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THE ANNUAL CYCLE OF EARTH EMITTED RADIATION DISTRIBUTION

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ABSTRACT

Measurements of longwave radiation from the Earth Radiation Budget (ERB) experiment aboard the Nimbus 6 spacecraft have been analyzed to show the annual cycle of the distribution of Earth emitted radiation

INTRODUCTION

The Earth Radiation Budget (ERB) instrument on the Nimbus 6 and Nimbus 7 spacecraft has provided a wealth of information about the Earth's radiation field (ref. 1). The instrument has wide-field-of-view (WFOV) radiometers for measuring total radiation leaving the Earth and shortwave (solar) radiation reflected by the Earth (ref. 2), so that longwave radiation emitted by the Earth can be determined. In this paper, results are presented for the annual cycle of longwave radiation distribution. The radiation field $q(\theta,\phi,t)$ at the top of the atmosphere may be described in the form

$$q(\theta,\phi,t) = \sum_{m,n} C_n^m(t)\, Y_n^m(\theta,\phi)$$

where θ is the colatitude, ϕ is the longitude of a point t is time. The coefficients $C_n^m(t)$ serve as a method of describing the time dependent distribution of emitted radiation. The $C_n^m(t)$ have been calculated from the ERB WFOV data.

Because the WFOV radiometers measure radiation flux incident from all directions onto a flat plate, the problem of relating these measurements to the radiation at the top of the atmosphere is one of resolution enhancement, or deconvolution. The theory of deconvolution has been developed for Earth emitted radiation (refs. 3 and 4) and has been applied to Nimbus 6 ERB data (refs. 5 through 7). The longwave deconvolution technique provides the C_n^m directly. For the results presented here the C_n^m were computed using a nominal limb darkening function.

RESULTS

The $C_n^m(t)$ have been computed for 1 month averages for 1 year of Nimbus 6 ERB data, from July 1975 through June 1976. The axisymmetric terms (m = 0) dominate up to n = 5, beyond which the pattern appears random. The magnitudes of $C_n^m(t)$ decrease rapidly with increasing n. The results are shown in figures 1 and 2 for $C_n^o(t)$ for n = 0 through 12.

Figure 1 shows the yearly cycle of $C_o^o(t)$, $C_1^o(t)$ and $C_2^o(t)$. The $C_o^o(t)$ term is the global average emitted radiation. The $C_1^o(t)$ term is a measure of hemispherical differences, or pole to pole differences. Its annual cycle is seen to have a nearly perfect sine shape, with a total range between its minimum and maximum values of 20 W/m^2. It does not oscillate about zero, but has a bias of 2-1/2 W/m^2. If the Earth were symmetric about the equator, one would expect the C_n^o terms for odd n values to have time histories which are symmetric about the time axis. Thus, the 2-1/2 W/m^2 bias in the annual cycle of C_1^o is due to land/ocean distribution differences between the Northern and Southern Hemispheres. The $C_2^o(t)$ term may be considered to be a measure of equator to pole gradient. It is seen to have an average value of approximately - 26 W/m^2, with a small variation which appears to be nearly semiannual.

The $C_n^o(t)$ for n = 3 through 12 are shown in figure 2. The C_3^o is nearly sinusoidal, with a total variation of 15 W/m^2 and a mean of approximately 4 W/m^2. As with C_1^o, this bias is a result of hemispheric differences of land/ocean distribution. The C_4^o term has a mean of approximately - 7 W/m^2 with variation of 5 W/m^2. Its shape is not so sinusoidal as the C_1^o or C_3^o histories. The C_5^o through C_{10}^o terms each have a significant annual sine component, and the C_6^o and C_8^o terms have a bias such that they do not change signs. The maximum absolute value decreases with increasing n until C_{11}^o and C_{12}^o, which are small and show little discernible pattern. Previous studies by Green and Smith (ref. 6) have indicated that twelfth degree is the limit of deconvolution for the orbit altitude of Nimbus 6. Whether the lack of pattern in the computed values of C_{11}^o and C_{12}^o is due to the nature of the atmosphere or due to the limitations of sampling and analysis is unclear at present.

CONCLUDING REMARKS

Analysis of 1 year of longwave data from the ERB instrument aboard Nimbus 6 shows a surprisingly simple variation with time of the longwave distribution. Analysis of other years of data will help to define the average annual cycle better, and to define the interannual variations. In order to complete the description of the radiation budget, work is ongoing at Langley Research Center to develop a technique for deconvolutiong shortwave WFOV data.

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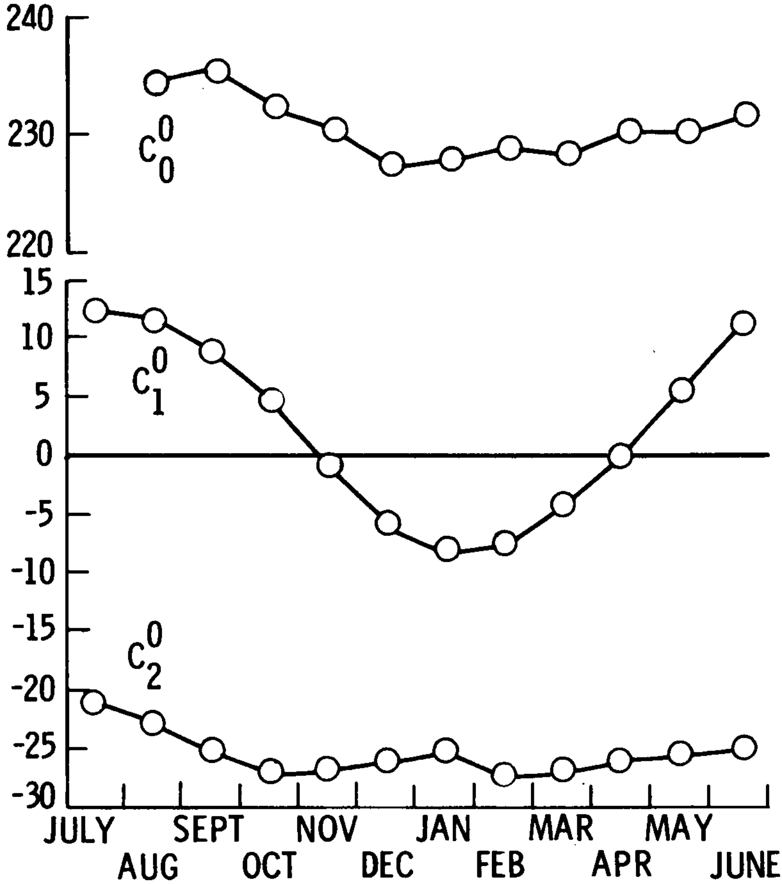

Figure 1. C_n^o histories for n = 0, 1, 2, for July 1975 through June 1976

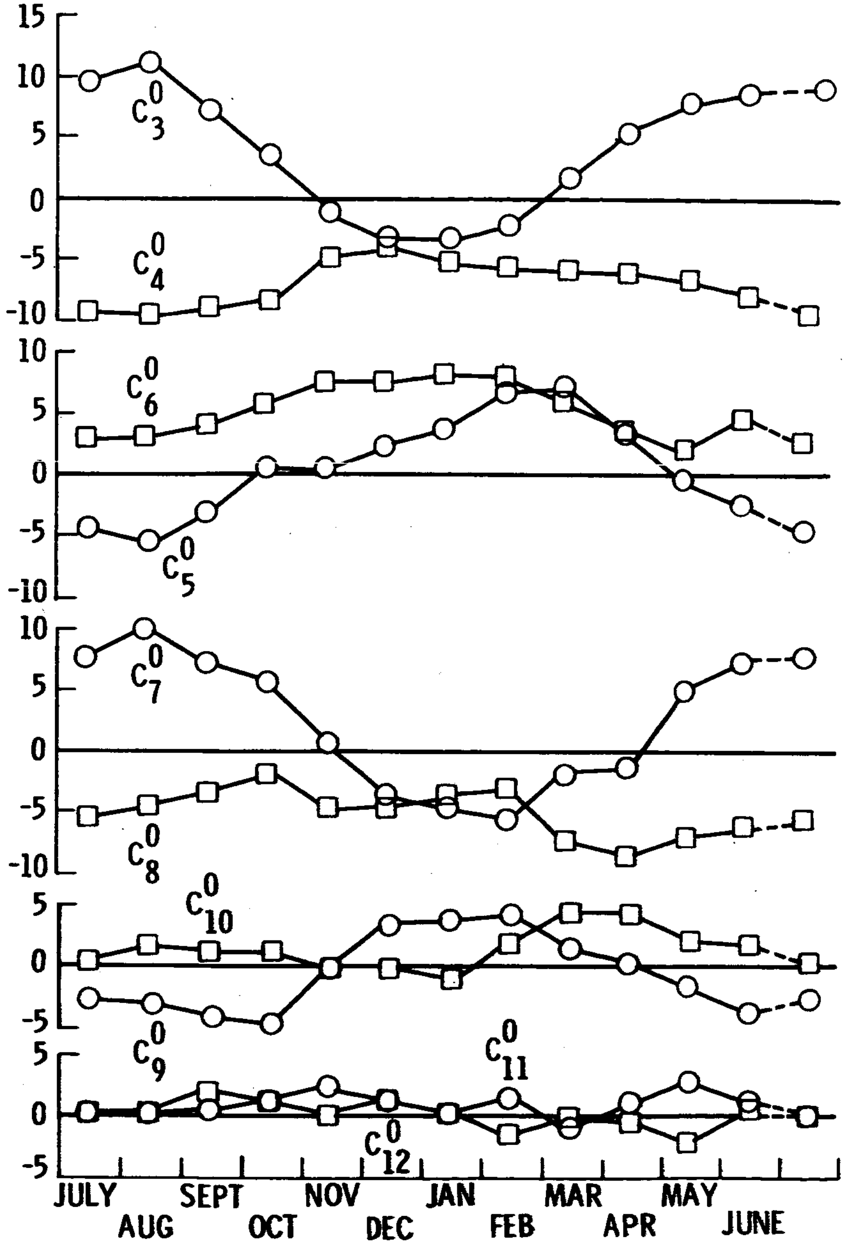

Figure 2. C_n^o histories for n = 3 through 12 for July 1975 through June 1976.