

Extreme Precipitation and Its Long-Term Changes over China and the U.S.

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Links of Climate Signals across the N. Pacific

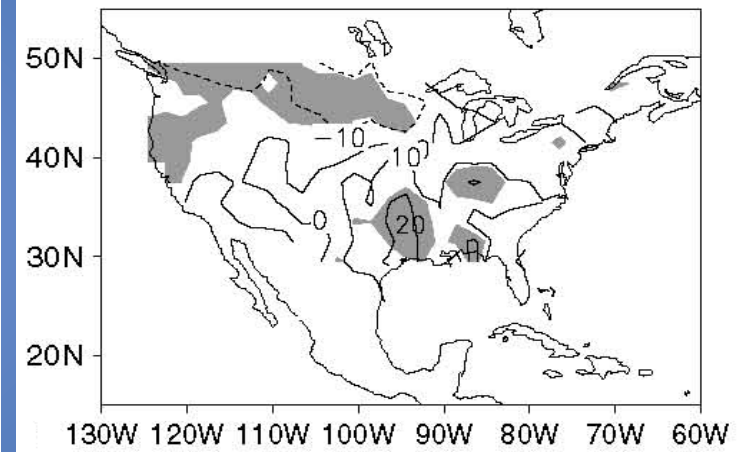
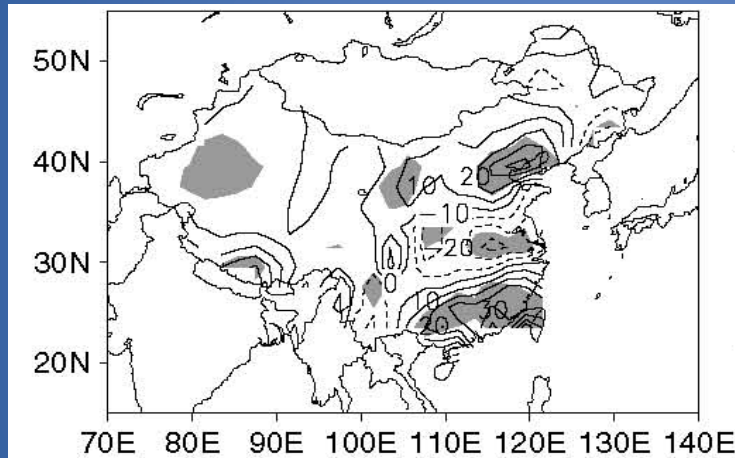
- Lau and Weng (2002; JMSJ):
identified two atmospheric teleconnection patterns linking the summer precipitation over East Asia and the U.S. on interannual timescales
- Wang, Wu and Lau (2001; JCLIM):
found that there existed a teleconnection between the western North Pacific summer monsoon and North America climate
- Zhang, Yang and Kousky (2005; AAS):
investigated the relationship between the South Asian High and the climate anomalies in the Asian-Pacific-American sector
- Ding and Wang (2005, JCLIM):
revealed a near circumglobal teleconnection pattern in the summer mid-latitude circulation of the Northern Hemisphere, which is accompanied by rainfall anomalies in both East Asia and North America

Two More Most Relevant Studies

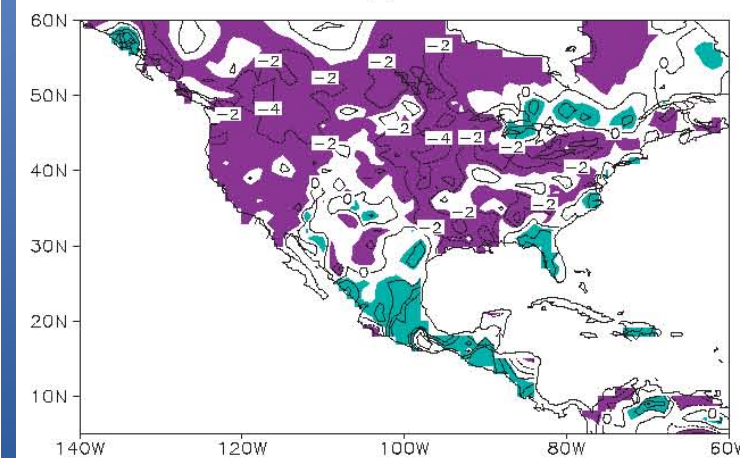
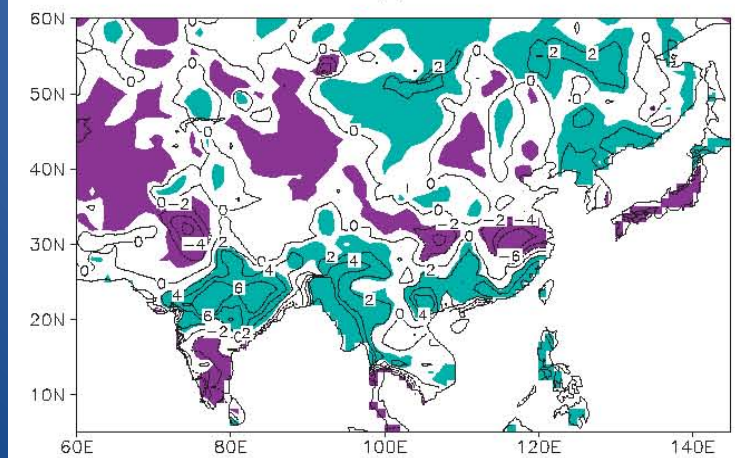
Li, Q., S. Yang, V. Kousky, W. Higgins, K.-M. Lau, and P. Xie, 2005: Features of cross-Pacific climate shown in the variability of China and US precipitation. *Int. J. Climatol.*, **25**, 1675-1696.

Zhao P., S. Yang, H. Wang, and Q. Zhang, 2011: Interdecadal Relationships between the Asian–Pacific Oscillation and Summer Climate Anomalies over Asia, North Pacific, and North America during a Recent 100 Years. *J. Climate*, **24**, 4793-4799

**Li et al.
(2005)**



**Zhao et
al. (2011)**



Outline

1. Data and analysis method
 2. Annual means*
 3. Seasonality*
 4. On-going studies
 5. Summary

*Focusing on related SST and circulation patterns

1. Data and Analysis Method

➤ **Data**

China daily precipitation over 468 stations, 1961-2009

U.S. Daily Precipitation Gridded Analysis (Xie et al. 2007; Chen et al. 2008), 1948-2009

ERSST and NCEP-NCAR Reanalysis

➤ **Angular Distance Weighting (ADW) Interpolation**

➤ **Sen's Slope estimation and Mann-Kendall test**

➤ **Indices:**

Total precipitation (P_{tot})

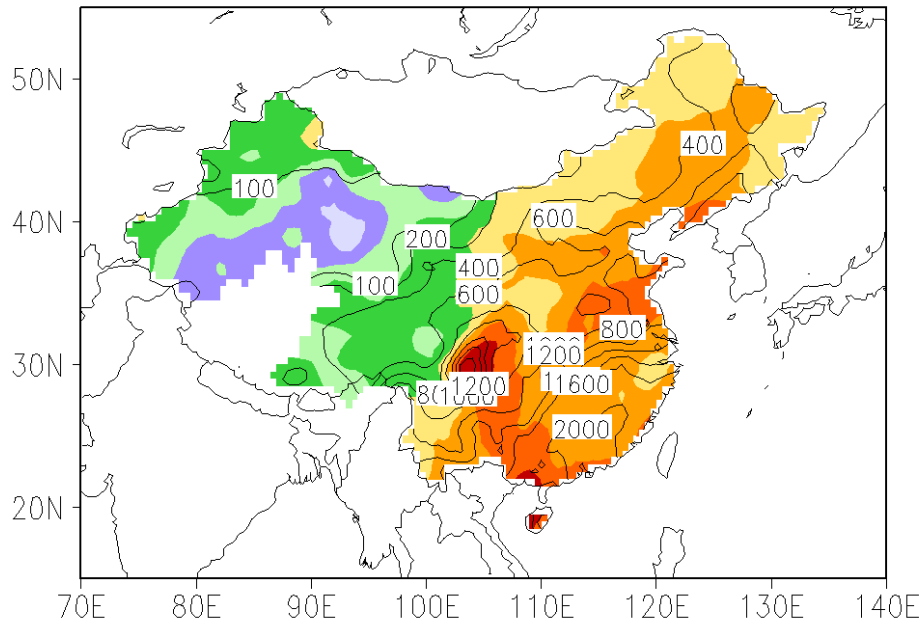
Extreme precipitation (P_{95})

Ratio of extreme to total precipitation (Ratio)

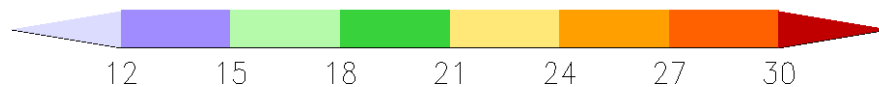
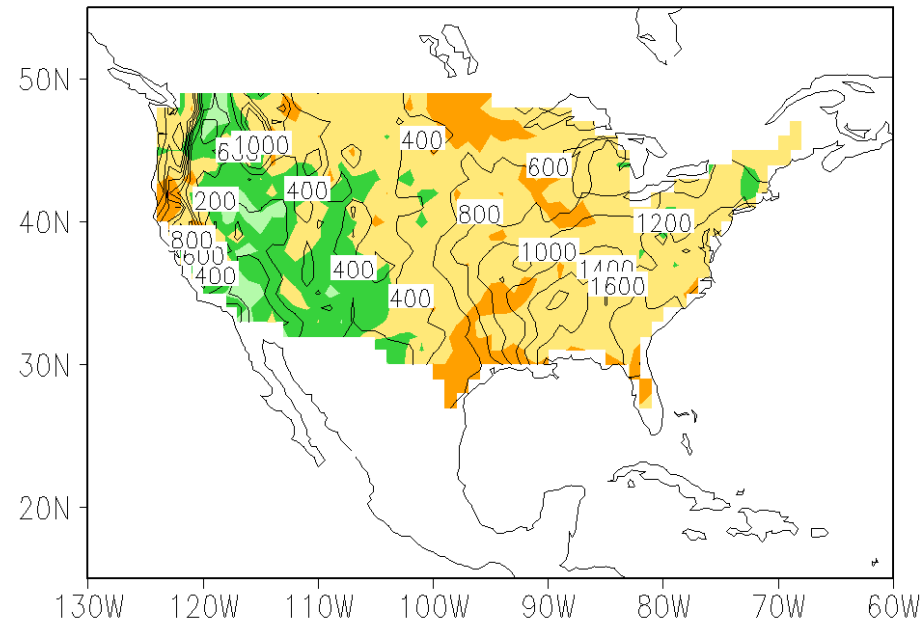
2. Annual Means

Annual P_{tot} P_{95}/P_{tot} (Ratio) Climatology

China



USA

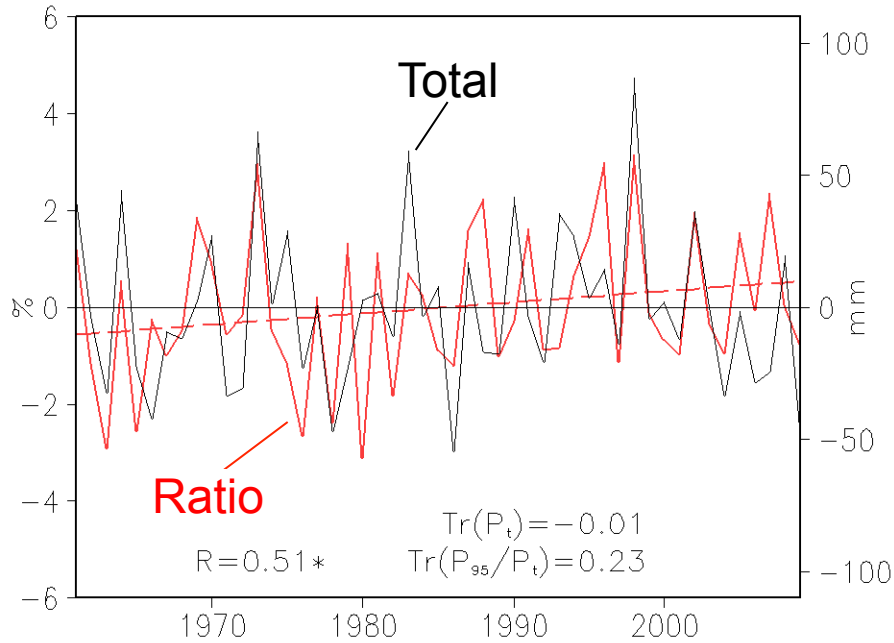


Shaded: Ratio; Contour: Total

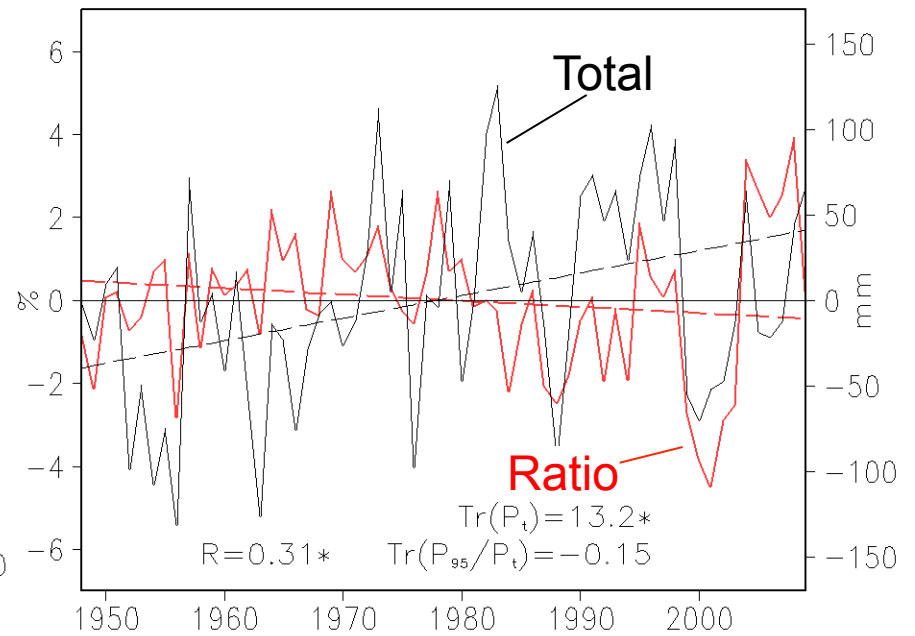
Changes of Annual Total Precipitation (mm) and Ratio (%)

Annual P_{tot} P_{95}/P_{tot} (Ratio) and Trends

China



USA

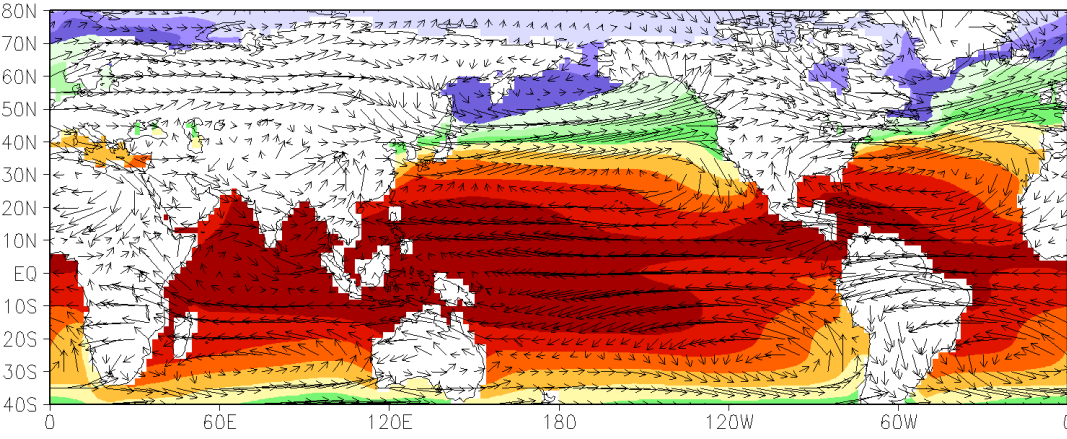


Annual Extreme Indices and Their Trends (in parentheses)

Indices (Trends)	China	USA
Total precipitation (mm; mm/decade)	603.7(-0.01)	739.0 (13.2*)
Extreme precipitation (mm; mm/decade)	157.0 (2.11)	176.7 (4.3*)
Ratio(%; %/decade)	23.3 (0.23)	22.1 (-0.15)
Wet days (day; day/decade)	63.3 (-0.30)	88.9 (2.67**)
Extreme wet days (day; day/decade)	3.2 (0.04)	4.6 (0.09)

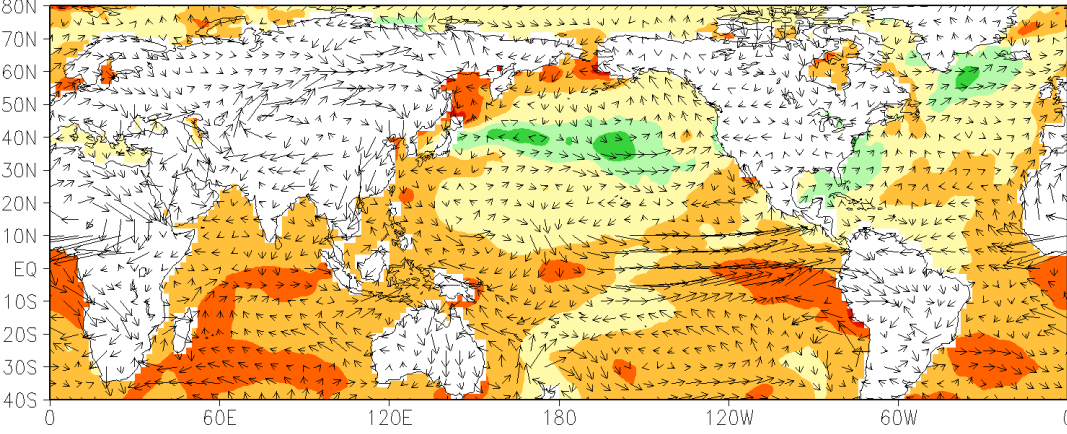
* and **: values significantly exceeding 95% and 99% confidence levels

SST and UV850 Climatology (1948–2009) Annual



Climatological Ts/SST and V850

Mean(1990–2009)–Mean(1948–1967) Annual



Differences in Ts/SST and V850 (1990-2009 Minus 1948-1967)

Relationships of Ts/SST and V850 with China Precipitation

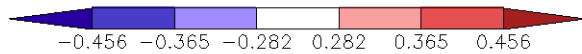
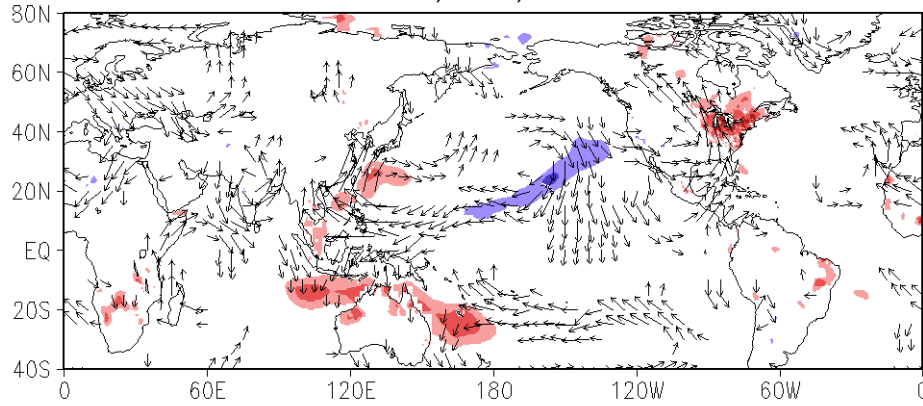
(Upper panels: total precipitation; Lower panels: precipitation ratio)

Original

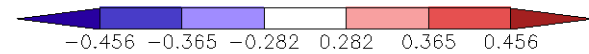
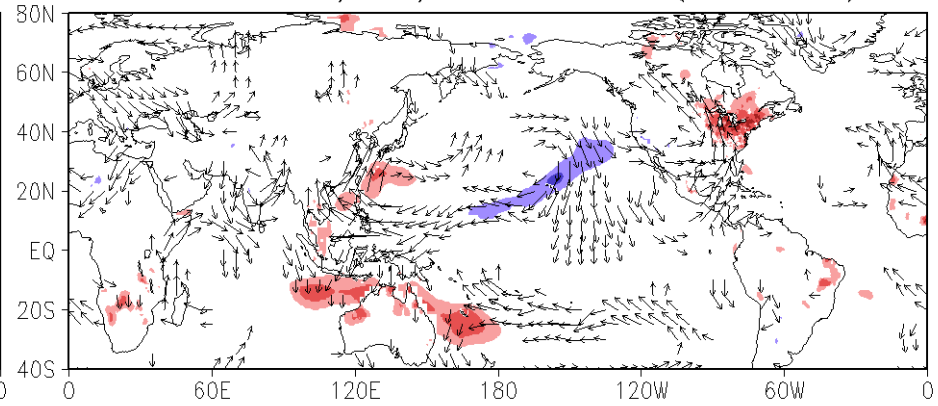
China

Detrended

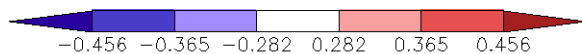
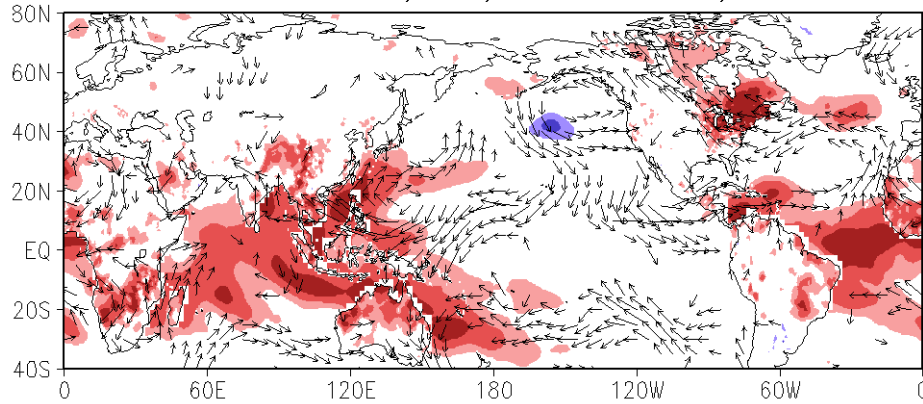
Correlation of Ts/SST/UV850 to P_{tot} Ann



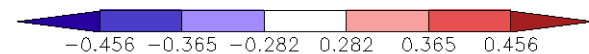
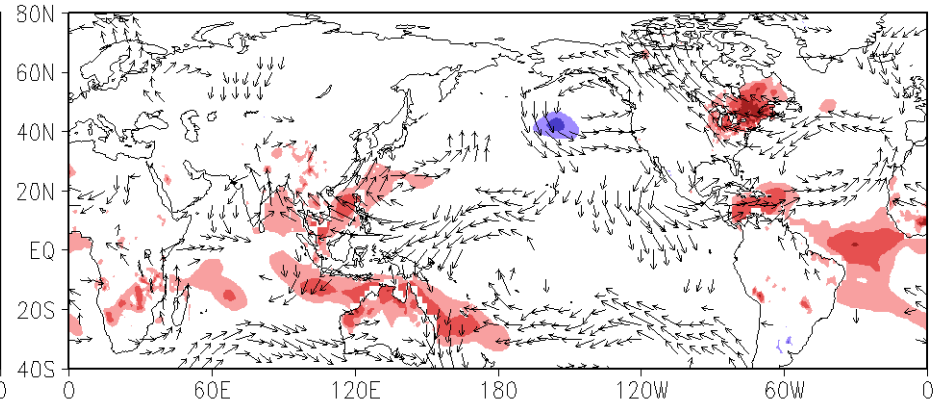
Correlation of Ts/SST/UV850 to P_{tot} (detrended) Ann



Correlation of Ts/SST/UV850 to P_{95}/P_{tot} Ann



Correlation of Ts/SST/UV850 to P_{95}/P_{tot} (detrended) Ann



Relationships of Ts/SST and V850 with U.S. Precipitation

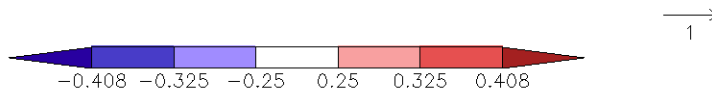
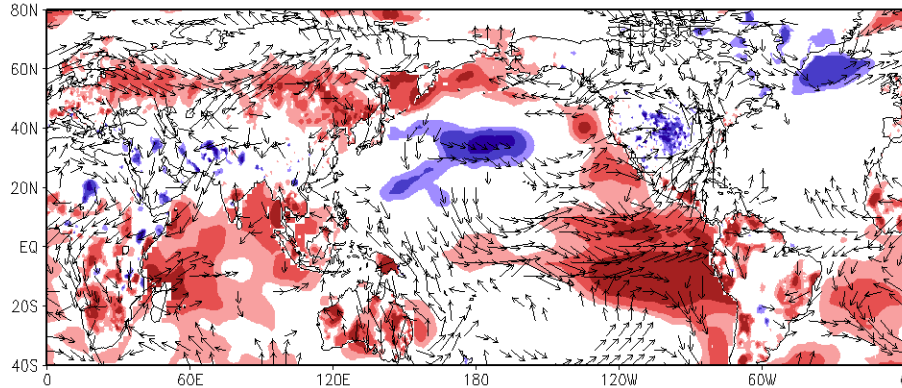
(Upper panels: total precipitation; Lower panels: precipitation ratio)

Original

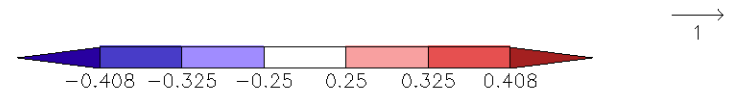
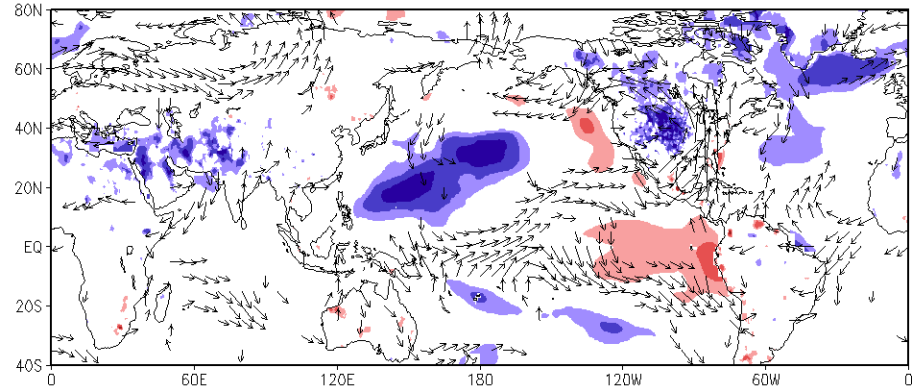
USA

Detrended

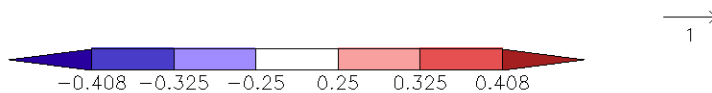
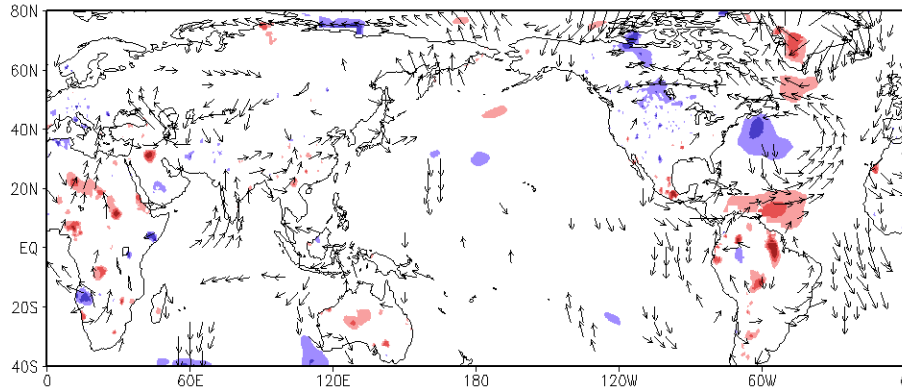
Correlation of Ts/SST/UV850 to P_{tot} Ann



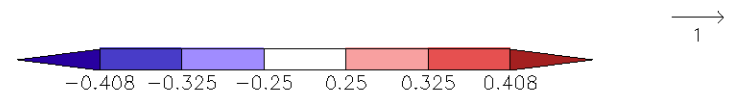
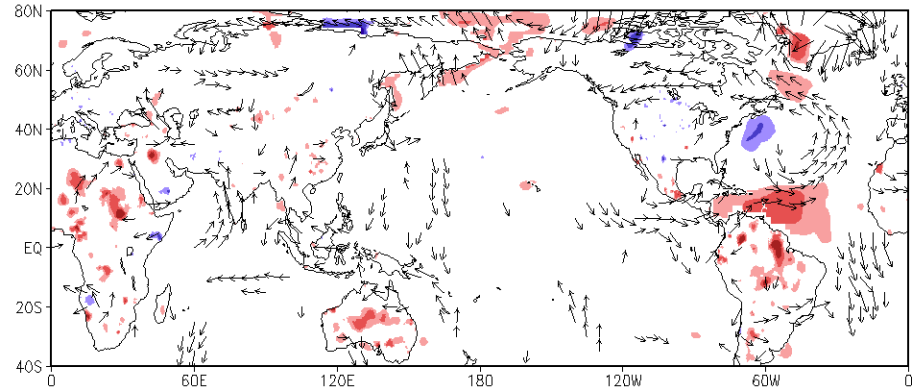
Correlation of Ts/SST/UV850 to P_{tot} (detrended) Ann



Correlation of Ts/SST/UV850 to P_{95}/P_{tot} Ann



Correlation of Ts/SST/UV850 to P_{95}/P_{tot} (detrended) Ann



3. Seasonality

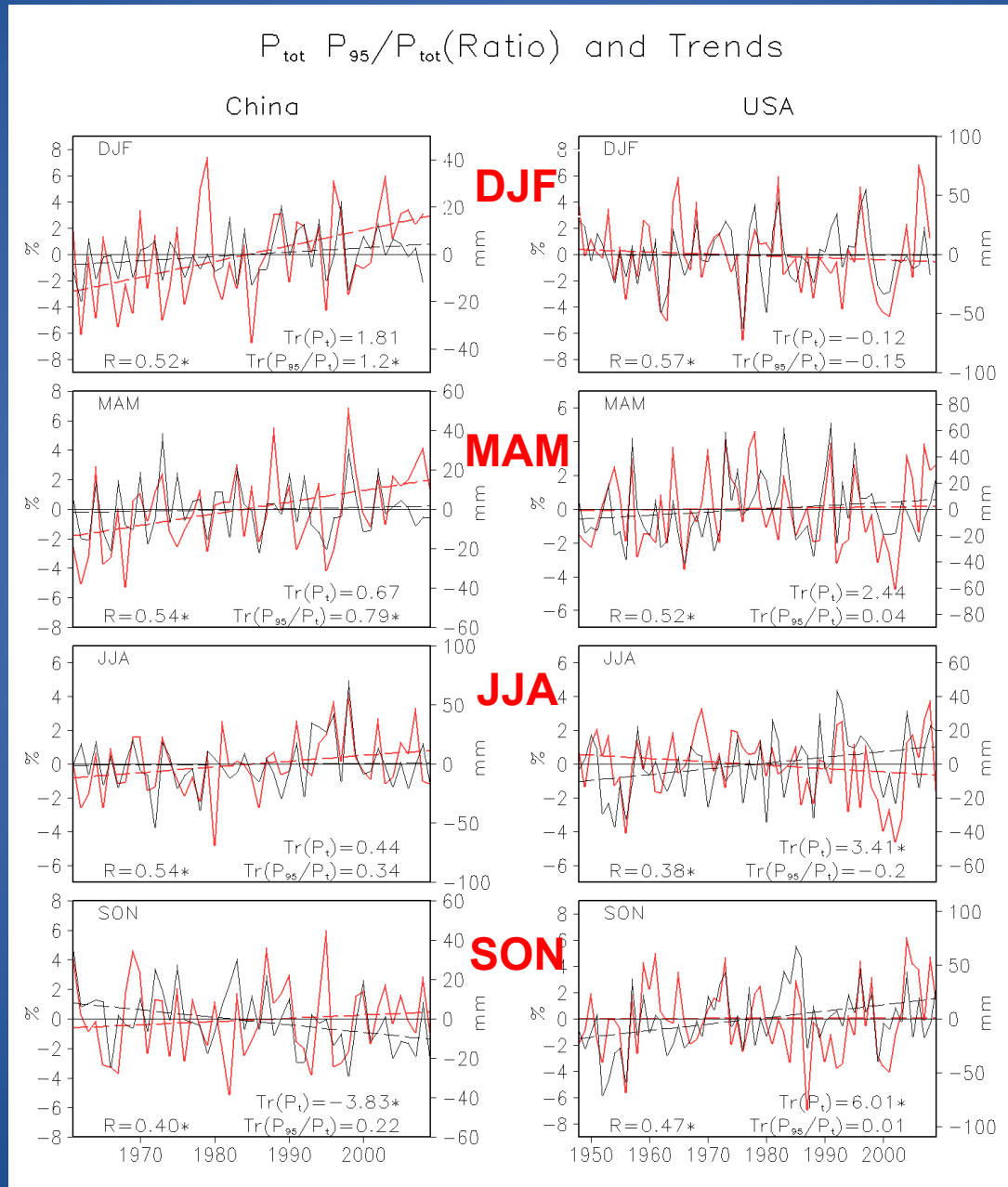
DJF

MAM

JJA

SON

Changes of Seasonal Total Precip (black) & Ratio (Red)



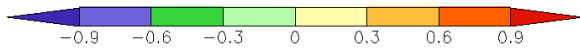
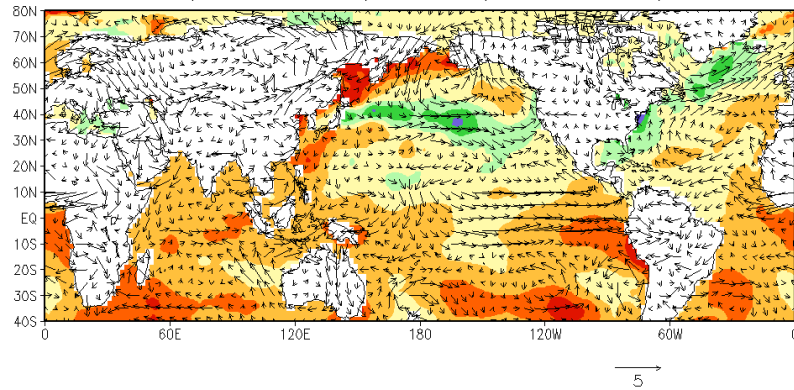
Seasonal Extreme Indices and Their Trends (in parentheses)

	Indices	China	USA
DJF	Total precipitation (mm; mm/decade)	35.2 (1.81)	163.5 (-0.12)
	Extreme precipitation (mm; mm/decade)	7.4 (0.71)	36.9 (-0.24)
	Ratio (%; %/decade)	14.0 (1.2**)	17.2 (-0.15)
	Wet days (day; day/decade)	6.5 (0.22)	20.6 (0.41)
	Extreme wet days (day; day/decade)	0.3 (0.04**)	1.1 (-0.01)
MAM	Total precipitation (mm; mm/decade)	140.0 (0.67)	194.0 (2.44)
	Extreme precipitation (mm; mm/decade)	33.2 (0.77)	43.9 (1.15)
	Ratio (%; %/decade)	18.4 (0.79**)	18.3 (0.04)
	Wet days (day; day/decade)	15.8 (0.05)	23.6 (0.54*)
	Extreme wet days (day; day/decade)	0.8 (0.03*)	1.2 (0.02)
JJA	Total precipitation (mm; mm/decade)	316.3 (0.44)	206.0 (3.41*)
	Extreme precipitation (mm; mm/decade)	76.7 (1.50)	48.7 (0.75)
	Ratio (%; %/decade)	21.3 (0.34)	19.3 (-0.20)
	Wet days (day; day/decade)	27.0 (-0.22)	25.0 (0.56*)
	Extreme wet days (day; day/decade)	1.4 (0.01)	1.3 (0.02)
SON	Total precipitation (mm; mm/decade)	120.2 (-3.83**)	175.2 (6.01*)
	Extreme precipitation (mm; mm/decade)	29.6 (-0.84)	43.2 (1.48*)
	Ratio (%; %/decade)	19.1 (0.22)	18.9 (0.01)
	Wet days (day; day/decade)	14.2 (-0.45**)	19.7 (0.83*)
	Extreme wet days (day; day/decade)	0.7 (-0.01)	1.0 (0.03)

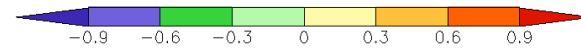
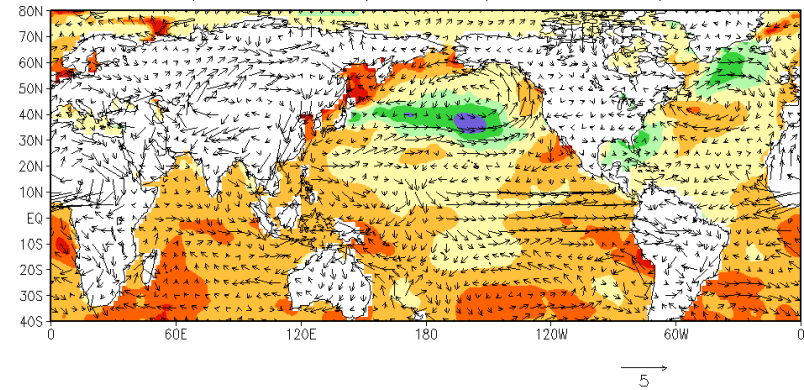
* and **: values significantly exceeding 95% and 99% confidence levels

Differences in Ts/SST & V850 (1990-2009 Minus 1948-1967) for DJF, MAM, JJA and SON

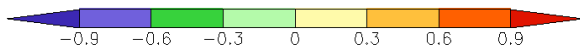
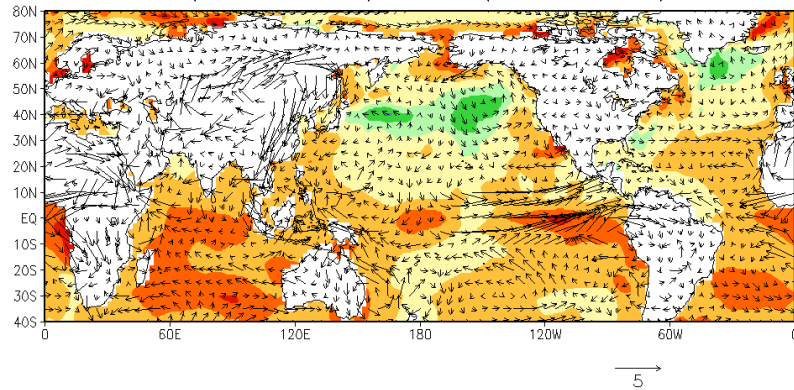
mean(1990-2009)-mean(1948-1967) DJF



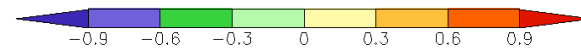
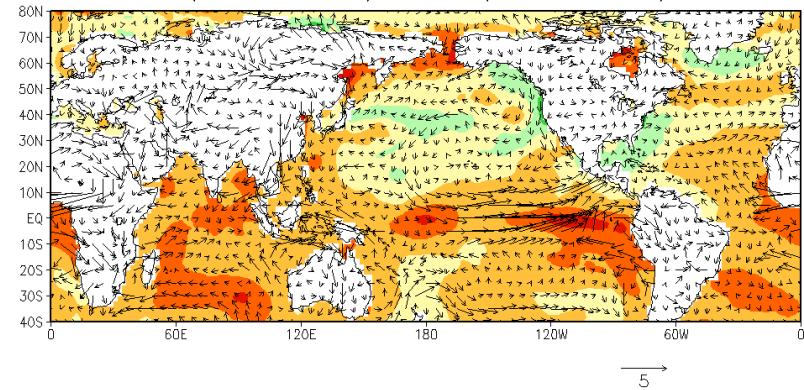
mean(1990-2009)-mean(1948-1967) MAM



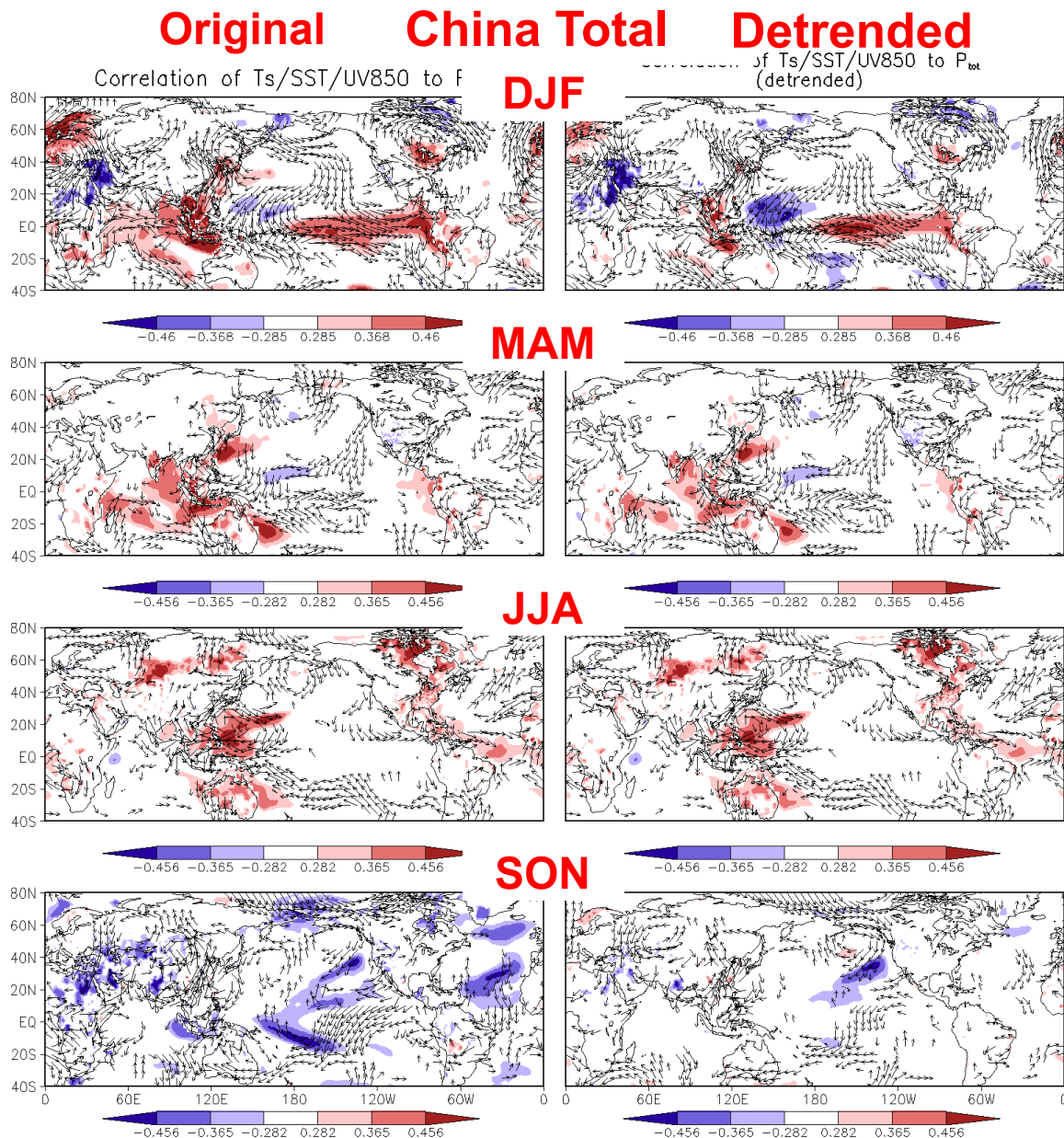
mean(1990-2009)-mean(1948-1967) JJA



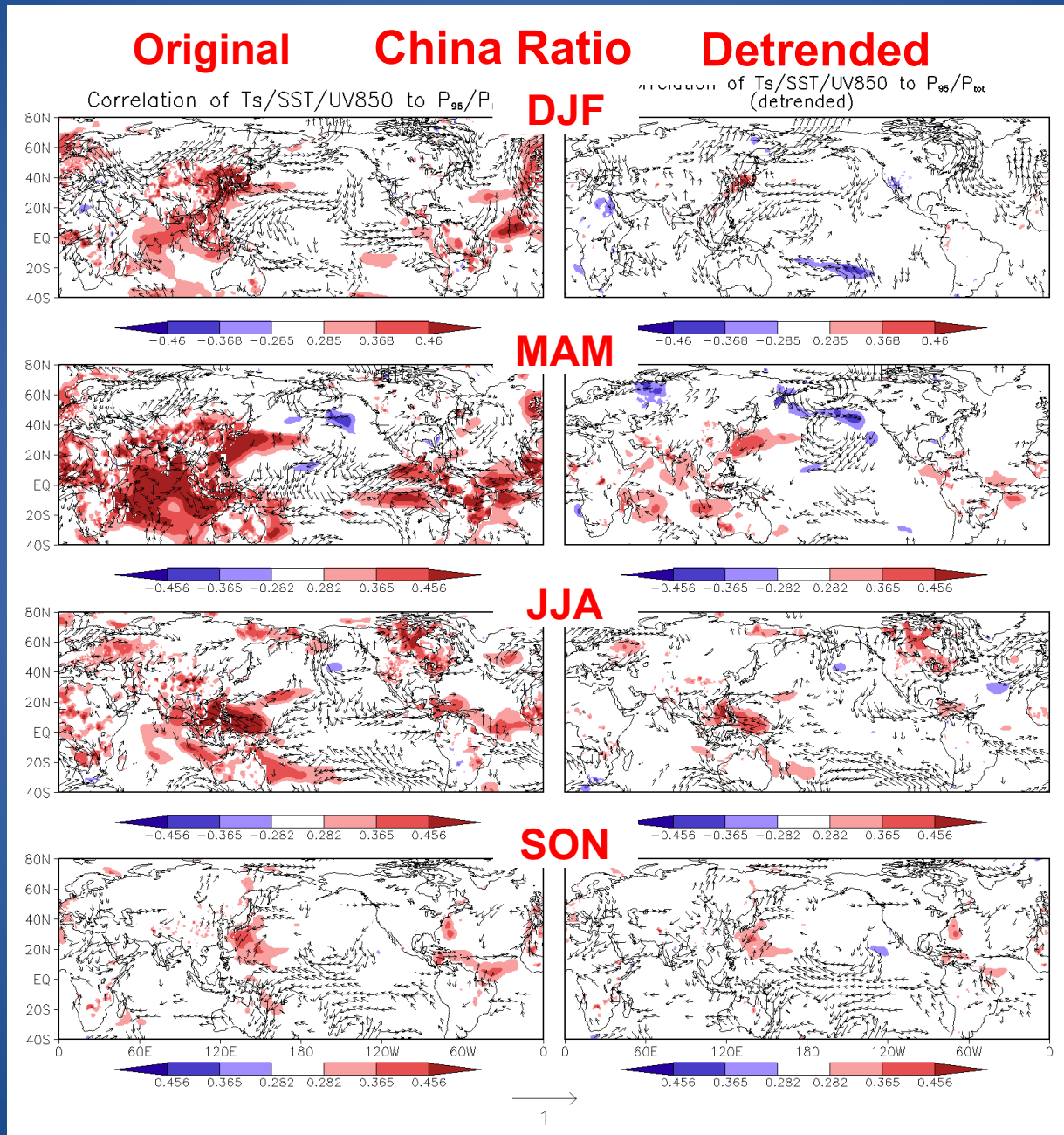
mean(1990-2009)-mean(1948-1967) SON



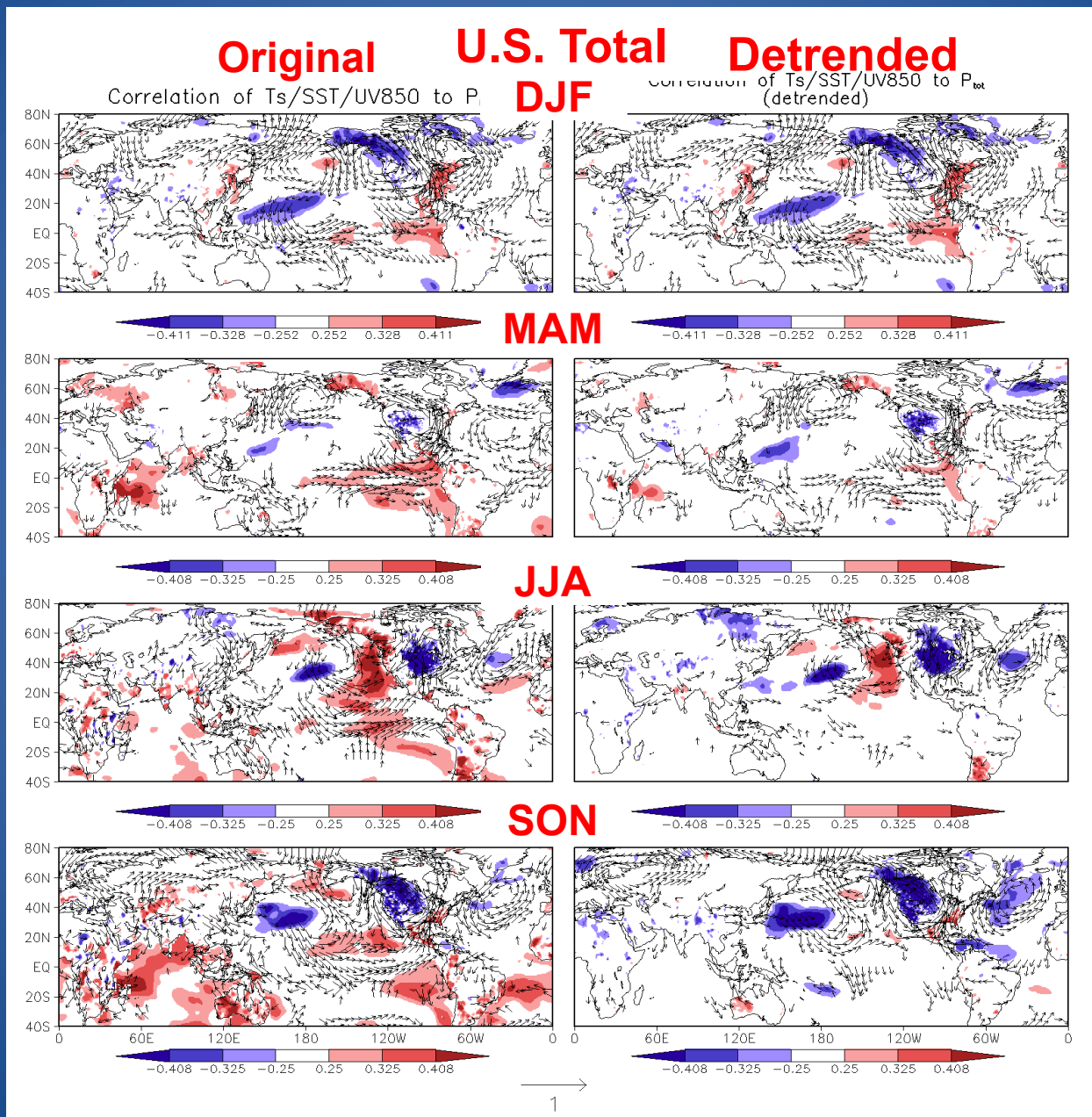
Seasonal Relations of Ts/SST and V850 with China Total Precip



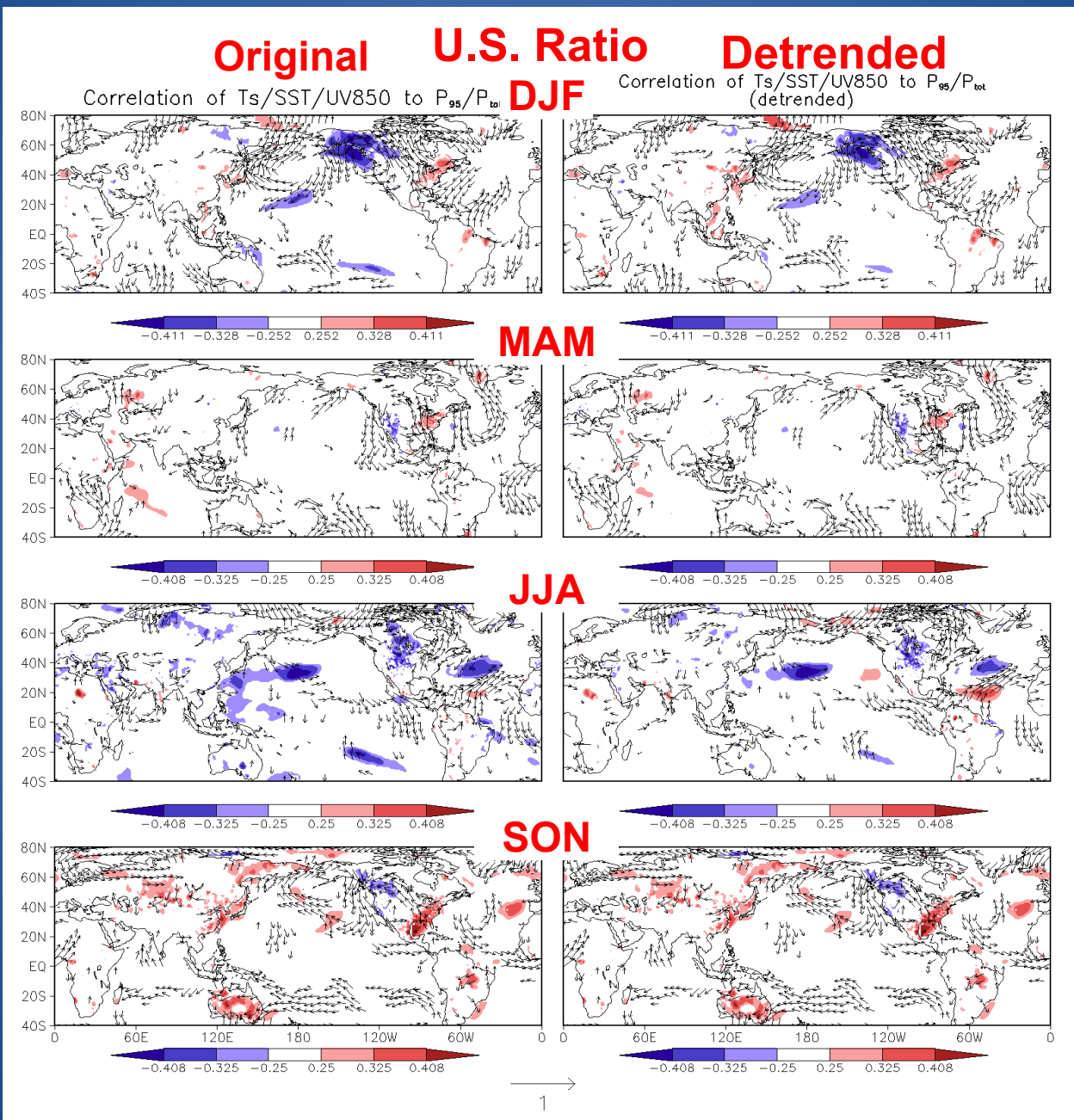
Seasonal Relations of Ts/SST and V850 with China Precip Ratio



Seasonal Relations of Ts/SST and V850 with U.S. Total Precip

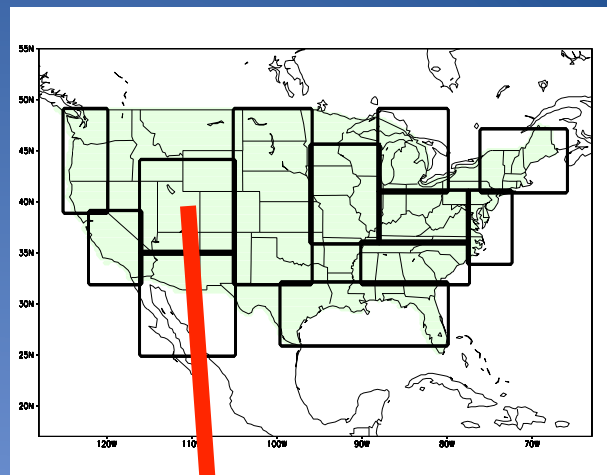
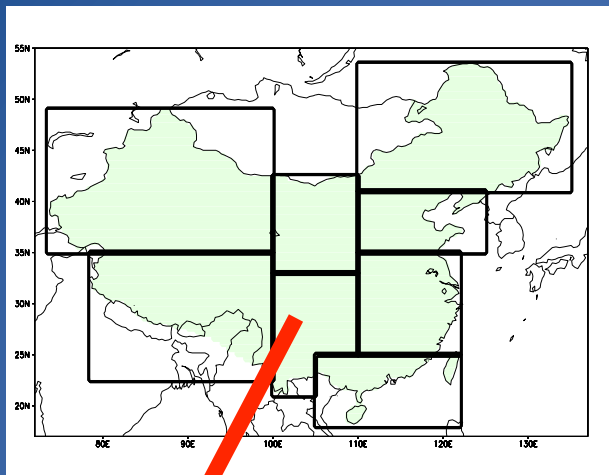


Seasonal Relations of Ts/SST and V850 with U.S. Precip Ratio

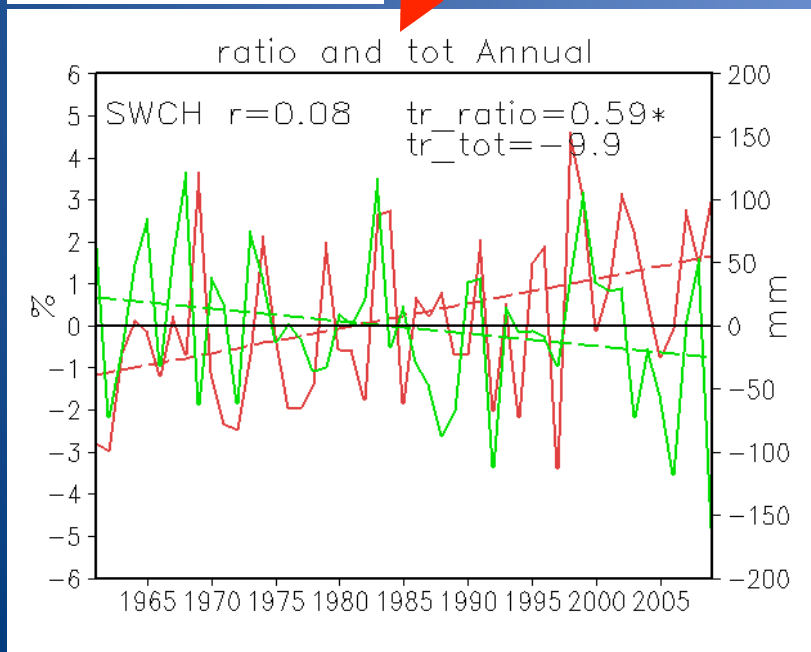


4. On-Going Work

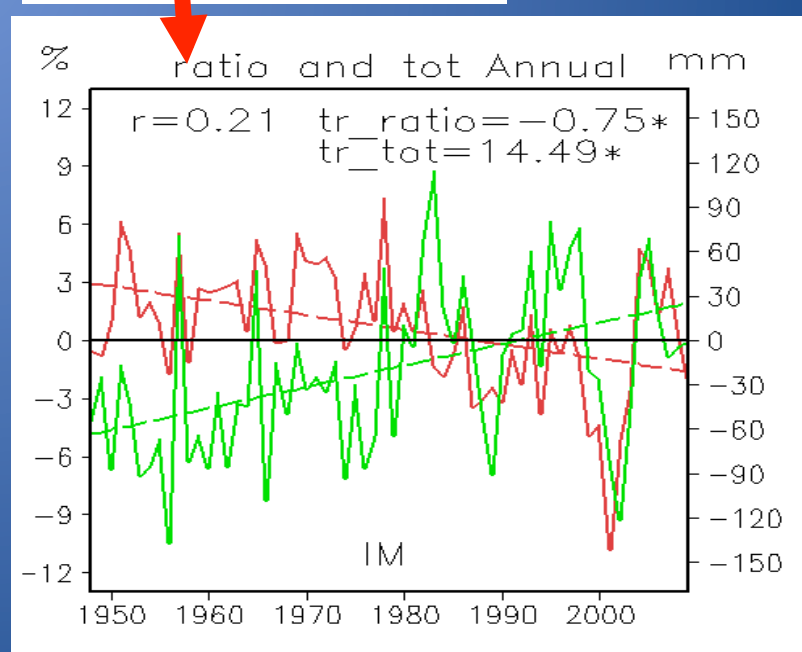
4.1 Regional Rainfalls



SW China

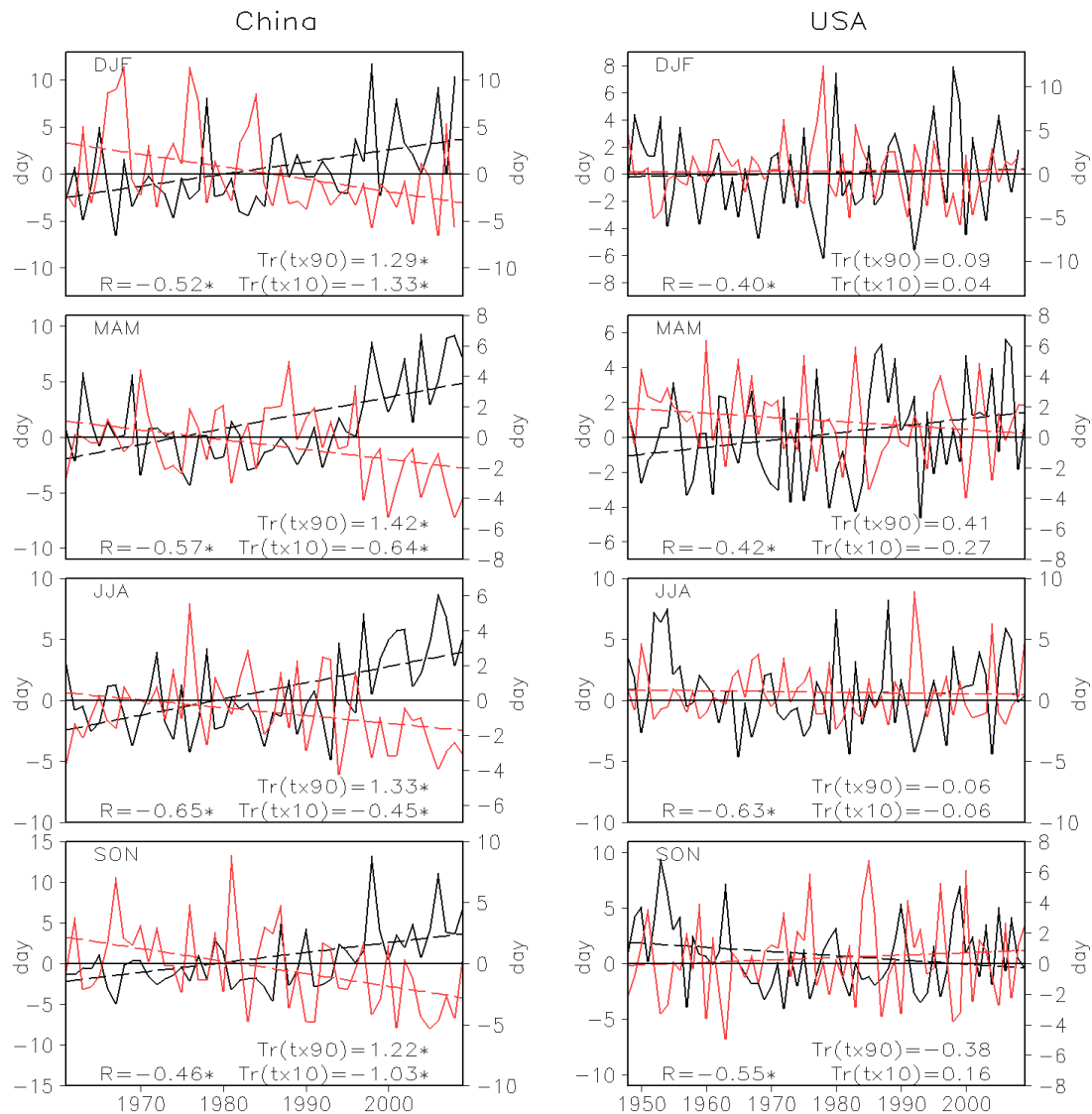


Inter-Mountains



4.2 Extreme Temperatures

Warm Day (Tx90) and Cold Day (Tx10)



- Warm days
- Cold days
- Warm nights
- Cold nights
- Maximum value of T_{max}
- Minimum value of T_{max}
- Maximum value of T_{min}
- Minimum value of T_{min}
- Daily temperature range
- Frost days (T_{min} < 0°C)
- Summer days (T_{max} > 25°C)
- Icing days (T_{max} < 0°C)
- Tropical nights (T_{min} > 20°C)

5. Summary

1. Annual precipitation over China:

Total: no trend

Ratio: a positive trend; linked to warming in the Indian Ocean and the tropical western Pacific, an anomalous anticyclonic pattern over the tropical western Pacific and the South China Sea (SST and atmospheric circulation over the Atlantic as well?)

2. Annual precipitation over U.S.

Total: a significant positive trend; linked to warming in the Indian Ocean and the tropical eastern Pacific, an anomalous cyclonic pattern over U.S. (warming over the tropical South Atlantic as well?)

Ratio: an insignificant negative trend

3. **In China**, precip ratio exhibits positive trends in all seasons, esp. in winter and spring, linked to warming in the Indian Ocean and tropical oceans in the western and eastern Pacific and the Atlantic. Total precip shows a significant negative trend in autumn, linked to cooling in the tropical central Pacific and the Atlantic

In U.S., total precip shows positive trends in all seasons (except winter) esp. in summer and fall, linked to warming in the eastern Pacific and the Indian Ocean. Precip ratio exhibits no significant trends esp. the near-zero trend in fall