

Retrieval of Land-surface Parameters for Climate Models from Multiangular Optical Measurements

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Abstract Vegetation cover attributes play a major role in surface energy budgets through their impact on photosynthetic processes and albedo. This paper presents a semiempirical approach to retrieve vegetation properties relevant for climate studies. The methods rely on multiangular measurements and will rather apply to datasets of sensors systems such as POLDER in order to generate global maps of surface parameters.

Key words Surface parameters, Kernel-driven Models, Multiangular measurements

1 INTRODUCTION

Biophysical processes in the boundary layer are important for climate study since they mediate water and energy balance. Hence, surface datasets must be developed upon which coarse inputs to the General Circulation Models (GCMs) can be derived. The study of long-term and large-scale of meteorological and ecological processes is served by routine remote sensing observations. Data sets from AVHRR are widely used to monitor vegetation dynamics, notable through NDVI cycles which serves to first classify pixels in vegetation types and further map surface parameters from look up tables. NDVI measurement from AVHRR is however constrained by bidirectional effects which yields uncertainty on the derived maps. On the other hand, the retrieval of surface parameters from inverting physical BRDF (Bidirectional Reflectance Distribution Function) models yields a difficulty since these models are rather defined for homogeneous targets while satellite data refer to mixed pixels and are somewhat noisy with a lack of multiangular observations. In this paper, it is proposed an alternative approach for retrieving surface parameters useful for climate in considering kernel-driven BRDF models to simulate vegetation indices in sun-view optimum ge-

ometries. These parameters are albedo, fraction of vegetation, LAI, f_{APAR} , roughness length. The methods rely on BRDF and will apply to multiangular instruments such as POLDER (POLarization and Di-rectionality of Earth Reflectance) onboard ADEOS^[1]. Example of application is given here with airborne POLDER data acquired over semiarid areas during HAPEX-Sahel in 1992. Maps of surface parameters are obtained from relationships calibrated with point measurements for major vegetation species.

2 ALGORITHMS FOR RETRIEVING SURFACE PARAMETERS

Kernel-driven models are now implemented in algorithms of data processing of next sensors systems^[2,3]. The model of Roujean *et al.*^[4] reads:

$$\rho = k_0 + k_1 f_1(\theta_s, \theta_v, \phi) + k_2 f_2(\theta_s, \theta_v, \phi) \quad (1)$$

where f_1 and f_2 are kernels describing the geometric-optical and volume effects, respectively, and $k_i=0,1,2$ are the retrieved parameters related to surface properties. Parameter k_0 stands for the reflectances at $\theta_s = \theta_v = 0$. Eq. (1) will serve to derive POLDER albedos products.

Other parameters useful for climate are the fraction of vegetation, the daily fraction f_{APAR} of absorbed

PAR, LAI, and roughness length. The model in (1) is used to simulate the reflectance in sun/view geometries where individual linear relationships are established between vegetation indices and surface parameters. Radiative transfer simulations and simple statements guided the approach. For instance, vertical observations indicate the percent cover while oblique measurements describe the vertical structure of vegetation^[5].

The fraction of vegetation σ_f is introduced is most land-surface parameterization schemes for partitioning vegetation and soil fluxes. It is close to the vertical radiation interception which is a linearly related to the zenith-nadir reflectance k_0 of Eq. (1). The use of the difference vegetation index $(DVI)_0$ serves to minimize the soil background effect:

$$(DVI)_0 = (k_0)_{NIR} - (k_0)_{VIS} = 0.433\sigma_f + 0.05 \quad (2)$$

The coefficients in (2) are obtained from fit with airborne POLDER and ground measurements over a set of canopies. The relative error on σ_f retrieved from (2) is less than 10%.

The LAI controls most physical, biological and hydrological processes of plant canopies. It is simply inferred here from σ_f in assuming a random orientation for leaves:

$$\sigma_f \approx 1 - e^{-0.46LAI} \quad (3)$$

The daily fraction f_{APAR} is central for quantitative assessments of the primary production and canopy stomatal conductance. Radiative transfer simulations have shown the existence of an optimum geometry ($\theta_s = 45^\circ$, $\theta_v = 60^\circ$, $\phi = 0^\circ$) to measure f_{APAR} (Roujean and Bréon, 1995)^[6].

$$\begin{aligned} (RDVI)_{opt} &= \frac{(\rho_{NIR})_{opt} - (\rho_{VIS})_{opt}}{\sqrt{(\rho_{NIR})_{opt} + (\rho_{VIS})_{opt}}} \\ &= 0.552f_{APAR} + 0.116 \end{aligned} \quad (4)$$

The roughness length z_0 is calculated from the protrusion parameter (k_1/k_0) derived from (1) in the visible range where shadowing effects are enhanced by vegetation absorption and so strongest heterogeneities are noticed. This involves also the canopy height

h^* :

$$z_0 = 0.5(h^*)(k_1/k_0)_{vis} \quad (5)$$

3 APPLICATION TO AIRBORNE POLDER DATA

Airborne POLDER data sets have been collected over various biomes such as semiarid vegetations (HAPEX-Sahel in Niger, 1992), Boreal forests (BOREAS in Canada, 1994), and crops (ALPILLES in France, 1996). It is shown here observations over the Central West Supersite (15km by 15km) of the HAPEX-Sahel experiment. The dominant vegetations are shrub fallow, millet crop and tiger bush. POLDER images were projected on a Mercator grid and atmospherically corrected in using the 5S code and sunphotometer measurements. A POLDER flight consists of 5 parallel flight lines in the principal plane and one in the perpendicular plane. Thus, the BRDF is well sampled at a given sun angle with a pixel size about 25m. The previous equations were verified thanks to in situ measurements^[7] and further applied to the whole image. At the start of vegetation on September 3, map of visible albedo shows important local contrasts due to bright soils (Fig. 1) while map of near infrared albedo indicates mostly topography (Fig. 2). The LAI varies fewly in the center part of the image due to the presence of a grassland underlayer, and stresses the stripes of tiger bush on the edge (Fig. 3).

4 CONCLUSION AND FUTURE PLANS

This paper presented a semiempirical approach based on BRDF for retrieving surface parameters useful for climate. The method benefits from kernel coefficients which will be available outputs of future data processing and remains applicable to mixed pixels. Before to be implemented, the proposed relationships will require further evaluations over the larger range of vegetations in terms of accuracy and robustness. In this regard, different kernels can be tested and also the effect of angular sampling. This approach represents and opportunity to deliver a few months after

POLDER launch updated global maps of surface parameters. The derived maps will serve as realistic surface conditions to better constrain future runs of GCMs.

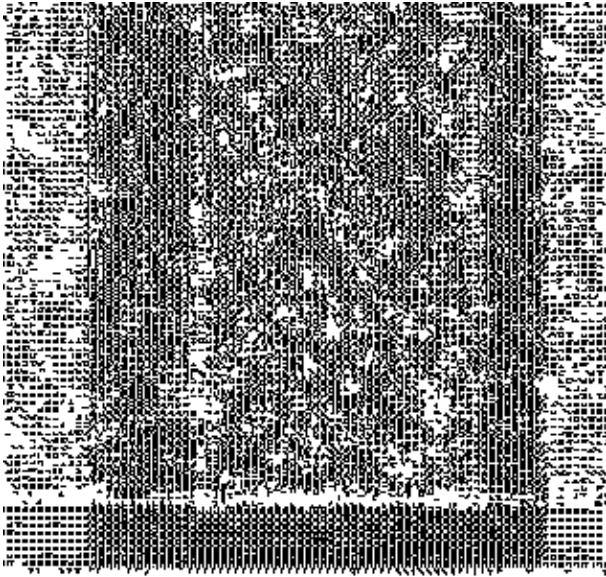


Fig. 1 Mean albedo at 670 nm from POLDER on september 3 on the central west site. Values are between 0.10 (black pixels) and 0.25 (white pixels)

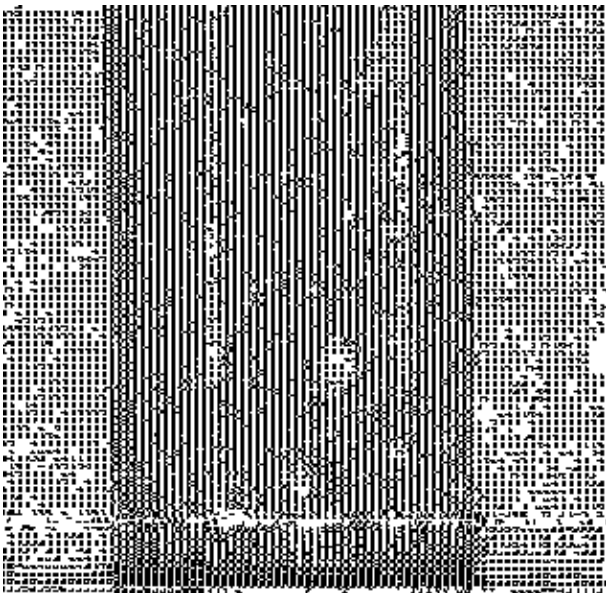


Fig. 2 Mean albedo at 850 nm from POLDER on September 3 on the Central West site. Values are between 0.25 (black pixels) and 0.40 (white pixels)

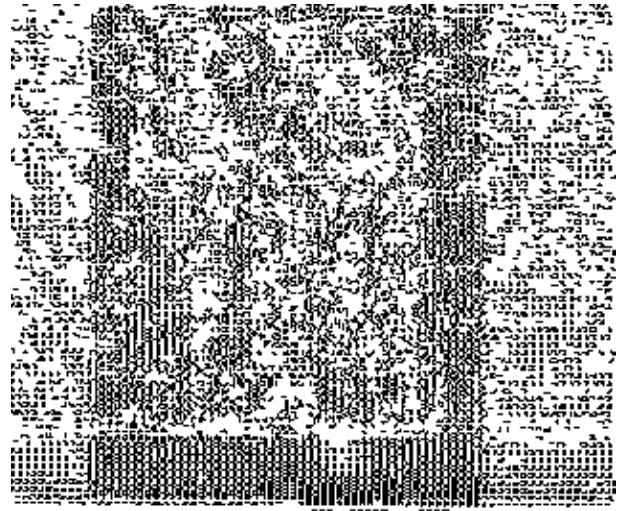


Fig. 3 LAI from POLDER on September 3 on the Central West site. Values are between 0.3 (black pixels) and 2 (white pixels)

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Jean-Louis Roujean was born November 1963 and received the Ph. D. degree in environmental physics and chemistry sciences (speciality remote sensing) in November 1991 from the Paul Sabatier University, Toulouse, France, while he was working at LERTS. His primary field of interest is the modeling

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从多角度光学观测中提取气候模型的陆面参数

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摘要 植被覆盖特征影响光合作用和反照率，是表面能量估计中的主要因素。该文论述一种为进行气候研究提取植被特性的半经验方法，这种方法基于多角度观测数据，有希望用诸如 POLDER 等遥感数据，产生表面参数的全球图。

关键词 表面参数，核驱动模型，多角度观测