Environmental impacts of ozone depletion and its interactions with climate change

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Abstract. The key climate change factors that are likely to have the biggest impact on terrestrial ecosystems include increasing greenhouse gas emissions, rising temperatures, frequent drought and flooding events. Superimposed on these are increasing levels of UV-B (280-315 nm) radiation due to stratospheric ozone depletion as well as due to changes in cloud cover, pollution levels, deforestation, and subsequent land-use change, all of which are likely to increase UV-B radiation reaching biological systems. This situation makes it important that research continues to focus on potential interactions among the different environmental conditions.

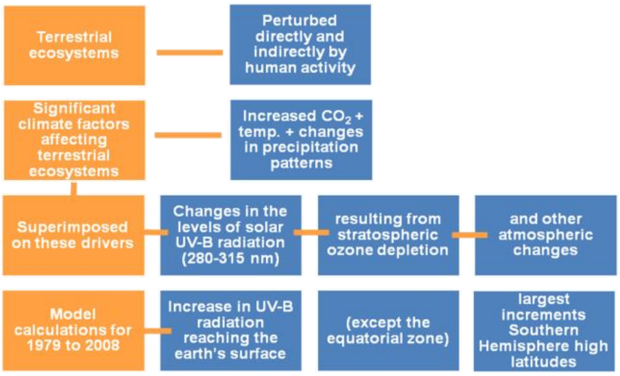

Figure 1. Complex environmental changes likely to have significant impacts on terrestrial ecosystems.

Current assessment and predictions of implications of increasing UV-B radiation and other environmental changes

The success of the Montreal Protocol has removed the large impact of the ozone depleting substances. However, it is becoming clear that the predicted elevated UV-B

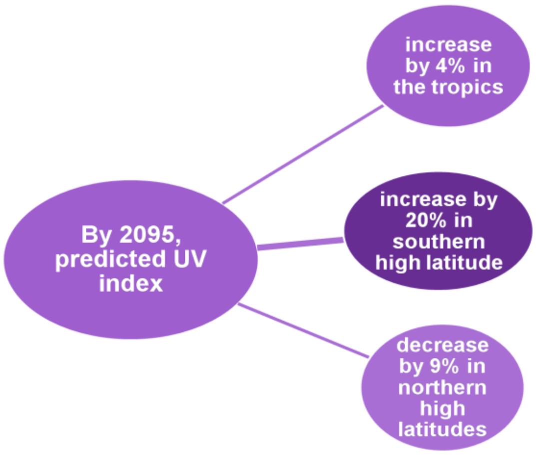

Figure 2. UV irradiance will not necessarily follow ozone recovery, but will be modified by other climate-induced changes (data from Hegglin and Shepherd, 2009).

The consequences of climate change interactions include spreading of vector-borne diseases into new geographical locations, changes in species competitiveness and vitality, as well as a range of indirect effects. Modern agricultural practices are primed to further unbalance life on Earth unless concerted action is taken. Overlaid on the direct impact of changes, are the many feedback processes of e.g. increased UV radiation, CO_2 and other greenhouse gases, aerosol concentrations and the biogeochemical cycling of compounds including carbon, nitrogen, methane and bioavailable toxic substances.

The main ecological consequences of an increased UV-B radiation component for several plant systems are decreases in biomass production, and changes in species composition and abundance. Depending on the environmental factor, plant response to UV-B radiation can convey tolerance to other environmental conditions, and may result in a greater or lesser tolerance. One such example is the often reported decrease in herbivory that appears to be due not only to some direct effects on insects, but also to the UV-induced increases in phenolic compounds by the host plant (Caputo et al. 2006, Izaguirre et al. 2007).

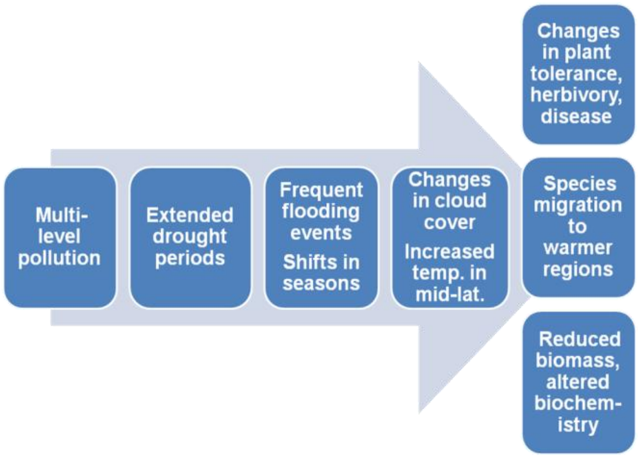

Figure 3. Complexities of climate change and their impacts.

Other interacting environmental factors which have been shown to increase tolerance to UV-B radiation in some plants are drought, freezing temperatures and warming (Feng et al. 2007, Turnbull et al. 2009, Cechin et al. 2008, Teklemariam and Blake 2004). Several lines of evidence point to a reduction in reactive oxygen species as one acclimative response (Han et al. 2009).

Although there is not much penetration of solar radiation of the UV component into soils, biomass and morphology of root systems can be affected much more than the above-ground plant shoots. These systemic responses of plants to UV-B radiation can affect also the below-ground environment for other organisms. One of a growing number of examples is the UV-B-induced increase in phenolic compounds in leaves which can also result in an increase in these compounds in plant roots, resulting in a reduction in roundworms below ground surface (Koti et al. 2007).

Conclusions

The complexity of the impacts and feedback processes of climate change are altering terrestrial ecosystem response and functioning, and are likely to intensify as climate change is enhanced. The interactive effects of UV-B radiation with other climatic variables can result in no discernable response or changes in resilience. These biological responses are likely to contribute to an evolving set of acclimation and adaptation strategies or impaired functioning, making the study of UV-B radiation effects within the framework of a changing climate of importance for understanding current and future climate impacts on terrestrial ecosystems.

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