ΜΕΤΕΩΡΟΛΟΓΙΑ.— **On the Role of the Tropopause in Solar-Weather Relations,** *by Christos S. Zerefos**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ἠλία Μαριολοπούλου.

Increasing evidence of statistically significant link between solar corpuscular streams and lower stratospheric and upper tropospheric circulation appeared during the last few years. Roberts and Olson (1973), assuming a solar origin of magnetically disturbed days, showed that wintertime 300 mb troughs that entered the North Pacific area, displayed significant greater deepening than troughs entering the same region at other times.

Schuurmans (1969) reported statistically significant 24-hour 500 mb and 300 mb height changes following a list of 81 flares, selected according to their importance. He reported a cooling just above the tropopause, although this latter result was based on data mainly from a single station (ship B). Evidence of stratospheric air influxes down to 3 Km above sea level following solar flares was found by Reiter (1973). Moreover a 28-day periodicity in Radon Concentrations in three antarctic stations were speculated to be related with the same periodicity, which exists in the solar cosmic ray component (Lambert et al. 1970, Lambert et al. 1974).

Our previous work on solar proton event influence on the earth's lower atmospheric regions, can be summarized as follows:

1. Statistically significant 24-hour height changes at constant pressure levels above 500 mb were found to occur on the average a few hours after solar proton events (Zerefos, 1973).

2. A warming of about. 1° K/day in the lower stratosphere in high latitudes, with a maximum in the Alaskan area, followed proton events (Zerefos, 1974).

3. An increase in the thickness of the 30-50 mbs layer was found in phase with the solar activity cycle (Zerefos et al. 1973).

Since stratospheric-tropospheric exchange processes could be

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triggered by solar activity (Reiter, 1973) the tropopause playing a vital role in such interrelations, we were encouraged by the above stated investigations to study tropopause temperature variations as well as changes of the mean temperatures throughout the upper tropospheric and lower stratospheric layers, following solar proton events.

Tropopause temperature checked data were taken from Northern Hemisphere Data Tabulations, Daily series, Par. II, N.C.C., for all stations in operation during the period 1956-1969 (83 stations). These stations are located in the geographic region defined by the meridians 20° W to 180° and Northern of 35° N to the pole. During that period a list of 33 proton flares was found to satisfy the objective criteria described in a previous paper (Zerefos, 1974). This list was used in the presend study to investigate the 24-hour tropopause temperature changes following these flares, i e. the temperature difference between the first aerological observation after a flare and the observation 24 hours earlier.

Student's t-test was applied, in a superposed epoch analysis, to the mean 24-hour tropopause temperature changes (mean of 33 cases) the t-statistic being plotted in Fig. 1.

In ten stations centered in 8 significant (at the 5% level) areas, the t-value was found to be greater than 2. This percentage (12%) of significant mean tropopause temperature changes is to be compared with the 24-hour percentage of 300 mb height changes before a flare, which was found to be 5. 8% (Zerefos, 1973). Unfortunately because of lack of data and the large computational effort, no tropopause temperature data before a flare are available at this time. From Fig. 1 it appears that areas of the same sign are meridional-like distributed. This is possibly related to the 300 mb circulation before a flare, since there was found a meridional circulation prevailing before these flares (Zerefos, 1973, Appendix Fig. 1) suggesting that a flare effect on the atmosphere strongly depends on the initial atmospheric conditions (Schuurmans, 1969).

An important property of Fig. 1 is the tropopause warming near the Alaskan Gulf, of about the same order as that required to explain Robert's and Olson's (1973) findings. On the other hant, moving eastwards there is a middle latitude predominance of a cooler tropopause after a flare in agreement with Schuurmans' work.

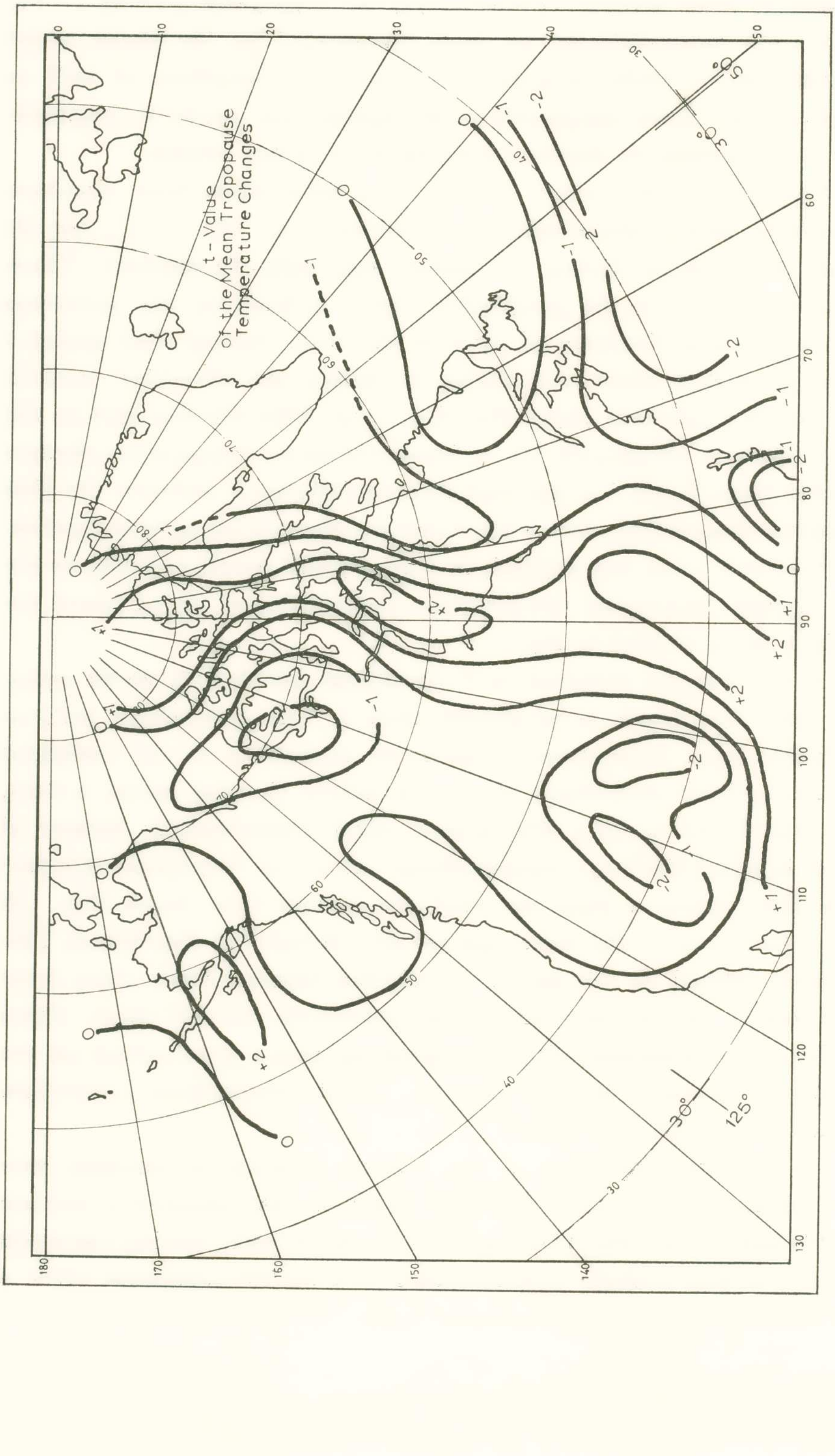

Fig. 1.

The above mentioned properties together with a high altitude and latitude warming after solar proton events (Zerefos, 1974) led us to compute latitudinal means of the mean temperature change of the layers 50-300 mbs, 50-200 mbs and 50-100 mbs following the same list of proton flares, the latitudinal gradient of which is shown in Fig. 2.

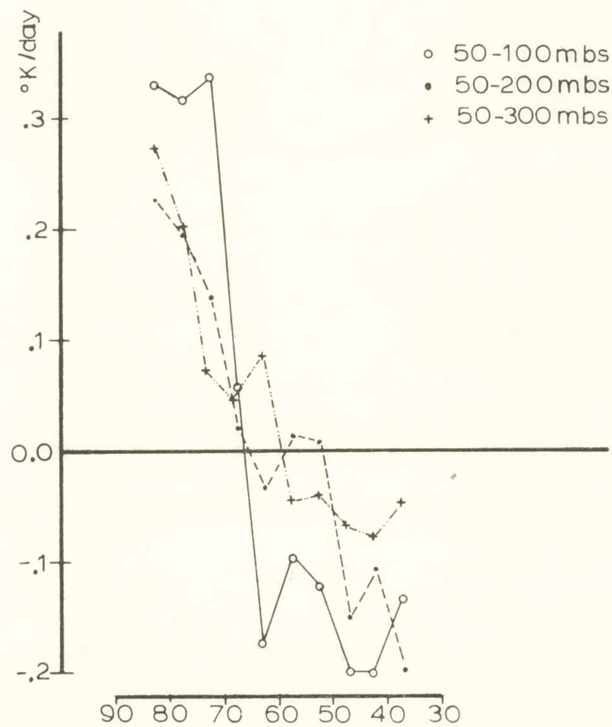

Fig. 2.

From Fig. 2 we can easily see that a small latitude zone, centered at about 60 deg. latitude, separates two regions of mean temperature changes of the above mentioned isobaric layers: A cooling region to the south of 55 deg. and a heating region, which is more pronounced to the North of 70 deg. latitude.

A tentative mechanism that may eventually explain the above findings could be as follows: soon after a high energy solar flare, energetic protons deflected by the earth's magnetic field move towards thicker atmospheric layers to the ozone layer; ozone could be produced there via dissociation of molecular oxygen, the O_2 ions playing an important role for this process (Mantis et al. 1973). This process obviously becomes very fast in the lower stratospheric regions. As soon as the ionizing corpuscular radiation reaches tropopauses heights, ozone could be destroyed because of an OH production due to dissociation of water vapor as originally suggested by Schuurmans (1969). Because of the

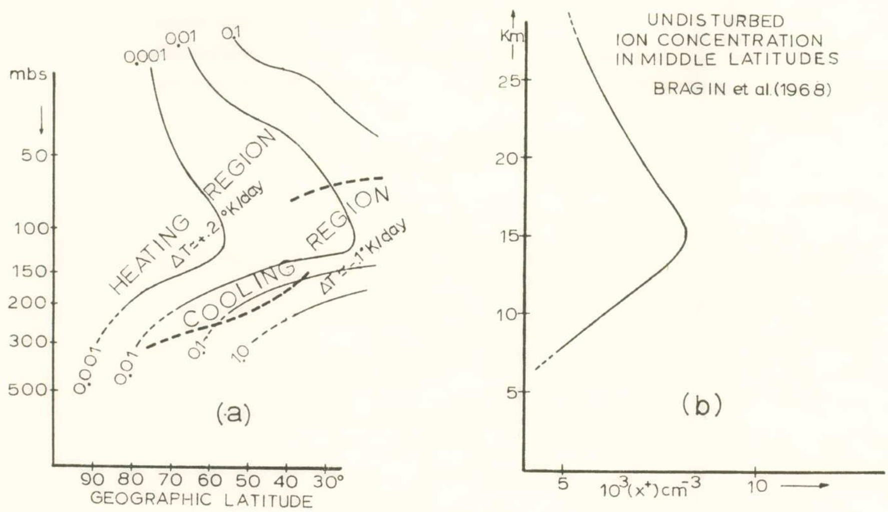

Fig. 3.

importance of the water vapor distribution in altitude and latitude for the proposed hypothesis, we read-off contour values (in gr/Kgr) of meridional water vapor latitude and altitude distribution from Webb (1966), which are plotted in Fig. 3 (a) the dashed curve referring to the tropopause.

The hypothesis stated above is briefly summarized in Fig. 3 (a). For comparison Fig. 3 (b) shows the undisturbed ion concentration in middle latitudes from Bragin et al. (1968) measurements. Figures 3 (a) and (b) could be used as a starting point for a numerical aeronomic model, which hat to take into account an increase in the ion concentration during disturbed conditions by a reasonable factor (see also Mantis et al. 1973) as well as the initial atmospheric conditions. An experiment on the high latitude ozone production hypothesis is going to start within this year at the University of Minnesota (Mantis, 1974).

Before ending I would like to express my hope that the present work could be a promising one for further investigations regarding solar weather relations.

ΠΕΡΙΛΗΨΙΣ

Ἐκτίθενται ἐν ὀλίγοις πρόσφατοι ἐνδείξεις δι' ἀνταλλαγῶν μεταξὺ τῆς στρατοσφαίρας καὶ τῆς τροποσφαίρας, ἐλεγχομένων ὑπὸ τῆς ἡλιακῆς δραστηριότητος. Εἰς τὴν παροῦσαν μελέτην εὑρέθησαν διὰ τοῦ ἐλέγχου - t στατιστικῶς σημαντικαὶ μεταβολαὶ εἰς τὴν θερμοκρασίαν τῆς τροποπαύσεως, αἵτινες ἔλαβον χώραν κατὰ τὴν διάρκειαν ἡλιακῶν ἐκλάμψεων ὑψηλῆς ἐνεργείας. Αἱ κατὰ ζώνας πλάτους μεταβολαὶ ἐντὸς εἰκοσιτεσσάρων ὡρῶν τῆς μέσης θερμοκρασίας τῶν ἰσοβαρικῶν στρωμάτων (50-100) mb, (50-200) mb καὶ (50-300) mb, αἵτινες ἠκολούθησαν ἡλιακὰς ἐκλάμψεις πρωτονίων, δεικνύουν ὑπεράνω μὲν τῶν βορείων πλατῶν θέρμανσιν τῆς κατωτέρας στρατοσφαίρας (∼. 2°K/ἡμέραν) ὑπεράνω δὲ τῶν νοτιωτέρων πλατῶν ψῦξιν τῆς ἀνωτέρας τροποσφαίρας (∼. 1°K/ἡμέραν). Διὰ τὴν ἐξήγησιν τῶν ἀνωτέρω εὑρημάτων προτείνεται δοκιμαστική τις ὑπόθεσις, βασιζομένη ἀφ' ἑνὸς μὲν ἐπὶ τῆς δυνατότητος παραγωγῆς ὄζοντος διὰ τῆς διασπάσεως τοῦ μοριακοῦ ὀξυγόνου ὑπὸ τῶν δευτερογενῶν ἠλεκτρονίων τῶν ἐκλάμψεων ὑπὲρ τὰ βόρεια πλάτη (>60°), ἀφ' ἑτέρου δὲ ἐπὶ τῆς πιθανῆς καταστροφῆς τοῦ ὄζοντος ὑπὸ παραγομένων ὑδροξυλιόντων ὑπεράνω τῶν νοτιωτέρων πλατῶν (<50°). Ἡ παραγωγὴ τῶν ὑδροξυλιόντων κατὰ τὴν διάρκειαν τῶν τοιούτων γεγονότων δυνατὸν ὅπως προέλθῃ ἐκ τῆς διασπάσεως τῶν ὑδρατμῶν ὑπὸ τῶν δευτερογενῶν ἠλεκτρονίων τῶν ἐκλάμψεων. Ἡ ὑπόθεσις αὕτη ἐνισχύεται ὑπὸ τοῦ γεγονότος, καθ' ὃ ἡ τροπόπαυσις, οὖσα κεκλιμένη πρὸς τοὺς πόλους διαδραματίζει πρωτεύοντα ρόλον εἰς τὴν πρὸς τὰ νοτιώτερα τῶν πλατῶν βαθμίδα παροχῆς τῶν ὑδρατμῶν. Ὁ προταθεὶς μηχανισμὸς εὑρίσκεται ἐν συμφωνίᾳ πρὸς τὰς ἐκτεθείσας μεταβολὰς τῆς μέσης θερμοκρασίας τῶν κατωτέρων στρατοσφαιρικῶν καὶ ἀνωτέρων τροποσφαιρικῶν ἰσοβαρικῶν στρωμάτων, ὡς καὶ πρὸς ἑτέρας διαπιστώσεις περιγραφομένας εἰς τὸ κείμενον.

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