Development of global 0.5° hourly land surface air temperature data

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4th WCRP International Conference on Reanalysis

7-11 May 2012, Silver Spring, MD

Our recent work on reanalysis (NRA, ERA-40, CFSR, MERRA, ERA-Int)

a) Near-surface fields and surface fluxes using data from 12 cruises over global ocean (Brunke et al. 2011)
b) Near-surface fields and surface fluxes using data from 35 flux towers over North America (Decker et al. 2012)
c) Near-surface fields and surface fluxes using data over Tibet Plateau (Wang and Zeng 2012; **Poster on Wed-Fri**)
d) Near-surface fields and surface fluxes using data over sea ice (ongoing work)

e) Climatology of tropospheric specific humidity inversion (Brunke et al., in preparation; **Poster on Mon-Tue**)

f) Global hourly Ta data development (**this talk**)

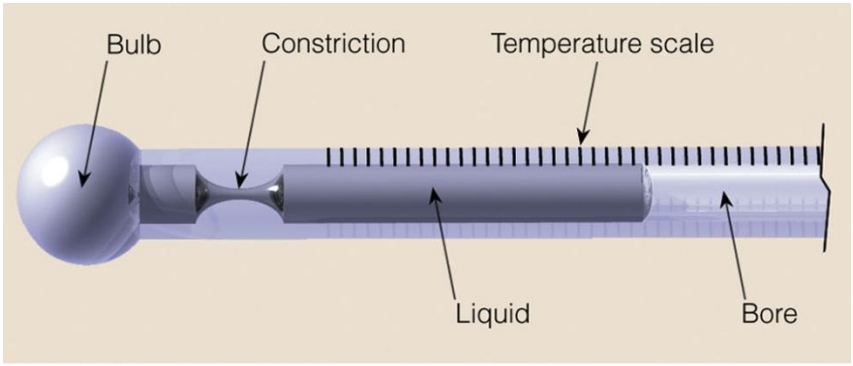
1. What Is Monthly Mean Land Surface Air Temperature? (Zeng and Wang, *AGU Eos*, 10 April 2012)

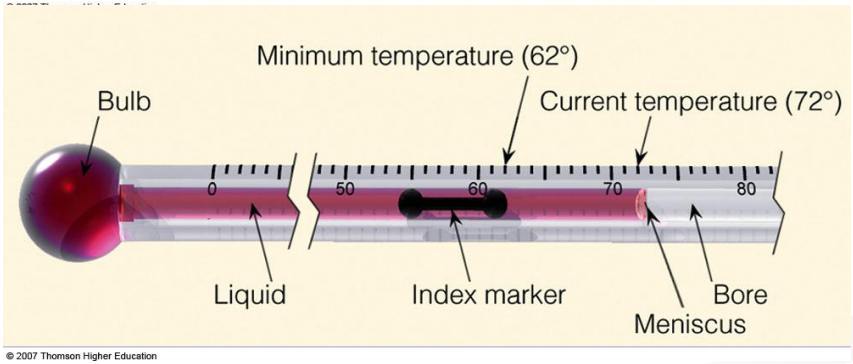
Current practice in observation, modeling, and application:

daily or monthly mean: (Tmax + Tmin)/2

---D. G. Fahrenheit invented the mercury thermometer in 1714

---Tmax and Tmin are convenient for human observers to read





Liquid-in-glass thermometers

It is time to use true monthly mean based on 24 hourly data

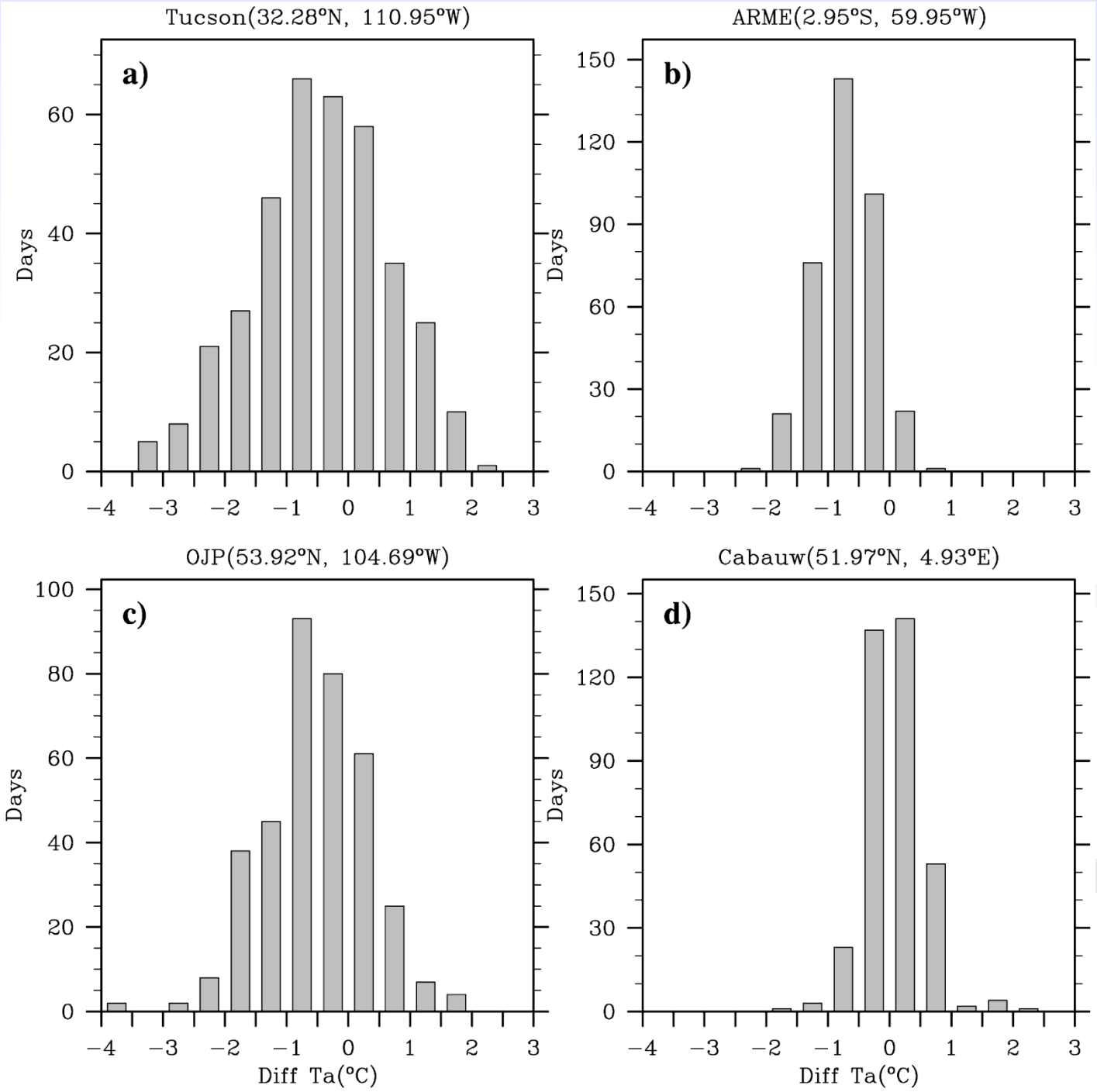
- wide use of automated electrical thermometer
- steady decrease in price of electronic products

- 24-hr average differs from (Tmax+Tmin)/2 (e.g. Brooks 1921)
- Tmax andTmin (including their timing) are strongly affected by transient factors (e.g., cloud cover)
- unclear if 24 hr mean or (Tmax+Tmin)/2 from IPCC models are used for model-data comparison.
- even more damaging if the trend is computed from (Tmax+Tmin)/2 in early years and 24-hr mean in later years

This requires the revision of guidelines from national weather and climate centers and World Meteorological Organization.

NWS ASOS

How large are the daily differences between 24-hr average and (Tmax +Tmin)/2?

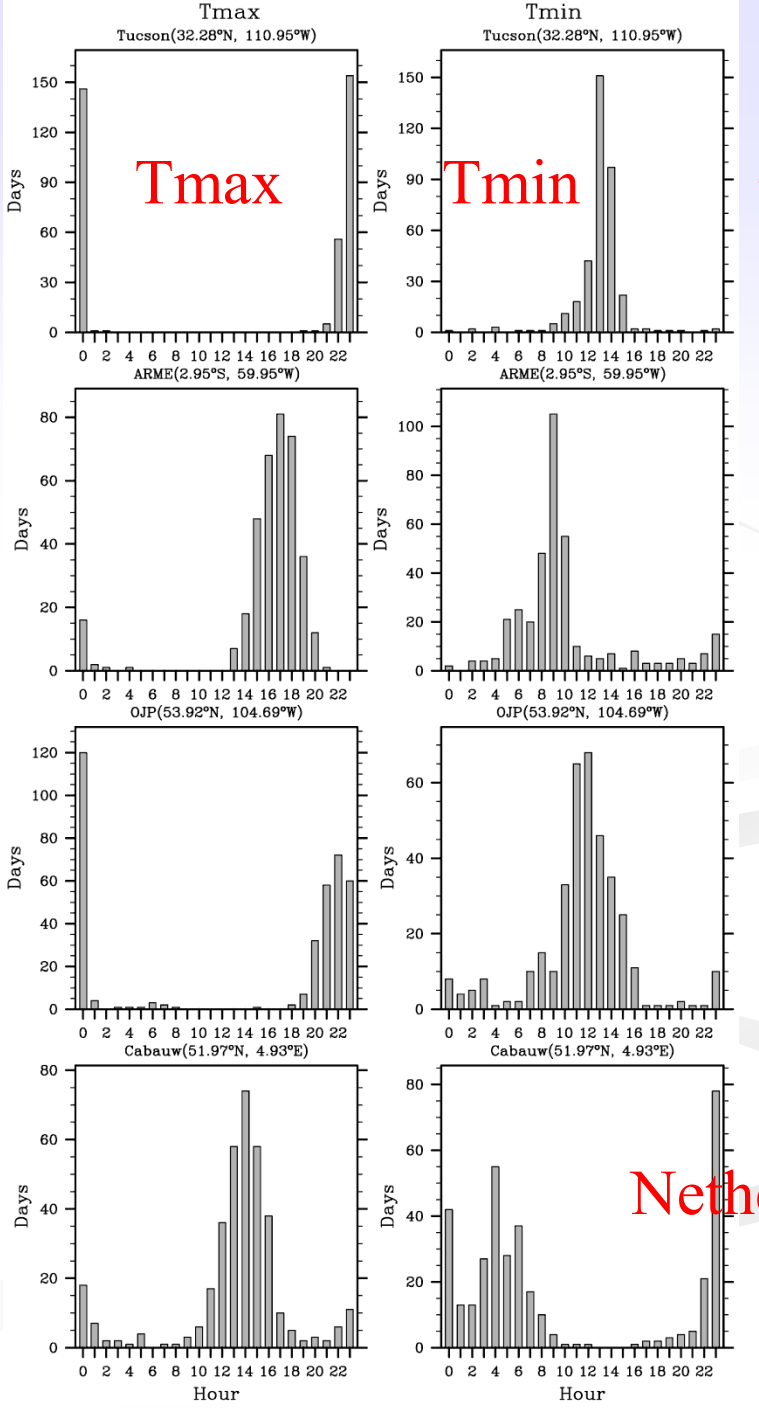


How often does Tmax occur in early afternoon and Tmin occur near sunrise?

Amazon

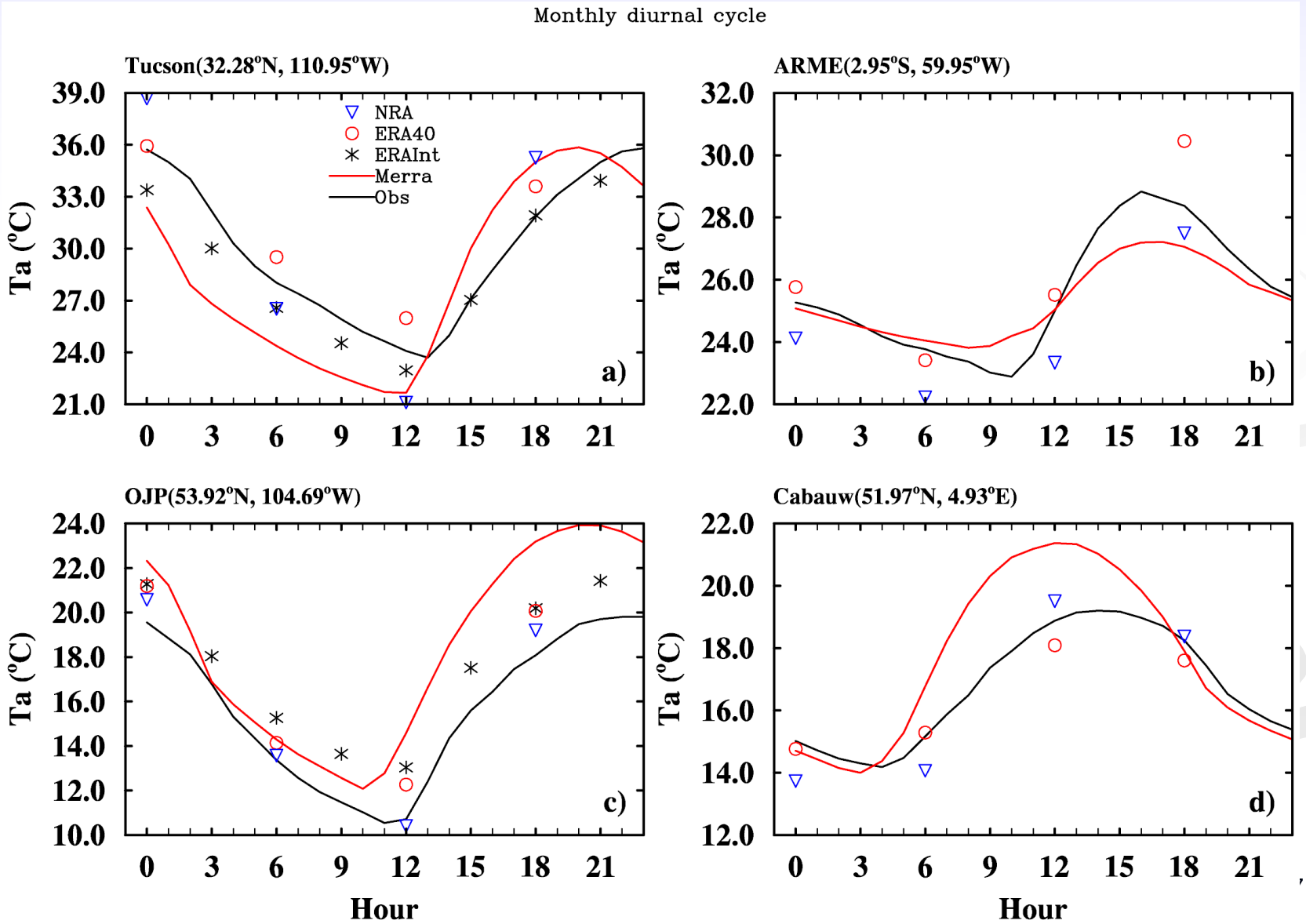
Boreal Forest in Canada

Distribution of Timing based on hourly observations in one year

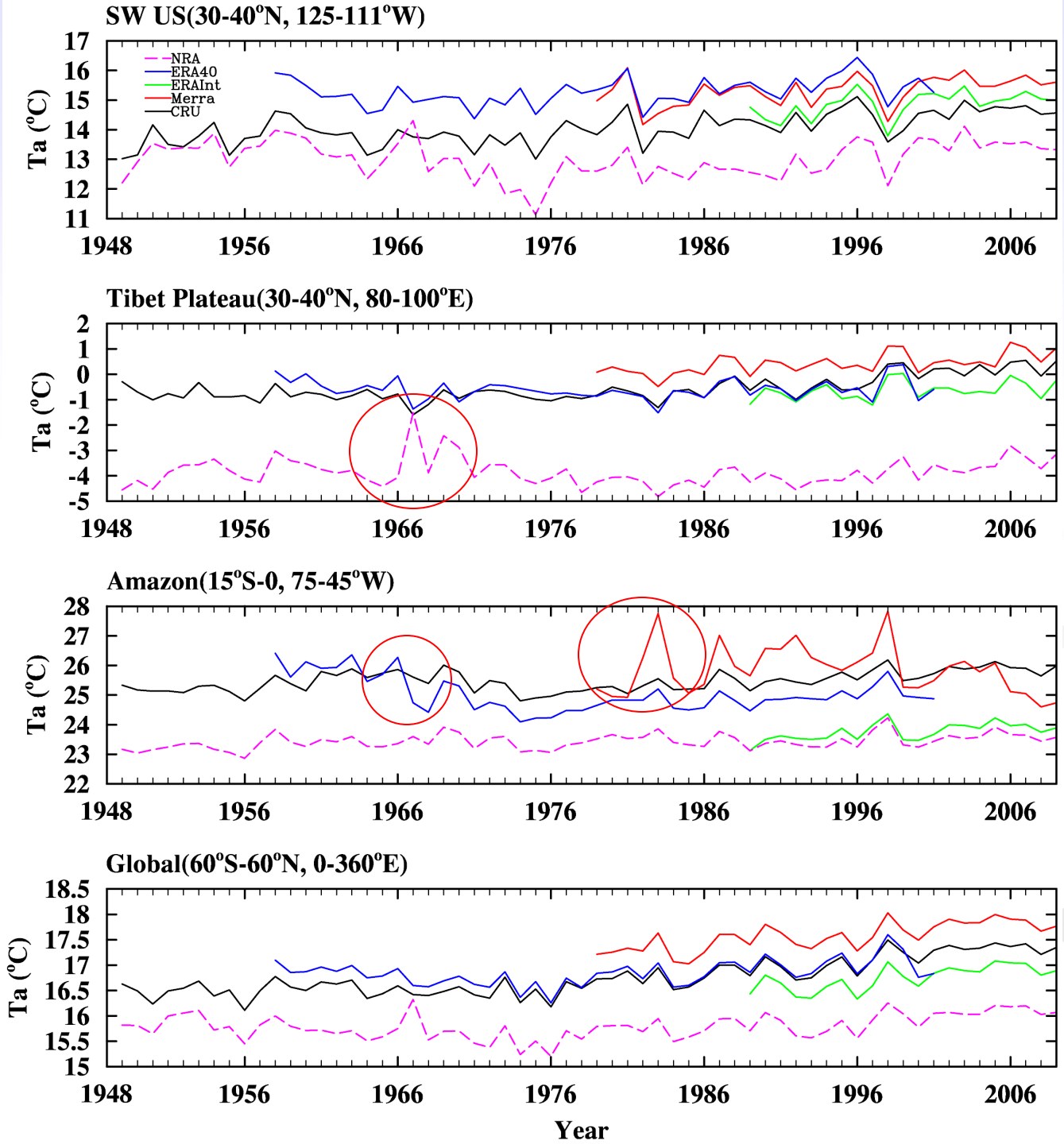


2. How good is reanalysis air temperature (T)

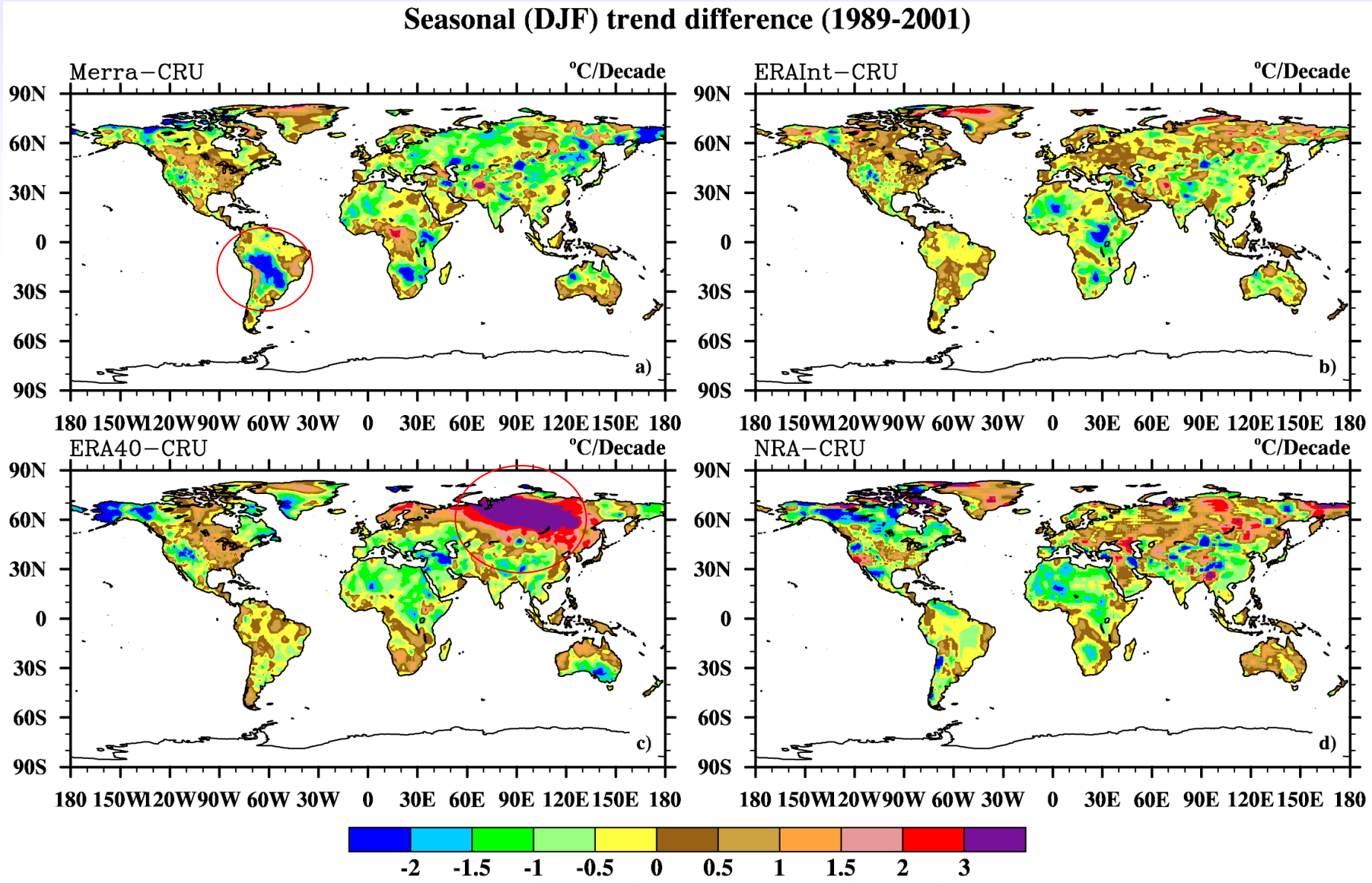
July-averaged diurnal cycle



Compared with annual mean CRU data



The point: hourly Ta from reanalysis are not good enough



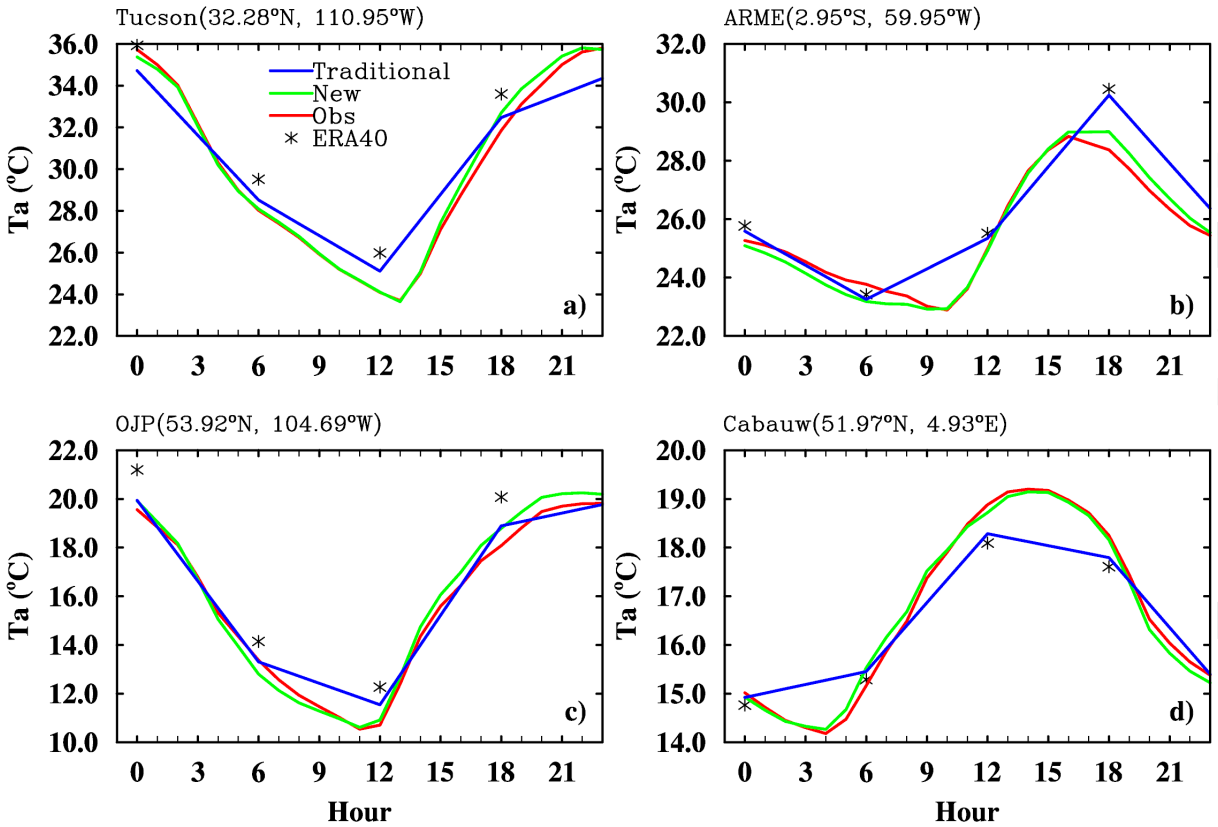
3. How to adjust reanalysis T?

Traditional approach:

- linear interpolation for diurnal cycle;
- monthly mean T bias correction

Our approach:

- monthly-averaged hourly diurnal cycle for interpolation
- monthly mean Tmax and Tmin bias correction



Adjusted reanalysis products

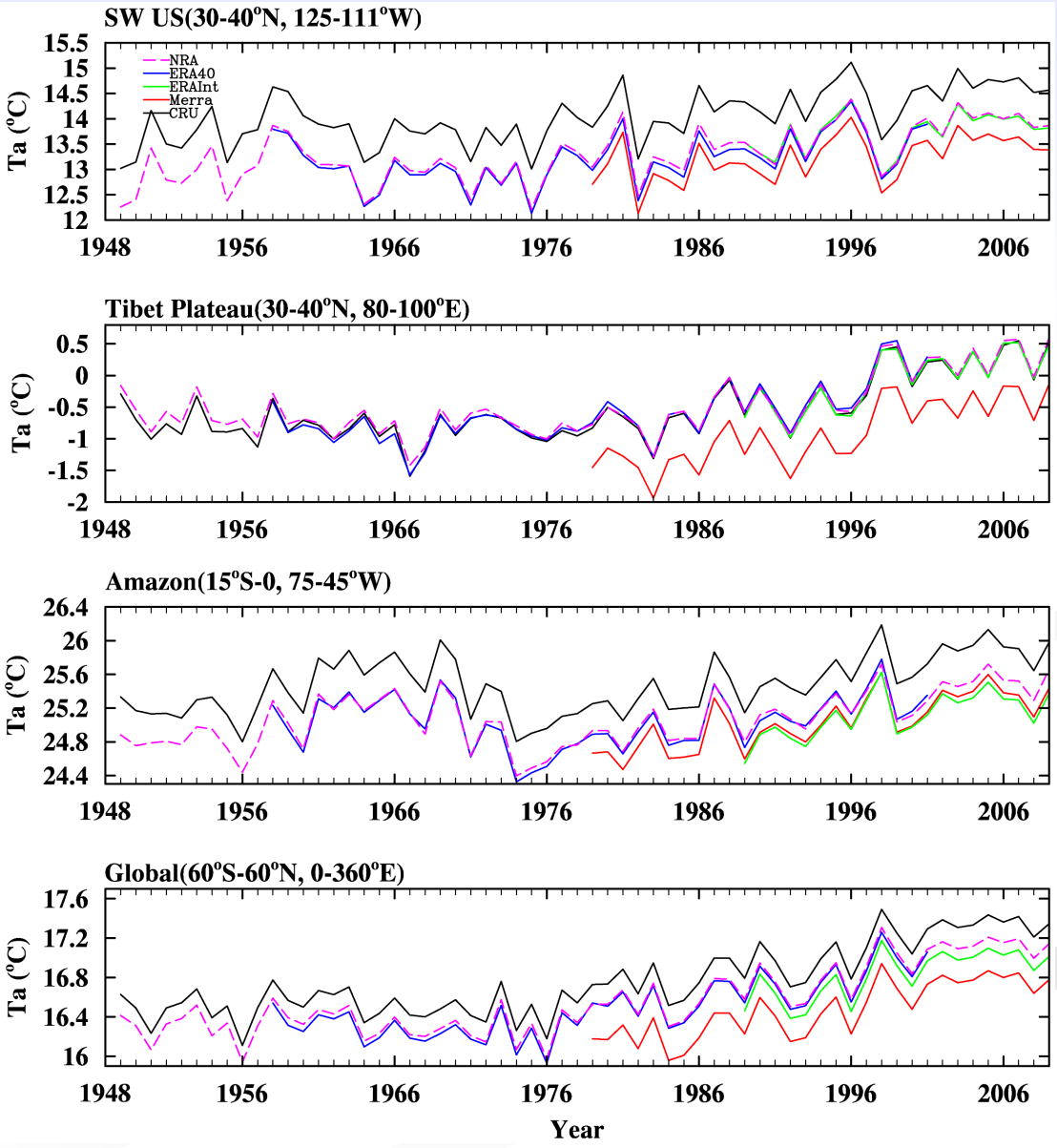
NRA: 6-hr, 1948-2009

ERA-40: 6-hr, 1958-2001 (diurnal cycle based on MERRA hourly T climatology)

ERA-Int: 3-hr, 1989-2009 (diurnal cycle based on linear interpolation)

MERRA: 1-hr, 1979-2009

Each adjusted reanalysis gives exactly the same Tmax, Tmin, (and Tm) as CRU data



4. Adjusted reanalysis results

(MERRA: Tm = 24-hr average; Tmax and Tmin refer to the max and min values of the monthly averaged diurnal cycle)

4.1. Global mean trend over land (60N-60S; 1979-2009) (˚C/dec)

	CRU	MERRA	
Jan	.25	.25	
Jul	.27	.27	Tm
Ann	.28	.28	
Jan	.22	.24	
Jul	.27	.27	Tmax
Ann	.28	.28	
Jan	.29	.26	
Jul	.27	.27	Tmin
Ann	.28	.27	

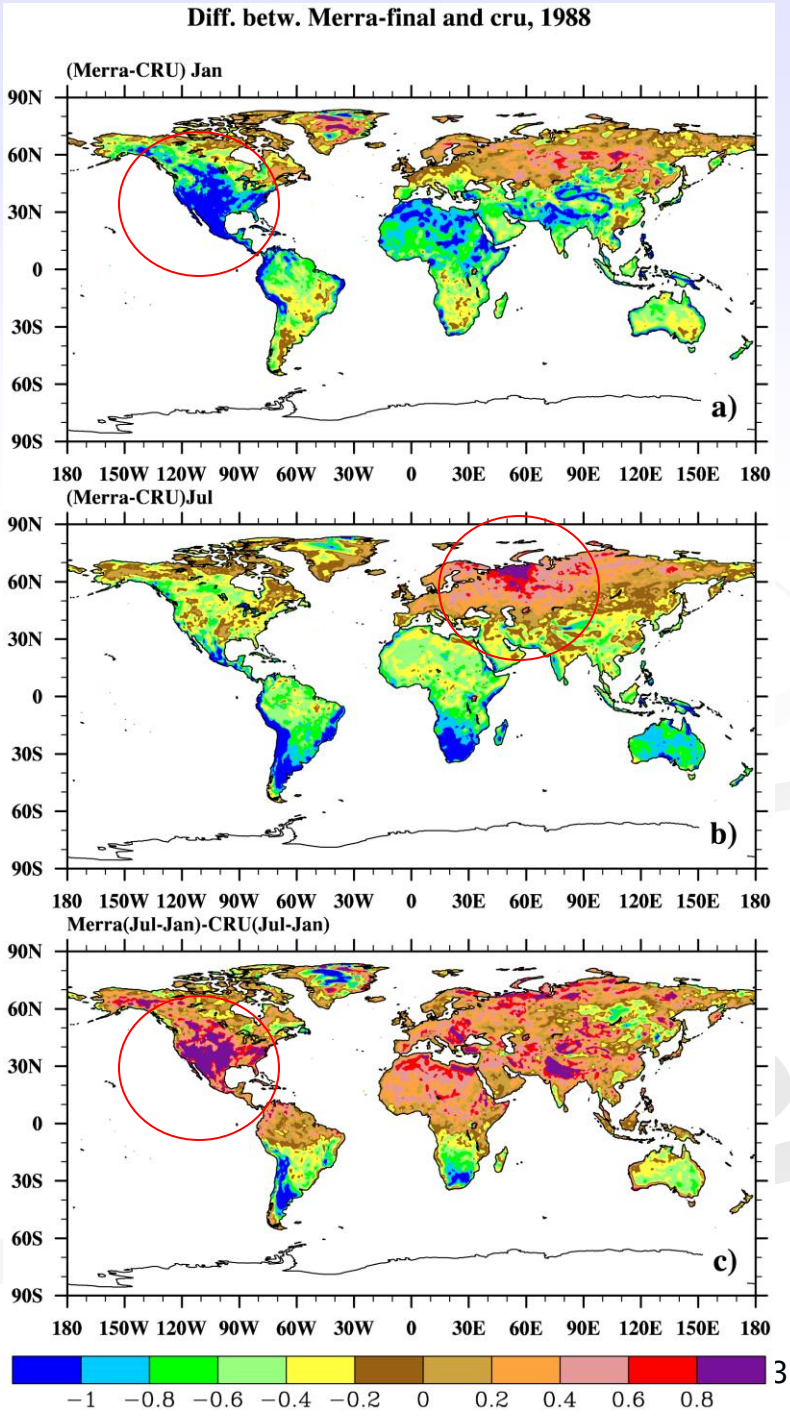
Key point: CRU January (Tmax-Tmin) decreases much faster (-0.07˚C/dec) than the adjusted MERRA (-0.02˚C/dec).

4.2 Jan and Jul 1988 and (Jul - Jan) between 24-hr mean and (Tmax + Tmin)/2 based on adjusted MERRA

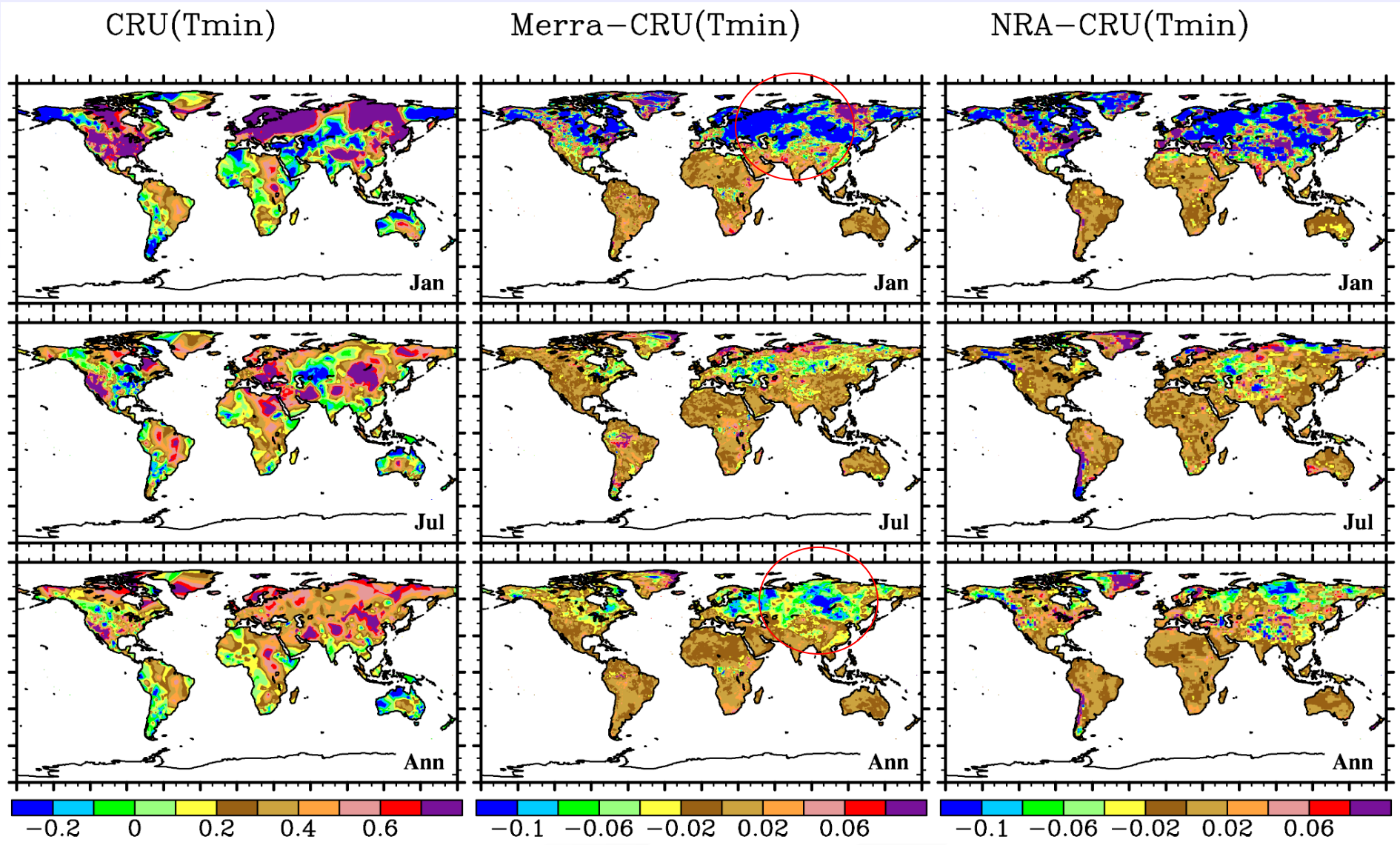
mean= -0.51; min=-3.16; max=1.78

mean= -0.39; min=-2.98; max=1.41

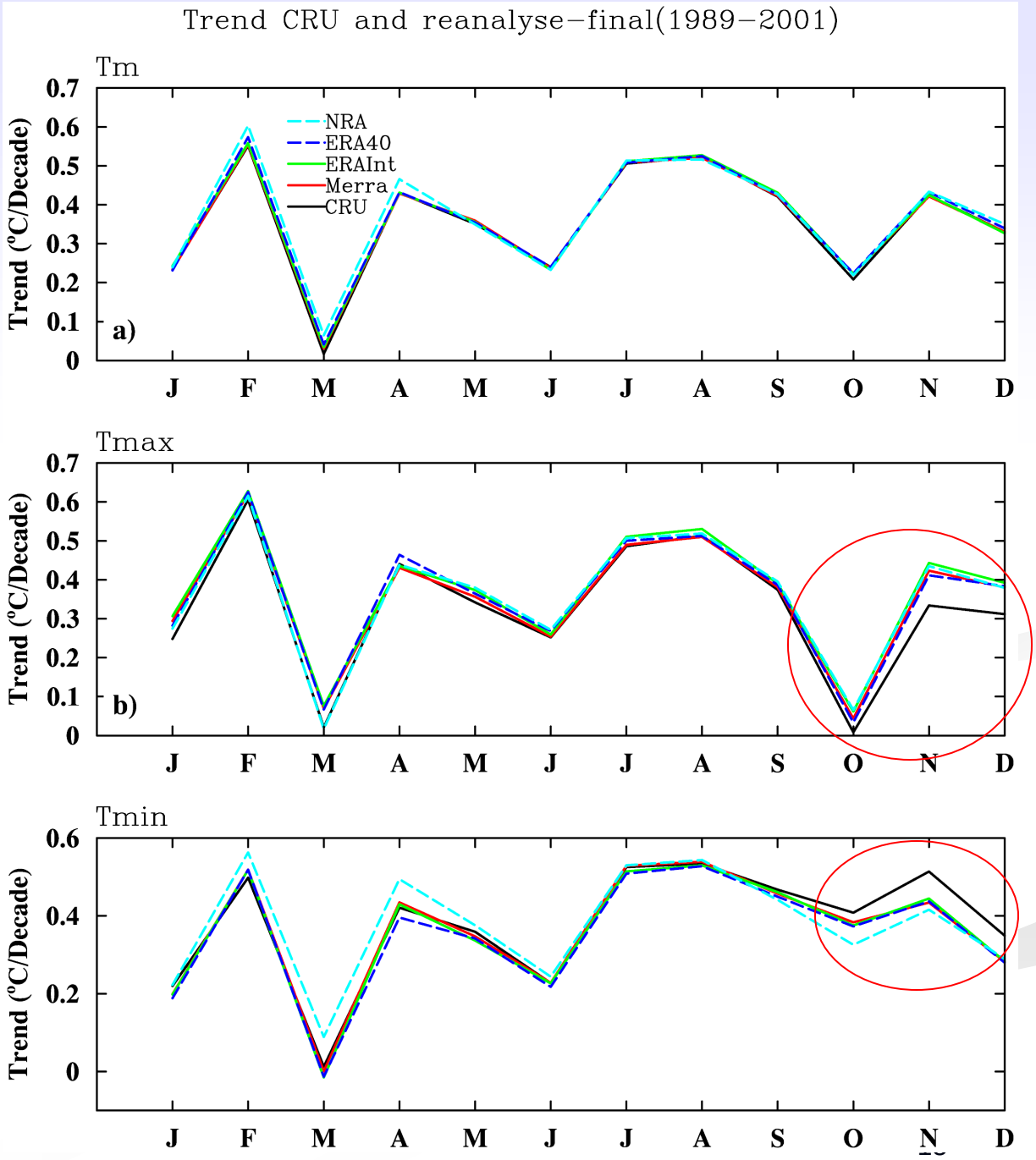
mean= 0.11; min=-2.77; max=3.30



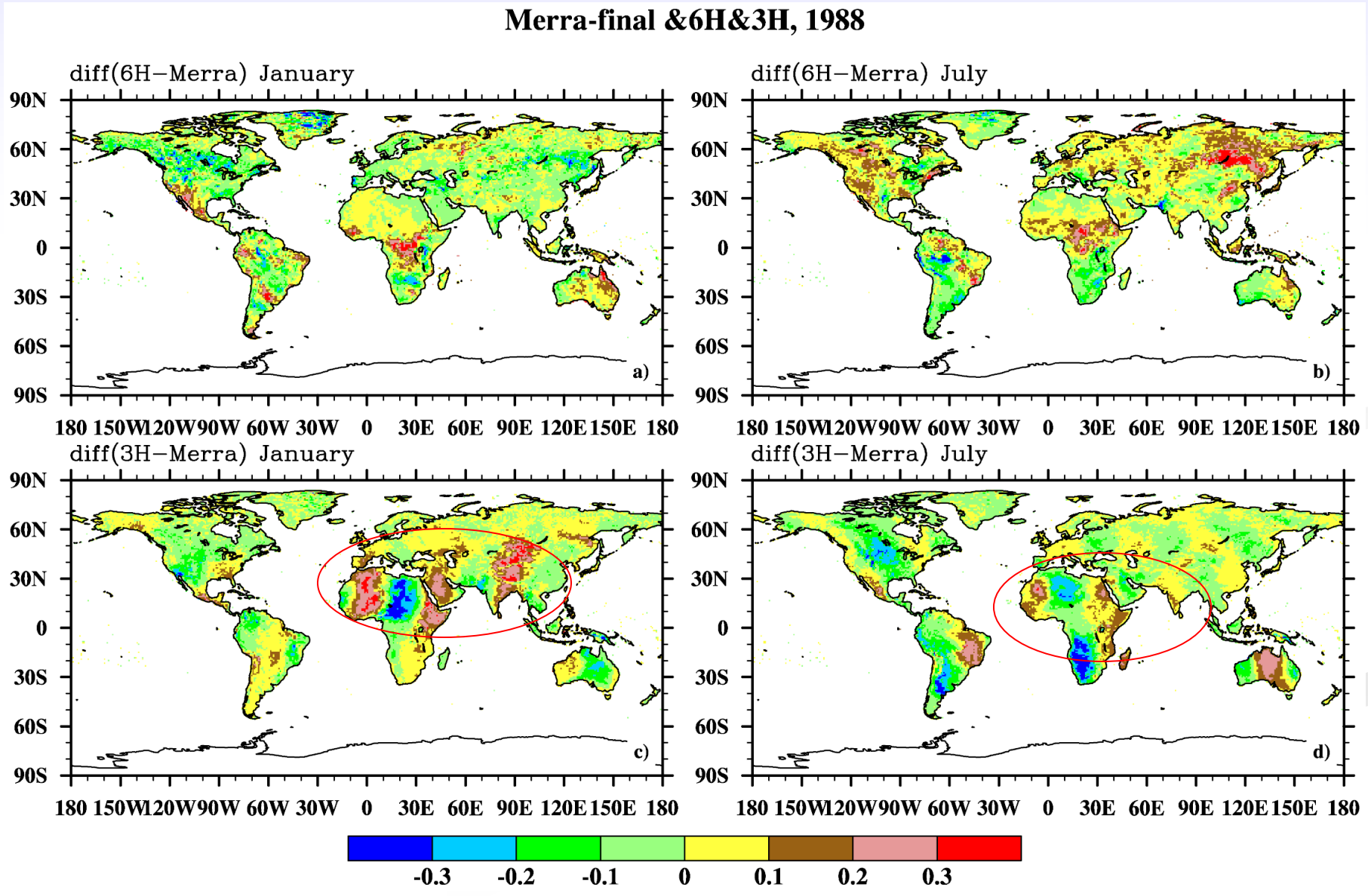
4.3. Tmin trend from 1979-2009 (˚C/dec)



4.4. Trend from 1989-2001 (˚C/dec) from four reanalyses



4.5. what is the impact of diurnal cycle adjustment of 6-hourly NRA and ERA-40 as well as 3-hourly ERA-Int?



5. Summary

(1) The traditional approach to adjust reanalysis T is not appropriate for the diurnal cycle

(2) A new adjustment approach is developed and the adjusted reanalysis T data have exactly the same monthly Tmax and Tmin data from CRU

(3) CRU (Tmax-Tmin) in winter decreases with time from 1979-2009 much faster than the adjusted MERRA data

(4) The adjusted hourly MERRA data (1979-2009) are ready for community use. The adjusted hourly NRA, ERA-40, and ERA-Int data are adequate for various applications (but caution is needed for trend analysis)

(5) It is time to use 24-hourly mean to represent daily and monthly mean T in observational data record

(6) The next generation of reanalysis should save hourly (rather than 3-hr or 6-hr) 2-D near-surface fields.

4.6. Can you compute trend by using data from different periods: NRA (1948-1957), ERA-40 (1958-1988), and ERA-Int (1989-2009)?