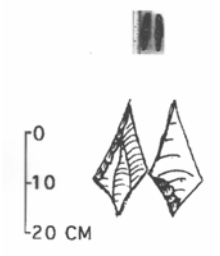
CLIMATE CHANGE

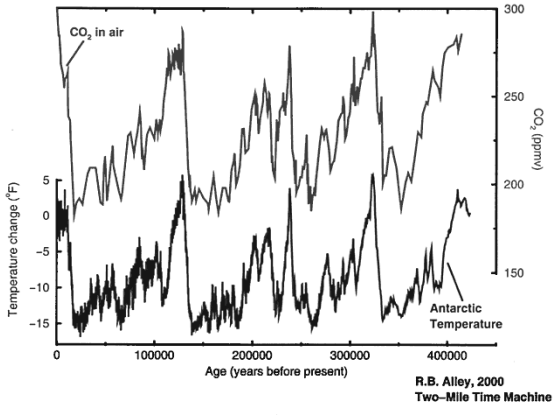


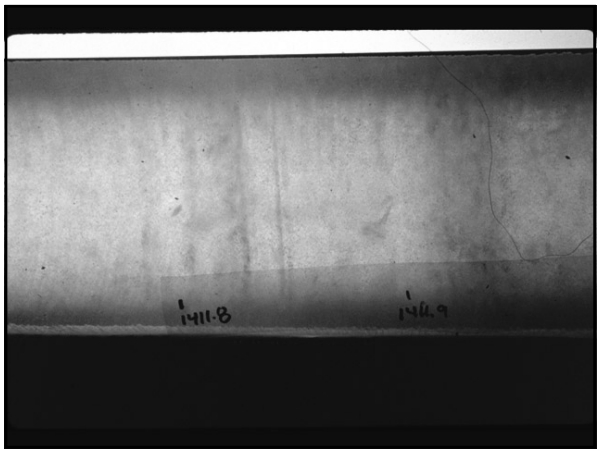
Mark Cane
Lamont Doherty Earth Observatory of Columbia University
For Environmental Sciences PH P6300 September 9, 2003

CLIMATE CHANGE:
PAST
FUTURE
PRESENT

CLIMATE VARIATIONS - El Niño

Impacts on Health





Ice cores give wonderful climate records:

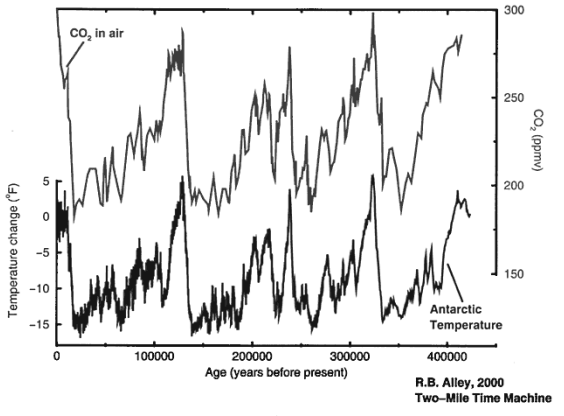
- Age from counting annual layers (checked many ways!);
- Snow accumulation from layer thicknesses;
- Temperature at site in several ways;
- Wind-blown dust, sea-salt, etc. from elsewhere;
- Trapped bubbles of old air with swamp-gas methane, etc.;
- All on common time scale;

Many other sources of info. on past climate:

- Tree rings, ocean sediments, cave formations, packrat middens, and more;

Use knowledge of past climates to:

- Test models that predict future;
- Learn what to put in models;
- Assess possibilities: something that happened is possible.



Ice Age Cycles:

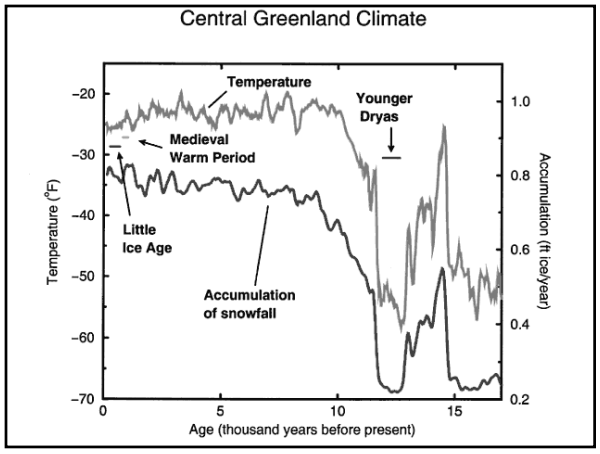
- Global - and approximately globally synchronous
- Timing matches timing of orbital variations
- Can be modeled with some skill *if* CO_2 is specified
- We know the CO_2 changed, but how?
- Models tend to underestimate changes
- Which suggests that models are under-sensitive
- With implications for forecasts of future climate change

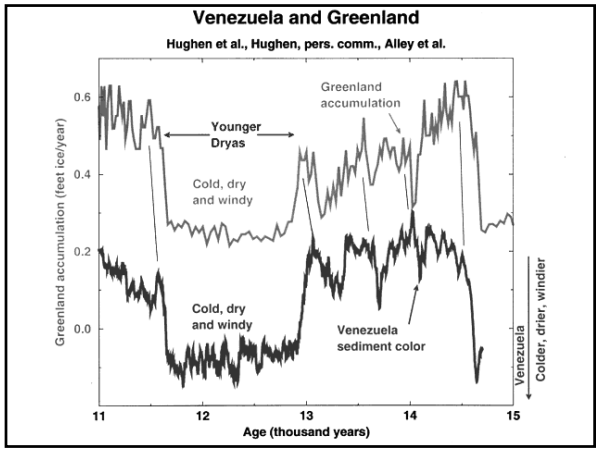
LGM: model vs data

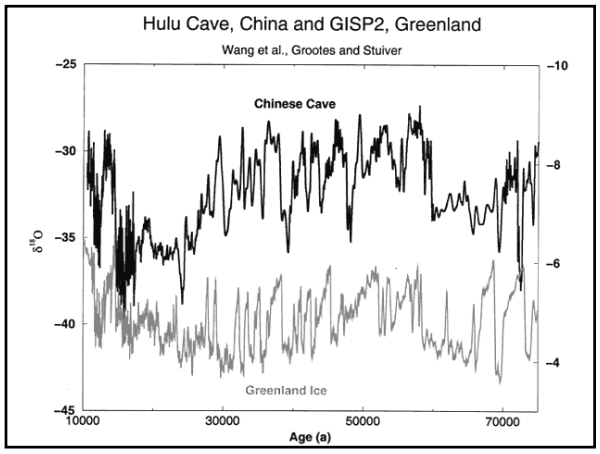
Site	ΔT_{obs} °C	ΔT_{model} °C	Model Error	$\Delta T_{model}/\Delta T_{obs}$
GISP2	-15 to -20	-13.4	4.1	0.77
Britain	-13	-9.2	3.8	0.71
France	-7.4	-6.5	0.9	0.88
New Mexico	-5.5	-3.6	1.9	0.65
Texas	-5.2	-6.4	-1.2	1.23
Yucatan	-6 to -8	-3.6	3.4	0.51
Barbados	-5	-2.6	2.4	0.52
Panama	-5 to -6	-3.2	2.3	0.58
Colombia	-6 to -8	-3.7	3.3	0.53
Ecuador	-6	-3.4	2.6	0.57
Mt. Kenya	≈-4.5	-2.3	2.2	0.51
Burundi	-3	-2.8	0.2	0.93
Papua	≈-8	-2.9	5.1	0.36
E. Brazil	-5.4	-2.3	3.1	0.43
Huascaran	-8 to -12	-4.0	6.0	0.40
Mozambique	-3	-2.6	0.4	0.87
S. Brazil	-6	-1.7	4.3	0.28
Vostok	-15	-6.2	8.8	0.41
Avg.	-7.5	-4.5	3.0	0.62

Modified from Pollard and Thompson, QSR, 1997

Many of the changes in the paleoclimate record were abrupt



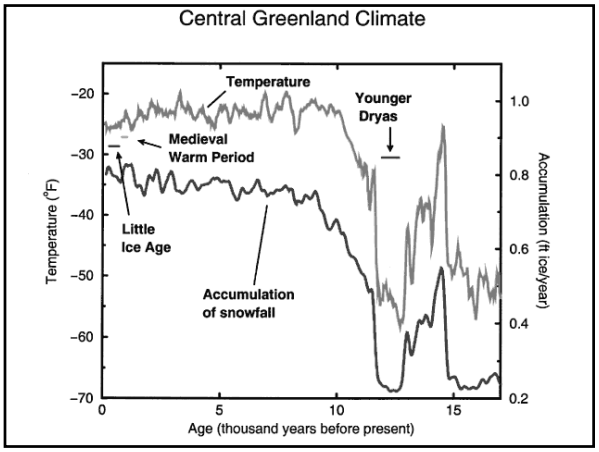


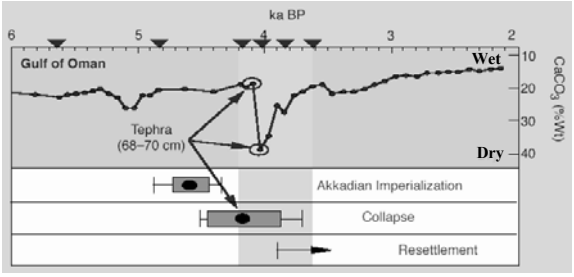


The paleoclimatic record of the *Holocene* points to episodes that were:

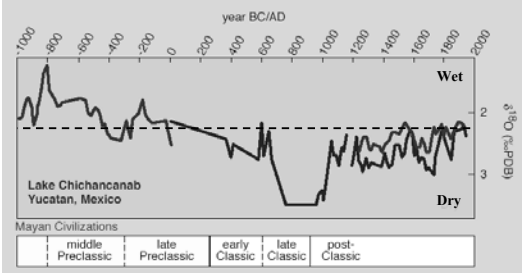
- **Abrupt - not expected**
- **Unprecedented in magnitude - in the experience of societies affected**
- **Persistent - lasting long enough to exceed usual remedies**

⇨ **societal disruption or collapse**

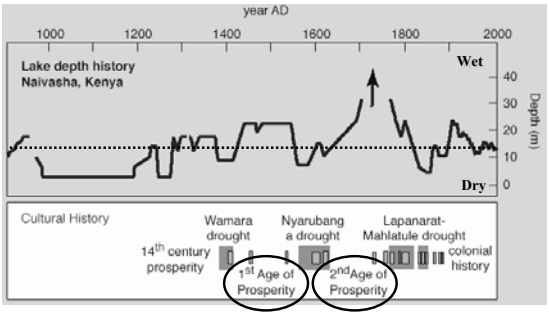




Source: *Cullen et al., 2000*



Source: *Hodell et al., 2001*



***Source**:* Verschuren et al., 2000

Abrupt Climate Changes

- Real - they happened
- Large - 1/3 to 1/2 of glacial/interglacial changes
- Global (as far as we can tell)
- Rapid - in as little as 10 years (meaning big changes every year)
- Repeated - not unusual with the long view
- In warm times, not just ice ages
- No satisfactory theory for them
- Our models (the ones we rely on to predict the future) do not generate them
- Societies have often not survived them

The Anthropocene Age:

A Human-dominated geological episode…with a global imprint

P. Crutzen & E. Stoermer, 2000

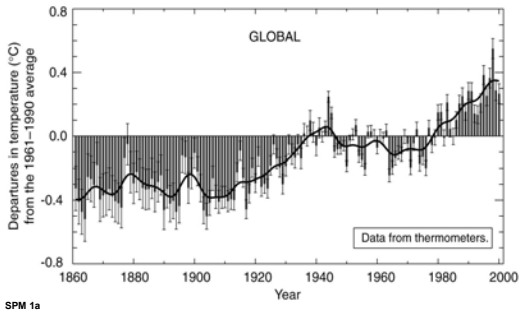
Today…

- **1.4B cattle….with a global impact on CH_4 levels…**
- **SO_2 release is ~160Tg yr^{-1}…~2x all natural emissions…**
- **More N_2 fixed synthetically & applied as fertilizer than is fixed naturally in all terrestrial ecosystems…**
- **Half of all accessible freshwater is used by mankind…impacts on rivers, groundwater….depletion & contamination…**

.

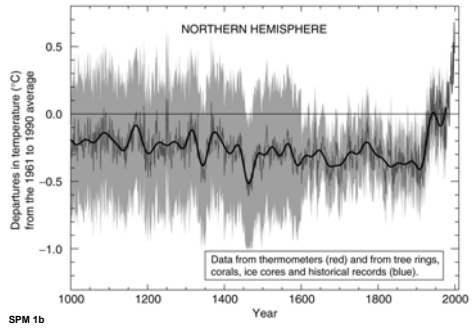
- **Species extinction rate has increased by orders of magnitude within the last 200 years…**
- **Toxic substances contaminate many regions…**
- **Man-made gases have depleted stratospheric ozone levels…**
- **Vast quantities of fossil carbon are returned to the atmosphere each year (~6.3 Gt/C yr^{-1})**
- **CO_2 radiative forcing is now ~1.5W m^{-2}**

Variations of the Earth's surface temperature for the past 140 years



SPM 1a

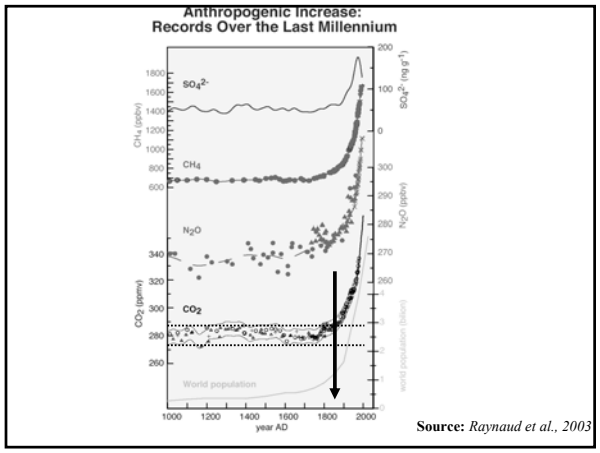
Variations of the Earth's surface temperature for the past 1,000 years



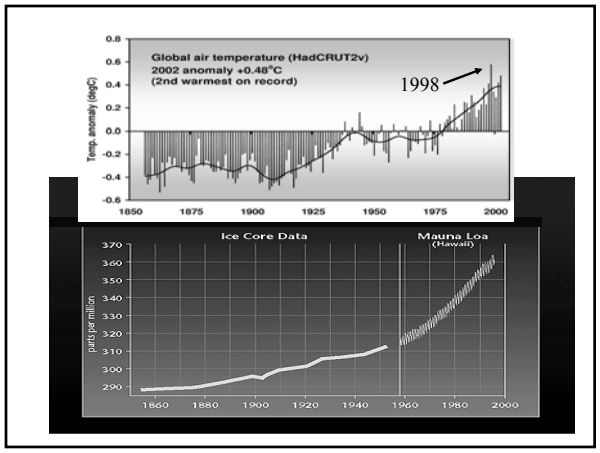
SPM 1b

Kilimanjaro 1970

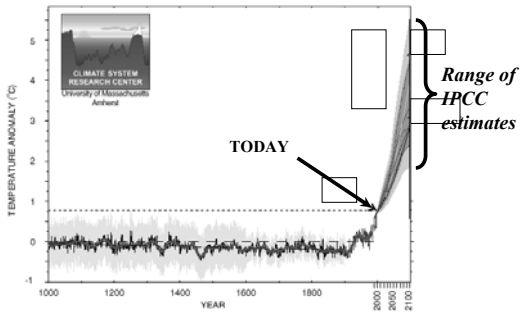
Kilimanjaro 2000

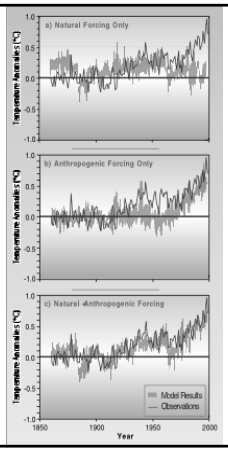


Source: *Raynaud et al., 2003*

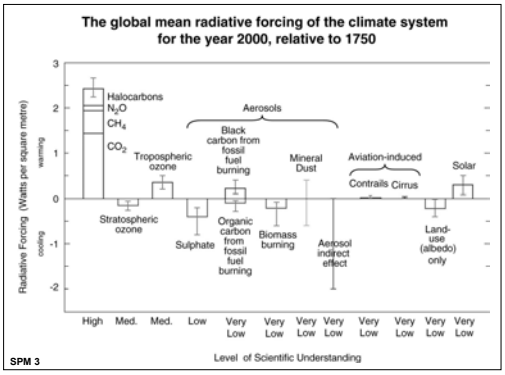


Northern hemisphere mean annual temperatures of the last millennium… and the next century



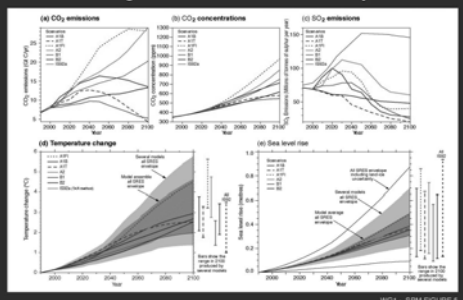


The global mean radiative forcing of the climate system for the year 2000, relative to 1750



SPM 3

The global climate of the 21st century

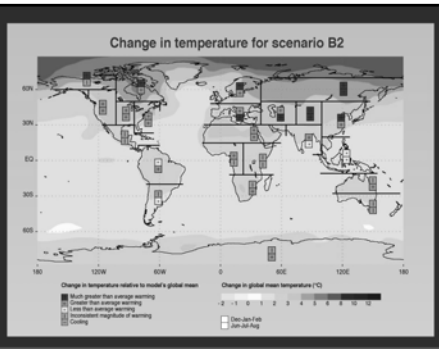


WG1 - SPM FIGURE 5

IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

Change in temperature for scenario B2

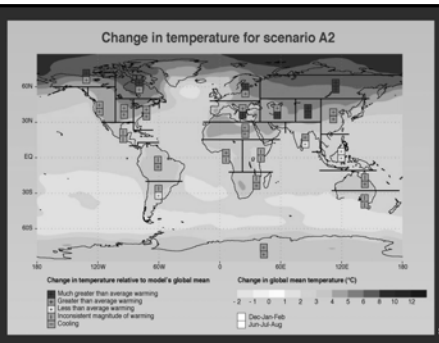


SYR - FIGURE 3-2 b

IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

Change in temperature for scenario A2

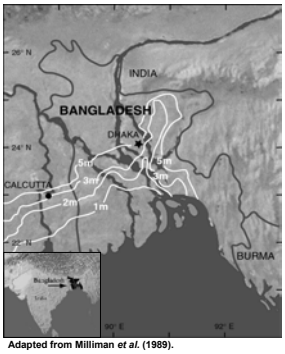


SYR - FIGURE 3-2 a

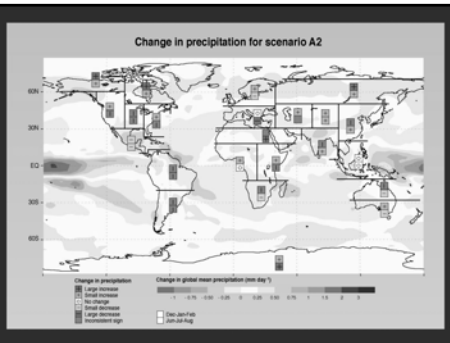
IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

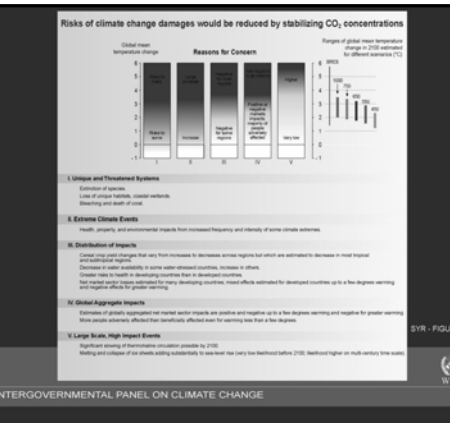
WMO UNEP

Sea-level transgression scenarios for Bangladesh



Adapted from Milliman *et al.* (1989).





QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

THE NEW YORK TIMES, WEDNESDAY, AUGUST 6, 2003

The Paradox of Global Warming

By ERIC ASIMOV

Some wines have benefited from a warmer earth.

GLOBAL warming is a fearsome proposition, dredging up visions of rising tides engulfing shoreline cities, and other cataclysms. For winemakers, especially those in historically cool grape-growing regions, the changing climate has already markedly affected their lives and wines.

"This has been great, no doubt," said Johannes Selbach, speaking by telephone last week from Zeltingen, Germany, where his family has grown grapes along the Mosel River since the 17th century. "Just look at the row of fine vintages we've had. From 1986 through this year it has been strikingly warmer than any time I can remember. Everybody talks about it here."

Wherever winemakers have historically struggled against the elements, hoping to coax just enough warmth from the constant to release the sugar inside the grapes and achieve ripeness, the last decade seems to have brought little but blue skies.

In Germany, the run of good and great vintages since 1988 has been, as Mr. Selbach said, unprecedented. Piedmont in northwest Italy had a great vintage every year from 1985 to 2001. In Oregon, the run of excellent vintages began in 1998. In Champagne, where single-vintage bottlings were once the exception, done only in the best years, vintages were declared nine times in the decade from 1990 to 1999, as against six in the 1980's and four in the 1970's. That increase may in part be because of the higher prices the Champagne producers can demand for vintage bottles; greed may have been influenced by the bigger, riper grape harvests.

While scientists and politicians debate the reasons for global warming, the gradual heating of the atmosphere is well established. Temperatures around the world have on average increased about one degree Fahrenheit since 1900, said Jay Lawrimore, chief of

Continued on Page 2

INSIDE

AT MY TABLE 3
Nigella Lawson's kinda-sorta Chinese spareribs.

OFF THE MENU 2
Jimmy Rodriguez's new beachhead: City Island.

WINES OF THE TIMES 6
23 grüner veltliners and how they fared.

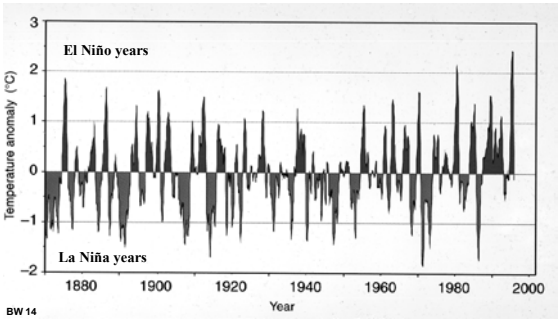
RESTAURANTS 9
William Grimes weighs in on an Italian stalwart, San Domenico.

Jonathan Player for The New York Times

CLIMATE VARIATIONS - El Niño

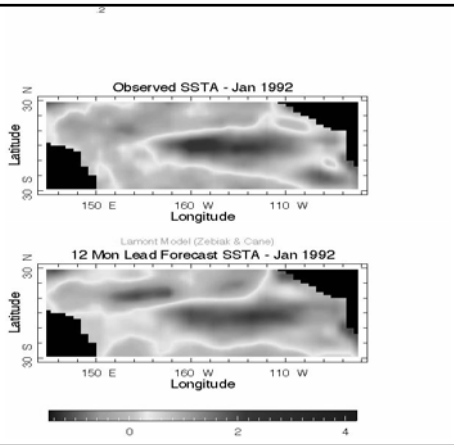
Impacts on Health

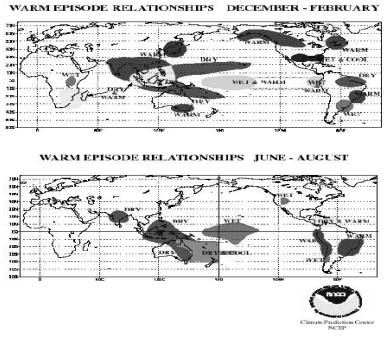
The 1997/98 El Niño Strongest on Record*



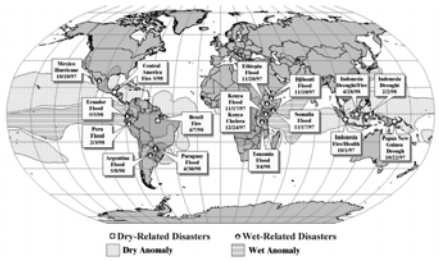
BW 14

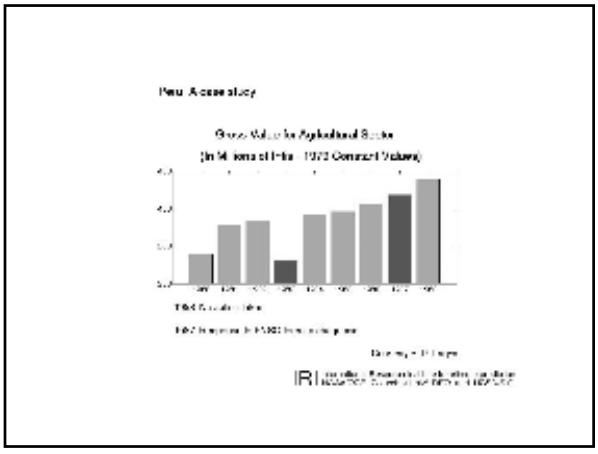
*As shown by changes in sea-surface temperature (relative to the 1961-1990 average) for the eastern tropical Pacific off Peru

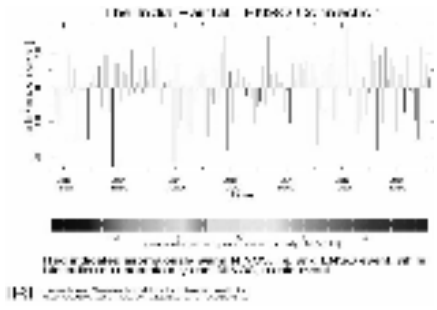




iri.columbia.edu







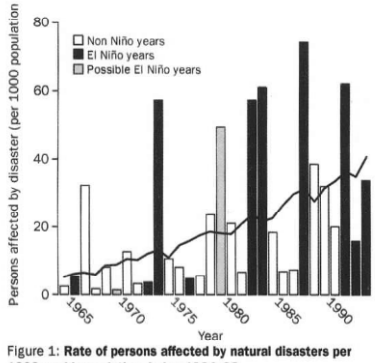
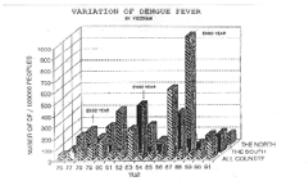
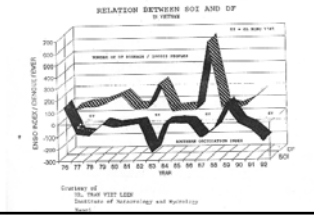


Figure 1: **Rate of persons affected by natural disasters per 1000 world population during 1964–93**
Continuous line represents predicted values from time-series regression.

Exploring the Linkages between the El Niño-Southern Oscillation (ENSO) and Human Health





Courtesy of
DL. Thai VIET LIEN
Institute of Meteorology and Hydrology

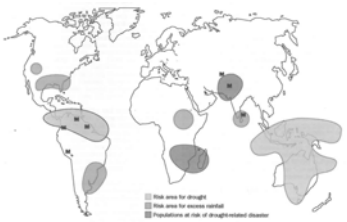


Figure 1: ENSO teleconnections and risk map for malaria
Risk areas for drought and rainfall based on teleconnections associated with El Niño.* M shows areas where there is a risk of epidemic malaria after the onset of an El Niño event.

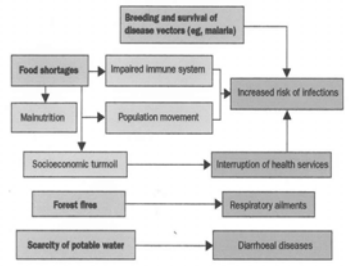
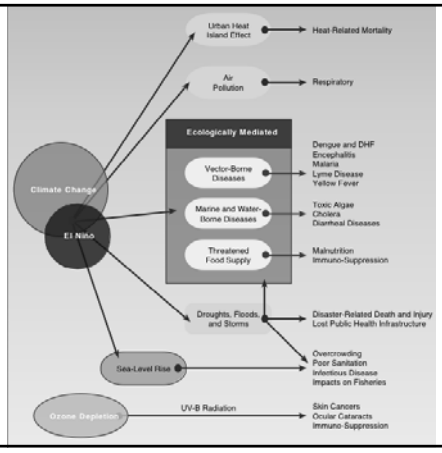


Figure 2: **Potential health effects of drought in developing countries**



- The climate record shows many examples of rapid changes in both glacial and warm times
- These abrupt climate changes have had major impacts on civilizations
- Models do not simulate these changes; they appear to be less sensitive than nature

- We *are* in the Anthropocene Age
- and we are not getting out of it any time soon
- There will be surprises; sudden surprises
- Do models underestimate what lies ahead of us?
- It is difficult to disentangle current effects of greenhouse warming and natural variations
- Natural variations such as El Niño have profound impacts on human affairs, including health
- Predictions of El Niño have been used to mitigate impacts

Will we apply what we have learned to

CLIMATE CHANGE?