Supplementary Materials of the Paper Titled "SleepBoost: A Multi-level Tree-based Ensemble Model for Automatic Sleep Stage Classification."

Table S1: Few of the Time Domain Features with Computational Equations

Symbol	Feature	Computational Equation
T1	Mean	$X_{mean} = \overline{X(n)} = \frac{1}{N}\sum_{n=1}^{N} X(n)$
T2	Standard Deviation	$S^2 = \frac{1}{N}\sum_{n=1}^{N} X(n)^2$
T10	Maximum-Minimum Distance (MMD)	$MMD = \sum_{n=1}^{N} \lvert \Delta {x_k}^2 - \Delta {y_k}^2 \rvert$
T11	Skewness	$Skewness = \frac{1}{Ns^3}\sum_{n=1}^{N} X(n)^3$
T12	Kurtosis	$Kurtosis = \frac{1}{Ns^4}\sum_{n=1}^{N} X(n)^4 - 3$
T13	Hjorth Mobility (HM)	$HM = \sigma_{x'} / \sigma_x$
T14	Hjorth Complexity (HC)	$HC = (\sigma_{x''} / \sigma_{x'}) / (\sigma_{x'} / \sigma_x)$

Table S2: Direct Frequency Domain Feature Symbols with Computational Method

Symbol	Band Range	Band Power Equation
E1	Total Band Power	$\sum_{i=2}^{9} E_i$
E2	Delta-Low (low − δ)	$\sum_{n=1}^{N_{FE}} \left(\frac{F_{low-\delta}(n)}{N_{FFT}}\right)^2$
E3	Delta-High (high − δ)	$\sum_{n=1}^{N_{FE}} \left(\frac{F_{high-\delta}(n)}{N_{FFT}}\right)^2$
E4	Theta (θ)	$\sum_{n=1}^{N_{FE}} \left(\frac{F_{\theta}(n)}{N_{FFT}}\right)^2$

E5	Alpha (α)	$\sum_{n=1}^{N_{FE}} \left(\frac{F_{\alpha}(n)}{N_{FFT}}\right)^2$
E6	Beta-Low ($low-\beta$)	$\sum_{n=1}^{N_{FE}} \left(\frac{F_{low-\beta}(n)}{N_{FFT}}\right)^2$
E7	Beta-High ($high-\beta$)	$\sum_{n=1}^{N_{FE}} \left(\frac{F_{high-\beta}(n)}{N_{FFT}}\right)^2$
E8	Gamma-Low ($low-\gamma$)	$\sum_{n=1}^{N_{FE}} \left(\frac{F_{low-\gamma}(n)}{N_{FFT}}\right)^2$

Table S3: Derived Frequency Domain Feature Symbols with Computational Method

Symbol	Computational Method	Symbol	Computational Method
D1	E2/E1	D11	E3 / (E4 + E5)
D2	E3/E1	D12	E4 / (E3 + E5)
D3	E4/E1	D13	E5 / (E3 + E4)
D4	E5/E1	D14	E2 / (E3 + E8)
D5	(E6+E7)/E1	D15	E5 / E8
D6	E8/E1	D16	(E6 + E7) / E8
D7	(E4+E5)/E1	D17	E5 / E4
D8	E5 / (E6 + E7)	D18	(E2 + E3) / E4
D9	(E4 + E5)/ (E5 + E6 + E7)	D19	(E2 + E6) /E8
D10	E4 / (E6 + E7)		

Table S4: Mutual Information score of the Extracted Features. The selected features (MI>0.23) are the outcome of FEB.

Feature	Score	Feature	Score
T1	0.042485	**E8**	**0.419602**
T2	**0.347657**	D1	0.199302
T3	**0.353386**	D2	0.149341
T4	**0.284747**	**D3**	**0.287843**
T5	**0.299136**	**D4**	**0.236044**
T6	0.025880	**D5**	**0.275494**
T7	0.027754	**D6**	**0.425125**
T8	**0.347627**	**D7**	**0.293913**
T9	0.156388	D8	0.178499
T10	**0.252733**	D9	0.145969
T11	0.092827	D10	0.176975
T12	0.182327	**D11**	**0.265373**
T13	**0.259253**	**D12**	**0.259368**
T14	0.215531	D13	0.195384
E1	**0.285492**	D14	0.185443
E2	**0.258157**	**D15**	**0.236044**
E3	0.131009	**D16**	**0.275495**
E4	**0.286056**	D17	0.104727

E5	0.218092	**D18**	**0.292402**
E6	**0.245486**	D19	0.201943
E7	**0.438057**		

Algorithm S1: Reward-Based Adaptive Weight Allocation

```
Input: M = {Prediction of RF (P), LGBoost (Q) and CatBoost (R) on Validation
Data (X_V)}
Output: W = {W_RF, W_LGBoost and W_CatBoost}
--------------------------------------------------------------------------
W = [0.0] * 3
for i in M:
   δ= 0
   flag ← {f_p, f_q, f_r }
   if (P[i] equals Y_V[i]) then
      δ += 1
      f_p  ← 1
   if (Q[i] equals Y_V[i]) then
      δ += 1
      f_q ← 1
   if R[i] equals Y_V[i]) then
      δ += 1
      f_r ←  1
   if (0 less than δ less than equals 3):
      if (δ equals 2):
         for k in range(len(flag)):
            if (flag [k] == 1):
               W [k] += 0.33
            else:
               W [k] -=(0.67/3)
      if (δ equals 1):
         for k in range(len(flag)):
            if (flag [k] == 1):
               W [k] += 0.67
      else:
               W [k]-=(0.33/3)

W_RF = W [0]/ ∑W
W_LGBoost = W [1]/ ∑W
W_CatBoost W [2]/ ∑W

return W_RF, W_LGBoost and W_CatBoost
```

Table S5: Selected Features with different Threshold (0.1, 0.2, 0.3 and 0.23 shown with the selected features highlighted in green)

0.2251 (0.23)	**0.1**	**0.2**	**0.3**
T1 0.042915	T1 0.042915	T1 0.042915	T1 0.042915
T2 0.347539	T2 0.347539	T2 0.347539	T2 0.347539
T3 0.353566	T3 0.353566	T3 0.353566	T3 0.353566
T4 0.286584	T4 0.286584	T4 0.286584	T4 0.286584
T5 0.299050	T5 0.299050	T5 0.299050	T5 0.299050
T6 0.026612	T6 0.026612	T6 0.026612	T6 0.026612
T7 0.025196	T7 0.025196	T7 0.025196	T7 0.025196
T8 0.348570	T8 0.348570	T8 0.348570	T8 0.348570
T9 0.157253	T9 0.157253	T9 0.157253	T9 0.157253
T10 0.252697	T10 0.252697	T10 0.252697	T10 0.252697
T11 0.092827	T11 0.092827	T11 0.092827	T11 0.092827
T12 0.182327	T12 0.182327	T12 0.182327	T12 0.182327
T13 0.259253	T13 0.259253	T13 0.259253	T13 0.259253
T14 0.215531	T14 0.215531	T14 0.215531	T14 0.215531
E2 0.258157	E2 0.258157	E2 0.258157	E2 0.258157
E3 0.131009	E3 0.131009	E3 0.131009	E3 0.131009
E4 0.286055	E4 0.286055	E4 0.286055	E4 0.286055
E5 0.218089	E5 0.218089	E5 0.218089	E5 0.218089
E6 0.245516	E6 0.245516	E6 0.245516	E6 0.245516
E7 0.437998	E7 0.437998	E7 0.437998	E7 0.437998
E8 0.419738	E8 0.419738	E8 0.419738	E8 0.419738
E1 0.285492	E1 0.285492	E1 0.285492	E1 0.285492
D1 0.199297	D1 0.199297	D1 0.199297	D1 0.199297
D2 0.149341	D2 0.149341	D2 0.149341	D2 0.149341
D3 0.287843	D3 0.287843	D3 0.287843	D3 0.287843
D4 0.236044	D4 0.236044	D4 0.236044	D4 0.236044
D5 0.275495	D5 0.275495	D5 0.275495	D5 0.275495
D6 0.425099	D6 0.425099	D6 0.425099	D6 0.425099
D7 0.293913	D7 0.293913	D7 0.293913	D7 0.293913
D8 0.178499	D8 0.178499	D8 0.178499	D8 0.178499
D9 0.145968	D9 0.145968	D9 0.145968	D9 0.145968
D10 0.176971	D10 0.176971	D10 0.176971	D10 0.176971
D11 0.265373	D11 0.265373	D11 0.265373	D11 0.265373
D12 0.259368	D12 0.259368	D12 0.259368	D12 0.259368
D13 0.195384	D13 0.195384	D13 0.195384	D13 0.195384
D14 0.185447	D14 0.185447	D14 0.185447	D14 0.185447
D15 0.236044	D15 0.236044	D15 0.236044	D15 0.236044
D16 0.275495	D16 0.275495	D16 0.275495	D16 0.275495
D17 0.104727	D17 0.104727	D17 0.104727	D17 0.104727
D18 0.292402	D18 0.292402	D18 0.292402	D18 0.292402
D19 0.201943	D19 0.201943	D19 0.201943	D19 0.201943

Table S6: Performance of M4 (Selected features with adaptive weight allocation during ensemble) using different set of global MI threshold score.

Threshold Value	Accuracy	F1-Score	K
0.1	85.41	79.56	0.794
0.2	85.93	80.38	0.809
0.3	73.28	68.91	0.723
0.23	**86.30**	**80.90**	**0.81**

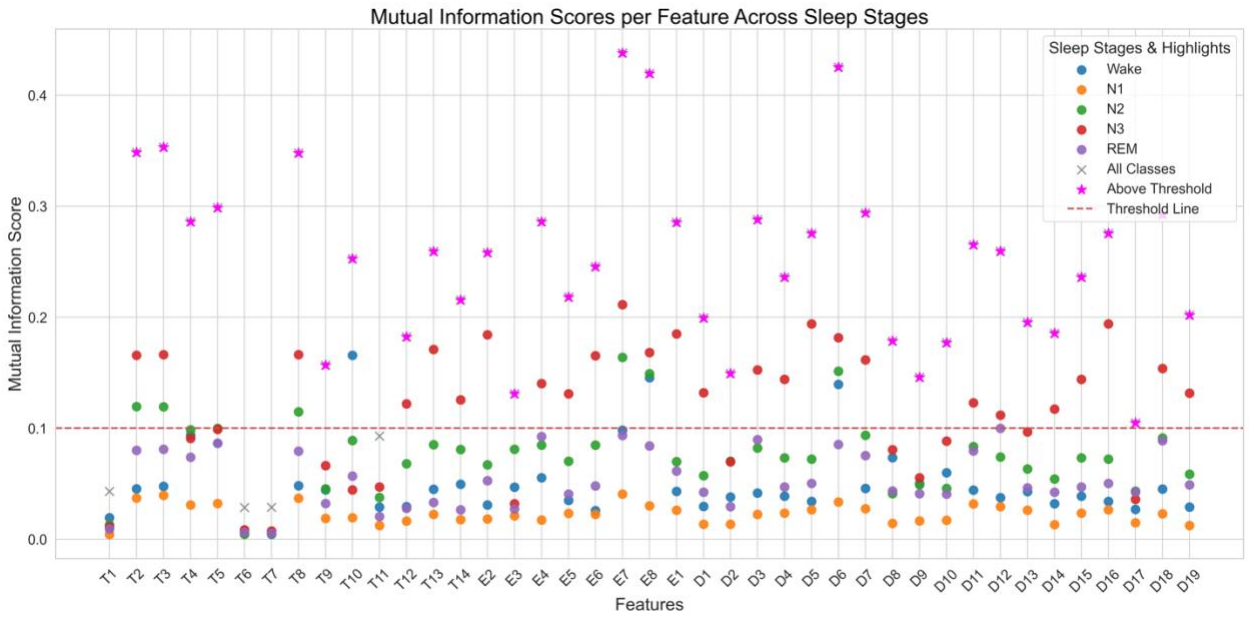

Figure S1(a): [**Threshold Value 0.1]** Comparison of feature importance when considering a single class, termed as Local MI Score (LMIS), versus when considering all classes, termed as Global MI Score (GMIS).

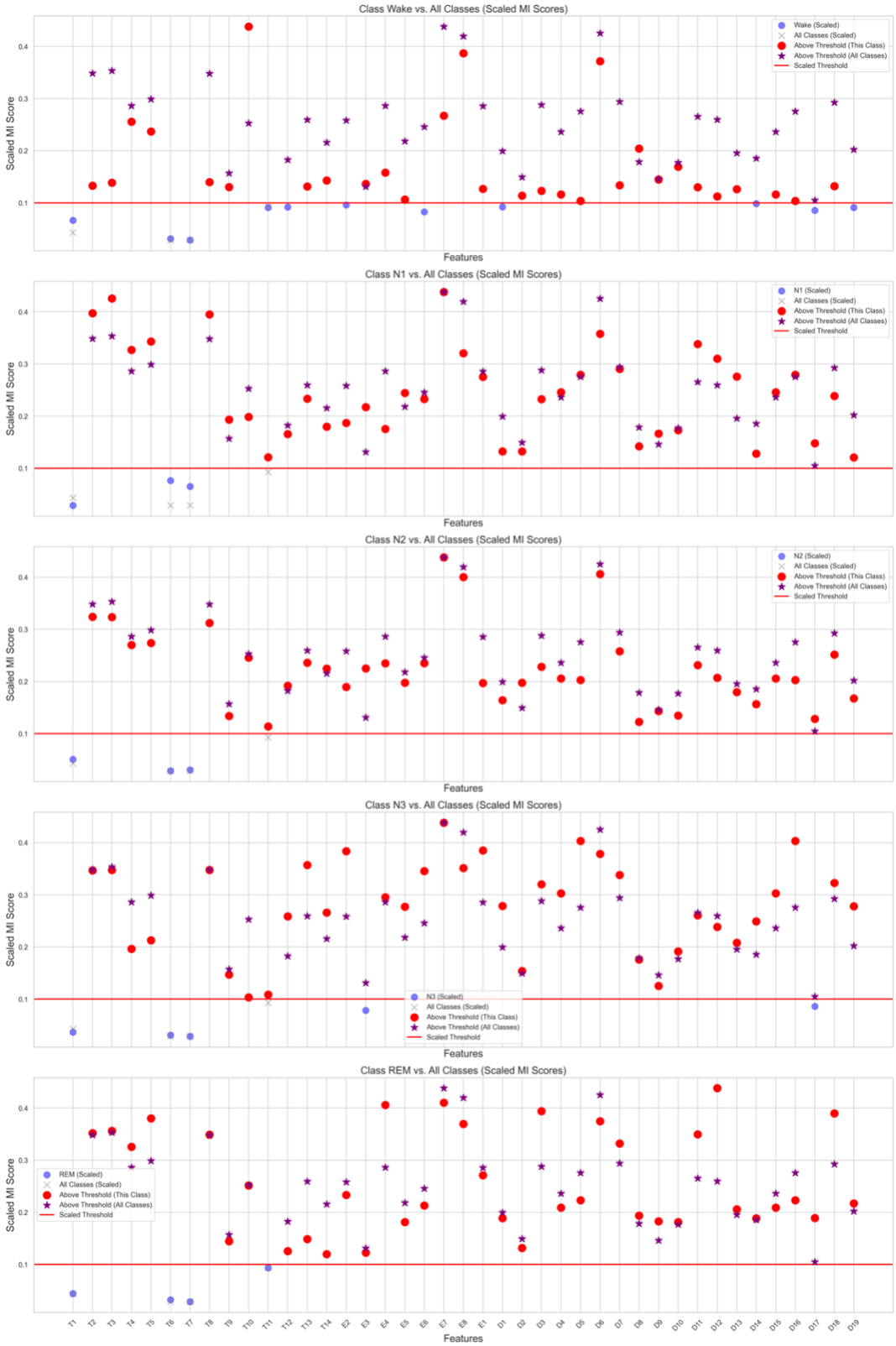

Figure S1(b): [**Threshold Value 0.1]** Comparison of feature importance when considering a single class, termed as Local MI Score (LMIS), versus when considering all classes, termed as Global MI Score (GMIS).

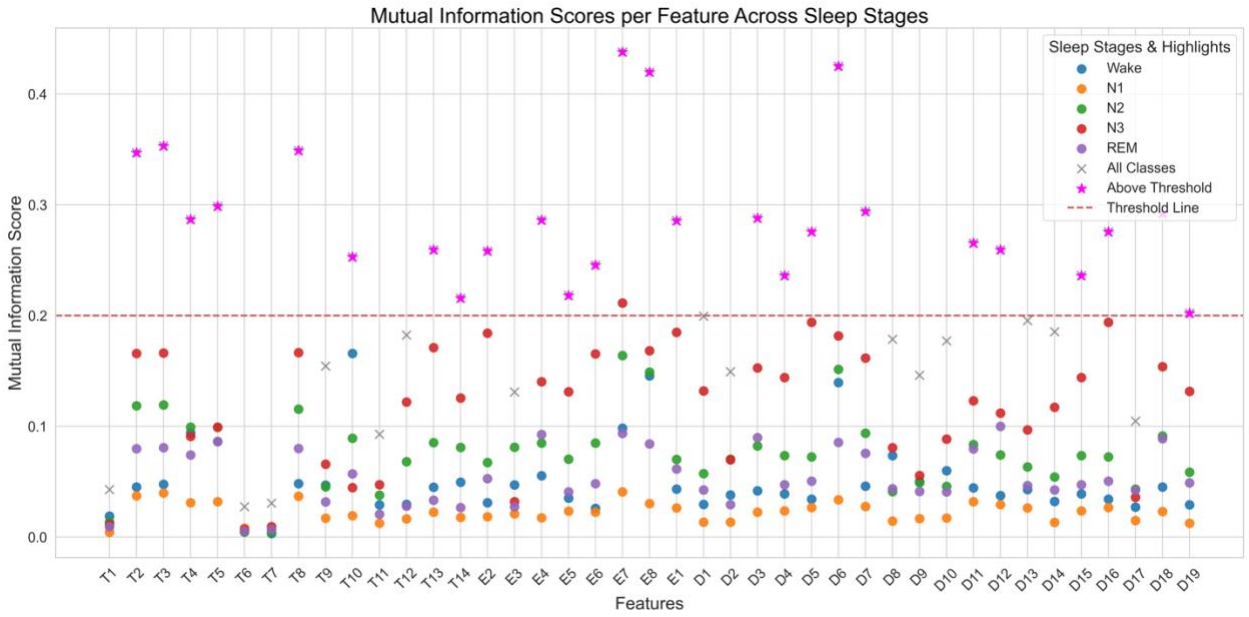

Figure S1(c): [**Threshold Value 0.2]** Comparison of feature importance when considering a single class, termed as Local MI Score (LMIS), versus when considering all classes, termed as Global MI Score (GMIS).

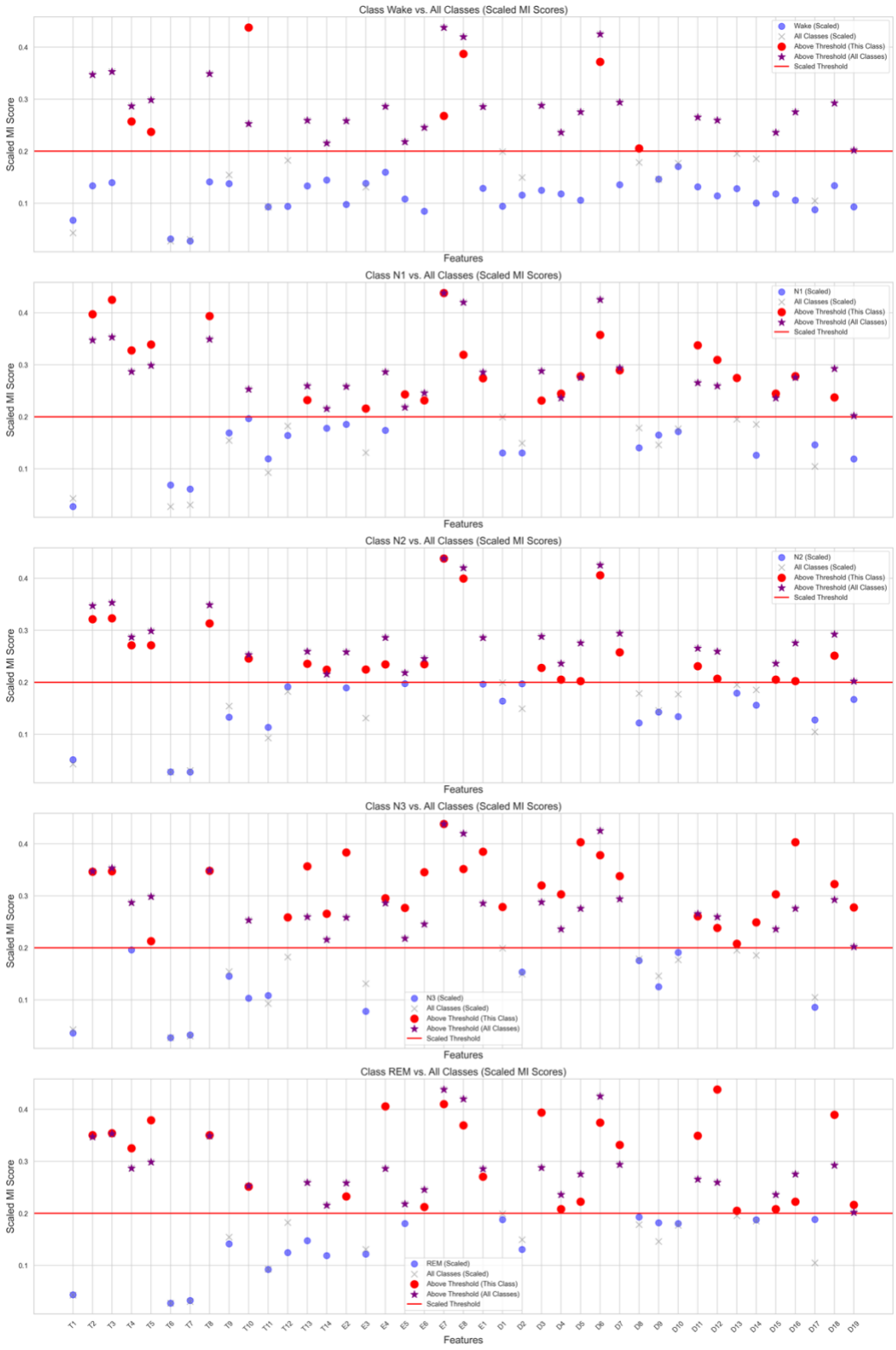

Figure S1(d): [**Threshold Value 0.2]** Comparison of feature importance when considering a single class, termed as Local MI Score (LMIS), versus when considering all classes, termed as Global MI Score (GMIS).

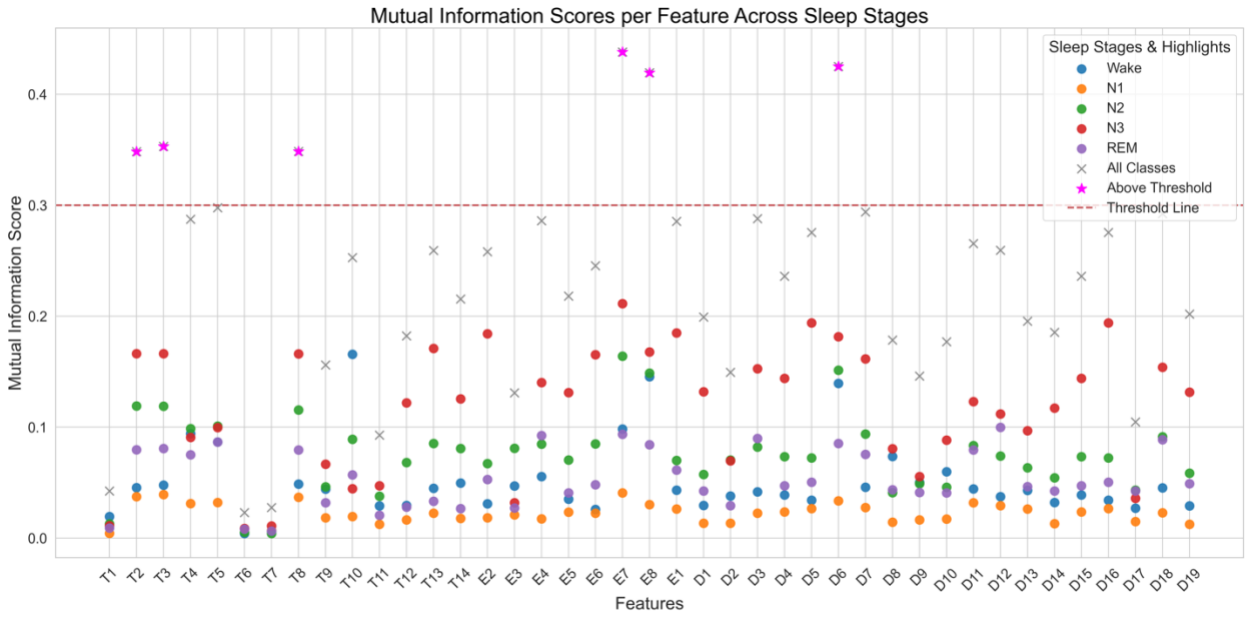

Figure S1(e): [**Threshold Value 0.3]** Comparison of feature importance when considering a single class, termed as Local MI Score (LMIS), versus when considering all classes, termed as Global MI Score (GMIS).

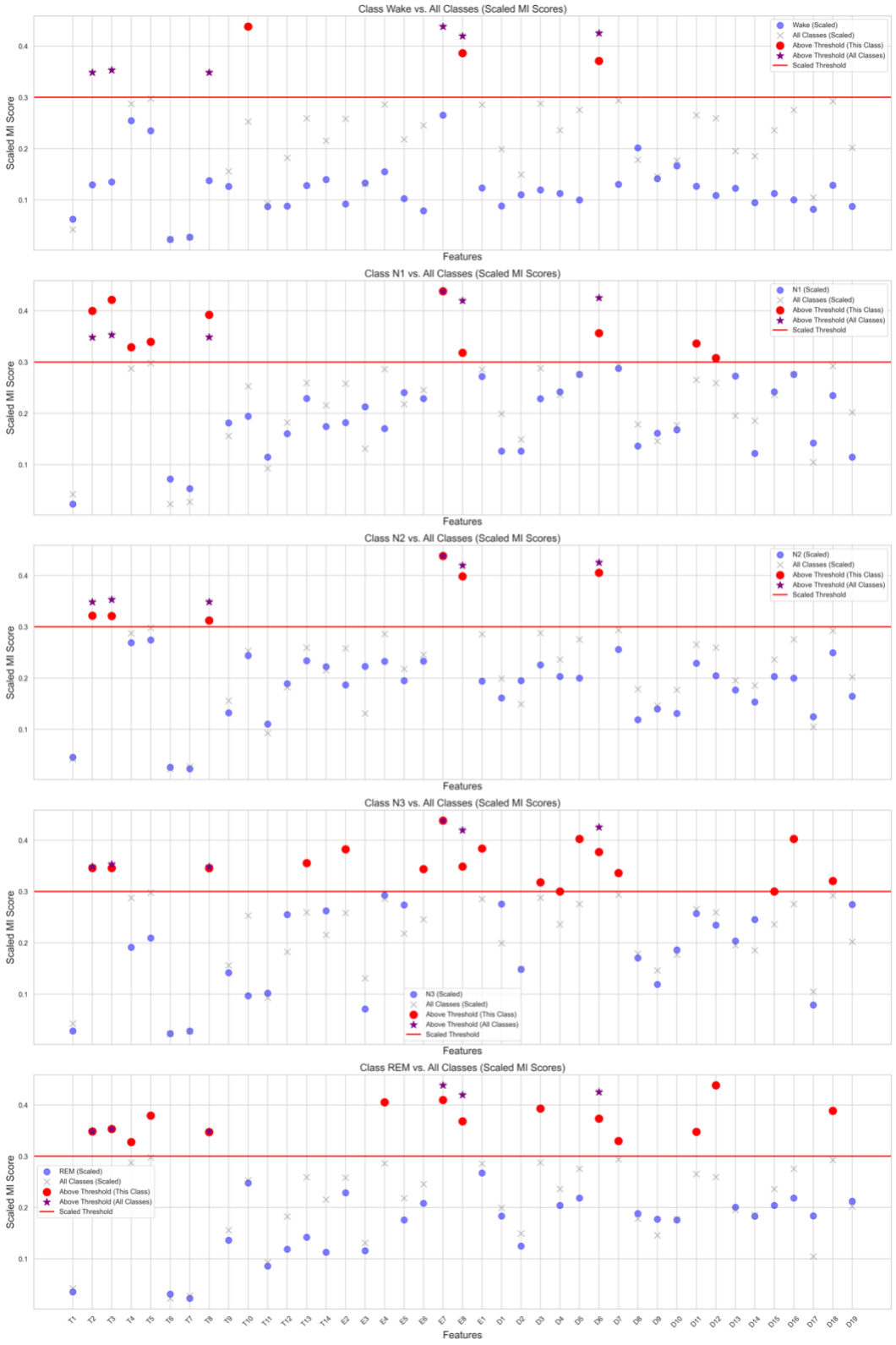

Figure S1(f): [**Threshold Value 0.3]** Comparison of feature importance when considering a single class, termed as Local MI Score (LMIS), versus when considering all classes, termed as Global MI Score (GMIS).