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Climate impacts on rising atmospheric CO2 from long-term time-series of CO2 and O2

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The long-term time series of atmospheric CO_2 and O_2 concentrations from the Scripps Institution of oceanography now span 51 and 19 years, respectively. These time series will be presented together with the ice-core CO_2 records and discussed in terms of the processes controlling the atmospheric CO_2 rise, particularly the sensitivity of the natural sinks for CO2 in the land and ocean to climate changes.

The CO_2 record provides constraints on the sensitivity of the land sinks to climate. The CO_2 rise can be expressed as an anomaly relative to the trend expected from fossil-fuel burning, land use emissions, and uptake by the land biosphere and oceans, with the latter two processes depicted by simple reservoir models (land sink driven by CO2 fertilization). Despite uncertainties, the anomaly computed this way shows an evident link with global land temperature, with both the anomaly and temperature trend showing breaks in slope around 1940 and 1980. Climate effects on the land biosphere may thus explain two otherwise puzzling features in the CO_2 record: the plateau in growth in the 1940s and the persistent high growth after 1980. The implied effect of warming on CO2 suggested by this decadal variability is too small to be a significant climate feedback, however.

Additional constraints on the climate sensitivity of ocean sinks can be obtained by combining the CO_2 and O_2 records. The ocean CO_2 sink that would have been obtained in the absence of climate change is quite well constrained based on ocean observations of chlorofluorocarbons. This sink can be compared to the sink computed from the global O_2 budget, assuming the oceans have not been a long-term source or sink for O_2. The comparison reveals a significant discrepancy, which suggests that climate changes are impacting some combination of the long-term O_2 and CO_2 fluxes. The climate effect is qualitatively consistent with ocean models, which predict that warming will reduce oceanic uptake of CO_2 and induce oceanic outgassing of O_2.