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Radiative, convective and dynamical feedbacks in the Tropical area

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The modulation of radiative processes by changes in water vapor and cloudiness, and therefore in convection or large-scale atmospheric dynamics is at the origin of a combination of partially compensating positive and negative feedbacks, in close association with the definition of dynamical regimes. Following Pierrehumbert (1995) a very useful paradigm, has been to oppose the moist ascending unstable regions of the Hadley cells, and the dry subsidence areas, which are stabilized by strong radiation to space. It introduces the idea of a strong linkage between the radiative and dynamical conditions in the Tropics: the definition of dry or moist areas is of course closely associated with the location of the Hadley-Walker. radiative equilibrium, as revealed by satellite images, with a strong contrast between adjacent very moist and very dry areas. This bimodal nature of the intertropical water vapor distribution is not reflected into the temperature field. which is on the contrary very uniform throughout the whole area, raising the question of how the Hadley-Walker circulation can maintain near-equilibrium radiative conditions.

This issue has been investigated using first a very simplified, almost analytic, model of the radiative equilibrium which was described by Li et al (1997). Ide et al (2001) have shown that the form of the equations could explain how similar near-equilibrium energy balance conditions could be maintained in two areas sharing the same temperature profile, but very different water vapor profiles. By using results from the LMD GCM and/or observed reanalysis, as input to this simplified 1D-model, it was found that, very consistently, the two dry and moist transmissivities which ensures radiative equilibrium have a close qualitative relationship with the observations.

In a second phase a considerably enhanced model was developed and used by Bellon et al (2003) to investigate the role of convection and that of dynamics in regulating the competition between the moist unstable and dry stable areas. The model introduces a representation of moist convection and a coupling between the two columns, in the form of water and energy exchanges. It is also coupled to a simple ocean mixed-layer, and can be used for conceptual climate sensitivity experiments. The results of this model will be described in the broad context of scenarios associated with possible future climate changes.

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