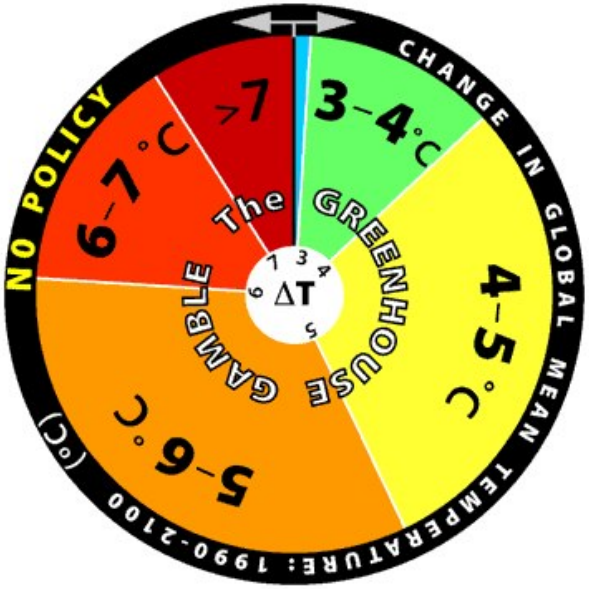
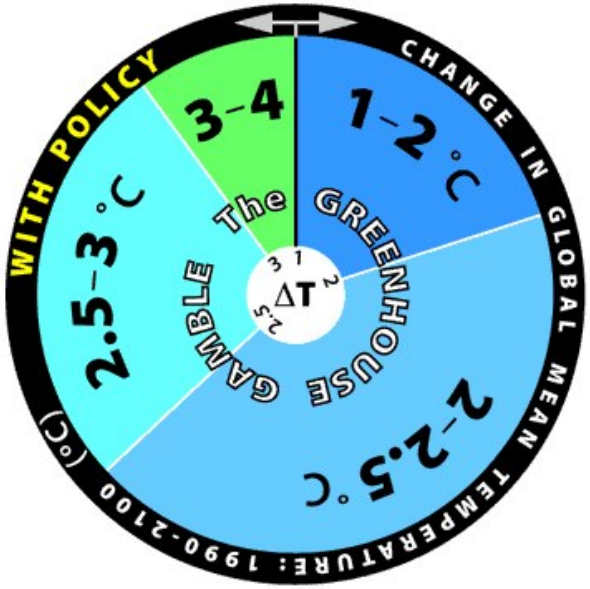
Atmospheric CO_2 & Climate Sensitivity in a Warmer World

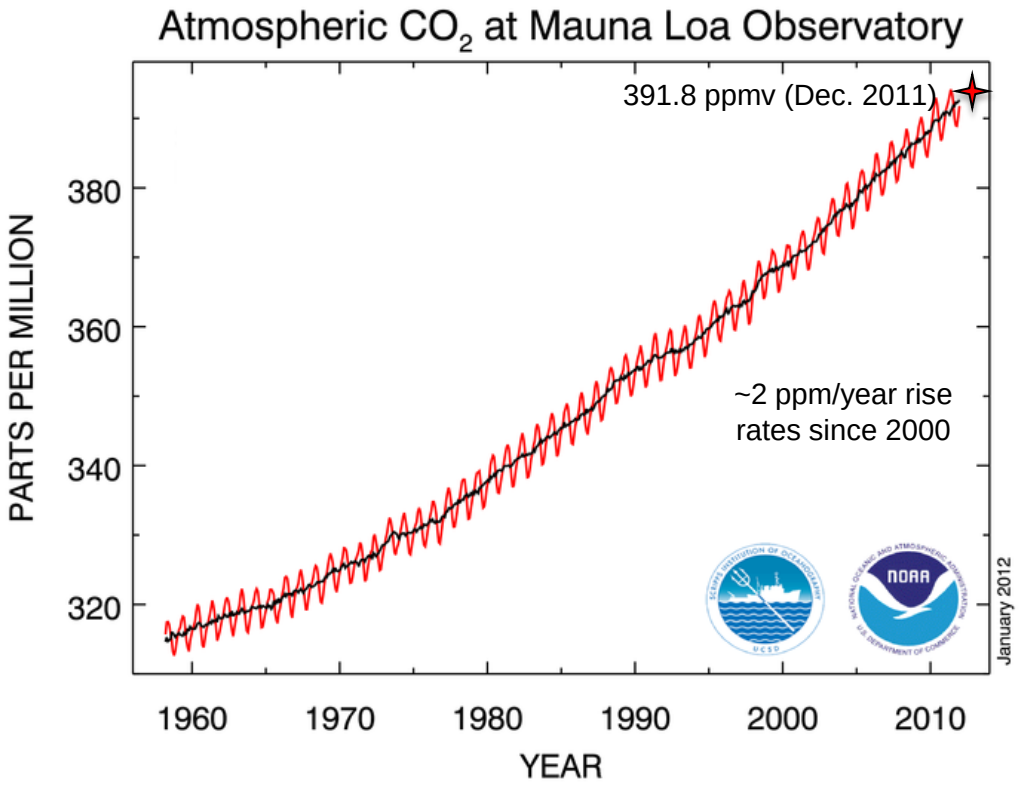




Isabel P. Montañez

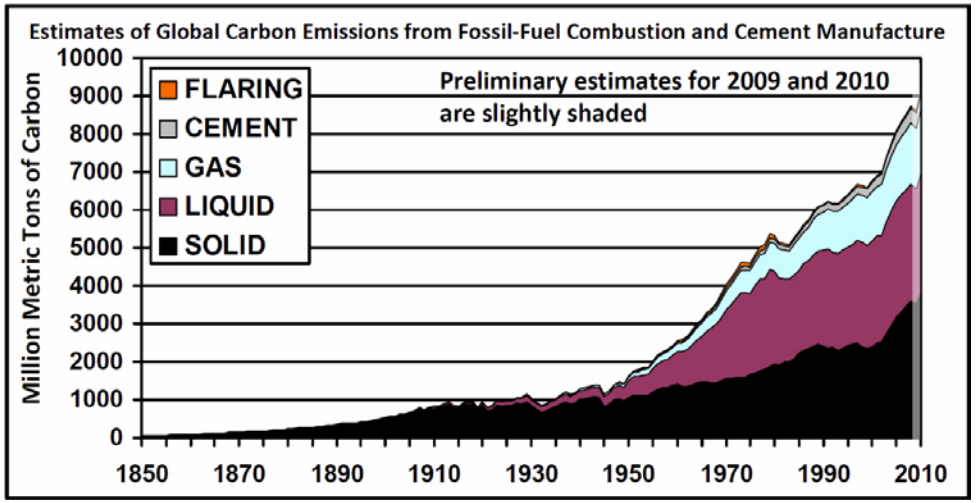
University of California, Davis, CA

Roulette wheels from http://globalchange.mit.edu/resources/gamble/



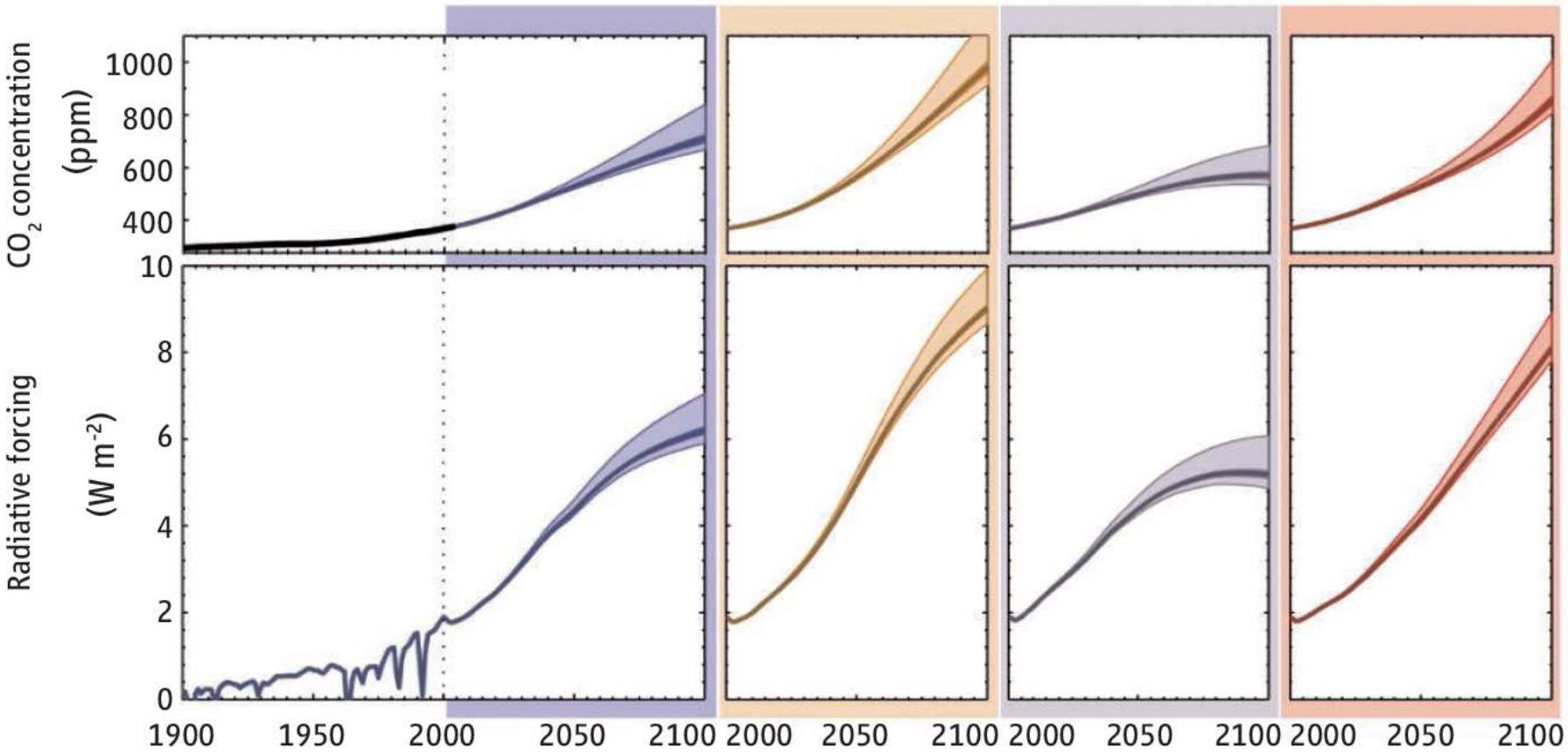
www.esrl.noaa.gov

6% increase in C emissions, 2010



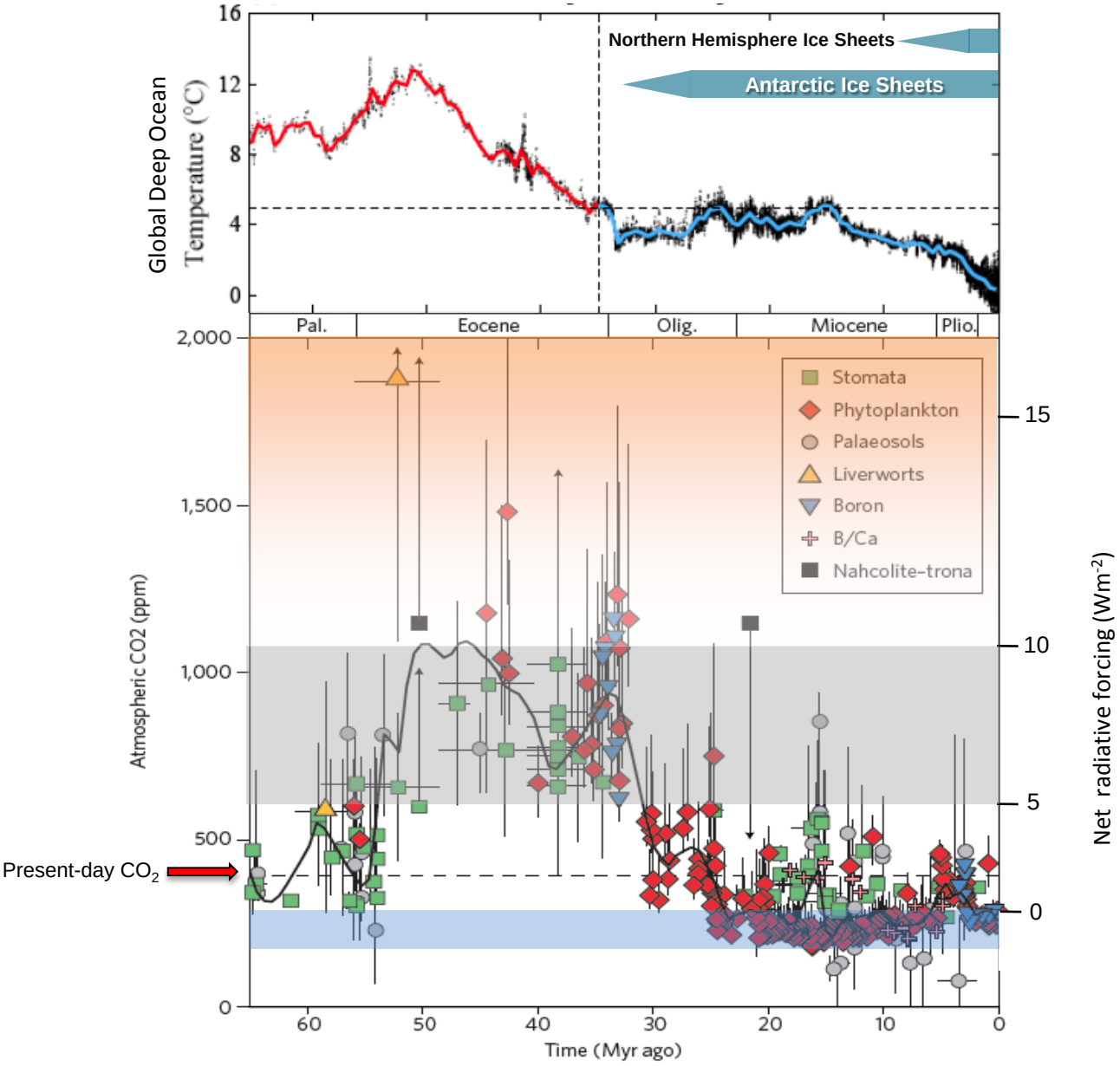
www.cdiac.ornl.gov

Current & Future Emission Scenarios

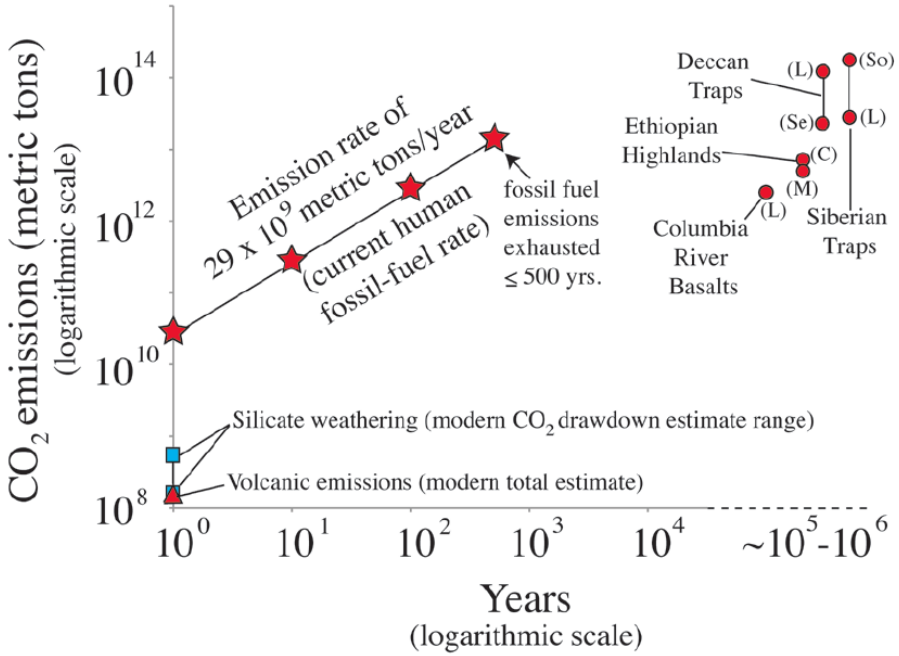


From Kliehl, 2011 (after Special Report on Emissions Scenarios (SRES), IPCC, 2007)

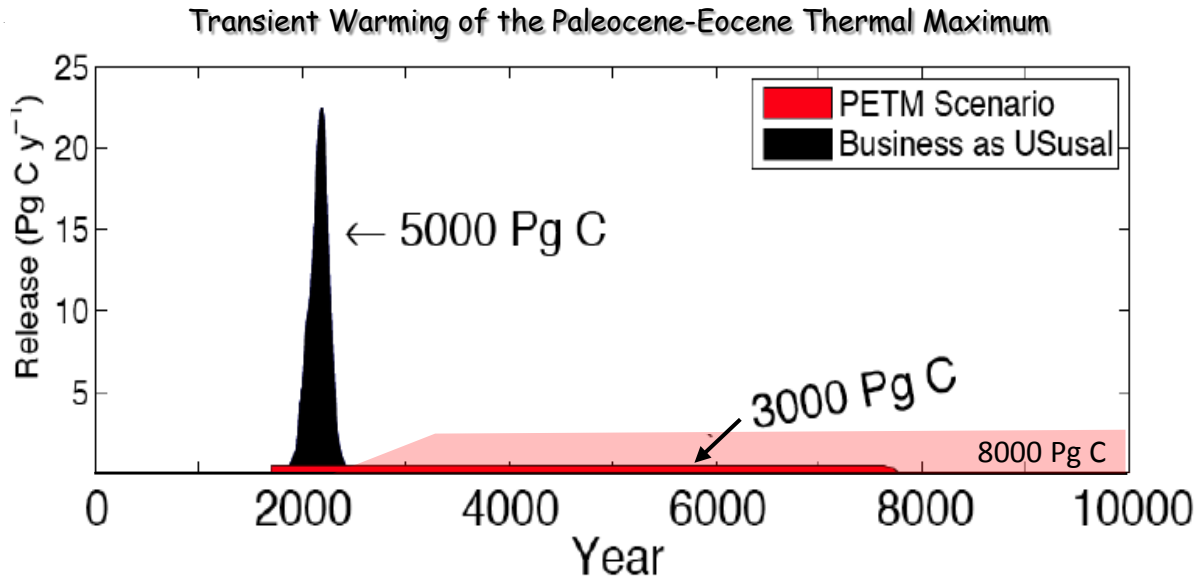
Where are we headed?



Modified from Beerling & Royer, 2011;
Zachos et al., 2008; net radiative forcing from Kiehl, 2011



From Kidder & Worsley, 2012

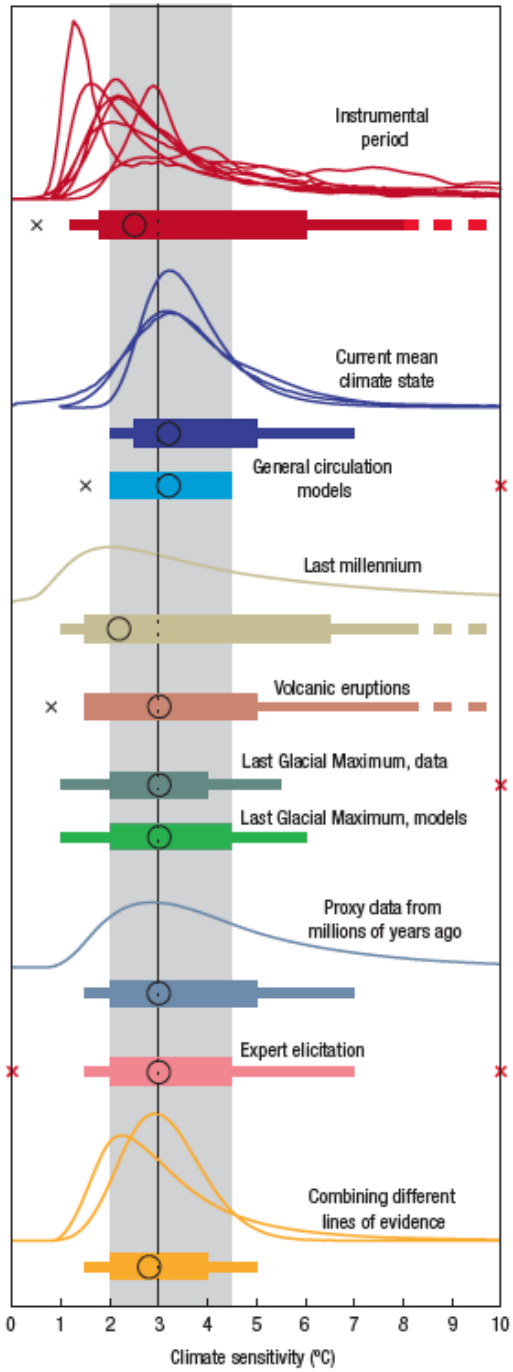


NRC, (Montañez et al.), 2011, *Understanding Earth's Deep Past: Lessons for Our Climate* Future

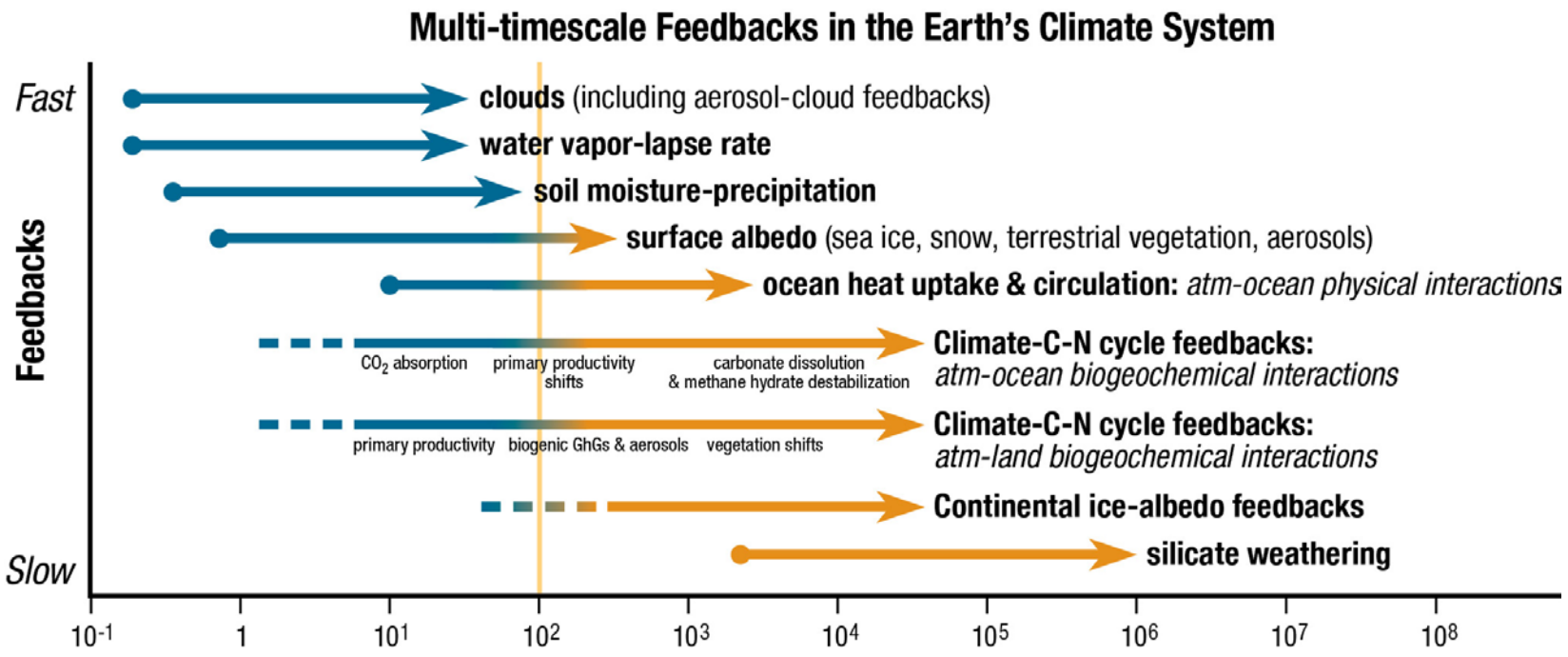
Climate Sensitivity

Global **equilibrium** surface warming following a doubling of atmospheric CO_2 concentration

Transient climate response – the warming at a point of CO_2 doubling



From Knutti & Hegerl, 2008


Multi-timescale Feedbacks in the Earth's Climate System
Fast
Feedbacks
Slow
clouds (including aerosol-cloud feedbacks)
water vapor-lapse rate
soil moisture-precipitation
surface albedo (sea ice, snow, terrestrial vegetation, aerosols)
ocean heat uptake & circulation: atm-ocean physical interactions
CO2 absorption
primary productivity shifts
carbonate dissolution & methane hydrate destabilization
Climate-C-N cycle feedbacks:
atm-ocean biogeochemical interactions
primary productivity
biogenic GhGs & aerosols
vegetation shifts
Climate-C-N cycle feedbacks:
atm-land biogeochemical interactions
Continental ice-albedo feedbacks
silicate weathering
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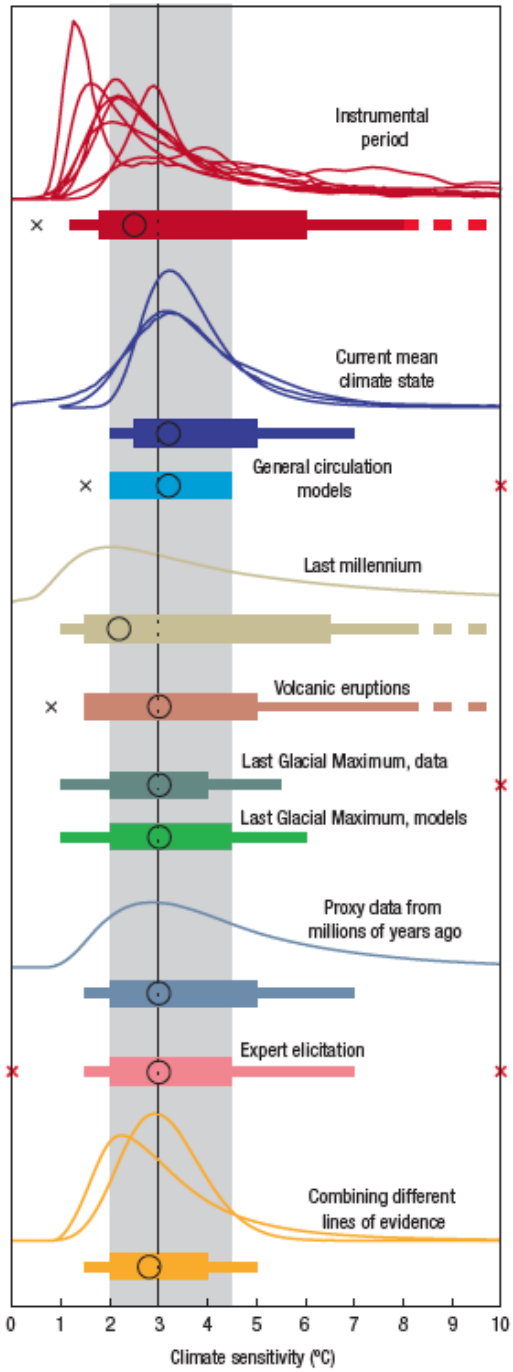
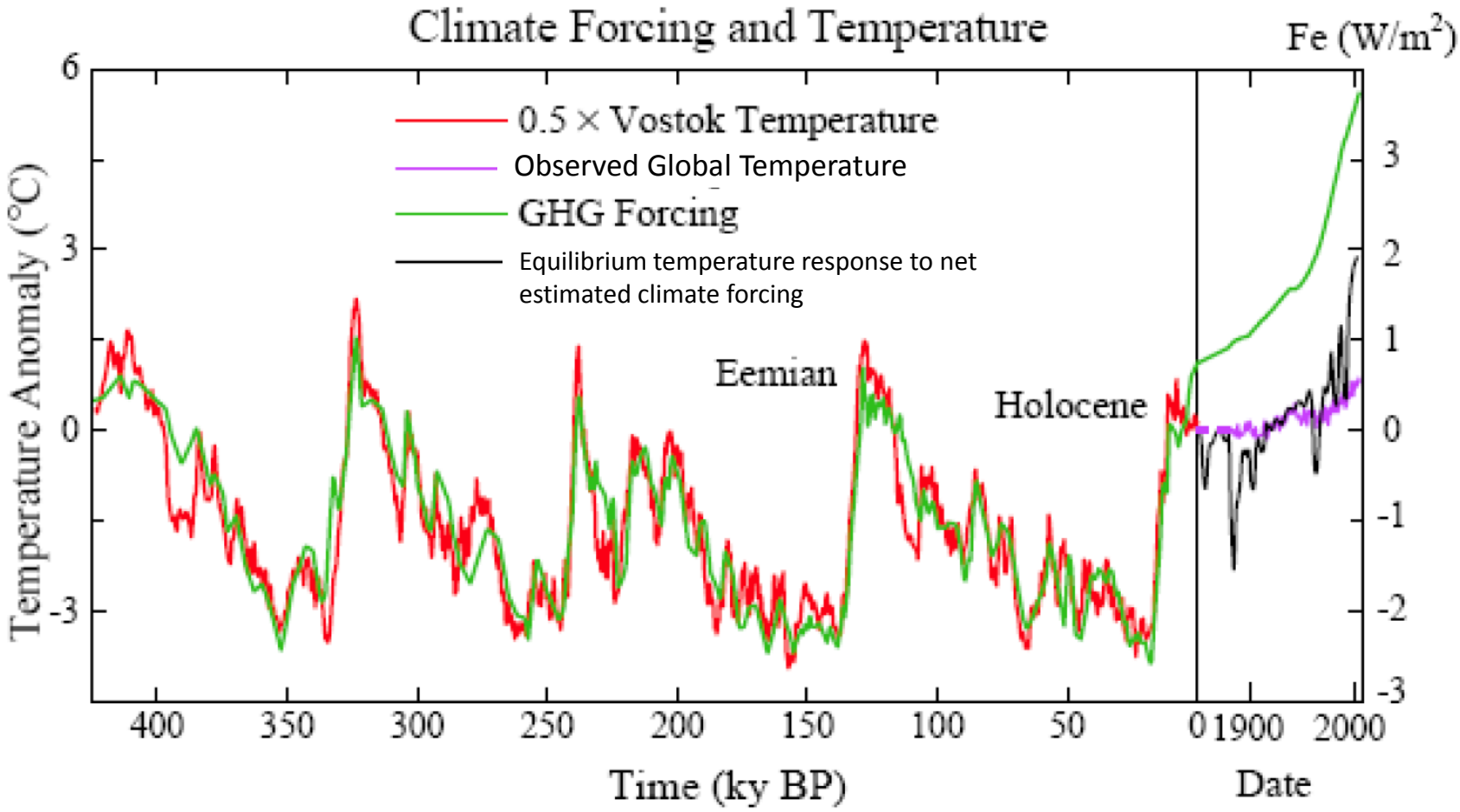


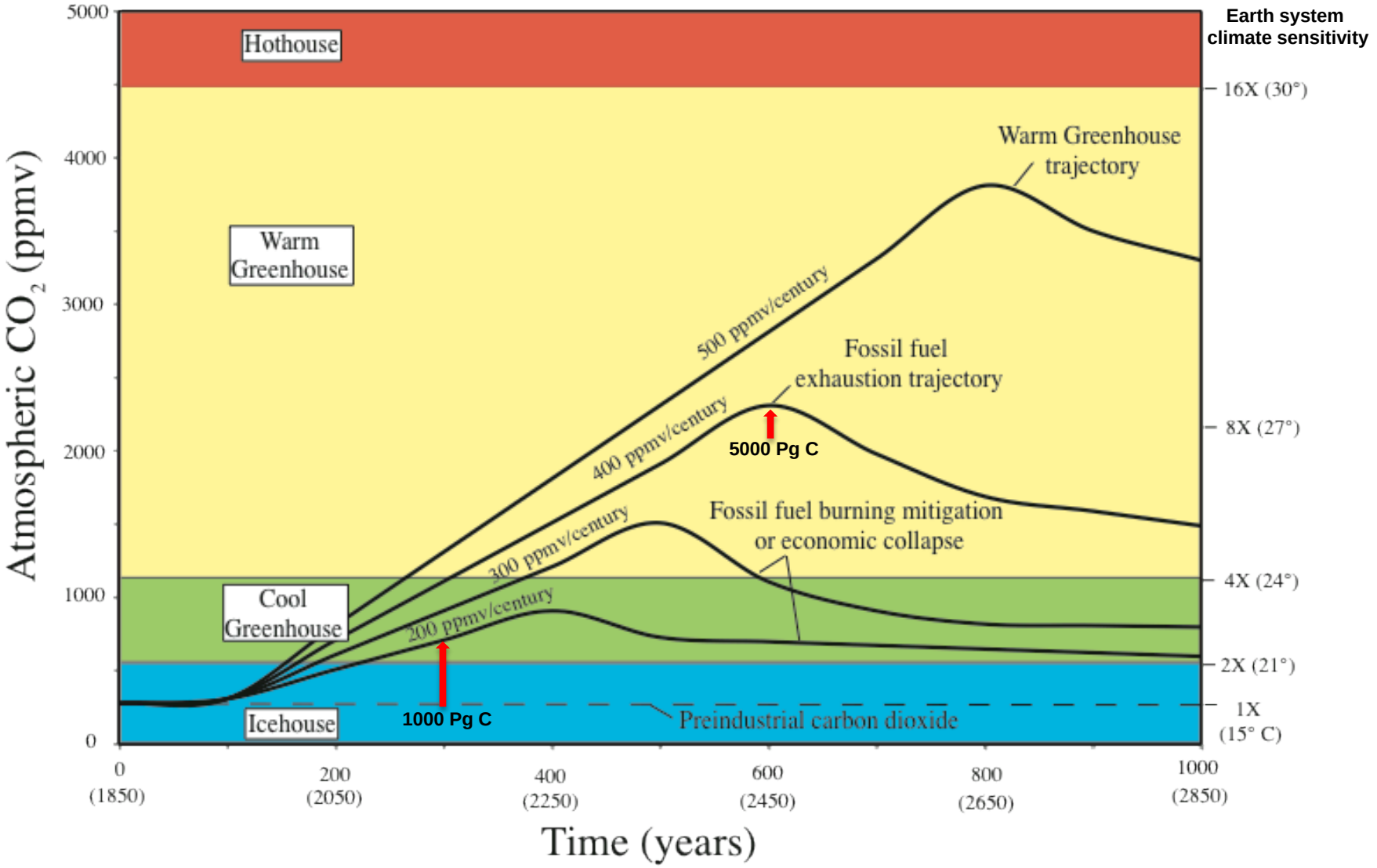
From Knutti & Hegerl, 2008

Warming in the Pipeline

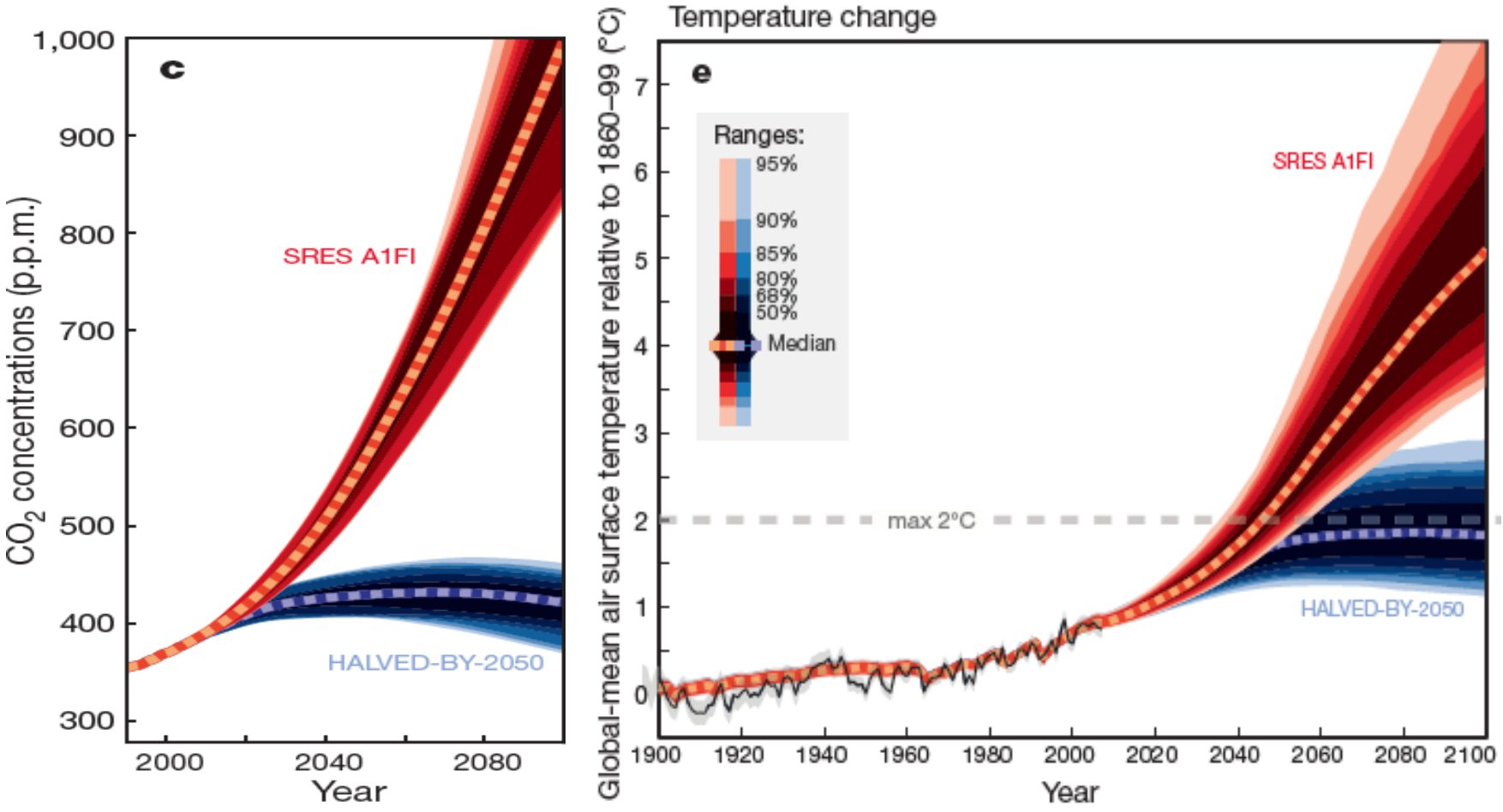


Hansen et al. 2008

Can Humans Induce a Greenhouse Climate?

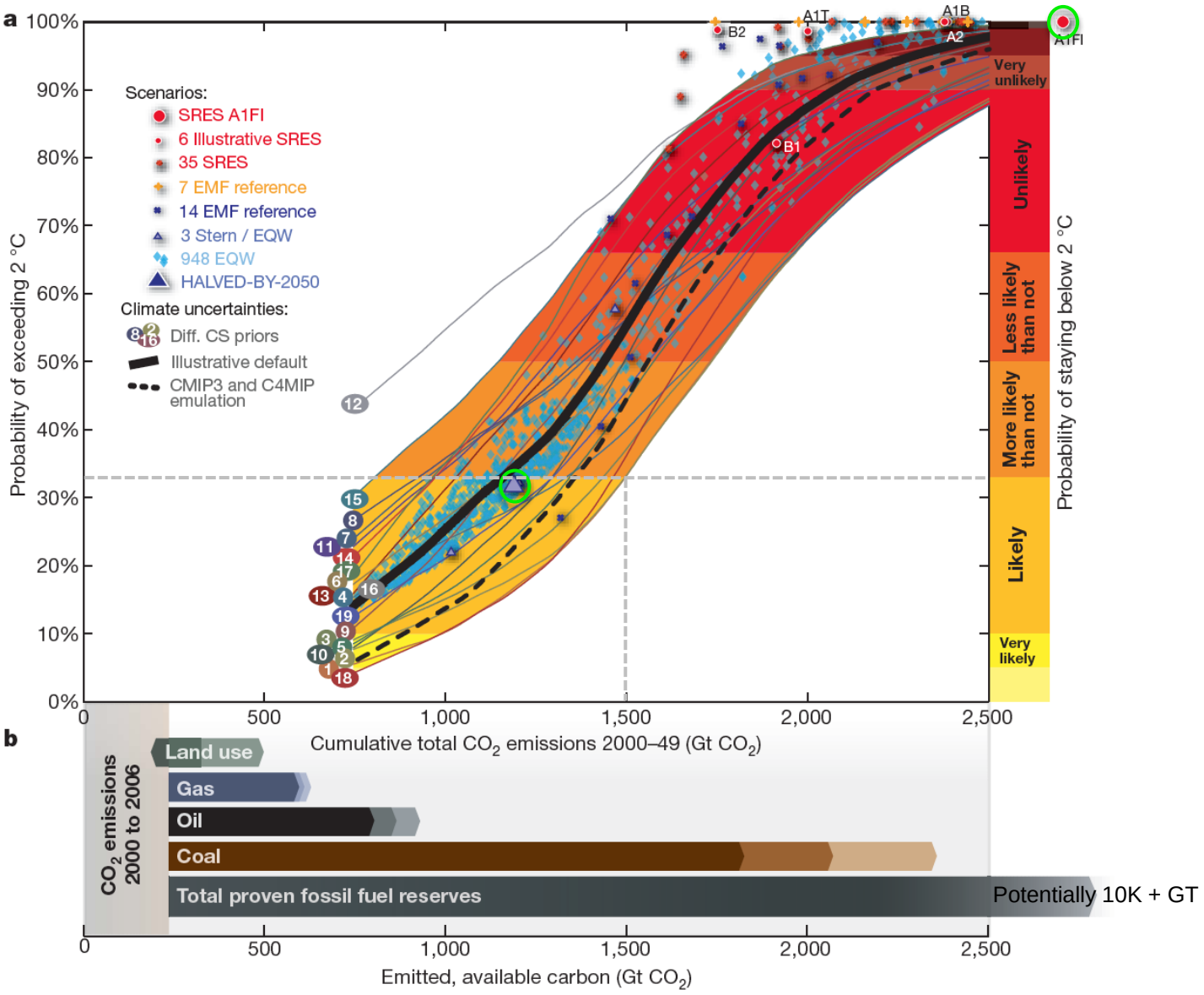


From Kidder & Worsley, 2012



Reduced complexity coupled C cycle-climate model & transient climate response (2 – 4.5 C)

From Meinshausen et al., 2009



From Meinshausen et al., 2009

Summary Points

- By ~2100 - without a reduction in C emissions - atmospheric CO_2 could increase to levels last experienced on Earth more than 30 million years ago – prior to the establishment of Antarctic and Greenland ice sheets.

- Given long residence time of elevated CO_2 in the atmosphere – it is unlikely that global warming will be a century-timescale phenomenon.

- Climate sensitivity is likely time- and state-dependent – fast feedback estimates may not appropriately characterize future warming in a high CO_2 world.

- CO_2 stabilization target of 400 ppmv may be too high given the possibility of accelerating 'slow' feedbacks and climate sensitivity higher than 4.5 C, and the current growth in fossil fuel emissions & extraction.