Lightkurve functionalities

June 7, 2022

[44]:
```
import numpy as np
import matplotlib.pylab as plt
import seaborn as sns
import lightkurve as lk
# %matplotlib auto
```

0.0.1 WASP-100b LightCurve

Wasp-100 is a F-type star of about 1.5 Msun and twice the size of sun with solar metalicity. A jupiter-sized planet was detected orbiting wasp-100 in a circular orbit with a period less than 3 days (Hellier et al 2014). As the star is located near ecliptic plane, TESS has observed Wasp-100 in all 13 sectors during year 1. Therefore, there is high precision photometric observations of nearly 360 days. It shows a transit depth of around 1% the out-of-transit flux level.

The unflattened fluxes show small modulation in mean flux levels which has been removed by using the *flatten* method. The light curve folded with a period of 2.85 days shows clear transit-like event.

[92]:
```
# searching
search_results = lk.search_lightcurve('TIC 38846515', radius=None,␣
↪exptime='short', cadence=None, mission='TESS',
                                      author='SPOC', quarter=None, month=None,␣
↪campaign=None,
                                      sector=(1,2,3,4,5,6,7,8,9,10,11,12,13),␣
↪limit=None)
search_results
```

[92]:
```
SearchResult containing 13 data products.

 #     mission      year author exptime target_name distance
                                  s                  arcsec
--- -------------- ---- ------ ------- ----------- --------
  0 TESS Sector 01 2018   SPOC     120    38846515      0.0
  1 TESS Sector 02 2018   SPOC     120    38846515      0.0
  2 TESS Sector 03 2018   SPOC     120    38846515      0.0
  3 TESS Sector 04 2018   SPOC     120    38846515      0.0
  4 TESS Sector 05 2018   SPOC     120    38846515      0.0
  5 TESS Sector 06 2018   SPOC     120    38846515      0.0
  6 TESS Sector 07 2019   SPOC     120    38846515      0.0
```

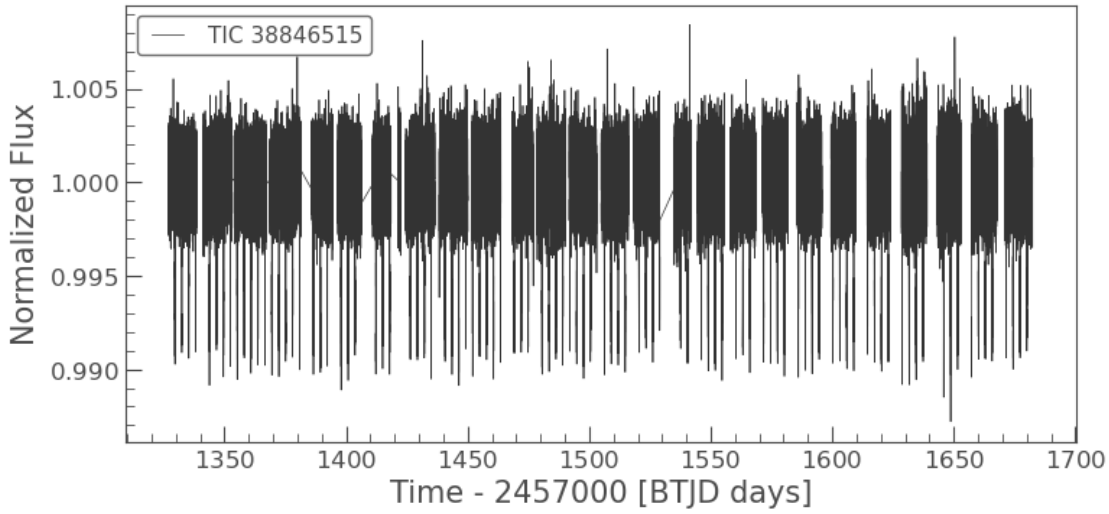
```
 7 TESS Sector 08 2019   SPOC     120    38846515      0.0
 8 TESS Sector 09 2019   SPOC     120    38846515      0.0
 9 TESS Sector 10 2019   SPOC     120    38846515      0.0
10 TESS Sector 11 2019   SPOC     120    38846515      0.0
11 TESS Sector 12 2019   SPOC     120    38846515      0.0
12 TESS Sector 13 2019   SPOC     120    38846515      0.0
```

[93]:
```
# downloading
lc = search_results.download_all(quality_bitmask='default', download_dir=None,␣
↪cutout_size=None)
lc = lc.stitch()
```

```
Warning: 30% (5871/19412) of the cadences will be ignored due to the quality
mask (quality_bitmask=175).
```

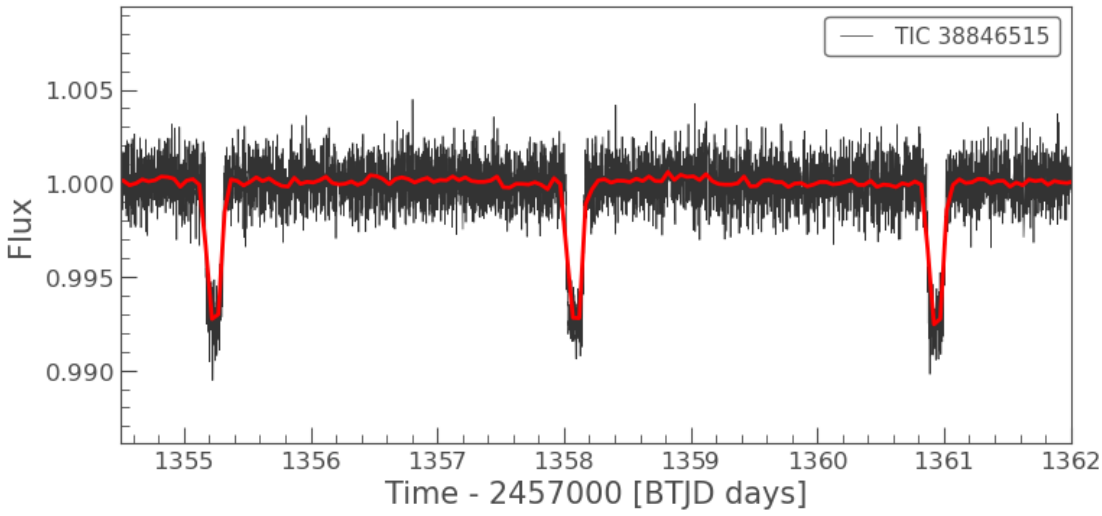
[94]:
```
# plotting
lc.plot()
```

[94]: <AxesSubplot:xlabel='Time - 2457000 [BTJD days]', ylabel='Normalized Flux'>

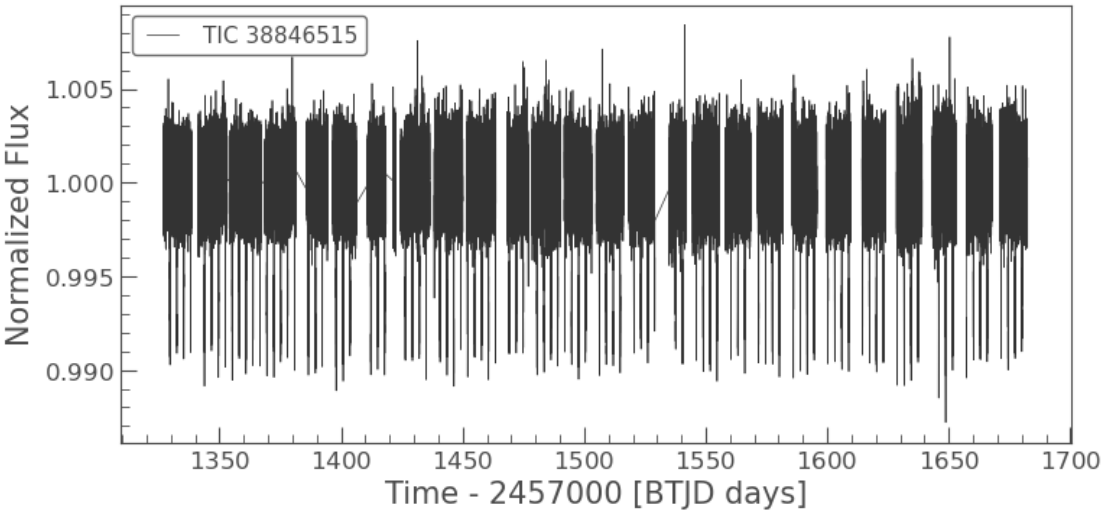


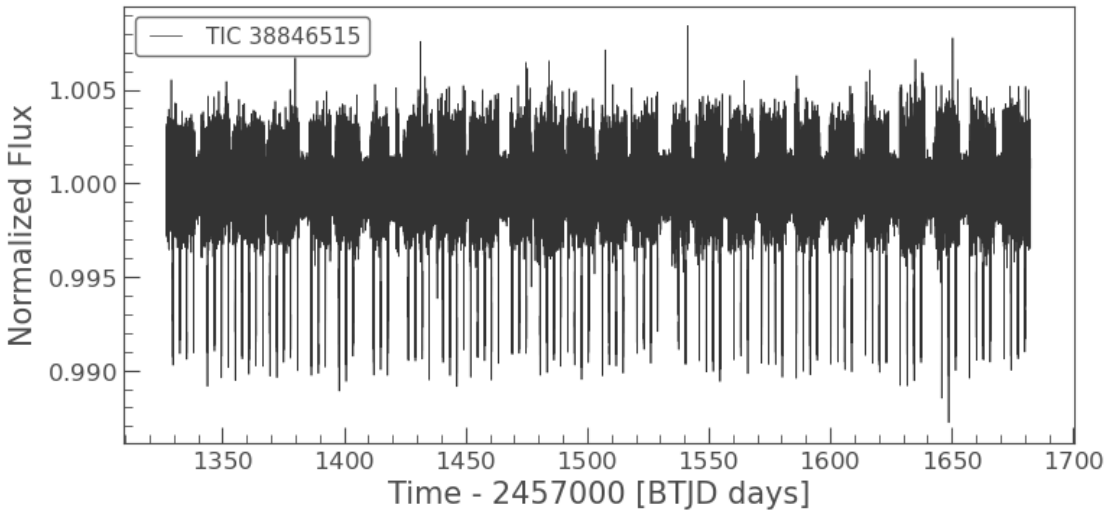
[95]:
```
ax = lc.plot()
ax.set_xlim(1354.5,1362)
lc.bin(time_bin_size=0.05).plot(ax=ax,color='r',lw=2)
plt.savefig('wasp_100_bin.eps');
```

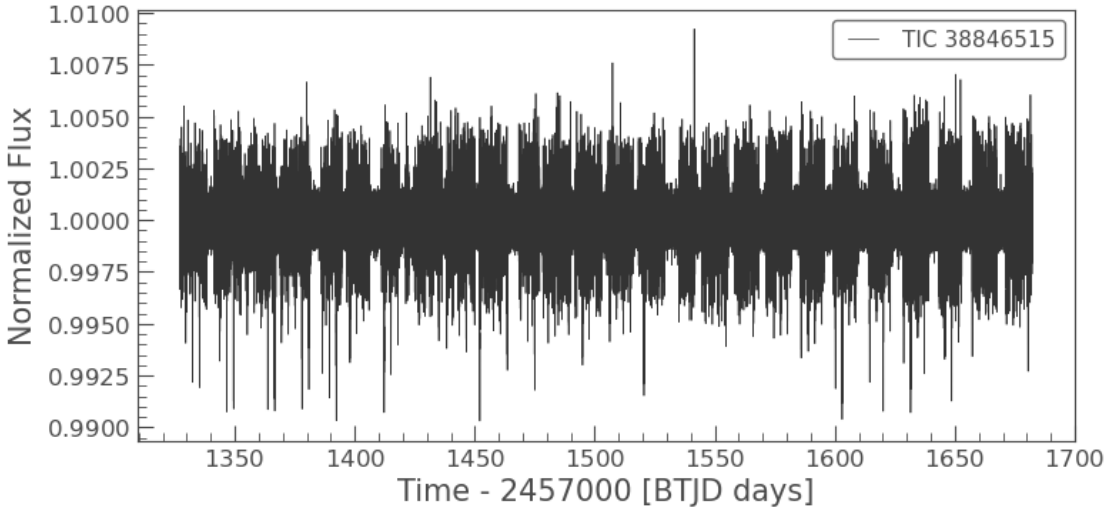
```
The PostScript backend does not support transparency; partially transparent
artists will be rendered opaque.
The PostScript backend does not support transparency; partially transparent
artists will be rendered opaque.
```



[96]:
```
lc_gfill = lc.fill_gaps()
lc.plot()
lc_gfill.plot()
lc_gfill.flatten(11).plot();
```

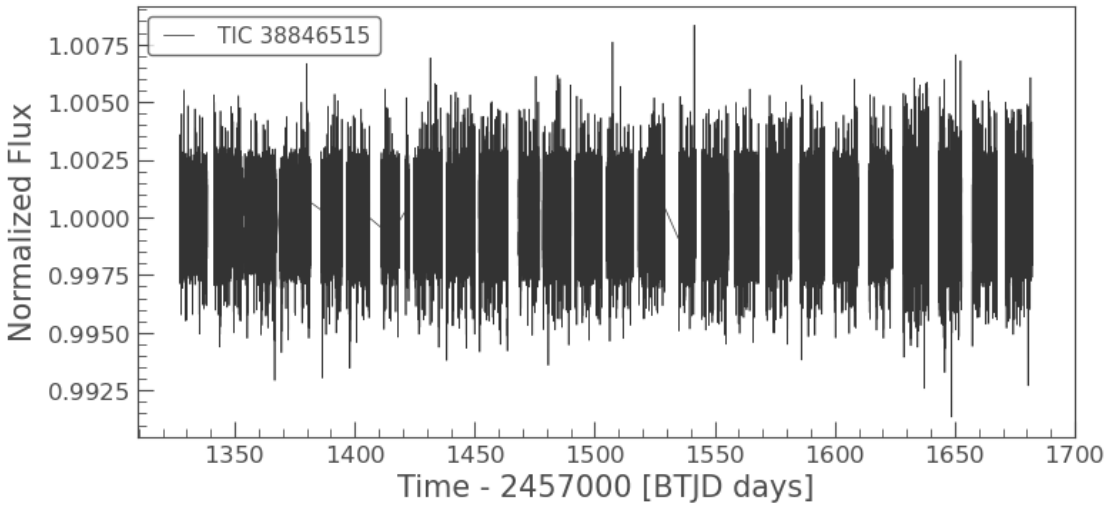




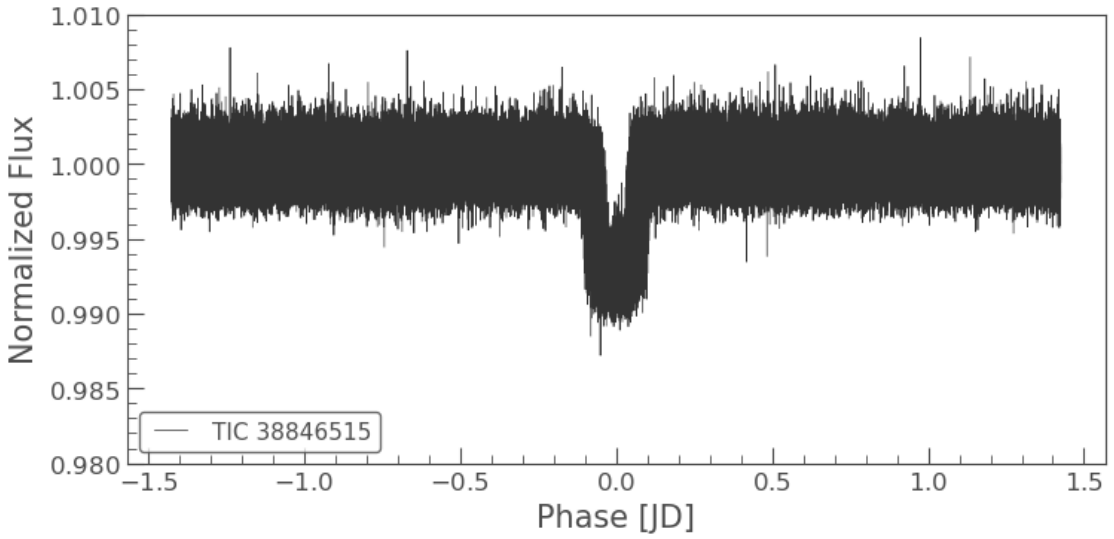


[6]:
```
clc = lc.flatten(11)
clc.plot()
```

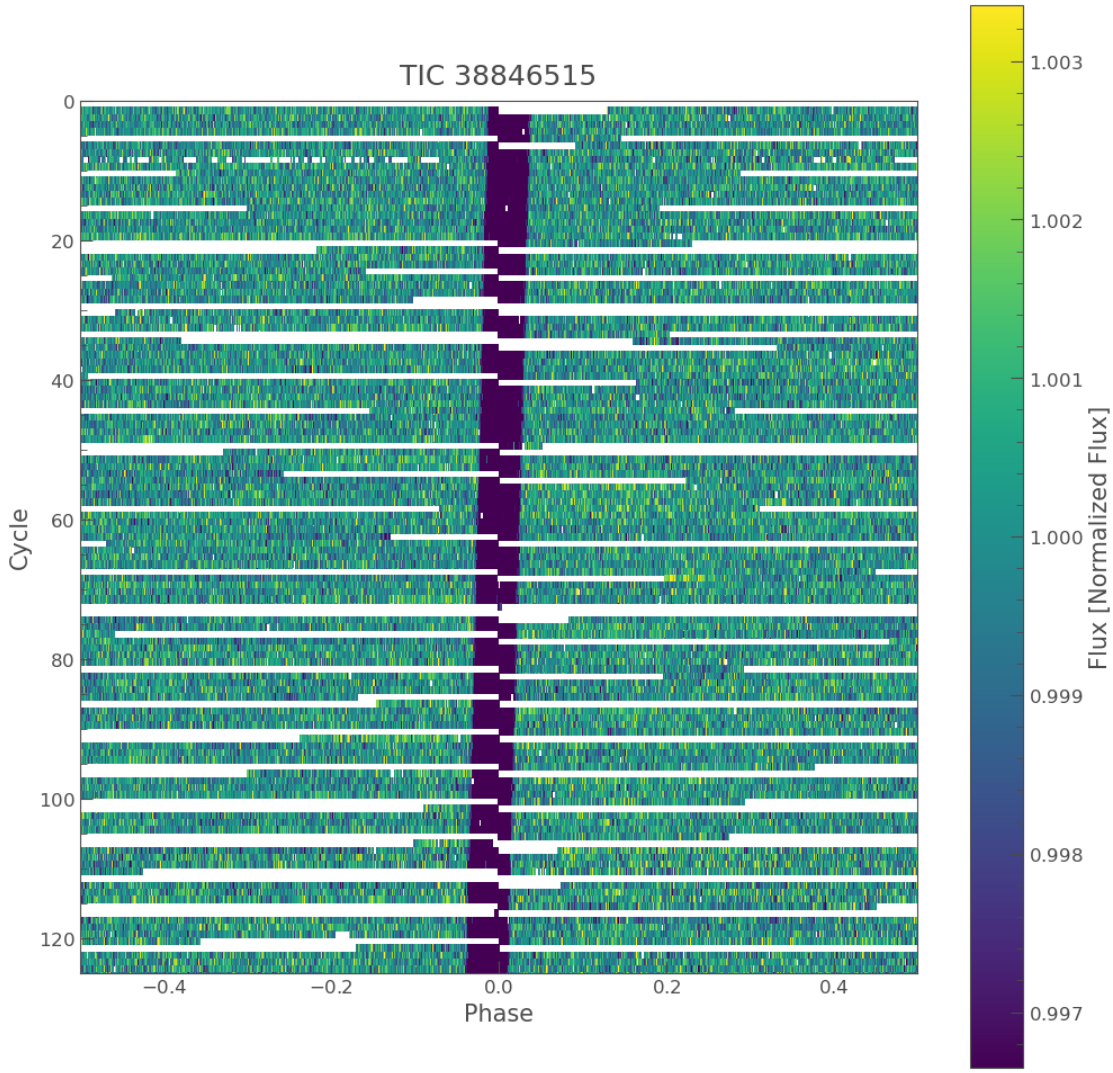
[6]: <AxesSubplot:xlabel='Time - 2457000 [BTJD days]', ylabel='Normalized Flux'>



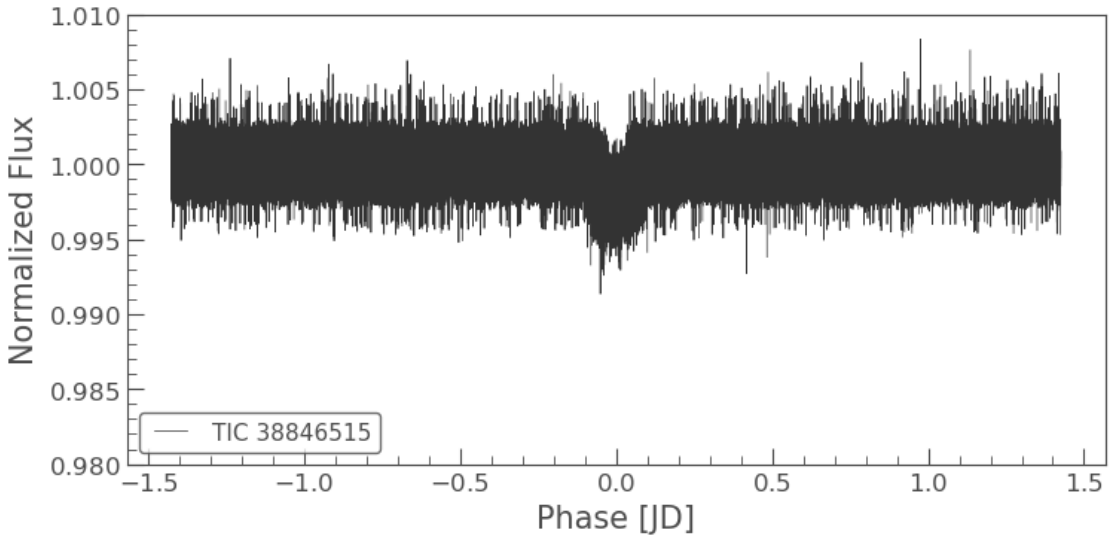
[7]:
```
p, t0 = 2.85, 1500.5573
folded_lc = lc.fold(period=p, epoch_time=t0)
ax = folded_lc.plot()
ax.set_ylim(0.98,1.01);
```



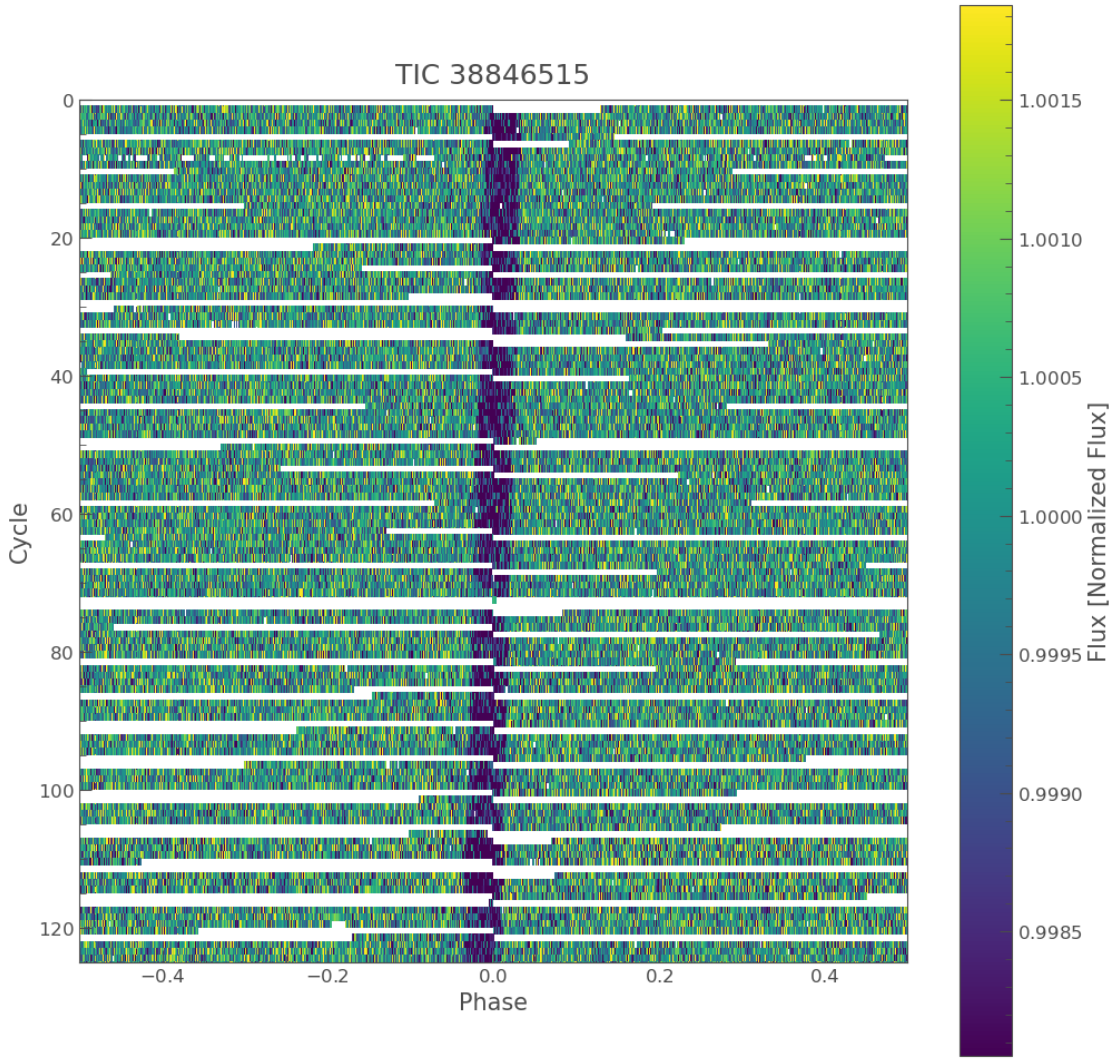
[8]:
```
folded_lc.plot_river();
```



[9]:
```
p, t0 = 2.85, 1500.5573
folded_lc = clc.fold(period=p, epoch_time=t0)
ax = folded_lc.plot()
ax.set_ylim(0.98,1.01);
```



[10]:
```
folded_lc.plot_river();
```



Eclipsing binary - flattening problem

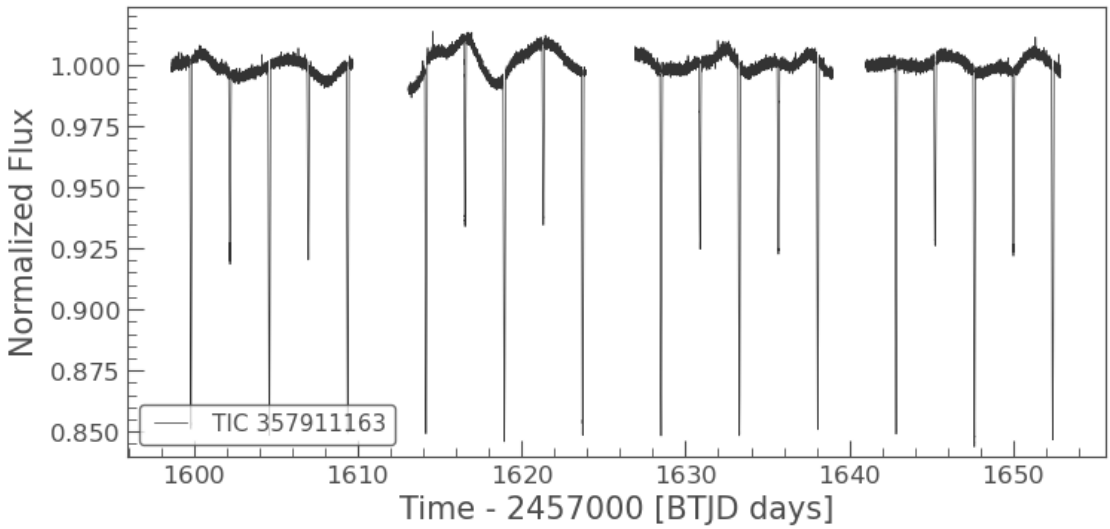
[11]:
```
search_results = lk.search_lightcurve('TIC 357911163', radius=None,
                                      exptime='short', cadence=None,
                                      mission='TESS', author='SPOC',
                                      quarter=None, month=None,
                                      campaign=None,
                                      sector=(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26),
                                      limit=None)
search_results
```

[11]:
```
SearchResult containing 2 data products.

 #      mission      year author exptime target_name distance
```

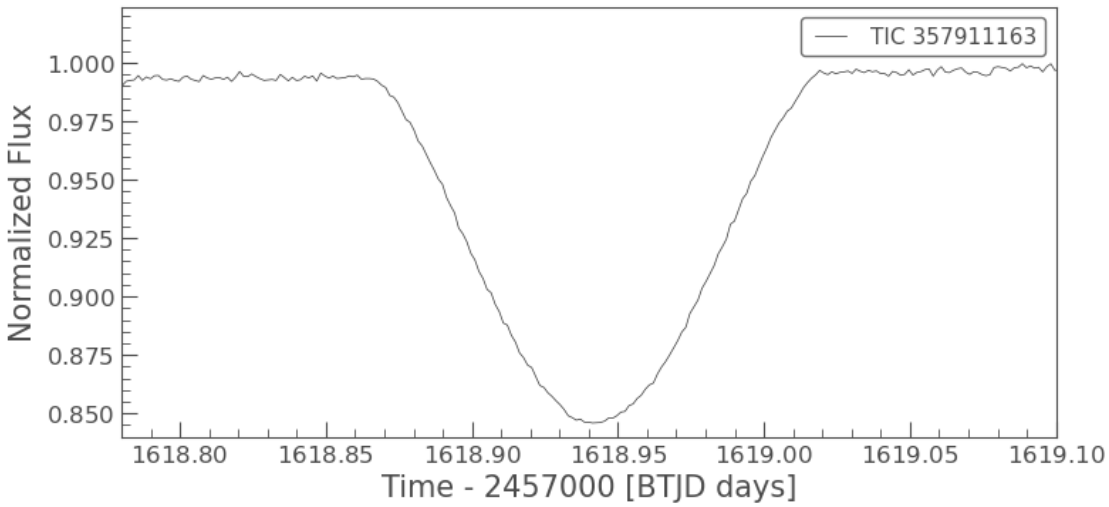
```
                                      s                  arcsec
---  --------------  ----  ------  -------  -----------  --------
  0  TESS Sector 11  2019  SPOC        120    357911163       0.0
  1  TESS Sector 12  2019  SPOC        120    357911163       0.0
```

[12]:
```
# downloading
lc = search_results.download_all(quality_bitmask='default', download_dir=None,␣
 ↪cutout_size=None)
lc = lc.stitch()
```

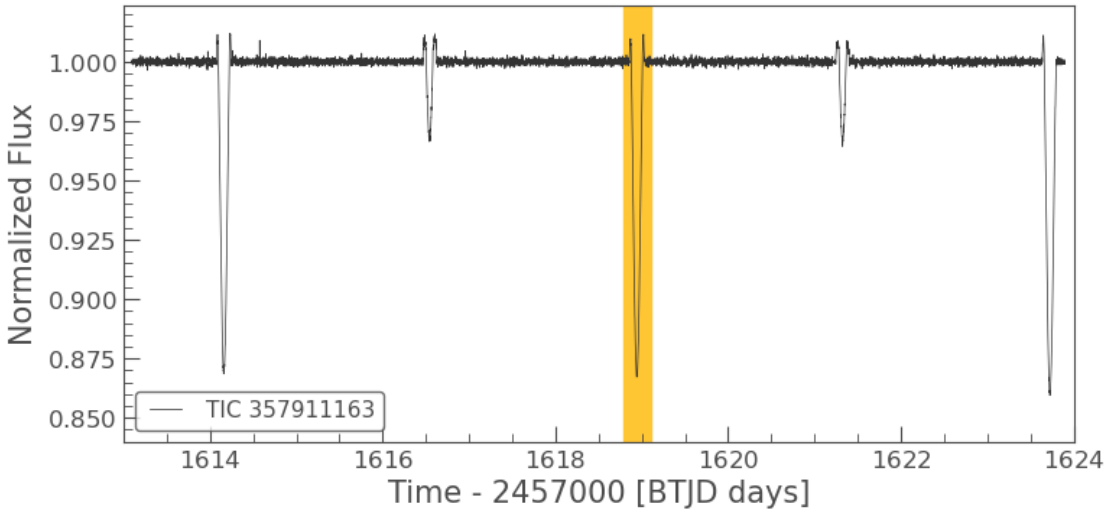
[13]:
```
ax = lc.plot()
ax.set_ylim(0.84,1.024);
```



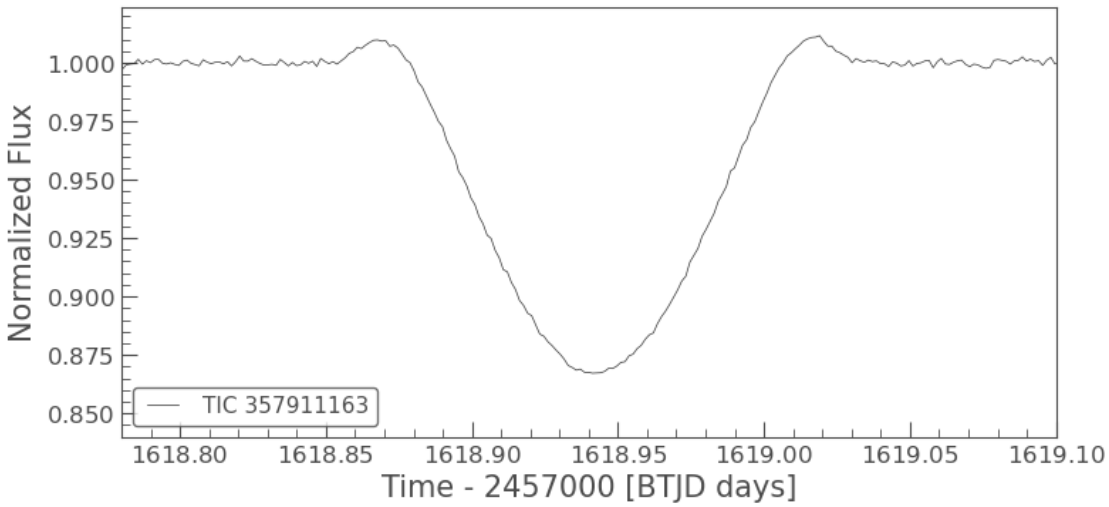
[14]:
```
ax = lc.plot()
ax.set_ylim(0.84,1.024)
ax.set_xlim(1618.78,1619.1);
```



[15]:
```
clc = lc.flatten(105)
ax = clc.plot()
ax.set_ylim(0.84,1.024)
ax.set_xlim(1613,1624)
ax.axvspan(1618.78,1619.1,color='#FFC633');
```



[16]:
```
clc = lc.flatten(105)
ax = clc.plot()
ax.set_ylim(0.84,1.024)
ax.set_xlim(1618.78,1619.1);
```



Transit mask

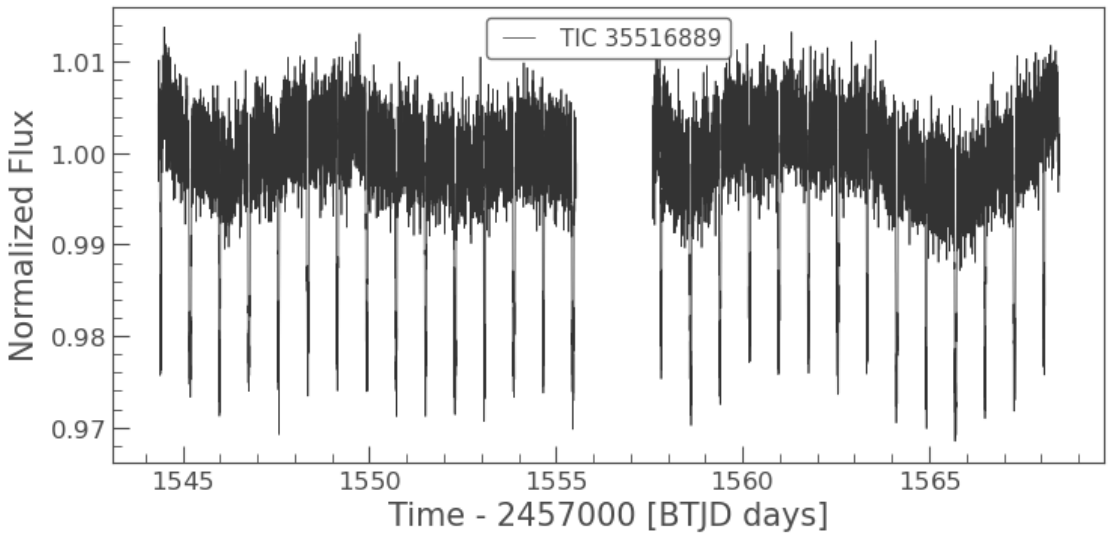
[78]:
```
# Wasp 19
search_results = lk.search_lightcurve('TIC 35516889', radius=None,
                                      exptime='short', cadence=None,
                                      mission='TESS', author='SPOC',
                                      quarter=None, month=None,
                                      campaign=None,
                                      sector=(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26),
                                      limit=None)
search_results
```

[78]:
```
SearchResult containing 1 data products.

 #     mission     year author exptime target_name distance
                                  s                 arcsec
--- -------------- ---- ------ ------- ----------- --------
  0 TESS Sector 09 2019   SPOC     120    35516889      0.0
```

[79]:
```
# downloading
lc = search_results.download_all(quality_bitmask='default', download_dir=None,
                                 cutout_size=None)
lc = lc.stitch()
```

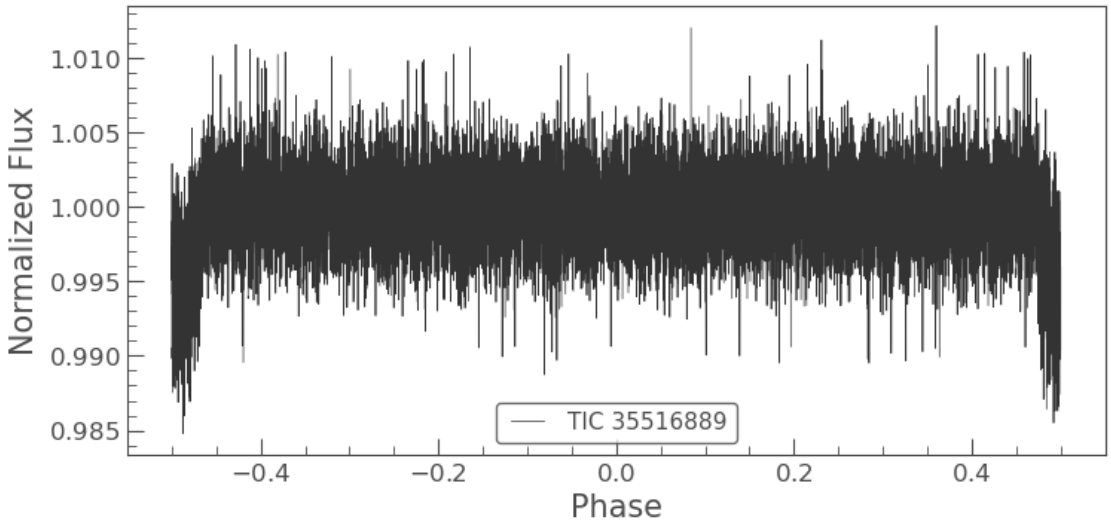
[86]:
```
lc.plot()
```

[86]:
```
<AxesSubplot:xlabel='Time - 2457000 [BTJD days]', ylabel='Normalized Flux'>
```

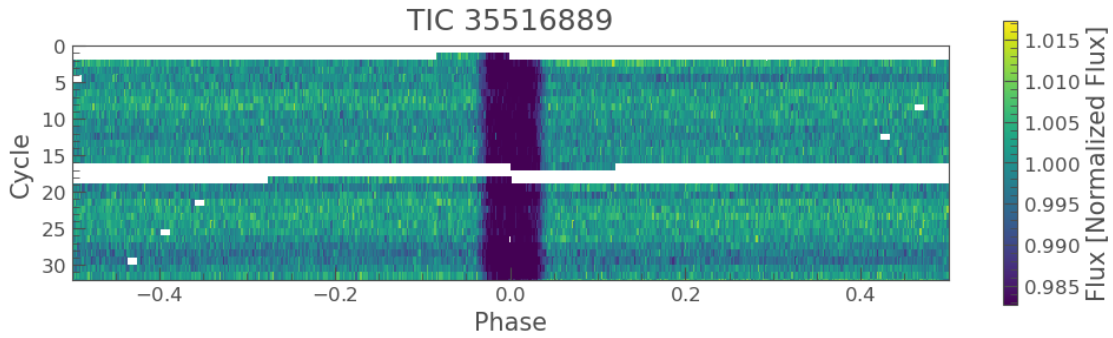


[87]:
```
lc.flatten(11).fold(period=0.78884,normalize_phase=True).plot()
```

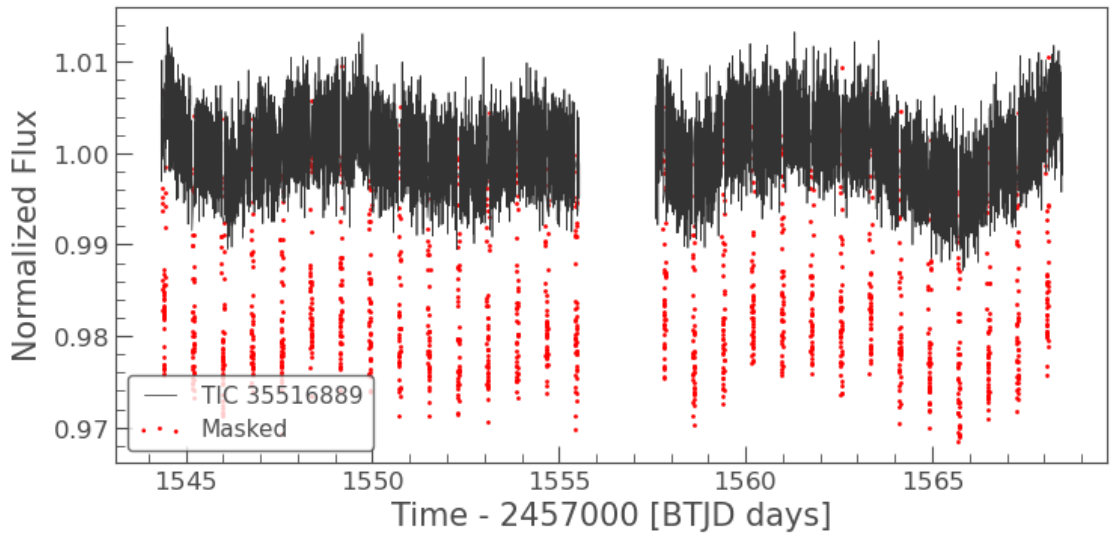
[87]: <AxesSubplot:xlabel='Phase', ylabel='Normalized Flux'>



[81]:
```
lc.fold(period=0.78884).plot_river()
plt.savefig('wasp19_riverplot.eps',dpi=200)
```

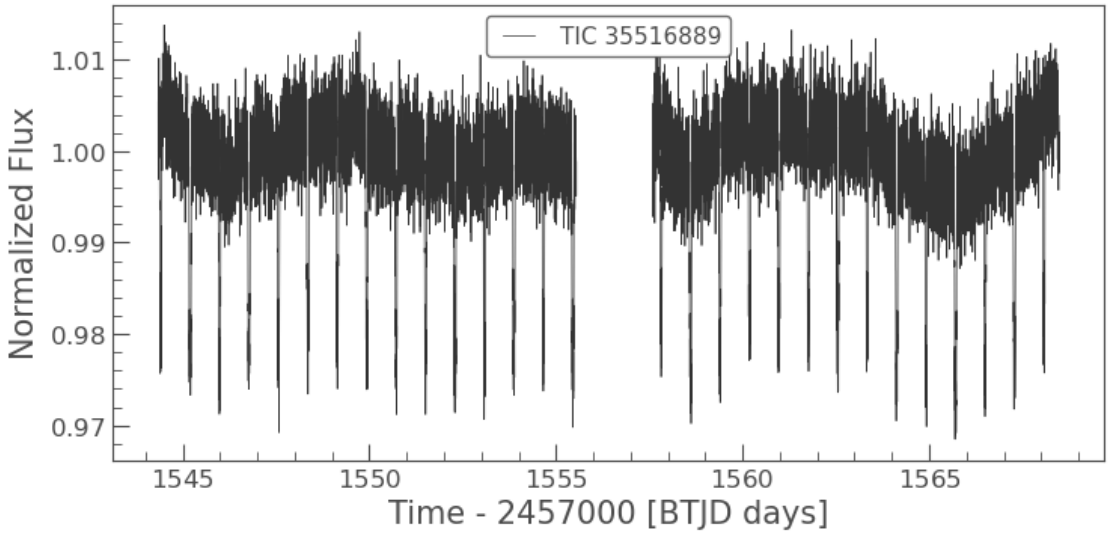


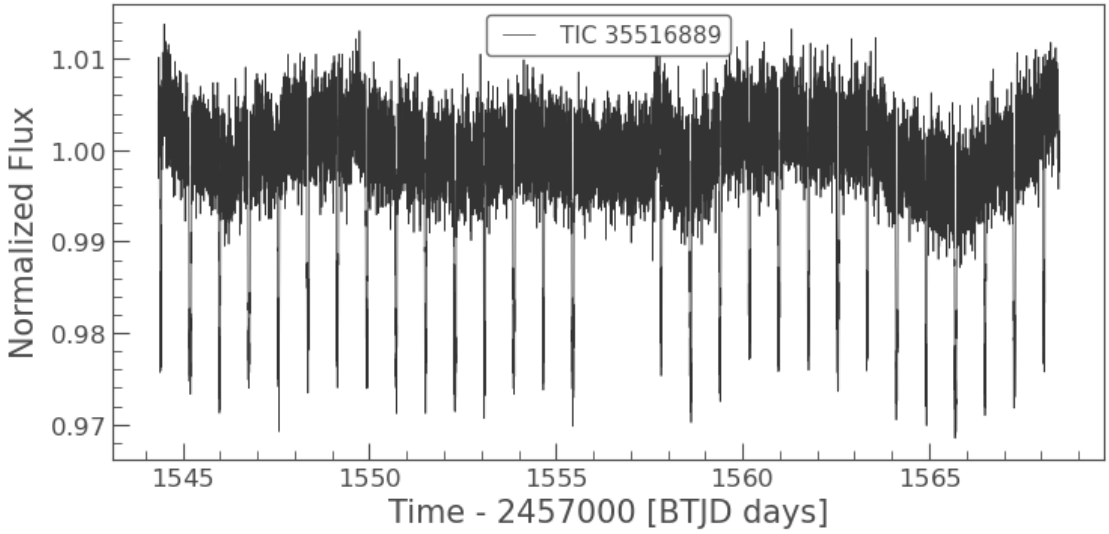
[51]:
```
p, t0, tdur = 0.78884, -597.2872, 0.067

planet_mask = lc.create_transit_mask(period=p,transit_time=t0,duration=tdur)
masked_lc = lc[~planet_mask]
ax = masked_lc.plot()
lc[planet_mask].scatter(ax=ax, c='r', label='Masked');
```

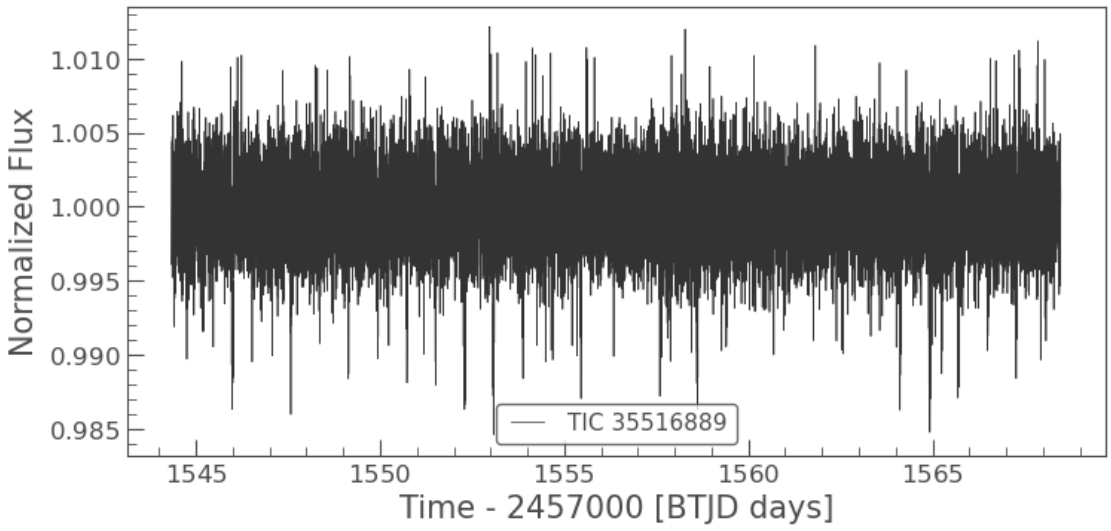


[52]:
```
lc_gfill = lc.fill_gaps()
lc.plot()
lc_gfill.plot()
lc_gfill.flatten(11).plot()
```

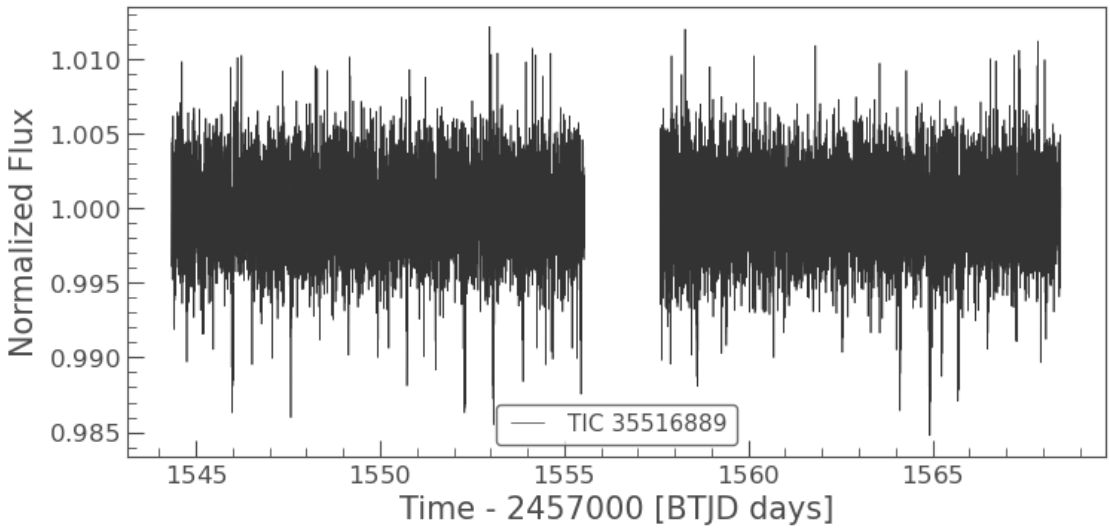
[52]: <AxesSubplot:xlabel='Time - 2457000 [BTJD days]', ylabel='Normalized Flux'>

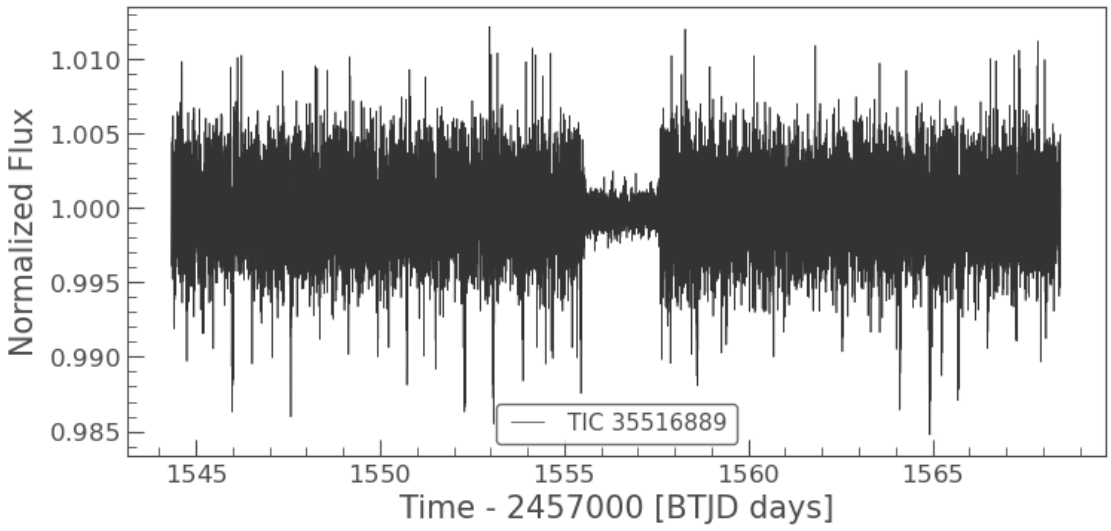

TIC 35516889
Normalized Flux
1.01
1.00
0.99
0.98
0.97
1545
1550
1555
1560
1565
Time - 2457000 [BTJD days]

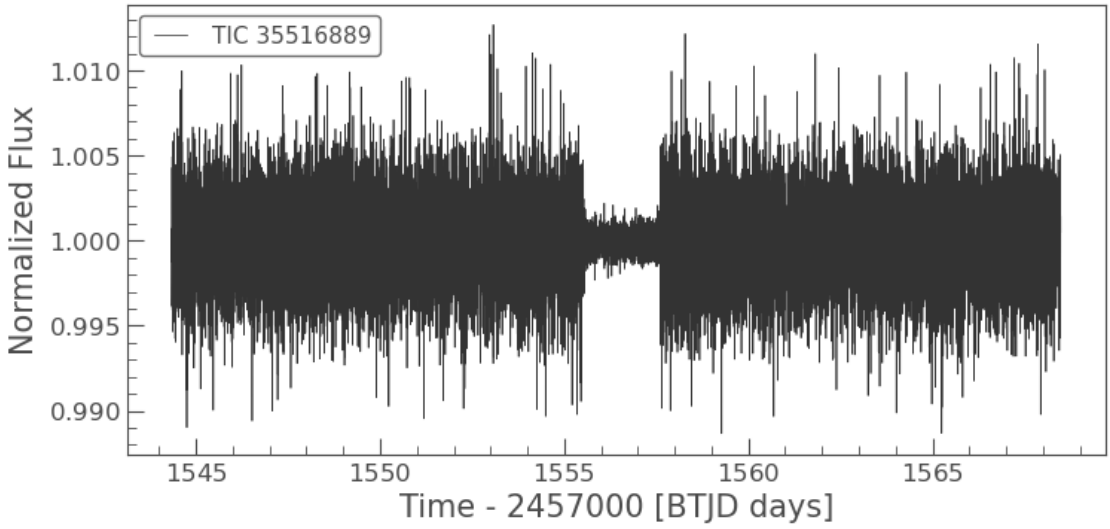

TIC 35516889
Normalized Flux
1.01
1.00
0.99
0.98
0.97
1545
1550
1555
1560
1565
Time - 2457000 [BTJD days]



[42]:
```
clc = lc.flatten(11)
clc_gfill = clc.fill_gaps()
clc.plot()
clc_gfill.plot()
```







Binary vs eclipsing

[45]:
```
# unknown probably contact binary
search_results = lk.search_lightcurve('TIC 140757590', radius=None,
                                      exptime='short', cadence=None,
                                      mission='TESS', author='SPOC',
                                      quarter=None, month=None,
                                      campaign=None,
                                      sector=(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26),
                                      limit=None)
```

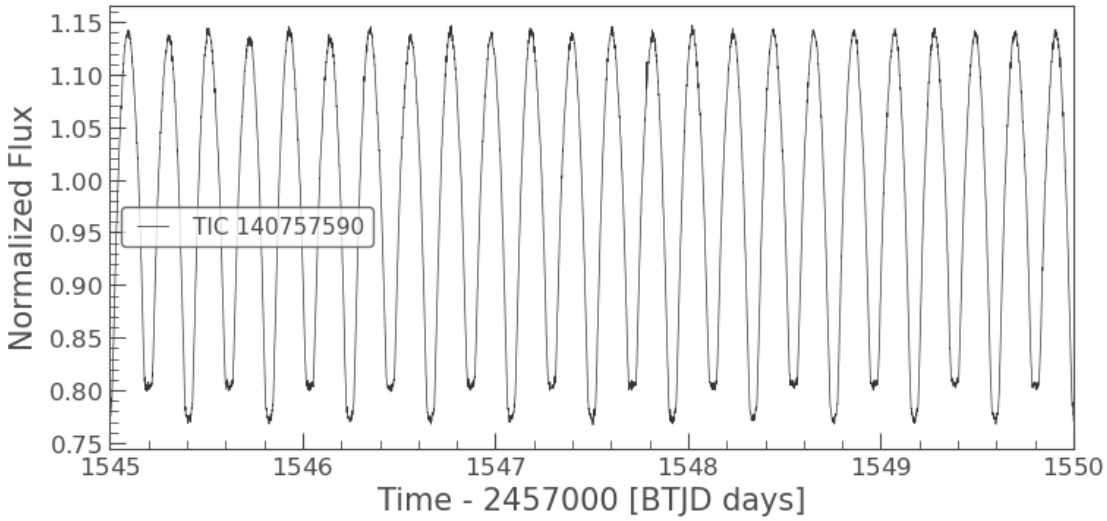
```
search_results
```

[45]:
```
SearchResult containing 5 data products.

 #      mission      year author exptime target_name distance
                                   s                  arcsec
--- -------------- ---- ------ ------- ----------- --------
  0 TESS Sector 09 2019   SPOC     120   140757590      0.0
  1 TESS Sector 10 2019   SPOC     120   140757590      0.0
  2 TESS Sector 11 2019   SPOC     120   140757590      0.0
  3 TESS Sector 12 2019   SPOC     120   140757590      0.0
  4 TESS Sector 13 2019   SPOC     120   140757590      0.0
```

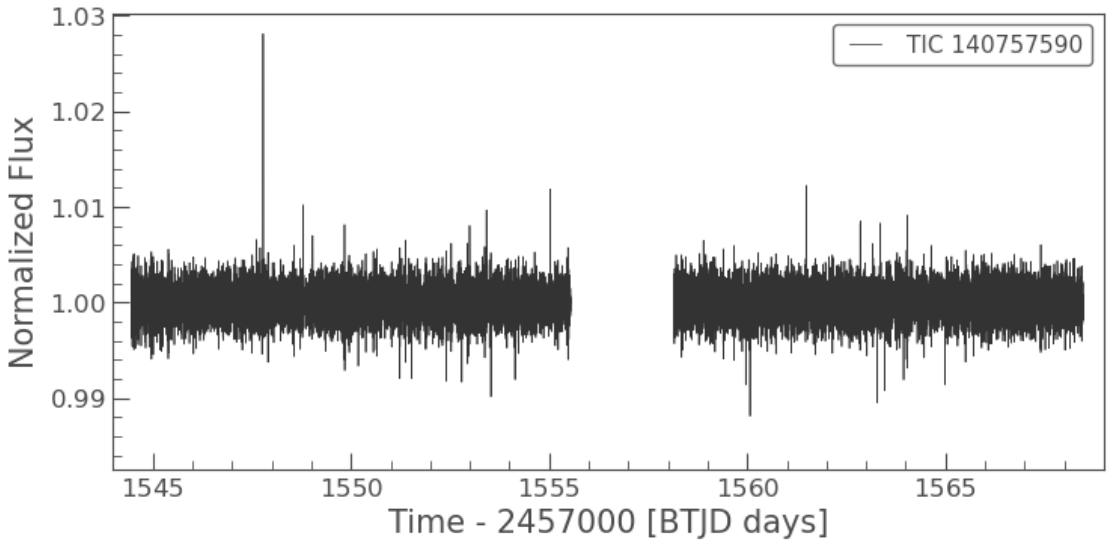
[46]:
```
# downloading
lc = search_results.download_all(quality_bitmask='default', download_dir=None,␣
 ↪cutout_size=None)
lc = lc.stitch()
```

[48]:
```
ax = lc.plot()
ax.set_xlim(1545,1550);
# plt.savefig('TIC140757590_zoom_lc.eps');
```

```
The PostScript backend does not support transparency; partially transparent
artists will be rendered opaque.
The PostScript backend does not support transparency; partially transparent
artists will be rendered opaque.
```

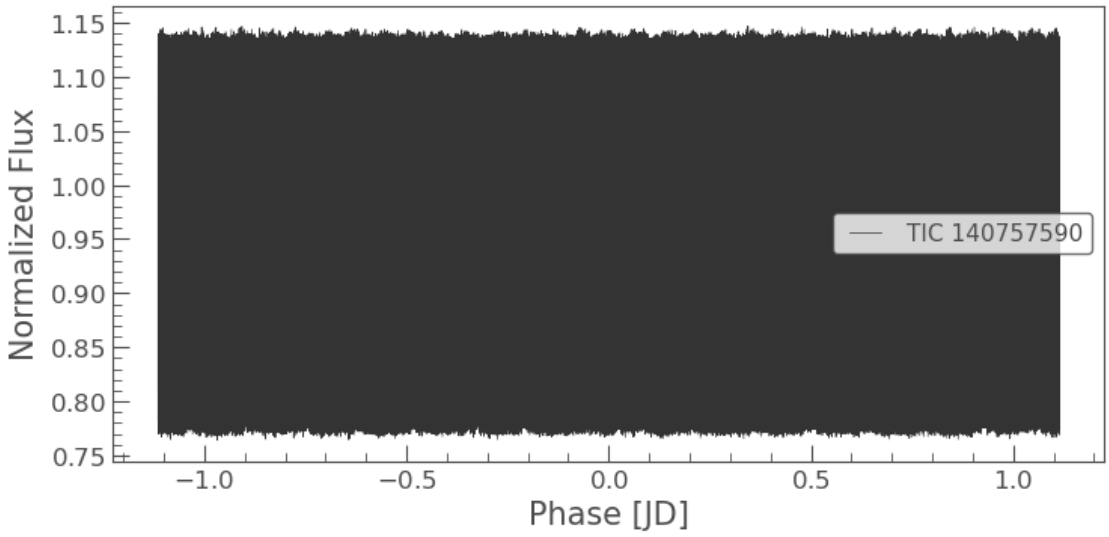


[33]:
```
clc = lc.flatten(11)
clc.plot()
```



[34]:
```
lc.fold(period=2.2277898).plot()
```

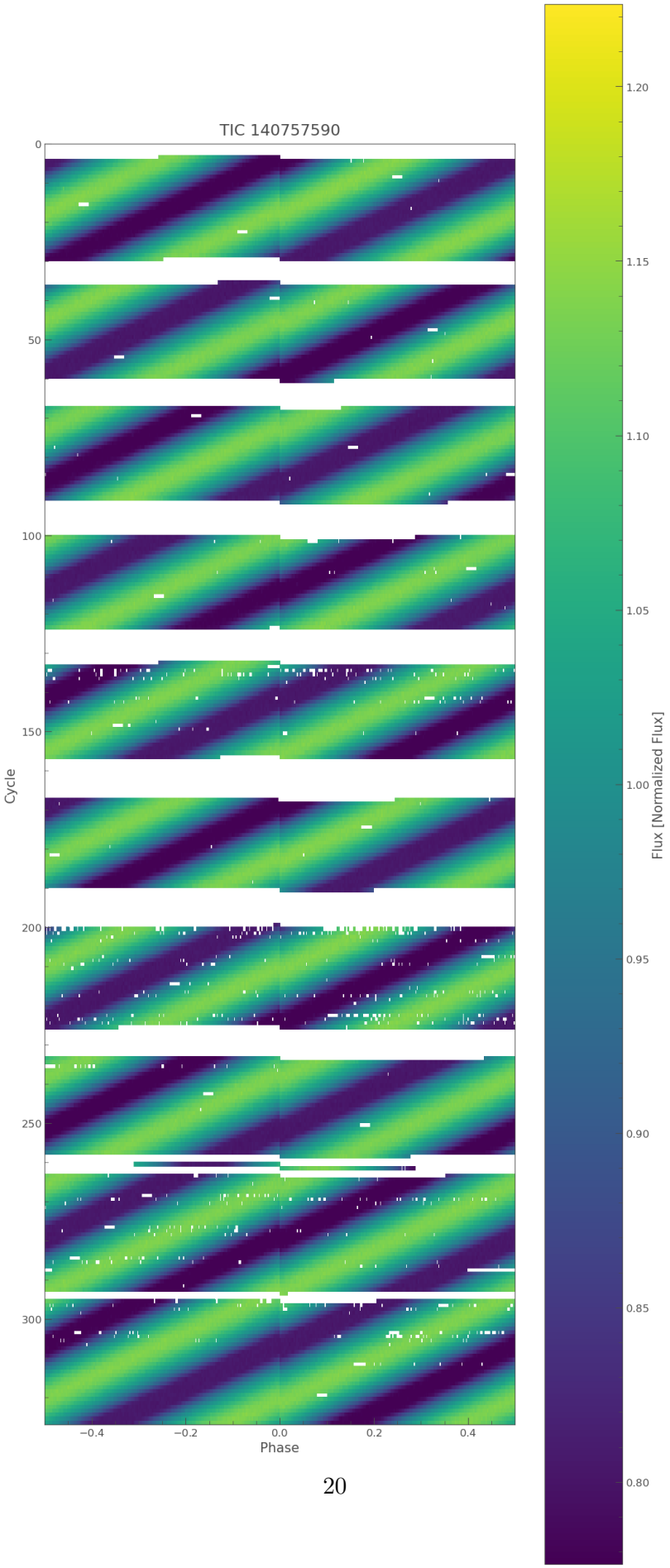
[34]:
```
<AxesSubplot:xlabel='Phase [JD]', ylabel='Normalized Flux'>
```



Note that the filter introduces caldera-like features near the eclipses

[26]:
```
p, t0 = 0.426, 1544.571
folded_lc = lc.fold(period=p, epoch_time=t0)lc.
 ↪fold(period=bls_period,epoch_time=t0).plot_river()
folded_lc.plot_river()
```

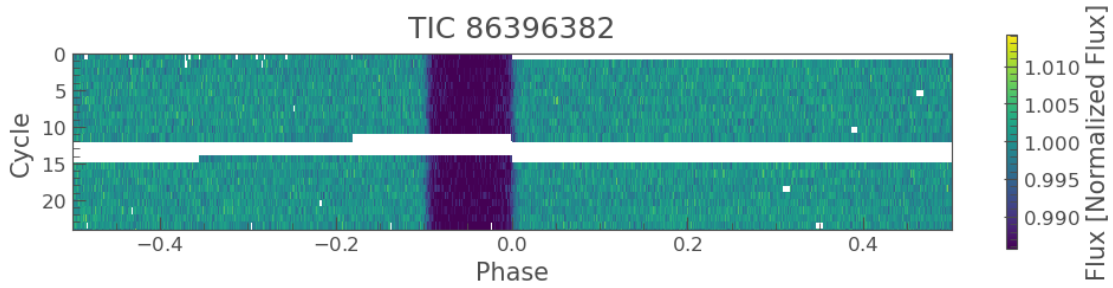
[26]: <AxesSubplot:title={'center':'TIC 140757590'}, xlabel='Phase', ylabel='Cycle'>


TIC 140757590
Cycle
Phase
Flux [Normalized Flux]
0
50
100
150
200
250
300
−0.4
−0.2
0.0
0.2
0.4
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80

WASP-12b

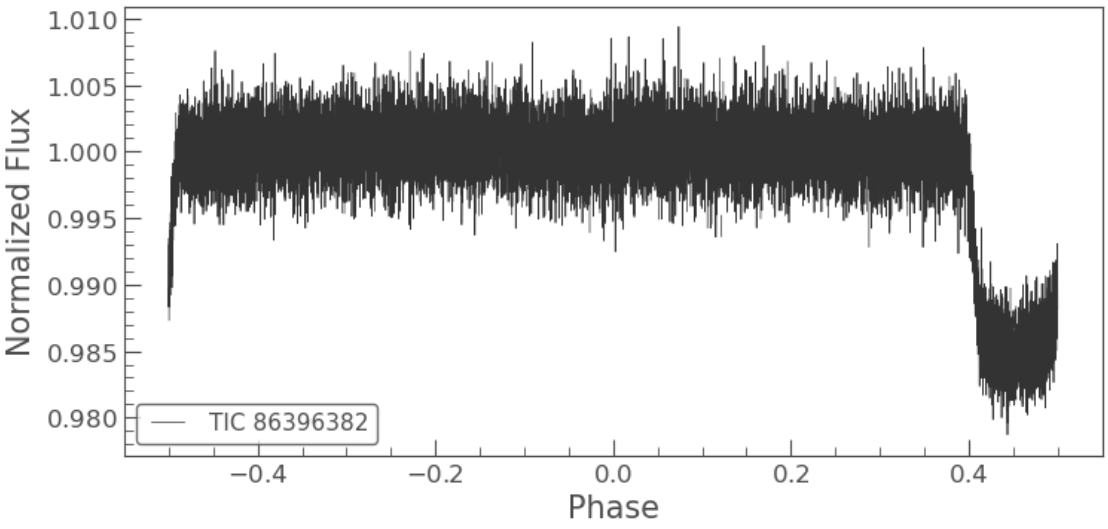
[89]:
```
# downloading
search_results = lk.search_lightcurve('TIC 86396382', radius=None,
                                      exptime='short', cadence=None,
                                      mission='TESS', author='SPOC',
                                      quarter=None, month=None,
                                      campaign=None,
                                      sector=(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26),
                                      limit=None)

lc = search_results.download_all(quality_bitmask='default', download_dir=None,
cutout_size=None)
lc = lc.stitch()

lc.fold(period=1.09141937).plot_river()
# plt.savefig('wasp12_riverplot.eps',dpi=200)
```

[89]: <AxesSubplot:title={'center':'TIC 86396382'}, xlabel='Phase', ylabel='Cycle'>



[69]:
```
lc.fold(period=1.09141937,normalize_phase=True).plot()
```

[69]: <AxesSubplot:xlabel='Phase', ylabel='Normalized Flux'>


1.010
1.005
1.000
0.995
0.990
0.985
0.980
Normalized Flux
TIC 86396382
−0.4
−0.2
0.0
0.2
0.4
Phase