AIR MOTIONS IN THE VICINITY OF MT. EVEREST AS DEDUCED FROM PILATUS PORTER FLIGHTS

by Edward E. Hindman, The City College, New York, USA and Capt. Emil J. Wick (Ret.), Royal Nepalese Airlines, Cointrin, Switzerland

Presented at the XXI OSTIV Congress, Wiener-Neustadt, Austria (1989)

SUMMARY

Air motions in the vicinity of Mt. Everest are reported from 12 years of Pilatus Porter flights. A "funnelling" effect was discovered which permitted soaring flights of the Porter to altitudes above its ceiling. Two different air flows are postulated to occur around and over the summit pyramid: flow-separation and laminar flow. Air motion measurements and theoretical studies are identified which may help understand the postulated air flows.

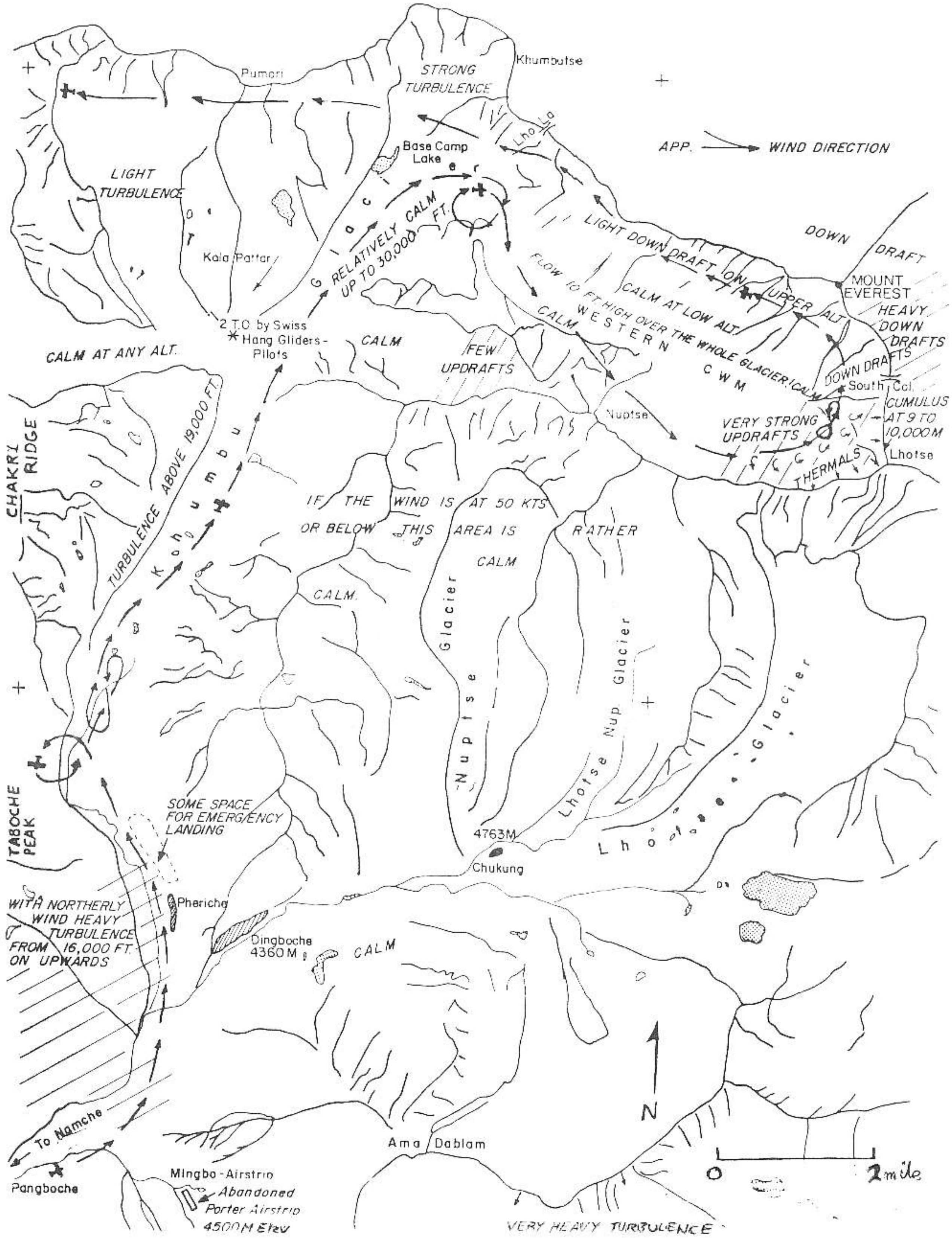


Figure 2 Air motions deduced from the Porter flights in the Everest region. The line of arrows denotes a typical flight path.

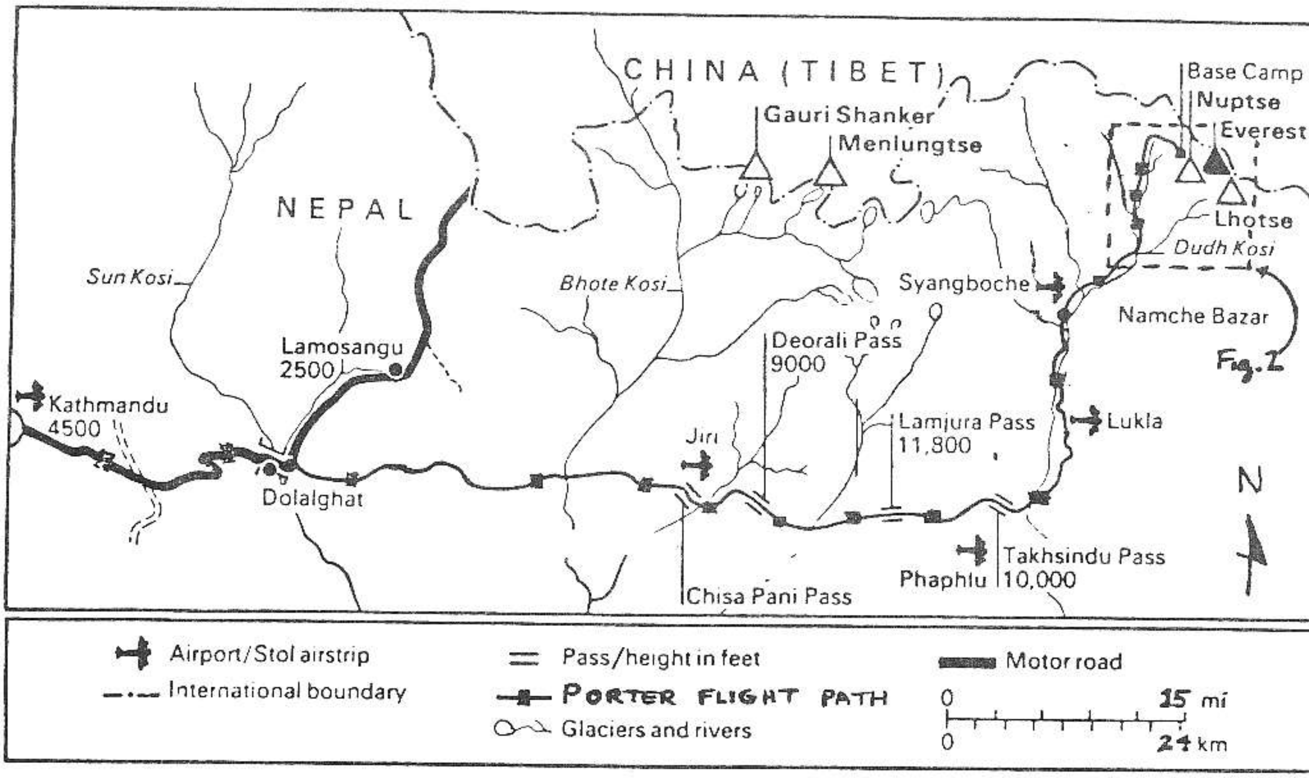


Figure 1. The flight path of the Pilatus Porter aircraft between Kathmandu and the Everest region. The enlargement of the Everest region in Figure 2 is identified by the dashed box.

1. INTRODUCTION

For a twelve year period, 1974-1986, a Pilatus Porter STOL aircraft was flown in Nepal by the second author, as described by Ronnau (1978). Approximately 2,000 flights were conducted between Kathmandu and the Everest Massif (see Figure 1). As a result of these flights, information has been obtained on the updrafts, downdrafts and turbulence in the vicinity of the mountain. These data, although qualitative, may help the effects of the high Himalayan mountains on atmospheric motions of all scales to be understood.

In this paper, we report a "funnelling" effect caused by the West Cwm of Everest which permitted soaring flights of the Porter to altitudes above its ceiling. Also, banner clouds and cap clouds caused by Everest illustrate two different air flows; the meteorological conditions causing the flows remain to be determined.

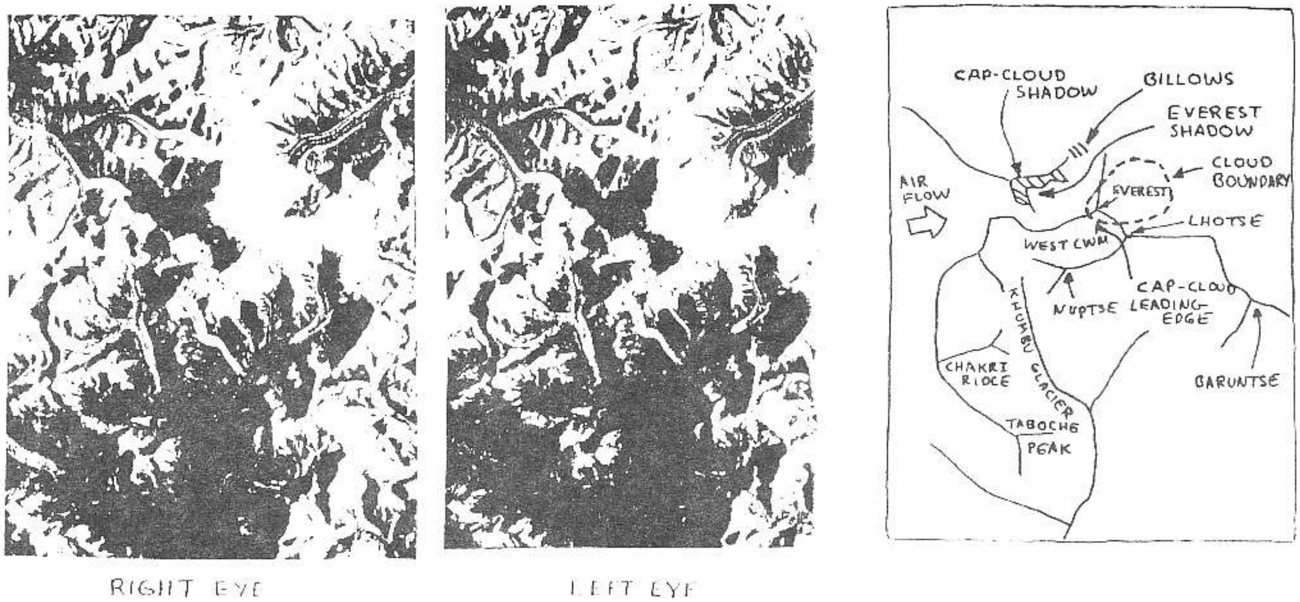
2. PROCEDURES

The Porter flights were conducted for tourists to view Mt. Everest and for mountaineering supply and rescue missions. The flights occurred under VFR conditions and when southwesterly to westerly upper air flows were present. It was found that northwesterly flows caused severe rotor activity along the flight path. The approximately two hour flights were conducted in the morning hours to avoid the substantial convective turbulence along the foothills. The foothills are located between Kathmandu and the Lukla air strip (see Figure 1). Flights were conducted when the upper air flows were typically less than 50 m/s to avoid severe turbulence. These conditions occurred generally during late October to mid-December (post-monsoon and pre-winter) and May-June (post-winter and pre-monsoon); a result consistent with Kathmandu winds-aloft data reported by Reinhardt et. al. (1985).

During wintertime between the Lukla and Synagboche airstrips, the Dudh Kosi Valley is frequently covered by stratus in the morning. Above the stratus (4000-4500 m) the air between the airstrips is often very rough. Frequently, in February, frequently no clouds occur in the valleys. In these cases, the flights could only be made at very low altitudes in the valleys approaching Lukla or Syangboche airstrips owing to severe turbulence higher up in the Dudh Kosi valley. Only south of Lukla would smoother conditions occur in the valley.

3. RESULTS

A routine flight pattern in the region of Mt. Everest is illustrated in Figure 2. The flight pattern followed the valleys, which were usually nearly calm, until reaching Syangboche airfield. There, a transition occurred to the high-speed westerly airflows. As a result of the high-speed flows, two wake turbulence regions were often encountered. The first region was downwind (east) of Taboche peak and the second was downwind (east) of the Chakri ridge. To avoid these regions, the plane flew underneath the wakes. Altitude was gained



.Figure 3. A view of the Everest region from a space shuttle overflight on December 2, 1983 at 0931 LST. The pictures are mounted as a stereo-pair for 3D viewing. Landmarks for the photographs are given on the schematic to the right. (Photo courtesy of M. Reinhardt, DFVLR).

either in spiral or figure-eight patterns between the wakes and over Base camp.

The West Cwm was entered if low wind speeds existed (<50 m/s) above Base camp. Strong hill lift was frequently encountered on the west face of Lhotse. When possible, soaring flights were conducted between about 7,800 m to 10,000 m (Cu cloud base over Lhotse). On leaving the Cwm, strong downdrafts were encountered immediately downwind of the southeast and west ridges of Everest. The rising air motions on the face of Lhotse reveal a "funnelling" effect caused by the West Cwm and the downdrafts reveal sinking air in the lee of Everest. The "funnelling" effect was not predicted from initial Everest air flow simulations by Hindman (1986).

Additional air flow information has been obtained from photographs of clouds formed by the Massif itself. The common banner-cloud demonstrates strong rising air in the lee of the peak and subsequent cloud formation, while a less common cap-cloud forms over the summit indicating a rising motion upwind of the summit and sinking air downwind.

Figure 3 is an on-top view of a cap cloud from a Shuttle over-flight on December 2, 1983 at 0931 LST. The figure is a stereo-pair and can be viewed in 3D using the "cross-eye" technique (Fraser, 1968). Careful inspection of the figure reveals the leading edge of the cap cloud slightly upwind of the summit and the thin cap cloud above the summit. It appears the downwind portion of the cloud shadow contains Kelvin-Helmholtz billows; indications of wave-activity downwind of the summit. This conclusion is consistent with the Chinese observations of lee-waves downwind of Everest (Gao, 1981).

Douglas (1982) reports that banner clouds occur from isolated peaks in the Alps when the wind speed increases dramatically near the summits. Further, he reports that the banner and cap clouds differ primarily because of their moisture sources: the banner clouds appear to draw their moisture from lower down than do the cap clouds; cumulus on lower ridges are observed with banner clouds. Douglas reports that the presence of cap clouds and the absence of banner clouds probably indicates that the layer some 600 m or so underneath the cap cloud is relatively dry and stable; he reports that cap clouds indicate moist, strong winds at summit levels.

Inspired by the work of Douglas, we postulate that the banner and cap clouds caused by the Everest pyramid are visible manifestations of two separate and distinct flow conditions as illustrated in Figure 4. The banner cloud is caused by flow-separation while the cap cloud is caused by a non-separated (laminar) flow. Rising air occurs on the lee side of the summit pyramid during flow-separation while sinking air occurs on the lee side during laminar flow.

The air motion reports in Figure 2 appear to support the laminar flow condition. The reports show sinking air on the lee of the summit pyramid and updrafts on the windward face of Lhotse. Also, light downdrafts are reported on the south side

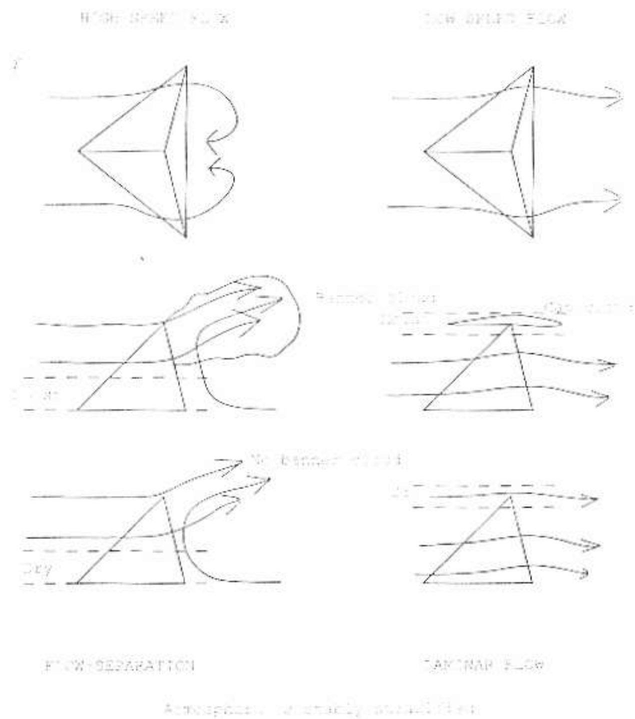


Figure 4. Postulated air flows around and over Mt. Everest: flow-separation and laminar flow.

of the West ridge. It is argued that light updrafts probably occurred on the north side (windward side) of the West ridge.

The air motions reported in Figure 2 and those postulated in Figure 4 form the basis for guiding numerical simulations of the airflow around and over Mt. Everest. The numerical mesoscale model of Lee, et. al. (1988) may be a suitable one for studying the airflows. A systematic investigation with the model of vertical distributions of temperature, wind and moisture conditions may help explain the meteorological conditions which cause the banner and cap clouds. This knowledge will be valuable for helping understand the flow fields and, hence wind forecasts for the region.

4. CONCLUSIONS

Air motions are reported from Pilatus Porter flights in the vicinity of Mt. Everest. A "funnelling" effect caused by the West Cwm of Everest was discovered which permitted soaring flights of the Porter to altitudes above its ceiling. Also, banner clouds and cap clouds caused by Everest are postulated to illustrate two different airflows, flow-separation and laminar flow, respectively.

Detailed air motion measurements of Everest-induced airflows would quantify the qualitative results reported here. Further, such measurements are required to test 3D numerical simulations of Everest airflows. Such knowledge may help wind forecasts for future Everest flights, as well as climbing activities.

Finally, the measurements and numerical simulations may identify hill-lift regions which could enable a soaring ascent of Everest (in a modern sailplane) from near the Syangboche airstrip to the summit.

5. REFERENCES

BONNINGTON, C. (1973): The Ultimate Challenge. Stein & Day, New York, NY, 352 pp.

DOUGLAS, C.K.M. (1928): Some alpine cloud forms. Q.J. Royal Meteor. Soc., 54, 175-178.

FRASER, A.B. (1969): Stereoscopic cloud photography. Weather, 23, 505-514.

GAO, D. (1981): Explorative studies of meso- and microscale systems of waves over Qomoolangma Feng (Mt. Everest). Ppts. 2nd Conf. Mt. Meteor., Am. Meteor. Soc., Boston, 24-27.

HINDMAN, E.E. (1986): Ascending Mt. Everest through soaring flight. OSTIV Publication XVIII.

LEE, T.J., R.A. PIELKE, R.C. KESSLER and J. WEAVER (1988): Influence of "cold pools" downstream of mountain barriers on downslope winds and "flushing." Submitted to Monthly Weather Review.

REINHARDT, M.E., NEINIGER, B., KUETTNER, J.P. DeORLEANS-BORBON, A., ADHIKARY, S.P. and LERT (1985): First results of airborne measurements of the mountain-valley circulation in the Kali Gandaki valley, Nepal by motorglider. OSTIV Publication XVIII.

RONNAU, M. (1978): Der letzte Adler vom Mount Everest. Flieger Magazine, July, 26-33.

WASHBURN, B. (1988): Mount Everest: Surveying the Third Pole. J. National Geographic Society, 174, 653-659.