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The climate–carbon cycle feedback: An eventual saturation

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A saturation of climate–carbon cycle feedback was found earlier in the simulations with the IAP RAS climate model of intermediate complexity (IAP RAS CM). Here, this eventual saturation is studied with respect to the time scales associated with a growth of CO_2 anthropogenic emissions. The simulations with the IAP RAS CM forced by synthetic fossil fuel emission scenarios are performed. These emissions grow exponentially in time with a characteristic timescale $t_p = 25 - 250\ yr$. In all performed simulations, climate–carbon cycle feedback parameter f initially grows, attains a maximum (at time $(3 - 7) \times t_p$ for the selected small value of initial emission), and then decreases eventually tending to unity. As diagnosed, this behaviour is due to decrease of transient climate sensitivity with time. These results are further interpreted by using a conceptual linearised coupled model. With the latter model, it is shown that this saturation is due to weak, logarithmic, dependence of the carbon dioxide radiative forcing on its atmospheric concentration. This eventual climate–carbon cycle feedback saturation leads to the non–monotonic behaviour of climate–carbon cycle parameter f in time. In particular, this feedback plays only a minor role in the early part of the integration. Afterwards, its strengthes but eventually saturates (after a characteristic time of several t_p. This eventual saturation is expected for other climate models provided a length of integration is large enough for a given emission scenario.