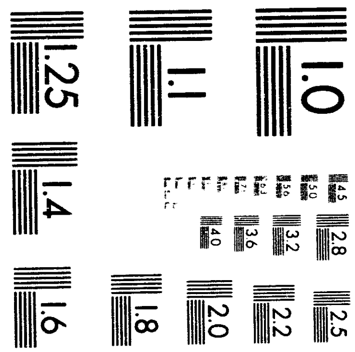
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

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CO_2 Impulse Response Curves for GWP Calculations

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Lawrence Livermore National Laboratory

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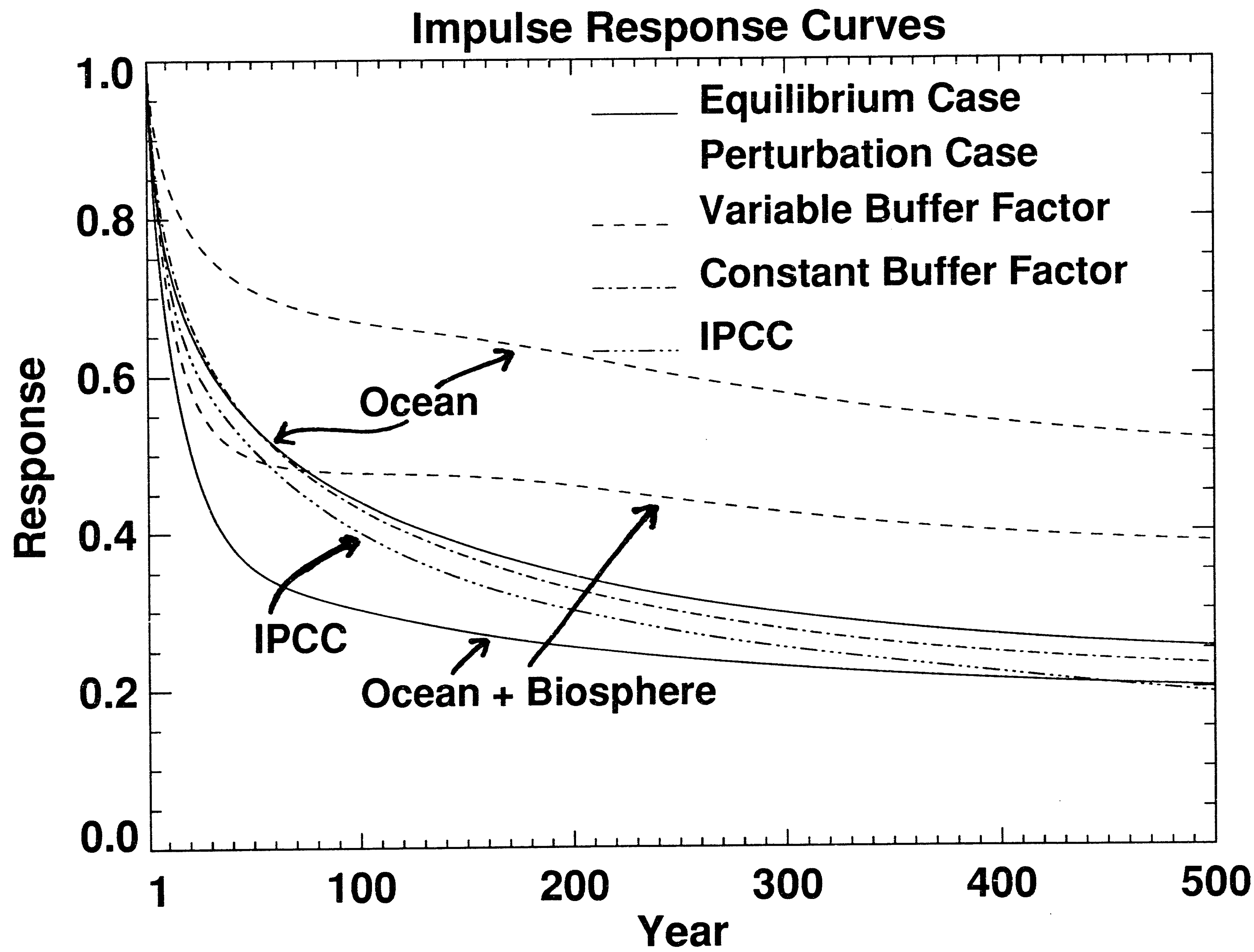
CO_2 Impulse Response Curves For GWP Calculations

The primary purpose of Global Warming Potential (GWP) is to compare the effectiveness of emission strategies for various greenhouse gases to those for CO_2, GWPs are quite sensitive to the amount of CO_2. Unlike all other gases emitted in the atmosphere, CO_2 does not have a chemical or photochemical sink within the atmosphere. Removal of CO_2 is therefore dependent on exchanges with other carbon reservoirs, namely, ocean and terrestrial biosphere. The climatic-induced changes in ocean circulation or marine biological productivity could significantly alter the atmospheric CO_2 lifetime. Moreover, continuing forest destruction, nutrient limitations or temperature induced increases of respiration could also dramatically change the lifetime of CO_2 in the atmosphere. Determination of the current CO_2 sinks, and how these sinks are likely to change with increasing CO_2 emissions, is crucial to the calculations of GWPs.

Attached Figure shows the impulse response curves derived for the IPCC requested cases (Equilibrium and Perturbation cases). For both the cases the pulse is 10 Gt C as proposed by IPCC. However, the time of the pulse given is different for both the cases. In the 'equilibrium case' the pulse is instantaneously injected into the steady state atmosphere. In the 'perturbation case' the model was initialized to a 278 ppmv steady-state at year 1765. The model was then run from 1765 to 1990, with the specified total CO_2 emissions as obtained from the inverse calculations. From 1990 onwards, the model was run with the S650 emission scenario both with and without an additional 10 Gt C pulse injected into the 1995 atmosphere. In addition to the ocean, the living biomass and the soil will also absorb the carbon. Therefore, attached figure also shows the response to a pulse input with and without biospheric reservoirs.

It is interesting to note that the impulse response function is sensitive to the initial state of the ocean-atmosphere system into which CO_2 is emitted. This is due to the fact that in our model the CO_2 flux from the atmosphere to the mixed layer is a nonlinear function of ocean surface total carbon which appears in the buffer factor ξ. At the pre industrial time, short term CO_2 absorption capacity of ocean was higher. Therefore in the first fifty years the decay of the CO_2 was more rapid in the equilibrium case than in the perturbation case. When the industrial production continues to increase, ξ will rise with the partial pressure of CO_2 in the mixed layer. At the same time the short term capability of the oceans to absorb CO_2 from the atmosphere will decrease. Attached Figure also shows that the response functions for both cases (perturbation and equilibrium cases) are similar when ξ remains constant with time. The response function for the equilibrium case is similar to that obtained by Siegenthaler and Oeschger (1987) using their box-diffusion model and was used by IPCC for the GWP calculations.

There is a quite large difference between the runs with and without biosphere, demonstrating the importance of the terrestrial biosphere for the CO_2 cycle. The biosphere absorbs additional CO_2 from the atmosphere, producing an enhanced short term decay which converges toward the no-biosphere case at longer time. Therefore, for the calculations of the impulse response curves, complete carbon cycle system of three main reservoirs, atmosphere-ocean-terrestrial biosphere, must be used.


Impulse Response Curves
Equilibrium Case
Perturbation Case
Variable Buffer Factor
Constant Buffer Factor
IPCC
Ocean
IPCC
Ocean + Biosphere
Response
1.0
0.8
0.6
0.4
0.2
0.0
1
100
200
300
400
500
Year

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