FORM A:

GACP Accomplishment Report

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Cloudless Scene Identification for aerosol retrieval from TOMS measurements

A method to derive aerosol optical depth over land and water surfaces using satellite based measurements in the near-UV spectral region has recently been developed. The method retrieves information on different types of atmospheric aerosols ranging from non-absorbing sulfates to highly UV-absorbing mineral dust. In addition to optical depth derivation, the method provides information on aerosol absorptivity (i.e., single scattering albedo). This retrieval method can be applied to radiance measurements by the Total Ozone Mapping Spectrometer (TOMS) under cloud free conditions. In the case of absorbing aerosols, the height of the aerosol layer above the surface must be accurately known. Here we propose a research effort to combine TOMS measurements of backscattered ultraviolet radiation and infrared observations by the THIR (1979-85), OCTS (1996-97) and SeaWIFS (1997-present) sensors, to identify cloud free areas where the near UV method can be applied to retrieve properties of non-absorbing aerosols. We also propose to derive information on absorbing aerosols for specific events, within the same periods, for which the aerosol vertical distribution can be prescribed using lidar measurements or any other available aerosol profile information.

Long-term goal

Our long-term research goal is the development of a truly global (land and ocean surfaces), long-term (nearly twenty years) climatology of aerosol properties. However, since the TOMS instrument was not originally conceived as an aerosol sensing tool, it lacks a way to positively identify and reject radiances contaminated by sub-pixel size clouds. In addition, the inversion of the TOMS signal to characterize UV-absorbing aerosols requires that the height of the aerosol layer above the surface be known. The achievement of this goal, therefore, presents the formidable challenge of developing innovative approaches to overcome the above mentioned difficulties.

Specific Research Objectives

The focus of our research effort is the development of approaches to address the current limitations of the TOMS aerosol data by making use of external data sets and modeling results.

Sub-pixel cloud contamination:

The approach consists of using infrared and (or) visible measurements from space collocated in time and space with the TOMS observations to identify those pixels of minimum cloud contamination where the near UV technique to retrieve aerosol properties can be applied. Once the TOMS data is cloud screened, a multiyear data set of non-absorbing (or weakly UV-absorbing ) aerosol optical depth over the oceans and the continents will be produced. This is the main objective of the work currently underway as part of the GACP project.

Aerosol layer height:

We are also investigating the incorporation in the TOMS aerosol retrieval algorithm of model calculations, using assimilated meteorological data, as a way to prescribe the height of UV-absorbing aerosol layers. Several research efforts, which are also part of the GACP project, are addressing the modeling issue. If successful, the main application of this approach would be to the historical TOMS record that goes back to 1978.

In addition to the modeling approach, aerosol vertical distribution can also be directly obtained from lidar measurements. The available lidar measurements over the past 20 years, however, are not adequate to provide the global coverage needed. In the next few years, however, aerosol vertical information on a global basis will become available as currently scheduled missions which include space-based lasers (GLAS-ICESAT and PICASSO-CENA) will start operating.

Approach

To develop the TOMS cloud screening technique, several pairs of TOMS-IR (or visible) data sets have been identified: TOMS and THIR (both onboard Nimbus7) during the period 1979-1985; TOMS, OCTS and POLDER (all onboard the Adeos satellite) during the period Sept 96-June 97, and TOMS (Earth Probe) and SeaWIFS (SeaStar) for the period August 97 to present.

The approach consists of ‘filling up‘ the large TOMS pixels with the smaller size pixels of the IR or visible sensor measurements. By examining the spatial homogeneity of the IR (or visible) radiance measurements within the TOMS pixel, a decision on the degree of cloud contamination affecting the TOMS pixel is made. Aerosol properties are then retrieved only on those pixels of minimum cloud contamination.

Tasks completed

During the first year of GACP, we have mainly concentrated on producing the collocated UV-IR data sets. We have started with the TOMS-THIR pair of data sets which covers the 1979-1985 period. Daily files (at the TOMS Level 2 resolution) of the 11.5 micron radiance standard deviation have been produced for the months of January and August for the 1979-1985 period.

A data set of cloud free ADEOS TOMS backscattered radiances have been produced by making use of the cloud screening process by the POLDER sensor.

Threshold values of the 11.5 micron radiance standard deviation over ocean and land areas have been determined by comparison of the THIR data with a similar AVHRR product.

Mineral dust vertical distribution produced by the GOCART chemical transport model (Mian Chin and Paul Ginoux research, also part of GACP) have been used to retrieve dust properties from Earth-Probe TOMS observations in 1997.

Results

Sample aerosol retrievals using cloud screened TOMS data have been carried out.
Optical Depth of minerals dust aerosols making use of model predicted aerosol layer height has also been obtained.
Preliminary validation of Earth Probe TOMS results in 1997 using the Aeronet database has also been carried out.

Future plans

Activities for the second year of the GACP project include:

Completion of production of cloud free TOMS backscattered radiances for the period 1979-1985 and application of the near-UV aerosol optical depth retrieval technique to the Nimbus-7 TOMS data.

Prepare a journal publication on Nimbus7 TOMS-THIR retrieval of aerosol properties.

Application of the near-UV method to ADEOS-TOMS and Earth Probe TOMS observations using the cloud screening capability of OCTS and POLDER (both on the ADEOS spacecraft) and SeaWIFS sensors.

Publication on the combined use of TOMS-POLDER-OCTS to identify cloud free pixels and retrieve aerosol properties.

FORM C: FUTURE PLANS

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The near UV technique of aerosol properties retrieval will be applied to the global TOMS-THIR collocated data set for the period 1979-1985. A multi-year climatology over the oceans and the continents will be produced. We intend to make use of model predicted absorbing aerosol layer heights when available.

A journal article on the combined use of TOMS and THIR for aerosol retrieval will be prepared.

The combination of multiple sensors approach to retrieve aerosols from near UV measurements will be extended to the Earth Probe and ADEOS TOMS sensors.

Based on what has been learned on this project we will examine the feasibility of extending the application of the combination of sensors method to the 1986-1993 period, by combining TOMS, AVHRR and GOES data sets.

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