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Scaling of the first order structure function of the AIRS observed water vapor field

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The scale invariance of many atmospheric quantities has been established empirically. Few studies have considered the global climatology of scale invariance of atmospheric water vapor. The Atmospheric Infrared Sounder onboard NASA's Aqua satellite has provided global physical retrievals of water vapor vertical profiles with ~50km nadir resolution. The AIRS observed water vapor profiles have been shown to exhibit variance scaling across a wide range of length scales and it has been suggested that the observed scaling could be used to develop global climate model subgrid scale parameterizations and to validate climate simulations (Kahn and Teixeira, 2009). In this work we present a characterization of the scale invariance of the first structure function of the AIRS observed water vapor field. In particular, we will present a nearly global climatology of the the first structure function scaling exponent across scales ranging from 50km to 500km. The use of a structure function methodology allows the testing of assumptions of homogeneity and isotropy in the water vapor field which are implicitly made by other methods of analysis. Emphasis will be placed on the methodology used to compute scaling exponents from satellite observations and on the effects of inhomogeneity and anisotropy on the computed exponents. Global maps of first structure function scaling exponents derived from AIRS water vapor retrievals will be presented. Our results show the presence of two distinct scaling regimes, one which characterizes water vapor spatial variability in the boundary layer, and a second which characterizes the spatial variability within the free troposphere. The two regimes are characterized by substantially different scaling exponents, which can be used to describe the spatial correlations within the AIRS observations. In particular, boundary layer scaling exponents are found to be near 1/3, while free tropospheric scaling exponents are found to be generally greater than 1/2 and most frequently near 0.55. Furthermore, within each regime the computed scaling exponents vary only over a small range suggesting that the exponents may be a universal property of the water vapor distribution for each regime. Finally, the physical mechanism responsible for the formation of each regime will be conjectured and extension of the methodology to the assessment of GCM simulated water vapor fields will be proposed.