Implications of "Peak Oil" for Atmospheric CO_2 and Climate

(*in preparation*)

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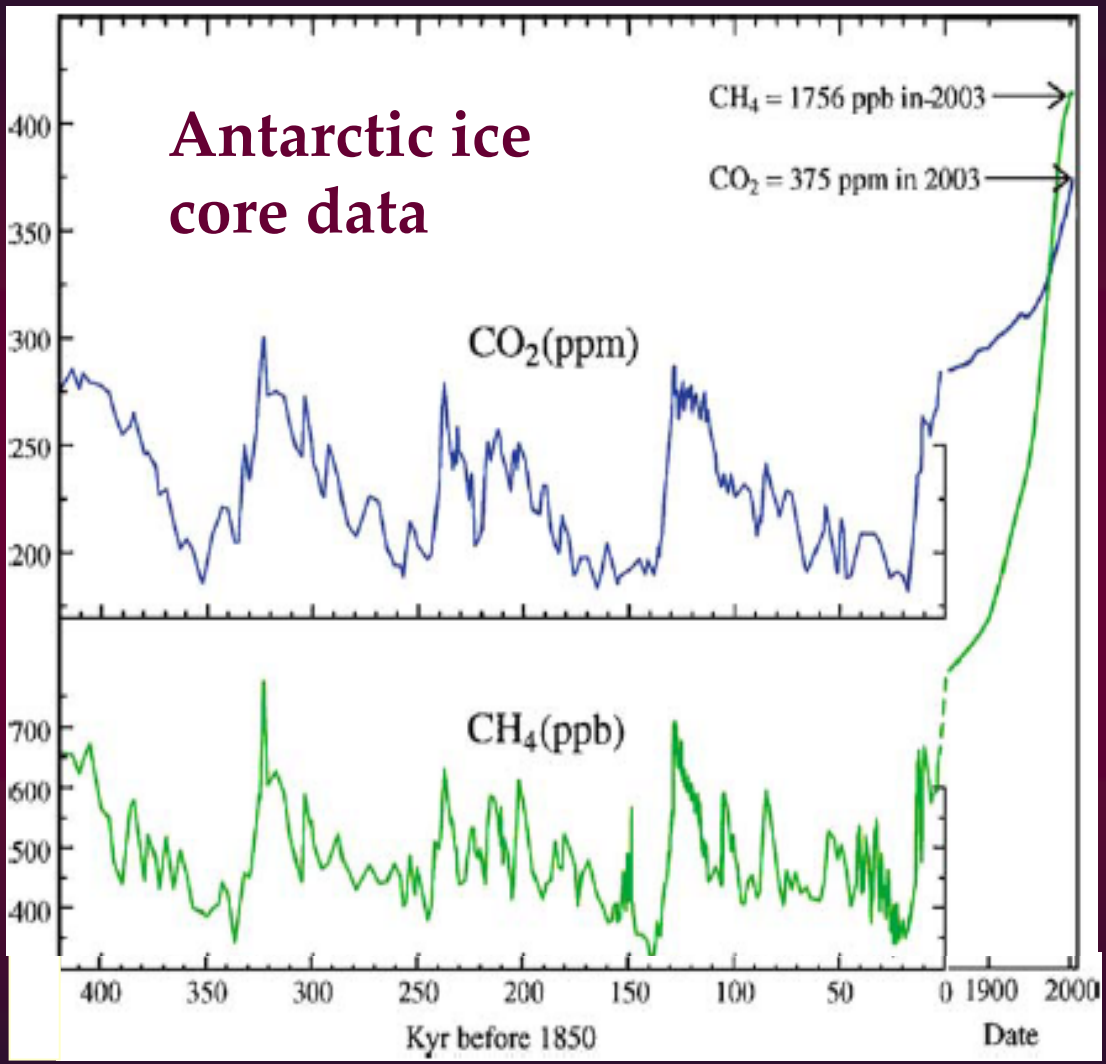
→ draft copy: pubs.giss.nasa.gov or arxiv.org

Goals/motivation

- Develop emissions trajectories that **explicitly** incorporate plausible fossil fuel peaks (i.e. resource limitations)
  - Focus on general (simple) mitigation scenarios that keep atmospheric CO_2 below 450 ppm (currently ~382 ppm)
- Guide climate change mitigation policies using plausible mitigation scenarios

Anthropogenic GHG changes

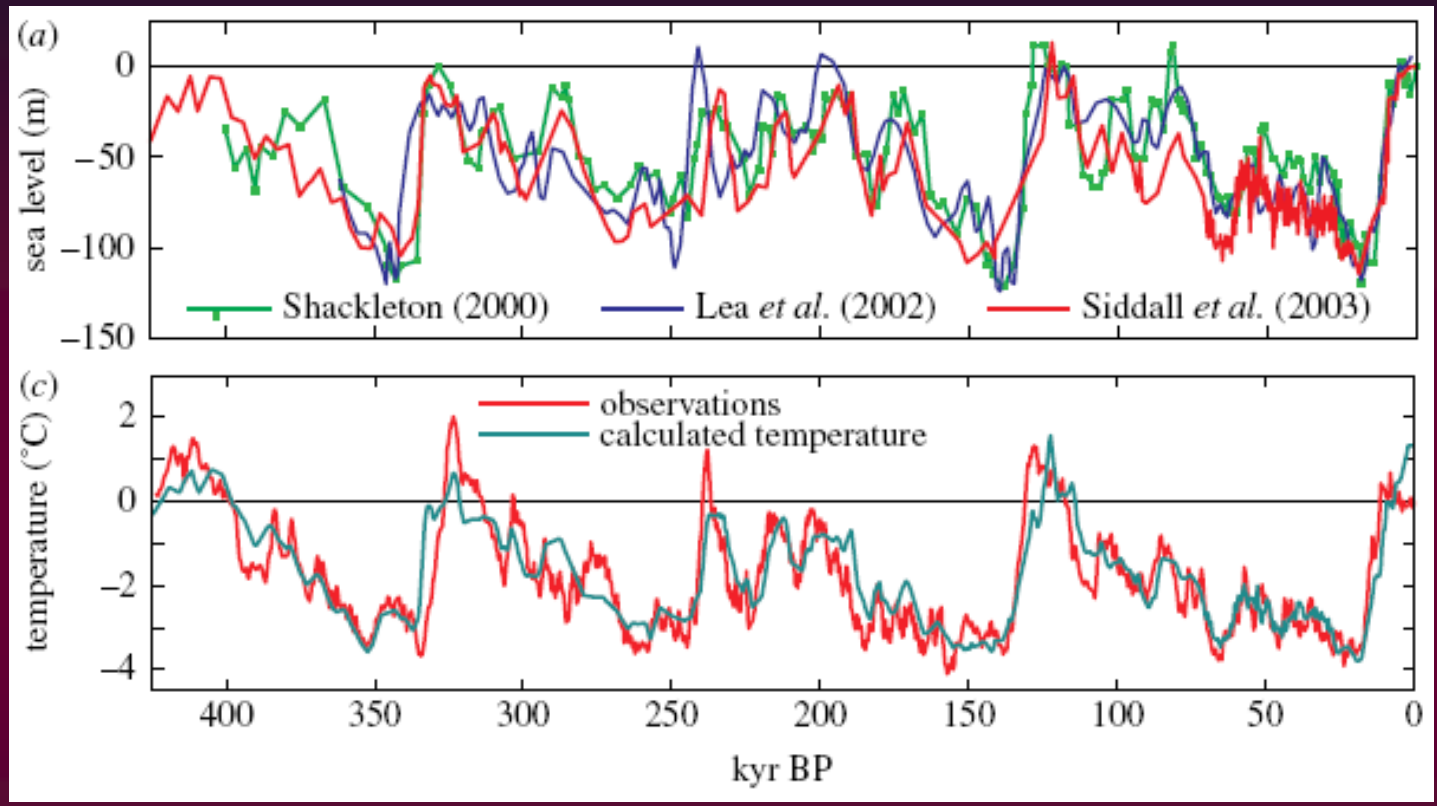


→ Rate and magnitude of changes **unprecedented** in millions of years

→ this is now basically indisputable...

J. Hansen, Clim. Change 68, 2005

Past sea level vs. temperature



Hansen et al., PTRS-A 365, 2007

- If temp. kept <1°C, sea level probably won't rise over 5-6 m;
- more than 2-3°C ⇒ sea level might rise 15-35 m!

⇒ GOAL: KEEP 21st-c. TEMP. BELOW ~1°C

We're NOT attempting to…

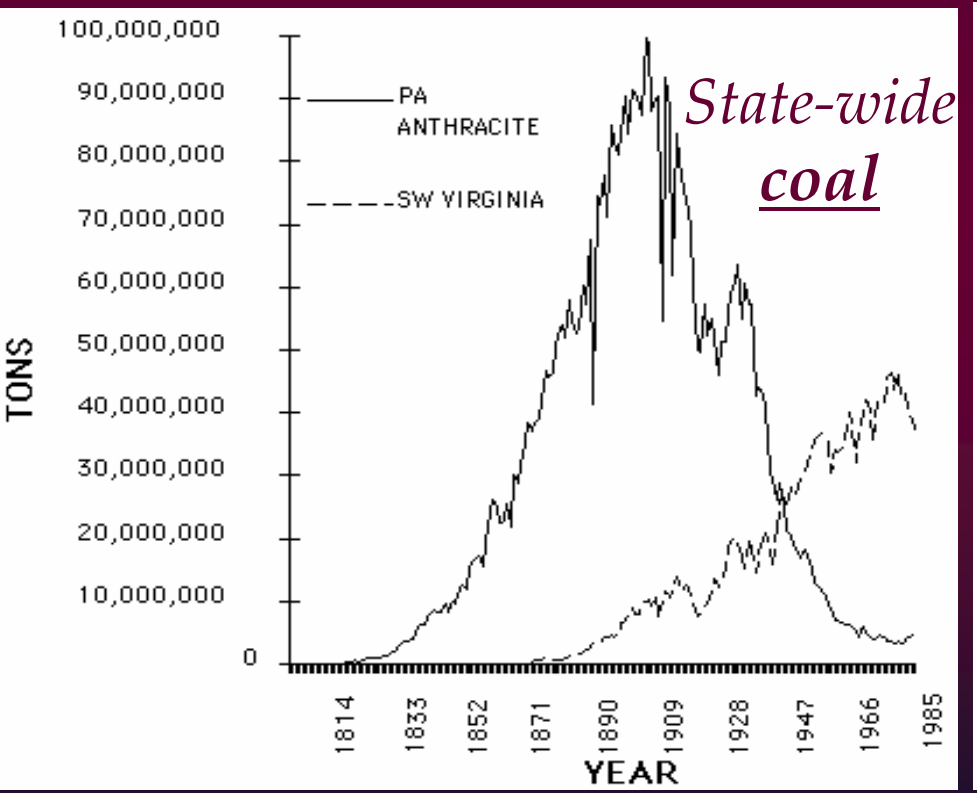
- pinpoint *timing* of peaks, or resolving debate over *magnitudes* (focus is on implications for climate)
  - endorse a specific set of reserve estimates (looked at *range*, citing common sources)
- debunk IPCC-SRES scenarios ("benchmark" scenarios in modeling studies…are actually useful for bracketing the *range of possibilities*)
- develop *probabilistic* scenarios (wanted to minimize socioeconomic assumptions, hence took deliberately broad, simple approach)

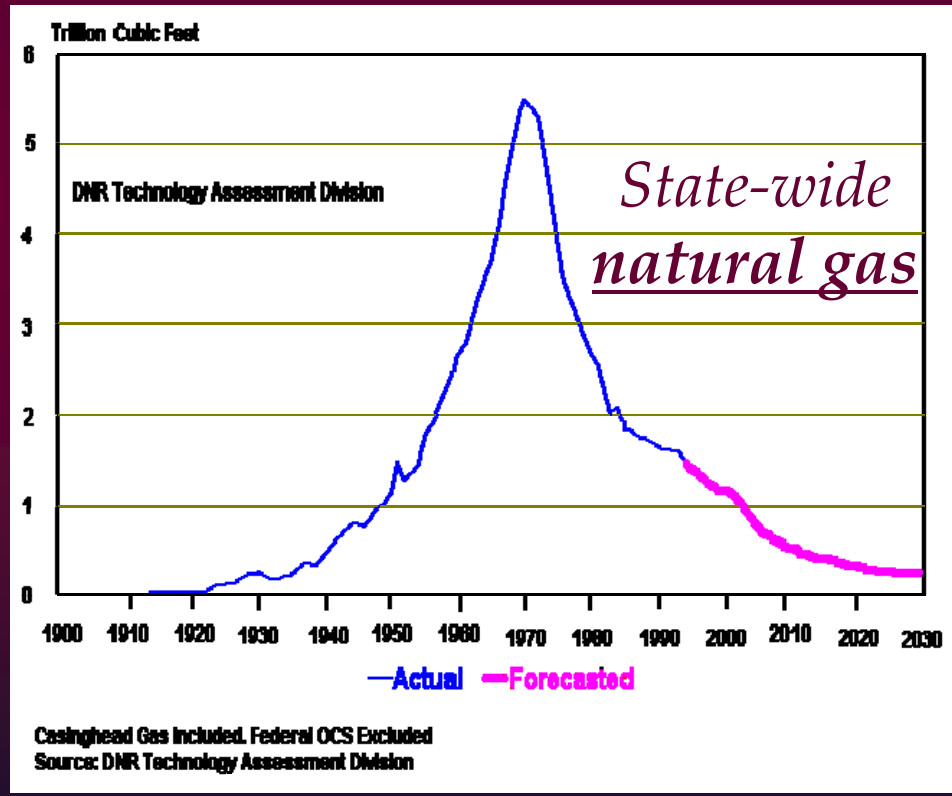
Definitions

- Proven reserves: Supplies known to *exist* with high degree of certainty (*magnitudes* debatable…)
  - Conventional: usable under current/near-term econ., envir., and tech. conditions
  - Unconventional: exist in different form, not (yet) as feasible energetically/economically
- Reserve growth: likely additions to reserves using current/near-term tech. (again, magnitudes vary)
- *Except as noted,* "peak" refers to Hubbert-type peak (~midpoint of total resource base for each fuel)

General view of fossil fuel peaks

- Mineral geologists realized many decades before Hubbert that use of any finite, geologically constrained resource follows similar pattern...

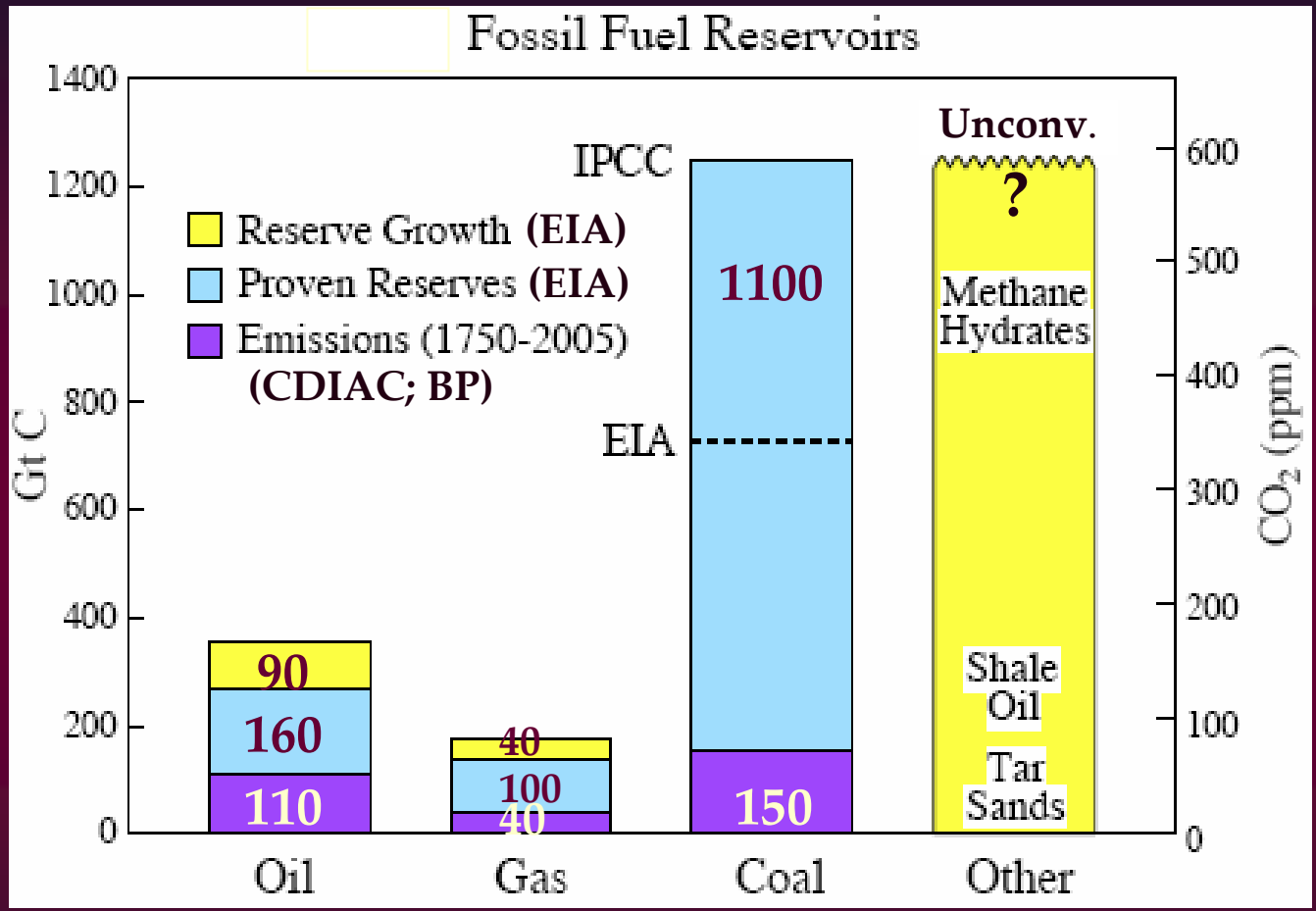




Milici & Campbell, USGS, 1997

Lam, La. DNR, 1998

Assumed resource supplies



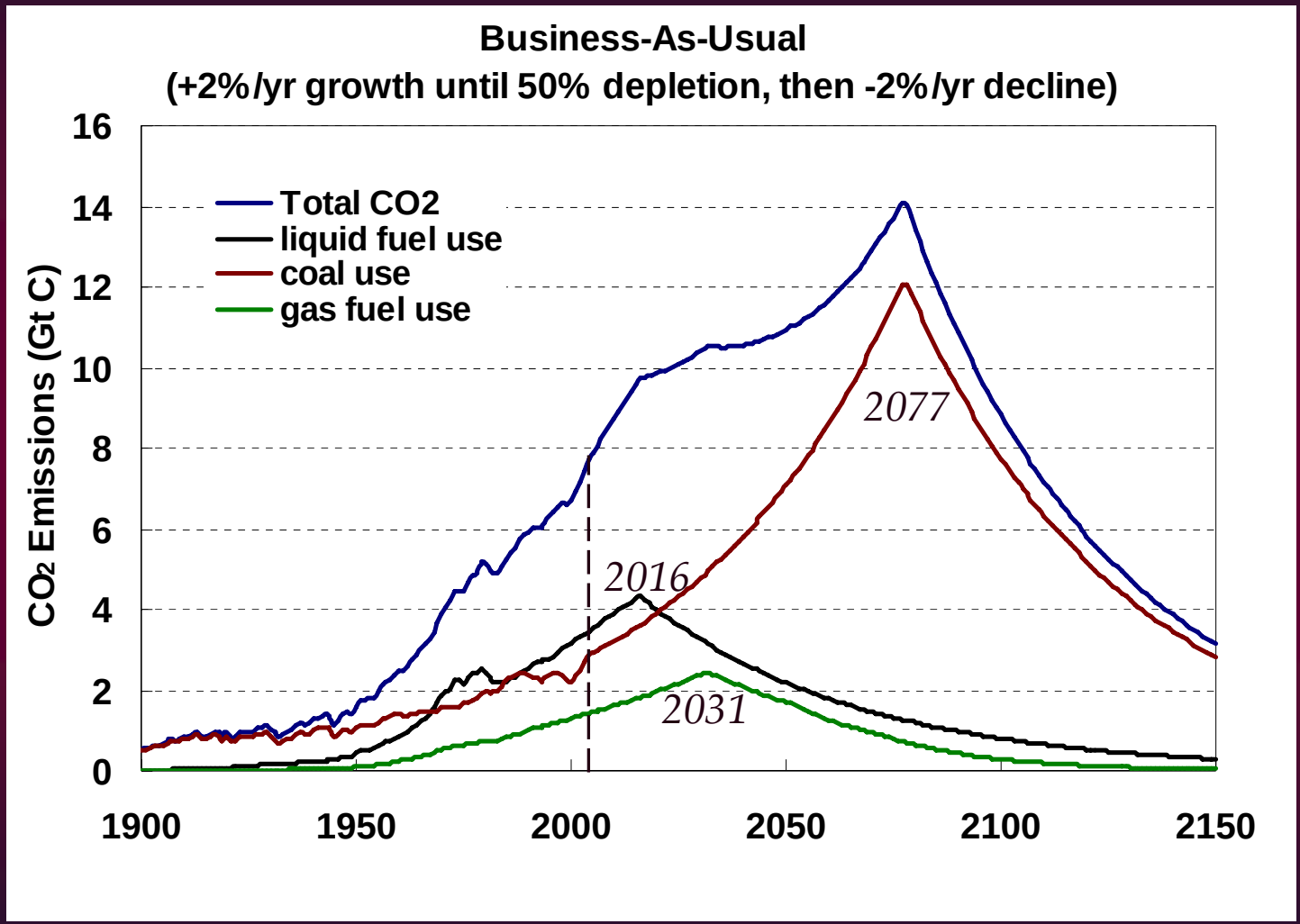
Conversions

- Oil: 1 Gt C ≈ 8.2 Gbl ≈ 50 EJ
- Gas: 1 Gt C ≈ 60 Tc.f. ≈ 65 EJ
- Coal: 1 Gt C ≈ 1.7 Gs.t. ≈ 39EJ

Overview of emissions scenarios

- All scenarios reflect global emissions for each fuel
- 1 "business-as-usual" scenario (without mitigation)
- 4 mitigation scenarios
  - Coal emissions phased out by 2050
  - 4 different peak oil emissions trajectories (3 of which simply from published sources)
  - Gas emissions trajectory assumed same in each case

"Business-As-Usual" scenario



% change, 2007-2050: +30%

21st c. emissions:

~1080 total

~710 coal

~240 oil

~130 gas

2007-2050 emissions:

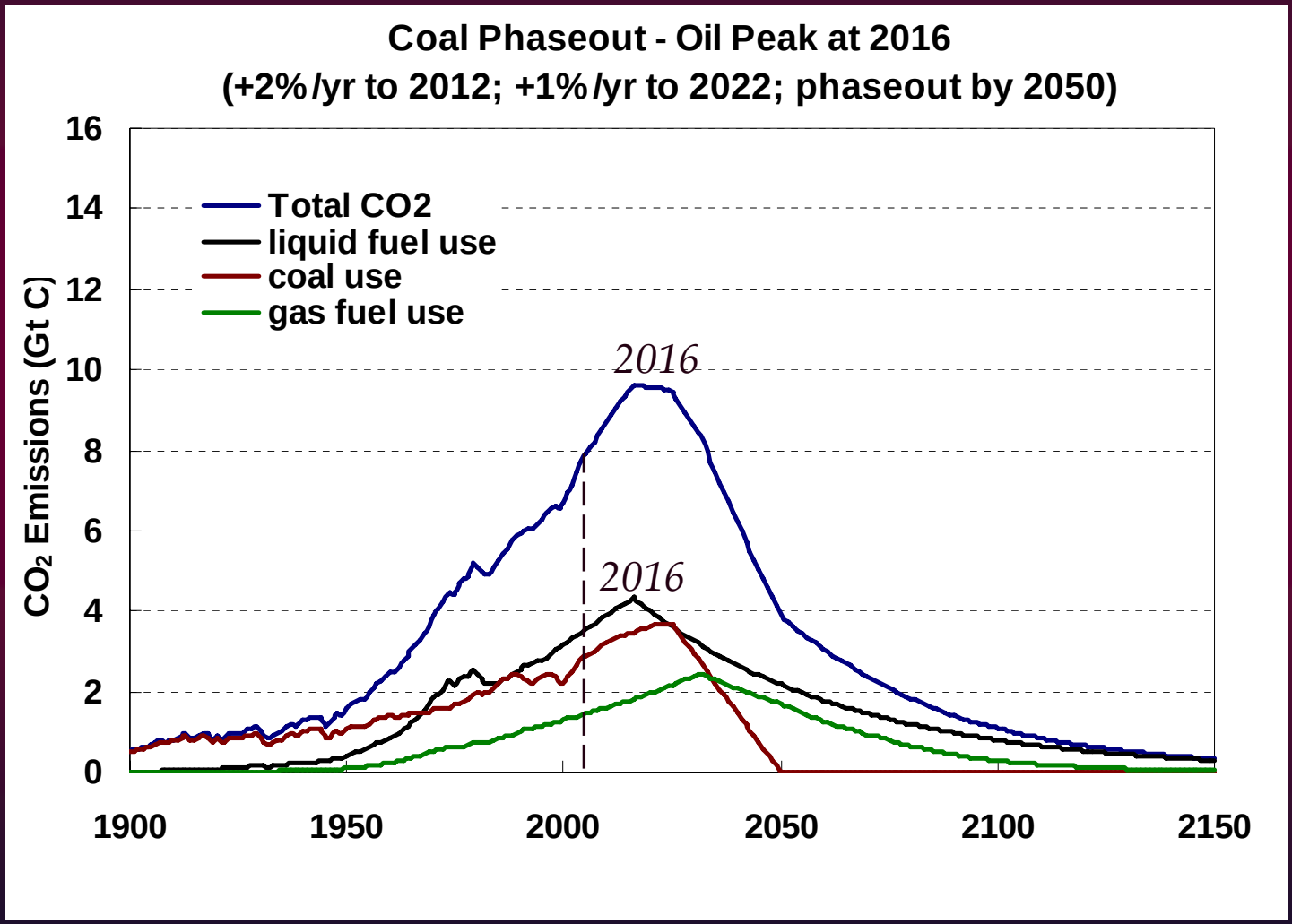
~430 total

~210 coal

~140 oil

~80 gas

"Coal Phase-out" scenario (baseline)



% change, 2007-2050: -57%

21st c. emissions:

~500 total

~130 coal

~240 oil

~130 gas

2007-2050 emissions:

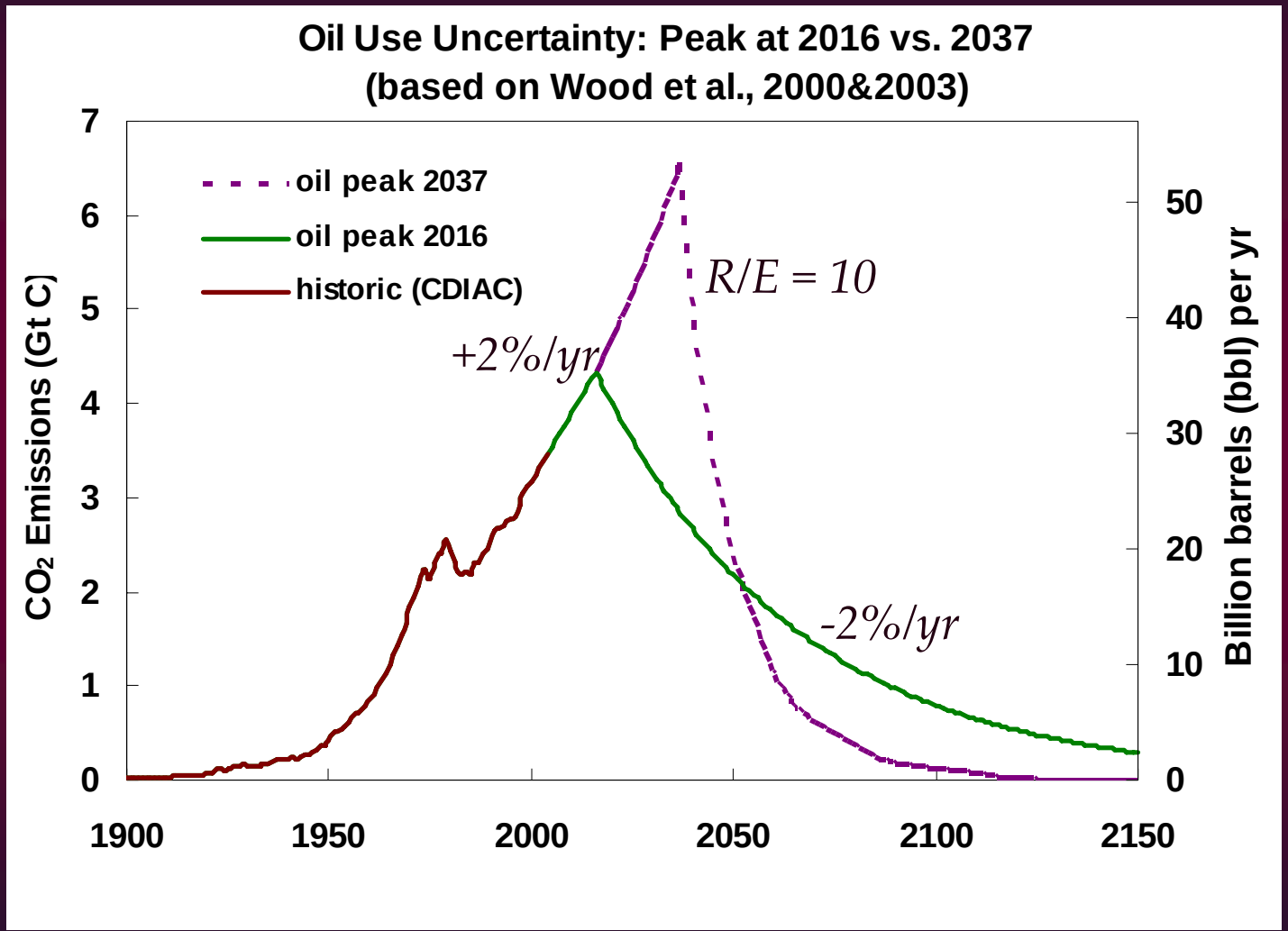
~330 total

~110 coal

~140 oil

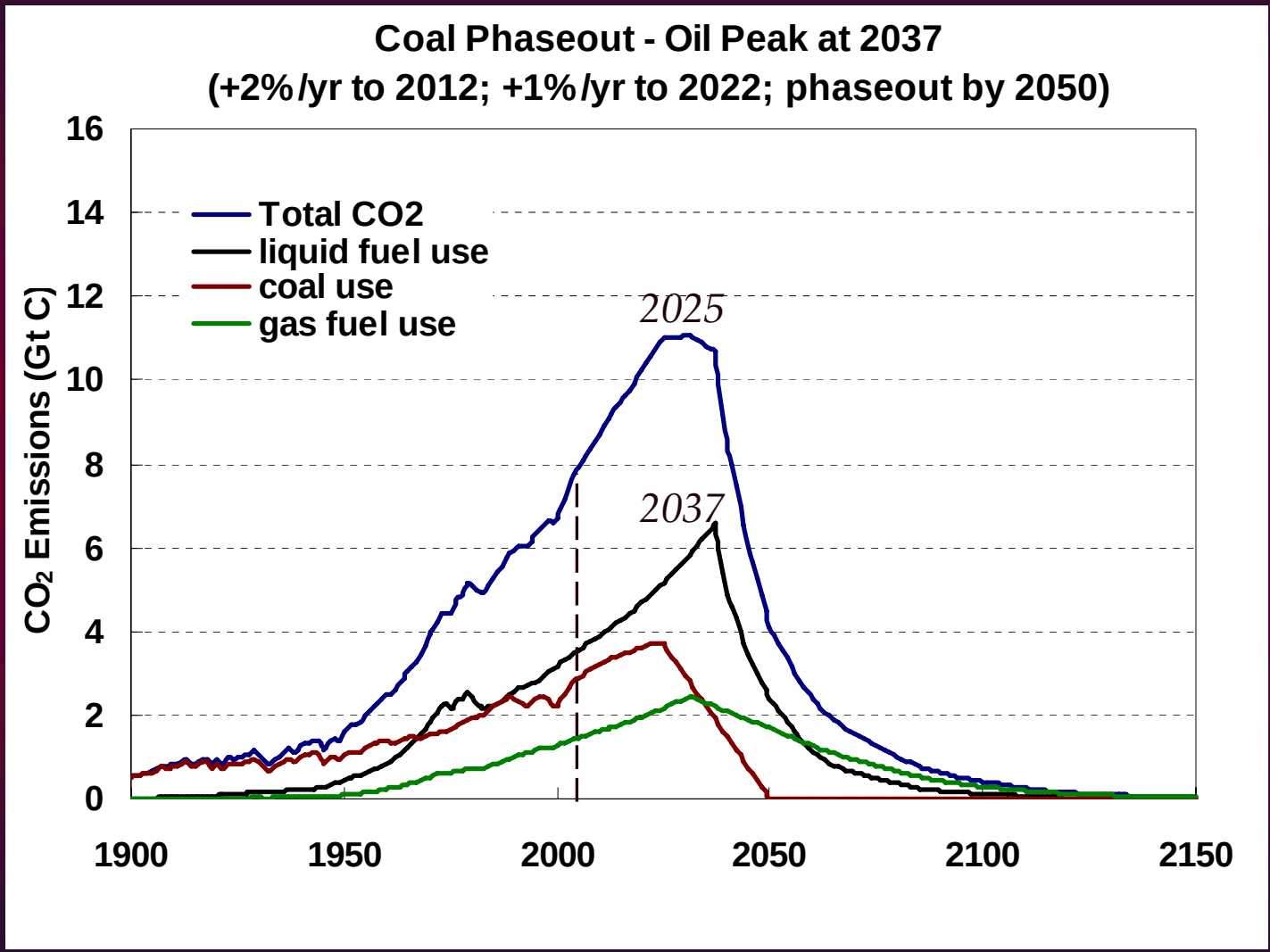
~80 gas

Alternative peak oil trajectory



Total resource base: ~3000 Gbl (both cases)

"Fast Oil Use" scenario



21st c. emissions:

~520 total

~130 coal

~260 oil

~130 gas

2007-2050 emissions:

~390 total

~110 coal

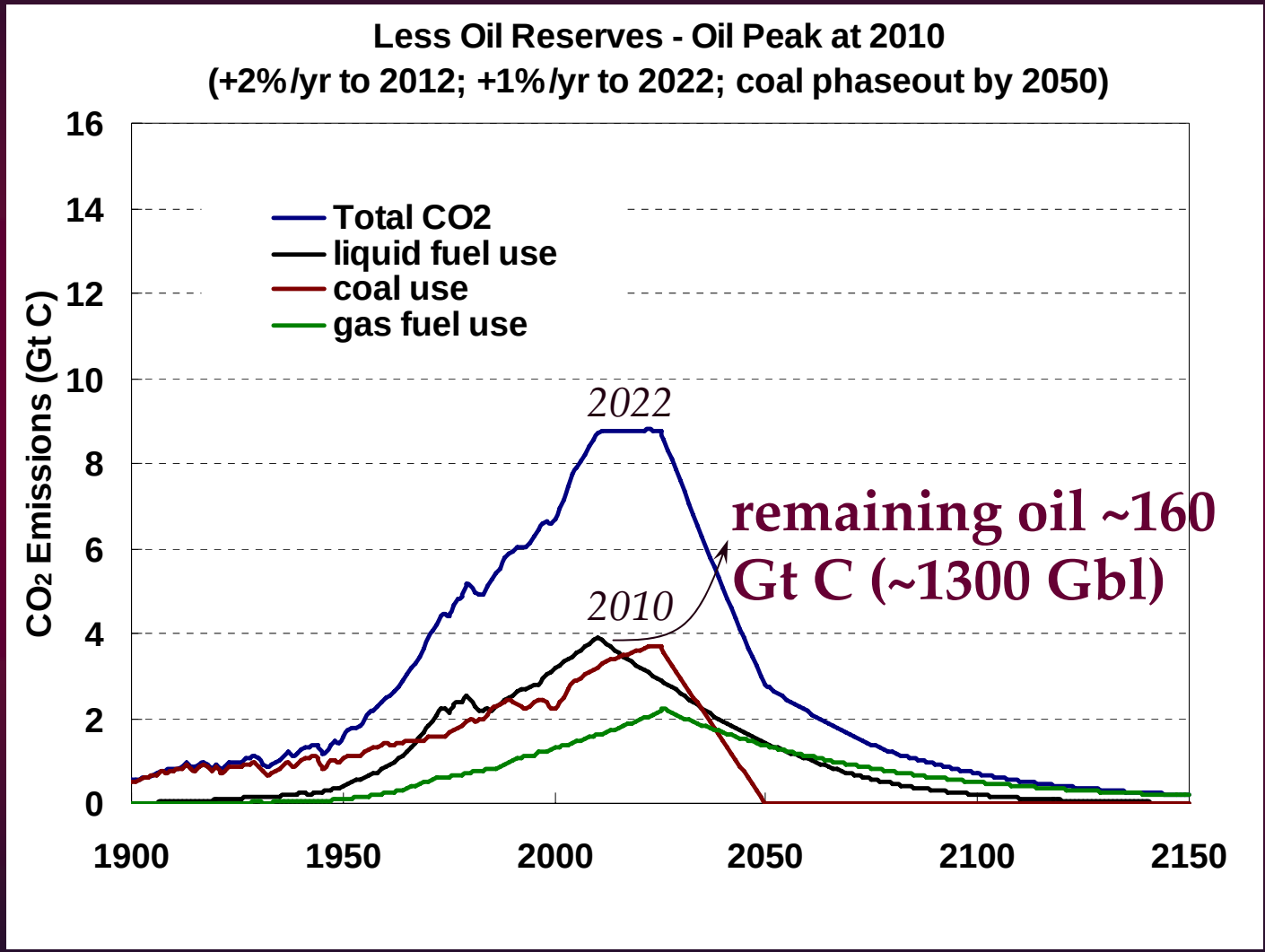
~200 oil

~80 gas

Total resource base: ~3000 Gbl (both cases)

% change, 2007-2050: -54%

"Less Oil Reserves" scenario



% change, 2007-2050: -66%

21st c. emissions:

~430 total

~130 coal

~170 oil

~130 gas

2007-2050 emissions:

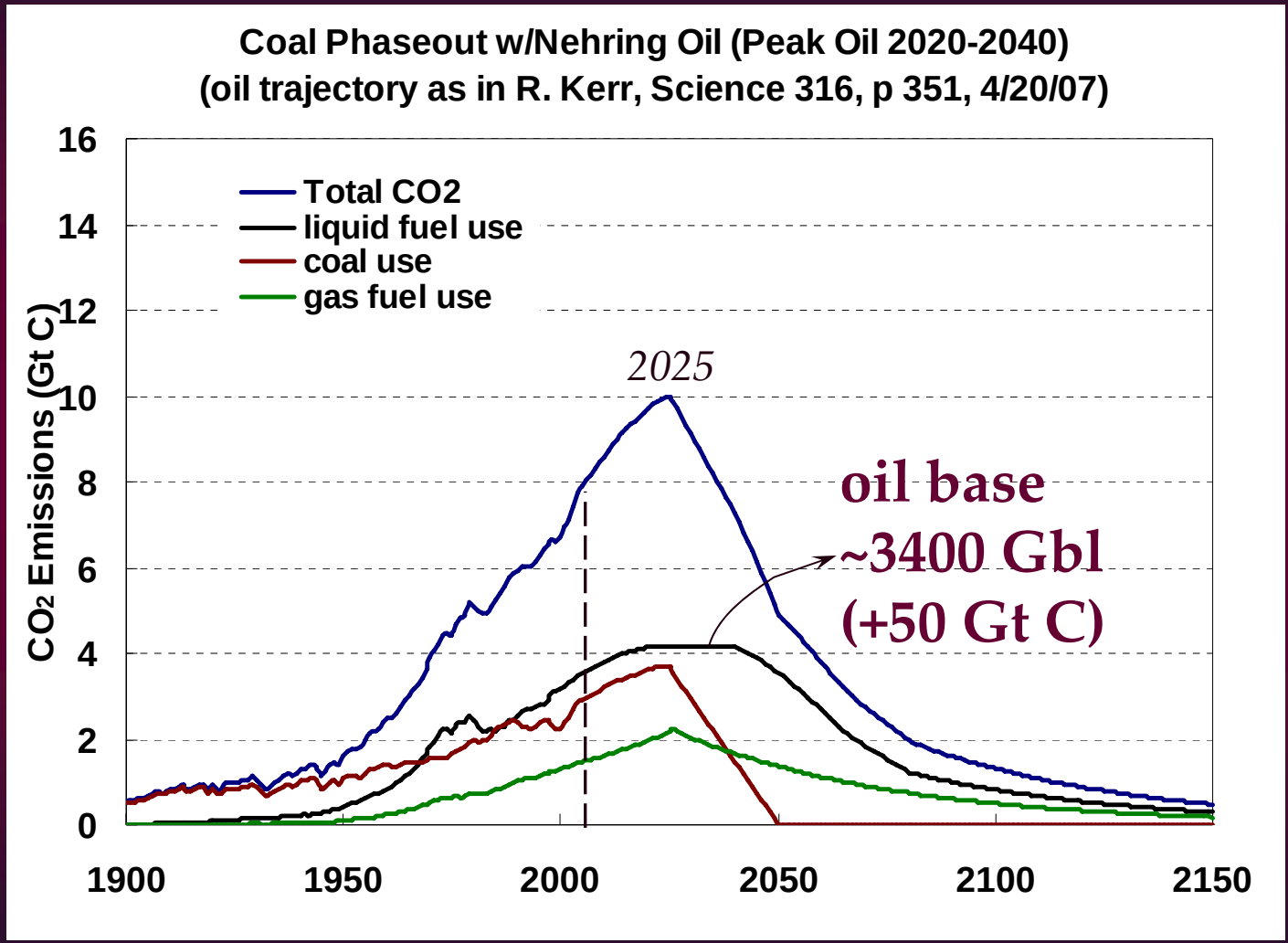
~300 total

~110 coal

~120 oil

~80 gas

"Peak Oil Plateau" scenario



% change, 2007-2050: -40%

21st c. emissions:

~550 total

~130 coal

~290 oil

~130 gas

2007-2050 emissions:

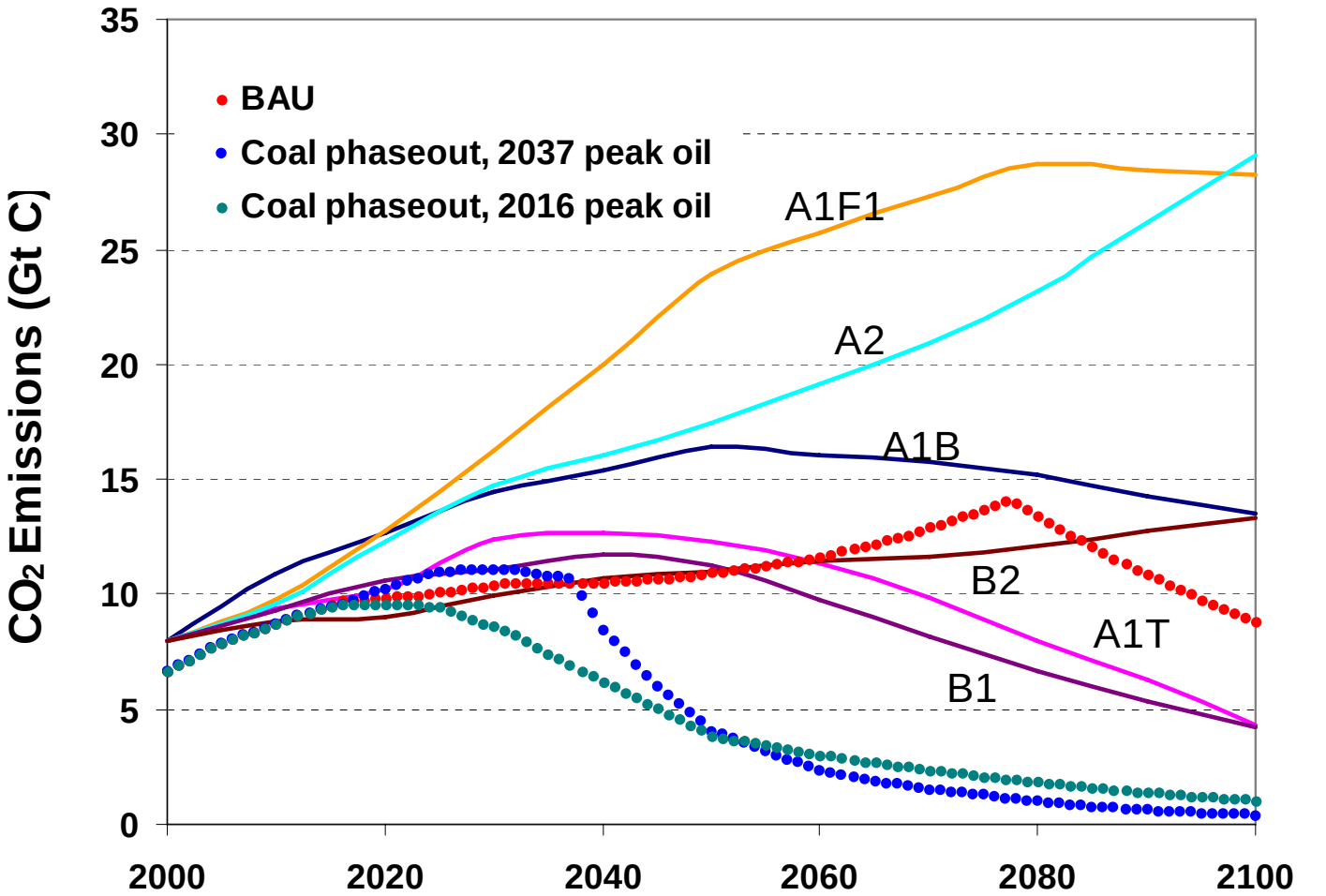
~360 total

~110 coal

~180 oil

~80 gas

Comparison with SRES scenarios

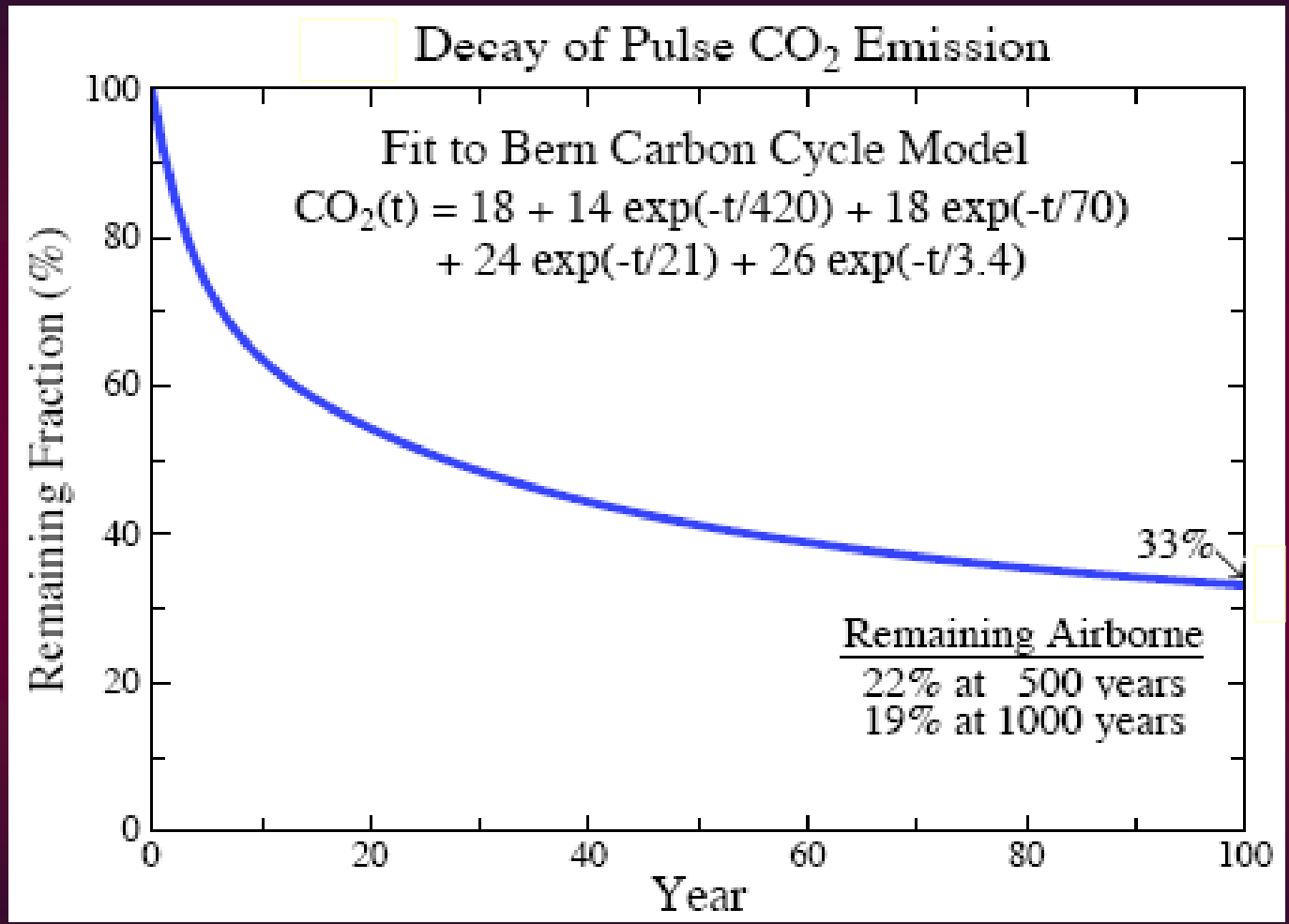


21st c. emissions:

- **A2: ~1800**
- **Coal phaseout: ~500**
- **Fast Oil Use: ~530**

- Our BAU lower than SRES BAU
- Our phaseout scenario far lower than "low" B1, A1T

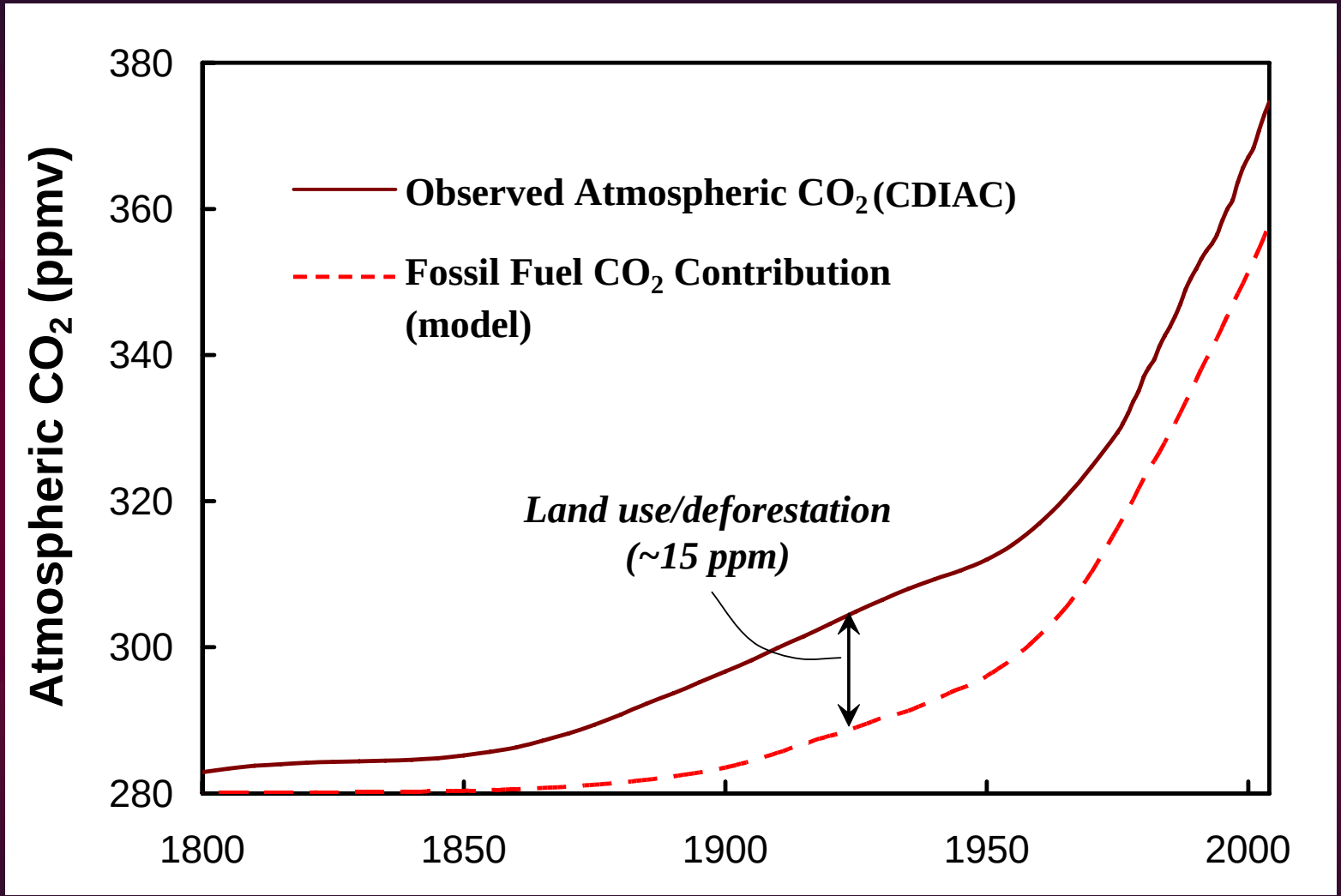
CO_2 time series calculation



eq. from Shine et al., Clim. Change 68, 2005

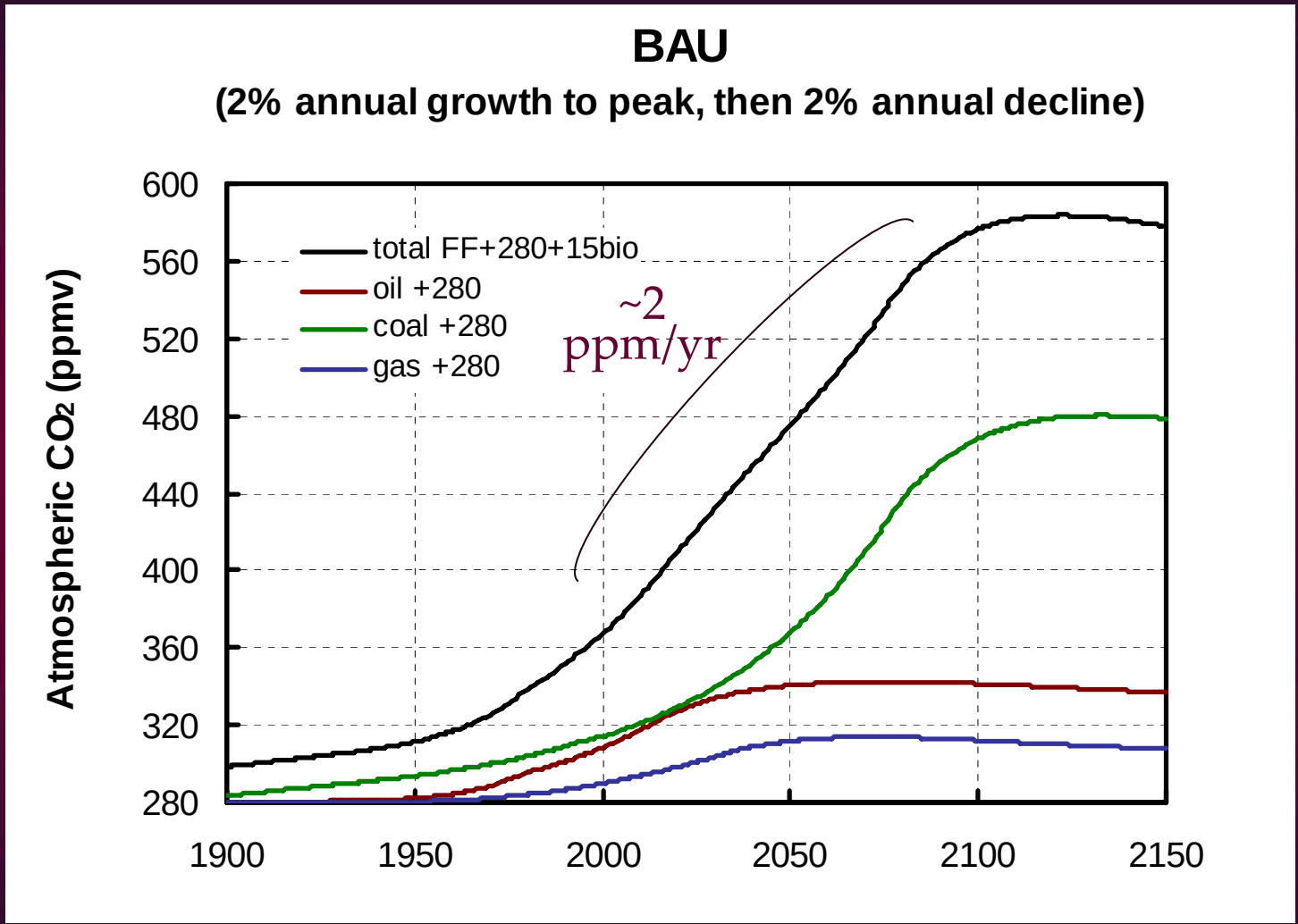
→ Drawback: doesn't represent climate feedbacks

Calculated CO_2 vs. data



→ Total fossil fuel CO_2 added to date: >80 ppm

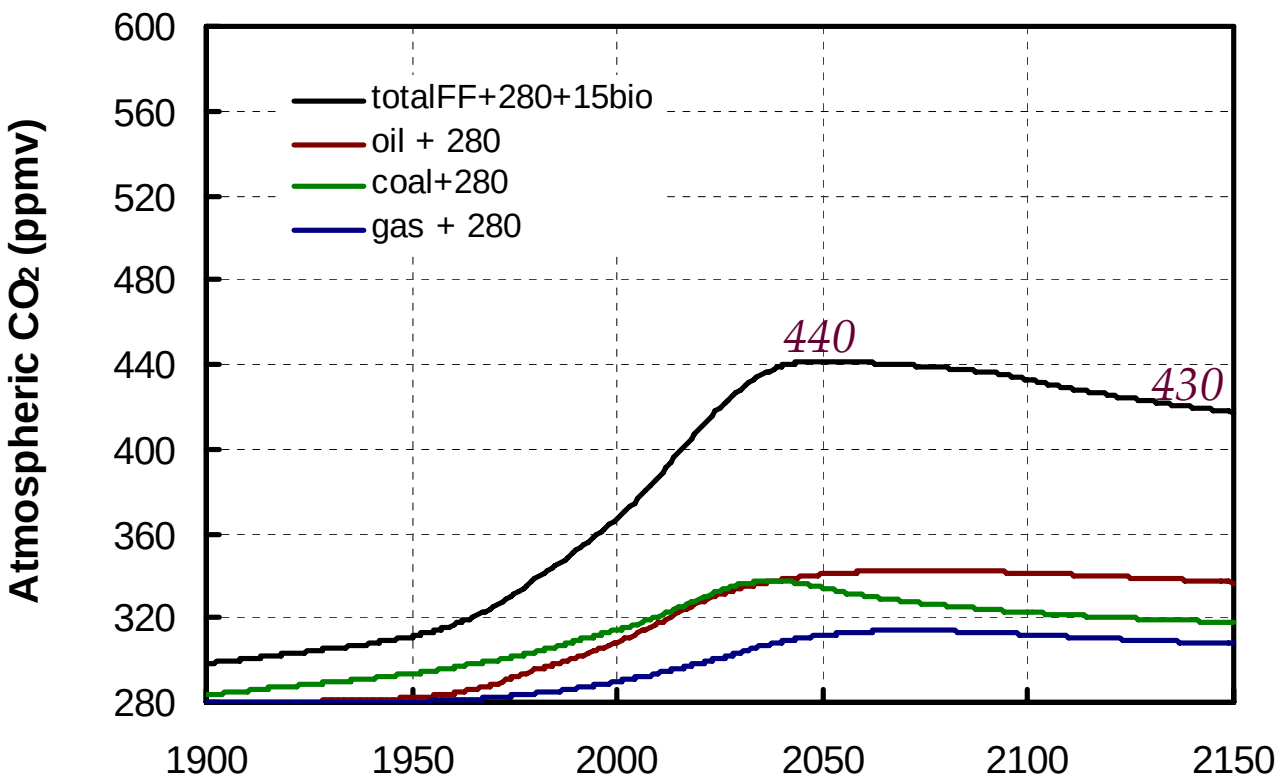
Projected CO_2: BAU



CO_2 ~580 ppm by 2100 ⇒ ΔRF ~ +2.5 W/m^2

⇒ *Warming under 1°C* ***unlikely*** *to be achieved* ⇒ ***DAI***

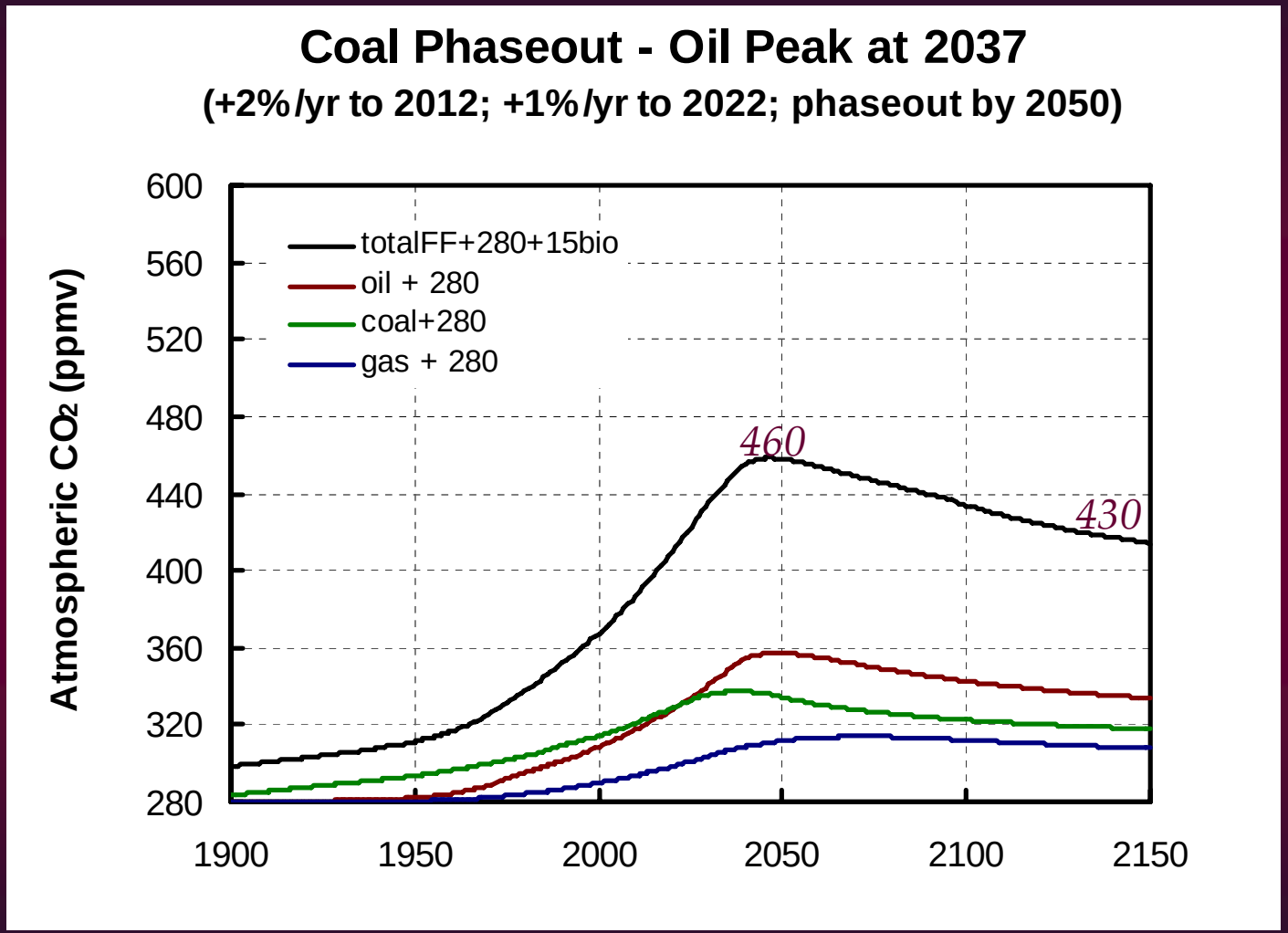
Projected CO_2: Coal Phase-out



$\Rightarrow$ 21st-c. $\Delta RF \approx +0.8$ W/m^2

$\Rightarrow$ Warming under 1°C achievable

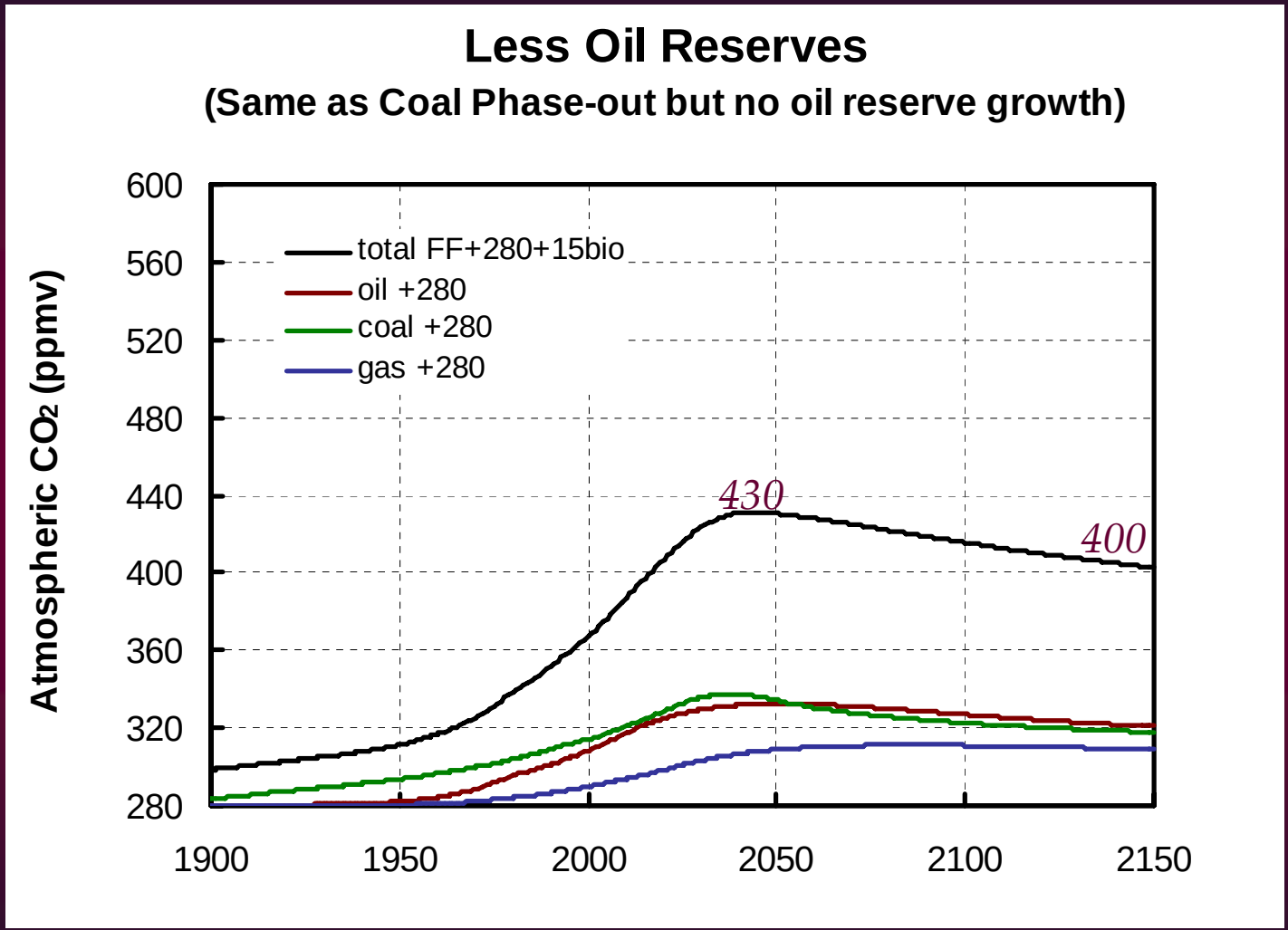
Projected CO_2: Fast Oil Use



$\Rightarrow$ 21st-c. $\Delta RF \approx +1.1$ W/m^2

$\Rightarrow$ Warming under 1°C still achievable

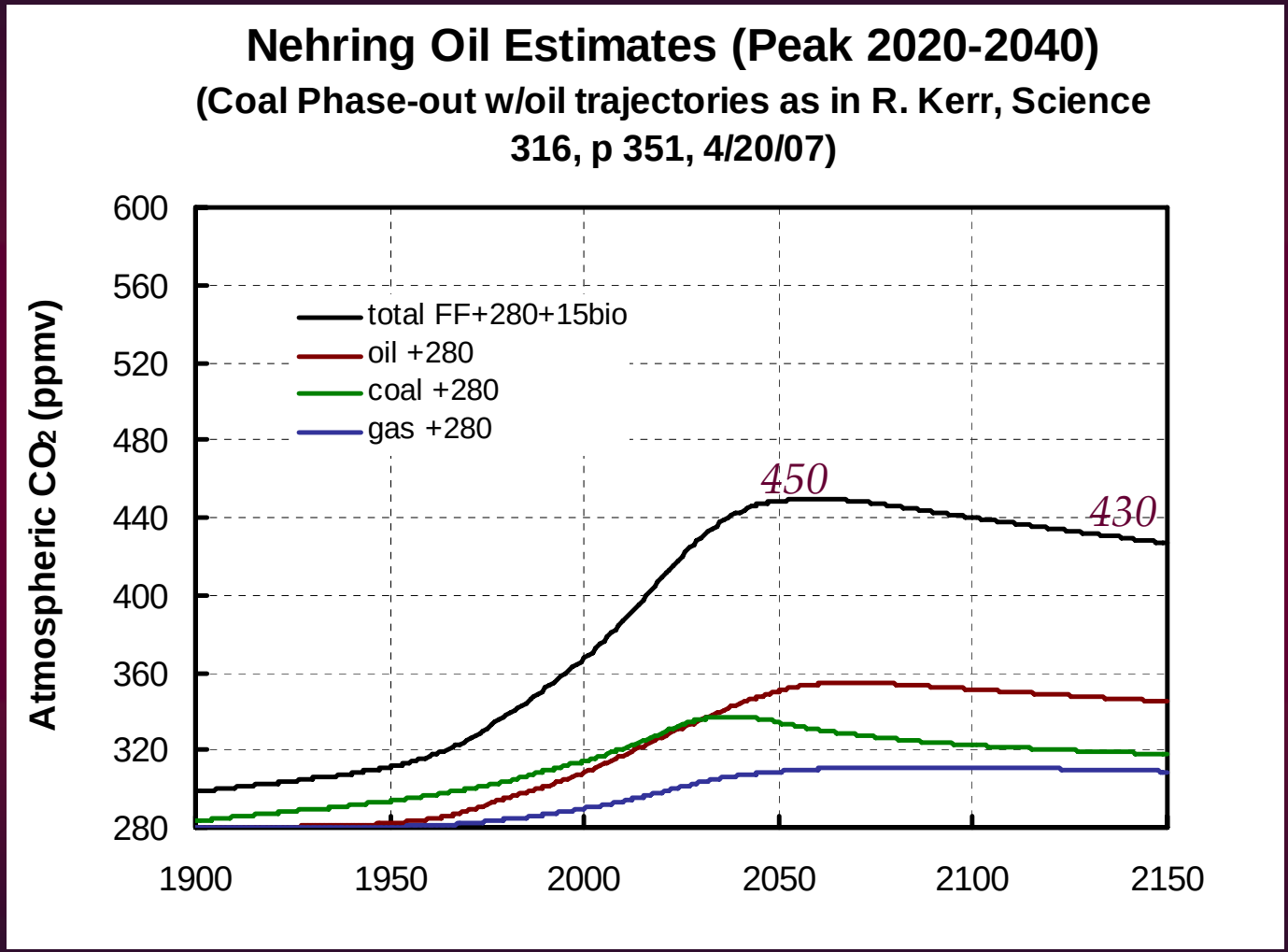
Projected CO_2: Less Oil Reserves



$\Rightarrow$ 21st-c. $\Delta RF \approx +0.7$ W/m^2

$\Rightarrow$ Warming under 1°C achievable

Projected CO_2: Peak Oil Plateau



$\Rightarrow$ 21st-c. $\Delta RF \approx +1$ W/m^2

$\Rightarrow$ Warming under 1°C achievable

Results summary

Scenario	Peak CO_2 level	Year of peak
BAU	~580 ppm	~2100
Fast Oil Use	~455 ppm	~2050
Peak Oil Plateau	~450 ppm	~2060
Coal Phase-out	~440 ppm	~2050
Less Oil Reserves	~430 ppm	~2040
IPCC, WEC oil & gas	~420 ppm	~2040
Coal phase-out 2010–2030	~420 ppm	~2030

Conclusions/implications

- BAU ⇒ DAI!; feedbacks almost certain
- Coal phaseout by mid-century would have numerous benefits: minimize feedbacks, keep warming below ~1°C, cleaner air

  ⇒**Sequestering coal emissions must be a top priority**
- Peak oil uncertainty: earlier peak "better" than fixed R:E ratio: CO_2 ~15 ppm lower, decline rate doesn't plummet, less tempted to turn to unconv.?
- Large-scale use of unconventional resources w/o sequestration ⇒ **dangerous CC guaranteed**!

Broad policy recommendations

- COAL EMISSIONS PHASEOUT MUST BE ENACTED SOON!
  - Legally binding global treaty; rising price on carbon emissions domestically
  - Other near term focus should be on energy efficiency and conservation measures
- Viable alternative energy sources after doing FULL energy/carbon accounting
  - carbon-neutral/negative biofuels and renewables; nuclear(?)

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