remote sensing

Editorial

Editorial for Special Issue: "Remotely Sensed Albedo"

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Land surface (bare soil, vegetation, and snow) albedo is an essential climate variable that affects the Earth's radiation budget, and therefore, is of vital interest for a broad number of applications: Thematic (urban, cryosphere, land cover, and bare soil), climate (Long Term Data Record), processing technics (gap filling, data merging), and products validation (cal/val). The temporal and spatial patterns of surface albedo variations can be retrieved from satellite observations after a series of processes, including atmospheric correction to surface spectral Bidirectional Reflectance Factor (BRF), and Bidirectional Reflectance Distribution Function (BRDF) modelling.

The processing chain for deriving surface albedo introduces cumulative errors that can affect the accuracy of the retrieved satellite albedo products (MISR, MODIS, VEGETATION, and Proba-V). A new method is proposed to estimate Directional Hemispherical Reflectance (DHR) and Bi-Hemispherical Reflectance (BHR) from measured variables (downwelling, upwelling, and diffuse shortwave radiation) at 19 tower sites from the FLUXNET network, Surface Radiation Budget Network (SURFRAD), and Baseline Surface Radiation Network (BSRN) networks. The pixel-to-pixel comparison between DHR/BHR retrieved from coarse-resolution satellite observations and upscaled from tower sites from 2012 to 2016 emphasizes the parameters involved (land cover type, heterogeneity level, and instantaneous vs. time composite retrievals) [1].

Global warming effects pose a significant change in the albedo of the boreal forest areas as revealed by observed trends in AVHRR satellite albedo magnitude before and after the snow/ice melt season between 40°N and 80°N from 1982 to 2015. Absolute change is 4.4 albedo percentage units per 34 years. The largest changes in pre-melt-season albedo are concentrated in boreal forest, rather than tundra, and are consistent over large areas. The mean of absolute change of start date of the melt season is 11.2 days per 34 years, 10.6 days for end date of the melt season, and 14.8 days for length of the melt season. The albedo intensity preceding the start of the melt season correlates with climatic parameters (air temperature, precipitation, and wind speed) but is primarily affected by the changes in vegetation [2].

Still, at high latitudes, ice albedo feedback affects the global climate based on LTDR of MODIS and VIIRS product routinely disseminated by NOAA. An angular bin regression method acting as gap-filling supports the simulations of a physically-based sea-ice BRDF representing different types and mixing fractions (snow, ice, and seawater). A comparison of six years of ground measurements at 30 automatic weather stations gathered/derived from the Programme for Monitoring of the Greenland Ice Sheet (PROMICE) and the Greenland Climate Network (GC-NET) shows low bias (~0.03) and root mean squared error (RMSE) about 0.07) [3].

Long-term surface albedo datasets are essential for global climate analysis. A method originally developed for MODIS was applied to AVHRR LTDR reflectance to estimate daily surface albedo, which corrects for directional effects using the instantaneous Normalized Difference Vegetation Index (NDVI) and multiyear MODIS BRDF shapes. To reduce the high noise in the red band caused by atmospheric effects, different approaches were analyzed. It was reported that deriving BRDF parameters from 15+ years of observations reduces the average noise by up to 7% in the Near Infrared (NIR) band and 6% in the NDVI, in comparison to using 3-year windows. By successively estimating the volumetric BRDF parameter (V) and geometric BRDF parameter (R), an extra 8% and 9% noise in the red and NIR bands can be further reduced [4].

LTDR of MODIS surface albedo supports decision-makers for climate mitigation in complement with requirements of a time-evolving high spatial resolution albedo that can be estimated by the 30 m Landsat data merged with a time-averaged MODIS BRDF product. Validation over different land covers (cropland, deciduous broadleaf forest, evergreen needleleaf forest, grassland, and evergreen broadleaf forest) using ground measurements provides a root mean squared error (RMSE) of 0.0085–0.0152 [5].

Since surface albedo is known to be related to land cover type and vegetation structure, the question is: How can it be separated from environmental drivers such as temperature and snow cover? A case study for topographically complex regions in Norway was selected to spectrally unmix MODIS albedo in using high resolution observations. The outcomes are improved constraints on land cover-dependent albedo parameterizations for the purpose of climate and hydrological models. Forecasting surface albedo on a monthly basis is possible from the forest structure, snow cover, and near surface air temperature. New insights are offered between the impact of a changing climate on albedo and anthropogenic land use/land cover change (LULCC) [6].

In urban areas, surface albedo determines the heat storage, depending on landscape alteration, air quality, and human activities. The impact of these factors is studied by a partial derivative method, vegetation index data, and night time light data. Quantitative estimates of the contribution from natural climate change and human activities looked at the Jing-Jin-Ji region of China during its highest population growth, between 2001 and 2011. Albedo trends are equal to 0.0065 and 0.0012 per year, before and after urbanization, respectively, meaning that an increase from 15% to 48.4% infers a decrease in albedo of 0.05 [7].

Gridded satellite albedo refers to a large footprint. A total of 1,820 paired high-resolution Landsat TM and MODIS albedo data from five land cover types were used to evaluate the spatial representativeness of the MODIS albedo product based on semivariograms and coefficients of variations. Landsat TM albedo data was aggregated to 450 m–1800 m using two different methods. Comparison with MODIS albedo indicates that, for evergreen broadleaf forests, deciduous broadleaf forests, open shrub lands, woody savannas, and grasslands, the MODIS 500 m daily albedo product represents a spatial scale of approximately 630 m. For mixed forests and croplands, the representative spatial scale is about 690 m [8].

MODIS 500 m albedo was used to derive spectral and broadband bare soil products over the United States using a soil line approach based on red and green spectral signatures. Compared with 30 m Landsat data, MODIS bare soil albedo indicates a bias of 0.003 and an RMSE of 0.036. Soil moisture from the Advanced Microwave Scanning Radiometer–Earth Observing System (AMSR-E) reveals a reduction of bare soil according an exponent law due the darkening effect of moisture. Land cover type is an indicator for determining the magnitude of bare soil albedos, whereas the soil type is an indicator for determining the slope of soil lines over sparsely vegetated areas, as it describes the soil texture, roughness, and composition [9].

The Harmonized Landsat/Sentinel-2 (HLS) project aims to generate a seamless surface reflectance product by combining observations from USGS/NASA Landsat-8 and ESA Sentinel-2 satellites. Observations are associated with invariant viewing geometry, but still yearly illumination variations. BRDF normalization applied to the HLS product at 30 m spatial resolution relies on MODIS BRDF parameters at 1 km spatial resolution. Unsupervised classification of HLS images is used to disaggregate the BRDF parameters to build a BRDF parameters database at HLS scale. Tested over a desert target and an Amazonian forest, the method reduces the coefficient of variation (CV) of the red and near infrared bands by 4% in forest and keeps a low CV of 3% to 4% for the deserts [10].

Landscape albedo can be estimated using images acquired with a consumer-grade camera on board an unmanned aerial vehicle (UAV). Flight experiments conducted at two sites in Connecticut shows that the UAV estimate of visible-band albedo of an urban playground (0.043 ± 0.077) under clear sky conditions agrees reasonably well with the estimate based on the Landsat image (0.052 ± 0.013). Shortwave albedo estimate, as suited for climate applications, would require the deployment of a camera with a near-infrared waveband [11].

UAV can provide small-scale, mobile remote measurements that fill this resolution gap, as shown for a deciduous northern hardwood forest, a spruce plantation, and a cropped willow field. Estimated albedo from concomitant UAV and fixed tower measurements agrees well and UAV measurements captured site-to-site variations in albedo-like surface heterogeneity related to land use. Clearly, UAV measurements are valuable as a useful tool to stratify the landscape albedo in terms of biomass, phenology, foliar chemistry, and canopy water content [12].

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