6.2 VALIDATION OF THE GSWP2 BASELINE SIMULATION

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1. INTRODUCTION

Global Soil Wetness Project (GSWP) is open to anyone with a unique Land Surface Scheme (LSS) and an interest in participating. All participants run their LSSs with the provided forcing and boundary conditios, and provide the results of this ”baseline” integration. One of the most important goal of GSWP is to produce state-of-the-art global data sets of land surface fluxes, state variables and related hydrological quantities for 10-year period (1986-1995). Currently, there exists no global-wide capacity to directly measure the fluxes of water and energy over the continental surfaces, and thus we must rely on the highest-quality estimates based on model simulations. The GSWP-2 outputs will be combined with global precipitation products and ocean flux estimates to asesess our scientific accounting of the global water cycle and to update our current depiction of the global energy cycle[1].

Baseline simulation has already finished, and sensitivity runs are now in progress. Due to the time schedule and huge amount of data sets, GSWP-2 simulation had started without enough validation and quality check of the provided forcing data. Now several kinds of data sets are ready for use for the sensitivity experiments. Considering the goal of GSWP, baseline simulation should be run by the ”best” dataset. Off course, there is no ”perfect” global dataset. Information on the bias and accuracy in the forcing dataset will be helpful for the data analysis. In this study, forcing data sets of GSWP-2 are analyzed and compared with surface measurement to see which is the best dataset and what kind of bias are there.

2. DATA SET FOR ANALYSIS

2.1. *Validation Data*

The dataset used for validation is the global surface summary of day (GlobalSOD) data produced by the National Climatic Data Center (NCDC). This dataset is based on data exchanged under the World Meteorological Organization (WMO) World Weather Watch Program, and it is placed on line by NCDC for easy access by outside users (http://www.ncdc.noaa.gov/). The online data files begin with January 1994, and two years data (1994 Jan to 1995 Dec) are used. 11888 stations' data are included in this dataset, and roughly 8000 stations' data are typically available. Other periods of the summary of day data (up to 20 years or more) can be obtained off-line from NCDC. The daily elements included in the dataset are 13 items. Among them, the following items are used in this analysis; Mean temperature, Mean dew point, Mean wind speed, Maximum sustained wind speed, Maximum temperature, Minimum temperature, Precipitation amount. As will be shown later, the data analysis is intended not to see the seasonal variation but to see the intra-seasonal or day-to-day variation. Thus, statistics (CC, RMSE, etc.) are calculated for each month. To get enough samples for this statistics, those stations which have at least 20-days data for each of 24 month (from 1994 Jan to 1995 Dec) and located within GSWP grids (one degree grid box) are selected for analysis. There are some grids which have more than two stations inside. In that case, one representative station the height of which is nearest that of GSWP grid is selected. Through these processes, 2349 stations are selected.

2.2. *GSWP-2 Forcing Data*

The starting point for GSWP-2 is the ISLSCP Initiative II data set. There are two parallel versions of the meteorological data in the ISLSCP dat set: National Centers for Environmental Prediction/Department of Energy (NCEP/DOE) and European Center for Medium-range Weather Forecasts (ECMWF) reanalyses. Using the observationally-based precipitation, surface radiation, and near-surface meteorology data, reanalysis products were ”hybridized”. Because the full 10-year period of the NCEP/DOE reanalysis data were available before ECMWF's reanalysis, the hybridized (with CRU data) version of the NCEP/DOE data set was selected for the baseline simulation (**B0**). The original reanalysis products are used in the sensitivity experiments (**M1, M2**).

Several observational precipitation data sets are available from ISLSCP Initiative II: the Climate Research Unit (CRU), the Global Precipitation Climatology Center (GPCC), and the Global Precipitation Climatology Project (GPCP). Due to wind-caused gauge undercatch for precipitation, wind correction is applied. These data are hybridized with reanalysis rainfall estimates to produce a 3-hourly precipitation product. The final product of GSWP-2 baseline simulation (**B0**) is a combination of

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gauge-based (GPCC, CRU) and satelite based (GPCP) product depending on the gauge density. The original reanalysis products and some combination of data processing are used in the sensitivity experiments (**P1-P4, PE**). The name of each data set and its experiment are listed in **Table 1**.

Table 1 List of forcing data for baseline and sensitivity experiments

Tair	cru(B0), ncep(M1), era(M2)
Qair	cru(B0), ncep(M1), era(M2)
Wind	ncep(B0, M1), era(M2)
Rainf/ Snowf	gswp(B0), era(P1), eragswp(PE) gpccwc(P2), gpcc(P3), ncep(P4)

note: cru = NCEP+CRU, era = ECMWF,
gswp = NCEP+GPCC+GPCP,
eragswp = ECMWF+GPCC+GPCP,
gpccwc = NCEP+GPCC+wind correction,
gpcc = NCEP+GPCC, , ncep = NCEP

3. DATA ANALYSIS

3.1. *Statistics for daily data*

3-hourly data are processed to produce the daily values which are comparable with observation (NCDC GlobalSOD). They are the following six items: mean temperature (**Tair**), mean vapor pressure (**Eair**), mean wind speed (**Wind**), maximum wind speed (**Windmax**), diurnal temperature range (**Tmax-Tmin**), and daily precipitation (**Precip**).

Daily data are plotted against observation to calculate correlation coefficient (CC) and root mean square error (RMSE) of each grid. Also, monthly mean value (**MV**) and standard deviation (**SD**) are calculated for the monthly data analysis. Here, **SD** is used as an index of day-to-day variation within one month time series.

Fig. 1 shows an example of the scatter plot of **Eair** for 1994 June at Kyoto, Japan. Statistics for this month are shown in this figure. MV1 and SD1 are for NCDC data, MV2 and SD2 are for GSWP-2 forcing data. In this case, CC=0.820 and RMSE=2.801. **MV** of GSWP is slightly smaller than that of NCDC, and **SD** of GSWP is much smaller than that of NCDC. In the same way, daily data statistics are calculated for each grid (station) and each month. **Fig. 2** shows an correlation coefficient for **Tmax-Tmin** on 1994 July. In this case, CC is very low in the middle part of United States and eastern part of China. **Fig. 3** shows an difference of monthly mean wind speed. In general, pink and red color dominates, and it is infered that wind speed of GSWP data set is stronger than NCDC. Same kind of panels can be drawn for 6 items, for 4 statistics (CC, RMSE, MV2-MV1, SD2-SD1), for 24 month, and for each dataset. But these panels include too much information, and they are not easy to see which is the "best" dataset.

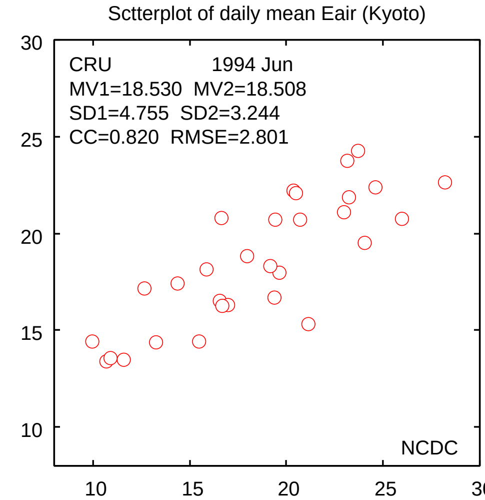

Fig. 1 Scattered diagram of Eair (Kyoto, 1994 Jun)

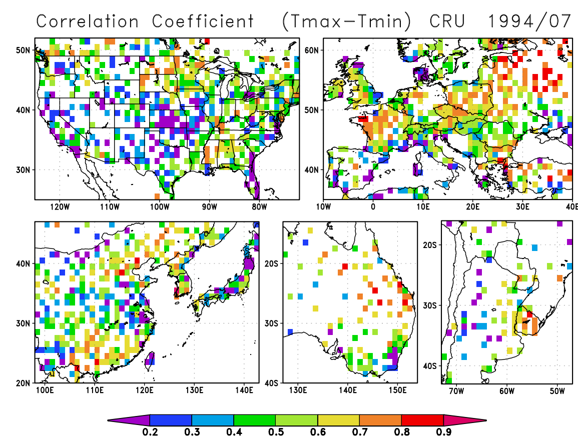

Fig. 2 Spatial distribution of correlation coefficient of Tmax-Tmin (1994 Jul)

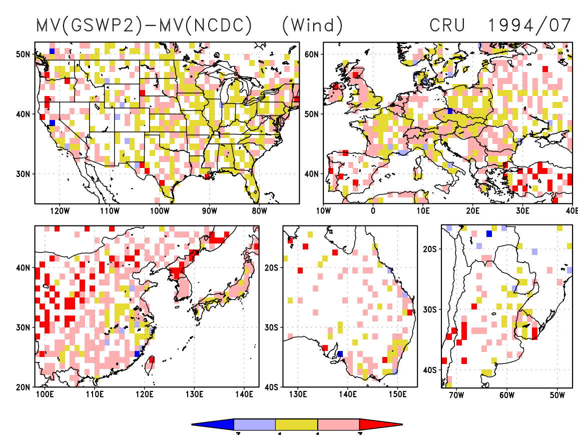

Fig. 3 Spatial distribution of difference of monthly mean value of Wind (1994 Jul)

3.2. *Statistics for monthly data*

Each station has one **MV** and **SD** for each month. To evaluate the overall performance (accuracy) of each dataset, monthly values of all grids are plotted against observation. Here, statistics (CC and RMSE) are calculated for global, and for each continent (see **Fig. 4**). **Fig. 5** to **Fig. 8** are the time series of CC and RMSE of global field for each data set. Seasonal cycle can be seen in these statistics. Also there is a significant difference in the accuracy of each data set.

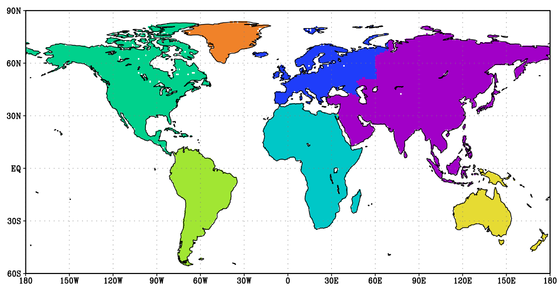

Fig. 4 Grid mask for each continent

(1) Mean Temperature (Tair)

CC of MV (CCMV) and CC of SD (CCSD) for **era** is highest. Also RMSE of SD (RMSD) for **era** is the lowest. While RMSE of MV (RMMV) for **cru** is the lowest. In another words, **era** is the best in terms of CCMV, CCSD, and RMSD, and **cru** is the best in terms of RMMV.

(2) Mean Vapor Pressure (Eair)

CCMV and CCSD for **era** is the highest, and RMMV and RMSD for **era** is the lowest. In another words, **era** is the best in all aspects (CCMV, CCSD, RMMV, and RMSD). On the contrary, **cru** is worst among these three data sets.

(3) Mean Wind Speed (Wind)

CCMV of **era** is higher than **ncep**, while CCSD is almost same. RMMV and RMSD for **era** is lower than **ncep** (**era** is better than **ncep**).

(4) Maximum Wind Speed (Windmax)

CCMV and CCSD is almost same. RMMV of **ncep** have large seasonality, and RMMV of **ncep** is larger in winter and smaller in summer. RMSD of **ncep** is lower. As for maximum wind, it is difficult to say which is better.

(5) Diurnal Temperature Range (Tmax-Tmin)

CCMV and CCSD for **era** is the highest. RMMV and RMSD for **era** and **ncep** are almost same. In another words, **era** is the best, and **cru** is worst among these three data sets.

(6) Precipitation (Precip)

gpcc is the best in all aspects. But it must be noted that **gpcc** data set is gauge based dataset, and the surface stations' data used for validation are already utilized to produce this data set. So it is natural that **gpcc** data set is judged as "best" if we compare at the location where raingauge data are available. It is better to check the quality of precipitation in a basin scale with evapotranspiration and discharge data also. Especially, RMMV and RMSD of **gpccwc** are very bad. There is a possibility that wind correction was too much due to the too strong wind speed of **ncep**.

Same kind of figures are drawn for each continent (Asia, Europe, Africa, North America, South America, and Oceania). Based on these information, the accuracy of each data set is ranked, and it is summarized in **Table 2** (Greenland is omitted since sample number is too small).

4. CONCLUSION

In this study, several kind of forcing data sets of GSWP-2 are analyzed and compared with surface measurement (NCDC GlobalSOD). The accuracy of each data sets is ranked in terms of CC and RMSE of monthly mean values and standard deviation (day-to-day variation). As a result, following conclusions are obtained.

1. As for near surface meteorology (Tair, Eair, and Wind), **era** data set is the best. It is worth trying to produce hybridized dataset from ECMWF reanalysis.
2. As for precipitation, **gpccwc** data set is very bad. It is better to use **era** wind speed data for gauge correction.
3. Considering that **gpcc** data is gauge based data set, **eragswp** is better for use as baseline simulation.

Acknowledgements

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References

[1] International GEWEX Project Office, 2002: GSWP-2: The Second Global Soil Wetness Project Science and Implementation Plan. IGPO Publication Series **37**, 75pp.

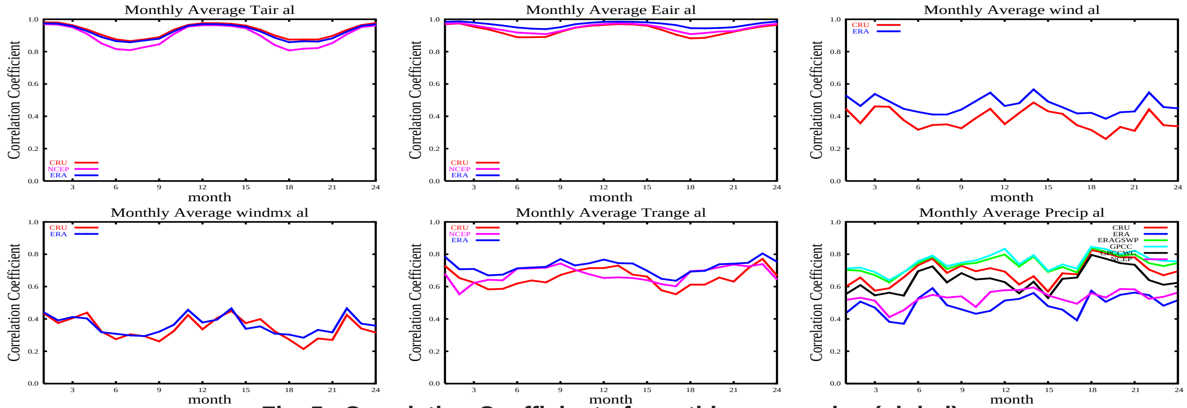

Fig. 5 Correlation Coefficient of monthly mean value (global)

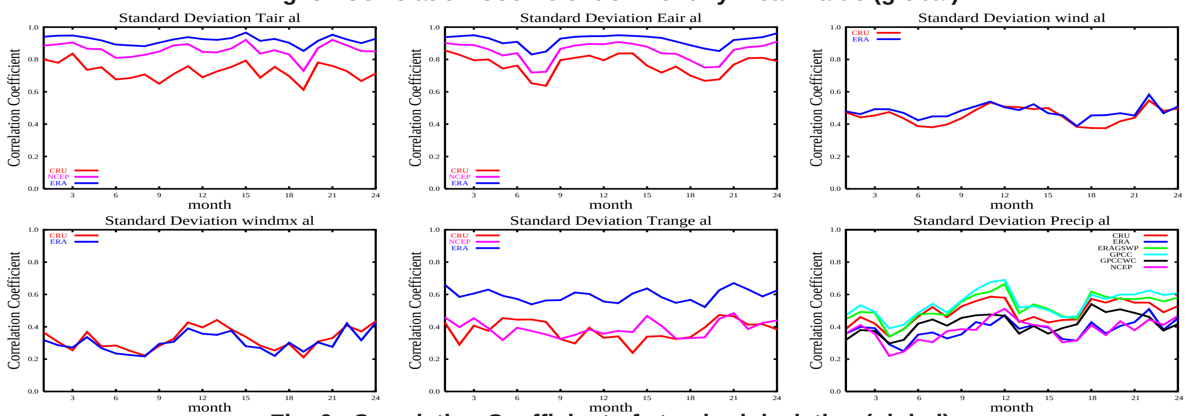

Fig. 6 Correlation Coefficient of standard deviation (global)

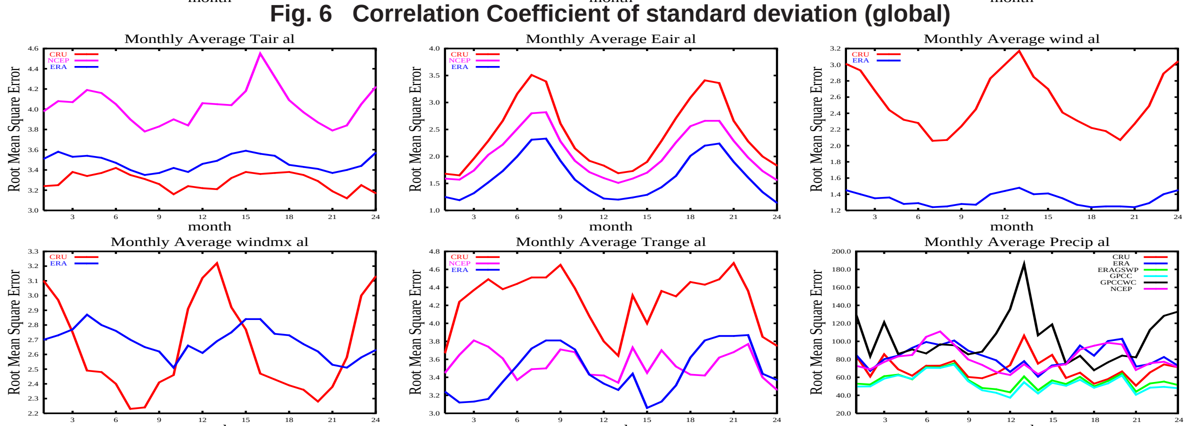

Fig. 7 Root mean square error of monthly mean value (global)

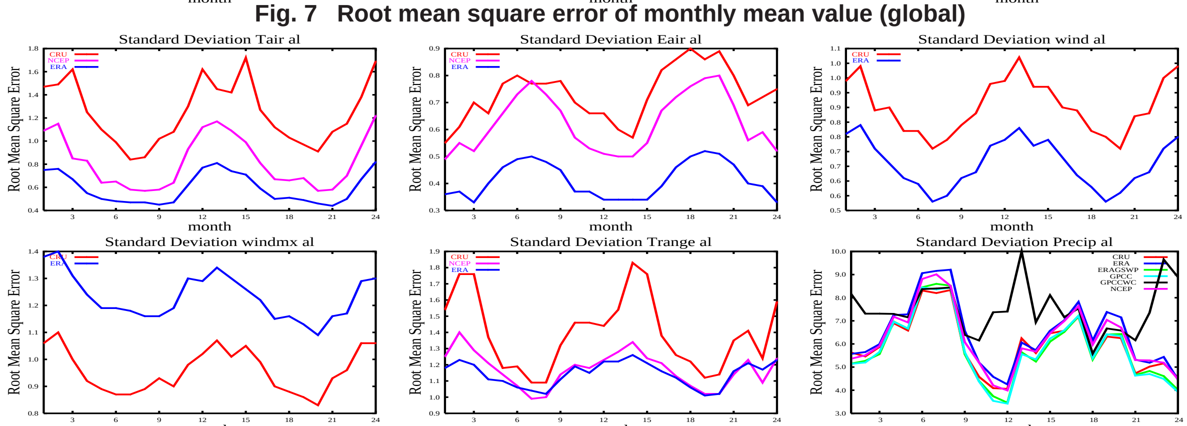

Fig. 8 Root mean square error of standard deviation (global)

Table 2   Rank of the accuracy of data set

	CCMV	GL	AS	EU	AF	NA	SA	OC	CCSD	GL	AS	EU	AF	NA	SA	OC
Tair	cru	1	1	1	1	1	1	1	cru	3	3	3	2	3	3	3
	era	1	2	1	2	1	2	2	era	1	1	1	1	1	1	1
	ncep	3	3	3	3	3	3	3	ncep	2	2	2	2	2	2	2
Eair	cru	3	3	3	3	3	3	2	cru	3	3	3	3	3	3	3
	era	1	1	1	1	1	1	1	era	1	1	1	1	1	1	1
	ncep	2	2	2	2	2	2	3	ncep	2	2	2	2	2	2	2
Wind	era	1	1	2	2	1	2	2	era	1	1	2	2	1	2	2
	ncep	2	2	1	1	2	1	1	ncep	2	2	1	1	2	1	1
Windmax	era	1	1	2	2	1	2	2	era	2	1	2	2	1	2	2
	ncep	2	2	1	1	1	1	1	ncep	1	2	1	1	2	1	1
Tmax-Tmin	cru	3	1	1	1	1	1	2	cru	2	2	2	2	2	2	2
	era	1	2	2	2	2	2	1	era	1	1	1	1	1	1	1
	ncep	2	3	3	3	3	3	3	ncep	2	2	3	3	3	3	3
Precip	gswp	3	3	4	4	3	3	3	gswp	3	3	3	3	3	3	3
	era	6	6	5	5	5	5	4	era	5	6	4	5	5	5	4
	eragswp	2	2	2	2	2	2	2	eragswp	2	1	2	1	2	4	1
	gpccwc	4	4	3	3	4	4	5	gpccwc	4	4	4	4	4	2	5
	gpcc	1	1	1	1	1	1	1	gpcc	1	1	1	1	1	1	1
	ncep	5	5	6	6	6	6	6	ncep	5	5	6	6	6	6	6

	RMMV	GL	AS	EU	AF	NA	SA	OC	RMSD	GL	AS	EU	AF	NA	SA	OC
Tair	cru	1	1	1	1	2	1	1	cru	3	3	3	3	3	3	3
	era	2	2	2	2	1	2	2	era	1	1	1	1	1	1	1
	ncep	3	3	3	3	3	3	3	ncep	2	2	2	2	2	2	2
Eair	cru	3	3	3	3	3	3	3	cru	3	3	3	3	2	3	3
	era	1	1	1	1	1	1	1	era	1	1	1	1	1	1	1
	ncep	2	2	2	2	2	2	2	ncep	2	2	2	2	2	2	2
Wind	era	1	1	1	1	1	1	1	era	1	1	1	2	1	2	2
	ncep	2	2	2	2	2	2	2	ncep	2	2	2	1	2	1	1
Windmax	era	1	1	1	2	2	2	2	era	2	2	2	2	2	2	2
	ncep	1	2	1	1	1	1	1	ncep	1	1	1	1	1	1	1
Tmax-Tmin	cru	3	3	3	1	3	3	2	cru	3	3	3	3	3	3	3
	era	1	1	1	2	2	2	1	era	1	2	2	1	1	1	2
	ncep	2	2	2	3	1	1	3	ncep	2	1	1	2	2	2	1
Precip	gswp	3	3	5	3	3	3	3	gswp	3	3	5	1	3	1	3
	era	5	6	2	5	4	6	3	era	5	5	4	5	4	6	4
	eragswp	2	2	3	2	2	2	2	eragswp	2	1	1	3	2	3	1
	gpccwc	6	4	6	4	6	4	6	gpccwc	6	6	6	3	6	4	6
	gpcc	1	1	1	1	1	1	1	gpcc	1	1	1	1	1	1	1
	ncep	4	5	4	6	5	5	5	ncep	4	4	3	6	4	5	5

GL: Global, AS: Asia, EU: Europe, AF: Africa, NA: North America, SA: South America, OC: Oceania
CCMV: Correlation coefficient of monthly mean value, CCSD: Correlation coefficient of standard deviation,
RMMV: Root mean square error of monthly mean value, RMSD: Root mean square error of standard deviation