Near Infrared Radiation in Northern Greenland

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1. Introduction

Measurements of near infrared (0.7–3.0 μ) direct solar and global (direct+diffuse) radiation were taken on clear days near Thule, on the edge of the Icecap, in Northern Greenland (76°24′N, 68°19′W) during May and June 1964. Since published information on near infrared radiation in polar regions is limited, this note presents a brief analysis of the measurements. Instrumentation consisted of Epply pyranometers, 2 m above the surface, and normal incidence pyrheliometers installed on a manually operated altitude-azimuth mount. All instruments were equipped with Schott RG-8 filters.

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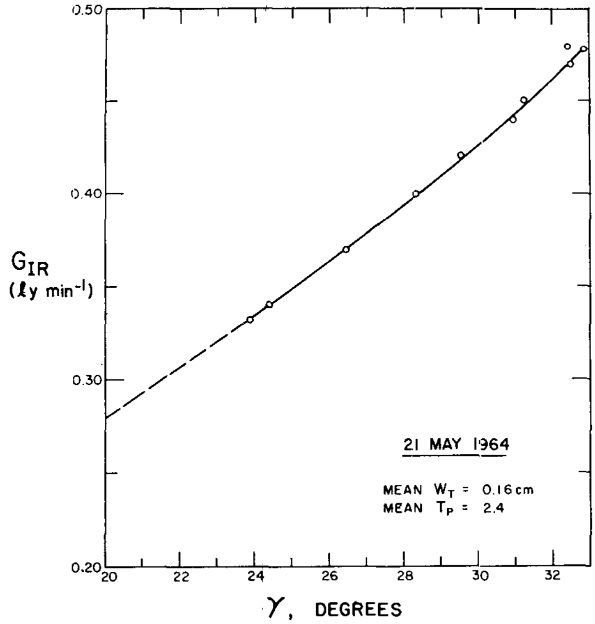

FIG. 1. Near infrared global radiation G_{IR} as a function of the solar altitude γ.

Pyranometers were leveled and filters cleaned daily or as required. Measurements were recorded by a potentiometric strip-chart recorder which was calibrated daily and periodic time checks were from a time standard radio signal.

2. Results

Fig. 1 shows the diurnal pattern of near infrared global radiation on a day of nearly average atomospheric conditions as observed during the period. Maximum solar altitude γ was about 33° or only 3° less than at the summer solstice. Mean atmospheric turbidity T_p, computed according to IGY recommendations (International Council of Scientific Unions, 1958), and atmospheric water vapor content w_T, computed from radiosonde data, were 2.4 and 0.16 cm, respectively. For the entire measurement period T_p averaged 2.6 with a range of 2.3–3.5 and w_T averaged 0.16 cm with a range of 0.13–0.18 cm.

Near infrared global radiation constituted about 51% of the total global radiation for all days of measurement and remained in the range 50–53%.

Fig. 2 shows near infrared and total solar beam transmittance as a function of γ. Computations were made using the solar constant (International Council of Scientific Unions, 1958) for extraterrestrial total solar radiation and by graphical integration of extraterrestrial spectral solar intensity curves (Fritz, 1951) for extraterrestrial near infrared solar radiation. Near infrared solar beam transmittance ranged between 68% when $\gamma=36°$ to 47% when $\gamma=11°$. Total solar beam transmittance varied from about 59% at $\gamma=36°$ to 29% at $\gamma=10°$.

The highest value of diffuse sky radiation, calculated from global and normal incidence radiation, was 0.12 ly min^{-1} in the near infrared and 0.26 ly min^{-1} in the total solar spectrum. Both values occurred on 28 May at 0818 TST when $\gamma=28°$. T_p and w_T were the highest observed during the entire period. The lowest value of diffuse radiation, at $\gamma \geq 15°$, was 0.03 ly min^{-1} for the near infrared and 0.11 ly min^{-1} for the total solar spectrum. Both values occurred on 1 June at 1954 TST when $\gamma=15°$. T_p was fairly low (2.5) and w_T was the lowest recorded during the entire period.

Diffuse radiation constituted about 16% of the global radiation in the near infrared and about 23% in the total solar spectrum. Gerdel and Diamond (1956) found that diffuse radiation was about 19% of global radiation at a site on the Greenland icecap with a continuous snow surface. Higher atmospheric turbidity at the edge of the icecap probably contributes to the higher percentage of diffuse radiation to global radiation. Turbidity measurements made near the location of Gerdel and Diamond's observations averaged 1.9 during a one month period in August and September 1963.

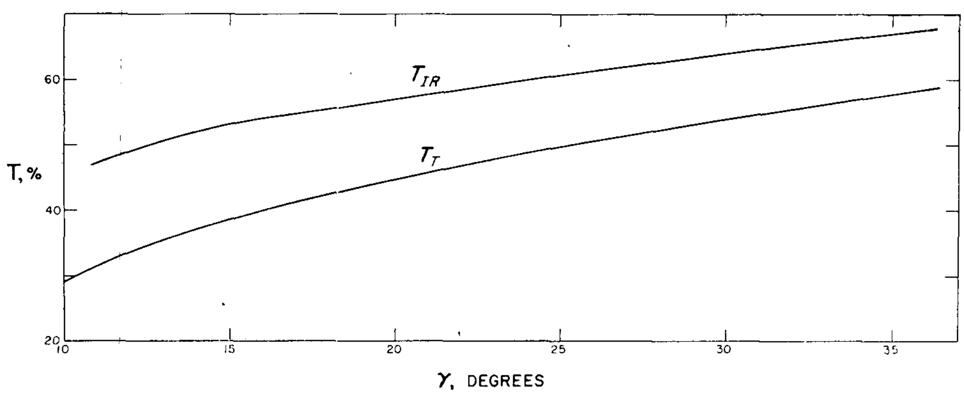

FIG. 2. Near infrared T_{IR} and total T_T solar beam transmittance as a function of the solar altitude γ.

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A Rational Approximation for Saturation Vapor Pressure over the Temperature Range of Sea Water

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It is an immediate consequence of the Clausius-Clapeyron equation that the saturation vapor pressure e_s of an ideal gas in equilibrium with its own condensate is a decaying exponential function of $L/(R_sT)$, where L is the latent heat, R_s the specific gas constant for the substance, and T the Kelvin temperature. For water vapor in equilibrium with liquid water and e_s in millibars, the handbook (Berry *et al.*, 1945, p. 343) form of the complete relation is

$$\ln\left(\frac{e_s}{6.105}\right)=25.22\left(\frac{T-273}{T}\right)-5.31\ln\left(\frac{T}{273}\right), \quad (1)$$

which accounts for the dependence of latent heat upon temperature.

When e_s is to be evaluated by computer, for example in a general circulation model with hydrological cycle, computational efficiency is substantially improved if we replace (1) by a rational approximation. We begin by selecting a value T_0 near the center of the range to be treated. Expanding the logarithm in (1), we obtain

$$e_s=A\exp\{B(1-T_0/T)-C(1-T_0/)^2+O[(1-T_0/T)^3]\},$$

where

$$A=6.105\exp\{25.22(1-273/T_0)+5.31\ln(273/T_0)\},$$
$$B=25.22(273/T_0)-5.31,\quad C=2.655.$$

Next we employ the continued fraction expansion for the exponential function (Wall, 1948, p. 348). Truncating at the fifth term, rewriting as a simple fraction, and neglecting terms of order $(1-T_0/T)^3$ in numerator and denominator yields the approximate formula

$$e_s\doteq\frac{T^2-c_1T+c_2}{c_3T^2-c_4T+c_5}, \quad (2)$$

with

$$c_1=2(B^2+3B-6C)T_0/D,$$
$$c_2=(B^2-6C)T_0^2/D,$$
$$c_3=(12+B^2-6B+6C)/AD,$$
$$c_4=2(B^2-3B+6C)T_0/AD,$$
$$c_5=(B^2+6C)T_0^2/AD,$$

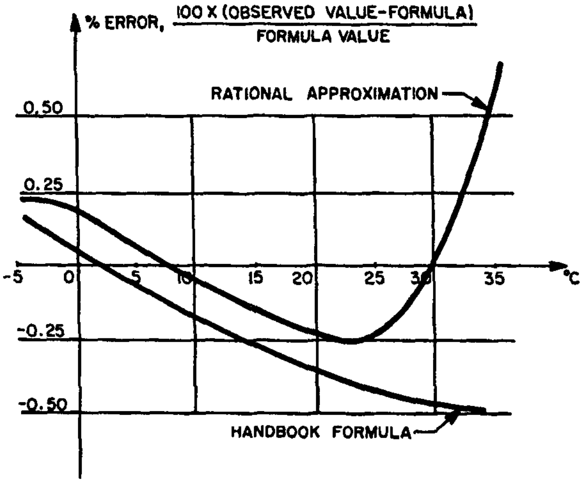

FIG. 1. Error curves for the formulas.

where

$$D=12+B^2+6B-6C.$$

To cover the temperature range of sea water, we choose $T_0=287$. The approximation (2) then becomes

$$e_s\doteq\frac{T^2-488.56T+60009.3}{0.0361622T^2-24.209T+4104.45}. \quad (3)$$

Comparing results obtained from (3) with the observed values (Byers, 1959, p. 158) yields the error curve shown in Fig. 1. The corresponding curve for the handbook formula is included for comparison. The derivation of (3) indicates that the curves should touch at 14C, but the rational approximation was improved somewhat by judicious rounding of the c_i. The originally computed values, to seven significant figures, were

$$c_1=488.5568,\quad c_2=60009.27$$
$$c_3=0.03616217,\quad c_4=24.20942,\quad c_5=4104.454.$$

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