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SBUV/2 Long-Term Measurements of Solar Spectral Variability

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The NOAA-11 SBUV/2 spectral solar data have been corrected for long-term instrument changes to produce a 5.5 year data record during solar cycle 22 (December 1988 - October 1994). Residual drifts in the data at long wavelengths are ±1% or less. At 200-205 nm, where solar variations drive stratospheric photochemistry, these data indicate long-term solar changes of 5-7% from the maximum of Cycle 22 in April 1991 through the end of the NOAA-11 data record. Comparisons of NOAA-11 data with UARS SUSIM and SOLSTICE for the period October 1991 - October 1994, when all 3 instruments were operating simultaneously, show that the observed long-term variations in 200-205 nm irradiance agree to within 2%. This result is consistent with predictions from the Mg II proxy index.

The SBUV/2 instruments represent a valuable resource for long-term solar UV activity studies because of their overlapping data records. In addition to the NOAA-11 data presented here, the NOAA-9 SBUV/2 instrument began taking data in March 1985 and is still operating, providing a complete record of Cycle 22 behavior from a single instrument. Three additional SBUV/2 instruments are scheduled to be launched between 1997 and 2003, which should permit full coverage of solar cycle 23.

- Daily measurements made over 160-405 nm wavelength region from December 1988 to October 1994

- On-board calibration system corrects for diffuser reflectivity change <u>only</u>

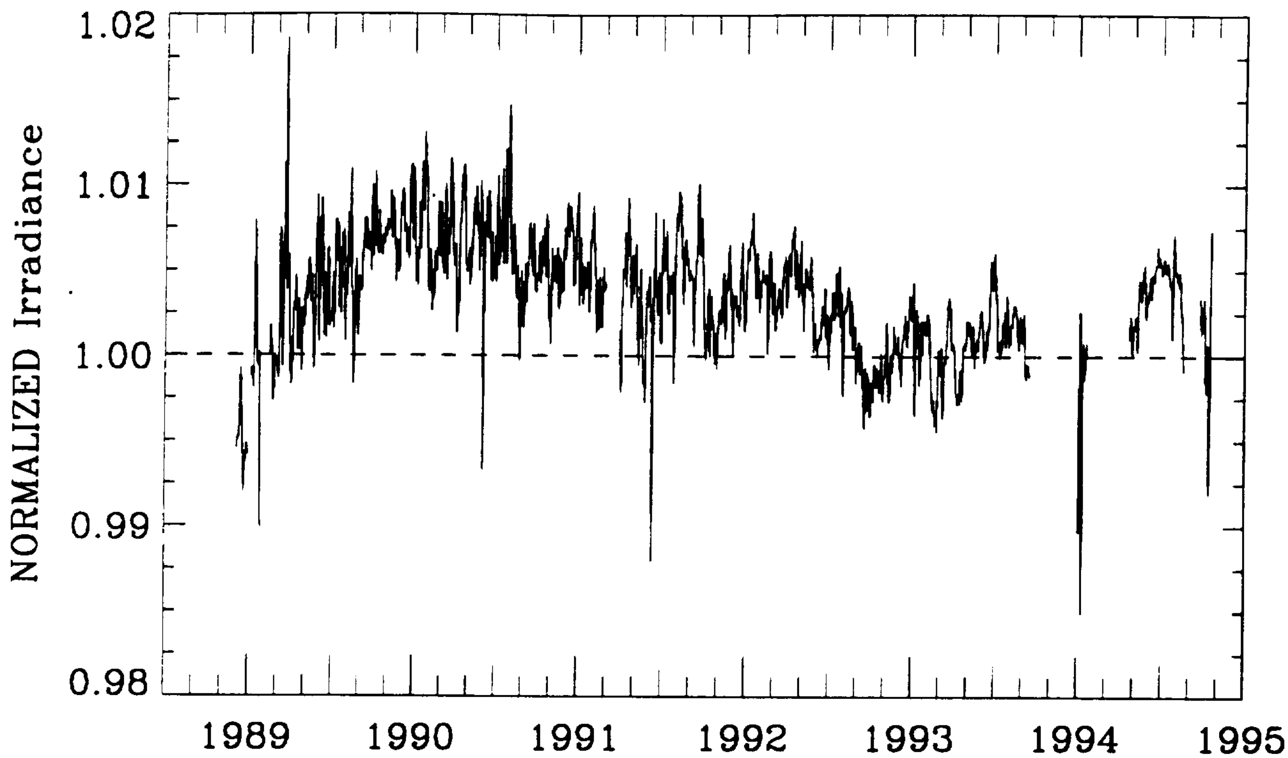
- Coincident observations with SSBUV flights used to characterize long-term instrument throughput changes as functions of time, wavelength

- NOAA-11 irradiance data show long-term drift $\leq$ 1% for λ > 300 nm; This is consistent with expectation of little/no solar activity, indicates accuracy of corrections

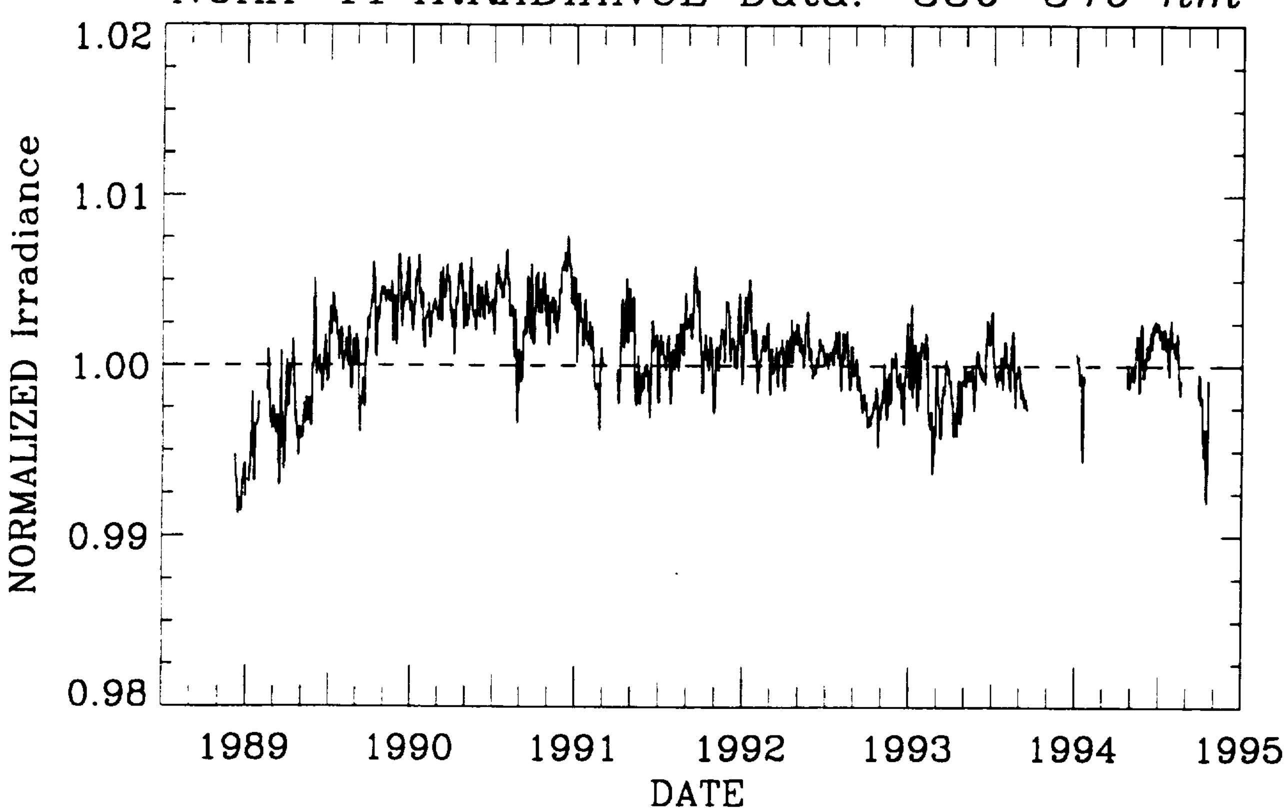
- Shorter wavelengths show regular rotational modulation (up to 5-6% at 200-208 nm, 2-3% at 240-250 nm) during maximum and decline of Cycle 22; Periods of 13-day variability in Fall 1991, late 1992 also present

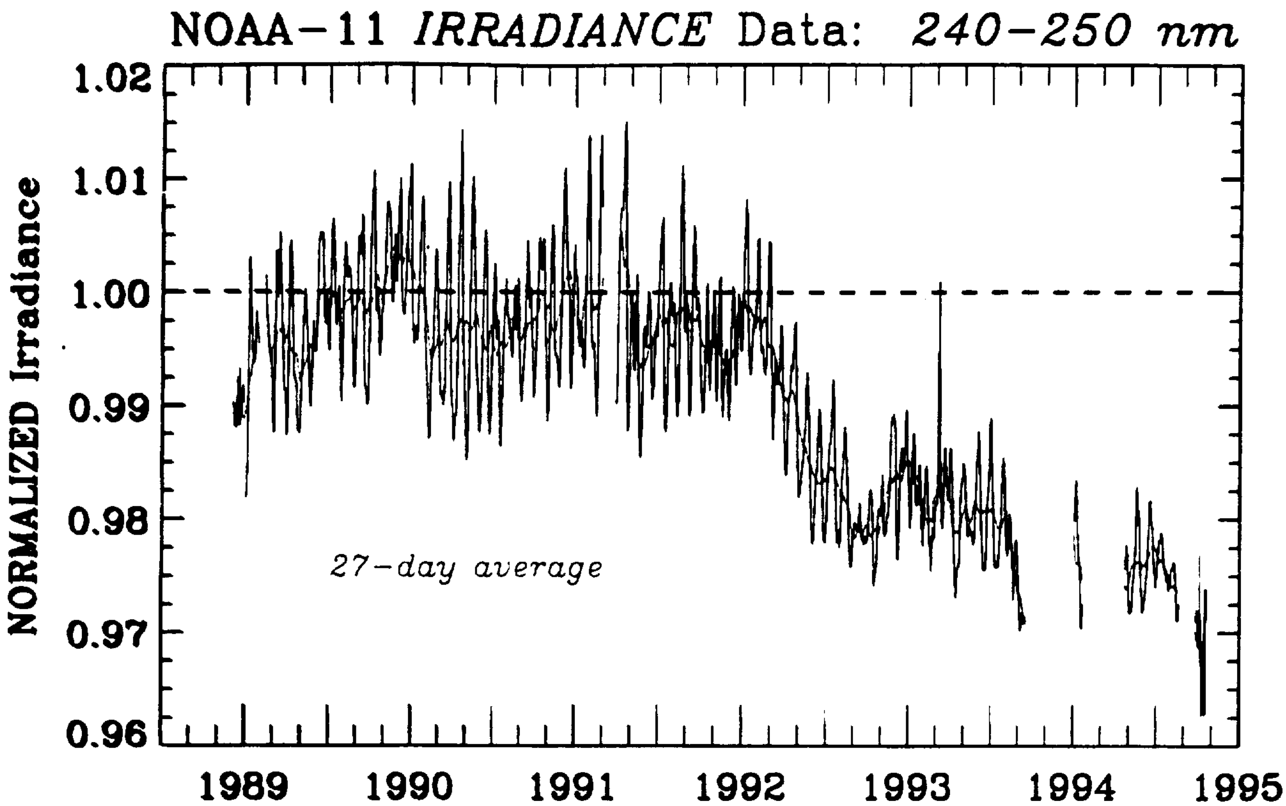
NOAA-11 Solar Irradiance Results

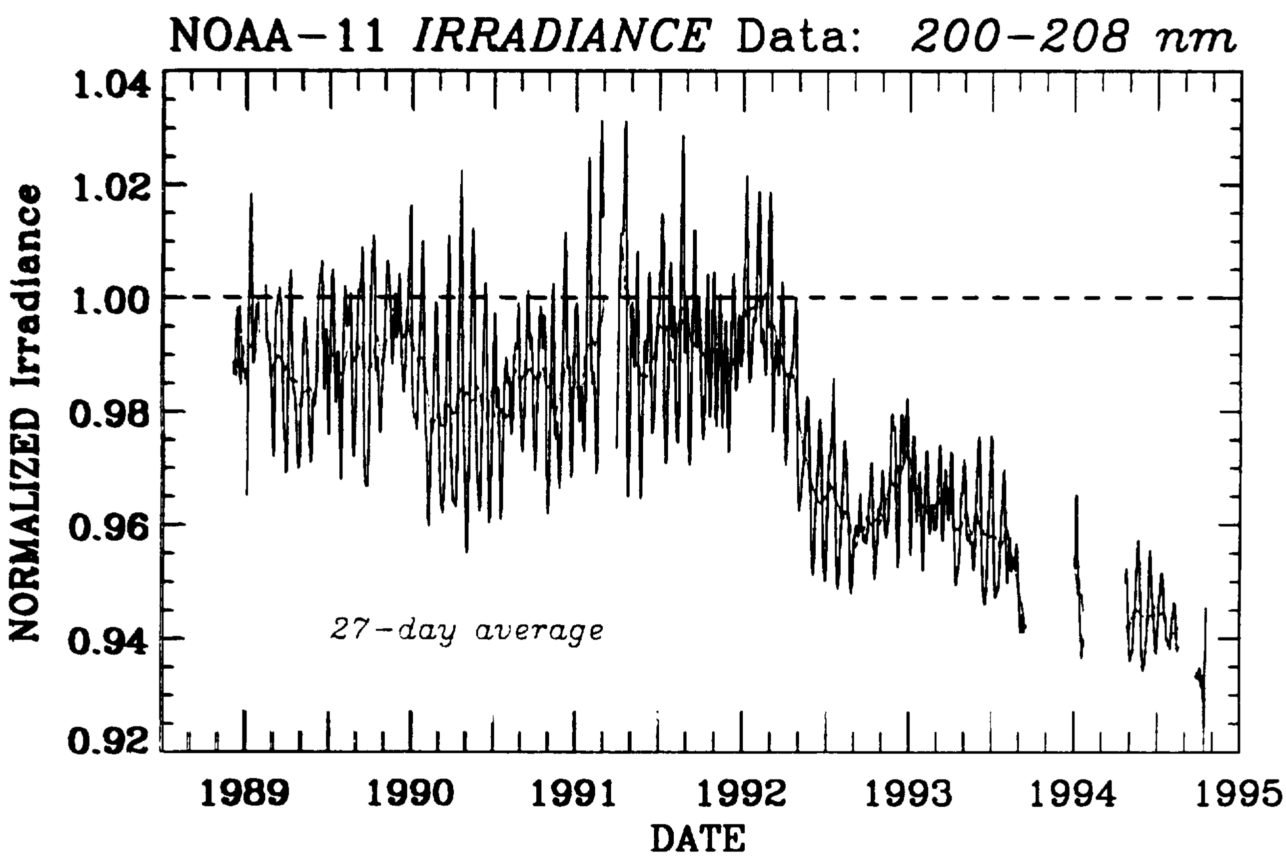
NOAA-11 *IRRADIANCE* Data: *380-390 nm*



NOAA-11 *IRRADIANCE* Data: *330-340 nm*

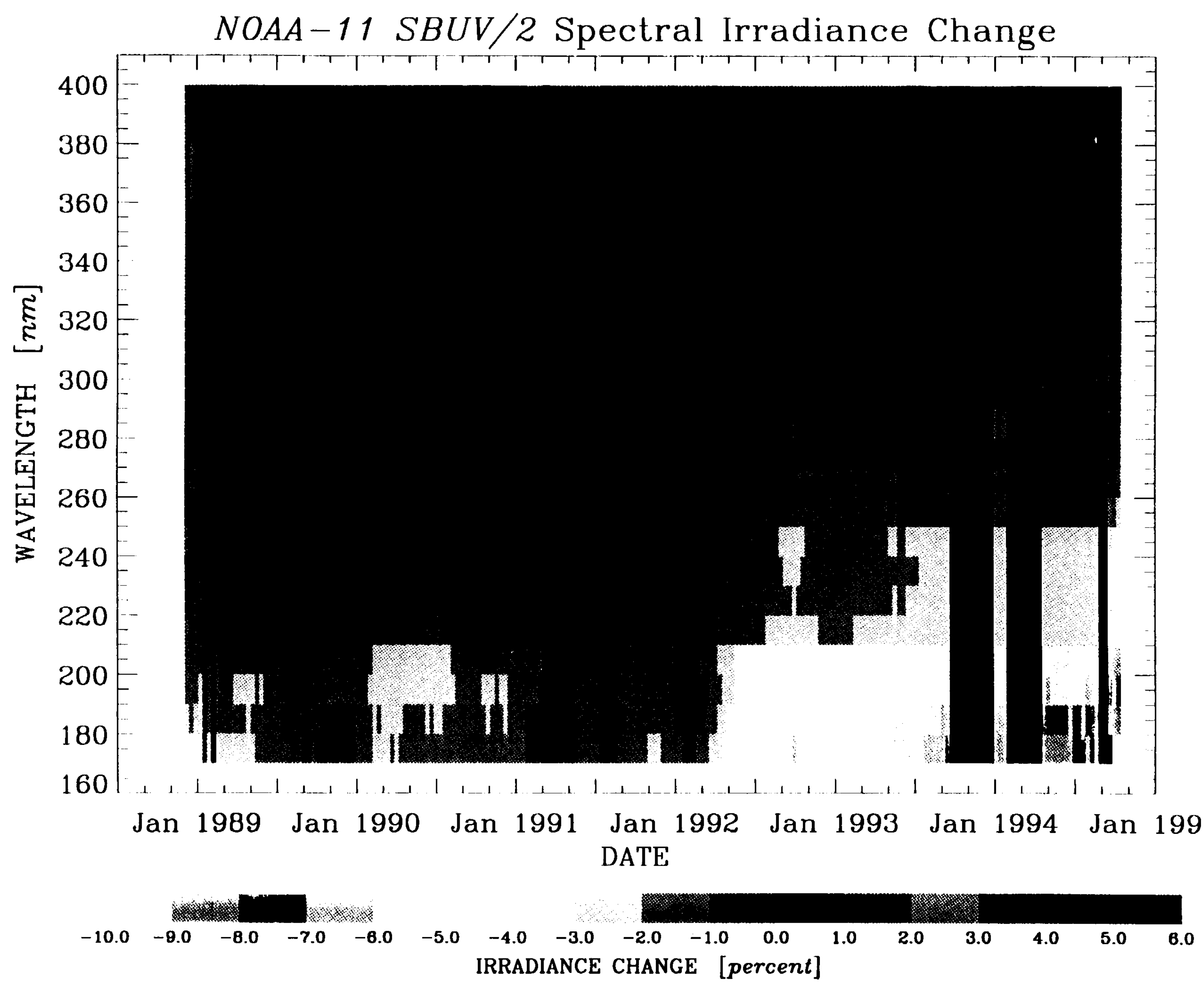



NOAA-11 IRRADIANCE Data: 240-250 nm
NORMALIZED Irradiance
1.02
1.01
1.00
0.99
0.98
0.97
0.96
27-day average
1989
1990
1991
1992
1993
1994
1995


NOAA-11 IRRADIANCE Data: 200-208 nm
NORMALIZED Irradiance
1.04
1.02
1.00
0.98
0.96
0.94
0.92
27-day average
1989
1990
1991
1992
1993
1994
1995
DATE

- Plot of all data in 10 nm bands (81-day average) shows $\Delta F < \pm 1\%$ [*darker green*] for $\lambda > 270$ nm, more long-term change shortward of Mg edge at 210-250 nm [*lighter green*], largest change below Al edge at $\lambda < 210$ nm [*yellow, orange*]; End of Cycle 22 maximum in Spring 1992 visible at $\lambda < 270$ nm

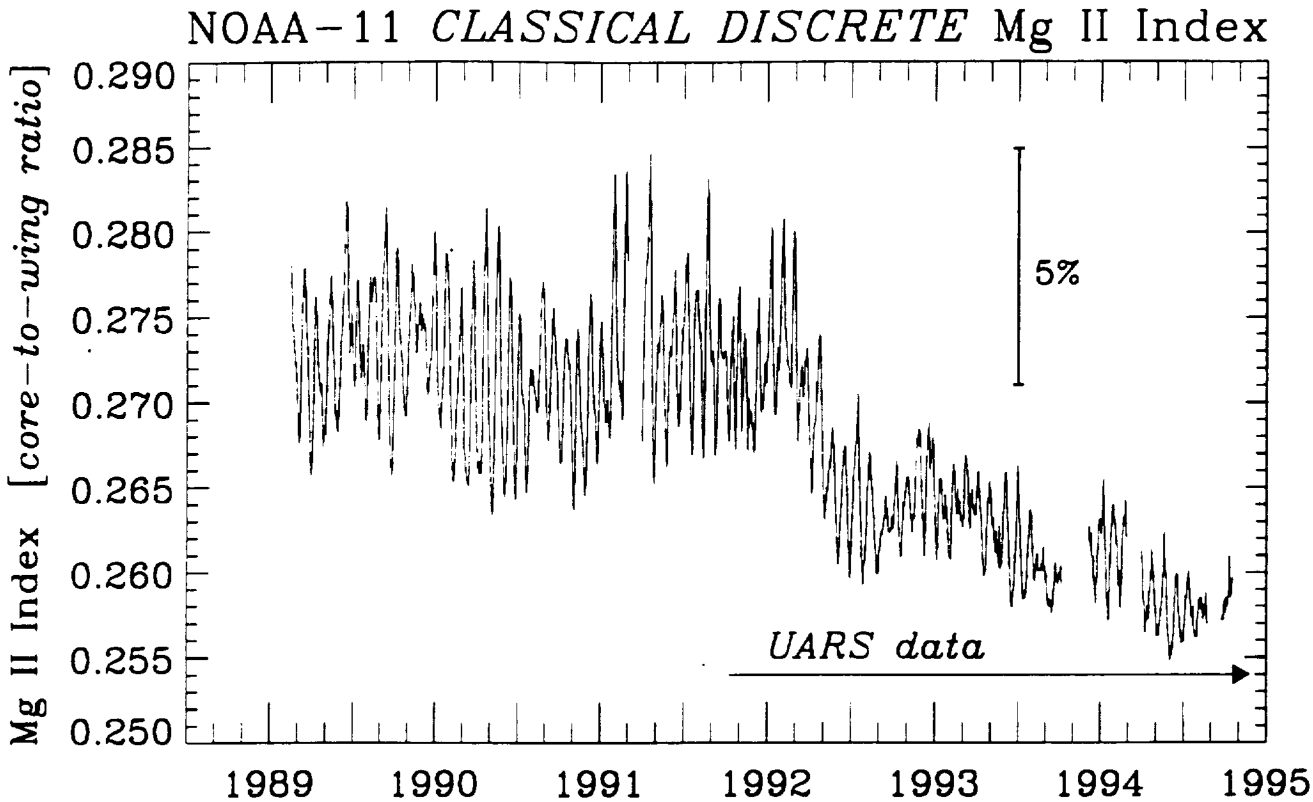
- Long-term changes at short wavelengths determined from smoothed data are approximately 6% at 200-208 nm, 3-3.5% at 240-250 nm; *How can we evaluate instrument drift at these wavelengths?*

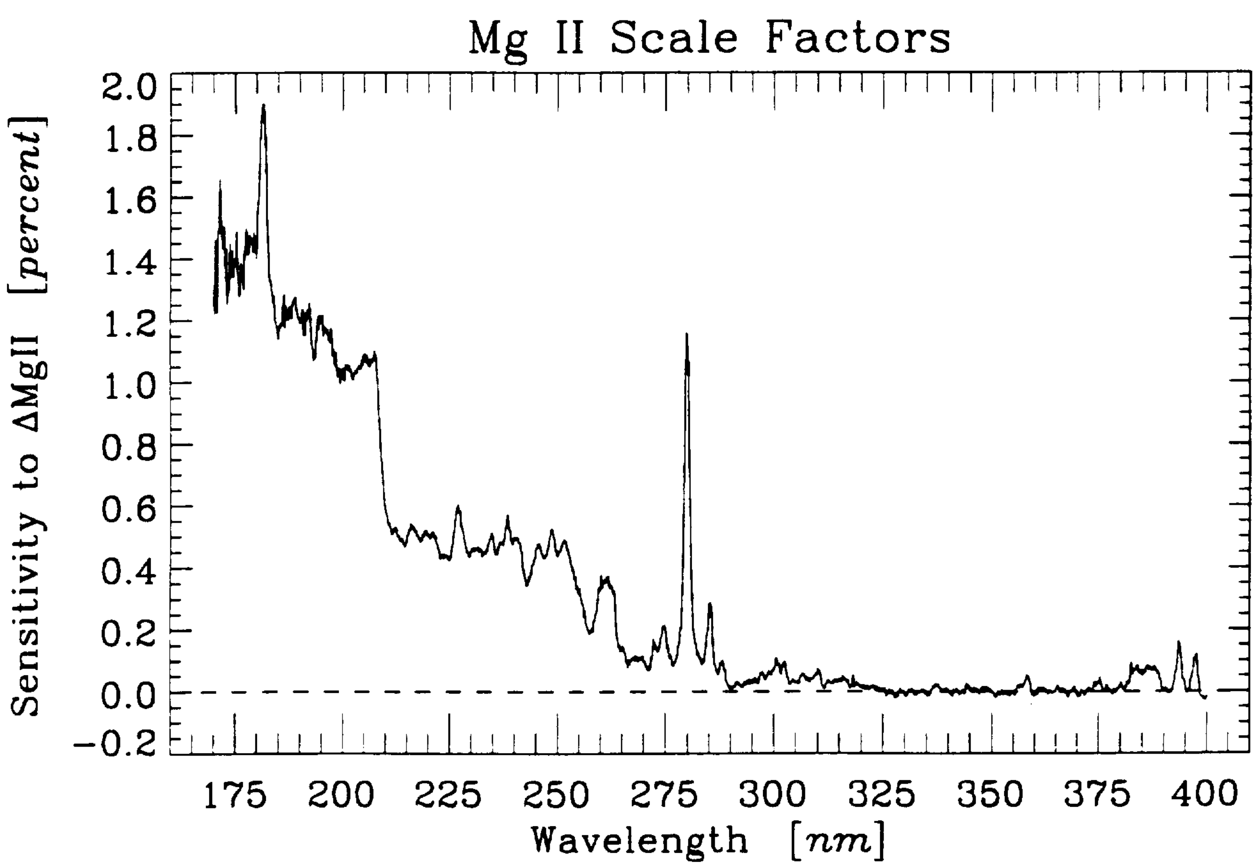

NOAA-11 SBUV/2 Spectral Irradiance Change
WAVELENGTH [nm]
400
380
360
340
320
300
280
260
240
220
200
180
160
Jan 1989
Jan 1990
Jan 1991
Jan 1992
Jan 1993
Jan 1994
Jan 1995
DATE
-10.0 -9.0 -8.0 -7.0 -6.0 -5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0
IRRADIANCE CHANGE [percent]

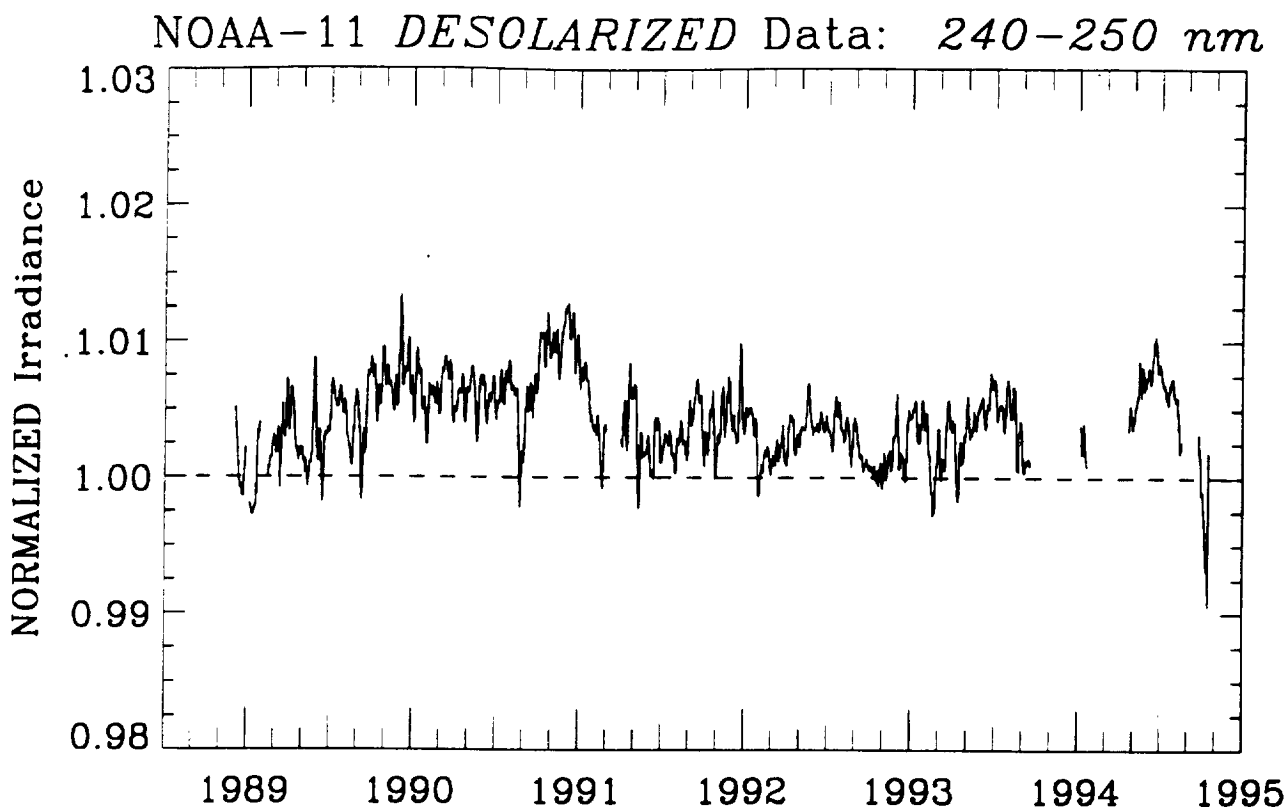
- Solar irradiance variations modeled using NOAA-11 Mg II index, scale factors; NOAA-11 Mg II agrees with NOAA-9 Mg II, SUSIM Mg II to within 1% during overlap periods

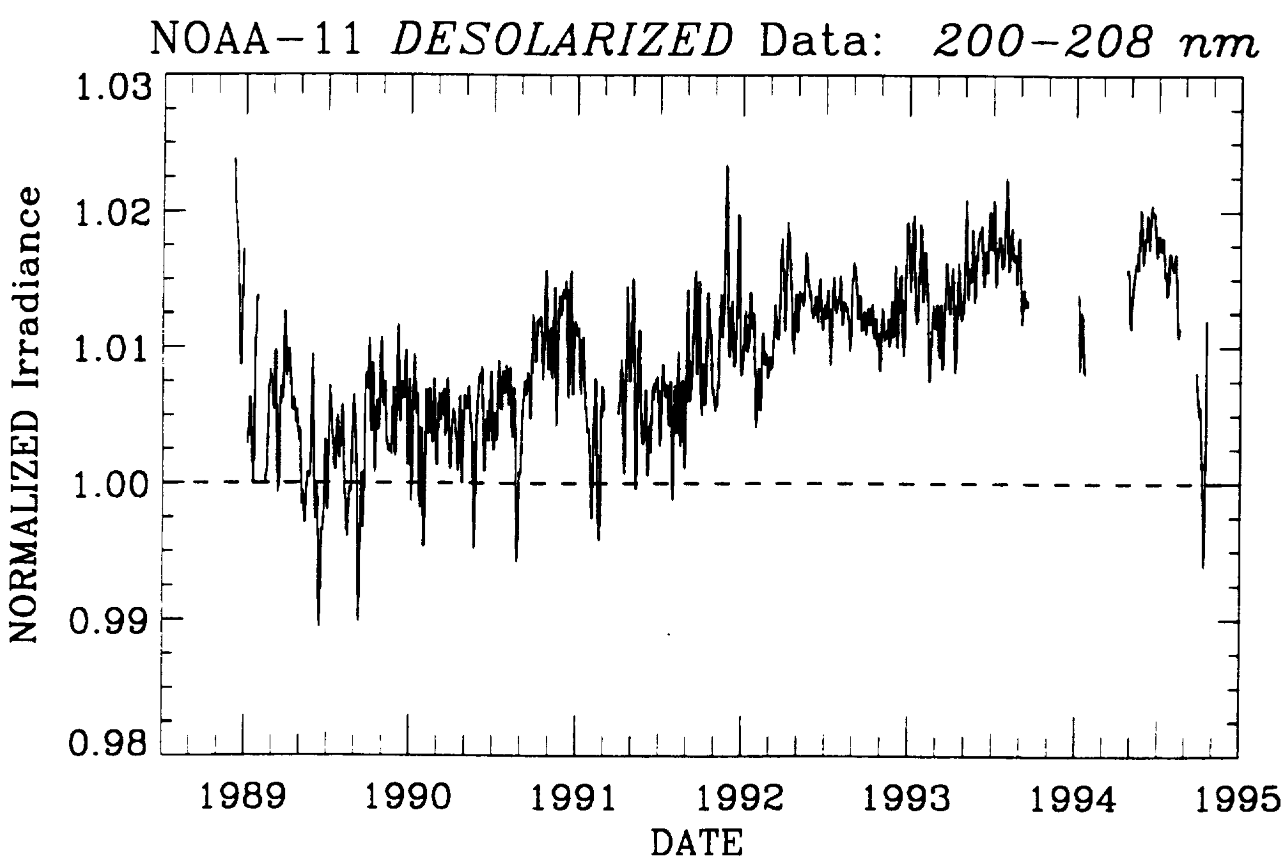
- "Desolarized" NOAA-11 irradiance data has long-term drift of +2% at 200-208 nm, < 1% at 240-250 nm

- If (Mg II + scale factor) result is correct for long-term change, $\Delta F_{solar} \approx -(6\text{-}7)\%$ at 200-208 nm, $-(3\text{-}4)\%$ at 240-250 nm during 1989-1994; *Compare with other instruments for validation*


NOAA-11 CLASSICAL DISCRETE Mg II Index
Mg II Index [core-to-wing ratio]
0.290
0.285
0.280
0.275
0.270
0.265
0.260
0.255
0.250
5%
UARS data
1989
1990
1991
1992
1993
1994
1995


Mg II Scale Factors
Sensitivity to ΔMgII [percent]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
175
200
225
250
275
300
325
350
375
400
Wavelength [nm]


NOAA-11 *DESOLARIZED* Data: *240-250 nm*
NORMALIZED Irradiance
1.03
1.02
1.01
1.00
0.99
0.98
1989
1990
1991
1992
1993
1994
1995

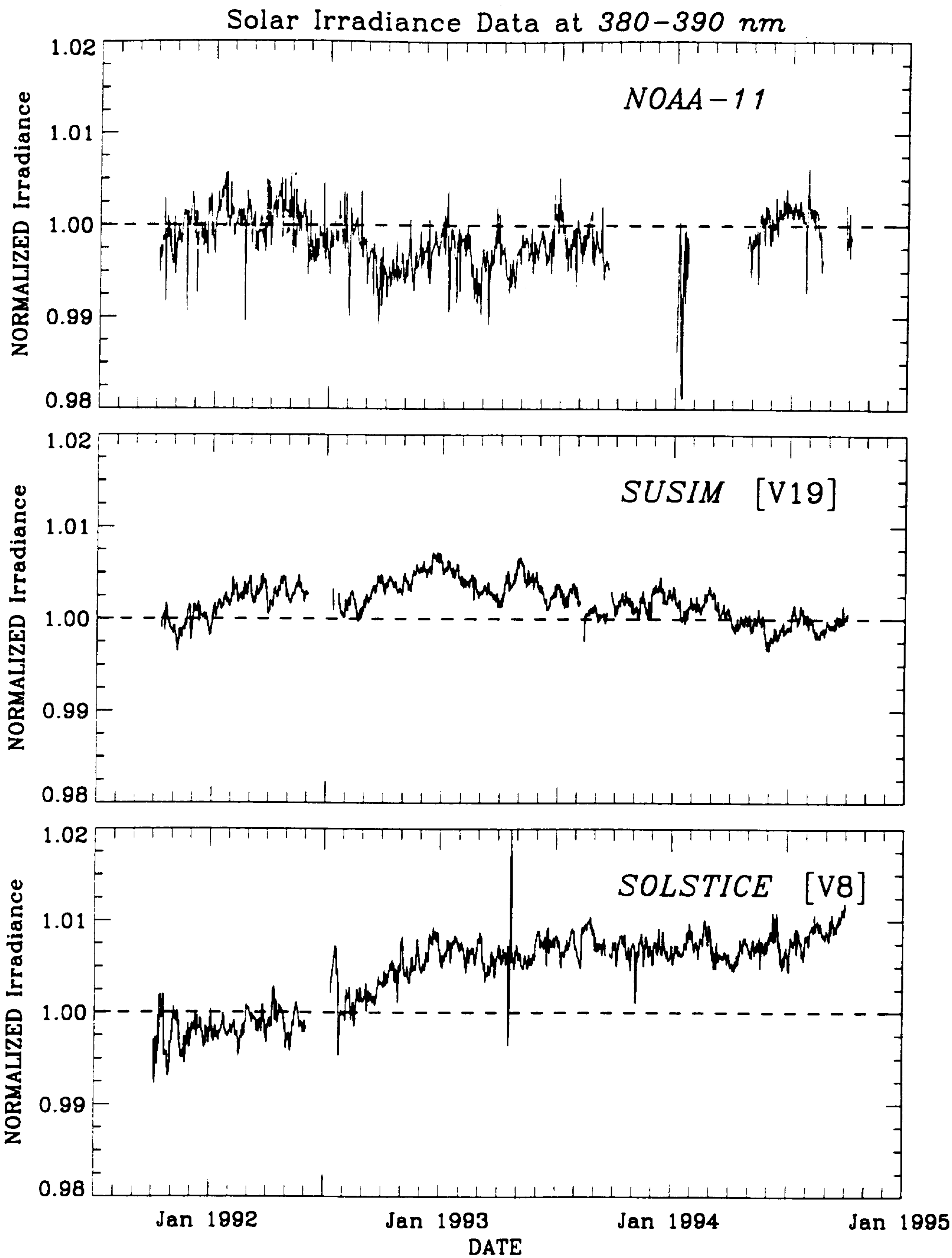

NOAA-11 *DESOLARIZED* Data: *200-208 nm*
NORMALIZED Irradiance
1.03
1.02
1.01
1.00
0.99
0.98
1989
1990
1991
1992
1993
1994
1995
DATE

- NOAA-11 data overlap UARS solar instruments (SUSIM, SOLSTICE) during Oct 1991 - Oct 1994; Results shown here use SUSIM V19 data, SOLSTICE V8 data

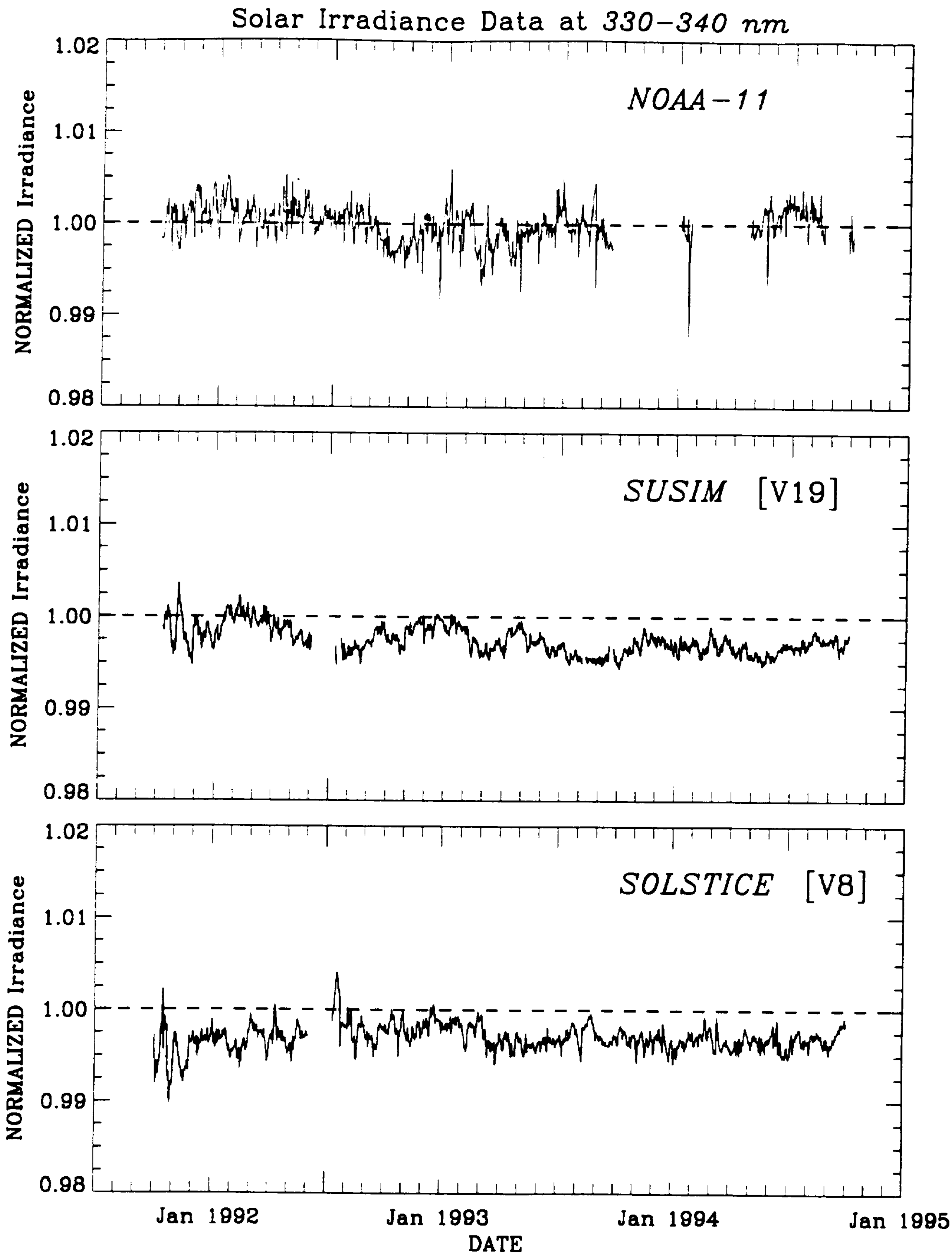
- Long wavelengths ($\lambda > 300$ nm) generally have $\Delta F <$ $\pm 1\%$; Raw data at short wavelengths ($\lambda < 260$ nm) show similar rotational activity, long-term decrease

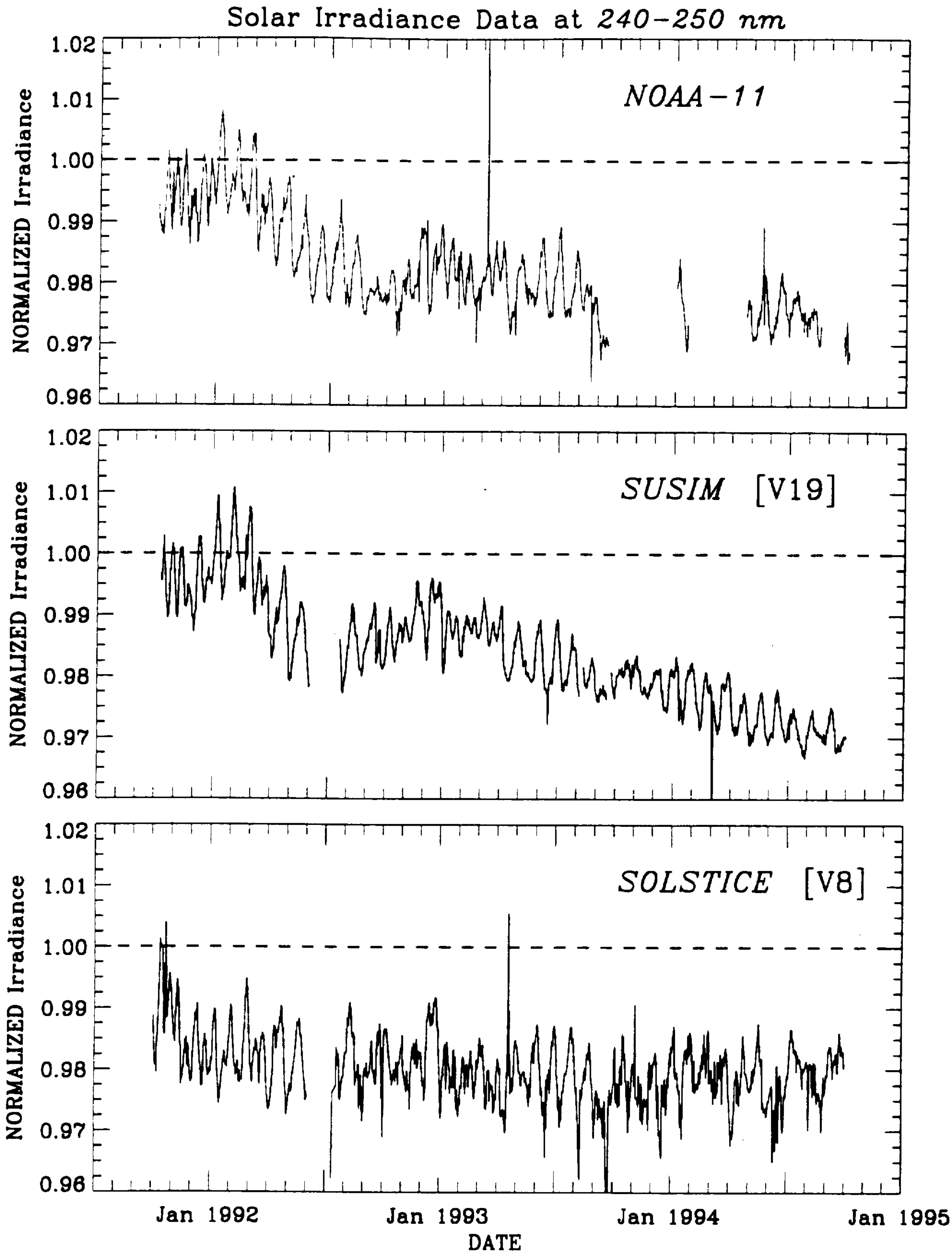
- Evaluate drift at short wavelengths by removing predicted solar change from all data; Results good to 1-2% for selected bands; No indication of long-term bias in Mg II-based solar change values

Comparisons with UARS Irradiances

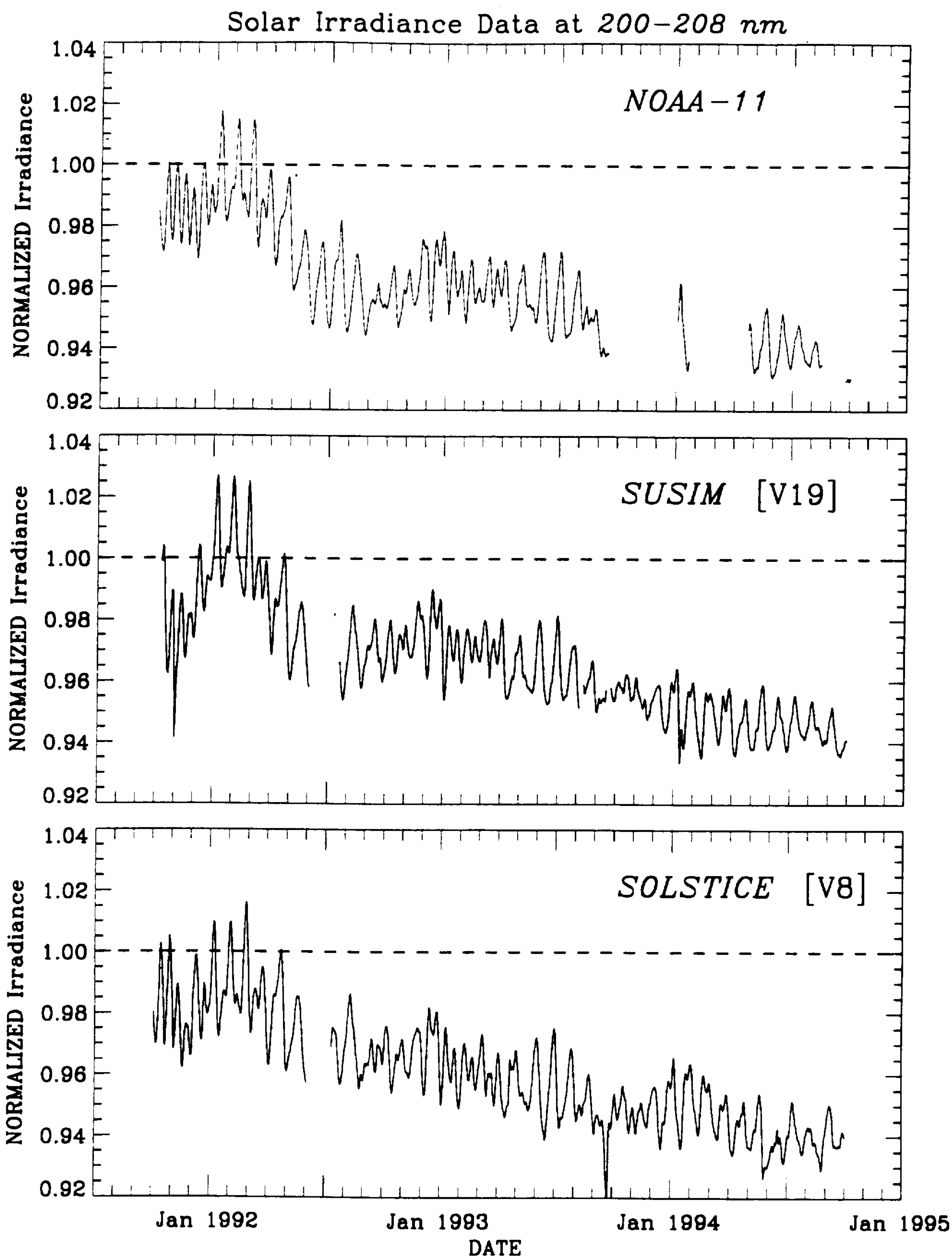


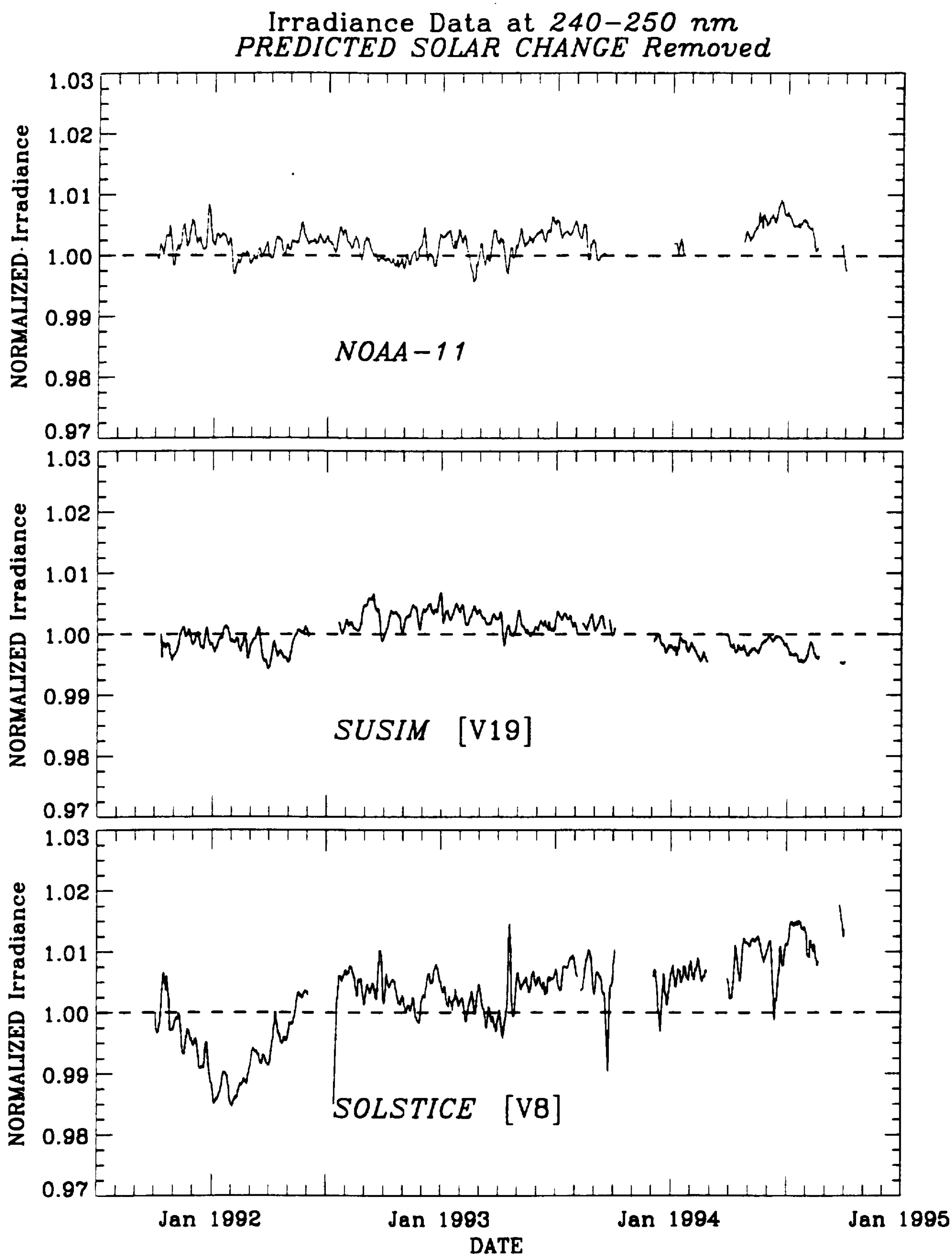
Solar Irradiance Data at 380–390 nm
NOAA–11
SUSIM [V19]
SOLSTICE [V8]
NORMALIZED Irradiance
1.02
1.01
1.00
0.99
0.98
Jan 1992
Jan 1993
Jan 1994
Jan 1995
DATE


Solar Irradiance Data at 330–340 nm
NOAA–11
SUSIM [V19]
SOLSTICE [V8]
NORMALIZED Irradiance
1.02
1.01
1.00
0.99
0.98
Jan 1992
Jan 1993
Jan 1994
Jan 1995
DATE

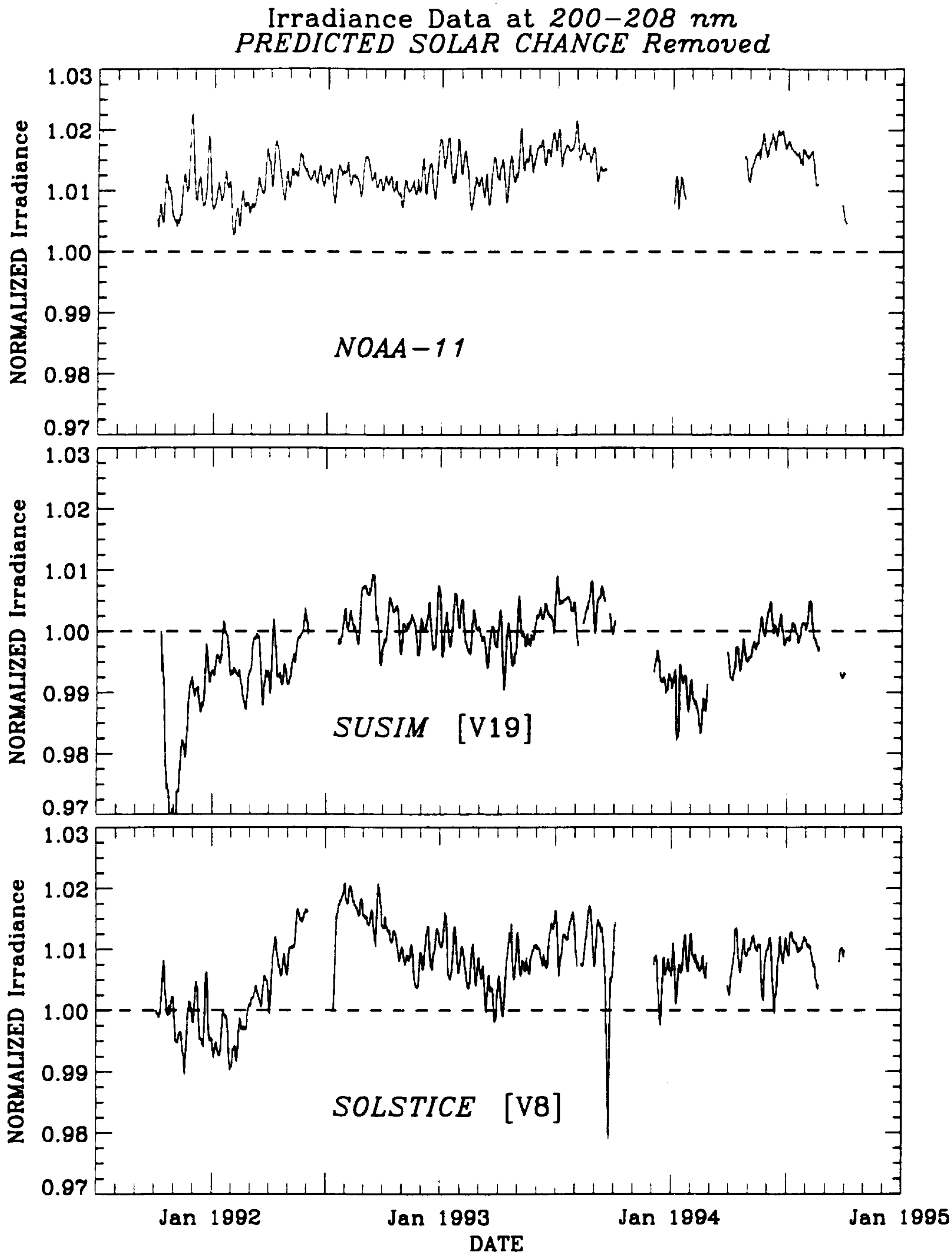


Solar Irradiance Data at 240–250 nm
NOAA–11
SUSIM [V19]
SOLSTICE [V8]
NORMALIZED Irradiance
1.02
1.01
1.00
0.99
0.98
0.97
0.96
Jan 1992
Jan 1993
Jan 1994
Jan 1995
DATE


Solar Irradiance Data at 200–208 nm
NOAA–11
SUSIM [V19]
SOLSTICE [V8]
NORMALIZED Irradiance
1.04
1.02
1.00
0.98
0.96
0.94
0.92
Jan 1992
Jan 1993
Jan 1994
Jan 1995
DATE



Irradiance Data at 240–250 nm
PREDICTED SOLAR CHANGE Removed
NORMALIZED Irradiance
1.03
1.02
1.01
1.00
0.99
0.98
0.97
NOAA–11
SUSIM [V19]
SOLSTICE [V8]
Jan 1992
Jan 1993
Jan 1994
Jan 1995
DATE

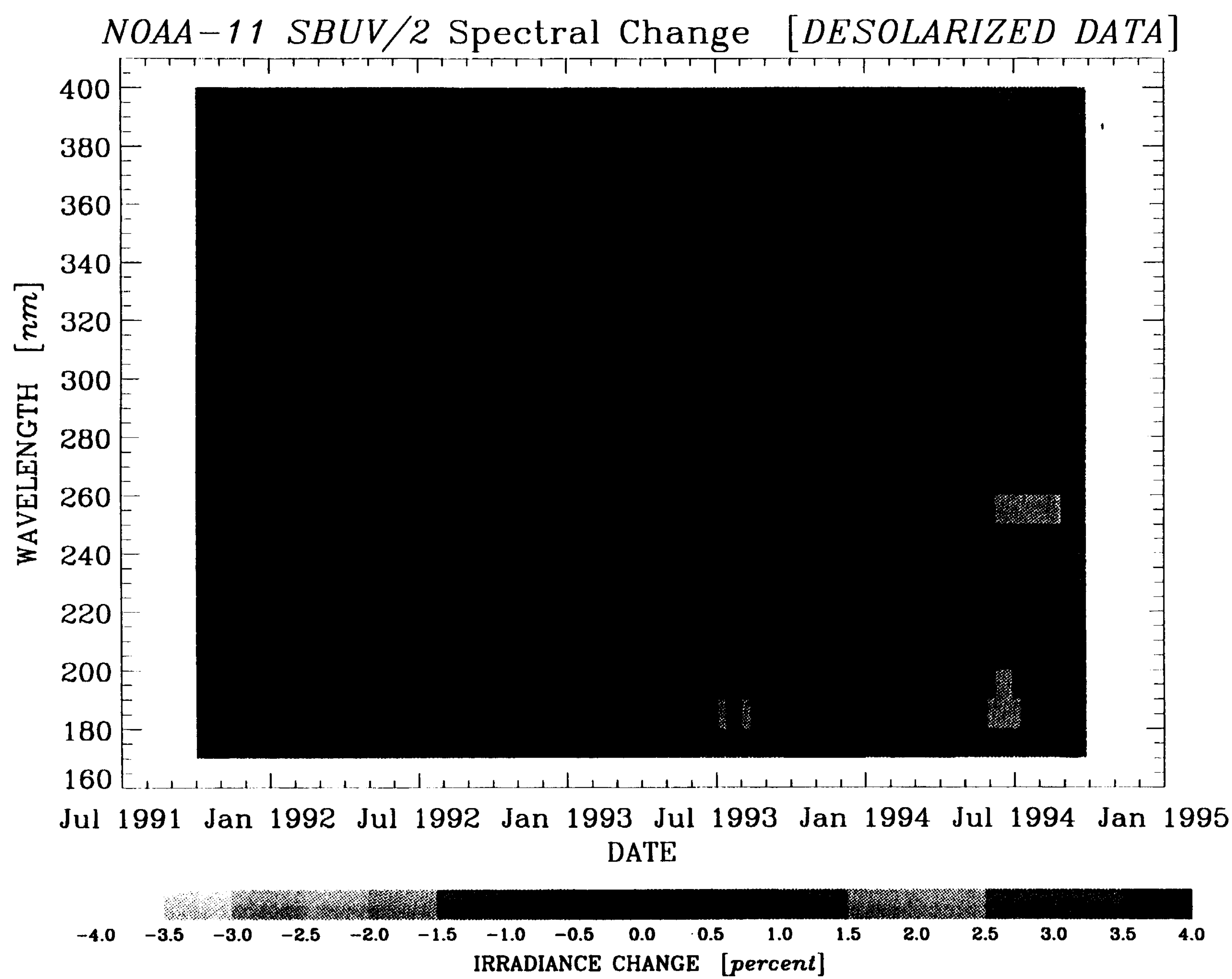

Irradiance Data at 200–208 nm
PREDICTED SOLAR CHANGE Removed
NORMALIZED Irradiance
1.03
1.02
1.01
1.00
0.99
0.98
0.97
NOAA–11
SUSIM [V19]
SOLSTICE [V8]
Jan 1992
Jan 1993
Jan 1994
Jan 1995
DATE

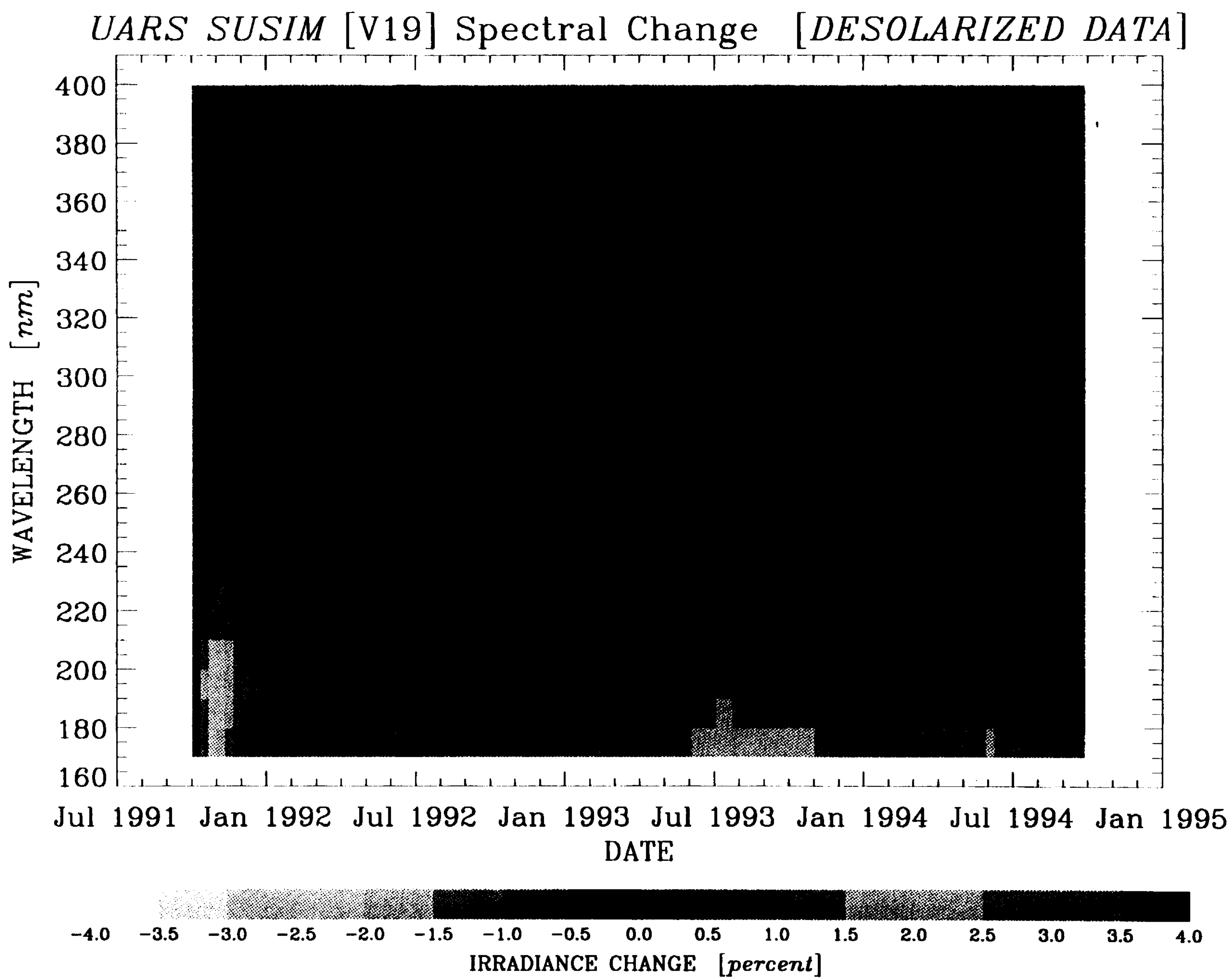
- For full comparison, remove predicted solar change from all 10 nm bands and plot together

    - **NOAA-11** data mostly within ±1% range, with drift of +1-2% at $\lambda < 200$ nm [*light green*]; These data represent later part of NOAA-11 data record

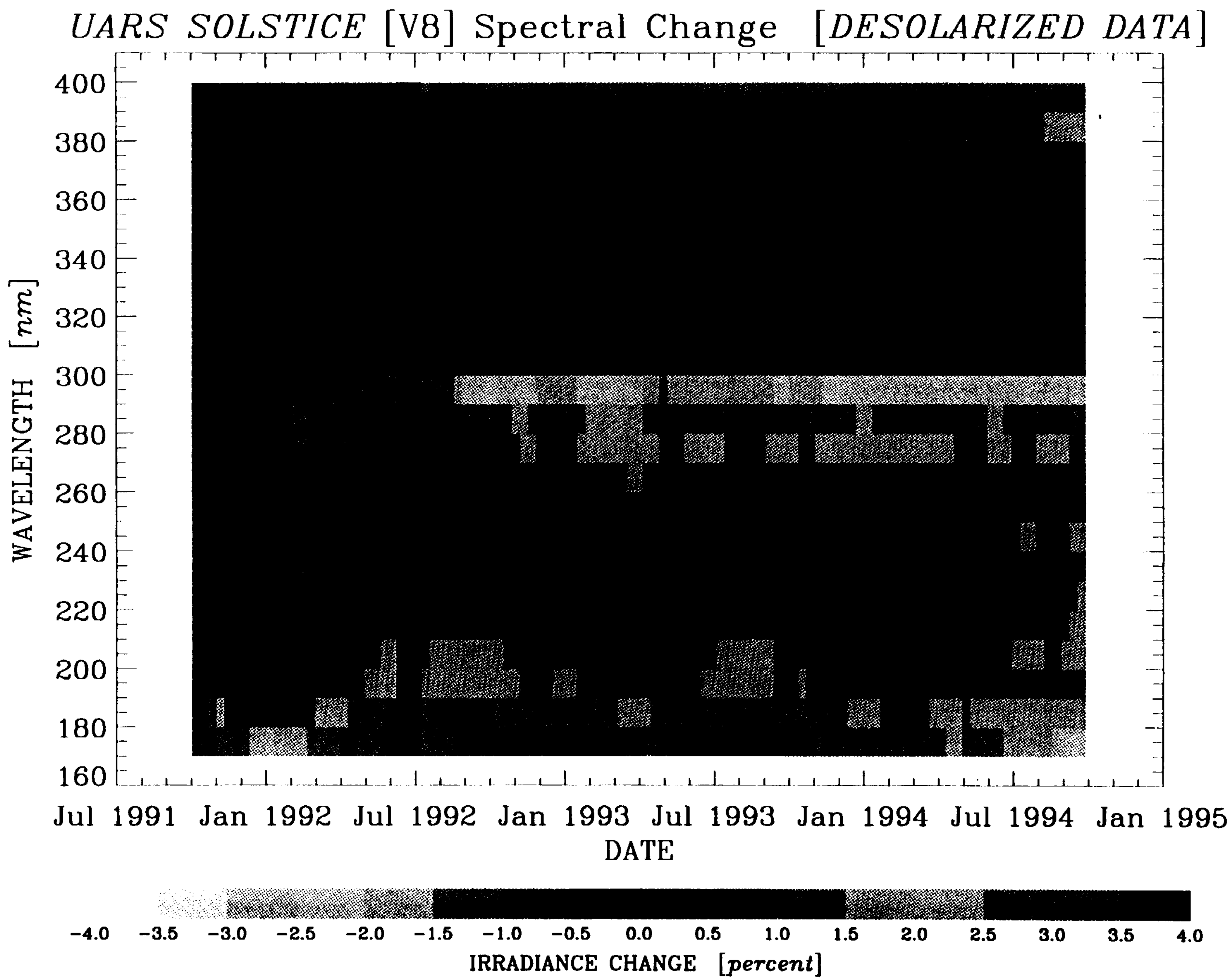
    - **SUSIM** data fall in ±1% range, except for early dip at $\lambda < 230$ nm [*yellow*] and additional drift at 170-190 nm

    - **SOLSTICE** data good to ~1% at 300-380, 220-260 nm; Drifts of –2% or more present in 260-300 nm region, particularly 290 nm [*yellow*]; Data for $\lambda < 210$ nm have positive drift, reaching $\Delta F = 3\text{-}4\%$ at 180-190 nm [*blue*]


NOAA−11 SBUV/2 Spectral Change [DESOLARIZED DATA]
WAVELENGTH [nm]
400
380
360
340
320
300
280
260
240
220
200
180
160
Jul 1991
Jan 1992
Jul 1992
Jan 1993
Jul 1993
Jan 1994
Jul 1994
Jan 1995
DATE
−4.0
−3.5
−3.0
−2.5
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
IRRADIANCE CHANGE [percent]



UARS SUSIM [V19] Spectral Change [DESOLARIZED DATA]
WAVELENGTH [nm]
400
380
360
340
320
300
280
260
240
220
200
180
160
Jul 1991 Jan 1992 Jul 1992 Jan 1993 Jul 1993 Jan 1994 Jul 1994 Jan 1995
DATE
−4.0 −3.5 −3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
IRRADIANCE CHANGE [percent]


UARS SOLSTICE [V8] Spectral Change [DESOLARIZED DATA]
WAVELENGTH [nm]
400
380
360
340
320
300
280
260
240
220
200
180
160
Jul 1991
Jan 1992
Jul 1992
Jan 1993
Jul 1993
Jan 1994
Jul 1994
Jan 1995
DATE
−4.0 −3.5 −3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
IRRADIANCE CHANGE [percent]

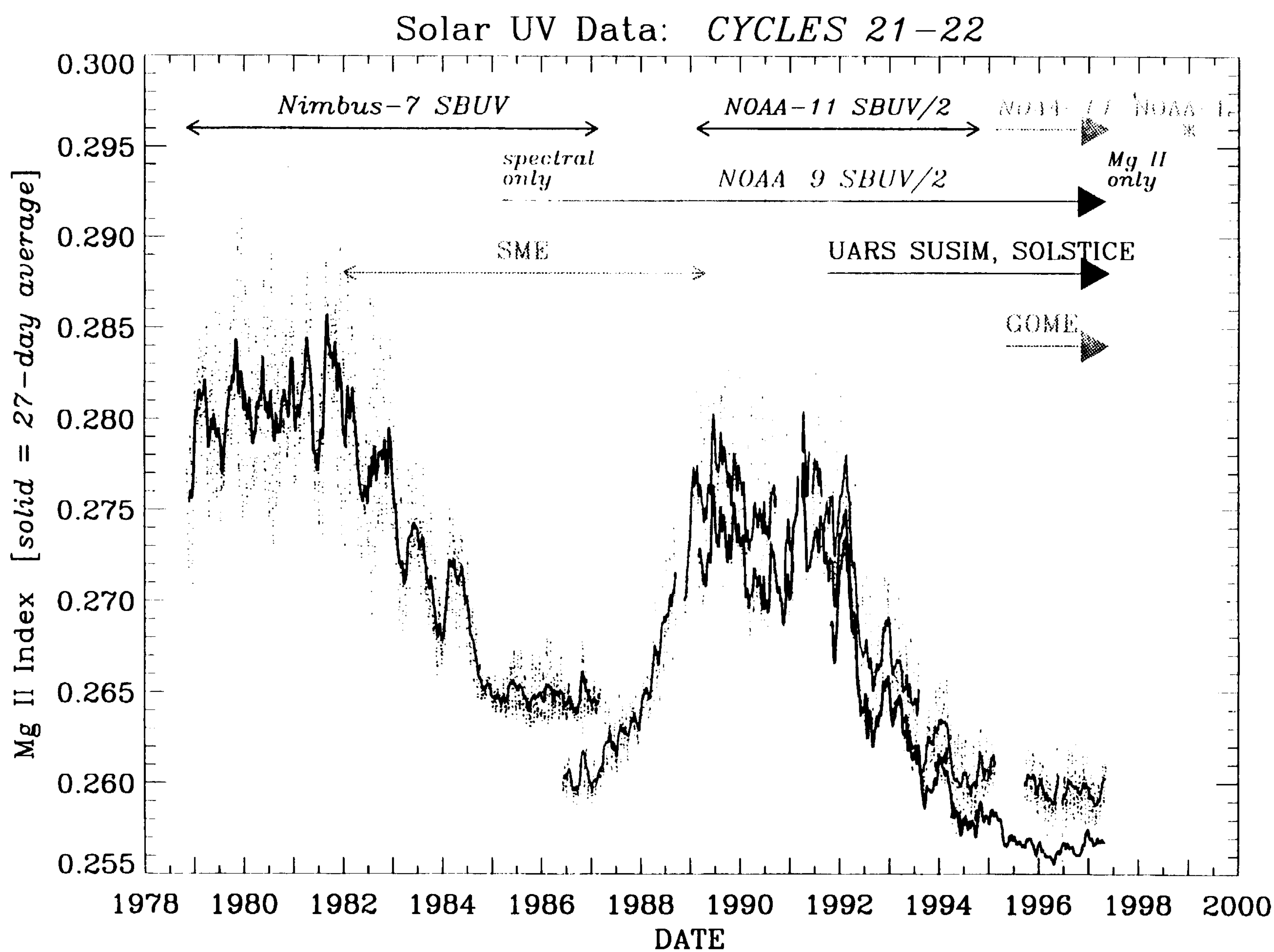
- NOAA-11 solar spectral irradiance data [170-400 nm, December 1988 - October 1994] have been processed with full corrections based on SSBUV coincident data

- Results have long-term accuracy of ±1% at most wavelengths; Solar change from late 1989 (maximum of Cycle 22) to October 1994 (close to minimum) ≈ –(6-7)% at 200-208 nm, –(3-4)% at 240-250 nm

- Comparisons with coincident UARS data during 1991-1994 show that NOAA-11 irradiance data have comparable long-term accuracy, representation of short-term variations

- NOAA-11, NOAA-9 discrete Mg II index data and Mg II scale factors now available at anonymous FTP site [*ssbuv.gsfc.nasa.gov*]; **NOAA-11 spectral irradiance data will be available on-line in Summer 1997**

CONCLUSIONS


Solar UV Data: CYCLES 21-22
Nimbus-7 SBUV
NOAA-11 SBUV/2
spectral only
NOAA 9 SBUV/2
Mg II only
SME
UARS SUSIM, SOLSTICE
GOME
Mg II Index [solid = 27-day average]
DATE
0.300
0.295
0.290
0.285
0.280
0.275
0.270
0.265
0.260
0.255
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000