In [1]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```python
# Set Visualization Style
sns.set(style="whitegrid", palette="muted")
plt.rcParams["figure.figsize"] = (10, 6)
```

In [3]:
```python
df = pd.read_csv("earthquake_data_tsunami.csv")
```

In [4]:
```python
print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 782 entries, 0 to 781
Data columns (total 13 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   magnitude  782 non-null    float64
 1   cdi        782 non-null    int64  
 2   mmi        782 non-null    int64  
 3   sig        782 non-null    int64  
 4   nst        782 non-null    int64  
 5   dmin       782 non-null    float64
 6   gap        782 non-null    float64
 7   depth      782 non-null    float64
 8   latitude   782 non-null    float64
 9   longitude  782 non-null    float64
 10  Year       782 non-null    int64  
 11  Month      782 non-null    int64  
 12  tsunami    782 non-null    int64  
dtypes: float64(6), int64(7)
memory usage: 79.6 KB
None
```

In [5]:
```python
print(df.describe())
```

```
        magnitude         cdi         mmi          sig         nst  \
count  782.000000  782.000000  782.000000   782.000000  782.000000   
mean     6.941125    4.333760    5.964194   870.108696  230.250639   
std      0.445514    3.169939    1.462724   322.465367  250.188177   
min      6.500000    0.000000    1.000000   650.000000    0.000000   
25%      6.600000    0.000000    5.000000   691.000000    0.000000   
50%      6.800000    5.000000    6.000000   754.000000  140.000000   
75%      7.100000    7.000000    7.000000   909.750000  445.000000   
max      9.100000    9.000000    9.000000  2910.000000  934.000000   

             dmin         gap       depth    latitude   longitude  \
count  782.000000  782.000000  782.000000  782.000000  782.000000   
mean     1.325757   25.038990   75.883199    3.538100   52.609199   
std      2.218805   24.225067  137.277078   27.303429  117.898886   
min      0.000000    0.000000    2.700000  -61.848400 -179.968000   
25%      0.000000   14.625000   14.000000  -14.595600  -71.668050   
50%      0.000000   20.000000   26.295000   -2.572500  109.426000   
75%      1.863000   30.000000   49.750000   24.654500  148.941000   
max     17.654000  239.000000  670.810000   71.631200  179.662000   

              Year       Month     tsunami  
count   782.000000  782.000000  782.000000  
mean   2012.280051    6.563939    0.388747  
std       6.099439    3.507866    0.487778  
min    2001.000000    1.000000    0.000000  
25%    2007.000000    3.250000    0.000000  
50%    2013.000000    7.000000    0.000000  
75%    2017.000000   10.000000    1.000000  
max    2022.000000   12.000000    1.000000  
```

In [6]:
```python
print(df.head())
```

```
   magnitude  cdi  mmi  sig  nst   dmin   gap    depth  latitude  longitude  \
0        7.0    8    7  768  117  0.509  17.0   14.000   -9.7963    159.596   
1        6.9    4    4  735   99  2.229  34.0   25.000   -4.9559    100.738   
2        7.0    3    3  755  147  3.125  18.0  579.000  -20.0508   -178.346   
3        7.3    5    5  833  149  1.865  21.0   37.000  -19.2918   -172.129   
4        6.6    0    2  670  131  4.998  27.0  624.464  -25.5948    178.278   

   Year  Month  tsunami  
0  2022     11        1  
1  2022     11        0  
2  2022     11        1  
3  2022     11        1  
4  2022     11        1  
```

In [7]:
```python
df.isnull().sum()
```

```
Out[7]: magnitude    0
        cdi          0
        mmi          0
        sig          0
        nst          0
        dmin         0
        gap          0
        depth        0
        latitude     0
        longitude    0
        Year         0
        Month        0
        tsunami      0
        dtype: int64
```

```
In [8]: # Handling Missing Values
        df = df.dropna(subset=['latitude', 'longitude', 'magnitude', 'depth'])
        print("Cleaned Data Shape:", df.shape)
```

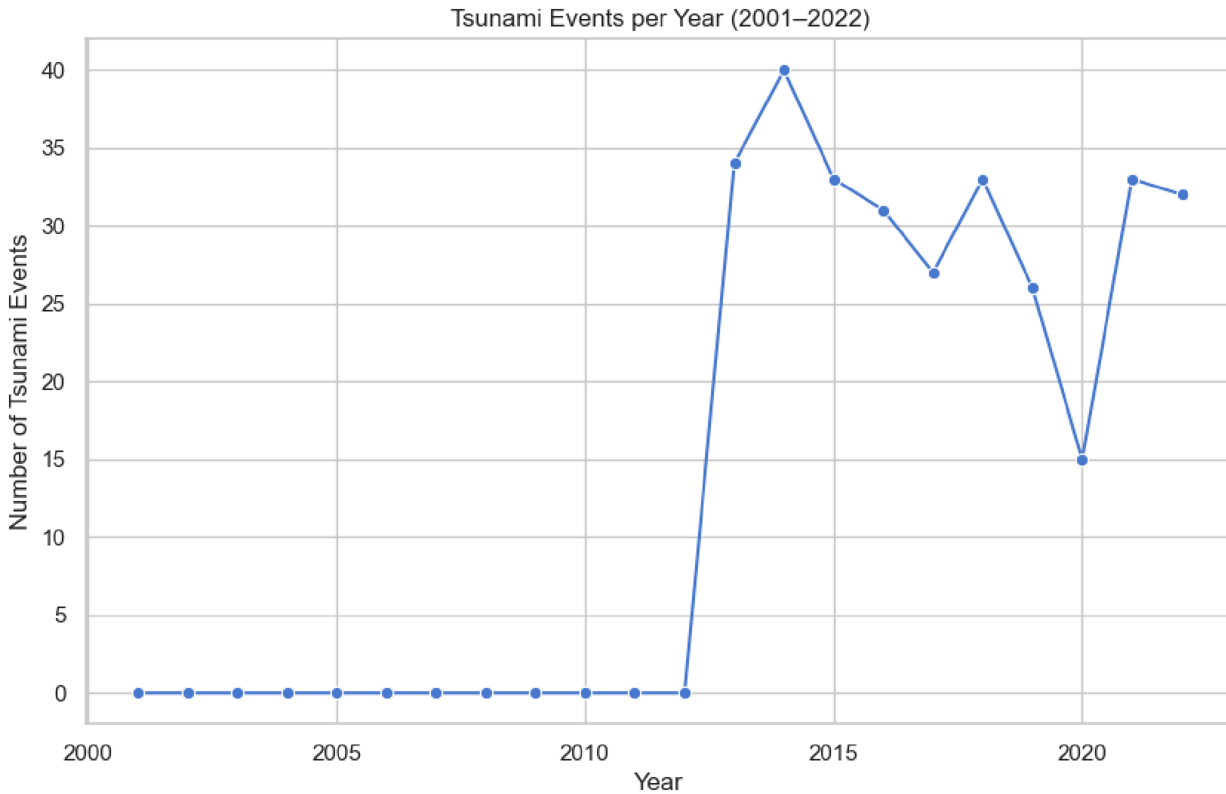
```
Cleaned Data Shape: (782, 13)
```

```
In [9]: # Combine year and month into a single date column
        df['date'] = pd.to_datetime(df['Year'].astype(str) + '-' + df['Month'].astype(
```

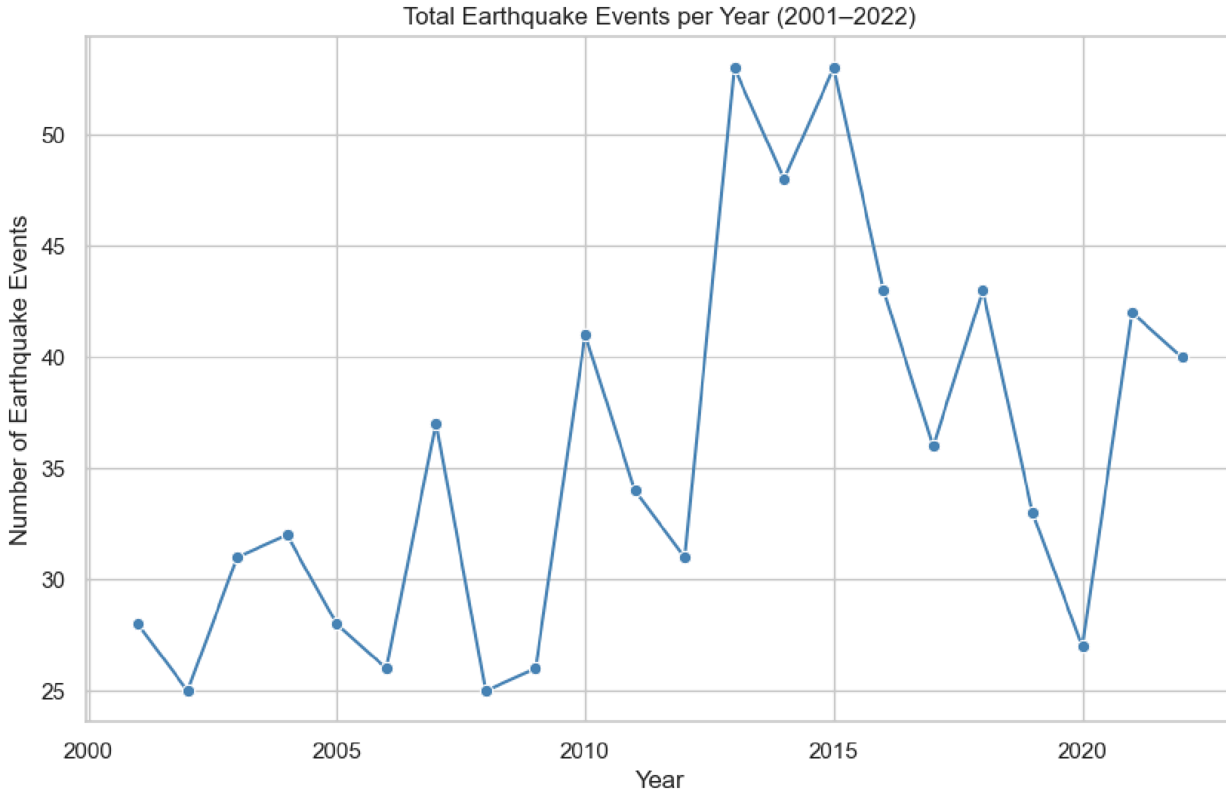
1. Time-Series Analysis

```
In [10]: df['Year'] = pd.to_datetime(df['date']).dt.year
         yearly_counts = df.groupby('Year')['tsunami'].sum()
```

```
In [11]: plt.figure()
         sns.lineplot(x=yearly_counts.index, y=yearly_counts.values, marker="o")
         plt.title("Tsunami Events per Year (2001–2022)")
         plt.xlabel("Year")
         plt.ylabel("Number of Tsunami Events")
         plt.show()
```

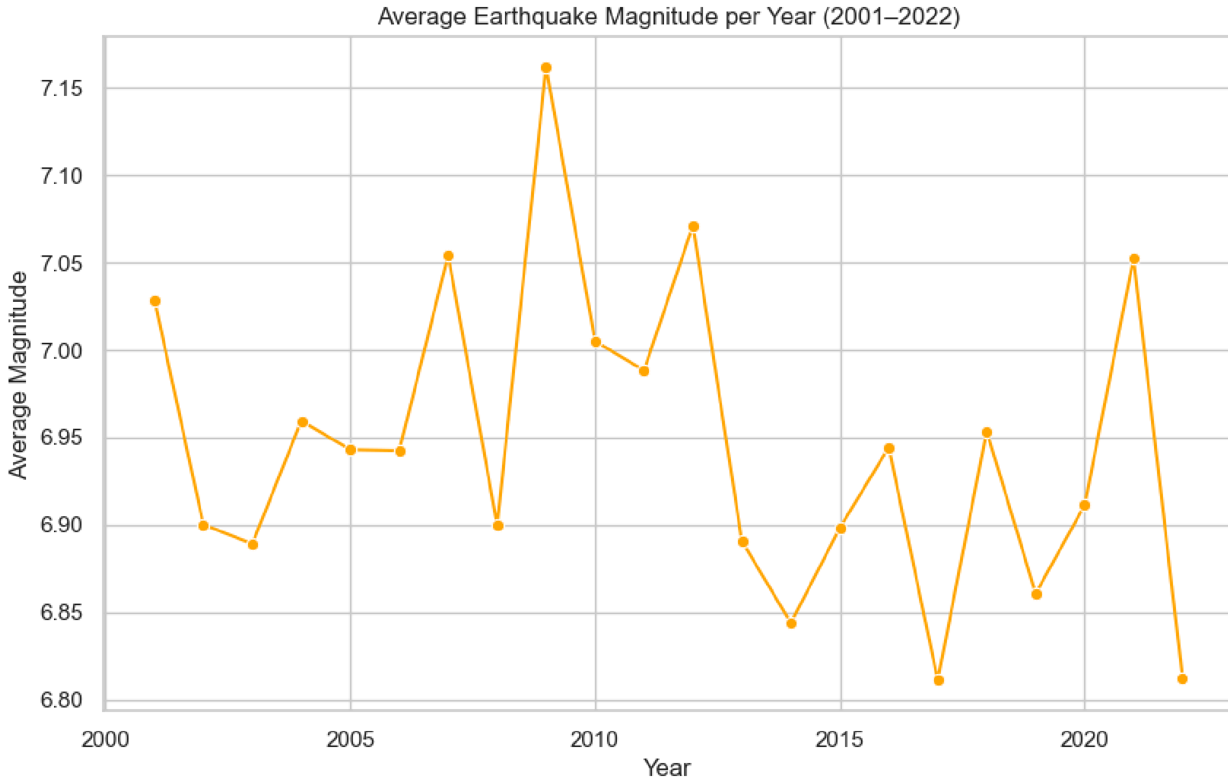


In [22]:
```
yearly_eq_counts = df.groupby('Year').size()

plt.figure()
sns.lineplot(x=yearly_eq_counts.index, y=yearly_eq_counts.values, marker="o",
plt.title("Total Earthquake Events per Year (2001–2022)")
plt.xlabel("Year")
plt.ylabel("Number of Earthquake Events")
plt.show()
```



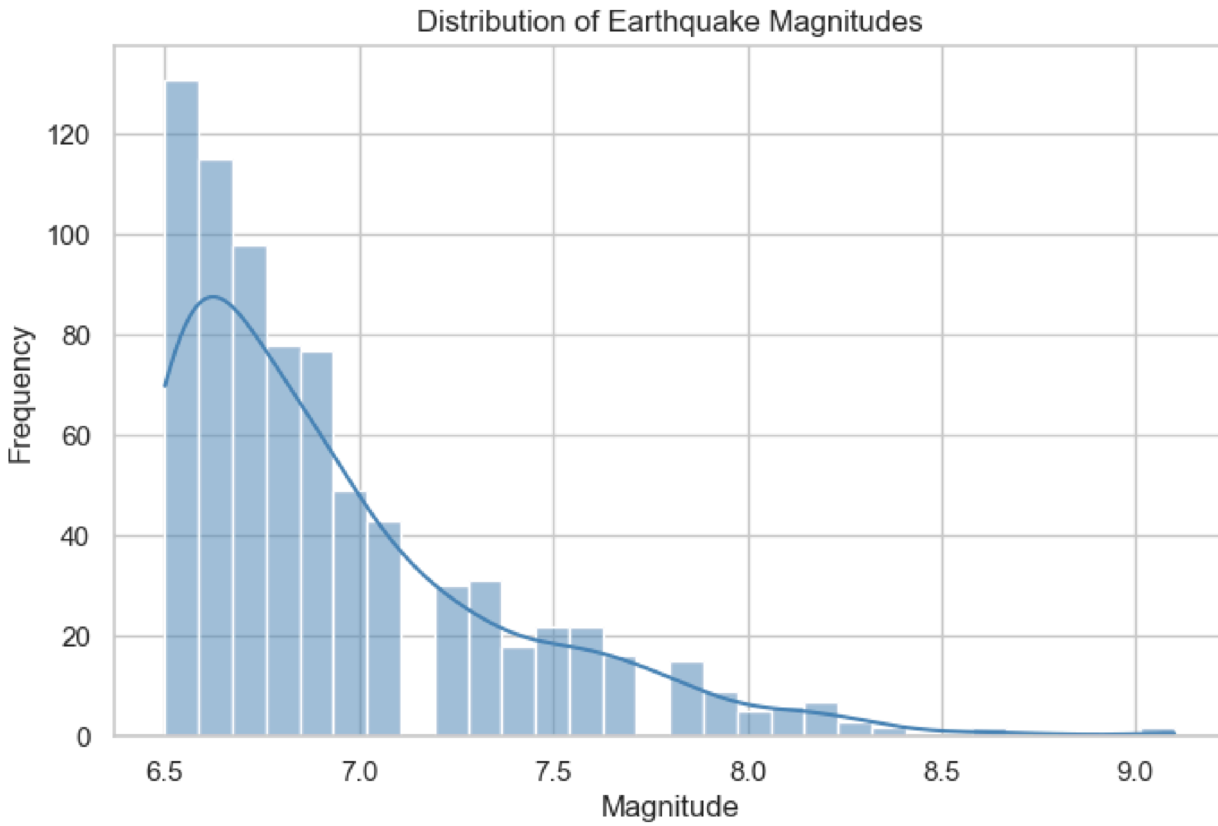
In [23]:

```
yearly_mag = df.groupby('Year')['magnitude'].mean()

plt.figure()
sns.lineplot(x=yearly_mag.index, y=yearly_mag.values, marker="o", color="orang
plt.title("Average Earthquake Magnitude per Year (2001–2022)")
plt.xlabel("Year")
plt.ylabel("Average Magnitude")
plt.show()
```

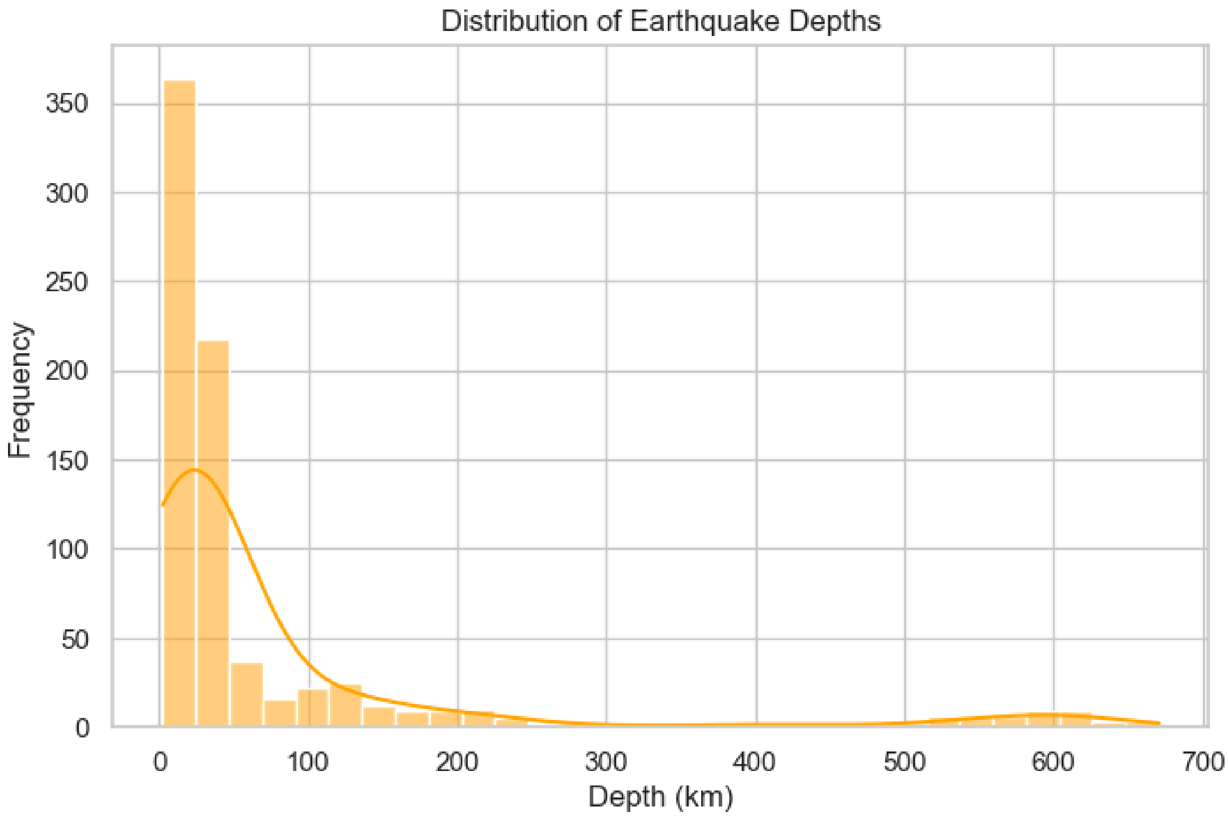


2. Magnitude & Depth Distributions

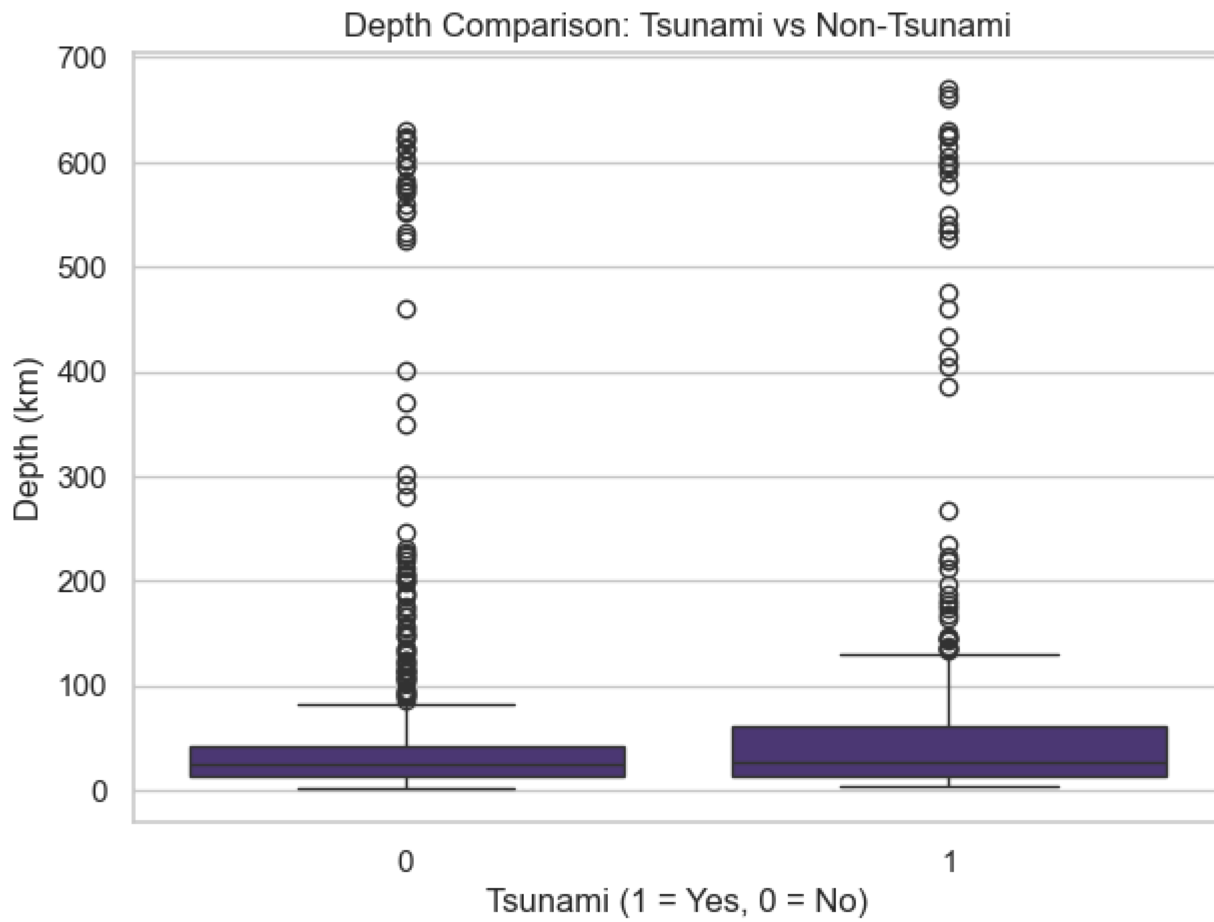
In [25]:
```
sns.set(style="whitegrid", palette="viridis")
# a) Distribution of Earthquake Magnitudes
plt.figure(figsize=(8, 5))
sns.histplot(df['magnitude'], bins=30, kde=True, color='steelblue')
plt.title("Distribution of Earthquake Magnitudes")
plt.xlabel("Magnitude")
plt.ylabel("Frequency")
plt.show()
```



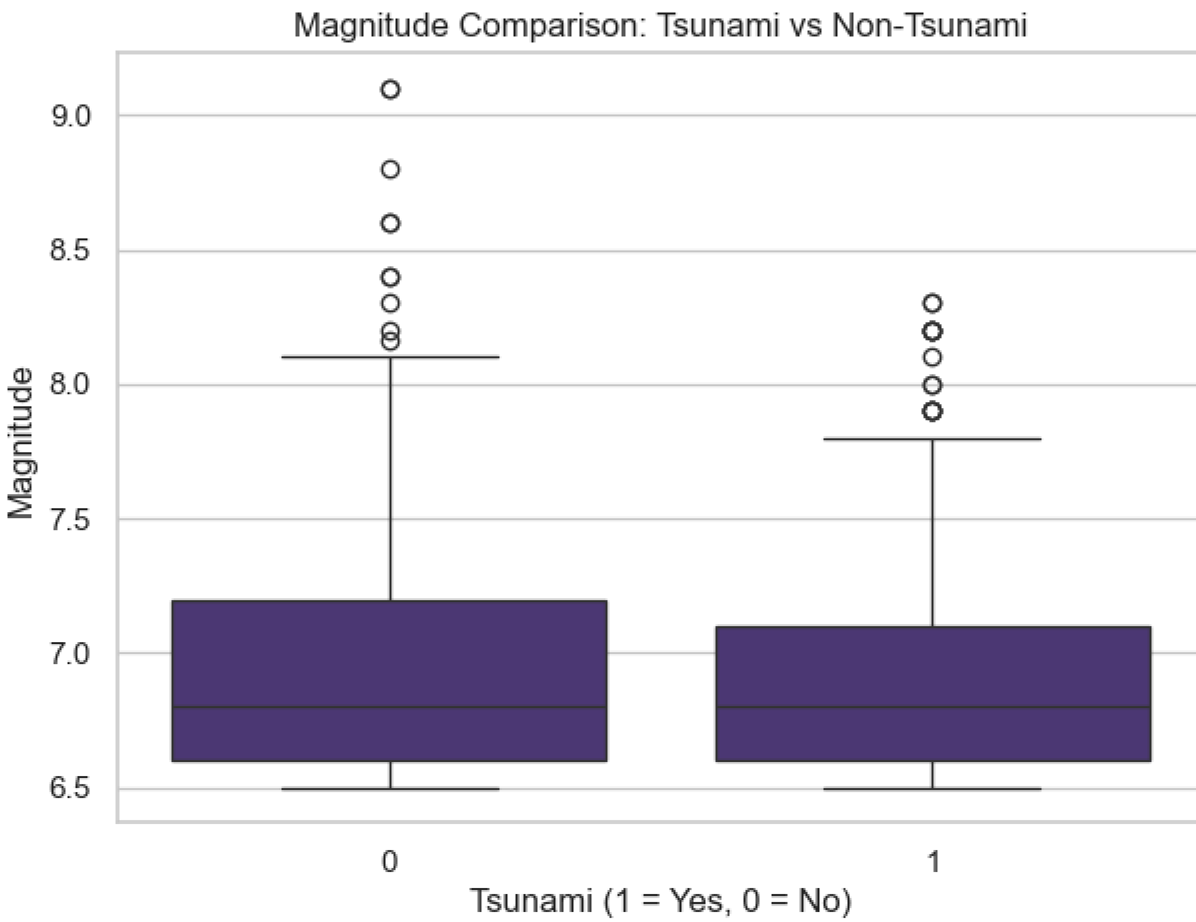
In [26]:
```
# b) Distribution of Earthquake Depths
plt.figure(figsize=(8, 5))
sns.histplot(df['depth'], bins=30, kde=True, color='orange')
plt.title("Distribution of Earthquake Depths")
plt.xlabel("Depth (km)")
plt.ylabel("Frequency")
plt.show()
```



In [28]:
```
# Boxplot for Depth
plt.figure(figsize=(7, 5))
sns.boxplot(x="tsunami", y="depth", data=df)
plt.title("Depth Comparison: Tsunami vs Non-Tsunami")
plt.xlabel("Tsunami (1 = Yes, 0 = No)")
plt.ylabel("Depth (km)")
plt.show()
```



In [27]:
```
# c) Compare Magnitude and Depth: Tsunami vs Non-Tsunami
# Boxplot for Magnitude
plt.figure(figsize=(7, 5))
sns.boxplot(x="tsunami", y="magnitude", data=df)
plt.title("Magnitude Comparison: Tsunami vs Non-Tsunami")
plt.xlabel("Tsunami (1 = Yes, 0 = No)")
plt.ylabel("Magnitude")
plt.show()
```



In [29]:
```
# Average magnitude and depth for tsunami vs non-tsunami events
avg_stats = df.groupby('tsunami')[['magnitude', 'depth']].mean().reset_index()
print("\nAverage Magnitude and Depth by Tsunami Occurrence:")
print(avg_stats)
```

```
Average Magnitude and Depth by Tsunami Occurrence:
   tsunami  magnitude      depth
0        0   6.942803  69.667356
1        1   6.938487  85.656796
```

In [30]:
```
# d) Highlight Major Earthquakes (Magnitude ≥ 8.0)
major_quakes = df[df['magnitude'] >= 8.0].sort_values(by='date', ascending=Tru

print("\nMajor Earthquakes (Magnitude ≥ 8.0):")
print(major_quakes[['date', 'latitude', 'longitude', 'magnitude', 'depth', 'ts
```

```
Major Earthquakes (Magnitude ≥ 8.0):
           date  latitude  longitude  magnitude   depth  tsunami
767 2001-06-01  -16.2650   -73.6410       8.40   33.00        0
712 2003-09-01   41.8150   143.9100       8.16   27.00        0
669 2004-12-01  -49.3120   161.3450       8.10   10.00        0
668 2004-12-01    3.2950    95.9820       9.10   30.00        0
657 2005-03-01    2.0850    97.1080       8.60   30.00        0
628 2006-05-01  -19.9900  -173.9070       8.00   60.50        0
627 2006-05-01  -20.1870  -174.1230       8.00   55.00        0
614 2006-11-01   46.5920   153.2660       8.30   10.00        0
611 2007-01-01   46.2430   154.5240       8.10   10.00        0
606 2007-04-01   -8.4660   157.0430       8.10   24.00        0
597 2007-08-01  -13.3860   -76.6030       8.00   39.00        0
593 2007-09-01   -4.4380   101.3670       8.40   34.00        0
535 2009-09-01  -15.4890  -172.0950       8.10   18.00        0
517 2010-02-01  -36.1220   -72.8980       8.80   22.90        0
476 2011-03-01   38.2970   142.3730       9.10   29.00        0
440 2012-04-01    0.8020    92.4630       8.20   25.10        0
441 2012-04-01    2.3270    93.0630       8.60   20.00        0
414 2013-02-01  -10.7990   165.1140       8.00   24.00        1
393 2013-05-01   54.8920   153.2210       8.30  598.10        1
356 2014-04-01  -19.6097   -70.7691       8.20   25.00        1
285 2015-09-01  -31.5729   -71.6744       8.30   22.44        1
198 2017-09-01   15.0222   -93.8993       8.20   47.39        1
170 2018-08-01  -18.1125  -178.1530       8.20  600.00        1
129 2019-05-01   -5.8119   -75.2697       8.00  122.57        1
74  2021-03-01  -29.7466  -177.2240       8.10   28.93        1
60  2021-07-01   55.3154  -157.8290       8.20   35.00        1
59  2021-07-01   55.4742  -157.9170       8.20   46.66        1
56  2021-08-01  -58.4157   -25.3206       8.10   22.79        0
```

In [14]:

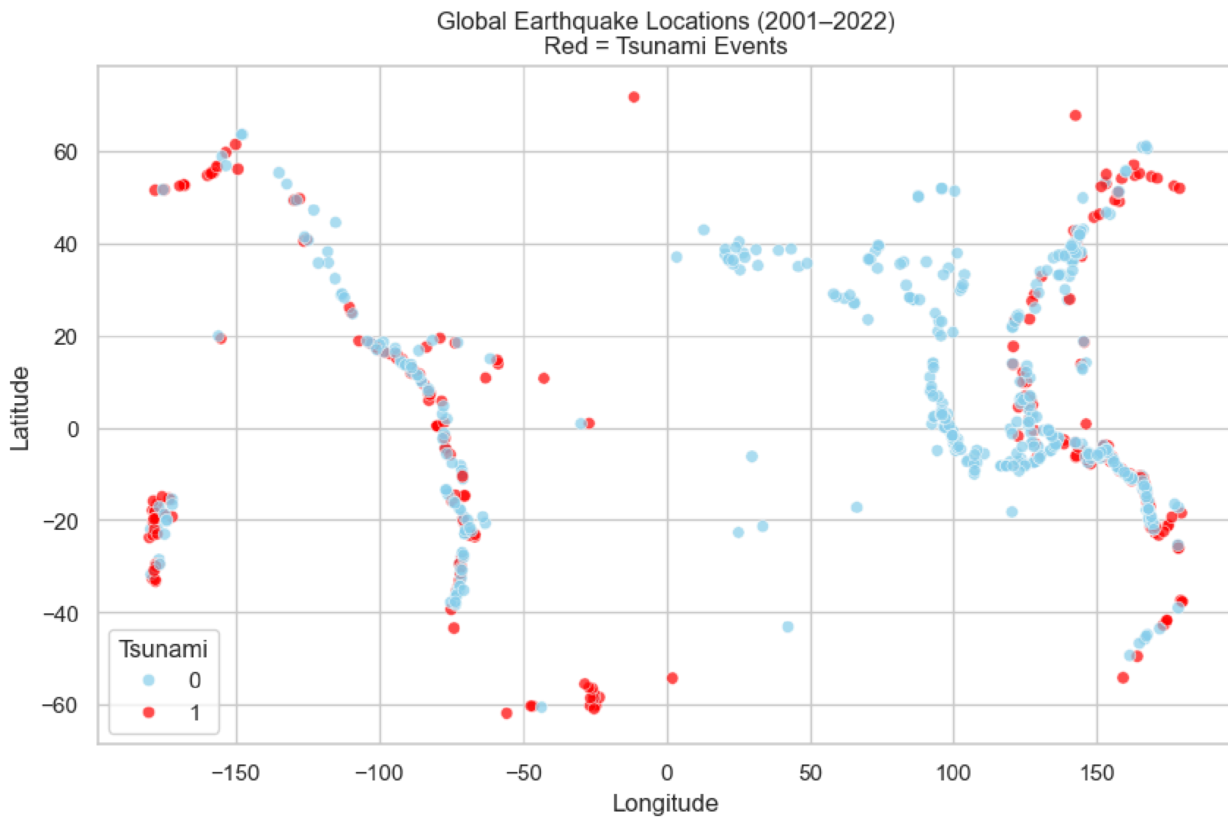
```python
# Highlight Major Earthquakes (≥8.0)
major_quakes = df[df['magnitude'] >= 8.0].sort_values(by='date', ascending=Tru

print("Major Earthquakes (Magnitude ≥ 8.0):")
print(major_quakes[['date', 'latitude', 'longitude', 'magnitude', 'depth', 'ts
```

```
Major Earthquakes (Magnitude ≥ 8.0):
           date  latitude  longitude  magnitude   depth  tsunami
767 2001-06-01  -16.2650   -73.6410       8.40   33.00        0
712 2003-09-01   41.8150   143.9100       8.16   27.00        0
669 2004-12-01  -49.3120   161.3450       8.10   10.00        0
668 2004-12-01    3.2950    95.9820       9.10   30.00        0
657 2005-03-01    2.0850    97.1080       8.60   30.00        0
628 2006-05-01  -19.9900  -173.9070       8.00   60.50        0
627 2006-05-01  -20.1870  -174.1230       8.00   55.00        0
614 2006-11-01   46.5920   153.2660       8.30   10.00        0
611 2007-01-01   46.2430   154.5240       8.10   10.00        0
606 2007-04-01   -8.4660   157.0430       8.10   24.00        0
597 2007-08-01  -13.3860   -76.6030       8.00   39.00        0
593 2007-09-01   -4.4380   101.3670       8.40   34.00        0
535 2009-09-01  -15.4890  -172.0950       8.10   18.00        0
517 2010-02-01  -36.1220   -72.8980       8.80   22.90        0
476 2011-03-01   38.2970   142.3730       9.10   29.00        0
440 2012-04-01    0.8020    92.4630       8.20   25.10        0
441 2012-04-01    2.3270    93.0630       8.60   20.00        0
414 2013-02-01  -10.7990   165.1140       8.00   24.00        1
393 2013-05-01   54.8920   153.2210       8.30  598.10        1
356 2014-04-01  -19.6097   -70.7691       8.20   25.00        1
285 2015-09-01  -31.5729   -71.6744       8.30   22.44        1
198 2017-09-01   15.0222   -93.8993       8.20   47.39        1
170 2018-08-01  -18.1125  -178.1530       8.20  600.00        1
129 2019-05-01   -5.8119   -75.2697       8.00  122.57        1
74  2021-03-01  -29.7466  -177.2240       8.10   28.93        1
60  2021-07-01   55.3154  -157.8290       8.20   35.00        1
59  2021-07-01   55.4742  -157.9170       8.20   46.66        1
56  2021-08-01  -58.4157   -25.3206       8.10   22.79        0
```

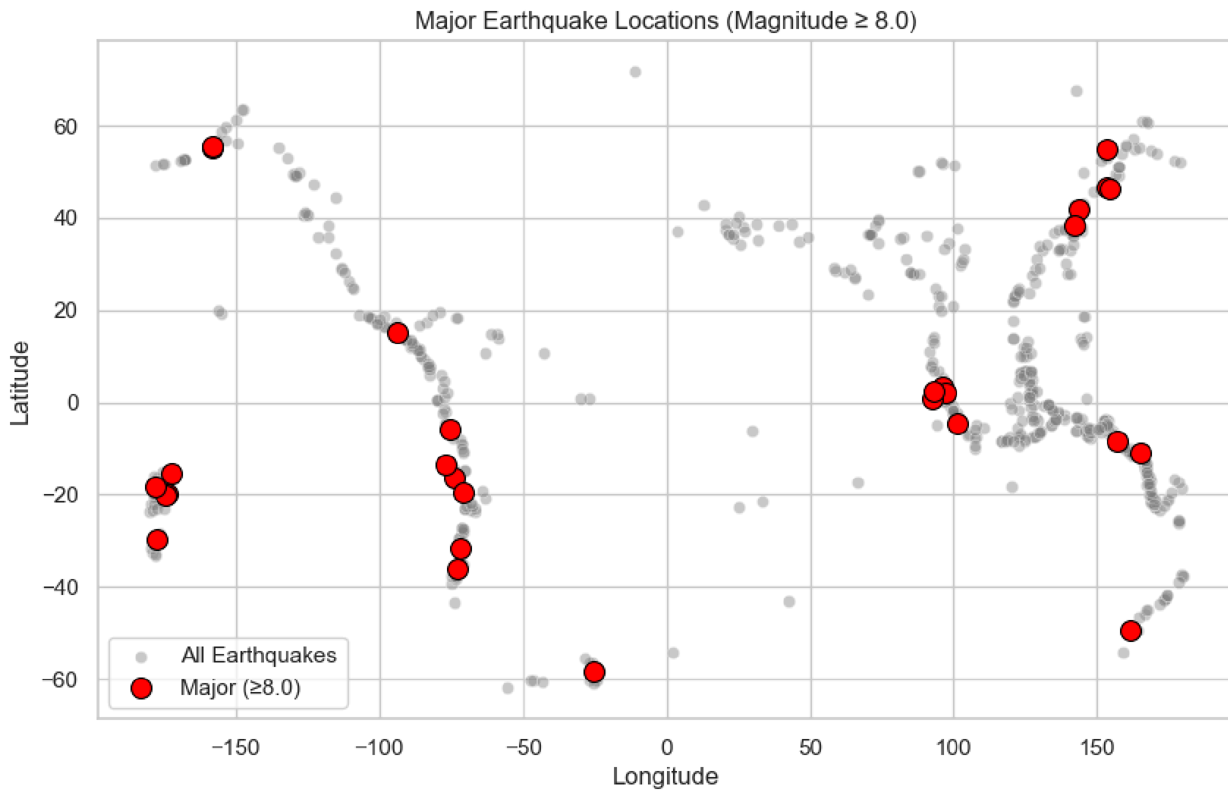
3. Geographic Distribution

In [33]:

```
sns.set(style="whitegrid", palette="coolwarm")
# a) Earthquake Locations: Tsunami vs Non-Tsunami (2D Plot)
plt.figure(figsize=(10, 6))
sns.scatterplot(
    x="longitude", y="latitude",
    hue="tsunami",
    data=df,
    alpha=0.7,
    palette={0: "skyblue", 1: "red"}
)
plt.title("Global Earthquake Locations (2001–2022)\nRed = Tsunami Events")
plt.xlabel("Longitude")
plt.ylabel("Latitude")
plt.legend(title="Tsunami")
plt.show()
```

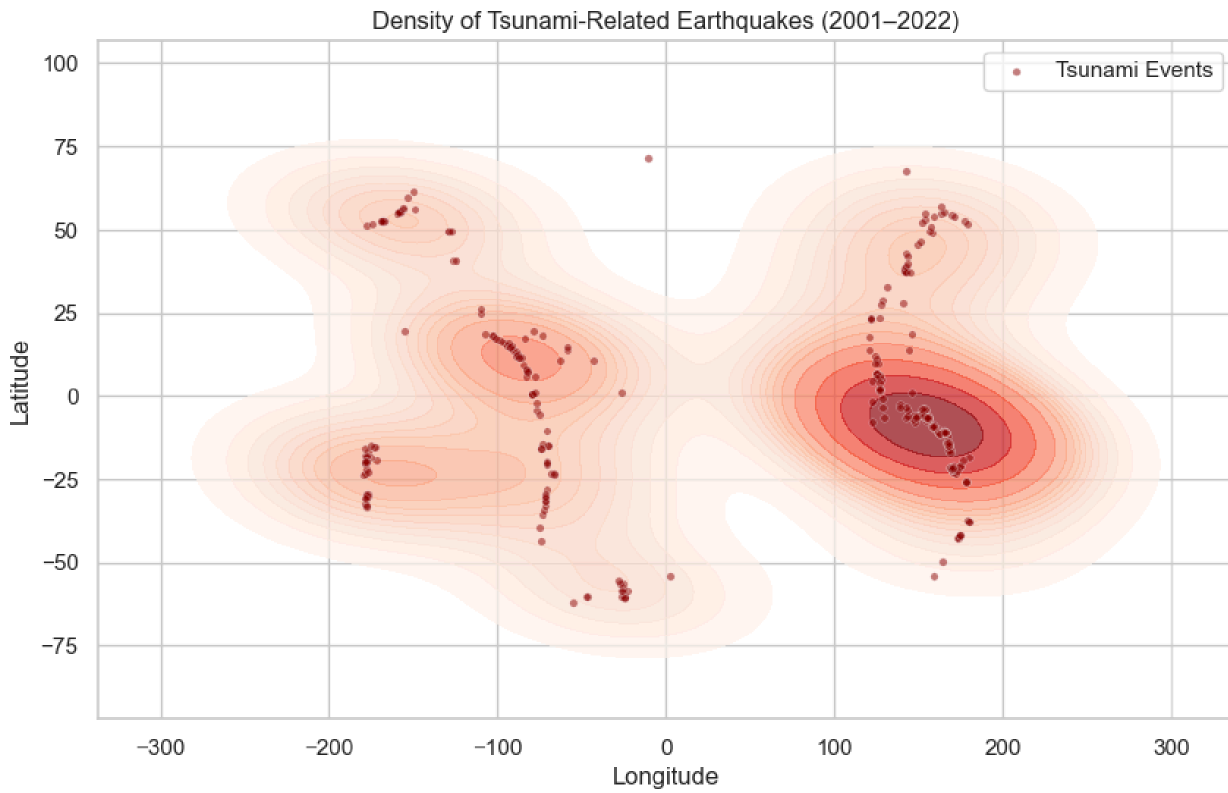


In [34]:
```
# b) Highlight Major Earthquakes (Magnitude ≥ 8.0) on the Map
plt.figure(figsize=(10, 6))
sns.scatterplot(
    data=df,
    x='longitude', y='latitude',
    alpha=0.4, color='gray', label='All Earthquakes'
)
# Overlay major (≥8.0) earthquakes in red
sns.scatterplot(
    data=major_quakes,
    x='longitude', y='latitude',
    color='red', s=100, edgecolor='black', label='Major (≥8.0)'
)
plt.title("Major Earthquake Locations (Magnitude ≥ 8.0)")
plt.xlabel("Longitude")
plt.ylabel("Latitude")
plt.legend()
plt.show()
```



In [35]:

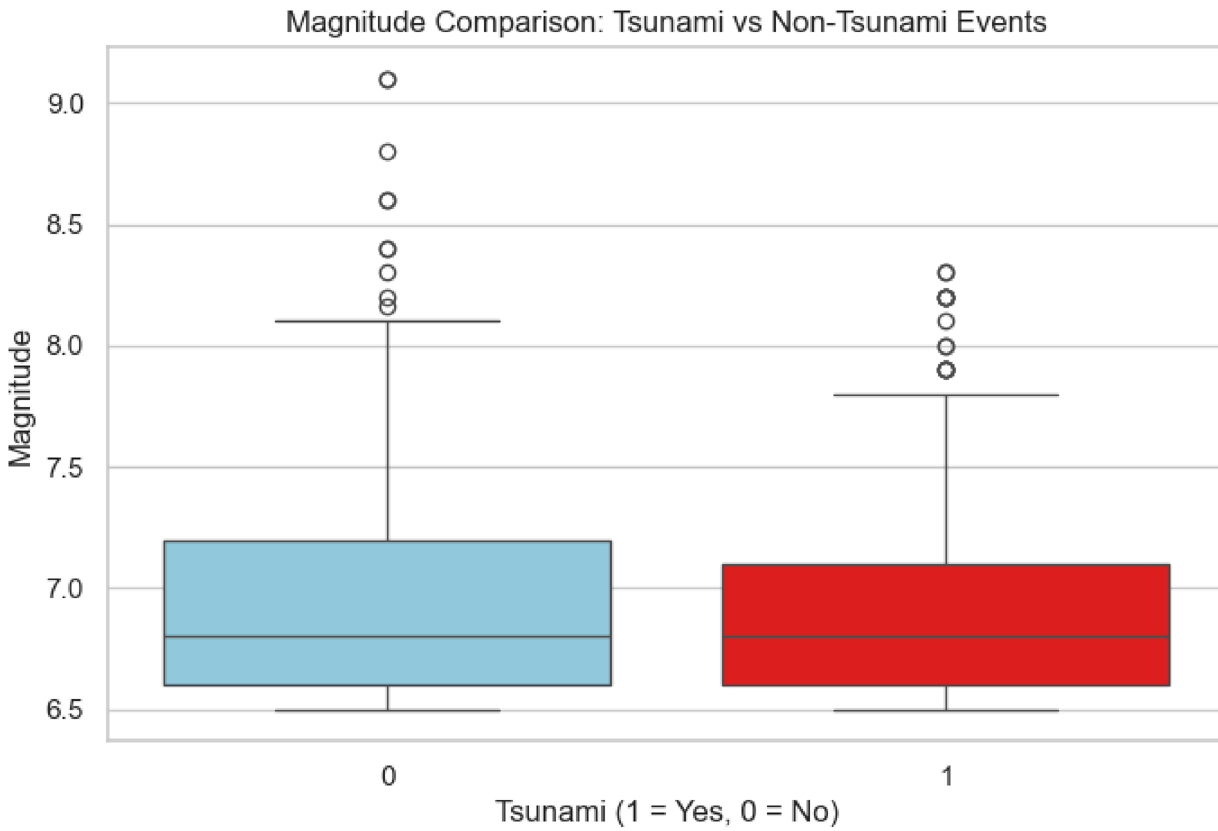
```
# c) Identify Clusters / Regions with Higher Tsunami Event Concentration
plt.figure(figsize=(10, 6))
# KDE (density) plot for tsunami events
sns.kdeplot(
    data=df[df['tsunami'] == 1],
    x='longitude', y='latitude',
    fill=True, cmap='Reds', levels=15, alpha=0.7
)
# Overlay scatter points for tsunami events
sns.scatterplot(
    data=df[df['tsunami'] == 1],
    x='longitude', y='latitude',
    color='darkred', s=15, alpha=0.5, label='Tsunami Events'
)
plt.title("Density of Tsunami-Related Earthquakes (2001–2022)")
plt.xlabel("Longitude")
plt.ylabel("Latitude")
plt.legend()
plt.show()
```



4. Statistical and Comparative Analysis:

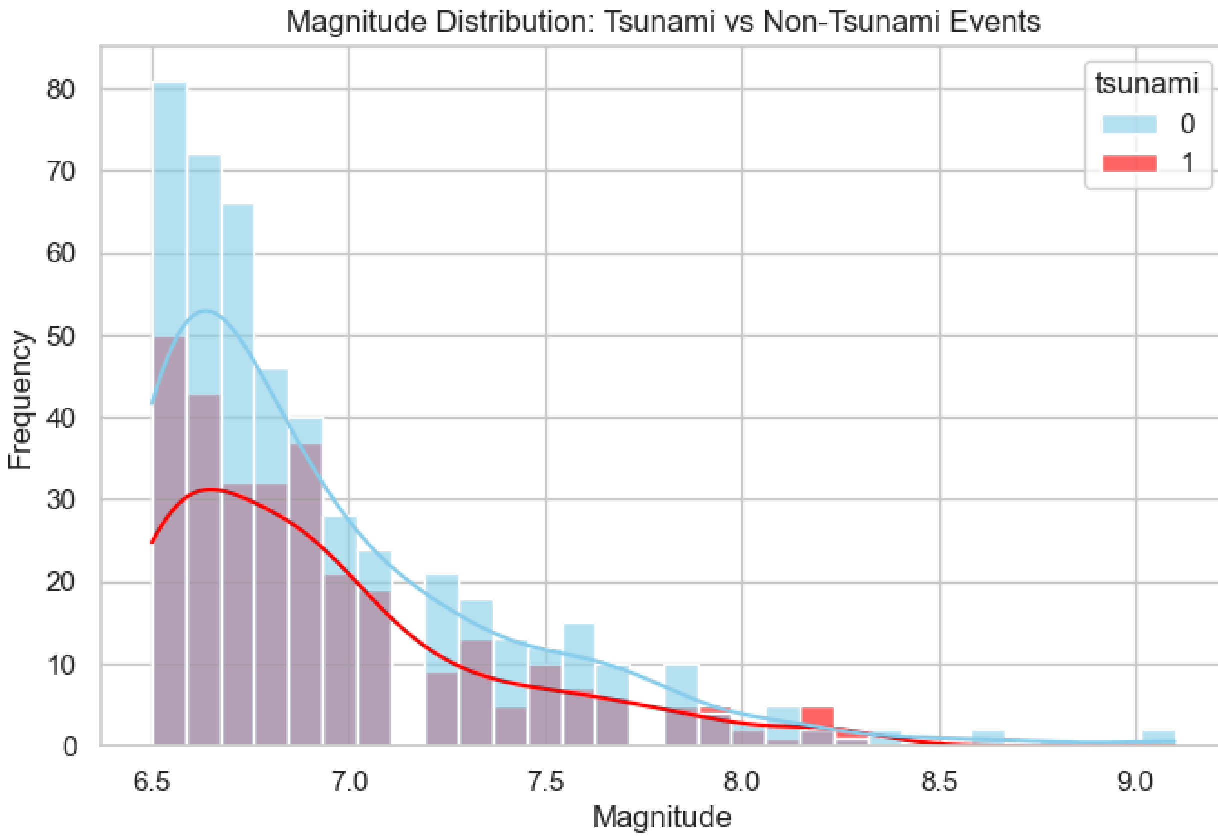
In [36]:

```
# a) Box Plot: Compare Magnitude by Tsunami Presence
plt.figure(figsize=(8, 5))
sns.boxplot(
    x='tsunami', y='magnitude',
    hue='tsunami', data=df,
    palette={0: 'skyblue', 1: 'red'},
    legend=False
)
plt.title("Magnitude Comparison: Tsunami vs Non-Tsunami Events")
plt.xlabel("Tsunami (1 = Yes, 0 = No)")
plt.ylabel("Magnitude")
plt.show()
sns.set(style="whitegrid", palette="coolwarm")
df['tsunami'] = df['tsunami'].astype(int)
```



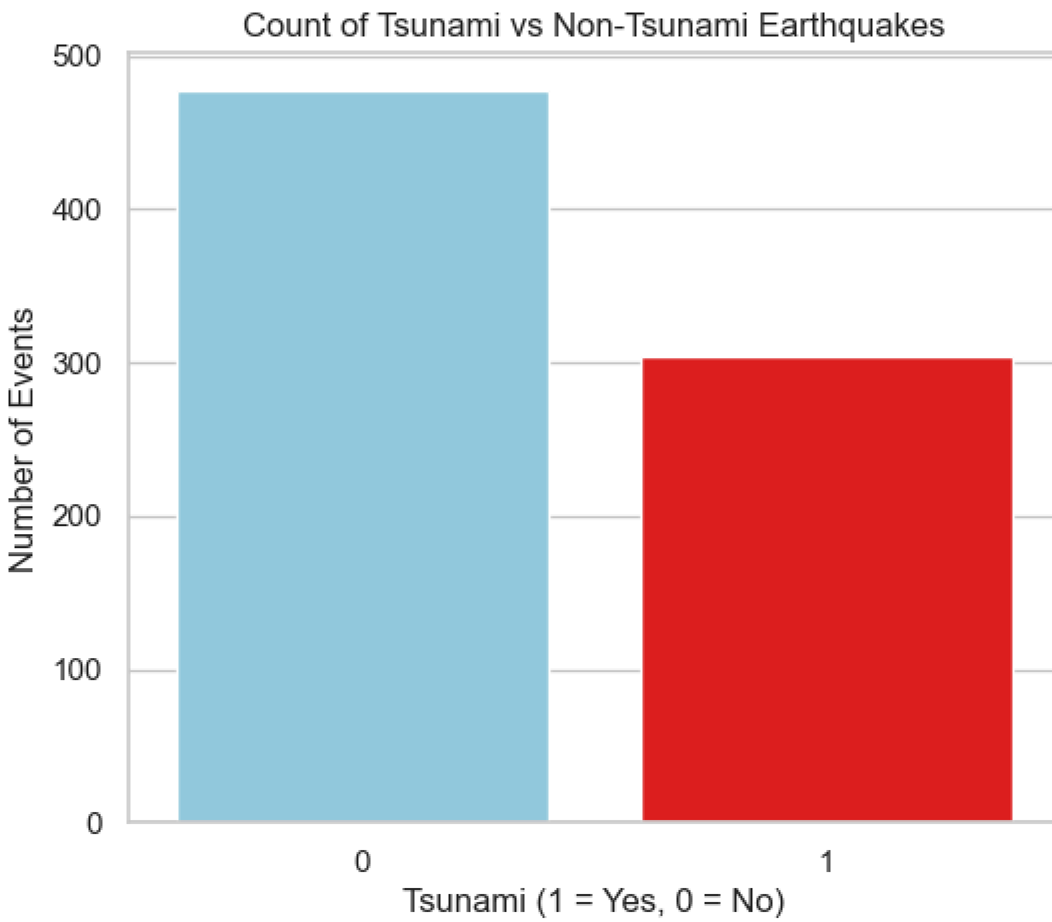
In [37]:

```
# b) Histogram: Magnitude Distribution by Tsunami Status
plt.figure(figsize=(8, 5))
sns.histplot(
    data=df,
    x='magnitude',
    hue='tsunami',
    bins=30,
    kde=True,
    palette={0: 'skyblue', 1: 'red'},
    alpha=0.6
)
plt.title("Magnitude Distribution: Tsunami vs Non-Tsunami Events")
plt.xlabel("Magnitude")
plt.ylabel("Frequency")
plt.show()
```



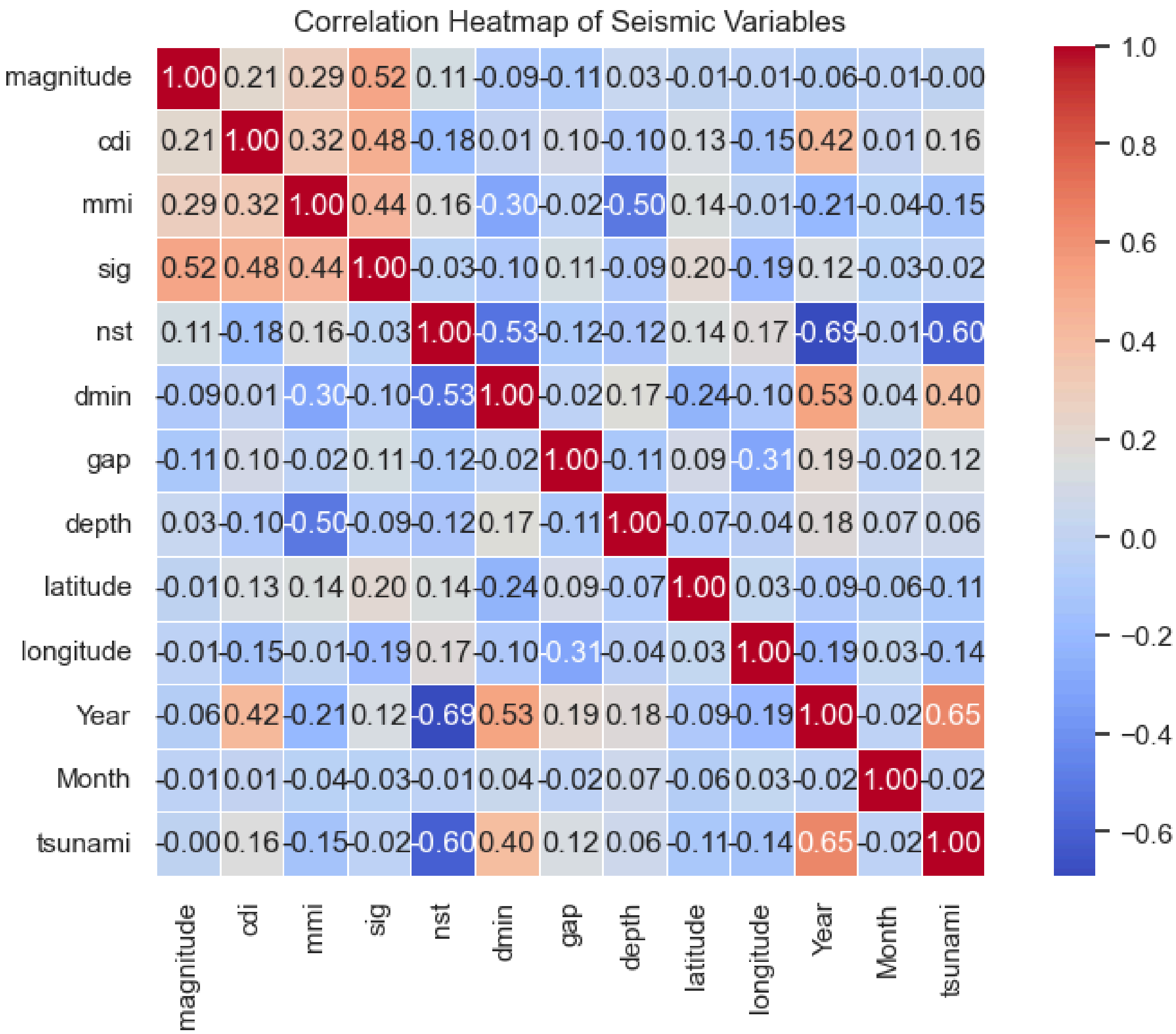
In [40]:

```
# c) Bar Chart: Count of Tsunami vs Non-Tsunami Events
plt.figure(figsize=(6, 5))
sns.countplot(
    x='tsunami',
    hue='tsunami',
    data=df,
    palette={0: 'skyblue', 1: 'red'},
    legend=False
)
plt.title("Count of Tsunami vs Non-Tsunami Earthquakes")
plt.xlabel("Tsunami (1 = Yes, 0 = No)")
plt.ylabel("Number of Events")
plt.show()
```



In [41]:

```
# (d) Correlation Heatmap of Numerical Seismic Features
plt.figure(figsize=(10, 6))
numeric_cols = df.select_dtypes(include=np.number)
corr = numeric_cols.corr()

sns.heatmap(
    corr,
    annot=True,
    cmap='coolwarm',
    fmt=".2f",
    linewidths=0.5,
    square=True
)
plt.title("Correlation Heatmap of Seismic Variables")
plt.show()
```



5.Insights and Observations:

1. Time-Based Analysis
2. Yearly fluctuations with peaks in active years (2004, 2011).
3. No steady rise; global seismic activity is irregular but impactful.
4. Magnitude & Depth
5. Tsunami quakes: high magnitude (≥6.5) and shallow (≤50 km).
6. Most ≥8.0 events cause tsunamis.
7. Shallow boundary quakes pose highest risk.
8. Geographic Distribution

9. Tsunami events cluster along subduction zones (Pacific Ring of Fire).
10. Non-tsunami quakes are globally spread.
11. High-density zones near ocean trenches.
12. Statistical Insights
13. Tsunami events → higher magnitudes, fewer in number.

Correlations: . Tsunami quakes have higher magnitudes but are less frequent.

. Greater magnitude increases, and deeper focus decreases tsunami likelihood.

In [ ]:

```

```