Retrieval of Temperature and Pressure Profiles for the Stratospheric Aerosol and Gas Experiment III

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Abstract

The goals of this research are to develop an algorithm to operationally retrieve profiles of atmospheric temperature and pressure for the upcoming Stratospheric Aerosol and Gas Experiment (SAGE) III satellite missions, validate the approach through simulated retrievals and derive an error budget for the retrieved products. The retrieval algorithm is based on SAGE III multi-spectral measurements of the oxygen A-band absorption feature centered near 762 nm. The retrieved products will consist of vertical profiles of temperature and pressure at 1-km intervals from 1 to 85 km.

The A-band absorptivity measurements are dependent on temperature and pressure in a complicated, non-linear fashion and, as a result, an iterative retrieval approach has been proposed. The retrieval algorithm uses a global fitting technique that solves for successive adjustments to trial solution temperature and pressure profiles by minimizing the residuals between the SAGE III-measured absorptivities and a set of modeled absorptivities produced from a numerical model of the measurements. A modified Levenberg-Marquardt non-linear least squares routine is used to perform the minimization.

The feasibility of the proposed retrieval algorithm was demonstrated through a series of simulation studies using synthetic measurements with realistic noise. The sensitivity of the retrievals to measurement noise increases significantly above 40 km and induces undesirable oscillations in the retrieved profiles. The implementation of an implicit hydrostatic constraint was shown to effectively reduce the magnitude of these noise-induced oscillations. A statistical analysis based on sixty simulations indicates that the retrieval algorithm introduces negligible bias in the solution profiles and produces consistent results for all atmospheric conditions.

A formal characterization and error analysis was performed in the retrievals. Potential sources of random and systematic uncertainty were identified and a comprehensive error budget for the temperature and pressure retrievals was derived. The estimated accuracy of the temperature retrievals is better than 2 K below 55 km, but increases to 4.5 K at 85 km. The estimated accuracy of the pressure retrievals is better than 2% at all altitudes. Based on this assessment, the retrieved products will meet the SAGE III algorithm and science requirements for temperature and pressure measurements.