Mon Dec 8

This week:

Mon: HW#6 DUE
Climate Impacts in the Pacific NW (Dr. Phil Mote)

Tues: Discussion of guest lectures (Gammon, Anderson, Mote)
Energy Alternatives

Wed: Global warming forecasts (HW 6, etc)
Energy alternatives
Principles for a positive future
Course Evaluation

Fri: FINAL, here, 8:30am

Upcoming talks:

Tuesday 9 December

12:30 310 ATG

Weather discussion

2:30 A-118 Physics/Astronomy Aud (PAA)

"Weird Life" by Dr. Steven Benner

Wednesday 10 December

12:30 425 OSB (Ocean Science Bldg)

"Climate change and pollution in the Arctic"
Dr Robie Macdonald

Friday 12 December

3:30 14 OTB (Oceanography Teaching Bldg)

"Climate models and Abrupt Climate Change",
Dr Thomas Stocker

Tues Dec 9

Announcements

- HW 6 will not be returned before final, but key posted to web
- final exam emphasizes second half of course
- Phil Mote's letter to The Oregonian was published

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questions re: Evidence of Global Warming (Richard Gammon)

Some of the questions from yesterday's talk:

*How does CO2 harm the ocean? How does global warming harm the corral reefs? How important (to humans) is it that corral reefs are dying?

How are heat-related deaths determined? How do we know these are due to global warming? Could they have been prevented?

Cost of weather-related disasters is dramatically increasing... but isn't part of this due to putting buildings in disaster-prone areas?

*How are forest fires caused by global warming?

How does the increase in GHGs cause both global warming at the surface and cooling of the stratosphere? Why are effects larger in NH?

The beach in my home town in Japan disappeared overnight. Was this because of the ice melting and sea level rising?

questions re: Evidence of Global Warming (Richard Gammon)

*Arctic: What is permafrost? If global warming is heating up the Arctic, why are some regions (e.g. central Greenland) getting colder?

*Explain how ice melting sometimes does and sometimes does not cause sea level to rise?

Politics: Why are the politicians so unaware of this evidence? What does Putin not like about the Kyoto Protocol?

What is the solution? Can we really stop using fossil fuels? Wouldn't the harm to the economy be even worse than global warming?

*Future: How long before we recover from global warming, once we implement a solution?

Questions re: Skeptical view of current global warming paradigm (Tad)

physical processes of aerosol forcing:

How do the direct and indirect aerosol forcings work? How do aerosols modify the properties of clouds? Is there any actual evidence of aerosol effects on cloud?

How do you know the aerosol plume coming off China is not a regular cloud?

If aerosol forcing is greater than IPCC has led us to believe, would this be confined to small areas like the Northeast US?

Do the forcing forecasts account for switching from oil to coal and the increased aerosol pollution that will cause?

Would deliberate release of aerosols be a solution to global warming?

Questions re: Skeptical view of current global warming paradigm (Tad)

forward and inverse calculations:

Forward and inverse method of calculating aerosol forcing: which is more accurate?

Doesn't the inverse calculation (of aerosol forcing) assume that there are no other forcings that haven't been properly accounted for?

Why are the forward calculations so different from each other (especially F)?

uncertainty

Why is the aerosol forcing so uncertain? How can it be reduced or can it be reduced?

If uncertainty in total forcing is so great now, why does it decrease in the future?

If aerosol emissions increased in the future, would aerosol forcing uncertainty increase even though they dont stay long in the atmosphere?

How do you know the uncertainty? Can it really be so large? Isn't all this talk about uncertainty just to please the skeptics?

Why is the uncertainty of the inverse calculations so small?

Questions re: Skeptical view of current global warming paradigm (Tad)

attribution:

Confusion about Jim Hansen's graphs fitting the temperature record - what exactly is the meaning of the different tests?

Attribution plot: What happened in 1880's to make models and observations differ?

the current paradigm:

If hundreds of scientists reviewed the IPCC report, why didn't the problem of circular logic get noticed by anyone?

So the Application studies have ignored forward calculations ... Why are scientists so willing to manipulate information to fit their preferred hypotheses?

Which would have a larger influence on the accuracy of climate predictions: understanding the aerosol forcings or understanding the climate's lag factor and sensitivity?

If the current paradigm is shown to be wrong... what then?

Questions re: Skeptical view of current global warming paradigm (Tad)

misc:

If you had 5 minutes (e.g. on national TV) what would you say to convince the world that global warming is real?

Comment: It seems that we won't know how the climate system works until it is too late!

Could we discuss energy alternatives?

Would it be possible to pump CO2 into space?

Questions re: Regional climate change in the Pacific NW (Phil Mote)

physical processes:

Why does being near an ocean slow the warming process?

Why is the warming focused on the Arctic regions, not Antarctic and or equatorial?
land/ocean (more land in NH), ice-albedo feedback (reduction in snow cover and sea-ice)

If conditions get warmer and wetter, then there will be less snowpack at low elevations but shouldn't there also be more snowpack at high elevations to compensate?

How can sea level rise in some places and fall in others? (rise of Neah Bay and fall of Tacoma)

What is the net change in carbon stored in biomass for the state of Washington?

Are you saying that you know the observed changes in the Pacific NW are due to global warming... or that this is likely?

Why is there such a strong relation between temperature increase and precipitation increase?

Questions re: Regional climate change in the Pacific NW (Phil Mote)

<u>forecasts and consequences:</u>

What emissions were assumed for the predicted climate change?

Will the Olympics lose their snow? Will warming continue to the point where the snow will be gone entirely from this region?

How will biodiversity and carbon storage in this region be affected?

Is it bad to have trees coming into the alpine meadows? Are the changes in climate necessarily bad?

Does less snowpack mean less water to humans?

Why does precipitation increase in 2020's but decrease in 2040's?

How do changes here compare to California? Will we get more immigration? (If so, this population burden may have a larger impact than climate change.)

Why do you say that economic models are more uncertain than climate models?

With increased precipitation, will weathering in the mountains increase?

Questions re: Regional climate change in the Pacific NW (Phil Mote)

what to do:

Can we adapt to the changes you predict?
Are "vector-borne" diseases linked to other causes besides climate?
What is the cost of preventing the warming versus adapting to the warming?
Is there anything we can do in this region to prevent the warming?
How should homes etc be designed to be ready for the coming changes?
How can we make decisions if there is so much uncertainty? Why are people so worried if the forecasts are all so uncertain?
Can't we store the rainwater, rather than letting it all run off?

science institutions and scientists:

What is the role of the Climate Impacts Group... to make predictions or do devise solutions and/or preventative measures?
Where does climate impacts group get its funding?
Why do some climate scientists overhype the situation? Are they "crying wolf"?

Energy Alternatives

need:

i. population projected to peak and stabilize at ~10 billion

ii. current energy use is ~12 TW, 85% from fossil fuels

iii. to stabilize at 550 ppm CO2, we need ~15 TW emission-free energy by 2050

12 TW is 2000 Watts per person

or 20, 100 W lightbulbs (24 hours a day) per person

note: human body runs on about 100 Watts

Energy Alternatives

improving efficiency:

power plants 35-50%
diesal engines: 30-35%
gasoline engines: 15-25%
fuel cells: up to 70%, run on hydrogen
gasoline to hydrogen: 75-80%

lighter, more efficient cars could get double current mileage
switch to mass transit
conservation via building practices, recycling, etc

carbon sequestration

produce hydrogen fuel in centralized plants (requires energy, presumably from fossil fuels)
recover the CO2 and sequester in deep ocean or mine shafts

Energy Alternatives

renewable energy

- hydropower and firewood (close to saturation)
- solar, wind, geothermal, etc are currently <1% of global energy
- 10 TW from biomass plantations requires similar land area to all current agriculture
- 10 TW from solar requires an area about 500 km square
  - 220,000 km^2 vs current 3 km^2 (massive but not insurmountable scale-up)
- use solar energy to manufacture hydrogen (hydrolize water)?
- space-based solar collectors?
- wind power limited to certain locations... hard to imagine scaling up more than factor of 10-100

Energy Alternatives

nuclear fission

- at 10 TW, only 6-30 years of proven uranium reserves
- waste disposal and security issues

nuclear fussion

- no working technology at present
- prospects are murky

geoengineering or climate engineering

- reflect about 2% of sunlight with stratospheric particles
  - or space mirrors
- technical feasibility not well known
- unintended consequences very likely

Wed Dec 10

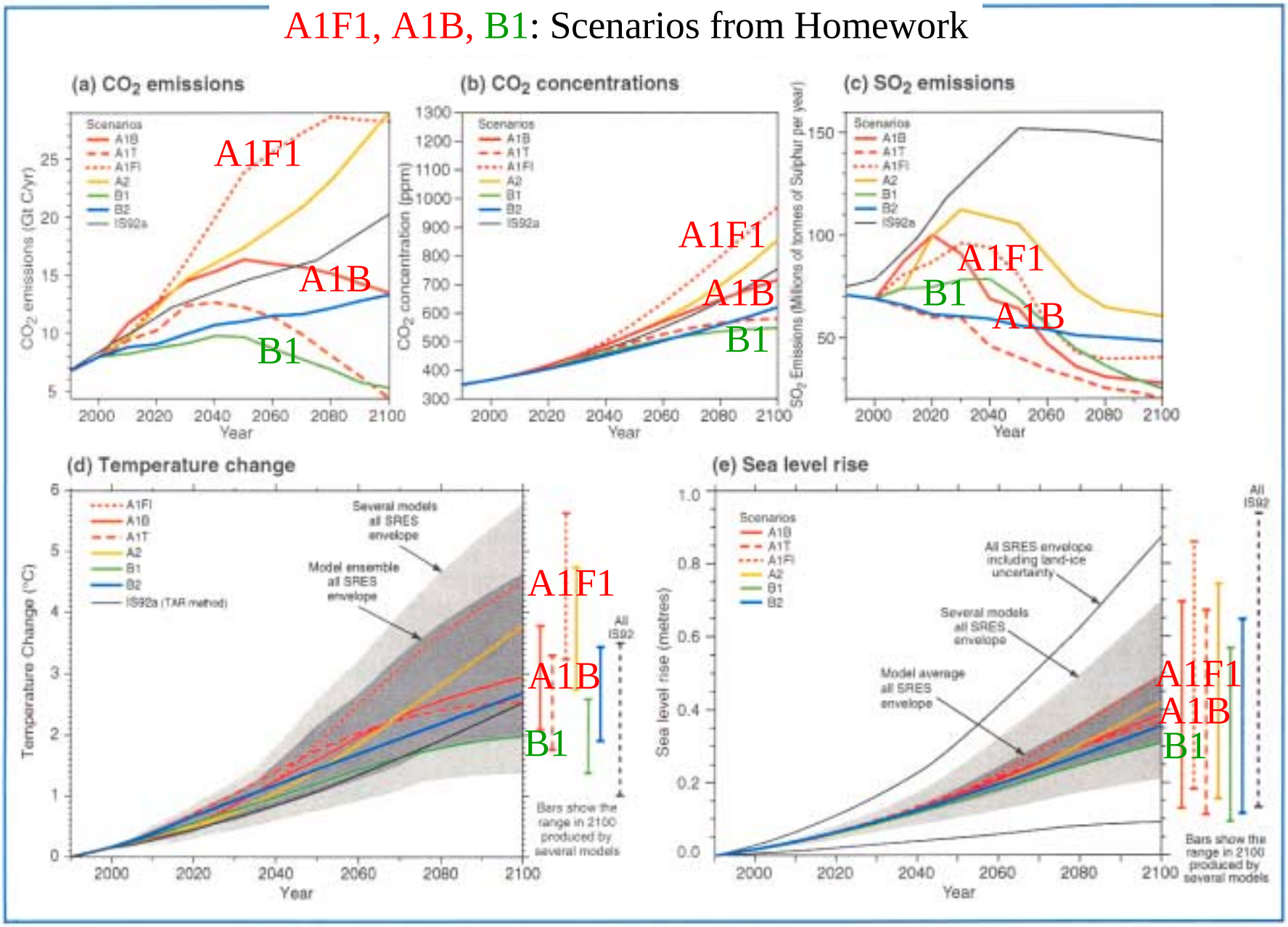
Today: Global warming forecasts (HW 6, etc)
Energy alternatives
Principles for a positive future
The End
Course Evaluation

Fri: FINAL, here, 8:30am
reports due (writing credit)

Mon Dec 15: last day to turn in extra credit

IPCC SPM Fig 5: scenarios and projections

A1F1, A1B, B1: Scenarios from Homework



2050 Forecast

$$\Delta T = \lambda * \Delta F * \text{lag\_factor}$$

assume lag_factor = 0.66

Forecast Change in GAAST by 2050

	low λ 0.4	med. λ 0.8	high λ 1.2
low ΔF 3.3 W/m^2	0.9 K	1.7 K	2.6 K
med. ΔF 4.1 W/m^2	1.1 K	2.2 K	3.2 K
high ΔF 4.8 W/m^2	1.3 K	2.5 K	3.8 K

range 2.1 K (nature of Earth system)

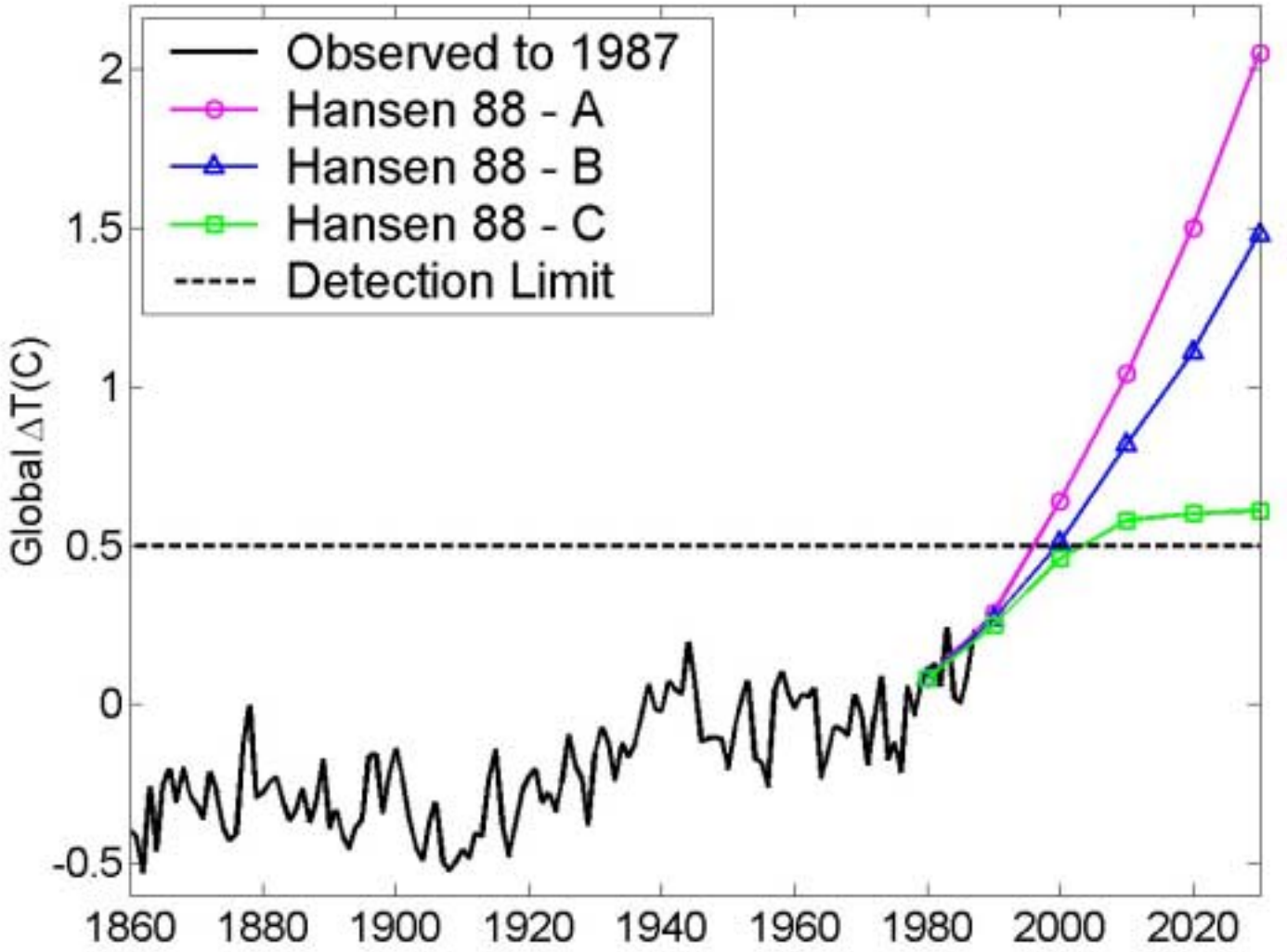
class average prediction

range 0.8 K (human choice)

Global warming forecast: Hansen (1988)

ultimate test of scientific understanding: **Prediction** (of the future!)

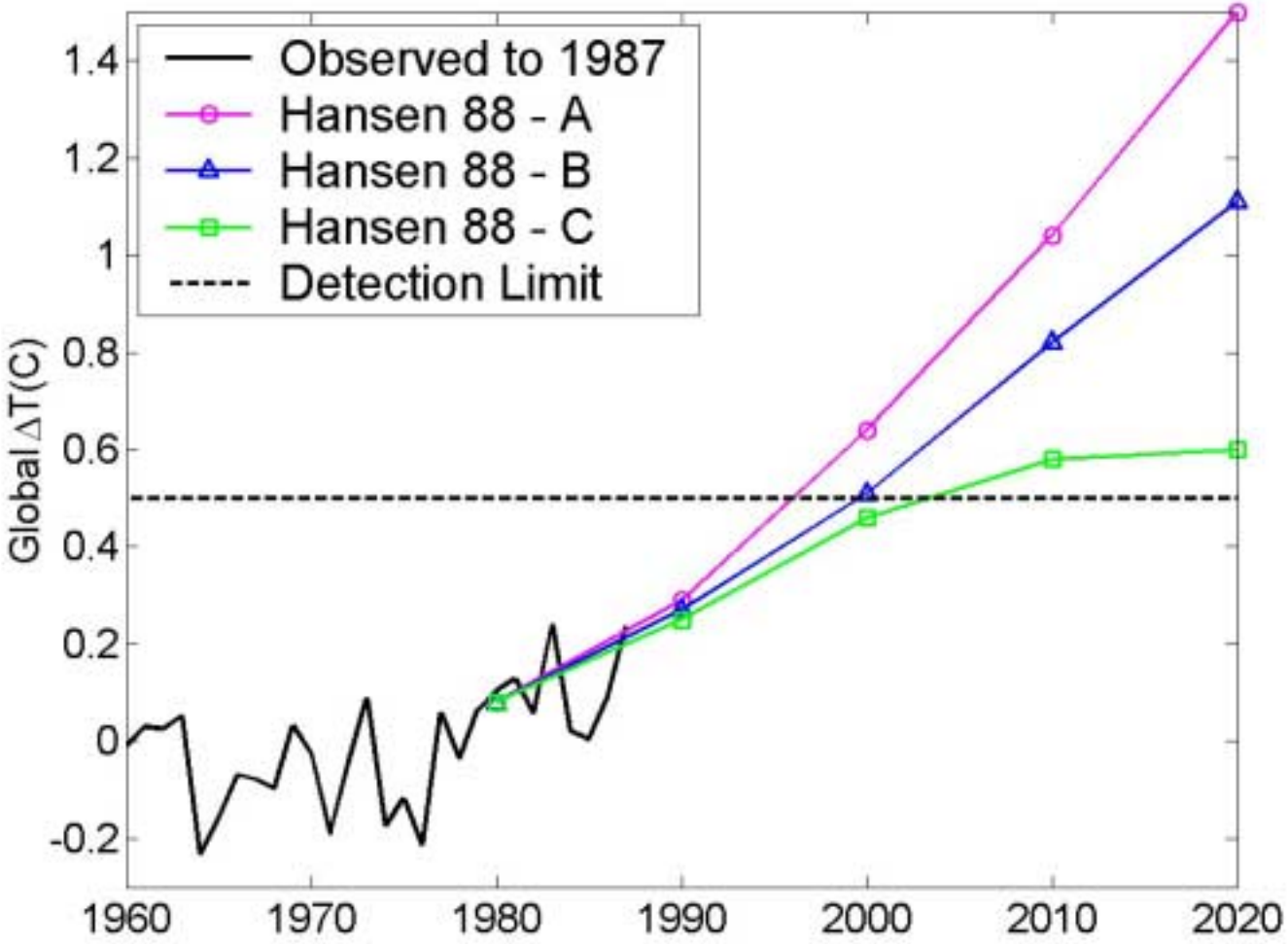
Hansen et al. (1988), J. Geophys. Res., 93, 9341-9364 (on class website)



GAAST Prediction - Notes

expanded view:

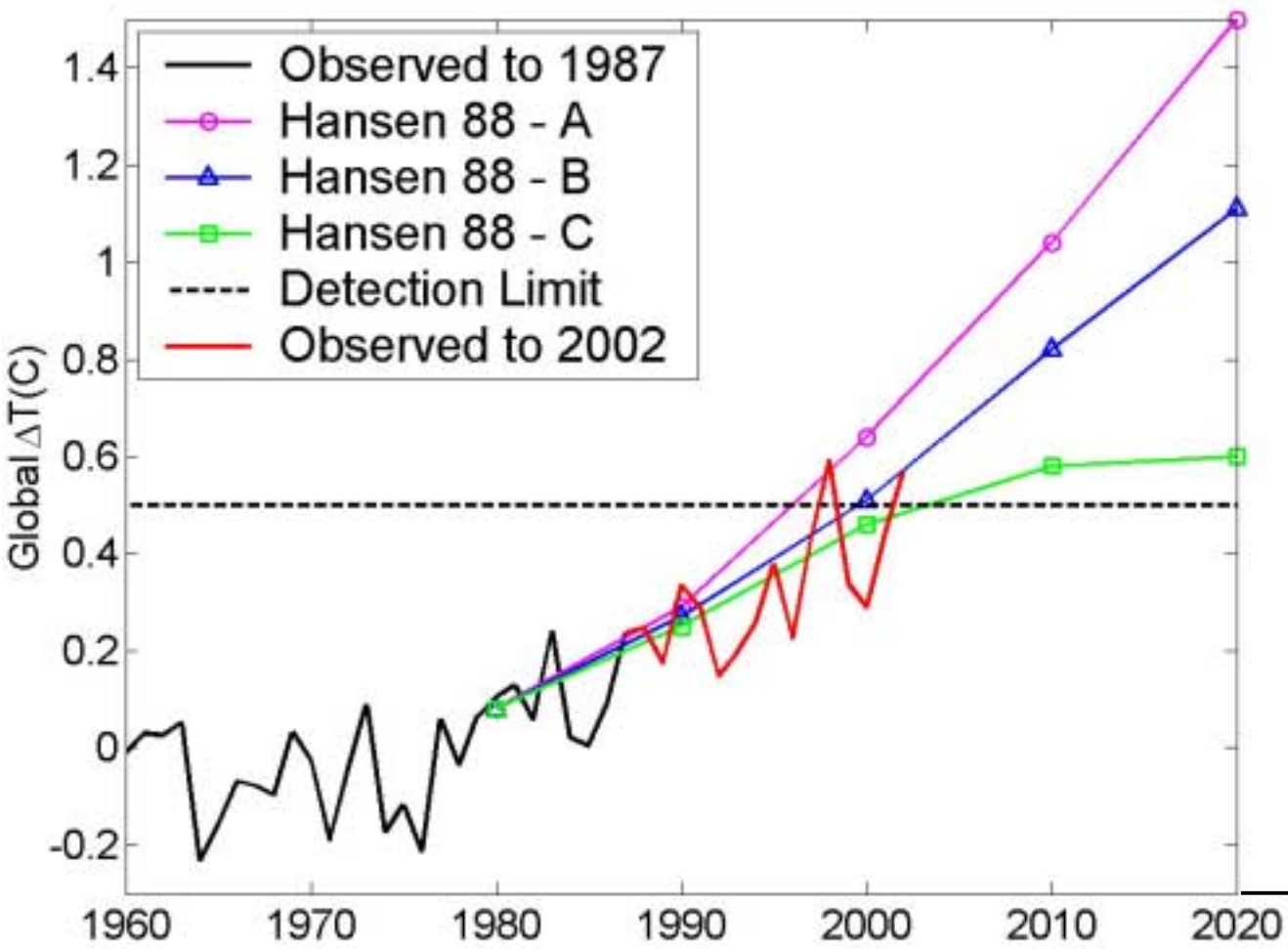
- no dramatic warming trend was evident in 1988
- Hansen's group predicted GW signal would be detected above the noise of natural variability by the end of the century, for all emission scenarios



GAAST Prediction - Success

2.2

class average prediction for 2050

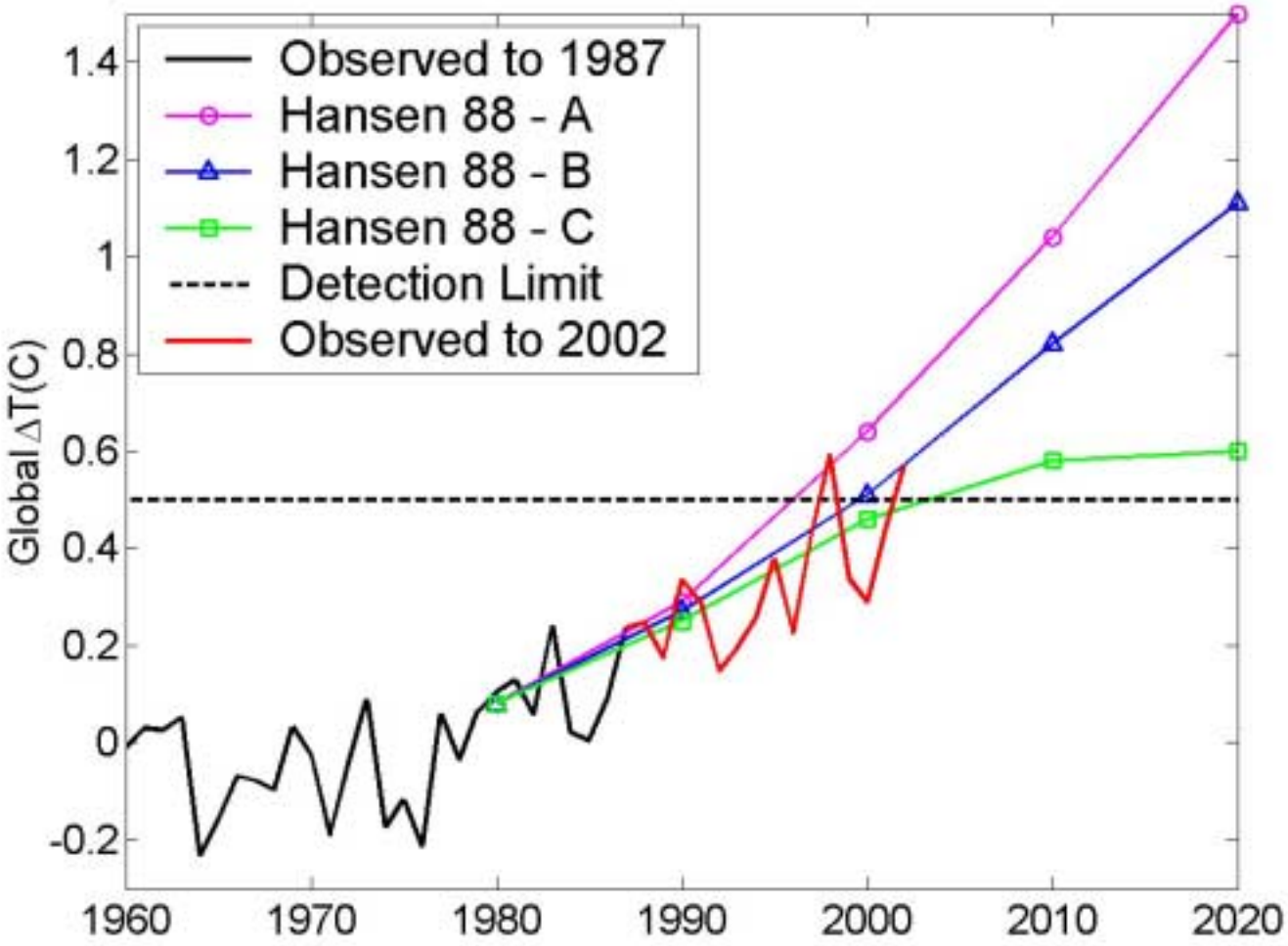


2050

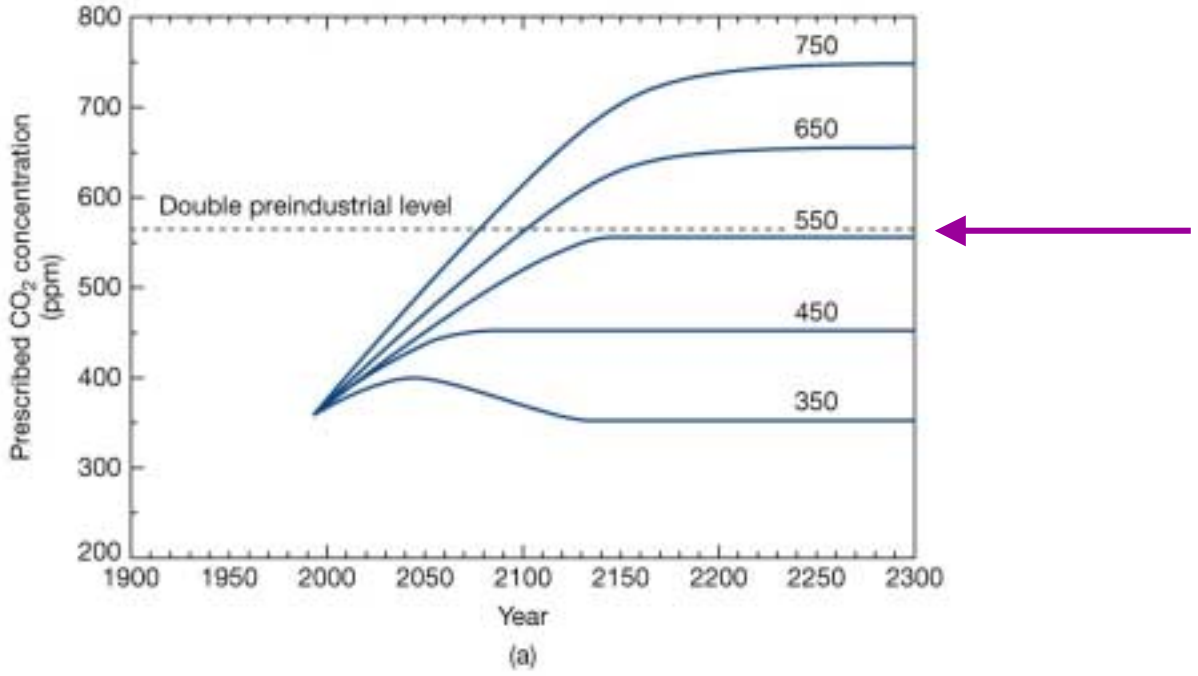
GAAST Prediction - Lessons

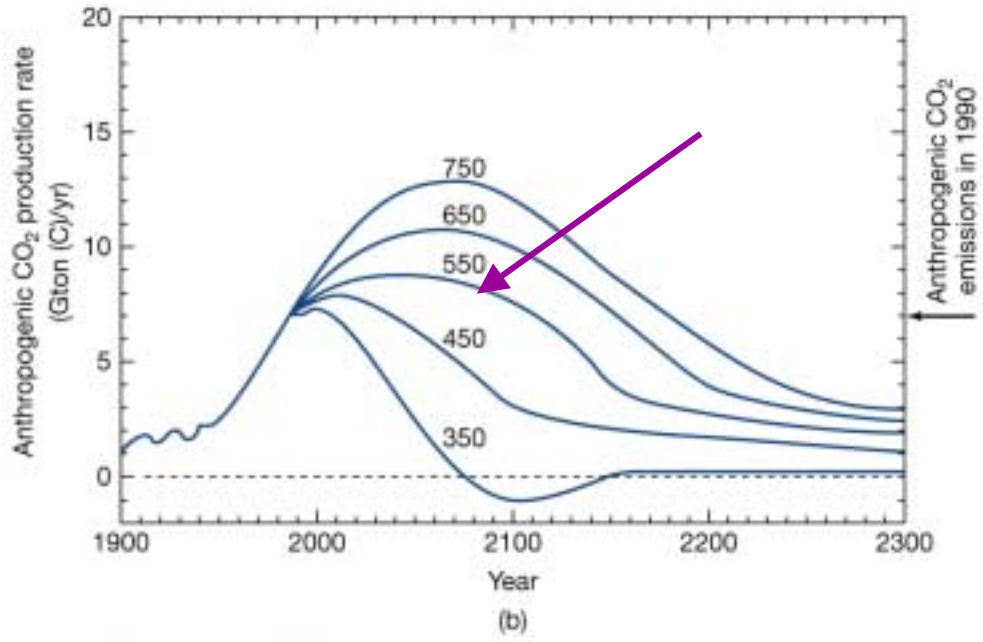
conclude:

- the current global warming paradigm led to a remarkably successful prediction
- we are still hovering around the detection threshold
- the question of "detection" is virtually certain to be resolved in your lifetime



Energy Alternatives: paths to CO2 stabilization





Energy Alternatives: SUMMARY

current situation:

- global, primary energy production is 12 TW (i.e. 12 * 10^{12} Watts)
- 85% from fossil fuels

need:

- to stabilize CO2 at 550 ppm (double pre-industrial)
- and accomodate rising population and economic progress
- need 10-30 TW emission-free energy by 2050

solutions:

• improving efficiency	a few TW, safe, feasible, immediate
• carbon sequestration	?
• renewable (esp. solar)	technically feasible, probably safe
• nuclear fission	a few TW, dangerous
• nuclear fussion	?

for further information:

Hoffert et al (2002), Science, 298, 981-987 (pdf on class website)

Energy and the Environment (2002) by Fay and Golomb, 313 pp

How should we think about global warming?

coming catastrophy? hoax? confusing multiplicity of uncertainties?

- climate change is dangerous and we must confront this danger rationally
- but, the danger of direct human impacts on environment is likely to be greater
- societal choices in this generation - especially regarding energy production - are likely to have very significant impact on future generations
- doubling carbon dioxide (which is all but inevitable) does constitute "dangerous interference with the climate system"
- going beyond a doubling would be very easy and very foolish
- preventing this will require a revolution in energy technology
- a rational response is not necessarily a modest response
- what is needed to make a difference is an "Apollo Program" for energy
  e.g. "within a decade, eliminate US strategic dependence on foreign oil"

Principles for a positive future

from: The Ice Chronicles by Paul Mayewski and Frank White, 2002

1. Climate change will have both positive and negative consequences.
2. No matter what we do, the climate will change
3. We must change with it.
4. We should not wait for perfect knowledge to take needed actions.
5. Technology can help, but it cannot save us from ourselves.
6. We must set long-range climate policy and then be patient.

Tips for writing letters of recommendation…

For the chronically absent:

"A man like him is hard to find."

"It seemed his career was just taking off."

For the office drunk:

"I feel his real talent is being wasted here."

"We generally found him loaded with work to do."

For an employee with no ambition:

"He could not care less about the number of hours he put in."

"You would indeed be fortunate to get this person to work for you."

"He consistently achieves the standards he sets for himself."

For the all-around worthless employee:

"I cannot recommend this candidate too highly."