**Table** 1 Candidate triggering factors and their decomposition parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Candidate triggeringfactors | Decomposition parameter | Decompositionor not | Reordered number of adaptively decomposed factors |
|  |  |
|  | 1 | - | No |  |
|  | 1 | - | No |  |
|  | 5 | 513.7014 | Yes | 、、、、 |
|  | 4 | 439.1801 | Yes | 、、、 |
|  | 4 | 553.0224 | Yes | 、、、 |
|  | 4 | 518.4594 | Yes | 、、、 |
|  | 1 | - | No |  |
|  | 1 | - | No |  |
|  | 2 | 1054.4428 | Yes | 、 |
|  | 1 | - | No |  |
|  | 4 | 80.5204 | Yes | 、、、 |
|  | 1 | - | No |  |
|  | 1 | - | No |  |
|  | 5 | 1.1915 | Yes | 、、、、 |
|  | 1 | - | No |  |
|  | 4 | 12.9752 | Yes | 、、、 |
|  | 3 | 1.2945 | Yes | 、、 |
|  | 3 | 1.3186 | Yes | 、、 |
|  | 3 | 1.2945 | Yes | 、、 |
|  | 1 | - | No |  |
|  | 1 | - | No |  |
|  | 1 | - | No |  |

Note: When , the candidate triggering factor is not decomposed based on the OVMD method.

**Table 2** Performance comparison of the prediction models for the cumulative displacements

|  |  |  |  |
| --- | --- | --- | --- |
| Monitoring site | Model | Evaluation index | Total number ofinput factors |
| *RMSE* | *R2* | *MAPE* | *AIC* |
| Training set | Testing set | Training set | Testing set | Training set | Testing set | Training set | Testing set |
| ZG93 | ① | 17.4751 | 16.3650 | 0.9993 | 0.9954 | 3.25E-06 | 6.4971E-05 | 64.7607 | 64.6049 | 29.52 |
| ② | 38.6489 | 40.2726 | 0.9965 | 0.9784 | 1.30E-05 | 2.7789E-04 | 139.3090 | 139.3913 | 66 |
| (-0.5804) | (-0.6554) | (-7.68E-05) | (-4.66E-04) | (-2.68E-07) | (-5.84E-06) | (-2.0435) | (-2.0501) |
| ③ | 39.2250 | 27.9394 | 0.9964 | 0.9816 | 3.85E-06 | 3.7987E-05 | 83.3385 | 82.6601 | 38 |
| (-2.5648) | (-1.3649) | (-3.42E-04) | (-1.63E-03) | (-7.02E-08) | (+3.18E-06) | (-2.1908) | (-2.1292) |
| ④ | 14.5159 | 34.3427 | 0.9995 | 0.9879 | 1.25E-06 | 2.3064E-04 | 317.3505 | 319.0728 | 156 |
| (+0.0190) | (-0.1152) | (+1.28E-06) | (-4.81E-05) | (+1.28E-08) | (-1.06E-06) | (-1.6192) | (-1.6312) |
| ⑤ | 16.0672 | 34.0923 | 0.9994 | 0.9872 | 1.76E-06 | 2.4165E-04 | 251.5536 | 253.0581 | 123 |
| (+0.0151) | (-0.1896) | (+1.07E-06) | (-8.77E-05) | (+1.59E-08) | (-1.89E-06) | (-1.9982) | (-2.0160) |
| ZG118 | ① | 16.6814 | 23.1888 | 0.9993 | 0.9974 | 5.94E-06 | 1.7911E-04 | 52.1402 | 52.6742 | 23.26 |
| ② | 33.8939 | 32.2191 | 0.9971 | 0.9835 | 7.54E-06 | 2.0235E-04 | 139.0465 | 138.9451 | 66 |
| (-0.4027) | (-0.2113) | (-5.15E-05) | (-3.25E-04) | (-3.73E-08) | (-5.44E-07) | (-2.0334) | (-2.0185) |
| ③ | 36.6687 | 24.9150 | 0.9966 | 0.986 | 5.01E-06 | 7.9450E-05 | 85.2038 | 84.4309 | 39 |
| (-1.2698) | (-0.1097) | (-1.72E-04) | (-7.24E-04) | (+5.93E-08) | (+6.33E-06) | (-2.1006) | (-2.0176) |
| ④ | 13.7103 | 46.0783 | 0.9995 | 0.9862 | 6.81E-07 | 3.4136E-04 | 317.236 | 319.6607 | 156 |
| (+0.0224) | (-0.1724) | (+1.51E-06) | (-8.44E-05) | (+3.96E-08) | (-1.22E-06) | (-1.9971) | (-2.0113) |
| ⑤ | 14.8868 | 23.7909 | 0.9994 | 0.9911 | 9.85E-07 | 1.0860E-04 | 263.4010 | 264.3386 | 129 |
| (+0.0170) | (-0.0057) | (+9.46E-07) | (-5.96E-05) | (+4.69E-08) | (+6.67E-07) | (-1.9979) | (-2.0017) |
| XD01 | ① | 25.6475 | 23.6041 | 0.9993 | 0.9965 | 2.41E-06 | 8.4140E-05 | 59.2778 | 59.0712 | 26.4 |
| ② | 49.0062 | 58.4528 | 0.9976 | 0.9806 | 1.39E-05 | 2.7140E-04 | 139.7839 | 140.1364 | 66 |
| (-0.5899) | (-0.8800) | (-4.29E-05) | (-4.02E-04) | (-2.91E-07) | (-4.73E-06) | (-2.0330) | (-2.0471) |
| ③ | 40.3796 | 57.8299 | 0.9967 | 0.9874 | 1.59E-05 | 1.1883E-04 | 86.1150 | 85.3967 | 39 |
| (-1.1692) | (-2.7163) | (-2.06E-04) | (-7.22E-04) | (-1.07E-06) | (-2.75E-06) | (-2.1299) | (-2.0893) |
| ④ | 14.4541 | 35.0616 | 0.9998 | 0.9920 | 7.55E-08 | 4.2518E-05 | 317.3420 | 319.1142 | 156 |
| (+0.0864) | (-0.0884) | (+3.86E-06) | (-3.47E-05) | (+1.80E-08) | (+3.21E-07) | (-1.9912) | (-2.0065) |
| ⑤ | 20.6926 | 30.0310 | 0.9996 | 0.9919 | 6.87E-07 | 1.1932E-05 | 266.0595 | 266.8045 | 130 |
| (+0.0478) | (-0.0620) | (+2.90E-06) | (-4.44E-05) | (+1.66E-08) | (+6.97E-07) | (-1.9960) | (-2.0051) |

Notes: ① denotes the proposed OVMD-GWO-KELM model based on optimized factors; ② denotes the VMD-GWO-KELM model based on candidate factors; ③ denotes the VMD-GWO-KELM model based on candidate factors that are optimized by the GRA method; ④ denotes the VMD-GWO-KELM model based on adaptively decomposed candidate factors; ⑤ denotes the VMD-GWO-KELM model based on adaptively decomposed candidate factors that are optimized by the GRA method. Taking the proposed model as the comparison target, the positive or negative values in brackets represent the improvement or decrease in the model performance indexes with each addition of an input factor, respectively.