

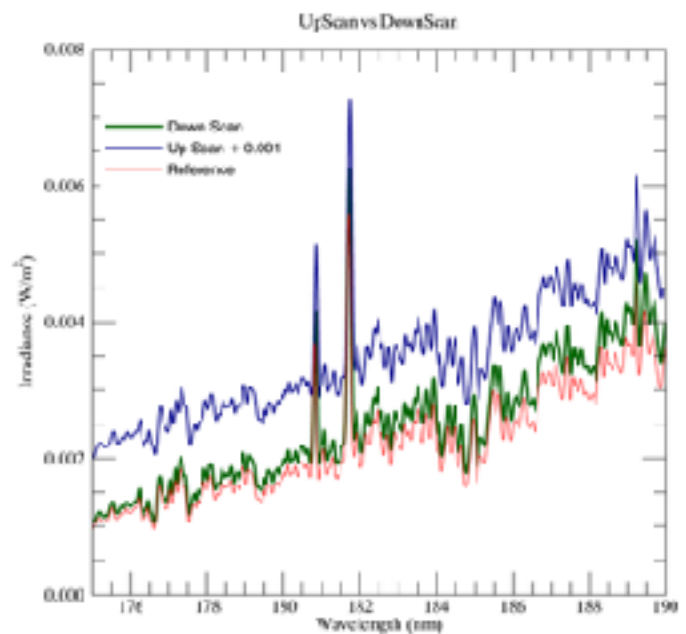
**Please calculate the irradiance in watts/m<sup>2</sup> and compare the scan data. Provide plots of your results along with your code. Specifically, plot the region around the two emission lines at ~180nm. Also, calculate the ratio of each scan wrt the reference spectrum and plot the results.**

All code is in IDL and is provided via this git repository: [https://github.com/spenton/SORCE\\_penton.git](https://github.com/spenton/SORCE_penton.git). The conversion from telemetry to irradiance in watts/m<sup>2</sup> involves the following steps:

**Read the raw telemetry:** The routine `get_telem.pro` is an IDL routine to read the provided telemetry ascii file for each of the 5 orbits. It calls a base routine (`get_instrumentTelemetry.pro`) then uses the input start and end times to parse the full telemetry structure. An IDL structure with all telemetry items of interest is returned. As described in the instructions, the routine `gp_to_wave.pro` converts from grating position to wavelength.

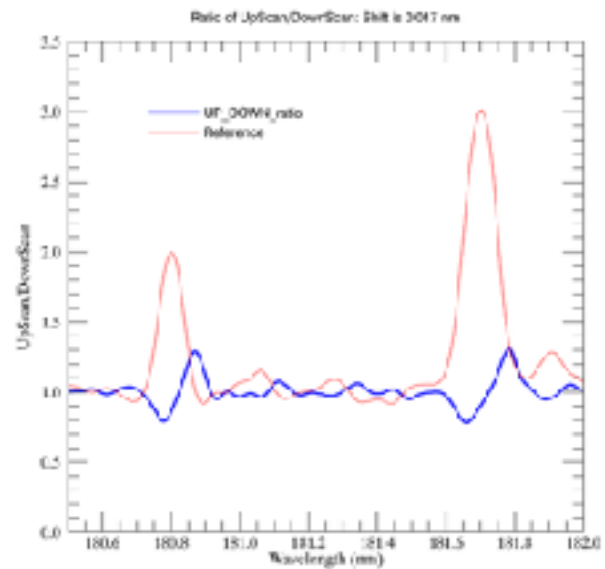
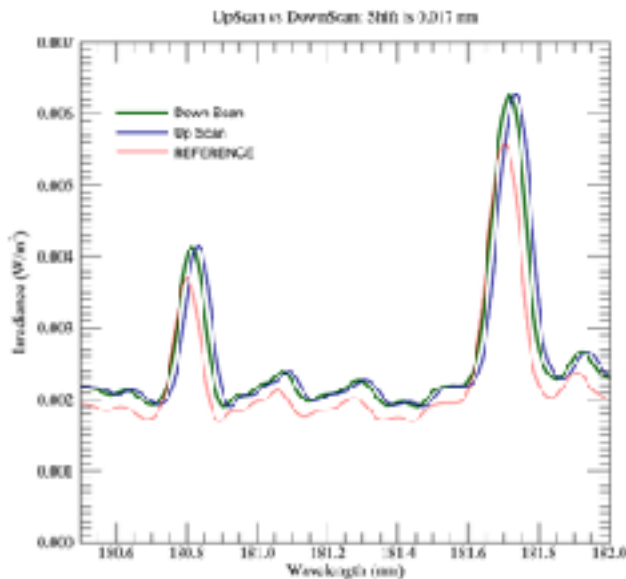
### **Determine Irradiance<sup>1</sup>:**

Watt/m<sup>2</sup> is obtained by using the energy (in J) per photon (`get_energyperphoton.pro`) and the number of photons per cm<sup>2</sup> per second per nm (`get_ph_per_s_cm2_nm.pro`), assuming a wavelength independent area of 0.01 cm<sup>2</sup>. These routines determine the bin size (dispersion) from the telemetry to convert between irradiance and spectral irradiance (irradiance/nm). To the right is a comparison of the Up vs Down Scan Data (the Down Scan Data has been shifted up).



<sup>1</sup> The units of the reference spectrum (irradiance; watts/m<sup>2</sup>) seem odd to be. I am accustomed to units of flux (ergs/s/cm<sup>2</sup>/Å), so I was expecting spectral irradiance (watts/m<sup>2</sup>/nm). I've matched my units to those of the reference spectrum.

Zooming in on the Sill lines (and losing the offset), a clear shift of about 0.17 nm is obvious. A ratio of the Up/Down Scan data clearly shows the offset. Both appear to be shifted wrt the reference spectrum, 0.014 nm (Up) and 0.031 nm (Down)



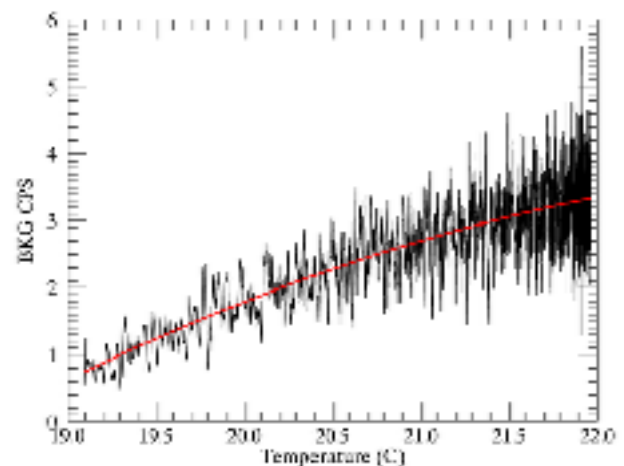
**Optional corrections :** It was unclear whether debugging this offset was part of the assignment, but I thought I would try a few basic calibrations anyway.

Return temperatures as part of the telemetry. The routines `get_detectorTemp.pro` and `get_detTemp_bytime.pro` interpolate the provided temperature data to include temperatures in the returned structure.

Add doppler correction. The routine `DOPPCORR.pro` provides a spacecraft doppler correction to the wavelengths. The routine `get_distdopp_bytime.pro` interpolates into the provided doppler data to return the appropriate doppler (and distance) factors. The doppler factor provided is assumed to be  $(1.0+v/c)$ . The assumption is backed up by the scale of the corrections ( $\sim 4$  km/s) and the maximum expected for the orbit indicated ( $\sim 8$  km/s max velocity wrt the sun).

Add distance correction. The routine `DISTCORR.pro` applies a distance correction to the counts arrays. This routine also calls `get_distdopp_bytime.pro`. It assumes that the provided distance factor is  $(R/R_0)$ , and the correction is applied as  $1./\text{distancefactor}^2$ .

Add temperature-dependent background correction. The routines `darkcorr.pro` and `get_bkgcounts_byinttime.pro` are called to interpolate the provided temperature data to and apply a temperature dependent background correction. Note that a simple parabola fit (using `POLY_FIT`) was constructed to model the background correction. This analysis can be found in `eval_darkcorr.pro`. The adopted solution was  $\text{bkg\_cps} = -69.795 + 6.119 \cdot \text{temp} - 0.127 \cdot \text{temp}^2$ , as shown in the figure.



An example of the returned final structure of `get_telem()` is:

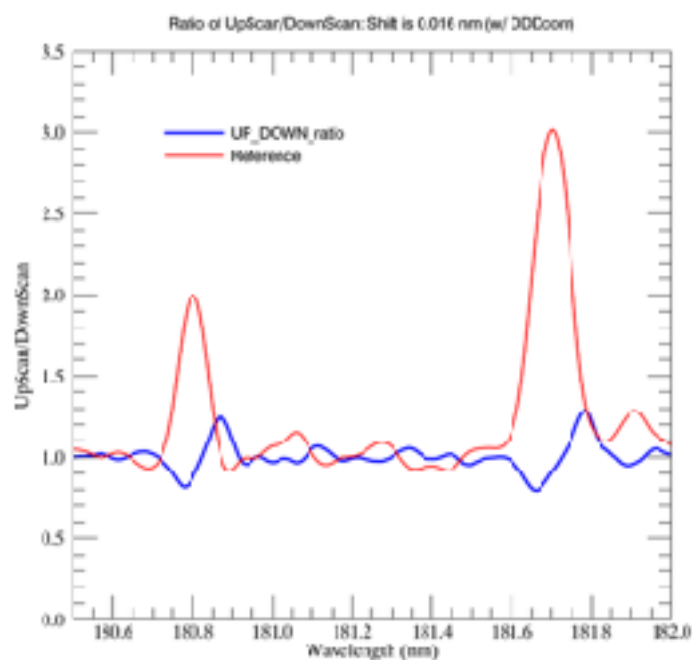
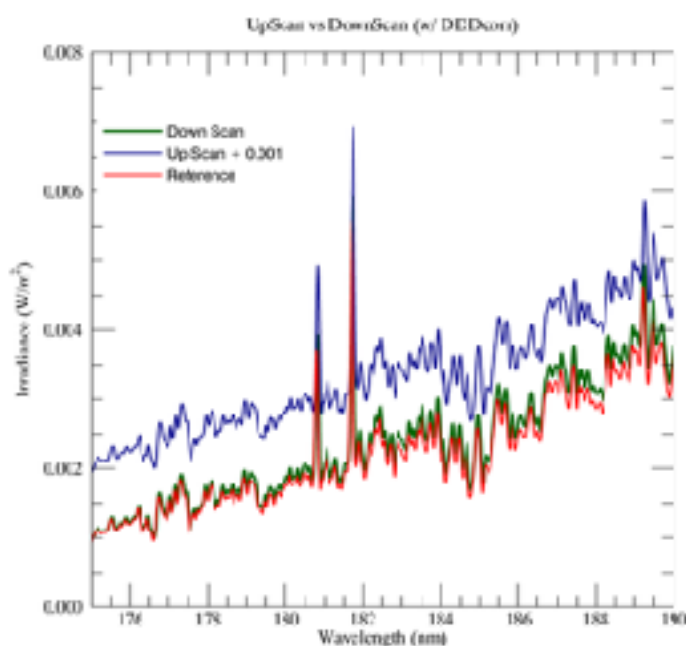
```
; EXAMPLE:
;           DownScan=[9.434134508500002E14, 9.434178736700002E14]
;           DS_telem=get_telem(DownScan,/add_darkcorr,/add_distcor,/add_doppcorr)
;           help,DS_telem,/str
;
;   START_TIME    FLOAT      9.43413e+14
;   END_TIME      FLOAT      9.43418e+14
;   TIMES_MS      DOUBLE     Array[2354]
;   TIMES_S       DOUBLE     Array[2354]
;   TIME_MS0      DOUBLE     9.4341346e+14
;   TIME_S0       DOUBLE     9.4341346e+11
;   TEMPS         DOUBLE     Array[2354]
;   GGRATPOS      FLOAT      Array[2354]
;   GWAVES        DOUBLE     Array[2354]
;   GCOUNTS       FLOAT      Array[2354]
;   IRR           DOUBLE     Array[2354]
;   WAVES         DOUBLE     Array[2354]
;   COUNTS        DOUBLE     Array[2354]
;   DELTA_WAVES   DOUBLE     Array[2354]
;   BINSIZE       DOUBLE     0.0063524922
;   DOPPCORR      INT        1
;   DWAVES        DOUBLE     Array[2354]
;   DW            DOUBLE     Array[2354]
;   DISTCORR      INT        1
;   DCOUNTS       DOUBLE     Array[2354]
;   DR            DOUBLE     Array[2354]
;   DARKCORR      INT        1
;   BKGCOUNTS    DOUBLE     Array[2354]
;   BKG           DOUBLE     Array[2354]
;   INTTIME_S     FLOAT      Array[2354]
;   EDGE_TRIM     INT        2
```

Repeating the above plots with DOPPCORR, DISTCORR, and DARKCORR enabled produces very similar results (also the offsets have all been reduced by 0.001 nm, and the flux calibration looks better).

### **What are your thoughts?**

There is a 0.016nm zero point offset in the wavelength solution at the Sill lines (185nm). Since Doppler, distance, and dark corrections did not move the shift between the up and down scans, a simple zero point shift doesn't solve the entire problem. My initial suspicion was that there is a thermal drift to the grating mechanism that has not been accounted for. The QuickScan data could be used to prove this. However, unless I missed something, even though the temperature of

the QuickScan orbit was identical to the other orbits, I don't see any drift of the required magnitude of the wavelength solution wrt time (but I did see some residual doppler corrections that I must not be catching).



My next guess would be some hysteresis due to the change in scan direction, but I have no data to examine this hypothesis.

