Supplementary Materials

5.1 Traditional benchmark functions

The convergence curves obtained by all algorithms are displayed in Fig. S1, where it shows the best performance of the suggested HGTO-BWO algorithm compared to the others. Moreover, Fig. S2 shows the boxplots of experimental and traditional benchmark functions, it shows the distribution of the data obtained during the trail runs, the lower and upper boundaries represent the largest and lowest values obtained by the considered approaches.

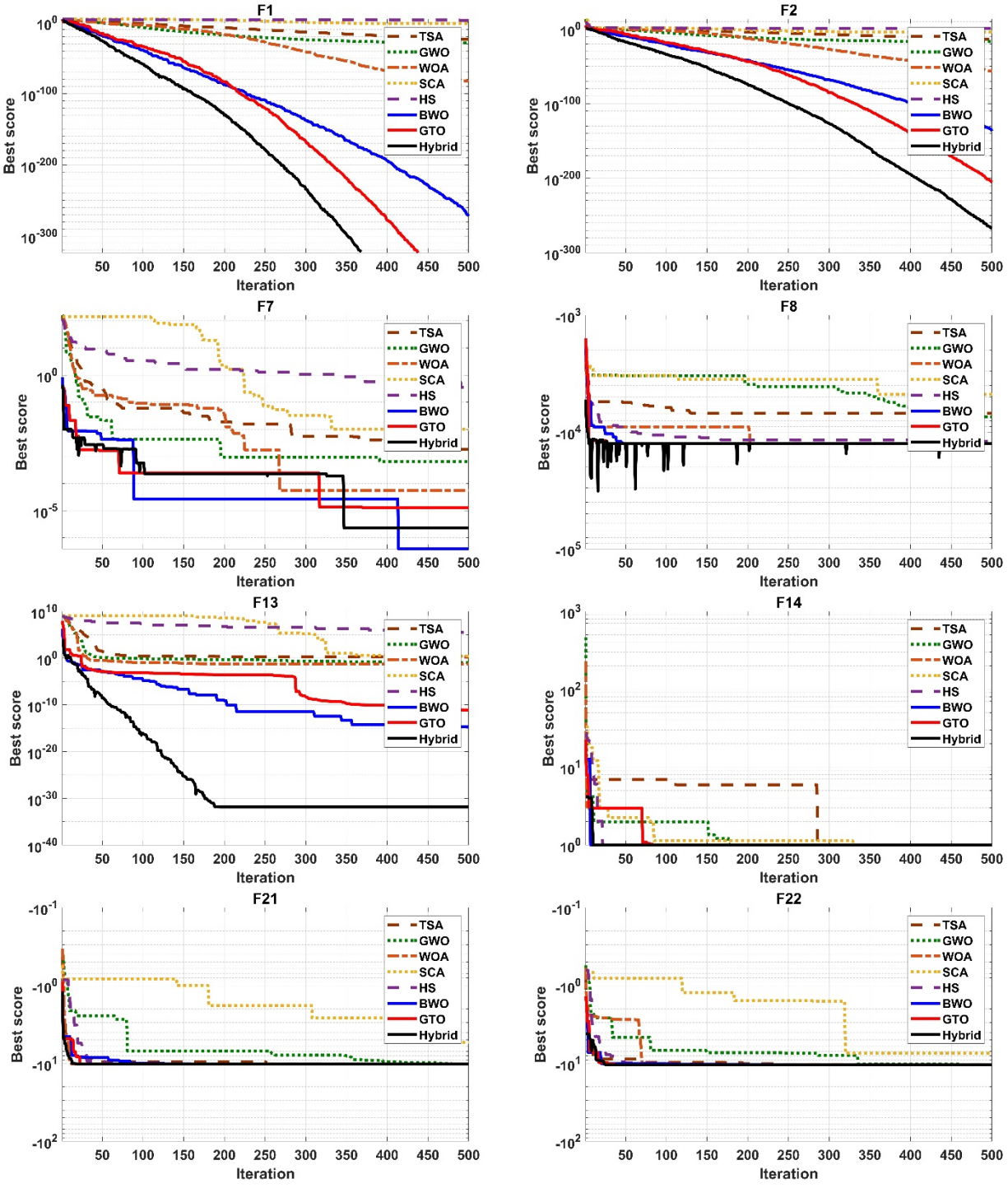


Figure S1. The convergence curves of some traditional benchmark functions achieved by the proposed hybrid approach and others.

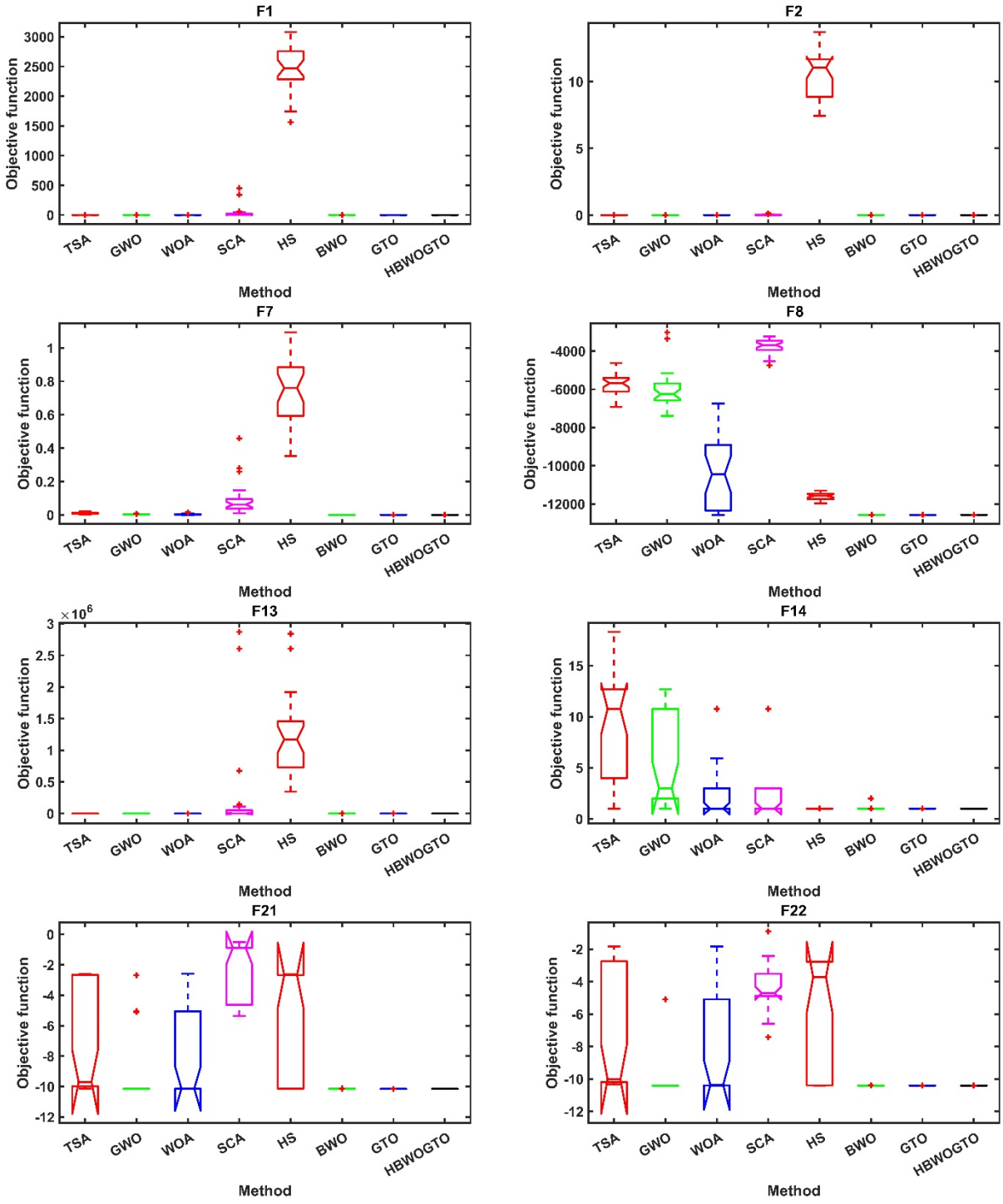


Figure S2. The boxplots curves of some traditional benchmark functions obtained via the proposed hybrid approach and others.

5.2 CEC-C06 2019 benchmark functions

Fig. S3 displays the convergence plots which have been obtained from all algorithms. Furthermore, Fig. S4 introduces the boxplots of optimizers during solving the CEC-C06 2019 benchmark function, the curves show the propagation and deviation of the data obtained during the considered number of runs.

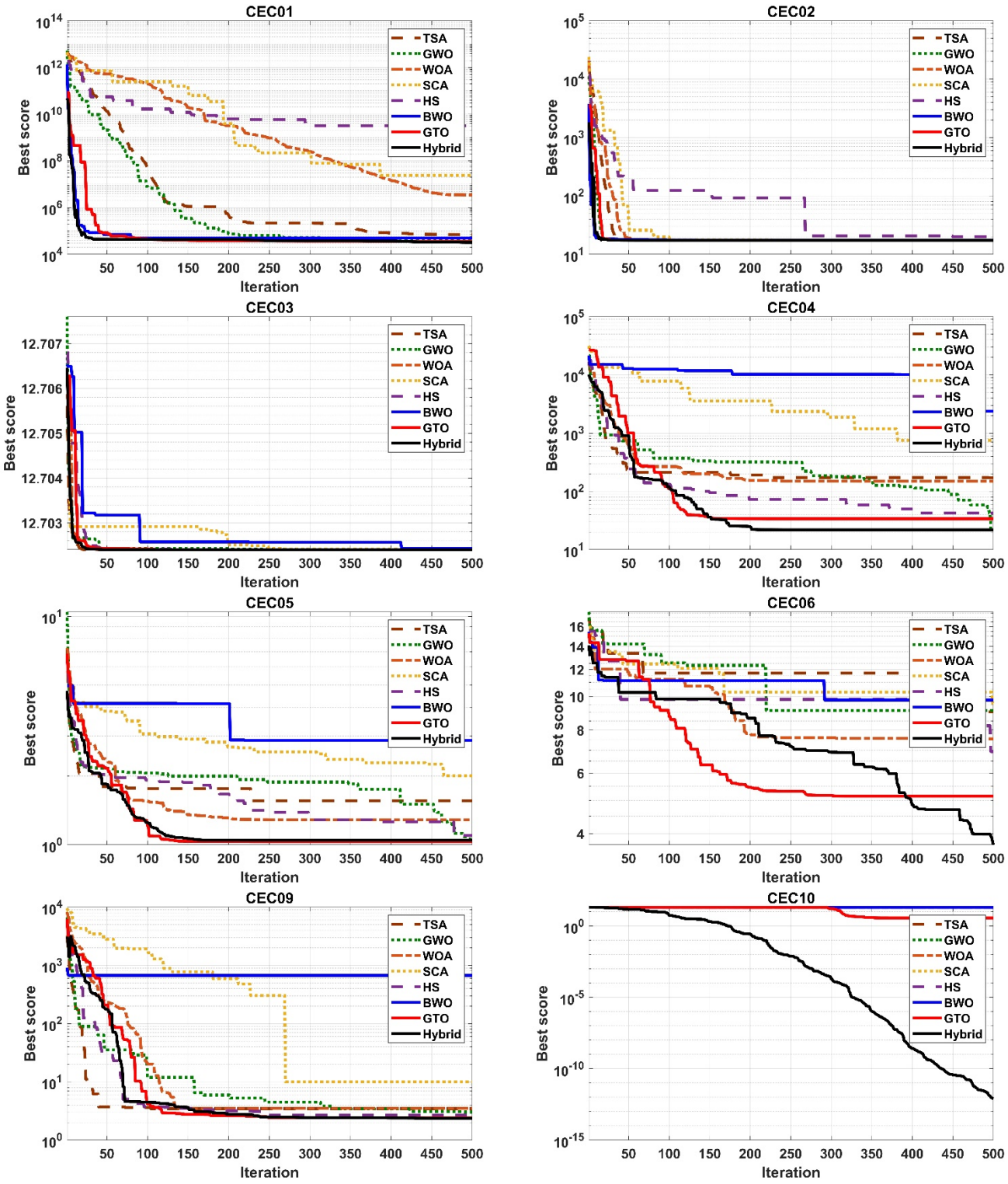


Figure S3. The convergence of some CEC- 2019 functions achieved by the proposed hybrid method and others.

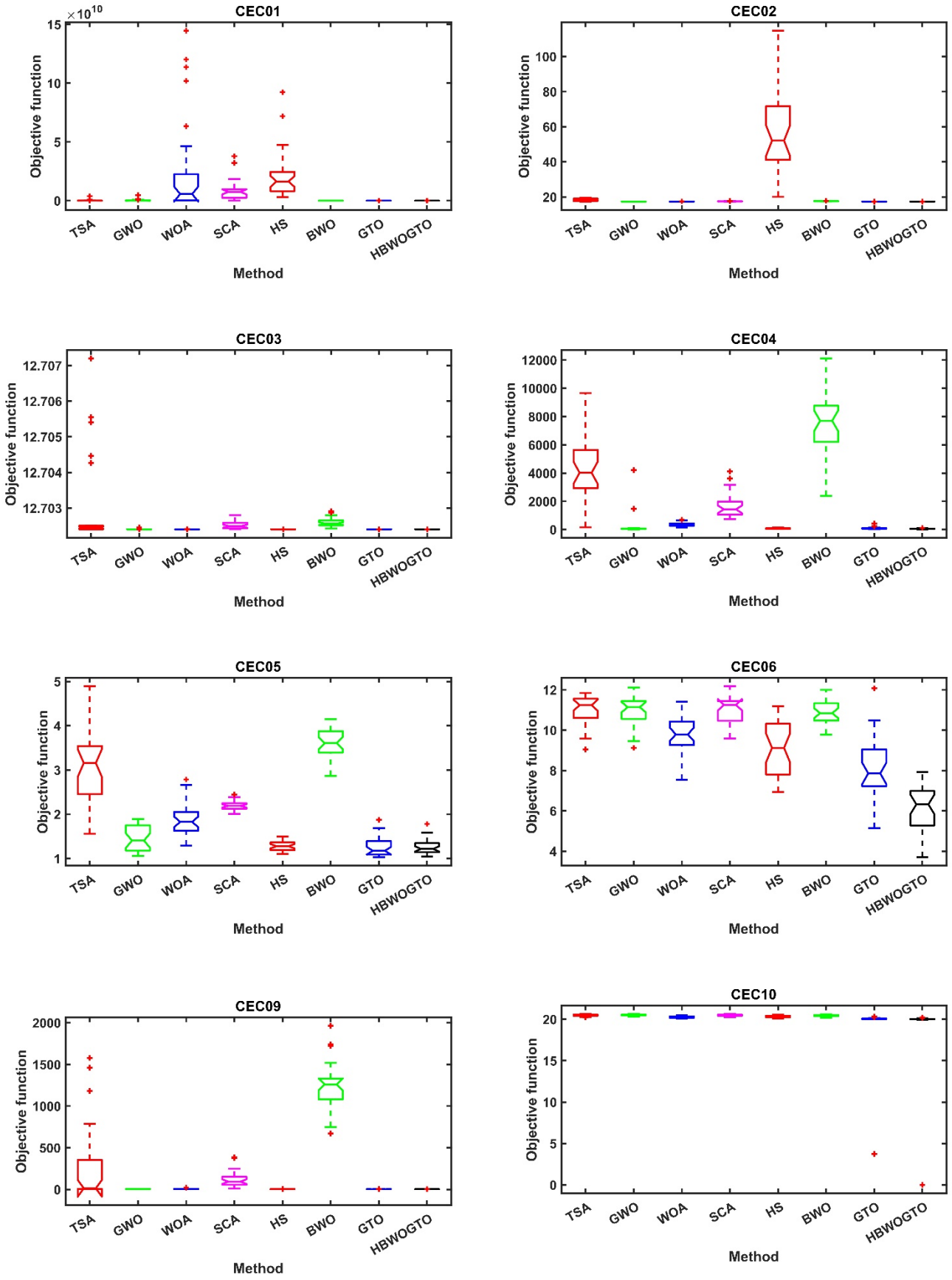
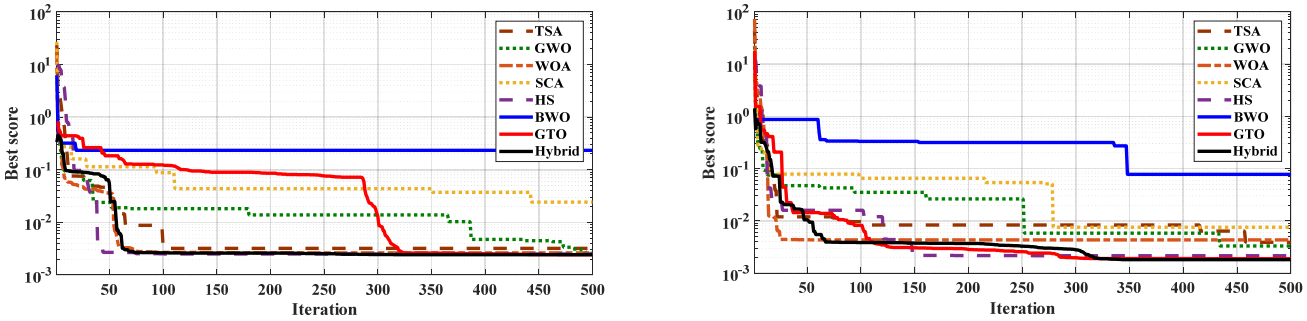


Figure S4. The boxplots curves of some CEC-2019 functions obtained via the proposed hybrid approach and others.

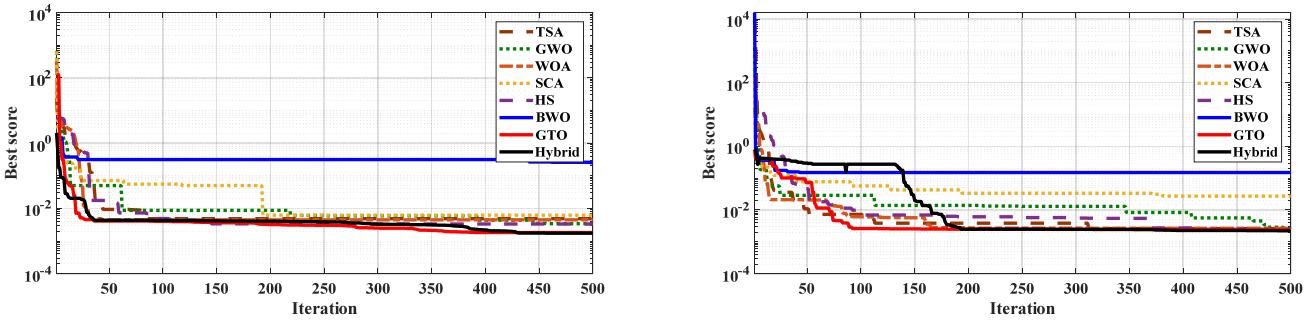
6.1.2. PV panel

Fig. S5 displays the variation of fitness value through the iterative process for DDM constructed via the proposed approach and others. Also, Fig. 6 depicts the RMSE performance achieved through the iterative process for TDM.



(a) (b)

Figure S5. Performance of RMSE through iteration process for DDM (a) PWP-201 and (b) STM6-40/36.



(a) (b)

Figure S6. RMSE with numeral of iteration for TDM (a) STM6-40/36 panels and (b) PWP-201.