OBJECTIVES FOR TODAY'S CLASS:

- **Address the problems of QUANTIFYING NATURE in Global Change**

- **Learn what the KEELING CURVE is, why it is important, & why "350" is an important data point on the curve**

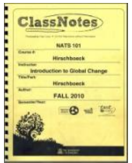
- **Review exponential relationships and the Powers of 10 (important tools to express change and vast ranges of size, speed, time, etc.)**

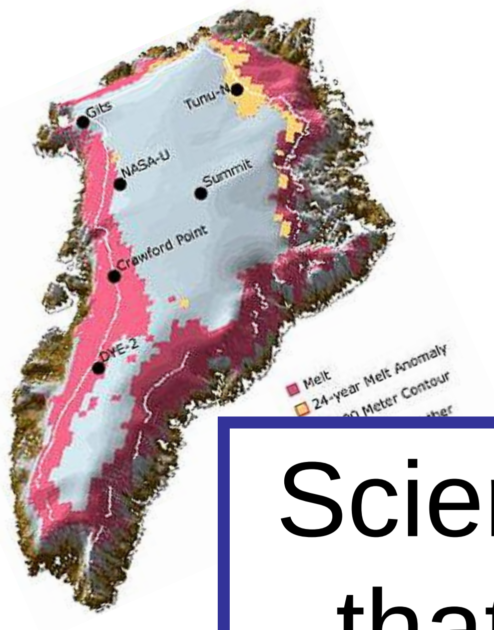
- **Learn terminology to describe changes depicted in TIME SERIES graphs**

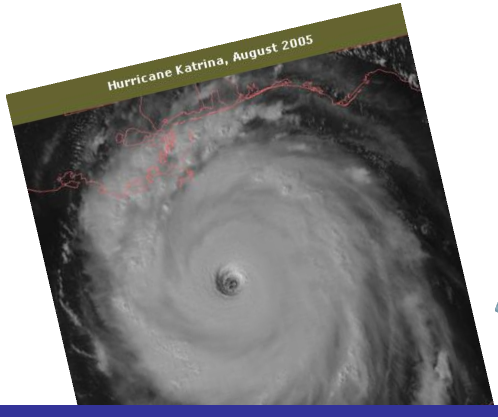
WRAP-UP OF:

Topic #1
GLOBAL CHANGE OVERVIEW
&
Topic #2
ON SCIENCE & BEING A SCIENTIST

Pick it up for Thursday's class ➔

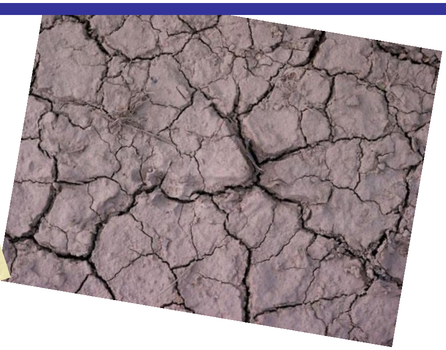






Science is demonstrating that this planet is more vulnerable than had previously been thought.

~ Richard Benedick



The Big Picture: Indicators & Issues

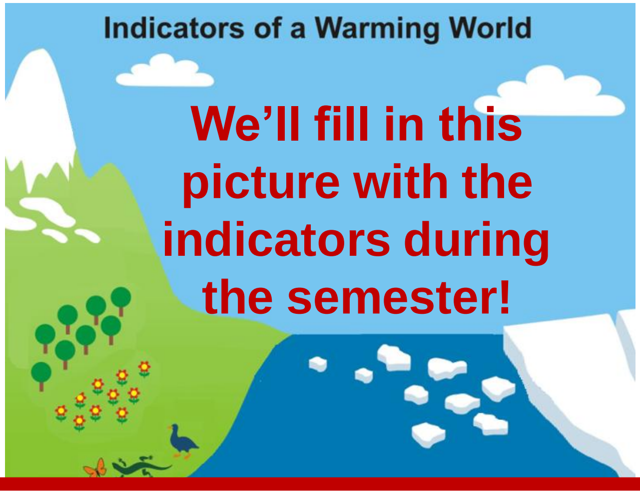
THE BIG PICTURE:
KEY INDICATORS & CONCLUSIONS BASED ON THE CONVERGENCE OF A LARGE BODY OF SCIENTIFIC RESEARCH

1. **Climate Change is real**: change has happened, change is happening, change will continue to happen in the future
2. The **Earth is warming**
3. **Humans** are causing a significant portion of this recent warming
4. The warming **will continue**
5. Globally the **net result will be bad** for people, plants, and animals
6. There are **legitimate unresolved questions**
7. There are related -- but distinctly different -- **global change processes of great concern**:
   specifically, **ozone depletion** & **biodiversity loss**

HOW DO WE KNOW ?

THE ISSUES

1-Global Climate Change = How do we know it's happening and what is causing it (human vs. natural)? How will it affect regions, people, plants, animals? Can we do anything about it?



We'll also address these issues!

2- Sustainability (ecological) = How do we use our natural resources without depleting their stocks or irrevocably damaging ecosystems and the climate for future generations?

3-Sustainability (economic) = How can economic activity progress at a rate that meets (or surpasses) the needs of the planet and its population?

4. Choices & Solutions (Mitigation & Adaptation) = Are (2) and (3) above at cross-purposes? What realistically effective actions can individuals and institutions take to address these issues?

The most used "denier" arguments about the causes and effects of climate change **:**

Climate's changed before

It's the sun

It's not bad

It's cooling

There is no consensus

Models are unreliable

Temp record is unreliable

Animals and plants can adapt

It hasn't warmed since 1998

And so forth. . . . .

We'll talk about what the science says about these!

From:
http://www.skepticalscience.com/

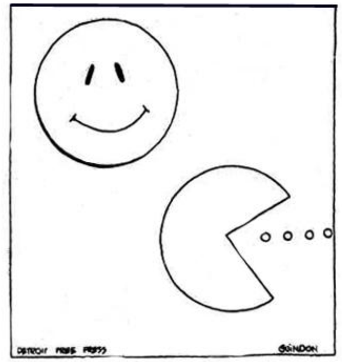
METHODS USED IN GC SCIENCE

- Experiments
- Observations
- Modeling
- Standard "tools of science"-- hypotheses, prediction, testing, theories

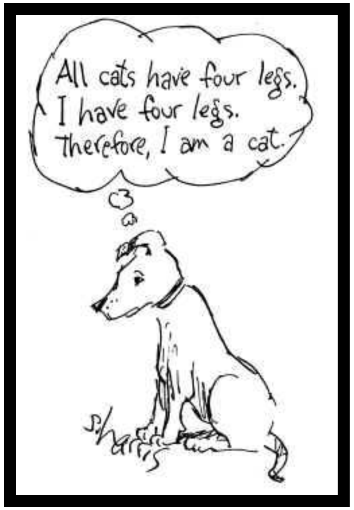
Any unique to GC??

- **Global Computer / Circulation Modeling: GCMs**
- **Determining Past Changes from "Natural Archives" (e.g. tree rings)**
- **Remote Sensing of the Environment**

PART A: CARTOONS ABOUT SCIENCE & SCIENTISTS:



In the year 2074, A.D., a curator at the Museum of Modern Art in New York will conclude that the happy face and Pac-Man were done by the same artist.



"IT STARTED WITH A SIMPLE CASE OF PEER-REVIEW."

"IT'S OUR NEW ASSEMBLY LINE. WHEN THE PERSON AT THE END OF THE LINE HAS AN IDEA, HE PUTS IT ON THE CONVEYOR BELT, AND AS IT PASSES EACH OF US, WE MULL IT OVER AND TRY TO ADD TO IT."

PART B: PHRASES ABOUT SCIENCE FOR MATCHING:

__5___ Curiosity & self-discovery tend to motivate scientists *(“Ask questions! . . ” Paul Ehrenfest)*

__4__ Dedicated & persistent research yields benefits *(“No, it’s a great life . . .” Steven Weinberg)*

__2__ Scientists are attracted by the wonder, awe, & joy found in their research *(“The joy of insight . . .” Victor Weisskopf)*

__1__ Inspiration emerges from a well-informed mind *(“Newton’s . . act of the prepared imagination” John Tyndall)*

__7__ Theories cannot be verified, but they can be falsified *(“No amount . . . can prove me right . . .” Albert Einstein)*

__3__ Self-deception can color an observation *(“ ...art to be learned -- not to see what is not.” Maria Mitchell)*

__6__ Knowledge is ever-changing *(“law of change ... Nature never stands still ...” Laurence Gould)*

Topic #3 QUANTIFYING GLOBAL CHANGE:

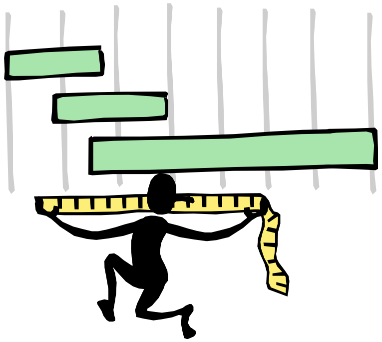
Scale, Rates of Change, Time Series Plots & Footprints

"The one universal ever-operating law throughout has been the law of change . . ."

~ Laurence M. Gould

On QUANTIFYING NATURE

- ***Quantify*** **(def) = to make explicit the logical quantity of; to determine, express, or measure the quantity of**



No page # ?

(Listen and/or take notes. You can review the slide in Class Follow-Up later)

. . . On Quantifying Nature

PROBLEM: Scientists are faced with a major problem when they try to quantify nature:

- **Enormous RANGE of spatial and temporal SCALES.**
- **Enormous range in the NUMBERS of things.**
- **Nature CHANGES in different ways and at different RATES.**

. . .On Quantifying Nature

We need a way to:

Express Earth and Global Change processes mathematically

To sort out the causes of global change

Remember: GC is not a "LABORATORY SCIENCE"

YOU & I ARE LIVING THE EXPERIMENT
– one unrepeatable experiment!

. . .On Quantifying Nature

Hence global change scientists use:

mathematical expressions
equations
symbols
models &

SCIENTIFIC NOTATION: e.g., 6.4×10^{-9}
to measure, analyze, and
"run experiments" on the Earth.

NOTE: This is a short Scientific Notation Review on p 14 of CLASS NOTES – see also examples in SGC E-text Chapter 2 on Atoms

POLITICS vs EQUATIONS ?

"Yes, we have to divide up our time like that, between our politics and our equations.

But to me our equations are far more important, for politics are only a matter of present concern.

A mathematical equation stands forever."

~ Albert Einstein

Through quantifying change over time . . . .

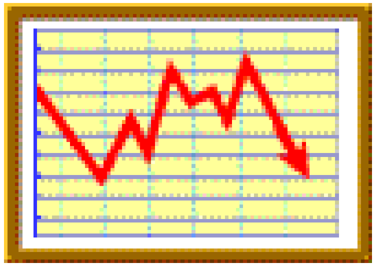
How can claims like these be evaluated?

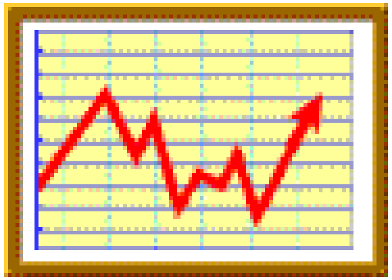
. . . in a "Time Series" plot

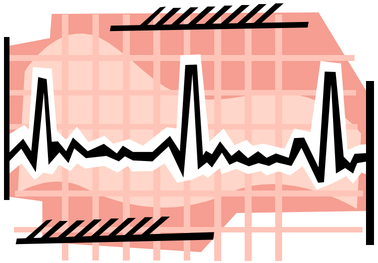
Quantifying Change over TIME:

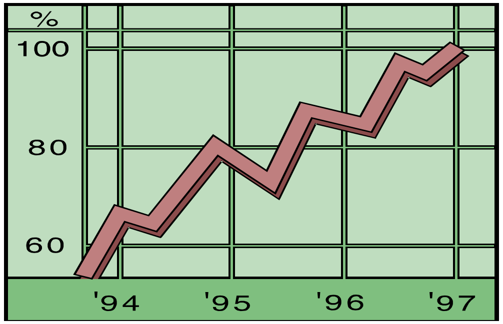
To quantify global change we examine TIME SERIES CHANGE:

A time series is a plot of value of some variable (x) at each point in time (t):









Quantifying Change over TIME:

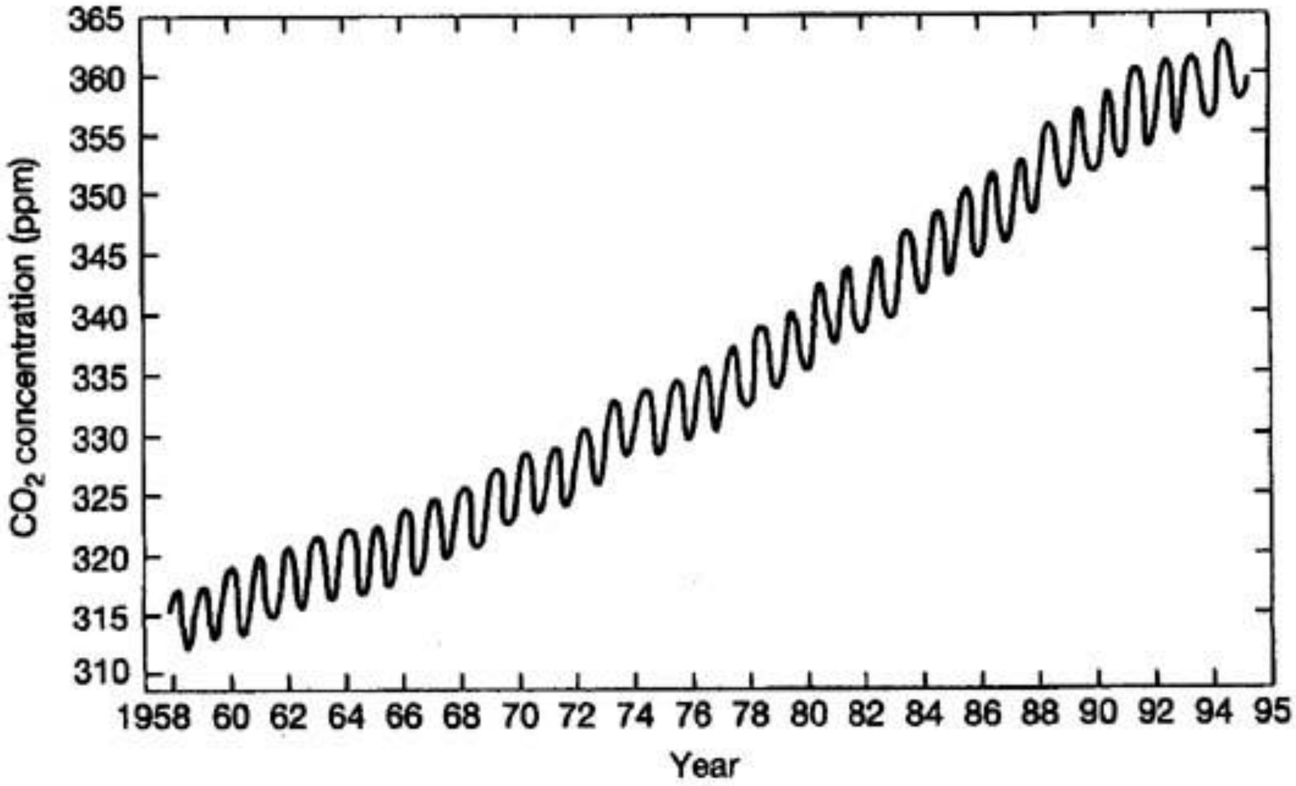
We also need to quantify
RATES OF CHANGE:

Change in some variable (x)
per change in time (t)

d(x) / d(t)   where d = "change in,"

x = a variable, t = time

e.g. the "Keeling curve"



"the average rate of increase of CO^2 concentration since 1958 has been 43 ppm / 37 yr (or about 1.2 ppm/yr)"

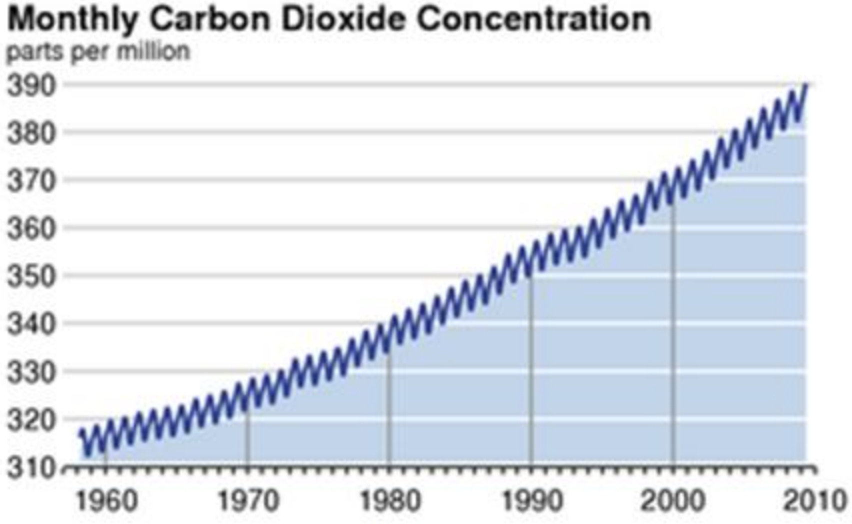
ppm = parts per million

WELCOME TO SCRIPPS CO2

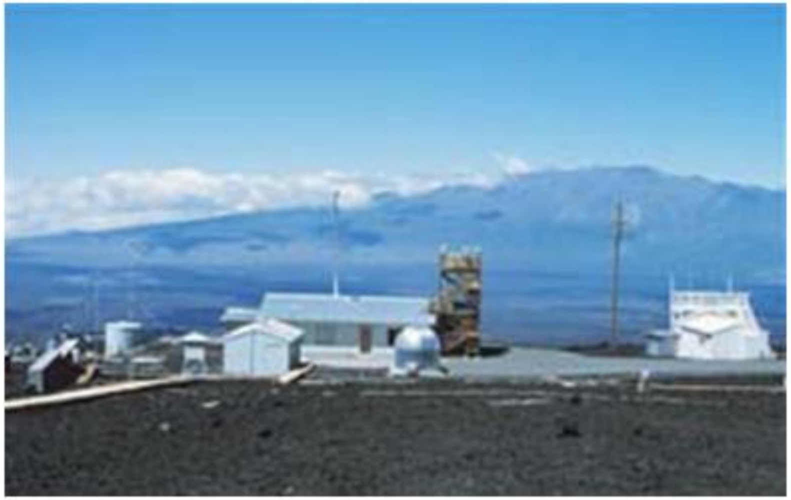
Welcome to the Home of the Keeling Curve

This site is dedicated to Dave Keeling, the first person to make high precision continuous measurements of carbon dioxide levels in the atmosphere.

CO_2 Concentration at Mauna Loa Observatory, Hawaii

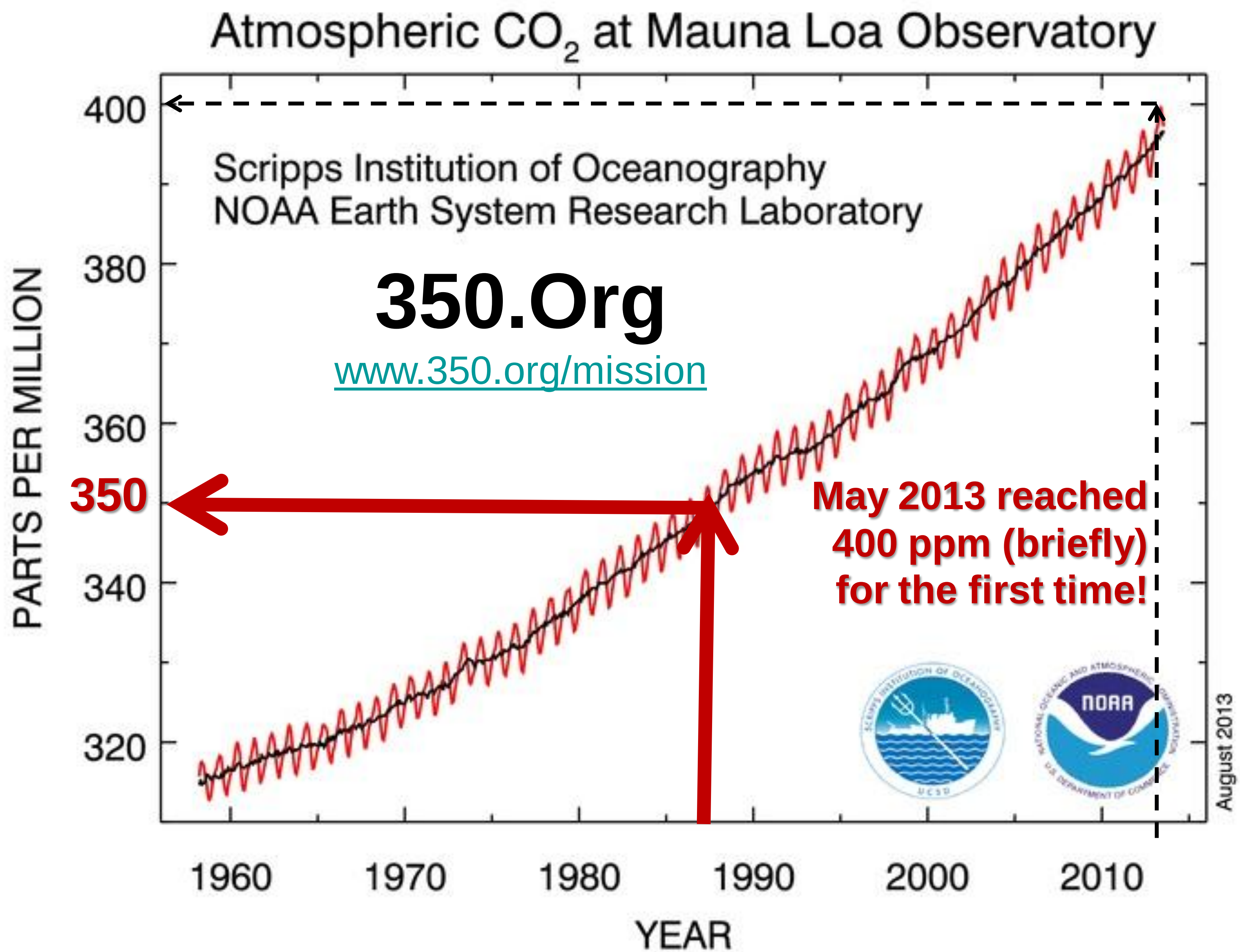


Keeling Curve



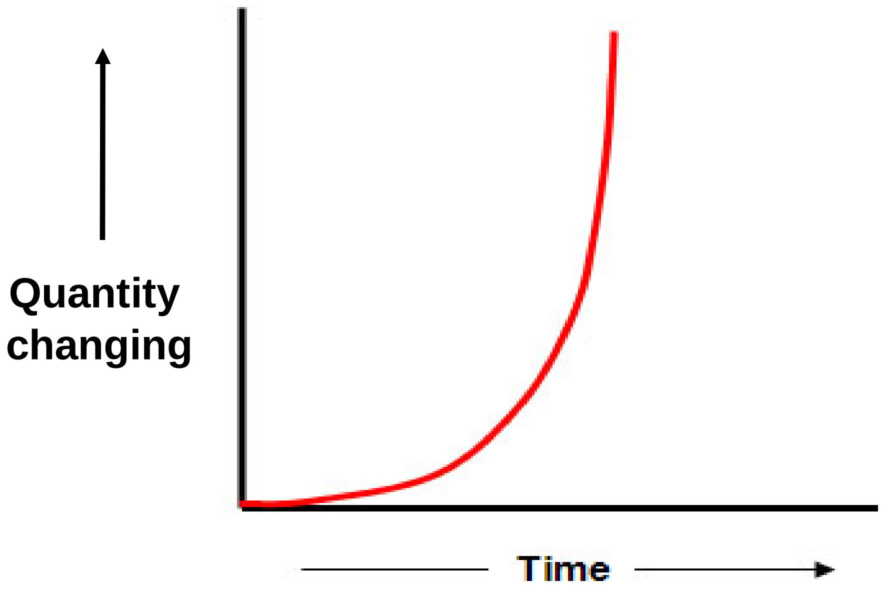
Mauna Loa Observatory

http://scrippsco2.ucsd.edu/



Graph is from: http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo

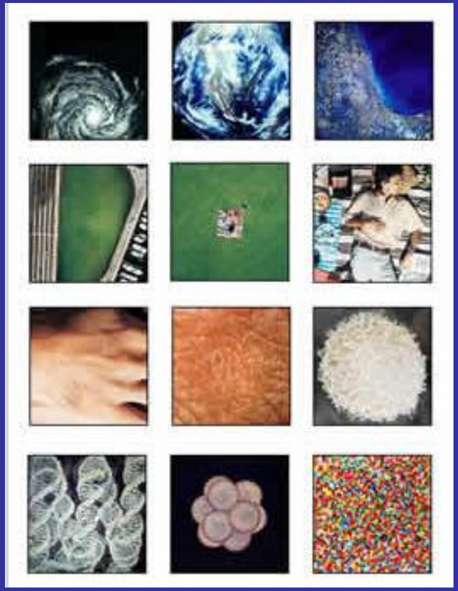
Powers of 10 can be used to express exponential rates of change



A Classic Video on
The Relative Spatial Scale of Things:

"POWERS OF 10"

http://www.powersof10.com/film

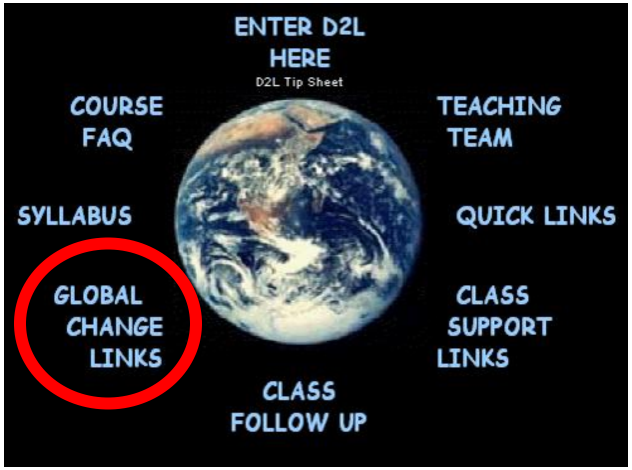


"In 1977, Charles and Ray Eames made a nine-minute film called Powers of Ten that still has the capacity today to expand the way we think and view our world. Over ten million people have since seen the film . . . ."

"Eventually, everything connects."

- Charles Eames

THINKING MORE DEEPLY: ABOUT "POWERS OF 10" via WEBSITES:



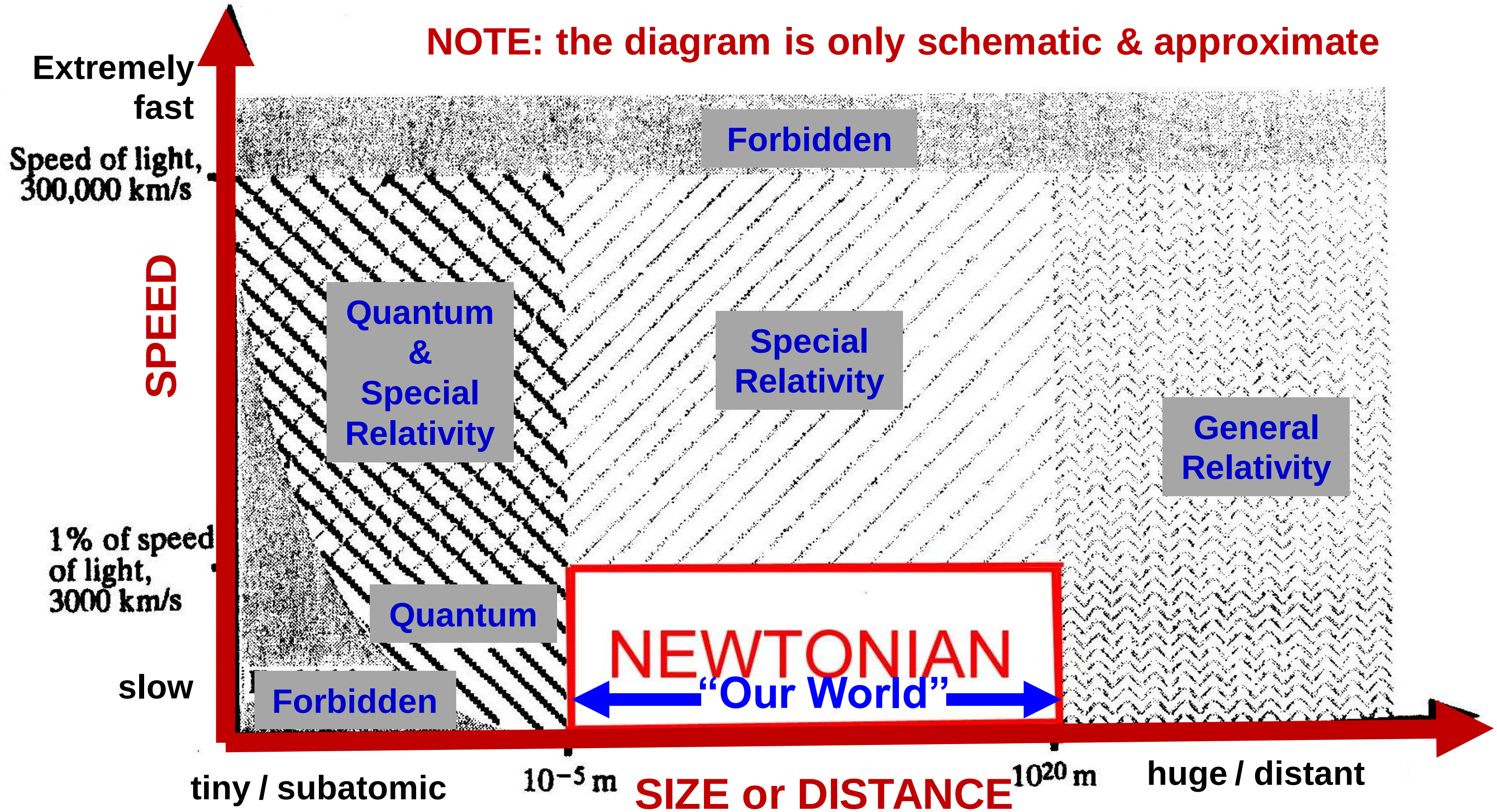
Powers of 10 -- classic video

Powers of 10 website - updated website companion to the classic video by Charles & Ray Eames

Cosmic View: The Universe in 40 Jumps - online version of classic book by Kees Boeke

Powers of 10 Interactive Tutorial - an online Java journey -- similar to the video

The Relative Scale of Things



Newtonian physics breaks down for very SMALL objects, very LARGE objects, & very FAST objects.

Newton's laws of motion also break down for strong gravitational forces, such as those near a neutron star or black hole.

IN-CLASS ACTIVITY

"Think-Pair-Share"
Exercise on:
PLOTTING CHANGE OVER TIME

RECOGNIZING & DESCRIBING DIFFERENT TYPES OF CHANGE AS DEPICTED IN TIME SERIES PLOTS

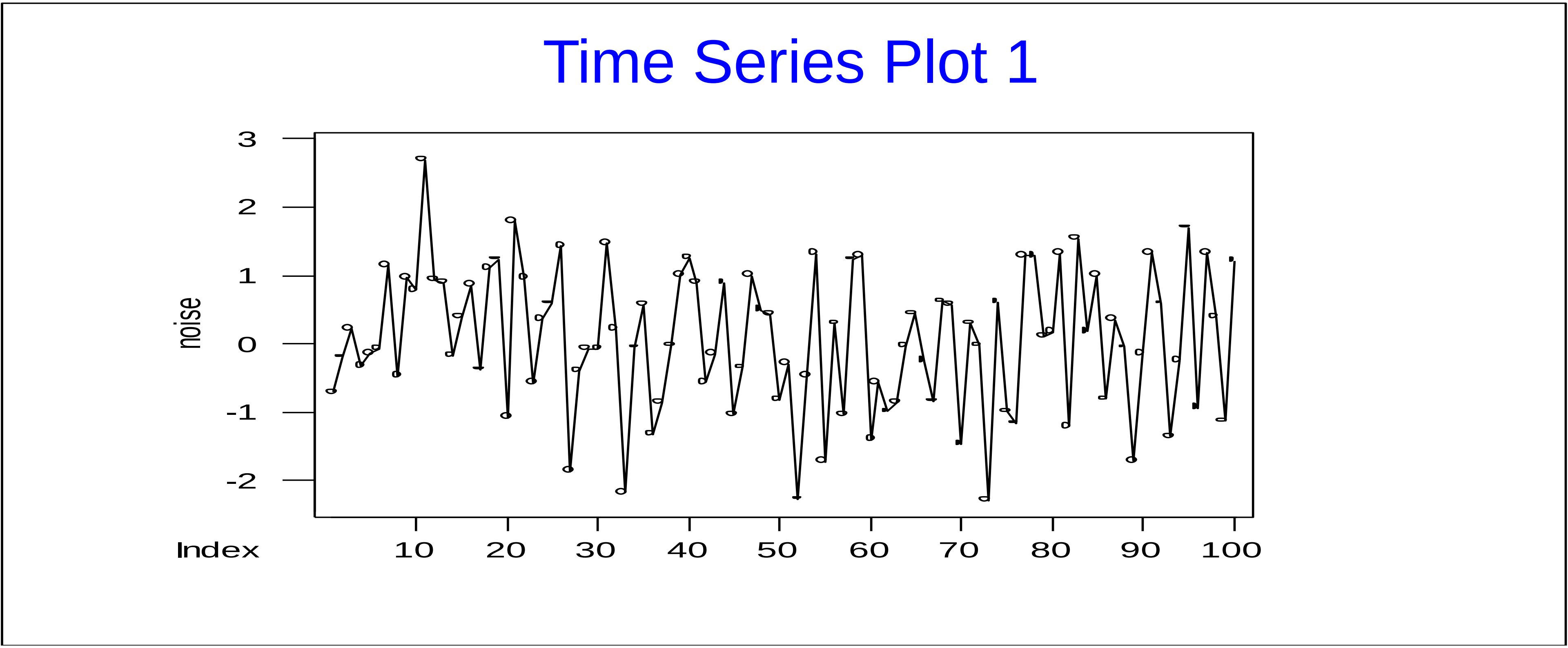
Here are some terms that will help you describe time changes more precisely in fewer words:

- **Mean** = average (a constant mean stays the same over time and looks like a horizontal line.)
- **Variance** = the range of fluctuations (wiggles) above and below the mean (statistically the variance is the square of the standard deviation about the mean)

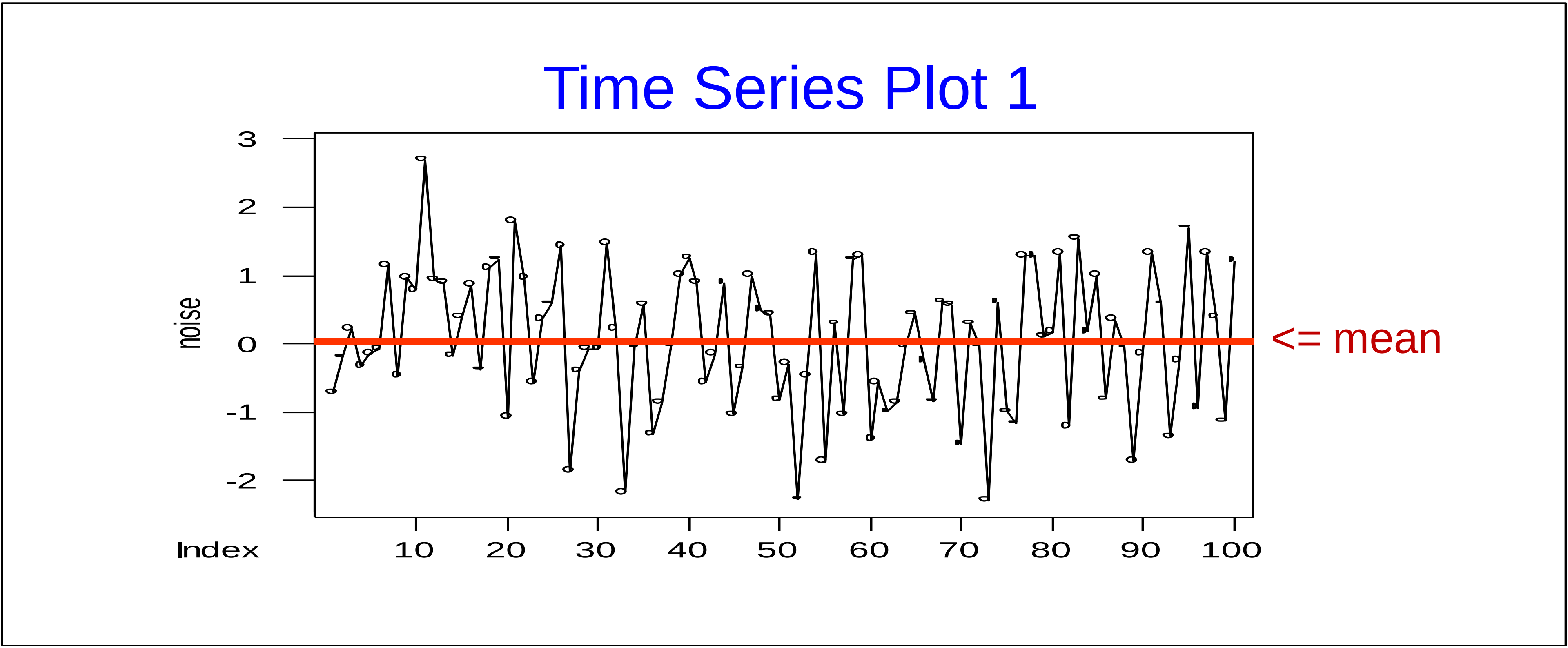
Terms (cont.)

Periodic = perfect oscillations (fluctuations) (going up and down regularly or in a perfect wave-like motion)

- **Quasi-periodic** = almost regular oscillations (in nature things are quite often quasi-periodic rather than perfect oscillations)
- **Trend** = a line of general direction (increasing or decreasing)

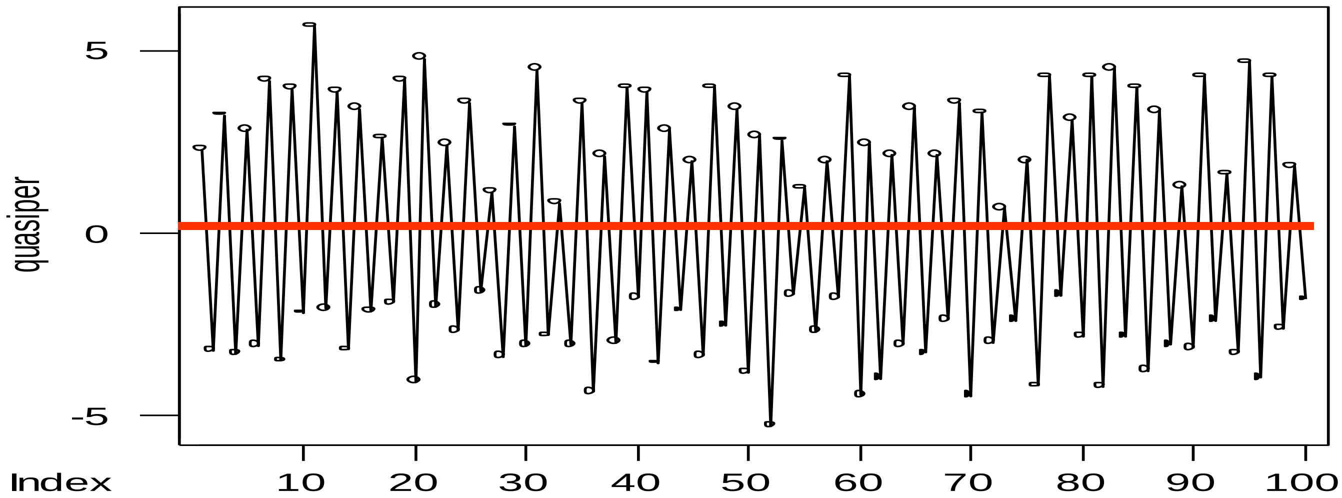


Draw in the MEAN line for this time series.



“White Noise” or “Random”plot -- This plot appears to go up and down without any regular pattern (e.g., randomly); there are about as many points above the time series mean (average) as below; and the range of wiggles (variance) above and below the mean seems to be about the same over time.

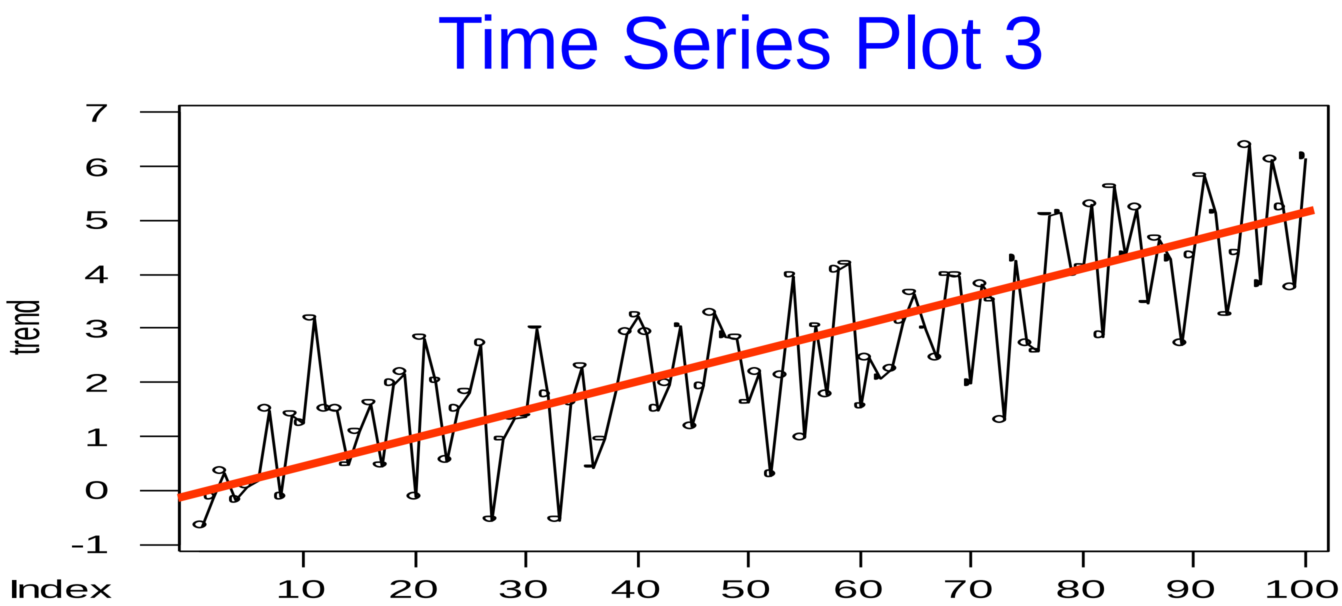
Time Series Plot 2



Regular ups and downs . . . but not perfect . .

Is the mean constant?

Is the variance constant?

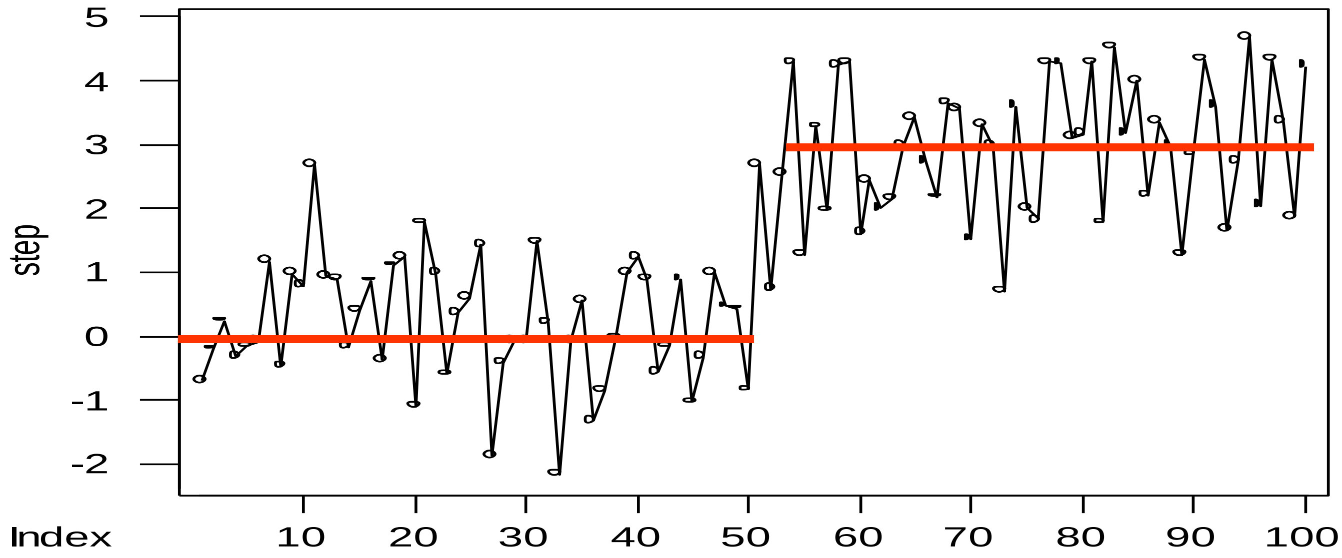


Hmmm, something is changing here . . .

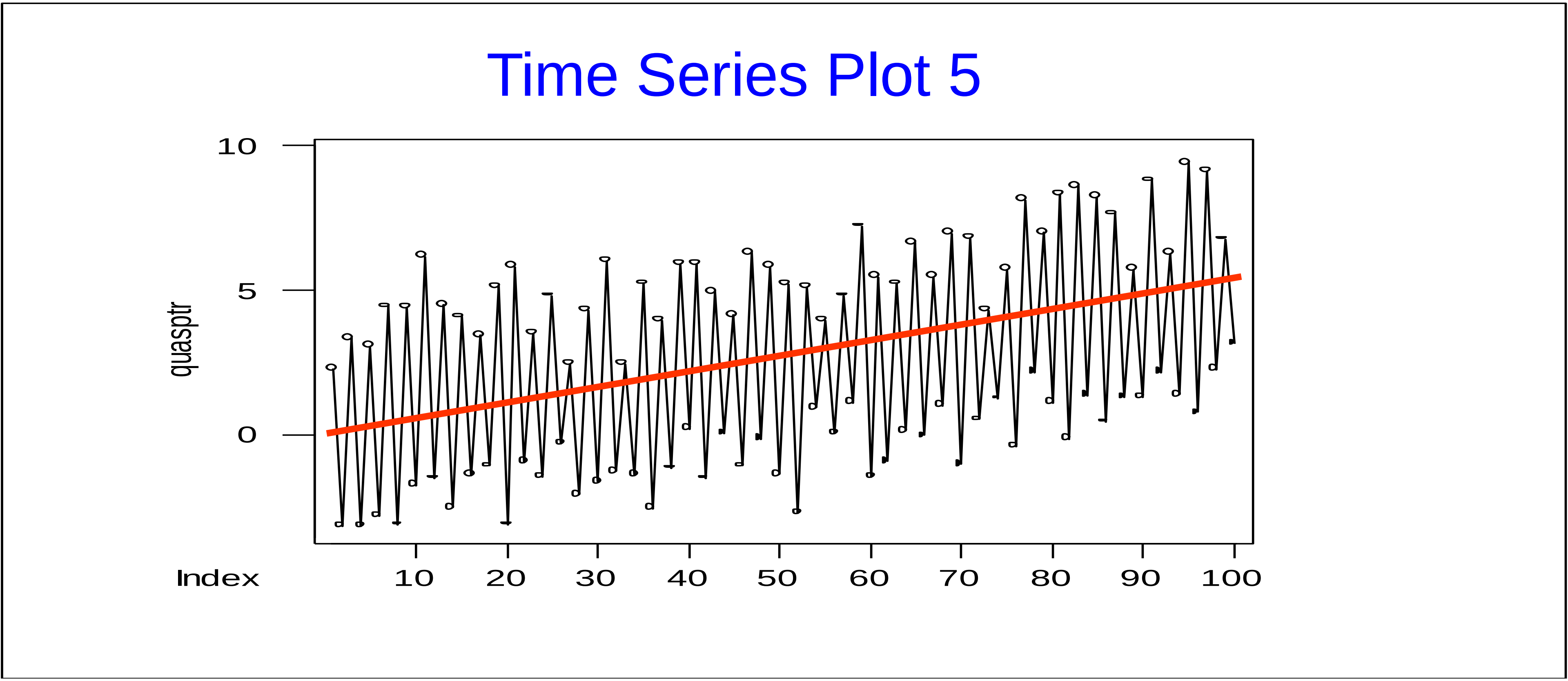
What's happening to the mean?

Is the variance constant?

Time Series Plot 4



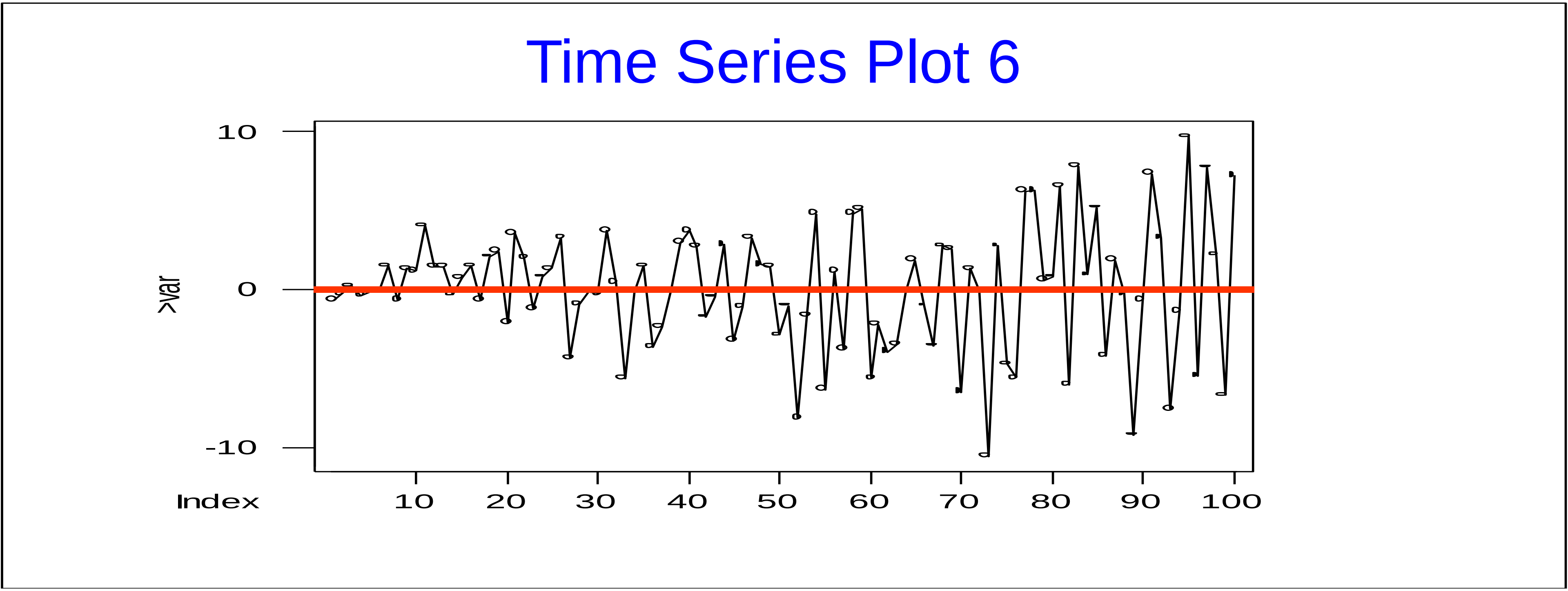
Looks a little like a "set of stairs" with an abrupt jump between two series, each with a constant __________



Looks like Plot #3, but it's different – in what way?

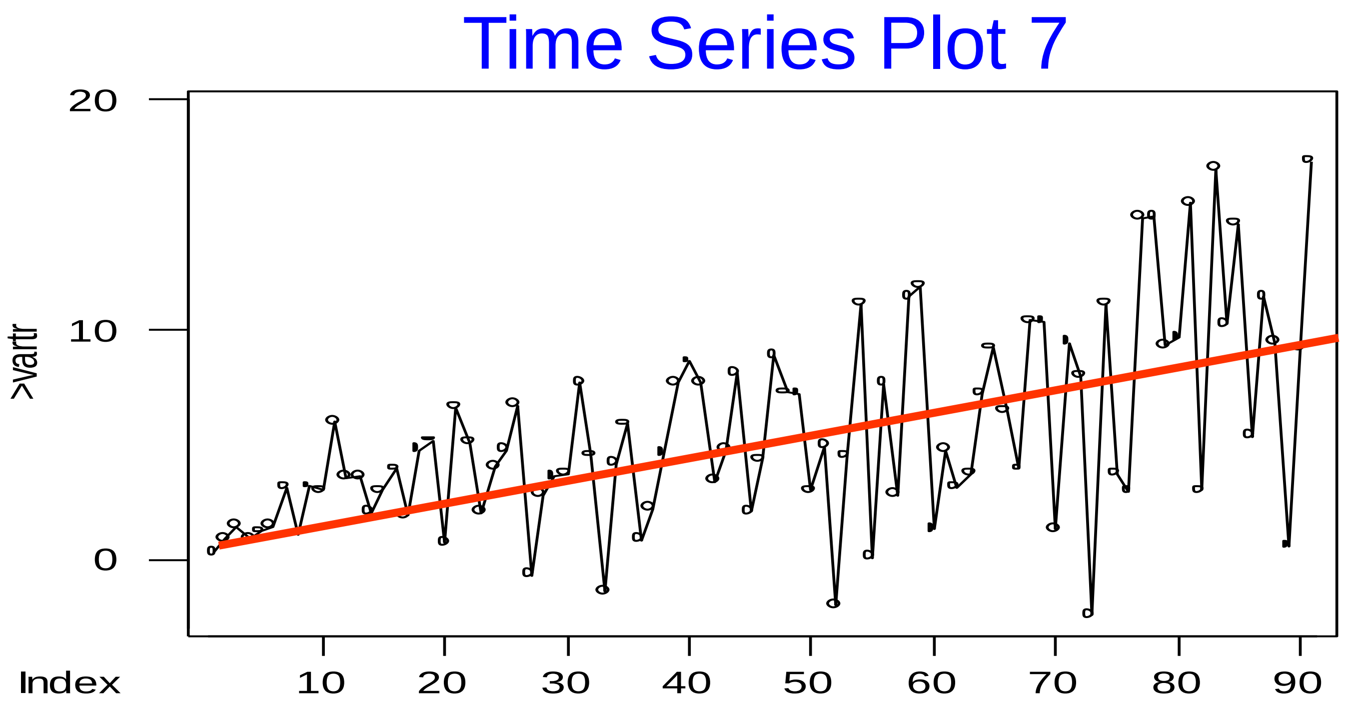
What's going on with the mean?

The variance?



What's going on with the mean?

The variance?

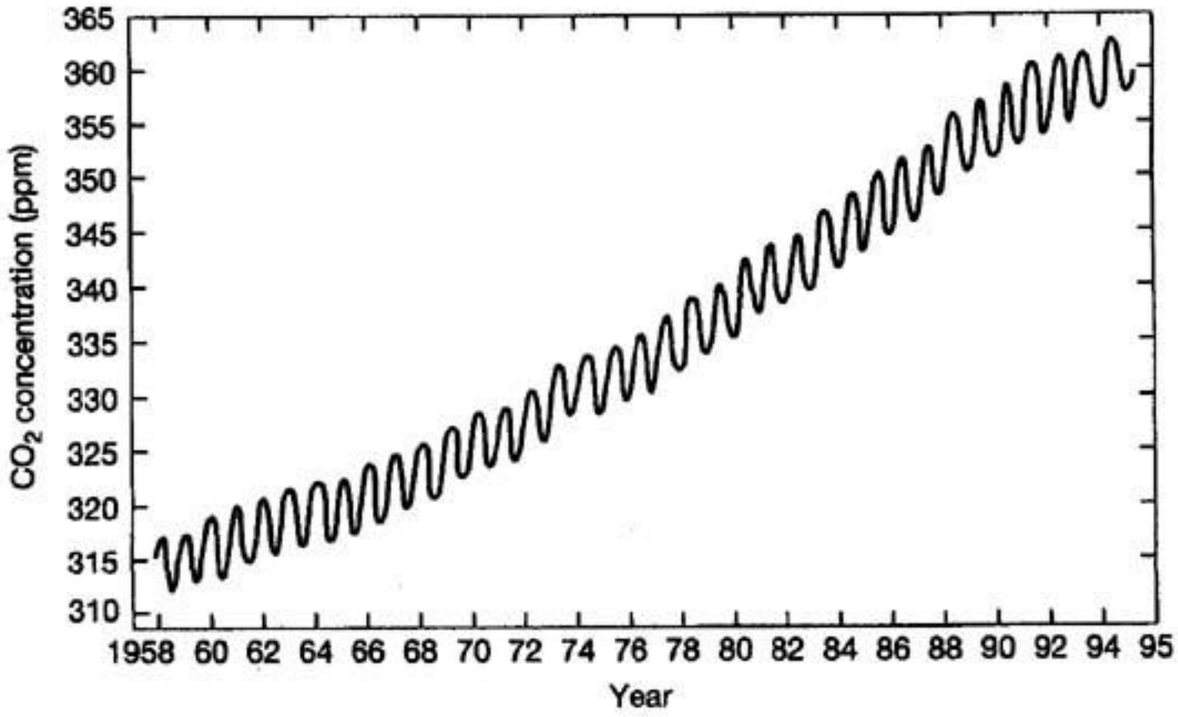


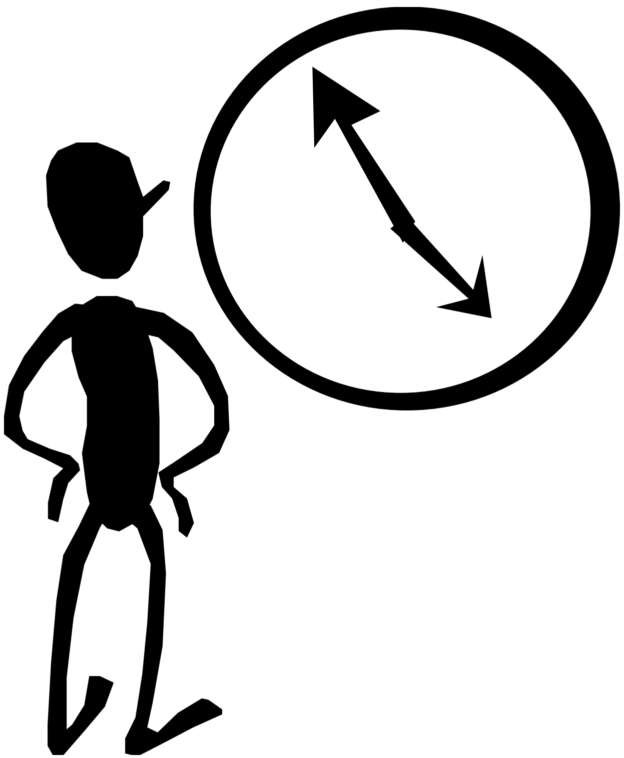
Is there a trend?

What’s going on with the mean over time?

What’s going on with the variance?

the “Keeling curve” is most like Plot # ____ ?

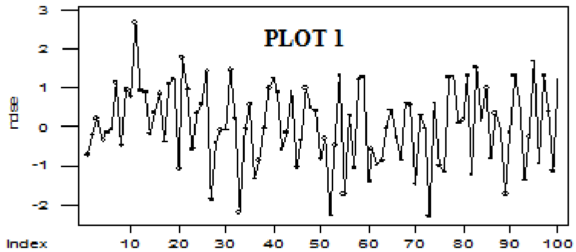




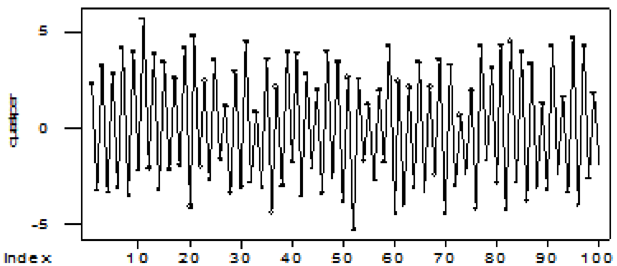
IT'S TIME TO END YOUR DISCUSSION . . .

PLEASE WRAP IT UP AND QUIET DOWN.

ANSWERS TO TIME SERIES GRAPHS

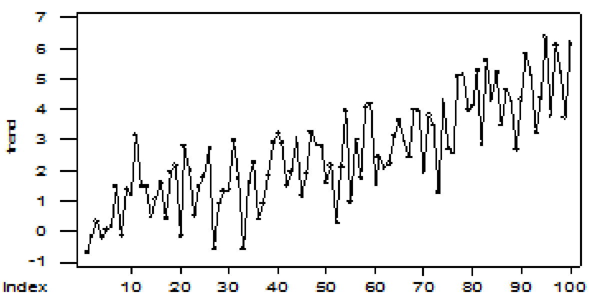


PLOT #1: “White noise” (random fluctuations) but with constant mean and variance *[answer given for you]*



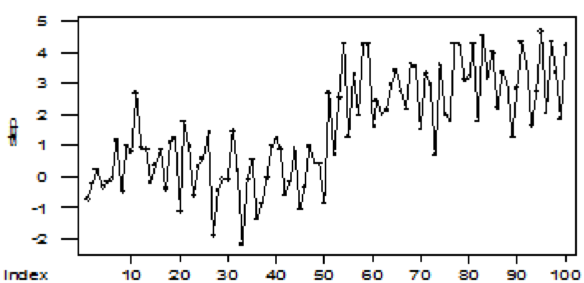
PLOT 2

PLOT #2: “Quasi-periodic plot” with constant mean and variance.
[Graph goes up and down very regularly (periodically); the mean stays the same, the range of fluctuations above and below the mean stays about the same over time.]



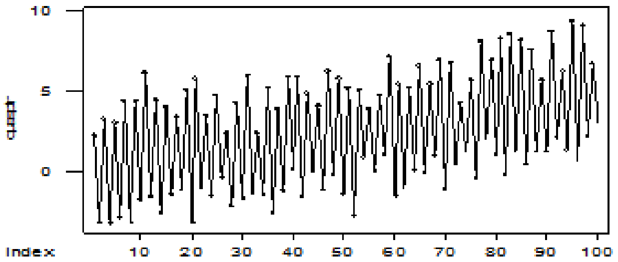
PLOT 3

PLOT #3: “Trend” plot with the mean increasing over time, but a constant variance. *[Graph shows trend of increasing values and increasing mean; the range of fluctuations is about the same.]*

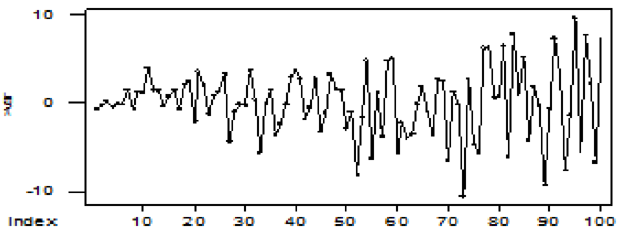


PLOT 4

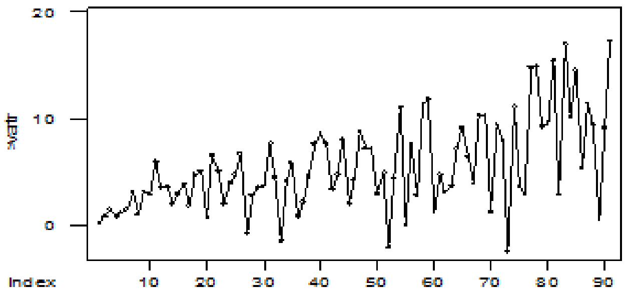
PLOT #4: “Step Change” plot with an abrupt jump between two series like Plot 1.
[Graph shows a “jump” or abrupt change between two different time series, each having a constant mean and variance]



PLOT 5



PLOT 6



PLOT 7

PLOT #5: “Quasi-periodic with upward trend” plot

[Graph shows an increasing trend and increasing mean, but has regular periodic ups and downs above and below the increasing mean.]

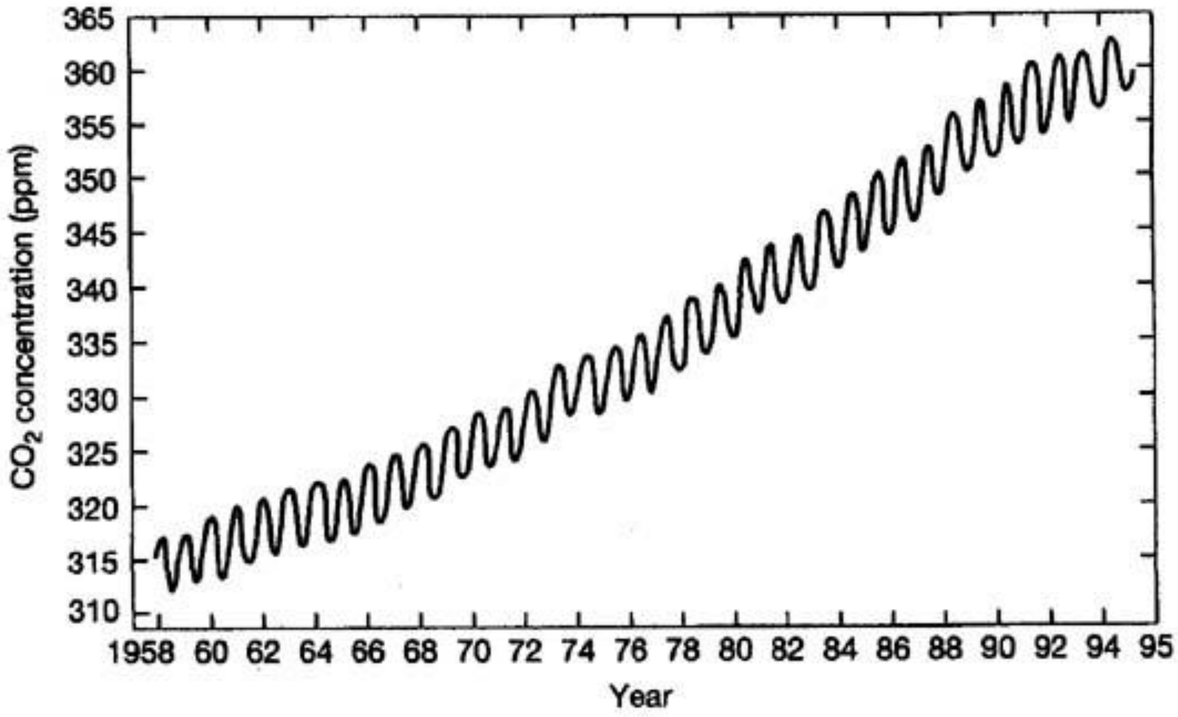
PLOT #6 “Increasing variance but constant mean” plot.

[Graph’s mean is constant but the range of fluctuations above and below the mean increases over time.]

PLOT #7 “Trend with increasing mean and increasing variance” plot

[Graph had both an increasing mean and an increase in the range of fluctuations above and below the mean over time – the extremes are getting bigger!]

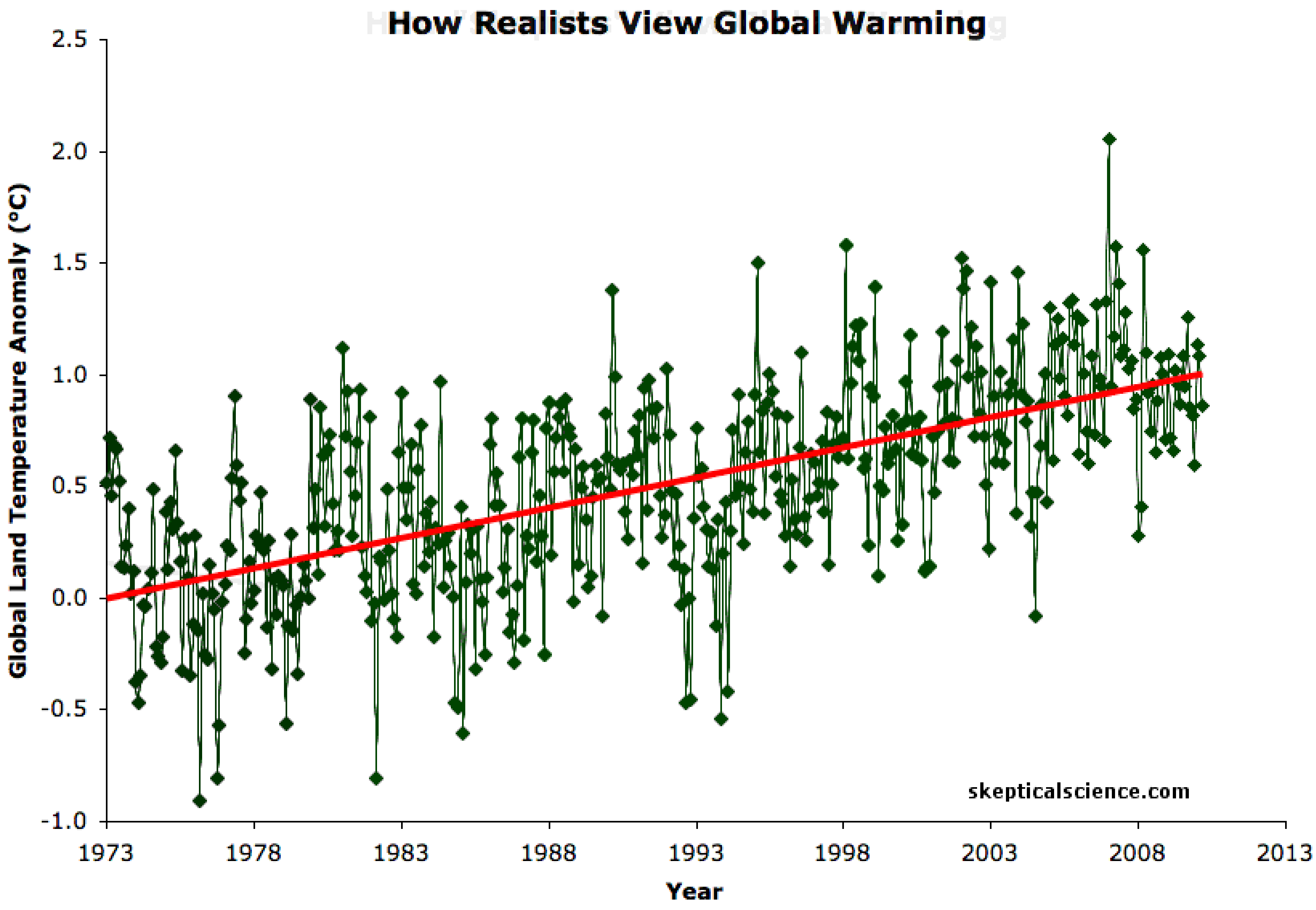
the “Keeling curve” is most like Plot # 3 (or 5)



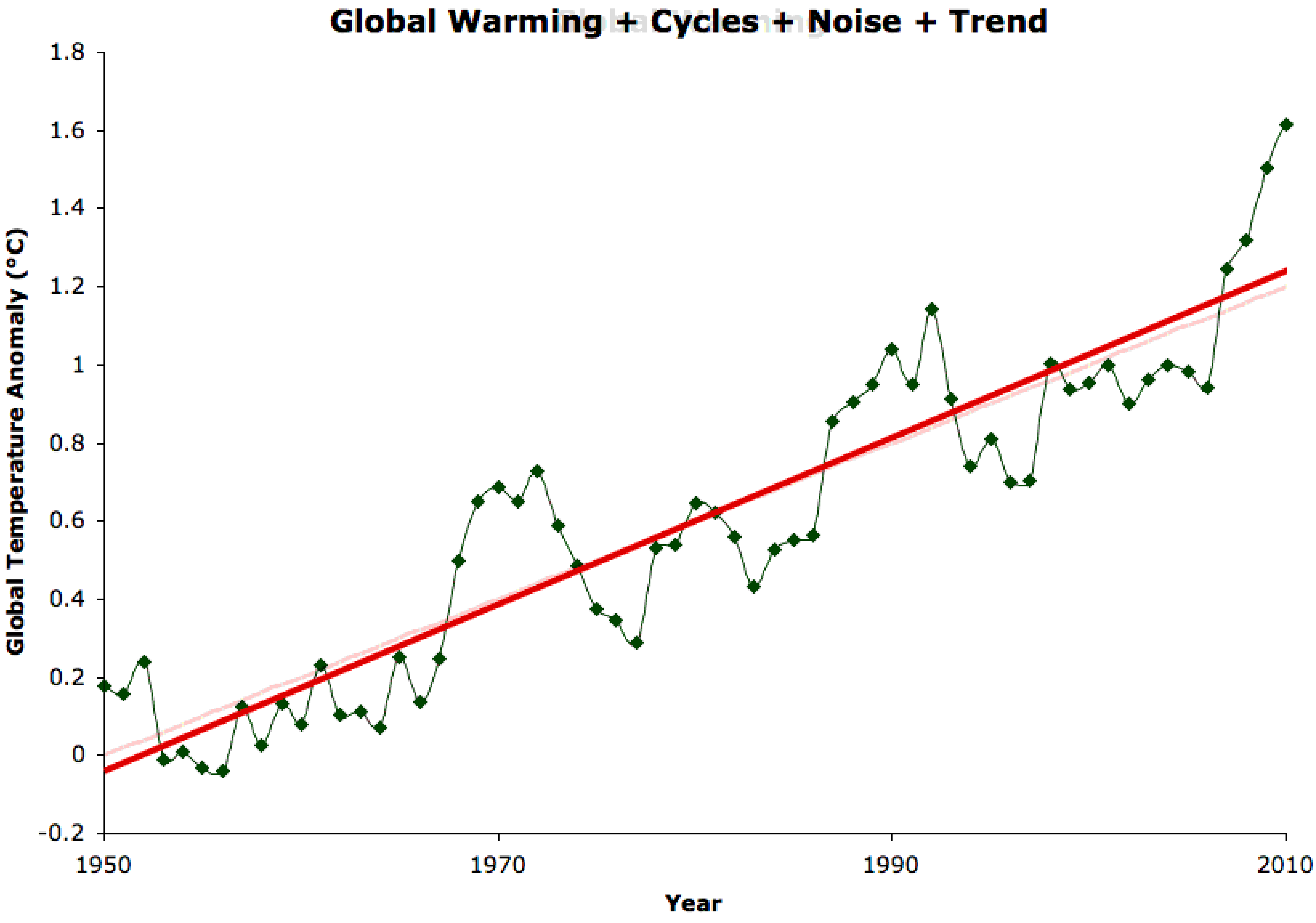
But what's the difference between TRENDS and UP & DOWN VARIATIONS???

http://www.youtube.com/watch?v=e0vj-0imOLw&feature=player_embedded

From SKEPTICALSCIENCE.COM website:

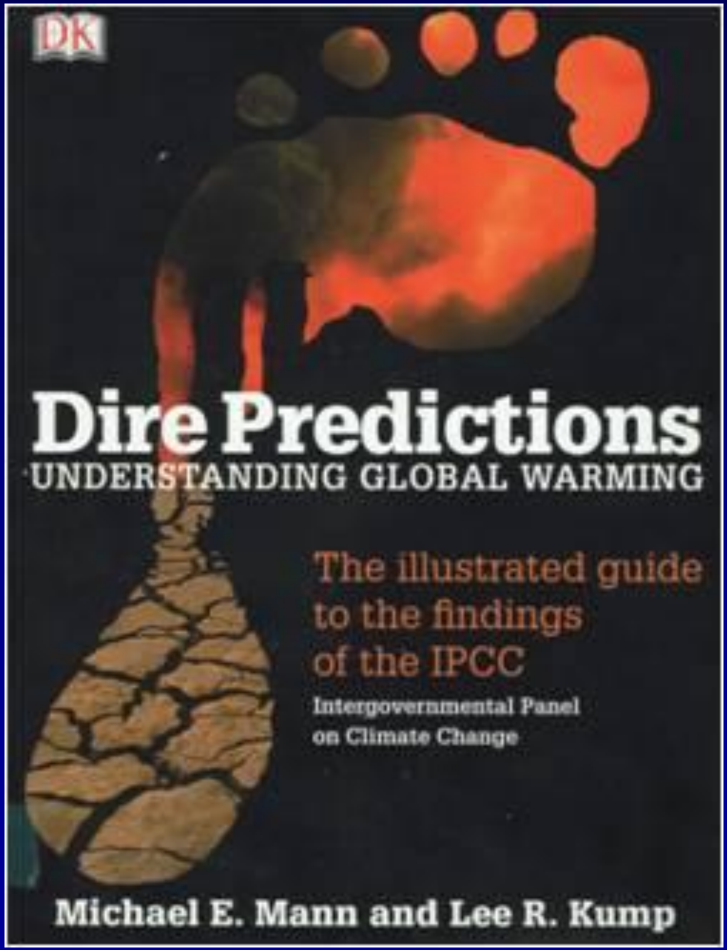


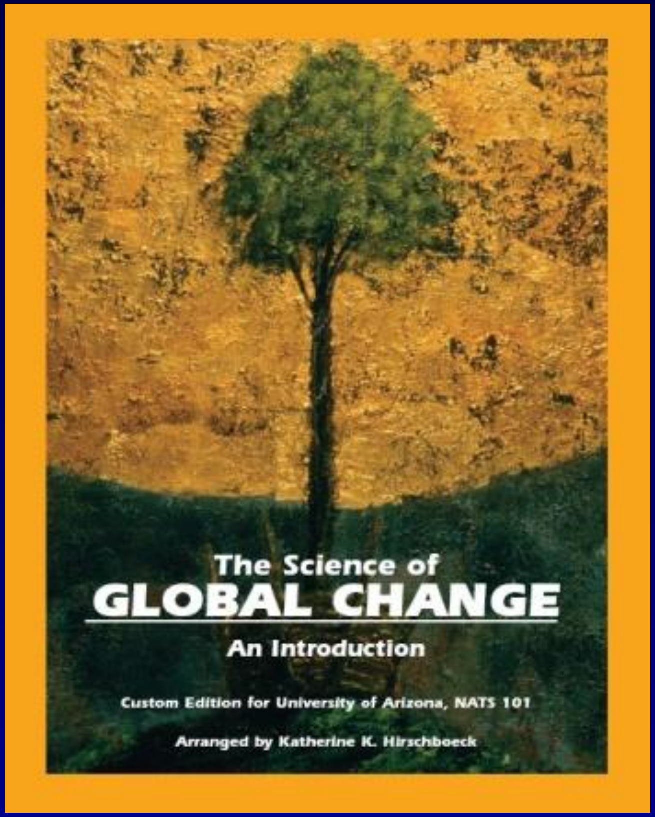
http://www.skepticalscience.com/going-down-the-up-escalator-part-1.html



http://www.skepticalscience.com/going-down-the-up-escalator-part-2.html

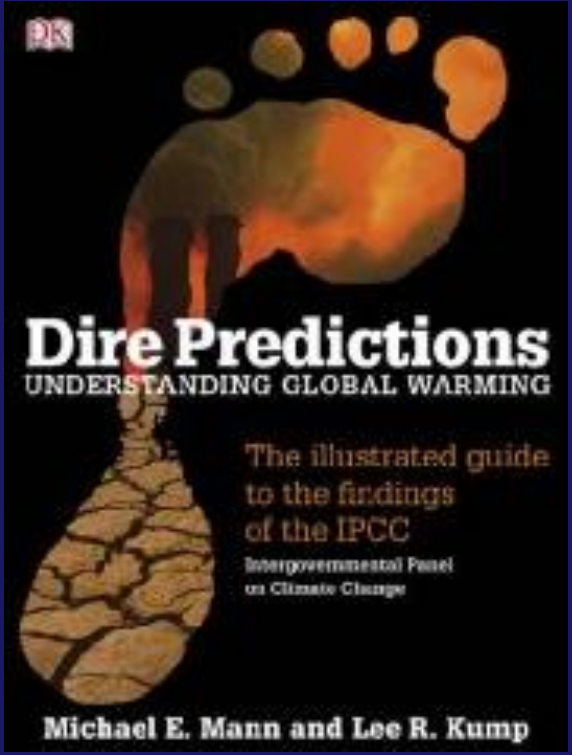
Cover of your other TEXTBOOK:





"Cover" of the E-TEXT

CALCULATE YOUR FOOTPRINT!



FIRST HOMEWORK ASSIGNMENT:

For next TUESDAY'S CLASS Sep 10th
bring in the results the assignment
Linking-to-Life PART A: YOUR FOOTPRINT
(worth 10 pts)

- http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/

A Tool for Quantifying Global Change Impacts:
"The Footprint" Concept

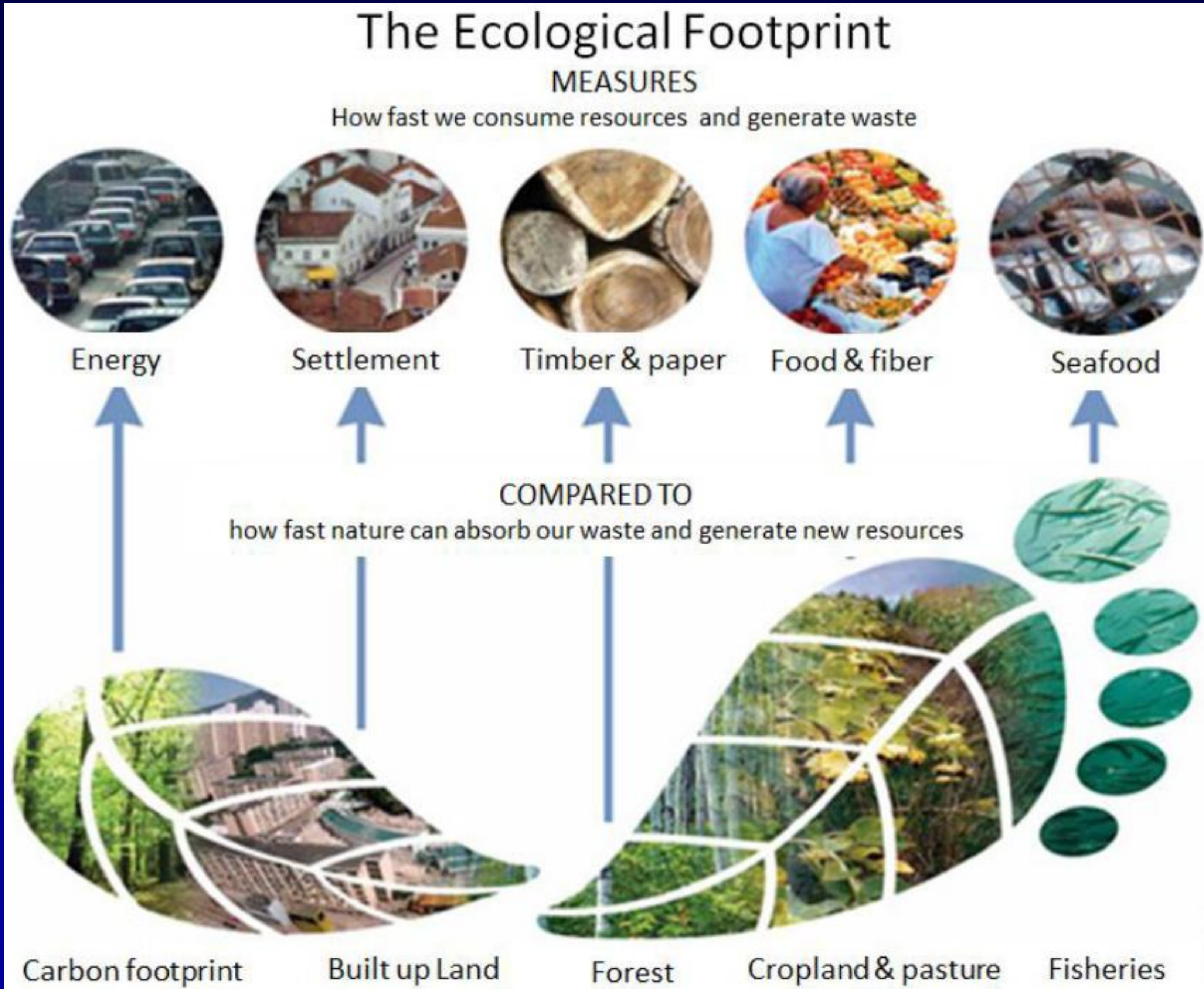
Examples: Ecological Footprint, Carbon Footprint, Water Footprint

Your Ecological Footprint = A measure of how much area of Earth's biologically productive land and water you require . . .

(a) to produce all the **RESOURCES** you consume , and

(b) to absorb the **WASTE** you generate

. . . . using prevailing technology and resource management practices.


The Ecological Footprint
MEASURES
How fast we consume resources and generate waste
Energy
Settlement
Timber & paper
Food & fiber
Seafood
COMPARED TO
how fast nature can absorb our waste and generate new resources
Carbon footprint
Built up Land
Forest
Cropland & pasture
Fisheries

The Ecological Footprint includes:

AREAS for producing the resources consumed
SPACE for accommodating buildings, roads needed
ECOSYSTEMS for absorbing the waste emissions, (such as carbon dioxide.)

The Ecological Footprint is usually measured in GLOBAL HECTARES (or sometimes, number of "Earth's needed").

(This is because trade is global and therefore an individual or country's Ecological Footprint includes land or sea from all over the world.)

The Footprint can be computed for an individual, a particular activity, a group of people, or an entire nation

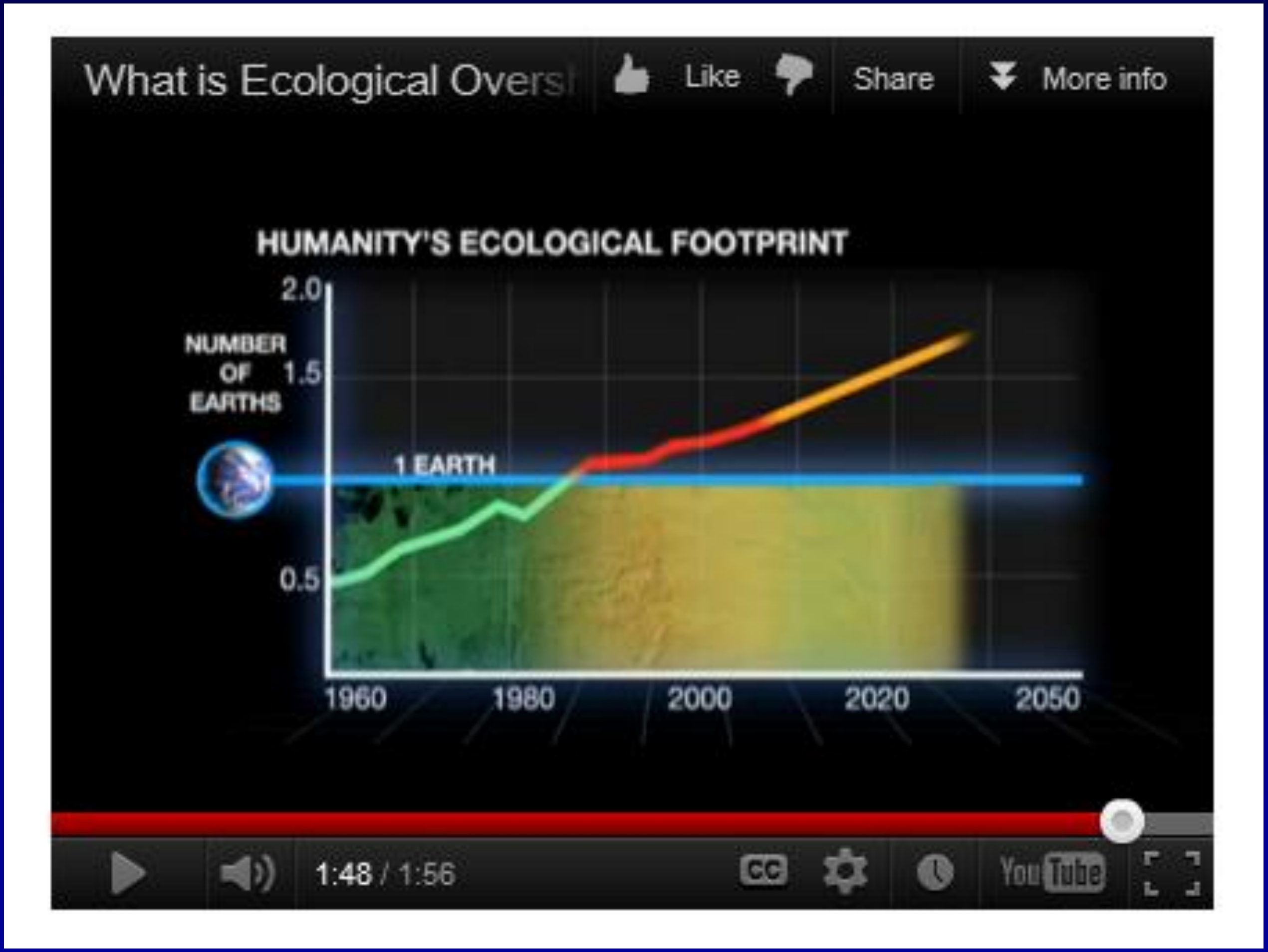
EARTH OVERSHOOT DAY **2013**

. . . was on August 20th this year!

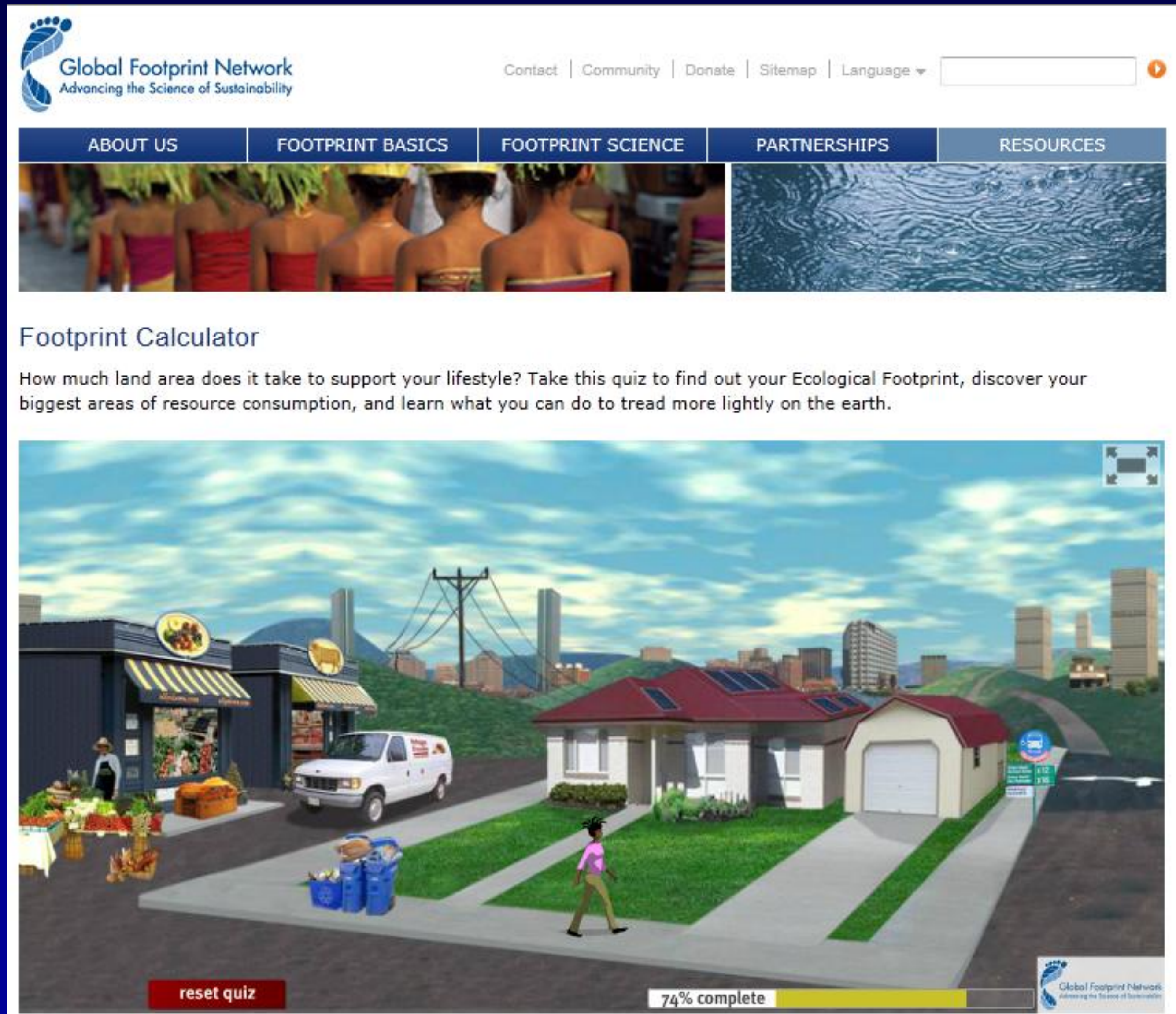
in 2003 it was on Sep 22

in 1993 it was on Oct 21

http://www.footprintnetwork.org/en/index.php/GFN/page/video_overshoot_explained/

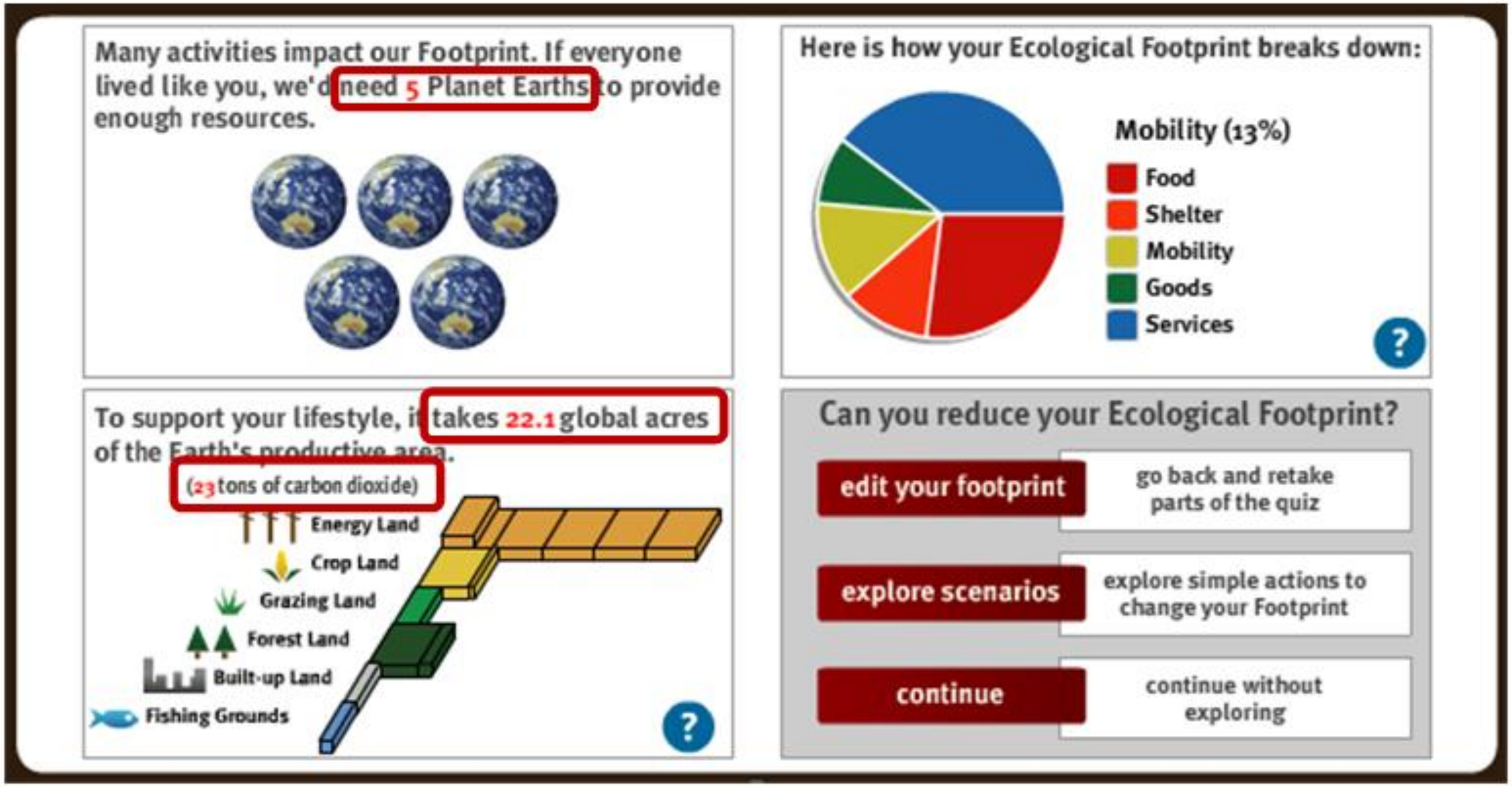


ECOLOGICAL FOOTPRINT CALCULATOR



http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/

USA AVERAGE Ecological Footprint (based on 2008 data)



The Ecological Footprint calculator "represents the amount of land and sea area needed to provide the resources a person needs (food, shelter, etc.), and absorb the wastes they create (including carbon dioxide)"

SOURCE: http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_calculator_frequently_asked_questions/

PROJECT PART A
SIMPLIFIED DIRECTIONS:

1) Compute Footprint
   http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/

2) Save in a document and date it

3) Write a short summary of what you noticed about what's contributing to YOUR footprint (1 paragraph)

4) Deposit in the D2L Dropbox (will be opened up for submissions on Thursday) & due 1 week from today.

Recap of what we did today:

- **Review and wrap up science concepts from Monday & Wednesday's class**

- **Address the problems of QUANTIFYING NATURE in Global Change**

- **Learn what the KEELING CURVE is, why it is important, & why "350" is an important data point on the curve**

- **Review exponential relationships and the Powers of 10: important tools to express change and vast ranges of size, speed, time, etc.**

- **Learn terminology to describe changes depicted in TIME SERIES graphs**

REMEMBER FOR THURSDAY:

(1) Your first <u>GRADED</u> RQ (RQ-1) based on the ATOMS Chapter (at the very end of the E-TEXT) is is due THIS THURSDAY Sep 5th The quiz will be locked at the cutoff time: 30 minutes before our next class begins.

Please don’t wait until the last minute!

(2) CLICKER Debut: Please register your CLICKER or RESPONSE WARE Device ID and bring your device to class on THURSDAY for use in class! **Directions on how to REGISTER your CLICKER/ ResponseWare for use in THIS class are in D2L**

(3) Registration directions for your E-text are posted under QUICK LINKS and also in the D2L Checklist.