Changes in CO_2 Through 2100 With and Without a Wind-Water-Solar (WWS) Transition

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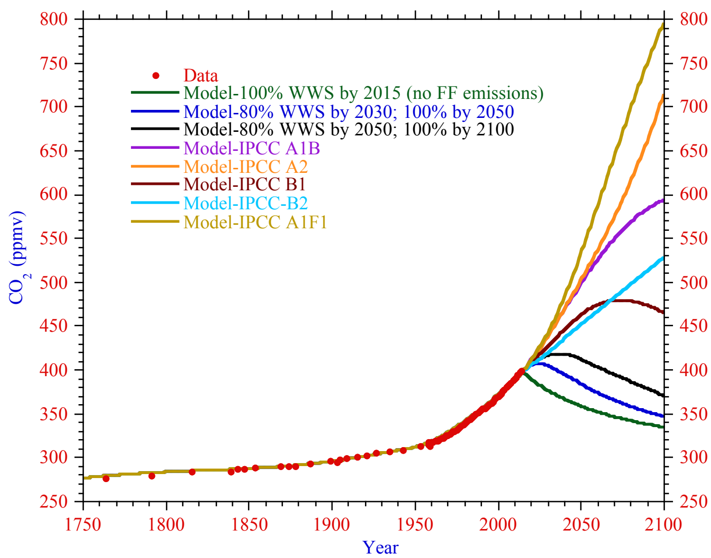
Figure 9.6. Comparison of historic (1751 to 2014) observed CO_2 mixing ratios (ppmv) from the Siple ice core (Neftel et al., 1994) and the Mauna Loa Observatory (Tans and Keeling, 2015) with GATOR-GCMOM model results (Jacobson, 2014) for the same period plus model projections from 2015 to 2100 for five Intergovernmental Panel on Climate Change (IPCC) scenarios (IPCC, 2000) and three WWS scenarios: an unobtainable case of 100 percent WWS by 2015; a case of 80 percent WWS by 2030 and 100 percent by 2050 (from Figure 9.5), and a less-aggressive case of 80 percent WWS by 2050 and 100 percent by 2100.



The model was set up as in Jacobson (2005a) with two columns (one atmospheric box over 38 ocean layers plus one atmospheric box over land). It treated full ocean chemistry in all layers, vertical ocean diffusion with canonical diffusion coefficients, ocean removal of calcium carbonate for shell and rock formation, ocean photosynthesis by phytoplankton and the sinking of its detritus, gas-ocean transfer, and emissions from fossil fuels and land use change. The net carbon sink over land was calculated accounting for time-dependent green-plant photosynthesis, plant and soil respiration, and weathering. No data assimilation or nudging of model results to observations was performed. Preindustrial CO_2 was 276 parts per million by volume (ppmv). Fossil-fuel emissions from 1751 to 1958 were from Boden et al. (2011); from 1959 to 2014 were from Le Quere et al. (2015), and for 2015 onward were from three WWS scenarios scaled from 2014 emission and from five individual IPCC scenarios. Land use change emissions per year were held constant at 300 Tg-C/y for 1751 to 1849; from Houghton (2015) for 1850 to 1958; from Le Quere et al. (2015) for 1959 to 2014, from the IPCC (2000) A1B scenario for the WWS cases from 2015 to 2100; and from the individual IPCC scenarios for the remaining cases. Thus, some land use change emissions continued in all scenarios. The average e-folding lifetime of CO_2 in the air upon a decrease in CO_2 (estimated from the green 100 percent WWS curve in the figure) is about 90 years. This is longer than the data-constrained e-folding lifetime, which is based upon CO_2 increasing, of 30 to 60 years (Jacobson, 2012a). The reason for the difference is that, as CO_2 increases, the air is always supersaturated with respect to the ocean, so the ocean serves as a welcome sink for excess atmospheric CO_2. As CO_2 begins to decrease in the air, it reaches equilibrium with the ocean, making it difficult for more CO_2 in the air to dissolve in ocean surface water, increasing CO_2's atmospheric lifetime. However, photosynthesis by phytoplankton and the sinking of phytoplankton detritus; formation of ocean shells and rocks from dissolved CO_2, and land removal of CO_2 still occur.

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