Report on the meteorological conference in Helsinki, May 1953.

In May 19—22, 1953, a Symposium on some actual meteorological problems was held in the building of the Institute of Physics, Helsinki. The meeting was arranged by the Geophysical Society of Finland and the Institute of Meteorology, University of Helsinki. The papers presented at the conference were centred around problems of practical and theoretical aerology including numerical forecasting. In addition also some problems of micrometeorology were discussed. Prof. E Palmén was elected general chairman. Dr. L. Vuorela acted as general secretary.

PROGRAM

Tuesday Morning, May 19, 0900—1230

CHAIRMAN: Prof. E. Palmén, Academy of Finland, Helsinki.

Welcome to Delegates: Prof. E. Palmén (twenty delegates from seven foreign countries, Denmark, Germany, Iceland, Japan, Norway, Sweden and U.S.A., were present).

Some Problems of the Jet Stream. Prof. C.-G. Rossby, Institute of Meteorology, University of Stockholm.

A Case Study of Variations in Structure and Circulation About Westerly Jet Streams Over Europe. Lt. W. E. Hubert, U.S. Office of Naval Research and Institute of Meteorology, University of Stockholm.

On the Fields of Wind and Temperature Over Japan and Adjacent Waters During Winter of 1950—1951. Mr. K. Mōri, Central Meteorological Observatory, Tokyo, and Institute of Meteorology, University of Stockholm.

Tuesday Afternoon, May 19, 1400—1800

PRESSCONFERENCE in the library of the Institute of Physics.

CHAIRMAN: Prof. R. Fjörtoft, Institute of Meteorology, University of Copenhagen.

Tropopausenzirkulation. Prof. P. Raethjen, Geophysikalisches Institut der Universität Hamburg.

Correlation Functions for Observed Winds in the Upper Atmosphere. Mag.scient. E. Eliasen, Institute of Meteorology, University of Copenhagen.

Subtropical and Polar-front Jet Streams. Prof. E. Palmén, Academy of Finland, Helsinki.

On the Upper Wind Distribution connected with Invasion of Upper Tropical Air. Dr. L. Vuorela, Institute of Meteorology, University of Helsinki.

Wednesday Morning, May 20, 0900—1230

CHAIRMAN: Prof. C.-G. Rossby, Institute of Meteorology, University of Stockholm.

Outlines of a Project for a Scale Analysis of Atmospheric Motions. Prof. R. Fjörtoft, Institute of Meteorology, University of Copenhagen.

On the Demands Upon the Aerological Network from the Viewpoint of Numerical Forecasting. Dr. A. Eliassen, Institute for Research of Weather and Climate, Oslo.

The Adjustment of a Non-balanced Velocity Field Towards Geostrophic Equilibrium in a Stratified Fluid. Fil.lic. B. Bolin, Institute of Meteorology, University of Stockholm.

Attempts with Fjörtoft's Graphical Method. Cand.mag. K. Pedersen, Institute for Research of Weather and Climate, Oslo.

Wednesday Afternoon, May 20, 1345—1730

CHAIRMAN: Prof. J. Keränen, Meteorological Central Office, Helsinki (ret.).

Streakiness of the Wind Field and Vorticity Transformations in the Free Atmosphere. Dr. C. W. Newton, Woods Hole Oceanographic Institution and Institute of Meteorology, University of Stockholm.

The Lag Coefficient of Hygroscopic Hygrometers. Prof. V. Väisälä, Institute of Meteorology, University of Helsinki.

EXCURSION to Wiiki, the experimental station of the Institute of Meteorology, University of Helsinki, with demonstration of the Väisälä-radiotheodolite.

Wednesday Evening, May 20, 1900

BANQUET in the country club »Kalastajatorppa — Fiskartorpet». Host: Institute of Meteorology, University of Helsinki.

Thursday Morning, May 21, 0930—1200

CHAIRMAN: Prof. P. Raethjen, Geophysikalisches Institut der Universität Hamburg.

Untersuchungen der troposphärischen Kältepole der höheren Breiten. Prof. R. Scherhag, Institut für Meteorologie und Geophysik der Freien Universität Berlin.

Über die Temperaturschwankungen in der Stratosphäre. Dr. V. Rossi, Meteorologische Zentralanstalt, Helsinki.

Thursday Afternoon, May 21, 1400—1630

CHAIRMAN: Mr. J. R. Fulks, U.S. Weather Bureau, Washington, D.C.

A Case of Strong Convection in the Stratosphere. Fil.lic. L. Raab, Swedish Meteorological and Hydrological Institute, Stockholm.

The Motion of Surface Pressure Centers in Relation to Upper Mean Maps. Mr. M. Jensen and Mr. W. Nielsen, Danish Meteorological Institute, Copenhagen.

A Preliminary Study of Apparent Diurnal and Seasonal Variations of Upper Air Temperature at Narsarssuak, Greenland. Mr. A. D. Belmont, Department of Meteorology, University of California, Los Angeles.

Time-lapse Photographs of Clouds. Fil.lic. G. Árnason, Institute of Meteorology, University of Stockholm.

Friday Morning, May 22, 0930—1200

CHAIRMAN: Dr. A. Eliassen, Institute for Research of Weather and Climate, Oslo.

On Frost Formation in Soil. Prof. J. Keränen, Meteorological Central Office, Helsinki (ret.).

A Note on the Eddy Conductivity in Statically Unstable Conditions. Dr. A. Nyberg, Swedish Meteorological and Hydrological Institute, Stockholm.

Fog in Relation to Discontinuities in the Pressure Field. Fil.lic. Aili Nurminen, Meteorological Central Office, Helsinki.

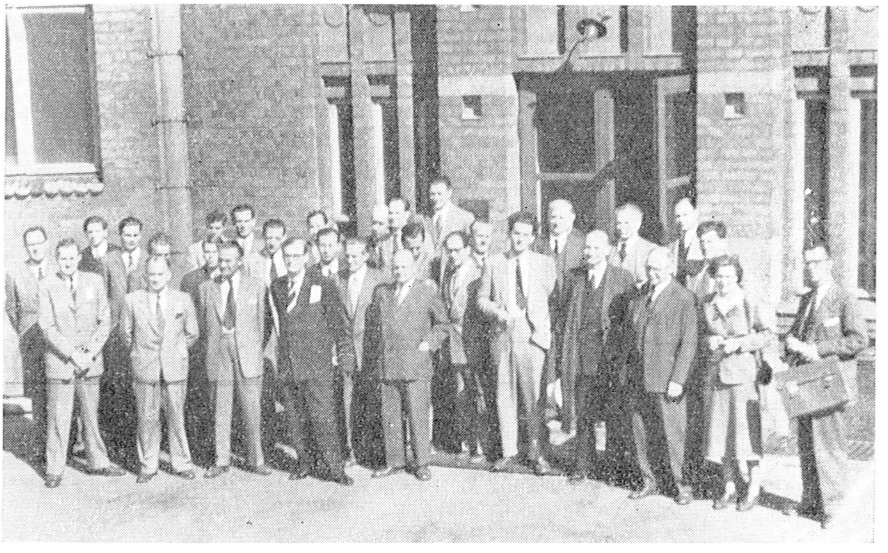

Fig. 1. A group of participants in front of the Institute of Physics. First row (from left to right): Hubert (USA), Franssila (Finland), Nyberg, Raab (Sweden) and Palmén (Finland). Second row (from left to right): Rossi, Ylinen (Finland), Lorentzen (behind Franssila), Jensen, Nielsen (Denmark), Mõri (Japan), Eliasen (Denmark), Eliassen (Norway), Tuominen (Finland), Fjörtoft (Denmark), Raethjen (Germany), Rossby (Sweden) and Newton & Newton (USA). Third row (from left to right): Rapeli (Finland), Pedersen (Norway), Palosuo (Finland), Belmont (USA), Simojoki, Vuorela, Venho (Finland), Scherhag (Germany), Keränen, Väisälä (Finland), Fulks (USA) and Bolin (Sweden).

Fig. 2. From the excursion to Wiiki. Persons (from left to right): Hubert (USA), Johansson (Finland), Eliassen (Norway), Väisälä (Finland), Pedersen (Norway), Arnason (Iceland), Rossby (Sweden), Fjörtoft (Denmark), Belmont, Newton (behind), Fulks (USA) and Eliasen (Denmark).

Abstracts

SOME PROBLEMS OF THE JET STREAM

Carl-Gustav Rossby

An abstract not available.

The following persons participated in the discussion: Palmén, Raethjen, Rossby and Tuominen.

A CASE STUDY OF VARIATIONS IN STRUCTURE AND CIRCULATION ABOUT WESTERLY JET STREAMS OVER EUROPE

William E. Hubert

This paper contains a case study of multiple wind maxima over western Europe during January 1951. One stratospheric and two tropospheric jet streams (600 km. apart) are shown over the British Isles, where the flow was almost zonal and quite steady latitudinally for the period discussed. The northernmost tropospheric jet stream rises locally as much as 3 000 meters in height and 13 degrees in potential temperature during a 12-hour period. The southernmost maximum curves sharply southward downstream to pass over the Mediterranean. Two 30-hour mean cross sections (means of six observation times), at longitude 4° West and at longitude 10° East, show the space changes in wind, temperature and potential temperature in the exit region of the jet stream. Mean vertical velocities over the same 30-hour period are computed using several different techniques; the errors due to restrictive assumptions are discussed. It is shown that neglect of ageostrophic components may change the vertical motion results by as much as 50 %. The vertical-motion patterns are significantly different from those suggested by some previous studies, with rising motions on the right side of the jet in the difluence region.

Comments: Palmén.

ON THE FIELDS OF WIND AND TEMPERATURE OVER JAPAN AND ADJACENT WATERS DURING WINTER OF 1950—1951

Keitaro Möri

First, a mean cross section along the meridian 140° E during three months (Dec. 1950—Feb. 1951) is discussed. The main characteristics are

1) an extremely strong subtropical jet (75 m sec^{-1}) situated at 33° N near 190 mb;

2) a semi-stationary sloping surface which separates almost barotropic warm tropical air in the south from more-or-less baroclinic temperate air situated in the north;

3) a slight indication of a polar-front jet situated near 230 mb at 41° N; the weak intensity of this jet depends upon the strong variability in position of the polar front;

4) much higher temperatures in the

upper troposphere to the south, and much lower temperatures in the lower troposphere north of the subtropical jet, as compared with mean conditions at 76° E and 80° W.

The computed mean winds at 140° E are compared with the mean isotachs given by YEH over China, at the 12-km level. Using the acceleration determined from the isotach pattern, the mean angle of cross-contour flow at this level is determined to be about 8° (between longitudes 110° and 140° E), with a mean cross-contour component of 8 m sec^{-1} toward lover heights in the centre of the mean jet stream.

Secondly, daily meridional cross sections through Japan are presented for the period 8 to 15 December 1950. These show an extremely strong individual jet stream in which the observed maximum wind speed reached a velocity of more than 110 m sec^{-1}, with near-zero absolute vorticity to the south. An associated nearly-isothermal layer underneath is much deeper (up to 4 and even 6 km) than in other parts of the globe. It is suggested that this unusual depth results from a combination of a stable layer associated with the semistationary subtropical jet, and the polar front when the latter moves southward in east Asia. The behaviour of the tropopause in the intermediate atmosphere south of the polar front during this series suggests subsidence of the tropopause and its transformation into the lower boundary of a deep stable layer which is transformed into some kind of front separating the real tropical air from a more temperate air moving in from the regions north of the Himalayas.

Discussion: Palmén, Newton and Vuorela.

TROPOPAUSENZIRKULATION

Paul Raethjen

Als »Tropopausenzirkulation» berechnet der Vortragende eine planetarische *Meridionalzirkulation*, welche sich von den Tropen bis zum Polargebiet erstreckt mit aufsteigenden Ast in den Tropen und absteigendem Ast im Polargebiet, mit polwärts fliessenden Massen *über* der Tropopause (flach abgleitend) und aequatorwärts fliessenden Massen in der *oberen* Troposphäre. Da diese Zirkulation im Meridianschnitt die Tropopause umschliesst und da ihre Entstehung und Existenz mit der planetarischen Tropopause verbunden ist, soll sie »Tropopausenzirkulation» heissen.

Sie hat grosse Bedeutung für;

1) das *permanente* planetarische Zirkulationssystem,

2) die *Störungen* dieses Systems.

Diese Bedeutung zeigt sich:

a) direkt in den *Beobachtungen*,

b) durch theoretische Diskussion in den *dynamischen Zusammenhängen*.

Diese zweimal-doppelte Bedeutung wird in dem Vortrag kurz geschildert folgendermassen:

1a) Die *permanente Existenz* der Tropopausenzirkulation zeigt sich in folgenden Beobachtungen:

α) Die »obere Inversion» ist infolge langwelliger Ausstrahlung (ebenso wie jede troposphärische Inversion) eine Abgleitfläche.

β) Dieses wird bestätigt durch die sehr geringe relative Feuchtigkeit (~ 5%) der Substratosphäre gemässigter Breiten, desgleichen durch den Wolkenmangel der Stratosphäre.

γ) Die grosse Sichtweite der frischen Polarluftmassen lässt vermuten, dass im Polargebiet eine permanente Luftzufuhr aus der Stratosphäre vorhanden ist (Mangel an opaleszenter Trübung).

1b) *Dynamische Effekte* der permanenten Tropopausenzirkulation sind:

α) Die permanente Zufuhr von Westwindimpulsen (Rotationsmoment) von tropischen nach gemässigten Breiten in der Substratosphäre (im oberen Zirkulationsast).

β) Die permanente Erneuerung zyklonaler Relativvorticity in der oberen Troposphäre gemässigter Breiten durch vertikale Dehnung und horizontale Konvergenz im unteren Zirkulationsast.

2a) *Plötzliche Störungen* des planetarischen Zirkulationssystems erscheinen oft in gemässigten Breiten als Zyklogenesis der oberen Troposphäre. Ein typischer Beispiel dieser Art (im Westküstengebiet Europas am 25. bis 30. April 1951) wird in 500-mb-Karten gezeigt. In diesem Beispiel waren die untersten Schichten der Troposphäre offensichtlich nicht an der Zyklogenesis beteiligt.

2b) Das plötzliche Auftreten sehr kräftiger *zyklonaler Relativvorticity* erklärt sich zwanglos, wenn man annimmt, dass dabei grosse Luftmassen aus der polaren Substratosphäre nahezu isentrop aequatorwärts in die obere Tropo sphäre vorstossen und sich dabei ungefähr auf den quasipermanenten Isentropenflächen bewegen. Dann dehnen sich diese Massen vertikal und müssen daher Horizontalkonverzeng besitzen, also zyklonale Vorticity gewinnen.

α) In dem gezeigten Biespiel (25. bis 30. 4. 51) ist dieses nach Ansicht des Vortragenden die einzige mögliche dynamische Erklärung.

β) Auch im Normalfall einer Frontalzyklogenesis unter starker Beteiligung der untersten Schichten dürfte der obere »Keileinschub» aus der niedrigen Substratosphäre in die (hohe) obere Troposphäre sehr bedeutsam sein. Jedenfalls erklärt sich die im »Delta» einer Frontalzone bevorzugte Zyklogenesis auf diese Art.

Discussion: Palmén, Raethjen and Bolin.

CORRELATION FUNCTIONS FOR OBSERVED WINDS IN THE UPPER ATMOSPHERE

Erik Eliasen

For a two-dimensional turbulent flow the following correlation functions are considered

$$R_1(r) = \frac{\overline{u(x,y)\; u(x+r,y)}}{\overline{u^2}}$$

$$R_2(r) = \frac{\overline{v(x,y)\; v(x+r,y)}}{\overline{v^2}}$$

where u and v are the velocity components in the direction of respectively the x-axis and y-axis. The bar denotes a mean value taken over a certain area. In the case of non-divergent and isotropic motion the following relation is valid

$$R_2 = R_1 + r\frac{dR_1}{dr}$$

It is an important point of view in the statistical theory of turbulence that this relation shall hold generally for distances r, which are small compared with the external non-isotropic influences. Considering the time variations of the velocity in a fixed point a similar relations holds, when the distance r is replaced by an interval of time and the direction of the x-axis is taken as the direction of the mean flow. Mean values are in this case taken over a certain time.

The correlation functions for the time intervals are computed on the basis of the observed winds in the 500-mb level at København in the time 1/7—31/12 1950. The correlation functions for space variations are computed by taking the geostrophic winds at some grid points from a 500-mb map. In both cases there is a good agreement with the above formula for the smaller intervals of respectively time and length.

Finally the relation between the correlation functions and the energy spectrum is considered.

Discussion: Bolin and A. Eliassen.

SUBTROPICAL AND POLAR-FRONT JET STREAMS

Erik Palmén

Extensive investigations by use of upper air data have during the last few years contributed considerably to the knowledge of the characteristic atmospheric structure and the corresponding wind distribution in the free atmosphere. One of the most important contributions in this field is probably the discovering of the upper tropospheric jet stream. There has, however been some confusion concerning the mean latitudinal position of the jet stream. According to NAMIAS and CLAPP the upper tropospheric jet has a position in January between the latitudes 20—35° N when determined from mean meridional cross sections. On the other hand the jet phenomenon studied by the use of synoptic charts is closely connected with the polar-front zone at the 500-mb level, which in most cases shows a much more northern position varying mostly between the latitudes 30 and 70° N. This indicates that it is necessary to distinguish between two different types of jet streams. The southern jet is formed at the northern boundary of the tropical circulation cell, whereas the northern jet, showing much stronger variations in latitude and intensity, is closely connected with the polar front and its typical disturbances.

An attempt was made to determine the average position of both jets during January. The position of the northern or polar-front jet cannot be determined from mean meridional cross sections. It is therefore hard to give any finite values for the position and mean velocity of this northern jet. One can, however, conclude that the polar-front jet, on the average, has its northernmost position (around latitude 55° N) over the eastern parts of the Pacific and Atlantic Oceans, and its southernmost position over the east coasts of the continents. The position of the southern or subtropical jet could approximately be determined from mean meridional cross sections as has been made by Namias and Clapp. The mean latitude of the subtropical jet coincides therefore closely with the latitudes given by Namias and Clapp. There is, however, one region where this jet stream has a much more northern position. That is in the region south of Japan. According to investigations by YEH and MŌRI the mean latitude of the subtropical jet should here be around 33° N, and not around 21° N as proposed by Namias and Clapp.

On the whole the subtropical jet seems to reach its northernmost positions at the longitudes where the polar-front jet reaches its southernmost positions, and vice versa. In the regions of the large quasi-permanent troughs in the westerlies it therefore very often happens that both jets practically coincide. In these regions one then observes extremely strong winds reaching average values of up to 80 m sec^{-1} in the region south of Japan.

Comments: Raethjen.

ON THE UPPER WIND DISTRIBUTION CONNECTED WITH INVASION OF UPPER TROPICAL AIR

Lauri A. Vuorela

A short preliminary report about a paper published in this issue of *Geophysica*, p. 105. (see the abstract there).

Discussion: Fjörtoft, Palmén, Raethjen, Rossby, Scherhag, Bolin and Eliassen.

OUTLINES OF A PROJECT FOR A SCALE ANALYSIS OF ATMOSPHERIC MOTIONS

Ragnar Fjörtoft

An abstract not available.

Discussion: Fjörtoft, Palmén, Rossby, Bolin and Newton.

ON THE DEMANDS UPON THE AEROLOGICAL NETWORK FROM THE VIEWPOINT OF NUMERICAL FORECASTING

Arnt Eliassen

The numerical methods of forecasting developed so far involve the use of the geostrophic approximation and can therefore be used in extratropical regions only. The methods require only the contour field at a number of levels to be known initially from the observations. It is tentatively estimated that a station distance of about 300 km between radiosonde stations without wind measurements, and 500 km between radiosonde stations with wind measurements would define the contour fields in sufficient detail, provided there were no observation errors. An even denser network of stations is desired in order to compensate for the loss of information caused by random errors in the observations. It is also important to reduce the systematic errors; however, this must be done by the other means. Since the initial data must be known over a considerable area outside the region for which one wants to forecast, it is particularly important to improve the aerological network over the extratropical regions of the oceans of the northern hemisphere. In the southern hemisphere, aerological data are by far to sparse to permit the use of numerical methods.

The paper was written as a supporting paper for the session of the Aerological Commission in August 1953. It was presented with the intention to give those who had anything to add the opportunity to bring their opinions to the President of the CAé Professor VAN MIEGHEM, before the session of the CAé.

Discussion: Palmén, Scherhag, Bolin, Newton, Nyberg and Fulks.

THE ADJUSTMENT OF A NON-BALANCED VELOCITY FIELD TOWARDS GEOSTROPHIC EQUILIBRIUM IN A STRATIFIED FLUID

Bert Bolin

The adjustment of the field of motion and the mass field towards geostrophic equilibrium has been studied using the following model: An infinite current along the x-axis exists in a stratified incompressible fluid with an upper free surface. The velocity field perpendicular to the yz-plane may have an arbitrary structure but is assumed to be of finite width. However, this field of motion is not balanced by any horizontal pressure gradient. During the adjustment towards geostrophic equilibrium a set of inertia gravity oscillations are generated and travel out in the direction of both the positive and negative y-axis. The speed of this influence is investigated as well as the intensity of the deformations generated in the surroundings of the current. A close relationship between the horizontal and vertical extension of the currents is found. Small-scale variations of the field of motion are eliminated to a much larger extent than the large-scale currents during such adjustment processes.

Comments: Raethjen.

ATTEMPTS WITH FJÖRTOFT'S GRAPHICAL METHOD

Kåre Pedersen

A series of 24 hour prognostic 500-mb maps have been constructed using FJÖRTOFT's graphical method (Tellus, Vol. 4, No. 3). The series comprises 16 cases, viz. 1—5 April 1951, 1—6 July 1951 and 2—6 January 1952. A distance $d = 650$ km was used in constructing the space mean fields. An attempt was made to analyze the errors in the prognostic maps and find their relationship to possible sources of error.

The method did not give much indications of the changes in intensity of the pressure systems that actually occurred. In January, and to a certain extent also in April, the forecast positions of the areas of rising pressure were much better than the forecast positions of areas of falling pressure. In the case of large cyclones (wave length larger than $4d$), the forecast position was in general found to be to the left of the actual track, as should be expected from the method. In the case of deepening cyclones, this type of error seemed to be accentuated. There were also indications that large errors in the forecast occur when the geostrophic temperature advection is strong. Furthermore, the level of nondivergence seemed to be lower in January and April than in July.

Discussion: Palmén and Scherhag.

STREAKINESS OF THE WIND FIELD AND VORTICITY TRANSFORMATIONS IN THE FREE ATMOSPHERE

Chester W. Newton

Examples of analyses of the wind velocity field at 300 mb are shown, which demonstrate that: (a) In cases where the belt of strongest winds apparently splits into two currents at different latitudes, there are in reality two or more jet streams flowing close together upstream from the split. This is not always evident from the contour analysis but is revealed if actual wind observations are considered. (b) Very rapid individual changes in the absolute vorticity about a vertical axis, of the order of up to twice the Coriolis parameter in 24 hours, commonly take place in the upper troposphere in both winter and summer.

The process of frontogenesis in the free atmosphere is considered from the point of view of simultaneous generation of the vorticity and temperature fields, rather than assuming that one field forms and the other adjusts itself later. Observations show that frontogenesis in the temperature field away from the earth's surface cannot be accounted for only by dilatation in a horizontal plane. Likewise the association of high values of vorticity with great vertical stability indicates that horizontal divergence processes cannot be responsible for the high vorticity observed in frontal layers.

The strong changes of vorticity about a vertical axis in such cases are shown to be due mainly to the terms commonly neglected in the vorticity equation, involving the creation of vorticity from vertical wind shear through horizontal gradients of vertical motion. The required vertical shear is in turn created partly from horizontal shear by differential lateral advection of the existing wind velocity field at different levels, and partly by differential axial accelerations due to the variation of cross-contour flow with height. The vertical and lateral components of circulation required for creation of the vorticity field at the same time contribute to changes in the horizontal and vertical gradients of potential temperature, of the right sign to balance the wind distribution.

Discussion: Palmén and Bolin.

THE LAG COEFFICIENT OF HYGROSCOPIC HYGROMETERS

Vilho Väisälä

A theory of the lag of hygroscopic hygrometers, especially of the hair hygrometer, is reported.[1]) There are two forms of the lag equation

$$U - U_s = \gamma \frac{dX}{d\tau} \quad \text{and} \quad U - U_s = \beta \frac{dU_s}{d\tau}$$

with

$$\gamma = \beta \frac{dU_s}{dX} = \beta U'_s$$

Here U is the relative humidity (%), U_s the reading of the hair hygrometer, X the relative lengthening of the hair ($X = 100 \frac{\Delta l}{\Delta l_0}$, $\Delta l =$ absol. lengthening of the hair from 0 to U_s %, Δl_0 from 0 to 100 %) and $\tau =$ time. The functional dependence of U_s and X is given by the well known Gay-Lussac scale. γ is independent of humidity but it depends on air temperature and pressure as well as on the ventilation function. When the ventilation function is supposed to be directly proportional to the air density it follows that

$$\gamma = \varkappa \frac{T}{E} .$$

$\varkappa$ is nearly a constant, approximately $\varkappa = 5$. Thus

$$U = U_s + \varkappa \frac{T}{E} \frac{dX}{d\tau} = U_s + \frac{\varkappa}{U'_s} \frac{T}{E} \frac{dU_s}{d\tau}$$

or approximately

$$U = U_s + 5 \frac{T}{E} \frac{dX}{d\tau}$$

A humidity sounding through the trade inversion is corrected by means of this last formula.

Discussion: Palmén, Raethjen, Rossby, Väisälä and Nyberg.

[1]) VÄISÄLÄ, V., 1952: Theory of the lag coefficient of hygroscopic hygrometers. *Univ. of Helsinki, Institute of Meteorology, Mitteilungen-Papers* No 71, 10 pp. and *Geophysica*, this issue, p. 87.

UNTERSUCHUNGEN DER TROPOSPHÄRISCHEN KÄLTEPOLE DER HÖHEREN BREITEN

Richard Scherhag

Eingehende Bearbeitungen der sogenannten Kaltlufttropfen haben ergeben, dass deren Fortbewegung weitgehend durch die Bodenisobaren bestimmt wird. Alle in dieser Hinsicht bisher untersuchten Kaltlufttropfen waren von kleineren Umfang und hatten allgemeins keinen grösseren Durchmesser als etwa 1 000 Kilometer. Nachdem sich in den letzten Jahren herausgestellt hat, dass die allgemeine Zirkulation stets in einige wenige, umfangreiche Kältezentren, die vielleicht als »Kältepole» bezeichnet werden können, aufgespalten ist, wurde die Frage untersucht, ob für diese Kältepole die gleichen Gesetze gelten wie für die kleineren Kaltlufttropfen.

Schon die im Jahresmittel nach der kanadischen Seite der Arktis hin zu beobachtende Verschiebung des arktischen Kältezentrums lässt sich aus dem mitteleren Verlauf der Bodenisobaren erklären. Darüber hinaus zeigt sich, dass in der kalten Jahreszeit allein aus der Lage der ozeanischen Wärmequellen eine Aufspaltung der kältesten Gebiete in zwei getrennte Zentren über dem kanadischen Archipel und Nordostsibirien erwartet werden muss und dass die Lage dieser beiden mittleren Kältepole sehr genau mit den beiden Gebieten zusammenfällt, die am weitesten von der mitteleren 0°-Isotherme entfernt sind.

Eine Auszählung der Häufigkeit des gleichzeitigen Auftretens mehrerer Kältepole hat ergeben, dass in etwa 80 % aller

Fälle 3 oder 4 Kältepole die Zirkulation der Nordhemisphäre beherschen. Dabei haben Untersuchungen der Zugbahnen zahlreicher dieser Kältepole ergeben, dass sie ebenso wie die kleineren Tropfen dem Verlauf der Bodenisobaren folgen bezw. mit der damit übereinstimmenden stärksten Strömung ziehen. Ein besonders eindrucksvoller Beispiel dieser Art haben wir im Frühjahr 1951 erlebt, als sich ein solcher Kältepol bei starker Ausprägung des arktischen Hochs zweimal rings um den Pol auf einer meist zwischen dem 60. und 70. Breitengrad verlaufenden Bahn verfolgen liess und auf diese Weise im Verlauf der Höhenlage der 500 mb-Fläche und der Temperatur der freien Atmosphäre eine dominierende nahezu 30-tägige Welle hervorrief.

Eine besondere Rolle kam jenem Kältepol zu, der sich Anfang Januar des Jahres 1953 aus der Arktis nach den westlichen Teilen Kanadas begab und zunächts westwärts bis zur Küste des Stillen Ozeans verlagerte, wo er dann umkehrte und im Verlauf von 14 Tagen stetig nach Osten vorrückte, bis er am 30. Januar, durch einen von Neufundland nach Nordosten in seine Rückseite erfolgenden Warmluftvorstoss beschleunigt, südlich von Island in die Flanke einer sich zunächst normal verhaltenden, nordostwärts ziehenden Wellenzyklone geriet. Dabei wurde dieser Kaltlufttropfen in einer ganz schmalen Zunge in die Zyklone einbezogen, und durch den daraus resultierenden ebenso plötzlichen und vehementen prätongalen Druckfall wie posttongalen Druckanstieg entwickelte sich, innerhalb von wenigen Stunden jenes Orkantief, das die in der Nacht zum 1. Februar 1953 eingetretene Sturmflutkatastrophe in der nordwestlichen Nordsee verursachte, wobei allerdings als weitere unglückliche Zufälle die gleichzeitige Springflut-Phase, das sich beinahe von Jan Mayen bis nach Holland nahezu geradlinig erstreckende Orkanfeld und ein durch vorhergehendes Tauwetter verursachter hoher Wasserstand der holländischen Flüsse hinzukamen.

Dass im Winter nicht nur in der Troposphäre, sondern auch in der Stratosphäre abgeschlossene und langsam wandernde Höhentief- und Kältezentren vorhanden sind, haben schon die ersten zirkumpolaren Stratosphärenkarten ergeben, die in den letzten Monaten gezeichnet worden sind. Noch bedeutungsvoller scheinen in Höhen von mehr als 20 000 Metern aber die ausgedehnten Antizyklonen zu sein, die mitten im Winter örtliche Stratosphärenströmungen erzeugen können und deren Entstehungsursache noch eingehend erforscht werden muss.

Discussion: Palmén, Raethjen, Scherhag and Nyberg.

ÜBER DIE TEMPERATURSCHWANKUNGEN IN DER STRATOSPHÄRE

Veikko Rossi

Das aerologische Beobachtungsmaterial am Observatorium Ilmala ($\varphi = 60° 12'$, $\lambda = 24° 55''$) und in Sodankylä ($\varphi = 67° 22'$, $\lambda = 26° 39'$) zeigt im Januar und Februar 1952 ziemlich grosse und schnelle Temperaturschwankungen in der Stratosphäre. Über diese schnelle Erwärmung in der Höhe von 20—30 Km besonders am Ende Februar hat SCHERHAG[1]) eine beschreibende Darstellung gegeben und eine Hypothese über die Erwärmung entwickelt.

Das finnische aerologische Material zeigt, dass die erste Erwärmung am Ende Januar ziemlich deutlich in Süd-Finnland, aber sehr schwach in Nord-Finnland hervortrat. Es ist sehr wahrscheinlich, dass die Erwärmung zuerst in Berlin und etwas später in

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[1]) SCHERHAG, R., 1952: Die explosionsartigen Stratosphärenerwärmungen des Spätwinters 1951/1952. *Berichte d. Deutsch. Wetterdienstes i.d. US-Zone* No 38, 51—63.

Ilmala beobachtet wurde. Die höchsten Temperaturen wurden in Berlin und Kopenhagen beobachtet.

Die zweite Erwärmung 27 Tage später wurde zuerst in Sodankylä und ein Tag später in Ilmala und zwei Tage später in Berlin beobachtet. Die starke Temperaturerhöhung verbreitete sich von Norden nach Süden mit einer Geschwindigkeit von c. 30 Km/St.

Die schnelle Temperaturerhöhung in Grönland trat zwischen 6—9 Februar hervor, was darauf hindeutet, dass diese Erwärmung eine eigene System bildet.

Statistische Untersuchungen des aerologischen Materials in Ilmala für die Jahre 1939—1952 zeigen, dass entsprechend starke Temperaturschwankungen nur im Winter auftreten. Die Temperaturschwankungen im Winter 1952 sind die grössten, die bisher beobachtet sind.

Die Luftströmungen während der verschiedenen Erwärmungsperioden haben verschiedene Richtungen in der Höhe von 100 mb. Deshalb ist es wahrscheinlich, dass in der Stratosphäre warme Luftmassen aus verschiedenen Richtungen strömen können und ganz spezielle stratosphärische Wetterlagen verursachen.

Als Ursache der grossen Temperaturerhöhungen können wir Korpuskularstrahlung der Sonne, Ozongehalt und Subsidenz erwähnen. Weil das Ozongehalt im Winter grosse Schwankungen in Nord-Europa[2]) zeigt und die Höhe des Ozonmaximums bei grosser Ozonmenge kleiner als bei kleinerer Ozonmenge ist, deutet dies darauf hin, dass Subsidenz eine Vergrösserung der Ozonmenge verursacht. Weil die grosse Temperaturschwankungen in der Stratosphäre im Zusammenhang mit verschiedenen Windrichtungen beobachtet sind, ist es wahrscheinlich, dass die Vertikalbewegungen in der Stratosphäre im Zusammenhang mit Störungen der zonalen Strömung entstehen.

Discussion: Raethjen, Scherhag and Rossi.

[2]) TØNSBERG, E. and. K. LANGLO OLSEN, 1943: Investigations on Atmospheric Ozone at Nordlysobservatoriet, Tromsø. *Geof. Publikasjoner*, XIII, No 12, 39 pp.

A CASE OF STRONG CONVECTION IN THE STRATOSPHERE

Lars Raab

At the 4th of Feb. 1953, 1500 GCT, the radiosonde launched in Östersund, Central Sweden, experienced in the 15 km level a downward motion due to a strong convective cell of a vertical extent of half a km. The ascending velocity of the sonde was investigated in detail from the heigth-time curve of the sounding, and assuming the bouyance force only to vary slowly with time, the vertical velocity of the different parts of the convective cell and also in the rest of the atmosphere could be calculated. The calculations show that in the troposhere and the lower stratosphere there was vertical motions due to gravitational waves and from 12 km up to 18 km there was no indications at all of any vertical movement except for the convective cell and its surroundings, where a slight upward motion of 1 m/s could be detected. The downdraft of the cell was 25 m/s in half a minute or a 400 m layer, the updraft was 10 m/s in 500 m. The accuracy was estimated to 30 %.

In the region up to $15^1/_2$ km there was weak easterly or no winds inside a cold-pool which during the day entered from Central Russia. The lower stratosphere above the cold-pool was warm as a result of the downward motion in the cold-pool-region. Over the North-Atlantic an intence high pressure ridge extended northwards into the polar region and into higher levels. A stratospheric cold-pool in the layers above 100 mb with its center north of Greenland then experienced a south-easterly motion (according to Professor SCHERHAGs lecture in the morning of 21th May) causing northwesterly cold advection over Östersund and instabilization in a one kilometer deep layer (15—16 km) with heavy convection as the result. The weather situation persisted several days and also at the 6th of Feb. a similar convective cell could be detected in the same level. The downdraft was here only 5 m/s and the updraft 3 m/s.

Discussion: Palmén, Väisälä, Bolin, Eliassen, Newton, Raab and Fulks.

THE MOTION OF SURFACE PRESSURE CENTERS IN RELATION TO UPPER MEAN MAPS

K. Mørch Jensen and A. Wiin Nielsen

A comparison has been made between the actual 500-mb map and the 500-mb space-mean-map used as fields of displacements for surface pressure centers. The accuracy of more than 100 forecasts of the movement of pressure centers has been studied. The quantity

$$F = \frac{\Delta r}{\frac{L+r}{2}}$$

where Δr is the distance between the forecasted and the actual arrived position of the center, r the length of the actual travelled distance and L the distance between two consecutive centers of the same kind, is introduced as an error-index. For the vector Δr we have:

$$\overline{\Delta r} = \overline{f} + \overline{A_2}$$

where $\overline{f}$ (»the delay») is measured in direction of the displacement, and $\overline{A_2}$ (»the derailment») is measured perpendicular to this direction and in direction of lower potential. The unit for A_2 is dam potential-difference in the field of displacement. r^* is the length of the forecasted distance. The results, here stated as mean values with their standard deviations added, were:

1° with the actual 500-mb map used as field of displacement in connection with the known 50 % rule:

$$\begin{aligned} F &= 0.22 \\ f/r^* &= -0.3 \pm 0.8 \\ A_2 &= -4.7 \pm 7.0 \text{ (dam)} \\ r &= 1\,340 \text{ km} \end{aligned}$$

2° with the 500-mb space-mean-field (see R. FJÖRTOFT: Tellus, Vol. 4, No. 3, August 1952) used as field of displacement in connection with a supposed 100% rule:

$$\begin{aligned} F &= 0.25 \\ f/r^* &= -0.24 \pm 0.17 \\ A_2 &= -4.0 \pm 3.8 \text{ (dam)} \\ r &= 1\,130 \text{ km} \end{aligned}$$

In case 2° it is possible, using the obtained values for f/r^* and A_2, to reduce the value of F to 0.20. In case 1° a reduction is impossible because of the great standard deviations.

Discussion: Fulks, Hubert and Jensen.

A PRELIMINARY STUDY OF APPARENT DIURNAL AND SEASONAL VARIATIONS OF UPPER AIR TEMPERATURE AT NARSARSSUAK, GREENLAND

Arthur D. Belmont

Radiosonde temperature-pressure data from Narsarssuak (BW-1), 61° N, from soundings taken two to four times daily from 1946—48, and from Thule (77° N), from soundings taken twice daily from 1947—1949 were examined for seasonal and diurnal characteristics. BW-1 data for

1948 was also summarized for two different definitions of season. The extreme diurnal range of the four mean monthly temperature at BW-1 for selected pressure levels varied from 0.5 to 5.1° C for levels from 950 to 350 mb, and from 0.6 to 9.7° C in the lowest stratosphere. At all levels up to 300 mb the maximum temperature occurred in the summer and the minimum in the winter. Above an irregular tropopausal transition zone the maximum was in early spring and the minimum in fall. Relatively high temperature in early spring for levels from 200 to 60 mb were indicated by very limited data, and if real, may reflect seasonal increase in ozone at higher levels. There was a pronounced tendency for the temperature difference, noon minus midnight, to diminish or even become negative at levels from 300—100 mb in winter and early spring at both BW-1 and Thule. It was not considered likely that changes of this character could be caused by any indirect solar radiation, at these seasons and heights. Suggestions for further measurements in the arctic were presented.

Discussion: Palmén, Rossby, Scherhag, Bolin, Nyberg and Fulks.

TIME-LAPSE PHOTOGRAPHS OF CLOUDS

Geirmundur Árnason

A short cloud-film taken from the roof of the building of the Institute of Meteorology, University of Stockholm, was shown. One of the most interesting features was the appearance of stationary clouds (altocumulus lenticularis) at 3 600 meters height in the immediate environments of Stockholm, where country is flat and the hills do not exceed 100 meters. In the absence of mountains within a reasonable distance, one is inclined to believe that stationary clouds at the 3—4 km's level may be produced by very small hills.

Another feature of interest was the development of cu clouds over the city, inasmuch as the sequence of photographs indicated a bubble structure in accordance with the theory advocated by the British school in cloud physics.

Finally some ci clouds were shown with bright streaks in parhelic circle positions.

Discussion: Palmén, Raethjen and Rossby.

ON FROST FORMATION IN SOIL

Jaakko Keränen

In this paper which has been published in the geographical series *Fennia* 73, No. 1, Helsinki 1951, the author discusses some physical phenomena in the frost formation of natural soil species.

The depth of the freezing soil layer can be calculated with sufficient accuracy from the cold flux into the earth by means of the formula

$$x = \frac{1}{80\,p}\,(K_0 - K_x - W_k),$$

wher K_0 is the flux into the frost layer, K_x the flux downward at the depth x, W_k the cold content in the frost layer and p the soil moisture in volume percentage.

The freezing of the soil is counteracted by the heat content which has been accumulated in the soil during the warm season. Thus there exists a heat flux upwards with a remarkable capacity to thaw frost formation from below. This flux can thaw a frost layer of 84 cm during the months November—April in a sand soil with the moisture 12 % in the climatic conditions of South Finland. In spring, after the melting of the snow cover, this heat is nearly consumed. At this time begins the penetrating of heat through the surface into the earth. This heat forms the principal factor in the thawing of the soil frost. Consequently the last rest of the soil frost lays near the deepest part of the frost layer.

The latent heat of the freezing water can give appearences to interesting temperature phenomena. Positive temperature values, about 0.5° C, have been found by the first phase of the freezing close to the place, and, correspondingly, slight negative temperatures occur in the frozen layer during an intensive thawing process.

Comments: Palmén.

A NOTE ON THE EDDY CONDUCTIVITY IN STATICALLY UNSTABLE CONDITIONS

Alf Nyberg and Lars Raab

Some temperature measurements have been made at the river Indalsälven near the town Östersund in Central Sweden. One series of measurements was made on 12 Febr. 1953 on the windward side of the river over a snow field. The temperature was uniformly —18° C in the three levels 1 cm, 3 m and 6 m above the snow surface. The temperature was also measured from a 6 m high bridge over the river, no ice cover was formed over the water as the speed of the stream was too high, about 1 m/sec. Over the water the temperature was —11° in 1 cm, —15.3° in 10 cm, —17.3° in 50 cm, —17.6° in 3 m and —18.0° in 9 m. The wind was 2—3 m/sec in the level 6 m and the wind-way from the shore to the point of measurement at the bridge was about 100 m. An estimation of the eddy conductivity A_z shows that in 1 cm A_z is about 60.10^{-4} c.g.s. This value is only twice as large as the corresponding value obtained by NYBERG[1]) over a snow surface at extremely stable conditions. The turbulence thus seems to have been of an almost purely dynamical type and convection did not play an important role in spite of the facts that the stratification was very unstable and that even the density rapidly increased with height. It is assumed that the eddy conductivity due to convection is a function of the dimension of the system. At a wind speed of 2 m/sec. more than 100 m is needed to obtain real convective cells.

Discussion: Palmén, Raethjen, Bolin and Hela.

1) NYBERG, A., 1939: Temperature measurements in an air layer very close to a snow surface. *Stat. Met. Hydr. Anst. Communications, Series of papers*, No 27, 44 pp.

FOG IN RELATION TO DISCONTINUITIES IN THE PRESSURE FIELD

Aili Nurminen

Fog, including very low clouds, may sometimes form in connection with discontinuities in the pressure field. By discontinuities we understand here, firstly, the fronts. But in Southern Finland fogs seldom occur on active fronts, except when a front is just forming over the locality. Discussion of this type of fog is therefore omitted in this connection. — Secondly, wind-convergence lines are important causes of fog.

The surface chart is essential for a study of the discontinuities. To get a clearer picture, because of the weakness of the pressure gradients and the obscurity of the discontinuities, isobars for each millibar must be drawn. The upper-air charts, on the other hand, explain the development of the whole system.

Stagnated anticyclones. If radiation fog has set in in the morning or at night, it sometimes happens that the sun radiation cannot disperse the fog. There must be some factors which prevent the dissipation of fog. Primarily the persistence of fog seems to be due to the mixing and upgliding of two air currents of different temperatures and humidities which converge into a cloud at the lower levels or somewhat higher up. On the other hand, if there is no fog originally, fog may form on a convergence line if the air near the ground is hazy previously, presumably rich in condensation nuclei. Observations show that the convergence zone must be accompanied by clouds or fog at the point, where, in an apparently homogenous air mass on the ground, the anticyclonic curvature of the isobars changes into a cyclonic one.

Depressions. On apparently harmless convergence lines fog may occur as a result of different processes. The most important of these processes are evaporation and mixing. When a cold front with rain has passed over the locality, the rain which has just evaporated condenses again and, due to the discontinuities in the pressure field and the peculiar orography, fog forms. Occasionally, in a depression, several discontinuities or secondary disturbances in the cold air may form in the rear of a cold front.

The discontinuity lines which bring patches of bad weather to Helsinki district will appear on the surface charts so early, 10—24 hours before, that good short-time forecasts can be made. To see the formation of discontinuity lines in good time beforehand one should have at one's disposal numerous and reliable hourly observations for a limited area, and the observations should be plotted on detailed charts. A satisfactory number of upper-wind observations are also necessary. Only thus good results can be obtained.

Comments: Palmén.