Experience with ozone X-sections and UV-RSS

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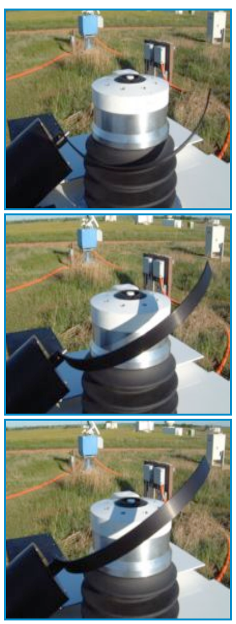
UV-RSS direct irradiance from shadowbanding

UV-RSS104 at Table Mountain, Colorado since June 2003

Deployments

10/97 Intercomparison, Table Mt., CO
Prototype NMOS: 512 pixels

09/01 Diffuse IOP, SPG, OK
05/03 Aerosols IOP, SPG, OK
06/03 Intercomparison, Table Mt., CO

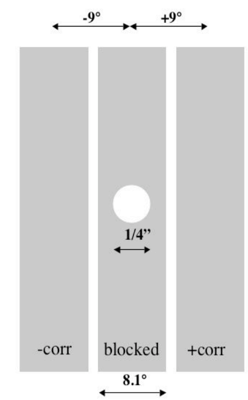


Shading of RSS105

$$I_{Diffuse} = [Unblocked - \tfrac{1}{2}(Cor^{+} + Cor^{-}) + Blocked] / A_{Diff}$$

$$I_{Direct} = [\tfrac{1}{2}(Cor^{+} + Cor^{-}) - Blocked] / A_{Dir}(\alpha,\zeta)$$

$$I_{Total} = I_{Diffuse} + I_{Direct}$$



Geometry

X-sections sources, acronyms and resolution

Bass-Paur (BP) - Jim Slusser (temperature parametrized)
Resolution=0.025nm (Liu et al. 2007)

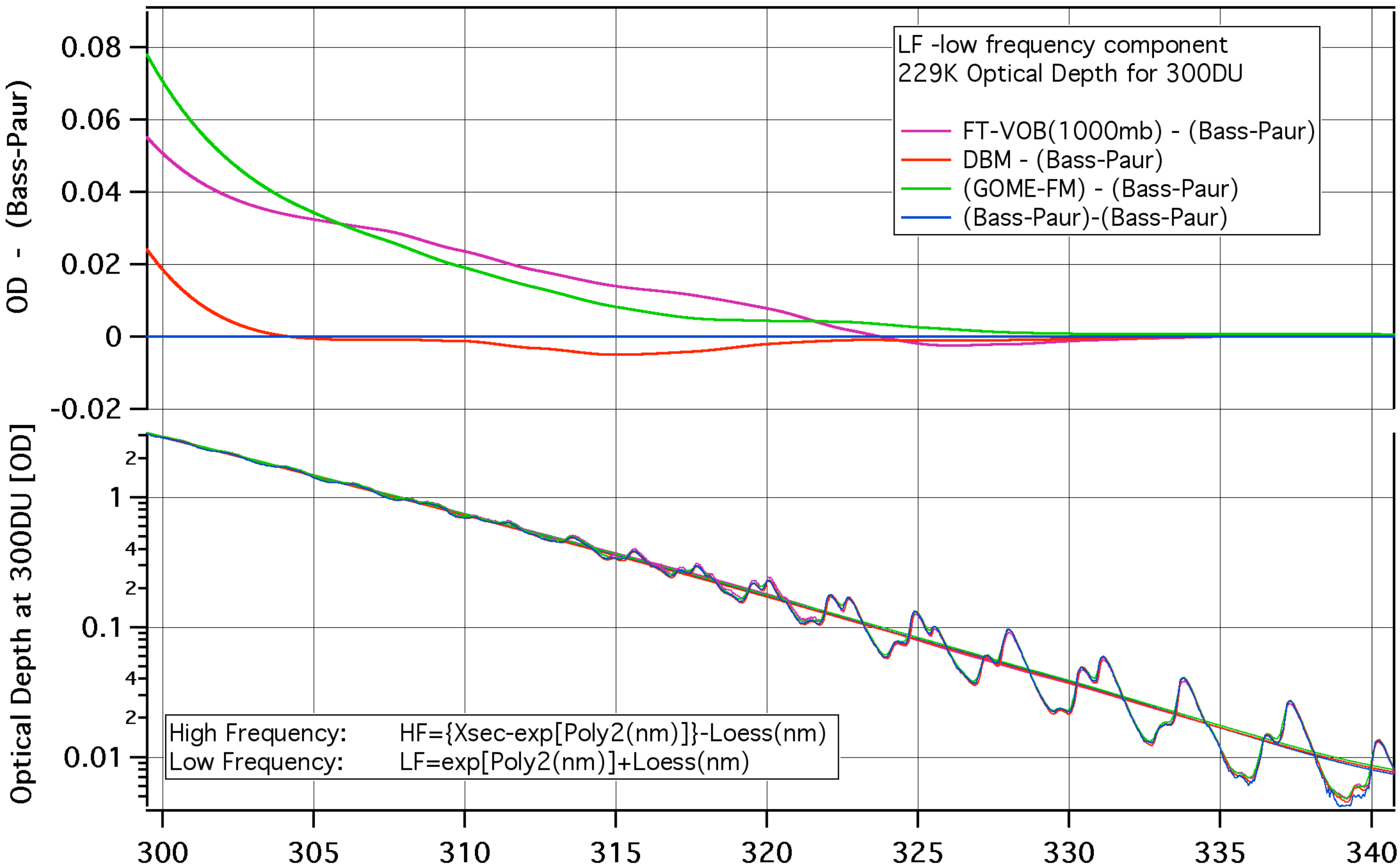
Daumont (1992)-Brion(1993)-Malicet (1995) (DBM) - web site (1)
Resolution=0.01nm (Liu et al. 2007)

Burrows et al. 1999 (GOME-FM) - web site (2)
Resolution=0.02nm (Liu et al. 2007)

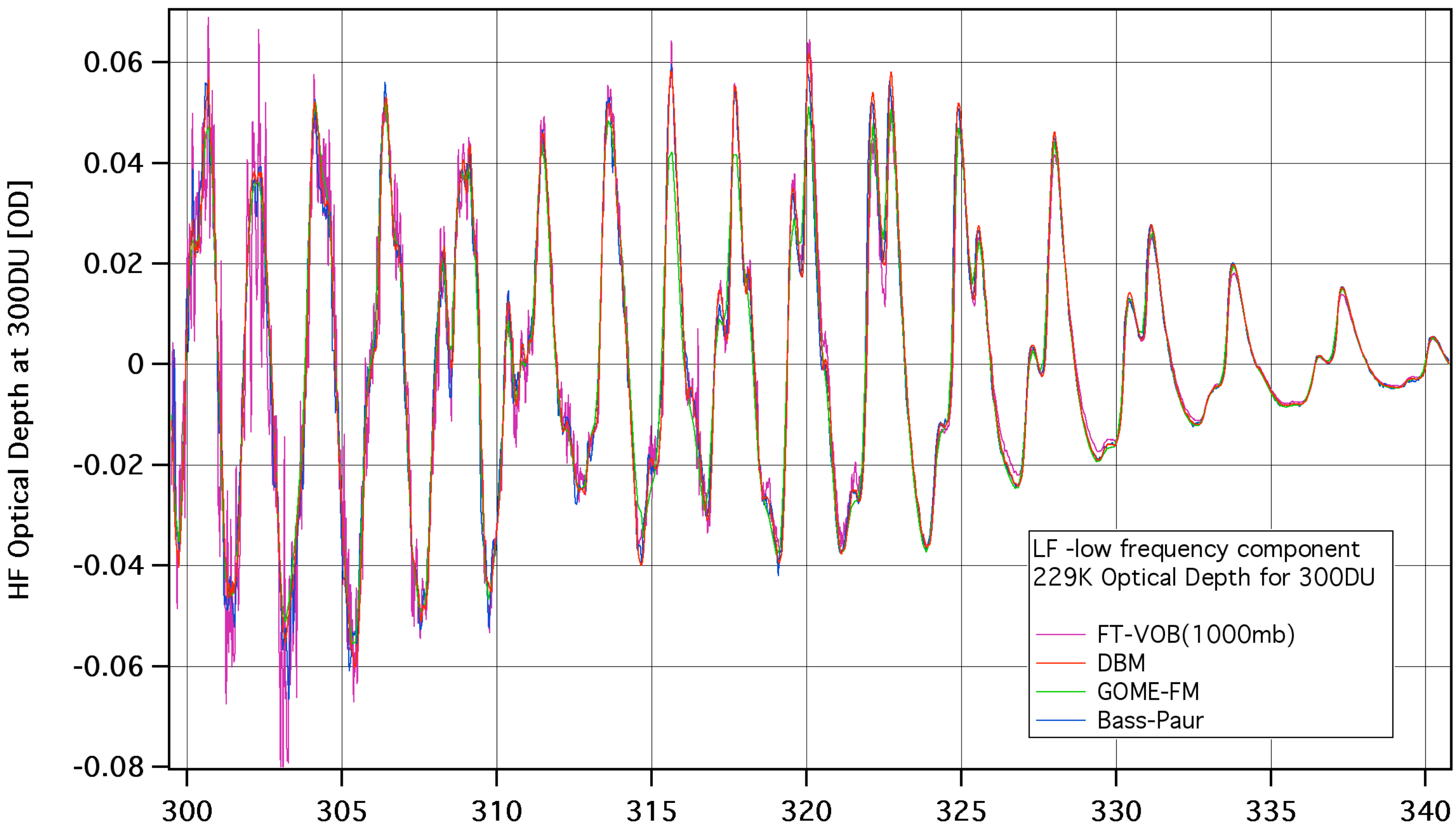
Voigt et al. 2001 (FT-VOB) - web site (2)
Resolution=5cm^{-1} (File header)

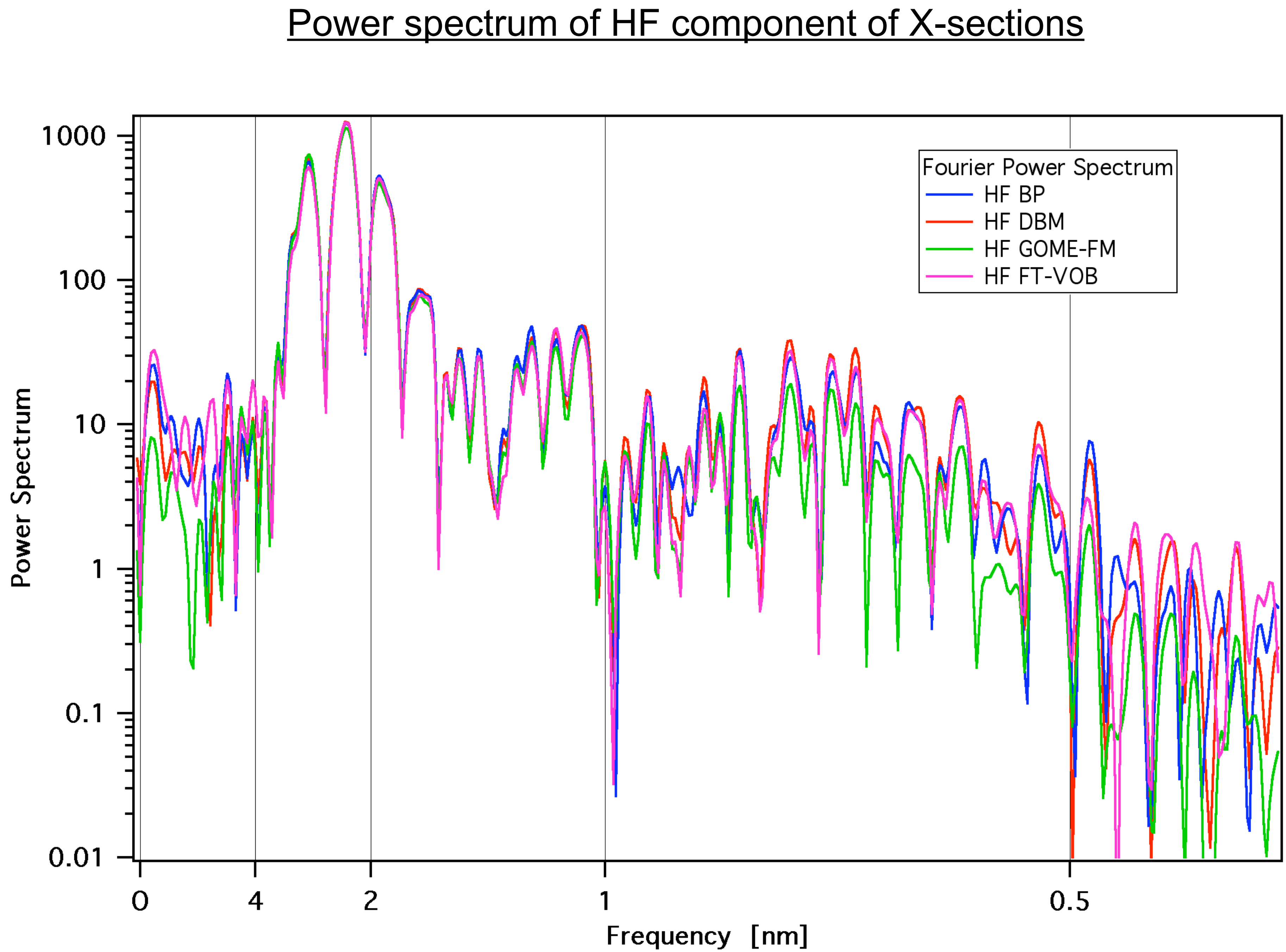
(1) MPI-Mainz-UV-VIS Spectral Atlas of Gaseous Molecules
(2) http://www.atmosphere.mpg.de/enid/c1…

Low frequency component of X-sections



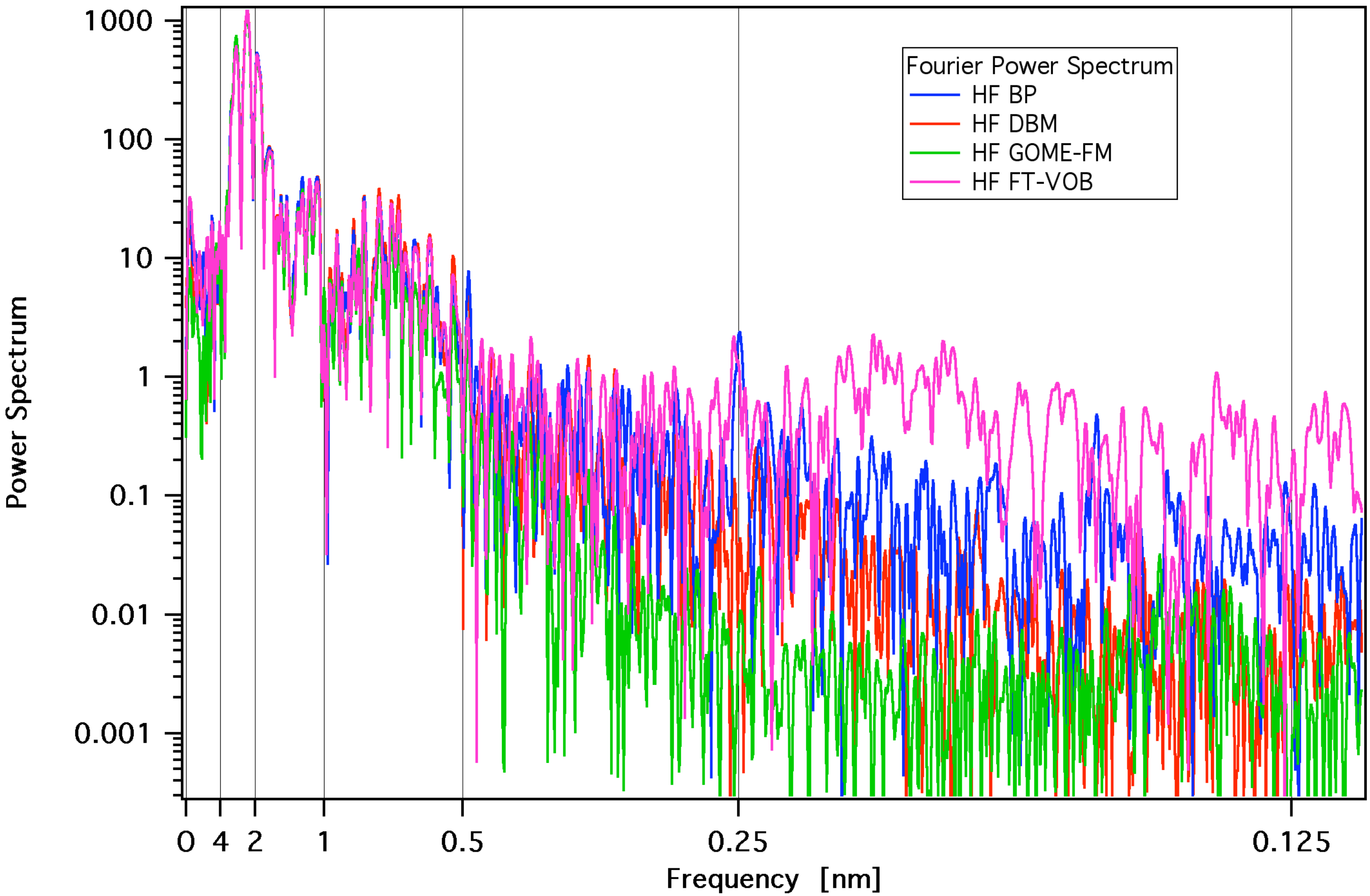
High frequency component of X-sections

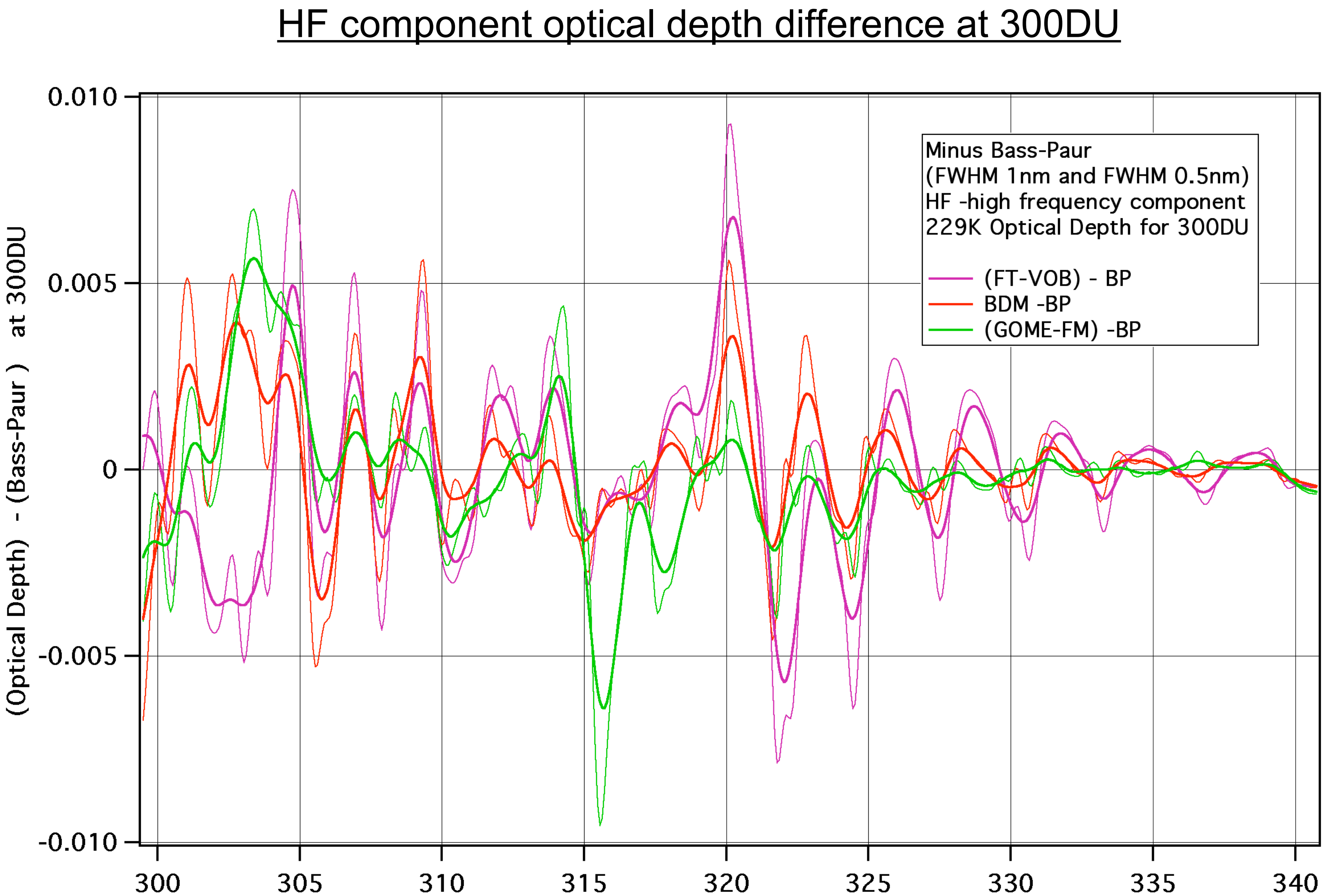




Power spectrum of HF component of X-sections
Fourier Power Spectrum
HF BP
HF DBM
HF GOME-FM
HF FT-VOB
Power Spectrum
1000
100
10
1
0.1
0.01
0
4
2
1
0.5
Frequency [nm]

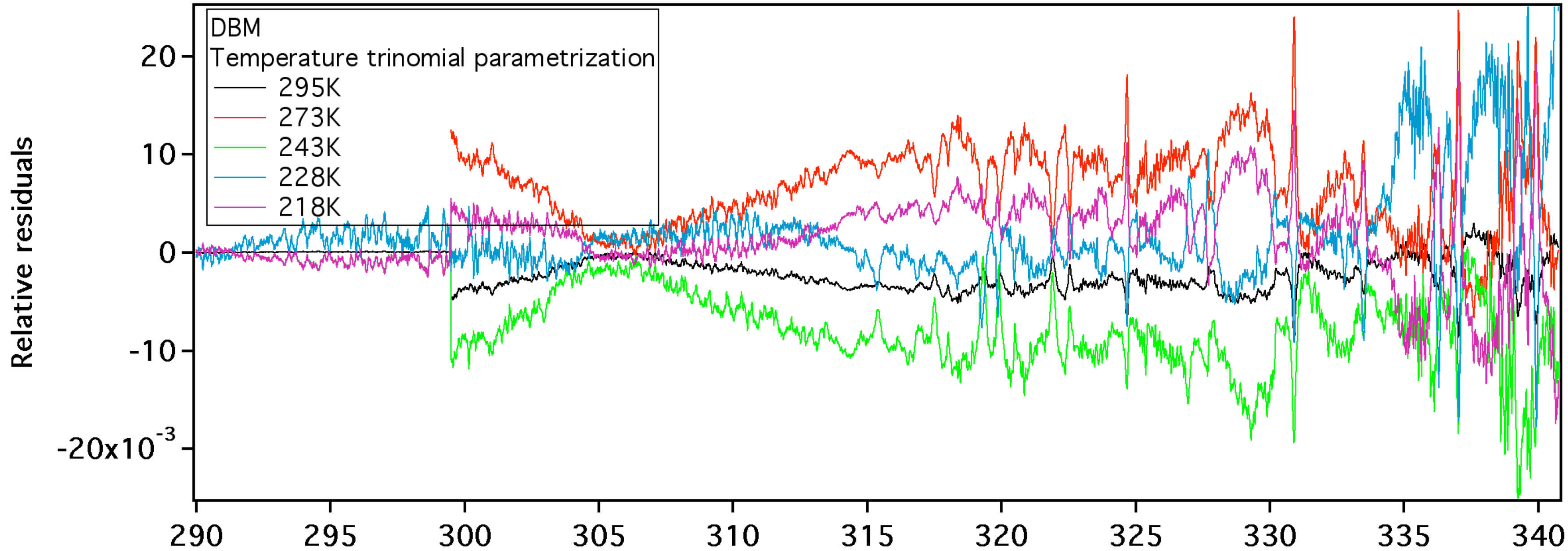
Power spectrum of HF component of X-sections

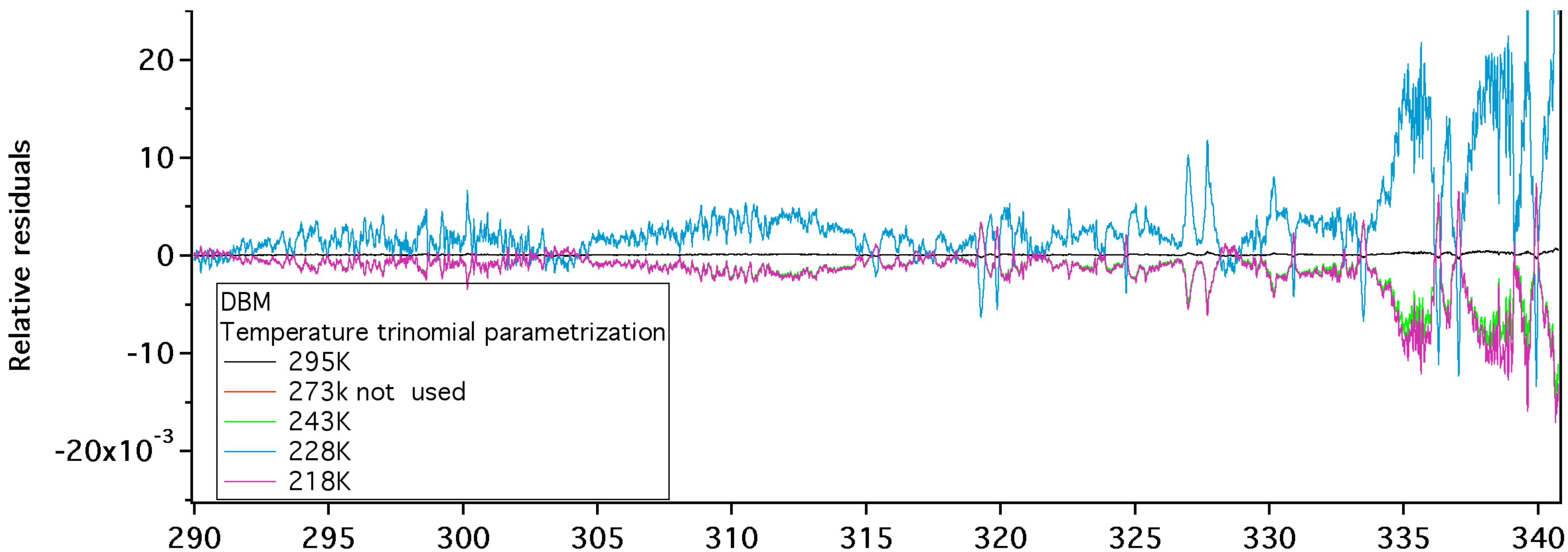




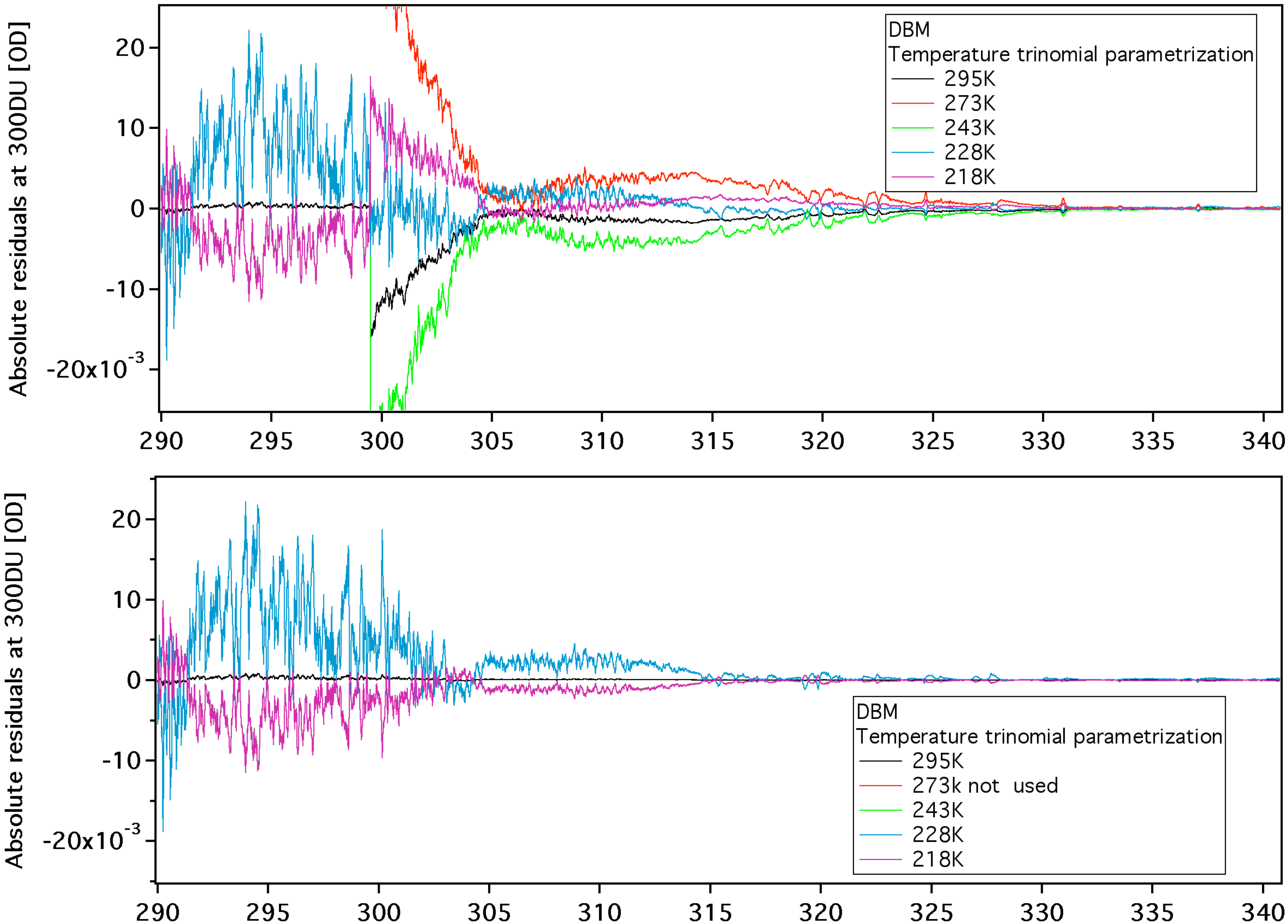
HF component optical depth difference at 300DU
Minus Bass-Paur
(FWHM 1nm and FWHM 0.5nm)
HF -high frequency component
229K Optical Depth for 300DU
(FT-VOB) - BP
BDM -BP
(GOME-FM) -BP
(Optical Depth) - (Bass-Paur) at 300DU
0.010
0.005
0
-0.005
-0.010
300
305
310
315
320
325
330
335
340

DBM trinomial fit residuals (relative)

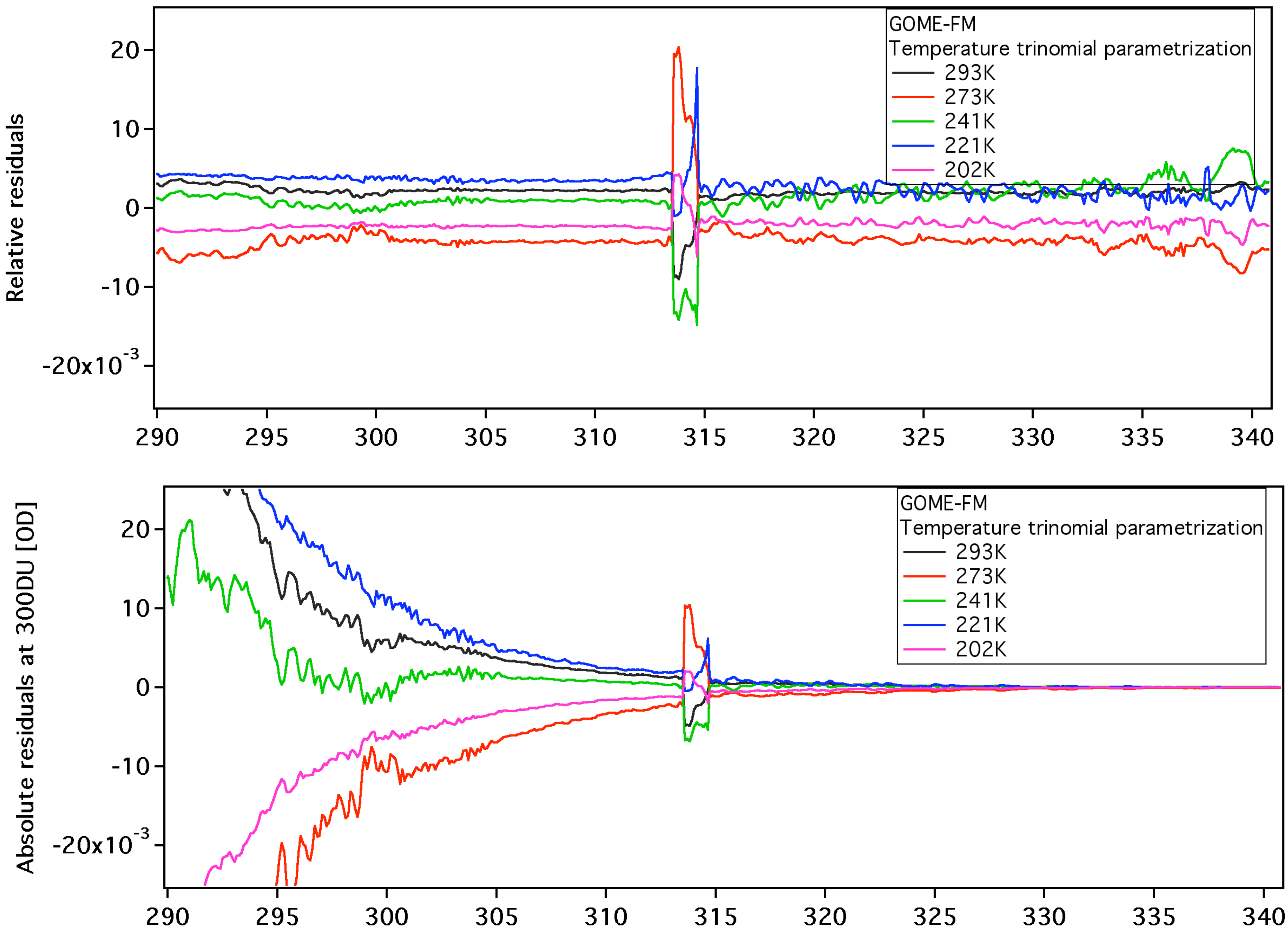




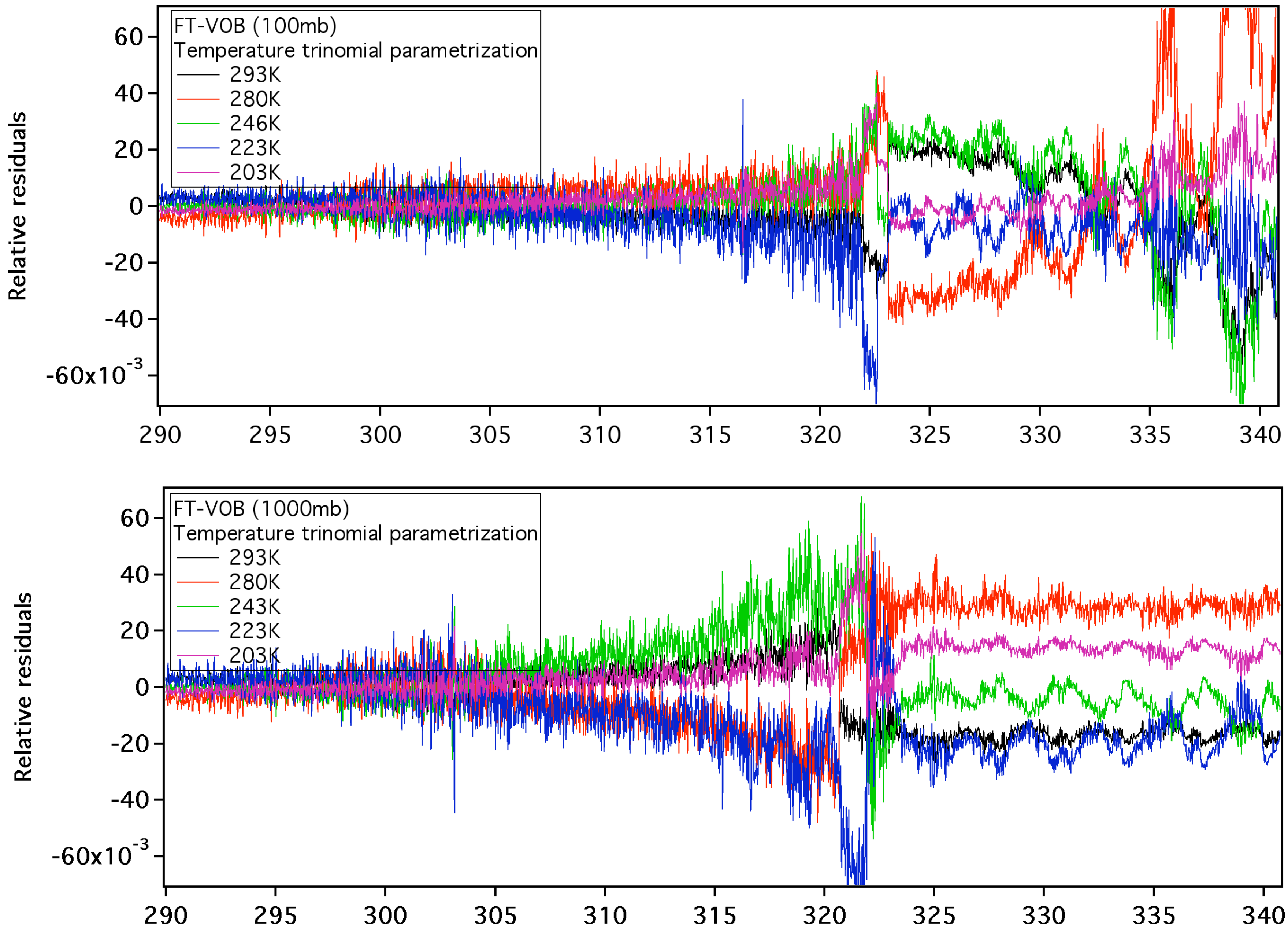
DBM trinomial fit residuals (absolute at 300DU)



GOME-FM trinomial fit residuals (relative and absolute)



FT-VOB trinomial fit residuals (relative 100mb &1000mb)



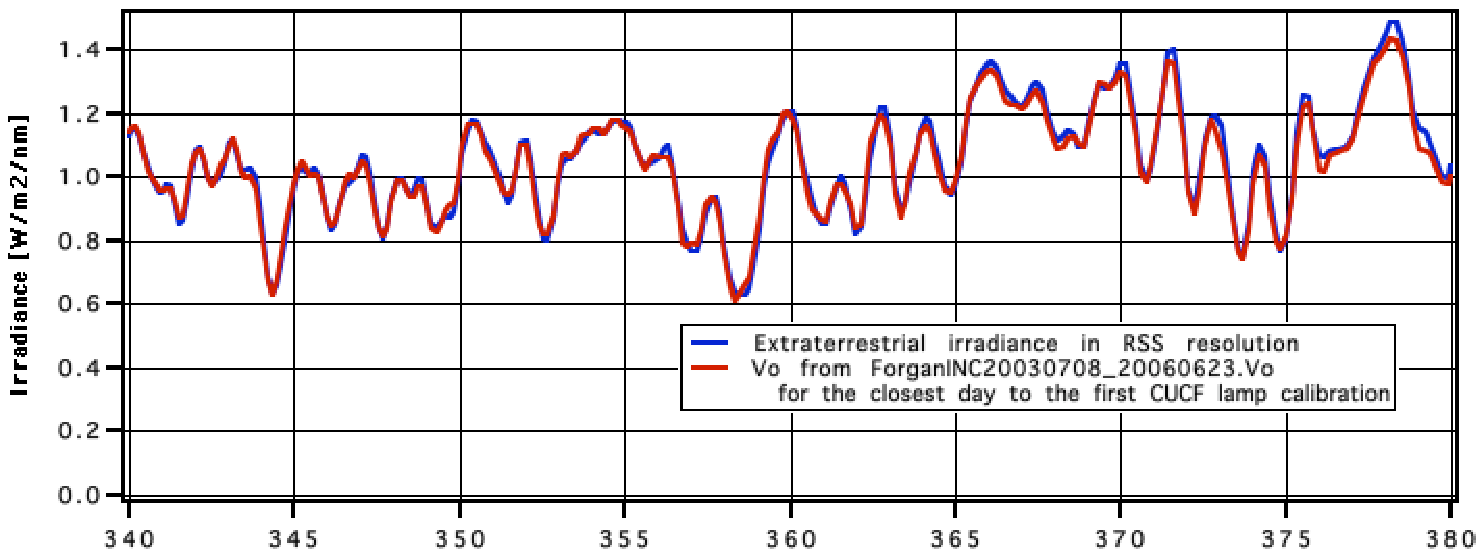
Simultaneous ozone and aerosols retrievals

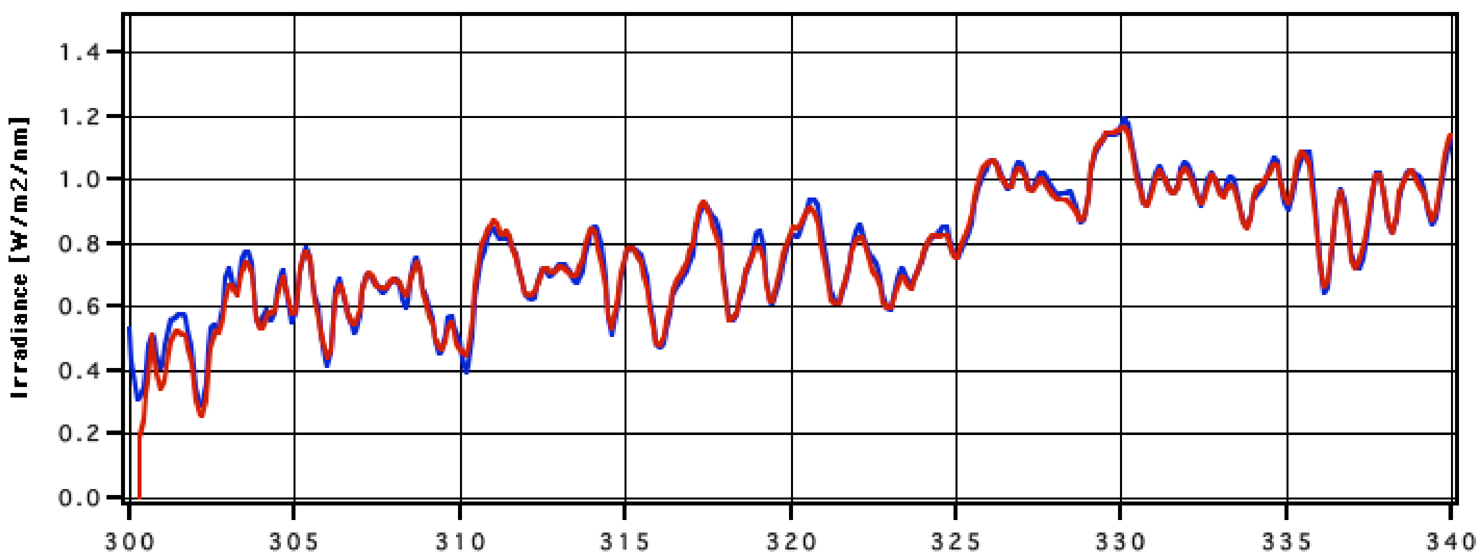
$$\tau(\lambda) = -\frac{1}{m_{air}} \ln \frac{V(\lambda)}{V_0^{doy}(\lambda)}$$

$$\min_{DU,\alpha.\beta} \int_{\lambda_1}^{\lambda_2} \left| \tau(\lambda) - \tau_R(\lambda) - DU \cdot a_{O_3}^{doy}(\lambda) \frac{m_{O_3}^{doy}}{m_{air}} - (\beta + \alpha \cdot \lambda) \frac{m_{aer}}{m_{air}} \right|^2 d\lambda$$

$$a_{O_3}^{doy}(\lambda) = k_{doy} \cdot a_{SUM}(\lambda) + (1 - k_{doy}) \cdot a_{WIN}(\lambda)$$

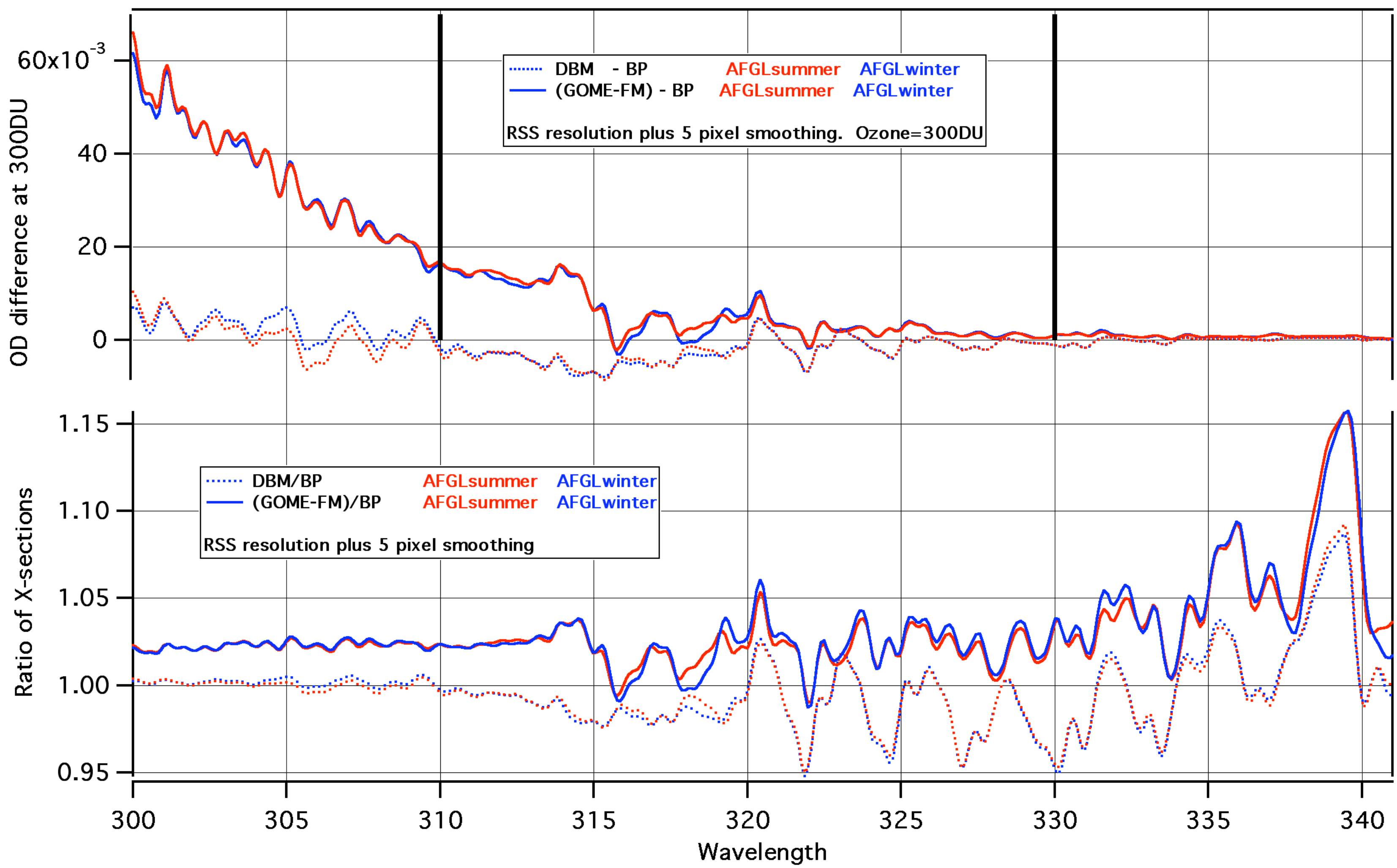
Comparison of Vo with ET spectrum



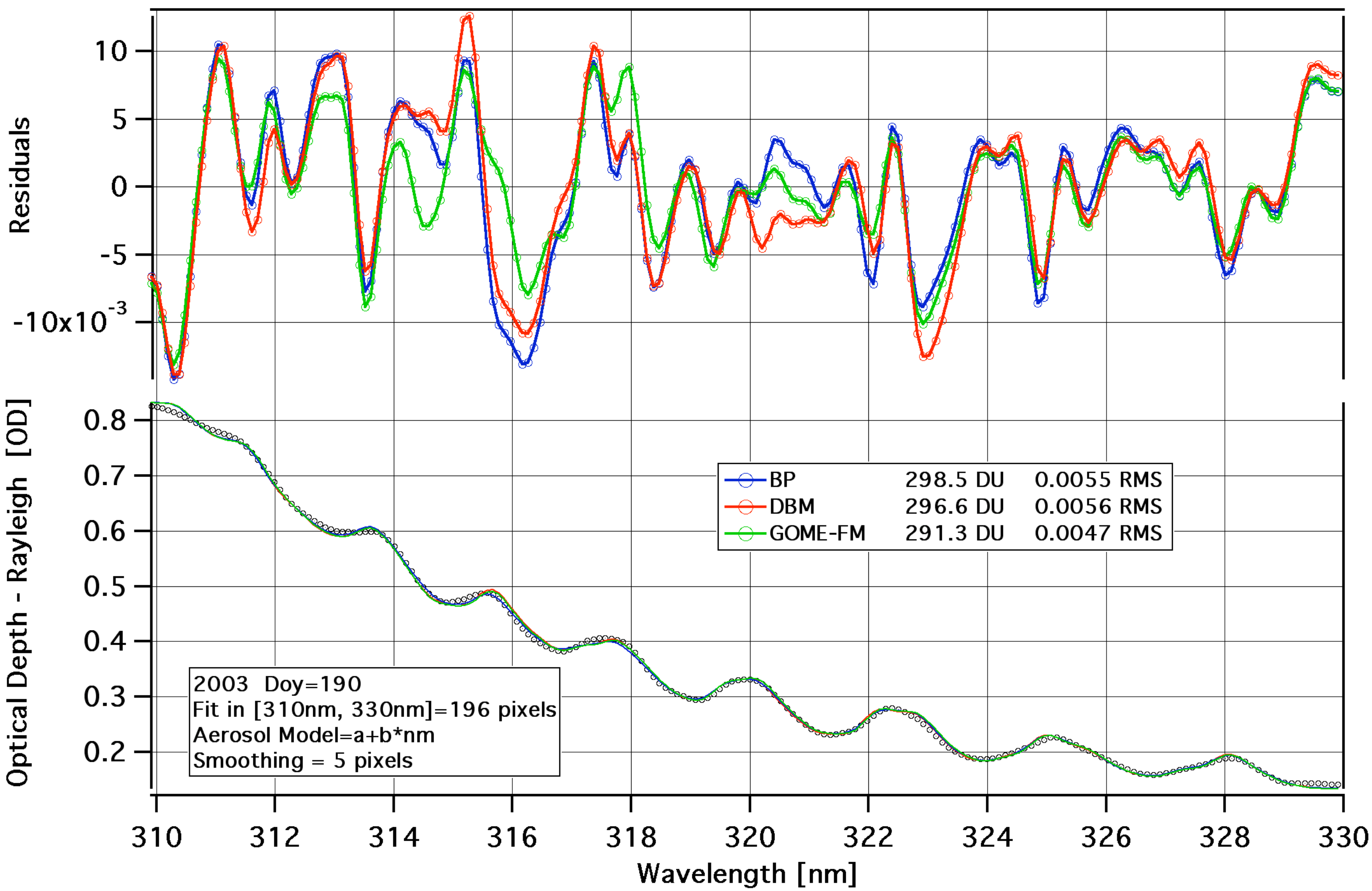


ET Spectrum from: G. Bernhard et al. (2004). *J. Geophys. Res.*, *109*, D21207, doi:10.1029/2004JD004937
http://www.biospherical.com/nsf/Version2/JGRpaper.asp

Winter & Summer AFGL X-sections



Example of retrieval residuals

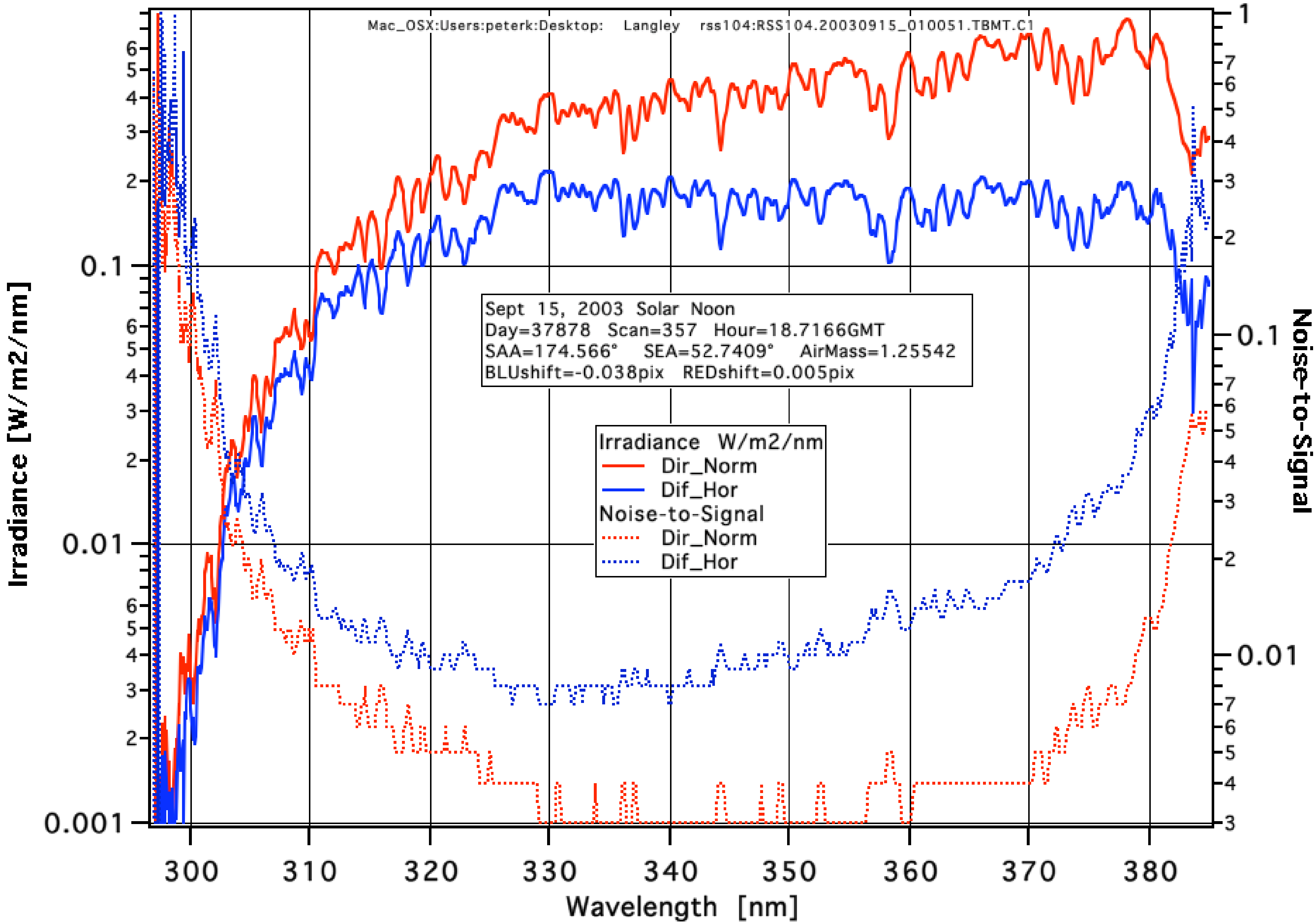


N=5412: 10-30 spectra per day (airmass<4) from 409 clear and semi-clear days between June 2003 and June 2006, Table Mt., Boulder, Colorado

Parameter	O3 X-section	Avg	StDev	Min	Max
O3	BP	300.6	32.0	192.5	427.0
	DBM	298.1	31.6	191.4	422.9
	GOME-FM	293.2	31.2	187.5	416.3
Fit rms	BP	0.0048	0.0012	0.0025	0.0099
	DBM	0.0048	0.0012	0.0026	0.0099
	GOME-FM	0.0043	0.0013	0.0022	0.0099
N=5412	BP	N=4992 for rms<0.01 [OD]			
	DBM	N= 4989 for rms<0.01 [OD]			
	GOME-FM.	N= 5001 for rms<0.01 [OD]			

O3 X-section	Parameter	Avg	StDev	Min	Max	Intercept	Slope
DBM minus BP	O3 [DU]	-2.47	0.48	-4.1	-1.0	0.81884	0.9890
	AOD 310nm	0.0094	0.0012	0.005	0.014	0.00929	1.0009
	AOD 330nm	-0.0003	0.0001	-0.001	-0.0001	-0.00036	1.0001
GOME-FM minus BP	O3 [DU]	-7.41	0.79	-10.6	-4.9	-0.03622	0.9754
	AOD 310nm	0.0023	0.0003	0.001	0.004	0.00236	1.0001
	AOD 330nm	-0.0001	0.0001	-0.0003	0.0002	-0.00009	1.0004

Examples of irradiance and noise-to-signal from UV-RSS



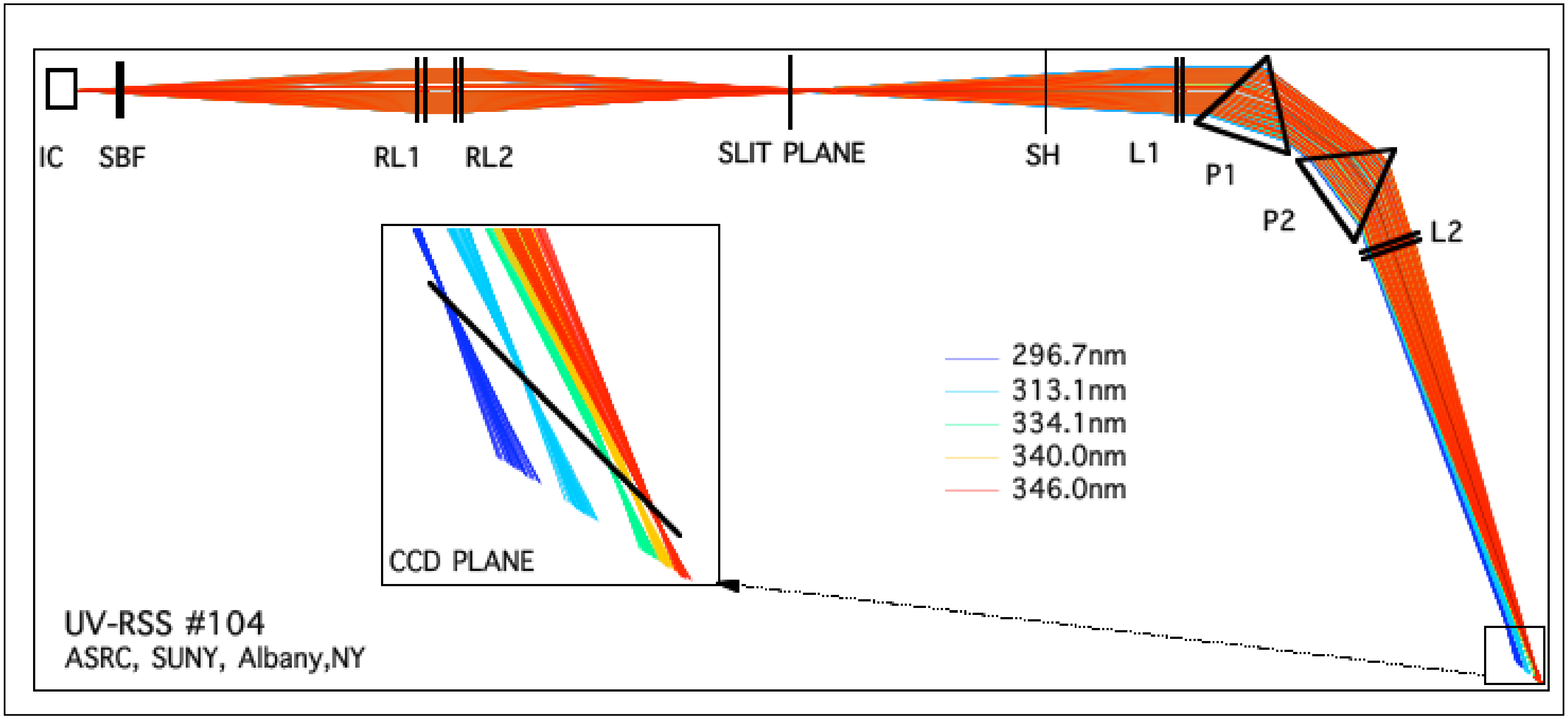
EXTRA SLIDES

UV-RSS optical layout

Nominal range: 297nm-385nm =734 pixels
Noise limited at 297 and filter limited at 385nm

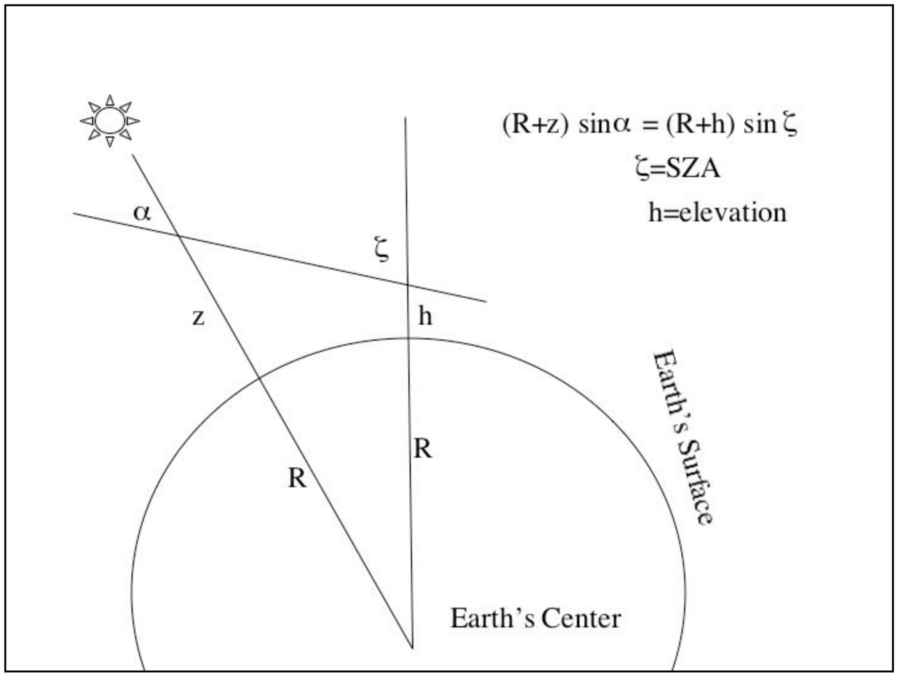
At 300nm fwhm=0.311nm=3.69pix
At 380nm fwhm=0.613nm=3.57pix

Stray light =0.5 *10^{-5} from 325nm HeCd laser
Slit function is approximately Gaussian



The UV-RSS optics and its specification was described by Kiedron et al. *Proc. SPIE* 4482, 2001. And applications of visible version of RSS was described by Harrison et al. *J. Geophys. Res.* 108: 4424, 2003.

Ozone mass and ozone profile X-sections



$$m_{O_3} = \int \frac{p(z)}{\sqrt{1-\left(\frac{1+h/R}{1+z/R}\right)^2 \sin^2 \zeta}} dz$$

$$\bar{a}_{O_3} = \frac{1}{m_{O_3}} \int \frac{a_{O_3}(T(z)) \cdot p(z)}{\sqrt{1-\left(\frac{1+h/R}{1+z/R}\right)^2 \sin^2 \zeta}} dz$$

$$\int p(z) dz = 1$$

Ozone profile cross-section is dependent on SZA. However for SZA<80°
ozone profile cross-section for SZA=0° can be used with error less than 0.1%.