Paper No. 50

SPATIAL DISTRIBUTION OF EARTH FLUX DENSITY FROM UNRESTRICTED FIELD OF VIEW RADIATION MEASUREMENTS

W. L. Weaver, *Langley Research Center, Hampton, Virginia*

Abstract

A study was conducted in which simulated irradiances were reduced to Earth flux densities on different scales, and results are given from an analysis of Nimbus 6 data

INTRODUCTION

Measurements with unrestricted field of view (UFOV) flat plate radiometers can give very accurate estimates of global flux densities, provided the measurements are adequate in spatial and diurnal coverage. Simulation studies at Langley (Ref. 1 and 2) have shown that these detectors can also provide estimates of flux densities in latitude zones. This paper reports results of an analysis to determine if UFOV measurements can be used to estimate flux densities on scales smaller than the detector's Earth FOV. Simple geometric considerations were employed to reduce simulated irradiances to Earth flux densities. A spatial distribution of emitted flux density is also presented and discussed which was inferred from UFOV measurements of Nimbus 6.

SIMULATION STUDY

Simulated irradiance measurements from a satellite were calculated using a model of the Earth's emitted flux density which is based on Nimbus 3 data (Ref. 3). The Earth's surface was divided into 1654 flux regions, each with an area equal to a 5-degree latitude by 5-degree longitude region at the equator. The directional characteristics of the field were modeled either as lambertian or by a limb darkening function based on Nimbus 2 data (Ref. 3). A calculation was allowed to be influenced by all flux regions whose centers fell within the detector's Earth FOV. Measurement altitude was 600 km. A geometric shape factor was used to reduce the irradiances to estimates of flux density at the Earth's surface (Earth radius = 6371 km). These estimates of flux density were compared to model-derived average flux densities for concentric circles centered at the detector's FOV. A model-derived average flux density is the mean value derived directly from all 5-degree by 5-degree flux regions within the given circle.

Figure 1 shows results from two sets of measurements obtained in an equatorial orbit. One was obtained with a lambertian radiation model, and the other assumed the average limb darkening function (Ref. 3). Each data point (average measurement error) represents the average of the absolute errors between the estimated and the model-derived values of flux density for all measurements in the set. It is apparent that the results are not sensitive to the directional models. This is probably due to the fact that the detector gives much less weight to radiation from regions at the limb than to that near nadir. Flux densities inferred from the measurements are seen to be better estimates of modeled-derived flux densities over areas smaller than the detector FOV than over the detector's total Earth FOV. The area of best estimate appears to be for an area corresponding to an ECA of about 20 degrees. Such a circle encloses only about 15 to 20 percent of the detector's total Earth FOV, but the radiation from the area comprises about 80 percent of the measured irradiance.

Figure 2 shows results from individual measurements calculated every 10 degrees along the ground track of a Sun synchronous orbit having an inclination of 100 degrees. The directional model was assumed to be lambertian. Circles represent errors between estimated and model-derived flux densities for the detector's total Earth FOV. Squares show the errors when the estimated values are compared to model-derived values for a circle of ECA = 20 degrees. Estimates for the total FOV are seen to be in error by as much as 12 percent, and in almost all cases errors are less for the smaller circle. The average measurement error for the smaller scale is 60 percent less than that for the total FOV. Note that the errors can be either positive or negative; that is, the shape factor can overestimate or underestimate the average flux density. This was the reason for using the average of the absolute errors as a figure of merit in comparing results in figure 1. These results suggest that spatial distributions of estimated emitted flux densities derived from UFOV radiation measurements, using geometric shape factors, can be interpreted on scales smaller than the detector Earth FOV.

NIMBUS 6 DATA ANALYSIS

Longwave irradiances measured by the UFOV flat plate detectors on Nimbus 6 during August 1975 have been analyzed. Nimbus 6 is in a Sun synchronous orbit with a northward equatorial crossing of 12 noon local time. Irradiances were reduced, using shape factors, to estimates of flux density at an altitude of 30 km. Flux densities were averaged over 10-degrees latitude by 10-degree longitude regions. The spatial distribution of emitted flux density based on these averaged values is shown in figure 3.

These results are in good agreement with UFOV results reported in reference 4. Large-scale flux density patterns are identified in a latitude zone extending from 20 degrees south to 40 degrees north, where in some cases, longitudinal gradients are as strong as latitudinal gradients. The patterns, particularly over Africa, Europe, and Asia show details on a scale which appears to be much smaller than the detector FOV (ECA = 60 deg.).

CONCLUSIONS

A simulation study indicates that UFOV radiation measurements can be used to estimate Earth emitted flux densities on scales smaller than the detector FOV, and a spatial distribution of emitted flux density from Nimbus 6 data tend to confirm this result.

REFERENCES

1. Weaver, W. L.: Simulation Study of a Method for Analyzing Wide Field of View Radiometer Measurements from Satellites and Some Analysis of ESSA 7 Data. NASA CP 2029, Nov. 1977

2. Green, Richard N.: Simulation Studies of Wide and Medium Field of View Earth Radiation Data Analysis. NASA TP 1182, May 1978.

3. Raschke, Ehrhard; Vonder Haar, Thomas H.; Pasternak, Musa; and Bandeen, William R.: The Radiation Balance of the Earth-Atmosphere System from Nimbus 3 Radiation Measurements. NASA TN D-7249, April 1973.

4. Smith, W. L.; Hickey, J.; Howell, H. B.; Jacobowitz, H; Hilleary, D. T.; and Drummond, A. J.: Nimbus-6 Earth Radiation Budget Experiment. Appl. opt., vol. 16, no. 2, Feb. 1977, pp. 306-318.

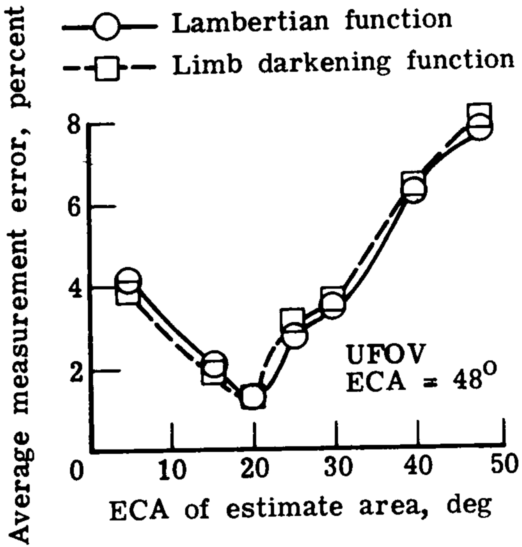

Fig. 1 - Errors in estimating flux density over circular regions smaller than the detector FOV. Altitude = 600 km.

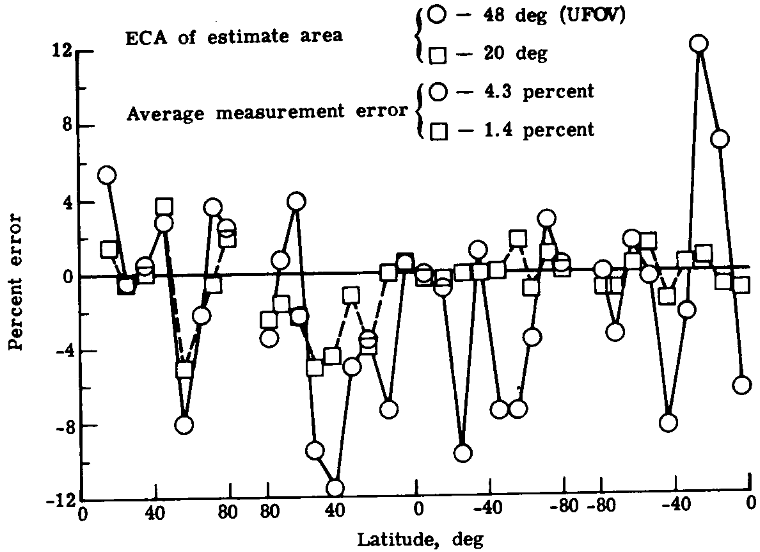

Fig. 2 - Errors in estimating flux density from individual measurements with UFOV detector. Altitude = 600 km, Lambertian model.

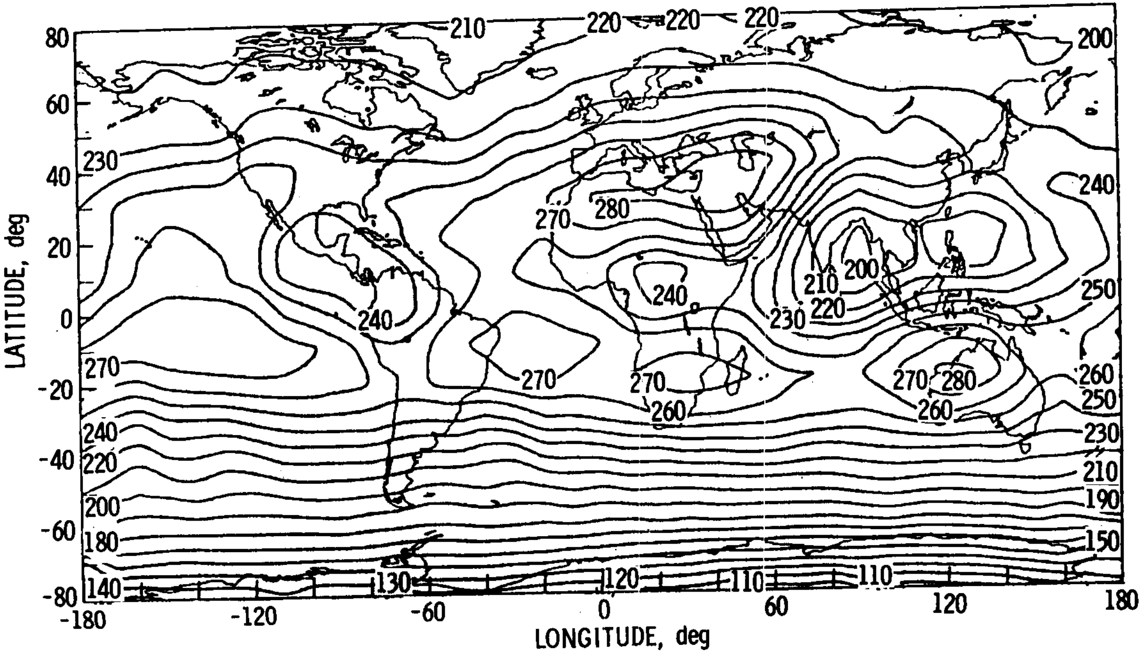

Fig. 3 - Spatial distribution of Earth emitted flux density for August 1975, from UFOV measurements on Nimbus 6. Units are W/m^2.