Box 1.8. Ozone depletion potentials (ODPs) and equivalent effective stratospheric chlorine (EESC)

Ozone depletion potentials (ODPs) are used as a simple measure for quantifying the effect of various ozone-depleting compounds on the ozone layer, and have proved to be an important quantity for the formulation of the Montreal Protocol and its Amendments. The ODP is defined as the integrated change in total ozone per unit mass emission of a specific ozone-depleting substance relative to the integrated change in total ozone per unit mass emission of CFC-11 (WMO, 1995; WMO, 2003).

For the calculation of the ODP of an ozone-depleting substance, the change in total ozone per unit mass of emission of this substance may be determined with numerical models. As an alternative, Solomon *et al*. (1992) have formulated a semi-empirical approach for determining ODPs based mainly on observations rather than on models.

The quantities required for the semi-empirical approach are the physical properties of the halocarbons, their lifetimes, the so-called fractional release factor Φ – a factor representing the factor of inorganic halogen release in the stratosphere from observations relative to CFC-11 – and in the case of bromine, a quantification of the catalytic efficiency of ozone destruction relative to chlorine. For long-lived gases that are well mixed in the troposphere the definition of the semi-empirical ODP of a particular halogen compound is (Solomon *et al.,* 1992; Chapter 1 of WMO, 2003)

$$\mathrm{ODP} = \Phi \cdot \alpha \cdot \frac{\tau_x}{\tau_{\mathrm{CFC-11}}} \frac{M_{\mathrm{CFC-11}}}{M_x} \frac{n_x}{3}$$

Here, τ is the global lifetime of the long-lived gas, M is the molecular weight, n is the number of halogen atoms and α is the relative efficiency of any halogen compound compared with chlorine. For bromine, $\alpha = 45$ (Daniel *et al*., 1999). The current best estimates of ODPs by both the model and the semi-empirical methods are listed in Table 1.2 together with the ODP values originally adopted for the formulation of the Montreal Protocol.

The equivalent effective stratospheric chlorine (ESSC) is an index that is similar to an ODP. It relates the total stratospheric chlorine and bromine levels to the tropospheric release of halocarbons. It was defined as a mixing ratio by Daniel *et al*. (1995):

$$\mathrm{EESC} = \left(\sum_{\substack{\text{chlorine-}\\\text{containing}\\\text{compounds}}} n_x Cl_{\mathrm{trop}}^{t-3} \Phi + \sum_{\substack{\text{bromine-}\\\text{containing}\\\text{compounds}}} n_x \alpha Br_{\mathrm{trop}}^{t-3} \Phi \right) F_{\mathrm{CFC-11}}$$

where Cl_{trop}^{t-3} represents the stratospheric halocarbon mixing ratio at time t, and accounts for the approximately three years it takes to travel from the source of emission into the lower stratosphere; $F_{\mathrm{CFC-11}}$ is the fractional release of halogens into the stratosphere from CFC-11, which is considered to be proportional to the change in column ozone.