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Information content of the outgoing thermal radiation spectra with respect to vertical ozone distribution

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The significance of ozone for atmospheric processes has stimulated the development of systems for its monitoring. Satellite methods of remote sensing that measure outgoing thermal radiation are the only sources that provide information on ozone independent of solar illumination. The outgoing thermal radiation spectra measured by the IKFS-2 spectrometer aboard the “Meteor-M” N2 satellite contain information on the ozone content in the atmosphere. To study the information content of the spectra with respect to ozone profiles, we constructed experimental covariance matrices of the vertical ozone distribution and cross-covariance matrices between ozone and temperature profiles using ozonesonde data over the years of the instrument's mission. We built and analysed the averaging kernels of the inverse problem and estimated the degrees of freedom for signal (DOFS). For calculating derivatives of the outgoing thermal radiation, we used the LBLRTM (Line-By-Line Radiative Transfer Model) code. The calculations were performed for different mean climatic temperature profiles. We considered both the retrieval using ozone mixing ratio profile covariance matrices only and the retrieval which took into account temperature-ozone cross-covariance matrices. The largest DOFS value, which is up to 4, is observed for the tropics and summer temperature models. The smallest DOFS (3.0–3.8) correspond to the winter middle and subarctic latitudes.

We estimated the relative errors of the ozone content retrieval. Simultaneous retrieval of ozone and temperature profiles considering their cross-covariances leads to a 0.5–2.5% reduction of the retrieval errors. One independent piece of information corresponds on average to the 1000–230 hPa layer, which is equivalent to the tropospheric layer. Thus, the ozone content in the troposphere may be derived from the IKFS-2 measurements with an error of 7.7–8.5% depending on the atmospheric temperature profile.

We demonstrate the possibility of deriving the ozone vertical distribution elements from the satellite measurements of the outgoing thermal radiation spectra.

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