



# **MODIS optical throughput degradation Impact on relative spectral response and on ocean color products**

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**IOCS**

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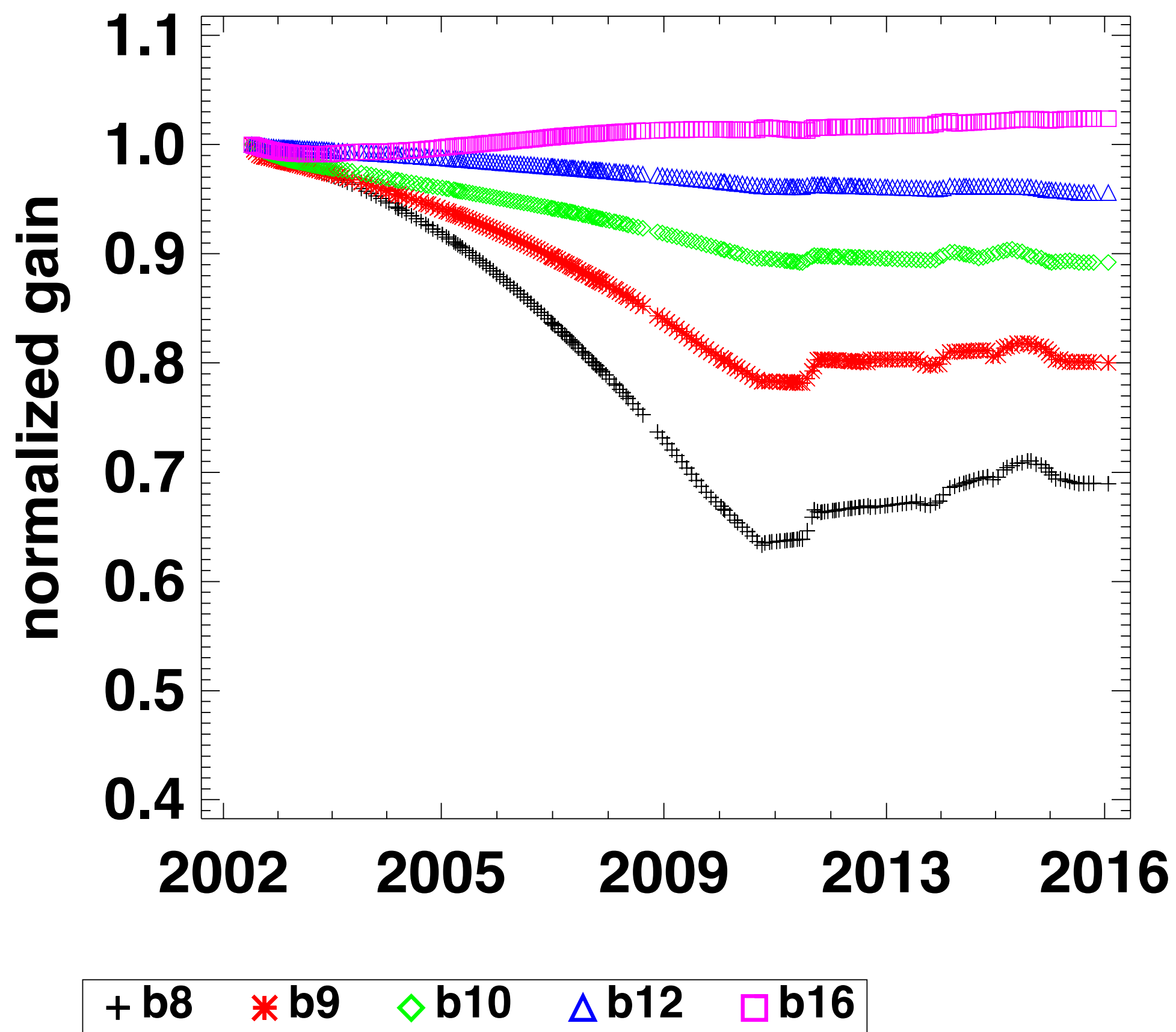
# Introduction

- Relative Spectral Response (RSR) is a key component in radiometric calibration and ocean color products retrieval
- On-orbit, if the instrument's optical throughput change varies by wavelength, RSR will change (modulate)
- Estimate MODIS Aqua Optical throughput change vs. wavelength
- Estimate RSR modulation over time.
  - Impact on radiometric calibration
  - Impact on ocean color products

**optical degradation → modulated RSRs → radiometric calibration  
→ ocean color products**



# MODIS Aqua Optical Degradation



Aqua normalized gain (1/m1) vs. time

$$g = T * r * Eg$$

$g$ : system gain

$T$ : optical throughput

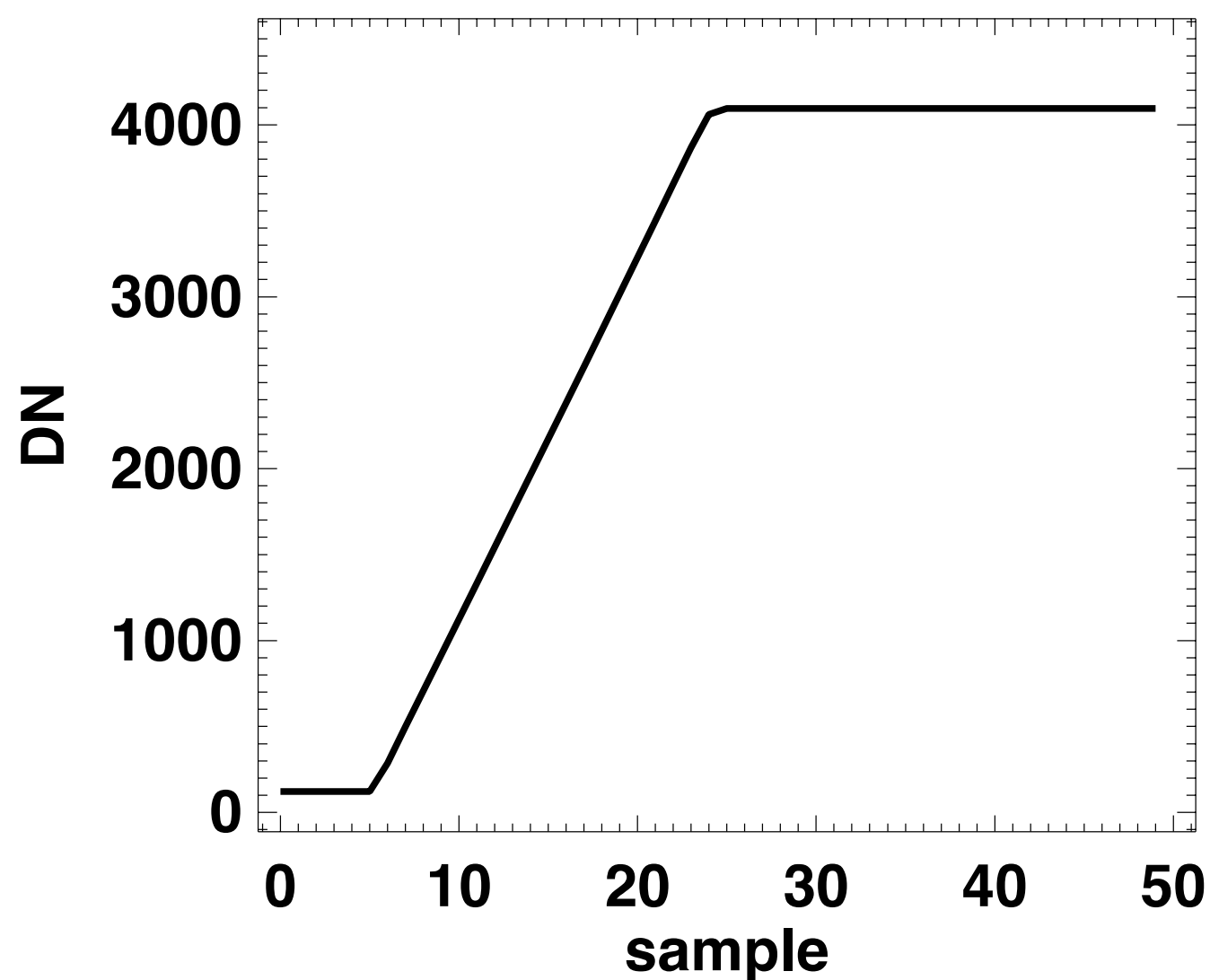
$r$ : detector's responsivity

$Eg$ : electronic gain

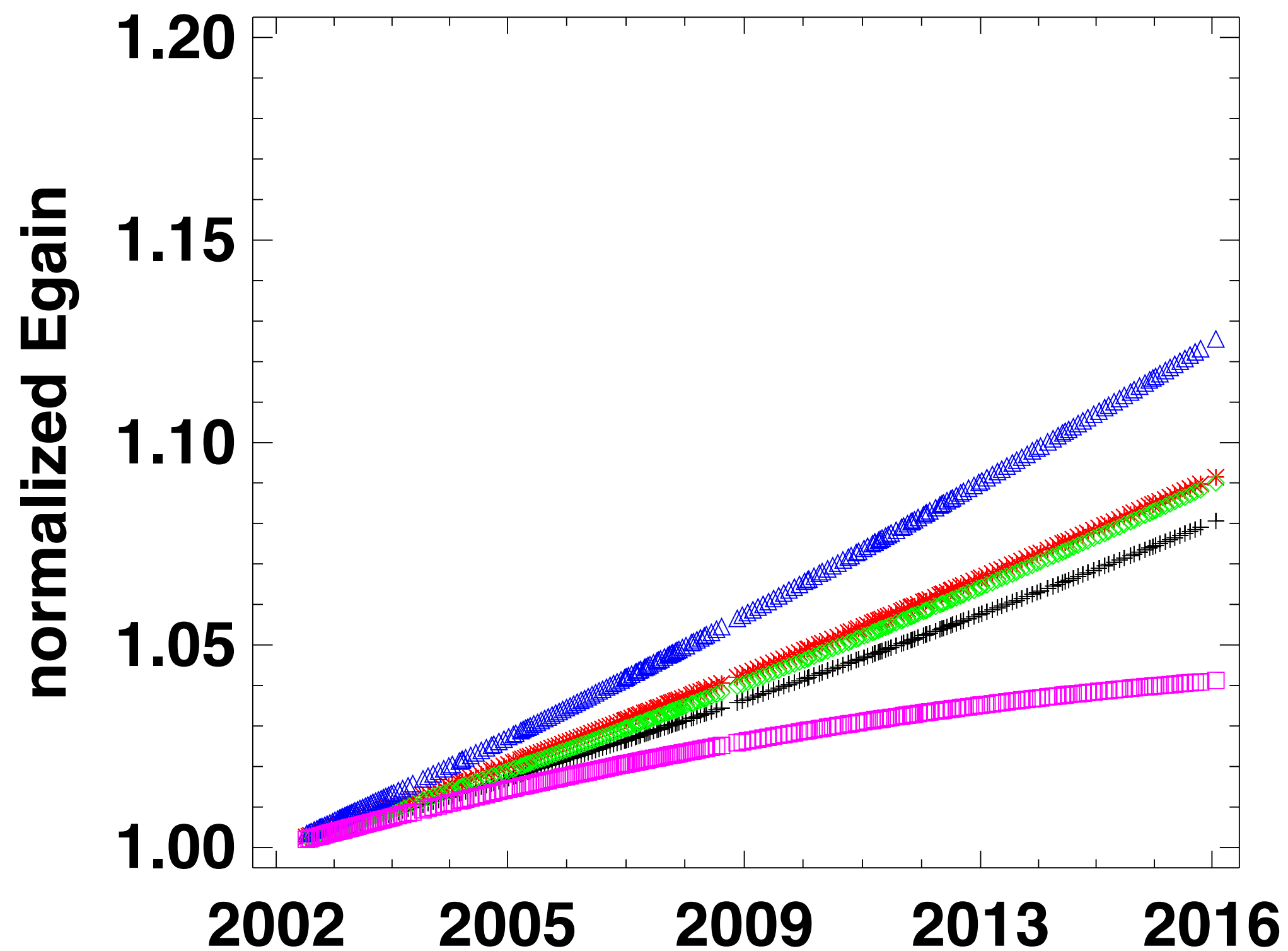
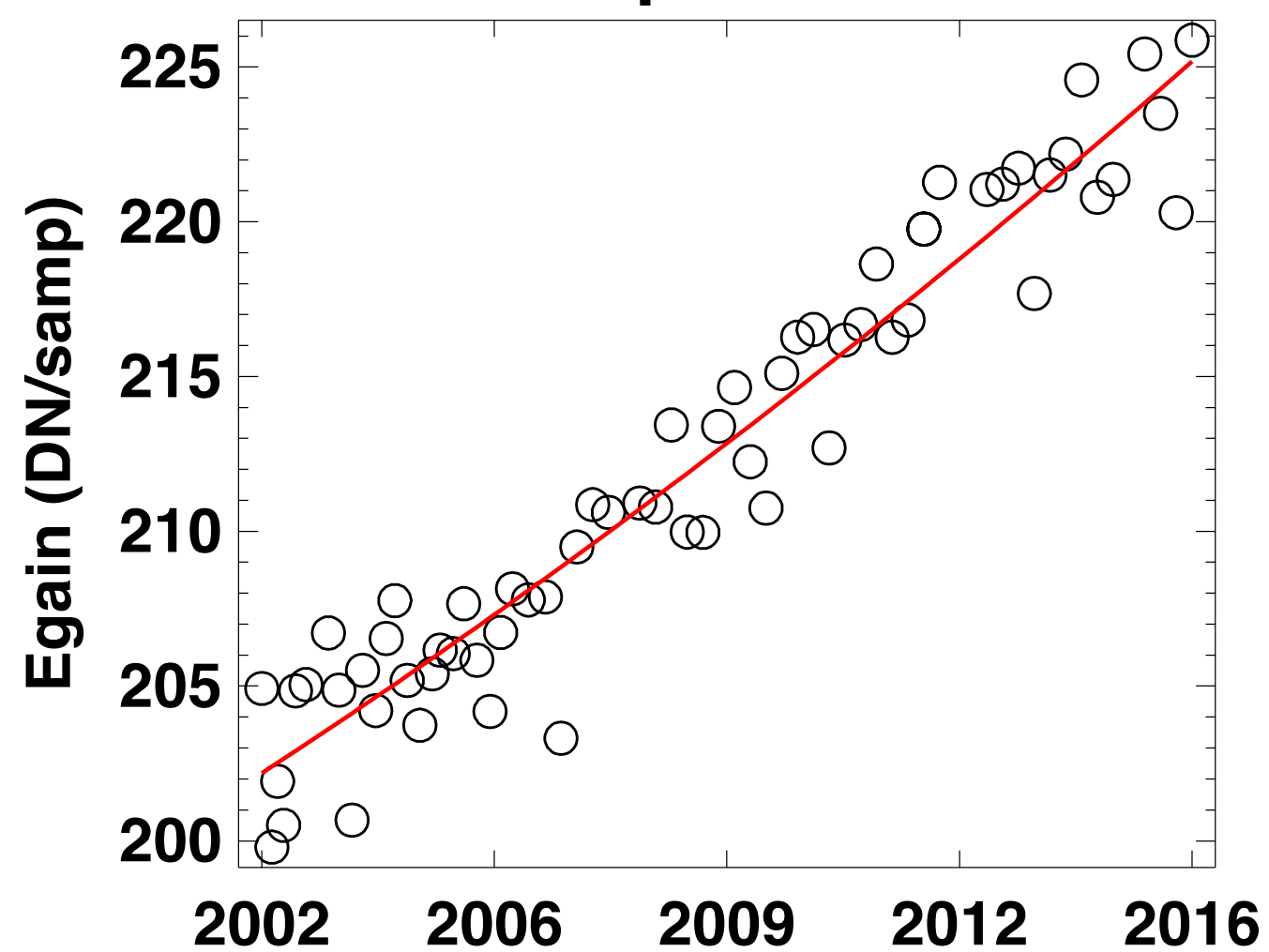
	Wavelength (nm)
Band 8	412
Band 9	443
Band 10	488
Band 11	531
Band 12	551
Band 13	667
Band 14	678
Band 15	748
Band 16	869



# Electronic Gain



Aqua b12

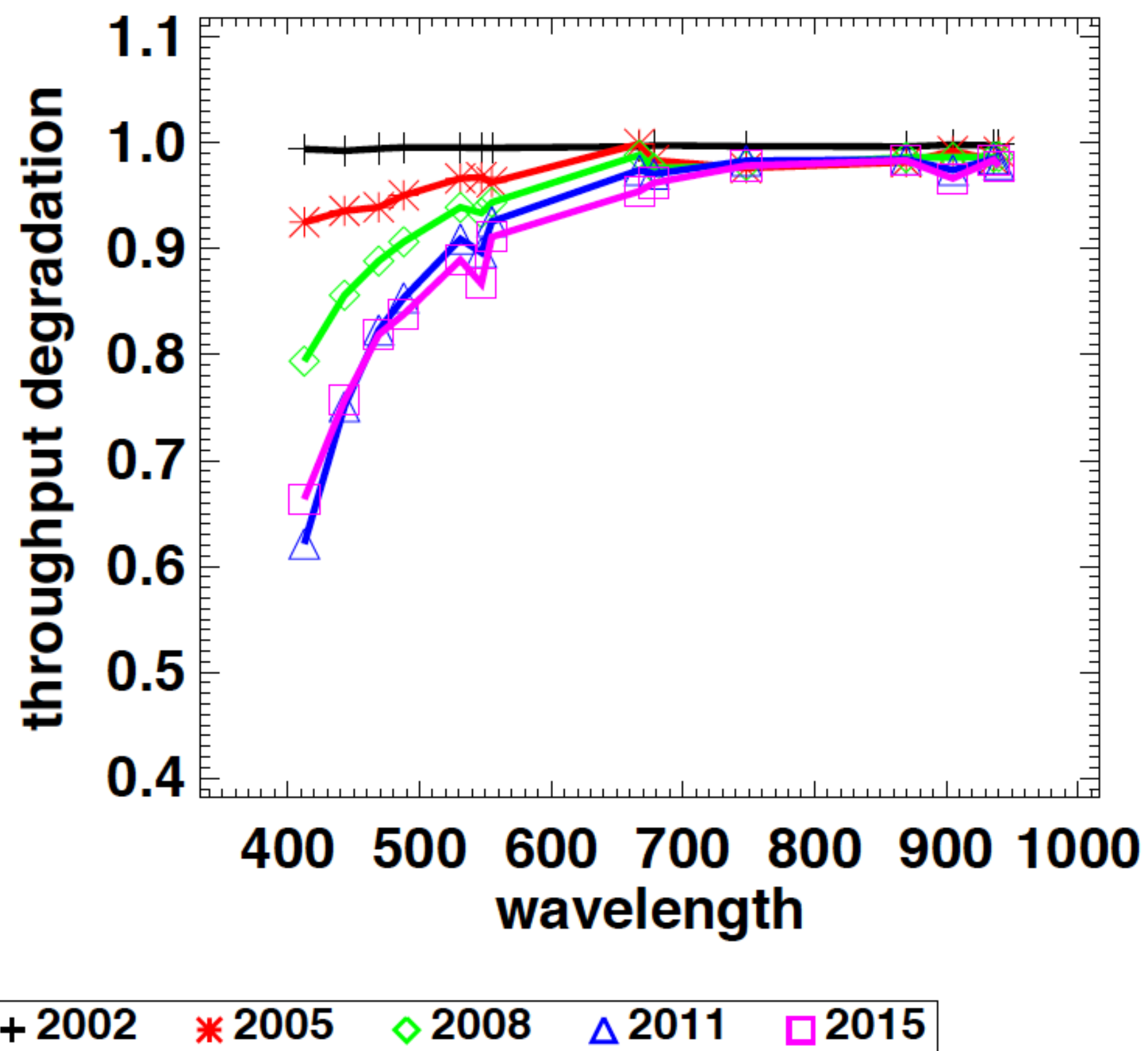
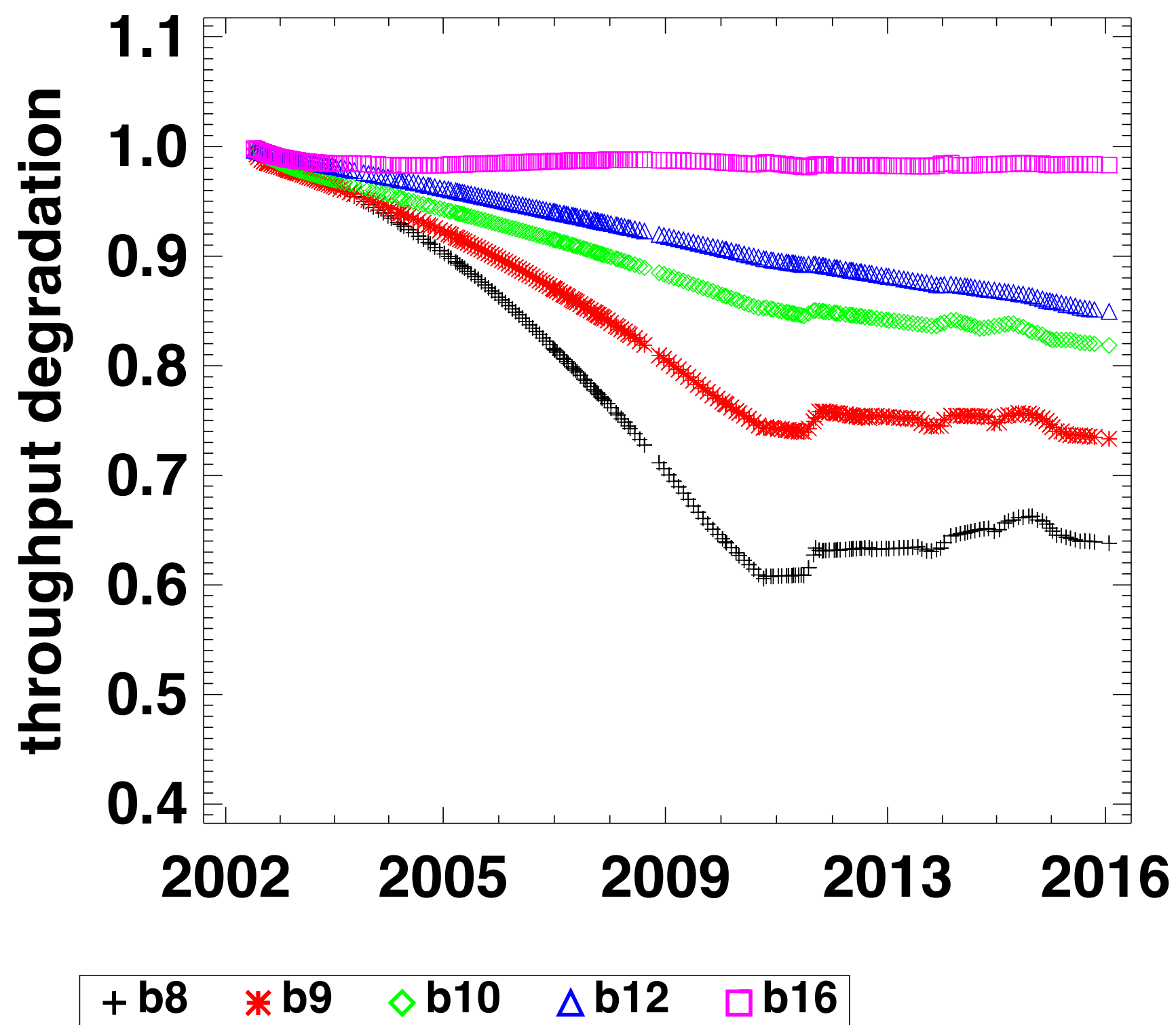


+ b8 \* b9 ◇ b10 △ b12 □ b16

- Aqua electronic calibration was performed periodically
- Electronic gain increased over time



# Aqua Optical Degradation



Assume detector responsivity ( $r$ ) change among bands/detectors are the same, optical degradation ( $D$ ) can be computed by system gaine ( $g$ ) and electronic gain ( $Eg$ )

$$D(\lambda, t) = \frac{\overline{g(\lambda, t)}}{Eg(\lambda, t)}$$

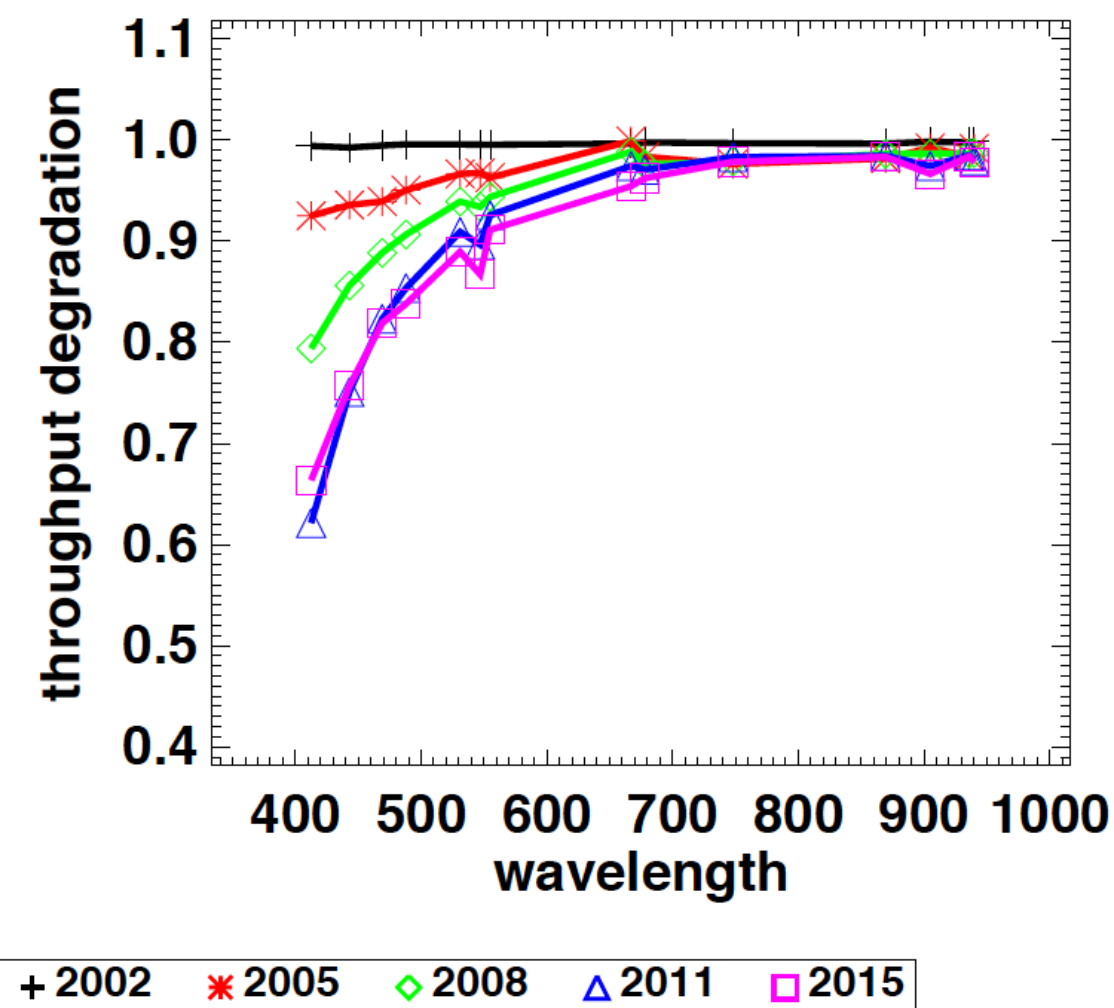




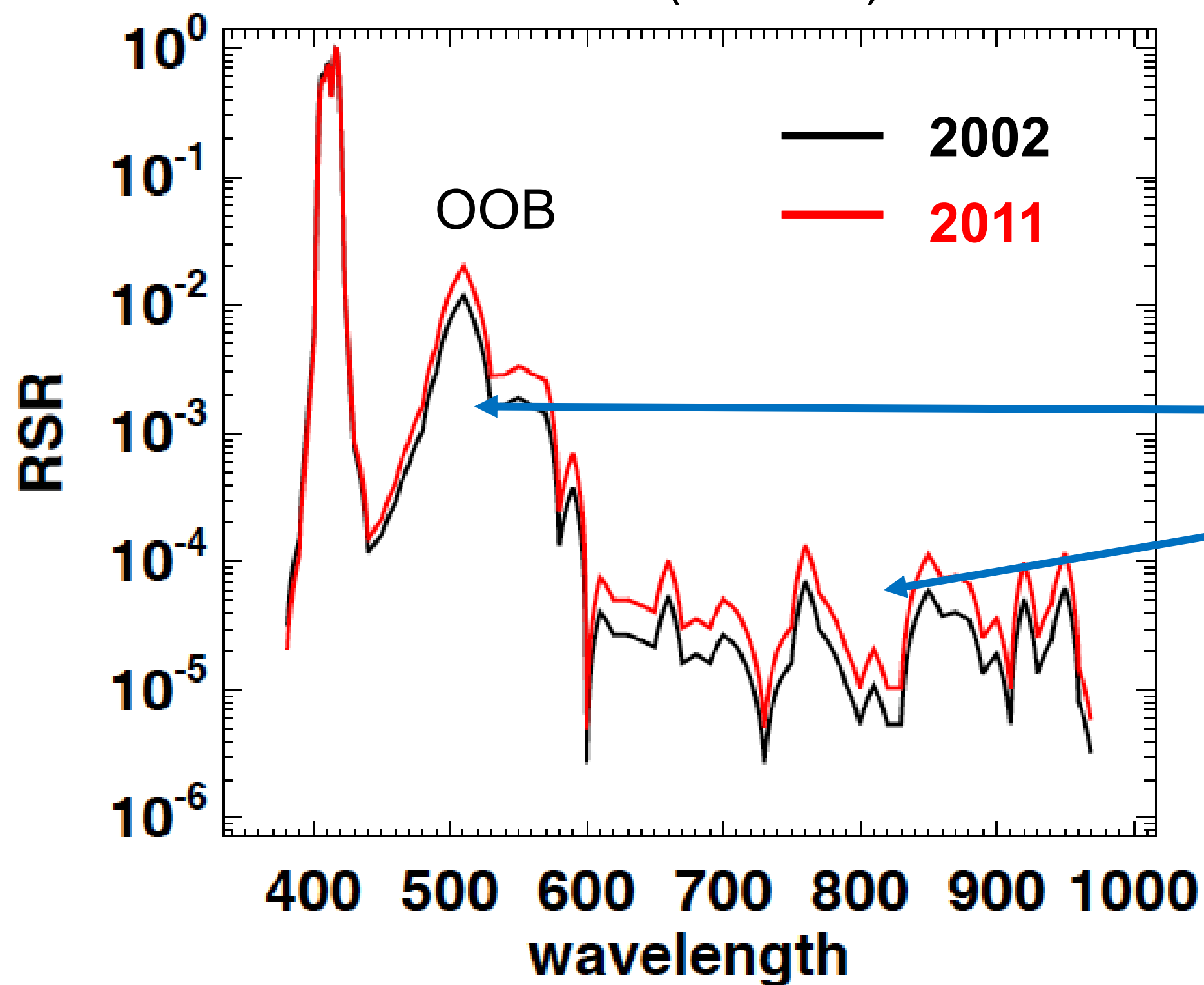
# Modulated RSRs

$$RSR_{\text{modulated}}(\lambda, t) = \frac{RSR_{\text{original}}(\lambda)D(\lambda, t)}{\max(RSR_{\text{original}}(\lambda)D(\lambda, t))}$$

$D(\lambda, t)$  = degradation at wavelength  $\lambda$  at time  $t$



Band 8 (412 nm)

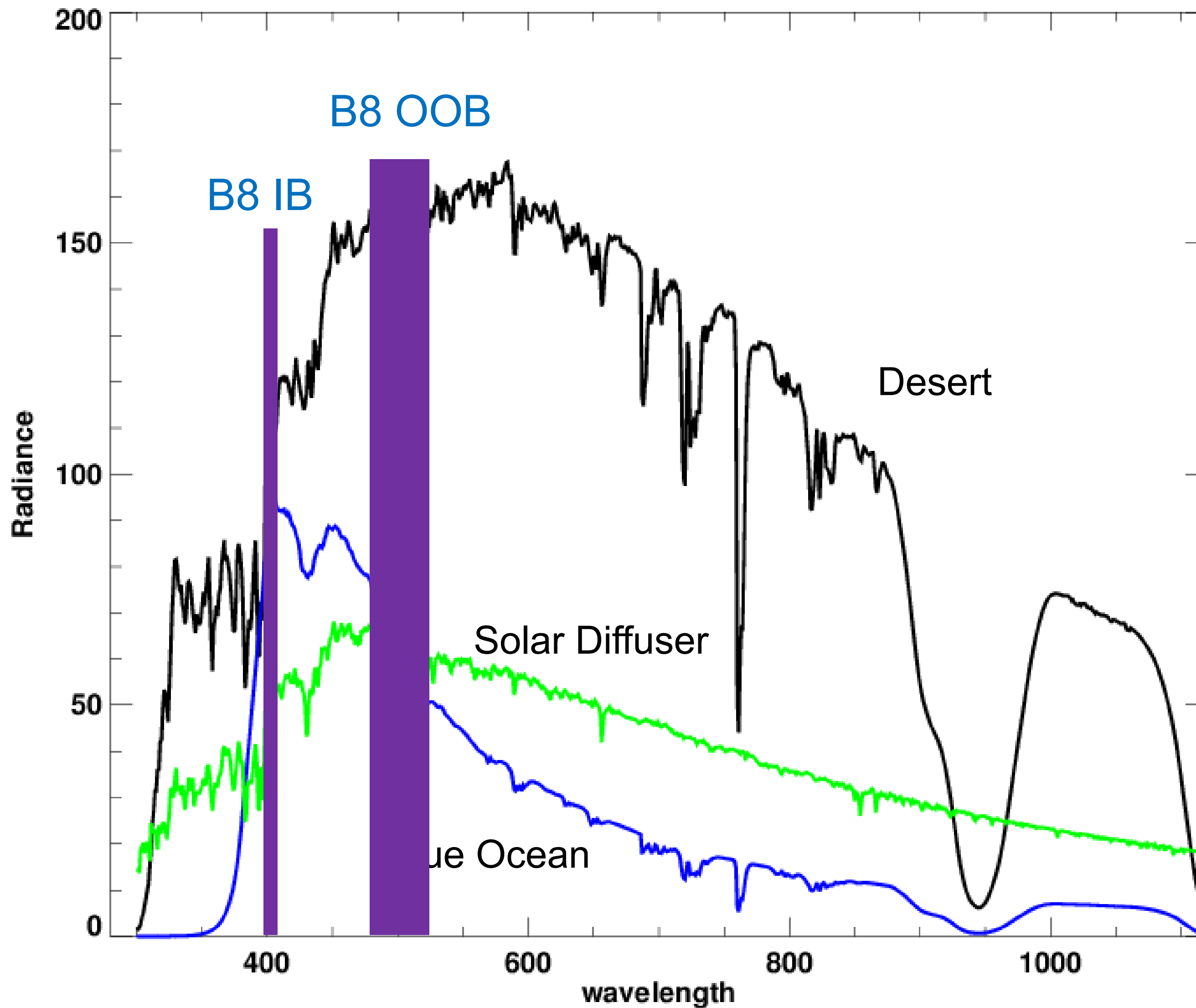


Impact from RSR change

- In-band region: mostly cancel out.
- large at high OOB region.
- small on low RSR region



# Target Spectra

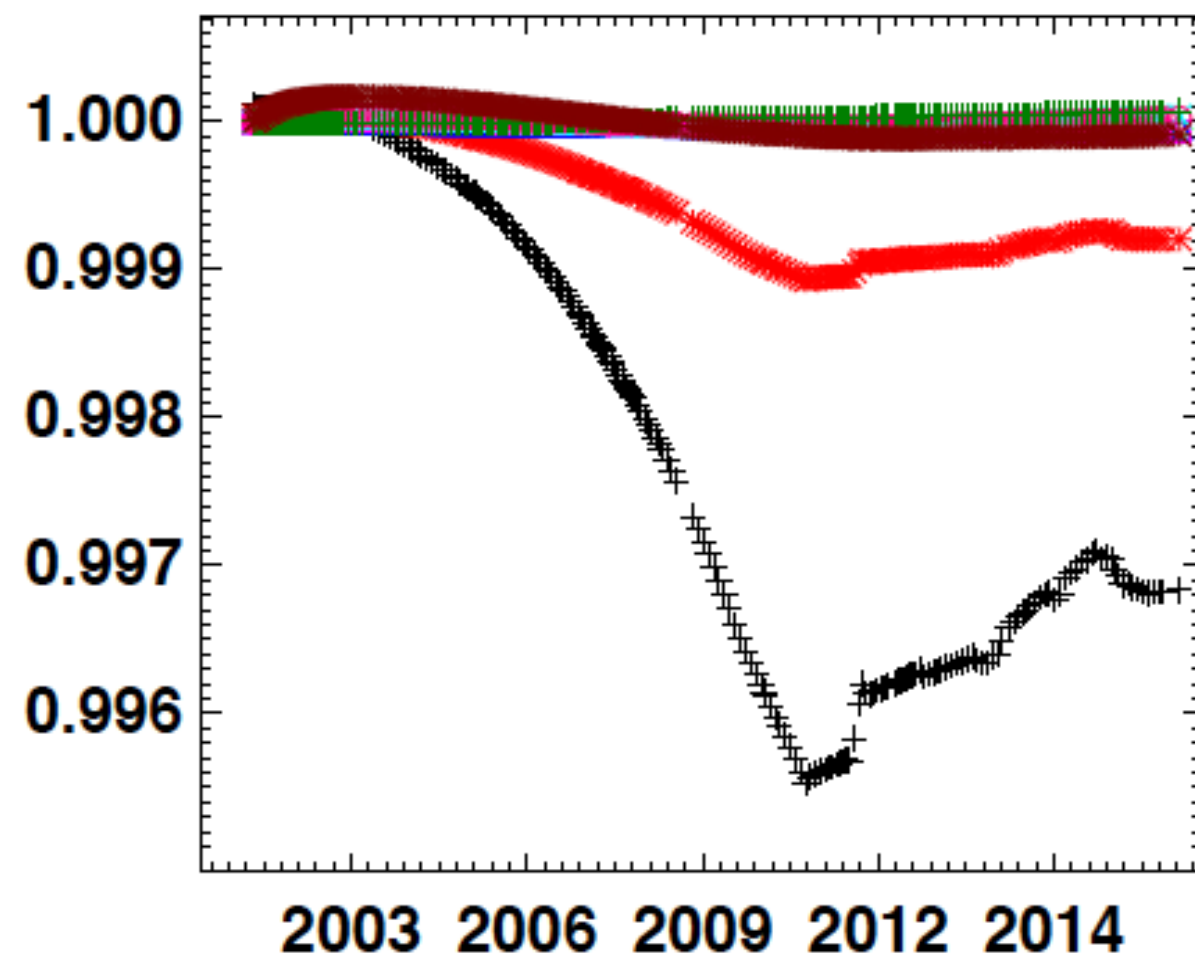


- Calibration target: desert / SD
- Scene: blue ocean
- RSR modulation impact due to spectrum differences between calibration targets and scene.
- band 8 example

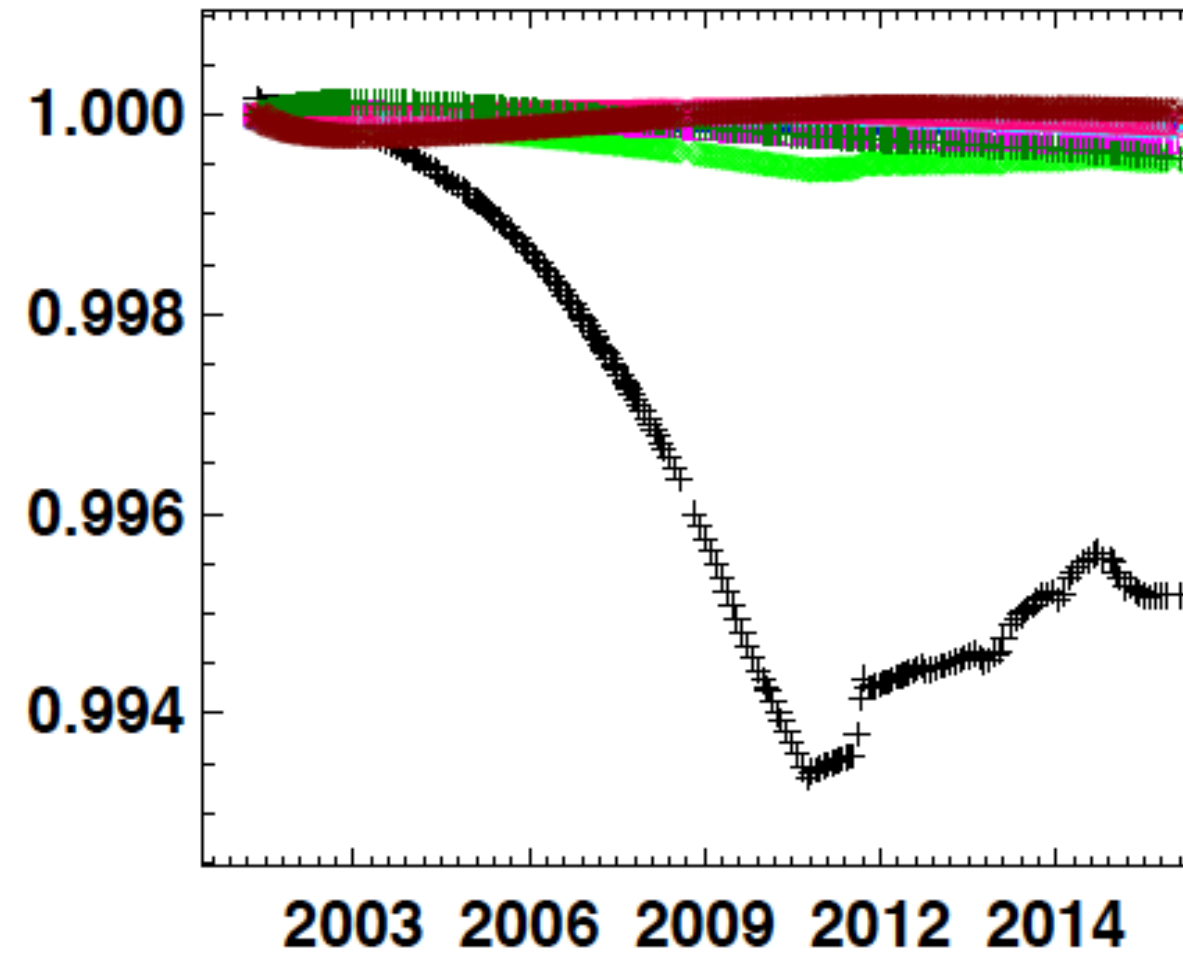


# Modulated RSR Effects

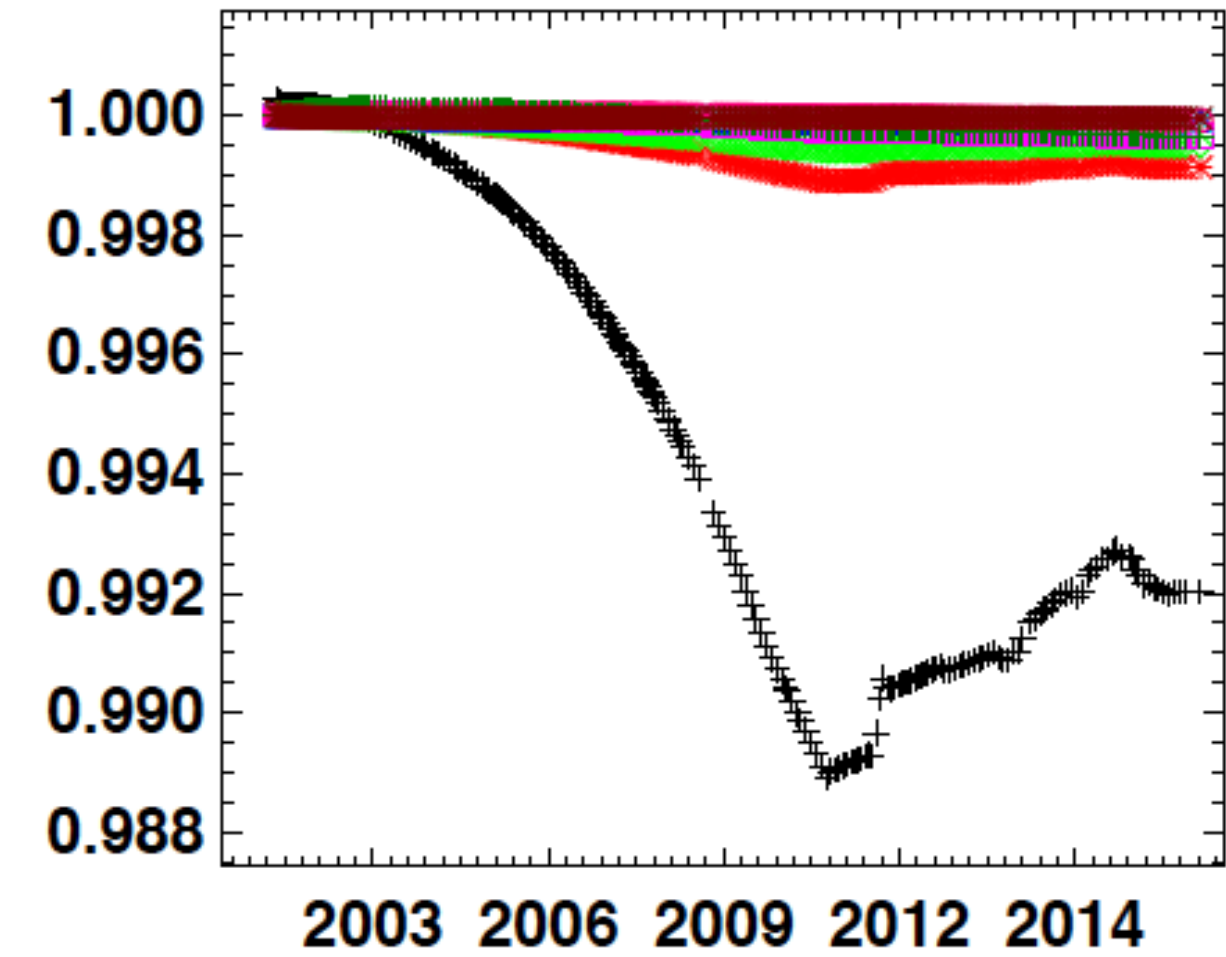
(a) *Gain bias*



(b) *scene bias*



(c) *Total retrieved bias*



+ b8 \* b9 ◇ b10 △ b11 □ b12 × b13L ○ b14L + b15 \* b16

Temporal trend for RSR modulation impact on ocean color bands

(a) System gain determination

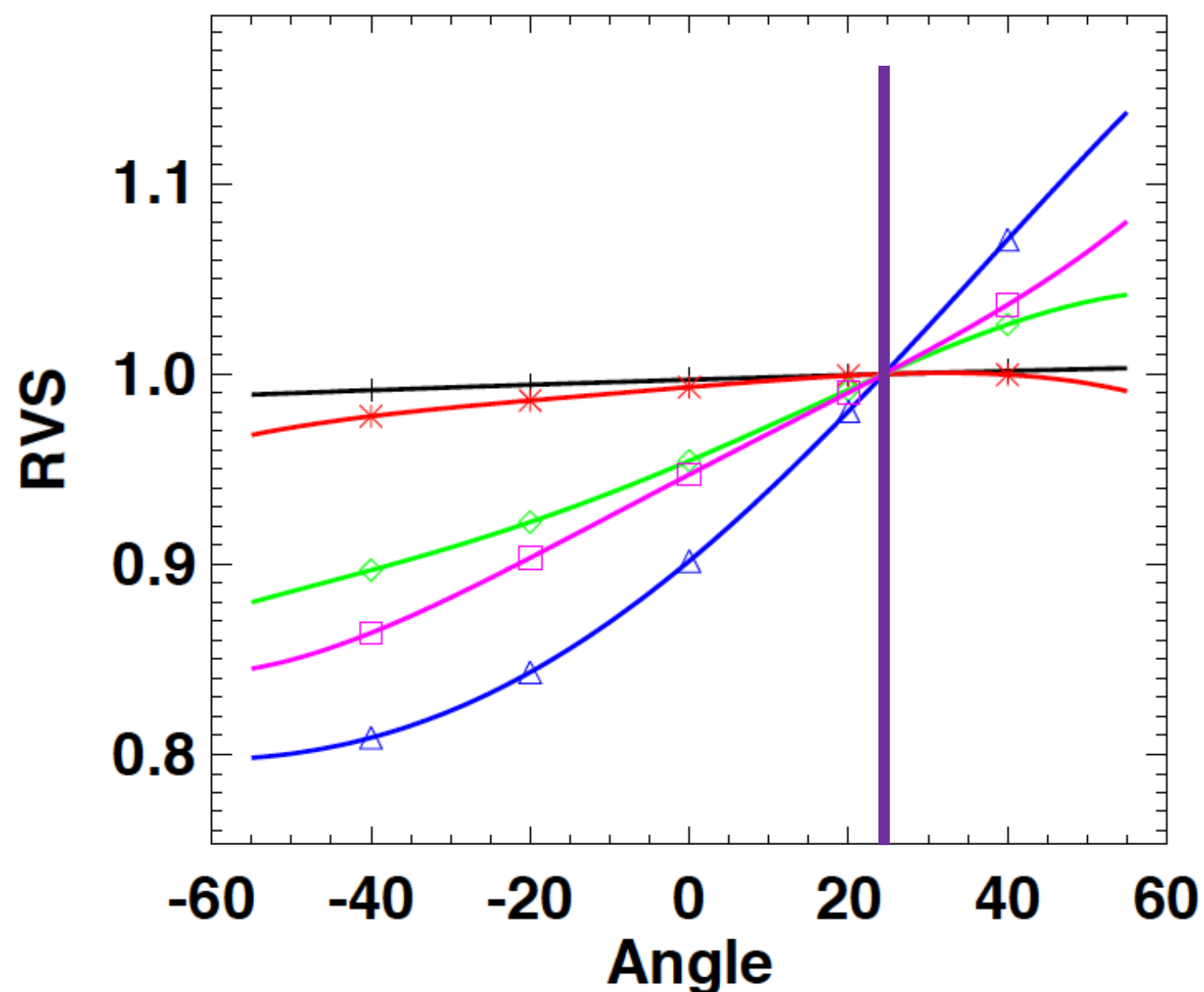
(b) ocean scene radiance

(c) total bias ( $B_{ret}$ ) on ocean color products



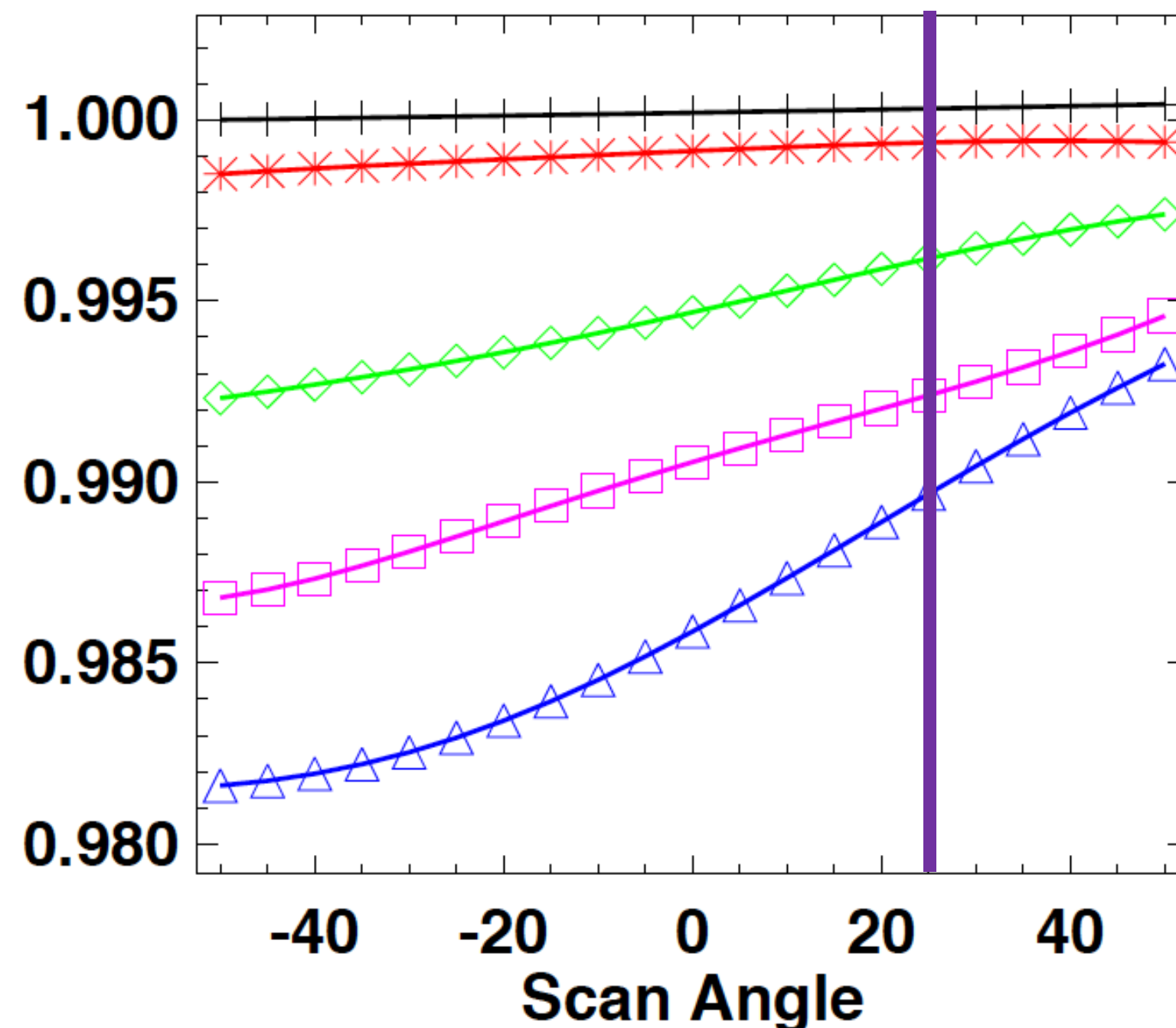


# Scan Angle dependency

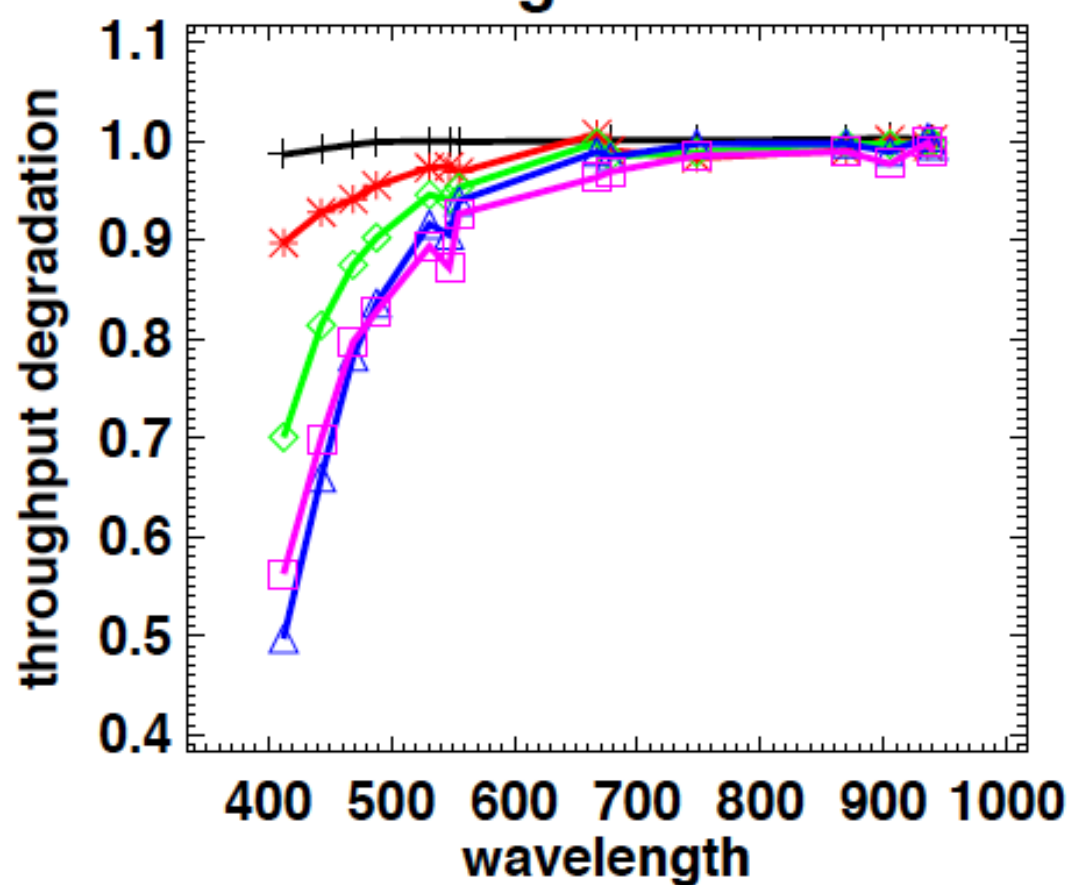


+ 2002 \* 2005 ◇ 2008 △ 2011 □ 2015

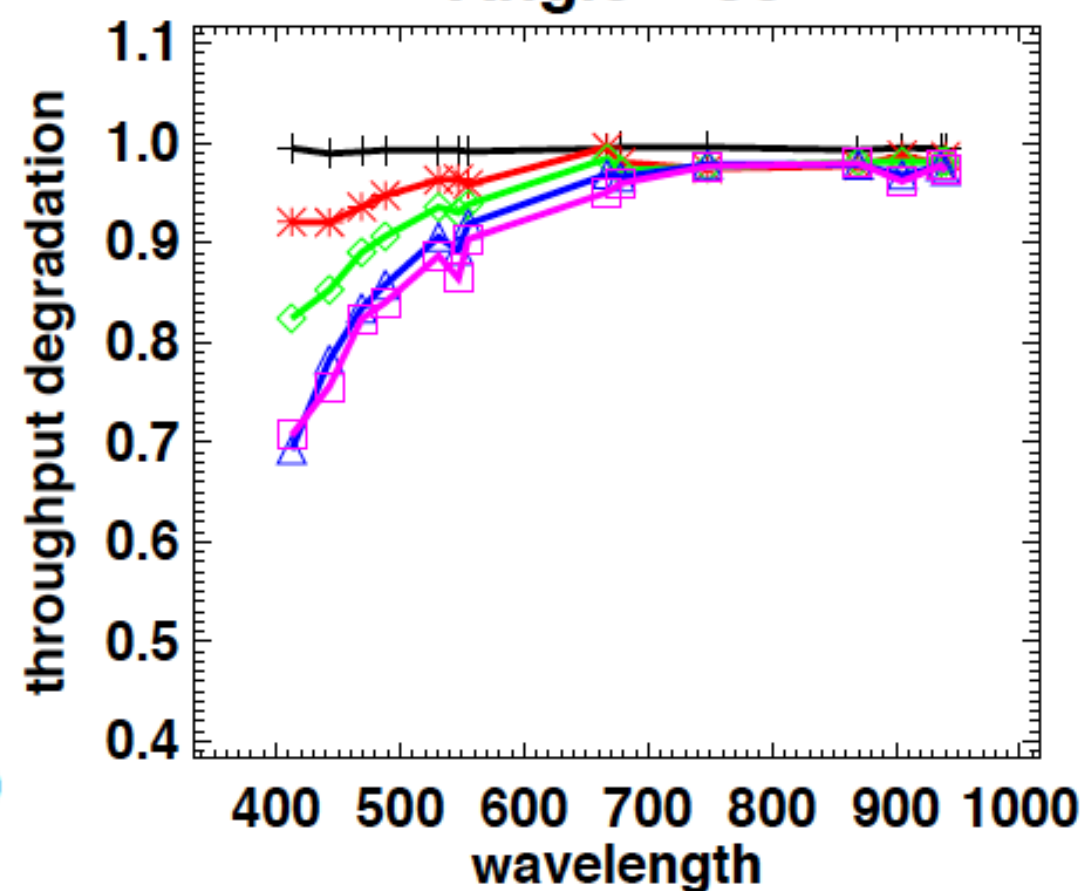
Calibration Bias ( $B_{ret}$ )



Angle = -50



Angle = 50



Band 8 RVS

- Large RVS change over time
- throughput change vs. angle
- RSR modulation / calibration impact varies by scan angle



# Summary

- The estimated MODIS Aqua optical throughput showed a degrading trend that is wavelength dependent
- The wavelength dependent degradation will reshape the relative spectral response (RSR) function.
- The RSR is also scan angle dependent due to change in response versus scan angle.
- Aqua RSR modulation impact on ocean color products is most significant on band 8 (up to 1.8% at typical ocean scene).
- The RSR modulation impact for the rest of the ocean bands are at  $\sim < 0.1\%$ .
- Large out-of-band response in RSR is the main reason for wavelength dependent, optical throughput degradation to have meaningful impact on RSR and ocean color products



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# Backup Slides

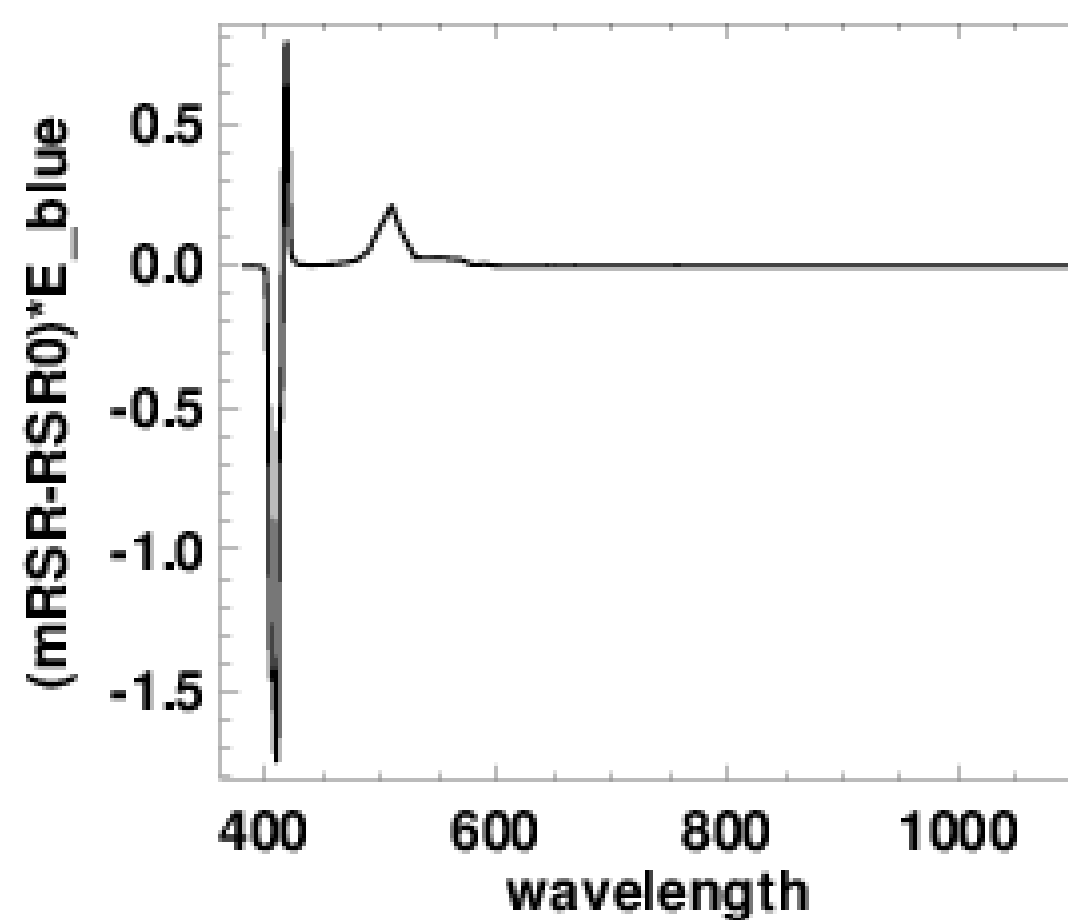
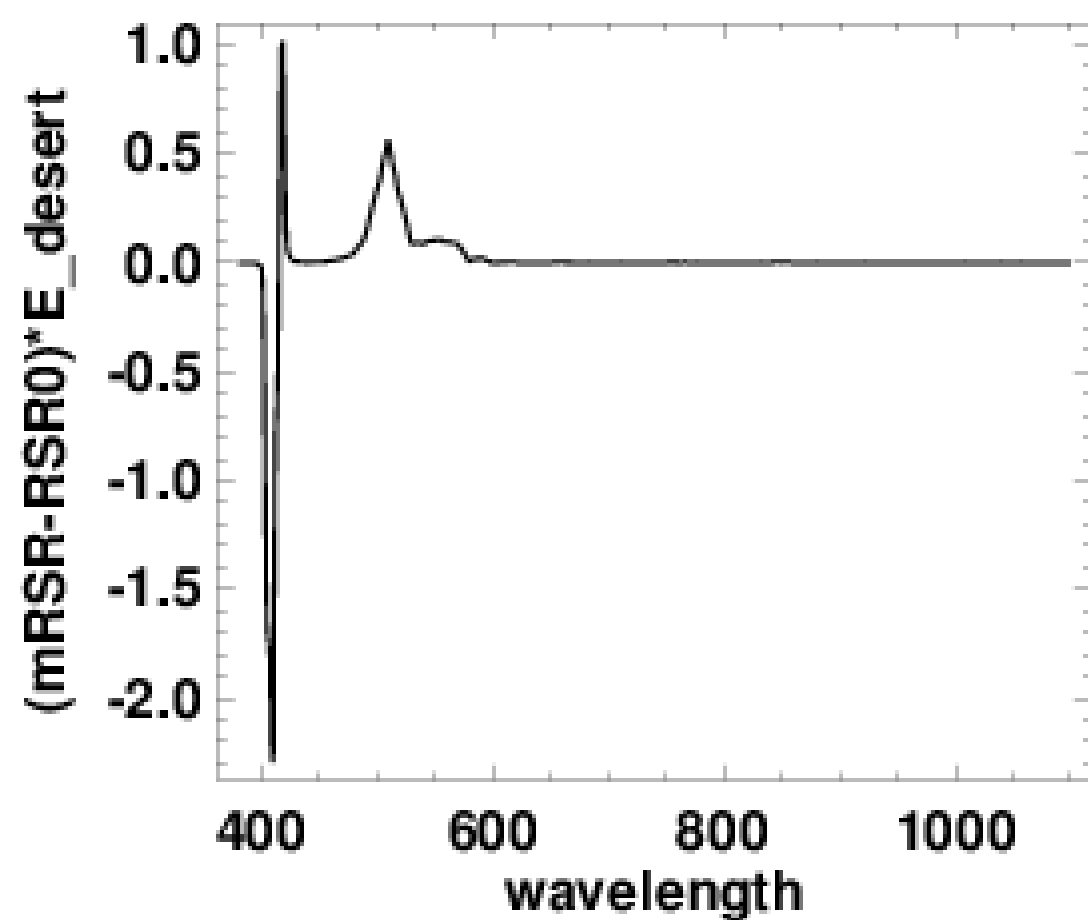
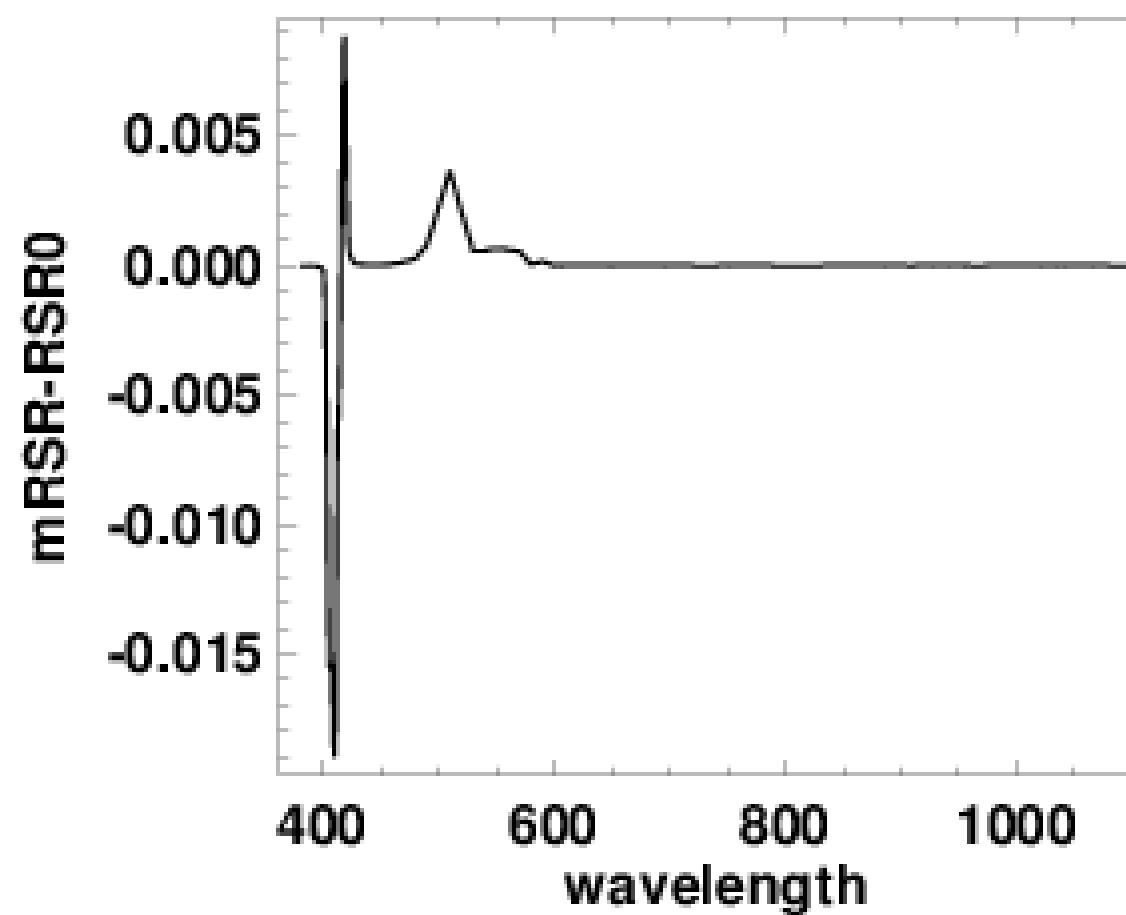
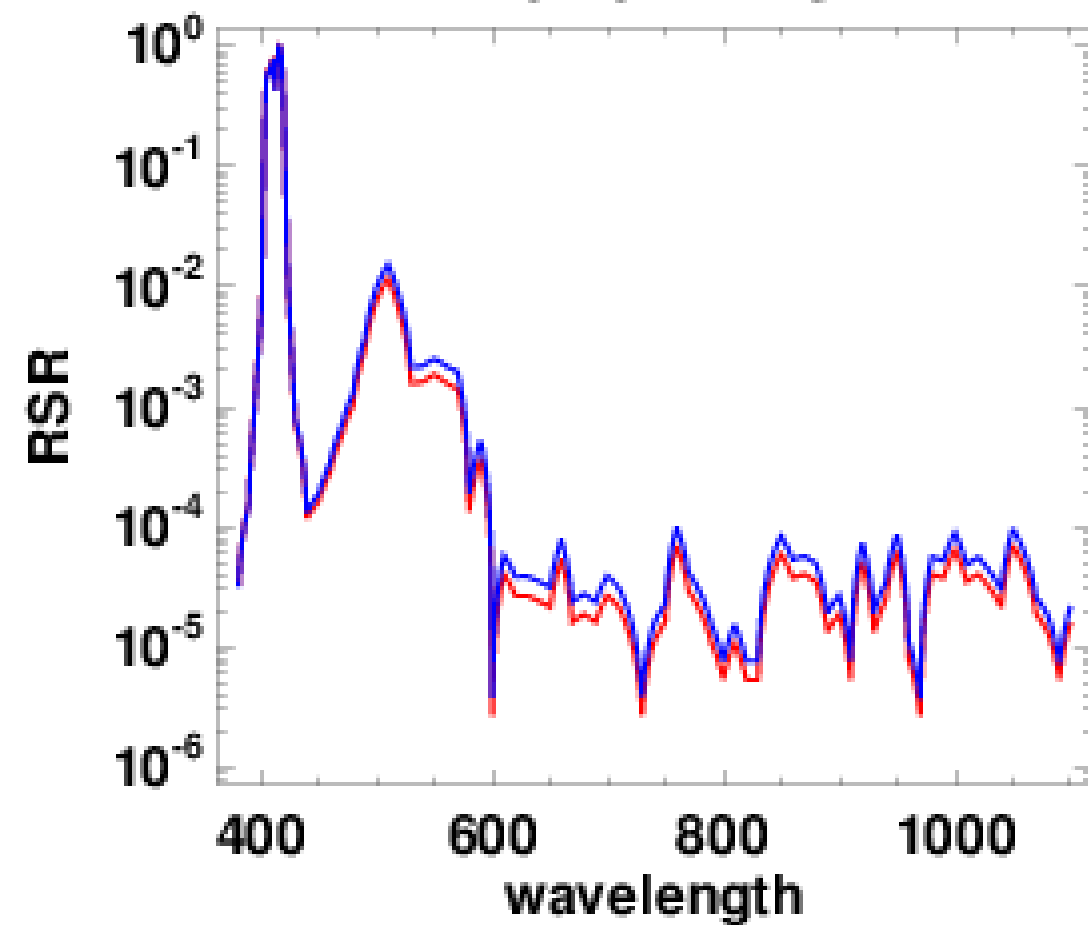


	Center Wavelength (nm)	Band Width (nm)
Band 8	412	15
Band 9	443	10
Band 10	488	10
Band 11	531	10
Band 12	551	10
Band 13	667	10
Band 14	678	10
Band 15	748	10
Band 16	869	10

Table 1: MODIS ocean band spectral specification.



Band 8



+ 2002 \* 2015