Recent Global Warming as Observed by AIRS and Depicted in GISSTEMP and MERRA-2

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Overview

This paper compares monthly mean anomaly time series of earth surface temperature T_s contained in 4 different data sets.

AIRS/AMSU Version-6

September 2002 – August 2016

AMSU A2 died in September 2016

AIRS Only Version-6 (AO)

September 2002 – September 2017

MERRA-2

September 2002 – September 2017

*GISS TEMP(GIS)

September 2002 – July 2017

*GIS is considered the “Gold Standard” of surface temperature data sets. GIS uses only in-situ measurements.

Construction of Monthly T_s Anomalies

We constructed T_s anomalies for each data set on a 1^o lat by 1^o lon spatial scale. The T_s anomaly for a given month, in a given year, is the difference of its value for that year from a 14 year T_s climatology we constructed for that month.

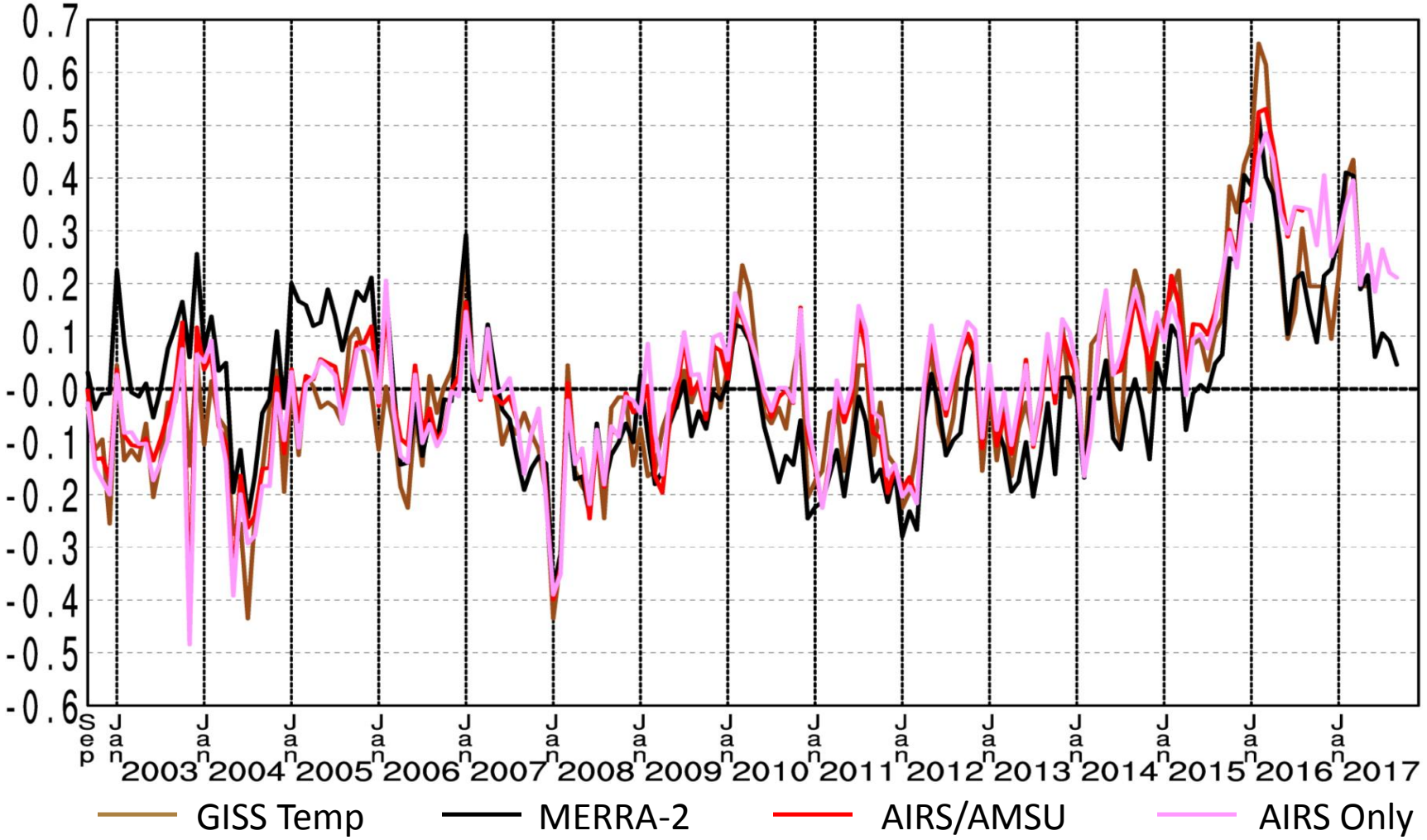
Monthly Climatologies

Monthly climatologies are based on 14 consecutive years for that month.

September–December: 14 consecutive years from September 2002-December 2015.

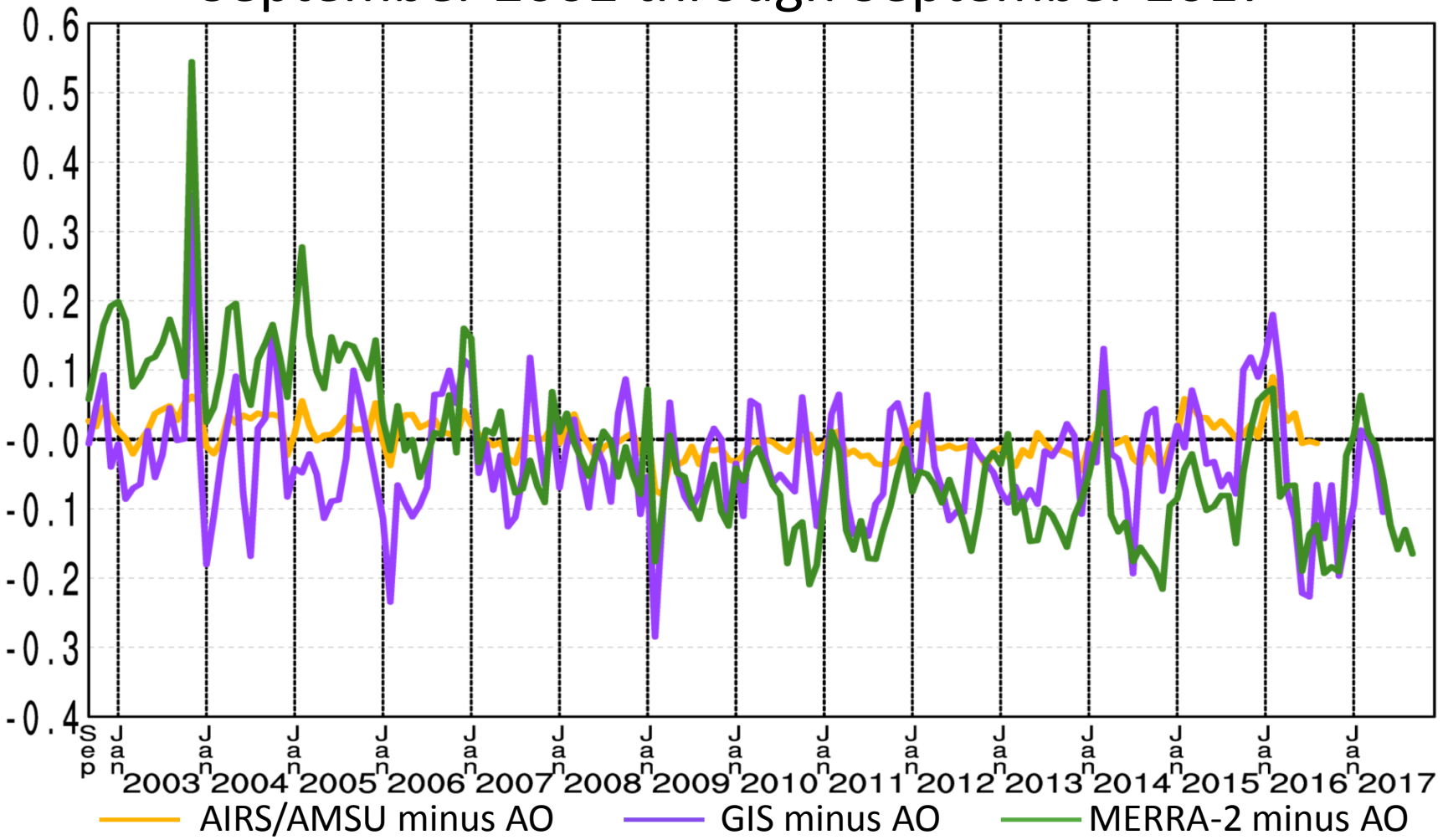
January–August: 14 consecutive years from January 2003-August 2016.

Global Mean Surface Skin Temperature Anomaly (K)
September 2002 through September 2017



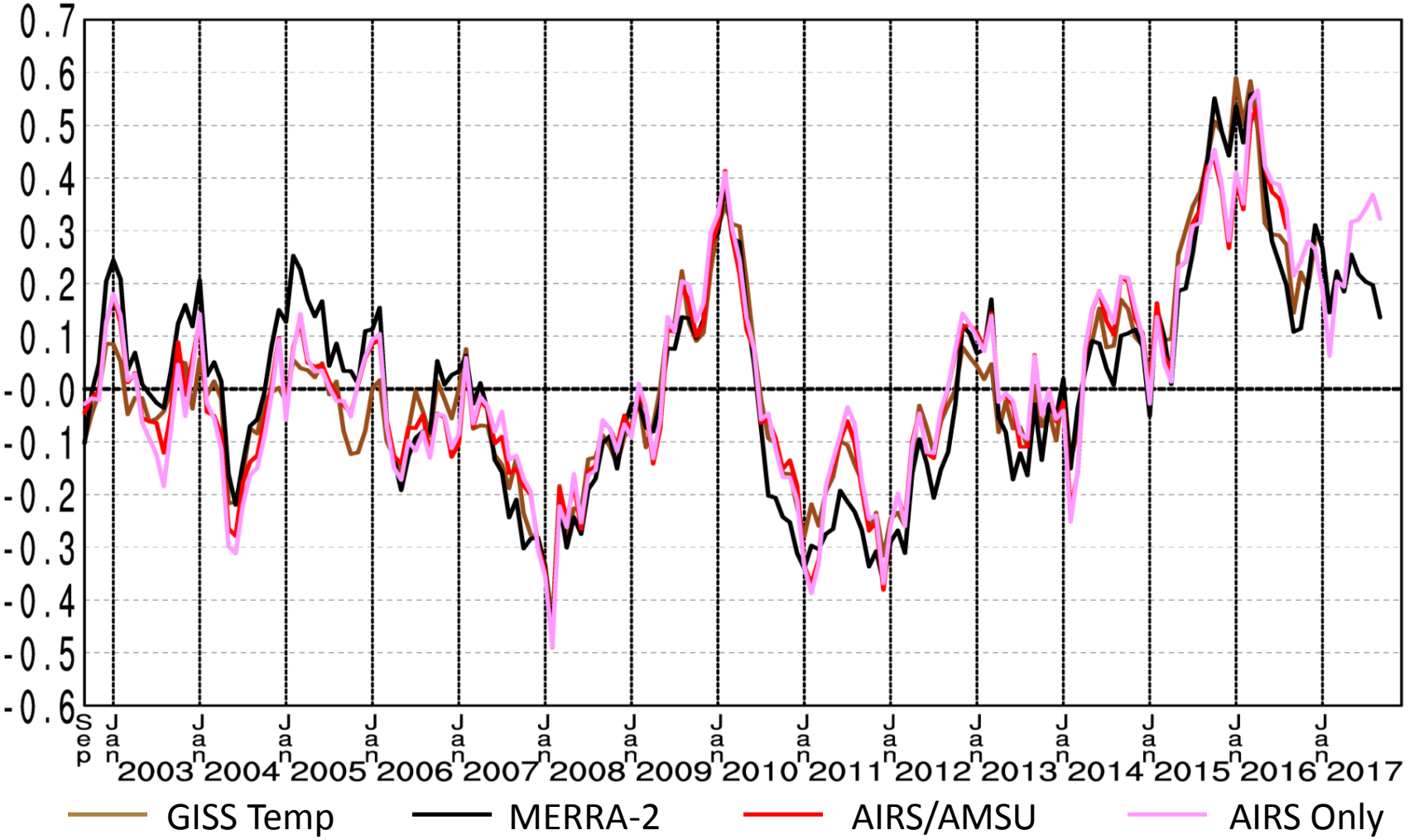
All data sets show oscillations, but with an onset of significant global warming starting in 2015, with a peak in 2016.

Global Mean Surface Skin Temperature Anomaly Differences from AIRS Only (K) September 2002 through September 2017



AIRS/AMSU anomalies match those of AO very closely over their common time period. MERRA-2 anomalies have a discontinuity compared to AO in the 2007-2008 time frame. They are higher through 2006 and lower after 2009.

Tropical Mean Surface Skin Temperature Anomaly (K)
September 2002 through September 2017



Tropical mean GIS data is only available through December 2016. The tropics, representing 50% of the globe, has warmed as much as the whole globe did after 2015. Therefore tropical and extratropical warming has been the same after 2015.

T_s Anomaly Spatial Plots

Two types of spatial plots related to T_s anomalies are shown.

1) Average rates of change (ARCs) of anomaly time series.

The ARC of an anomaly time series is the slope of the least squares fit to the anomaly time series (*K/yr*).

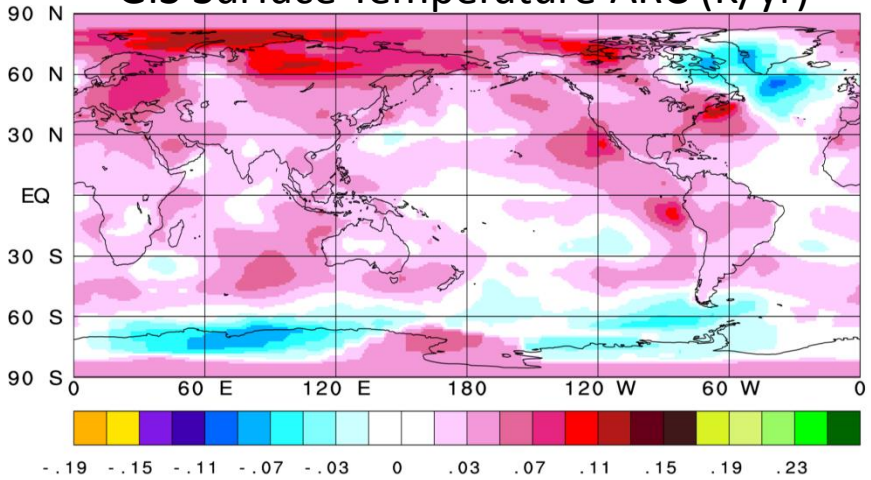
We compare ARCs of AO, GIS, and MERRA-2 T_s values over the time period September 2002 through July 2017, as well as anomalies for July 2017.

2) Spatial plots of recent AO T_s anomalies.

Monthly mean T_s anomalies have large scale structures. Some areas are warmer than their climatological values, and some are cooler. These locations change from month to month, and year to year, but recent global mean T_s anomalies are all positive, as are tropical mean anomalies.

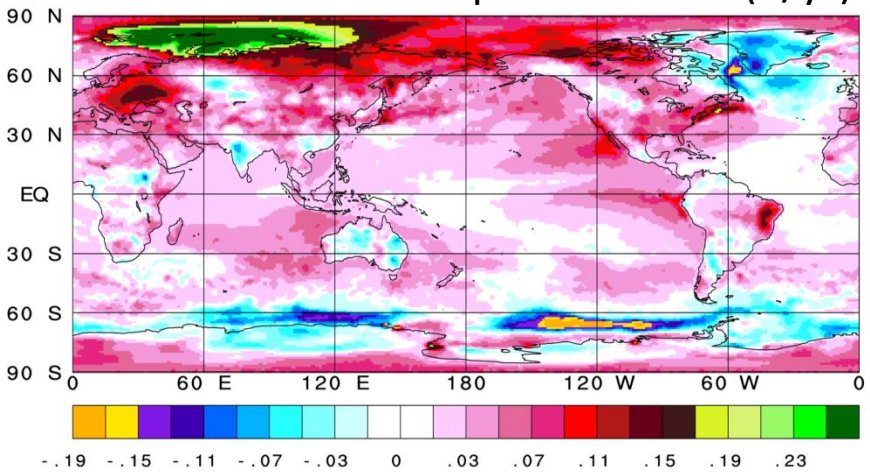
September 2002 through July 2017

GIS Surface Temperature ARC (K/yr)



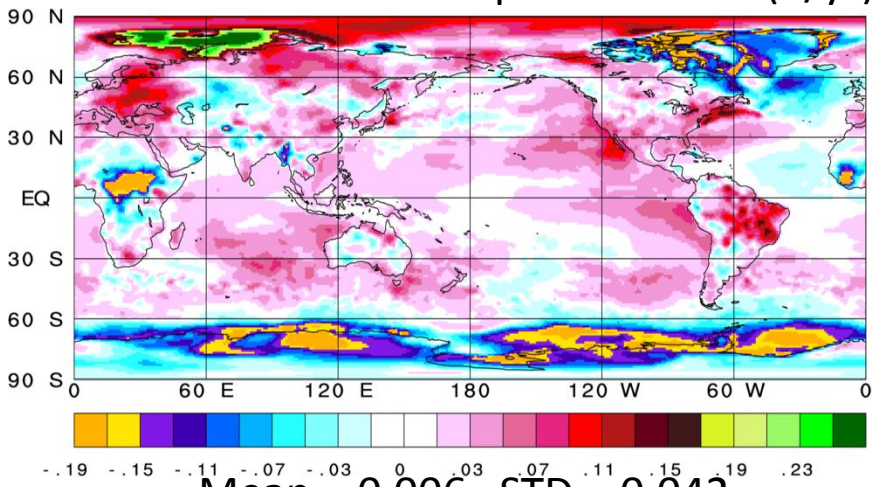
Mean = 0.021 STD = 0.023

AO Surface Skin Temperature ARC (K/yr)



Mean = 0.024 STD = 0.032

MERRA-2 Surface Temperature ARC (K/yr)



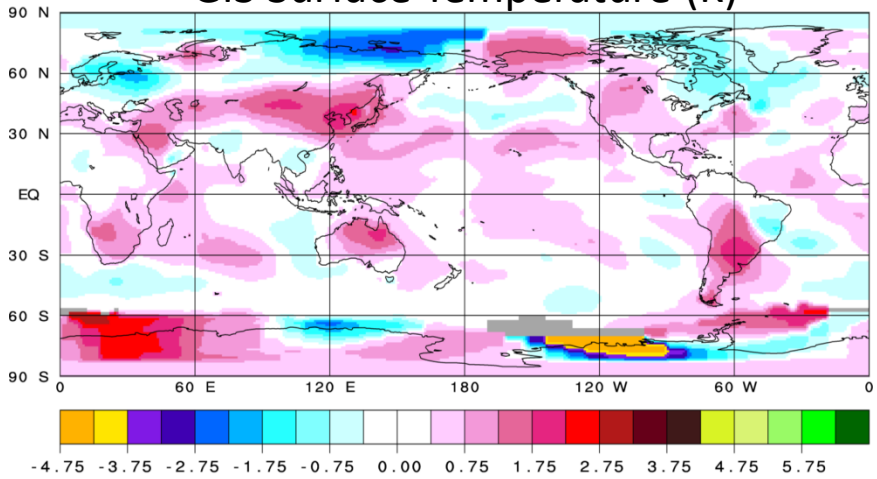
Mean = 0.006 STD = 0.042

AIRS and GIS both show the Earth's surface has warmed globally by about 0.022K/yr over the period September through July 2017. GIS is at a 2^o x 2^o spatial resolution. Therefore, its features are smaller and smoother than those of AIRS. The relative patterns agree very well.

The discontinuity in MERRA-2 T_s anomalies has resulted in a spurious global trend showing almost no warming. Significant differences between AO and MERRA-2 ARCs exist over Africa and Antarctica.

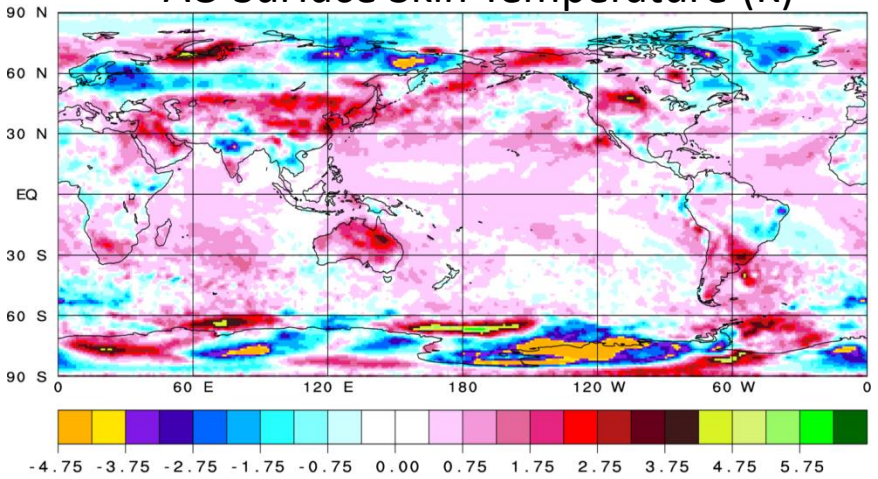
July 2017 Surface Temperature Anomaly

GIS Surface Temperature (K)



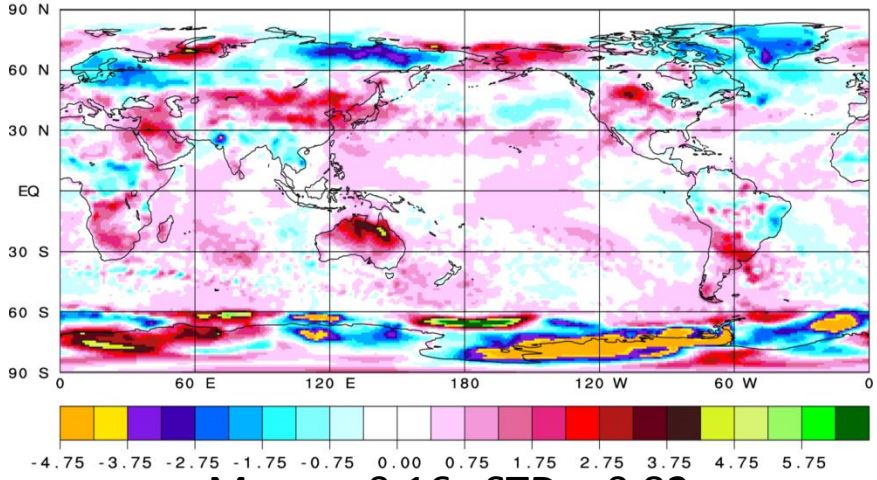
Mean = 0.23 STD = 0.57

AO Surface Skin Temperature (K)



Mean = 0.26 STD = 0.80

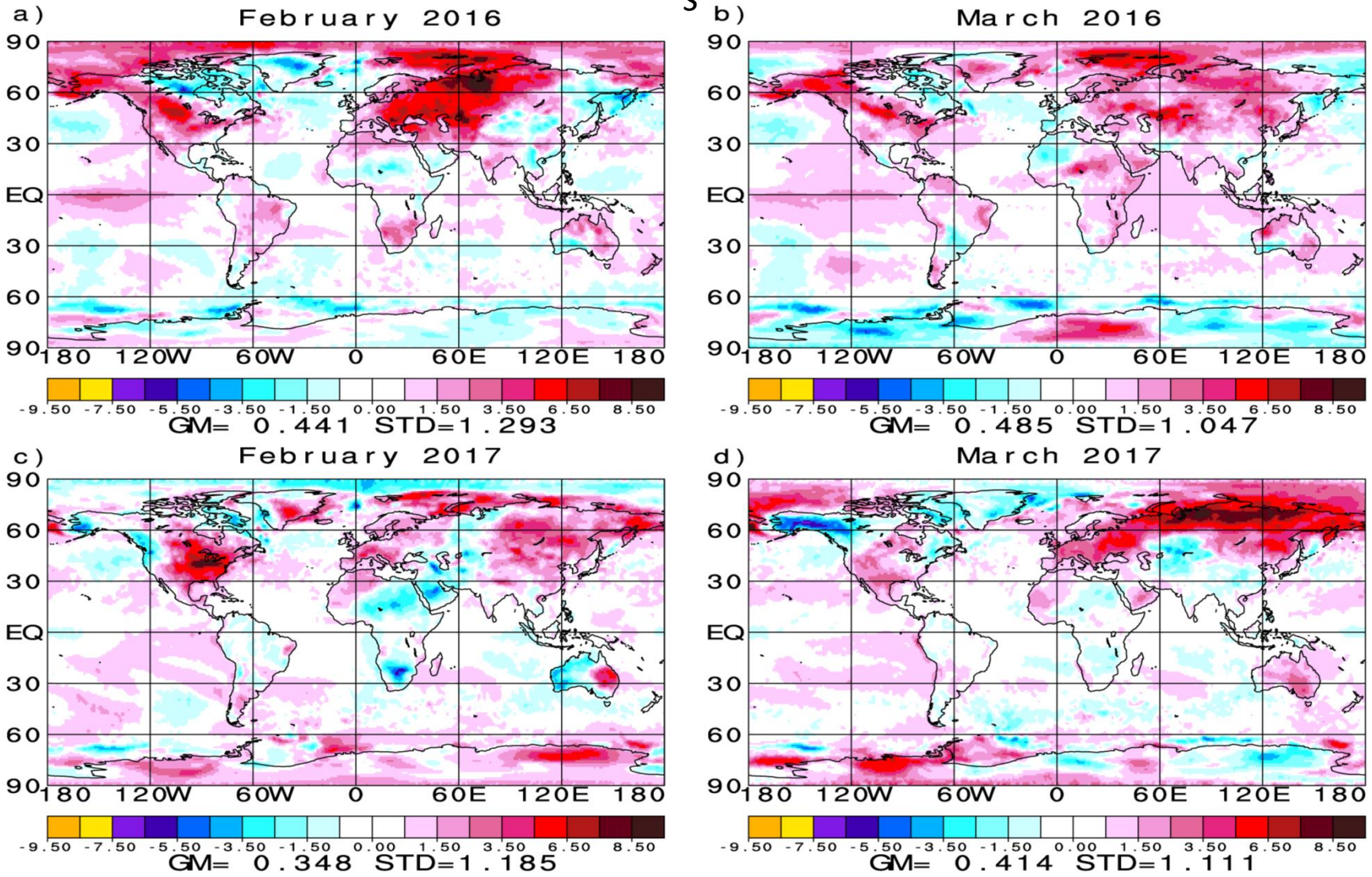
MERRA-2 Surface Temperature (K)



Mean = 0.16 STD = 0.82

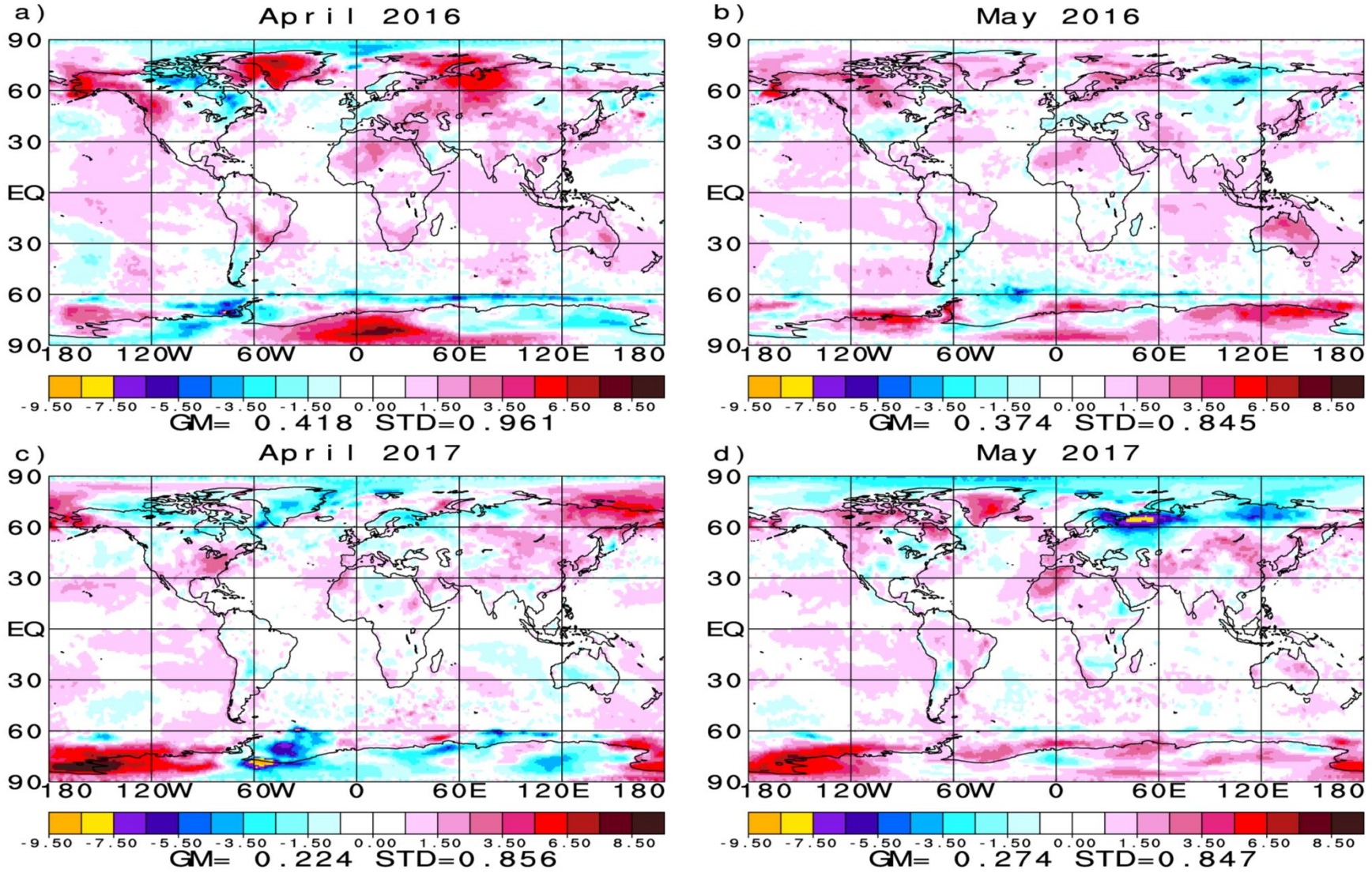
Basic patterns of AIRS and GIS July 2017 T_s anomalies are very similar. As with ARCs, GIS anomalies are smoother and weaker. The global mean MERRA-2 T_s anomaly is less positive than those of AO or GIS, but July 2017 anomaly patterns agree reasonably well with those of AO.

Recent AO T_s Anomalies



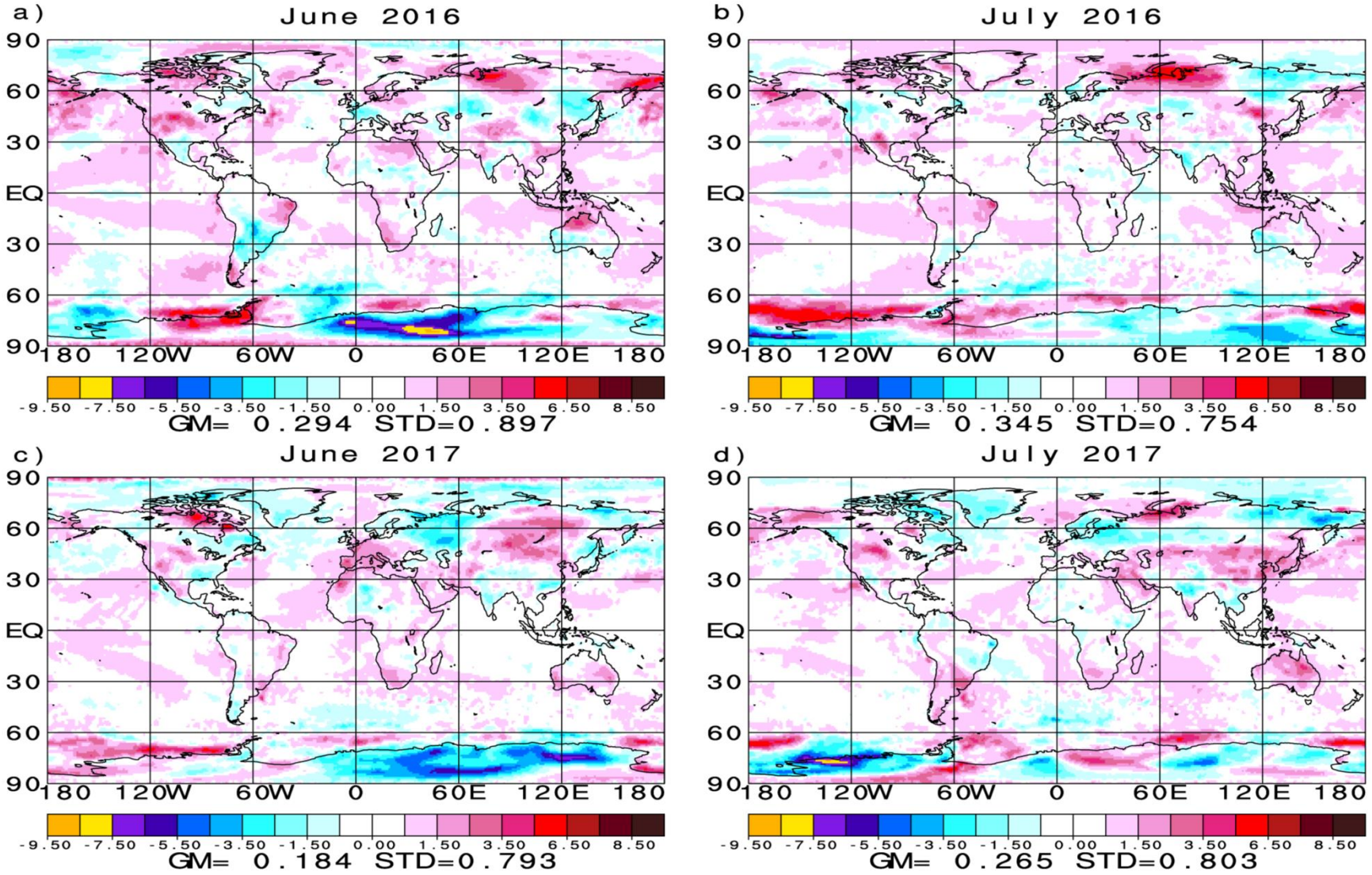
February and March 2016 and 2017 all have very large positive global mean T_s anomalies. All anomalies show an El Niño pattern, with values larger in 2016 than in 2017. Corresponding global mean T_s anomalies are also more positive in 2017.

Recent AO T_s Anomalies



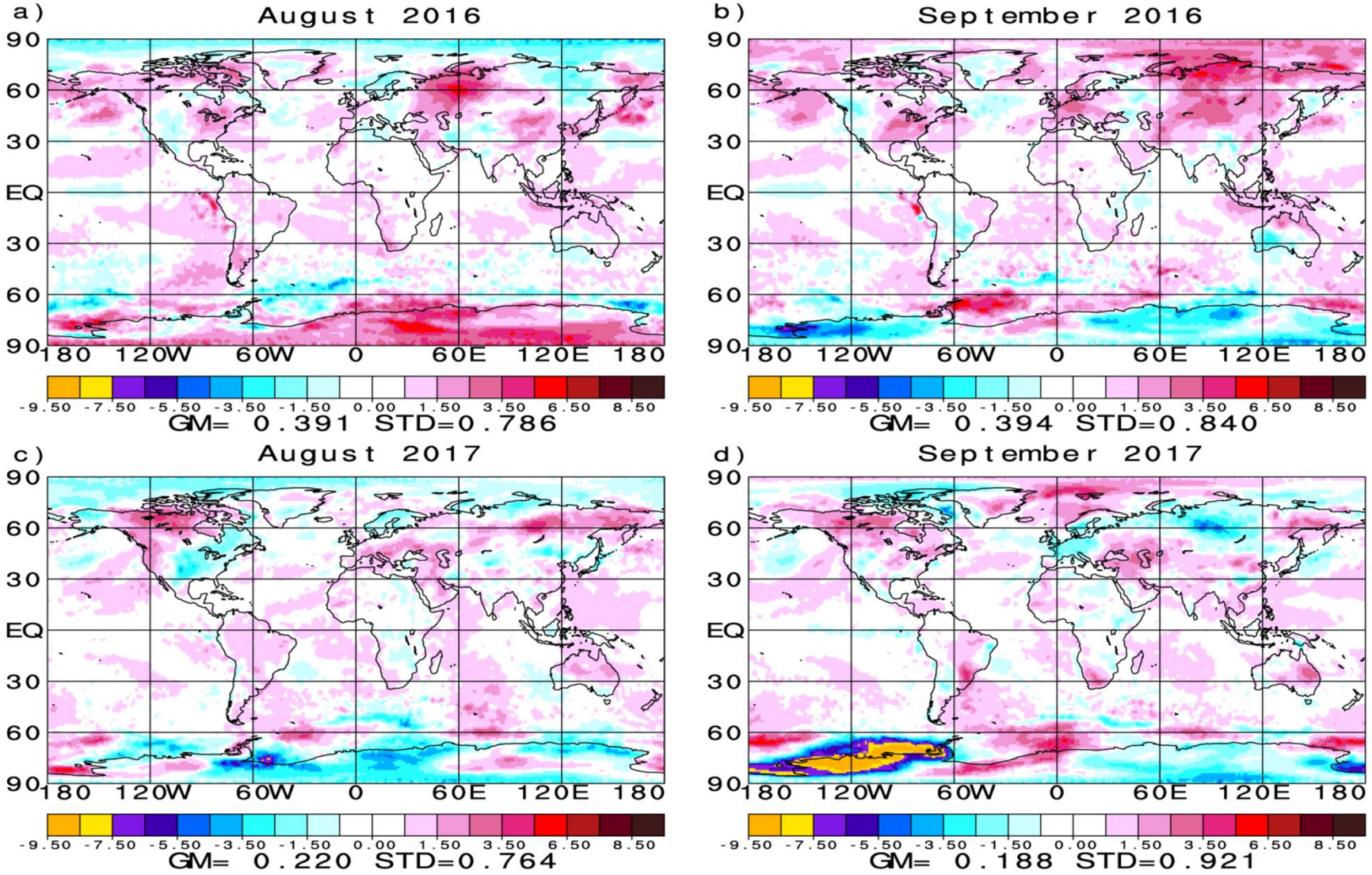
El Niño conditions still exist in all months, but are weaker than they were in February and March. Global mean T_s anomalies are positive, but are less so than in the previous 2 months. The largest T_s anomalies occur poleward of 60^{o}N and 60^{o}S.

Recent AO T_s Anomalies



El Niño conditions no longer exist, but positive global mean T_s anomalies still exist. T_s anomalies are largest in polar regions, especially in local winter.

Recent AO T_s Anomalies



La Niña conditions are beginning in both 2016 and 2017. Global mean T_s anomalies remain positive, but are less in 2017 than in 2016. Part of this reduction is a result of large negative T_s anomalies poleward of 60°S.

Summary

- AIRS Version-6 monthly mean level-3 surface temperature products confirm the result, depicted in the GISSTEMP dataset, that the earth's surface temperature has been warming since early 2015, though not before that. AIRS is at a higher spatial resolution than GISSTEMP, and produces sharper spatial features which are otherwise in excellent agreement with those of GISSTEMP.
- Version-6 AO T_s anomalies are consistent with those of Version-6 AIRS/AMSU. Version-7 AO anomalies should be even more accurate, especially at high latitudes.
- ARCs of MERRA-2 T_s anomalies are spurious as a result of a discontinuity which occurred somewhere between 2007 and 2008. This decreases global mean trends.