THE METEOROLOGICAL CONDITIONS FOR DYNAMIC SOARING IN THE JETSTREAM AND IN THE LOW-LEVEL JET

F. Weber
Institute für Physik der Atmosphäre

W. Trommsdorf
DFVLR

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For static soaring, all sources of energy have now been utilized. By means of topographical winds, thermal convection and mountain waves results have been achieved which never would have been dreamed of at the beginning of motorless flying. Dynamic soaring, however, on which soaring pioneers had pinned so much hope, still represents an unsolved problem.

As you all know, gradients of wind velocity are to be utilized as a source of energy for dynamic soaring; on the one hand, by means of elements of turbulence and, on the other hand, by using zones of shear of the wind. The extraction of energy from gusts is not feasible in practice. However, it seems to be quite possible to extract energy from zones of vertical wind shear. Studies have been conducted for the last two decades and have shown that jet streams near the surface, the so-called Low Level Jets with considerable values of shear, appear in the lower troposphere, especially within the earth's boundary layer. Furthermore, there are observed considerable vertical changes of wind velocity in high tropospheric jet streams, whose wind maxima are, in general, to be found at about 1-2 kt below the tropopause. These high jet streams, representing large-area phenomena and thus apt to be picked up by routine aerological observation methods, have been studied extensively and are well known. There are, however, still considerable technical impediments as far as their exploitation for dynamic soaring is concerned because of their altitude. Therefore, there are relatively only few reports on high tropospheric jet streams, especially on the polar-front jet stream.

On the other hand, usage of the shearing current for dynamic soaring within the Low Level Jet seems to be successful with conventional planes. Low tropospheric jets are found in certain atmospheric conditions. The wind maximum obviously occurs nearly at the upper limit of the Ekman-layer, i.e. about 1000 m above the surface. The layer next to the surface, i.e. the Prandtl-layer or surface-layer with extreme values of shear extending to a height of about 30 m, has been studied relatively well for a long time now. However, it is not practical to make use of this.

Ideas about the phenomenon and the conditions of origin of Low Level Jets are still rather nebulous.

B l a c k a d a r (1957) understands by Low Level Jet a significant wind maximum in the lowest troposphere.

up to 1.5 km of height (5000 ft.) together with a decrease of wind velocity of 5 kt just above it. However, he says nothing about the absolute velocity of wind or the magnitude of vertical and horizontal shear.

B o n n e r (1968) - who, among other studies, worked out a climatology of the Low Level Jet for the USA - took as a basis for his research work the definition given by Blackadar. According to him, however, the significant wind maximum originally could be registered up to a height of 2.5 km above surface. Finding in his studies a relatively high frequency of LLJs between 1.0 and 1.5 km above surface, he chose 1,500 m as the highest level at which a wind maximum may still be called a Low Level Jet.

U h l i g (1971) reported on the frequency of LLJ over Altenstadt in the northern foothills of the Alps. He used a similar criterion: "The LLJ is a significant wind maximum within the lowest layer above surface, which in meteorology means an atmospheric layer reaching from 10 m to 1,500 m height above the surface, above which the velocity decreases by 5 kt (or 3 m/s) up to the next minimum or up to 3,000 m above the surface, whichever is lower." However, he was only in a position to do pilot-balloon observations.

P o d h o r s k y (1969) studied the Low Level Jet over southwest Slovakia. He took into consideration only wind velocities of 30 m/s or more, this being the condition usually considered with regard to high tropospheric and stratospheric jet streams.

It was not the intention to decide here which wind maxima in the low troposphere may really be called Low Level Jet. The object and aim of our work was the studying of low tropospheric wind maxima in the foothills of the Alps with regard to their significance for aeronautical problems, especially for dynamic soaring. As a principle, we took as a basis the criteria given by Blackadar, Bonner and Uhlig. A deviation is only seen in the fact that the wind maximum must be below 3,000 m above the surface.

We had at our disposal the original data of ascent of the radiosonde station of Munchen-Riem from 1968 through 1972, which included 7,000 ascents. This station was chosen as it is situated on one of the most crowded airports of Germany and, furthermore, because it was considered likely that the chain of the Alps running in the west-east direction would have an essential influence on the direction and velocity of the Low Level Jet.

Figure 1 shows the mean frequency of Low Level Jets over Munich at the different hours of the day. The numbers mean that, for example at 00^{00} on 131 days of a year, there may come up a LLJ, i.e. almost every third day. The maximum of 36 $^{0}/o$ is reached at midnight which may well be attributed to frequent nocturnal inversions and the wind maxima accompanying them. Blackadar (1957) showed that in most cases, wind maxima are to be registered at the upper boundary (boundary layer) of nocturnal inversions. The relatively high frequency of LLJ at all hours of the day is rather surprising.

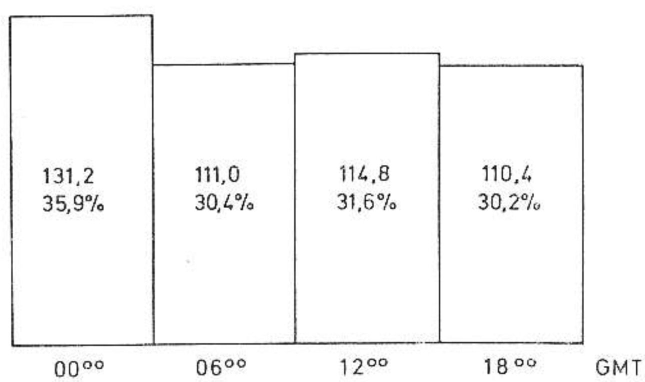

FIGURE 1. Mean Frequency of the Phenomenon of Low Level Jets Over Munich at the Different Hours of the Day, 1968 - 1972

In the course of the year, the Low Level Jet shows its least frequency in summer, i.e. hardly 28 °/o. During the other seasons the frequency is between 32.6 °/o and 34.1 °/o with its maximum in autumn (Figure 2).

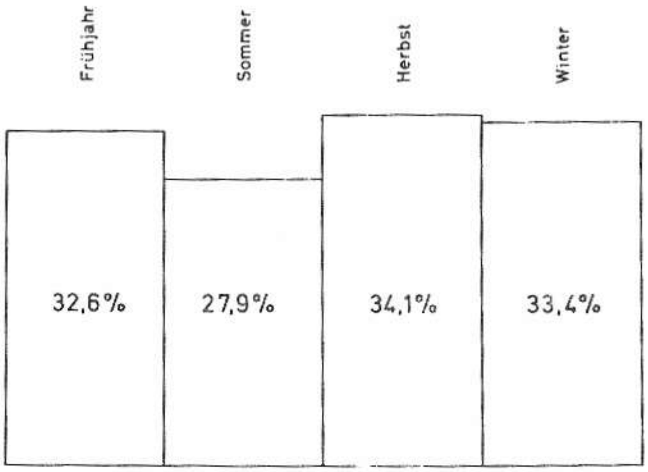

FIGURE 2. Mean Frequency in % of the LLJ over Munich at the Different Seasons of the Year, 1968 - 1972

Figure 3 shows the altitude at which the maximum of the Low Level Jet over Munich is usually registered, in relation to the hours of the day. At 00^{00}, 06^{00} and 18^{00} GMT, the maxima are to be found between 0.5 and 1.0 km of height; at 12^{00} between 1.0 and 1.5 km, that is to say at a higher level. On the whole, however, it can be said that wind maxima preponderate in the layers between 0.5 and 2 km of height. Bonner (1968) discovered - as already mentioned - a relatively high frequency of Low Level Jets at altitudes of 1.0 to 1.5 km. Podhorsky (1969) who, as mentioned at the beginning, had studied the phenomenon of the Low Level Jet over southwest Slovakia by means of radiosonde ascents from Vienna (1957-1966), registered the maximum velocity at a level of 1,500 to 2,000 m. However, he defined a "true" Low Level Jet as having a wind velocity of at least 30 m/s.

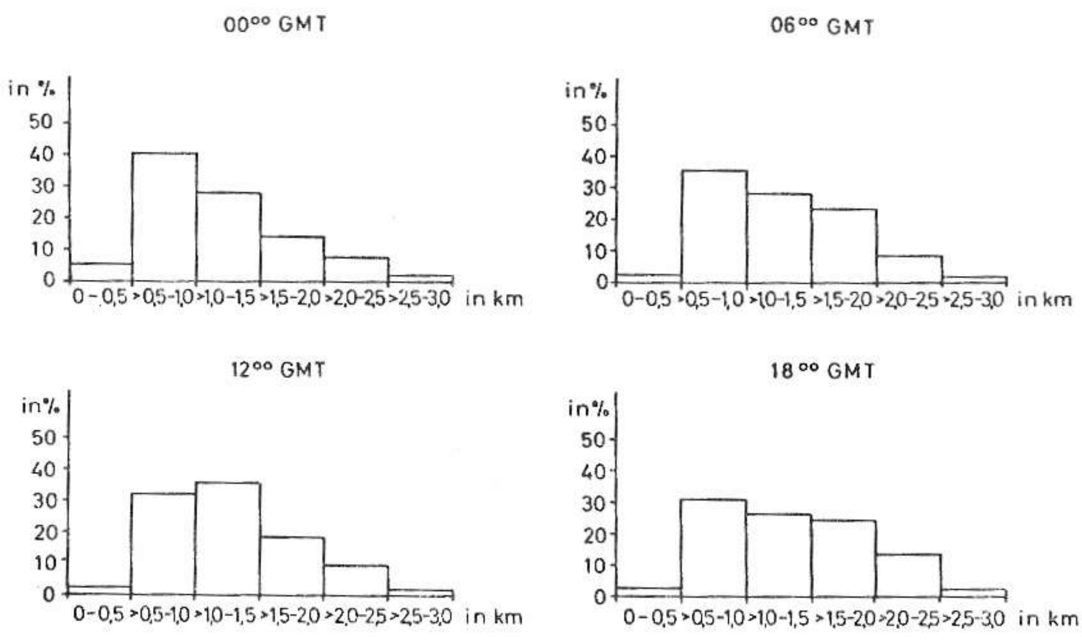

FIGURE 3. Mean Frequency in % of the Altitudes of Wind Maxima of LLJs over Munich, 1968 - 1972

As seen from Figure 4, the most frequent wind velocities ranged from 5 m/s to 15 m/s. Velocities between 15 and 20 m/s were, however, relatively frequent too.

The maximum wind velocities registered over Munich within a period of five years ranged from 40 to 45 m/s. These high winds were, however, rather rare, they occurred on six days only.

The highest wind velocity in a LLJ during the period of research was measured at 06^{00} GMT on February 13, 1970, running up to about 43 m/s, i. e. roughly 155 km/h.

On 37 days Low Level Jets with velocities of 30 m/s or more were observed.

For a comparison here are the values. Podhorsky found for Vienna: 165 cases within a period of ten years; on an average, there are about three times as many Low Level Jets with 30 m/s or more over Vienna than over Munich.

In general, there were cyclonic west weather situations on days with LLJ exceeding 30 m/s over Munich.

Table 1 shows the frequency of the different wind directions in Low Level Jets at the height of the wind maximum as for the four times of ascent. Preference is quite obviously given to the directions of 270° resp. 300° and 90°. This behaviour is clearly shown for the 12^{00} time of ascent in Figure 5.

The Low Level Jet over Munich is primarily orientated to the chain of the Alps. Bonner (1968) already stated that the wind direction in a Low Level Jet coincides with the direction of the mountains.

Podhorsky (1969) showed that the Low Level Jets over Vienna are most frequently combined with westerly wind directions. This fact might be significant for the planning of soaring flights on a dynamic basis.

The relation between direction and velocity of wind at the height of the wind maximum is to be seen from table 2. It becomes evident here that, with an increasing wind velocity, the Low Level Jet adapts itself more and more to the west-east direction of the Alps.

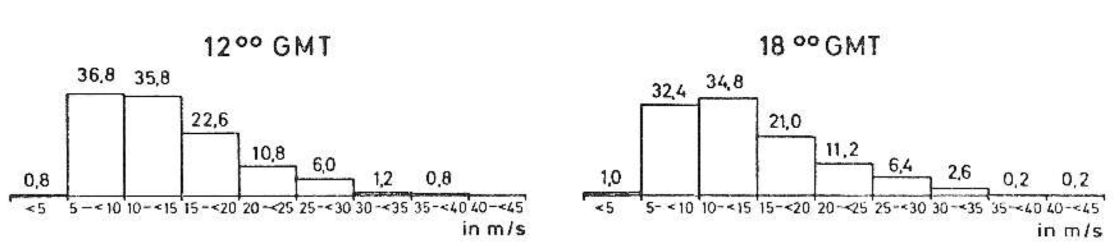

FIGURE 4. Mean Frequency of Velocities in a LLJ over Munich, 1968 - 1972

TABLE 1. FREQUENCY OF DIFFERENT WIND DIRECTIONS IN LLJs OVER MUNICH AT THE HEIGHT OF THE WIND MAXIMUM, 1968 - 1972

	360°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
00^{00}GMT	6	14	17	71	52	18	15	19	57	268	97	21
06^{00}GMT	7	3	21	58	25	14	12	14	48	257	80	14
12^{00}GMT	8	4	10	60	46	18	11	14	59	242	86	15
18^{00}GMT	6	8	12	79	35	15	16	12	50	207	91	16

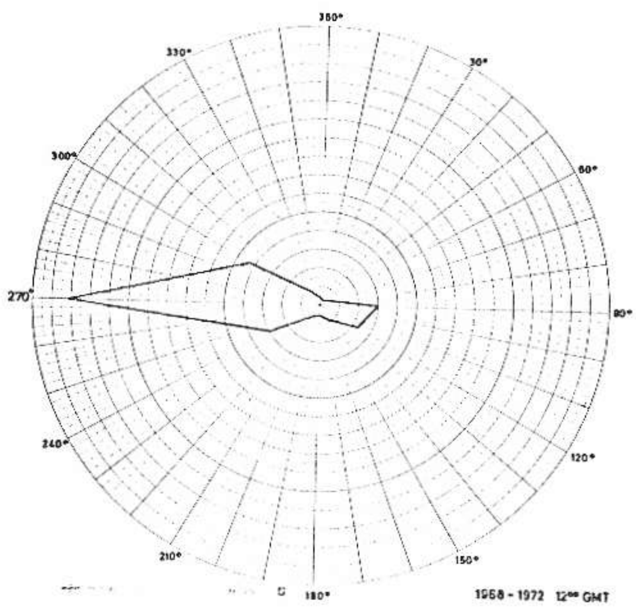

FIGURE 5. Graph on the Frequency of the Phenomenon of LLJ over Munich, 1968 - 1972, 12^{00}GMT

Uhlig (1971) also found: "The west-east orientation becomes more and more distinct the heavier the wind becomes."

With regard to dynamic soaring, we are, in the first place, interested in the values of shear below the wind maximum of a Low Level Jet, as well as in the vertical thickness (depth) of the shearing-zones and the altitudes in which they are registered. Here are the results, again for the years of 1968-1972.

Figures 6 and 7 show the mean frequency of single values of shear for days with LLJ over Munich. The analysis was made in steps of 0.5 m/s/100 m. All values > 6 m/s/100 m were taken together into one class. Values of shear of less than 1 m/s per 100 m were deemed of no interest for dynamic soaring and have thus not been considered here. Values of shear in the range 1 m/s/100 m to 1.5 m/s/100 m are registered as being the most frequent. Values of shear of 2.5 m/s/100 m and more appear relatively seldom. But occasionally there are even values of shear of more than 5 m/s/100 m. The highest value was about 10 m/s/100 m (19-6-1969, 12^{00} GMT).

It must be mentioned here that the routine values of wind are picked up by radar in intervals of a minute; continuous measurement would certainly show up far higher values of shear, but in those cases the thickness (depth) of layers would be lower. Peak values may be expected in well-marked inversions where changes of wind directions of approximately 180° might not be rare.

TABLE 2. NUMBER OF CASES OF LLJ OVER MUNICH DURING FOUR ASCENTS IN THE PERIOD OF 1968 - 1972: WIND DIRECTIONS AND WIND VELOCITIES AT THE HEIGHT OF THE WIND MAXIMUM

	360°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	Summen
< 5 m/s	—	3	3	5	4	2	2	4	7	7	1	1	39
5 - < 10 m/s	18	18	34	125	106	49	25	34	56	138	82	35	720
10 - < 15 m/s	9	7	18	107	45	15	22	15	58	270	136	21	723
15 - < 20 m/s	—	—	4	28	5	1	3	7	46	262	74	8	438
20 - < 25 m/s	—	1	—	—	—	—	—	1	23	178	38	—	241
25 - < 30 m/s	—	—	—	—	—	—	1	—	17	80	15	1	114
30 - < 35 m/s	—	—	—	—	—	—	—	—	2	25	3	—	30
35 - < 40 m/s	—	—	—	—	—	—	—	—	4	7	—	—	11
40 - < 45 m/s	—	—	—	—	—	—	—	—	1	5	—	—	6
Summen	27	29	59	265	160	67	53	61	214	972	349	66	2322

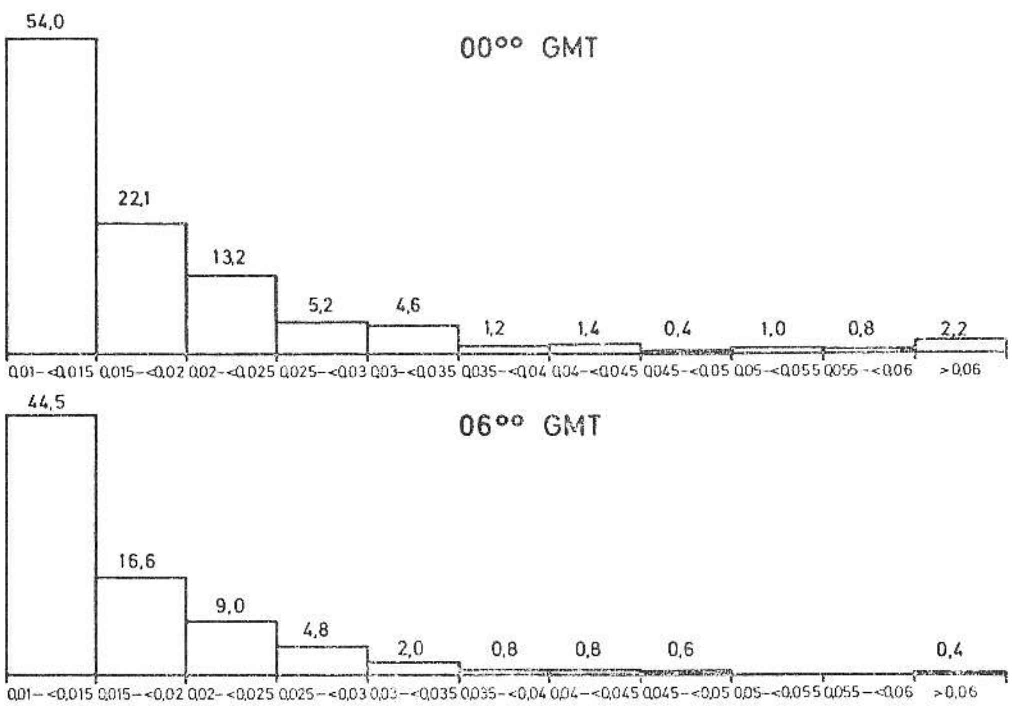

FIGURE 6. Mean Frequency of single values of Shear for Days with LLJ over Munich, 1968 - 1972, 00^{00} and 06^{00}GMT

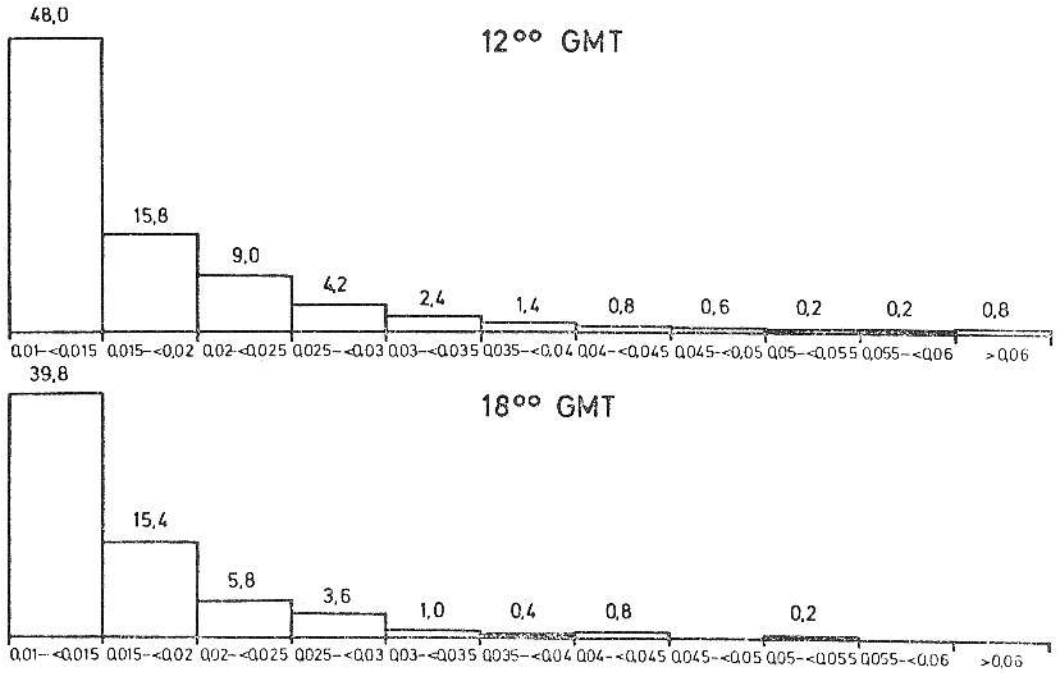

FIGURE 7. Mean Frequency of Single Values of Shear for Days with LLJ over Munich, 12^{00} and 18^{00}GMT 1968 - 1972

The altitudes in which these values of shear are found can be seen from figures 8 and 9. It may be said that generally speaking values of shear of 1 m/s/100 m or more are most frequently registered in the lowest layers. These values of shear are, by far, less frequent at altitudes of more than 1.0 km. In our studies, we did not take into consideration the layer between surface and 10 m above surface.

Here are some final remarks regarding statistics about the LLJ concerning the depths of layers, in which vertical shearings of 0.01 s^{-1} or more are registered. The most frequent ones are depths of layers from 250 to 500 m. Depths of layers of more than 1000 m with vertical shearings of 1 m/s/100 m or more are encountered relatively seldom (Figure 10).

Examples for Typical (Characteristic) Wind Maxima

In the following, special stress will be put on some characteristic cases of Low Level Jet with, to some extent, quite substantial shearing-values.

The first graph (Figure 11) shows the aerological data of an ascent of May 12, 1970 at 00^{00} GMT, at Munchen-Riem. The significant wind maximum of 60 kt occurred at about 1900 m above the surface. All layers of the tropo- and stratosphere above it show values of wind which are considerably lower. In the low and medium troposphere the wind direction was nearly 250^{0}. On the mountain station of the Zugspitze at about 3000 m above sea level were registered peak gusts of 160 km/h, i.e. about 86 kt. The weather situation of that day was "TM" = Low Central Europe.

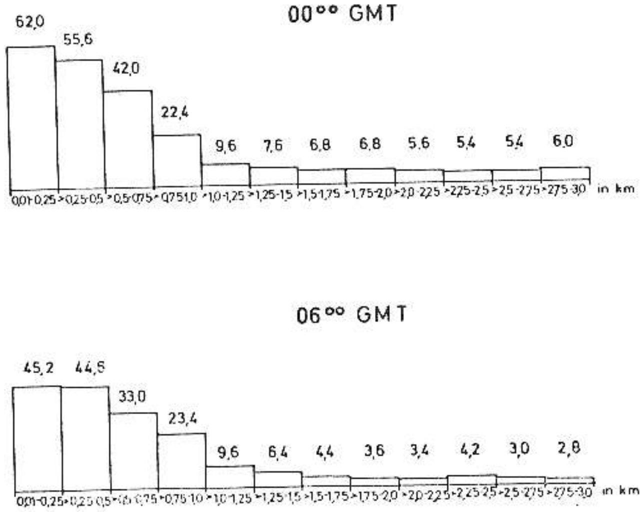

FIGURE 8. Mean Frequency of Values of Shear $\frac{\Delta V}{\Delta Z} \geqq 0.01\ s^{-1}$ in Single Altitudes over Munich, 1968 - 1972

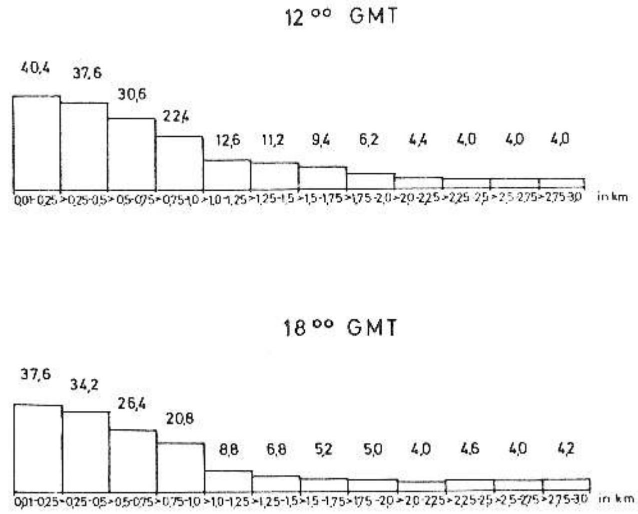

FIGURE 9. Mean Frequency of Values of shear $\frac{\Delta V}{\Delta Z} \geqq 0.01\ s^{-1}$ in Single Altitudes over Munich, 1968 - 1972

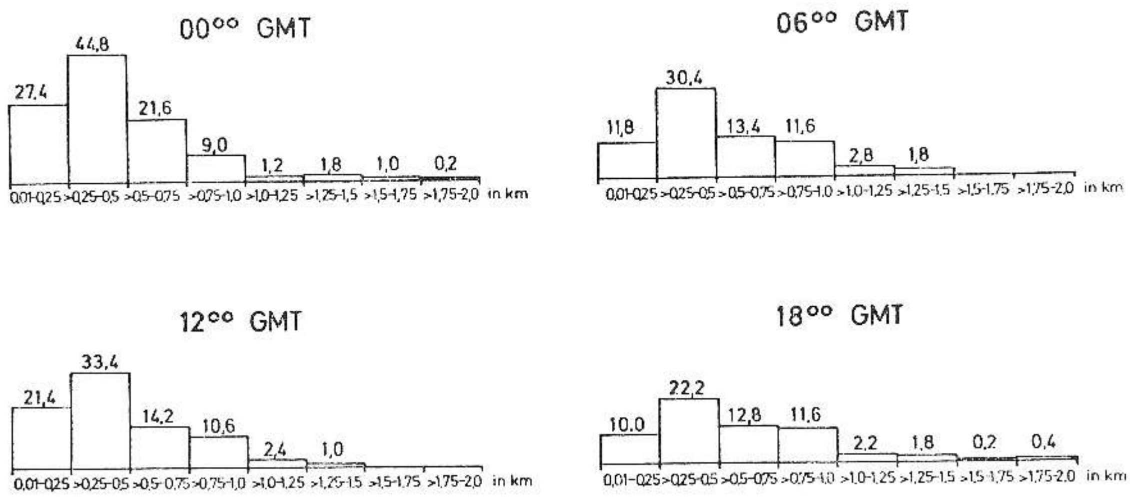

FIGURE 10. Mean Frequency of Depths of Layers with Shearings of $\geqq 0.01\ s^{-1}$ in Low Level Jets over Munich, 1968 - 1972

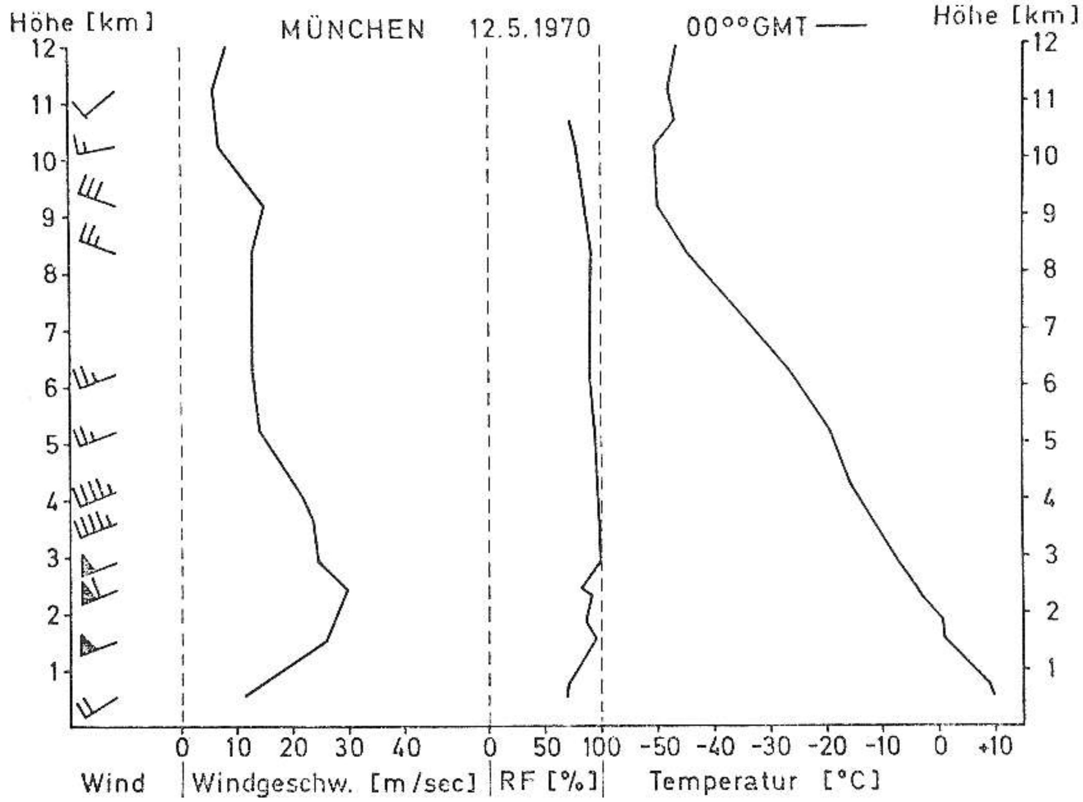

FIGURE 11. Radiosonde Observation of Munich of May 12, 1970, 00^{00} GMT

The wind maximum which at 00^{00} was at about 1900 m above the surface, was registered at heights of 970, 960 respectively 870 m during the three following ascents. The maximum wind velocity, which amounted to 30 m/s at 00^{00} remained practically constant at all times.

At 00^{00} the wind shear in the lower layer showing a depth of almost 1000 m was approximately 1.5 m/s/100 m, and in the following ascents, increased to about 2.2 m/s/100 m.

On December 3, 1970, at 12^{00} GMT wind velocities of 82 kt (about 42 m/s) were measured at a height of 1370 m above the surface at the upper limit of a faintly marked inversion (Figure 12). The vertical wind shear for this layer came out to be 3 m/s/100 m. The surface weather showed a well-marked cyclone over the the north of East Germany. A high of atmospheric pressure area (an anticyclone) with its center over the southwest Alps extended to the north of Yugoslavia. The direction of the wind at the height of the wind maximum was 280°. The general weather situation was "Wz" (cyclonic west weather).

On November 8, 1969 at 06^{00} and at 12^{00} GMT there was observed a Low Level Jet at the height of the planetary boundary layer at about 750 and 900 m respectively above the surface, with respective wind velocities of 37 and 30 m/s (Figure 13). At

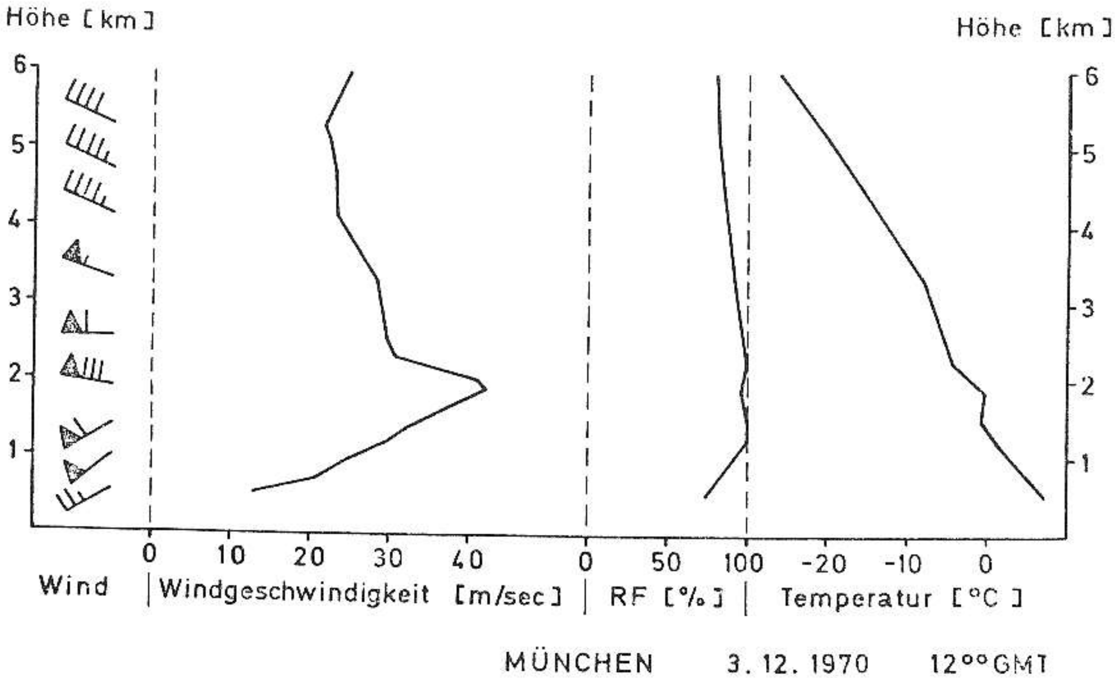

FIGURE 12. Radiosonde Observations of Munich of December 3, 1970, 12^{00} GMT

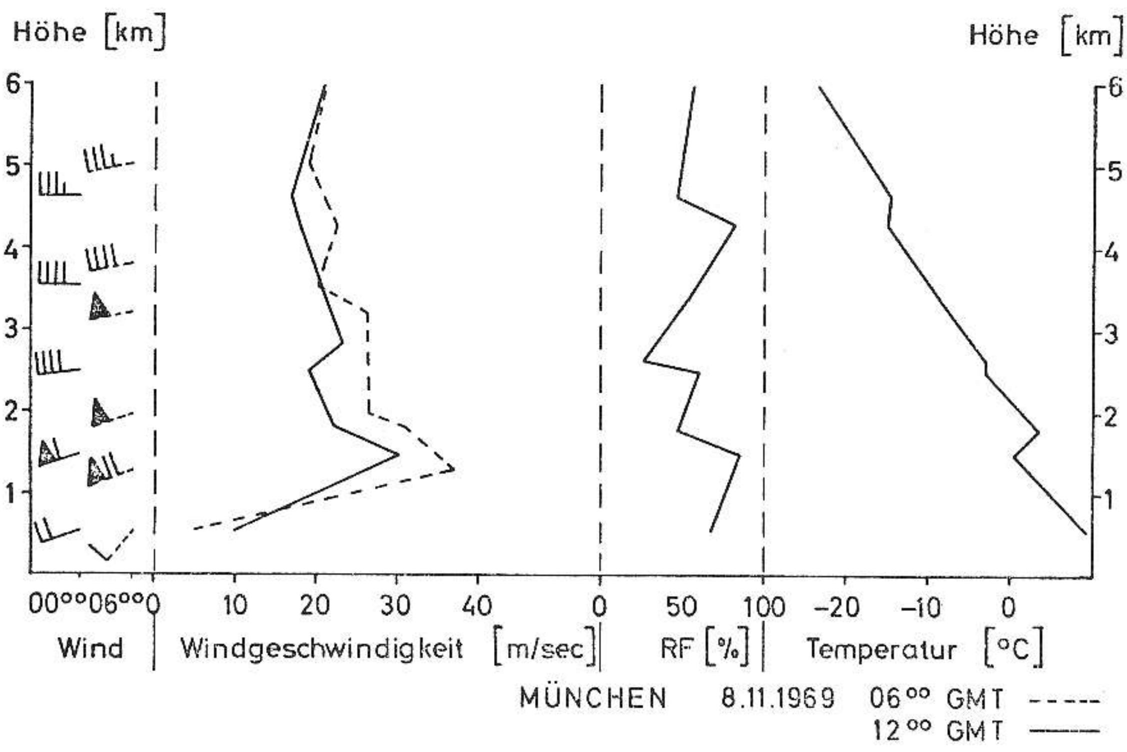

FIGURE 13. Radiosonde Observations of Munich of November 8, 1969 06^{00} and 12^{00} GMT

06^{00} the vertical shear was roughly 4.3 m/s/100 m in the layer with a depth of about 750 m. At 12^{00} the wind shear had gone down to 2.2 m/s/100 m at 900 m of layer depth.

In November, 1972, there were observed particularly distinct low tropospheric jet streams over Munich. Time and again, Low Level Jets with high maxima of wind velocity and respective shearing-zones appeared in a cyclonic west weather situation beginning with the 13th of November.

Radiosonde observations of November 17, 1972, at 12^{00} and of November 18, 1972, at 00^{00} GMT will serve as examples.

At noon on November 17, the significant wind maximum with 30 m/s occurred at a height of 800 m above the surface. The wind direction near the surface was nearly east. Up to the height of the wind maximum, the wind turned almost to the west (Figure 14). The vertical wind shear within the layer reaching from the surface up to 800 m was 4.5 m/s/100 m. Here only the scalar shear was measured. The vector shear was to some extent, higher.

The surface weather chart for the same data showed a flat cyclonic system (flat low) with its center over the northwest of France. A warm front emanating from it extended as far as Vienna. Temperatures of $1\text{-}4^{0}$ C prevailed in the north of the warm front, whereas south of it there were temperatures of $13\text{-}15^{0}$ C.

On November 18, 1972, the Low Level Jet was still markedly distinct (Figure 15). At 00^{00} GMT, the wind reached about 30 m/s at about 700 m above surface. The vertical wind shear in this layer was again about 4.5 m/s/100 m.

The weather situation of November, 1972, showed that a Low Level Jet situation might last for several days.

As a final remark on Low Level Jets, I should like to mention that this phenomenon has already been observed and studied over the USA, Canada, Peru, Tschad, Kenya, the USSR, the Indian Ocean and the Antarctic.

Let us now consider the meteorological conditions for dynamic soaring within high tropospheric jet streams, especially the polar front jet.

According to a definition of the WMO, "a jet-stream is a strong narrow current concentrated along a quasi-horizontal axis in the upper troposphere or in the stratosphere, characterized by strong vertical and lateral wind shears and featuring one or more velocity maxima. Normally, a jet-stream is thousands of kms in length, hundreds of kms in width and some kms in depth. The vertical shear of wind is of the order of 5-10 m/s per km, and the lateral shear is of the order of 5 m/s per 100 km. An arbitrary lower limit of 30 m/s is assigned to the speed of the wind along the axis of a jet-stream."

On about 60 days of the year, one has to be prepared for jet streams in Germany. In order to study the polar-front jet and its turbulence, the author has made aircraft measurements, mostly over southern Germany, together with the Air Force of Germany (Bundesluftwaffe) in the years 1960 to 1962. In all cases, the wind shears in the vertical were obtained mostly by means of the original radiosonde observations of Munich and Stuttgart.

Below are given values of shear below and above the wind maximum (the core) of a jet stream based respectively on 39 and 29 ascents of radiosondes. The lower number of values obtained above the core was due to the range of radar instruments being relatively small at that time.

Shears lower than about 1.0 m/s/100 m are of no interest for

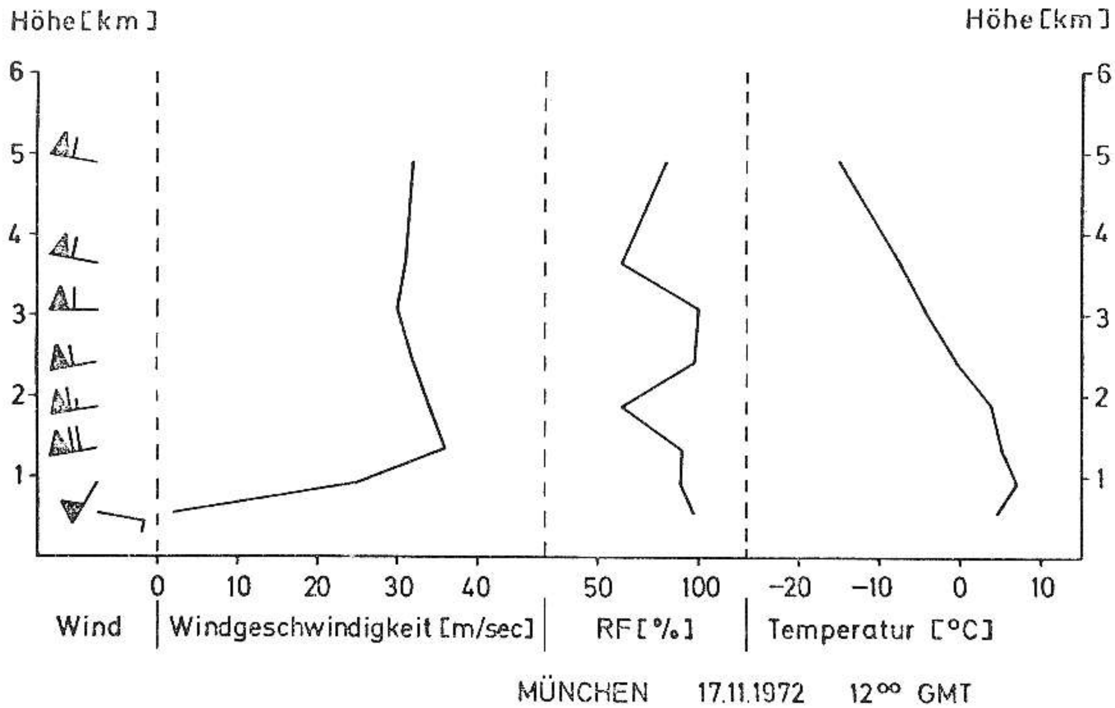

FIGURE 14. Radiosonde Observations of Munich of November 17, 1972 12^{00} GMT

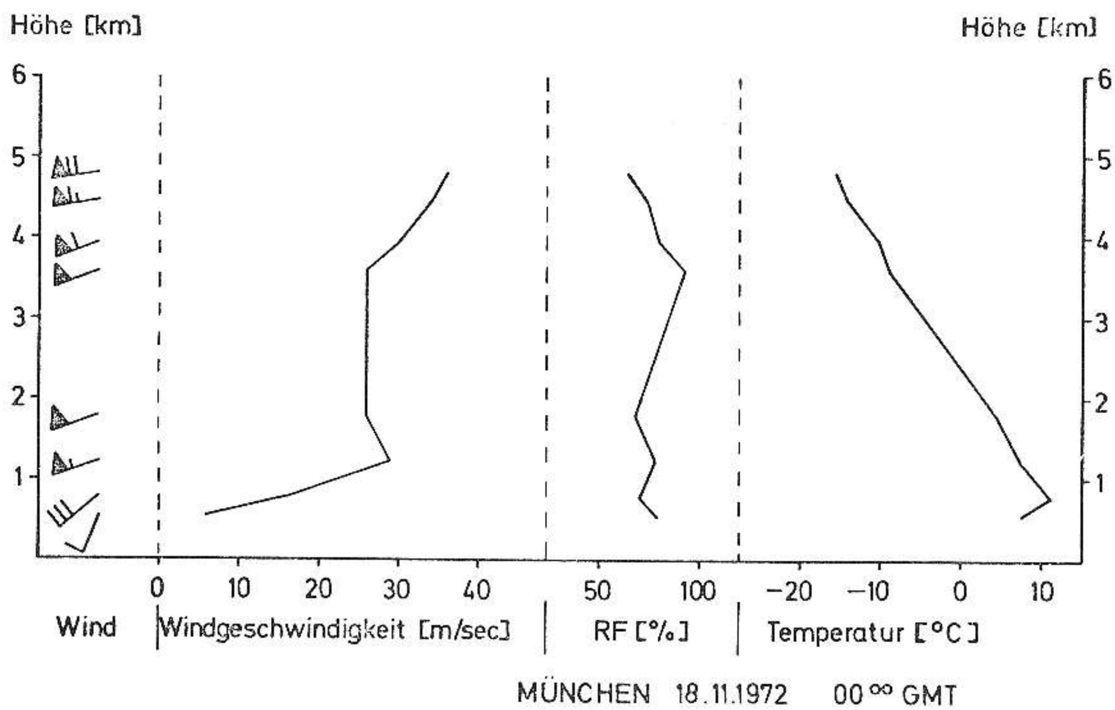

FIGURE 15. Radiosonde Observations of Munich of November 18, 1972 00^{00} GMT

dynamic soaring. But very often there are values between 1.0 and 2.0 m/s/100 m, as can be seen from table 3. Shears of 3 m/s/100 m and more are not even rare above the wind maximum (the core) of the jet. Vertical wind shears in the order of about 4 m/s/100 m seem to represent a kind of upper limit in high tropospheric jet streams. But we must remember once more that here also wind measurements were performed in intervals of a minute as had been done for the Low Level Jet.

The frequencies of the depths of layers at certain shears below and above the core of a jet are to be seen from table 4. Most often the layer depth is about 250 to 500 m. Layers of more than 1000 m depth are very rare regarding the shear of interest here.

Well, at which heights are these values of shear in polar-front jet streams to be observed? In general it may be said, as our statistics have also shown, that they are from 5 to 12.5 km, (tables 5 and 6). The layer below the core of the jet roughly corresponds to altitudes between 5 and 9 km, and that above the jet-core to between 9 and 12 km.

To conclude, here are some characteristic wind profiles in a tropospheric jet stream. On January 31, 1962 at 12^{00} GMT, there were found values of shear of the order of 1.5 m/s/100 m in a north-jet over Nancy in a layer with a depth of 1000 m. The layer was observed at a height of 4-5 km which is relatively low (Figure 16). Quite substantial shears were registered within the jet-core as well as above and below the wind maximum of the jet, between 8.5 and 10.5 km height. Incidentally, on that day, a significant wind maximum in the lowest troposphere was observed over Nancy, too.

Figure 17 shows the wind situation over Stuttgart for the same day. Between 6 and 7 km height, there were shears of the order of 2.4 m/s/100 m. But also at higher altitudes, up to the tropopause, there occurred considerable wind shears. Here again there was a low tropospheric jet-stream with its maximum speed at 2 km above sea level and values of shear of the order of 1.5 m/s/100 m.

The following example for January 12, 1962, at 12^{00} GMT at Stuttgart is typical of a so-called disturbed wind profile (Figure 18). Within the core of the jet stream, there was a rather striking secondary wind maximum as well as remarkable increase and decrease of wind strength in the vertical. Such wind profiles occur in certain synoptical conditions which we cannot discuss in detail here. Values of shear of the order of 2.5 m/s/100 m were observed between 7.5 and 8 km height, and values of the order of 3.6 m/s/100 m above the wind maximum of the jet in a layer with a depth of more than 1000 m.

It is worth mentioning that at the same time there occurred a surprisingly similar wind situation at Munchen-Riem, the station 200 km

TABLE 3. VERTICAL WIND SHEAR IN m/s/100 m IN THE REGION OF POLAR-FRONT JETS

	0,5 - <1,0	1,0 - <1,5	1,5 - <2,0	2,0 - <2,5	2,5 - <3,0	3,0 - <3,5	3,5 - <4,0	≥ 4,0
JET-UNTERKANTE	75	31	27	8	4	2	1	1
JET-OBERKANTE	35	23	14	7	-	5	4	1

TABLE 4. FREQUENCY OF THE DEPTHS OF LAYERS AT CERTAIN VALUES OF SHEAR (1960, 1961, 1962) IN THE REGION OF POLAR-FRONT JETS

Jet-Unterkante: 39 Fälle

$\frac{\Delta v}{\Delta z}$ / 100m	0-250	>250-500	>500-750	>750-1000	>1000-1250	>1250-1500
0,5-<1,0m/s	3	30	12	14	7	6
1,0-<1,5m/s	1	16	6	6	-	1
1,5-<2,0m/s	2	19	3	2	1	-
2,0-<2,5m/s	2	6	-	1	-	-
2,5-<3,0m/s	-	3	1	-	-	-
3,0-<3,5m/s	1	1	-	-	-	-
3,5-<4,0m/s	-	1	-	-	-	-
>4,0 m/s	-	1	-	-	-	-

Jet-Oberkante: 29 Fälle

$\frac{\Delta v}{\Delta z}$ / 100m	0-250	>250-500	>500-750	>750-1000	>1000-1250	>1250-1500
0,5-<1,0m/s	1	23	6	2	3	-
1,0-<1,5m/s	1	13	5	2	-	-
1,5-<2,0m/s	1	7	2	3	-	-
2,0-<2,5m/s	-	7	-	-	-	-
2,5-<3,0m/s	-	-	-	-	-	-
3,0-<3,5m/s	-	3	2	-	-	-
3,5-<4,0m/s	-	3	-	-	1	-
>4,0 m/s	1	-	-	-	-	-

TABLE 5. FREQUENCY OF SHEARINGS BELOW THE CORE OF A JET (1960, 1961, 1962; 39 CASES) BY POLAR-FRONT-JETS

$\frac{\Delta v}{\Delta z}$ / 100 m	5000-5500	>5500-6000	>6000-6500	>6500-7000	>7000-7500	>7500-8000	>8000-8500	>8500-9000	>9000-9500	>9500-10000	>10000-10500	>10500-11000	>11000-11500	>11500-12000
0,5-<1,0 m/s	9	11	15	16	18	18	11	6	9	11	9	5	2	1
1,0-<1,5 m/s	4	4	4	3	3	5	7	6	3	3	5	3	1	-
1,5-<2,0 m/s	6	5	6	6	4	1	-	3	4	2	-	-	-	-
2,0-<2,5 m/s	1	1	1	1	2	3	2	1	1	1	-	-	-	-
2,5-<3,0 m/s	1	1	1	1	1	1	1	-	-	-	-	1	1	-
3,0-<3,5 m/s	-	-	-	-	-	1	1	-	-	-	-	-	-	-
3,5-<4,0 m/s	-	-	-	-	-	1	-	-	-	-	-	-	-	-
>4,0 m/s	-	-	-	1	-	-	-	-	-	-	-	-	-	-

TABLE 6. FREQUENCY OF SHEARINGS ABOVE THE CORE OF A JET (1960, 1961, 1962; 29 CASES) BY POLAR-FRONT-JETS

$\frac{\Delta V}{\Delta Z}$ /100m	7500-8000	>8000-8500	>8500-9000	>9000-9500	>9500-10000	>10 000-10500	>10 500-11 000	>11 000-11500	>11 500-12000	>12 000-12500	>12 500-13000	>13000-13500	>13 500-14000	>14 000
0,5-<1,0 m/s	-	1	2	5	6	6	7	7	6	7	7	4	2	1
1,0-<1,5 m/s	-	1	2	2	4	5	5	7	9	9	3	1	-	-
1,5-<2,0 m/s	1	1	3	2	4	5	3	4	3	2	1	1	-	-
2,0-<2,5 m/s	1	1	1	1	1	-	-	2	2	1	1	-	-	-
2,5-<3,0 m/s	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3,0-<3,5 m/s	-	-	1	1	1	2	2	1	1	1	-	-	-	-
3,5-<4,0 m/s	-	-	-	1	2	3	2	1	-	-	-	-	-	-
>4,0 m/s	-	-	-	-	-	-	1	-	-	-	-	-	-	-

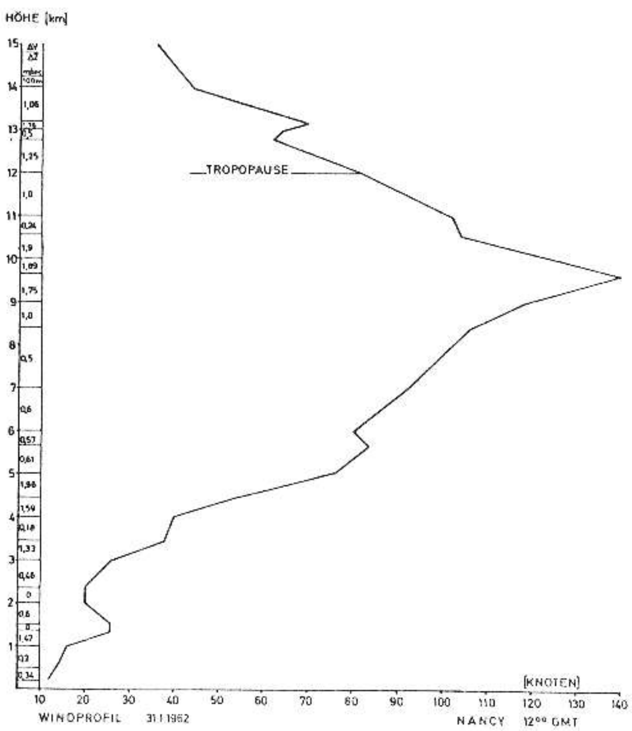

FIGURE 16. Wind Profile of Nancy of January 31, 1962, 12^{00} GMT

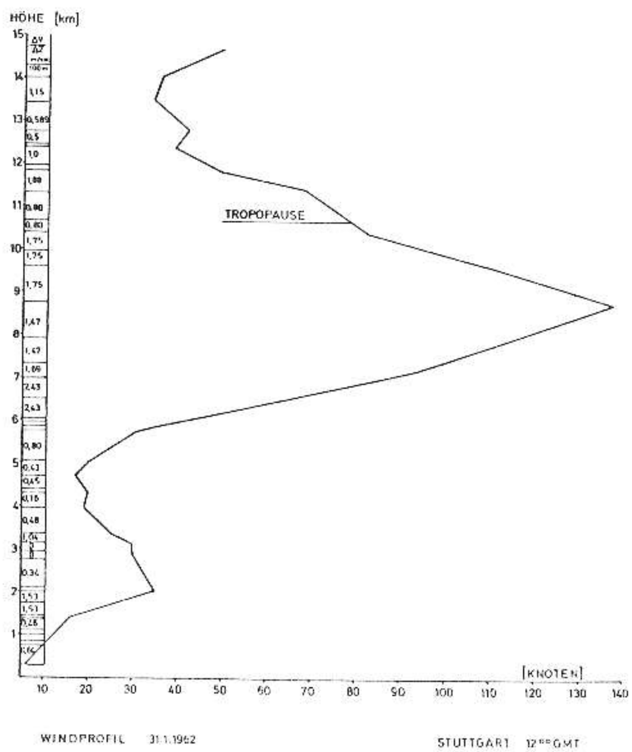

FIGURE 17. Wind Profile of Stuttgart of January 31, 1962, 12^{00} GMT

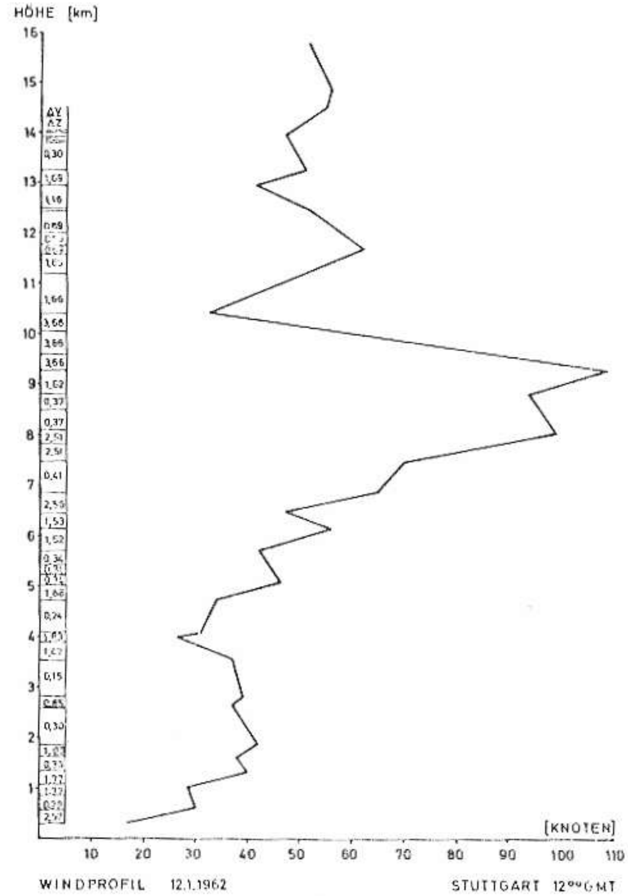

FIGURE 18. Wind Profile of Stuttgart of January 12, 1962, 12^{00} GMT

farther east. Even the values of shear were almost the same. Above the wind maximum of the jet they reached 3.92 m/s/100 m.

Finally, it seems that scientific knowledge as well as technical conditions have now reached a level which seems to permit the practical exploitation of atmospheric shear streams for dynamic soaring.

Editor's Note: Readers interested in other work on the possibilities of jet stream soaring should see the review by Kuettner and McLean in OSTIV Publication V; their paper was presented at the VII OSTIV Congress, Osieczna, Poland, June 1958.

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