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Satellite Observed Land Skin Temperature Variations: 1981-1998

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INTRODUCTION

Increases in the concentrations of atmospheric gases that absorb thermal radiation ("greenhouse gases") result in a climate system response, a change of temperature fields to compensate for the increased atmospheric opacity. The conventional measurement used in climate change study has been surface air temperature (T_a) obtained from the WMO stations (Jones et.al. 1999), which represents some combination of the surface radiative temperatures and that of the overlying atmosphere. Measurements of surface radiative temperature from satellite, i.e. skin temperature (T_s), can be more directly interpretable in terms of the surface response to increase of greenhouse gases (Jin and Dickinson 2001).

NOAA polar-orbiting satellites have monitored skin temperature using AVHRR for more than twenty years. This global observation has spatial resolution of 1 Km at nadir, samples twice daily. Unfortunately, this observation cannot be directly used in studies of global climate change because of the problems of satellite orbit drift, cloud contamination, and lack of diurnal cycle information. Corrections for these problems have been developed to reduce such errors (Jin and Dickinson 1999, 2000, Gutman 1999, Jin 2000, Jin and Treadon 2001) and to produce a diurnal cycle data set for land surface skin temperature (referred to as "LSTD"). Inferred from the thermal emission of terrestrial surfaces, LSTD are some combination of vegetation canopies and soils. The data set includes the 24-hour average, maximum, and minimum values of diurnal cycle, and are tabulated at monthly intervals and 8 Km resolution. This data set provides an independent source of information regarding global changes of surface temperature over the last two decades. The stand deviation of individual monthly average values are estimated to be about 1 to 2 C and to include spatially varying biases because of variations in surface emissivity and other such factors. However, such biases are largely reduced when studying anomalies.

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DATA EVALUATION

It is essential to validate LSTD before applying it in studies of climate change. Due to the lack of other independent, long-term, high resolution, global observations, NCEP reanalysis, which is physically consistent, is considered as the most helpful data to examine the spatial and temporal variations of LSTD (Kalnay et. al. 1996).

Figure 1 is the climatology of diurnal averaged skin temperature for July. The data are averaged from 1981-1998 at half degree resolution which is scaled up from original 8 Km. The snow-covered areas such as southward of 60S are not retrieved. Comparison with the NCEP reanalysis shows encouraging consistency between these two data. More importantly, satellite data present more spatial structures of temperature with details valuable for studies of regional climate. Figure 2 compares zonal mean AVHRR-based T_s with NCEP reanalysis for July 1997 (upper panel) and July 1988 (lower panel), for land areas only. Ev-

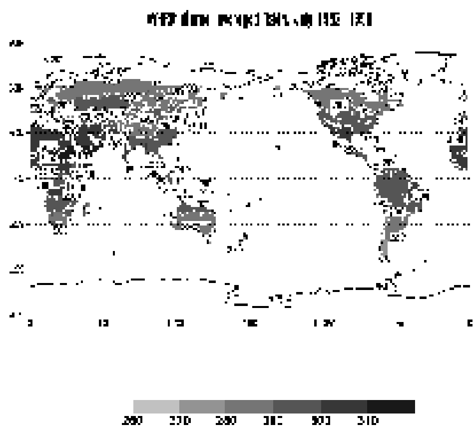


Figure 1:

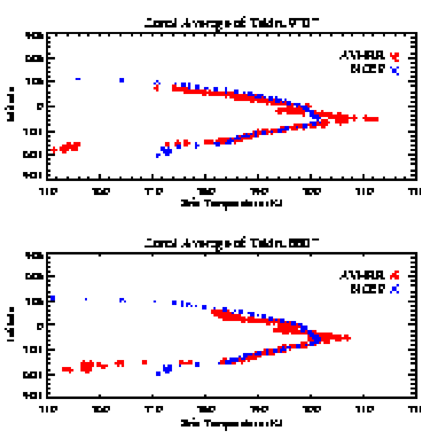
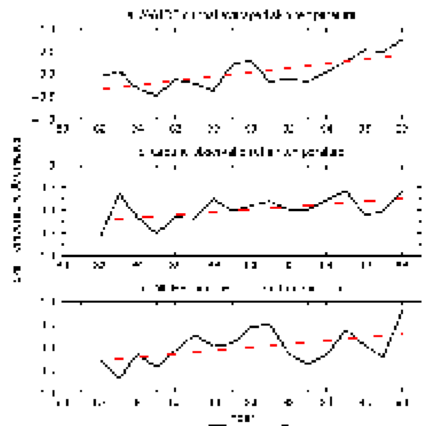


Figure 2:



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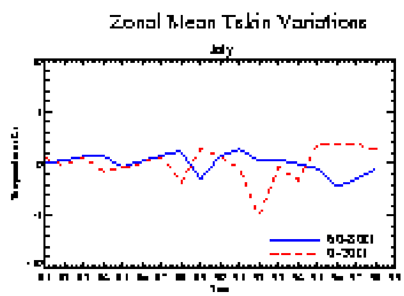

Figure 4:

idently, the two agree with each other very well except at the tropical areas. The large discrepancies in the tropics are partly due to the imperfect first guess field of the assimilation scheme (Trenberth et.al. 2001), and partly due to the problems of AVHRR T_s retrieval at arid areas. The agreements of 1988 and 1997 indicate that the quality of the data is generally reliable for most land areas in El Nino and La Nina events.

RESULTS

Figure 3 compares the anomalies of global mean satellite T_s, WMO T_a, and NCEP reanalysis of T_s. An obvious positive trend during the study period is observed from these three surface temperature data sets. Satellite AVHRR T_s has increased at 0.43 C/decade, while the rates for T_a and NCEP T_s are 0.28 C/decade and 0.34 C/decade, respectively. The consistency of satel-

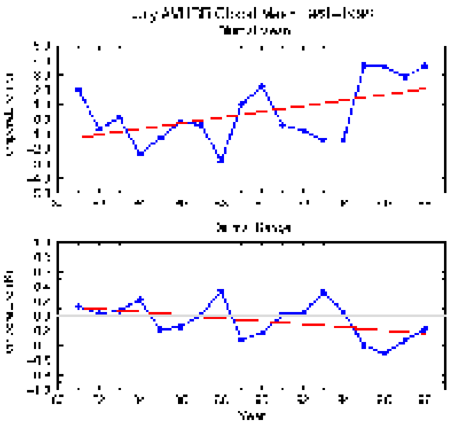

Figure 5:

lite T_s and NCEP/NCAR reanalysis suggests that a warming does occur during 1981-1998. In addition, the exact rate of increase depends on how global and annual averages are calculated.

Seasonality and latitude-dependence are also evident from LSTD. Figure 4 is the zonal mean T_s anomalies during 1981-1998, for 0-20N and 60-80N respectively. Although in July the variations of T_s is not as significant as in January (not shown), low latitudes have larger variations of T_s than that of high latitudes. This is the same result as reported from GCM (Schneider and Dickinson, 1974), implying a positive lapse rate feedback.

Land-biosphere-atmosphere interactions are responsible for global and regional climate changes. High resolution satellite data makes it possible to study the variation of T_s over different land cover. Figure 5 is T_s anomalies over desert and semi-desert areas at low latitudes. Although the trend may not be statistically significant, desert areas show larger interannual variations than those of other areas. Furthermore, the diurnal range of skin temperature decreases during 1982 to 1998 (Fig. 5 lower panel), which is similar to the global averaged result.

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