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# ON A CERTAIN EFFECT OF MOUNTAIN MASSES ON AERIAL PHOTOGRAPHY

By

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**Abstract:** *Ground relief affects aerial photography in many ways (distortion, problems of photo-interpretation etc).*

*Of particular interest is the effect of ground relief upon photogrammetric refraction, consisting in differentiations of refractive index values, due to the variations of thermodynamic parameters because of the relief, in connection with free air.*

*In this paper we endeavour to study refractive index at high altitudes, namely the mountain mass of Ayios Antonios on Mt Olympus, in correlation with refractive index in free air, calculated upon data of radiosonde observations from Mikra' s Upper Air Station in Thessaloniki.*

*There is evidence of the influence of mountain masses, which, combined with the effect of atmospheric pressure, produces differences in values of refractive index between corresponding places upon certain altitudes and in the free air.*

## 1. INTRODUCTION.

The effect of ground relief on aerial photography appears under many aspects, that is as displacement of ground points illustrated on the photographic film, due to altitude differences, or as problems of photointerpretation, from the general variability, caused by ground relief, of thermal conditions, humidity, covering, reflection of light, etc.

Besides the above, the effect of ground relief in the study of photogrammetric refraction is also of interest, from the viewpoint that

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the refractive index depends on thermodynamic parameters, which is the subject examined herein.

In the relative works (Leijonhuvfud 1950, Faulds and Brock 1964, Bertram 1966, Schut 1966) the refractive index in various elevated ground points is usually correlated with the refractive index of the same altitude in the free air, calculated from data of standard atmospheres.

We, being interested in the study of photogrammetric refraction in the greek area (Patmios 1971, Patmios 1972), by means of actual meteorological data, undertake here a study of the refractive index, calculated from data of radiosonde observations from Mikra's (Thessaloniki) upper air station.

On the mountain mass of Ayios Antonios (Mt Olympus) a meteorological network of surface stations was started in 1961, manned and operated by the Institute of Meteorology and Climatology of the Aristotelian University of Thessaloniki [4]; the nearest upper air station of the greek network is that of Mikra - Thessaloniki, within a distance in which radiosonde data are considered valid.

The surface stations of the above mentioned mountain area, because of the deep ravines and the updroughts rising in them and causing condensation, are quite often covered by convective clouds [1], besides the ones produced by more general dynamic factors.

Moreover, the mountain mass of Olympus, remaining snow - free during the summer season, acts as an additional thermal source [1].

All the meteorological data used herein, have been obtained from the records of the Institute of Meteorology and Climatology of the University of Thessaloniki.

## 2. METEOROLOGICAL DATA; OBSERVATIONAL PERIOD; WEATHER CONDITIONS.

2.1 The meteorological data used herein have been obtained as follows :

From the midday (12:00 GMT) radiosonde observation of Mikra-Thessaloniki upper air station, we have taken data of temperature and pressure in the free air, for levels of 2.817 m and 1.850 m. corresponding to the altitudes upon Ayios Antonios, on which stand the surface stations of Olympus Scientific Center (O.S.C.) (elev. 2. 817 m, on top of the cone of Ayios Antonios) And the Skiing Center (S.C.) (elev. 1. 850 m., on the axis of Sparmos ravine - Skiing Center - Ayios Antonios, facing south towards the plane of Thessaly).

Values of the above elements have been obtained by plotting and reading on thermodynamic diagrams of the WBAN-31A/ADIABATIC CHART/U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU type, the corresponding temperature-height (T. H.) and pressure-height (p. H.) curves, taken from temperature and pressure data, contained in daily weather maps of the greek National Meteorological Service, for the standard and significant levels [8].

From midday observations at the O. S. C. and the S. C. surface stations, we have taken values of temperature and atmospheric pressure, as well as the existing cloud cover.

Finally, from the midday observation of the surface meteorological station of the Institute of Meteorology and Climatology in the University of Thessaloniki, we have taken the cloud cover existing above the area of Thessaloniki, where the sounding was effected.

2. 2 The observational period examined here, is that of the summer 1969 (from June 28 to October 14, when the meteorological network of Mt Olympus was in operation), and especially the days of that season, when a radiosonde observation was effected at the upper air station of Mikra. The above days, 86 in all, are distributed per month as in the following Table I.

TABLE I

*Number of days examined per month*

| *J* | *J* | *A* | *S* | *O* | *Σ* |
|---|---|---|---|---|---|
| 3 | 30 | 21 | 19 | 13 | 86 |

2.3 Various weather conditions prevailed in the area of Greece during the above days, described generally by the corresponding pressure pattern - weather type [6]. Thus the 86 days examined, are distributed per weather type as in the following Table II.

TABLE II

*Distribution of days examined per weather type.*

| *I* | *II* | *III* | *IV* | *V* | *VI* | *VII* | *VIII* | *IX* | *X*a | *X*b | *XI* | *XII* | *Σ* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 12 | — | 4 | 5 | 2 | 2 | 3 | 6 | — | 3 | 3 | 1 | 86 |

In order to have a conception of the existing state of sky in the area of Mt Olympus (O. S. C. and S. C.), as well as in the area of Thessaloniki, we give in the following Table III the number of days, on which the total cloudiness of the midday observation corresponded to the figures of the first raw of this Table (giving cloudiness in tenths of sky covered)

TABLE III

*Number of days per tenths of sky covere, in each station.*

| Cloudiness | 0 | Traces | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Σ | v |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A.U.T. | 2 | 5 | 5 | 5 | 6 | 8 | 6 | 7 | 10 | 10 | 9 | 13 | 86 | — |
| O.S.C. | — | — | 7 | 2 | 5 | 4 | 5 | 6 | 4 | 5 | 11 | 37 | 86 | 40 |
| S.C. | 11 | — | 1 | 2 | 2 | 1 | — | — | 1 | 1 | 12 | 55 | 86 | 9 |

and where in the columm marked v we have included the number of cases on which the surface stations under consideration were near or in the clouds.

## 3. STUDY OF METEOROLOGICAL DATA AND REFRACTIVE INDEX.

From air temperature and pressure values, obtained as above, we have calculated [8] the corresponding values n of the refractive index, using the following relation 3. 1 :

$$n = 1 + \frac{n_0 - 1}{1 + at} \cdot \frac{p}{1013{,}25} \qquad 3.1$$

where $n_o$ = 1,0002926 is the refractive index of the atmosphere for 0° C temperature and 1013,25 mb pressure,

a = 0,00366 is the temperature expansion coefficient of air,
t = is the air temperature in degrees Celsius (°C),
p = air pressure in mb.

Instead of the value n representing the refractive index, we have followed, as it is usual [8] the formula :

$$N = (n - 1)\ 10^6 \qquad 3.2$$

from now on meaning by N the refractive index.

In Table IV have been included the minima, mean, and maxima of air temperature (°C), air pressure (mb), and refractive index (N), corresponding to the 86 days examined for the surface stations of O. S. C. and

S. C. on Mt Olympus, and also for levels corresponding to their (the stations') altitudes in the free air.

TABLE IV

*Minima, mean and maxima of air temperature, pressure, and refractive index in the surface stations and in the free air.*

| | O.S.C. (elevation 2.817 m) | | | Free air (level of 2.817 m) | | |
|---|---|---|---|---|---|---|
| | Minimum | Mean | Maximum | Minimum | Mean | Maximum |
| P (mb) | 720 | 729,9 | 735 | 717 | 726,3 | 732 |
| T (C°) | —1,3 | 5,0 | 12,5 | —2,0 | 3,9 | 10,8 |
| N | 201,5 | 206,9 | 211,9 | 200,8 | 206,8 | 212,8 |
| | S. C. (elevation 1.850m) | | | Free air (level of 1.850m) | | |
| P (mb) | 824 | 832,4 | 838 | 812 | 818,1 | 824 |
| T (°C) | 3,1 | 13,5 | 23,4 | 0,0 | 9,5 | 17,0 |
| N | 221,7 | 229,6 | 238,2 | 221,4 | 228,3 | 237,7 |

In order to illustrate the effect of the ground relief of mountain masses as a thermal body, we have found the differences of air temperature between each couple of surface station and its corresponding level in the free air. In Table V we give a distribution of these differences per 1°C, for intervals as the ones written in the upper raw of the Table.

The thermal effect being different on an elevated ground point and in the free air, combined with the generally more complicated influence of atmospheric pressure (due to morphological circulation factors), resulted in different values of refractive index on the ground relief and in the free air; these differences are distributed as per the following Table VI.

## 4. Conclusions.

1. Air temperature values were found to be (Table V) generally higher in the surface stations (in every case for the O. S. C. station and in 80, 2 % of the cases in the S. C. station) than those of the correponding levels in the free air, because the mountain mass of Ayios Antonios on Mt Olympus acts as a thermal source.

2. As concerns the refractive index, comparison indicates (Table VI) a higher percentage of higher values on the ground; there is however a certain dispersion of values, because the various combinations of air temperature and pressure, have each time a different effect upon the refractive index.

TABLE V

*Distribution of temperature differences between each couple of station and its corresponding level in the free air.*

| Interval °C | —3,0 | —3,0<br>—2,1 | —2,0<br>—1,1 | —1,0<br>—0,1 | 0,0<br>0,9 | 1,0<br>1,9 | 2,0<br>2,9 | 3,0<br>3,9 | 4,0<br>4,9 | 5,0<br>5,9 | 6,0<br>6,9 | 6,9 | Σ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_{osc}$ 2817m — $T_{free\ air}$ 2817m | 1 | 2 | 3 | 11 | 20 | 18 | 21 | 7 | 1 | 1 | | 1 | 86 |
| $T_{sc}$ 1850m — $T_{free\ air}$ 1850m | | | | | 4 | 7 | 15 | 17 | 17 | 14 | 12 | | 86 |

TABLE VI

*Distribution of refractive index differences between each couple of surface station and its corresponding level in free air.*

| Interval N | —3,0 | —3,0<br>—2,1 | —2,0<br>—1,1 | —1,0<br>—0,1 | 0,0<br>0,9 | 1,0<br>1,9 | 2,0<br>2,9 | 3,0<br>3,9 | 4,0<br>4,9 | 4,9 | Σ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $N_{osc}$ 2817m — $N_{free\ air}$ 2817m | 1 | 1 | 10 | 23 | 29 | 14 | 4 | 2 | | 2 | 86 |
| $N_{osc}$ 1850m — $N_{free\ air}$ 1850m | | | 5 | 15 | 30 | 18 | 10 | 7 | 1 | | 86 |

3. As to the variation of air temperature, (gradient) pressure, and refractive index values with height, mean values show a larger decrease on the elevated ground (8,5 °C/102.5 mb/ 22.7 N) than in the free air (5.6 °C/91.8 mb/21.5 N) for the difference of 967 m that exists between the two stations.

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ΠΕΡΙΛΗΨΙΣ

## ΠΕΡΙ ΜΙΑΣ ΕΠΙΔΡΑΣΕΩΣ ΤΩΝ ΟΡΕΙΝΩΝ ΟΓΚΩΝ ΚΑΤΑ ΤΗΝ ΛΗΨΙΝ ΑΕΡΟΦΩΤΟΓΡΑΦΙΩΝ

Ὑπὸ

Ε. ΠΑΤΜΙΟΥ * καὶ Γ. ΛΙΒΑΔΑ **

Κατὰ τὴν λῆψιν ἀεροφωτογραφιῶν τὸ ἀνάγλυφον ἐπιδρᾶ ποικιλοτρόπως (παραμορφώσεις, φωτοερμηνευτικὰ προβλήματα κ.λ.π.).

Ἐνδιαφέρον παρουσιάζει ἡ ἐπίδρασις τοῦ ἀναγλύφου κατὰ τὴν μελέτην τῆς φωτογραμμετρικῆς διαθλάσεως, συνισταμένη εἰς διαφοροποιήσεις τῶν τιμῶν τοῦ δείκτου διαθλάσεως, ὀφειλομένας εἰς μεταβολὰς τῶν θερμοδυναμικῶν παραμέτρων λόγῳ ἀναγλύφου, ἐν σχέσει πρὸς τὴν ἐλευθέραν ἀτμόσφαιραν.

Ἐνταῦθα ἐπιχειροῦμεν μελέτην τοῦ δείκτου διαθλάσεως ἐπὶ ὑψομέτρου, συγκεκριμένως ἐπὶ τοῦ ὀρεινοῦ ὄγκου τοῦ Ἁγίου Ἀντωνίου εἰς Ὄλυμπον, ἐν συσχετισμῷ πρὸς τὸν δείκτην διαθλάσεως εἰς τὴν ἐλευθέραν ἀτμόσφαιραν, ὑπολογιζόμενον ἐκ τῶν δεδομένων τῶν ραδιοβολήσεων τοῦ σταθμοῦ ἀνωτέρας ἀτμοσφαίρας εἰς Μίκραν Θεσσαλονίκης.

Διαπιστοῦται ἡ θερμικὴ ἐπίδρασις τῶν ὀρεινῶν ὄγκων ἥτις, συνδυαζομένη πρὸς τὴν ἐπίδρασιν τῆς ἀτμοσφαιρικῆς πιέσεως, δημιουργεῖ διαφορὰς εἰς τὰς τιμὰς τοῦ δείκτου διαθλάσεως μεταξὺ ἀντιστοίχων θέσεων ἐπὶ ὑψομέτρου καὶ εἰς τὴν ἐλευθέραν ἀτμόσφαιραν.

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