DETERMINATION OF ATMOSPHERIC AEROSOL PROPERTIES OVER LAND USING SATELLITE MEASUREMENTS

BY ALEXANDER A. KOKHANOVSKY AND GERRIT DE LEEUW

Global aerosol properties (e.g., the concentration of particles and their size, shape, chemical composition, and optical properties) are poorly understood. This is mostly because the aerosol properties rapidly change in space and time and ground-based observations, are very sparse. Satellite observations provide high temporal (geostationary orbits) and spatial (some instruments in sun-synchronous orbits) resolution of aerosol properties with the same instruments and hence the same accuracy over a large area. Some of them provide daily global coverage. However, the interpretation of signals (e.g., the backscattered light intensity) as detected with an instrument on a satellite is a difficult matter and, theoretically, the problem belongs to the class of ill-defined inverse problems of the radiative transfer theory for the underlying surface–atmosphere system (Kokhanovsky 2008). It is not uncommon that different research groups retrieve different aerosol properties (e.g., the spectral aerosol optical thickness) using the same observations but different processing schemes and a priori assumptions. To encourage the intercomparison of different satellite aerosol products from diverse algorithms and observations and provide a public forum for evaluating their workings, a series of workshops devoted to these and related topics was started in 2007. The first workshop was convened in Bremen, Germany and the second workshop is planned for 2009 in Bonn, Germany. Topics of discussions at the Bremen workshop included various satellite aerosol optical thickness retrieval methods, the description of modern satellite instrumentation, and the information content of satellite measurements

THE BREMEN WORKSHOP ON THE DETERMINATION OF ATMOSPHERIC AEROSOL PROPERTIES OVER LAND USING SATELLITE MEASUREMENTS

WHAT: Sixty-three participants from 14 countries discussed current trends, problems, and uncertainties related to the determination of aerosol properties (e.g., the spectral aerosol optical thickness) over land derived from spaceborne observations of the reflected solar light in the visible region of the electromagnetic spectrum.
WHEN: 21–22 June 2007
WHERE: Bremen, Germany

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with respect to the aerosol properties retrievals from spaceborne observations. Cloud-screening algorithms were also discussed. Most of the presentations were concerned with the aerosol optical thickness retrievals over land.

HIGHLIGHTS. Each of the five sessions focused on applications of different types of satellite observations. Extended review presentations began each session, and poster sessions were held as well. We summarize the first three sessions below. The concluding sessions 4 and 5 were aimed at the description of global aerosol properties and the discussion of various validation strategies. The conclusions from these two sessions are summarized online (www.iup.uni-bremen.de/~hoyning/).

The first session was devoted to understanding what information can be acquired from multiple views and polarization measurements. Retrievals using the National Aeronautics and Space Administration's (NASA's) Multiangle Imaging Spectroradiometer (MISR), the French Space Agency's Polarization and Directionality of the Earth's Reflectances (POLDER) instrument, and the European Space Agency's (ESA's) Compact High Resolution Imaging Spectrometer (CHRIS) on board its Project for On-Board Autonomy (Proba) spacecraft were discussed. An analysis on the general information content of multiple-viewing-angle intensity and polarization measurements was presented. MISR is one of the most advanced spectroradiometers currently operating in space. This instrument measures the backscattered solar radiation at several angles and wavelengths simultaneously, which allows for the retrieval of aerosol optical properties over bright land surfaces, such as deserts, with high accuracy. The very large range of scattering angles it captures (60°–160° at midlatitudes) enables better constraints on particle shape and size.

POLDER measures the polarization state of backscattered light (linear polarization ratio and direction), in addition to the spectral and multiview observations, which proves to be useful in a number of applications, including the fine-mode aerosol optical thickness retrieval and also the determination of the shape of the particles/cloud thermodynamic state. The hyperspectral CHRIS instrument is mounted on board the Proba satellite. Its distinctive feature is the increased spatial resolution (20 m). However, the small swath width (18 km) renders this instrument less important for global observations. The Proba satellite allows pointing to observe the same scene from five different angles within a short time interval.

The second topic was the use of double-view observations of the same scene as performed by the Advanced Along-Track Scanning Radiometer (AATSR) on board the Environmental Satellite (ENVISAT). Although the reduced number of angles in the AATSR observation setup (nadir and 55° forward), as compared to MISR, limits its use for the phase function and shape of particles/types of aerosol assessment, the instrument has a capability to perform thermal infrared measurements, which enables better cloud-screening techniques as compared to the instruments mentioned above. Also the observation of the scene in the forward view enables increased sensitivity to the atmospheric signal (as compared to that from the nadir observations) due to a long atmospheric path. The combined Along-Track Scanning Radiometer (ATSR-2) on board the *European Remote Sensing Satellite* (*ERS-2*) and AATSR observations provide the longest record of the aerosol optical thickness (from 1995) measured by a double-view instrument from space. Preliminary results show aerosol optical depth at 550 nm and surface reflectance to be the key output from the generation of the 12-yr combined ATSR-2–AATSR global aerosol product [ESA Grid Processing on Demand (G-POD) Project, http://eogrid.esrin.esa.int/]. The surface reflectance is retrieved for each 1-km pixel corresponding to the top-of-atmosphere observations, while aerosol optical depth is produced on a 10 km × 10 km grid.

The third session was aimed at the presentation and evaluation of retrievals using single-view instruments such as the Moderate Resolution Imaging Spectroradiometer (MODIS), the Medium Resolution Imaging Spectrometer (MERIS), the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS), the Spinning Enhanced Visible and Infrared Imager (SEVIRI), the Ozone Monitoring Instrument (OMI), and the Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY). Also, the first results of the intercomparison of satellite measurements of the aerosol optical thickness were reported (Kokhanovsky et al. 2007). Single-view instruments are very much limited with respect to the determination of the aerosol optical thickness over land from space because neither phase function nor the surface bidirectional reflectance distribution function (BRDF) can be accurately determined from measurements themselves.Therefore, a priori assumptions are made in operational retrieval schemes. Clearly, the choice of the phase function/aerosol model for the retrieval is crucial for the performance of the retrieval scheme. The use of the blue channels (e.g., at 412 nm) for the aerosol optical thickness retrieval was extensively discussed. The reflectance from most surfaces is small in the UV and blue (several percent only). Therefore, these channels are of particular importance for future atmospheric aerosol satellite missions because the influence of a priori unknown surface contribution is minimal.

GENERAL COMMENTS AND FUTURE PLANS. In addition to creating a special aerosol retrievals intercomparison group a special book on aerosol satellite retrieval techniques over land, based on select presentations, has been published in 2009 (Kokhanovsky and de Leeuw 2009) by Springer-Praxis (www.springer.com/earth+sciences/book/978-3-540-69396-3).

Information on the Bremen workshop, including presentations, poster sessions, and a photo of participants, can be found online (www.iup.uni-bremen.de/~hoyning/projectsaerosol/accentaerosolworkshop2007/index.html). The next workshop will be hosted by the Physics Center Bad Honnef (Germany) on 16–19 August 2009 (www.pbh.de/en/index.shtml).

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