INFRARED CALIBRATION
Menzel
September 1993

For cloud applications, radiances must be RMS accurate to better than

.25 mW/m2/ster/cm-1 (longwave)

.004 mW/m2/ster/cm-1 (shortwave)

Procedure

assume linear radiometer (radiance linear wrt volts measured)

$$R = m V + b$$

expose radiometer to two known sources to set line

space	$Rz = m Vz + b$
bb	$Rbb = m Vbb + b$

repeat often so that temperature changes in foreoptics are tracked by Vz

correct for non-linearity by determining q before launch

$$R = q V^2 + m V + b$$

or in another form

$$R = m V (1 + q V) + b$$

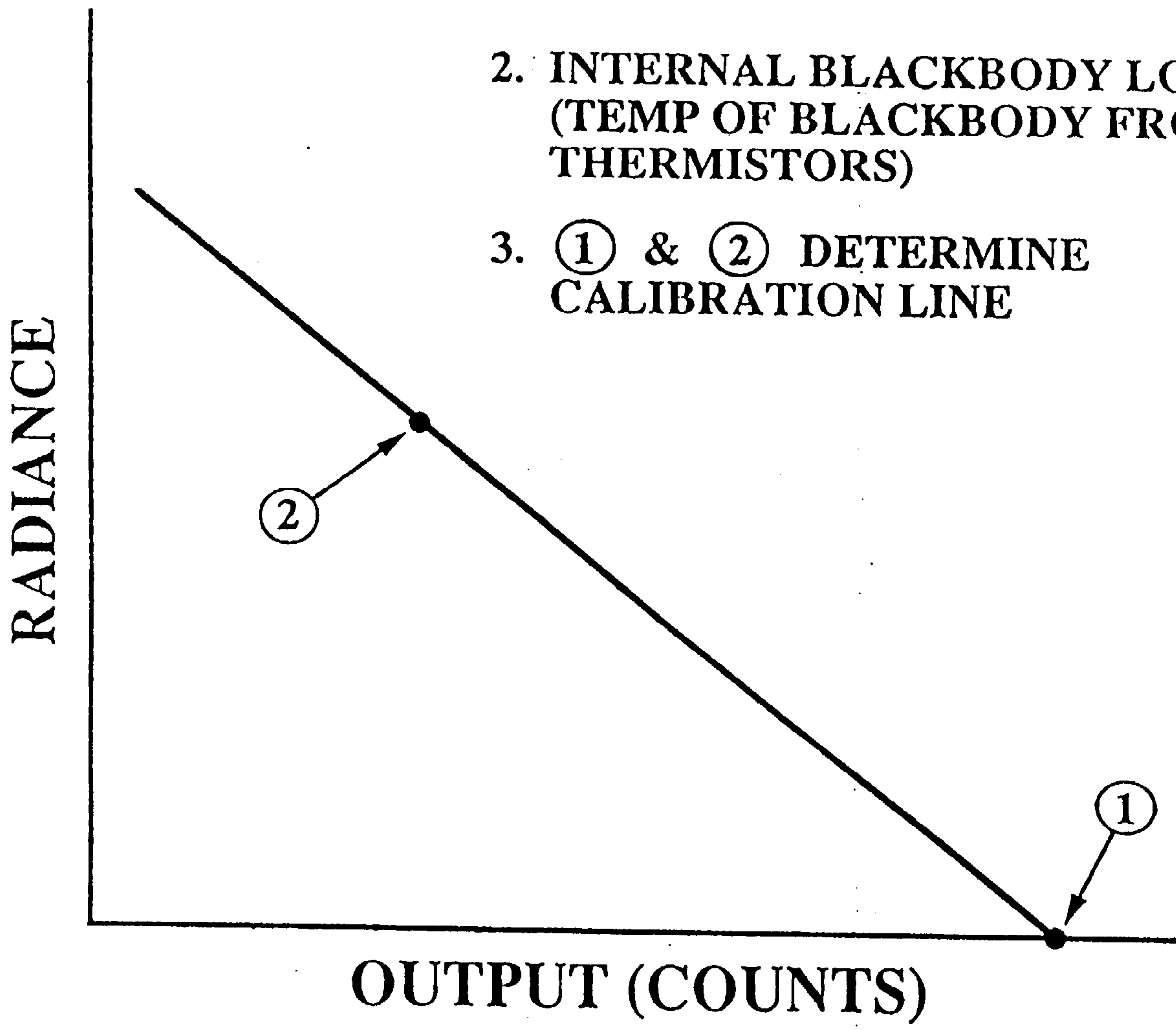
determine q for several baseplate temperatures

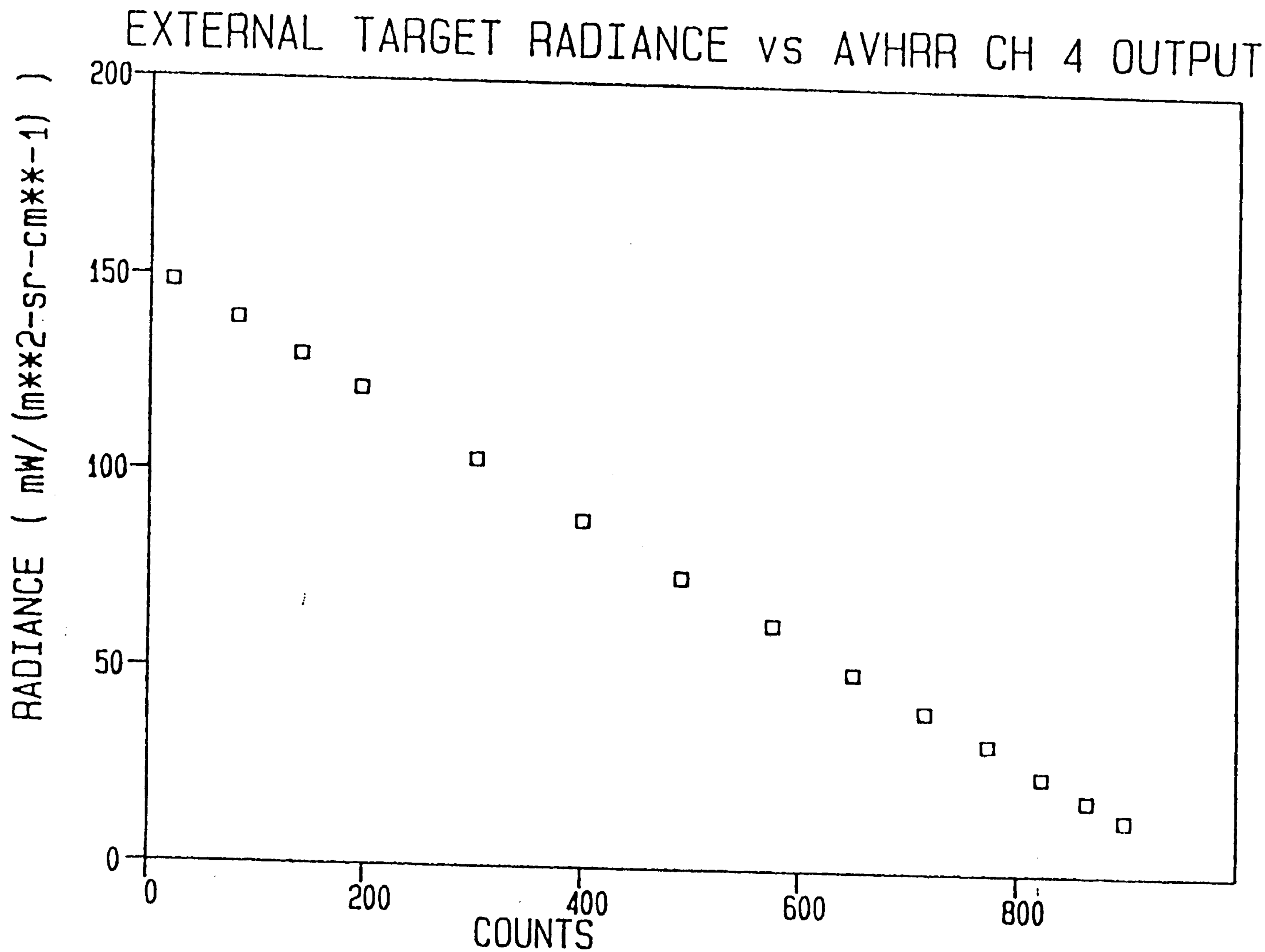
Examples from NOAA polar orbiters

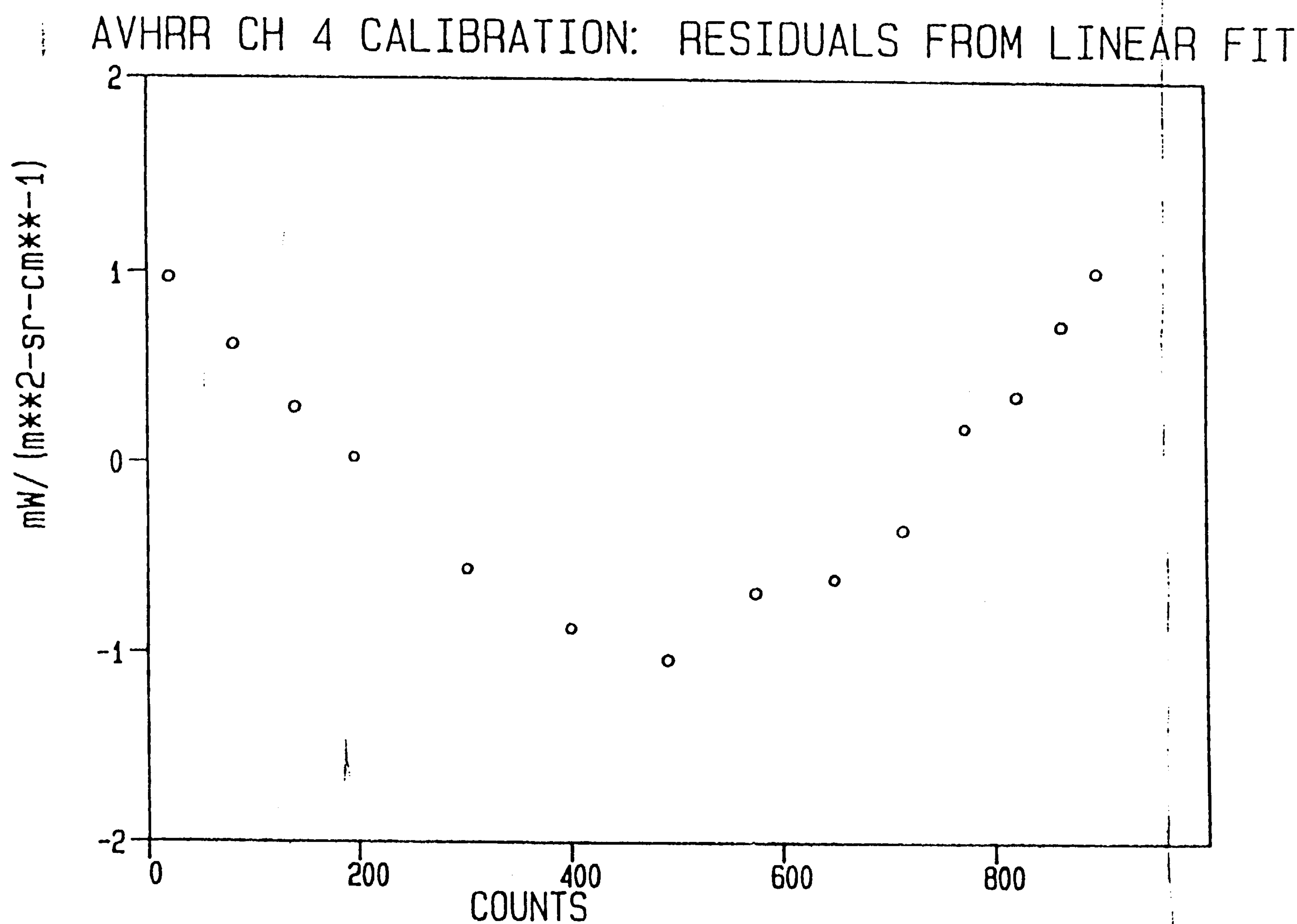
Implementation

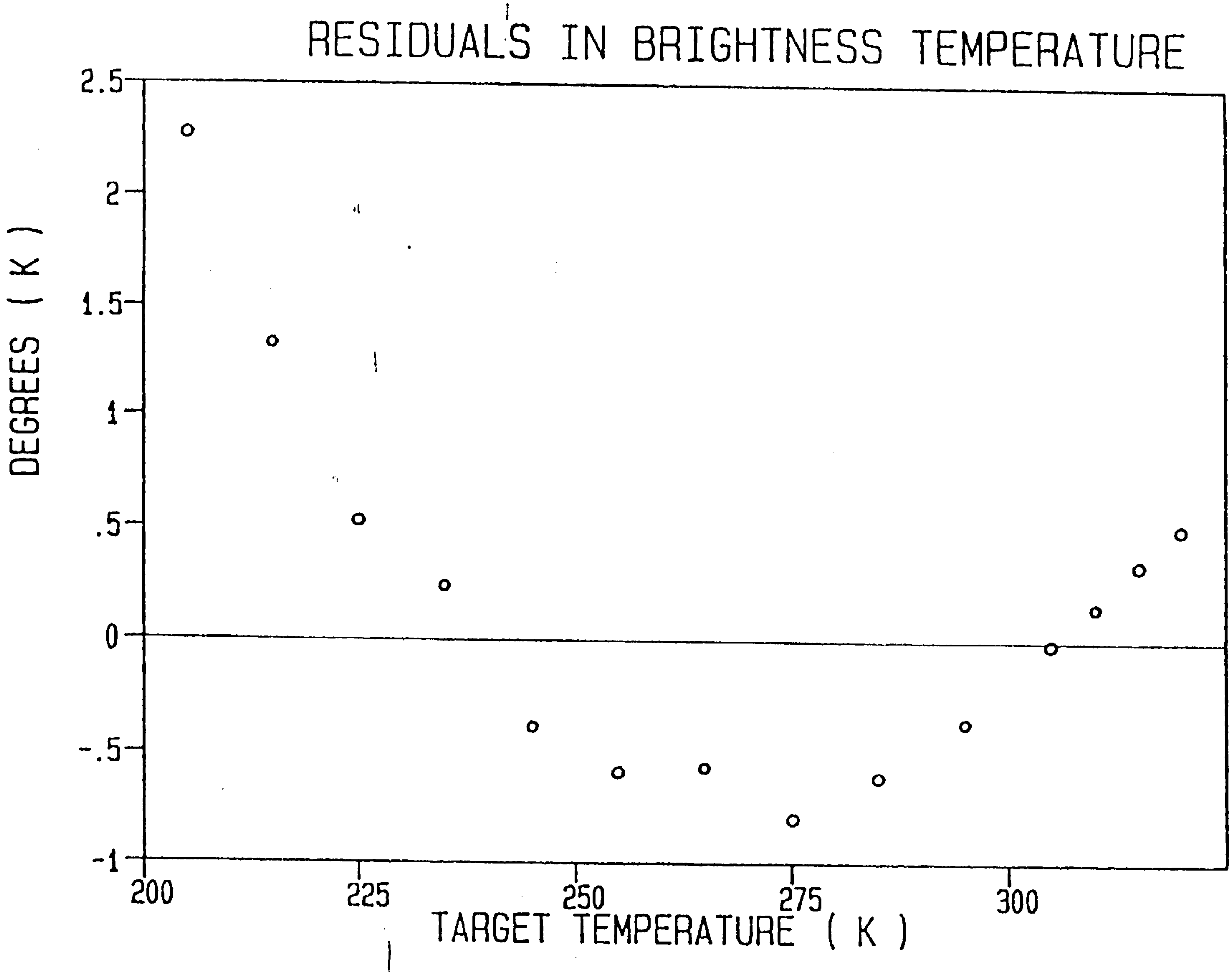
IN - ORBIT CALIBRATION (IR ONLY)

1. SPACE LOOK
2. INTERNAL BLACKBODY LOOK (TEMP OF BLACKBODY FROM THERMISTORS)
3. 1 & 2 DETERMINE CALIBRATION LINE

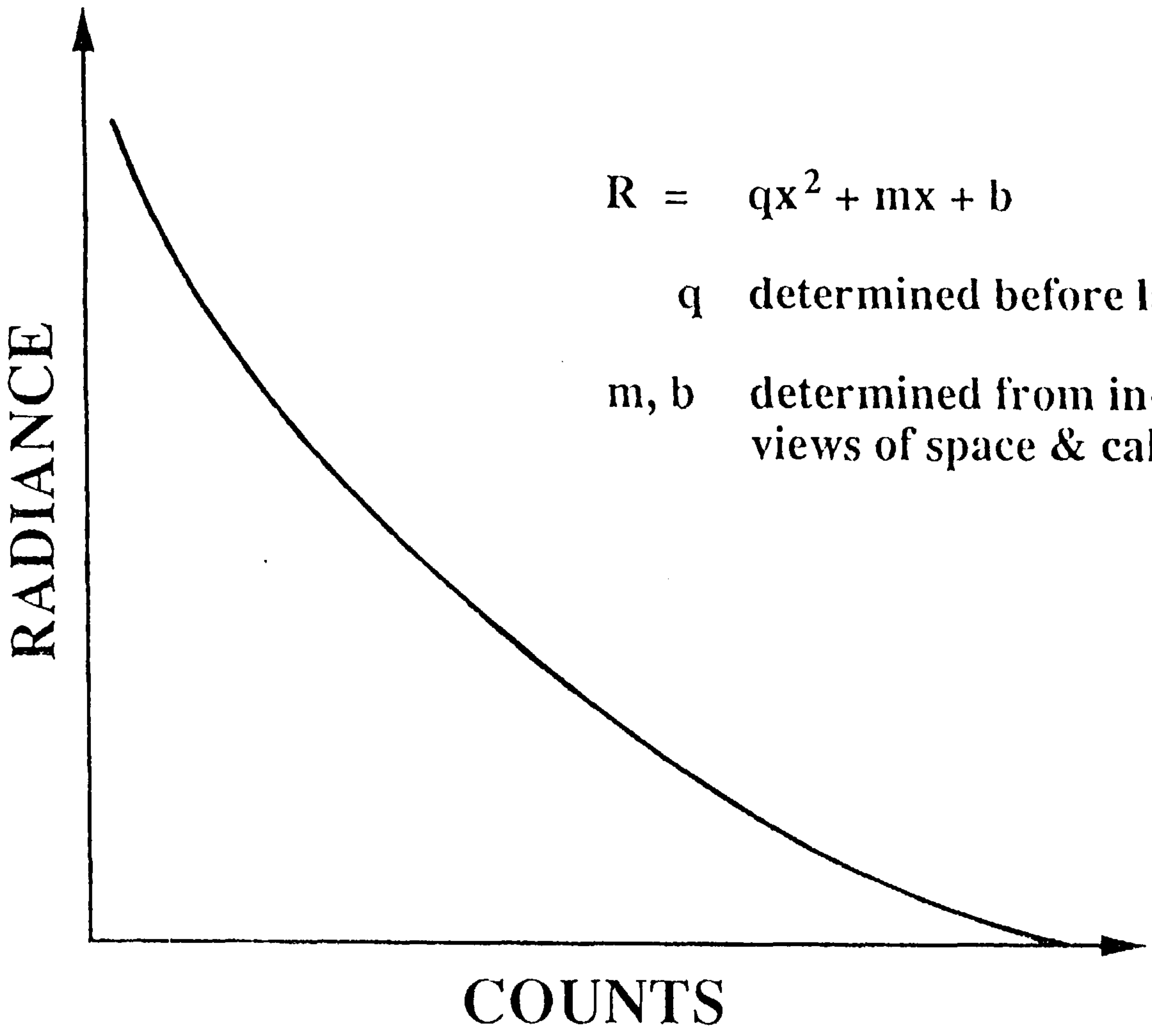


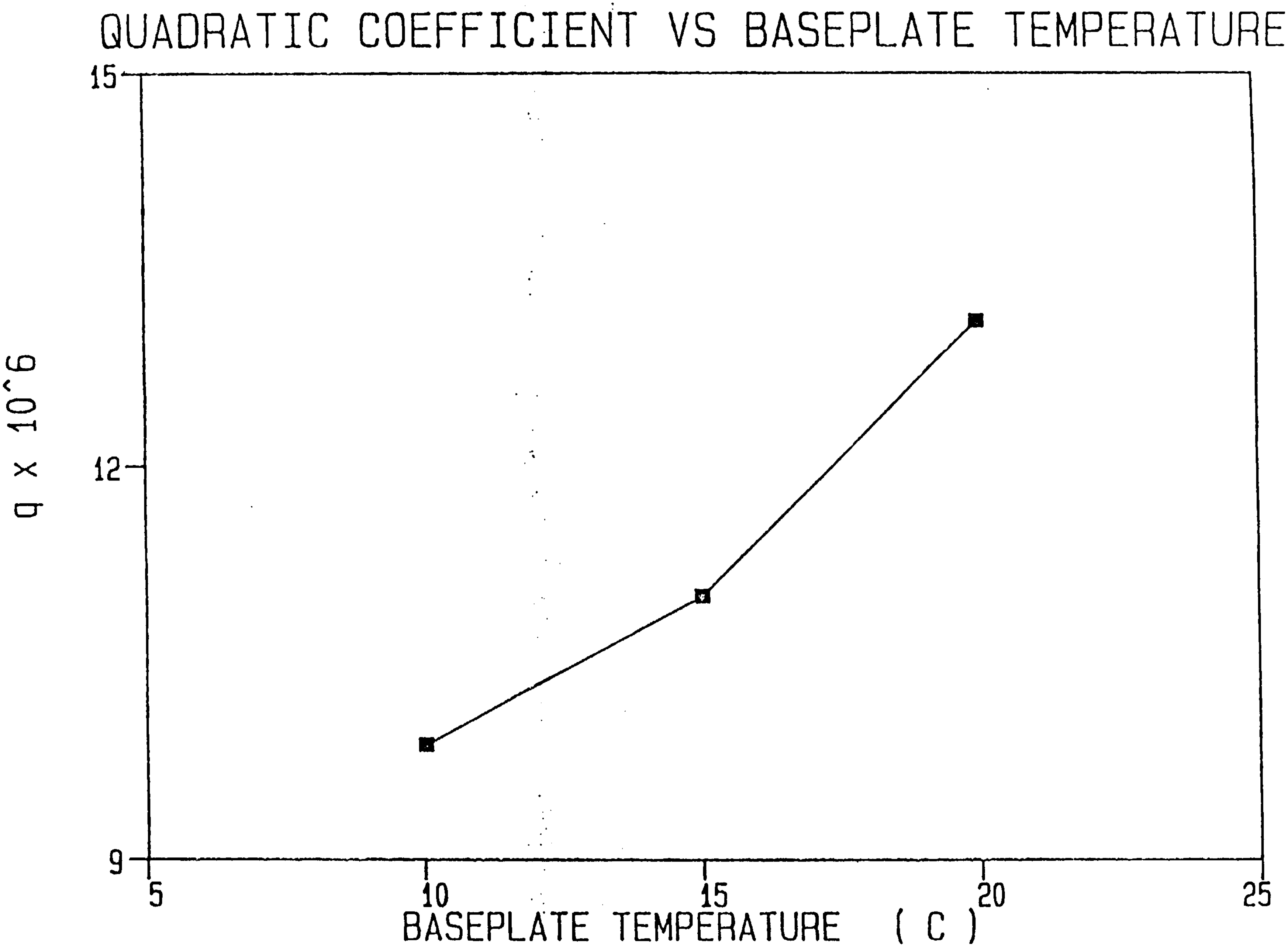

EXTERNAL TARGET RADIANCE vs AVHRR CH 4 OUTPUT
RADIANCE (mW/(m**2-sr-cm**-1))
200
150
100
50
0
0
200
400
600
800
COUNTS

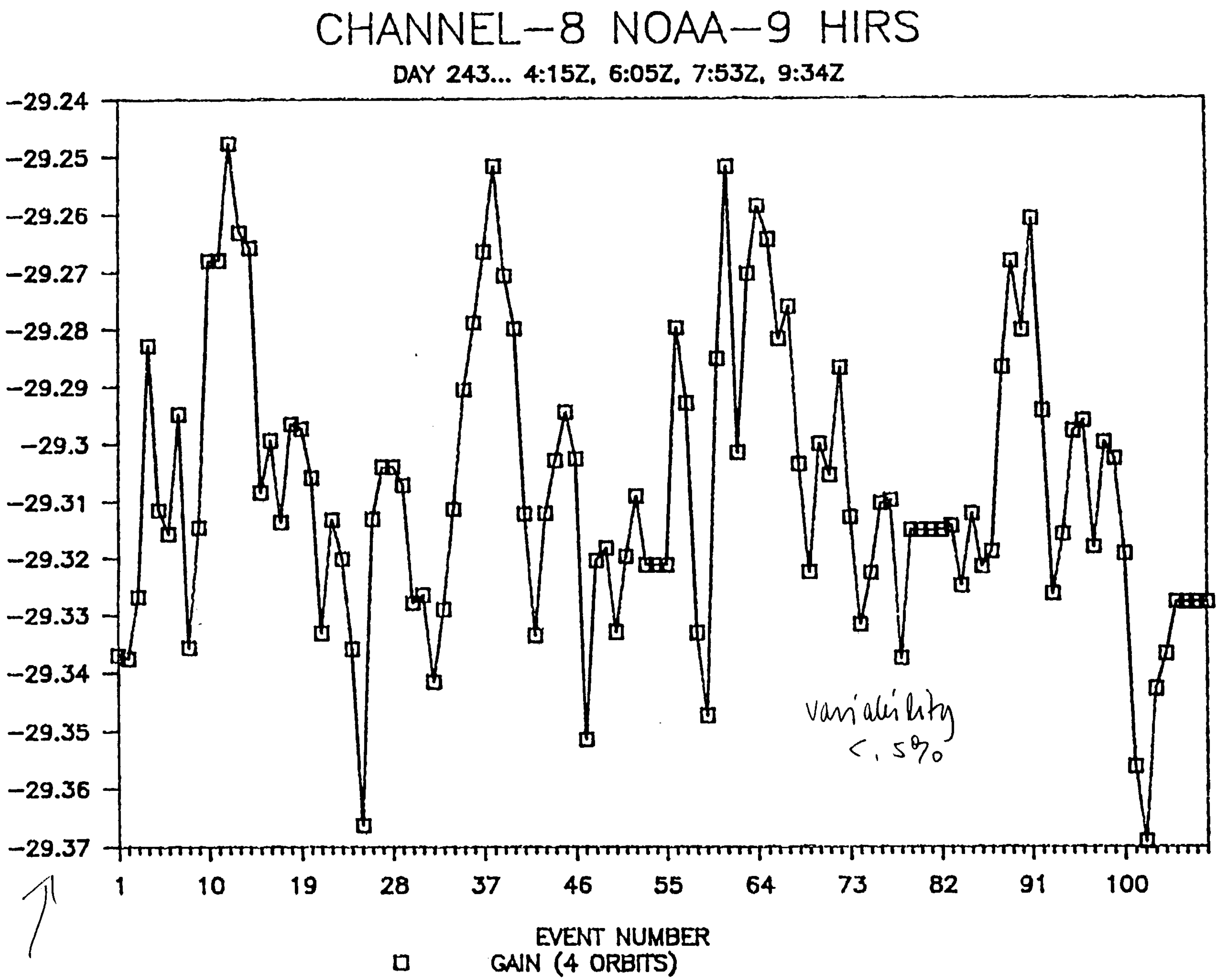

AVHRR CH 4 CALIBRATION: RESIDUALS FROM LINEAR FIT
mW/(m**2-sr-cm**-1)
COUNTS
2
1
0
-1
-2
0
200
400
600
800


RESIDUALS IN BRIGHTNESS TEMPERATURE
DEGREES (K)
2.5
2
1.5
1
.5
0
-.5
-1
200
225
250
275
300
TARGET TEMPERATURE (K)

QUADRATIC CALIBRATION EQUATION



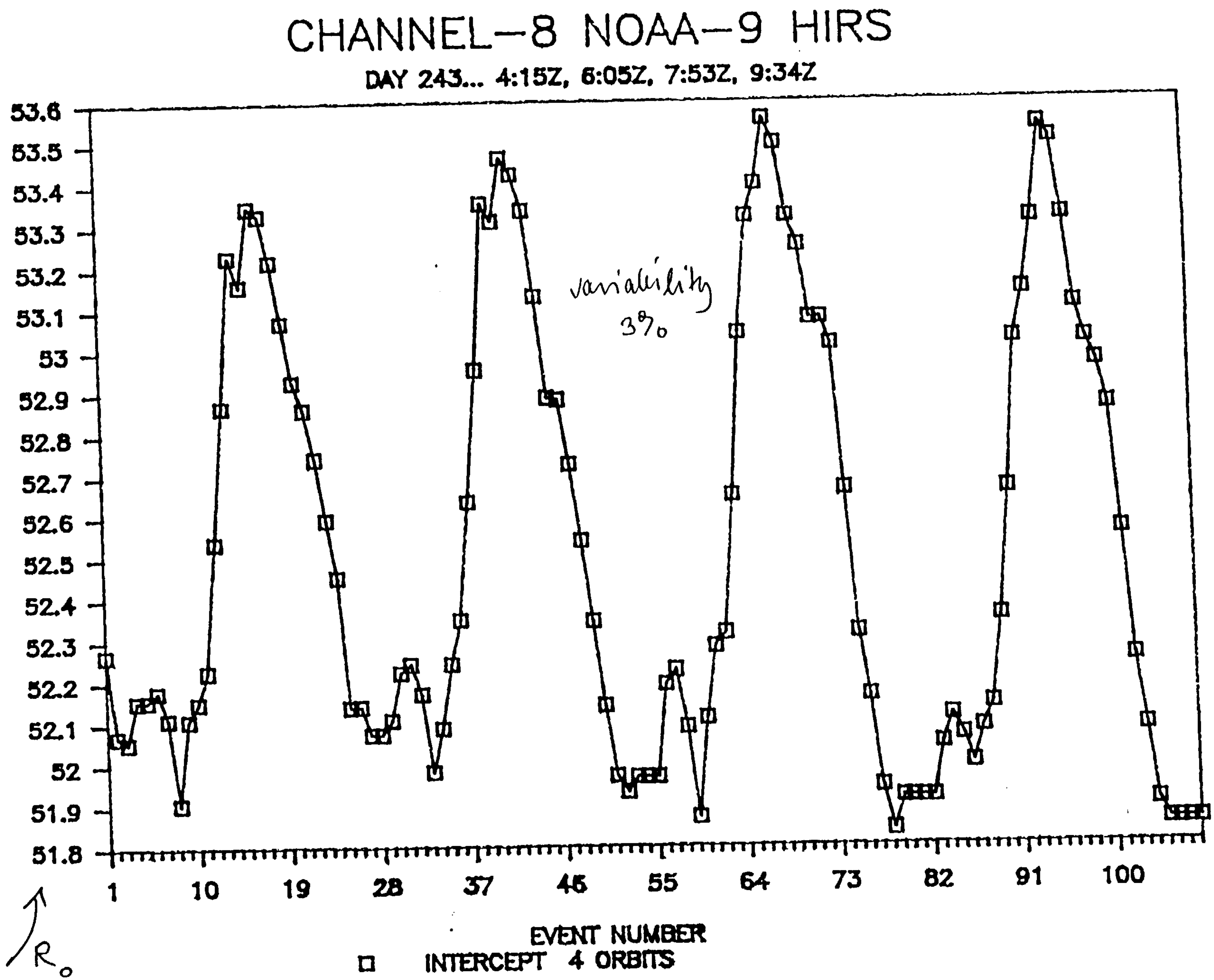

QUADRATIC COEFFICIENT VS BASEPLATE TEMPERATURE
15
12
9
q x 10^6
5
10
15
20
25
BASEPLATE TEMPERATURE (C)



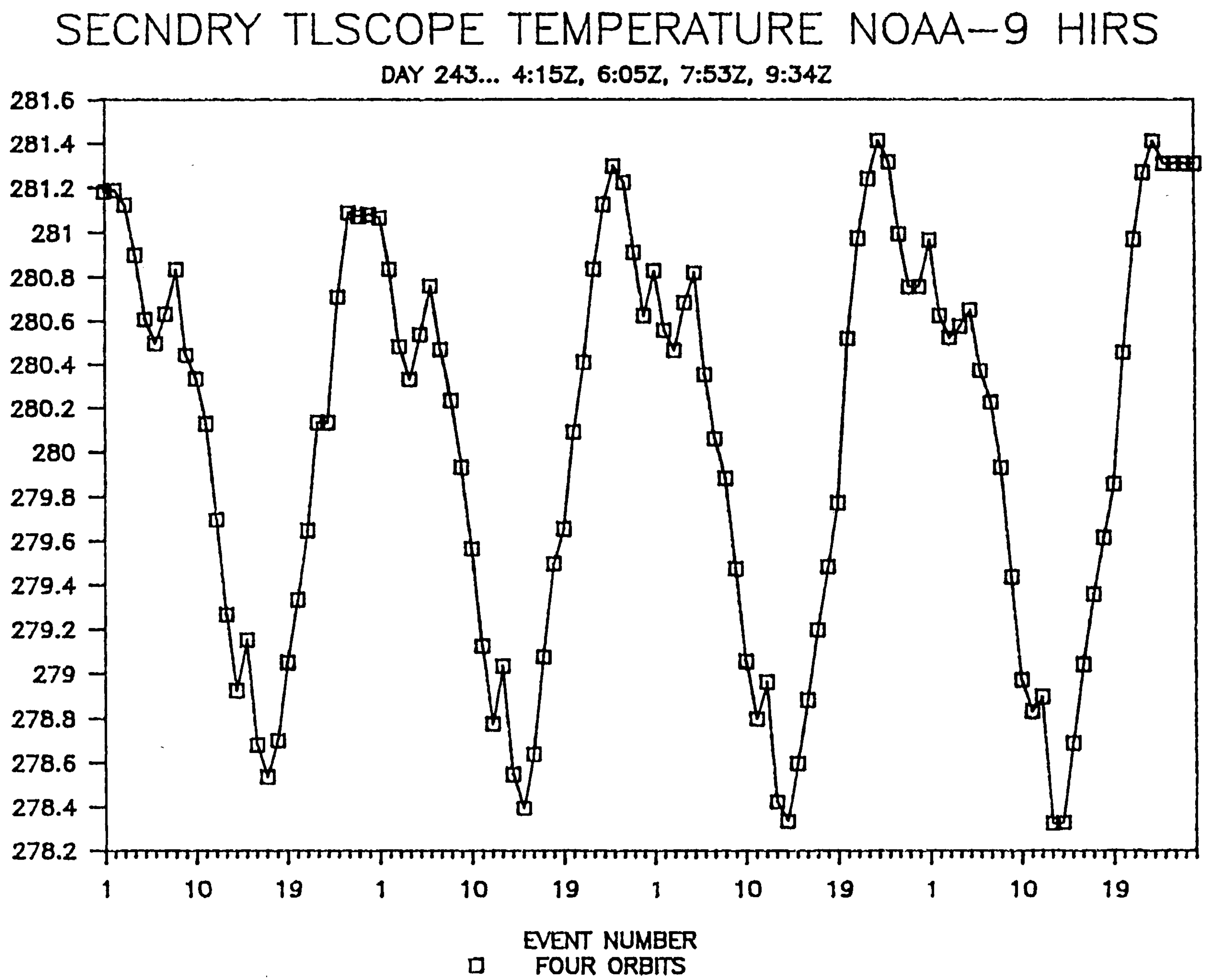
g

gain

intercept



CHANNEL-8 NOAA-9 HIRS
DAY 243... 4:15Z, 6:05Z, 7:53Z, 9:34Z
53.6
53.5
53.4
53.3
53.2
53.1
53
52.9
52.8
52.7
52.6
52.5
52.4
52.3
52.2
52.1
52
51.9
51.8
1
10
19
28
37
46
55
64
73
82
91
100
EVENT NUMBER
INTERCEPT 4 ORBITS
variability
3%
R_o


SECNDRY TLSCOPE TEMPERATURE NOAA-9 HIRS
DAY 243... 4:15Z, 6:05Z, 7:53Z, 9:34Z
281.6
281.4
281.2
281
280.8
280.6
280.4
280.2
280
279.8
279.6
279.4
279.2
279
278.8
278.6
278.4
278.2
1
10
19
1
10
19
1
10
19
1
10
19
EVENT NUMBER
FOUR ORBITS

IMPLEMENTATION

1. CONVERT THERMISTOR READING

(EXT BB, FOREOPTICS) TO TEMPERATURE USING

$$T = \alpha_0 + \alpha_1 x + \alpha_2 x^2 + \alpha_3 x^3 .$$

NEED: PRE-LAUNCH DETERMINATION OF THERMISTOR PERFORMANCE THROUGH RANGE OF EXPECTED IN-FLIGHT BASEPLATE TEMPERATURES (CUBIC FIT REQUIRES MORE THAN FOUR TEMPERATURE PLATEAUS)

2. CALCULATE RADIANCE FOR EACH SPECTRAL BAND

$$R(T) = \int SR(\nu)\, B(\nu,T)\, d\nu$$

WHERE SR IS THE NORMALIZED SPECTRAL RESPONSE. USE CUBIC FIT

$$R(T) = \beta_0 + \beta_1 T + \beta_2 T^2 + \beta_3 T^3 .$$

NEED: PRE-LAUNCH DETERMINATION OF FILTER RESPONSES.

3. CORRECT VOLTAGE READING FOR NONLINEARITY APPROPRIATE TO BASEPLATE TEMPERATURE

$$V' = V + f(T_{bp})V^2 + f'(T_{bp})V^3$$

NEED: PRE-LAUNCH DETERMINATION OF NONLINEARITY THROUGH RANGE OF EXPECTED INFLIGHT BASEPLATE TEMPERATURES (AT FIVE PLATEAUS)

4. DETERMINE TARGET RADIANCE

$$R = R_{BB}(V' - V_z')/(V_{BB}' - V_z')$$

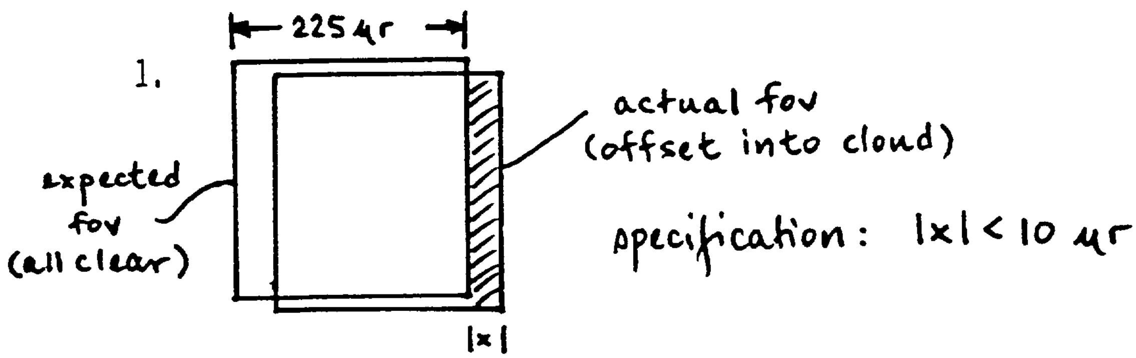
NEED: SPACE AND BB VIEW AS OFTEN AS POSSIBLE; IN BETWEEN EXTRAPOLATE CALIBRATION BY TRACKING FOREOPTICS TEMPERATURE(S).

REGISTRATION

A. FOR SOUNDING OVER A GIVEN AREA, THE MULTISPECTRAL OBSERVATIONS MUST ALL COME FROM THE SAME AREA.

B. MISREGISTRATION EFFECTS THE CLOUD CLEARING ALGORITHM.

1.



ΔR ≡ ERROR ≡ DIFFERENCE BETWEEN RADIANCES OF ACTUAL AND EXPECTED FOVS

$$= (X/225)(N_{CLOUD} - N_{CLEAR})$$

2. EXAMPLE FOR GOES-I CHANNEL 5 (750 CM^{-1}) VIEWING T_{CLOUD} = 220°K AND T_{SFC} = 280°K, MAXIMUM MISREGISTRATION ERROR IS

$$\Delta R = (10/225)(37.5 - 108.7) = -3.2 \text{ MW/STER/M}^2\text{/CM}^{-1}$$

(SPECIFIED SINGLE SAMPLE NOISE = .44 $MW/STER/M^2/CM^{-1}$)

Data needed to define IR MODIS calibration algorithm
and its relative and absolute accuracy.

Menzel/Kaufman

March 1993

1) Spectral response for each IR detector/spectral channel combination
   a) system spectral response function (best estimate)

2) Calibration tested for several instrument thermal configurations
   a) stabilize to isothermal temperatures in foreoptics,
   b) simulate "inflight" temperature gradients
   (orbit low in earth shadow, orbit high in daylight)
   c) isolate selected foreoptics components with a high
   temperature (use clip on heater).

3) Stray radiation must be characterized as a function of view angle
   a) background when viewing blackbody
   b) background when viewing space
   c) background when viewing earth target

4) Non linear response and repeatability must be characterized
   a) at least ten external target temperatures
   (more temperatures should be pursued)
   b) repeated measurements at different times
   c) record should include
      * time of test
      * thermistor readings of all foreoptics components
      * thermistor readings of internal bb
      * detector counts for target, int bb, and space
        (mean and std)

5) Data will be used to calculate R=a+bC+qC2
   a) for each thermal configuration
   b) for each detector
   c) for each spectral channel.

   and to characterize nonlinearity of the calibration equation
   as a function of instrument temperature (q(T)).

6) Half will be used to specify algorithm, half to determine cal alg
   performance.