CORRESPONDENCE

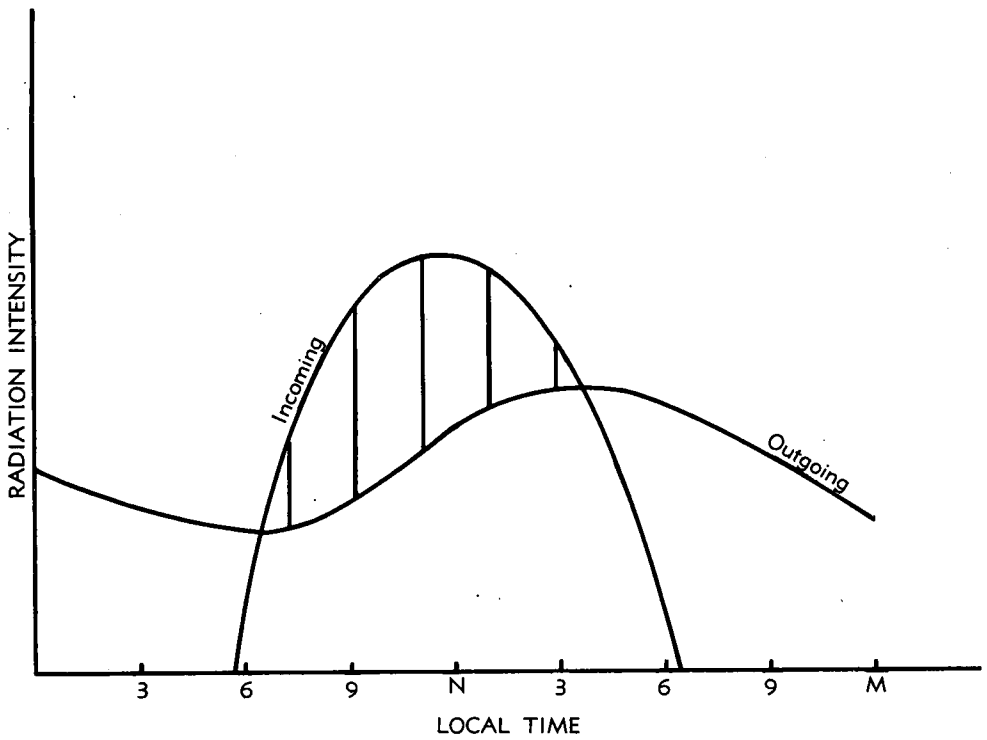
1. Minimum and Maximum Extreme Temperatures at the Soil Surface

In Mason's excellent article "Soil temperatures - Giles, Western Australia", Aust. Met. Mag. No.24, March 1959, p.10, I do not agree with the first of the following two statements (page 15):

"Theoretically the time of maximum temperature at the soil surface would be at local noon when the incoming radiation is a maximum".

"Again, the minimum temperature of the soil surface should occur theoretically near sunrise".

The simplest theory takes into account only the incoming solar radiation and the outgoing radiation from the earth's surface. The latter is proportional to the 4th power of the earth's surface temperature (in degrees absolute). Therefore, the curve of the terrestrial radiation (see figure) has extremes at the same time as the soil temperature curve. Though the figure is only qualitative



it shows that the minimum temperature of the earth's surface occurs shortly after sunrise and the maximum temperature a few hours after noon. This is in excellent agreement with Mr. Mason's data of the temperature at one inch depth.

Willem van der Bijl

Department of Physics,
Kansas State University,
Manhattan, Kansas.

16th October 1959

Reply

I thank Professor van der Bijl for his interest and comment on the article. It is agreed that the statement, which he queries, is not quite correct as it stands. It would perhaps be better to have said "soon after local noon". This however is still at variance with the Professor's comment that the "maximum temperature occurs a few hours after noon".

It is not clear from the comment and diagram whether the Professor is arguing (a) that while there is a net radiation flux directed towards the soil surface, the soil surface temperature must continue to rise (this completely ignores soil conduction and convective heat transfer) or (b) that the times of maximum and minimum surface temperature are given by the turning points on the "outgoing" radiation curve; this of course follows from Stefan's Law and there can be no argument over this. The argument arises over the shape of the curve and experimental evidence should be presented to prove that this is indeed the shape of the curve. I have not been able to locate such evidence.

To take one example of evidence to the contrary, refer to Fig. 1 in Brooks and Rhoades article in Trans. Am. Geophys. Union, Vol. 35, No. 1, the soil temperature is shown to reach a maximum "near local noon".

Arguing in a qualitative way from the original paper on the Giles data, it is clear that the maximum temperature at 8 inches occurs about $7\frac{1}{2}$ hours after noon, at 4 inches about 4 hours after noon,

at 1 inch about 1½ hours after noon. There is no evidence to suggest that this trend in the magnitude of the lag should reverse between 1 inch and the soil surface. If this trend is maintained, the soil surface maximum should occur within 45 minutes of noon.

B. Mason

Divisional Office,
Bureau of Meteorology,
Adelaide.

6th November 1959

---

2. Vertical Motion in a Jet Stream

The article "Probable Lee Wave over Victoria", in Australian Meteorological Magazine No 23 of December, 1958, dealing with an abortive flight of a Vampire jet aircraft due to downdraft, contains some interesting deductions. This note suggests an alternative explanation of the downdraft.

Lee Wave Theory

The application of Scorer's parameter - to produce a profile which will indicate the possibility of lee waves - requires the computation of the horizontal component of the wind at right angles to the ridge or slope (Factor U). In this case the parameter has been applied without just cause as U for the whole of the flight is practically zero - the effective winds paralleling the ridge throughout.

At the time of this occurrence a project was being carried out at Aircraft Research and Development Unit, Laverton, in conjunction with Dr. U. Radok of Melbourne University, designed to measure lee wave effect, particularly in the Warburton area. On this day, 23 May, 1958, the flying program was cancelled as the stream was considered unsuitable for lee wave formation, because it was parallel to the ranges. Further, no aircraft in the area or on air-routes in the vicinity reported marked turbulence or standing wave effect. For the waves to have been in evidence at 35,000 feet, pronounced activity would have been encountered at lower altitudes.

Vertical Motion Theory

Theoretical and statistical studies of jet streams have shown that at the entrance (western end) to the jet there is a flow component from the equator side to the pole side reaching its maximum at the level of the jet centre, accompanied by ascent below the jet core on the equator side, and descent below the jet on the pole side.

This circulation is in accordance with dynamical theory, being a direct circulation, i.e. vertical motion upwards in the warm air and downwards in the cold air, converting potential to kinetic energy.

At the jet exit (eastern end), there is an indirect circulation with ascent in the cold air and descent in the warm air, and the cross jet flow is from pole to equator.

These cross-axis flows have been calculated in the order of 5-15 knots for jet cores of 70 knots or better, and fall off to zero approximately 150 millibars below the jet axis. It appears quite reasonable to assume vertical currents in the order of 5-10 knots within 50-100 millibars of the jet core, following the pattern illustrated.

Application to Vampire Incident

A Vampire aircraft, in the configuration and at the altitude of the aircraft quoted, is rather marginally placed dragwise. Rate of climb at 155 knots I.A.S. at 35,000 feet is 5-600 feet per minute. In other words, the change in attitude in order to maintain altitude in a downdraft of 5-600 feet per minute, that is, a downdraft of 5-6 knots, would result in a reduction in I.A.S. from 240 to 155 knots.

As shown above, vertical currents of 5-6 knots are quite in order in a stream of 130 plus knots.

At 300 mb upper wind reports in the region of interest are so sparse that the jet axis may have been to the south of the track rather than as indicated in Fig. 6 of the article. By flying parallel to the jet axis the aircraft could then be in the downdraft area north of the exit region of the jet axis. In flying further north of the axis the aircraft apparently avoided the area of strong downdraft just north of the axis.

Rainfall associated with Jet Stream

Statistically, it has been shown that approximately twice as much rain falls at the left entrance and right exit of a jet stream as falls in the right entrance and left exit, with practically equal falls either side of the jet centre.

These rainfall patterns agree with accepted theory, and would be expected from the vertical circulation.

In order to associate the rainfall with the jet axis, the time/rate of rainfall, and its position relative to the axis would have to be known, as the 24 hour rainfall totals cover both entrance and exit of the stream. Consideration must also be given to terrain when examining isohyet patterns - in this case practically all heavy falls are on windward slopes.

Conclusions

For the pilot who finds himself in this position - in a downdraft area, flying upwind in the vicinity of a jet core - two courses are open:

(a) Maintain I.A.S. and descend with the air, knowing that there is a high level bottom to the descending air layer, and a longitudinal limit. The decrease in air speed, and increase in fuel consumption at the lower level will be far less demanding than the high fuel consumption and slow ground speed resulting in trying to maintain flight level.

(b) Take up a heading 90 degrees to wind direction, until area of descending air has been cleared. If this takes the aircraft away from the jet core, a better ground speed will result; if towards the jet, the increase in wind speed will be much less than the decrease in airspeed due to change of attitude.

(Reference Murray, R. and Daniels, S. 1953 Q.J.R. Met. Soc. 79 pp 236 - 241).

J.J. McGann

Meteorological Office,
Laverton.

12th October 1959

Reply

Mr. McGann's suggested explanation of the downdraft south of the Victorian Dividing Ranges on the afternoon of 23 May 1958 has been read with interest.

For my own part, I am not satisfied that the lee-wave theory adequately explains the phenomenon and it was admitted that the dimensions of the suggested lee-wave seemed too large to be accommodated within the scheme according to Scorer's treatment. However it is doubtful whether vertical velocities associated solely with the circulations arising from cross-jet (a-geostrophic) components reach values of the order quoted by Mr. McGann; what little there is in the literature suggests an order of centimetres per second. If vertical motions over a wide area reach values of 5-6 knots without the effect of some other super-imposed mechanism such as standing waves it is strange that, as far as is known, this has not been reported by aircrews on special reconnaissance of jet streams.

Referring to the accuracy of the 300 mb analysis it is agreed that the analysed position of a jet axis obtained from observations over 500 miles apart is doubtful but with predominantly zonal flow with little air-value one may also question the existence of jet entrance and exit regions.

Mr. McGann states that the airflow paralleled the ranges. Fig. 5 of the article in question shows that there were NW gradient winds over western Victoria on the afternoon of the 23rd. Adelaide's morning upper winds are probably more representative of the airflow over western Victoria on the afternoon of the 23rd than Laverton's morning winds. Considering the component of Adelaide's winds normal to a ridge with an orientation of 080-260° the following results are obtained.

Layer	Wind	U	l^2
Below 4000 ft	310° 17 kt	12 kt	Very large
4000-6000	300 20	13	Very large
6000-17000	290 40-50	20-25	8
Above 17000	280 70-100	20-40	8

These conditions are favourable for the formation of lee waves, although less favourable than was indicated in the original arrangement when the total speed of the wind was used.

Although the absence of reports of standing waves at low levels and the distance of the downdraft from the ranges does detract from the standing wave explanation, the persistence of the downdraft while the route paralleled the ranges and its cessation at the end of the ranges (near Hamilton) seem to suggest a lee wave phenomenon. As Mr. McGann says, standing waves would not have been expected in the Warburton area where the gradient flow paralleled the ranges and the Vampire flight passing over this area returning to Sale was not affected by the phenomenon.

The observations on the flight under consideration do not entirely fit any known model and, in any case, the data are not sufficiently detailed to resolve the question.

A. Garriock

Central Office,
Melbourne

24th February 1960

CORRIGENDUM

In the Australian Meteorological Magazine No. 23 (Probable lee wave over Victoria by E.J. Desmond, T.B. Halbert and A. Garriock) please make the following correction:-

p48, caption of Fig. 6, "23rd May 1958" to read "22nd May 1958".