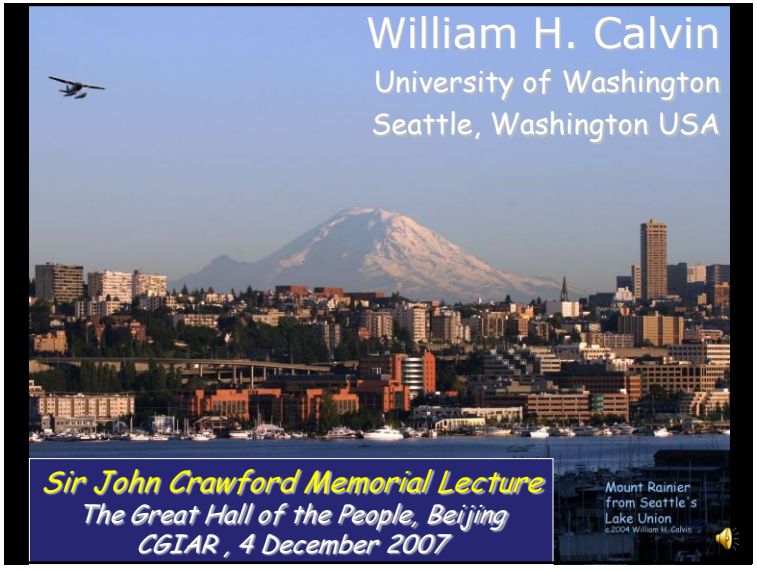
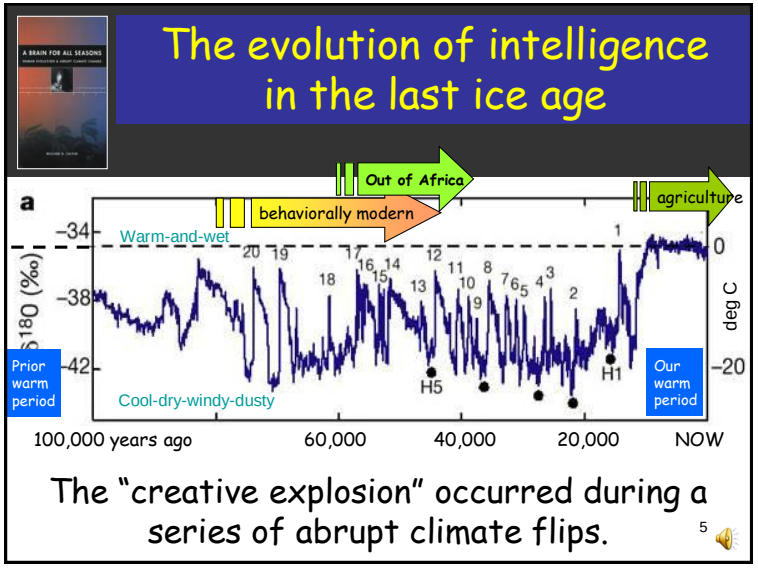


Up from the apes

- Common ancestor 7,000,000 years ago
  - Upright posture, loss of big canines
- Toolmaking, bigger brain 2,500,000 yr
- *Homo sapiens* 200,000 years ago, look like us.
- Fine tools, art, "modern mind," *"think like us."* 50,000 years ago (last <1%).



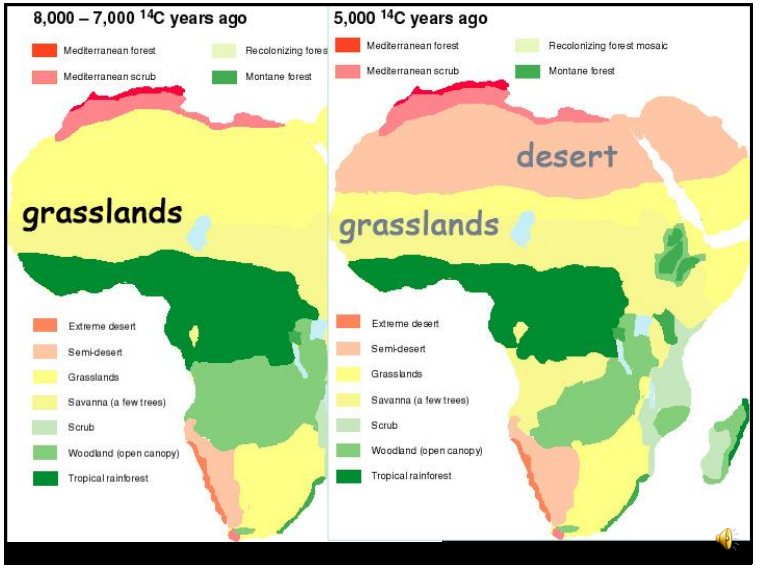
What it takes to finally settle down.

Table 2 Four agricultural societies developed independently

Location	Species	Development
Levant	Wheat, barley, chickpeas, flax, sheep, goats	~ 9,000 ybp
China	Rice, millet, pigs, silkworms	by 9,500 ybp
Mesoamerica	Corn, beans, squash, turkey	by 5,500 ybp
Andes and Amazonia	Potato, manioc, guinea pig, llama	by 5,500 ybp

Springer

Joan Feynman · Alexander Ruzmaikin
"Climate stability and the development of agricultural societies."
Climatic Change (2007) 84:295–311 DOI 10.1007/s10584-007-9248-1



About 5,200 years ago, the Sahara lost monsoon rainfall and, over several centuries, lost its grass and grazing animals.

This was the stimulus for the great irrigation civilizations and the need for tax accountants. (That's how *writing* began, 3200 BCE).

Up from the apes

- Common ancestor 7,000,000 years ago
  - Upright posture, loss of big canines
- Toolmaking, bigger brain 2,500,000 yr
- *Homo sapiens* 200,000 years ago, look like us.
- Fine tools, art, "modern mind" 50,000 years ago (last <1%) *"think like us."*
- Agriculture, settlements 10,000 years
- Irrigation, taxes, writing, cities, armies 5,000 years ago (last <0.1%).
- Science in last 500 years (last 1% of last 1%)
- Climate science in the last 50 years (0.00001%).

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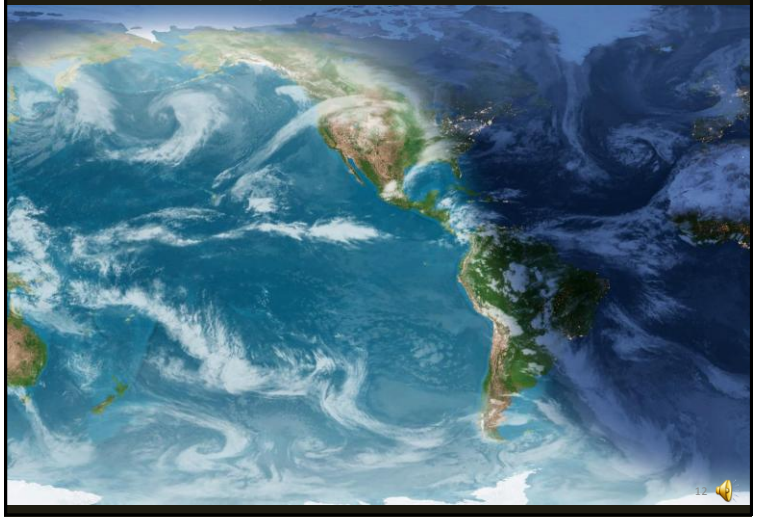
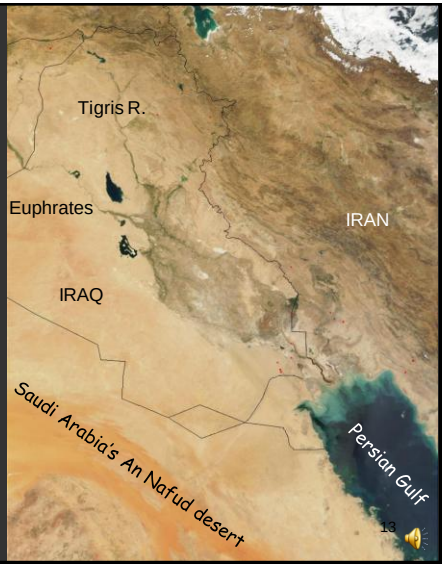
9. The Need (and Ability) to "Turn on a Dime."

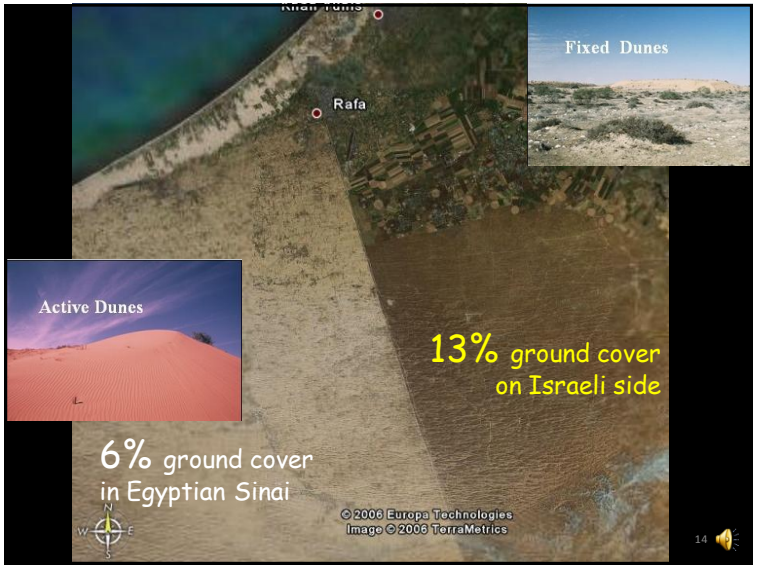
Albedo: bright clouds, deserts, ice, snow



FERTILE CRESCENT

- Agriculture may darken light-colored land.

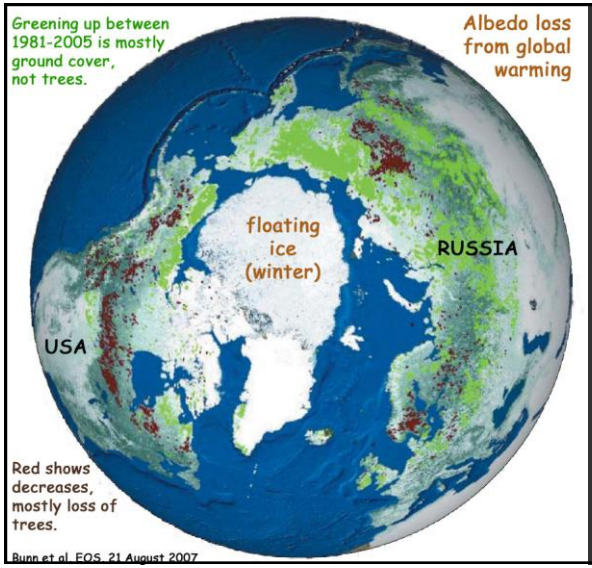




Fresh snow reflects 90% back to space.
After surface melt, only 70% reflects.

Therefore the snow absorbs 3x as much heat the next day.

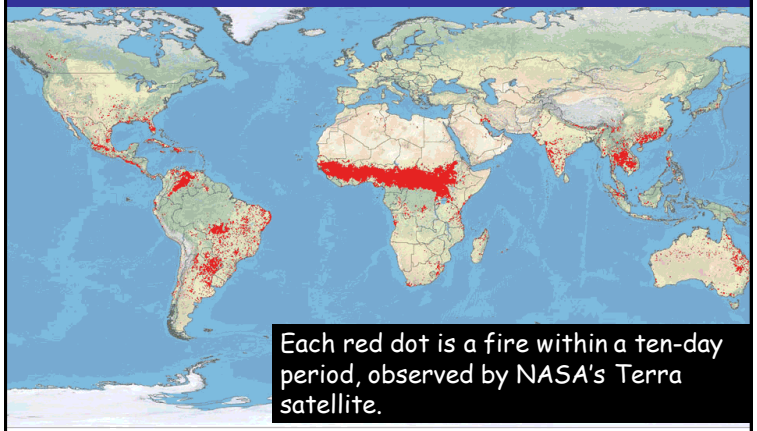
The same thing happens with dust and soot.



Open ocean waters absorb almost ten times more solar radiation than sea ice — a phenomenon known as the ice-albedo feedback.

17

Direct heating of the air from soot



Each red dot is a fire within a ten-day period, observed by NASA's Terra satellite.

18

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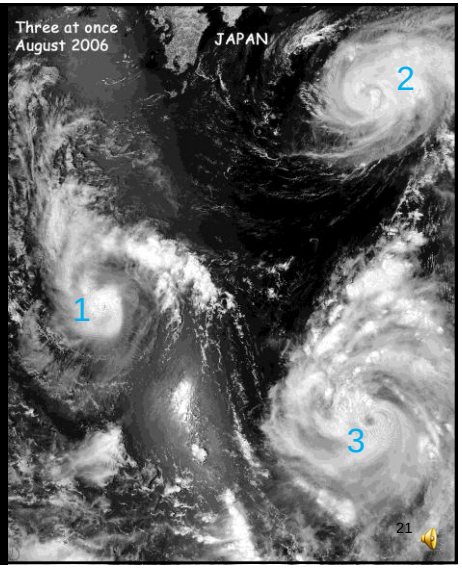
19

There is already MORE EXTREME WEATHER:

- Heat waves
  - 35,000 deaths in Europe in 2003
- High winds, because land warms more than ocean.



NONLINEAR:

As the wind speed increases 20%, from 50 mph to 60 mph, the damage goes up not 20% but 500%.

[6X insurance claims]

180 kmh wind gusts in northern Utah
More high winds are predicted as global warming increases.

It is the widening of the extremes that does the damage, not the higher averages per se.

23

Wider extremes in climate get us closer to flip thresholds.

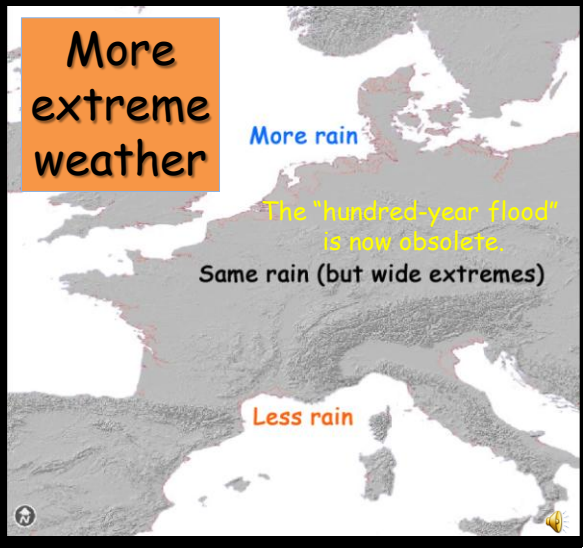
Sometimes a mere delay can produce a flip:

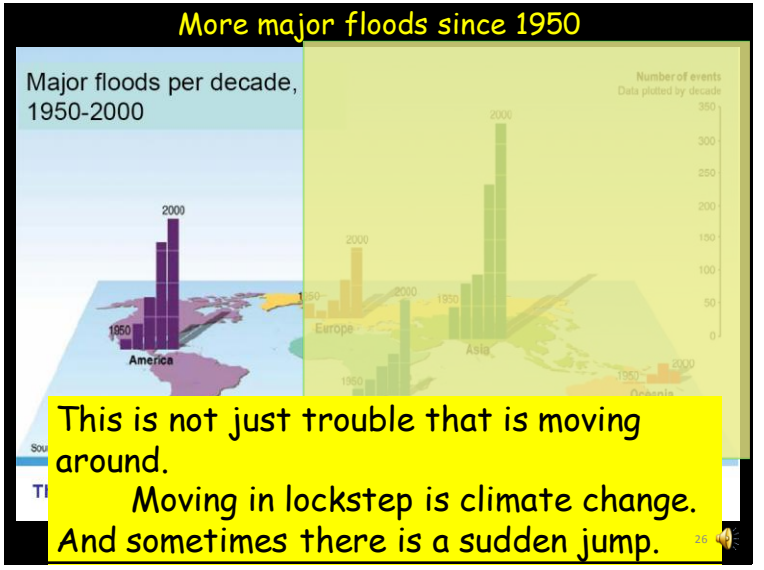
Delay the spring rains by a month—and lose the second crop. Flip production to half.

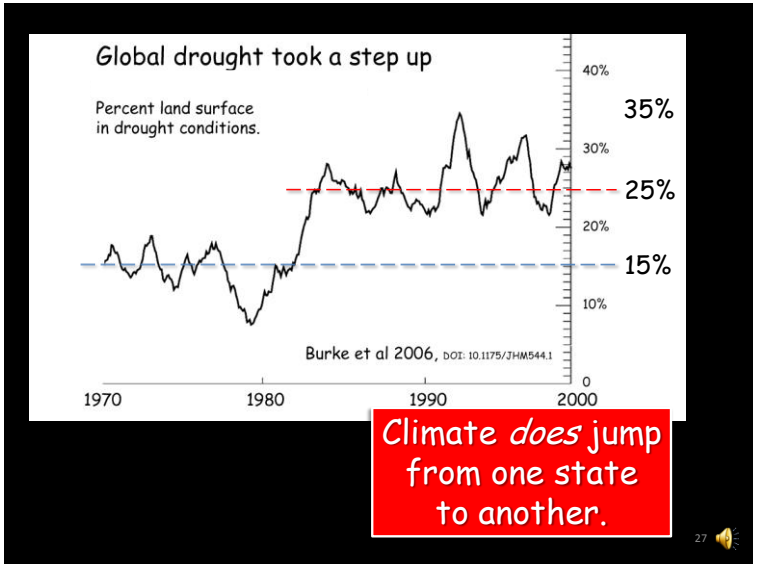
Blown-over garbage truck in Bill Gates' neighborhood of Seattle in 1999

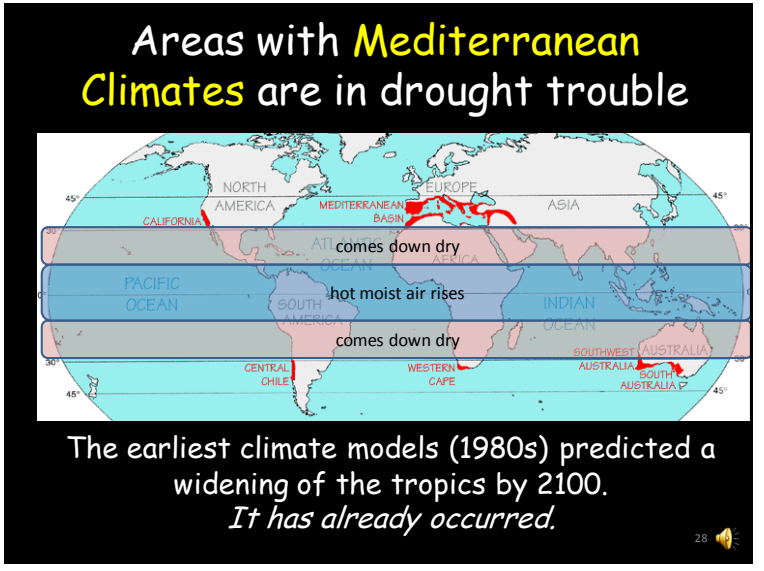
24

Models predicted more rain for northern Europe, less for southern – and with more floods and droughts for all.

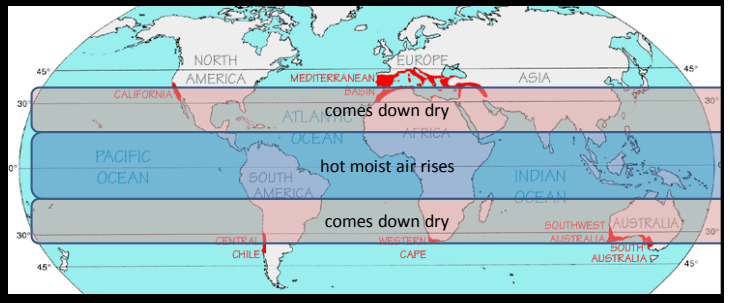








Areas with Mediterranean Climates are in drought trouble



The earliest climate models (1980s) predicted a widening of the tropics by 2100.
It has already occurred.

29

Western Australia desert

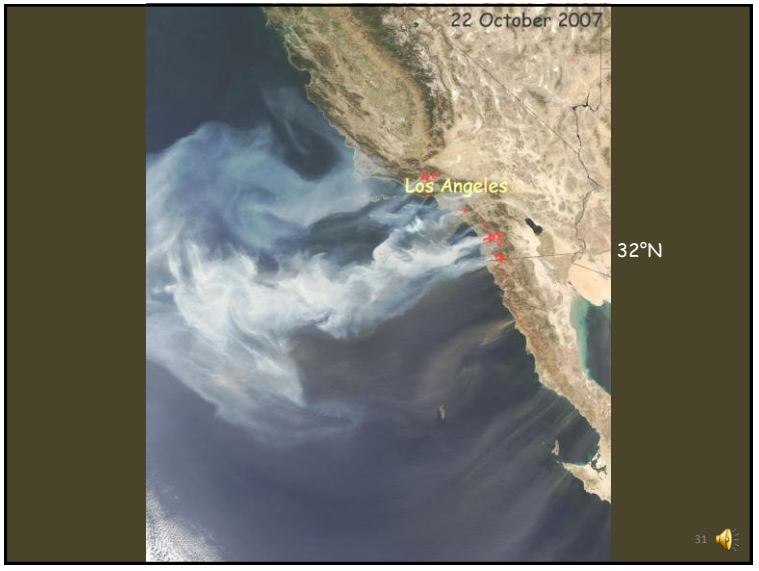
GREEN holds water in dry season
RED parched in dry season

Climate may jump from one state to another.

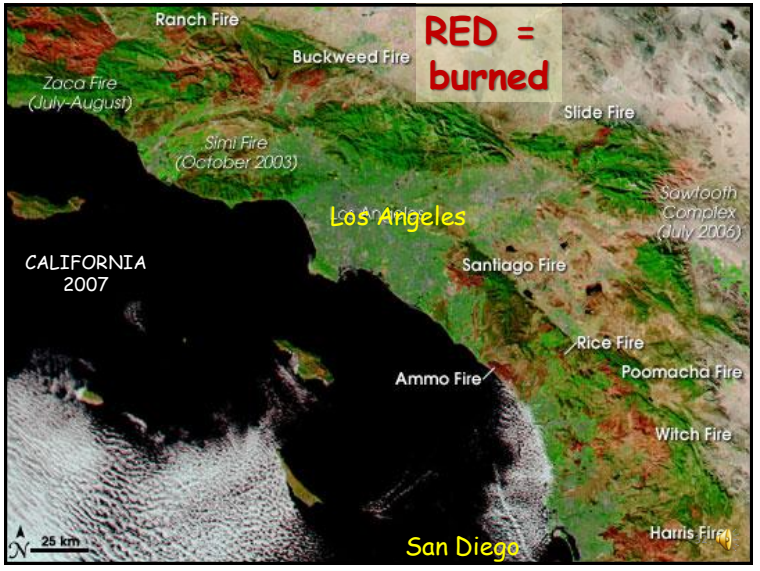
PERTH
32°S

Perth reservoir inflows dropped 50% after 1975.
Dropped to one-third in 1997.

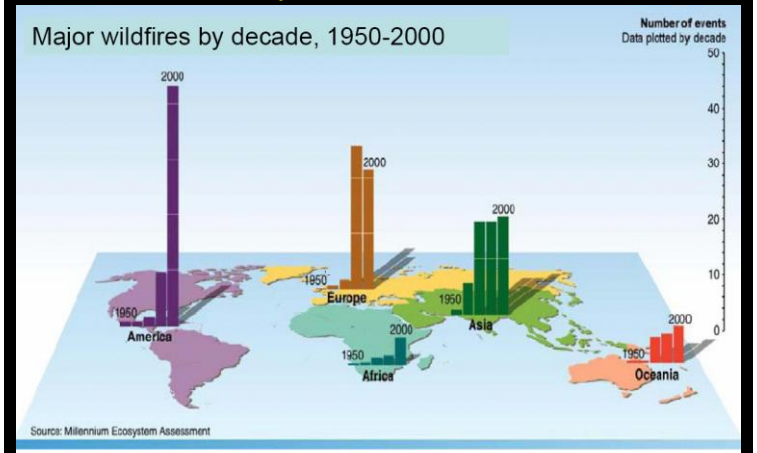
30



31



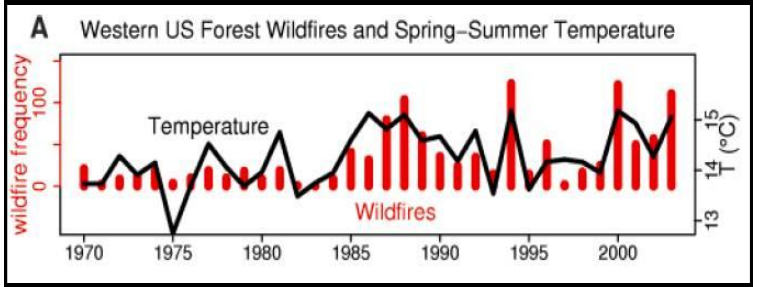
More major wildfires since 1950



The trend has been sharply upward everywhere.

IPCC report 2007

With drought and heat comes more fire.



34

Will burnt forests re-grow in time? No.

Normally, what is cut down in agriculture, losing CO_2 by fire or decomposition, is replaced later in the year by new growth that recaptures an equivalent amount of CO_2.

If a ead wood decompo entury to recaptur the air.

Climate may jump from one state to another.

And, due to a local peculiarity, the Amazon will not re-grow at all, stopping at the savanna stage of plant succession.

35

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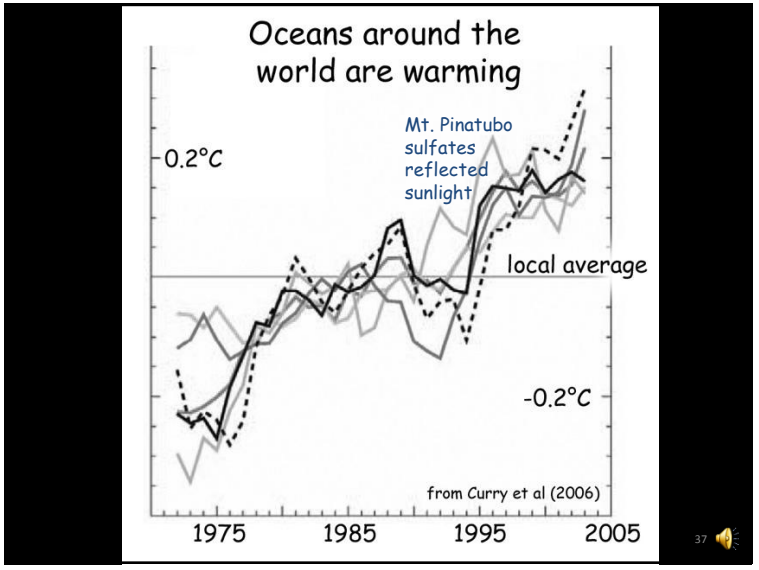
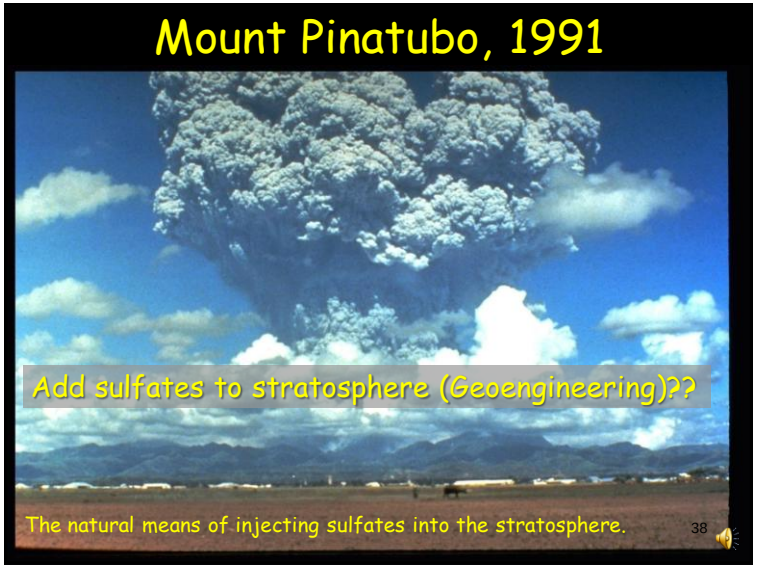
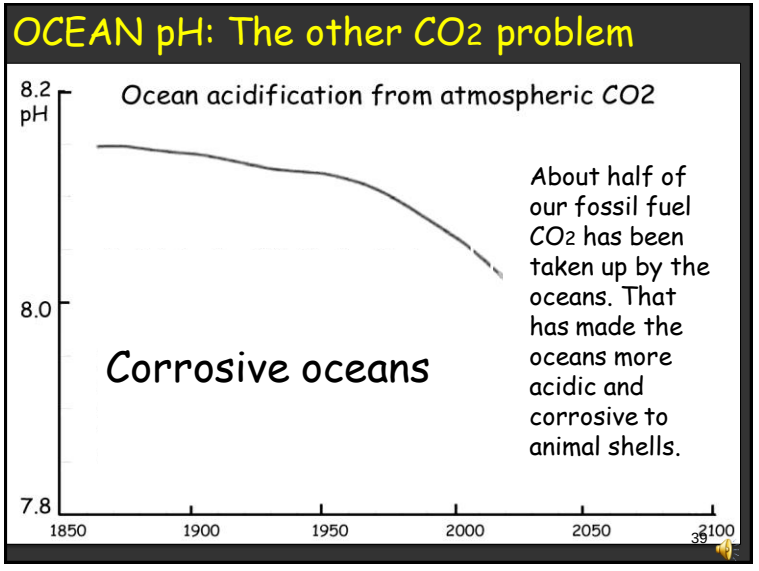
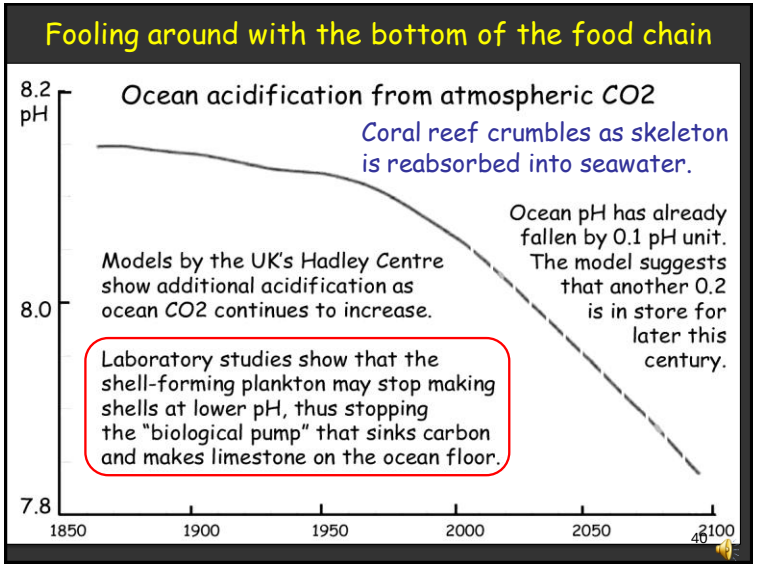
36


Oceans around the world are warming
Mt. Pinatubo sulfates reflected sunlight
0.2°C
local average
-0.2°C
from Curry et al (2006)
1975
1985
1995
2005
37


Mount Pinatubo, 1991
Add sulfates to stratosphere (Geoengineering)??
The natural means of injecting sulfates into the stratosphere.
38


OCEAN pH: The other CO2 problem
8.2 pH
Ocean acidification from atmospheric CO2
8.0
7.8
1850
1900
1950
2000
2050
2100
Corrosive oceans
About half of our fossil fuel CO2 has been taken up by the oceans. That has made the oceans more acidic and corrosive to animal shells.
39


Fooling around with the bottom of the food chain
8.2 pH
Ocean acidification from atmospheric CO2
Coral reef crumbles as skeleton is reabsorbed into seawater.
Ocean pH has already fallen by 0.1 pH unit. The model suggests that another 0.2 is in store for later this century.
Models by the UK's Hadley Centre show additional acidification as ocean CO2 continues to increase.
Laboratory studies show that the shell-forming plankton may stop making shells at lower pH, thus stopping the "biological pump" that sinks carbon and makes limestone on the ocean floor.
8.0
7.8
1850
1900
1950
2000
2050
2100
40

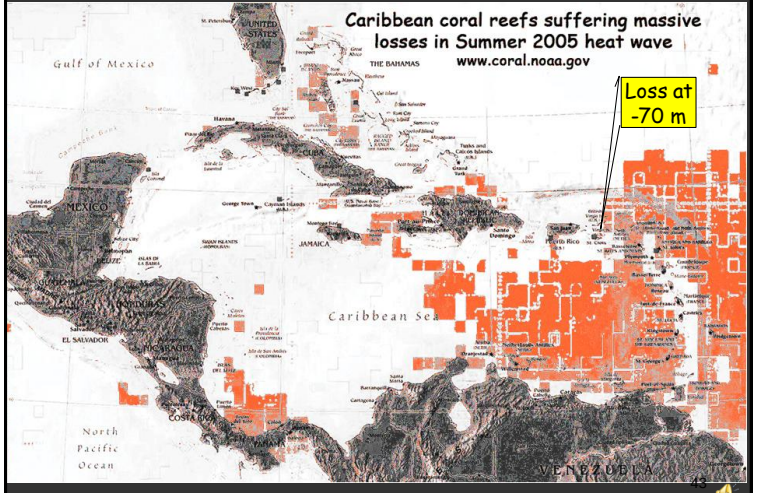
Getting into hot water

41

Coral Reefs

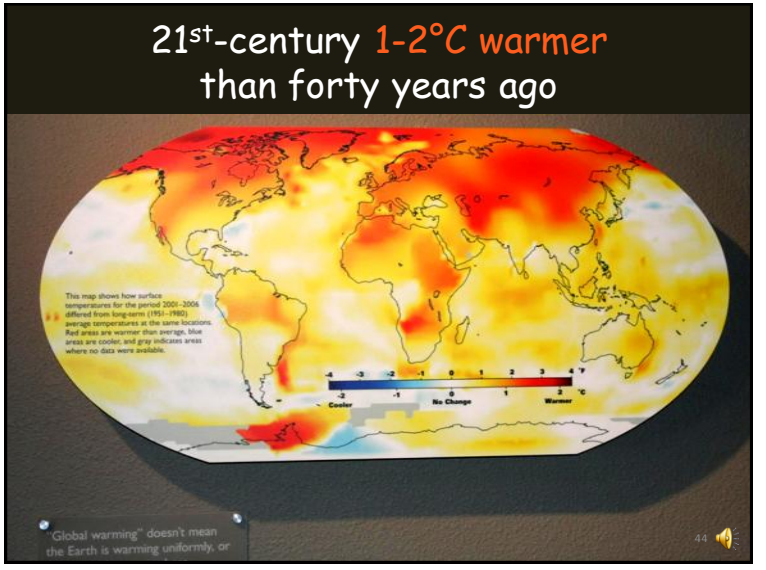
42

Caribbean 2005 coral disaster



43

21st-century 1-2°C warmer than forty years ago



44

Arctic sea ice

1970-1999 average

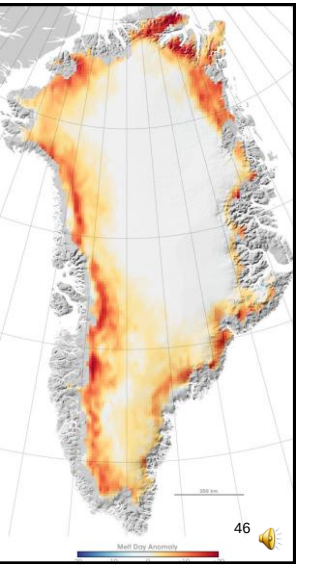
The Arctic floating sea ice that remained in September 2007

No sea level rise.

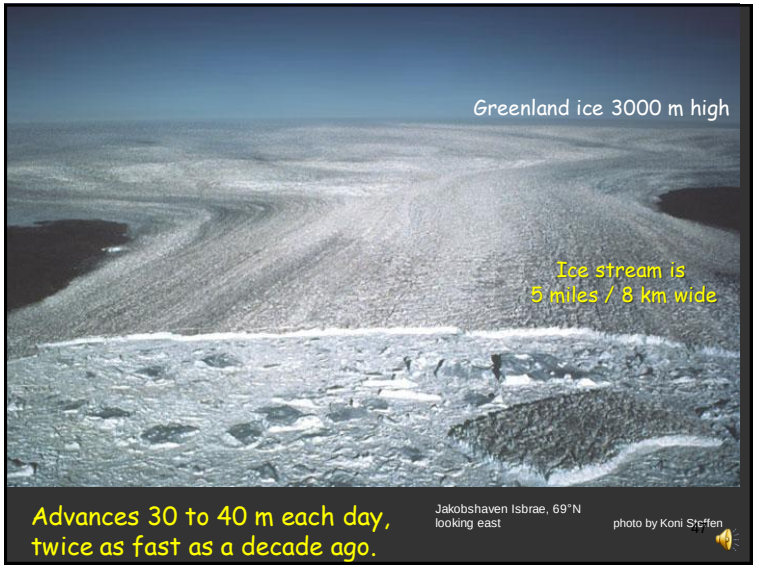
45

GREENLAND areas of increased surface melt in Summer 2005.

But the real way Greenland loses ice is by sliding chunks of it into the ocean, instantly raising sea level.



46



47

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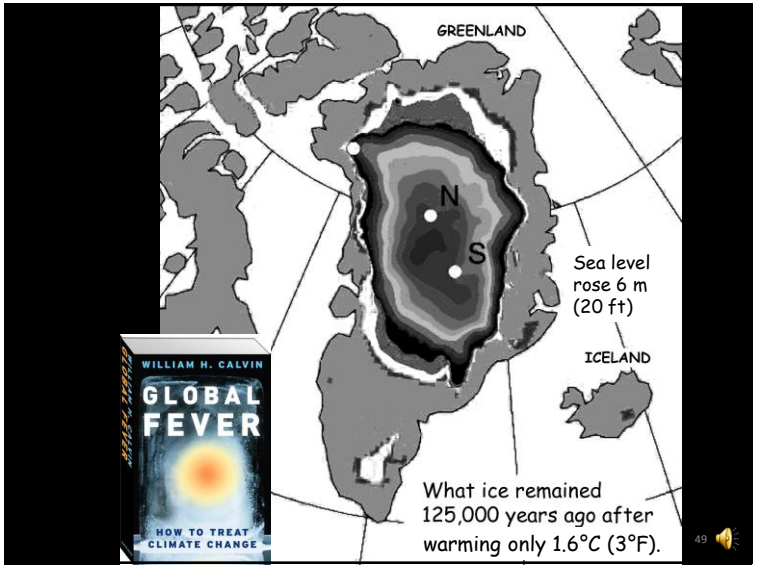
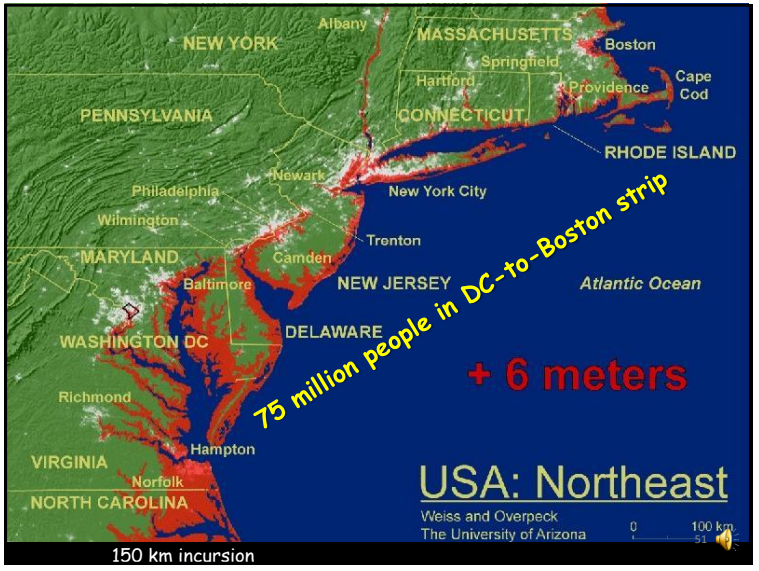
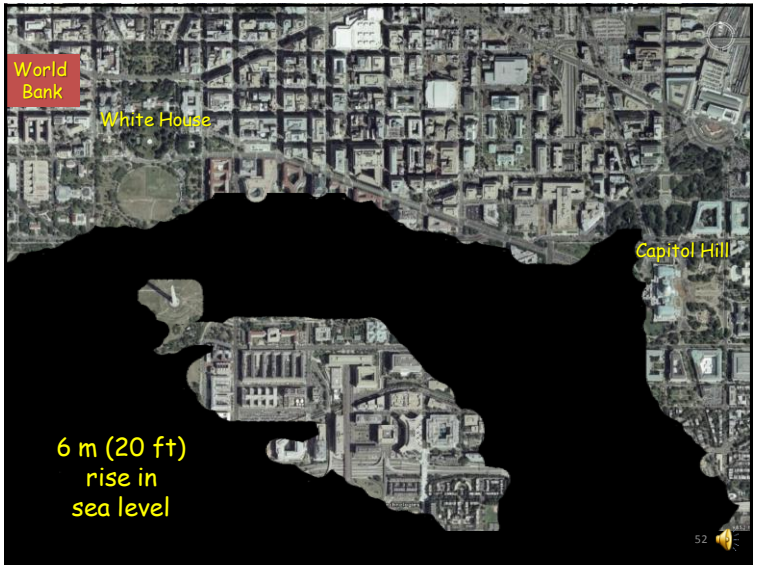
48

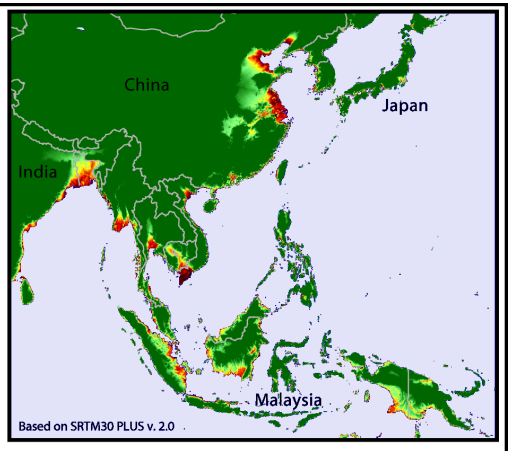

GREENLAND
N
S
Sea level rose 6 m (20 ft)
ICELAND
What ice remained 125,000 years ago after warming only 1.6°C (3°F).
WILLIAM H. CALVIN
GLOBAL FEVER
HOW TO TREAT CLIMATE CHANGE
49


ALABAMA
GEORGIA
Atlantic Ocean
Panama City
Pensacola
Tallahassee
Jacksonville
Gainsville
+ 6 meters
Daytona Beach
Orlando
Gulf of Mexico
Cape Canaveral
This is what happened 125,000 years ago when Greenland warmed as much as it will when global warming reaches 1.6° C/3° F.
Think 15 million climate refugees.
Saint Petersburg
Tampa
FLORIDA
Fort Myers
Fort Lauderdale
Miami
USA: Florida
Weiss and Overpeck
The University of Arizona
0
100 km
Key West
50


NEW YORK
Albany
MASSACHUSETTS
Boston
Springfield
Hartford
Providence
Cape Cod
PENNSYLVANIA
CONNECTICUT
RHODE ISLAND
Philadelphia
Newark
New York City
Wilmington
Trenton
MARYLAND
Camden
Baltimore
NEW JERSEY
Atlantic Ocean
WASHINGTON DC
DELAWARE
75 million people in DC-to-Boston strip
+ 6 meters
Richmond
Hampton
VIRGINIA
Norfolk
NORTH CAROLINA
USA: Northeast
Weiss and Overpeck
The University of Arizona
0
100 km
51
150 km incursion


World Bank
White House
Capitol Hill
6 m (20 ft) rise in sea level
52

Many river deltas in Asia will be inundated.



70 million climate refugees, just from Bangladesh.

53

The average elevation in the Maldives is only 1.5 m above sea level.

330,000 people are living on the edge.

54

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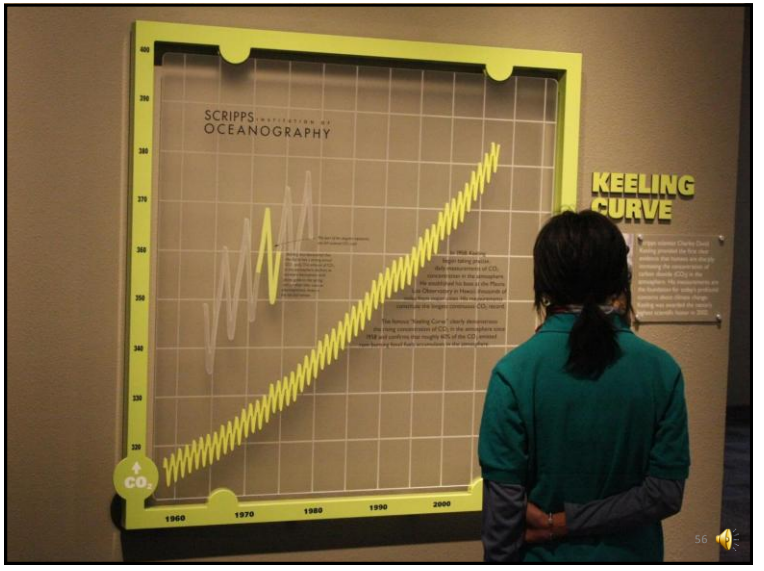
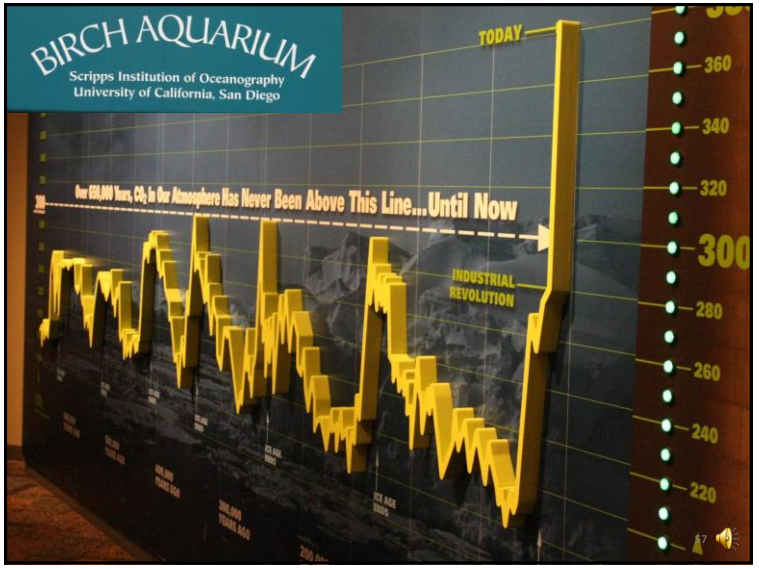


56



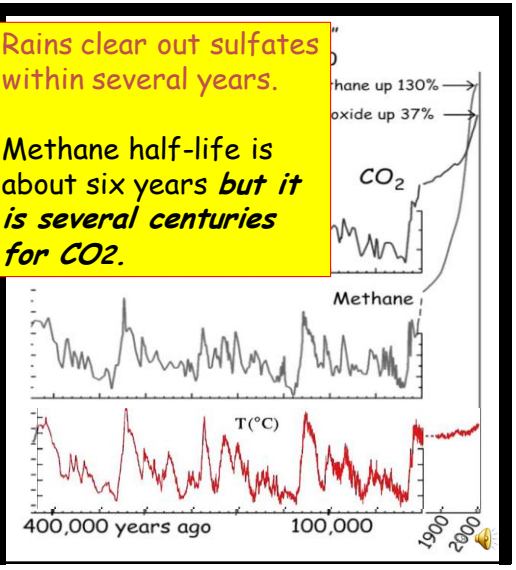
Spike in Methane and in CO_2.

Since methane is 23X as potent as CO_2, can multiply concentration by 23 and add to CO_2.

Can do "CO_2 equivalents" for N_2O and others.

Rains clear out sulfates within several years.

Methane half-life is about six years ***but it is several centuries for CO2.***



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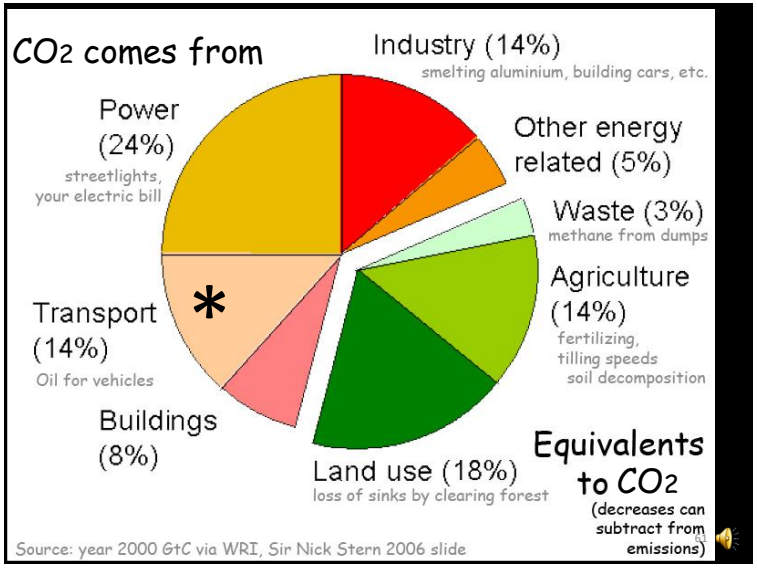


Wheels

Back to front page »

NOVEMBER 24, 2007, 9:41 AM

L.A. Auto Show: Driving Honda's Fuel-Cell FCX

By NORMAN MAYERSOHN

TAGS: AUTO SHOW, FUEL CELL, HONDA FCX, HYDROGEN, LOS ANGELES

The Honda FCX Clarity, powered by a hydrogen fuel cell, will be leased to retail customers next year.

LOS ANGELES — Before hustling off to LAX for my flight home from the auto show last Sunday, I spent a morning driving what may be the most advanced road vehicle on the planet: the Honda FCX Clarity. This fuel-cell-powered car, unveiled in production-ready form at the convention center earlier in the week, will be built in small numbers and leased next summer to retail customers for their everyday use.

Converting Commuters

Hydrogen produced by clean electricity for fuel cell car.

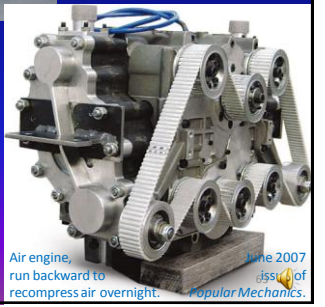
Compressed air vehicles, again using clean electricity to produce an inter-mediate mobile fuel.

62

Air car

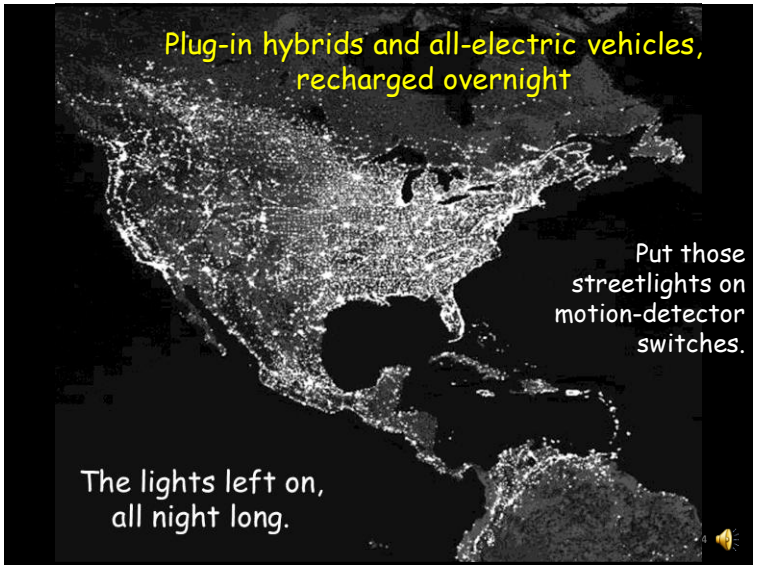
(with free air cooling)

India's largest automaker is set to start producing the world's first commercial air-powered vehicle. "Some 6,000 zero-emissions Air Cars are scheduled to hit Indian streets in August of 2008. This six-seat taxi is powered entirely by a tank filled with **compressed air**."



Air engine, run backward to recompress air overnight.

June 2007 issue of *Popular Mechanics*.

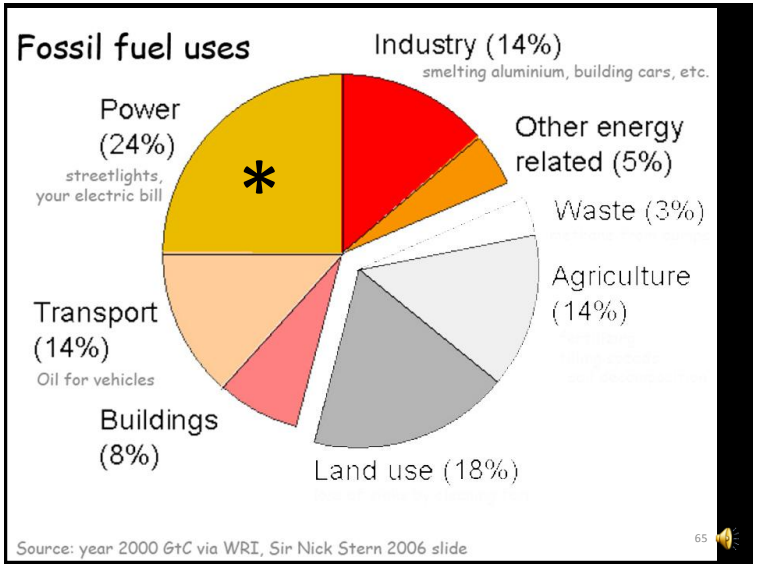


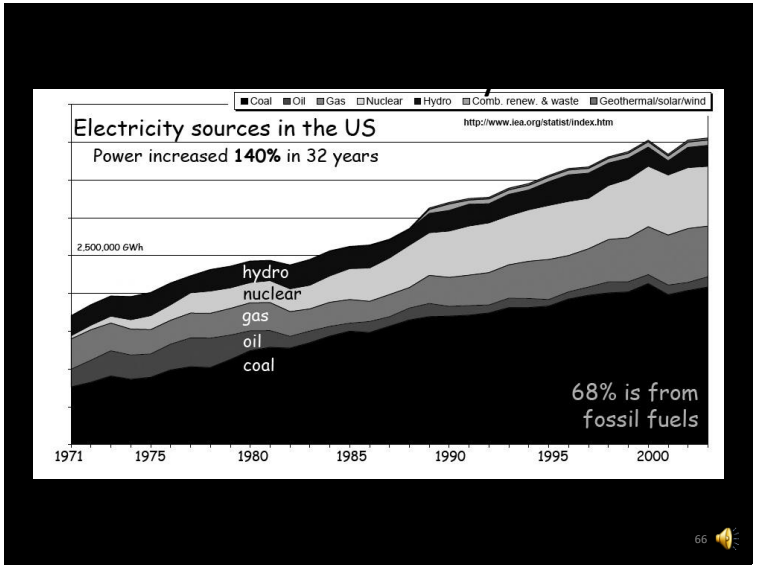
Plug-in hybrids and all-electric vehicles, recharged overnight

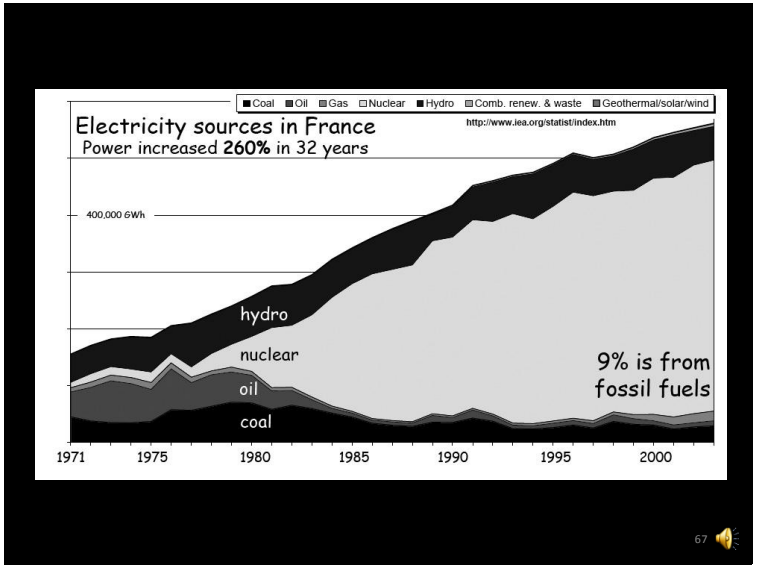
Put those streetlights on motion-detector switches.

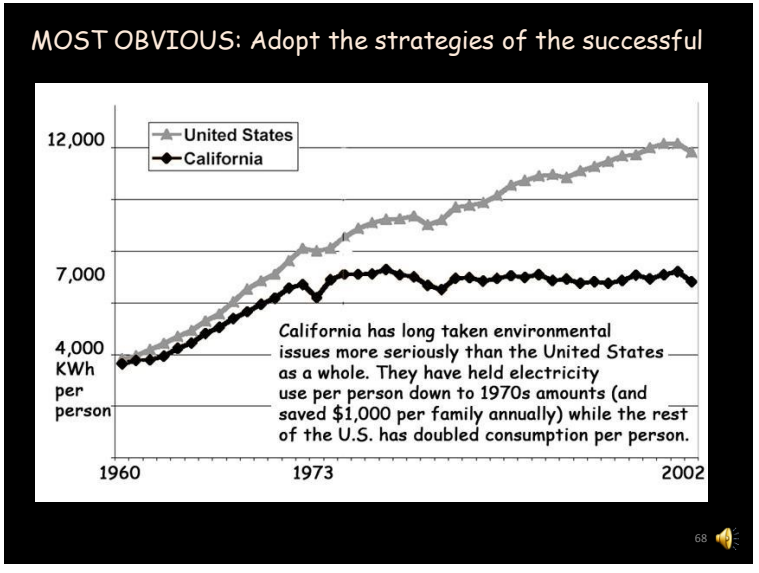
The lights left on, all night long.

64





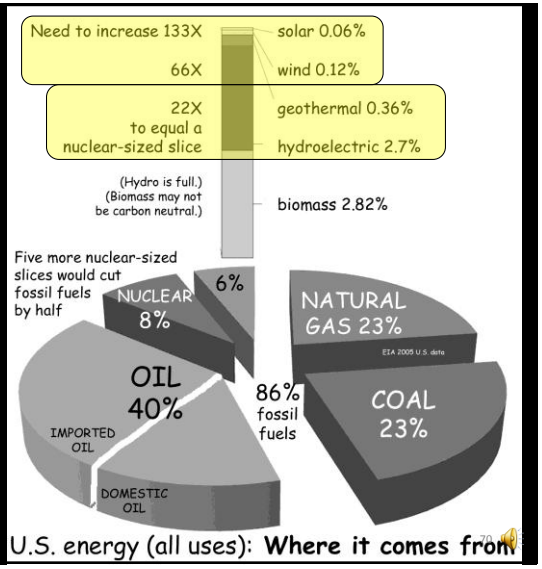


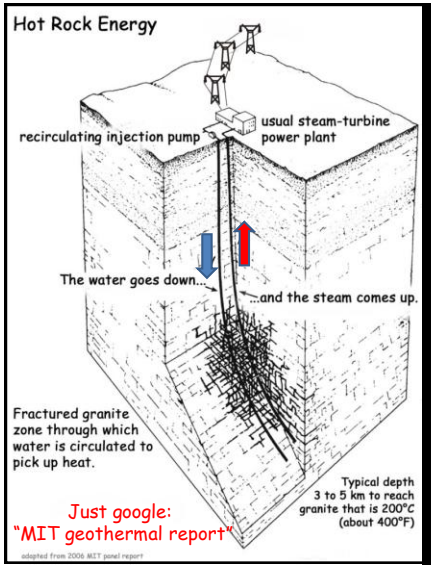


- Need several gigawatts of new clean power *every week (and that's just for new demand in China alone, much more for replacement and other countries)* .
  - *Even more as substitute electricity for gasoline*
- Solar and wind are, alas, not on that scale, and *they do not scale up well*: unstable electrical grids mean that they will need storage to smooth out the current they provide.

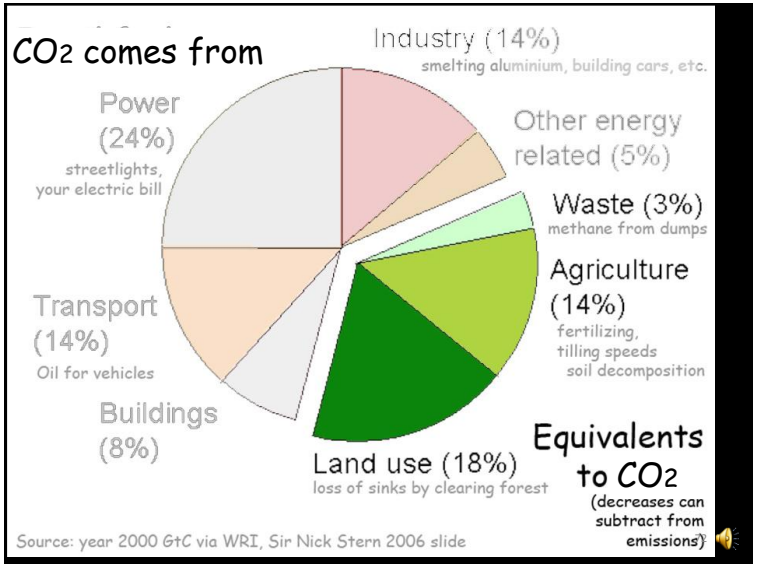
69

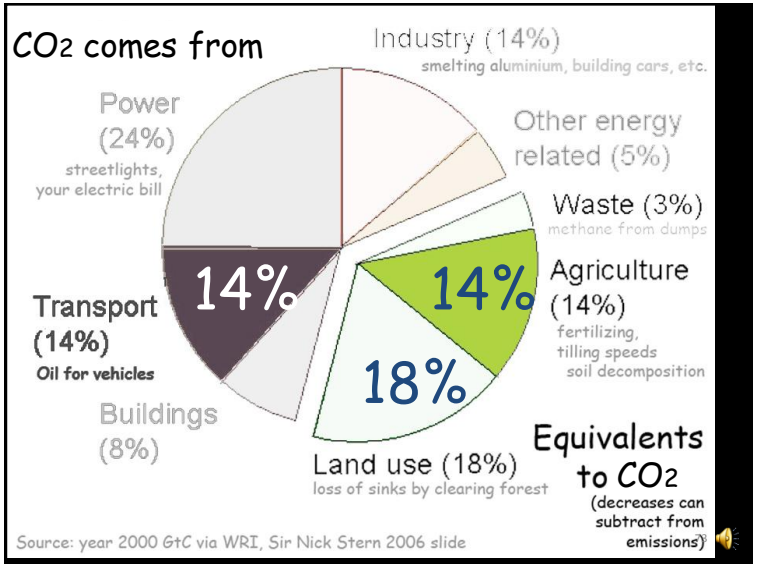
3rd generation standardized nuclear power plants can be cloned in 2-3 years. Safer than hydro.





- Deep geothermal ("heat mining") pumps down water, gets steam back up to run steam turbine.
- No pollution, small footprint, steady output.
- Also suitable for developing countries.





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75

REDUCING EMISSIONS IS NOT ENOUGH:
Must take excess carbon *out of circulation*

1. Plant many more trees
2. Manage the ocean to sink more CO_2
3. Wave-driven pump to carry surface waters down to depths.
4. Artificial photosynthesis
5. Burn *biomass* , capture and store CO_2
6. Store biomass in sealed landfills.

Could get more carbon sinks from more forest…

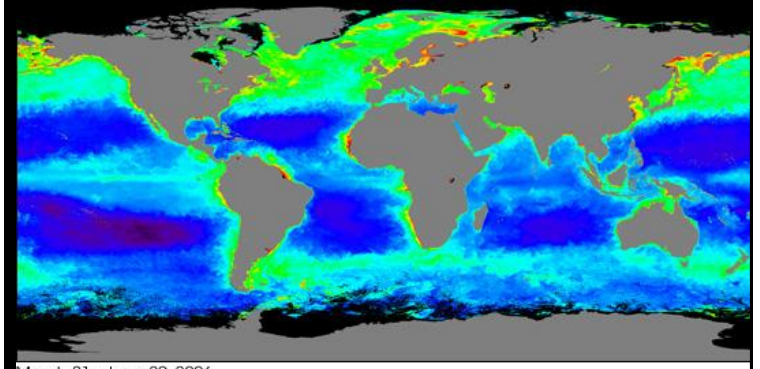
but when the climate forecast is for hot, dry, and windy…

it is too easy for fire to quickly put your sequestered carbon back into circulation.

So not reliable.

Southern California, October 2007
New York Time

Oceans already do half of the world's photosynthesis, CO_2 to O_2



78

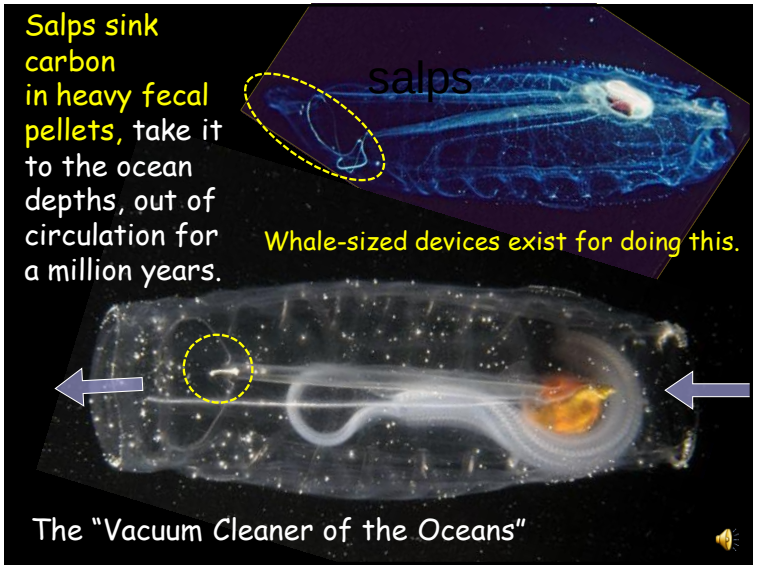
The "biological pump" sinks $CaCO_3$

Coccolithophores

http://www.biol.tsukuba.ac.jp/~inouye

SINKING SHELLS: A major way of taking carbon out of circulation for millions of years.

Salps sink carbon in heavy fecal pellets, take it to the ocean depths, out of circulation for a million years.



Taking atmospheric carbon out of circulation for hundreds of years.

It is the carbon in the air which is the big problem as it exchanges readily with surface and leaves.

The CO_2 concentration depends on how much carbon can circulate and we are adding 8 gigatonnes a year to the circulating carbon.

Taking organic matter out of the circulation--before it decomposes and releases CO_2 into the air--is required to avoid ocean acidification and global fever. 82

Taking atmospheric carbon out of circulation for hundreds of years.

For example, biomass such as sawdust and corn stalks can be buried in a capped landfill, along with treated sewage solids and feedlot wastes.

Muddy river waters can be detoured through settling ponds that are then sealed.

"Saving the soil for future generations" is an additional benefit.

83

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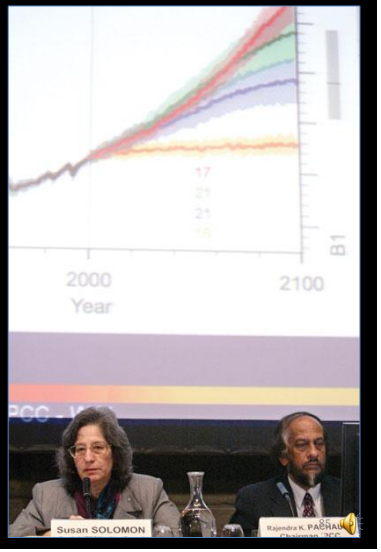
84

While they say very little about the *sudden* things that might happen, as when rain forests suffer a Big Burn, the 2007 IPCC reports do tell us what the 2050 future will be like if the new climate evolves *slowly*—and that now shows that there is only a ten-year window for effective action.



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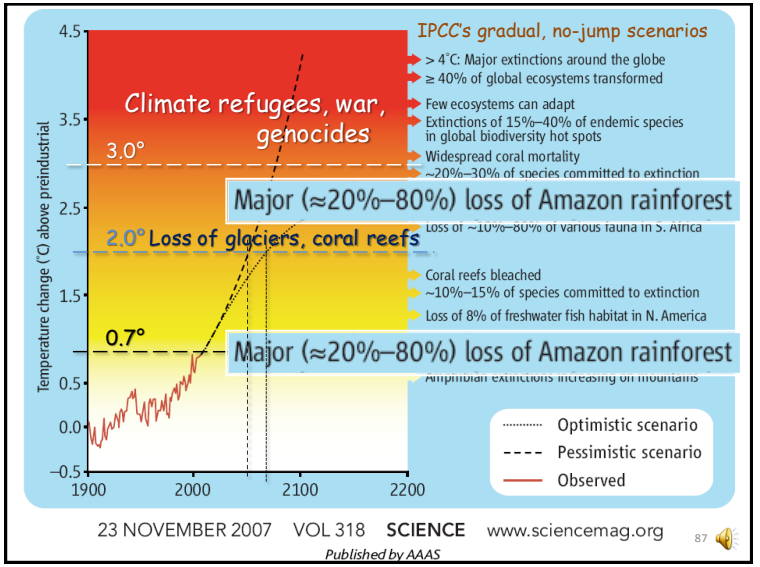
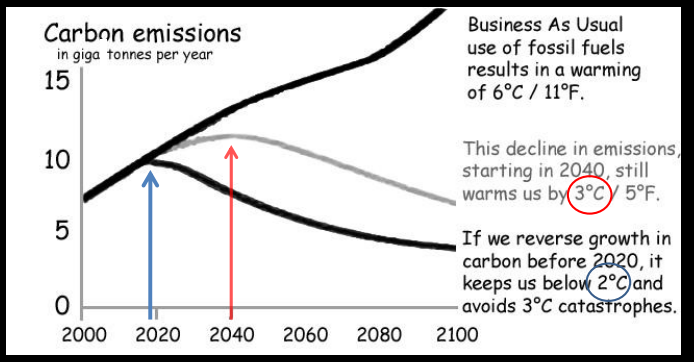


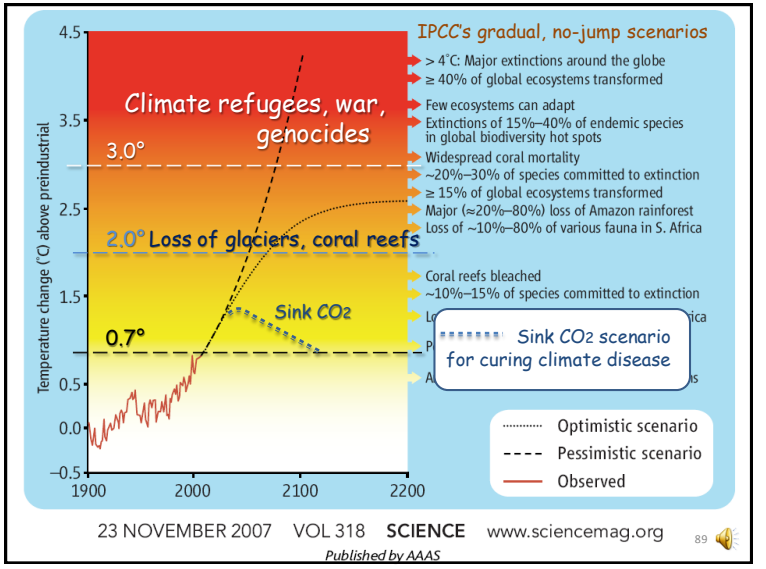
87

The next decade's progress is crucial



Instead of tolerating emissions,
better a scenario to remove atmospheric CO_2.

88



89

The people who study the abrupt climate shifts of the past have an aphorism:

Climate is like a drunk:

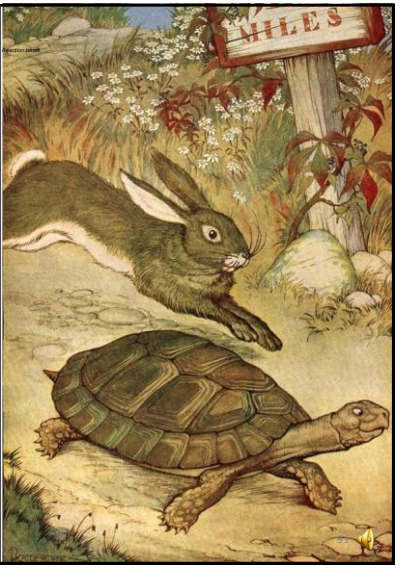
Left alone, it sits.

Forced to move, it staggers.

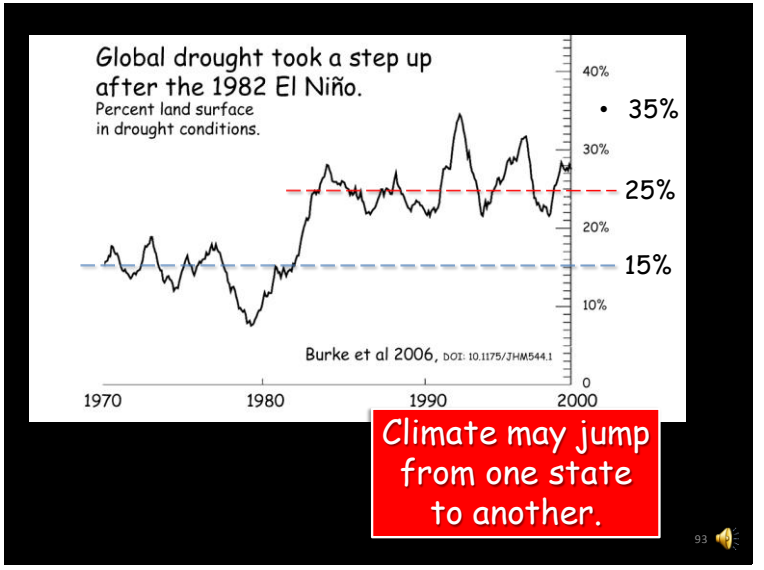
90

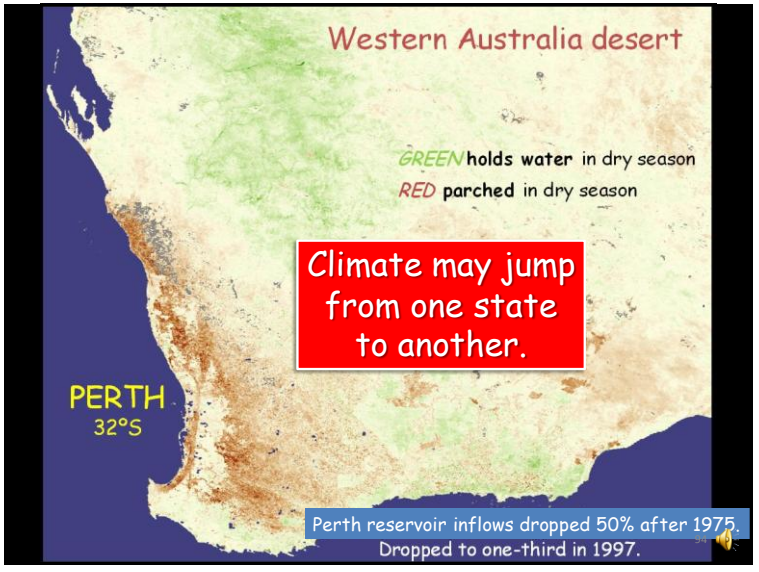
The Tortoise and the Hare is a fable attributed to Aesop. The hare soon left the tortoise far behind and decided to take a nap midway through the course. The tortoise, crawling slowly but steadily, won the race.

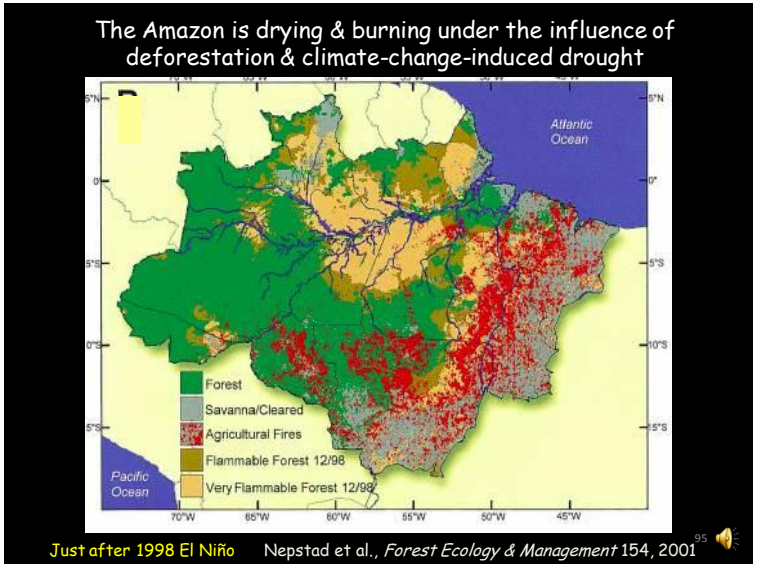
Think of our race finish line, however, as the drop off for a fast decent into Hell. The hare jumps and naps, but the tortoise's progress is slow and sure.



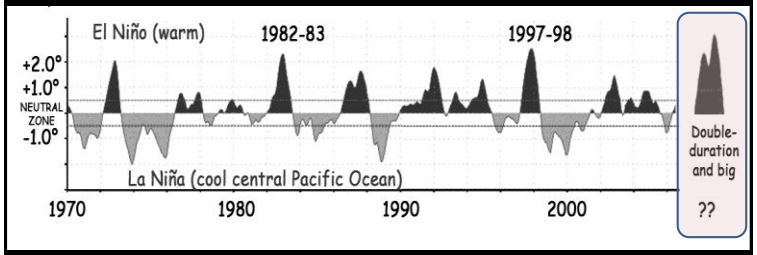
- The IPCC models treat climate as if it moved in a stately manner like a tortoise.
- They all assume that the Hare conveniently takes a long nap.
- *That is not a safe assumption.*





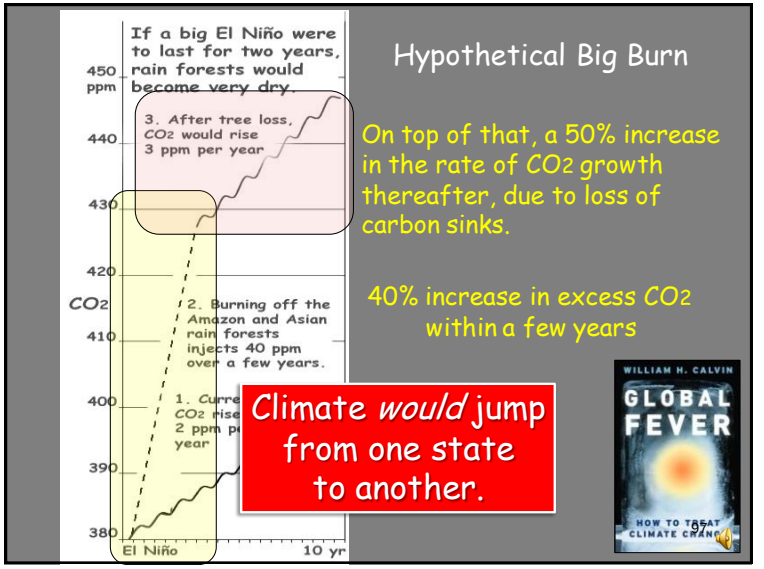


A big El Niño dries out the rain forests of Amazonia, Borneo



If a big one lasted two years instead of one....

96

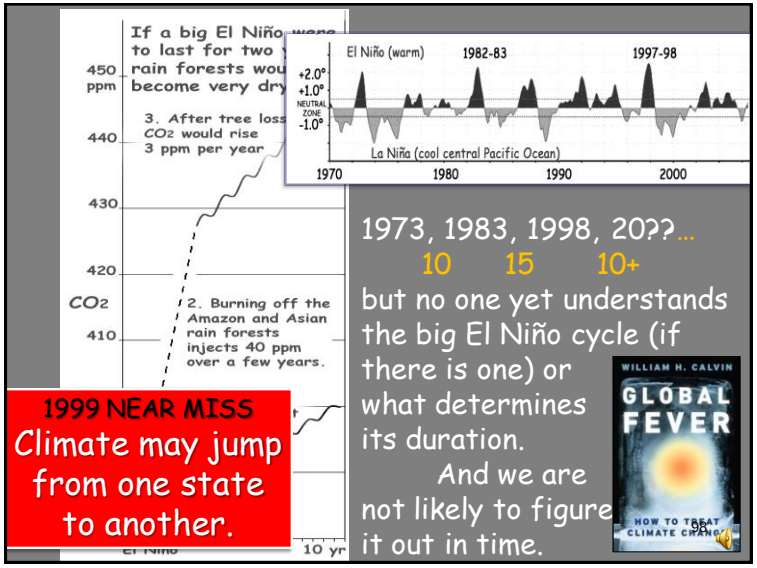


Hypothetical Big Burn

On top of that, a 50% increase in the rate of CO_2 growth thereafter, due to loss of carbon sinks.

40% increase in excess CO_2 within a few years

Climate *would* jump from one state to another.



1999 NEAR MISS
Climate may jump from one state to another.

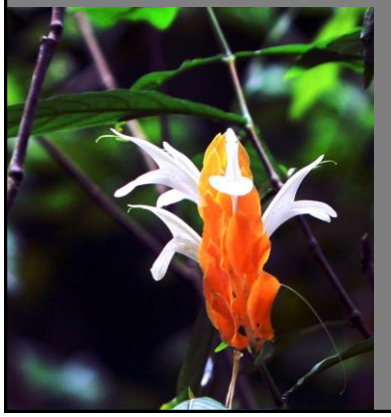
1973, 1983, 1998, 20??...
10 15 10+

but no one yet understands the big El Niño cycle (if there is one) or what determines its duration.

And we are not likely to figure it out in time.

98

The Big Burn also causes a mass extinction event: *about half of all Amazon species will go extinct.*



99

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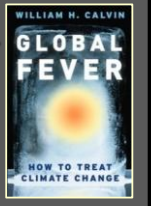
101

Some good reasons for optimism

1. Good longer-term power solutions are already designed and tested. The 3rd Industrial Revolution should provide more. See...
2. Can do the near-term with existing technologies (if we act quickly).
3. We can indeed "Turn on a dime." We have done it before.



102

Three existing technologies, in combination, could solve the near-term part of the problem.

1. Plug-in hybrid vehicles so daily commute is mostly from the electrical grid. Start retiring supertankers.
2. Start building enough nuclear & geothermal power plants to retire old coal plants.
3. Subsidize countries apt to modernize, using their own coal or oil, by drilling deep geothermal wells for them.

DO THIS WORLDWIDE, and emissions *growth* will stop by 2020, limiting overheating to 2°C

103

Some good reasons for optimism

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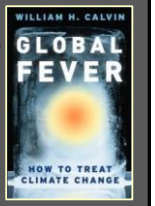


104

President Franklin D. Roosevelt used the metaphor of a "four alarm fire up the street" that needed to be extinguished immediately, whatever the cost.

> From a standing start in late 1941, the automakers converted—in a matter of months, not years—more than 1,000 automobile plants across thirty-one states . . . In one year, General Motors developed, tooled, and completely built from scratch 1,000 Avenger and 1,000 Wildcat aircraft . . . GM's duck `was designed, tested, built, and off the line in ninety days' . . . Ford turned out one B-24 [bomber] every 63 minutes.
>
> —Jack Doyle, *Taken for a Ride,* 2000

Now there's a source of optimism: we did it before.

105

The Great Use-it-or-lose-it Intelligence Test

The public interest requires doing today those things that men of intelligence and goodwill would wish, five or ten years hence, had been done.

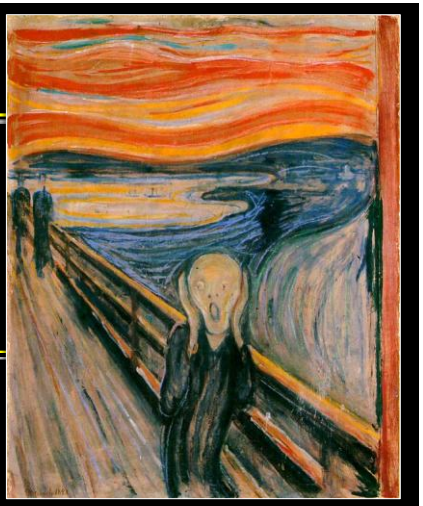
– Edmund Burke

106

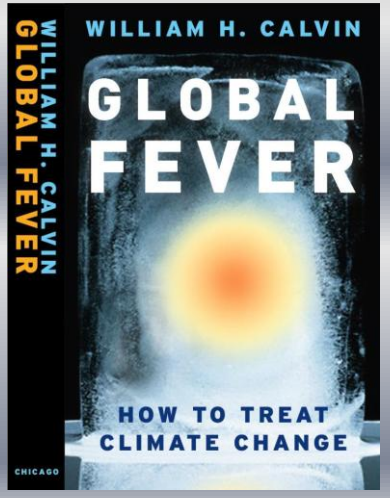
The End

My books and talks may be found at:

WilliamCalvin.org



Edvard Munch, *The Scream*



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