Supporting Information for "An Evaluation of the Variable Resolution-CESM for Modeling California's Climate"

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Additional Supporting Information (Files uploaded separately)

1. VR-CESM 0.25° grid mesh file

2. VR-CESM 0.125° grid mesh file
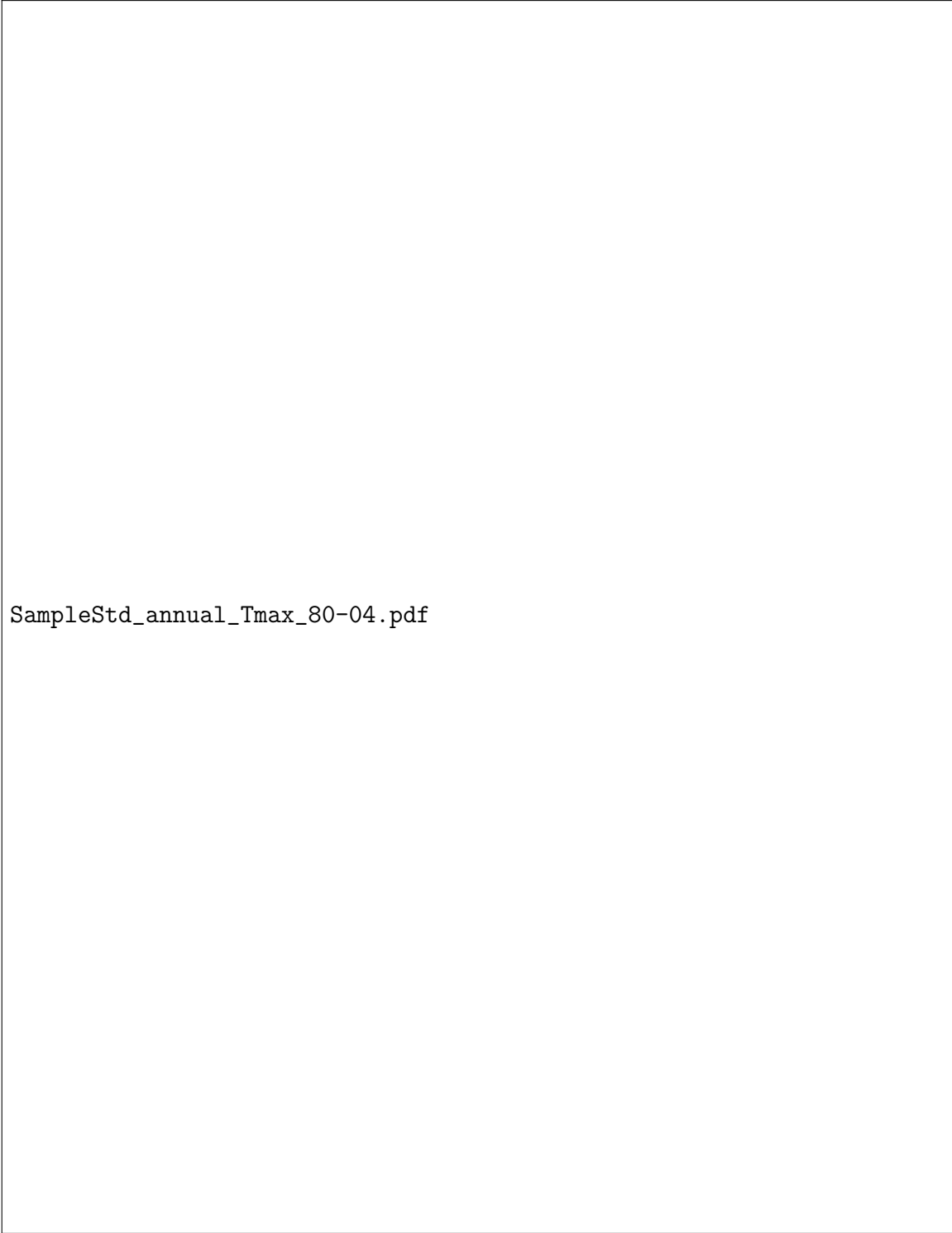
Introduction

This supporting information includes:

1) The original grid-refined mesh files describing the variable-resolution cubed-sphere grids;

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2) The interannual variability plots of mean T_{max}, T_{min}, T_{avg} and Pr in simulations and PRISM over 5, 10, 20 and 25 years. These plots show that our simulation period from year 1980-2005 is appropriate for the regional climatology studies in this paper;

3) Figures depicting the spatial distribution of T_{max}, T_{min}, T_{avg} and Pr trends in models and PRISM over the period 1980-2005, including the indicator of statistical significance under the two-tailed t-statistic with a significance level of 0.05;

4) Plots of seasonally-averaged T_{max}, T_{min}, and T_{avg} for seasons not addressed in this paper, and associated tabulated statistics;

5) Results from a globally uniform CESM run at 0.25° spatial resolution with the finite volume (FV) dynamical core [*Wehner et al.*, 2014].

References

Wehner, M. F., K. Reed, F. Li, Prabhat, J. Bacmeister, C.-T. Chen, C. Paciorek, P. Gleckler, K. Sperber, W. D. Collins, A. Gettelman, and C. Jablonowski (2014), The effect of horizontal resolution on simulation quality in the Community Atmospheric Model, CAM5.1, *J. Model. Earth. Sys.*, doi:10.1002/2013MS000276.

SampleStd_annual_Tmax_80-04.pdf

Figure S1. Sample standard deviation of annual T_{max} from models and PRISM with 5 year step from year 1980.

SampleStd_annual_Tmin_80-04.pdf
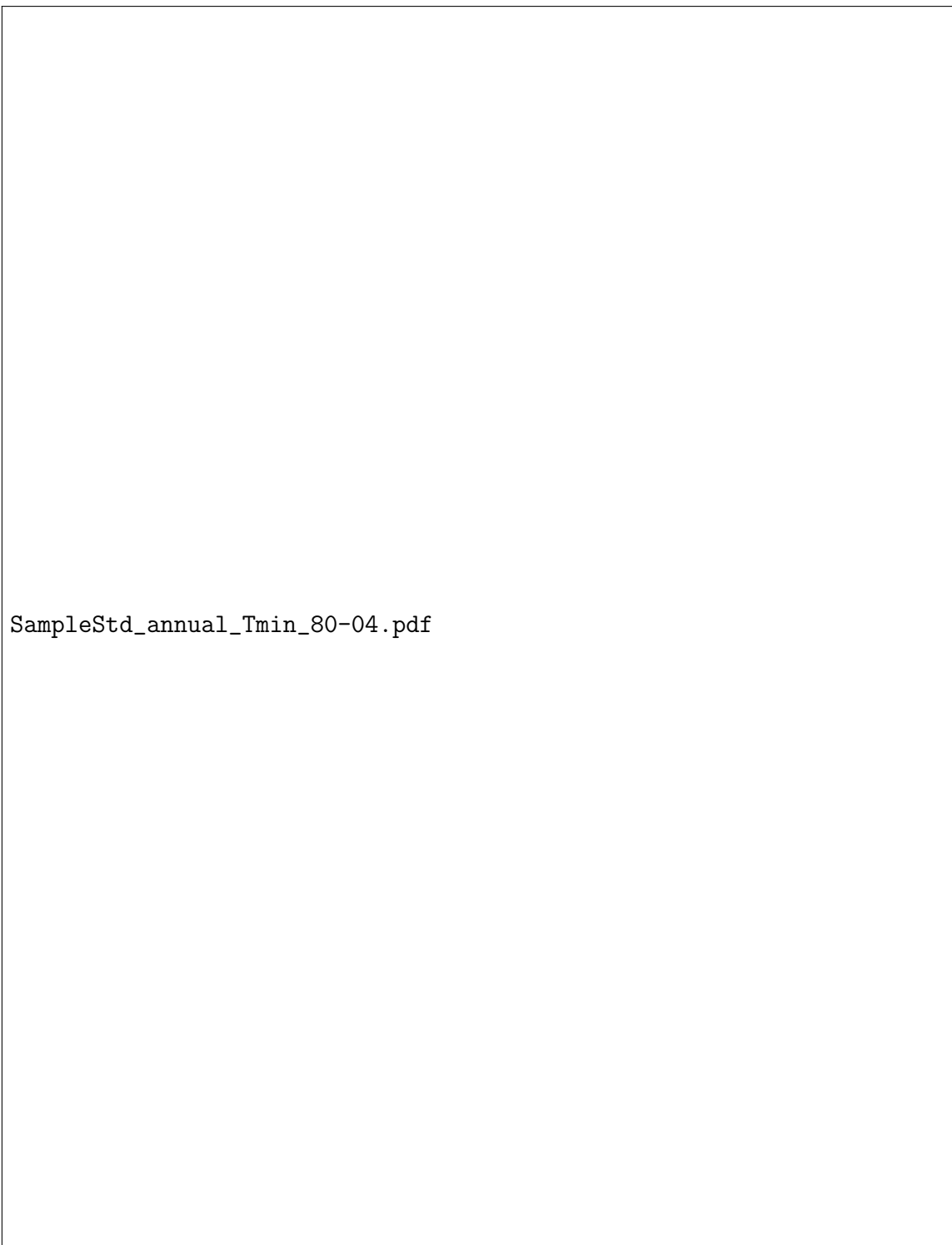
Figure S2.   Sample standard deviation of annual T_{min} from models and PRISM with 5 year step from year 1980.

SampleStd_annual_Tavg_80-04.pdf

Figure S3.   Sample standard deviation of annual T_{avg} from models and PRISM with 5 year step from year 1980.

SampleStd_annual_Pr_80-04.pdf

Figure S4.   Sample standard deviation of annual Pr from models and PRISM with 5 year step

from year 1980.

SampleStd_JJA_Tmax_80-04.pdf

Figure S5.   Sample standard deviation of JJA T$_{max}$ from models and PRISM with 5 year step

from year 1980.

SampleStd_JJA_Tmin_80-04.pdf
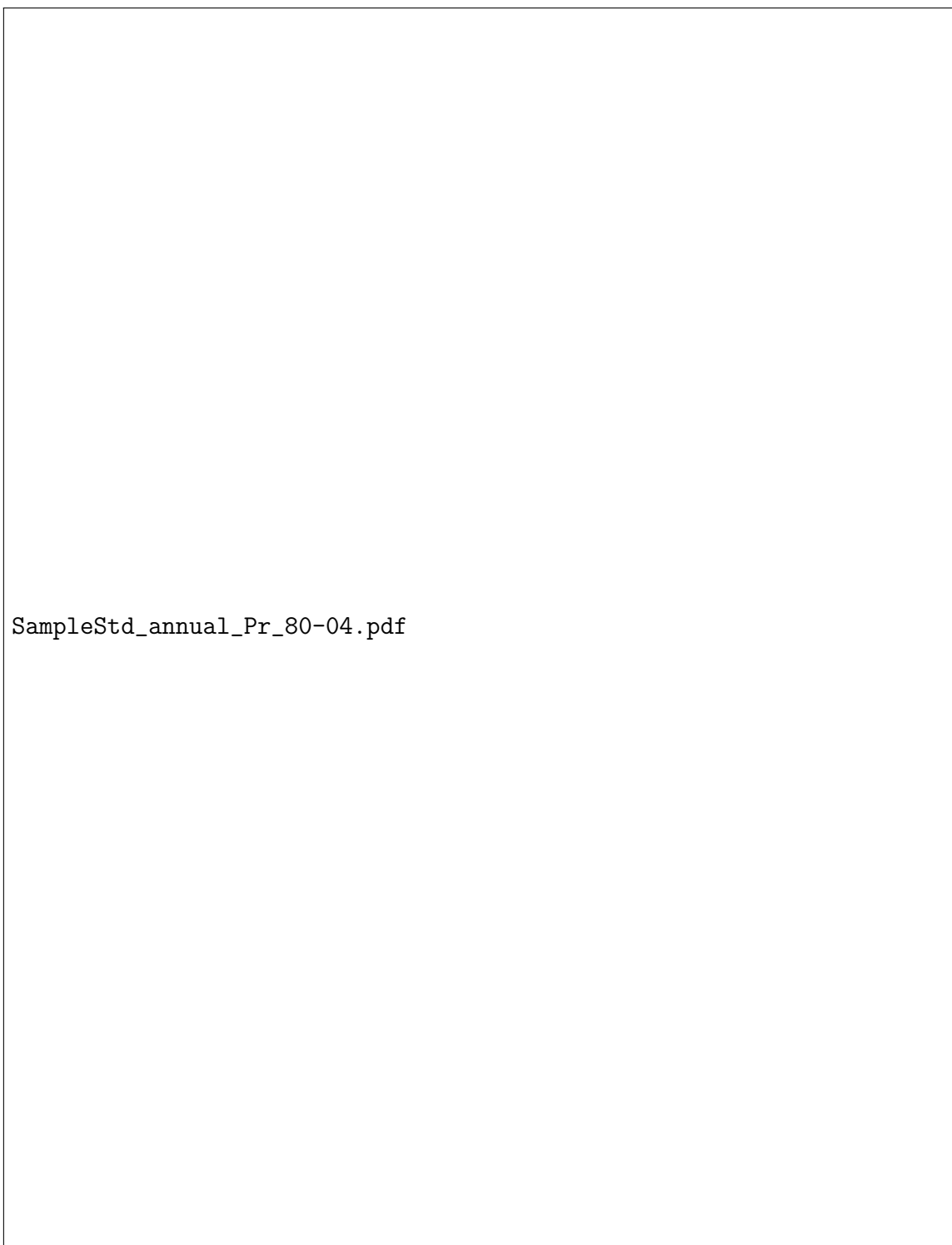
Figure S6.   Sample standard deviation of JJA T_{min} from models and PRISM with 5 year step from year 1980.

SampleStd_JJA_Tavg_80-04.pdf

Figure S7.   Sample standard deviation of JJA T_{avg} from models and PRISM with 5 year step from year 1980.

SampleStd_DJF_Pr_80-04.pdf

Figure S8.   Sample standard deviation of DJF Pr from models and PRISM with 5 year step from year 1980.

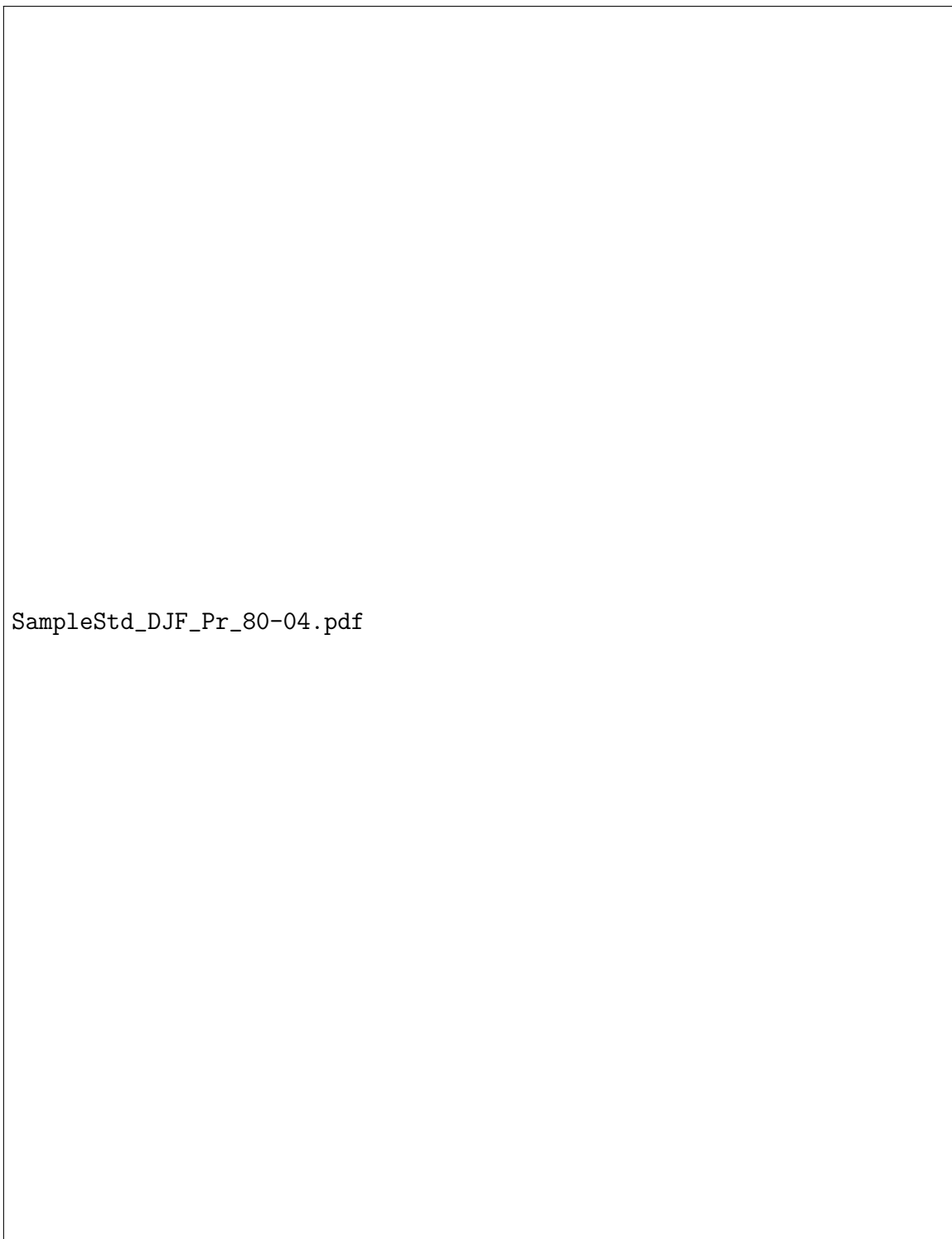Ttest_AnnualT2_timeTrend_over_1980-2005.pdf

Figure S9. Results of Student's t-test for a statistically significant linear time trend of annual T_{max}, T_{min} and T_{avg} over 1980-2005 of models and PRISM.

Ttest_JJAT2_timeTrend_over_1980-2005.pdf
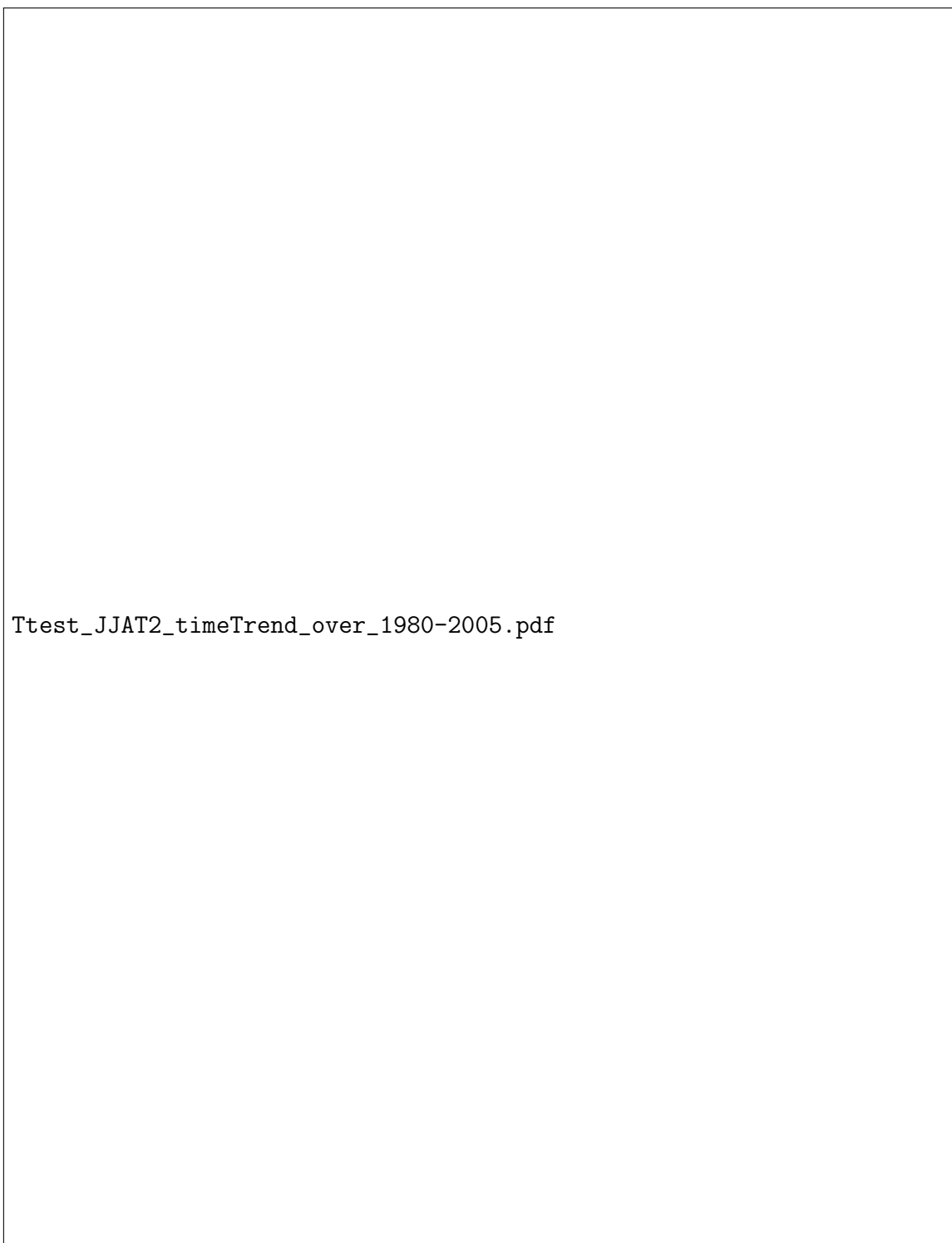
Figure S10.   Results of Student's t-test for a statistically significant linear time trend of JJA

T_{max}, T_{min} and T_{avg} over 1980-2005 of models and PRISM.

Ttest_precipitation_timeTrend_over_1980-2005.pdf

Figure S11. Results of Student's t-test for a statistically significant linear time trend of annual and DJF precipitation over 1980-2005 of models and PRISM.

t2_JJA_with_uniform_CESM.pdf

Figure S12.   Same as Figure 4 for season JJA along with uniform CESM 0.25°.

t2_MAM.pdf

Figure S13.   As Figure 4 for season MAM along with uniform CESM 0.25°.

t2_SON.pdf

Figure S14. As Figure 4 for season SON along with uniform CESM 0.25°.

t2_DJF.pdf
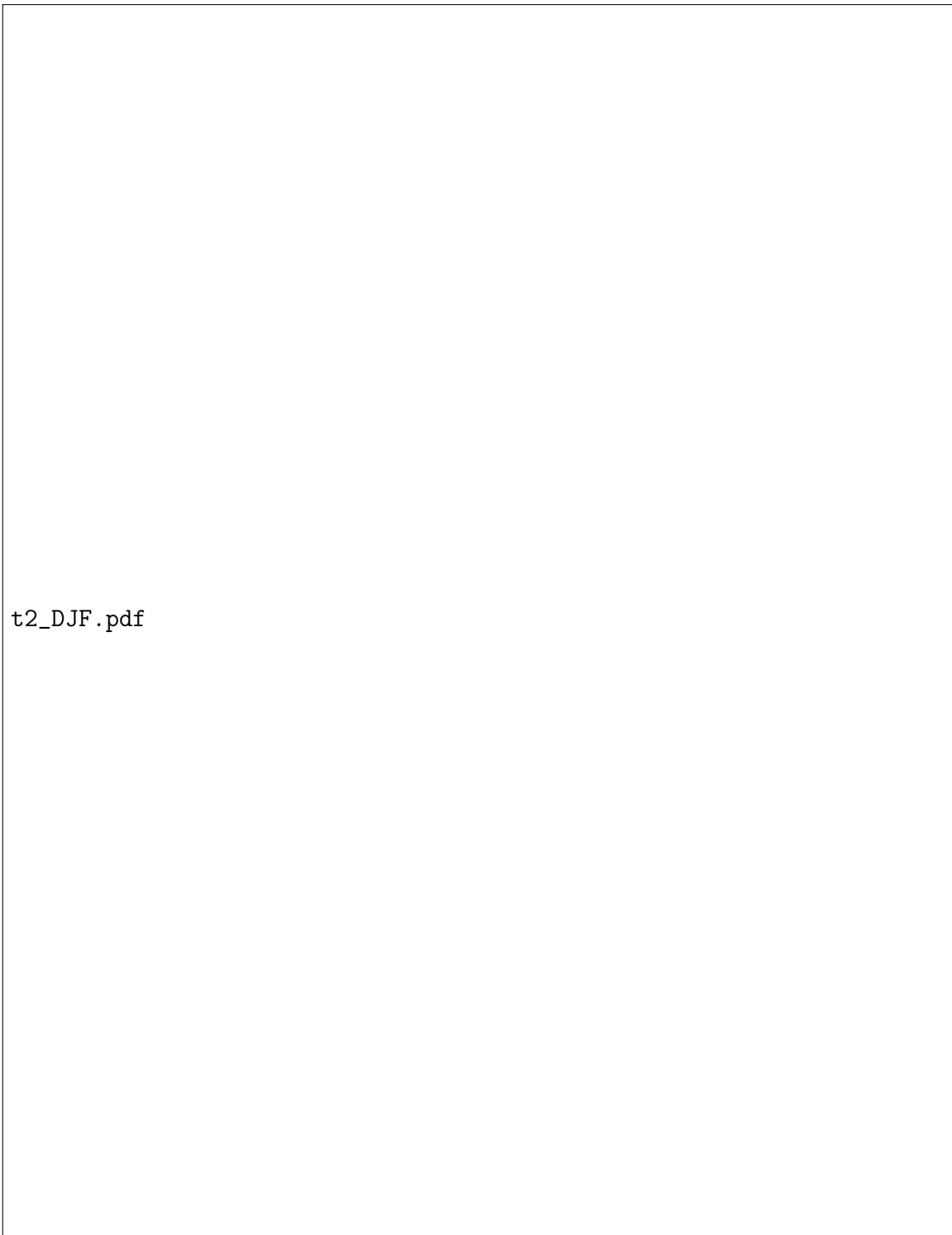
Figure S15. As Figure 4 for season DJF along with uniform CESM 0.25°.

trd_t2avg_allzones_with_uniform_CESM.pdf
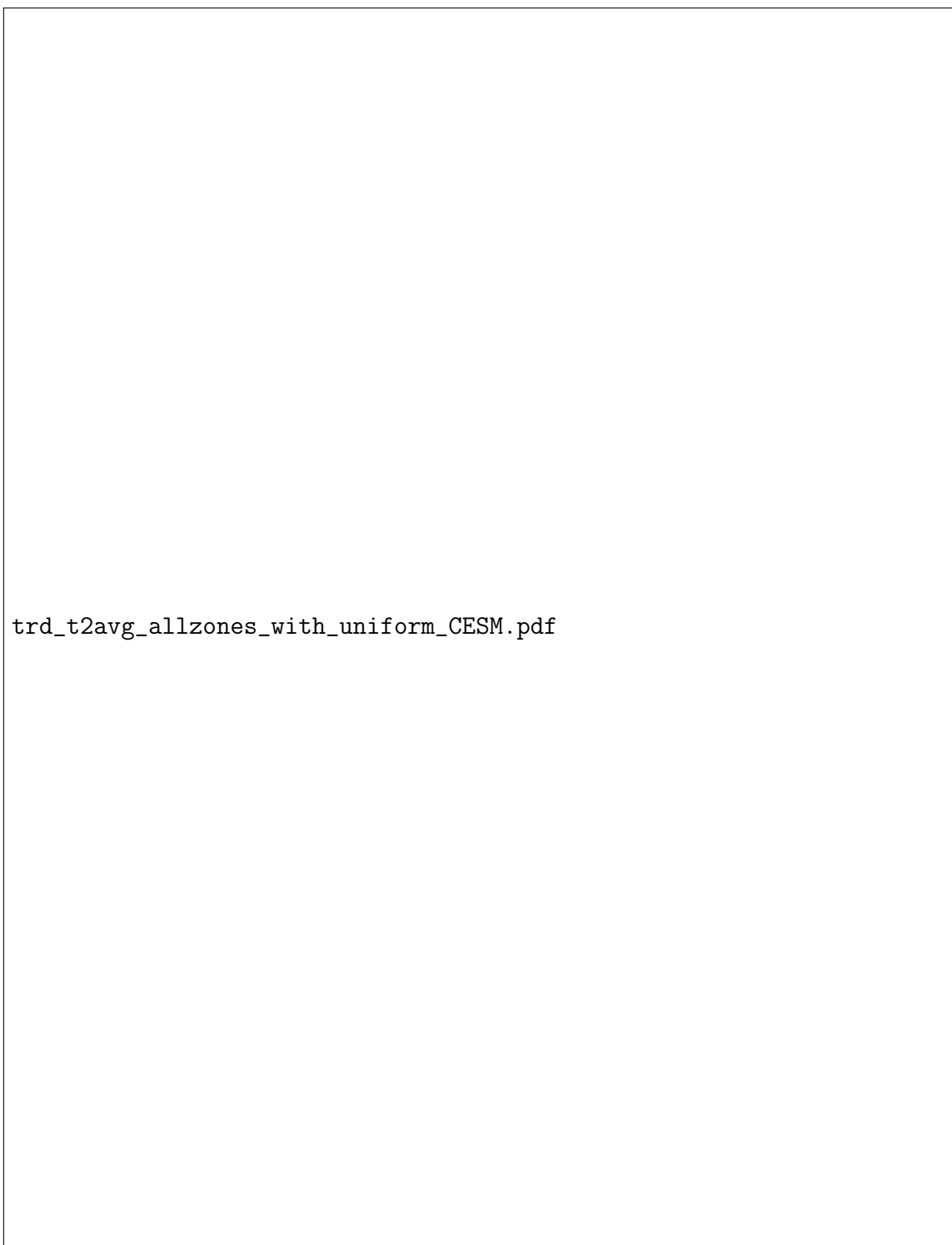
Figure S16.   As Figure 6 but with the addition of uniform CESM 0.25°.

pr_DJF_Annual_with_uniform_CESM.pdf
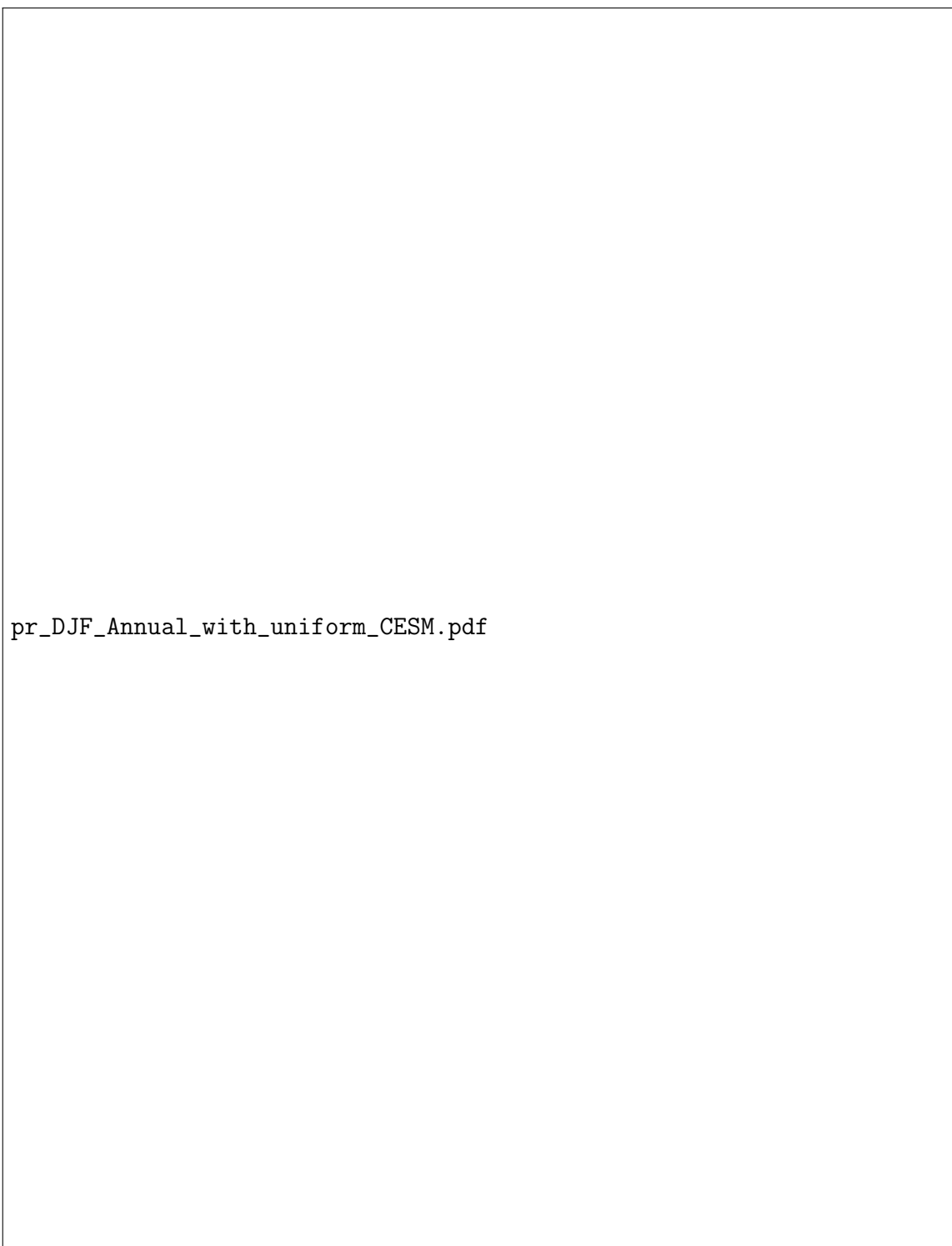
Figure S17. As Figure 9 but with the addition of uniform CESM 0.25°.

trd_pr_allzones_with_uniform_CESM.pdf

Figure S18.   As Figure 11 but with the addition of uniform CESM 0.25°.

taylor_diagram_with_uniform_CESM.pdf

Figure S19. As Figure 14 but with the addition of uniform CESM 0.25°.

Table S1.   RMSD ($°C$), MSD ($°C$) and Spatial Correlation (Corr) for seasonally-averaged

MAM (March-April-May) temperature over California

RMSD	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	1.776	2.212	2.297	2.164	2.033	2.344	2.686
VR-CESM 0.125°	1.727	1.841	2.145	1.883	1.908	2.214	2.287
WRF 27km	1.945	2.062	2.433	1.863	1.991	2.366	2.541
WRF 9km	3.114	2.065	3.060	1.568	1.801	2.969	2.293
Uniform CESM 0.25°	2.680	2.112	3.059	2.404	2.674	3.099	2.631

MSD	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	-0.859	1.308	-0.813	0.681	-0.819	-0.608	1.350
VR-CESM 0.125°	-1.261	0.983	-1.274	0.328	-1.202	-1.052	0.952
WRF 27km	-1.066	0.745	-1.020	0.117	-0.942	-0.818	0.788
WRF 9km	-2.516	1.259	-2.530	0.604	-1.312	-2.305	1.227
Uniform CESM 0.25°	-1.191	0.417	-1.139	-0.212	-1.398	-0.938	0.458

Corr	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	0.997	0.963	0.995	0.963	0.990	0.994	0.942
VR-CESM 0.125°	0.998	0.975	0.996	0.972	0.993	0.995	0.959
WRF 27km	0.996	0.959	0.994	0.968	0.991	0.994	0.937
WRF 9km	0.993	0.971	0.994	0.983	0.994	0.993	0.962
Uniform CESM 0.25°	0.993	0.960	0.990	0.949	0.984	0.989	0.938

Table S2.   RMSD ($^\circ C$), MSD ($^\circ C$) and Spatial Correlation (Corr) for seasonally-averaged SON (Sept.-Oct.-Nov.) temperature over California.

RMSD	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	1.591	3.866	2.065	2.788	1.777	2.088	3.837
VR-CESM 0.125°	1.212	3.906	1.652	2.851	1.524	1.900	3.797
WRF 27km	1.665	3.022	2.111	1.784	1.663	2.059	3.060
WRF 9km	2.262	3.788	2.574	2.322	1.285	2.402	3.615
uniform CESM 0.25°	2.605	3.344	2.970	2.789	2.464	2.999	3.444

MSD	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	0.122	3.303	-0.353	1.766	-0.240	0.102	3.063
VR-CESM 0.125°	0.394	3.439	-0.126	1.908	-0.048	0.353	3.134
WRF 27km	0.181	2.044	-0.295	0.507	-0.739	0.158	1.807
WRF 9km	-1.412	3.310	-1.931	1.779	-0.673	-1.451	3.004
uniform CESM 0.25°	-0.187	2.415	-0.655	0.877	-0.826	-0.205	2.175

Corr	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	0.998	0.950	0.996	0.975	0.994	0.996	0.951
VR-CESM 0.125°	0.999	0.957	0.998	0.978	0.996	0.997	0.961
WRF 27km	0.997	0.949	0.996	0.982	0.995	0.996	0.948
WRF 9km	0.996	0.953	0.996	0.986	0.997	0.996	0.959
uniform CESM 0.25°	0.993	0.956	0.992	0.965	0.989	0.991	0.952

Table S3.   RMSD ($°C$), MSD ($°C$) and Spatial Correlation (Corr) for seasonally-averaged DJF temperature over California.

RMSD	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	1.959	2.751	2.196	2.015	1.742	2.253	2.700
VR-CESM 0.125°	1.633	2.302	2.035	1.840	1.747	2.089	2.318
WRF 27km	1.699	2.756	2.106	1.734	1.537	2.033	2.665
WRF 9km	1.876	2.753	2.324	1.865	1.324	2.169	2.625
uniform CESM 0.25°	2.979	2.072	3.339	2.500	3.211	3.310	2.408

MSD	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	-0.549	2.108	-0.984	0.977	-0.920	-0.774	1.836
VR-CESM 0.125°	-0.723	1.678	-1.178	0.541	-1.202	-0.978	1.345
WRF 27km	-0.075	2.027	-0.510	0.895	-0.620	-0.302	1.759
WRF 9km	-1.049	2.214	-1.504	1.077	-0.594	-1.301	1.880
uniform CESM 0.25°	-1.862	-0.010	-2.293	-1.142	-2.616	-2.085	-0.280

Corr	UW		PRISM			Daymet	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{avg}	T_{max}	T_{min}
VR-CESM 0.25°	0.989	0.856	0.988	0.925	0.978	0.987	0.856
VR-CESM 0.125°	0.993	0.900	0.991	0.941	0.979	0.989	0.898
WRF 27km	0.992	0.842	0.987	0.931	0.982	0.988	0.838
WRF 9km	0.990	0.859	0.987	0.942	0.987	0.988	0.870
uniform CESM 0.25°	0.980	0.922	0.977	0.885	0.926	0.976	0.893

Table S4.   RMSD (mm/day), MSD (mm/d), MRD, Spatial Correlation (Corr) for averaged

precipitation over California

MAM	CPC				UW			
	RMSD	MSD	MRD	Corr	RMSD	MSD	MRD	Corr
VR-CESM 0.25°	0.542	0.279	0.264	0.981	0.589	0.193	0.265	0.968
VR-CESM 0.125°	0.554	0.291	0.267	0.979	0.579	0.217	0.263	0.970
WRF 27km	0.448	-0.183	0.209	0.975	0.587	-0.269	0.234	0.970
WRF 9km	2.143	1.370	0.881	0.966	1.991	1.295	0.783	0.971
uniform CESM 0.25°	0.601	0.182	0.254	0.971	0.611	0.096	0.259	0.964
MAM	**PRISM**				**DAYMET**			
	RMSD	MSD	MRD	Corr	RMSD	MSD	MRD	Corr
VR-CESM 0.25°	0.542	0.279	0.264	0.981	0.589	0.193	0.265	0.968
VR-CESM 0.125°	0.554	0.291	0.267	0.979	0.579	0.217	0.263	0.970
WRF 27km	0.448	-0.183	0.209	0.975	0.587	-0.269	0.234	0.970
WRF 9km	2.143	1.370	0.881	0.966	1.991	1.295	0.783	0.971
uniform CESM 0.25°	0.601	0.182	0.254	0.971	0.611	0.096	0.259	0.964

JJA	CPC				UW			
	RMSD	MSD	MRD	Corr	RMSD	MSD	MRD	Corr
VR-CESM 0.25°	0.138	-0.017	0.361	0.903	0.138	-0.008	0.359	0.905
VR-CESM 0.125°	0.153	-0.006	0.388	0.889	0.148	0.005	0.375	0.897
WRF 27km	0.213	0.010	0.587	0.850	0.186	0.019	0.515	0.892
WRF 9km	1.013	0.644	2.518	0.853	1.000	0.654	2.654	0.881
uniform CESM 0.25°	0.177	-0.034	0.471	0.835	0.179	-0.025	0.467	0.837
JJA	**PRISM**				**DAYMET**			
	RMSD	MSD	MRD	Corr	RMSD	MSD	MRD	Corr
VR-CESM 0.25°	0.138	-0.017	0.361	0.903	0.138	-0.008	0.359	0.905
VR-CESM 0.125°	0.153	-0.006	0.388	0.889	0.148	0.005	0.375	0.897
WRF 27km	0.213	0.010	0.587	0.850	0.186	0.019	0.515	0.892
WRF 9km	1.013	0.644	2.518	0.853	1.000	0.654	2.654	0.881
uniform CESM 0.25°	0.177	-0.034	0.471	0.835	0.179	-0.025	0.467	0.837

SON	CPC				UW			
	RMSD	MSD	MRD	Corr	RMSD	MSD	MRD	Corr
VR-CESM 0.25°	0.536	0.346	0.338	0.984	0.579	0.323	0.351	0.966
VR-CESM 0.125°	0.381	-0.054	0.223	0.969	0.471	-0.067	0.260	0.956
WRF 27km	0.382	-0.271	0.247	0.982	0.506	-0.294	0.278	0.971
WRF 9km	1.851	1.297	1.091	0.960	1.779	1.283	1.065	0.964
uniform CESM 0.25°	0.365	0.022	0.214	0.972	0.479	-0.001	0.271	0.955
SON	**PRISM**				**DAYMET**			
	RMSD	MSD	MRD	Corr	RMSD	MSD	MRD	Corr
VR-CESM 0.25°	0.536	0.346	0.338	0.984	0.579	0.323	0.351	0.966
VR-CESM 0.125°	0.381	-0.054	0.223	0.969	0.471	-0.067	0.260	0.956
WRF 27km	0.382	-0.271	0.247	0.982	0.506	-0.294	0.278	0.971
WRF 9km	1.851	1.297	1.091	0.960	1.779	1.283	1.065	0.964
uniform CESM 0.25°	0.365	0.022	0.214	0.972	0.479	-0.001	0.271	0.955