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Comparison between rocket - and radio-sonde data and Nimbus E satellite data - preliminary results

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COMPARISONS BETWEEN ROCKET - AND RADIO-SONDE DATA AND NIMBUS E SATELLITE DATA - PRELIMINARY RESULTS

HA/IG/9

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Introduction

This report describes the method that has been adopted in the High Atmosphere branch for comparing data from the Selective Chopper Radiometer on the Nimbus E satellite and 'conventional' rocket-and-radio-sonde data. There seem to be two main ways of performing a direct comparison.

Some early results from the application of these comparisons are then described, using data extracted from the 'daily tapes' of Nimbus E data obtained from the Clarendon Laboratory, Oxford.

Methods of comparison

An earlier report[1] described the production of objectively analysed charts of both the northern and southern hemisphere of radiances measured by the differenced B channels and top A channel of the SCR on Nimbus E and standard thickness derived from these radiance measurements. The grid on which the analysis were performed was a 61 x 61 square grid exscribing the octagon used in the operational Met O 2 analyses. As well as producing grid point values of the various fields, spot values at points on the grid coincident with rocket-sonde stations were also calculated. These were obtained by interpolation from the surrounding grid points using the formula

$$f(o) = (1 - x)(1 - y)\, f(A) + x(1 - y)\, f(B) + (1 - x)\, y f(c) + xy\, f(D)$$

where the points O, A, B, C, D and the distances x and y are shown in fig 1 and f(N) represents the value of the field at point N.

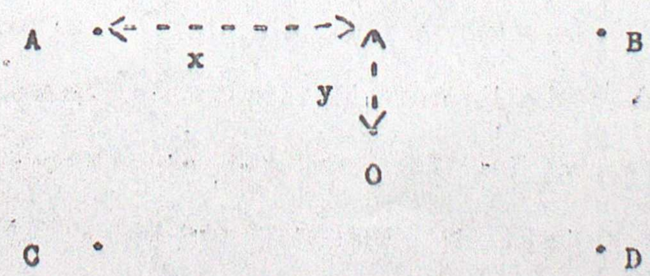


figure 1

This was done for each of 19 rocket-sonde stations which make soundings fairly regularly in the northern hemisphere and for each day that 'daily tapes' were obtained from Oxford, namely 18 - 22 January, 12 - 16 February and 16 - 18 July all in 1973. For those stations which launched a rocket on a particular day, a temperature profile determined at the 50 levels defined by

$$P = P_o \exp(-N/5) \quad , \quad N = 0, 1, -- 49$$

$$P_o = 1013 \cdot 246 \text{ mb}$$

was produced using the data from the rocket-sonde to give the upper part of the profile and data from a radio-sonde launched on the same day, but not at precisely the same time, from the same or a nearby location to give the lower part of the profile. Those parts of the profile which were above the highest level that data were received from the rocket-sonde were completed using climatological data[2]. These altitudes are, however, relatively unimportant as they are well above the peak of the highest channel of the SCR. Where the rocket-and radio-sonde soundings overlapped, a mean value was taken, while on some occasions there was a gap between the top of the radio-sonde ascent and the bottom of the rocket firing. This necessitated an interpolation being performed sometimes complicated by the fact that the interpolation needed to include the tropopause.

Having produced the data, two forms of comparison could then be carried out:-

(a) Direct comparison of radiances

Here, the radiances measured by the satellite instrument over a rocket-sonde station (or, more precisely, the value of the radiance field, objectively analysed, at a point coincident with a rocket-sonde station) were compared directly with values deduced from the combined rocket-sonde/radio-sonde profile. These deduced values were calculated using the Planck formula to convert the temperature profile into a profile of Planck radiances at the frequency measured by a particular SCR channel. The 'measured' radiance, R, for this channel could then be calculated by applying the formula

$$R = \sum_{j=1}^{50} W_j \; B_j$$

where W is the weighting function for the channel and B is the Planck radiance profile.

(b) Comparison of thickness

In this case, various thicknesses (namely 1000-300 mb, 300-100 mb, 100-30 mb, 30-10 mb, 10-3 mb and 3-1 mb) were calculated directly from the rocket-sonde/radio-sonde profile and compared with these spot values retrieved from the Nimbus E radiance measurements using the maximum probability technique for retrieval.

Before discussing the results, some points should be made concerning the relative merits of these two comparison methods. The second method has the disadvantage that an unknown error, ie that produced by the inversion technique, has been introduced whereas (a) is a pure comparison of measured values (assuming that we have an accurate knowledge of the weighting function matrix). However, (a) has two disadvantages; firstly, a knowledge of the complete rocket-sonde/radio-sonde profile up to level 50 is required and hence, as discussed before, a certain amount of interpolation and extrapolation is necessary. Figure 2 is an example of such a profile showing some of these uncertainties, together with the retrieved profile at the same point. Secondly, the form of the results of the comparisons are not perhaps suitable for the user of the satellite data, who may be more interested in results in the form of temperature or thickness errors.

Results

There were a total of 23 profiles which could be obtained to a reasonable degree of completeness on the dates between 18-22 January and 12-16 February 1973 in the northernhemisphere. Geographically, these ranged from the tropics (eg Fort Sherman and Antigua) to quite high latitudes (eg Chatanika). There were on these occasions, however, no complete profiles available in the 70-90° N latitude band. The results of the comparisons are shown below in tables 1 and 2.

	B12	B23	B34	A1
Mean (meas-calc)	-3.74	2.29	0.83	1.30
Standard Deviation	3.06	3.55	2.13	1.44

Table 1 Comparison of measured and calculated radiances ('radiance units' - ergs cm^{-2} sec^{-1} $(cm^{-1})^{-1}$ st^{-1}) ie satellite radiances and sonde 'radiances'.

	1000-300 mb	300-100	100-30	30-10	10-3	3-1
Mean (retrieved-measured)	10.82	-1.36	7.28	9.62	6.87	-9.20
Standard Deviation	15.61	8.44	6.77	11.35	11.70	14.93

Table 2 Comparison of measured and retrieved thicknesses (decametres).

It is not proposed to discuss these results in any detail as the sample used was small. However some comments can be made, the first of which concerns the rocket firings. On some occasions, it is the uncorrected temperatures (without radiation corrections for example) which are broadcast over the teleprinter network and used in this study. These corrections may be very large (about 20°C) at high altitudes, the final versions of the firings not being available for some time. This should not affect the A1 channel results, the peak of this channel falling well within the region covered by the radiosondes.

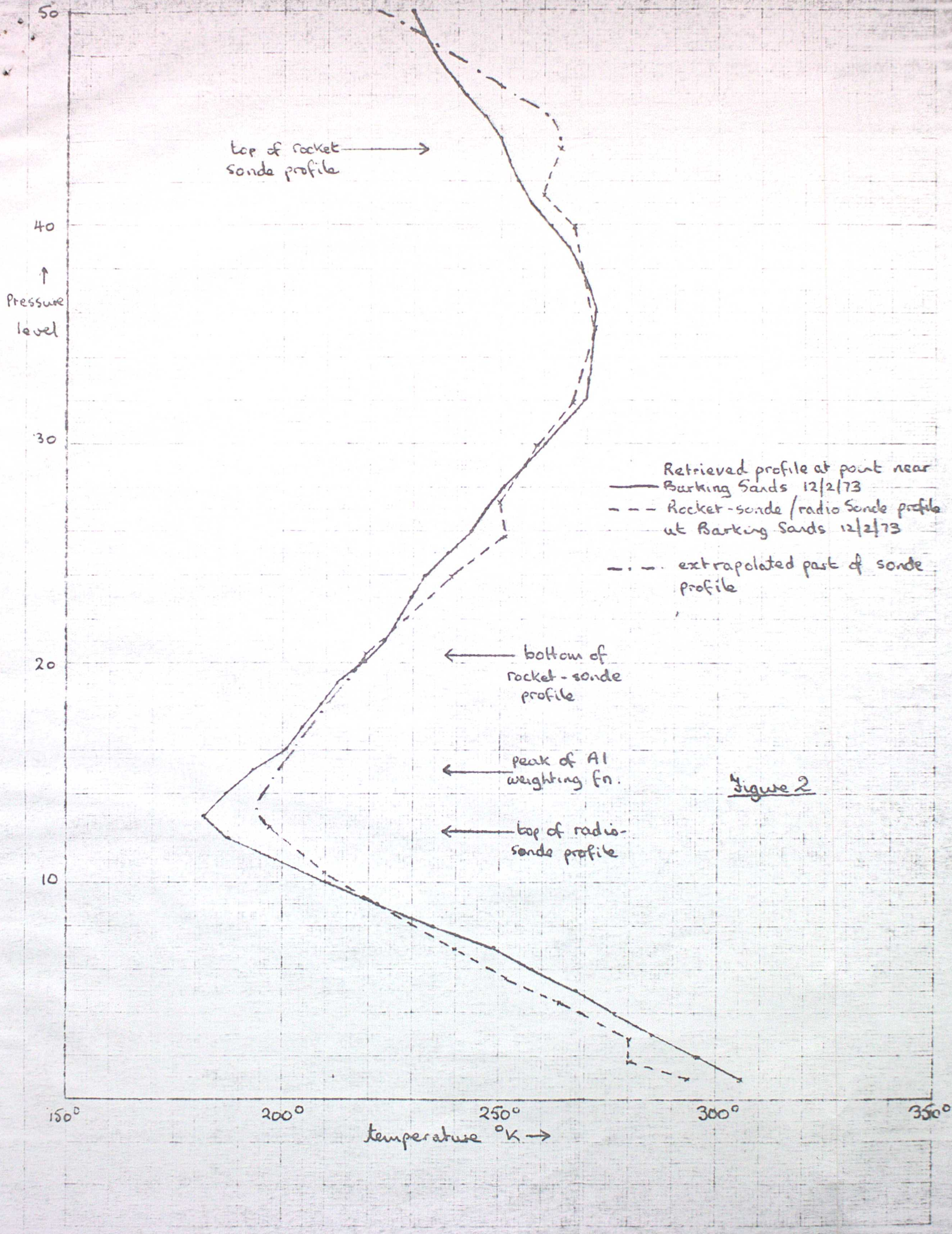
A second comment concerns the comparison of 1000-300 mb thicknesses. Table 2 shows that this thickness produces worse comparisons than higher levels as would be expected from the fact that no channels used in the work measure radiation emitted from lower regions of the atmosphere. Otherwise, the discrepancy between the two forms of measurements increases from a minimum at the 100-30 mb layer to a peak at the 3-1 mb layer.

It is hoped to carry out the kind of comparisons described here with a much larger sample and possibly with different thicknesses - larger layers so as to be more in keeping with the breadth of the weighting functions. Clearly these kinds of results will be vital to potential users of data from satallite-borne radiometers.

References

(1) Hunt, R.D. The production of mean daily radiances and high-level thickness charts from Nimbus E data Met O 19 internal report HA/IG/8 1974.

(2) US Standard Atmosphere Supplements prepared under sponsorship of ESSA, NASA and USAF 1966.



50
40
30
20
10
↑ Pressure level
top of rocket sonde profile
bottom of rocket-sonde profile
peak of A1 weighting fn.
top of radio-sonde profile
Retrieved profile at point near Barking Sands 12/2/73
Rocket-sonde / radio sonde profile at Barking Sands 12/2/73
extrapolated part of sonde profile
150°
200°
250°
300°
350°
temperature °K →

Figure 2