CIRCULATION IN THE MESOSPHERE AND LOWER THERMOSPHERE DURING THE MAP/WINE PERIOD

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One of the scientific programs in the MAP project "Winter in the Northern Europe" (1983-1984) involved an analysis of circulation processes in the middle atmosphere which characterized that winter period. For this purpose a series of rocket soundings was conducted in the USSR. At Heiss Island (polar latitude) and Volgograd station (middle latitude) the sounding was conducted twice a week from December to February. Besides this, four daily series were carried out (with 10 firings a day), two of them on December 9 and 19, one on January 18 and the last one on February 22.

Other data analyzed involved rocket sounding results obtained at a number of stations (Andoya and Lista, Norway; Ahtopol, Bulgaria; Riory, Japan; Thumba, India; Primrose Lake , Canada; Shemya, P. Kennedy, Antigua, P. Mugu and Kwajalein, USA; research vessels), as well as NOAA-7 data submitted by Great Britian. In order to investigate deviations of the mean winds for the MAP/WINE period from the circulation conditions of other winters, from CIRA 1972 (CIRA, 1972) and from the climatic norm (TARASENKO, 1969; GAIGEROV et al., 1981) rocket sounding data of Churchill and Barrow stations for many years were used as well as the "Pressure Modulated Radiometer" (PMR) channel 3000 data from the Nimbus-6 satellite for 1975-78 (LABITZKE and BARNETT, 1981), which enabled the author to compile geopotential fields and to calculate winds in the geostrophic approximation for comparison with the meteor winds. The maximum of the weighting function of channel 3000 occurs at an altitude of 80 km.

Let us analyze briefly the large scale processes of the winter of 1983-1984 which determined the circulation in the period of the experiment. The winter of 1983-1984 differed from other winter periods - a very deep cyclonic stratomesopheric vortex which reached its maximal development in January and early in February was present. A very high location of the lower boundary of the mesosphere (the stratopause) was also observed, sometimes as high as 58-60 in January.

The structure of the pressure field changed in late February due to a rapid intensification of the Pacific anticyclone and the shifting of its center to 70°N. The cyclonic vortex stepped away from the polar region toward Euroasia, and centered on 65°N. On February 22 the polar region was occupied by a high pressure area which came from the Pacific. A global change of the pressure field took place (Fig. 1). During the last several days of February the anticyclone shifted away from the Pole and the geopotential heights in its center decreased.

At the levels of the lower and middle mesosphere, large scale processes from December to mid-February were characterized by a well-

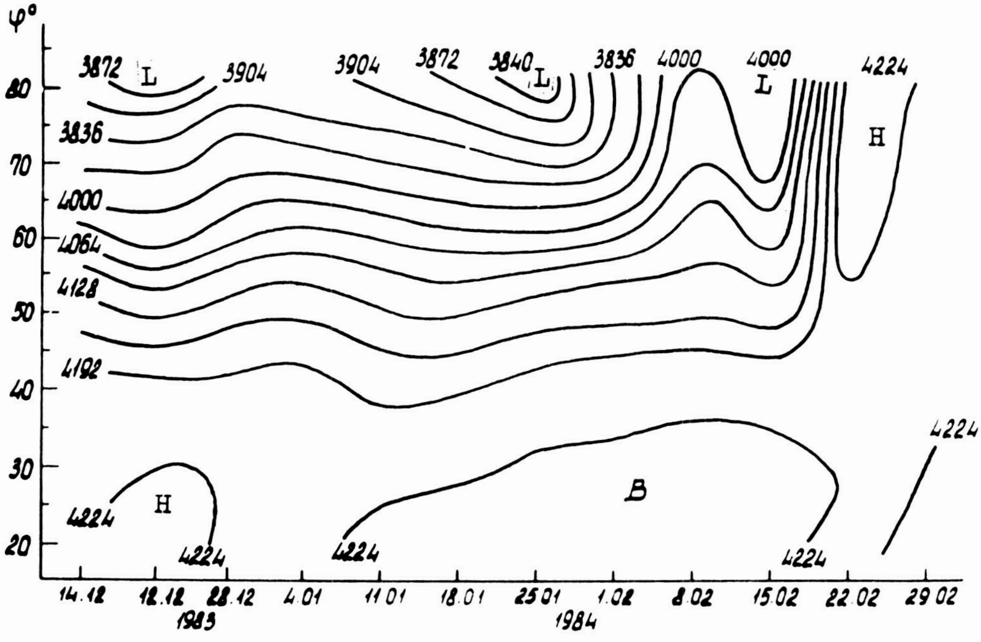

Fig. 1 Time-latitude section of zonal mean geopotential heights at 2 hPa (dm).

developed cyclone typical of the winter period. Late in February the pressure field was complicated and exhibited a four-cell structure.

Figures 2 and 3 present fields of the zonal and meridional components of geostrophic wind calculated from the geopotential field at a constant pressure surface located near the lower boundary of the mesosphere. The geopotential field at the 2-hPa level was obtained from rocket sounding data and PMR radiances on the NOAA-7 satellite.

Mean data for this period a weak easterly wind over the Greenland sea, since the center of the polar cyclone was displaced from the geographic pole to the European-Atlantic sector of the Arctic to a greater extent than had usually been observed. The observed asymmetry of the polar cyclone created large pressure gradients (greater than climatological values) over Central Europe and therefore caused large asymmetry in the zonal distribution of the wind field.

Thus, the westerly wind speeds reached greater values over Central Europe than over North America (80 mps and 30 mps, respectively). The stratospheric field of zonal wind (at 2 hPa) was characterized by the presence of an area of easterlies with speeds up to 7 mps over the Pacific regions. It should be noted that easterly winds are not observed each winter. Mean climatic data (GAIGEROV et al., 1981) reveal that in the Pacific Ocean area (north of 30°N) only a reduction of westerly flow (down to 5-7 mps) is observed due to the intensification and northern shift of the Pacific anticyclone on some days in the winter period. During the period considered here the low latitude stratosphere (south of 10°N) was occupied by area of easterlies which is in accordance with the normal climatic conditions. In the extratropical latitudes, with the exception of the Pacific Ocean and Greenland Sea, the wind was westerly which is also in agreement with the climatic conditions. The analysis of the fields of the meridional circulation showed that at the 2 hPa level two major meridional circulation cells were observed which stretched from the tropics to the Pole.

Eurasia was mainly occupied by southerly winds with their center over northern Siberia. Northerly flow dominated over eastern and central parts of the Pacific and America.

The meridional wind component is highly variable and reference atmospheric models existing now include only the zonal component (CIRA 1972).

Studies made earlier showed (TARASENKO, 1979; GAIGEROV et al., 1981) that maximum variability of zonal and meridional wind components in the lower mesosphere is recorded in winter. The summer time wind regime is relatively stable. At upper mesospheric and lower thermospheric levels, variations of meteorological parameters are of the same order of magnitude in winter and summer which is likely to be related to the penetration of planetary and gravity waves into there layers as well as to tidal effects. Results presented in Table 1 can serve as an example of the standard deviations of zonal wind with altitude.

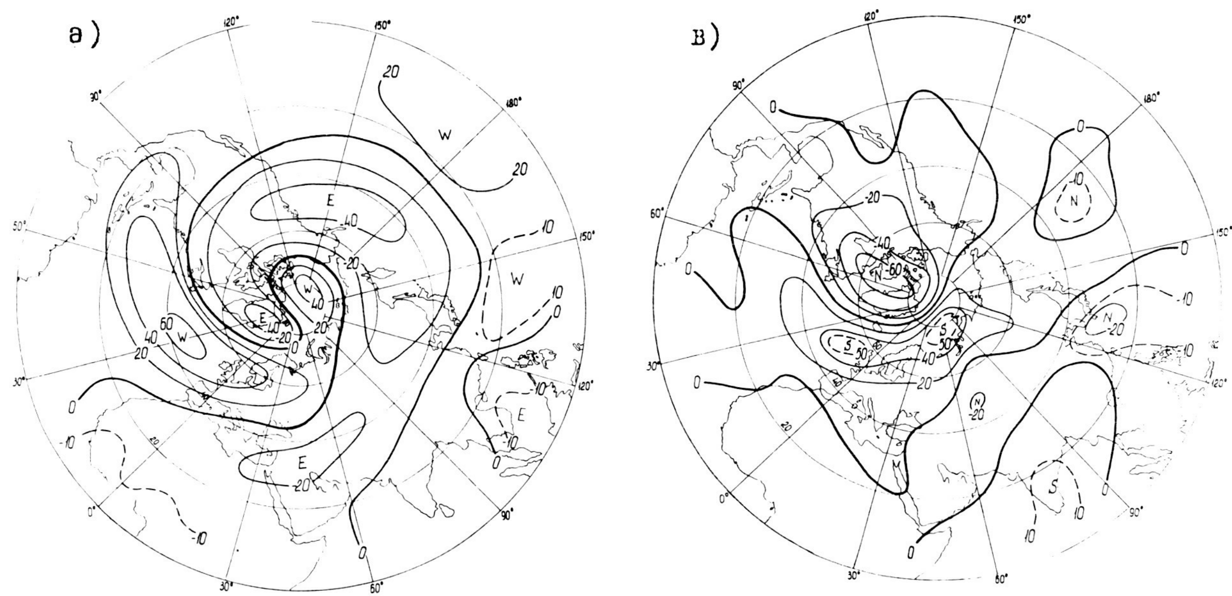

Fig. 2 Fields of zonal (a) and meridional (b) components of geostrophic wind speed (mps) at 2 hPa for February 22, 1984.

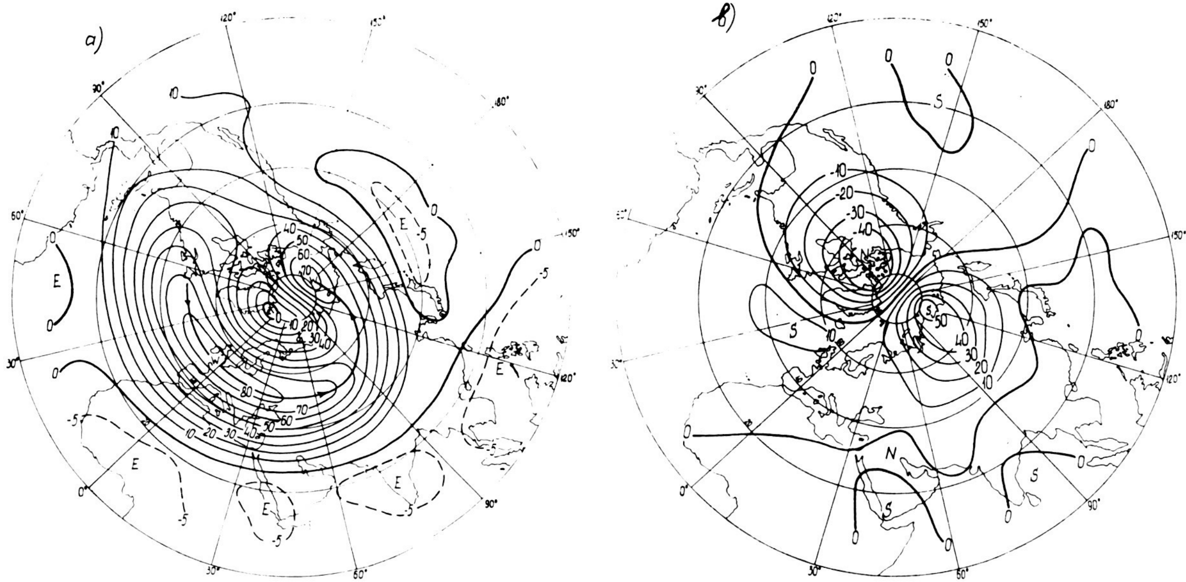

Fig. 3 Mean fields of zonal (a) and meridional (b) components of geostrophic wind speed (mps) at 2 hPa for the period from December, 1983, to February, 1984.

Table 1

Standard deviations (σ) of the zonal wind component for various stations in winter.

H km	Barrow (71°N)	Churchill (59°N)
50	24.6	28.2
60	24.9	24.2
70	36.5	42.2
80	46.8	45.7
90	55.1	57.2

During the period of MAP/WINE, northerly winds of about 40 to 60 mps were observed above 60 km over Heiss Island. The zonal component in high latitudes, above 60 km, was more variable. Westerly winds changed several times into easterlies in the mesosphere and lower thermosphere, mainly due to the migration of the center of the "circumpolar cyclone" (Figs. 4 and 5).

In middle latitudes (Volgograd) easterly winds at lower mesospheric levels were recorded only during warmings accompanied by circulation reversals while in the upper mesosphere (above 70 km) and lower thermosphere they were frequently observed (Fig. 6).

It is possible that easterly winds in the upper mesosphere and lower thermosphere testify to the fact that the height of the winter strato-mesospheric cyclone in middle latitudes is less than in polar latitudes, and in some periods the upper boundary of the winter circumpolar vortex occurs at altitudes exceeding 70 km (Fig. 7).

Mean values of zonal wind in the geostrophic approximation as a function of latitude (ψ) and longitude (λ) and their zonal mean values for January in the middle mesosphere (0.1 hPa ~ 60-64 km) based on rocketsonde and satellite data and in the lower thermosphere (0.001 hPa ~ 90-95 km) based on rocketsonde, satellite, meteor trail and ionospheric observations are presented in Table 2.

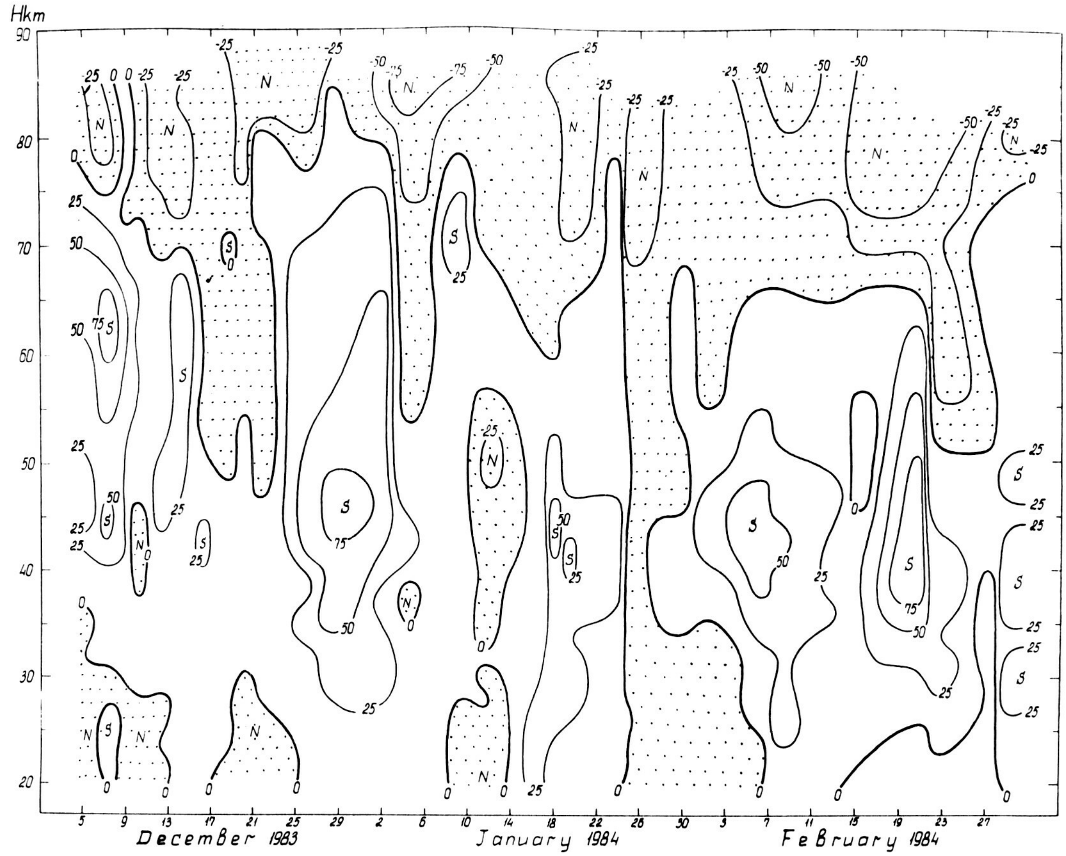

Fig. 4 Time-altitude section of meridional wind component (mps) over Heiss Island for the period of December 1983, - February 1984.

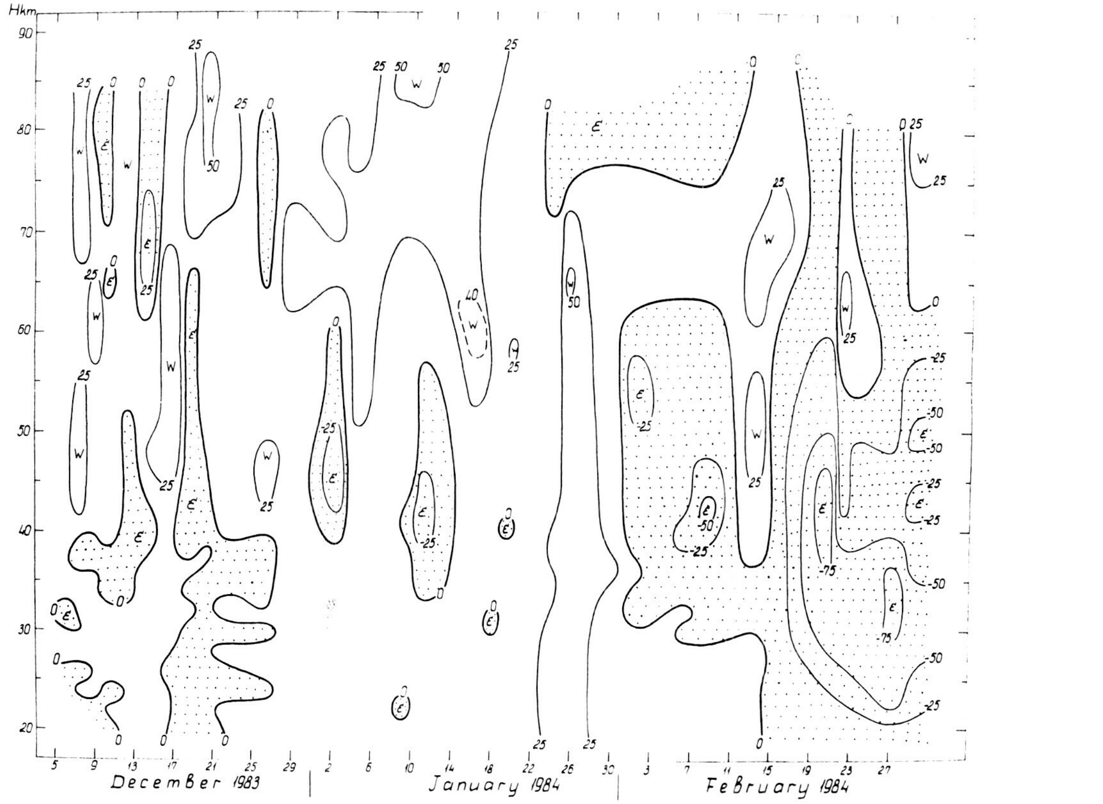

Fig. 5 Time-altitude section of zonal wind component (mps) over Heiss Island for the period of December 1983 - February 1984.

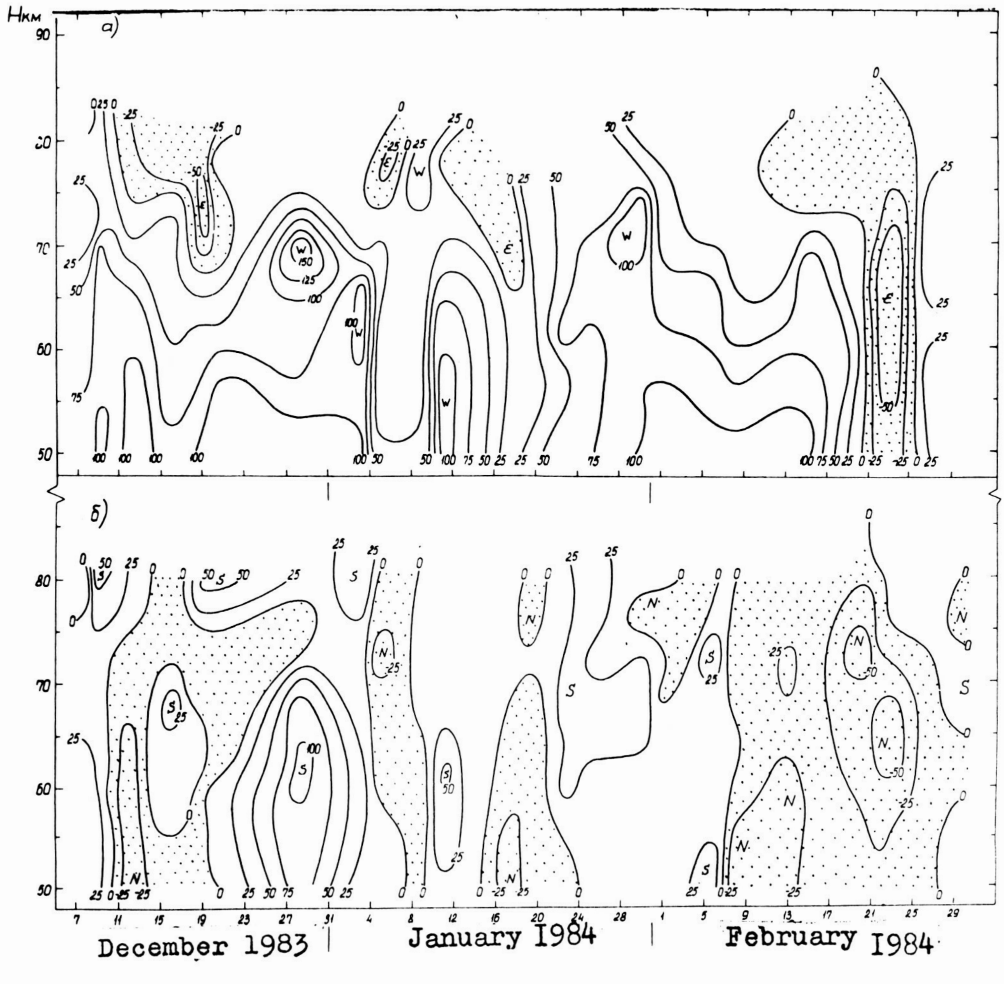

Fig. 6 Time-altitude section of zonal (a) and meridional (b) wind components (mps) over Volgograd station for the period of December 1983 - February 1984.

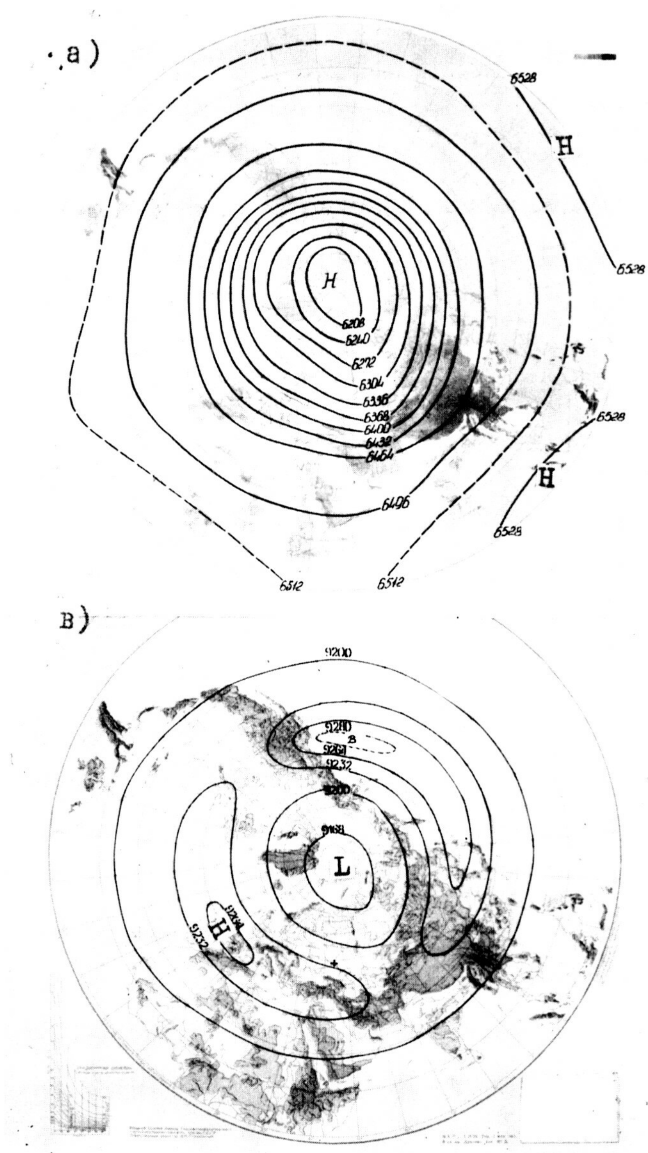

Fig. 7 Mean constant pressure chart at 0.01 hPa (a) and at 0.001 hPa (b) for January.

Table 2.

Mean values of zonal wind component (mps) over the European region, zonally averaged values of zonal wind and model values (CIRA 1972) at two constant-pressure levels and three latitudes.

AT	ψN	λE							$\bar{U}$	CIRA-72
		0	10	20	30	40	50	60		
0.1hPa	70	27	32	32	33	33	34	34	44	19
	60	42	40	39	37	35	35	32	45	54
	50	42	40	42	42	45	45	40	59	58
0.001hPa	70	10	10	10	9	7	6	5	10	--
	60	15	14	12	12	10	10	9	15	--
	50	18	18	17	16	16	14	14	19	15

References

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