In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
from IPython import get_ipython
import warnings
warnings.filterwarnings("ignore")
```

In [2]:

```
data = pd.read_csv('rainfall_aus.csv')
```

In [3]:

```
data.head()
```

Out[3]:

	Date	Location	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustDir	WindGustS
0	01-12-2008	Albury	13.4	22.9	0.6	NaN	NaN	W	
1	02-12-2008	Albury	7.4	25.1	0.0	NaN	NaN	WNW	
2	03-12-2008	Albury	12.9	25.7	0.0	NaN	NaN	WSW	
3	04-12-2008	Albury	9.2	28.0	0.0	NaN	NaN	NE	
4	05-12-2008	Albury	17.5	32.3	1.0	NaN	NaN	W	

5 rows × 23 columns

In [4]:

```
data.tail()
```

Out[4]:

	Date	Location	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustDir	Wind
145455	21-06-2017	Uluru	2.8	23.4	0.0	NaN	NaN	E	
145456	22-06-2017	Uluru	3.6	25.3	0.0	NaN	NaN	NNW	
145457	23-06-2017	Uluru	5.4	26.9	0.0	NaN	NaN	N	
145458	24-06-2017	Uluru	7.8	27.0	0.0	NaN	NaN	SE	
145459	25-06-2017	Uluru	14.9	NaN	0.0	NaN	NaN	NaN	

5 rows × 23 columns

In [5]:

```
data.shape
```

Out[5]:

```
(145460, 23)
```

In [6]:

```
data.columns
```

Out[6]:

```
Index(['Date', 'Location', 'MinTemp', 'MaxTemp', 'Rainfall', 'Evaporatio
n',
       'Sunshine', 'WindGustDir', 'WindGustSpeed', 'WindDir9am', 'WindDir3
pm',
       'WindSpeed9am', 'WindSpeed3pm', 'Humidity9am', 'Humidity3pm',
       'Pressure9am', 'Pressure3pm', 'Cloud9am', 'Cloud3pm', 'Temp9am',
       'Temp3pm', 'RainToday', 'RainTomorrow'],
      dtype='object')
```

In [7]:

```
data.duplicated().sum()
```

Out[7]:

```
0
```

In [8]:

```
data.isnull().sum()
```

Out[8]:

```
Date                 0
Location             0
MinTemp           1485
MaxTemp           1261
Rainfall          3261
Evaporation      62790
Sunshine         69835
WindGustDir      10326
WindGustSpeed    10263
WindDir9am       10566
WindDir3pm        4228
WindSpeed9am      1767
WindSpeed3pm      3062
Humidity9am       2654
Humidity3pm       4507
Pressure9am      15065
Pressure3pm      15028
Cloud9am         55888
Cloud3pm         59358
Temp9am           1767
Temp3pm           3609
RainToday         3261
RainTomorrow      3267
dtype: int64
```

In [9]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 145460 entries, 0 to 145459
Data columns (total 23 columns):
 #   Column         Non-Null Count   Dtype  
---  ------         --------------   -----  
 0   Date           145460 non-null  object 
 1   Location       145460 non-null  object 
 2   MinTemp        143975 non-null  float64
 3   MaxTemp        144199 non-null  float64
 4   Rainfall       142199 non-null  float64
 5   Evaporation    82670 non-null   float64
 6   Sunshine       75625 non-null   float64
 7   WindGustDir    135134 non-null  object 
 8   WindGustSpeed  135197 non-null  float64
 9   WindDir9am     134894 non-null  object 
 10  WindDir3pm     141232 non-null  object 
 11  WindSpeed9am   143693 non-null  float64
 12  WindSpeed3pm   142398 non-null  float64
 13  Humidity9am    142806 non-null  float64
 14  Humidity3pm    140953 non-null  float64
 15  Pressure9am    130395 non-null  float64
 16  Pressure3pm    130432 non-null  float64
 17  Cloud9am       89572 non-null   float64
 18  Cloud3pm       86102 non-null   float64
 19  Temp9am        143693 non-null  float64
 20  Temp3pm        141851 non-null  float64
 21  RainToday      142199 non-null  object 
 22  RainTomorrow   142193 non-null  object 
dtypes: float64(16), object(7)
memory usage: 25.5+ MB
```

In [10]:

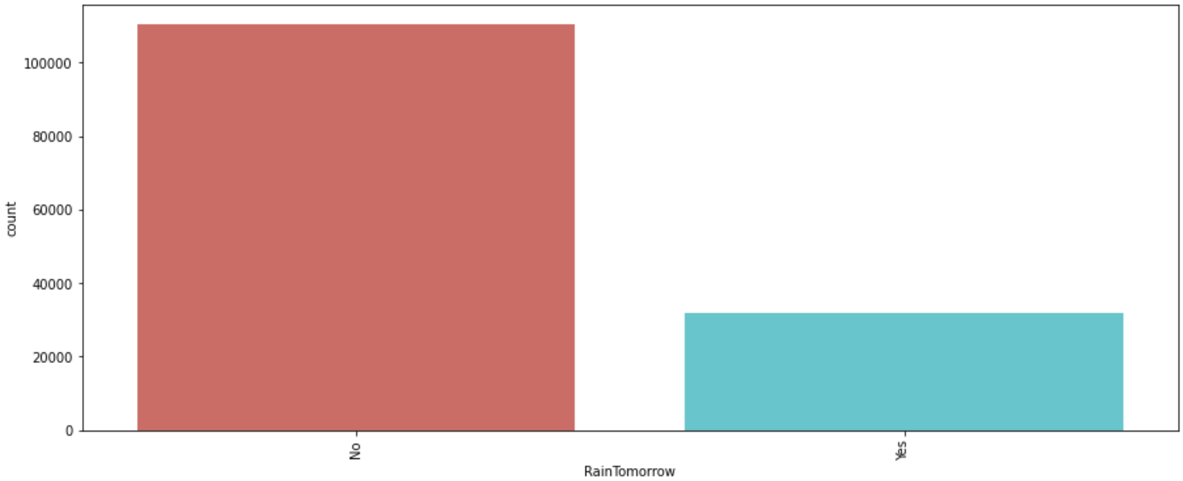
```
data.describe()
```

Out[10]:

	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustSp
count	143975.000000	144199.000000	142199.000000	82670.000000	75625.000000	135197.000
mean	12.194034	23.221348	2.360918	5.468232	7.611178	40.035
std	6.398495	7.119049	8.478060	4.193704	3.785483	13.607
min	-8.500000	-4.800000	0.000000	0.000000	0.000000	6.000
25%	7.600000	17.900000	0.000000	2.600000	4.800000	31.000
50%	12.000000	22.600000	0.000000	4.800000	8.400000	39.000
75%	16.900000	28.200000	0.800000	7.400000	10.600000	48.000
max	33.900000	48.100000	371.000000	145.000000	14.500000	135.000

In [11]:

```
plt.figure(figsize=(15,6))
sns.countplot(x= data["RainTomorrow"], data = data, palette='hls')
plt.xticks(rotation = 90)
plt.show()
```



In [13]:

```
corrmat = data.corr()
corrmat
```

Out[13]:

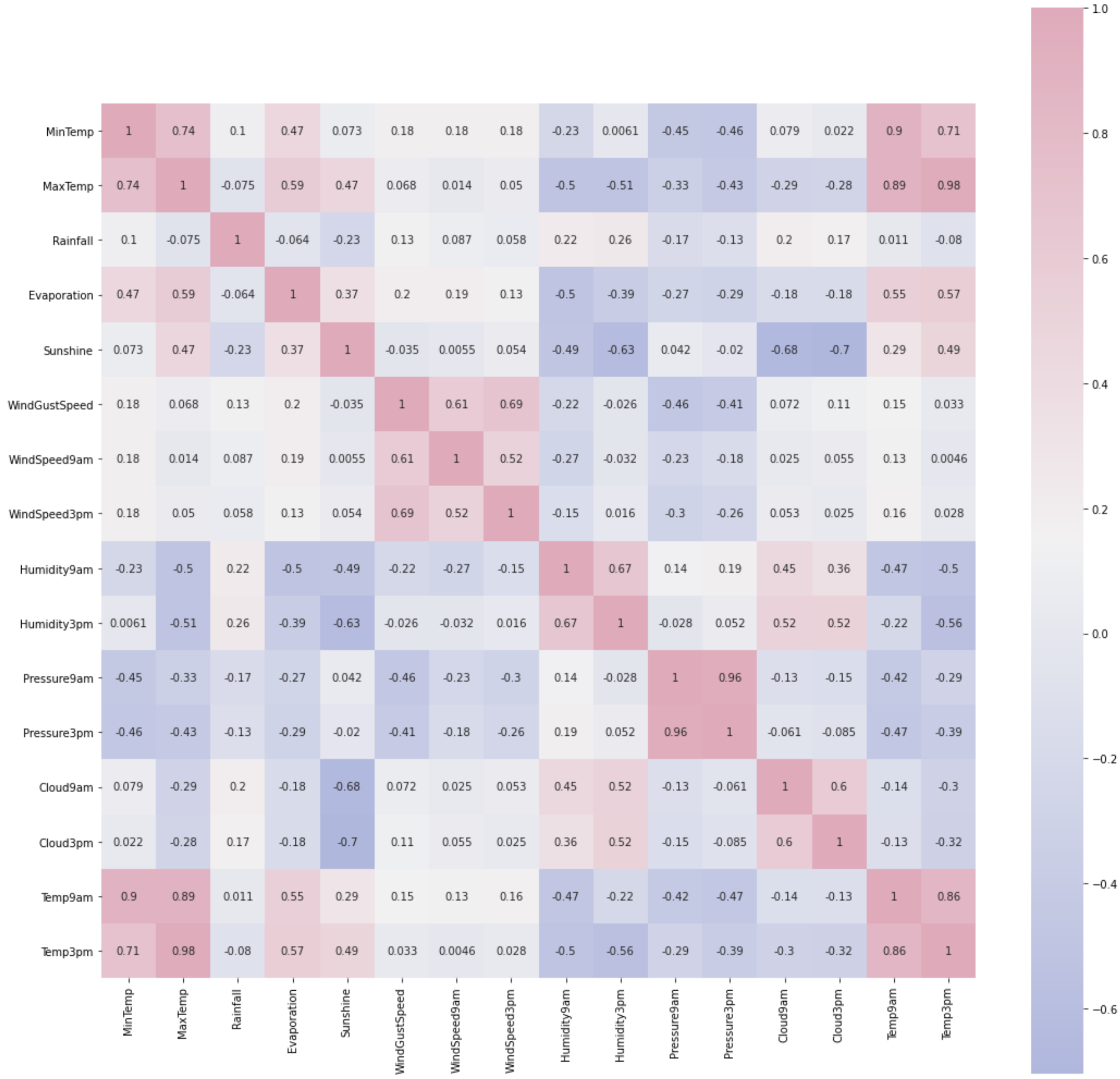
	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustSpeed	WindS
MinTemp	1.000000	0.736555	0.103938	0.466993	0.072586	0.177415	
MaxTemp	0.736555	1.000000	-0.074992	0.587932	0.470156	0.067615	
Rainfall	0.103938	-0.074992	1.000000	-0.064351	-0.227549	0.133659	
Evaporation	0.466993	0.587932	-0.064351	1.000000	0.365602	0.203021	
Sunshine	0.072586	0.470156	-0.227549	0.365602	1.000000	-0.034750	
WindGustSpeed	0.177415	0.067615	0.133659	0.203021	-0.034750	1.000000	
WindSpeed9am	0.175064	0.014450	0.087338	0.193084	0.005499	0.605303	
WindSpeed3pm	0.175173	0.050300	0.057887	0.129400	0.053834	0.686307	
Humidity9am	-0.232899	-0.504110	0.224405	-0.504092	-0.490819	-0.215070	-
Humidity3pm	0.006089	-0.508855	0.255755	-0.390243	-0.629130	-0.026327	-
Pressure9am	-0.450970	-0.332061	-0.168154	-0.270362	0.041970	-0.458744	-
Pressure3pm	-0.461292	-0.427167	-0.126534	-0.293581	-0.019719	-0.413749	-
Cloud9am	0.078754	-0.289370	0.198528	-0.183793	-0.675323	0.071736	
Cloud3pm	0.021605	-0.277921	0.172403	-0.182618	-0.703930	0.109168	
Temp9am	0.901821	0.887210	0.011192	0.545115	0.291188	0.150150	
Temp3pm	0.708906	0.984503	-0.079657	0.572893	0.490501	0.032748	

In [14]:

```python
cmap = sns.diverging_palette(260,-10,s=50, l=75, n=6, as_cmap=True)
plt.subplots(figsize=(18,18))
sns.heatmap(corrmat,cmap= cmap,annot=True, square=True)
```

Out[14]:

<AxesSubplot:>



In [15]:

```
lengths = data["Date"].str.len()
lengths.value_counts()
```

Out[15]:

```
10    145460
Name: Date, dtype: int64
```

In [16]:

```
data['Date']= pd.to_datetime(data["Date"])
data['year'] = data.Date.dt.year

def encode(data, col, max_val):
    data[col + '_sin'] = np.sin(2 * np.pi * data[col]/max_val)
    data[col + '_cos'] = np.cos(2 * np.pi * data[col]/max_val)
    return data

data['month'] = data.Date.dt.month
data = encode(data, 'month', 12)

data['day'] = data.Date.dt.day
data = encode(data, 'day', 31)

data.head()
```

Out[16]:

	Date	Location	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustDir	WindGustS
0	2008-01-12	Albury	13.4	22.9	0.6	NaN	NaN	W	
1	2008-02-12	Albury	7.4	25.1	0.0	NaN	NaN	WNW	
2	2008-03-12	Albury	12.9	25.7	0.0	NaN	NaN	WSW	
3	2008-04-12	Albury	9.2	28.0	0.0	NaN	NaN	NE	
4	2008-05-12	Albury	17.5	32.3	1.0	NaN	NaN	W	

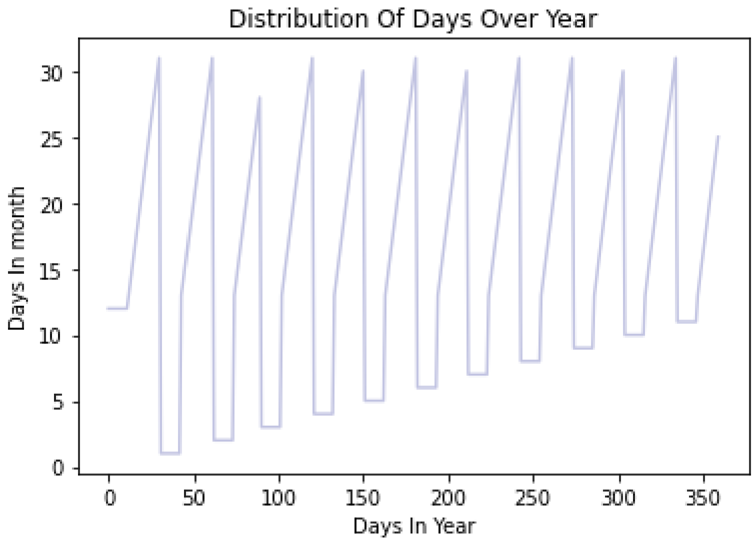
5 rows × 30 columns

In [17]:

```
section = data[:360]
tm = section["day"].plot(color="#C2C4E2")
tm.set_title("Distribution Of Days Over Year")
tm.set_ylabel("Days In month")
tm.set_xlabel("Days In Year")
```

Out[17]:

```
Text(0.5, 0, 'Days In Year')
```

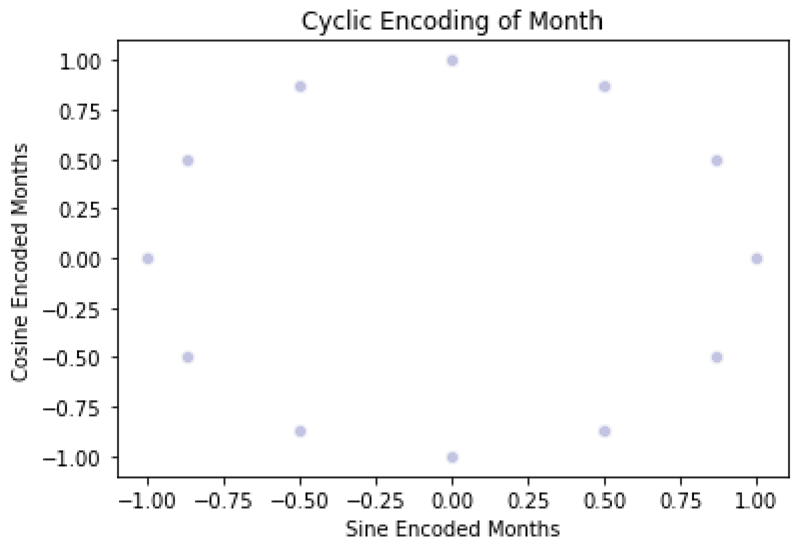


In [18]:

```
cyclic_month = sns.scatterplot(x="month_sin",y="month_cos",
                               data=data, color="#C2C4E2")
cyclic_month.set_title("Cyclic Encoding of Month")
cyclic_month.set_ylabel("Cosine Encoded Months")
cyclic_month.set_xlabel("Sine Encoded Months")
```

Out[18]:

```
Text(0.5, 0, 'Sine Encoded Months')
```

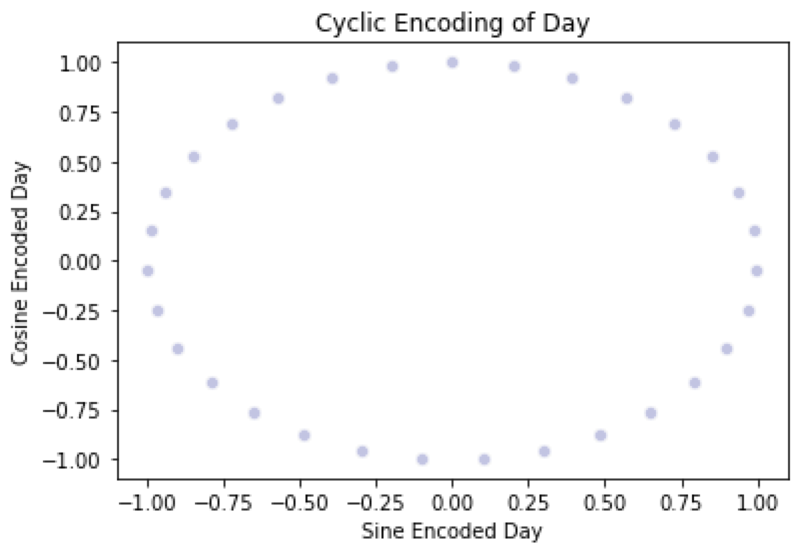


In [19]:

```
cyclic_day = sns.scatterplot(x='day_sin',y='day_cos',data=data,
                             color="#C2C4E2")
cyclic_day.set_title("Cyclic Encoding of Day")
cyclic_day.set_ylabel("Cosine Encoded Day")
cyclic_day.set_xlabel("Sine Encoded Day")
```

Out[19]:

```
Text(0.5, 0, 'Sine Encoded Day')
```



In [20]:

```
s = (data.dtypes == "object")
object_cols = list(s[s].index)

print("Categorical variables:")
print(object_cols)
```

```
Categorical variables:
['Location', 'WindGustDir', 'WindDir9am', 'WindDir3pm', 'RainToday', 'Rain
Tomorrow']
```

In [21]:

```
for i in object_cols:
    print(i, data[i].isnull().sum())
```

```
Location 0
WindGustDir 10326
WindDir9am 10566
WindDir3pm 4228
RainToday 3261
RainTomorrow 3267
```

In [22]:

```
for i in object_cols:
    data[i].fillna(data[i].mode()[0], inplace=True)
```

In [23]:

```
t = (data.dtypes == "float64")
num_cols = list(t[t].index)

print("Neumeric variables:")
print(num_cols)
```

```
Neumeric variables:
['MinTemp', 'MaxTemp', 'Rainfall', 'Evaporation', 'Sunshine', 'WindGustSpe
ed', 'WindSpeed9am', 'WindSpeed3pm', 'Humidity9am', 'Humidity3pm', 'Pressu
re9am', 'Pressure3pm', 'Cloud9am', 'Cloud3pm', 'Temp9am', 'Temp3pm', 'mont
h_sin', 'month_cos', 'day_sin', 'day_cos']
```

In [24]:

```
for i in num_cols:
    print(i, data[i].isnull().sum())
```

```
MinTemp 1485
MaxTemp 1261
Rainfall 3261
Evaporation 62790
Sunshine 69835
WindGustSpeed 10263
WindSpeed9am 1767
WindSpeed3pm 3062
Humidity9am 2654
Humidity3pm 4507
Pressure9am 15065
Pressure3pm 15028
Cloud9am 55888
Cloud3pm 59358
Temp9am 1767
Temp3pm 3609
month_sin 0
month_cos 0
day_sin 0
day_cos 0
```

In [25]:

```
for i in num_cols:
    data[i].fillna(data[i].median(), inplace=True)

data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 145460 entries, 0 to 145459
Data columns (total 30 columns):
 #   Column         Non-Null Count   Dtype
---  ------         --------------   -----
 0   Date           145460 non-null  datetime64[ns]
 1   Location       145460 non-null  object
 2   MinTemp        145460 non-null  float64
 3   MaxTemp        145460 non-null  float64
 4   Rainfall       145460 non-null  float64
 5   Evaporation    145460 non-null  float64
 6   Sunshine       145460 non-null  float64
 7   WindGustDir    145460 non-null  object
 8   WindGustSpeed  145460 non-null  float64
 9   WindDir9am     145460 non-null  object
 10  WindDir3pm     145460 non-null  object
 11  WindSpeed9am   145460 non-null  float64
 12  WindSpeed3pm   145460 non-null  float64
 13  Humidity9am    145460 non-null  float64
 14  Humidity3pm    145460 non-null  float64
 15  Pressure9am    145460 non-null  float64
 16  Pressure3pm    145460 non-null  float64
 17  Cloud9am       145460 non-null  float64
 18  Cloud3pm       145460 non-null  float64
 19  Temp9am        145460 non-null  float64
 20  Temp3pm        145460 non-null  float64
 21  RainToday      145460 non-null  object
 22  RainTomorrow   145460 non-null  object
 23  year           145460 non-null  int64
 24  month          145460 non-null  int64
 25  month_sin      145460 non-null  float64
 26  month_cos      145460 non-null  float64
 27  day            145460 non-null  int64
 28  day_sin        145460 non-null  float64
 29  day_cos        145460 non-null  float64
dtypes: datetime64[ns](1), float64(20), int64(3), object(6)
memory usage: 33.3+ MB
```

In [27]:

```
import datetime
from sklearn.preprocessing import LabelEncoder
from sklearn import preprocessing
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from keras.layers import Dense, BatchNormalization, Dropout, LSTM
from keras.models import Sequential
from keras.utils import to_categorical
from keras.optimizers import Adam
from tensorflow.keras import regularizers
from sklearn.metrics import precision_score, recall_score, confusion_matrix, classi
from keras import callbacks
```

In [28]:

```
label_encoder = LabelEncoder()
for i in object_cols:
    data[i] = label_encoder.fit_transform(data[i])

data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 145460 entries, 0 to 145459
Data columns (total 30 columns):
 #   Column         Non-Null Count   Dtype
---  ------         --------------   -----
 0   Date           145460 non-null  datetime64[ns]
 1   Location       145460 non-null  int32
 2   MinTemp        145460 non-null  float64
 3   MaxTemp        145460 non-null  float64
 4   Rainfall       145460 non-null  float64
 5   Evaporation    145460 non-null  float64
 6   Sunshine       145460 non-null  float64
 7   WindGustDir    145460 non-null  int32
 8   WindGustSpeed  145460 non-null  float64
 9   WindDir9am     145460 non-null  int32
 10  WindDir3pm     145460 non-null  int32
 11  WindSpeed9am   145460 non-null  float64
 12  WindSpeed3pm   145460 non-null  float64
 13  Humidity9am    145460 non-null  float64
 14  Humidity3pm    145460 non-null  float64
 15  Pressure9am    145460 non-null  float64
 16  Pressure3pm    145460 non-null  float64
 17  Cloud9am       145460 non-null  float64
 18  Cloud3pm       145460 non-null  float64
 19  Temp9am        145460 non-null  float64
 20  Temp3pm        145460 non-null  float64
 21  RainToday      145460 non-null  int32
 22  RainTomorrow   145460 non-null  int32
 23  year           145460 non-null  int64
 24  month          145460 non-null  int64
 25  month_sin      145460 non-null  float64
 26  month_cos      145460 non-null  float64
 27  day            145460 non-null  int64
 28  day_sin        145460 non-null  float64
 29  day_cos        145460 non-null  float64
dtypes: datetime64[ns](1), float64(20), int32(6), int64(3)
memory usage: 30.0 MB
```

In [29]:

```
features = data.drop(['RainTomorrow', 'Date','day', 'month'], axis=1) # dropping ta

target = data['RainTomorrow']

col_names = list(features.columns)
s_scaler = preprocessing.StandardScaler()
features = s_scaler.fit_transform(features)
features = pd.DataFrame(features, columns=col_names)

features.describe().T
```

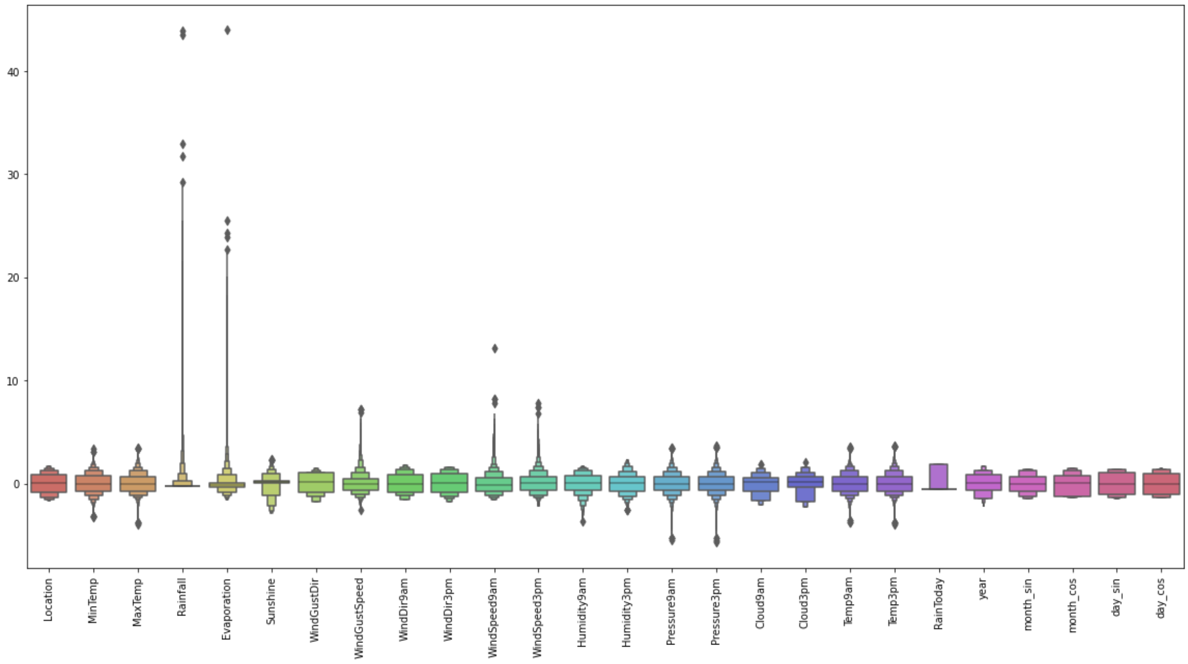
Out[29]:

	count	mean	std	min	25%	50%	75%
Location	145460.0	7.815677e-18	1.000003	-1.672228	-0.899139	0.014511	0.857881
MinTemp	145460.0	-4.501830e-16	1.000003	-3.250525	-0.705659	-0.030170	0.723865
MaxTemp	145460.0	3.001220e-16	1.000003	-3.952405	-0.735852	-0.086898	0.703133
Rainfall	145460.0	7.815677e-18	1.000003	-0.275097	-0.275097	-0.275097	-0.203581
Evaporation	145460.0	-3.282584e-17	1.000003	-1.629472	-0.371139	-0.119472	0.006361
Sunshine	145460.0	-5.424080e-16	1.000003	-2.897217	0.076188	0.148710	0.257494
WindGustDir	145460.0	6.252542e-18	1.000003	-1.724209	-0.872075	0.193094	1.045228
WindGustSpeed	145460.0	1.824961e-16	1.000003	-2.588407	-0.683048	-0.073333	0.460168
WindDir9am	145460.0	7.190423e-17	1.000003	-1.550000	-0.885669	0.000105	0.885879
WindDir3pm	145460.0	8.284618e-17	1.000003	-1.718521	-0.837098	0.044324	0.925747
WindSpeed9am	145460.0	5.627287e-17	1.000003	-1.583291	-0.793380	-0.116314	0.560752
WindSpeed3pm	145460.0	6.565169e-17	1.000003	-2.141841	-0.650449	0.037886	0.611499
Humidity9am	145460.0	2.250915e-16	1.000003	-3.654212	-0.631189	0.058273	0.747734
Humidity3pm	145460.0	-8.440931e-17	1.000003	-2.518329	-0.710918	0.021816	0.656852
Pressure9am	145460.0	-4.314254e-16	1.000003	-5.520544	-0.616005	-0.006653	0.617561
Pressure3pm	145460.0	5.027043e-15	1.000003	-5.724832	-0.622769	-0.007520	0.622735
Cloud9am	145460.0	-1.016038e-16	1.000003	-2.042425	-0.727490	0.149133	0.587445

	count	mean	std	min	25%	50%	75%
Cloud3pm	145460.0	7.346736e-17	1.000003	-2.235619	-0.336969	0.137693	0.612356
Temp9am	145460.0	7.503050e-17	1.000003	-3.750358	-0.726764	-0.044517	0.699753
Temp3pm	145460.0	-6.877796e-17	1.000003	-3.951301	-0.725322	-0.083046	0.661411
RainToday	145460.0	-8.988029e-18	1.000003	-0.529795	-0.529795	-0.529795	-0.529795
year	145460.0	2.080221e-14	1.000003	-2.273637	-0.697391	0.090732	0.878855
month_sin	145460.0	-8.011069e-18	1.000003	-1.424382	-0.715973	-0.007564	0.700845
month_cos	145460.0	9.735403e-17	1.000003	-1.397692	-1.208546	0.014112	0.720014
day_sin	145460.0	-2.165187e-17	1.000003	-1.403031	-1.018734	-0.001896	1.014942
day_cos	145460.0	6.375883e-17	1.000003	-1.402828	-1.066146	-0.056419	0.998236

In [30]:

```
plt.figure(figsize=(20,10))
sns.boxenplot(data = features, palette = 'hls')
plt.xticks(rotation=90)
plt.show()
```



In [31]:

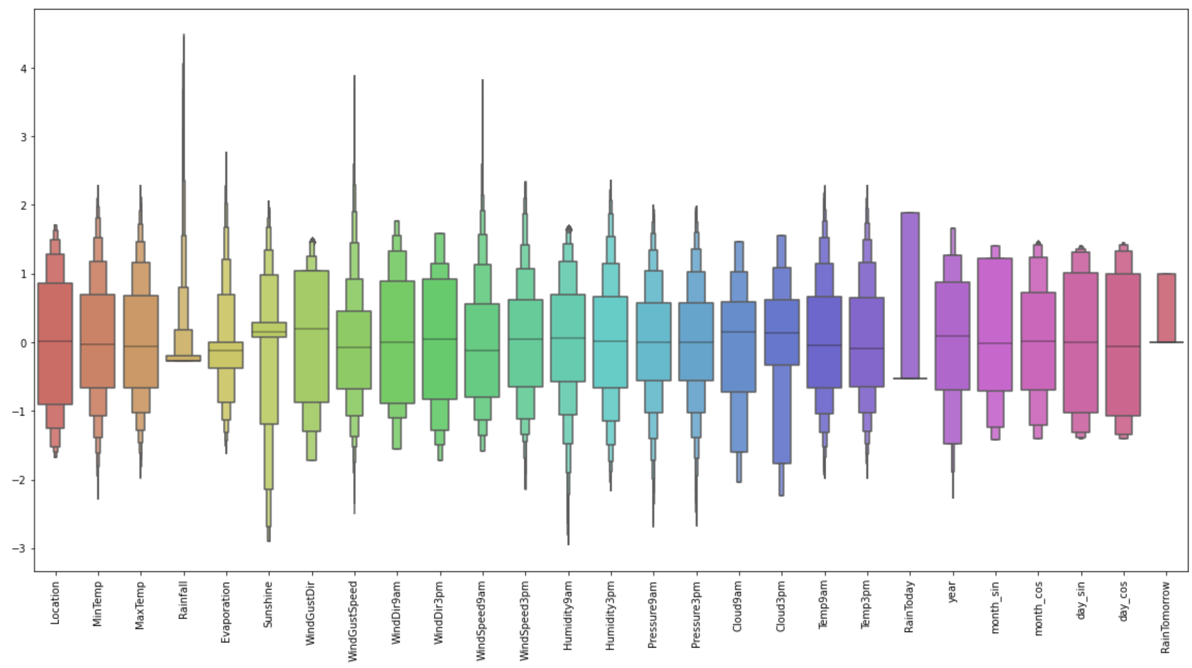
```
 features["RainTomorrow"] = target

features = features[(features["MinTemp"]<2.3)&(features["MinTemp"]>-2.3)]
features = features[(features["MaxTemp"]<2.3)&(features["MaxTemp"]>-2)]
features = features[(features["Rainfall"]<4.5)]
features = features[(features["Evaporation"]<2.8)]
features = features[(features["Sunshine"]<2.1)]
features = features[(features["WindGustSpeed"]<4)&(features["WindGustSpeed"]>-4)]
features = features[(features["WindSpeed9am"]<4)]
features = features[(features["WindSpeed3pm"]<2.5)]
features = features[(features["Humidity9am"]>-3)]
features = features[(features["Humidity3pm"]>-2.2)]
features = features[(features["Pressure9am"]< 2)&(features["Pressure9am"]>-2.7)]
features = features[(features["Pressure3pm"]< 2)&(features["Pressure3pm"]>-2.7)]
features = features[(features["Cloud9am"]<1.8)]
features = features[(features["Cloud3pm"]<2)]
features = features[(features["Temp9am"]<2.3)&(features["Temp9am"]>-2)]
features = features[(features["Temp3pm"]<2.3)&(features["Temp3pm"]>-2)]

features.shape
```

Out[31]:

(127536, 27)

In [32]:

```
plt.figure(figsize=(20,10))
sns.boxenplot(data = features,palette = 'hls')
plt.xticks(rotation=90)
plt.show()
```



In [33]:

```
X = features.drop(["RainTomorrow"], axis=1)
y = features["RainTomorrow"]

X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size = 0.2,
                                                    random_state = 42)

X.shape
```

Out[33]:

```
(127536, 26)
```

In [34]:

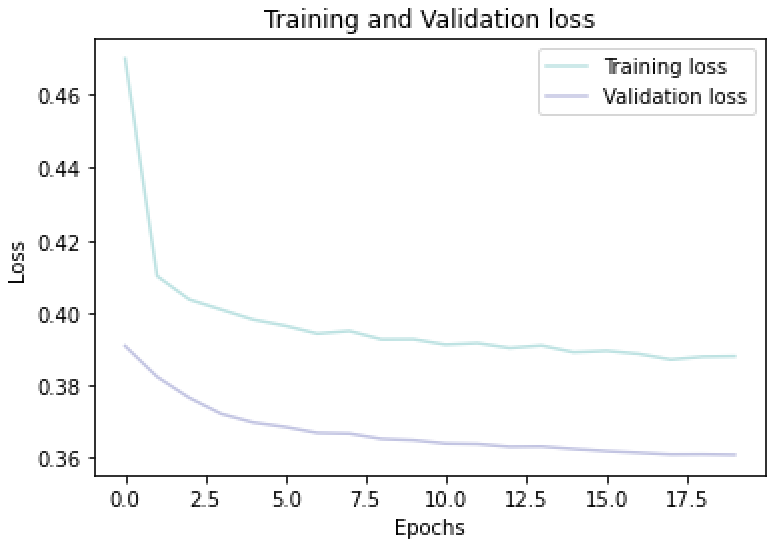
```
early_stopping = callbacks.EarlyStopping(
    min_delta=0.001,
    patience=20,
    restore_best_weights=True,
)

model = Sequential()

model.add(Dense(units = 32, kernel_initializer = 'uniform', activation = 'relu', in
model.add(Dense(units = 32, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dense(units = 16, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dropout(0.25))
model.add(Dense(units = 8, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dropout(0.5))
model.add(Dense(units = 1, kernel_initializer = 'uniform', activation = 'sigmoid'))

opt = Adam(learning_rate=0.00009)
model.compile(optimizer = opt, loss = 'binary_crossentropy', metrics = ['accuracy']

history = model.fit(X_train, y_train, batch_size = 32,
                    epochs = 20, callbacks=[early_stopping],
                    validation_split=0.2)
```

```
Epoch 1/20
2551/2551 [==============================] - 5s 2ms/step - loss: 0.4700 -
accuracy: 0.7841 - val_loss: 0.3908 - val_accuracy: 0.7860
Epoch 2/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.4101 -
accuracy: 0.8106 - val_loss: 0.3823 - val_accuracy: 0.8413
Epoch 3/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.4037 -
accuracy: 0.8120 - val_loss: 0.3765 - val_accuracy: 0.8424
Epoch 4/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.4009 -
accuracy: 0.8131 - val_loss: 0.3721 - val_accuracy: 0.8437
Epoch 5/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3981 -
accuracy: 0.8131 - val_loss: 0.3697 - val_accuracy: 0.8450
Epoch 6/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3964 -
accuracy: 0.8148 - val_loss: 0.3685 - val_accuracy: 0.8450
Epoch 7/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3942 -
accuracy: 0.8163 - val_loss: 0.3668 - val_accuracy: 0.8451
Epoch 8/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3950 -
accuracy: 0.8140 - val_loss: 0.3666 - val_accuracy: 0.8448
Epoch 9/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3927 -
accuracy: 0.8157 - val_loss: 0.3652 - val_accuracy: 0.8456
Epoch 10/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3927 -
accuracy: 0.8145 - val_loss: 0.3648 - val_accuracy: 0.8463
Epoch 11/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3912 -
accuracy: 0.8177 - val_loss: 0.3639 - val_accuracy: 0.8464
Epoch 12/20
```

```
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3916 -
accuracy: 0.8163 - val_loss: 0.3638 - val_accuracy: 0.8455
Epoch 13/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3903 -
accuracy: 0.8170 - val_loss: 0.3630 - val_accuracy: 0.8459
Epoch 14/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3910 -
accuracy: 0.8156 - val_loss: 0.3631 - val_accuracy: 0.8452
Epoch 15/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3891 -
accuracy: 0.8163 - val_loss: 0.3624 - val_accuracy: 0.8449
Epoch 16/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3895 -
accuracy: 0.8164 - val_loss: 0.3618 - val_accuracy: 0.8455
Epoch 17/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3886 -
accuracy: 0.8169 - val_loss: 0.3613 - val_accuracy: 0.8458
Epoch 18/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3871 -
accuracy: 0.8182 - val_loss: 0.3609 - val_accuracy: 0.8450
Epoch 19/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3879 -
accuracy: 0.8172 - val_loss: 0.3609 - val_accuracy: 0.8450
Epoch 20/20
2551/2551 [==============================] - 4s 2ms/step - loss: 0.3880 -
accuracy: 0.8170 - val_loss: 0.3608 - val_accuracy: 0.8444
```

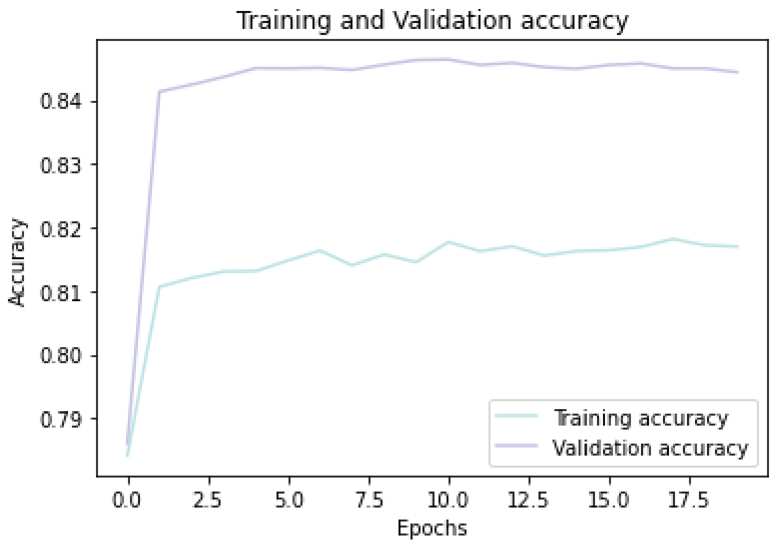
In [35]:

```python
history_df = pd.DataFrame(history.history)

plt.plot(history_df.loc[:, ['loss']], "#BDE2E2", label='Training loss')
plt.plot(history_df.loc[:, ['val_loss']],"#C2C4E2", label='Validation loss')
plt.title('Training and Validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend(loc="best")

plt.show()
```



In [36]:

```
history_df = pd.DataFrame(history.history)

plt.plot(history_df.loc[:, ['accuracy']], "#BDE2E2", label='Training accuracy')
plt.plot(history_df.loc[:, ['val_accuracy']], "#C2C4E2", label='Validation accuracy

plt.title('Training and Validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



In [37]:

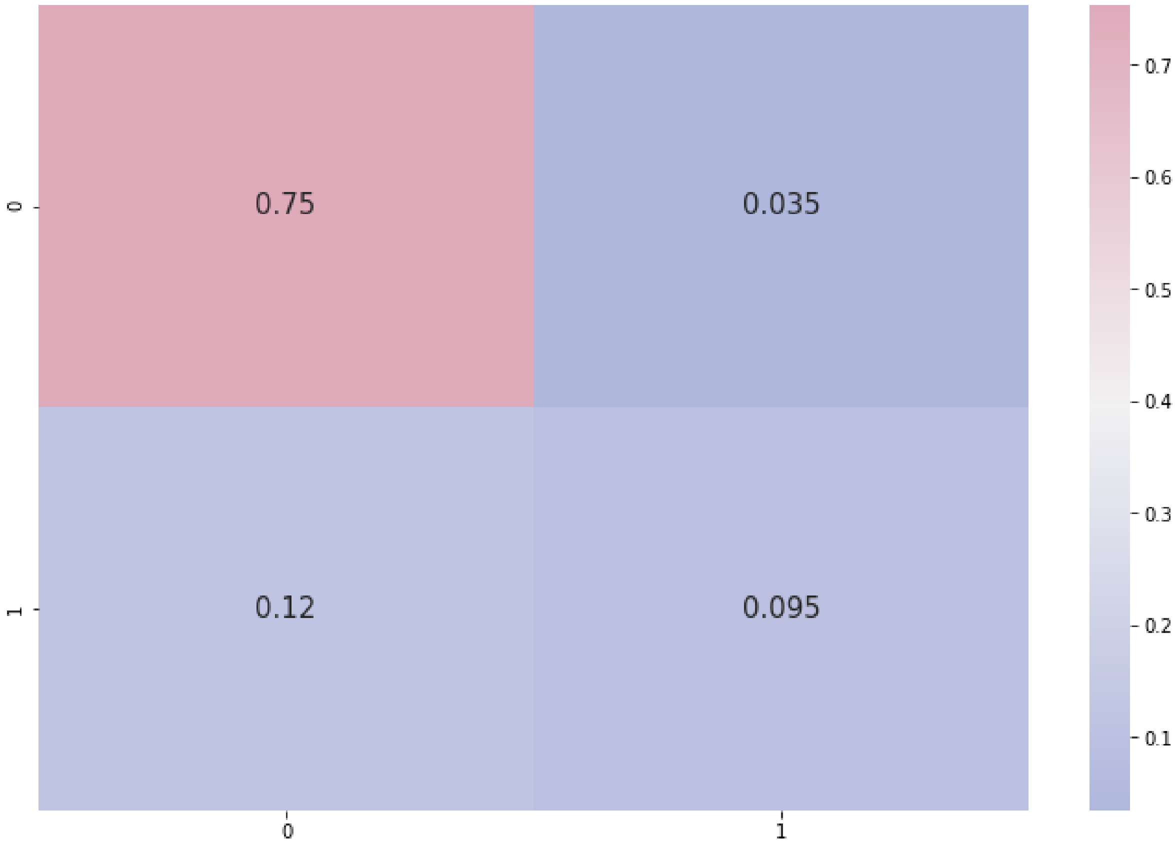
```
y_pred = model.predict(X_test)
y_pred = (y_pred > 0.5)
```

In [38]:

```
cmap1 = sns.diverging_palette(260,-10,s=50, l=75, n=5, as_cmap=True)
plt.subplots(figsize=(12,8))
cf_matrix = confusion_matrix(y_test, y_pred)
sns.heatmap(cf_matrix/np.sum(cf_matrix), cmap = cmap1, annot = True,
            annot_kws = {'size':15})
```

Out[38]:

```
<AxesSubplot:>
```



In [39]:

```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.87      0.96      0.91     20110
           1       0.73      0.45      0.56      5398

    accuracy                           0.85     25508
   macro avg       0.80      0.70      0.73     25508
weighted avg       0.84      0.85      0.83     25508
```