Geophysical Research Abstracts, Vol. 7, 10164, 2005
SRef-ID: 1607-7962/gra/EGU05-A-10164

Space-time differential stratification of aerosols and cirrus clouds from high resolution lidar data

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We use state-of-the-art lidar data of aerosols and cirrus clouds. Several vertical space - time cross-sections with resolution of 3.75m in the vertical, 1s in time and spanning 3-4 orders of magnitude in scale) were analyzed. We find that the statistics of both weak and strong fluctuations in backscatter follow an anisotropic generalization of the classical (isotropic) Corrsin-Obukhov law of passive scalar advection; the overall (x,y,z,t) space is found to have an "elliptical dimension" characterizing the stratification equal to 1+1+5/9+2/3=29/9 corresponding (in conditions with no mean wind) to $k_x^{-3/5}$, $k_y^{-3/5}$,$k_z^{-11/5}$ scaling in space and ω^{-2} scaling in time. This is further generalized to conditions with a mean wind (this has the effect of rotating the axes of the scale function generator). The analyses show that both cirrus and aerosols had very similar scaling properties.

In order to perform data analyses using this generalized notion of scale and to test the generalized Corrsin-Obukhov law, we developed and applied new method of data analysis based on a nonlinear transformation of space-time intervals. This was used to calculate multidimensional structure functions of various orders to both test the theory and directly determine the unit ball defining the generalized notion of scale. Using this new technique and more traditional power spectrum analysis we verify the theory to within about 10% over more than 3 orders of magnitude of space-time scales.

Finally, we show how to make multifractal models with the observed statistical characteristics (including wave-like phenomenologies), we simulate radiative transfer on the resulting cloud density fields and study the statistics of the single scattered radiation.