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Ocean Optics Protocols For Satellite Ocean Color Sensor Validation, Revision 3, Volume 2

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Chapter 14

Sun and Sky Radiance Measurements and Data Analysis Protocols

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14.0 INTRODUCTION

This chapter is concerned with two types of radiometric measurements that are required to verify atmospheric correction algorithms and to calibrate vicariously satellite ocean color sensors. The first type is a photometric measurement of the direct solar beam to determine the optical thickness of the atmosphere. The intensity of the solar beam can be measured directly, or obtained indirectly from measurements of diffuse global upper hemispheric irradiance. The second type is a measurement of the solar aureole and sky radiance distribution using a CCD camera, or a scanning radiometer viewing in and perpendicular to the solar principal plane.

From the two types of measurements, the optical properties of aerosols, highly variable in space and time, can be derived. Because of the high variability, the aerosol properties should be known at the time of satellite overpass. Atmospheric optics measurements, however, are not easy to perform at sea, from a ship or any platform. This complicates the measurement protocols and data analysis. Some instrumentation cannot be deployed at sea, and is limited to island and coastal sites. In the following, measurement protocols are described for radiometers commonly used to measure direct atmospheric transmittance and sky radiance, namely standard sun photometers, fast-rotating shadow-band radiometers, automated sky scanning systems, and CCD cameras. Also discussed are methods of data analysis and quality control, as well as proper measurement strategies for evaluating atmospheric correction algorithms and atmospheric parameters derived from satellite ocean color measurements.

14.1 AUTOMATIC SUN PHOTOMETER AND SKY RADIANCE SCANNING SYSTEMS

The technology of ground-based atmospheric aerosol measurements using sun photometry has changed substantially since Volz (1959) introduced the first hand-held analog instrument almost four decades ago. Modern digital units of laboratory quality and field hardiness collect data more accurately and quickly and are often equipped for onboard processing (Schmid et al. 1997; Ehsani 1998, Forgan 1994; and Morys et al. 1998). The method used remains the same, i.e., a detector measures through a spectral filter the extinction of direct beam solar radiation according to the Beer-Lambert-Bouguer law:

$$V(\lambda) = V_o(\lambda)\left(\frac{d_o}{d}\right)^2 \exp\left[-\left(\tau(\lambda)M\right)\right]t_g(\lambda), \tag{14.1}$$

where $V(\lambda)$ is the measured digital voltage, $V_0(\lambda)$ is the extra-terrestrial voltage, M is the optical air mass, $\tau(\lambda)$ is the total optical depth, λ is wavelength, d and d_o are respectively the actual and average earth-sun distances, and $t_g(\lambda)$ is the transmission of absorbing gases. The total optical depth is the sum of the Rayleigh and aerosol optical depth.