



An estimation of the polar temperature amplification induced by the lapse-rate and the surface-albedo feedback, using a slab-ocean climate model

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The atmospheric temperature will change in response to a forcing, but the change may not be constant with height in the atmosphere. The dependence of the temperature change with height gives rise to the lapse-rate feedback. In a warmer climate, the saturated mixing ratio of water vapour increases more at lower than at upper levels in the troposphere. Therefore due to enhanced latent heat release, the atmosphere tends to warm more in the upper than in the lower troposphere in regions where strong convection is present, such as at tropical latitudes. This results in enhanced radiation back to space and a more efficient cooling of the Earth system, which is contributing to a negative lapse-rate feedback. The opposite situation prevails at the high latitudes where stable stratification conditions in the lower troposphere result in a larger warming of the surface-near atmosphere than of the upper troposphere, which contributes to a positive lapse-rate feedback.

Hence the lapse-rate feedback is assumed to be negative at low latitudes and positive at high latitudes. Here we explore the effect of the lapse-rate feedback on the polar temperature amplification using a slab-ocean climate model CESM1 from National Center for Atmospheric Research, Boulder, US. By locking the temperature change in the radiation code to a column-mean value which is independent of height in the troposphere, the lapse-rate feedback is suppressed. Doubling-of-CO₂ experiments where the lapse-rate feedback has been removed are compared with experiments where it is retained.

In a similar way the surface-albedo feedback is removed by keeping the surface albedo fixed in the entire model system. On the basis of model versions where either one or both of the feedbacks are suppressed, we are able to separate the effect of the surface-albedo feedback and the lapse-rate feedback on the polar temperature amplification.