Advances in Soaring Technique in Australia

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Presented at the 12th OSTIV Congress, Alpine, USA (1970)

Summary
The current state of gliding in Australia is reviewed. Australian conditions have long favoured standard convection soaring, but waves created by hills and convection currents have recently come to be explored and offer a bright future.

Introduction
The acceptance of glass fibre as a load-bearing structural material has brought about a sharp improvement in glider performance due to the smooth surfaces attainable. Australia has been at some disadvantage in following this trend due to remoteness from Europe and to the comparatively undeveloped gliding movement. In general, clubs tend to be small and heavily pre-occupied with training, but a few are now moving towards firmly based large-scale operation employing full-time staff. The movement is strongly club-oriented, with very few private owners, but there is a growing number of syndicates, often with 6–8 members, owning sailplanes. The local manufacturer, Schneider, has built almost half the fleet, especially notable aircraft being the Kookaburra two-seater and the Boomerang standard class sailplane, of conventional wooden construction. Assembly of glass fibre aircraft has commenced, and eventually complete manufacture is contemplated, but the inability of the small local market is a problem faced in common with the other aircraft builders in Australia.
In eastern Australia cross-country flying has been concentrated chiefly in a strip about 150–200 miles wide, extending over a belt along the inland side of the mountain ranges, where the country has been cleared for wheat farming and sheep grazing. Further inland the country is too rough for field landings and too poorly served with roads for cross-country flying without careful prior reconnaissance. Clubs near the major centres of population near the coast are restricted by the heavily timbered mountains and by the requirements of other air traffic, and consequently make expeditions inland for most of their cross-country flying.
The mileage flown has increased greatly in the last few years, brought about as much by increased piloting skills engendered by competition as by improvements in aircraft performance. Prominent among these skills is meteorological knowledge, and in the following section we outline some salient features of weather in Australia in relation to soaring, dealing mainly with convection in summer and lee waves in winter.

Large-Scale Weather Systems
Australia is an island continent, spanning latitudes from the tropics to the disturbed westerlies. Topographically the Great Dividing Range extends unbroken down the east coast and bends westward into Victoria (fig. 1a), and, although low, is a considerable barrier to the usually shallow SE trade winds in the north, and also to the more transitory flows further south. In summer the sub-tropical anticyclones progress along the southern margin of the land mass and there is a weak easterly mean flow at low levels, which gives place aloft to increasing westerlies, due to the southward decrease of mean temperature. In the normal course of events, frontogenesis occurs in the cols between anticyclones, and a roughly weekly cycle is apparent. Cold frontal passages give temperature fall at the onset of cool southerly streams, followed by several days with rising temperatures as easterly flow is re-established, often then culminating in one or more «blow-up» days, when strong N–NW winds advect hot dry air from the interior, with high fire risk.
Near the coast frontal characteristics are highly variable, ranging from intense line squalls, with associated roll clouds, thunderstorm and large temperature falls to barely perceptible cloudless changes very similar to sea breezes, but distinguishable from the latter by the sustained SW–S airflows which follow. By the time a front has moved inland 200 miles or so the temperature contrast across it will be small, due to the rapid modification of the cold air by surface heating, and it will have typically only broken high or middle cloud and a very persistent wind shear. A dry front extending far inland may often be re-activated when it encounters moister air from the Tasman Sea, giving rise to afternoon or evening thunderstorms.
Even if no rain has fallen, soaring conditions are usually poor immediately following a front, due probably to the strong subsiding motion. Conditions improve as the onshore airflow weakens and surface heating deepens the convection layer, and are best in the deep northerly airstreams, although strong gusty winds and blowing dust can then be hazardous. There are, of course, wide deviations from the pattern described, notably the deepening of troughs to the west of the Dividing Range, with southward extension of the summer tropical rainfall.
As far as is known, only one deliberate use of cold frontal lift for cross-country flying has been made in Australia. In October 1960, S. Cant seized a fleeting opportunity to fly in clear air in advance of a frontal roll cloud, which he described as a buttressed wall, which continually engulfed the prefrontal air in fresh condensation. At 7,000 feet he was prevented from climbing higher by an overhanging shelf of cloud, and, heading southeast flew 60 miles.

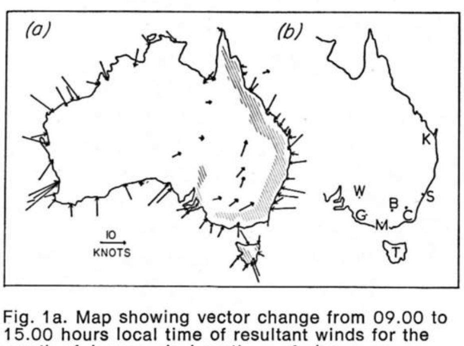

Fig. 1a. Map showing vector change from 09.00 to 15.00 hours local time of resultant winds for the month of January. b. Locations of places mentioned in text.

Airflow Resulting from Differential Surface Heating
On the ground, Australian weather tends to be monotonously repetitive, with temperature rising during the morning to about the level of the previous day or perhaps a little higher; the sequence is then interrupted more or less vigorously. To the glider pilot the soaring conditions are much more variable, as differences of air trajectory can largely affect the depth of convection and the strength and reliability of thermals. Predominantly dry ground and clear skies make available a large proportion of the incoming solar energy as sensible heat, which warns the overlying air column. The diurnal temperature range is large as a result, and air which has spent 2–3 days on the continent is deeply unstable from the ground up. The strong contrasts which develop near the coasts give rise to frequent sea breezes, which can penetrate far inland. In figure 1a the vector changes from 09.00 to 15.00 hours local time of the mean monthly resultant surface winds for January have been plotted as arrows directed towards the ob-

serving stations, the values having been obtained from wind rose frequencies [1, 2]. At stations close to the coast the sea breeze would often have set in before 09.00 hours, thus giving smaller vector changes than at stations further inland, so caution is needed in making comparisons. However, all stations show changes consistent with sea breeze influence, and the largest changes are found in Western Australia. Along the northern coast the cloudiness of the wet season reduces the sea breeze during summer, and changes there are larger around the equinoctial periods. The vectors for some inland stations in eastern Australia also show consistent changes of comparable magnitude, which have long been recognised in synoptic forecasting practice, implying convergence along the Dividing Range.

A number of field studies [3–5] have shown that at some distance inland the sea breezes have the characteristic «nose» structure of density currents, as do some cold fronts (see also Simpson [6] for a discussion of recent tank experiments). Glider pilots in Australia have long been aware of the absence of lift in the sea-breeze air, and have used the lift at the front on segments of cross-country flights. The sea-breeze front is often marked by dust at low levels, or by a line of cloud, as seen in figure 2 (location* W) and in figure 3 (location W) which shows that the vertical motion extended to cirrus levels on that occasion. At Gawler, north of Adelaide (location A) the sea-breeze sets in early in the morning, and sometimes returns late in the afternoon, giving rise to extensive lift. Glider pilots could contribute much to the climatology of the sea-breeze by giving accounts such as that by Pickett-Heaps [7] of flights in the Cooma-Canberra area (location C).

Fig. 2. Line of cumulus marking sea breeze front, Morgan, South Australia, 7 January 1966, looking southward. Cloud base 9,000 feet.

Fig. 3. Line of cumulus marking sea breeze front, Waikerie, South Australia, 8 January 1966, looking westward at sunset. The disturbance produced cloud at cirrus levels.

Lee Waves

Meteorologists in Australia have had a continuing interest in lee waves since the account in 1949 of waves over Tasmania sufficiently strong to prevent a DC-3 aircraft from maintaining cruising altitude [8, location T]. In another instance a jet fighter nearly ran out of fuel on a cross-country flight to the lee of the Dividing Range in Victoria [9, location M]. Detailed analyses of the variations in the rate of ascent of radiosonde balloons has enabled estimates of wavelength and amplitude to be made in three studies [10, location T; 11, location K; 12, location T]; in the last, Andersen reproduced a satellite photograph establishing that the wave train originated over the main mountain massif of Tasmania, and he also showed the general utility of the simple relationship $\lambda = 0.18\,\overline{U}$ for forecasting wavelength (λ) given $\overline{U}$, the mean tropospheric wind component across the range. The foregoing studies depended on adventitious observations, whereas Radok progressed towards set-piece experiments aimed at relating the flow pattern in a vertical plane to the upstream wind and temperature profiles, using instrumented powered aircraft to make traverses [13, 14]. In one of these experiments an attempt to soar a glider in the wave failed, and effective wave flights by glider have been made only in the last 2–3 years.

Wave flights have been made at a number of places in Victoria, the highest being that by Hedt [15, location G], who climbed from release at 3,300 feet to 23,600 feet over the Grampian Range in a flight curtailed by nightfall. Aspland [16, location K] has described one of a number of flights made at Kingaroy, Queensland, where there is a range 10 miles long and only 1,500 feet above the surrounding terrain, which produced a train of at least five waves with lift extending to over 15,000 feet. He writes: «The ideal meteorological set up is to have a high pressure cell centred fairly high up over the continent, and an intense low pressure area off the coast of New South Wales. The low is not essential, but its presence usually results in a much stronger SW airstream and cloud which marks the position of the wave nicely at low levels with roll clouds. True lenticular clouds are a rare sight on days when high flights are made.» The last remark is particularly pertinent, as the air at middle levels is often dried by subsidence. The prospects for winter wave soaring in southern Queensland are especially good, as the mean position of the jet-stream is overhead, and winds increase steadily with height, whereas in Victoria the mountain range is oriented east–west, and waves occur typically with low-level N–NW airflow, backing aloft to westerly, giving wind components perpendicular to the range diminishing with height.

Melbourne (location M) is ringed by high ground to the north and west, and a wide variety of wave clouds is commonly observed. The gliding field at Bacchus Marsh, close to the western range, is so placed that wave lift has been contacted from winch launches. These waves are of short wavelength, and the impression gained from several flights is that these are unsteady, whereas the longer waves, contacted by aerotow, are more persistent. Lenticulars are well formed in association with the long waves, whereas small patches of fracto-cumulus are more typical of the short waves. A cloud form which sometimes can be seen during wave flow over Victoria is shown in figure 4. Typically a thin line of dense cirrus cloud initially forms transverse to the flow, and then diverging fallstreaks develop rapidly, assuming tangled patterns.

In the future, aircraft with low sinking speed over a wide range of horizontal speeds will enable us to use waves more often, and a flight by Jinks to around 20,000 feet in a Diament at Waikerie (location W), some 50 miles from the nearest hills is indicative of what may be expected.

Convection

The Australian pilot readily recalls the hot cloudless days with dust devils crossing fallow paddocks and strong narrow thermals rising to over 10,000 feet, coupled with heavy sink and turbulence in the straight glides. There are other days, however, which he prefers to forget, when a low inversion can keep maximum heights below 3,000 feet, even well inland. The cross-country pilot comes to expect a wide variety of conditions, both from day to day, and during the course of a single day, as indicated by Reid and Wu [17]. Variations in depth and strength of convection have been noted by groups of pilots and by comparison of operations at sites 50–100 miles apart, which might be attributable to differences of trajectory or to meso-scale convergence-divergence patterns set up by diurnal

* For location references see figure 1b.

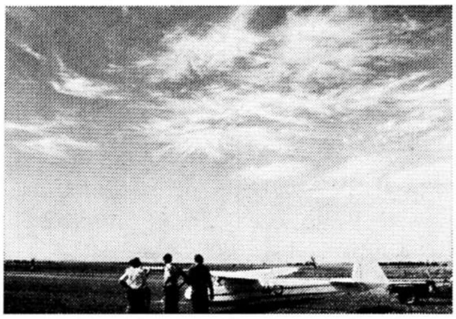

Fig. 4. Cirrus fibratus forming on an occasion of lee wave flow at Bacchus Marsh, Victoria. 11.00 hours, 2 April 1966, looking ENE.

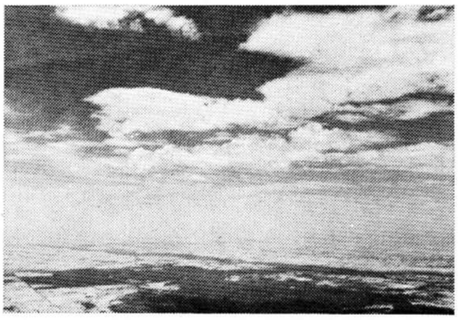

Fig. 5. Lenticular clouds forming in conjunction with cumuli on 27 December 1967, 10 miles NE of Benella, Victoria. Looking NNE, cloud base about 6,000 feet.

heating. If showers have occurred the previous evening, the cold outflows at low levels can cover wide areas and give rise to marked patchiness in convection. Upper cloudiness also plays a part, in that a few feathers of cirrus in the afternoon can transform a race into a distance task; and yet on other days excellent thermals have been found under uniform thick altostratus.

Conditions in Australia are often favourable for observation of effects arising from the combination of strong thermals and large wind shear in the vertical. Especially during the early hours of convection, downwind drift in thermals can vary greatly, and quite large horizontal displacements can occur when they penetrate layers of strong shear. Early morning pilot balloon winds are frequently subject to low level jet effects, making them unrepresentative of conditions later in the day. Jaeckisch [18] has described lift extending above convection streets on occasions with a transverse upper flow. Jinks reported climbing in a similar manner above an individual cumulus in 1966, and on the 1st January 1968 several pilots made climbs in clear air on the up-shear side of rather large flat cumuli, about 2,000 feet deep. Simpson [19] describes how he flew out from cloud base: «About 100 yards out from the cloud, the air became smooth and the audio gave a squeak. This was followed by a steady squeal as the lift slowly increased to 200 ft/min. I started to beat backwards and forwards, keeping the nose pointed slightly into wind while maintaining position in front of the cloud. I could hear the faint almost electrical hum that the Ka-6 makes in the silky smooth air of wave. 7,000 ft ... 8,000 ft ... cloud top ... lift improves to ca. 400 ft/min, and the airspace limit of 10,000 feet is soon reached.» On this occasion no contest task had been set due to extensive cloud cover associated with an almost stationary front. The cloud sheet broke up and strong thermals developed, forming individual cumuli with no streeting evident. Less than a quarter of the 50 or so pilots who flew used this lift, and most of those who did were alerted to the possibility by radio. Had a task been set, probably none would have persisted with the relatively weak lift. A few days earlier lenticular clouds had formed in conjunction with cumuli, figure 5, and it was possible to gain height while flying straight beneath the lenticulars, which were oriented transverse to the low-level flow. Probably the same mechanism was operating on that occasion also.

Conclusion

Gliding has been intimately connected with advances in aeronautics and meteorology. The basic discoveries of frontal lift, thermals and lee waves were made in the era prior to 1939, and the last 25 years have seen consolidation of soaring technology through improvements in aircraft and instruments and by pilot training, both explicitly and in competition. If, was Irving has suggested, we are entering an era of diminishing returns in aircraft design, we should look for better understanding of the atmosphere. There is a need for better recording of flight conditions than that provided by the customary barograph and highly subjective description, so that measurements of such quantities as inter-thermal spacing and rate of climb in thermals could be made more readily available to sailplane designers and meteorologists. For research into small-scale atmospheric motions, such as convection, lee waves and perhaps CAT, the new generation of powered sailplanes now under development, retaining the low speed, low wingloading characteristics of sailplanes, together with freedom from the necessity to use lift to remain airborne, would be useful complements to conventional aircraft. There are areas in Australia which could be more readily explored by powered sailplane with greater safety and at very much lower cost than by the pure sailplane.

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