2014 STAR JPSS Science Team Annual Meeting

Derivation of solar irradiance for OMPS nadir instruments

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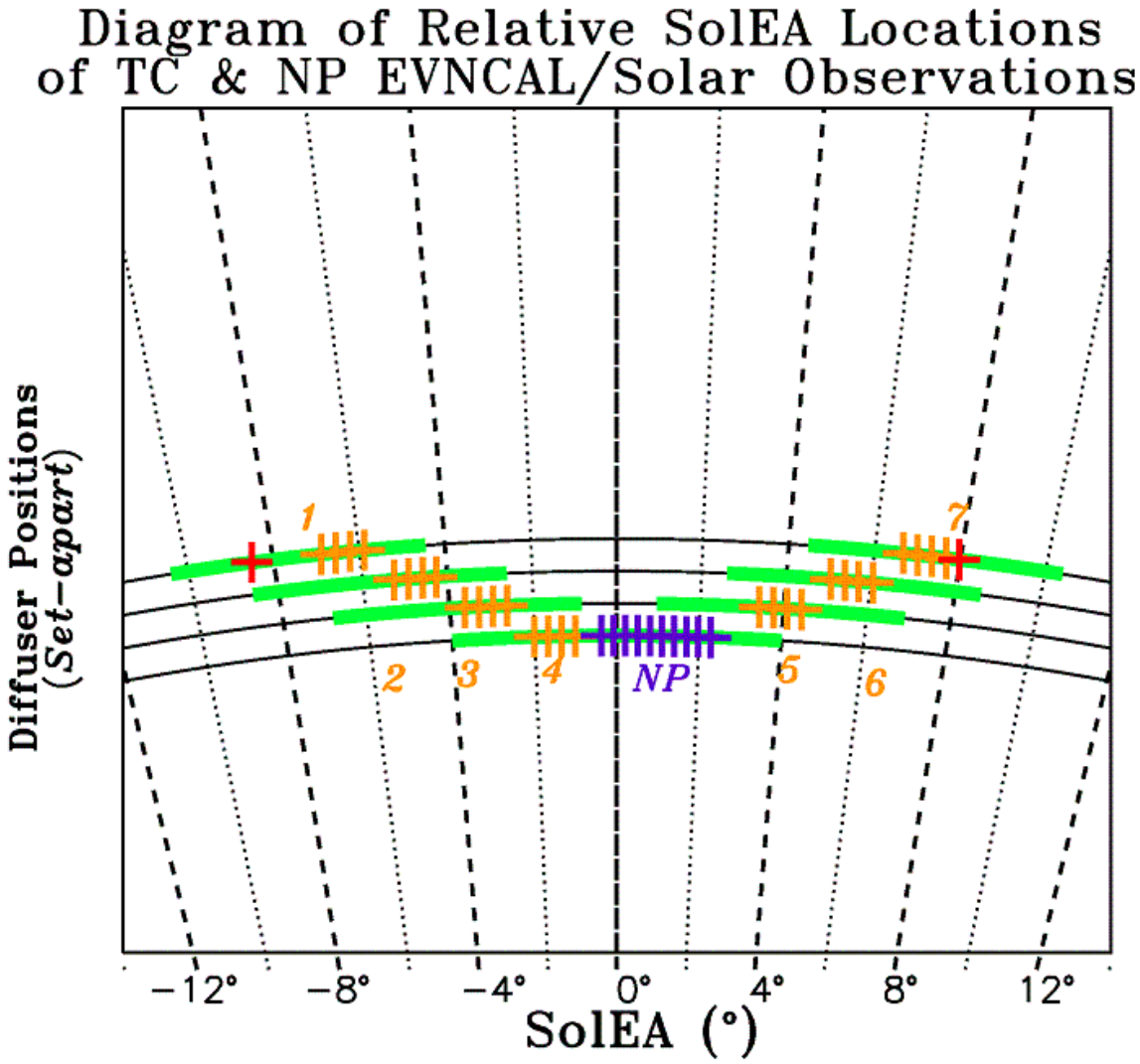
Solar Cal ConOps Changes

- Original: EVNCAL/EVNREF
  - Minimum number
    - 3 observations (obs.) at each NM DiffPos: IT=600 msec & 8 coadds
    - 9 obs. at NP DiffPos (#4): IT=332 msec & 15 coadds
- Current: 3orb_EV_Solar_N / 3orb_EV_RefSolar_N
  - Same ITs and numbers of coadds
  - 16 or 17 obs. at each NM DiffPos, & 23 for NM DiffPos nadir (#4)
  - 15 obs. for NP DiffPos
  - Observations span *most* of the goniometric range for each Diff Pos
    - Optimized number of images implemented
    - Provides better handling of diffuser features
    - Provides better statistics
    - 1st time for an *optimal approach;* prior approaches more *minimal*
    - *Bonus* of 9 additional observations for NM at DiffPos 1 & & on 3rd orbit
    - Compromise: To span entire goniometric ranges for all DiffPos, one would need 4-orbits, due to the overlap of DiffPos

Original Solar Calibration Layout



Diffuser Positions set-apart (fanned-out) to show goniometric Solar Elevation Angle Ranges vs Nadir Diffuser Positions

Green = Nadir Diffuser Goniometric Ranges

Orange = TC Observations Start &/or End Times, & DiffPos Numbers

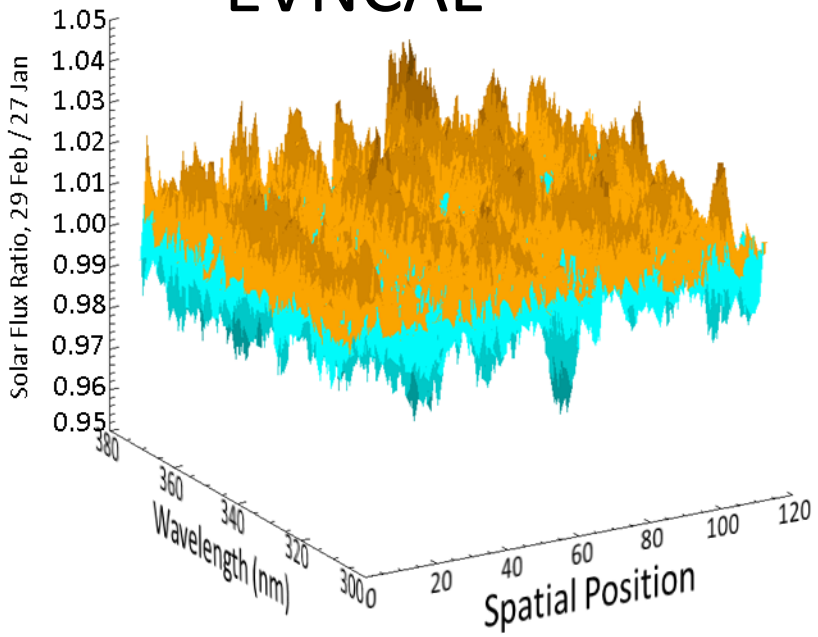
Purple = NP Observations Start &/or End Times

Red = Initial & Final Diffuser Movements for Solar Cal

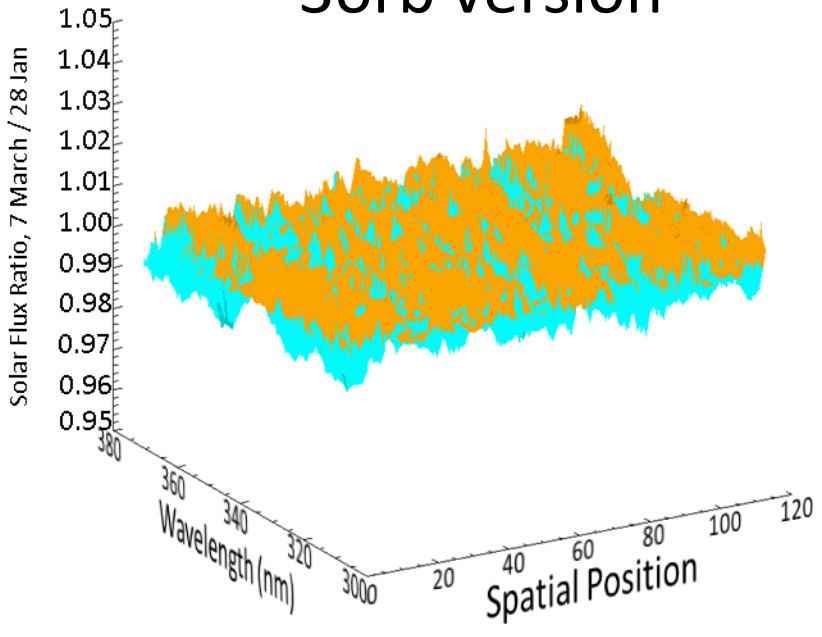
TC = NM

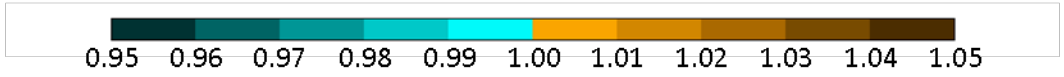
Solar Flux Ratio Comparisons: Working Solar Cal Options: TC4

EVNCAL



3orb version



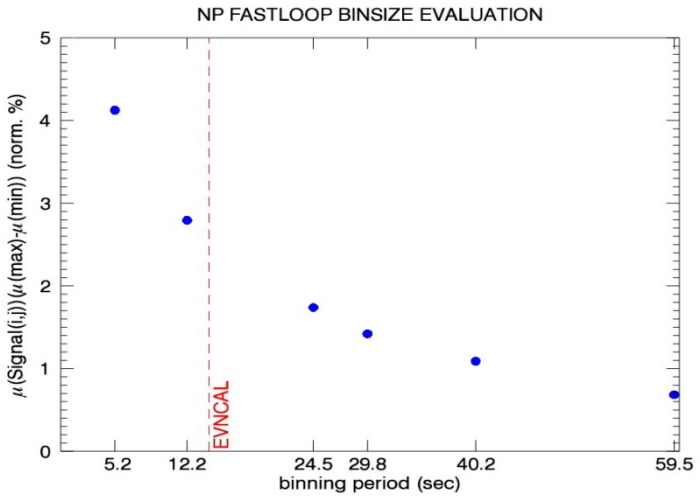


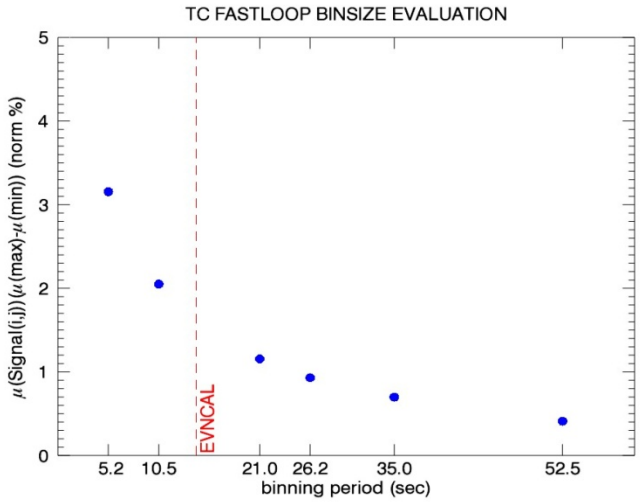
Gon. SolEA range ≈ 0.9°
across 3 measurements

Gon. SolEA range ≈ 8°
Better statistics? Y.E.S.

Reduction of Solar Diffuser Features

Peak-to-Peak Variation / Mean Signal vs Binning Period

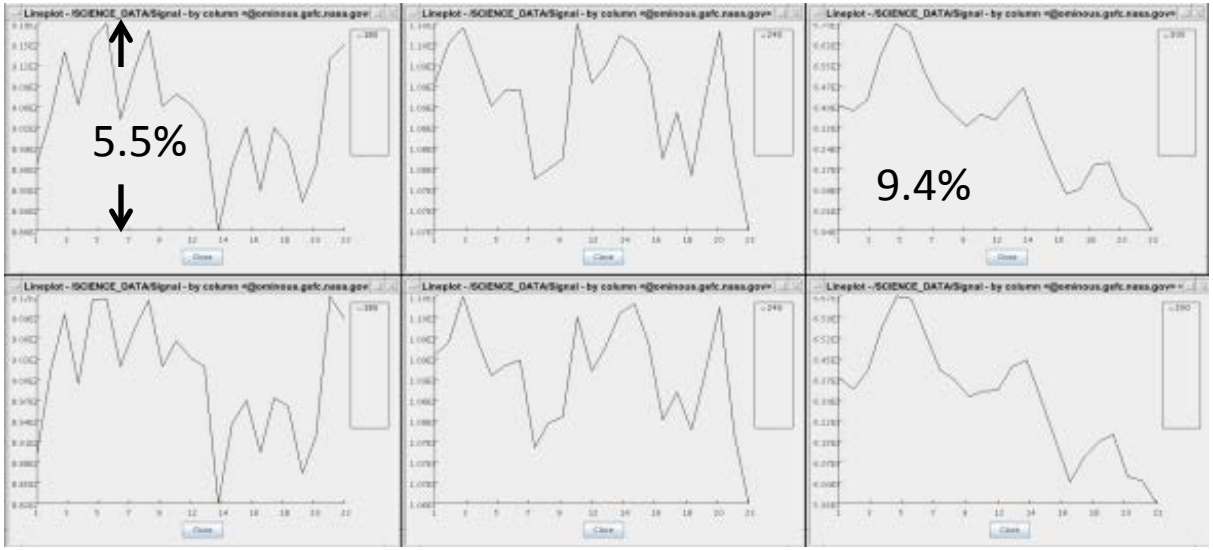




- NP Binning Period (sec)
- IDL> print,0.332d*15*[3, 16]
- 14.94 79.68
- 4X or 5X reduction

- TC Binning Period (sec)
- IDL> print,0.6d*8*[3, 16, 17, 23]
- 14.40 76.80 81.60 110.40
- Approximate 4X reduction

Solar Diffuser Features



Fluxes from WRK obs.
Following 2nd & 4th Solar REFs

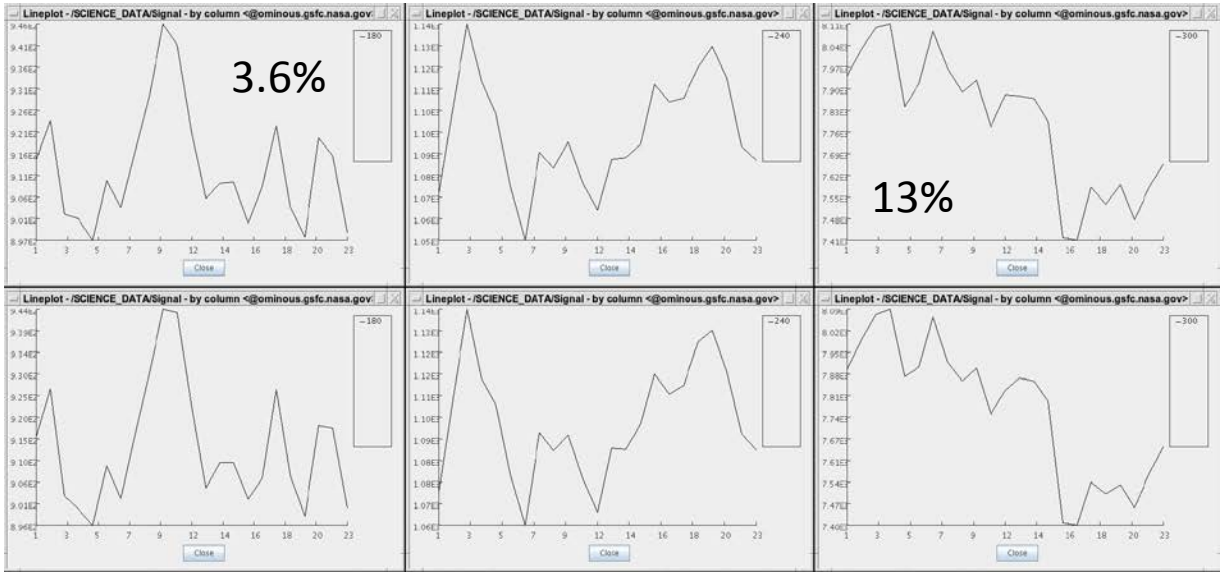
3orb, WRK Diff, TC4
3 Spectral Positions
Same Spatial Location

Not noise
Repeatable structure

3orb, REF Diff, TC4
Everything else same.

WRK & REF distinct & have unique features

Motion primarily in SolEA Angle, 8°

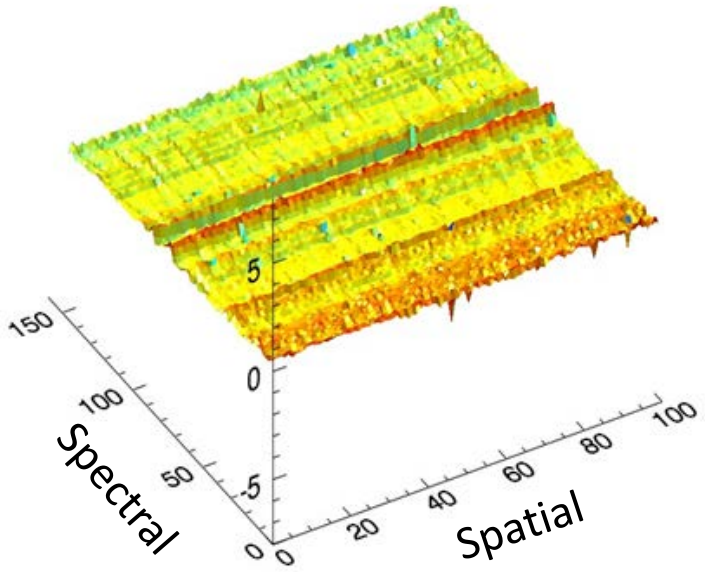


NP Solar Cal Diffuser-Feature Comparisons as Function of Solar Beta Angles

NP: Apr-4/Mar-21

β = 18.95°

σ = 0.189%

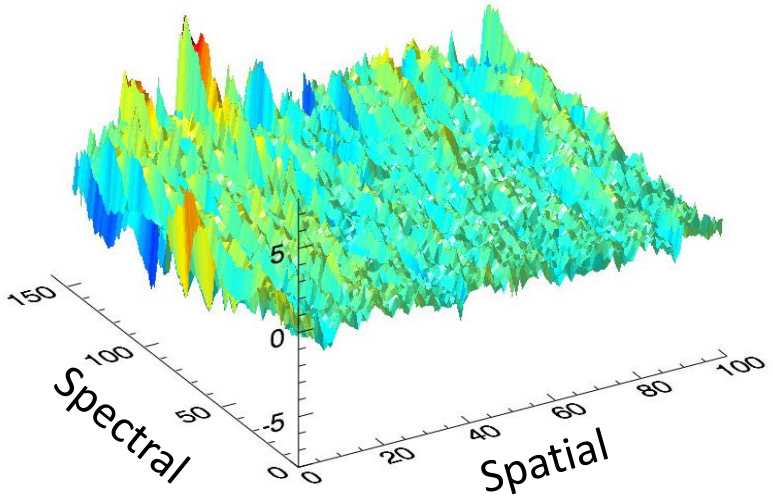


- Working Diff, 3orb observations
- Vertical (z) axes are Percent Difference
- 3 lines near 280 nm are ignored

NP: Jun-27/Mar-21

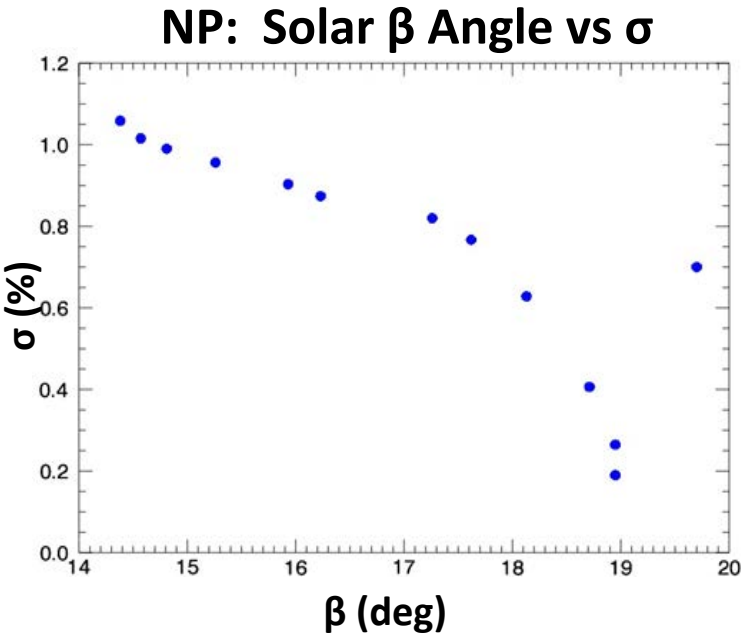
β = 14.57°

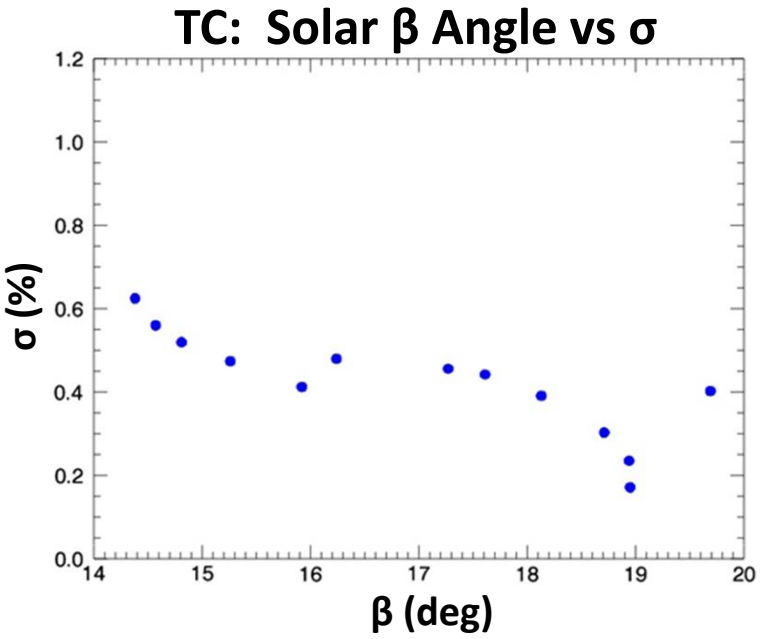
σ = 1.015%



- Differences in β significantly effect σ

Solar Cal Diffuser-Feature Comparisons as Function of Solar Beta Angle





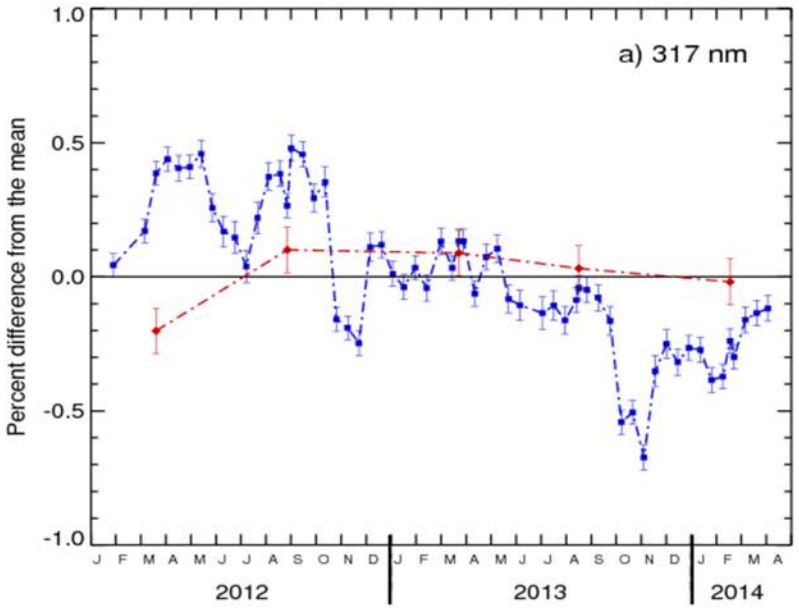
- Diffuser features minimized at same β
- **Infers repeating Solar Ref Cals at same β is advantageous**

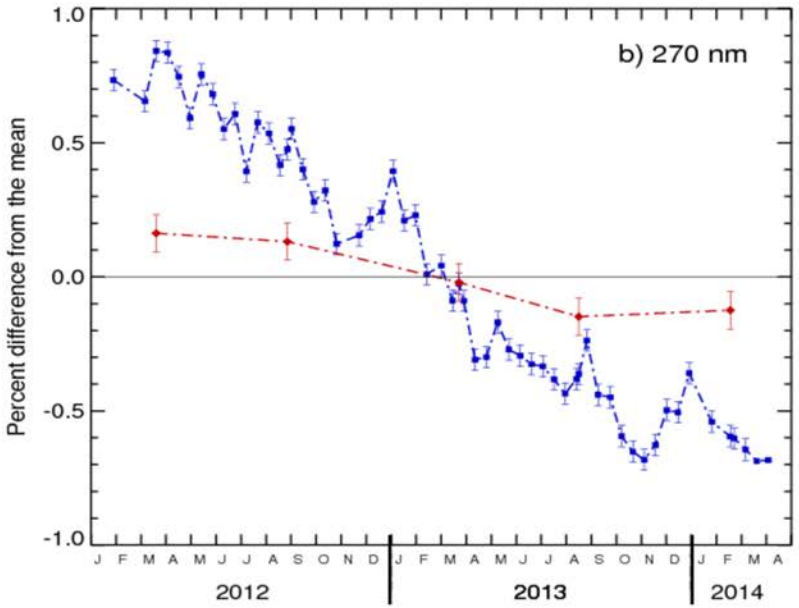
- Similar results for NM Working Diff

Solar Cal ConOps Change Summary

- 3orb vs Original Nadir Solar Cal Plan
  - Makes use of most of the goniometric ranges
    - Collects many more measurements
    - Different from most prior missions
    - Minimizes diffuser features
      - Most critical aspect
      - Significant improvement over original method
- Repeating Ref Cals at same Solar β Angle further lessens effect of diffuser features
  - Also different from prior missions

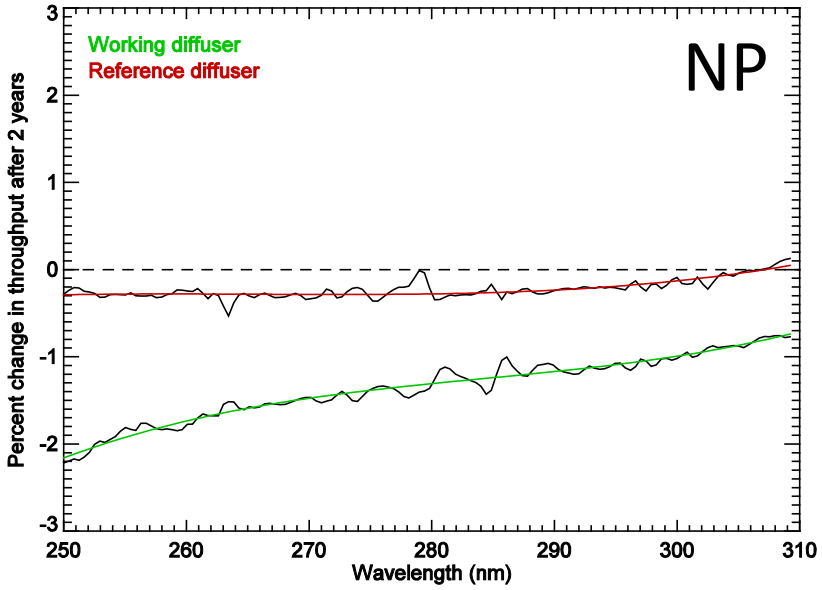
Nadir, Solar Cal, Throughput Time Series: NM & NP Sample

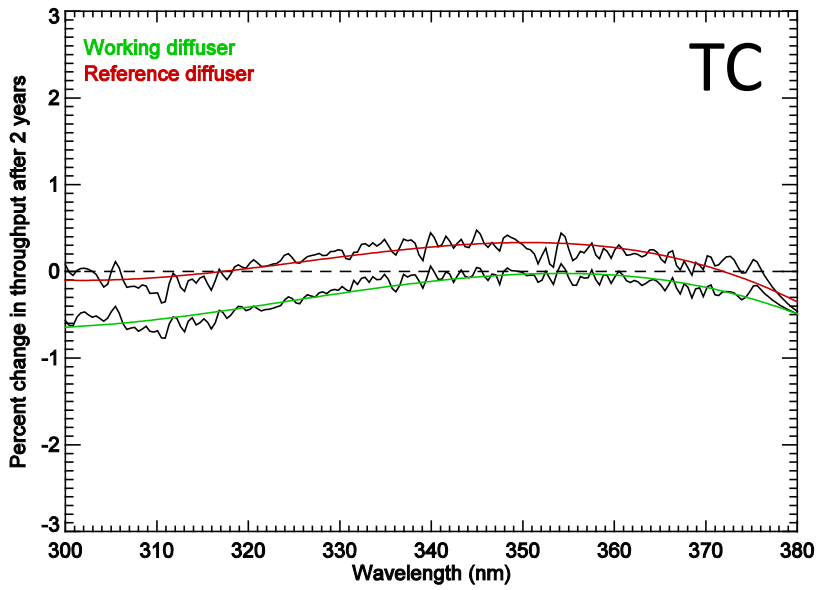




- NM Working Diff (on left) shows max, peak-to-peak, throughput variation of ~1.2 %
- NP (right) shows max, peak-to-peak variation of approx'ly 1¼ %
- Some systematic variations are evident
- Ref Diffuser obs. (in red) indicate little change in NM, and perhaps ¼ % change in NP
- Working Diff obs (blue) less than ½ % for NM, and approx'ly ½% per year for NP
- Not sensitive to solar activity

Net Throughput Changes after 2 Years



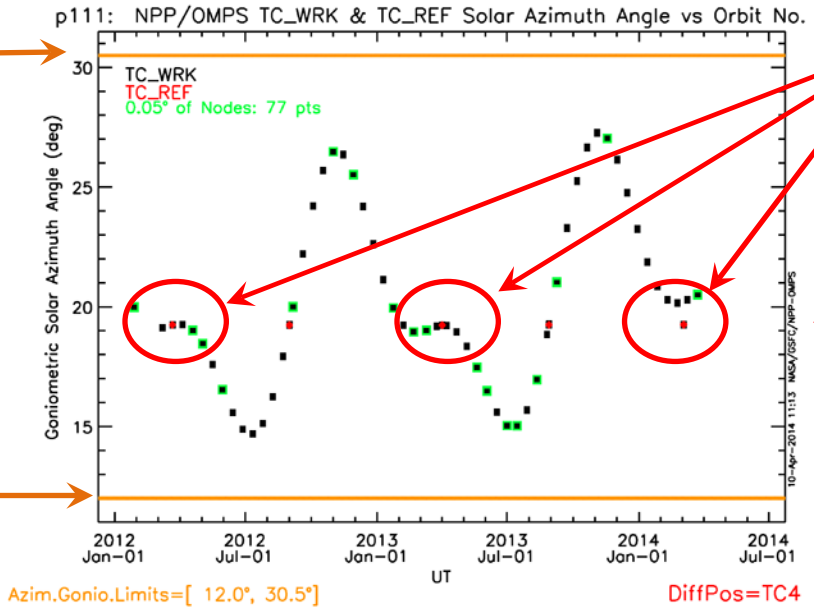


- Corrected for Solar Activity
- Small wavelength correction not applied (0.0x nm)

- No corrections for Solar Activity
- No wavelength corrections

Solar Ref Cals & Az.Angle Variation

Wrk
Ref



Gonio Limits

Saddle-points

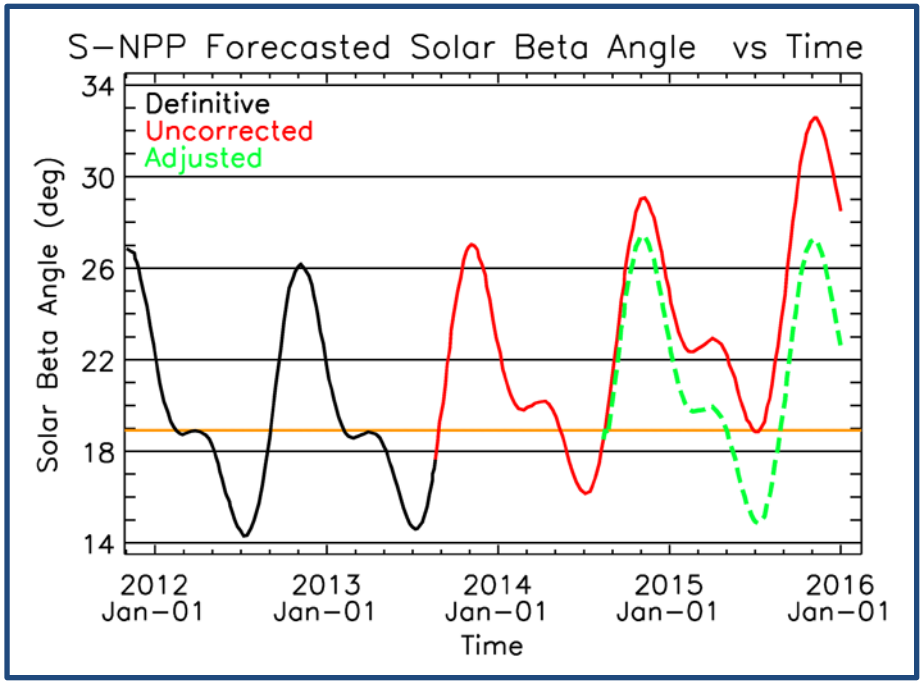
Solar Ref Cals:

- **Collect approx'ly semi-annually**
- **Maintain same Solar Azimuth Angle for all Ref Obs.**
- **Use saddle-point timeframe for 1st obs of year: Feb to late April**
- **2nd obs of year in late August**

- *Saddle-Points* occur due to elliptical Earth orbit and varying Sun-Earth distance
- *Saddle-Point* timeframe: Provides opportunity to re-run a Solar Ref Cal if needed (e.g., data was lost, unplanned spacecraft event, etc.)
- Late-August timeframe has fast rate-of-change: No second chances!
- However, one other significant challenge with this plan: Orbit Drift.

Solar Ref Cal Planning

- Challenges going forward
  - Changes in inclination are accelerating
  - Eastward drift in LTAN is also accelerating
  - Eventually drift beyond gonio. azimuthal range
- If not corrected, the Saddle-point
  - will move up by >1° per year
  - Will move later into July



Plans to begin orbital corrections in mid-2014:

- Involves both orbital inclination and LTAN
- Not a quick fix

Current Expected Schedule:

- 6th Solar Ref Cal in late July or early August
- Orbital adjustments should improve 7th Solar Ref Cal
- Sufficient improvements to obtain without requesting a 2nd yaw maneuver is TBD

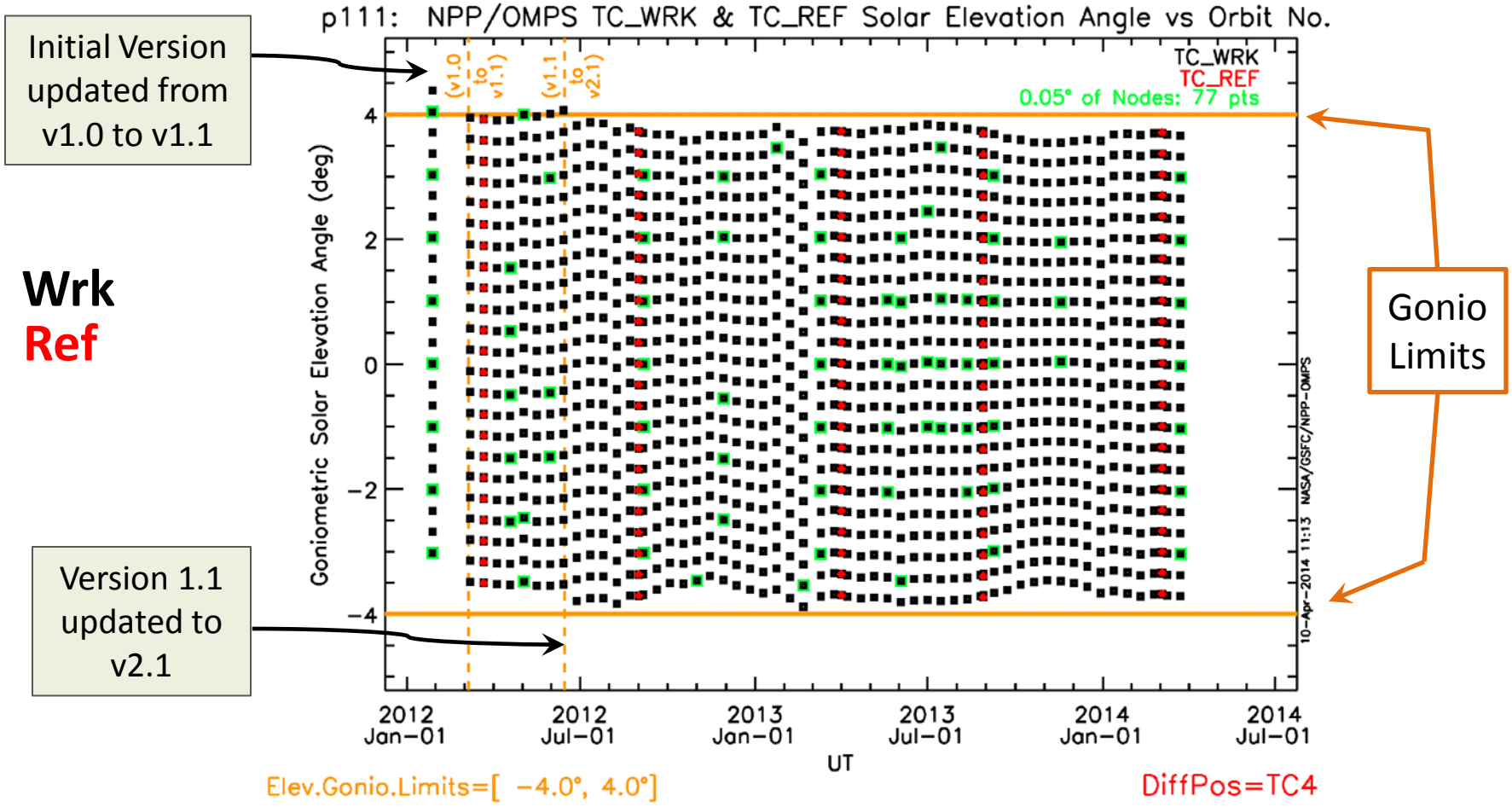
Notes and Thoughts for OJ1

- Keep new approach of using same Beta Angles for Solar Ref Cals
  - Minimizes diffuser features
  - Needs to be somewhat adjustable in time
- Benefits of 3orb vs 3-observations Solar Cals
  - Better statistics (reduced diffuser features)
- Effects of orbit maintenance still TBD
  - Honing plans & skills at MOT during S-NPP mission
- Different diffuser material: QVD
  - Less diffuser features

S-NPP/OMPS Solar Measurements

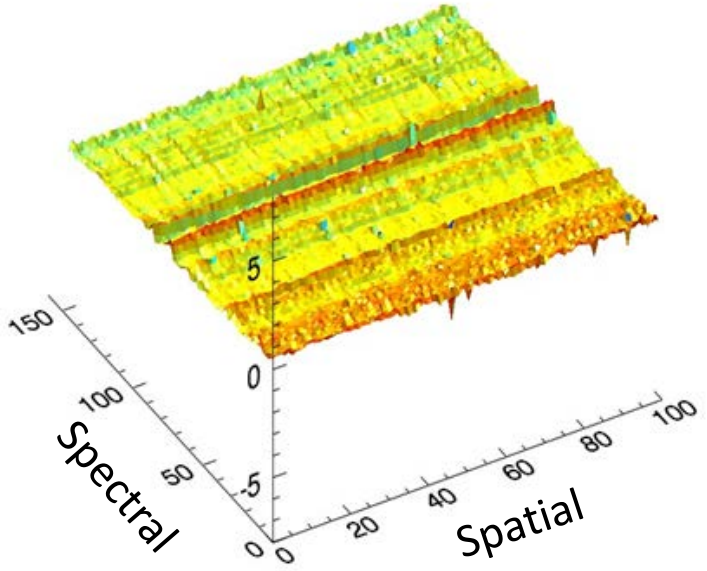
Back-Up Slides

3orb Solar Elevation Angle Goniometric Coverage: TC4



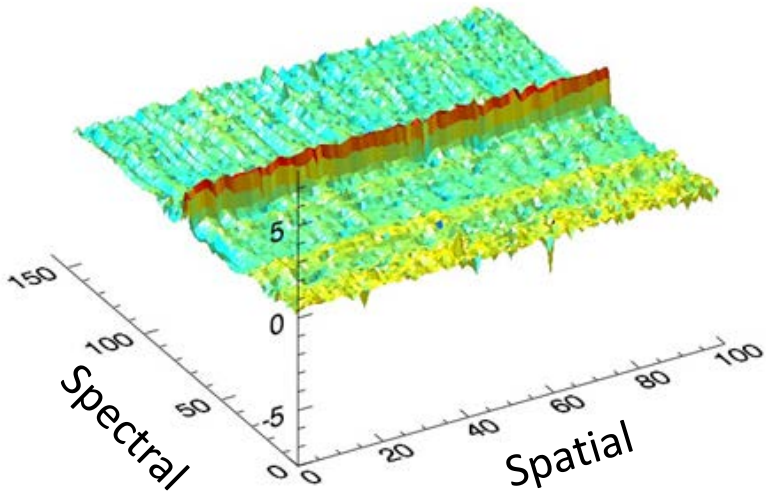
NP Solar Cal Diffuser-Feature Comparisons at Similar Solar Beta Angles

NP: Apr-4/Mar-21
β = 18.95°
σ = 0.189%



- Working Diff obs.
- Vertical (z) axes are Percent Difference
- 3 lines near 280 nm are ignored

NP: Aug-31/Mar-21
β = 18.95°
σ = 0.264%



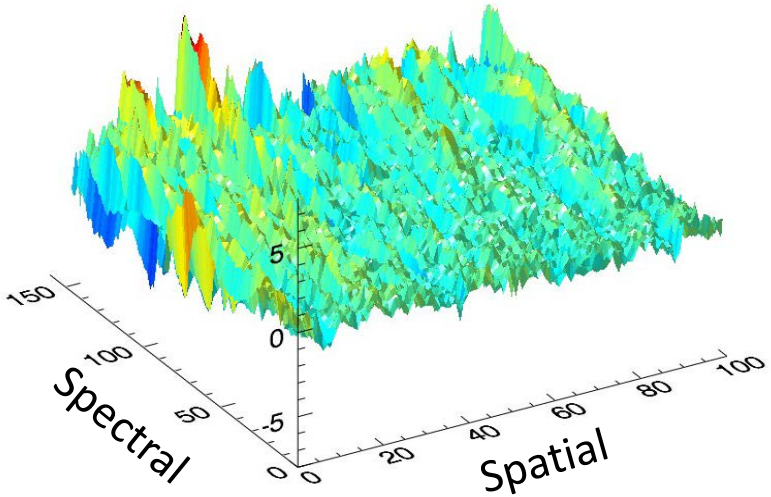
- Left: ~2 weeks apart
- Right: >5 months apart
- **σ for both examples ~ 0.25%**

NP Solar Cal Diffuser-Feature Comparisons at Different Solar Beta Angles

NP: Jun-27/Mar-21

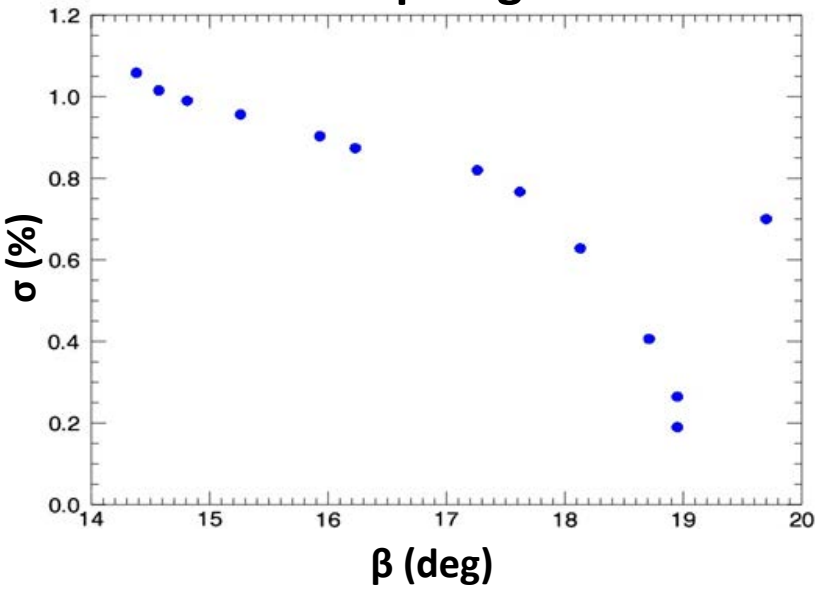
β = 14.57°

σ = 1.015%



- Working Diff obs.
- Vertical (z) axis is Percent Difference
- 3 lines near 280 nm are ignored

NP: Solar β Angle vs σ



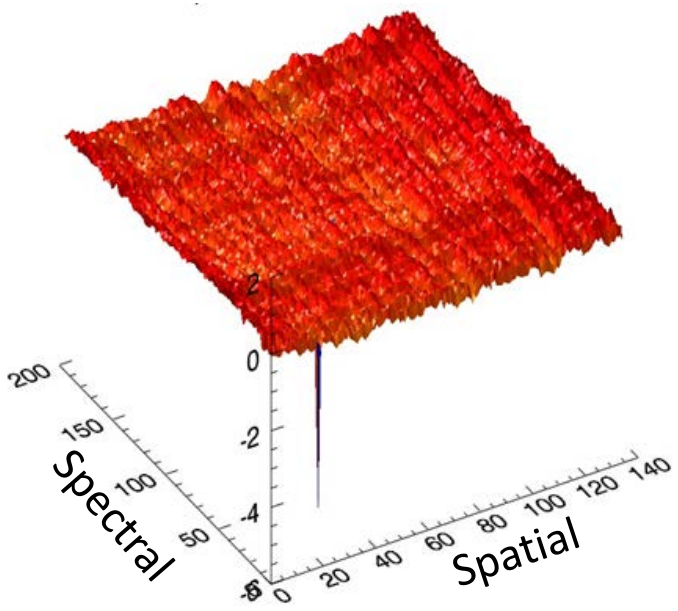
- From an early study with 13 obs.
- Differences in β significantly affect σ
- Diffuser features minimized at same β
- **Repeat Solar Ref Cals for NP at same β a good idea**
  - Need to compensate for orbit drift

TC Solar Cal Diffuser-Feature Comparisons at Similar Solar Beta Angles

TC: Apr-4/Mar-21

β = 18.95°

σ = 0.171%

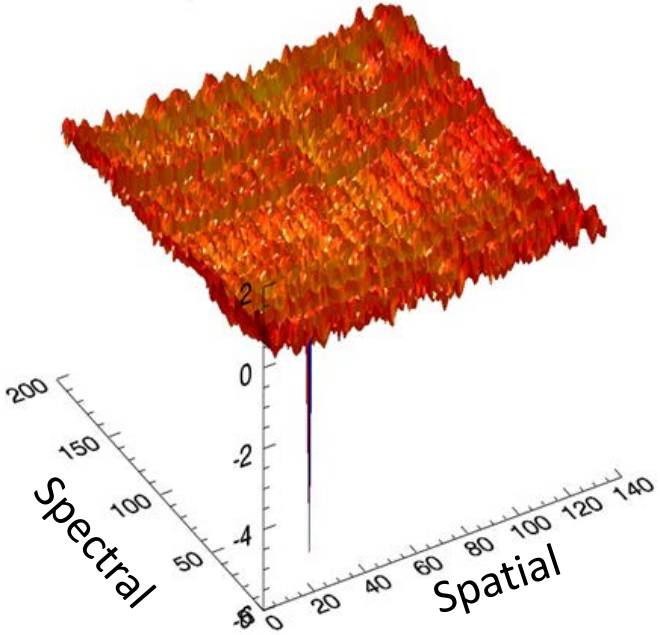


- Working Diff obs.
- Vertical (z) axes are Percent Difference

TC: Aug-31/Mar-21

β = 18.94°

σ = 0.235%



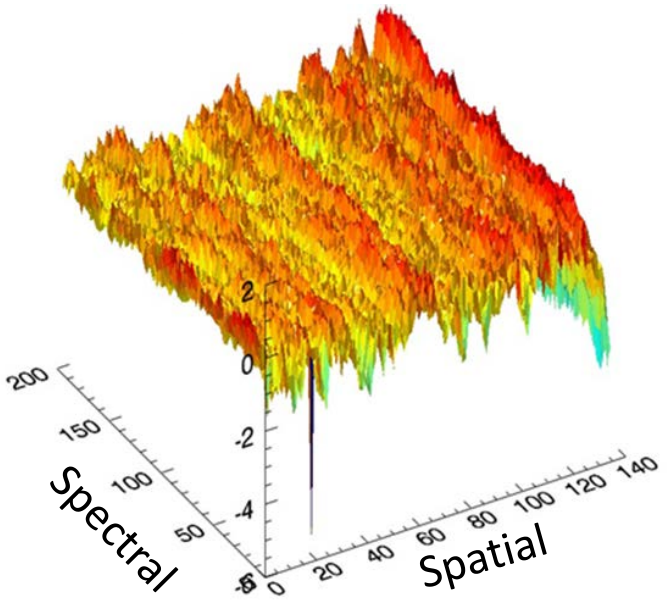
- Left: ~2 weeks apart
- Right: >5 months apart
- **σ for both examples ~ 0.25%**

TC Solar Cal Diffuser-Feature Comparisons at Different Solar Beta Angles

TC: Jun-27/Mar-21

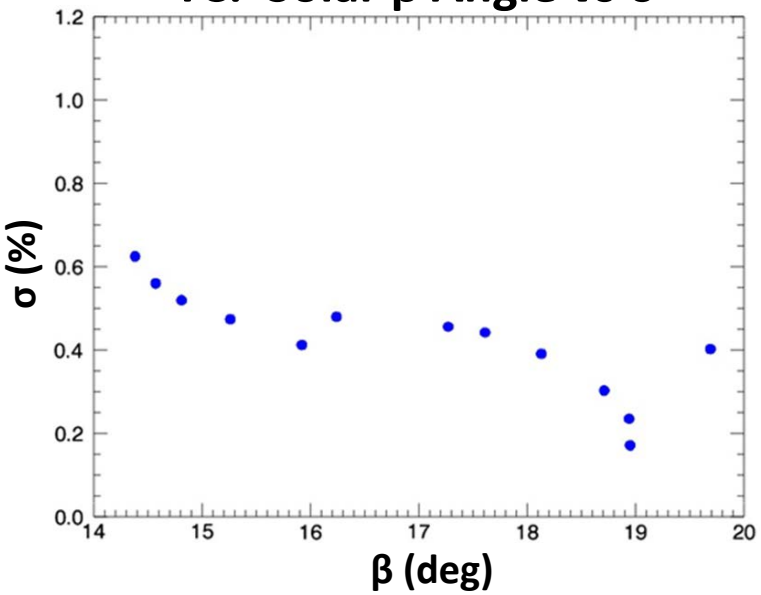
β = 14.57°

σ = 0.560%



- Working Diff obs.
- Vertical (z) axis is Percent Difference

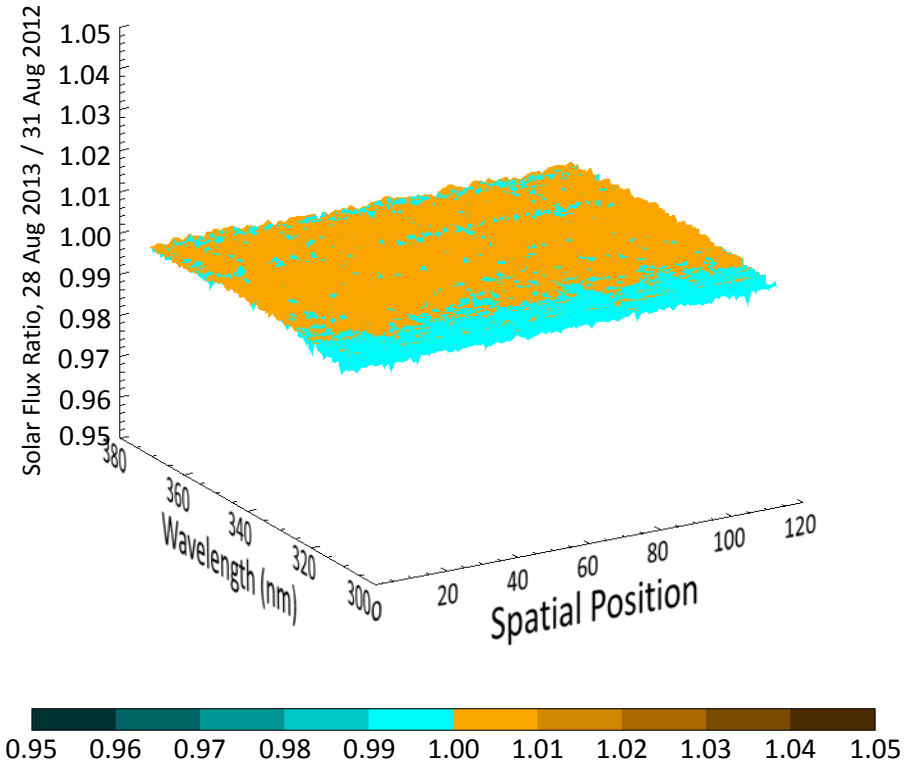
TC: Solar β Angle vs σ



- Early study with 13 obs.
- Differences in β significantly affect σ
- Diffuser features minimized at same β
- **Repeat Solar Ref Cals for TC at same β also a good idea**
  - Need to compensate for orbit drift

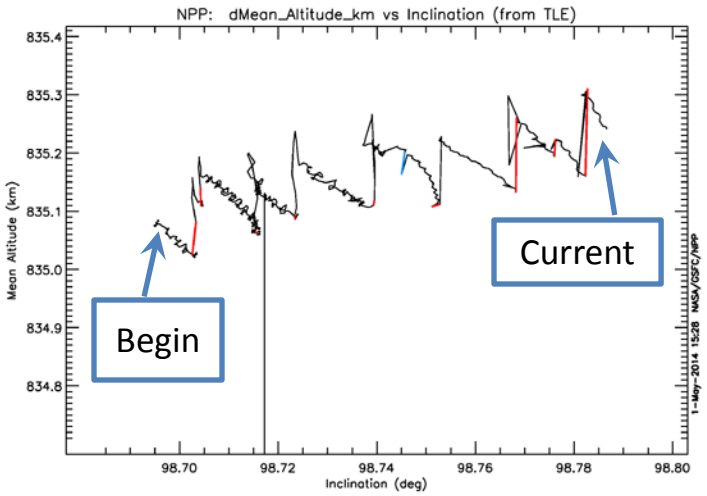
Comparisons at Similar Solar Beta Angles: 2nd & 4th Ref Cals

Ratio of 4th to 2nd NM Solar Ref Cal



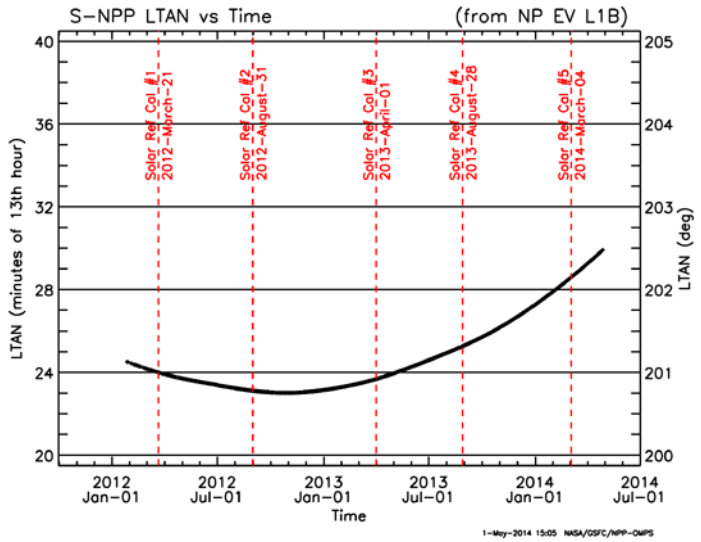
- August of 2012 & 2013 Ref Cals
- Diffuser features minimized
- Benefits Ref Cals
  - Minimizes 1 source of uncertainty: the goniometry corrections
- Not possible, in general, for Solar Working CALs
  - Solar Azimuth Angle varies throughout the year
  - Have many more to find similar β angle comparisons

S-NPP Orbit Drift vs Time



Info from TLE: Mean Altitude vs Inclination

- Inclination slowly increasing
- Net increase of ~0.09°
- Mean altitude has slight increase
- ➔ Rate of precession a little too large



Info from L1B: LTAN vs Time

- Minimum near end of 2012
- Accelerating rate to later LTAN since
- Began at 13:25 LT
- Now at 13:30 LT
- ➔ approx'ly 1.3° increase in Solar β

MOT to correct drifts

- Timeframe is this summer
- Slowly correct orbit