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Ozone profile smoothness as a priori information in the inversion of limb measurements

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In this work we discuss inclusion of a priori information about smoothness of atmospheric profiles in inversion algorithms. The smoothness requirement can be formulated in the form of Tikhonov-type regularization, where the smoothness of atmospheric profiles is considered as a constraint or in the form of Bayesian optimal estimation (maximum a posteriori method, MAP), where the smoothness of profiles can be included as a priori information.

We develop further two recently proposed retrieval methods. One of them - Tikhonov-type regularization according to the target resolution - develops the classical Tikhonov regularization. The second method - maximum a posteriori method with smoothness a priori - effectively combines the ideas of classical MAP method and Tikhonov-type regularization. We propose a grid-independent formulation for the proposed inversion methods, thus isolating the choice of calculation grid from the question how strong the smoothing should be.

The methodology for creating smoothness a priori information is developed. The smoothness of the ozone profile is characterized by the characteristic scale of the fine structure, which, in turn, is defined as the correlation length of the ozone profile fluctuations. The analysis of the smoothness of ozone profiles based on 11-years ozone sonde measurements at Sodankylä is performed. It is found that the characteristic scale has slight seasonal variations and can therefore be considered as a relatively stable atmospheric characteristic. The mean values of the characteristic scale are ˜1 km for altitudes below 10 km, and ˜1.4 km for altitudes 10-25 km.

The discussed approaches are applied to the problem of ozone profile retrieval from stellar occultation measurements by the GOMOS instrument on board the Envisat

satellite. Realistic simulations for the typical measurement conditions with smoothness a priori information created from the analysis of ozone soundings at Sodankylä and analysis of total retrieval error illustrate the advantages of the proposed inversion methods.

The proposed methods are equally applicable to other profile retrieval problems from remote sensing measurements.