Chapter 9
Retrieval of Surface Albedo from Satellite Sensors

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Abstract Observations from a number of polar-orbiting and geostationary satellite sensors are now being used to produce operational land surface albedo products for range of modeling applications. The MODIS, MISR and Meteosat algorithms are presented as examples of the current strategies being employed to best exploit multi-day sequential, multi-angular instantaneous, and multi-temporal observations and accurately specify the reflective qualities of the underlying surface. While these retrievals represent a major advance in the remote sensing of the spatial and temporal heterogeneity of the surface, issues such as atmospheric correction, directional-to-hemispherical conversion, and spectral interpolation remain to confound the satellite signal and introduce uncertainties and variability within and between products. Nevertheless, the potential of using multiple products and fusing recent observations with remotely sensed historical data must be explored as a realistic way to meet the needs of the modeling community.

Keywords: MODIS · MISR · Meteosat · albedo · reflectance · anisotropy

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9.1 Introduction

The availability of a large number of directional observations sampling the viewing hemisphere over a particular land surface can effectively capture its surface anisotropy and thus be used to accurately compute the surface albedo of that surface. While numerous samples may be possible in the field or laboratory, remotely sensed retrieval methods based on data from individual satellites usually must suffice with a limited number of directional reflectances of the surface, and the producers of such data sets must acknowledge that these observations may not necessarily represent a well-distributed sampling (Privette et al., 1997). Therefore a model is usually adopted to characterize the surface anisotropy—a model which can be inverted with a finite set of angular samples and then be used to predict surface reflectance in any sun-view geometry and derive surface albedo (Roujean et al., 1992; Walthall et al., 1985; Rahman et al., 1993; Engelsen et al., 1996; Wanner et al., 1997; Pinty et al., 2000a; Bréon et al., 2002; Maignan et al., 2004).

The acquisition of directional measurements from an individual sensor is determined by its scanning configuration and the platform’s orbital characteristics (Barnsley et al., 1994). However, cloud obscuration always reduces the number of clear-sky observations possible. Therefore, in the case of a single field of view sensor such as the MODerate Resolution Imaging Spectroradiometer (MODIS), on board the polar orbiting Terra and Aqua platforms, an adequate directional sampling of surface reflectances can only be obtained by the accumulation of sequential observations over a specified time period. Multi-angular instruments such as the Multiangle Imaging SpectroRadiometer (MISR) instrument (also on board the Terra platform) obtain sufficient simultaneous directional observations to specify the surface anisotropy whenever a cloud-free acquisition is possible. Geostationary sensors (such as Meteosat) must trade numerous acquisitions under different illumination conditions during a day for directional observations to obtain the angular information necessary to sample the surface’s directional characteristics. Since 2000, all of these approaches have been implemented operationally to produce robust surface albedo fields for use in climate, hydrological, biogeochemical, and weather prediction models.

9.2 Background

As a key land physical parameter controlling the surface radiation energy budget (Dickinson, 1983, 1995), global surface albedo with an absolute accuracy of 0.02–0.05 is required by climate models at a range of spatial and temporal scales (Henderson-Sellers and Wilson, 1983). Land cover-based schemes have historically been adopted in most of the land surface models and climate models for the parameterization and specification of surface albedo (Bonan et al., 2002; Sellers et al., 1996). Natural landscapes, however, are a collection of nested objects in a hierarchy and various processes control the biophysical characteristics at different spatial scales (Woodcock and Harward, 1992; Collins and Woodcock, 2000).