Photoionsation and Photoelectron ionosation rate calcualtions for NRL new bins for X-rays

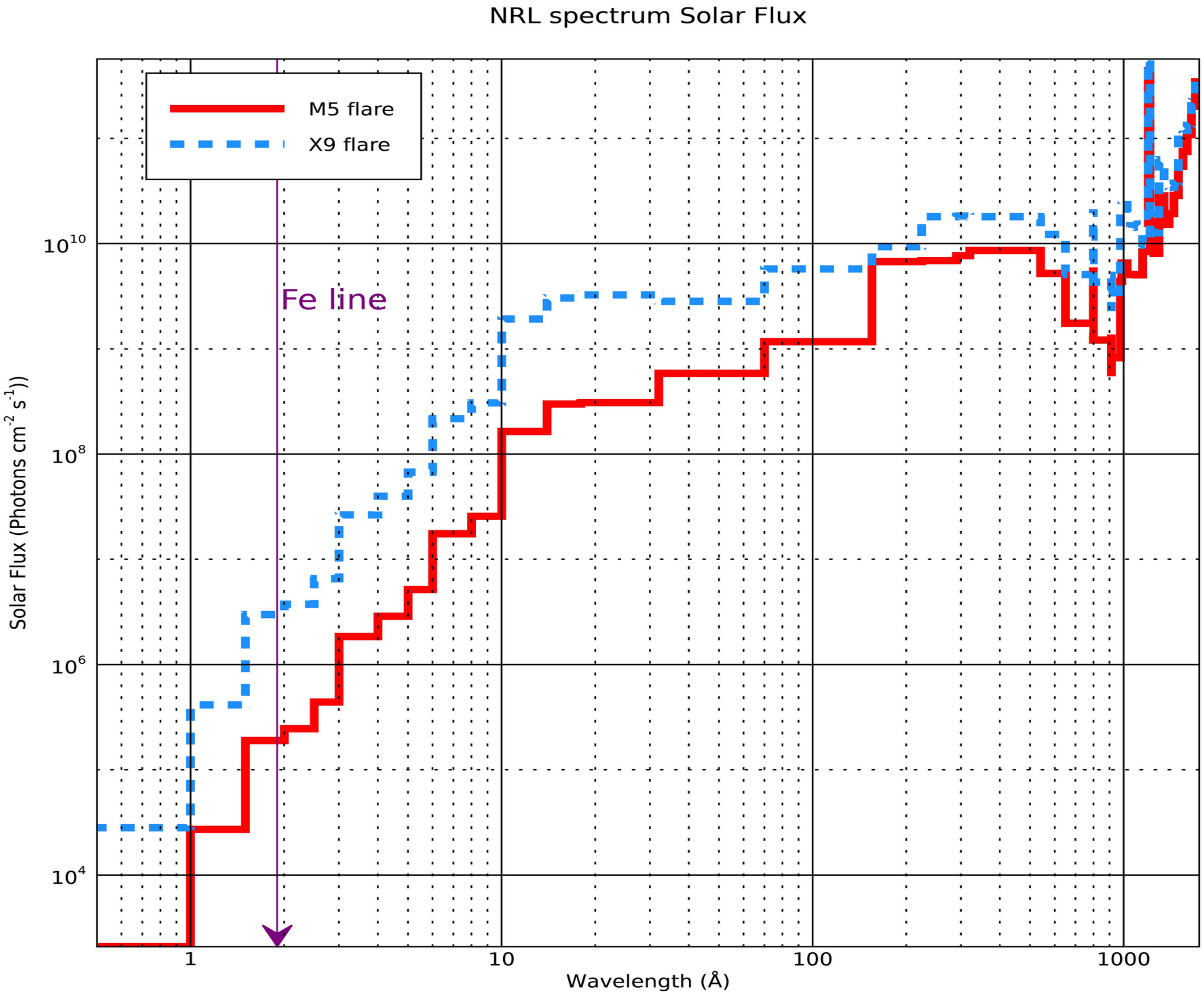
NRL Spectra

1.This is the NRL spectra for two flares m5 and x9.

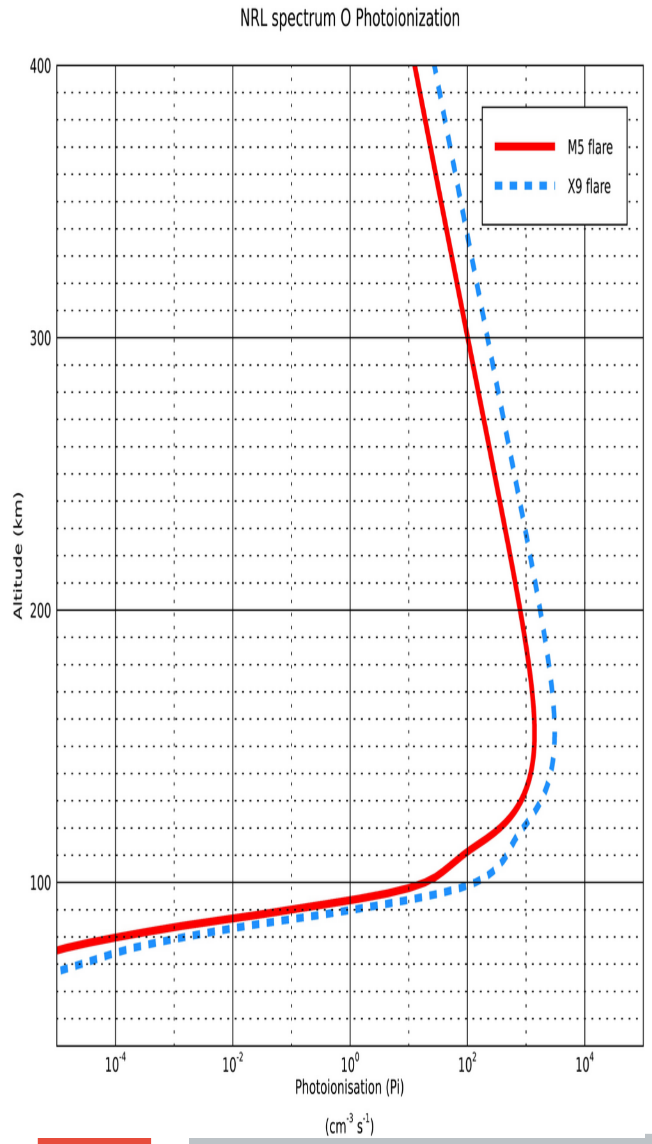
2. The binning procedure for xray flare ionization parameterization (Done by Dave) as below:
 "Break up the three shortest wavelength bins of Solomon and Qian into 12 higher resolution bins. Bins to be expanded are the 0.5-4 A, 4-8A and 8-18A"

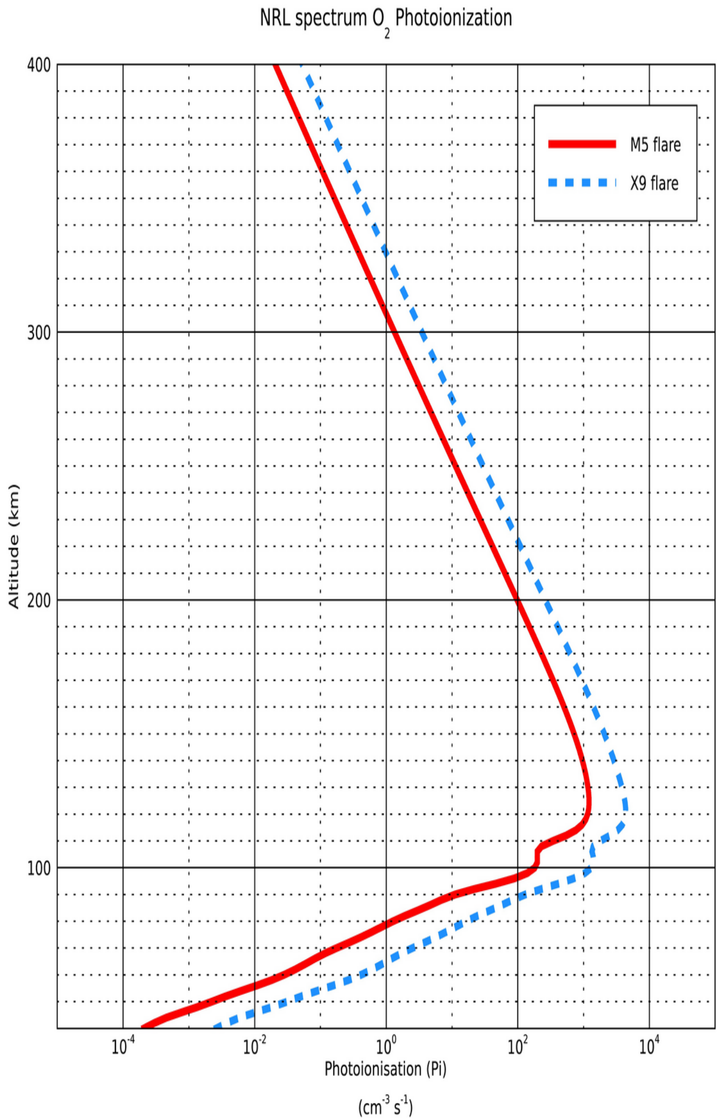
3. In the plot on the right side, I have simply plotted the two spectra.

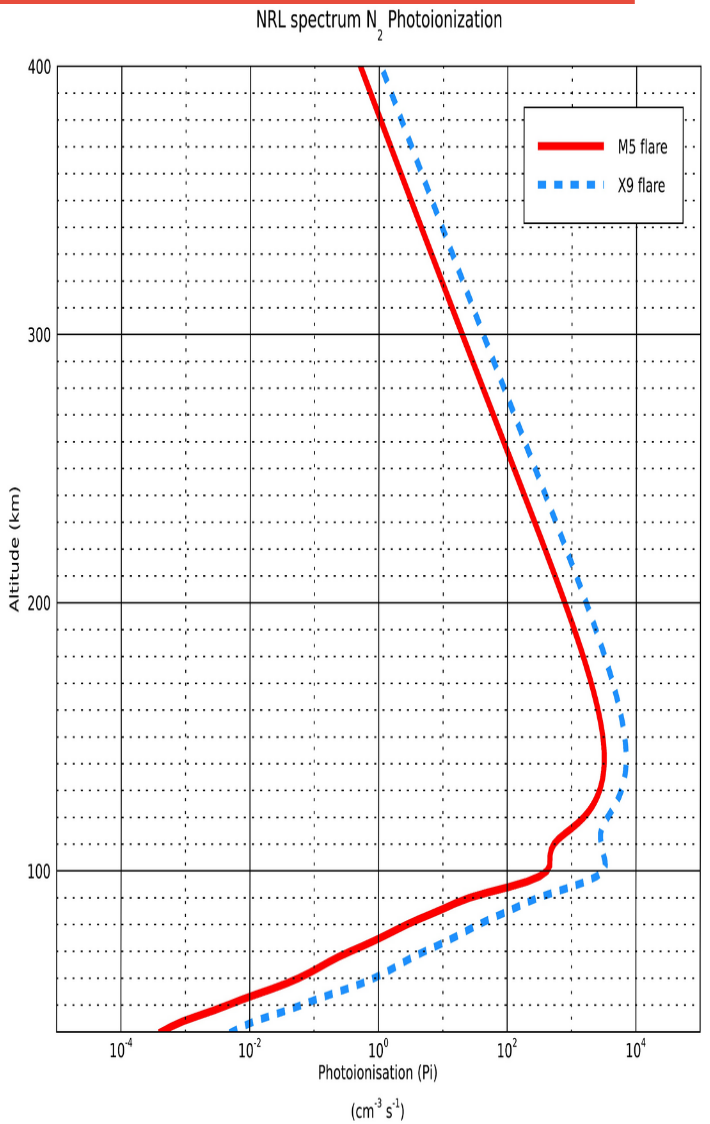
4. I have also shown the Fe XV line (1.9 A) in the plot since Dave was interested in it.



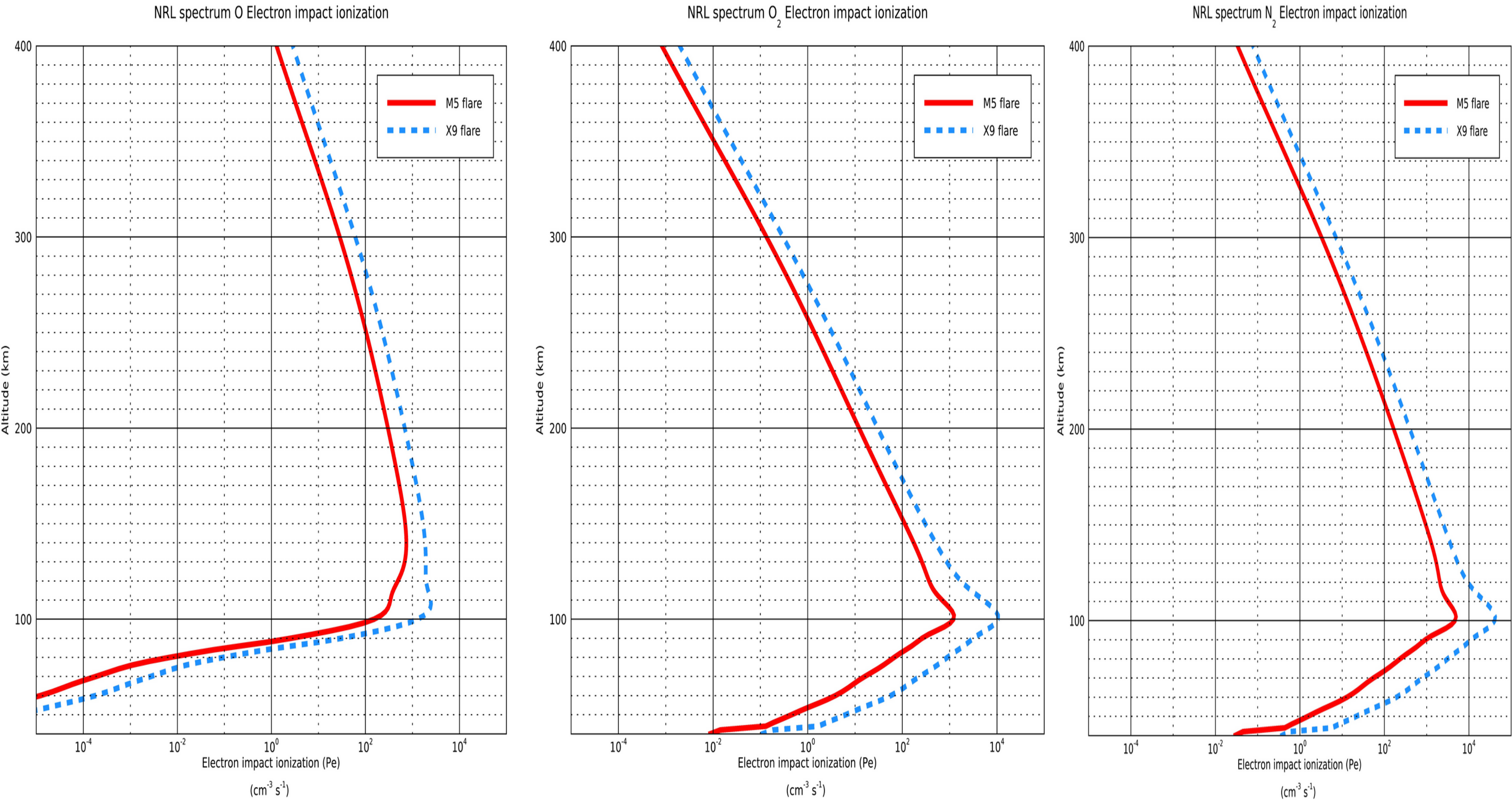
Photoionsation rates for the two spectra



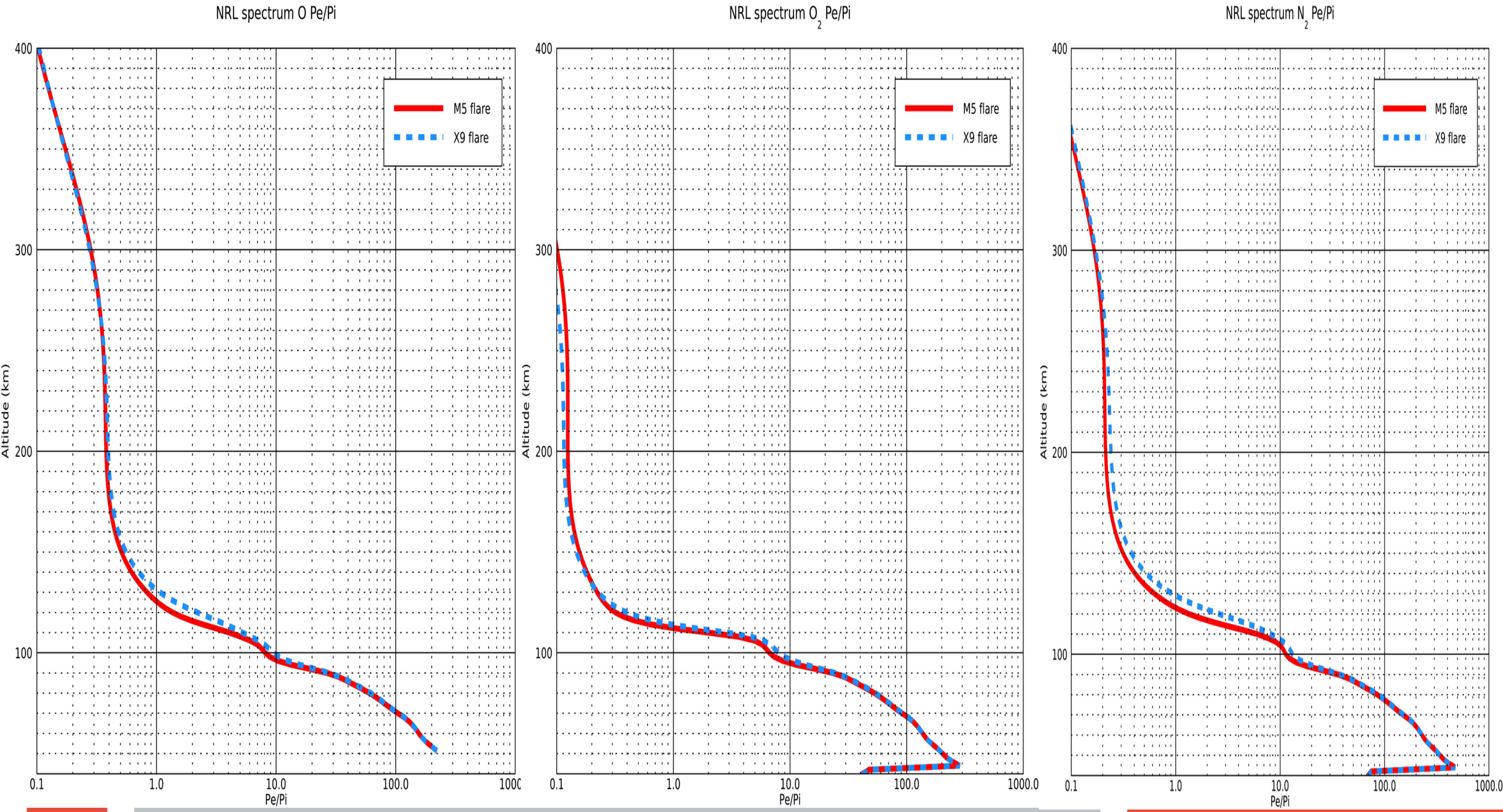




Photoelectron ionisation rates for the two spectra



Pe/Pi ratios for the two spectra



Explanation of plots of slides 3-5

1. These are the normal 3 plots that I always do:
a. Photoionisation rates (Pi)
b. Photoelectron ionisation rates (Pe)
c. Pe/Pi ratios

2. Basically, the x9 flare is stronger than the m5 flare, so the Pi and the Pe are larger for the x9, which is expected

3. Last time, there was a problem when I was checking with SQ’05 and SQ’05 + Fe line (supplied by Dave). I was supposed to get more Pe and Pi for the latter case,since there was an added Fe line, but I did not.
That was mainly because the NRL spectra did not have the same binning as the SQ’05 paper, but I had taken the cross-sections given in the paper and so the results were not correct.

4. Here the results are correct because with more solar flux, I am getting increased photoionisation and photoelectron production.

Dave’s Calcualtion

Dave used the Henke and Fennelly cross-sections to calculate the N2 absorption cross-sections and altitude where optical depth tau=1 for each of the solar flux bins from 0.5-18 A.
This is what he had given:

“The n2 cross section comes from Henke where I doubled the atomic nitrogen values they give to get N2. A test of this at 23.5 angstroms gave 7.95E-19 cm -2 and at 24 angstrom, 8.3E-19 cm-2 and Judy Fennelly’s table has 8E-19 at 23.7 angstroms. The altitudes are derived from assuming an exponential density with constant scale height (= 7 km) and solving tau = 1 = n(z)*sigma*H, for z. Overhead sun is assumed. If there is a 60 degree zenith angle, the altitudes of tau =1 go up by 5 km or so. The selection of bins gives roughly 5 km resolution between 60-100 km”

Bin #	min λ	max λ	Mean λ (A)	Mean σ_{N2abs} (mega-barns)	Alt of tau=1 (km)
1	0.5	1	0.75	2.48e-5	43
2	1	1.5	1.25	1.47e-4	55.5
3	1.5	2	1.75	4.57e-4	63.5
4	2	2.5	2.25	1.02e-3	69.1
5	2.5	3	2.75	1.9e-3	73.3
6	3	4	3.5	4.0e-3	78.7
7	4	5	4.5	8.55e-3	84
8	5	6	5.5	1.55e-2	88.1
9	6	8	7	3.12e-2	93
10	8	10	9	6.32e-2	98
11	10	14	12	0.14	103.5
12	14	18	16	0.30	109

Results of the Model- M5 flare

Slides (8-11) are the results from the model. The N_2 data can be compared to the calculated results (slide 7).

1. This slide contains the results for O_2 for the M5 flare spectra, for the first twelve wavelength bins.

2. The 5th column is the O_2 absorption cross-section for the corresponding bin that is obtained from the Henke and Fennely cross-sections data

3. The 6th column is the altitude where the optical depth tau=1. Here the optical depth is the one that I got by summing over all the species, so it will be same for all the species

O2 data						
Bin #	λ min (A)	λ max (A)	Mean λ (A)	Mean σ_{O2abs} (mega-barns)	Alt of tau=1 (km)	pe/pi
1	0.5	1	0.75	6.21E-05	46	334.877
2	1	1.5	1.25	2.73E-04	58	186.124
3	1.5	2	1.75	8.33E-04	66	130.287
4	2	2.5	2.25	1.88E-03	72	100.683
5	2.5	3	2.75	3.66E-03	76	81.520
6	3	4	3.5	6.95E-03	80	64.217
7	4	5	4.5	1.50E-02	84	48.234
8	5	6	5.5	2.66E-02	88	37.864
9	6	8	7	5.25E-02	90	28.250
10	8	10	9	1.05E-01	94	19.553
11	10	14	12	2.25E-01	100	12.568
12	14	18	16	4.71E-01	104	6.803

Results of the Model- M5 flare

1. This slide contains the results for N_2 for the M5 flare spectra, for the first twelve wavelength bins.

2. The 5th column is the N_2 absorption cross-section for the corresponding bin that is obtained from the Henke and Fennelly cross-sections data

3. The 6th column is the altitude where the optical depth tau=1. Here the optical depth is the one that I got by summing over all the species, so it will be same for all the species

4. Now you can compare this result for the cross-section and altitude of optical depth =1 with slide 7

5. Here the zenith angle is about a degree. The altitudes are pretty close to the ones calculated in slide 7 and the order of the cross-sections are also close. The altitudes from the model and the calculated model differ by about 3km. This looks like a good accuracy to me. However, I am not sure what level of accuracy we are looking for here.

6. I have also added the pe/pi ratios here, so that you can compare it to the ones in the x9 flare

N2 data						
Bin #	λ min (A)	λ max (A)	Mean λ (A)	Mean σ_{N2abs} (mega-barns)	Alt of tau=1 (km)	pe/pi
1	0.5	1	0.75	3.38E-05	46	556.789
2	1	1.5	1.25	1.49E-04	58	311.116
3	1.5	2	1.75	4.55E-04	66	217.68
4	2	2.5	2.25	1.03E-03	72	166.902
5	2.5	3	2.75	2.04E-03	76	134.385
6	3	4	3.5	3.91E-03	80	104.992
7	4	5	4.5	8.59E-03	84	77.55
8	5	6	5.5	1.56E-02	88	59.915
9	6	8	7	3.15E-02	90	43.827
10	8	10	9	6.43E-02	94	29.973
11	10	14	12	1.41E-01	100	19.07
12	14	18	16	3.02E-01	104	10.289

Results of the Model- X9 flare

1. This slide contains the results for O_2 for the X9 flare spectra, for the first twelve wavelength bins.

2. The 5th column is the O_2 absorption cross-section for the corresponding bin that is obtained from the Henke and Fennelly cross-sections data

3. The 6th column is the altitude where the optical depth tau=1. Here the optical depth is the one that I got by summing over all the species, so it will be same for all the species

4. Now you can compare this result for the cross-section and altitude of optical depth =1 with slide 8 (O_2 for M5 flare)

5.The altitude of unit optical depth is the same, which is obvious I did not change the absorption cross-sections or the column density

6. If you compare the pe/pi ratios, they are almost equal to that obtained in slide 8. So for this binning, the pe/pi ratios are stable. I think here the accuracy is pretty good.

O2 data						
Bin #	λ min (A)	λ max (A)	Mean λ (A)	Mean σ_{O2abs} (mega-barns)	Alt of tau=1 (km)	pe/pi
1	0.5	1	0.75	6.21E-05	46	334.877
2	1	1.5	1.25	2.73E-04	58	186.125
3	1.5	2	1.75	8.33E-04	66	130.288
4	2	2.5	2.25	1.88E-03	72	100.687
5	2.5	3	2.75	3.66E-03	76	81.5237
6	3	4	3.5	6.95E-03	80	64.220
7	4	5	4.5	1.50E-02	84	48.237
8	5	6	5.5	2.66E-02	88	37.864
9	6	8	7	5.25E-02	90	28.252
10	8	10	9	1.05E-01	94	19.552
11	10	14	12	2.25E-01	100	12.565
12	14	18	16	4.71E-01	104	6.802

Results of the Model- X9 flare

1. This slide contains the results for N_2 for the X9 flare spectra, for the first twelve wavelength bins.

2. The 5th column is the N_2 absorption cross-section for the corresponding bin that is obtained from the Henke and Fennelly cross-sections data

3. The 6th column is the altitude where the optical depth tau=1. Here the optical depth is the one that I got by summing over all the species, so it will be same for all the species

4. Now you can compare this result for the cross-section and altitude of optical depth =1 with slide 7 (Dave's calculations) and slide 9 (N_2 data for M5 flare)

5. The altitudes of unit optical depth results are identical to slide 9 which is the case of M5 flare for N_2

6. As discussed before, the model altitudes differ from the calculated altitudes by about 3km in most of the bins.

7. The model cross-sections are also similar to the calculated ones.

8. The pe/pi ratios for M5 and X9 flares are same

N2 data						
Bin #	λ min (A)	λ max (A)	Mean λ (A)	Mean σ_{N2abs} (mega-barns)	Alt of tau=1 (km)	pe/pi
1	0.5	1	0.75	3.38E-05	46	556.789
2	1	1.5	1.25	1.49E-04	58	311.116
3	1.5	2	1.75	4.55E-04	66	217.68
4	2	2.5	2.25	1.03E-03	72	166.908
5	2.5	3	2.75	2.04E-03	76	134.391
6	3	4	3.5	3.91E-03	80	104.998
7	4	5	4.5	8.59E-03	84	77.554
8	5	6	5.5	1.56E-02	88	59.918
9	6	8	7	3.15E-02	90	43.829
10	8	10	9	6.43E-02	94	29.971
11	10	14	12	1.41E-01	100	19.066
12	14	18	16	3.02E-01	104	10.286

Conclusions

- The main result that I wanted to check if the altitudes of unit optical depth from the calculations are close to that obtained from the model. In the calculations, it is assumed that the all the atmosphere is N_2 and also the solar zenith angle is zero degree. The model has a zenith angle of 1 degree. That hardly changes the altitudes.

- Most of the tau=1 altitudes from the model are about 3km off from the calculated values. Not sure if this accuracy will suffice.

- I also added the pe/pi ratios for N_2 and O_2 for both the M5 and X9 flares. If you compare, them, they are equal for both of the flare conditions for each species.

- Also, the plots of the spectra are added in the beginning. The X9 is the stronger flare and so the photo-ionisation and photo-electron ionisation rates are greater in the X9 flare case.

- Lastly, you can see that the pe/pi ratios for all the three species (slide 5) remain constant for the m5 and x9 flare conditions, which is the ultimate goal.