

MODIS Calibration & Characterization Report

Reflective Band Spectral Sensitivity Studies

By

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MODIS Bands 1-7 (Primary Scientific Purpose)

| Band N | Ground Resolution GIFOV [m] | FWHM Band Pass* | | Primary Scientific Purpose |
|-----------|--------------------------------------|--------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------|
| | | Lower 50% Bandpass λ_{Min} [nm] | Upper 50% Bandpass λ_{Max} [nm] | |
| 1 | 250 | 620 | 670 | Vegetation Chlorophyll Absorption Land Cover Transformations Cloud/Edge Detection/Masks |
| 2 | 250 | 841 | 876 | Cloud/Vegetation/Water/Edge Detection Land Cover Transformations/Masks |
| 3 | 500 | 459 | 479 | Soil & Vegetation Differences |
| 4 | 500 | 545 | 565 | Green Vegetation |
| 5 | 500 | 1230 | 1250 | Leaf & Canopy Properties |
| 6 | 500 | 1628 | 1652 | Snow & Cloud Differences/Masks |
| 7 | 500 | 2105 | 2155 | Land & Cloud Properties |

* FWHM (Full Width at Half Maximum) = $\lambda_{Max} - \lambda_{Min}$,
 where $\lambda_{Max} = \lambda_c + (BW/2)$ and $\lambda_{Min} = \lambda_c - (BW/2)$,
 λ_c is the Center Wavelength and BW is Bandwidth

DK0015

MODIS Bands 8-19, 26 (Primary Scientific Purpose)

| Band N | Ground Resolution GIFOV [m] | FWHM Band Pass* | | Primary Scientific Purpose |
|-----------|--------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------------|
| | | Lower 50% Bandpass λ_{Min} [nm] | Upper 50% Bandpass λ_{Max} [nm] | |
| 8 | 1000 | 405 | 420 | Water Color (Chlorophyll/Pigments/Sediments) Atmospheric Scattering/Cloud Mask |
| 9 | 1000 | 438 | 448 | Water Color |
| 10 | 1000 | 483 | 493 | Water Color |
| 11 | 1000 | 526 | 536 | Water Color |
| 12 | 1000 | 546 | 556 | Sediments |
| 13 | 1000 | 662 | 672 | Sediments, Atmosphere |
| 14 | 1000 | 673 | 683 | Chlorophyll Fluorescence |
| 15 | 1000 | 743 | 753 | Aerosol Properties |
| 16 | 1000 | 862 | 877 | Aerosol and Atmospheric Properties |
| 17 | 1000 | 890 | 920 | Water Vapor/Atmospheric Properties |
| 18 | 1000 | 931 | 941 | Water Vapor/Atmospheric Properties |
| 19 | 1000 | 915 | 965 | Water Vapor/Atmospheric Properties |
| 26 | 1000 | 1360 | 1390 | Cirrus Cloud/Cloud Mask |

* FWHM (Full Width at Half Maximum) = $\lambda_{Max} - \lambda_{Min}$,
 where $\lambda_{Max} = \lambda_c + (BW/2)$ and $\lambda_{Min} = \lambda_c - (BW/2)$,
 λ_c is the Center Wavelength and BW is Bandwidth

DK0016

MODIS Bands 20-29 (Primary Scientific Purpose)

| Band N | Ground Resolution GIFOV [m] | FWHM Band Pass* | | Primary Scientific Purpose |
|-----------|--------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------|
| | | Lower 50% Bandpass λ_{Min} [nm] | Upper 50% Bandpass λ_{Max} [nm] | |
| 20 | 1000 | 3660 | 3840 | Sea Surface Temperature |
| 21 | 1000 | 3931 | 3987 | Forest Fires/Volcanoes |
| 22 | 1000 | 3929 | 3989 | Cloud |
| 23 | 1000 | 4020 | 4080 | Cloud/Surface Temperature/Cloud Mask |
| 24 | 1000 | 4433 | 4498 | Cloud/Surface Temperature/Cloud Mask |
| 25 | 1000 | 4482 | 4549 | Tropical Temperature/Cloud Fraction |
| 27 | 1000 | 6535 | 6895 | Tropical Temperature/Cloud Fraction |
| 28 | 1000 | 7175 | 7475 | Mid-Tropical Humidity |
| 29 | 1000 | 8400 | 8700 | Upper-Tropical Humidity |

* FWHM (Full Width at Half Maximum) = $\lambda_{Max} - \lambda_{Min}$,
 where $\lambda_{Max} = \lambda_c + (BW/2)$ and $\lambda_{Min} = \lambda_c - (BW/2)$,
 λ_c is the Center Wavelength and BW is Bandwidth

DK0017

MODIS Bands 30-36 (Primary Scientific Purpose)

| Band N | Ground Resolution GIFOV [m] | FWHM Band Pass* | | Primary Scientific Purpose |
|-----------|--------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------|
| | | Lower 50% Bandpass λ_{Min} [nm] | Upper 50% Bandpass λ_{Max} [nm] | |
| 30 | 1000 | 9580 | 9880 | Surface Temperature/Cloud Mask |
| 31 | 1000 | 10780 | 11280 | Total Ozone |
| 32 | 1000 | 11770 | 12270 | Cloud/Surface Temperature |
| 33 | 1000 | 13185 | 13485 | Cloud/Surface Temperature |
| 34 | 1000 | 13485 | 13785 | Cloud Height & Fraction |
| 35 | 1000 | 13785 | 14085 | Cloud Height & Fraction |
| 36 | 1000 | 14085 | 14385 | Cloud Height & Fraction |

* FWHM (Full Width at Half Maximum) = $\lambda_{Max} - \lambda_{Min}$,
 where $\lambda_{Max} = \lambda_c + (BW/2)$ and $\lambda_{Min} = \lambda_c - (BW/2)$,
 λ_c is the Center Wavelength and BW is Bandwidth

DK0018

MODIS Reflective Band Spectral Specification Changes: Center Wavelength

| MODIS Band | Original 1/17/92 | | Adjusted 5/12/92 | | Change | | Rationale |
|------------|------------------|-----|------------------|-----|--------|------|--------------------------------------------------------------|
| | CW | Tol | CW | CWT | CW | CWT | |
| 1 | 659 | 5 | 645 | 4 | -14 | -1 | Increase distance to chlorophyl and water absorption bands |
| 2 | 865 | 5 | 858 | 2.2 | -7 | -2.8 | Center band between strong water absorption features |
| 3 | 470 | 5 | 469 | 4 | -1 | -1 | Increase distance to Fraunhofer line at 487nm. |
| 4 | 555 | 5 | 555 | 4 | 0 | -1 | No spectral issues. Trade of CWT for BWT per vendor request. |
| 5 | 1240 | 6 | 1240 | 5 | 0 | -1 | CWT reduced for BWT relaxation per vendor request. |
| 6 | 1640 | 8 | 1640 | 7 | 0 | -1 | CWT reduction traded for BWT increase per vendor request. |
| 7 | 2130 | 10 | 2130 | 8 | 0 | -2 | CWT reduction traded for BWT increase per vendor request. |

DK-0002

MODIS Reflective Band Spectral Specification Changes: Bandwidth

| MODIS Band | Original 1/17/92 | | Adjusted 5/12/92 | | Change | | Rationale |
|------------|------------------|------|------------------|------|--------|-----|--------------------------------------------------------------|
| | BW | BWT | BW | BWT | BW | BWT | |
| 1 | 50 | 3.3 | 50 | 4 | 0 | 0.7 | Increase distance to chlorophyl and water absorption bands |
| 2 | 40 | 4.3 | 35 | 4.3 | -5 | 0 | Center band between strong water absorption features |
| 3 | 20 | 2.4 | 20 | 2.8 | 0 | 0.4 | Increase distance to Fraunhofer line at 487nm. |
| 4 | 20 | 2.8 | 20 | 3.3 | 0 | 0.5 | No spectral issues. Trade of CWT for BWT per vendor request. |
| 5 | 20 | 6.2 | 20 | 7.4 | 0 | 1.2 | CWT reduced for BWT relaxation per vendor request. |
| 6 | 20 | 8.2 | 24.6 | 9.8 | 4.6 | 1.6 | CWT reduction traded for BWT increase per vendor request. |
| 7 | 50 | 10.7 | 50 | 12.8 | 0 | 2.1 | CWT reduction traded for BWT increase per vendor request. |

DK-0001

MODIS Reflective Band Spectral Specification Changes: Center Wavelength

| MODIS Band | Original 1/17/92 | | Adjusted 5/12/92 | | Change | | Rationale |
|------------|------------------|------|------------------|------|--------|-----|-----------------------------------------------------------------------------------|
| | CW | Tol | CW | CWT | CW | CWT | |
| 8 | 415 | 2 | 412 | 2 | -3 | 0 | CW moved down to center on Fraunhofer line. BWT relaxed per vendor request. |
| 9 | 443 | 1 | 443 | 1.1 | 0 | 0.1 | No issue. BWT relaxation per vendor request. |
| 10 | 490 | 1 | 488 | 1.2 | -2 | 2 | CW moved down to center on Fraunhofer line. CWT and BWT relaxed - vendor request. |
| 11 | 531 | 2 | 531 | 2 | 0 | 0 | BWT relaxed per vendor request. |
| 12 | 555 | 5 | 551 | 5 | -4 | 0 | CW moved away from water absorption feature at 556nm. |
| 13 | 667 | 1,-2 | 667 | 1,-2 | 0 | 0 | No Issues |
| 14 | 681 | 1 | 678 | 1 | -3 | 0 | Complex issues resulted in shifting CW down by 3 nm. |
| 15 | 750 | 2 | 748 | 2 | -2 | 0 | Shift of CW to 748 recommended by Oceans team. |
| 16 | 865 | 5 | 869 | 5 | 4 | 0 | Shift of CW to 869 nm to increase distance to water feature. |
| 17 | 905 | 1 | 905 | 2.3 | 0 | 1.3 | Relaxation of CWT & BWT approved per vendor request. |
| 18 | 936 | 1 | 936 | 2.3 | 0 | 1.3 | Relaxation of CWT & BWT approved per vendor request. |
| 19 | 940 | 1 | 940 | 2.4 | 0 | 1.4 | Relaxation of CWT & BWT approved per vendor request. |
| 26 | | | 1375 | 6 | | | Cirrus cloud band not defined at time of study. |

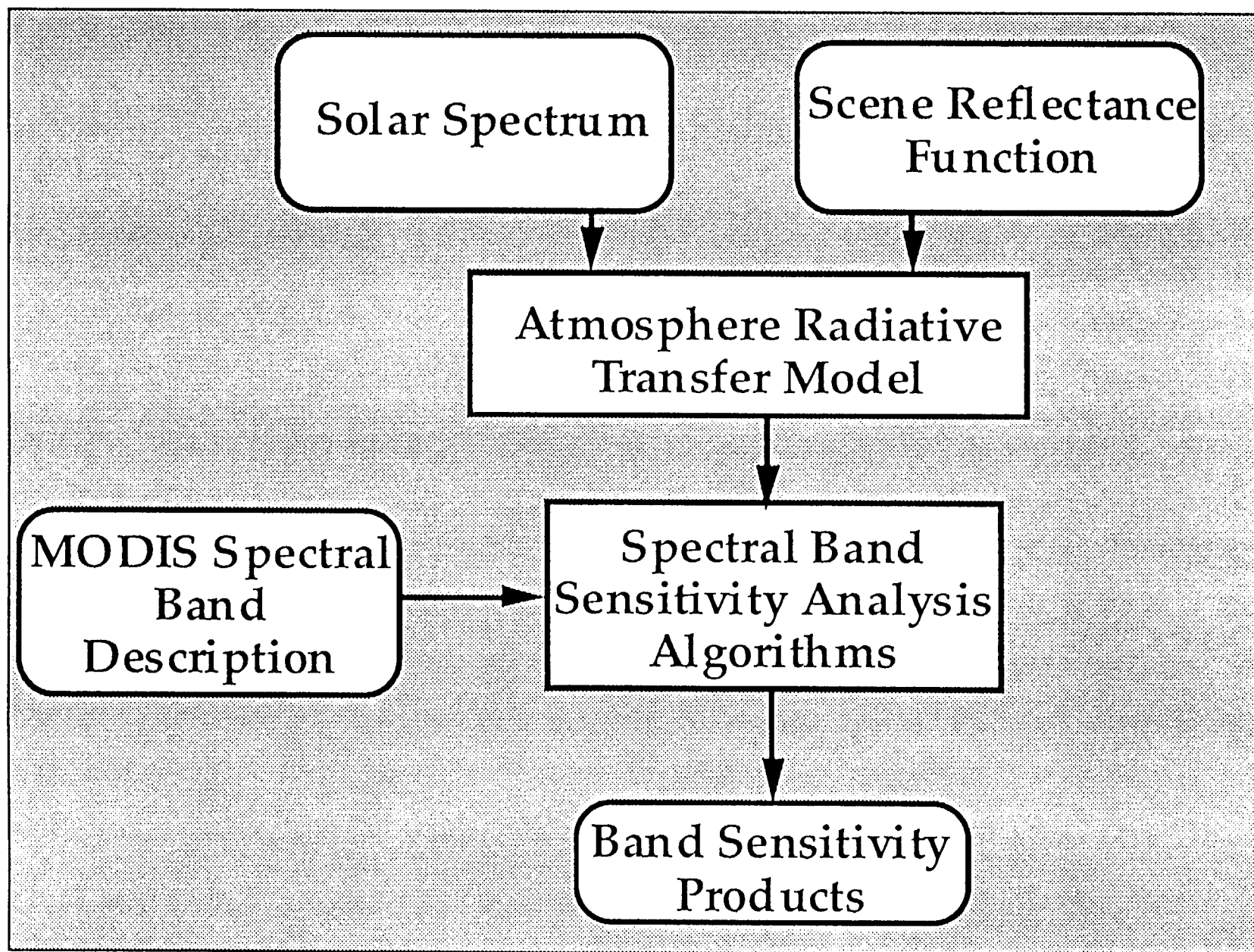
DK-0004

MODIS Reflective Band Spectral Specification Changes: Bandwidth

| MODIS Band | Original 1/17/92 | | Adjusted 5/12/92 | | Change | | Rationale |
|------------|------------------|-----|------------------|-----|--------|-----|-----------------------------------------------------------------------------------|
| | BW | BWT | BW | BWT | BW | BWT | |
| 8 | 15 | 1 | 15 | 1.5 | 0 | 0.5 | CW moved down to center on Fraunhofer line. BWT relaxed per vendor request. |
| 9 | 10 | 1.1 | 10 | 1.6 | 0 | 0.5 | No issue. BWT relaxation per vendor request. |
| 10 | 10 | 1.2 | 10 | 1.7 | 0 | 0.5 | CW moved down to center on Fraunhofer line. CWT and BWT relaxed - vendor request. |
| 11 | 10 | 1.3 | 10 | 1.9 | 0 | 0.6 | BWT relaxed per vendor request. |
| 12 | 10 | 1.4 | 10 | 1.4 | 0 | 0 | CW moved away from water absorption feature at 556nm. |
| 13 | 10 | 1.7 | 10 | 1.7 | 0 | 0 | No Issues |
| 14 | 10 | 1.7 | 10 | 1.7 | 0 | 0 | Complex issues resulted in shifting CW down by 3 nm. |
| 15 | 10 | 1.9 | 10 | 1.9 | 0 | 0 | Shift of CW to 748 recommended by Oceans team. |
| 16 | 15 | 4.3 | 15 | 4.3 | 0 | 0 | Shift of CW to 869 nm to increase distance to water feature. |
| 17 | 30 | 4.5 | 30 | 5.4 | 0 | 0.9 | Relaxation of CWT & BWT approved per vendor request. |
| 18 | 10 | 4.7 | 10 | 5.6 | 0 | 0.9 | Relaxation of CWT & BWT approved per vendor request. |
| 19 | 50 | 4.7 | 50 | 5.6 | 0 | 0.9 | Relaxation of CWT & BWT approved per vendor request. |
| 26 | | | 30 | 8 | | | Cirrus cloud band not defined at time of study. |

DK-0003

Sensitivity Analysis System Modules



DK0011

MODIS Band Output Radiance Change without Calibration
TOA Spectral Radiance Input (Kurucz solar spectrum, 1 cm water vapor, nominal vegetation reflectance)

| MODIS Band | Output Radiance Change | | | | | | | | |
|------------|------------------------|---------------|---------------|---------------|--------------|---------------|---------------|---------------|----------------|
| | CW Shift (-10) | CW Shift (-5) | CW Shift (-2) | CW Shift (-1) | CW Shift (0) | CW Shift (+1) | CW Shift (+2) | CW Shift (+5) | CW Shift (+10) |
| 1 | 2.5 | 0.9 | 0.3 | 0.1 | 0.0 | -0.1 | 0.0 | 0.2 | 1.7 |
| 2 | -2.3 | -0.6 | -0.3 | -0.2 | 0.0 | 0.2 | 0.2 | 1.3 | 2.0 |
| 3 | 6.7 | 2.9 | 1.2 | 0.5 | 0.0 | -0.5 | -0.5 | -2.9 | -6.8 |
| 4 | 5.2 | 2.5 | 1.1 | 0.5 | 0.0 | -0.6 | -0.6 | -3.1 | -6.1 |
| 5 | 5.9 | 3.4 | 1.5 | 0.7 | 0.0 | -0.8 | -1.6 | -4.1 | -7.9 |
| 6 | 1.5 | 1.2 | 0.6 | 0.3 | 0.0 | -0.3 | -0.7 | -1.8 | -3.8 |
| 7 | 1.8 | 1.1 | 0.5 | 0.3 | 0.0 | -0.3 | -0.3 | -2.0 | -5.8 |
| 8 | no data | no data | 1.3 | 0.6 | 0.0 | -0.5 | -0.8 | -2.3 | -7.3 |
| 9 | -7.7 | -2.5 | -0.7 | -0.5 | 0.0 | 0.8 | 0.9 | 3.2 | 2.7 |
| 10 | 12.0 | 5.9 | 2.1 | 1.0 | 0.0 | -0.7 | -0.2 | -0.4 | -3.3 |
| 11 | 1.2 | 1.5 | 0.6 | 0.2 | 0.0 | -0.3 | -0.3 | -2.8 | -5.6 |
| 12 | 4.1 | 2.3 | 1.1 | 0.6 | 0.0 | -1.1 | -1.1 | -3.3 | -6.2 |
| 13 | -11.0 | -6.2 | -2.4 | -1.3 | 0.0 | 1.4 | 1.5 | 8.2 | 17.0 |
| 14 | -15.0 | -7.5 | -3.0 | -1.4 | 0.0 | 1.3 | 1.1 | 2.6 | -2.4 |
| 15 | -17.0 | -9.0 | -3.3 | -1.5 | 0.0 | 1.0 | 0.6 | 0.3 | 22.0 |
| 16 | -6.2 | -2.2 | -0.6 | -0.3 | 0.0 | 0.5 | 0.7 | 3.6 | 6.1 |
| 17 | 38.0 | 18.0 | 6.9 | 3.4 | 0.0 | -3.2 | -2.9 | -14.0 | -26.0 |
| 18 | 304.0 | 110.0 | 22.0 | 7.8 | 0.0 | -2.8 | -2.8 | 5.7 | 11.0 |
| 19 | 22.0 | 8.0 | 2.7 | 1.3 | 0.0 | -1.0 | -1.9 | -3.1 | -3.7 |
| 26 | 84.0 | 17.0 | 3.5 | 1.4 | 0.0 | -1.0 | -0.8 | -5.2 | -22.0 |

DK-0006

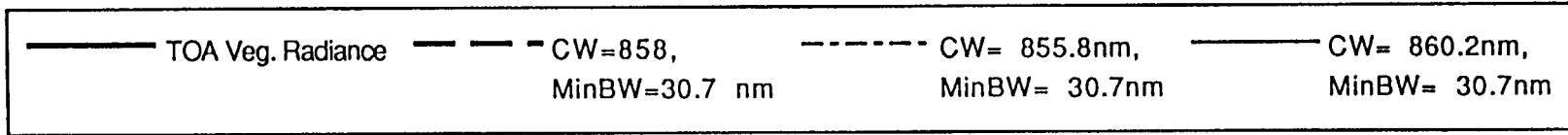
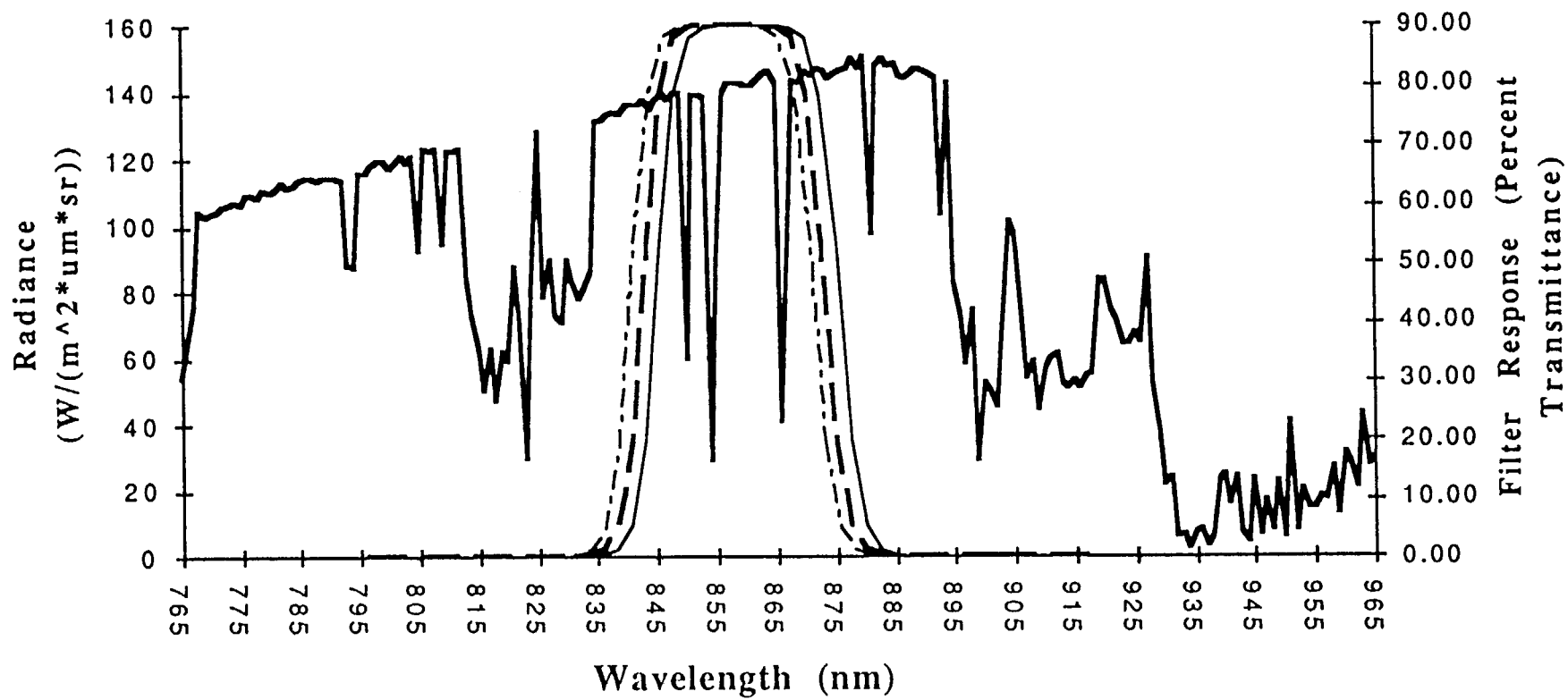
MODIS Band Output Radiance Change after Calibration with Solar Diffuser due to Shift in Filter Center Wavelength Compensated by Solar Change Ratio

TOA Spectral Radiance Input (Kurucz solar spectrum, 1 cm water vapor, nominal vegetation reflectance)

| MODIS Band | Output Radiance Change | | | | | | | | |
|------------|------------------------|---------------|---------------|---------------|--------------|---------------|---------------|---------------|----------------|
| | CW Shift (-10) | CW Shift (-5) | CW Shift (-2) | CW Shift (-1) | CW Shift (0) | CW Shift (+1) | CW Shift (+2) | CW Shift (+5) | CW Shift (+10) |
| 1 | 0.7 | 0.0 | -0.2 | -0.1 | 0.0 | 0.2 | 0.1 | 1.3 | 4.0 |
| 2 | -4.3 | -1.7 | -0.7 | -0.4 | 0.0 | 0.4 | 0.6 | 2.2 | 3.7 |
| 3 | 5.9 | 3.0 | 1.2 | 0.6 | 0.0 | -0.5 | -1.0 | -2.5 | -4.4 |
| 4 | 4.2 | 1.9 | 0.7 | 0.3 | 0.0 | -0.3 | -1.0 | -2.1 | -4.4 |
| 5 | 4.4 | 2.6 | 1.1 | 0.6 | 0.0 | -0.6 | -1.4 | -2.9 | -5.4 |
| 6 | -0.1 | 0.4 | 0.3 | 0.1 | 0.0 | -0.2 | -0.5 | -1.1 | -2.5 |
| 7 | -1.0 | -0.4 | -0.1 | -0.1 | 0.0 | 0.1 | -0.3 | 0.2 | 0.3 |
| 8 | no data | no data | -0.2 | -0.1 | 0.0 | 0.0 | -0.4 | 1.7 | 3.3 |
| 9 | 9.5 | 3.0 | 0.4 | 0.1 | 0.0 | 0.1 | 0.7 | -0.9 | -3.9 |
| 10 | 2.3 | 1.3 | 0.4 | 0.3 | 0.0 | -0.4 | -1.4 | -3.7 | -7.4 |
| 11 | 2.7 | 0.8 | 0.4 | 0.2 | 0.0 | -0.2 | -0.6 | -1.9 | -5.4 |
| 12 | 4.1 | 1.3 | 0.4 | 0.2 | 0.0 | -0.2 | -1.3 | -1.6 | -3.9 |
| 13 | -11.4 | -7.0 | -3.1 | -1.6 | 0.0 | 2.2 | 3.7 | 9.9 | 20.1 |
| 14 | -18.2 | -9.3 | -3.7 | -1.8 | 0.0 | 1.8 | 3.0 | 7.4 | 7.4 |
| 15 | -17.4 | -9.4 | -3.6 | -1.7 | 0.0 | 1.3 | 2.0 | 3.1 | -4.7 |
| 16 | -7.7 | -3.3 | -1.1 | -0.5 | 0.0 | 0.6 | 1.3 | 4.1 | 7.0 |
| 17 | 29.4 | 15.2 | 5.7 | 2.8 | 0.0 | -2.5 | -5.4 | -9.7 | -11.0 |
| 18 | 278.5 | 104.0 | 21.1 | 7.4 | 0.0 | -2.5 | -2.2 | 10.6 | 34.3 |
| 19 | 13.9 | 5.0 | 1.6 | 0.7 | 0.0 | -0.5 | -1.2 | 1.7 | 16.9 |
| 26 | 73.1 | 13.7 | 2.4 | 0.9 | 0.0 | -0.4 | -1.1 | -0.5 | -5.5 |

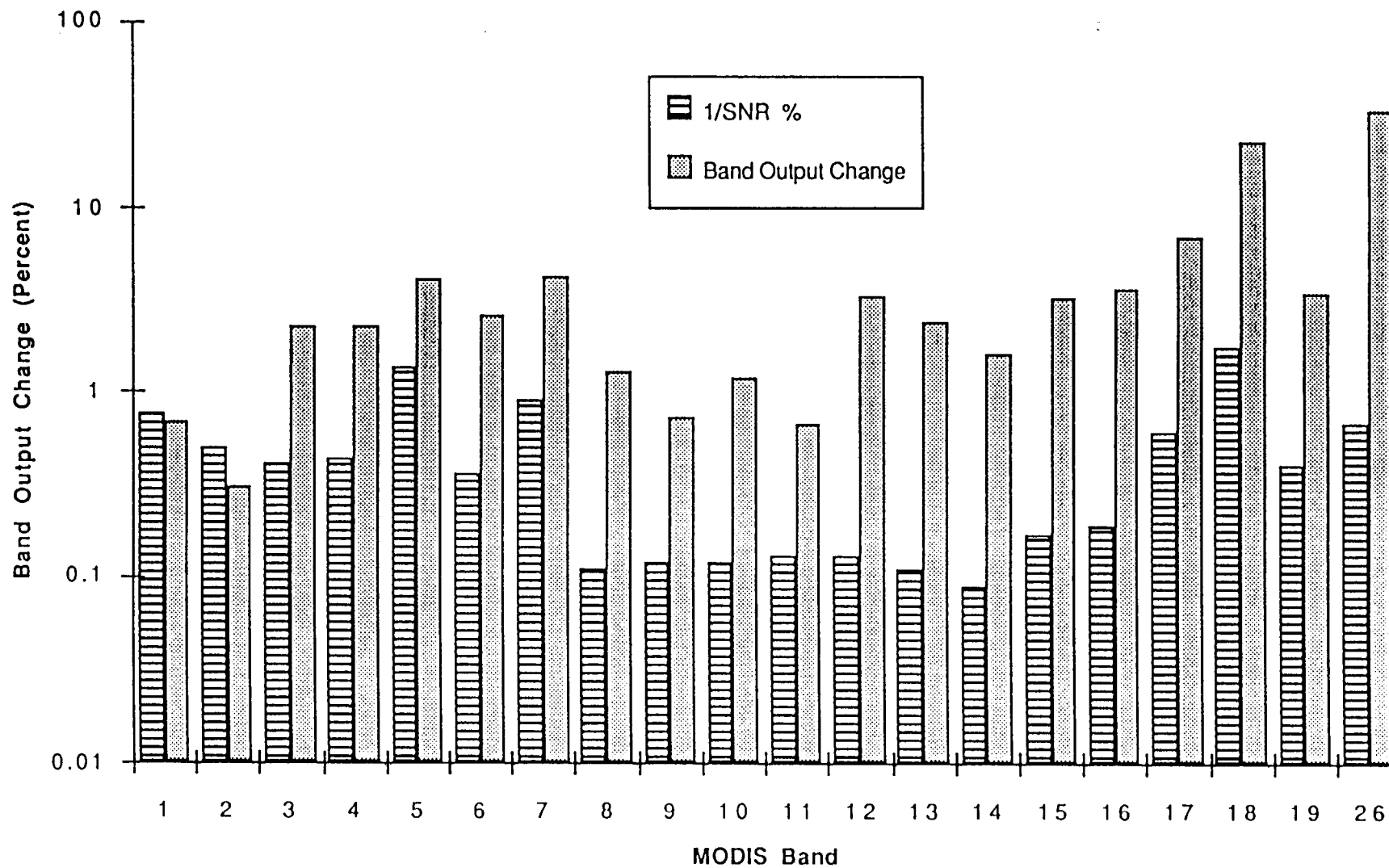
DK-0005

Proposed (5/12/92) MODIS Band-2 Filter Response and Vegetation Radiance Spectra (TOA)



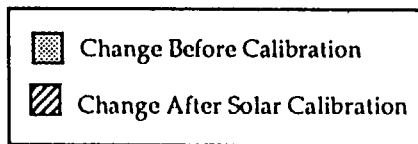
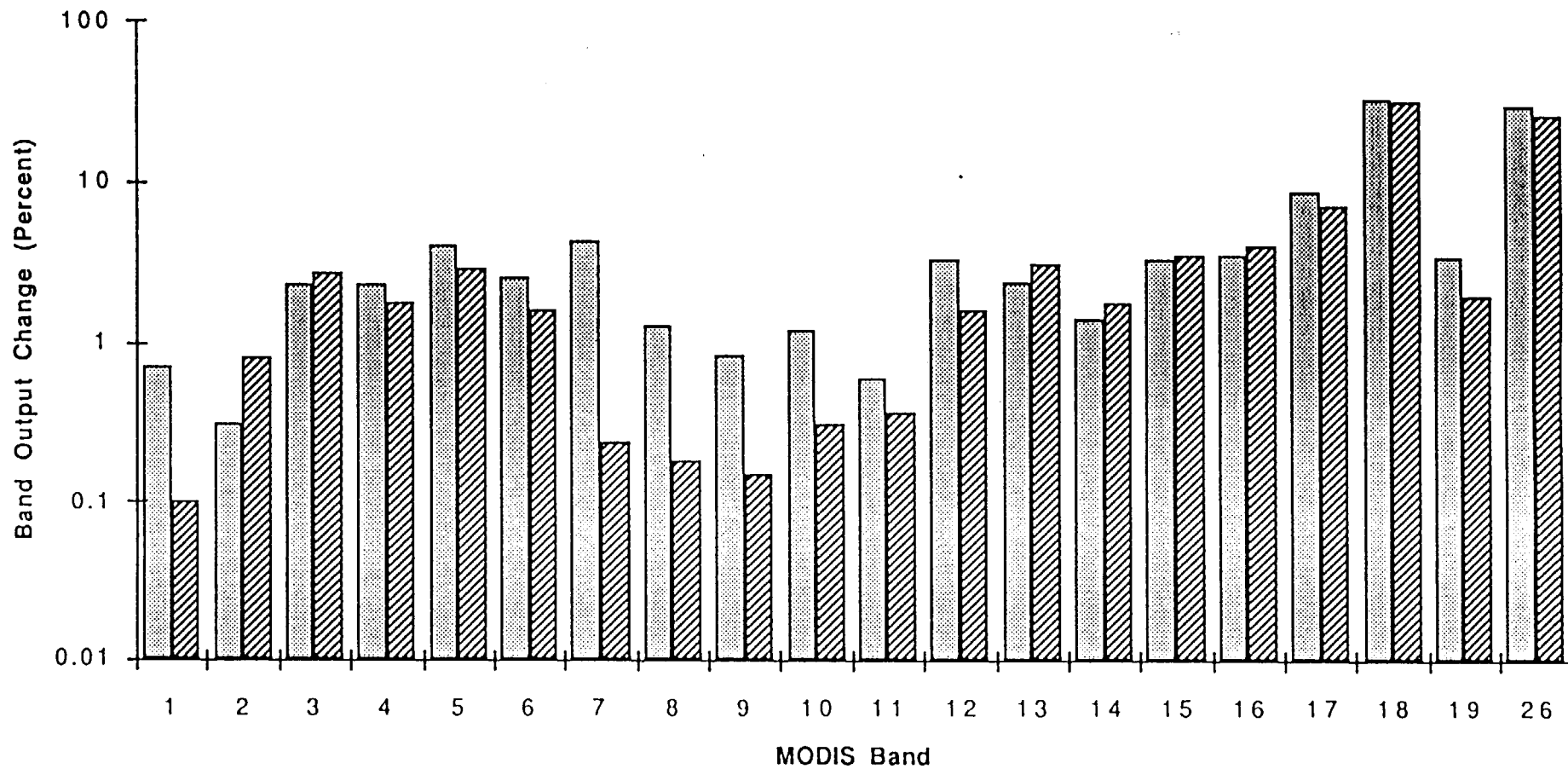
DK0014

*MODIS Spectral Band Output Change due to Shift in Center Wavelength
 (Plotted Value is Max. Abs. Change in the Center Wavelength Tolerance Range)
 (J. Barker, 6 Aug., 1993)*



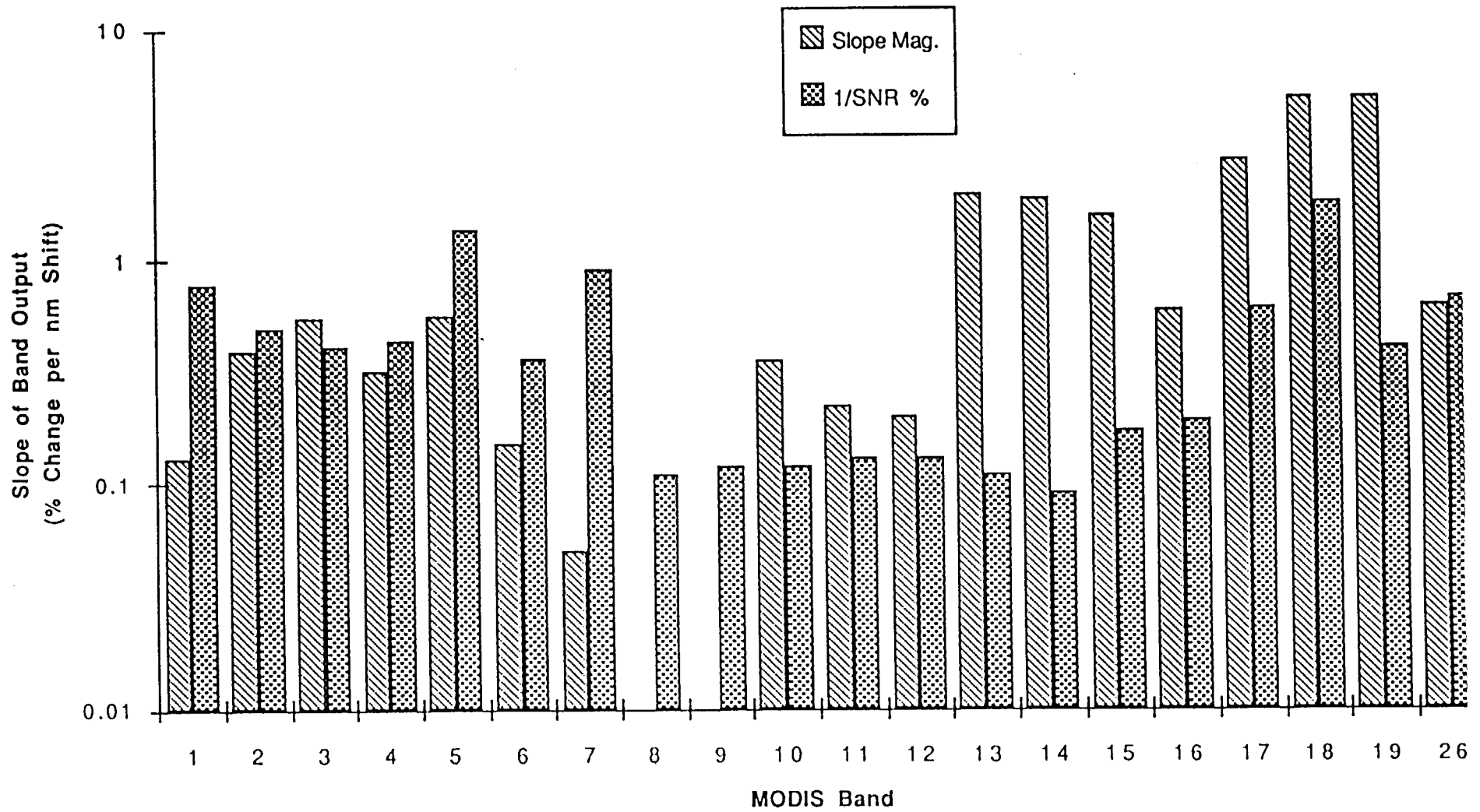
DK-0009

MODIS Spectral Band Output Radiance Change due to Center Wavelength Change
 (Plotted value is Max. Abs. Change in the CW tolerance range)
 (J. Barker, 6 Aug., 1993)



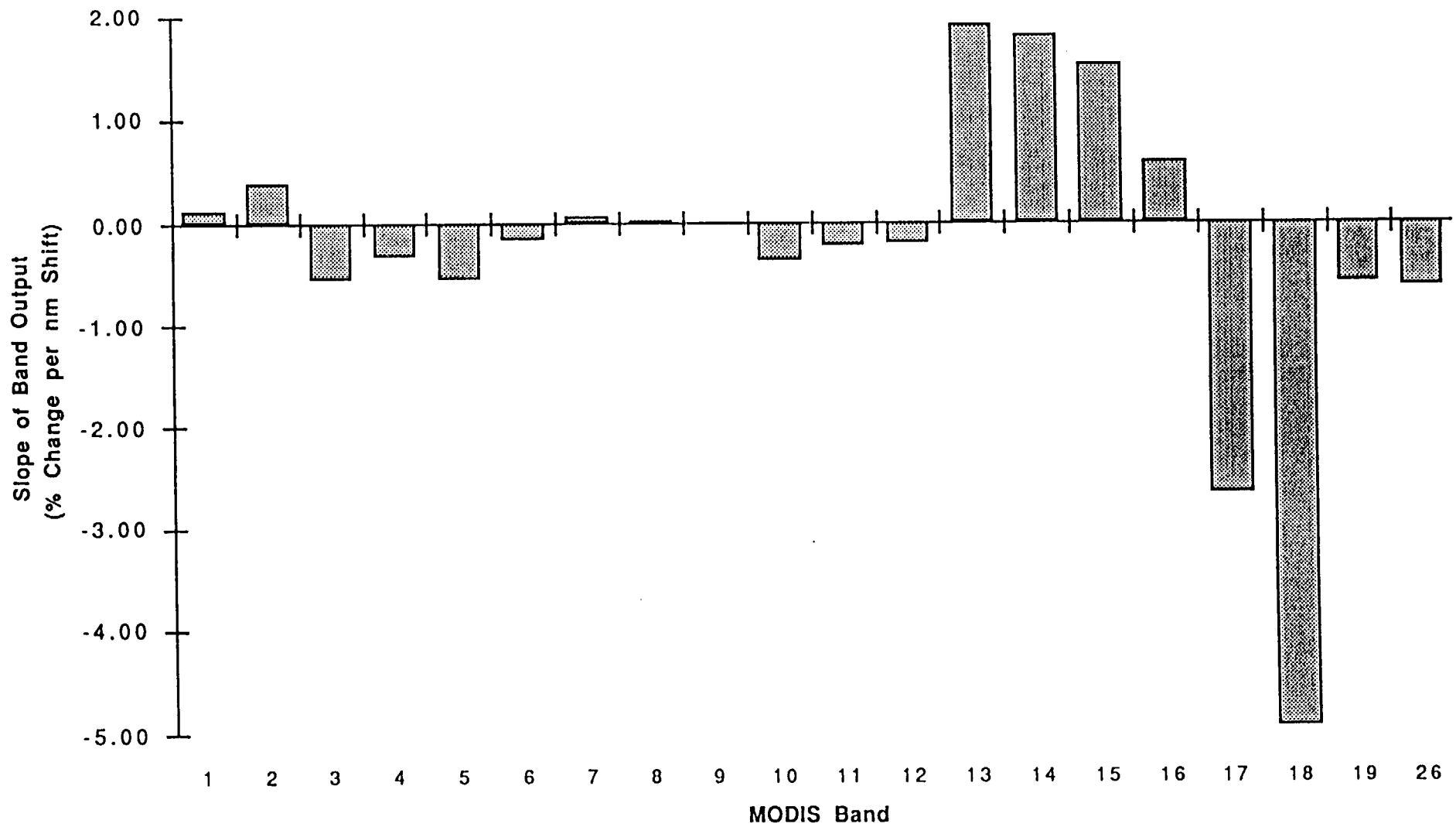
DK0013

Sensitivity of MODIS Reflective Band Output to Center Wavelength Shift
 (J. Barker, 6 Aug., 1993)



DK-0008

Sensitivity of MODIS Reflective Band Output to Shift in Center Wavelength
(J. Barker, 6 Aug., 1993)



DK-0007