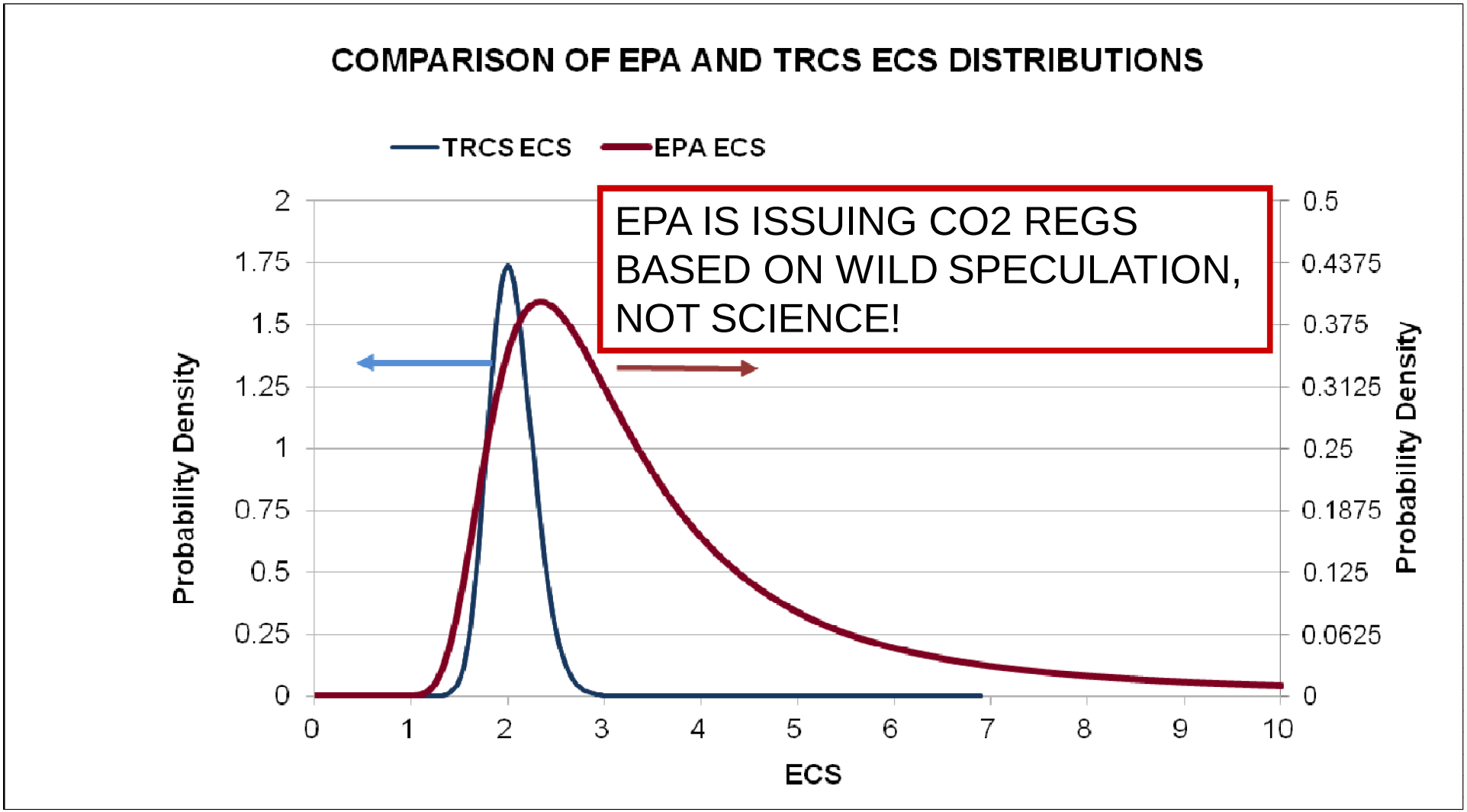

US Gov't Over-Reacting to Climate Concern

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- **Potential Problems don't require premature critical decisions with potentially severe adverse consequences**
- **EPA has already decided it must act to prevent a climate disaster**
  - **Bases its uncertain climate forecast on un-validated model predictions in United Nation's IPCC reports**
  - **Developed complex, highly uncertain and scientifically indefensible Social Cost of Carbon metric to justify benefits of CO2 emissions regulations**
- **Our nation needs an objective, scientific review of EPA Social Cost of Carbon (SCC) calculations used to justify CO2 emission regulations**

Conclusions

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- **IPCC climate models not sufficiently accurate for use in critical AGW public policy decision-making**
- **AGW can be bounded using available data**
  - **Actual climate data forecasts < 1K additional AGW by 2100**
  - **Maximum expected warming should be beneficial; not necessarily harmful**
  - **More CO2 in the atmosphere is definitely beneficial as a powerful plant fertilizer**
- **Current AGW "pause" should continue for about 20 years**
- **Economic justification for EPA and DoE CO2 emissions control regulations is based on un-validated models**

Conclusions

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- **Equilibrium Climate Sensitivity (ECS) is not an appropriate climate sensitivity metric for regulatory decisions**
  - **Currently used by EPA for 300 year forecast of AGW Temps**
  - **ECS requires > 1000 years for final ECS temp value to be reached**
  - **Atmospheric CO2 will increase and then decline as fossil fuel reserves become more difficult to find and expensive to produce**
  - **Very unlikely that CO2 in atmosphere will be rising after 2200**
  - **Need more realistic, verifiable metrics with much less uncertainty**
- **EPA's use of ECS for regulatory decisions for CO2 emissions needs independent, objective scientific review**

Recommendations

TRCS

- **We propose Transient Climate Sensitivity (TCS) as the appropriate metric to guide regulatory decisions**
  - **TCS = 1.2 deg K ; TCS(1 + β) = 1.8K (Effects of all GHG)**
  - **TCS uncertainty << ECS uncertainty << uncertainty in EPA SCC**
- **AGW forecasts need highly reliable models assessing a reasonable range of GHG emissions scenarios for the future**
  - **Our simple, rigorously derived, algebraic bounding model provides conservative projections for AGW with slowly rising GHG**
  - **Models must recognize that the earth's eco-system removes about half of the fossil fuel CO2 emissions each year**
  - **Low climate sensitivity and reasonable emissions scenarios ↓ AGW Threat**