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Climate Variability and Change as Represented by the NASA GEWEX SRB(Rel3.0) Data

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The NASA GEWEX-SRB (Global Energy and Water cycle Experiment - Surface Radiation Budget) project produces and archives shortwave and longwave atmospheric radiation data at the top of the atmosphere (TOA) and the Earth's surface. The archive holds continuous records of shortwave/longwave downward/upward radiative fluxes starting from July 1983 at 1 degree by 1 degree resolution for the entire globe. The data are available as 3-hourly, daily and monthly means. As of now, the data in the archive is Release 3.0, spanning 24.5 years up to December 2007.

The satellite-based data are produced using two algorithms, the primary one and the quality-check one. The primary shortwave algorithm is adapted from Pinker and Laszlo (1992), and the longwave algorithm from Fu et al. (1997). The quality-check shortwave algorithm, also known as the Langley Parameterized Shortwave Algorithm, was developed by Staylor (2001), and the longwave algorithm by Gupta et al. (1992).

Primary inputs to the models include: shortwave and longwave radiances from International Satellite Cloud Climatology Project (ISCCP) pixel-level (DX) data, cloud and surface properties derived therefrom, temperature and moisture profiles from GEOS-4 reanalysis product obtained from the NASA Global Modeling and Assimilation Office (GMAO), and column ozone amounts constituted from Total Ozone Mapping Spectrometer (TOMS), TIROS Operational Vertical Sounder (TOVS) archives, and Stratospheric Monitoring-group's Ozone Blended Analysis (SMOBA), an assimilation product from NOAA's Climate Prediction Center.

The data in the archive have been validated systemically against the Baseline Surface Radiation Network (BSRN) data, the World Radiation Data Centre (WRDC) data, and the Global Energy Balance Archive (GEBA) data, and found in generally good agreement with the ground-based observations.

On the basis of the validation of the data, we examine the variability and change of the global climate system as represented by the SRB data. We first investigate how the known climatic variations, such as the interannual El Niño-Southern Oscillation, the North Atlantic Oscillation and the intraseasonal Madden-Julian Oscillation leave footprints in the global and regional radiation fields at the TOA and the Earth's surface. The presence of signals of these known variations gives further credence to the satellite-based radiation data. Then we compute the trends of the radiative fluxes at individual sites and on regional, zonal and global scales. Although ground-based measurements are generally considered superior in quality, they are spatially and temporally limited and often discontinuous, which creates challenges for trend analysis on regional and global scales, and makes global energy budget at the Earth's surface and TOA in the context of climate change impossible. In the trend analysis on various spatial scales, we consider uncertainties of the data, time spans, autocorrelations and other factors that affect the derived trends as Weatherhead et al. (1998, 2002) have done. We also consider the influences of the chosen segment of time and ending time of a given time series on the derived trend as Liebmann et al. (2010) have discussed, and this approach may give us insight into whether the detected trend is robust or accidental.

The study shows that large-scale interannual and intraseasonal climatic variations are manifested in the satellite-based data which are, therefore, valuable not only for climatological studies but, with further improvement in the future, can be potentially useful for predictions. Continued and uninterrupted satellite observation of the atmosphere will resolve the questions and challenges in trend-related issues.