Experiment: Smoothing and Trend Removal in Ozone Hole Data

1. Importing Necessary Libraries

In this section, we import essential Python libraries for handling time series data, visualization, and applying smoothing techniques such as moving averages and exponential smoothing.

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from statsmodels.tsa.seasonal import seasonal_decompose
from statsmodels.tsa.holtwinters import ExponentialSmoothing
```

2. Loading the Dataset

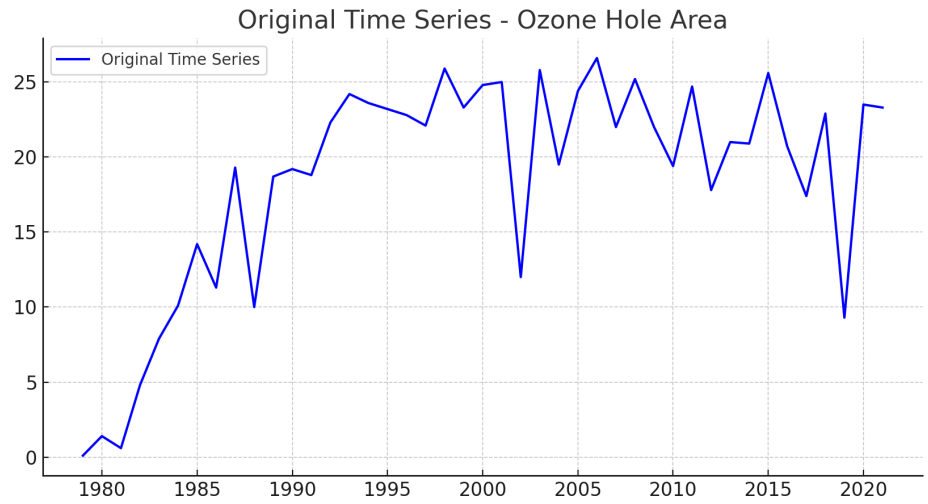
The dataset contains yearly observations of the ozone hole area. We load it into a pandas DataFrame, convert 'Year' into a datetime format, and set it as the index for time series operations.

```
ozone_df = pd.read_csv('/mnt/data/OzoneHole_Data.csv')
ozone_df['Year'] = pd.to_datetime(ozone_df['Year'], format='%Y')
ozone_df.set_index('Year', inplace=True)
```

3. Plotting the Original Time Series

We visualize the original time series to observe the variations in the ozone hole area over time.

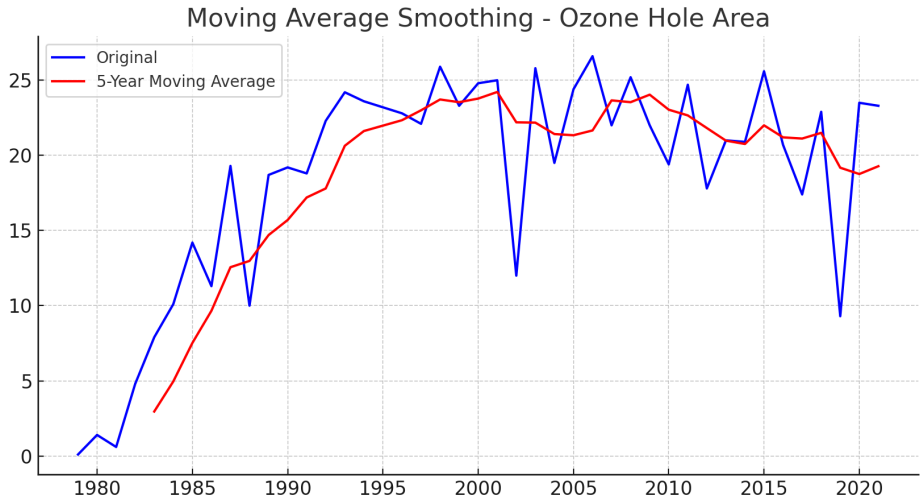
```
plt.figure(figsize=(10, 5))
plt.plot(ozone_df['Hole Area'], label='Original Time Series', color='blue')
plt.title('Original Time Series - Ozone Hole Area')
plt.legend()
plt.show()
```



4. Moving Average Smoothing

A moving average with a window of 5 years is applied to smooth fluctuations and highlight underlying trends in the ozone hole area measurements.

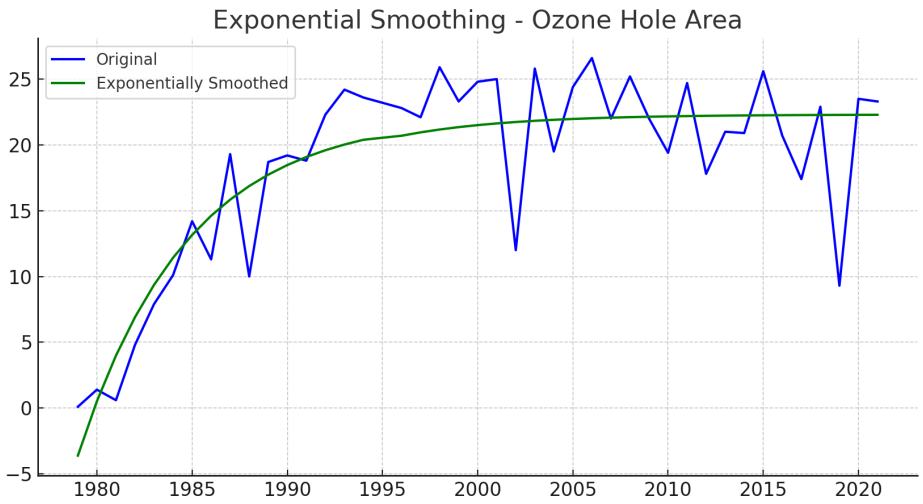
```
window_size = 5
rolling_mean = ozone_df['Hole Area'].rolling(window=window_size).mean()
```



5. Exponential Smoothing

Exponential smoothing applies weighted averages where more recent observations have higher influence. This method captures trends while keeping responsiveness to changes.

```
exp_smooth = ExponentialSmoothing(ozone_df['Hole Area'], trend='add', seasonal=None, damped_trend=True).fit()
ozone_df['Smoothed'] = exp_smooth.fittedvalues
```



6. Trend Extraction using Seasonal Decomposition

Seasonal decomposition is used to break the time series into trend, seasonal, and residual components, enabling the removal of long-term trends.

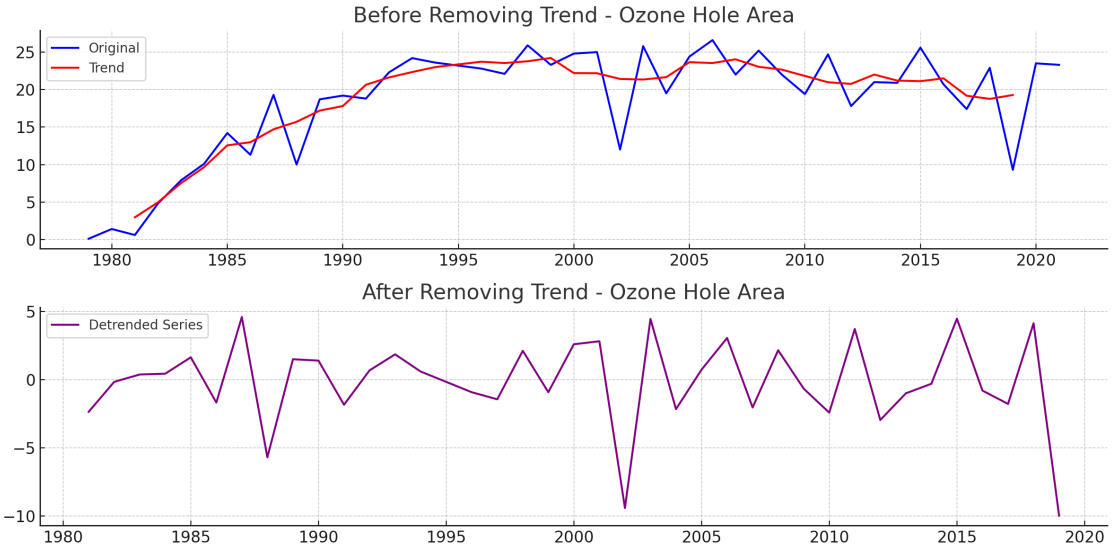
```
decomposition = seasonal_decompose(ozone_df['Hole Area'], model='additive', period=5)
trend = decomposition.trend
detrended_series = ozone_df['Hole Area'] - trend
```

7. Visualization: Before and After Trend Removal

This visualization compares the original series with the detrended series, demonstrating the effectiveness of trend removal techniques.

```
plt.figure(figsize=(12,6))
plt.subplot(2,1,1)
plt.plot(ozone_df['Hole Area'], label='Original', color='blue')
plt.plot(trend, label='Trend', color='red')
plt.title('Before Removing Trend - Ozone Hole Area')
plt.legend()

plt.subplot(2,1,2)
plt.plot(detrended_series, label='Detrended Series', color='purple')
plt.title('After Removing Trend - Ozone Hole Area')
plt.legend()
plt.show()
```



8. Result

The analysis of ozone hole data using smoothing techniques and trend extraction was successfully implemented. Moving averages and exponential smoothing effectively highlighted trends, and seasonal decomposition enabled precise trend removal.