P6.32 DECADAL VARIABILITY OF EARTH RADIATION BUDGET DEDUCED FROM SATELLITE ALTITUDE CORRECTED ERBE/ERBS NONSCANNER DATA

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1. INTRODUCTION

Continuous monitoring of the Earth's Radiation field at the top of the atmosphere (TOA) is essential for understanding climate and climate variability on Earth. Recent discovery of large decadal variability in tropical mean Earth radiation budget from overlapping satellite instruments records (Wielicki et al., 2002a) has further highlighted the critical needs for high quality continuous long-term satellite measurements in climate research. This study will examine the regional, zonal, tropical (20^{o}N to 20^{o}S), and near-global (60^{o}N to 60^{o}S) aspect of decadal variability in Earth radiation budget using the latest satellite altitude corrected Earth Radiation Budget Experiment (ERBE; Barkstrom, 1984)/ Earth Radiation Budget Satellite (ERBS) Nonscanner data between 1985 and 1999. Section 2 will provide a general description of the data and analysis method used in this study. Preliminary results of decadal changes in outgoing longwave radiation (longwave), reflected shortwave radiation (shortwave), and net downward radiation (net) will be discussed in section 3. Section 4 will give a summary of this work.

2. DATA

The near global broadband radiation measurements used in this study are extracted from the 15 years of ERBE/ERBS Edition2 wide-field-of-view (WFOV) shape factor Nonscanner dataset between 1985 and 1999. The ERBS is on a 57^o inclined orbit and has excellent near-global cover between 60^{o}N and 60^{o}S. The spatial resolution of the ERBE/ERBS WFOV shape factor Nonscanner data is 10^o by 10^o. The ERBS orbit also has a precessing cycle that allows for complete diurnal sampling of local times in a 72-day period for every region it observes. In the tropics, it will sample the complete diurnal cycle in a 36-day period from both daytime and nighttime measurements.

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2.1 *Satellite Altitude Correction*

The ERBS altitude (shown in Fig. 1) has slowly dropped from 611 km to 585 km over the 15-year period. The ERBS Edition2 Nonscanner data does not include energy correction due to this minor drop in the satellite altitude (Lee et al., 2003). For this study, a set of satellite altitude correction coefficient was developed using the time series of ERBS altitude record and applied to the ERBS Edition2 Nonscanner TOA radiation data to account for these changes. These satellite altitude corrected radiation data will be included in the future Edition3 version of ERBE/ERBS WFOV shape factor Nonscanner data. Figure 2 shows the time series of tropical mean (20^{o}N to 20^{o}S) ERBS Nonscanner radiative energy budget with and without this minor satellite altitude correction. In general, the altitude correction lowers the original reported tropical mean longwave/shortwave decadal change by 1.5/0.7 Wm^{-2}, respectively. It also moves the decadal tropical net radiation change from -0.5 Wm^{-2}, to around 1.4 Wm^{-2}.

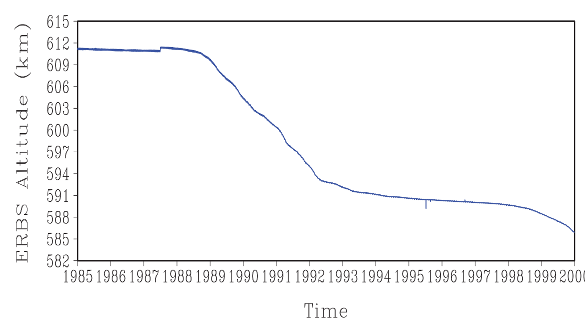

FIG. 1. Time series of ERBS altitude (km) from 1985 to 1999.

2.2 *Data Analysis Techniques*

In order to reduce the diurnal aliasing problem in the Nonscanner dataset resulted from shift in local time of satellite observations over the 15-year period (Wielicki et al., 2002b), the ERBS Nonscanner data is first averaged into 72-day means (i.e.,

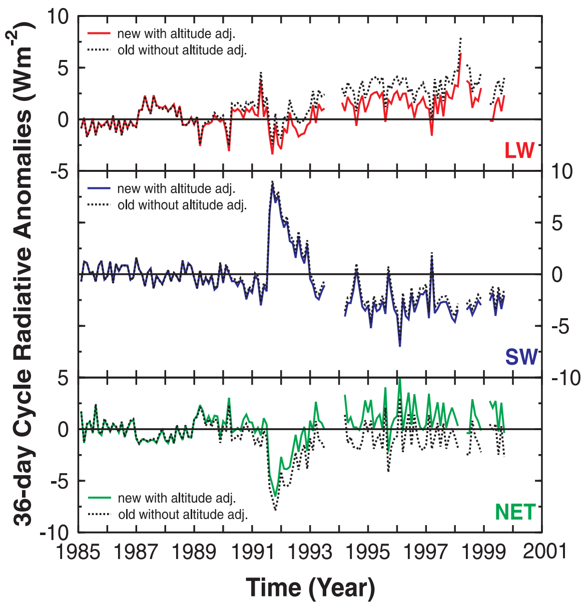

FIG. 2. Time series of tropical mean broadband radiation budget (longwave, shortwave, and net) from 1985 to 1999 with (solid colored lines) and without satellite altitude corrections (black dotted lines).

the complete precession cycle of the satellite) based on the same technique used in ERBE time-space averaging algorithm. These 72-day means of top-of-atmosphere (TOA) longwave, shortwave, and net radiation are then used in our decadal change analysis. In this study, the decadal changes are defined as the averaged TOA radiation changes between 1985-89 period and 1994-97 period. These periods are careful chosen to avoid contamination of the mean fields from changes in regional climate due to Mt. Pinatubo volcanic eruption and the large 1998 ENSO event. Decadal changes are calculated independently for every region over the entire dataset. These regional data are then averaged into zonal mean decadal changes. Finally, zonally mean changes are area-weighted to obtain tropical and near global mean decadal changes.

3. RESULTS

3.1 *Regional Decadal Changes*

Figure 3 to 5 show regional maps of decadal change in longwave, shortwave, and net radiation, respectively. Positive and negative decadal changes are evident in all three figures. Negative changes in longwave radiation (shown in Fig. 3) include areas over Northern and Central Africa, Arabian sea, Arabian and Indian Peninsula, interior part of Australia, oceanic regions off the southeast of Australia, central and eastern equatorial Pacific ocean, land regions bordering the U.S. and Canada, regions at the southern tip of South America and the adjacent oceans, and maritime regions west of South Africa. The largest positive change occurs over the Indian ocean while the largest negative change happens over regions between the Arabian and Indian Peninsula. There are also more regions with positive changes than those with negative changes on the longwave map.

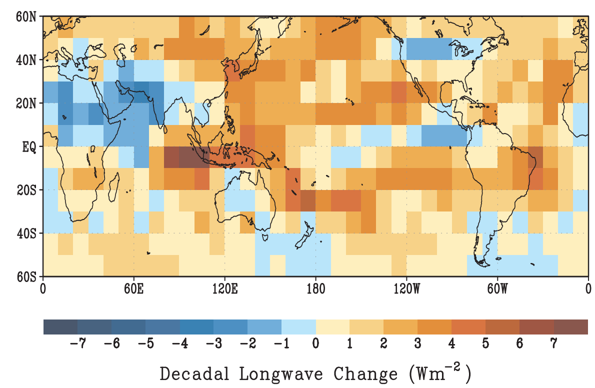

FIG. 3. Regional map of decadal longwave radiation changes between 1985-89 period and 1994-97 period.

The regional patterns of decadal changes in shortwave radiation (given in Fig. 4) generally have similar magnitudes but with opposite direction to those of the longwave changes, indicating possible changes in cloudiness and/or cloud properties over the decade. There are some exceptions to this general statement. For example, there are no corresponding decadal increases in shortwave radiation over North Africa, Arabian Peninsula, interior part of Australia, and Central and Eastern Pacific Ocean. Overall, there are more regions with negative changes than those with positive changes on the shortwave map.

The decadal changes in net radiation (shown in Fig. 5) are the combined effect of both longwave and shortwave changes. This map is shown in the exact same scale as the longwave and shortwave map. In general, there are positive decade changes over most of the tropics. The largest positive changes happen at regions over Northern Africa and maritime regions of Equatorial Eastern

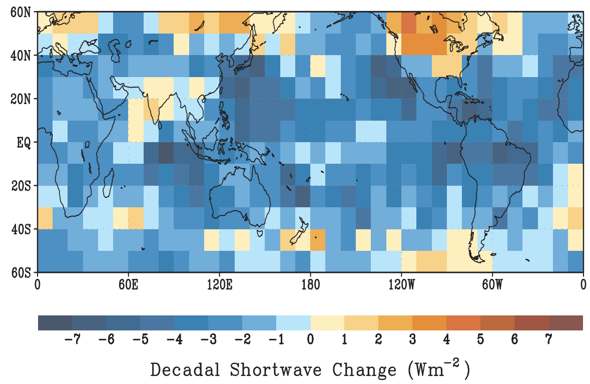

FIG. 4. Regional map of decadal shortwave radiation changes between 1985-89 period and 1994-97 period.

Pacific Ocean. The negative decade changes in the tropics occur in the areas surrounding Indonesia and New Guinea and in maritime regions over South Atlantic Ocean. Over the mid-latitude regions, the decadal changes are mostly negative over the Northern Hemisphere. Over the Southern Hemisphere, the decadal changes over the mid-latitude regions contain both positive and negative changes.

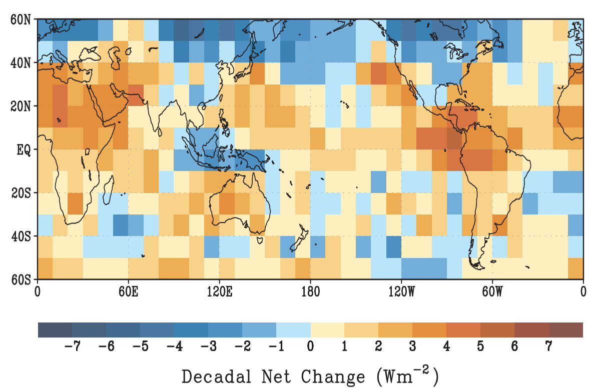

FIG. 5. Regional map of decadal net radiation changes between 1985-89 period and 1994-97 period.

3.2 *Zonal Mean, Tropical Mean and Near Global Mean Decadal Changes*

Figure 6 shows zonal mean profiles of decadal changes in longwave, shortwave, and net radiation for the period from 1985-89 to 1994-97. The zonal mean profile of decadal longwave changes is positive through all latitudes while the zonal profile for the decadal shortwave changes is mostly negative except at one latitude zone between 50^{o} and 60^{o}N. In addition, the zonal mean decadal changes in shortwave radiation are larger than those of the longwave radiation. The zonal mean profile of decadal net radiation changes is mostly positive except for the two latitude zones between 40^{o} and 60^{o}N. Furthermore, the magnitudes of the zonal mean decadal net radiation changes are larger over the Northern Hemisphere than those in the Southern Hemisphere.

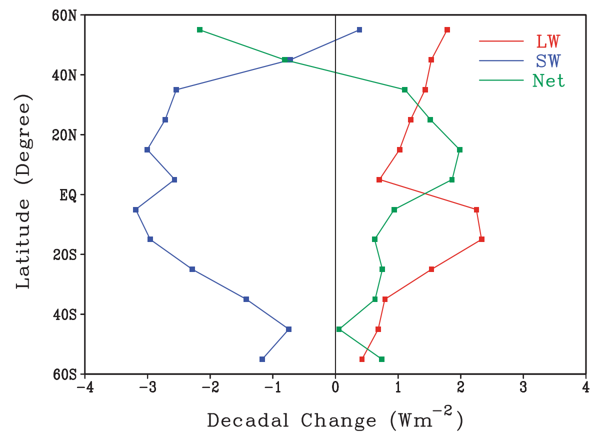

FIG. 6. Zonal mean profile of decadal change in longwave (red), shortwave (blue) and net (green) radiation between 1985-89 period and 1994-97 period.

Table 1 shows the decadal changes of longwave, shortwave and net radiation over the same two periods for two large area averages: tropics (20^{o}N to 20^{o}S) and near-globe (60^{o}N to 60^{o}S). For the tropics at a whole, the longwave has increased by 1.6 Wm^{-2}, the shortwave has decreased by 3.0 Wm^{-2}, and the net has increased by 1.4 Wm^{-2}. For the near global mean, the changes are slightly smaller. The longwave has increased by 1.3 Wm^{-2}, the shortwave has decreased by 2.1 Wm^{-2}, and the net has increased by 0.7 Wm^{-2}.

TABLE 1. Decadal changes (Wm^{-2}) in longwave, shortwave, and net radiation between 1985-89 period and 1994-97 period for the tropics (20^{o}N to 20^{o}S) and near-globe (60^{o}N to 60^{o}S).

	Longwave	Shortwave	Net
20^{o}N-20^{o}S	1.6	-3.0	1.4
60^{o}N-60^{o}S	1.3	-2.1	0.7

4. SUMMARY

Continuous monitoring of the Earth's Radiation field at the top of the atmosphere (TOA) is essential for understanding climate and climate variability on Earth. This paper presents preliminary results of decadal variability of Earth radiation budget using satellite altitude corrected ERBE/ERBS WFOV shape factor Nonscanner data. The ERBS altitude has slowly dropped from 611 km to 585 km over the 15-year period. The ERBS Edition2 Nonscanner data currently in the archive do not include energy correction due to this minor drop in the satellite altitude. In this study, a set of satellite altitude correction coefficient was developed using time series of ERBS altitude record and applied to the ERBS Edition2 Nonscanner TOA radiation data to account for these changes. A new Edition3 version of the ERBS/ERBS WFOV shape factor nonscanner data that include these minor satellite altitude corrections are currently under validation. It will be released to the scientific community in the near future once these validation activities are completed. Users interested in these new data should contact the NASA Langley Atmospheric Science Data Center at Hampton, Virginia. While the minor altitude correction did not significantly change the major conclusions of previous reported tropical mean decadal finding, it did decrease the overall longwave and shortwave tropical mean decadal changes. The tropical mean decadal net radiation changes now appear to be slightly positive for the period from 1985-89 to 1994-97.

In this study, 72-day averaging technique is used to overcome the diurnal aliasing problem in the Nonscanner data resulted from the shift in local time of ERBS observations during the 15-year period. Decadal changes of Earth radiation budget (longwave, shortwave, and net) for the period between 1985-89 and 1994-97 show many interesting regional patterns with both positive and negative changes. Over the tropics, there are more regions with positive net radiation changes than those with negative net radiation changes. While negative net radiation changes dominate the mid-latitude regions in the Northern Hemisphere, both positive and negative net radiation changes are observed for mid-latitude regions over the Southern Hemisphere. The zonal mean profiles of Earth radiation budget show a positive/negative decadal changes in longwave/shortwave radiation, respectively. The shortwave changes are larger than the longwave changes and results in a positive decadal net radiation changes in most latitude zone between 60^{o}S and 40^{o}N. The net radiation changes are negative for latitude zones between 40^{o}N and 60^{o}N. For the tropics at a whole, the longwave radiation has increased by 1.6 Wm^{-2}, the shortwave radiation has decreased by 3.0 Wm^{-2}, and the net radiation has increased by 1.4 Wm^{-2} between late 80s' and the mid 90's. For the near global mean, the changes are slightly smaller. The longwave radiation has increased by 1.3 Wm^{-2}, the shortwave radiation has decreased by 2.1 Wm^{-2}, and the net radiation has increased by 0.7 Wm^{-2} during the same two periods.

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