4.10 A COMBINED SCARAB-ERBS DATA PRODUCT

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1. INTRODUCTION

The first Scanner for Radiation Budget (ScaRaB-1) instrument, a cooperative project of France, Russia, and Germany, flew aboard the Russian operational weather satellite Meteor-3/7, producing high quality broadband measurements of the Earth's reflected solar radiation (SWR) and outgoing longwave radiation (OLR) from March 1994 though February 1995 (Kandel et al., 1994). During that same period, NASA's Earth Radiation Budget Experiment (ERBE) nonscanner instrument flying aboard the Earth Radiation Budget Satellite (ERBS) was collecting analogous broadband SWR and OLR measurements (Barkstrom and Smith, 1986). Similar data processing techniques were used in reducing both the ScaRaB and ERBE data to generate monthly mean radiation budget distributions (Viollier et al., 1995, Brooks et al., 1986). Temporal and spatial sampling constraints of each of the data sets result in weaknesses in the monthly products which may be overcome by combining the two data sets to produce a single monthly radiation budget data product with improved temporal and spatial coverage.

2. ORBITAL CHARACTERISTICS

The Meteor-3/7 was launched on January 24, 1994 into a 1200 km polar orbit with a posigrade inclination of 82^{o}. This orbit precesses through all local times in about seven months (cf. Capderou, 1995). The orbit orientation is such that not all latitudes are sampled during daylight hours, so that not all latitudes have measurements of solar radiation. Also, during some months Meteor-3/7 flew in a near-terminator orbit, for which the ScaRaB instrument lacks both daytime and nighttime measurements. This sampling geometry creates problems when averaging over the diurnal cycle to obtain daily-averaged OLR. Consequently, for some regions there are months when it is not possible to compute either OLR or SWR monthly means.

The ERBS was launched on October 4, 1984 into a 611 km orbit with an inclination of 57^{o}. This orbit precesses through all local times every 72 days. The ERBE instrument has temporal sampling problems similar to those of the ScaRaB-1 instrument. Because of the inclined orbit, ERBS observations are restricted to between 60^{o}N and 60^{o} S latitude.

Table 1 compares the orbital characteristics of the Meteor 3/7 and ERBS platforms. When measurements from both ScaRaB and ERBE are combined into a single data product, it is possible to com -

Table 1: Orbital Characteristics at Launch

Platform:	Meteor 3/7	ERBS
Launch date	January 25, 1994	October 4, 1984
Inclination (degrees)	82.6	57.0
Period (minutes)	109.37	96.75
Mean altitude (km)	1200	611
Eccentricity	.00144	.00141
Precession rate (deg/day)	-0.706	-3.95
Precession period (days)	213	72

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pute a set of monthly means which is more nearly complete than is possible from either instrument alone.

3. SAMPLING PATTERNS

Figures 1 - 5 illustrate the improvement in temporal and spatial coverage that is obtained by combining the ScaRaB and ERBE data sets. In these figures, each line shows the ground track for a single day, generally the first, fifteenth, and last day of the month. Lines labeled “E” are for the ERBE orbit; lines labeled “S” are for the ScaRaB orbit.

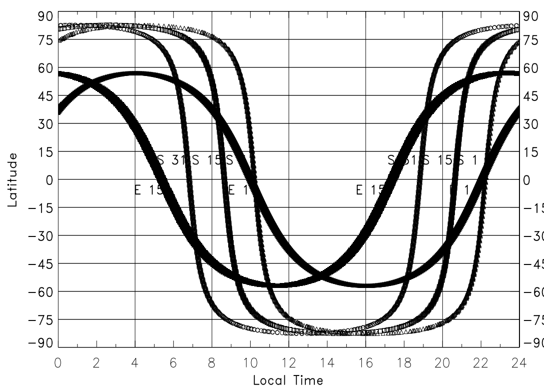

Figure 1. Latitude-local time coverage of ScaRaB-1 and ERBE nonscanner instruments for March 1994.

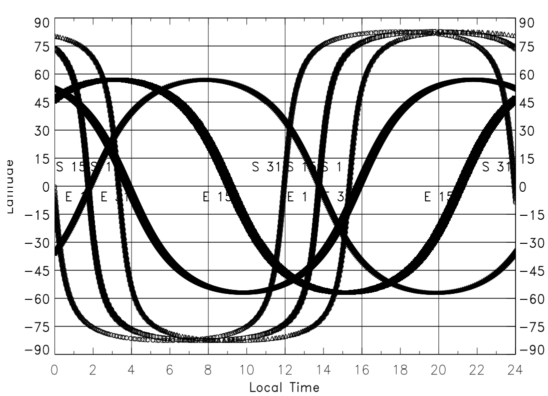

Figure 2. Latitude-local time coverage of ScaRaB-1 and ERBE nonscanner instruments for May 1994.

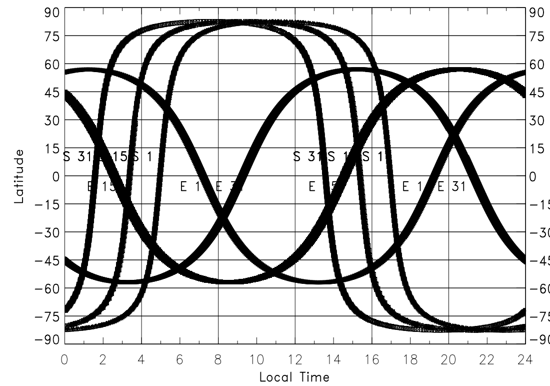

Figure 3. Latitude-local time coverage of ScaRaB-1 and ERBE nonscanner instruments for August 1994.

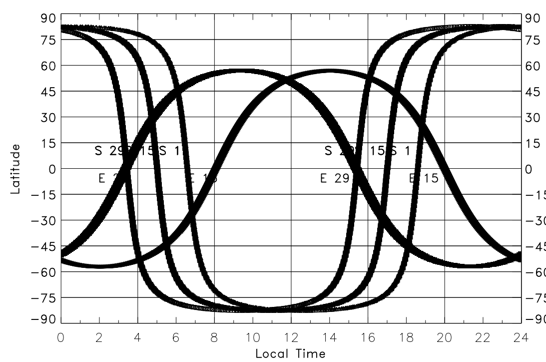

Figure 4. Latitude-local time coverage of ScaRaB-1 and ERBE nonscanner instruments for November 1994.

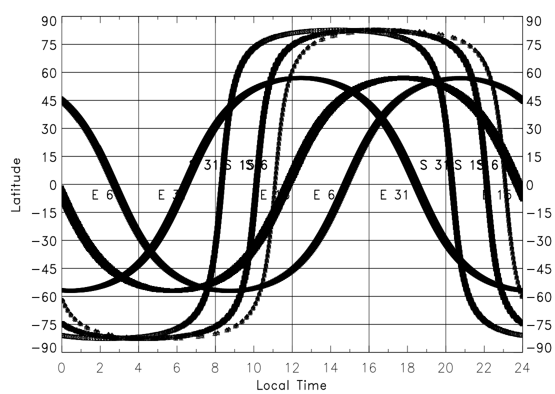

Figure 5. Latitude-local time coverage of ScaRaB-1 and ERBE nonscanner instruments for January 1995.

During March 1994 (figure 1), the addition of ERBE data does not substantially change the sampling distribution. In May 1994 (figure 2), however, the addition of the ERBE data adds daytime coverage to both hemispheres, and improves the spatial coverage. A similar improvement in temporal and spatial coverage is seen in August 1994 (figure 3). In November 1994, ScaRaB operated in near-terminator conditions (figure 4), so that limited day and night data are available for diurnal modeling, resulting in a higher uncertainty in the monthly mean flux values. The addition of the ERBE data greatly enhances the temporal and spatial sampling for this month. January 1995 (figure 5) is similar to March 1994 in its sampling pattern. Again, the addition of the ERBE data does not greatly change the spatial and temporal distribution of data for this month.

4. DATA PROCESSING

A modification of the ERBE data processing software is used to produce a combined ScaRaB-ERBS data product, combining the ERBE nonscanner WFOV data product with the ScaRaB A-3 data product. ScaRaB data processing produced broadband SW and LW fluxes for both all-sky and clear sky conditions on the same temporal and spatial scales as the ERBE scanner data products (Kandel et al., 1998). These include instantaneous averages for 2.5 degree regions, as well as monthly mean values for 2.5 degree regions. Table 2 identifies the various ScaRaB data products and corresponding ERBE data products. No ERBE scanner instruments were operational during the ScaRaB time period. Instead, the ERBE nonscanner WFOV data products are available and will be combined with the ScaRaB data products. The ERBE WFOV data were analyzed using two different methods (Smith et al., 1986), a numerical filter technique for resolution enhancement in the along-track direction, from which a 5-degree gridded product was generated, and a shape factor technique, from which a 10-degree gridded product was generated. The ERBE S10n numerical filter data product is used for the combined ScaRaB/ERBE product. In addition to a coarser resolution, the nonscanner data differ from the scanner data in that clear sky fluxes are not calculated for nonscanner data. Thus the combined product will not include clear sky data, and will, in effect, be a nonscanner product.

In order to accomplish this, the ScaRaB data must first be nested into a 5-degree grid to be compatible with the ERBE WFOV data. ScaRaB data processing was designed so that monthly averages were distributed among four different data products, depending on the type of averaging that was done. These four data products must now be combined into a single data product analogous to the single ERBE S10n monthly data product. Figure 6 is a schematic of the process used to produce the combined ScaRaB/ERBE data product.

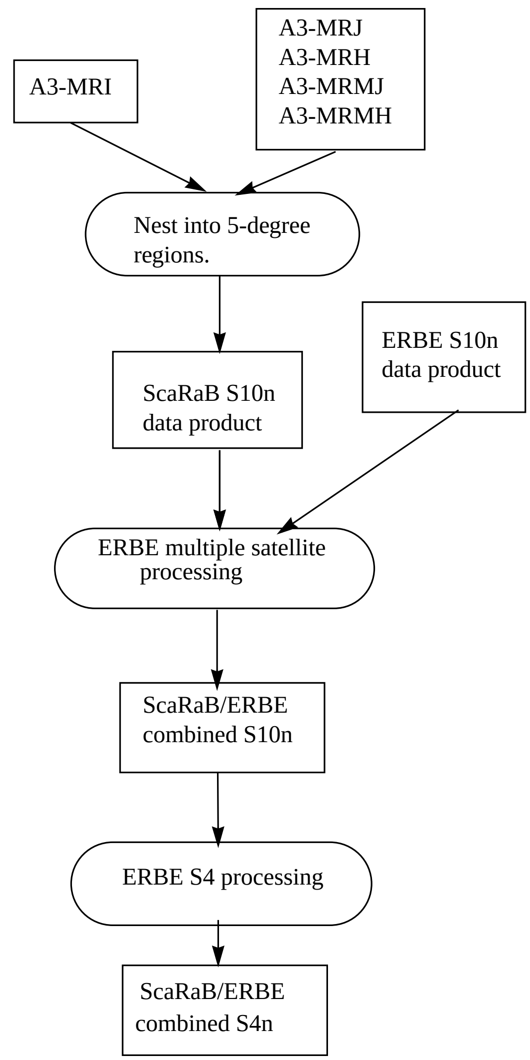

Figure 6. Process used to create the combined ScaRaB/ERBE monthly regional gridded data product.

We used a modification of the ERBE S4 Regional, Zonal, and Global Gridded output product processing software to nest the ScaRaB 2.5-degree data into 5-degree regions. Using this ScaRaB nested data, we build a data product that looks like the ERBE S10n nonscanner Earth Radiant Flux and Albedo regional gridded product. We can then use the ERBE multiple satellite software with no modifications to create a ScaRaB/ERBS combined satellite S10n data product, and the ERBE S4 processing software with no modifications to create a combined ScaRaB/ERBE S4n data product.

The ERBE data used in this analysis are available from the Langley Atmospheric Sciences Data Center (ASDC), and may be accessed via the World Wide Web at http://eosweb.larc.nasa.gov.

Table 2: Corresponding ScaRaB and ERBE Data Products

ScaRaB Data Product	Description	ERBE Data Product
A2	Daily instantaneous TOA fluxes after spectral correction and geophysical transformation	S8 (scanner) S7 (nonscanner)
A3-MRI	Instantaneous regional mean fluxes	S9 (scanner) S10n (nonscanner) Record 2 (hourly/day data)
A3-MRJ	Daily regional mean fluxes	S9 (indices 63-837) S10n (indices 40-473)
A3-MRH	Hourly regional mean fluxes	S9 (indices 838-1845) S10n (indices 474-977)
A3-MRMJ	Monthly (day) regional mean fluxes	S9 (indices 1-31) S10n (indices 1-25)
A3-MRMH	Monthly (hour) regional mean fluxes	S9 (indices 32-62) S10n (indices 26-39)

5. ACKNOWLEDGEMENTS

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