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Atmospheric trace gases profile retrievals from balloon measurements using an evolutionary operator

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Abstract

Most operational atmospheric inversion methods are based on Bayesian probability theory, e.g. optima
tion method (OEM). OEM requires a high computational cost due to the inversion of a large covarianc
describing the uncertainties of observed spectra [1]. It can also produce false solutions [2,3] due to:
priori covariance matrix in conjunction with the error covariance matrix being unable to reduce the c
number of the inverted matrix sufficiently to block the noise transferring from the measurement spa
state space in an ill-posed inversion and the solution oscillates, ii) the solution converges to a differer
shape because of the construction of a reliable a-priori covariance is almost impossible where the varia
the atmospheric parameters is unbounded. Usually the inference of the a-priori probability distribution
on the information from an inappropriate/uncertain data inversion and is itself unreliable [4].

An alternative is the nonlinear regularized iterative method (NRIM), which is fast and accurate for
nonlinear ill-posed inversion problems in a variety of scientific disciplines such as signal processing, a
control, image processing, economy, biology and medicine etc. Usually the zero/first/second derivative
is used to regularize the solution in NRIM. One of the common criticisms is that these operators a
enough for identifying the general trends and large features, not good for fine resolutions. Thus, we
a new “evolutionary operator”, which evolves in every iteration followed by the solution of the sta
parameters of the former iteration. It minimizes the regularization error in sense of the characteristi
stabilizer and also minimizes the noise error in an ill-posed inversion by reducing the condition numb
inverted matrix.

A mixed quadratic and cubic line search method is used for the nonlinear retrievals. We use a regulari
least squares method to determine the optimal regularization strength where the noise criterion is i
considered as a residual norm. Additional retrieval metrics, such as the model resolution matrix and the
of freedom in the retrieval, which characterize the vertical resolution of the retrievals, are also deriv
simulated retrievals as well as the retrieval from the data of a balloon based spectroscopic measuremen
discussed. The successful retrieval results obtained using O_3 and CH_4 as test cases will be presented.

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