Welcome Back to GC 170A Intro to Global Change

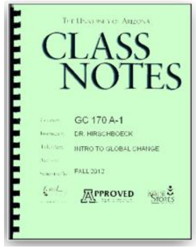
Thursday Aug 28

ANNOUNCEMENTS

1. Here for the FIRST TIME today?

   Please pick up a COURSE INFORMATION SHEET & a BACKGROUND FORM from the table in the front of the room and be sure to turn in the Background Form to a TA before you leave today.

2. CLASS NOTES PACKETS are NOW available in the UA BOOKSTORE! http://www.ltrr.arizona.edu/kkh/class-notes.html

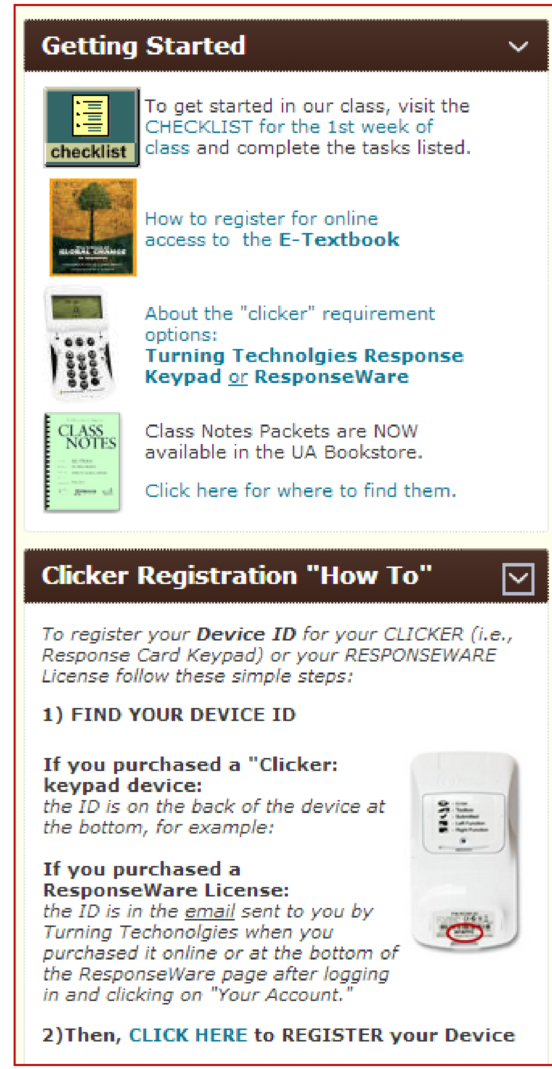


3. If you brought your Class Notes to class today:
   GREAT! You'll use them!
   If you were not able to pick up a copy yet,
   get a handout from the TA to use in class today . . . .

4. If you wish to ADD this class, see Dr H AFTER class today!

ANNOUNCEMENTS cont.

5. Please **Register your** E-Text access & your Clicker or ResponseWare as soon as possible. (You'll need them both next week.)
   Directions on how are posted in D2L:



6. See the **D2L Checklist** for what tasks you should be working on NOW and to get ready for next week.
   (Next Week's Checklist will be posted Friday)

www.ltrr.arizona.edu/kkh/natsgc/

CONSIDER BEING A PRECEPTOR!

About the Teaching Team Program
& becoming a Preceptor

(see Syllabus & GC 170A website for additional details on being a Preceptor in this class,

Then EMAIL Dr H if you are interested and want to set up an appointment for next week.

General Education Teaching Teams Program

The University Of Arizona

Teaching Teams Program

Putting People Back Into Education

POP QUIZ
ON THE SYLLABUS, FAQ
and other
COURSE LOGISTICS . . .

Q1: What should you do if you miss class?

Q2: When can you use a laptop during class?

Q3: If you are late for class, where will you find a copy of the ANNOUCEMENTS given at the start of class?

Q4: Under what conditions may I leave the classroom in the middle of class and then come back in after a few minutes?

ANY OTHER QUESTIONS ABOUT THE COURSE?

One last item: BE SURE YOU LOOK AT THE SEMESTER –ON-A-PAGE and are aware of our
SCHEDULED TEST & EXAM DATES
Don’t make plans to travel or be gone then!

OBJECTIVES FOR TODAY'S CLASS:

- **Get an overview of the problems of Global Climate Change and learn ways of QUANTIFYING NATURE in Global Change**

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

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

- **Learn terminology to describe changes depicted in TIME SERIES graphs like the Keeling Curve**

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**

So what is GC Science telling us, based on these methods?

THE BIG PICTURE:
the Basic Science Indicators
& Key Issues

Class Notes
page # ➔ p 6

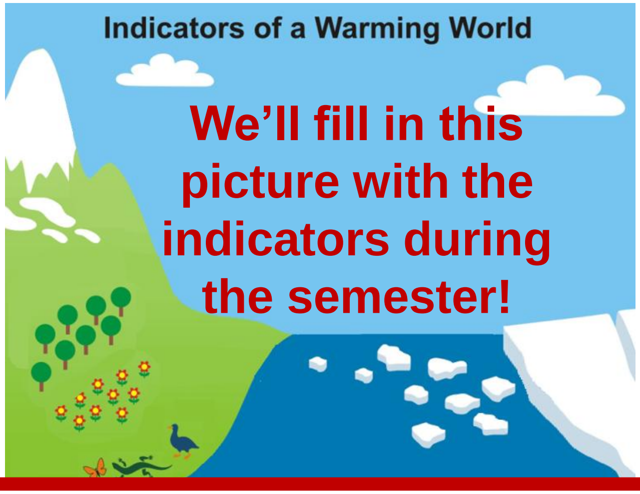
THE BASICS:
WHAT THE SCIENCE IS SAYING BASED ON THE CONVERGENCE OF A LARGE BODY OF SCIENTIFIC RESEARCH

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 <u>know</u> 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 "Climate Myths" about the causes and effects of climate change* :**

This semester we'll examine what the science actually says about these!

Climate's changed before

It's the sun

It's not bad

There is no consensus

It's cooling

Models are unreliable

Temp record is unreliable

Animals and plants can adapt

It hasn't warmed since 1998

And so forth. . . . .

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

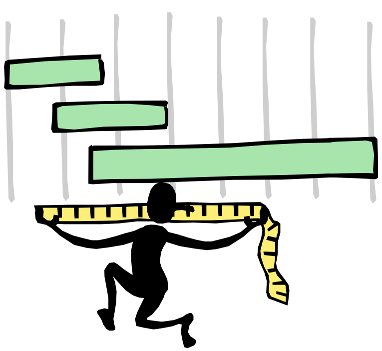
Topic #2
QUANTIFYING GLOBAL CHANGE:

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 <u>mathematically</u>

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 12 of CLASS NOTES – see also examples in SGC E-text Chapter 2 on Atoms

Our Quote-of-the-Day is from Albert Einstein!

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

Top of p 11

In this class, we'll focus on the SCIENCE
. . . but POLICY & ECONOMICS
(and therefore Politics & the Market)
play a role in this issue too!

"The series marks a major effort from an editorial page that has in the past been criticized by progressives for publishing misleading columns about global warming."

http://mediamatters.org/blog/2014/08/26

28 Aug 2014

The Washington Post

The Post's View

A climate for change: A solution conservatives could accept

A PROMINENT member of Congress has proposed a comprehensive national climate-change plan. It's only 28 pages long, it's market-based, and it would put money into the pockets of most Americans.

This is not the first time that Rep. Chris Van Hollen (Md.), a House Democratic leader, has made the point that the best climate-change policy is not complicated. He introduced a similar plan in 2009. The underlying logic is older still: Since the beginning of the climate debate, mainstream economists, left and right, have argued that the best way to cut greenhouse gases is to use simple market economics, putting a price on emissions that reflects the environmental damage they cause.

As economists see it, the nation is giving a massive implicit subsidy to the users of fossil fuels, who fill the air with carbon dioxide, imposing real costs on society, without paying for the privilege. Make users pay for the carbon dioxide they emit and they will waste less energy, while investment will flow into low-carbon technologies. The nation would obtain emissions cuts at a minimum cost to the economy.

This is Economics 101, but Republicans have largely ceded the free-market arena to Democrats such as Mr. Van Hollen. His proposal would put a limit on the country's greenhouse-gas emissions, a cap that would decline each year. Beneath that cap, companies would have to buy permits for the emissions their fuels produce. The buying and selling of permits would set a market price for carbon dioxide. The government would rebate all of the revenue from selling permits back to anyone with a Social Security number, offsetting any rise in consumer prices for 80 percent of ...

Why The Washington Post Is Running A Series Of Editorials On The "Existential Threat" Of Climate Change

Blog ››› August 26, 2014 12:52 PM EDT ››› JOE STRUPP

Like 975 Tweet 161 g+1 8 264

...t is publishing a week of climate change editorials aimed at sparking action ... editor Fred Hiatt calls "an existential threat to the planet."

...ia Matters about the ongoing series, Hiatt said that the Post views this as a moment ...egin to get unstuck." He believes that increasingly dire warnings from scientists about ...ge and new regulations aimed at reducing carbon pollution could lead to new ...So we wanted to encourage that process and also put forward as you'll see later in ...aches that we think would make a lot of sense and might at some point even be ...

...t from an editorial page that has in the past been criticized by progressives for ...about global warming.

...tial threat to the planet, I believe that, so you don't get much bigger than that," ...n the week of editorials. "That doesn't mean that you can set aside other ...us today, but over time ... the longer we wait to do something about it, the ...nd the more disruptive the response will be."

...faltering national debate on this issue, while today's offering explain... ...ile the world warms."

Through quantifying change over time . . . .

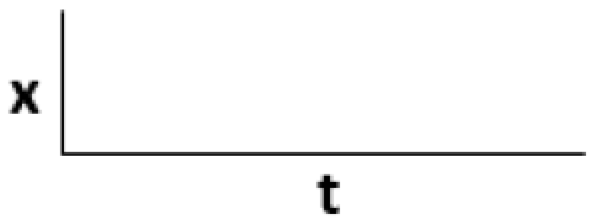
How can claims like these be evaluated?

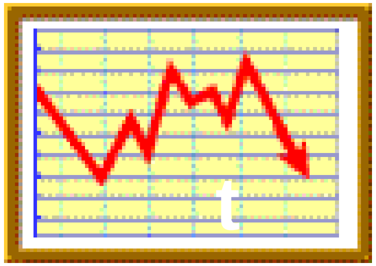
. . . in a "Time Series" plot of data !

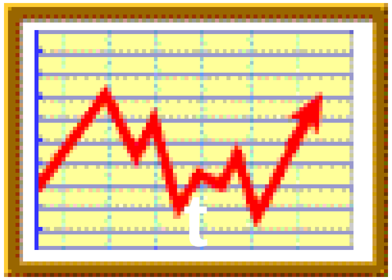
Quantifying Change over TIME:

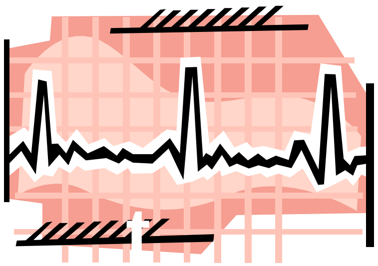
To quantify global change we examine TIME SERIES CHANGE:

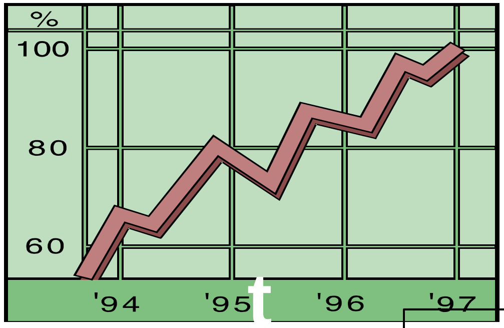
A time series is a plot of value of some variable (x) at each point in time (t):











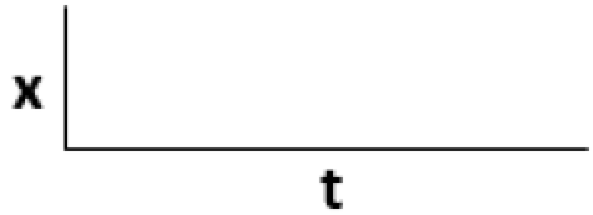
Quantifying Change over TIME:

We also need to quantify
RATES OF CHANGE:

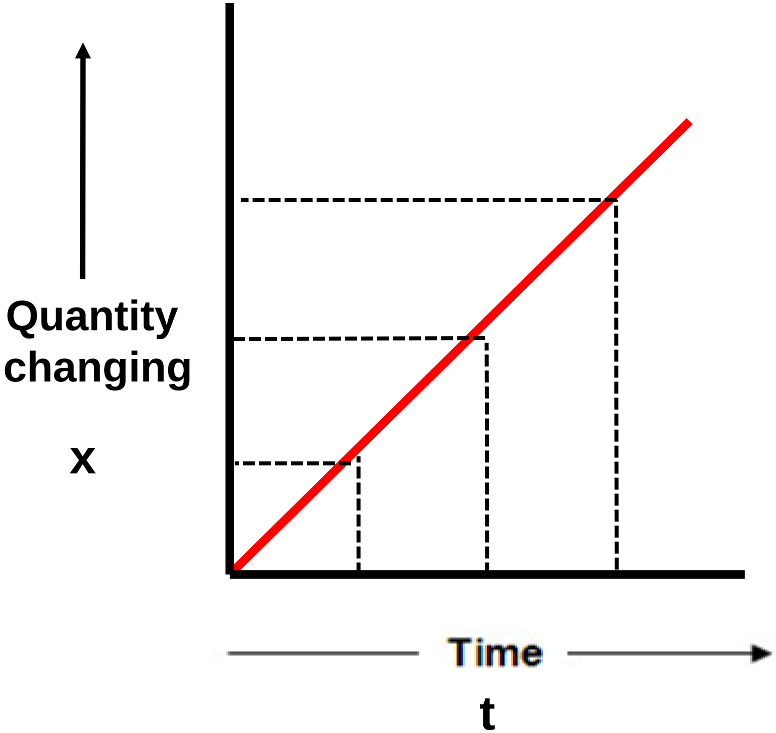
Change in some variable (x)
per change in time (t)

d(x) / d(t) where d = “change in,”

x = a variable, t = time



Sometimes change over time is "orderly" and the future is easy to predict!

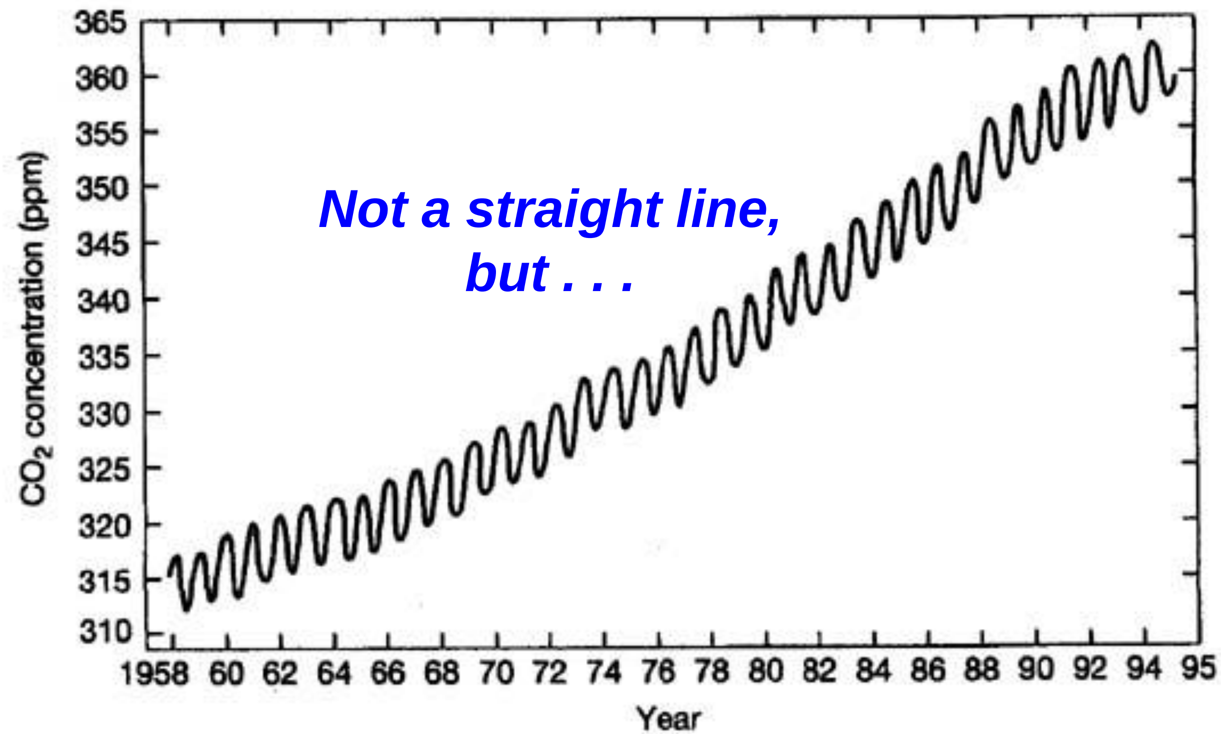


a "linear" function

A linear equation is an equation for a straight line

In this graph,
for each equal increment of time (t),
the amount of change (x) is
THE SAME

e.g. the "Keeling curve"



. . . we can still compute the <u>AVERAGE RATE OF INCREASE</u> of Carbon Dioxide over time due to fossil fuel emissions and other factors:

"The average rate of increase of CO^2 concentration since 1958 has been

43 ppm / 37 yr (or about 1.2 ppm/yr)"

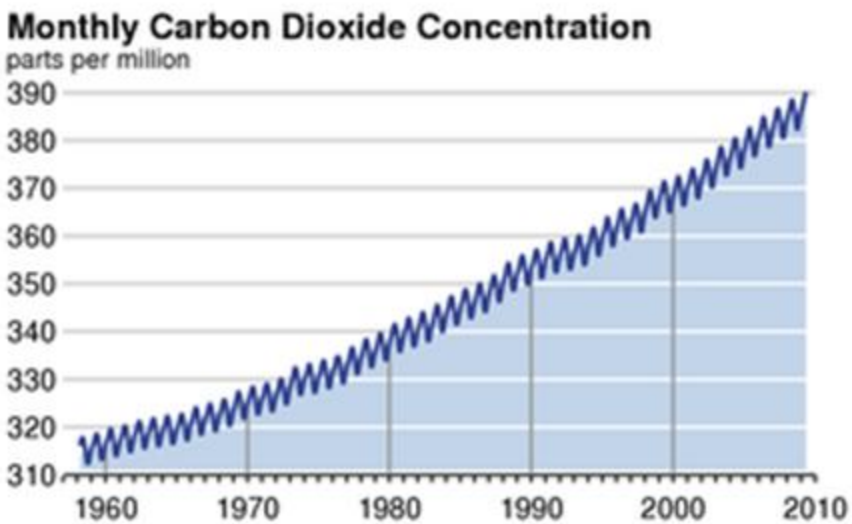
ppm = parts per million

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.

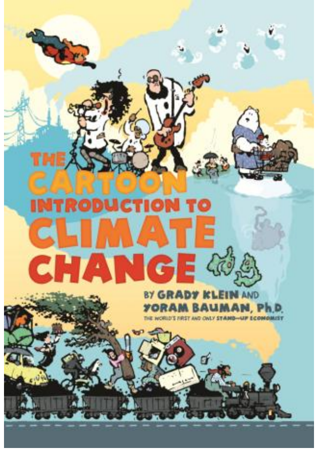
CO_2 Concentration at Mauna Loa Observatory, Hawaii



Keeling Curve

Mauna Loa Observatory

http://scrippsco2.ucsd.edu/

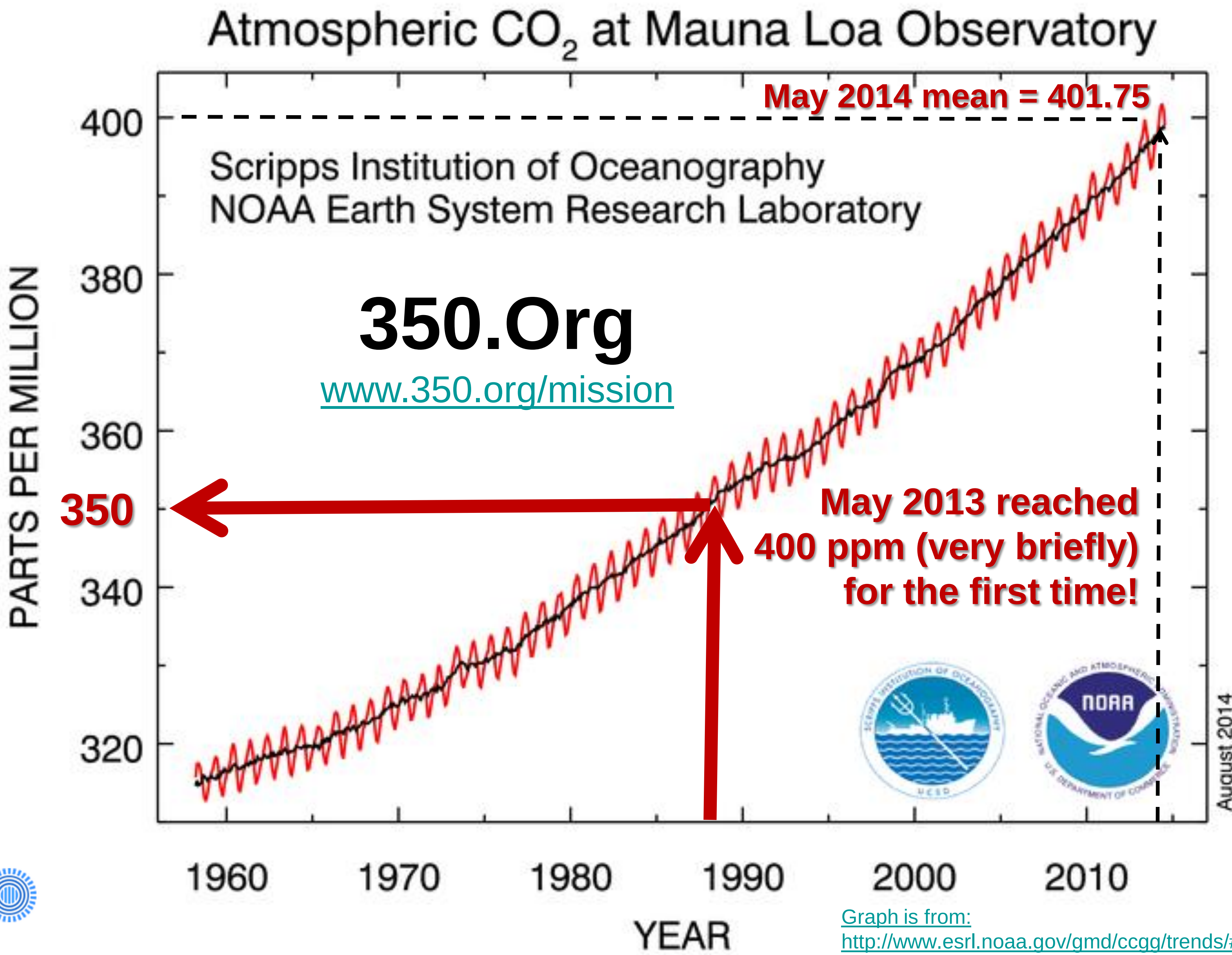


🡐 We then viewed a few slides from
Chapter 4 (p 41-46)
of the _Cartoon Introduction to Climate Change_.
The slides shown covered:
Dave Keeling and the Keeling Curve

NOTE: If you'd like to see the slides — or the entire book— please support the authors by purchasing *The Cartoon Introduction to Climate Change* from your favorite bookstore – or share a copy with a few classmates! **The Cartoon Introduction to Climate Change** by Grady Klein & Yoram Bauman (2014) http://islandpress.org/cartoon-introduction-climate-change

(Available in paperback for ~$19.99 or in Ebook format online for $18.99. For **more options** (which may be less expensive) check **online bookseller sites** for new or used versions, as well as commercial online stores such as Barnes & Noble or Amazon for new, used, Kindle or Nook versions.)

A number of copies of *The Cartoon Introduction to Climate Change* may still be available for $19.95 in the basement of the ASUA Bookstore; find it on the shelves under the author: BAUMAN



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

Where does 350 ppm come from?

Target atmospheric CO2: Where should humanity aim?

J. Hansen (1 and 2), M. Sato (1 and 2), P. Kharecha (1 and 2), D. Beerling (3), R. Berner (4), V. Masson-Delmotte (5), M. Pagani (4), M. Raymo (6), D. L. Royer (7), J. C. Zachos (8) ((1) NASA GISS, (2) Columbia Univ. Earth Institute, (3) Univ. Sheffield, (4) Yale Univ., (5) LSCE/IPSL, (6) Boston Univ., (7) Wesleyan Univ., (8) Univ. California Santa Cruz)

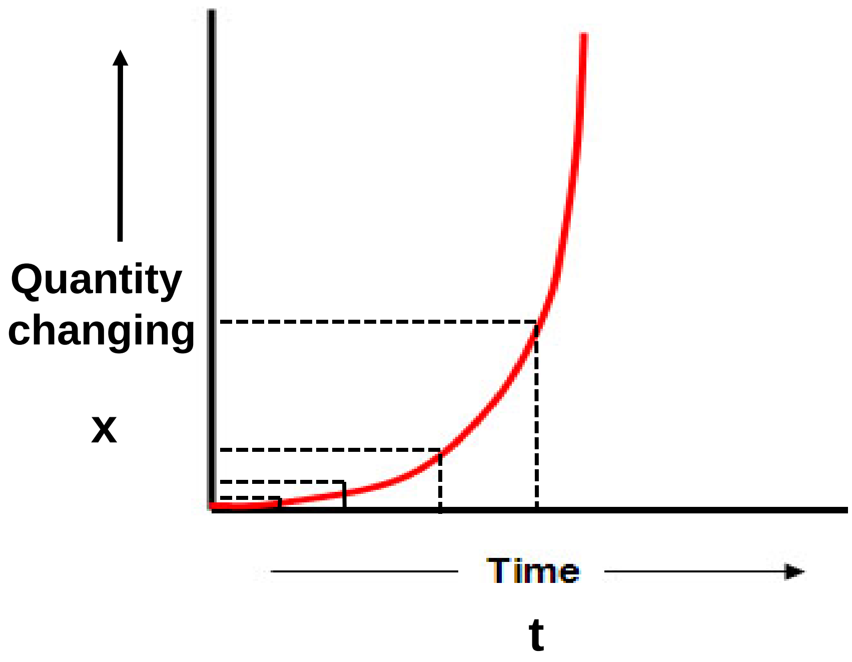
(Submitted on 7 Apr 2008 (v1), last revised 15 Oct 2008 (this version, v3))

Paleoclimate data show that climate sensitivity is ~3 deg-C for doubled CO2, including only fast feedback processes. Equilibrium sensitivity, including slower surface albedo feedbacks, is ~6 deg-C for doubled CO2 for the range of climate states between glacial conditions and ice-free Antarctica. Decreasing CO2 was the main cause of a cooling trend that began 50 million years ago, large scale glaciation occurring when CO2 fell to 450 +/- 100 ppm, a level that will be exceeded within decades, barring prompt policy changes. If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO2 will need to be reduced from its current 385 ppm to at most 350 ppm. The largest uncertainty in the target arises from possible changes of non-CO2 forcings. An initial 350 ppm CO2 target may be achievable by phasing out coal use except where CO2 is captured and adopting agricultural and forestry practices that sequester carbon. If the present overshoot of this target CO2 is not brief, there is a possibility of seeding irreversible catastrophic effects.

Journal reference: Open Atmos. Sci. J. (2008), vol. 2, pp. 217-231
DOI:10.2174/1874282300802010217

The <u>RATE of change</u> over time can also change,
i.e. with each increment of time
the <u>amount of change</u> CHANGES

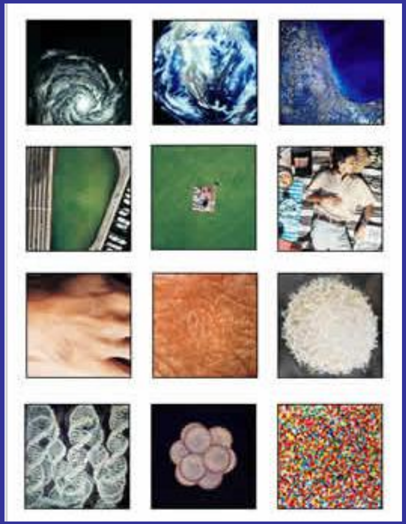
Powers of 10 can be used to express <u>exponential</u> rates of change



A Classic Video on
The Relative Spatial Scale of Things:

“POWERS OF 10”

http://www.powersof10.com/film



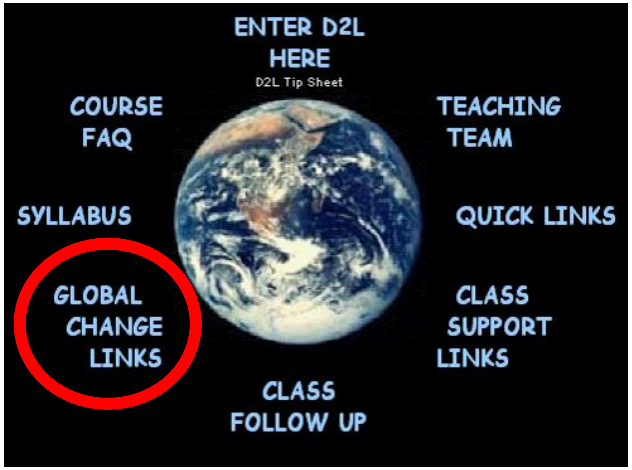
“In 1977, Charles and Ray Eames made a nine-minute film called Powers of Ten that still has the capacity today to expand the way we think and view our world. Over ten million people have since seen the film . . . .”

"Eventually, everything connects.“

- Charles Eames

Follow along with the Journey on Page 12

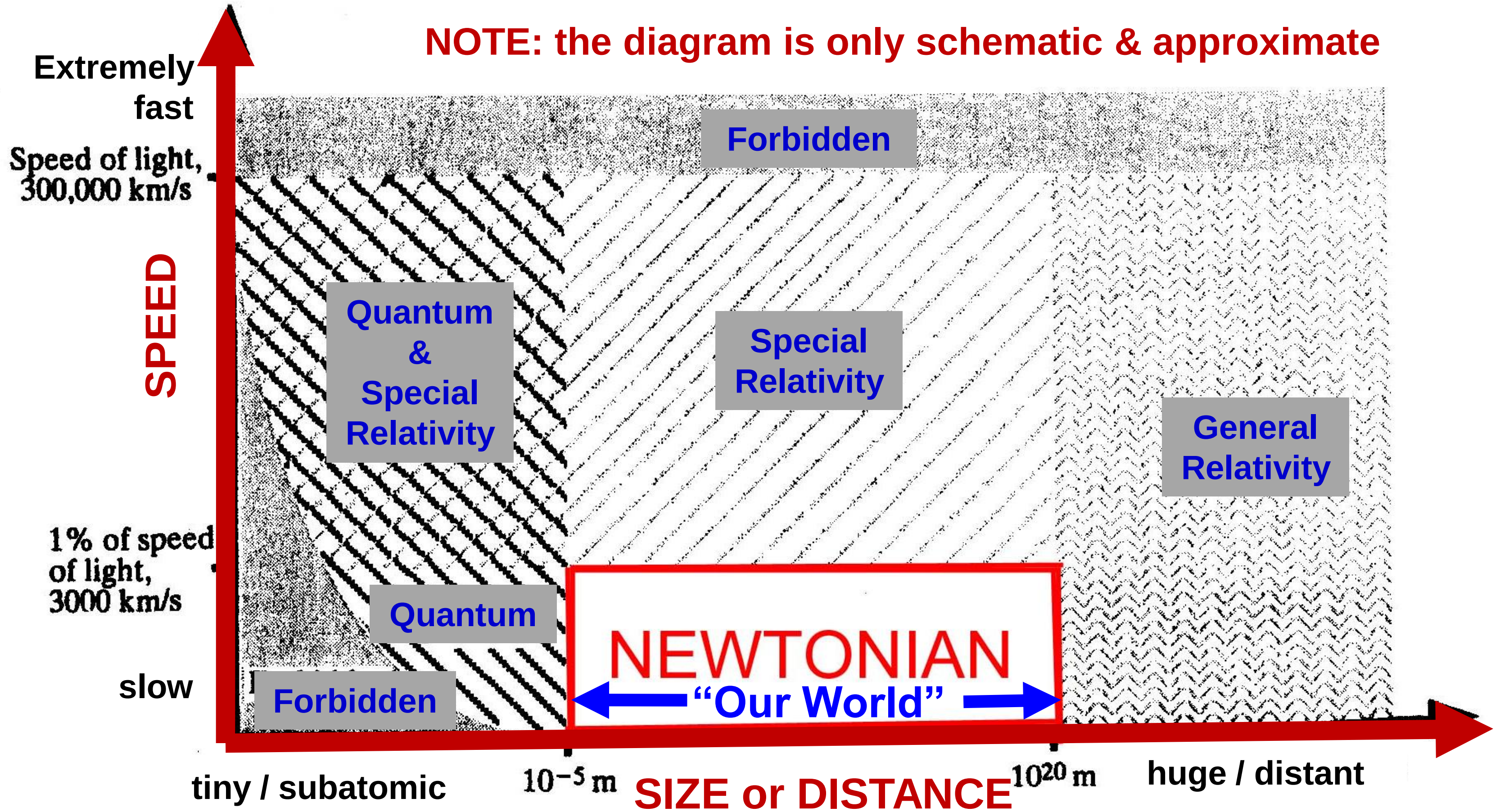
THINKING MORE DEEPLY: ABOUT "POWERS OF 10" via WEBSITES:



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



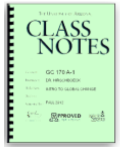
Newtonian physics breaks down for very SMALL objects, very LARGE objects, & very FAST objects.

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

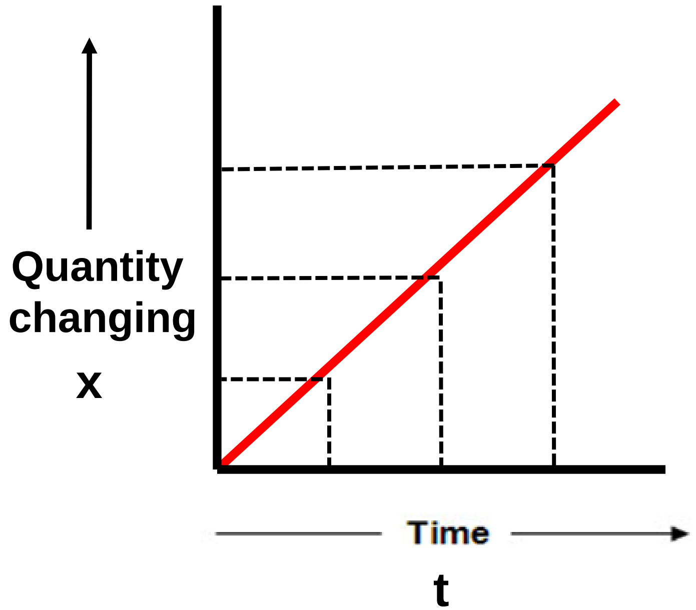
Exercise on:
PLOTTING CHANGE OVER TIME

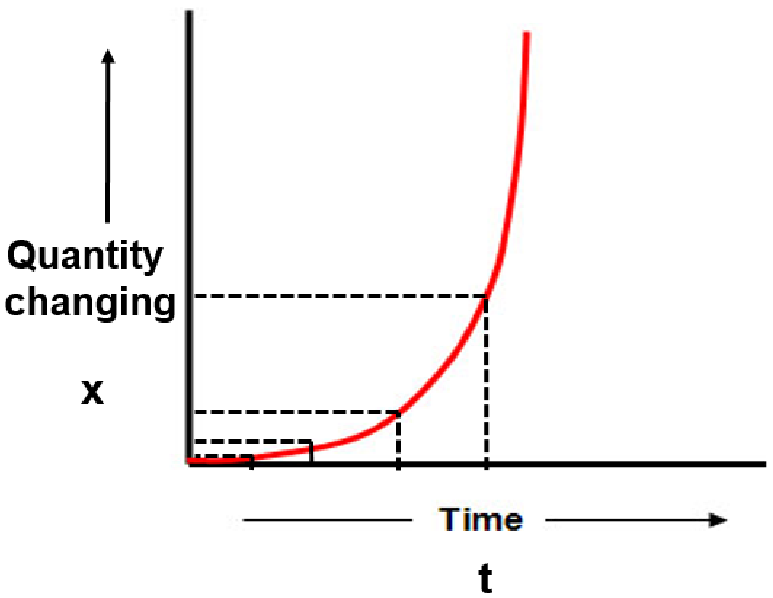
First, some background . . .



Handout or Class Notes → p 13

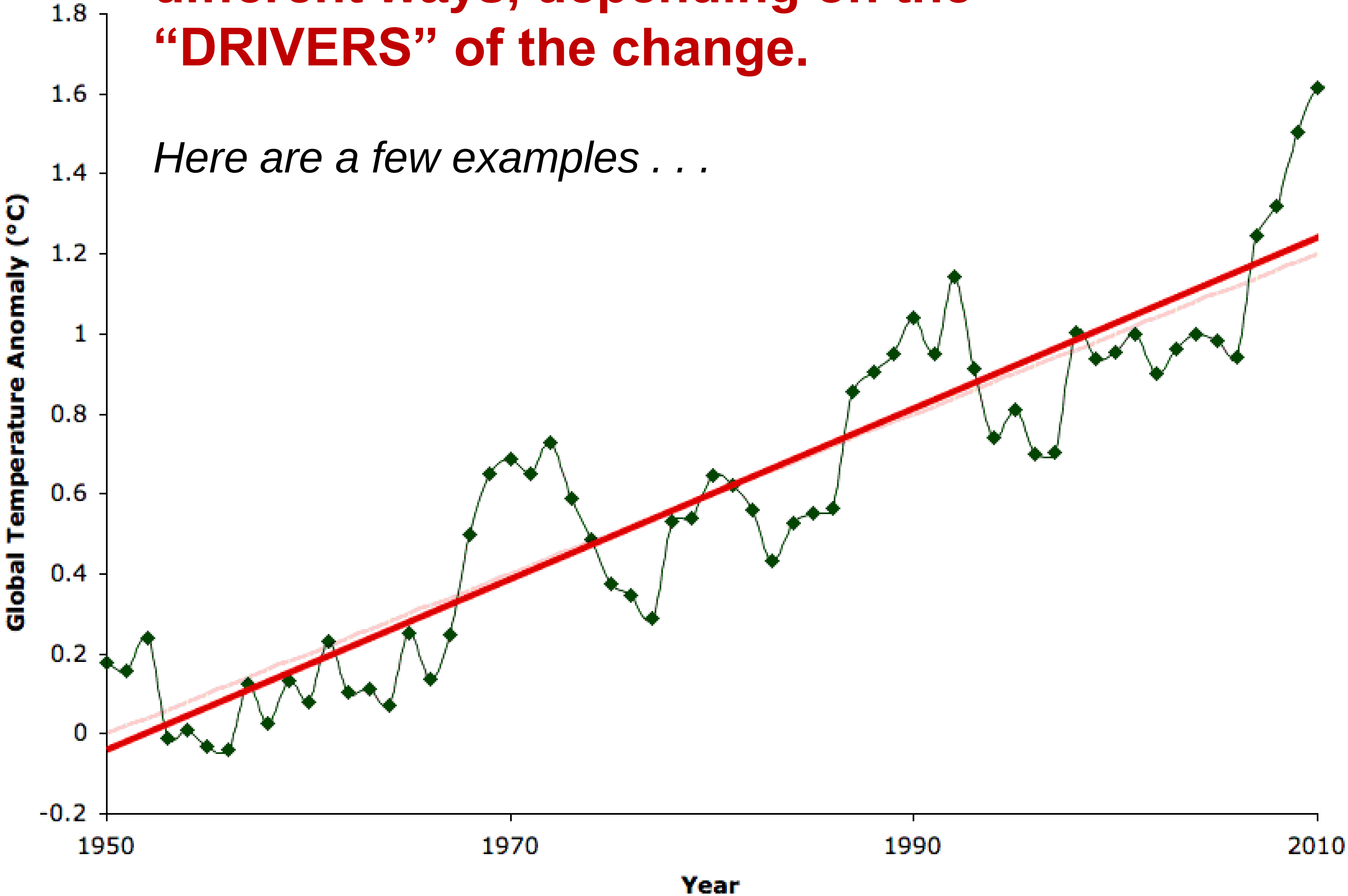
Which type of TIME SERIES represents an easily predicted future . . . .?





Change over time can proceed in many different ways, depending on the “DRIVERS” of the change.

Here are a few examples . . .



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

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

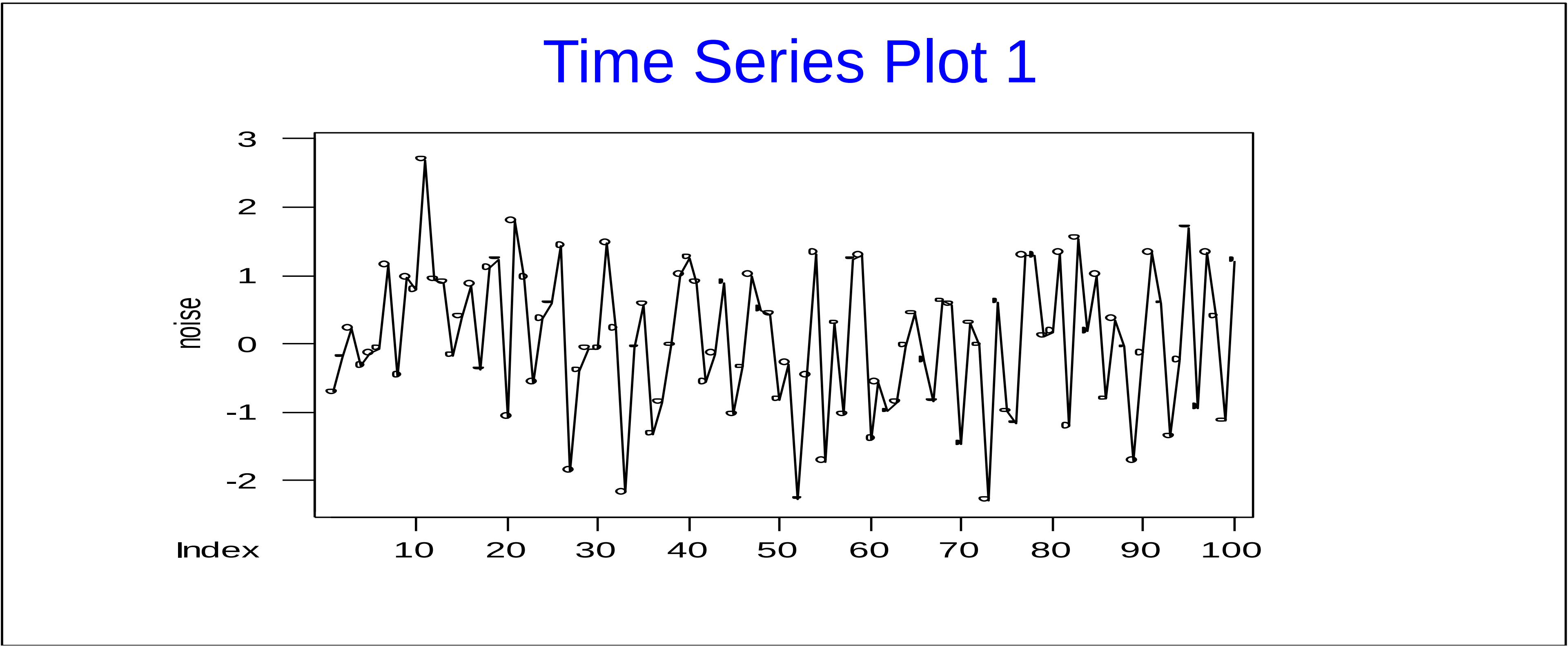
Here are some terms that will help you describe time changes more precisely in fewer words:

- **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)

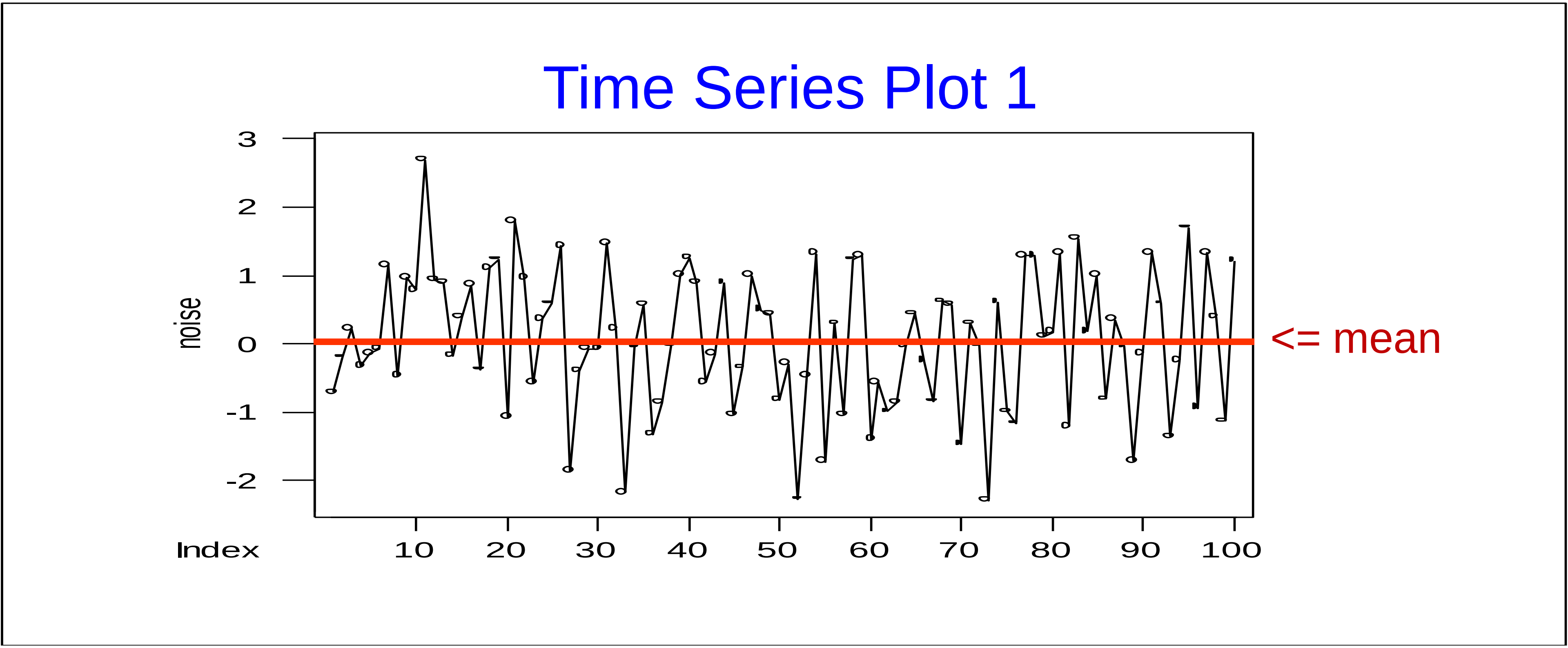
Terms (cont.)

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)

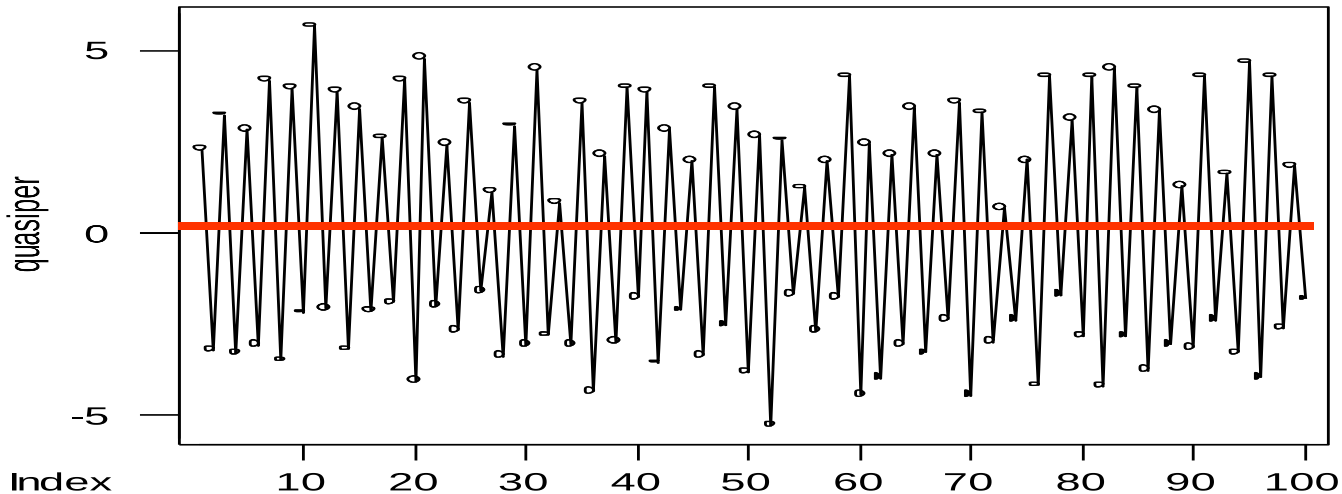


Draw in the MEAN line for this time series.



"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.

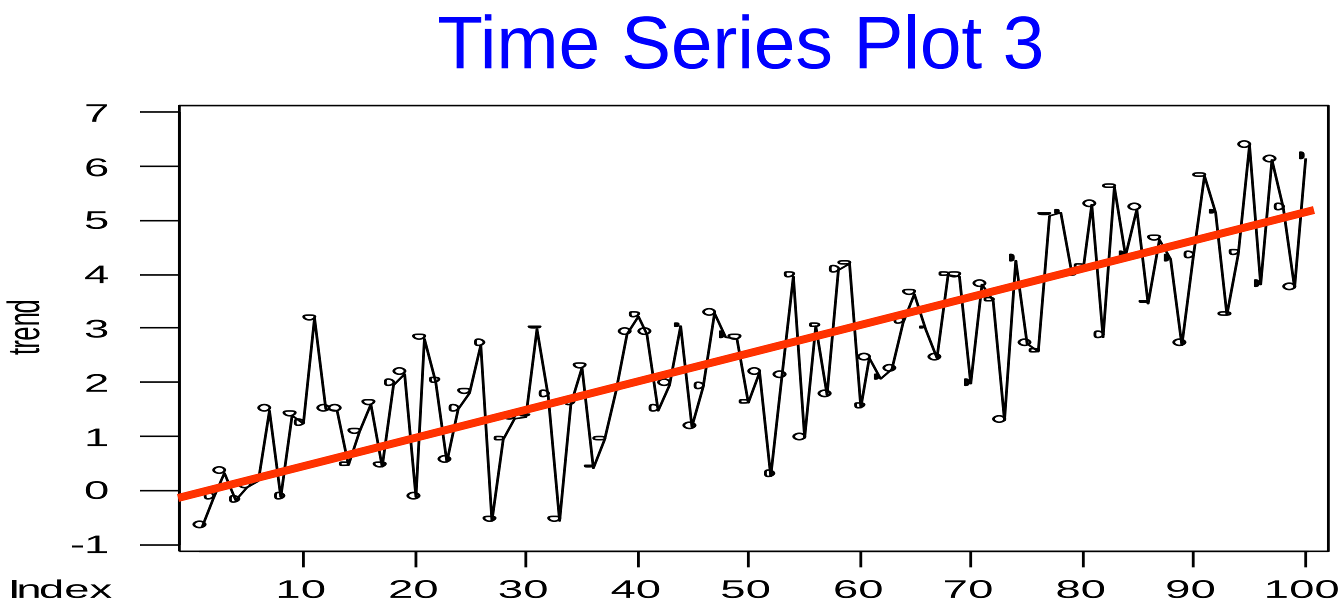
Time Series Plot 2



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

Is the mean constant?

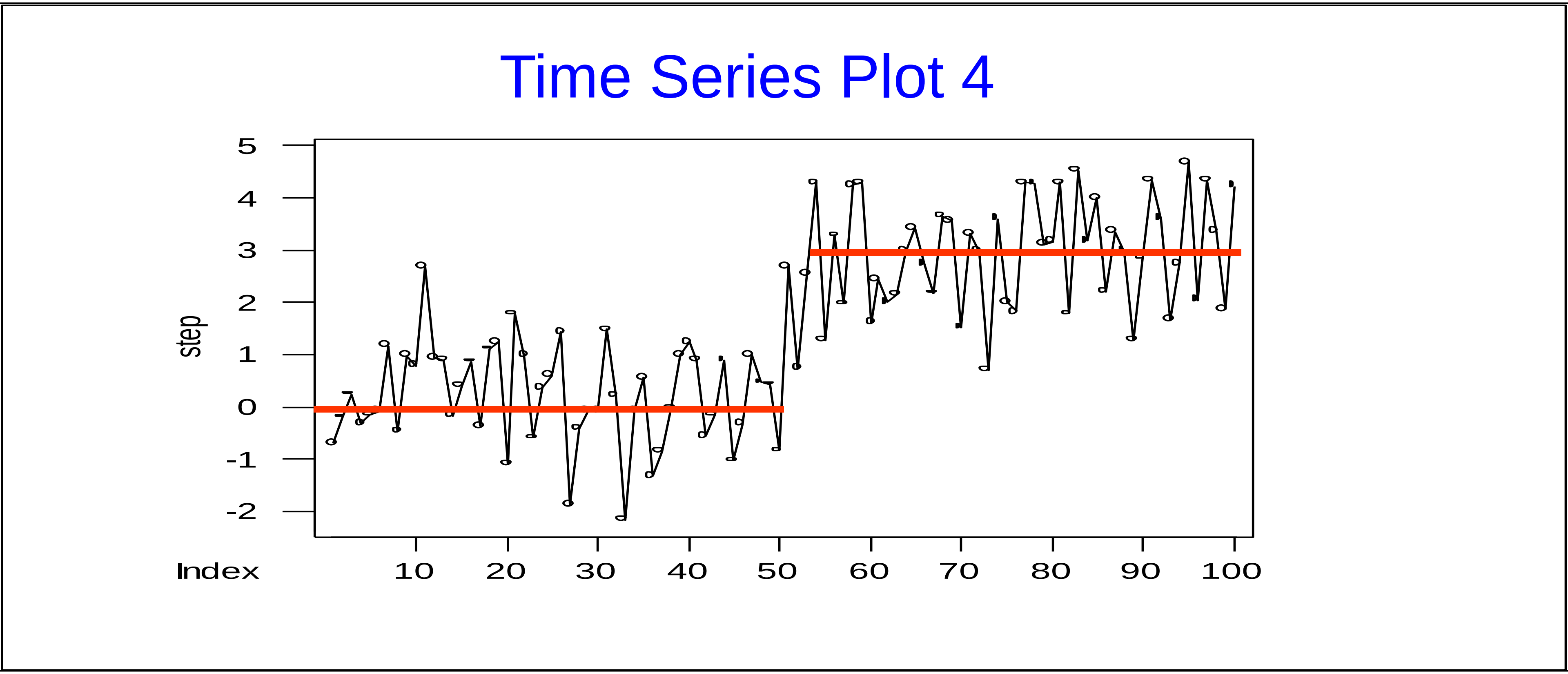
Is the variance constant?



Hmmm, something is changing here . . .

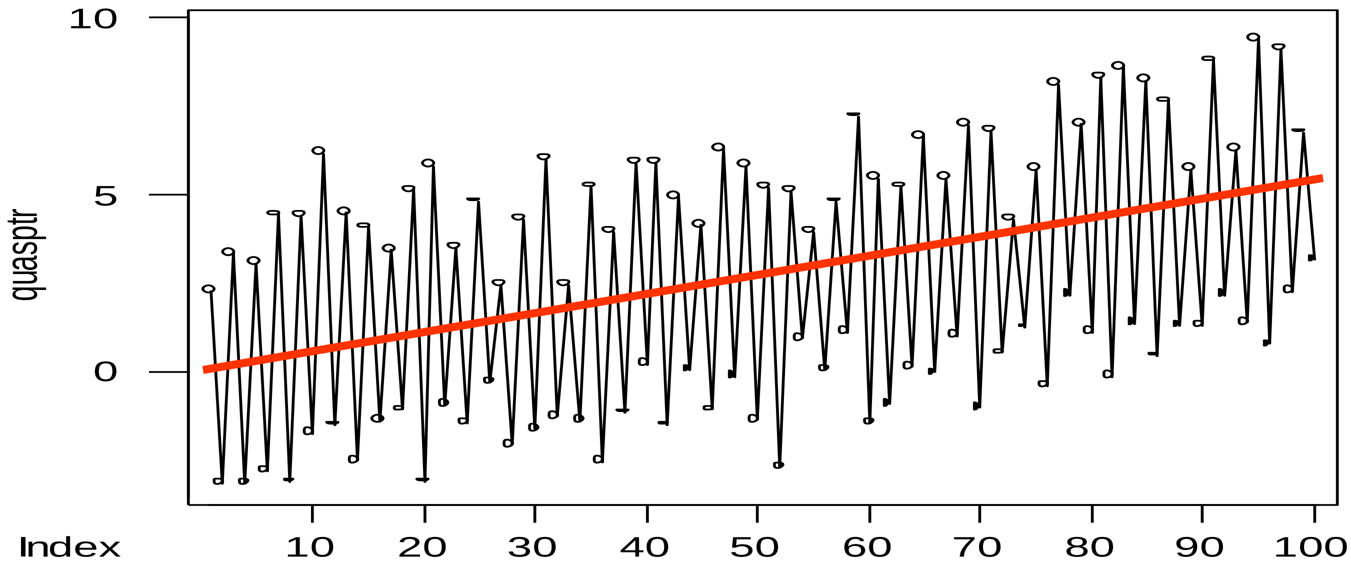
What’s happening to the mean?

Is the variance constant?



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

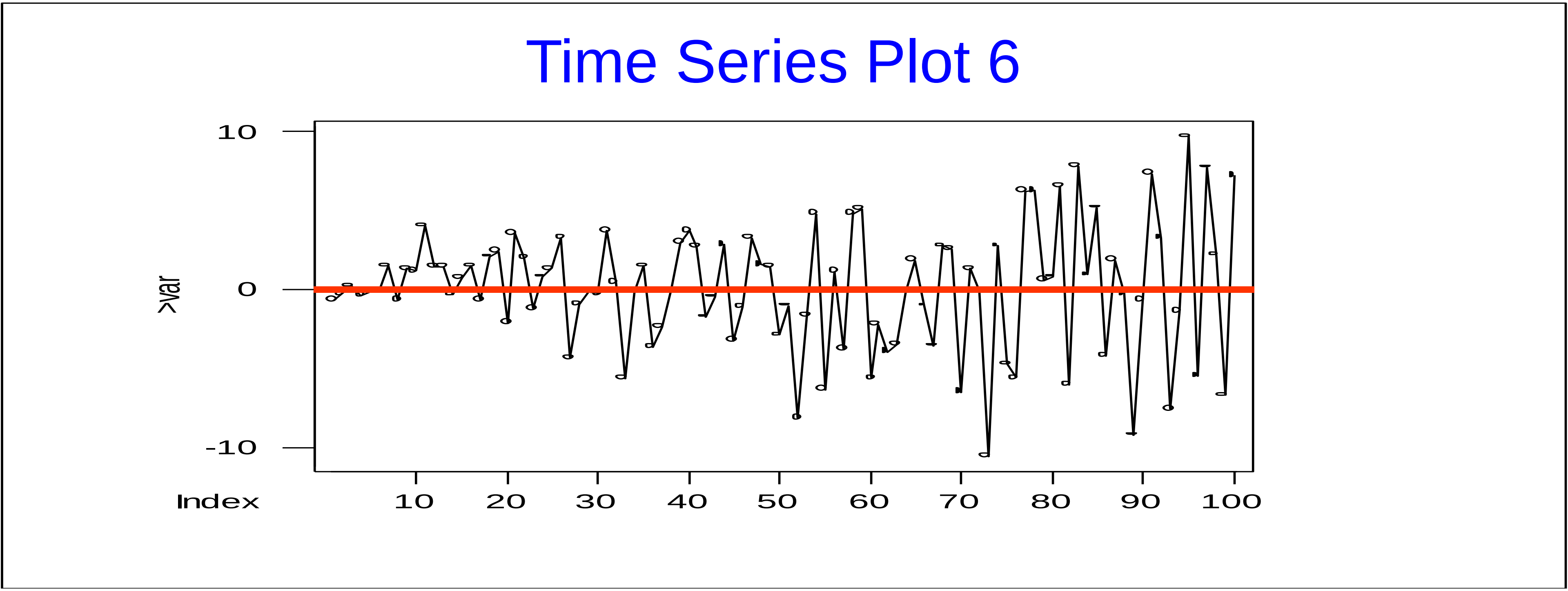
Time Series Plot 5



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

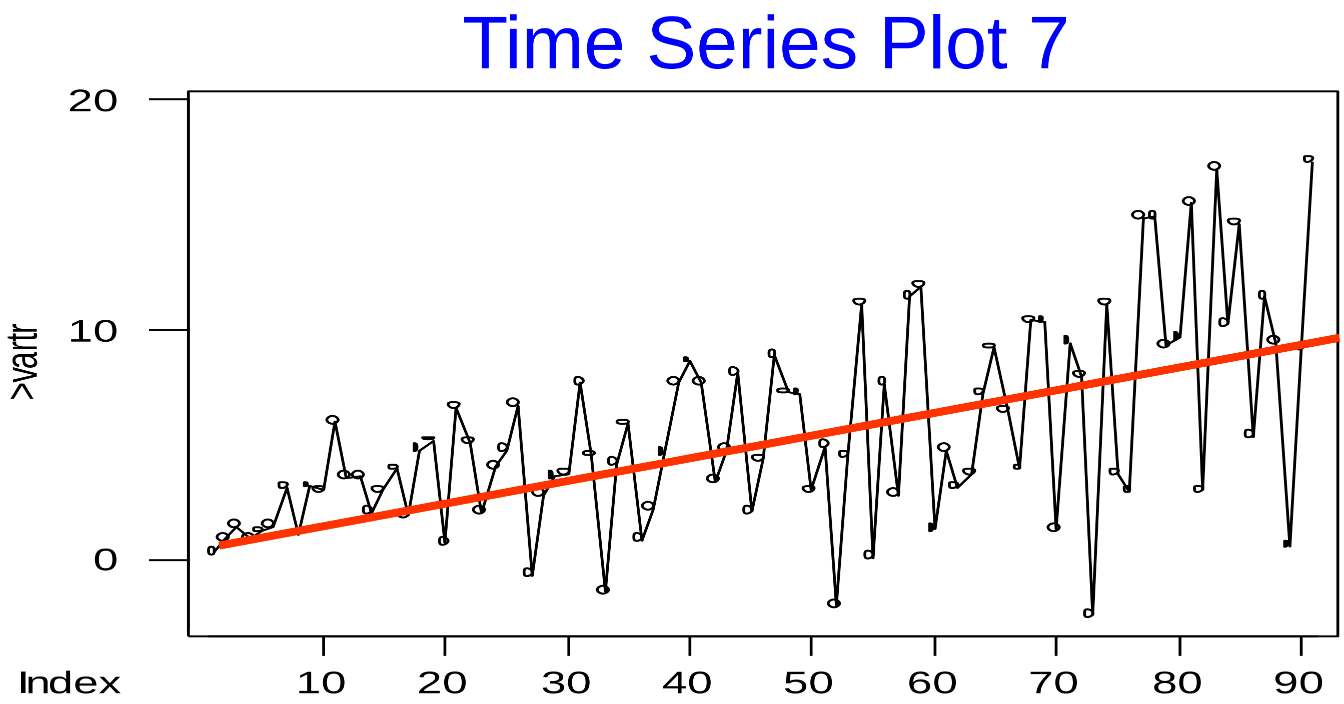
What's going on with the mean?

The variance?



What's going on with the mean?

The variance?

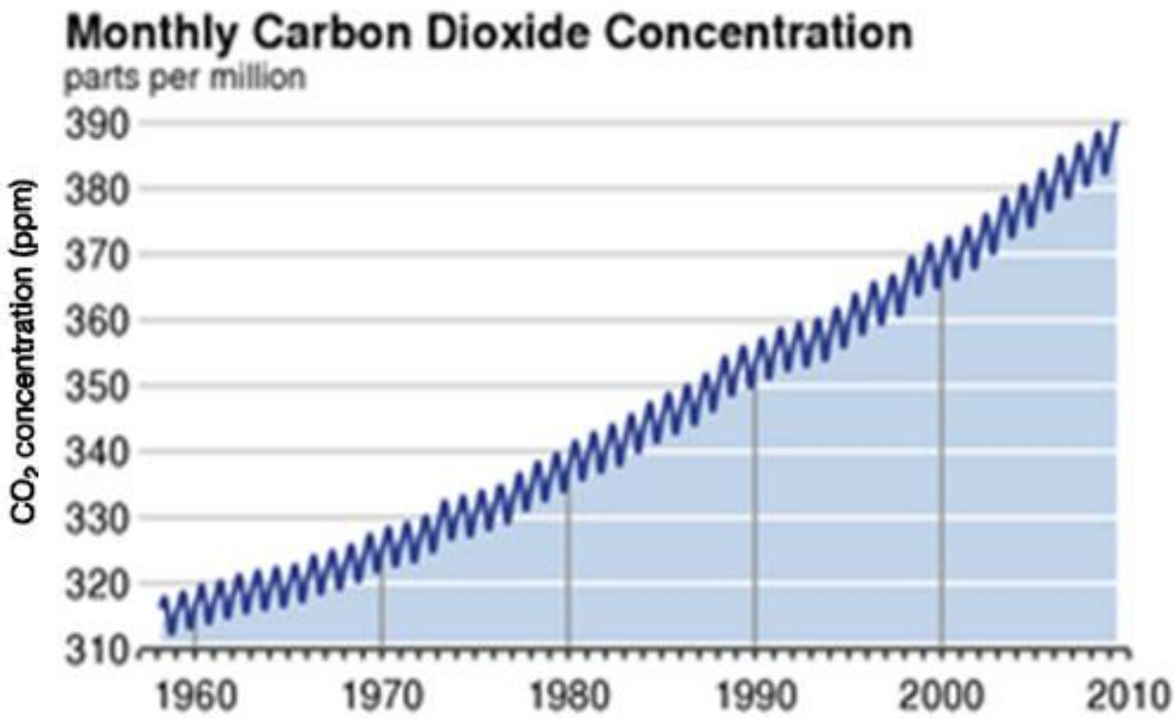


Is there a trend?

What's going on with the mean over time?

What's going on with the variance?

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



Keeling Curve

IN-CLASS ACTIVITY

Exercise on:
PLOTTING CHANGE OVER TIME

"Think-Pair-Share"

THINK about the questions. . . . then **PAIR** up with someone nearby . . . and **SHARE** (discuss your ideas and answers)

pp 13-14 in CLASS NOTES

ANSWERS TO TIME SERIES GRAPHS
Will be given next Tuesday in class . . .

Dr H Required Disclaimer: This is an opportunity for interested students, not an "official" course activity or endorsement . . .

Lastly, the following visitor to class talked about . . .

Eric Traub on Green Corps

"DIVEST UA"

"*Nothing could be more important than training the next generation of environmental leaders; they are the future of the future. And no one has done it more consistently and reliably than Green Corps.*"

– Bill McKibben, climate activist and founder of 350.org

Student activists at Virginia Tech call on the university to move beyond coal.

Recap of what we did today:

-**Wrap up some science concepts from Tuesday'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**

Have a great
Labor Day weekend!

GO CATS!