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Non parametric statistical downscaling of satellite measurements at different scales: linking observations from a lidar and a passive microwave sounder

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Constraining the tropical water cycle is critical for assessing its role in the climate system and its changes. This study aims to better understand the relationships between the main components of the water cycle over the tropics by combining, for the first time, instantaneous satellite observations of the tropical water vapour from the passive microwave sounder SAPHIR/Megha-Tropiques and of the fine vertical distribution of clouds from the CALIPSO lidar CALIOP. Because the instantaneous satellite observations are characterized by different horizontal resolutions (10x10 km for SAPHIR and 90 m for CALIOP) a scaling method is defined in order to overcome the difference in the spatial sampling. Firstly, the instantaneous CALIOP measurements are co-located in space and time and clustered according to the vertical characteristics of the clouds from their scattering ratio. Secondly, for each cluster, the relative humidity of the passive sounder is estimated from the vertical profiles of the cloud scattering ratios via non-parametric statistical regression methods (Generalized Addictive Models and Random Forests). These estimates are then refined to account for the different spatial resolutions of the satellite measurements, through an iterative model fitting algorithm which attempts to maintain the consistency between the coarsely-resolved observations of relative humidity and the finer observations of the vertical cloud profiles. The 'pseudo-observations' of relative humidity generated via these scaling relationships at the measurement scale of the cloud parameters represent an innovative approach to improve the sub-grid parameterization in General Circulation Models (GCM) as well as to better constrain the uncertainties in the GCM-simulated cloud feedback.