TEMPORAL AND SPATIAL CHANGES OF CLIMATE ELEMENTS IN HUNGARY

TEMPERATURE

- **Climatological studies, 3rd century BC:**
  - Ceremony Reports; (phenological observations)
  - Book of Zhou-dinasty;
  - Book of Huaj Nan-Tzu;
  - **Spring and autumn yearbooks of Lu;** (agricultural calendar) → 1 year = 12 moon months = 24 chi (two-weekly period); prepared specifically for provinces of Honan and Shanxi;

- **Climatological studies, 2nd-3rd century AD (Han-dinasty)**
  - Reports on Folk traditions and customs;
  - Notes on spaces and rooms;
  - **The first description on monsoon climate** (East-China: non-trpoical monsoon)

Spring and autumn yearbooks of Lu – 24 chi

Serial no.	Chinese name	English equivalent	Starting time
1.	Li Chun	Beginning of spring	Feb 4-5.
2.	Jü Suj	Spring rains	Feb 19-20.
3.	Ching Chö	Awakening of insects	Mar 6-7.
4.	Chun Fen	Spring equinox	Mar 21-22.
5.	Ching Ming	Clear and bright (sunshien and clear skies)	Apr 5-6.
6.	Ku Jü	Dust-rain (April spring)	Apr 20-21.
7.	Li Hsia	Beginning of summer	May 6-7.
8.	Hsaio Man	Grain is swelling	May 21-22.
9.	Mang Chung	Leaping to spike	Jun 6-7.
10.	Hsiao Chö	Summer solstice	Jun 21-22.
11.	Hsiao Zhö	Less warm	Jul 7-8.
12.	Ta zhö	Heat wave	Jul 23-24.
13.	Li Chiu	Beginning of autumn	Aug 8-9.
14.	Chu Zhö	End of the heat	Aug 23-24.
15.	Paj Lu	White dew (hoar)	Sep 8-9.
16.	Chiu Fen	Autumn equinox	Sep 23-24.
17.	Han Lu	Cold dew (rime)	Oct 8-9.
18.	Suang Chiang	freeze	Oct 24.
19.	Li Tung	Beginning of winter	Nov 7-8.
20.	Hsiao Hsüe	kisebb havazás (hószállingózás)	Nov 22-23.
21.	Ta Hsüe	Heavy snowfall	Dec 7-8.
22.	Tung Chö	Winter solstice	Dec 23-24.
23.	Hsia Han	Less cold	Jan 5-6.
24.	Ta Han	Very cold	Jan 20-21.

SOIL TEMPERATURE

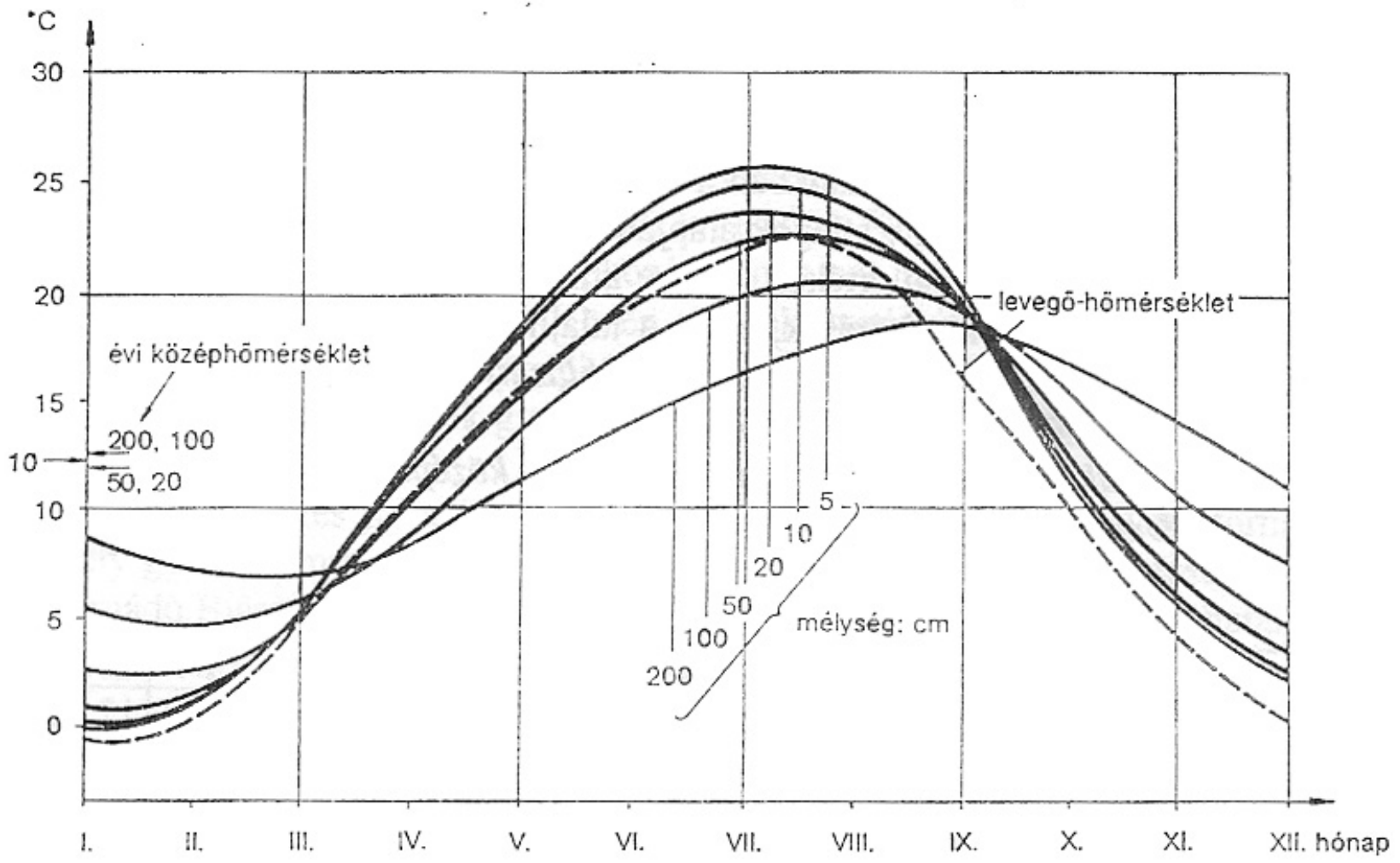
- The importance of soil in influencing air temperature is decisive: long-wave radiation of the warming soil that absorbs solar radiation heats the air as well.
- Soil temperature can only be mapped on microclimatic level, since it is too patchy. Regional differences happen in accordance with the variety of the soil types.
- Temporal dynamics of the soil temperature is the same in different areas of the country.
- Daily course of the temperature can be detected only at the top 1 m soil level.

- On the surface, the maximum is at 14 o'clock, while the minimum is at dawn. The maximum may exceed even the air temperature.
- The daily pendulum at 50 cm depth is <1°C, while at 1 m it is much smaller.
- The maximum at 50 cm depth occurs in the evening, while the minimum at noon, due to the slow heat transfer of the soil.
- In the annual course of the soil temperature there is a substantial difference between the topsoil (0-50 cm) and the deeper soil levels.
- In the topsoil the maximum temperature occurs in July, while the minimum in February; the phase leg is minimal.
- In the level of 100-200 cm, the maximum temperature happens in August. The minimum temperature at 100 cm occurs in February, while at 200 cm in March. The shift in this latter case reaches ~1 month.

Mean monthly and annual averages of the soil temperature (°C), Debrecen, 1952-1960

cm	J.	F.	M.	Á.	M.	J.	J.	A.	Sz.	O.	N.	D.	Év
5	0,2	0,1	5,0	12,5	19,5	24,2	26,7	24,9	19,1	11,5	5,5	2,3	12,6
10	0,5	0,0	4,6	11,9	18,5	23,6	25,7	24,4	19,0	11,7	5,9	2,5	12,4
20	1,2	0,8	5,0	11,5	17,7	22,8	24,3	23,2	18,5	11,9	6,1	3,0	12,2
50	2,1	1,4	4,3	10,3	15,8	20,0	22,3	22,1	19,0	12,9	7,8	4,1	11,8
100	4,6	3,6	5,0	9,5	14,2	17,9	20,4	20,7	18,8	14,4	10,2	6,5	12,1
200	7,1	5,9	5,8	8,5	12,1	14,9	17,4	18,4	17,9	15,4	12,5	9,3	12,1

- In africultural / ecological point of view, the heat storage of the soil is important. Due to its heat content, the soil slowly but effectively compensates autumn cooling.
- From August to March, each soil layer is warmer than the air.
- From March the subsoil is significantly colder, while the topsoil gets warmer than the air.



Mean annual course of the soil temperature in different depths, sand soil, Kecskemét

Daily course of warming of different soil types :

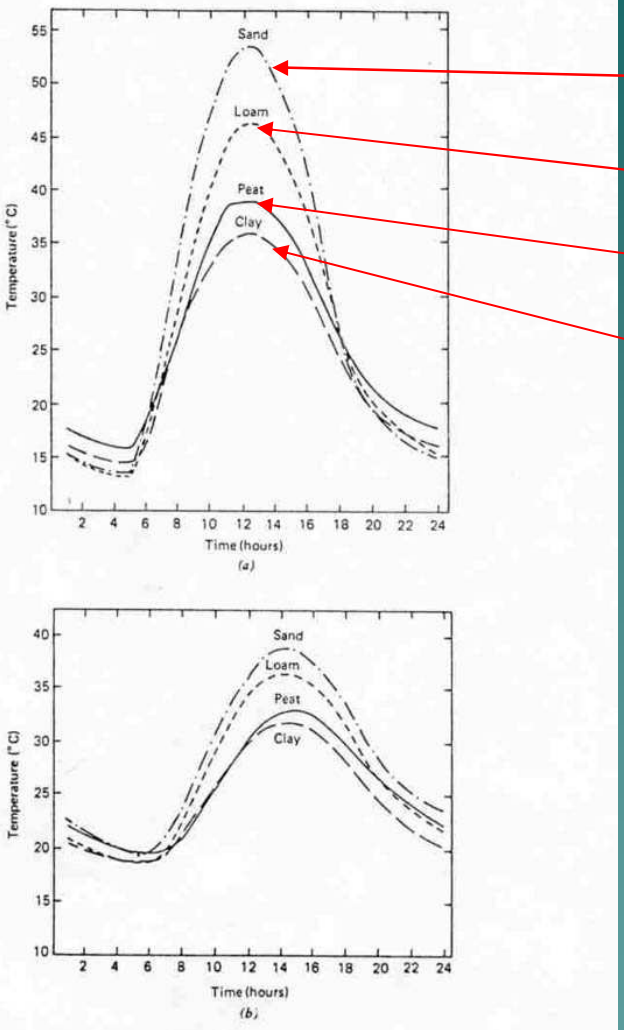


Fig. 2.6 Daily course of temperature (*a*) at the surface and (*b*) at a depth of 50 mm on clear summer days at Sapporo, Japan (after Yakuwa, 1946).

From: Rosenberg et al. (1983)

sand

loess

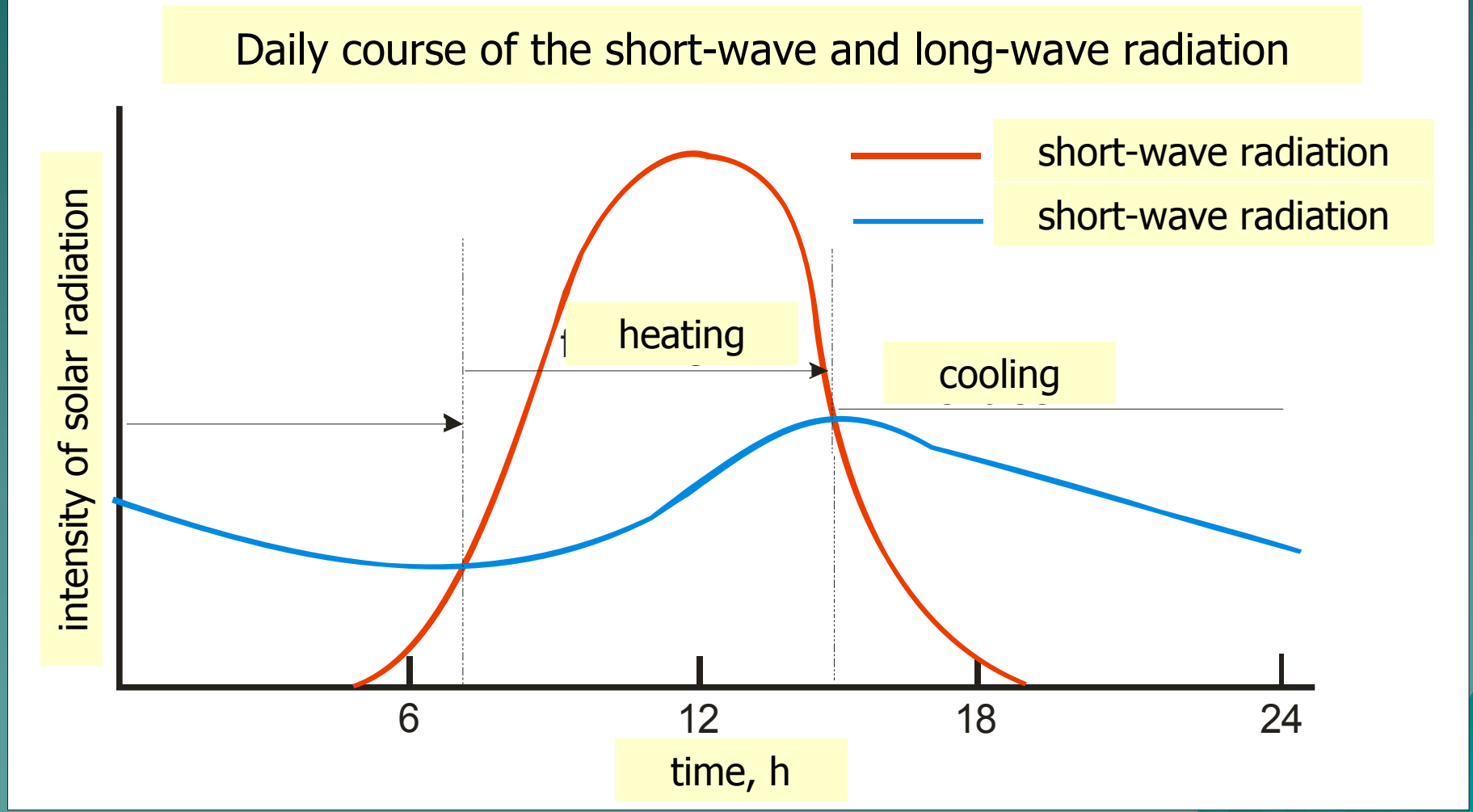
peat

clay

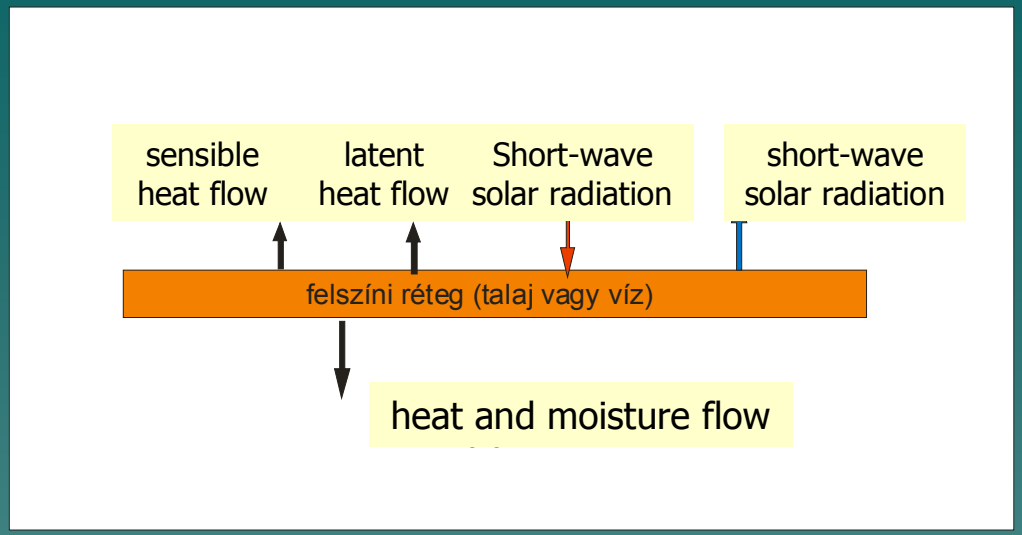
In case of equal weight, warming depends on heat capacity (density * specific heat)

The temperature difference between the surface and the layer deeper by 5 cm depends on the heat-conductivity. The larger the difference, the smaller the heat conductivity.

Daily course of the short-wave and long-wave radiation



Heat budget of the surface



$\Delta Q = c \cdot m \cdot \Delta T$

Specific heat

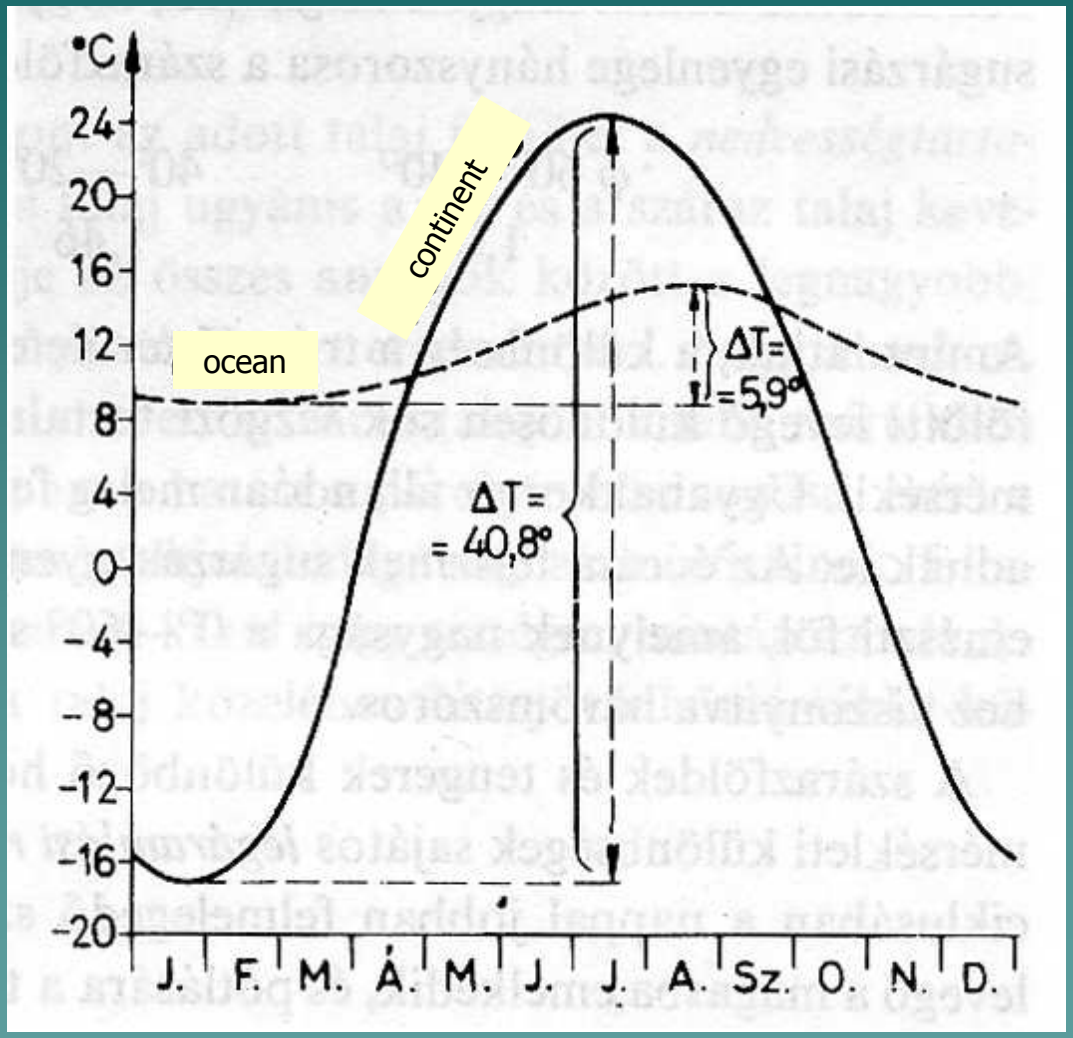
Heat capacity

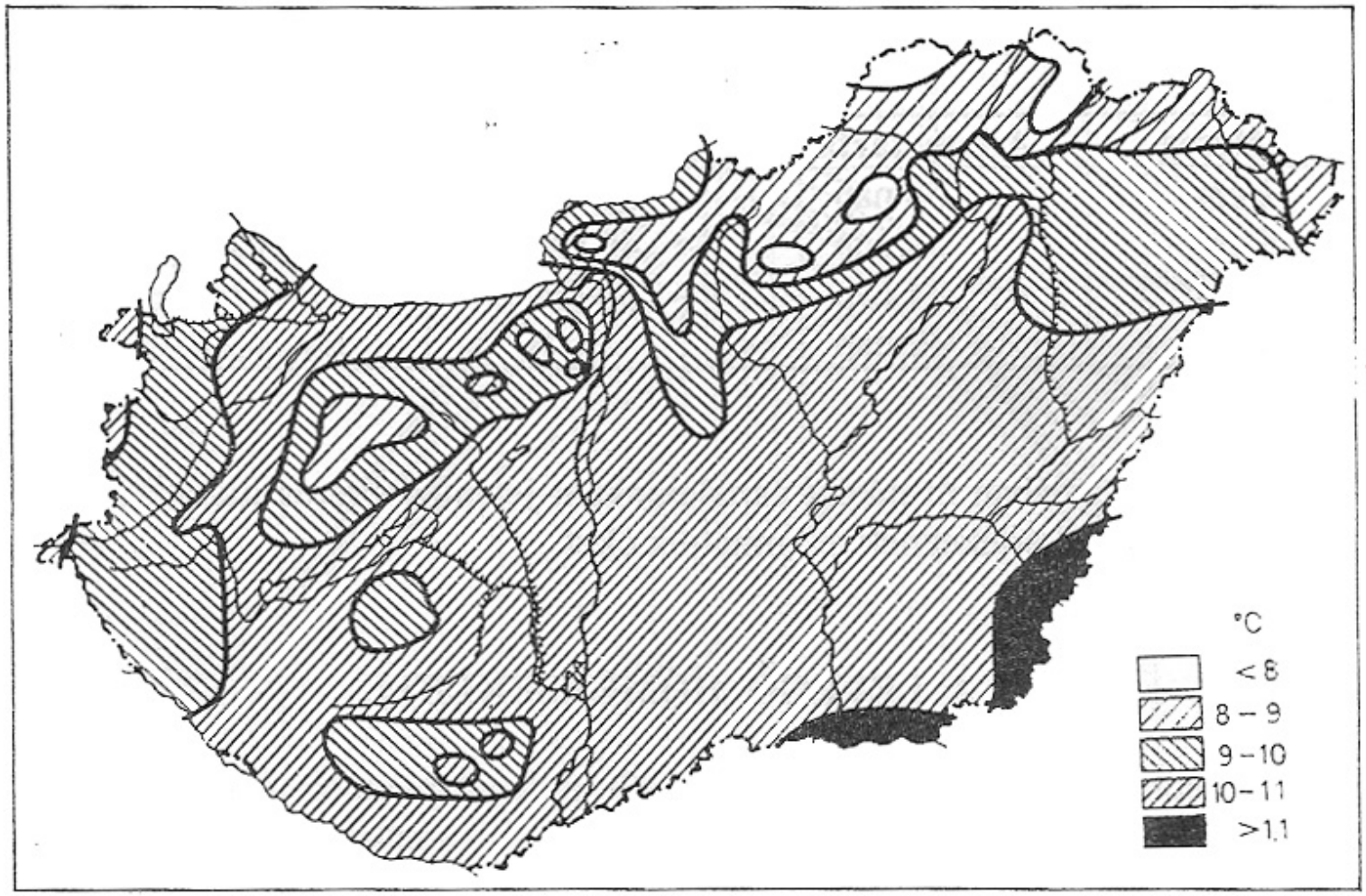
material	heat conductivity (J/m/K/s)	density (kg/m^3)	specific heat (J/kg/K)
granite	4.61	2600	837
water	0.63	1000	4187
ice	2.30	900	2135
fresh snow	0.08	100	2135
old snow	0.29	400	2135
wet sand	1.68	1600	1250
dry sand	0.17	1400	837
humusz	1.26	1300	1834
wet meadow soil	0.84	1500	3350
dry meadow soil	0.06	1500	1834
air	0.02	1,3	1005

AIR TEMPERATURE

- Air temperature is one of the most basic and most important climatic elements.
- Its actual value assumes the complexity of radiation and surface effects. It characterizes the heat balance.
- Its value is of basic importance in agricultural, ecological and human bioclimatological points of view.

Annnual curse of air temperature over continents and ocenas:

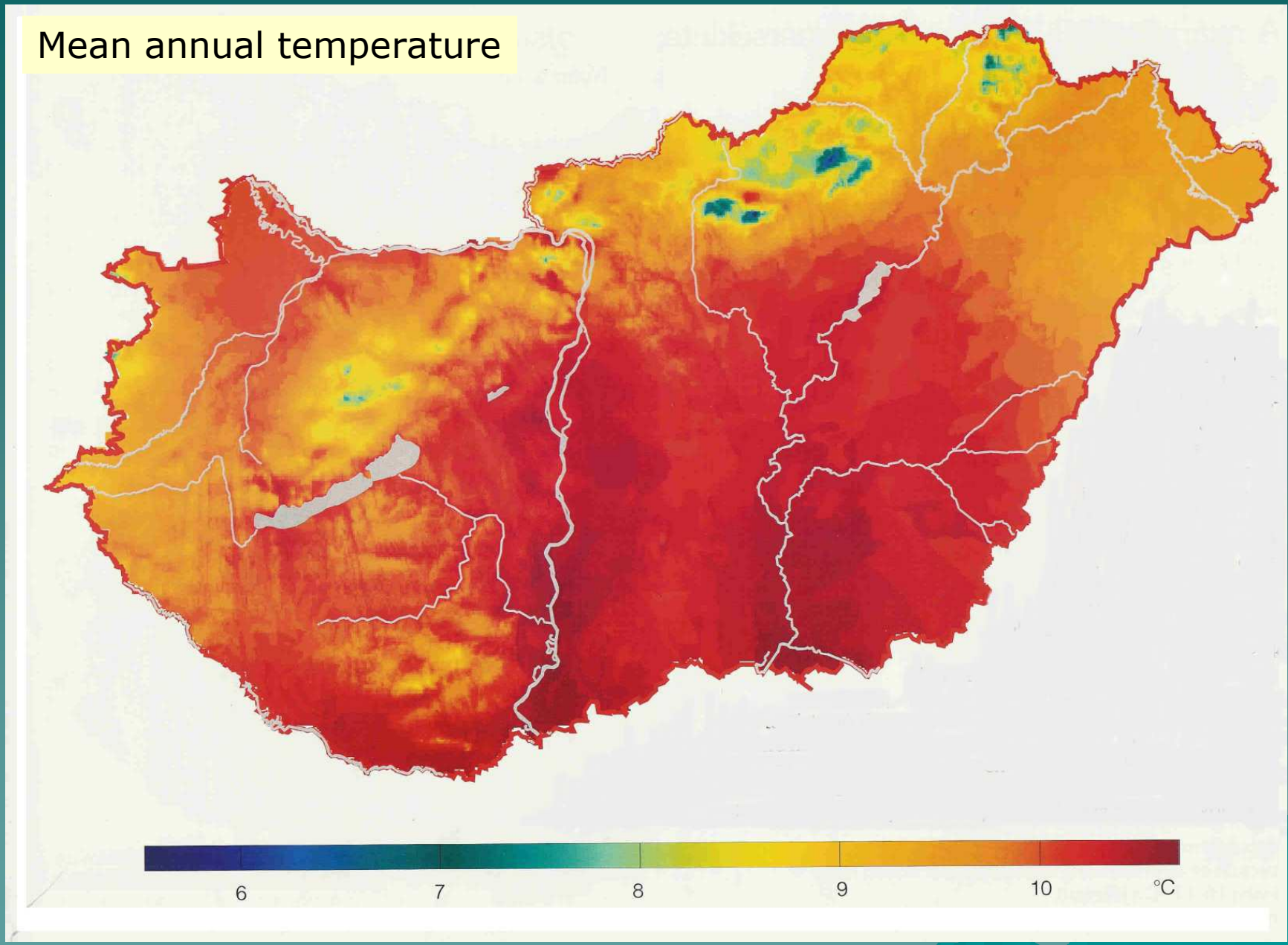




Areal distribution of annual mean temperature (°C) in Hungary

- On the map of the mean annual temperature we can establish that a 3° N-S range corresponds to around 3°C difference in mean annual temperature.
- The isotherms show no regular N-S arrangement: medium-range mountains in Hungary appear as cold islands with their 6-7°C (Kékes, 5°C) mean annual temperatures.
- Warmest is the Soth-east Alföld (>11°C).
- Until 200 m height above sea level 10-11°C is characteristic for the major area of Hungary. Exceptions are: Nyírség, Szatmár-Bereg, Bodrogköz.
- In the mean annual temperature even a 6°C difference may also occur from one year to another; hence this climate element has a great variability.

Mean annual temperature



Distribution of mean monthly temperature in the Carpathian basin:

$$t = A \cdot \varphi + B \cdot \lambda + C \cdot z + D$$

	J.	F.	M.	Á.	M.	J.	J.	A.	Sz.	O.	N.	D.
A	−0,60	−0,45	−0,74	−0,82	−0,69	−0,77	−0,90	−0,86	−0,80	−0,76	−0,66	−0,41
B	−0,27	−0,14	−0,06	0,08	0,12	0,12	0,09	0,09	0,06	0,04	−0,04	−0,17
C	−0,24	−0,37	−0,56	−0,63	−0,66	−0,65	−0,63	−0,61	−0,55	−0,46	−0,42	−0,31
D	31,9	24,3	41,9	48,4	46,8	53,6	62,3	59,7	53,3	46,2	37,2	23,4

Mean annual temperature pendulum:

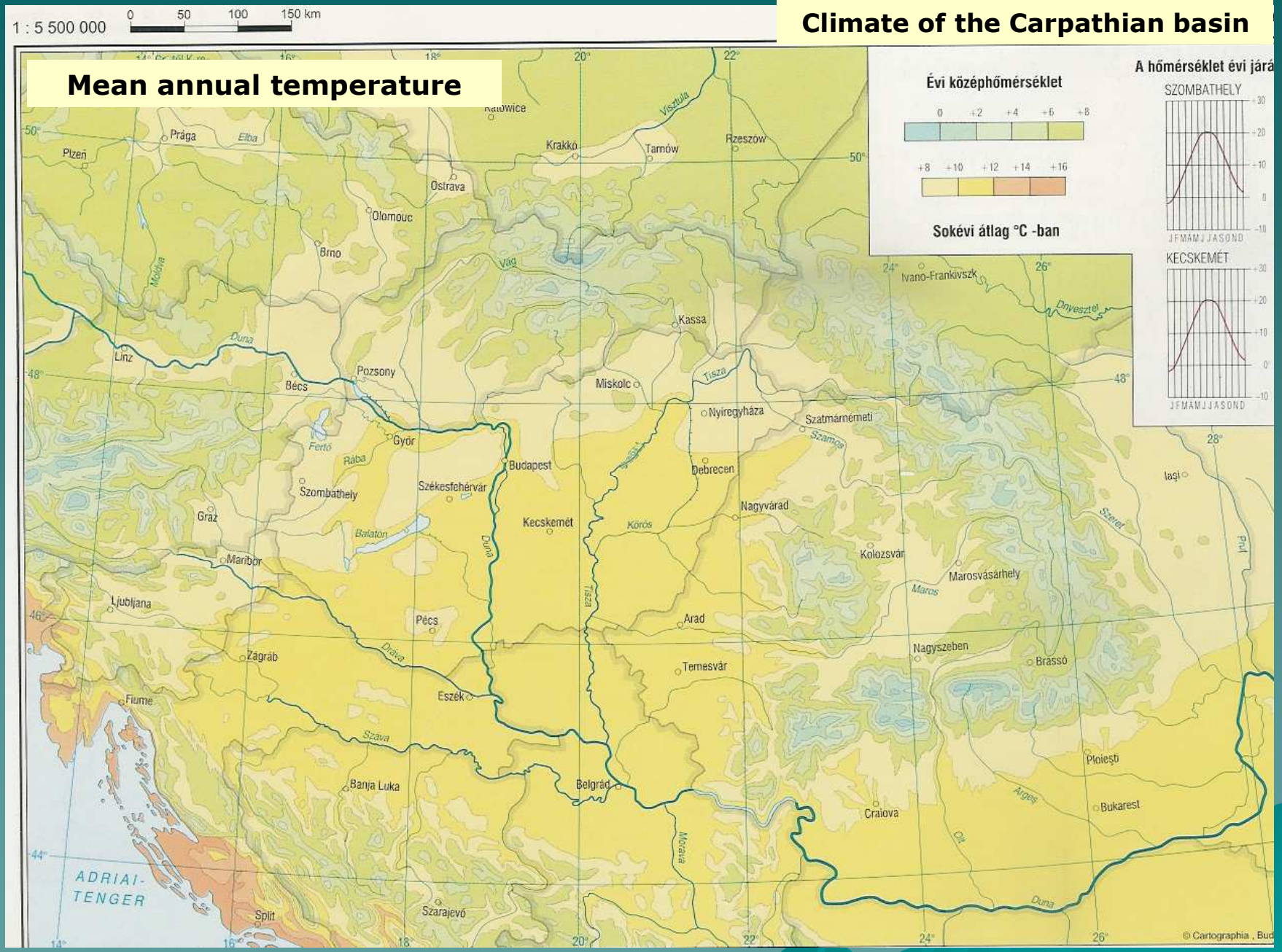
$$t = (A_{Jul} - A_{Jan}) \cdot \varphi + (B_{Jul} - B_{Jan}) \cdot \lambda + (C_{Jul} - C_{Jan}) \cdot z + (D_{Jul} - D_{Jan})$$

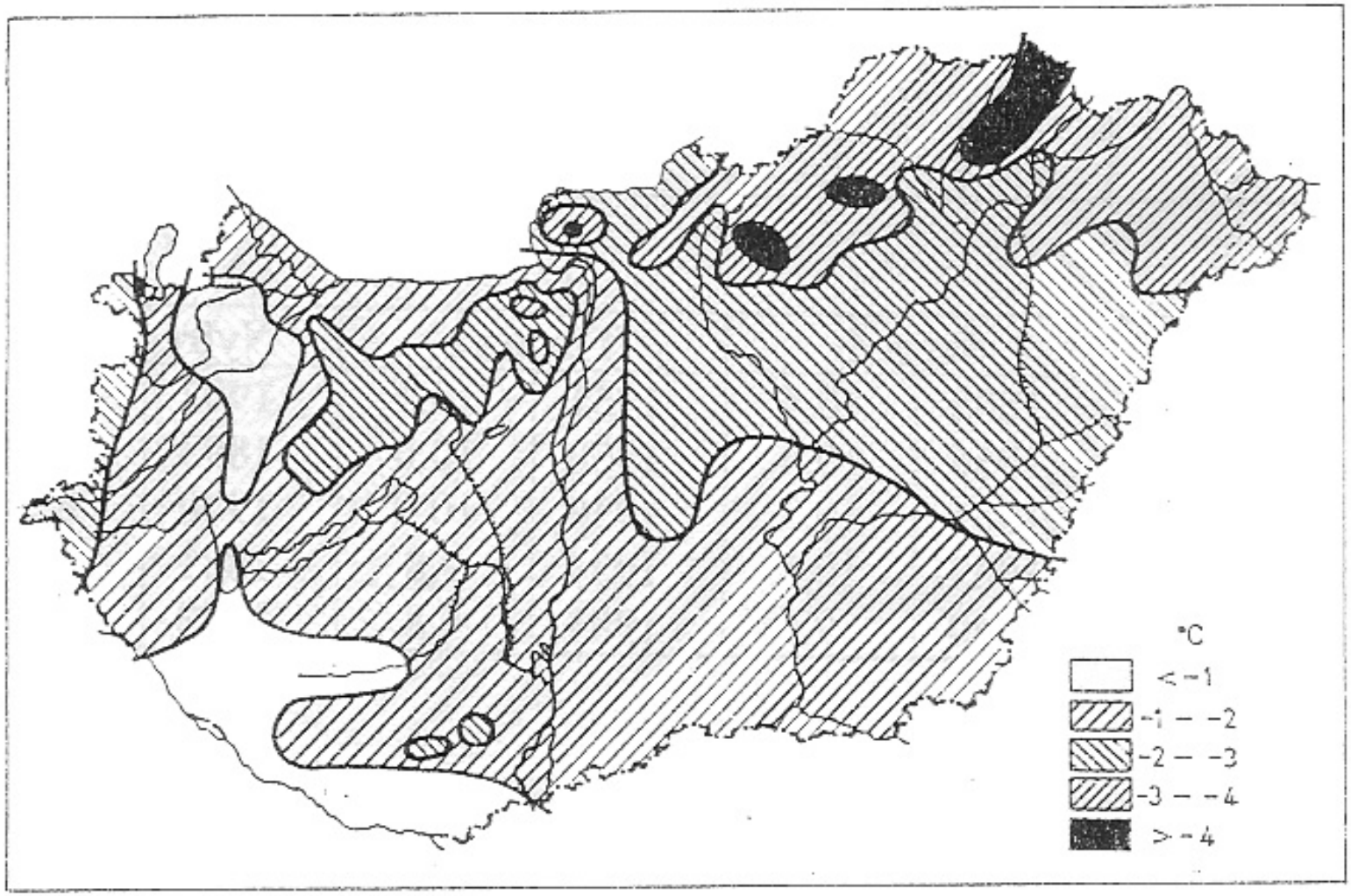
The weight of the continental and oceanic influences in the distribution of temperature:

	Tél			Nyár		
	+	winter	A	+	summer	A
Magyaróvár	54 %	46 %	0,08	48 %	52 %	−0,04
Budapest	54 %	44 %	0,11	48 %	52 %	−0,04
Szeged	57 %	43 %	0,15	46 %	54 %	−0,08
Nyíregyháza	56 %	44 %	0,11	47 %	53 %	−0,05

Climate of the Carpathian basin

Mean annual temperature

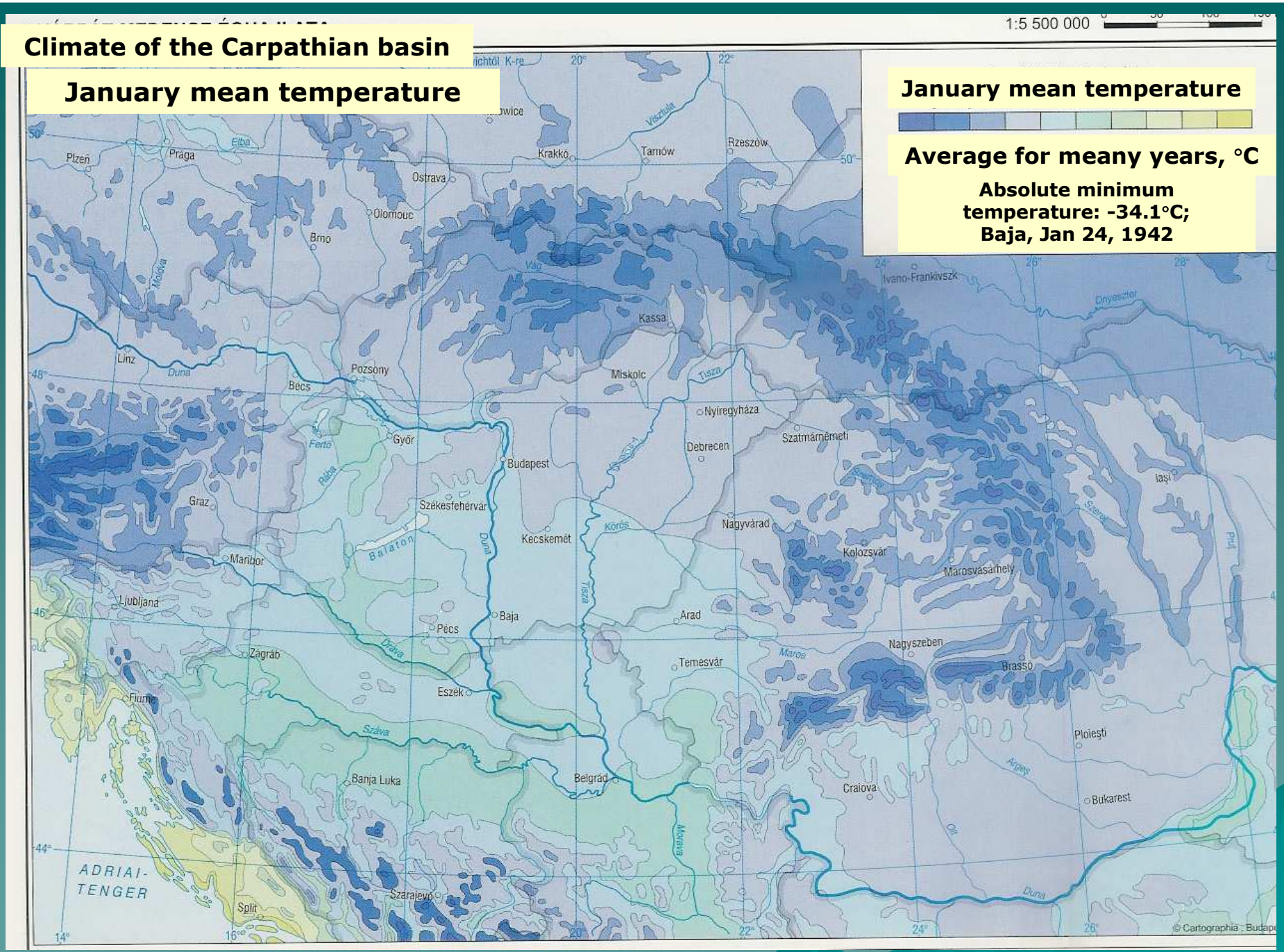




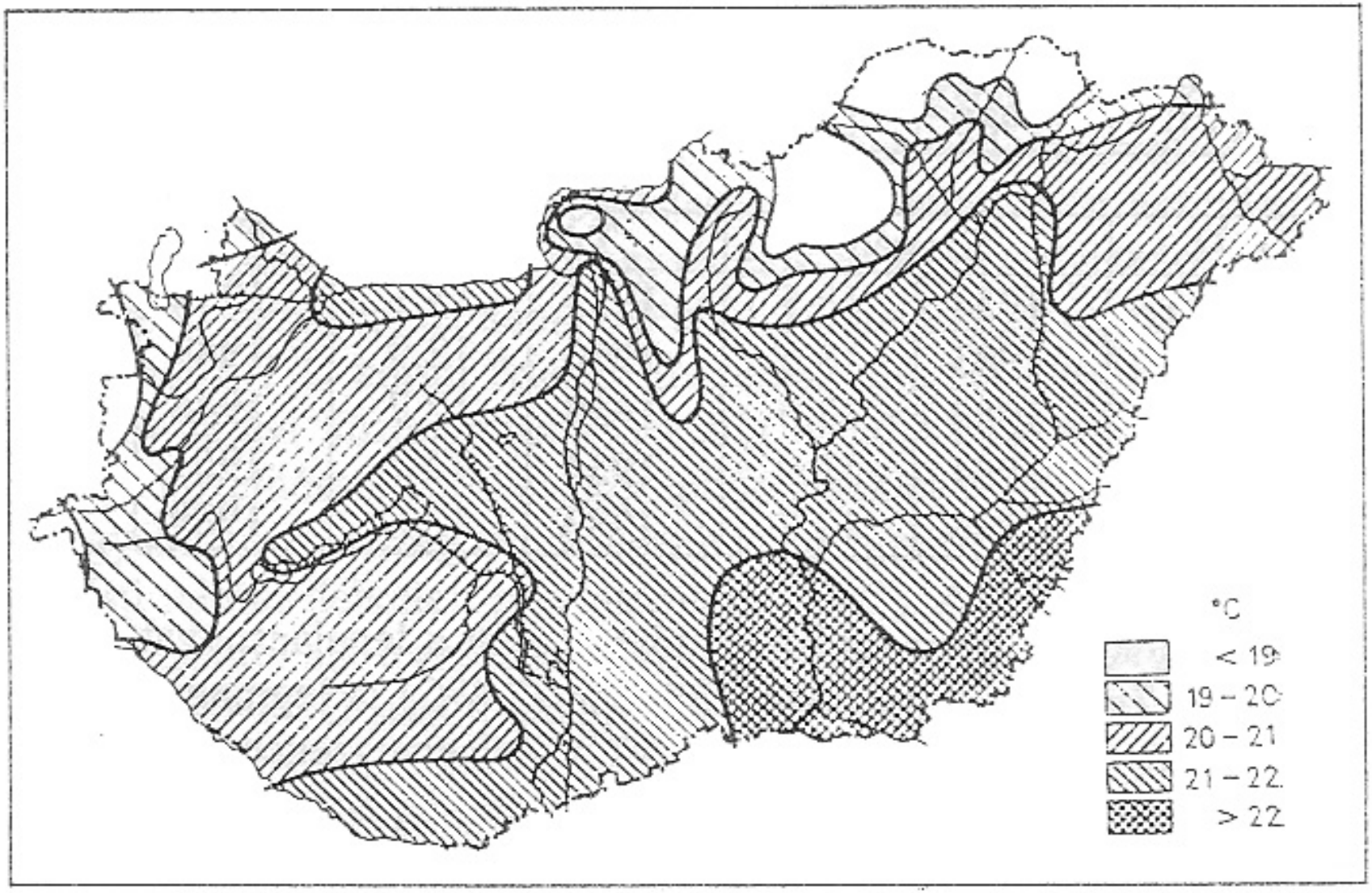
Areal distribution of the January mean temperature (°C) in Hungary

Climate of the Carpathian basin

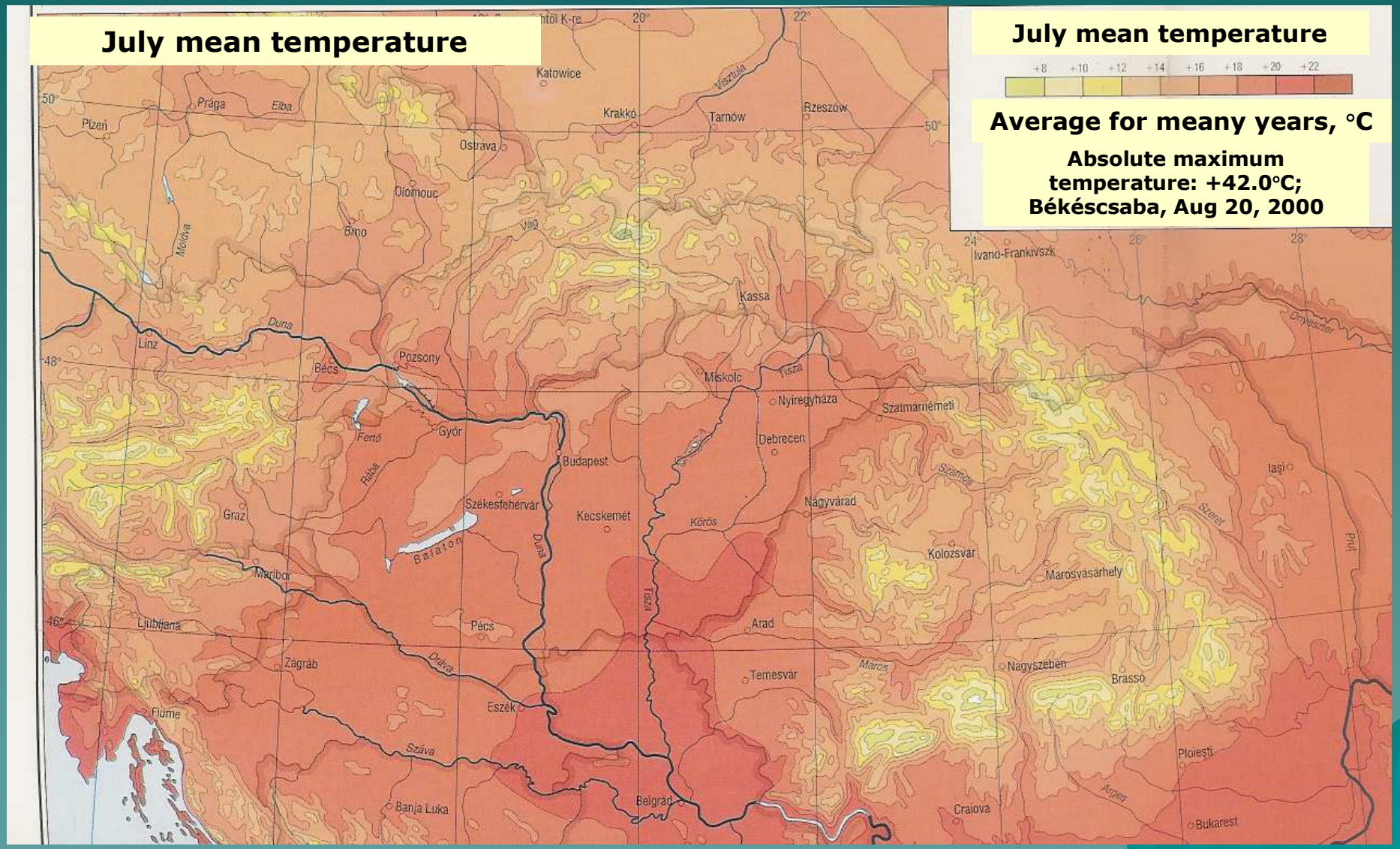
January mean temperature



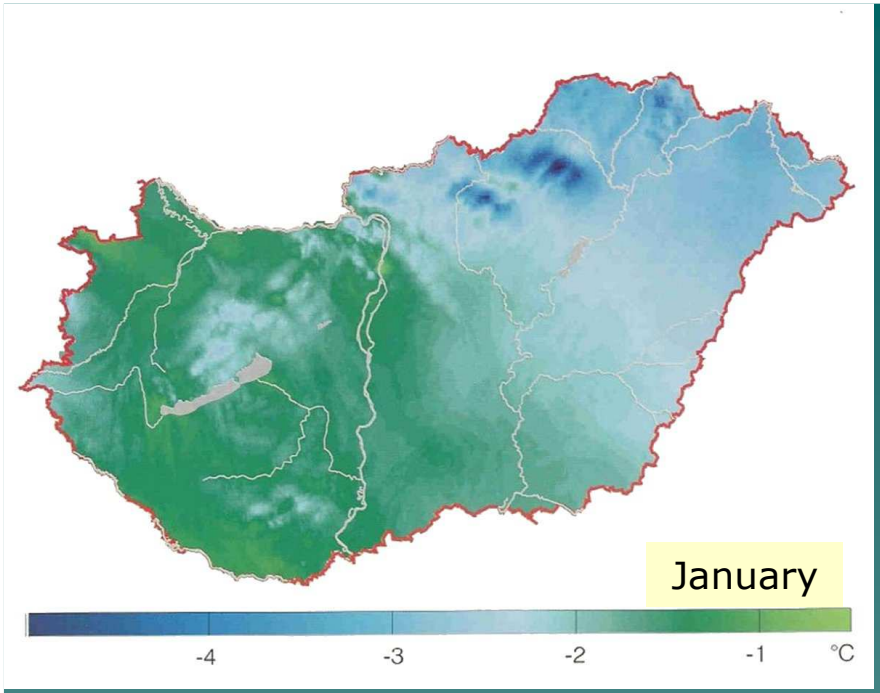
- Winter and summer half-year temperatures show substantial differences.
- *Coldest month in Hungary is January*. Its mean temperature is between -4°C and 0°C on average.
- Temperature is most influenced by the nearby air prressure action centres.
- *Coldest area is NE-Alföld* (Siberian maximum).
- *For the area of Nyírség, the proximity of Kárpátalja region is an important aspect, while for Szatmár-Beregi Plain, and Takta- and Bodrogköz areas are so called „freeze corners"*.
- *Mildest area is SW-Dunántúl* (Genoa cyclones).
- The mean temperature in January is between -9 and -11°C, as well as between +5 and +6°C, where the extreme values are characteristics mean temperatures of Finland and the Italian Riviera.

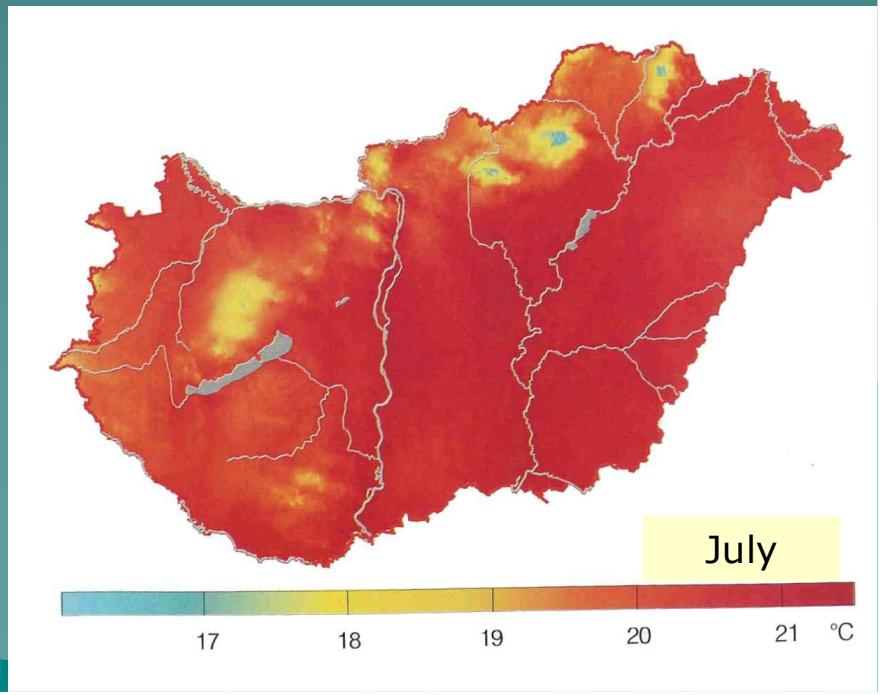


Areal distribution of the July mean temperature (°C) in Hungary

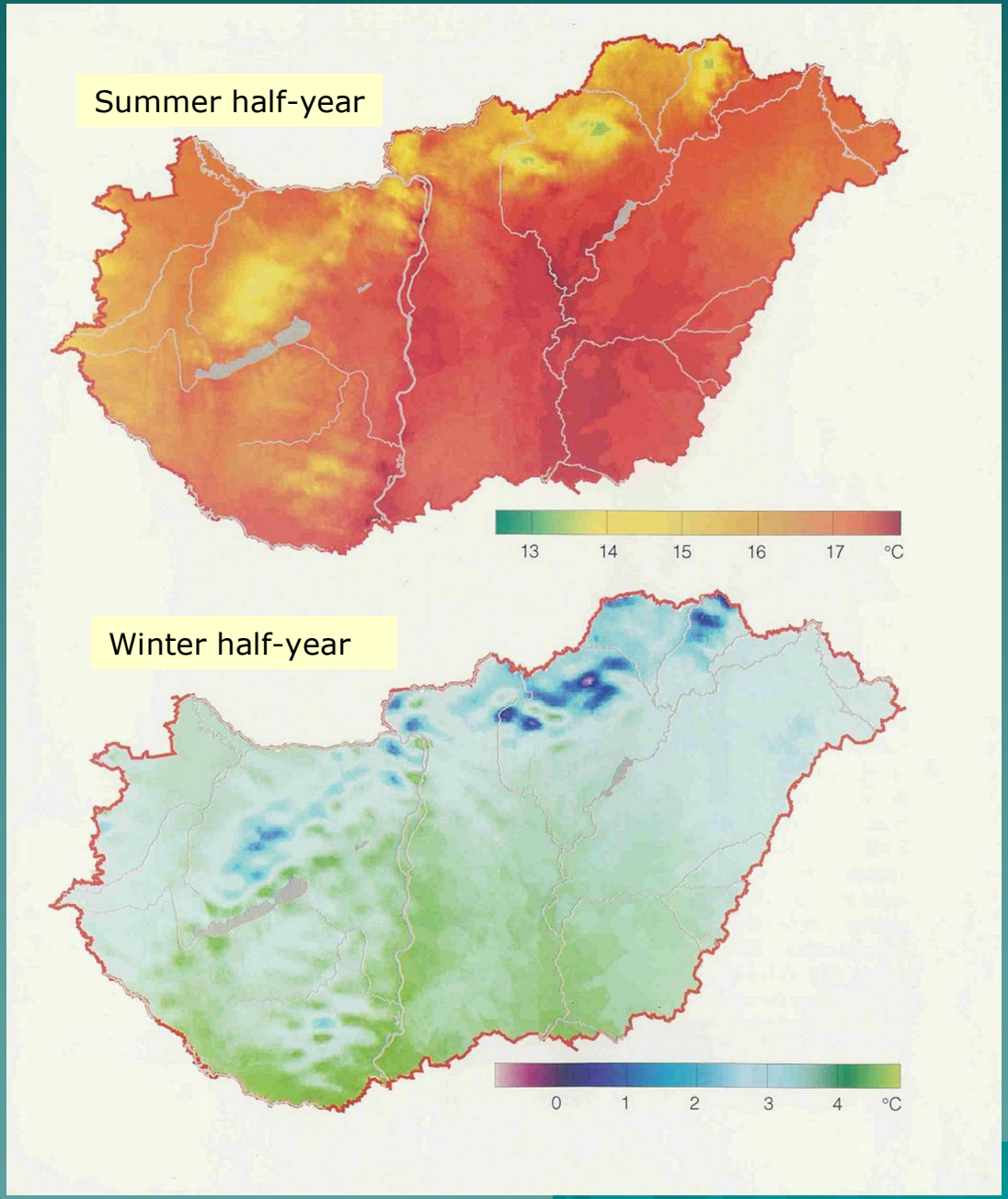

July mean temperature
July mean temperature
+8 +10 +12 +14 +16 +18 +20 +22
Average for meany years, °C
Absolute maximum temperature: +42.0°C; Békéscsaba, Aug 20, 2000
Katowice
Visztula
Krakkó
Tarnów
Rzeszów
Ostrava
Plzeň
Praga
Elba
Olomouc
Brno
Morva
Vág
Ivano-Frankivszk
Kassa
Dnyeszter
Linz
Duna
Pozsony
Bécs
Miskolc
Tisza
Nyiregyháza
Szatmárnémeti
Fertő
Győr
Debrecen
Budapest
Rába
Iasi
Székesfehérvár
Kecskemét
Szamos
Nagyvárad
Graz
Körös
Szeret
Balaton
Kolozsvár
Prut
Maribor
Marosvásárhely
Ljubljana
Pécs
Arad
Zagráb
Drava
Temesvár
Maros
Nagyszeben
Brassó
Fiume
Eszék
Száva
Ploiești
Argeș
Banja Luka
Belgrád
Craiova
Bukarest

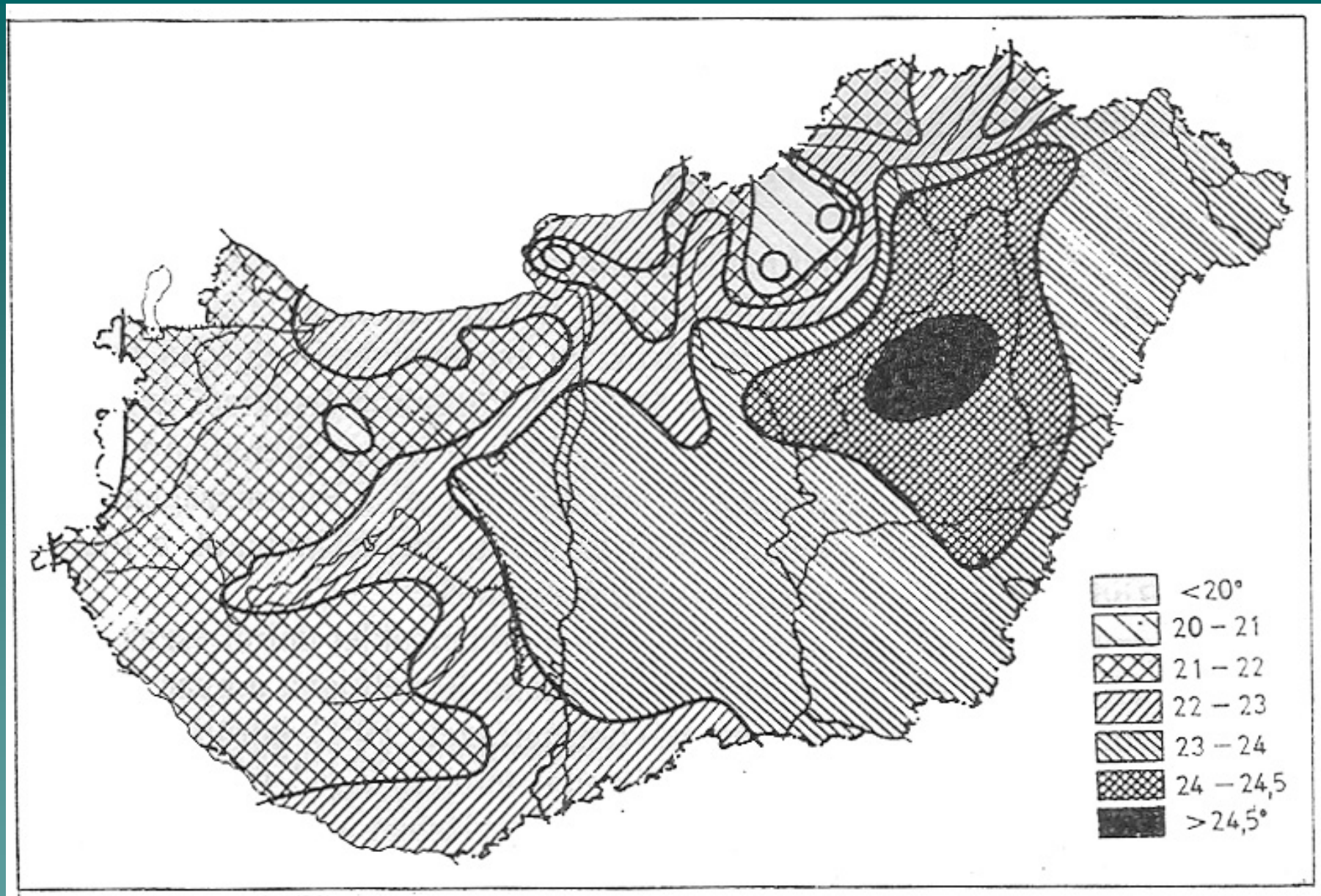
- The hottest month in Hungary is July.
- Mean July temperature increases from 19°C to above 22°C from south to north, and from south to east and west to east.
- In Dunántúl area rather the change from west to east is characteristics, due to the oceanic-continental transition.
- In Alföld, concentric isotherms occur resulting from the basin character.
- This is the result of the cool oceanic air currents coming from north-west (Icelandic minimum – cool and rainy summer) and the warm continental and Mediterranean air currents coming from south-east (Azores maximum – hot, dry summer).


January
-4
-3
-2
-1
°C


July
17
18
19
20
21
°C

Mean temperature of the winter- and summer half-year





Mean annual temperature pendulum (°C) in Hungary

- Mean annual temperature pendulum is an important feature of a given climate area. This means the mean temperature difference between January and July.
- The extent of pendulum increases with the increasing effect of pendulum, namely it is suitable for expressding the degree of continentality.
- Its value increases parallel with the increasing continentality and towards the centre of the basin.
- Is minimum occurs at SW-Dunántúl area with 21°C-22°C.
- Its value at the most part of Alföld and the Mezőföld area is 23°C-24°C.
- Its maximum happens at the area of Nagykunság-Hortobágy with 24.5°C.
- In the mountainous areas, with increasing height, the pendulum decreases. At the height of 5-600 m its value is 20-21°C, while above 700 m height it is less than 20°C.

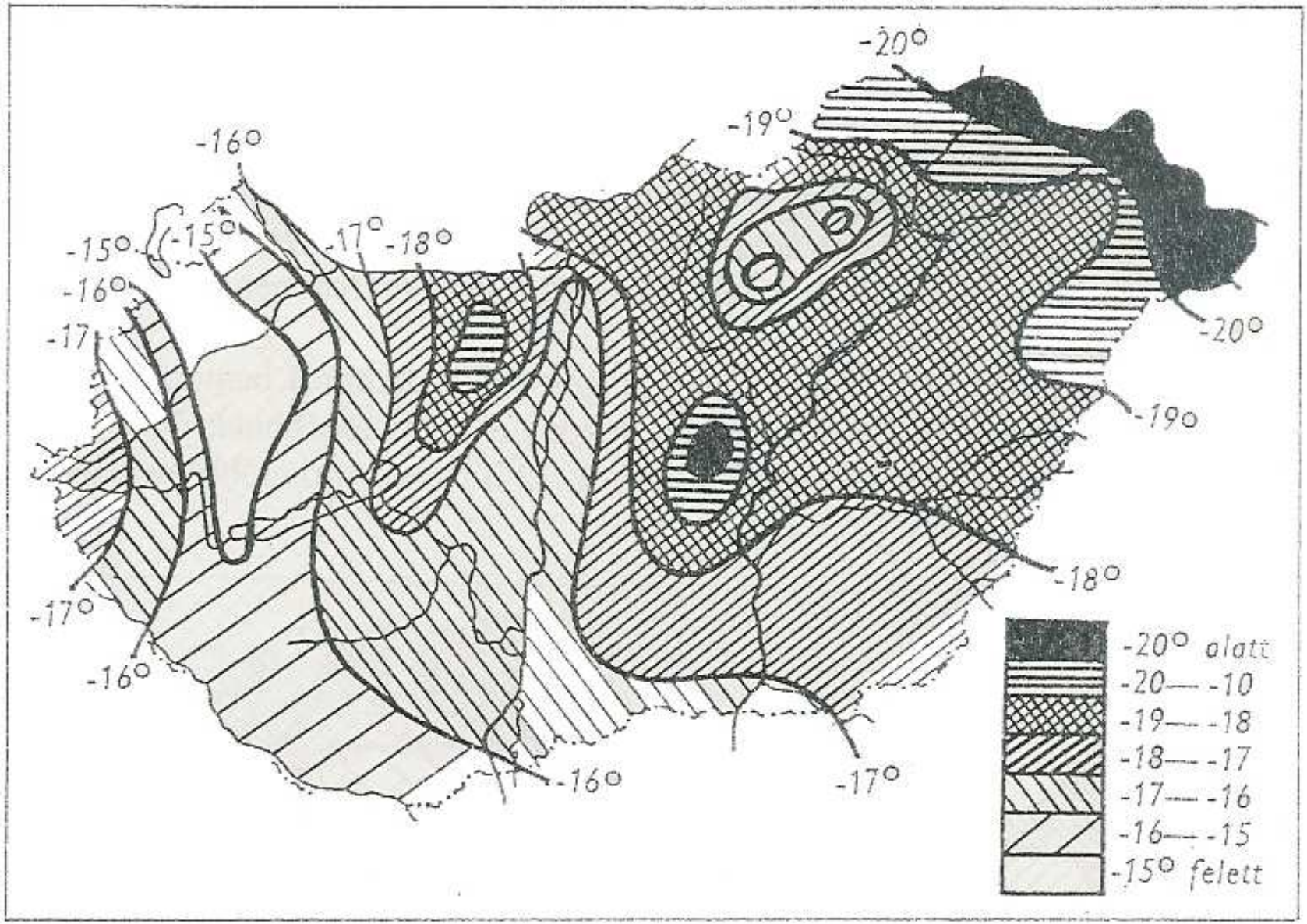
- Mean daily pendulum of temeparture is also an important parameter.
- *Its minimum value occurs in the short-day cloudy December* (4-6°C).
- *Its highest value happens in the long-day summer months* (11-13°C).

Daily mean maximum (a) and minimum (b) air temperature and the daily mean pendulum, °C, 1901-1950

Állomás		J.	F.	M.	Á.	M.	J.	J.	A.	Sz.	O.	N.	D.
M. magyaróvár	a	1,1	3,5	9,6	15,4	20,8	23,6	25,9	25,3	21,2	14,6	7,5	2,9
	b	-1,2	-2,9	1,0	4,9	9,6	12,6	14,6	13,8	10,6	5,6	1,6	-2,0
	c	5,3	6,4	8,6	10,5	11,2	11,0	11,3	11,5	10,6	9,0	5,9	4,9
Pécs	a	2,2	4,9	11,2	16,6	21,7	24,9	27,5	27,1	23,0	16,5	9,2	4,3
	b	-3,8	-2,7	1,8	6,0	11,1	14,0	16,1	15,2	11,7	7,1	2,7	-1,2
	c	6,0	7,6	9,4	10,6	10,6	10,9	11,4	11,9	11,3	9,4	6,5	5,5
Budapest	a	1,7	4,4	10,8	16,5	22,4	25,6	27,9	27,4	23,1	16,1	8,1	3,4
	b	-3,2	-2,1	2,0	6,4	11,1	13,9	16,1	14,9	11,8	7,1	2,6	-0,8
	c	4,9	6,5	8,8	10,1	11,3	11,7	11,8	12,5	11,3	9,0	5,5	4,2
Szeged	a	1,7	4,1	10,9	16,7	22,4	25,3	28,0	27,0	22,7	16,8	9,0	3,9
	b	-4,4	-3,0	1,6	6,2	11,4	14,7	16,5	15,6	12,0	7,1	2,4	-1,0
	c	6,1	7,1	10,3	10,5	11,0	10,6	11,5	11,4	10,7	9,7	6,6	4,9
Nyíregyháza	a	0,1	2,6	9,6	16,0	22,0	25,0	27,2	26,3	22,2	15,6	7,8	2,4
	b	-6,0	-4,5	0,1	4,6	9,5	12,6	14,1	13,3	9,5	4,9	0,9	-3,0
	c	6,1	7,1	9,5	11,4	12,5	12,4	13,1	13,0	12,7	10,7	6,9	5,4
Kékestető	a	-2,3	-0,9	3,8	8,9	14,6	17,9	20,1	19,8	15,9	9,9	3,2	-0,3
	b	-6,8	-6,1	-2,7	1,9	6,6	9,8	12,2	11,3	8,3	3,3	-1,2	-4,3
	c	4,5	5,2	6,5	7,0	8,0	8,1	7,9	8,5	7,6	6,6	4,4	4,0

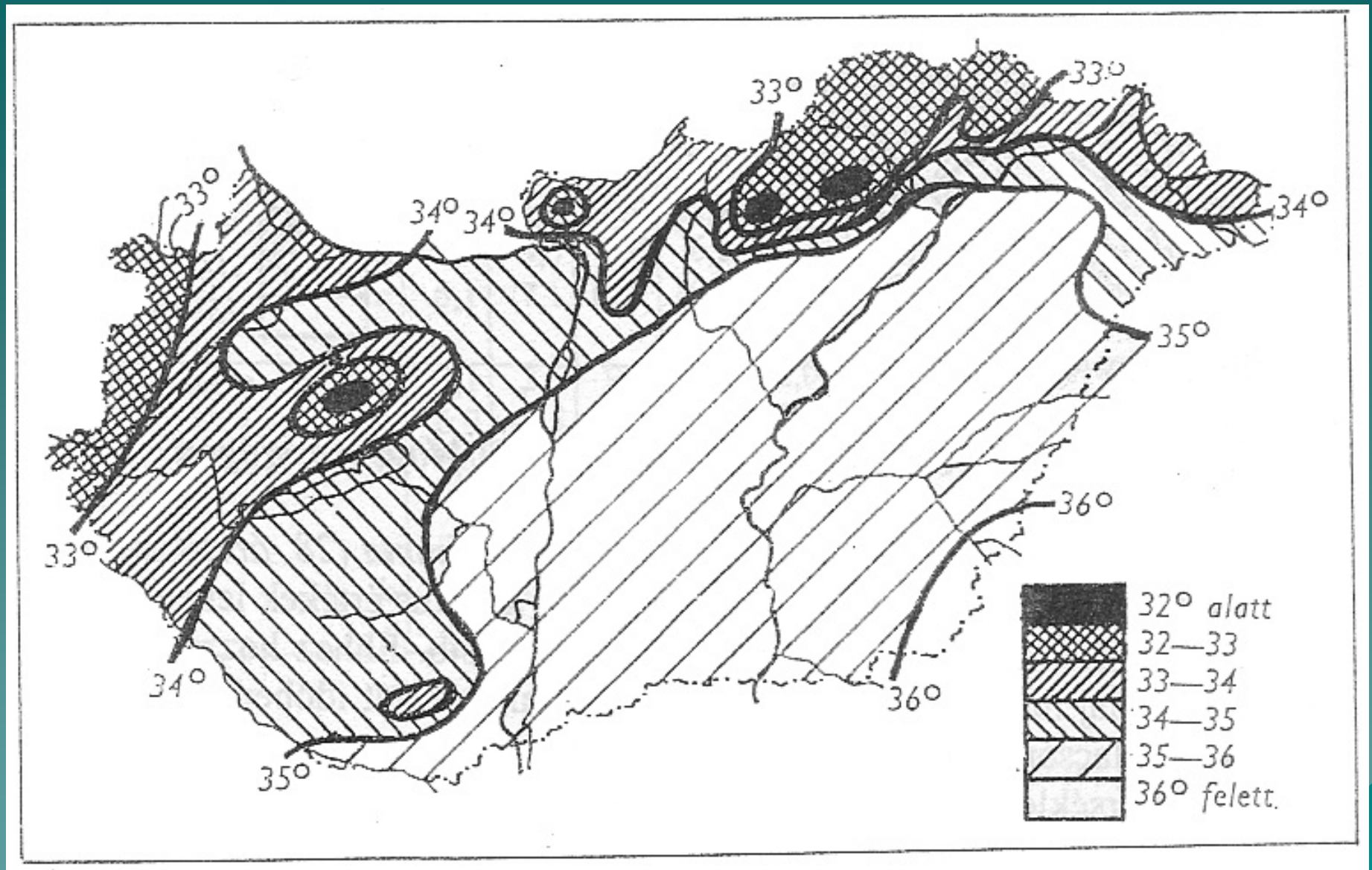
- Tenperature conditions of the mountainous regions in Hungary substantially differ from those of plain areas.
- The vertical temperature gradient, caharacterizing altitudinal changes of temperature, shows minor differences mountain by mountain, due to the different location and topography.
- Seasonal variations are greater, that occur due to the frequent inversion situations in the winter half-year.

Mountain	Winter	Spring	Summer	Autumn
Mátra	0,4	0,7	0,7	0,5°C/100m
Bükk	0,2	0,6	0,7	0,5°C/100m
Pilis	0,5	0,7	0,7	0,5°C/100m
Mecsek	0,5	0,5	0,7	0,5°C/100m



Mean annual minimum temperature (°C) in Hungary

- The mean annual minimum temperature isbetween *-15°C and -20°C*. The ground-level radiation minimum temperature may be smaller by 2-3 (in extreme cases by 4-5)°C compared to the standard values measured at 2 m height.
- This is an important parameter for agriculture, in terms of overwintering of the autumn sowings.
- In mild winters its value is between -8 and -10°C, while in grim winters its value is between -25 and -30°C.
- Absolute minimum temperature (-35°C) was measured at Görömbölytapolcán (today Miskolctapolca) on Fberuary 16, 1940.
- At *Dunántúl area E-W, while at Alföld basin-like feature of temperature distribution is characteristic*, as a result of a weakening oceanic effect and basin location from west to east.

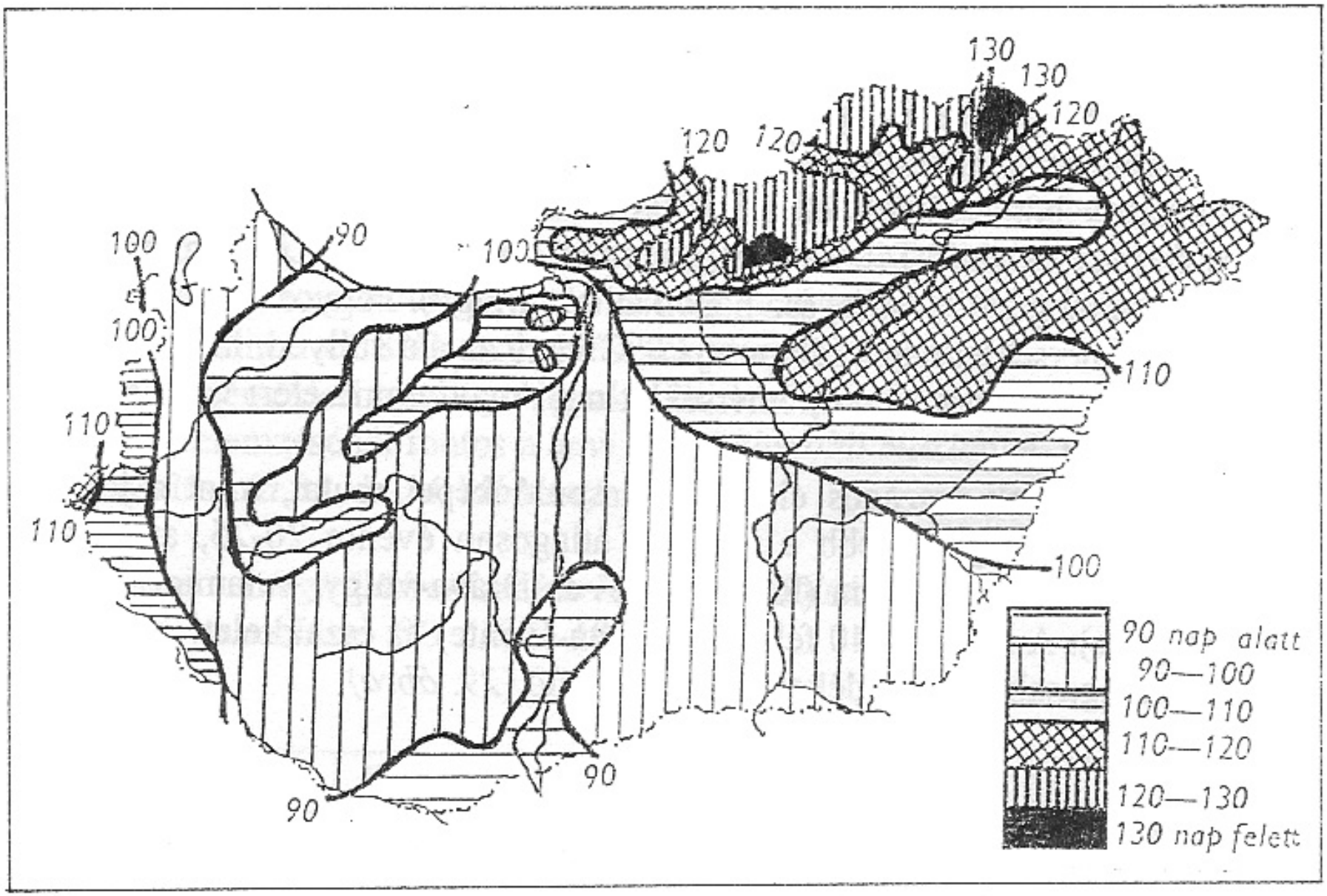


Mean annual maximum temperature (°C) in Hungary

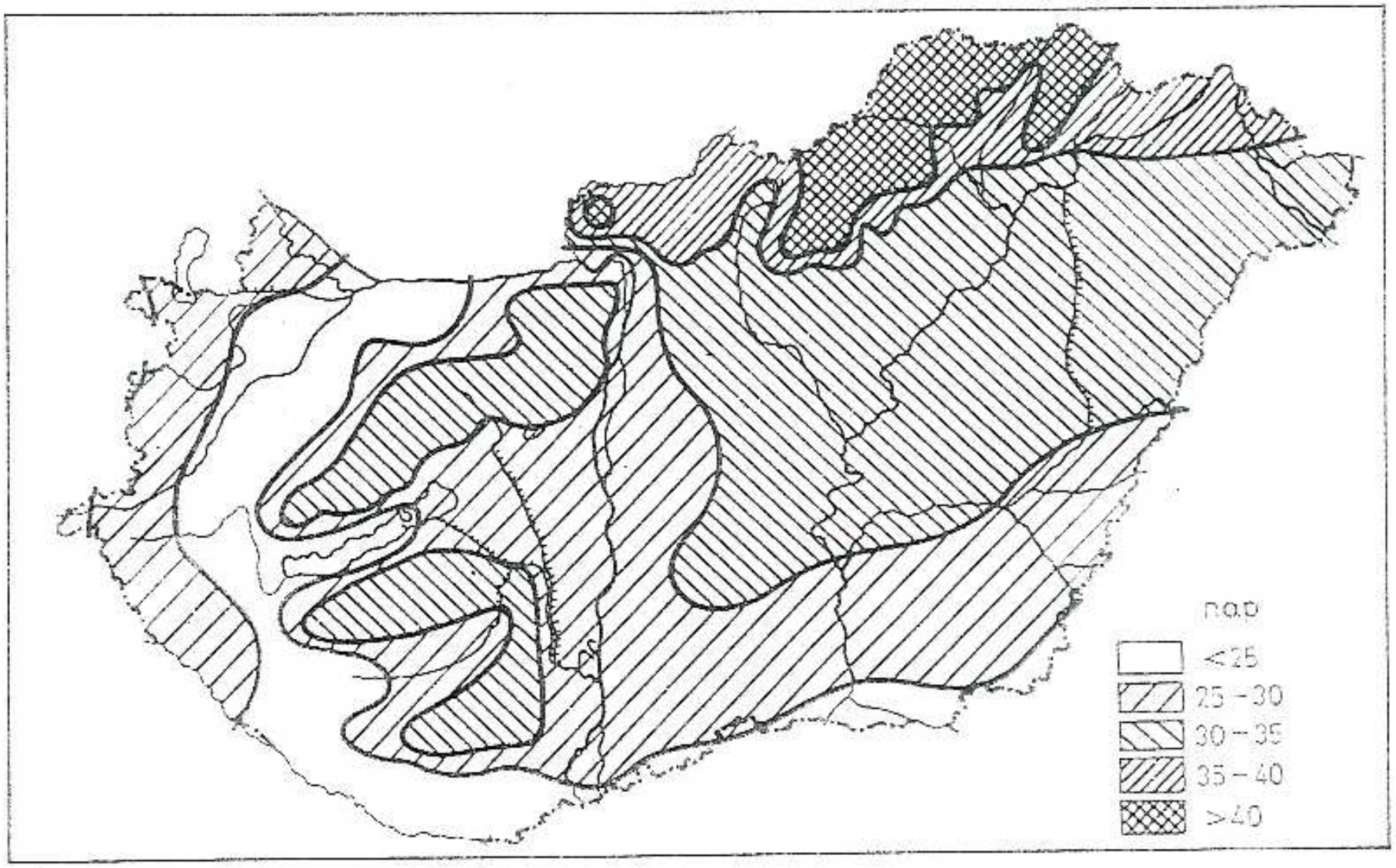
- The strongest annual warming (mean annual maximum) may reach up to 36°C at the south-east part of the country and its value is decreasing from here towards north and west, reaching 32-33°C.
- Cooler years the largest warming is about 30°C, while in warmer years it may exceed a 40°C.
- Absolute maximum: August 20, 2000, Békéscsaba, 42.0°C.
- In this way, absolute pendulum of temperature in Hungary reaches 77.0°C, which is three-quarter of the value characteristic for extremely continental subarctic areas.

- Important parameters to characterize the climate are summer and winter threshold days, among which the number of frost days, winter days and summer days are of great significance.
- The number of winter threshold days are increasing from south-west towards north-east.
- The number of summer threshold days are increasing from west and east towards south-east, in accordance with the oceanic-continental transition. Their number is decreasing with the increasing height above sea level.

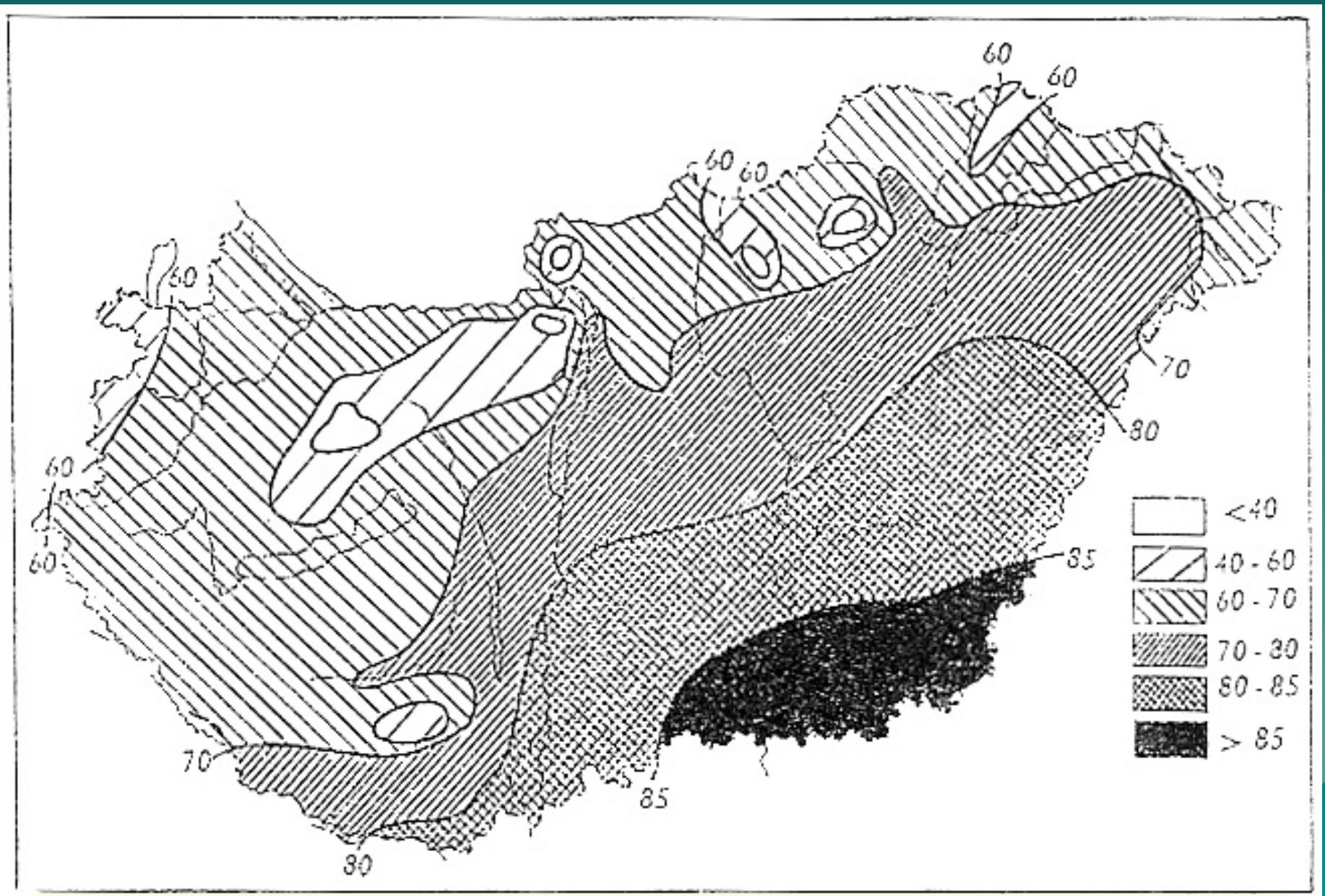
Spec. Temp. days	M.magyaróvár	Pécs	Kecskemét	Nyíregyháza	Kékestető
grim (min. ≤-10°C)	13	8	13	17	16
winter max.≤0°C)	29	23	31	33	71
frost (min. ≤0°C)	95	84	91	109	144
summer (max. ≥ 25°C)	62	79	80	78	6
heat (max. ≥30°C)	12	23	23	21	0
hot (max. ≥ 35°C)	1	2	2	2	0



Average number of frost days in Hungary



Average number of winter days in Hungary



Average number of summer days in Hungary

Always look on the bright side of things!

We finished for today, goodbye!

ямарваа нэг зүйлийн гэгээлэг
талыг нь үргэлж олж харцгаая

өнөөдөртөө ингээд дуусгацгаая, баяртай

让我们总是从光明的一面来看待事物吧！

今天的课程到此结束，谢谢！

دعونا ننظر دائما إلى الجانب المشرق من الأشياء!

انتهينا لهذا اليوم، وداعا!