Calibration of the EPIC visible and NIR channels

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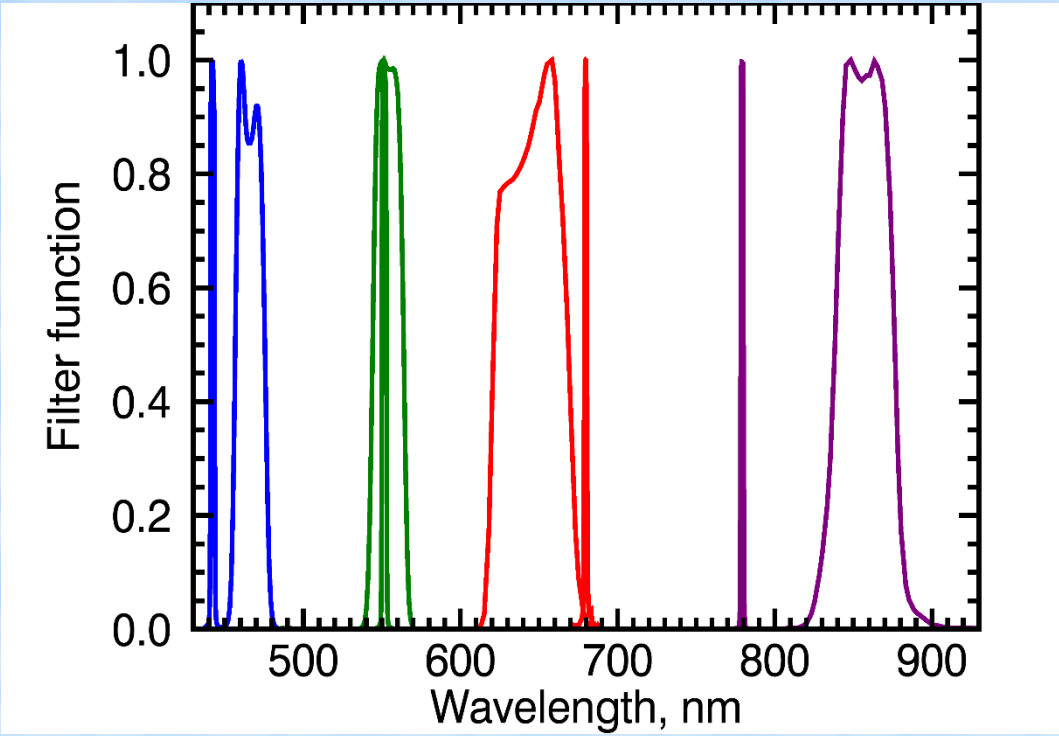
- MODIS Aqua and Terra L1B 1km reflectances matching four EPIC visible and NIR channels:

EPIC channel (Full Width in nm)	MODIS Band (Bandwidth)
443±1 nm (3±0.6)	3 (459-479nm)
551±1 nm (3±0.6)	4 (545-565nm)
680±0.2 nm (3±0.6)	1 (620-670nm)
779.5±0.3 nm (2±0.4)	2 (841-876nm)



- data between June 2015 and February 2016 are used

Pixel matching

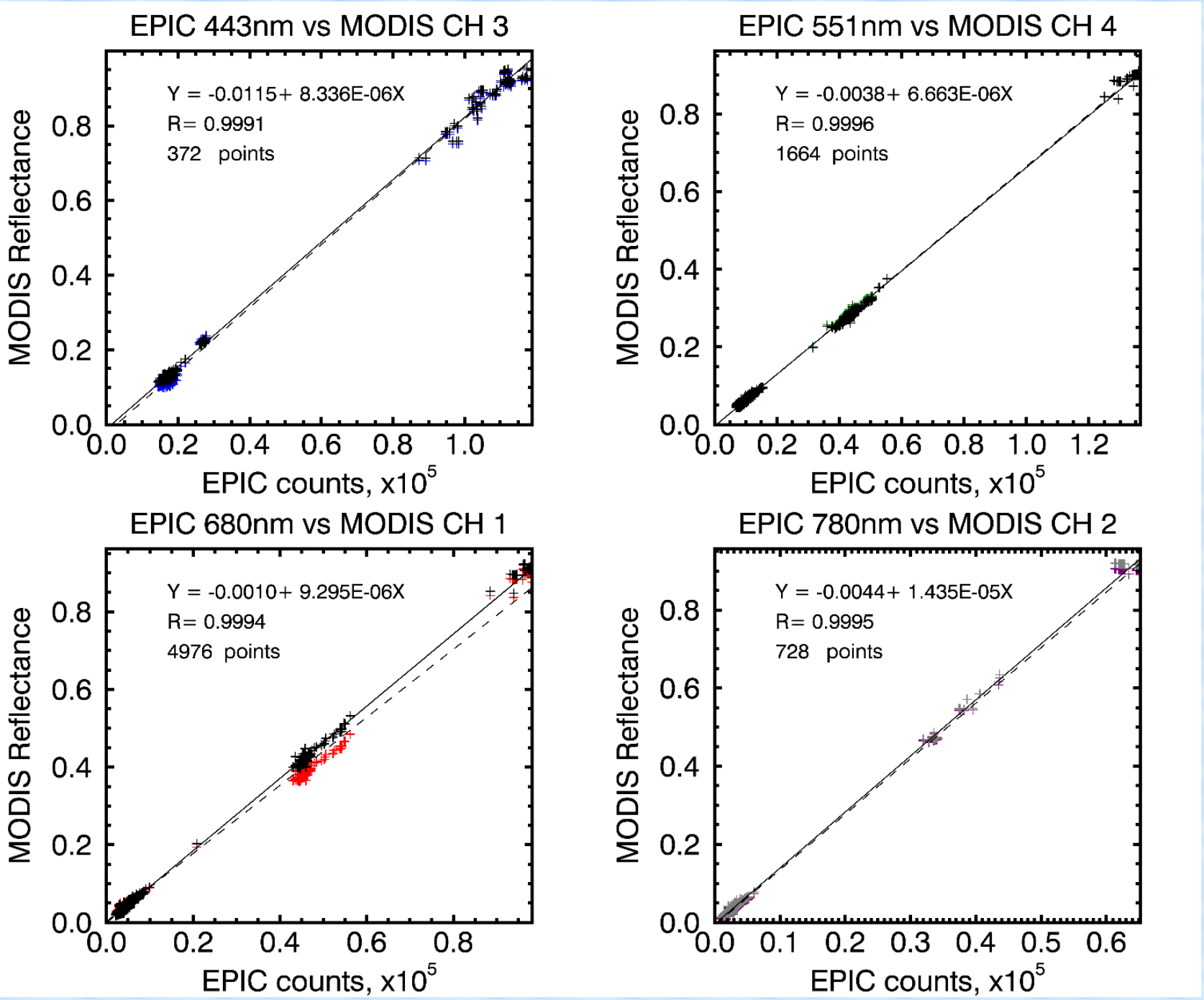
For each EPIC image favorable MODIS pixels are identified:

- scattering angle should match to within 0.5 deg
- temporarily collocated to within 10min
- spatially collocated to within 25 km radius
- Solar zenith angle (SZA) is less than 60 deg
- relative standard deviation is found for each EPIC 5x5 pixel neighborhood and for collocated MODIS pixels
- standard deviation is used to select the most homogeneous scenes.

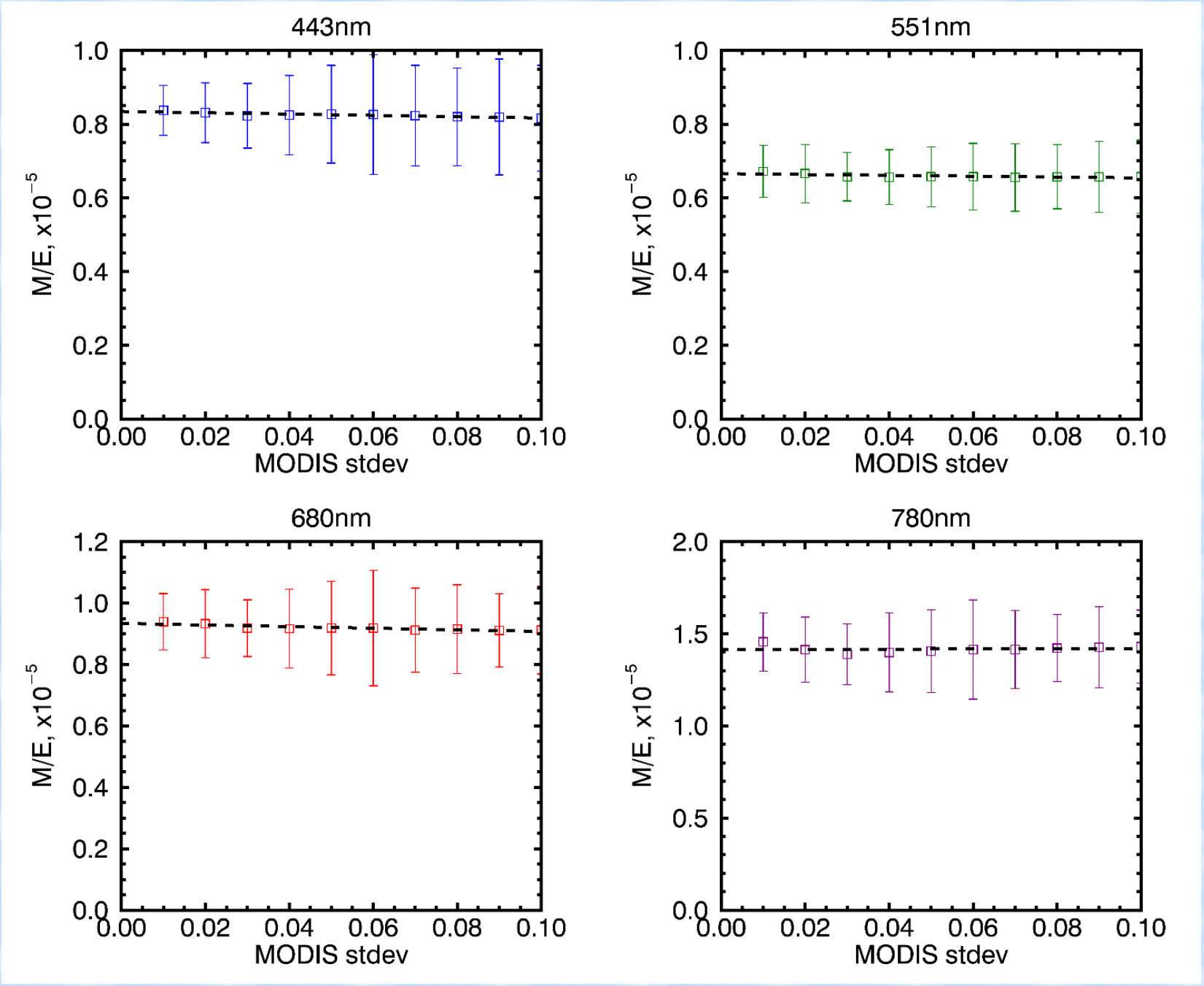
Two methods to determine calibration coefficients:

- linear regression between EPIC counts and MODIS reflectances
- Mean MODIS/EPIC ratio for MODIS relectances greater than 0.6

Regression analysis



MODIS/EPIC ratio estimates



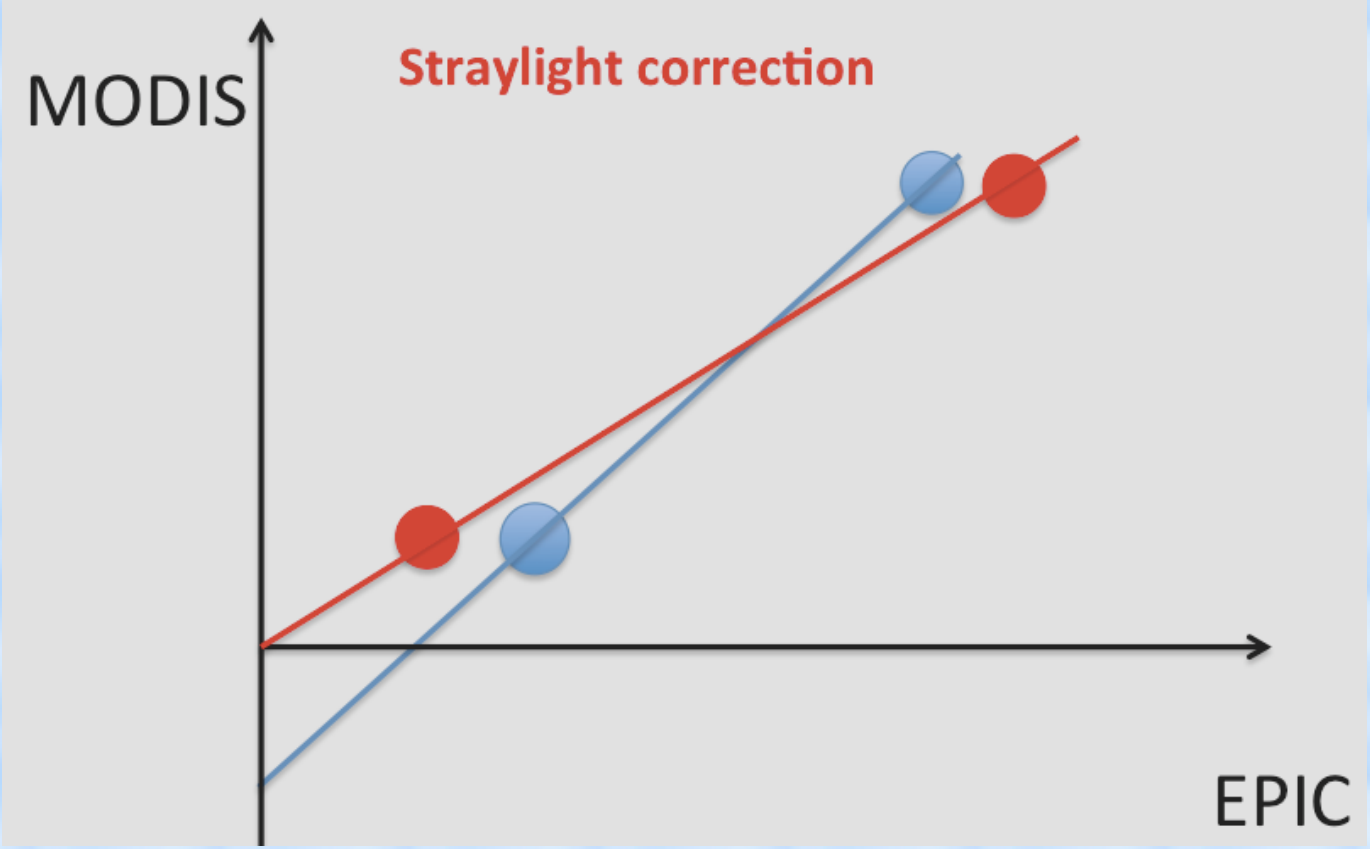
Calibration and EPIC Data Versions 1, 2, 3

- Improvements and corrections in each successive data version require new radiometric calibration
- Some modifications have a greater effect on calibration
  examples: straylight correction and geolocation
- Experience with the calibration of Versions 1 and 2 will inform expectations for Version 3

The effect of straylight correction

Compared to the initial release of the EPIC data the second release includes a number of improvements, including a straylight correction algorithm which is based on laboratory measurements and in-flight lunar observations).

The effect of straylight correction on the calibration coefficients is a reduction of both the slope and the intercept of the fit



The effect of Improved Geolocation

- The use of the most uniform scenes for calibration is expected to minimize the effect of errors in geolocation.
- Thus we do not expect large changes in Version 3 radiometric calibration
- Improved geolocation may reduced the scatter in matched points (evidence was seen in the Version 1 to Version 2 transition)
- This may allow for improved calibration accuracy

Spectral Correction

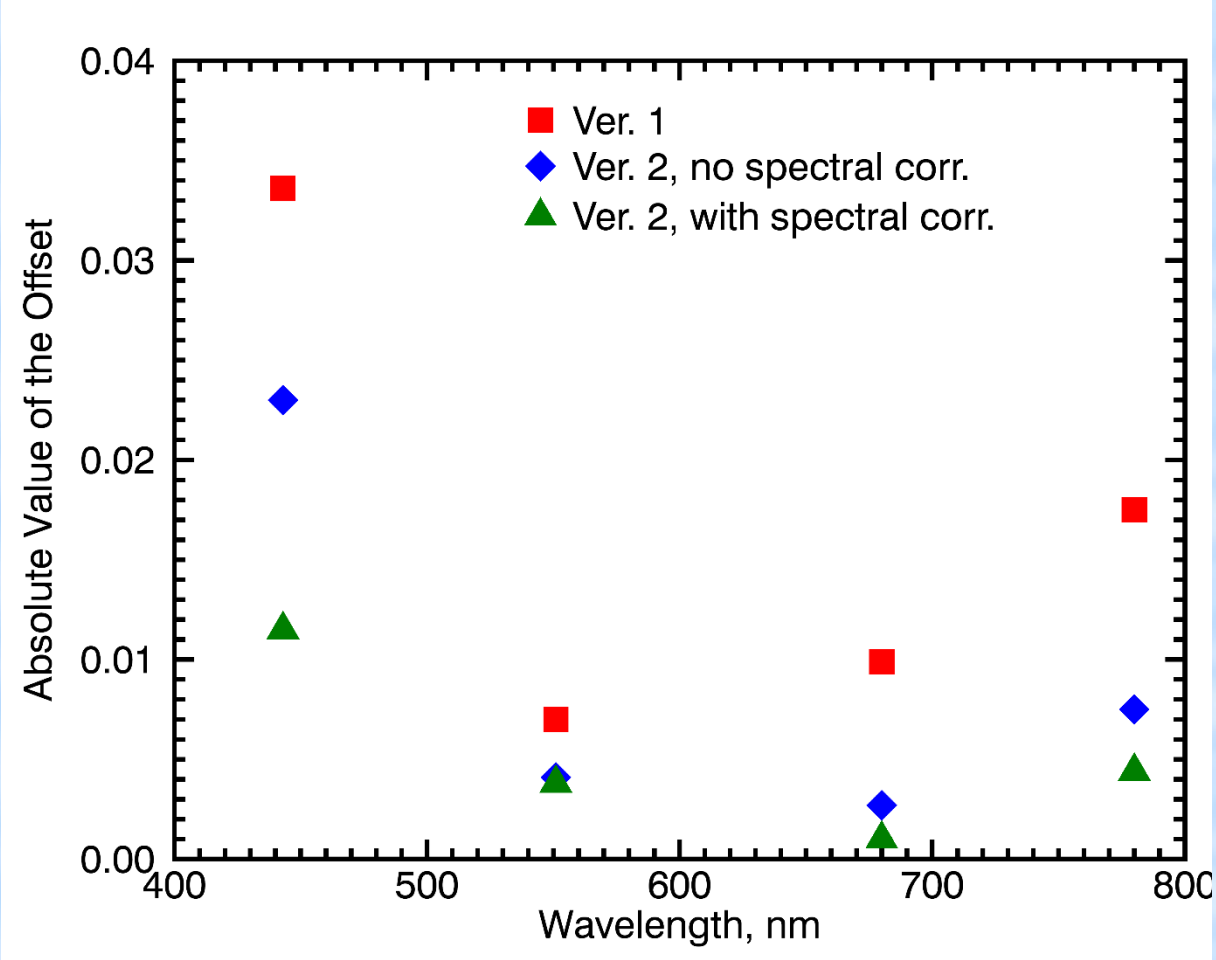
To compensate for the differences in the position and spectral width of the corresponding EPIC and MODIS channels In version 2 calibration we employed spectral band adjustment factors (SBAFs) which convert MODIS reflectance values to equivalent EPIC reflectance for various surface types.

These factors were obtained from https://cloudsgate2.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=SBAF

and employ the analysis of the SCHIAMACHY hyperspectral data for various surface targets to account for the differences in MODIS and EPIC spectral response functions (Scarino et al., 2016).

Ver 1 vs Ver 2 Calibration

Version 1		
EPIC Channel	Calibration coefficients	M/E / Reg. diff. (%)
443 nm	8.80E-6	2.79
551 nm	6.90E-6	1.98
680 nm	1.00E-5	1.01
780 nm	1.50E-5	0.41
	Version 2	
443 nm	8.34E-06	0.1
551 nm	6.66E-06	0.5
680 nm	9.30E-06	0.5
780 nm	1.435E-05	1.4



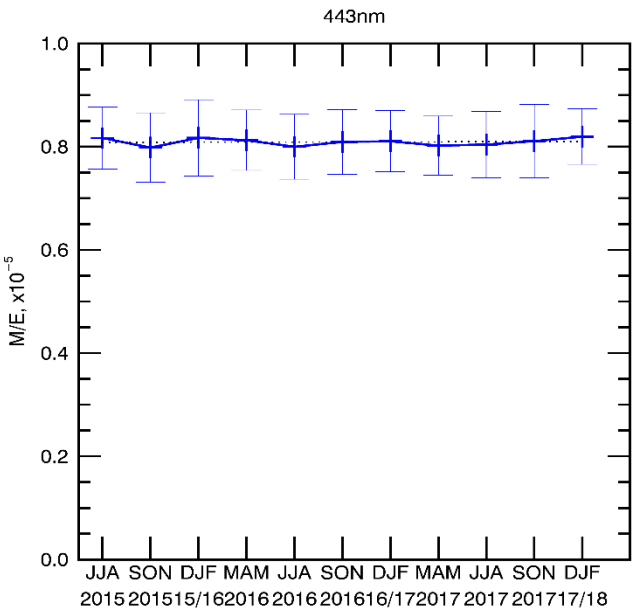
Using Multiple Satellite Datasets to improved calibration for Version 3

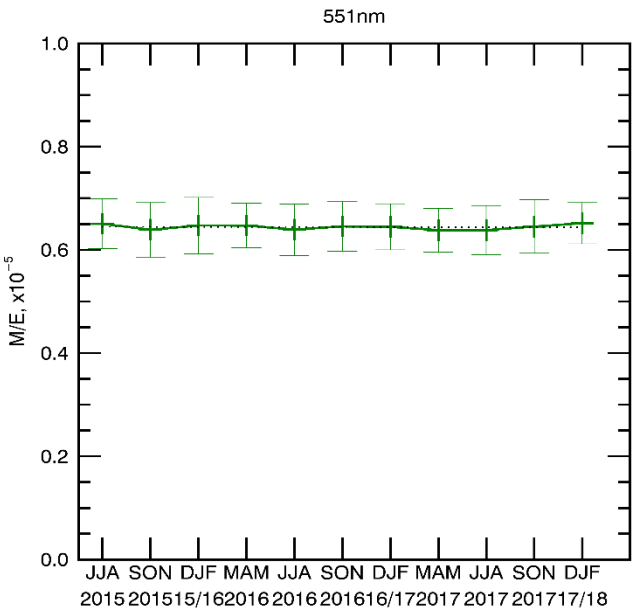
- A proposal is submitted to DSCOVR ROSES
- Identify LEO satellite observations with the same viewing geometry as EPIC measurements (e.g. MODIS, VIIRS, OCO-2, GOME-2, MISR, GOSAT) in visible and NIR spectral regions.
- Determine EPIC calibration coefficients using regressions or reflectance to counts ratios.
- Select the most homogeneous scenes that match EPIC fields of view by aggregating higher-resolution pixels.
- Perform radiative transfer and empirical viewing geometry and spectral corrections to help match LEO and EPIC scenes.
- Use lunar views (OCO-2, LRO) to independently calibrate EPIC channels, in particular O_2 absorbing channels.
- Perform an inter-comparison of calibration coefficients derived by various methods to determine the optimal set.
- Monitor stability and update the calibration as needed.

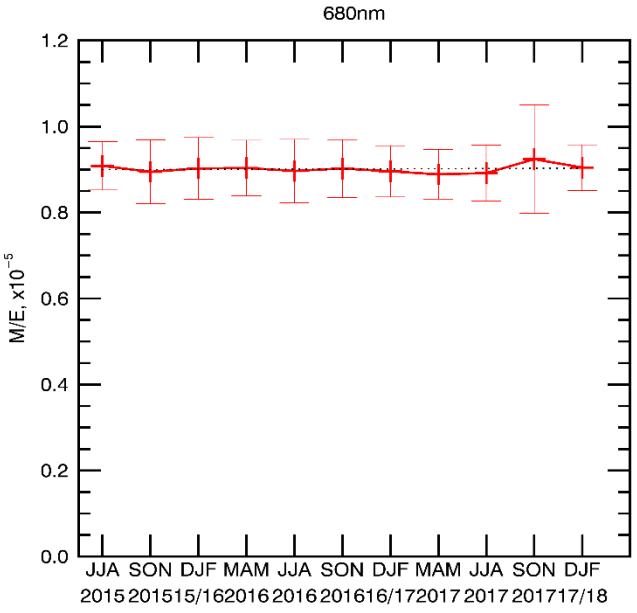
Using Multiple Satellite Datasets to improved calibration for Version 3

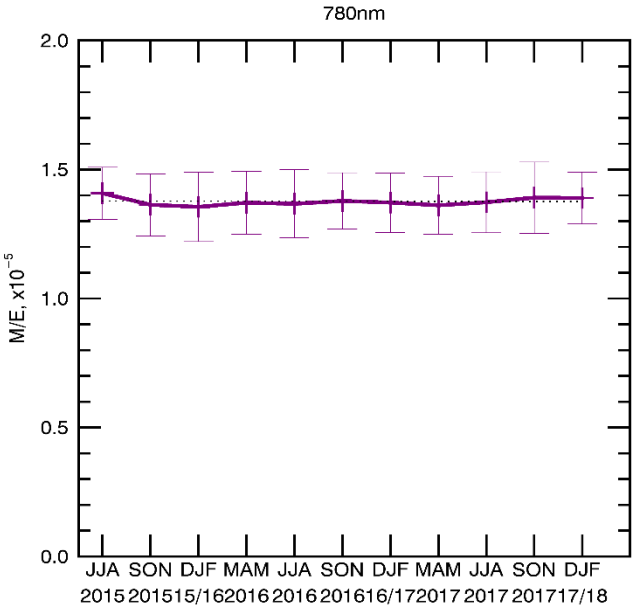
Satellite Instruments for EPIC Calibration Visible and NIR Channel matching						
Instrument	Central wavelength (nm)					
EPIC	443 ±1	551 ±1	680±.02	687.75±.02	764±.02	779.5±.03
MODIS (Aqua and Terra)	Band 3 469±10	Band 4 555±10	Band 1 645±25			Band 2 858.5±17
VIIRS	M2 445±18	M4 555±20	M5 672±20			M6 M7 746±15 865±39
MISR	446±42	558±29	672±22			867±40
OCO2 Earth and lunar views					Spectrally resolved O_2 A band	
GOME-2	Spectrally resolved 240 – 790					
GOSAT (FTS, CAI)			678		Spectrally resolved O_2 A band	870
LRO (LROC) (Lunar views)	415±36	566 ±20	689 ±39	689±39		

Seasonal dependence









MODIS - ROLO comparison

- agree to within approximately 10%
- ROLO coefficients being systematically lower.
- In absolute terms the 4 non-absorbing channels are in a better agreement compared to the two O2 absorbing channels (688nm and 764nm)
- Good agreement in relative spectral terms (about 3%)