On the Possibility of Atmospheric Infrared Cooling Estimates from Satellite Observations

ROMEO R. SABATINI AND VERNER E. SUOMI

Department of Meteorology, University of Wisconsin

8 May 1962

The total atmospheric infrared cooling from the surface to the top of the radiometersonde ascent (average burst pressure, 34 mb) was calculated for 193 nocturnal ascents made at various stations in the United States and Caribbean from October 1960 to January 1961. Only ascents that went above 100 mb were used for this study. The upward (F_{up}) and downward (F_{down}) fluxes of infrared radiation were measured through the atmosphere by means of the Suomi-Kuhn radiometer (1958) attached to the standard U. S. Weather Bureau radiosonde. The infrared cooling rate, $\Delta T/\Delta t$, was then obtained from the divergence of the net radiation flux ($F_{\mathrm{net}}=F_{\mathrm{up}}-F_{\mathrm{down}}$):

$$\frac{\Delta T}{\Delta t}=\mathrm{const}\frac{\Delta F_{\mathrm{net}}}{\Delta p}.$$

If $\Delta T/\Delta t$ is expressed in deg Celsius per day, F_{net} in langleys min^{-1}, and Δp in millibars, the constant assumes the numerical value 5904.6. C, the total atmospheric cooling in deg Celsius per day, is equal to $\Delta T/\Delta t$ computed from the surface to the top of the ascent. C was correlated with the outgoing infrared flux at the top of the ascent, F, expressed in langleys per minute. Correlation coefficients R were calculated for all ascents and for ascents through different cloud cover conditions. The results are presented in Fig. 1, and Table 1.

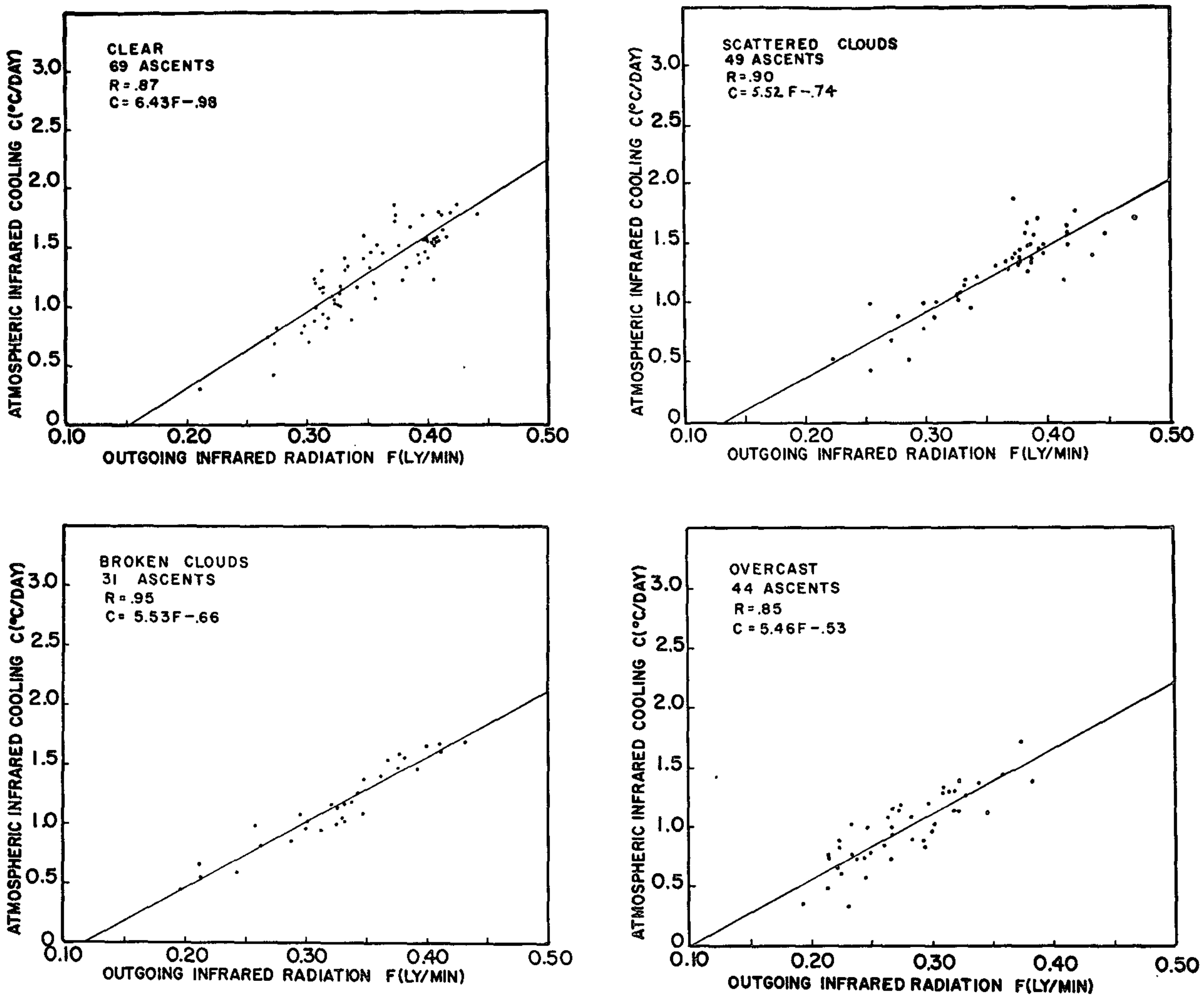
When we combined all the ascents, we obtained a single regression equation expressing the relationship between atmospheric infrared cooling and outgoing infrared radiation which holds to a fairly high degree of confidence, regardless of the kind or quantity of clouds the radiometer is looking down upon. It is expected that in the polar regions, where the atmosphere contains a minimum of water vapor, the surface temperature also would have to be taken into consideration. Investigations are now underway by us to determine how the total atmospheric infrared cooling in the polar regions varies with both surface temperature and outgoing infrared radiation at the top of the atmosphere. The importance of the high correlation obtained is readily realized when we consider that a satellite measuring the outgoing flux of infrared radiation over the whole earth-atmosphere system can readily give, at least for low and middle latitudes, good spatial and temporal estimates of the atmospheric infrared cooling, a major term in the energy balance of the earth-atmosphere system.

TABLE 1. Summary of correlation coefficients R, and regression equations.

Cloud cover	R	Regression equation
Clear	0.87	$C=6.43F-0.98$
Scattered	0.90	$C=5.52F-0.74$
Broken	0.95	$C=5.53F-0.66$
Overcast	0.85	$C=5.46F-0.53$
All ascents	0.88	$C=5.14F-0.53$

REFERENCES

Suomi, V. E., 1958: The radiation balance of the earth from a satellite. *Annals of the I.G.Y.*, **6**, 331–340.
——, and P. M. Kuhn, 1958: An economical net radiometer. *Tellus*, **10**, 160–163.



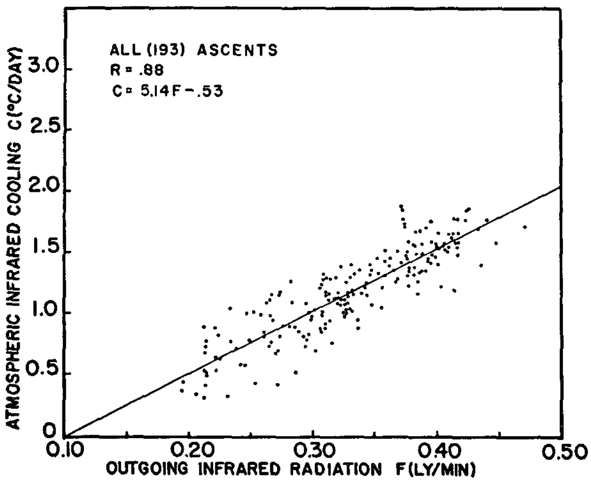


FIG. 1. Scatter diagrams showing the relationship between outgoing infrared radiation flux F at the top of the radiometersonde ascent (abscissa), and total atmospheric infrared cooling C from the surface to the top of the ascent (ordinate), for different sky cover conditions. F is in langleys per min, C is in deg Celsius per day. R is the correlation coefficient. Only ascents that went above 100 mb were considered. The average burst height was 34 mb.