Box 1.3. Radiative forcing and climate sensitivity

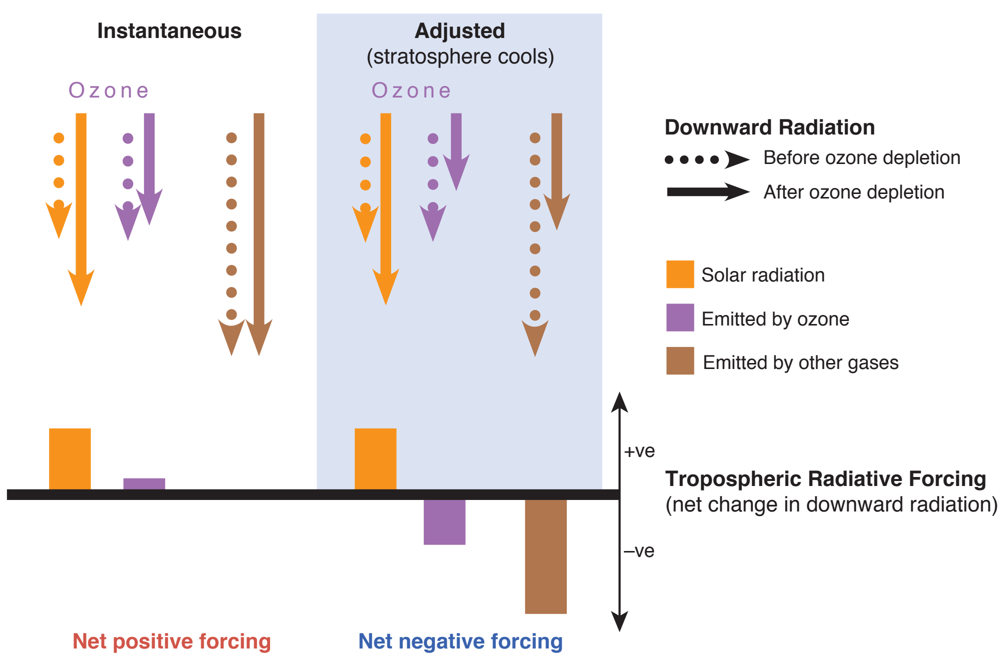
Radiative forcing is a useful tool for estimating the relative climate impacts, in the global mean, of different climate change mechanisms. Radiative forcing uses the notion that the globally averaged radiative forcing (ΔF) is related to the globally averaged equilibrium surface temperature change (ΔT_s) through the climate sensitivity (λ):

$$\Delta T_s = \lambda \Delta F$$

The reason surface temperature changes in different models are not usually compared directly is that the climate sensitivity is poorly known and varies by a factor of three between different climate models (IPCC, 2001, Chapter 9). Further, climate model studies have shown that, for many forcing mechanisms, λ in an individual climate model is more or less independent of the mechanism. These two factors enable the climate change potential of different mechanisms to be quantitatively contrasted through their radiative forcings, while they remain difficult to compare through their predicted surface temperature changes. Unfortunately, certain radiative forcings, including ozone changes, have been shown to have different climate sensitivities compared with carbon dioxide changes (IPCC, 2001, Chapter 6; WMO, 2003, Chapter 4). One of the reasons for this difference is that some aspects of the radiative forcing definition, such as tropopause height, have a large impact on the ozone radiative forcing (see below). These factors are the main reasons for the large uncertainty in the ozone radiative forcing and the global mean climate response.

Why is the radiative forcing of stratospheric ozone negative?

The radiative forcing is defined as the change in net radiative flux at the tropopause after allowing for stratospheric temperatures to readjust to radiative equilibrium (IPCC, 2001, Chapter 6). The details of this definition are crucial for stratospheric ozone, and are explained in the figure.



Box 1.3, Figure. The instantaneous effect of stratospheric ozone depletion (left-hand side of schematic) is to increase the shortwave radiation from the Sun reaching the tropopause (because there is less ozone to absorb it), and to slightly reduce the downward longwave radiation from the stratosphere, as there is less ozone in the stratosphere to emit radiation. This gives an instantaneous net positive radiative forcing. However, in response to less absorption of both shortwave and longwave radiation in the stratosphere, the region cools, which leads to an overall reduction of thermal radiation emitted downward from the stratosphere (right-hand side of schematic). The size of this adjustment term depends on the vertical profile of ozone change and is largest for changes near the tropopause. For the observed stratospheric ozone changes the adjustment term is larger than the positive instantaneous term, thus the stratospheric ozone radiative forcing is negative.