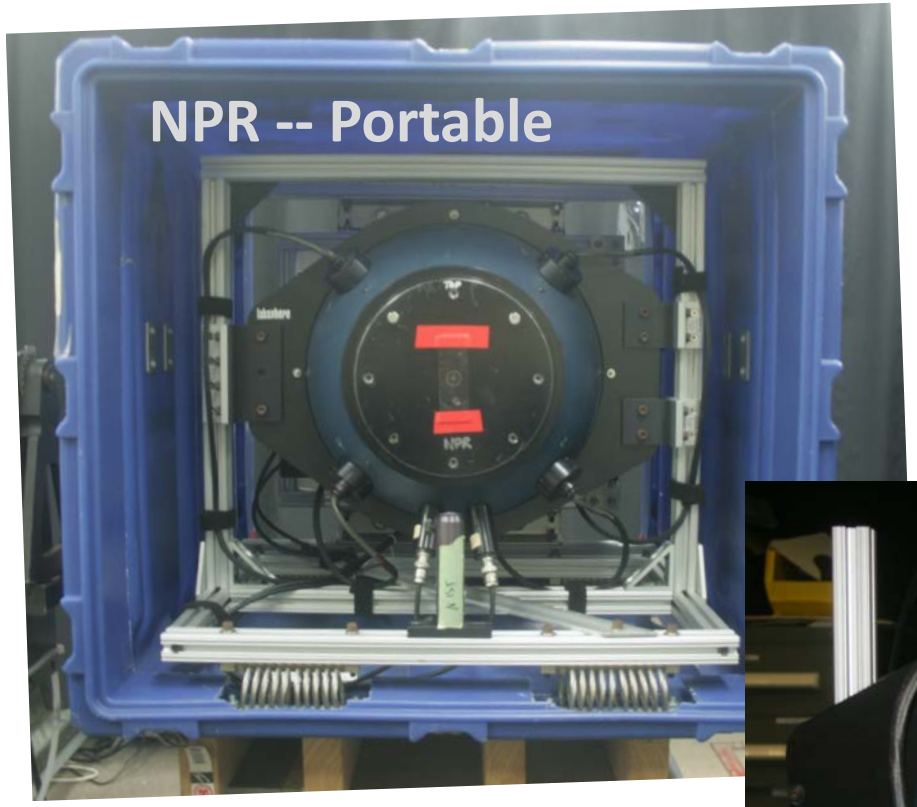
VIIRS Ocean Color Science Meeting

NPR, NII, and VXR Time Series

Carol Johnson



NPR and NII Integration Sphere Spectral Radiance Source Standards

VXR Portable Filter Radiometer, 6 channels at SeaWiFS type bands

Three Applications

- The Nxx spectral radiance $L(\lambda)$ and the VXR relative spectral responsivites (RSRs) are known: **Calibrate VXR with the Nxx spheres**
- The Nxx $L(\lambda)$ is unknown but the absolute spectral responsivities (ASRs) of the VXR bands are known: **Calibrate the Nxx spheres at the 6 VXR wavelengths**
- Both $L(\lambda)$ and the ASRs are known: **Validate the Nxx and VXR values**, as well as the veracity of the VXR to transfer between source and detector – based facilities (e.g. FASCAL and SIRCUS at NIST)

Interpolations are Required

$$S_b = \int L(\lambda) F_b\, r_b(\lambda)\, d\lambda$$

S = Signal, *b* = filter band, *F***r* = ASR, *r* = RSR

$$\lambda_{b,m} = \frac{\int \lambda\, L(\lambda) F_b\, r_b(\lambda)\, d\lambda}{\int L(\lambda) F_b\, r_b(\lambda)\, d\lambda} = \frac{\int \lambda\, L(\lambda) r_b(\lambda)\, d\lambda}{\int L(\lambda) r_b(\lambda)\, d\lambda}$$

$$\Delta\lambda_{b,m} = \frac{\int L(\lambda) F_b\, r_b(\lambda)\, d\lambda}{L(\lambda_{b,m}) F_b\, r_b(\lambda_{b,m})} = \frac{\int L(\lambda) r_b(\lambda)\, d\lambda}{L(\lambda_{b,m}) r_b(\lambda_{b,m})}$$

The moment wavelengths and the bandpasses are the same for ASR or RSR values, but vary with the spectral distribution of the source – by how much depends on the spectral out of band in the filters

$$F_b\, r_b(\lambda_{b,m}) = \frac{S_b}{L(\lambda_{b,m})\, \Delta\lambda_{b,m}}$$

Calibrate the VXR

$$L(\lambda_{b,m}) = \frac{S_b}{F_b\, r_b(\lambda_{b,m})\, \Delta\lambda_{b,m}}$$

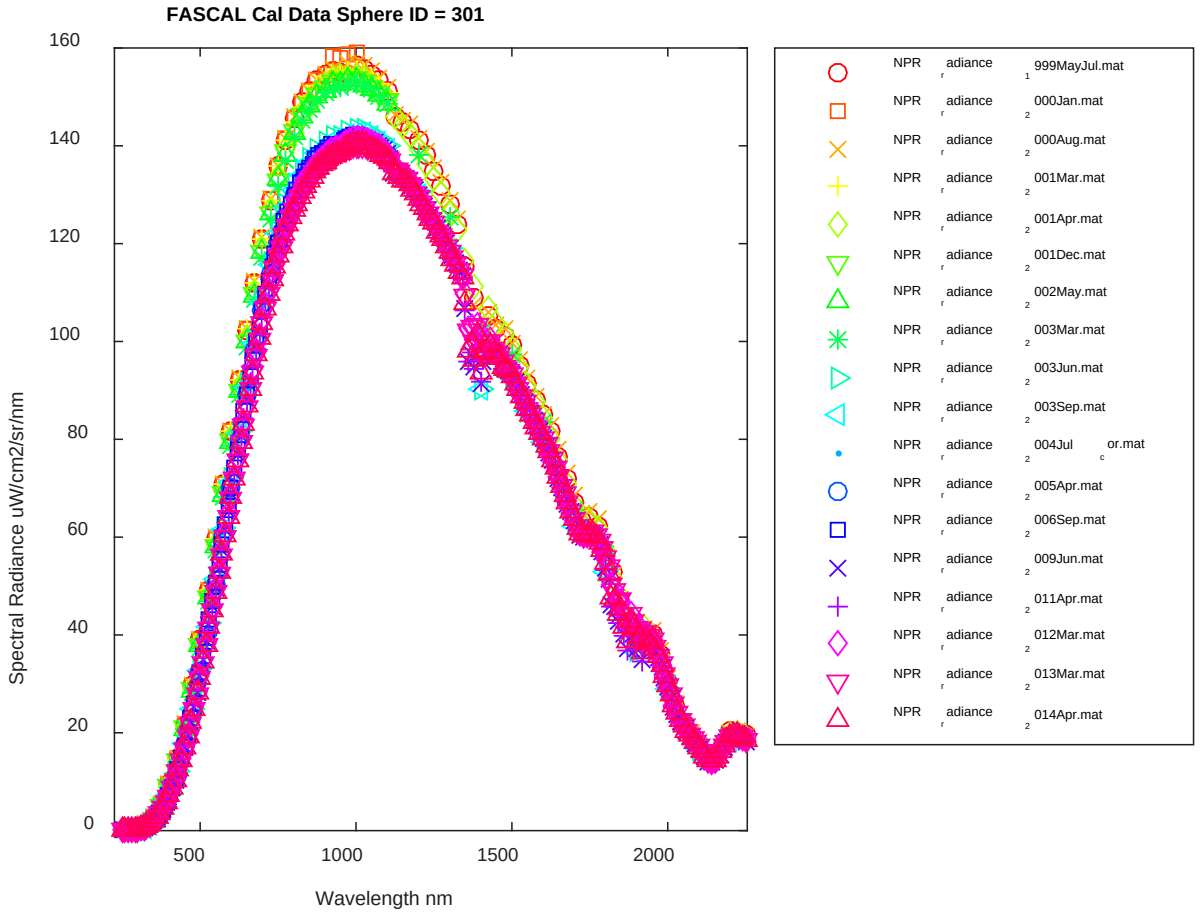
Calibrate the Nxx

$$\text{Does } S_b = L(\lambda_{b,m}) F_b\, r_b(\lambda_{b,m})\, \Delta\lambda_{b,m}\ ?$$

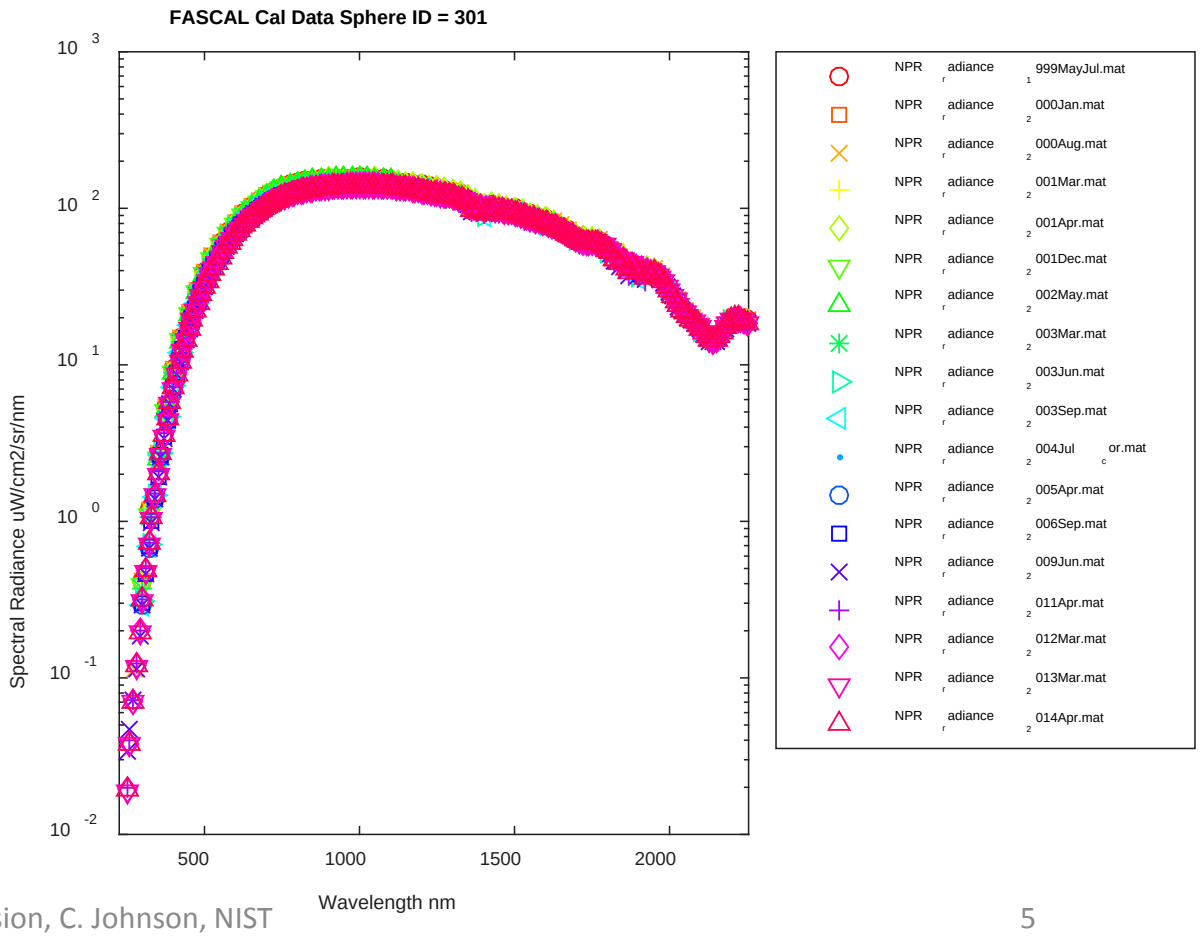
$$\text{Or, does } S_b = \int L(\lambda) F_b\, r_b(\lambda)\, d\lambda\ ?$$

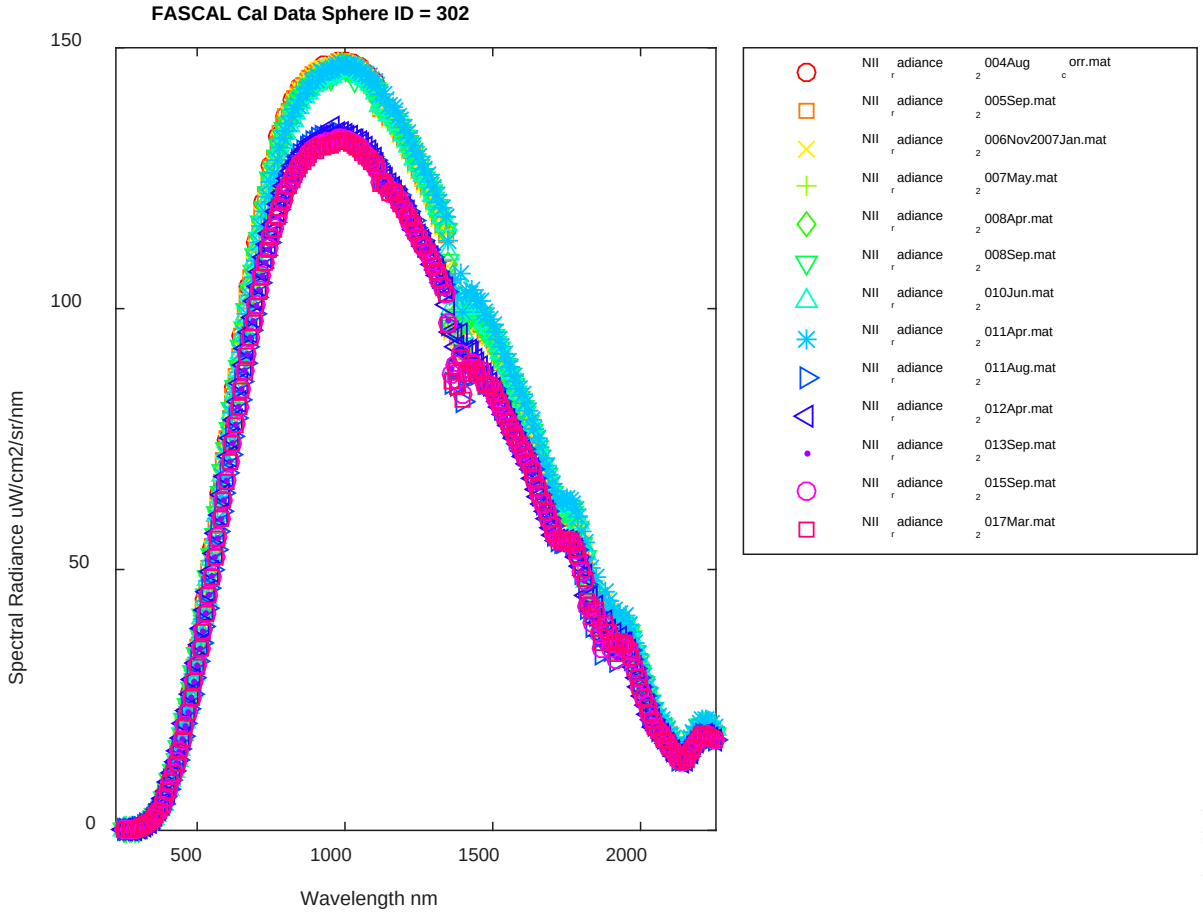
Validate FASCAL, SIRCUS,
& VXR efficacy

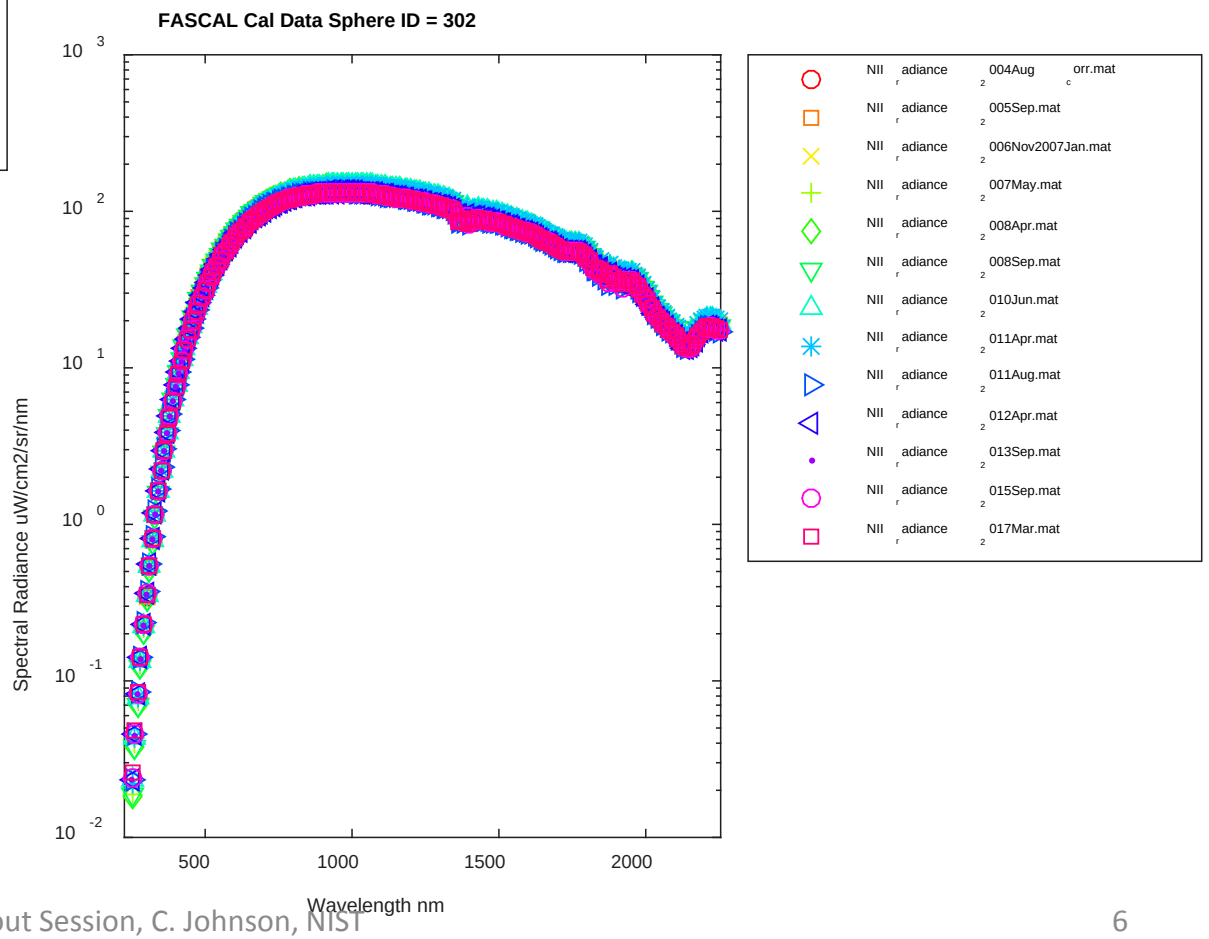
Parr and Johnson, *J. Res. NIST*, **116**, 751 – 760 (2011).



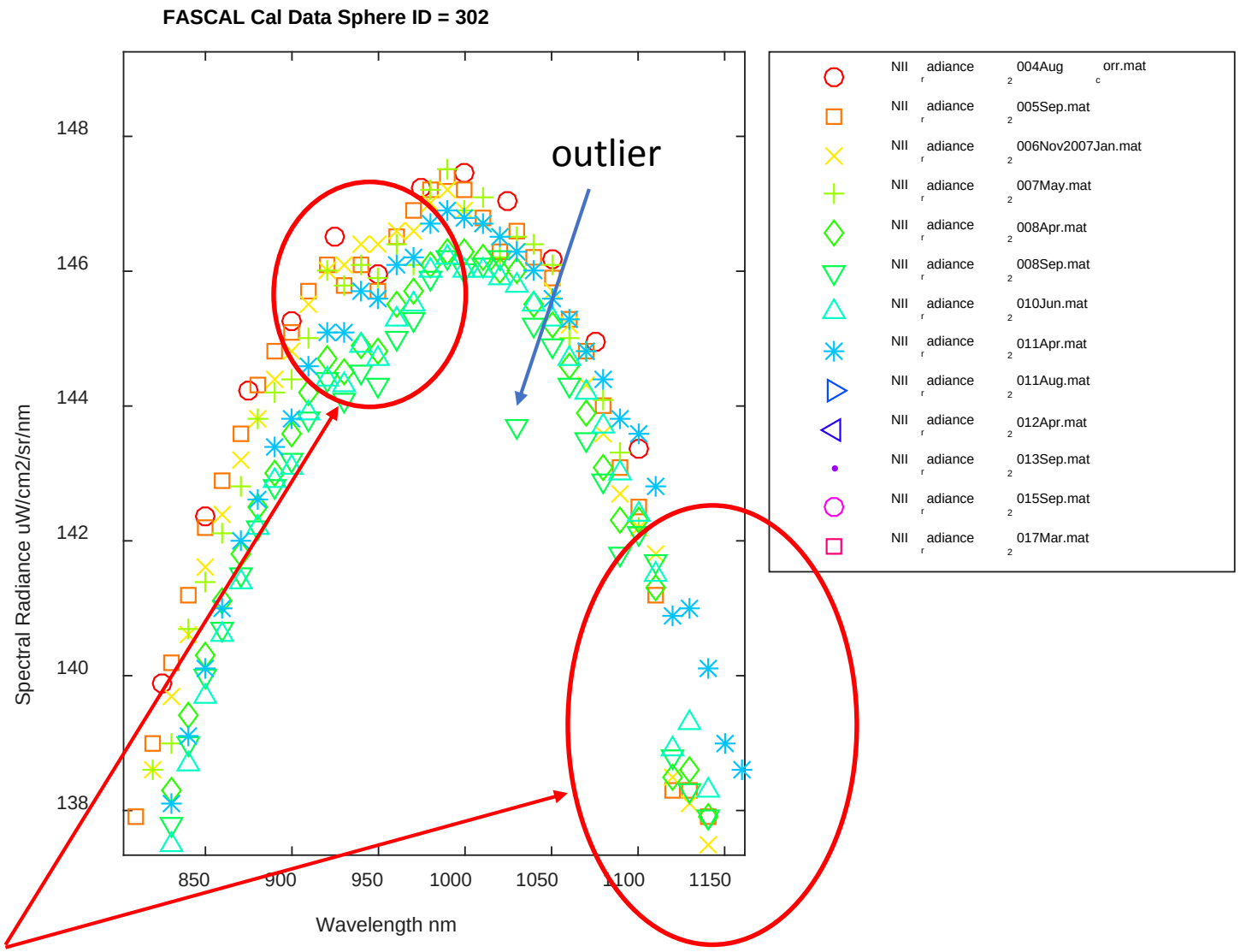
NPR FASCAL history, four lamp sets, multiple calibrations on each lamp set.
Data not uniform in spectral coverage or density of values. 18 Years of use.







NII FASCAL history, two lamp sets, multiple calibrations on each lamp set.
Data not uniform in spectral coverage or density of values. 13 Years of use.



atmospheric absorption

First Approach: Analytical function (physical basis, consistent interpretation of data, identification of outliers, estimates of uncertainty at interpolated points).

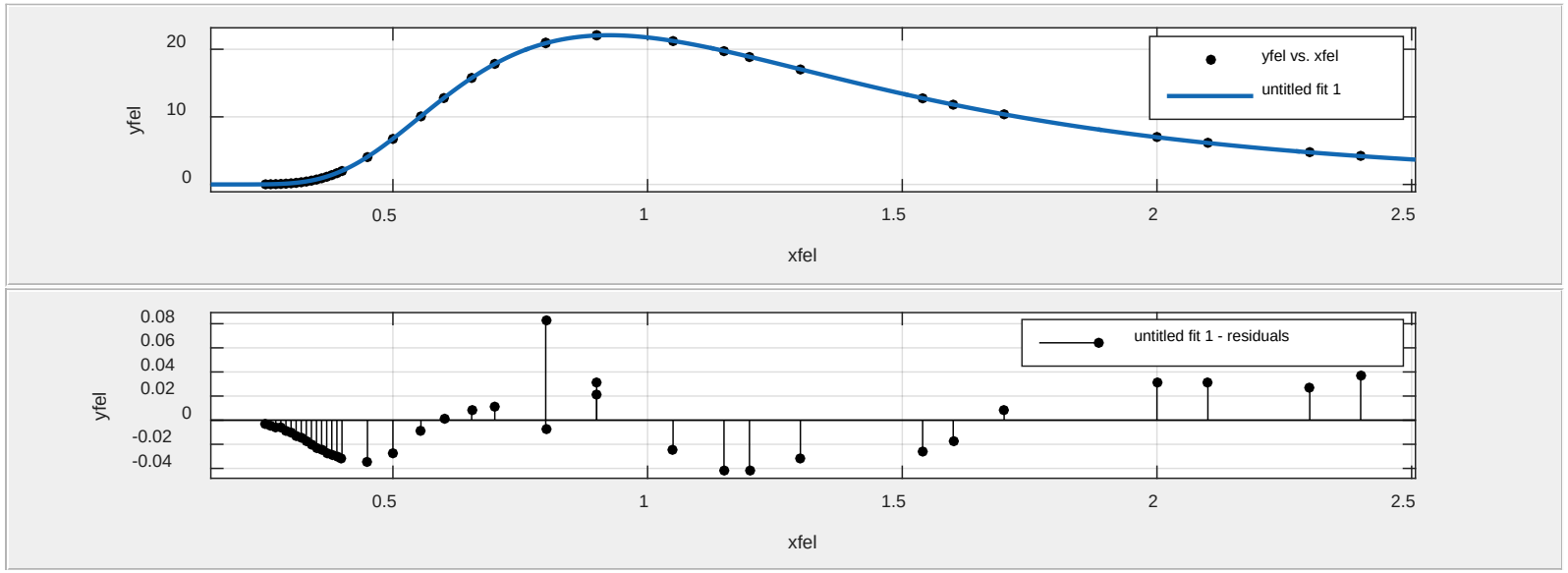
Regions of atmospheric features were excluded: 760 nm, 915 to 985 nm, 1100 to 1150 nm, 1300 to 1500 nm, & 1730 to 1980 nm (use of integrating sphere increases the path length)

The 1973 NBS Spectral Irradiance method was explored (region subdivided spectrally)

$$\ln(\lambda^5 L(\lambda)) = a + \frac{b}{\lambda}$$

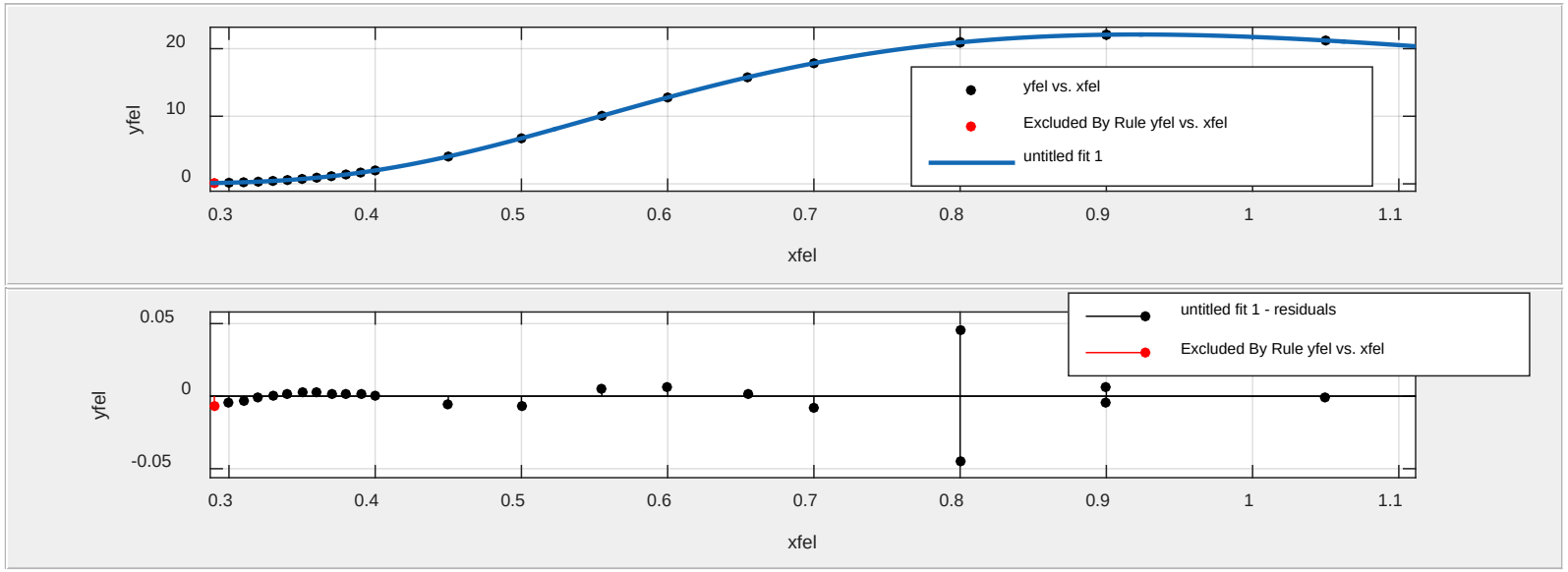
$$L(\lambda) = \left[\sum_{i=0}^{n} c_i \lambda^i\right] \exp(b/\lambda)$$

FEL Irradiance standard (wavelength is in micrometers)



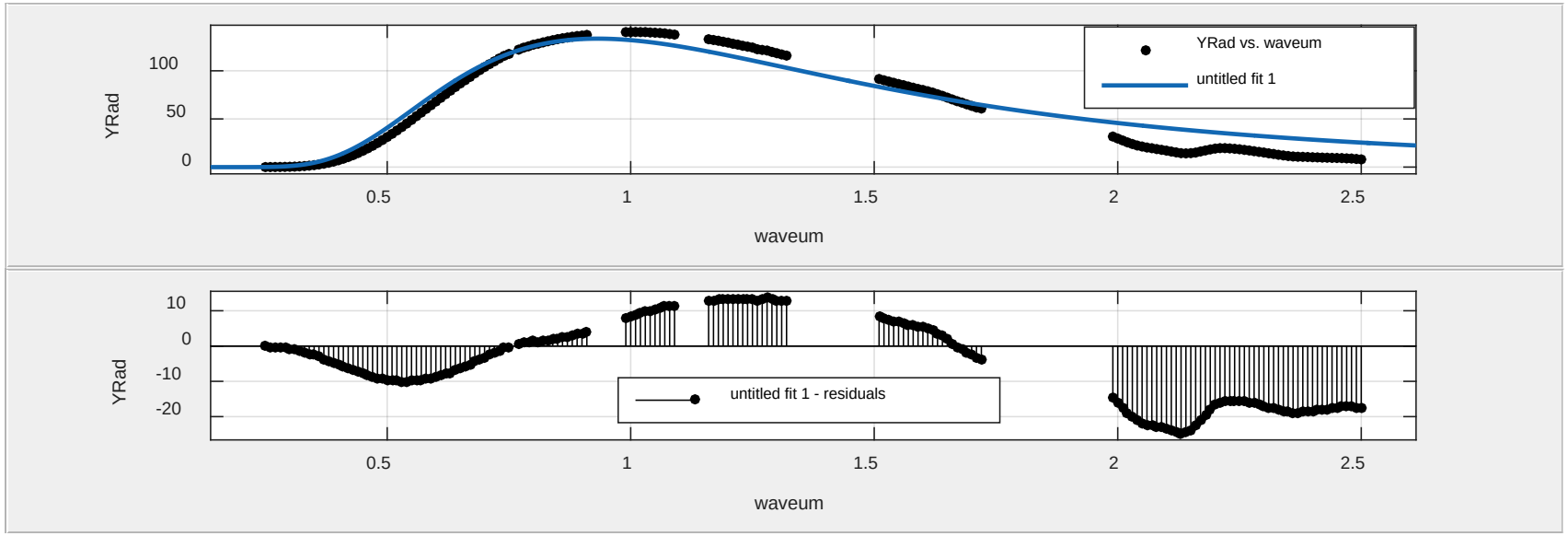
N = 1, full range, unweighted
SSE = 0.026, ADRS = 1

N = 4, 300 nm to 1100 nm, unweighted
SSE = 0.004, ADRS = 1



Note: I'm fitting in one step – did not linearize the blackbody term

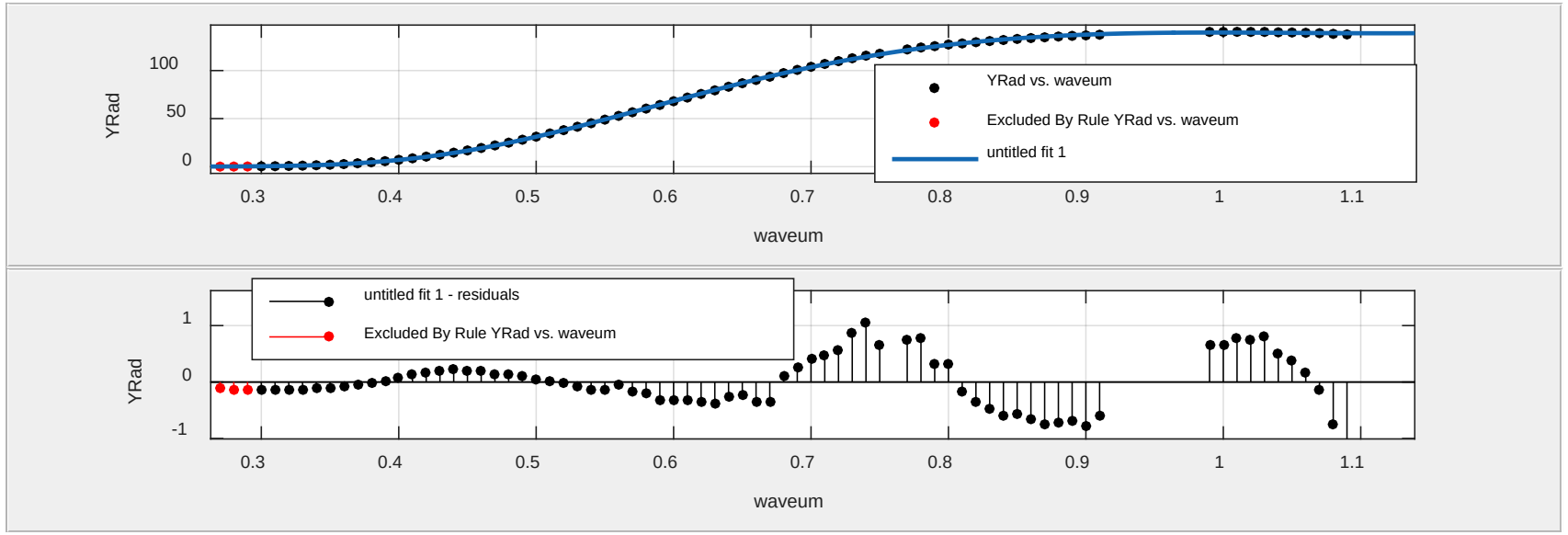
NPR April 2014 FASCAL data (wavelength is in micrometers)

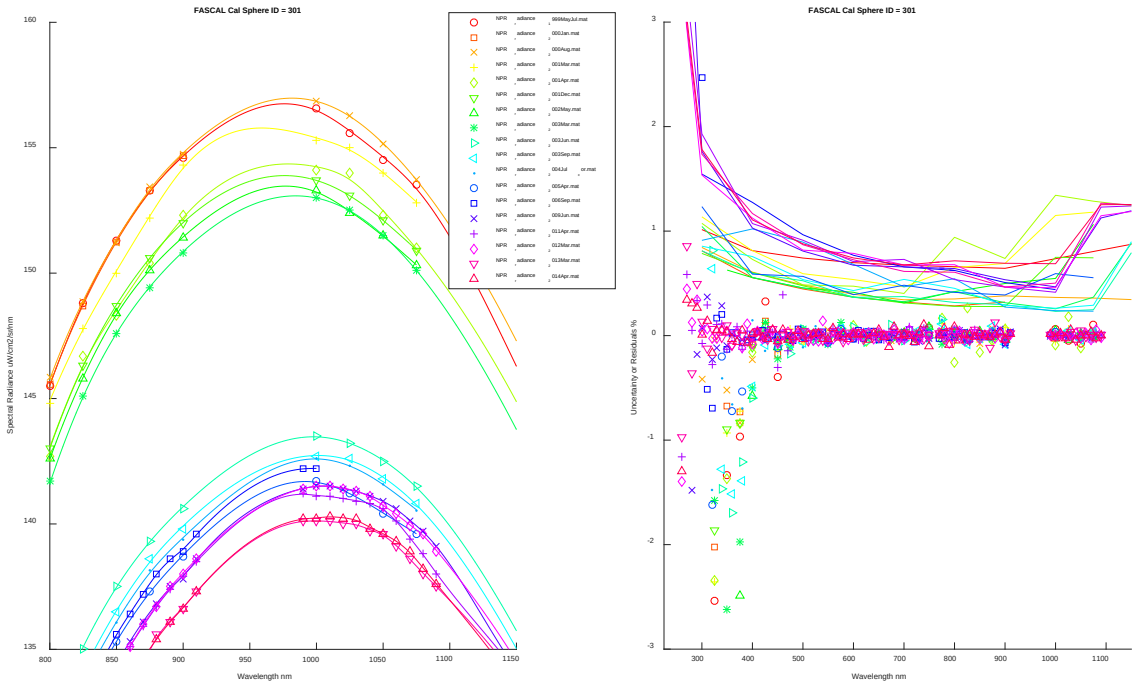


N = 0, full range, unweighted
SSE = 2.6E4, ADRS = 0.940

N = 4, 300 nm to 1100 nm, unweighted
SSE = 15.2, ADRS = 0.9999

Note: Residuals fall outside the FASCAL uncertainties; fit is sensitive to starting parameters; residuals have structure

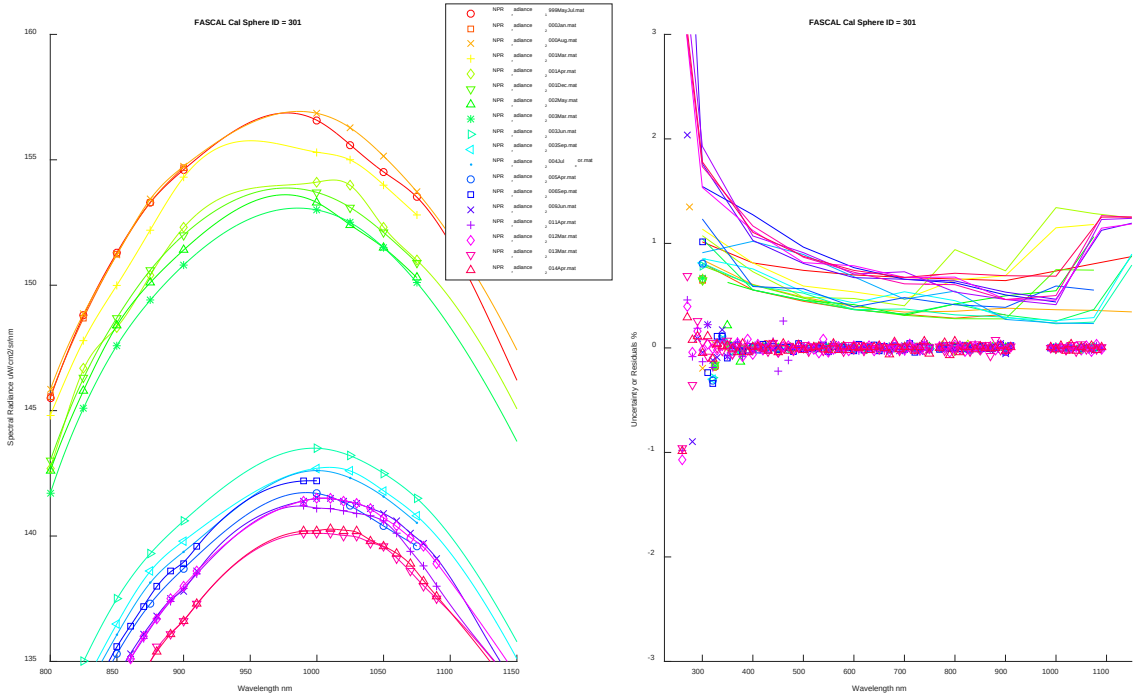


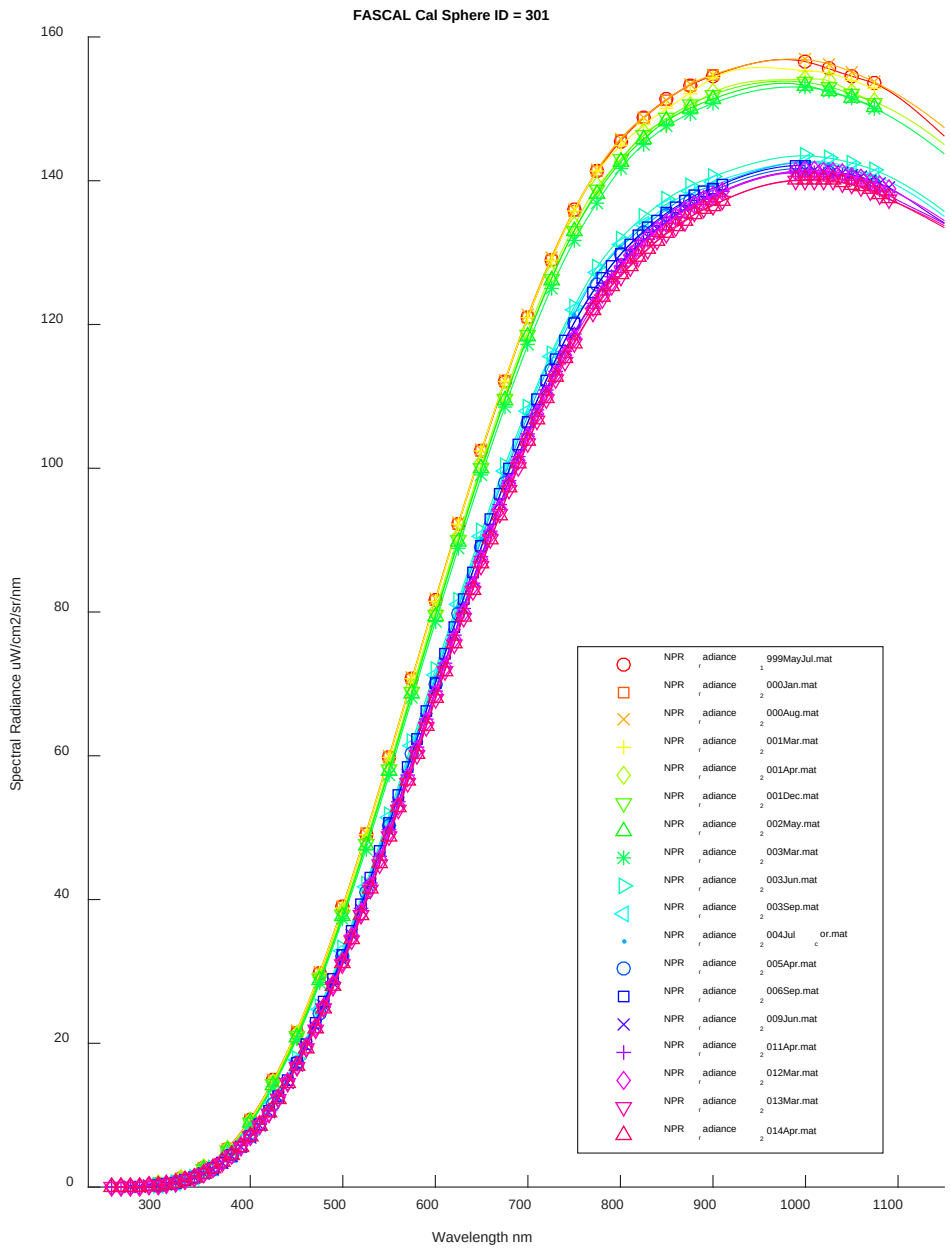


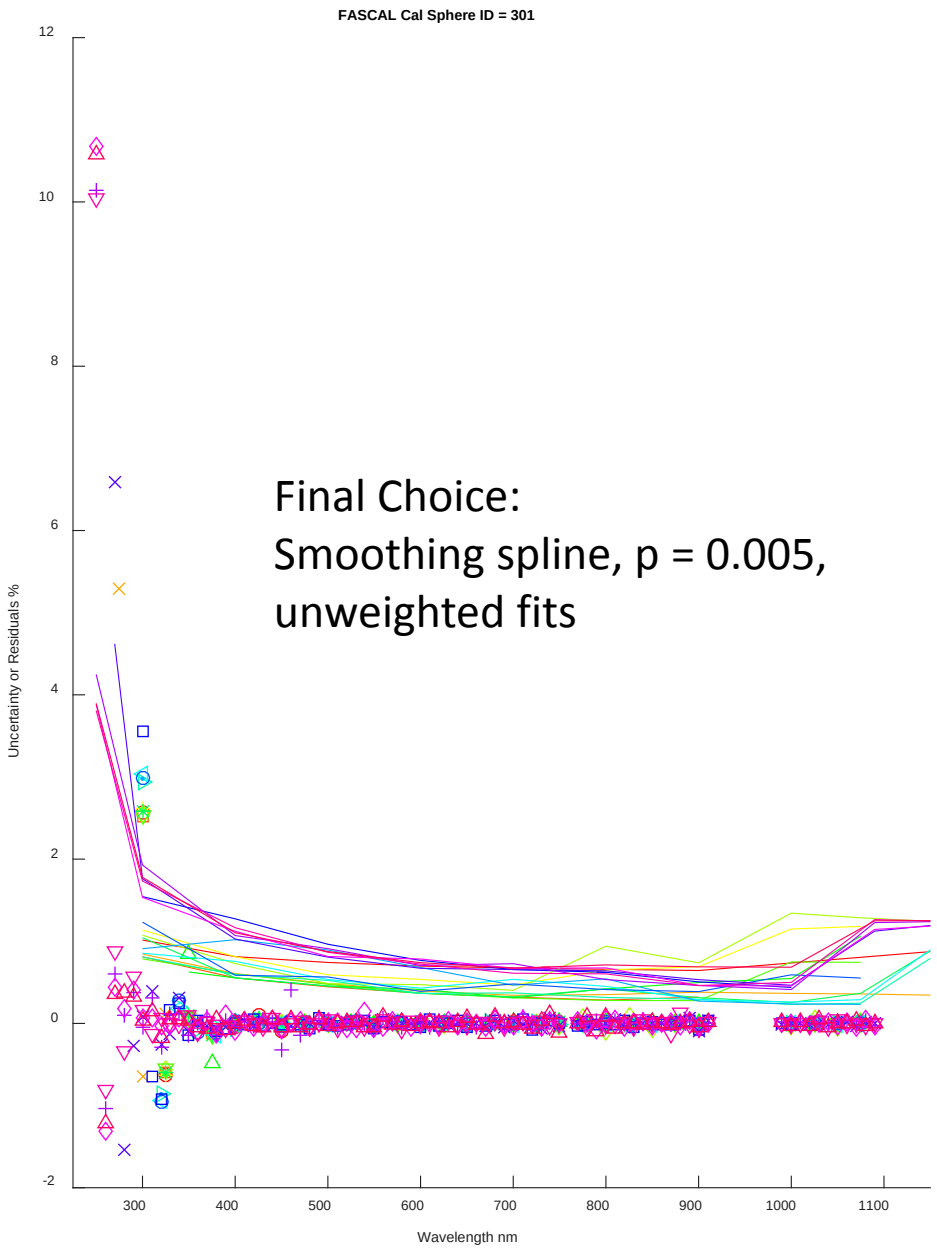
Smoothing spline, strong smoothing (p = 0.007)

Second approach: Interpolate with smoothing splines (new grid is every 0.1 nm)

Smoothing spline, weak smoothing (p = 0.02)



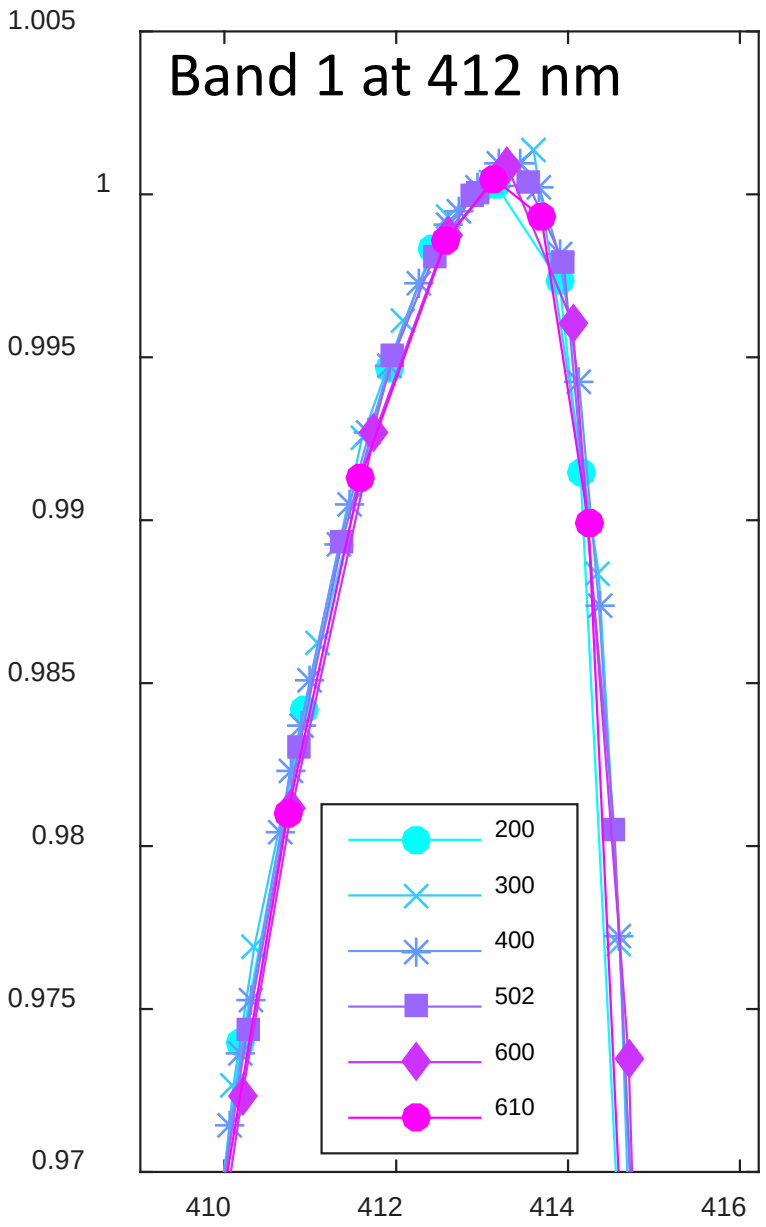


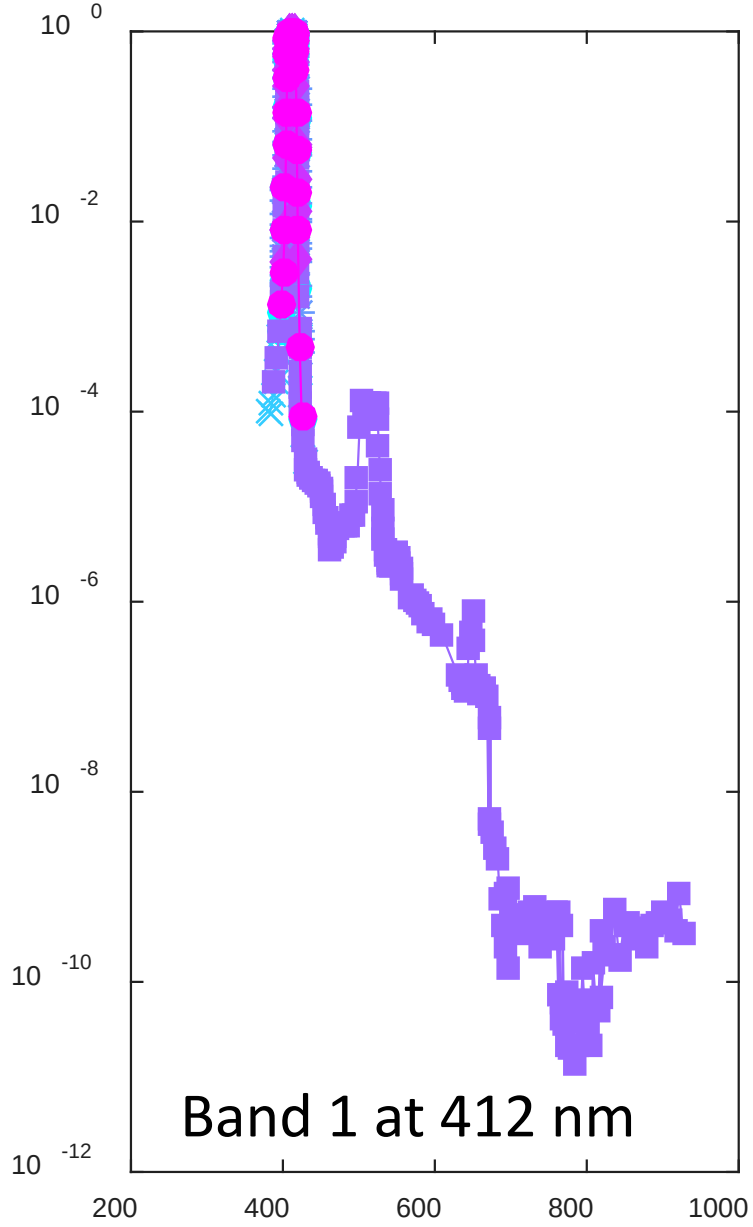


Final Choice:
Smoothing spline, p = 0.005, unweighted fits

VXR RSRs

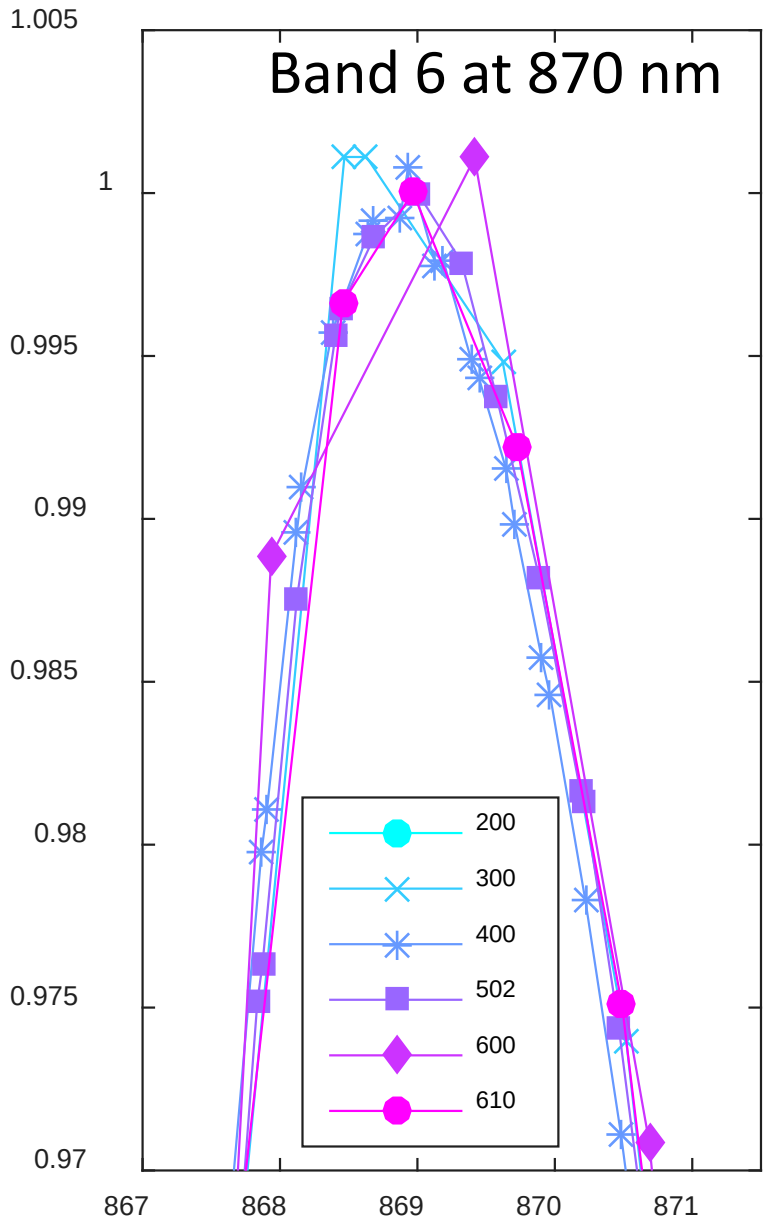
Composite of 6 SIRCUS ASR calibrations – 1999 to 2011

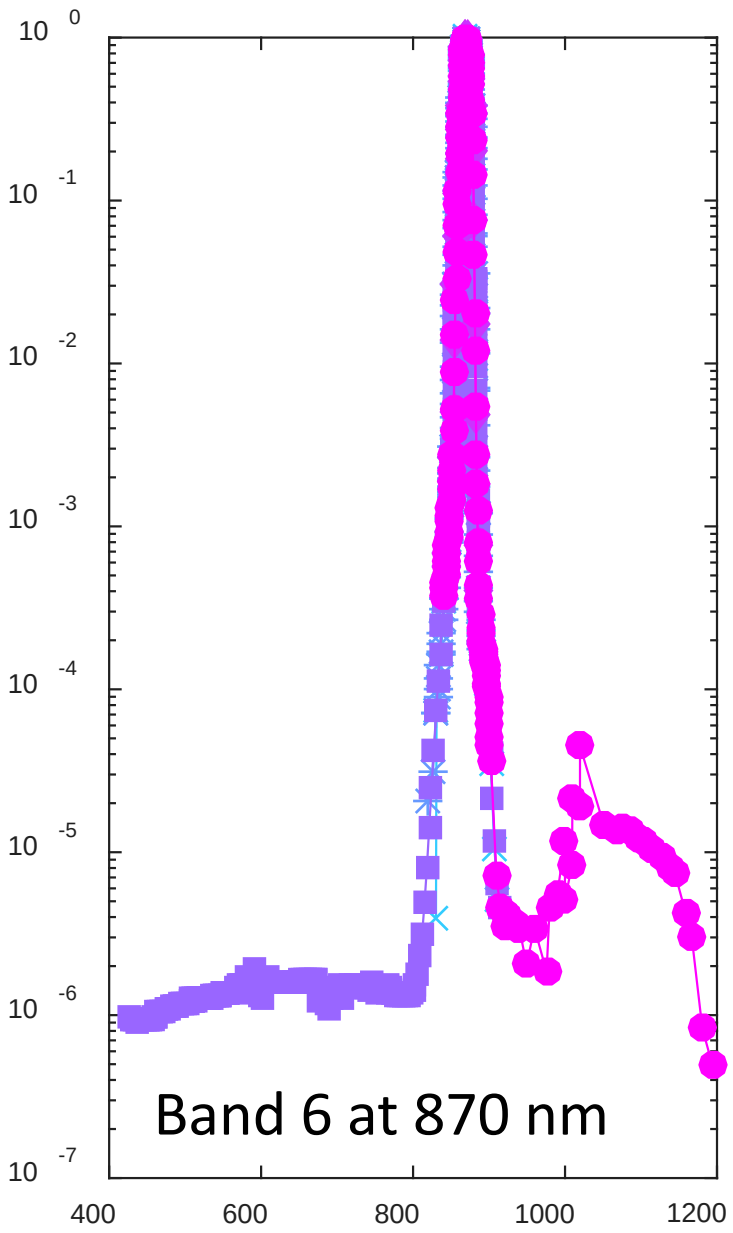


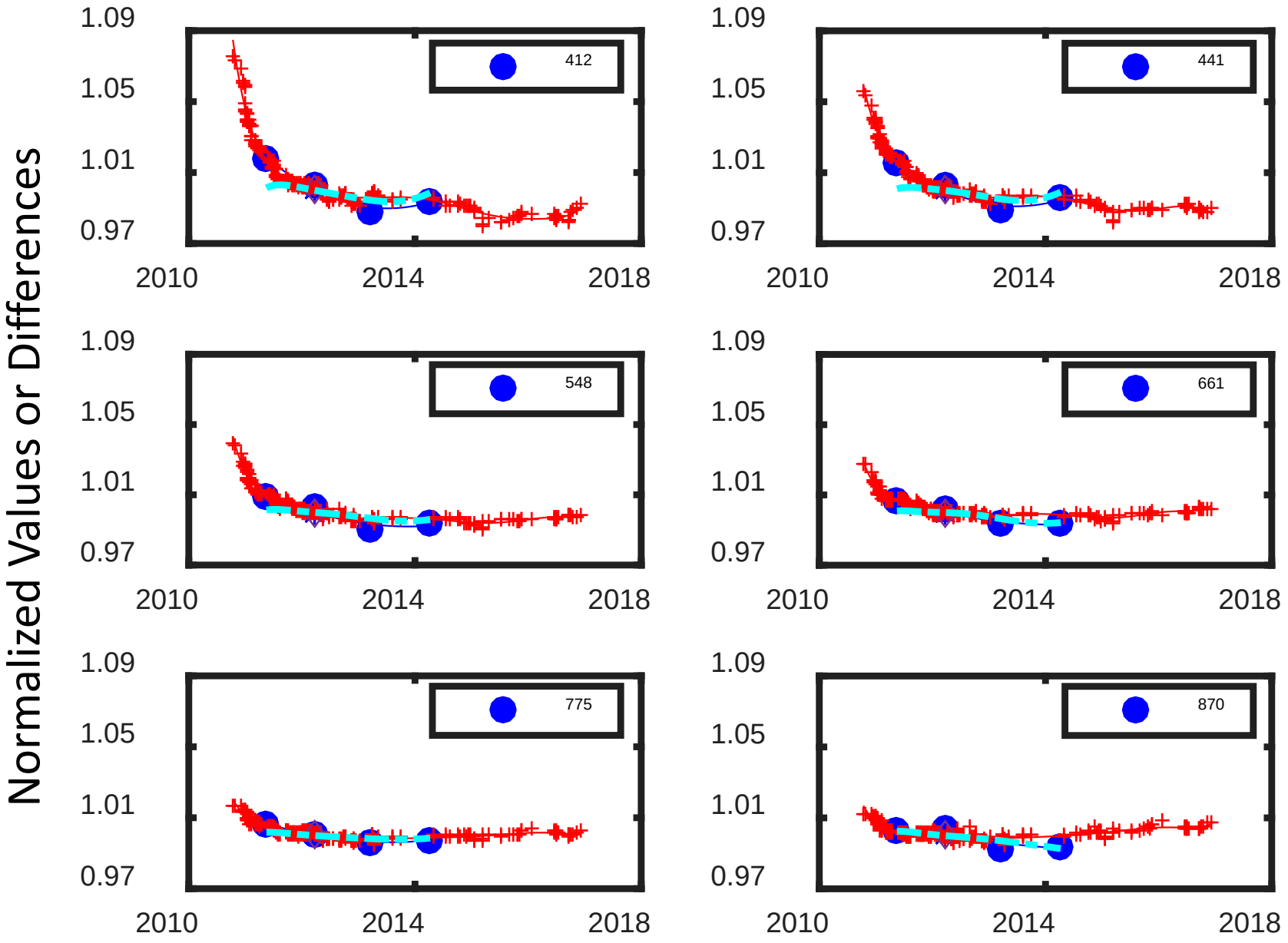


VXR RSRs

Composite of 6 SIRCUS ASR calibrations – 1999 to 2011







NPR Sphere Lamp Set 4

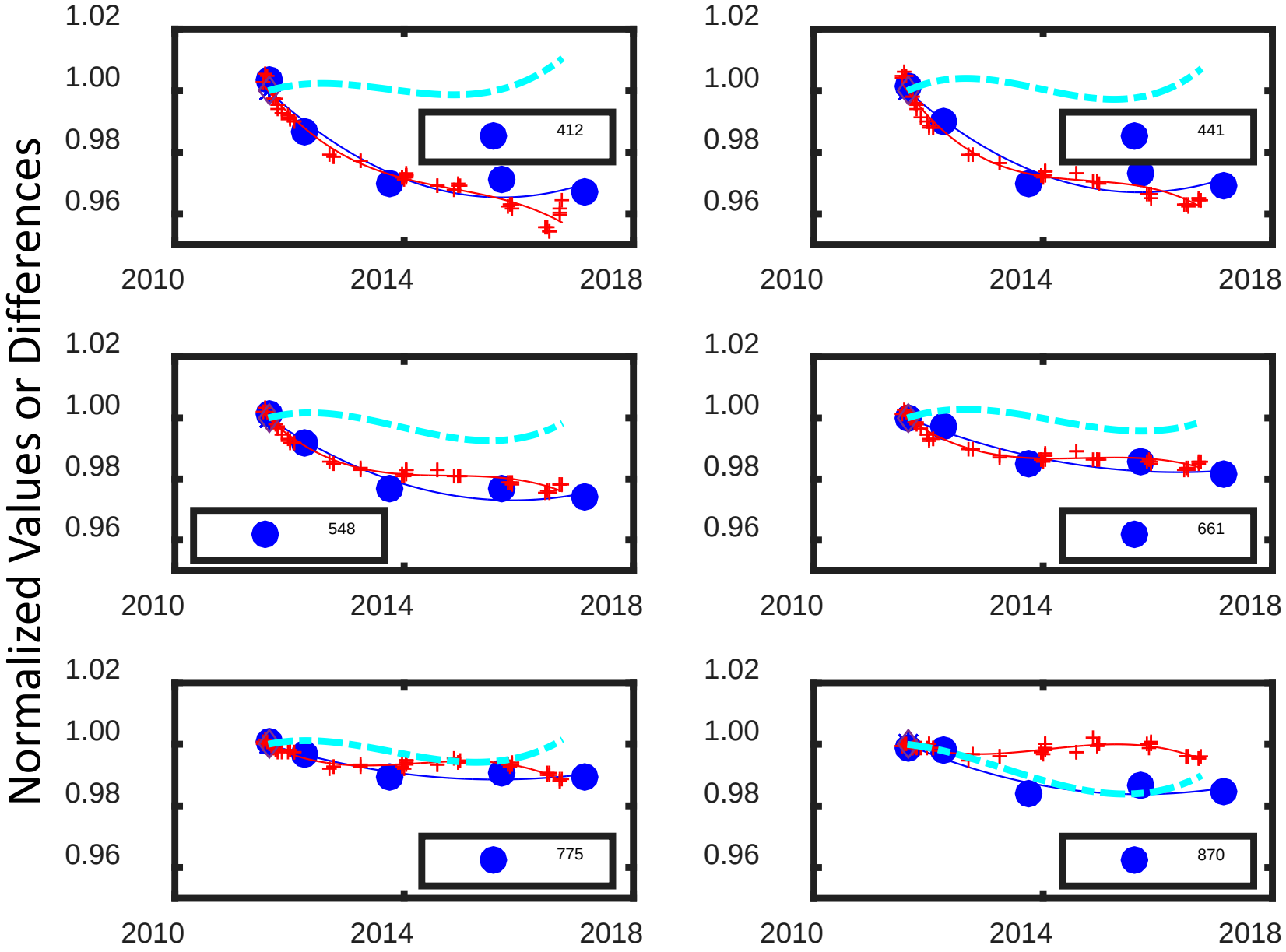
Blue: Band average FASCAL w VXR RSRs;
Red: VXR net signals; Lines = poly fits;

Cyan line = difference

$L(\lambda_{b,m},t)$ and $S_b(t)$ were normalized to the FASCAL time with the minimum difference to a VXR signal file

FASCAL: N = 2
VXR: N = 8

NII Sphere Lamp Set 2



Blue: Band average FASCAL w VXR RSRs;
Red: VXR net signals;
Lines = poly fits;

Cyan line = difference

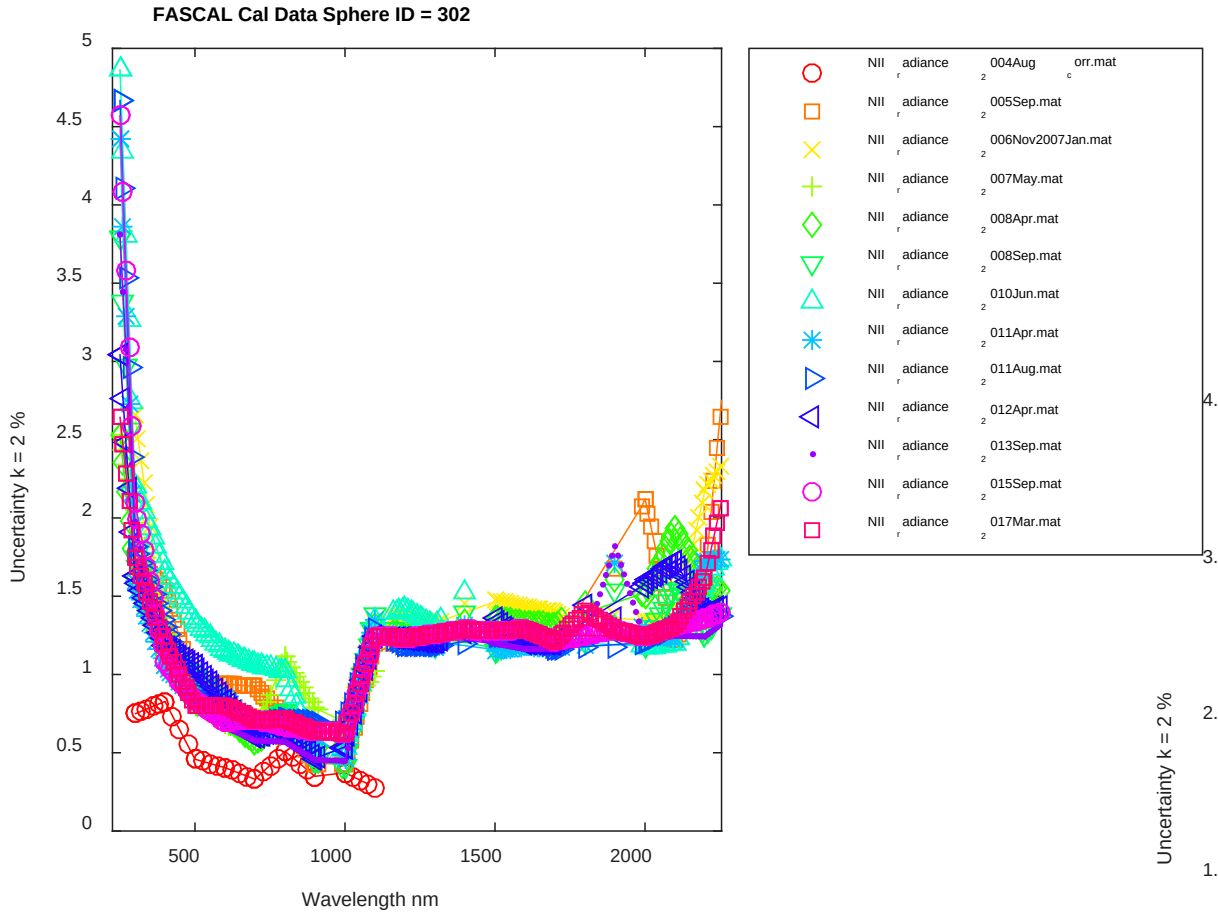
$L(\lambda_{b,m},t)$ and $S_b(t)$ were normalized to the FASCAL time with the minimum difference to a VXR signal file

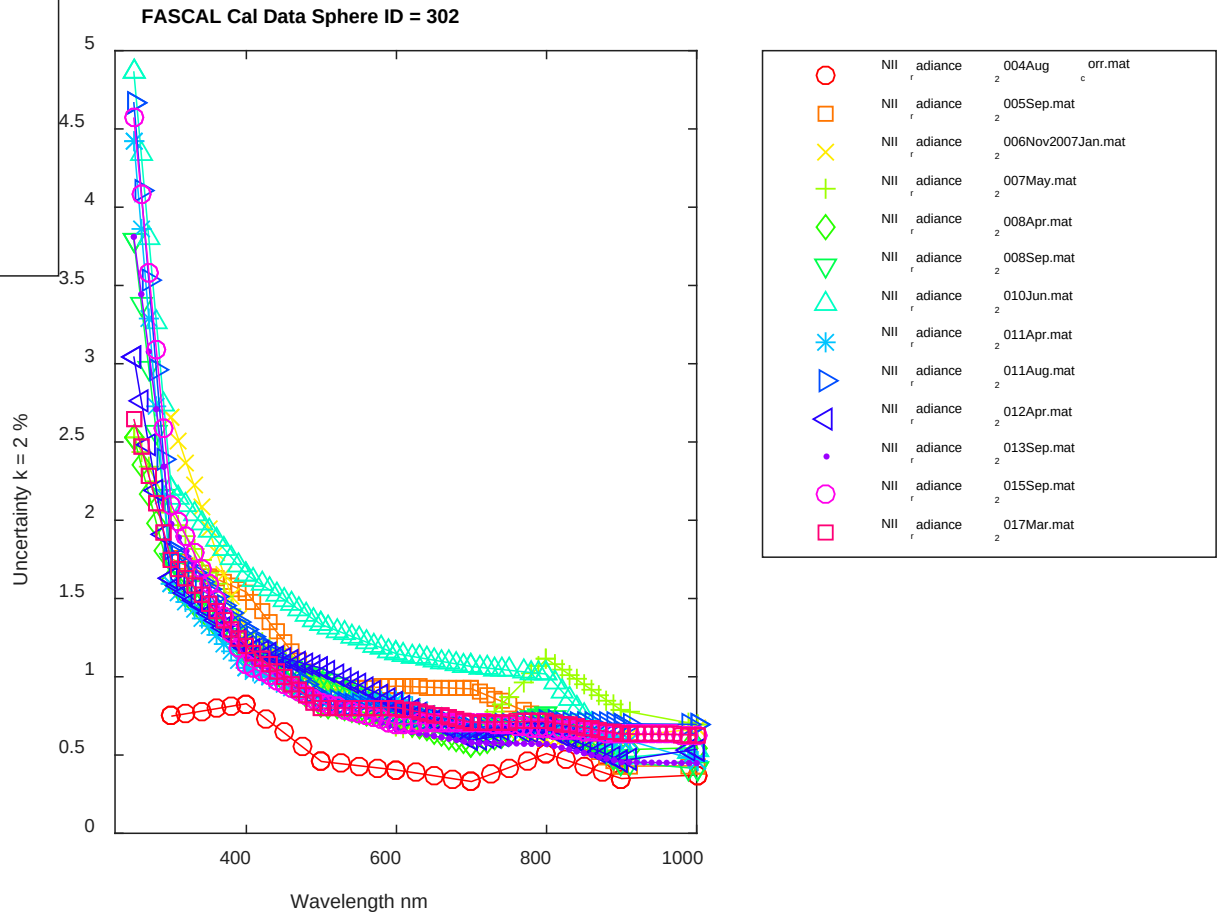
FASCAL: N = 2
VXR: N = 3

Observations & To Do

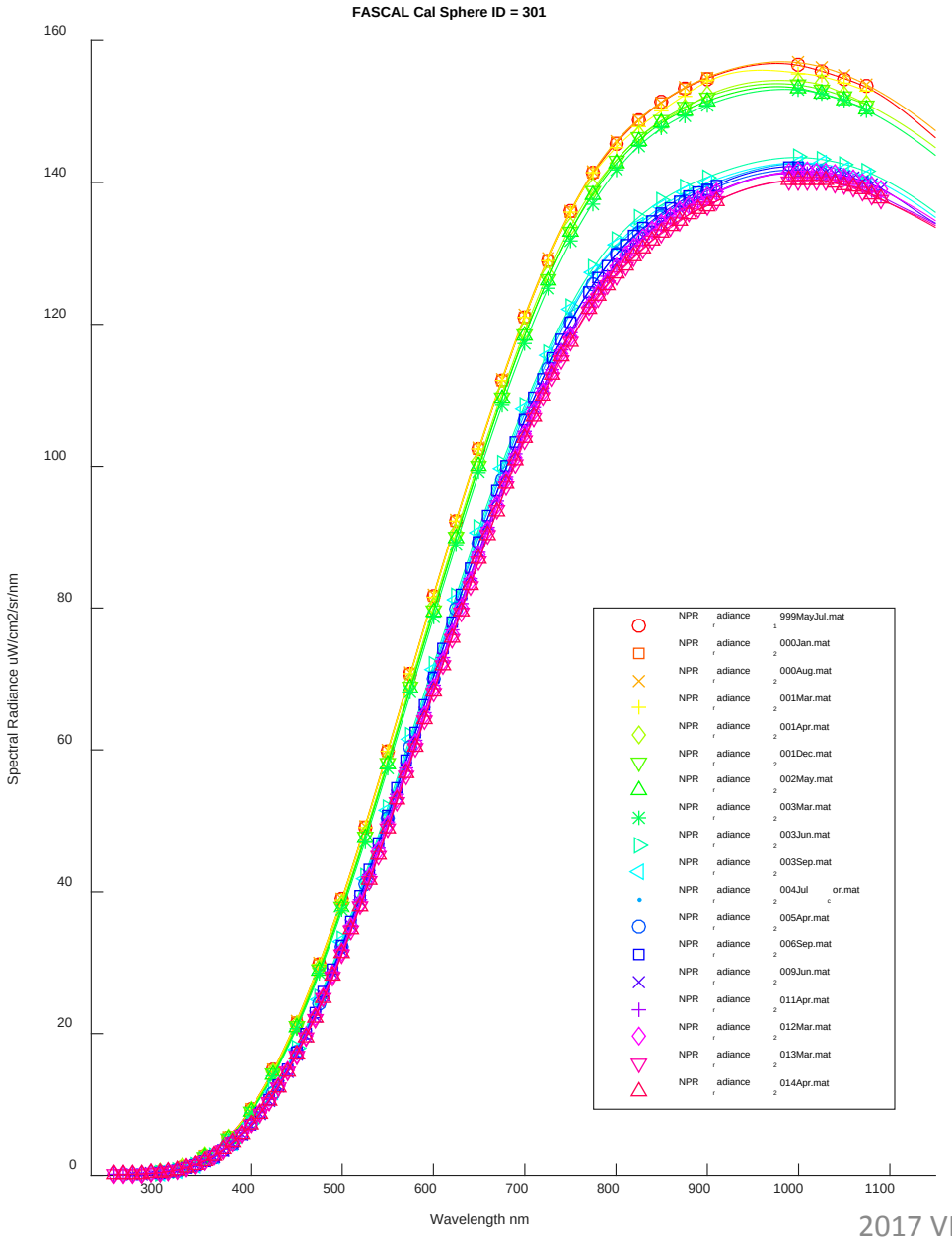
- Lamps operated de-rated last beyond the rated lifetime
- Repeated calibrations on one lamp set necessary
- Change in blue for NPR LS4 attributed to poorly seasoned lamps
- VXR and FASCAL agree to within 1%, indicates VXR stable over this time frame if we assume FASCAL is reproducible
- Four other lamp sets, with data back to 1999, remain
- Can use these results to assign ASRs and compare to the SIRCUS results for the VXR (six different calibrations, 1999 to 2011).
- Integrating spheres more difficult to model than FELs or FELs/plaque

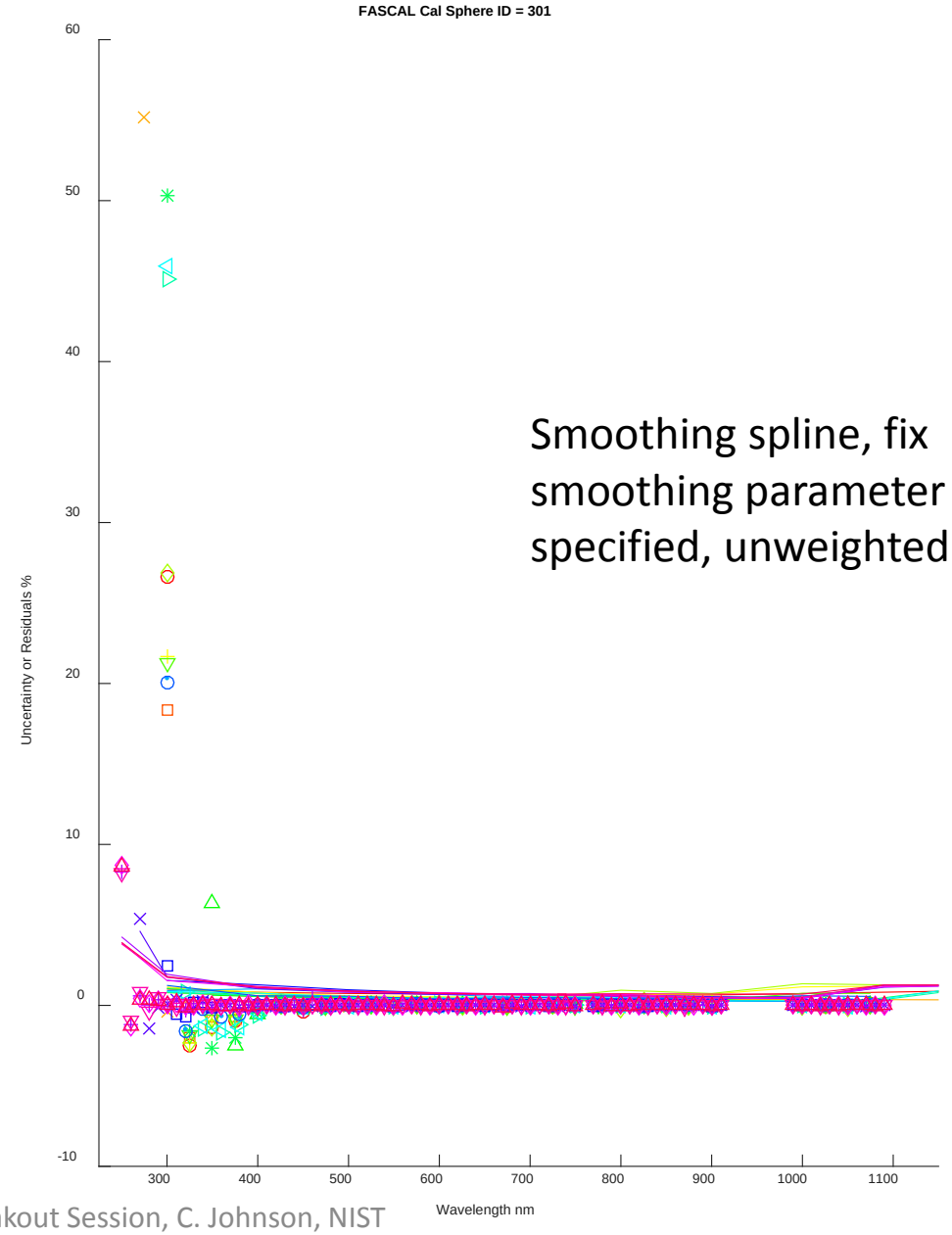
Backup



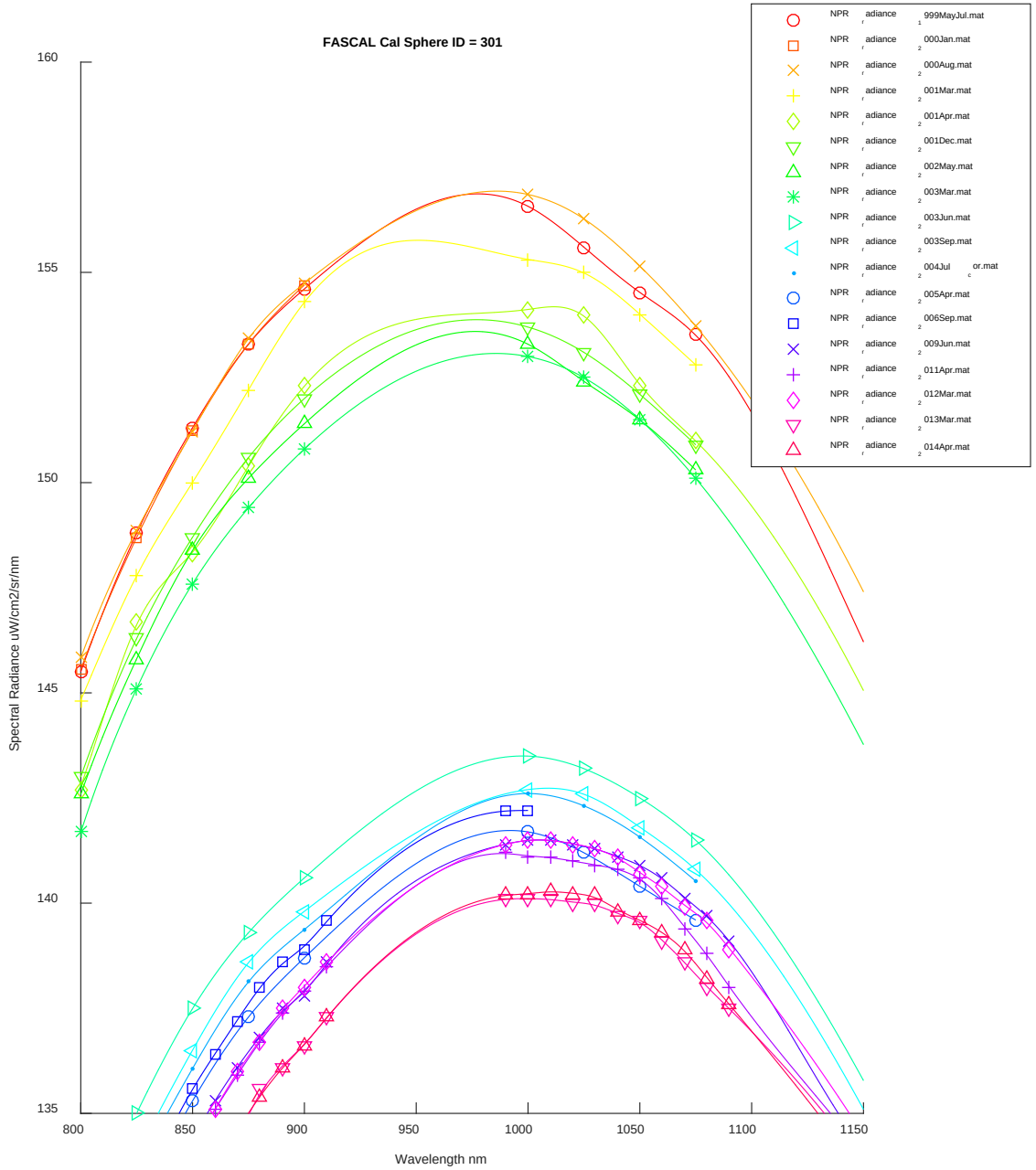


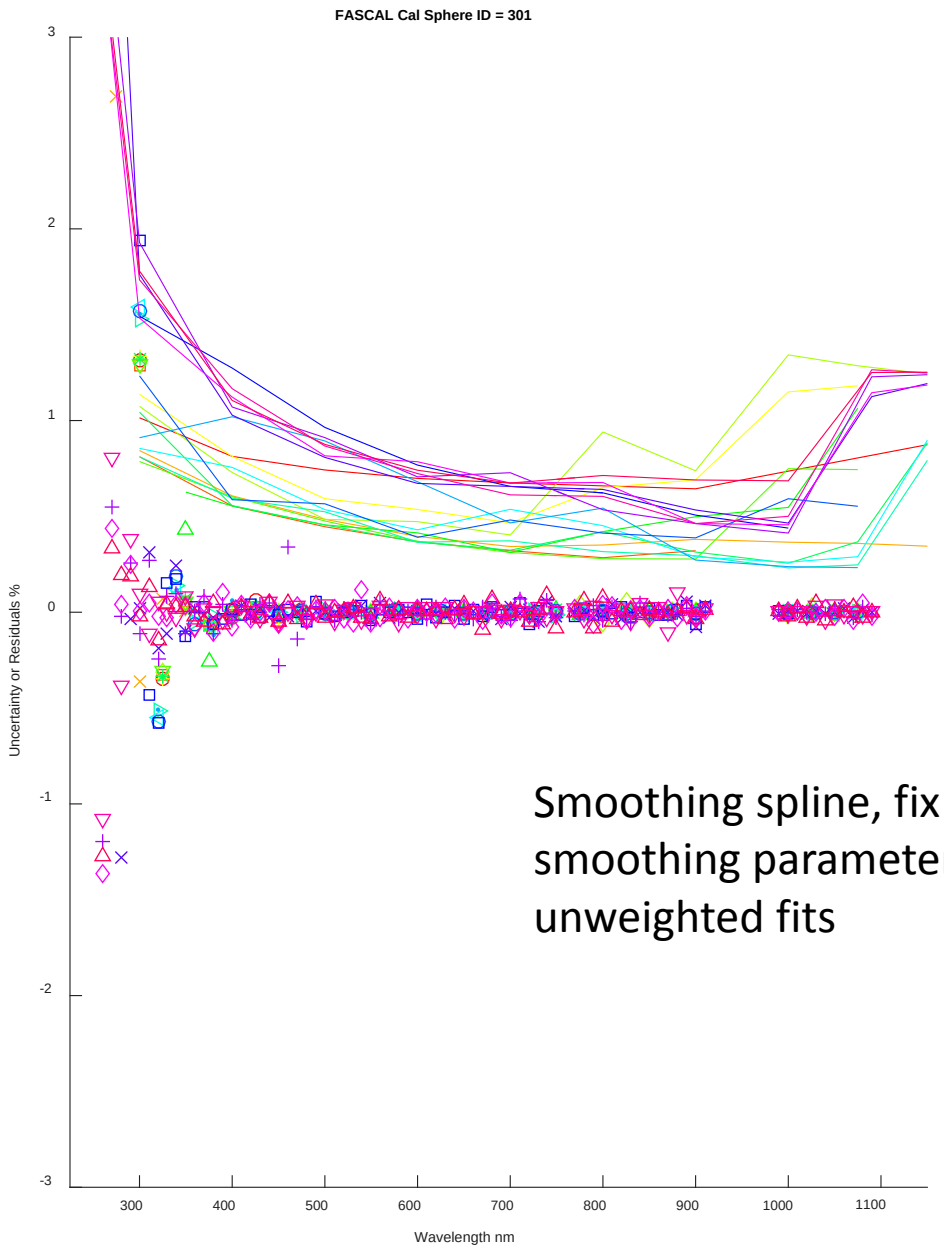
Expanded uncertainties over the full range



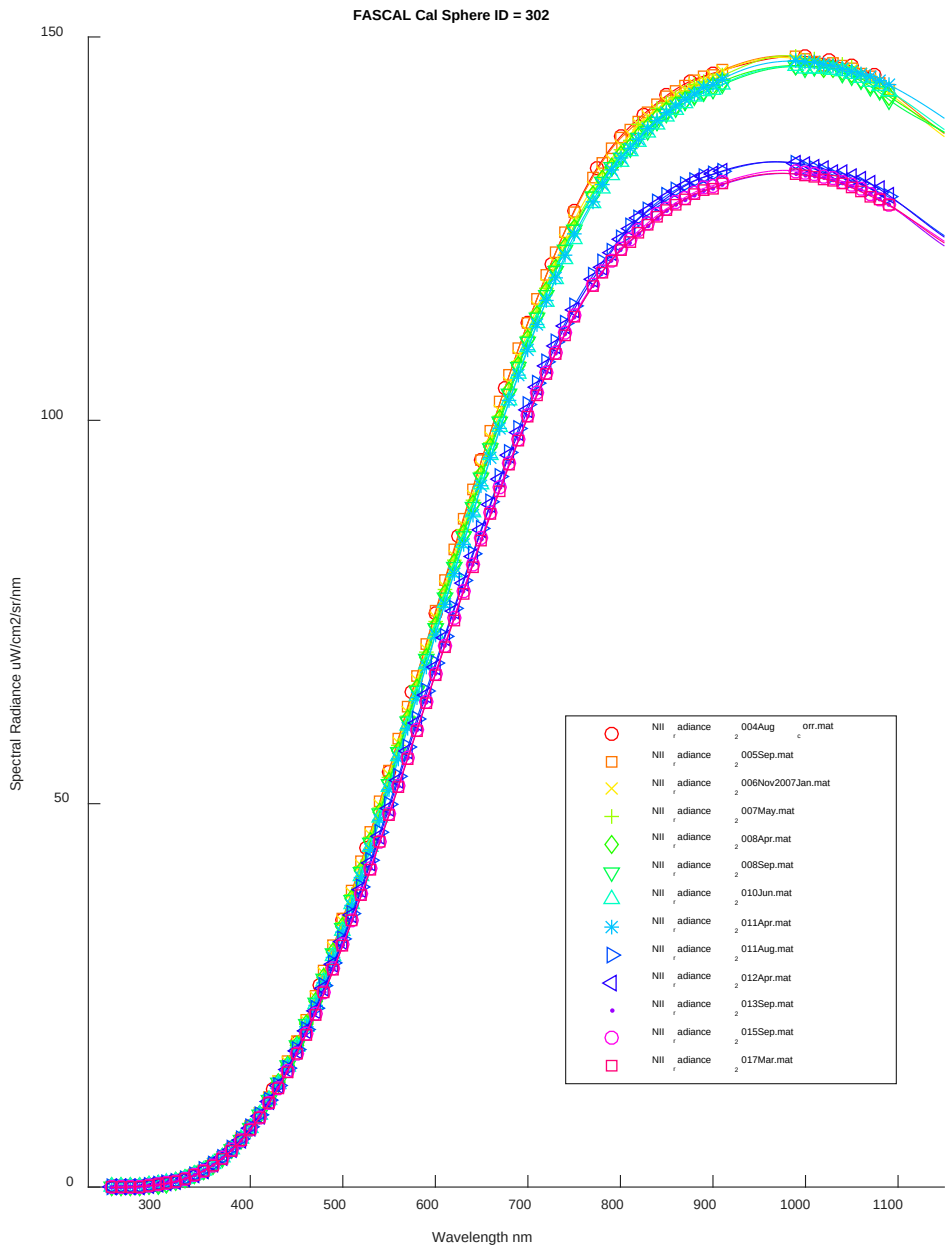


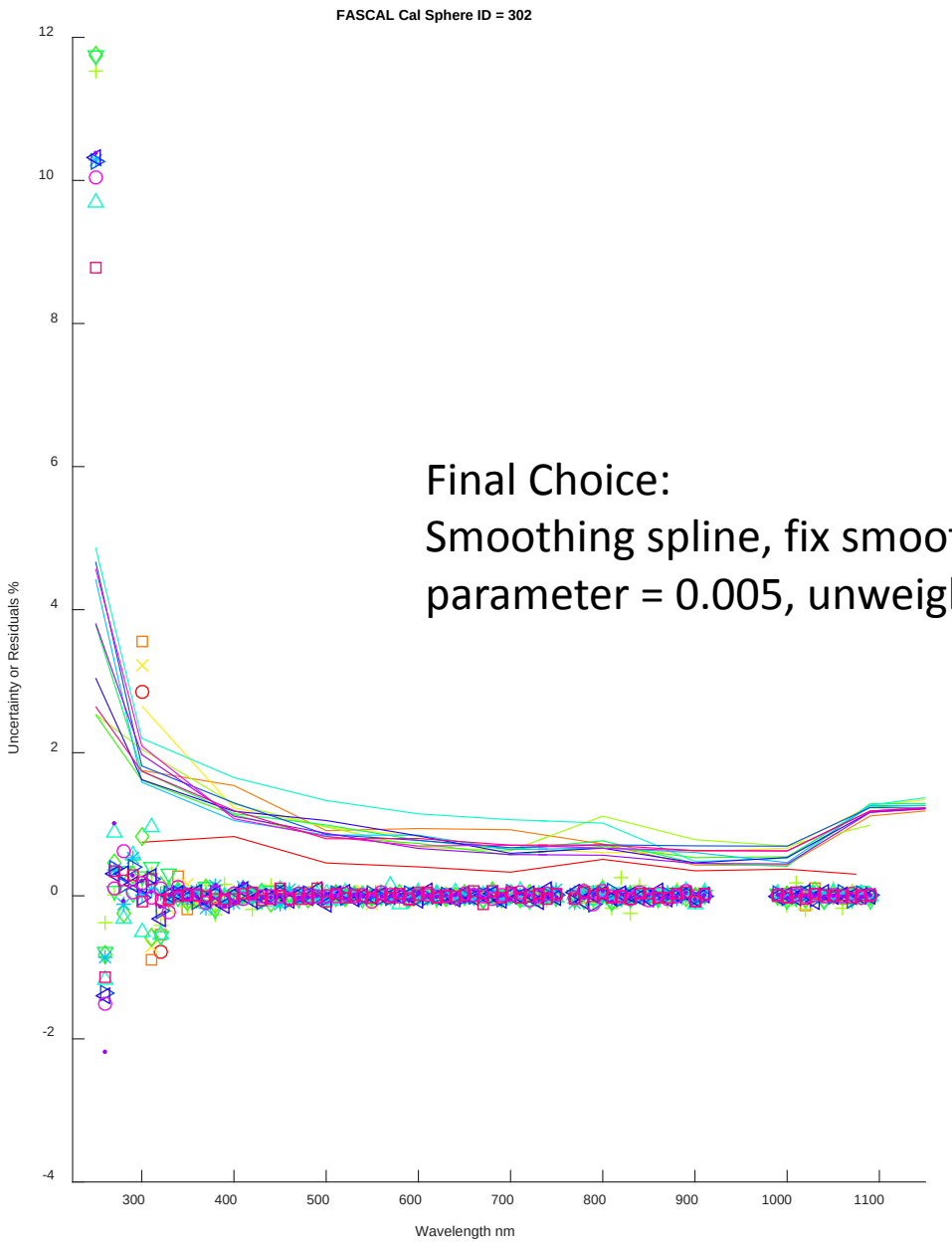
Smoothing spline, fix smoothing parameter not specified, unweighted fits



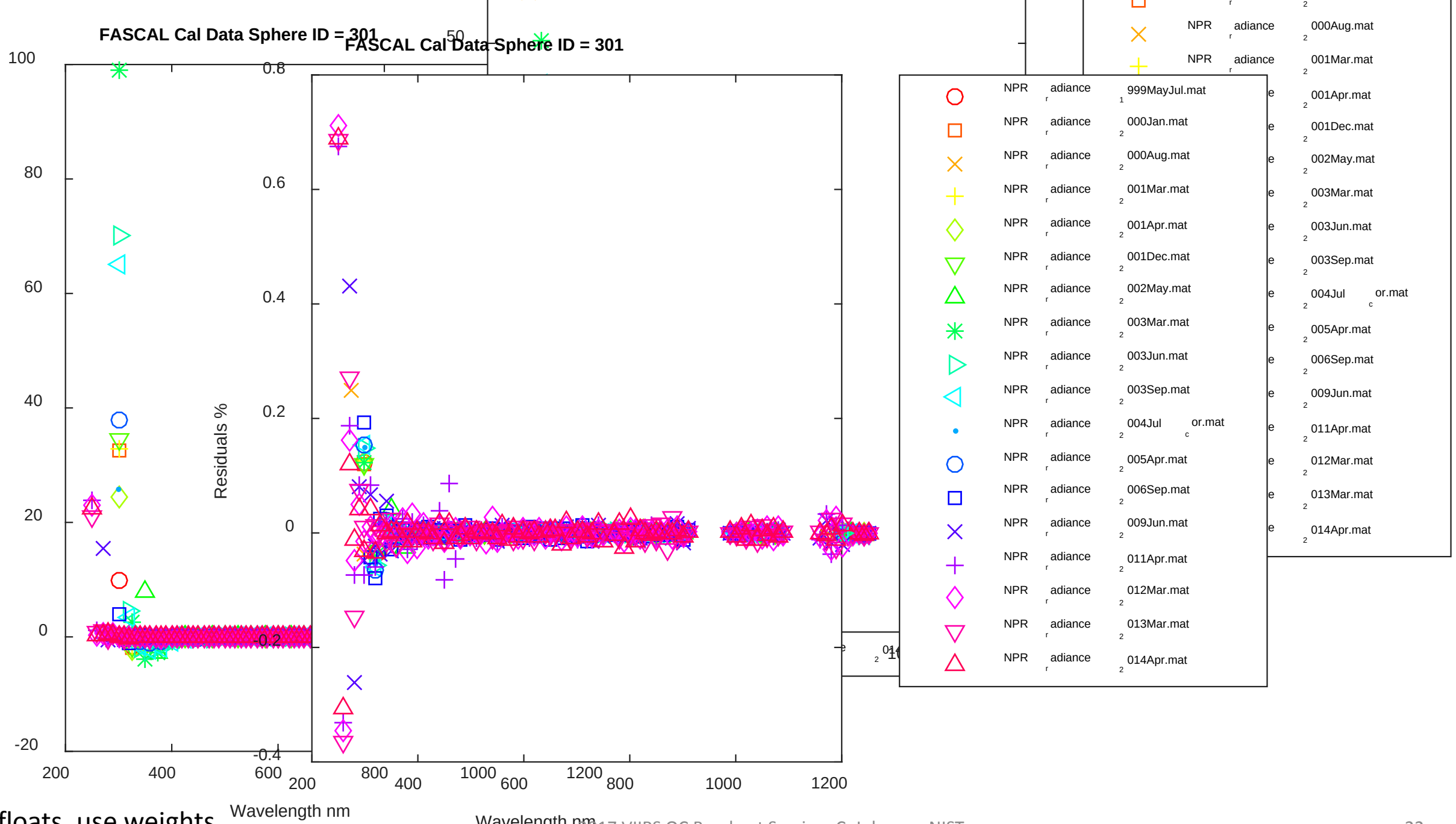


Smoothing spline, fix smoothing parameter = 0.01, unweighted fits

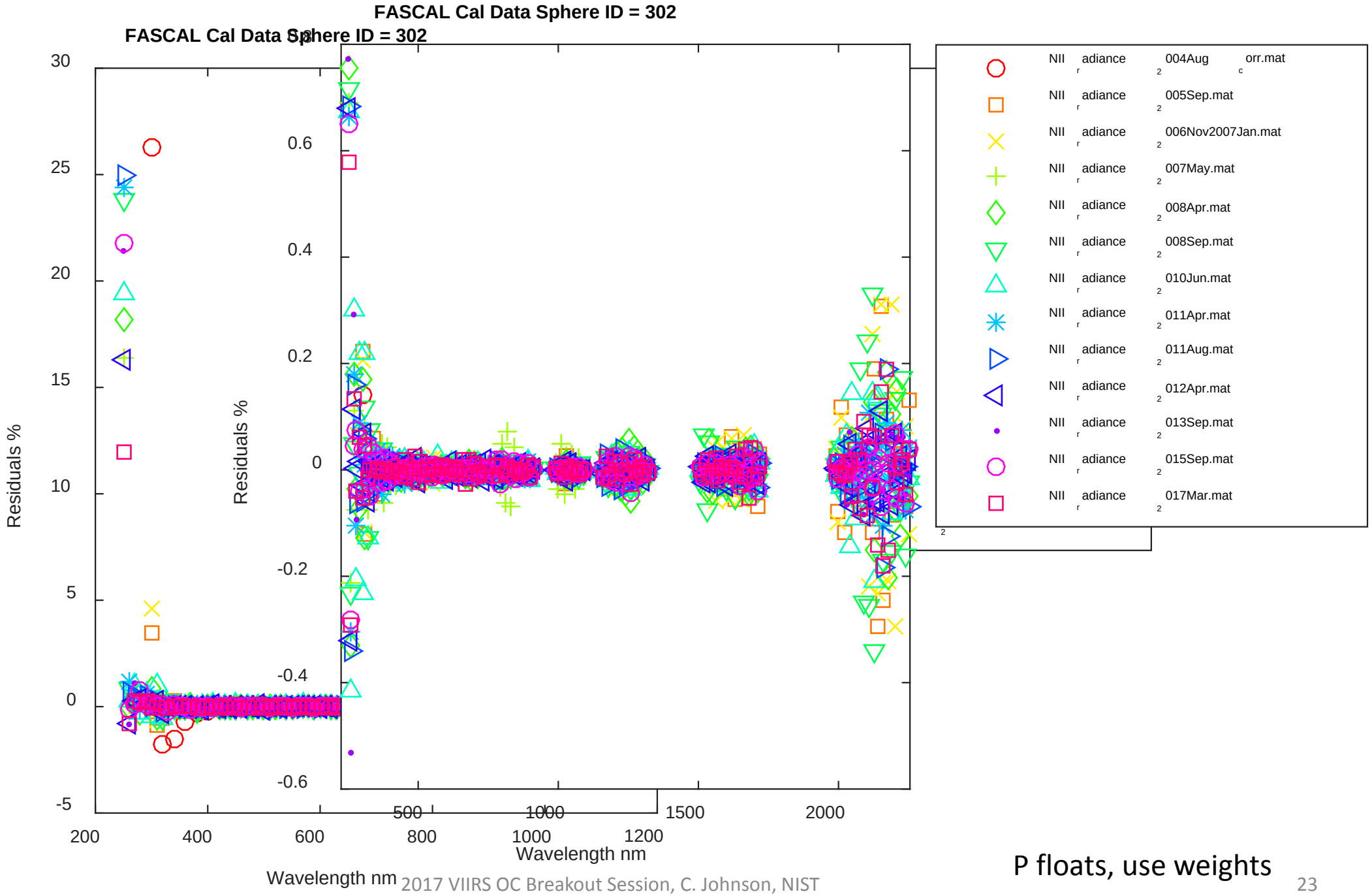




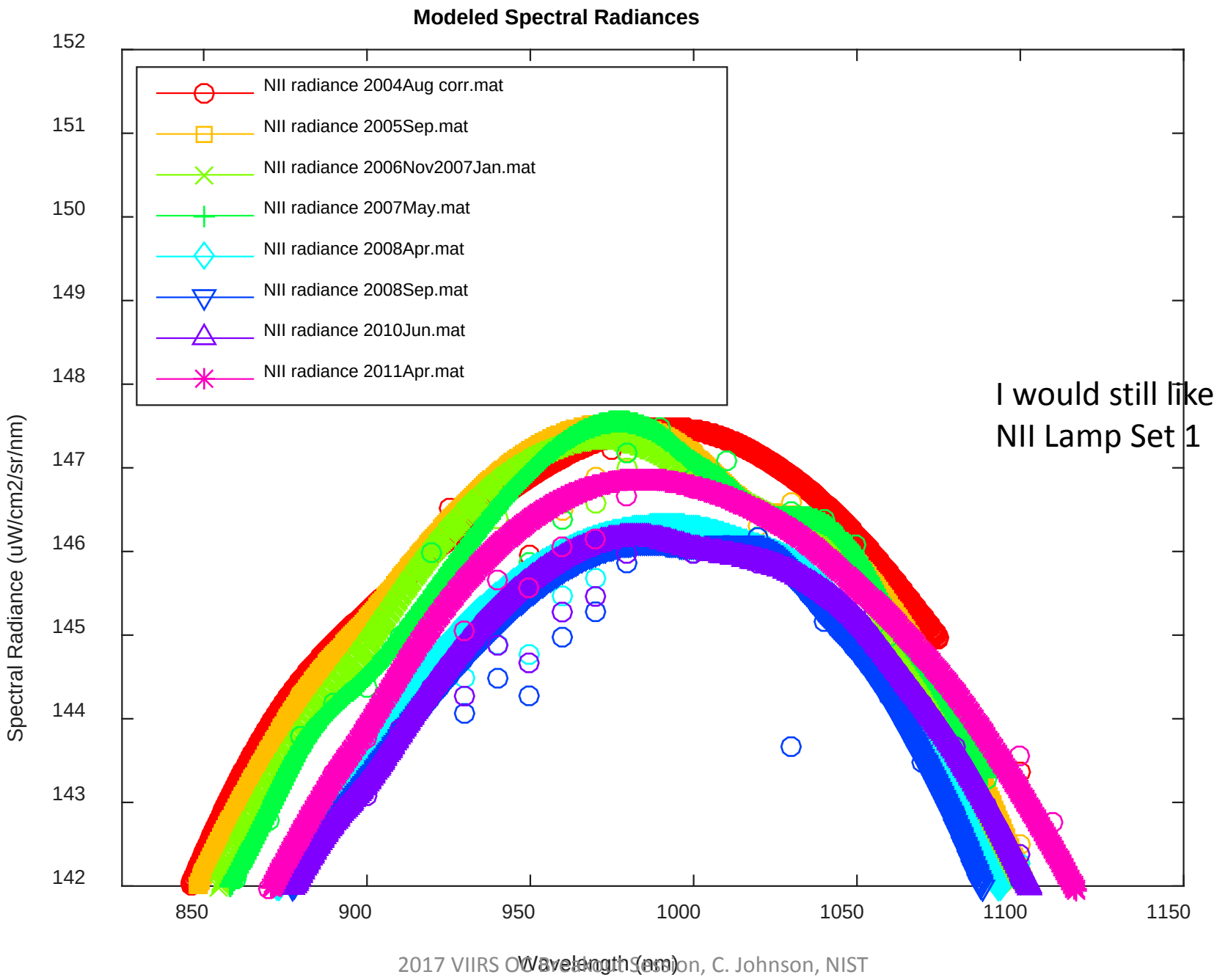
Final Choice:
Smoothing spline, fix smoothing parameter = 0.005, unweighted fits



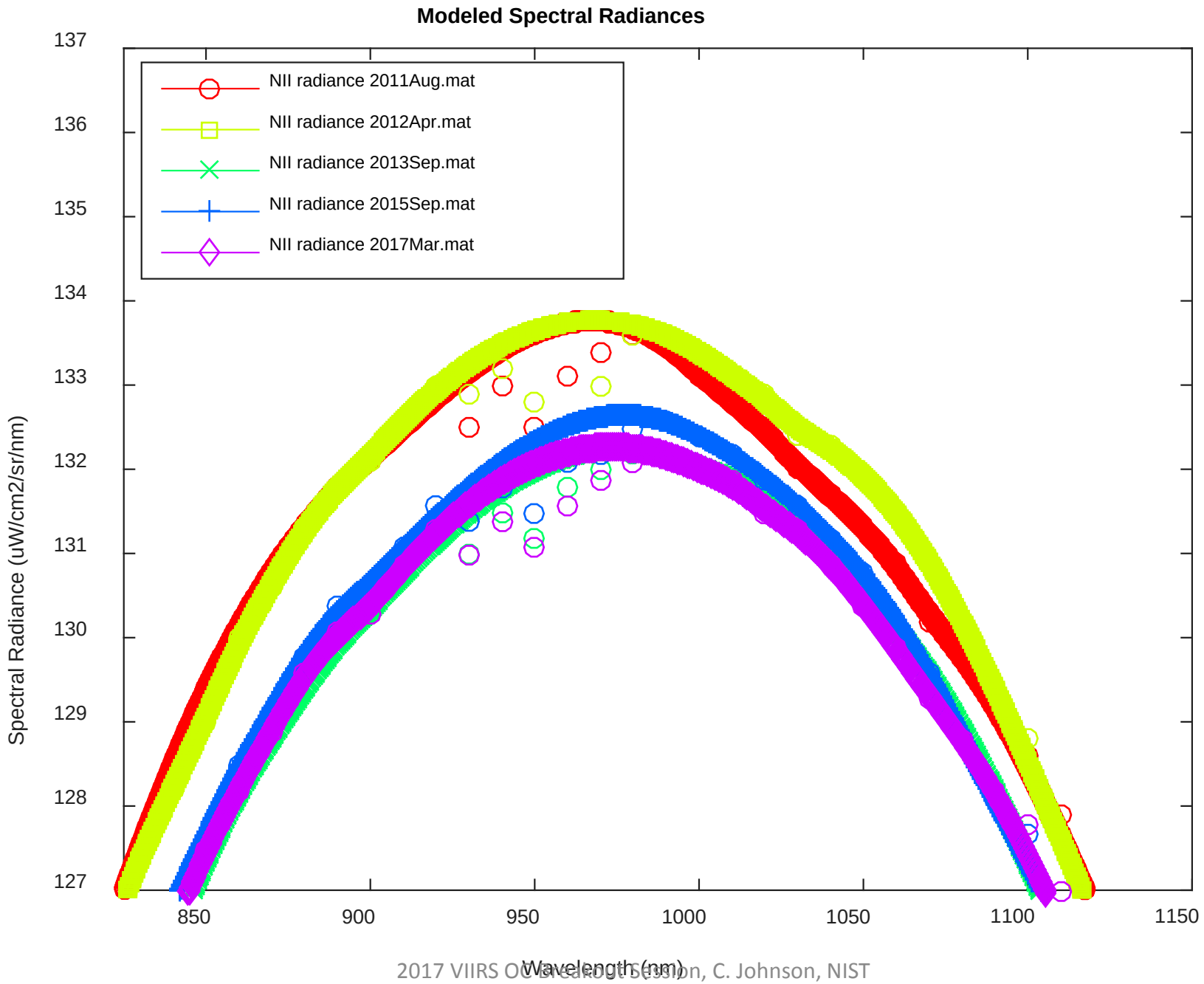
floats, use weights

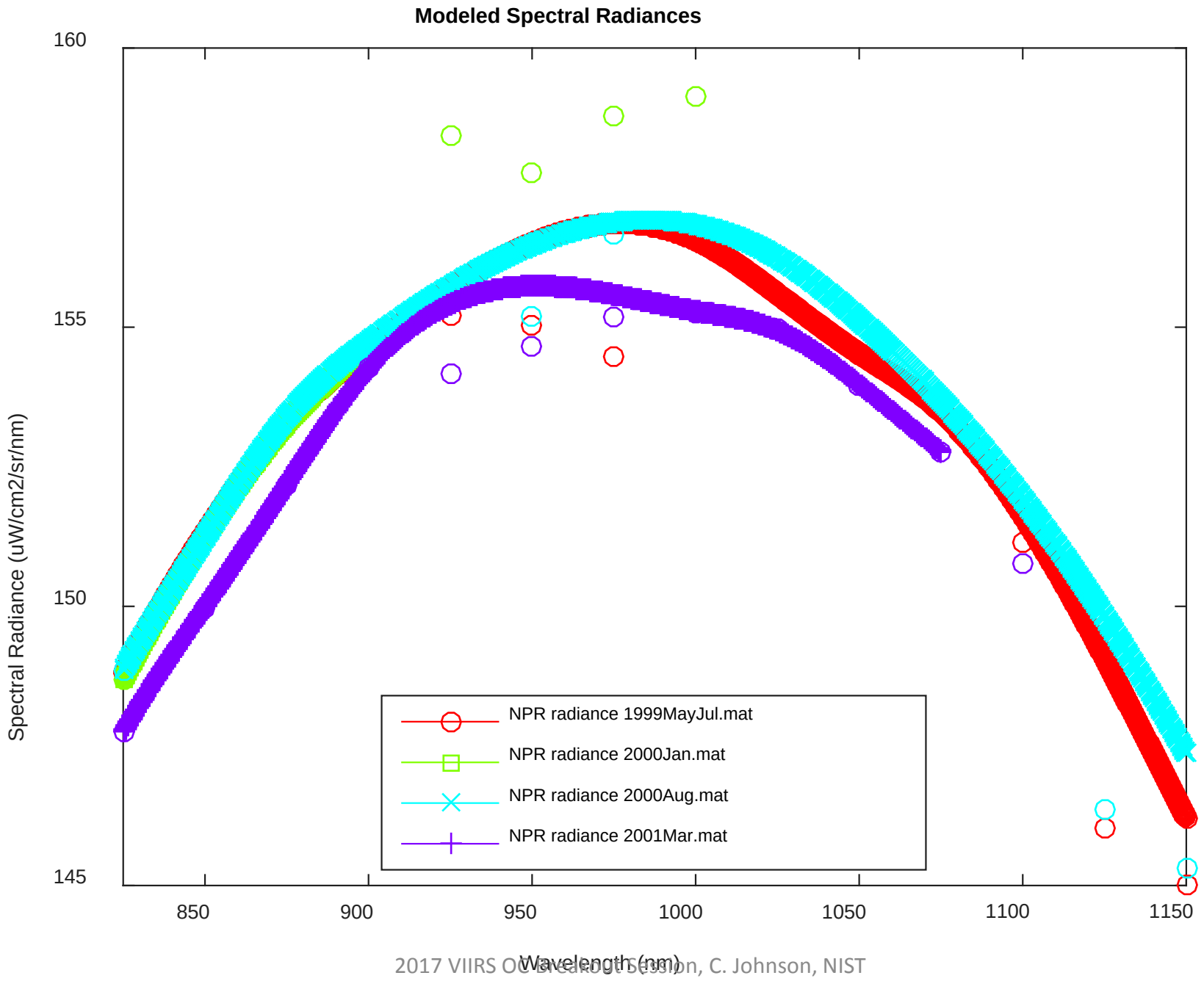


P floats, use weights

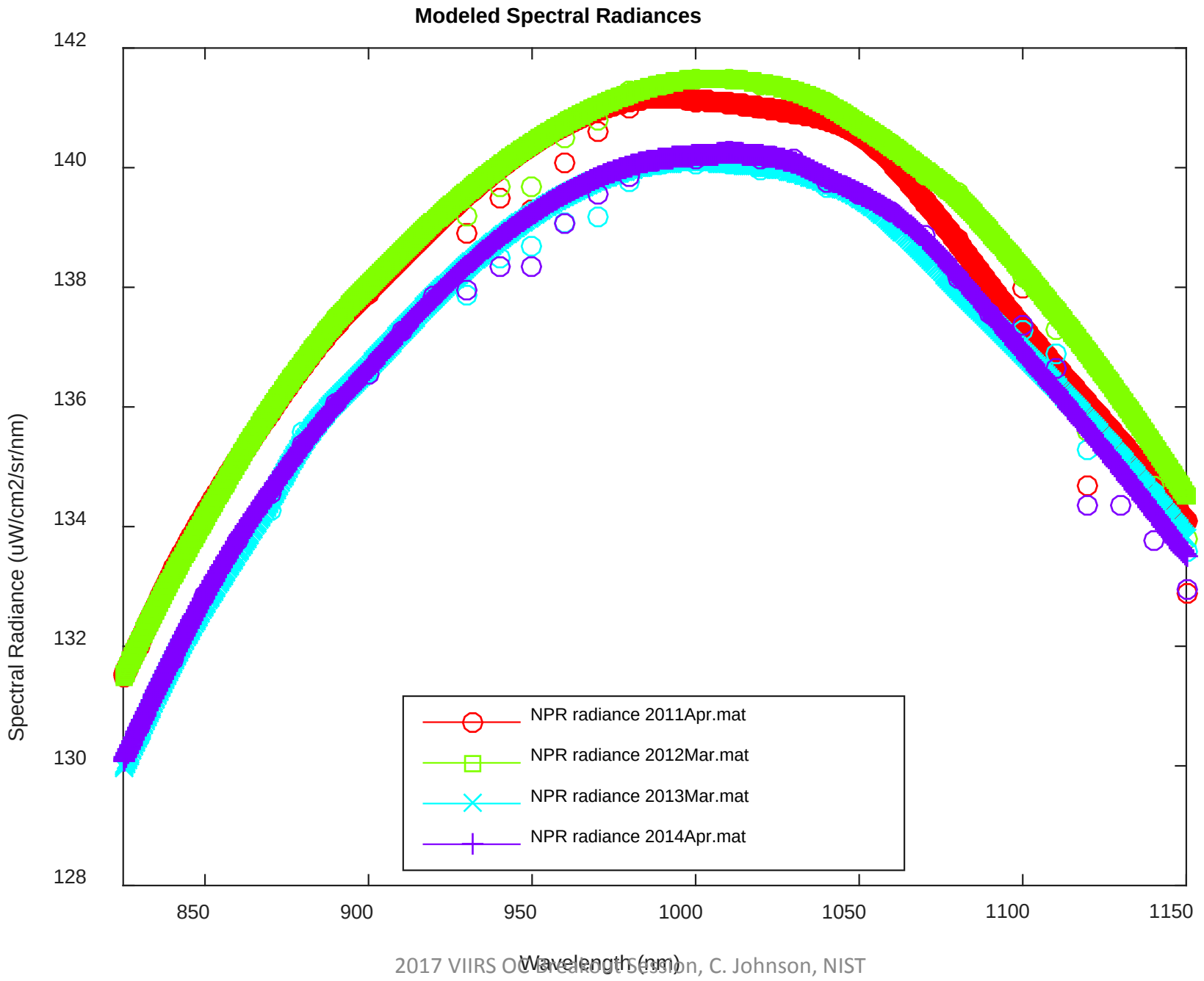


I would still like a physics based model
NII Lamp Set 1


Modeled Spectral Radiances
NII radiance 2011Aug.mat
NII radiance 2012Apr.mat
NII radiance 2013Sep.mat
NII radiance 2015Sep.mat
NII radiance 2017Mar.mat
Spectral Radiance (uW/cm2/sr/nm)
Wavelength (nm)
137
136
135
134
133
132
131
130
129
128
127
850
900
950
1000
1050
1100
1150



Better to have more fascal wavelengths here every 25



Here every 10 nm
Lamp set 4