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- Recent Final Revised Papers
- Volumes and Issues
- Special Issues
- Library Search
- Title and Author Search

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Alerts & RSS Feeds
General Information
Submission
Review
Production
Subscription
Comment on a Paper

Volumes and Issues   Contents of Issue 2

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Retrieving global aerosol sources from satellites using inverse modeling

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Abstract. Understanding aerosol effects on global climate requires knowing the global distribution of tropospheric aerosols. By accounting for aerosol sources, transports, and removal processes, chemical transport models simulate the global aerosol distribution using archived meteorological fields. We develop an algorithm for retrieving global aerosol sources from satellite observations of aerosol distribution by inverting the GOCART aerosol transport model.

The inversion is based on a generalized, multi-term least-squares-type fitting, allowing flexible selection and refinement of a priori algorithm constraints. For example, limitations can be placed on retrieved quantity partial derivatives, to constrain global aerosol emission space and time variability in the results. Similarities and differences between commonly used inverse modeling and remote sensing techniques are analyzed. To retain the high space and time resolution of long-period, global observational records, the algorithm is expressed using adjoint operators.

Successful global aerosol emission retrievals at 2°×2.5 resolution were obtained by inverting GOCART aerosol transport model output, assuming constant emissions over the diurnal cycle, and neglecting aerosol compositional differences. In addition, fine and coarse mode aerosol emission sources were inverted separately from MODIS fine and coarse mode aerosol optical thickness data, respectively. These assumptions are justified, based on observational coverage and accuracy limitations, producing valuable aerosol source locations and emission strengths. From two weeks of daily MODIS observations during August 2000, the global placement of fine mode aerosol sources agreed with available independent knowledge, even though the inverse method did not use any a priori information about aerosol sources, and was initialized with a "zero aerosol emission" assumption. Retrieving coarse mode aerosol emissions was less successful, mainly because MODIS aerosol data over highly reflecting desert dust sources is lacking.

The broader implications of applying our approach are also discussed.

Final Revised Paper (PDF, 3863 KB) Discussion Paper (ACPD)

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