4. Strategies for Achieving Carbon Balance

The atmospheric carbon balance, with the assumption that CO_2-fertilisation accounts for all the 'missing sink', is expressed as:

$$2.123\frac{d}{dt}C(t) = Q_{\rm foss}(t) + D_{\rm n}(t) - S_{\rm ocean}(t) - S_{\rm fert}(t) \qquad (4.1)$$

This provides an essential constraint on the modelling. In general terms, the specifications in Appendix A invoke two principles:

1. The terms in the current (i.e., 1980s' mean) modelled carbon budget as expressed by equation (4.1) should be consistent with observations.
2. There should be continuity in processes from the past to the future: the future balance should be achieved using the same processes as for the past.

Two of the ways in which these requirements translate into procedures for initialising the models for calculations beyond 1990 are:

The standard forward initialisation: Use $Q_{\rm foss}(t)$, $D_{\rm n}(t)$ exactly as specified, with $S_{\rm ocean}(t)$ calculated (possibly using a ^{14}C calibration) and $S_{\rm fert}(t)$ calculated. The parameterisation of $S_{\rm fert}$ is tuned to give the best possible agreement with the observed record of $C(t)$. The precise details of how this is done are left open.

The standard inverse initialisation: Use specified $Q_{\rm foss}(t)$ and calculated $S_{\rm fert}(t)$ and $S_{\rm ocean}(t)$ and track the prescribed $C(t)$ in order to deduce $D_{\rm n}(t)$. The model parameters are to be tuned to give $\bar{D}_{\rm n} = 1.6$ GtC/yr averaged over the 1980s.

Post-1990: The fluxes $S_{\rm ocean}$ and $S_{\rm fert}$ are to be calculated using the same parameters as in the initialisation phase. The land-use flux $D_{\rm n}$ is prescribed. This leaves the model integration defining a relation between $Q_{\rm foss}(t)$ and $C(t)$, either of which can be used to determine the other. Calculations of both types are requested in the instructions.

The prescribed CO_2 concentration for the period 1 January 1980 to 31 December 1989 shows an increase of 15.9 ppmv, an average rate of increase of 3.38 GtC/yr. For the same period our standard cases had average sources of $\bar{Q}_{\rm foss} = 5.45$ GtC/yr and $\bar{D}_{\rm n} = 1.58$ GtC/yr. In terms of the atmospheric budget shown in equation (4.1), this constrains the sum of oceanic and fertilisation fluxes to be $S_{\rm ocean} + \bar{S}_{\rm fert} = 3.65$ or more generally $S_{\rm ocean} + \bar{S}_{\rm fert} = 2.07 + \bar{D}_{\rm n}$. This is shown diagramatically in Figure 4.1. It is possible to take combinations of the oceanic and terrestrial fluxes, whether computed by full models or partial models, and combine them in pairs subject to the balance constraint.

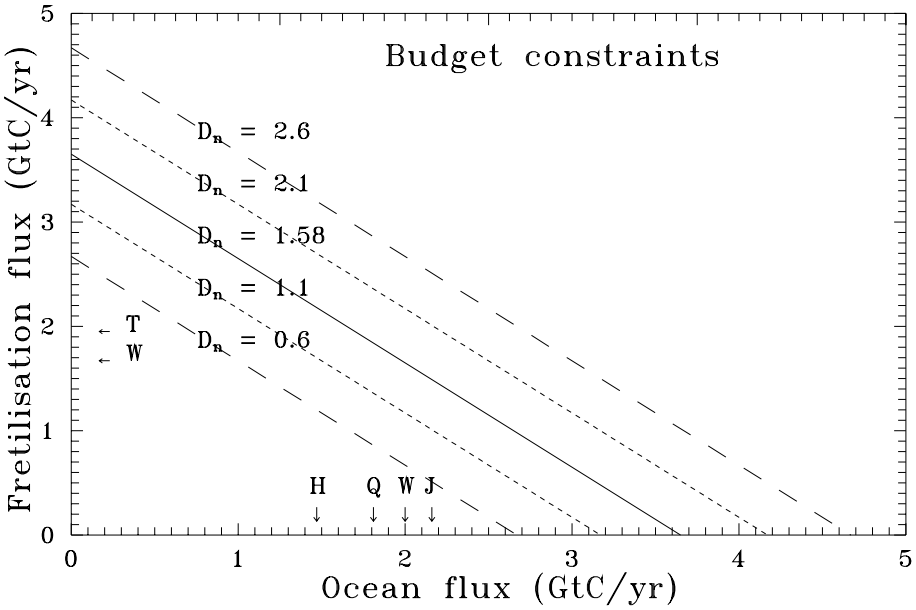

Figure 4.1. Relation between components of the atmospheric carbon budget averaged over 1980–89. The lines for various mean 'land-use' fluxes specify the combinations of ocean flux and fertilisation flux that are compatible with a balanced atmospheric budget. Labelled points along the axes show fluxes calculated for some of the models. Within the specifications of Appendix A, the 'fertilisation' and 'ocean' components of different models can be combined, subject to implying an acceptable 'land-use' term.

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