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The 30-year global land surface products and their validations: multi-forcing simulations

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1 Introduction

Global land surface data is absent from observation, and Land Surface Model (LSM) is useful tools to produce the reliable surface hydrology and flux datasets; The simulations of LSM is based on atmospheric forcing datasets and model parametrization schemes. Community Land Surface Model version 4.5 (CLM4.5) is used to offline simulate global terrestrial water and energy changes for 1980-2009 at 0.5deg x0.5deg horizontal resolution. CLM4.5 is driven by FOUR surface atmospheric forcing datasets: CLM default global forcing data – CRUNCEP (a combination of CRU and NCEP/NCAR reanalysis), and three new developed ones based on reanalysis products –MERRA, ERAInterim and CFSR. The simulations are evaluated with various observation-based data, including in-situ measured soil moisture, evapotranspiration, runoff, and snow, and soil temperature for permafrost. The 30-year products of this work, in particular, the ensemble results from CLM4.5 and multi atmospheric forcing datasets facilitate the research on the terrestrial hydrology and energy fluxes, for example, the relationship of precipitation and soil moisture, floods and droughts, the partition of precipitation into evapotranspiration and runoff, and the partition of radiation into latent and sensible heat fluxes.

2 Model and Data

2.1 Model

- NCAR Community Land Surface Model version 4.5 (CLM4.5, Oleson et al. 2013)

2.2 Atmospheric forcing data

- CRUNCEP: CRU+ NCEP/NCAR reanalysis (0.5°x0.5°, 6-hourly , CLM default))
- Our new developed reanalysis-based data sets:
- MERRA (1/2° x1/3°, 1-hourly, NASA/AMO)
- ECMWF Interim (ERAI, 0.75°x0.75°, 3-hourly, ECMWF)
- CFSR (0.5°x0.5°, 6-hourly, NCEP)
- Precipitation in three NEW reanalysis-based forcing datasets was bias-corrected by GPCP V2.2, and then they were downscaled to 0.5°x0.5°, and run for 1979-2009.

2.3 Validation data

Parameters	Regional/station number	Time range	Sources
Soil moisture	226/China	1993-2006	NMIC/CMA
	19 /Illinois	1981-2004	Illinois meteo
Snow depth	567/China	1980-2009	NMIC/ CMA
SWE	324/China	1980-2009	NMIC CMA
Runoff	Gridded/GL	Climato	GRDC
Evapotranspiration	Gridded/GL	1982-2008	Jung et al. (2010)
heat fluxes	34/GL	1991-2009	Fluxnet
Soil temperature	112/Russia, 178/China	1981-2000	NMIC/CMA, Metro.Russia

Table 1 Validation data used in this study.

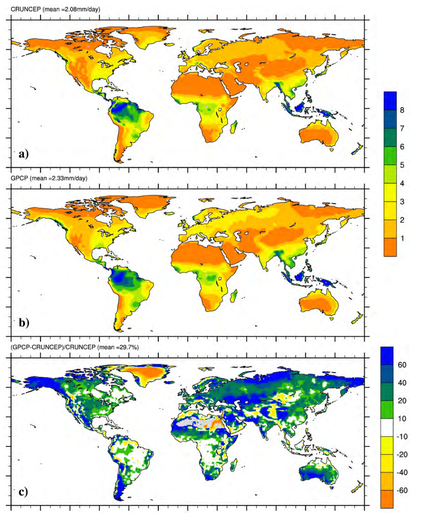

Figure 1 Annual precipitation from CRUNCEP, GPCP and their differences

References:

Wang, A., Zeng, X. & Guo, D. 2016: Estimates of global surface hydrology and heat fluxes from the Community Land Model (CLM4.5) with four atmospheric forcing datasets. *J. Hydrometeoro.* 17, 2493-2510. doi: 10.1175/JHM-D-16-0041.1

Guo, D, Wang, H., & Wang, A. 2017: Sensitivity of historical simulation of the permafrost to different atmospheric forcing data sets from 1979 to 2009. *J. Geophys. Res.: Atmos*, 122, 12,269–12,284. doi.10.1002/2017JD027477.

Guo, D., Wang, A., Li, D., & Hua, W. 2018: Simulation of changes in the near-surface soil freeze/thaw cycle using CLM4.5 with four atmospheric forcing data sets. *J. Geophy. Res.: Atmos.* 123. doi.10.1002/2017JD028097.

Oleson, K. and coauthors, 2013: Technical description of version 4.5 of the Community Land Model. NCAR Tech. Note, NCAR/TN-503+STR, 420 pp. www.CESM.ucar.edu.

3 Results

3.1 Soil moisture

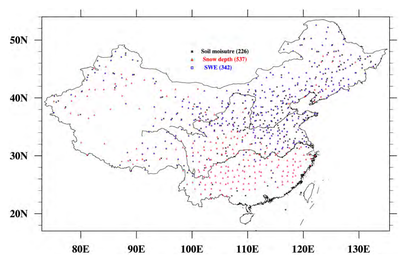

Figure 3 Stations for soil moisture and snow observations in China

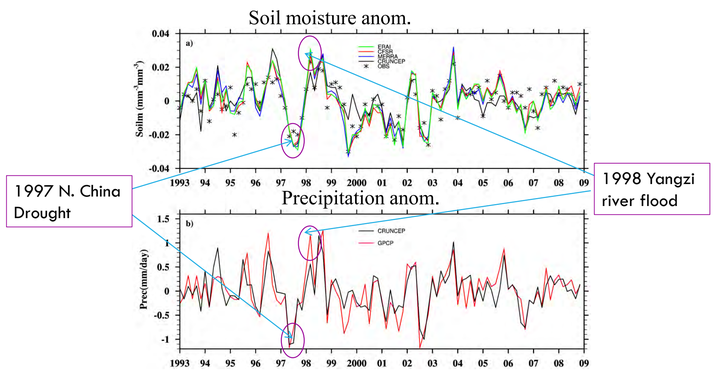

Figure 4 Monthly soil moisture anomalies (10cm, Apr-Sep) averaged over 226 stns in China for 1993-2008

3.2 Snow depth and SWE

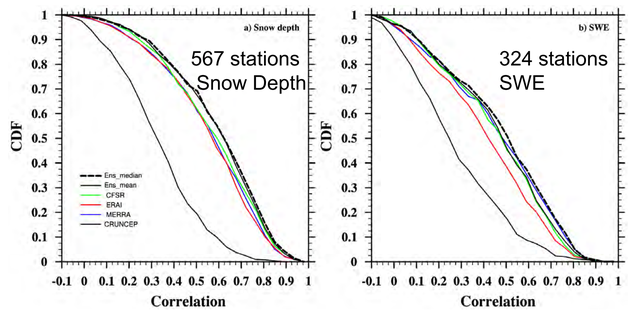

Figure 5 CDF of the correlation between observations and simulations from 1980-2009 for a) monthly snow depth, and b) monthly SWE in China

	China			Illinois,USA
	Soil moisture	Snow depth	SWE	Soil moisture
CRUNCEP	0.38	0.35	0.29	0.46
MERRA	0.47	0.57	0.48	0.47
CFSR	0.48	0.56	0.43	0.46
ERAI	0.48	0.58	0.47	0.48
Ens-mean	0.48	0.60	0.47	0.48

Table 2 Mean correlation between station observations and model simulations

3.3 Soil temperature and permafrost

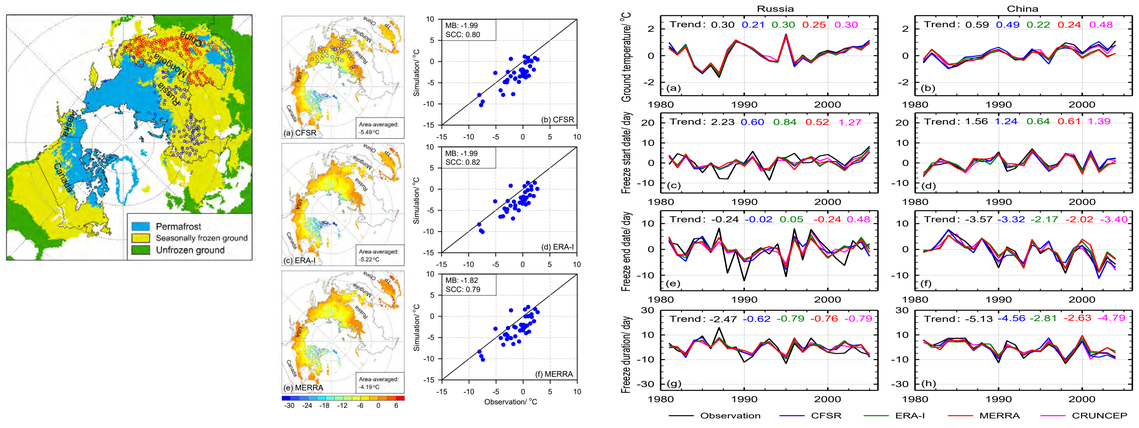

Figure 6 (Left):Soil temperature observation sites and permafrost regions; (Middle) Mean soil temperature at a depth of 1 m over permafrost region based on CLM4.5 simulations of CFSR (a), ERA-I (c) and MERRA (e), and their validations with station observations (b, d, f); (Right):(a,b) Ground temperature, (c, d) Freeze start date, (e, f) freeze end date, and (g, h) freeze duration from observation, four simulations, and their linear trends in both Russia and China

4 Summary

- This study produces the global 30-year (1979-2009) at 0.5°x0.5 land surface hydrology and heat flux products based on CLM4.5 offline simulations, which can be used in various applications.
- We constructed three new global land surface model forcing datasets based on MERRA, CFSR, and ERAI reanalyzes with the monthly precipitation adjusted by GPCP v2. All data are available from the authors.
- Compared with in-situ observation, the simulated soil moisture and snow from newly constructed forcing datasets are better than those from CRUNCEP, but the CRUNCEP simulated permafrost are better over some sites. The multi-simulation ensembles are generally superior or comparable to the best individual simulations.
- The dispersion of LSMs simulation due to parameterization schemes are much larger than those due to atmospheric forcing data sets.