HMM for Weather Prediction

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
from hmmlearn import hmm
from sklearn.preprocessing import KBinsDiscretizer
from sklearn.metrics import confusion_matrix
import seaborn as sns

import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)
```

In [2]:
```
# ========== Data Generation ==========
# Define states and parameters
states = ["Sunny", "Cloudy", "Rainy"]
n_states = len(states)
```

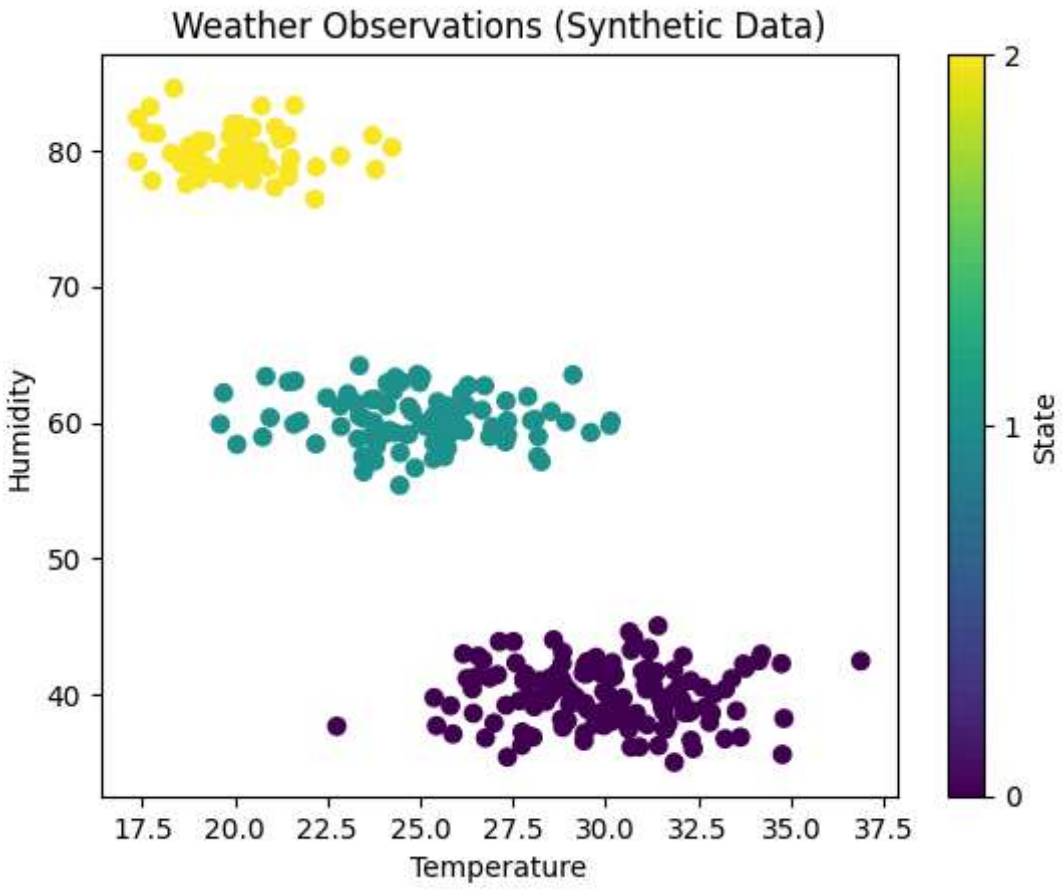
In [3]:
```
# Emission parameters (means and covariances)
means = np.array([
    [30, 40],  # Sunny
    [25, 60],  # Cloudy
    [20, 80]   # Rainy
])

covars = np.array([
    [[5, 0], [0, 5]],   # Sunny
    [[4, 0], [0, 4]],   # Cloudy
    [[3, 0], [0, 3]]    # Rainy
])
```

In [4]:
```
# Generate synthetic data
np.random.seed(42)
n_samples = 300
hidden_states = np.random.choice(n_states, size=n_samples, p=[0.5, 0.3, 0.2])

observations = np.array([
    np.random.multivariate_normal(means[state], covars[state])
    for state in hidden_states
])
```

In [5]:
```
# Plot the generated observations
plt.scatter(observations[:, 0], observations[:, 1], c=hidden_states, cmap='viridis')
plt.xlabel("Temperature")
plt.ylabel("Humidity")
plt.title("Weather Observations (Synthetic Data)")
plt.colorbar(ticks=[0, 1, 2], label='State')
plt.show()
```



In [6]:
```
# ========== Discrete HMM ==========
# Discretizing the continuous observations into bins
discretizer = KBinsDiscretizer(n_bins=3, encode='ordinal', strategy='uniform')
X_discrete = discretizer.fit_transform(observations).astype(int)
```

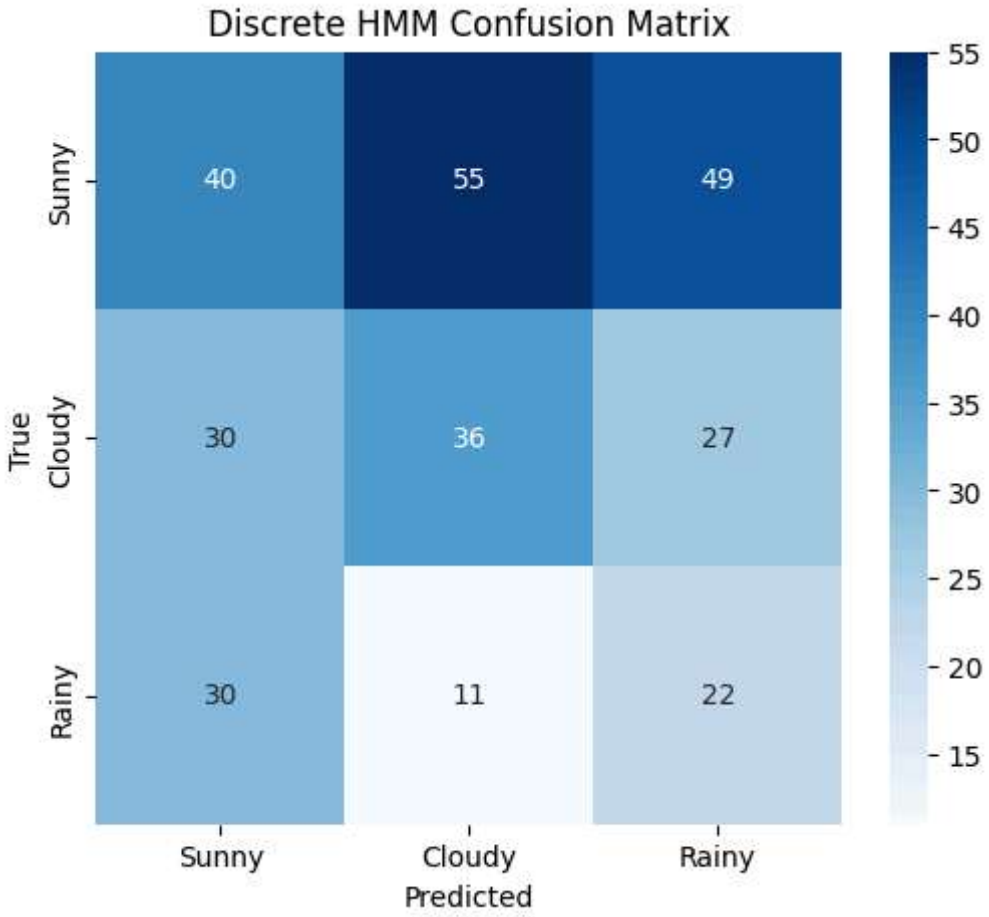
In [7]:
```
# Reshape for hmmlearn input
X_discrete_seq = X_discrete[:, 0].reshape(-1, 1)


hmm_discrete = hmm.CategoricalHMM(n_components=n_states, n_iter=100)
hmm_discrete.fit(X_discrete_seq)
hidden_preds_discrete = hmm_discrete.predict(X_discrete_seq)
```

In [8]:
```
# Accuracy and confusion matrix for Discrete HMM
accuracy_discrete = np.mean(hidden_preds_discrete == hidden_states)
print(f"Discrete HMM Accuracy: {accuracy_discrete:.2f}")
```

```
Discrete HMM Accuracy: 0.33
```

In [9]:
```
plt.figure(figsize=(6, 5))
sns.heatmap(confusion_matrix(hidden_states, hidden_preds_discrete),
            annot=True, fmt='d', cmap='Blues',
            xticklabels=states, yticklabels=states)
plt.title("Discrete HMM Confusion Matrix")
plt.xlabel("Predicted")
plt.ylabel("True")
plt.show()
```

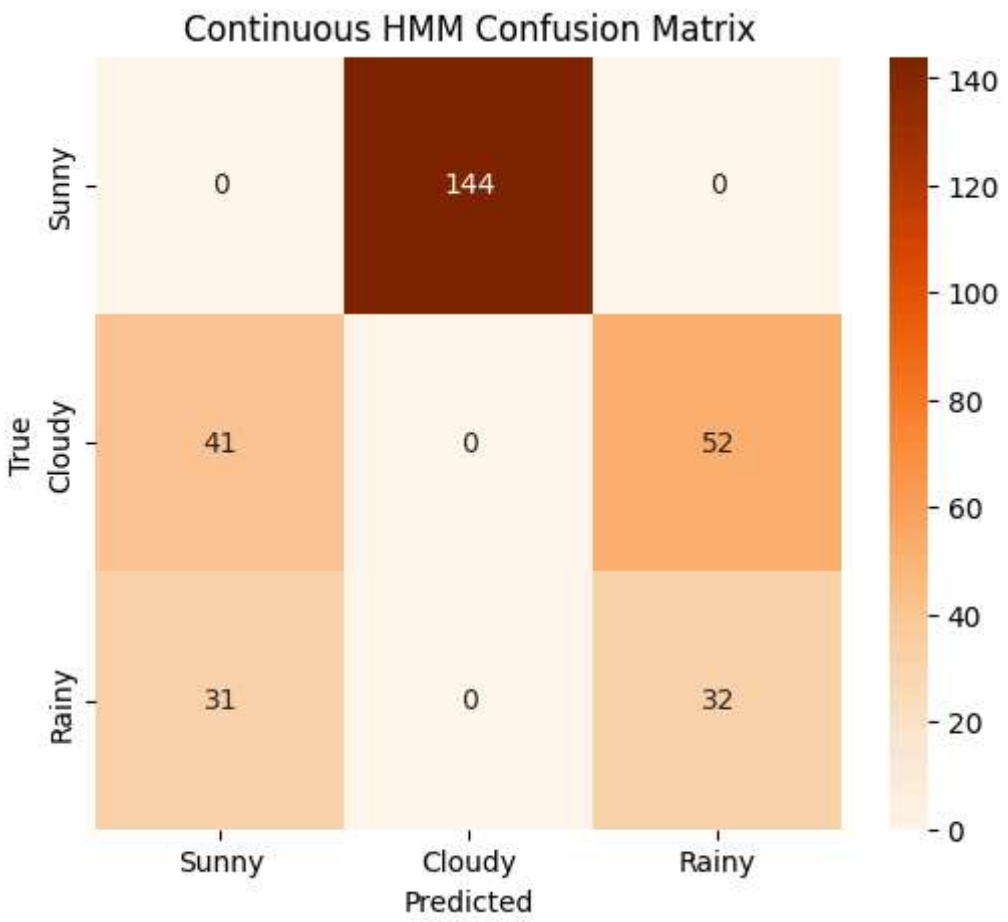


In [10]:
```
# ========== Continuous HMM ==========
hmm_continuous = hmm.GaussianHMM(n_components=n_states, covariance_type="full", n_iter=100)
hmm_continuous.fit(observations)
hidden_preds_continuous = hmm_continuous.predict(observations)
```

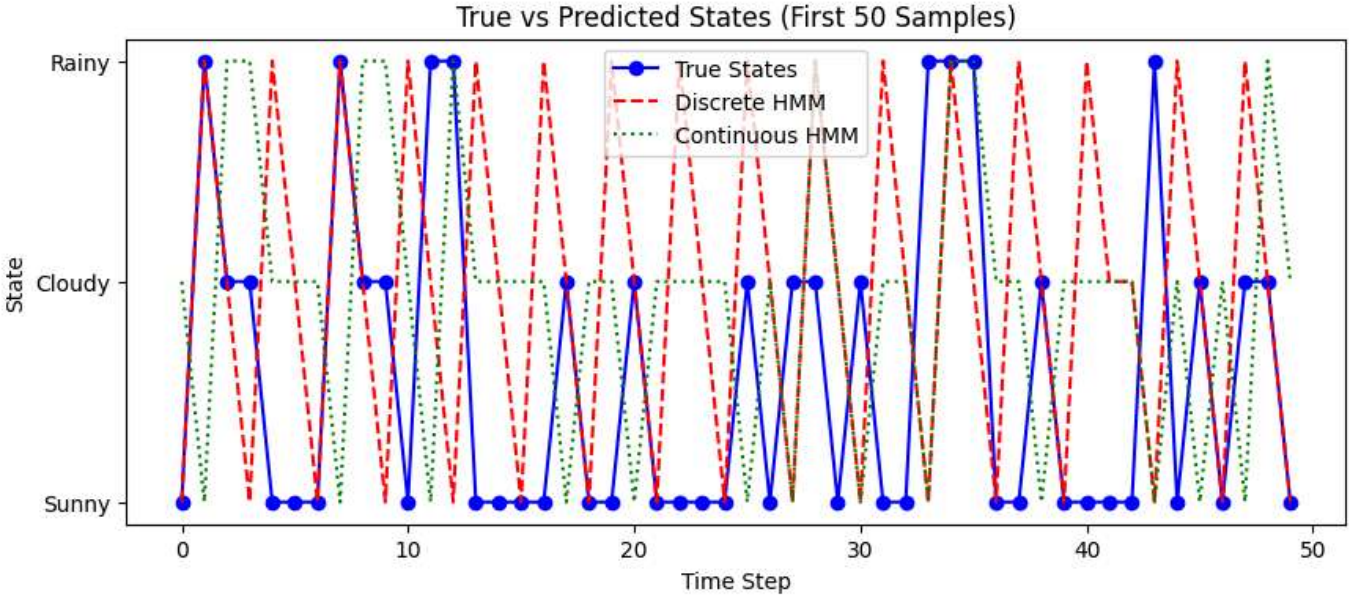
In [11]:
```
# Accuracy and confusion matrix for Continuous HMM
accuracy_continuous = np.mean(hidden_preds_continuous == hidden_states)
print(f"Continuous HMM Accuracy: {accuracy_continuous:.2f}")
```

```
Continuous HMM Accuracy: 0.11
```

In [12]:
```
plt.figure(figsize=(6, 5))
sns.heatmap(confusion_matrix(hidden_states, hidden_preds_continuous),
            annot=True, fmt='d', cmap='Oranges',
            xticklabels=states, yticklabels=states)
plt.title("Continuous HMM Confusion Matrix")
plt.xlabel("Predicted")
plt.ylabel("True")
plt.show()
```

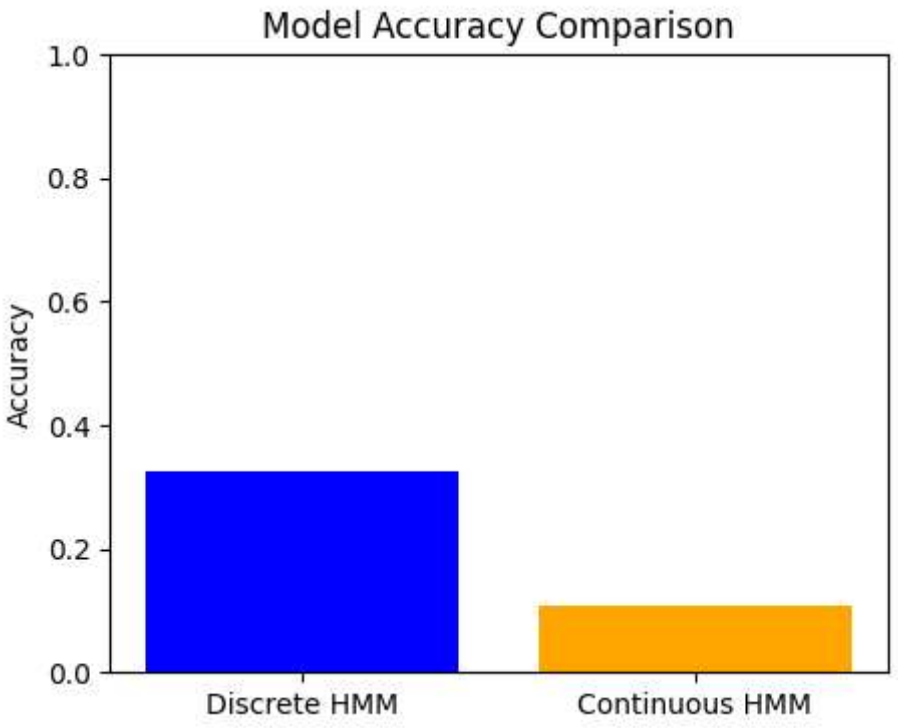


In [13]:
```
# ========== Visual Comparison ==========
plt.figure(figsize=(10, 4))
plt.plot(hidden_states[:50], 'bo-', label="True States")
plt.plot(hidden_preds_discrete[:50], 'r--', label="Discrete HMM")
plt.plot(hidden_preds_continuous[:50], 'g:', label="Continuous HMM")
plt.legend()
plt.xlabel("Time Step")
plt.ylabel("State")
plt.title("True vs Predicted States (First 50 Samples)")
plt.yticks([0, 1, 2], states)
plt.show()
```



In [14]:
```
# Accuracy Comparison Bar Plot
plt.figure(figsize=(5, 4))
plt.bar(['Discrete HMM', 'Continuous HMM'], [accuracy_discrete, accuracy_continuous],
        color=['blue', 'orange'])
```

```
plt.title('Model Accuracy Comparison')
plt.ylabel('Accuracy')
plt.ylim(0, 1)
plt.show()
```



In [ ]: