Evaluation of the Multi-reanalysis products with station observations over the Tibetan Plateau

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1 Introduction

Tibetan Plateau (TP) is the highest plateau in the world and its average elevation is above 4000 m with an area of about 2.5 million square kilometers. Due to its high elevation and complex terrain, the land-atmosphere interaction over the TP directly influences the thermal and water budget in the local middle troposphere which, through large-scale atmospheric circulation, also affects weather and climate over other regions. Therefore, understanding the water and energy interaction between land and overlying atmosphere would greatly help to understand the weather and climate change over both TP and surround areas.

Because of the complex topography, severe weather, and environmental condition over the TP, it is very difficult to obtain in-situ measured meteorology variables, especially for long-term over large areas. The in situ observation stations, mainly from Chinese Meteorological Administration (CMA), are too sparse for representation of large areas. The global reanalysis products provide high resolution and continuous variables, which could be used as a surrogate over the TP. However, the reanalysis products contain uncertainties from various sources which are inherent in the reanalysis processes. Thus, it is necessary to evaluate and compare various reanalysis products with available in-situ measured observations before they are used to represent meteorology states over the TP.

Reference: Wang, A., and X. Zeng (2012), Evaluation of multireanalysis products with in situ observations over the TibetanPlateau, J. Geophys. Res., 117, D05102, doi:10.1029/2011JD016553

2 Data

Observation:

a) Daily precipitation and air temperature over CMA 63 stations for (1992-2001);
b) Other surface meteorology variables (radiation, wind, pressure, and humidity) over 9 stations for Oct. 2002- Dec. 2004 from CAMP/Tibet experiments;

Reanalysis:

MERRA, NCEP/NCAR-1 (NRA-1), ERA-40, ERA-Interim, GLDAS, CFSR

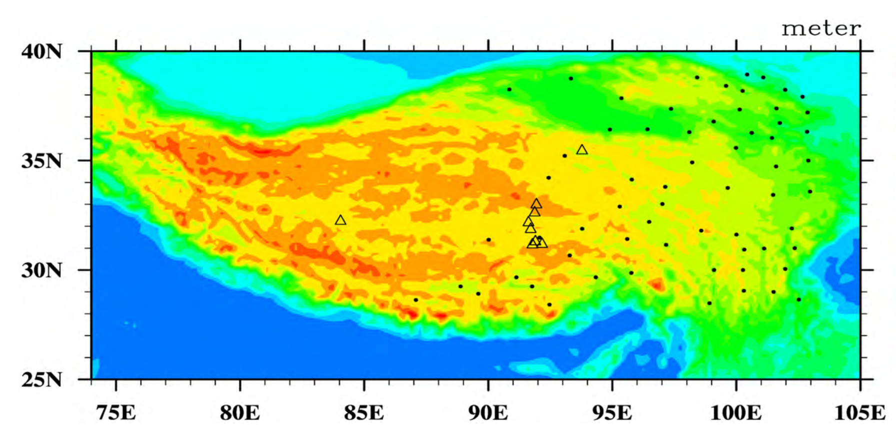

Figure 1. Topography (meter) and locations of the 63 CMA stations (dot) and 9 CAMP stations (triangle) over the Tibetan Plateau.

3 Method

a) Compute statistical quantities : Correlation coefficient (ρ), Ration of the standard deviations (σ_d/σ_{obs}), Standard deviation of differences (σ_d), Mean bias (BIAS)

b) Ranking approach to quantify the relative skill of each variables among different reanalyses, and three steps are used to process ranking.

1) Compute statistical quantities between reanalysis products and observation at each point;
2) Rank each statistical quantity among six reanalyses at each station: give 1 to the reanalysis with best performance in terms of statistical quantity, and 6 to the one with the worst performance;
3) Averaged ranks over all 63 CMA stations, and 9 CAMP/Tibet stations;
4) Reanalysis product with the smallest averaged rank rate for a variable is the best representation of that variable.

4 Results

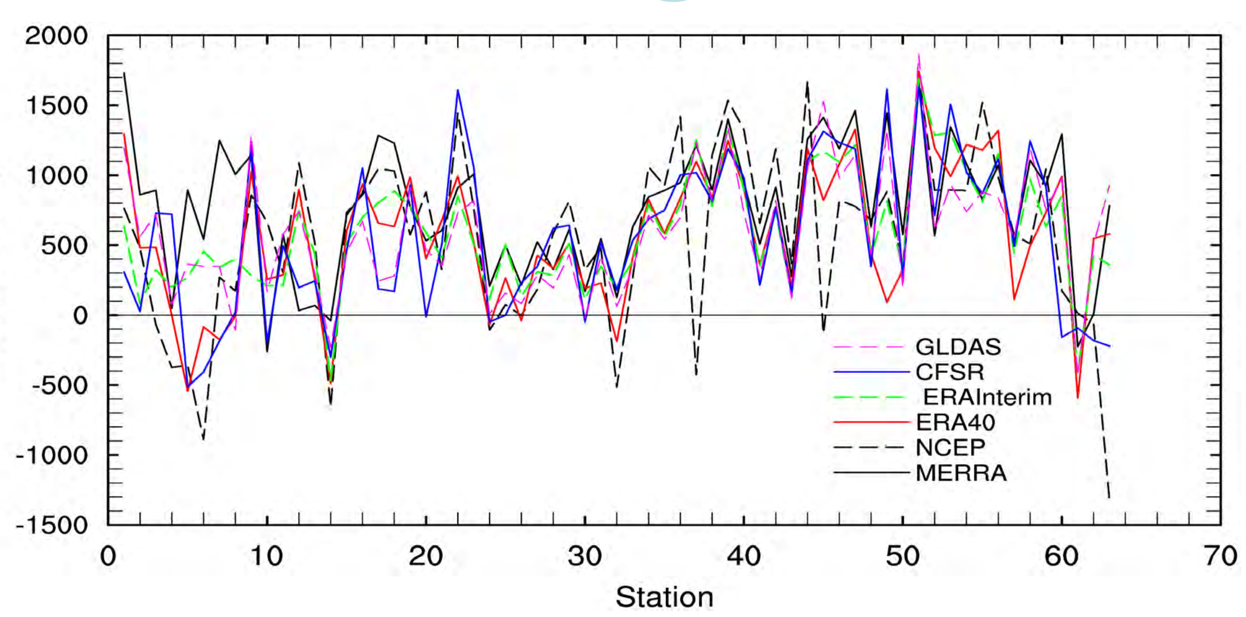

Figure 2. Surface elevation differences between reanalysis grid cell and station locations (reanalysis – station).

• Overall, surface elevations in reanalyses are higher than station locations.

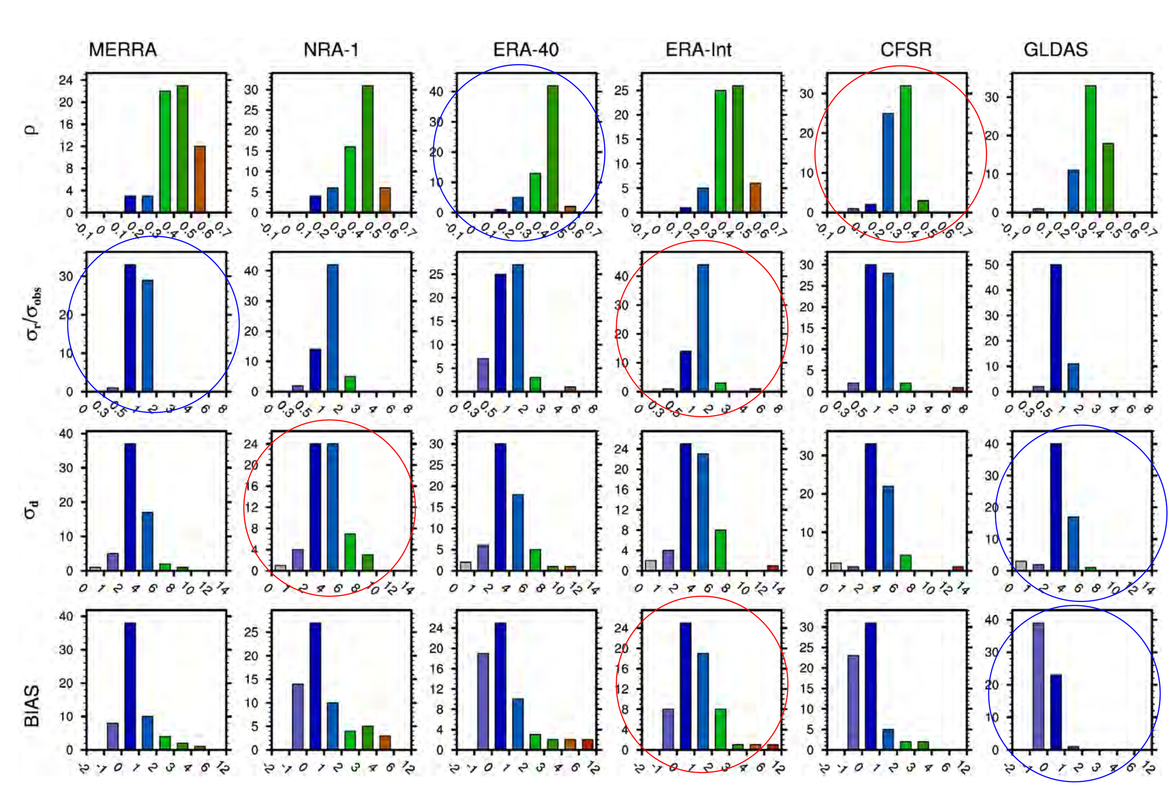

Figure 3. Histograms of daily precipitation statistics computed from six reanalysis products and observations over the 63 CMA stations for 1992-2001. The correlation coefficient (r), ratio of standard derivations (sd/sobs), root mean square error (RMSE) (mm/day), and mean biases (BIAS) (mm/day) are shown in the x-axis, while the number of stations for each bin is shown in the y-axis.

• Blue: the best performance
• Red: the worst performance

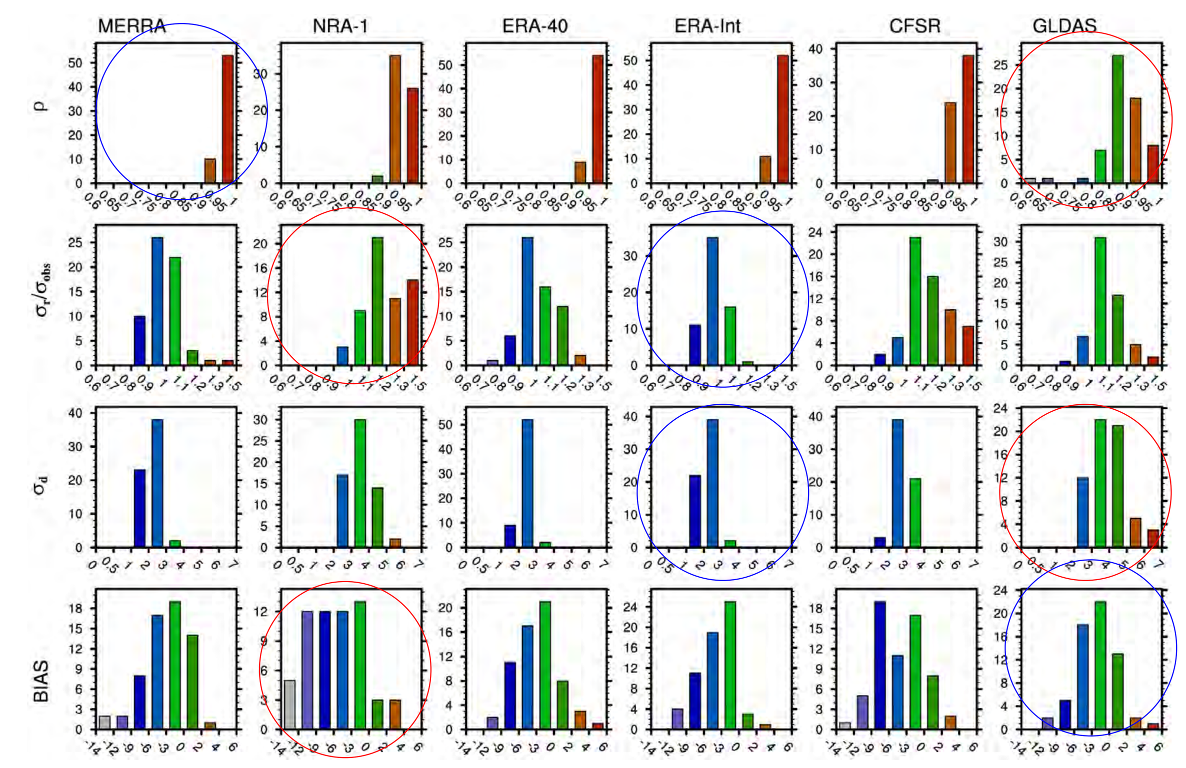

Figure 4. Same as Figure 3, but for daily air temperature (^oC).

• The cold biases in reanalyses are mainly caused by higher surface elevation.

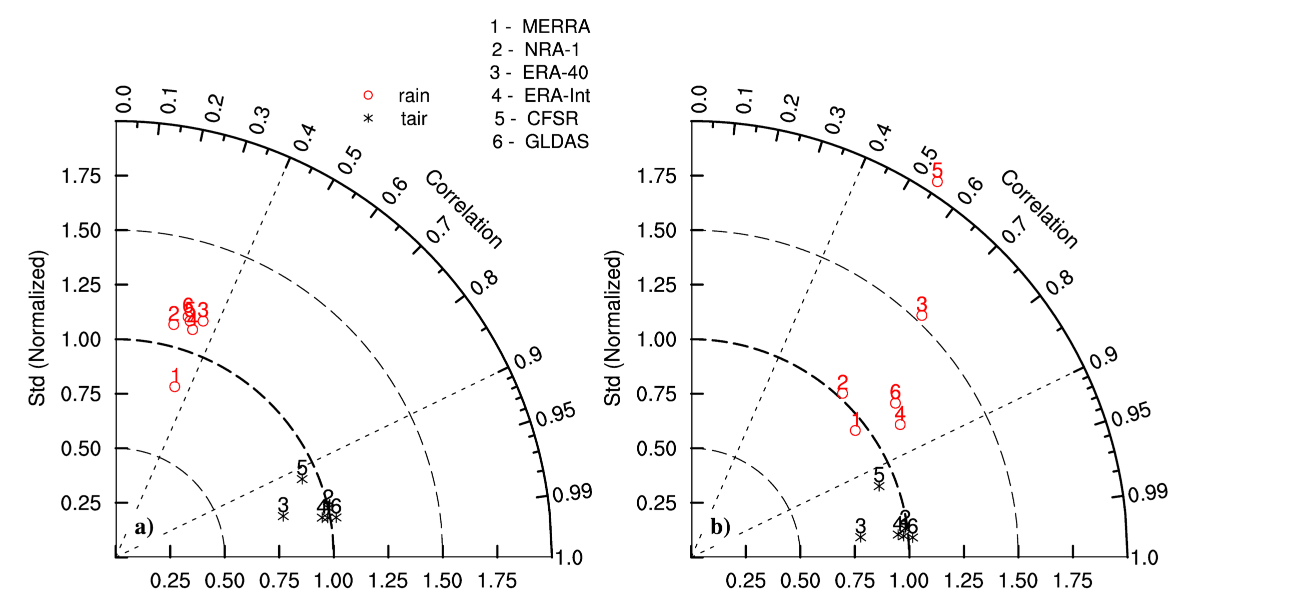

Figure 5. Taylor diagrams of a) daily; and b) monthly precipitation (red circle) and air temperature (blue star) for 1992-2001. The correlation and ratio of standard deviations are firstly computed in situ observations and six reanalysis products at each station, and then averaged across 63 stations.

Ranking results for
a) Precipitation

	ρ		σ_r/σ_{obs}		σ_d		BIAS	
	Daily	Mon.	Daily	Mon	Daily	Mon.	Daily	Mon
MERRA	2.83	1.89	2.90	3.16	2.98	2.43	3.62	3.62
NRA-1	2.83	3.29	3.62	4.29	4.52	4.33	4.05	4.06
ERA-40	2.62	4.25	3.65	3.89	2.51	3.75	3.90	3.90
ERA-Int	3.11	1.97	3.92	4.00	4.78	3.38	4.29	4.27
CFSR	5.17	4.63	3.63	3.44	3.84	3.68	3.11	3.11
GLDAS	4.44	4.97	3.27	2.22	2.37	3.43	2.03	2.03

b) Air temperature

	ρ		σ_r/σ_{obs}		σ_d		BIAS	
	Daily	Mon.	Daily	Mon	Daily	Mon.	Daily	Mon
MERRA	2.03	1.81	2.78	2.84	1.90	1.87	2.95	2.95
NRA-1	4.86	4.40	5.24	5.21	5.30	4.94	4.97	4.97
ERA-40	2.70	2.56	2.87	2.94	2.68	2.44	3.14	3.14
ERA-Int	2.08	2.32	2.67	2.68	1.81	2.16	3.21	3.21
CFSR	3.41	3.94	4.08	4.06	2.73	3.95	4.03	4.03
GLDAS	5.92	5.98	3.37	3.27	5.57	5.63	2.70	2.70

• Blue: the best performance; Red: the worst performance

Ranking results for other variables
a) correlation coefficient (daily)

	ρ		σ_r/σ_{obs}		σ_d		BIAS	
	Daily	Mon.	Daily	Mon	Daily	Mon.	Daily	Mon
MERRA	2.67	2.17	1.71	1.83	2.38	2.00	2.78	2.67
NRA-1	4.56	3.17	3.86	4.00	3.88	4.13	4.00	4.56
ERA-40	4.44	3.17	2.71	4.86	4.63	2.50	4.44	4.44
ERA-Int	2.33	1.83	2.43	2.83	1.38	1.63	1.33	2.33
CFSR	1.00	4.67	4.29	1.50	2.75	4.75	2.44	1.00
GLDAS	2.67	2.17	1.71	1.83	2.38	2.00	2.78	2.67

b) Mean Bias (daily)

	ρ		σ_r/σ_{obs}		σ_d		BIAS	
	Daily	Mon.	Daily	Mon	Daily	Mon.	Daily	Mon
MERRA	3.67	4.00	1.29	3.17	3.63	2.22	2.78	3.67
NRA-1	5.00	4.60	5.00	4.17	4.38	4.56	3.00	5.00
ERA-40	1.78	2.67	2.29	3.50	2.63	4.00	3.11	1.78
ERA-Int	3.00	1.83	3.71	1.83	1.25	1.44	2.56	3.00
CFSR	1.56	1.83	2.71	2.33	3.13	2.78	3.56	1.56
GLDAS	3.67	4.00	1.29	3.17	3.63	2.22	2.78	3.67

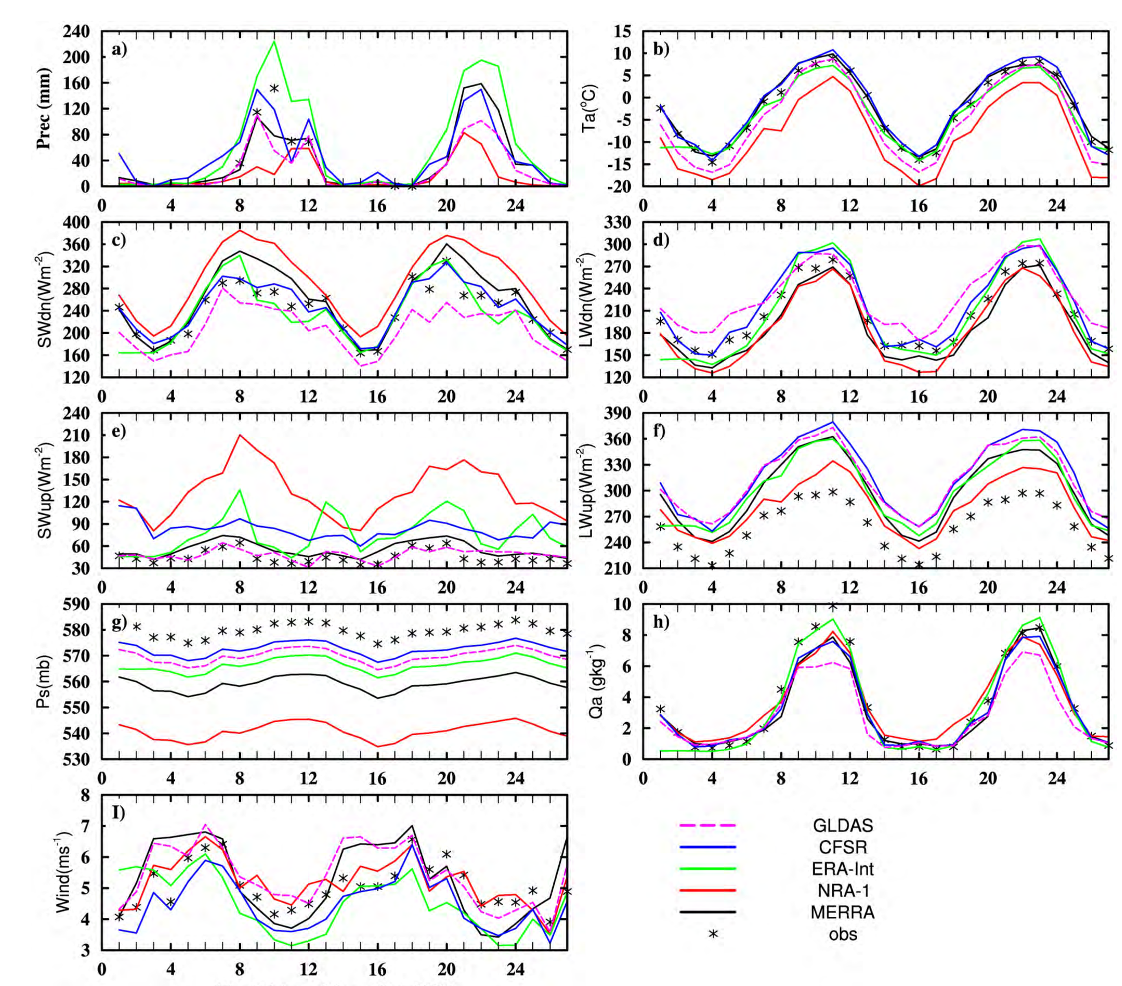

Figure 6. Comparisons of monthly meteorological variables between five reanalyses and observations at the MS3478 site (31.9°N, 91.7°E, Ele. 4620m) from October 2002 to December 2004. The variables includes: a) precipitation (mm/month), b) air temperature (^oC), c) downward shortwave radiation (Wm-2), d) downward longwave radiation (Wm^{-2}), e) upward shortwave radiation (Wm^{-2}), f) upward longwave radiation (Wm^{-2}), g) surface pressure (mb), h) specific humidity ($k(kg)^{-1}$), and i) wind speed (ms^{-1})

5 Summary

- Over 63 CMA stations, ERA-Int has the best overall performance in both daily and monthly Tair, while MERRA high correlation with observations. GLDAS has the best performance in both daily and monthly Prec., ERA-40 and MERRA have the highest correlation coefficient for daily and monthly prec., respectively.
- Over 9 CAMP stations, CFSR shows the best overall performance, followed by GLDAS, although the best ranking scores are different for different variables.
- NRA-1 shows the worst overall performance compared with both CMA and CAMP data.
- Over most stations, the surface elevation in reanalyses are higher than the station locations, which is the major reason of cold biases in reanalyses.
- No reanalysis product is superior to others in all variables at both daily and monthly time scales, various reanalysis products should be combined for the study of weather and climate over the TP.