Table S1. The comparison of different RFVL based models in forecasting SPI3 and SPI6 drought indices – Station 1

Drought Indices	Input Comb.	Models	Training				Testing			
			RMSE	MAE	R²	NSE	RMSE	MAE	R²	NSE
SPI3	SPI3t-1	RFVL	0.504	0.364	0.783	0.783	0.521	0.365	0.758	0.686
		PSO	0.487	0.338	0.815	0.815	0.514	0.364	0.768	0.701
		GA	0.485	0.340	0.817	0.817	0.512	0.361	0.768	0.705
		GWO	0.483	0.338	0.819	0.819	0.510	0.352	0.795	0.710
		SSO	0.479	0.337	0.827	0.827	0.502	0.358	0.786	0.725
		SSA	0.454	0.317	0.865	0.865	0.500	0.344	0.805	0.731
		HGS	0.433	0.292	0.887	0.887	0.489	0.337	0.815	0.752
	SPI3t-1,SPI3t-2	RFVL	0.520	0.373	0.780	0.780	0.553	0.387	0.734	0.618
		PSO	0.503	0.357	0.788	0.787	0.551	0.387	0.736	0.622
		GA	0.501	0.353	0.789	0.789	0.551	0.385	0.736	0.623
		GWO	0.492	0.351	0.806	0.806	0.549	0.384	0.734	0.626
		SSO	0.480	0.339	0.825	0.825	0.542	0.381	0.742	0.641
		SSA	0.473	0.334	0.835	0.835	0.541	0.380	0.754	0.644
		HGS	0.465	0.324	0.849	0.849	0.537	0.374	0.776	0.653
SPI6	SPI6t-1,SP6t-2	RFVL	0.504	0.364	0.824	0.734	0.507	0.369	0.756	0.639
		PSO	0.443	0.278	0.858	0.848	0.450	0.299	0.791	0.748
		GA	0.426	0.267	0.873	0.873	0.447	0.298	0.807	0.754
		GWO	0.422	0.263	0.876	0.876	0.445	0.295	0.813	0.758
		SSO	0.420	0.262	0.880	0.880	0.441	0.293	0.818	0.765
		SSA	0.417	0.260	0.884	0.884	0.440	0.289	0.820	0.766
		HGS	0.397	0.246	0.911	0.911	0.432	0.288	0.826	0.782
	SPI6t-1,SPI6t-2,SPI6t-3,SPI6t-4	RFVL	0.484	0.336	0.817	0.817	0.488	0.301	0.761	0.673
		PSO	0.430	0.275	0.867	0.867	0.448	0.292	0.785	0.728
		GA	0.421	0.269	0.879	0.879	0.441	0.289	0.794	0.738
		GWO	0.408	0.260	0.897	0.897	0.440	0.287	0.808	0.755
		SSO	0.392	0.257	0.915	0.915	0.437	0.283	0.811	0.760
		SSA	0.386	0.250	0.923	0.923	0.433	0.279	0.819	0.771
		HGS	0.372	0.230	0.939	0.939	0.430	0.275	0.829	0.782

Table S2. The comparison of different RFVL based models in forecasting SPI3 and SPI6 drought indices –

Station 3

Drought Indices	Input Comb.	Models	Training				Testing			
			RMSE	MAE	R²	NSE	RMSE	MAE	R²	NSE
SPI3	SPI3t-1	RFVL	0.472	0.323	0.778	0.778	0.548	0.371	0.764	0.727
		PSO	0.462	0.315	0.795	0.795	0.547	0.369	0.770	0.730
		GA	0.452	0.308	0.815	0.815	0.545	0.366	0.768	0.733
		GWO	0.448	0.305	0.820	0.820	0.530	0.363	0.798	0.760
		SSO	0.438	0.290	0.835	0.835	0.520	0.352	0.810	0.779
		SSA	0.434	0.287	0.841	0.841	0.519	0.354	0.811	0.781
		HGS	0.405	0.263	0.888	0.888	0.515	0.351	0.814	0.785
	SPI3t-1,SPI3t-2	RFVL	0.480	0.334	0.764	0.764	0.609	0.431	0.732	0.610
		PSO	0.479	0.332	0.768	0.768	0.576	0.392	0.745	0.675
		GA	0.474	0.331	0.770	0.770	0.569	0.385	0.765	0.689
		GWO	0.471	0.328	0.772	0.772	0.566	0.382	0.775	0.695
		SSO	0.467	0.321	0.786	0.786	0.530	0.355	0.800	0.760
		SSA	0.463	0.317	0.793	0.793	0.548	0.370	0.769	0.727
		HGS	0.461	0.315	0.796	0.796	0.530	0.355	0.800	0.760
SPI6	SPI6t-1,SP6t-2	RFVL	0.448	0.282	0.816	0.816	0.558	0.340	0.734	0.663
		PSO	0.444	0.283	0.819	0.819	0.458	0.279	0.810	0.756
		GA	0.441	0.281	0.825	0.825	0.452	0.280	0.808	0.766
		GWO	0.436	0.280	0.833	0.833	0.444	0.258	0.813	0.779
		SSO	0.417	0.262	0.864	0.864	0.434	0.268	0.818	0.805
		SSA	0.414	0.260	0.868	0.868	0.427	0.250	0.823	0.808
		HGS	0.408	0.253	0.878	0.878	0.426	0.251	0.828	0.809
	SPI6t-1,SPI6t-2,SPI6t-3,SPI6t-4	RFVL	0.445	0.284	0.820	0.820	0.511	0.322	0.768	0.706
		PSO	0.426	0.272	0.853	0.853	0.471	0.292	0.779	0.734
		GA	0.422	0.269	0.859	0.859	0.445	0.276	0.811	0.777
		GWO	0.382	0.238	0.917	0.917	0.439	0.271	0.818	0.788
		SSO	0.361	0.221	0.948	0.948	0.428	0.259	0.823	0.796
		SSA	0.356	0.222	0.955	0.955	0.426	0.248	0.835	0.809
		HGS	0.331	0.196	0.969	0.969	0.422	0.237	0.841	0.815

Table S3. The comparison of different RFVL based models in forecasting SPI9 and SPI12 drought indices –

Station 1

Drought Indices	Input Comb.	Models	Training				Testing			
			RMSE	MAE	R²	NSE	RMSE	MAE	R²	NSE
SPI9	SPI9t-1,SPI9t-2, SPI9t-3,	RFVL	0.467	0.317	0.859	0.859	0.495	0.344	0.766	0.747
		PSO	0.449	0.311	0.863	0.863	0.493	0.339	0.769	0.749
		GA	0.448	0.310	0.864	0.864	0.488	0.335	0.775	0.757
		GWO	0.444	0.306	0.869	0.869	0.479	0.322	0.835	0.790
		SSO	0.417	0.290	0.894	0.894	0.447	0.305	0.825	0.817
		SSA	0.406	0.283	0.901	0.904	0.433	0.300	0.836	0.826
		HGS	0.395	0.276	0.910	0.910	0.425	0.294	0.845	0.835
	SPI9t-1,SPI9t-2,SPI9t-3,SPI9t-4,SPI9t-5	RFVL	0.476	0.336	0.847	0.847	0.592	0.416	0.650	0.588
		PSO	0.466	0.316	0.860	0.860	0.517	0.351	0.768	0.726
		GA	0.464	0.313	0.862	0.862	0.500	0.352	0.791	0.755
		GWO	0.461	0.310	0.865	0.865	0.485	0.333	0.778	0.761
		SSO	0.440	0.302	0.884	0.884	0.478	0.322	0.834	0.791
		SSA	0.432	0.298	0.892	0.892	0.476	0.315	0.833	0.794
		HGS	0.428	0.296	0.896	0.896	0.463	0.314	0.828	0.815
SPI12	SPI12t-1,SPI12t-2, SPI12t-3,	RFVL	0.441	0.293	0.882	0.882	0.525	0.383	0.689	0.647
		PSO	0.348	0.242	0.950	0.950	0.429	0.299	0.821	0.794
		GA	0.341	0.236	0.956	0.956	0.420	0.298	0.841	0.805
		GWO	0.347	0.235	0.952	0.952	0.429	0.299	0.821	0.794
		SSO	0.327	0.226	0.966	0.966	0.388	0.264	0.870	0.846
		SSA	0.323	0.222	0.969	0.969	0.410	0.283	0.845	0.818
		HGS	0.302	0.209	0.983	0.983	0.387	0.263	0.870	0.847
	SPI12t-1,SPI12t-2,SPI12t-3,SPI12t-4,SPI12t-5	RFVL	0.381	0.276	0.894	0.894	0.502	0.339	0.738	0.685
		PSO	0.344	0.243	0.953	0.953	0.409	0.299	0.836	0.819
		GA	0.340	0.241	0.957	0.957	0.400	0.270	0.848	0.831
		GWO	0.328	0.235	0.964	0.964	0.398	0.268	0.854	0.834
		SSO	0.319	0.219	0.971	0.971	0.390	0.262	0.864	0.844
		SSA	0.315	0.226	0.974	0.974	0.388	0.261	0.863	0.846
		HGS	0.299	0.212	0.985	0.985	0.379	0.235	0.876	0.857

Table S4. The comparison of different RFVL based models in forecasting SPI9 and SPI12 drought indices – Station 3

Drought Indices	Input Comb.	Models	Training				Testing			
			RMSE	MAE	R²	NSE	RMSE	MAE	R²	NSE
SPI9	SPI9t-1,SPI9t-2, SPI9t-3,	RFVL	0.273	0.138	0.828	0.828	0.393	0.193	0.795	0.779
		PSO	0.271	0.133	0.830	0.830	0.366	0.160	0.833	0.812
		GA	0.269	0.128	0.833	0.833	0.357	0.153	0.836	0.824
		GWO	0.261	0.122	0.843	0.842	0.350	0.149	0.842	0.831
		SSO	0.222	0.111	0.884	0.884	0.340	0.145	0.855	0.842
		SSA	0.212	0.109	0.893	0.893	0.337	0.142	0.867	0.846
		HGS	0.206	0.104	0.910	0.910	0.333	0.137	0.873	0.849
	SPI9t-1,SPI9t-2,SPI9t-3,SPI9t-4,SPI9t-5	RFVL	0.294	0.149	0.806	0.806	0.422	0.218	0.762	0.742
		PSO	0.274	0.127	0.827	0.827	0.411	0.216	0.783	0.756
		GA	0.269	0.125	0.832	0.832	0.404	0.200	0.786	0.762
		GWO	0.261	0.121	0.842	0.842	0.360	0.172	0.841	0.819
		SSO	0.248	0.117	0.856	0.856	0.355	0.155	0.852	0.835
		SSA	0.229	0.109	0.873	0.873	0.346	0.152	0.854	0.821
		HGS	0.223	0.107	0.886	0.886	0.337	0.150	0.855	0.839
SPI12	SPI12t-1,SPI12t-2, SPI12t-3,	RFVL	0.299	0.163	0.847	0.847	0.366	0.195	0.831	0.804
		PSO	0.289	0.156	0.866	0.866	0.325	0.173	0.838	0.827
		GA	0.284	0.152	0.873	0.872	0.297	0.139	0.849	0.836
		GWO	0.279	0.148	0.877	0.877	0.294	0.131	0.862	0.847
		SSO	0.261	0.142	0.902	0.902	0.289	0.128	0.869	0.853
		SSA	0.245	0.131	0.906	0.906	0.284	0.123	0.872	0.858
		HGS	0.229	0.118	0.919	0.919	0.281	0.127	0.891	0.876
	SPI12t-1,SPI12t-2,SPI12t-3,SPI12t-4,SPI12t-5	RFVL	0.293	0.158	0.858	0.858	0.318	0.156	0.833	0.806
		PSO	0.287	0.154	0.869	0.869	0.300	0.148	0.856	0.841
		GA	0.281	0.148	0.875	0.875	0.295	0.137	0.859	0.844
		GWO	0.262	0.144	0.888	0.888	0.288	0.128	0.867	0.849
		SSO	0.247	0.133	0.905	0.905	0.285	0.124	0.888	0.863
		SSA	0.240	0.128	0.911	0.911	0.281	0.121	0.890	0.872
		HGS	0.225	0.115	0.922	0.922	0.276	0.114	0.893	0.880

Table S5. The comparison of different RFVL based models in SPI6 drought estimation for the test period using Periodicity with optimal inputs

| Station	Input Comb.	Models	Training				Testing			
			RMSE	MAE	R²	NSE	RMSE	MAE	R²	NSE
Station 1	OPT SPI6+MN	RFVL	0.478	0.319	0.821	0.820	0.475	0.329	0.766	0.683
		PSO	0.426	0.273	0.873	0.873	0.436	0.277	0.796	0.753
		GA	0.416	0.265	0.885	0.885	0.431	0.273	0.811	0.765
		GWO	0.405	0.251	0.901	0.901	0.424	0.266	0.818	0.767
		SSO	0.379	0.236	0.934	0.934	0.413	0.257	0.824	0.775
		SSA	0.364	0.225	0.953	0.953	0.406	0.255	0.828	0.777
		HGS	0.342	0.204	0.959	0.959	0.401	0.252	0.839	0.790
Station 2	OPT SPI6+MN	RFVL	0.442	0.281	0.824	0.824	0.508	0.318	0.771	0.709
		PSO	0.423	0.268	0.857	0.857	0.467	0.289	0.782	0.737
		GA	0.421	0.265	0.862	0.862	0.442	0.274	0.815	0.779
		GWO	0.380	0.235	0.921	0.921	0.436	0.267	0.820	0.790
		SSO	0.359	0.216	0.951	0.951	0.425	0.256	0.825	0.799
		SSA	0.354	0.214	0.959	0.959	0.424	0.245	0.838	0.811
		HGS	0.330	0.193	0.971	0.971	0.420	0.236	0.845	0.817
Station 3	OPT SPI6+MN	RFVL	0.442	0.281	0.824	0.824	0.508	0.318	0.771	0.709
		PSO	0.423	0.268	0.857	0.857	0.467	0.289	0.782	0.737
		GA	0.421	0.265	0.862	0.862	0.442	0.274	0.815	0.779
		GWO	0.380	0.235	0.921	0.921	0.436	0.267	0.820	0.790
		SSO	0.359	0.216	0.951	0.951	0.425	0.256	0.825	0.799
		SSA	0.354	0.214	0.959	0.959	0.424	0.245	0.838	0.811
		HGS	0.330	0.193	0.971	0.971	0.420	0.236	0.845	0.817

Table S6. The comparison of different RFVL based models in SPI9 drought estimation for the test period using Periodicity with optimal inputs

Station	Input Comb.	Models	Training				Testing			
			RMSE	MAE	R²	NSE	RMSE	MAE	R²	NSE
Station 1	OPT SPI9+MN	RFVL	0.465	0.315	0.868	0.868	0.491	0.341	0.775	0.756
		PSO	0.444	0.302	0.873	0.873	0.478	0.338	0.789	0.762
		GA	0.430	0.297	0.880	0.880	0.471	0.336	0.817	0.789
		GWO	0.410	0.281	0.895	0.895	0.452	0.305	0.827	0.806
		SSO	0.392	0.254	0.898	0.898	0.435	0.293	0.832	0.822
		SSA	0.375	0.247	0.904	0.904	0.419	0.280	0.851	0.843
		HGS	0.363	0.240	0.915	0.915	0.409	0.244	0.854	0.848
Station 2	OPT SPI9+MN	RFVL	0.391	0.240	0.799	0.799	0.426	0.289	0.792	0.762
		PSO	0.389	0.238	0.803	0.803	0.398	0.285	0.818	0.803
		GA	0.385	0.235	0.805	0.805	0.395	0.275	0.828	0.809
		GWO	0.376	0.233	0.819	0.819	0.383	0.264	0.833	0.813
		SSO	0.342	0.216	0.855	0.855	0.375	0.260	0.835	0.814
		SSA	0.310	0.185	0.882	0.882	0.372	0.256	0.836	0.818
		HGS	0.305	0.183	0.891	0.891	0.370	0.253	0.844	0.825
Station 3	OPT SPI9+MN	RFVL	0.271	0.134	0.833	0.833	0.390	0.190	0.799	0.783
		PSO	0.267	0.130	0.835	0.835	0.364	0.157	0.837	0.815
		GA	0.265	0.126	0.838	0.838	0.355	0.150	0.840	0.827
		GWO	0.256	0.120	0.846	0.846	0.346	0.148	0.845	0.834
		SSO	0.228	0.114	0.880	0.880	0.342	0.146	0.852	0.840
		SSA	0.215	0.111	0.890	0.890	0.339	0.144	0.864	0.843
		HGS	0.210	0.107	0.904	0.904	0.337	0.139	0.870	0.845

Table S7. The comparison of different RFVL based models in SPI12 drought estimation for the test period using Periodicity with optimal inputs

| Station	Input Comb.	Models	Training				Testing			
			RMSE	MAE	R²	NSE	RMSE	MAE	R²	NSE
Station 1	OPT SPI12+MN	RFVL	0.374	0.273	0.900	0.899	0.495	0.336	0.744	0.689
		PSO	0.341	0.241	0.956	0.956	0.401	0.294	0.839	0.822
		GA	0.334	0.238	0.962	0.962	0.397	0.267	0.852	0.835
		GWO	0.324	0.233	0.967	0.967	0.394	0.266	0.858	0.840
		SSO	0.321	0.230	0.969	0.969	0.392	0.264	0.860	0.841
		SSA	0.318	0.228	0.970	0.970	0.390	0.263	0.861	0.843
		HGS	0.303	0.219	0.979	0.979	0.385	0.243	0.868	0.851
Station 2	OPT SPI12+MN	RFVL	0.295	0.163	0.901	0.901	0.342	0.206	0.795	0.781
		PSO	0.292	0.160	0.904	0.904	0.332	0.211	0.805	0.793
		GA	0.290	0.158	0.905	0.905	0.323	0.201	0.816	0.803
		GWO	0.281	0.155	0.917	0.917	0.300	0.178	0.844	0.823
		SSO	0.249	0.144	0.943	0.943	0.289	0.166	0.871	0.845
		SSA	0.244	0.138	0.951	0.951	0.275	0.158	0.881	0.856
		HGS	0.228	0.121	0.962	0.962	0.264	0.154	0.884	0.868
Station 3	OPT SPI12+MN	RFVL	0.291	0.158	0.858	0.858	0.315	0.153	0.837	0.810
		PSO	0.284	0.154	0.869	0.869	0.297	0.145	0.859	0.844
		GA	0.278	0.148	0.875	0.875	0.291	0.134	0.864	0.848
		GWO	0.258	0.141	0.888	0.888	0.287	0.125	0.870	0.855
		SSO	0.250	0.138	0.905	0.905	0.287	0.126	0.883	0.860
		SSA	0.244	0.133	0.907	0.907	0.284	0.124	0.886	0.868
		HGS	0.229	0.125	0.912	0.912	0.280	0.118	0.890	0.876
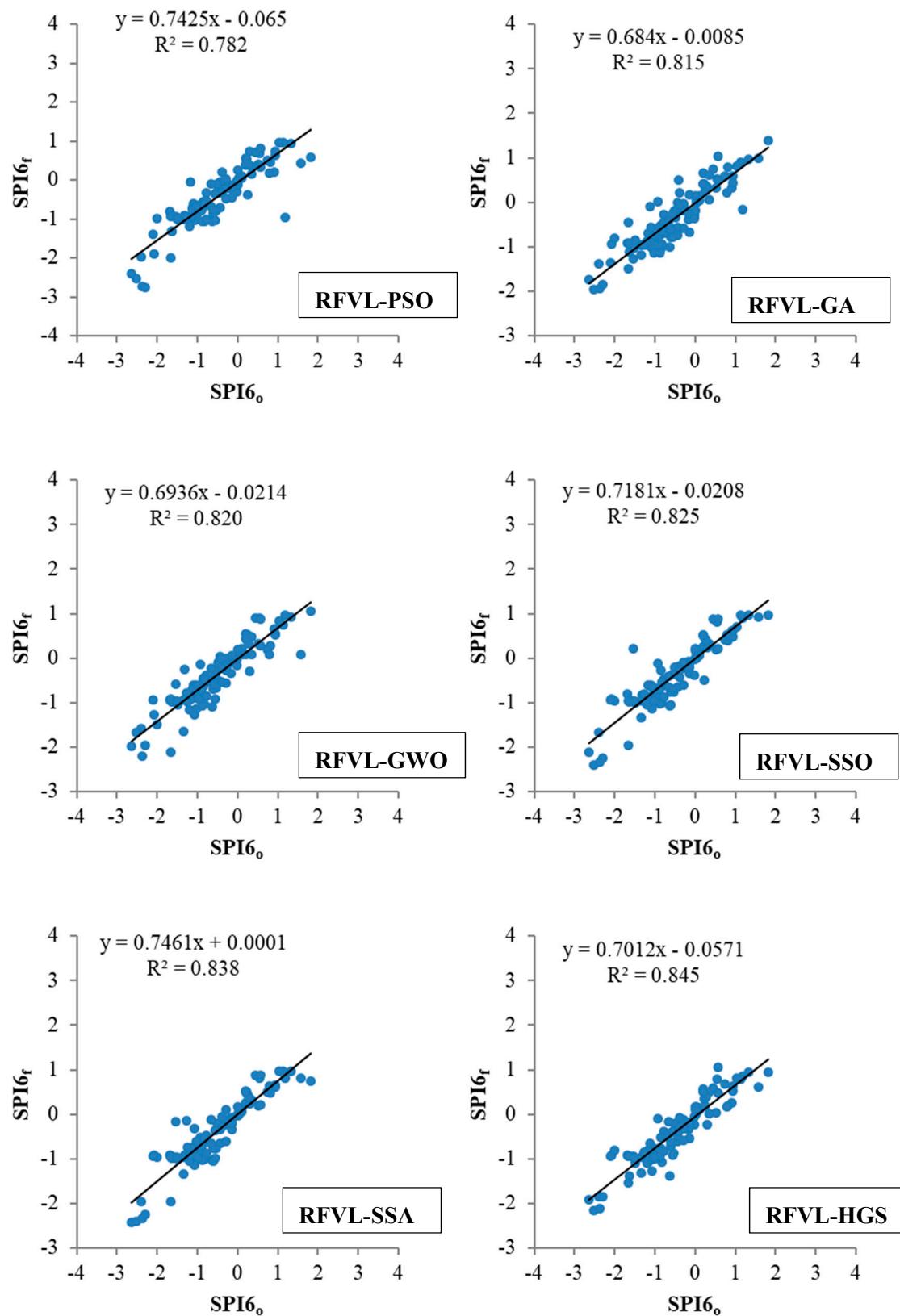
Figure S1. Scatterplots of the observed and predicted SPI6 drought index by different RFVL based models in the test period –Station 2
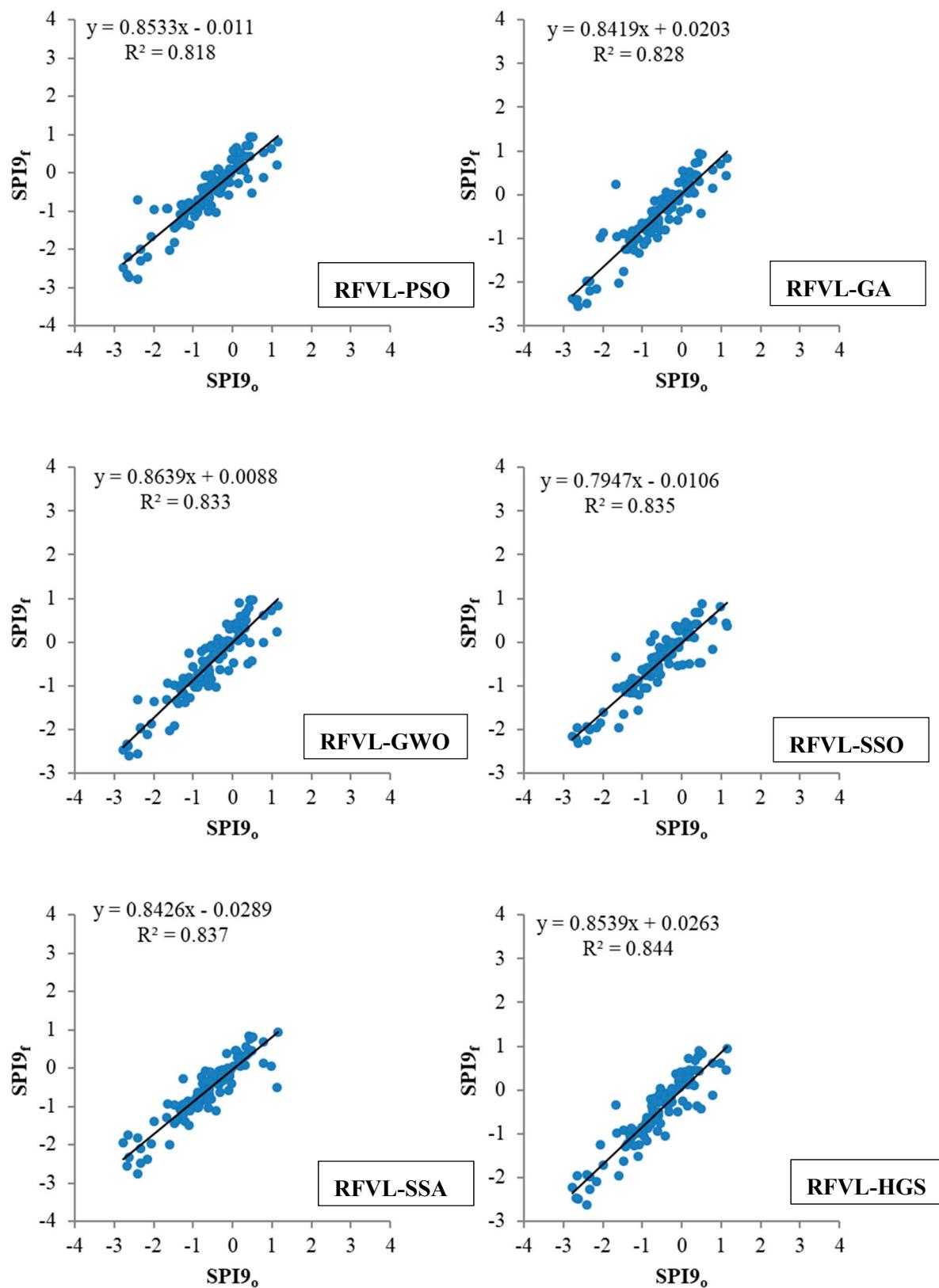
Figure S2. Scatterplots of the observed and predicted SPI9 drought index by different RFVL based models in the test period –Station 2
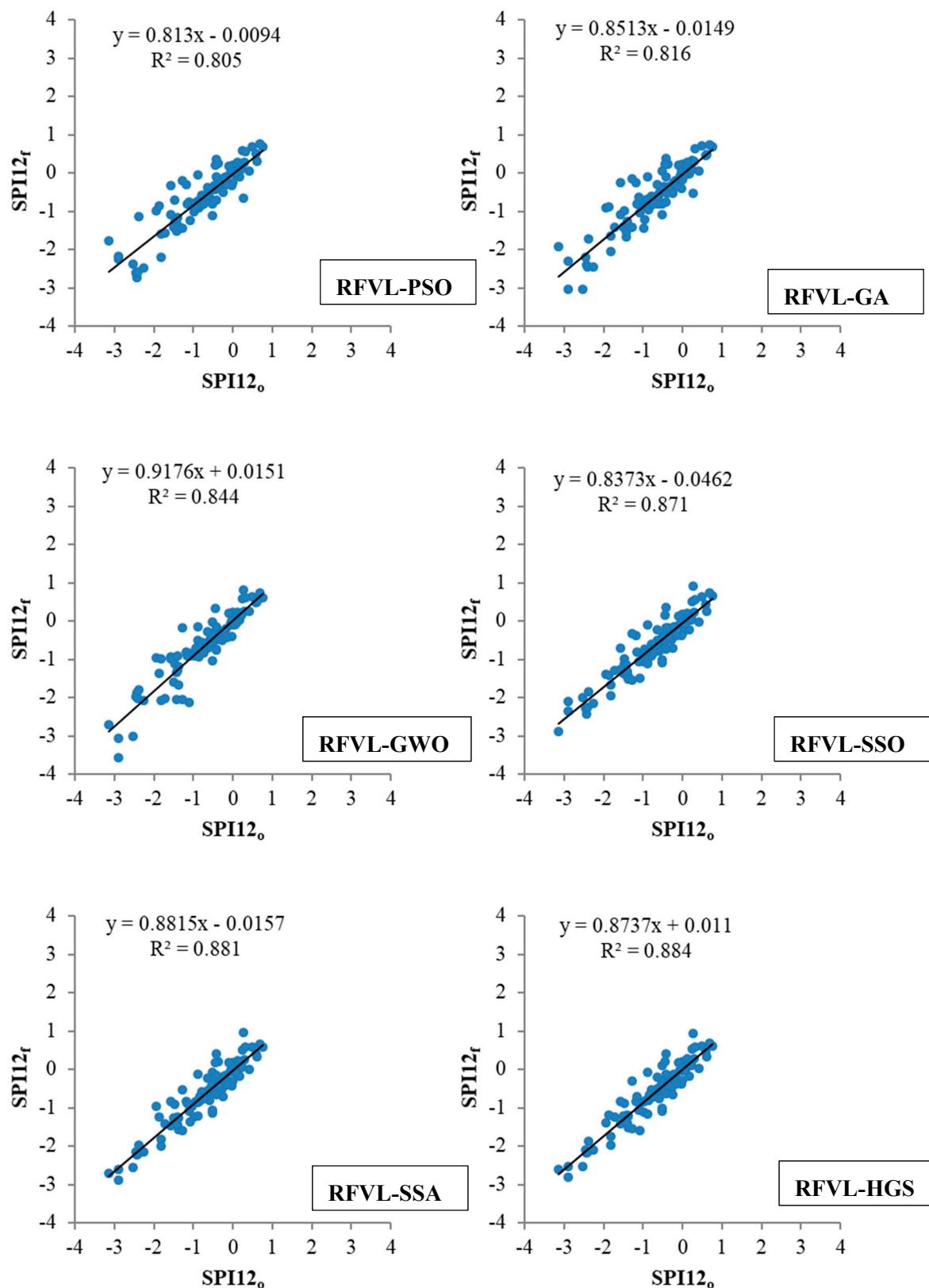
Figure S3. Scatterplots of the observed and predicted SPI12 drought index by different RFVL based models in the test period –Station 2
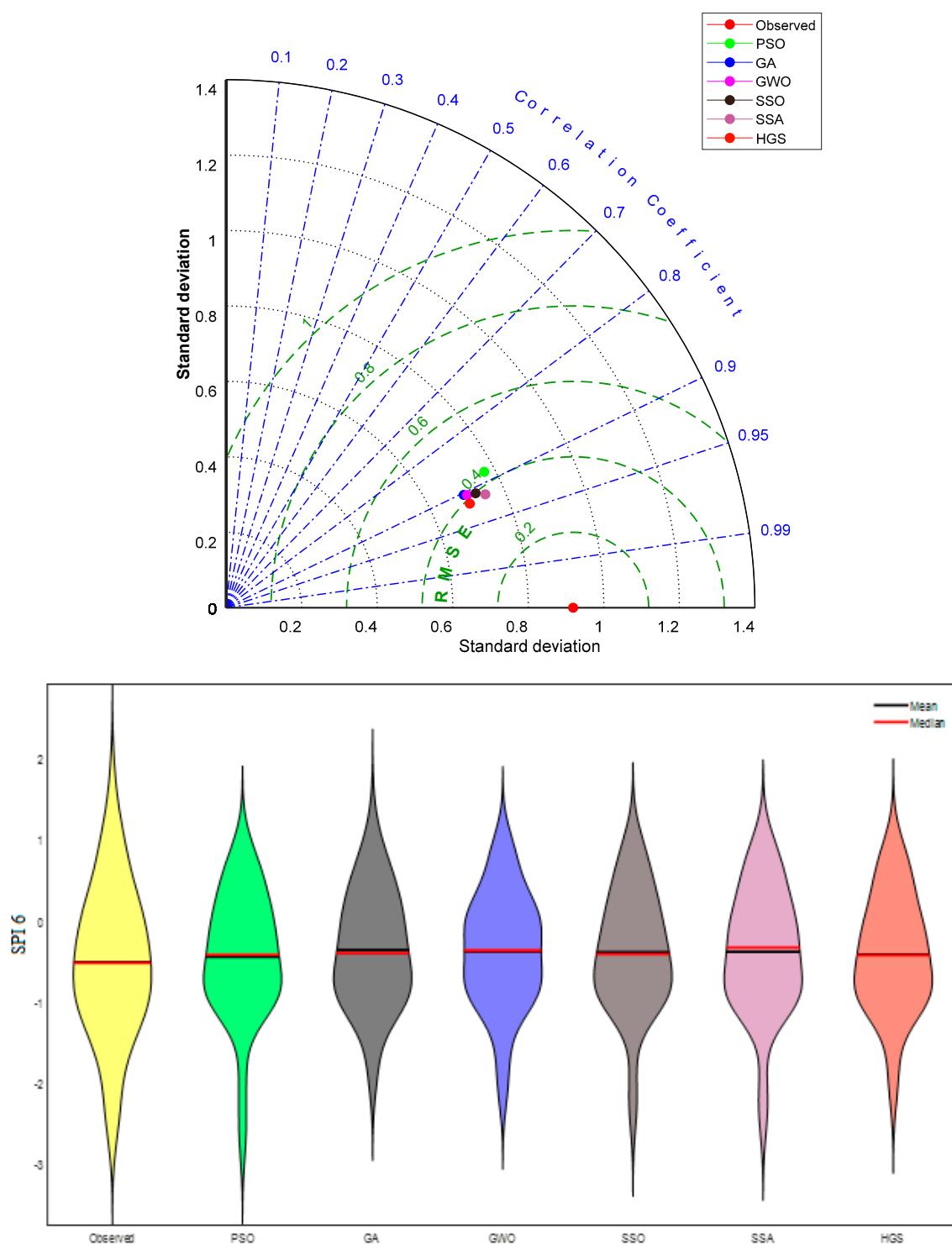
Figure S4. Taylor and Violin diagrams of SPI6 drought index by different RFVL based models in the test period –Station 2
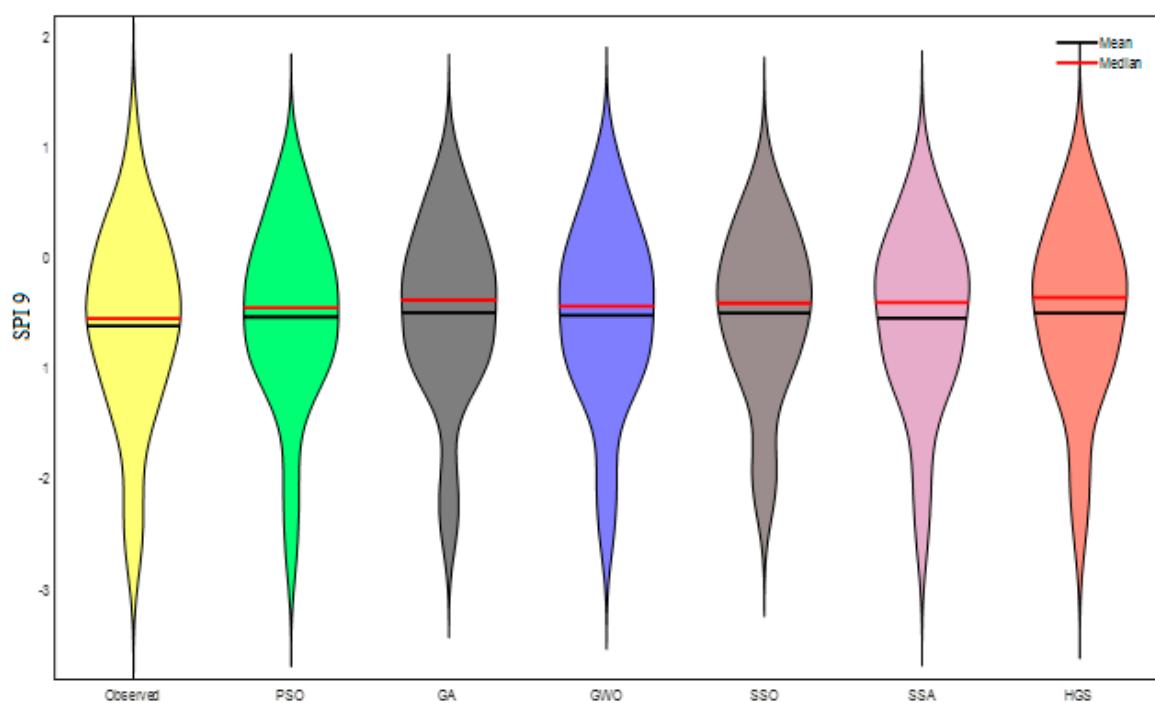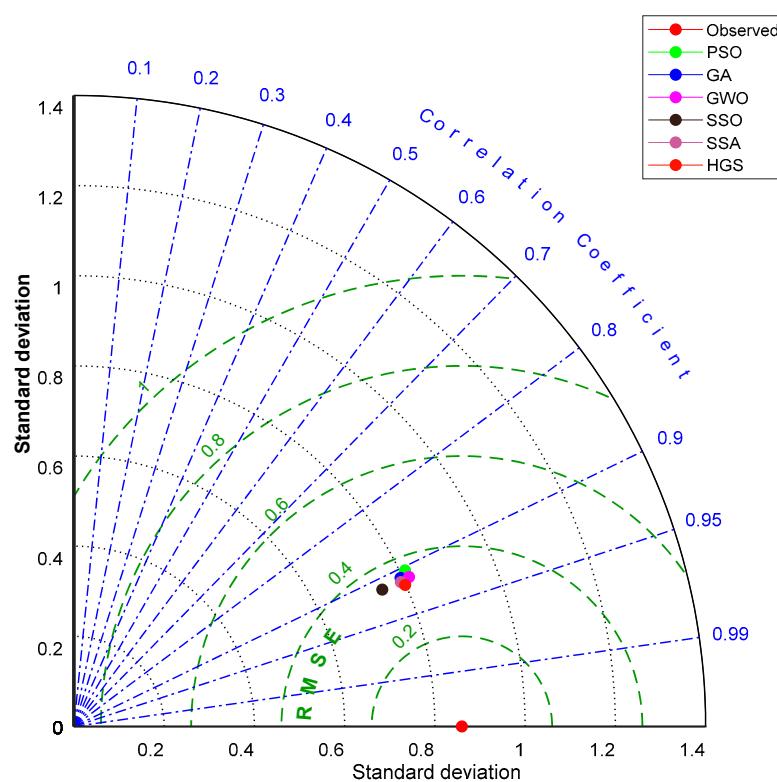
Figure S5. Taylor and Violin diagrams of SPI9 drought index by different RFVL based models in the test period –Station 2
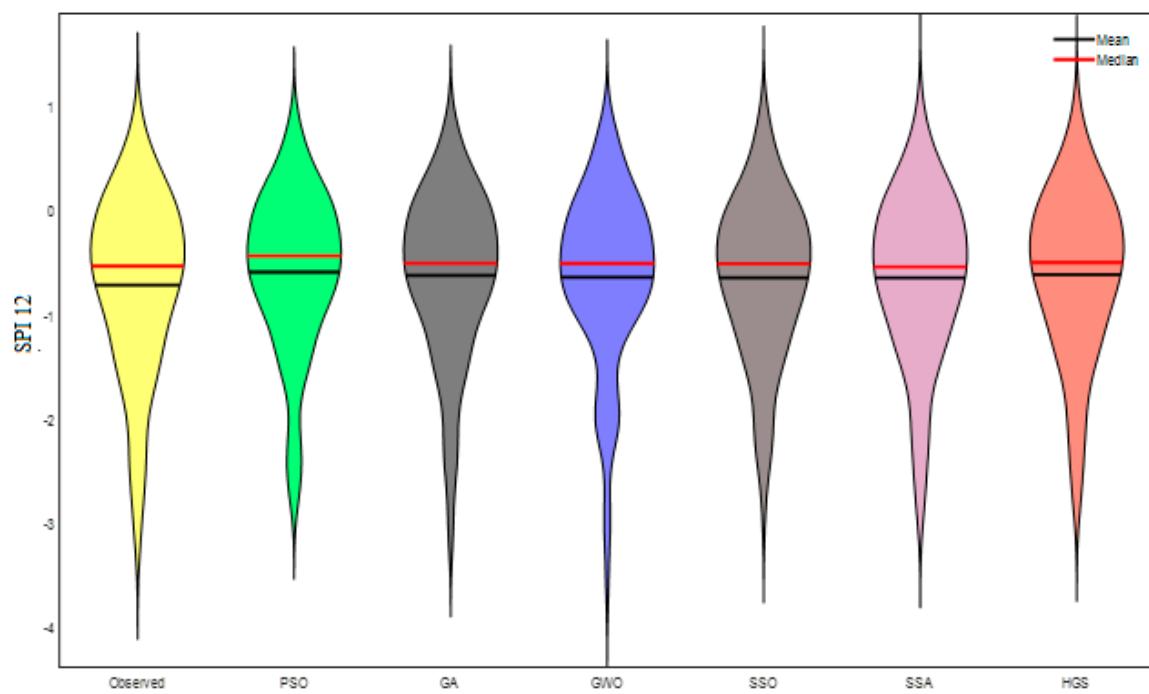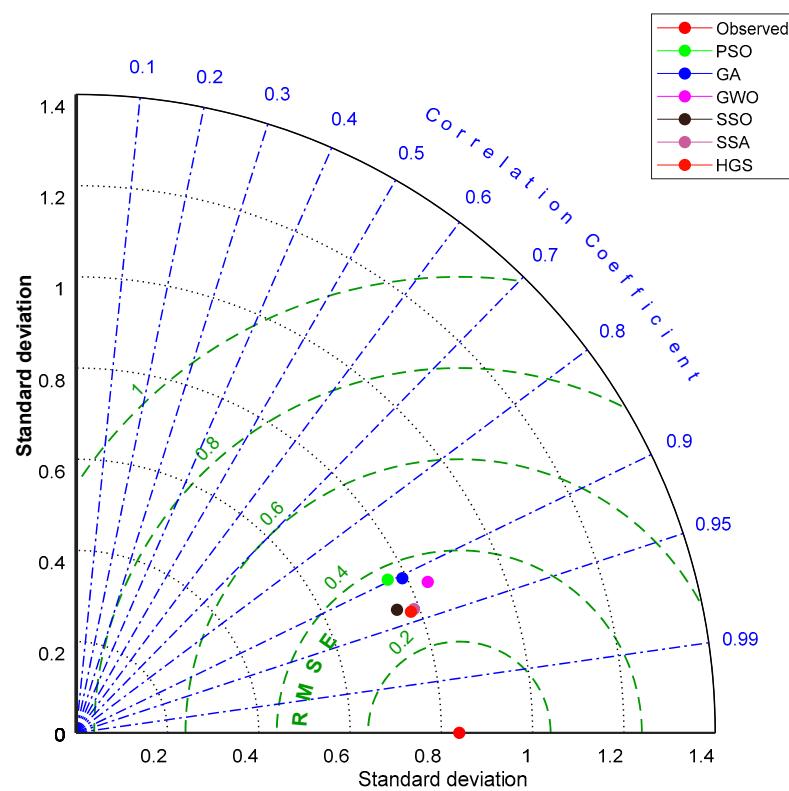
Figure S6. Taylor and Violin diagrams of SPI12 drought index by different RFVL based models in the test period –Station 2