INTERANNUAL VARIABILITY OF SURFACE RADIATION BUDGET

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1. INTRODUCTION

A twelve-year-plus (July 1983 to October 1995) global dataset of surface shortwave (SW) and longwave (LW) radiative parameters on a 1°x1° grid was recently completed under the NASA/GEWEX Surface Radiation Budget (SRB) Project at the NASA Langley Research Center (LaRC; Stackhouse et al. 2002; Gupta et al. 2004). Both SW and LW surface fluxes were derived with two sets of radiation algorithms: one set designated as primary and the other as quality-check. Several top-of-atmosphere (TOA) radiation budget parameters were also derived with the primary algorithms. Surface fluxes from all algorithms were extensively validated with ground-based measurements obtained from the Baseline Surface Radiation Network (BSRN) and the Global Energy Balance Archive (GEBA). This dataset is identified as SRB Release 2 and is available to science community at – http://eosweb.larc.nasa.gov/PRODOCS/srb/table_srb.html.

The purpose of the present study was to advance the validation objective by determining if the dataset was able to capture the variability associated with interannual phenomena which occurred during its period. The dataset was, therefore, used to examine the interannual variability of SRB parameters associated with regional/global phenomena, such as the El Nino/La Nina episodes and the North Atlantic Oscillation (NAO). The variability was examined in terms of surface flux anomalies derived from the primary algorithm products. Surface flux anomalies were compared with corresponding TOA flux anomalies derived from satellite measurements from the Earth Radiation Budget Experiment (ERBE) and also from primary algorithm products. Surface and corresponding TOA flux anomalies associated with Mt. Pinatubo eruption were also examined.

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2. RADIATION MODELS AND INPUT DATA

The NASA/GEWEX SRB (hereafter GEWEX/SRB) project makes use of two sets of algorithms. One set of SW and LW algorithms is designated as primary, and the other set designated quality-check as follows: the primary SW algorithm is Pinker and Laszlo (1992); the primary LW algorithm is an adaptation of Fu et al. (1997) by P. Stackhouse; the quality-check SW algorithm is known as the Langley Parameterized Shortwave Algorithm (LPSA; Gupta et al. 2001); and the quality-check LW algorithm is Gupta et al. (1992). For detailed descriptions of these algorithms, the reader is referred to the references cited above. Meteorological inputs for this project were obtained from many satellite data archives and data assimilation products. Cloud properties were derived on a 1°x1° resolution using International Satellite Cloud Climatology Project (ISCCP; Rossow and Schiffer 1991) pixel-level (DX) datasets. Other meteorological input, namely, the temperature and humidity profiles were taken from GEOS-1 reanalysis product of the Global Modeling and Assimilation Office at NASA Goddard Space Flight Center (GSFC). Ozone data were obtained from the Total Ozone Mapping Spectrometer (TOMS) archive.

3. RESULTS AND DISCUSSION

Three significant El Nino/Southern Oscillation (ENSO) episodes occurred during the period of this dataset. The first was an El Nino of moderate strength which peaked in May 1987. The second was a La Nina which peaked in July 1988 and the third, another El Nino which peaked in March 1992 and was stronger than the one of May 1987.

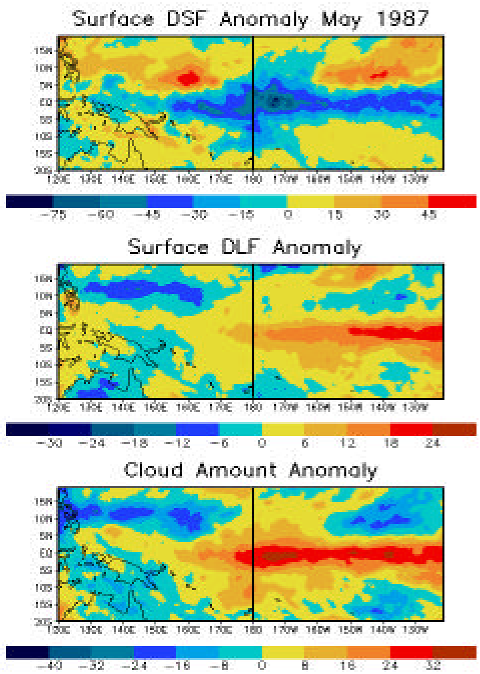

Fig. 1. DSF, DLF, and total cloud amount anomalies associated with the May 1987 El Nino

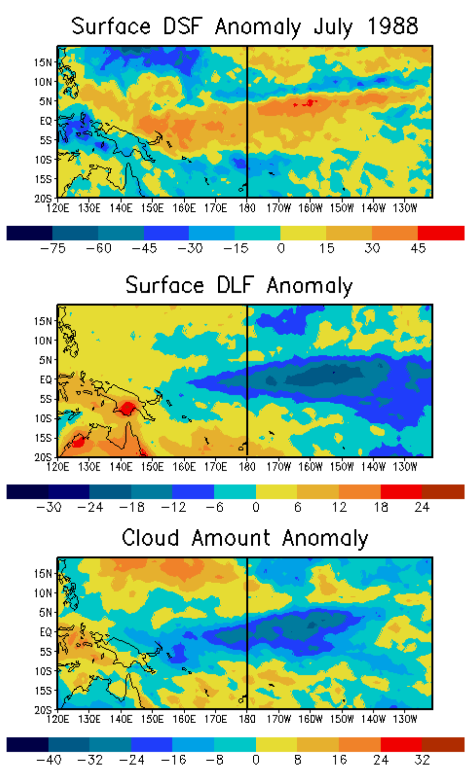

Fig. 2. DSF, DLF, and total cloud amount anomalies associated with the July 1988 La Nina.

Figure 1 shows the distribution of the anomalies of downward SW flux (DSF), downward LW flux (DLF), and total cloud amount for the May 1987 El Nino over western Pacific (120E-180; 20S-20N) and eastern Pacific (180-120W; 20S-20N) regions. These anomalies for May 1987 were computed relative to 12-year averages for the month of May (1984-1995). The distributions show that the flux anomalies are driven primarily by cloud amount anomalies even though other meteorological variables may also be making smaller contributions. The anomalies indicate a movement of clouds from western to eastern Pacific during the El Nino. The result is a negative anomaly for DLF in the western Pacific and a positive anomaly in the eastern Pacific. The DSF anomalies have the opposite sign and are considerably larger in magnitude. The anomalies for the July 1988 La Nina shown in Fig. 2 present an exactly opposite picture. Results for the March 1992 El Nino, not presented here because of the size limitation of this abstract, show it to be stronger than the May 1987 episode.

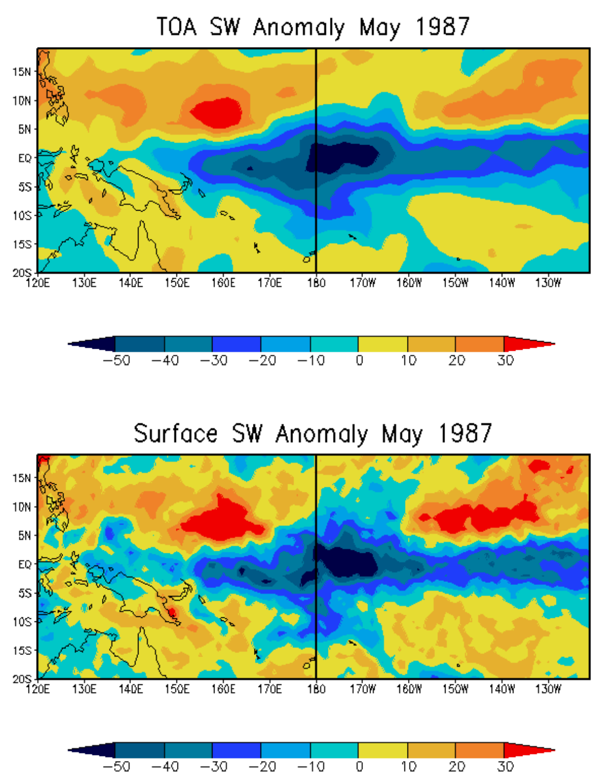

Fig. 3. Anomalies of TOA and surface absorbed SW fluxes associated with the May 1987 El Nino.

The verity of the surface flux anomalies presented in Figs. 1 and 2 in particular, and of the entire SRB Release 2 dataset in general, was put to a severe test in this study. The anomalies of certain SRB parameters derived from the Release

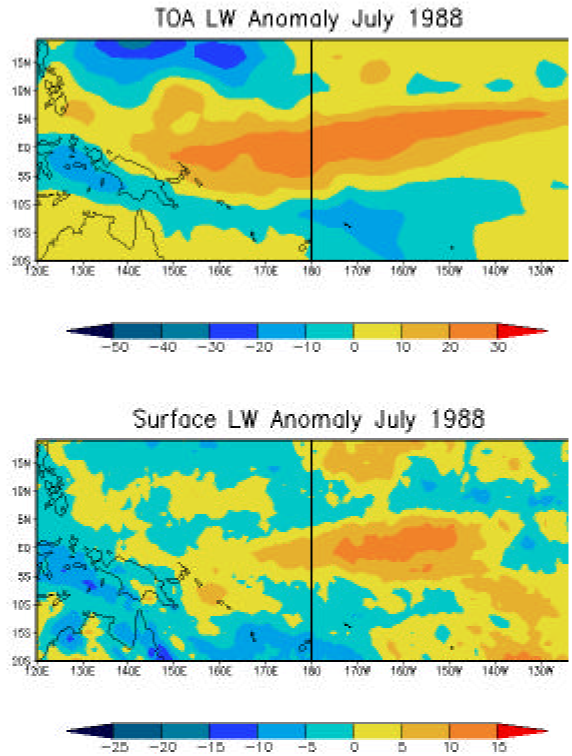

Fig. 4. Anomalies of OLR and surface net LW fluxes associated with the July 1988 La Nina.

2 dataset were examined vis-a-vis those of corresponding TOA parameters derived from the ERBE scanner measurements. Figure 3 shows a comparison between anomalies of surface absorbed SW flux with those of TOA absorbed SW flux derived from ERBE data for May 1987. The TOA absorbed SW flux was derived by subtracting ERBE measurements of reflected SW fluxes from TOA insolation. Also, TOA anomalies for May 1987 were derived relative to a 5-year average for May (1985-1989). Figure 3 shows positive anomalies for the western Pacific and strong negative anomalies for the eastern Pacific for both TOA and surface absorbed SW fluxes. This is in keeping with the shift of cloudiness from western

to eastern Pacific during El Nino episodes. Also, comparable indicating that absorption of SW radiation in the clouds is relatively small. SW anomalies for the July 1988 La Nina (not shown here) were opposite of the El Nino anomalies.

The relationship of TOA and surface LW flux anomalies is illustrated for the July 1988 La Nina episode. The top panel shows the anomalies of OLR derived from ERBE scanner data. The lower panel represents the anomalies of net LW flux (NLF) at the surface treated as a positive number. This is at a slight variance with the practice of treating NLF as a negative number but was necessary to present a meaningful comparison with OLR anomalies because OLR is mostly treated as a positive number. The figure shows that both OLR and NLF decrease in the western Pacific and increase in the eastern Pacific in response the movement of clouds. However, the magnitude of the surface anomaly is about half that of the TOA anomaly. This is in keeping with expectation of stronger interaction between LW radiation and clouds and the significant decoupling between LW radiation budgets at the TOA and at the surface.

Figure 5 shows the deseasonalized anomalies of DSF (top), DLF (middle), relative to the multi-parameter ENSO index (bottom) for 1983 to 1996. The flux anomalies show curves for global averages and those for western and eastern Pacific regions separately. Both DSF and DLF time series show strong correlation with the ENSO index though the DLF signal is relatively conspicuous. Among the two regions of the Pacific, the signal for the eastern Pacific is

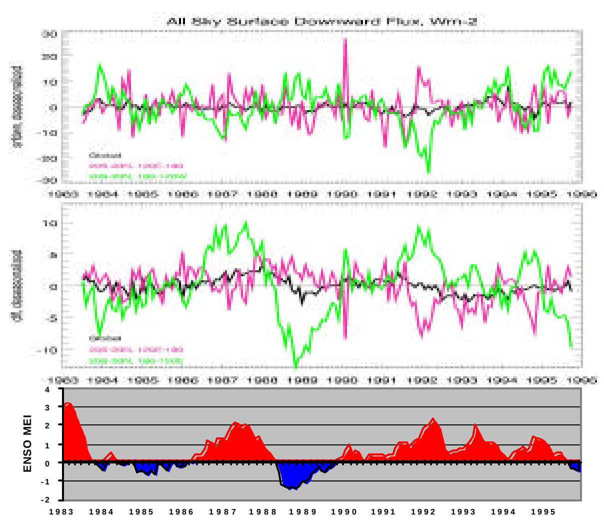

Fig. 5. Time series of deseasonalized anomalies of DSF and DLF averaged over the globe, and western and eastern Pacific regions. Multi-parameter ENSO index is also shown.

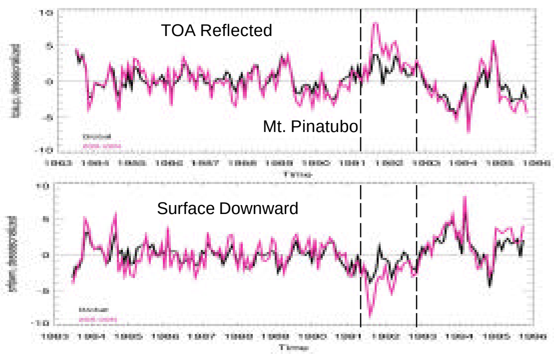

Fig. 6. Time series of deseasonalized anomalies of TOA reflected SW flux and DSF averaged over the globe and the tropics (20S-20N) showing the effect of Mt. Pinatubo eruption.

stronger than for the western Pacific.

Figure 6 shows the time-series of deseasonalized anomalies for TOA reflected SW flux (top) and DSF (bottom) for averages over the globe and the tropical region (20S-20N). These anomalies clearly indicate the effect of Mt. Pinatubo eruption which built up after the June 1991 episode and slowly decayed over the next 18 months. As expected, the signals indicating the increase of reflected SW flux and the decrease of DSF are relatively stronger for the tropical averages than for the global averages.

4. CONCLUDING REMARKS

A 12-year-plus (July 1983-October 1995) dataset of SRB parameters on a 1 x 1 grid has been developed recently at NASA/LaRC under the sponsorship of the GEWEX Radiation Panel. This dataset was used to examine the anomalies of SW and LW fluxes associated with the interannual phenomena which occurred during the period of the dataset. The DSF and DLF anomalies over the western and eastern Pacific regions clearly showed signals to the May 1987 and March 1992 El Nino and the July 1988 La Nina. The surface anomalies were subjected to a stringent test of verity by comparing them with corresponding TOA anomalies derived from an entirely independent source, namely, ERBE measurements. Close correspondence between the surface anomalies and satellite derived TOA anomalies establishes a high degree of confidence in the former and thus the entire SRB Release 2 dataset.

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