elfin_energy_flux

November 27, 2024

1 How much did the > 50 keV electrons contribute to the atmospheric energy flux?

[68]:
```
import matplotlib.pyplot as plt
from mpl_toolkits.axes_grid1.axes_divider import make_axes_locatable
import matplotlib.colors
import numpy as np

import pad
```

[2]:
```
time_range = ('2022-09-04T04:18:00', '2022-09-04T04:23:00')
kev_erg_factor = 1.6E-9  # The conversion factor from KeV to egs.
precipitation_solid_angle = 2*np.pi
```

[ ]:
```
pad_obj_eflux = pad.EPD_PAD(
    'a', time_range, start_pa=0, min_counts=None, accumulate=1,␣
  ↪spin_time_tol=(2.5, 12),
    lc_exclusion_angle=10, nflux=False
)
```

```
C:\Users\shumkms1\Documents\research\pad\src\pad\analysis\_pad.py:393:
UserWarning: The BLC/DLC ratios are all NaNs. This could be due to the
lc_exclusion_angle excluding all pitch angles sampled.
  warnings.warn(
C:\Users\shumkms1\Documents\research\pad\src\pad\analysis\_pad.py:400:
RuntimeWarning: invalid value encountered in divide
  (self.blc_std/self.blc)**2 +
```

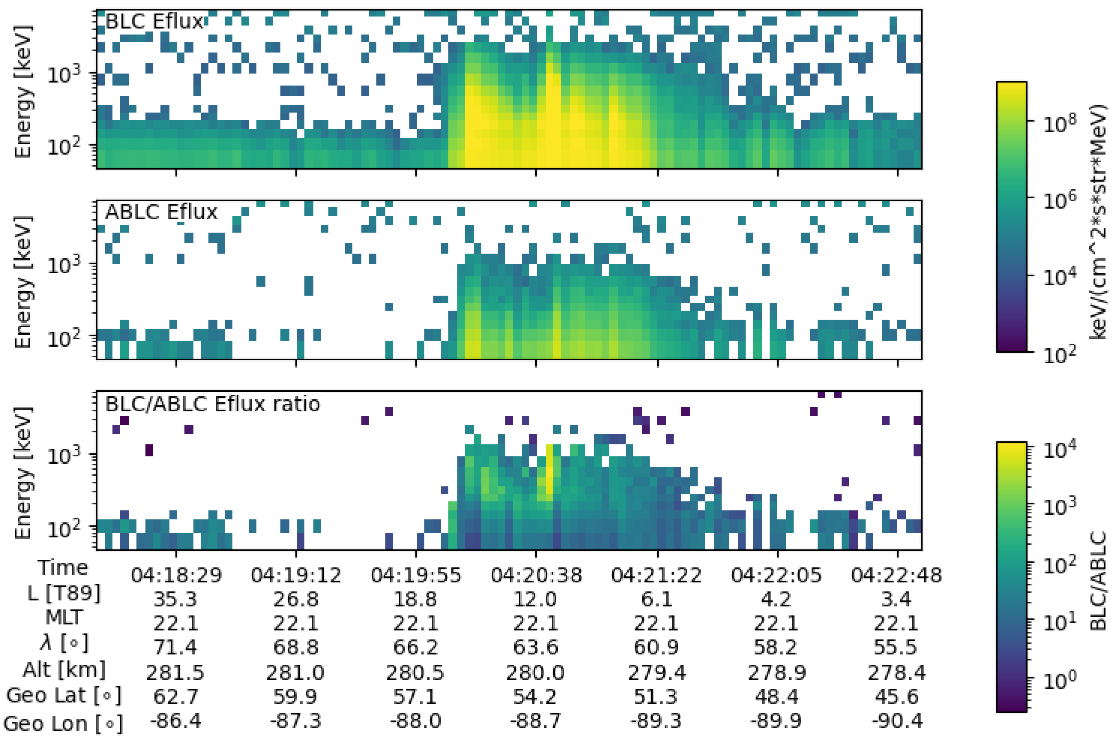
1.1 Plot the BLC and ABLC energy fluxes

Let's compare the amount of energy flux that disspiated in the atmosphere vs made it back out?

[38]:
```
fig, ax = plt.subplots(3, 1, sharex=True, figsize=(10, 6))
p = ax[0].pcolormesh(
            pad_obj_eflux.pad.time,
            pad_obj_eflux.energy,
            pad_obj_eflux.blc.T,
            shading='nearest',
```

```python
            norm=matplotlib.colors.LogNorm(vmin=1E2, vmax=1E9)
            )
p2 = ax[1].pcolormesh(
            pad_obj_eflux.pad.time,
            pad_obj_eflux.energy,
            pad_obj_eflux.ablc.T,
            shading='nearest',
            norm=matplotlib.colors.LogNorm(vmin=1E2, vmax=1E9)
            )
p3 = ax[2].pcolormesh(
            pad_obj_eflux.pad.time,
            pad_obj_eflux.energy,
            pad_obj_eflux.blc.T/pad_obj_eflux.ablc.T,
            shading='nearest',
            norm=matplotlib.colors.LogNorm()
            )

pad_obj_eflux.plot_position(ax[-1])

labels = ('BLC Eflux', 'ABLC Eflux', 'BLC/ABLC Eflux ratio')
for ax_i, label in zip(ax, labels):
    ax_i.set_yscale('log')
    ax_i.set_ylabel('Energy [keV]')
    _text = ax_i.text(0.01, 0.99, label, transform=ax_i.transAxes, va='top')
    _text.set_bbox(dict(facecolor='white', linewidth=0, pad=0.1, edgecolor='k'))

fig.subplots_adjust(left=0.25, right=0.8)
cbar_ax0 = fig.add_axes([0.85, 0.5, 0.02, 0.3])
cbar_ax1 = fig.add_axes([0.85, 0.1, 0.02, 0.3])
fig.colorbar(p, cax=cbar_ax0, label=pad_obj_eflux._flux_units)
fig.colorbar(p3, cax=cbar_ax1, label='BLC/ABLC')

ax[-1].xaxis.set_major_locator(plt.MaxNLocator(7))
ax[-1].xaxis.set_label_coords(-0.04, -0.007*7)
ax[-1].xaxis.label.set_size(10)
```

```
C:\Users\shumkms1\AppData\Local\Temp\ipykernel_39128\3583179850.py:19:
RuntimeWarning: divide by zero encountered in divide
  pad_obj_eflux.blc.T/pad_obj_eflux.ablc.T,
C:\Users\shumkms1\AppData\Local\Temp\ipykernel_39128\3583179850.py:19:
RuntimeWarning: invalid value encountered in divide
  pad_obj_eflux.blc.T/pad_obj_eflux.ablc.T,
```



>10x of the >50 keV energy flux was dissipated in the atmosphere. In other words, less than 10% of the energy flux made it back out.

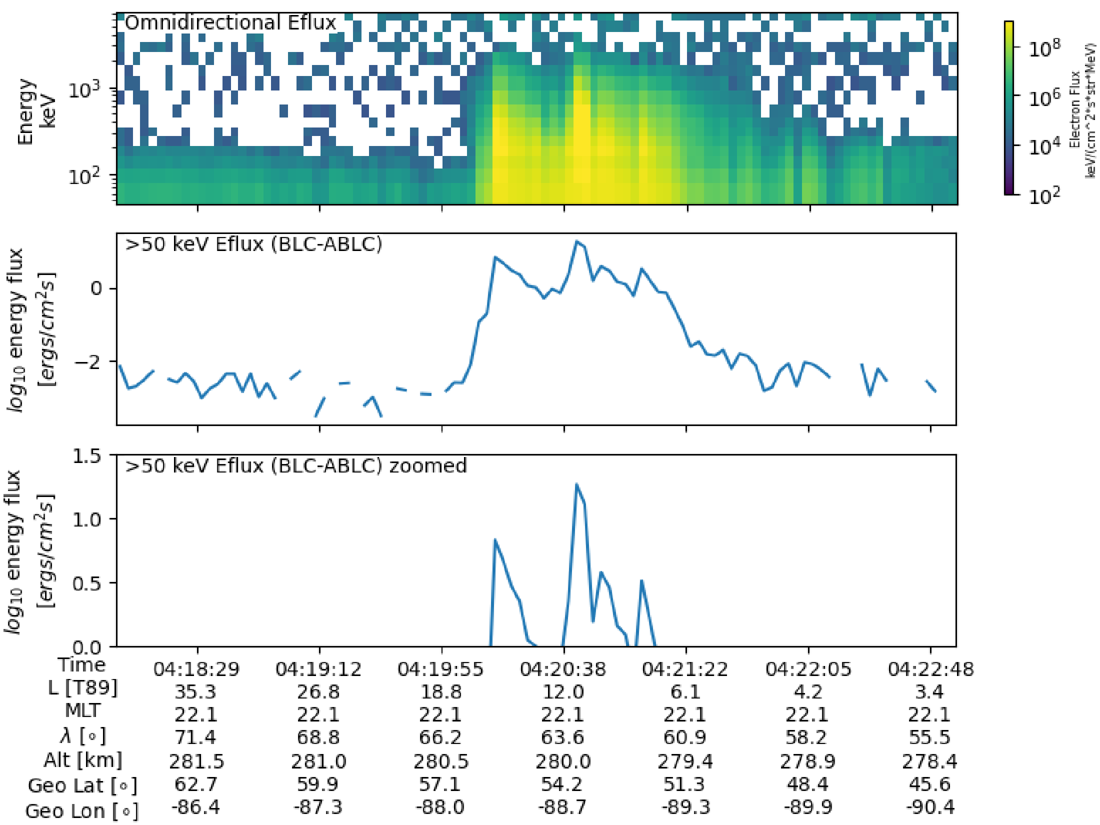
1.2 What was the $>50keV$ energy flux that ELFIN observed

[58]:
```
energy_widths_mev = (pad_obj_eflux.energy_widths[:, 1]-pad_obj_eflux.
    ↪energy_widths[:, 0])/1E3
eflux_ergs = kev_erg_factor*precipitation_solid_angle*(pad_obj_eflux.blc -␣
    ↪pad_obj_eflux.ablc)*energy_widths_mev
relativistic_eflux = np.nansum(eflux_ergs, axis=1)
```

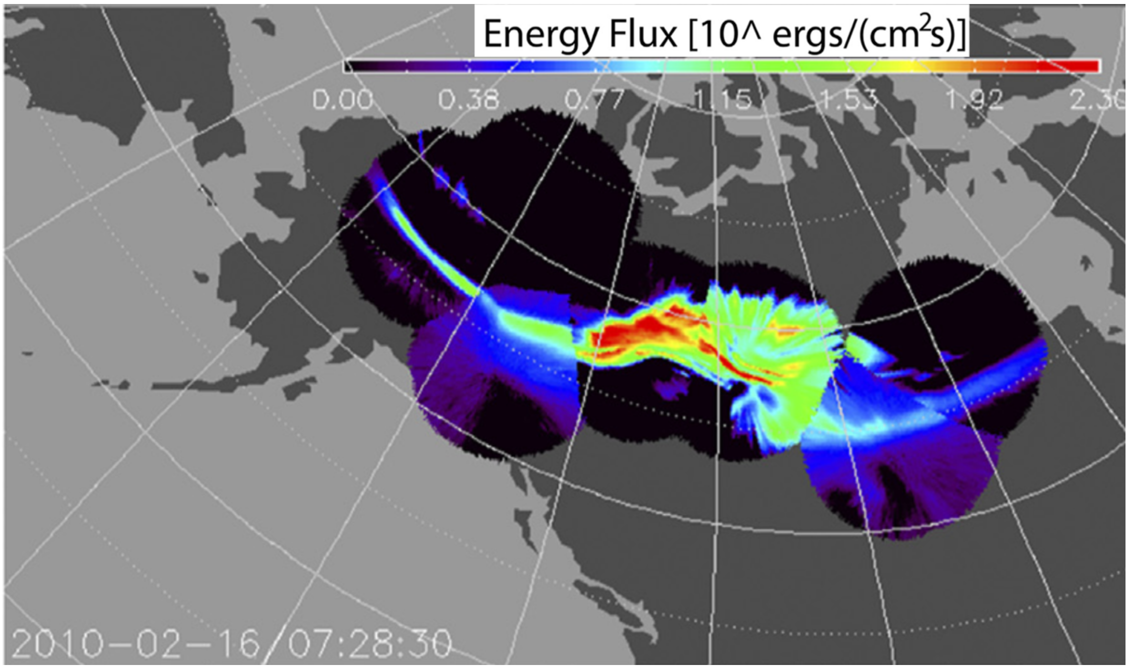
[74]:
```
fig, bx = plt.subplots(3, 1, sharex=True, figsize=(8, 6))
pad_obj_eflux.plot_omni(bx[0], labels=True, colorbar=True, vmin=1E2, vmax=1E9,␣
    ↪pretty_plot=False, fraction=0.05)
bx[1].plot(pad_obj_eflux.pad.time, np.log10(relativistic_eflux))
bx[2].plot(pad_obj_eflux.pad.time, np.log10(relativistic_eflux))
pad_obj_eflux.plot_position(bx[-1])
bx[-1].xaxis.set_major_locator(plt.MaxNLocator(7))
bx[-1].xaxis.set_label_coords(-0.04, -0.007*7)
bx[-1].xaxis.label.set_size(10)

for bx_i in bx[[1, 2]]:
    bx_i.set_ylabel(f'$log_{{10}}$ energy flux\n$[ergs/cm^{{2}}s]$')
```

```
    divider = make_axes_locatable(bx_i)
    cax = divider.append_axes("right", size="10%", pad=0.08)
    cax.remove()
bx[-1].set_ylim(0, None)

labels = ('Omnidirectional Eflux', '>50 keV Eflux (BLC-ABLC)', '>50 keV Eflux␣
 ↪(BLC-ABLC) zoomed')
for ax_i, label in zip(bx, labels):
    _text = ax_i.text(0.01, 0.99, label, transform=ax_i.transAxes, va='top')
    _text.set_bbox(dict(facecolor='white', linewidth=0, pad=0.1, edgecolor='k'))
plt.tight_layout()
```

```
C:\Users\shumkms1\AppData\Local\Temp\ipykernel_39128\2665303501.py:3:
RuntimeWarning: invalid value encountered in log10
  bx[1].plot(pad_obj_eflux.pad.time, np.log10(relativistic_eflux))
C:\Users\shumkms1\AppData\Local\Temp\ipykernel_39128\2665303501.py:4:
RuntimeWarning: invalid value encountered in log10
  bx[2].plot(pad_obj_eflux.pad.time, np.log10(relativistic_eflux))
```



While the plasma sheet energy flux was very low, the IB and radiation belt precipitation contibuted between 1-13 ergs/(cm^2 s). This is not too different from the Gabrielse+2021 results (the greem stuff). However, our results are harder to compare with Newell+2009, but Newell's bottom panel of Fig. 5 shows a higher diffuse aurora energy flux during active times.



How does the > 50 keV energy flux compare to the auroral energy flux? This seems like a tossup.