Version 6 Surface Skin/Surface Air Temperature Differences and their Interannual Variability

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Background

This research is a continuation of previous AIRS Sounder Science Team work, now being done under the proposal "Development, Validation, and Scientific Evaluation of a Multi-Year Sounder Based Climate Data Set using Products Derived from AIRS, CERES, MODIS, and TOVS Observations".

The surface skin/surface air temperature difference $\Delta T_{s,a}$ is defined as the difference between two standard Version 6 products, surface skin temperature, T_{skin} (SurfSkinTemp) and surface air temperature, $T(p_s)$ (SurfAirTemp) where p_s is the surface pressure.

$$\Delta T_{s,a} = T_{skin} - T(p_s)$$

$\Delta T_{s,a}$ is a very important parameter with regard to the understanding of the sensible heat flux between Earth's surface skin and its atmosphere.

Version 6 Generation of T_{skin} and $T(p_s)$

AIRS radiances are very sensitive to changes in T_{skin}, which is derived simultaneously with shortwave spectral emissivity $\varepsilon_{sw}(v)$, and spectral surface bi-directional reflectance $\rho_{sw}(v)$, using AIRS channels between 2396 cm^{-1} and 2665 cm^{-1}. On the other hand, AIRS radiances are not sensitive to changes in $T(p)$ very near the surface.

$T(p)$ retrievals are generated by adding relatively coarse structure (≈ 2 km) changes to the initial temperature guess $T^0(p)$. Fine vertical structure in $T(p)$ comes from fine structure in $T^0(p)$. AIRS Version 6 generates for the first time reasonable values of $T(p_s)$ because the Neural-Net first guess $T^0(p)$ contains very accurate low level temperature profile fine structure. This was not the case in Version-5, which used a regression guess for $T^0(p)$.

Influence of T_{skin} on $T(p_s)$

The *T(p)* retrieval step is performed after the T_{skin} retrieval. *T(p)* is not constrained in anyway by T_{skin}. T_{skin} is used in the generation of the radiances, R_i^{comp}, for those channels used in the *T(p)* retrieval step. R_i^{comp} is a function of T_{skin} and *T(p)*.

T(p) is determined so as to make R_i^{comp} (T_{skin}, *T(p)*) best match the radiances R_i for those channels used in the *T(p)* retrieval process. If T_{skin} is too warm (cold), this would make R_i^{comp} too high (low) for a given *T(p),* and the solution would tend to lower (raise) values of *T(p)* to compensate for the error in T_{skin}. Therefore, errors in T_{skin} would tend to produce errors in $T(p_s)$ of the opposite sign, and consequently degrade $\Delta T_{s,a}$.

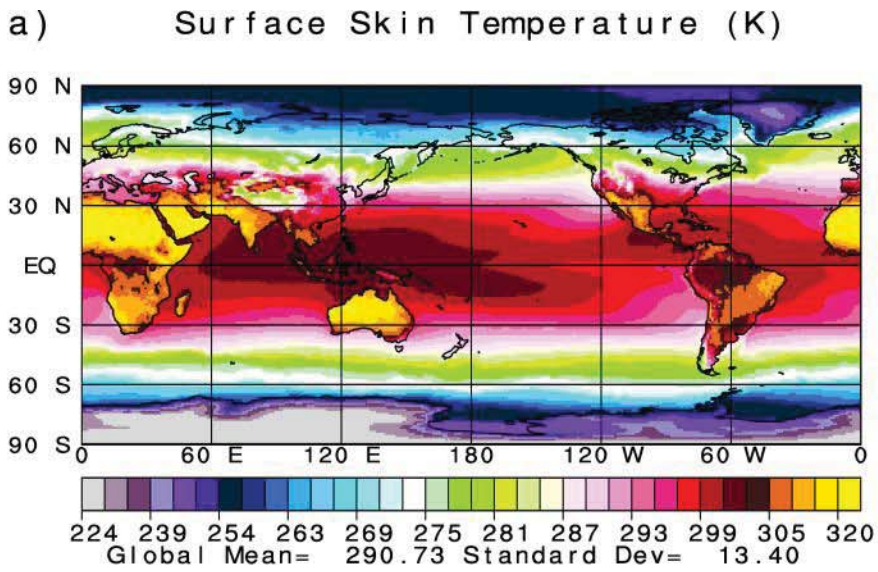
Objective of the Talk

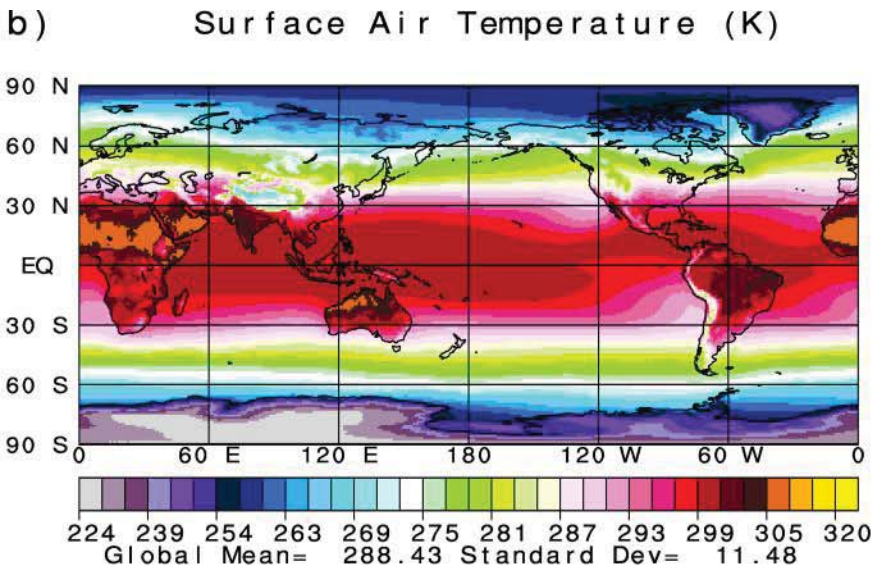
The objective of this talk is to show the characteristics of $\Delta T_{s,a}$ in terms of its climatology, and also to show its interannual variability

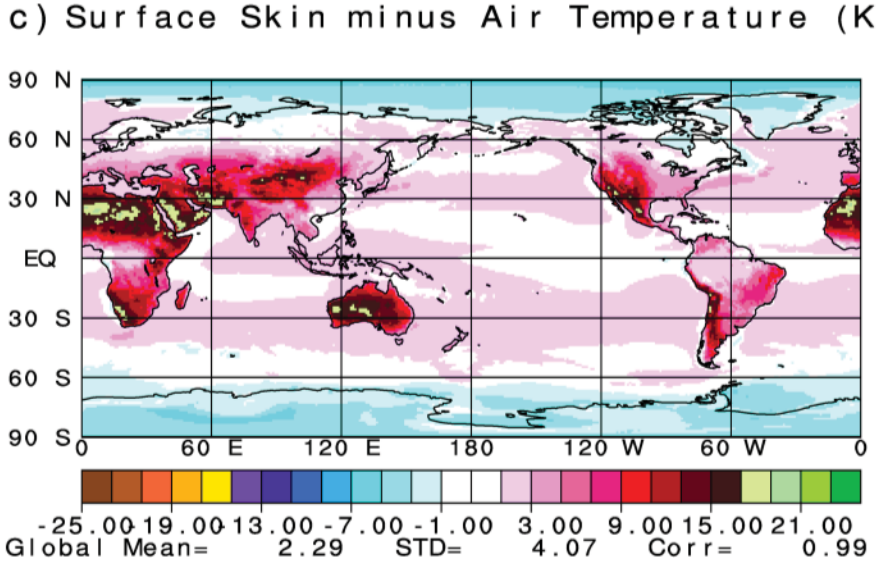
AIRS Version-6 Level-3 data now covers the 12 year period September 2002 through August 2014. We constructed 1:30 PM and 1:30 AM monthly mean climatologies on a 1° x 1° spatial scale by averaging the grid point values of a parameter for that month over the 12 year time period

The next viewgraphs show annual mean and seasonal mean climatologies of $T_{s,a}$ at both 1:30 PM and 1:30 AM local times

Annual Mean Climatology 1:30 PM





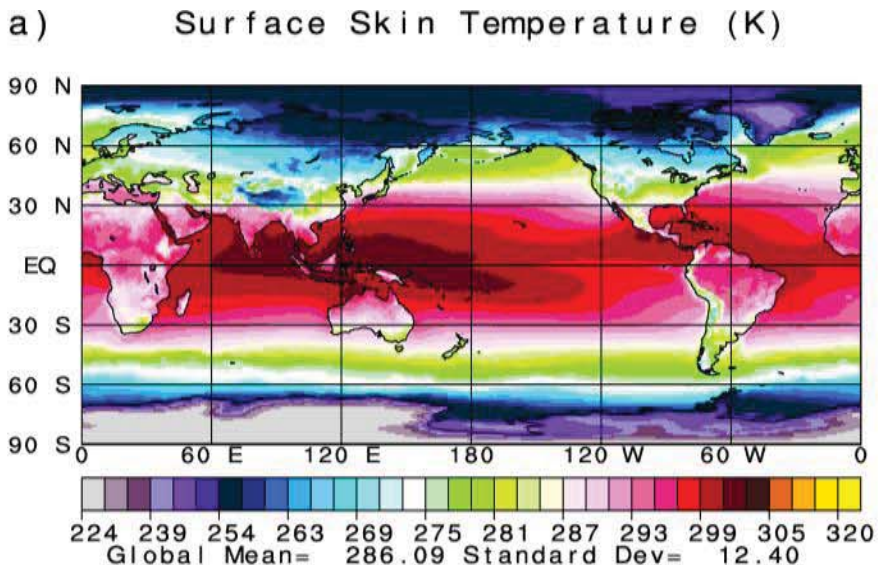


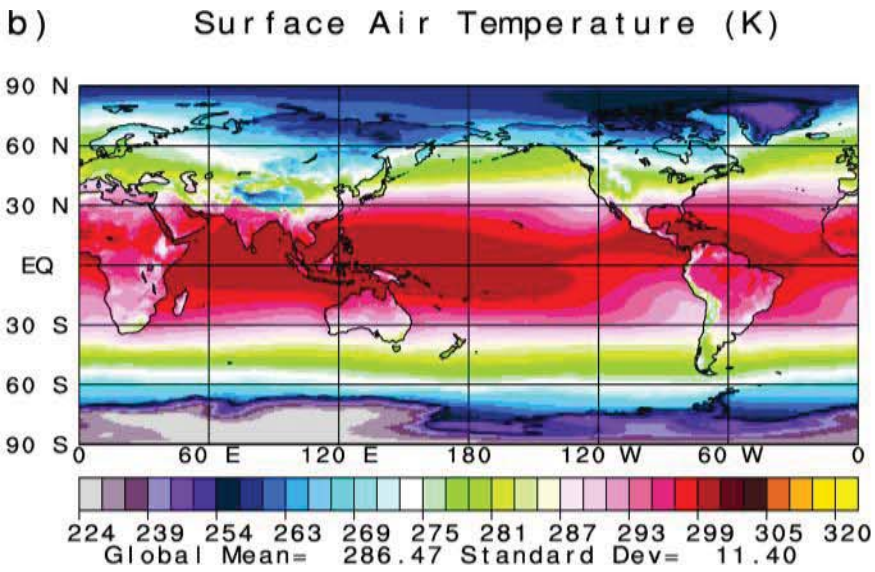
The 1:30 PM annual mean surface skin temperature is considerably warmer than the surface air temperature over land, especially in arid areas.

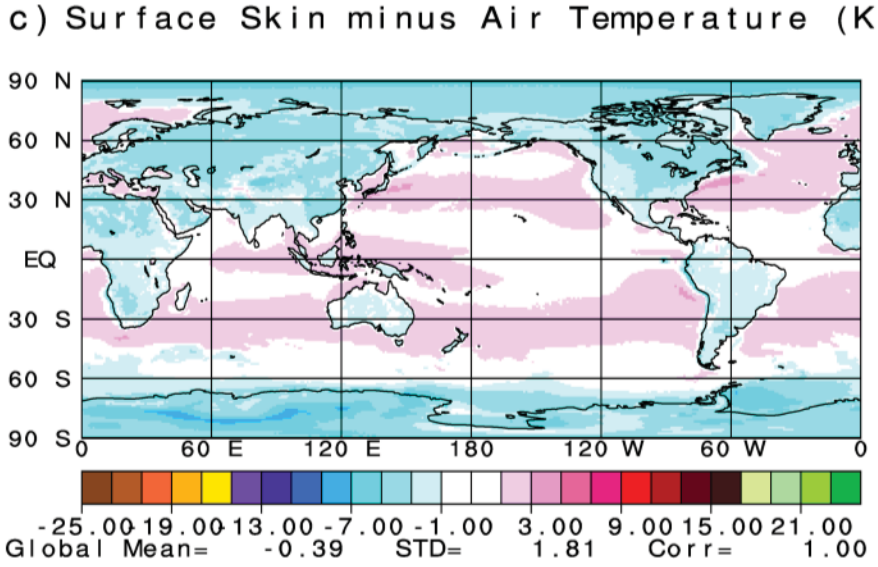
Oceanic surface skin temperatures also tend to be warmer than surface air temperatures in the mid-latitudes.

Polar surface skin temperatures are colder than surface air temperatures except over open ocean

Annual Mean Climatology 1:30 AM



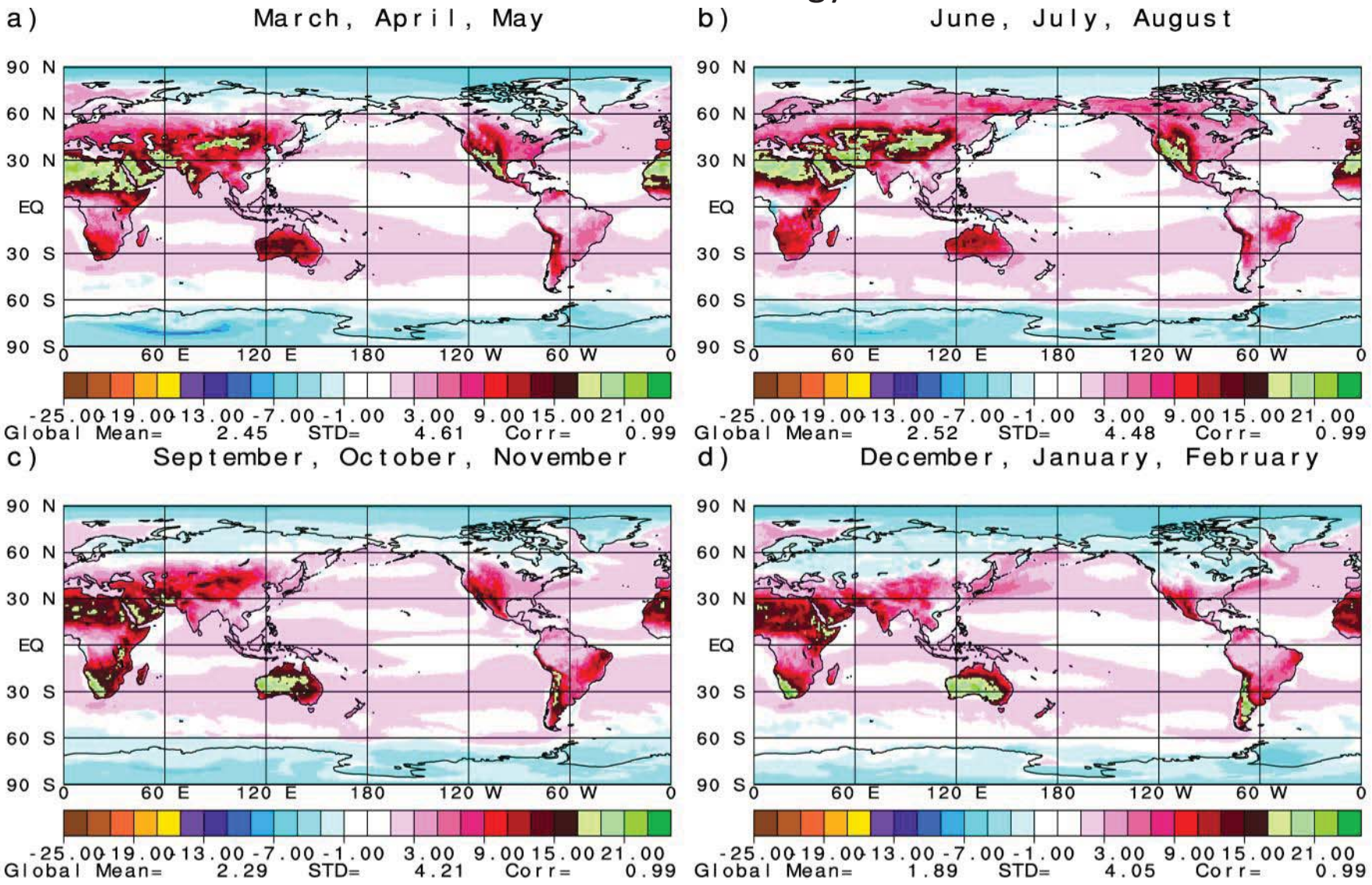




The 1:30 AM annual mean surface skin, surface air temperature differences are similar to that at 1:30 PM over ocean and in polar regions.

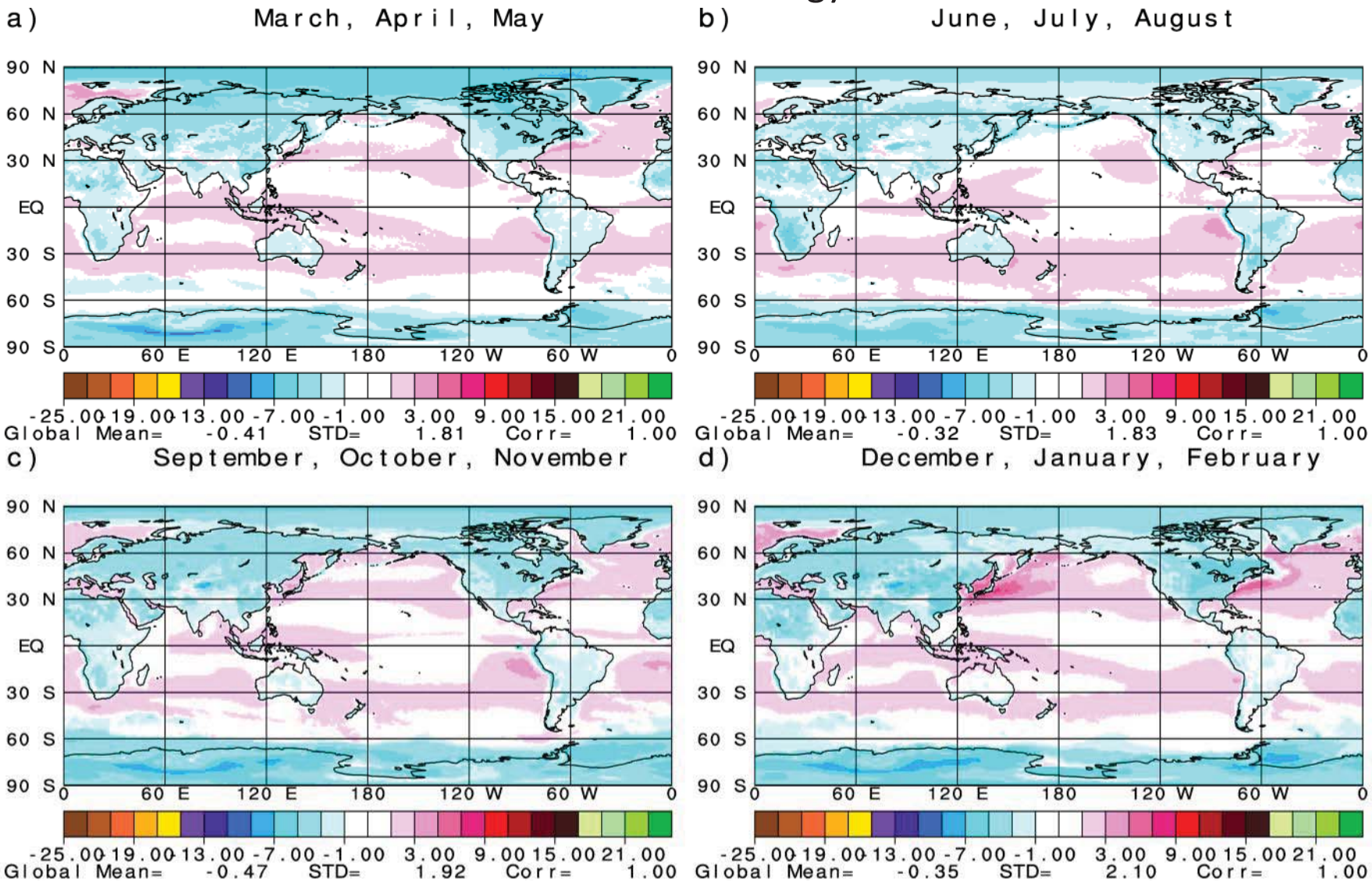
Unlike at 1:30 PM, most land area surface skin temperatures are colder than surface air temperatures at 1:30 AM

Surface Skin Temperature minus Surface Air Temperature (K)
Seasonal Mean Climatology 1:30 PM



The basic patterns of 1:30 PM surface skin temperature minus surface air temperature are common in all seasons. Over land, local spring and local summer patterns are similar to each other, as are local fall and local winter patterns.

Surface Skin Temperature minus Surface Air Temperature (K)
Seasonal Mean Climatology 1:30 AM



Interseasonal differences of 1:30 AM surface skin minus surface air temperatures over land are smaller than at 1:30 PM. Ocean surface skin temperatures are significantly warmer than surface air temperatures off the east coast of Asia and North America in the winter.

Interannual Variability of $\Delta T_{s,a}$

We depict interannual variability of $\Delta T_{s,a}$ in terms of the behavior of its anomaly time series

The grid point anomaly for a month in a given year is the value of the product for that month minus its climatology

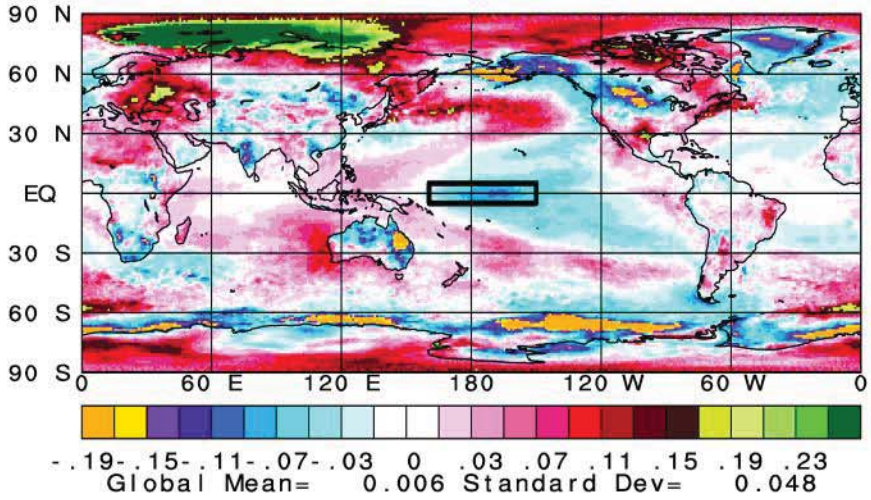
The Average Rate of Change (ARC) of a product is the slope of the linear least squares fit to the anomaly time series

The El Niño Correlation (ENC) is the correlation of the anomaly time series with that of the El Niño Index (ENI)

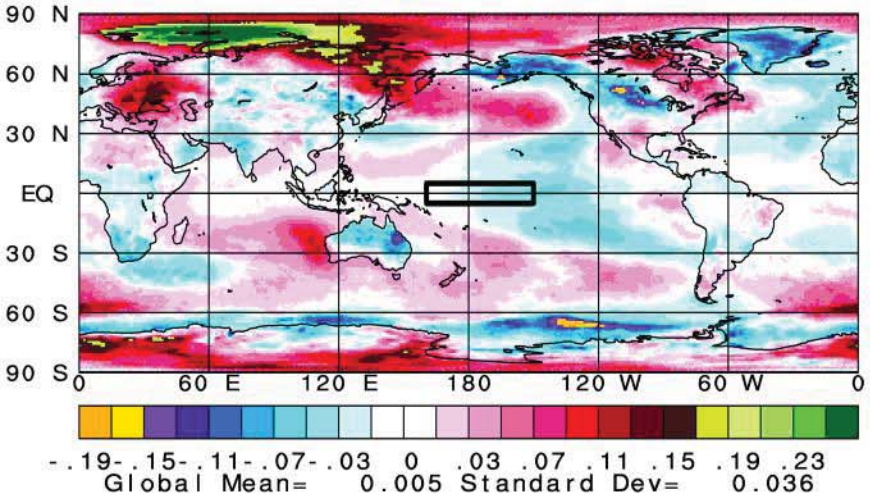
The ENI for a given month is the NOAA Niño-4 SST minus its climatology as computed over the same 12 consecutive years

AIRS Version-6 ARCs (K/yr)
September 2002 through August 2014 1:30 AM/PM Average

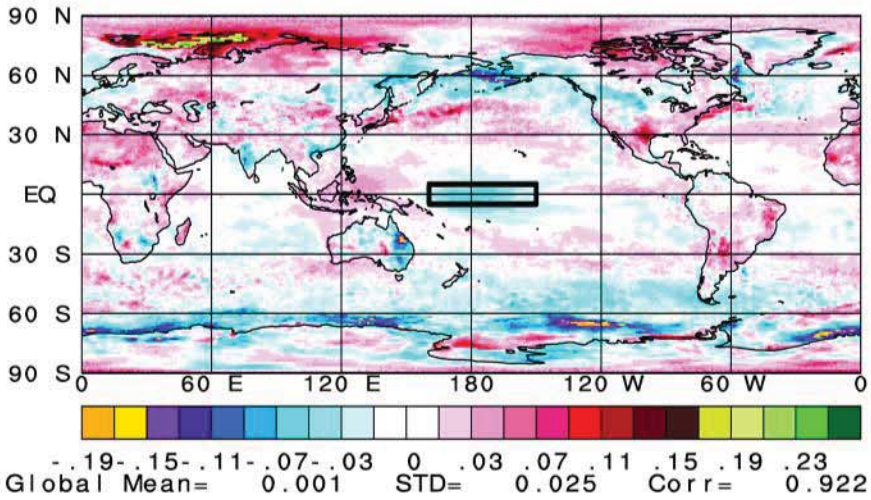
a) Surface Skin Temperature



b) Surface Air Temperature



c) Surface Skin minus Surface Air Temp

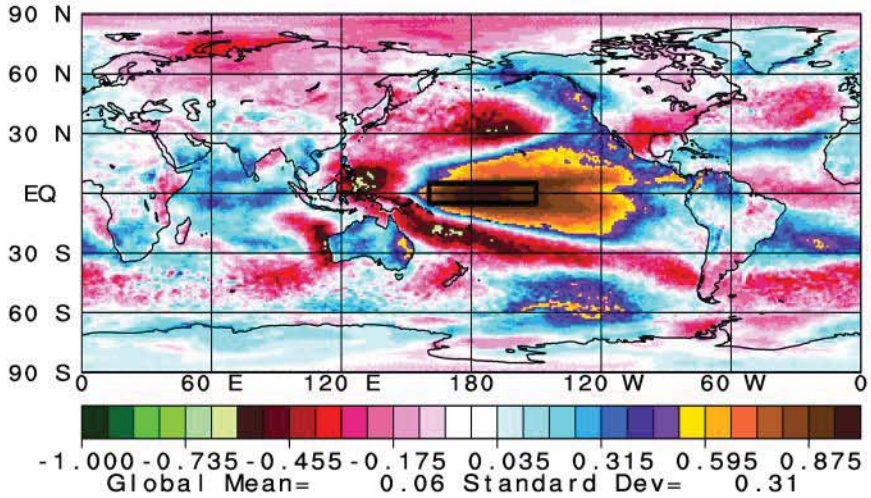


Niño 4 region

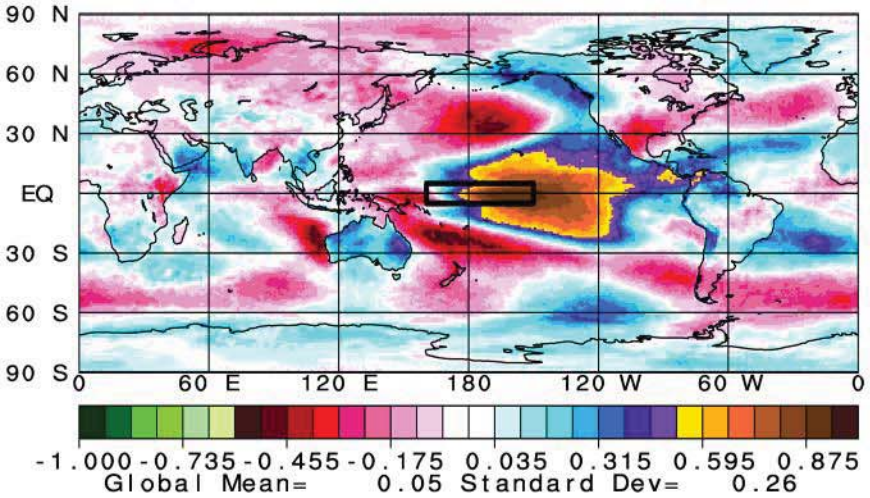
- ARCs of surface skin and surface air temperatures show pronounced spatial patterns, which are highly correlated with each other in space. ARCs of surface skin temperature are generally larger than those of surface air temperature.
- Surface skin temperatures over the Niño 4 region have cooled over the last 12 years, which started with an El Niño.
- There has been considerable warming of both surface skin and air temperature at high northern latitudes, but cooling over Greenland.

AIRS Version-6 ENCs
September 2002 through August 2014 1:30 AM/PM Average

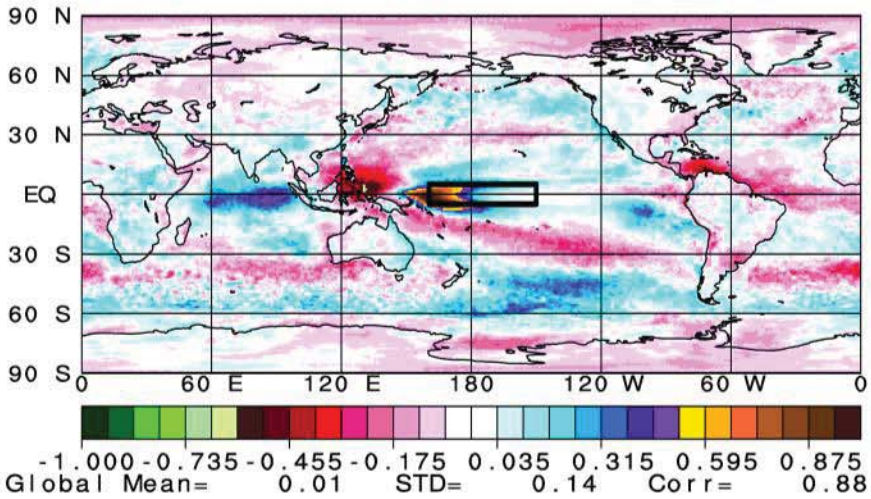
a) Surface Skin Temperature



b) Surface Air Temperature



c) Surface Skin minus Surface Air Temp



ENCs of surface skin minus surface air temperature exhibit a strong oscillation centered over Indonesia

Local anomaly time series of surface skin and air temperatures are each highly correlated (or anti-correlated) with the El Niño Index. ENCs of surface skin temperature are similar to those of surface air temperature but larger. These correlations are the main cause for the patterns of ARCs. Regions with positive correlations cool, as the Niño 4 region did, while regions with negative correlations warm. Temperature anomalies in polar regions are not highly correlated with El Niño.

Niño 4 region

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Summary

We computed level-3 values of surface skin minus surface air temperature $\Delta T_{s,a}$ by subtracting level-3 values of $T(p_s)$ from level-3 values of T_{skin}

Level-3 values of $\Delta T_{s,a}$ appear to be of high quality with regard to both their climatology and interannual variability. We encourage researchers (including ourselves) to study characteristics of $\Delta T_{s,a}$ to evaluate if it is currently accurate enough for their research purposes.

While level-3 values of $\Delta T_{s,a}$ are easy to generate using Version 6 products, does the Science Team feel that level-3 values of $\Delta T_{s,a}$ should be written out as a separate product when the next version of the AIRS retrieval system is configured? Version 6 QC flags for T_{skin} and $T(p_s)$ are not identical. $\Delta T_{s,a}$ should have its own QC flag.