# Climate Variability of Extreme Weather Events Observed by the Atmospheric Infrared Sounder (AIRS)

Sun Wong and Joao Teixeira

JPL/California Institute of Technology

March 17, 2014 (AIRS Science Team Meeting)

©2014 California Institute of Technology.
Government sponsorship acknowledged.

**Questions:**

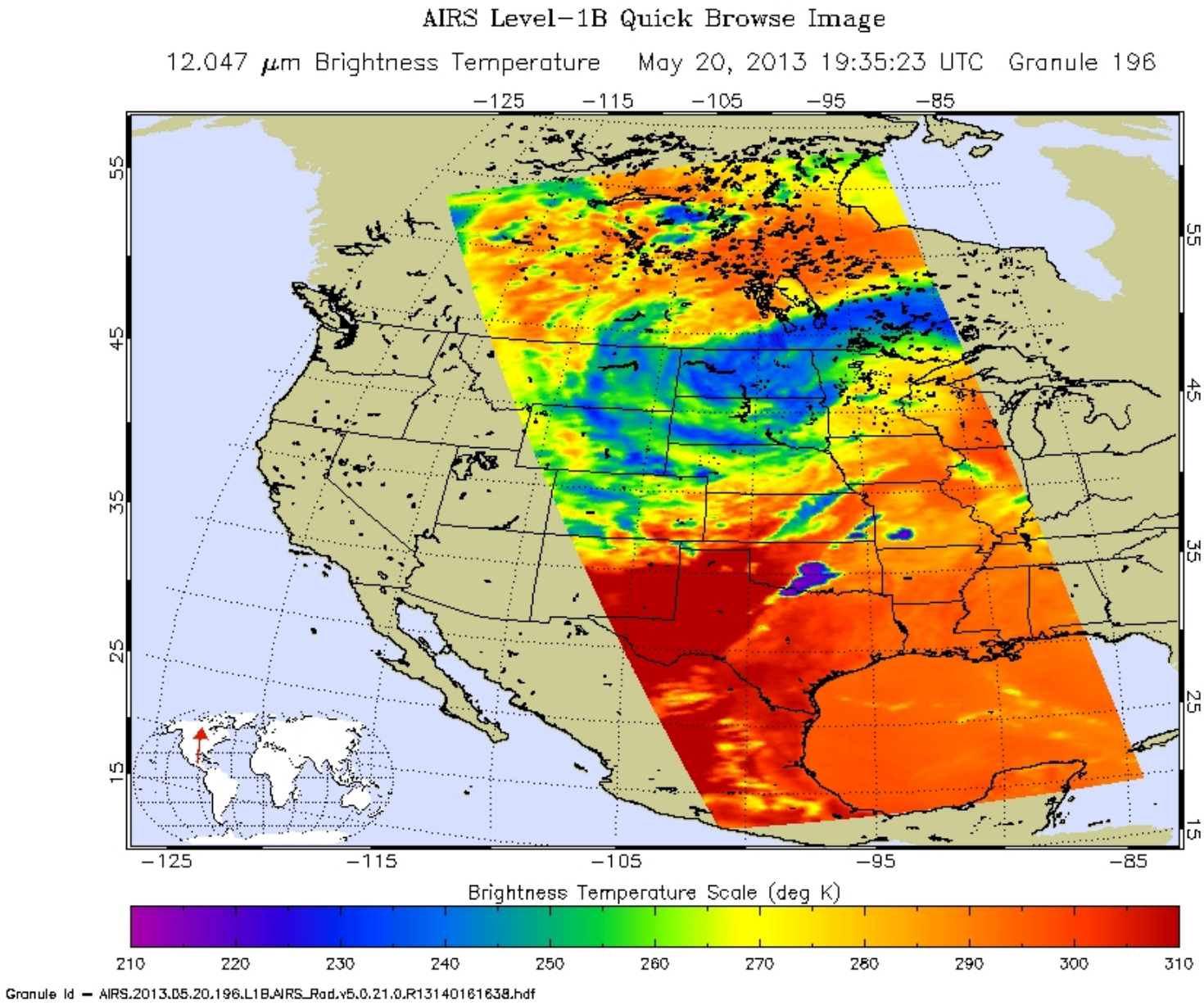
- Global mean precipitation constrained by energy balance

Extreme precipitation scales with the non-linear Clausius-Clapeyron relation (~7%/K)

- Regional observations show precipitation extremes more sensitive to surface T change, at a rate higher than predicted by the Clausius-Clapeyron relation (e.g., Lenderink and Meijgaard, 2008; Allan et al., 2010)

- Global observations using space-borne direct measurements of radiance

# AIRS L1B BT and a Tornado Event



## AIRS L1B to Study Extreme Events:

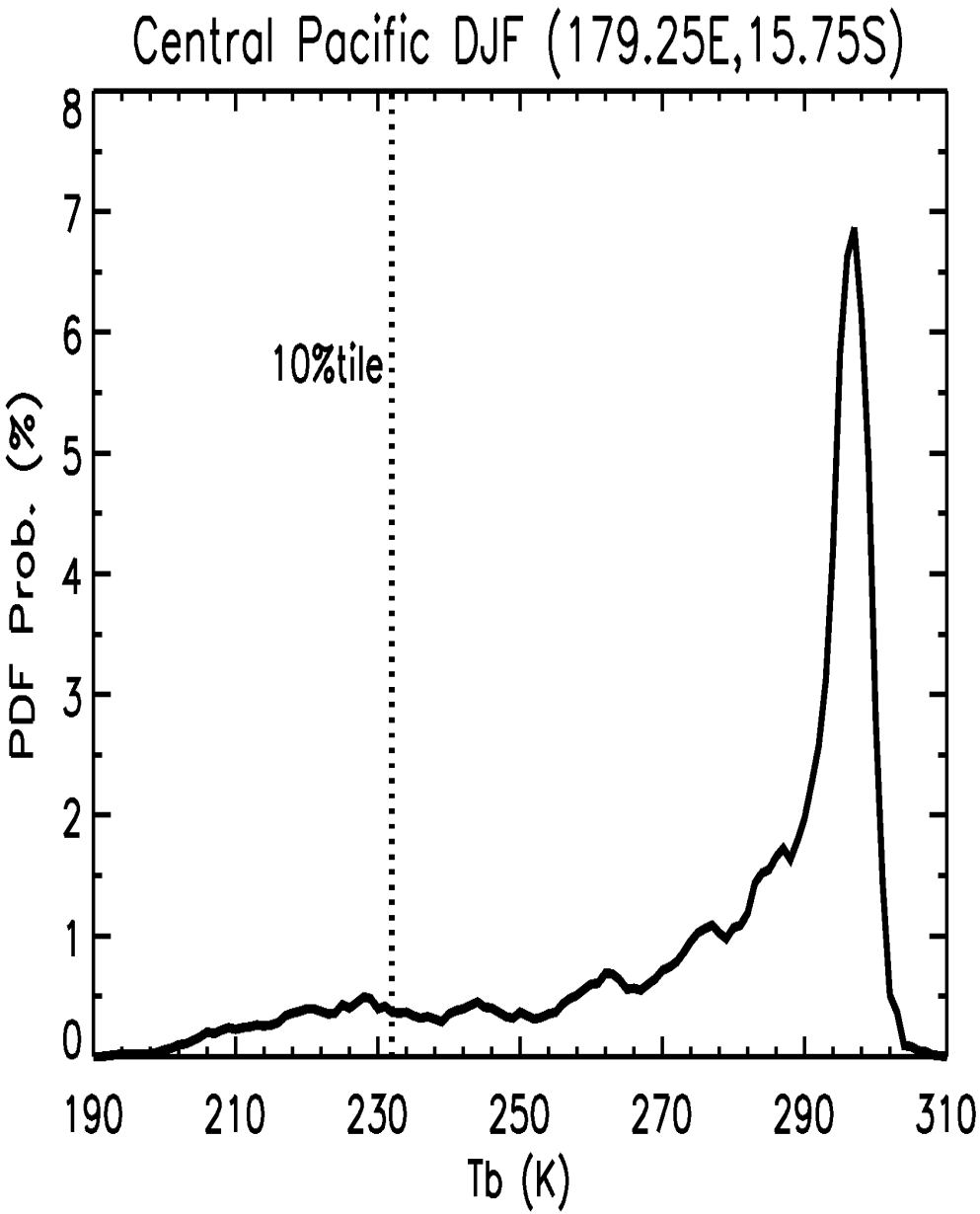
- Heavy storms are associated with cold cloud top.

- Ascending AIRS L1B BT (1231 $cm^{-1}$ ) at nadir for 2003-2011 (focus on the cold-end of the PDF)

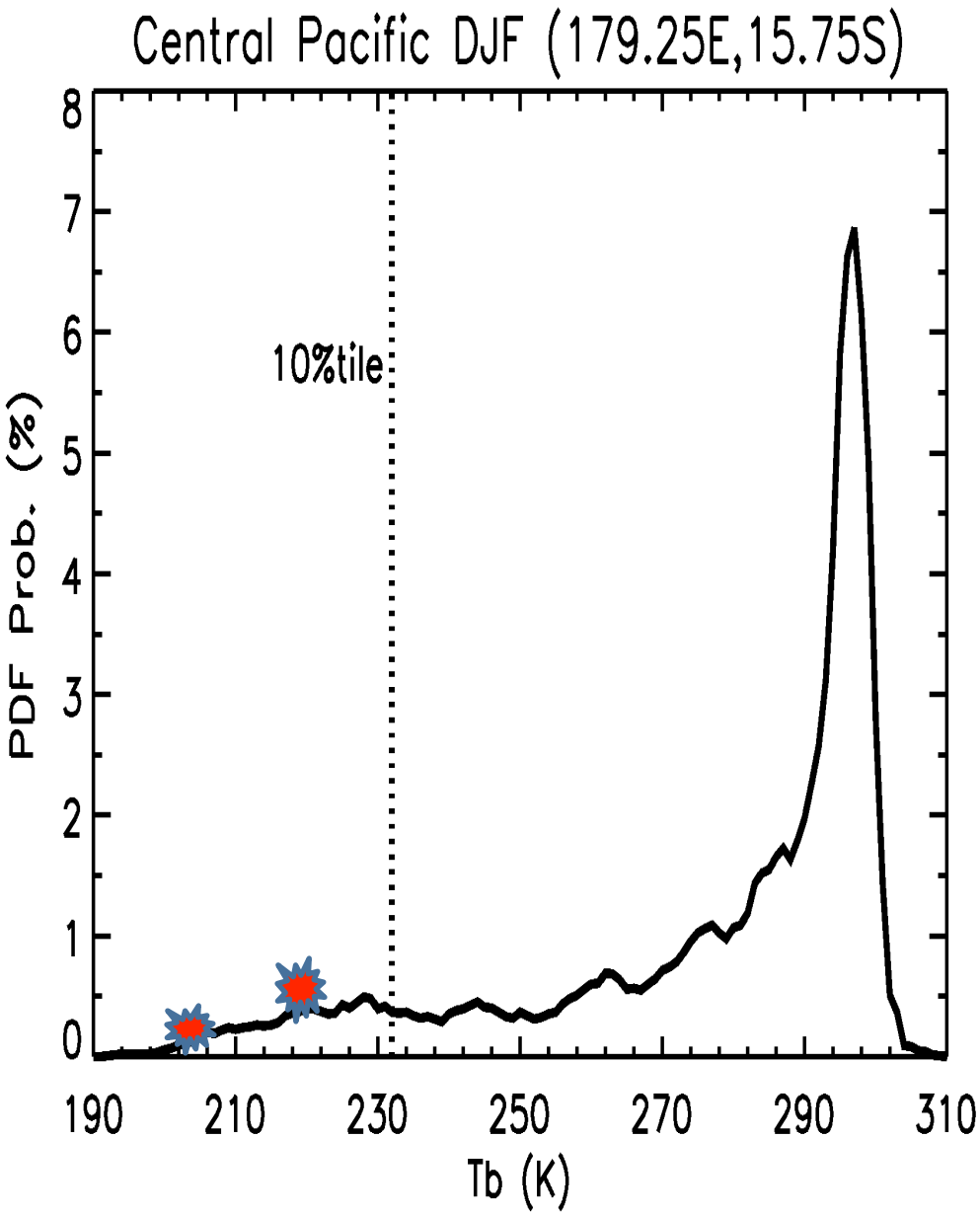
- Noon-time GSFC MERRA SST for 2003-2011

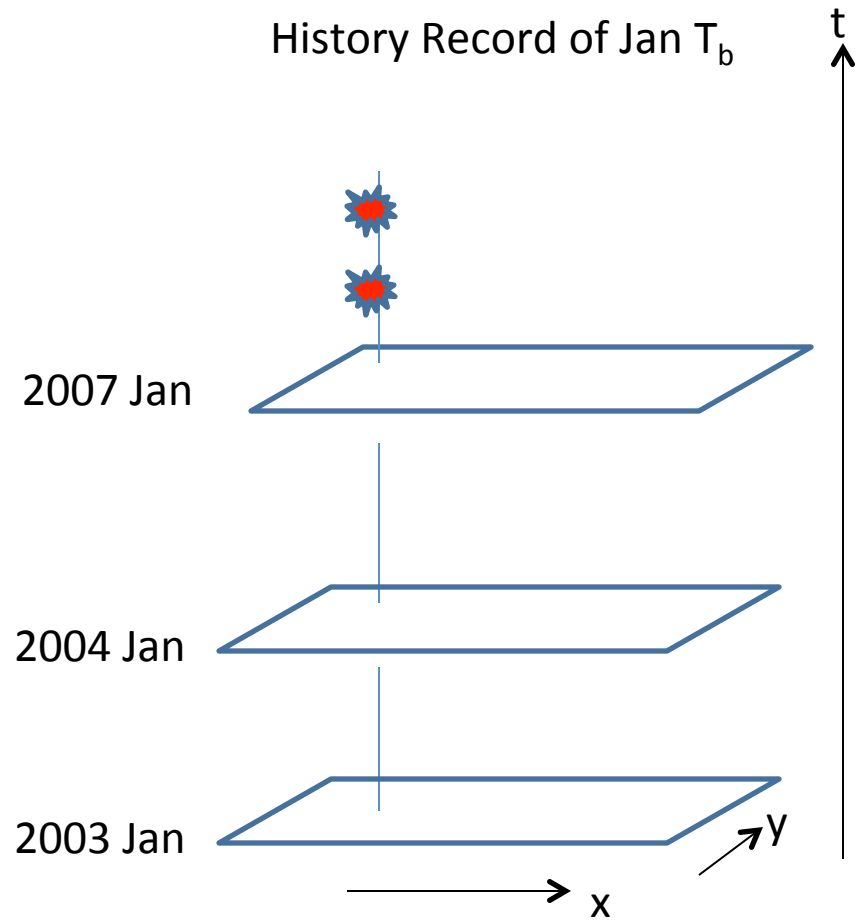
- Sensitivity of extreme weathers associated with development of strong deep convections and storms against natural variability (e.g., Seasonal cycle and ENSO)

# Schematic Diagrams of Finding for BT Cold-End Extremes

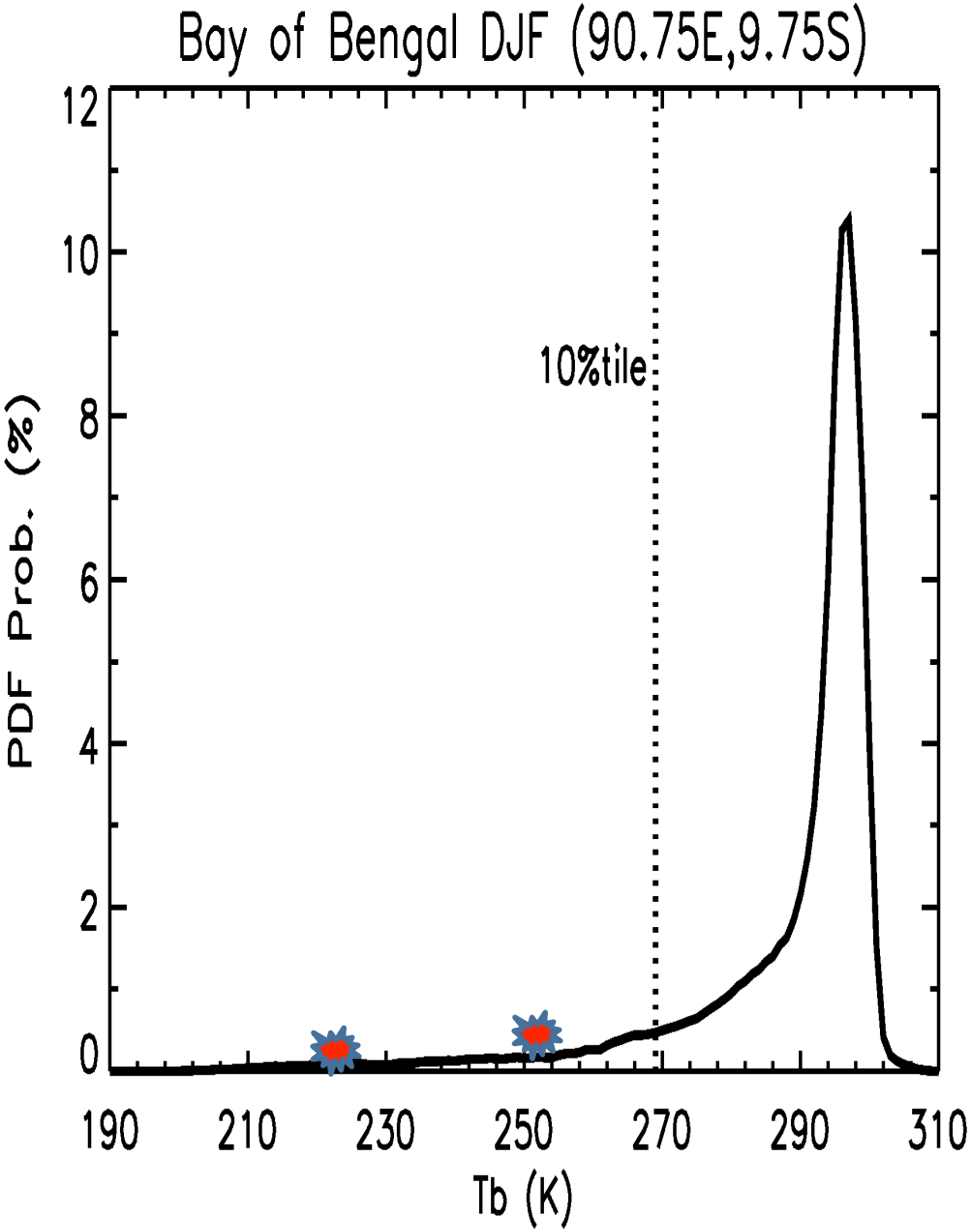


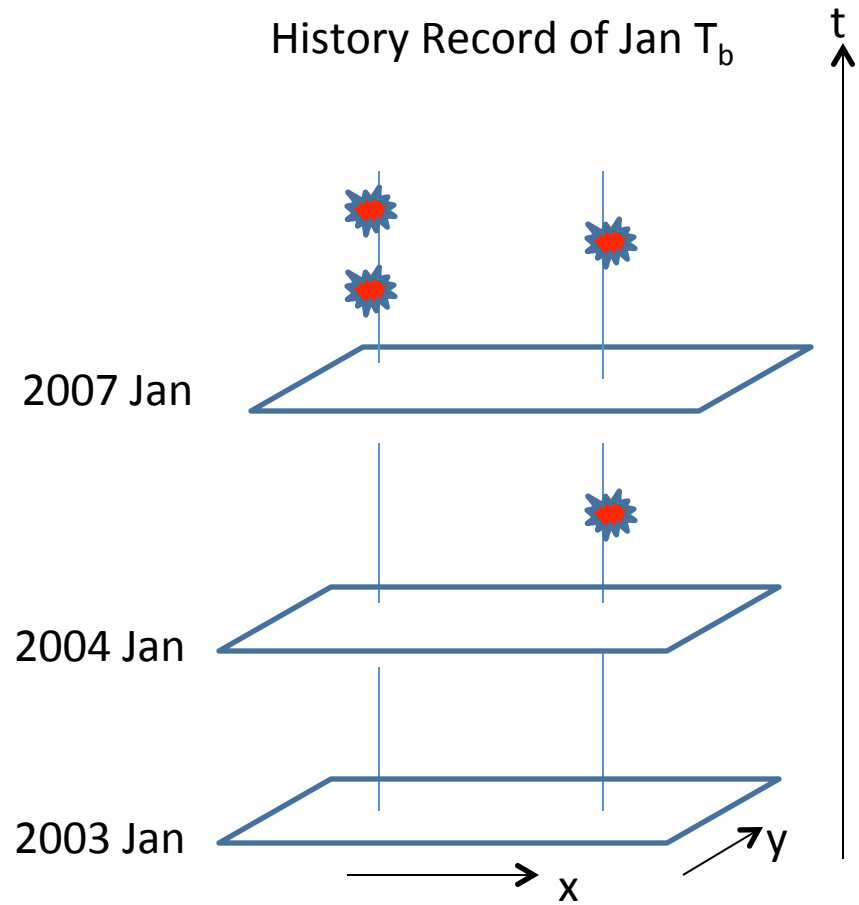
# Schematic Diagrams of Finding for BT Cold-End Extremes



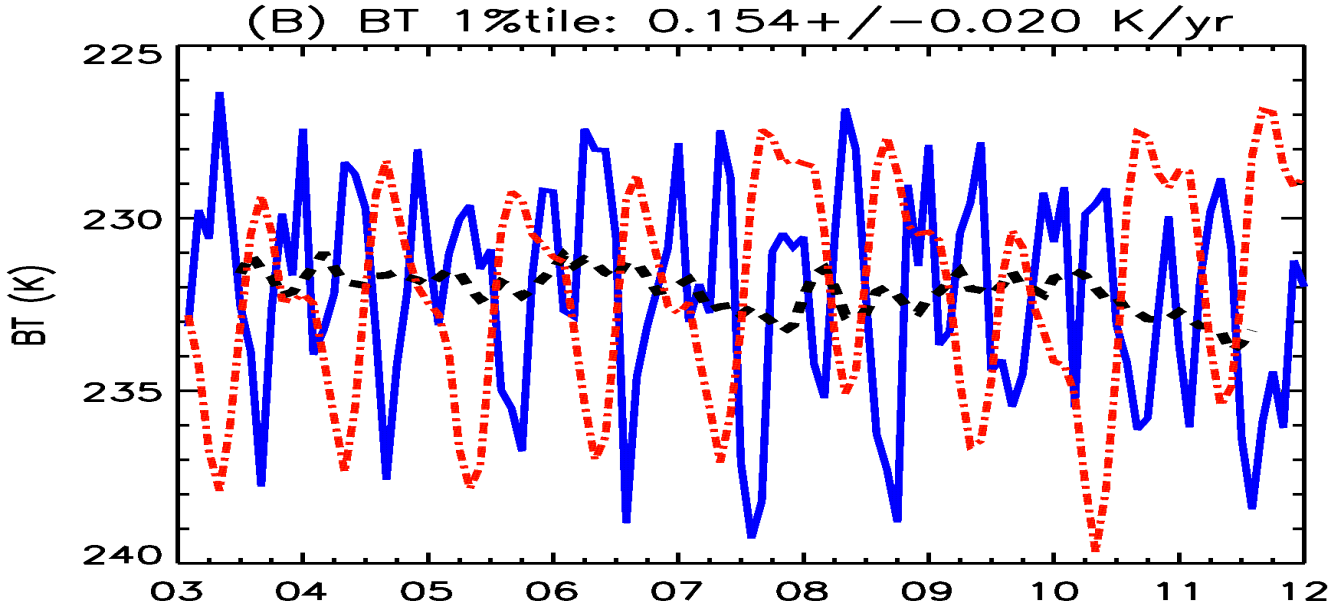



# Schematic Diagrams of Finding for $T_b$ Cold-End Extremes



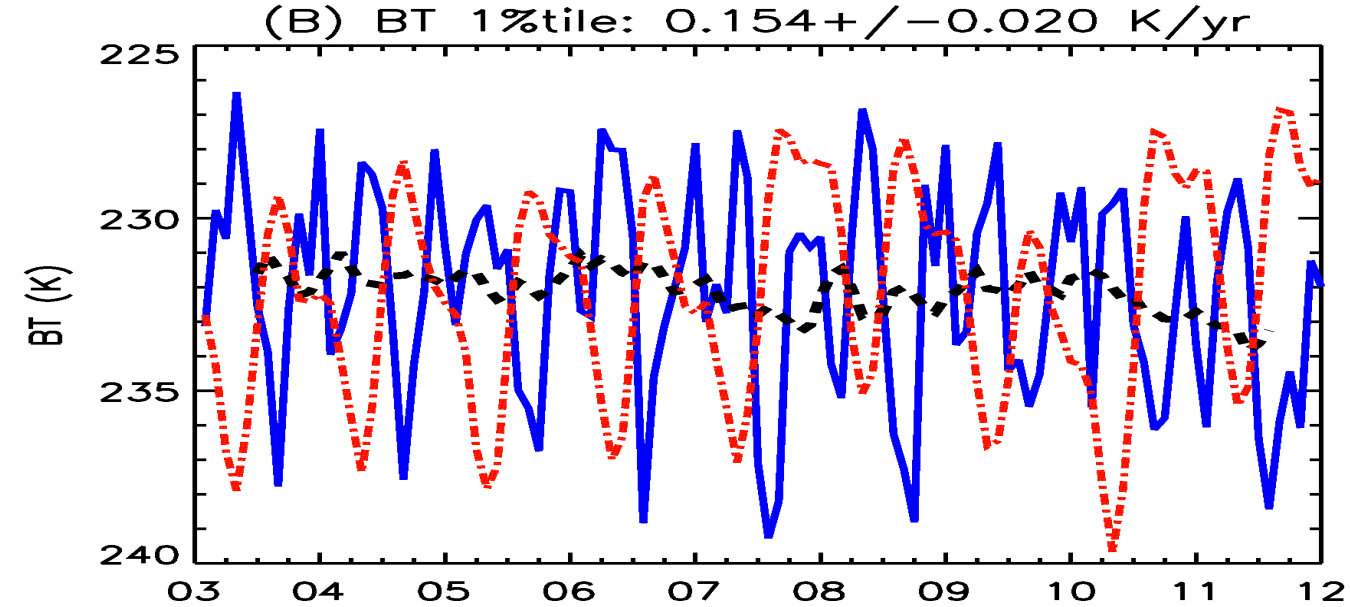



# Monthly Mean Time Series (2003-2011)

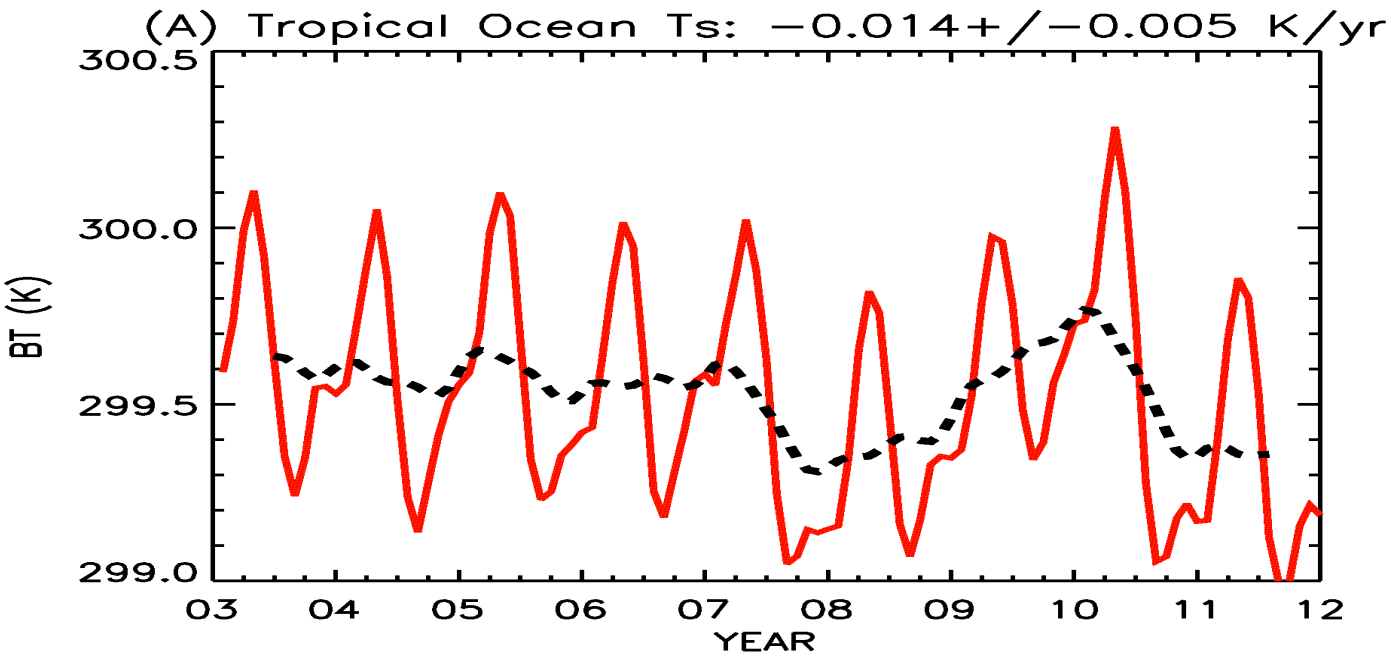



Monthly mean 1%tile BT averaged over tropical ocean

# Monthly Mean Time Series (2003-2011)

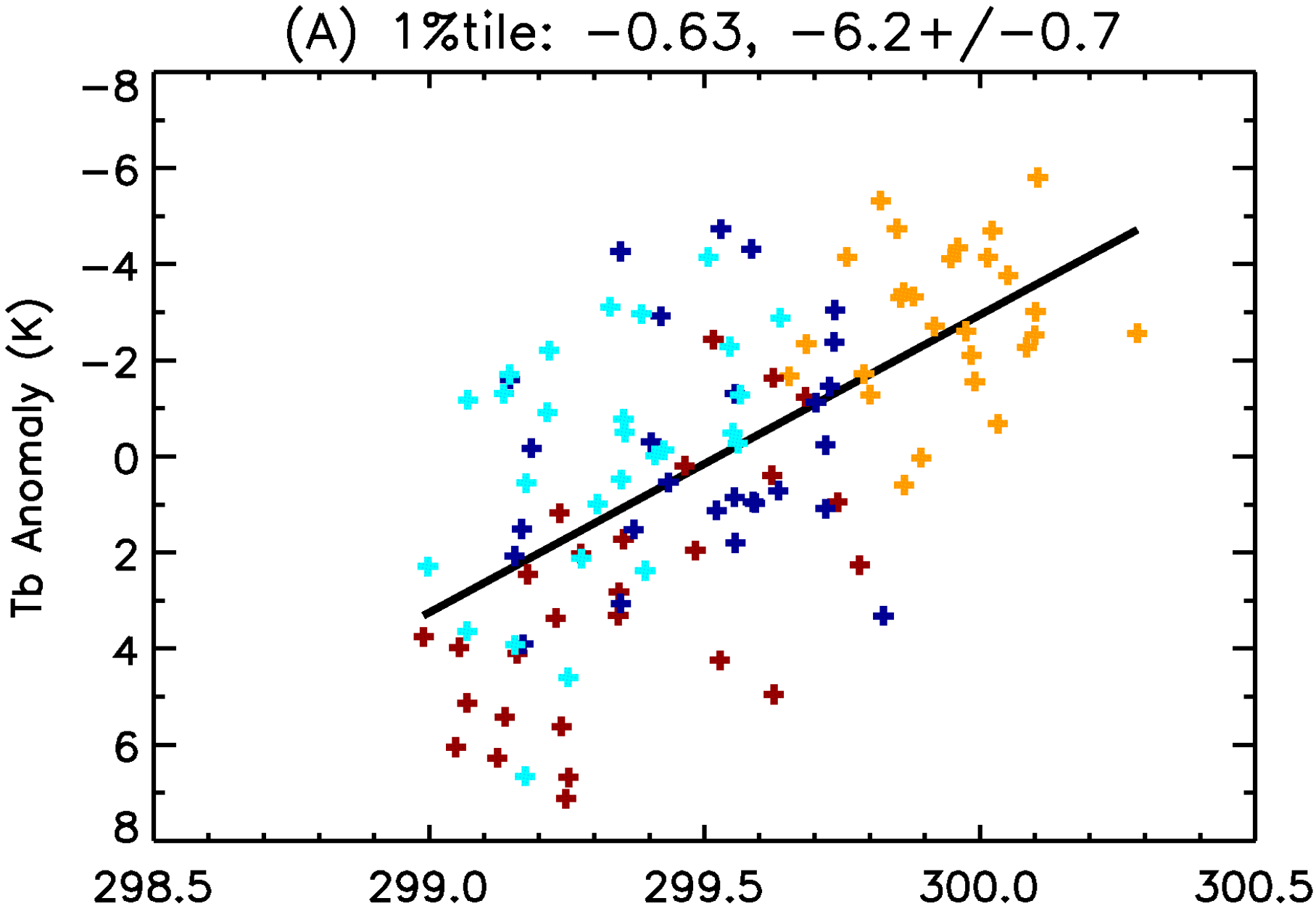



Monthly mean 1%tile BT averaged over tropical ocean

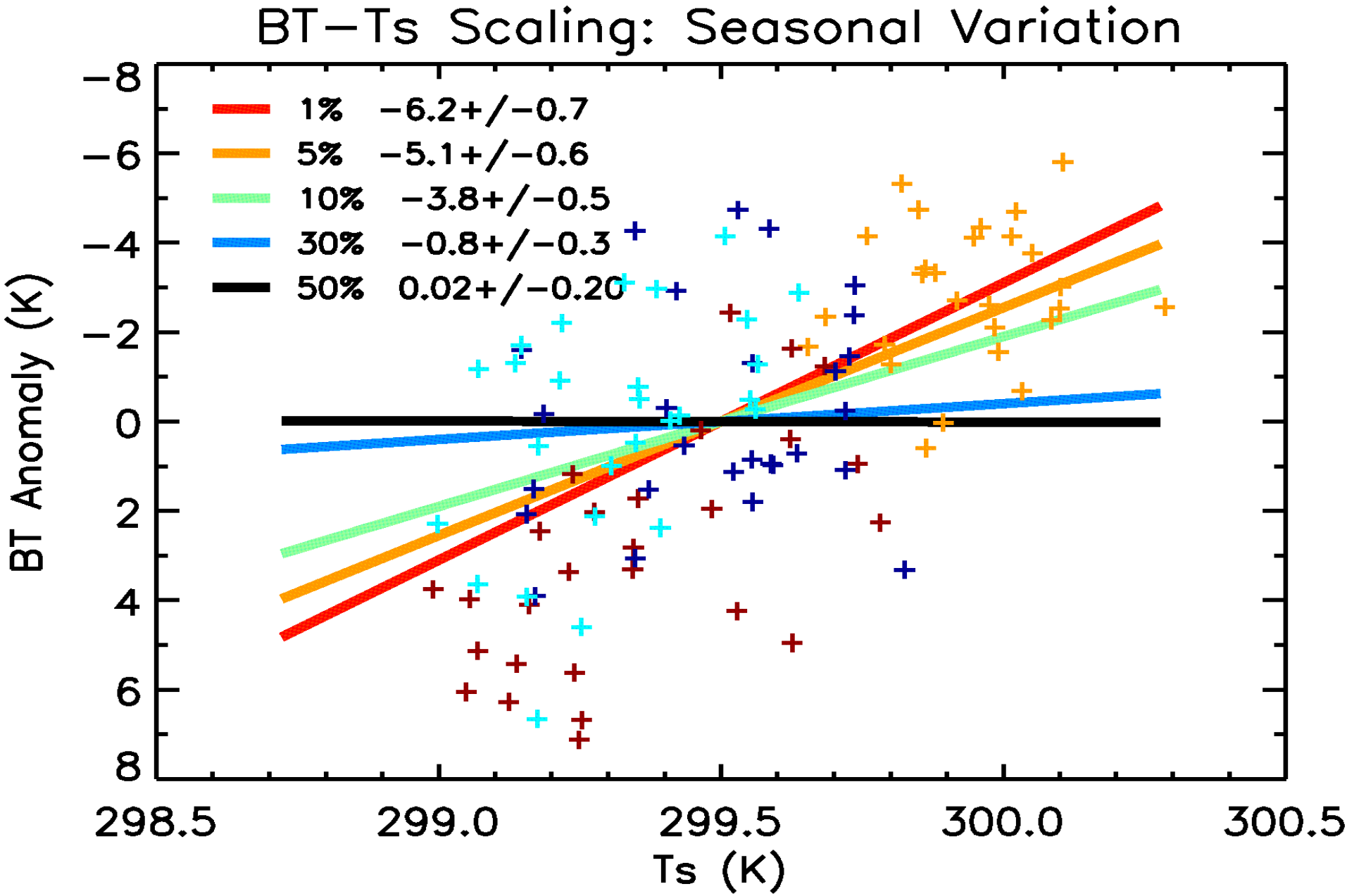



Monthly mean tropical SST

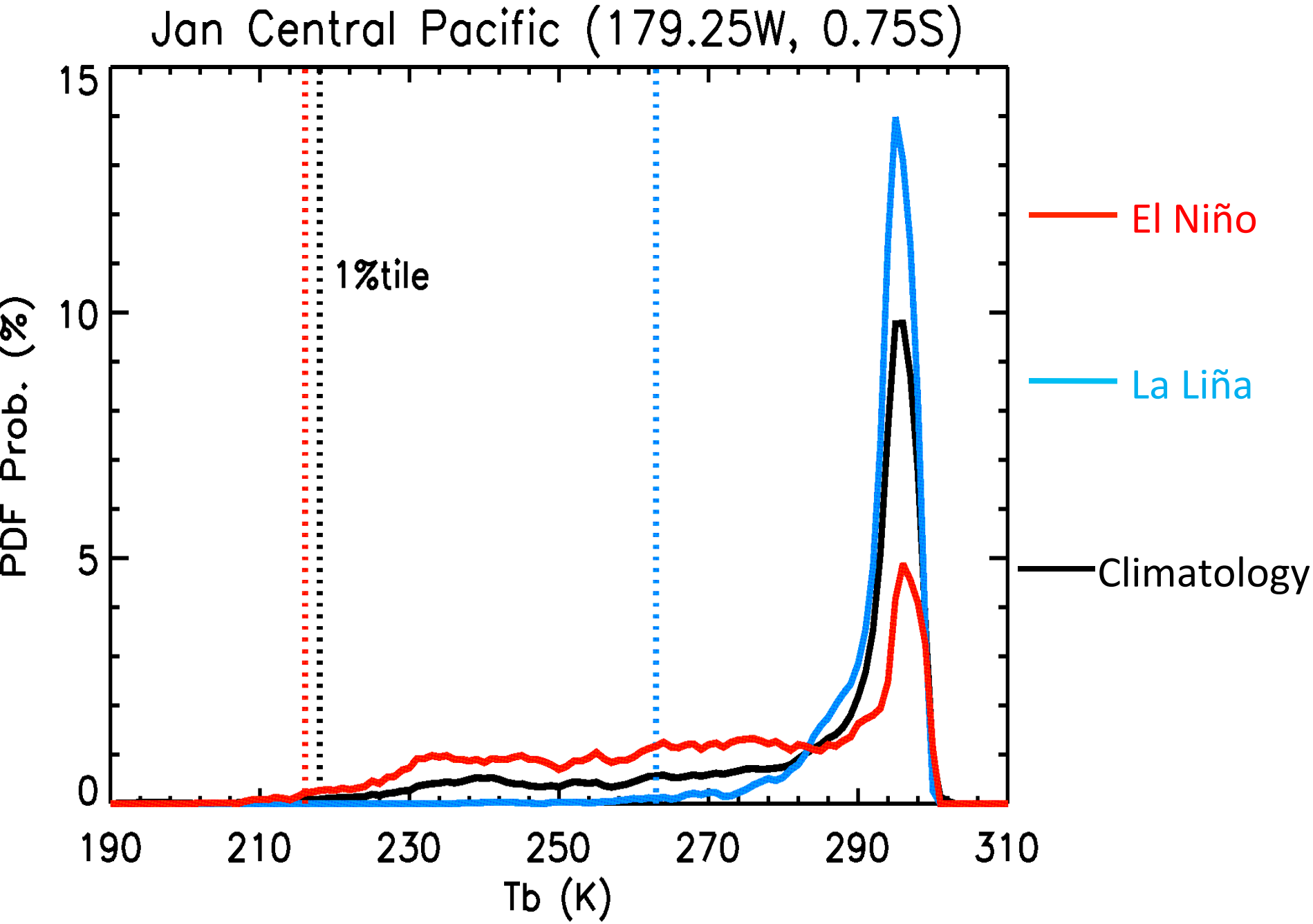
# Tropical Monthly Mean BT vs SST (Seasonal Cycle)



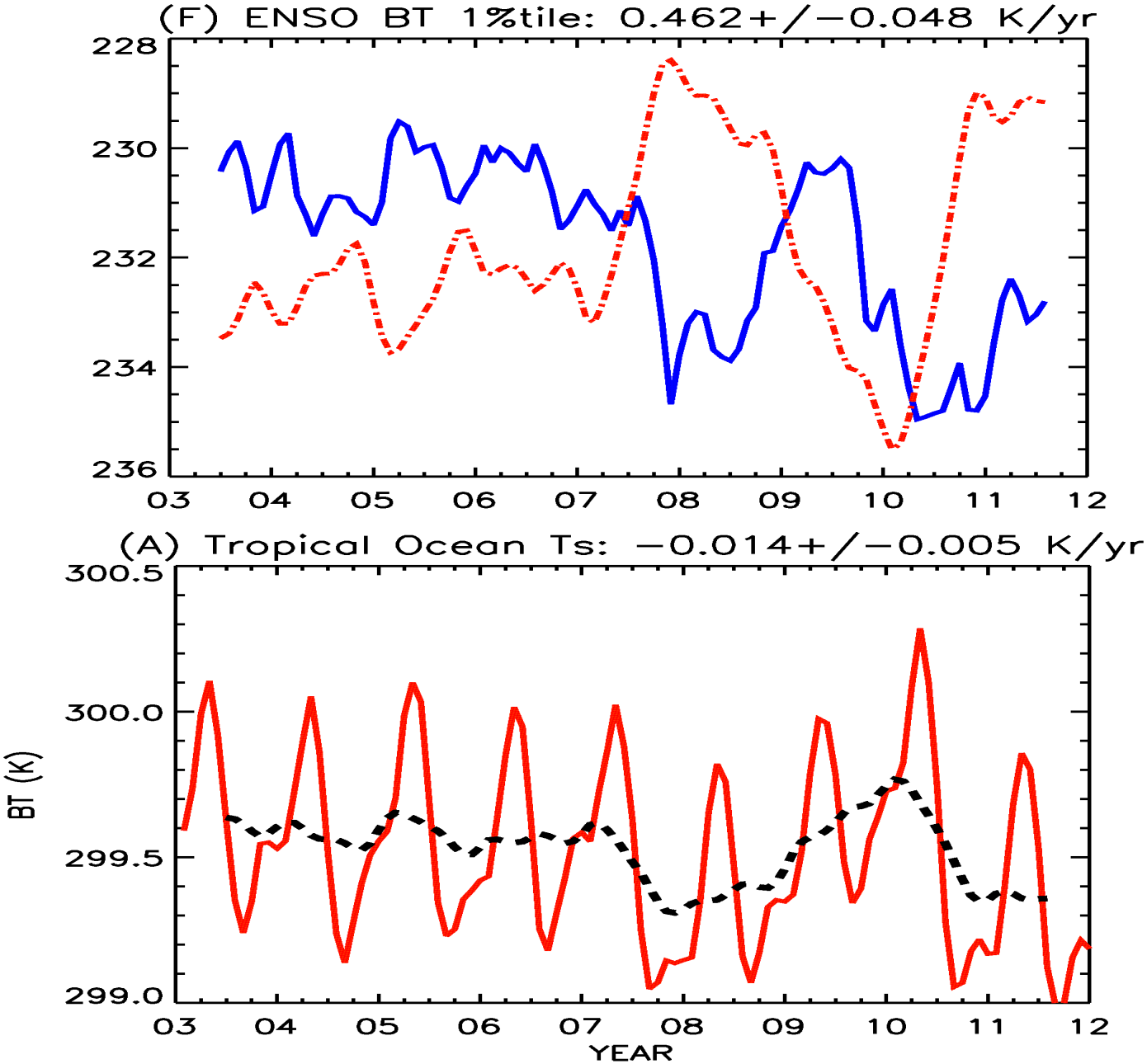
# Tropical Monthly Mean BT vs SST (Seasonal Cycle)



# ENSO PDFs for January



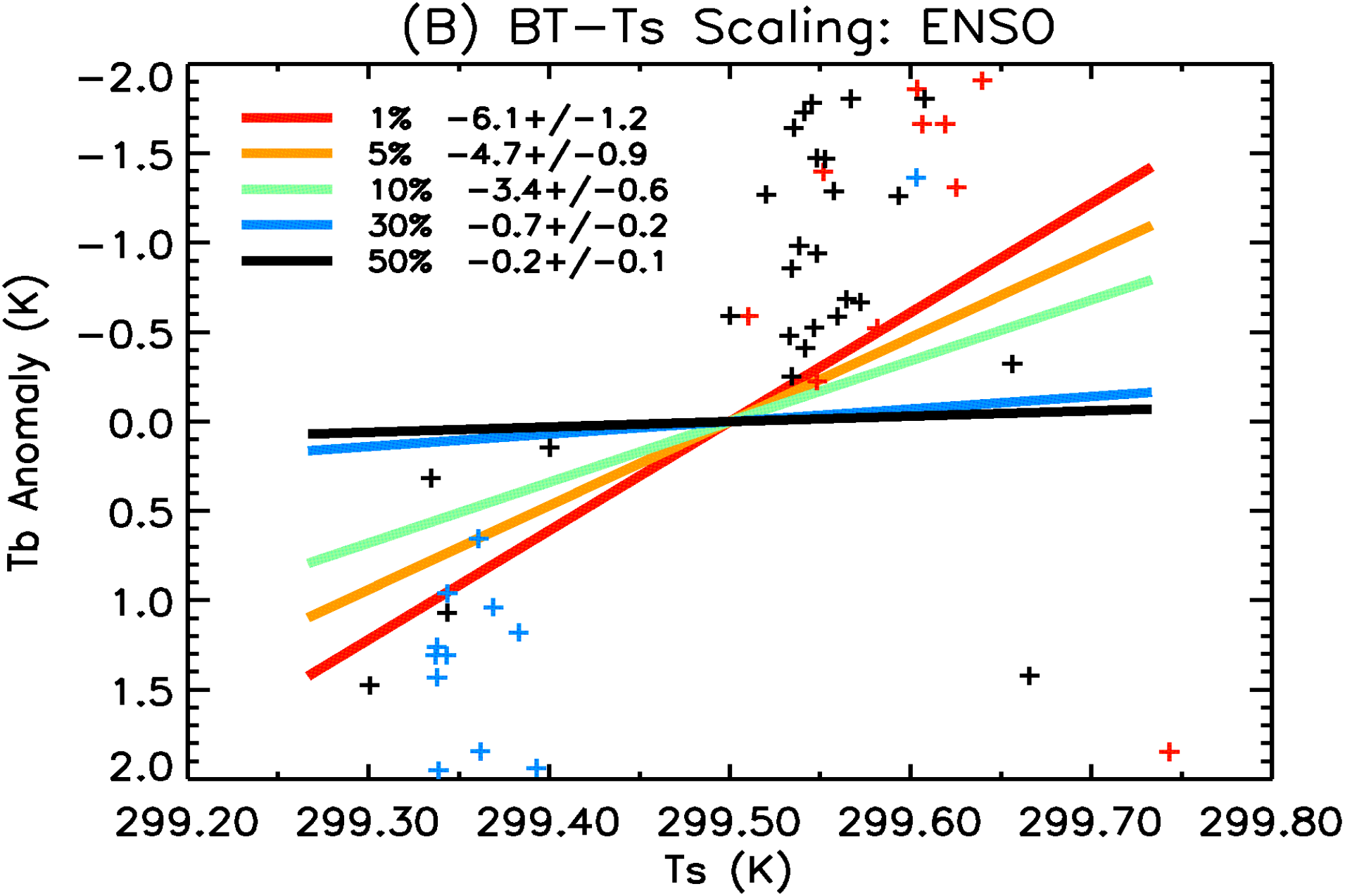
# Monthly Mean Time Series Using ENSO PDF (2003-2011)




Monthly mean 1%tile BT averaged over tropical ocean

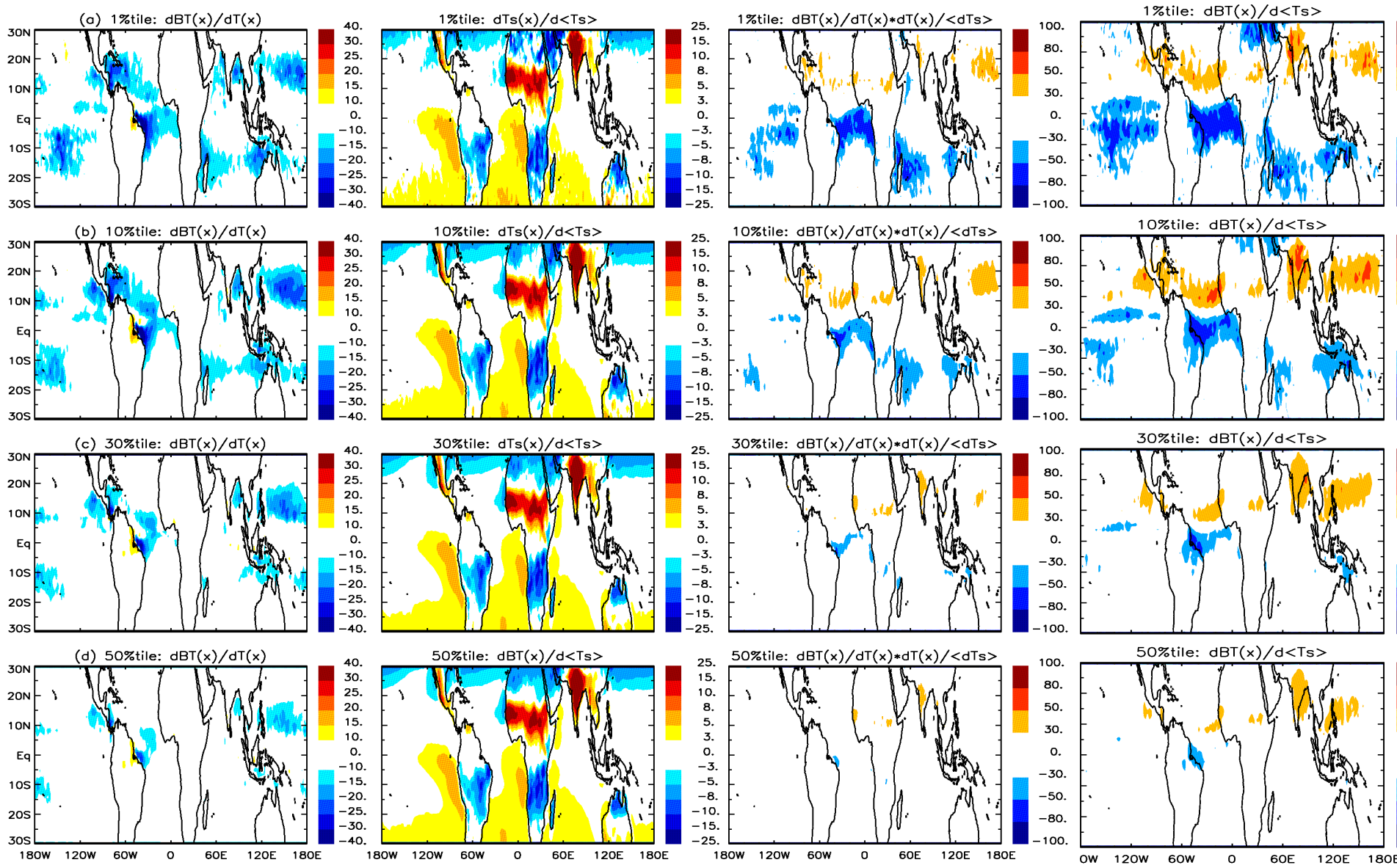
Monthly mean tropical SST

# Tropical Monthly Mean BT vs SST (ENSO)



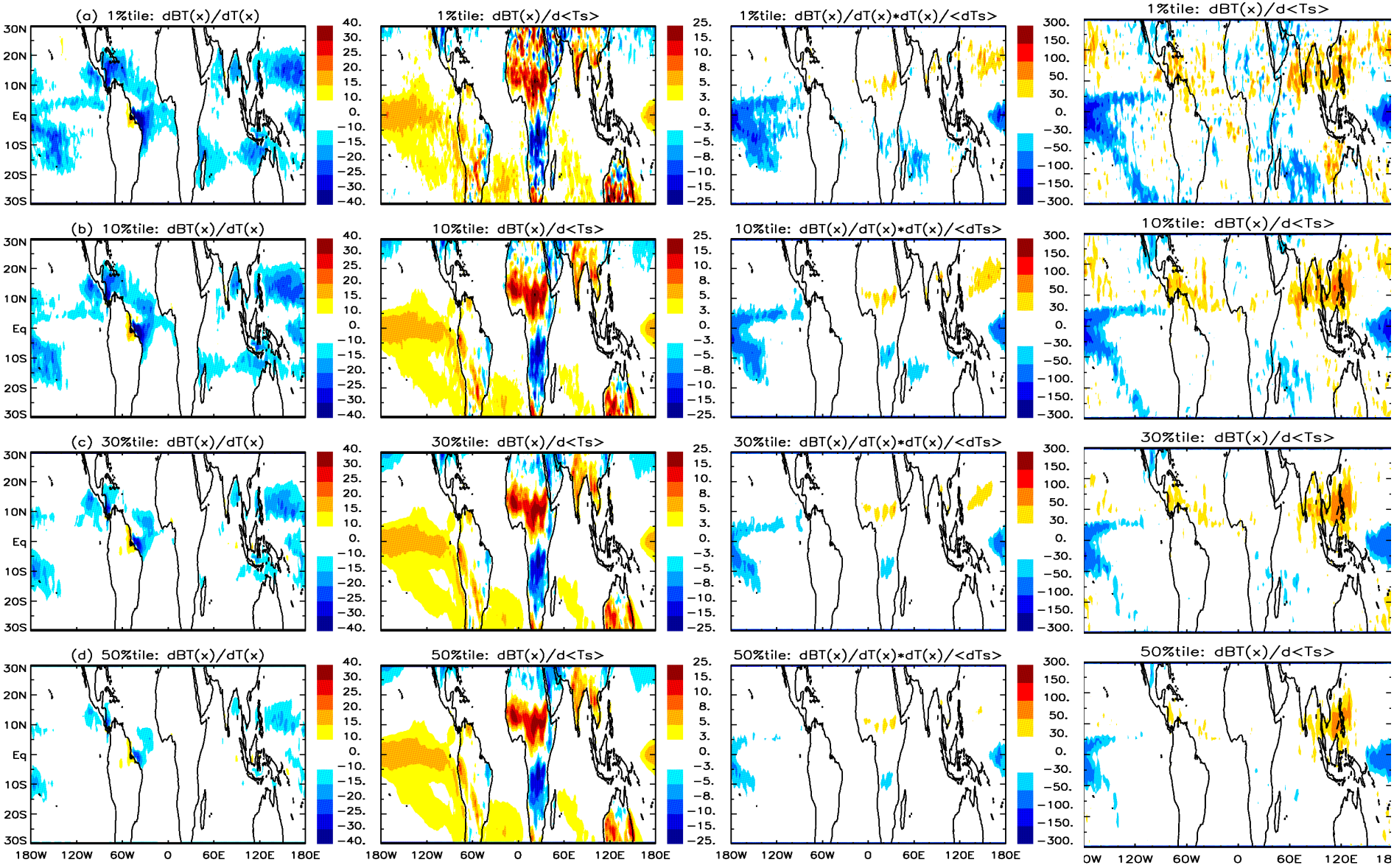
$$dBT(x,t)/d\langle T_s\rangle(t) = \partial BT(x,t)/\partial T_s(x,t) \cdot dT_s(x,t)/d\langle T_s\rangle(t) + \ldots\ldots$$

$\partial BT_p(x,t)/\partial T_s(x,t)$ | $dT_s(x,t)/d\langle T_s\rangle(t)$ | Product | $dBT_p(x,t)/d\langle T_s\rangle(t)$

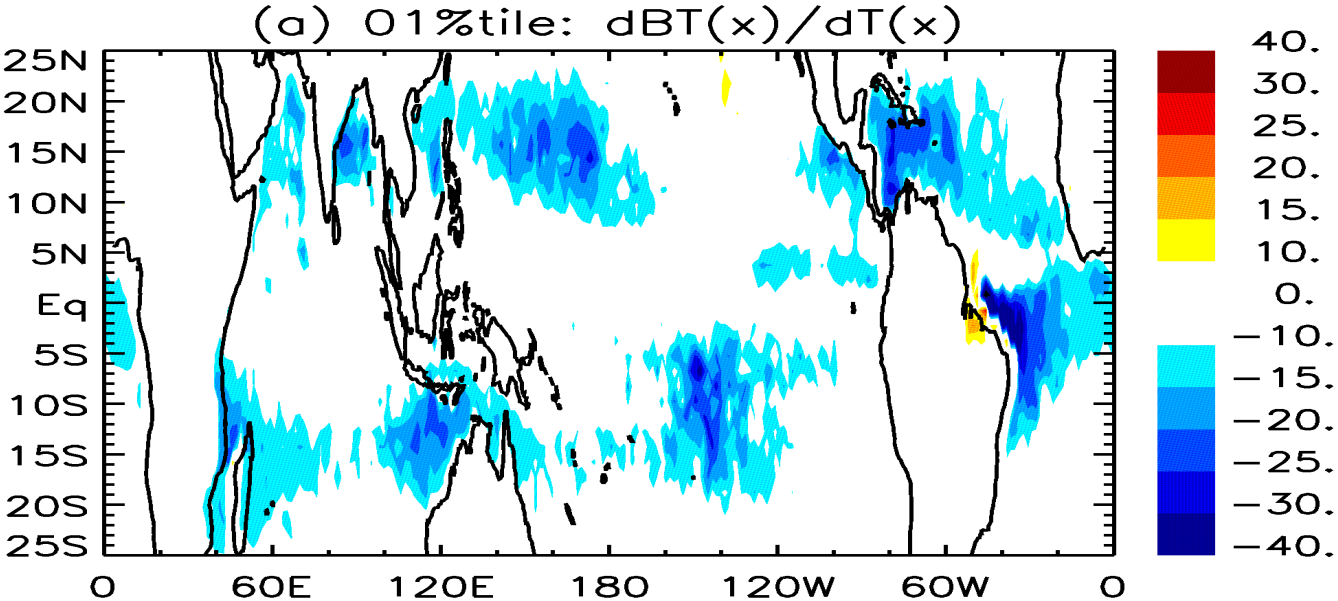


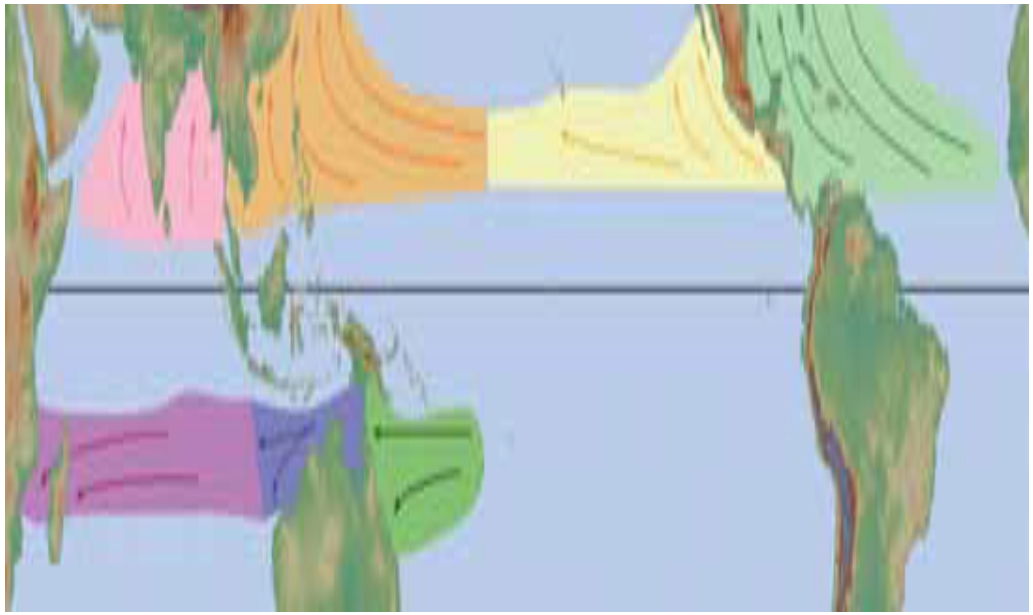
$$dBT_p(x,t)/d\langle T_s\rangle(t) = \partial BT_p(x,t)/\partial T_s(x,t) \cdot dT_s(x,t)/d\langle T_s\rangle(t) + \ldots\ldots$$

$\partial BT_p(x,t)/\partial T_s(x,t)$ | $dT_s(x,t)/d\langle T_s\rangle(t)$ | Product | $dBT_p(x,t)/d\langle T_s\rangle(t)$



# Sensitivity of BT to SST and Regimes of TC Development



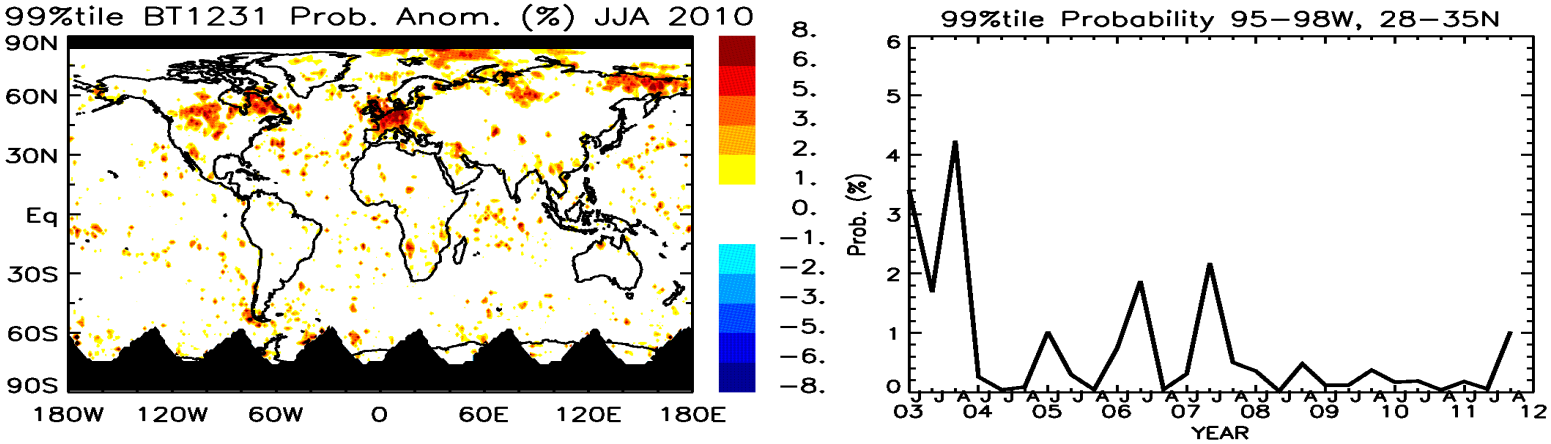



Regions of Frequent Tropical Cyclones Visit and Genesis

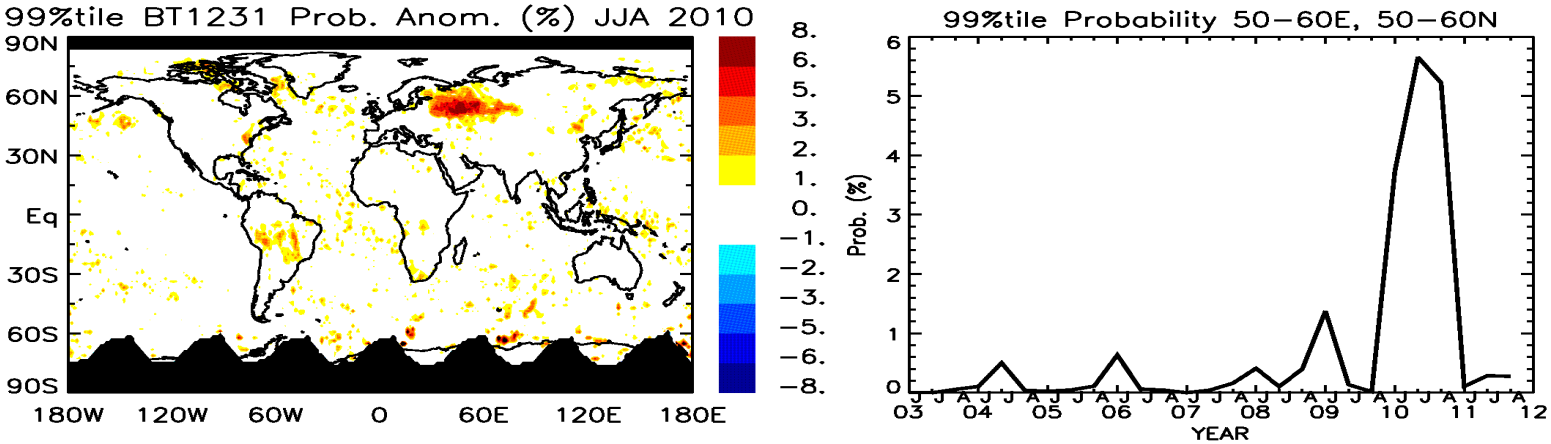
## Conclusion:

- Tropical extreme weather events associated with the development of strong convection and storms are more sensitive to warming of the ocean surface than mean events are

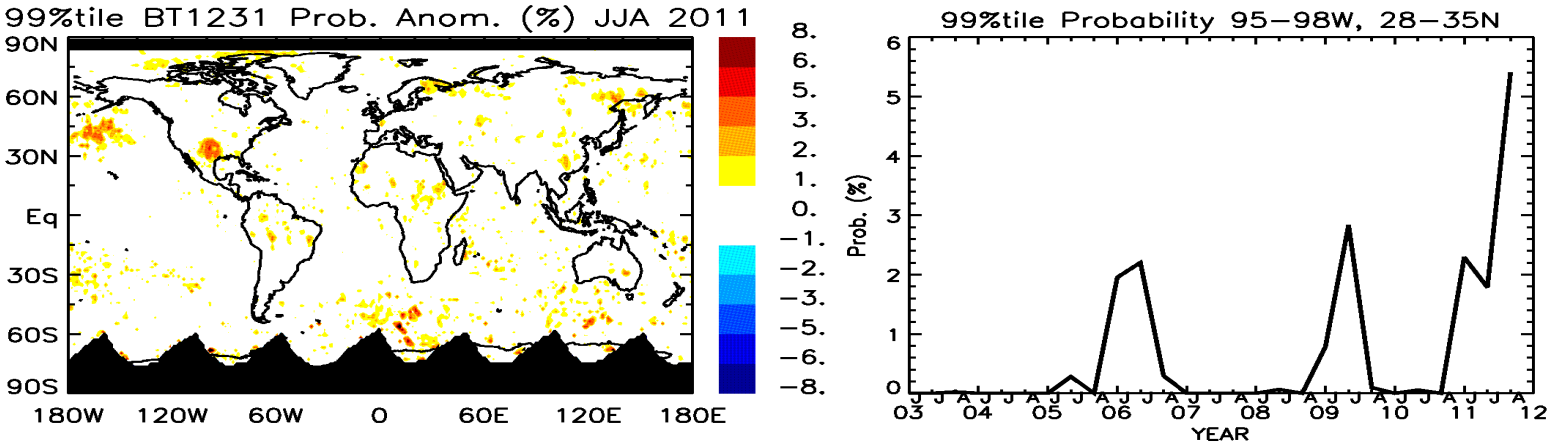
# The Hot End of the PDFs: Summer Heat Waves




Europe 2003

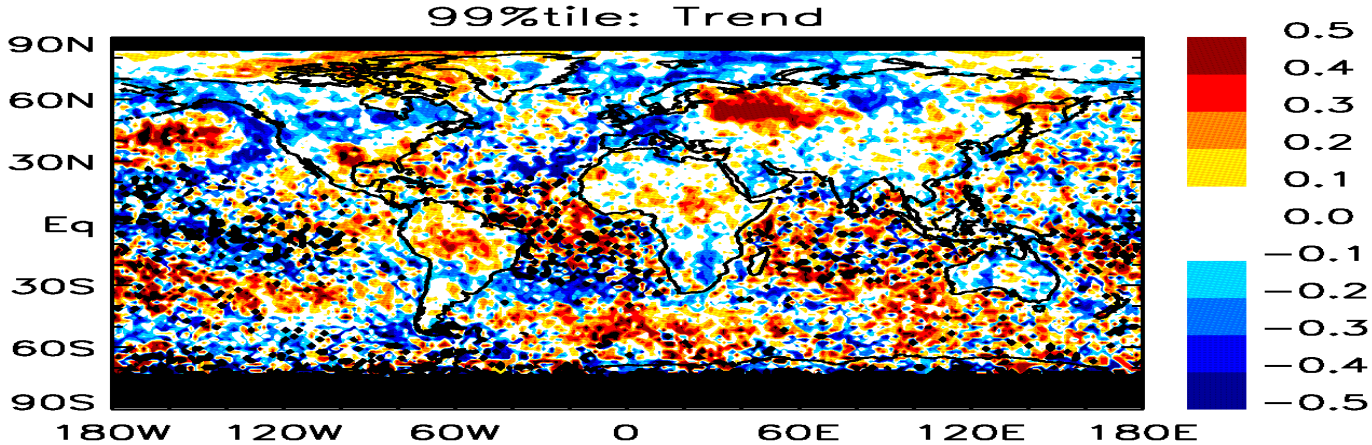



Russia 2010

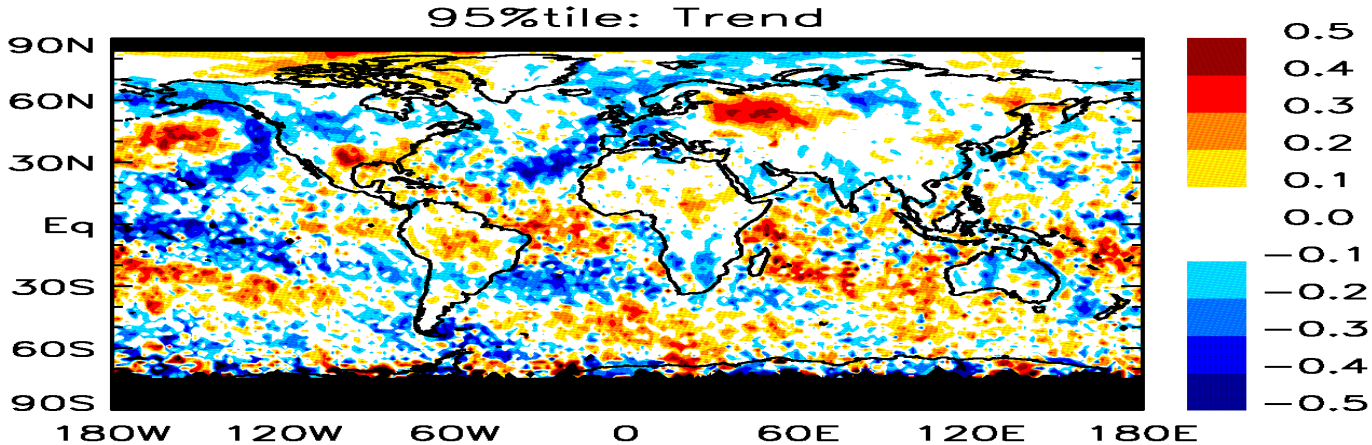



Texas 2011

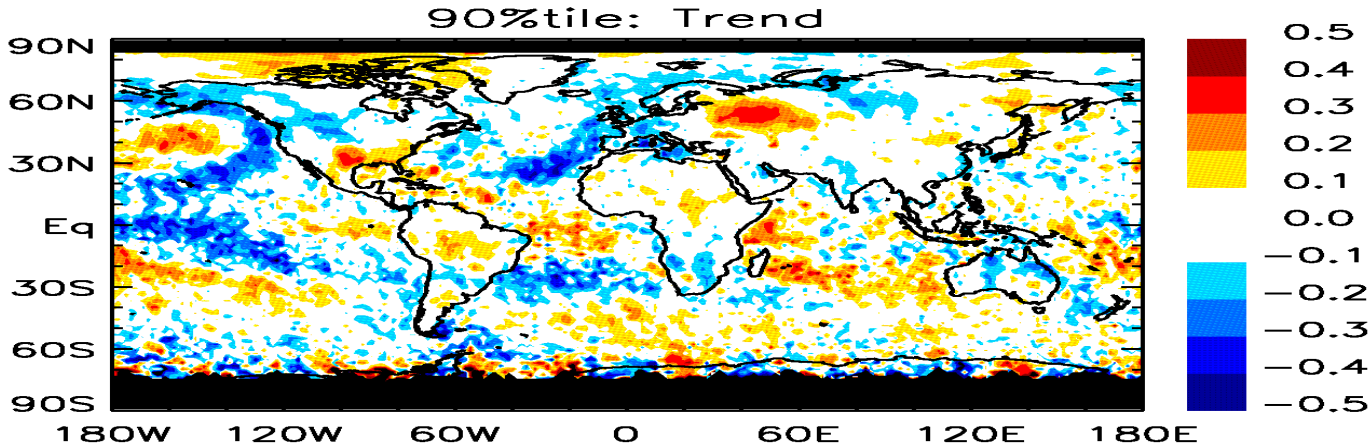
# Relative Trends in Probability of Occurrence of Heat Extremes (JJA)




99%tile

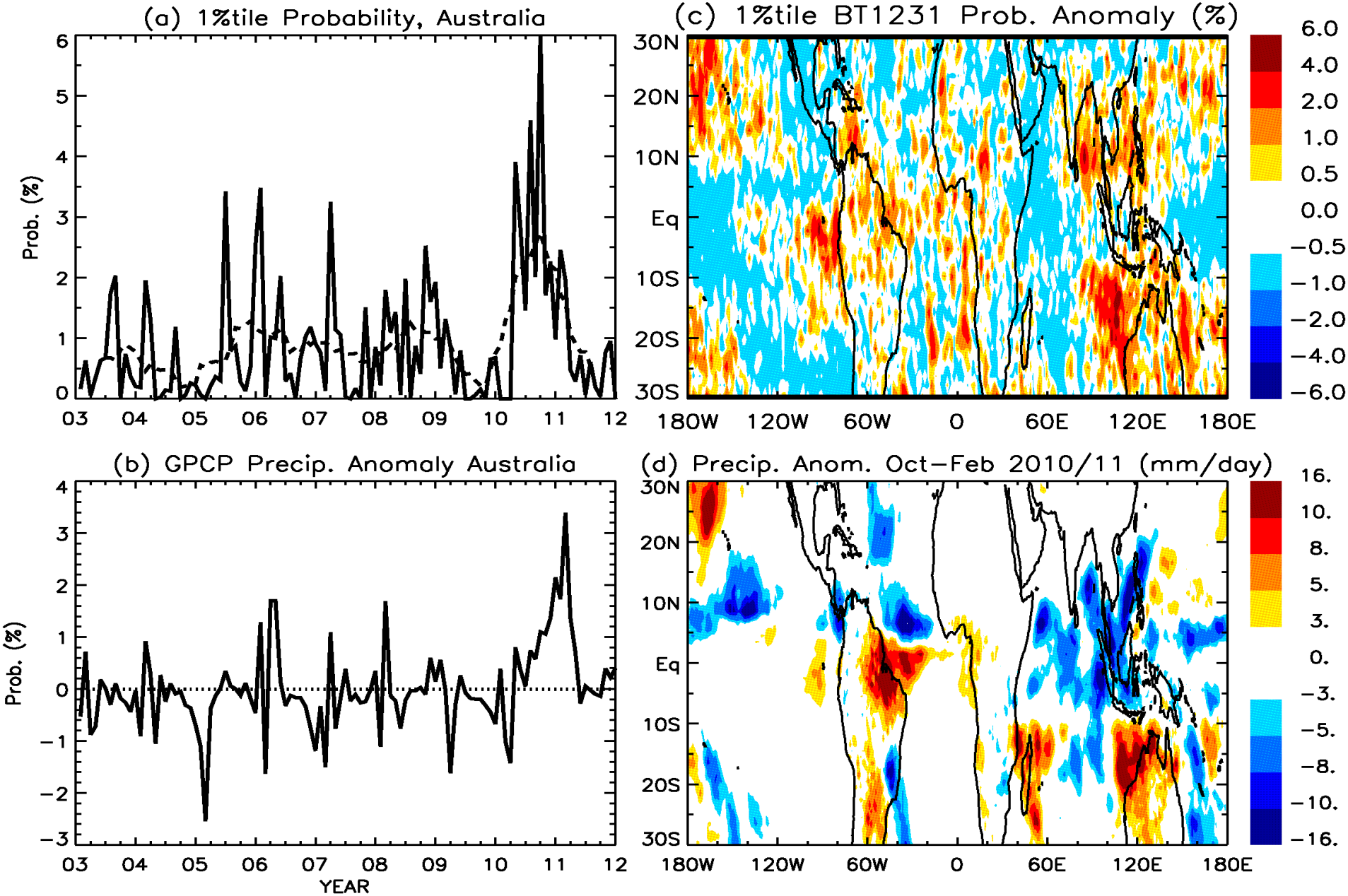



95%tile

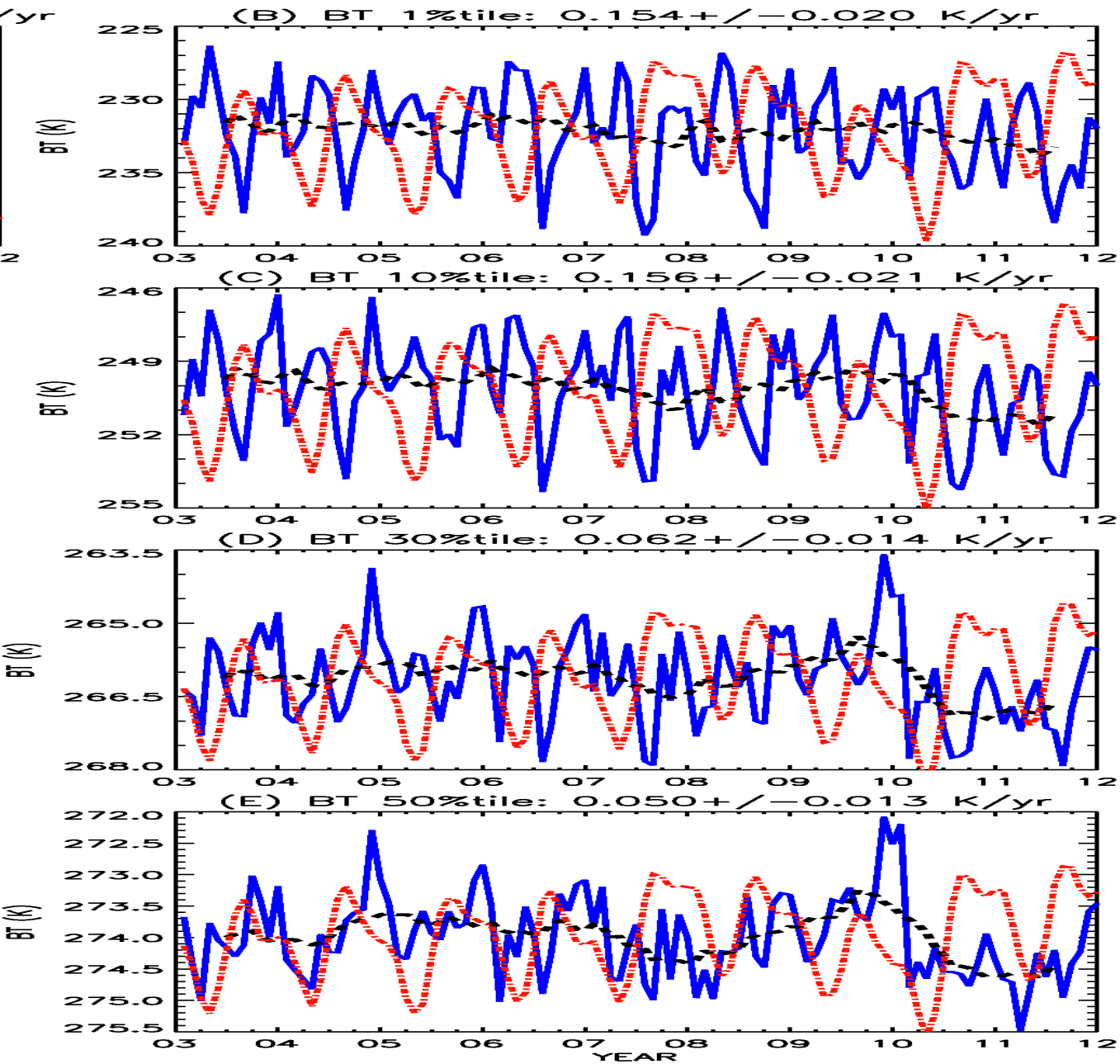



90%tile

# Australia Extreme Rainfall in 2010-2011 Austral Summer



# Monthly Mean Time Series (2003-2011)




1%tile
0.154±0.020 K/yr

10%tile
0.156±0.021 K/yr

30%tile
0.062±0.021 K/yr

50%tile
0.050±0.013 K/yr

# AIRS L1B to Study Extreme Events:

- Heavy storms are associated with cold cloud top. (e.g., Aumann et al., 2008)

- Confusion of diurnal variability is minimized

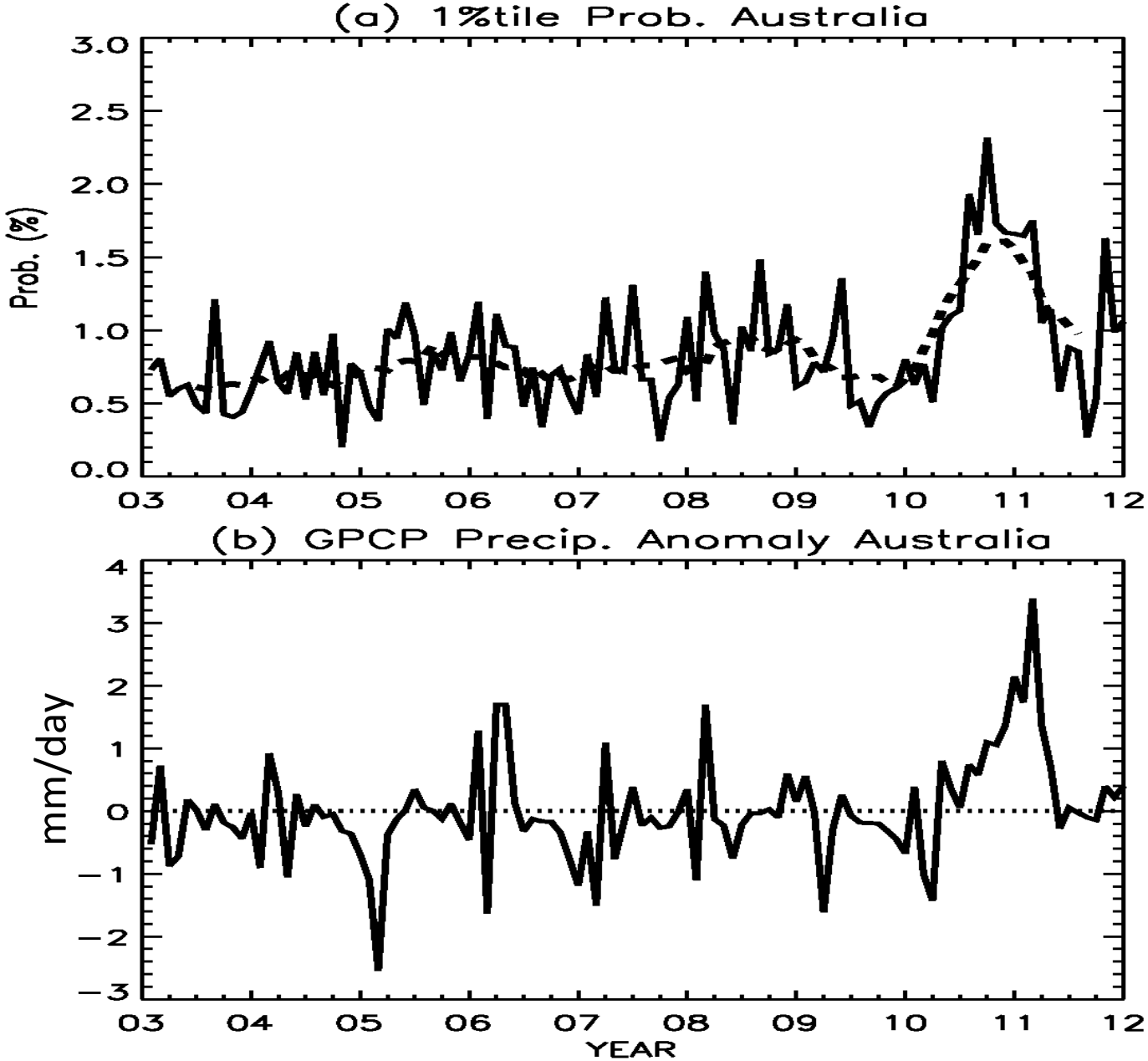
- Absolute radiometric calibration accuracy

- High radiometric and frequency stability

- Ascending AIRS L1B BT (1231 $cm^{-1}$ ) at nadir for 2003-2011 (focus on the cold-end of the PDF)

- Noon-time GSFC MERRA SST for 2003-2011

# Australia Extreme Rainfall in 2010-2011 Austral Summer




AIRS 1%tile BT Occurrence Frequency

GPCP monthly mean precip. anomaly (mm/day)