JESSICA GATTA

Weather Prediction Analysis

KNN – DECISION TREE – ANN MODELS

Analysis conducted by: Jessica Gatta
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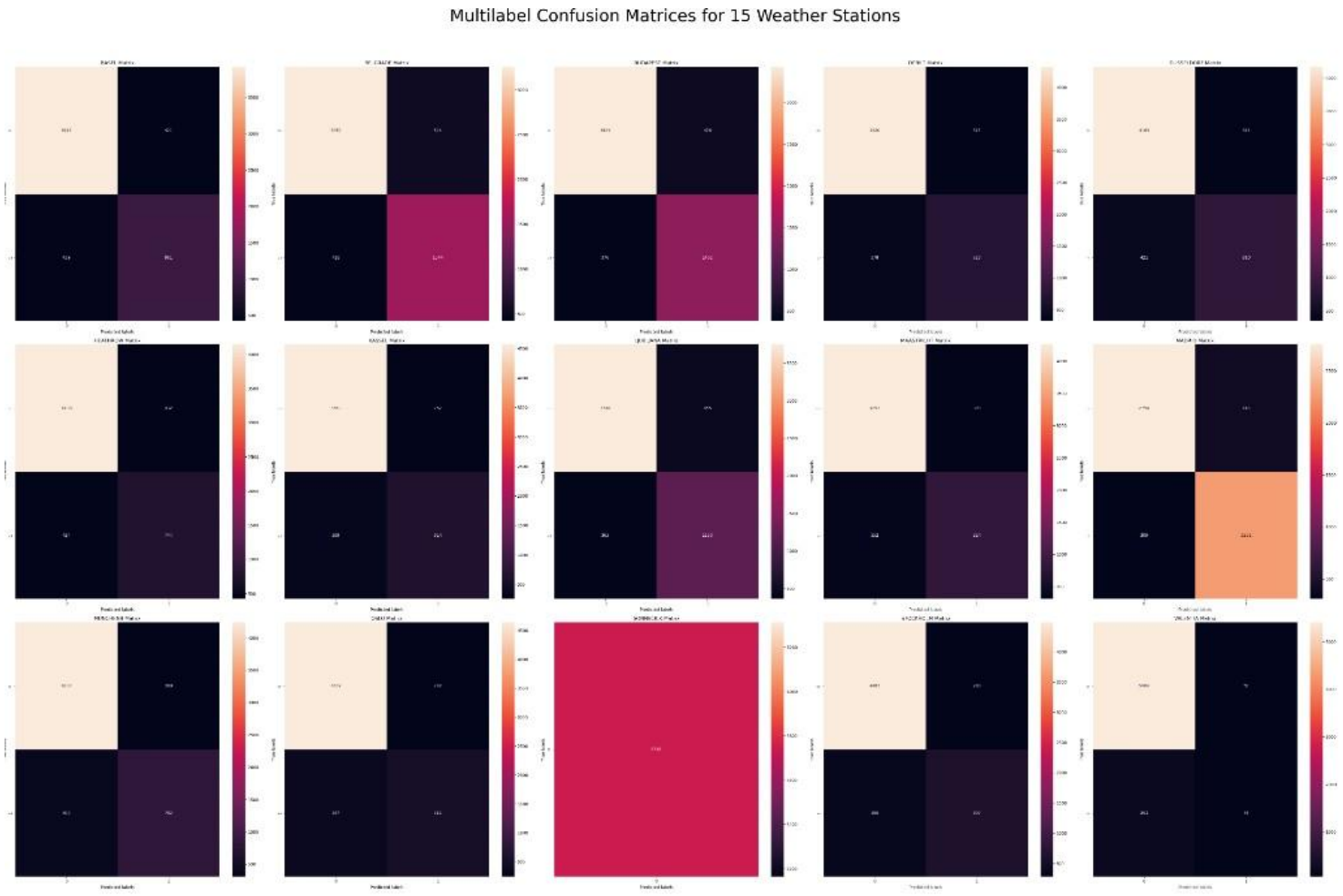

Objective

ClimateWins aims to use European temperature data to predict whether a day will be pleasant enough for outdoor activities. Pleasant days are labeled as 1, and unpleasant days as 0. The goal of this analysis is to evaluate the KNN model's predictive ability and see how it performs across different weather stations.

Model Overview

The analysis uses a K-Nearest Neighbors (KNN) algorithm with a multilabel approach, predicting multiple stations at once. Performance is evaluated by using confusion matrices for each station.

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Results by Station

The table below shows the model's performance for each station, including accurate predictions, false positives, false negatives, and overall accuracy:

	Weather Station	Accurate Predictions	False Positive	False Negative	Accuracy Rate
0	BASEL	961 - 3917	421	439	0.85
1	BELGRADE	1544 - 3252	524	418	0.84
2	BUDAPEST	1462 - 3424	476	376	0.85
3	DEBILT	723 - 4320	317	378	0.88
4	DUSSELDORF	810 - 4164	343	421	0.87
5	HEATHROW	744 - 4138	432	424	0.85
6	KASSEL	614 - 4563	252	309	0.90
7	LJUBLJANA	1180 - 3740	455	363	0.86
8	MAASTRICHT	824 - 4253	309	352	0.88
9	MADRID	2261 - 2750	418	309	0.87
10	MUNCHENB	792 - 4237	309	400	0.88
11	OSLO	512 - 4637	242	347	0.90
12	SONNBLICK	0 - 5738	0	0	1.00
13	STOCKHOLM	607 - 4483	283	365	0.89
14	VALENTIA	74 - 5404	58	202	0.95

Analysis

The model shows varying accuracy across stations. Sonnblick achieved perfect accuracy, while stations like Madrid were less precise, especially for predicting pleasant weather. This suggests that the model may perform best where training data patterns are consistent but could struggle to generalize in more variable conditions. The perfect score at Sonnblick may indicate overfitting, meaning the model memorized the training data instead of learning to generalize. Differences in performance across stations highlight the need for more diverse training data to ensure the model works well in different locations.

Recommendations & Conclusions

To improve the model, the training dataset should include a wider range of weather patterns. Applying techniques like cross-validation or ensemble methods could enhance reliability. Overall, the KNN model performs well in some stations, but its effectiveness varies across Europe. Increasing diversity in training data and validation will help the model generalize better and make more reliable predictions.

Weather Prediction Analysis – ANN Model & Decision Tree

Objective

ClimateWins aims to use European temperature and weather data to predict whether a day will be pleasant enough for outdoor activities. Pleasant days are labeled as 1, and unpleasant days as 0. The goal of this analysis is to evaluate the predictive ability of the Decision Tree (DT) and Artificial Neural Network (ANN) models and compare them to the KNN model from Exercise 1.4.

Model Overview

Both the Decision Tree and ANN models were applied in a multi-output approach, predicting all stations at once. The ANN was tested under three scenarios with different hidden layers and iterations to find the best combination of accuracy and generalization. Scaled data was used for the ANN to ensure variables with larger ranges, like cloud cover and snow depth, did not dominate the predictions. Performance is evaluated using confusion matrices for each station, recording accurate predictions, false positives, false negatives, and overall accuracy.

Results by Station

- **Decision Tree**
  - Training accuracy is extremely high, with all stations reaching 1.0 accuracy for both pleasant and unpleasant predictions.
  - Testing accuracy is lower, with stations like Heathrow (0.90), Stockholm (0.91), and Valencia (0.94) showing some misclassifications.
  - Sonnblick is fully accurate in both training and testing.

- **ANN**
  - Scenario 1 (5,5): Training accuracy ranges from 0.85–0.97, with testing accuracy lower (0.84–0.97). Some stations like Heathrow and Belgrade show weaker performance.
  - Scenario 2 (20,10,5): Training accuracy improves across most stations (0.87–1.00), and testing accuracy also increases slightly (0.87–0.98).
  - Scenario 3 (50,20,10): Training accuracy remains very high (0.94–1.00), and testing accuracy reaches the highest values across almost all stations (0.92–0.98). This scenario achieves the best balance between learning the patterns in the data and generalizing to unseen data, making it the most robust ANN configuration.
  - Sonnblick again achieves perfect accuracy.
  - Stations like Madrid and Valencia have very high testing accuracy (0.98, 0.97), while stations with more variable weather, like Oslo or Maastricht, are slightly lower (~0.94–0.96).

Analysis

- Best performing algorithm: The ANN, specifically Scenario 3, performs best overall. It maintains high accuracy while avoiding overfitting, unlike the Decision Tree, which perfectly memorizes the training data. Scenario 3 was selected because it consistently produces the highest testing accuracy across all stations, showing that it generalizes better than Scenarios 1 and 2 while still achieving strong training performance.

- Overfitting and pruning: The Decision Tree shows signs of overfitting — perfect training accuracy vs slightly lower testing accuracy. Pruning is recommended to simplify the tree, reduce overfitting, and improve generalization.
- Fully accurate stations: Sonnblick is consistently predicted perfectly in both models.
- Data features affecting accuracy: Variables with extreme ranges, such as precipitation, snow depth, and cloud cover, appear to help models identify pleasant vs unpleasant days. Scaling these features was especially important for the ANN to ensure balanced weighting.

Recommendations & Conclusions

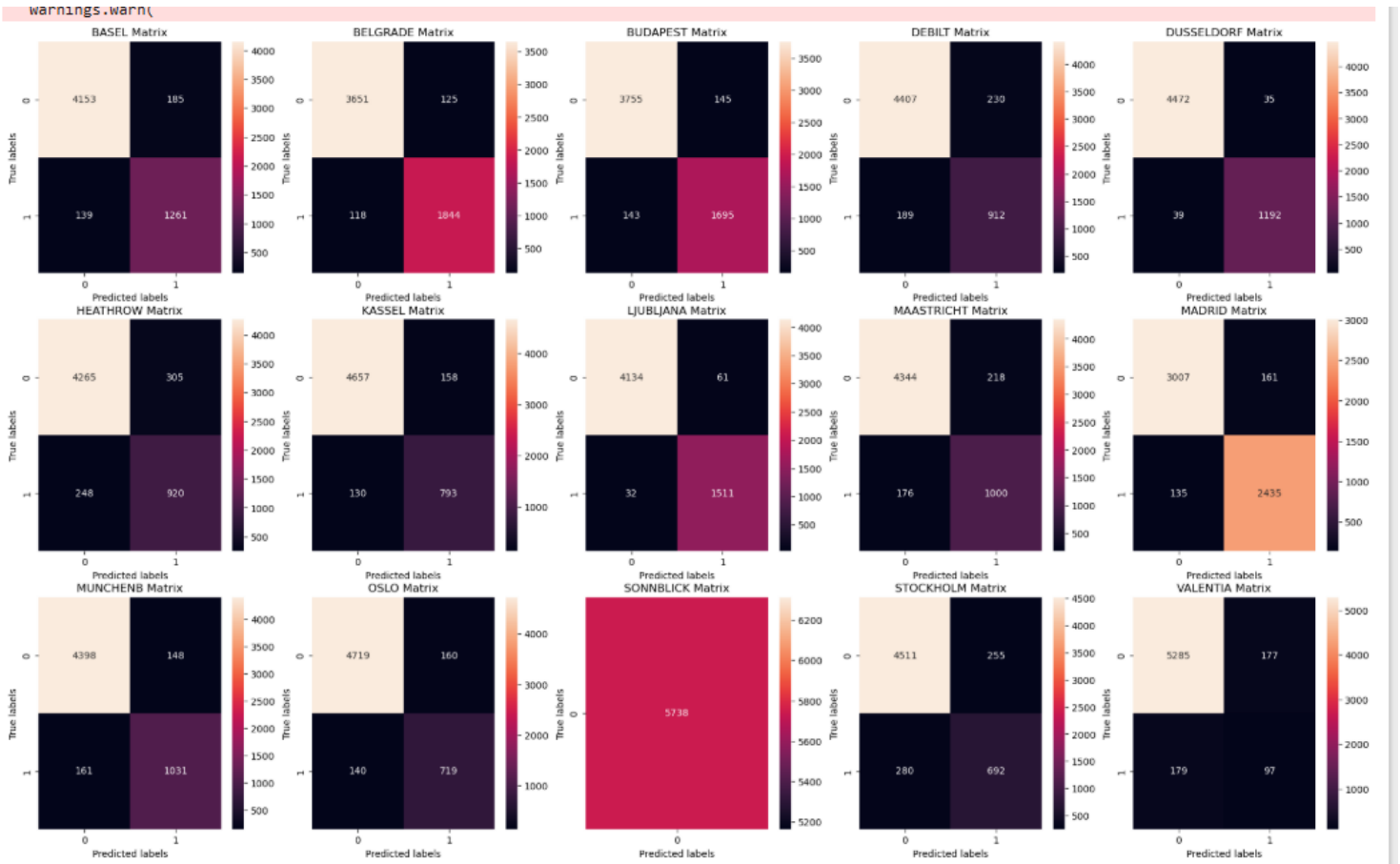
I recommend ClimateWins use the **ANN model, Scenario 3**, for predicting pleasant days. It provides high accuracy across stations, better generalization to testing data, and has room for further improvement by tuning the number of layers, nodes, and iterations. The Decision Tree can provide quick interpretability but should be pruned to reduce overfitting. Overall, the ANN is the most robust choice for the current European weather data.

Decision Tree Matrices and Tables

- **Training**

	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	12948	4264	0	0	1.0
1	BELGRADE	11182	6030	0	0	1.0
2	BUDAPEST	11619	5593	0	0	1.0
3	DEBILT	13854	3358	0	0	1.0
4	DUSSELDORF	13509	3703	0	0	1.0
5	HEATHROW	13421	3791	0	0	1.0
6	KASSEL	14361	2851	0	0	1.0
7	LJUBLJANA	12379	4833	0	0	1.0
8	MAASTRICHT	13622	3590	0	0	1.0
9	MADRID	9535	7677	0	0	1.0
10	MUNCHENB	13637	3575	0	0	1.0
11	OSLO	14492	2720	0	0	1.0
12	SONNBLICK	17212	0	0	0	1.0
13	STOCKHOLM	14290	2922	0	0	1.0
14	VALENTIA	16314	898	0	0	1.0

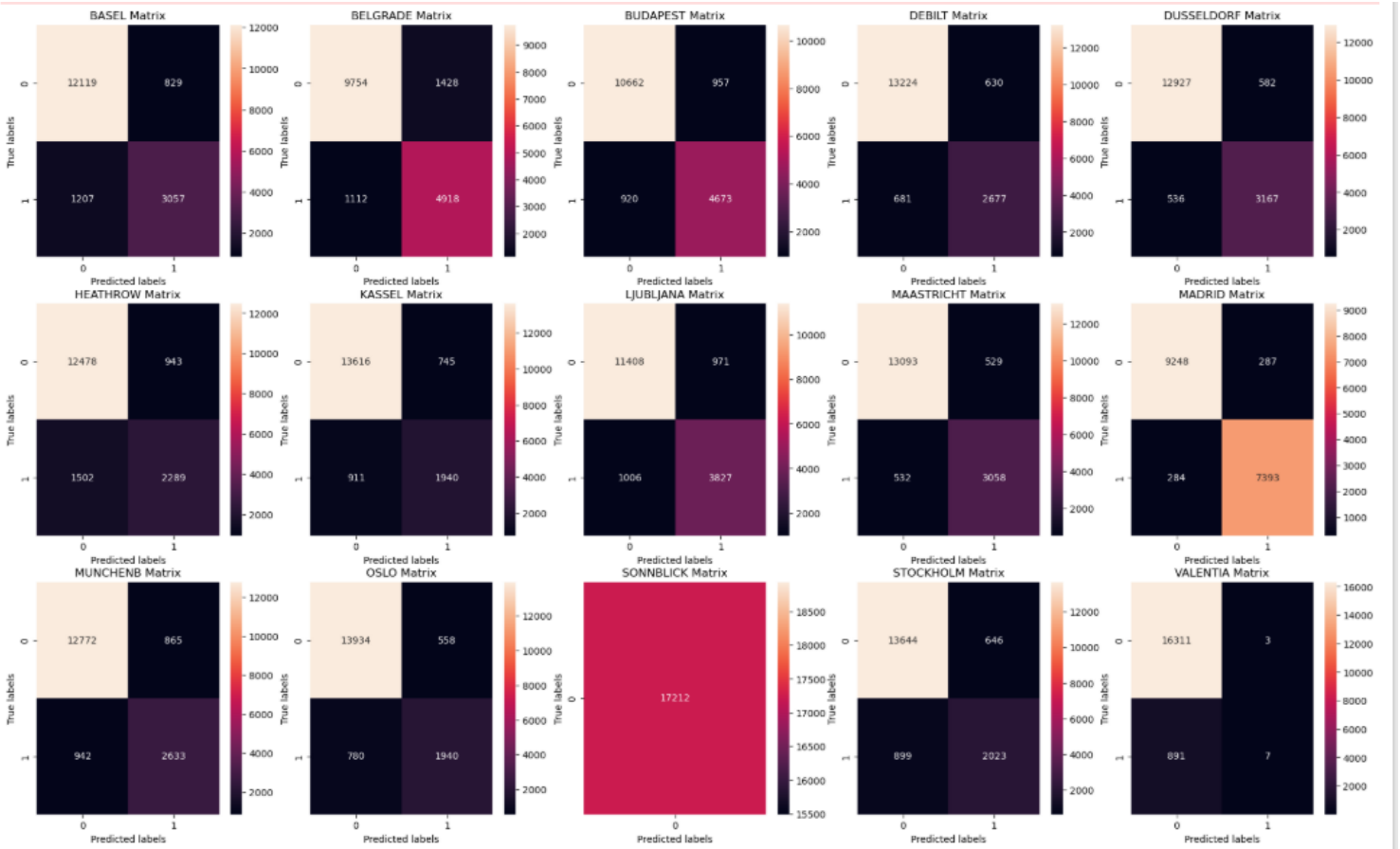
- **Testing**



	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	4153	1261	185	139	0.94
1	BELGRADE	3651	1844	125	118	0.96
2	BUDAPEST	3755	1695	145	143	0.95
3	DEBILT	4407	912	230	189	0.93
4	DUSSELDORF	4472	1192	35	39	0.99
5	HEATHROW	4265	920	305	248	0.90
6	KASSEL	4657	793	158	130	0.95
7	LJUBLJANA	4134	1511	61	32	0.98
8	MAASTRICHT	4344	1000	218	176	0.93
9	MADRID	3007	2435	161	135	0.95
10	MUNCHENB	4398	1031	148	161	0.95
11	OSLO	4719	719	160	140	0.95
12	SONNBLICK	5738	0	0	0	1.00
13	STOCKHOLM	4511	692	255	280	0.91
14	VALENTIA	5285	97	177	179	0.94

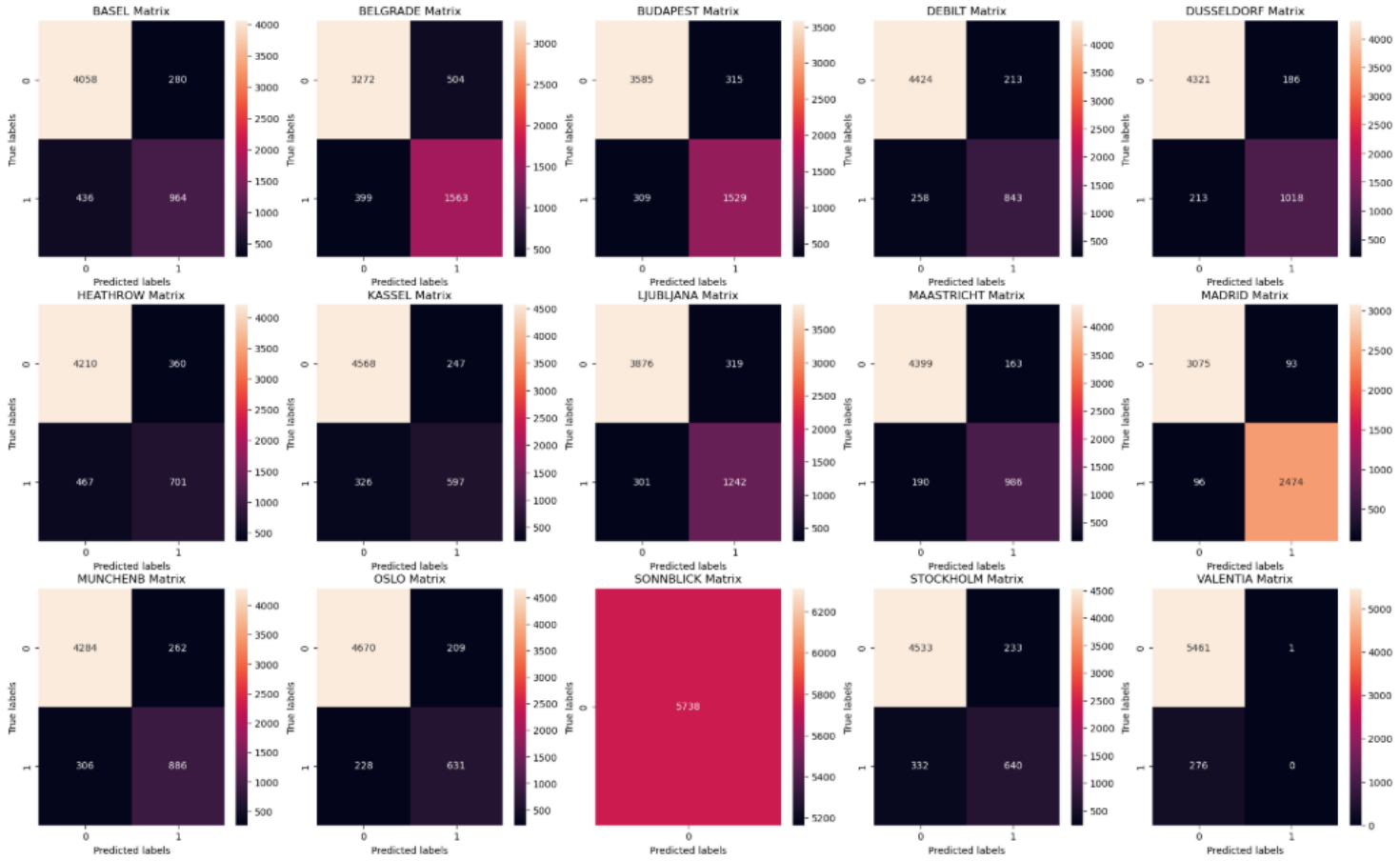
ANN MODEL Matrices and Tables per Scenario

- Scenario 1 Training



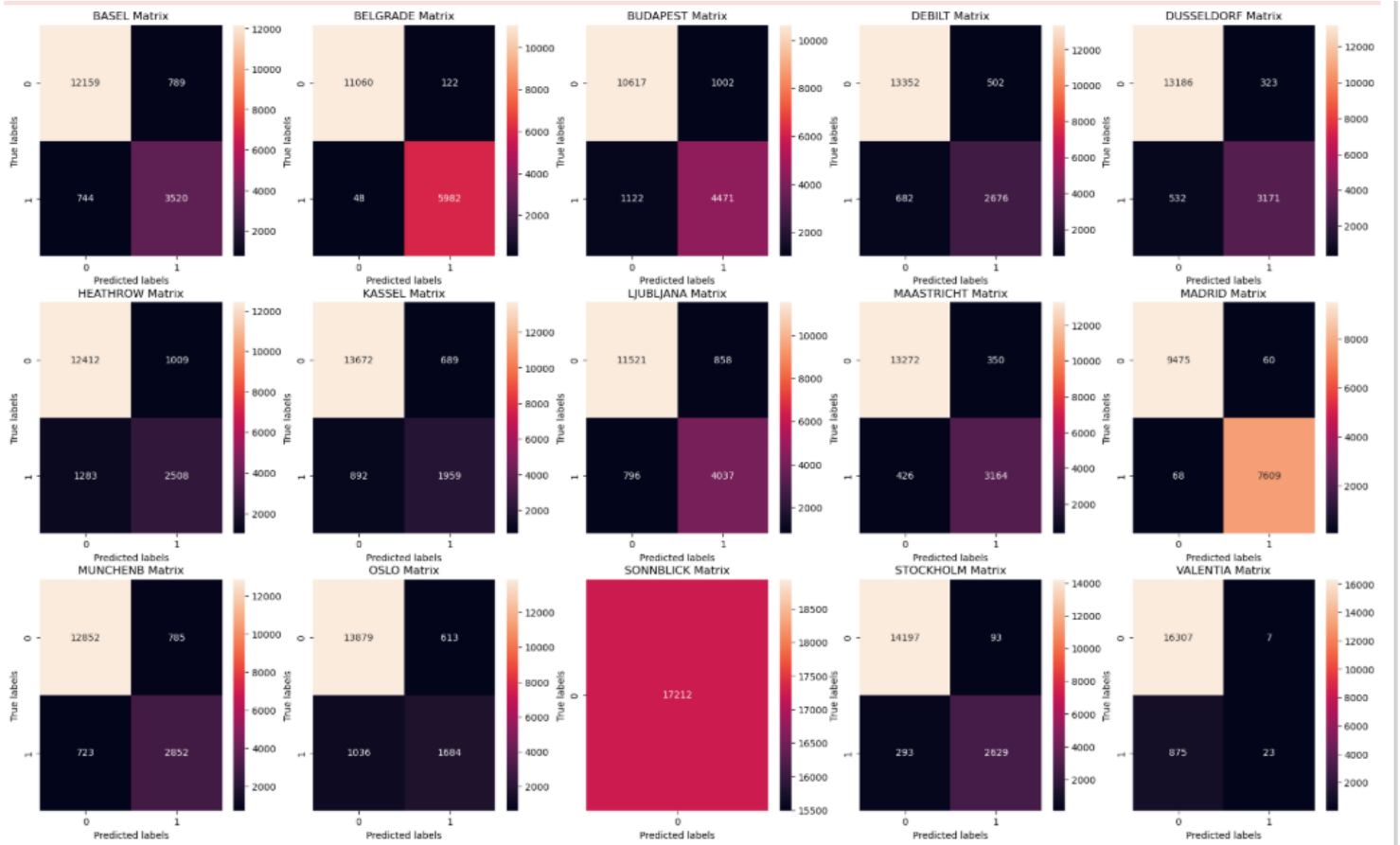
	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	12119	3057	829	1207	0.88
1	BELGRADE	9754	4918	1428	1112	0.85
2	BUDAPEST	10662	4673	957	920	0.89
3	DEBILT	13224	2677	630	681	0.92
4	DUSSELDORF	12927	3167	582	536	0.94
5	HEATHROW	12478	2289	943	1502	0.86
6	KASSEL	13616	1940	745	911	0.90
7	LJUBLJANA	11408	3827	971	1006	0.89
8	MAASTRICHT	13093	3058	529	532	0.94
9	MADRID	9248	7393	287	284	0.97
10	MUNCHENB	12772	2633	865	942	0.90
11	OSLO	13934	1940	558	780	0.92
12	SONNBLICK	17212	0	0	0	1.00
13	STOCKHOLM	13644	2023	646	899	0.91
14	VALENTIA	16311	7	3	891	0.95

- Scenario 1 Testing



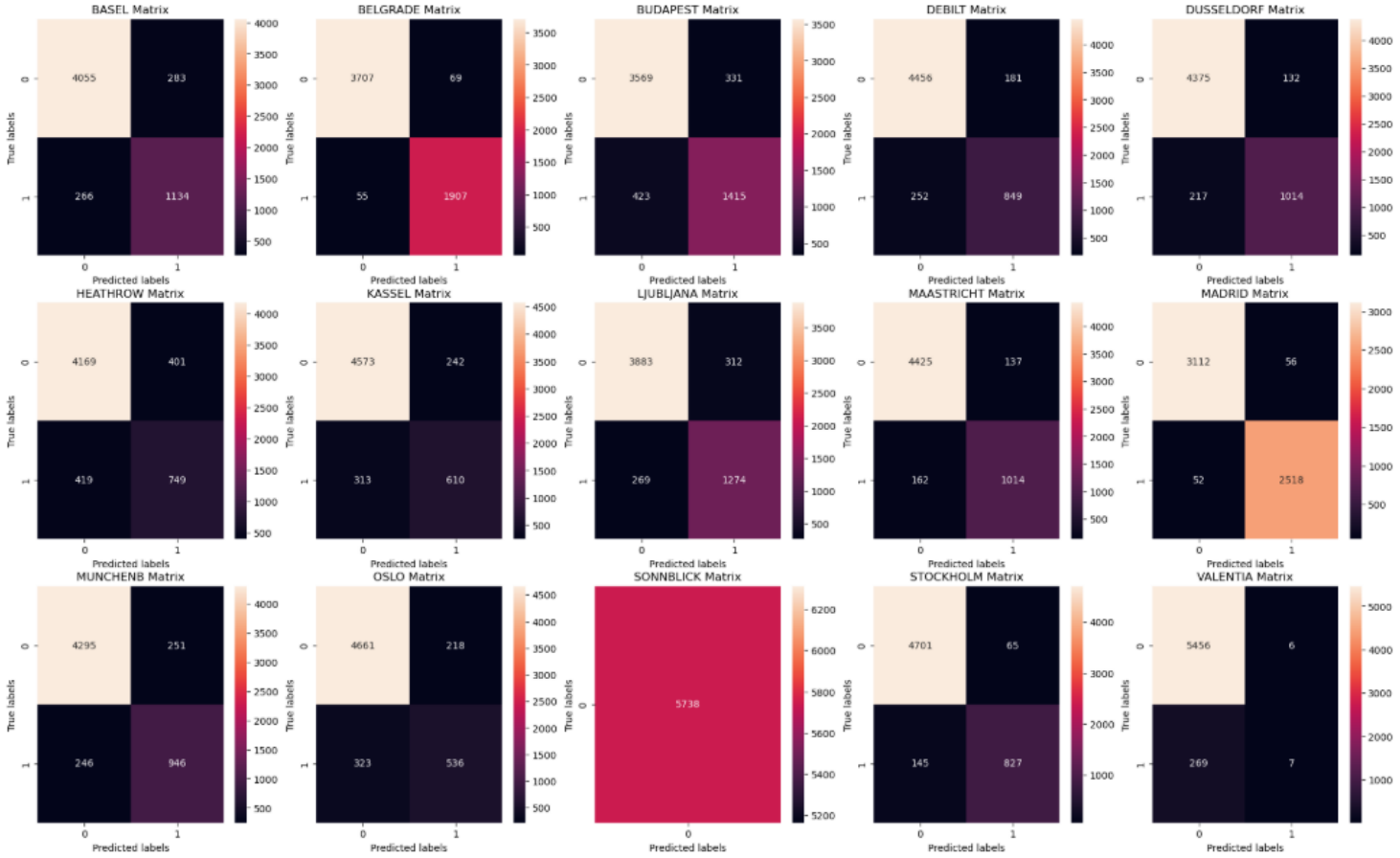
	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	4058	964	280	436	0.88
1	BELGRADE	3272	1563	504	399	0.84
2	BUDAPEST	3585	1529	315	309	0.89
3	DEBILT	4424	843	213	258	0.92
4	DUSSELDORF	4321	1018	186	213	0.93
5	HEATHROW	4210	701	360	467	0.86
6	KASSEL	4568	597	247	326	0.90
7	LJUBLJANA	3876	1242	319	301	0.89
8	MAASTRICHT	4399	986	163	190	0.94
9	MADRID	3075	2474	93	96	0.97
10	MUNCHENB	4284	886	262	306	0.90
11	OSLO	4670	631	209	228	0.92
12	SONNBLICK	5738	0	0	0	1.00
13	STOCKHOLM	4533	640	233	332	0.90
14	VALENTIA	5461	0	1	276	0.95

- Scenario 2 Training



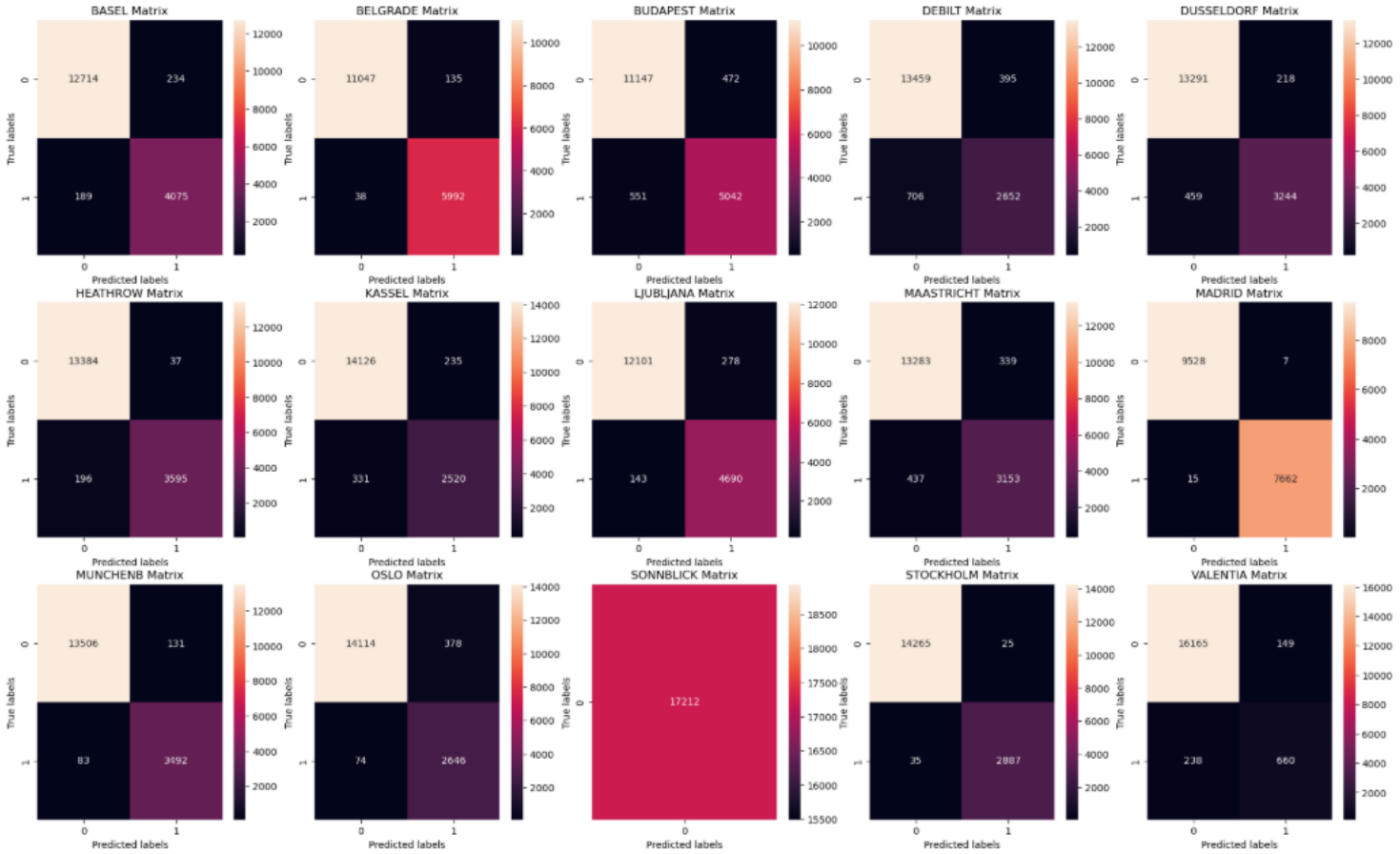
	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	12159	3520	789	744	0.91
1	BELGRADE	11060	5982	122	48	0.99
2	BUDAPEST	10617	4471	1002	1122	0.88
3	DEBILT	13352	2676	502	682	0.93
4	DUSSELDORF	13186	3171	323	532	0.95
5	HEATHROW	12412	2508	1009	1283	0.87
6	KASSEL	13672	1959	689	892	0.91
7	LJUBLJANA	11521	4037	858	796	0.90
8	MAASTRICHT	13272	3164	350	426	0.95
9	MADRID	9475	7609	60	68	0.99
10	MUNCHENB	12852	2852	785	723	0.91
11	OSLO	13879	1684	613	1036	0.90
12	SONNBLICK	17212	0	0	0	1.00
13	STOCKHOLM	14197	2629	93	293	0.98
14	VALENTIA	16307	23	7	875	0.95

- Scenario 2 Testing



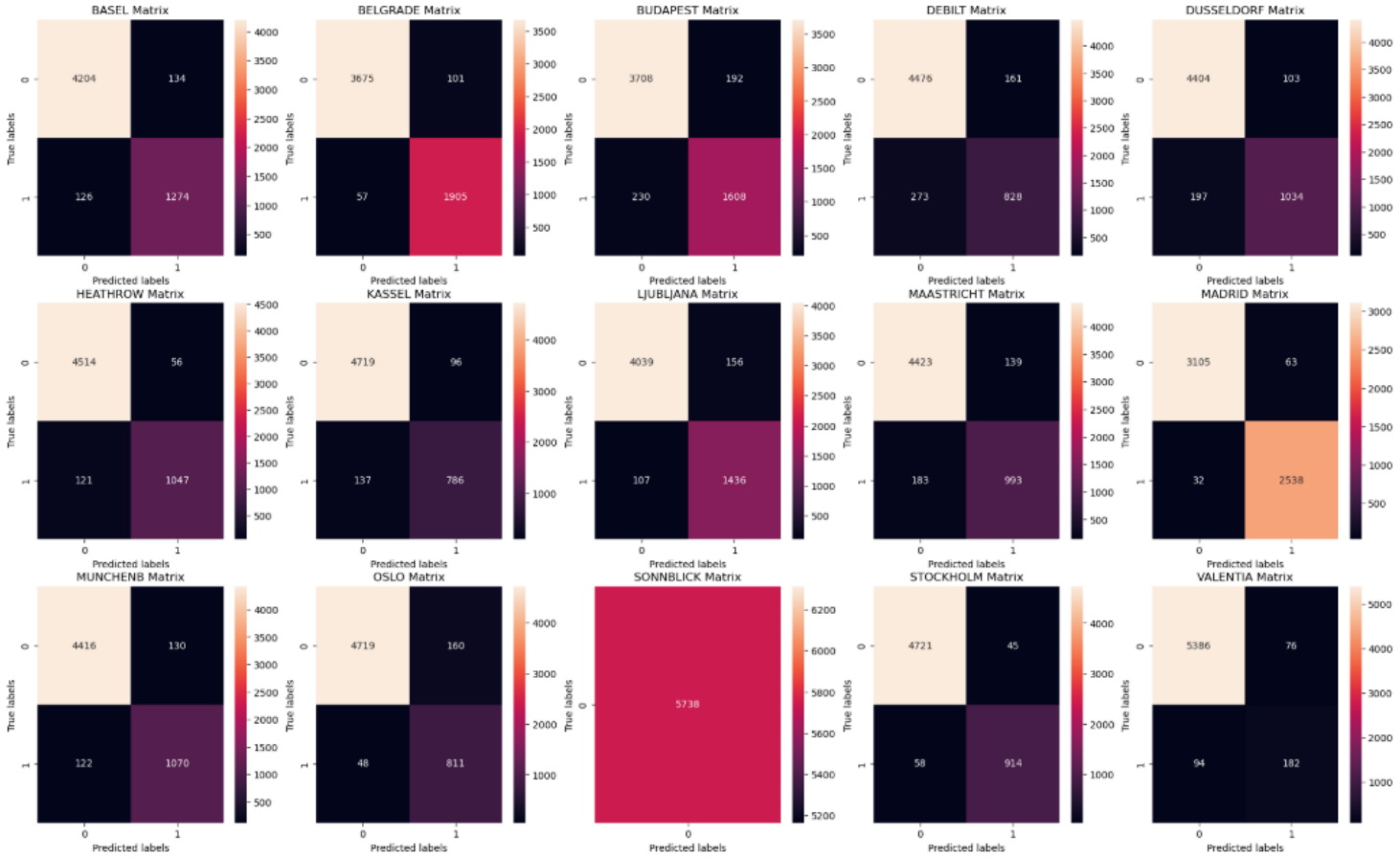
	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	4055	1134	283	266	0.90
1	BELGRADE	3707	1907	69	55	0.98
2	BUDAPEST	3569	1415	331	423	0.87
3	DEBILT	4456	849	181	252	0.92
4	DUSSELDORF	4375	1014	132	217	0.94
5	HEATHROW	4169	749	401	419	0.86
6	KASSEL	4573	610	242	313	0.90
7	LJUBLJANA	3883	1274	312	269	0.90
8	MAASTRICHT	4425	1014	137	162	0.95
9	MADRID	3112	2518	56	52	0.98
10	MUNCHENB	4295	946	251	246	0.91
11	OSLO	4661	536	218	323	0.91
12	SONNBLICK	5738	0	0	0	1.00
13	STOCKHOLM	4701	827	65	145	0.96
14	VALENTIA	5456	7	6	269	0.95

- Scenario 3 Training



	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	12714	4075	234	189	0.98
1	BELGRADE	11047	5992	135	38	0.99
2	BUDAPEST	11147	5042	472	551	0.94
3	DEBILT	13459	2652	395	706	0.94
4	DUSSELDORF	13291	3244	218	459	0.96
5	HEATHROW	13384	3595	37	196	0.99
6	KASSEL	14126	2520	235	331	0.97
7	LJUBLJANA	12101	4690	278	143	0.98
8	MAASTRICHT	13283	3153	339	437	0.95
9	MADRID	9528	7662	7	15	1.00
10	MUNCHENB	13506	3492	131	83	0.99
11	OSLO	14114	2646	378	74	0.97
12	SONNBLICK	17212	0	0	0	1.00
13	STOCKHOLM	14265	2887	25	35	1.00
14	VALENTIA	16165	660	149	238	0.98

- Scenario 3 Testing



	Station	Accurate 0	Accurate 1	False Pos	False Neg	Accuracy Rate
0	BASEL	4204	1274	134	126	0.95
1	BELGRADE	3675	1905	101	57	0.97
2	BUDAPEST	3708	1608	192	230	0.93
3	DEBILT	4476	828	161	273	0.92
4	DUSSELDORF	4404	1034	103	197	0.95
5	HEATHROW	4514	1047	56	121	0.97
6	KASSEL	4719	786	96	137	0.96
7	LJUBLJANA	4039	1436	156	107	0.95
8	MAASTRICHT	4423	993	139	183	0.94
9	MADRID	3105	2538	63	32	0.98
10	MUNCHENB	4416	1070	130	122	0.96
11	OSLO	4719	811	160	48	0.96
12	SONNBLICK	5738	0	0	0	1.00
13	STOCKHOLM	4721	914	45	58	0.98
14	VALENTIA	5386	182	76	94	0.97