Firstly, I make a dataframe from one instance of gpx data from a run to start building the code that will map this geo-spatially.

In [52]:
```
import xml.etree.ElementTree as ET
import pandas as pd
from geopy.distance import geodesic

# Define GPX file path
gpx_file_path = "skye_strava_data/activities/12111055853.gpx"

# Parse the GPX XML file
tree = ET.parse(gpx_file_path)
root = tree.getroot()

# define the namespace for GPX
ns = {"default": "http://www.topografix.com/GPX/1/1"}

# Extract track points
track_data = []
for trkpt in root.findall(".//default:trkpt", ns):
    lat = float(trkpt.get("lat"))
    lon = float(trkpt.get("lon"))
    ele = float(trkpt.find("default:ele", ns).text)
    time = trkpt.find("default:time", ns).text
    track_data.append((lat, lon, ele, time))

#convert to datafrom and convert time to datetime
df = pd.DataFrame(track_data, columns=["Latitude", "Longitude", "Elevation", "Ti
df["Time"] = pd.to_datetime(df["Time"])

df.head()
```

Out[52]:

	Latitude	Longitude	Elevation	Time
0	51.595759	-0.376236	63.6	2024-08-10 12:38:15+00:00
1	51.595746	-0.376215	63.6	2024-08-10 12:38:16+00:00
2	51.595732	-0.376193	63.6	2024-08-10 12:38:17+00:00
3	51.595719	-0.376172	63.7	2024-08-10 12:38:18+00:00
4	51.595705	-0.376151	63.7	2024-08-10 12:38:19+00:00

In [53]:
```
## An elementary example of how to calculate distance and speed from GPX data
# Calculate distances between consecutive points
distances = [0]  # First point has no previous point to compare to
for i in range(1, len(df)):
    prev_point = (df.iloc[i - 1]["Latitude"], df.iloc[i - 1]["Longitude"])
    curr_point = (df.iloc[i]["Latitude"], df.iloc[i]["Longitude"])
    distance = geodesic(prev_point, curr_point).meters  # Distance in meters
    distances.append(distance)

df["Distance (m)"] = distances
df["Cumulative Distance (m)"] = df["Distance (m)"].cumsum()

# Calculate time differences
df["Time Diff (s)"] = df["Time"].diff().dt.total_seconds().fillna(0)
```

```
# Calculate speed (m/s) and convert to km/h
df["Speed (m/s)"] = df["Distance (m)"] / df["Time Diff (s)"]
df["Speed (km/h)"] = df["Speed (m/s)"] * 3.6  # Convert m/s to km/h

# Calculate pace (minutes per km)
df["Pace (min/km)"] = (1 / df["Speed (km/h)"]) * 60

df.head()

#df.to_csv("processed_run_dataTEST.csv", index=False)
```

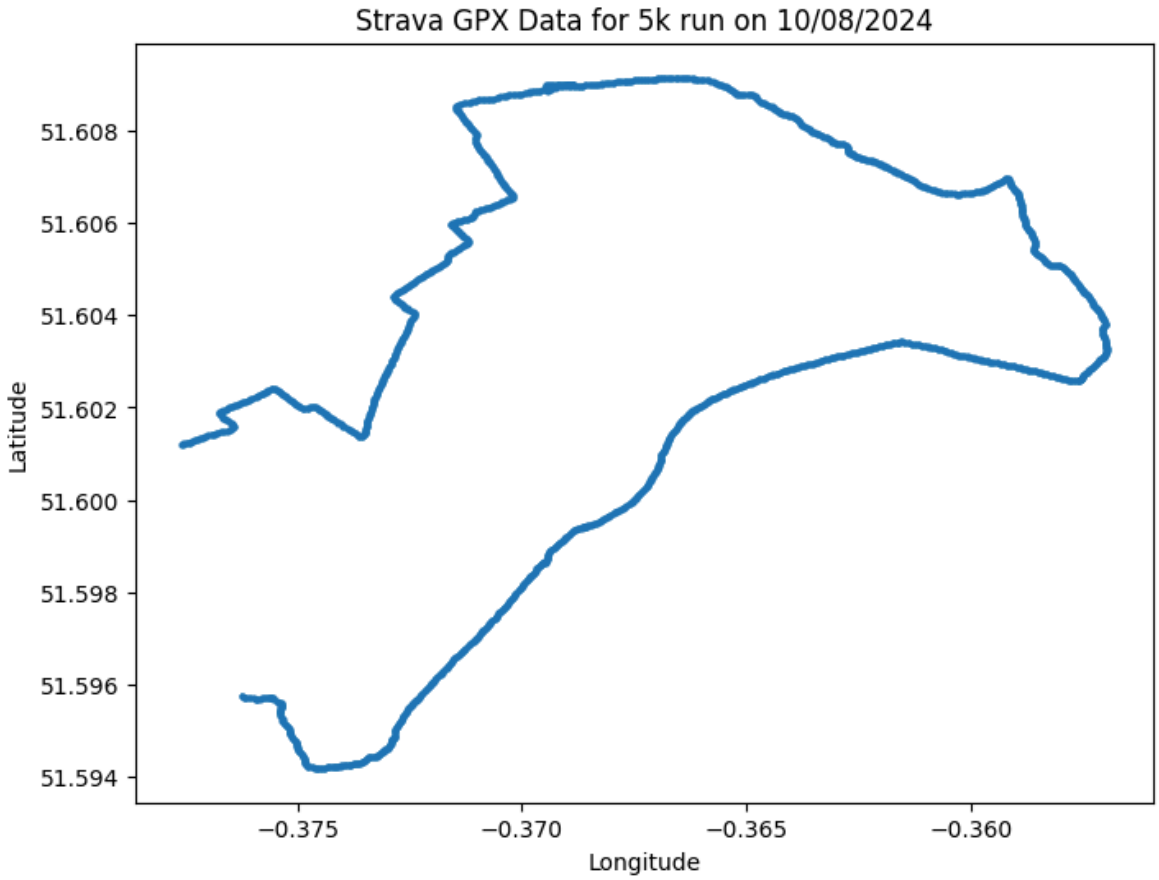
Out[53]:

	Latitude	Longitude	Elevation	Time	Distance (m)	Cumulative Distance (m)	Time Diff (s)	Spee (m/
0	51.595759	-0.376236	63.6	2024-08-10 12:38:15+00:00	0.000000	0.000000	0.0	Na
1	51.595746	-0.376215	63.6	2024-08-10 12:38:16+00:00	2.051728	2.051728	1.0	2.05172
2	51.595732	-0.376193	63.6	2024-08-10 12:38:17+00:00	2.179517	4.231245	1.0	2.17951
3	51.595719	-0.376172	63.7	2024-08-10 12:38:18+00:00	2.051729	6.282974	1.0	2.05172
4	51.595705	-0.376151	63.7	2024-08-10 12:38:19+00:00	2.131623	8.414597	1.0	2.13162

At this point I am experimenting with visualising the data and building a function to plot the data, shown in the simple lat/lon plot below.

In [54]:

```
import matplotlib.pyplot as plt

plt.figure(figsize=(8, 6))
plt.plot(df["Longitude"], df["Latitude"], marker="o", linestyle="-", markersize=
plt.xlabel("Longitude")
plt.ylabel("Latitude")
plt.title("Strava GPX Data for 5k run on 10/08/2024")
plt.show()
```



The following code loops through all the gpx files in the directory - each representing a strava activity - and creates a dataframe for each one. It appends each activity to the meta list.

In [55]:
```
import os
import xml.etree.ElementTree as ET
import pandas as pd
from geopy.distance import geodesic

# identify the folder containing GPX files
gpx_folder = "skye_strava_data/activities"

# Parsing the GPX files and extracting data
summary_data = []
ns = {"default": "http://www.topografix.com/GPX/1/1"}

for filename in os.listdir(gpx_folder):
    if filename.endswith(".gpx"):
        file_path = os.path.join(gpx_folder, filename)
        tree = ET.parse(file_path)
        root = tree.getroot()

        # Get date
        date_tag = root.find(".//default:time", ns)
        if date_tag is None:
            continue
        date = date_tag.text[:10]

        # Get run name
        name_tag = root.find(".//default:name", ns)
        name = name_tag.text if name_tag is not None else filename
```

```
        # Extract points
        points = []
        times = []
        for trkpt in root.findall(".//default:trkpt", ns):
            lat = float(trkpt.get("lat"))
            lon = float(trkpt.get("lon"))
            time = trkpt.find("default:time", ns).text
            points.append((lat, lon))
            times.append(pd.to_datetime(time))

        if len(points) < 2:
            continue

        # Calculate distance and duration
        distance = sum(geodesic(points[i-1], points[i]).km for i in range(1, len
        duration = (times[-1] - times[0]).total_seconds() / 60

        # Calculate average pace
        avg_pace = duration / distance if distance > 0 else 0
        pace_str = f"{int(avg_pace)}:{int((avg_pace % 1) * 60):02d}"

        # Add to list
        summary_data.append({
            "Filename": filename,
            "Name": name,
            "Date": date,
            "Distance (km)": round(distance, 2),
            "Duration (min)": round(duration, 1),
            "Avg Pace (min/km)": pace_str
        })

# save and display
df_summary = pd.DataFrame(summary_data)
print(df_summary)
#df_summary.to_csv("all_run_summary.csv", index=False)
```

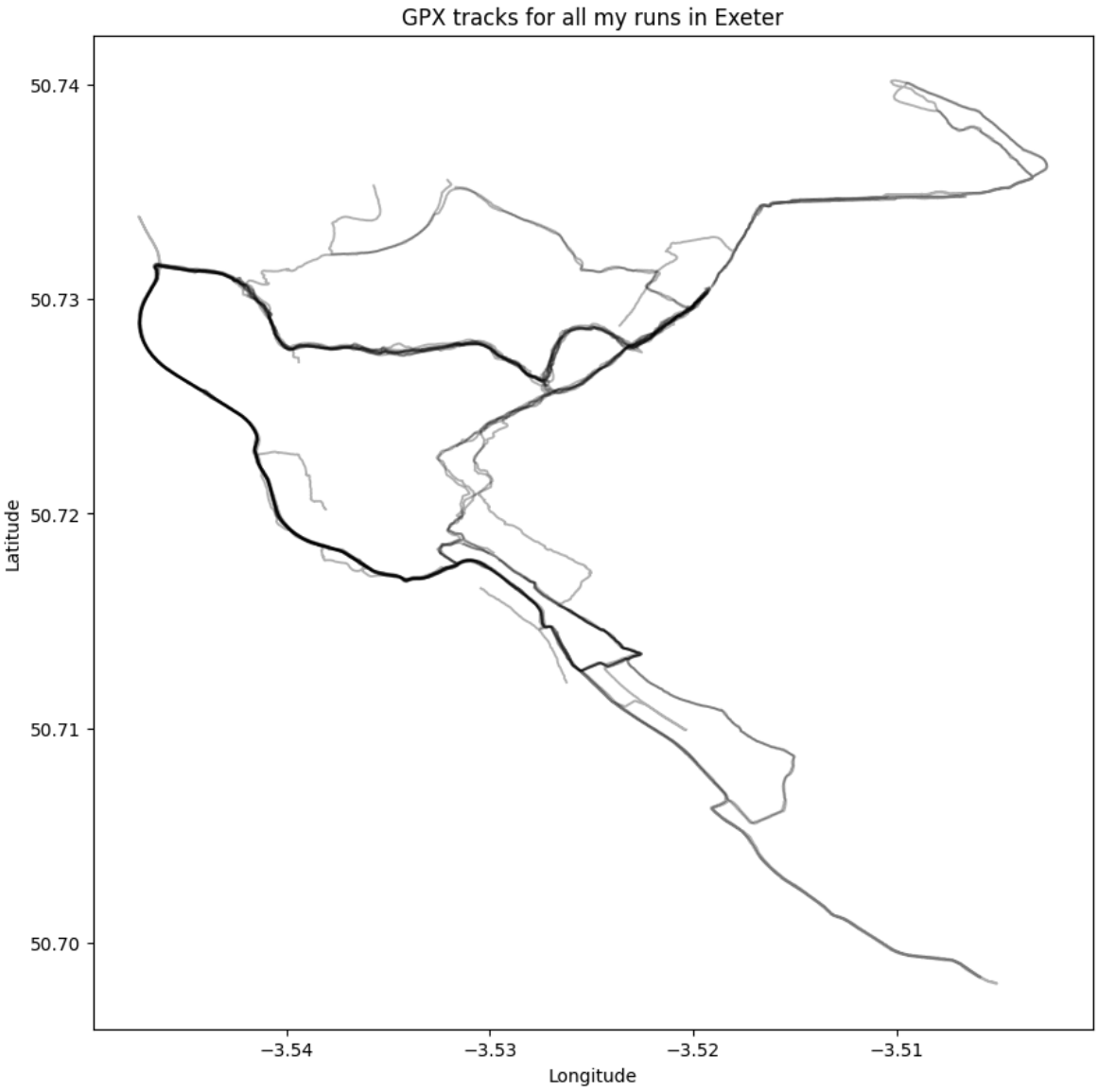
	Filename	Name	Date	Distance (km)	Duration (min)	Avg Pace (min/km)
0	12111055853.gpx	2nd 5k	2024-08-10	5.03	30.4	6:02
1	12152574009.gpx	sheffield river run	2024-08-15	5.72	43.6	7:37
2	12230956645.gpx	a bit wet	2024-08-24	5.02	28.8	5:44
3	12238486493.gpx	easy cali warmup	2024-08-25	1.76	11.9	6:46
4	12246214233.gpx	with dad	2024-08-26	5.02	31.8	6:20
5	12296670661.gpx	bloody boiling ft dad	2024-09-01	6.62	43.0	6:30
6	12313259437.gpx	wakehams hill sprint	2024-09-03	0.22	1.1	4:52
7	12415303984.gpx	run to climbing	2024-09-15	2.82	15.8	5:36
8	12448999123.gpx	uni girls run club	2024-09-19	4.12	29.1	7:03
9	12549317388.gpx	Afternoon Run	2024-10-01	5.02	27.1	5:24
10	12563420745.gpx	Lunch Run	2024-10-03	1.98	11.5	5:47
11	12605893440.gpx	wet run to shops	2024-10-08	1.14	5.7	5:02
12	12637471964.gpx	illness can’t stop me	2024-10-12	5.75	35.4	6:08
13	12675866249.gpx	Morning Run	2024-10-17	1.46	7.5	5:09
14	12676002534.gpx	Lunch Run	2024-10-17	3.17	16.9	5:20
15	12715977585.gpx	shops	2024-10-22	1.31	6.9	5:13
16	12829195732.gpx	Afternoon Run	2024-11-05	1.33	7.6	5:44
17	12835528902.gpx	Morning Run	2024-11-06	5.06	28.8	5:41
18	12897500282.gpx	Morning Run	2024-11-14	1.84	9.4	5:06
19	12959282742.gpx	Afternoon Run	2024-11-22	2.42	13.9	5:45
20	13000928038.gpx	Lunch Run	2024-11-28	10.03	59.6	5:56
21	13119560129.gpx	Morning Run	2024-12-15	4.01	25.4	6:20
22	13128292001.gpx	Afternoon Run	2024-12-16	5.50	30.0	5:27
23	13353472644.gpx	Afternoon Run	2025-01-14	6.47		
24	13388748661.gpx	Afternoon Run	2025-01-18	5.02		
25	13659209713.gpx	Lunch Run	2025-02-18	4.03		
26	13676524078.gpx	Morning Run	2025-02-20	5.03		
27	13713749530.gpx	Afternoon Run	2025-02-24	5.55		
28	13787778111.gpx	Afternoon Run	2025-03-04	10.24		
29	13797572455.gpx	Afternoon Run	2025-03-05	2.00		
30	13820635290.gpx	first park run !	2025-03-08	5.08		
31	13916422795.gpx	Afternoon Run	2025-03-18	6.93		
32	13953862394.gpx	Lunch Run	2025-03-22	11.55		
33	13984482156.gpx	run clurb	2025-03-25	5.10		

```
23          37.0            5:43
24          26.6            5:17
25          23.1            5:44
26          28.4            5:38
27          30.2            5:26
28          68.1            6:39
29          11.0            5:29
30          28.1            5:31
31          44.1            6:21
32          70.0            6:03
33          31.4            6:09
```

The following two plots visualise all of my runs in exeter. The first plot is a simple grayscale plot with adjusted alpha to show the density of runs in certain areas. The second plot employs a same structre of code but uses a different colour map and adds a terrain basemap to make it more readable and visually appealing.

In [56]:
```
# GPX folder
gpx_folder = "skye_strava_data/activities"

# List of target dates - runs in exeter identified on my Strava account - potent
target_dates = [
    "2024-09-09", "2024-09-15", "2024-09-19", "2024-10-01", "2024-10-03", "2024-
    "2024-10-17", "2024-10-22", "2024-11-05", "2024-11-06", "2024-11-14", "2024-
    "2025-01-14", "2025-01-18", "2025-02-18", "2025-02-20", "2025-03-04", "2025-
    "2025-03-18", "2025-03-22", "2025-03-25"
]

ns = {"default": "http://www.topografix.com/GPX/1/1"}

plt.figure(figsize=(10, 10))
plt.title("GPX tracks for all my runs in Exeter")
plt.xlabel("Longitude")
plt.ylabel("Latitude")

# Loop over files
for filename in os.listdir(gpx_folder):
    if filename.endswith(".gpx"):
        file_path = os.path.join(gpx_folder, filename)
        tree = ET.parse(file_path)
        root = tree.getroot()

        # Get date
        date_tag = root.find(".//default:time", ns)
        if date_tag is None:
            continue  # Skip if no date
        date = date_tag.text[:10]

        if date in target_dates:
            # Extract points
            lats = []
            lons = []
            for trkpt in root.findall(".//default:trkpt", ns):
                lat = float(trkpt.get("lat"))
                lon = float(trkpt.get("lon"))
                lats.append(lat)
                lons.append(lon)

            # Plot
```

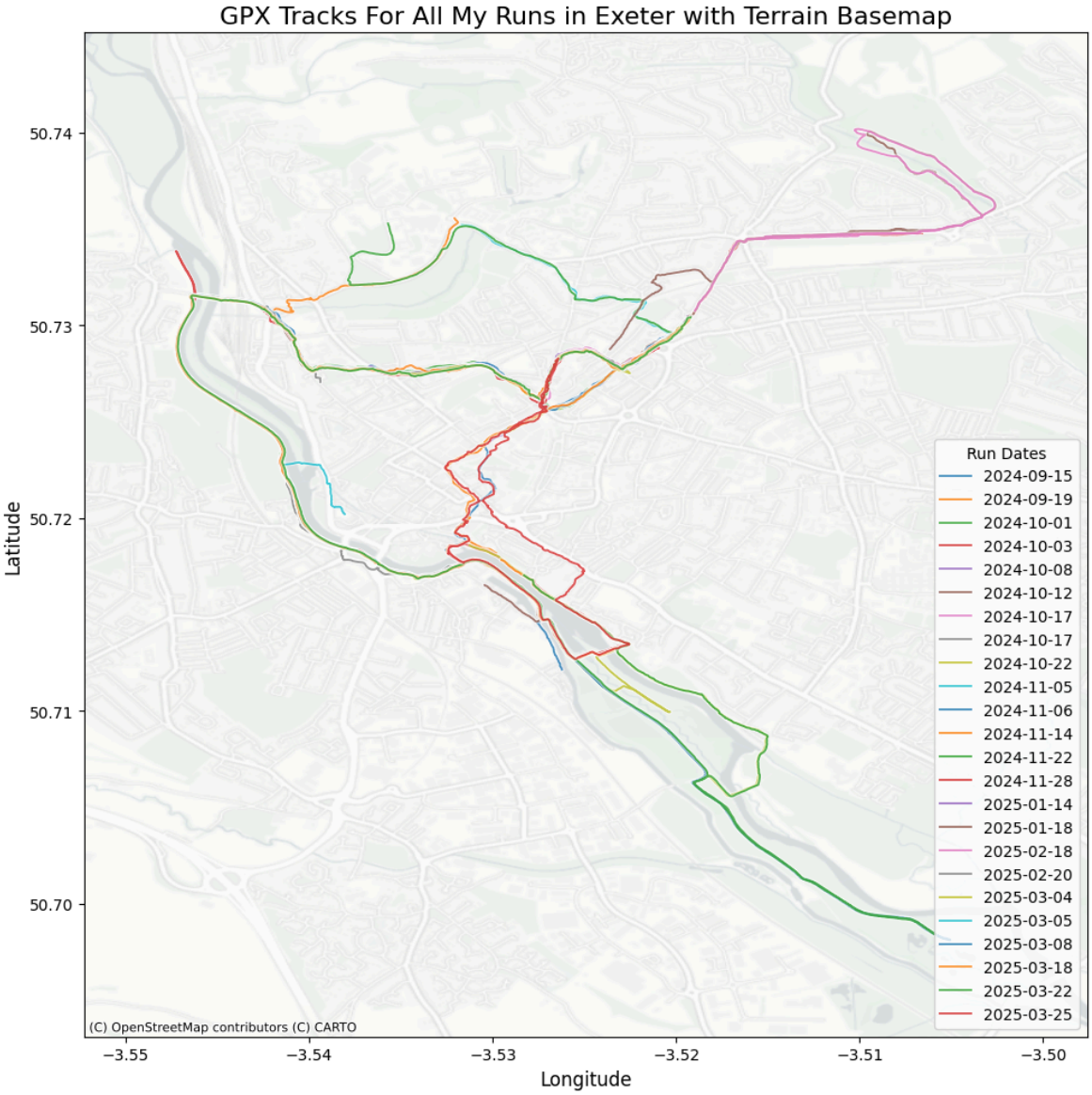
```
            plt.plot(lons, lats, alpha=0.3, linewidth=1.3, label=date, color="bl

#plt.savefig("all_exeter_runs_mapped_grayscale", dpi=300, bbox_inches="tight")

plt.show()
```



In [57]:

```
import os
import xml.etree.ElementTree as ET
import matplotlib.pyplot as plt
import contextily as ctx

#same format as above
gpx_folder = "skye_strava_data/activities"
target_dates = [
    "2024-09-09", "2024-09-15", "2024-09-19", "2024-10-01", "2024-10-03", "2024-
    "2024-10-17", "2024-10-22", "2024-11-05", "2024-11-06", "2024-11-14", "2024-
    "2025-01-14", "2025-01-18", "2025-02-18", "2025-02-20", "2025-03-04", "2025-
    "2025-03-18", "2025-03-22", "2025-03-25"
]
ns = {"default": "http://www.topografix.com/GPX/1/1"}

# Store all route coordinates
all_lats = []
all_lons = []
```

```
# Set up the plot
plt.figure(figsize=(10, 10))

# Loop over files
for filename in os.listdir(gpx_folder):
    if filename.endswith(".gpx"):
        file_path = os.path.join(gpx_folder, filename)
        tree = ET.parse(file_path)
        root = tree.getroot()

        # Get date
        date_tag = root.find(".//default:time", ns)
        if date_tag is None:
            continue
        date = date_tag.text[:10]

        if date in target_dates:
            lats = []
            lons = []
            for trkpt in root.findall(".//default:trkpt", ns):
                lat = float(trkpt.get("lat"))
                lon = float(trkpt.get("lon"))
                lats.append(lat)
                lons.append(lon)

            # Plot each route with bold colors and outline
            plt.plot(lons, lats, color="white", linewidth=3, alpha=0.5)  # Outli
            plt.plot(lons, lats, linewidth=1.3, label=date, alpha=0.8)  # Main r

            all_lats.extend(lats)
            all_lons.extend(lons)

# Basemap - Grayscale map
if all_lats and all_lons:
    xmin, xmax = min(all_lons), max(all_lons)
    ymin, ymax = min(all_lats), max(all_lats)

    plt.xlim(xmin - 0.005, xmax + 0.005)  # Add a bit of padding
    plt.ylim(ymin - 0.005, ymax + 0.005)

    ax = plt.gca()
    ctx.add_basemap(
        ax,
        crs="EPSG:4326",
        source=ctx.providers.CartoDB.PositronNoLabels,
        alpha=0.9  # Slight transparency to make lines stand out
    )

# Aesthetic adjustments
plt.xlabel("Longitude", fontsize=12)
plt.ylabel("Latitude", fontsize=12)
plt.title("GPX Tracks For All My Runs in Exeter with Terrain Basemap", fontsize=

plt.legend(fontsize=10, loc="lower right", title="Run Dates")
plt.tight_layout()

#plt.savefig("all_exeter_runs_mapped_colour", dpi=300, bbox_inches="tight")

plt.show()
```

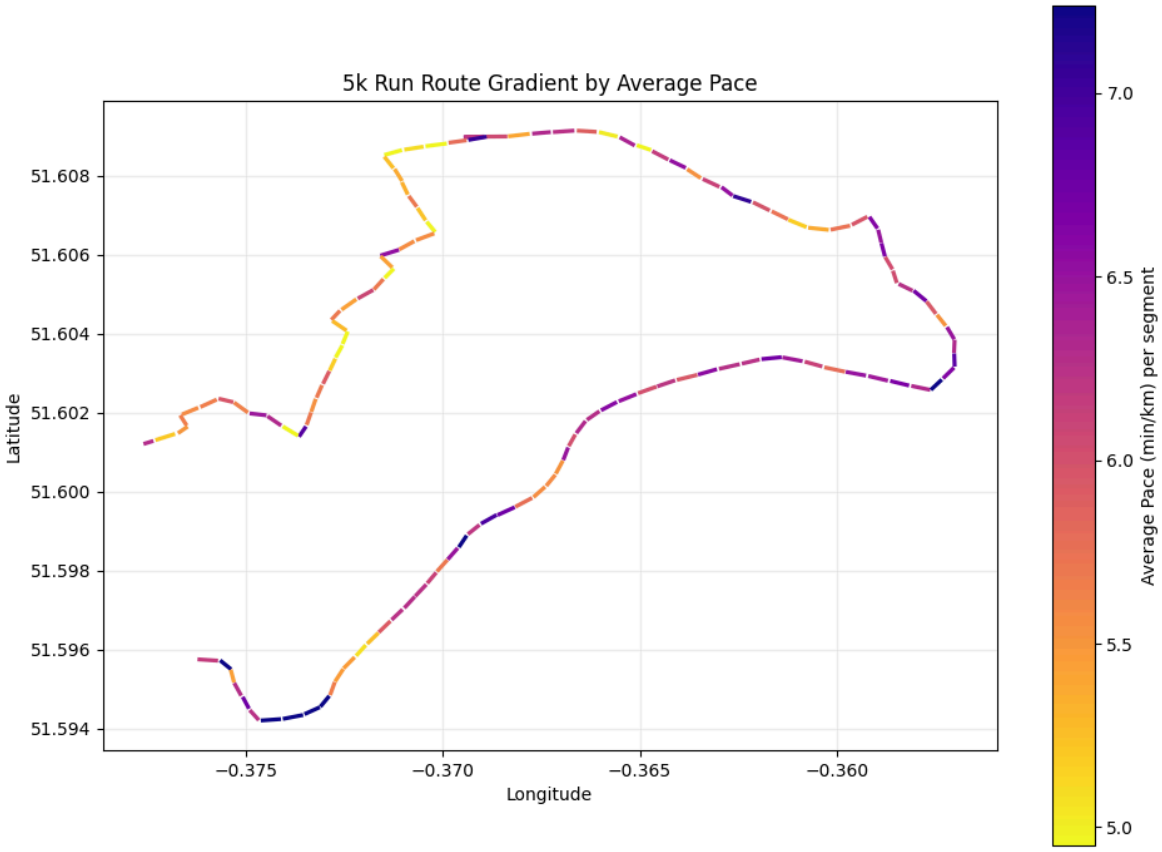


Plotting average pace on a map, with lots of trial and error in use of bins to make segments where average speeds are calculated so it is visually smooth.

In [58]:
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
from geopy.distance import geodesic
from matplotlib.collections import LineCollection
from matplotlib.colors import Normalize
from matplotlib.cm import ScalarMappable, get_cmap

# load the processed data
df = pd.read_csv("processed_run_dataTEST.csv")
df = df.dropna(subset=["Latitude", "Longitude", "Speed (m/s)"])
df = df[df["Speed (m/s)"] > 0]

# calculate distances and cumulative distances
distances = [0]
for i in range(1, len(df)):
    prev = (df.iloc[i-1]["Latitude"], df.iloc[i-1]["Longitude"])
    curr = (df.iloc[i]["Latitude"], df.iloc[i]["Longitude"])
    dist = geodesic(prev, curr).meters
    distances.append(dist)
df["Distance (m)"] = distances
```

```
df["Cumulative Distance (m)"] = df["Distance (m)"].cumsum()

# Binning the data - lots of testing here
bin_size = 40  # 40 meters per bin
df["Bin"] = (df["Cumulative Distance (m)"] // bin_size).astype(int)

# create segments and calculate average pace for each bin
segments = []
avg_paces = []

for bin_id, group in df.groupby("Bin"):
    if len(group) < 2:
        continue

    start = (group.iloc[0]["Longitude"], group.iloc[0]["Latitude"])
    end = (group.iloc[-1]["Longitude"], group.iloc[-1]["Latitude"])

    avg_speed = group["Speed (m/s)"].mean()
    avg_pace = (1000 / avg_speed) / 60  # min/km

    segments.append([start, end])
    avg_paces.append(avg_pace)

segments = np.array(segments)

# normalising the average paces for color mapping
vmin = np.percentile(avg_paces, 5)
vmax = np.percentile(avg_paces, 95)
norm = Normalize(vmin=vmin, vmax=vmax)
cmap = get_cmap("plasma_r")  # Reversed plasma: faster = darker, slower = lighte

# creating line collection
lc = LineCollection(segments, cmap=cmap, norm=norm)
lc.set_array(np.array(avg_paces))
lc.set_linewidth(2.3)

# plotting and more aesthetic adjustments
fig, ax = plt.subplots(figsize=(10, 7))
ax.add_collection(lc)
ax.scatter(df["Longitude"], df["Latitude"], color="white", s=1, alpha=0.7)

cbar = fig.colorbar(ScalarMappable(norm=norm, cmap=cmap), ax=ax)
cbar.set_label("Average Pace (min/km) per segment")

ax.set_title("5k Run Route Gradient by Average Pace")
ax.set_xlabel("Longitude")
ax.set_ylabel("Latitude")
ax.set_aspect('equal')
ax.grid(True, alpha=0.2)
plt.tight_layout()
#plt.savefig("5k_run_gradient_by_average_pace.png", dpi=300, bbox_inches="tight"
plt.show()
```

```
C:\Users\leath\AppData\Local\Temp\ipykernel_19388\3526903856.py:51: MatplotlibDep
recationWarning: The get_cmap function was deprecated in Matplotlib 3.7 and will
be removed in 3.11. Use ``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.
get_cmap()`` or ``pyplot.get_cmap()`` instead.
  cmap = get_cmap("plasma_r")  # Reversed plasma: faster = darker, slower = light
er
```



Using CSV 'activities' from issy_strava_data and skye_strava_data - it is an array with information about each activity recorded.

In [59]:
```
issy_activities_df = pd.read_csv("issy_strava_data/activities.csv")
issy_activities_df.head()

skye_activities_df = pd.read_csv("skye_strava_data/activities.csv")
#skye_activities_df.head()
issy_activities_df.head()
```

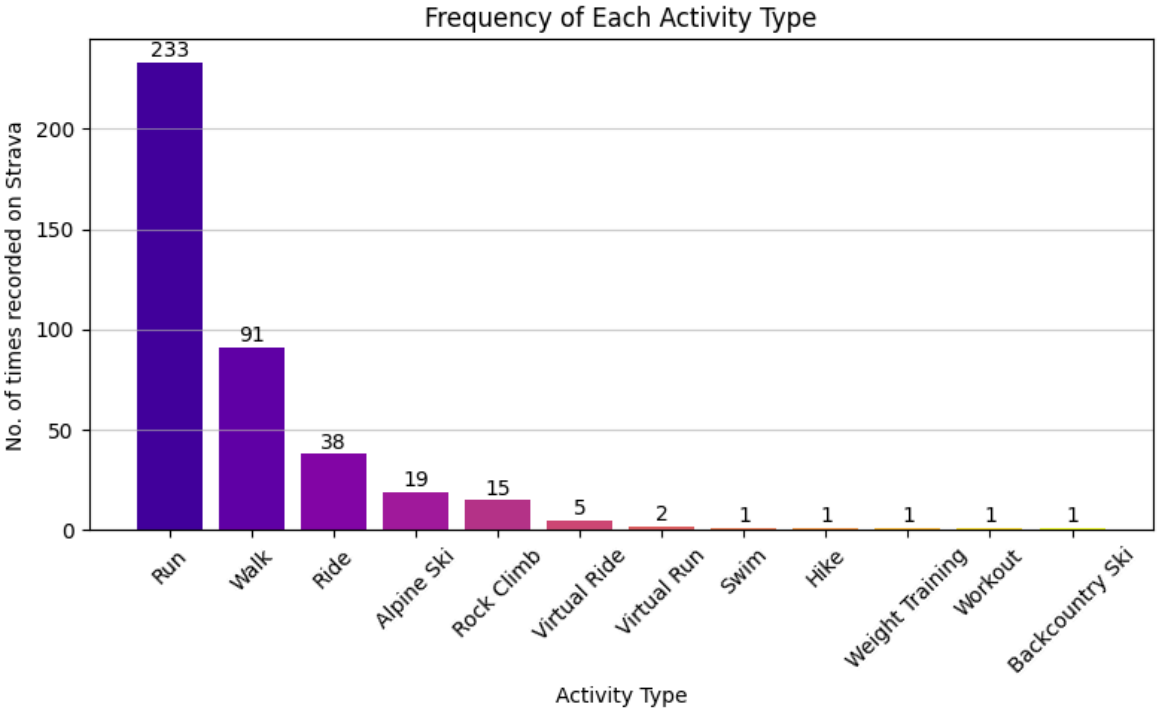
Out[59]:

	Activity ID	Activity Date	Activity Name	Activity Type	Activity Description	Elapsed Time	Distance	Max Heart Rate	Rel E
0	6422476991	24 Dec 2021, 14:11:29	Afternoon Run	Run	NaN	325	0.57	NaN	
1	6433719220	24 Dec 2021, 14:18:58	Afternoon Run	Run	NaN	260918	0.2	NaN	
2	6433794819	27 Dec 2021, 14:47:43	Afternoon Run	Run	NaN	965	1.54	NaN	
3	6433898857	27 Dec 2021, 15:04:14	Afternoon Run	Run	NaN	1284	2.6	NaN	
4	6451441446	31 Dec 2021, 13:58:12	Afternoon Run	Run	NaN	559	1.52	NaN	

5 rows × 94 columns

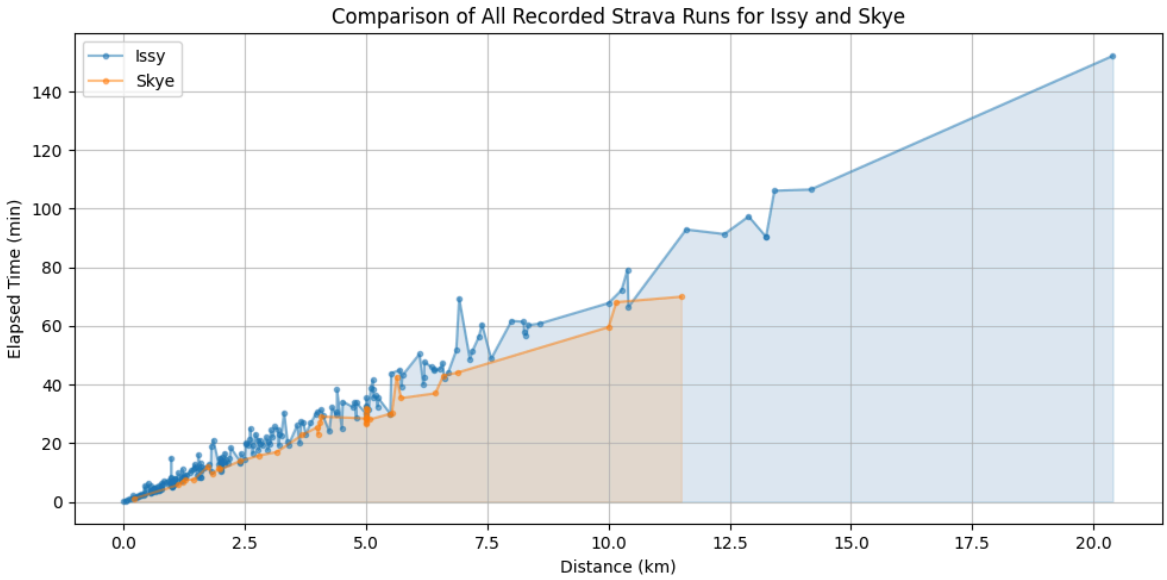
Issy has many more activities recorded than me so I thought it would be interesting to see which activities are her favourite.

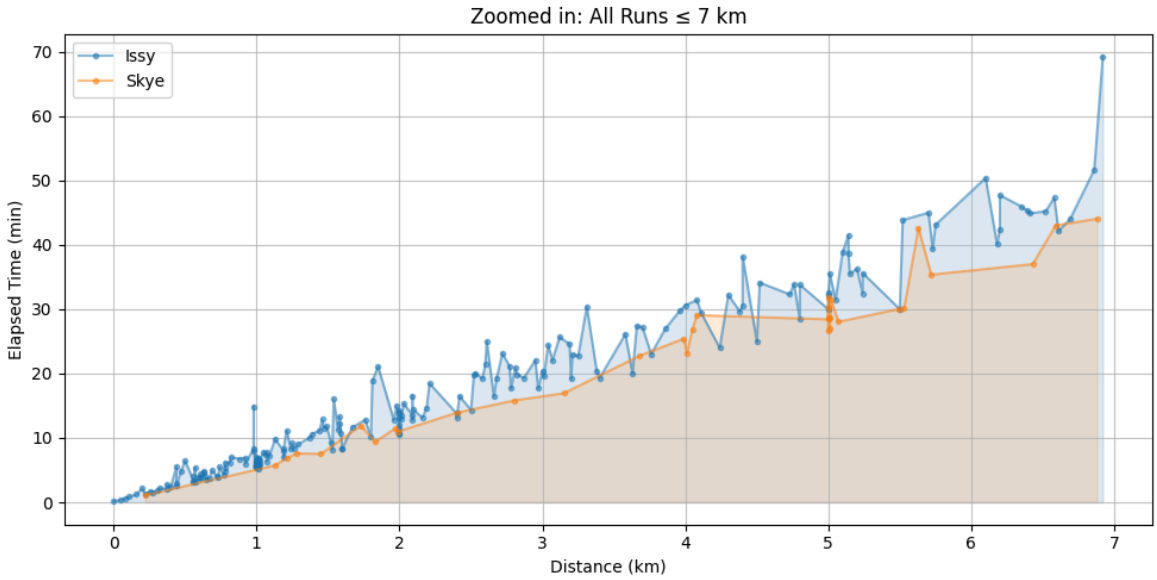
In [60]:
```
import matplotlib.pyplot as plt
import matplotlib.cm as cm
import numpy as np

# Count the number of occurrences of each activity type
activity_counts = issy_activities_df["Activity Type"].value_counts()

plt.figure(figsize=(8, 5))
colors = cm.plasma(np.linspace(0.1, 1, len(activity_counts)))
bars = plt.bar(activity_counts.index, activity_counts.values, color=colors)

# Add value labels above bars
for bar in bars:
    height = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, height + 0.5, f"{int(height)}",
             ha='center', va='bottom', fontsize=10)

plt.title("Frequency of Each Activity Type")
plt.xlabel("Activity Type")
plt.ylabel("No. of times recorded on Strava")
plt.xticks(rotation=45)
plt.grid(axis='y', alpha=0.6)
plt.tight_layout()

#plt.savefig("activity_freq_issy.png", dpi=300, bbox_inches="tight")
plt.show()
```



In [61]:
```
# Filter both dataframes to only include runs
issy_runs = issy_activities_df[issy_activities_df["Activity Type"] == "Run"]
skye_runs = skye_activities_df[skye_activities_df["Activity Type"] == "Run"]

# Remove anomaly to clean data
issy_runs = issy_runs[issy_runs["Elapsed Time"] != 260918].reset_index(drop=True

# Clean distance values and convert to float
issy_runs["Distance"] = issy_runs["Distance"].astype(str).str.replace("'", "").a
skye_runs["Distance"] = skye_runs["Distance"].astype(str).str.replace("'", "").a
# Convert Elapsed Time from seconds to minutes
issy_runs["Elapsed Time"] = issy_runs["Elapsed Time"] / 60
skye_runs["Elapsed Time"] = skye_runs["Elapsed Time"] / 60

# Sorting numerical valyes for plotting
issy_runs = issy_runs.sort_values("Distance")
skye_runs = skye_runs.sort_values("Distance")

# Create stacked plots
fig, (ax1, ax2) = plt.subplots(2, 1, figsize=(10, 10))  # <- changed to (2, 1)

# Making the first plot that shows full range of distances
ax1.plot(issy_runs["Distance"], issy_runs["Elapsed Time"], label="Issy", color="
ax1.plot(skye_runs["Distance"], skye_runs["Elapsed Time"], label="Skye", color="
ax1.fill_between(issy_runs["Distance"], issy_runs["Elapsed Time"], alpha=0.15, c
ax1.fill_between(skye_runs["Distance"], skye_runs["Elapsed Time"], alpha=0.15, c
ax1.set_title("Comparison of All Recorded Strava Runs for Issy and Skye")
ax1.set_xlabel("Distance (km)")
ax1.set_ylabel("Elapsed Time (min)")
ax1.grid(True, alpha=0.7)
ax1.legend()

# Plotting second subplot that shows a zoomed-in view of runs less than 7km
issy_short = issy_runs[issy_runs["Distance"] <= 7]
skye_short = skye_runs[skye_runs["Distance"] <= 7]

ax2.plot(issy_short["Distance"], issy_short["Elapsed Time"], label="Issy", color
```

```
ax2.plot(skye_short["Distance"], skye_short["Elapsed Time"], label="Skye", color
ax2.fill_between(issy_short["Distance"], issy_short["Elapsed Time"], alpha=0.15,
ax2.fill_between(skye_short["Distance"], skye_short["Elapsed Time"], alpha=0.15,
ax2.set_title("Zoomed in: All Runs ≤ 7 km")
ax2.set_xlabel("Distance (km)")
ax2.set_ylabel("Elapsed Time (min)")
ax2.grid(True, alpha=0.7)
ax2.legend()

plt.tight_layout()
#plt.savefig("issy_skye_run-comparison.png", dpi=300, bbox_inches="tight")
plt.show()
```





In [ ]: