Geophysical Research Abstracts, Vol. 7, 10063, 2005
SRef-ID: 1607-7962/gra/EGU05-A-10063

Detection of the new phenomenon of turbulent thermal diffusion of aerosols in laboratory experiments

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We discuss a new phenomenon of turbulent thermal diffusion associated with turbulent transport of aerosols in the atmosphere and in laboratory experiments. The essence of this phenomenon is the appearance of a nondiffusive mean flux of particles in the direction of the mean heat flux. This phenomenon causes formation of large-scale inhomogeneities in the spatial distribution of aerosols that accumulate in the regions of minimum mean temperature of the surrounding fluid. The effect of turbulent thermal diffusion was detected experimentally in two experimental apparatuses: oscillating grids turbulence generator and multi-jet turbulence generator. These both devices are capable of producing a confined homogeneous isotropic turbulent flow with a very small mean velocity. We studied transport of aerosols in a turbulent air flow with the imposed vertical mean temperature gradient. We used Particle Image Velocimetry to determine the turbulent velocity field, and an Image Processing Technique based on an analysis of the intensity of Mie scattering to determine the spatial distribution of aerosols. Analysis of the intensity of laser light Mie scattering by aerosols showed that aerosols accumulate in the vicinity of the minimum mean temperature due to the effect of turbulent thermal diffusion. In the experiments with two directions of the vertical mean temperature gradient, it was found that in a flow with a downward mean temperature gradient (unstably stratified flow) particles accumulate in the vicinity of the top wall of the test chamber. In a flow with an upward mean temperature gradient (stably stratified flow) particles accumulate in the vicinity of the bottom wall of the test chamber. The effect of turbulent thermal diffusion is important in various atmospheric phenomena, e.g., transport of pollutants and smog formation. This effect can explain formation of the large-scale aerosol layers inside atmospheric temperature inversions.