April 12, 2004 E/RA1:JS

MEMORANDUM FOR: The Record

FROM: J. Sullivan
Satellite Meteorology and Climatology Division (SMCD)

SUBJECT: Prelaunch calibration of the thermal channels on the NOAA-N {NOAA-18} AVHRR A306:
information needed by data producers

E/SP13 - A. Morgan, C. Paris, J. Sapper
E/RA1 - C. Cao, X. Wu, A. Heidinger, D. Tarpley
E/RA3 - A. Harris
E/CC33 - K. Kidwell
E/SP12 - R. Levin
SA07 - E. Miller
SA06 - W. Mazur
NASA/GFSC Code 480 - C. Richardson
USGS EROS Data Center - K. Gallo

PURPOSE of MEMO

The NOAA-N polar-orbiting satellite is scheduled to be launched in December, 2004 with the Advanced Very High Resolution Radiometer (AVHRR) A306 as one of its instruments. This six-channel radiometer has three channels that respond to visible and near-infrared radiation and three channels that mainly respond to thermal radiation emitted from the Earth=s surface. Channels 1, 2, and 3A respond to reflected solar radiation. AVHRR thermal channels 3B, 4, and 5 are located in the Awindow@ regions of atmospheric transmission; they sense emitted surface or cloud top radiance with relatively little atmospheric absorption. Channel 3B also responds to reflected solar radiation during the daylight portion of each orbit. Figure 1 shows the spectral response functions for the three NOAA-N thermal channels. Data from all six channels are used to measure sea and land surface temperatures, outgoing longwave radiation, aerosol amount, and vegetation health, and to detect clouds, snow, fire, and drought.

During July, 2001 the instrument maker ITT performed prelaunch laboratory calibration tests on the thermal channels of the NOAA-M AVHRR A306. NESDIS used this data to characterize the instrument response. A portion of the data measured in prelaunch is needed to convert the raw counts transmitted from the AVHRR in orbit into the physical variable of radiance/brightness temperature. ***The purpose of this memo is to tabulate the relevant thermal channel algorithms and prelaunch numerical data needed by NESDIS Operations to process the in-orbit data. HRPT data producers use the same steps and the same coefficients in their processing algorithms. Algorithm details and explanations are given in the following sections, <u>numerical values are given in Appendix A</u>, and results of interest more to specialists are in Appendix B.***

1. PRELAUNCH CALIBRATION

<u>Overview</u>

Calibration is defined as the process of determining the response of an instrument to known input signals. Basic prelaunch AVHRR thermal channel calibration is straightforward in principle. The radiometer views a blackbody source, whose temperature is accurately measured and constant in time, for a period of one minute. During this minute the AVHRR outputs 3,600 count values; each count value is an integer in the 0 to 1023 range. The average count and the blackbody temperature value make up one data point in the calibration. The first goal of calibration is to make sure that when the radiance input from the blackbody is constant the AVHRR count output is also constant; the instrument precision is indicated by the standard deviation of the 3,600 count values. The temperature of the blackbody is then changed, the setup allowed to come into equilibrium, and a new set of 3,600 AVHRR counts are recorded at the new temperature. This same sequence is repeated at a number of different blackbody temperatures. The collection of data points (blackbody temperature/radiance, AVHRR count) constitutes the calibration of the AVHRR. Figure 2 illustrates the prelaunch setup schematically. The principle is simple; in practice the engineering needed to guarantee that the blackbody output remains constant for a minute, and that no unwanted radiation enters the AVHRR, leads to a large investment of time and money.

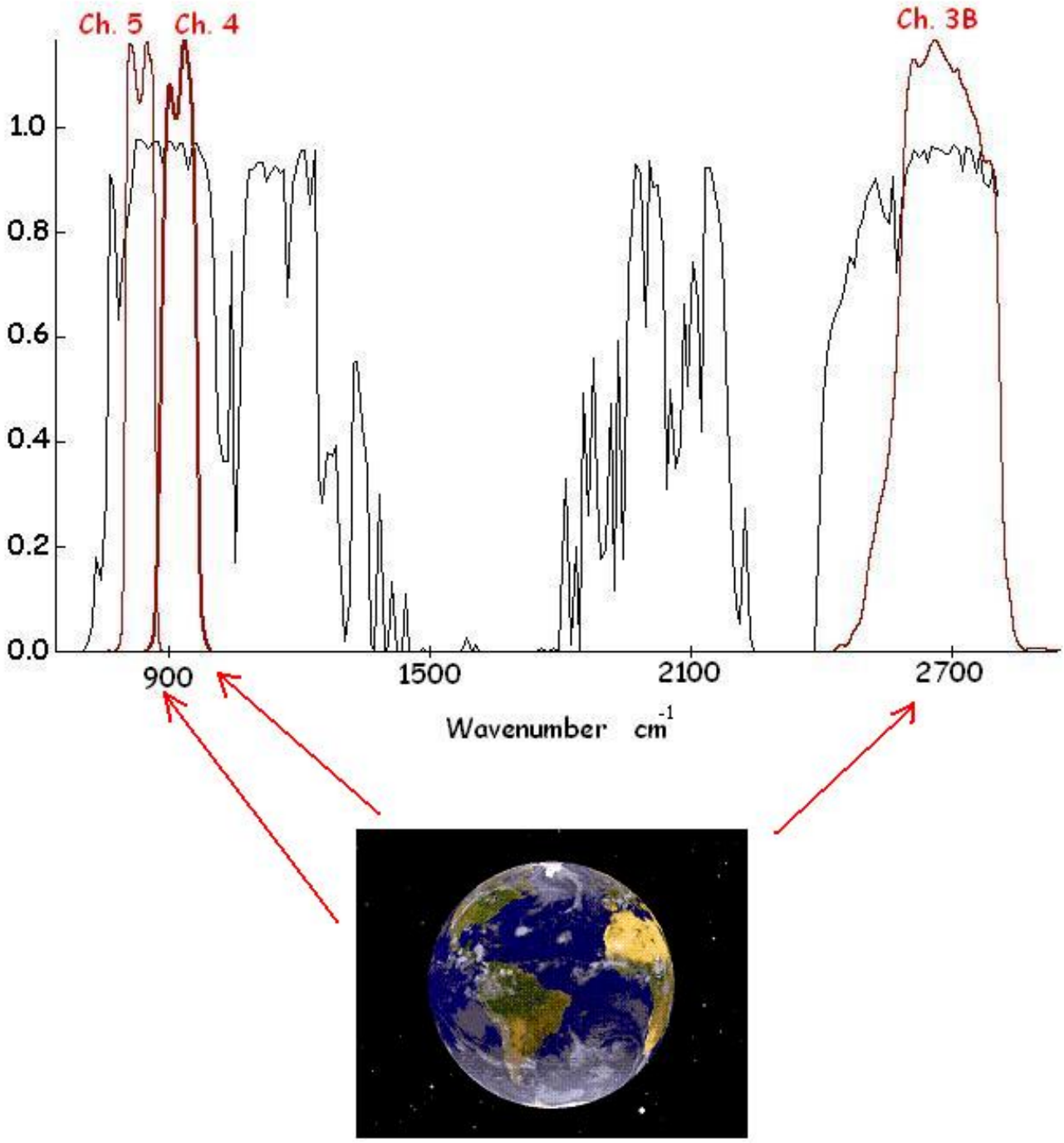

Figure 1. The red curves show the spectral response functions for channels 3b, 4, and 5 of the NOAA-N AVHRR. The black line shows the atmospheric transmission curve from MODTRAN for an Arctic atmosphere with a surface temperature of 270K.

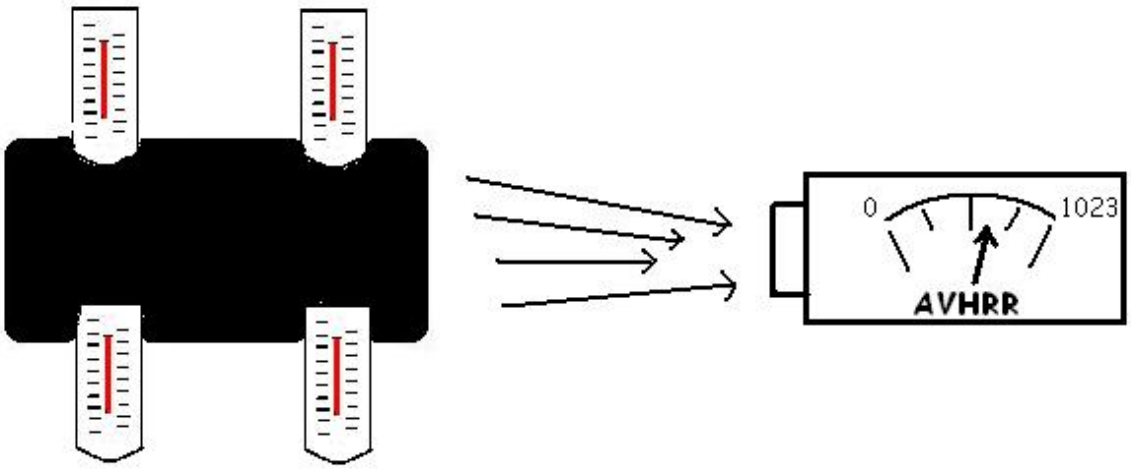

Figure 2. Schematic picture of basic prelaunch calibration for the AVHRR thermal channels.

1a. Thermal Channels Calibration

To understand the prelaunch calibration setup it helps to compare it to the in-orbit calibration setup. Figure 3 shows both setups. In-orbit calibration has only one blackbody, called the internal blackbody or internal calibration target (ICT). During one orbit, the temperature of this blackbody varies 2-3K and during the AVHRR lifetime stays (hopefully) in the 15C to 25C range. The other calibration target is cold space; there is so little energy received in the AVHRR thermal channel spectral windows from space that it can be considered to have zero radiance. The Earth itself is the third target during each AVHRR in-orbit scanline. Prelaunch calibration uses three blackbodies. The internal one, the ICT, is the same one used during in-orbit calibration; it is attached to the AVHRR baseplate. The second blackbody is held at approximately 90K, and effectively can be considered to emit zero radiance for the AVHRR thermal channels. The third one, called the external blackbody or external calibration target (ECT), is the prelaunch substitute for the Earth target, and generates the dominant part of prelaunch calibration information.

The top part of Figure 4 shows the basic prelaunch laboratory measurement setup. All three blackbodies are held at a precisely measured temperature for one minute. The ICT and ECT blackbody temperatures are measured by Platinum Resistance Thermometers (PRTs) imbedded in them, shown schematically in the figure. The PRT output is an integer count value, which is converted to temperature using equations provided by ITT. The AVHRR itself receives radiant energy from the blackbody and outputs an integer count with a value from 0 to 1023. The first calibration goal is that when the blackbody temperatures are stabilized, the AVHRR should

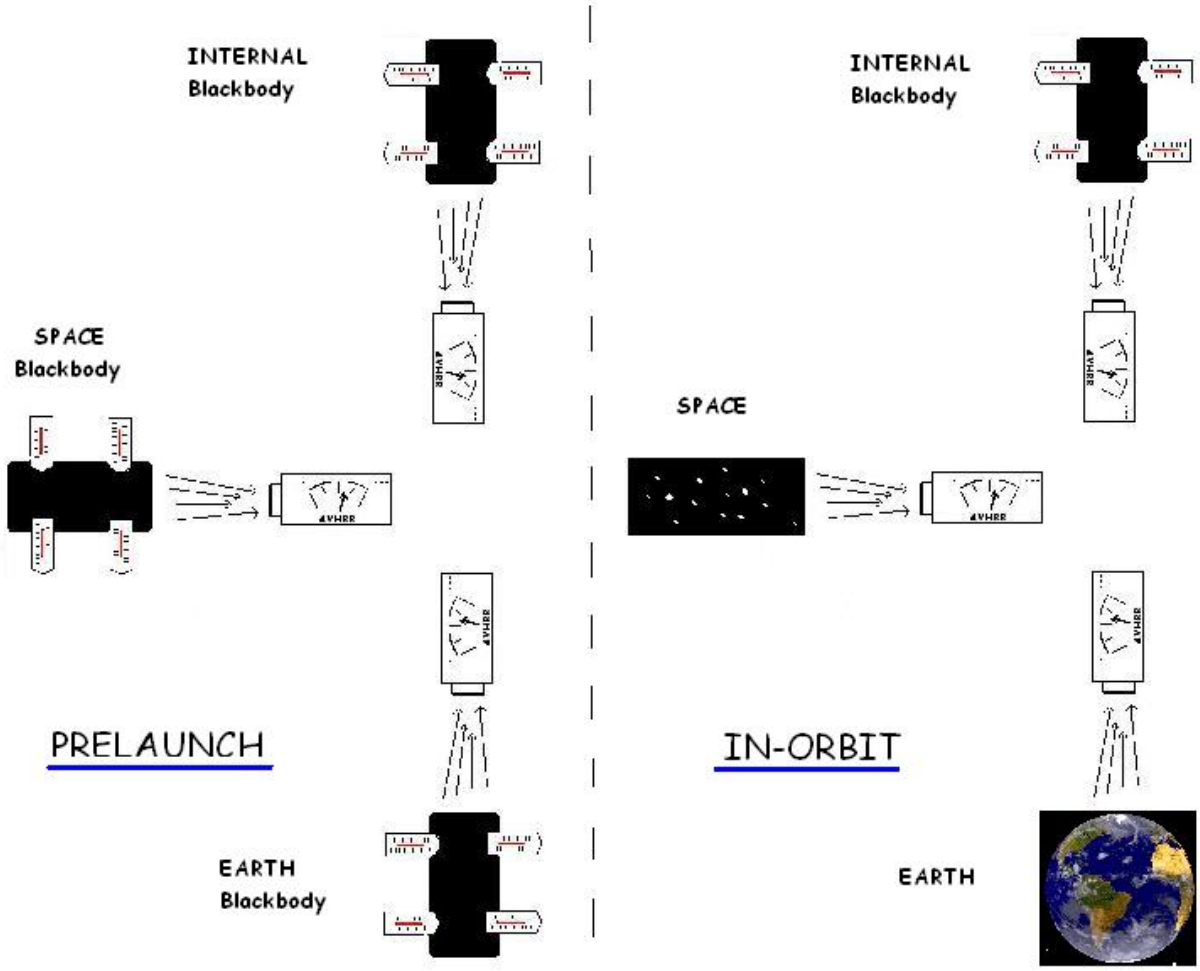

Figure 3. The left side of the figure shows the prelaunch calibration setup schematically and the right side shows the in-orbit calibration setup.

output a constant count value. To check this, one minute worth (3,600 counts) of data is collected. In actual practice, the AVHRR output is generally constant to within ∀1 count in this situation.

Once the AVHRR stability is confirmed at one temperature, the temperature of the external blackbody is changed, stabilized again, and the calibration process is repeated. In NOAA-N prelaunch testing, the process was repeated at 17 different blackbody temperatures ranging from 180K to 335K. The basic experimental data are 17 pairs of blackbody temperature and average AVHRR count values.

The basic data are then converted to 17 pairs of (AVHRR radiance, AVHRR count) data. The blackbody emits energy (photons) at essentially all wavelengths; the energy emitted at each wavelength varies with temperature and is computed using the Planck function. However, each AVHRR channel responds only to photons within a finite wavelength interval; this is independent of blackbody temperature and is measured by the spectral response function. For each of the three thermal channels, the AVHRR radiance at any temperature T is a weighted average of the Planck blackbody radiance; the weights are supplied by the spectral response function for each channel. The bottom part of Figure 4 shows the Channel 4 spectral response curve and the Planck blackbody function curves at three different temperatures.

When AVHRR radiance computed from prelaunch data is plotted against AVHRR count, the graph is linear for channel 3B and nearly linear for channels 4 and 5. The radiance versus count curve for channels 4 and 5 is accurately fit by a quadratic. While in orbit, a calibration that closely resembles the prelaunch one is done each AVHRR scanline. However, because the AVHRR only looks at one blackbody (the ICT) and cold space in the in-orbit calibration sequence, radiance can only be modeled as a linear function in AVHRR count. The residual, the difference between the prelaunch quadratic fit and the in-orbit linear estimate, is provided to data producers by NESDIS. This difference is called the nonlinear radiance correction.

Finally, it is known that for a constant external blackbody temperature the AVHRR count output also depends on the operating temperature of the AVHRR itself, which is monitored by PRTs in the internal target. Consequently, the NOAA-N AVHRR was tested on five different days, with the operating temperature held at nominal values of 10, 15, 20, 25, and 30C on the respective days.

This memo provides data producers with the necessary data from prelaunch measurements outlined in the previous paragraphs, listed in the order they are used in data processing:
1. equations to convert the count output of each internal blackbody PRT to temperature,
2. equations needed to convert blackbody temperature to AVHRR radiance for each channel,
3. nonlinear radiance correction equations for channels 4 and 5.

Details about these three results are given in the following section and the numerical values are given in Appendix A.

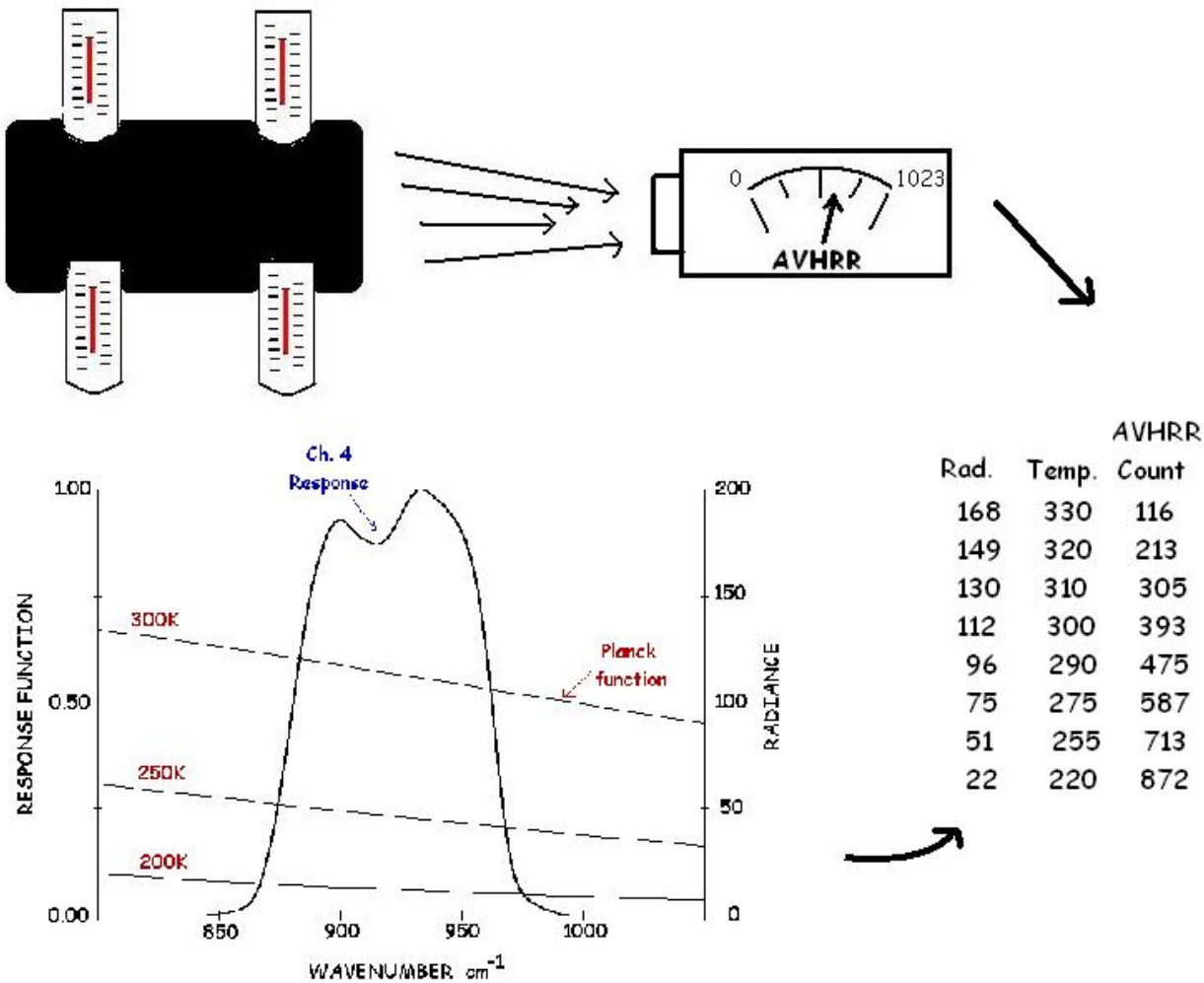

Figure 4. The top figure shows a blackbody emitting thermal radiation that the AVHRR senses. The blackbody temperature is measured by four thermometers; the AVHRR outputs a digital count. The bottom figure shows Planck blackbody curves weighted by the AVHRR channel 4 response function to produce AVHRR radiances

2. Platinum Resistance Thermometer (PRT) count-to-temperature conversion equations

The first prelaunch detail delivered to NESDIS Operations is the set of equations that convert the count output from the four Platinum Resistance Thermometers (PRTs) in the internal blackbody, shown schematically in Figure 4, into temperature. In orbit, a different PRT is sampled each scanline; every fifth scanline PRT count values are set equal to 0 to indicate that a set of four PRTs has just been sampled. The count value C_{PRT} of each PRT is converted to temperature T_{PRT} by the formula

$$T_{PRT} = d0 + d1 \cdot C_{PRT} + d2 \cdot C_{PRT}^2 + d3 \cdot C_{PRT}^3 + d4 \cdot C_{PRT}^4 . \qquad (1)$$

The coefficients d0, d1, d2, d3, and d4 vary slightly for each PRT. Values for the coefficients are found in Appendix A, Table A1. Coefficients d3 and d4 are 0 for NOAA-N, just as they were for NOAA-15 and NOAA-17. (The d3 and d4 values for NOAA-16 were non-zero.)

3. Blackbody temperature-to-AVHRR radiance conversion equations

Each channel responds only to radiation from a limited spectral region. The spectral region for NOAA-N AVHRR thermal channel 3B is centered near 2660 cm^{-1}, 928 cm^{-1} for channel 4, and 833 cm^{-1} for channel 5 (or 3.7, 10.8, and 11.9μ), as shown in Figure 1. The radiance N_{BB} sensed in each thermal AVHRR channel from the internal blackbody at temperature T_{BB} is the weighted mean of the Planck function over the spectral response of the channel. The bottom part of Figure 4 shows this graphically for the NOAA-N channel 4. The table shows that a 300K blackbody has an AVHRR radiance of 112 $mW/(m^2\ sr\ cm^{-1})$, corresponding to a radiance on the 300K Planck curve near the middle of the spectral window. The spectral response function for each channel is measured in approximately 200 wavelength intervals and provided by ITT. NESDIS then changes this information into the wavenumber domain and computes the AVHRR radiance. In practice, a look-up table relating radiance to temperature is generated for each channel. In each table, for all temperatures between 180K and 340K, in steps of 0.1K, the table specifies the AVHRR radiance. The tables are referred to as AEnergy Tables@. We have found empirically that the following two-step equation accurately reproduces Energy Table equivalent blackbody temperatures to within ∀ 0.01K in the 180 to 340K range. Each thermal channel has one equation, which uses a centroid wavenumber v_C and an Aeffective@ blackbody temperature T_{BB}*. The two steps are

$$T_{BB}^* = A + B \cdot T_{BB} \qquad (2)$$

$$N_{BB} = c1 \cdot v_C^3 \ / \ [\exp(c2 \cdot v_C / T_{BB}^*) - 1]$$

where the first and second radiation constants are:

$c1 = 1.1910427 \times 10^{-5}\ mW/(m^2 \cdot sr \cdot cm^{-4})$
$c2 = 1.4387752\ cm \cdot K$.

The values for v_C and the coefficients A and B for NOAA-N AVHRR channels 3B, 4, and 5 are found in Appendix A, Table A2.

4. Nonlinear radiance correction equations

For channel 3B, the relation between radiance and count is effectively linear. However, the

Mercury-Cadmium-Telluride detectors used for channels 4 and 5 have a nonlinear response to incoming radiance. Prelaunch laboratory measurements show that:

a. scene radiance is a slightly nonlinear (quadratic) function of AVHRR output count,
b. the nonlinearity depends on the AVHRR operating temperature.

Table 1 illustrates fact (b), showing that, for the same source blackbody temperatures, the AVHRR responses from the 15C and 20C calibration runs differ. Fact (a), the quadratic nature of the different curves is shown indirectly in Figure 5.

Table 1. Temperature T, radiance N, and count data for NOAA-N AVHRR A306 channel 4 calibration runs at 15C, and 20C. Temperature units are degrees K and radiance units are $mW/(m^2\ sr\ cm^{-1})$.

T	N	15C count	20C count
180	5.8	962	963
220	22.0	870	872
255	51.0	710	713
285	88.7	508	515
310	129.9	298	306
335	180.0	55	64

In-orbit calibration views only two targets, cold space and the internal calibration target blackbody. From these two calibration points, a linear approximation to the actual quadratic radiance versus count curve is determined. The difference between the radiance measured in prelaunch and the in-orbit linear estimate is called the nonlinear radiance correction. The current NESDIS method used to provide the nonlinear corrections to users has two useful features:

a. it accurately reproduces the measured prelaunch data,
b. for each channel, the correction is a <u>single quadratic function</u> of the linear radiance estimate,; the coefficients in the quadratic are independent of the AVHRR operating temperature.

The AVHRR outputs count values C_S, C_E, and C_{BB} as it views cold space, the Earth scene, and the internal blackbody, respectively. Count values from the four internal blackbody PRTs are also output, converted to internal blackbody temperature T_{BB} and then to AVHRR radiance N_{BB}, using Equation (3). Denoting the radiance of space value by N_S, the linear estimate N_{LIN} for the Earth scene radiance is computed by,

$$N_{LIN} = N_S + \frac{(N_{BB} - N_S)}{(C_{BB} - C_S)} A (C_E - C_S) \qquad (3)$$

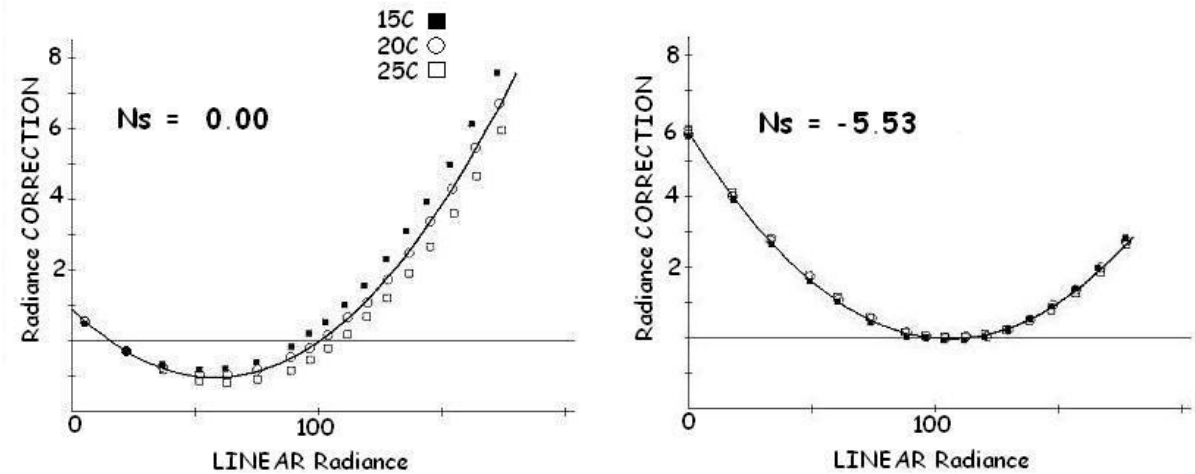

Figure 5. The symbols indicate the nonlinear radiance corrections for the NOAA-N AVHRR channel 4 at three operating temperatures, 15C, 20C and 25C for radiance of space N_S = 0.00 and for N_S = -5.53. The solid lines are quadratics in linear radiance fit to the data from the 20C operating temperature calibration run. Radiance units are mW/(m^2 sr cm^{-1}) .

Physically, the radiance of space is effectively 0 mW/(m^2 sr cm^{-1}) in the AVHRR thermal channels . Mathematically, N_S can be any value, as long as the chosen value is not changed in data processing during the entire AVHRR lifetime. Figure 5 shows graphically the reasoning behind the current NESDIS nonlinear radiance correction method. First, linear radiance estimates are computed using Equation (3) on the prelaunch data and subtracted from the actual prelaunch radiances. The resulting NOAA-N channel 4 nonlinear radiance corrections for three different AVHRR temperatures, 15, 20, and 25C, are plotted against linear radiance. In the left graph N_S = 0.00 mW/(m^2 sr cm^{-1}) and in the right graph N_S = -5.53 mW/(m^2 sr cm^{-1}). When N_S = 0.00, the difference in the three radiance correction curves is apparent. However, when N_S = -5.53 the radiance corrections at the three operating temperatures fall nearly on the same curve. The curve, shown by the line in Figure 5, is a quadratic in linear radiance. By varying N_S from 0.00 to -10.00 mW/(m^2 sr cm^{-1}) in increments of 0.01 on the computer and comparing the differences between the three curves in the least-squares sense, we found empirically that the value N_S = -5.53 forced the three curves to coincide the closest. For channel 5, the same behavior occurs at the N_S value of -2.22 mW/(m^2 sr cm^{-1}).

The accuracy of the NESDIS nonlinear correction can be assessed by comparing the computed corrected radiances to the measured prelaunch radiances. We ***derived*** the corrections using data from only three calibration runs (15, 20, and 25C). We ***compared*** the computed and measured radiances using data from these three runs, plus data from the 10 and 30C runs. The comparison

uses both independent and dependent data. When radiance differences are converted to temperature differences, the method reproduces the measurements with an RMS error of approximately 0.08K in channel 4 and 0.03K in channel 5. 78% of channel 4 absolute differences are less than 0.10K and 86% of channel 5 are less than 0.05K. NESDIS uses these non-zero N_S values in AVHRR 1b processing to generate linear estimates and then applies a single correction curve for each channel, independent of AVHRR operating temperature.

The linear radiance estimate N_{LIN} is computed from Equation (3) using the non-zero radiance of space N_S . Then, the linear radiance value is input into a quadratic equation to generate the nonlinear radiance correction,

$$N_{COR} = b0 + b1 \cdot N_{LIN} + b2 \cdot N_{LIN}^2 . \qquad (4)$$

Finally, the Earthscene radiance N_E is obtained by adding N_{COR} to N_{LIN},

$$N_E = N_{LIN} + N_{COR} . \qquad (5)$$

Values for N_S and the quadratic coefficients b0, b1, and b2 are found in Table A3, Appendix A.

From the NOAA-15 AVHRR on, NESDIS now incorporates the nonlinear radiance corrections for AVHRR thermal channels 4 and 5 into the level 1b data stream. Level 1b data users compute the Earthscene radiance N_E in units of mW/(m^2 sr cm^{-1}) from the Earthscene count C_E by the formula

$$N_E = a0 + a1 \cdot C_E + a2 \cdot C_E^{\,2} . \qquad (6)$$

The coefficients a0, a1, and a2 are derived by algebraically substituting Eq. 3 into Eqs. (4) and (5), and collecting the terms that multiply the constant, C_E, and $C_E^{\,2}$.

5. Summary of AVHRR thermal channel calibration equations for data producers

--- values for all necessary coefficients are found in Appendix A ---

compute the blackbody temperature T_{BB}:

$$T_{PRT1} = d0 + d1 \cdot C_{PRT1} + d2 \cdot C_{PRT1}^2 + d3 \cdot C_{PRT1}^3 + d4 \cdot C_{PRT1}^4$$

$$T_{PRT2} = \quad .....$$

$$T_{PRT3} = \quad .....$$

$$T_{PRT4} = \quad .....$$

$$T_{BB} = (T_{PRT1} + T_{PRT2} + T_{PRT3} + T_{PRT4}) / 4$$

compute the blackbody radiance N_{BB} from blackbody temperature:

$$T_{BB}^* = A + B \cdot T_{BB}$$

$$N_{BB} = c1 \cdot v_C^3 / [\exp(c2 \cdot v_C / T_{BB}^*) - 1]$$

compute the Earthview radiance N_E using the nonlinearity correction:

$$N_{LIN} = N_S + (N_{BB} - N_S) \cdot (C_S - C_E) / (C_S - C_{BB})$$

$$N_{COR} = b0 + b1 \cdot N_{LIN} + b2 \cdot N_{LIN}^2$$

$$N_E = N_{LIN} + N_{COR}$$

convert Earthview radiance to equivalent blackbody temperature: (helpful for debugging)

$$T_E^* = c2 \cdot v_C / \log[1 + (c1 \cdot v_C^3 / N_E)]$$

$$T_E = (T_E^* - A) / B$$

MISCELLANY

In the nitty-gritty of operational practice, there are more details than are listed in this Memo. For these details, the interested reader is referred to the AVHRR calibration section, Section 7.1, on the NOAA KLM-and-N satellite documentation website:

http://www2.ncdc.noaa.gov/docs/klm/index.htm

Finally, I want to point out an assumption that underlies much of the information that has been presented in this memo: ***for the thermal channels, relevant variables measured in prelaunch keep the same value during the in-orbit lifetime of the AVHRR.*** In other words, we assume that the PRT count-to-temperature conversion equations and the channel spectral response functions remain constant. We also tacitly assume that the quadratic behavior of the radiance versus count curves stays the same.

Appendix A

Table A1. NOAA-N AVHRR A306 coefficients d_0, d_1, d_2, d_3, and d_4 that relate temperature T_{PRT} (degrees Kelvin) of each PRT to count value C_{PRT} by the equation:

$$T_{PRT} = d0 + d1 \cdot C_{PRT} + d2 \cdot C_{PRT}^2 + d3 \cdot C_{PRT}^3 + d4 \cdot C_{PRT}^4 .$$

PRT	d0	d1	d2	d3	d4
1	276.601	0.05090	1.657 E-06	0	0
2	276.683	0.05101	1.482 E-06	0	0
3	276.565	0.05117	1.313 E-06	0	0
4	276.615	0.05103	1.484 E-06	0	0

Table A2. Values for the centroid wavenumber υ_c, and the coefficients A and B in the equations used to convert blackbody temperature into AVHRR radiance for the NOAA-N AVHRR A306 thermal channels.

	υ_c	A	B
channel 3B	2659.7952	1.698704	0.996960
channel 4	928.1460	0.436645	0.998607
channel 5	833.2532	0.253179	0.999057

Table A3. Radiance of Space and coefficients for the nonlinear radiance correction quadratic for NOAA-N AVHRR A306 thermal channels 4 and 5.

	N_S	b0	b1	b2
Channel 4	-5.53	5.82	-0.11069	0.00052337
Channel 5	-2.22	2.67	-0.04360	0.00017715

Appendix B

B1. Quadratic Radiance versus Count Curve is Very Accurate for Channels 4 and 5

The prelaunch radiance versus count curve for AVHRR channel 4 or channel 5 is not a straight line and there is a different curve for each AVHRR operating temperature. This is shown by Table 1 in the Text, where the NOAA-N channel 4 external blackbody temperatures T, radiances N, and AVHRR count values C are shown for calibration runs at 15C, and 20C. For each calibration run, prelaunch data from the external blackbody show that NOAA-N AVHRR radiance N versus count output C curves for channels 4 and 5 are very accurately fit by a quadratic,

$$N(C,t) = k_0(t) + k_1(t) \cong C + k_2(t) \cong C^2 , \qquad \text{(B1)}$$

where t = the AVHRR operating temperature. For each run, the RMS difference between fitted radiance and measured radiance is about 0.04 radiance units. For comparison, in the sea-surface temperature (SST) region, a typical radiance value is 90 radiance units, so the relative difference between fit and measurement is about 1 part in 2200 of the measurement itself. For NOAA-N AVHRR channel 4, Table B1 compares the NESDIS fitted radiance to measured radiance for the 15C calibration run.

Table B1. NOAA-N AVHRR A306 channel 4 measured radiance compared to the radiance calculated from the quadratic in Eq. (B1) for the 15C calibration run. Temperature units are degrees K and radiance units are mW/(m^2 sr cm^{-1}).

T	measured N	Fitted N
180	5.84	5.90
220	21.98	21.99
240	36.27	36.24
275	74.52	74.51
290	96.20	96.17
305	120.08	120.12
315	138.71	138.71
330	168.18	168.17

Table B2 lists the quadratic coefficients $k_0(t)$, $k_1(t)$, and $k_2(t)$ for all five calibration runs and both channels 4 and 5. The intercept and slope coefficients $k_0(t)$ and $k_1(t)$ do vary measurably with operating temperature t. As an example, for channel 4 at C = 500 counts (SST region), when an average $k_0(t)$ is used instead of $k_0(15)$ or $k_0(25)$, a difference of about 1.5K results. For $k_1(t)$, the same process results in a 0.75K change. However, $k_2(t)$ can be considered relatively independent of operating temperature t; substituting an average $k_2(t)$ causes a change of only 0.02K in the SST region.

Table B2 Coefficients for the quadratic fit of N versus C for all five operating temperatures of the NOAA-N AVHRR A306. Coefficient units are radiance, radiance/count, and radiance/count^2 , respectively.

t	$k_0(t)$	$k_1(t)$	$k_2(t)$
	Channel 4		
10C	188.8	-0.2093	0.0000199
15C	191.5	-0.2126	0.0000204
20C	193.7	-0.2146	0.0000203
25C	195.9	-0.2170	0.0000204
30C	198.8	-0.2208	0.0000214
	Channel 5		
10C	204.8	-0.2139	0.0000077
15C	205.4	-0.2146	0.0000079
20C	205.7	-0.2147	0.0000076
25C	206.3	-0.2152	0.0000077
30C	206.8	-0.2161	0.0000081

B2. Linear Radiance versus Count Curve is Very Accurate for Channel 3B

The radiance versus count behavior of thermal channel 3B on the NOAA-N (and all other AVHRRs) is advertised to be linear. To check this, I used the simple property of a straight line that all pieces of the straight line have the same slope. The prelaunch data was measured at 17 different temperatures (180K, 220K, 240K, ... 335K), providing 17 different (AVHRR radiance, AVHRR count) points. I computed the radiance versus count slope, the inverse gain, between points (1,2), (1,3), … (1,17), then points (2,3), … (2,17), etc. In all, there are 136 pairs of points. The median of the 136 slopes, using the 20C calibration run data, was -0.0026423 { mW/(m^2 sr cm^{-1}) } / count. 120 out of the 136 slopes, or 88%, were within ***∀2 parts in a 1,000*** of the median slope. This is consistent straight line behavior. Table B3 shows prelaunch external blackbody temperature, and channel 3B radiance and count values for the NOAA-N AVHRR A306 from the 20C calibration run. The slopes farthest from the median were generally from straight line sections at lower radiance or temperature. In this region, any noise in the count values (minimum change = ∀1 count) affects the slope value strongly.

Table B3. Temperature, radiance, and count data for NOAA-N AVHRR channel 3B from the 20C calibration run. Temperature units are degrees K and radiance units are mW/(m^2 sr cm^{-1}).

T	N	C
180	0.0001	991.6
220	0.0064	989.1
240	0.0274	981.0
275	0.2018	913.3
290	0.4149	830.9
305	0.7964	683.4
315	1.1734	537.8
330	2.0213	210.4

B3. Thermal Spectral Response Functions are "in-family" for the AVHRR A306

Users of NOAA-16 AVHRR thermal channel data, such as Dr. A. Harris, were suspicious of the spectral response function data for this instrument. Conversations with ITT revealed that the NOAA-16 AVHRR A301 was the first of the newer AVHRR/3's for which ITT used an upgraded test setup to make the spectral response function measurements. After checking their results thoroughly, ITT concluded the setup was most likely in error for the A301 measurements. {They believe the NOAA-15 and NOAA-17 measurements, done at a later date, are correct.} Since this episode, we now check the spectral response data by the simple method of comparing it to spectral response function datasets from previous AVHRRs. All these previous spectral responses were within specification, even that from the NOAA-16. However, when they were plotted against each other, it was obvious to the eye that the NOAA-16 was noticeably different from the others, sometimes called "out-of family".

Figure 6 shows that the spectral response functions from the thermal channels of the NOAA-N AVHRR A306 are quite comparable to those from the NOAA-12, -14, -15, and -17. They are "in-family". A more quantitative way to do these comparisons is to convolute the spectral responses from various AVHRRs with different atmospheres in a radiative transfer code and compare the top-of-the-atmosphere radiances. I don't have this capability now but hope to have it soon.

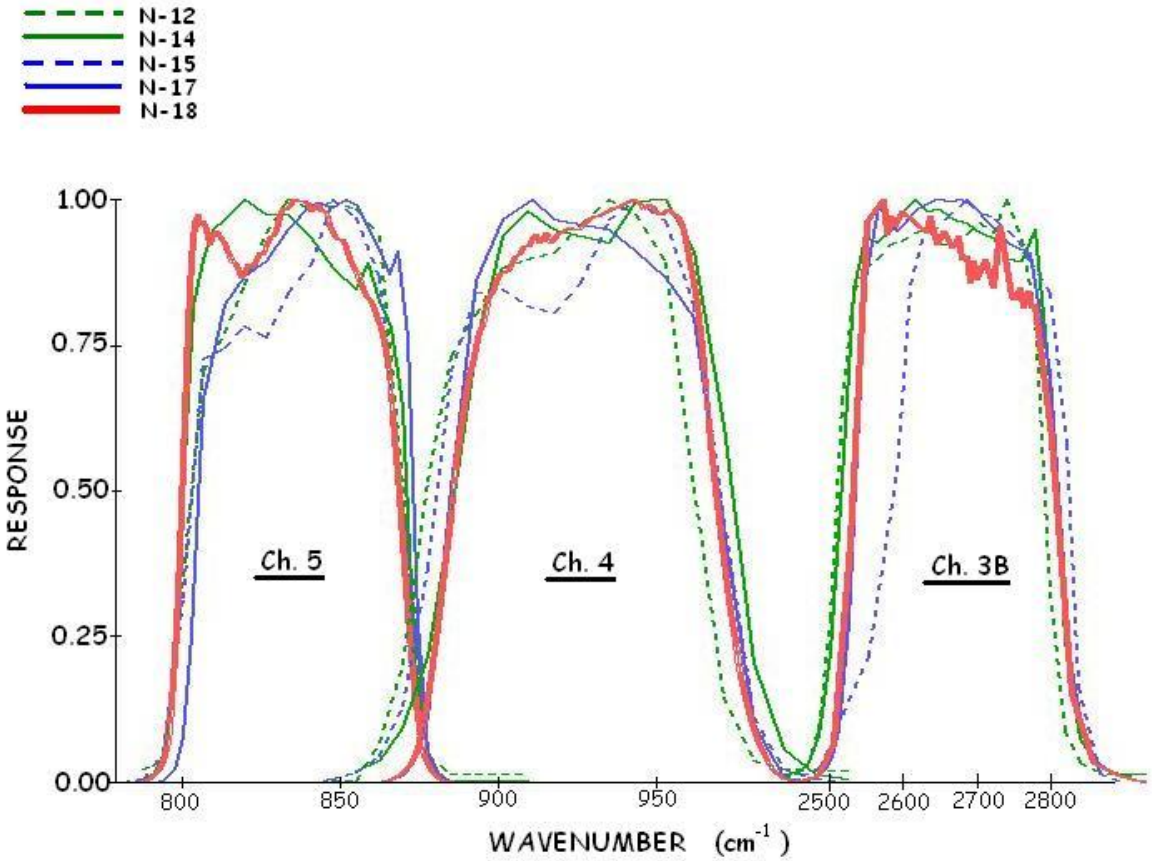

Figure 6. Spectral response functions from NOAA-N AVHRR A306 thermal channels compared to those from the NOAA-12, NOAA-14, NOAA-15, and NOAA-17 AVHRRs.