ABSOLUTE SOLAR INTENSITIES AND THE SOLAR CONSTANT

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Abstract. Absolute intensity measurements made in high altitudes on board of an aircraft are of less accuracy than ground based observations made at locations with favourable atmospheric conditions. As things stand, the rms-errors appear to be $\geqslant 3\%$ and $\leqslant 2\%$ respectively. Some of the reasons are sketched.

The talk of Dr Code this morning has pointed out the tendency to *over*estimate absolute measurements, which are made from aircrafts at high altitudes, in comparison to ground-based observations. As you may remember, Dr Code preferred the solar energy distribution obtained by Arvesen *et al.* (1969), the accuracy of which was given as $\pm 3\%$ in the visual region, as $\pm 6\%$ at 3200 Å, and as $\pm 25\%$ at 3000 Å. These errors are clearly larger than those errors which are caused by atmospheric extinction for ground-based observations, provided these are made at places with good atmospheric conditions.

In fact, the gain in stability of atmospheric extinction which one gets, if one ascends e.g. from the Jungfraujoch Scientific Station at 3.6 km to a height of 12 km, is not as large as to compensate the disadvantages, which are necessarily connected with aircraft flights.

As at the ground, the short wave region below 0.3 μ is cut off completely also at 12 km altitude by the ozone layer. The infrared region beyond 3–4 μ is generally blocked by at least one, mostly more glass or quartz windows in front of the equipment. That means, the advantages ascribed to high altitude observations can concern the spectral region from 0.3 to 3 μ only.

The extinction is – of course – less at an altitude of 12 km than at 3.6 km, but it is much more difficult to obtain its correct, instantaneous value. The flight-time is limited (2–4 h) and usually permits only 1–2 spectral scans per day. To evaluate approximately the extinction, data of different flights have to be combined. This procedure requires that the (zenith-) extinction at a given altitude (e.g. 12 km) does not vary with the seasons (Arvesen's observations were made in August and October!) and that the extinction is the same above a desert area in the middle of a continent as it is above the ocean. These assumptions may be very misleading.

The accuracy obtainable for ground-based observations is to be seen in Figure 1 ($\lambda > 0.3\ \mu$!). Here a comparison is made between observations which were obtained mainly at high mountain stations with good atmospheric conditions, and the continuum of the 'Harvard Smithsonian Reference Atmosphere' (HSRA).

For wavelengths above 0.6 μ the standard deviation of one observation relative to

B. Hauck and B.E. Westerlund (eds.), Problems of Calibration of Absolute Magnitudes and Temperature of Stars, 149–152.

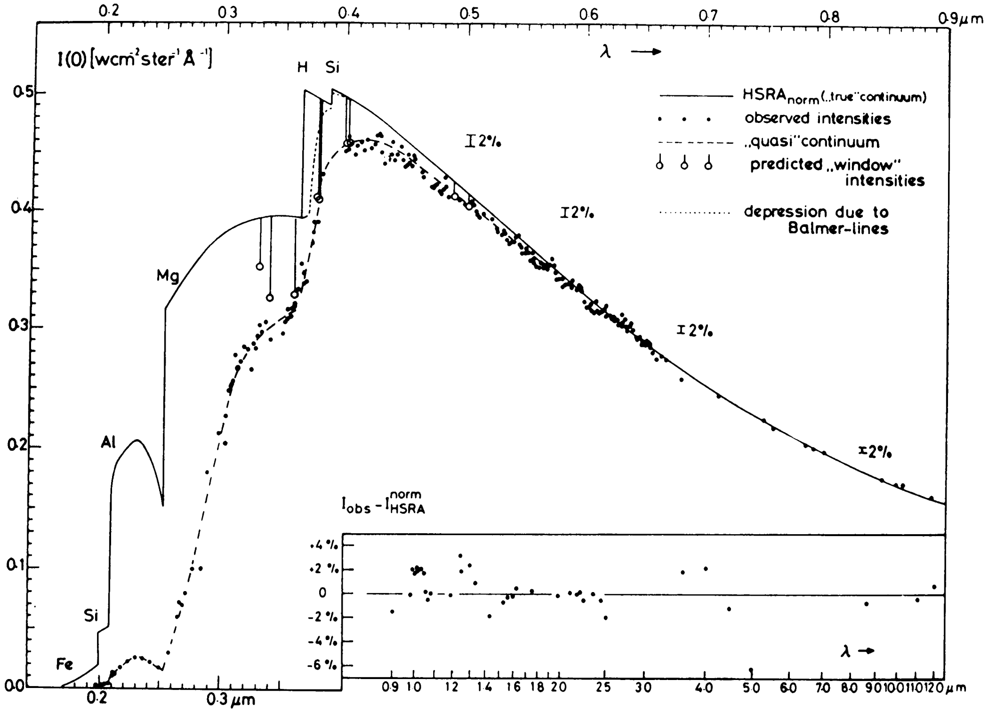

Fig. 1. Normalized HSRA continuum and the actual observations according to: Bonnet (1968; $\lambda < 0.29\ \mu$), Houtgast (1968; $\lambda\lambda$ 0.2977–0.3275 μ), Labs and Neckel (1968, 1970; $\lambda\lambda$ 0.3290–1.2470 μ), Pierce (1954; $\lambda\lambda$ 1.2986–2.5074 μ), Farmer and Todd (1964; $\lambda\lambda$ 3.6–5.0 μ), and Saiedy (1960; $\lambda\lambda$ 8.63–12.02 μ). Predicted window intensities and Balmer line depression, both being related to normalized HSRA continuum, according to Holweger (1970).

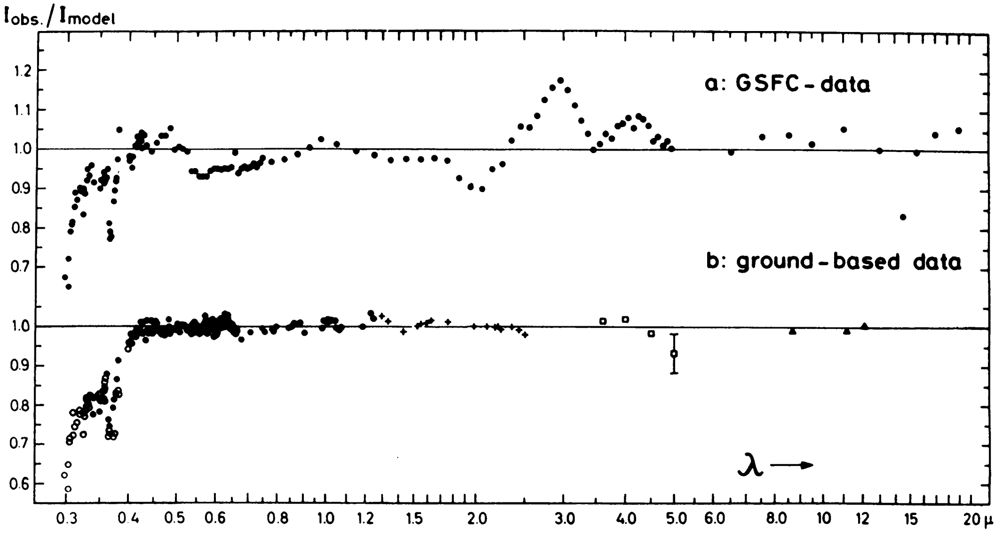

Fig. 2. Ratio of observed 'continuum' intensities to model-continuum. (Below 0.5 μ the observed intensities are those in the highest 'windows'. For details see Labs and Neckel, 1968, 1970.) (a) For the 'GSFC-continuum' corresponding to the irradiance observed within 'NASA 711 Galileo' flight experiment of GSFC. (b) For high mountain observations with careful determination of atmospheric extinction, according to Houtgast (○) 1970, Labs and Neckel (●) 1970, Pierce (+) 1954 Farmre, and Todd (□) 1964, and Saidy (▲) 1960.

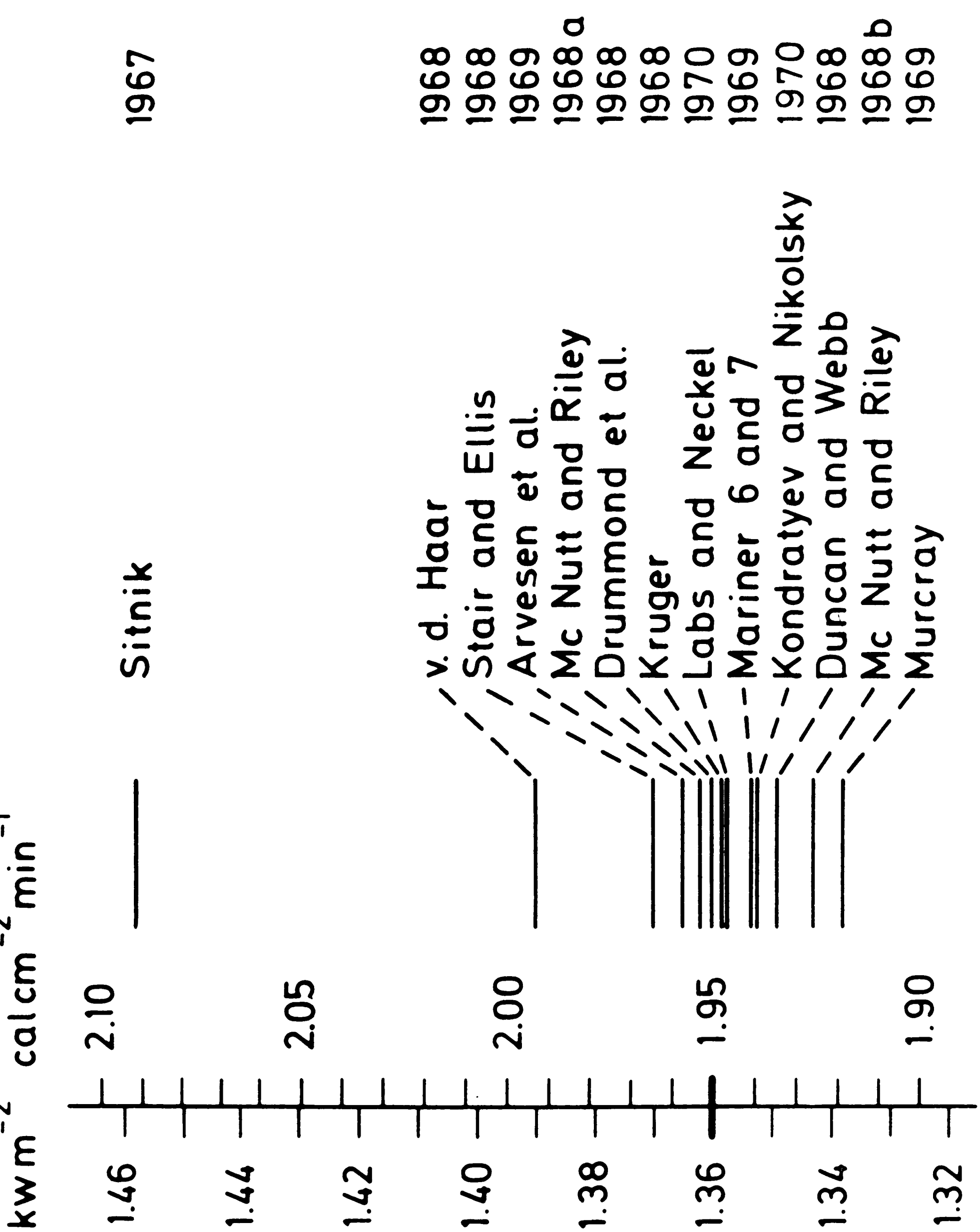

Fig. 3. Recent measurements of the solar constant.

the HSRA continuum is $\pm 1.3\%$. Shortward of 0.6 μ the observed intensities are below the model continuum and form a 'quasi continuum'. Down to 0.36 μ the differences are fully explainable by the 'line haze' evaluated quantitatively by Holweger (1970). Also in this spectral region the mean error appears to be less than 2%.

Figure 2 compares the ground-based observations with the results obtained within a flight experiment of the Goddard Space Flight Center (GSFC). It appears very likely that the 'waves' of the 'GSFC-continuum' relative to the model continuum reflect just the experimental inaccuracies of the original irradiance data rather than intrinsic characteristics of the solar atmosphere.

Figure 3 may give some idea about the correctness of the absolute scale of the solar intensities discussed above. This figure compares all values of the solar constant obtained since 1967, including the value derived by us, which was mainly based on the ground-based irradiance data. The value of Arvesen (originally 1.390 kW cm^{-2}) has been lowered by 2.5%, due to a correction of the lamp calibration reported by Duncan (1969). The best value of the solar constant appears to be close to 1.95 cal cm^{-2} min^{-1} or 1.36 kw m^{-2}.

References

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Duncan, C. H.: 1969, 'Radiation Scales and the Solar Constant', Goddard Space Flight Center Report No. X-713-69-382, Greenbelt, Maryland.
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DISCUSSION

Pecker: I agree with Dr Neckel on the great weight of good ground-based experiments. But the 'best fit' with HSRA model could be somewhat misleading, as Gingerich has precisely been using Labs and Neckel energy distribution in the spectrum (it is, so far as T is concerned, a purely empirical model).

Neckel: Figures 1 and 2 should demonstrate that it is possible to find a model, which obeys (1) the observations and (2) the fundamental physical laws such as hydrostatic equilibrium etc. There are many sets of observations, e.g. the GSFC-data and the Russian observations, which can not be represented by such a model atmosphere.