GLASS Albedo Product

Technical Guide

Land-surface albedo refers to the ratio of reflected to incoming solar radiation at the Earth's surface over the solar spectral domain. As one of the fundamental forcing parameters in climate models, surface albedo plays an important role in the Earth's radiant energy budget. Spatio-temporal variability in albedo is often associated with environmental change and human activities as well. Global change researches demand spatially intact and long time continuous global albedo product. But remote sensing retrieval results from single sensor are limited by sensor characteristics, acquisition condition as well as cloud coverage. The preferred solution is to combine data from multiple sensors/satellite and derive one complete and consistent dataset.

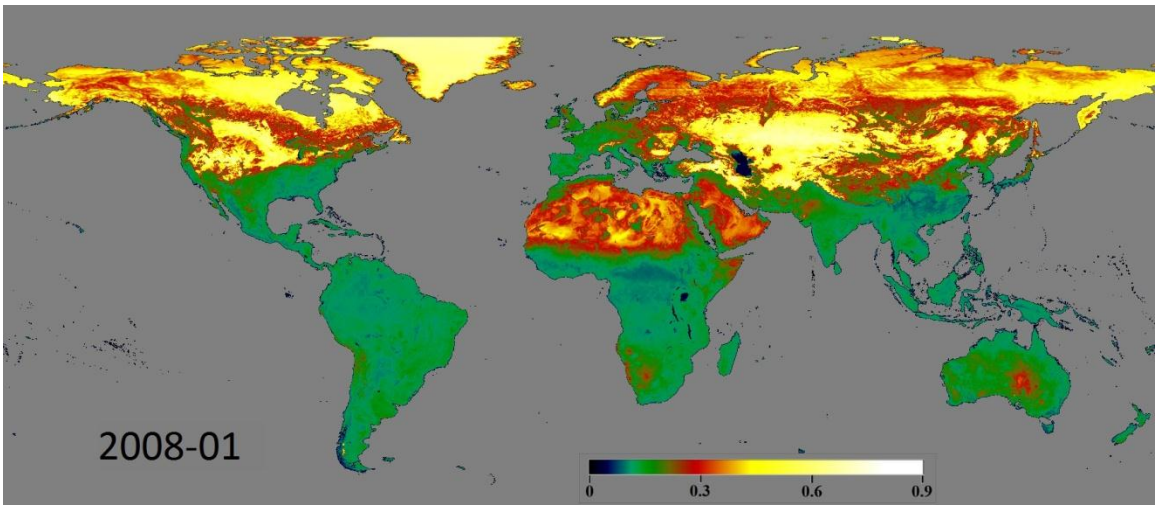

Figure 1 . GLASS monthly average albedo product on Jan, 2008.

GLASS(Global LAnd Surface Satellite) is a series of remote sensing products generated by the search team in the College of Global Change and Earth System Sciences, Beijing Normal University. It aims at providing long time land surface key parameters for global change study and climate modeling. The GLASS shortwave(300–3000nm) albedo product will provide high quality gapless global albedo product from 1985 to 2010.

GLASS albedo product from 2000 to 2010

The information source for the GLASS albedo product from Feb 19, 2000 to Dec 31, 2010, is the MODIS sensors onboard the Terra and Aqua satellites.

Both the AB1 and AB2 algorithms are applied to retrieve the shortwave surface albedo from the MODIS data(). The input of AB1 is the multiband directional reflectance at the surface, which corresponds to the atmosphere correction products MOD09GA/MYD09GA released by NASA. The output of AB1 is an intermediate product called either GLASS02A21, which corresponds to Terra, or GLASS02A22, which corresponds to Aqua. The AB2 algorithm is based on the apparent reflectance at the top of the atmosphere. The main input of AB2 is the MODIS calibrated radiance products MOD021km/MYD021km released by NASA. For the purpose of geometric processing, the geolocation products MOD03/MYD03 are necessary. The MODIS cloud mask products MOD35/MYD35 are also adopted to provide cloud information. The outputs of AB2 are intermediate products called GLASS02A23 and GLASS02A24, corresponding to Terra and Aqua, respectively.

So, we have 4 intermediate products, each corresponding to different algorithms and data sources. Instead of sending all these products together to the user, GLASS chooses to merge them into one final product with the STF algorithm. The inputs of STF are the 4 intermediate products introduced above, and the length of temporal filter window is 17 days. The output final product is called GLASS02A06, which provides a gap-filled land surface shortwave BSA and WSA with a spatial resolution of 1 km and a temporal step of 1 day. The final product GLASS02A06 is recommended for data users, the released temperature resolution is 8 days.

GLASS albedo product from years 1981-2000

The information source of the GLASS albedo product before 2000 is the AVHRR data. The Long-term Land Data Record (LTDR) project has archived and preprocessed the AVHRR data from 1981 to 2000 (Pedelty et al. 2007). Version 3 of the project's released AVHRR dataset has been geometrically and atmospherically corrected. GLASS combines the AB1 algorithm and STF algorithm in a pipeline program to generate an albedo product from the LTDR AVHRR dataset. Compared to MODIS, the AVHRR data has less spectral channels, reduced number of temporal samples (AVHRR is once a day while MODIS is twice a day) and much lower spatial representativeness (AVHRR Global Area Coverage dataset

processes only one scan line out of every three). In order to adequately accumulate valid observations for the STF algorithm, the length of temporal filter window is enlarged to 33 days. The resulting final product is called GLASS02A05; it has a spatial resolution of 0.05 deg and a temporal step of 8 days, and it extends from July 4, 1981, to Feb 18, 2000.

A summary of all of the intermediate and final albedo products in GLASS is presented in Table 1. Currently only the final products, i.e., LASS02A06 after 2000 and GLASS02A05 before 2000, are available to public users.

Table 1 List of GLASS albedo intermediate and final products

Prod. Name	product type	algorithm	Input data	temporal step	composition interval	Projection	spatial resolution
GLASS02A21	intermediate	AB1	MOD09GA	1 day	1 day	SIN	1 km
GLASS02A22	intermediate	AB1	MYD09GA	1 day	1 day	SIN	1 km
GLASS02A23	intermediate	AB2	MOD021km	1 day	1 day	SIN	1 km
GLASS02A24	intermediate	AB2	MYD021km	1 day	1 day	SIN	1 km
GLASS02A06	final	STF	GLASS02A21 GLASS02A22 GLASS02A23 GLASS02A24	1 day / 8 days	17 days	SIN	1 km
GLASS02A05	final	AB1+STF	LTDR AVHRR dataset	8 days	33 days	CMG	0.05 deg

GLASS albedo products are filed in HDF format. There are 3 scientific datasets in the product file: “Albedo_BSA_shortwave”, “Albedo_WSA_shortwave”, and “QC”. The “Albedo_BSA_shortwave” and “Albedo_WSA_shortwave” are respectively shortwave black-sky albedo at local noon solar angle and white-sky albedo stored in short integer data type. The scale factor that converts the digital number to albedo value is 0.0001.

The “QC” (quality control) flag gives a pixel-wise description of the data processing parameters as well as credibility of the result. The flag is a 16-bit data field provided for each pixel. The bitwise interpretation of the QC flag for the GLASS02A05 and GLASS02A06 products is given in Table 2, and the details of this interpretation can be found in the user manual. The lowest two bits give an indication of the overall quality of the albedo product in the pixel, with ‘00’ indicating a “good” estimation result with the criterion of an uncertainty of less than 0.01 absolutely or 5% relatively, ‘01’ indicating an “acceptable” estimation with the criterion of an uncertainty of less than 0.05 absolutely or 10% relatively, ‘11’ indicating the most uncertain estimation in which the a priori value has been applied to fill the pixel, and ‘10’ indicating the state between “acceptable” and a “fill value”. In addition to the overall quality assessment, the uncertainty of the albedo estimation is also quantitatively given in bits 11-14.

This uncertainty estimation is first generated in the AB1 and AB2 algorithms and passed to the STF algorithm to derive the final uncertainty using statistical principles. However, this uncertainty is only a statistical estimation and does not always reflect the actual error in a specific case.

Table 2 Quality Control (QC) flags of the final GLASS albedo product

Bit No.	Parameter Name	Value/State	
0-1	Overall quality	00: good 10: with uncertainty	01: acceptable 11: prior value
2-3	Land cover state	00: vegetation 10: snow	01: bare ground 11: un-classified
4-5	Length of composite window	00: 8-day 10: 24-day	01: 16-day 11: 32-day
6-8	Number of actually used (clear-sky) intermediate products	000: 0 010: 2-3 100: 8-15 110: 32-63	001: 1 011: 4-7 101: 16-31 111: 64-127
9-10	Ratio of actually used to total number of intermediate products	00: more than 50% 10: 10%-25%	01: 25%-50% 11: less than 10%
11-14	Uncertainty of albedo retrieval	0000: 0.00-0.01 0010: 0.02-0.03 0100: 0.04-0.05 0110: 0.06-0.07 1000: 0.08-0.09 1010: 0.10-0.11 1100: 0.12-0.13 1110: 0.14-0.15	0001: 0.01-0.02 0011: 0.03-0.04 0101: 0.05-0.06 0111: 0.07-0.08 1001: 0.09-0.10 1011: 0.11-0.12 1101: 0.13-0.14 1111: >0.15
15	Albedo validity flag	0: valid value	1: invalid value

The visible part (400–700nm) of insolation is called photosynthetically active radiation (PAR). PAR constitutes the basic source of energy for biomass by controlling the photosynthetic rate of organisms on land, thus directly affecting plant growth. It is an indispensable variable in calculating gross primary production (GPP) or net primary production (NPP).GLASS PAR product was generated with 5 km spatial resolution and 3 hours temporal resolution from multiple polar-orbiting and geostationary satellites data globally using an improved look-up table method by radiative simulation based on MODTRAN. The basic idea of this improved algorithm is to establish the relationship between the surface radiation flux and top-of-atmosphere radiance through radiation simulation The satellite data include Moderate-Resolution Imaging Spectroradiometer (MODIS), the Meteosat Second Generation (MSG) SEVIRI, the Multi-functional Transport Satellite (MTSAT)-1R, and the Geostationary Operational Environmental Satellite (GOES) Imager (East and West). The global coverage of the selected geostationary satellite is illustrated in Figure 1. The details of the algorithm are described in the paper (Zhang et al., 2012).

Publications

S. H. Liu (2013) Direct-estimation algorithm for mapping daily land-surface broadband albedo from MODIS data. IEEE Transactions on Geoscience and Remote Sensing, accepted

Liu, N. F., Q. Liu et al. (2013) Mapping spatially-temporally continuous shortwave albedo for global land surface from MODIS data. Hydrology and Earth System Sciences Discussions, 9, 1-22, under review.

Liu, Q., L.Z. Wang et al. (2013) Preliminary Evaluation of the Long-term GLASS Albedo Product, International Journal of Digital Earth, under review.

Liang, S., J. Stroeve & J. Box (2005) Mapping daily snow/ice shortwave broadband albedo from Moderate Resolution Imaging Spectroradiometer (MODIS): The improved direct retrieval algorithm and validation with Greenland in situ measurement. Journal Geophysical Research, 110, D10109.

S. Liang, "A direct algorithm for estimating land surface broadband albedos from MODIS imagery," IEEE Transactions on Geoscience and Remote Sensing, vol. 41, no. 1, pp. 136-145, 2003

Liang, S. (2001) Narrowband to broadband conversions of land surface albedo I: Algorithms. Remote Sensing of Environment, 76, 213-238

Nanfeng Liu, Qiang Liu, Lizhao Wang, Jianguang Wen. A temporal filtering algorithm to reconstruct daily albedo series based on GLASS albedo product. 2011 IEEE International Geoscience and Remote Sensing Symposium, pp 4277-4280 , July 2011, Vancouver, Canada(EI:20114614517030)