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On determination of distribution of nitrogen dioxide sources in the troposphere using detailed measurements of GSA/Resurs-P No.2

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Nitrogen oxides (NO_x=NO+NO_2) plays a major role in the destruction of ozone in the stratosphere and its formation in the troposphere. Since 2013, a series of Russian Resurs-P satellites has been operating in sun-synchronous orbit. The GSA hyperspectral equipment installed on board the Resurs-P records scattered solar radiation in the spectral range of 430–520 nm, which is used to determine the content of such an impurity as nitrogen dioxide in the atmosphere. We have developed a method for determining the 2D field of NO_2 content based on Resurs-P GSA measurements, which allows us to obtain the NO_2 content with a spatial resolution of about 2.4 km with a typical accuracy of $1.0x10^{15}$ molecules/cm2 for space measurements on a 120 m data grid [1], which exceeds the spatial resolution of other modern satellite instruments. Its use made it possible in 2016 to identify for the first time point anthropogenic sources of impurity on an enterprise scale based on measurements from space [1]. A chemical transport model with high spatial resolution was developed to interpret the measurements [2].

The paper considers several methods for solving the inverse problem of determining the distribution of impurity sources based on the obtained highly detailed 2D fields of NO_2 content. At the first stage, a plume of NO2 distribution from a point stationary source was obtained based on the transport-chemical model. It was also shown that, at the observed NO_2 concentrations, the concentration in the plume linearly depends on the NO_x emission rate. As a result, a linear model was adopted for the formation of the spatial distribution of NO_2 depending on the spatial distribution of sources.

The first constructed method for estimating the distribution of sources is a linear estimate of the minimum variance with a constraint on the operator residual. In the case under consideration, the algorithm can be implemented using the fast Fourier transform, which transforms the measurement model into a problem with a diagonal matrix describing the linear transformation of the direct problem. The second method we considered is the estimation of quadratic programming with a restriction on the reconstructed signal in the form of its positivity. The resulting algorithm is nonlinear. To calculate this estimate, the gradient projection algorithm is used.

A significantly higher quality of restoration of the source distribution is shown when using the second approach.

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