Status Update: Wavelength Calibration at NASA for S-NPP/OMPS Nadir Mapper (NM) and Profiler (NP) Sensors

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Agenda

- Brief review of wavelength registration approach
- What’s new since the last Science Team Meeting?
  - Solar CBCs updated for new Initial Reference solar Flux [IRF] tables
    - Irradiance residuals
    - Radiance residuals
  - BPS grid parameter frozen and unfrozen
    - Improved intraorbital wavelength shift results (and chi-squared) for NM
    - NP much less sensitive to unfrozen BPS grid
  - For NM EV, studying correlations among reflectivity (or reflectance) fluctuations, BPS grid differences, and changes in a0
  - Implemented CBC generation routine for Nadir L1B (SDR)
    - NM: Based on tabulated intraorbital EV wavelength variation (no seasonal component)
    - NP: Based on tabulated seasonal solar wavelength variation (no intraorbital component)
- Plans for further development
  - Root hardware cause of NM temperature sensitivity, and fixes for J1 and J2 (from BATC)

NASA Wavelength Registration Algorithm (Update)

- A high-res solar spectrum (intially sampled at 0.01 nm) developed by KNMI for OMI is convolved with ~~the preflight~~ bandpasses centered in turn at each band center and separated by a variable grid parameter to form a synthetic solar spectrum
- For OMPS NP, solar activity corrections are applied to the synthetic spectrum
- A polynomial scaling function (useful for solar calibration, essential for EV) morphs synthetic irradiance into synthetic radiance
- An implementation of the Levenberg-Marquardt nonlinear least squares algorithm used to minimize the difference between synthetic and measured irradiance or radiance
- The final optimizing CBC and the spectral calibration coefficients used to constitute it at each spatial index are the principal products.

Dispersion Relation (Update)

- For both nadir sensors, each spatial index has an independent band center solution whose coefficients are applied as follows:

  CBC(iSpat,iSpec) = a0(iSpat) + a1(iSpat)*(iSpec-iSpec0) + a2(iSpat)*(iSpec-iSpec0)^2 + a3(iSpat)*(iSpec-iSpec0)^3

  where iSpat is the spatial pixel index, iSpec the spectral pixel index, and iSpec0 is the spectral pixel index of the fitting window lower bound.

- The current version of the algorithm varies only the constant offset term, a0, freezing a1, a2, and a3 at the values underlying the original BATC CBC. Small spatial irregularities in a0 reflect analogous structures along the slit edge found by BATC in prelaunch studies.

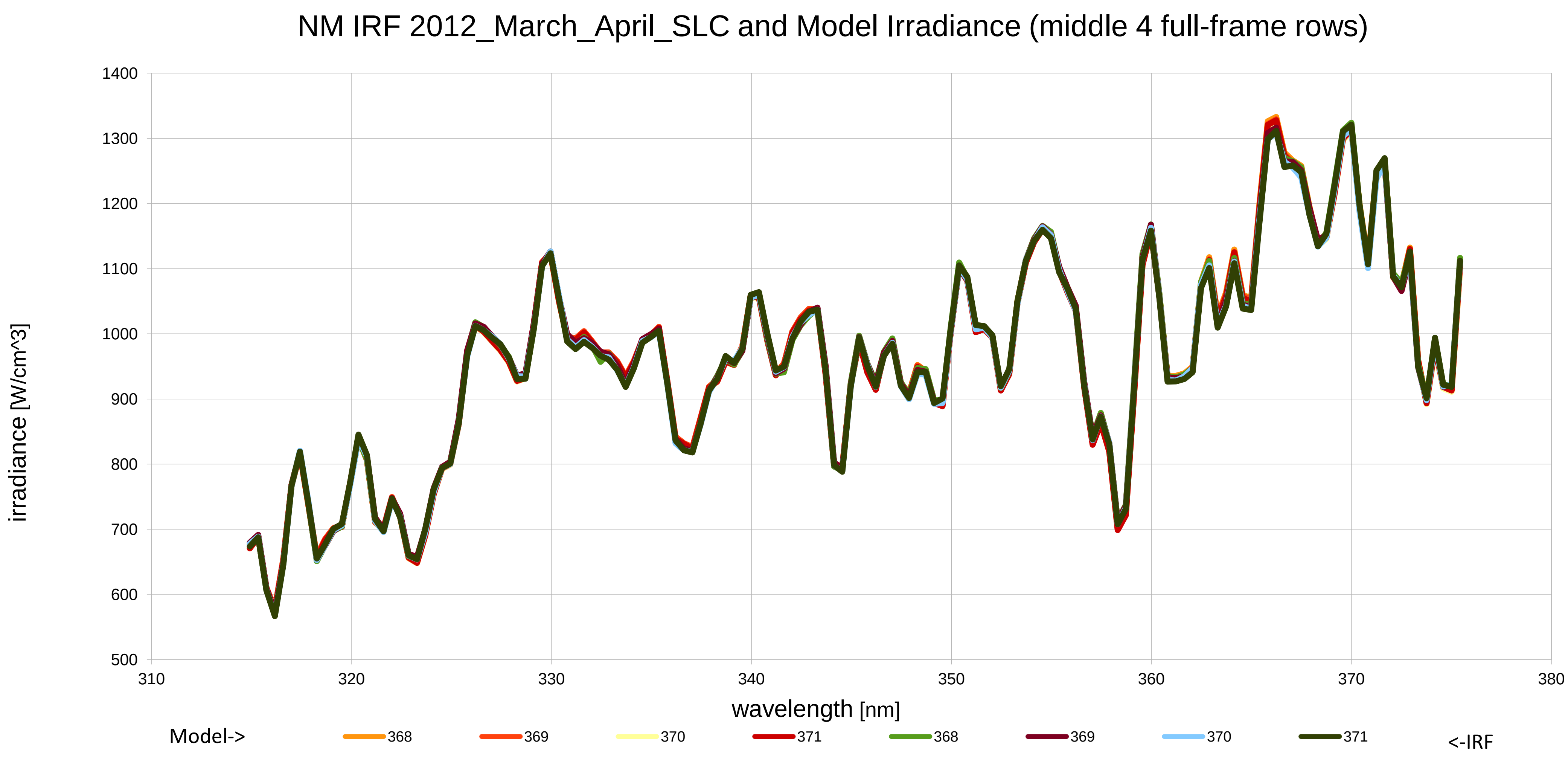
Spectral and Spatial Bounds used for NM and NP Irradiance and Radiance Fitting Windows

- NM solar calibration (Full-Frame)
  - Spatial Indices 16-763 (except for smear rows 370-409)
  - Spectral Indices 137-282 (about 315-375 nm)
- NM EV (Full-Frame)
  - Spatial Indices 16-763 (except for smear rows 370-409)
  - Spectral Indices 220-282 (about 349-375 nm) – avoids ozone
- NM EV (nominal and EV360)
  - Spatial Indices 0-35
  - Spectral Indices 108-182 (about 344-375 nm)
- NP solar calibration (Full-Frame)
  - Spatial Indices 36-135
  - Spectral Indices 64-164 (about 252-294 nm)
- NP EV (Full-Frame)
  - Spatial Indices 36-135
  - Spectral Indices 82-158 (about 259-292 nm) – avoids ozone
- NP EV (nominal) – 1 spatial index
  - Spectral Indices 26-102 (about 259-292 nm)

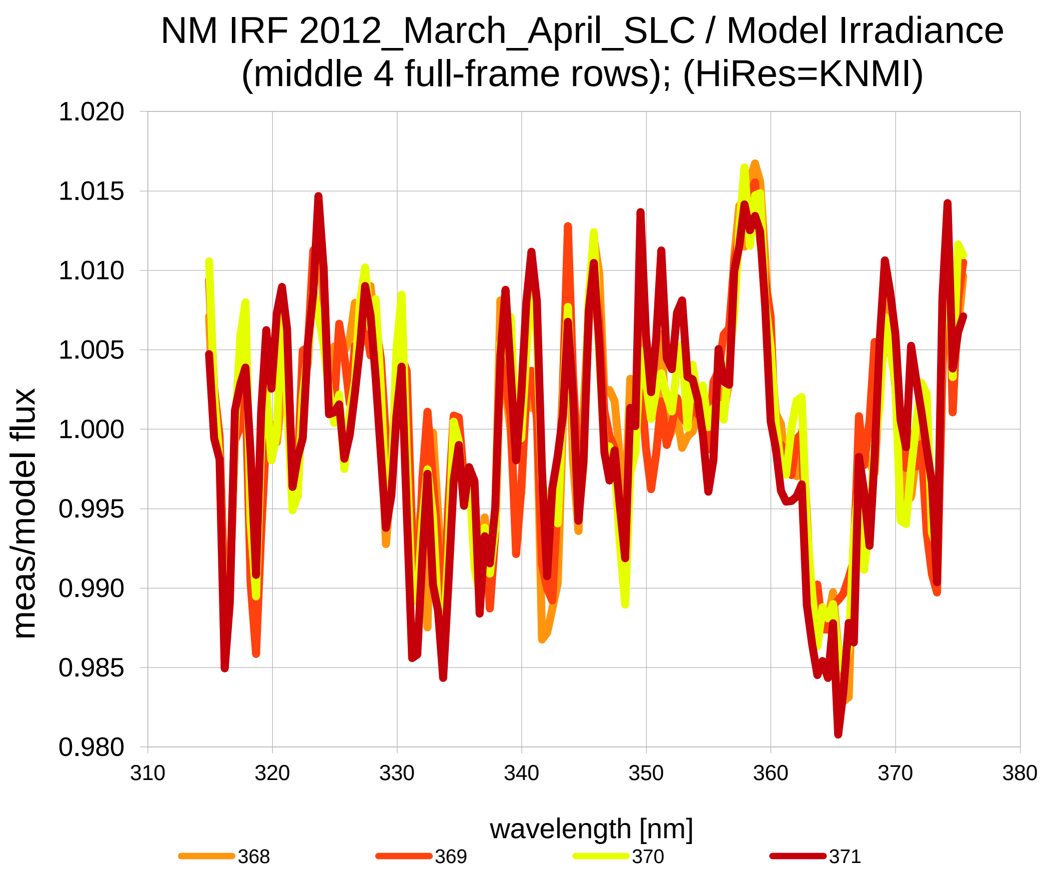
NM Irradiance Residuals

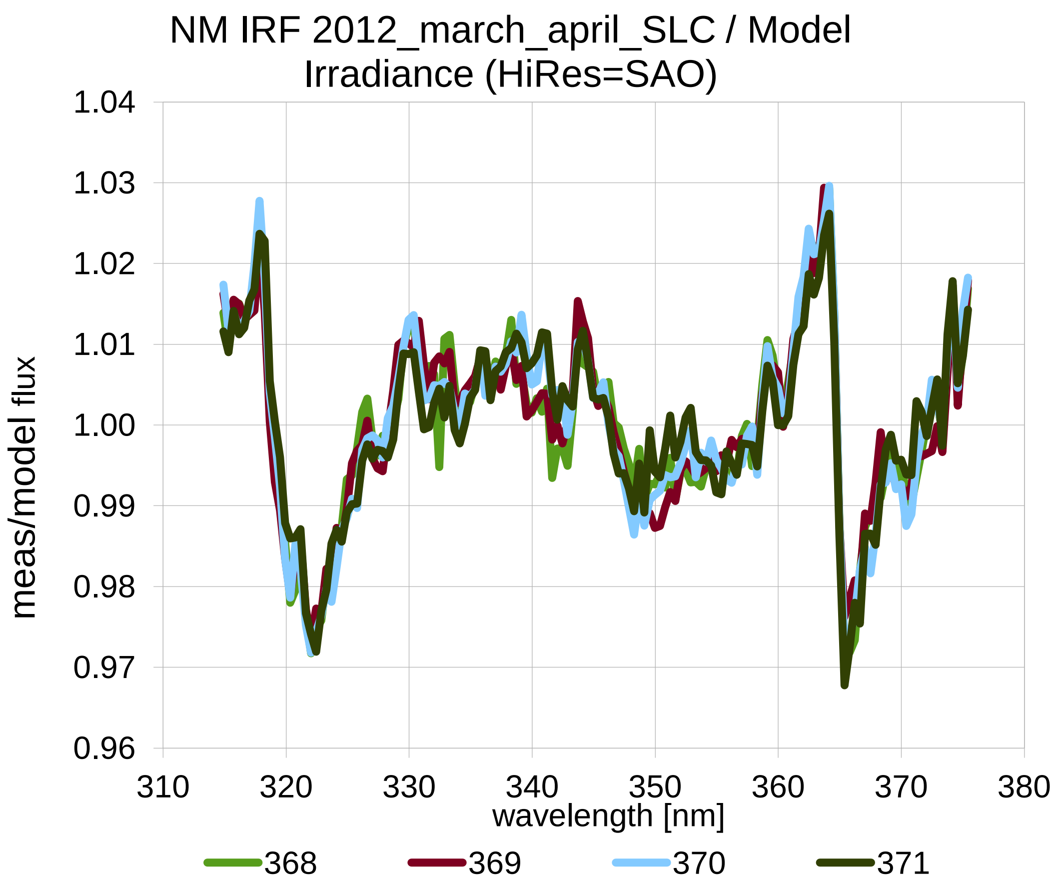
- Flux residuals here refer to the of measured flux / model flux from 1.
- Residuals demonstrate the quality of CBC and bandpass solutions
- Although a few “features” ~2% persist for different IRFs, different features on this scale appear when synthetic flux uses a different high-resolution reference solar flux (e.g., Kurucz-Chance 2010 (SAO) vs the KNMI flux used for OMI and preferred by NASA for OMPS
  - Most of these features appear to be artifacts of the high-res solar spectrum rather than of the algorithm used to derive the CBC
  - If they were caused by diffuser features, they should appear in both models
  - In any case, a0 (and therefore CBC) values generally differ by <0.01 nm when different high-resolution solar spectra are used.

NM Day 1 Solar Flux (IRF) and Model Flux



NM IRF Irradiance Residuals using Hi-Res Solar Flux from KNMI vs SAO (Kurucz-Chance)

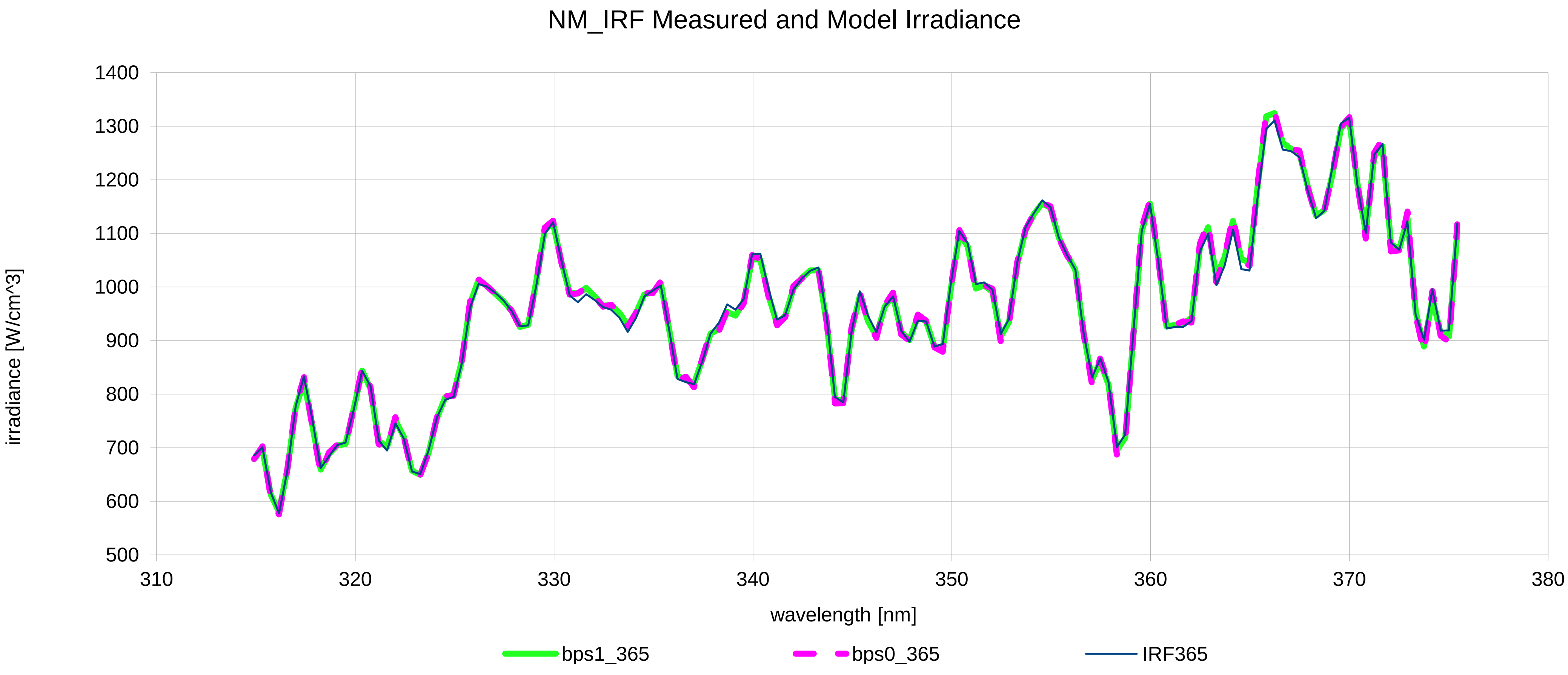




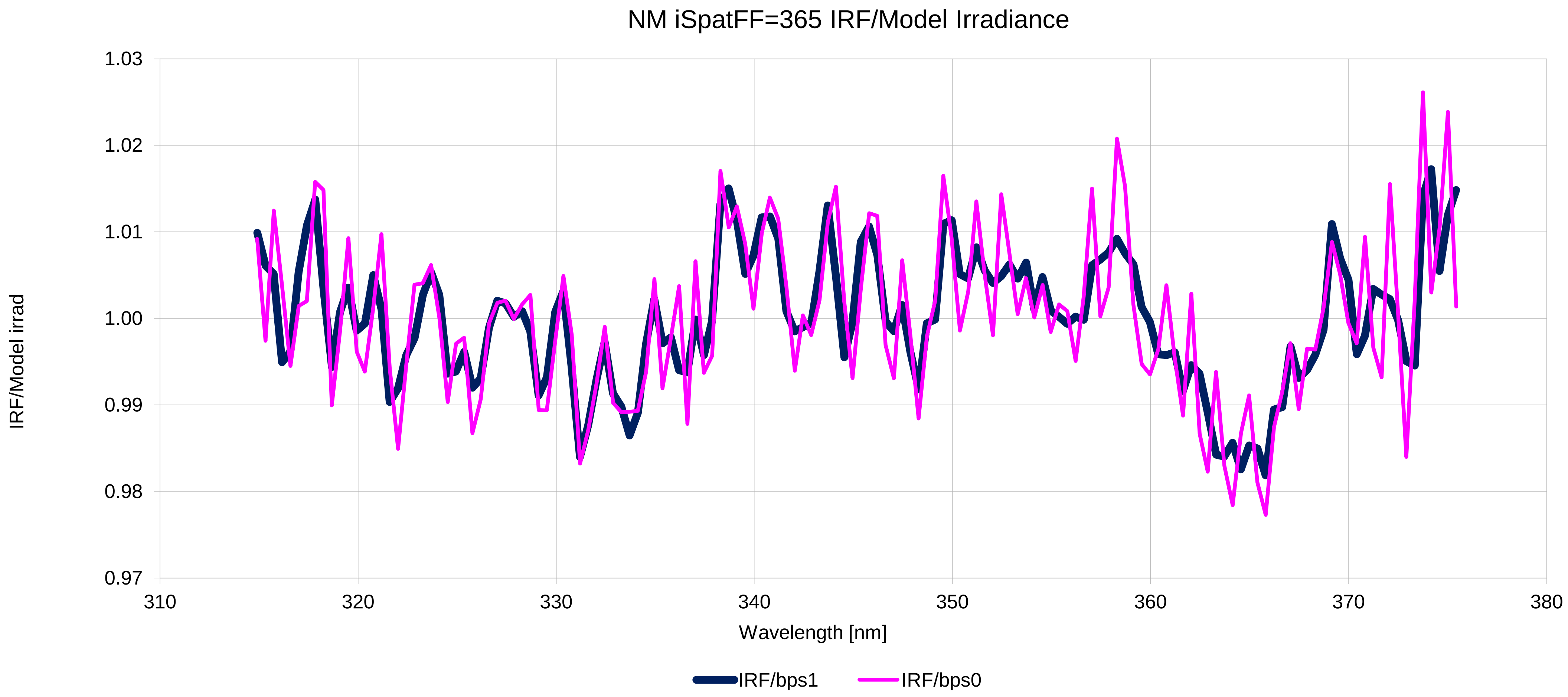
NM IRF and Model Flux – Free vs Frozen BPS grid parameter

- Even with the BPS grid parameter free, the high-res SAO spectrum generates synthetic flux with significantly larger residuals than the KNMI spectrum (whether or not the BPS grid parameter is frozen); only examples using the KNMI high-res spectrum will be shown.
- The free grid parameter produces significantly smaller residuals with the KNMI spectrum. This is the current model used for OMPS Nadir wavelength registration at NASA.

NM Measured (IRF) plus Model Flux with free (bps1) or frozen (bps0) grid parameter



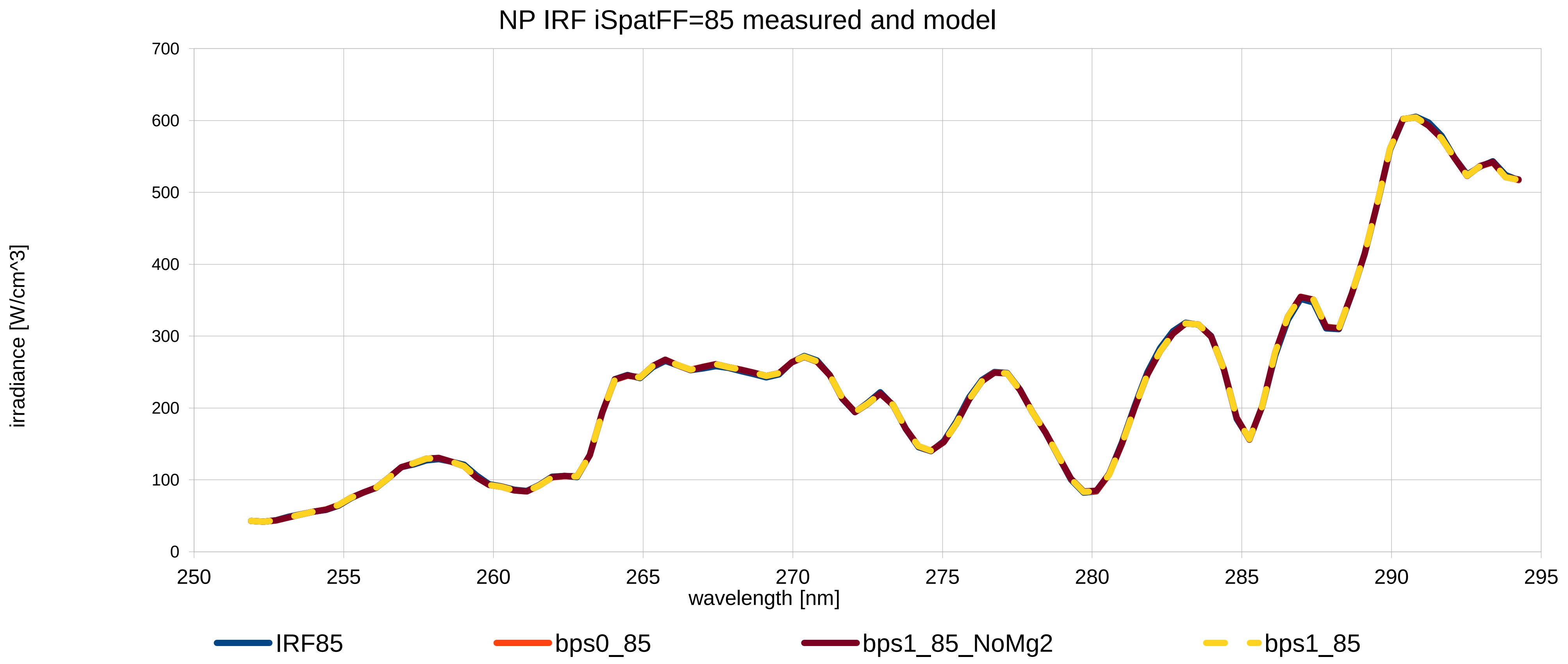
NM Measured/Model Irradiance
BPS Grid Free or Frozen



NP Irradiance Residuals

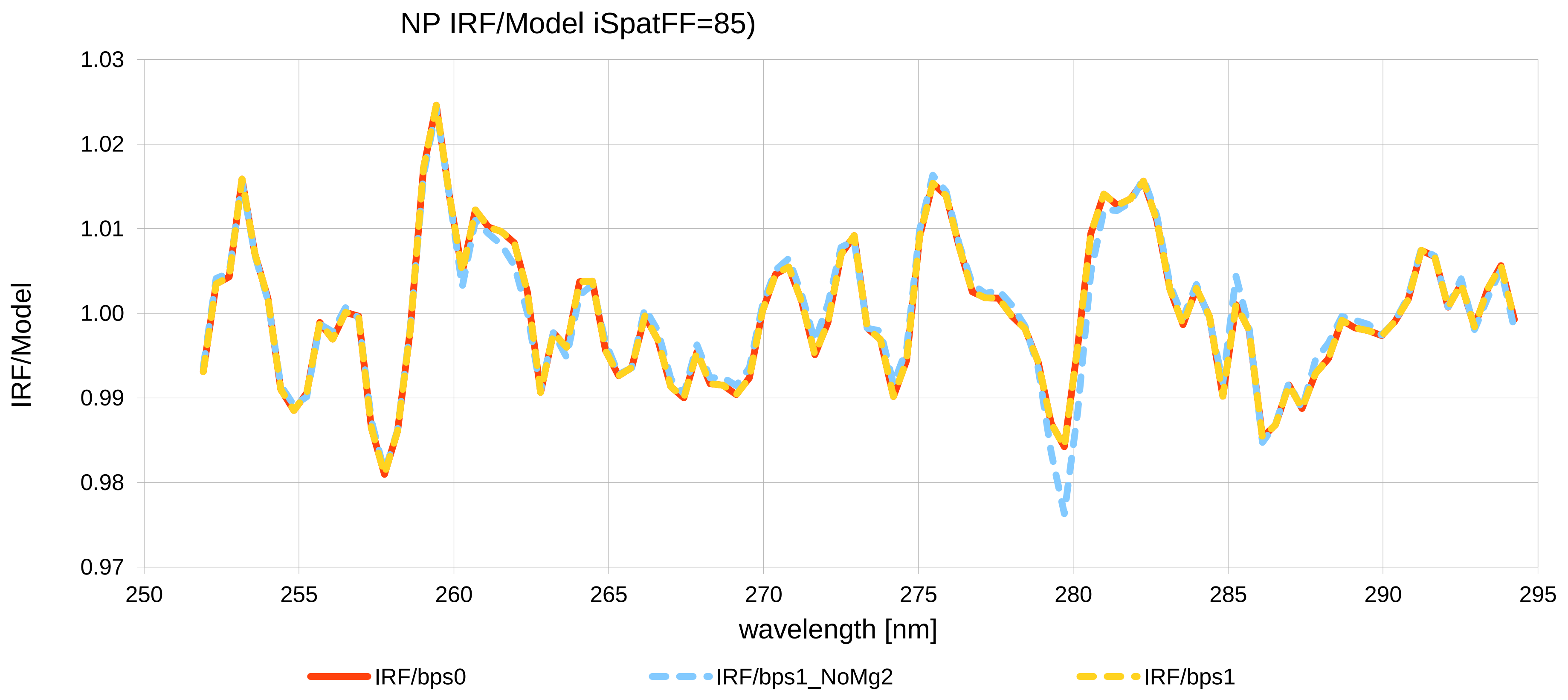
- The following slides compare NP irradiance residuals with and without BPS grid variation, solar activity corrections, and models using the SAO high-res solar spectrum as well as the KNMI spectrum
- Unlike NM, NP is almost insensitive to bandpass grid variation
- Note: Our composite IRF uses solar flux for 4 different dates, each with its own Mg II index; test used a date (April 17, 2012) with Mg II index ~mean
- Show current a0 as a function of date, compare with N_T_Telescope

NP Irradiance – IRF and Various Models: BPS grid frozen or free, solar activity corrected or not



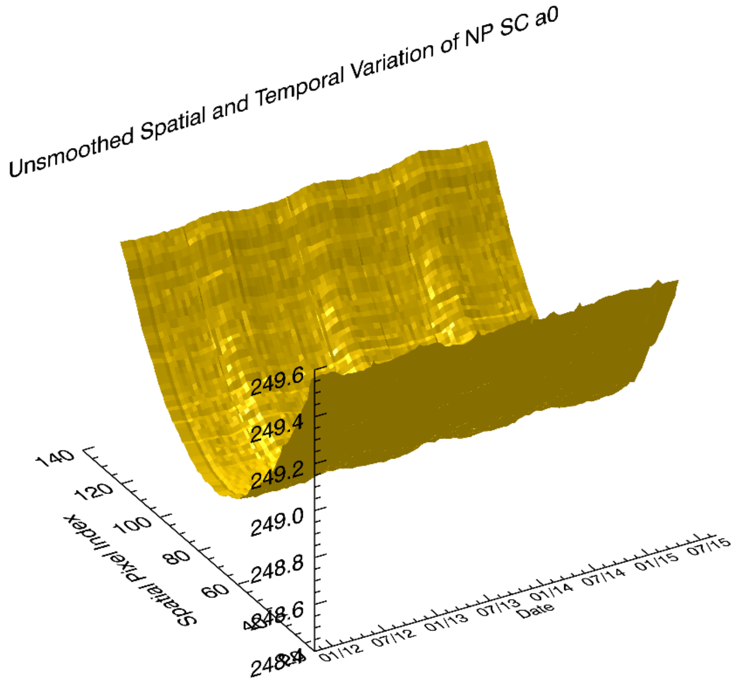
NP Irradiance Residuals Near Nadir

NP IRF/Model Flux near nadir (iSpat=85), BPS grid free and frozen; also shown is a BPS free-grid example w/o solar activity correction (NoMg2).

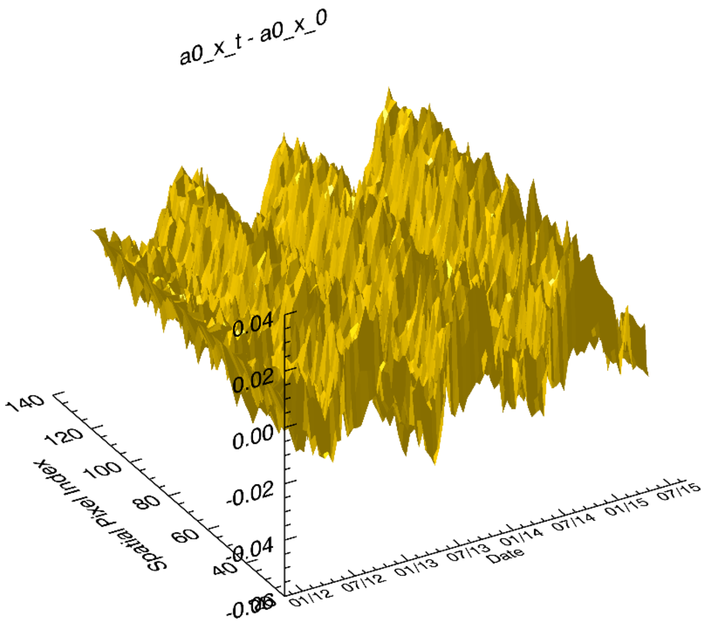


Seasonal Variation of NP Wavelength Scale

NP Solar Calibration -- Seasonal Variation of Wavelength Scale Offset a0



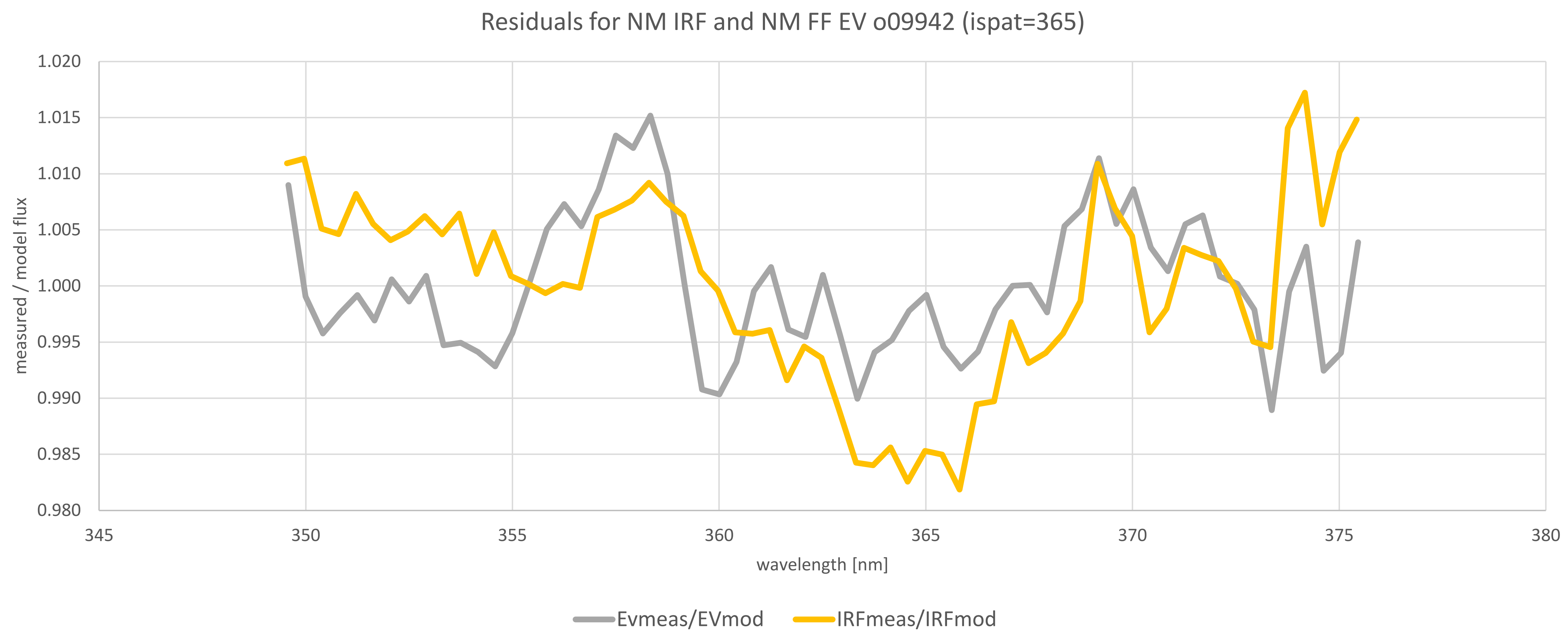
Seasonal Variation of da0, that is, a0(t) – a0 for 28 Jan 2012



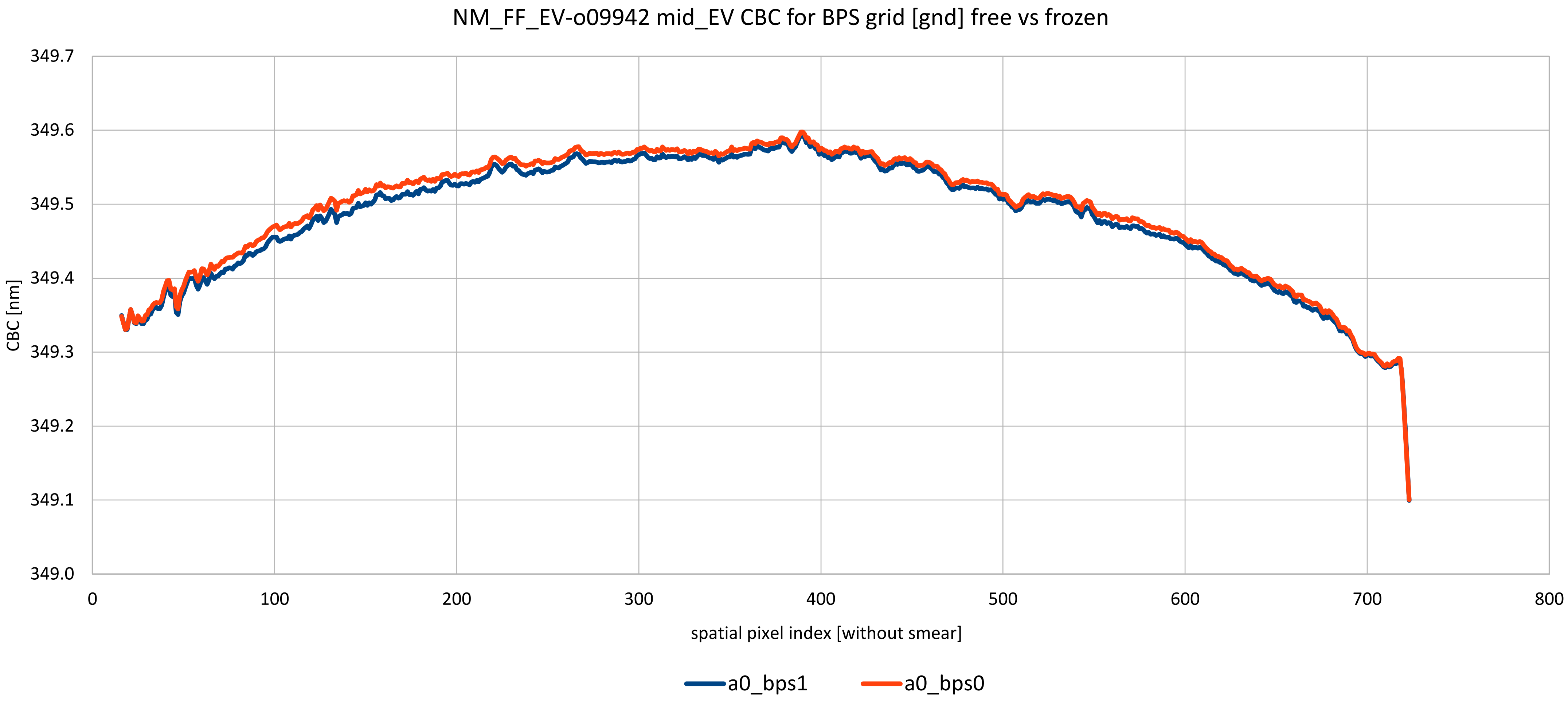
NM Radiance Residuals

- The [NASA] OMPS Nadir wavelength registration algorithm was designed for solar calibration, but can be used effectively (not necessarily in real time) for direct solutions of EV wavelength scale when spectral fitting windows are limited to wavelengths not absorbed by ozone.
- Steering clear of the “dichroic region” is desirable for solar as well as EV wavelength registration.
- For NM, a useful EV window is about 349-375 nm; whereas for solar calibration, 315-375 nm can be fitted and may be compared with a fit using the EV window.
- The following chart compares residuals (meas/model flux) for full-frame EV and for the IRF for the EV spectral fitting window for spatial index 365. They are of similar magnitude and appear topologically similar, which may be an artifact of the high-resolution solar spectrum (KNMI) used to construct the model flux in both cases.

Measured / Model Flux for NM IRF and full-frame EV near nadir

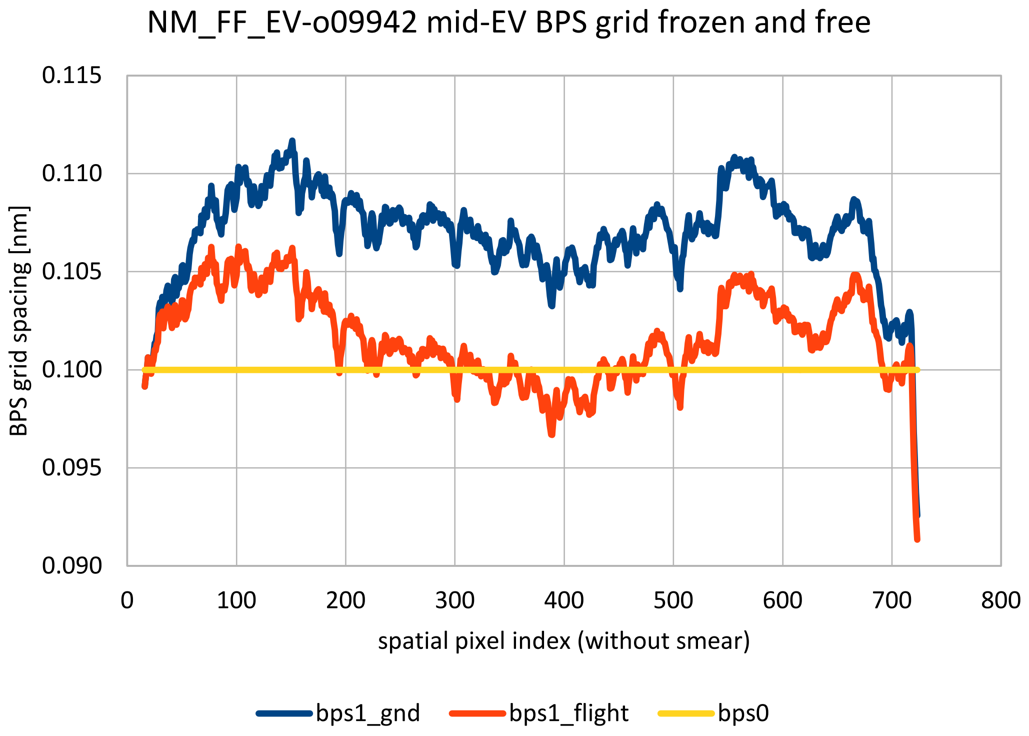


NM mid-EV a0 values when BPS Grid Spacing is Free (a0_bps1) or Frozen (a0_bps0)

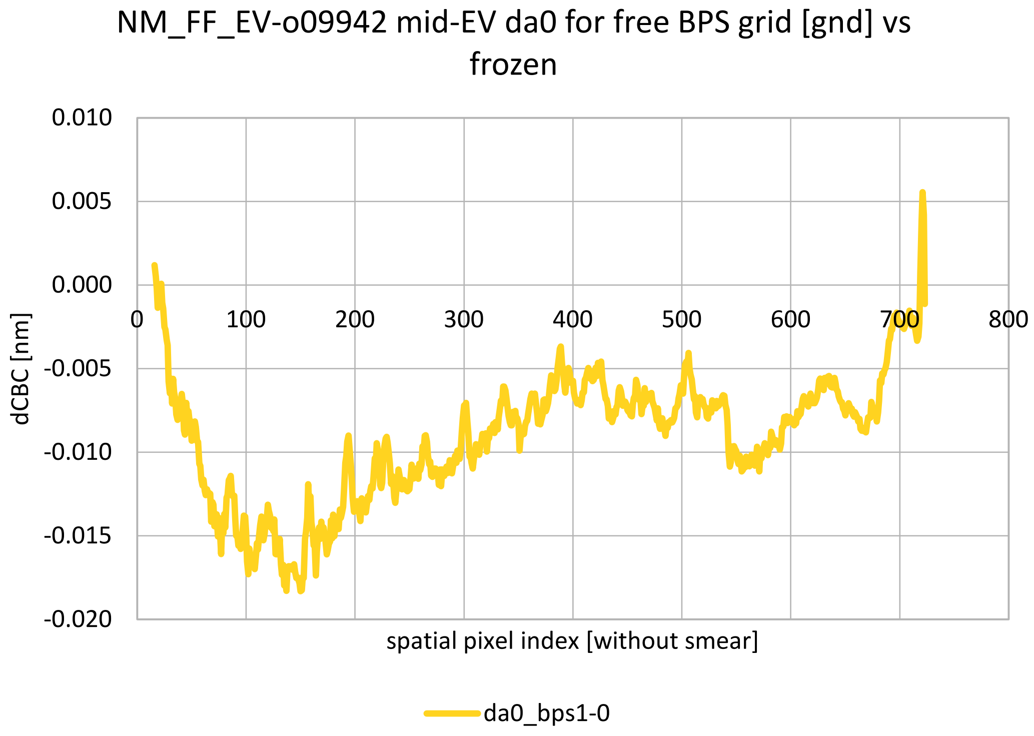


NM BPS Grid Parameter Variation and a0

Bandpass grid parameter solutions for NM_FF_EV using BANDPASS_GROUND vs BANDPASS_FLIGHT (original BATC estimate)



Differences between a0 for frozen vs free BPS grid parameter for NM_FF_EV, using BANDPASS_GROUND as the baseline

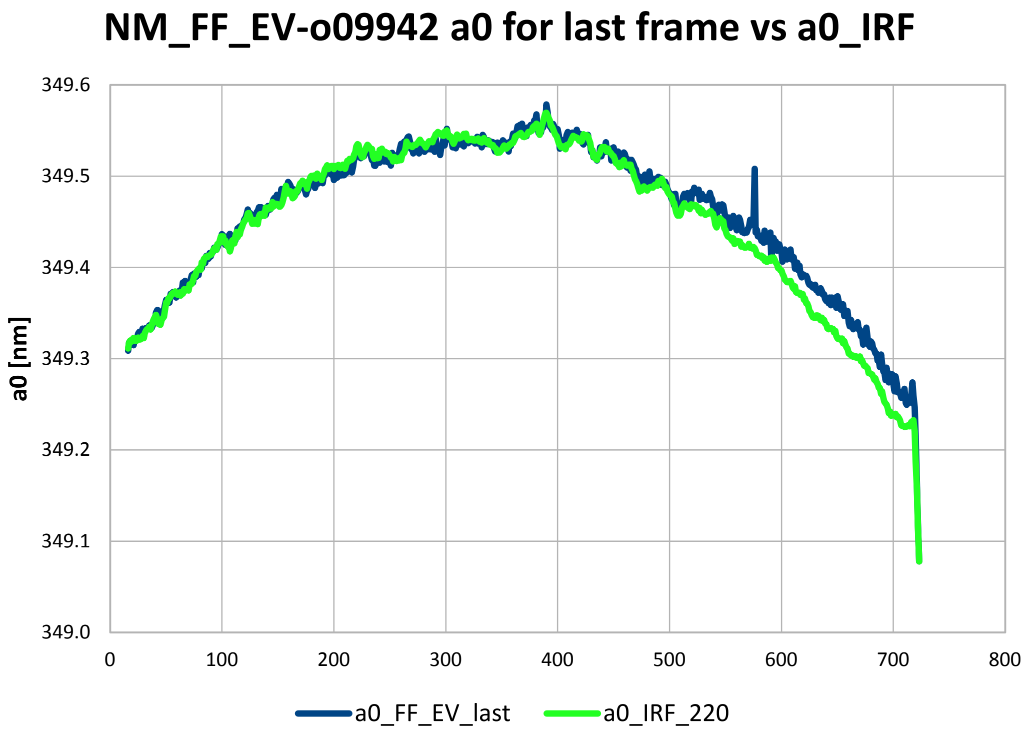


NM EV vs Solar Cal Cross-Track Spectral Divergence

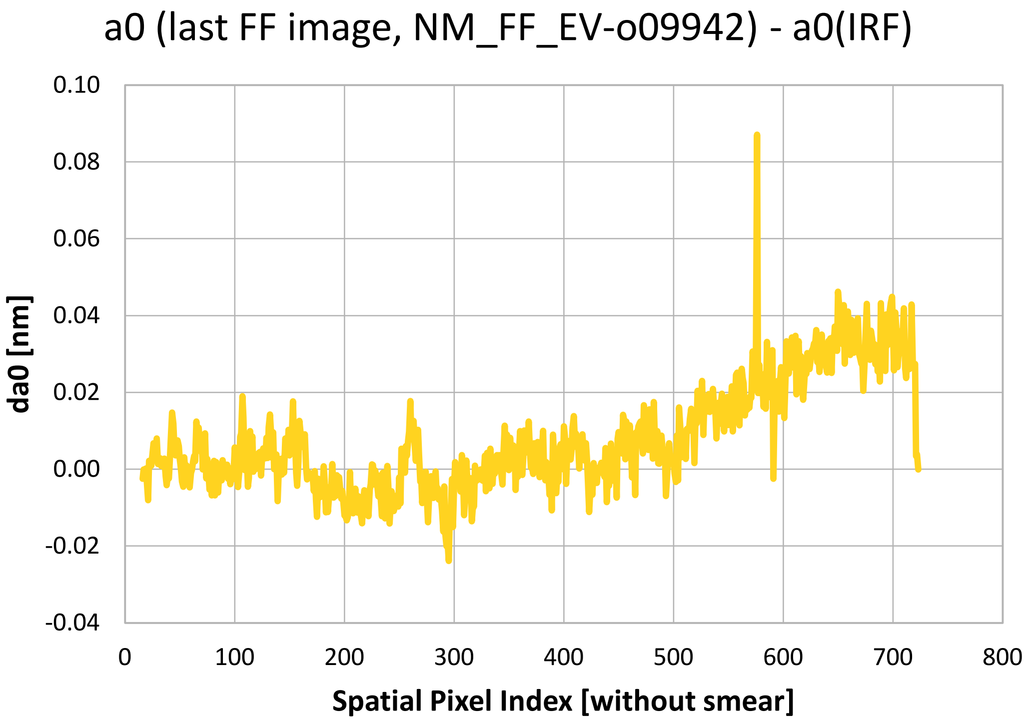
- The NM EV intraorbital wavelength offset, a0, converges to solar a0 except for the diffuser positions whose data are acquired beyond the range of nominal EV…

a0 for last EarthView frame vs a0 for the IRF

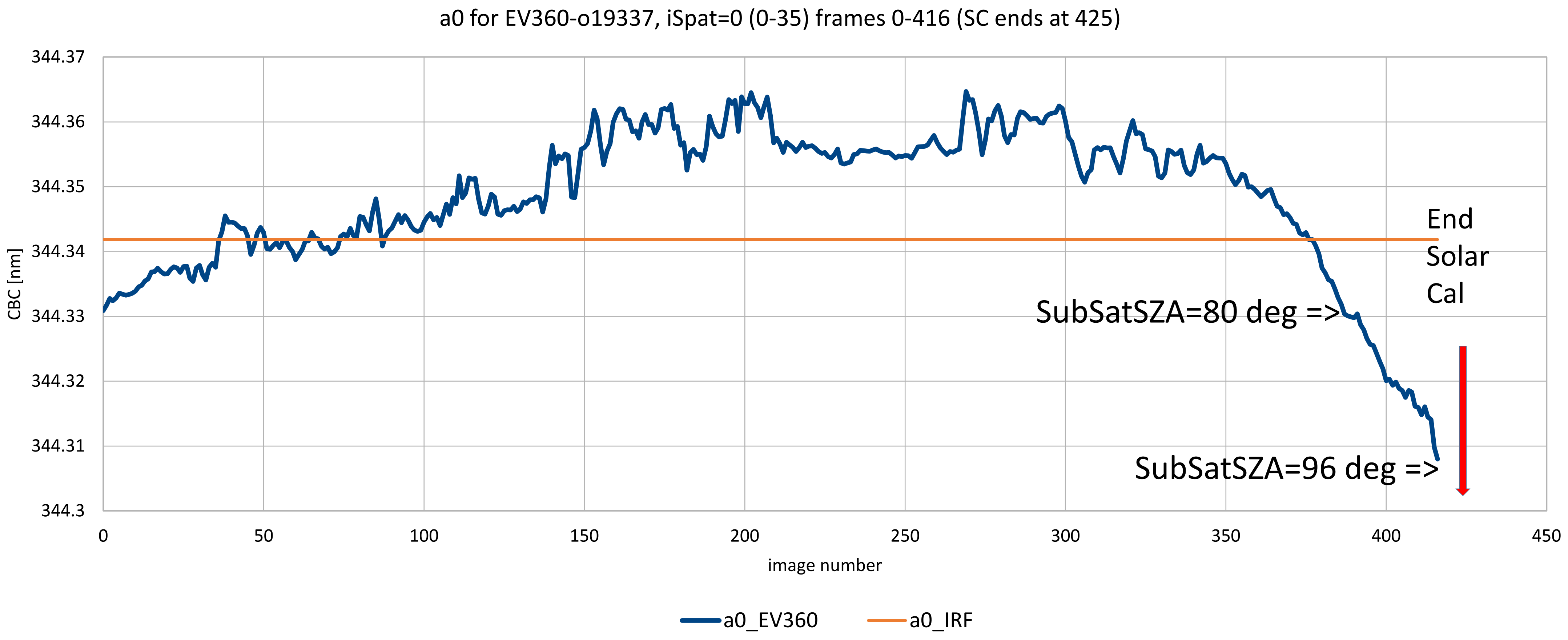
Note divergence of EV and solar a0 for spatial indices to the far right



da0 vanishes except for diffuser positions at SZA > 90 degrees

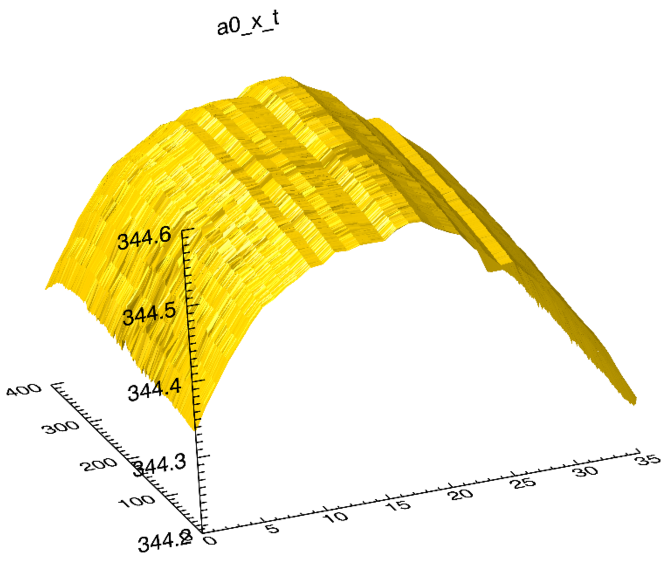


a0 (EV360), spatial macropixel=0, frames 0-416, and a0 for the IRF binned in new mCBC

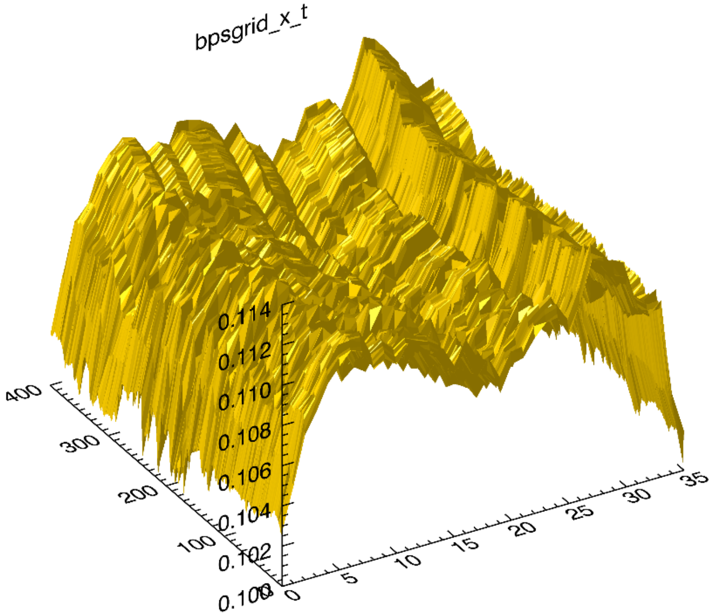


NM EV spatial and temporal dependence of a0 and BPS grid for nominal EarthView

NM_EV-o07231, a0 as a function of macropixel spatial index and frame

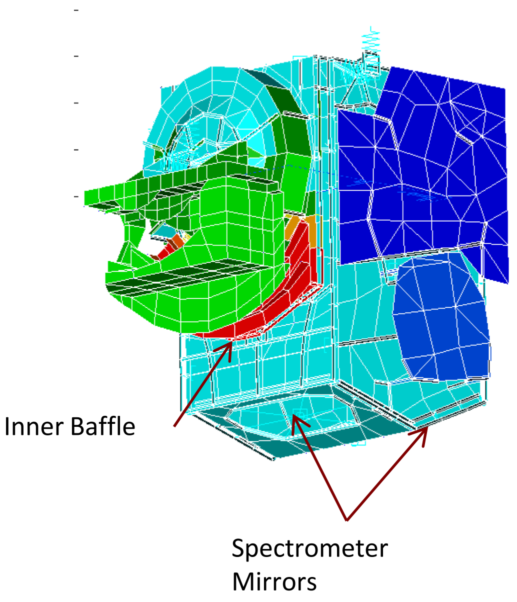


NM_EV-o07231, BPS grid as a function of spatial index and frame (baseline was BANDPASS_GROUND)



Task 5 Conduction to / from the Calibration Assembly is a Major Contributor

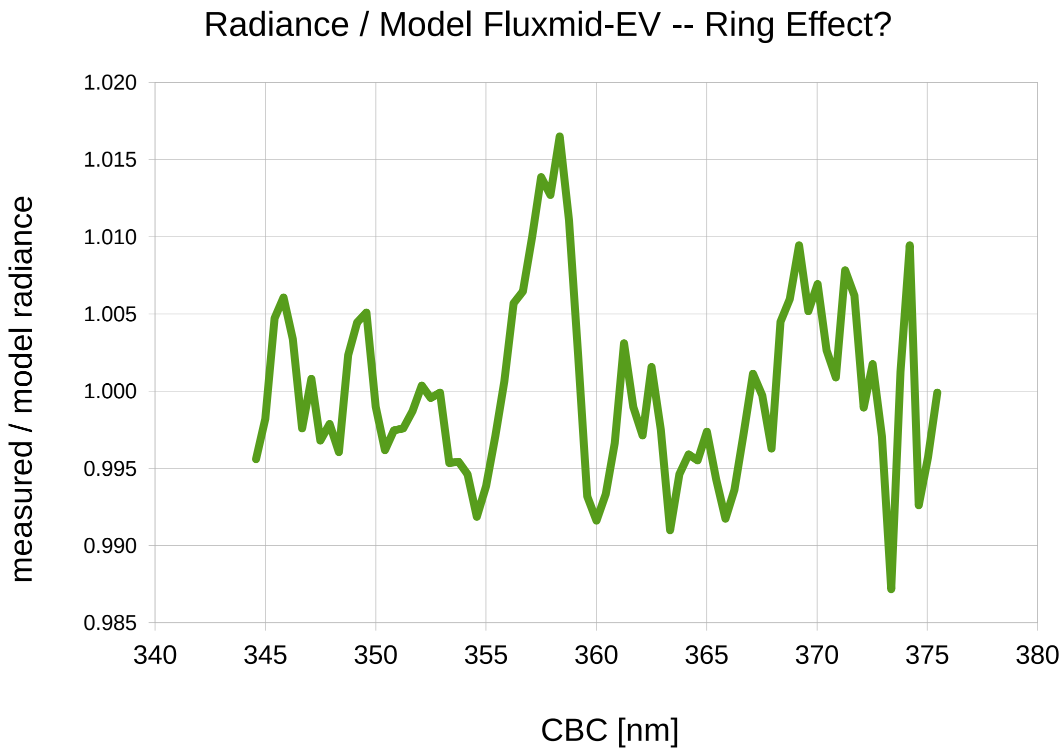
The baffles go through larger temperature swings than the telescope structure
Conduction to and from the Calibration Mechanism Assembly causes localized deformation on the front of the total column housing



Backup Slides

NM Radiance Residuals vs Ring Effect?

Mid-EV NM radiance residuals for TC_EV o07231, nominal EarthView



Ring effect near NM EV fitting window and spectral res., from Wagner, Chance, et al., Proc. of 1st DOAS Workshop, 1/2001, p. 6