weather

August 24, 2025

Dark-Fiber Charakterisierung für entanglement polarisierter QKD

Analyse des Einflusses meteorologischer Faktoren auf Messdaten

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Datensatz: Erfurt - Sundhausen

1 Vorbereitung der Datenanalyse

1.1 Ressourcen und Literatur

- Messdaten
- Messgerät
- Open-Meteo: Wetterdaten & Dokumentation
- Sonnenauf- und untergang

1.2 Verwendete Libraries / Softwaretools

[1]:
```
import requests
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.dates as mdates
import numpy as np
import io
import datetime
```

1.3 Eigene Hilfsfunktionen

[2]:
```
def lowpass(data, box = 100):
    box = box
    LP_filter = np.full(int(box), 1/box)
    lps = np.convolve(ydata, LP_filter)
    lps = lps[ int((box-1) / 2) :len(lps) - int((box - 1) / 2)]
```

```
    return lps

def highpass(data, box = 100):
    lps = lowpass(data, box)
    hps = data - lps[:-1]
    return hps
```

[3]:
```
def butter_filter(data, cutoff, fs=4, order=4, btype='low'):
    nyq = 0.5 * fs
    normal_cutoff = cutoff / nyq
    b, a = butter(order, normal_cutoff, btype=btype, analog=False)
    y = filtfilt(b, a, data)
    return y
```

2 Aufbereitung der Wetterdaten

[4]:
```
# Erfurt - Latitude: 51.0 & Longitude: 11.0

url = (
    "https://archive-api.open-meteo.com/v1/archive?"
    "latitude=51.0&longitude=11.0&"
    "start_date=2025-02-20&end_date=2025-02-27&"
  ␣
 ↪"hourly=temperature_2m,relative_humidity_2m,cloud_cover,wind_speed_10m,wind_direction_10m,r
    "timezone=Europe/Berlin"
)

response = requests.get(url)

if response.status_code == 200:
    data = response.json()
    weather = pd.DataFrame(data["hourly"])
    print(weather.head())
else:
    print("Fehler beim Abrufen:", response.status_code)
    print(response.text)
```

```
                time  temperature_2m  relative_humidity_2m  cloud_cover  \
0  2025-02-20T00:00            -2.9                    54            0
1  2025-02-20T01:00            -2.7                    50            0
2  2025-02-20T02:00            -2.5                    47            0
3  2025-02-20T03:00            -2.0                    50            0
4  2025-02-20T04:00            -2.4                    52           11

   wind_speed_10m  wind_direction_10m  rain
0             9.5                 143   0.0
1             9.8                 144   0.0
```

```
2              9.5                  148    0.0
3             11.6                  159    0.0
4             11.1                  166    0.0
```

[5]:
```
units = data['hourly_units']
weather_columns = []
for key, value in units.items():
    weather_columns.append(f'{key} [{value}]')

weather.columns = weather_columns
weather.head()
```

[5]:

	time [iso8601]	temperature_2m [°C]	relative_humidity_2m [%]	\
0	2025-02-20T00:00	-2.9	54	
1	2025-02-20T01:00	-2.7	50	
2	2025-02-20T02:00	-2.5	47	
3	2025-02-20T03:00	-2.0	50	
4	2025-02-20T04:00	-2.4	52	

	cloud_cover [%]	wind_speed_10m [km/h]	wind_direction_10m [°]	rain [mm]
0	0	9.5	143	0.0
1	0	9.8	144	0.0
2	0	9.5	148	0.0
3	0	11.6	159	0.0
4	11	11.1	166	0.0

[6]:
```
weather.to_csv("open-meteo_erfurt.csv", index=False)
```

[7]:
```
w_data = [
    {"header": "temperature_2m [°C]", "color" : "tab:red", "unit": "°C",␣
 ↪"label": "Temperature"},
    {"header": "relative_humidity_2m [%]", "color" : "tab:purple", "unit": "%",␣
 ↪"label": "Humidity"},
    {"header": "cloud_cover [%]", "color" : "tab:gray", "unit": "%", "label":␣
 ↪"Cloud Cover"},
    {"header": "wind_speed_10m [km/h]", "color" : "tab:green", "unit": "km/h",␣
 ↪"label": "Windspeed"},
    {"header": "wind_direction_10m [°]", "color" : "tab:orange", "unit": "°",␣
 ↪"label": "Winddirection"},
    {"header": "rain [mm]", "color" : "tab:cyan", "unit": "mm", "label": "Rain"}
]

for i in range(len(w_data)):
    print(f'{i}: {w_data[i]["label"]}')
```

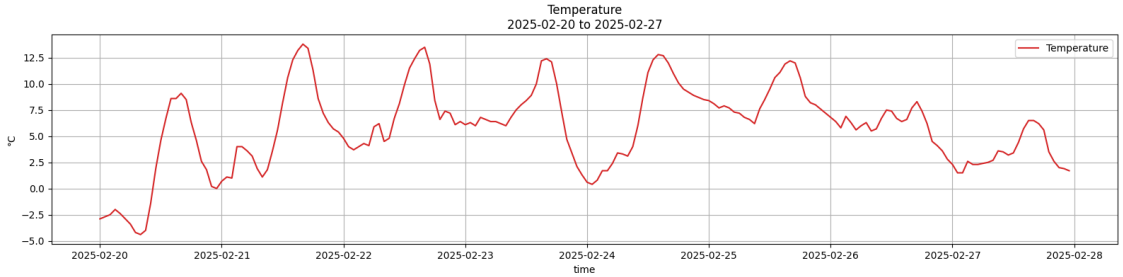
```
0: Temperature
1: Humidity
2: Cloud Cover
```

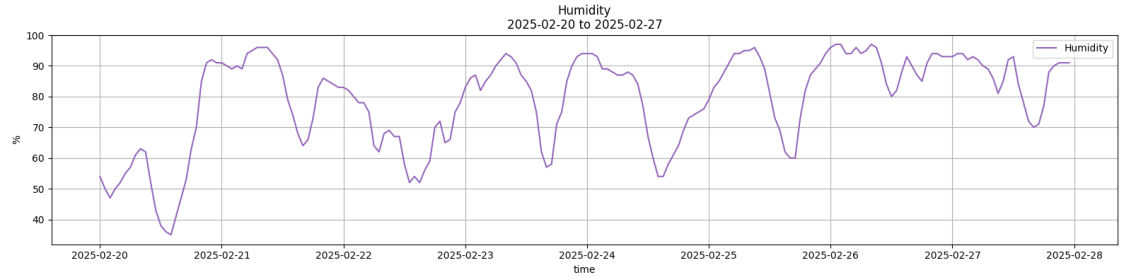
```
3: Windspeed
4: Winddirection
5: Rain
```

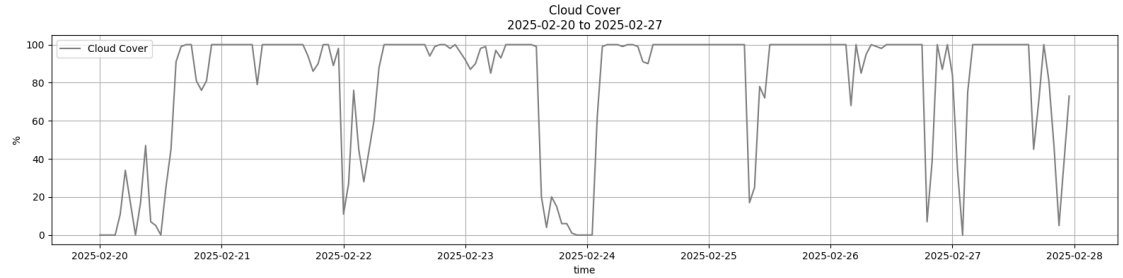
[8]:
```
sunrise = [
    datetime.datetime.strptime('2025-02-20 07:18:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-21 07:16:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-22 07:14:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-23 07:12:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-24 07:10:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-25 07:08:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-26 07:06:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-27 07:04:00', '%Y-%m-%d %H:%M:%S')
]
sunset =  [
    datetime.datetime.strptime('2025-02-20 17:41:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-21 17:43:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-22 17:44:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-23 17:46:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-24 17:48:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-25 17:50:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-26 17:51:00', '%Y-%m-%d %H:%M:%S'),
    datetime.datetime.strptime('2025-02-27 17:53:00', '%Y-%m-%d %H:%M:%S')
]
```

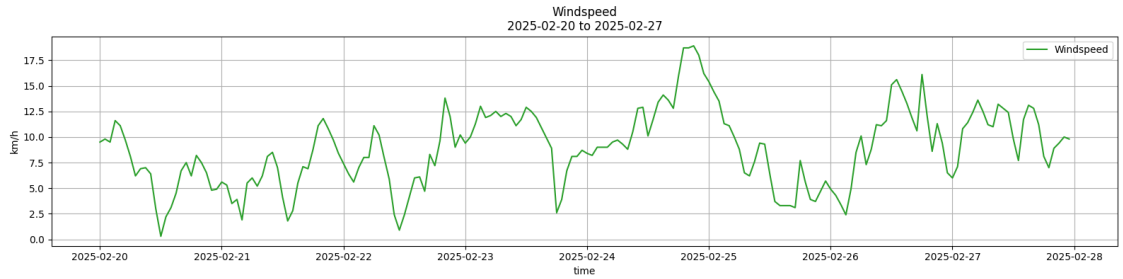
[9]:
```
weather[weather_columns[0]] = pd.to_datetime(weather[weather_columns[0]])
weather.set_index(weather_columns[0], inplace=True)
```

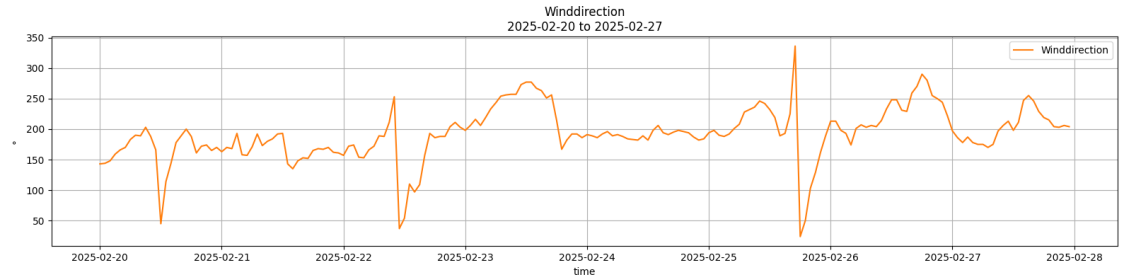
[13]:
```
fig, axs = plt.subplots(len(w_data), 1, figsize=(16, 24), sharex=False)

for i in range(len(w_data)):
    ax = axs[i] if len(weather_columns) > 1 else axs
    ax.plot(weather.index, weather[w_data[i]["header"]], label␣
 ↪=w_data[i]["label"], color=w_data[i]["color"])

    ax.grid()
    ax.legend(loc='best')
    ax.set_title(f'{w_data[i]["label"]}\n{weather.index[0].
 ↪strftime("%Y-%m-%d")} to {weather.index[-1].strftime("%Y-%m-%d")}')
    ax.set_xlabel("time")
    ax.set_ylabel(w_data[i]["unit"])

plt.tight_layout()
plt.show()
```

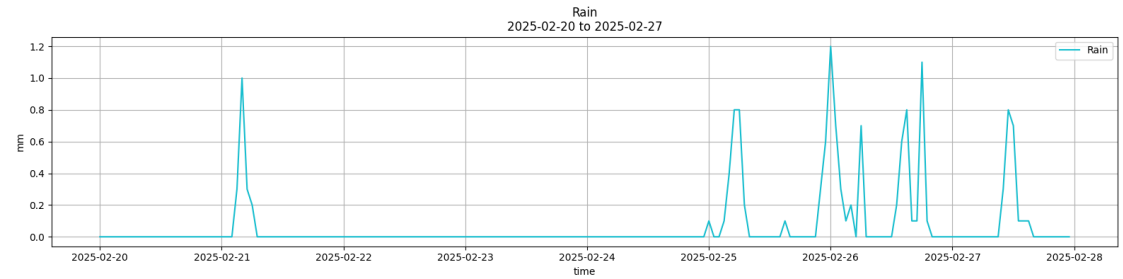

Temperature
2025-02-20 to 2025-02-27
Temperature
°C
time


Humidity
2025-02-20 to 2025-02-27
Humidity
%
time


Cloud Cover
2025-02-20 to 2025-02-27
Cloud Cover
%
time


Windspeed
2025-02-20 to 2025-02-27
Windspeed
km/h
time


Winddirection
2025-02-20 to 2025-02-27
Winddirection
°
time


Rain
2025-02-20 to 2025-02-27
Rain
mm
time

3 Aufbereitung der Messdaten

[14]:
```
filename ='20_02_to_26_02_Sundhausen to FZE port 2.csv'
skip = 8
sep = ";"

columns = ['Time[date hh:mm:ss] ', ' Elapsed Time [hh:mm:ss:ms]', ' Normalized␣
 ↪s 1 ', ' Normalized s 2 ', ' Normalized s 3 ', ' S 0 [mW]', ' S 1 [mW]', ' S␣
 ↪2 [mW]', ' S 3 [mW]', ' Azimuth[°] ', ' Ellipticity[°] ', ' DOP[%] ', '␣
 ↪DOCP[%] ', ' DOLP[%] ', ' Power[mW] ', ' Pol Power[mW] ', ' Unpol Power[mW]␣
 ↪', ' Power[dBm] ', ' Pol Power[dBm] ', ' Unpol Power[dBm] ', '␣
 ↪Power-Split-Ratio ', ' Phase Difference[°] ', ' Warning']
for c in range(len(columns)):
    print(c, ': ', columns[c])
```

```
0 :  Time[date hh:mm:ss]
1 :   Elapsed Time [hh:mm:ss:ms]
2 :   Normalized s 1
3 :   Normalized s 2
4 :   Normalized s 3
5 :   S 0 [mW]
6 :   S 1 [mW]
7 :   S 2 [mW]
8 :   S 3 [mW]
9 :   Azimuth[°]
10 :   Ellipticity[°]
11 :   DOP[%]
12 :   DOCP[%]
13 :   DOLP[%]
14 :   Power[mW]
15 :   Pol Power[mW]
16 :   Unpol Power[mW]
17 :   Power[dBm]
18 :   Pol Power[dBm]
19 :   Unpol Power[dBm]
20 :   Power-Split-Ratio
21 :   Phase Difference[°]
22 :   Warning
```

4 Zusammenhang zwischen Messdaten und Wetterdaten

4.1 Polarisationsgrad (DOP[%])

[15]:
```
degree = pd.read_csv(filename,skiprows=skip, sep=sep, usecols=[columns[0],␣
↪columns[11]])
```

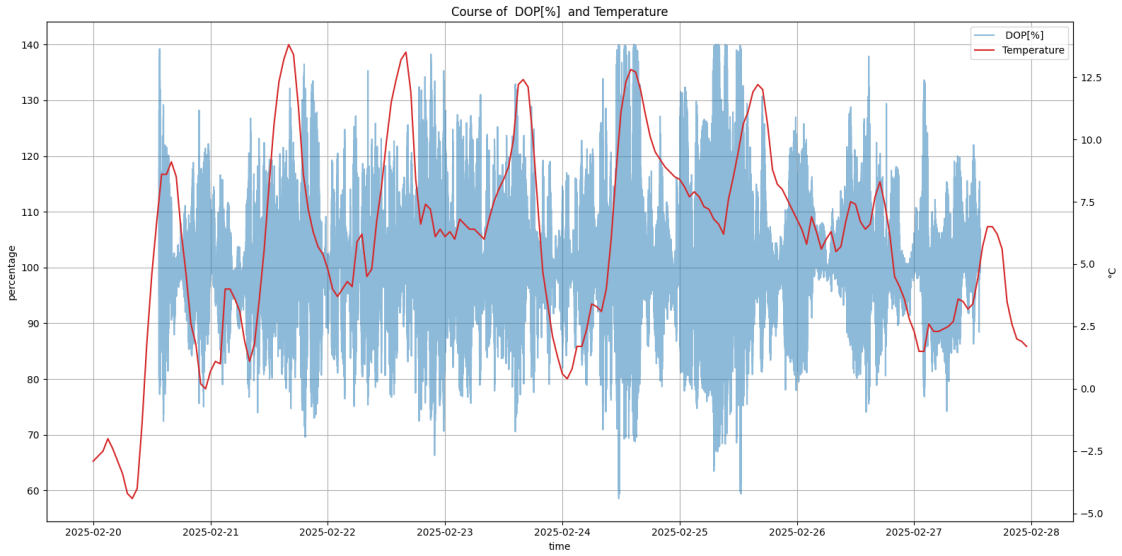
[16]:
```
degree[columns[0]] = pd.to_datetime(degree[columns[0]])
degree.set_index(columns[0], inplace=True)
```

[17]:
```
degree = degree[columns[11]]
degree = degree.drop(degree[(degree > 140) | (degree < 0)].index)

degree_daily = degree.groupby(degree.index.date)
degree_daily_list = list(degree_daily)
```

[18]:
```
weather_daily = weather.groupby(weather.index.date)
weather_daily_list = list(weather_daily)
```

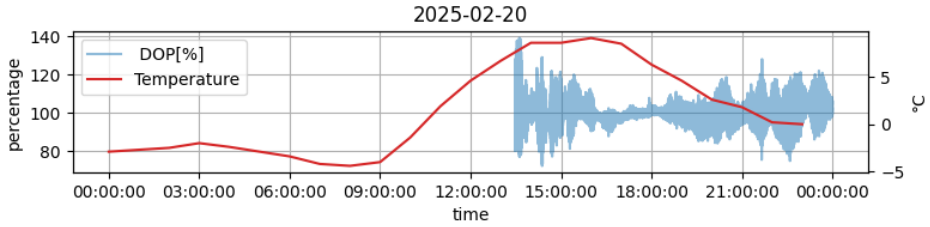
4.1.1 Originaldaten

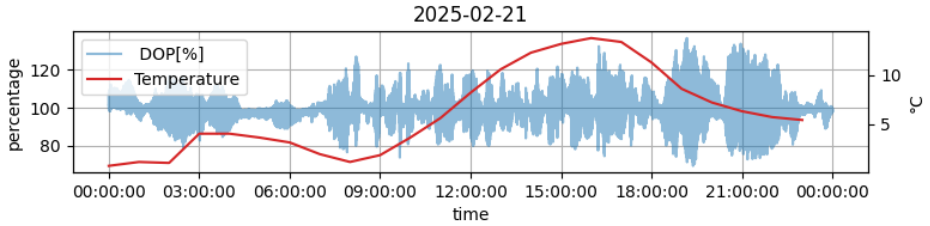
[19]:
```
current = 0 #Temperature

fig, ax1 = plt.subplots(figsize=(16, 8))

ax1.plot(degree.index, degree, label=columns[11], color="tab:blue", alpha = 0.5␣
↪)
ax1.set_xlabel('time')
ax1.set_ylabel('percentage')
h1, l1 = ax1.get_legend_handles_labels()

ax2 = ax1.twinx()

ax2.plot(weather.index, weather[w_data[current]["header"]],␣
↪label=w_data[current]["label"], color = w_data[current]["color"])
ax2.set_ylabel(w_data[current]["unit"])
h2, l2 = ax2.get_legend_handles_labels()

ax1.grid()
ax1.legend(h1+h2, l1+l2, loc="best")
ax1.set_title(f'Course of {columns[11]} and {w_data[current]["label"]}')

plt.tight_layout()
plt.show()
```

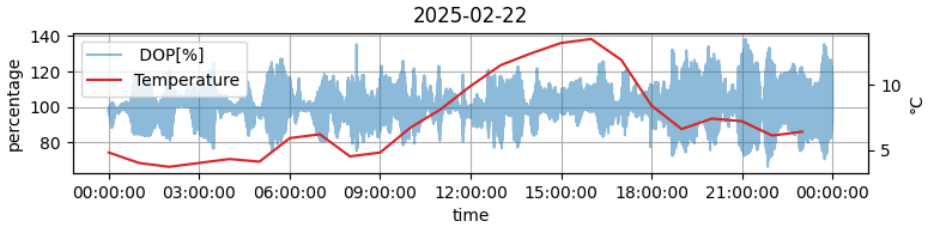


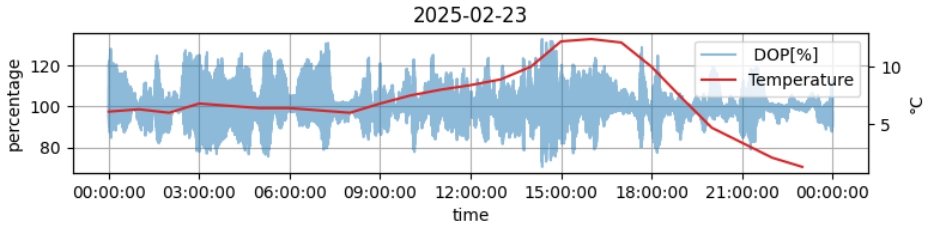
[20]:
```
current = 0 # Temperature

fig, axs = plt.subplots(len(degree_daily_list), 1, figsize=(8, 16),␣
 ↪sharex=False)

for i in range(len(degree_daily_list)):
    ax1 = axs[i] if len(degree_daily_list) > 1 else axs
    df_day = degree_daily_list[i][1]

    ax1.plot(df_day.index, df_day, label=columns[11], alpha=0.5)
    ax1.set_xlabel('time')
    ax1.set_ylabel('percentage')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather_daily_list[i][1].index,␣
 ↪weather_daily_list[i][1][w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"])
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
    ax1.set_title(degree_daily_list[i][0])
    ax1.xaxis.set_major_formatter(mdates.DateFormatter('%H:%M:%S'))

plt.tight_layout()
```

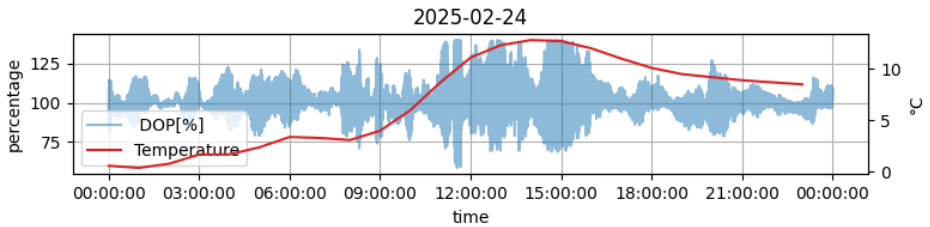
```
plt.show()
```

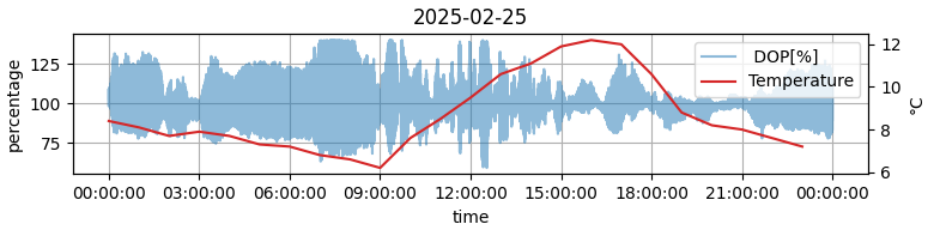

2025-02-20
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

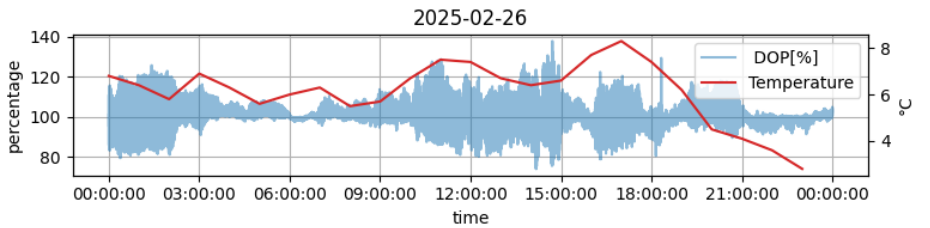

2025-02-21
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

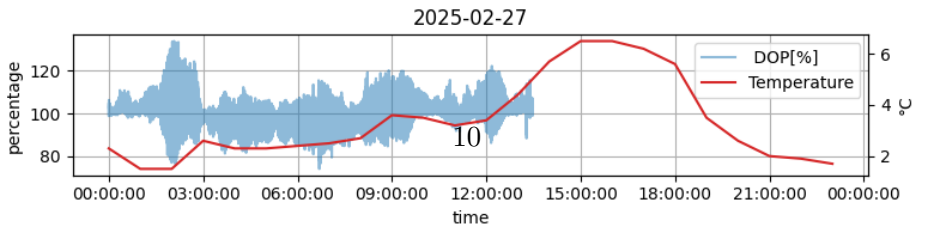

2025-02-22
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00


2025-02-23
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

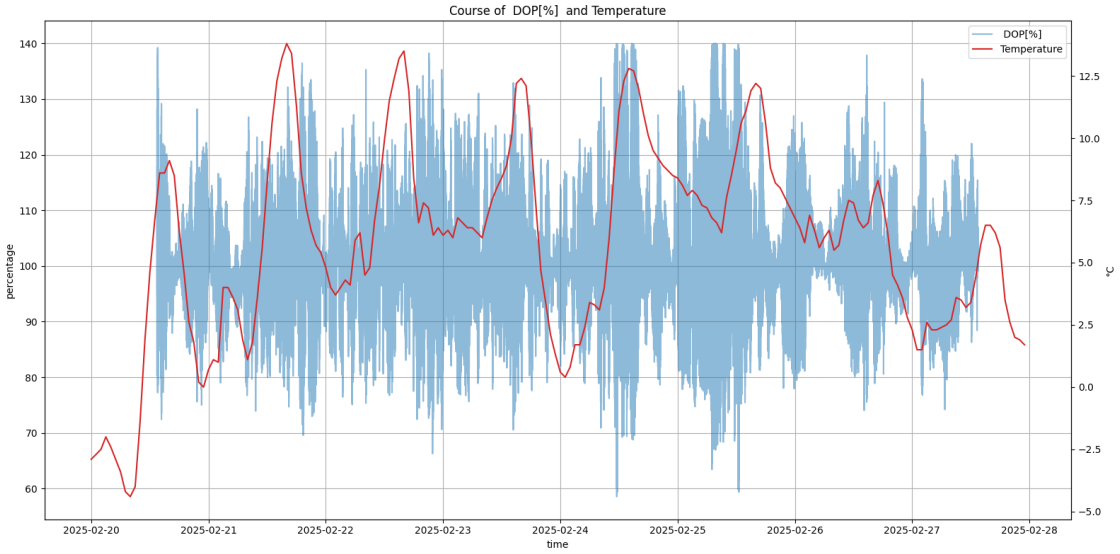

2025-02-24
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

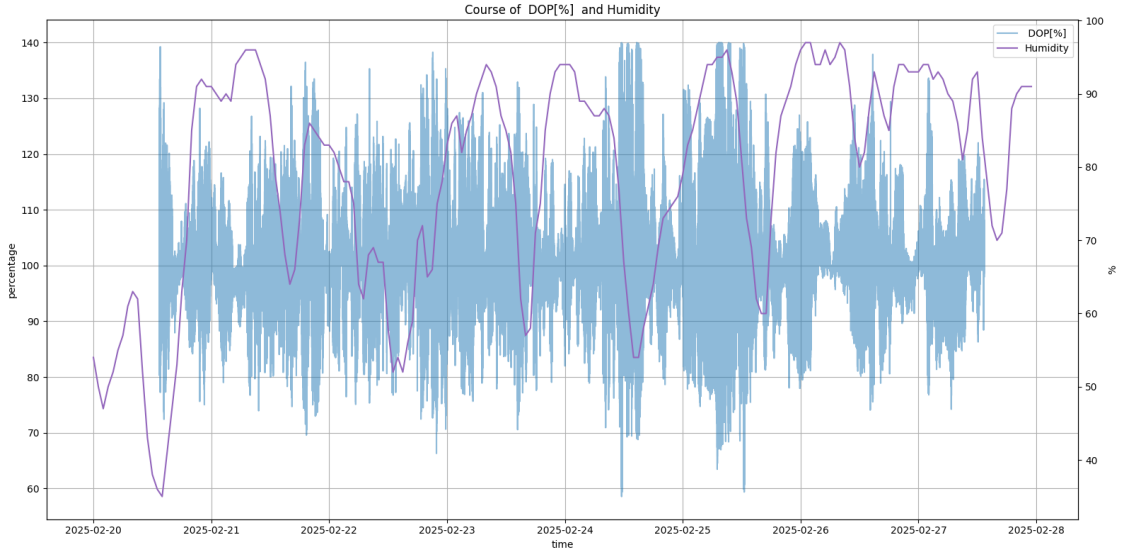

2025-02-25
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

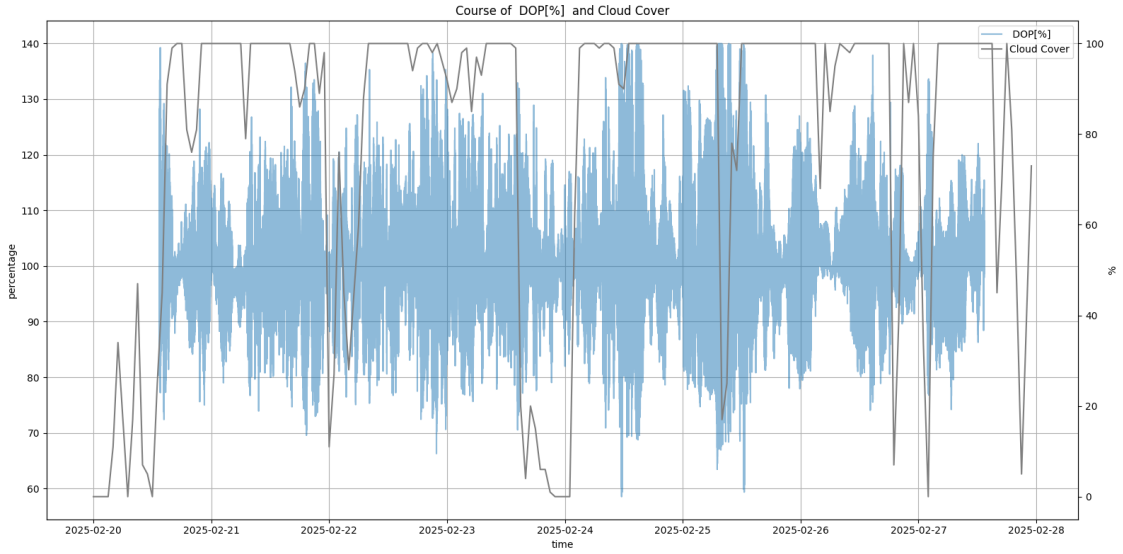

2025-02-26
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

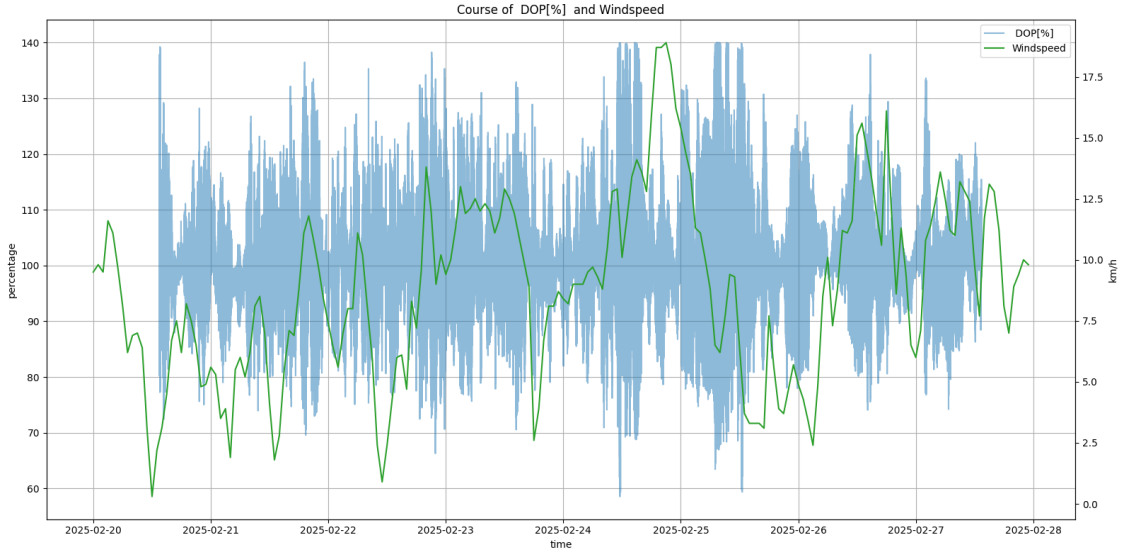

2025-02-27
DOP[%]
Temperature
percentage
℃
time
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

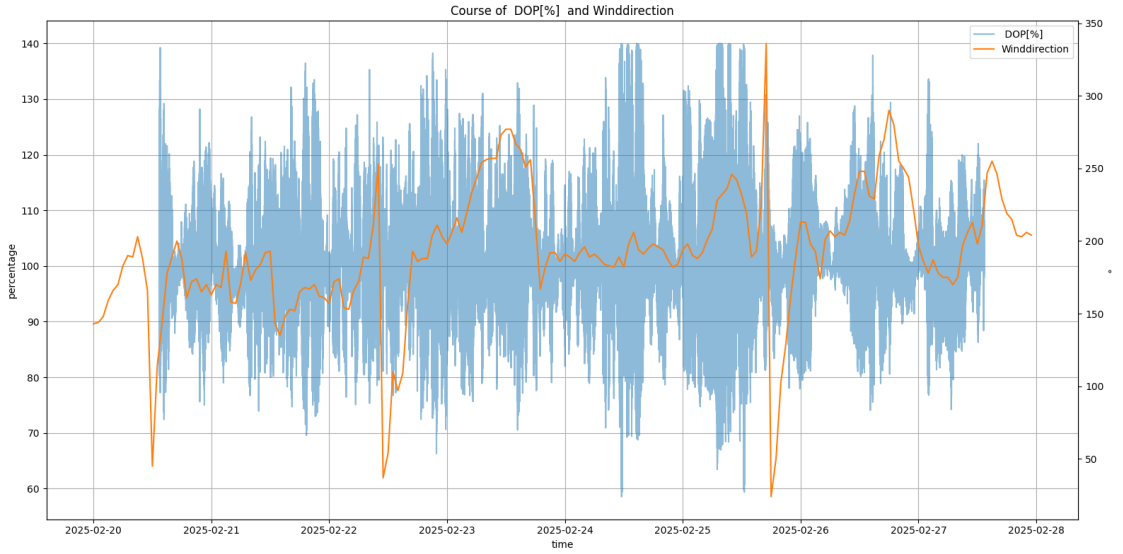
[21]:
```
for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))

    ax1.plot(degree.index, degree, label=columns[11], color="tab:blue", alpha =␣
 ↪0.5 )
    ax1.set_xlabel('time')
    ax1.set_ylabel('percentage')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"])
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
    ax1.set_title(f'Course of {columns[11]} and {w_data[current]["label"]}')

    plt.tight_layout()
    plt.show()
```

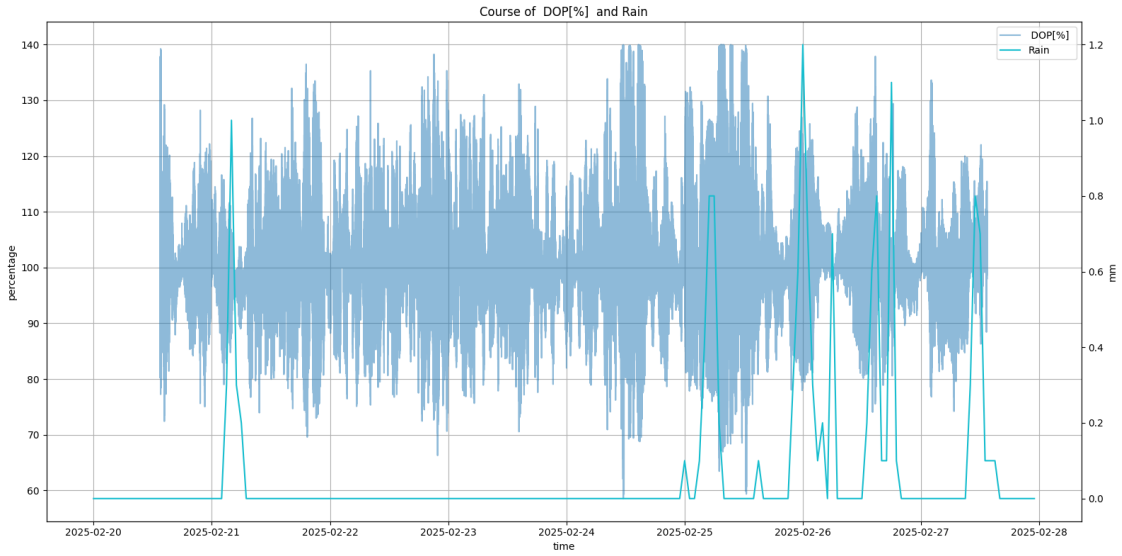



Course of DOP[%] and Humidity
DOP[%]
Humidity
percentage
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

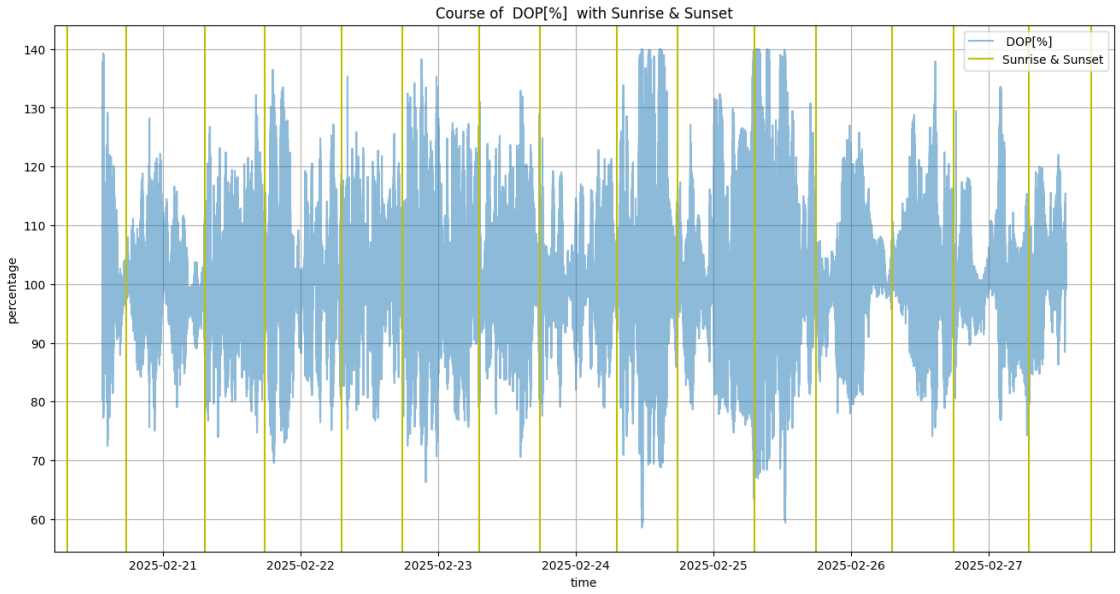

Course of DOP[%] and Cloud Cover
DOP[%]
Cloud Cover
percentage
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Course of DOP[%] and Windspeed
DOP[%]
Windspeed
percentage
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Course of DOP[%] and Winddirection
DOP[%]
Winddirection
percentage
°
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28



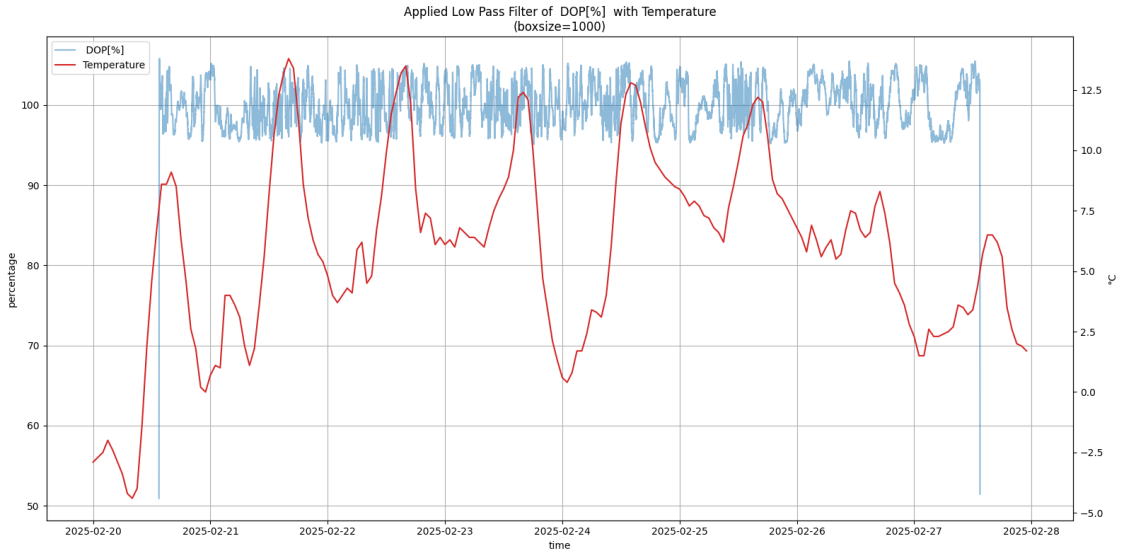
[22]:
```
# Sunlight (day-night context)

plt.figure(figsize = (16,8))
plt.plot(degree.index, degree, label=columns[11], alpha = 0.5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y')
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset')
    else: plt.axvline(x = sunset[i], color = 'y')
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Course of {columns[11]} with Sunrise & Sunset')
plt.xlabel('time')
plt.ylabel('percentage')
plt.show()
```

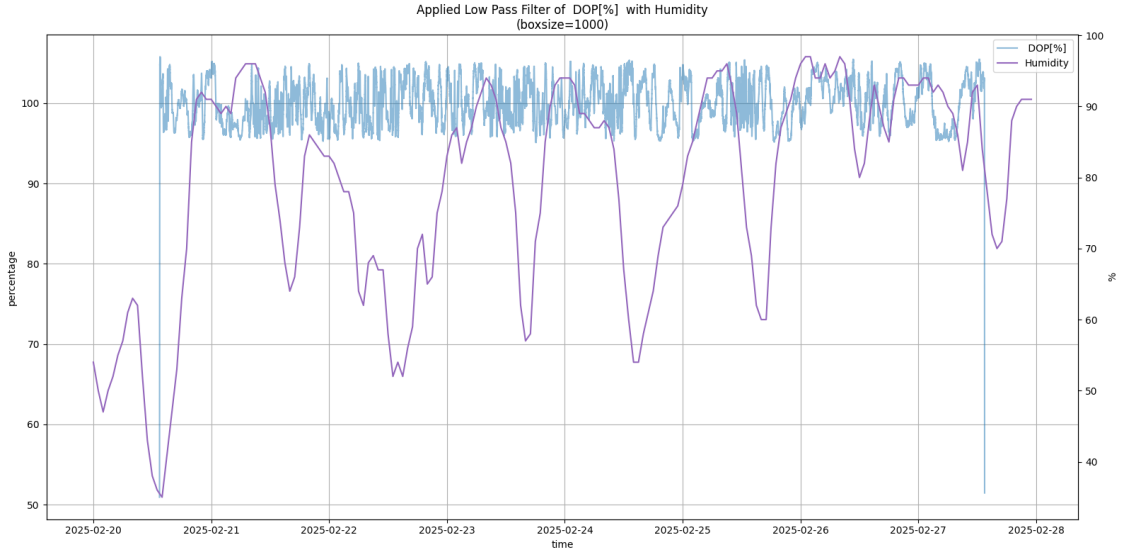


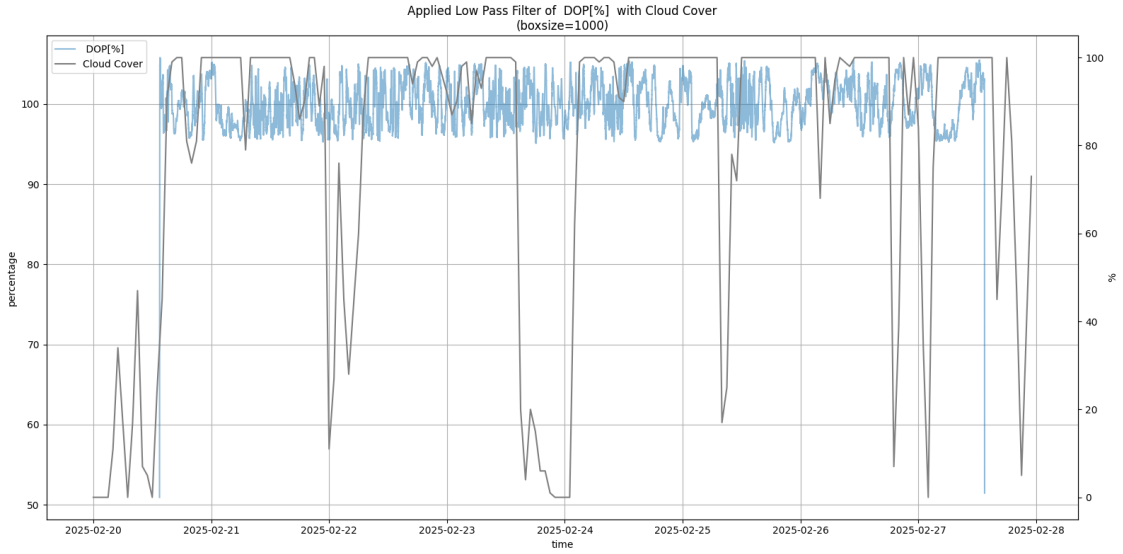
4.1.2 Anwendung von Tief- und Hochpassfiltern

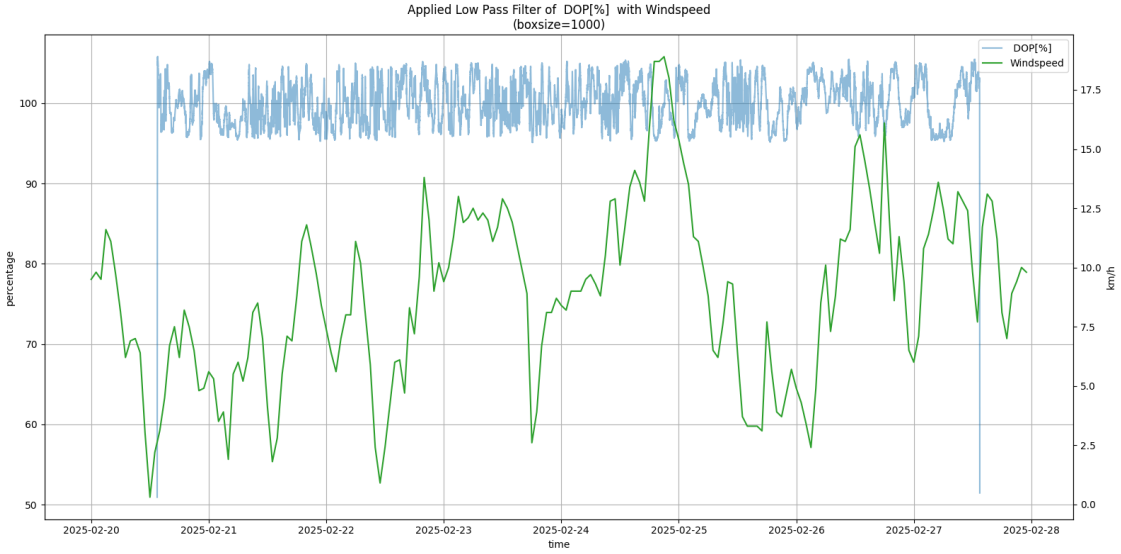
[23]:
```
box = 1000

for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))

    ydata = np.array(degree)
    lps = lowpass(ydata, box)

    ax1.plot(degree.index, lps[:-1] , label=columns[11], color="tab:blue",␣
 ↪alpha = 0.5 )
    ax1.set_xlabel('time')
    ax1.set_ylabel('percentage')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"])
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
    ax1.set_title(f'Applied Low Pass Filter of {columns[11]} with␣
 ↪{w_data[current]["label"]}\n(boxsize={box})')
```

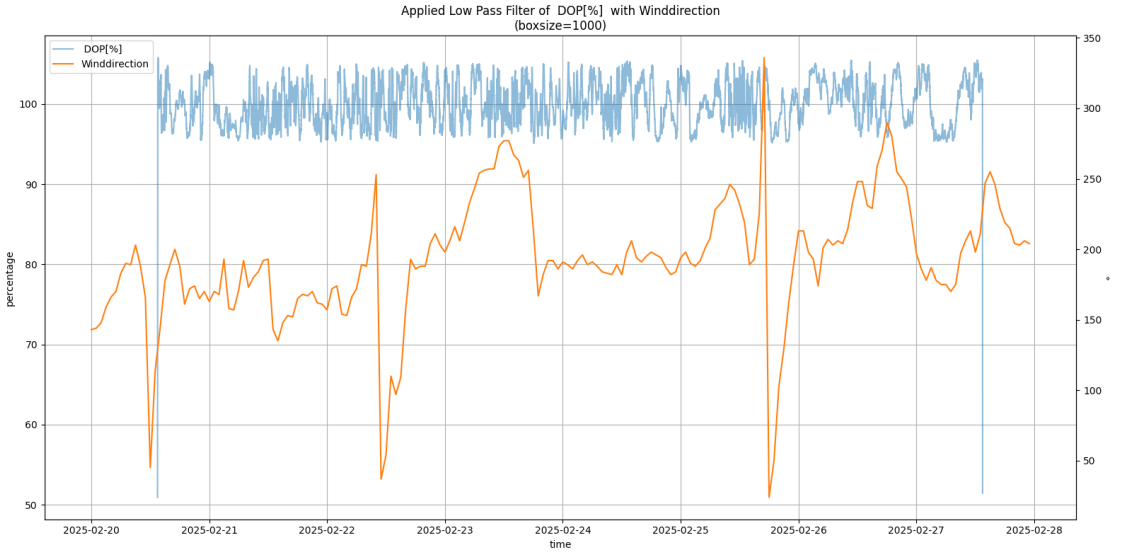
```
    plt.tight_layout()
    plt.show()


# Sunlight (day-night context)

plt.figure(figsize = (16,8))
ydata = np.array(degree)
lps = lowpass(ydata, box)
plt.plot(degree.index, lps[:-1], label=columns[11], alpha = 0.5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y')
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset')
    else: plt.axvline(x = sunset[i], color = 'y')
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Applied Low Pass Filter of {columns[11]} with Sunrise &␣
 ↪Sunset\n(boxsize={box})')
plt.xlabel('time')
plt.ylabel('percentage')
plt.show()
```

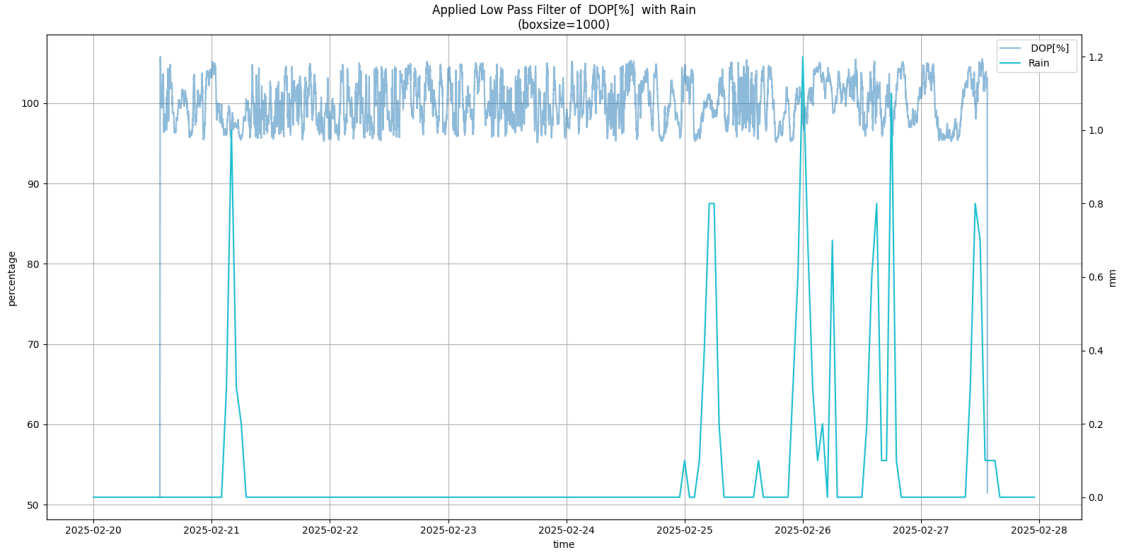


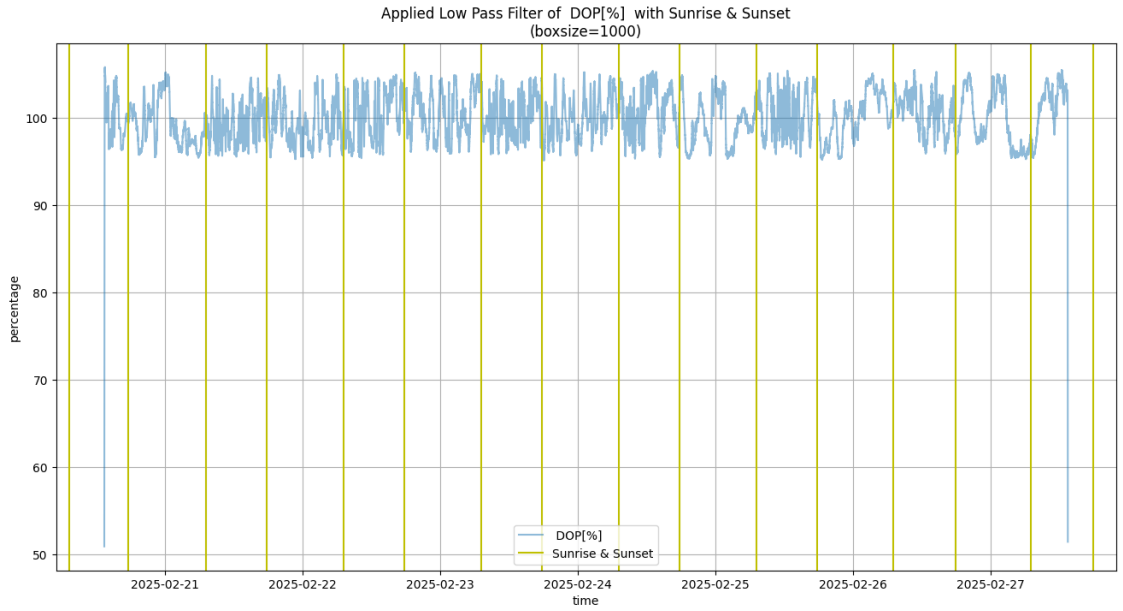

Applied Low Pass Filter of DOP[%] with Humidity
(boxsize=1000)
DOP[%]
Humidity
percentage
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied Low Pass Filter of DOP[%] with Cloud Cover
(boxsize=1000)
DOP[%]
Cloud Cover
percentage
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied Low Pass Filter of DOP[%] with Windspeed
(boxsize=1000)
DOP[%]
Windspeed
percentage
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

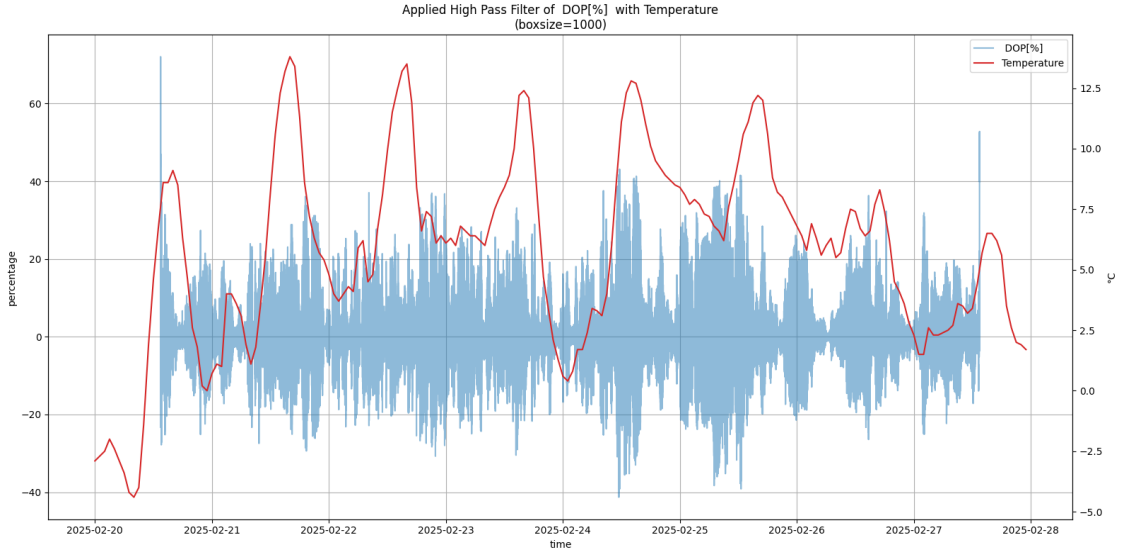

Applied Low Pass Filter of DOP[%] with Winddirection
(boxsize=1000)
DOP[%]
Winddirection
percentage
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

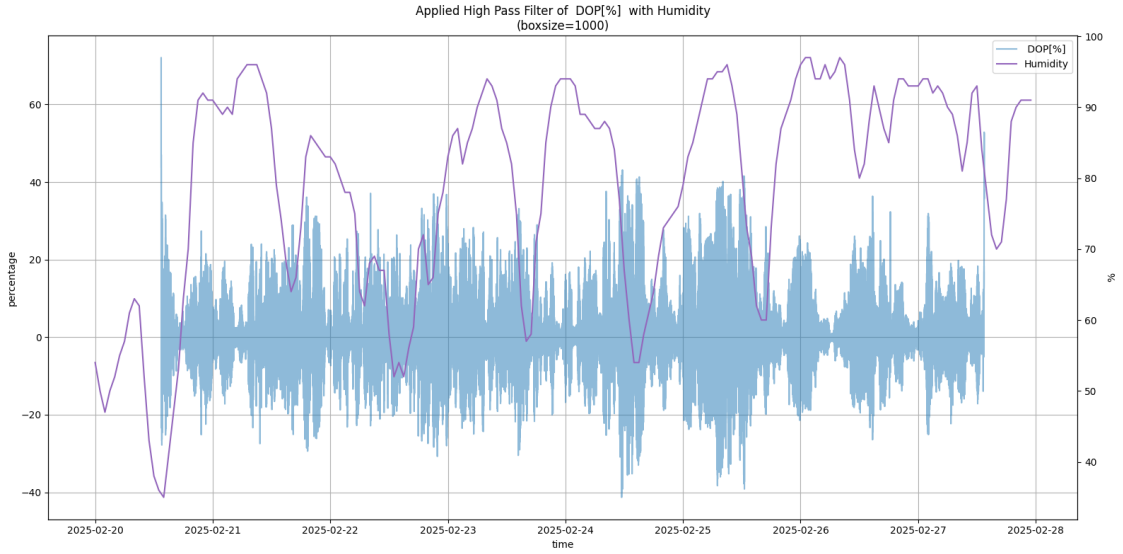


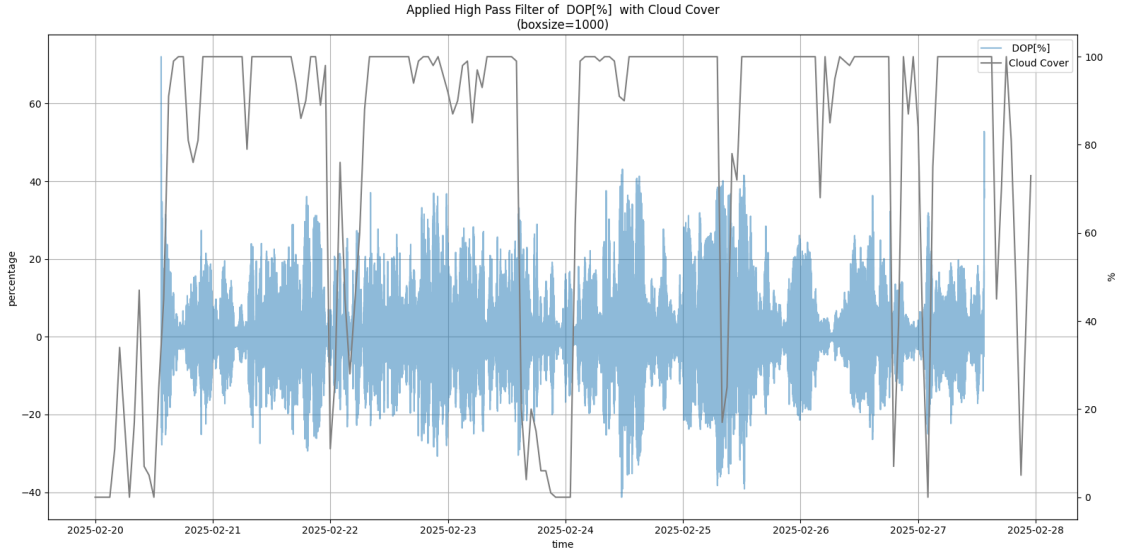


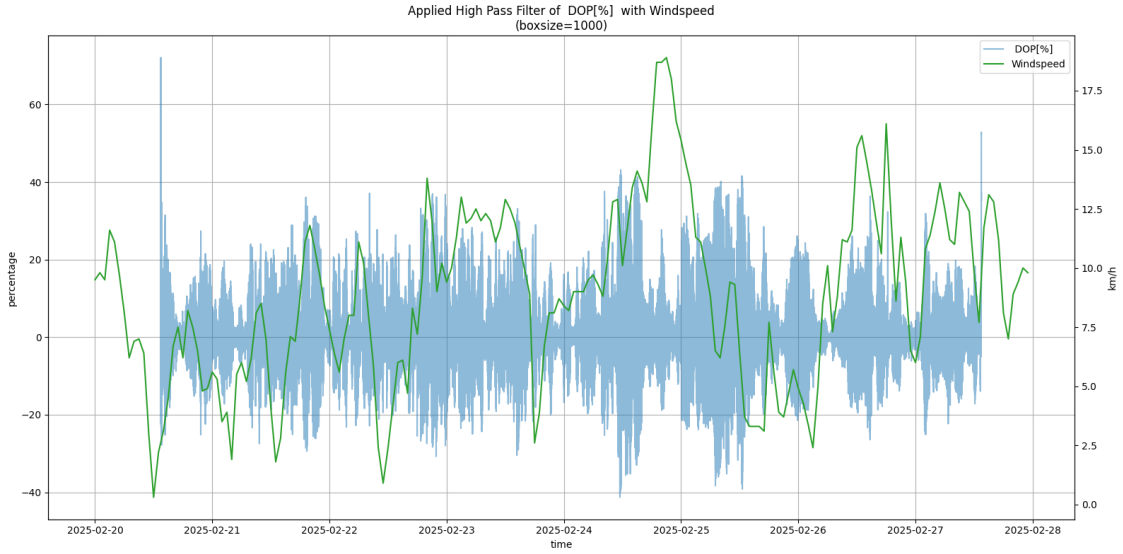
[24]:
```
box = 1000

for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))

    ydata = np.array(degree)
    hps = highpass(ydata, box)
```

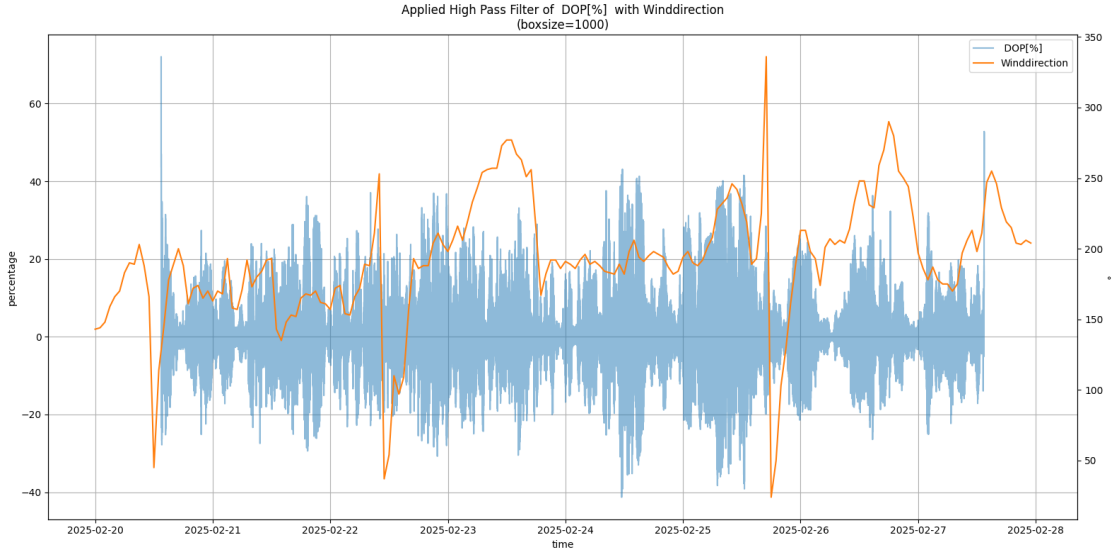
```
    ax1.plot(degree.index, hps , label=columns[11], color="tab:blue", alpha = 0.
 ↪5 )
    ax1.set_xlabel('time')
    ax1.set_ylabel('percentage')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"])
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
    ax1.set_title(f'Applied High Pass Filter of {columns[11]} with␣
 ↪{w_data[current]["label"]}\n(boxsize={box})')

    plt.tight_layout()
    plt.show()


# Sunlight (day-night context)

plt.figure(figsize = (16,8))
ydata = np.array(degree)
hps = highpass(ydata, box)
plt.plot(degree.index, hps, label=columns[11], alpha = 0.5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y')
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset')
    else: plt.axvline(x = sunset[i], color = 'y')
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Applied High Pass Filter of {columns[11]} with Sunrise &␣
 ↪Sunset\n(boxsize={box})')
plt.xlabel('time')
plt.ylabel('percentage')
plt.show()
```

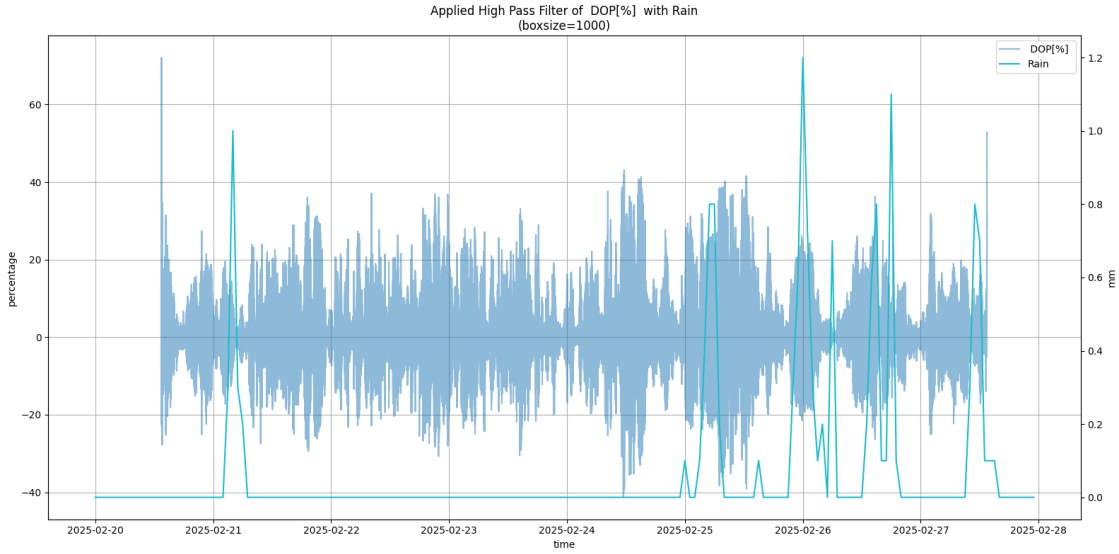

Applied High Pass Filter of DOP[%] with Temperature
(boxsize=1000)
DOP[%]
Temperature
percentage
°C
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

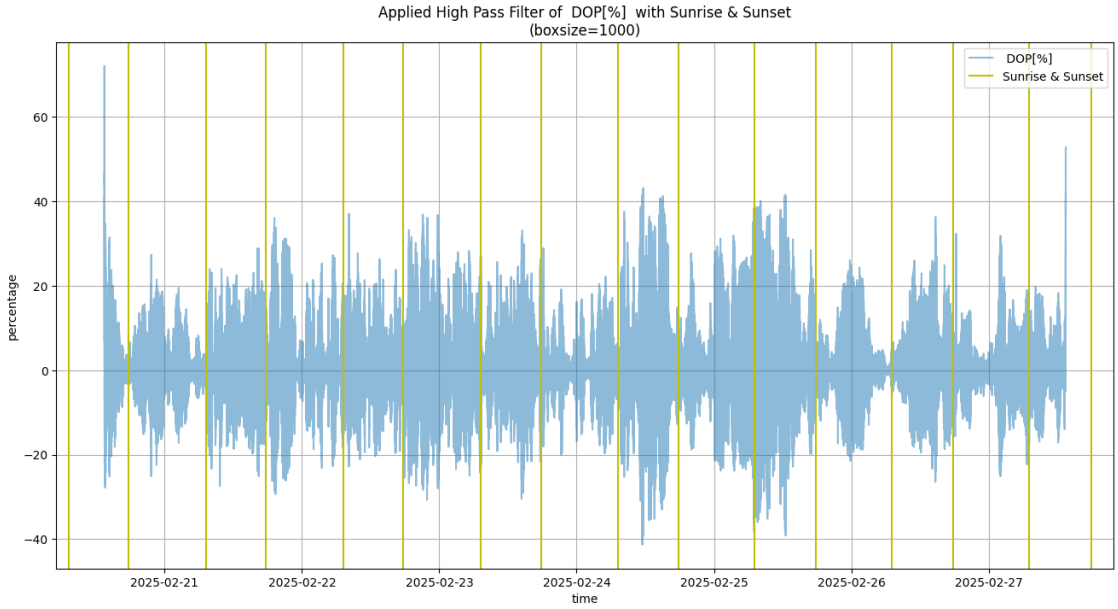

Applied High Pass Filter of DOP[%] with Humidity
(boxsize=1000)
DOP[%]
Humidity
percentage
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of DOP[%] with Cloud Cover
(boxsize=1000)
DOP[%]
Cloud Cover
percentage
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of DOP[%] with Windspeed
(boxsize=1000)
DOP[%]
Windspeed
percentage
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of DOP[%] with Winddirection
(boxsize=1000)
DOP[%]
Winddirection
percentage
°
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of DOP[%] with Rain
(boxsize=1000)
DOP[%]
Rain
percentage
mm
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28



4.2 Winkelparameter (Azimuth [°], Ellipticity[°])

[25]:
```
angle = pd.read_csv(filename,skiprows=skip, sep=sep, usecols=[columns[0],␣
↪columns[9], columns[10]])
```

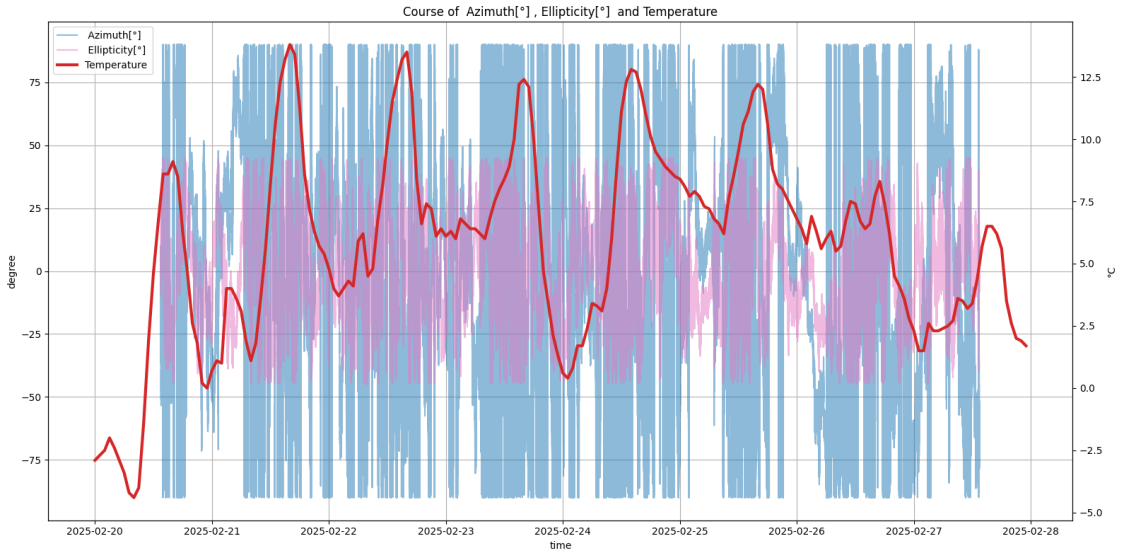
[26]:
```
angle[columns[0]] = pd.to_datetime(angle[columns[0]])
angle.set_index(columns[0], inplace=True)
```

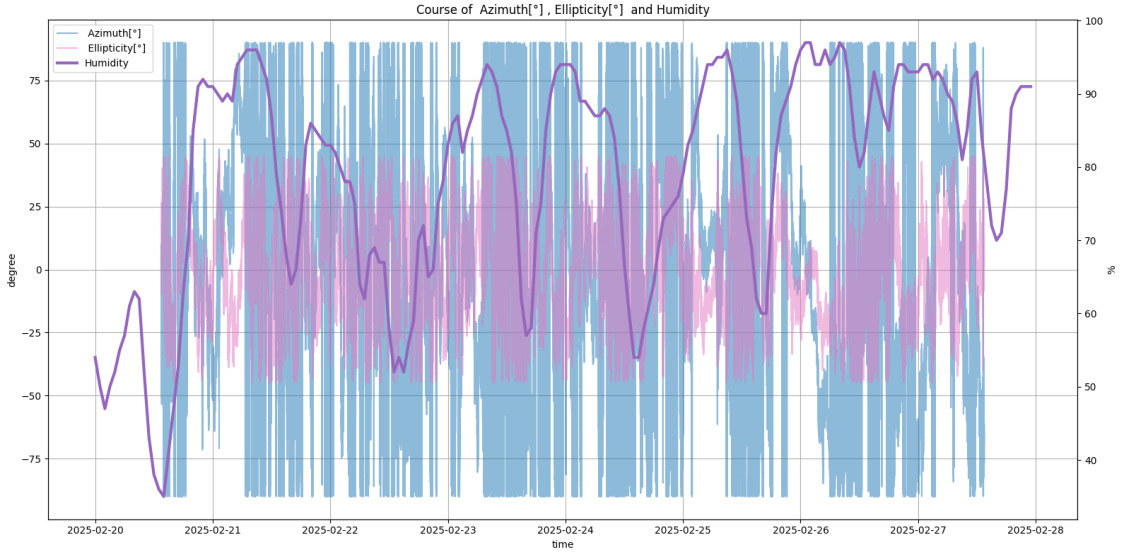
[27]:
```
angle_daily = angle.groupby(angle.index.date)
angle_daily_list = list(angle_daily)

angle_daily = angle.groupby(angle.index.date)
angle_daily_list = list(angle_daily)
```

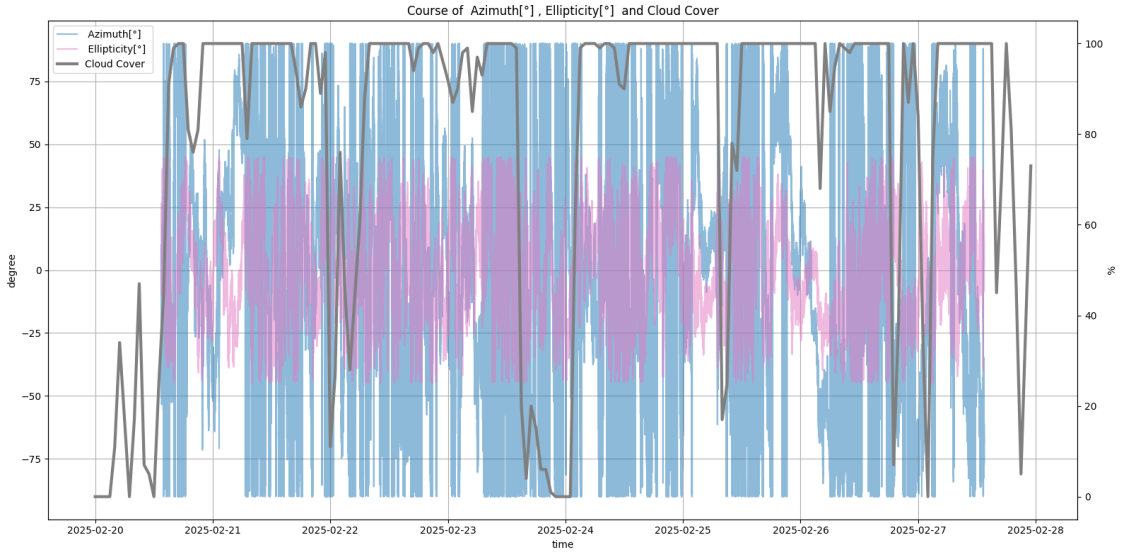
4.2.1 Originaldaten

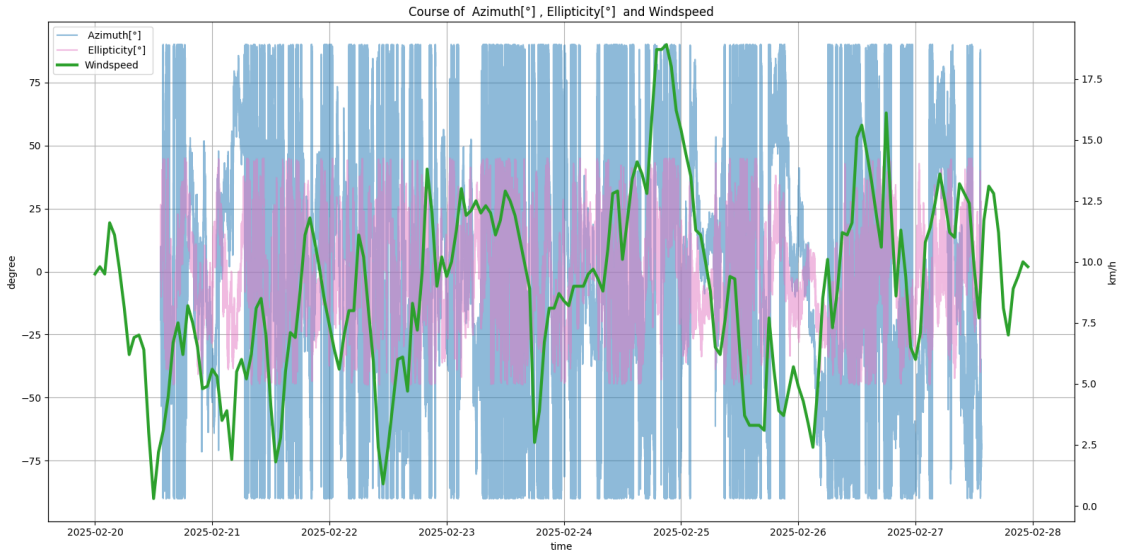
[28]:
```
for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))

    ax1.plot(angle.index, angle[columns[9]], label=columns[9], color= "tab:
↪blue", alpha= 0.5)
    ax1.plot(angle[columns[10]], label=columns[10], color= "tab:pink", alpha= 0.
↪5)
    ax1.set_xlabel('time')
    ax1.set_ylabel('degree')
    h1, l1 = ax1.get_legend_handles_labels()
```

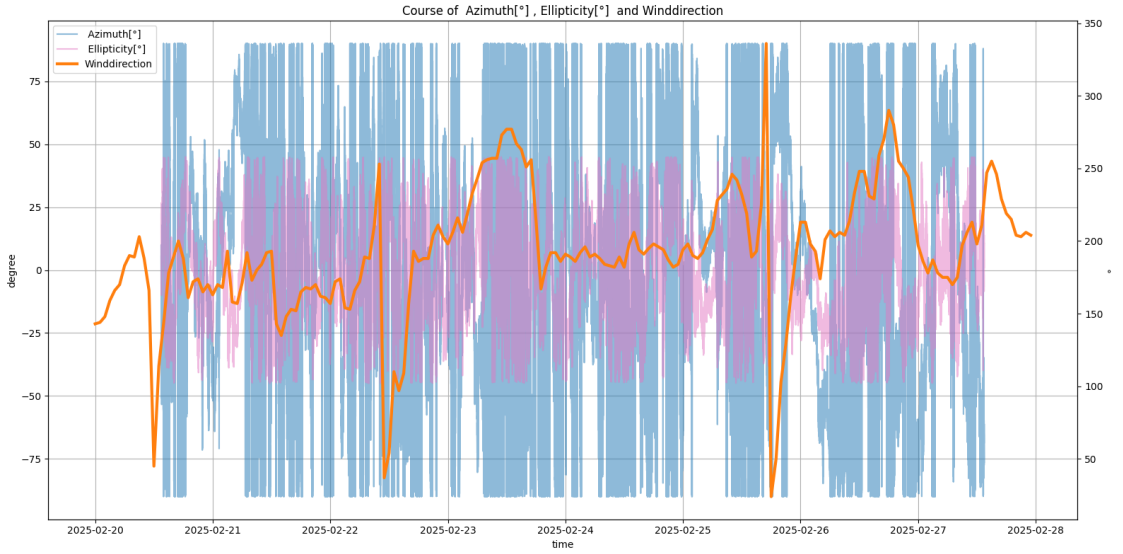
```
    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
↪label=w_data[current]["label"], color = w_data[current]["color"],␣
↪linewidth=3)
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
    ax1.set_title(f'Course of {columns[9]},{columns[10]} and␣
↪{w_data[current]["label"]}')

    plt.tight_layout()
    plt.show()
```

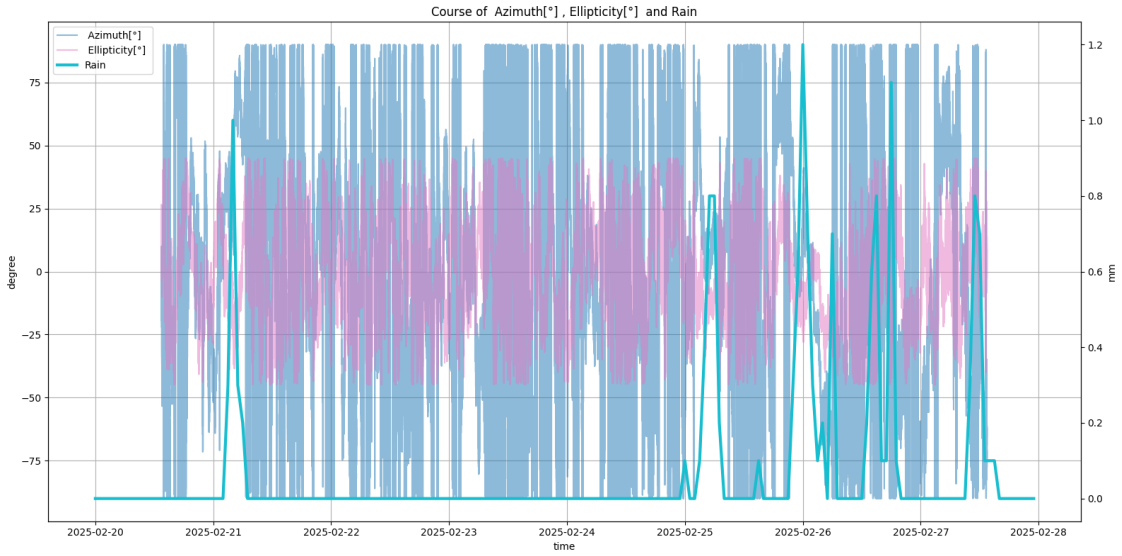



Course of Azimuth[°] , Ellipticity[°] and Humidity
Azimuth[°]
Ellipticity[°]
Humidity
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

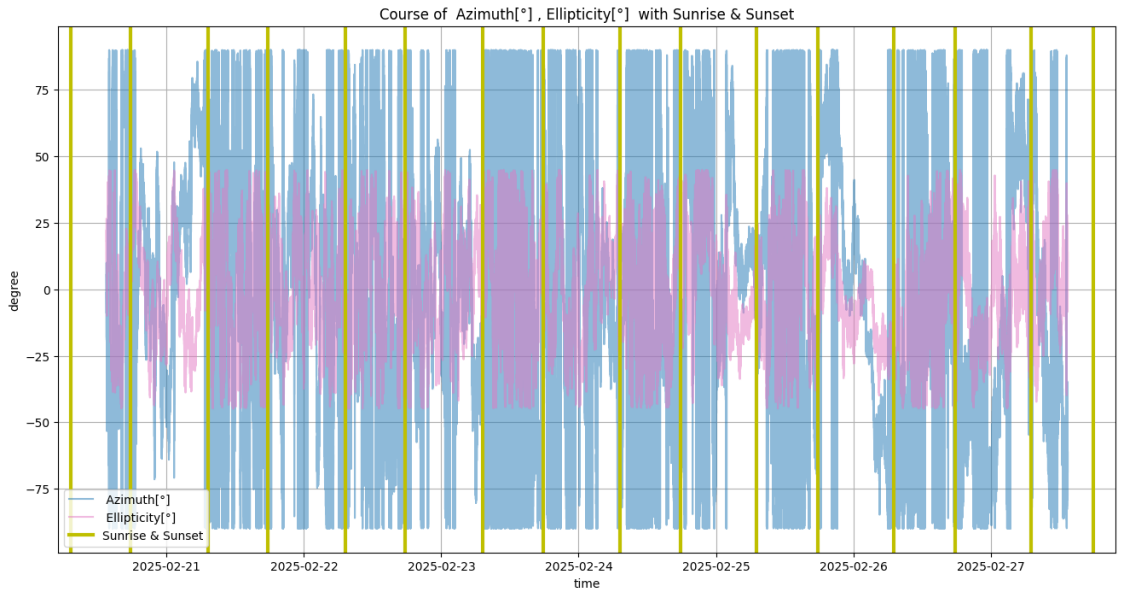

Course of Azimuth[°] , Ellipticity[°] and Cloud Cover
Azimuth[°]
Ellipticity[°]
Cloud Cover
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Course of Azimuth[°] , Ellipticity[°] and Windspeed
Azimuth[°]
Ellipticity[°]
Windspeed
degree
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

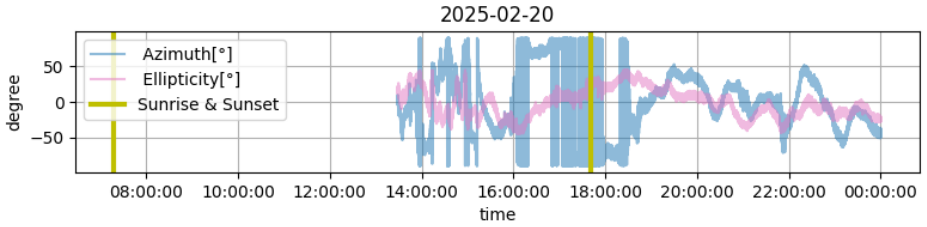

Course of Azimuth[°] , Ellipticity[°] and Winddirection
Azimuth[°]
Ellipticity[°]
Winddirection
degree
°
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

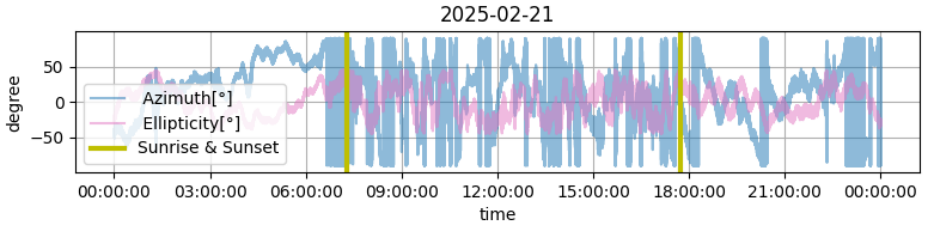


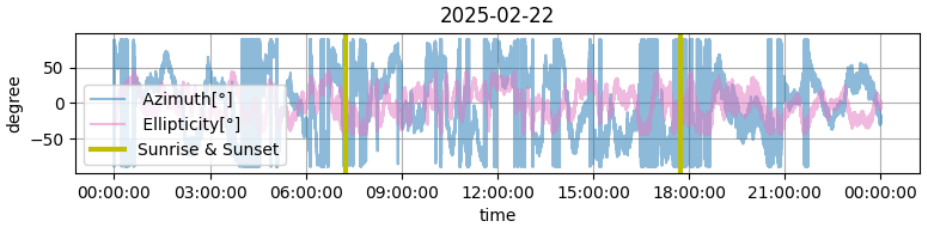
[29]:
```
# Sunlight (day-night context)

plt.figure(figsize = (16,8))
plt.plot(angle.index, angle[columns[9]], label=columns[9], color= "tab:blue",␣
 ↪alpha= 0.5)
plt.plot(angle.index, angle[columns[10]], label=columns[10], color= "tab:pink",␣
 ↪alpha= 0.5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y', linewidth=3)
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: plt.axvline(x = sunset[i], color = 'y', linewidth=3)
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Course of {columns[9]},{columns[10]} with Sunrise & Sunset')
plt.xlabel('time')
plt.ylabel('degree')
plt.show()
```

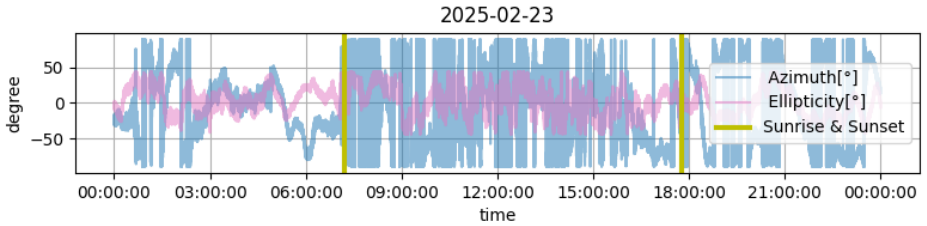


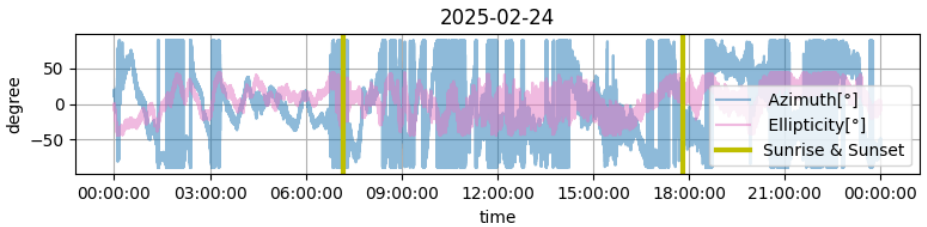
[30]:
```
fig, axs = plt.subplots(len(angle_daily_list), 1, figsize=(8, 16), sharex=False)

for i in range(len(angle_daily_list)):
    ax1 = axs[i] if len(angle_daily_list) > 1 else axs
    az = angle_daily_list[i][1][columns[9]]
    el = angle_daily_list[i][1][columns[10]]

    ax1.plot(angle_daily_list[i][1].index, az, label=columns[9], color= "tab:
 ↪blue", alpha= 0.5)
    ax1.plot(el, label=columns[10], color="tab:pink", alpha= 0.5)
    ax1.axvline(x = sunrise[i], color = 'y', linewidth=3)
    ax1.axvline(x = sunset[i], color = 'y', label = 'Sunrise & Sunset',␣
 ↪linewidth=3)
    ax1.set_xlabel('time')
    ax1.set_ylabel('degree')
    h1, l1 = ax1.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(loc="best")
    ax1.set_title(degree_daily_list[i][0])
    ax1.xaxis.set_major_formatter(mdates.DateFormatter('%H:%M:%S'))

plt.tight_layout()
plt.show()
```

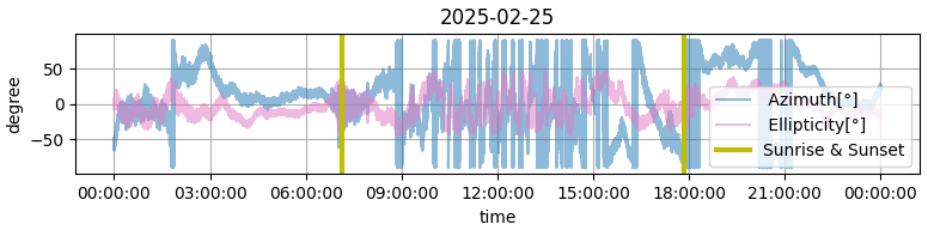

2025-02-20
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
08:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
00:00:00
time

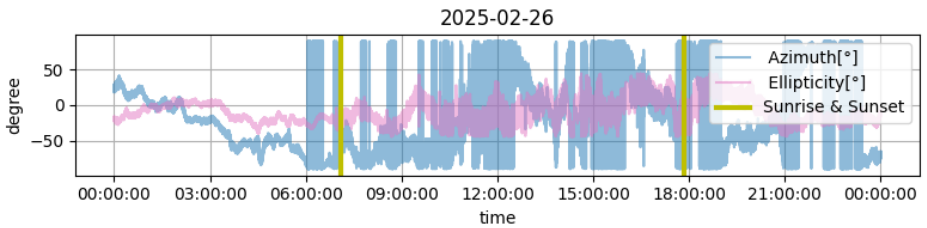

2025-02-21
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00
time

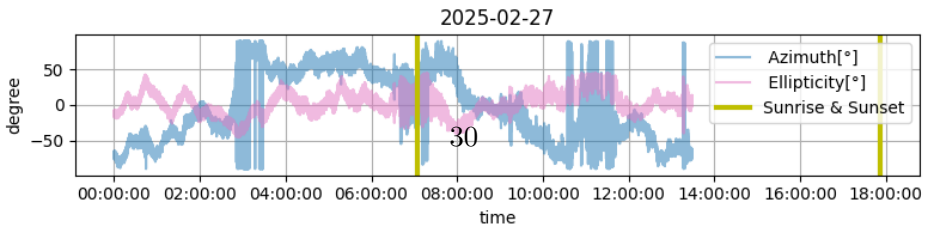

2025-02-22
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00
time


2025-02-23
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00
time


2025-02-24
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00
time


2025-02-25
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00
time


2025-02-26
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00
time

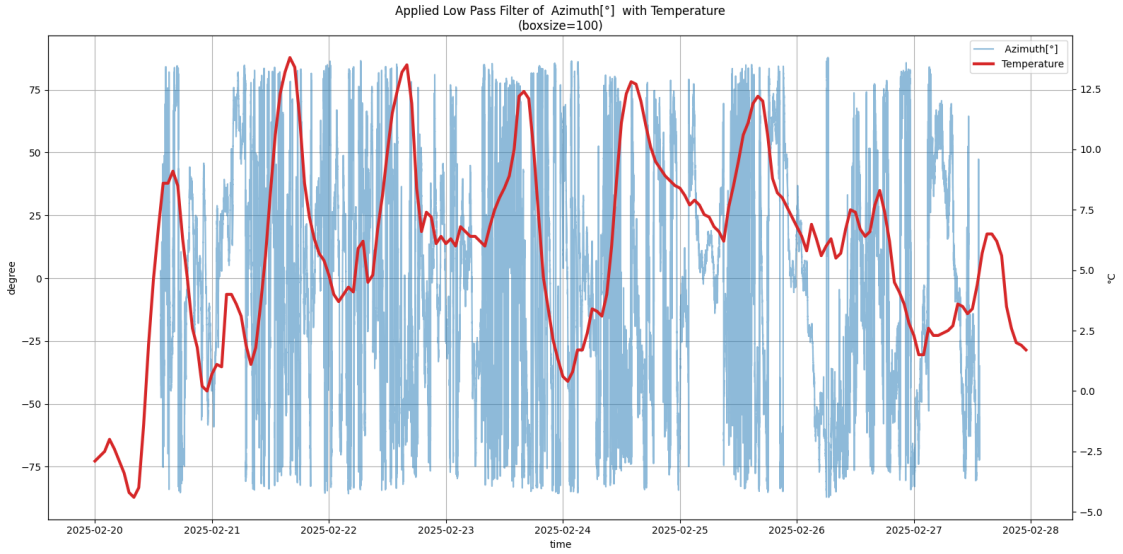

2025-02-27
Azimuth[°]
Ellipticity[°]
Sunrise & Sunset
degree
50
0
−50
00:00:00
02:00:00
04:00:00
06:00:00
08:00:00
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
time

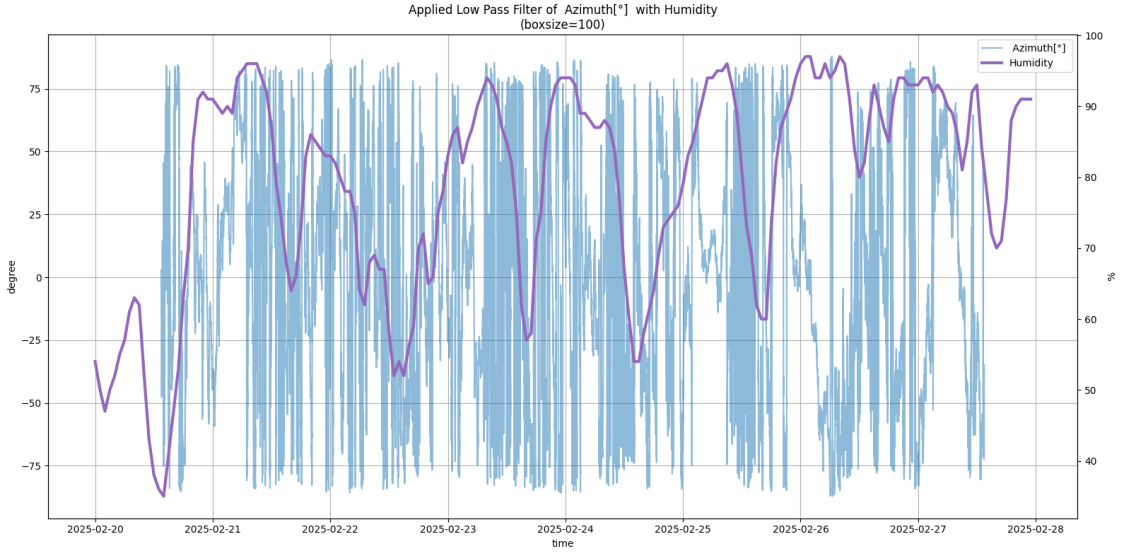
4.2.2 Anwendung des Tiefpassfilters

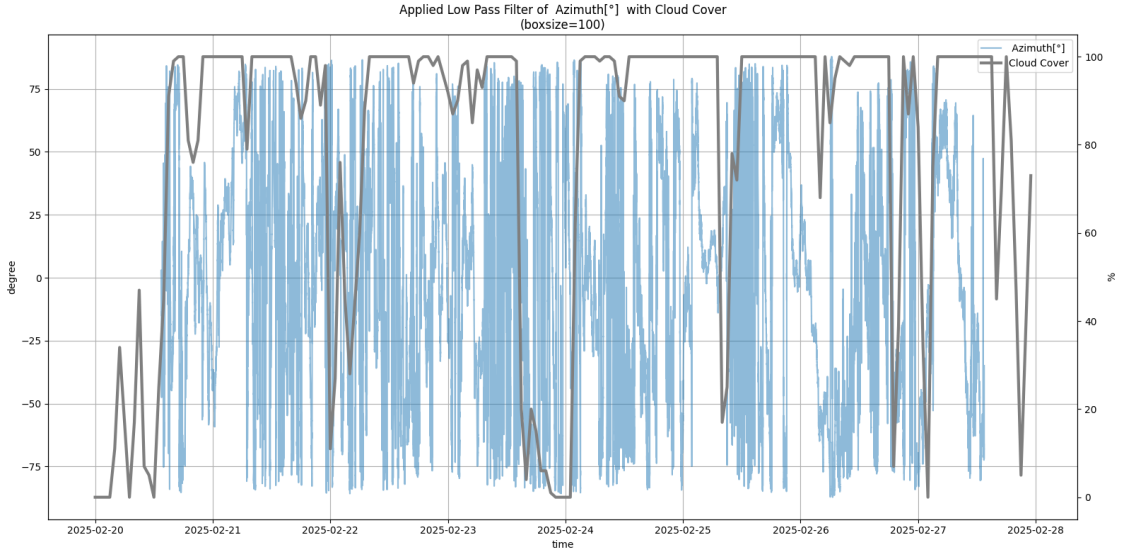
Azimuth

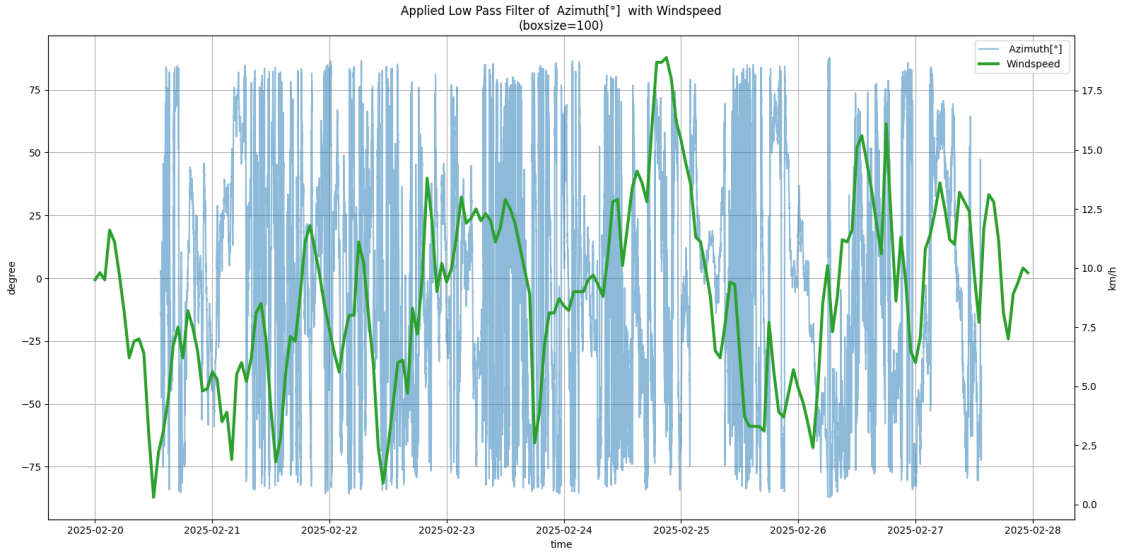
[31]:
```
box = 100

for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))

    ydata = np.array(angle[columns[9]])
    lps = lowpass(ydata, box)

    ax1.plot(angle.index, lps[:-1], label=columns[9], color= "tab:blue", alpha=␣
 ↪0.5)

    ax1.set_xlabel('time')
    ax1.set_ylabel('degree')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"],␣
 ↪linewidth=3)
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
    ax1.set_title(f'Applied Low Pass Filter of {columns[9]} with␣
 ↪{w_data[current]["label"]}\n(boxsize={box})')

    plt.tight_layout()
    plt.show()

# Sunlight (day-night context)

plt.figure(figsize = (16,8))

ydata = np.array(angle[columns[9]])
lps = lowpass(ydata, box)

plt.plot(angle.index, lps[:-1], label=columns[9], color= "tab:blue", alpha= 0.5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y', linewidth=3)
```

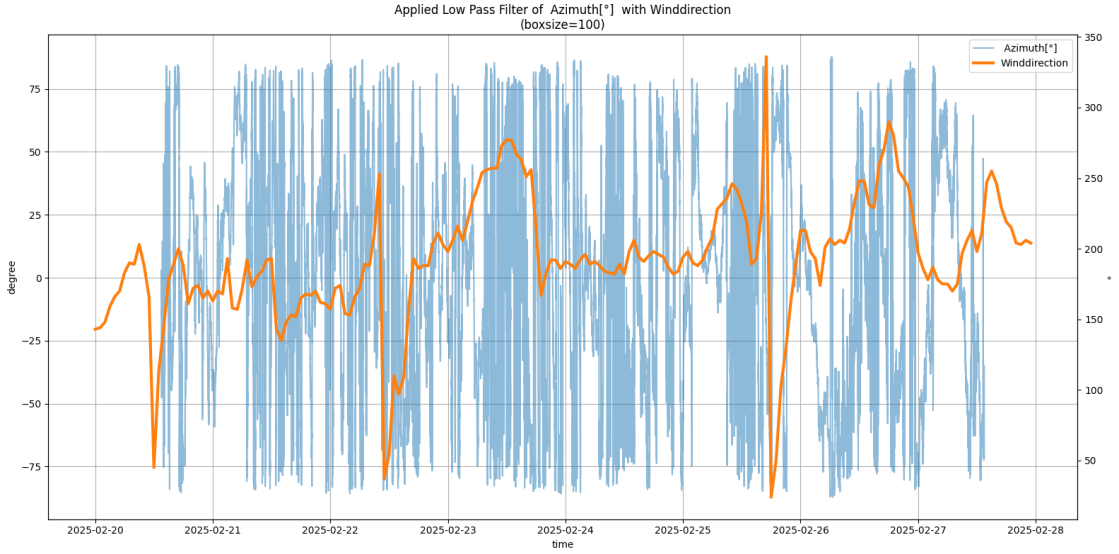
```
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: plt.axvline(x = sunset[i], color = 'y', linewidth=3)
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Applied Low Pass Filter of {columns[9]} with Sunrise &␣
 ↪Sunset\n(boxsize={box})')
plt.xlabel('time')
plt.ylabel('degree')
plt.show()
```

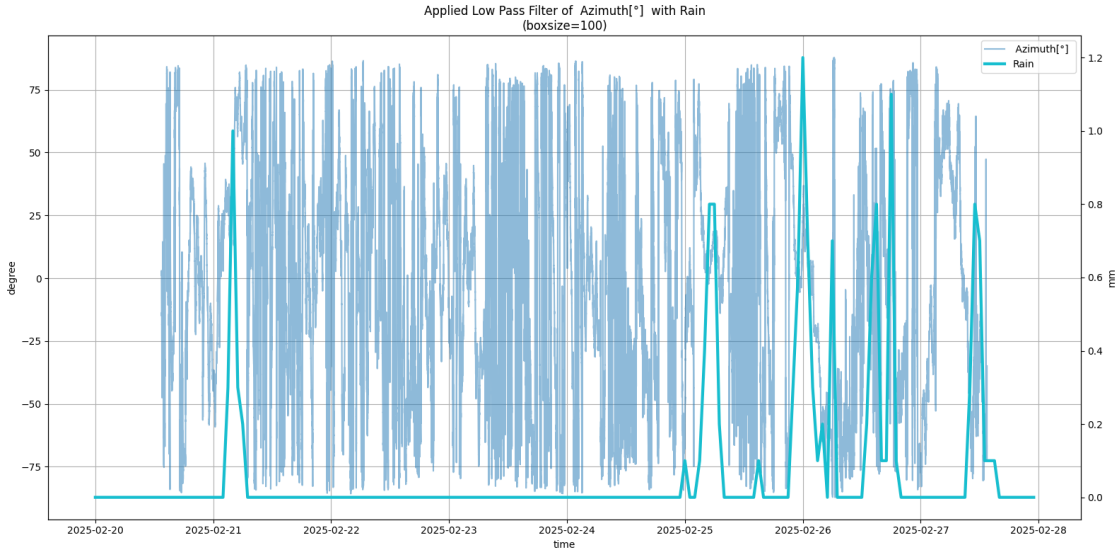


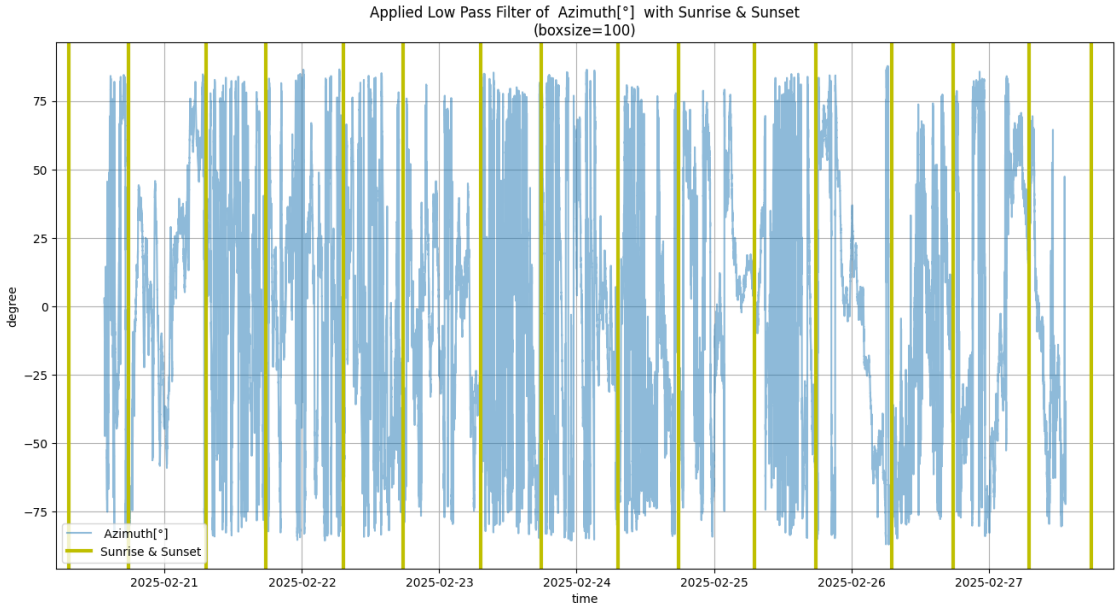



Applied Low Pass Filter of Azimuth[°] with Cloud Cover
(boxsize=100)
Azimuth[°]
Cloud Cover
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied Low Pass Filter of Azimuth[°] with Windspeed
(boxsize=100)
Azimuth[°]
Windspeed
degree
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied Low Pass Filter of Azimuth[°] with Winddirection
(boxsize=100)
Azimuth[°]
Winddirection
degree
°
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

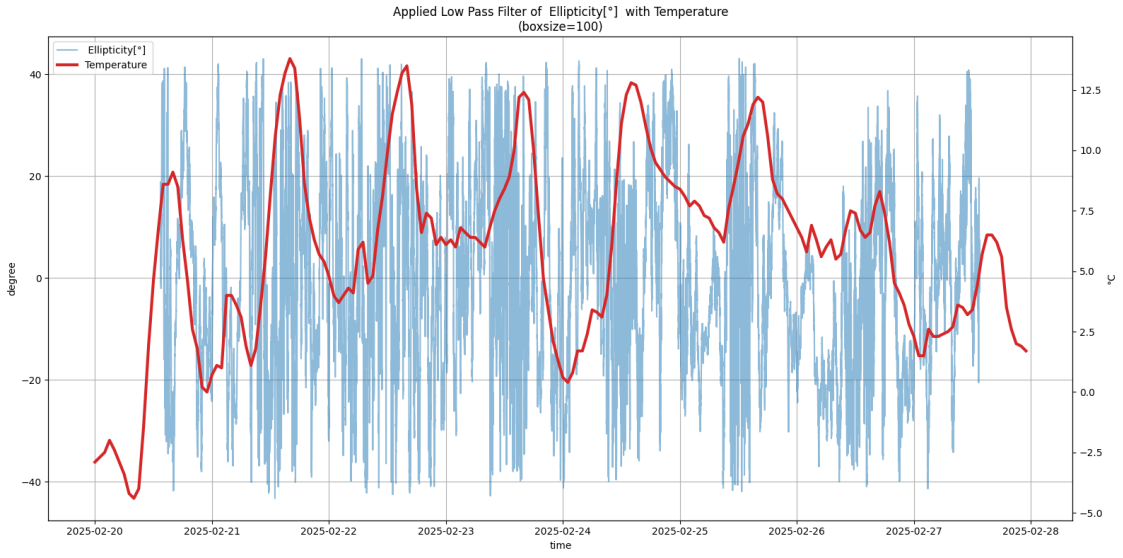

Applied Low Pass Filter of Azimuth[°] with Rain
(boxsize=100)
Azimuth[°]
Rain
degree
mm
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

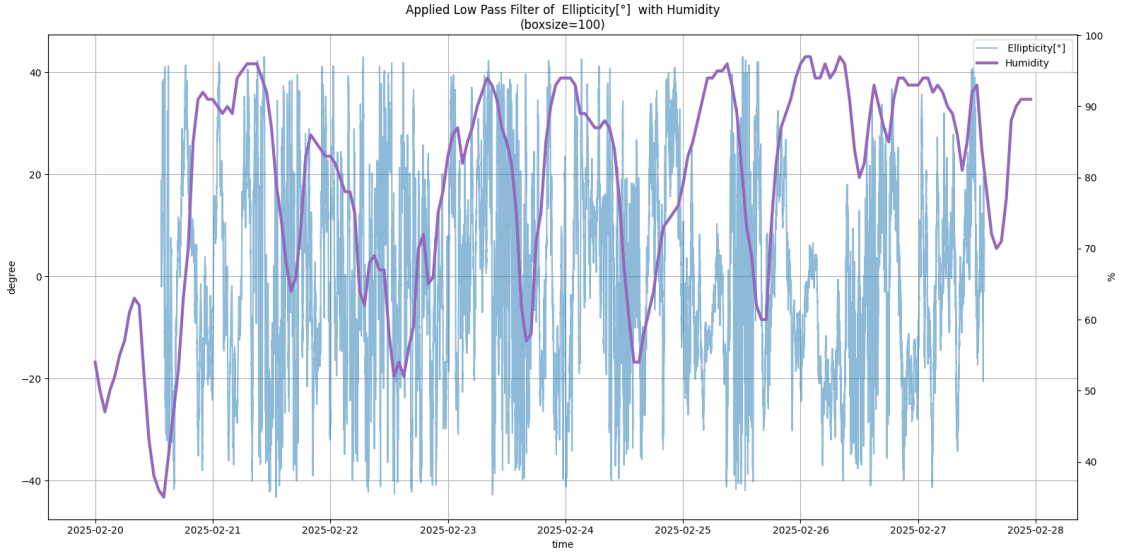


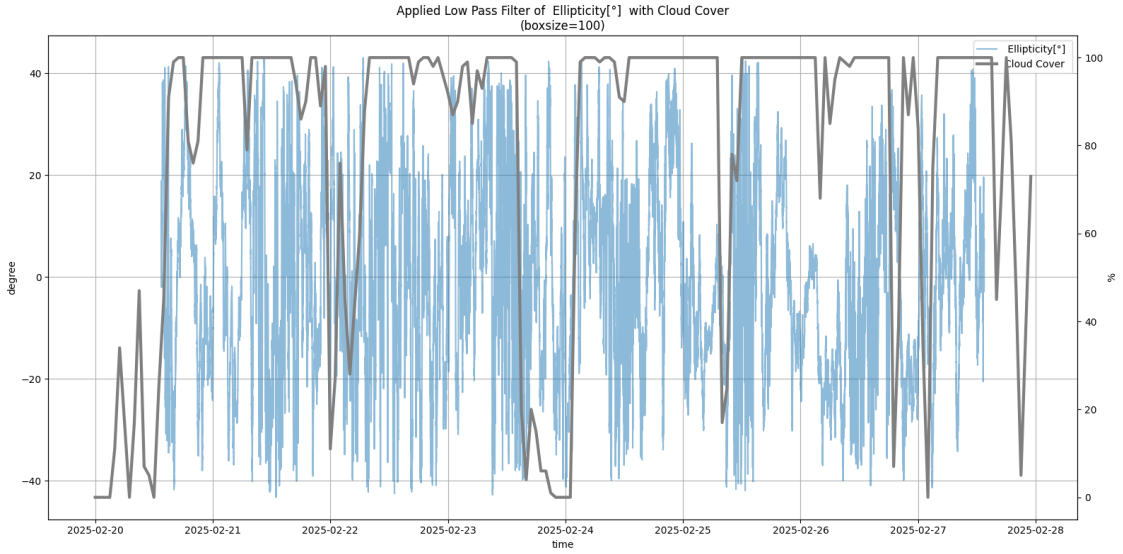
Ellipticity

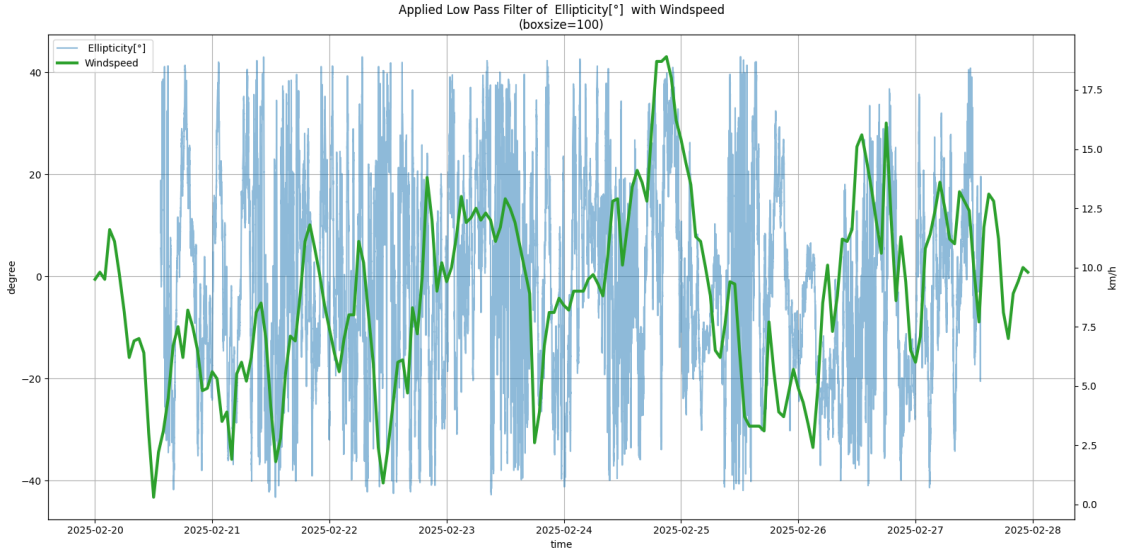
[32]:
```
box = 100

for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))

    ydata = np.array(angle[columns[10]])
    lps = lowpass(ydata, box)

    ax1.plot(angle.index, lps[:-1], label=columns[10], color= "tab:blue",␣
 ↪alpha= 0.5)

    ax1.set_xlabel('time')
    ax1.set_ylabel('degree')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"],␣
 ↪linewidth=3)
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
```

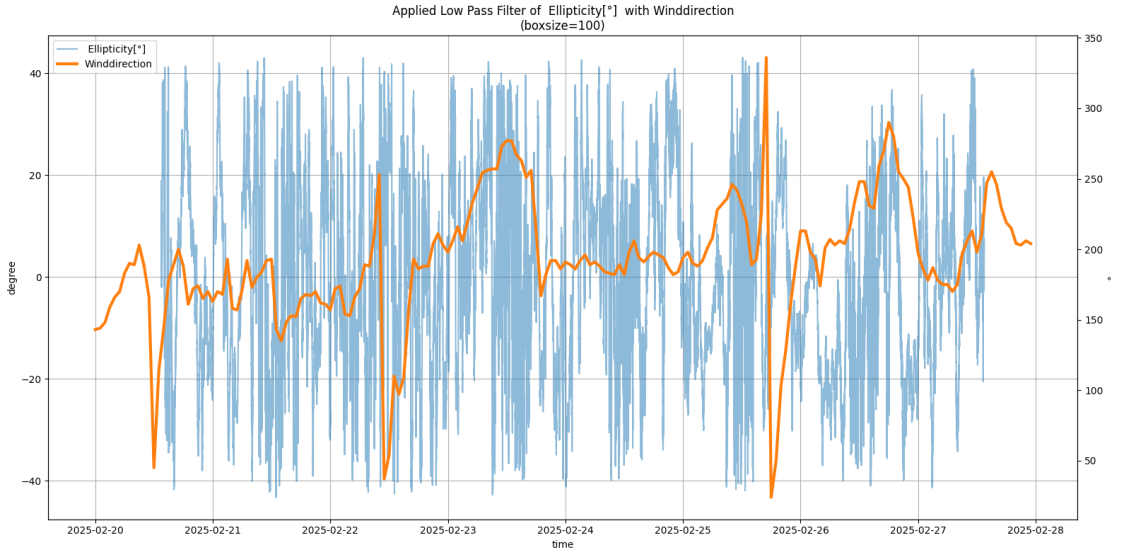
```
    ax1.set_title(f'Applied Low Pass Filter of {columns[10]} with␣
 ↪{w_data[current]["label"]}\n(boxsize={box})')

    plt.tight_layout()
    plt.show()

# Sunlight (day-night context)

plt.figure(figsize = (16,8))

ydata = np.array(angle[columns[9]])
lps = lowpass(ydata, box)

plt.plot(angle.index, lps[:-1], label=columns[10], color= "tab:blue", alpha= 0.
 ↪5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y', linewidth=3)
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: plt.axvline(x = sunset[i], color = 'y', linewidth=3)
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Applied Low Pass Filter of {columns[10]} with Sunrise &␣
 ↪Sunset\n(boxsize={box})')
plt.xlabel('time')
plt.ylabel('degree')
plt.show()
```

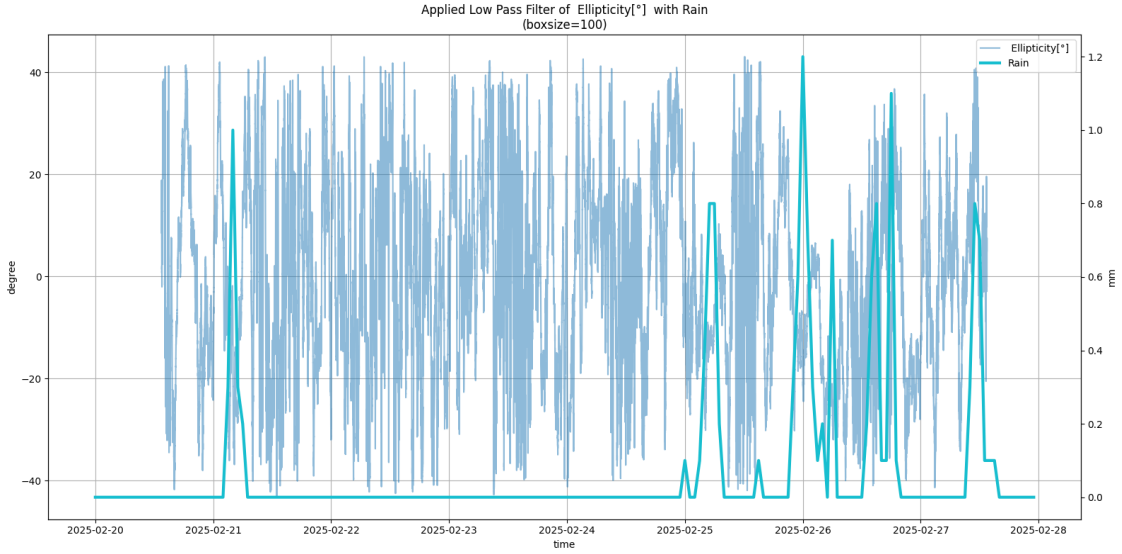


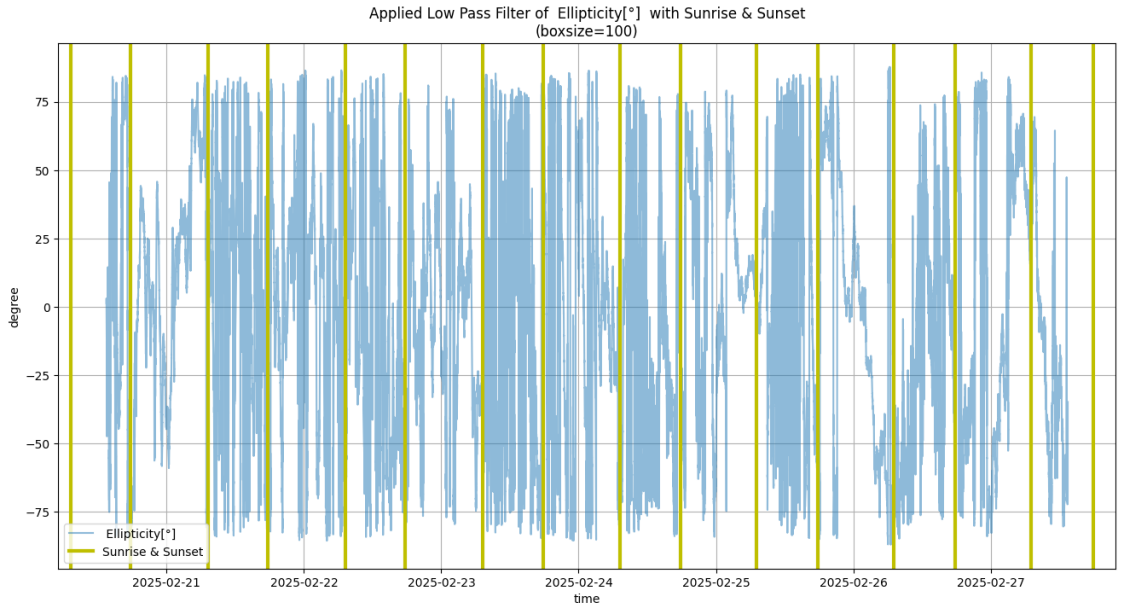

Applied Low Pass Filter of Ellipticity[°] with Humidity
(boxsize=100)
Ellipticity[°]
Humidity
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied Low Pass Filter of Ellipticity[°] with Cloud Cover
(boxsize=100)
Ellipticity[°]
Cloud Cover
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied Low Pass Filter of Ellipticity[°] with Windspeed
(boxsize=100)
Ellipticity[°]
Windspeed
degree
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied Low Pass Filter of Ellipticity[°] with Winddirection
(boxsize=100)
Ellipticity[°]
Winddirection
degree
°
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28



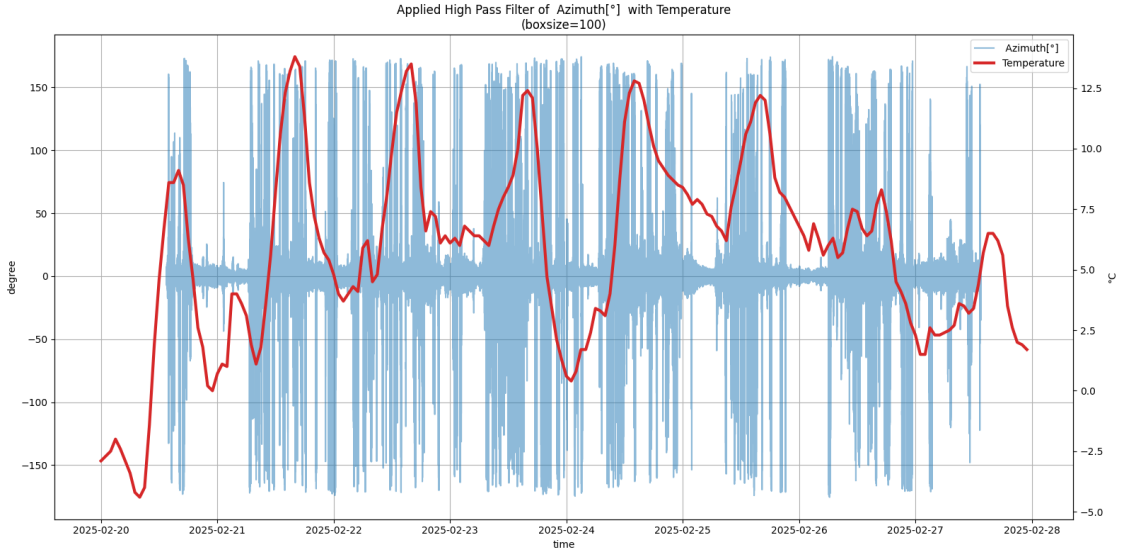


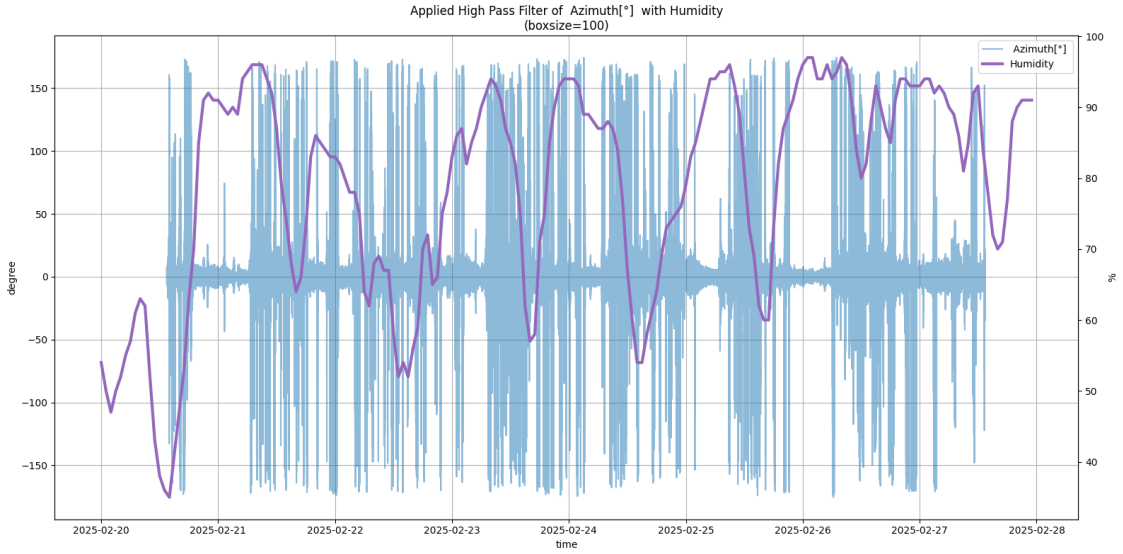
4.2.3 Anwendung des Hochpassfilters

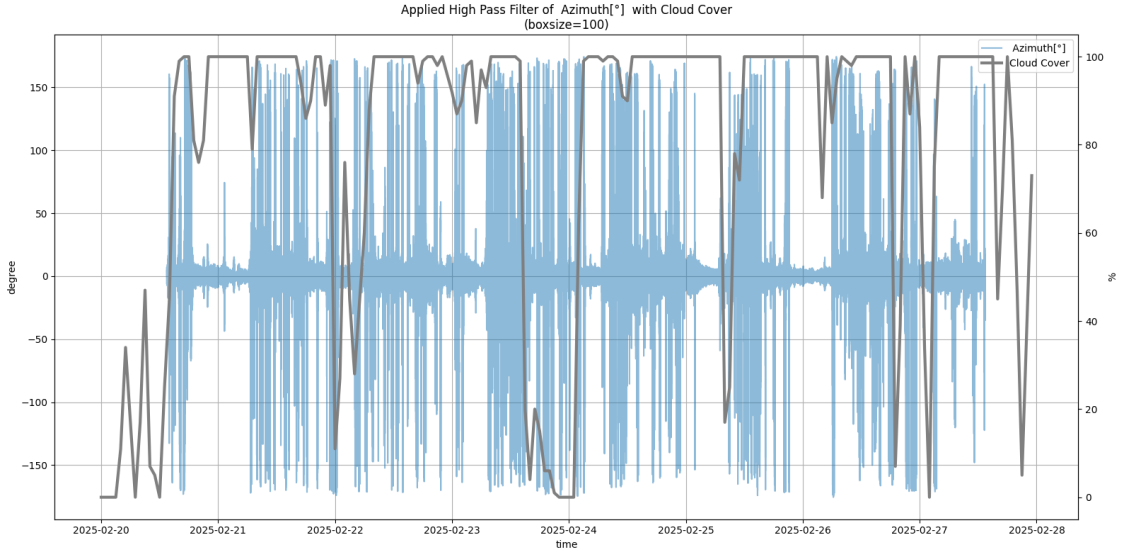
Azimuth

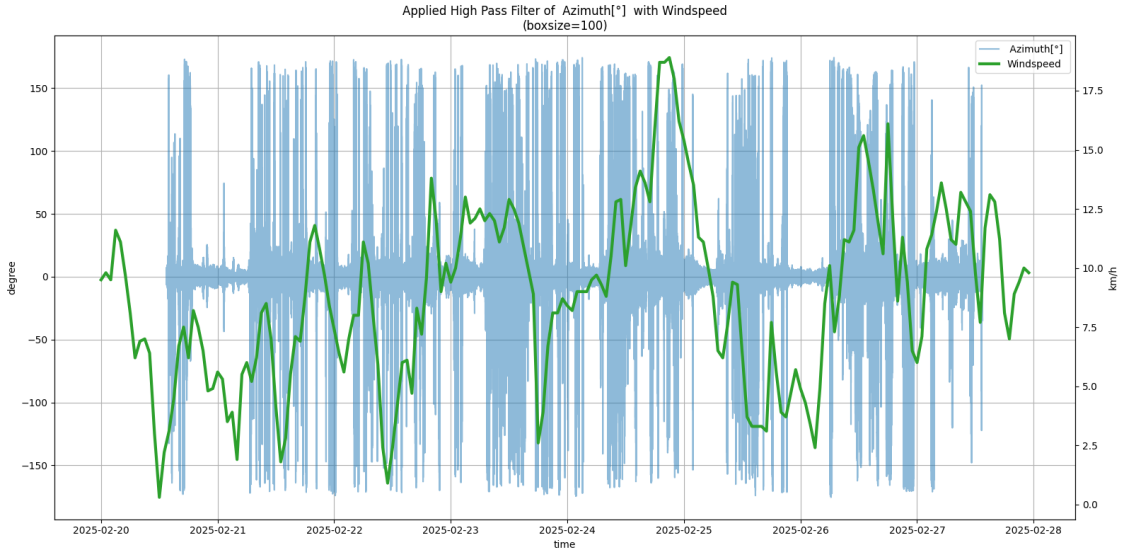
[33]:
```
box = 100

for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))
```

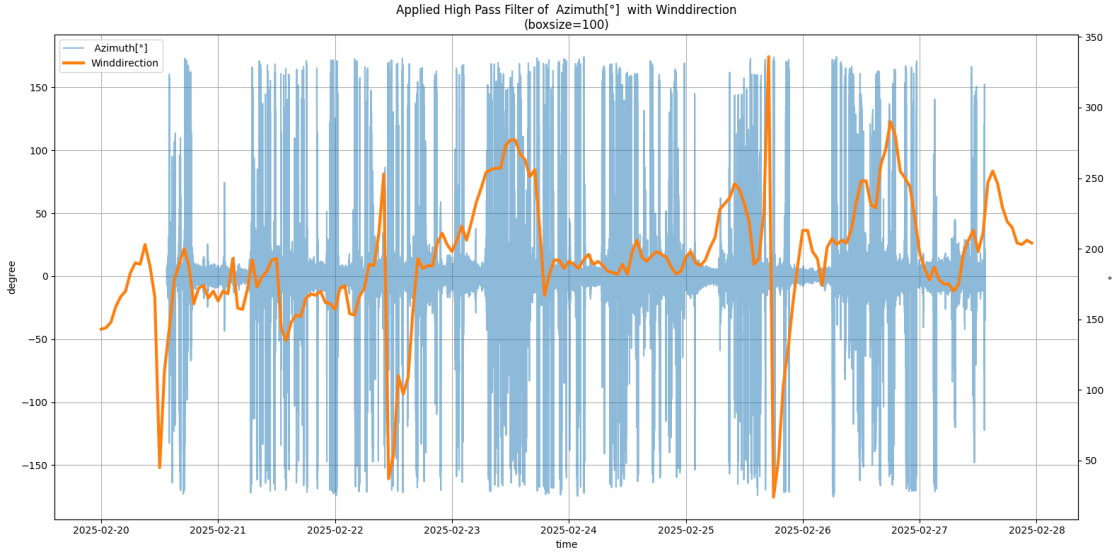
```
    ydata = np.array(angle[columns[9]])
    hps = highpass(ydata, box)

    ax1.plot(angle.index, hps, label=columns[9], color= "tab:blue", alpha= 0.5)

    ax1.set_xlabel('time')
    ax1.set_ylabel('degree')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"],␣
 ↪linewidth=3)
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
    ax1.set_title(f'Applied High Pass Filter of {columns[9]} with␣
 ↪{w_data[current]["label"]}\n(boxsize={box})')

    plt.tight_layout()
    plt.show()

# Sunlight (day-night context)

plt.figure(figsize = (16,8))

ydata = np.array(angle[columns[9]])
hps = highpass(ydata, box)

plt.plot(angle.index, hps, label=columns[9], color= "tab:blue", alpha= 0.5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y', linewidth=3)
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: plt.axvline(x = sunset[i], color = 'y', linewidth=3)
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Applied High Pass Filter of {columns[9]} with Sunrise &␣
 ↪Sunset\n(boxsize={box})')
plt.xlabel('time')
plt.ylabel('degree')
plt.show()
```

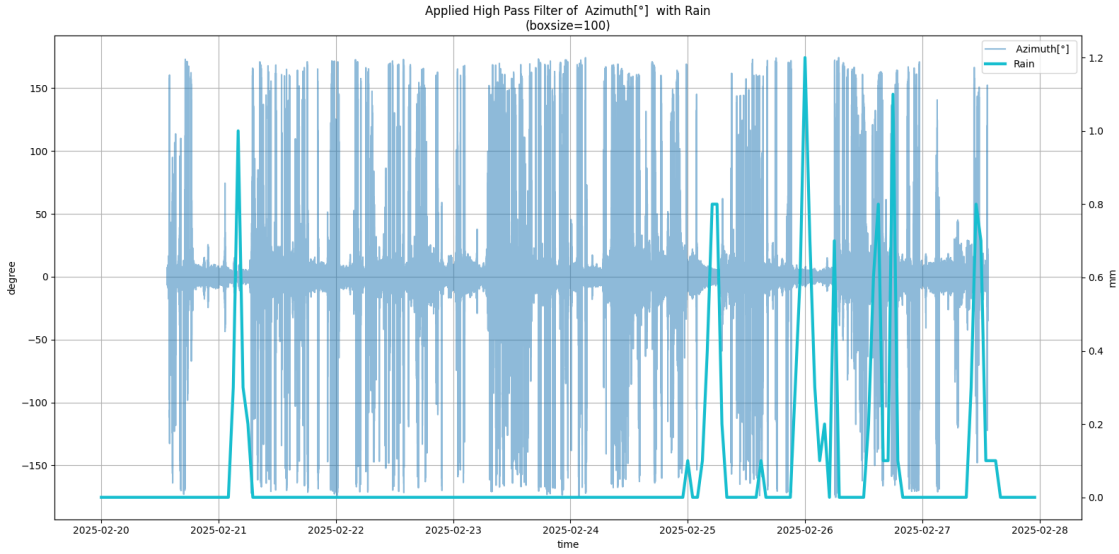

Applied High Pass Filter of Azimuth[°] with Temperature
(boxsize=100)
Azimuth[°]
Temperature
degree
°C
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

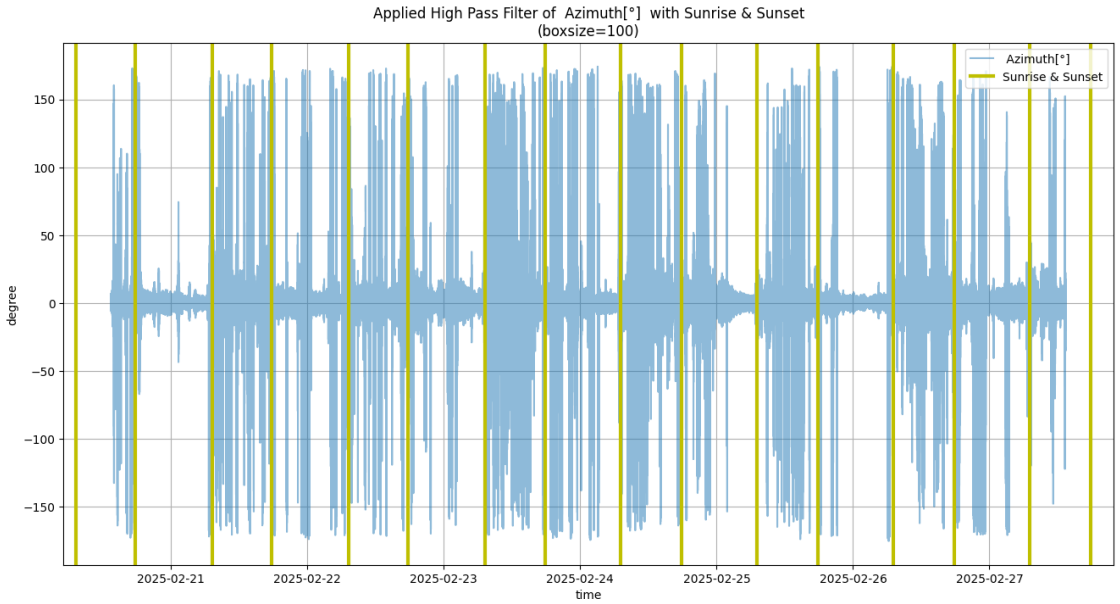

Applied High Pass Filter of Azimuth[°] with Humidity
(boxsize=100)
Azimuth[°]
Humidity
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of Azimuth[°] with Cloud Cover
(boxsize=100)
Azimuth[°]
Cloud Cover
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of Azimuth[°] with Windspeed
(boxsize=100)
Azimuth[°]
Windspeed
degree
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of Azimuth[°] with Winddirection
(boxsize=100)
Azimuth[°]
Winddirection
degree
°
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

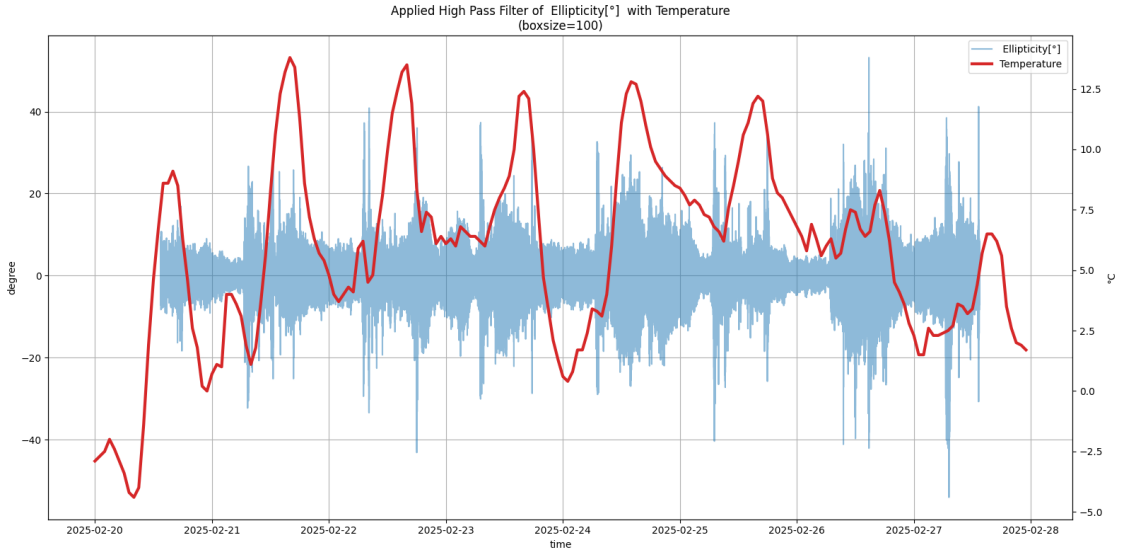

Applied High Pass Filter of Azimuth[°] with Rain
(boxsize=100)
Azimuth[°]
Rain
degree
mm
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

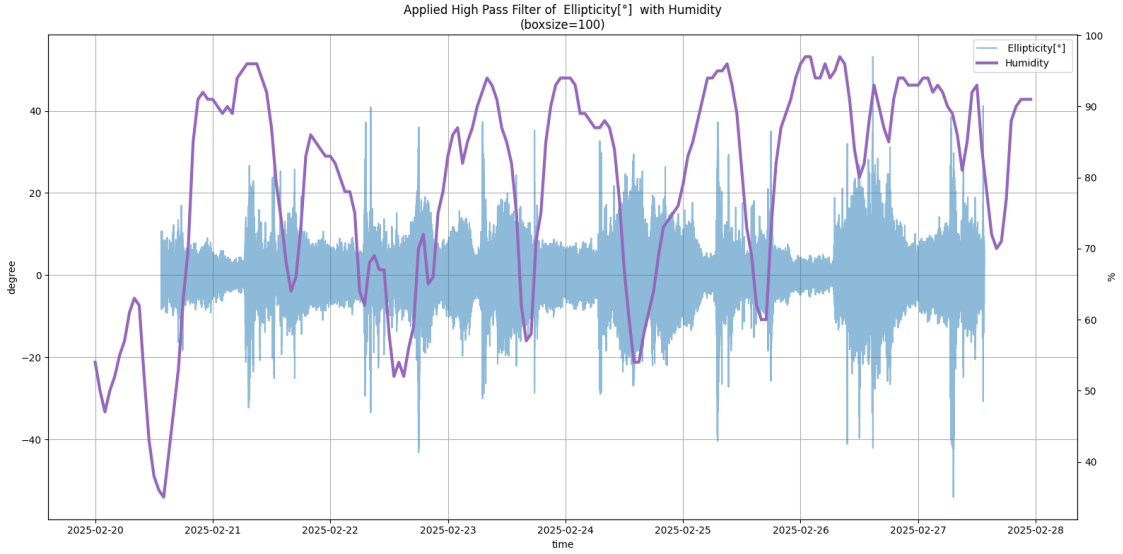


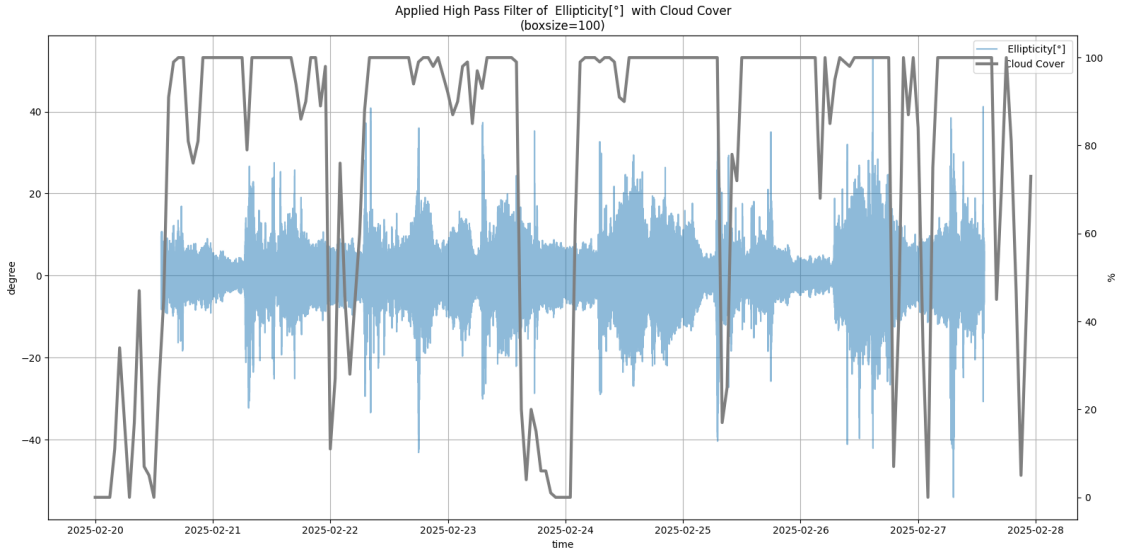
Ellipticity

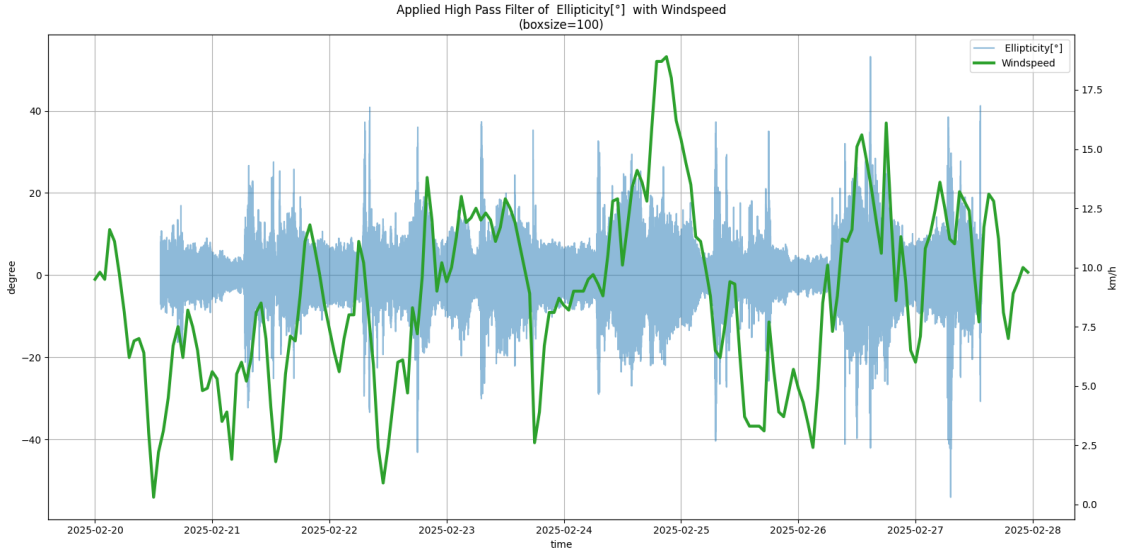
[34]:
```
box = 100

for current in range(len(w_data)):
    fig, ax1 = plt.subplots(figsize=(16, 8))

    ydata = np.array(angle[columns[10]])
    hps = highpass(ydata, box)

    ax1.plot(angle.index, hps, label=columns[10], color= "tab:blue", alpha= 0.5)

    ax1.set_xlabel('time')
    ax1.set_ylabel('degree')
    h1, l1 = ax1.get_legend_handles_labels()

    ax2 = ax1.twinx()

    ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"],␣
 ↪linewidth=3)
    ax2.set_ylabel(w_data[current]["unit"])
    h2, l2 = ax2.get_legend_handles_labels()

    ax1.grid()
    ax1.legend(h1+h2, l1+l2, loc="best")
```

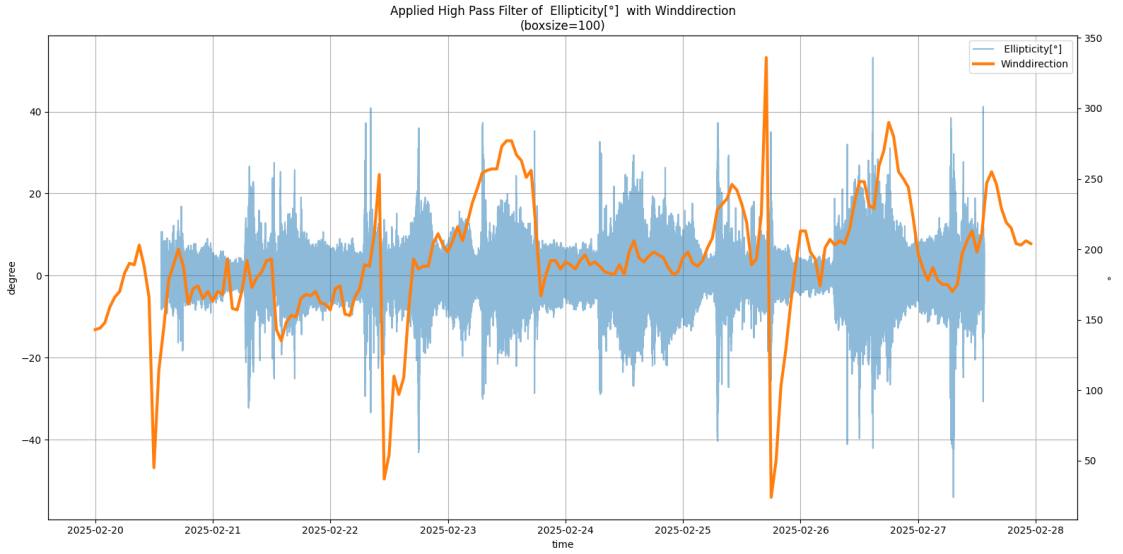
```
    ax1.set_title(f'Applied High Pass Filter of {columns[10]} with␣
 ↪{w_data[current]["label"]}\n(boxsize={box})')

    plt.tight_layout()
    plt.show()

# Sunlight (day-night context)

plt.figure(figsize = (16,8))

ydata = np.array(angle[columns[9]])
hps = highpass(ydata, box)

plt.plot(angle.index, hps, label=columns[10], color= "tab:blue", alpha= 0.5)
for i in range(len(sunrise)):
    plt.axvline(x = sunrise[i], color = 'y', linewidth=3)
    if i == 0: plt.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: plt.axvline(x = sunset[i], color = 'y', linewidth=3)
plt.grid()
plt.legend(loc = 'best')
plt.title(f'Applied High Pass Filter of {columns[10]} with Sunrise &␣
 ↪Sunset\n(boxsize={box})')
plt.xlabel('time')
plt.ylabel('degree')
plt.show()
```

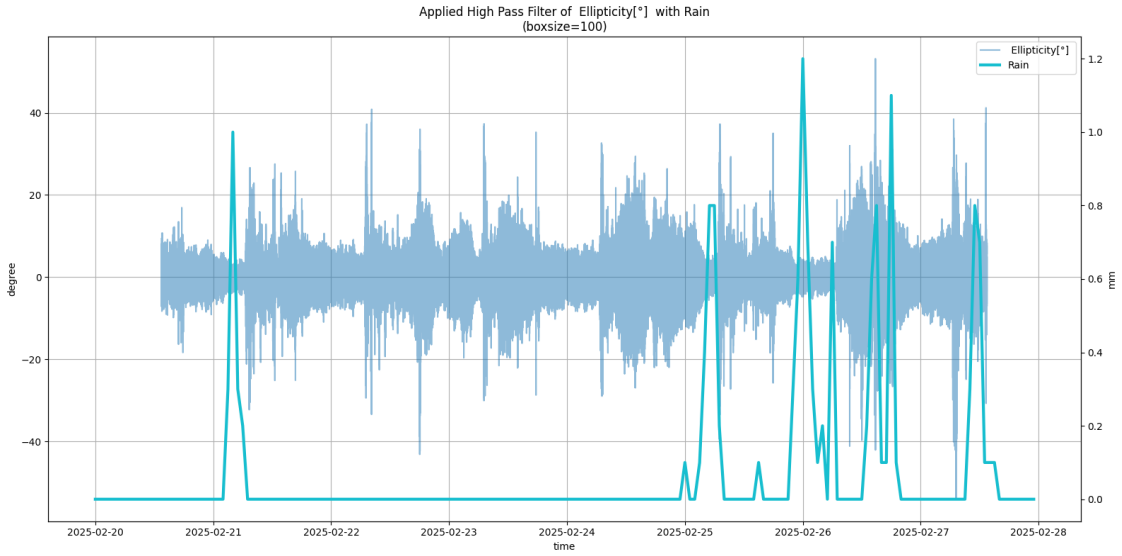


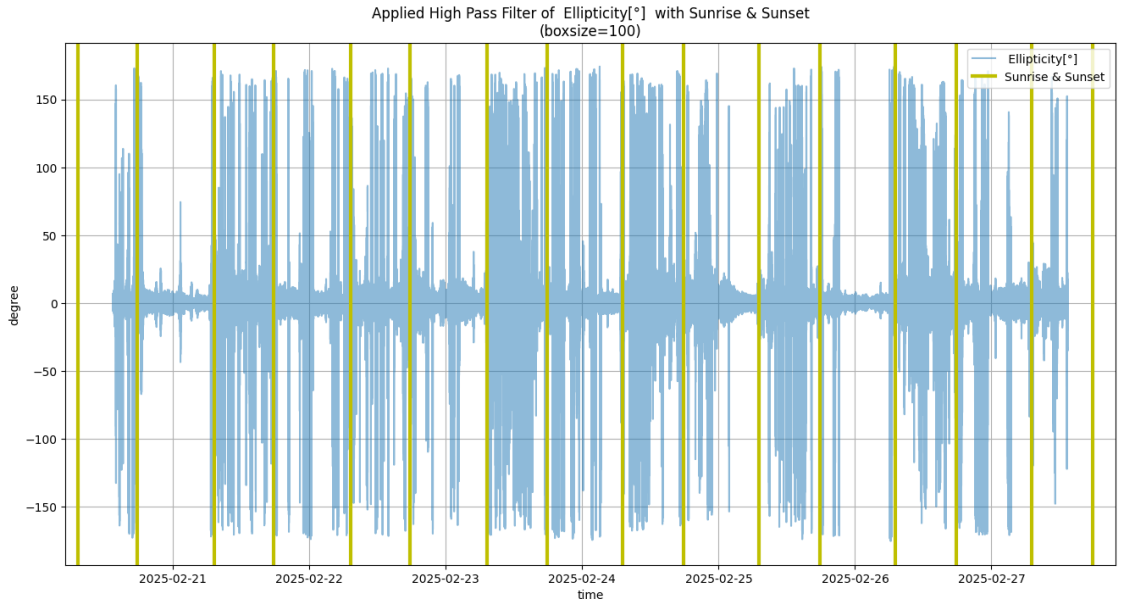

Applied High Pass Filter of Ellipticity[°] with Humidity
(boxsize=100)
Ellipticity[°]
Humidity
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of Ellipticity[°] with Cloud Cover
(boxsize=100)
Ellipticity[°]
Cloud Cover
degree
%
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of Ellipticity[°] with Windspeed
(boxsize=100)
Ellipticity[°]
Windspeed
degree
km/h
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28


Applied High Pass Filter of Ellipticity[°] with Winddirection
(boxsize=100)
Ellipticity[°]
Winddirection
degree
°
time
2025-02-20
2025-02-21
2025-02-22
2025-02-23
2025-02-24
2025-02-25
2025-02-26
2025-02-27
2025-02-28

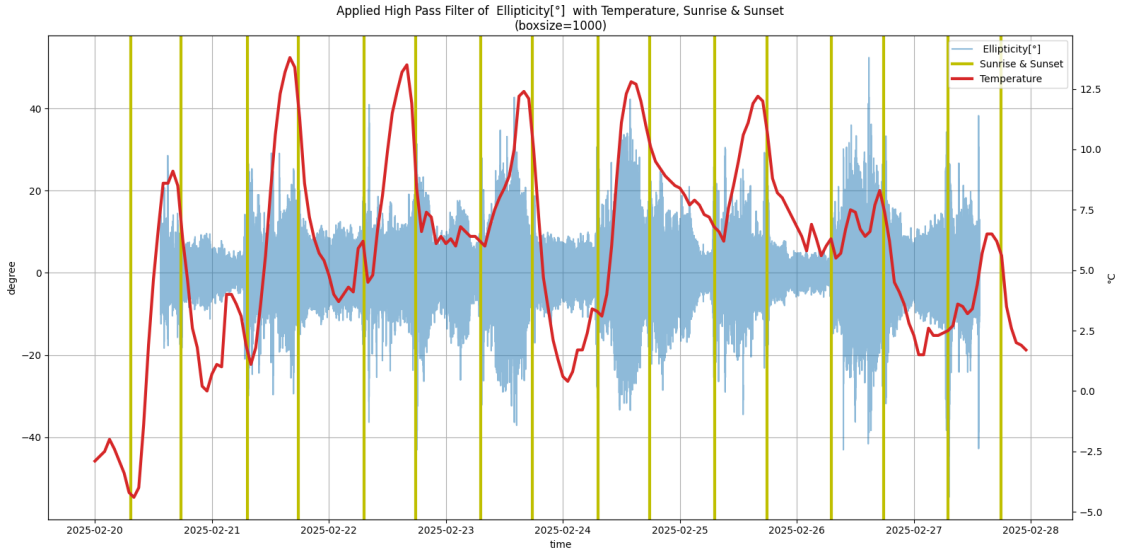




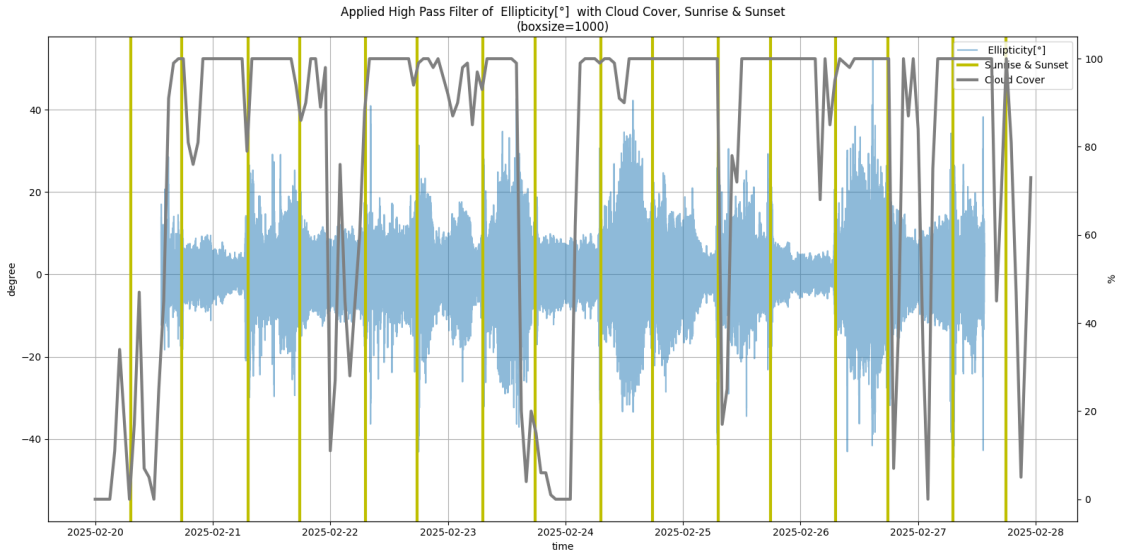
4.2.4 Untersuchung von Zusammenhängen zwischen Ellipticity und Wetter

[35]:
```
box = 1000
current = 0 #Temperature

fig, ax1 = plt.subplots(figsize=(16, 8))

ydata = np.array(angle[columns[10]])
```

```
hps = highpass(ydata, 1000)
ax1.plot(angle.index, hps, label=columns[10], alpha= 0.5)

for i in range(len(sunrise)):
    ax1.axvline(x = sunrise[i], color = 'y', linewidth=3)
    if i == 0: ax1.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: ax1.axvline(x = sunset[i], color = 'y', linewidth=3)

ax1.set_xlabel('time')
ax1.set_ylabel('degree')
h1, l1 = ax1.get_legend_handles_labels()

ax2 = ax1.twinx()

ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"],␣
 ↪linewidth=3)
ax2.set_ylabel(w_data[current]["unit"])
h2, l2 = ax2.get_legend_handles_labels()

ax1.grid()
ax1.legend(h1+h2, l1+l2, loc="best")
ax1.set_title(f'Applied High Pass Filter of {columns[10]} with␣
 ↪{w_data[current]["label"]}, Sunrise & Sunset\n(boxsize={box})')

plt.tight_layout()
plt.show()
```



[36]:
```
box = 1000
current = 2 #Cloud Cover

fig, ax1 = plt.subplots(figsize=(16, 8))

ydata = np.array(angle[columns[10]])
hps = highpass(ydata, 1000)
ax1.plot(angle.index, hps, label=columns[10], alpha= 0.5)

for i in range(len(sunrise)):
    ax1.axvline(x = sunrise[i], color = 'y', linewidth=3)
    if i == 0: ax1.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: ax1.axvline(x = sunset[i], color = 'y', linewidth=3)

ax1.set_xlabel('time')
ax1.set_ylabel('degree')
h1, l1 = ax1.get_legend_handles_labels()

ax2 = ax1.twinx()

ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"],␣
 ↪linewidth=3)
ax2.set_ylabel(w_data[current]["unit"])
h2, l2 = ax2.get_legend_handles_labels()

ax1.grid()
ax1.legend(h1+h2, l1+l2, loc="best")
ax1.set_title(f'Applied High Pass Filter of {columns[10]} with␣
 ↪{w_data[current]["label"]}, Sunrise & Sunset\n(boxsize={box})')

plt.tight_layout()
plt.show()
```



[37]:
```
box = 1000
current = 3 #Windspeed

fig, ax1 = plt.subplots(figsize=(16, 8))

ydata = np.array(angle[columns[10]])
hps = highpass(ydata, 1000)
ax1.plot(angle.index, hps, label=columns[10], alpha= 0.5)

for i in range(len(sunrise)):
    ax1.axvline(x = sunrise[i], color = 'y', linewidth=3)
    if i == 0: ax1.axvline(x = sunset[i], color = 'y',label = 'Sunrise &␣
 ↪Sunset', linewidth=3)
    else: ax1.axvline(x = sunset[i], color = 'y', linewidth=3)

ax1.set_xlabel('time')
ax1.set_ylabel('degree')
h1, l1 = ax1.get_legend_handles_labels()

ax2 = ax1.twinx()

ax2.plot(weather.index, weather[w_data[current]["header"]],␣
 ↪label=w_data[current]["label"], color = w_data[current]["color"],␣
 ↪linewidth=3)
ax2.set_ylabel(w_data[current]["unit"])
h2, l2 = ax2.get_legend_handles_labels()

ax1.grid()
```

```
ax1.legend(h1+h2, l1+l2, loc="best")
ax1.set_title(f'Applied High Pass Filter of {columns[10]} with␣
 ↪{w_data[current]["label"]}, Sunrise & Sunset\n(boxsize={box})')

plt.tight_layout()
plt.show()
```