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The radiative forcing potential of different climate geoengineering options

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Abstract. Climate geoengineering proposals seek to rectify the Earth's current radiative imbalance, either by reducing the absorption of incoming solar (shortwave) radiation, or by removing CO_2 from the atmosphere and transferring it to long-lived reservoirs, thus increasing outgoing longwave radiation. A fundamental criterion for evaluating geoengineering options is their climate cooling effectiveness, which we quantify here in terms of radiative forcing potential. We use a simple analytical approach, based on the global energy balance and pulse response functions for the decay of CO_2 perturbations. This aids transparency compared to calculations with complex numerical models, but is not intended to be definitive. Already it reveals some significant errors in existing calculations, and it allows us to compare the relative effectiveness of a range of proposals. By 2050, only stratospheric aerosol injections or sunshades in space have the potential to cool the climate back toward its pre-industrial state, but some land carbon cycle geoengineering options are of comparable magnitude to mitigation "wedges". Strong mitigation, i.e. large reductions in CO_2 emissions, combined with global-scale air capture and storage, afforestation, and bio-char production, i.e. enhanced CO_2 sinks, might be able to bring CO_2 back to its pre-industrial level by 2100, thus removing the need for other geoengineering. Alternatively, strong mitigation stabilising CO_2 at 500 ppm, combined with geoengineered increases in the albedo of marine stratiform clouds, grasslands, croplands and human settlements might achieve a patchy cancellation of radiative forcing. Ocean fertilisation options are only worthwhile if sustained on a millennial timescale and phosphorus addition probably has greater long-term potential than iron or nitrogen fertilisation. Enhancing ocean upwelling or downwelling have trivial effects on any meaningful timescale. Our approach provides a common framework for the evaluation of climate geoengineering proposals, and our results should help inform the prioritisation of further research into them.

Discussion Paper (PDF, 771 KB) Interactive Discussion (Closed, 9 Comments) Final Revised Paper (ACP)

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