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To: Phil Ardanuy

From: Dan Knowles

Subject: Thermal Band Data Simulation

Included here is the output of the data simulation routine which I have coded in C as a basis for an error analysis of the thermal bands. This data is created from a nominal case using a 5% non-linearity in the radiance versus voltage curve. Ltyp from the MODIS Specification was used as the Earth View radiance.

Scan Dependent Telemetry:

Tbb = 285 K
Tcav = 285 K

Earth View Frame Dependent Telemetry:

MODIS Band 20

DNev = 954.682
DNbb = 539.416
DNsv = 100
Gain = 5000
Vdc = 0.3572 mV
R a/d = 0.8192

MODIS Band 21

DNev = 191.377
DNbb = 113.652
DNsv = 100
Gain = 5000
Vdc = 0.20467 mV
R a/d = 0.8192

MODIS Band 22

DNev = 1239.28
DNbb = 712.693
DNsv = 100
Gain = 5000
Vdc = 0.36249 mV
R a/d = 0.8192

MODIS Band 23

DNev = 1272.84
DNbb = 736.097
DNsv = 100
Gain = 5000
Vdc = 0.37804 mV
R a/d = 0.8192

MODIS Band 24

DNev = 334.588
DNbb = 1210.79
DNsv = 100
Gain = 5000
Vdc = 0.70257 mV
R a/d = 0.8192

MODIS Band 25

DNev = 856.418
DNbb = 1221.93
DNsv = 100
Gain = 5000
Vdc = 0.672 mV
R a/d = 0.8192

MODIS Band 27

DNev = 500.23
DNbb = 1681.82
DNsv = 100
Gain = 5000
Vdc = 1.2694 mV
R a/d = 0.8192

MODIS Band 28

DNev = 753.655
DNbb = 1772.21
DNsv = 100
Gain = 5000
Vdc = 1.3421 mV
R a/d = 0.8192

MODIS Band 29

DNev = 2190.57
DNbb = 1680.07
DNsv = 100
Gain = 5000
Vdc = 1.4043 mV
R a/d = 0.8192

MODIS Band 30

DNev = 1063.34
DNbb = 2043.47
DNsv = 100
Gain = 5000
Vdc = 1.7271 mV
R a/d = 0.8192

MODIS Band 31

DNev = 2372.93
DNbb = 1929.83
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 1.7487 mV
Vdc2 = 17.663 mV
R a/d = 0.8192

MODIS Band 31hi

DNev = 3127.23
DNbb = 946.323
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 0.84702 mV
Vdc2 = 8.5557 mV
R a/d = 0.8192

MODIS Band 32

DNev = 2458.27
DNbb = 2031.44
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 3.0127 mV
Vdc2 = 30.431 mV
R a/d = 0.8192

MODIS Band 32hi

DNev = 3152.86
DNbb = 1040.33
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 1.3996 mV
Vdc2 = 14.137 mV
R a/d = 0.8192

MODIS Band 33

DNev = 1675.58
DNbb = 2341.57
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 4.7238 mV
Vdc2 = 47.715 mV
R a/d = 0.8192

MODIS Band 34

DNev = 1473.64
DNbb = 2374.88
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 5.8122 mV
Vdc2 = 58.709 mV
R a/d = 0.8192

MODIS Band 35

DNev = 1280.92
DNbb = 2388.38
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 5.8815 mV
Vdc2 = 59.409 mV
R a/d = 0.8192

MODIS Band 36

DNev = 917.782
DNbb = 2380.4
DNsv = 100
Gain1 = 1000
Gain2 = 5
Vdc1 = 4.789 mV
Vdc2 = 48.374 mV
R a/d = 0.8192

Simulation Parameters and Coefficients

MODIS Band 20

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 0.22862 Watts / m^2 / micron / sr
Lev = 0.45 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 0.3572 mV
Vbb = 0.46447 mV
Vev = 0.56586 mV

Pre-Launch Instrument Parameters:

Center wavelength = 3.75 microns
Blackbody emissivity = 0.992
Tauwarm = 0.7376
Taucold = 0.6939
Tautotal = 0.5118
Vo = 0.2 mV
q = -0.0250973 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0958133 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.959983 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.49132 mV / (Watts / m^2 / micron / sr)
Lo = 0.325352

MODIS Band 21

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 0.35481 Watts / m^2 / micron / sr
Lev = 2.38 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 0.20467 mV
Vbb = 0.20801 mV
Vev = 0.22698 mV

Pre-Launch Instrument Parameters:

Center wavelength = 3.959 microns
Blackbody emissivity = 0.992
Tauwarm = 0.7406
Taucold = 0.6939
Tautotal = 0.5139
Vo = 0.2 mV
q = -9.99705e-06 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -3.78543e-05 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.0183055 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.00940718 mV / (Watts / m^2 / micron / sr)
Lo = 0.49707

MODIS Band 22

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 0.35481 Watts / m^2 / micron / sr
Lev = 0.67 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 0.36249 mV
Vbb = 0.51207 mV
Vev = 0.64063 mV

Pre-Launch Instrument Parameters:

Center wavelength = 3.959 microns
Blackbody emissivity = 0.992
Tauwarm = 0.7922
Taucold = 0.6939
Tautotal = 0.5497
Vo = 0.2 mV
q = -0.0204689 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0677398 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.807887 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.444095 mV / (Watts / m^2 / micron / sr)
Lo = 0.372269

MODIS Band 23

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 0.42177 Watts / m^2 / micron / sr
Lev = 0.79 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 0.37804 mV
Vbb = 0.53334 mV
Vev = 0.66438 mV

Pre-Launch Instrument Parameters:

Center wavelength = 4.05 microns
Blackbody emissivity = 0.992
Tauwarm = 0.7836
Taucold = 0.7184
Tautotal = 0.5629
Vo = 0.2 mV
q = -0.0156151 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0492814 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.691671 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.389342 mV / (Watts / m^2 / micron / sr)
Lo = 0.465991

MODIS Band 24

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 0.82492 Watts / m^2 / micron / sr
Lev = 0.17 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 0.70257 mV
Vbb = 0.97376 mV
Vev = 0.75984 mV

Pre-Launch Instrument Parameters:

Center wavelength = 4.465 microns
Blackbody emissivity = 0.992
Tauwarm = 0.7007
Taucold = 0.6939
Tautotal = 0.4862
Vo = 0.2 mV
q = -0.0124441 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0526423 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.769422 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.374093 mV / (Watts / m^2 / micron / sr)
Lo = 1.40951

MODIS Band 25

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 0.88432 Watts / m^2 / micron / sr
Lev = 0.59 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 0.672 mV
Vbb = 0.94591 mV
Vev = 0.85668 mV

Pre-Launch Instrument Parameters:

Center wavelength = 4.515 microns
Blackbody emissivity = 0.992
Tauwarm = 0.7152
Taucold = 0.6939
Tautotal = 0.4963
Vo = 0.2 mV
q = -0.0110898 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0450232 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.706795 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.350782 mV / (Watts / m^2 / micron / sr)
Lo = 1.40827

MODIS Band 27

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 4.7407 Watts / m^2 / micron / sr
Lev = 1.16 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 1.2694 mV
Vbb = 1.6556 mV
Vev = 1.3671 mV

Pre-Launch Instrument Parameters:

Center wavelength = 6.715 microns
Blackbody emissivity = 0.992
Tauwarm = 0.6249
Taucold = 0.7196
Tautotal = 0.4497
Vo = 0.2 mV
q = -0.000774496 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.00382978 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.228518 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.102765 mV / (Watts / m^2 / micron / sr)
Lo = 11.3824

MODIS Band 28

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 5.7431 Watts / m^2 / micron / sr
Lev = 2.18 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 1.3421 mV
Vbb = 1.7504 mV
Vev = 1.5017 mV

Pre-Launch Instrument Parameters:

Center wavelength = 7.325 microns
Blackbody emissivity = 0.992
Tauwarm = 0.6245
Taucold = 0.6658
Tautotal = 0.4158
Vo = 0.2 mV
q = -0.000594135 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0034365 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.218636 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.0909087 mV / (Watts / m^2 / micron / sr)
Lo = 13.8099

MODIS Band 29

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 7.1275 Watts / m^2 / micron / sr
Lev = 9.58 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 1.4043 mV
Vbb = 1.7901 mV
Vev = 1.9147 mV

Pre-Launch Instrument Parameters:

Center wavelength = 8.55 microns
Blackbody emissivity = 0.992
Tauwarm = 0.5992
Taucold = 0.7228
Tautotal = 0.4331
Vo = 0.2 mV
q = -0.000344699 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.00183766 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.160993 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.0697262 mV / (Watts / m^2 / micron / sr)
Lo = 19.0703

MODIS Band 30

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 7.6637 Watts / m^2 / micron / sr
Lev = 3.69 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 1.7271 mV
Vbb = 2.2016 mV
Vev = 1.9623 mV

Pre-Launch Instrument Parameters:

Center wavelength = 9.73 microns
Blackbody emissivity = 0.992
Tauwarm = 0.6003
Taucold = 0.7513
Tautotal = 0.451
Vo = 0.2 mV
q = -0.000459113 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.00225718 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.186645 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.0841769 mV / (Watts / m^2 / micron / sr)
Lo = 20.4148

MODIS Band 31

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 7.5816 Watts / m^2 / micron / sr
Lev = 9.55 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 1.7663 mV
Vbb = 2.2131 mV
Vev = 2.3213 mV

Pre-Launch Instrument Parameters:

Center wavelength = 11.03 microns
Blackbody emissivity = 0.992
Tauwarm = 0.5796
Taucold = 0.6717
Tautotal = 0.3893
Vo = 0.2 mV
q = -0.000415341 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.00274054 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.206383 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.0803448 mV / (Watts / m^2 / micron / sr)
Lo = 21.9964

MODIS Band 31hi

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 7.5816 Watts / m^2 / micron / sr
Lev = 29.1 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 0.85557 mV
Vbb = 1.0622 mV
Vev = 1.5946 mV

Pre-Launch Instrument Parameters:

Center wavelength = 11.03 microns
Blackbody emissivity = 0.992
Tauwarm = 0.5796
Taucold = 0.6717
Tautotal = 0.3893
Vo = 0.2 mV
q = -8.62301e-05 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.000568971 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.0814291 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.0317004 mV / (Watts / m^2 / micron / sr)
Lo = 21.9964

MODIS Band 32

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 7.2261 Watts / m^2 / micron / sr
Lev = 8.94 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 3.0431 mV
Vbb = 3.5147 mV
Vev = 3.6189 mV

Pre-Launch Instrument Parameters:

Center wavelength = 12.02 microns
Blackbody emissivity = 0.992
Tauwarm = 0.4648
Taucold = 0.6802
Tautotal = 0.3162
Vo = 0.2 mV
q = -0.000498251 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.00498338 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.322635 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.102017 mV / (Watts / m^2 / micron / sr)
Lo = 33.2777

MODIS Band 32hi

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 7.2261 Watts / m^2 / micron / sr
Lev = 25.1 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 1.4137 mV
Vbb = 1.6433 mV
Vev = 2.1591 mV

Pre-Launch Instrument Parameters:

Center wavelength = 12.02 microns
Blackbody emissivity = 0.992
Tauwarm = 0.4648
Taucold = 0.6802
Tautotal = 0.3162
Vo = 0.2 mV
q = -0.000116122 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.00116142 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.12757 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.0403375 mV / (Watts / m^2 / micron / sr)
Lo = 33.2777

MODIS Band 33

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 6.5575 Watts / m^2 / micron / sr
Lev = 4.52 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 4.7715 mV
Vbb = 5.3187 mV
Vev = 5.1561 mV

Pre-Launch Instrument Parameters:

Center wavelength = 13.335 microns
Blackbody emissivity = 0.992
Tauwarm = 0.4071
Taucold = 0.6427
Tautotal = 0.2616
Vo = 0.2 mV
q = -0.000808475 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0118138 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.575448 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.150537 mV / (Watts / m^2 / micron / sr)
Lo = 38.2081

MODIS Band 34

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 6.3897 Watts / m^2 / micron / sr
Lev = 3.76 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 5.8709 mV
Vbb = 6.4263 mV
Vev = 6.2063 mV

Pre-Launch Instrument Parameters:

Center wavelength = 13.635 microns
Blackbody emissivity = 0.992
Tauwarm = 0.3696
Taucold = 0.6236
Tautotal = 0.2305
Vo = 0.2 mV
q = -0.000864048 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0162628 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.727831 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.167765 mV / (Watts / m^2 / micron / sr)
Lo = 43.588

MODIS Band 35

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 6.2194 Watts / m^2 / micron / sr
Lev = 3.11 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 5.9409 mV
Vbb = 6.4996 mV
Vev = 6.2292 mV

Pre-Launch Instrument Parameters:

Center wavelength = 13.935 microns
Blackbody emissivity = 0.992
Tauwarm = 0.369
Taucold = 0.6274
Tautotal = 0.2315
Vo = 0.2 mV
q = -0.000924804 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0172563 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.752816 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.174277 mV / (Watts / m^2 / micron / sr)
Lo = 42.5475

MODIS Band 36

Input Radiance:

Lsv = 0 Watts / m^2 / micron / sr
Lbb = 6.0479 Watts / m^2 / micron / sr
Lev = 2.08 Watts / m^2 / micron / sr

Detector Voltages:

Vsv = 4.8374 mV
Vbb = 5.3941 mV
Vev = 5.037 mV

Pre-Launch Instrument Parameters:

Center wavelength = 14.235 microns
Blackbody emissivity = 0.992
Tauwarm = 0.409
Taucold = 0.6102
Tautotal = 0.2496
Vo = 0.2 mV
q = -0.000991097 mV / (Watts / m^2 / micron / sr) ^ 2

Simulation Equation Coefficients:

a = -0.0159084 mV / (Watts / m^2 / micron / sr) ^ 2
b = 0.670377 mV / (Watts / m^2 / micron / sr)

Calibration Equation Coefficients:

m = 0.167326 mV / (Watts / m^2 / micron / sr)
Lo = 34.9498