



ON THE DYNAMICS OF THE ENHANCED GREENHOUSE EFFECT

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The equilibrium sensitivity of the Earth's climate to a CO₂ increase is studied using an idealized two-zone hemispheric model that is simple enough to allow analytical solutions. The model has two prognostic variables representing SSTs in the tropical and extratropical zones. The atmosphere is assumed to be in a state of energetic and dynamical balance, while the surface energy budget is closed by parameterizing the radiative and latent heat fluxes as functions of the two SSTs. The surface IR flux is parameterized using the results of a radiative model, which show that the water vapour IR feedback on SST perturbations is destabilizing. The latent heat flux, which is stabilizing (because of the consequent bypassing of the low level IR absorbers by moist convection and latent heat release aloft), is taken to be proportional to the air-sea humidity deficit and the surface wind speed. The former is parameterized in terms of a Clausius-Clapeyron dependence on temperature, while the latter is parameterized in terms of atmospheric angular momentum transport from the tropics to the extratropics. When the model's surface energy budget is subjected to an external radiative forcing corresponding to a CO₂ doubling, the induced warming is of the same order as that given by GCMs. Unlike the case of GCMs, however, the mechanism of the warming as it occurs in the simple model can be fully understood. The results suggest that the mechanism of the enhanced greenhouse effect cannot be discussed simply in radiative or local radiative-convective terms, but that global scale dynamics plays a central role through a ventilation feedback.