

SIRWEC2024

FROST-INDUCED BLACKICE PREDICTION USING ATMOSPHERIC DATA



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Jinhwan Jang, Ph. D.

Korea Institute of Civil Engineering and Building Technology (KICT)

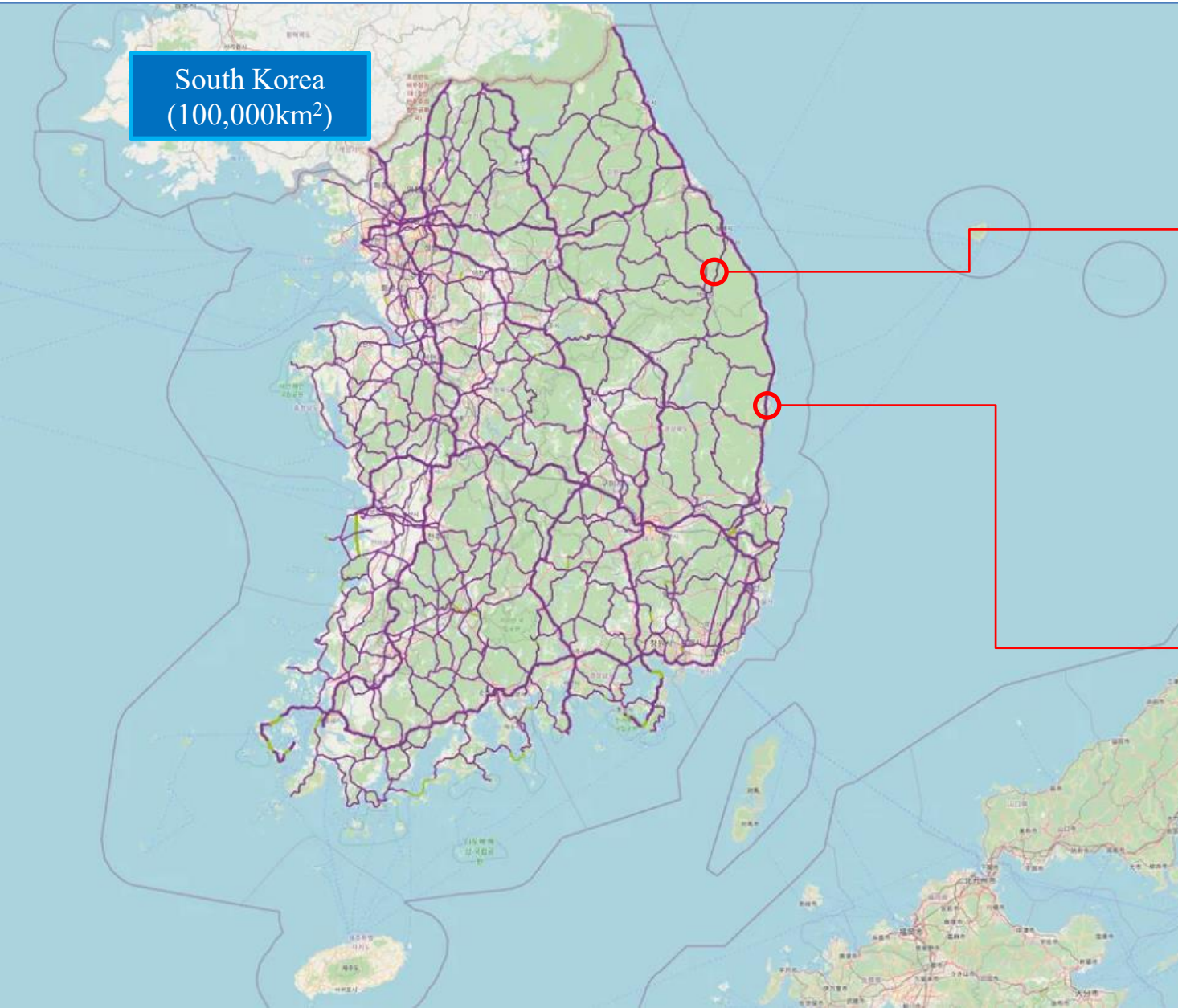
Contents

I. RWIS in Korea

II. Black Ice Prediction Using Atmospheric Data



Highway System in Korea



South Korea
(100,000km²)



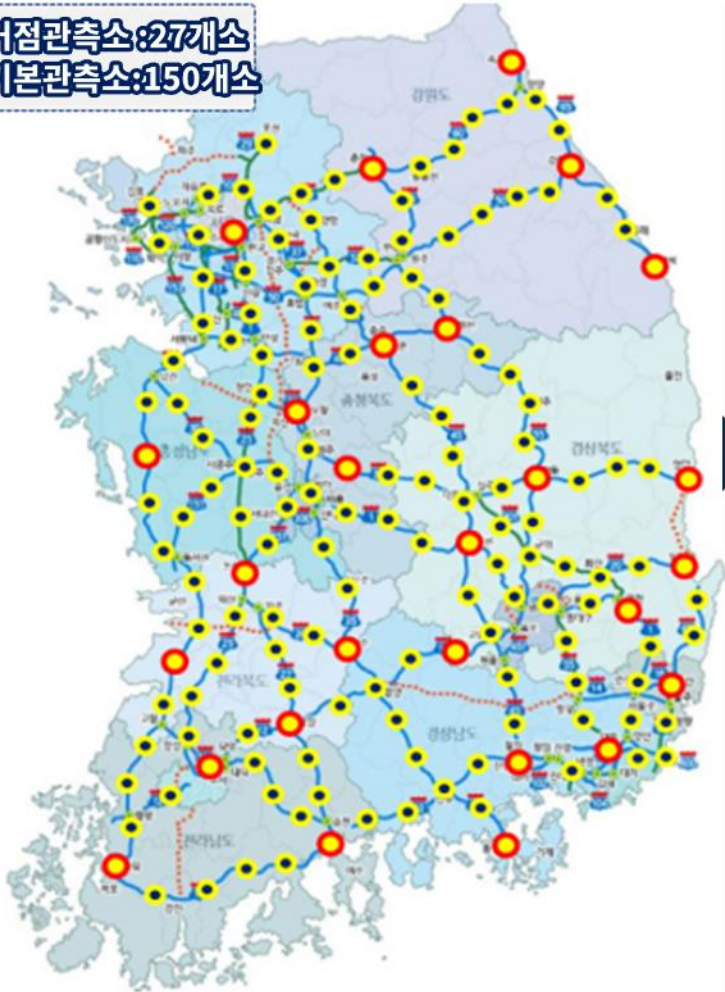
National Highway
(13,000km, 60-80km/h)



Freeway
(5,000km, 100-110km/h)

RWIS ESS Installment on Freeway (2022~2025)

● 거점관측소: 27개소
● 기본관측소: 150개소



번호	노선명	길이(km)	거점	기본	추진년도
1	중부내륙선	302	2	11	22년
2	서해안선	341	3	13	23년
3	경부선	416	3	15	24년
4	중앙선	289	2	10	
5	호남선	194	1	6	
6	영동선	234	2	8	
7	통영대전,중부선	333	2	11	
8	당진-영덕선	279	2	11	
9	무안-광주선,광주대구선	213	2	8	
10	순천-완주선	118	1	4	
11	새만금포항선	106	1	4	25년
12	남해선	274	2	11	
13	평택-제천선	127	1	5	
14	서울-양양선	151	1	6	
15	호남선의지선	54	0	2	
16	제2경인선	26	0	1	
17	동해선	224	2	9	
18	고창-담양선	43	0	2	
19	중부내륙선의지선	30	0	1	
20	서천-공주선	61	0	3	
21	평택-시흥선	40	0	2	
22	부산외곽순환선	49	0	2	
23	경인선	13	0	0	
24	제2중부선	31	0	1	
25	남해제2지선	20	0	1	
26	남해제1지선	18	0	0	
27	대전남부순환선	13	0	0	
28	중앙선의지선	17	0	0	
29	새만금포항선의지선	25	0	1	
30	울산선	14	0	0	
31	함양울산선	45	0	2	
합계		4,100	27	150	

Type of RWIS ESS

● RWIS ESS Design Criteria

Type		Sensor	Area	Height
Regional (100km)		Wind, Temperature, Precipitation, Humidity, Pressure, Visibility, Pavement sensor, Snow Accumulation, Ceilometer, Sunshine recorder	70m ²	12m
Local (20km)		Wind, Temperature, Precipitation, Humidity, Pressure, Visibility, Pavement	35m ²	7m
Ice/Fog	Ice (Ice-prone segment)	Pavement (Pavement status, Friction, Pavement temperature etc.)	10m ²	7m
	Fog (Fog-prone segment)	Visibility (Visible range)	10m ²	5m



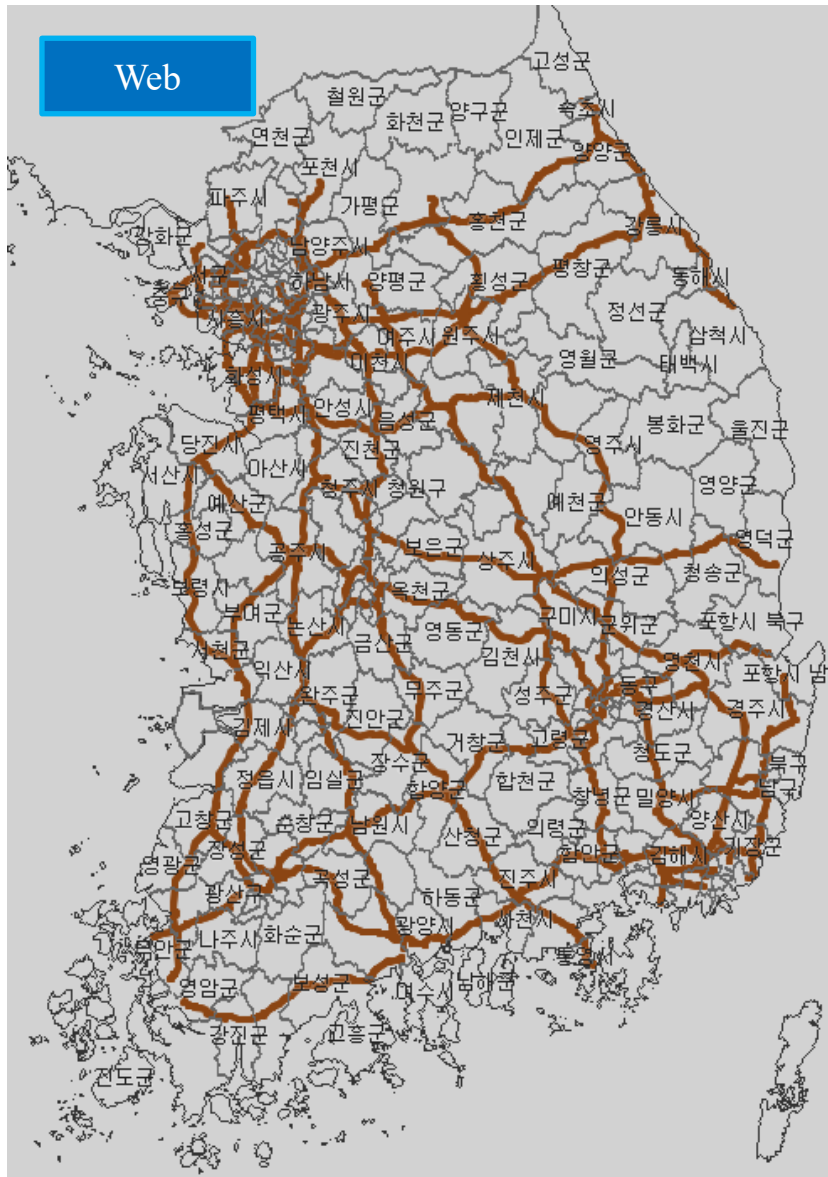
Regional
(100km)



Local
(20km 간격)

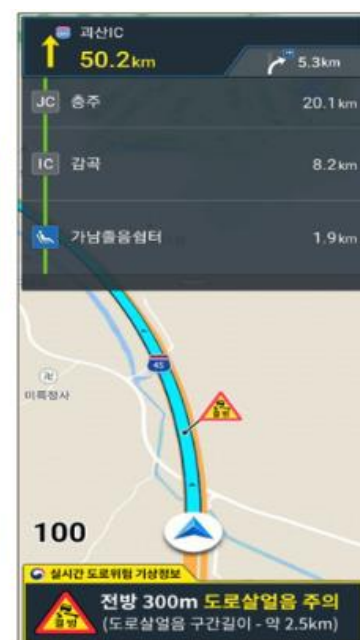


Ice/Fog
(Ice/Fog-prone segment)



Information Provision Scheme

Element	Sensor	Warning Level			
		0	1	2	3
Ice	Radar		Precipitation & above 4°C	Precipitation & 0-4°C	Precipitation & below 0°C
	Pavement	Dry		Moist/Wet	Snow/Ice
Fog	Visibility		1,000-500m	500-200m	200-0m



- Spatial Estimation

RWIS ESSs are spaced 20 km apart. Therefore, the pavement status between two consecutive RWIS ESSs must be estimated. It is essential to develop an appropriate methodology for this estimation.

- Temporal Prediction

For effective preventive maintenance of roads during winter, accurate forecast information is essential. Consequently, the development of reliable prediction techniques is necessary.

- Benefit of RWIS Deployment

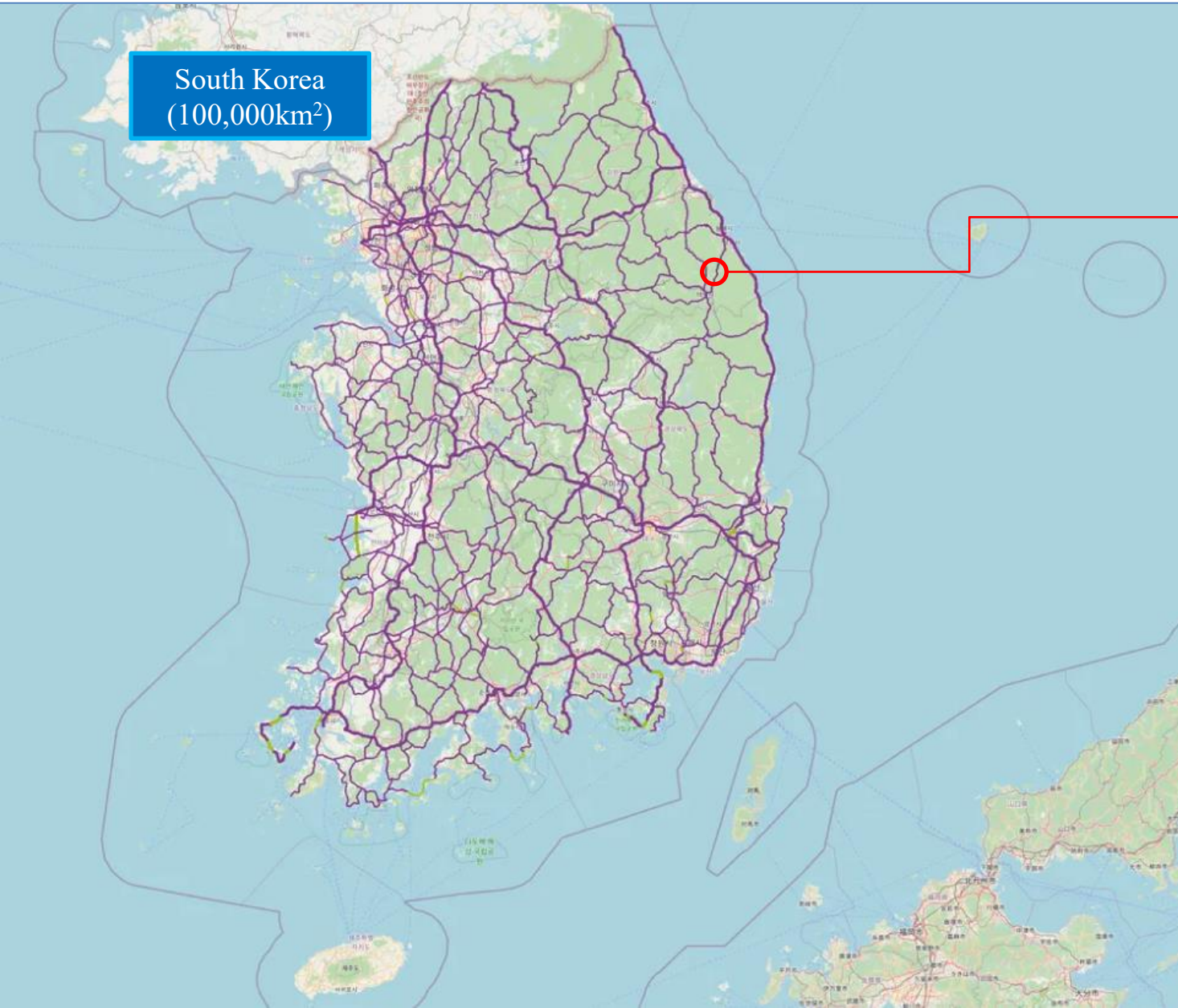
To justify the budget allocation for the deployment of RWIS, it is essential to guarantee social benefits. Consequently, a methodology for calculating the social benefits of RWIS must be established

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**II. Black Ice Prediction
Using Atmospheric Data**

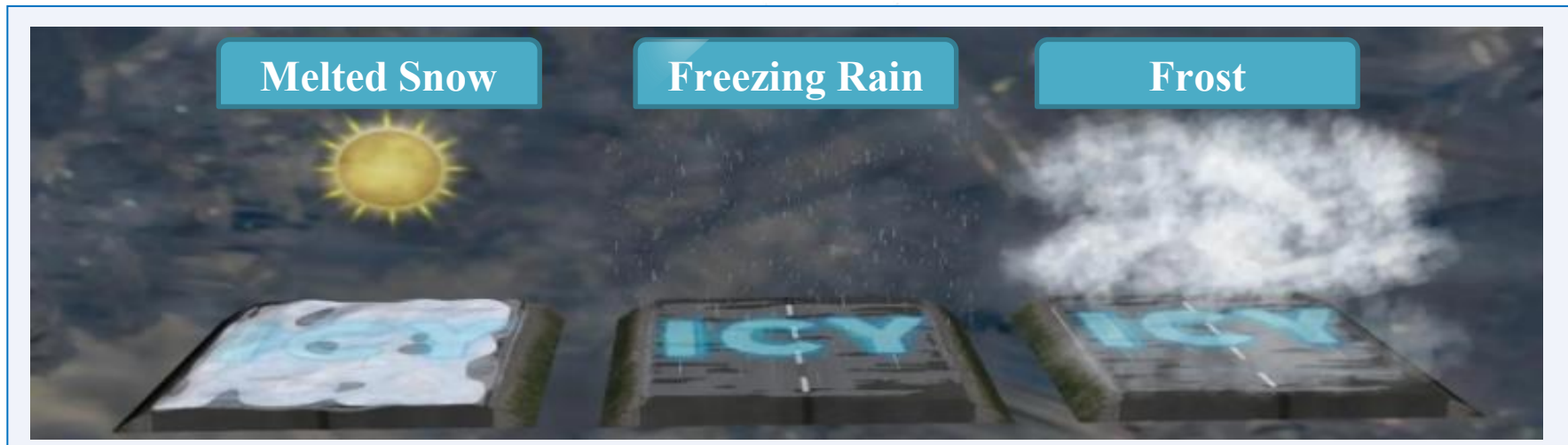




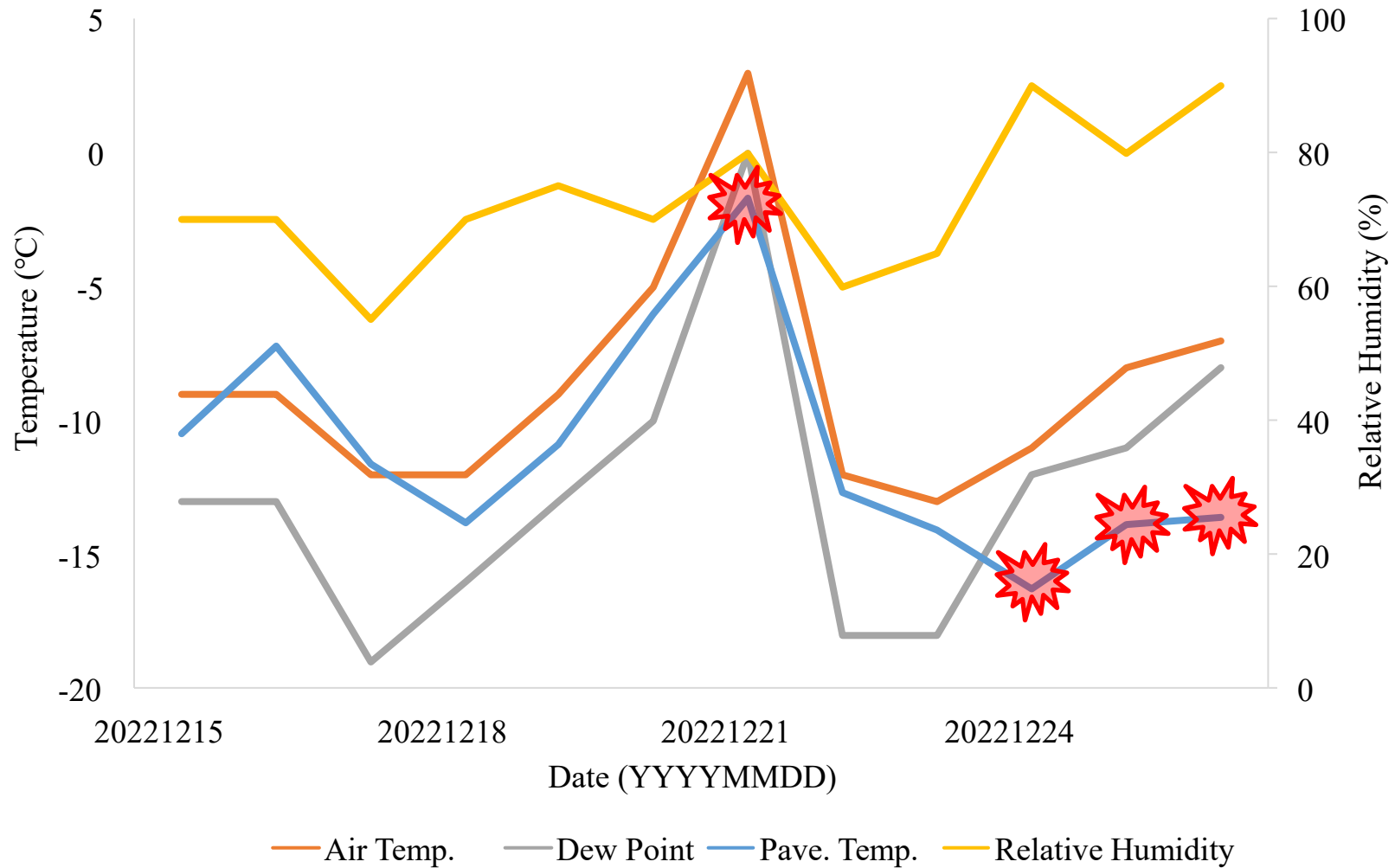
No RWIS is deployed

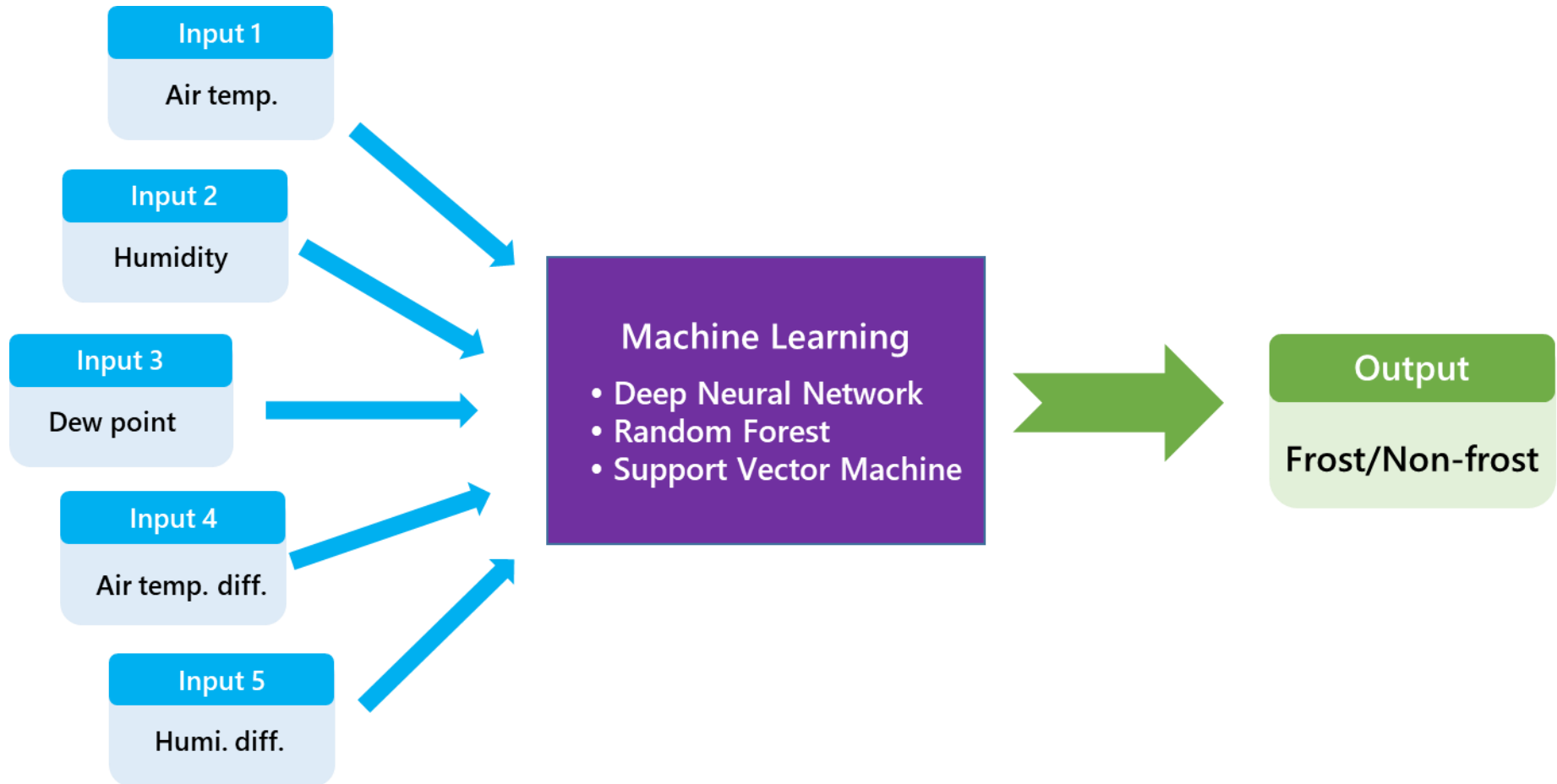


Black Ice must be estimated using atmospheric data



Frost-Induced Black Ice Formation Condition





Model Building

```

model = Sequential()

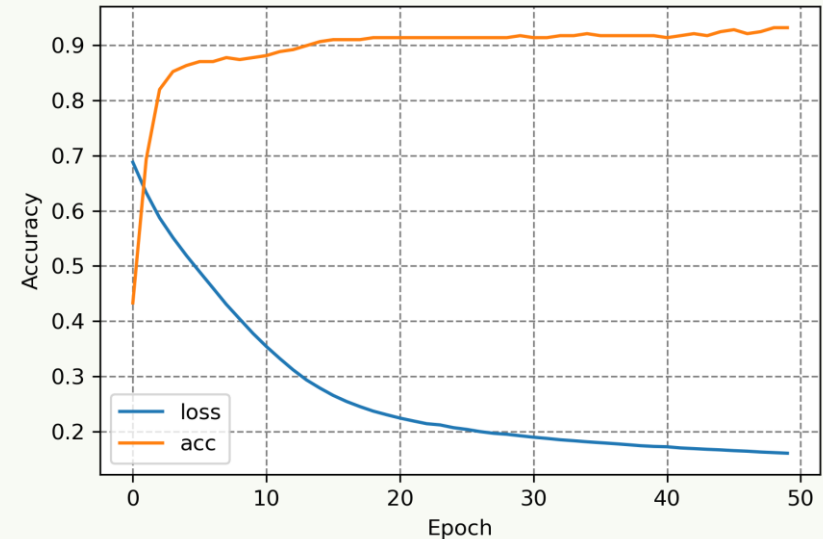
model.add(Dense(30,input_shape=(5,),activation='relu'))
model.add(Dense(20,activation='relu'))
model.add(Dense(1,activation='sigmoid'))

model.compile(loss='binary_crossentropy',
              optimizer='Adam',
              metrics=['accuracy'])
    
```

Layer (type)	Output Shape	Param #
dense_4 (Dense)	(None, 30)	180
dense_5 (Dense)	(None, 20)	620
dense_6 (Dense)	(None, 1)	21

Total params:	821	
Trainable params:	821	
Non-trainable params:	0	

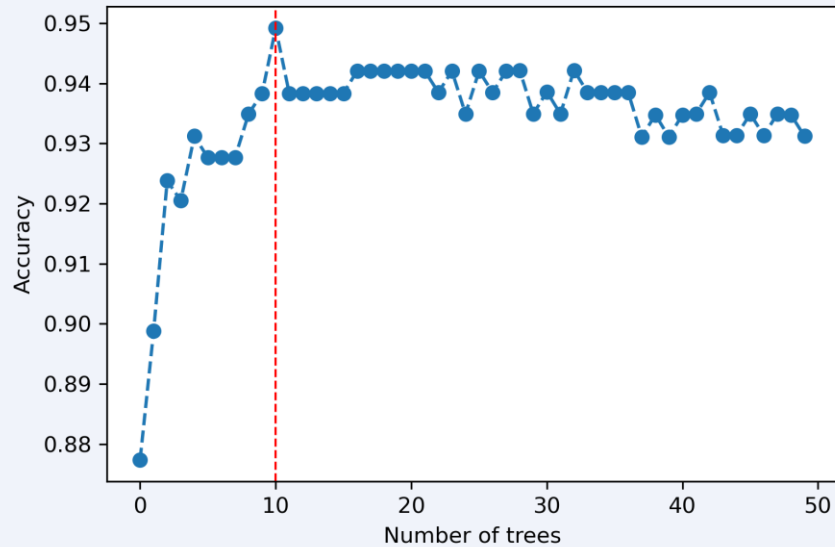
Performance



	precision	recall	f1-score	support
0	1.00	0.95	0.98	62
1	0.95	1.00	0.97	58
accuracy			0.97	120
macro avg	0.98	0.98	0.97	120
weighted avg	0.98	0.97	0.98	120

[[59 3]				
[0 58]]				

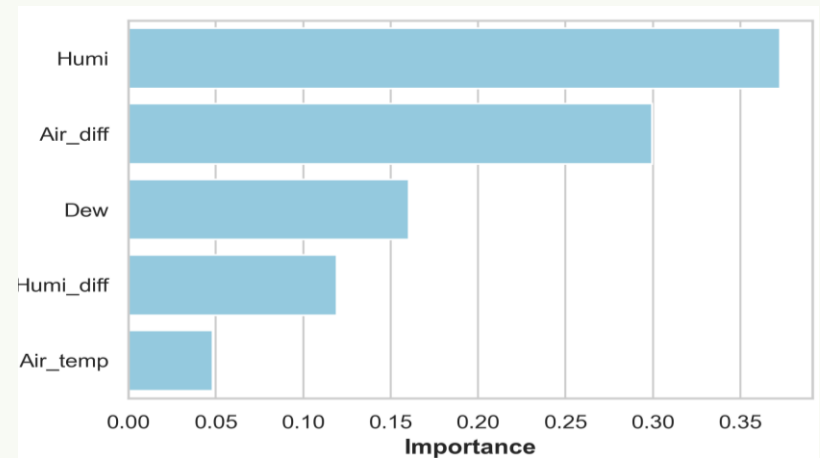
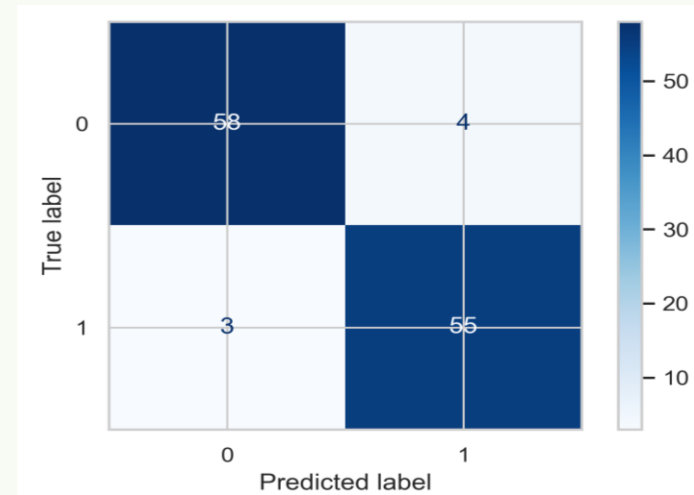
Model Building



```
param_grid = {'n_estimators': [1,5,10], 'max_depth':  
              [10,15,20], 'max_leaf_nodes': [10,30,50],  
              'criterion': ['gini', 'entropy'], 'max_features': ['auto',  
              'sqrt', 'log2']}
```

```
{'criterion': 'entropy', 'max_depth': 10, 'max_features': 'auto',  
'max_leaf_nodes': 30, 'n_estimators': 5}
```

Performance



Model Building

```
svc = SVC(random_state=2021)

param_grid = [{'kernel': ['linear'], 'C': [0.1, 1, 10, 100, 1000,
10000, 100000]},
              {'kernel': ['poly'], 'degree': [2, 3, 4], 'C': [0.1, 1,
10, 100, 1000, 10000, 100000]},
              {'kernel': ['rbf'], 'gamma': ['auto', 'scale'], 'C':
[0.1, 1, 10, 100, 1000, 10000, 100000]},
              {'kernel': ['sigmoid'], 'gamma': ['auto', 'scale'],
'C': [0.1, 1, 10, 100, 1000, 10000, 100000]}]
```

```
scores = ['precision', 'recall']
```

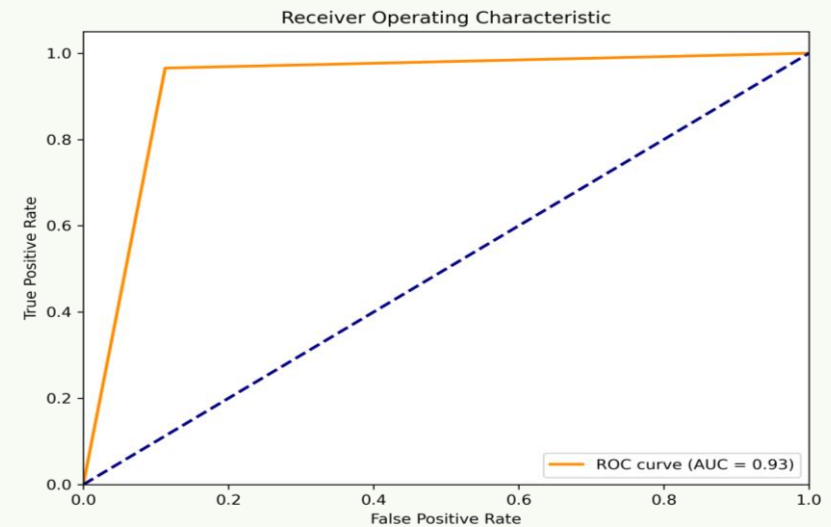
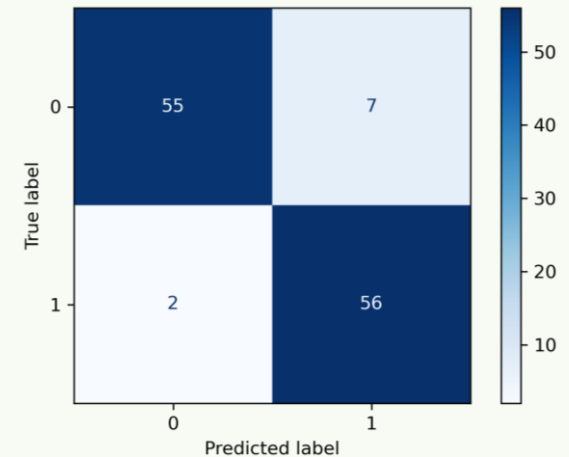
```
CV_svc = GridSearchCV(estimator=svc,
                      param_grid=param_grid, cv=10, verbose=0,
                      n_jobs=-1)
```

```
CV_svc.fit(X_train, y_train)
```

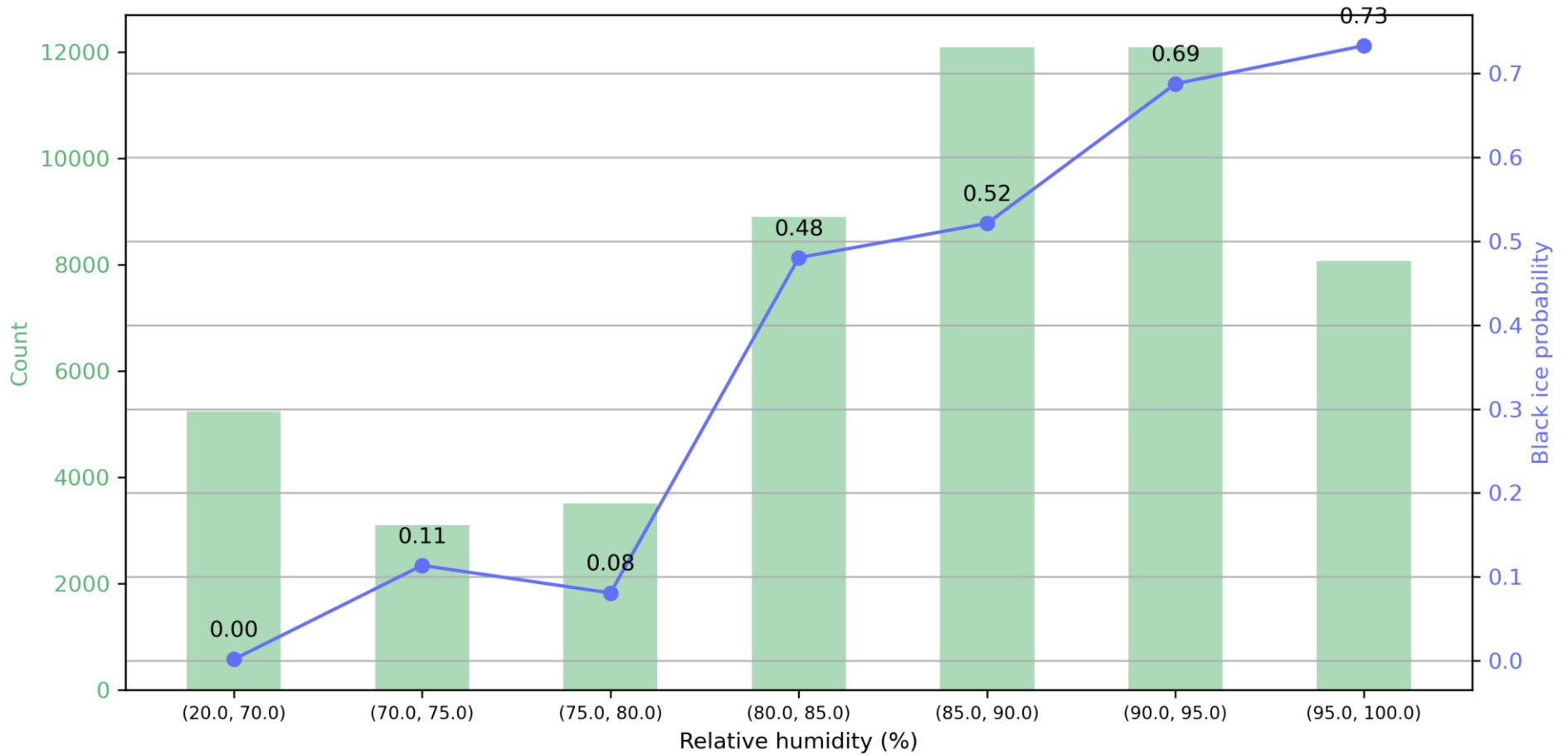
Bset parameters set found on training data set:

```
{'C': 100, 'gamma': 'auto', 'kernel': 'rbf'}
```

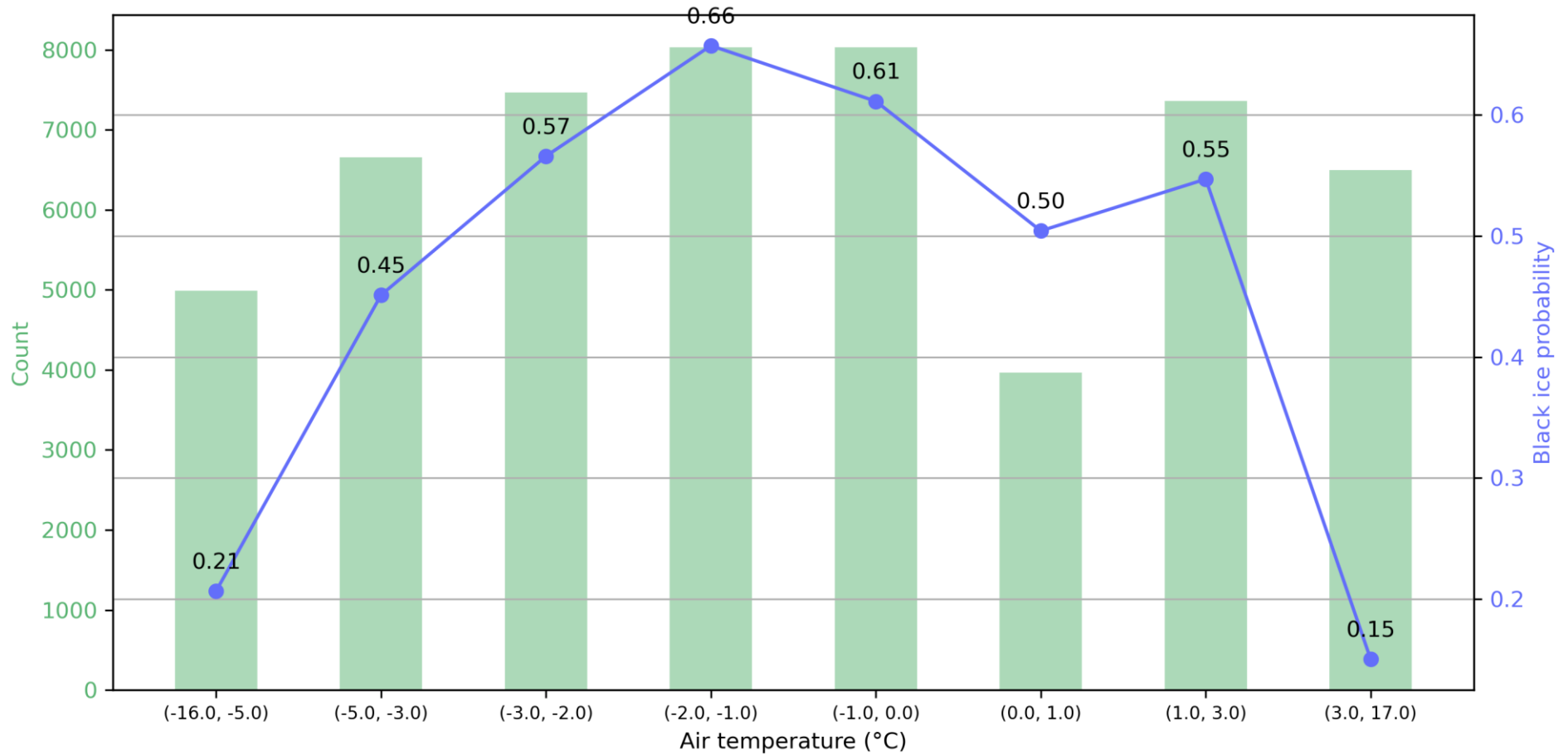
Performance



XAI (Target Plot): Relative Humidity



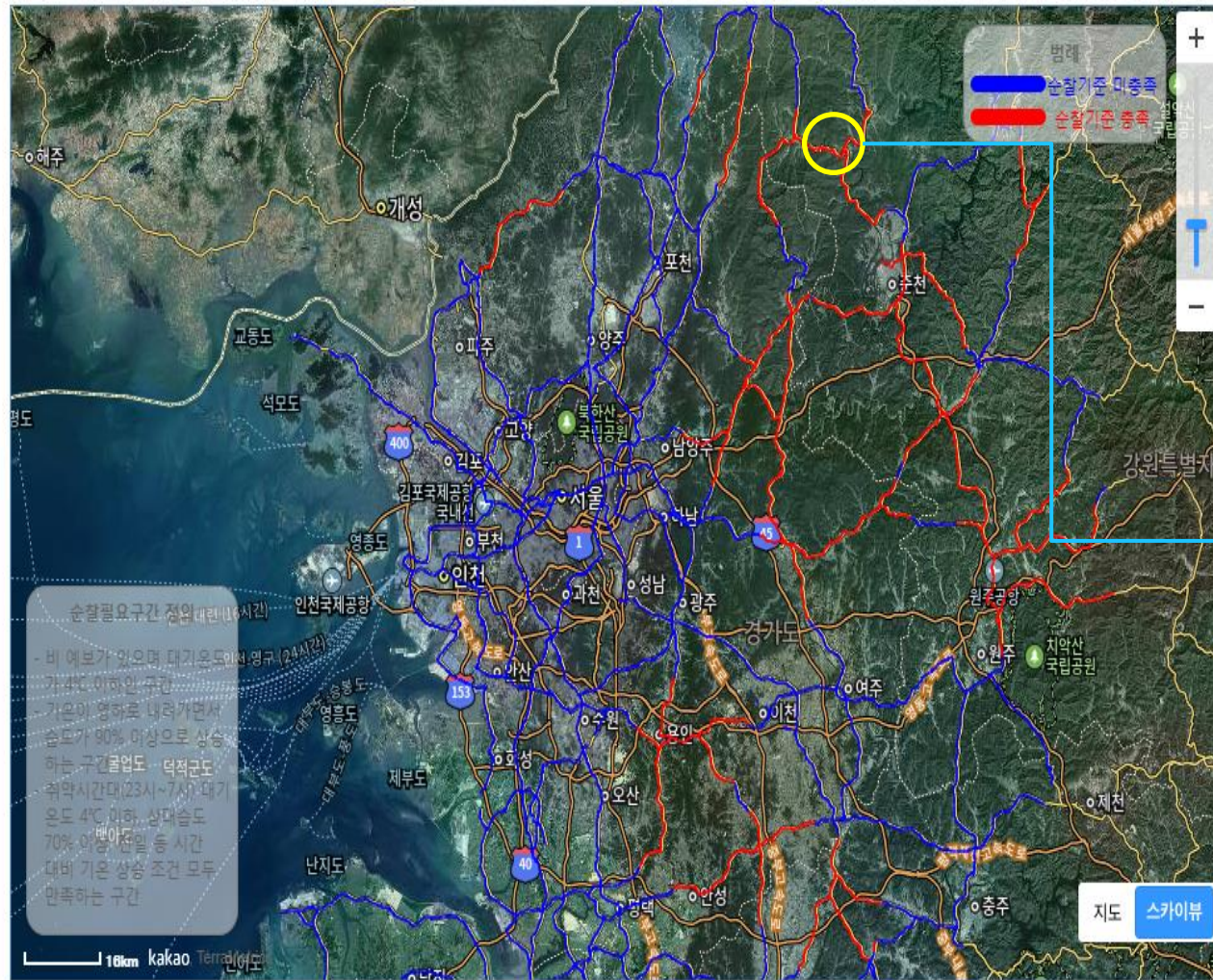
XAI (Target Plot): Air Temperature



야간순찰 필요구간 정보제공시스템

날짜 선택 : 2024-01-04

수도권



Highway Patrol (23:00 - 7:00)

Pavement Temperature Measurement

Chemical Application When Necessary

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Thank you for attention

Jinhwan Jang

jhjang@kict.re.kr