Improving RSB Calibration for Ocean Color

Frank De Luccia, Kameron Rausch, David Moyer,
Scott Houchin, Jason Cardema, Evan Haas, Gabriel Moy,
Ye Hong, Tim Wilkinson, William Chen

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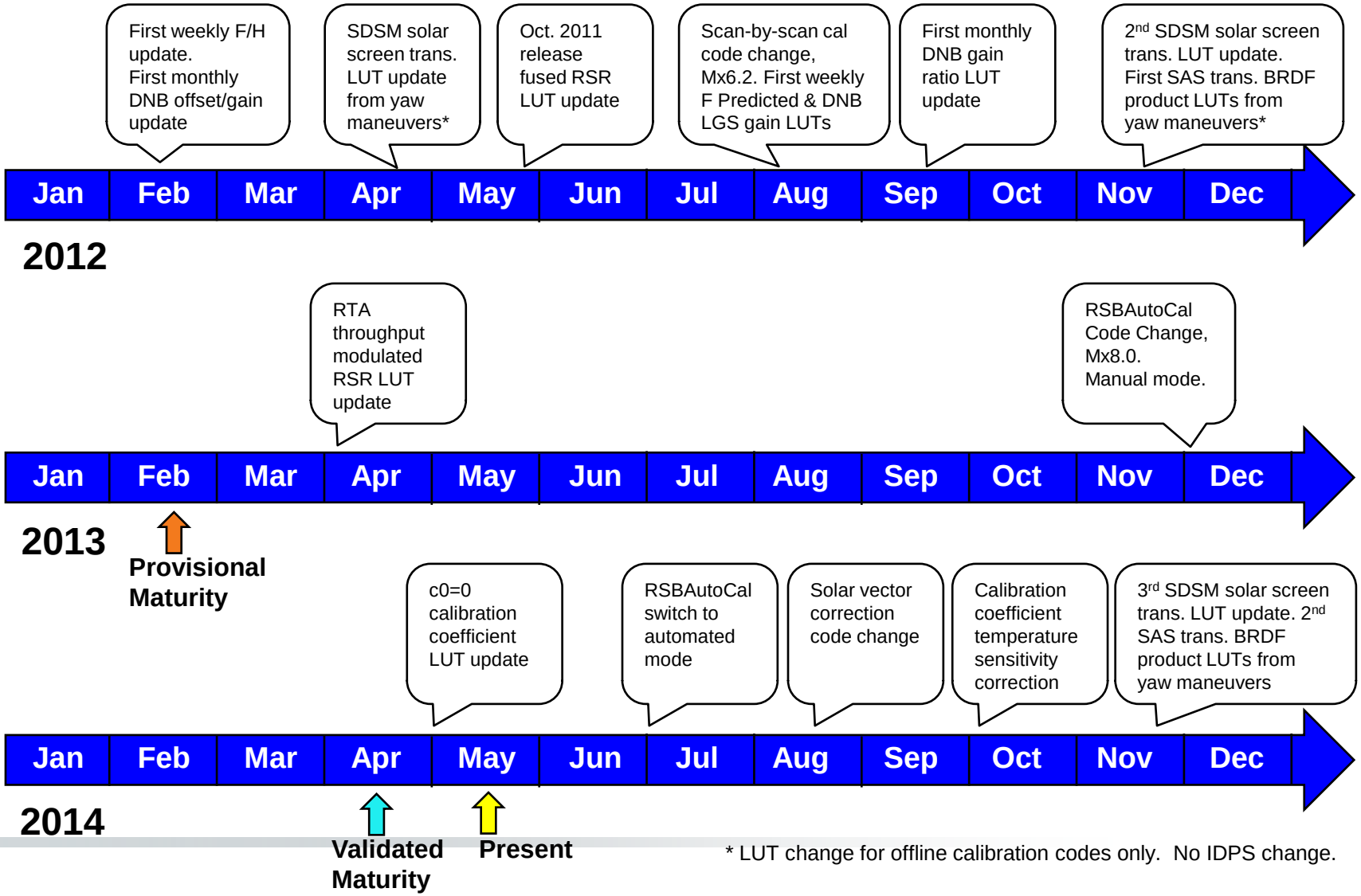
Topics

- SDR calibration operational methodology improvements
  - *Scan-by-scan F correction code change*
  - *Automated RSB calibration (RSBAutoCal) code change*
- SDR RSB radiometric model input parameter improvements
  - *C0 = 0 calibration coefficient LUT update*
  - *Screen transmission and solar diffuser reflectance LUT updates*
  - *Relative spectral response (RSR) LUT updates*
  - *Solar vector correction code change (in work)*
  - *Calibration coefficient LUT temperature dependence correction (in work*
  - *Screen transmission and solar diffuser reflectance LUT update using mission data to date and solar vector correction (in work)*
- Top-of-atmosphere reflectance trending over MOBY site
- Summary

Introduction

- The VIIRS RSB calibration, like the TEB calibration, is physics based and limited principally by the fidelity of the underlying radiometric model and knowledge of the model parameters
- Improvements made thus far since launch, and those in work, increase model parameter accuracy and therefore data product accuracy
  - *Almost every parameter in the radiance and reflectance retrieval equations has been modified by LUT changes during cal/val*
  - *Underlying radiometric model has remained unchanged*
- Significant code changes have also been made to apply the calibration more frequently, thereby improving data product stability as well as accuracy
- These improvements affect all the RSB, including the VisNIR, and therefore benefit Ocean Color performance

RSB Calibration Improvement Timeline



* LUT change for offline calibration codes only. No IDPS change.

SDR Calibration Operational Methodology Improvements

Regular Weekly and Monthly LUT Updates Maintain the RSB Calibration and Data Product Quality

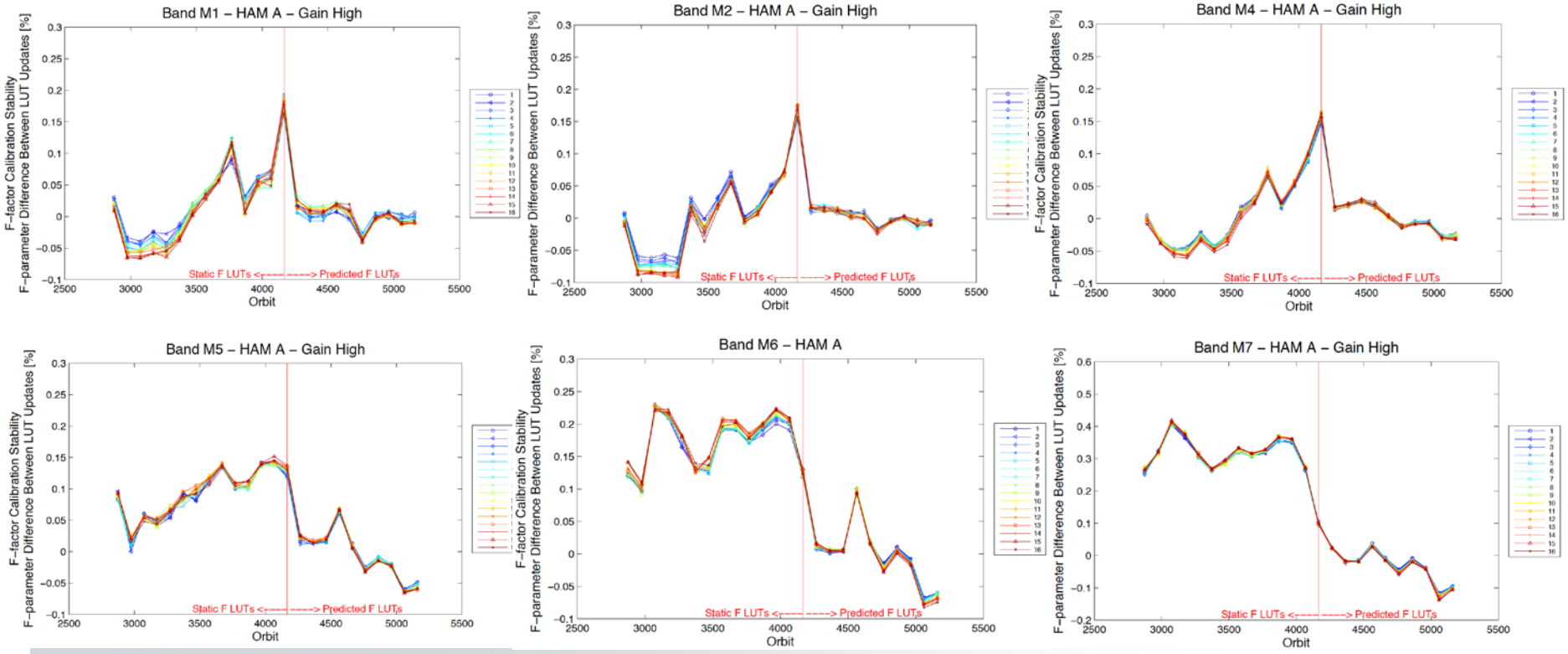
- Until the automated RSB calibration algorithm, RSBAutoCal, is switched to automated mode in IDPS, RSB calibration is being maintained by operational LUT updates.
- Every week two sets of updated LUTs derived from solar calibration are delivered to Data Products & Engineering Services (DPES) for functional testing by Tim Wilkinson, Aerospace
  - *F Predicted and DNB LGS Gain LUTs in Mx8.X for IDPS operations*
  - *F Predicted, DNB LGS Gain, and H LUTs in Mx7.2 for direct broadcast users*
- Every month updated DNB offset and gain ratio LUTs in Mx8.X derived from special data collects during new moon periods are delivered by William Chen, Aerospace
- These regular LUT updates are the backbone of RSB calibration to date, and ensuring their quality through IDPS code changes and changes in other LUTs is both challenging and essential to the quality of the SDR and downstream EDRs

Scan-by-Scan F Factor Correction Code Change

- In 2012 Aerospace developed modified SDR code to:
  - *Ingest F factor reference and trend data from LUTs for non-DNB bands*
  - *Ingest DNB LGS gains and trend data from LUTs for the DNB*
  - *Calculate F factors and DNB LGS gains "on the fly" on a scan-by-scan basis*
- Use of trend information and scan-by-scan updates was intended to improve improve the fidelity and continuity of the RSB calibration within the limits of the weekly manual LUT update process
- The scan-by-scan F correction code change, implemented in IDPS Mx6.2 on August 9, 2012, was successful in meeting its objectives
- The scan-by-scan F factor and DNB LGS gain correction continues to operate in the Mx8.X versions of the code that implement the automated RSB calibration algorithm (RSBAutoCal), whether in manual or automated mode

Scan-by-scan F Factor Correction Impacts on Data Product Radiometric Stability

- Metric plotted is F factor difference between updated LUT and the LUT it replaces at a common reference time
  - *Measures discontinuity in F factor when a LUT is replaced*



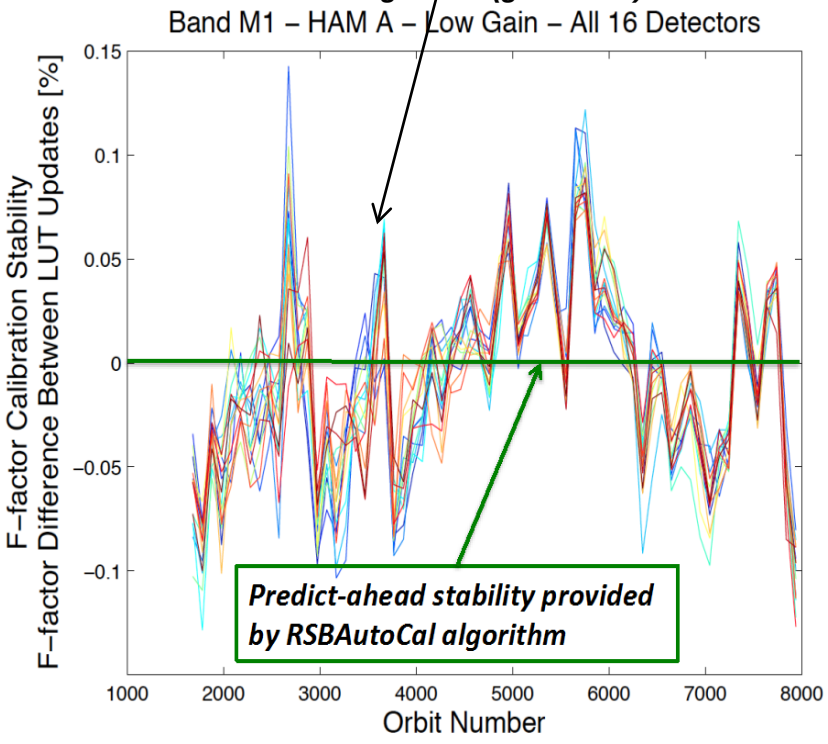
Continuity after code change was generally +/- 0.1%, even for bands affected by RTA throughput degradation

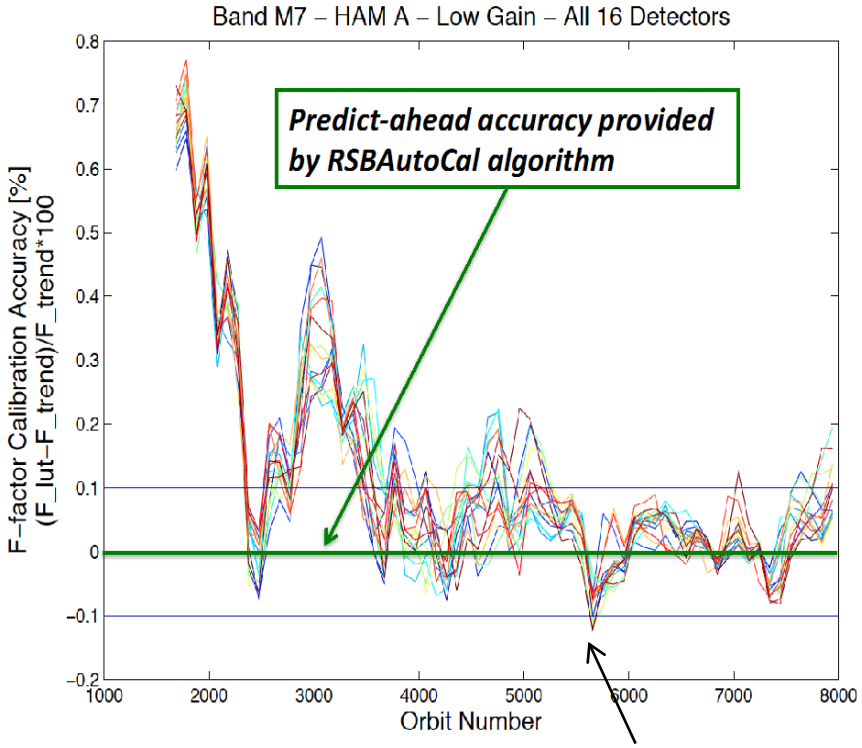
Automated RSB Calibration Code Change - RSBAutoCal

- In 2012/2013 Aerospace developed SDR code to fully automate RSB calibration
- F factors and DNB LGS gains and their time derivatives are calculated immediately after data acquisition from the SD each orbit and applied in the next orbit
  - *Eliminates discontinuities associated with weekly LUT updates*
  - *Eliminates predict-ahead accuracy error, difference between current best estimate F factors and LUT F factors and trends calculated based on calibration data 100-200 orbits old*
- Application of Robust Holt Winters filtering allows RSBAutoCal to maintain calibration during data outages and re-acquire new trends afterward, should they occur, without manual intervention
- RSBAutoCal inserted into IDPS operations with Mx8.0 in 11/2013
  - *Input LUTs recently adjusted to provide desired smoothing and outlier rejection*
  - *Under evaluation for transition from manual to automated mode*

RSBAutoCal Eliminates Calibration Discontinuities and Predict-Ahead Accuracy Errors

Discontinuities in F at instant of LUT replacement in operations each week are removed with RSBAutoCal algorithm (green line)





Time varying instantaneous difference between extrapolated F applied in operations and offline F without extrapolation is removed with RSBAutoCal algorithm (green line)

SDR RSB Radiometric Model Input Parameter Improvements

Calibration Coefficients Modified to c0 = 0 and Refit c2 version

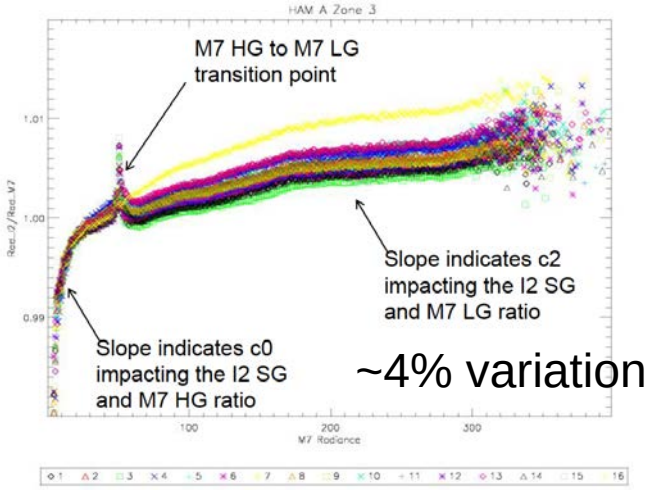
- Aerospace analysis of pre-launch TVAC data applied c0 = 0 constraint and demonstrated improved radiometric response characterization uncertainty and predicted calibrated response uniformity
  - *No theoretical basis for c0 coefficient – disappears in radiance path differencing*
  - *Nonzero c0 justified in TEB to absorb errors in self-emission parameters and radiometric model, essentially providing an on-orbit tuning parameter*
  - *C0 values derived from TVAC test data analysis shown to be statistically indistinguishable from zero for many, but not all, RSB bands*
    - Any earth sector-calibration sector offsets significant enough to disturb calibration, if they exist at present, would require separate compensation
- C0 = 0 coefficients shown to significantly reduce I2/M7 and I3/M10 differences on orbit
- C0 = 0 cal coefficient IDPS LUT update implemented in May 2014
- NASA OCC team already performs calibration with both c0 = 0 & c2 = 0

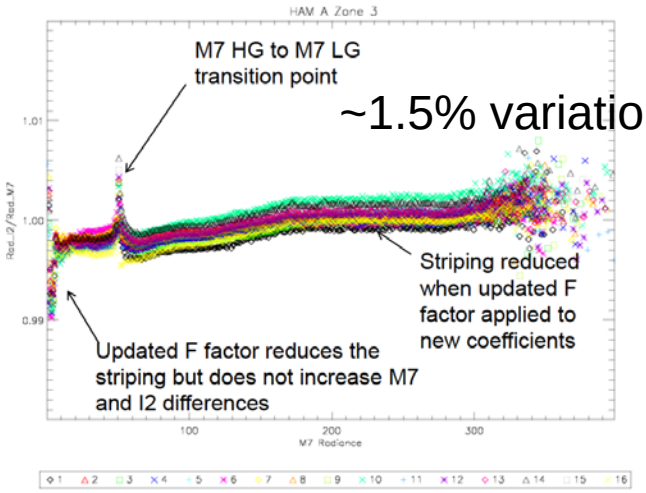
Modified c0 = 0 Calibration Coefficients with Refit c2 Improve Agreement Between Bands Under Same Filter

Baseline

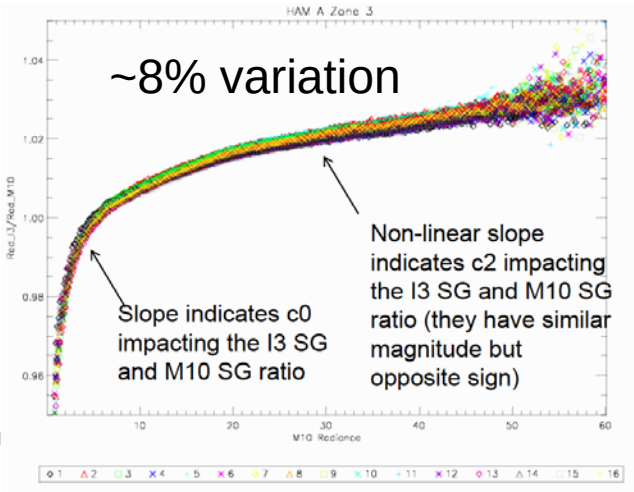
c0 = 0 & refit c2

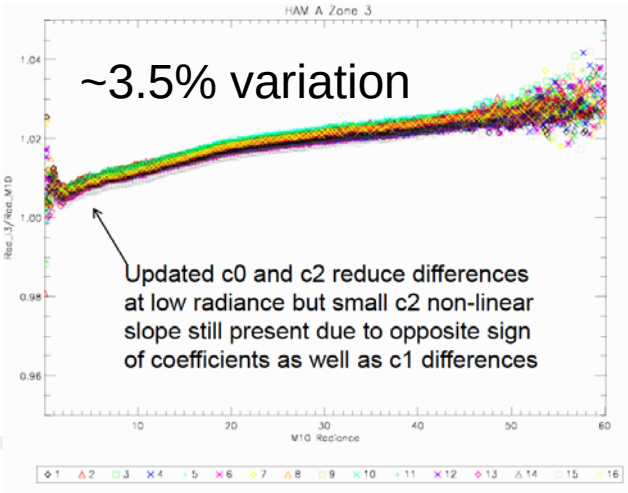
I2/M7 Ratio





I3/M10 Ratio





AEROSPACE

Improved Screen Transmission and Solar Diffuser (SD) Bidirectional Reflectance Distribution Function (BRDF) LUTs

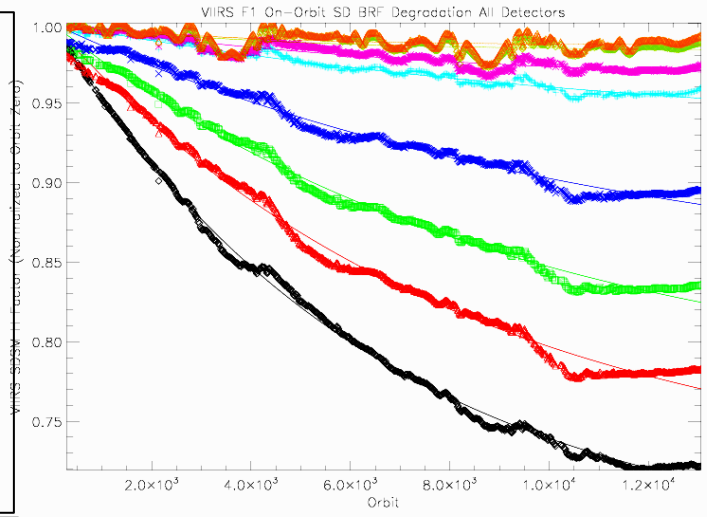
- SDSM solar screen transmission LUT derived by NASA VCST from yaw maneuver data incorporated in offline codes for operational IDPS F and H factor LUT calculation in April 2012
- New Solar Attenuation Screen (SAS) SD BRDF product LUTs, RTA view and SDSM view, derived by VCST from yaw maneuver data incorporated in offline F/H processing in November 2012, along with refined version of SDSM solar screen transmission LUT derived by Aerospace
  - *November 2012 version of LUTs went into IDPS operations with RSBAutoCal (manual mode) in Mx8.0 in November 2013*
- Improved SDSM screen transmission LUT decreased modulations and transmission errors in the H factor, resulting in improved calibration accuracy and stability
  - *Reduced H modulations reduce week-to-week differences in predicted F vs reference F in LUT updates*

Improved Screen Transmission and Solar Diffuser (SD) Bidirectional Reflectance Distribution Function (BRDF) LUTs (cont.)

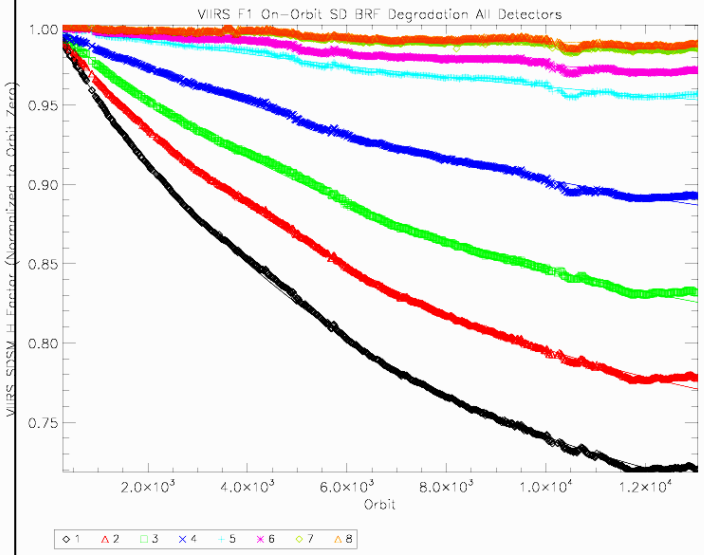
- Solar Attenuation Screen (SAS) SD BRDF product LUTs, RTA view and SDSM view, reduces spurious trend changes in calibration as solar azimuth varies over the year
- Update of all three operational LUTs in work and recommended for insertion in IDPS at time of solar vector correction code change in August 2014 or shortly thereafter

Improvement in H factor Behavior Due to Refined SDSM Solar Screen Transmission LUT

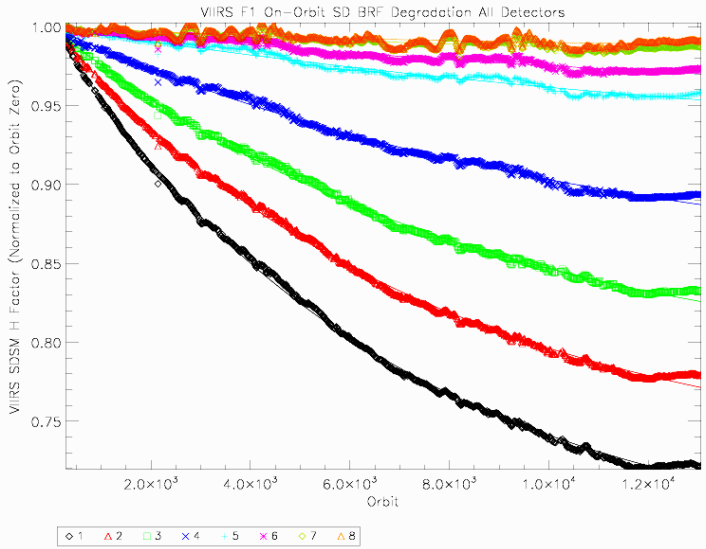
Pre-launch SDSM Solar Screen Transmission LUT



November 2012 SDSM Solar Screen Transmission LUT



April 2012 SDSM Solar Screen Transmission LUT



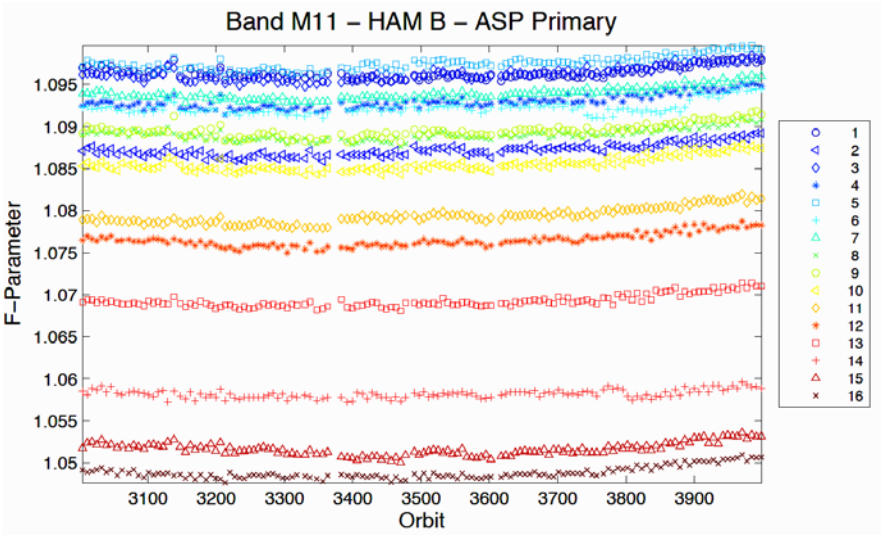
H factors using pre-launch SDSM screen transmission LUT contained errors causing “ripples” and biases in the H factor values (upper left).

H factors after the NASA VCST LUT update using yaw data removes transmission biases and a majority of the “ripples” (upper right).

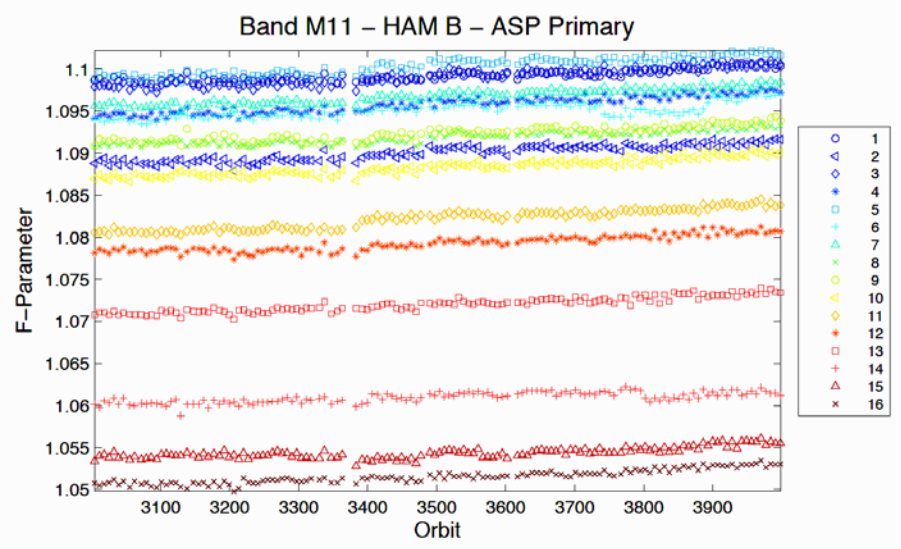
The 2nd LUT update used the NASA VCST LUT and the first 9 months of H factor data to remove the remaining “ripples” in the H factors (lower left).

Reduction in Spurious F Trend Change due to Nov 2012 SAS Transmission SD BRDF Product LUTs (from NASA VCST yaw data analysis)

At-launch LUTs



November 2012 LUTs



- M11 chosen as example as it has no significant modulations to obscure impact of this LUT change. All bands similarly affected
- Concave upward behavior in F trend centered on orbit where solar azimuth reverses (around 3600) largely removed
- Slight linear upward trend remains

RSB Relative Spectral Response (RSR) LUT Updates

- Chris Moeller of the University of Wisconsin led data analysis efforts leading to both RSR LUT updates
- May 2012 update
  - *Replaced at-launch RSRs for bands M1-M7 with NG-generated October 2011 fused RSR incorporating government team best-estimate spacecraft-level RSRs*
  - *Water vapor correction applied to M9*
  - *Improved data filtering for all RSB*
  - *<0.1% quantitative impact on SDR radiances*
- April 2013 update – Modulated RSR
  - *RSRs updated to take into account RTA throughput degradation as of 1 February 2013*
  - *<0.2% quantitative impact on SDR radiances*
- Need for future RSR update will be evaluated based on progress of RTA throughput degradation

Planned and Proposed Improvements not yet Implemented

- Correction of solar vector error discovered by NASA GEO team
  - *Impacts F factors at 0.1% level according to VCST preliminary analysis*
- Correction of calibration coefficient temperature dependency errors/omissions in current Delta C LUT
  - *Impact on M6 is annually cyclic at nearly 0.1%*
- 3rd update of SDSM solar screen transmission LUT and 2nd update of SAS transmission SD BRDF product LUTs, RTA and SDSM views, based on 2.5+ years of mission data supplementing the yaw maneuver data
  - *Impacts in shorter wavelength bands approach 0.2%*

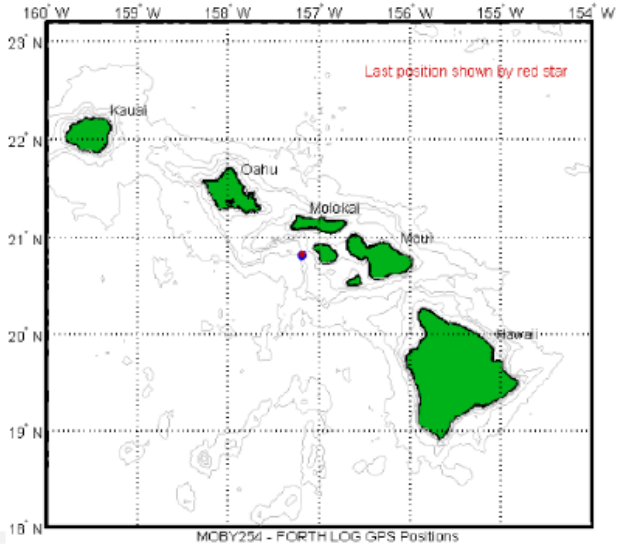
Impacts of all these improvements large enough to benefit OCC

Trending SDR Reflectance Over MOBY Site

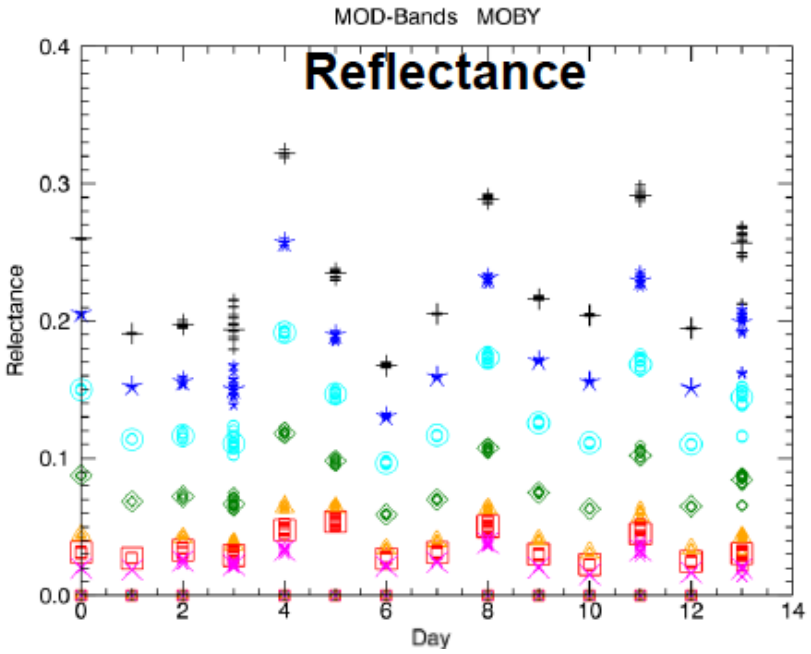
Data

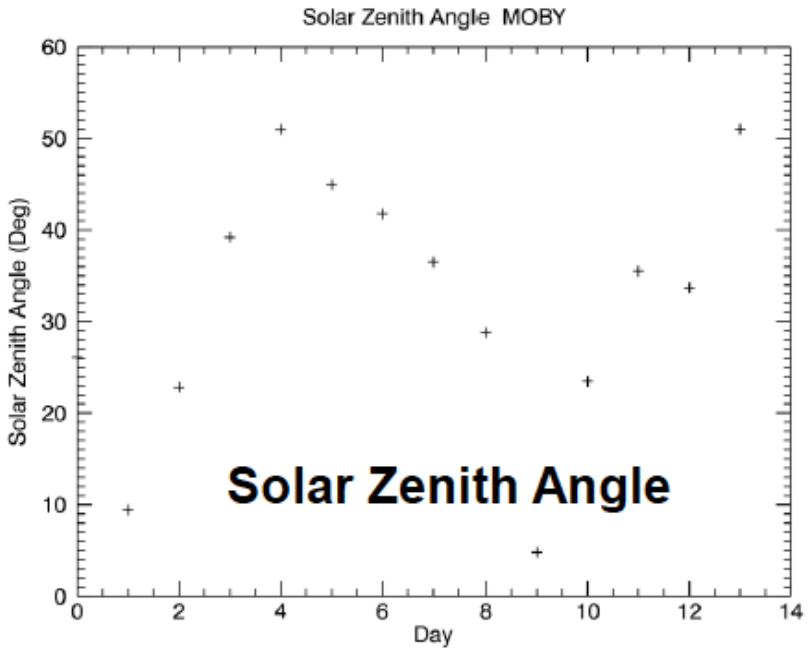
- VIIRS SDR over the MOBY site (see Figure below) were collected once a month from Feb 2012 to Dec 2013 (i.e. 23 Granules)
- Corresponding Cloud Mask (CM) IP data (available starting in May 2012) were also collected so that only *clear ocean* SDR data (and *no glint*) will be used for analyzing VIIRS reflectance stability

- 14 out of 23 granules passed the CM test
- Time series of reflectance for the 14 granules are displayed on the next slide

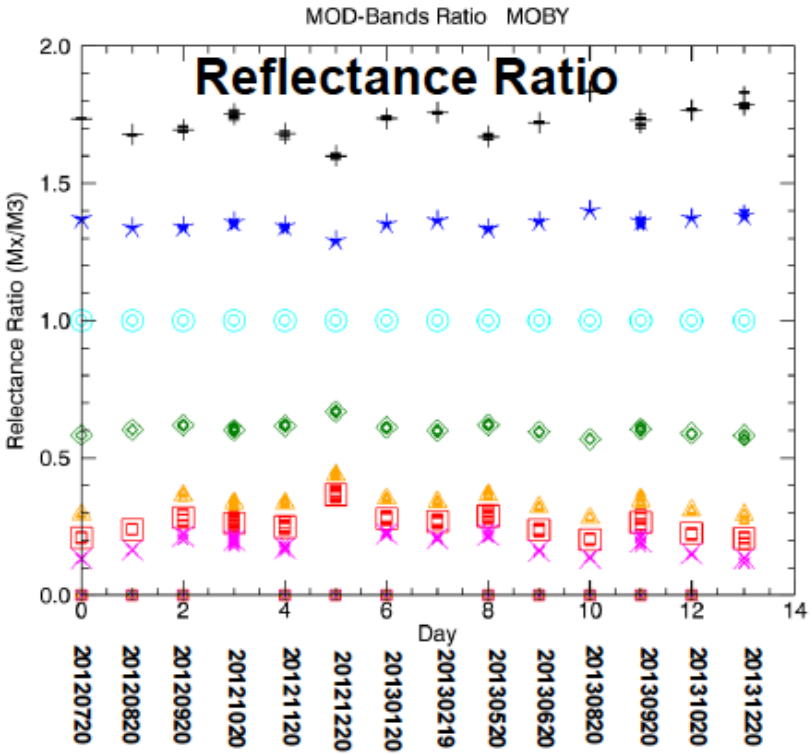


No Obvious TOA Reflectance Trend Change Over MOBY, 7/12–12/13





+ M01
* M02
M03
M04
M05
M06
x M07



- There are total 17 points for each day and each band (16 detectors (smaller symbols) plus the averaged one (larger symbol)).
- Screen criteria:
  1) Confidently clear
  2) No sun glint
  3) Sea water
  4) SZA < 75 deg
  5) Distance to MOBY site < 10 km

Summary

- Almost every parameter in the radiance and reflectance retrieval equations has been, or will be, improved in accuracy since launch
  - *An exception is Response vs Scan (RVS), which warrants further study*
- In our physics based RSB calibration these parameter accuracy improvements and the resulting SDR data product improvements necessarily benefit OCC and all other EDRs derived from the RSB
- The Scan-by-Scan F Correction and RSBAutoCal code changes apply the solar calibration immediately and smoothly after calibration data acquisition, taking into account trend information
  - *Result is significantly improved radiometric stability and accuracy relative to the soon-to-be-obsolete manual LUT update process*
- Preliminary radiometric stability studies over the Moby site show no obvious trend changes in reflectance for correlation with trend changes reported by the OCC team