Supplementary Materials for

Unprecedented 21st century drought risk in the American Southwest and Central Plains

Benjamin I. Cook,* Toby R. Ault, Jason E. Smerdon

*Corresponding author. E-mail: benjamin.i.cook@nasa.gov

This PDF file includes:

Fig. S1. For the individual models, ensemble mean soil moisture balance (PDSI, SM- 30cm, and SM-2m) for 2050–2099: ACCESS1.0, ACCESS1.3, BCC-CSM1.1, and CanESM2.
Fig. S2. Same as fig. S1, but for CCSM4, CESM1-BGC, CESM-CAM5, and CNRM-CM5.
Fig. S3. Same as fig. S1, but for GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, and GISS-E2-R.
Fig. S4. Same as fig. S1, but for INMCM4.0,MIROC-ESM, MIROC-ESM-CHEM, NorESM1-M, and NorESM1-ME models.
Fig. S5. Same as Fig. 1, but for the RCP 4.5 scenario.
Fig. S6. Regional average moisture balance time series (historical + RCP 8.5) from the first ensemble member of each model over the Central Plains.
Fig. S7. Same as fig. S6, but for the Southwest.
Fig. S8. Pearson's correlation coefficients for three time intervals from the models over the Central Plains: PDSI versus SM-30cm, PDSI versus SM-2m, and SM-30cm versus SM-2m.
Fig. S9. Same as fig. S8, but for the Southwest.
Fig. S10. Same as Fig. 2, but for the RCP 4.5 scenario.
Fig. S11. Same as Fig. 3, but for the RCP 4.5 scenario.
Fig. S12. Same as Fig.4, but for the RCP 4.5 scenario.
Fig. S13. Same as Fig. 5, but for the RCP 4.5 scenario.
Table S1. Continuous model ensembles from the CMIP5 experiments (1850–2099, historical + RCP8.5 scenario) used in this analysis, including the modeling center or group that supplied the output, the number of ensemble members, and the approximate spatial resolution.
Table S2. The number of soil layers integrated for our CMIP5 soil moisture metrics (SM-30cm and SM-2m), and the approximate depth of the bottom soil layer.

Supplementary Material: "Unprecedented 21st-Century Drought Risk in the American Southwest and Central Plains"

Benjamin I Cook[1,2], Toby R Ault[3] & Jason E Smerdon[2]

January 7, 2015

Description

This document contains tables providing details regarding the models used and the soil moisture metrics calculated, as well as supplemental figures in support of the main text (primarily for scenario RCP 4.5).

Table 1: Continuous model ensembles from the CMIP5 experiments (1850–2099, historical+RCP8.5 scenario) used in this analysis, including the modeling center or group that supplied the output, the number of ensemble members, and the approximate spatial resolution. Models indicated with ** also had the necessary diagnostics to complete the calculations for the RCP 4.5 scenario.

Model	Modeling Center (or Group)	# Runs	Lat/Lon Resolution
ACCESS1.0**	CSIRO-BOM[a]	1	1.25°x1.875°
ACCESS1.3	CSIRO-BOM[a]	1	1.25°x1.875°
BCC-CSM1.1**	BCC[b]	1	2.8°x2.8°
CanESM2**	CCCMA[c]	5	2.8°x2.8°
CCSM4**	NCAR[d]	6	0.94°x1.25°
CESM1-BGC**	NSF-DOE-NCAR[e]	1	0.94°x1.25°
CESM1-CAM5**	NSF-DOE-NCAR[e]	3	0.94°x1.25°
CNRM-CM5	CNRM-CERFACS[f]	4	1.4°x1.4°
GFDL-CM3**	NOAA GFDL[g]	1	2.0°x2.5°
GFDL-ESM2G**	NOAA GFDL[g]	1	2.0°x2.5°
GFDL-ESM2M**	NOAA GFDL[g]	1	2.0°x2.5°
GISS-E2-R**	NASA GISS[h]	1	2.0°x2.5°
INMCM4.0**	INM[i]	1	1.5°x2.0°
MIROC-ESM**	MIROC[j]	1	2.8°x2.8°
MIROC-ESM-CHEM**	MIROC[j]	1	2.8°x2.8°
NorESM1-M**	NCC[k]	1	1.9°x2.5°
NorESM1-ME**	NCC[k]	1	1.9°x2.5°

[a]Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia

[b]Beijing Climate Center, China Meteorological Administration

[c]Canadian Centre for Climate Modelling and Analysis

[d]National Center for Atmospheric Research

[e]Community Earth System Model Contributors

[f]Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancée en Calcul Scientifique

[g]NOAA Geophysical Fluid Dynamics Laboratory
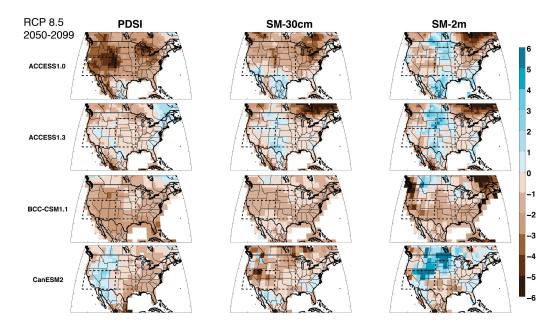
[h]NASA Goddard Institute for Space Studies

[i]Institute for Numerical Mathematics

[j]Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
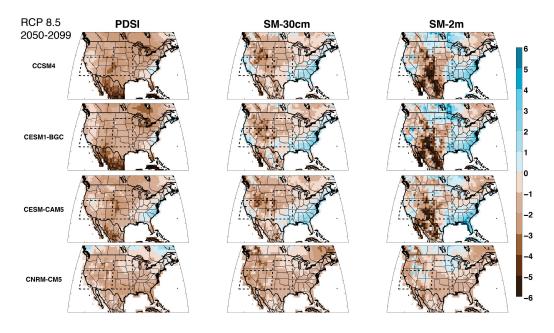
[k]Norwegian Climate Centre

Table 2: The number of soil layers integrated for our CMIP5 soil moisture metrics (SM-30cm and SM-2m), and the approximate depth of the bottom soil layer.
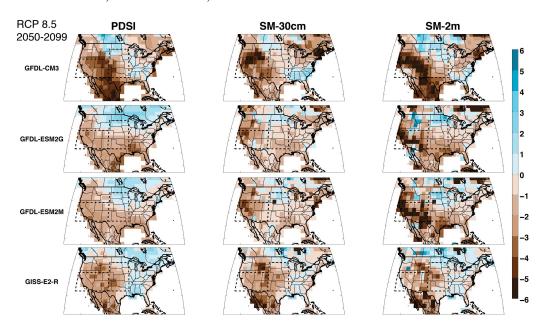
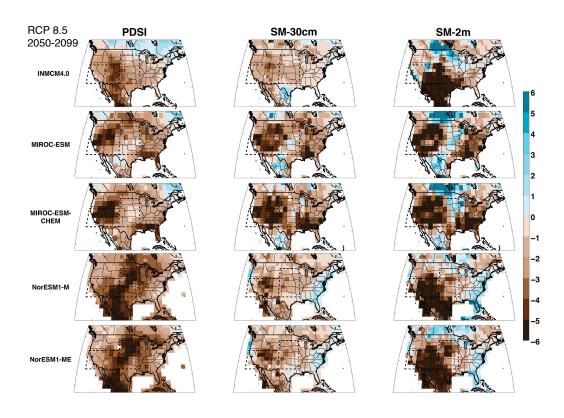| Model	Layers, SM-30cm	Depth, SM-30cm	Layers, SM-2m	Depth, SM-2m
ACCESS1.0	2	0.23 m	4	2.00 m
ACCESS1.3	4	0.44 m	6	3.16 m
BCC-CSM1.1	6	0.37 m	10	2.86 m
CanESM2	2	0.25 m	3	2.23 m
CCSM4	6	0.37 m	10	2.86 m
CESM1-BGC	6	0.37 m	10	2.86 m
CESM1-CAM5	6	0.37 m	10	2.86 m
CNRM-CM5	3	0.35 m	7	2.50 m
GFDL-CM3	7	0.35 m	14	2.40 m
GFDL-ESM2G	7	0.35 m	14	2.40 m
GFDL-ESM2M	7	0.35 m	14	2.40 m
GISS-E2-R	3	0.42 m	6	2.74 m
INMCM4.0	7	0.35 m	21	3.0 m
MIROC-ESM	3	0.63 m	5	3
MIROC-ESM-CHEM	3	0.63 m	5	3
NorESM1-M	6	0.37 m	10	2.86
NorESM1-ME	6	0.37 m	10	2.86

Supplementary Material Figure 1: For the individual models, ensemble mean soil moisture balance (PDSI, SM-30cm, SM-2m) for 2050–2099: ACCESS1.0, AC-CESS1.3, BCC-CSM1.1, and CanESM2.
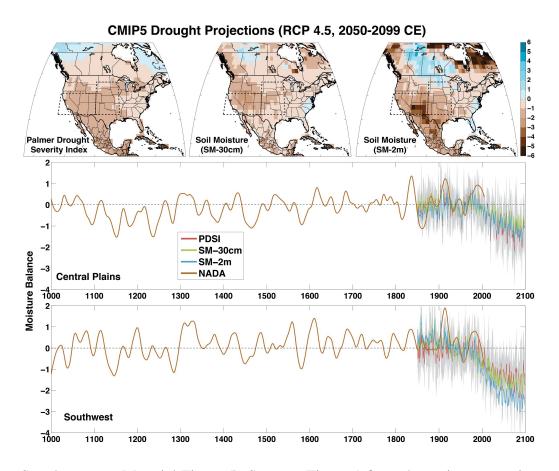
Supplementary Material Figure 2: As Supplemental Figure 1, but for CCSM4, CESM1-BGC, CESM-CAM5, and CNRM-CM5.
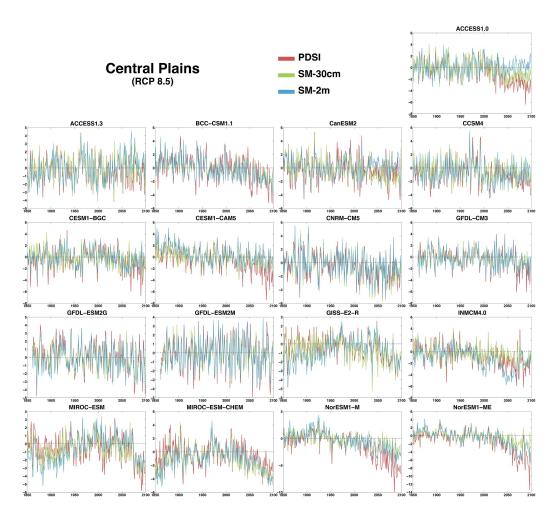

Supplementary Material Figure 3: As Supplemental Figure 1, but for GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, and GISS-E2-R.
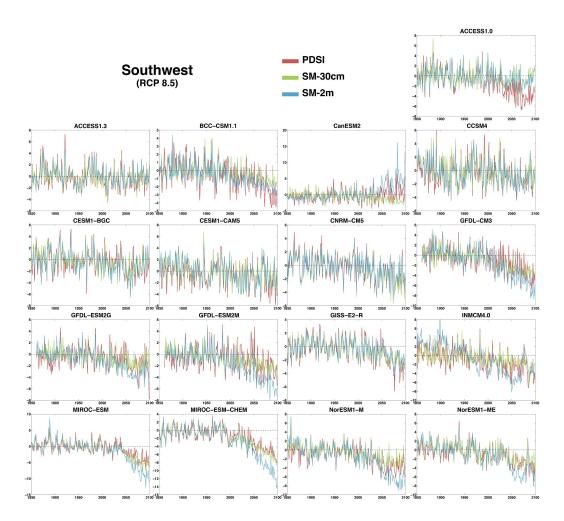
Supplementary Material Figure 4: As Supplemental Figure 1, but for INMCM4.0, MIROC-ESM, MIROC-ESM-CHEM, NorESM1-M, and NorESM1-ME models.
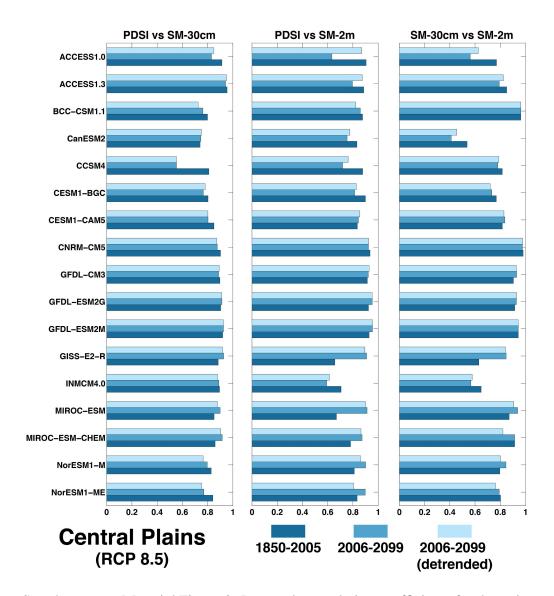
Supplementary Material Figure 5: Same as Figure 1 from the main manuscript, but for the RCP 4.5 scenario.
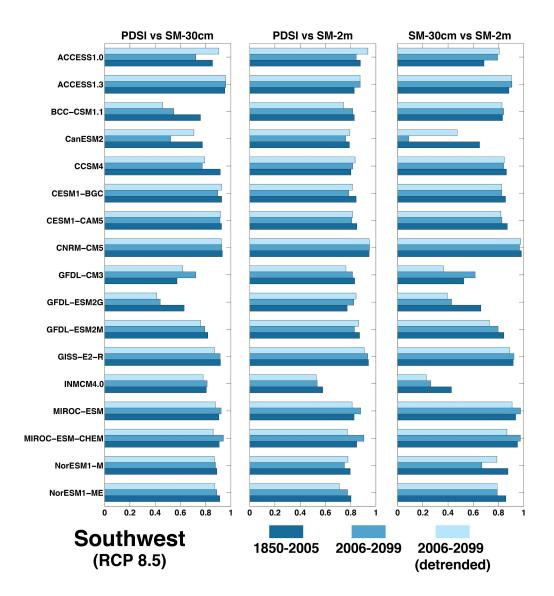
Supplementary Material Figure 6: Regional average moisture balance time series (historical+RCP 8.5) from the first ensemble member of each model over the Central Plains.
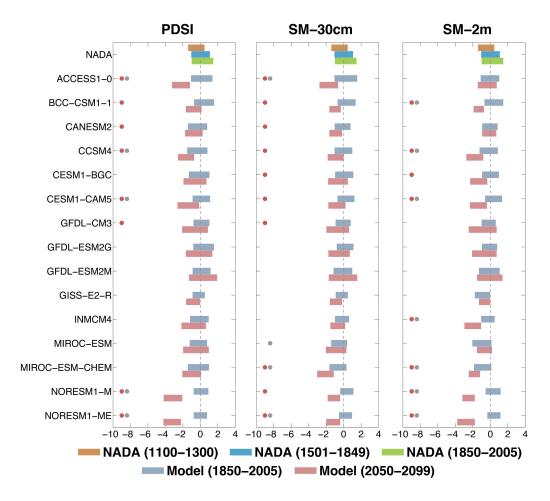
Supplementary Material Figure 7: Same as Supplemental Figure 6, but for the Southwest.

PDSI vs SM-30cm   **PDSI vs SM-2m**   **SM-30cm vs SM-2m**

Central Plains
(RCP 8.5)

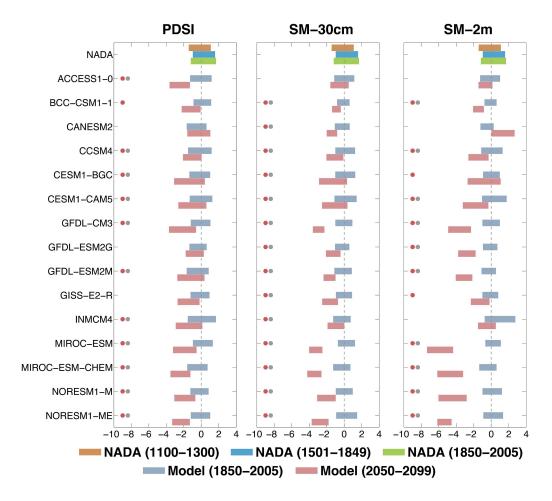1850-2005   2006-2099   2006-2099
(detrended)

Supplementary Material Figure 8: Pearson's correlation coefficients for three time intervals from the models over the Central Plains: PDSI versus SM-30cm, PDSI versus SM-2m, and SM-30cm versus SM-2m.
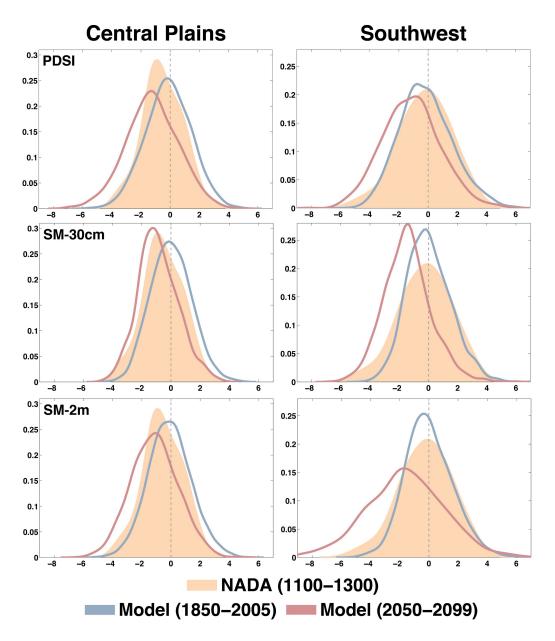
Supplementary Material Figure 9: Same as Supplemental Figure 8, but for the Southwest.
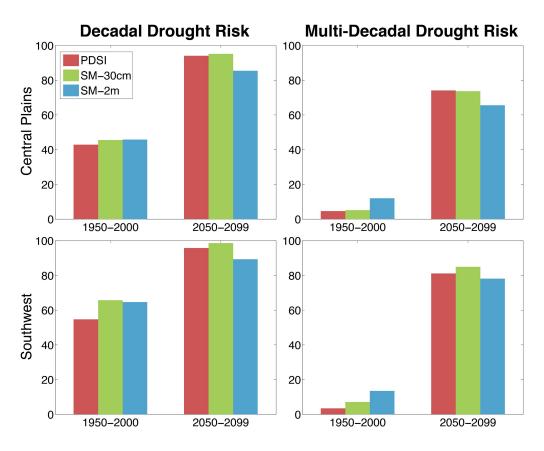
Supplementary Material Figure 10: Same as Figure 2 from the main manuscript, but for the RCP 4.5 scenario.

Supplementary Material Figure 11: Same as Figure 3 from the main manuscript, but for the RCP 4.5 scenario.

Supplementary Material Figure 12: Same as Figure 4 from the main manuscript, but for the RCP 4.5 scenario.

Supplementary Material Figure 13: Same as Figure 5 from the main manuscript, but for the RCP 4.5 scenario.