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General approach to the formulation and solution of the multi-parameter inverse problems of atmospheric remote sensing

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Inverse problems of atmospheric remote sensing can be formulated as multi-parameter problems in most cases. The parameters to be retrieved (the parameters of primary interest) are called the target parameters and the parameters which influence the retrieval are called the interfering parameters. The interfering parameters should be preset and controlled in one way or another or should be retrieved simultaneously with the target parameters. Very often the information about interfering parameters is available from different sources with different accuracy and, if vertical profiles are considered, in different altitude regions. Besides, often it is necessary to apply constraints or physical links to the parameters (for example, hydrostatic equilibrium equation for temperature and pressure profiles). The convenient way to account for all kinds of available information about target and interfering parameters and for all constraints is to combine these parameters in one joint vector and to formulate the inverse problem with respect to this vector. Under such approach the inverse problem can be written in a form of a system of vector-matrix equations, where each equation describes specific type of measurements or specific constraint in a linearized form. In case of constraint the traditional vector of measurements is treated as quantity, which describes the constraint and can be considered as pseudo-measurement. The advances of this general approach are demonstrated using, as an example, the algorithm for interpretation of ground-based measurements of brightness temperature of down-welling microwave radiation in the absorption lines which are traditionally used for ozone profile remote sensing. Inverse problem is formulated as a multi-parameter one with respect to ozone vertical profile (target parameter), and also vertical profiles of temperature, pressure, and water vapor (controlled interfering parameters). The possibility is shown to utilize in any combination additional radiosonde and satellite measurements of atmospheric parameters in different altitude regions (if available) and also to take into account physical links between parameters. Error estimates for retrieval of ozone average concentration in the layers 22-30 km, 30-40 km, 40-50 km, and 50-60 km are presented for summer and winter conditions (for different atmospheric total water content) and for different scenarios of interpretation of down-welling microwave radiation measurements in ozone absorption line 110 GHz.