[Journal of Advances in Modeling Earth Systems]

Supporting Information for

[Weekly to annual variability of surface soil moisture]

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Introduction

[Figure S1 to S5 gives more specific results related to this research. Figure S1 shows the global map of the mean surface soil moisture based on the SMAP observation (Entekhabi et al., 2010) after spatiotemporal normalization. Figure S2 shows the coefficient of variation of two ratios that represents the relationships between the variability of surface soil moisture, evapotranspiration, and precipitation among models over different time scales. Figure S3 shows the soil sand and clay content for the first two layers based on GSDE data (Shangguan et al., 2014). Figure S4 and S5 show the relationships between model biases and global soil sand and clay content, respectively. Table S1 shows some specific information of CMIP5 models (Taylor et al., 2012) used in this research.]

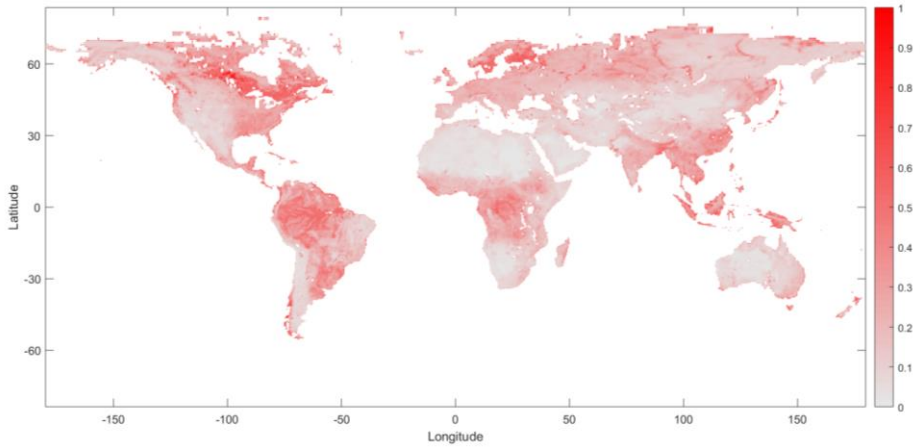

Figure S1. The mean SSM for observation after spatiotemporal normalization. Four years of data from the SMAP Level-3 product, spanning 1 April 2015 - 31 March 2019, are used. Firstly use original data to get the annual average SSM for each grid, and then rearrange them from small to large and normalized them from zero to one as:
$\overline{SSM} = (SSM - SSM_{min})/(SSM_{max} - SSM_{min})$.

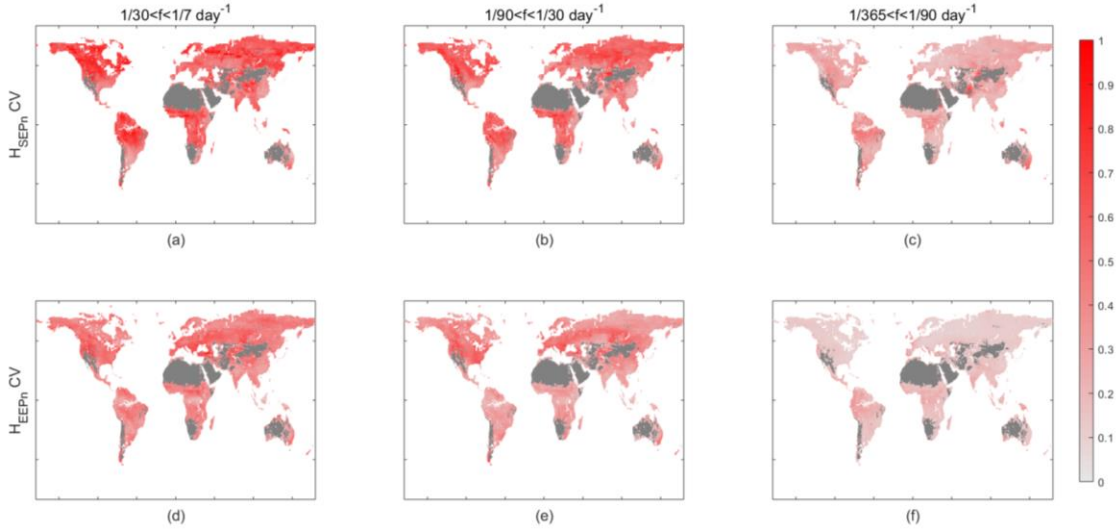

Figure S2. The coefficient of variation of $\mathrm{H_{SEP_n}}$ (Figure a-c) and $\mathrm{H_{EEP_n}}$ (Figure d-f) among models over different time scales. Similar to the coefficient of variation of $\mathrm{SSM_n}$ (Figure 4d – 4f), for each model, the coefficient of variation of $\mathrm{H_{SEP_n}}$ and $\mathrm{H_{EEP_n}}$ is calculated by the standard deviation divided by the mean for each frequency range. Grey parts are regions with SSM less than 0.1. The three columns from left to right represent results in weekly to monthly time scales, monthly to seasonal time scales, and seasonal to annual time scales.

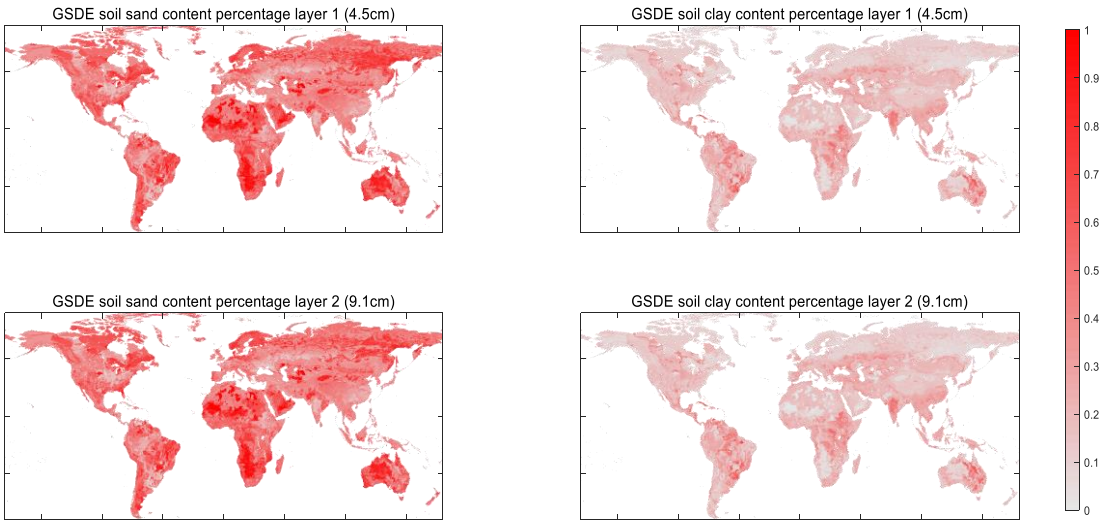

Figure S3. Sand content and clay content for the first two layers (0-4.5cm & 4.5-9.1 cm).

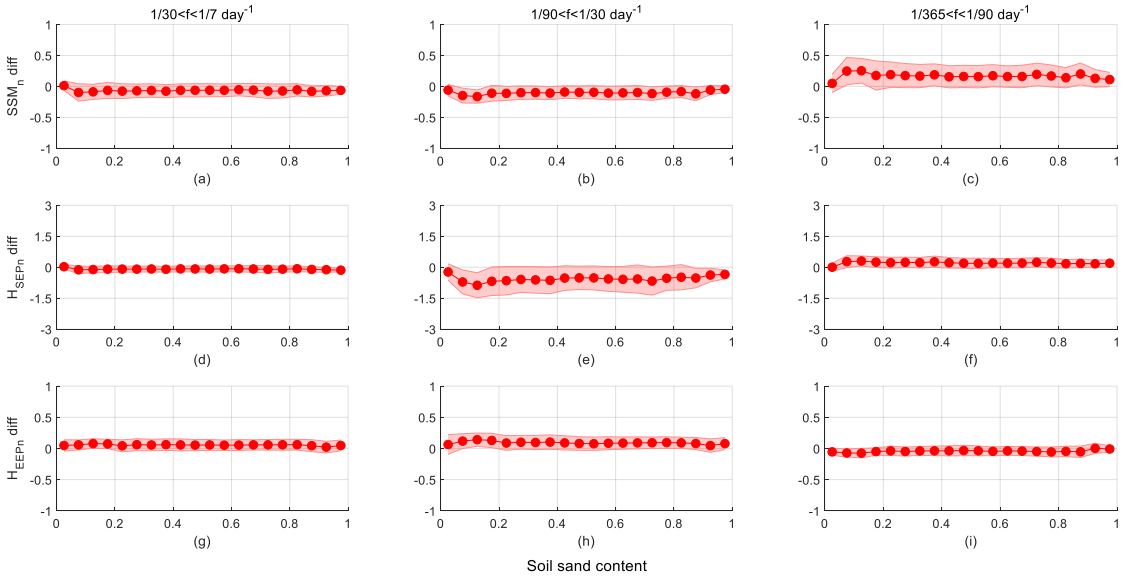

Figure S4. Averaged biases of SSM_n (Figure a-c), H_{SEP_n} (Figure d-f) and H_{EEP_n} (Figure g-h) between models and observations with global soil sand content. The three columns from left to right represent results in weekly to monthly time scales, monthly to seasonal time scales, and seasonal to annual time scales, respectively. The method to make this figure is similar to Figure 5.

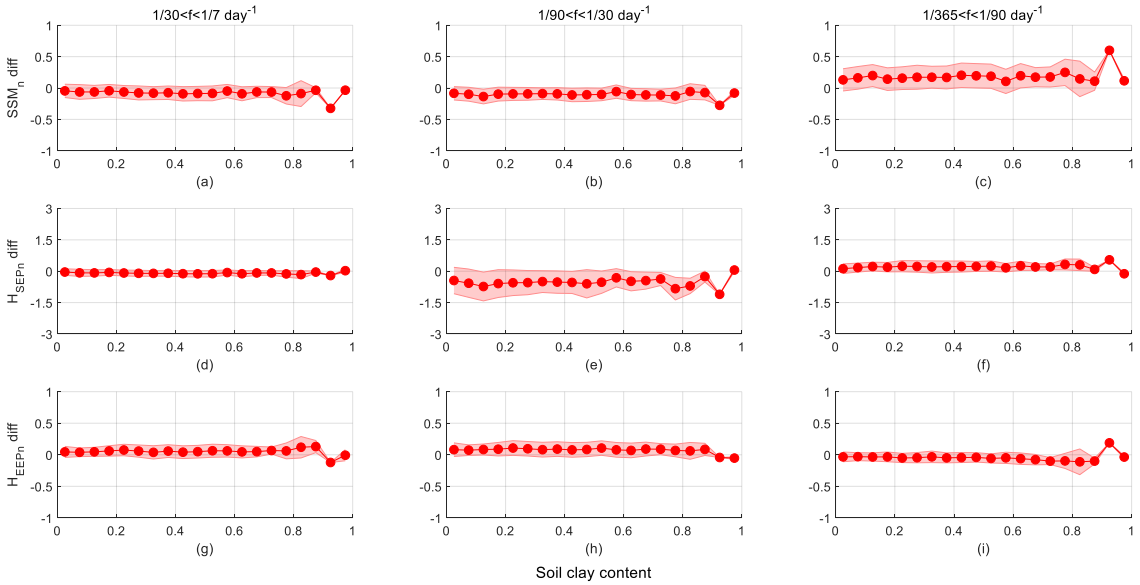

Figure S5. Averaged biases of SSM_n (Figure a-c), H_{SEP_n} (Figure d-f) and H_{EEP_n} (Figure g-h) between models and observations with global soil clay content. The three columns from left to right represent results in weekly to monthly time scales, monthly to seasonal time scales, and seasonal to annual time scales, respectively. The method to make this figure is similar to Figure 5.

Model version	Center	Forcings	Spatial Resolution	Temporal Coverage
BCC-CSM1.1	Beijing Climate Center, China Meteorological Administration	Nat Ant GHG SD Oz Sl Vl SS Ds BC OC	128*64	1950-01-01 – 2012-12-31
BNU-ESM	College of Global Change and Earth System Science, Beijing Normal University	Nat, Ant	128*64	1950-01-01 – 2005-12-31
CanESM2	Canadian Centre for Climate Modeling and Analysis	GHG, Oz, SA, BC, OC, LU, Sl,Vl (GHG includes CO2, CH4, N2O, CFC11, effective CFC12)	128*64	1850-01-01 – 2005-12-31
CNRM-CM5	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique (CNRM/CERFACS)	GHG, SA, Sl, Vl, BC, OC	256*128	1950-01-01 – 2005-12-31
CSIRO-Mk3.6	Commonwealth	Ant, Nat (all	192*96	1850-01-01

	Scientific and Industrial Research Organization/Queensland Climate Change Centre of Excellence (CSIRO-QCCCE)	forcings)		– 2005-12-31
GFDL-CM3	Geophysical Fluid Dynamics Laboratory	GHG, SA, Oz, LU, Sl, Vl, SS, BC, MD, OC (GHG includes CO2, CH4, N2O, CFC11, CFC12, HCFC22, CFC113)	144*90	1860-01-01 – 2005-12-31
GFDL-ESM2G	Geophysical Fluid Dynamics Laboratory	GHG, SD, Oz, LU, Sl, Vl, SS, BC, MD, OC (GHG includes CO2, CH4, N2O, CFC11, CFC12, HCFC22, CFC113)	144*90	1861-01-01 – 2005-12-31
GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory	GHG, SD, Oz, LU, Sl, Vl, SS, BC, MD, OC (GHG includes CO2, CH4, N2O, CFC11, CFC12, HCFC22, CFC113)	144*90	1861-01-01 – 2005-12-31
HadGEM2-CC	Met Office Hadley Centre	GHG, Oz, SA, LU, Sl, Vl, BC, OC, (GHG = CO2, N2O, CH4, CFCs)	192*145	1949-12-01 – 2005-11-30
HadGEM2-ES	Met Office Hadley Centre	GHG, SA, Oz, LU, Sl, Vl, BC, OC, (GHG = CO2, N2O, CH4, CFCs)	192*145	1949-12-01 – 2005-11-30
Institute for Numerical Mathematics	N/A	N/A	180*120	1950-01-01 – 2005-12-31
MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	GHG, SA, Oz, LU, Sl, Vl, SS, Ds, BC, MD, OC (GHG includes CO2, N2O, methane, and fluorocarbons; Oz includes OH and H2O2; LU excludes change in lake fraction)	256*128	1950-01-01 – 2009-12-31
MIROC-ESM	Atmosphere and Ocean Research Institute (The	GHG, SA, Oz, LU, Sl, Vl, MD, BC, OC	128*64	1950-01-01 – 2005-12-31

	University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology			
MIROC-ESM-CHEM	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	GHG, SA, Oz, LU, Sl, Vl, MD, BC, OC (Ozone is predicted)	128*64	1950-01-01 – 2005-12-31
MRI-CGCM3	Meteorological Research Institute	GHG, SA, Oz, LU, Sl, Vl, BC, OC (GHG includes CO2, CH4, N2O, CFC-11, CFC-12, and HCFC-22)	320*160	1950-01-01 – 2005-12-31
MRI-ESM1	Meteorological Research Institute	GHG, SA, Oz, LU, Sl, Vl, BC, OC (GHG includes CO2, CH4, N2O, CFC-11, CFC-12, and HCFC-22)	320*160	1950-01-01 – 2005-12-31
NorESM1-M	Norwegian Climate Centre (NorClim)	GHG, SA, Oz, Sl, Vl, BC, OC	144*96	1950-01-01 – 2005-12-31

Table S1. 17 CMIP5 climate models used in this research and some of their specific information.