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Separation of radiative feedback contributions to polar amplification

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When the climate system is forced by a doubling of the atmospheric CO_2 content, a number of feedback processes are induced, such as changes of water vapor, clouds and surface albedo. Here the CO_2 forcing and concomitant feedbacks are studied individually using the general circulation models NCAR CAM3 and ECHAM 6.0 coupled to mixed layer oceans. A technique for fixing the radiative effects of moisture, clouds and surface albedo by re-using these variables from $1\times CO_2$ and $2\times CO_2$ equilibrium climates in the models' radiation codes allows for a detailed decomposition of the problem in terms of forcings, feedbacks and their responses. The water vapor radiative feedback is found to approximately double the climate sensitivity, but while its radiative effect is strongly amplified at low latitudes, the resulting climate response displays about the same degree of polar amplification as the full all-feedbacks experiment. We conclude that while the water vapor feedback does not in itself lead to polar amplification by increasing the ratio of high- to low-latitude warming, it does double climate sensitivity both at low and high latitudes. In this manner, a polar amplification induced by other feedbacks in the system, such as the Planck, lapse rate and surface albedo feedbacks, is strengthened in the sense of increasing the difference in high and low latitude warming.