Composite Solar Spectral Irradiance Data Set V2 - Status

Matthew DeLand[1], Sergey Marchenko[1], Linton Floyd[2], Ramaswamy Tiruchirapalli[1]

[1]SSAI/NASA GSFC

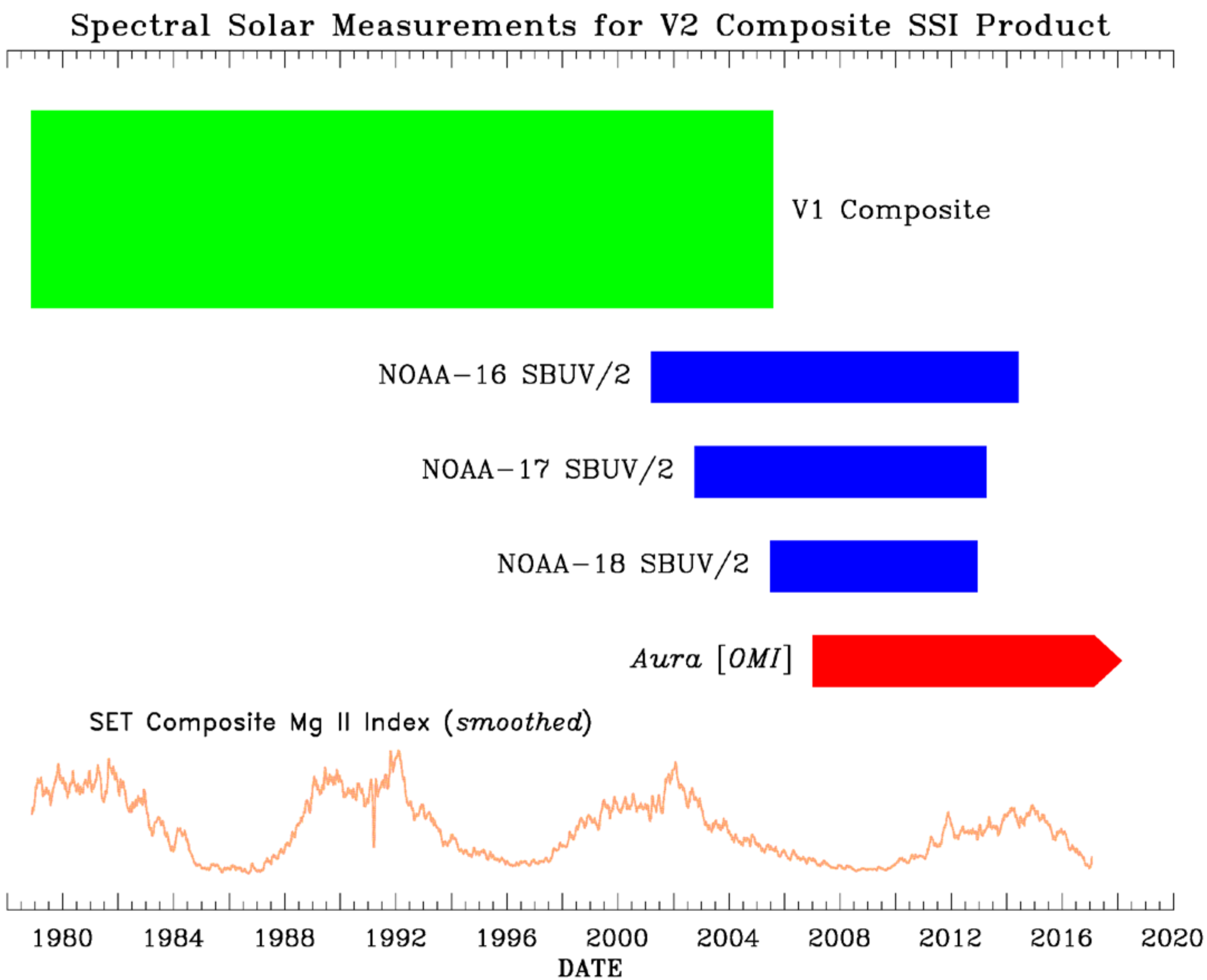
[2]SSRC

2nd SIST Science Meeting, Lanham, MD 11-12 May 2017

Introduction

- Project goal is to improve and extend composite solar spectral irradiance (SSI) data set created by *DeLand and Cebula* [2008] (V1).
- Multiple new irradiance data sets are needed to extend this product from July 2005 to the present.
- This presentation will review progress on improvements to the existing V1 data set, and describe the development of new SBUV/2 data sets for the V2 product.
- The following presentation by Sergey Marchenko will focus on the Aura OMI irradiance data set.

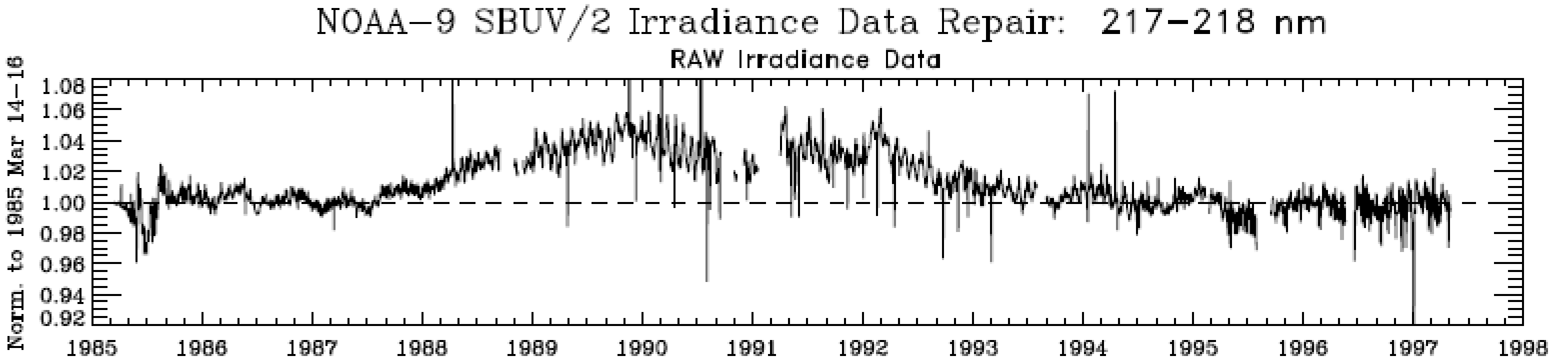
Timeline of New SSI Data



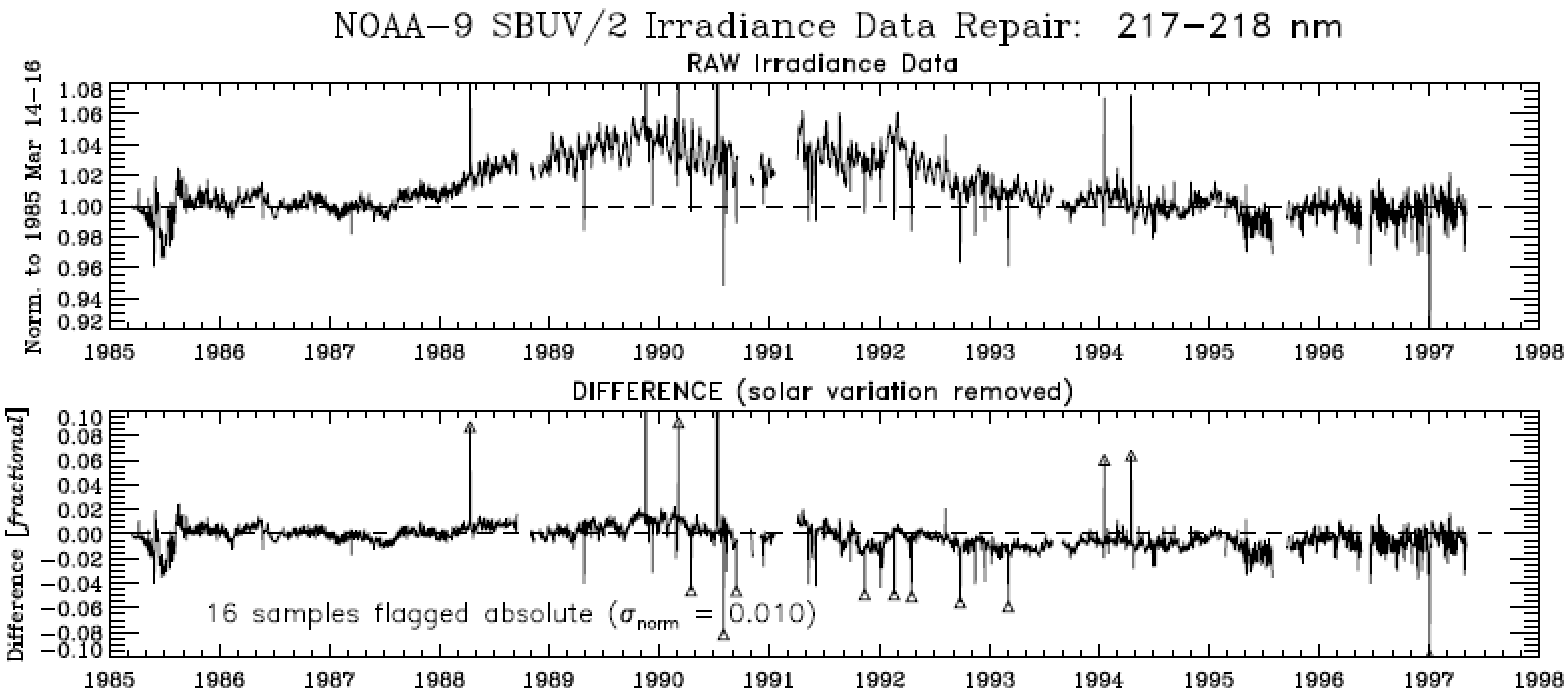
Outlier Identification and Removal

- SSI data sets can have outlier values (either high or low) at individual wavelengths and dates.
- How should such points be identified and removed relative to natural variability?
- Absolute thresholds are difficult to specify because of spectral dependence.
- Create time series at each wavelength, normalize to “Day 1” irradiance value, remove estimated solar activity (for diagnosis only).
- Calculate average and standard deviation of this data set.
- Identify points that exceed $\pm 4\ \sigma$ from average.
- Replace original sample with average of valid neighbors.
- NOTE: σ can be inflated by uncorrected drift → adjust by inspection as needed.

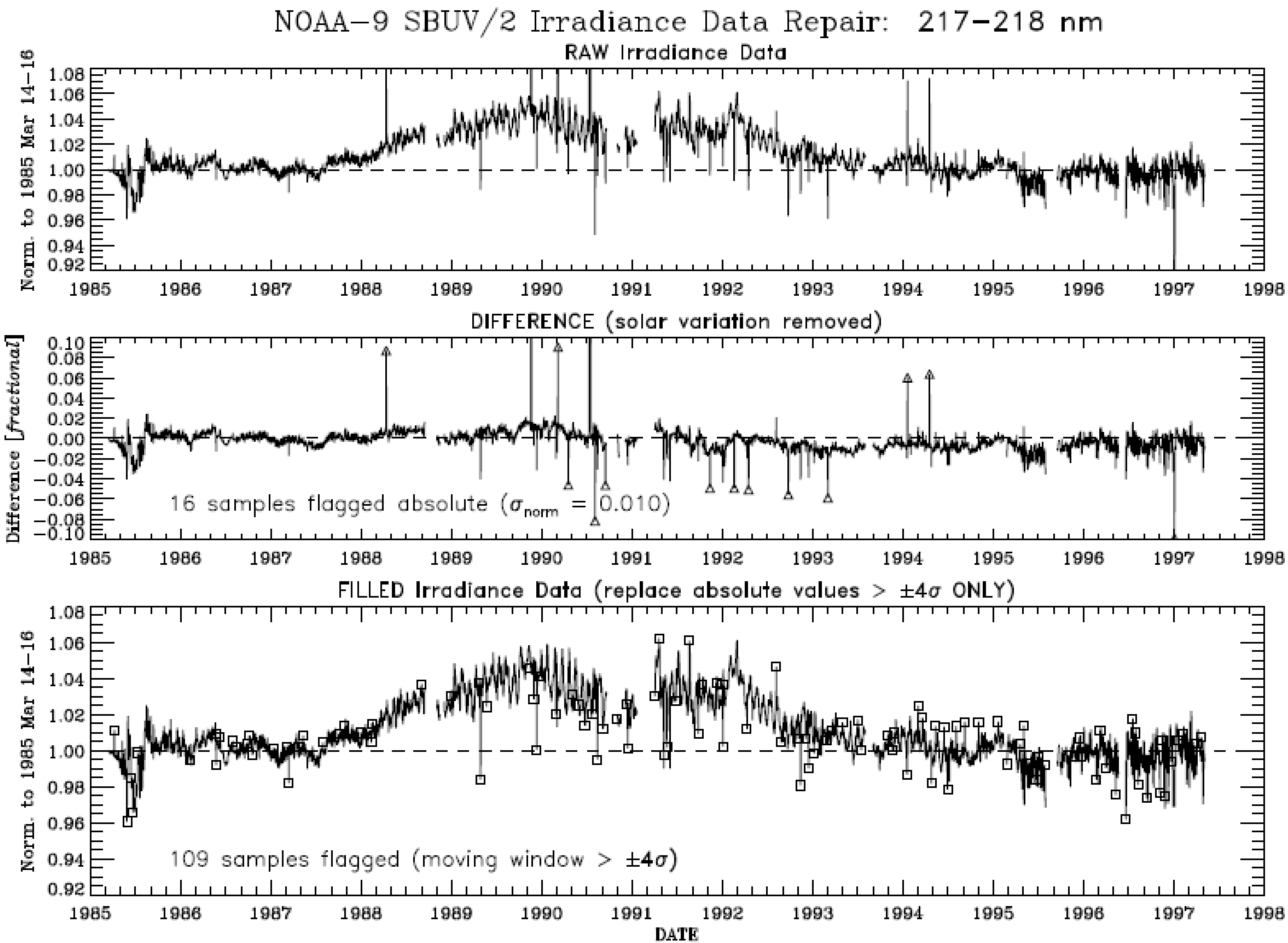
Outlier Removal - *raw*



Outlier Removal - *difference*



Outlier Removal - *corrected*



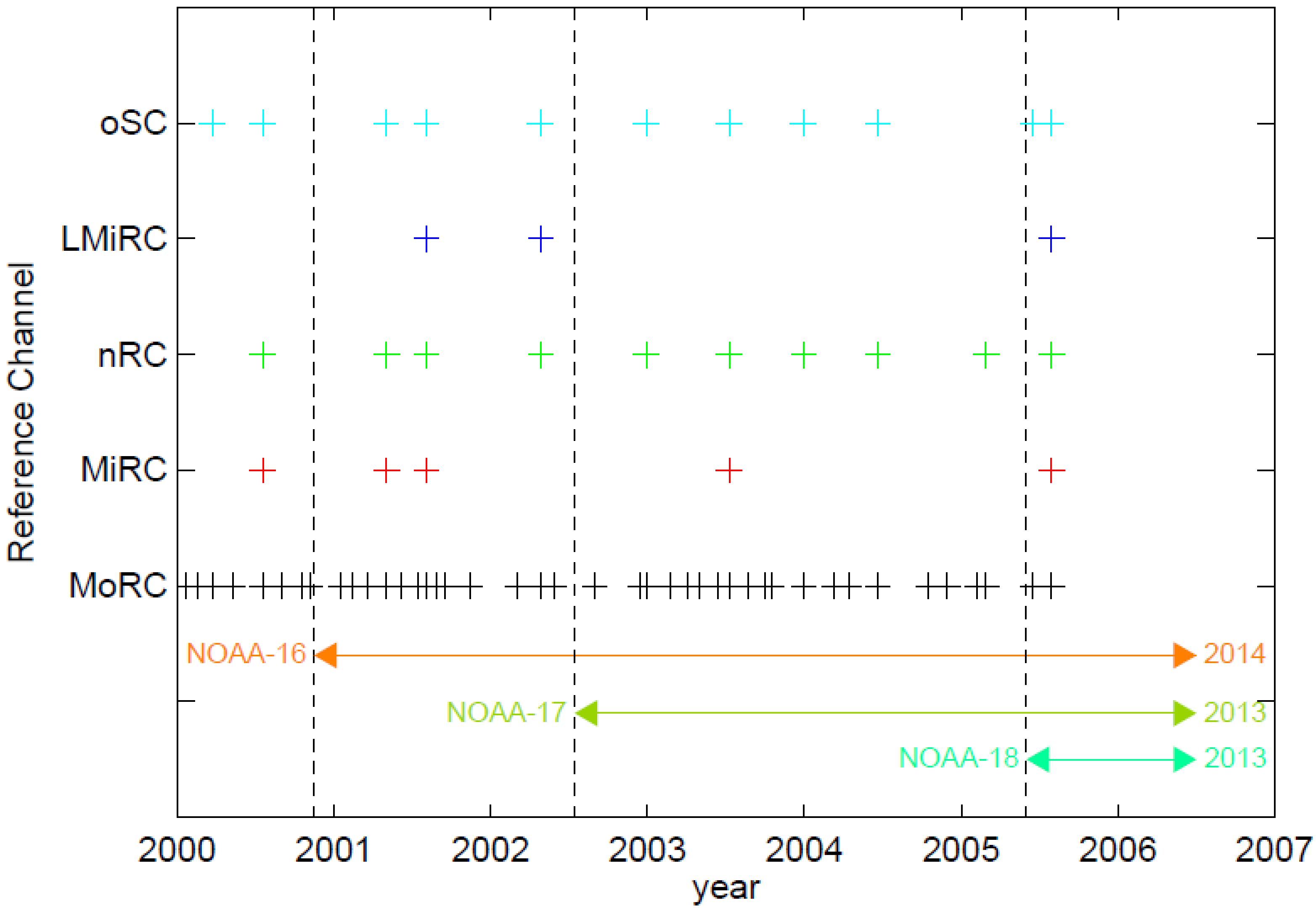
Additional SBUV/2 Irradiance Data

- NOAA-16 daily spectra (170-400 nm) cover Mar 2001 – Sep 2007 [+ spring 2008] before significant orbit drift issues appear (shadowing of solar diffuser).
- NOAA-17 daily spectra cover Oct 2002 – Dec 2010 before shadowing starts.
- Use same long-term correction approach as applied to NOAA-9 and NOAA-11 in V1 composite SSI data set:
  - Use UARS SUSIM reference spectra in place of SSBUV flights as absolute reference
  - Create "Day 1" ratio between NOAA-16 and SUSIM to remove calibration bias
  - Compare concurrent NOAA-16 observations to reference spectra on selected dates to establish benchmarks for correction
  - Create smooth fits (wavelength, time) for degradation function to correct SBUV/2 data

SUSIM Solar UV Spectral Irradiance Measurements Used for Instrument Calibration: General Approach

- To provide for the calibration of its working optics, SUSIM conducted numerous scans of various reference channels over its 14-year mission.
- These 5-nm resolution solar reference scans themselves were calibrated by measurements of 4 stable onboard deuterium lamps.
- The solar changes were also corrected for the difference between responsivity changes when viewing the Sun versus lamps.
- The ratios of the calibrated solar UV measurements at different times measure the solar UV irradiance change over the time between them.
- These “solar changes” provide the means for calibrating not only the SUSIM data, but also data from other coincident experiments, *e.g*. SBUV/2.

SUSIM Ref Channel Scans During NOAA-16, -17, and -18 Time Periods



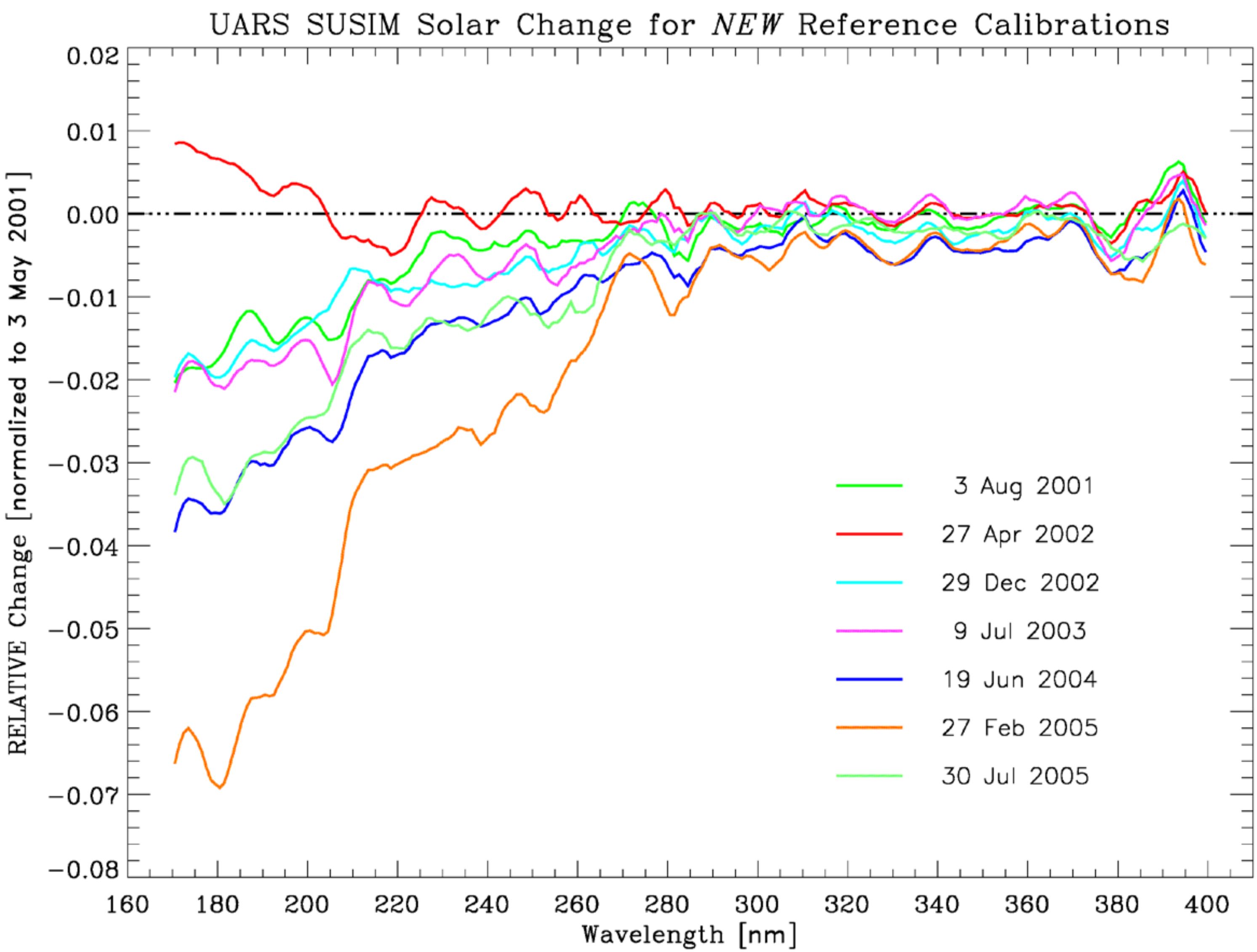
Reference Channel Solar Change Measurements

- The Reference Channel (RC) and new Reference Channel (nRC) made measurements on a roughly half year cadence from 10/1991 to 3/1999 and 3/1999 to the end of SUSIM mission (EoM) in 8/2005, respectively.
- The Mission Reference Channel (MiRC) made 4 measurements from 11/2000 (NOAA-16 start) to SUSIM EoM.
- Similarly, the Lower Mission Reference Channel (LMiRC) made 3 measurements from 11/2000 to EoM.
- The Monthly Reference Channel (MoRC) made measurements from 1/1992 to EoM on a monthly cadence (with some gaps).
- The Standard Reference Channel (SRC, aka oSC, the first working channel) consisted of the original working optics after their retirement on 3/1999. SRC measurements were afterwards simultaneous with those of the nRC.
- Reference channel scans were performed nearly simultaneously so that the various solar change estimates can be intercompared and merged.

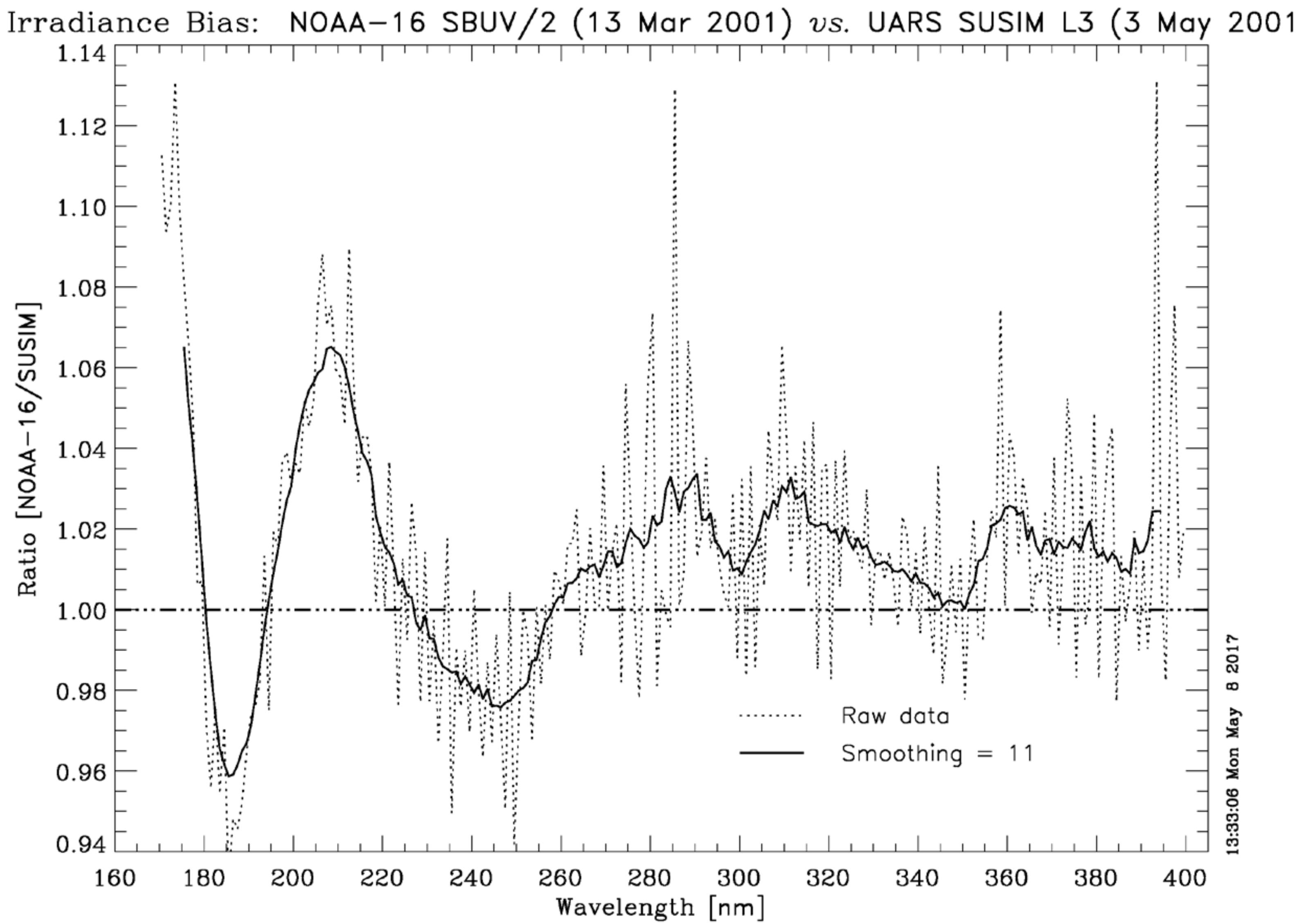
Approach to Forming the Solar Change Estimates (SCEs)

- The provided SCEs are composite estimates based on multiple SCE of the individual RC SCEs.
- The provided SCE is based on as many individual SCEs as possible.
- Each reference channel has its own level of data quality that varies with respect to mission time and wavelength.
- Generally, data quality is inversely proportional to the level of responsivity degradation and therefore UV exposure.
- The individual SCEs are weighted (or not included) accordingly to form the output SCE product.
- The dates chosen for the delivered SCEs were those when the nRC measurements were made.

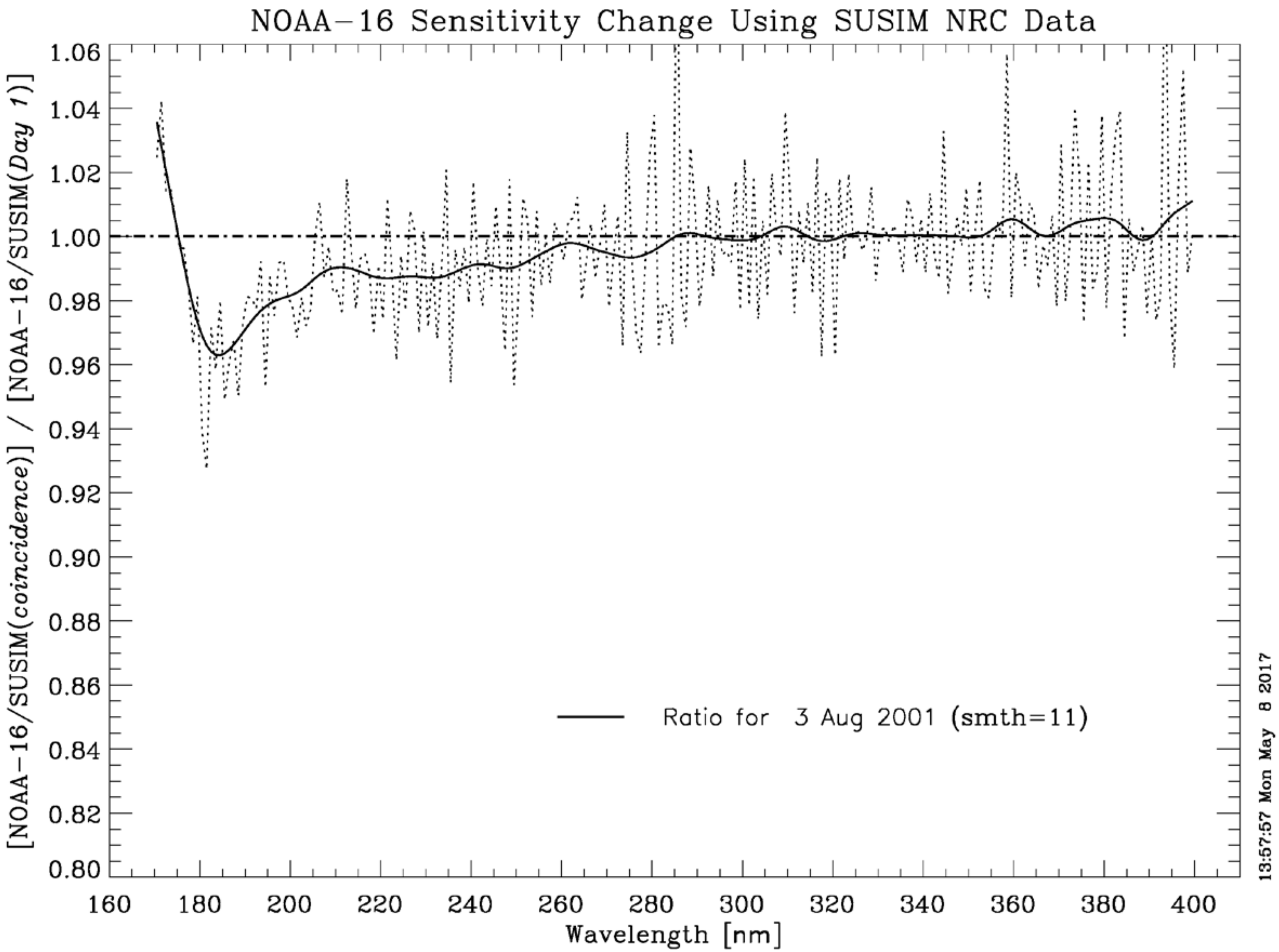
SUSIM Solar Change Estimates



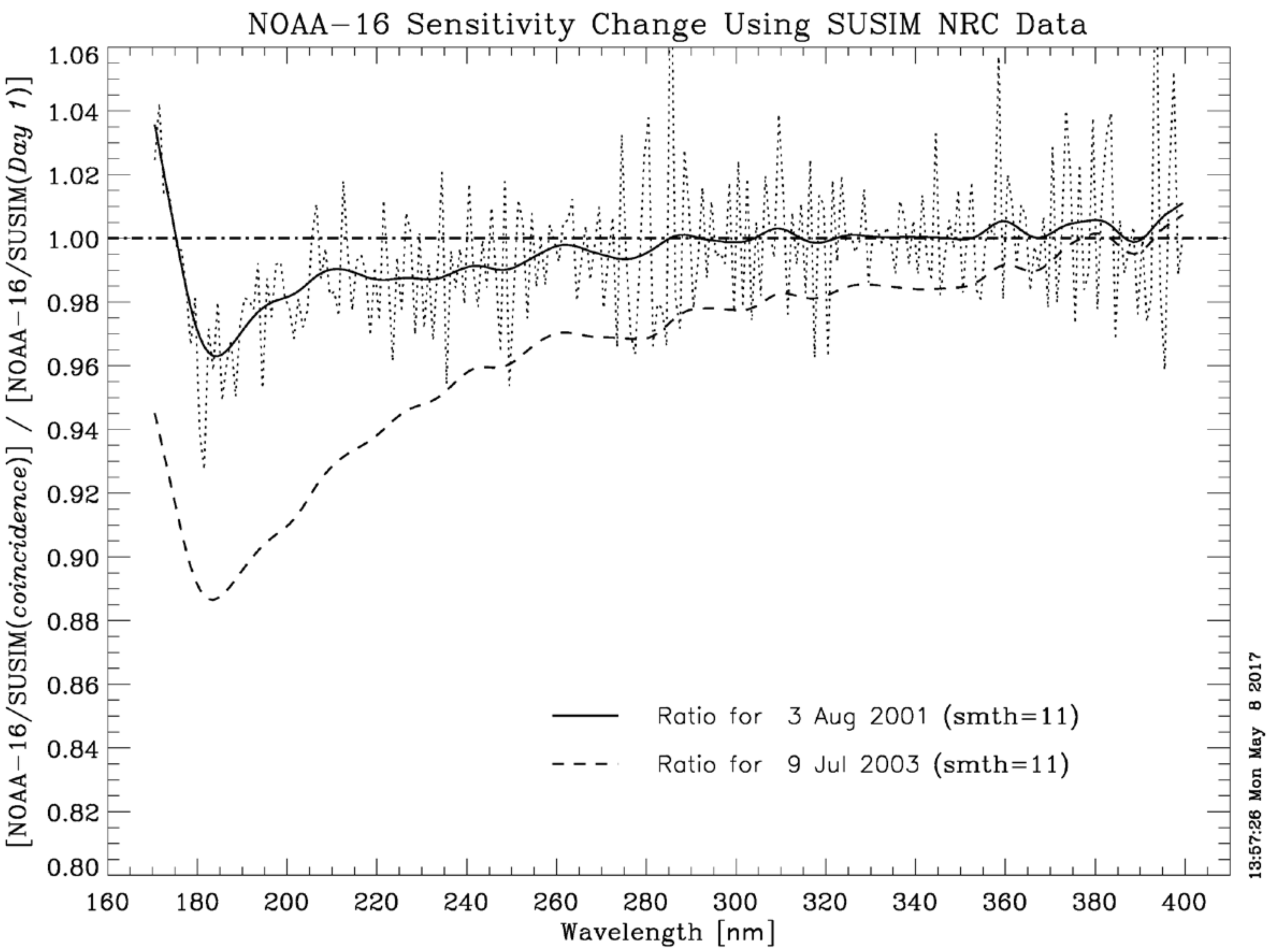
SBUV/2 “Day 1” Ratio *vs*. SUSIM



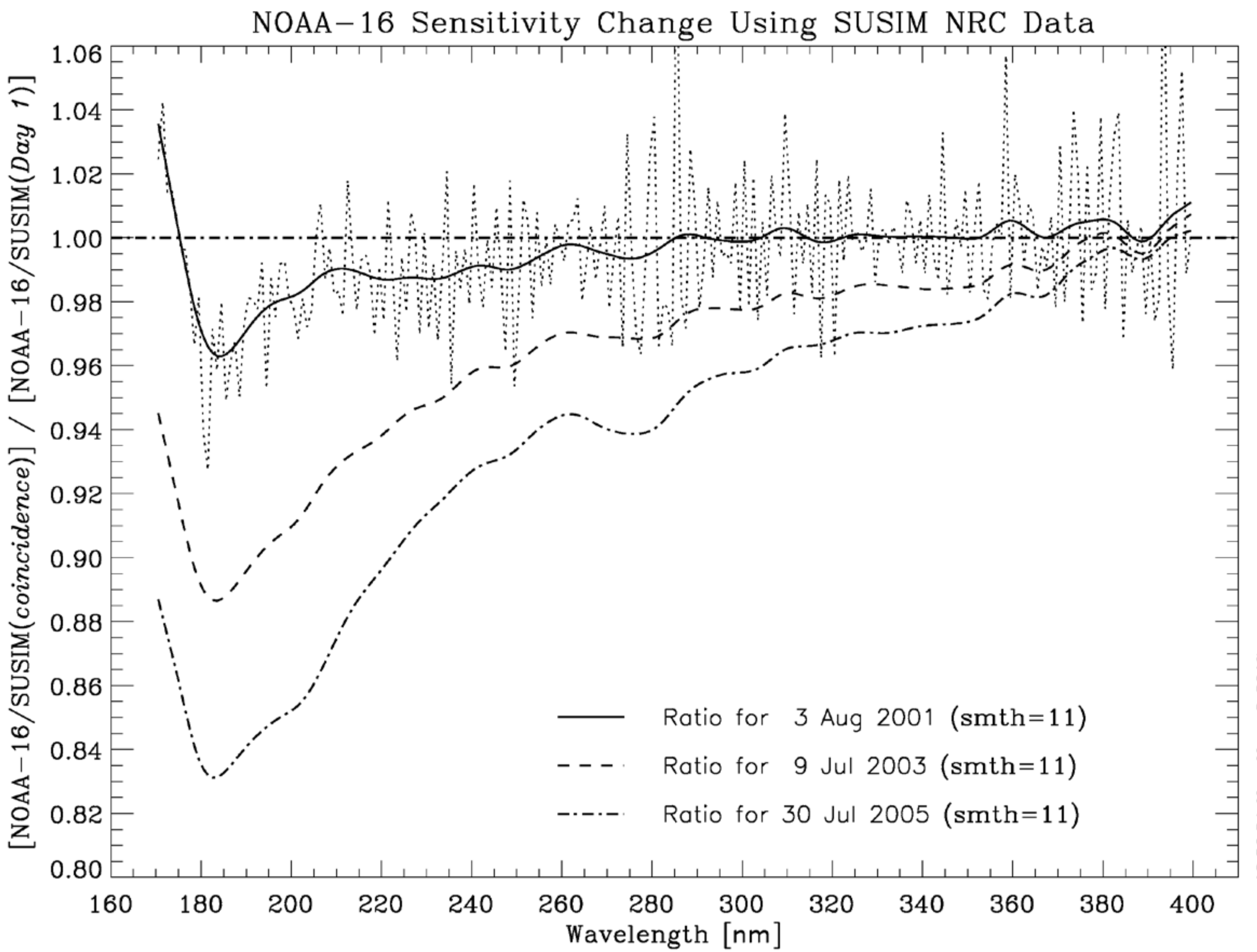
SBUV/2 Coincident Ratio *vs*. SUSIM - 1



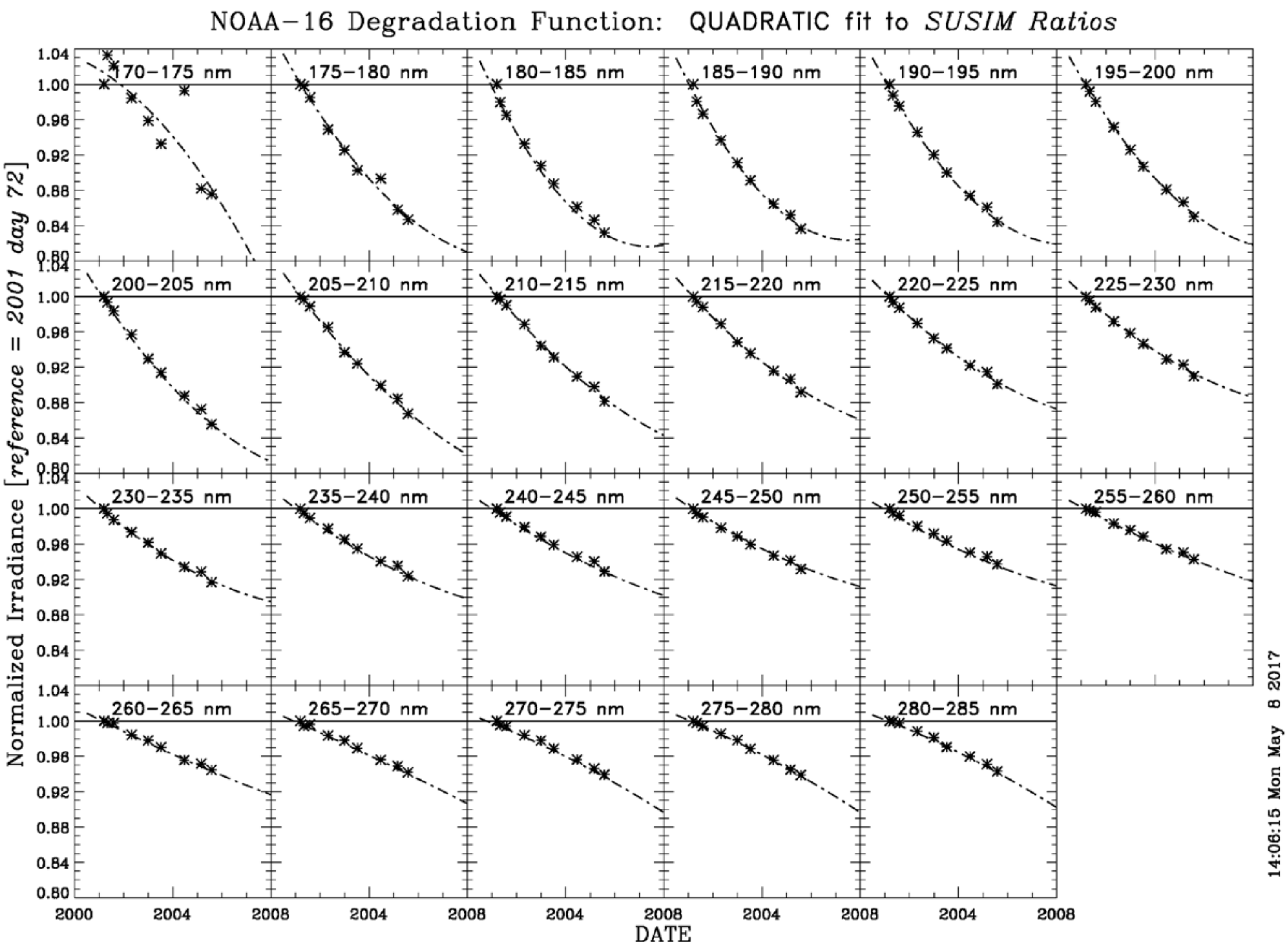
SBUV/2 Coincident Ratio *vs*. SUSIM - 2



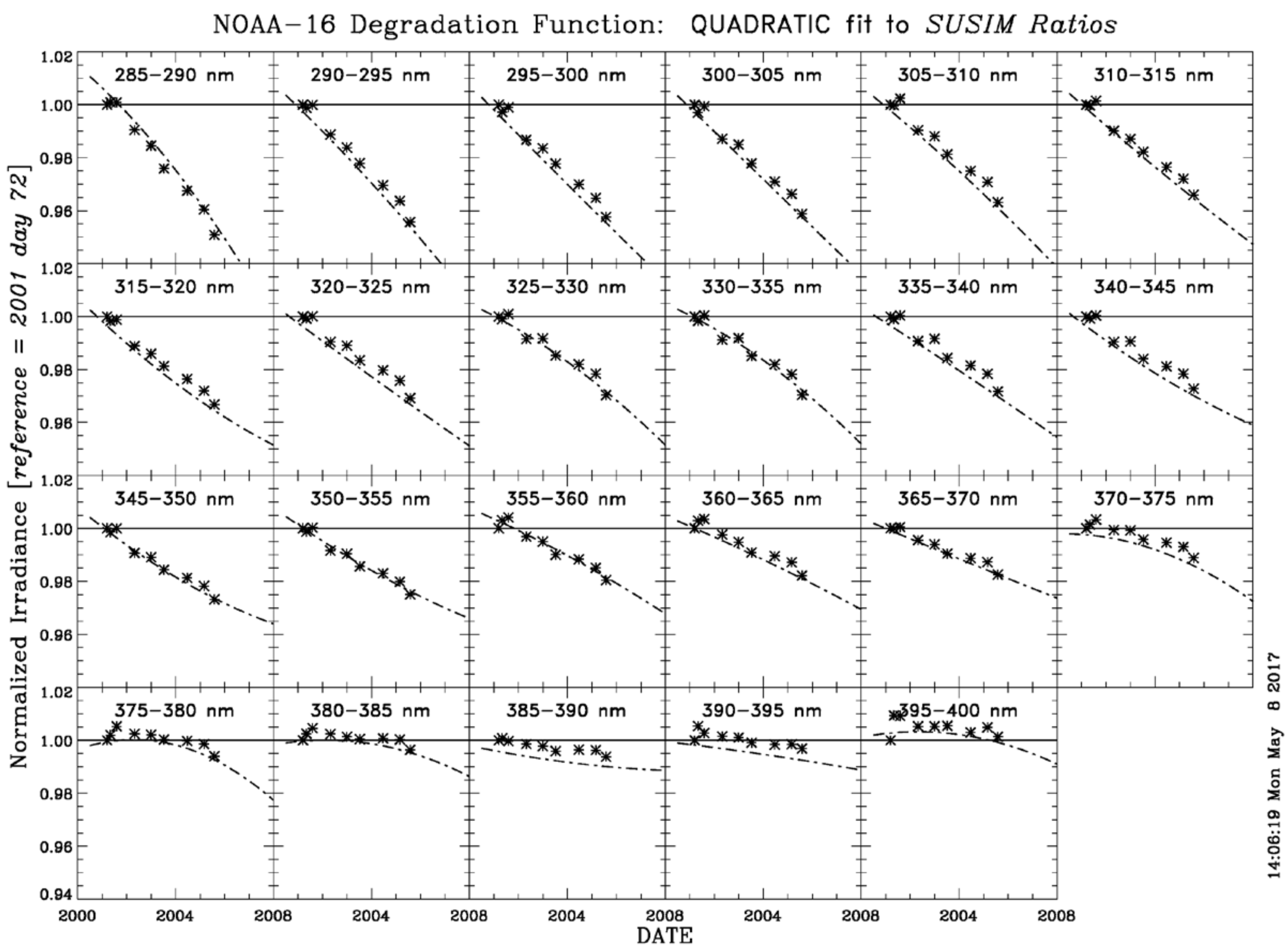
SBUV/2 Coincident Ratio *vs*. SUSIM - 3



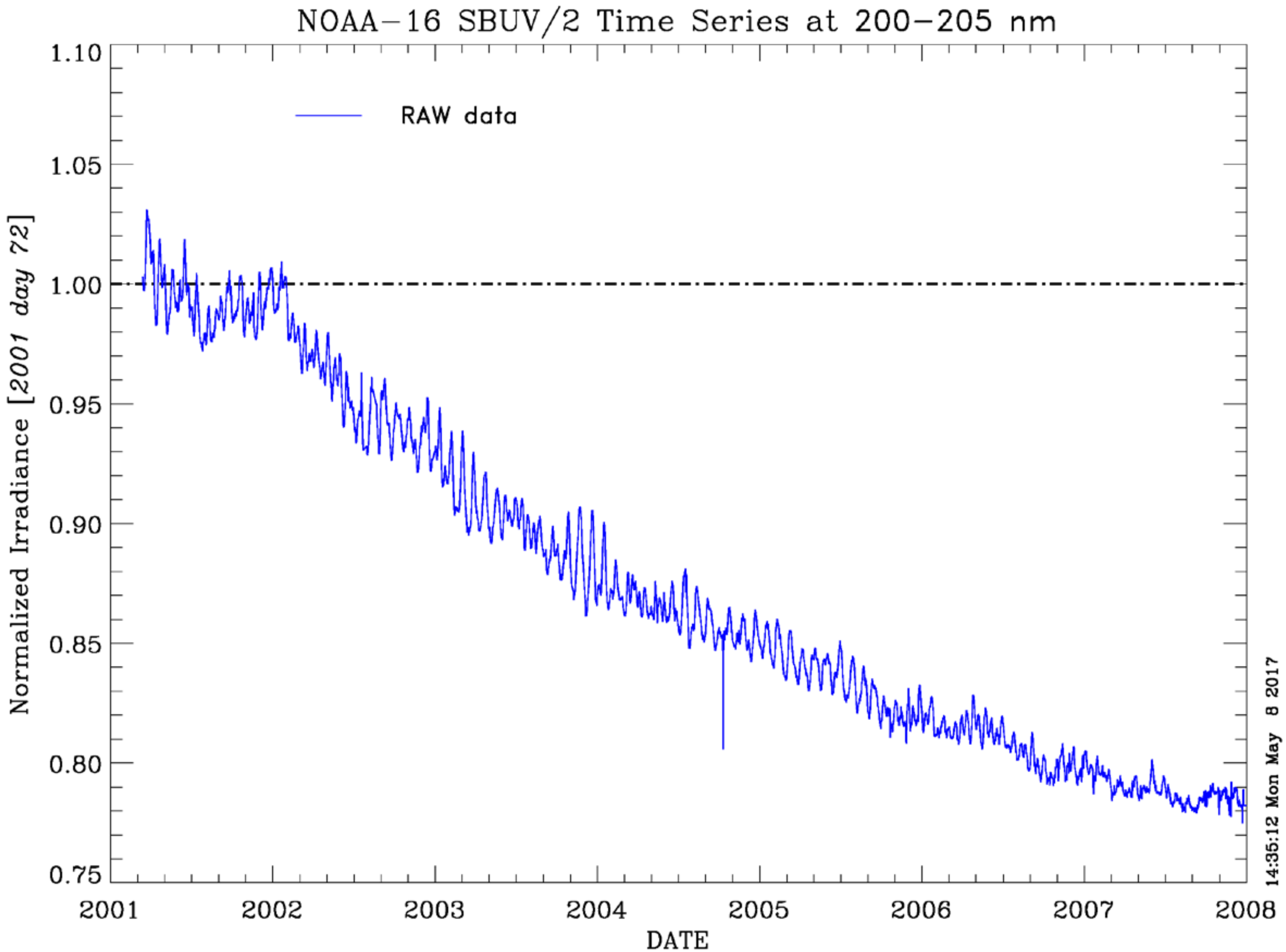
SBUV/2 Degradation Function – short λ



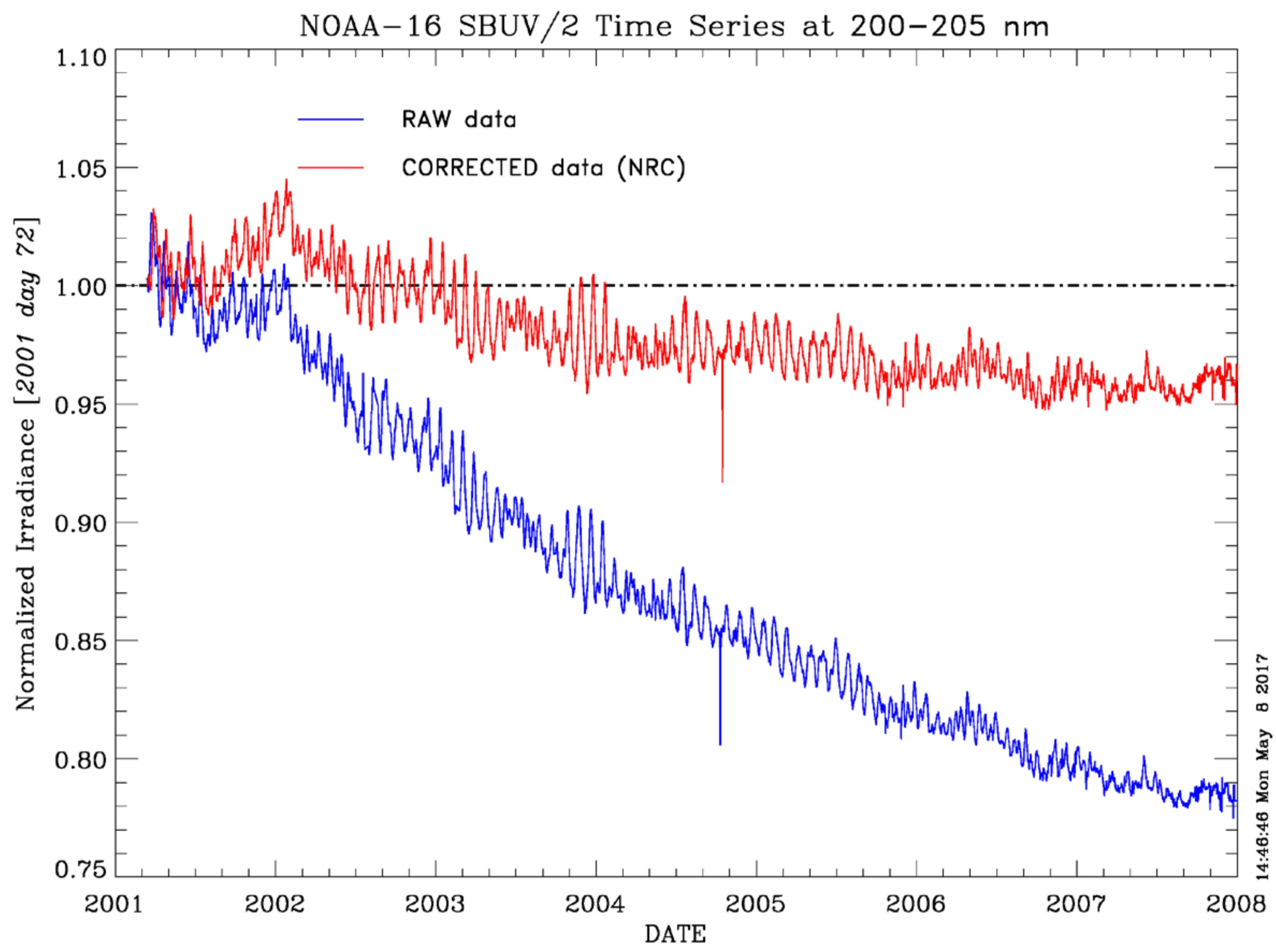
SBUV/2 Degradation Function – long λ



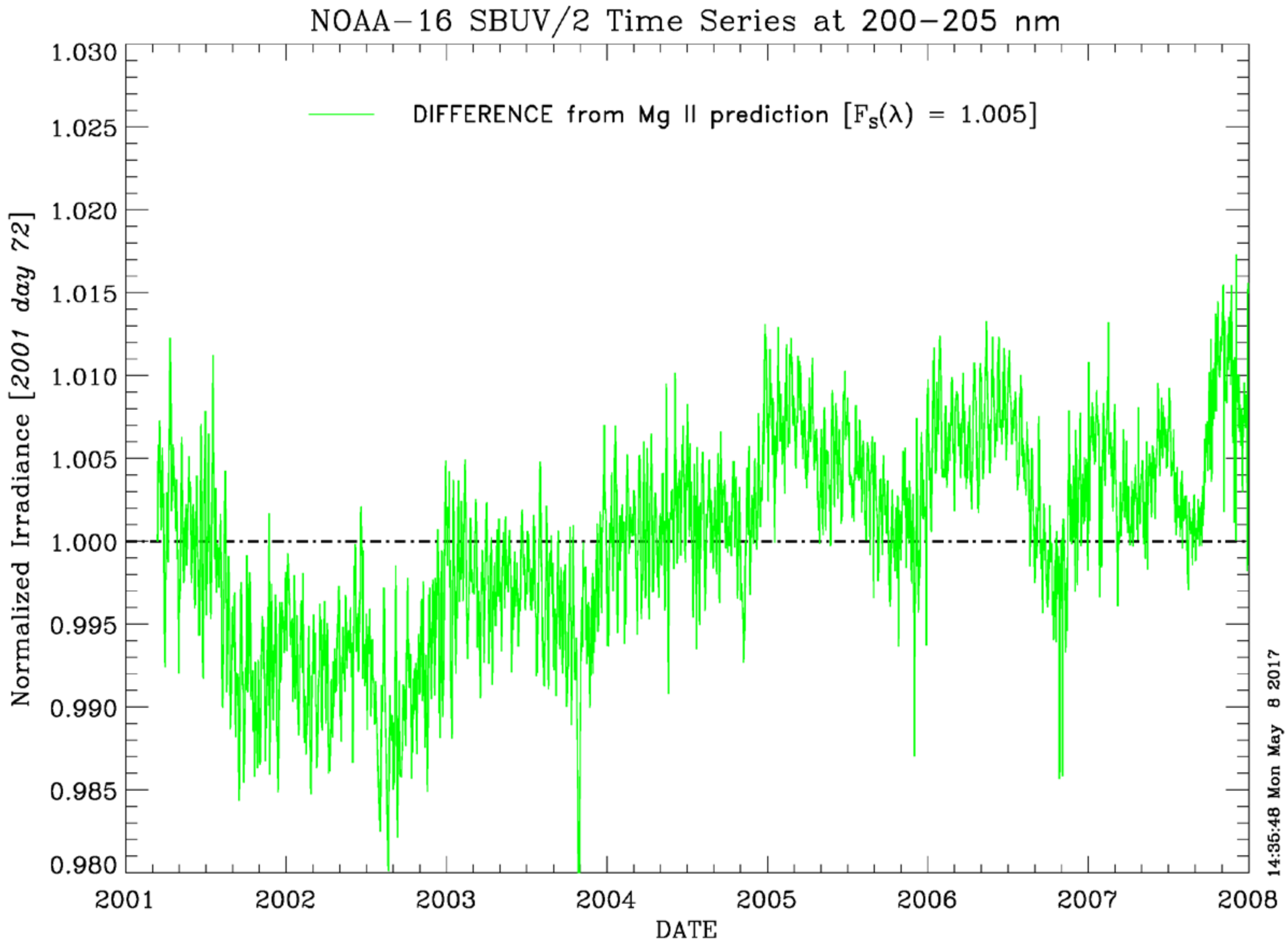
SBUV/2 Time Series – 200-205 nm



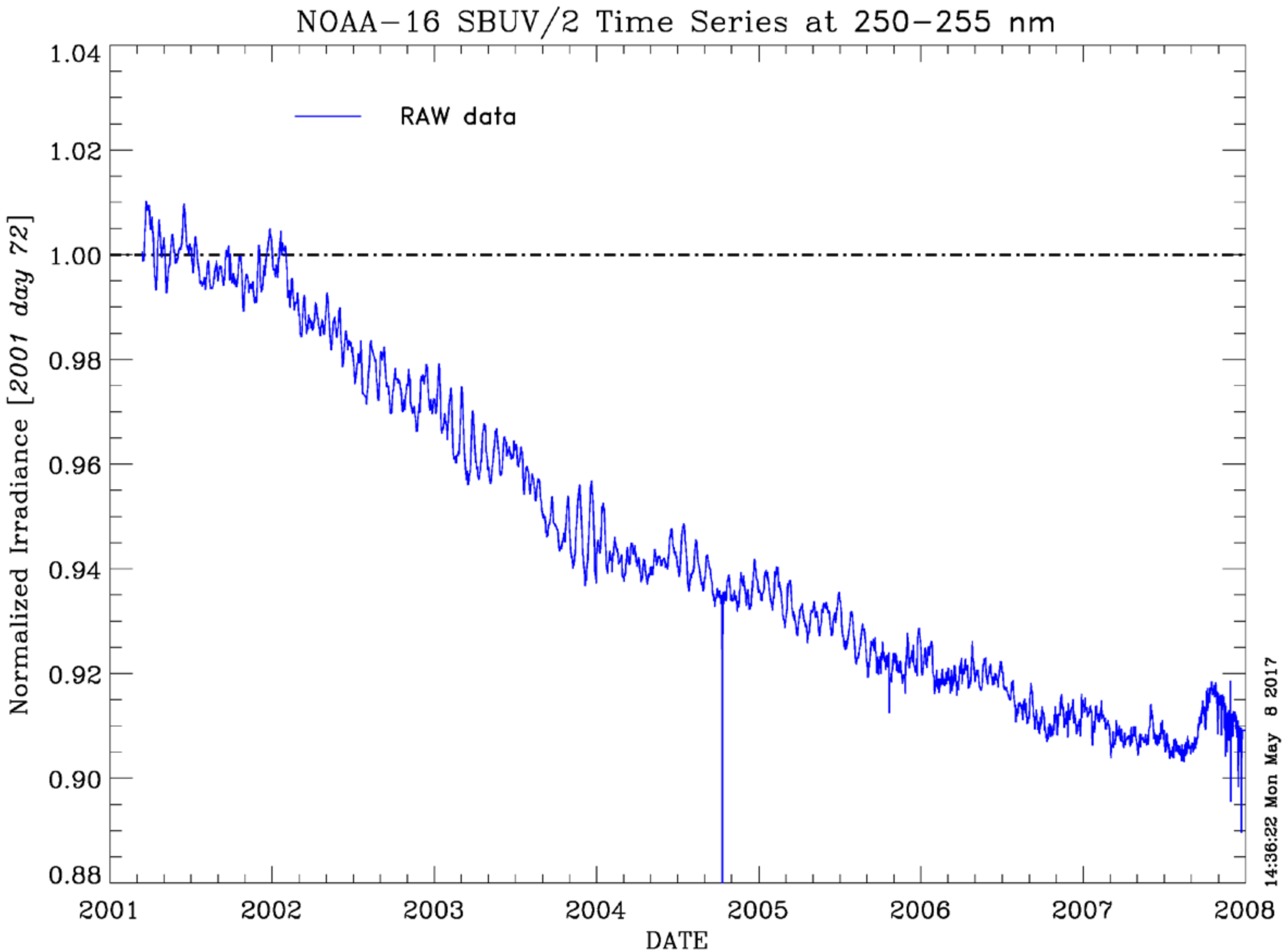
SBUV/2 Time Series – 200-205 nm



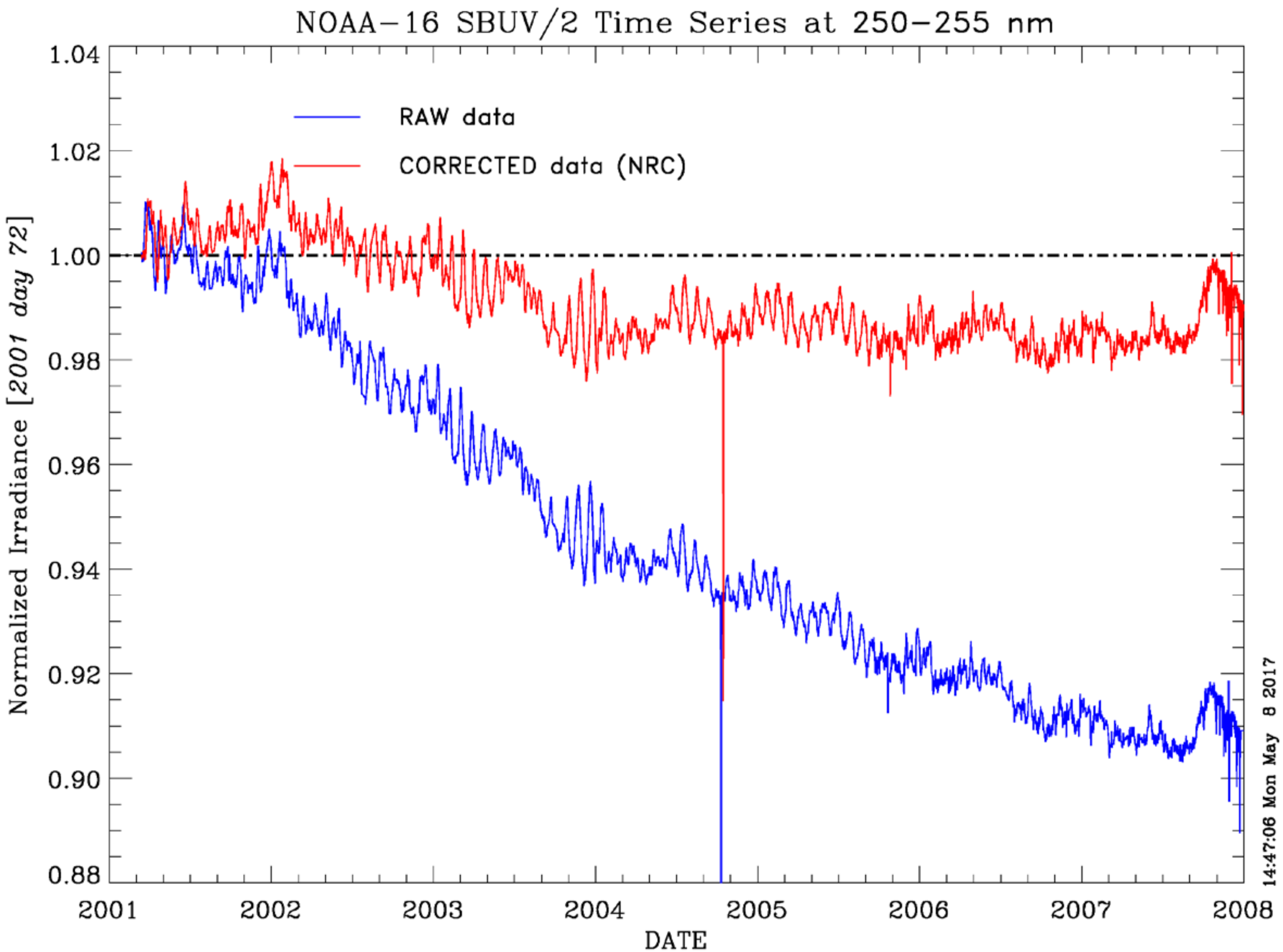
SBUV/2 Time Series – 200-205 nm



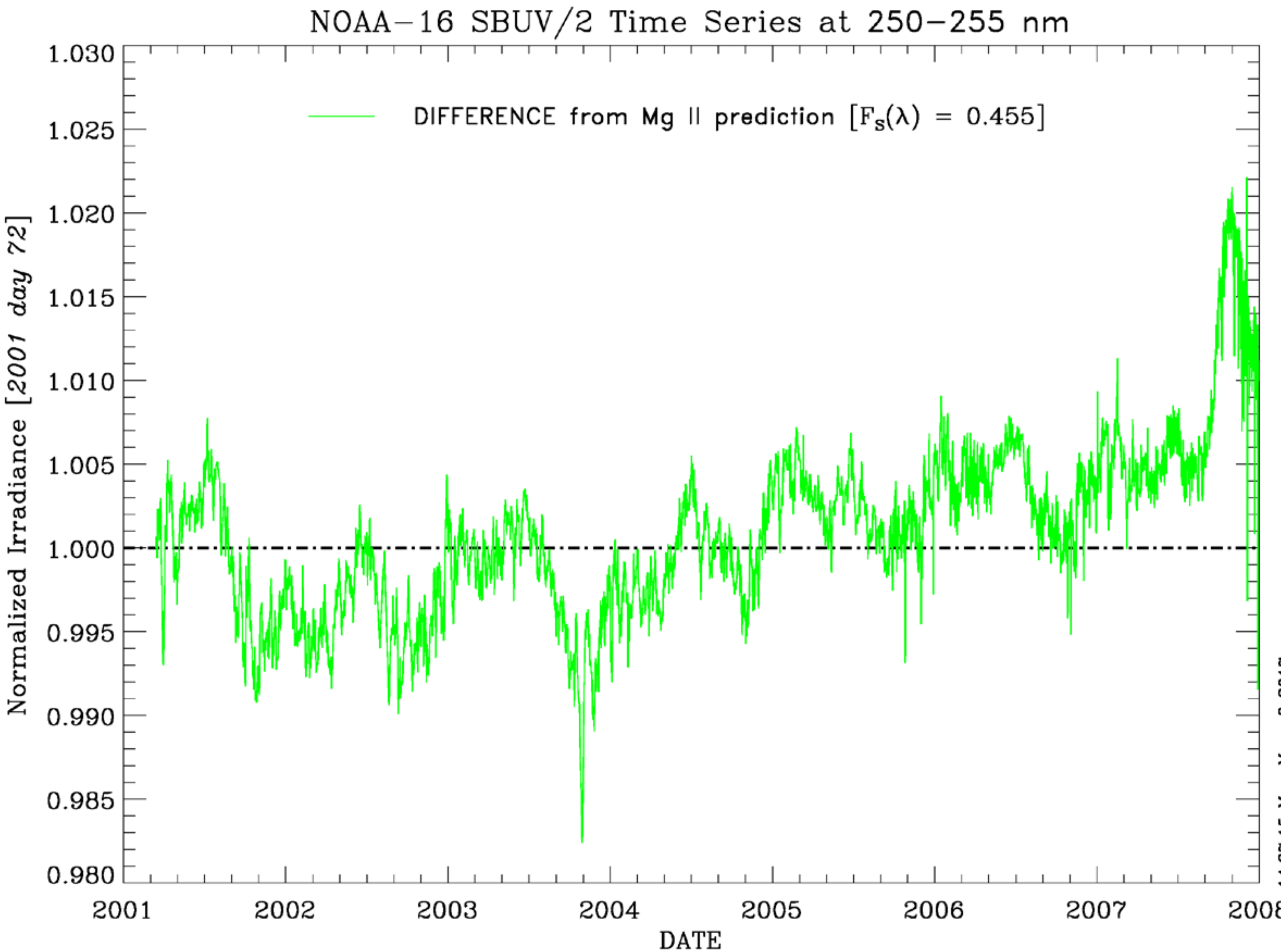
SBUV/2 Time Series – 250-255 nm



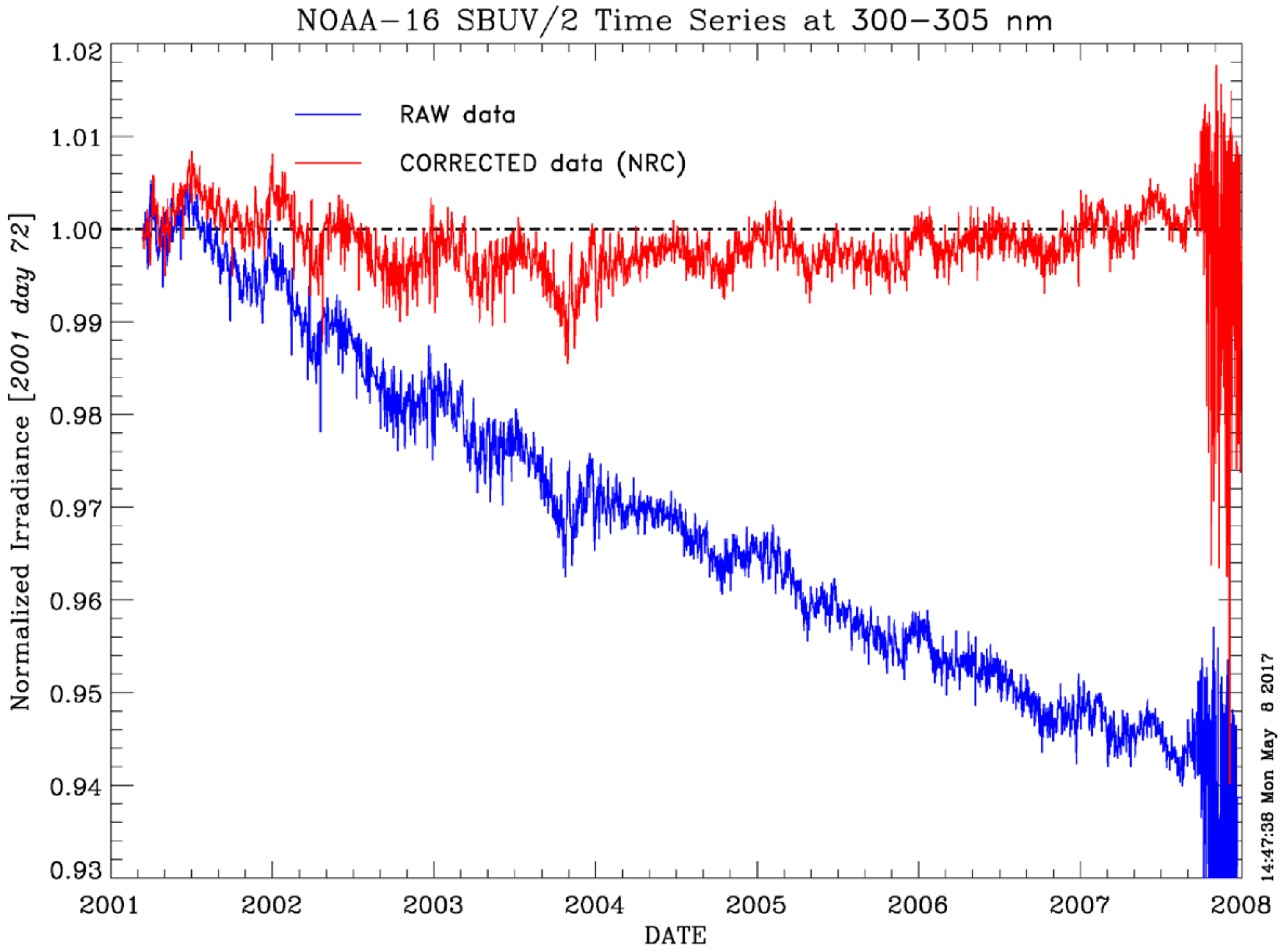
SBUV/2 Time Series – 250-255 nm



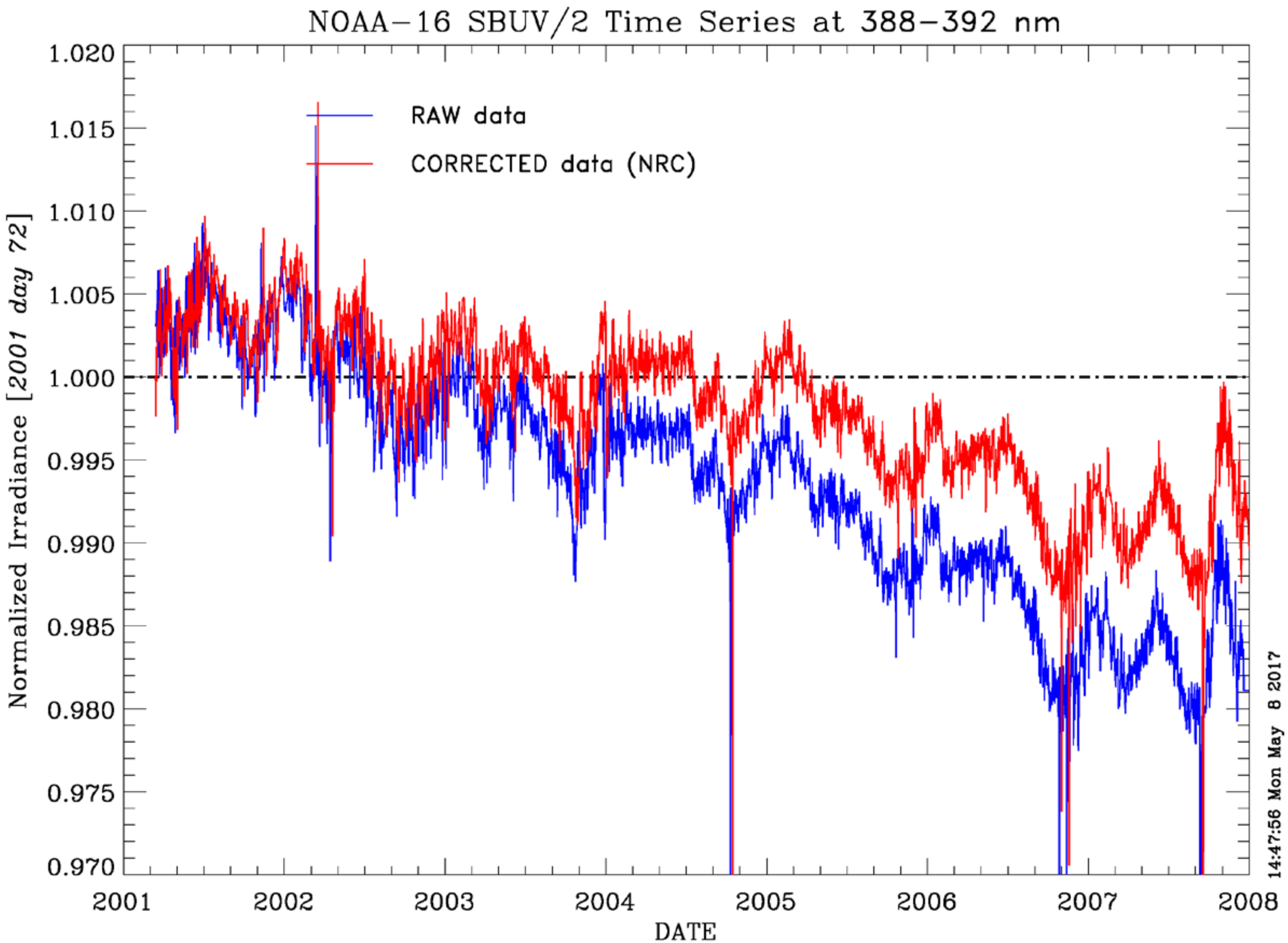
SBUV/2 Time Series – 250-255 nm



SBUV/2 Time Series – 300-305 nm



SBUV/2 Time Series – 388-392 nm



Next Steps for Project

- Create improved Nimbus-7, NOAA-9, NOAA-11 irradiance data sets in HDF format.
- Look at options to fine-tune NOAA-16 degradation function (*exponential?*).
- Create corrected NOAA-16 irradiance data set in HDF format.
- Apply same degradation correction approach to NOAA-17 SBUV/2 data set.
- Evaluate NOAA-16, NOAA-17, OMI data sets during 2005-2009 to select data for V2 composite product.

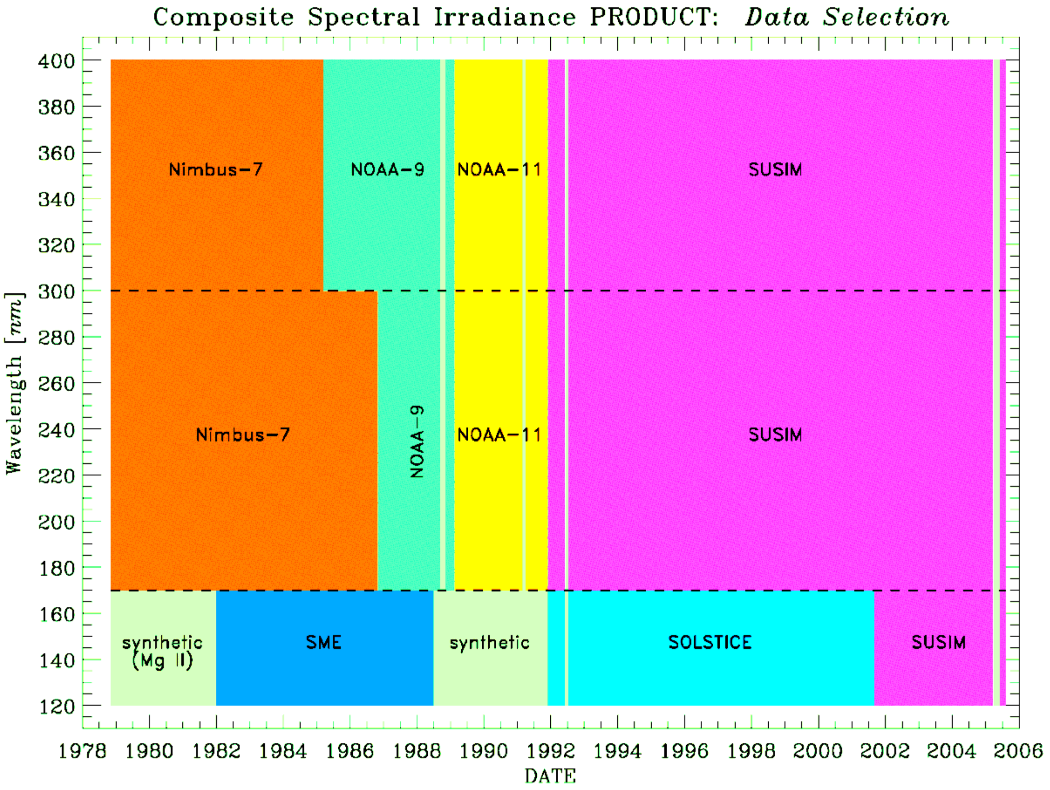
Backup Slides

Limitations of Current SSI Product

- Data set stops in mid-2005. First look at extending with SORCE data showed many differences in mid-UV [*DeLand and Cebula*, 2012].
- Step changes in time series at some inter-instrument transitions have been noted by other users. They should be removed.
- Current normalization spectrum (ATLAS-1) corresponds to high solar activity in 1992. Need lower activity level to best merge more recent data sets.
- Improve screening for outliers.

Existing Composite SSI Product

- Uses 1 nm binned products from each instrument.
- Normalize each data set to reference spectrum.
- Select single data set for each large spectral and temporal region.
- Fill data gaps with synthetic data.



DeLand and Cebula, *J. Geophys. Res.* (2008)