delhi_mosdac

October 22, 2020

1 ATMS Instrumentation Lab

Analysis of MOSDAC data for the Delhi region for the time period from 1st Jan 2015 to 1st Jan 2016. This is to the study the Seasonal variation of atmospheric variables and other important parameters over the Delhi region. Work done by Aditya Sengupta (Roll No. - 420AS2068)

[9]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
import requests

import seaborn as sns
import scipy.stats as stats
plt.style.use('seaborn-pastel')
sns.set_theme(style="whitegrid")

from descartes import PolygonPatch
import statsmodels.api as sm

import plotly.express as px
import plotly.graph_objects as go

from windrose import WindroseAxes
from windrose import plot_windrose
import matplotlib.cm as cm

%matplotlib inline
```

[10]:
```
data = pd.read_csv('DELHI_IMDE1662_01-01-2015_01-01-2016_Oct20_157810.csv',␣
↪index_col=0)
data.head()
```

[10]:

@STATION_ID	LATITUDE	LONGITUDE	ALTITUDE(m)	TIME(GMT)	\
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	0	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	1	

```
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27          NaN          2
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27          NaN          3
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27          NaN          4

                             DATE(GMT) TIME(IST)   DATE(IST)  AIR_TEMP(°C)  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  01/01/2015      5:30  01/01/2015          24.4
IMDE1662_14167E(AKSHARDHAM)  01/01/2015      6:30  01/01/2015          24.7
IMDE1662_14167E(AKSHARDHAM)  01/01/2015      7:30  01/01/2015          24.4
IMDE1662_14167E(AKSHARDHAM)  01/01/2015      8:30  01/01/2015          25.0
IMDE1662_14167E(AKSHARDHAM)  01/01/2015      9:30  01/01/2015          26.3

                             WIND_SPEED(m/s)  WIND_DIRECTION(deg)  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)              0.5                330.9
IMDE1662_14167E(AKSHARDHAM)              0.3                312.8
IMDE1662_14167E(AKSHARDHAM)              0.2                350.9
IMDE1662_14167E(AKSHARDHAM)              0.7                334.8
IMDE1662_14167E(AKSHARDHAM)              0.7                333.8

                             ATMO_PRESSURE(hpa)  HUMIDITY(%)  RAIN_FALL(mm)  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)               939.7         0.0            0.0
IMDE1662_14167E(AKSHARDHAM)               939.8         0.0            0.0
IMDE1662_14167E(AKSHARDHAM)               940.3         0.0            0.0
IMDE1662_14167E(AKSHARDHAM)               941.1         0.0            0.0
IMDE1662_14167E(AKSHARDHAM)               942.8         0.0            0.0

                            SUN_SHINE(hh:mm)  BATTERY_VOLTAGE(V)
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)              0:0              9953.0
IMDE1662_14167E(AKSHARDHAM)              0:0              9953.0
IMDE1662_14167E(AKSHARDHAM)              0:0              9953.0
IMDE1662_14167E(AKSHARDHAM)              0:0              9953.0
IMDE1662_14167E(AKSHARDHAM)              0:0              9953.0
```

[11]:
```
data.describe()
```

[11]:
```
           LATITUDE  LONGITUDE  ALTITUDE(m)    TIME(GMT)  AIR_TEMP(°C)  \
count  5.216000e+03    5216.00          0.0  5216.000000   5216.000000
mean   2.861000e+01      77.27          NaN    11.234663     30.169574
std    7.106109e-15       0.00          NaN     7.052097      3.696948
min    2.861000e+01      77.27          NaN     0.000000     21.600000
25%    2.861000e+01      77.27          NaN     5.000000     27.200000
50%    2.861000e+01      77.27          NaN    11.000000     30.400000
75%    2.861000e+01      77.27          NaN    17.000000     33.100000
max    2.861000e+01      77.27          NaN    23.000000     39.800000
```

```
       WIND_SPEED(m/s)  WIND_DIRECTION(deg)  ATMO_PRESSURE(hpa)  HUMIDITY(%)  \
count      5216.000000           5216.00000         5216.000000  5216.000000
mean          1.153911            239.07036          935.578604    38.890146
std           0.928608             92.41433            6.075187    48.272084
min           0.000000              0.00000          917.600000     0.000000
25%           0.500000            157.90000          930.400000     0.000000
50%           0.900000            275.20000          937.200000     0.000000
75%           1.600000            311.80000          940.300000    99.000000
max           6.500000            359.20000          948.200000    99.000000

       RAIN_FALL(mm)  BATTERY_VOLTAGE(V)
count    5216.000000              5216.0
mean        0.833397              9953.0
std         4.386465                 0.0
min         0.000000              9953.0
25%         0.000000              9953.0
50%         0.000000              9953.0
75%         0.000000              9953.0
max        73.000000              9953.0
```

[12]:
```
# Units used -
# Altitude in meters
# Time and Date in GMT
# Time in IST
# AIR_TEMP in celcius
# Wind speadd in m/s
# Wind direction in degrees
# atmos pressure in hPa
# Rain fall in mm
# Humidity in %
# Sunshine in hh:mm
# battery voltage in V

old_names = list(data.columns)
new_names = ["latitude",
             "longitude",
             "altitude",
             "time_gmt",
             "date_gmt",
             "time_ist",
             "date_ist",
             "Tc",
             "wind_speed",
             "wind_dir",
             "atmo_press",
             "humidity",
```

```
             "rainfall",
             "sunshine",
             "battery_voltage"]

d1 = zip(old_names,new_names)
name_dict = dict(d1)

data.rename(columns = name_dict, inplace=True)
data.head()
```

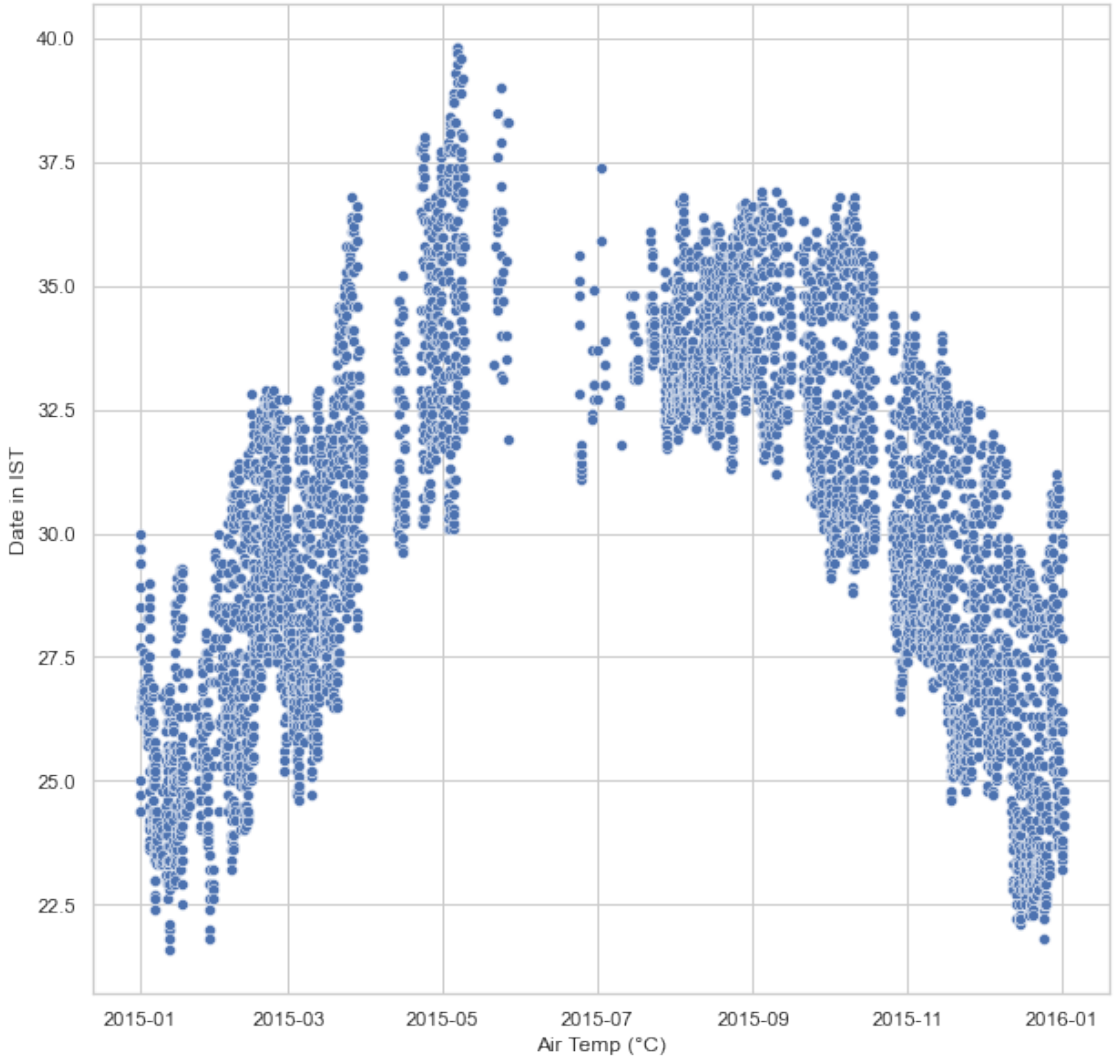
[12]:

@STATION_ID	latitude	longitude	altitude	time_gmt	date_gmt	time_ist	date_ist	Tc	wind_speed	wind_dir	atmo_press	humidity	rainfall	sunshine	battery_voltage
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	0	01/01/2015	5:30	01/01/2015	24.4	0.5	330.9	939.7	0.0	0.0	0:0	9953.0
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	1	01/01/2015	6:30	01/01/2015	24.7	0.3	312.8	939.8	0.0	0.0	0:0	9953.0
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	2	01/01/2015	7:30	01/01/2015	24.4	0.2	350.9	940.3	0.0	0.0	0:0	9953.0
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	3	01/01/2015	8:30	01/01/2015	25.0	0.7	334.8	941.1	0.0	0.0	0:0	9953.0
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	4	01/01/2015	9:30	01/01/2015	26.3	0.7	333.8	942.8	0.0	0.0	0:0	9953.0

[13]:
```
# Testing the validity of the data by plotting a time-series for raw data

data['date_ist'] = pd.to_datetime(data['date_ist'], errors='coerce')

plt.figure(figsize=(10,10))
```

```
sns.scatterplot(data = data, x='date_ist', y='Tc')
# plt.xticks(df_damage_count.index, rotation= 10)
plt.ylabel('Date in IST', fontsize=12)
plt.xlabel('Air Temp (°C)', fontsize=12)
```

[13]: Text(0.5, 0, 'Air Temp (°C)')



[14]:
```
# Obtain year, month and day as well as week columns from the data in IST

data['year'] = pd.DatetimeIndex(data['date_ist']).year
data['month'] = pd.DatetimeIndex(data['date_ist']).month
data['day'] = pd.DatetimeIndex(data['date_ist']).day

# Now let's make weeks -
```

```
# 1st method
#weekly_data = data.groupby("@STATION_ID").resample('W-Wed', label='right',␣
 ↪closed = 'right', on='date_ist').mean().reset_index().
 ↪sort_values(by='date_ist')
#weekly_data.head()

# 2nd method

data['date_ist'] = pd.to_datetime(data['date_ist'])
data['Week_Number'] = data['date_ist'].dt.week
#weekly_Tc = pd.DataFrame()
#weekly_Tc['Tc'] = data.Tc.resample('W').mean().reset_index().
 ↪sort_values(by='date_ist')
#weekly_Tc['error'] = data.Tc.resample('W').std().reset_index().
 ↪sort_values(by='date_ist')

#weekly_Tc.head()
data.head()

data.head()
```

```
<ipython-input-14-8ebec5d3e40c>:16: FutureWarning: Series.dt.weekofyear and
Series.dt.week have been deprecated.  Please use Series.dt.isocalendar().week
instead.
  data['Week_Number'] = data['date_ist'].dt.week
```

[14]:

@STATION_ID	latitude	longitude	altitude	time_gmt	date_gmt	time_ist	date_ist	Tc	wind_speed	wind_dir	atmo_press	humidity	rainfall
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	0	01/01/2015	5:30	2015-01-01	24.4	0.5	330.9	939.7	0.0	0.0
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	1	01/01/2015	6:30	2015-01-01	24.7	0.3	312.8	939.8	0.0	0.0
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	2	01/01/2015	7:30	2015-01-01	24.4	0.2				
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	3	01/01/2015	8:30	2015-01-01	25.0	0.7				
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	NaN	4	01/01/2015	9:30	2015-01-01	26.3	0.7				

```
IMDE1662_14167E(AKSHARDHAM)     350.9       940.3       0.0       0.0
IMDE1662_14167E(AKSHARDHAM)     334.8       941.1       0.0       0.0
IMDE1662_14167E(AKSHARDHAM)     333.8       942.8       0.0       0.0

                            sunshine  battery_voltage  year  month  day  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)      0:0           9953.0  2015      1    1
IMDE1662_14167E(AKSHARDHAM)      0:0           9953.0  2015      1    1
IMDE1662_14167E(AKSHARDHAM)      0:0           9953.0  2015      1    1
IMDE1662_14167E(AKSHARDHAM)      0:0           9953.0  2015      1    1
IMDE1662_14167E(AKSHARDHAM)      0:0           9953.0  2015      1    1

                             Week_Number
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)           1
IMDE1662_14167E(AKSHARDHAM)           1
IMDE1662_14167E(AKSHARDHAM)           1
IMDE1662_14167E(AKSHARDHAM)           1
IMDE1662_14167E(AKSHARDHAM)           1
```

[16]:
```
# Changing the order of columns for simplicity using lists
# Only run when the table changes accidentally to normal as before. Uncomment␣
 ↪the first 3 lines and then run.

#cols = list(data.columns)
#cols = cols[:7]+cols[-4:]+cols[7:15]
#data = data[cols]
data.head()
```

[16]:
```
                            latitude  longitude  altitude  time_gmt  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27       NaN         0
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27       NaN         1
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27       NaN         2
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27       NaN         3
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27       NaN         4

                              date_gmt time_ist   date_ist  year  month  day  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  01/01/2015     5:30 2015-01-01  2015      1    1
IMDE1662_14167E(AKSHARDHAM)  01/01/2015     6:30 2015-01-01  2015      1    1
IMDE1662_14167E(AKSHARDHAM)  01/01/2015     7:30 2015-01-01  2015      1    1
IMDE1662_14167E(AKSHARDHAM)  01/01/2015     8:30 2015-01-01  2015      1    1
IMDE1662_14167E(AKSHARDHAM)  01/01/2015     9:30 2015-01-01  2015      1    1

                             Week_Number    Tc  wind_speed  wind_dir  \
@STATION_ID
```

```
IMDE1662_14167E(AKSHARDHAM)            1  24.4         0.5     330.9
IMDE1662_14167E(AKSHARDHAM)            1  24.7         0.3     312.8
IMDE1662_14167E(AKSHARDHAM)            1  24.4         0.2     350.9
IMDE1662_14167E(AKSHARDHAM)            1  25.0         0.7     334.8
IMDE1662_14167E(AKSHARDHAM)            1  26.3         0.7     333.8

                           atmo_press  humidity  rainfall sunshine  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)      939.7       0.0       0.0      0:0
IMDE1662_14167E(AKSHARDHAM)      939.8       0.0       0.0      0:0
IMDE1662_14167E(AKSHARDHAM)      940.3       0.0       0.0      0:0
IMDE1662_14167E(AKSHARDHAM)      941.1       0.0       0.0      0:0
IMDE1662_14167E(AKSHARDHAM)      942.8       0.0       0.0      0:0

                           battery_voltage
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)          9953.0
IMDE1662_14167E(AKSHARDHAM)          9953.0
IMDE1662_14167E(AKSHARDHAM)          9953.0
IMDE1662_14167E(AKSHARDHAM)          9953.0
IMDE1662_14167E(AKSHARDHAM)          9953.0
```

[17]:
```
# Let's define some important values that we might want to analyse as a␣
 ↪time-series

drop_list = ["altitude","sunshine", "battery_voltage","time_gmt","date_gmt"]
data = data.drop(drop_list, axis = 1)
data.head()
```

[17]:
```
                           latitude  longitude time_ist   date_ist  year  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)    28.61      77.27     5:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)    28.61      77.27     6:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)    28.61      77.27     7:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)    28.61      77.27     8:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)    28.61      77.27     9:30 2015-01-01  2015

                           month  day  Week_Number    Tc  wind_speed  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)     1    1            1  24.4         0.5
IMDE1662_14167E(AKSHARDHAM)     1    1            1  24.7         0.3
IMDE1662_14167E(AKSHARDHAM)     1    1            1  24.4         0.2
IMDE1662_14167E(AKSHARDHAM)     1    1            1  25.0         0.7
IMDE1662_14167E(AKSHARDHAM)     1    1            1  26.3         0.7

                           wind_dir  atmo_press  humidity  rainfall
@STATION_ID
```

```
IMDE1662_14167E(AKSHARDHAM)     330.9       939.7       0.0       0.0
IMDE1662_14167E(AKSHARDHAM)     312.8       939.8       0.0       0.0
IMDE1662_14167E(AKSHARDHAM)     350.9       940.3       0.0       0.0
IMDE1662_14167E(AKSHARDHAM)     334.8       941.1       0.0       0.0
IMDE1662_14167E(AKSHARDHAM)     333.8       942.8       0.0       0.0
```

[18]:
```
# Let us ccalculate some important paramenters and add in the dataframe

# temp in Farh and Kel
data['Tf'] = 1.8 * data['Tc'] + 32
data['Tk'] = data['Tc'] + 273.15

# Dew Point temp (Tdf)in F
data['X'] = 1 - (0.01 * data['humidity'])
data['Tdc'] = data['Tc'] - (14.55 + 0.114 * data['Tc'])* data['X'] - ((2.5 + 0.
 ↪007 * data['Tc'])* data['X'])**3 - (15.9 + 0.117 * data['Tc']) *␣
 ↪data['X']**14
data['Tdf'] = (data['Tdc'] * 1.8) + 32

# saturation vapour pressure (Es) and vapour pressure (E)
data['Es'] = (6.11 * 10**(7.5 * data['Tc'] / (237.7 + data['Tc'])))
data['E'] = (6.11 * 10**(7.5 * data['Tdc'] / (237.7 + data['Tdc'])))
data['RH'] = (data['E']/data['Es']) * 100

# calculate virtual and dry potential temperature (theta) and saturated␣
 ↪potential temperature
data['Tv'] = (data['Tk'] / (1 - 0.378 * (data['E']/data['atmo_press']))) - 273.
 ↪15
data['theta'] = data['Tc'] * ((1000/data['atmo_press'])**0.2854)
data['M'] = (3 * (data['RH']*(3.884266 * 10 ** (( 7.5 * data['Tc'] ) / (237.7 +␣
 ↪data['Tc'])) ) /100 ))
data['thetaE'] = data['Tc'] * (1000**0.286) + (3*data['M'])

data = data.drop(['Tf','Tk','X','Tdf','M'], axis=1)
data.head()
```

[18]:
```
                            latitude  longitude time_ist   date_ist  year  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     5:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     6:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     7:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     8:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     9:30 2015-01-01  2015

                            month  day  Week_Number    Tc  wind_speed  …  \
@STATION_ID                                                             …
IMDE1662_14167E(AKSHARDHAM)     1    1            1  24.4         0.5  …
```

```
IMDE1662_14167E(AKSHARDHAM)      1    1            1  24.7         0.3  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  24.4         0.2  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  25.0         0.7  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  26.3         0.7  …

                            atmo_press  humidity  rainfall        Tdc  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)       939.7       0.0       0.0 -30.737677
IMDE1662_14167E(AKSHARDHAM)       939.8       0.0       0.0 -30.551952
IMDE1662_14167E(AKSHARDHAM)       940.3       0.0       0.0 -30.737677
IMDE1662_14167E(AKSHARDHAM)       941.1       0.0       0.0 -30.366297
IMDE1662_14167E(AKSHARDHAM)       942.8       0.0       0.0 -29.562611

                                    Es         E        RH         Tv  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  30.496360  0.470061  1.541369  24.456273
IMDE1662_14167E(AKSHARDHAM)  31.047343  0.478495  1.541179  24.757334
IMDE1662_14167E(AKSHARDHAM)  30.496360  0.470061  1.541369  24.456237
IMDE1662_14167E(AKSHARDHAM)  31.606989  0.487062  1.540993  25.058339
IMDE1662_14167E(AKSHARDHAM)  34.135031  0.525757  1.540228  26.363135

                                theta      thetaE
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  24.836975  178.639683
IMDE1662_14167E(AKSHARDHAM)  25.141584  180.851260
IMDE1662_14167E(AKSHARDHAM)  24.832451  178.639683
IMDE1662_14167E(AKSHARDHAM)  25.436910  183.063595
IMDE1662_14167E(AKSHARDHAM)  26.745850  192.659390

[5 rows x 21 columns]
```

[19]:
```python
# Let us define the seasons now -
#array for storing the size_class

season = []

for month in data.month:
    if month in [1,2,12]:
        season.append("Winter")
    elif month in [3,4,5]:
        season.append("Pre-Monsoon")
    elif month in [6,7,8,9]:
        season.append("Monsoon")
    elif month in [10,11]:
        season.append("Post-Monsoon")
    else:
        season.append("NA")
```

```
#Creating a column in the datafram called class_size
data['season'] = season
data.head()
```

[19]:

@STATION_ID	latitude	longitude	time_ist	date_ist	year	…
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	5:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	6:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	7:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	8:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	9:30	2015-01-01	2015	

@STATION_ID	month	day	Week_Number	Tc	wind_speed	…	…
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.5	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.7	0.3	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.2	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	25.0	0.7	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	26.3	0.7	…	

@STATION_ID	humidity	rainfall	Tdc	Es	…
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.737677	30.496360	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.551952	31.047343	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.737677	30.496360	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.366297	31.606989	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-29.562611	34.135031	

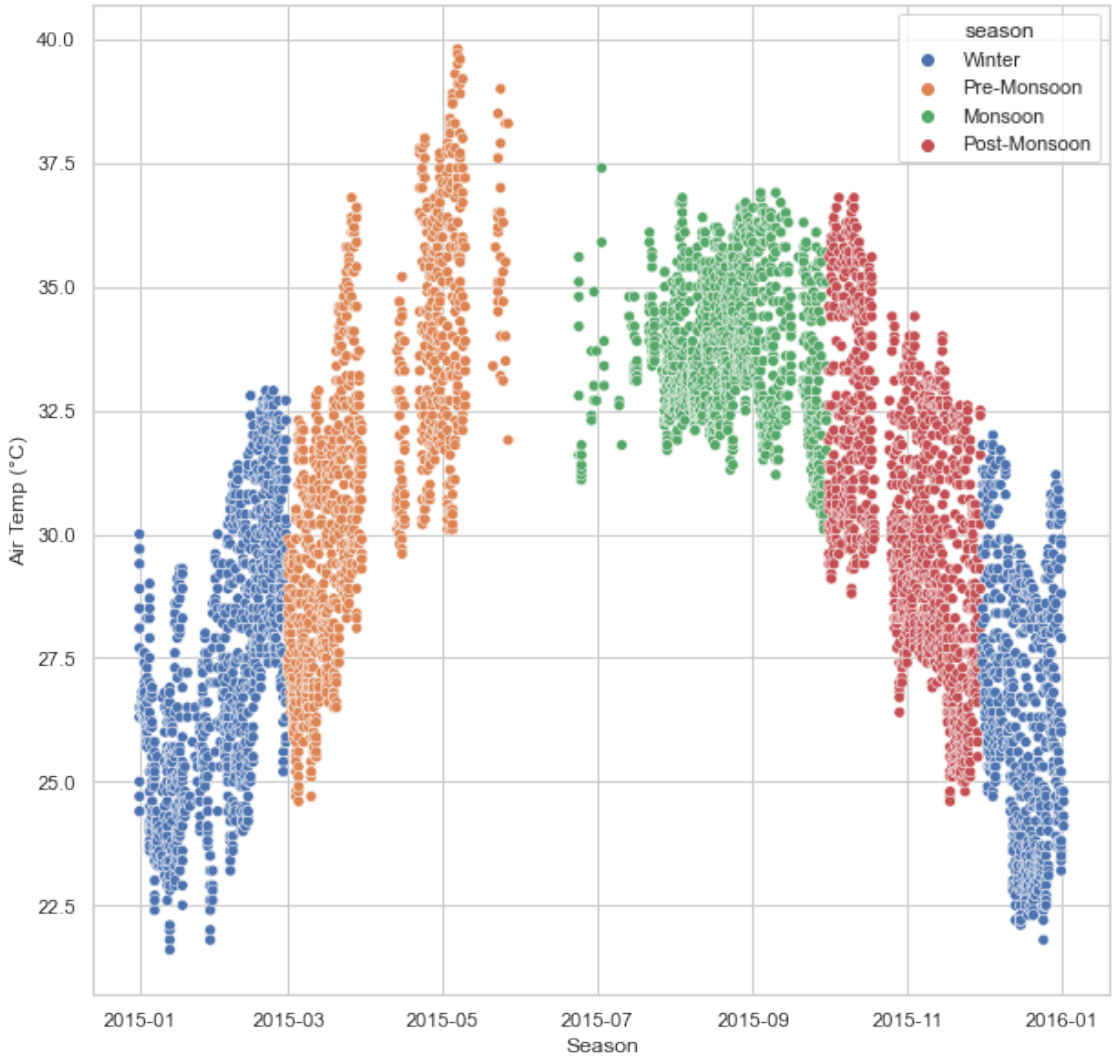
@STATION_ID	E	RH	Tv	theta	…
IMDE1662_14167E(AKSHARDHAM)	0.470061	1.541369	24.456273	24.836975	
IMDE1662_14167E(AKSHARDHAM)	0.478495	1.541179	24.757334	25.141584	
IMDE1662_14167E(AKSHARDHAM)	0.470061	1.541369	24.456237	24.832451	
IMDE1662_14167E(AKSHARDHAM)	0.487062	1.540993	25.058339	25.436910	
IMDE1662_14167E(AKSHARDHAM)	0.525757	1.540228	26.363135	26.745850	

@STATION_ID	thetaE	season
IMDE1662_14167E(AKSHARDHAM)	178.639683	Winter
IMDE1662_14167E(AKSHARDHAM)	180.851260	Winter
IMDE1662_14167E(AKSHARDHAM)	178.639683	Winter
IMDE1662_14167E(AKSHARDHAM)	183.063595	Winter
IMDE1662_14167E(AKSHARDHAM)	192.659390	Winter

[5 rows x 22 columns]

[20]:
```
# Let us find the mean values and std of the various parameters in different␣
↪seasons

# First make different dataframes for different seasons

plt.figure(figsize=(10,10))
sns.scatterplot(data = data, x='date_ist', y='Tc', hue='season')
#sns.lineplot(data = data, x='date_ist', y='Tc', hue='season')
#plt.xticks(rotation= 10)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Season', fontsize=12)
```

[20]:
```
Text(0.5, 0, 'Season')
```



[21]:
```
# Make smaller dataframes from the dataset

# we have premon, mon, postmon, and wint for different seasons and we have wint␣
 ↪2015 and 2016 for the two different years

# Run below only once
#data = data.drop(['time_gmt','date_gmt'], axis=1)

splits = list(data.groupby("year"))
data2015 = pd.DataFrame(splits[0][1])

splits1 = list(data2015.groupby("season"))

premon = pd.DataFrame(splits1[2][1])
mon = pd.DataFrame(splits1[0][1])
postmon = pd.DataFrame(splits1[1][1])
wint = pd.DataFrame(splits1[3][1])

wint.head()
```

[21]:

@STATION_ID	latitude	longitude	time_ist	date_ist	year	…
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	5:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	6:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	7:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	8:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	9:30	2015-01-01	2015	

@STATION_ID	month	day	Week_Number	Tc	wind_speed	…	…
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.5	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.7	0.3	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.2	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	25.0	0.7	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	26.3	0.7	…	

@STATION_ID	humidity	rainfall	Tdc	Es	…
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.737677	30.496360	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.551952	31.047343	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.737677	30.496360	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-30.366297	31.606989	
IMDE1662_14167E(AKSHARDHAM)	0.0	0.0	-29.562611	34.135031	

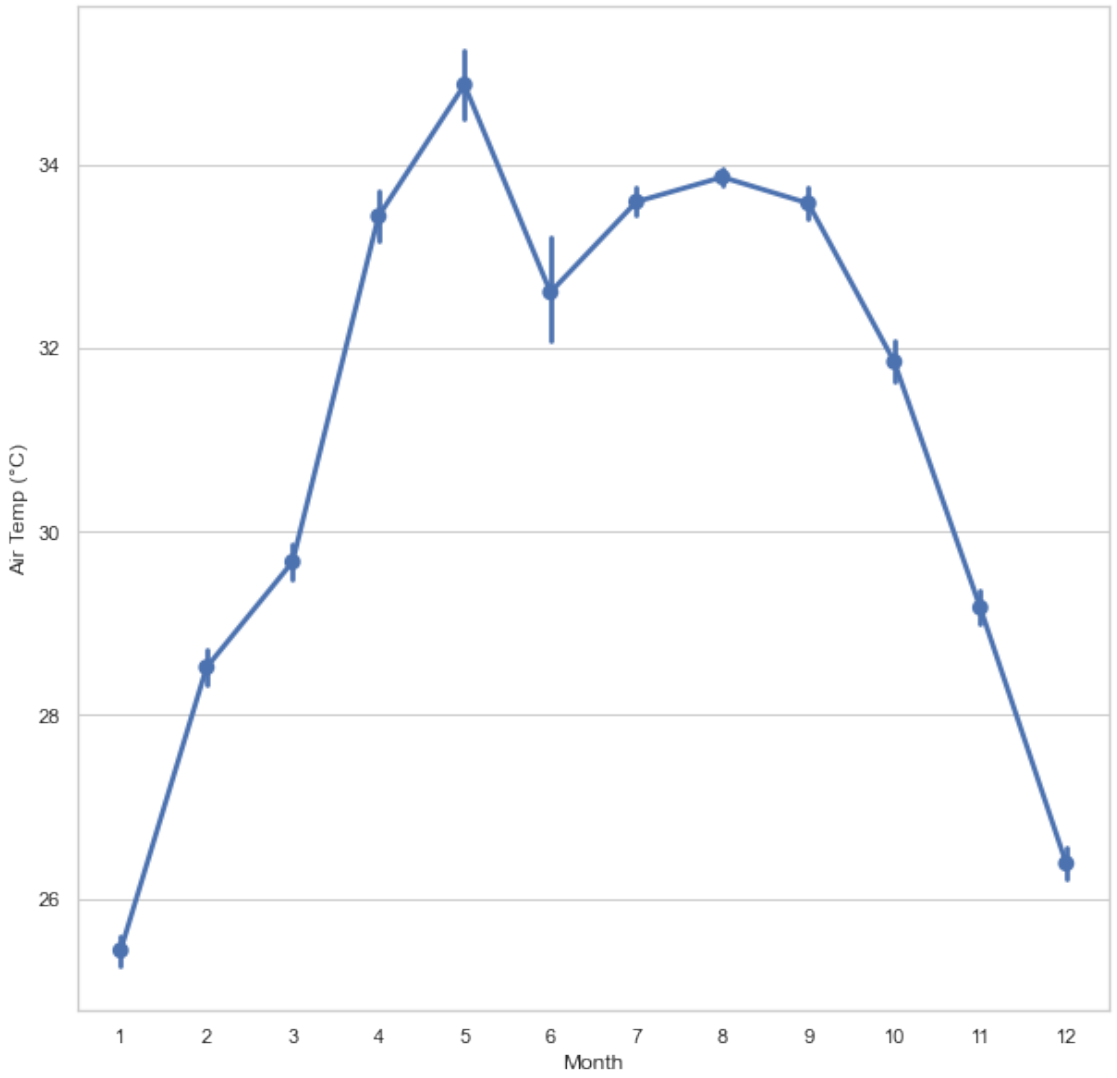
@STATION_ID	E	RH	Tv	theta	…
IMDE1662_14167E(AKSHARDHAM)	0.470061	1.541369	24.456273	24.836975	

```
IMDE1662_14167E(AKSHARDHAM)  0.478495  1.541179  24.757334  25.141584
IMDE1662_14167E(AKSHARDHAM)  0.470061  1.541369  24.456237  24.832451
IMDE1662_14167E(AKSHARDHAM)  0.487062  1.540993  25.058339  25.436910
IMDE1662_14167E(AKSHARDHAM)  0.525757  1.540228  26.363135  26.745850

                                thetaE  season
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter
IMDE1662_14167E(AKSHARDHAM)  180.851260  Winter
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter
IMDE1662_14167E(AKSHARDHAM)  183.063595  Winter
IMDE1662_14167E(AKSHARDHAM)  192.659390  Winter

[5 rows x 22 columns]
```

1.0.1 Air temperature seasonal variation

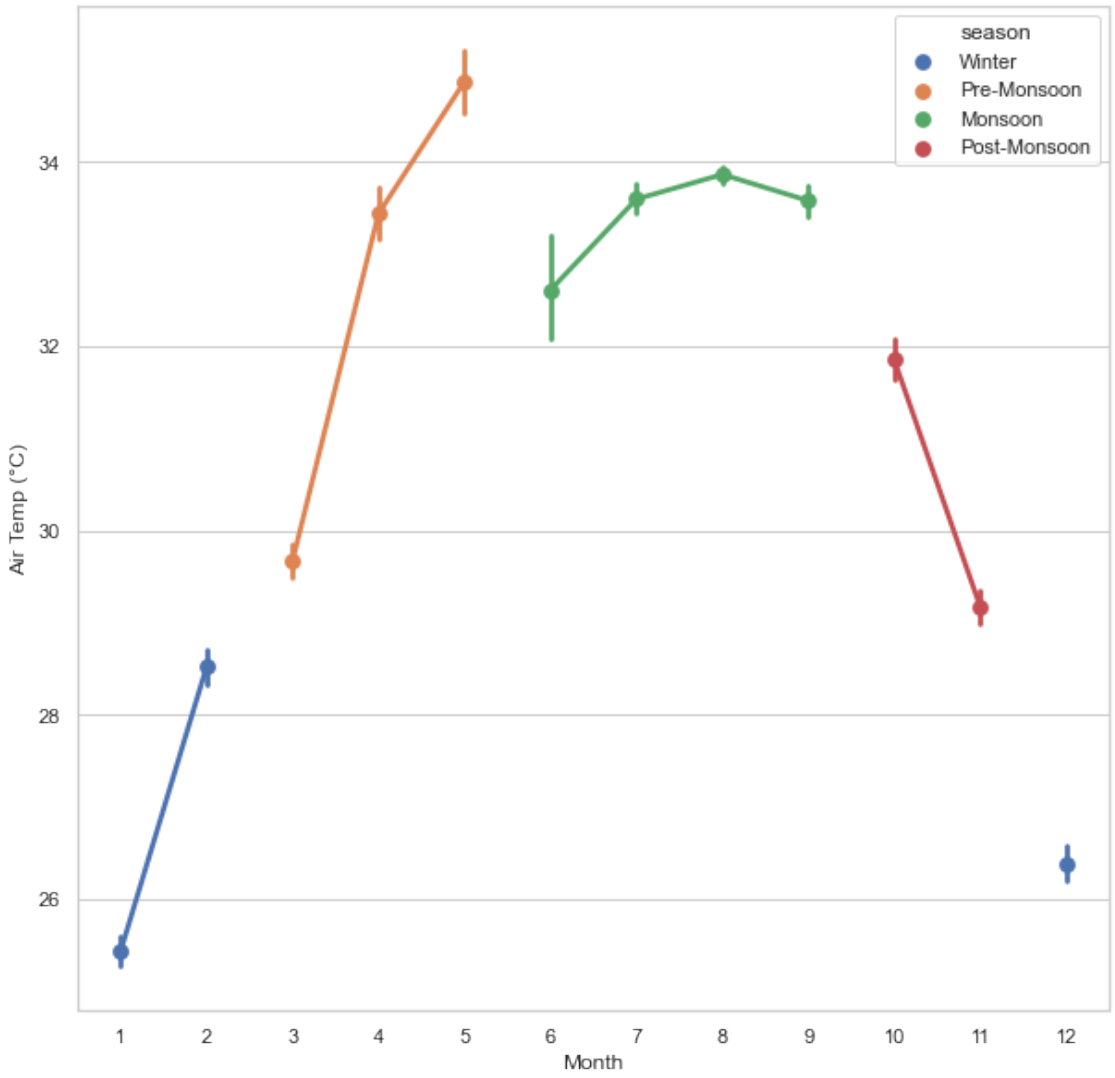
[22]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='month', y='Tc')
#plt.xticks(rotation= 10)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Month', fontsize=12)
```

[22]:
```
Text(0.5, 0, 'Month')
```



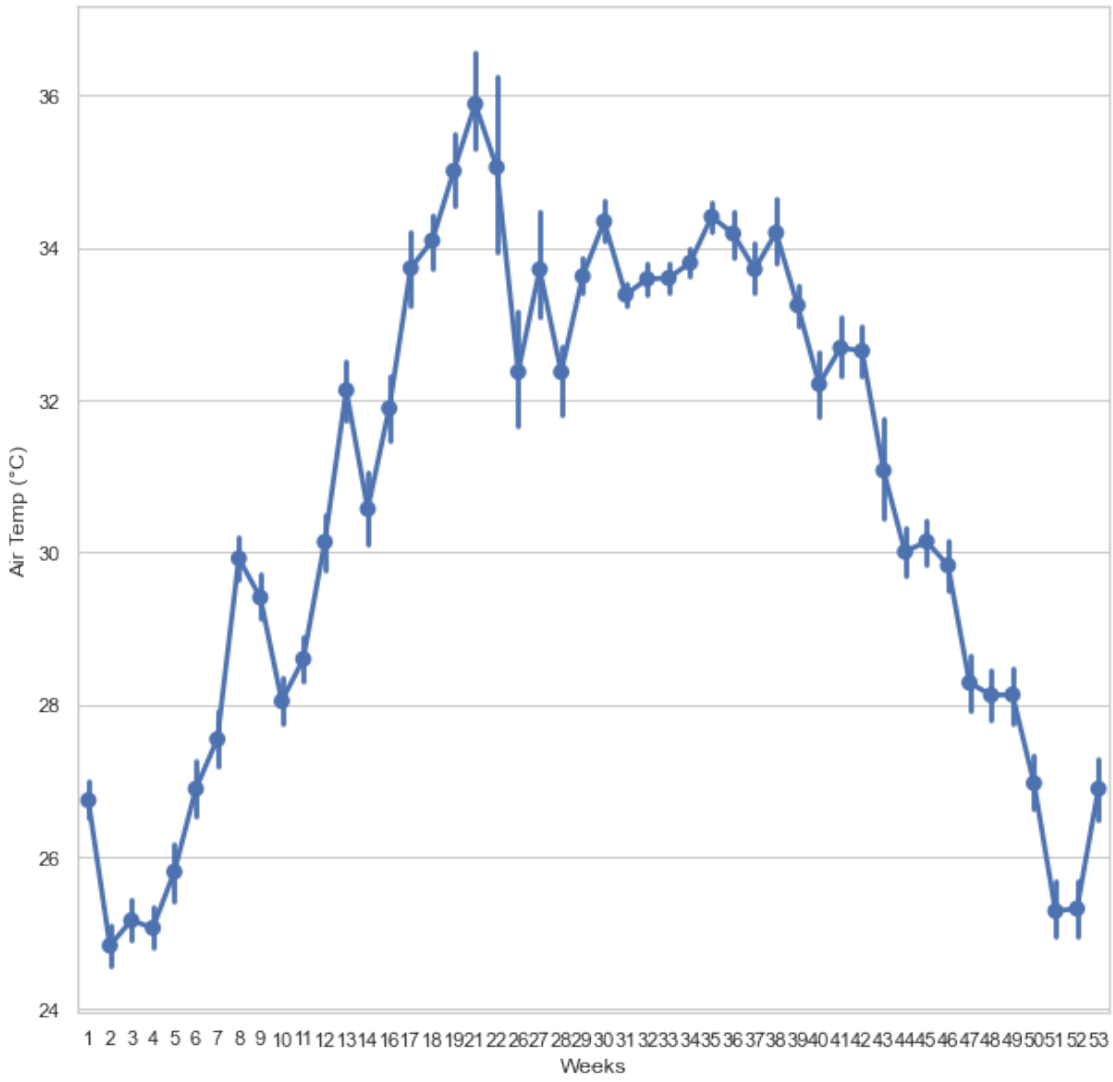
[23]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='month', y='Tc', hue='season')
#plt.xticks(rotation= 10)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Month', fontsize=12)
```

[23]: Text(0.5, 0, 'Month')



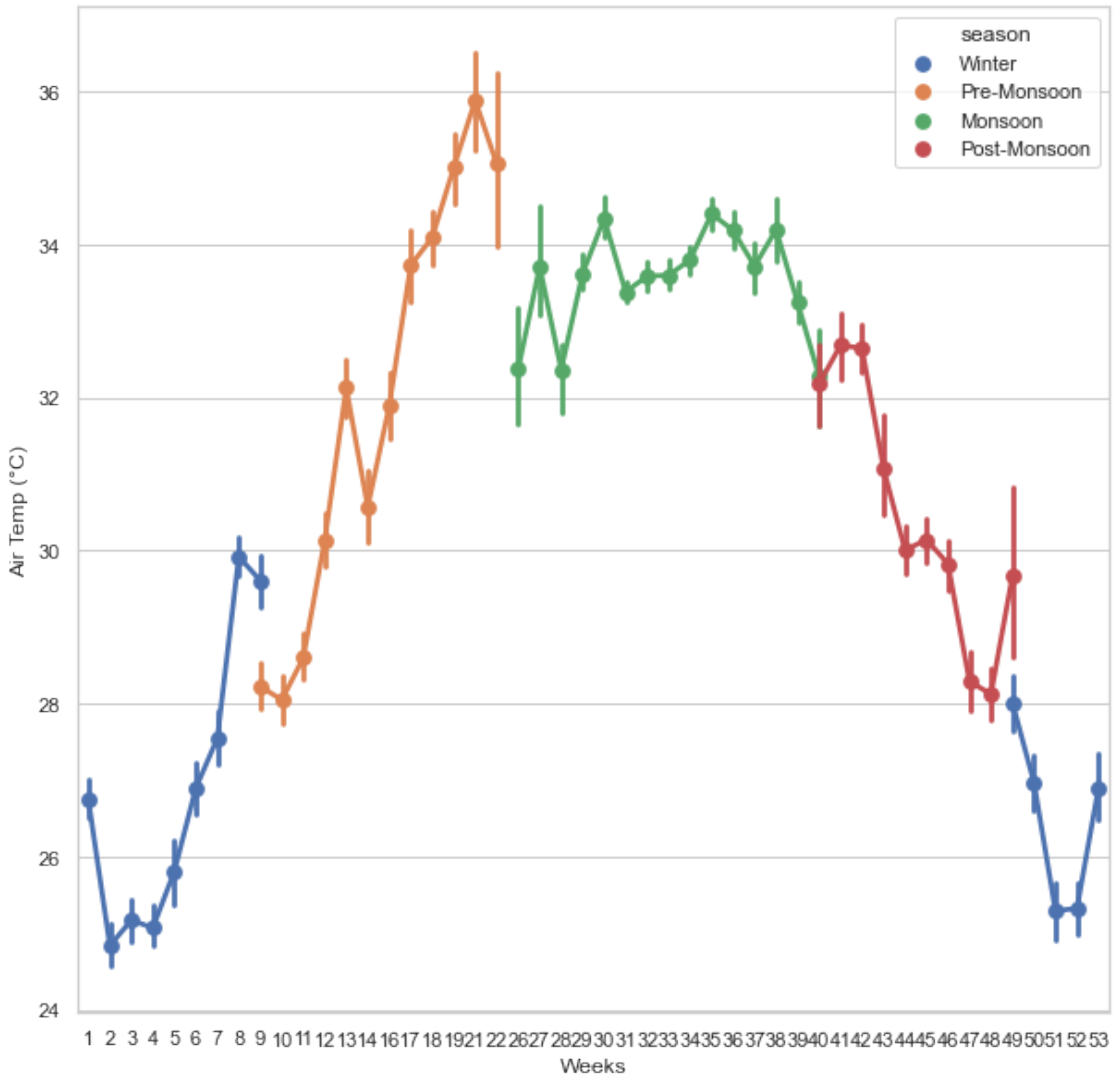
[24]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='Tc')
plt.xticks(rotation= 1)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[24]:
```
Text(0.5, 0, 'Weeks')
```



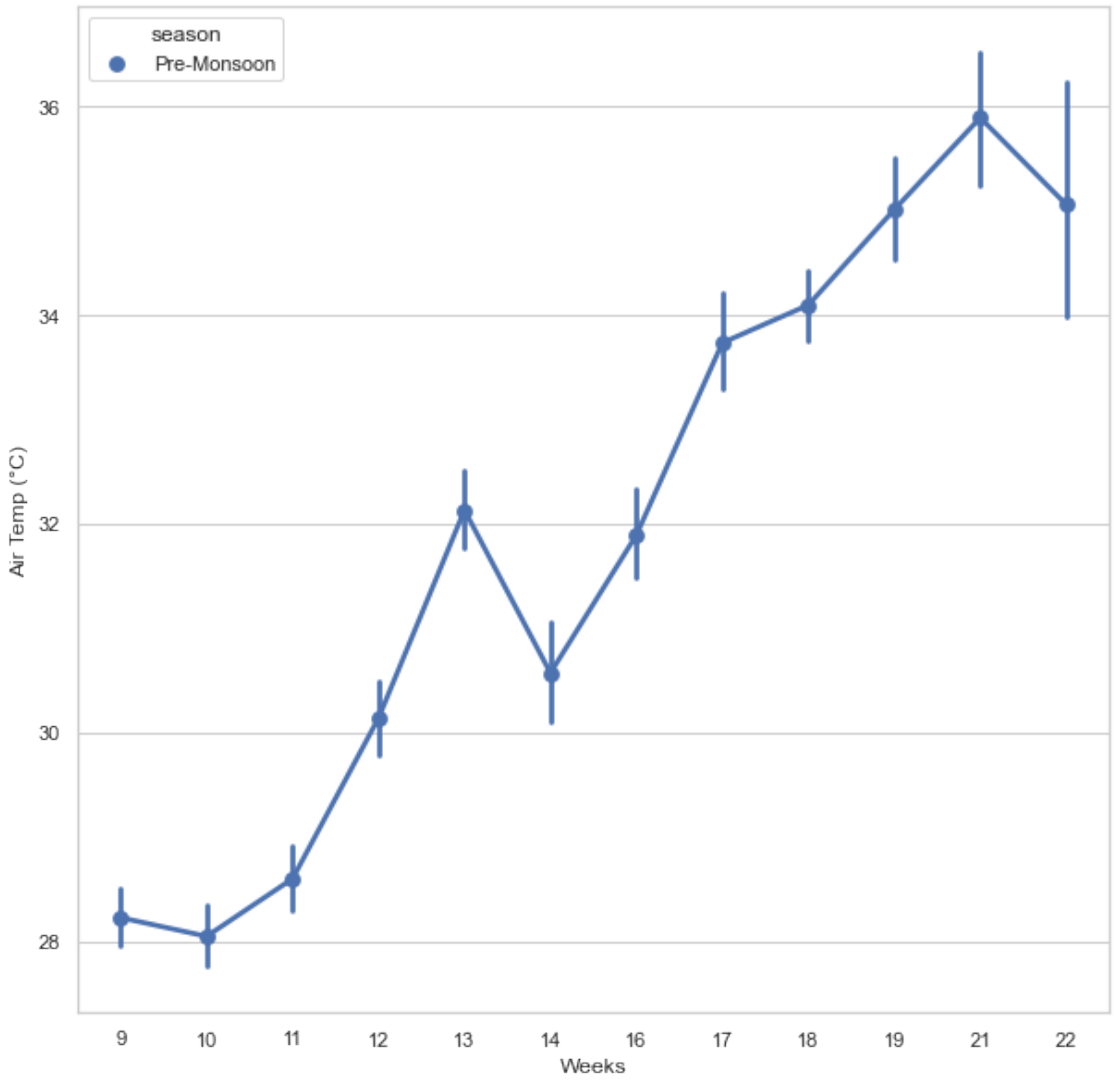
[25]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='Tc', hue='season')
plt.xticks(rotation= 1)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[25]:
```
Text(0.5, 0, 'Weeks')
```



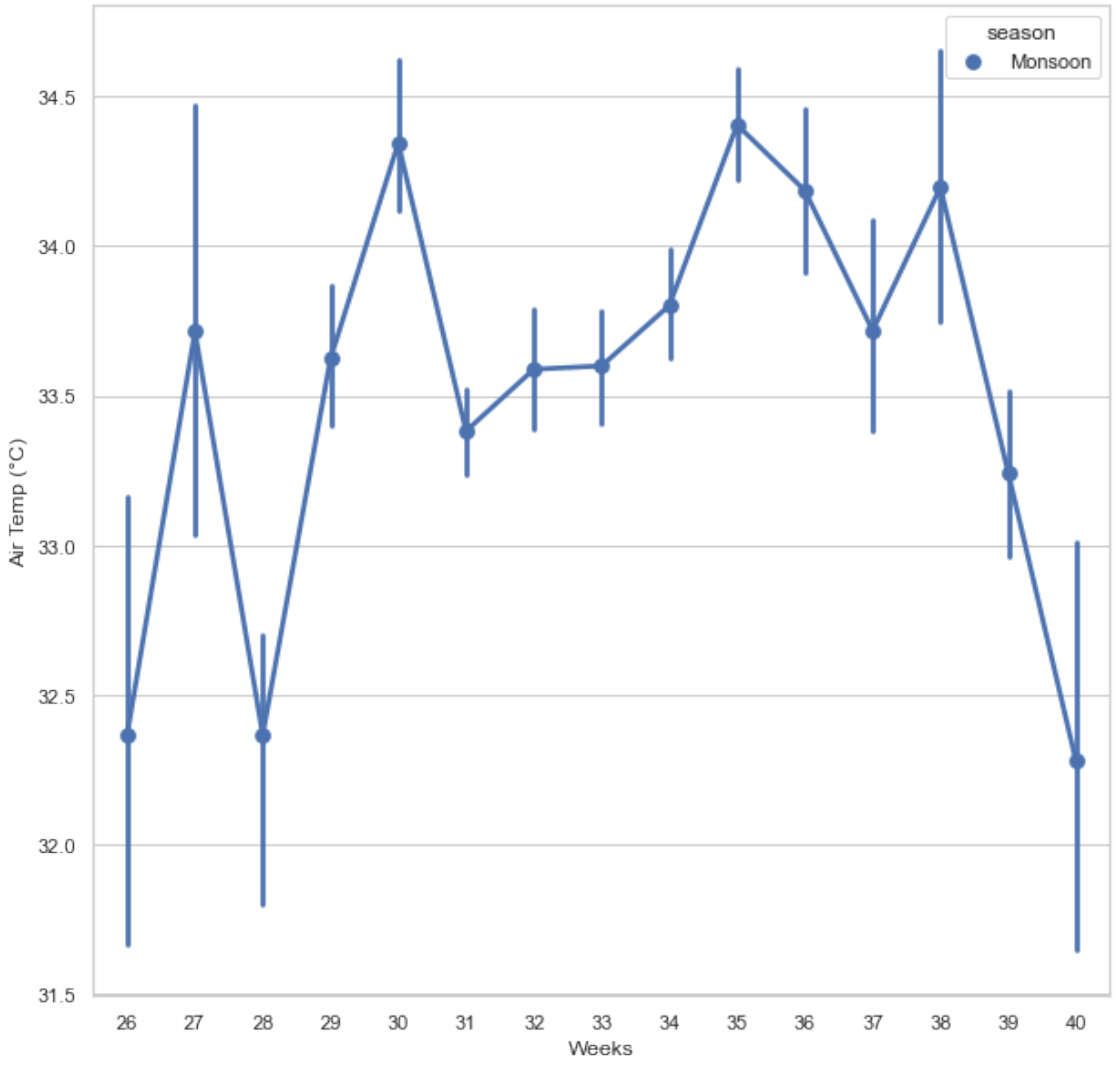
[26]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = premon, x='Week_Number', y='Tc', hue='season')
plt.xticks(rotation= 1)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[26]:
```
Text(0.5, 0, 'Weeks')
```



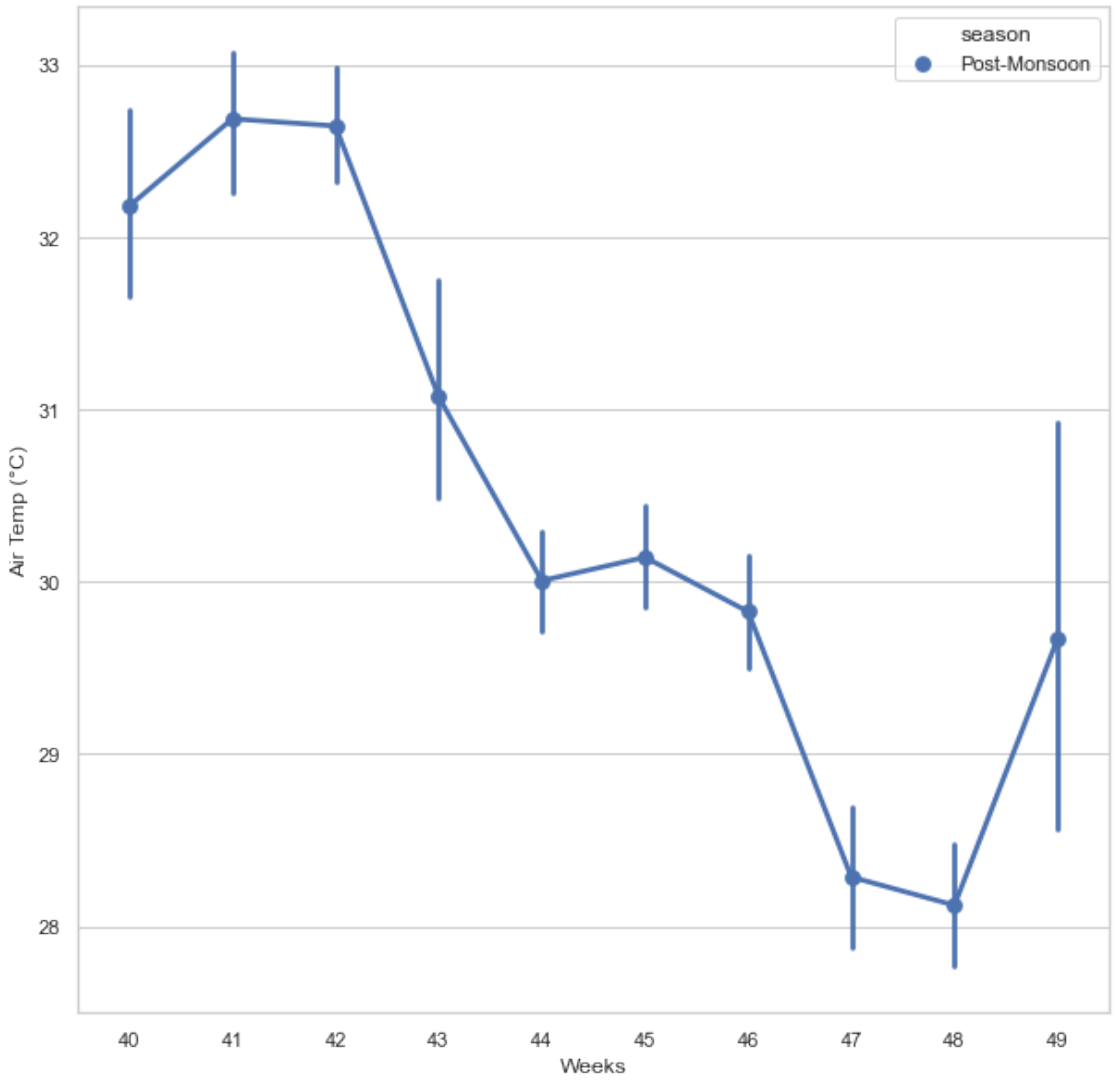
[27]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = mon, x='Week_Number', y='Tc', hue='season')
plt.xticks(rotation= 1)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[27]:
```
Text(0.5, 0, 'Weeks')
```



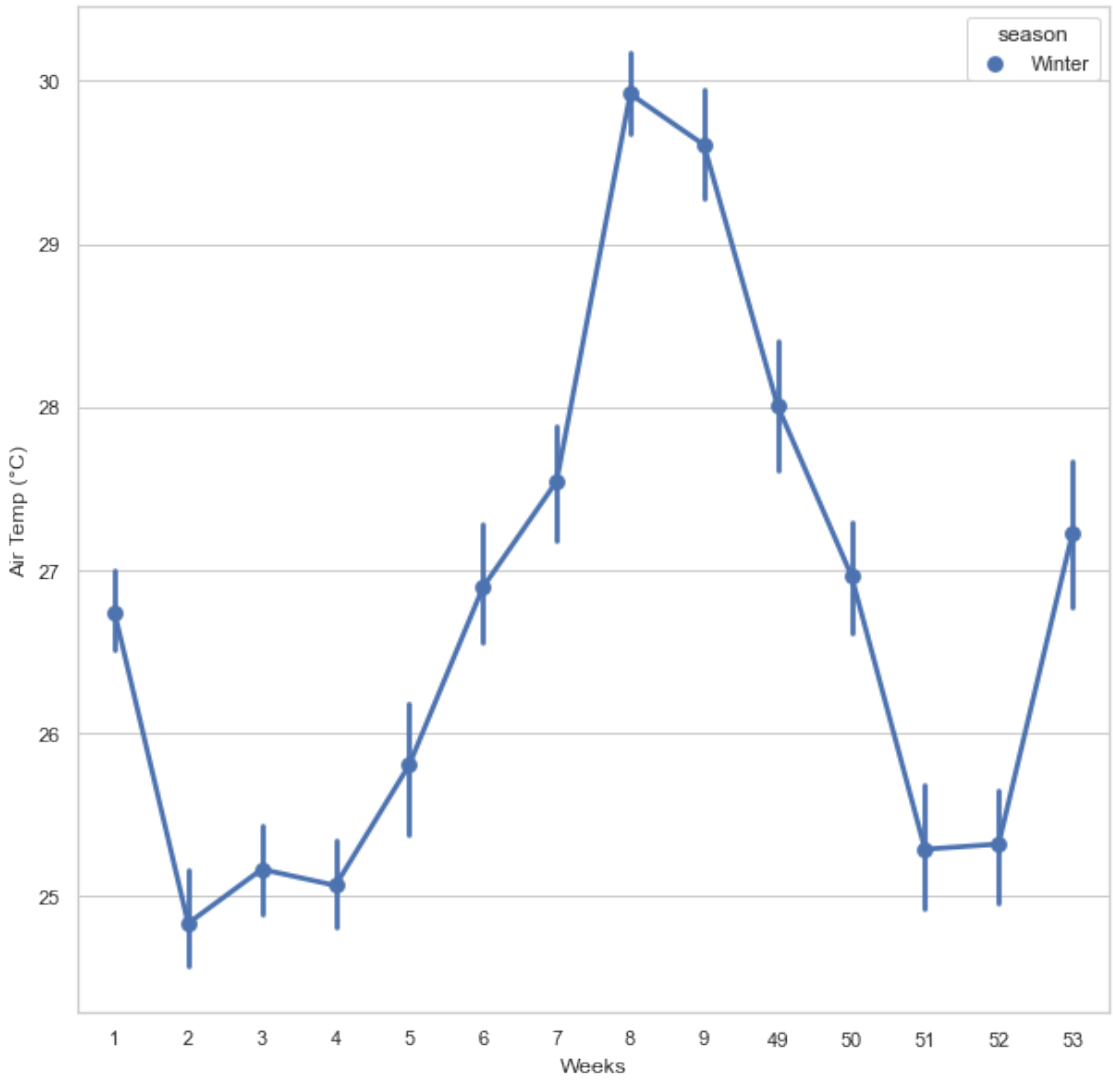
[28]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = postmon, x='Week_Number', y='Tc', hue='season')
plt.xticks(rotation= 1)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[28]:
```
Text(0.5, 0, 'Weeks')
```



[29]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = wint, x='Week_Number', y='Tc', hue='season')
plt.xticks(rotation= 1)
plt.ylabel('Air Temp (°C)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[29]:
```
Text(0.5, 0, 'Weeks')
```



1.0.2 Wind Speed Seasonal variation

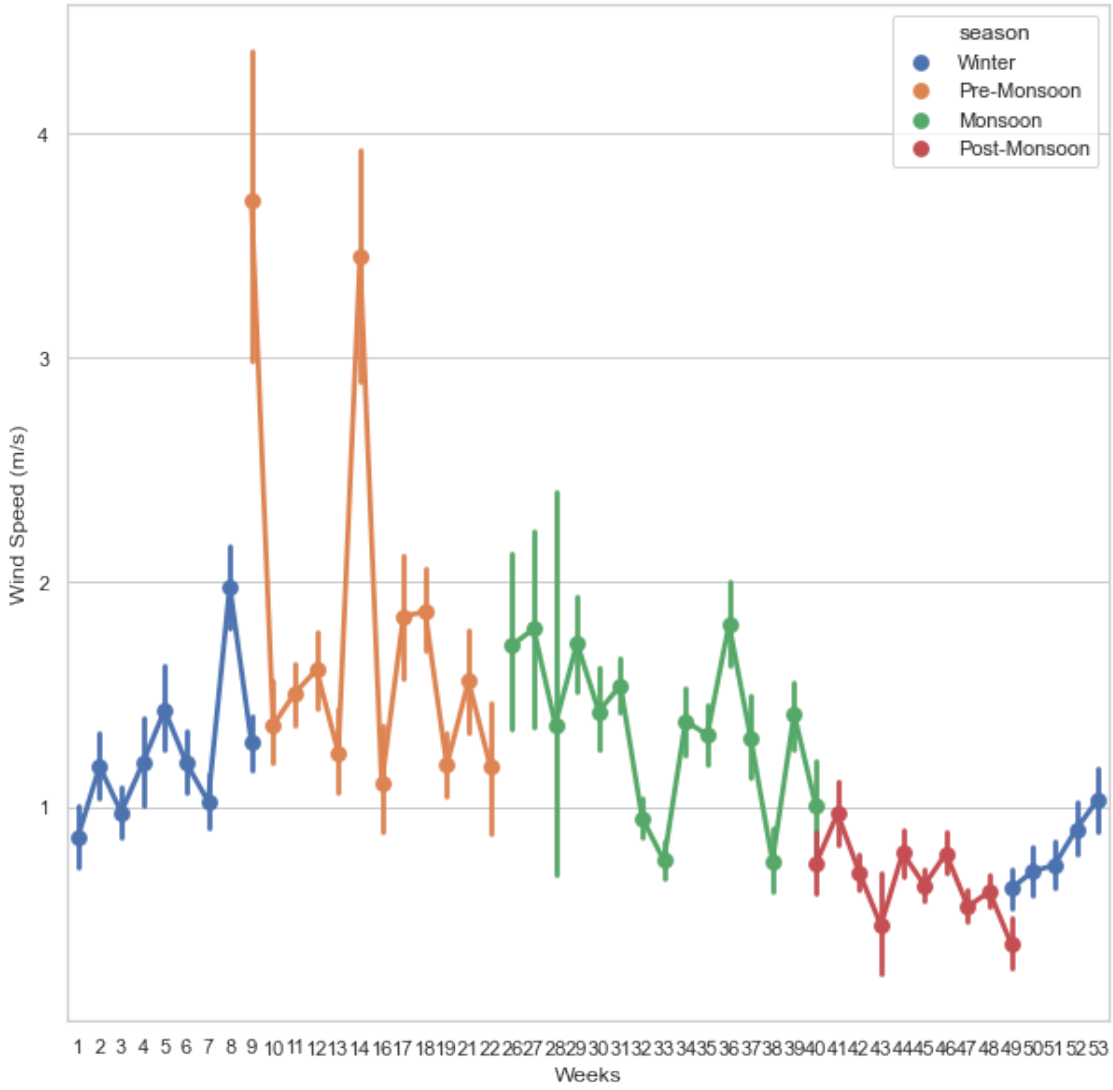
[30]:
```
data.head()
```

[30]:
```
                            latitude  longitude time_ist   date_ist  year  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     5:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     6:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     7:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     8:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     9:30 2015-01-01  2015

                            month  day  Week_Number    Tc  wind_speed  …  \
```

```
@STATION_ID                                                          …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  24.4         0.5  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  24.7         0.3  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  24.4         0.2  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  25.0         0.7  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  26.3         0.7  …

                            humidity  rainfall        Tdc         Es  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)       0.0       0.0 -30.737677  30.496360
IMDE1662_14167E(AKSHARDHAM)       0.0       0.0 -30.551952  31.047343
IMDE1662_14167E(AKSHARDHAM)       0.0       0.0 -30.737677  30.496360
IMDE1662_14167E(AKSHARDHAM)       0.0       0.0 -30.366297  31.606989
IMDE1662_14167E(AKSHARDHAM)       0.0       0.0 -29.562611  34.135031

                                  E        RH         Tv      theta  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  0.470061  1.541369  24.456273  24.836975
IMDE1662_14167E(AKSHARDHAM)  0.478495  1.541179  24.757334  25.141584
IMDE1662_14167E(AKSHARDHAM)  0.470061  1.541369  24.456237  24.832451
IMDE1662_14167E(AKSHARDHAM)  0.487062  1.540993  25.058339  25.436910
IMDE1662_14167E(AKSHARDHAM)  0.525757  1.540228  26.363135  26.745850

                                 thetaE  season
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter
IMDE1662_14167E(AKSHARDHAM)  180.851260  Winter
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter
IMDE1662_14167E(AKSHARDHAM)  183.063595  Winter
IMDE1662_14167E(AKSHARDHAM)  192.659390  Winter

[5 rows x 22 columns]
```

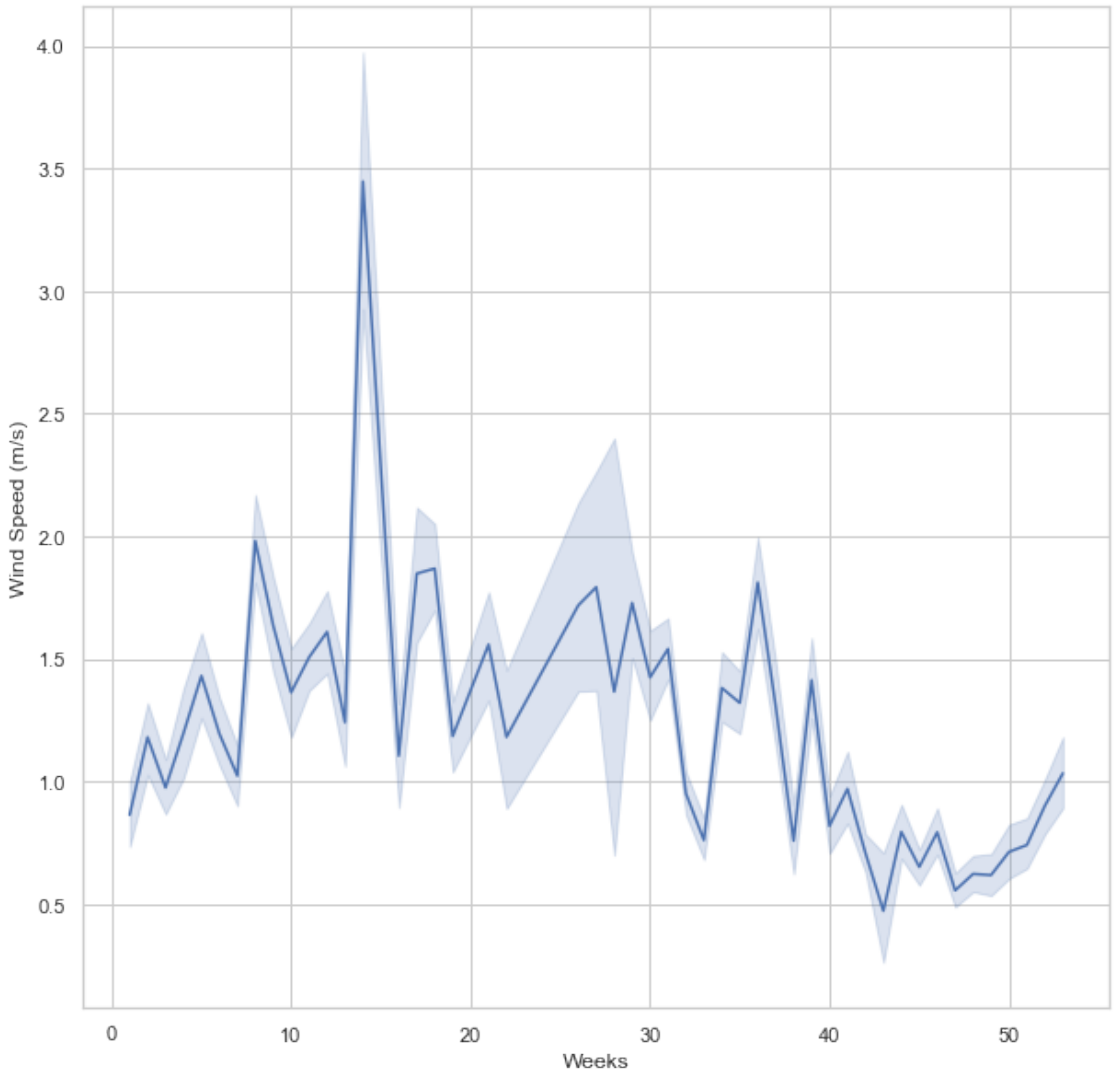
[31]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='wind_speed',␣
 ↪hue='season',style='season')
plt.xticks(rotation= 1)
plt.ylabel('Wind Speed (m/s)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[31]:
```
Text(0.5, 0, 'Weeks')
```



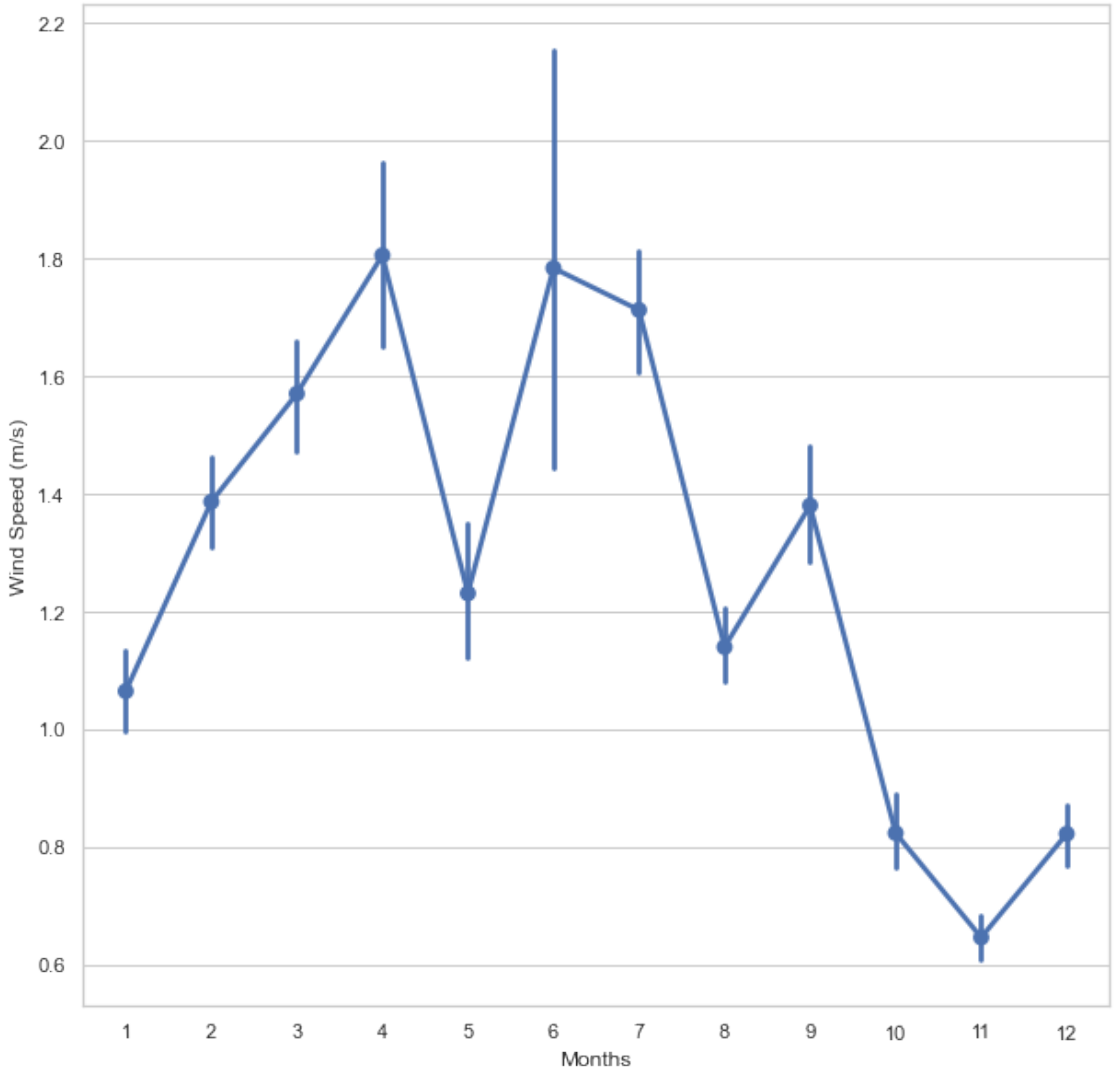
[32]:
```
plt.figure(figsize=(10,10))
sns.lineplot(data = data, x='Week_Number', y='wind_speed')
plt.xticks(rotation= 1)
plt.ylabel('Wind Speed (m/s)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[32]:
```
Text(0.5, 0, 'Weeks')
```



[33]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='month', y='wind_speed')
plt.xticks(rotation= 1)
plt.ylabel('Wind Speed (m/s)', fontsize=12)
plt.xlabel('Months', fontsize=12)
```

[33]: Text(0.5, 0, 'Months')



1.0.3 Wind direction seasonal variation

[34]:
```
# Before doing seasonal variation of wind direction we need to break the wind␣
 ↪speed into the
# zonal and meridional components of u and v and then find angle from that and␣
 ↪plot.

# The given wind direction is the vector direction and not meteorological␣
 ↪direction so we will get
# zonal and meridional in m/s as -

data['zonal_wind'] = data['wind_speed'] * (np.sin((np.pi/180)*data['wind_dir']))
data['meridional_wind'] = data['wind_speed'] * (np.cos((np.pi/
 ↪180)*data['wind_dir']))
```

```
data.head()
```

[34]:

@STATION_ID	latitude	longitude	time_ist	date_ist	year	\
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	5:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	6:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	7:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	8:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	9:30	2015-01-01	2015	

@STATION_ID	month	day	Week_Number	Tc	wind_speed	…	\
						…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.5	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.7	0.3	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.2	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	25.0	0.7	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	26.3	0.7	…	

@STATION_ID	Tdc	Es	E	RH	\
IMDE1662_14167E(AKSHARDHAM)	-30.737677	30.496360	0.470061	1.541369	
IMDE1662_14167E(AKSHARDHAM)	-30.551952	31.047343	0.478495	1.541179	
IMDE1662_14167E(AKSHARDHAM)	-30.737677	30.496360	0.470061	1.541369	
IMDE1662_14167E(AKSHARDHAM)	-30.366297	31.606989	0.487062	1.540993	
IMDE1662_14167E(AKSHARDHAM)	-29.562611	34.135031	0.525757	1.540228	

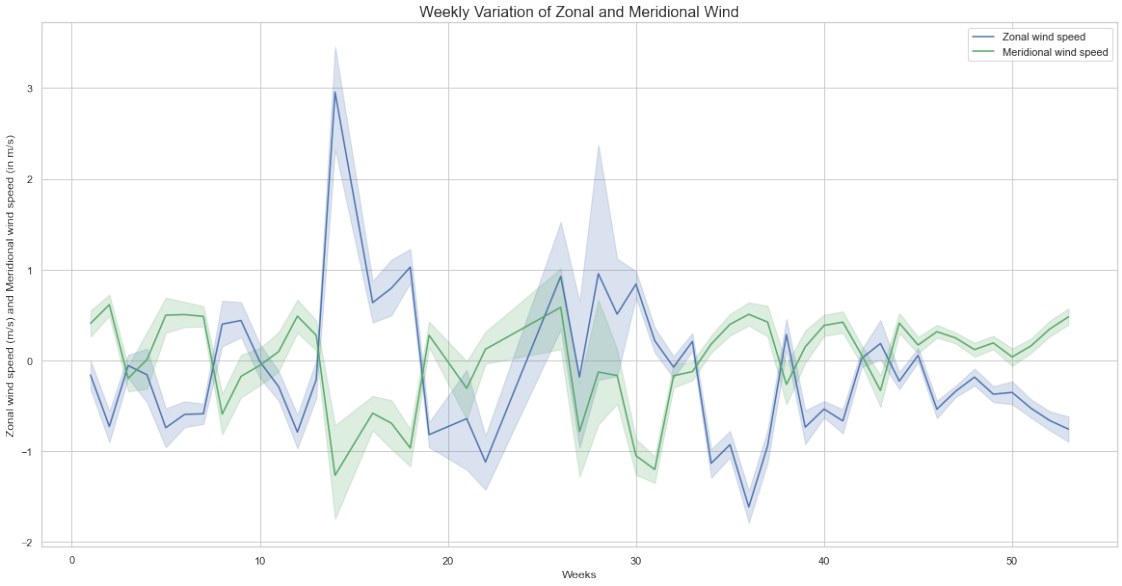
@STATION_ID	Tv	theta	thetaE	season	\
IMDE1662_14167E(AKSHARDHAM)	24.456273	24.836975	178.639683	Winter	
IMDE1662_14167E(AKSHARDHAM)	24.757334	25.141584	180.851260	Winter	
IMDE1662_14167E(AKSHARDHAM)	24.456237	24.832451	178.639683	Winter	
IMDE1662_14167E(AKSHARDHAM)	25.058339	25.436910	183.063595	Winter	
IMDE1662_14167E(AKSHARDHAM)	26.363135	26.745850	192.659390	Winter	

@STATION_ID	zonal_wind	meridional_wind
IMDE1662_14167E(AKSHARDHAM)	-0.243168	0.436886
IMDE1662_14167E(AKSHARDHAM)	-0.220119	0.203832
IMDE1662_14167E(AKSHARDHAM)	-0.031632	0.197483
IMDE1662_14167E(AKSHARDHAM)	-0.298046	0.633379
IMDE1662_14167E(AKSHARDHAM)	-0.309054	0.628081

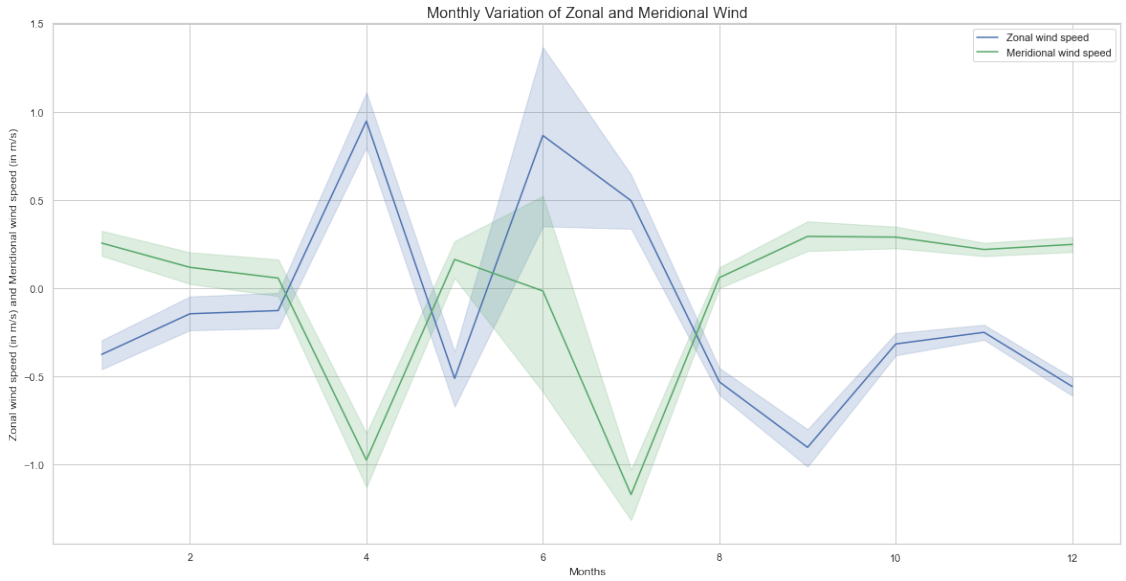
[5 rows x 24 columns]

[35]:
```
# This is the weekly variation of zonal and meridional wind
```

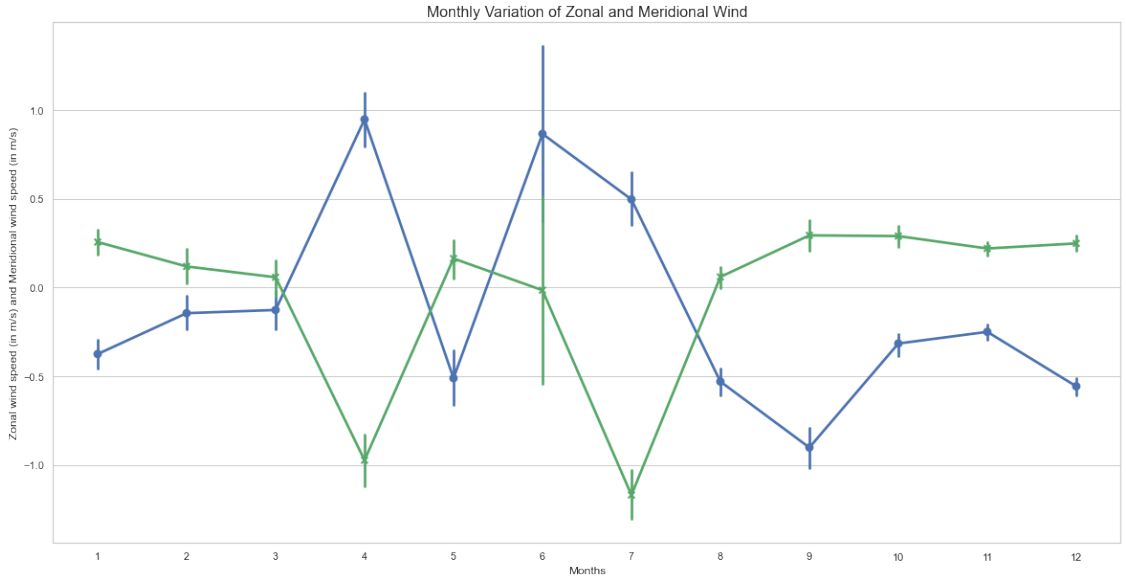
```
plt.figure(figsize=(20,10))
sns.lineplot(data = data, x='Week_Number', y='zonal_wind', markers="o",␣
 ↪label='Zonal wind speed')
sns.lineplot(data = data, x='Week_Number', y='meridional_wind', color='g',␣
 ↪markers="x", label='Meridional wind speed')
plt.xticks(rotation= 1)
plt.ylabel('Zonal wind speed (m/s) and Meridional wind speed (in m/s)',␣
 ↪fontsize=12)
plt.xlabel('Weeks', fontsize=12)
plt.title('Weekly Variation of Zonal and Meridional Wind', fontsize=16)
plt.savefig('zonal-meridional_weekly.png')
```



[36]:
```
# This is the monthly variation of zonal and meridional wind

plt.figure(figsize=(20,10))
sns.lineplot(data = data, x='month', y='zonal_wind', markers="o", label='Zonal␣
 ↪wind speed')
sns.lineplot(data = data, x='month', y='meridional_wind', color='g',␣
 ↪markers="x", label='Meridional wind speed')
plt.xticks(rotation= 1)
plt.ylabel('Zonal wind speed (in m/s) and Meridional wind speed (in m/s)',␣
 ↪fontsize=12)
plt.xlabel('Months', fontsize=12)
plt.title('Monthly Variation of Zonal and Meridional Wind', fontsize=16)
plt.savefig('zonal-meridional_monthly.png')
```



[37]:
```
plt.figure(figsize=(20,10))
sns.pointplot(data = data, x='month', y='zonal_wind',␣
 ↪markers="o",linestyle='-', label='Zonal wind speed')
sns.pointplot(data = data, x='month', y='meridional_wind', color='g',␣
 ↪markers="x",linestyle='--', label='Meridional wind speed')
plt.xticks(rotation= 1)
plt.ylabel('Zonal wind speed (in m/s) and Meridional wind speed (in m/s)',␣
 ↪fontsize=12)
plt.xlabel('Months', fontsize=12)
plt.title('Monthly Variation of Zonal and Meridional Wind', fontsize=16)
plt.savefig('zonal-meridional_monthly2.png')
```



1.0.4 WIND ROSE diagram

[38]:
```
# Another way of depicting wind direction is by using a Wind Rose

# Let us first make a column for strength and direction of the wind

strength = []

for wind_speed in data.wind_speed:
    if wind_speed >= 0.0 and wind_speed < 1.0:
        strength.append("0-1")
    elif wind_speed >= 1.0 and wind_speed < 2.0:
        strength.append("1-2")
    elif wind_speed >= 2.0 and wind_speed < 3.0:
        strength.append("2-3")
    elif wind_speed >= 3.0 and wind_speed < 4.0:
        strength.append("3-4")
    elif wind_speed >= 4.0 and wind_speed < 5.0:
        strength.append("4-5")
    elif wind_speed >= 5.0 and wind_speed < 6.0:
        strength.append("5-6")
    else:
        strength.append("6+")

direction = []

for wind_dir in data.wind_dir:
    if wind_dir >= 0.0 and wind_dir < 11.25:
        direction.append("N")
    elif wind_dir >= 11.25 and wind_dir < 33.75:
        direction.append("NNE")
    elif wind_dir >= 33.75 and wind_dir < 56.25:
        direction.append("NE")
    elif wind_dir >= 56.25 and wind_dir < 78.75:
        direction.append("ENE")
    elif wind_dir >= 78.75 and wind_dir < 101.25:
        direction.append("E")
    elif wind_dir >= 101.25 and wind_dir < 123.75:
        direction.append("ESE")
    elif wind_dir >= 123.75 and wind_dir < 146.25:
        direction.append("SE")
    elif wind_dir >= 146.25 and wind_dir < 168.75:
        direction.append("SSE")
    elif wind_dir >= 168.75 and wind_dir < 191.25:
```

```
        direction.append("S")
    elif wind_dir >= 191.25 and wind_dir < 213.75:
        direction.append("SSW")
    elif wind_dir >= 213.75 and wind_dir < 236.25:
        direction.append("SW")
    elif wind_dir >= 236.25 and wind_dir < 258.75:
        direction.append("WSW")
    elif wind_dir >= 258.75 and wind_dir < 281.25:
        direction.append("W")
    elif wind_dir >= 281.25 and wind_dir < 303.75:
        direction.append("WNW")
    elif wind_dir >= 303.75 and wind_dir < 326.25:
        direction.append("NW")
    elif wind_dir >= 326.25 and wind_dir < 348.75:
        direction.append("NNW")
    else:
        direction.append("N")

data['wind_strength'] = strength
data['direction'] = direction

data.head()
```

[38]:

@STATION_ID	latitude	longitude	time_ist	date_ist	year	\
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	5:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	6:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	7:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	8:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	9:30	2015-01-01	2015	

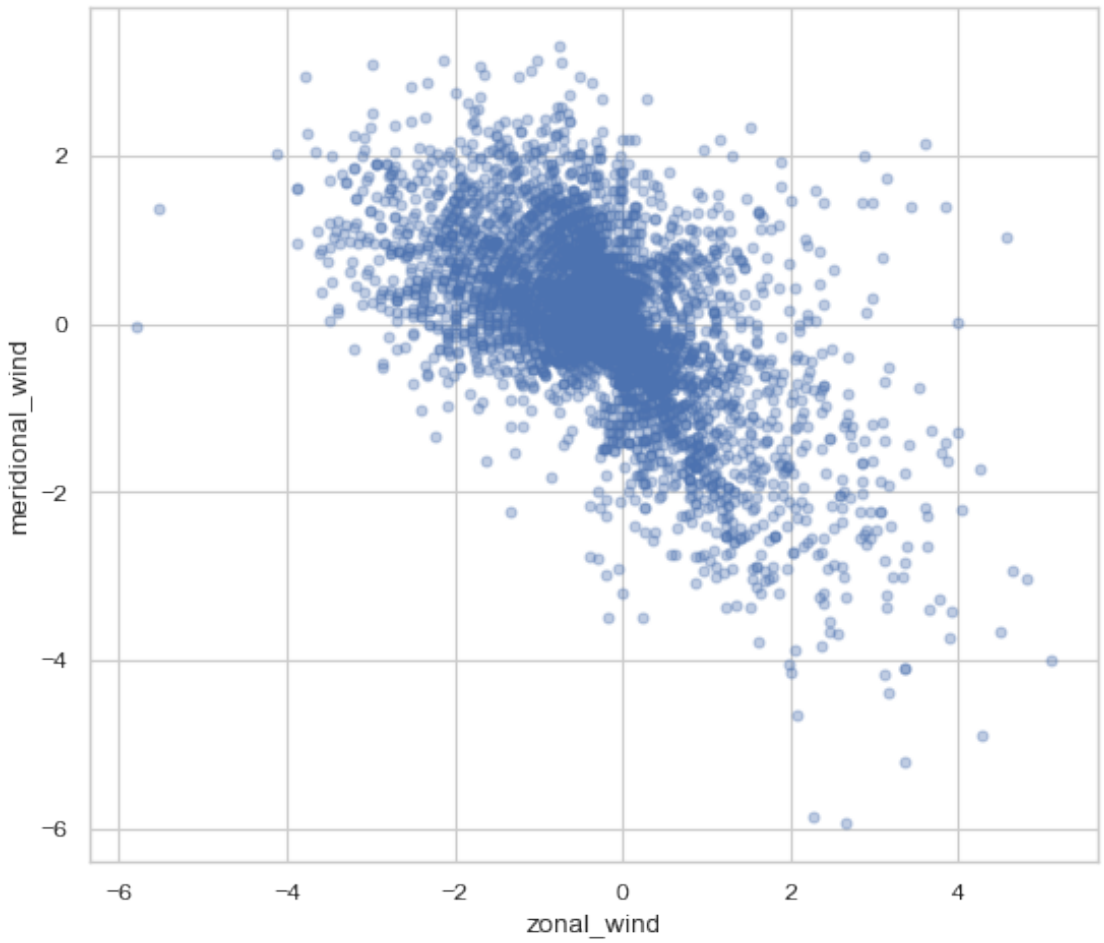
@STATION_ID	month	day	Week_Number	Tc	wind_speed	…	\
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.5	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.7	0.3	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.2	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	25.0	0.7	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	26.3	0.7	…	

@STATION_ID	E	RH	Tv	theta	\
IMDE1662_14167E(AKSHARDHAM)	0.470061	1.541369	24.456273	24.836975	
IMDE1662_14167E(AKSHARDHAM)	0.478495	1.541179	24.757334	25.141584	
IMDE1662_14167E(AKSHARDHAM)	0.470061	1.541369	24.456237	24.832451	
IMDE1662_14167E(AKSHARDHAM)	0.487062	1.540993	25.058339	25.436910	
IMDE1662_14167E(AKSHARDHAM)	0.525757	1.540228	26.363135	26.745850	

```
                                thetaE  season  zonal_wind  meridional_wind  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter   -0.243168         0.436886
IMDE1662_14167E(AKSHARDHAM)  180.851260  Winter   -0.220119         0.203832
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter   -0.031632         0.197483
IMDE1662_14167E(AKSHARDHAM)  183.063595  Winter   -0.298046         0.633379
IMDE1662_14167E(AKSHARDHAM)  192.659390  Winter   -0.309054         0.628081

                             wind_strength  direction
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW
IMDE1662_14167E(AKSHARDHAM)           0-1         NW
IMDE1662_14167E(AKSHARDHAM)           0-1          N
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW

[5 rows x 26 columns]
```

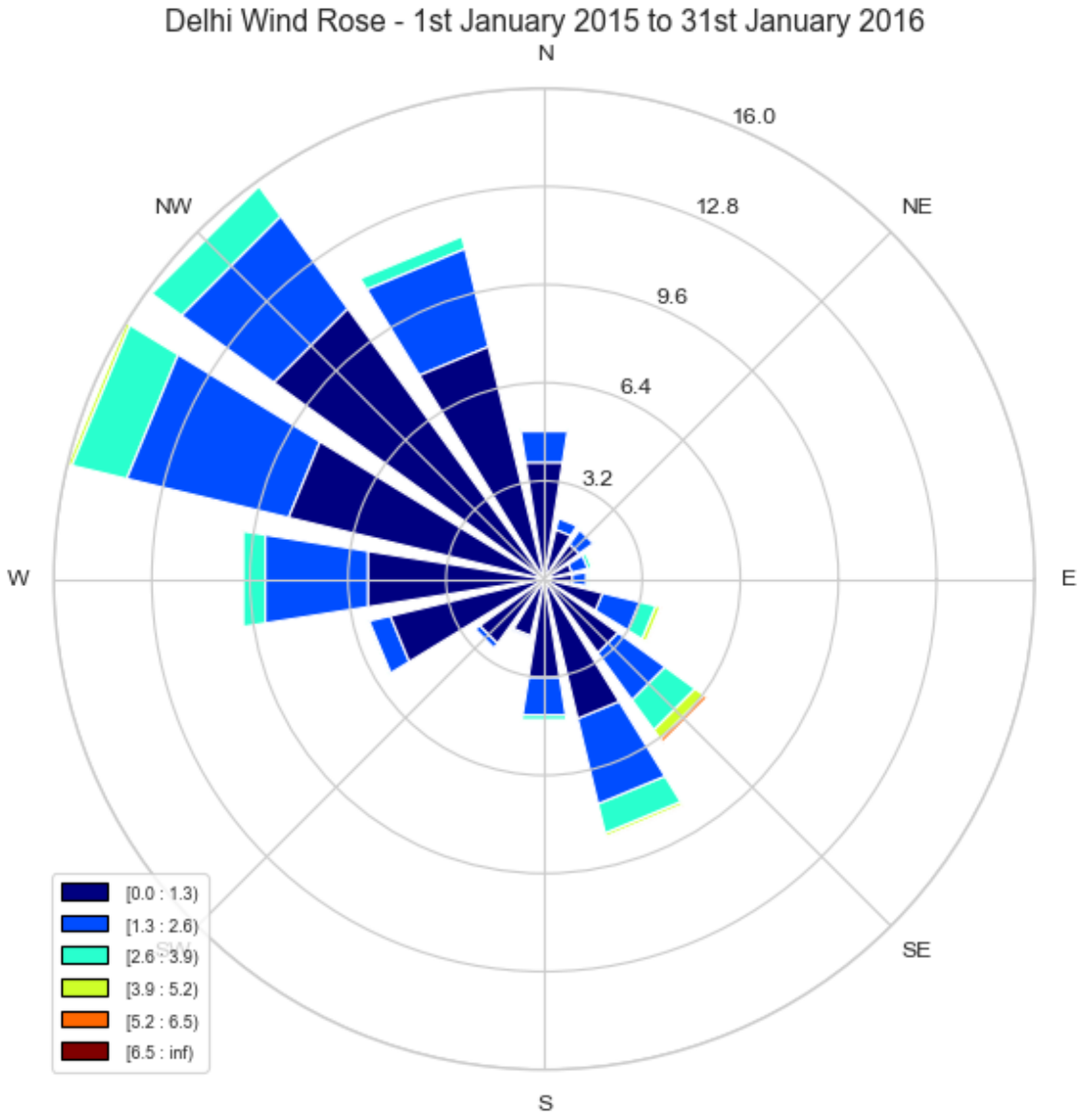
[39]:
```
fig, ax = plt.subplots(figsize=(8, 8), dpi=80)
x0, x1 = ax.get_xlim()
y0, y1 = ax.get_ylim()
ax.set_aspect('equal')
_ = data.plot(kind='scatter', x='zonal_wind', y='meridional_wind', alpha=0.35,␣
 ↪ax=ax)
```

```
*c* argument looks like a single numeric RGB or RGBA sequence, which should be
avoided as value-mapping will have precedence in case its length matches with
*x* & *y*.  Please use the *color* keyword-argument or provide a 2-D array with
a single row if you intend to specify the same RGB or RGBA value for all points.
```



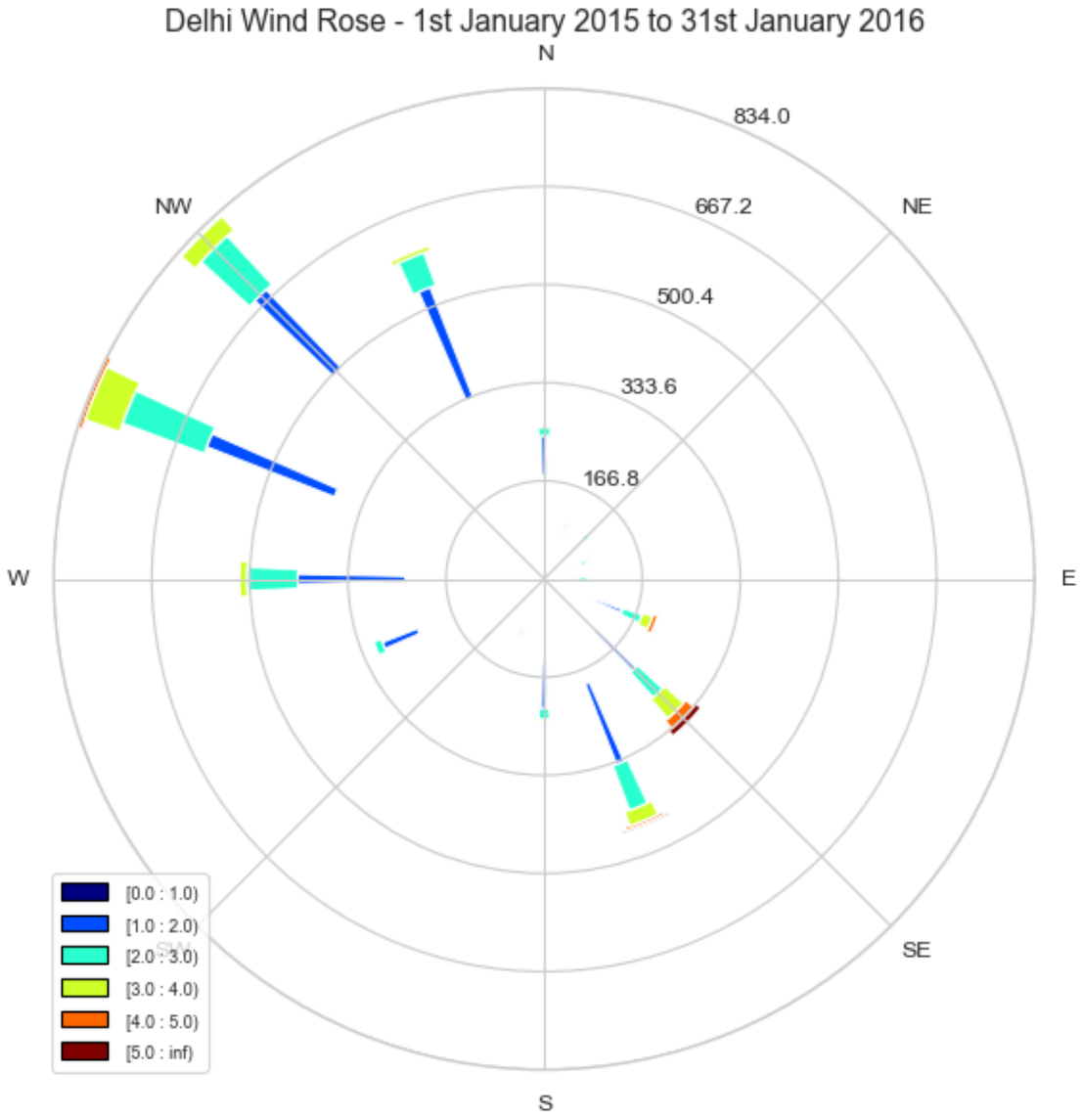
[50]:
```
# Here is a wind rose chart using Plotly express

# fig = px.bar_polar(data_percent, r="percent", theta="direction",␣
 ↪color="wind_strength",template="plotly_dark",
#                    color_discrete_sequence= px.colors.sequential.Plasma_r)
# fig1 = px.line_polar(data, r="percent", theta="direction",␣
 ↪color="wind_strength", line_close=True,
#             color_discrete_sequence=px.colors.sequential.Plasma_r)
# fig.show()
# fig1.show()

# Here is the wind rose chart using the WindRose library

ax = WindroseAxes.from_ax()
ax.bar(data.wind_dir, data.wind_speed, normed=True, opening=0.8,␣
 ↪edgecolor='white')
coordinates = ('E','NE','N','NW','W','SW','S','SE')
```

```
ax.set_xticklabels(coordinates)
ax.set_legend()
ax.set_title('Delhi Wind Rose - '\

             '1st January 2015 to 31st January 2016', fontsize=14)
plt.savefig('windrose_main.png')
```



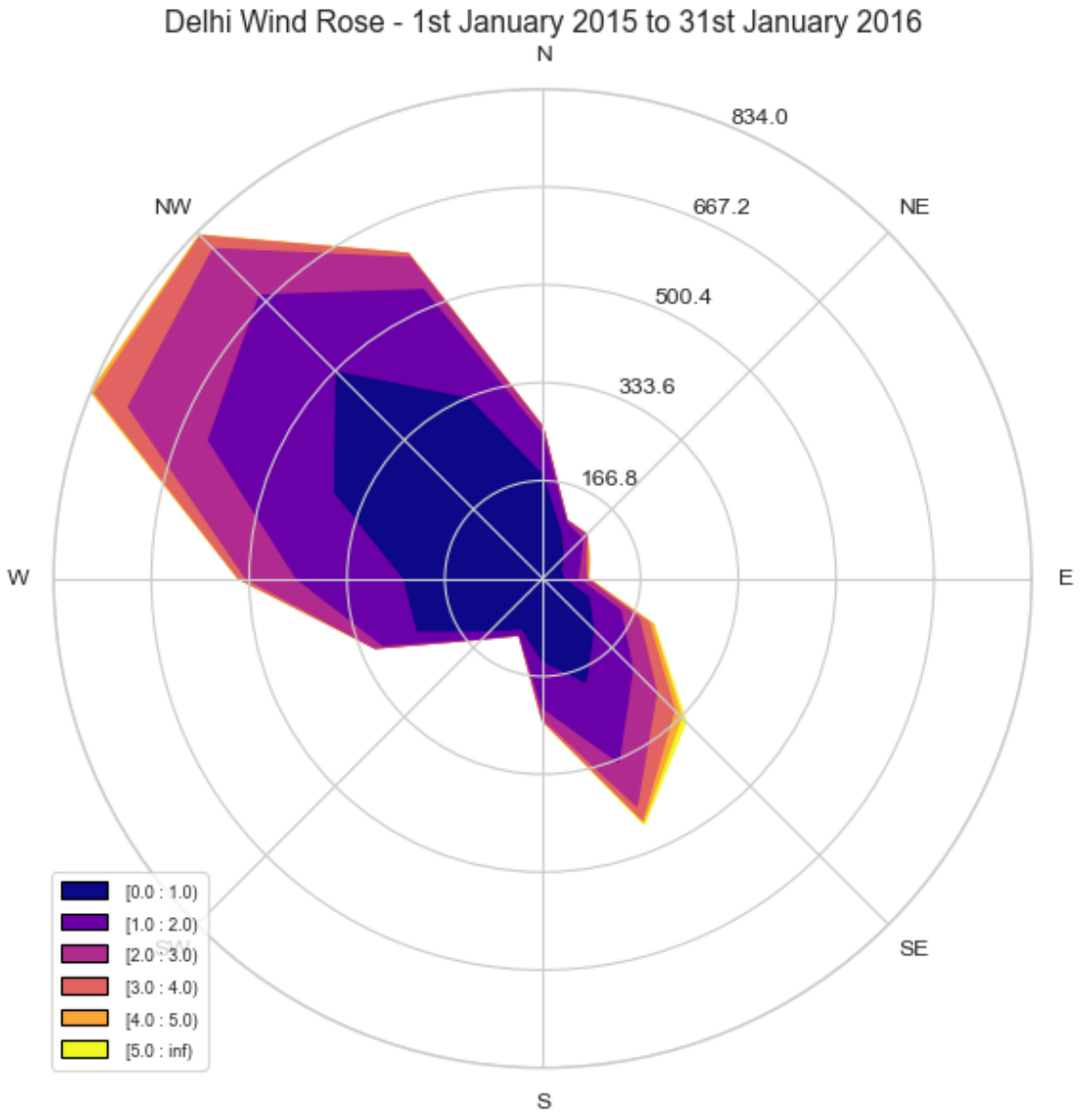
[75]:
```
# Alternative

ax = WindroseAxes.from_ax()
ax.box(data.wind_dir, data.wind_speed, bins=np.arange(0, 6, 1))
coordinates = ('E','NE','N','NW','W','SW','S','SE')
```

```
ax.set_xticklabels(coordinates)
ax.set_title('Delhi Wind Rose - '\

             '1st January 2015 to 31st January 2016', fontsize=14)
ax.set_legend()
plt.savefig('windrose_main2.png')
```



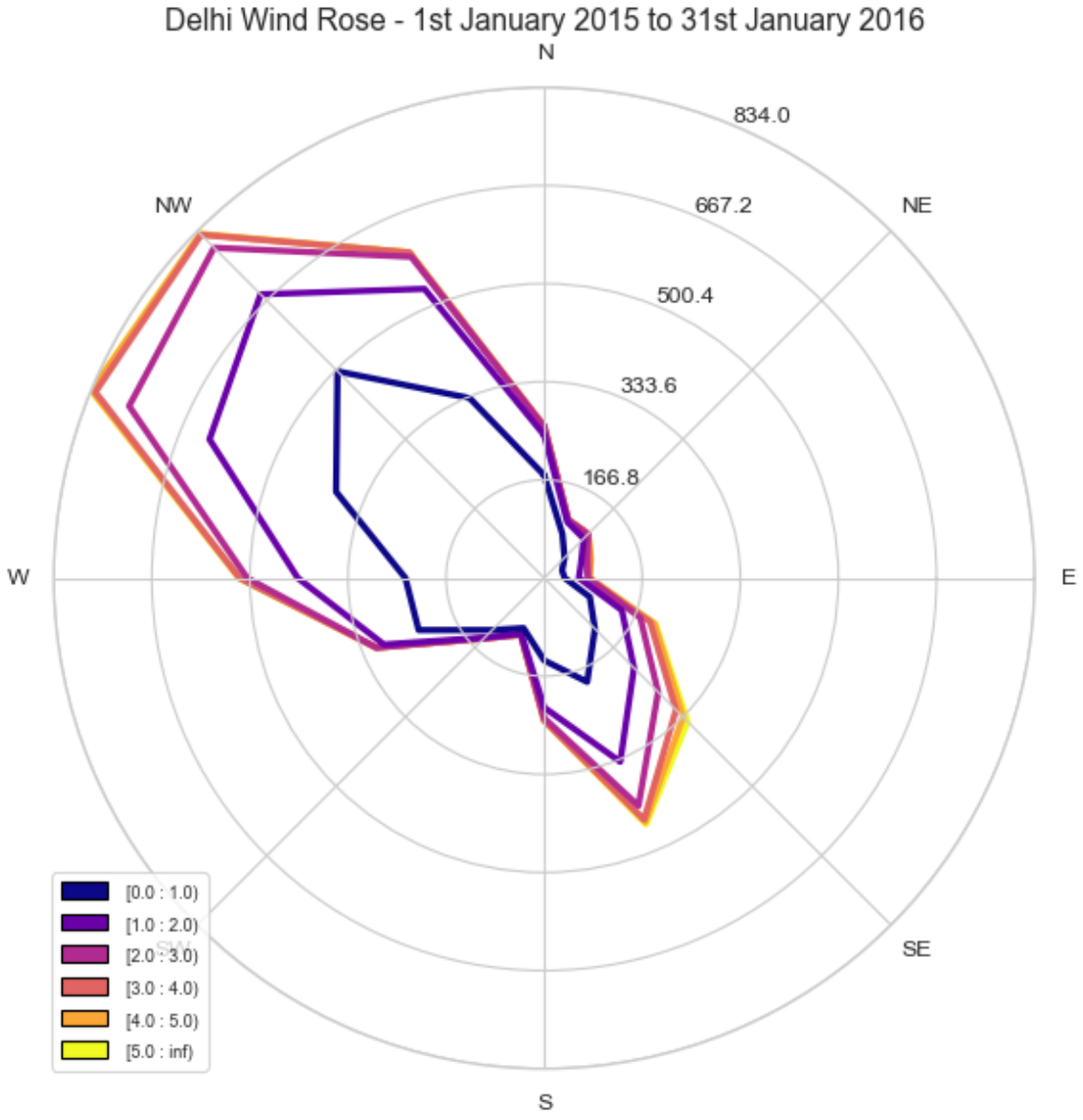
[51]:
```
# Alternatively

ax = WindroseAxes.from_ax()
ax.contourf(data.wind_dir, data.wind_speed, bins=np.arange(0, 6, 1), cmap=cm.
 ↪plasma)
```

```
#ax.contour(wd, ws, bins=np.arange(0, 6, 1), colors='black')
coordinates = ('E','NE','N','NW','W','SW','S','SE')
ax.set_xticklabels(coordinates)
ax.set_legend()
ax.set_title('Delhi Wind Rose - '\

            '1st January 2015 to 31st January 2016', fontsize=14)
plt.savefig('windrose_contourf.png')
```



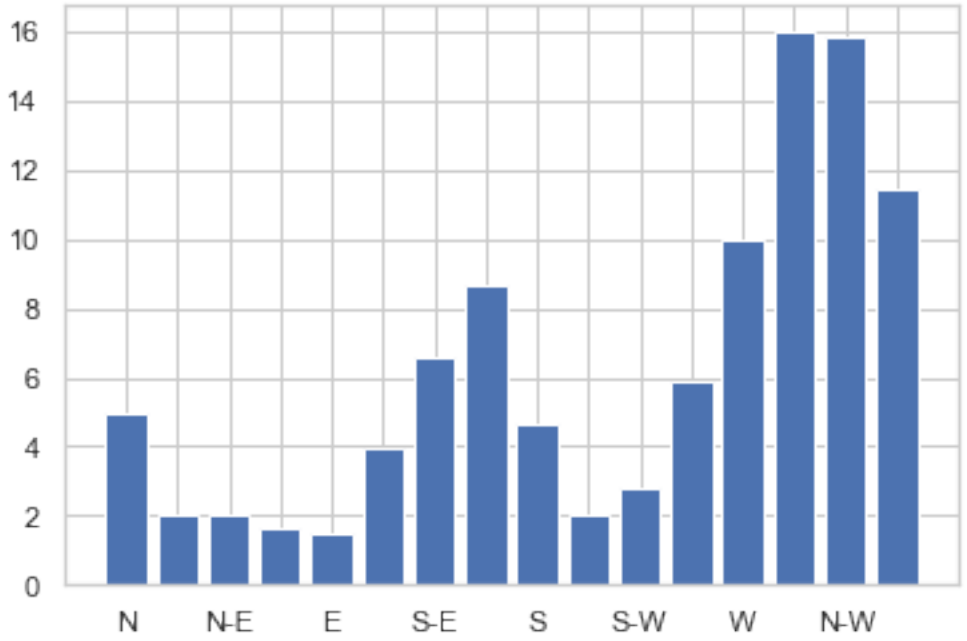
[52]:
```
# Alternative in Contour non-filled form

ax = WindroseAxes.from_ax()
```

```
ax.contour(data.wind_dir, data.wind_speed, bins=np.arange(0, 6, 1), cmap=cm.
 ↪plasma, lw=3)
coordinates = ('E','NE','N','NW','W','SW','S','SE')
ax.set_xticklabels(coordinates)
ax.set_legend()
ax.set_title('Delhi Wind Rose - '\

            '1st January 2015 to 31st January 2016', fontsize=14)
plt.savefig('windrose_contour.png')
```



[57]:
```
# frequency of each wind direction, for all wind speeds, do

ax.bar(data.wind_dir, data.wind_speed, normed=True, nsector=16)
table = ax._info['table']
wd_freq = np.sum(table, axis=0)
```

[58]:
```
direction = ax._info['dir']
wd_freq = np.sum(table, axis=0)
plt.bar(np.arange(16), wd_freq, align='center')
xlabels = ('N','','N-E','','E','','S-E','','S','','S-W','','W','','N-W','')
xticks=np.arange(16)
plt.gca().set_xticks(xticks)
plt.gca().set_xticklabels(xlabels)
plt.show()
plt.savefig('frequency.png')
```

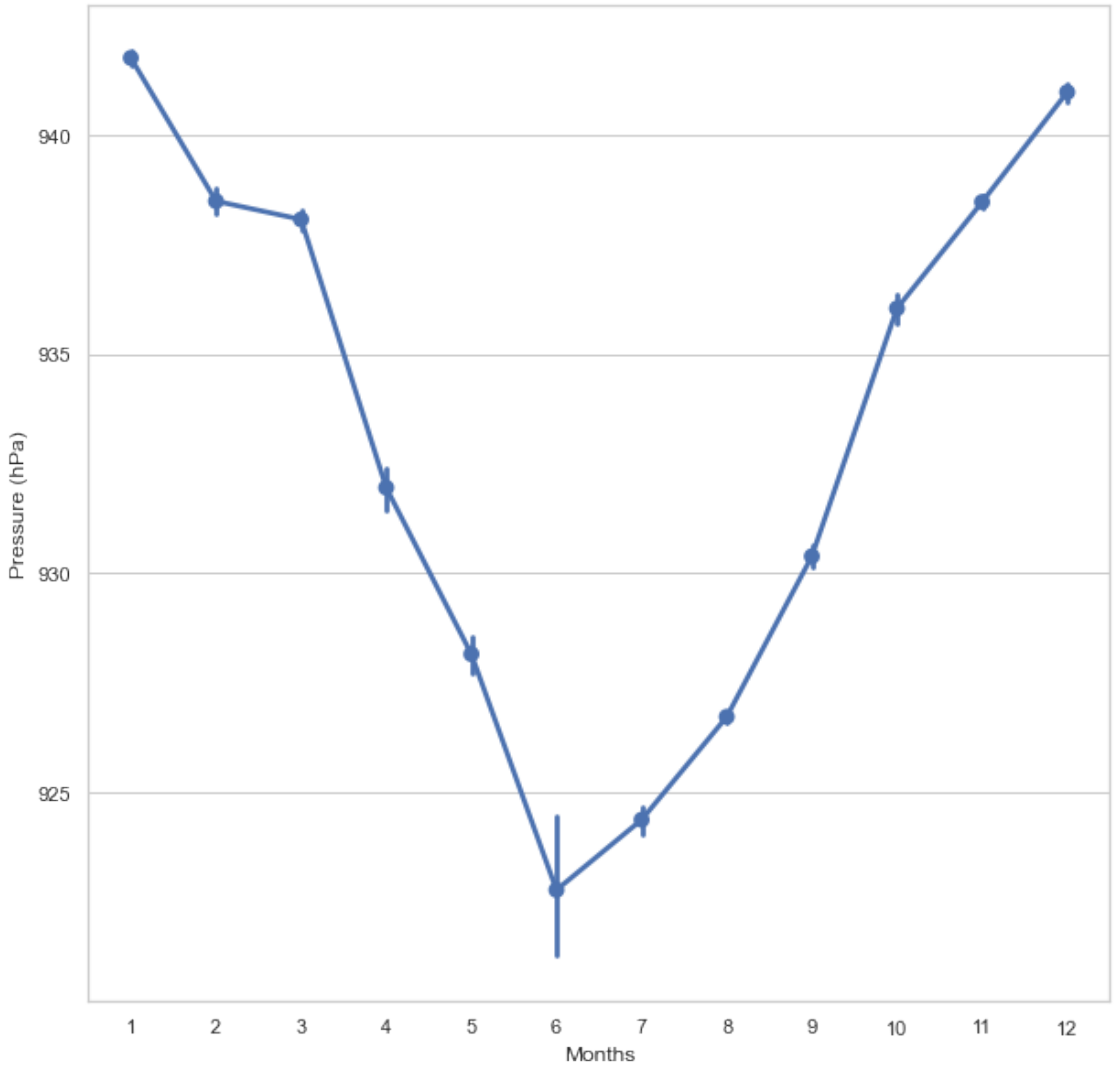



```
<Figure size 432x288 with 0 Axes>
```

1.0.5 Atmos Pressure Seasonal Variation

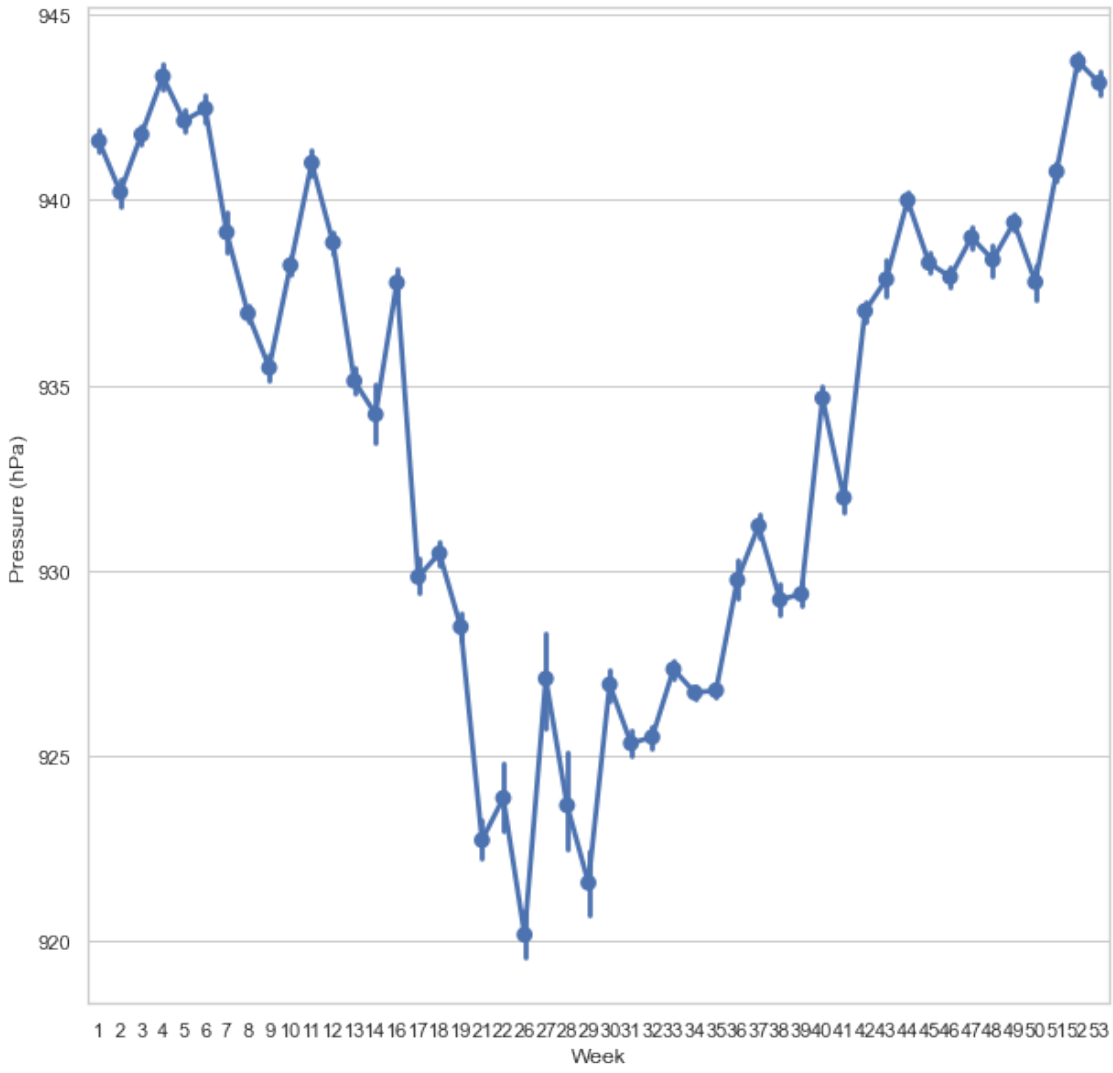
[59]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='month', y='atmo_press')
plt.xticks(rotation= 1)
plt.ylabel('Pressure (hPa)', fontsize=12)
plt.xlabel('Months', fontsize=12)
```

[59]: Text(0.5, 0, 'Months')



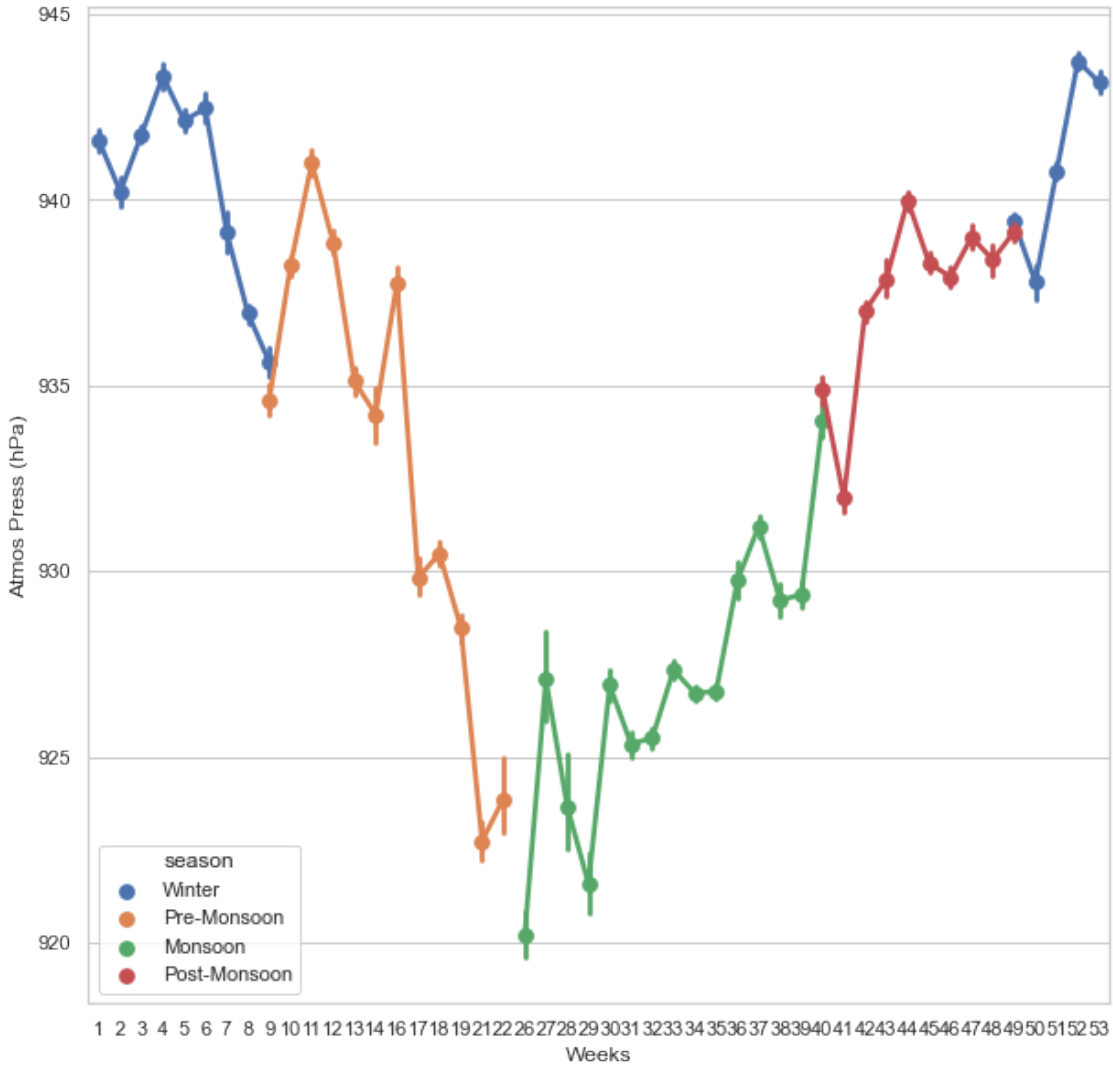
[60]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='atmo_press')
plt.xticks(rotation= 1)
plt.ylabel('Pressure (hPa)', fontsize=12)
plt.xlabel('Week', fontsize=12)
```

[60]: Text(0.5, 0, 'Week')



[61]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='atmo_press', hue='season',␣
↪style='season')
plt.xticks(rotation= 1)
plt.ylabel('Atmos Press (hPa)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

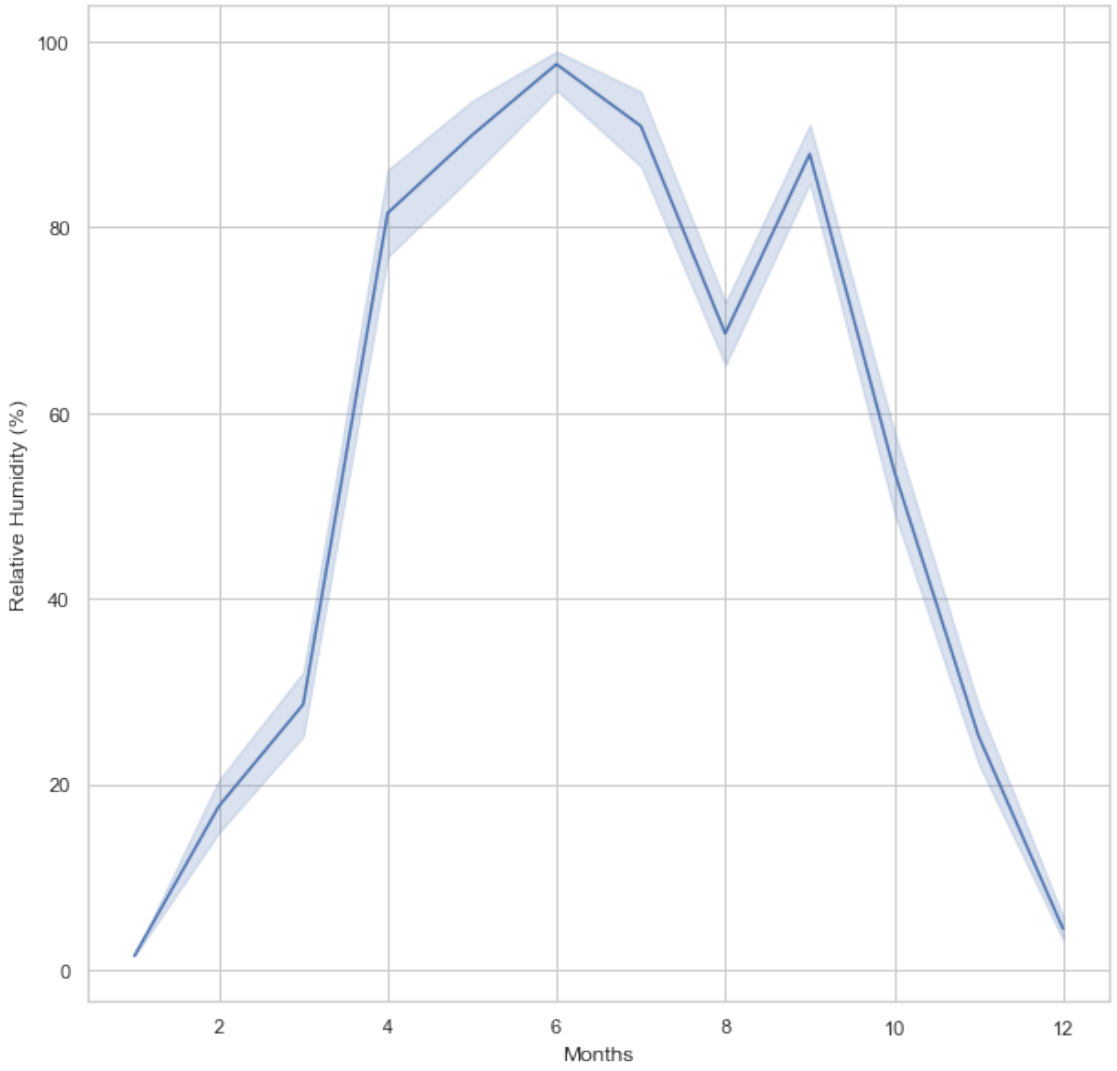
[61]:
```
Text(0.5, 0, 'Weeks')
```



1.0.6 Humidity Seasonal variation

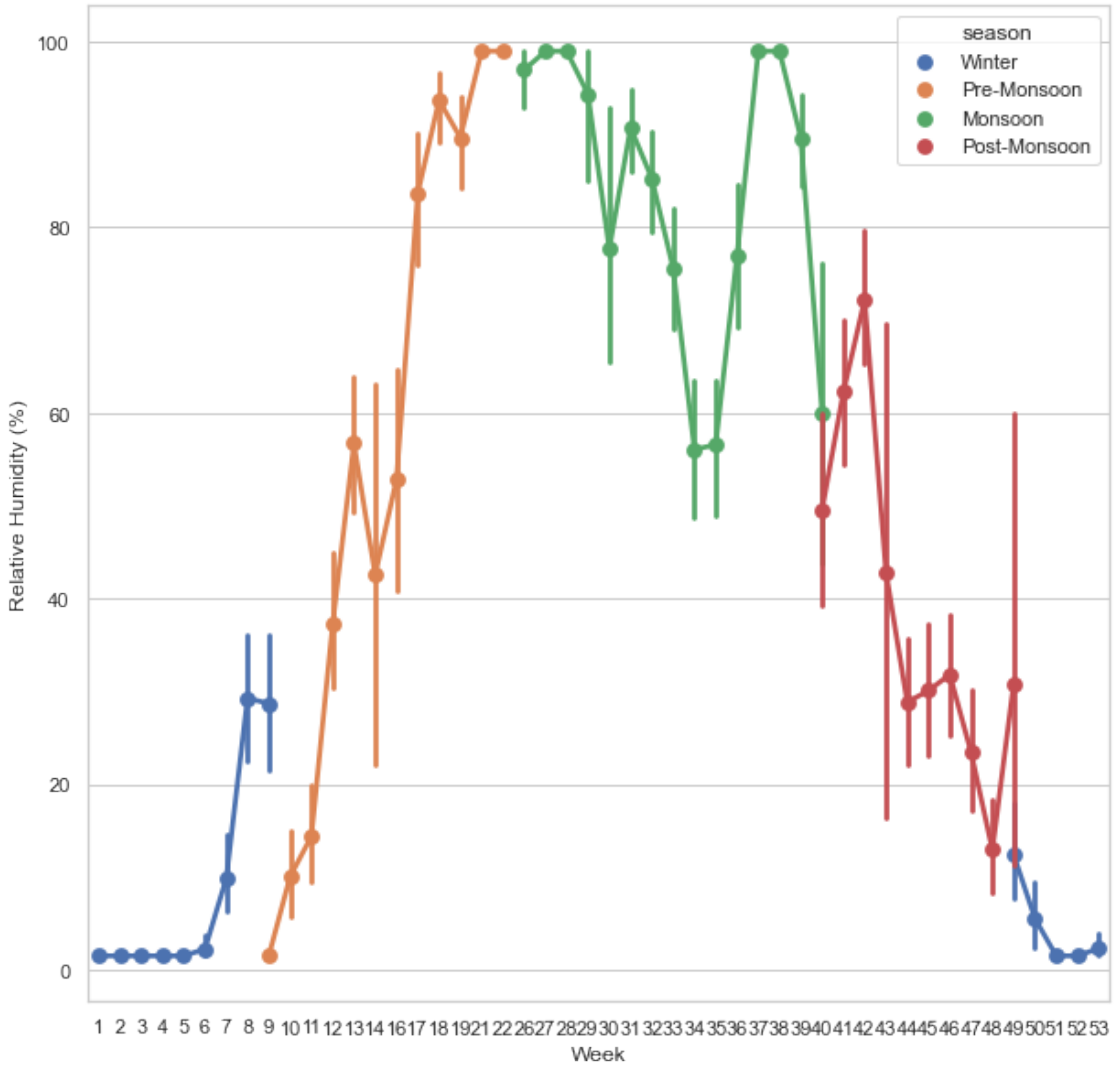
[62]:
```
plt.figure(figsize=(10,10))
sns.lineplot(data = data, x='month', y='RH')
plt.xticks(rotation= 1)
plt.ylabel('Relative Humidity (%)', fontsize=12)
plt.xlabel('Months', fontsize=12)
```

[62]:
```
Text(0.5, 0, 'Months')
```



[63]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='RH', hue='season',␣
 ↪style='season')
plt.xticks(rotation= 1)
plt.ylabel('Relative Humidity (%)', fontsize=12)
plt.xlabel('Week', fontsize=12)
```

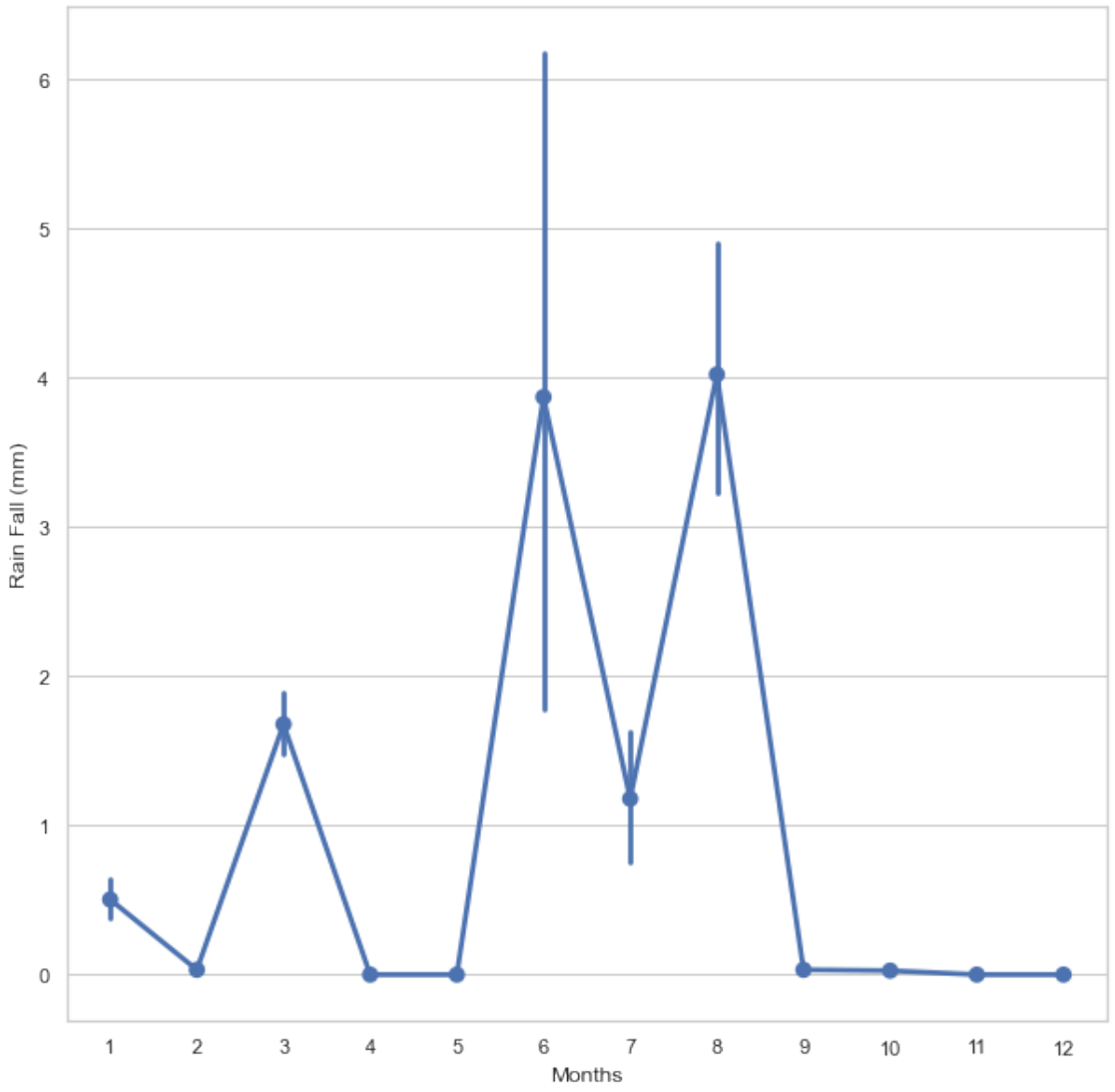
[63]:
```
Text(0.5, 0, 'Week')
```



1.0.7 Rainfall Seasonal variation

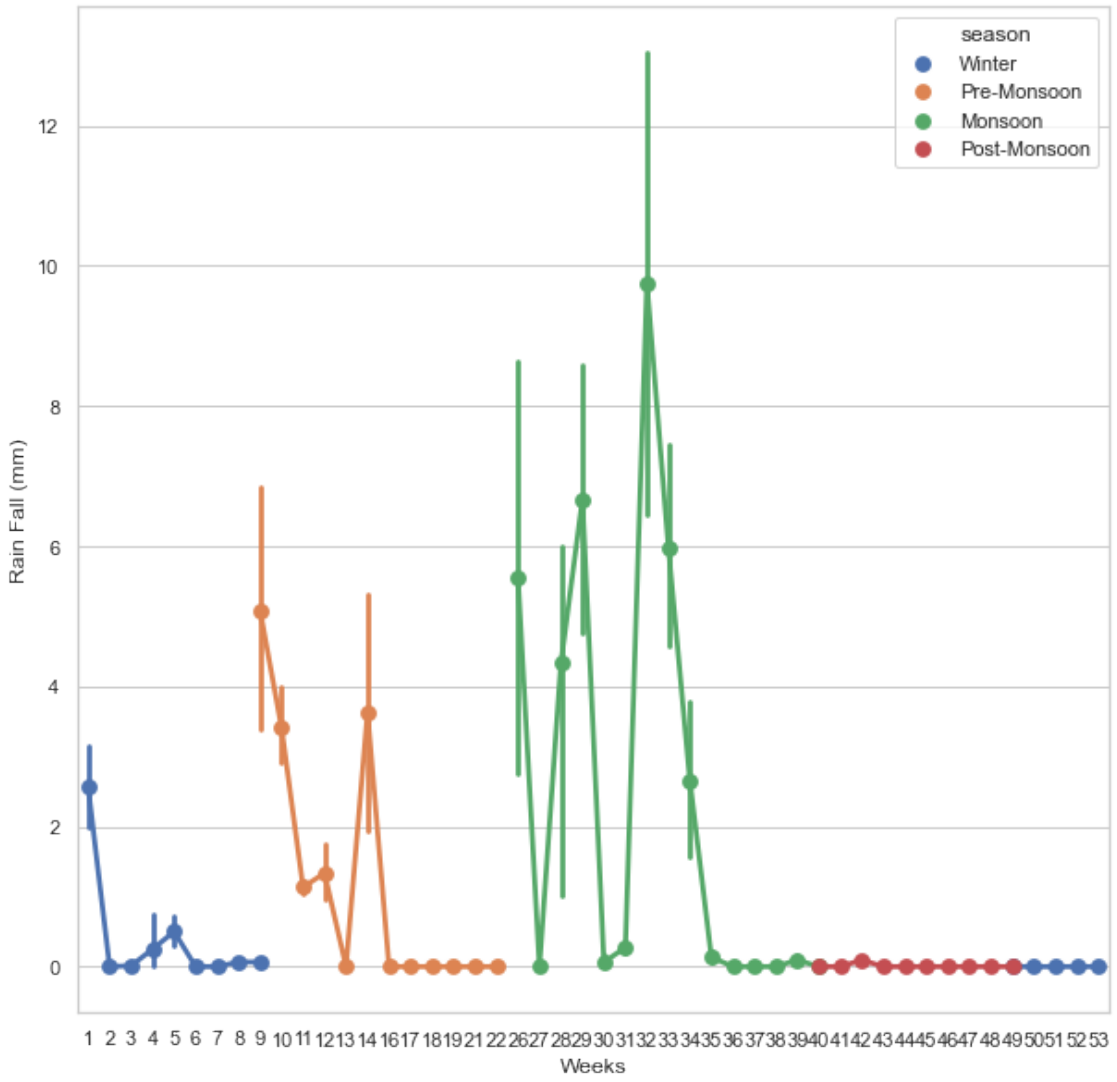
[64]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='month', y='rainfall')
plt.xticks(rotation= 1)
plt.ylabel('Rain Fall (mm)', fontsize=12)
plt.xlabel('Months', fontsize=12)
```

[64]:
```
Text(0.5, 0, 'Months')
```



[65]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='rainfall', hue='season',␣
 ↪style='season')
plt.xticks(rotation= 1)
plt.ylabel('Rain Fall (mm)', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[65]:
```
Text(0.5, 0, 'Weeks')
```



[66]:
```
data.head()
```

[66]:

@STATION_ID	latitude	longitude	time_ist	date_ist	year	\
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	5:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	6:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	7:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	8:30	2015-01-01	2015	
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	9:30	2015-01-01	2015	

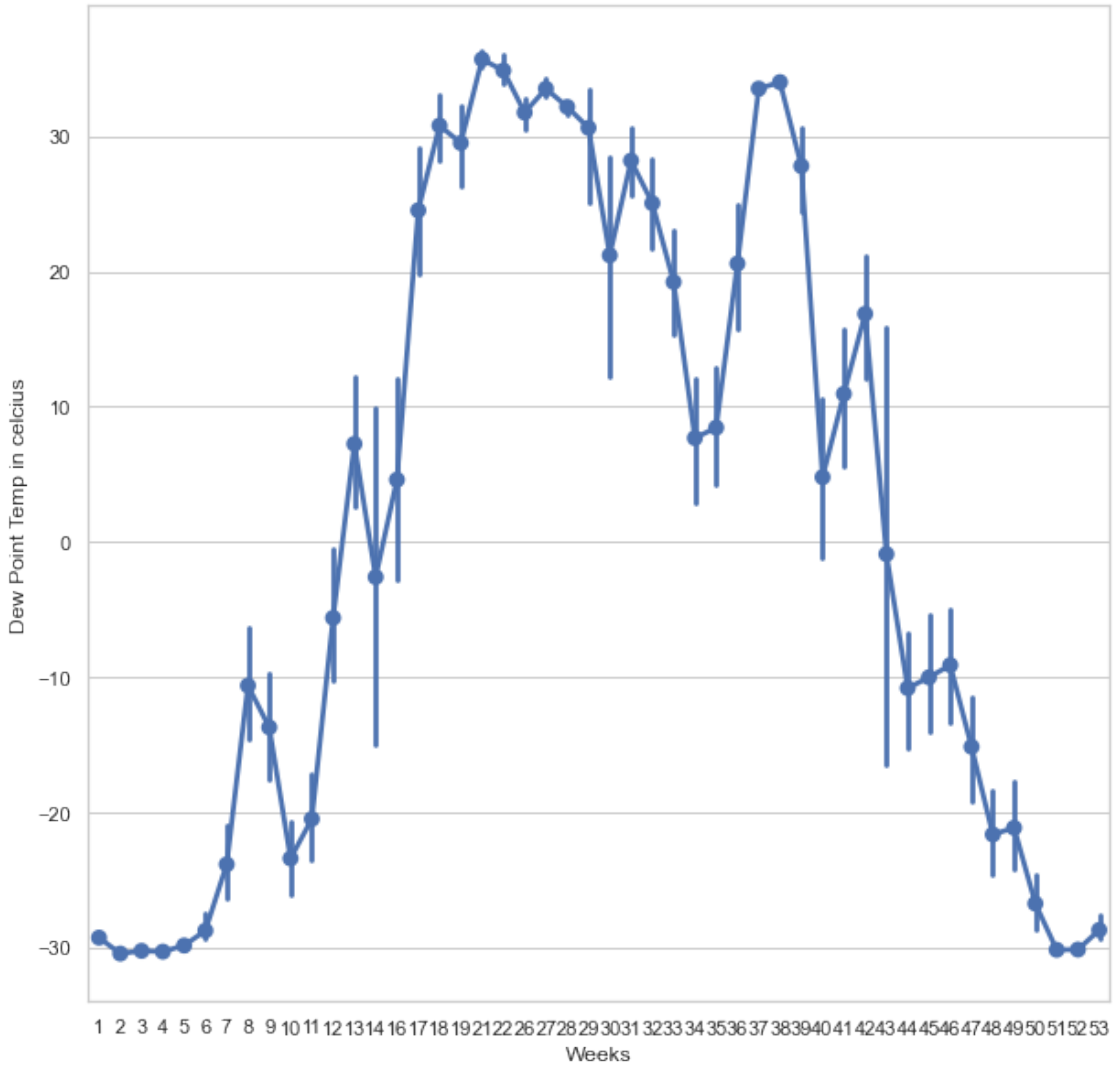
@STATION_ID	month	day	Week_Number	Tc	wind_speed	…	\
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.4	0.5	…	
IMDE1662_14167E(AKSHARDHAM)	1	1	1	24.7	0.3	…	

```
IMDE1662_14167E(AKSHARDHAM)      1    1            1  24.4         0.2  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  25.0         0.7  …
IMDE1662_14167E(AKSHARDHAM)      1    1            1  26.3         0.7  …

                                    E        RH         Tv      theta  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  0.470061  1.541369  24.456273  24.836975
IMDE1662_14167E(AKSHARDHAM)  0.478495  1.541179  24.757334  25.141584
IMDE1662_14167E(AKSHARDHAM)  0.470061  1.541369  24.456237  24.832451
IMDE1662_14167E(AKSHARDHAM)  0.487062  1.540993  25.058339  25.436910
IMDE1662_14167E(AKSHARDHAM)  0.525757  1.540228  26.363135  26.745850

                               thetaE  season  zonal_wind  meridional_wind  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter   -0.243168         0.436886
IMDE1662_14167E(AKSHARDHAM)  180.851260  Winter   -0.220119         0.203832
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter   -0.031632         0.197483
IMDE1662_14167E(AKSHARDHAM)  183.063595  Winter   -0.298046         0.633379
IMDE1662_14167E(AKSHARDHAM)  192.659390  Winter   -0.309054         0.628081

                            wind_strength  direction
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW
IMDE1662_14167E(AKSHARDHAM)           0-1         NW
IMDE1662_14167E(AKSHARDHAM)           0-1          N
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW

[5 rows x 26 columns]
```

1.0.8 Dew Point Temp Seasonal variation

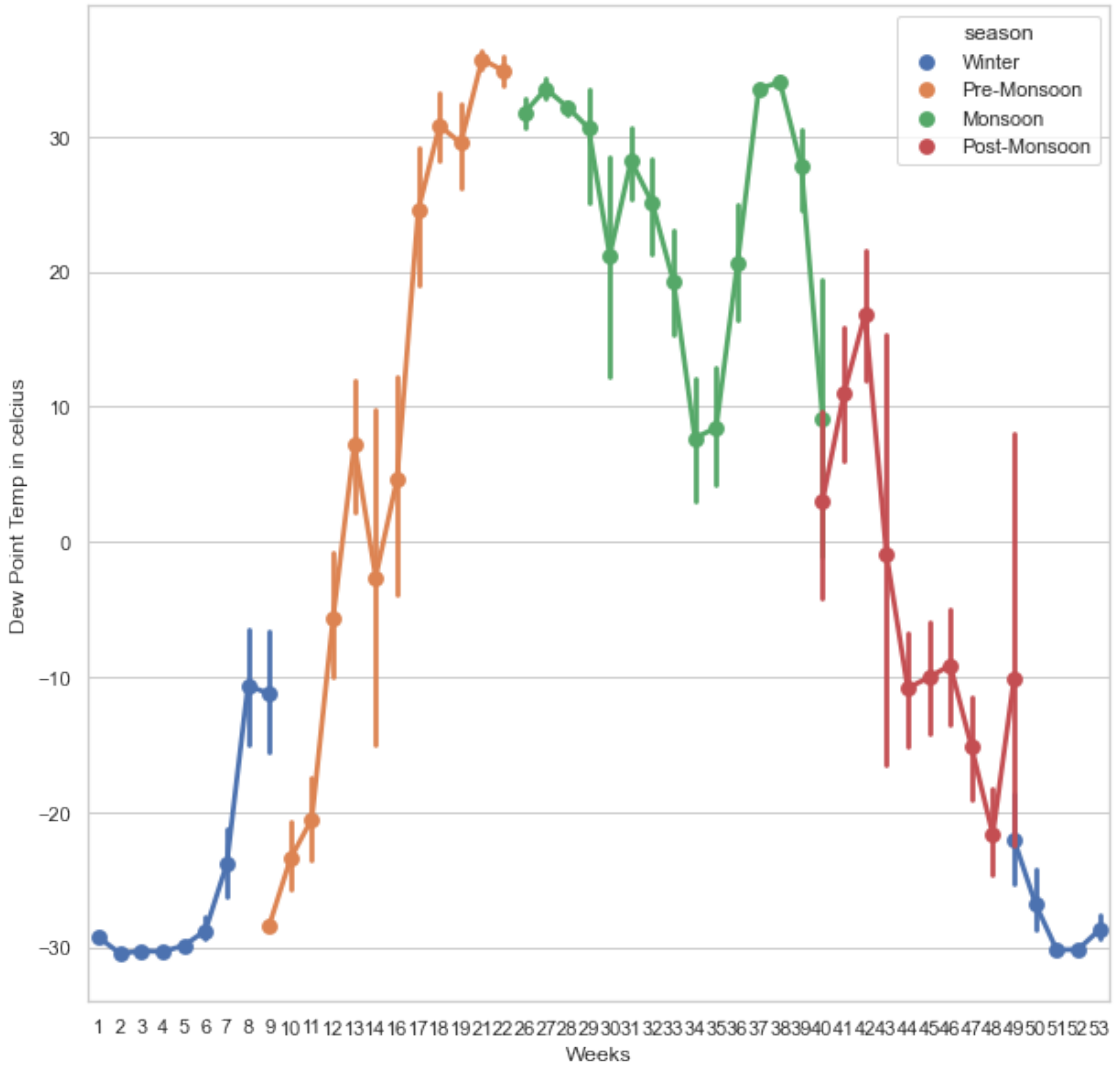
[67]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='Tdc')
plt.xticks(rotation= 1)
plt.ylabel('Dew Point Temp in celcius', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[67]:
```
Text(0.5, 0, 'Weeks')
```



[68]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='Week_Number', y='Tdc', hue='season',␣
 ↪style='season')
plt.xticks(rotation= 1)
plt.ylabel('Dew Point Temp in celcius', fontsize=12)
plt.xlabel('Weeks', fontsize=12)
```

[68]:
```
Text(0.5, 0, 'Weeks')
```

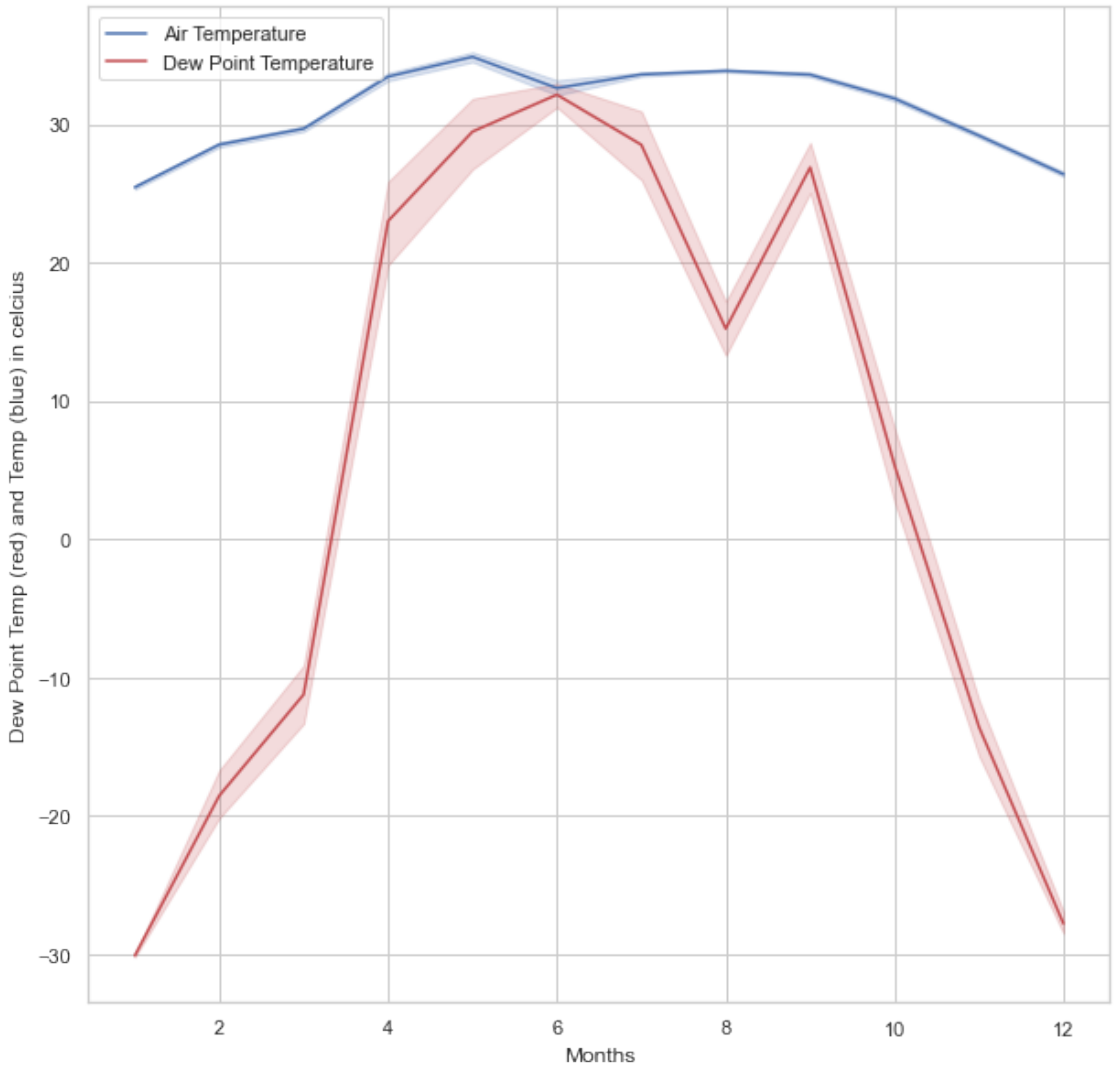


1.0.9 Dew point temp and Temp comparison

[69]:
```
plt.figure(figsize=(10,10))
sns.lineplot(data = data, x='month', y='Tc', markers="o", label='Air␣
↪Temperature')
sns.lineplot(data = data, x='month', y='Tdc',color='r', markers="x", label='Dew␣
↪Point Temperature')
plt.xticks(rotation= 1)
plt.ylabel('Dew Point Temp (red) and Temp (blue) in celcius', fontsize=12)
plt.xlabel('Months', fontsize=12)


# fig, ax = plt.subplots(figsize=(10,10))
```

```
# sns.pointplot(x='month', y='Tc', data=data, ax=ax, markers="o",␣
 ↪linestyles="-")
# ax2 = ax.twinx()
# sns.pointplot(x='month', y='Tdc', data=data, ax=ax2, color='r', markers="x",␣
 ↪linestyles="--")
# plt.show()
```

[69]: Text(0.5, 0, 'Months')



[70]:
```
data.head()
```

[70]:

@STATION_ID	latitude	longitude	time_ist	date_ist	year	\
IMDE1662_14167E(AKSHARDHAM)	28.61	77.27	5:30	2015-01-01	2015	

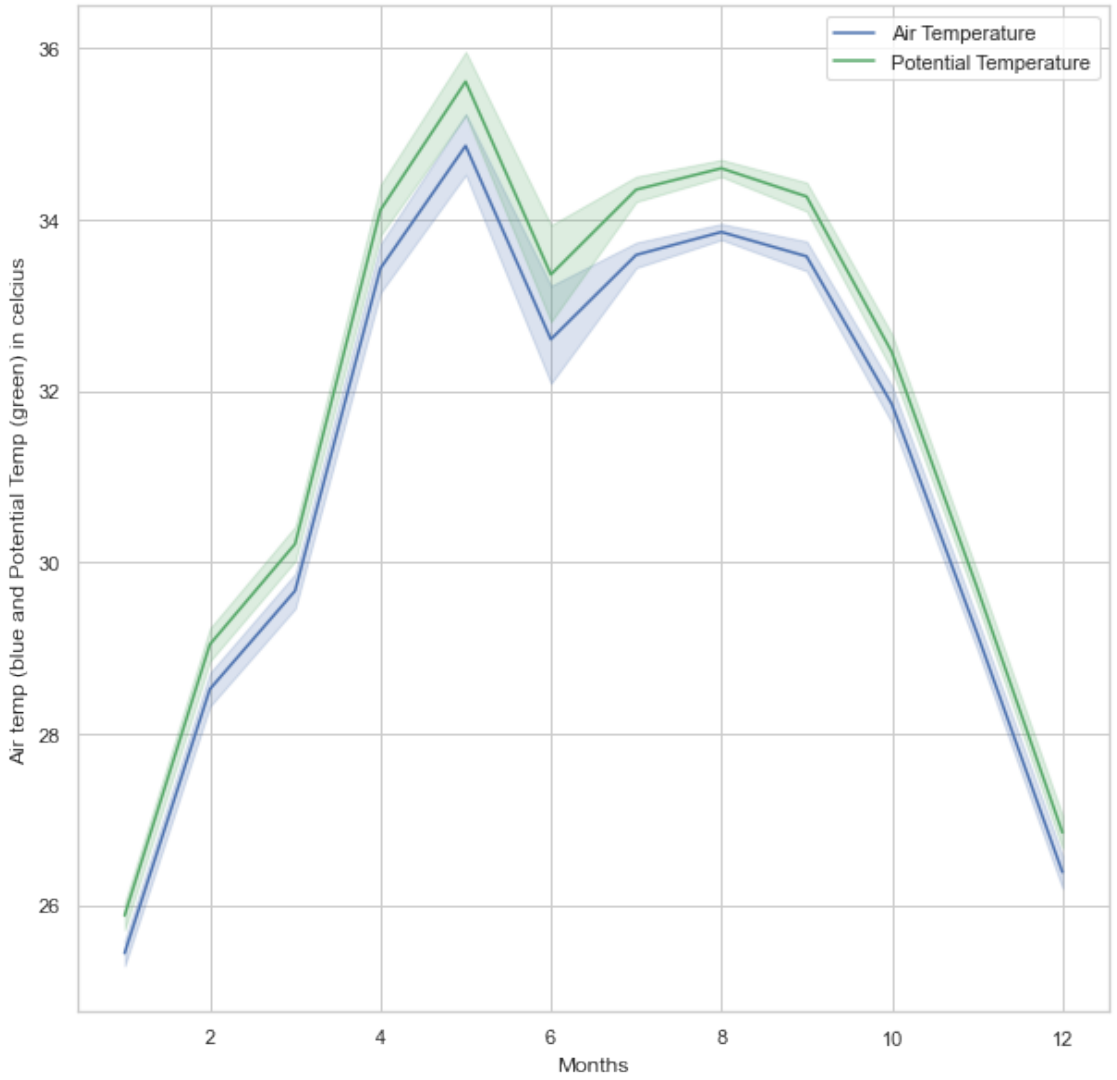
```
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     6:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     7:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     8:30 2015-01-01  2015
IMDE1662_14167E(AKSHARDHAM)     28.61      77.27     9:30 2015-01-01  2015

                            month  day  Week_Number    Tc  wind_speed  …  \
@STATION_ID                                                             …
IMDE1662_14167E(AKSHARDHAM)     1    1            1  24.4         0.5  …
IMDE1662_14167E(AKSHARDHAM)     1    1            1  24.7         0.3  …
IMDE1662_14167E(AKSHARDHAM)     1    1            1  24.4         0.2  …
IMDE1662_14167E(AKSHARDHAM)     1    1            1  25.0         0.7  …
IMDE1662_14167E(AKSHARDHAM)     1    1            1  26.3         0.7  …

                                   E        RH         Tv      theta  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  0.470061  1.541369  24.456273  24.836975
IMDE1662_14167E(AKSHARDHAM)  0.478495  1.541179  24.757334  25.141584
IMDE1662_14167E(AKSHARDHAM)  0.470061  1.541369  24.456237  24.832451
IMDE1662_14167E(AKSHARDHAM)  0.487062  1.540993  25.058339  25.436910
IMDE1662_14167E(AKSHARDHAM)  0.525757  1.540228  26.363135  26.745850

                               thetaE  season  zonal_wind  meridional_wind  \
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter   -0.243168         0.436886
IMDE1662_14167E(AKSHARDHAM)  180.851260  Winter   -0.220119         0.203832
IMDE1662_14167E(AKSHARDHAM)  178.639683  Winter   -0.031632         0.197483
IMDE1662_14167E(AKSHARDHAM)  183.063595  Winter   -0.298046         0.633379
IMDE1662_14167E(AKSHARDHAM)  192.659390  Winter   -0.309054         0.628081

                            wind_strength  direction
@STATION_ID
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW
IMDE1662_14167E(AKSHARDHAM)           0-1         NW
IMDE1662_14167E(AKSHARDHAM)           0-1          N
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW
IMDE1662_14167E(AKSHARDHAM)           0-1        NNW

[5 rows x 26 columns]
```

1.0.10 Potential Temp seasonal variation

[71]:
```
plt.figure(figsize=(10,10))
sns.lineplot(data = data, x='month', y='Tc', markers="o", label='Air␣
 ↪Temperature')
sns.lineplot(data = data, x='month', y='theta',color='g', markers="x",␣
 ↪label='Potential Temperature')
plt.xticks(rotation= 1)
```

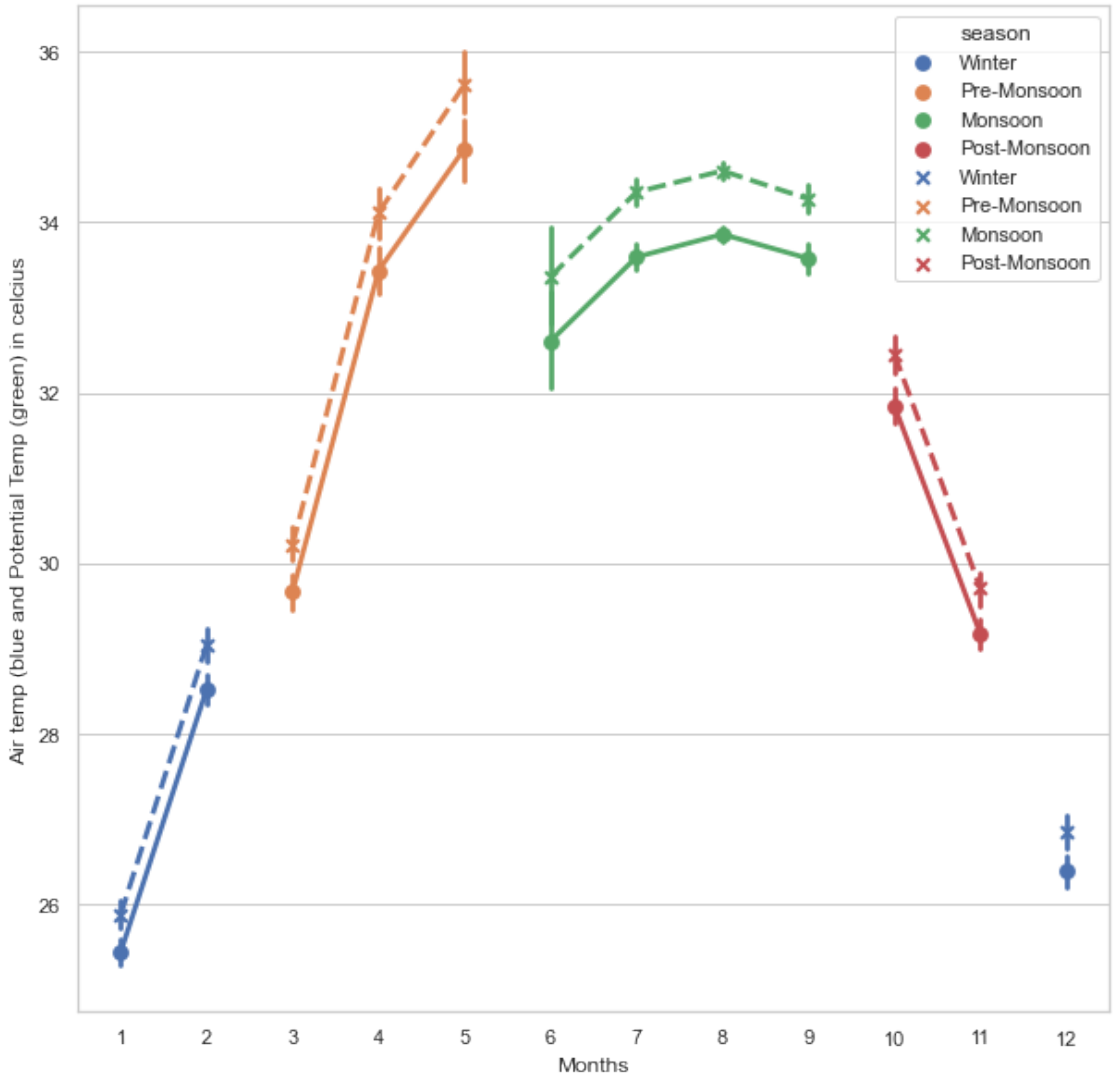
```
plt.ylabel('Air temp (blue and Potential Temp (green) in celcius', fontsize=12)
plt.xlabel('Months', fontsize=12)

# fig, ax = plt.subplots(sharex = True, figsize=(10,10))
# sns.pointplot(x='month', y='Tc', data=data, ax=ax, markers="o",␣
 ↪linestyles="-")
# ax2 = ax.twinx()
# sns.pointplot(x='month', y='theta', data=data, ax=ax2, color='r',␣
 ↪markers="x", linestyles="--")
# plt.show()
```

[71]: Text(0.5, 0, 'Months')



[72]:
```
plt.figure(figsize=(10,10))
sns.pointplot(data = data, x='month', y='Tc', markers="o", linestyles="-",␣
↪hue='season')
sns.pointplot(data = data, x='month', y='theta', markers="x", linestyles="--",␣
↪hue='season')
plt.xticks(rotation= 1)
plt.ylabel('Air temp (blue and Potential Temp (green) in celcius', fontsize=12)
plt.xlabel('Months', fontsize=12)
```

[72]:
```
Text(0.5, 0, 'Months')
```



[ ]:
```

```