# Paradox of SST and lower tropospheric temperature trends over the tropical Pacific Ocean

Xuezhi Bai [1,2], S. Cocke [2], T.E. LaRow[2], James J. O'Brien [2] and D. W. Shin [2]
*1. Institute of Oceanology, Chinese Academy of Sciences*
*2. Center for Ocean-Atmospheric Prediction Studies, Florida State University*
*(xzhbai@ms.qdio.ac.cn)*

Observed and modeled data were used to study the long term climate changes over the tropical Pacific Ocean, focusing on the different trends between SST and the low-mid tropospheric temperature revealed by recent satellite observations. The study indicated that various kinds of datasets confirmed the existence of differential temperature trends between the ocean surface and bulk troposphere above in terms of spatially averaged time series. The tropical Pacific SST has been warming at a rate of about 0.08 K/Dec in last 25 years, while the low-mid troposphere over the tropical Pacific has been warming at a smaller rate of about 0.04 K/Dec from MSU2LT V5.2 (MSU channel 2, low-mid tropospheric temperature) or even cooling from MSU2LT V5.1, NCEP/NCAR reanalysis 2 and ERA40 (Fig. 1a and Table 1).

Linear trend map in the tropical Pacific SSTs shows that, in past 25 years, the western Pacific has been warming while the central eastern part is cooling. A similar pattern was also found in the trend of MSU2LT V5.2, though it is more zonally symmetric than the trend in SST. Low-mid troposphere over the western Pacific has been warming at a larger rate than over the eastern Pacific. Whereas, in the old version of MSU2LT (V5.1) and NCEP2, low-mid troposphere over the eastern Pacific has been cooling since 1979 (Fig. 2). The warming in the western Pacific contributes more to this discrepancy. The enhanced zonal gradient of SSTs induces an enhanced Walker circulation like flow in lower troposphere (Fig.3). Another mechanism involved is the land-ocean distribution. With small heat capacities, land surfaces equilibrate much more rapidly with the temperature of the overlying air mass than does the ocean, i.e., the air over land warms quicker than that over ocean. This zonal different warming rate will induce large-scale convergence circulation, driving cold air from upper level to make the lower troposphere cool over the ocean (Fig.3).

All climate models employed in this study fail to reproduce the different trends shown in the observation (Fig.1b and Table 2). AGCM forced by prescribed SST (AMIP2 simulations) predicted a warming trend in low-mid troposphere almost at the same rate as SSTs. With including all observed natural and anthropogenic forcings, coupled models ($20^{th}$ century climate change simulations) predicted larger warming trend in low-mid troposphere than that in SSTs (Table 3). Comparison of standard deviations of MSU2LT and equivalent MSU2LT (MSUE) computed from the AMIP2 simulations reveals that the atmosphere model could not reproduce the true response of low-mid troposphere to the SSTA in the cold tongue region (Fig. 4).

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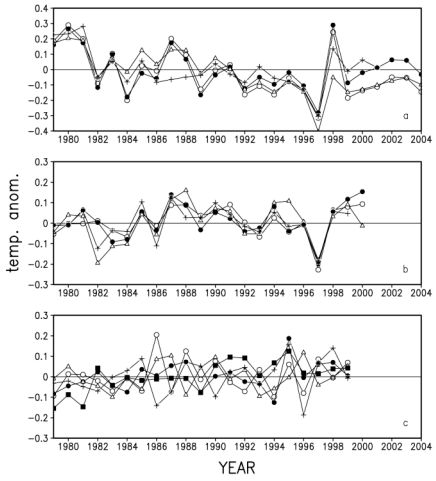


Fig.1 Annual differences of anomalies of various tropical Pacific low-mid tropospheric temperature versus SSTA. (a) MSU2LT V5.2 (closed circle), MSU2LT V5.1(open circle), NCEP2 (triangle) and ERA40 (cross) (b) AMIP2 simulations (c) 20c3m simulations

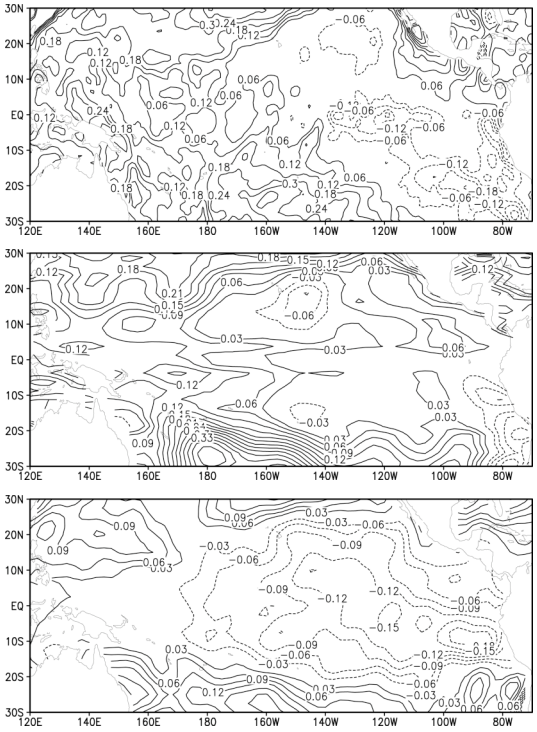

Fig.2 Linear trends in SST (top), MSU2LT V5.2(middle) and MSUE of NCEP2 (bottom)

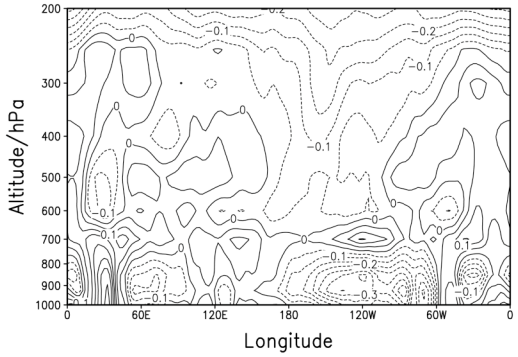


Fig.3 Linear trend in global tropical (20S-20N) tropospheric temperature

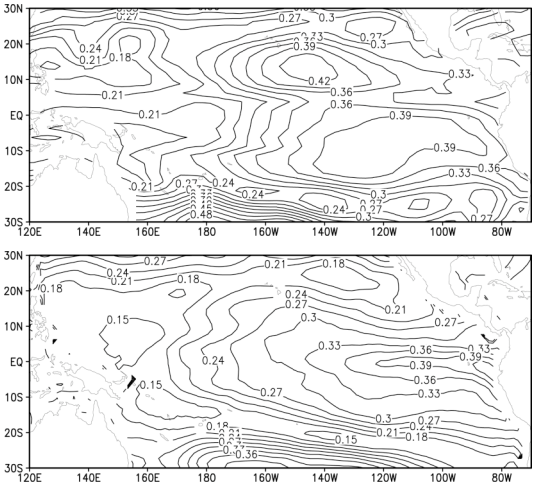

Fig.4 Standard deviations of MSU2LT(top) and MSUE in AMIP2 simulation using CAM (bottom)

Table 1 Trends in SST, MSU 2LT and MSUE 2LT of NCEP2 and ERA40 (K/Dec)

| | SST | MSU_2LT V5.1 | MSU_2LT V5.2 | NCEP2 | ERA40 |
|---|---|---|---|---|---|
| 1979-2004 | 0.08 | -0.023 | 0.04 | -0.04 | |
| 1979-1999 | 0.11 | -0.034 | 0.017 | -0.108 | -0.013 |

Table 2 Trends in MSUE of AMIP2 simulations

| | CAM3 | GISS3 | HadGem | ECHAM5 |
|---|---|---|---|---|
| 1979-1999 | 0.106 | 0.14 | 0.108 | 0.108 |

Table 3 Trends in MSUE (SST) of 20c3m simulations (K/Dec)

| | CCSM3 | GISS | HadgeM | ECHAM5/OMP | CGCM3.1 |
|---|---|---|---|---|---|
| 1979-1999 | 0.12 (0.098) | 0.14 (0.13) | 0.12 (0.085) | 0.14 (0.10) | 0.26 (0.18) |