OMPS Nadir Products Status & Path Forward

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Nadir Mapper / Total Ozone Key Points

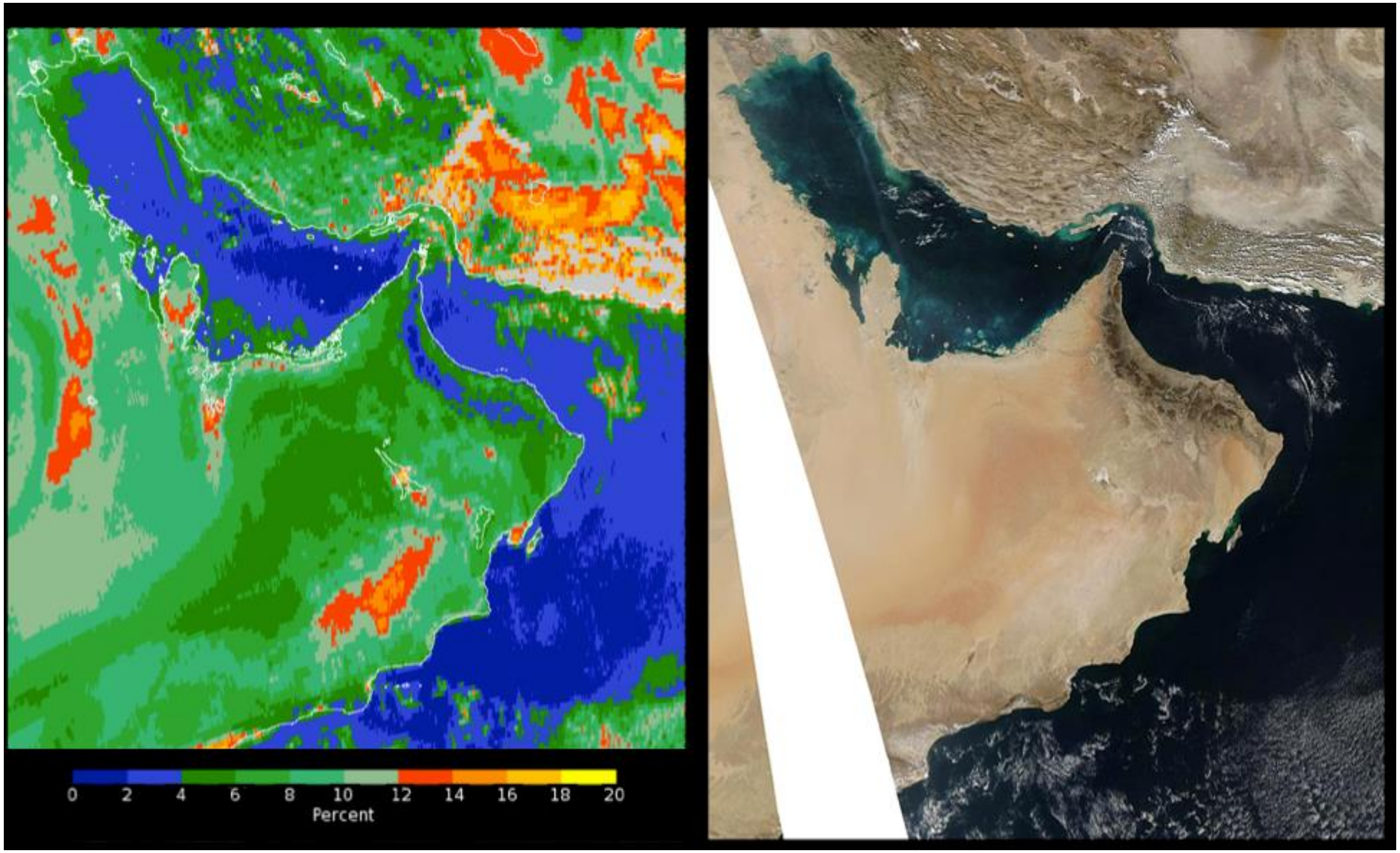
The OMPS NM SDR needs calibration adjustments (consistent with the intra-orbit wavelength scale adjustments) to reduce offsets with other products and to remove cross-track biases.

A new day 1 solar with a wavelength scale in the middle of the Earth-view range would give better results.

A better Out-of-Range Stray Light correction could help to resolve the Nadir Profiler SDR characterization between 300 nm & 310 nm.

The OMPS NM SDR can be used to provide a range of atmospheric composition product at high resolution.

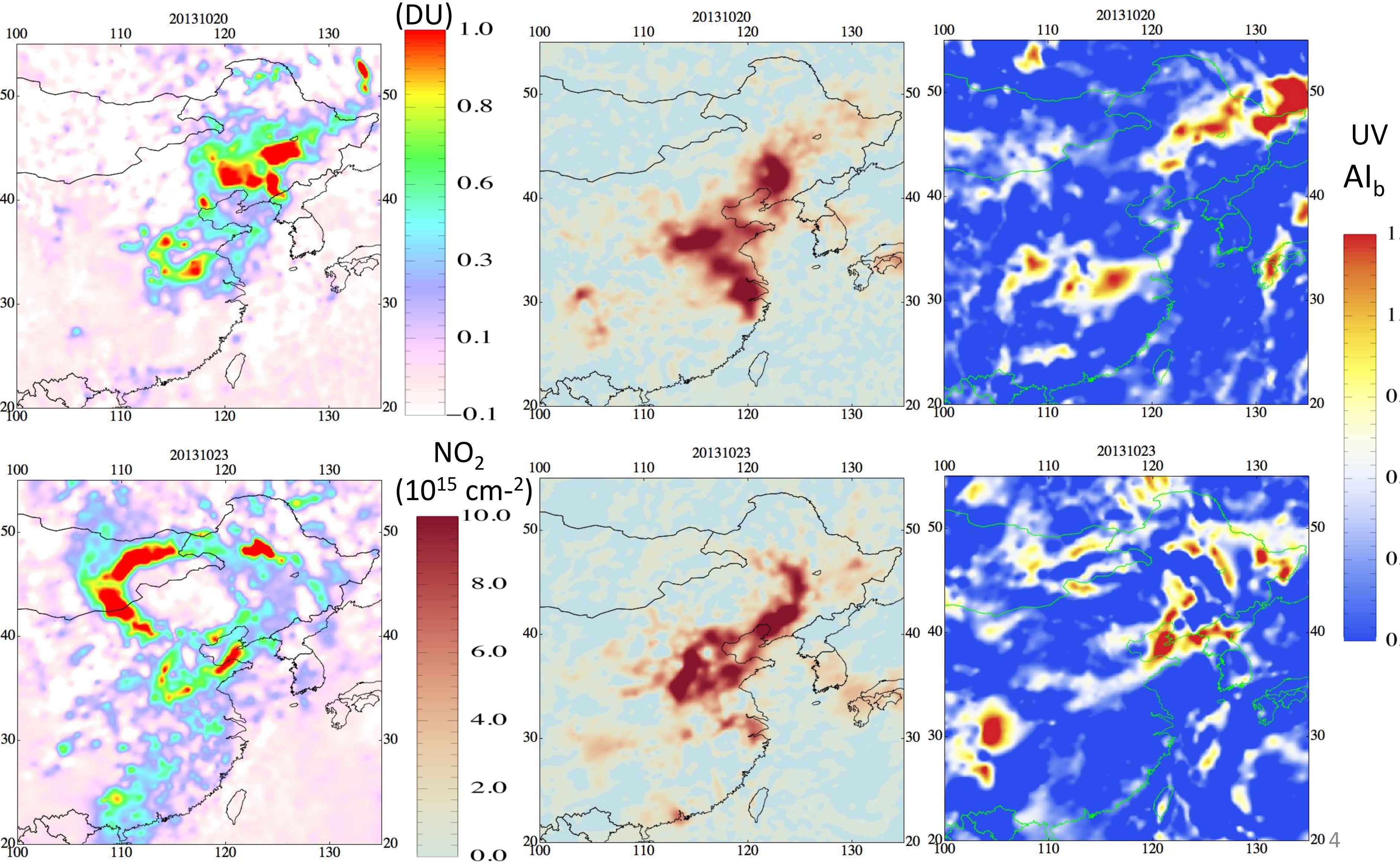
Figure 1. High-Spatial-Resolution Geolocation Comparison.
The image on the left shows a false color map of the OMPS effective reflectivity (from a single Ultraviolet channel at 380 nm) over the Arabian Peninsula region for January 30, 2012 when the instrument was making a special set of high-spatial-resolution measurements with 5×10 km^2 FOVs at nadir. The color scale intervals range from 0 to 2 % in dark blue to 18 to 20 % in yellow. The image on the right is an Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) Red-Green-Blue image for the same day.



The instrument is very stable, extremely flexible, and has excellent SNRs.

SO_2, NO_2 &Aerosols

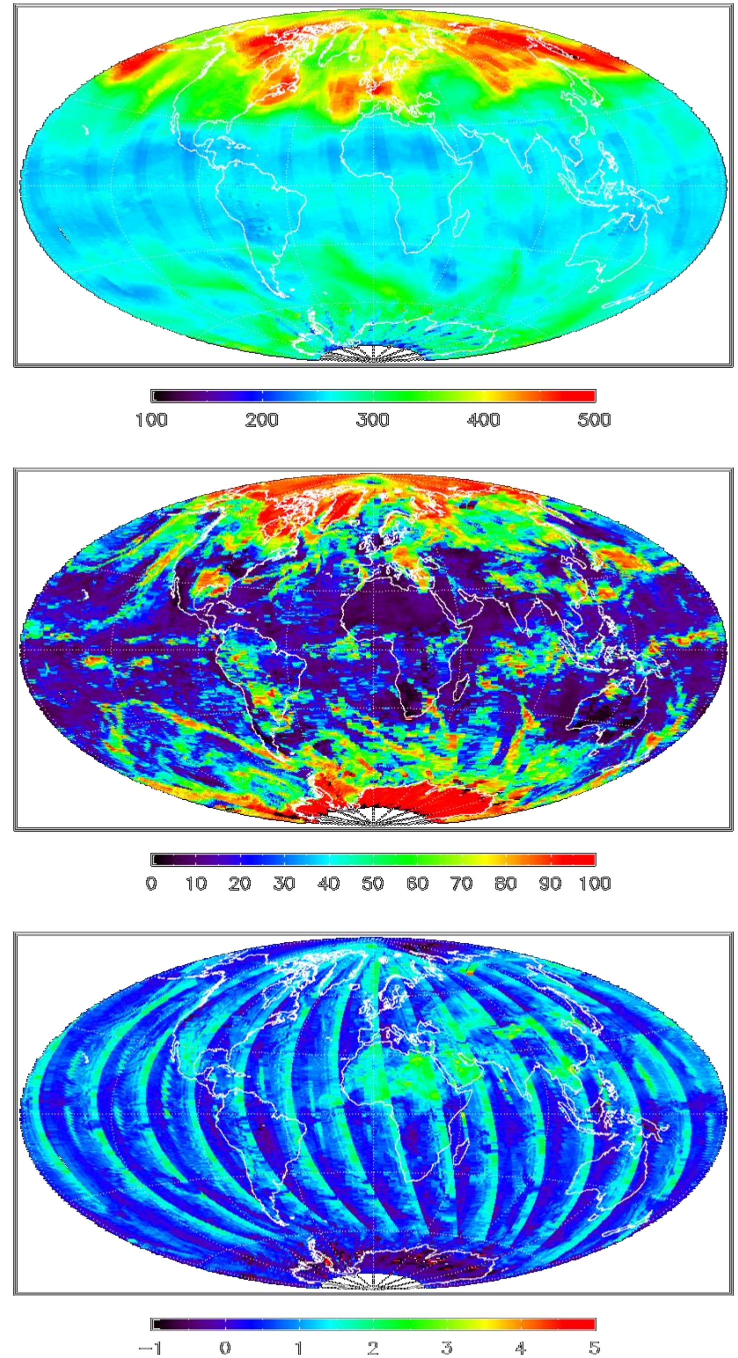
Figure 2. OMPS NM measurements can be used to make state-of-the-art SO_2, NO_2 and Aerosol maps for air quality and hazard applications.

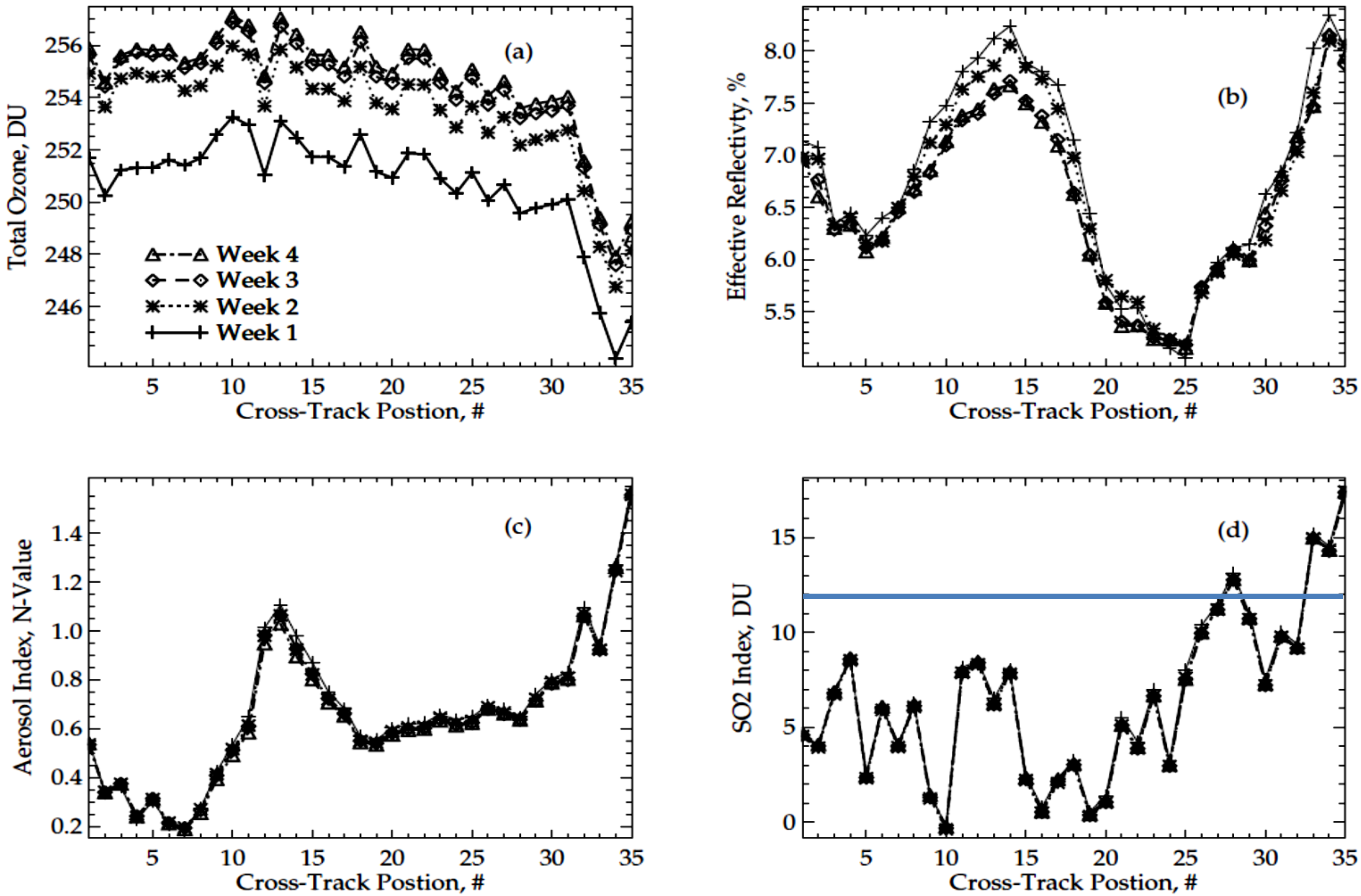


The overall retrieval algorithm is working well but the top and bottom figures clearly show cross-track calibration biases.

Figure 3. Daily global maps with false color images of three IDPS products for April 3, 2013: Top – Total column ozone for April 3, 2013 from the IDPS EDR product. The color bar gives the amounts in Dobson Units (1 DU = 1 milli-atm-cm); Middle – Effective reflectivity (average of the 364, 367, 372 and 377 nm channel estimates) for April 3, 2013 from the IDPS EDR product. The colors show varying reflectivity in percent; and Bottom – Absorbing aerosol index for April 3, 2013 from the IDPS EDR product. The colors show different levels of the index computed as a measurement residual for the 364 nm channel using the reflectivity estimate from the 331 nm channel. The units are in N-values which are approximately equivalent to 2.3% per unit. Daily images for the full record to date are available through links at

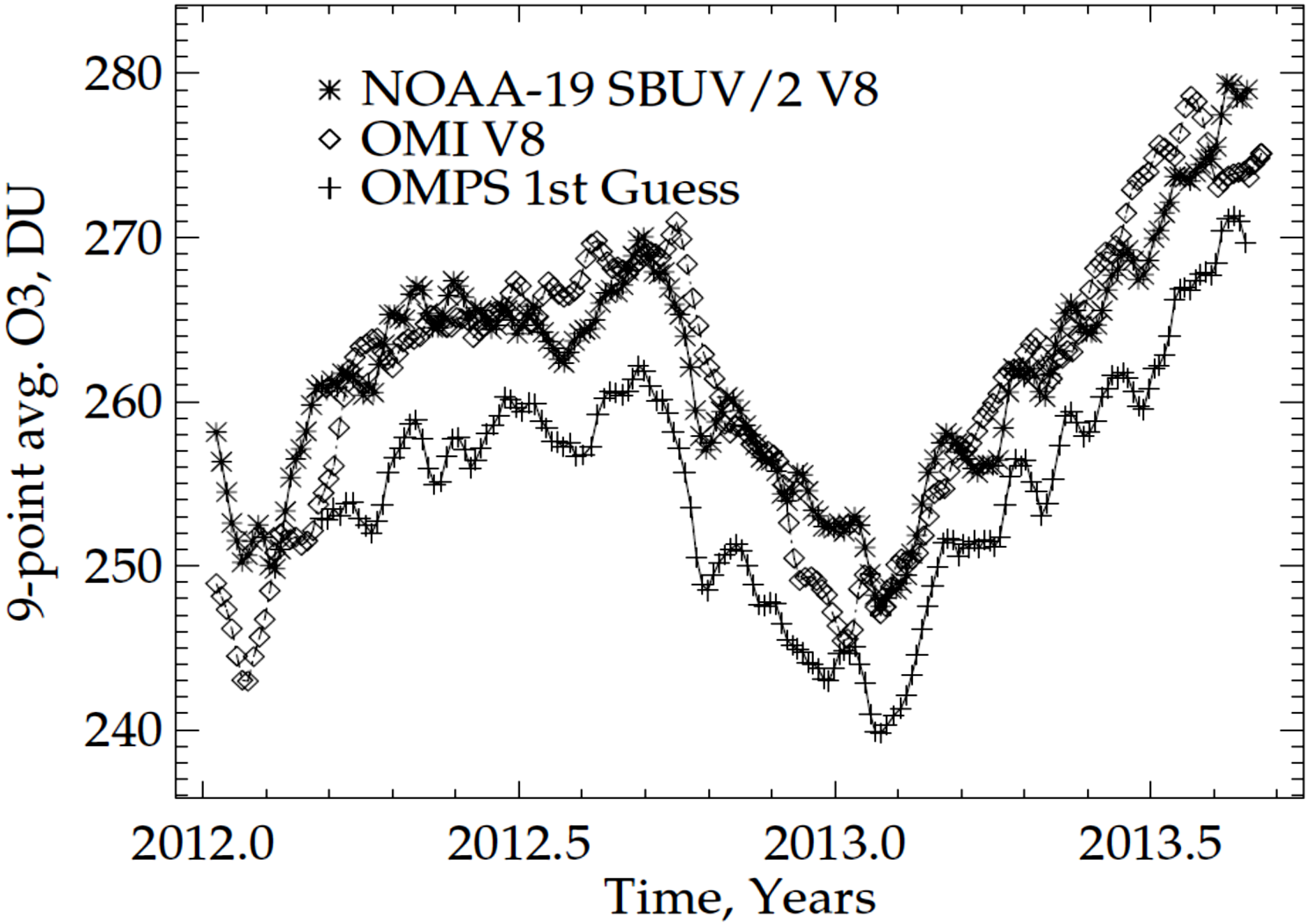
www.star.nesdis.noaa.gov/icvs/index.php.





Continues the same story on cross-track biases for four retrieved quantities in detail.

Figure 4. Weekly-averages of four retrieval parameters [(a) total column ozone in Dobson Units; (b) 1-percentile effective reflectivity (averages of the 364, 367, 372 and 377 nm channel estimates) in percent; (c) an aerosol index (the 364nm channel measurement residuals when the effective reflectivity for 331 nm is used to predict them) in N-value units (1 N value ~ 2.3 %); and (d) an SO_2 index in Dobson Units.] from the 1st Guess product versus Cross-Track position (Cross-track position 17 corresponds to the nadir position and 1 and 35 are the extreme viewing angles.) for April 2013 for a latitude/longitude box (20ºS to 20ºN, 100ºW to 180ºW) in the Equatorial Pacific Box.



Shows a negative overall bias in the OMPS TOZ relative to OMI and NOAA-19 SBUV/2. The next three slides continue this negative bias story.

Figure 5. Time series of daily average total column ozone satellite products in the Equatorial Pacific box. Each symbol is a nine-point time-centered moving average of daily mean ozone in the Equatorial Pacific Latitude/Longitude box for total column ozone estimates from NOAA-19 SBUV/2, NASA EOS Aura OMI, or S-NPP OMPS First Guess products.

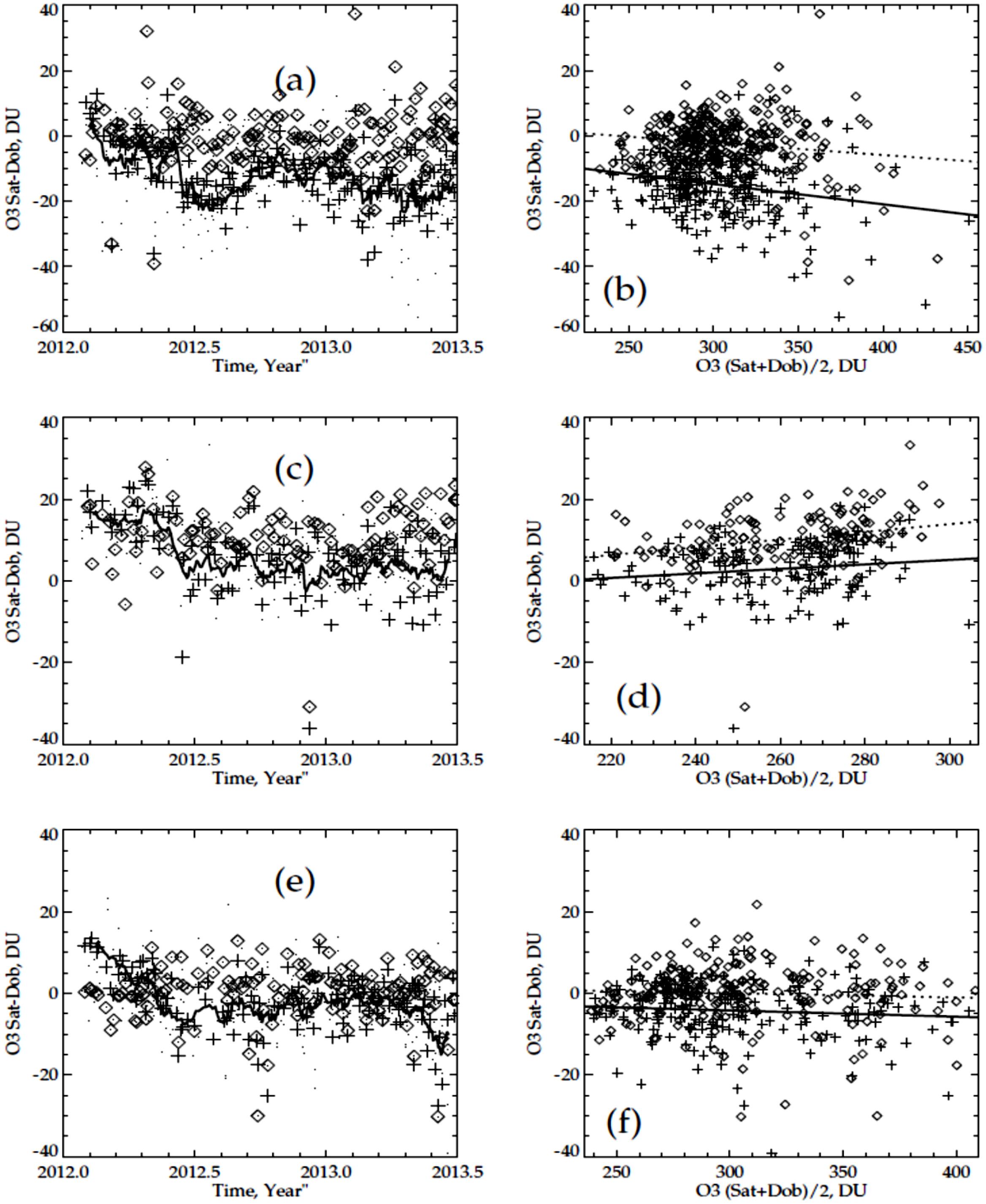


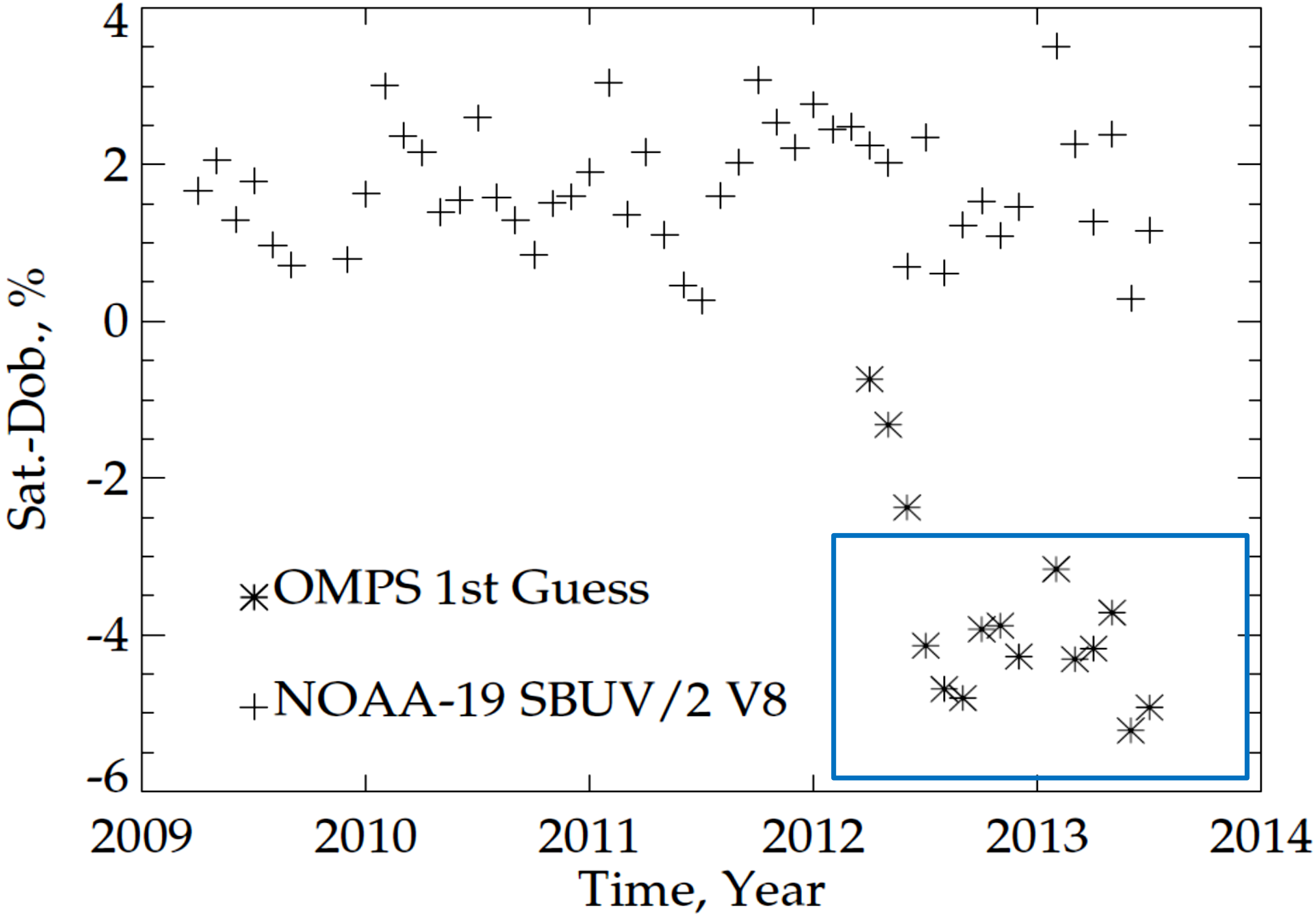
Figure 6. Comparison of OMPS and OMI total column ozone with Dobson estimates for Boulder CO, Manua Loa HI, and Lauder NZ. The figures on the left show the time series of differences for satellite overpass data minus the ground-based Dobson. The diamonds are for OMI and the plus signs are for OMPS. The solid line is the nine-point moving average for the OMPS data. The figures on the right are the satellite minus Dobson differences versus their averages. The solid lines are the linear regression fits for OMPS and the dotted lines are the fits for OMI both with equal noise assumptions. Figure pairs (a) and (b), (c) and (d), and (e) and (f) are for Boulder, Mauna Loa and Lauder, respectively.

Table 1. Statistics for Dobson Match-Up Data Sets In Figure 9.

Site # Days	Sat. Name	Avg_G DU	Avg_S DU	m_G	m_S	m_E	σ	δ DU	ε DU	ρ	Min_E DU	Max_E DU
BOU	OMPS	308.7	293.9	0.90	0.98	0.94	0.02	6.7	6.3	0.97	-10.6	-24.1
N=335	OMI	308.7	306.3	0.93	1.00	0.96	0.02	6.4	6.1	0.97	0.3	-8.1
MLO	OMPS	256.6[c]	259.4	0.99	1.13	1.06	0.03	4.7	4.9	0.93	0.4[c]	5.9[c]
N=217	OMI	256.6[c]	266.9	1.03	1.17	1.10	0.03	4.4	4.8	0.94	6.0[c]	15.6[c]
LAU	OMPS	304.5	300.2	0.97	1.00	0.99	0.02	4.8	4.7	0.99	-3.3	-5.8
N=270	OMI	304.5	304.4	0.97	1.01	0.99	0.02	5.3	5.2	0.98	0.6	-1.1

[c]The Dobson station is near the top of Mauna Loa. Satellite FOVs include ocean scenes. Adjustments from 6 to 12 DU have been used to account for these scene differences based on Hilo HI ozonesondes and standard ozone profiles.

The OMPS Bias estimates at the maximum and minimum data values for each station show negative biases.



Another view of the negative overall bias in the OMPS TOZ relative to ground-based Dobson Station estimates.

Figure 7. Monthly differences between matchup NOAA-19 SBUV/2 Version 8 total column ozone and OMPS 1st Guess total column ozone with a collection of Dobson observations from 22 stations from the World Ozone Data Center. For OMPS, the data are distance-weighted averages for estimates within 0.5º Latitude and SEC(Latitude)º Longitude of each station's location. For SBUV/2, the data are distance-weighted averages for estimates within 2.0º Latitude and 20º Longitude of each station's location. Each data point is a monthly average difference for the satellite instrument versus the Dobson ones. At least six matchup values are required for a station to be used in the monthly average. As few as five stations may have reported enough data for the later values.

This and the next three slides tell a story about the interaction of the wavelength scale shifts and the soft calibration to smooth out the SO_2 Index.

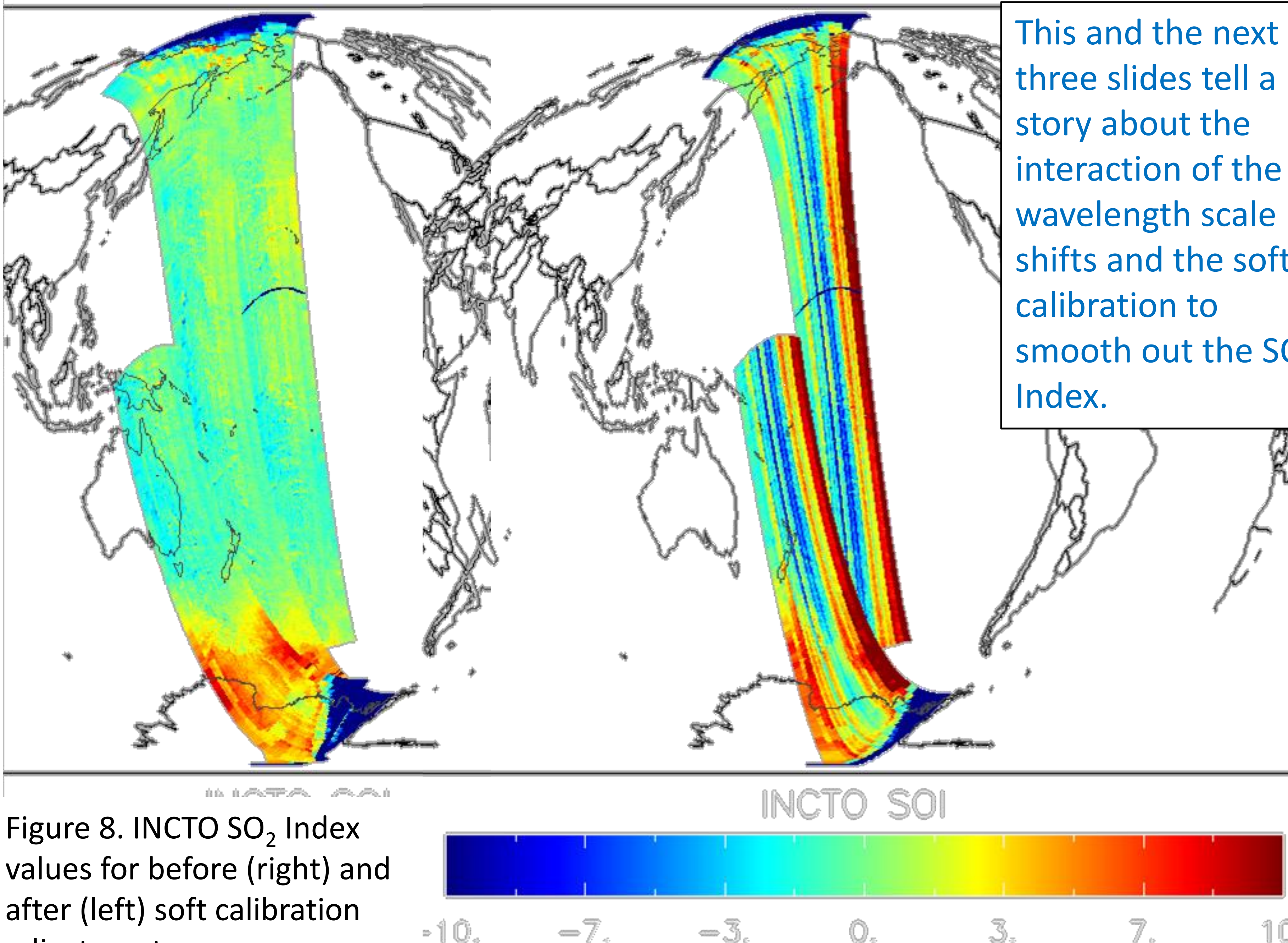


Figure 8. INCTO SO_2 Index values for before (right) and after (left) soft calibration adjustments.

Figure 9. Comparison of wavelength shift and soft calibration adjustments for a test Granule

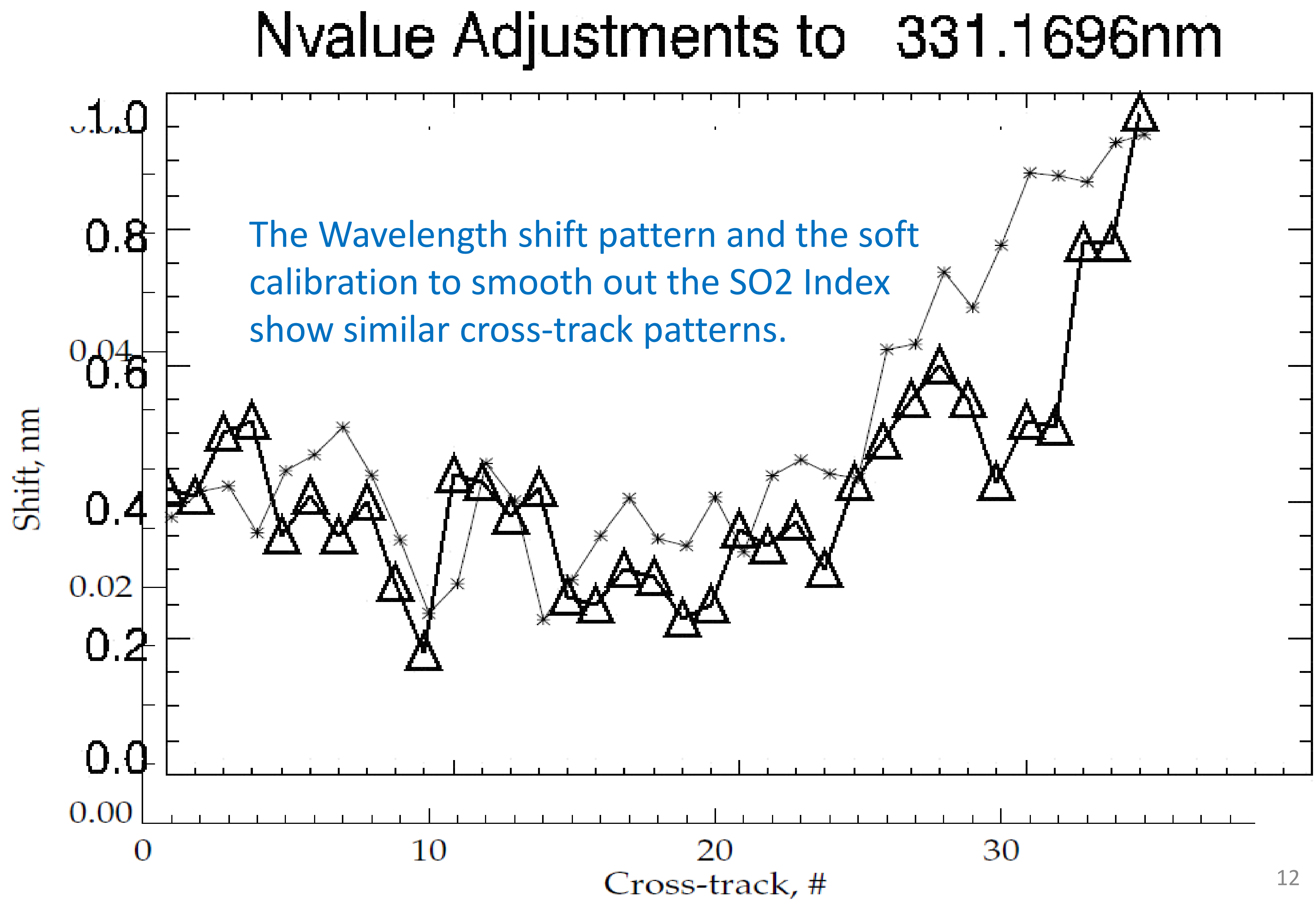


Figure 10. Solar flux changes for one scan from wavelength scale adjustments

The solar flux changes to account for the along-orbit wavelength scale shifts are complex.

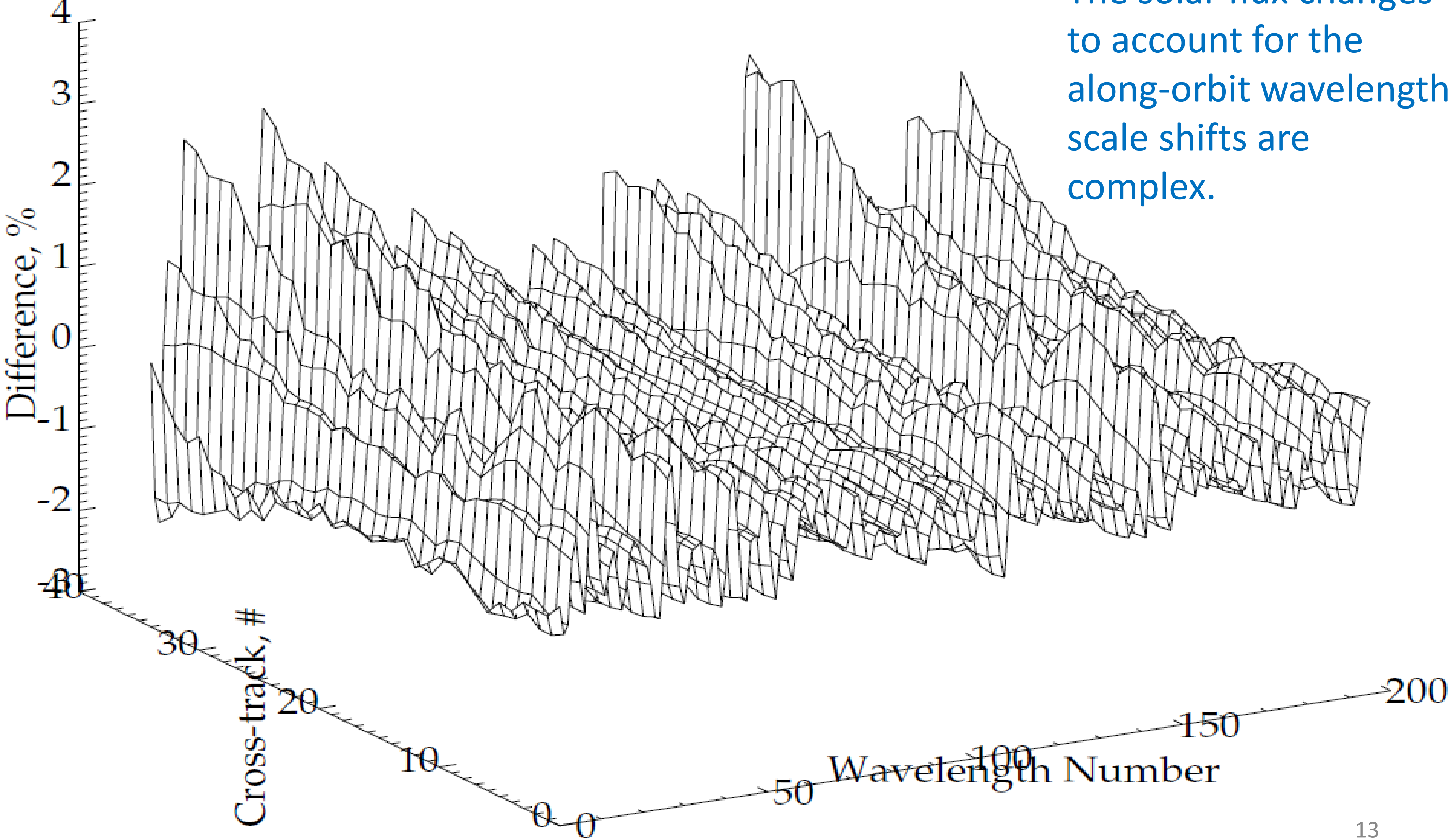
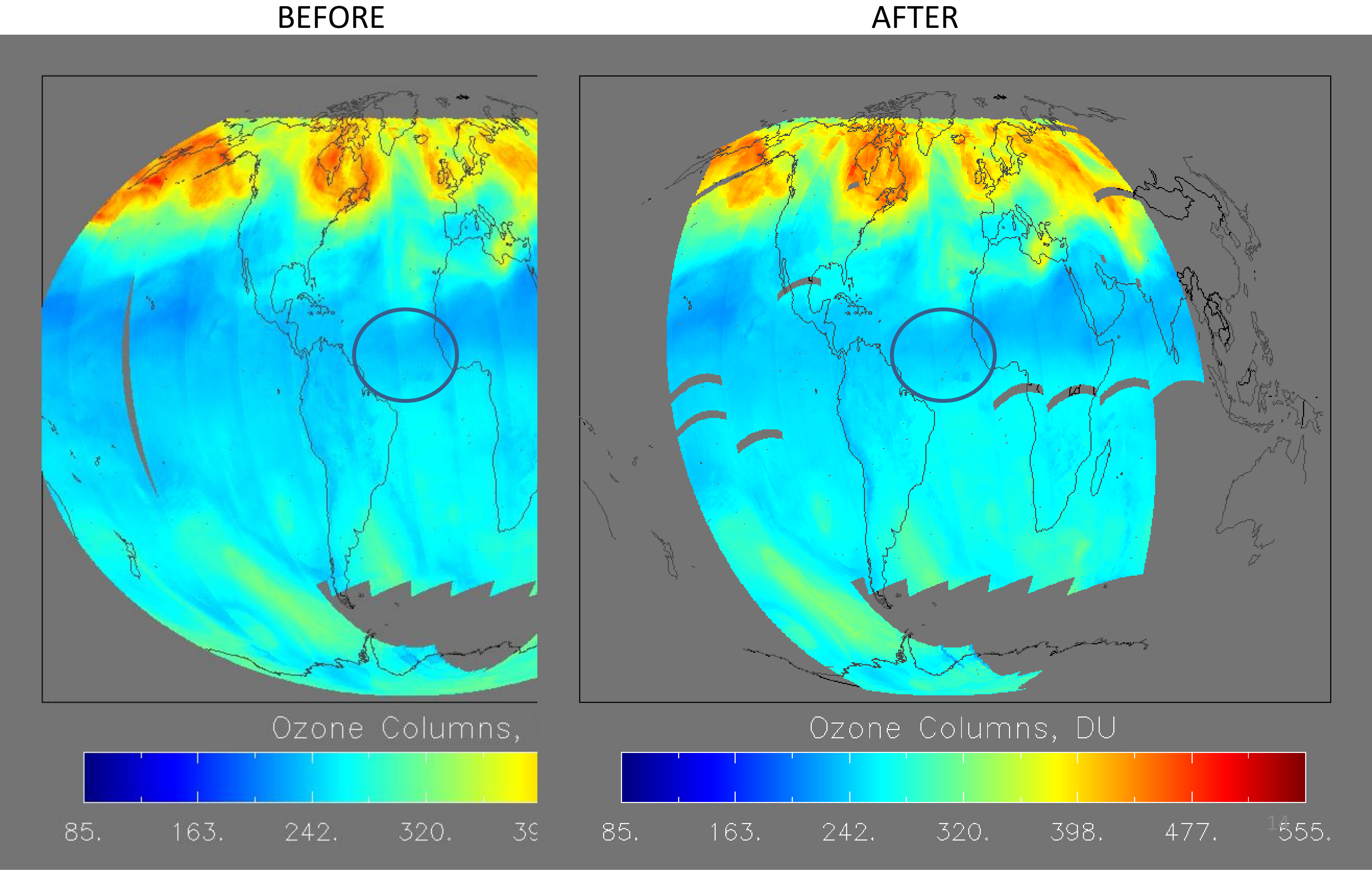


Figure 11. Effect of wavelength shift on INCTO Ozone



Notice reduced striping – better cross track consistency after wavelength shift

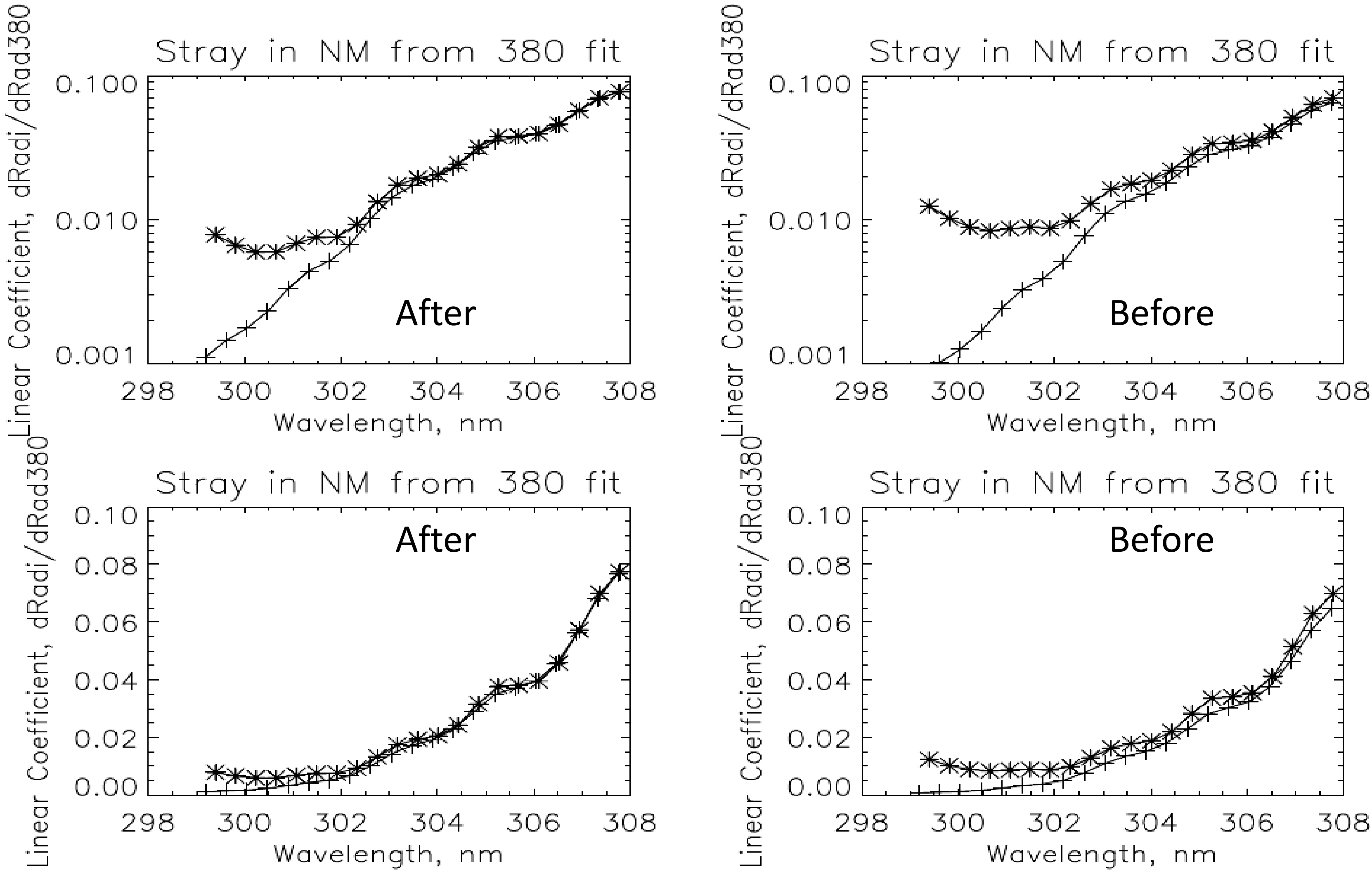


Figure 12. Results of a correlation study of 380 nm variations at small SZA versus variations at NP and NM channels below 308 nm. The method subtracts a smooth function of latitude from the radiances for all of the data sets and then looks for a linear relationship between the remaining variations at 380 nm with those for each of the target channels. At 380 nm, these variations are dominated by changes in the scene brightness. The figures on the left show the results for the current IDPS product. It has the stray light correction (but with the OOR set at 0). The figures on the right show the results for IDPS prior to the implementation of the stray light correction. The + symbols are for the NP channels and the * symbols are for the NM channels. The NP results show the expected fall off in sensitivity of radiances to scene brightness with decreasing wavelength (increasing ozone absorption.) These coefficients are in units of target radiance / source radiance .

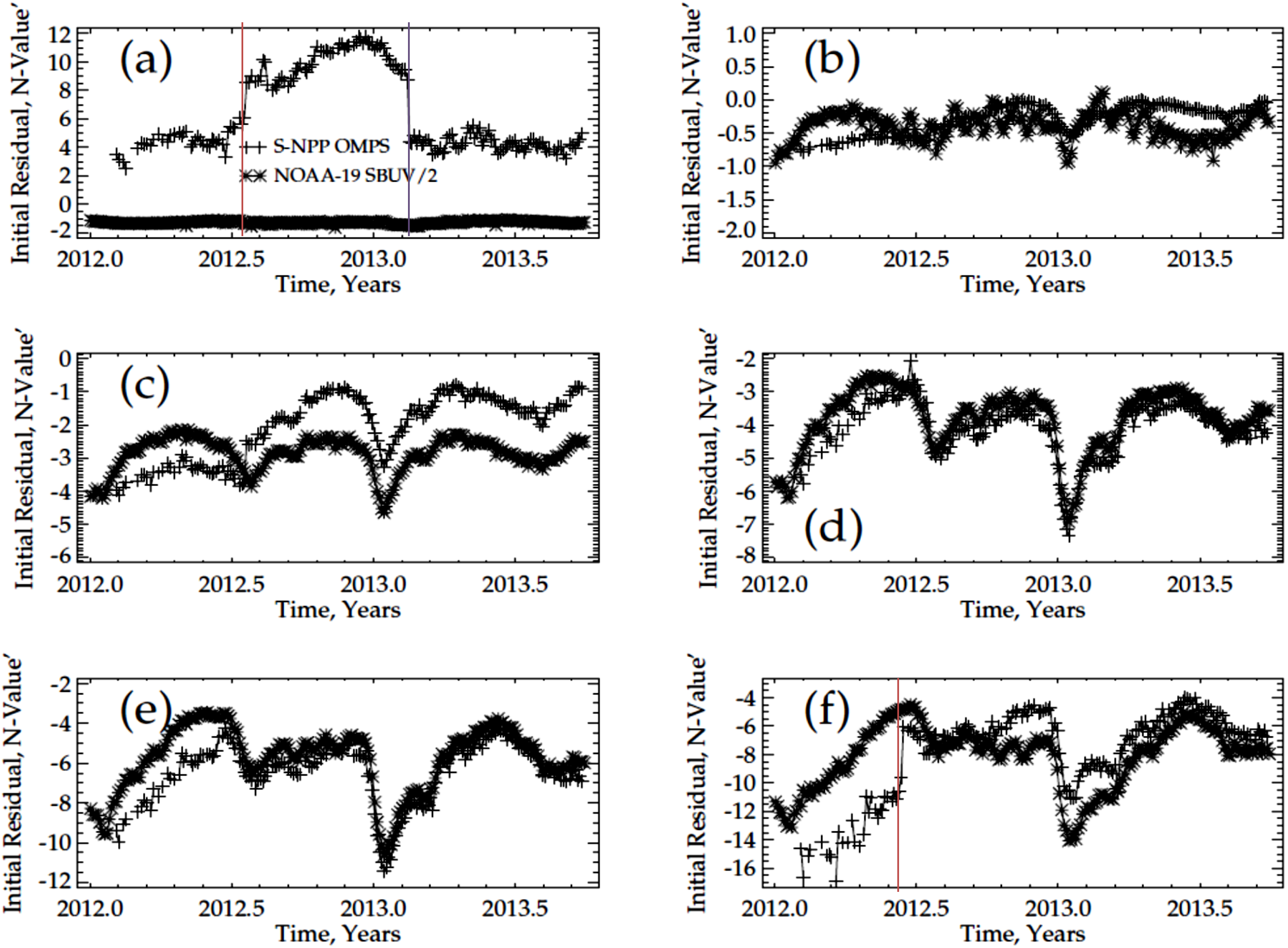
Nadir Profiler/ Nadir Ozone Profile Key Points

The OMPS NP SDR needs a stray light correction.

The OMPS NP SDR needs soft calibration adjustments. It is not know if this will solve the longer channel and total ozone versus profile ozone problems along the orbit or if there are dichroic stability effects.

The OMPS NP Day 1 Solar needs a revised wavelength scale.

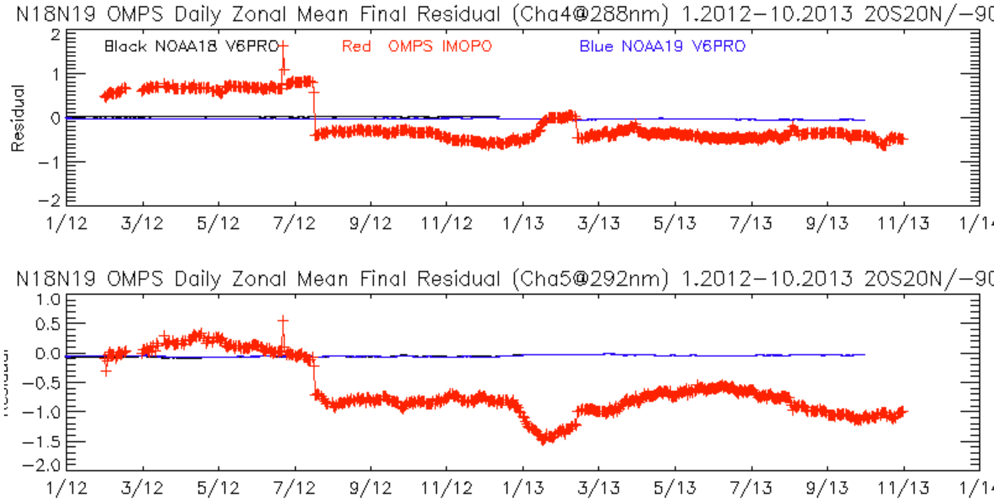
There are methods that could be used to adjust for the solar activity or for the annual cycle in wavelength scale to improve the products.

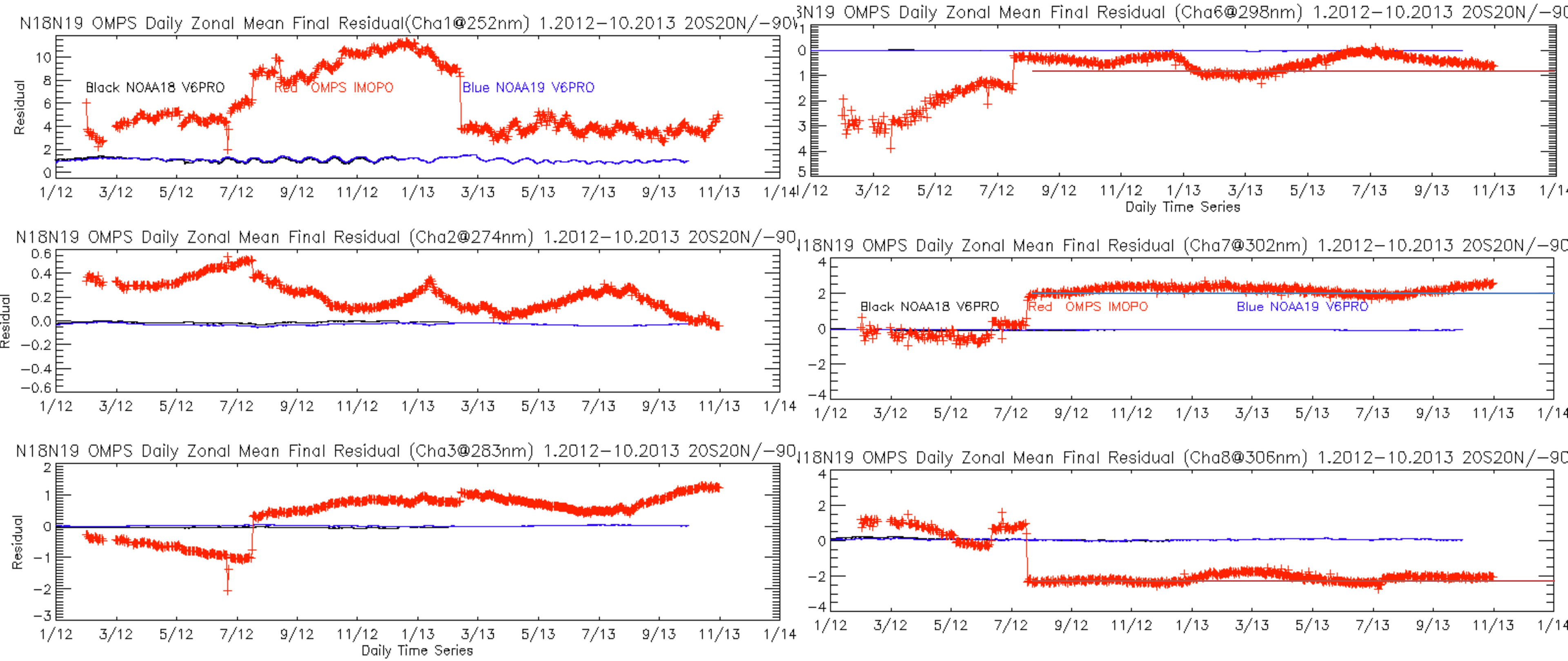


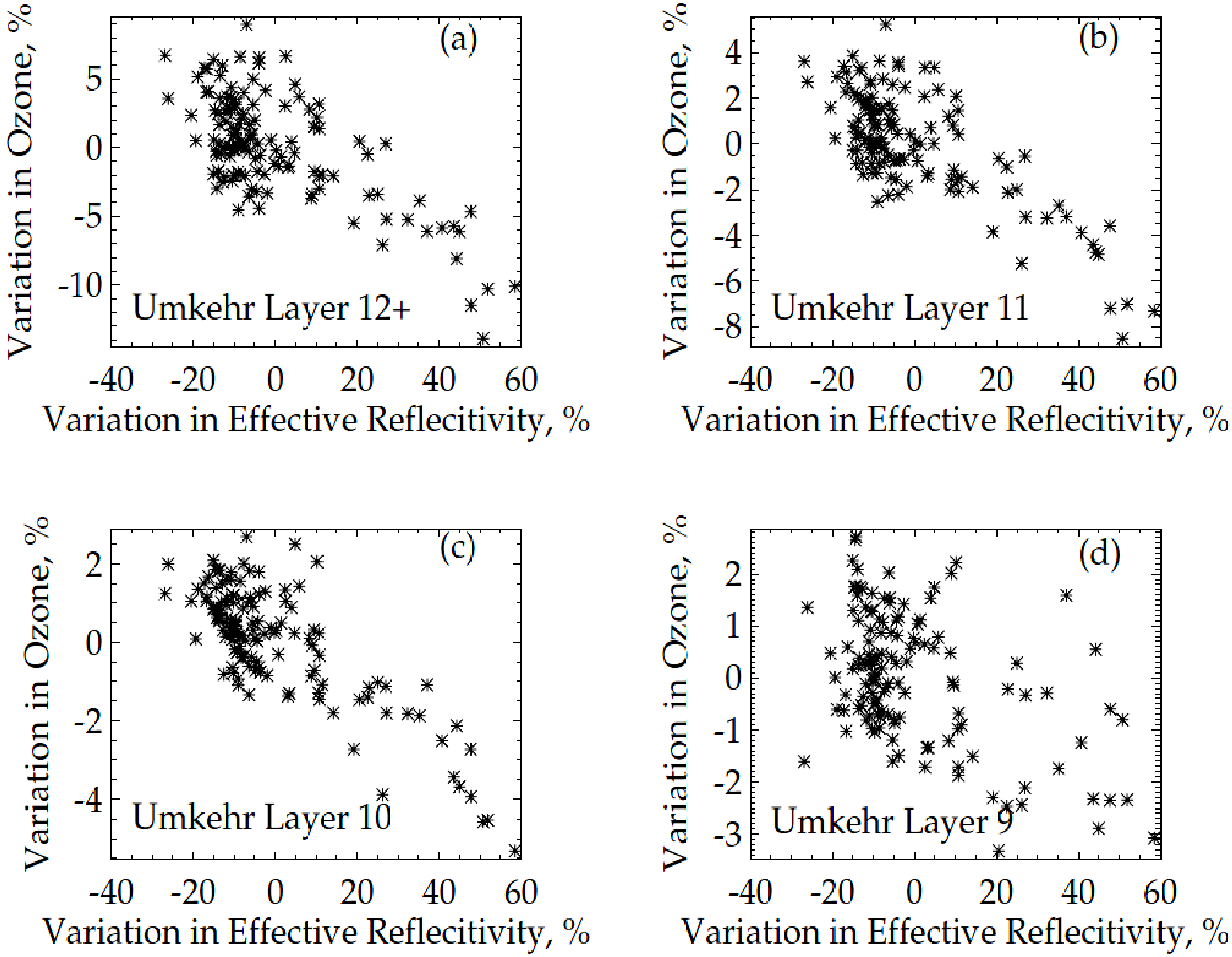
Time series of V6 Initial Residuals explain the average bias in the profile retrievals for OMPS NP versus NOAA-19 SBUV/2. (plus the use of 252 nm in NOAA-19 and current non-use for OMPS NP). SDR adjustments with new day 1 solar spectra (mid 2012) and the start of dark corrections (early 2013) are apparent.

Figure 13. Initial Measurement Residuals for OMPS-NP Version 6 Algorithm. The six figures show the daily average initial residuals for profile wavelengths (a) 252 nm (b) 274 nm, (c) 283 nm (d) 288 nm, (e) 292 nm, and (f) 298 nm for the V6PRO product from OMPS compared to the V6PRO product for the operational POES NOAA-19 SBUV/2 for the equatorial daily zonal means (20N to 20S) with 0-90W removed to avoid the SAA effects. Every third day is plotted to reduce clutter.

Figure 14. Time series of V6 Final Residuals for OMPS NP versus NOAA-19 SBUV/2. The large down/up/down pattern of the 298, 302 and 306 nm channels' residuals are troubling. Solar activity can be seen in the 252 nm residuals for both OMPS and SBUV/2.



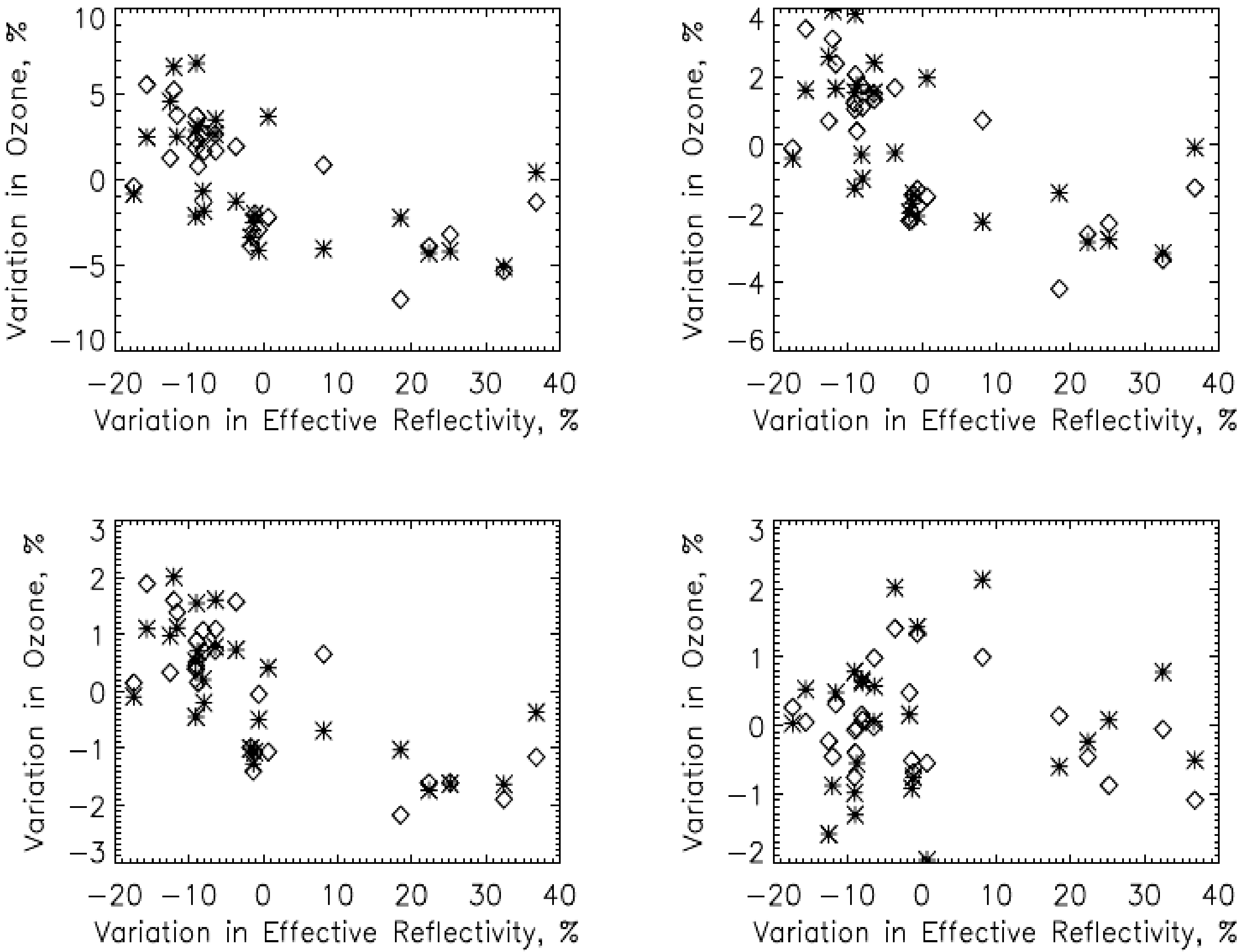




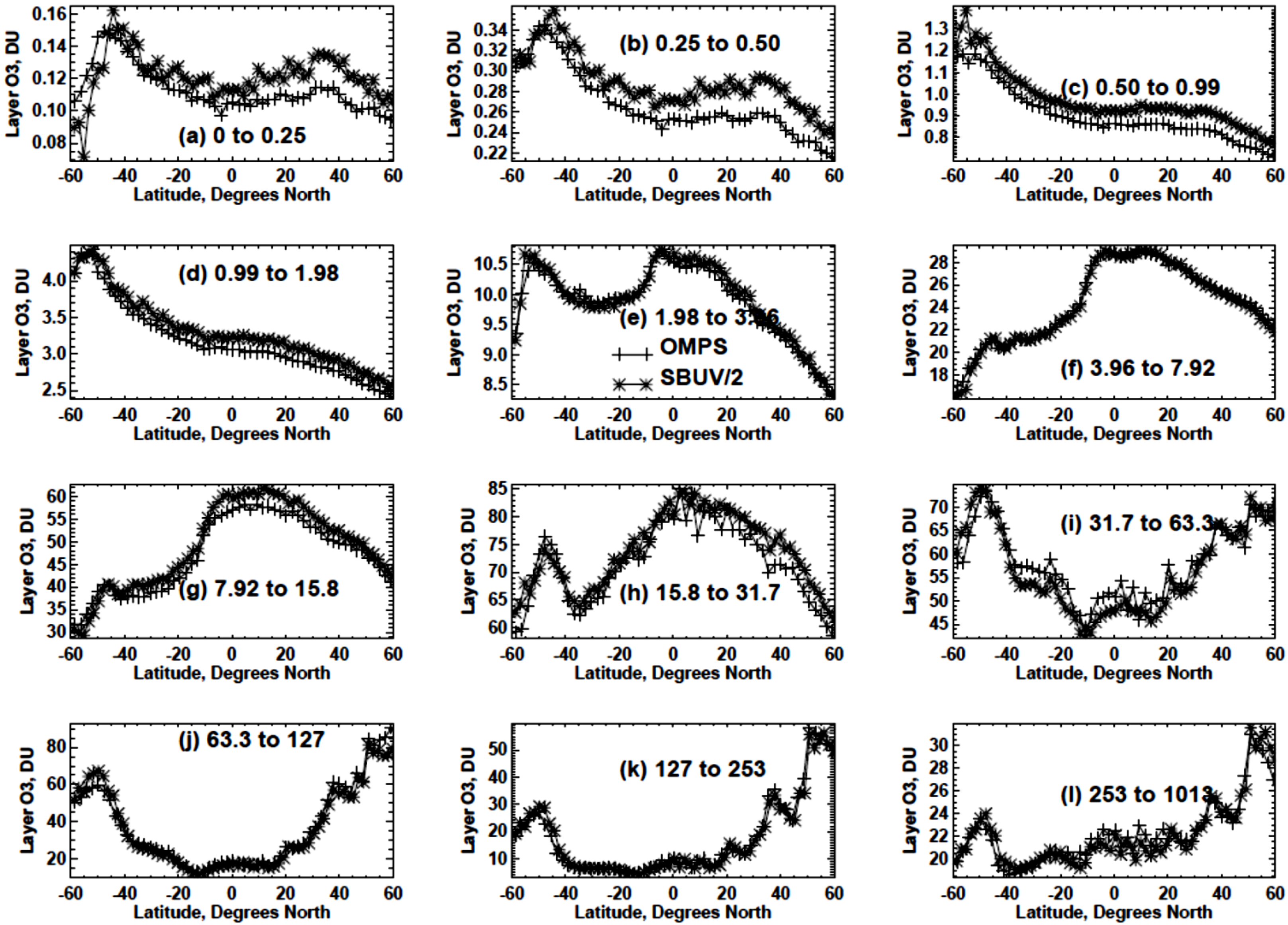
The correlations are not true geophysical variations but are symptomatic of stray light in the shorter profiling channels with longer wavelength sources; the algorithm interprets increased radiance as evidence of decreased ozone.

Figure 15. Scatter Plots of Ozone Layer Variations versus 331-nm Effective Reflectivity Variations for the first five orbits of May 15, 2013. The data sets are (a) Umkehr Layer 12 and above (< 0.25 hPa), (b) Umkehr Layer 11 0.25 – 0.50 hPa), (c) Umkehr Layer 10 (0.50 – 0.99 hPa), and (d) Umkehr Layer 9 (0.99 – 1.98 hPa). The variations are computed relative to smooth polynomial fits of each parameter versus latitude.

Figure 16. Single Orbit w*/wo<> the Stray Light Correction using the current Jabobian target/response matrix.

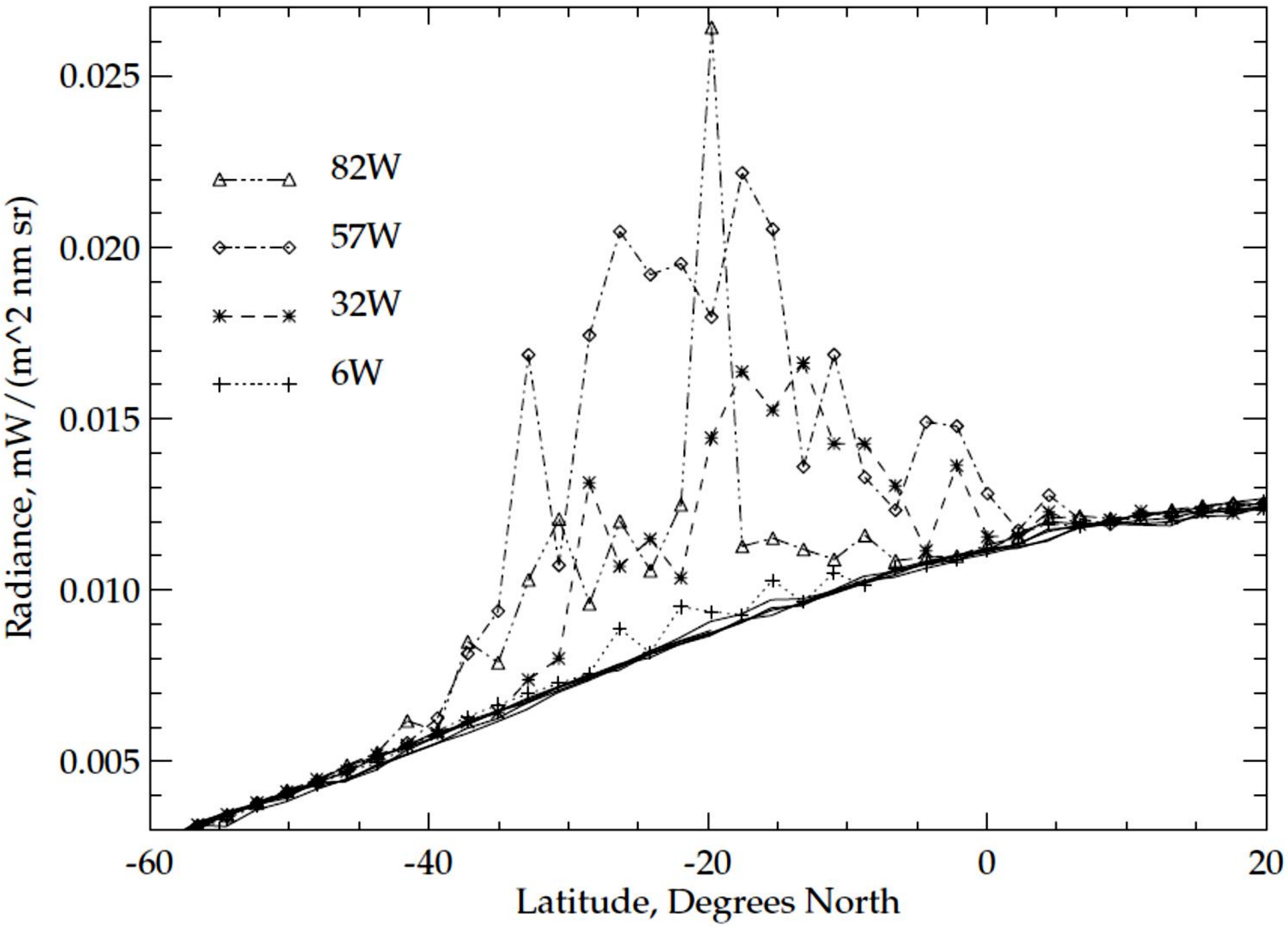


There is still more work to do to improve the NP SDR stray light correction.



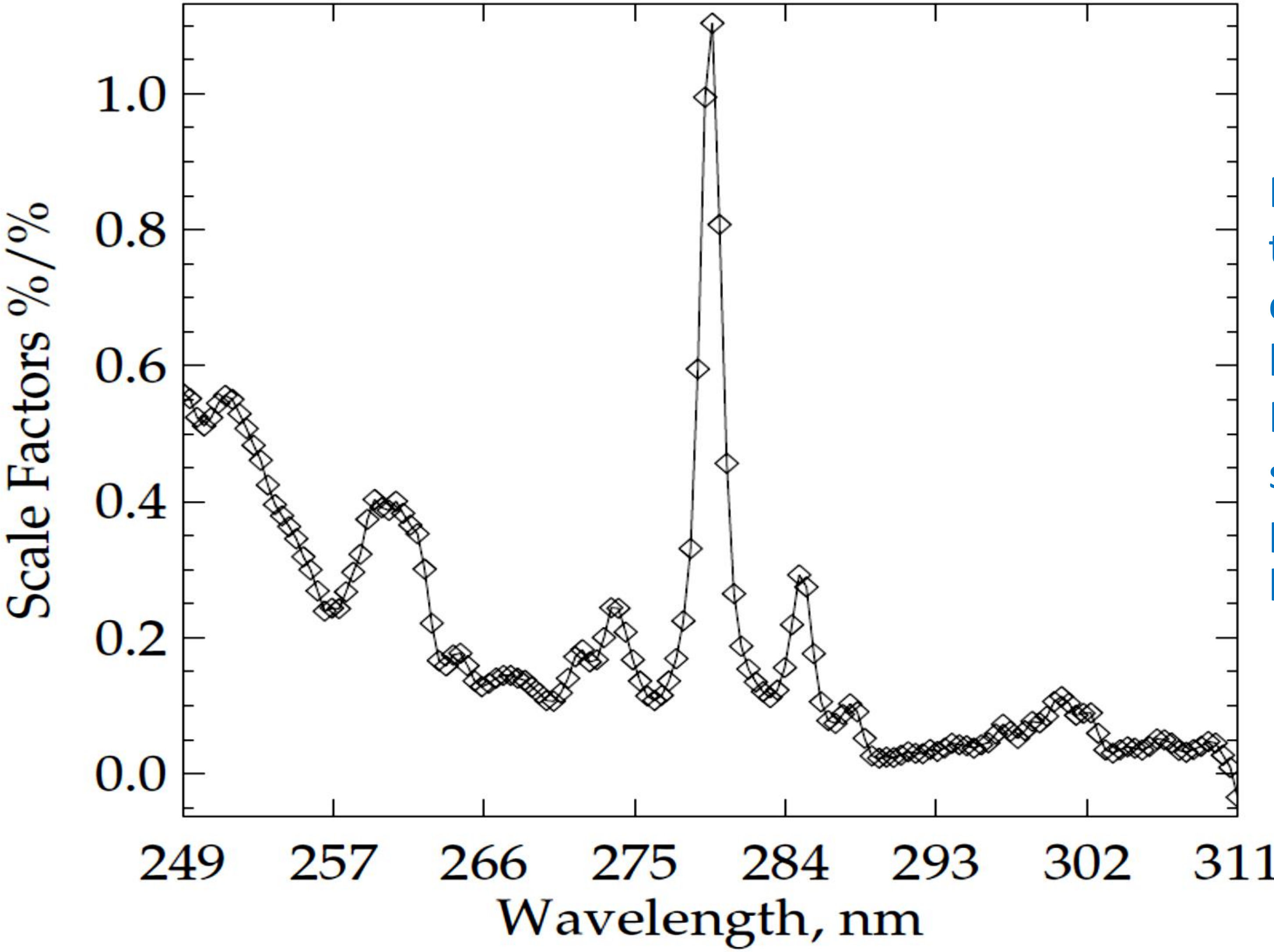
The biases and offsets from the stray light and initial calibration appear in the comparisons to NOAA-19 SBUV/2 ozone profile products for "chasing" orbits.

Figure 17. Chasing orbit comparisons of SBUV/2 and OMPS-NP Version 6 Ozone Profiles for July 10, 2013. Figures (a)-(l) show the 12 Umker layer amounts versus latitude for the two products. The layer boundaries are given in hPa within the figures. The two orbit are within 50 km and 15 minutes of each other at the Equator.



The SAA effects on the NP SDRs are on the order of the measurements at 252 nm. We might be able to make some corrections and reasonable products on the edges.

Figure 18. OMPS-NP Radiances at 252 nm versus latitude for portions of ten orbits for May 5, 2013. The radiances for the four orbits passing inside the SAA (large deviations) are called out in the figure with different symbols and line styles; the longitudes in degrees West of these four orbits at their Equator crossing points are given as well. The solid lines give the radiances for the other six orbits (three on each side) showing the expected increase in radiances as the solar zenith angles get smaller moving northward along the orbital tracks. The variations among these six are produced by longitudinal fluctuations in the stratospheric ozone field.

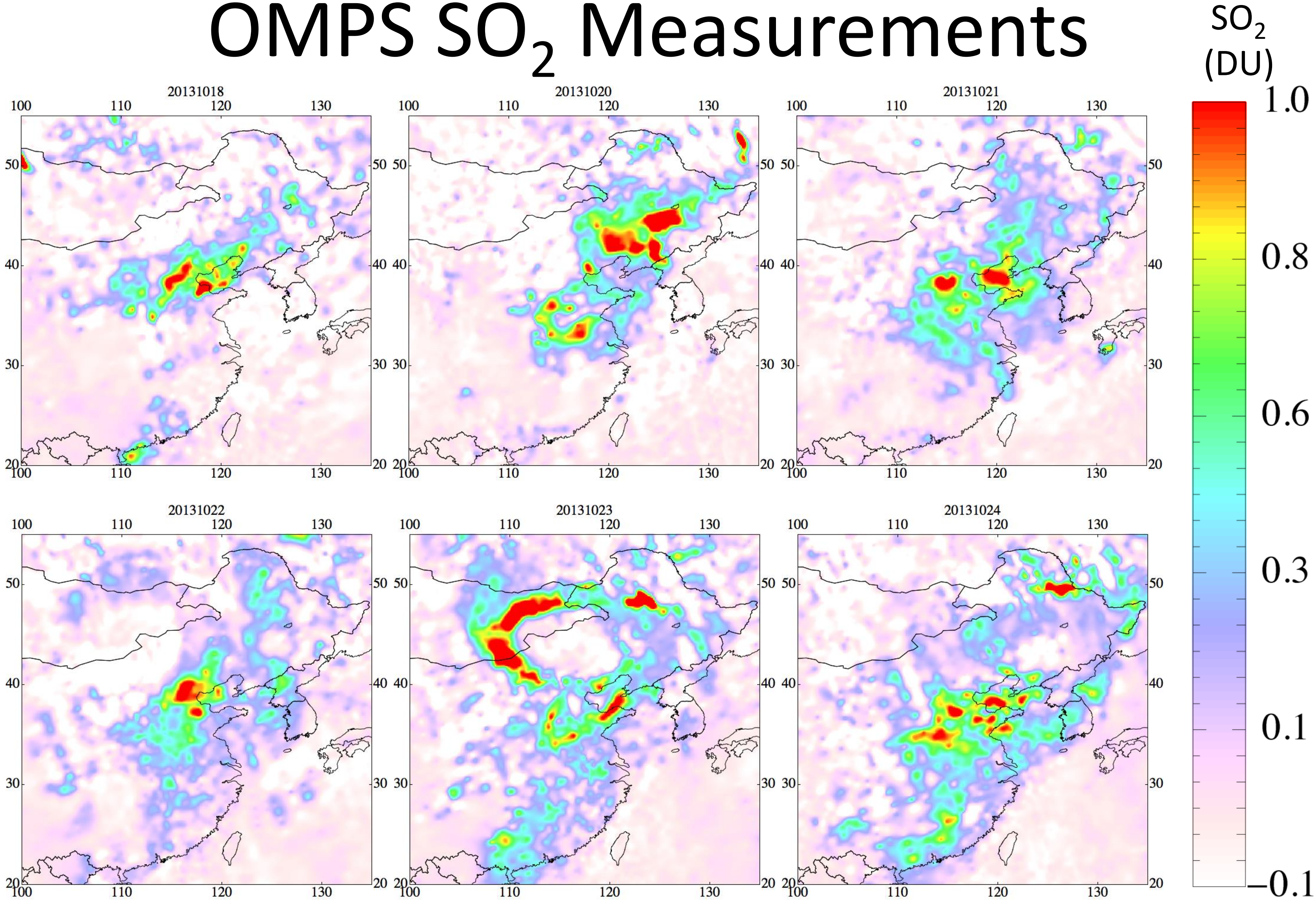


Real variations in the solar spectra can be estimated by using a Mg II Index and the scale factor pattern shown here.

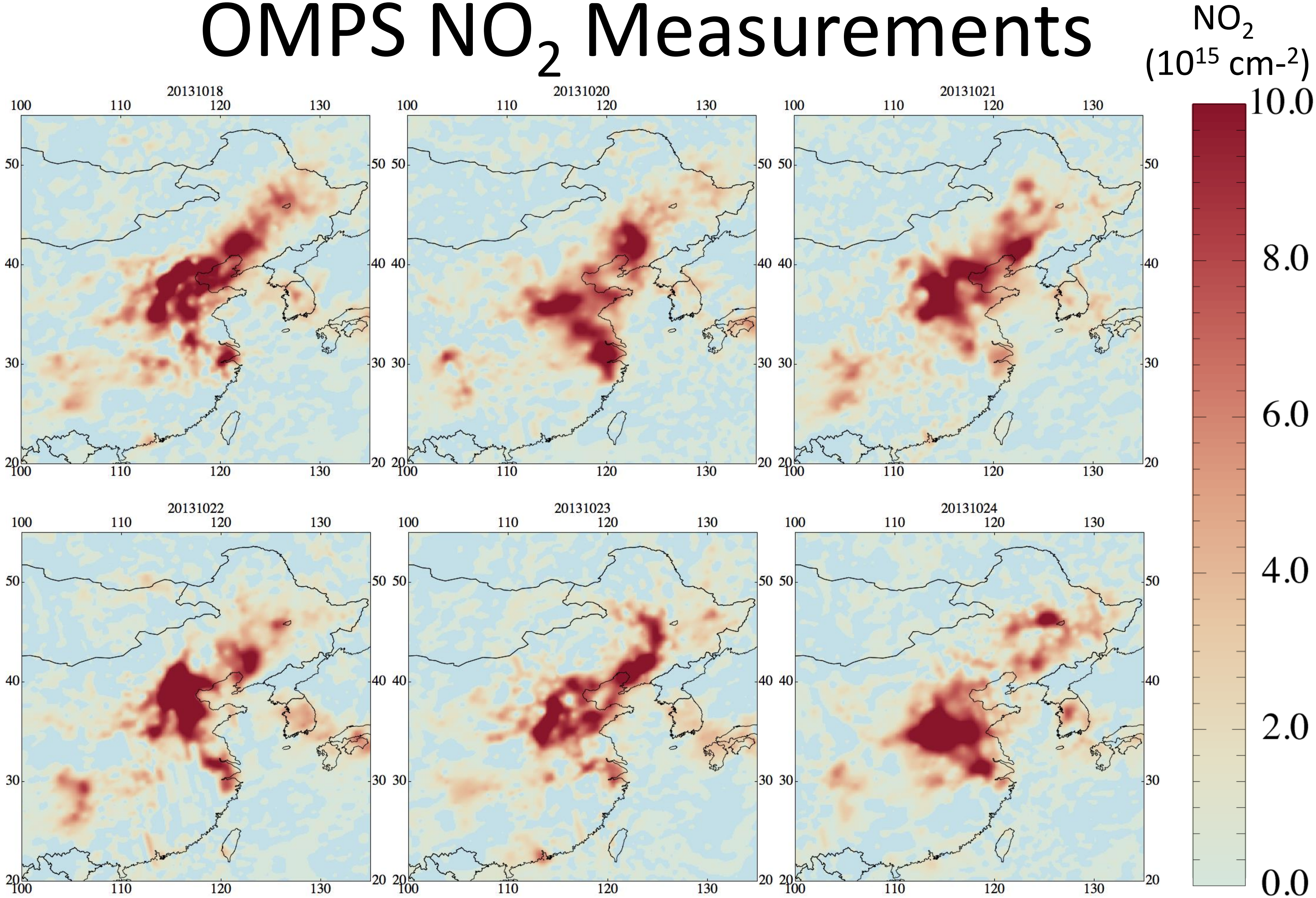
Figure 8. OMPS-NP Mg II Index Scale Factors for Solar Flux variations. These factors provide estimates of the expected changes in flux at a wavelength (at the OMPS-NP 1.1-nm FWHM bandpass resolution) due to solar activity as tracked by a Mg II line core-to-wing index. The Mg II Index created from the OMPS NP measurements for this study shows up to 3% variations over a 27-day solar rotation.

Backup

OMPS SO_2 Measurements



OMPS NO_2 Measurements



OMPS UV Aerosol Index