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Diurnal Variation of Wind Velocity and Pressure in the Upper Atmosphere

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Various writers have investigated the diurnal variation of wind at great heights by the analysis of pilot balloon ascents, and also studied the diurnal variation of pressure at high altitude by the analysis of mean hourly pressures observed at mountains. Here the present author intends to show the relation of the diurnal variation of wind velocity and the diurnal variation of pressure using the data observed at the Mt. Fuji Weather Station.

A standard Japanese weather station was inaugurated on the summit of Mt. Fuji (sometimes spelt as Mt. Huzi, 3772 m above M.S.L., 35°21′ N, 138°44′ E) on July 1, 1932 and, since then, regular observations are undertaken by well-trained observers without interruption, even during the Great War II. Mt. Fuji Weather Station is, to my knowledge, the highest meteorological observatory in the world among the weather stations which take the hourly observations throughout the year. Quite recently, meteorological data for a 10-year period (Jan. 1, 1933—Dec. 31, 1942) has been published under the following title:

Central Meteorological Observatory, Tokyo, 1949: FUJI-SAN NO KISHO (Weather at the Summit of Mt. FUJI), No. 1, (in Japanese).

The hourly mean pressures and the hourly mean wind speeds observed at the Mt. Fuji Weather Station is given in Table 1.

Table 1

135th meridian civil time	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h
Barometric pressure (mmHg)+400	79.09	78.99	78.88	78.84	78.89	79.02	79.17	79.33	79.45	79.49
Wind speed (m/sec)	15.17	15.07	15.28	15.30	15.21	15.09	15.06	14.80	14.79	14.71

11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h	mean
79.38	79.20	79.04	78.98	78.97	79.01	79.09	79.20	79.32	79.42	79.48	79.45	79.34	79.21	79.18
14.64	14.76	14.52	14.70	14.66	14.71	14.69	14.62	14.48	14.27	14.56	14.60	14.83	14.80	14.81

When the diurnal variation of pressure is subjected to harmonic analysis, it is found to have at least two important components and possibly four. To a high degree of approximation the hourly values of pressure and wind speed at Mt. Fuji may be represented by

$$b=479.18+0.063\sin(t+183°)+0.275\sin(2t+167°),$$

$$v=14.81+0.31\sin(t+22°)+0.14_5\sin(2t+6°),$$

where, the pressure is expressed in mmHg, the wind speed in m/sec, and t is the hour angle in which $t=0$ stands for $0h$ (135th meridian civil time), $t=90°$ for $6h$, 180° for $12h$, and 270° for $18h$. According to the harmonic analysis of pressure records for the same period at the Central Meteorological Observatory, Tokyo (barometer: 5.8 m above M.S.L., φ: 35°41′N, λ: 139°47′E),

$$b=760.78+0.526\sin(t+23°)+0.553\sin(2t+181°).$$

It has long been known that the semidiurnal tide in the atmosphere has some lag in phase with height. At about 4.5 km in the Alps, the phase of the semidiurnal tide as reported by A. WAGNER (1932, 1938) is about two hours behind that observed at low level stations. At the summit of Mt. Fuji (about 4 km above MSL) the phase of the semidiurnal tide is about half hour behind that observed at CMO, Tokyo, while the difference of longitude between Tokyo and Mt. Fuji is 1°3′. According to the theory of J. BJERKNES (1948), this tilte of the semidiurnal atmospheric tide may be of importance to the future contribution to atmospheric tidal theory.

When the correlation coefficient r between the daily march of the pressure and that of the wind speed is calculated from Table 1, it is found to have a high correlation as

$$r=-0.63\pm0.08,$$

that is, the diurnal variation of the wind speed seems to make double oscillation during the course of the day, although there is some doubt as to its significance in view of the indecisive result.

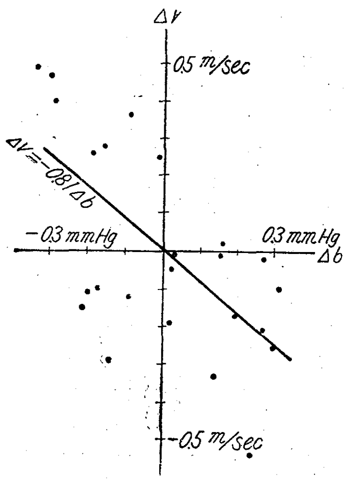

Fig. 1

Fig. 1 stands for hourly departures from the mean pressure versus hourly departures from the mean wind speed. The regression equation

(1) $$\Delta v=-0.81\cdot\Delta b$$

has been determined by the method of least squares, where the hourly departures from the mean pressure Δb is expressed in *mmHg*, and the hourly departures from the mean wind speed Δv is expressed in *m/sec*. This result apparently suggests that *some percentage of the released potential energy due to the lowering of the isobaric surfaces will contribute to the increase of wind speed in the upper atmosphere.*

According to ESPY-KÖPPEN's theory, the turbulent transfer coupling effects that cause the surface winds to increase during the day, cause winds aloft above plain regions and surface winds at high altitude stations to show an average minimum of velocity during midday hours. But Mt. Fuji is too high (4 km height)and is an isolated mountain, so that the diurnal variation of wind in the greater altitude must be attributed to some other mechanism different from that of ESPY-KÖPPEN's theory. An interesting question arises as to the relation between the diurnal variation of wind and that of pressure, in view of the fact that a close relation between barometric gradient and wind exists.

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