CORRESPONDENCE

Comments on "Surface Albedo over the Sahel from METEOSAT Radiances"

PIERRE-YVES DESCHAMPS AND GÉRARD DEDIEU

LERTS, Laboratoire d'Etudes et de Recherches en Télédétection Spatiale, Centre Spatial de Toulouse, 31055 Toulouse, France

20 June 1985

Pinty et al. (1985) recently reported about surface albedos derived from the radiances observed by the Meteosat geostationary satellite in the shortwave channel, 0.4 to 1.1 μm. Table 1 shows the surface albedo values that they published for three different locations in the Sahel, Western Africa, on July 1979, around 1130 GMT, where simultaneous surface measurements of the downward global solar radiation were available to correct the satellite data for the atmospheric transmission. Being involved in a similar investigation, we were surprised by the high albedo values reported by Pinty et al. in excess by a factor of about 1.5 as compared to those we obtained from METEOSAT-2 in July 1983 and 1984 at 1130 GMT, over the same locations—see Table 1. This factor of 1.5 cannot be explained by the different calibration factors available in the literature to derive a planetary albedo from the METEOSAT shortwave channel radiances (Moser et al., 1980; Kriebel, 1981; Koepke, 1982). We thus further analyzed the method used by Pinty et al., to correct for the atmospheric transmission in order to reduce the planetary albedo to a surface albedo.

Pinty et al. used the following formulae to relate the radiance observed by satellite at the top of the atmosphere, L_s, and its equivalent planetary albedo, α_p, to the surface albedo, α, and to the atmospheric transmittances $\tau(\theta_0)$ and $\tau(\theta_v)$ at solar and incidence zenith angles, θ_0 and θ_v, the intrinsic atmospheric reflectance, α_a, and the atmospheric albedo, α_s:

$$\alpha = \pi L_s/E_s = [\alpha_a + \alpha\tau(\theta_0)\tau(\theta_v)/(1 - \alpha\alpha_s)], \quad (1)$$

E_s being the solar irradiance at the top of the atmosphere. They also modeled the downward global radiation at the surface, E_g, as

$$E_g/E_s = \tau(\theta_0)/(1 - \alpha_s) \quad (2)$$

and deduced the following relationship when $\theta_0 \approx \theta_v$:

$$L_s \approx \alpha_a + A\alpha - A\alpha_s{}^2\alpha, \quad (3)$$

where $A = E_g{}^2/E_s$. In order to correct for atmospheric effects, Pinty et al., used surface observations of E_g, the downward global solar radiation to compute $A = E_g{}^2/E_s$. In their sensitivity study, α_a and α_s are shown to have minor consequences on the accuracy of the determination of the surface albedo, are estimated from the surface horizontal visibility and the formulation by Deschamps et al. (1981).

This formulation and the procedure explained to correct for the atmosphere, are correct with one exception, which leads to large errors on the determination of A, the major parameter. Pinty et al. omitted mention that Eqs. (1) and (2) are spectrally defined and integrated over different spectral intervals when applied to the METEOSAT shortwave spectral bandpass in (1) or to the whole solar spectrum in (2). More precisely, neglecting α_s in (1) and (2):

$$\alpha_p \approx \alpha \int \tau(\lambda, \theta_0)\tau(\lambda, \theta_v)E_s(\lambda)s(\lambda)d\lambda \Big/ \int E_s(\lambda)s(\lambda)d\lambda \quad (4)$$

while

$$E_g \approx \int \tau(\lambda, \theta_0)E_s(\lambda)d\lambda; \quad E_s = \int E_s(\lambda)d\lambda, \quad (5)$$

where $s(\lambda)$ is the spectral response of the METEOSAT shortwave channel, so that $A = E_g{}^2/E_s$ is more likely.

This was verified by computing and comparing the transmission factors for the atmospheric gases (i) in the METEOSAT shortwave channel for a double path through the atmosphere which would be the actual value, and (ii) over the whole solar spectrum, using $E_g{}^2/E_s$, (according to Pinty et al.). In the first case, we used the LOWTRAN 5 code (Kneizys et al., 1980) to integrate the gaseous transmission over the METEOSAT spectral response, and we added the effect of molecular scattering attenuation, from Tanre et al. (1979). In the second case, we used the parameterization by

TABLE 1. Mean surface albedos over three different sites in Africa.

	Pinty et al. (1985) July 1979	This study July 1983	This study July 1984
Dori, 14.05°N–0°	0.375	0.26	0.26
Ouagadougou, 12.42°N–0°	0.285	0.21	0.21
Fada-Ngourma, 12.06°N–0.4°E	0.279	0.20	0.20

TABLE 2. Comparison of the gaseous transmittances for a double path through the atmosphere, $\theta_0 = \theta_v = 0°$: computed in the METEOSAT shortwave channel and using the method by Pinty et al. (1985).

	METEOSAT transmittance	Pinty et al. $(E_g/E_s)^2$
Molecular scattering	0.965	0.93
Ozone absorption (0.3 atm cm STP)	0.97	0.95
Water vapor absorption (3.5 g cm^{-2})	0.89	0.74
Total	0.83	0.65

Lacis and Hansen (1974) which allows for calculating the effect of atmospheric gases on the downward global solar radiation, E_g, integrated over the whole solar spectrum. Ozone and water vapor contents were respectively set at 0.3 atm cm and 3.5 g cm^{-2}, $\theta_0 = \theta_v = 0°$; all values close to the observational conditions for the albedos reported in Table 1. No aerosol effect was included; their weak spectral behavior would produce about the same effect in the two cases. Results are shown in Table 2 where the effects of molecular scattering, ozone absorption, and water vapor absorption on a double path transmission through the atmosphere have been detailed. Water vapor absorption is obviously overestimated in the method used by Pinty et al., since it mostly occurs outside the METEOSAT shortwave channel. The total transmittance is underestimated by 1.3 in their method, resulting in an overestimation of the surface albedo by about the same factor, which is considerably larger than the accuracy that they evaluated and unsatisfactory to the requirements of climate studies.

We thus claim that the surface albedos given by Pinty et al. are in excess by a large factor because they overestimate the atmospheric correction. This leads to incorrect surface albedo values and could surely lead to erroneous conclusions on the time change of this albedo with the desertification process produced by climatic fluctuations.

Acknowledgments. The authors are supported by CNRS, Centre National de la Recherche Scientifique, and by CNES, Centre National d'Etudes Spatiales, France.

REFERENCES

Deschamps, P. Y., M. Herman and D. Tanre, 1981: Influence de l'atmosphère en télédétection des ressources terrestres. Modélisation et possibilités de corrections. *Spectral Signatures in Remote Sensing,* INRA, Versailles, 543–558.

Kneizys, F. X., E. P. Shettle, W. O. Galery, J. H. Chetwynd, L. W. Abreu, J. E. A. Selby, R. W. Fenn and R. A. MacClatchey, 1980: Atmospheric transmittance/radiance; computer code LOWTRAN 5. AFGL-TR-80-00067, Air Force Geophysics Laboratory, Hanscom AFB, 233 pp.

Koepke, P., 1982: Vicarious calibration in the solar spectral range by means of calculated radiances and its application to METEOSAT. *Appl. Opt.,* **21,** 2845–2854.

Kriebel, K. T., 1981: Calibration of the METEOSAT VIS-channel by airborne measurements. *Appl. Opt.,* **20,** 11–12.

Lacis, A. A., and J. E. Hansen, 1974: A parameterization of the absorption of solar radiation in the Earth's atmosphere. *J. Atmos. Sci.,* **31,** 118–133.

Moser, W., H. J. Preuss, E. Raschke and E. Ruprecht, 1980: Determination of radiation balance parameters using METEOSAT image data–preliminary studies. *Proc. 2nd METEOSAT Scientific User Meeting,* London, ESOC Darmstadt, K-1.

Pinty, B., G. Szejwach and J. Stum, 1985: Surface albedo over the Sahel from METEOSAT radiances. *J. Climate Appl. Meteor.,* **24,** 108–113.

Tanre, D., M. Herman, P. Y. Deschamps and A. De Leffe, 1979: Atmospheric modelling for space measurements of ground reflectances, including bidirectional properties. *Appl. Opt.,* **18,** 3587–3594.