SuPy1_Quickstart

February 10, 2022

[11]:
```
import matplotlib.pyplot as plt
import supy as sp
import pandas as pd
import numpy as np
from pathlib import Path

%matplotlib inline
```

[12]:
```
#sp.show_version()
```

[13]:
```
path_runcontrol = Path('/home/l1nux/Documents/SUEWS') / 'RunControl.nml'
```

[14]:
```
df_state_init = sp.init_supy(path_runcontrol)
```

```
2022-02-10 10:16:18,691 - SuPy - INFO - All cache cleared.
2022-02-10 10:16:19,521 - SuPy - WARNING - multiple years are set for grids:
Int64Index([1], dtype='int64', name='Grid'); SuPy will proceed with records of
the first year of each grid
```

[15]:
```
df_state_init.filter(like='method').T
```

[15]:

grid		1
var	ind_dim	
aerodynamicresistancemethod	0	2
basetmethod	0	1
evapmethod	0	2
emissionsmethod	0	1
netradiationmethod	0	13
roughlenheatmethod	0	2
roughlenmommethod	0	2
smdmethod	0	0
stabilitymethod	0	3
storageheatmethod	0	1
waterusemethod	0	0

[16]:
```
#grid = df_state_init.index[0]
#df_forcing = sp.load_forcing_grid(path_runcontrol, grid)
# by default, two years of forcing data are included;
```

```
# to save running time for demonstration, we only use one year in this demo
#df_forcing=df_forcing.loc['2012'].iloc[1:]
```

[17]:
```
df_state_init, df_forcing = sp.load_SampleData()
grid = df_state_init.index[0]
# by default, two years of forcing data are included;
# to save running time for demonstration, we only use one year in this demo
df_forcing=df_forcing.loc['2012'].iloc[1:]
```

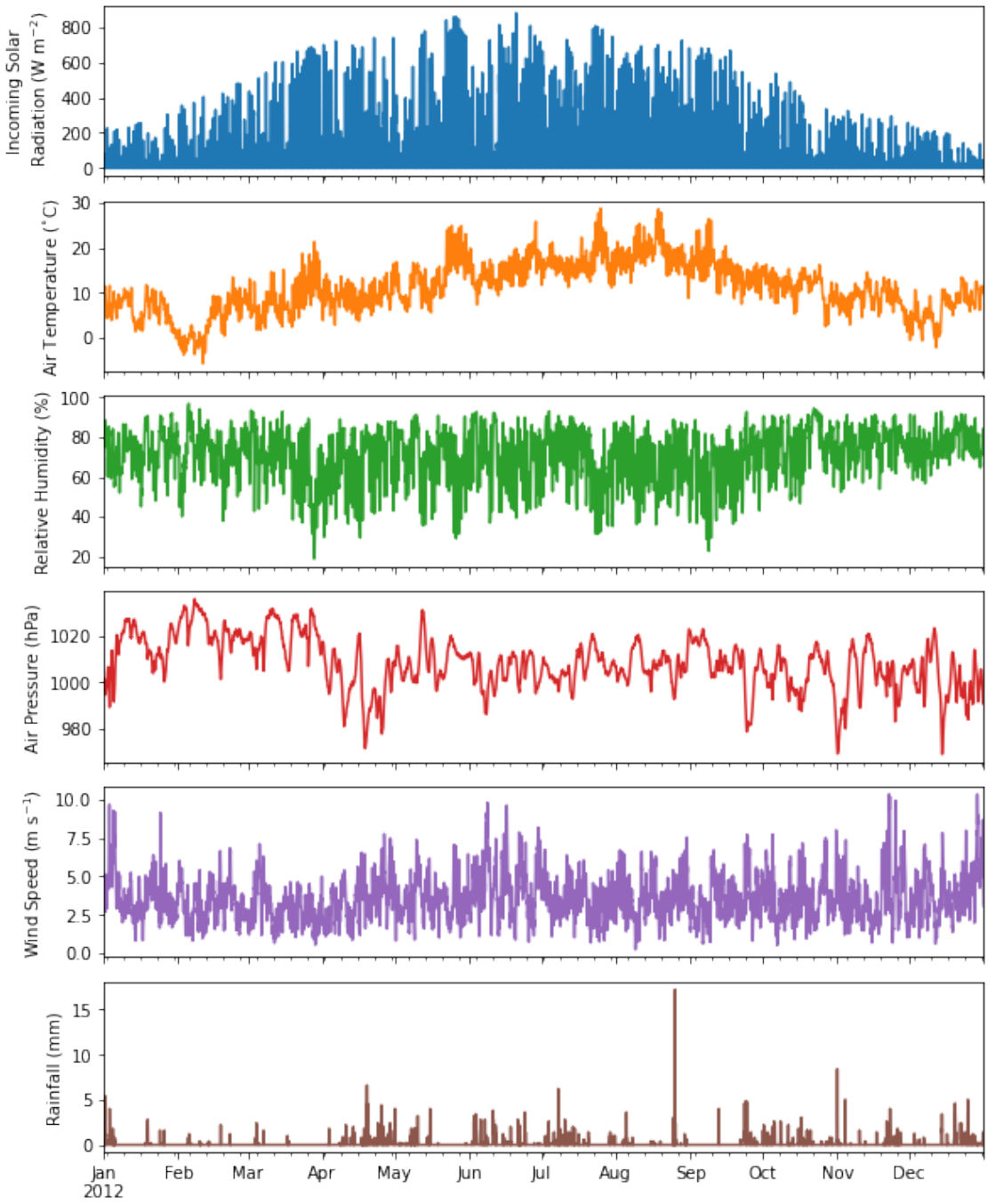
```
2022-02-10 10:16:21,544 - SuPy - INFO - All cache cleared.
```

[18]:
```
df_state_init.filter(like='sfr')
```

[18]:

var	sfr						
ind_dim	(0,)	(1,)	(2,)	(3,)	(4,)	(5,)	(6,)
grid							
1	0.43	0.38	0.0	0.02	0.03	0.0	0.14

[19]:
```
list_var_forcing = [
    "kdown",
    "Tair",
    "RH",
    "pres",
    "U",
    "rain",
]
dict_var_label = {
    "kdown": "Incoming Solar\n Radiation ($ \mathrm{W \ m^{-2}}$)",
    "Tair": "Air Temperature ($^{\circ}$C)",
    "RH": r"Relative Humidity (%)",
    "pres": "Air Pressure (hPa)",
    "rain": "Rainfall (mm)",
    "U": "Wind Speed (m $\mathrm{s^{-1}}$)",
}
df_plot_forcing_x = (
    df_forcing.loc[:, list_var_forcing].copy().shift(-1).dropna(how="any")
)
df_plot_forcing = df_plot_forcing_x.resample("1h").mean()
df_plot_forcing["rain"] = df_plot_forcing_x["rain"].resample("1h").sum()

axes = df_plot_forcing.plot(subplots=True, figsize=(8, 12), legend=False,)
fig = axes[0].figure
fig.tight_layout()
fig.autofmt_xdate(bottom=0.2, rotation=0, ha="center")
for ax, var in zip(axes, list_var_forcing):
    _ = ax.set_ylabel(dict_var_label[var])
```



[20]:
```
# view the surface fraction variable: `sfr`
df_state_init.loc[:,'sfr']
```

[20]:
```
ind_dim   (0,)  (1,)  (2,)  (3,)  (4,)  (5,)  (6,)
grid
1         0.43  0.38   0.0  0.02  0.03   0.0  0.14
```

[21]:
```
# view the second row of `df_forcing`, which is a pandas Series
df_forcing.iloc[1]
```

[21]:
```
iy       2012.000000
id          1.000000
it          0.000000
imin       10.000000
qn       -999.000000
qh       -999.000000
qe       -999.000000
qs       -999.000000
qf       -999.000000
U           5.176667
RH         86.195000
Tair       11.620000
pres     1001.833333
rain        0.000000
kdown       0.173333
snow     -999.000000
ldown    -999.000000
fcld     -999.000000
Wuh         0.000000
xsmd     -999.000000
lai      -999.000000
kdiff    -999.000000
kdir     -999.000000
wdir     -999.000000
isec        0.000000
Name: 2012-01-01 00:10:00, dtype: float64
```

[22]:
```
# view a particular position of `df_forcing`, which is a value
df_forcing.iloc[8,9]
```

[22]:
```
4.78
```

[23]:
```
# modify surface fractions
df_state_init.loc[:,'sfr']=[.1,.1,.2,.3,.25,.05,0]
# check the updated values
df_state_init.loc[:,'sfr']
```

[23]:
```
ind_dim  (0,)  (1,)  (2,)  (3,)  (4,)  (5,)  (6,)
grid
1         0.1   0.1   0.2   0.3  0.25  0.05     0
```

[24]:
```
df_output, df_state_final = sp.run_supy(df_forcing, df_state_init)
```

```
2022-02-10 10:16:26,563 - SuPy - INFO - ====================
```

```
2022-02-10 10:16:26,565 - SuPy - INFO - Simulation period:
2022-02-10 10:16:26,566 - SuPy - INFO -   Start: 2012-01-01 00:05:00
2022-02-10 10:16:26,567 - SuPy - INFO -   End: 2012-12-31 23:55:00
2022-02-10 10:16:26,568 - SuPy - INFO -
2022-02-10 10:16:26,569 - SuPy - INFO - No. of grids: 1
2022-02-10 10:16:26,570 - SuPy - INFO - SuPy is running in serial mode
2022-02-10 10:16:49,519 - SuPy - INFO - Execution time: 23.0 s
2022-02-10 10:16:49,521 - SuPy - INFO - ====================
```

[25]:
```
df_output.columns.levels[0]
```

[25]:
```
Index(['SUEWS', 'snow', 'RSL', 'BEERS', 'debug', 'DailyState'], dtype='object',
name='group')
```

[26]:
```
df_state_final.T.head()
```

[26]:
```
datetime                2012-01-01 00:05:00 2013-01-01 00:00:00
grid                                      1                   1
var              ind_dim
ah_min           (0,)                  15.0                15.0
                 (1,)                  15.0                15.0
ah_slope_cooling (0,)                   2.7                 2.7
                 (1,)                   2.7                 2.7
ah_slope_heating (0,)                   2.7                 2.7
```

[27]:
```
df_output.head()
```

[27]:
```
group                        SUEWS                                    \
var                          Kdown      Kup       Ldown         Lup
grid datetime
1    2012-01-01 00:05:00  0.176667  0.02332  344.179805  371.582645
     2012-01-01 00:10:00  0.173333  0.02288  344.190048  371.657938
     2012-01-01 00:15:00  0.170000  0.02244  344.200308  371.733243
     2012-01-01 00:20:00  0.166667  0.02200  344.210586  371.808562
     2012-01-01 00:25:00  0.163333  0.02156  344.220882  371.883893

group                                                                \
var                           Tsurf         QN         QF        QS
grid datetime
1    2012-01-01 00:05:00  11.607452 -27.249493  40.574001 -6.382243
     2012-01-01 00:10:00  11.622405 -27.317436  39.724283 -6.228797
     2012-01-01 00:15:00  11.637359 -27.385375  38.874566 -6.082788
     2012-01-01 00:20:00  11.652312 -27.453309  38.024849 -5.943907
     2012-01-01 00:25:00  11.667265 -27.521237  37.175131 -5.811855

group                                          …     DailyState  \
```

```
var                                QH        QE  … DensSnow_Paved
grid datetime                                    …
1    2012-01-01 00:05:00  19.663696  0.043054  …            NaN
     2012-01-01 00:10:00  18.593507  0.042137  …            NaN
     2012-01-01 00:15:00  17.530760  0.041219  …            NaN
     2012-01-01 00:20:00  16.475145  0.040302  …            NaN
     2012-01-01 00:25:00  15.426365  0.039385  …            NaN

group                                                                \
var                    DensSnow_Bldgs DensSnow_EveTr DensSnow_DecTr
grid datetime
1    2012-01-01 00:05:00            NaN            NaN            NaN
     2012-01-01 00:10:00            NaN            NaN            NaN
     2012-01-01 00:15:00            NaN            NaN            NaN
     2012-01-01 00:20:00            NaN            NaN            NaN
     2012-01-01 00:25:00            NaN            NaN            NaN

group                                                                    \
var                    DensSnow_Grass DensSnow_BSoil DensSnow_Water  a1  a2
grid datetime
1    2012-01-01 00:05:00            NaN            NaN            NaN NaN NaN
     2012-01-01 00:10:00            NaN            NaN            NaN NaN NaN
     2012-01-01 00:15:00            NaN            NaN            NaN NaN NaN
     2012-01-01 00:20:00            NaN            NaN            NaN NaN NaN
     2012-01-01 00:25:00            NaN            NaN            NaN NaN NaN

group
var                     a3
grid datetime
1    2012-01-01 00:05:00 NaN
     2012-01-01 00:10:00 NaN
     2012-01-01 00:15:00 NaN
     2012-01-01 00:20:00 NaN
     2012-01-01 00:25:00 NaN

[5 rows x 413 columns]
```

[28]:
```
df_output_suews = df_output['SUEWS']
```

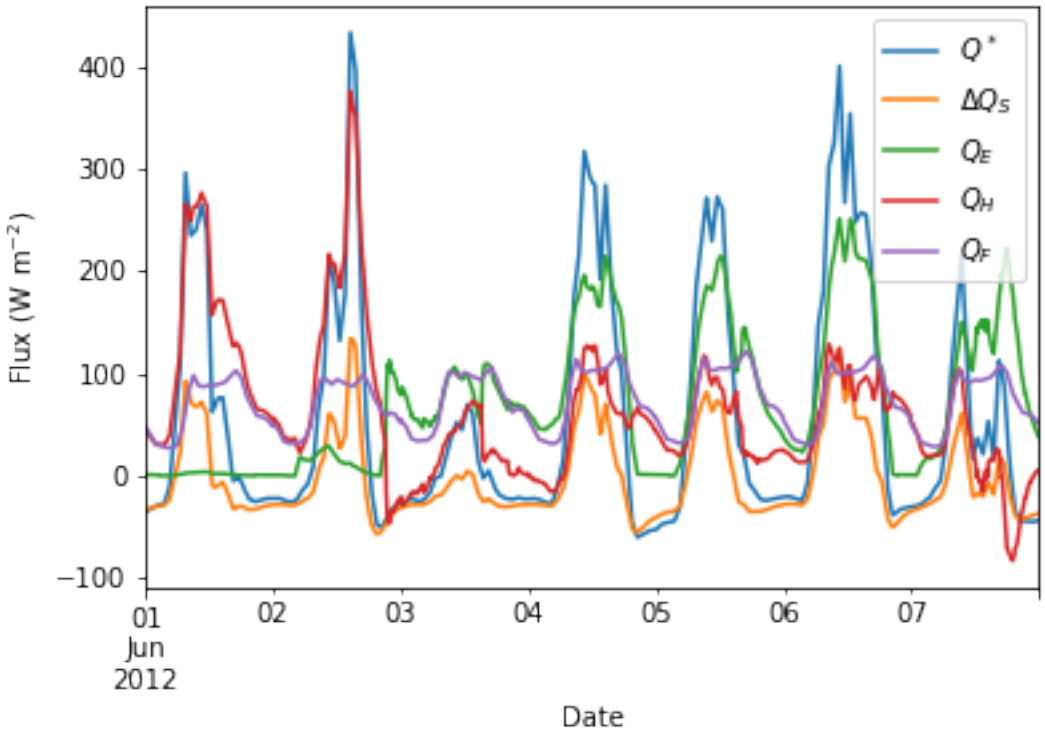
[29]:
```
df_output_suews.loc[:, ['QN', 'QS', 'QH', 'QE', 'QF']].describe()
```

[29]:
```
var                QN             QS             QH             QE  \
count  105407.000000  105407.000000  105407.000000  1.054070e+05
mean       39.883231       5.830101      66.548240  4.652944e+01
std       132.019300      49.161913      74.157727  6.882790e+01
min       -86.331686     -75.287258     -90.565502  6.067840e-07
25%       -42.499510     -27.895414      19.246830  9.564054e-01
```

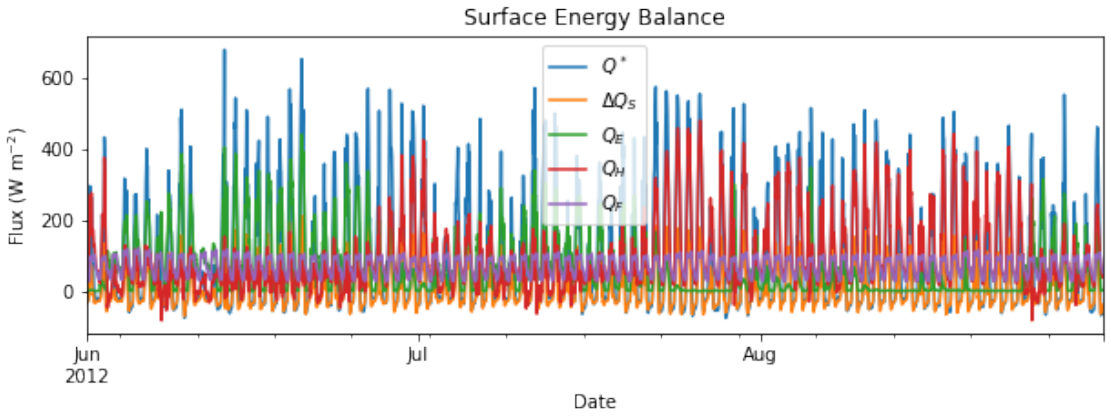
```
50%       -25.749393      -8.183963      48.782368  1.582384e+01
75%        74.815479      19.121287      92.111254  6.593333e+01
max       679.848644     237.932439     480.524868  5.034252e+02

var                QF
count  105407.000000
mean       79.024549
std        31.231867
min        26.327536
25%        50.058031
50%        82.883410
75%       104.812507
max       160.023207
```

[30]:
```
# a dict for better display variable names
dict_var_disp = {
    'QN': '$Q^*$',
    'QS': r'$\Delta Q_S$',
    'QE': '$Q_E$',
    'QH': '$Q_H$',
    'QF': '$Q_F$',
    'Kdown': r'$K_{\downarrow}$',
    'Kup': r'$K_{\uparrow}$',
    'Ldown': r'$L_{\downarrow}$',
    'Lup': r'$L_{\uparrow}$',
    'Rain': '$P$',
    'Irr': '$I$',
    'Evap': '$E$',
    'RO': '$R$',
    'TotCh': '$\Delta S$',
}
```

[31]:
```
ax_output = df_output_suews\
    .loc[grid]\
    .loc['2012 6 1':'2012 6 7',
         ['QN', 'QS', 'QE', 'QH', 'QF']]\
    .rename(columns=dict_var_disp)\
    .plot()
_ = ax_output.set_xlabel('Date')
_ = ax_output.set_ylabel('Flux ($ \mathrm{W \ m^{-2}}$)')
_ = ax_output.legend()
```

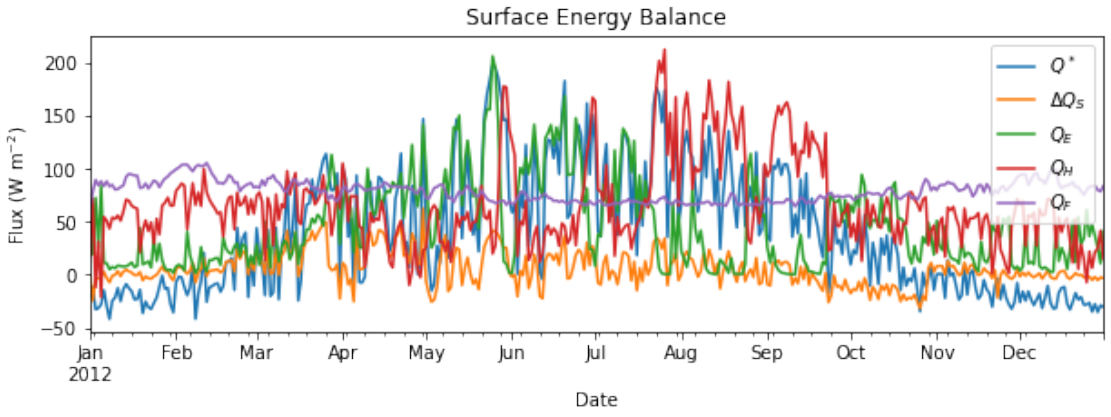


[32]:
```
# energy balance
ax_output = (
    df_output_suews.loc[grid]
    .loc["2012 6":"2012 8", ["QN", "QS", "QE", "QH", "QF"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Energy Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```

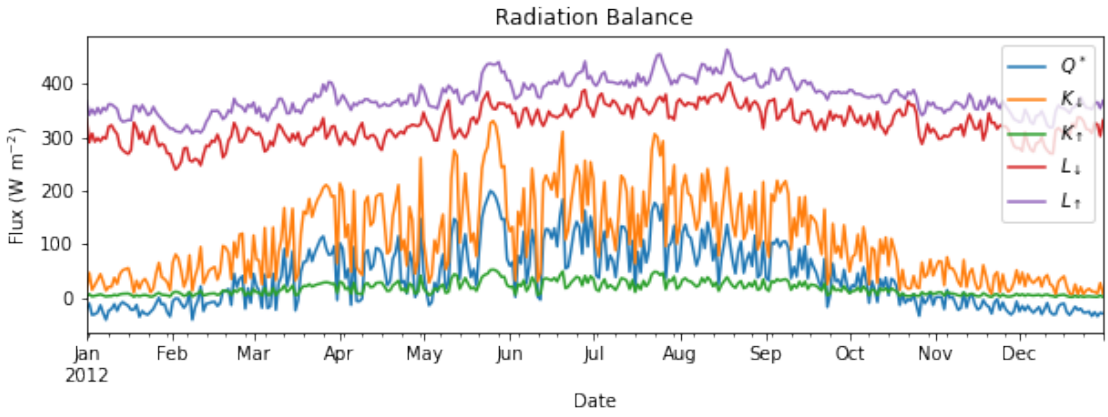


[33]:
```
rsmp_1d = df_output_suews.loc[grid].resample("1d")
# daily mean values
df_1d_mean = rsmp_1d.mean()
# daily sum values
df_1d_sum = rsmp_1d.sum()
```

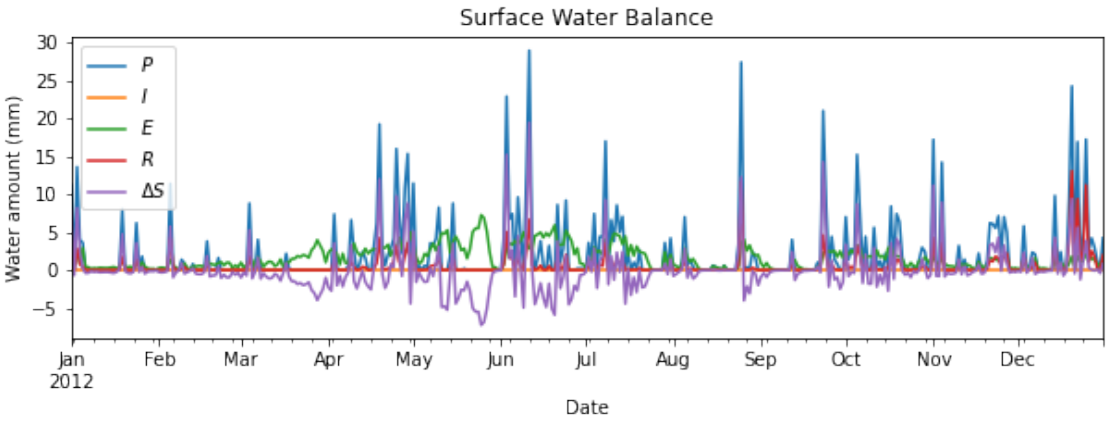
[34]:
```
# energy balance
ax_output = (
    df_1d_mean.loc[:, ["QN", "QS", "QE", "QH", "QF"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Energy Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```



[35]:
```
# radiation balance
ax_output = (
    df_1d_mean.loc[:, ["QN", "Kdown", "Kup", "Ldown", "Lup"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Radiation Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```



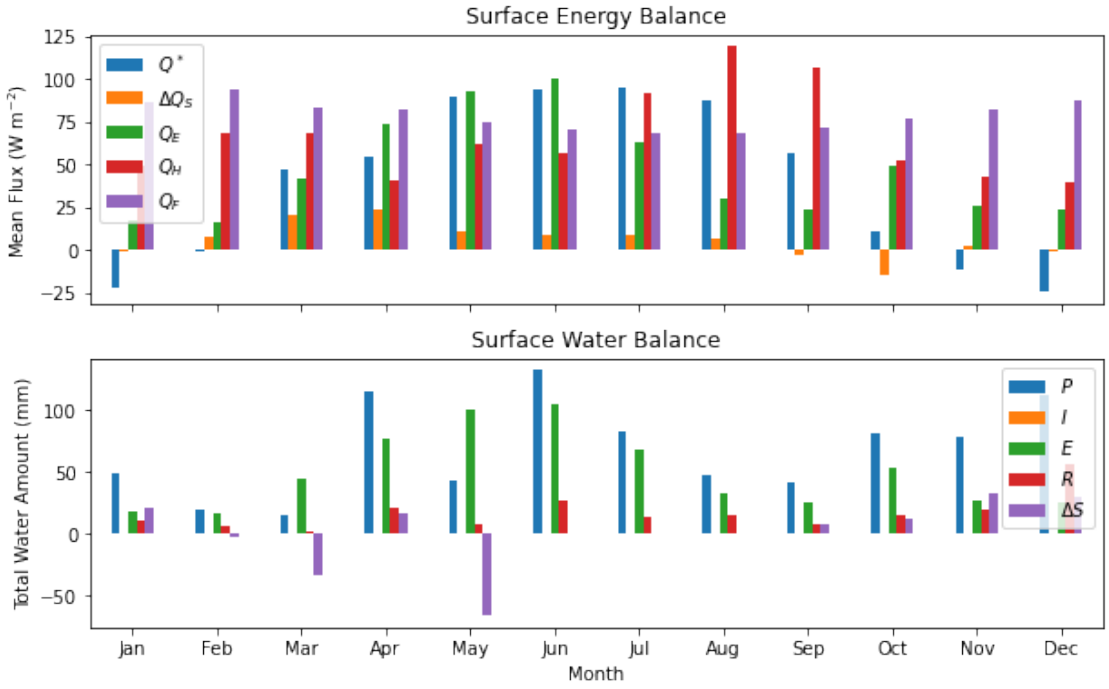
[36]:
```
# water balance
ax_output = (
    df_1d_sum.loc[:, ["Rain", "Irr", "Evap", "RO", "TotCh"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Water Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Water amount (mm)")
_ = ax_output.legend()
```



[37]:
```
# get a monthly Resampler
df_plot = df_output_suews.loc[grid].copy()
df_plot.index = df_plot.index.set_names("Month")
rsmp_1M = df_plot.shift(-1).dropna(how="all").resample("1M", kind="period")
# mean values
df_1M_mean = rsmp_1M.mean()
# sum values
```

```
df_1M_sum = rsmp_1M.sum()
```

[38]:
```
# month names
name_mon = [x.strftime("%b") for x in rsmp_1M.groups]
# create subplots showing two panels together
fig, axes = plt.subplots(2, 1, sharex=True)
# surface energy balance
df_1M_mean.loc[:, ["QN", "QS", "QE", "QH", "QF"]].rename(columns=dict_var_disp).
 ↪plot(
    ax=axes[0],  # specify the axis for plotting
    figsize=(10, 6),  # specify figure size
    title="Surface Energy Balance",
    kind="bar",
)
# surface water balance
df_1M_sum.loc[:, ["Rain", "Irr", "Evap", "RO", "TotCh"]].rename(
    columns=dict_var_disp
).plot(
    ax=axes[1],  # specify the axis for plotting
    title="Surface Water Balance",
    kind="bar",
)

# annotations
_ = axes[0].set_ylabel("Mean Flux ($ \mathrm{W \ m^{-2}}$)")
_ = axes[0].legend()
_ = axes[1].set_xlabel("Month")
_ = axes[1].set_ylabel("Total Water Amount (mm)")
_ = axes[1].xaxis.set_ticklabels(name_mon, rotation=0)
_ = axes[1].legend()
```



[39]:
```
df_output
```

[39]:
```
group                          SUEWS                                    \
var                            Kdown      Kup       Ldown         Lup
grid datetime
1    2012-01-01 00:05:00  0.176667  0.02332  344.179805  371.582645
     2012-01-01 00:10:00  0.173333  0.02288  344.190048  371.657938
     2012-01-01 00:15:00  0.170000  0.02244  344.200308  371.733243
     2012-01-01 00:20:00  0.166667  0.02200  344.210586  371.808562
     2012-01-01 00:25:00  0.163333  0.02156  344.220882  371.883893
…                              …         …         …           …
     2012-12-31 23:35:00  0.000000  0.00000  330.263407  363.676342
     2012-12-31 23:40:00  0.000000  0.00000  330.263407  363.676342
     2012-12-31 23:45:00  0.000000  0.00000  330.263407  363.676342
     2012-12-31 23:50:00  0.000000  0.00000  330.263407  363.676342
     2012-12-31 23:55:00  0.000000  0.00000  330.263407  363.676342

group                                                                   \
var                             Tsurf         QN         QF        QS
grid datetime
1    2012-01-01 00:05:00  11.607452 -27.249493  40.574001 -6.382243
     2012-01-01 00:10:00  11.622405 -27.317436  39.724283 -6.228797
     2012-01-01 00:15:00  11.637359 -27.385375  38.874566 -6.082788
     2012-01-01 00:20:00  11.652312 -27.453309  38.024849 -5.943907
```

```
     2012-01-01 00:25:00  11.667265 -27.521237  37.175131 -5.811855
…                              …         …         …        …
     2012-12-31 23:35:00  10.140000 -33.412935  53.348682 -4.399144
     2012-12-31 23:40:00  10.140000 -33.412935  52.422737 -4.397669
     2012-12-31 23:45:00  10.140000 -33.412935  51.496792 -4.395831
     2012-12-31 23:50:00  10.140000 -33.412935  50.570847 -4.393681
     2012-12-31 23:55:00  10.140000 -33.412935  46.174492 -4.391264

group                                              …     DailyState  \
var                                 QH         QE  … DensSnow_Paved
grid datetime                                      …
1    2012-01-01 00:05:00  19.663696   0.043054  …             NaN
     2012-01-01 00:10:00  18.593507   0.042137  …             NaN
     2012-01-01 00:15:00  17.530760   0.041219  …             NaN
     2012-01-01 00:20:00  16.475145   0.040302  …             NaN
     2012-01-01 00:25:00  15.426365   0.039385  …             NaN
…                              …         …   …           …
     2012-12-31 23:35:00  -0.482339  24.817231  …             NaN
     2012-12-31 23:40:00  -0.859781  24.267252  …             NaN
     2012-12-31 23:45:00  -1.244828  23.724516  …             NaN
     2012-12-31 23:50:00  -1.637043  23.188636  …             NaN
     2012-12-31 23:55:00  -0.057754  17.210575  …             0.0

group                                                                \
var                        DensSnow_Bldgs DensSnow_EveTr DensSnow_DecTr
grid datetime
1    2012-01-01 00:05:00              NaN            NaN            NaN
     2012-01-01 00:10:00              NaN            NaN            NaN
     2012-01-01 00:15:00              NaN            NaN            NaN
     2012-01-01 00:20:00              NaN            NaN            NaN
     2012-01-01 00:25:00              NaN            NaN            NaN
…                                     …              …              …
     2012-12-31 23:35:00              NaN            NaN            NaN
     2012-12-31 23:40:00              NaN            NaN            NaN
     2012-12-31 23:45:00              NaN            NaN            NaN
     2012-12-31 23:50:00              NaN            NaN            NaN
     2012-12-31 23:55:00              0.0            0.0            0.0

group                                                                \
var                        DensSnow_Grass DensSnow_BSoil DensSnow_Water
grid datetime
1    2012-01-01 00:05:00              NaN            NaN            NaN
     2012-01-01 00:10:00              NaN            NaN            NaN
     2012-01-01 00:15:00              NaN            NaN            NaN
     2012-01-01 00:20:00              NaN            NaN            NaN
     2012-01-01 00:25:00              NaN            NaN            NaN
…                                     …              …              …
```

```
     2012-12-31 23:35:00            NaN            NaN            NaN
     2012-12-31 23:40:00            NaN            NaN            NaN
     2012-12-31 23:45:00            NaN            NaN            NaN
     2012-12-31 23:50:00            NaN            NaN            NaN
     2012-12-31 23:55:00            0.0            0.0            0.0

group
var                             a1      a2      a3
grid datetime
1    2012-01-01 00:05:00       NaN     NaN     NaN
     2012-01-01 00:10:00       NaN     NaN     NaN
     2012-01-01 00:15:00       NaN     NaN     NaN
     2012-01-01 00:20:00       NaN     NaN     NaN
     2012-01-01 00:25:00       NaN     NaN     NaN
…                              …       …       …
     2012-12-31 23:35:00       NaN     NaN     NaN
     2012-12-31 23:40:00       NaN     NaN     NaN
     2012-12-31 23:45:00       NaN     NaN     NaN
     2012-12-31 23:50:00       NaN     NaN     NaN
     2012-12-31 23:55:00   0.36935  0.3242  8.0995

[105407 rows x 413 columns]
```

[40]:
```
list_path_save = sp.save_supy(df_output, df_state_final,)
```

[41]:
```
for file_out in list_path_save:
    print(file_out.name)
```

```
1_2012_DailyState.txt
1_2012_SUEWS_60.txt
1_2012_RSL_60.txt
1_2012_BEERS_60.txt
1_2012_debug_60.txt
df_state.csv
```

[ ]: