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Importance of Water Vapour in Conventional ("Dry") Potential Temperature for Tropical Dynamics

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Despite the fact that the potential temperature of an air parcel has a dependence on its water vapour content through the exponent on pressure dependence, potential temperature is often still calculated as if the parcel were moisture-free, assuming constant specific heat capacities. We show that such a moisture-free potential temperature approximation is not suitable for tropical regions. Moisture gradient terms are seen in the isentropic primitive equations when Exner's and Montgomery functions are generalised with moist specific heat capacities. In the tropics, the contribution to the horizontal momentum tendency by the horizontal moisture gradient is comparable to the contribution due to the Montgomery function, reflecting relatively strong local horizontal gradients in potential temperature created by inhomogeneous water vapour distribution in a large-scale background of weak horizontal temperature gradient. In such an environment, water plays an active role in tropical atmospheric dynamics even without the uptake or release of latent heat during phase changes. Hence, we suggest that the tropical troposphere is a place where the atmosphere can behave dynamically as a binary-component fluid at local and regional scales.