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Radiance Field Statistics in Two-Dimensional Multifractal Clouds

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Over the last twenty years, there have been several studies of radiative transfer in multifractal cloud fields, although it is only recently that clouds with large optical thicknesses have been considered; but on these only the "bulk" overall transmission and reflection coefficients were examined. In this contribution, we outline some new results which attempt to understand the relationship between the internal cloud and radiance fields, and this over wide ranges of scales and optical thicknesses. Using sparse matrix routines, we explicitly solve the discrete angle radiative transfer equations for the radiance and flux fields of two-dimensional (500 x 500 pixels) multifractal water density fields illuminated uniformly from above. The Fourier power spectra of the radiance and flux fields exhibit power-law behaviour for the middle range of wave vectors (corresponding to lengths not close to the pixel size or the cloud size). We find that the spectral exponents fall into two classes determined by the relationship between the Fourier transform direction and the radiance/flux direction. The power-law amplitudes also fall into two classes, but these are distinct from the exponent classes. We propose a theoretical understanding of the origin of these classes. In addition, we examine the correlations between the statistics of the radiance/flux fields and the underlying density fields.