issn 0065-3713

INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE

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AERONOMICA ACTA

A - N° 328 - 1988

Short term variability between 120 and 300 nm from SME observations

by

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FOREWORD

This paper has been presented at the "Solar Radiation Output Variations Workshop" held in the "National Center for Atmospheric Research" in Boulder, Colorado (USA), November 9-11, 1987. It will be published in the proceedings of the workshop.

AVANT-PROPOS

Ce travail a été présenté au "Solar Radiation Output Variations Workshop" qui s'est tenu au "National Center for Atmospheric Research" à Boulder, USA, du 9 au 11 novembre 1987. Il sera publié dans les comptes rendus de la réunion.

VOORWOORD

Dit artikel werd voorgesteld op de "Solar Radiation Output Variations Workshop" gehouden in het "National Center for Atmospheric Research" te Boulder, USA, van 9 tot 11 november 1987. Het zal gepubliceerd worden in de verslagen van de vergadering.

VORWORT

Dieser Artikel wurde vorgestellt am "Solar Radiation Output Variations Workshop" gehalten im "National Center for Atmospheric Research" in Boulder, USA, von 9 bis zum 11 November 1987. Der Text wird publiziert werden in den Berichten der Tagung.

SHORT TERM VARIABILITY BETWEEN 120 AND 300 NM FROM SME OBSERVATIONS

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Abstract

The 27-day rotation period is the dominant variation seen in time series of solar spectral irradiance. This feature is most pronounced at shorter wavelengths, especially Lyman-α, decreasing toward longer wavelengths. An FFT analysis has been used to isolate the amplitude of the 27-day variation in the SME irradiance data at all wavelengths, 120 to 300 nm, and at all times between January 1982 and December 1986.

Résumé

La période de rotation de 27 jours est la variation la plus évidente qui peut être observée dans les séries temporelles de mesure de l'éclairement énergétique du soleil dans l'ultraviolet. Cette variation est plus importante aux courtes longueurs d'onde, et plus spécialement, à Lyman α. Elle décroit en amplitude aux longueurs d'onde supérieures. Une analyse par transformée de Fourier a été utilisée pour étudier l'amplitude des variations à 27 jours en fonction de la longueur d'onde à partir des données du flux solaire fournies par le satellite SME, de janvier 1982 à décembre 1986, pour l'intervalle spectral s'étendant de 120 à 300 nm.

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Samenvatting

De omwentelingsperiode van 27 dagen is de meest duidelijke variatie die kan waargenomen worden in de tijdelijke reeksen metingen van de stralingssterkte van de zon in het ultraviolet. Deze variatie is het belangrijkst bij korte golflengten, meer bepaald Lyman-α, en neemt af bij langere golflengten. Een FFT analyse werd gebruikt om de amplitude van de 27 dagen durende variatie in functie van de golflengte te bestuderen aan de hand van de gegevens over de zonneflux die door de satelliet SME geleverd werden, van januari 1982 tot december 1986 voor het spectraal interval gaande van 120 tot 300 nm.

Zusammenfassung

Die Rotationsperiode von 27 Tage ist die deutlichste Variation die man kann beobachten in den zeitweiligen Serien Messungen von der Bestrahlungsstärke der Sonne im Ultraviolett. Diese Variation ist wichtigst bei kurzen Wellenlängen, mehr bestimmt Lyman-α, und nimmt ab bei langen Wellenlängen. Eine FFT Analyse wurde gebraucht um die Amplitude der 27 Tage währende Variation mit Rücksicht auf der Wellenlänge zu studieren anhand der Daten über der Sonnenstrahlung, bekommen mit dem Satellit SME, vom Januar 1982 zum Dezember 1986 für das Spektralintervall 120 zu 300 nm.

The study of solar variations in the ultraviolet is very important for both solar physics and aeronomy. More specifically, variations associated with the 27-day solar rotation and related atmospheric responses have been observed from the Nimbus-7 satellite and from the Solar Mesosphere Explorer (SME) and reported by Keating et al. (1987). Theoretical investigations have also been published by Brasseur et al. (1987).

The solar spectrometer on board SME (Thomas et al., 1980) has made continuous daily observations of the full-disk solar irradiance, 120 to 300 nm, since its launch in October, 1981. Time series of these data averaged over 1 nm intervals have already been analyzed to deduce long term variations during the declining phase of solar cycle 21. (London et al., 1984; Rottman, 1984; Rottman and London, 1984).

This work briefly describes a new analysis of the SME solar irradiance data performed using the Fast Fourier Transform (FFT) technique to isolate the solar flux modulation related to the 27-day solar rotation. An example of a typical time series has been given for Lyman-α by Rottman (1987). Figure 1 shows the corresponding power spectrum with the numerical filter centered at a frequency corresponding to the 27-day periodicity.

The analytic signal technique defined in Bracewell (1965) has been applied to estimate the amplitude of the 27-day modulation over the entire SME wavelength range. The amplitude of the 27-day modulation for Lyman-α covering the five year period, January 1, 1982 to December 31, 1986, is presented in Figure 2. The strongest amplitudes occur during the summer of 1982 and the weakest in early 1985. The amplitude of the 27-day modulation related to longer wavelengths, namely 145, 175, 205 and 215 nm, are given in Figure 3. It is evident in this figure that strong positive correlations between different wavelengths are not always the case. The time periods "a" and "b" in the figure display negative correlation for some wavelengths and the time period "c" shows a dramatic time lag.

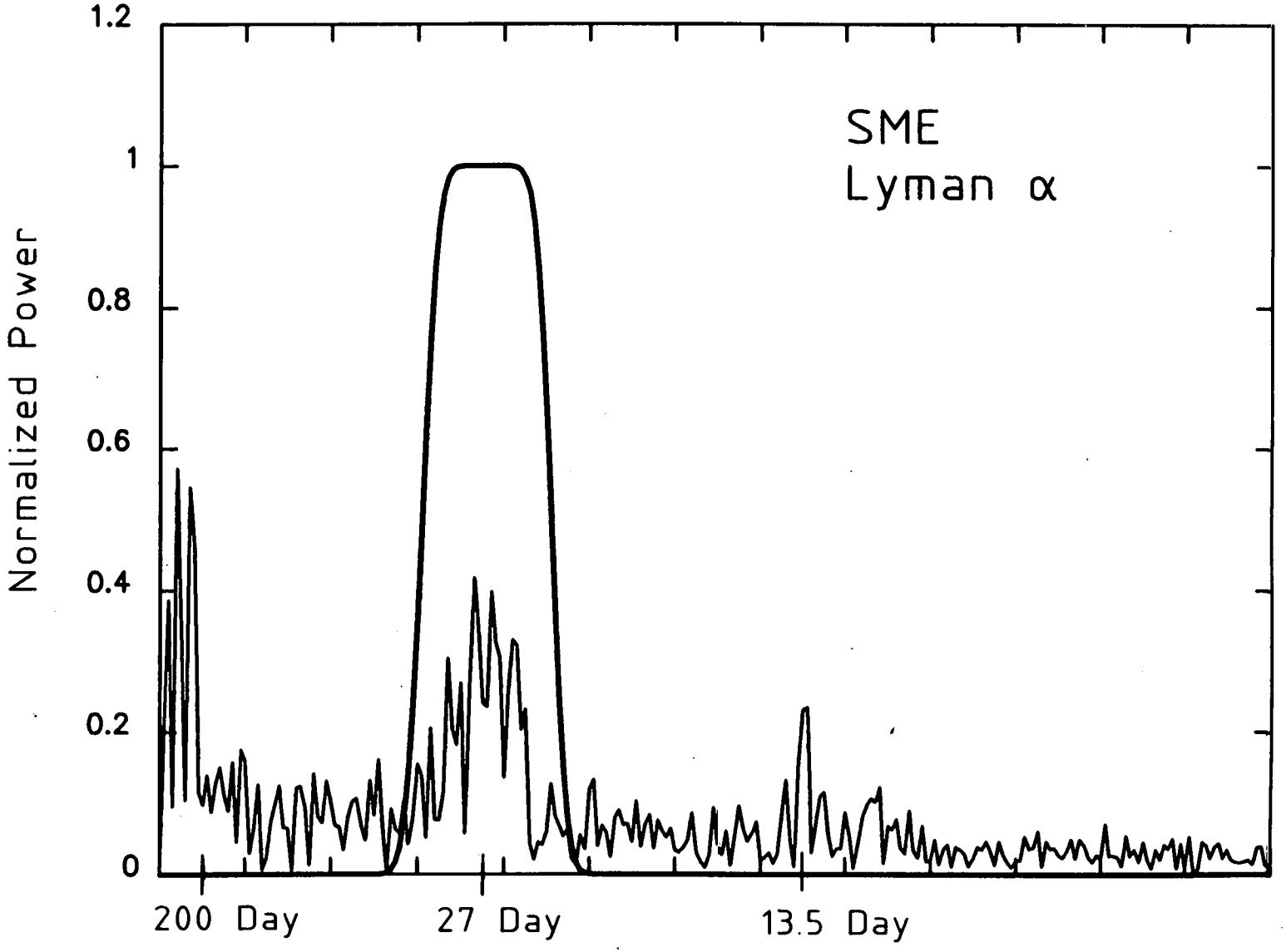

Fig. 1.- Power spectrum of Lyman-α time series and numerical filter centered at 27-day period.

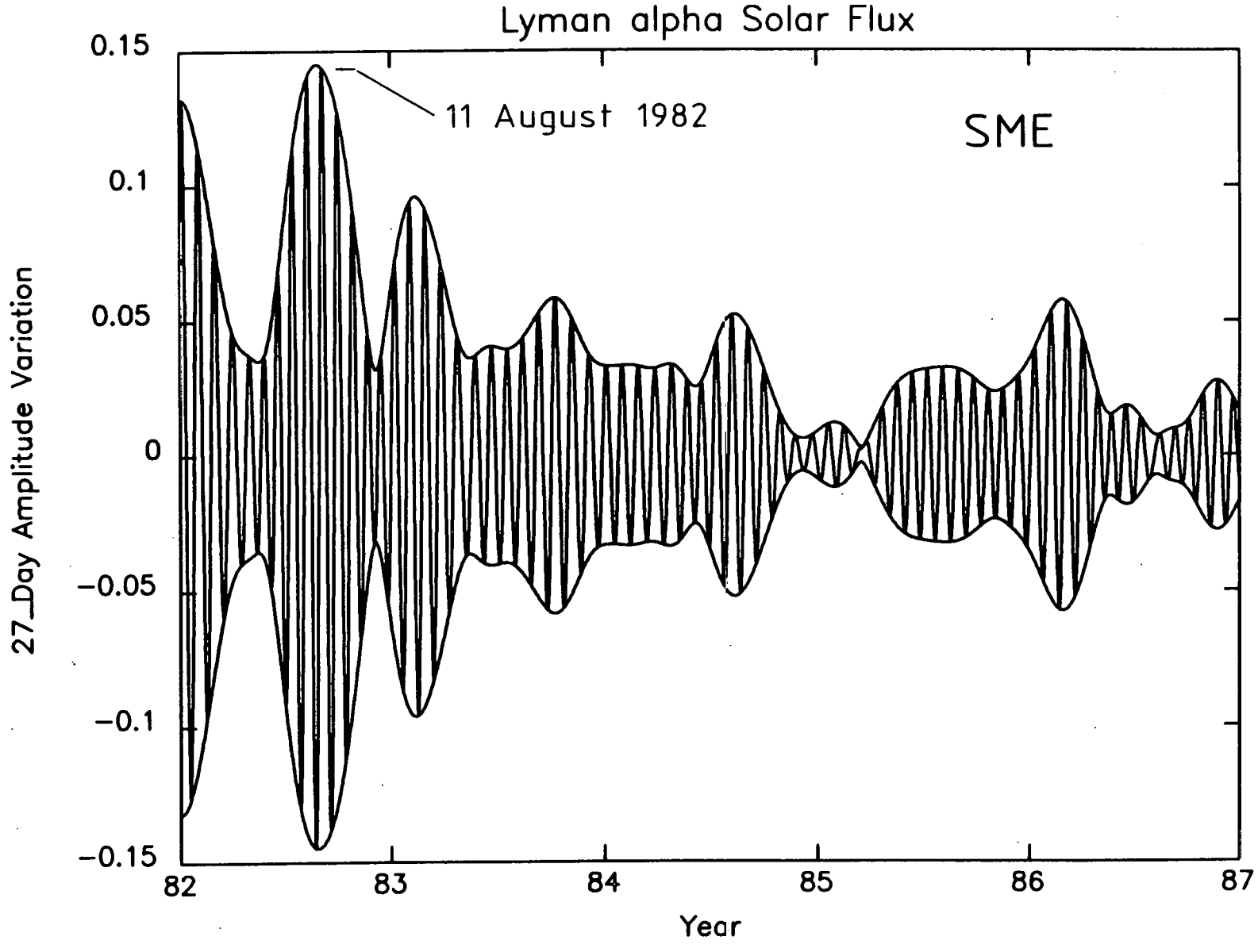

Fig. 2.- Amplitude of 27-day variations in Lyman-α.

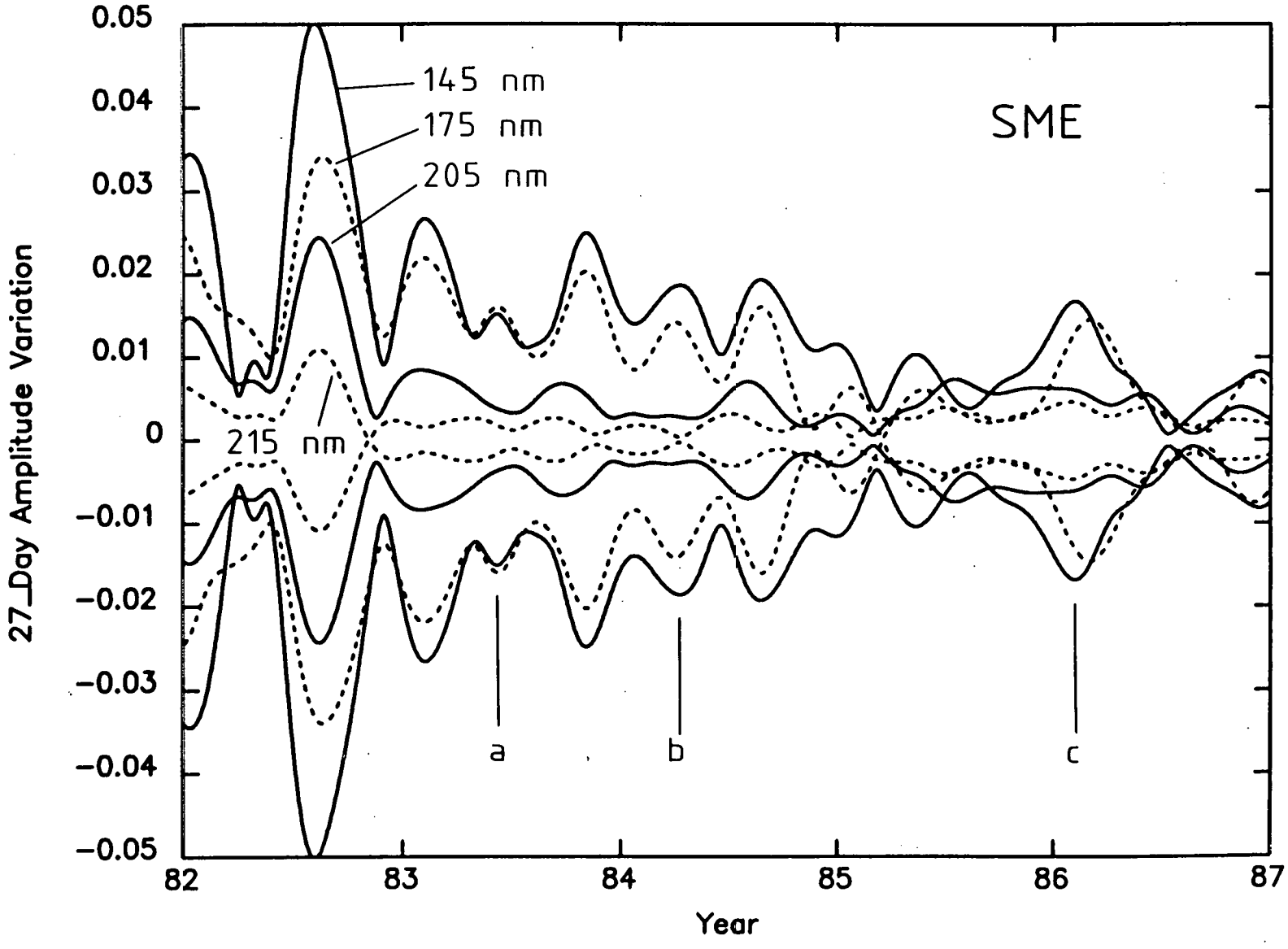

Fig. 3.- Amplitude of 27-day variations in 145, 175, 205 and 215 nm. Notes a, b, and c are described in text.

Figure 4 presents the 27-day peak-to-peak variations as a function of wavelength averaged over different time periods. The lower estimate is an average for the entire SME data set, 1982 through 1986, and may represent a mean value over solar cycle 21. The higher value is the average of four strong rotation periods in the Summer of 1982 and, in particular, the largest single rotation modulation seen in August of 1982 exceeds this high value by approximately 20%. On the other hand, a solar minimum estimate obtained from averaging all rotation periods in 1985 and 1986 produces a curve roughly one half of the low value given in Figure 4. The structure in the curves shown in Figure 4 correspond to the strong chromospheric emission lines in the solar spectrum and to the aluminium absorption edge at 210 nm. Important differences in the magnitude and shape of these 27-day modulation curves are being analyzed and more extensive discussions will be presented elsewhere. These amplitudes deduced from the SME observations are in reasonable agreement with those reported by Heath and Schlesinger (1986) for NIMBUS-7 SBUV data.

In conclusion, the available SME solar irradiance time series, 1982 to the present time, are being analyzed with the FFT technique in order to provide quantitative information on 27-day solar variations. This analysis will be carried out for all wavelengths between 115 and 300 nm, a range of fundamental importance for both middle atmosphere aeronomy and for solar physics. Correlations between different wavelengths must be made carefully. They differ dramatically for various episodes over solar cycle 21.

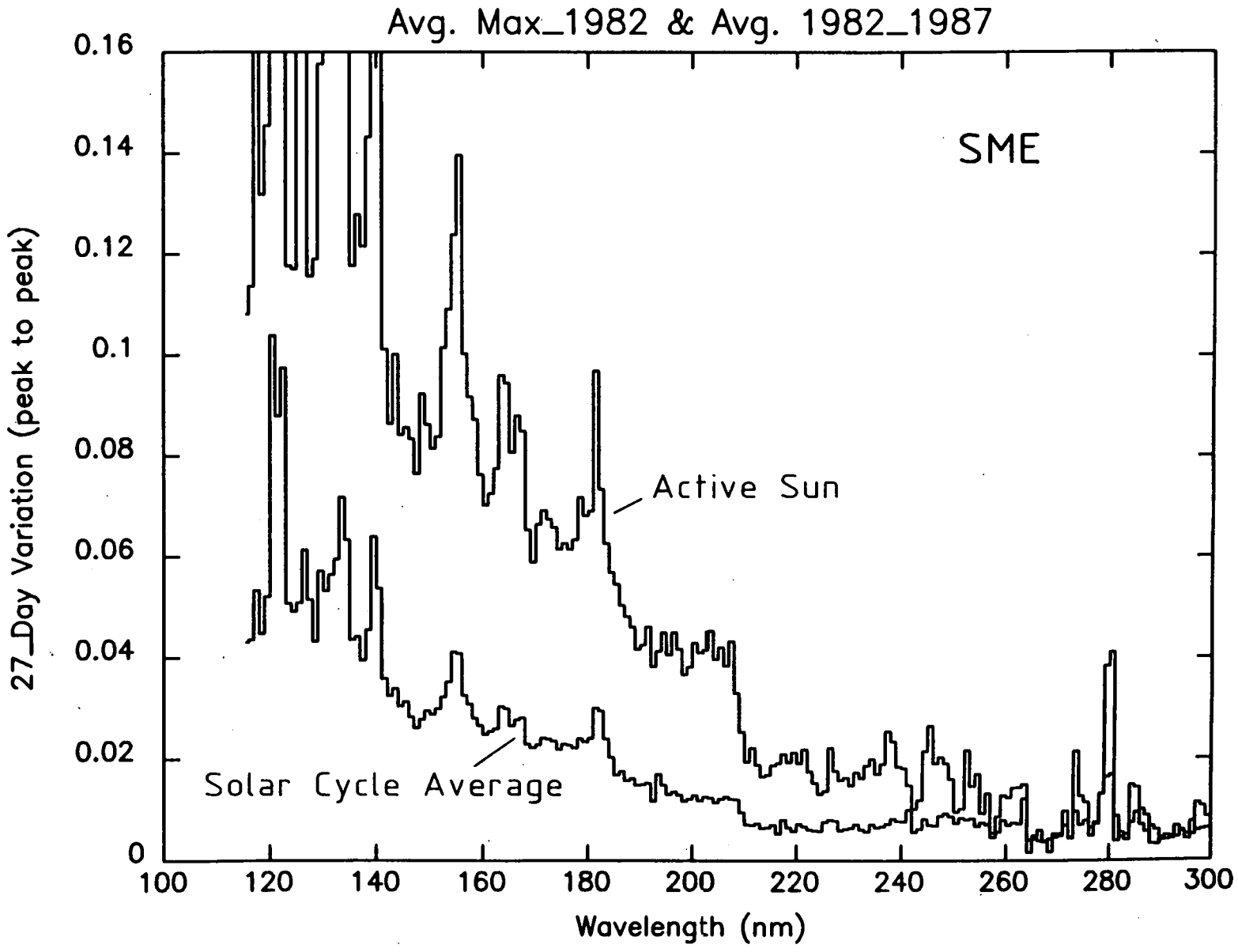

Fig. 4.- Amplitude of 27-day variations as a function of wavelength.

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