TECHNICAL MEMORANDUM

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The ECMWF climate system

C. Brankovic and J. van Maanen

Research Department

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ANNEX - Operational surface field climate users of the climate datasets, a system has been developed to serve as mediator between the original climate datasets and those derived from them. This system, known as PREPCLI (following the tradition of PREPEXP and PREPAN), is a user's interface with the complete climate system at ECMWF; it performs an interactive dialogue. PREPCLI interrogates users about their wishes regarding both the original and derived climate datasets. At the end of the interactive session batch jobs, the sublimate of the user's requirements, are created. The main feature of the system is its ability to handle different requirements with respect to output resolution.

This documentation is intended to introduce potential users to the climate datasets at ECMWF. In Section 2 the original climate datasets are discussed briefly; derived ones and how to produce them are explained in more detail in Section 3. The user's guide to PREPCLI as well as description of the PREPCLI filesets are in Section 4. For those who want to know more about the technical side of the climate system the file formats and I/O routines are described in the Appendices.

To work with PREPCLI only a small amount of knowledge about climate datasets and their usage is required.

2. ORIGINAL CLIMATE DATASETS

The following original climate datasets are currently available at ECMWF:

(1) Upper air (pressure levels) spectral climate

This climate was produced at ECMWF and contains monthly data averaged over a six year period (1979-1984). The data consists of spherical harmonics - triangularly truncated at wavenumber 42 - of geopotential, temperature, relative humidity, vorticity, divergence and vertical velocity at 13 standard pressure levels (1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50 and 30 mb).

(2) Upper air (pressure levels) N48 climate

This was also produced at ECMWF, and contains monthly data on a N48 grid at 15 standard pressure levels (13 levels as mentioned above plus 20 and 10 mb). It is a combination of two different datasets: the NCAR climate dataset and the Berlin University stratospheric dataset. It contains u and v wind components and geopotential heights at standard pressure levels, and precipitable water in the layers between pressure levels. The NCAR dataset is defined on a 5 degree lat/long grid and it represents the digitized data described by Crutcher and Meserve, 1970, and by Taljaard et al., 1969. The Berlin University data are explained by Knittel, 1976.

(3) Surface soil moisture climate

The data are defined on a global 4 x 5 degree lat/long grid and they are available for the 1st and 16th day of each month (Mintz and Serafini, 1981).

(4) Sea surface temperature climate

This dataset is well known as the RAND sea surface temperature dataset. The resolution of the data is 1 degree on a regular lat/long grid. Monthly mean temperatures at both open water and sea ice points are given, along with information on the extent of sea ice (Alexander and Mobley, 1971).

(5) Precipitation climate

This represents the monthly mean precipitation all over the globe in terms of area averages for 5 degree lat/long boxes. When using this dataset values are assigned to the central point of the boxes (Jaeger, 1971).

(6) Surface temperature climate

This dataset contains monthly mean air surface temperatures on a 5 degree regular lat/long grid (a N18 resolution grid). Data are described by Crutcher and Meserve, 1970, and by Taljaard et al., 1969.

(7) Terrain dataset

This was provided by the NCAR and is well known as the US Navy terrain data. It has the highest resolution currently available and contains a range of terrain parameters, such as mean terrain heights, maximum heights, minimum heights, terrain types, land/sea fraction, etc., on a regular 10' (1/6th of a degree) lat/long grid (Joseph, 1980; Cuming and Hawkins, 1979).

(8) Albedo climate

This is a yearly averaged climate field. There are two versions of albedo: smoothed and unsmoothed. The latter is used by the ECMWF climate system. The resolution for this dataset is N48, i.e., 1.875 degrees on a regular lat/long grid (Preuss and Geleyn, 1980; Geleyn and Preuss, 1983).

(9) Roughness length due to vegetation

It is defined on a regular 5 degree lat/long grid all over the globe (Baumgartner et al., 1976).

All original climate datasets, except (1) and (2), are converted to a common format for compatibility with other fields used in the climate system. This unique format is described in Appendix C. The original climate datasets will sometime be referred to as input climate datasets because they are used to derive the datasets described in the following section.

3. DERIVED CLIMATE DATASETS

The derived climate datasets fall into five groups which correspond to the tasks needed to create subsets of fields. They are as following:

(1) The US navy summary

(2) Upper-air climate in the line format

(3) Surface fields climate

(4) Cold start climate

(5) Data assimilation climate

3.1 The US Navy summary

For a given resolution the US Navy summary consists of seven fields describing various terrain properties:

(1) Land/sea fraction

(2) Mean terrain height

(3) Maximum terrain height

(4) Minimum terrain height

(5) Standard deviation of mean terrain height

(6) Roughness length due to orography

(7) Urbanisation fraction

Fields (1), (2), (3), (4) and (7) on a user-defined grid are computed as area averages of data on the original 10' regular lat/long grid. Land/sea fraction or land/sea mask is defined as a fraction between 0 and 1. It is assumed that the user-defined box contains land if the fraction has a value equal to or greater than 0.5. The standard deviation is calculated from the mean height and sub-grid scale variance estimated for each 10' box. The roughness length calculation is based on the analysis of the variance of mean heights, which in turn depends on the user-defined grid, number of significant ridges and maximum terrain height information (Tibaldi and Geleyn, 1981).

Fields (1), (2), (5) and (6) are used in the computation of the surface fields climate.

3.2 Upper air climate in line format

Six years (1979-1984) of standard pressure levels data are archived at ECMWF. According to the user's specification, this task will fetch the monthly mean spherical harmonics dataset, described in Section 2(1), and convert it to the line format.

The upper air climate is used to produce a part of the cold start climate described later (see Section 3.4). Furthermore, it may be used as a reference for verification purposes.

3.3 Surface fields climate

The range of the surface fields climate dataset is closely related to the model's physical parameterisation requirements. At the moment it contains the following ten fields:

(1) Surface geopotential (orography)
(2) Surface temperature
(3) Mid-layer soil temperature
(4) Deep-layer soil temperature
(5) Snow depth
(6) Surface soil moisture
(7) Mid-layer soil moisture
(8) Deep-layer soil moisture
(9) Albedo
(10) Roughness length

The maps of the operational surface fields are shown in the Annex.

(1) Orography (ϕ_s)

This is, undoubtedly, one of the most important surface fields. Once defined it determines directly or indirectly some other surface fields (temperatures for example) and it has an important role both in the analysis and forecast.

The model orography can be represented in terms of an area mean or an envelope orography. It is calculated according to the orography expression

$$\phi_s = g\,(H_m + \alpha\sigma) \qquad (1)$$

where g=9.80665 is the acceleration of the earth's gravity, H_m is the mean height on the user-defined grid retrieved from the US Navy summary dataset, α is the proportion of standard deviation to be added to the mean height over land points ($\alpha \neq 0$ for an envelope orography), and σ is the standard deviation of mean height defined for the same grid as H_m.

The operational orography (on a T106 Gaussian grid) is smoothed using a Gaussian filter (Tibaldi and Geleyn, 1981) with a radius of 50 km. The filtering smooths a field interpolated from the 10' grid. Then, the spectral fit is applied to the filtered orography. The purpose of spectral fitting is to ensure consistency in spectral resolution between the orography field and the resolution of the model's upper air fields. Orography ripples will appear as a consequence of spectral fitting (Fig. 1). A spectral fit is not carried out when a grid-point resolution is used.

Because of the spectral fitting some sea points may have non-zero altitudes. This means that the land/sea pattern must be independent of orographic height. Such a definition requires some care in the subsequent treatment of the surface temperature, as is discussed in the following section.

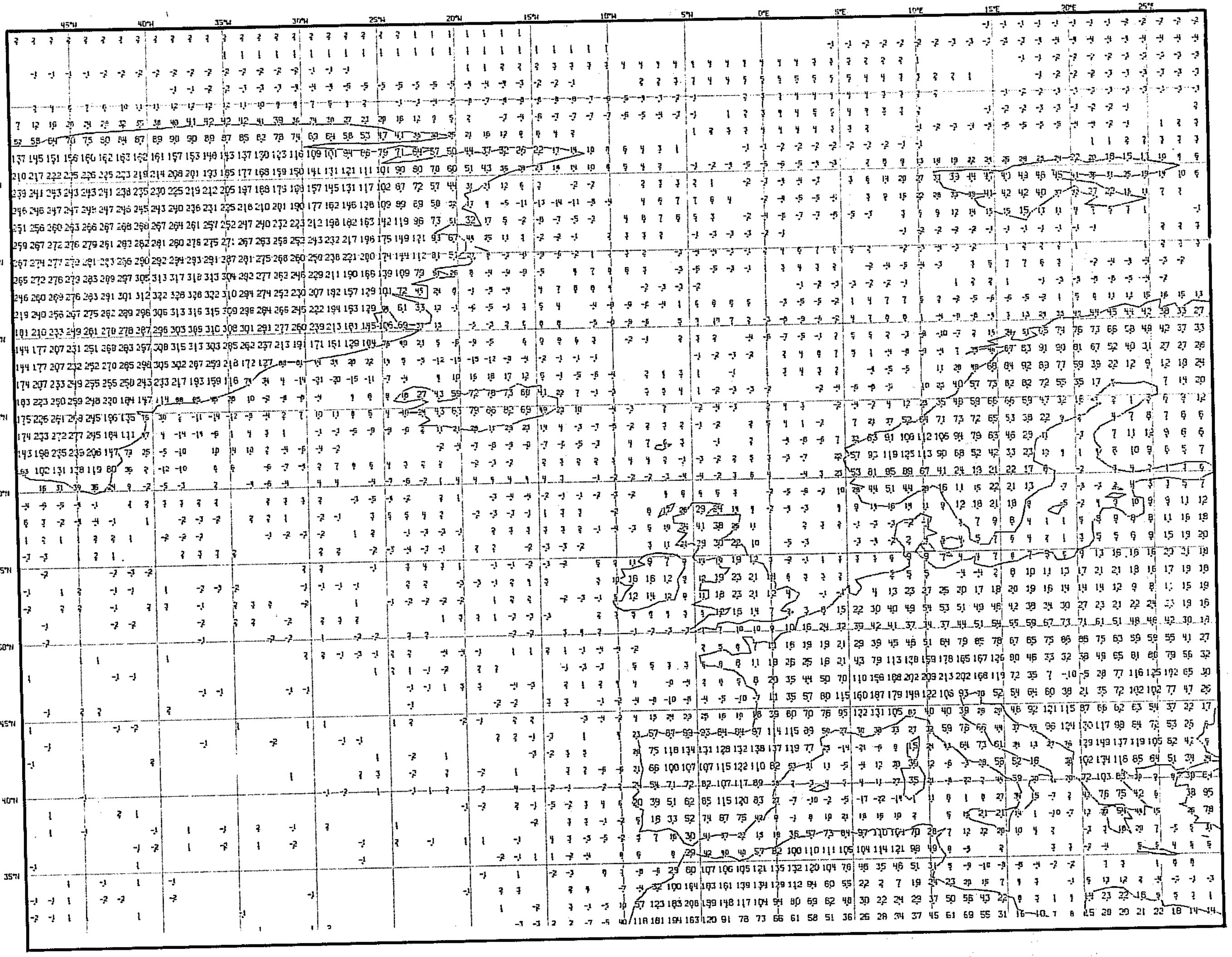

Fig. 1 Sample of the operational orography (dam). Small figures denote sea points, large one are land points and blank areas are sea points with zero altitude. Negative values over sea are due to spectral fitting. Note some very high values at sea points near the east coast of Greenland.

(2) Surface temperature (T_s)

A rather lengthy procedure is used to derive surface temperature T_s. Before explaining it in more detail, the two assumptions used in the definition of the T_s should be mentioned.

The original climate input dataset for the T_s computation over land is the one described in Section 2(6). Since these input data are surface air temperature data, an assumption is needed to obtain surface soil temperature data. The assumption is simply that surface air and surface soil are, climatologically, in thermal equilibrium. This is not necessarily the best assumption for all seasons but, in virtue of its simplicity and lack of any thing better, it was decided to make this assumption.

On the other hand, no precise information is available on the exact orography for which the original input air surface temperature (T_s^o) was evaluated. Therefore it seemed reasonable to assume that the T_s^o field should apply to an area mean orography of the same resolution as the original T_s^o dataset (N18 resolution; see Section 2(6)). Having in mind these assumptions T_s is then derived as follows.

Firstly, an N18 mean orography has to be interpolated to the user-defined grid as well as T_s^o itself. Interpolation of the N18 orography to the required grid is needed mainly to define a correction because of the differences between the mean and user-defined orographies ($+1\sigma$ envelope in the operational case). Note that even if the user requires a mean orography, differences may still emerge simply because of the different initial resolutions involved - 10' grid versus N18 grid. Then, the corrections are added to the interpolated T_s^o, now denoted as T_s^o (int). In terms of simple algebra the above can be expressed as

$$T_s^* = T_s^o\,(\text{int}) + (-\gamma/g)\,(\phi_s - \phi_s^{o,n}\,(\text{int})), \qquad (2)$$

where T_s^* is the surface temperature corrected for orography difference, T_s^o (int) is the original N18 surface temperature interpolated to the user-defined grid, γ is the assumed vertical temperature lapse rate (0.65/100 degm^{-1}), ϕ_s is the user-defined orography obtained from Eq.(1), and $\phi_s^{o,m}$ stands for the mean orography interpolated from the N18 grid to the user grid. The second term on the right-hand side of Eq.(2) represents the correction due to the orography difference (Fig. 2). It was found while testing the above procedure that in valleys near high and steep mountains Eq.(2) gives too much warming, thus no correction exceeding +5.0°C is allowed.

The next step is to blend T_s^* with the sea surface temperature, SST (Section 2(4)). Before doing this the sea ice pattern is extracted from the SST dataset. In the original RAND SST dataset monthly mean temperatures over sea ice points are given in degrees Kelvin, while sea points without ice (open water) have temperatures in degrees Celsius. The sea/sea-ice mask was created in such a way that zero has been assigned to all points with open water, and unity to all points with sea ice. It was found, however, that a number of sea ice points have positive temperatures. Therefore a consistency check for sea ice has been performed, i.e., ice is removed from all points where the sea surface temperature is above +1.0°C. The value of +1.0°C was chosen because of the assumption that sea ice may exist even if the temperature of the water is slightly above freezing. Then both sea surface temperature and sea/sea-ice masks are interpolated separately, using bilinear interpolation, to the user-defined grid.

The blending of SST and T_s^* is performed in a similar way to that described in Tibaldi and Geleyn, 1981. For land points T_s^* is used; for water points the SST is taken except for sea ice points. Over ice the surface temperature was taken as the minimum between the SST and T_s^*. This produces additional difficulties since ice points may have non-zero surface geopotential, especially over artificial orography (spectral) ripples.

To overcome this problem a further correction for sea ice points is imposed. In principle, this correction is similar to that given in Eq.(2). The temperature at an ice point is increased (decreased) by an amount $(\gamma/g)\phi_s$. Note that ϕ_s may be either negative or positive, so the new correction can be positive or negative.

Thus a new $T_s^{*\prime}$ surface temperature is defined. It is used as input to derive the snow climate (see paragraph (5) in this section). Once the snow climate is defined, a consistency constraint on $T_s^{*\prime}$ is imposed again and eventually T_s is created. The very last snow correction consists of bringing positive temperatures $T_s^{*\prime}$ down to 0°C over land points where snow is defined.

It should be pointed that before $T_s^{*\prime}$ is corrected by the snow climate a new consistency check for sea ice is performed. The critical temperature over which sea ice is not allowed to exist is now defined as -2.0°C. This newly defined sea ice cover is then used as an input to derive the albedo data.

(3) Mid-layer soil temperature (T_m)

From the surface soil temperature T_s, a mid-layer soil temperature T_m is derived. It represents the temperature of the ground in the layer between 7 and 50 cm. For a description of how soil processes are treated in the model

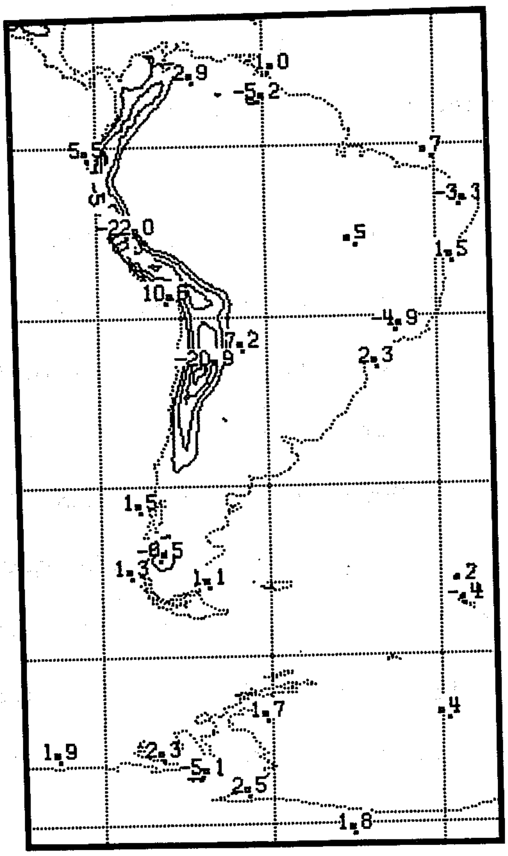

Fig. 2 Corrections over South America added to the surface temperature because of the difference between the operational T106 terrain heights and heights interpolated from the N18 grid to T106 grid. Note: the figure shows values greater than the +5 degree limit.

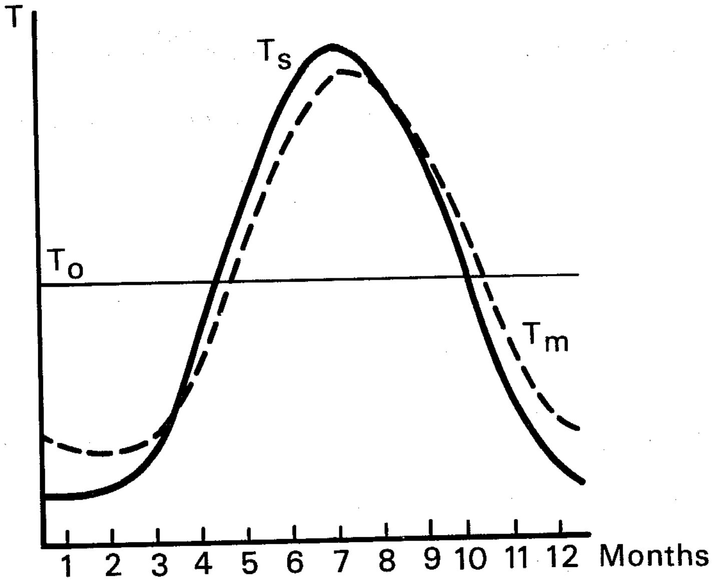

Fig. 3 Annual soil temperature distribution. T_s is a surface soil temperature and T_m is a temperature away from the surface.

dynamics see Louis (Ed.), 1984. The following considerations are the basis of the definition of T_m as used in the climate system.

It is supposed that T_m is a function of T_s, but with a smaller annual excursion. The ground conductivity also plays a role, thus a phase lag between T_m and T_s is assumed too. The yearly cycle of T_m can be imagined as a periodic function, which is determined by various parameters such as cloudiness, snow cover, etc. Usually, larger values of T_m are found in autumn than in spring (Fig. 3). The twelve monthly values of T_o define a mean annual surface soil temperature for every user-defined grid point. Soil temperature has been found by Geiger, 1979 to hardly alter with depth (1 degree in 2 metres), so for our purpose we assume it is a constant (This is consistent with the small maximum depth considered; in the model it is about 70 cm.) In other words T_o provides an estimate of the mean annual value of T_m (dashed line in Fig. 3). The above considerations help to define the T_m dependency upon T_s in a relatively simple way.

The monthly mean soil temperature $T_s^{(n)}$ (and also $T_m^{(n)}$) can be written as a sum of an annual mean temperature T_o and monthly anomaly (deviation) from T_o

$$T_s^{(n)} = T_o + A_s^{(n)} \tag{3a}$$

$$T_m^{(n)} = T_o + A_m^{(n)} \tag{3b}$$

Furthermore, the anomaly $A_m^{(n)}$ can be expressed as a function of surface temperature deviation $A_s^{(n)}$ by the following expression

$$A_m^{(n)} = c\ (aA_s^{(n)} + b\ A_s^{(n-1)}) \tag{4}$$

where a and b give the amounts of anomalies taken from the month n and previous month n-1 (a+b=1), and c<1 gives amplitude damping. By substituting

Eq.(4) into Eq.(3b) and defining $A_s^{(n)}$ and $A_s^{(n-1)}$ from Eq.(3a) one obtains that

$$T_m^{(n)} = (1-c)T_o + c(a\ T_s^{(n)} + b\ T_s^{(n-1)}) \tag{5}$$

The above equation is being used to derive $T_m^{(n)}$ with the following values of the constants a=0.8, b=0.2 and c=0.9. These values have been chosen so as to fit the observational data.

The map showing the global annual range of temperature T_m, i.e., the difference between warmest and coldest monthly mean values, is shown in Fig. 4. It is in good qualitative agreement with the map for soil temperature at 30 cm depth derived from 780 stations (Chang, 1957). Minima are in the tropics and maxima are over large extratropical continental areas. The North African maximum is quite close to that derived from station data; the South African and Australian maxima are just lower. The largest differences are in the regions of maxima far away from the tropics. In Siberia it is 50 degrees compared to 35 for station data, and the whole region of large values is shifted further to the north-east. Similarly in the Canadian polar region one finds a 35- against 25-degree maximum. These results may suggest that snow cover should be taken into account in more sophisticated way when creating T_s and T_m, or that the damping of the T_m amplitude should be latitudinally dependent. On the other hand it is not clear why in southern Latin America the maximum is lower than that derived from station data.

(4) Deep-layer soil temperature (T_d)

As for T_m, the deep-layer soil temperature is derived from Eq.(5), the only difference being that both phase lag and amplitude damping are greater than for T_m, i.e., a = b=0.5, and c=0.77. While T_s and T_m are altered during the forecast model run, T_d is kept constant.

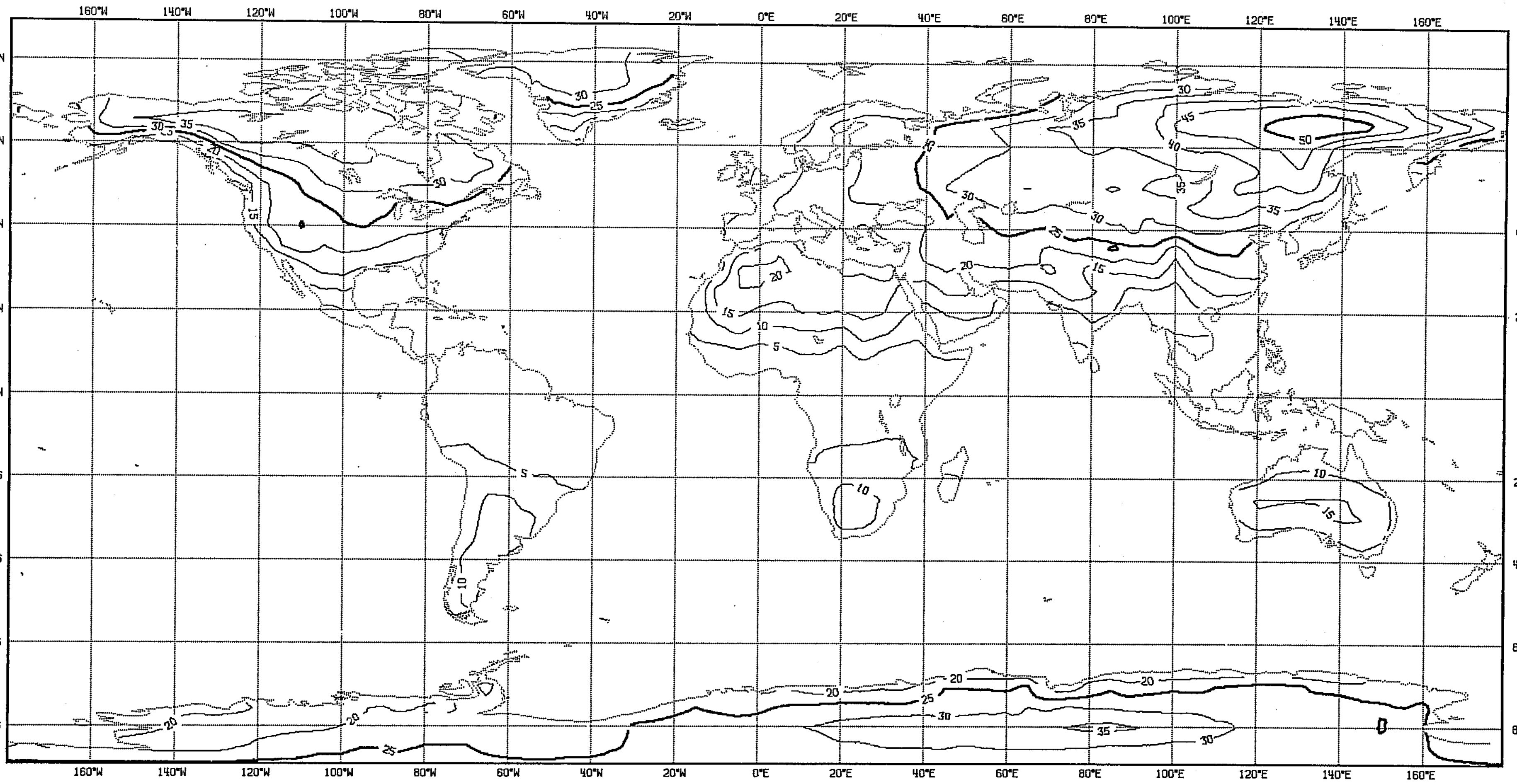

Fig. 4 Annual range of mid-layer soil temperature.

(5) Snow depth (Sn)

There are a variety of meteorological phenomena which have various degrees of impact on snow creation and snow destruction. Eventually, it was decided that only the combination of precipitation R and surface soil temperature T_s over land points would be considered when creating the snow climate.

Firstly, precipitation from Section 2(5) is interpolated to the user-defined grid on which T_s is already defined. The T_s used here was created for a mean orography regardless of the user-defined orography.

The computation of the snow depth at a single grid point is performed independently from the neighbouring points. The two functions, describing two main snow processes, are defined at each grid point. The first, a snow fall fraction coefficient C_s is defined by

$$C_s = \begin{cases} 0 & \text{if } T_s > 10°\text{C} \\ 0.5\,[1 - \sin(180 \frac{T_s}{\Delta T_s})] & \text{if } -10°\text{C} < T_s < 10°\text{C} \\ 1 & \text{if } T_s < -10°\text{C} \end{cases} \tag{6}$$

C_s models the fraction of monthly precipitation assumed to fall as snow (Fig. 5). ΔT_s represents the range of surface soil temperature between 100% snow creation and 100% snow melting and it is set to 20 degrees, i.e., between -10°C and +10°C.

The second function, M_s, gives the monthly amount of the snow melt and it is defined by

$$M_s = \begin{cases} c\,(T_s - T_{cr}) & \text{if } T_s > -10°\text{C} \\ 0 & \text{if } T_s < -10°\text{C} \end{cases} \tag{7}$$

where c=15/32 and T_{cr} is the critical temperature below which no snow melting is taking place (T_{cr}=-10°C). Both c and T_{cr} are empirical constants. Eq.(7)

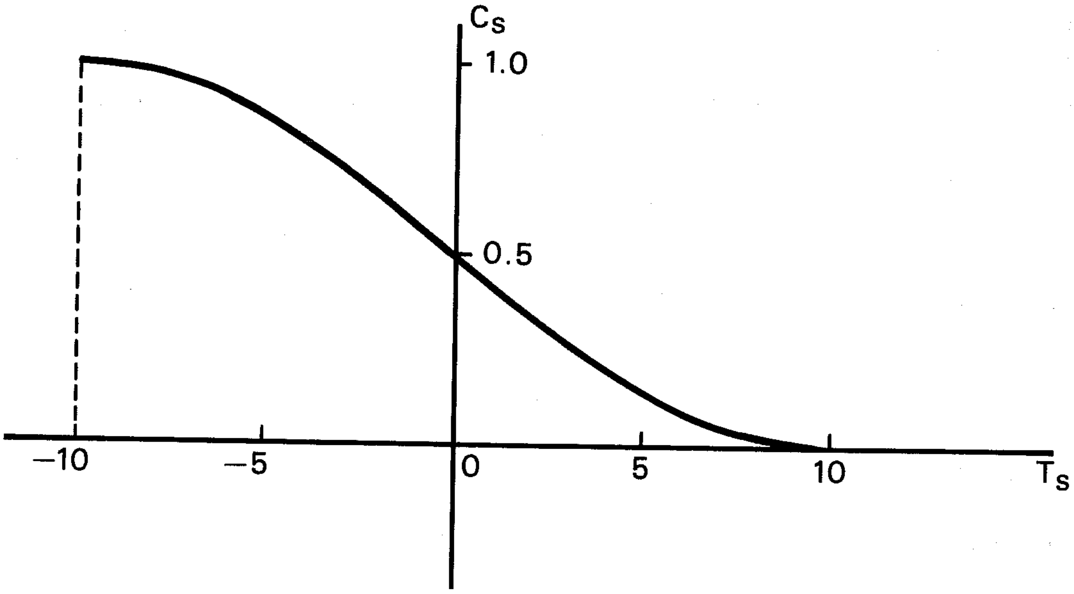

Fig. 5 Snowfall fraction coefficient function.

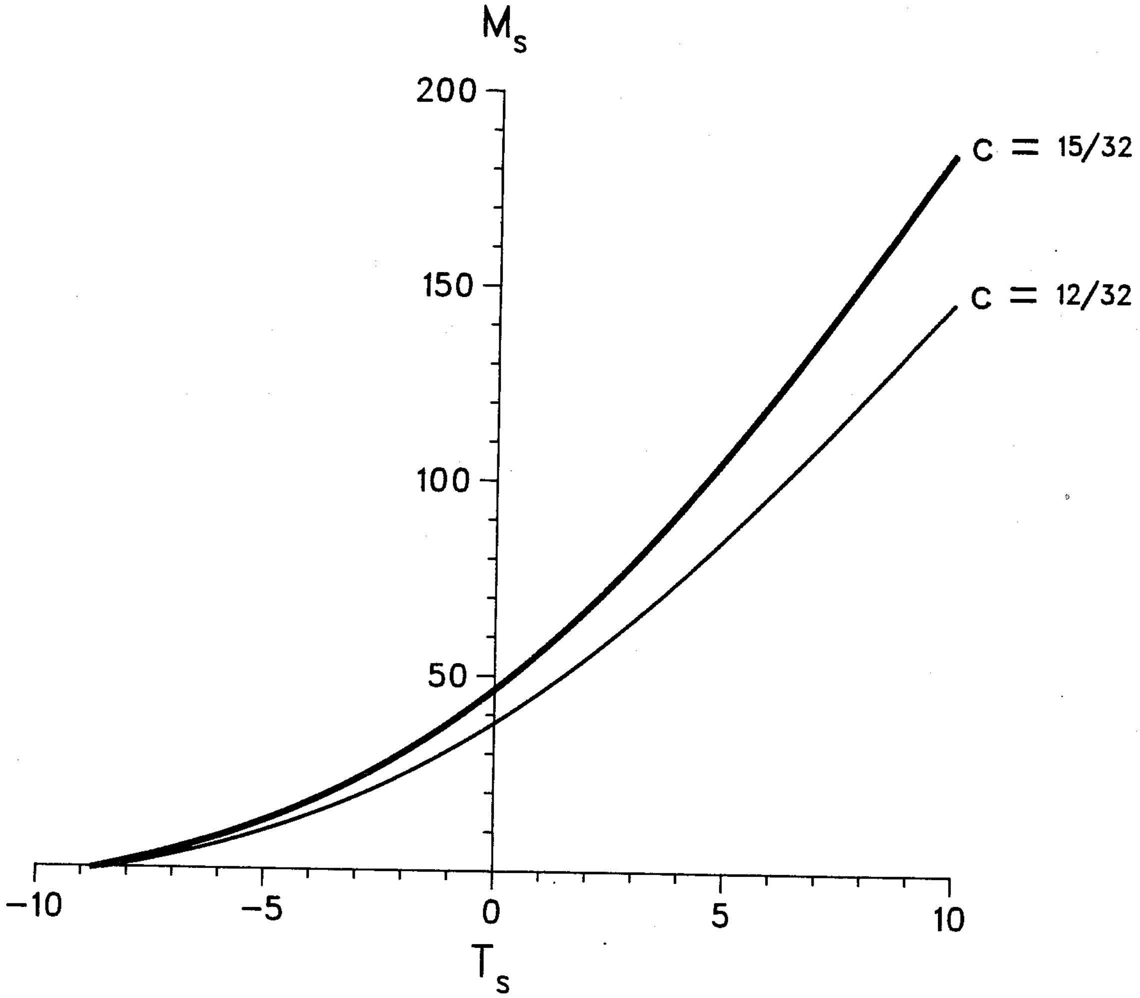

Fig. 6 Snow melting function.

has a parabolic shape (Fig. 6) which reflects the assumption that slower melting occurs for T_s between 0°C and -10°C, and faster melting when T_s is positive. c is a measure of the 'steepness' of the parabola; the greater the value of c, the faster snow melts.

The snow amount for each month n is then calculated as a function of the snow amount in the previous month n-1, the snowfall and snow melt:

$$Sn^{(n)} = R^{(n)} C_s^{(n)} - M_s^{(n)} + p\ Sn^{(n-1)} \qquad (8)$$

$R^{(n)}$ is the precipitation in month n, and p is a constant which describes the evaporation of snow, or in other words p is a fraction of the snow depth from the previous month n-1 which contributes to the snow depth of the current month n. The constant p is chosen to be 0.95.

Eq.(8) is used to iterate through a number of years until the snow climate values have reached a steady state. Particular attention was paid to the proper definition of areas with permanent snow cover. A study, based upon the 14 years weekly data derived by Dewey and Heim, 1982, has been undertaken. It was found that in the northern hemisphere only Greenland (excluding coastal parts) has a snow cover over the whole year in the complete 14 year period. Occasionally snow remained during the whole year at some of the Arctic islands and twice it occurred over the Himalayas. Therefore, perpetual snow is defined only over Greenland and in the southern hemisphere over Antartica. Other areas with perpetual snow, such as glaciers in Iceland, Andes, etc., are found to be too small to be captured even with the highest, T106, resolution. For perpetual snow a value of 10 metres is assigned, large enough not to be melted during the iterations.

After the snow climate has been computed, the T_s values greater than 0°C at grid points with snow were reduced to 0°C.

(6) Surface soil moisture (W_s)

This surface field is derived in a straightforward way from the original climate dataset described in Section 2(3). Original data are interpolated to a user-defined grid. The original maximum value of the moisture that the soil can hold is set to 15 cm of water. Since, in our case, the first ground layer reaches only 7.2 cm in depth, it is assumed that the maximum water content for this layer cannot exceed 2 cm, and therefore all original values are scaled accordingly.

The field is of no relevance over the model water points, where it is set to zero.

(7) Mid-layer soil moisture (W_m)

At present a three layer ground model is used in the ECMWF forecast model. The second or middle layer has a depth of 43.2 cm, i.e., it is six times thicker than the surface layer. Therefore, the maximum water content in this layer is assumed to be 12 cm. Note, however, that the value used in the forecast model is scaled to the depth of the first layer (Louis (Ed.), 1984, Chapter 6). Therefore, W_m must also be scaled accordingly and all W_m values are equal to W_s.

(8) Deep-layer soil moisture (W_d)

The same assumption as for W_m is used in treating W_d. The deep ground layer overlaps the middle layer and it is assumed that the soil moisture between these two layers is in balance. Thus, the total water content that the deep layer can hold must not exceed 12 cm. However, the W_d data are again scaled and therefore the W field is identical to that of W_d and W_s.

(9) Albedo (Al)

The first step in deriving the albedo field is to interpolate the unsmoothed original dataset described in Section 2(8) to a user-defined grid. Then the interpolated field is filtered by the same Gaussian filter as is used in the orography filtering.

Since sea ice has an important role in defining the global albedo it was necessary to derive an annual mean sea ice pattern. The following constraints are then imposed on the albedo field: over sea ice values are reset to 0.55; over open sea (water points) the albedo is 0.07; over land points the minimum albedo must not be below 0.07 and the overall maximum cannot exceed 0.80 (usually over snow-covered areas).

The albedo is used as a yearly background field, but the model alters it during the run according to the snow cover.

(10) Roughness length (Z_o)

The roughness length due to vegetation is an original climate dataset, Section 2(9), and therefore it must be interpolated from the original to the user-defined resolution. The total roughness length is calculated from a simple expression

$$Z_o = (Z_V^2 + Z_H^2)^{\frac{1}{2}} \qquad (9)$$

where Z_V is the roughness length due to vegetation on the user defined grid and Z_H is the roughness length derived from orography parameters and is part of the US Navy summary dataset. The information about urbanisation has already been built in to Z_H, in such a way that for 100% urban area a value of 2.5 metres is assumed.

The logarithm of blended roughness length Z_o is then smoothed by the same Gaussian filter as is used in the orography filtering. Finally, over sea and sea ice points Z_o is reset to 0.001 m. Values of Z_o are recomputed over sea in the model.

3.4 Cold start climate

The cold start climate can be defined as an initial state which might be used by the data assimilation system if no previous first guess forecast is available. The cold start climate is taken to be a monthly climate for each month of the year.

It consists of two parts. The first part contains the surface field climate dataset plus model work field and land/sea mask as a separate field. All fields are defined on the model's alternating Gaussian grid*. A temperature correction for the orography ripples over sea points, similar to that described by Eq.(2), was introduced in the surface temperature field. Namely, the surface fields, as a part of the cold start dataset, could possibly be used in the forecast model directly and therefore all fields must be ready for immediate use.

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*The alternating Gaussian grid can be described as a grid in which a Gaussian latitude from the northern hemisphere is followed by corresponding ('mirror') latitude from the southern hemisphere, starting at the polarmost Gaussian latitude.

The second part contains the upper air climate in spectral format at model levels, and the parameters stored are surface pressure, temperature, vorticity, divergence and relative humidity. It was derived from the upper air climate dataset described in Section 2(1) by converting it to grid point form, interpolating from standard pressure levels to model levels and converting back to spherical harmonics.

The cold start climate is a part of a monthly data assimilation climate and is derived during creation of the data assimilation climate (see Section 3.5). However, the cold start climate can be created separately for any user-defined spectral resolution, providing the surface fields climate for that resolution is defined (Section 4.7).

3.5 Data assimilation climate

The last group of derived climate datasets, the data assimilation climate, consists of some datasets described earlier; in fact it consists of ten files. It is a monthly climate because all files relate to the same month. Two of the files describe surface fields - surface climate on the model's alternating Gaussian grid and the first part of the cold start climate as described in Section 3.4.

All other files are related to the upper air fields. One of them is the second part of the cold start climate dataset, i.e., the spectral model level climate. In addition to that and because no forecast for the uppermost analysed levels is available, the N48 pressure climate, described in Section 2(2), is used. The remaining six files define some statistical properties needed for daily analysis runs. They can be divided into two groups: one contains the mean 6-hour forecast error statistics and the other contains upper air climate statistics. These statistics can be described as:

- correlations for mass and wind fields used in statistical interpolation to define the structure of the errors in the background field (6-hour forecast)
- forecast error amplitudes used by the mass/wind analysis
- forecast error amplitudes used by the humidity analysis

The climate errors serve to define the growth rate of the errors calculated in an analysis cycle, and 6-hour forecast errors are used to confine them within the limits of geostrophic and hydrostatic balance (Lönnberg and Shaw (Eds.), 1983).

From all surface fields only snow cover and soil moisture are analysed directly using the observations. The surface fields climate is employed here to prevent drift of the analysis from the climatologically defined limits.

4. USAGE OF PREPCLI

As mentioned earlier PREPCLI is a user's interface between original and derived climate datasets in the form of an interactive procedure. To use PREPCLI, simply type the following:

```
FETCH,PREPCLI,DIC
PREPCLI
```

During each PREPCLI session batch jobs for only one of five tasks described in Section 3 will be created. If, for instance, the user wants to create the surface fields climate which requires the US Navy summary to be defined, then two sessions with PREPCLI are needed. The first session will set up jobs for the US Navy summary creation and the second session will then set up jobs for surface fields climate creation.

4.1 The PREPCLI filesets and sequence number

When a PREPCLI session is completed properly, in most cases, a local fileset EXP_SEQ is generated. SEQ is a uniquely assigned sequence number and it increases by one each time the PREPCLI session terminates with a generated fileset EXP_SEQ. EXP_SEQ will contain a number of files depending on what task the user wants to be accomplished. The full list of files is as follows:

- JOBS
- JOBY
- JOBX
- MODFTN
- MODJCL
- PLOTUSN
- PLOTUAC
- PLOTSFC
- LOG

JOBS, JOBY and JOBX are jobs which are run in the batch mode and after their completion the user-defined derived climate dataset is created. They are described in Section 4.10. Optionally, EXP_SEQ may also contain two files MODFTN and MODJCL, and one of the three jobs PLOTUAC, PLOTUSN and PLOTSFC. MODFTN and MODJCL contain modifications that the user might impose upon the Fortran source library and/or to the JCL library (Section 4.3). When the surface fields climate is required, job PLOTSFC is added to plot some of the fields. If the US Navy summary is needed, the job PLOTUSN might be used to plot the field of mean terrain height. The job PLOTUAC might be easily adapted to plot any upper air field. The remaining file is called LOG and it keeps all relevant information about running PREPCLI.

All files/jobs generated during one PREPCLI session and stored in EXP_SEQ have the same group name of the form UID_SEQ, where UID represents the user identifier as retrieved from the Intercom session and SEQ has the same meaning as described above.

The local fileset EXP_SEQ becomes a subset of a permanent fileset PREPSET, ID=DIC, with the same group name as files in EXP_SEQ. This means that all files and jobs generated during a PREPCLI session are kept together and have a unique identifier. The user may retrieve at any time an earlier created EXP_SEQ, examine its contents, modify it, etc., and then replace it in PREPSET; or it could be destroyed if not needed.

4.2 Operational and more general climate datasets

At the beginning of the interactive session, PREPCLI will ask the user whether he/she is going to generate a climate for operational use or for more general purposes. The operational climate comprises a certain range of derived climate datasets used within the operational analysis and forecast system. As far as the climate system is concerned, the word 'operational' has a strict meaning only for the horizontal resolution and orography definition, because these two factors must be consistent with the other parts of the operational suite. No modifications in the Fortran source library or in the JCL are allowed when a climate for operations is required. On the other hand, the user may specify different original climate datasets at input rather than the defaults provided by PREPCLI. If that is the case, then the substitution must be in a format which is compatible with the other datasets used in the climate system. If any modification to the operational climate is required the user must run PREPCLI in mode 2 .

The second mode of using PREPCLI is fully user-oriented. The user may specify most of the components required for a particular task. Naturally, there are some restrictions, but they are rather few. For example, the user may specify the horizontal resolution and orography, replace the original input datasets (described in Section 2), or modify the established methodology (procedures) in deriving climate datasets.

Thus, the user interaction with the climate system fall into two groups: the first and less complicated would consist of a simple replacement of the system defaults; the second and possibly more complex would include the user changing of the climate software.

4.3 Update correction sets

Both, the Fortran source library and the JCL library are available as Cyber update program libraries (PLs). Therefore, the user can easily modify any of the Fortran routines or the JCL of Cray procedures. The Fortran update library is CLFTNPL,ID=DIC, and the Cray JCL update library is CLJCLPL,ID=DIC.

Each Cray procedure is a separate deck and corresponds to the task as defined at the beginning of Section 3. There is one additional JCL procedure which compiles the Fortran routines and manipulates the resolution.

If any modification either to the Fortran source or to the JCL is needed, the user has to create a separate permanent file containing update corrections. This file (or two files if modifications in both program libraries are required) will be added to the local fileset EXP_SEQ as MODFTN and/or MODJCL elements. The correction set is merged with the original update program library and a new library is created. MODFTN and MODJCL can be inspected and possibly modified any time after the fileset EXP_SEQ is created. These two files can be used to trace any previous corrections easily.

The master control character in the permanent file containing the JCL modifications should be '@'.

4.4 Horizontal resolution

The choice of the horizontal resolution is the main factor which determines the production of derived climate datasets. Once defined, the horizontal resolution directs the stream of events which depend on it. If the operational climate dataset is required then no option regarding resolution is given. Otherwise, two different types of resolution can be used: spectral (T resolution) and regular grid (N resolution).

T resolution defines a horizontal mesh with Gaussian latitudes, and the N resolution defines it with regular latitudes. In the east-west direction, both T and N resolutions are regular, i.e., longitudinal segments on any latitudinal circle are equal.

Some of the T and N resolutions are prestored in the climate system. This means there is no need to create the US Navy summary datasets (Section 3.1) for those resolutions. The prestored resolutions are as follows:

- T106, T63, T42, T21
- N48, N18

If the user-defined resolution differs from prestored ones then, again, only a T or N resolution may be specified.

For T resolution the number of Gaussian latitudes and the number of longitudinal points must be defined, but there is a certain relationship between them. Thus, if T40 is chosen, the least number of longitudinal points would be NLON=3M+1, where M=40. In practice NLON is rounded up to the even number most suitable for the Fast Fourier Transform. In our example NLON will be 128. The number of Gaussian latitudes is then NLAT=64, i.e., one half of NLON.

For the N resolution the user must provide a file containing parameters which will be read when jobs for the US Navy summary are running. In Appendix B it is explained how the resolution file for any N resolution can be created.

4.5 How to create the US Navy summary

For the operational or any other prestored resolution there is no need to create the US Navy summary dataset unless, the user wants to modify the Fortran source or the JCL employed. The multifile tape 18861A contains these summaries. File labels are of the form USNAVYrrr, where rrr stands for the resolution name (T63, N18, etc.). The operational resolution summary file has the name USNAVYT106.

If a non-prestored T resolution is wanted, the only parameter required is a target tape VSN to which a summary will be written. The file label is of the same format as above and rrr now refers to the user-defined T resolution.

In the case of a non-prestored N resolution, the user has to type-in a Cray text string needed for acquiring the resolution file. The length of the string can be up to 70 characters, including punctuation and single quotes at the beginning and at the end of the string, e.g.:

'MOUNT,SN=TEMP,VSN=TEMP01.ATTACH,Z,MYRESOLUTIONFILE,ID=ABC,SN=TEMP.'

Afterwards, as in the T resolution a target tape VSN is required. The resolution file for any regular grid resolution can be created as demonstrated in Appendix A.

The US Navy summary dataset contains seven files in the order described in Section 3.1. Data are in a binary blocked (BB) format. To retrieve any of the fields in Section 3.1, the dataset must be split using the COPYF directive. The Fortran program for reading fields has to contain the sequence of subroutine calls described in Appendix B.2. The job PLOTUSN from the user's personal fileset EXP_SEQ can be easily adapted to plot any of the US Navy summary fields. See Section 4.10 for how to use the job PLOTUSN.

4.6 How to create the upper air climate in line format

The first three characters of the month for which the upper air climate in line format is going to be created, has to be specified. Then PREPCLI asks how many variables of the six available are to be converted from spherical harmonics to line form either on regular or Gaussian latitudes. The line format is explained in Appendix C.2. The codes of the variables must be specified and they are exactly the same as used in the post processing:

1 - geopotential height

2 - temperature

7 - vertical velocity

10 - vorticity

27 - divergence

29 - relative humidity.

Codes can be specified in any order but they must be separated by commas, e.g., 1,2,29 if geopotential, temperature and humidity are processed.

The user must declare the number of levels required (1 to 13) and then the pressure level values in pascals. The order of levels is irrelevant, but they must be specified in the same way as the field codes, i.e., levels should be separated by commas. PREPCLI will ask the user to check the input line, thus, if an error occurred there is always a possibility to correct it. If all 13 levels required, then there is no need to type-in their values.

The job PLOTUAC, which can be found in the fileset EXP_SEQ, may be used or adapted to read and plot converted fields. In Section 4.10 an account of how to use this job is given.

4.7 How to create the surface fields climate

As for the US Navy summary, there is no need to create surface fields climate for operational use. However, if any of the defaults are going to be replaced by user-defined parameters or user's input datasets, then PREPCLI must be run in mode 2 ('for more general climate datasets'). The file labeled SFCLIMT106 on tape 10168A contains current operational surface fields climate. This, or any other tape containing surface fields climate, consists of 10 files in the following order: orography, surface soil temperature, roughness length, surface soil moisture, snow depth, albedo, mid-layer soil temperature, mid-layer soil moisture, deep-layer soil temperature and deep-layer soil moisture. The data are in the transparent format (DF=TR). To read any of the 10 files, the dataset must be split using the COPYF directive and the Fortran program has to contain the sequence of subroutine calls described in Appendix B.2. A convenient way of reading the surface climate field is to run the job PLOTSFC which can be found in the user's local fileset EXP_SEQ at the end of PREPCLI session when the creation of the surface climate dataset is requested (see Section 4.10).

It must be pointed out that creation of the surface fields climate dataset depends on the availability of the corresponding US Navy summary dataset. In the other words, the user may require the creation of the surface fields climate, but actual execution will not be possible unless the US Navy summary is available. In fact, PREPCLI will ask the user whether the summary is at its disposal. If so, the session continues normally; if not, PREPCLI will degrade the user's requirement to the level of the US Navy summary creation.

While running PREPCLI for the surface fields climate creation, the user will come across the questions relating to the orography treatment and to the replacements of input (or original climate) datasets. The orography type default is 1σ (σ is a standard deviation) envelope orography regardless of the user-defined resolution. But it can be easily altered to either a mean orography or to an envelope orography different from the default. In this case the user has to specify the amount of standard deviation to be added to the mean heights. For example, if the $\sqrt{2}\sigma$ envelope orography needed, the user will enter 1.41421.

The next question asked by PREPCLI is to define the radius of the Gaussian filter RG in metres. Defaults are as follows: for the T106 resolution RG=50000, for N48 RG=100000, and for all others RG=0.

If the T resolution is chosen then, by default, the orography will be spectrally fitted. But if the user does not want this to happen it can be easily avoided by typing 'N' when questioned. No spectral fit will be applied for any regular grid resolution.

The next five questions are related to the user's intentions about the input original climate datasets. At the moment, any of the following five original climate datasets (described in Section 2) can be replaced with the user's ones: surface soil moisture, sea surface temperature, precipitation, albedo and roughness length due to vegetation. As mentioned earlier, if substitution is going to happen then the input file must be formated so that it is compatible with the other files within the climate system. In addition, the user-defined SST input dataset should contain the sea ice information in a form similar to that described for the RAND SSTs, otherwise procedures for deriving surface temperature and albedo must be modified; see Appendices B and C about how the compatibility can be achieved.

Finally, the user must declare the target tape VSN, to which the surface fields climate will be written.

4.8 How to create the cold start climate

As mentioned in Section 3.4 the cold start climate dataset will be automatically created when producing the data assimilation climate, and it will be written to the data assimilation climate tape. On the other hand it may be created independently and then it is stored to the TEMP pack. In fact, two files will be stored with the file names SP_MON and G3_MON, where MON stands for the first three characters of the month the cold start climate is required for. The SP_MON file is in spectral form and G3_MON is defined on the model grid, as described in Section 3.4. The id of the files will be of the form UID_SEQ.

It is not possible to create a cold start climate without having already created the surface fields climate. For the operational cold start climate the tape containing operational surface fields climate may be used (by default), but the user may specify his own tape, again in Cray text string a format of up to 70 characters including single quotes. If running PREPCLI for non-operational purposes, the user must quote a Cray text string for acquiring the tape with surface climate.

The next question asked by PREPCLI is about the spectral pressure level climate. The user has an option either to use the system default or to supply his own tape.

It is not possible to create the cold start climate for an N resolution.

The reader is reffered to Louis (Ed.), 1985 (Section 6), for how to read the cold start files.

4.9 How to create the data assimilation climate

As for the cold start climate, the first three characters of the month the user wants to create the data assimilation climate for, has to be specified. Any of the following default datasets may be replaced by the user: surface fields climate, spectral pressure climate and N48 pressure climate. After the default tape VSN has been quoted by PREPCLI, the user may by typing 'GO' accept a default tape; alternatively by typing the Cray text string in the way descibed earlier, he can enforce the use of a tape provided by him. The first two input tapes relate to the cold start climate creation (see Section 4.8), and the third relates to the N48 pressure levels climate.

The data assimilation climate dataset cannot be realized without having these three climates at its disposal. Usually, both spectral and N48 pressure levels climates would be used by defaults, but the user has the freedom of replacing any of them by his own datasets. Then, it is the user's responsibility to create these datasets in a form required by the data assimilation suite. Similarly, the default surface fields climate may be replaced by the user, but in this case the climate system will take care of the creation of a compatible dataset.

4.10 Jobs created by PREPCLI

When the PREPCLI session terminates properly at least three batch jobs will be generated and placed in the local fileset EXP_SEQ. The exception is when PREPCLI finds there is no need for batch jobs to be created, since the required climate already exists. That could be, for instance, when the user requests the creation of the US Navy summary for prestored resolution. Then, PREPCLI will terminate by warning the user that there is no need to create the requested dataset. If that is the case, fileset EXP_SEQ contains no elements and it will not be placed in the permanent fileset PREPSET,ID=DIC, and therefore there is no increase in sequence number.

Otherwise, the jobs JOBS, JOBY and JOBX will be stored in the EXP_SEQ. JOBS simply starts the execution of the sequence of batch jobs. It retrieves JOBY from group UID_SEQ/EXP_SEQ from PREPSET and directs it to the input queue. JOBY is a Cyber procedure, and it retrieves Fortran and JCL libraries, updates them and possibly merges them with the update correction sets (see Section 4.3). Compile files are written to the TEMP pack. Note that the file containing Cray JCL is called a compile file, although it does not contain Fortran code. Subsequently, JOBY fetches JOBX from UID_SEQ/EXP_SEQ in PREPSET and then terminates. There is no output from JOBS and from JOBY if completed successfully. JOBX is a Cray job and it consists, basically, of two parts. In the first part the Fortran source (compile file) is retrieved from the TEMP pack and compiled, relevant libraries for the Cray tasks are acquired and the user-defined resolution is considered. In the second part the required climate dataset is created and stored. Thus, this second part corresponds to one of the tasks described in the subsections of Section 3.

Optionally, when the US Navy summary or surface fields climate or upper air climate in line format are needed, the jobs PLOTUSN, PLOTSFC or PLOTUAC may exist among other files in EXP_SEQ. They might be used for plotting the global field of mean heights from the US Navy summary, for plotting some of the surface fields or for reading and plotting any upper air field from the ECMWF climate system. The user may modify these jobs according to his own needs. PLOTUSN, PLOTSFC and PLOTUAC will not be submitted automatically.

The grid on which global fields will be plotted is always assumed to be a regular grid (regular matrix required by plotting package). Thus, if the user defines a T resolution, there will be some distortion in the north-south direction since Gaussian latitudes are not regular. For T106 such a distortion is negligible, but for very low resolutions (T21, for instance) it might be significant. It is the user's responsibility to adapt data to the nearest regular latitudes if a proper representation is wanted.

In calling subroutine LAREA1, the geographical coordinates of the bottom left and upper right corners of the global map are given as variables which can be easily replaced by the user. These corner points, as found in CYMPLT subroutine, relate to the T106 resolution.

All JCL parameters in PLOTUSN, PLOTSFC and PLOTUAC that need to be replaced are indicated as X's. The user has to replace his/her id, account and tape VSN for the tape containing the derived climate. The file label should be replaced according the resolution used. At the beginning of the PLOTSFC the user might wish to replace the month indicator IMON accordingly; it is set for January.

In the Fortran part of PLOTUSN, PLOTSFC and PLOTUAC the user should replace KLON and KLAT in the PARAMETER statement to be consistent with the variables NLON and NGL from the corresponding job JOBX (which can be found in the same personel fileset EXP_SEQ).

4.11 Job submission

JOBS described in the previous section will be, by default, submitted automatically when PREPCLI terminates. However, if the user wants to inspect or modify any of files from his/her local EXP_SEQ, non-automatic submisson must be chosen. After modification jobs/files should be replaced into local fileset EXP_SEQ and the EXP_SEQ should be replaced into permanent fileset PREPSET,ID=DIC. It is important to follow this, otherwise no subsequent modifications will be contained in the PREPSET, i.e., jobs/files will remain unchanged as created during the PREPCLI session. To run batch jobs after inspection or modification, it is sufficient to submit JOBS only.

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REFERENCES

Alexander, R.C. and R.L. Mobley, 1974: Monthly average sea-surface temperatures and ice-pack limits for 1° global grid. RAND Rep. R-1310-ARPA, 30 pp.

Baumgartner, A., H. Mayer and W. Metz, 1977: Weltweite Verteilung des Rauhigkeitsparameters z_0 mit Anwendung auf die Energiedissipation an der Erdoberfläche. Meteor.Rundschau., 30 , 43-48.

Chang, J.-H., 1957: Global distribution of the annual range in soil temperature. Transactions, Amer.Geophys.Union, 38 , 718-722.

Crutcher, H.L. and J.M. Meserve, 1970: Selected level heights, temperatures and dew points for the Northern Hemisphere. NAVAIR Atlas 50-1C-52, 132 pp. [Goverment Printing Office, Washington, DC.]

Cuming, M.J. and B.A. Hawkins, 1979: Preliminary description of the FNWC system for terrain data extraction and processing. Meteor.Internat.Incorporated Project M-245-05, 20 pp.

Dewey, K.F. and R. Heim, Jr., 1982: Variations in Northern Hemisphere snow cover utilizing digitized weekly charts from satellite imagery, 1967-1980. Proceedings of the 6th Annual Climate Diagnostics Workshop, Palisades, N.Y., 157-165.

Geiger, R., 1973: The climate near the ground. Harvard University Press, Cambridge, Mass., 611 pp.

Geleyn, J.F. and H.J. Preuss, 1983: A new data set of satellite-derived surface albedo values for operational use at ECMWF. Arch.Meteor.Geophys.Bioclim., Ser.A, 32 ,353-359.

Jaeger, L., 1976: Monatskarten des Niederschlages für die ganze Erde. Berichte des Deutschen Wetterdienstes 139 , 38 pp.

Knittel, J., 1976: Ein Beitrag zur Klimatologie der Stratosphäre der Südhalbkugel. Meteor.Abh., Freie Univ.Berlin, N.F., Ser.B, Bd 2.1.

Joseph, D., 1980: Navy 10' global elevation values. NCAR notes on the FNWC terrain data set, 3 pp.

Louis, J.F. (Ed.), 1984: ECMWF forecast model, Physical parameterisation. Research Manual 3, ECMWF Res.Dept.

Louis, J.F. (Ed.), 1985: ECMWF forecast model, Adiabatic part. Research Manual 2, ECMWF Res.Dept.

Lonnberg, P. and D. Shaw (Eds.), 1983: ECMWF data assimilation, Scientific Documentation. Research Manual 1, ECMWF Res.Dept.

Mintz, Y. and Y. Serafini, 1981: Global fields of soil moisture and land-surface evapotranspiration. NASA Goddard Space Flight Center Tech.Memo. 83907, Research review - 1980/81, 178-180.

Preuss, J.H. and J.F. Geleyn, 1980: Surface albedos derived from satellite data and their impact on forecast models. Arch.Meteor.Geophys.Biocl., Ser.A, 29, 345-356.

Taljaard, J.J., H. van Loon, H.L. Crutcher, and R.L. Jenne, 1969: Climate of the upper air, Part 1 - Southern Hemisphere; Temperatures, dew points and heights at selected pressure levels. NAVAIR Atlas 50-1C-55, 135 pp. [Goverment Printing Office, Washington, DC.]

Tibaldi, S. and J.F. Geleyn, 1981: The production of a new orography, land-sea mask and associated climatological surface fields for operational purposes. ECMWF Tech.Memo.No.40, 13 pp.

APPENDIX A - Resolution file for the regular grid

To create a resolution file for any N resolution, the following parameters must be specified:

- number of latitude rows NLAT (NLAT=2*NR+1, where NR stands for N resolution, e.g., NR=18)
- number of longitudinal points NLON at each latitude row (NLON=2*(NLAT-1))

Thus, for the regular N18 resolution we have NR=18, NLAT=37 and NLON=72. The file should be created with formatted WRITE, and the job shown overleaf serves as a guide to how it should be done.

Array NLON(NLA) specifies the number of longitude points for each regular latitude. Array ARES(3,NLA) specifies for each latitude: - ARES(1,NLA) latitude - ARES(2,NLA) initial longitude (usually Greenwich) - ARES(3,NLA) ending longitude

It is important to utilize the WRITE statements with exactly the same formats as shown above, because the resolution file is read by formatted READ.

```
XXX,T1,STCRA.  CRRESN - CATALOG N RESOLUTION FILE
ACCOUNT,XXXXXX.
CFT.
ASSIGN,DN=RESN18,A=FT61.
LDR.
DISPOSE,DN=RESN18,ID=XXX,DF=CB,MF=CY,DC=ST,
        TEXT='MOUNT,SN=TEMP,VSN=TEMP01.'
             'REQUEST,Z,SN=TEMP.'
             'CATALOG,Z,RESN18,ID=XXX,SN=TEMP.'.
*EOR
      PROGRAM CRRESN
C        CREATE N18 RESOLUTION FILE
      DIMENSION NLON(37), ARES(3,37)
      OPEN(61,FILE='RESN18',STATUS='NEW')
      NLAT=37
C
      DO 1 JLAT=1,NLAT
      NLON(JLAT)=72
      ARES(1,JLAT)=95.-5.*JLAT
      ARES(2,JLAT)=0.0
      ARES(3,JLAT)=355.0
    1 CONTINUE
C
      WRITE(61,'(I5)') NLAT
      WRITE(61,'(I20,3F20.10)')
     + (NLON(JLAT),(ARES(JPT,JLAT),JPT=1,3),JLAT=1,NLAT)
      CLOSE(61,STATUS='KEEP')
      STOP
      END
```

APPENDIX B - I/O subroutines

B.1 I/O subroutines library

The I/O routines described below can be found in the update program library CLIOPL,ID=DIC. It is not possible to modify any of these routines via an update correction set while running PREPCLI. They are used for reading/writing of surface fields and original climate datasets. By using them it is ensured that all fields are in a common format. Therefore the files can be read by any program in the climate suite, whatever the resolution might be.

B.2 Subroutines for reading

To read a surface field or any original climate dataset the following I/O subroutines have to be called, with the arguments defined in B.4:

```
CALL GTHDR (KU, KDDR, PDDR)
```

Read data descriptor records (ddrs) KDDR and PDDR from unit KU. This routine should be called first, before any other GT--- subroutine.

```
CALL GTVAR (KDDR, PDDR, KVAR)
```

Obtain variable code.

```
CALL GTRES (KDDR, PDDR, KLAT, KLONG, PWLTNL)
```

Obtain resolution.

```
CALL GTLSM (KDDR, PDDR, PLS, KADIM1, KADIM2)
```

Obtain land/sea mask.

CALL GTFLD (KDDR, PDDR, PAA, KADIM1, KADIM2)

Read the next global field. If the field does not change in the course of a year, this subroutine should be called once, otherwise the subroutine should be called 12 times, corresponding to the 12 months Jan, ..., Dec.

B.3 Subroutines for writing

To write a surface field or any user-defined climate dataset the following I/O subroutines have to be called, with the arguments as defined in B.4:

CALL PTHDR (KU, KDDR, PDDR)

Initialise the data desriptor records in preparation for writing to Fortran unit KU. This routine should be called before any other PT--- routine.

CALL PTVAR (KDDR, PDDR, KVAR)

Write variable code.

CALL PTRES (KDDR, PDDR, KLAT,KLONG PWLTNL)

Write resolution.

CALL PTLSM (KDDR, PDDR, PLS, KADIM1, KADIM2)

Write land/sea mask.

CALL PTFLD (KDDR, PDDR, PAA, KADIM1, KADIM2)

Write the next global data field. If the field is constant in the course of the year, there should be one call to this subroutine, otherwise there should be 12 calls corresponding to the 12 months Jan, ..., Dec.

B.4 Arguments of the subroutines

KU	Unit number for reading or writing.
KDDR	Array containing integer variables (first ddr, see B.5)
PDDR	Array containing real variables (second ddr, see B.5)
KVAR	Indicator for meteorological variable in the file (field code). Where possible, the number used is the same as is used in the post processing. A complete list of the numbers used is included in B.5.
KLAT	Number of latitude rows.
KLONG	Array with dimension KLAT. Element KLONG(JLAT) contains the number of longitude points in latitude row JLAT.
PWLTNL	Array with dimension (3,KLAT). PWLTNL(1,JLAT) contains the latitude of row JLAT. PWLTNL(2,JLAT)contains the longitude of the first point of row JLAT. PWLTNL(3,JLAT) contains the longitude of the last point of row JLAT.
PLS	Array with declared dimension (KADIM1,KADIM2), containing the land/sea mask information. The elements of PLS actually used are PLS(JLON,JLAT), with JLAT=1,...,KLAT, JLON=1,...,KLONG(JLAT).
PAA	Array with declared dimension (KADIM1,KADIM2), containing an arbitrary surface field. The elements of PAA actually used are PAA(JLON,JLAT), with JLAT=1,...,KLAT, JLON=1,...,KLONG(JLAT).

Note: It is advisable to specify fields dimensions at least as large as KADIM1=320 and KADIM2=160, which is the appropriate size for the T106 resolution.

B.5 The content of the ddr's

(1) First ddr, containing integer variables only :

Word	Description
1	length of first ddr (600)
2	length of second ddr (600)
3	date of creation of the file
4	time of creation of the file
5	indicator for meteorological variable (field code)
6	land/sea mask indicator:
	0 no land/sea mask information in the file
	1 record 3 is land/sea mask
7	number of data records after ddr's and land/sea mask
8 to 10	not allocated
11	number of latitude rows KLAT
12 to 12+KLAT-1	number of longitude points in each latitude row.
598	number of records already read or written
599	unit number for reading or writing
600	indicator to show that GTHDR or PTHDR has been called

(2) Second ddr, containing real variables only :

Word	Description
1 to 3*KLAT	latitude/longitude table NWLTNL

B.6 Variable codes

1 - surface geopotential

6 - surface pressure

11 - surface temperature

12 - surface soil moisture

13 - snow depth

14 - large scale rain

15 - convective rain

16 - snow fall

17 - vertical dissipation

18 - surface sensible heat flux

19 - latent heat flux

36 - cloud cover

37 - 10 metre u

38 - 10 metre v

39 - 2 metre temperature

40 - 2 metre dew point temperature

42 - mid-layer soil temperature

43 - mid-layer soil moisture

44 - land/sea mask

45 - surface roughness

46 - albedo

47 - emissivity

48 - surface solar radiation

49 - surface thermal radiation

50 - top solar radiation

51 - top thermal radiation

52 - u stress

53 - v stress

54 - evaporation

55 - deep-layer soil temperature

56 - deep-layer soil moisture

101 - urbanisation

APPENDIX C - Dataset formats

During a run of the climate system there are many intermediate datasets, i.e., datasets with intermediate results. For simplicity, it is desirable to have as few dataset formats as possible. Just before the datasets are output by the system they are converted into different formats, e.g. the cold start dataset has to be in format acceptable to the analysis.

The intermediate datasets range from the original compatible climates to the surface field climate datasets, and all of them have the same format. In these datasets the variables are stored as fields, one record corresponding to one global field, and each variable is stored in a dataset of its own (there is no mixing of different varaibles).

Other datasets, such as original non-compatible climates as received at the ECMWF or data assimilation files have formats different from the intermediate datasets. They are described in the original documentation and in the ECMWF Research Department Manuals.

This appendix deals with the formats of the intermediate datasets and of the upper air line formatted climate.

C.1 Intermediate dataset format

The three header records precede either twelve data records or one data record, depending whether or not the variable changes during the course of the year. An intermediate dataset could be read by using the sequence of routines described in B.2.

The dataset structure can be depicted as follows:

Record no.	Description
1	first data descriptor record (integers only)
2	second data descriptor record (reals only)
3	land/sea mask for the dataset resolution
4 or 4 to 15	data record(s) - global fields

The land/sea mask for each intermediate dataset is derived from the US Navy data for the original resolution of that particular variable. For instance, the original soil moisture compatible climate dataset contains the land/sea mask as the third record defined on 4x5 degree of lat/long grid.

The data record contains the data stored in a form of NLAT latitude lines each contining NLON longitude points, starting from the northernmost latitude. NLAT, NLON and other resolution dependent parameters are stored in the first two header records as described in B.5.

C.2 Line format of the upper air climate

The line format is in principle the grid point format but the variables are not in the form of global horizontal fields. They are vertical 'fields' and each data record corresponds to one latitude line. That means that for T106 resolution there are 160 data records plus 4 descriptor record preceding data records. The descriptor records are explained in Louis (Ed.), 1985.

Each data record contains one latitude of varaible A at the first pressure level, then variable A at the second level, and so on up to the top pressure level; then variable B at the first level, variable B at the second level and so on.

ANNEX - Operational surface fields climate

This Annex contains the plots of the global operational surface fields.

Mid-layer and deep-layer soil moisture are not shown, since they are the same as the surface soil moisture.

A1 Terrain heights (m). Contour interval is 500 m.

A2 Surface temperature (degrees Celsius). Contour interval is 5 degrees.

A3 Mid-layer soil temperature (degrees Celsius). Contour interval is 5 degrees.

A4 Deep-layer soil temperature (degrees Celsius). Contour interval is 5 degrees.

A5 Snow depth (cm). Contour interval is 50 cm, but isoline showing 25 cm of snow depth is drawn also. Dotted areas denote perpetual snow. 1 cm of snow depth corresponds to 1 mm of water equivalent.

A6 Soil moisture (percentage). Contour interval is 10%. Satured soil (100%) is shown by dotted areas.

A7 Albedo (percentage). Contour interval is 10%.

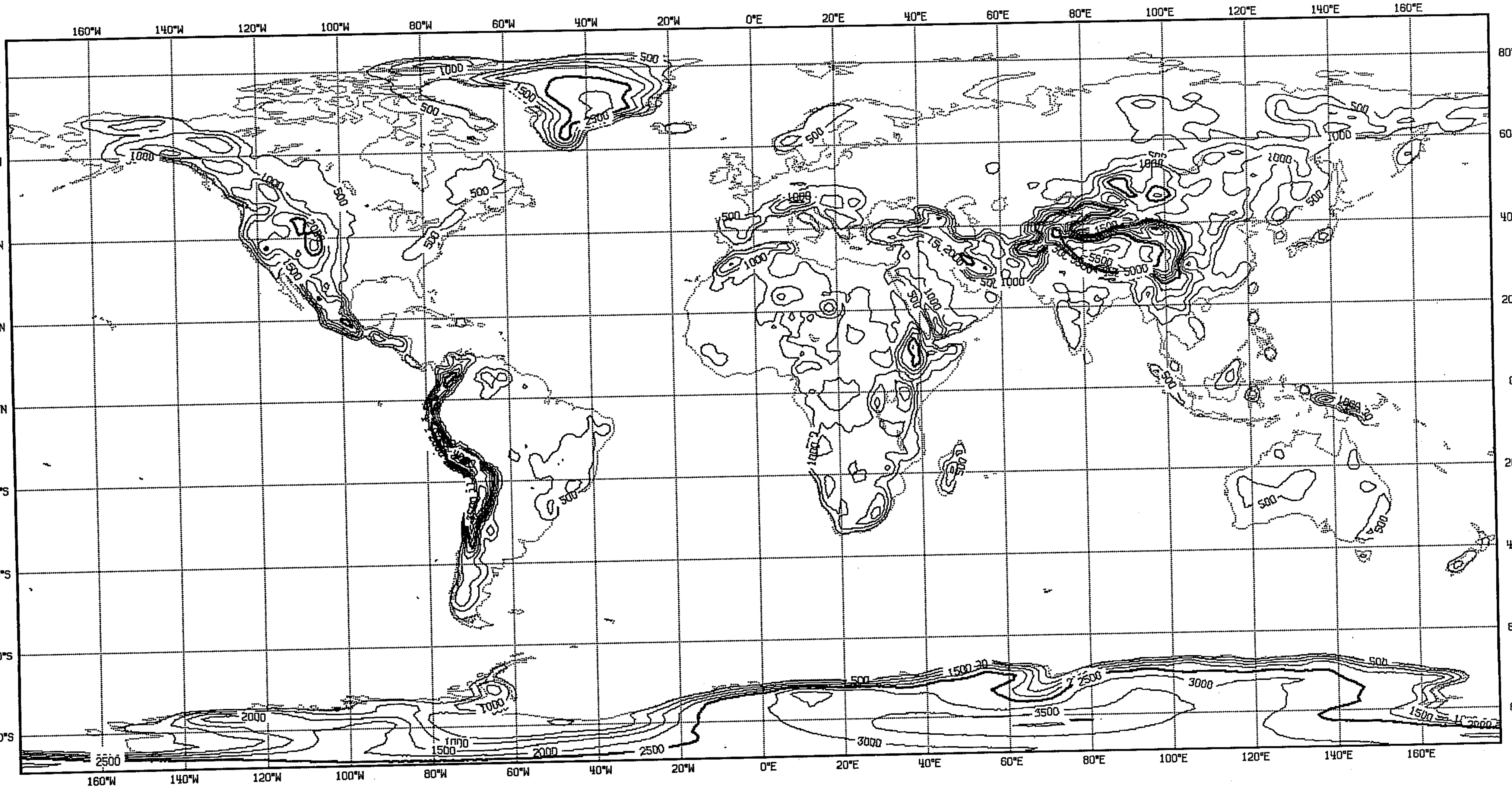
A8a Roughness length up to 50 cm with contours of every 10 cm. Dotted areas denote Z_0 values greater than 50 cm.

A8b Roughness length from 50 cm to 5 m with contours of every 50 cm. Dotted areas denote Z_0 values between 5 m and 20 m.

ANNEX A1

Terrain heights

A1 Terrain heights (m). Contour interval is 500 m.



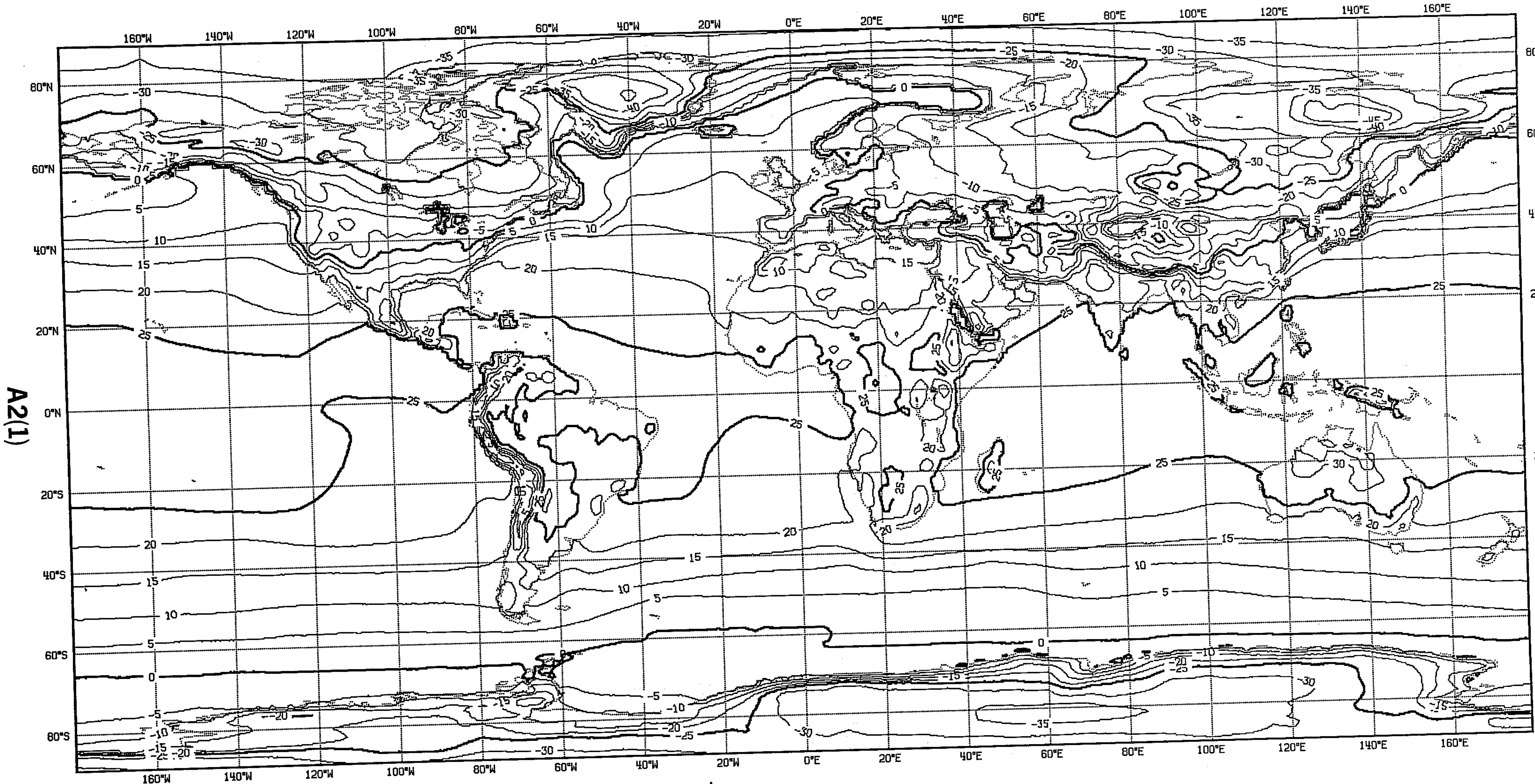
TERRAIN HEIGHTS

ANNEX A2(1) - A2(12)

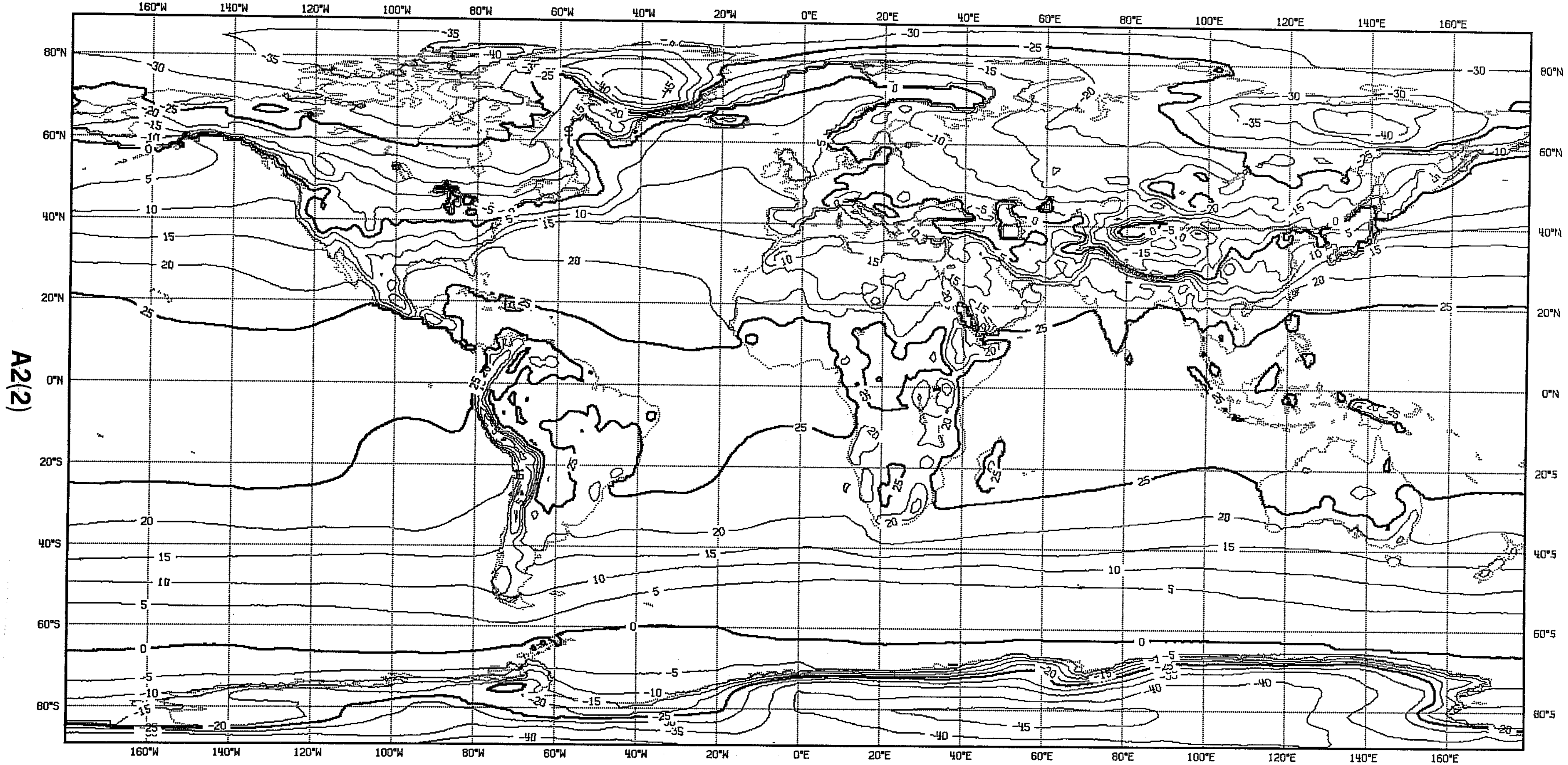
Surface temperature

A2 Surface temperature (degrees Celsius). Contour interval is 5 degrees.

A2(1)

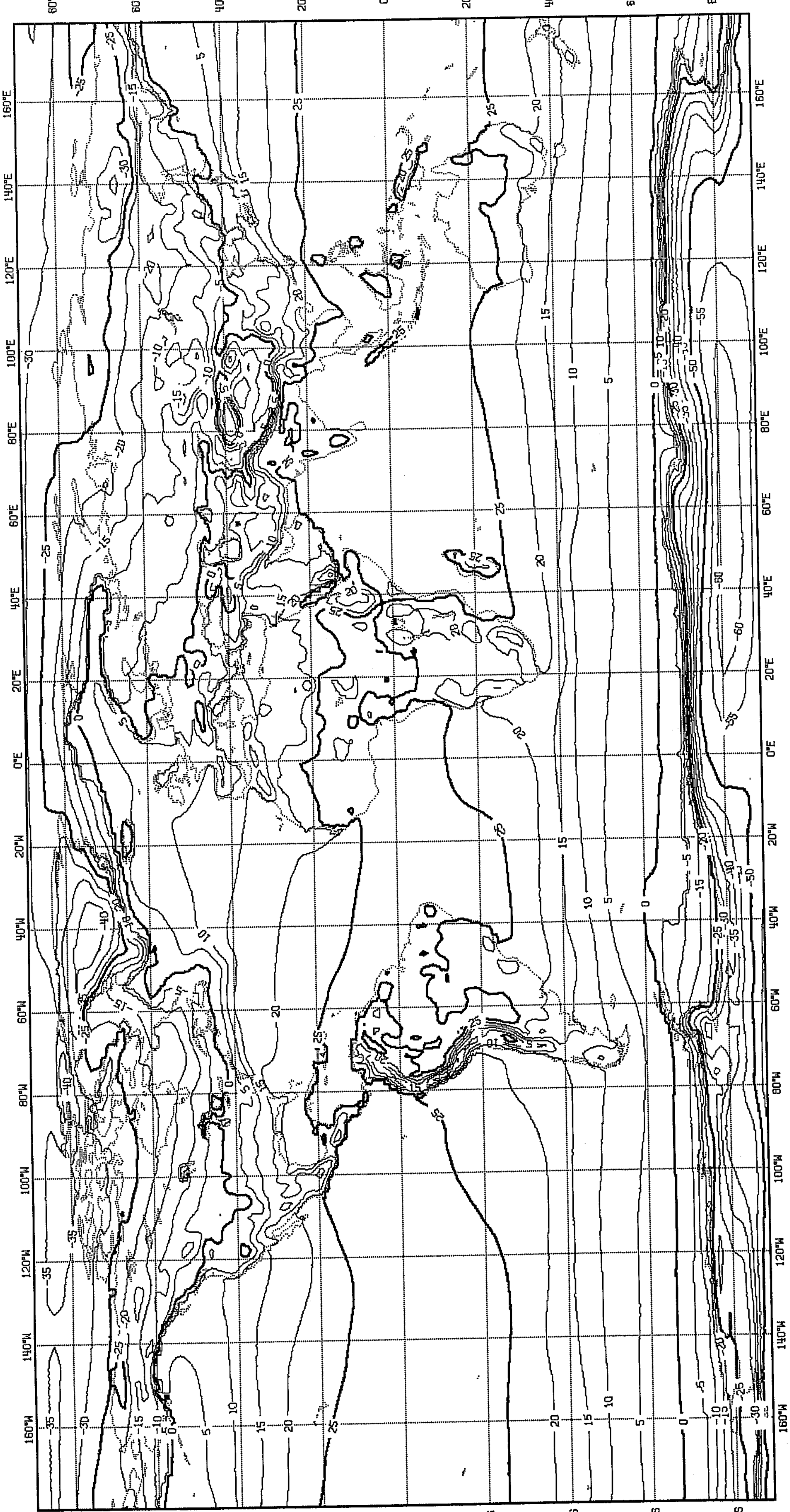


SURFACE TEMPERATURE MONTH 1



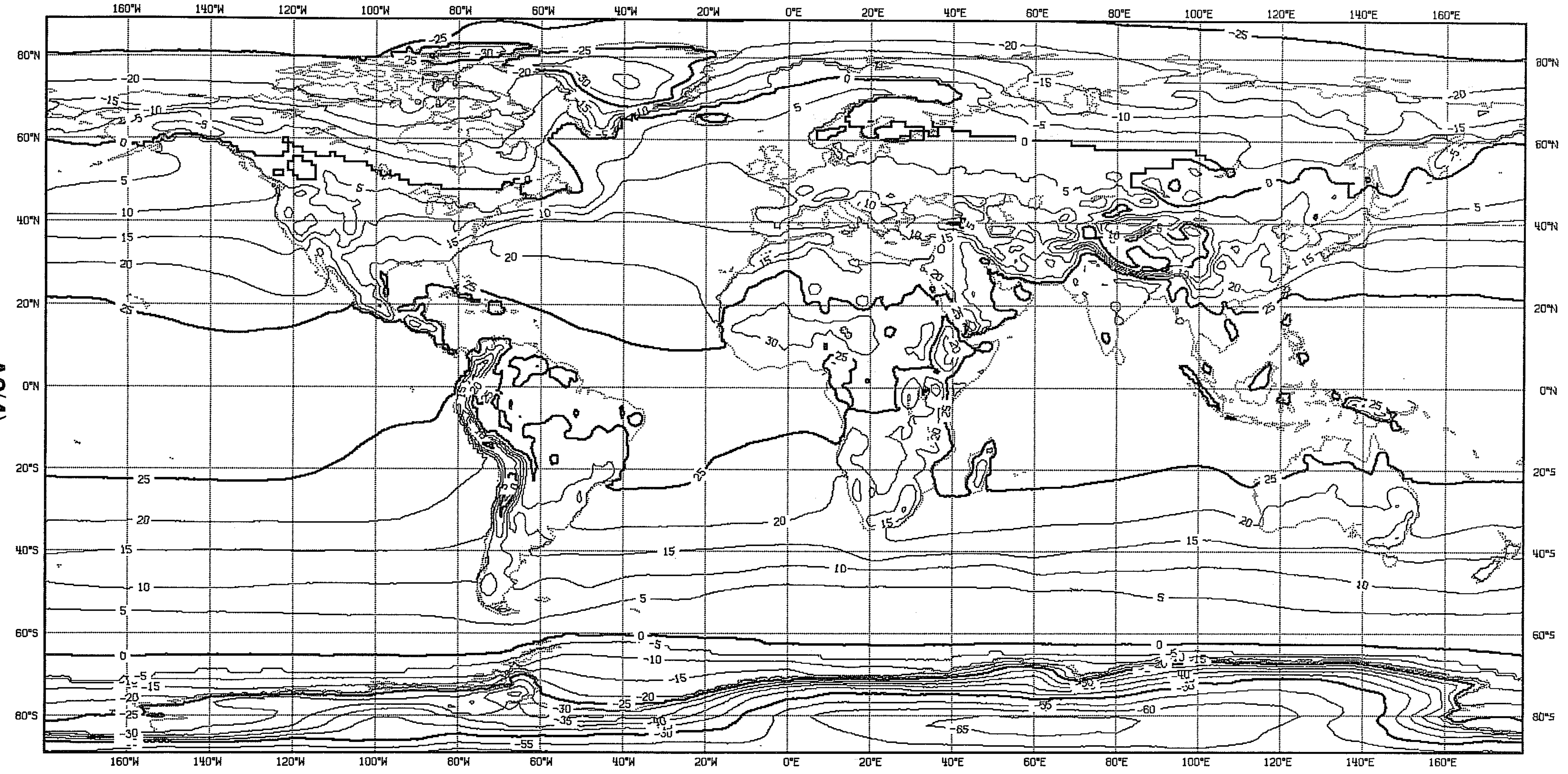
SURFACE TEMPERATURE MONTH 2

A2(2)



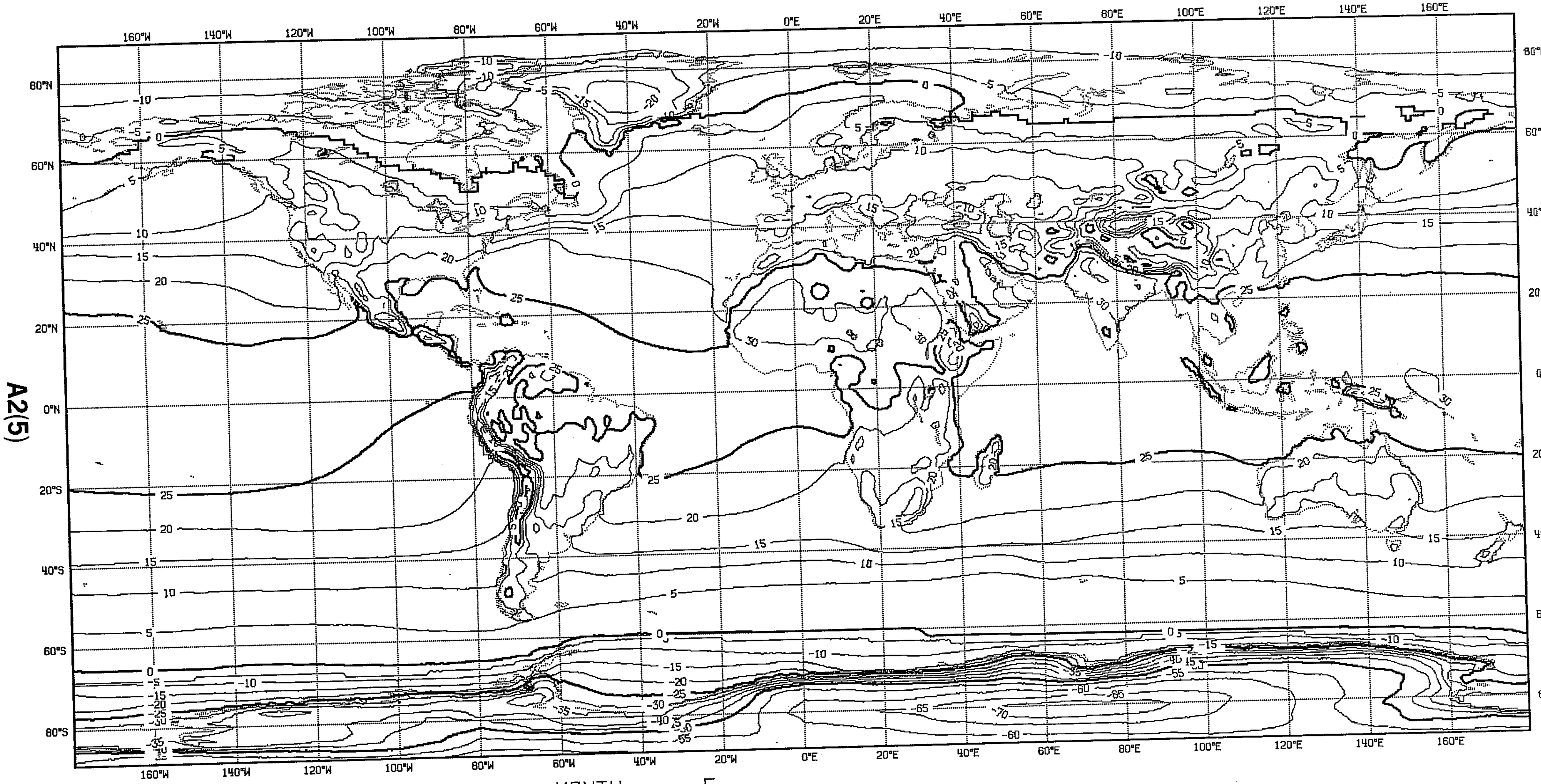
SURFACE TEMPERATURE MONTH 3

A2(3)

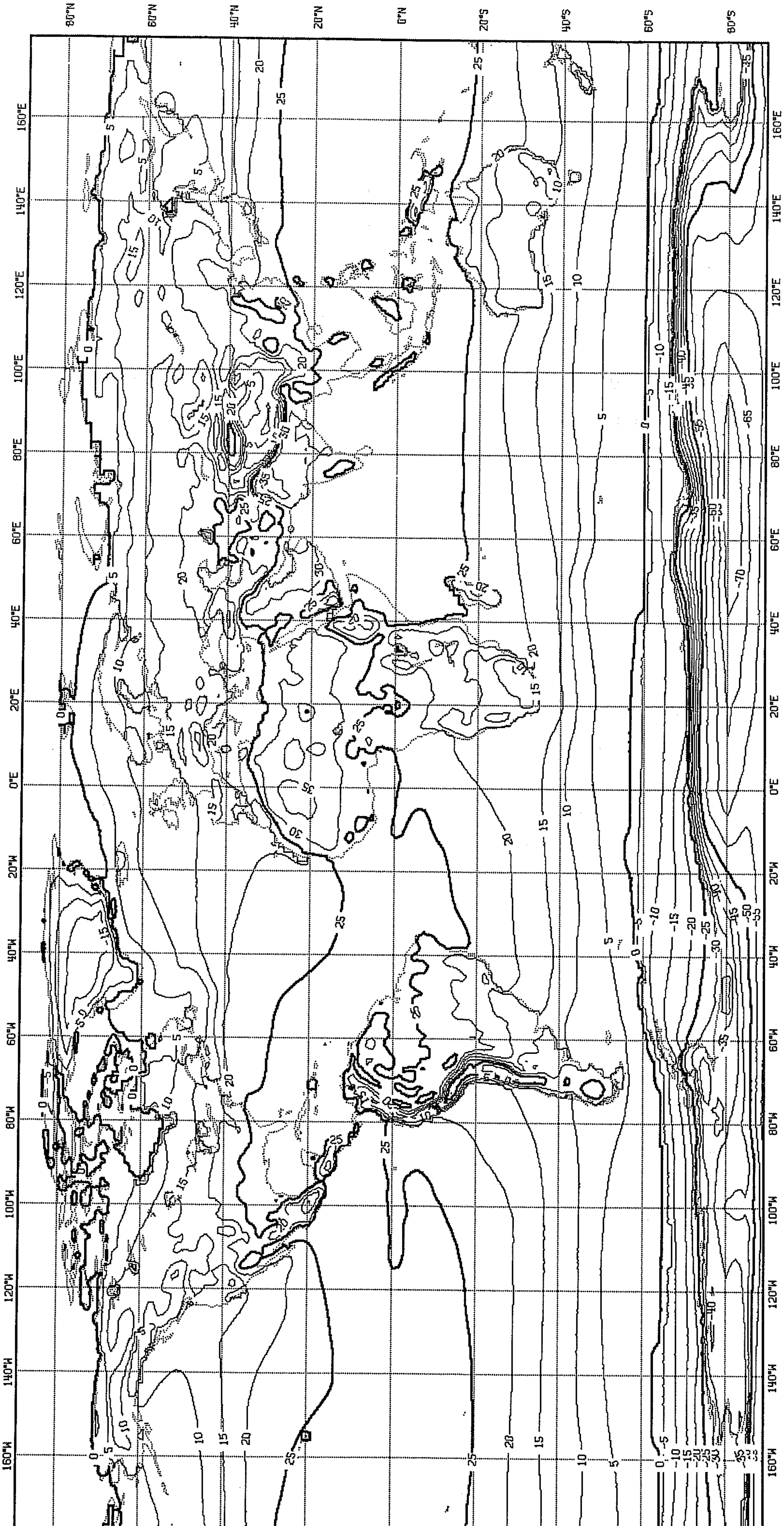


SURFACE TEMPERATURE MONTH 4

A2(5)

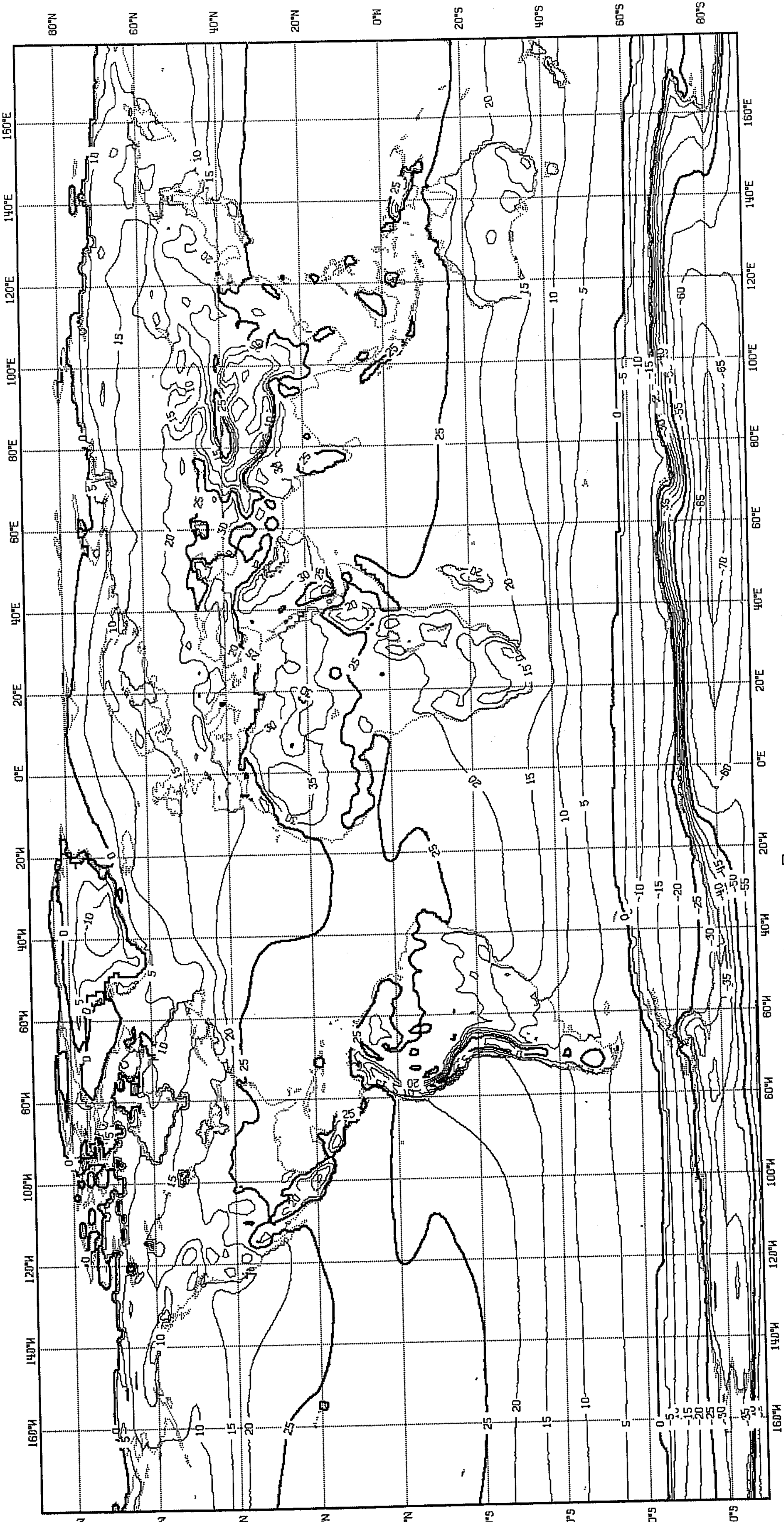


SURFACE TEMPERATURE MONTH 5



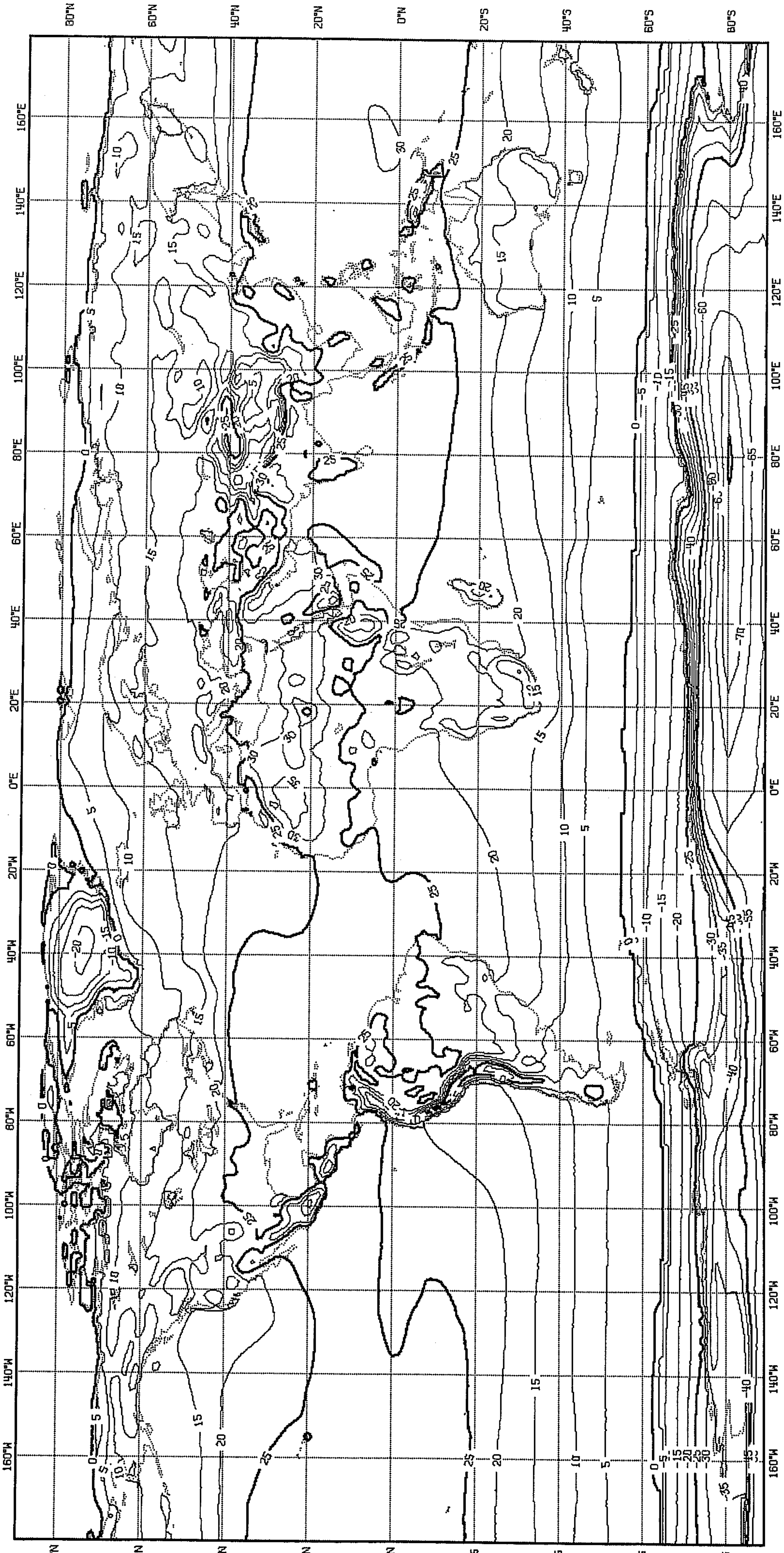
SURFACE TEMPERATURE MONTH 6

A2(6)

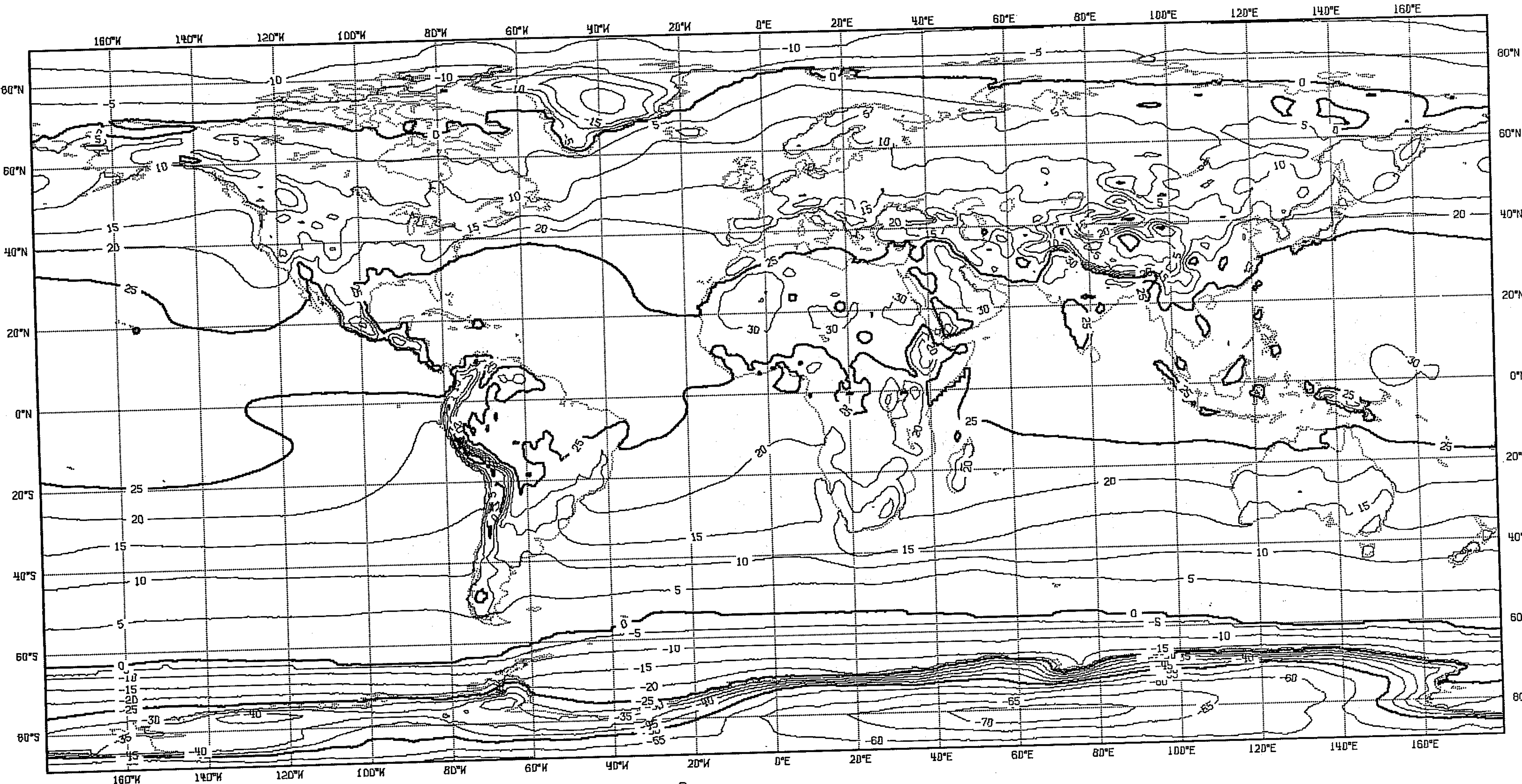


SURFACE TEMPERATURE MONTH 7

A2(7)



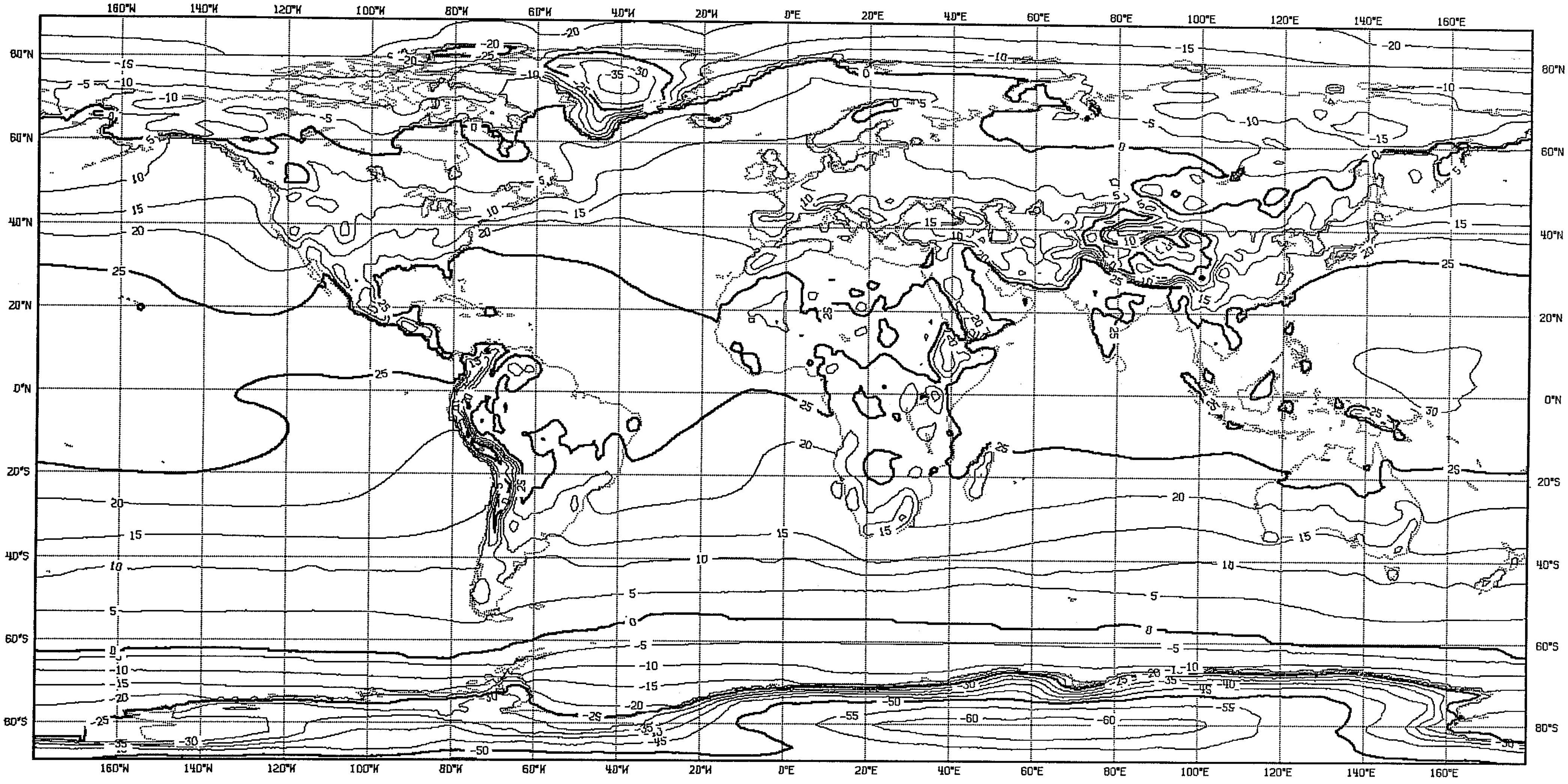
SURFACE TEMPERATURE MONTH 8



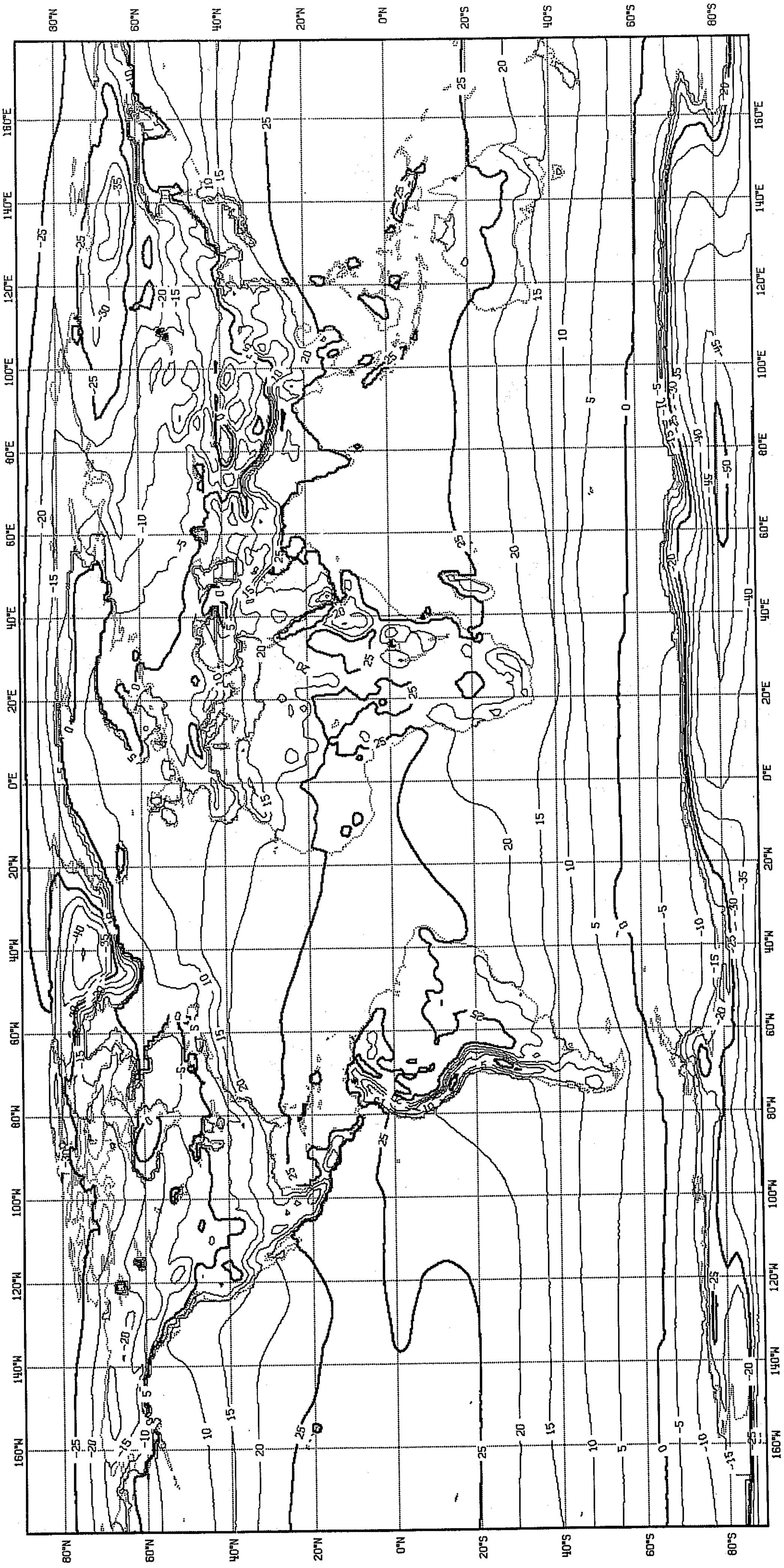
SURFACE TEMPERATURE MONTH 9

A2(9)

A2(10)

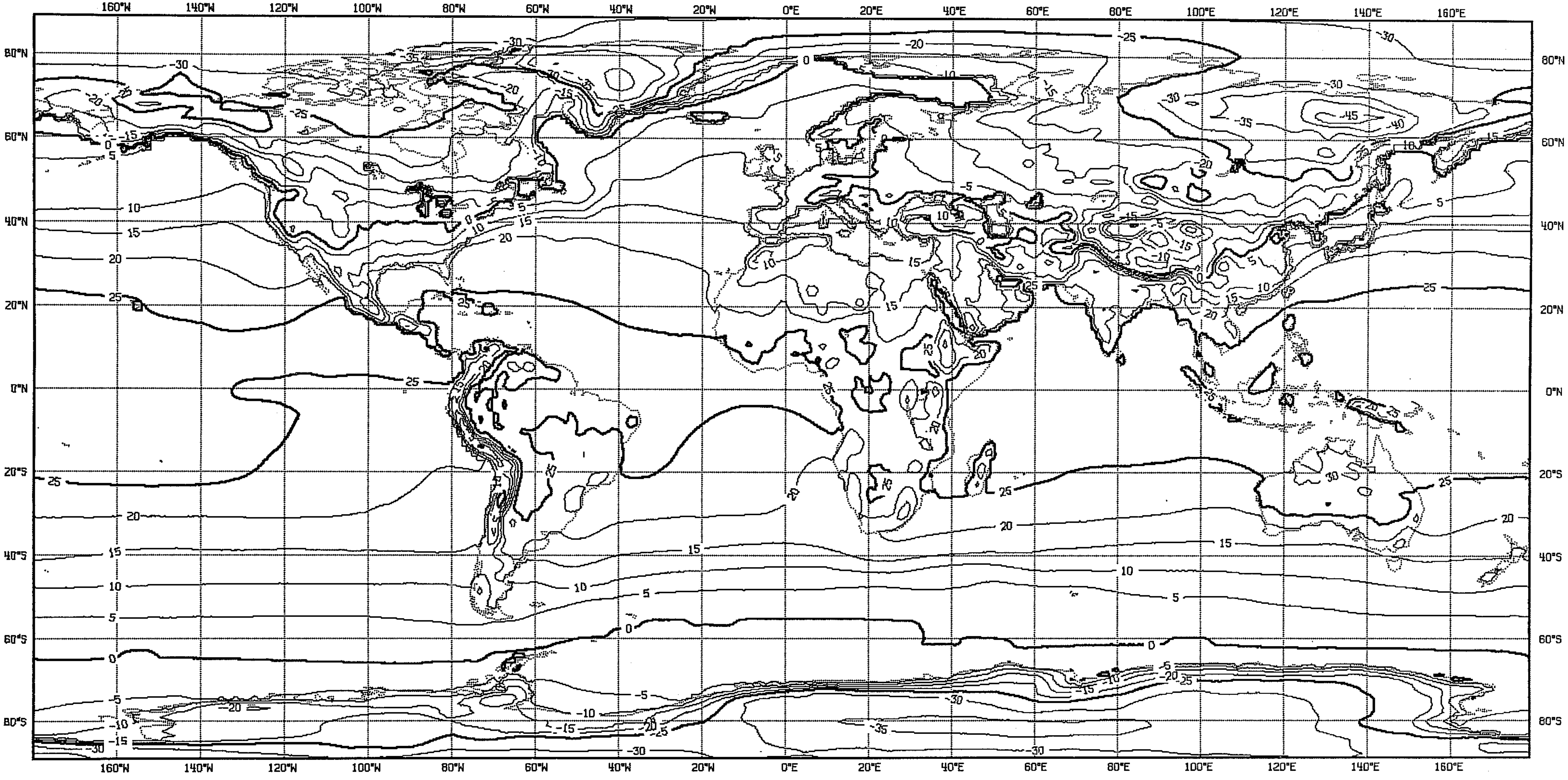


SURFACE TEMPERATURE MONTH 10



SURFACE TEMPERATURE MONTH 11

A2(11)



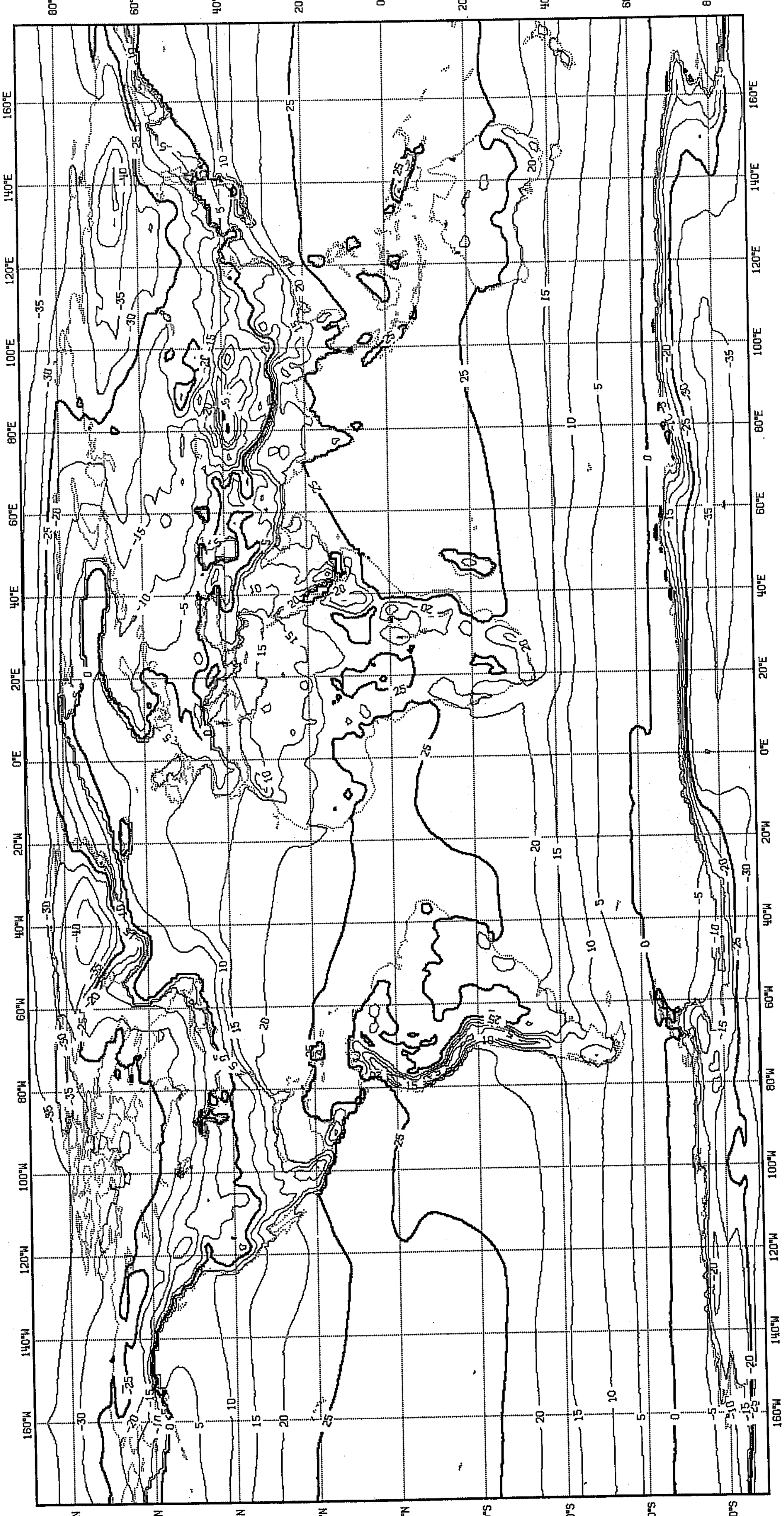
SURFACE TEMPERATURE MONTH 12

A2(12)

ANNEX A3(1) - A3(12)

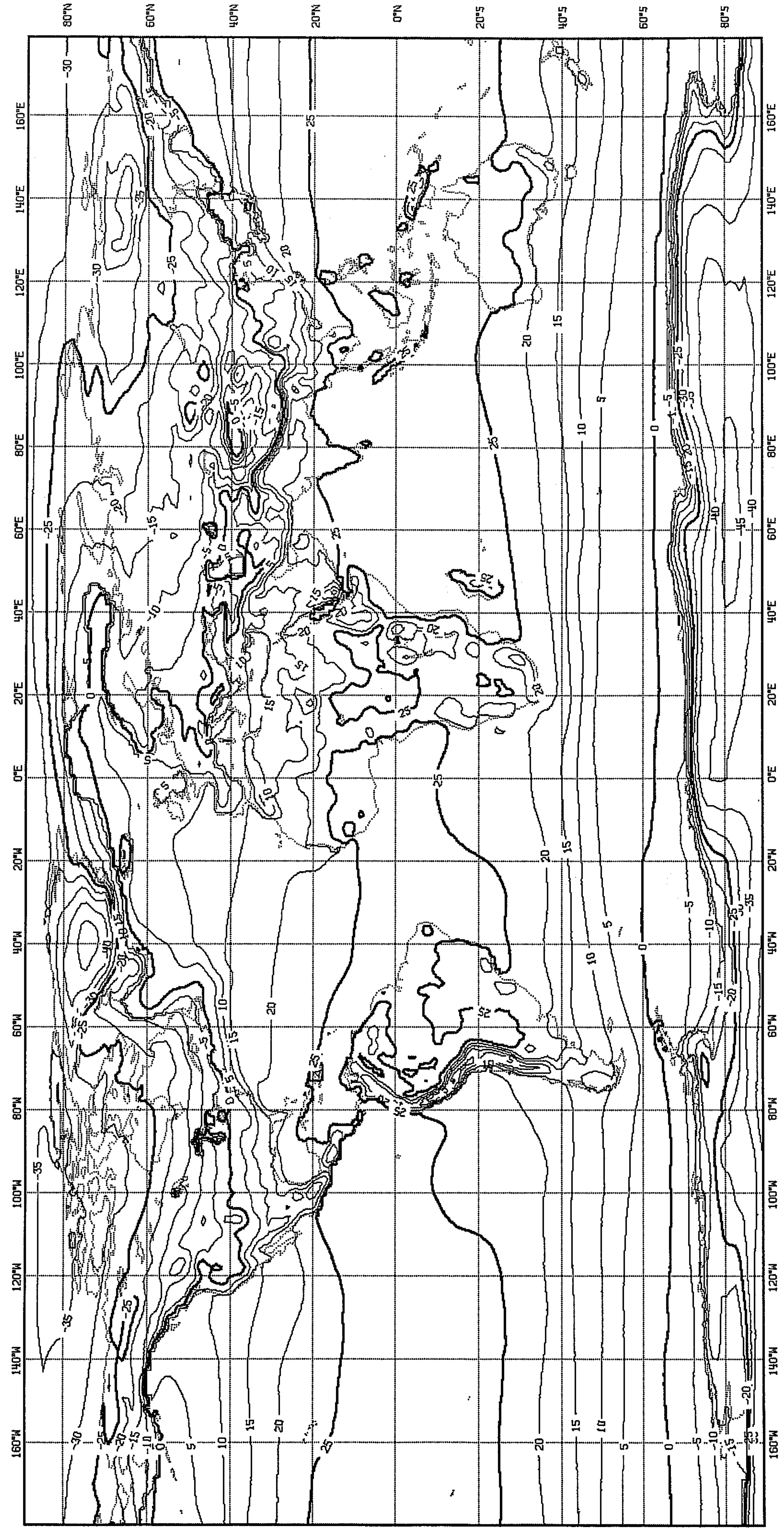
Mid-layer soil temperature

A3 Mid-layer soil temperature (degrees Celsius). Contour interval is 5 degrees.



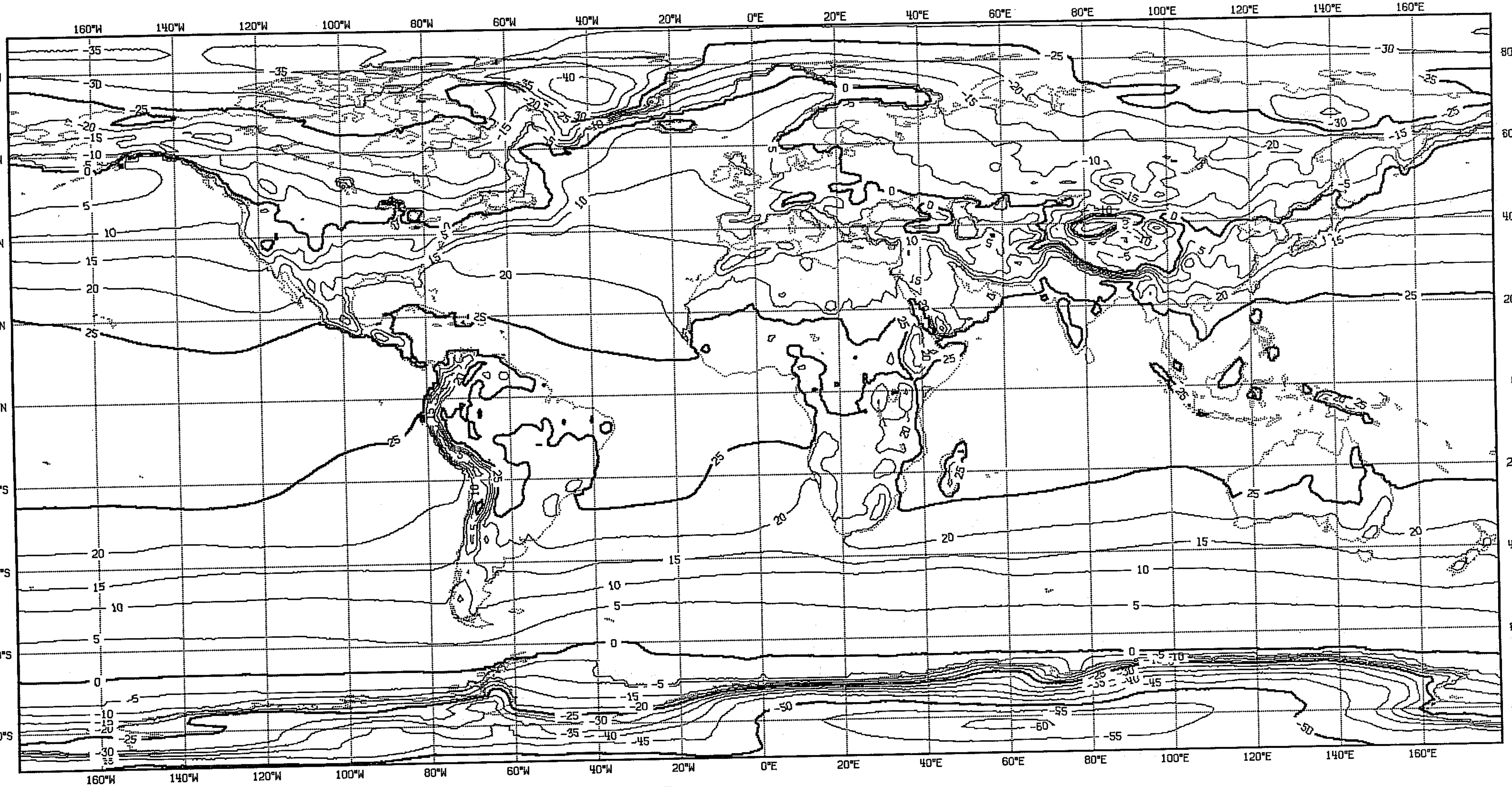
MID-LAYER SOIL TEMPERATURE MONTH 1

A3(1)

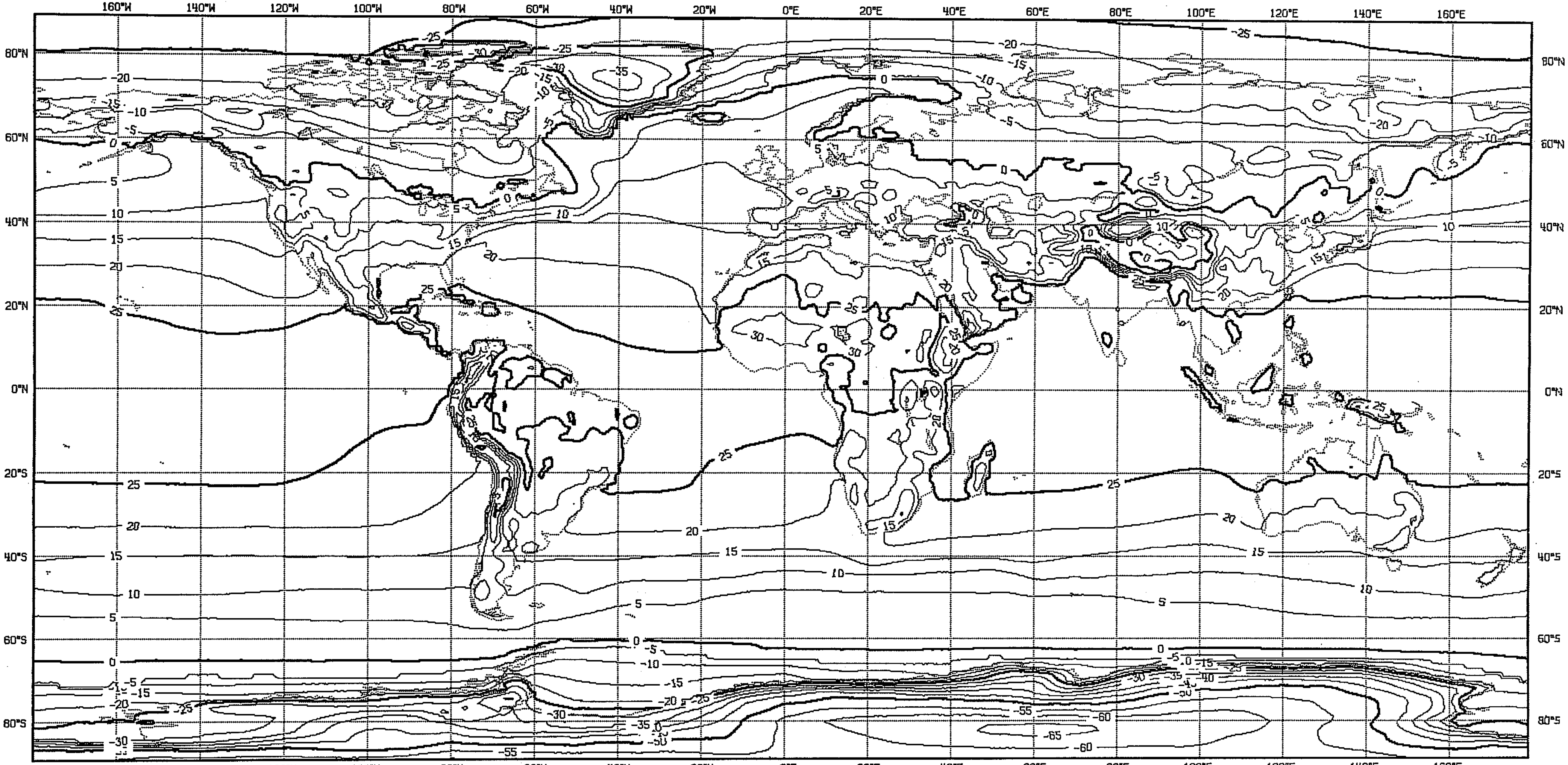


MID-LAYER SOIL TEMPERATURE MONTH 2

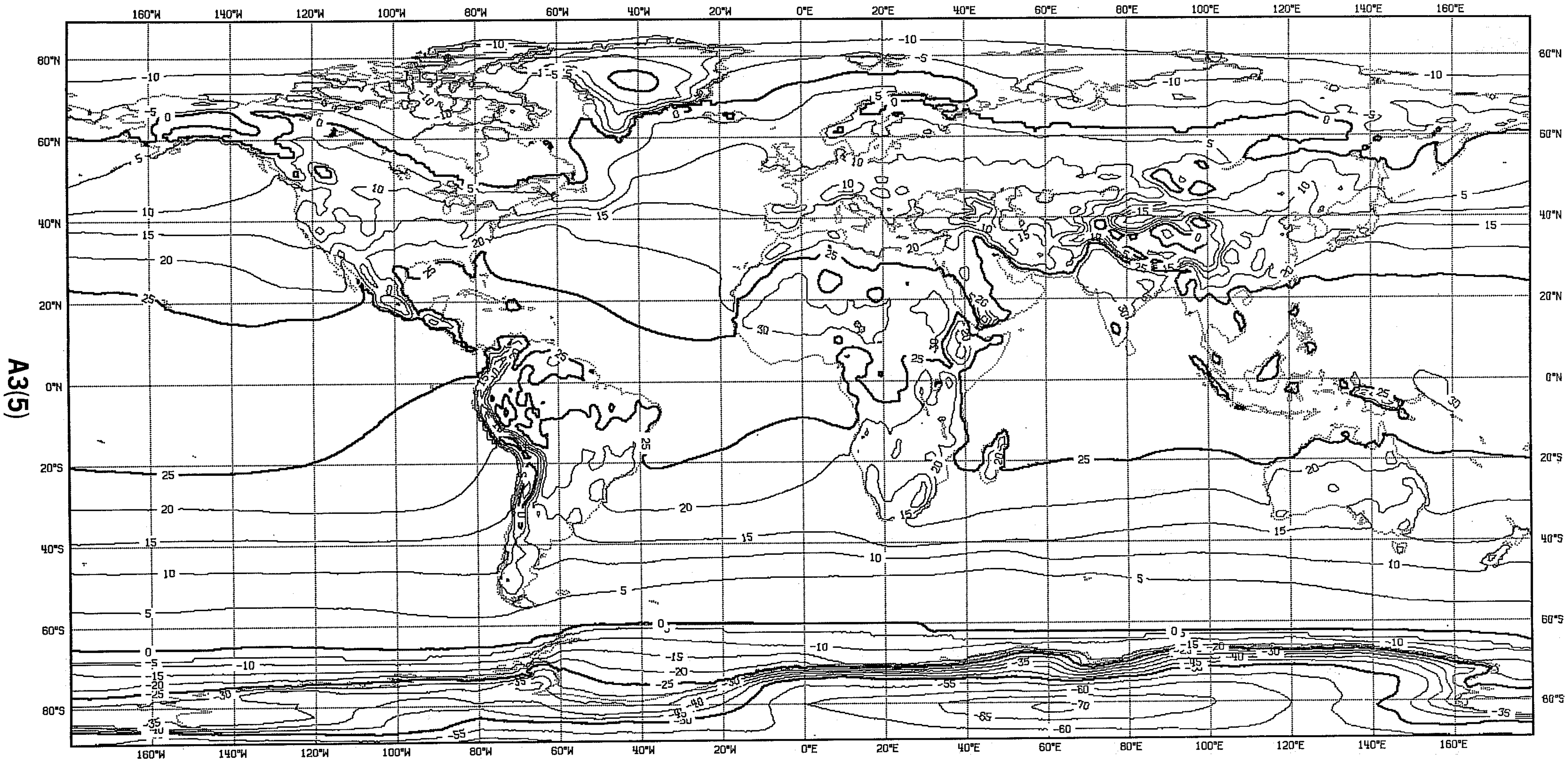
A3(2)



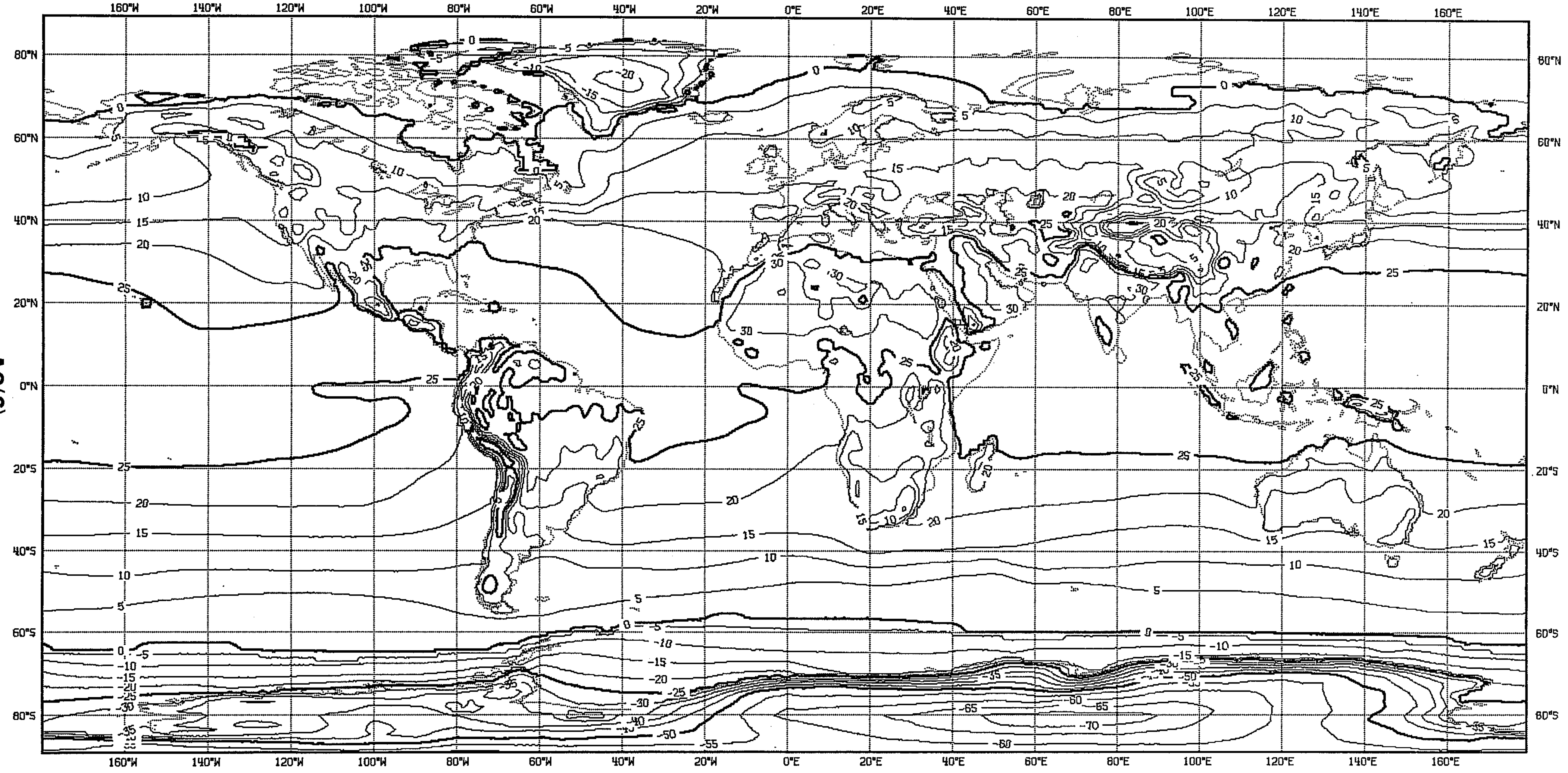
MID-LAYER SOIL TEMPERATURE MONTH 3



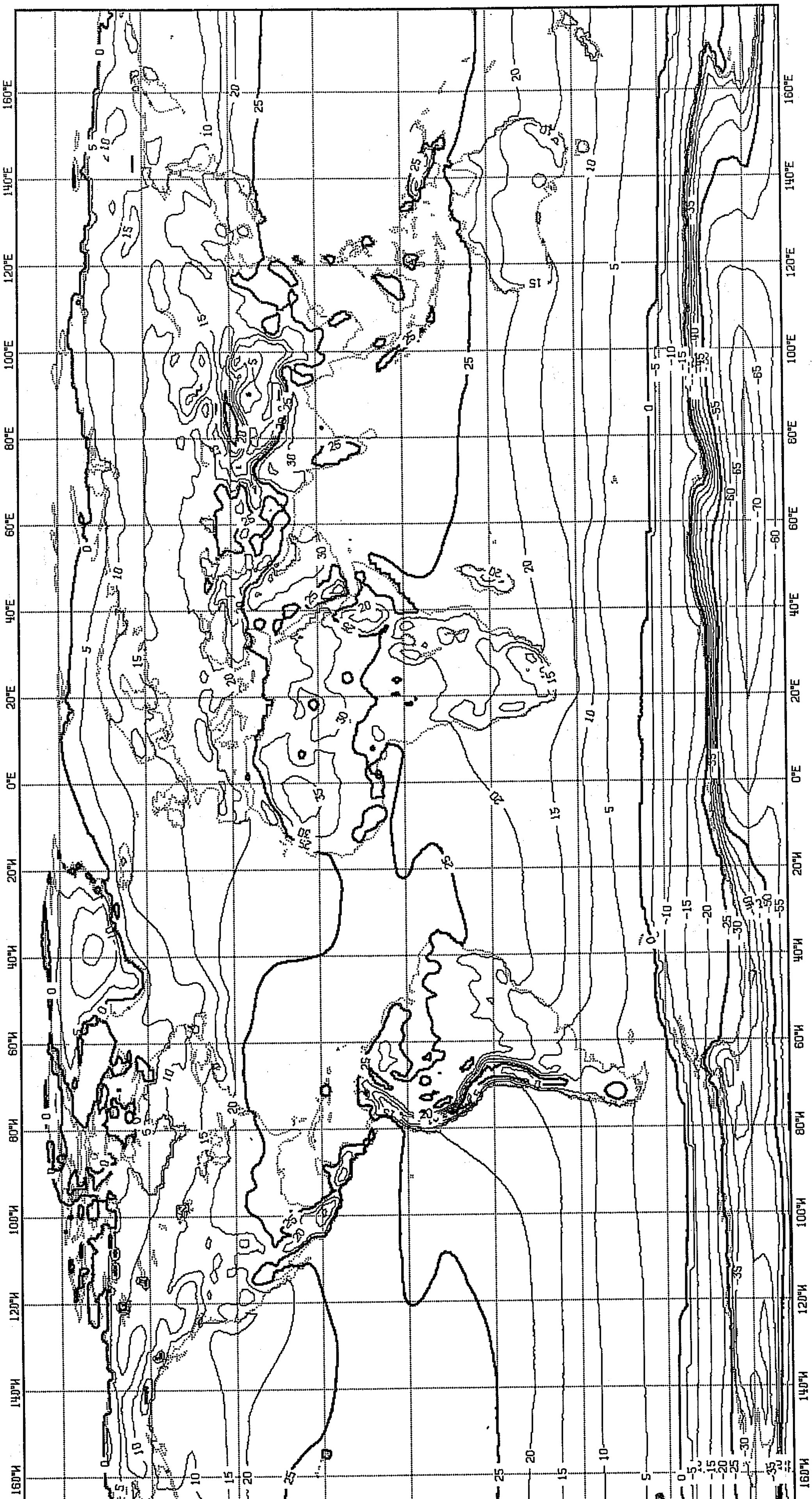
MID-LAYER SOIL TEMPERATURE MONTH 4



MID-LAYER SOIL TEMPERATURE MONTH 5

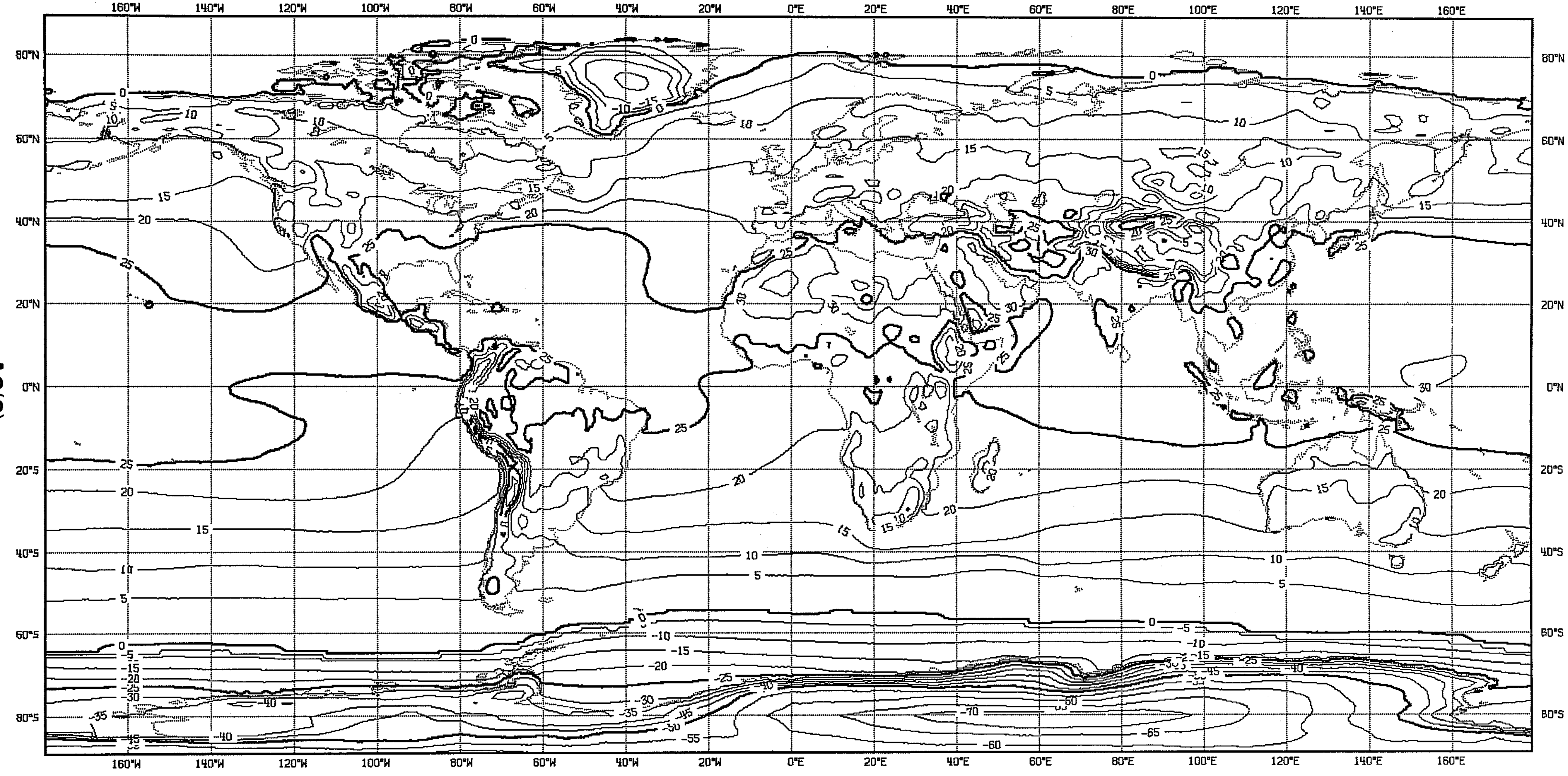


MID-LAYER SOIL TEMPERATURE MONTH 6



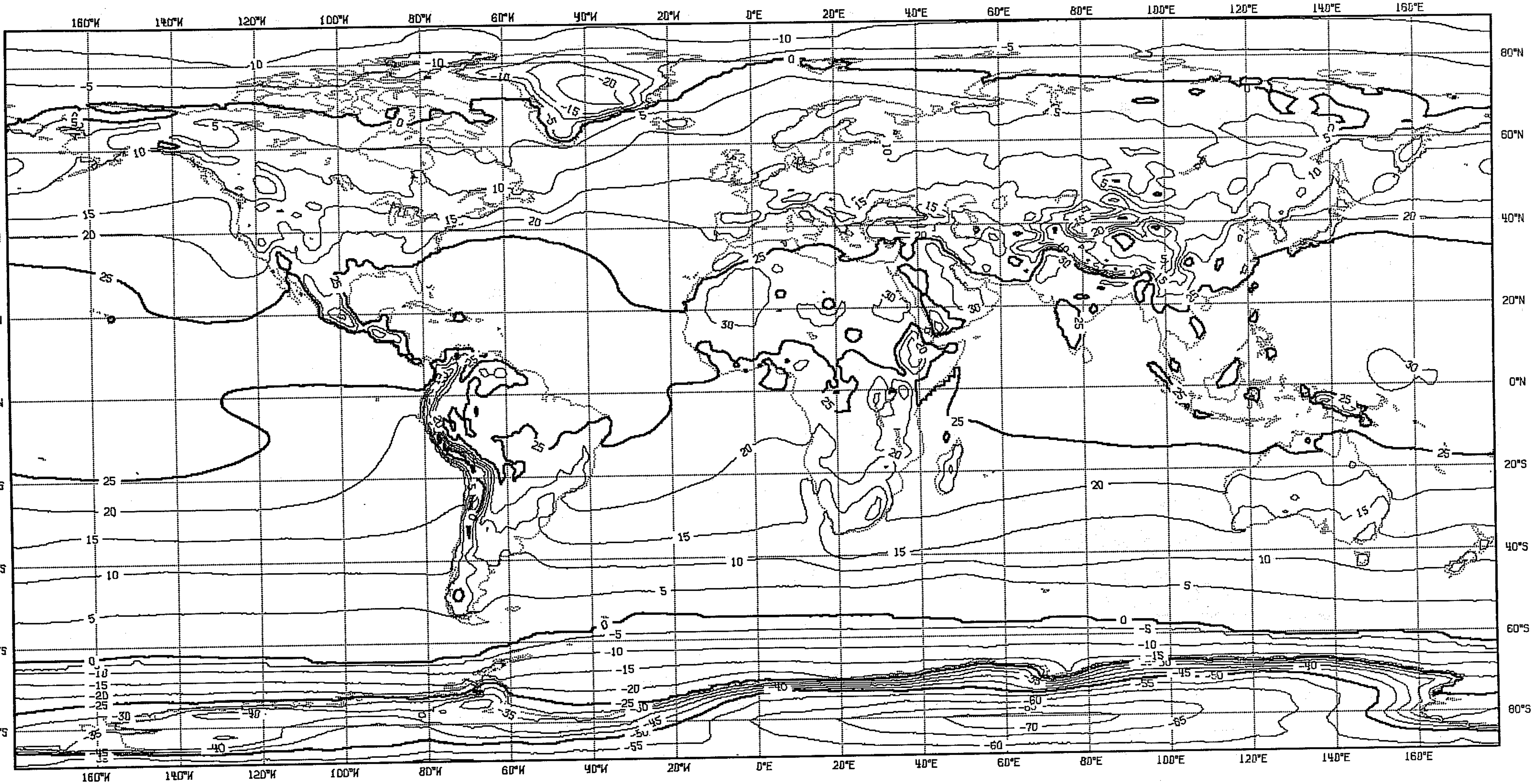
MID-LAYER SOIL TEMPERATURE MONTH 7

A3(7)



MID-LAYER SOIL TEMPERATURE MONTH 8

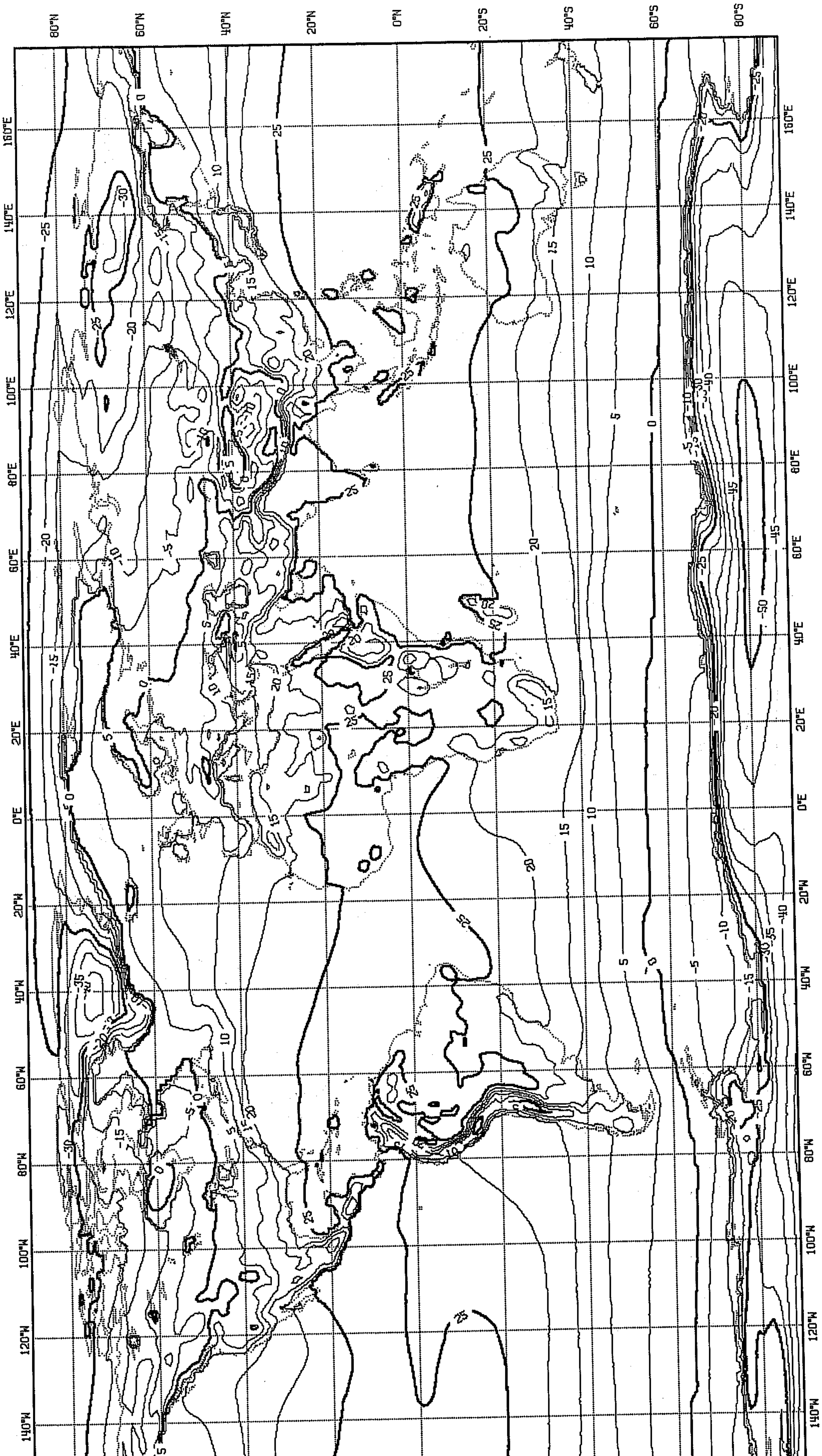
A3(8)



MID-LAYER SOIL TEMPERATURE MONTH 9

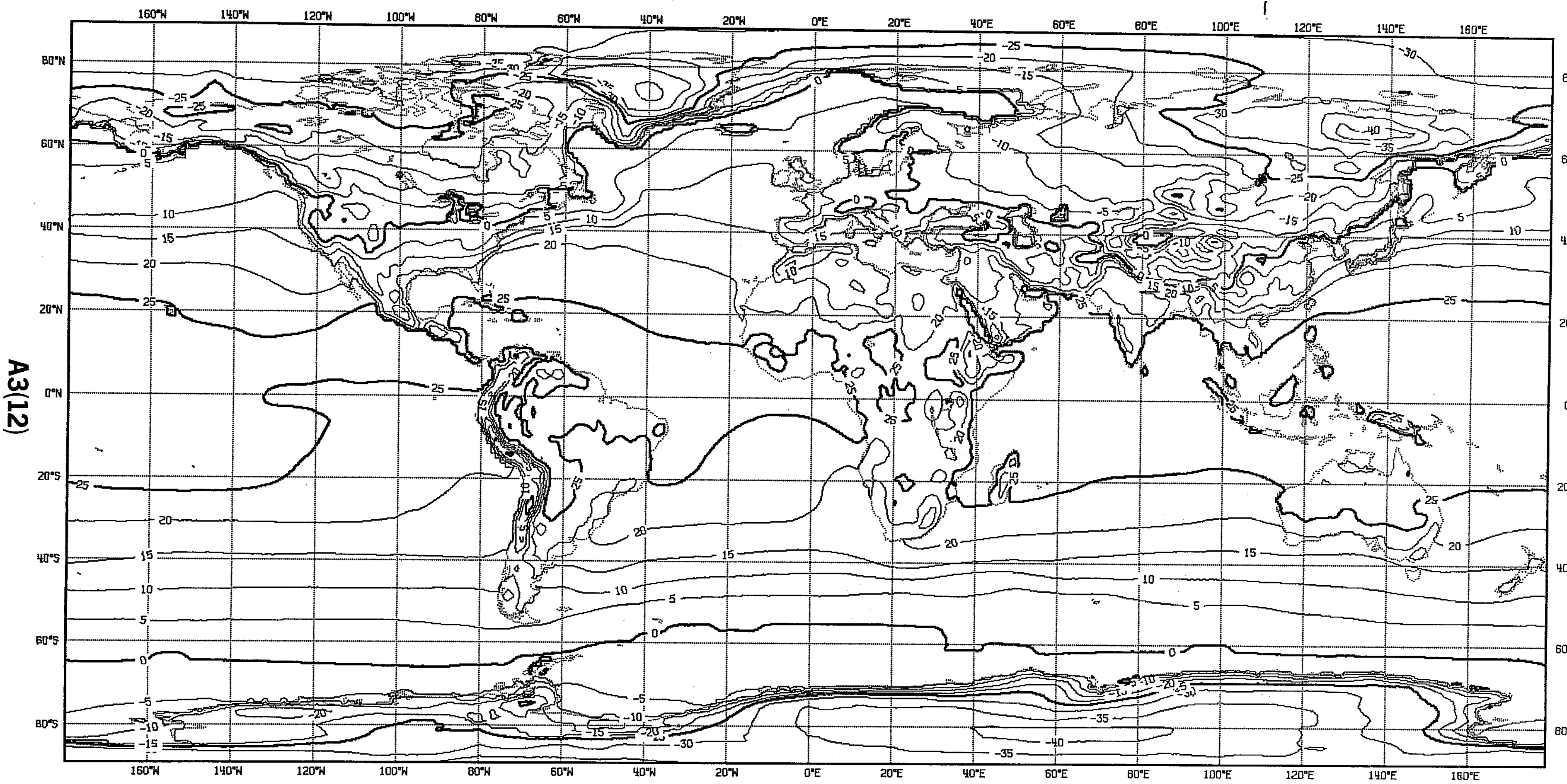
MID-LAYER SOIL TEMPERATURE MONTH 10

A3(10)



MID-LAYER SOIL TEMPERATURE MONTH 11

A3(11)

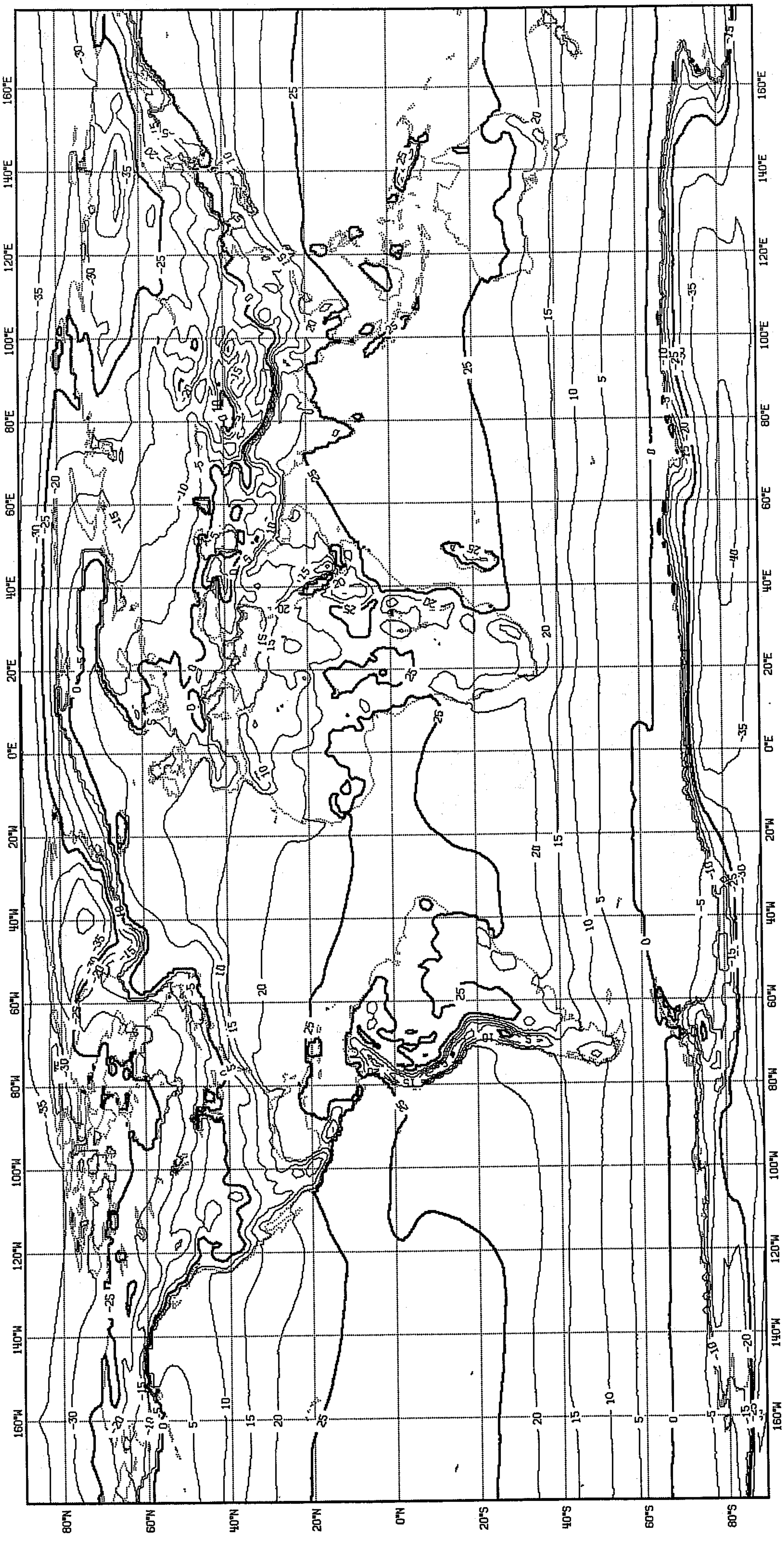


MID-LAYER SOIL TEMPERATURE MONTH 12

ANNEX A4(1) - A4(12)

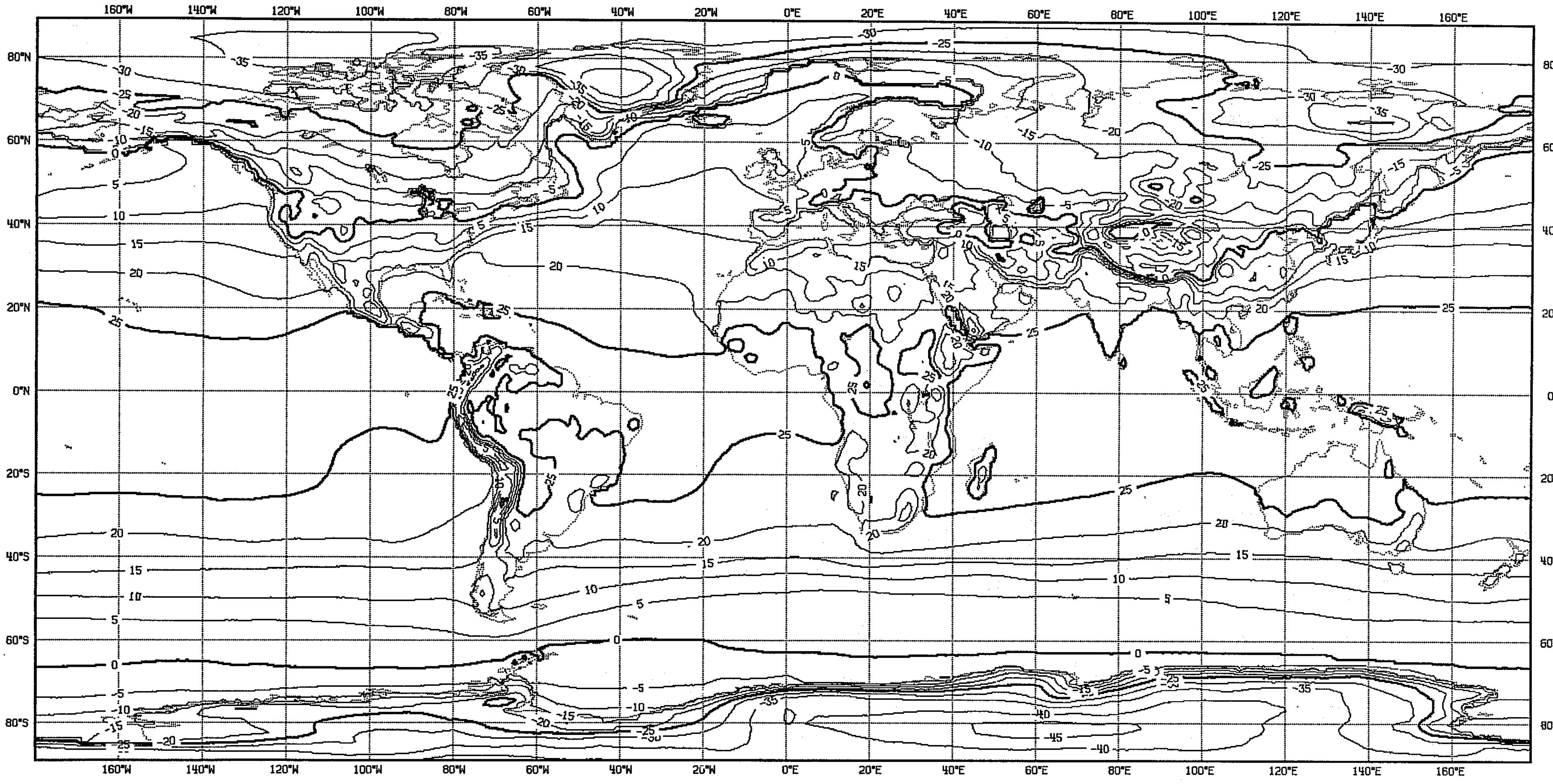
Deep-layer soil temperature

A4 Deep-layer soil temperature (degrees Celsius). Contour interval is 5 degrees.

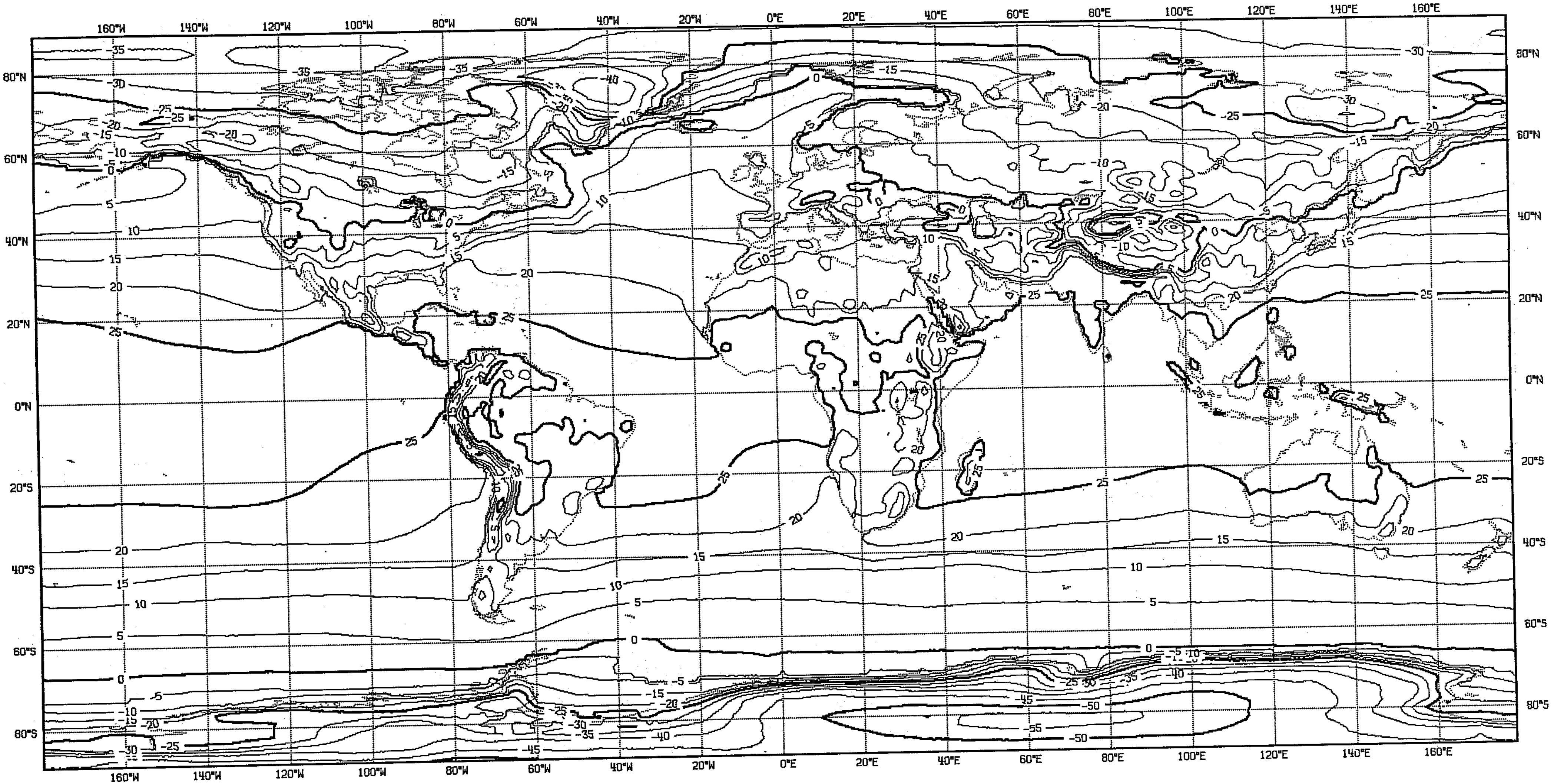


DEEP-LAYER SOIL TEMPERATURE MONTH 1

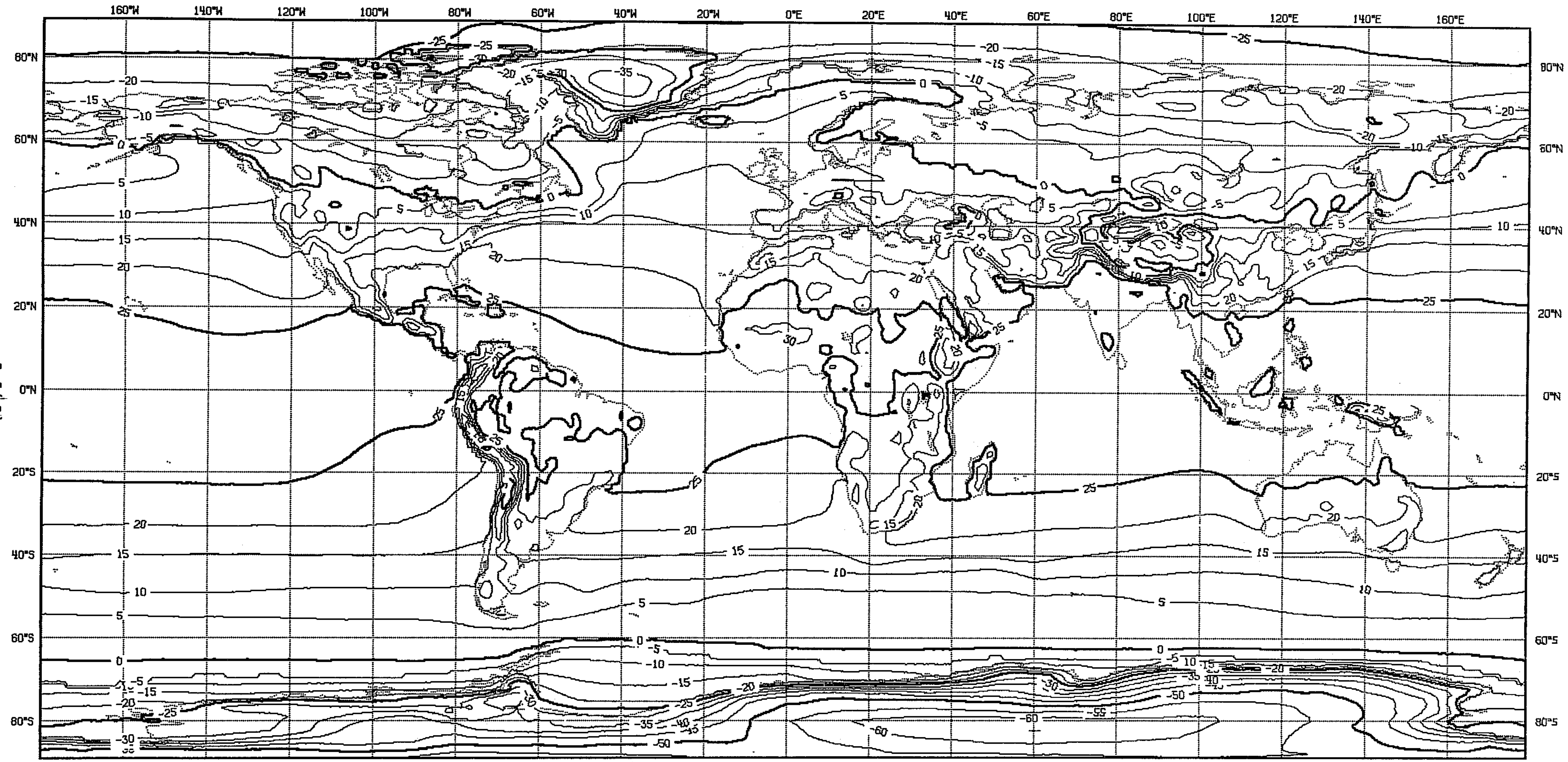
A4(1)



DEEP-LAYER SOIL TEMPERATURE MONTH 2

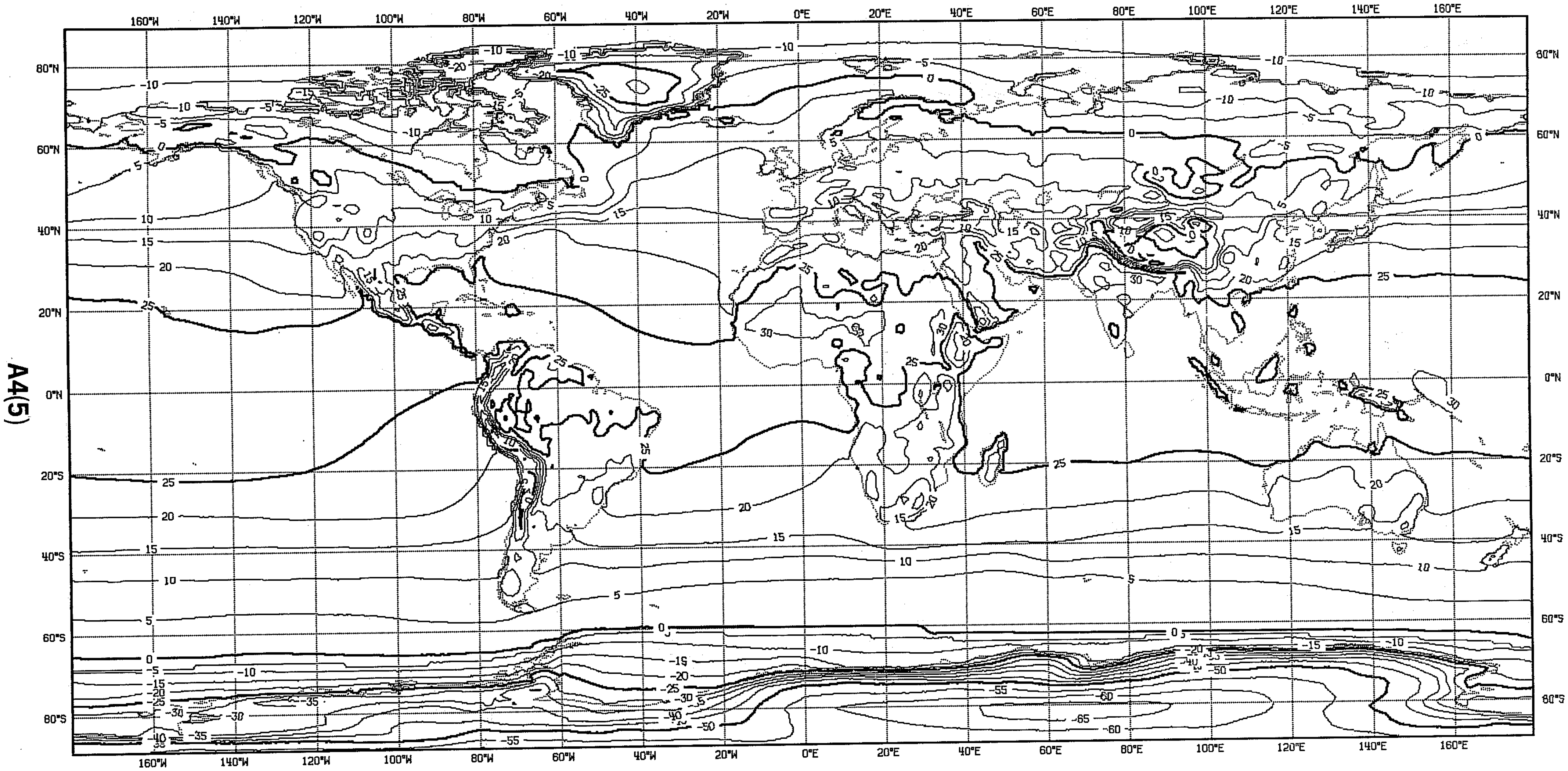


DEEP-LAYER SOIL TEMPERATURE MONTH 3

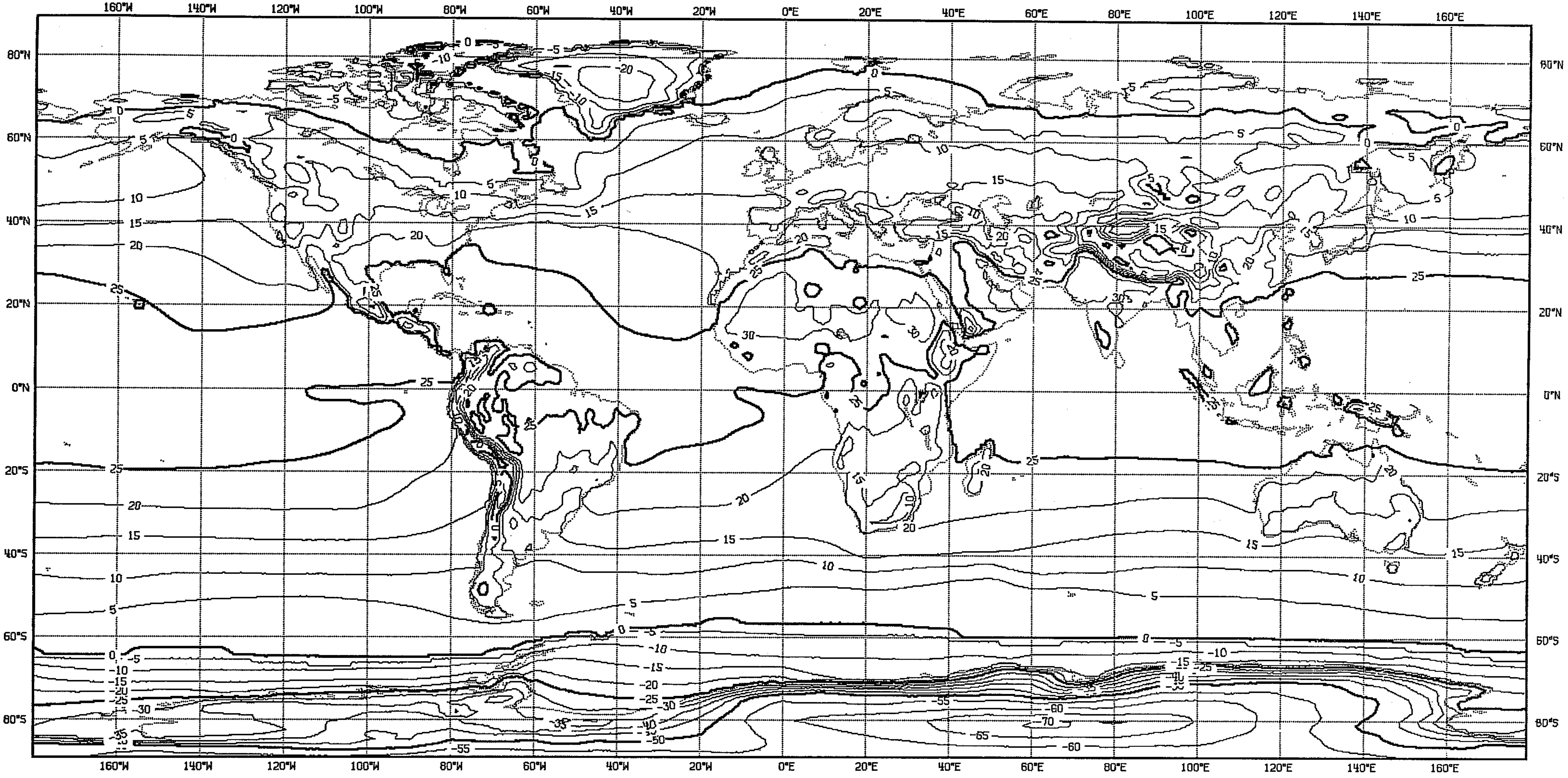


DEEP-LAYER SOIL TEMPERATURE MONTH 4

A4(5)

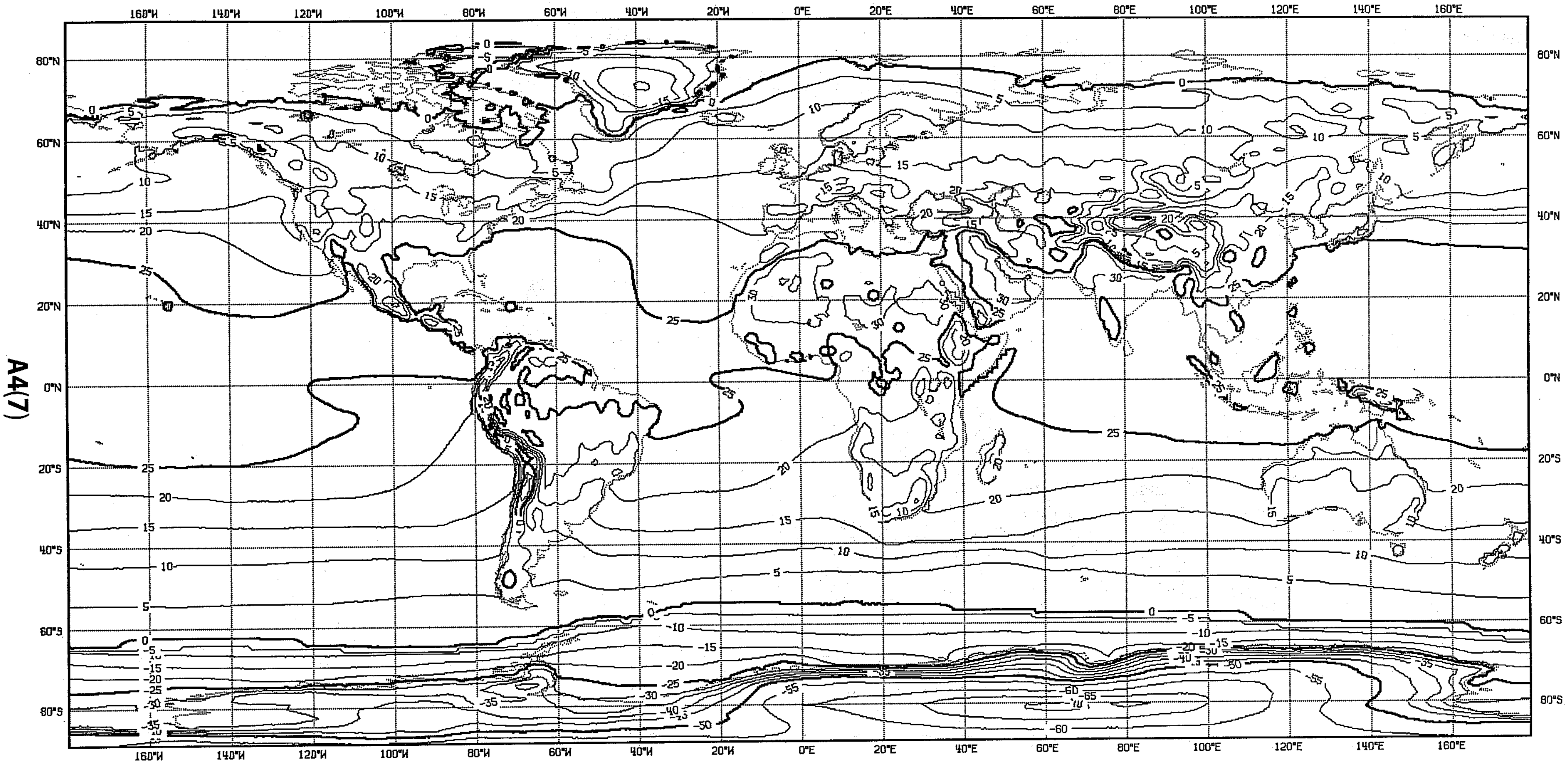


DEEP-LAYER SOIL TEMPERATURE MONTH 5

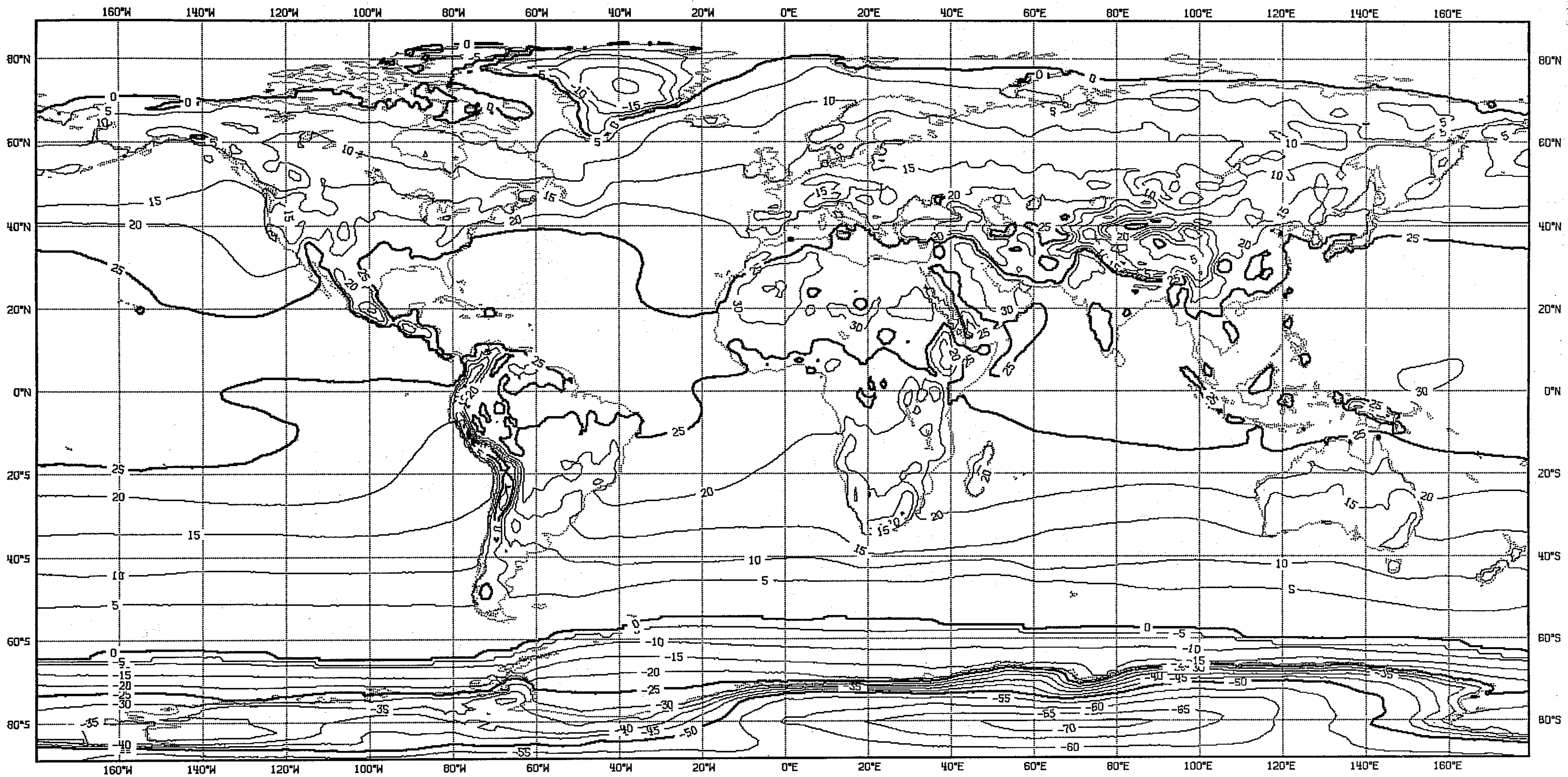


DEEP-LAYER SOIL TEMPERATURE MONTH 6

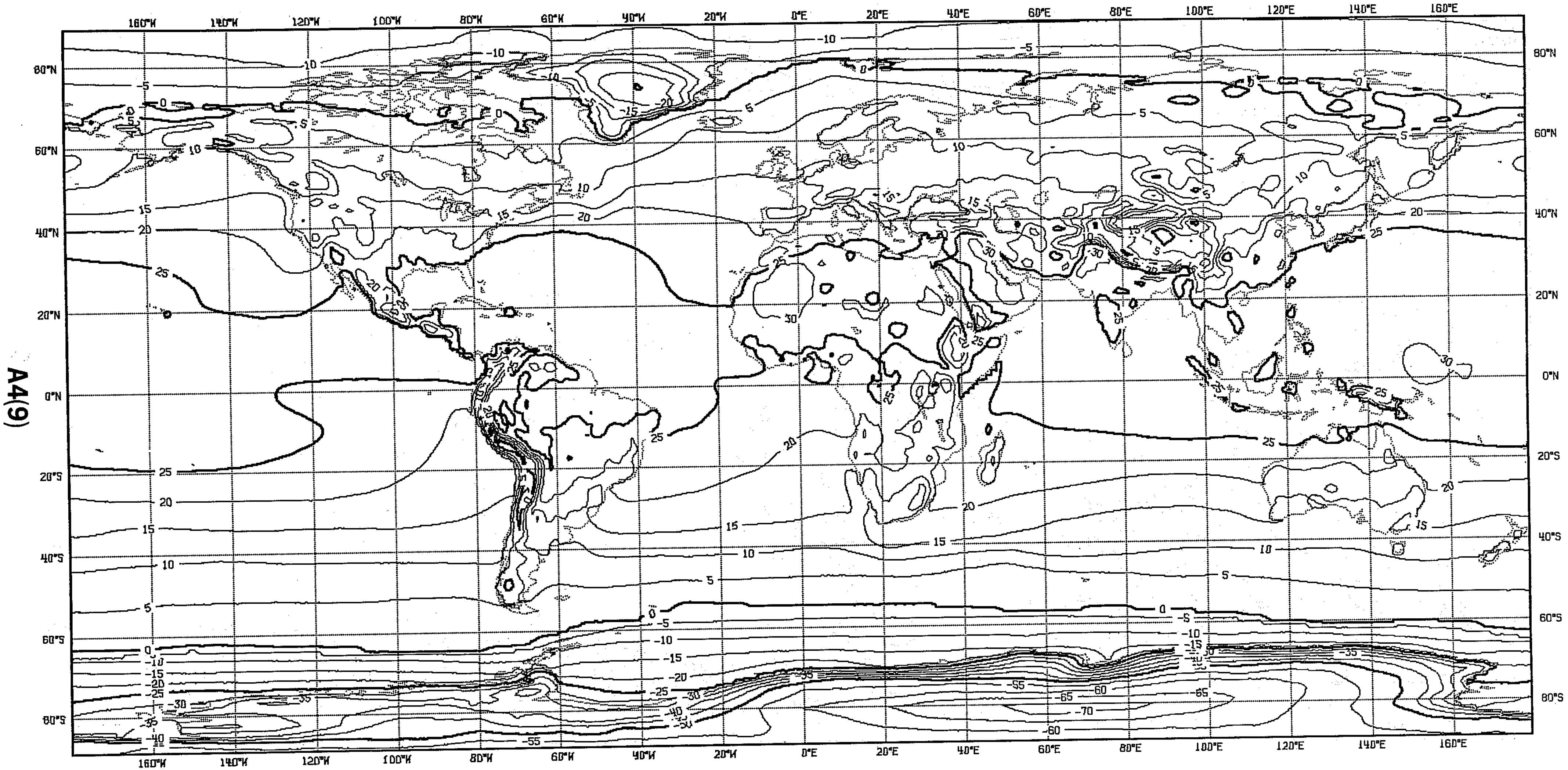
A4(6)



DEEP-LAYER SOIL TEMPERATURE MONTH 7

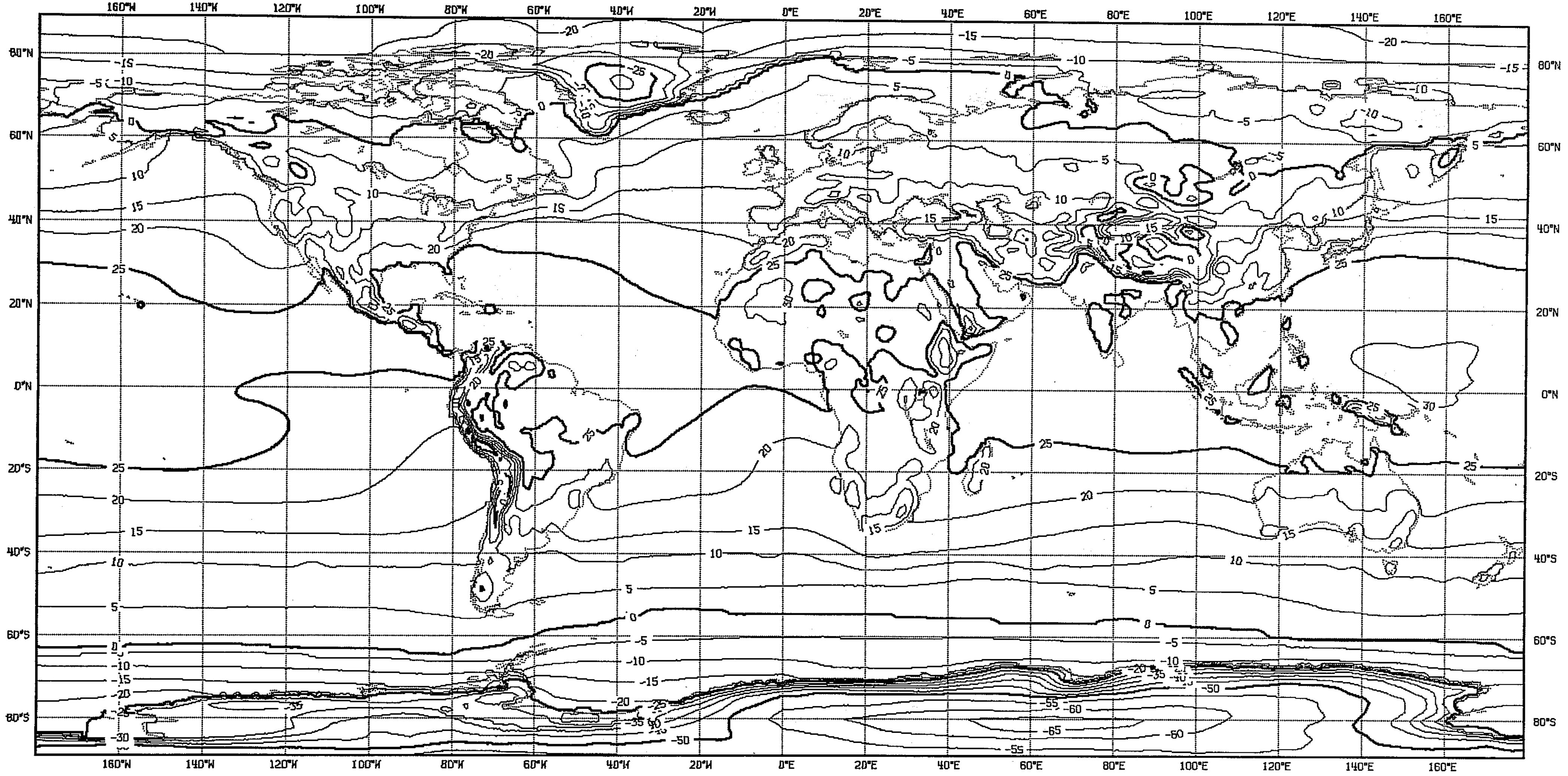


DEEP-LAYER SOIL TEMPERATURE MONTH 8

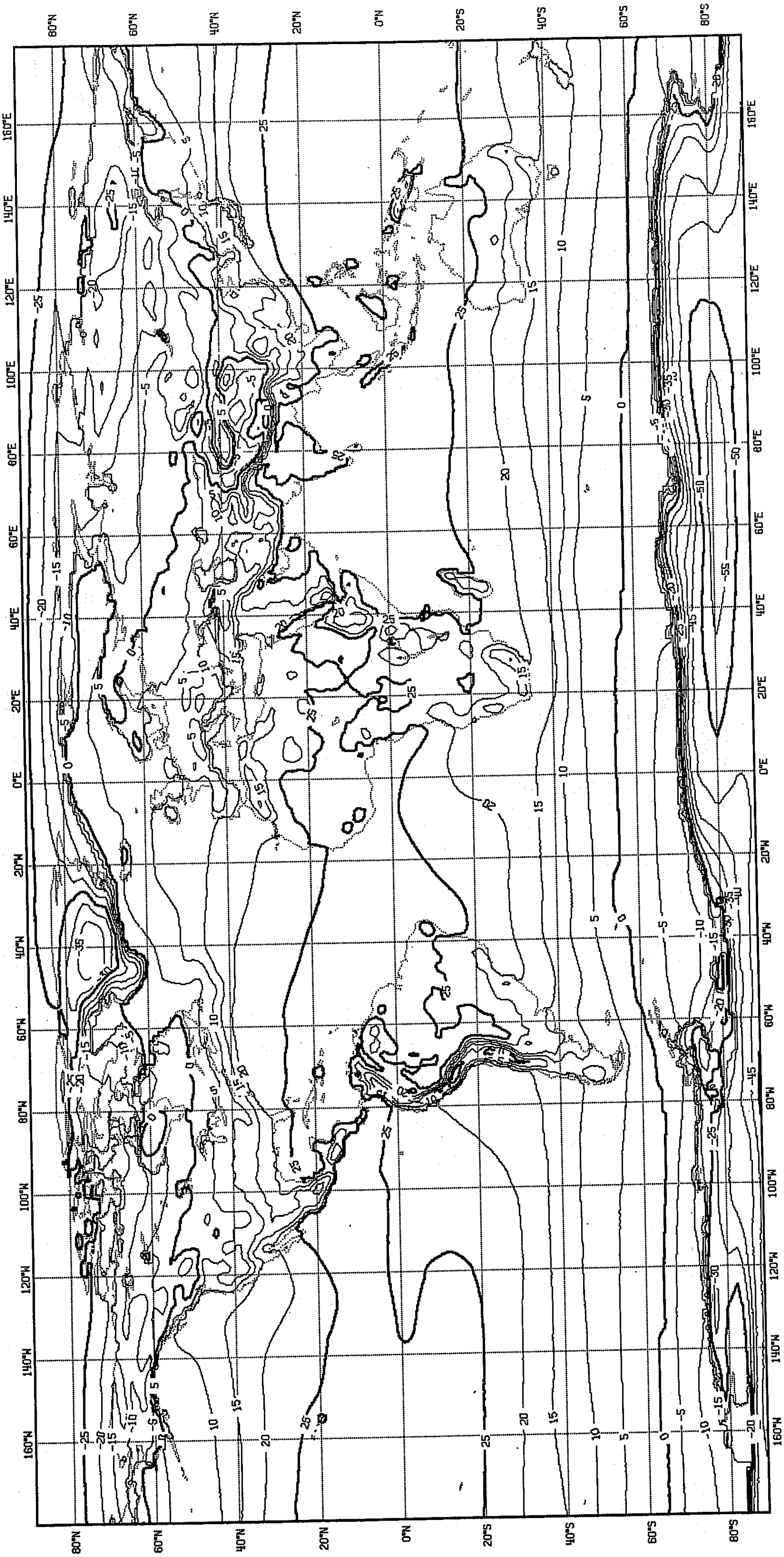


DEEP-LAYER SOIL TEMPERATURE MONTH 9

A4(10)

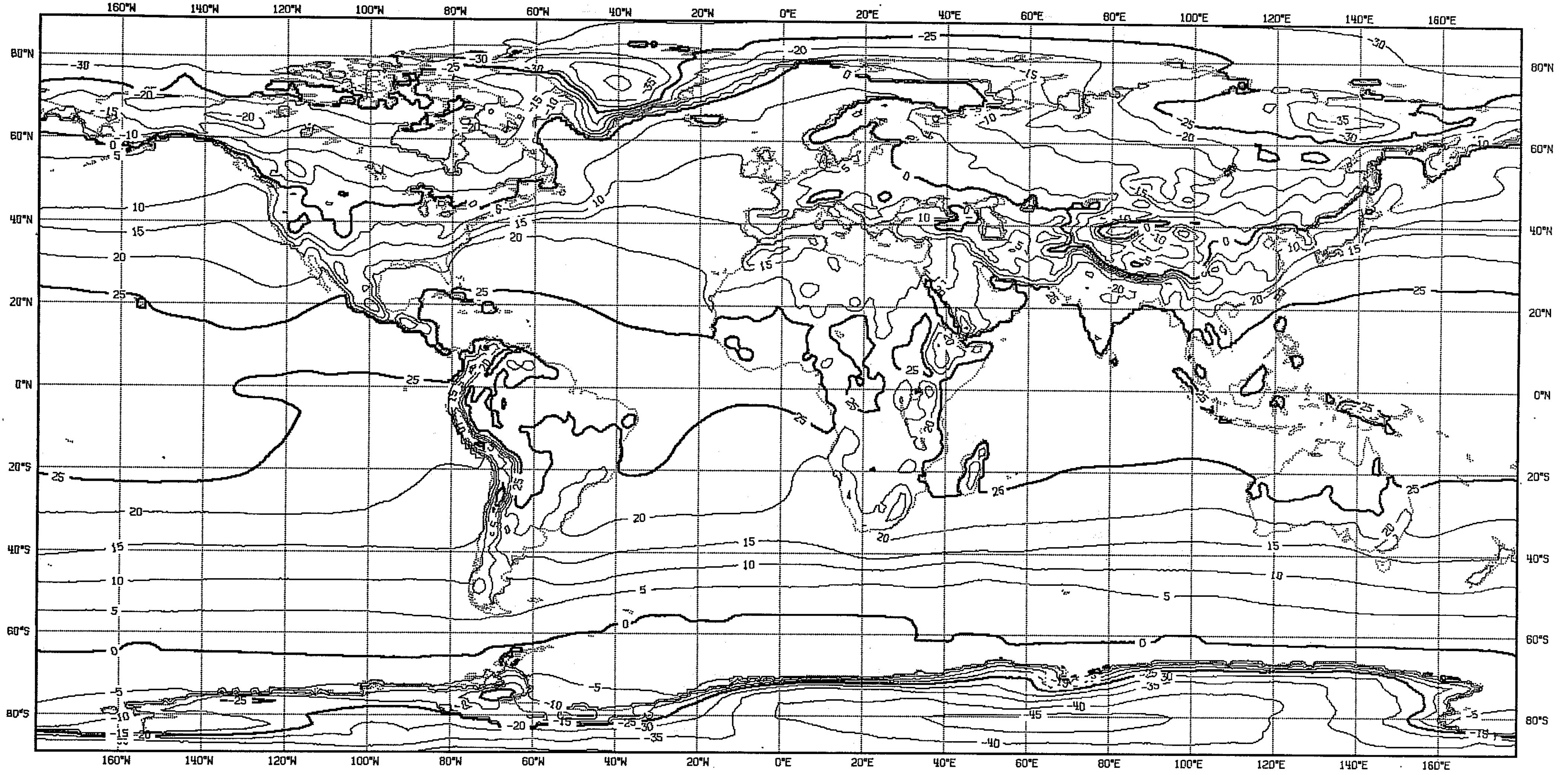


DEEP-LAYER SOIL TEMPERATURE MONTH 10



DEEP-LAYER SOIL TEMPERATURE MONTH 11

A4(11)



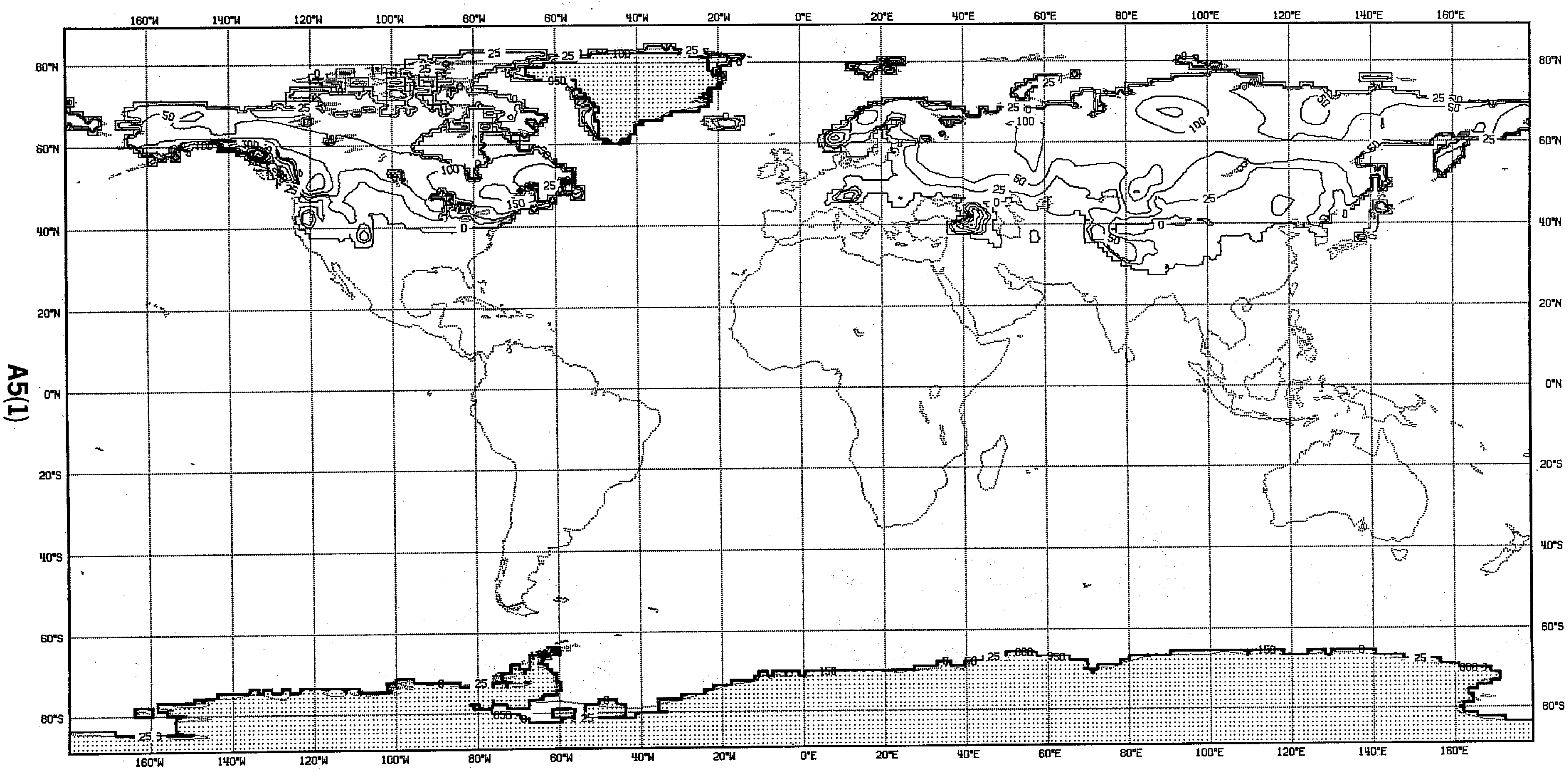
DEEP-LAYER SOIL TEMPERATURE MONTH 12

ANNEX A5(1) - A5(12)

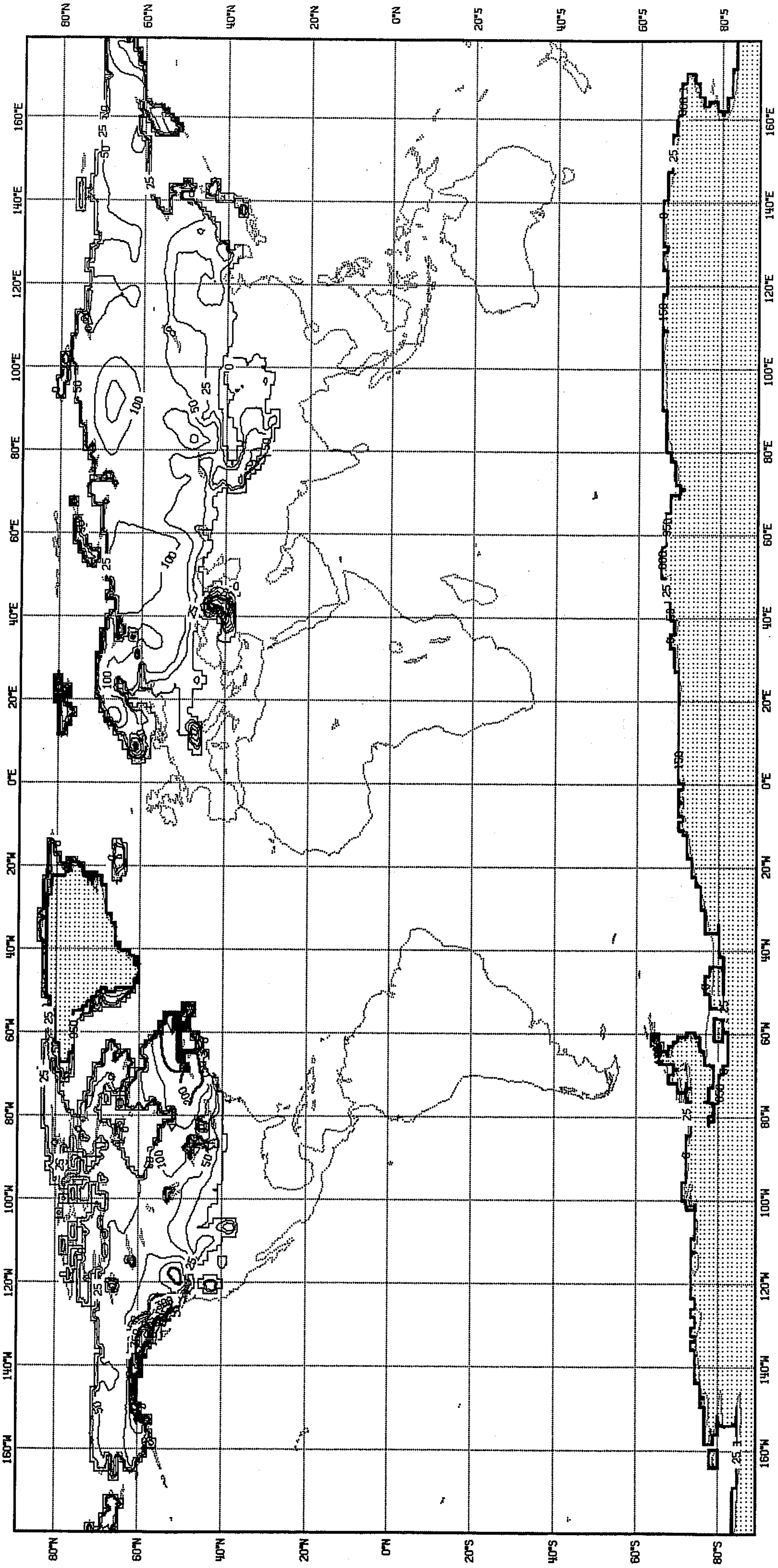
Snow depth

A5 Snow depth (cm). Contour interval is 50 cm but isoline showing 25 cm of snow depth is drawn also. Dotted areas denote perpetual snow. 1 cm of snow depth corresponds to 1 mm of water equivalent.

A5(1)

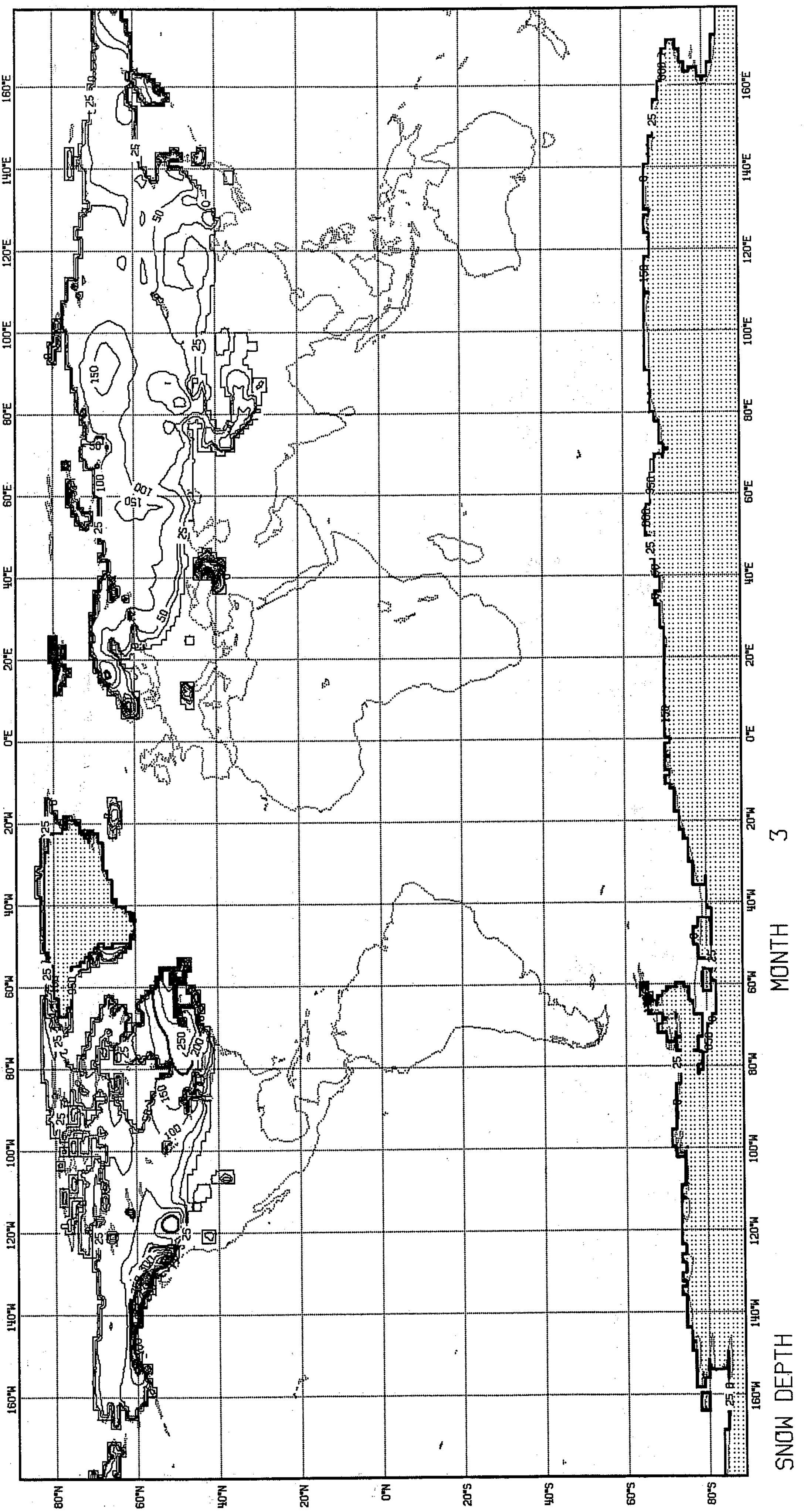


SNOW DEPTH MONTH 1

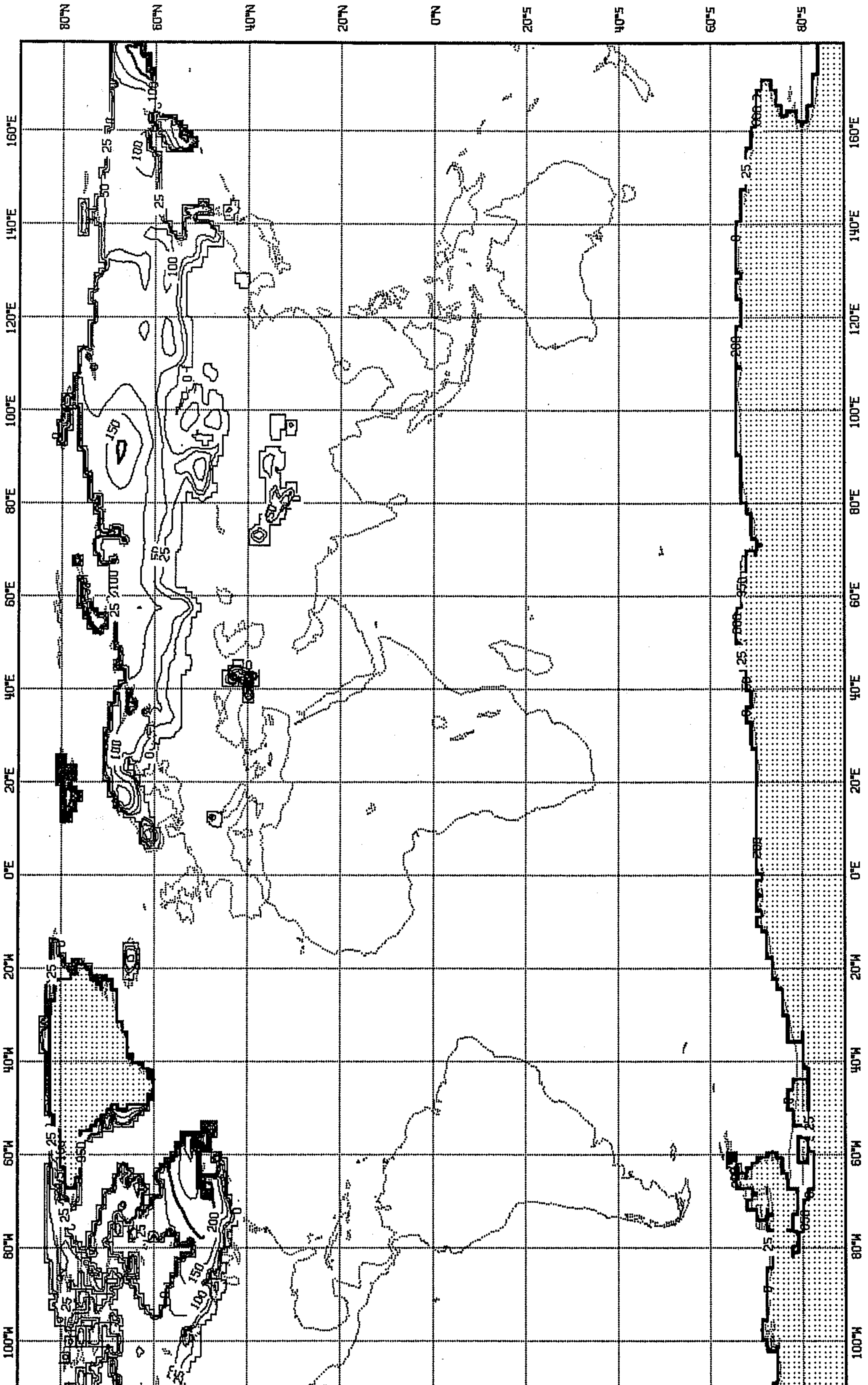


SNOW DEPTH MONTH 2

A5(2)


SNOW DEPTH
MONTH 3
80°N
60°N
40°N
20°N
0°N
20°S
40°S
60°S
80°S
160°W
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°E
20°E
40°E
60°E
80°E
100°E
120°E
140°E
160°E
25
50
100
150
200
250

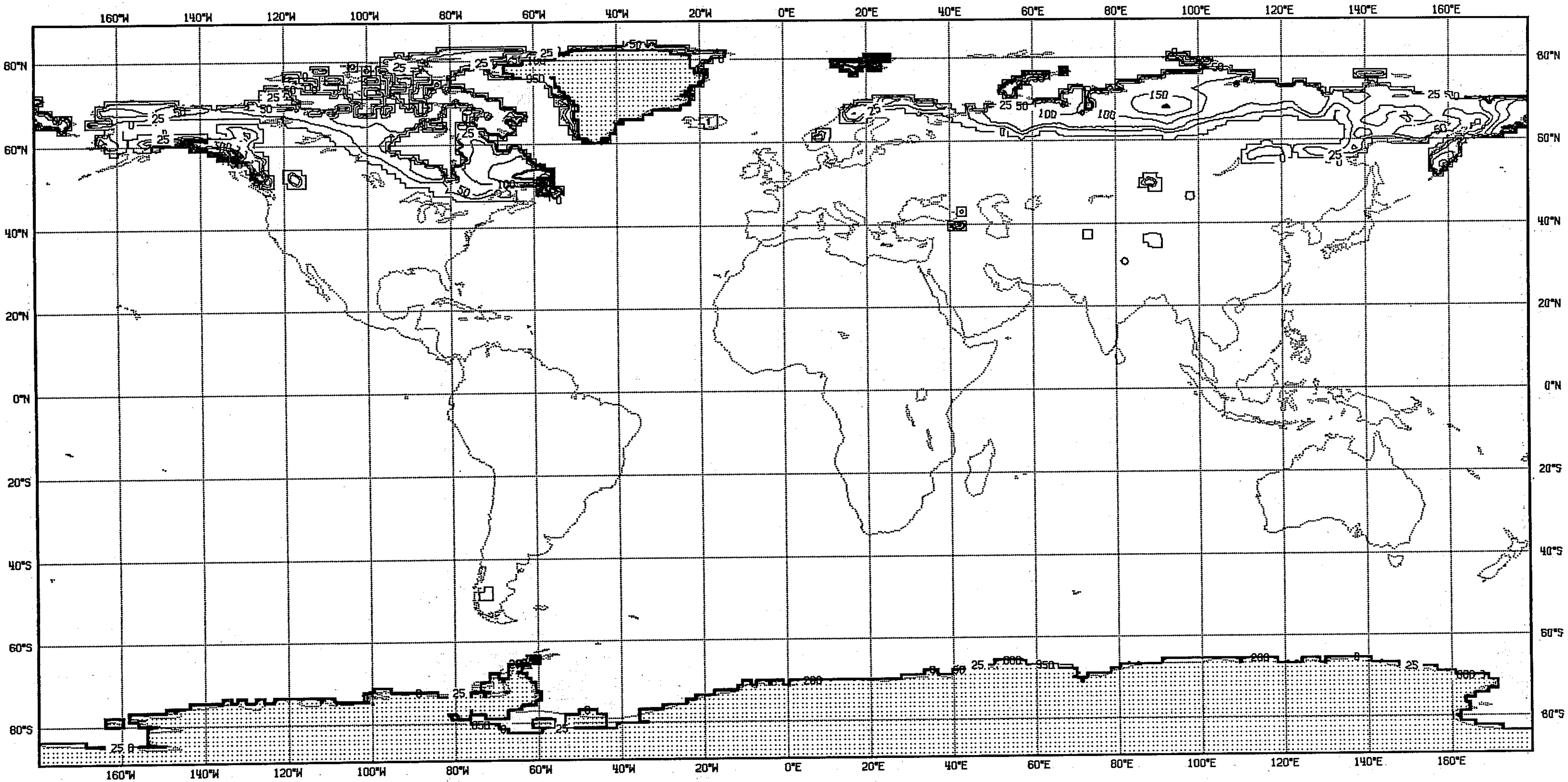
A5(3)



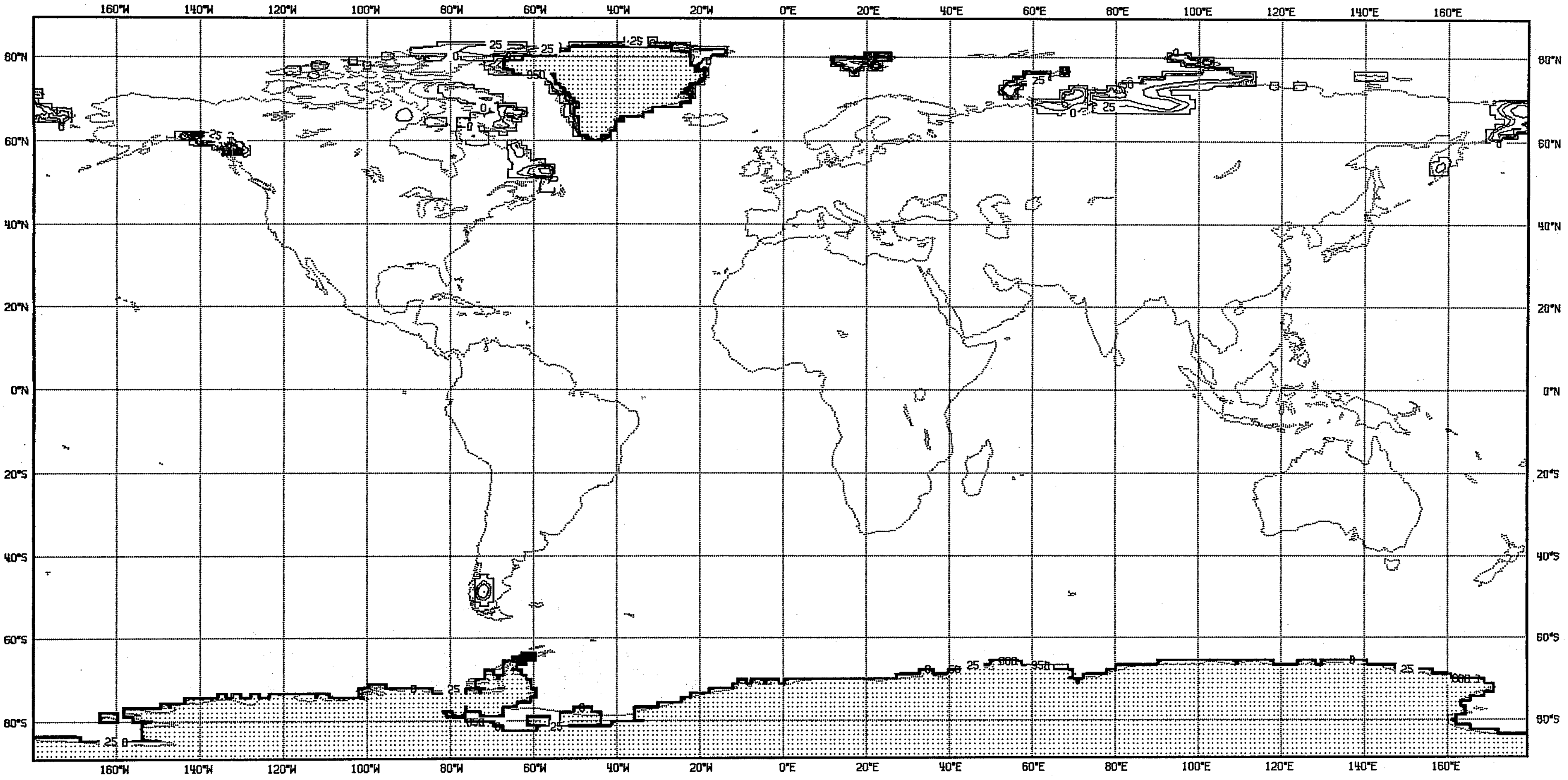
SNOW DEPTH MONTH 4

A5(4)

A5(5)

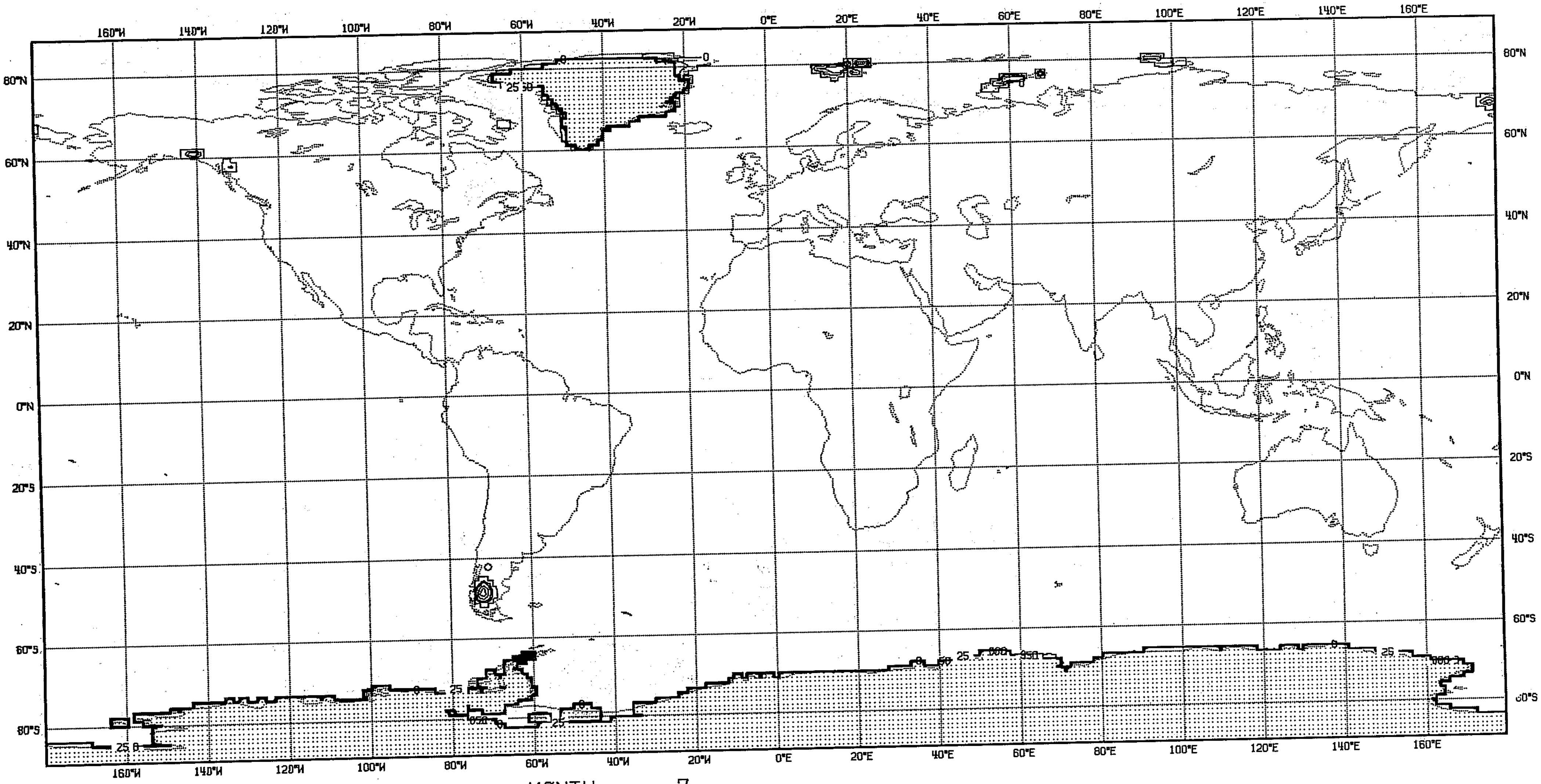


SNOW DEPTH MONTH 5



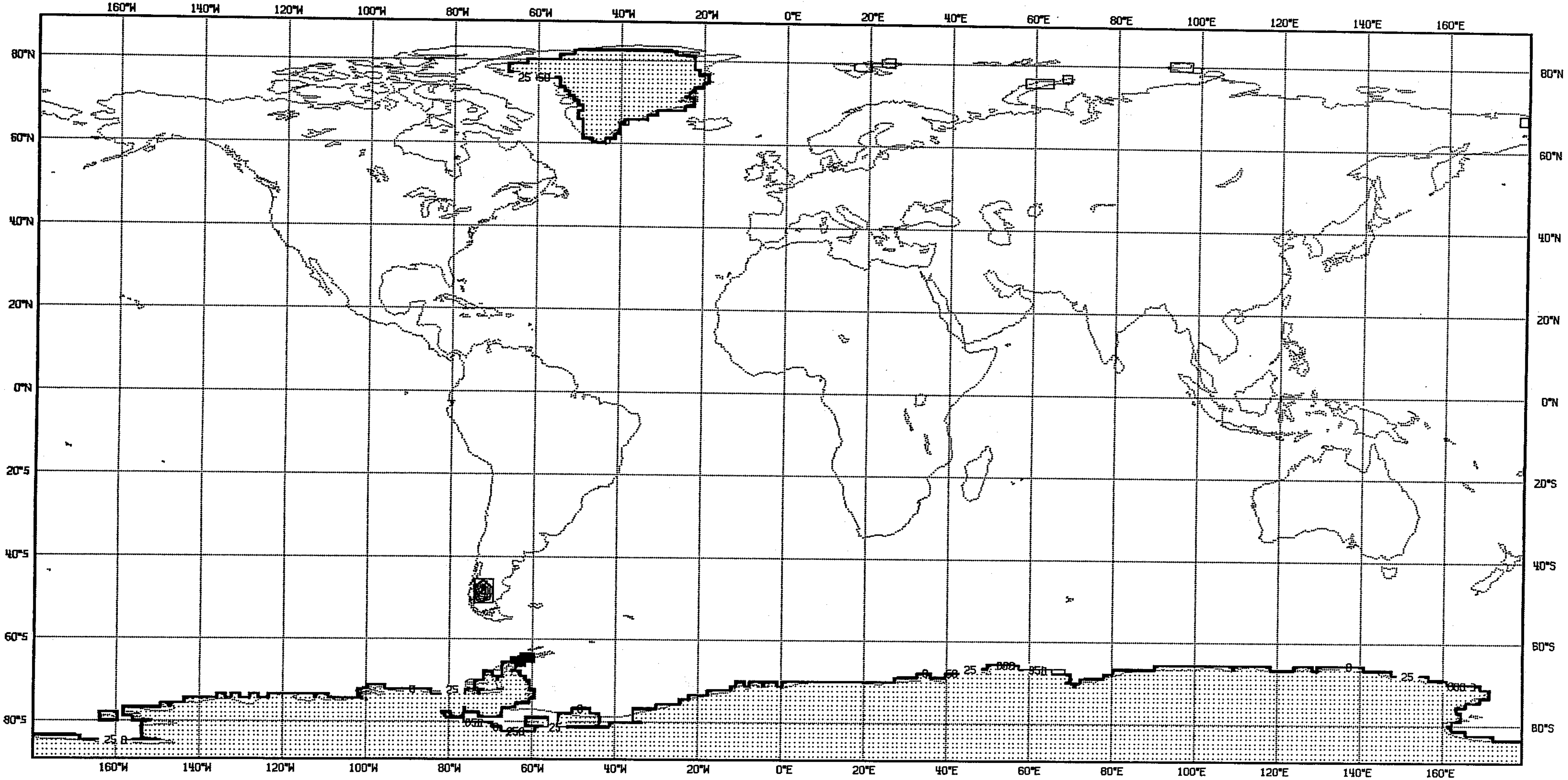
SNOW DEPTH MONTH 6

A5(6)

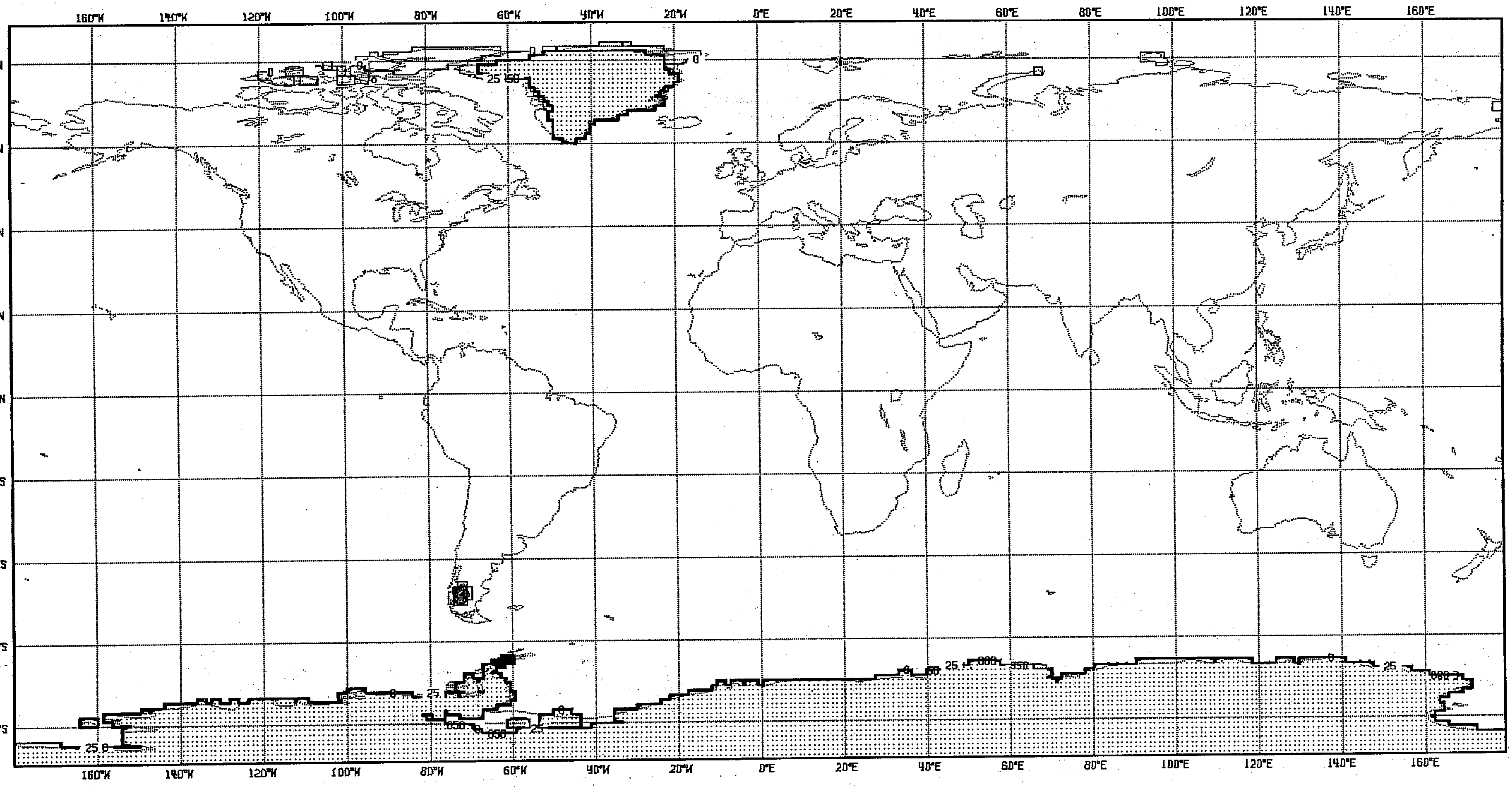


SNOW DEPTH MONTH 7

A5(7)

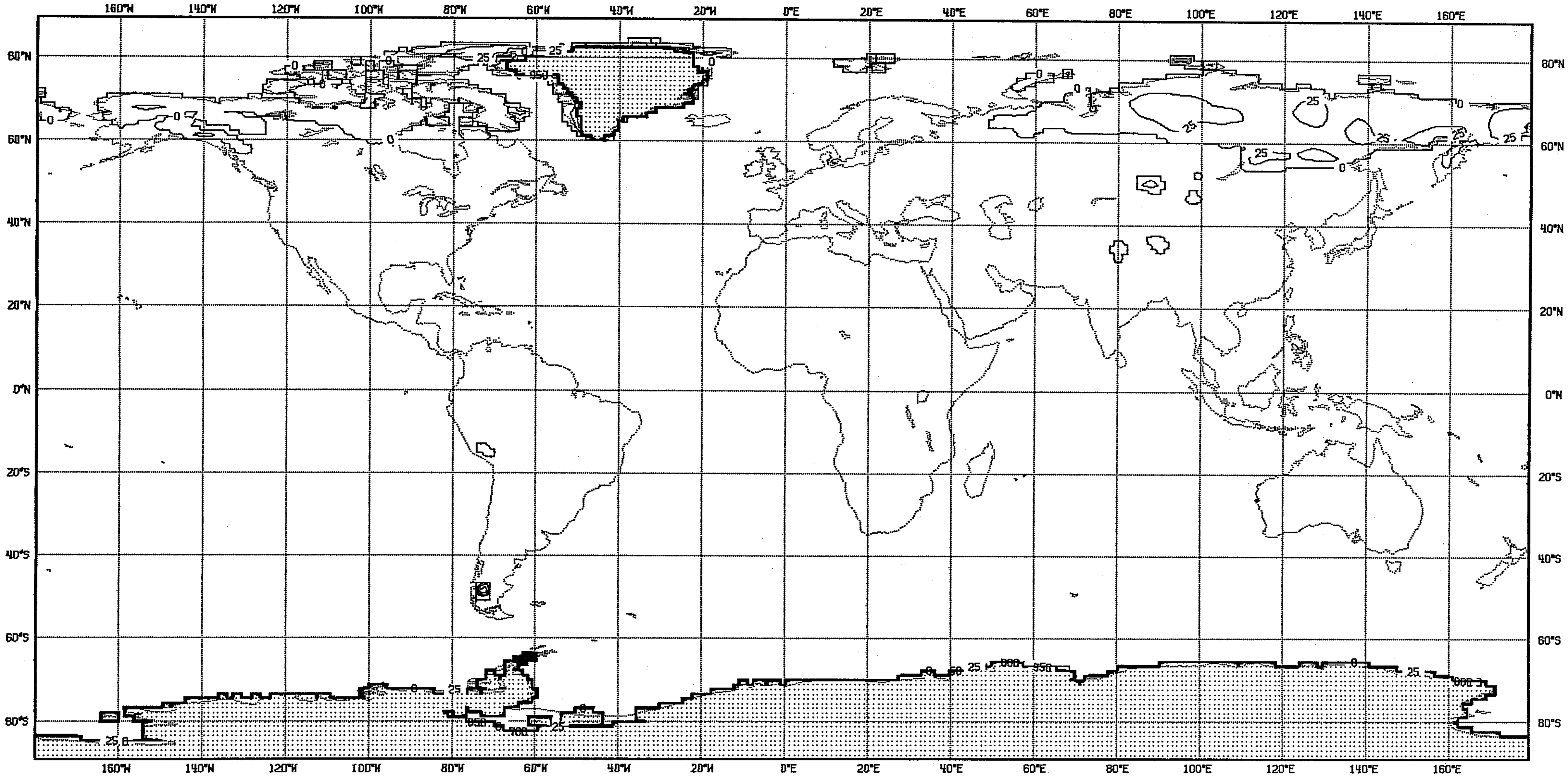


SNOW DEPTH MONTH 8



SNOW DEPTH MONTH 9

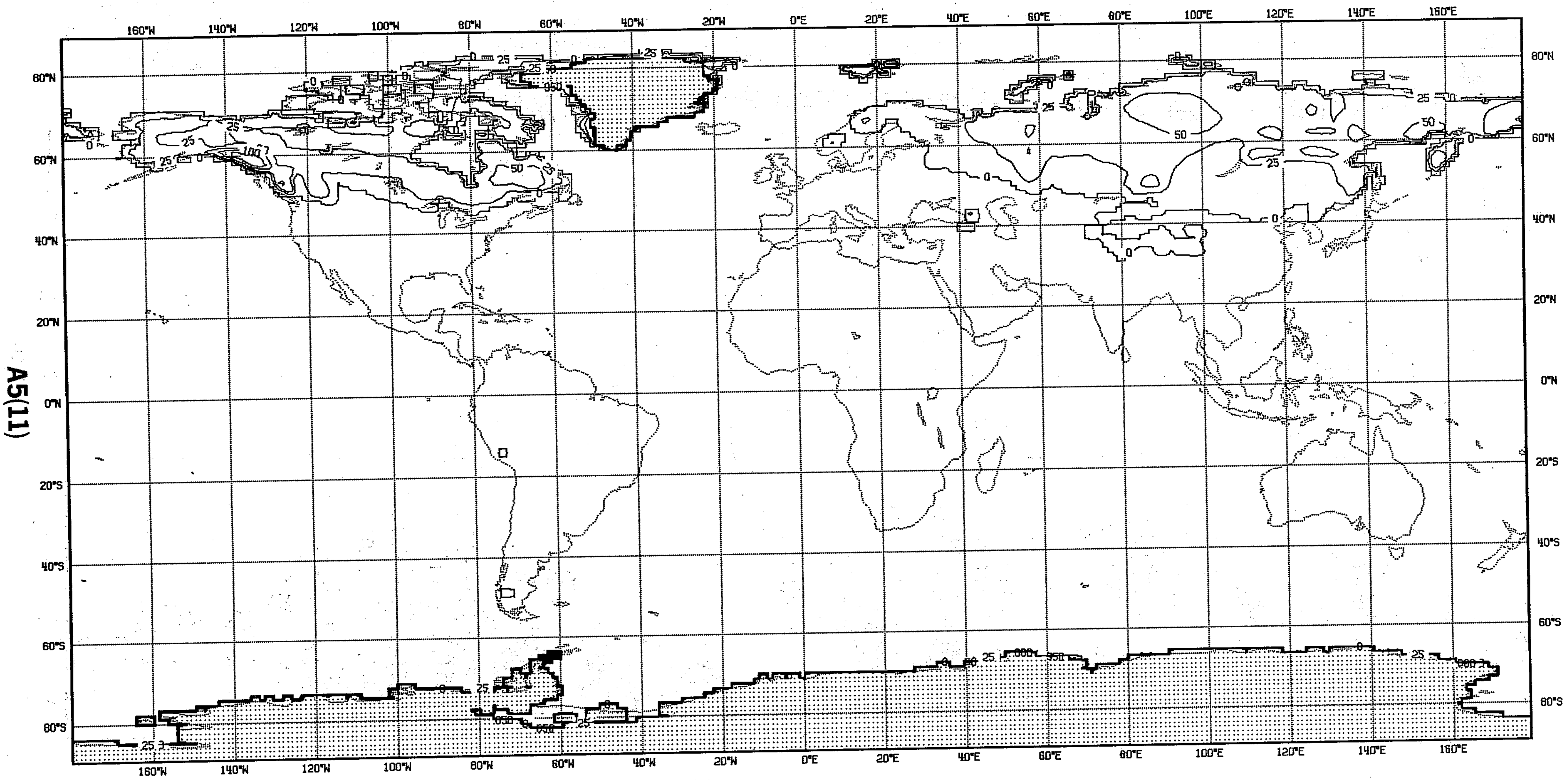
A5(9)



SNOW DEPTH MONTH 10

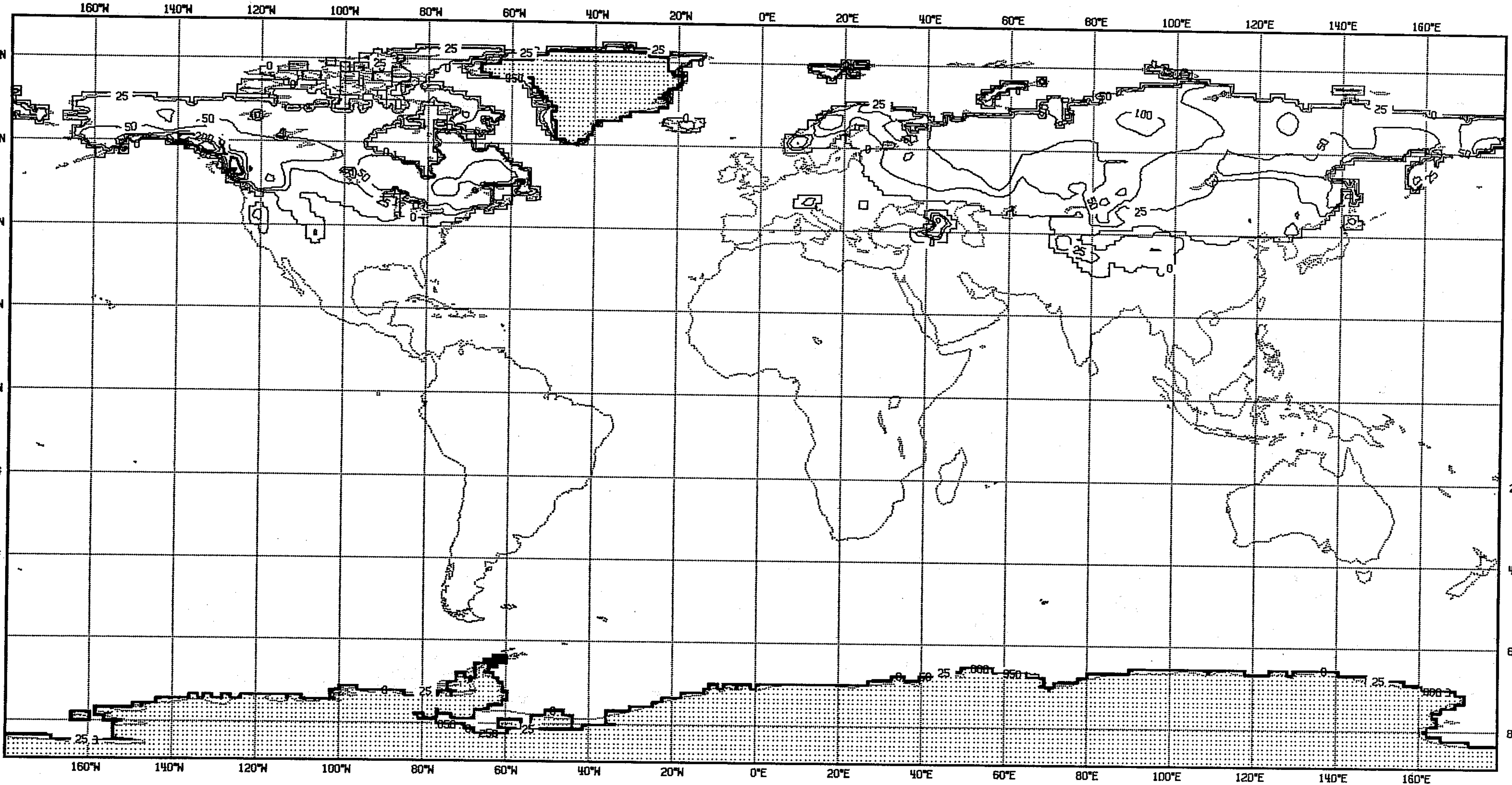
A5(10)

A5(11)



SNOW DEPTH MONTH 11

A5(12)

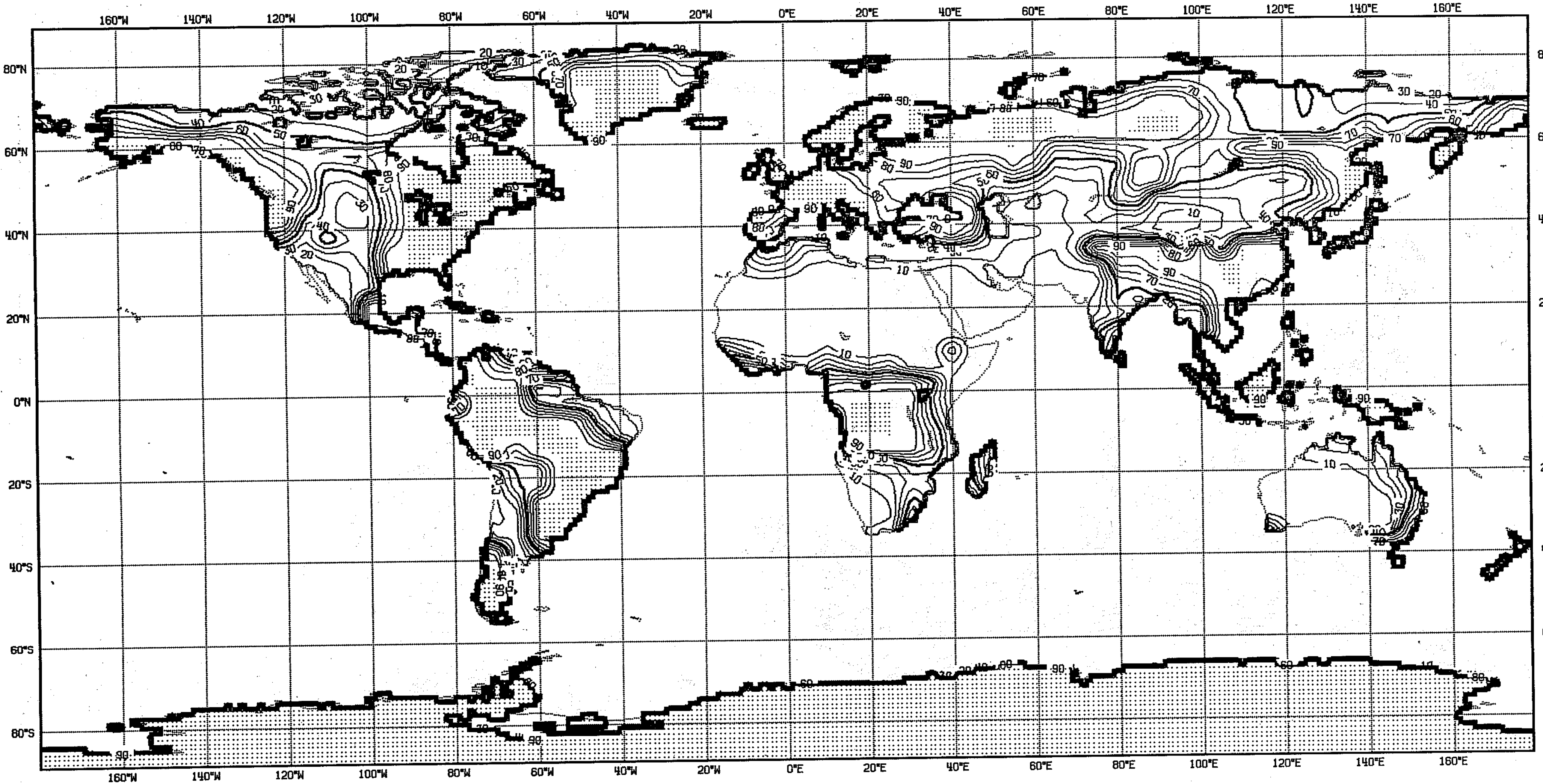


SNOW DEPTH MONTH 12

ANNEX A6(1) - A6(12)

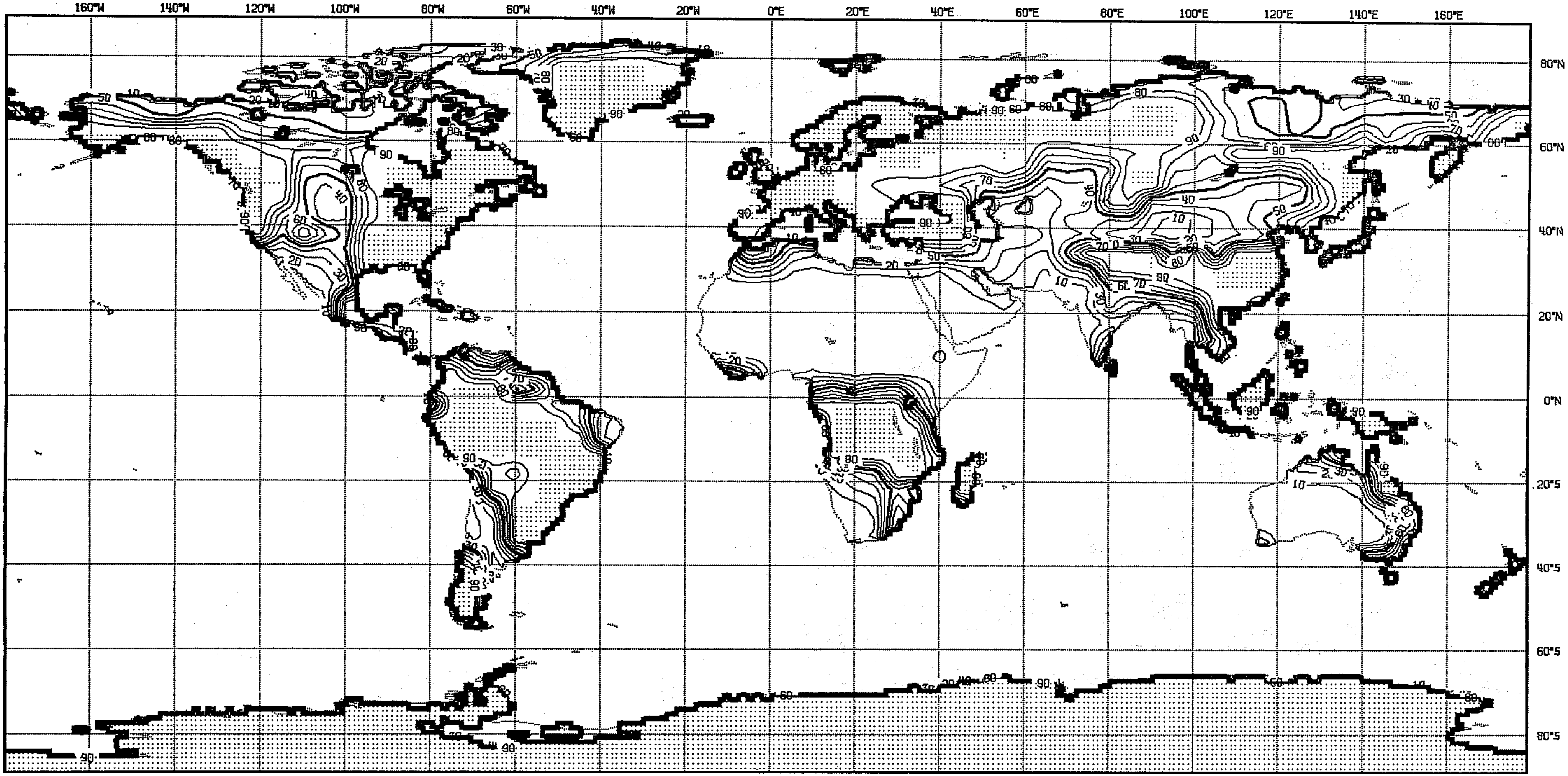
Soil moisture

A6 Soil moisture (percentage). Contour interval is 10%. Satured soil (100%) is shown by dotted areas.



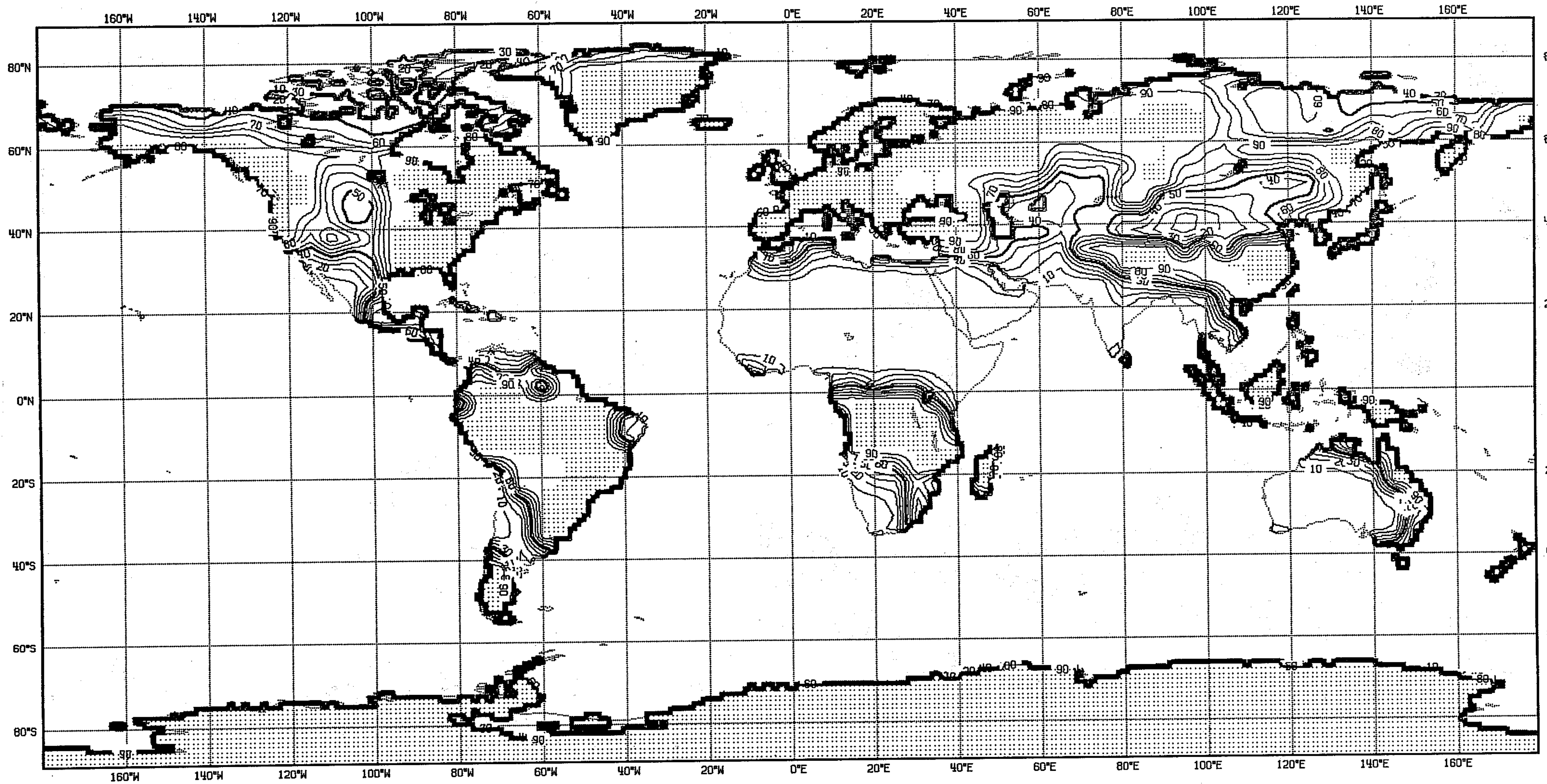
SOIL MOISTURE MONTH 1

A6(1)

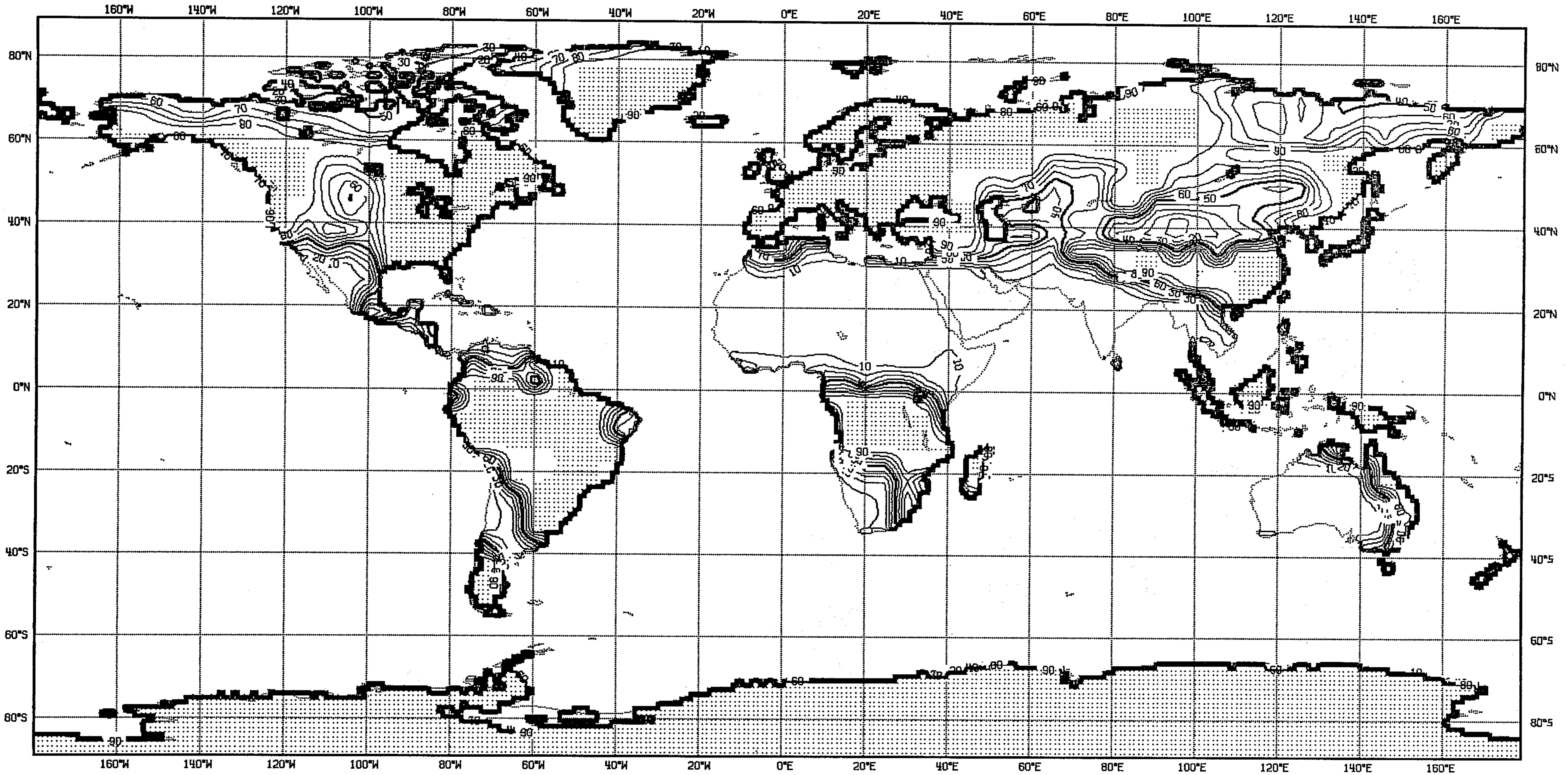


SOIL MOISTURE MONTH 2

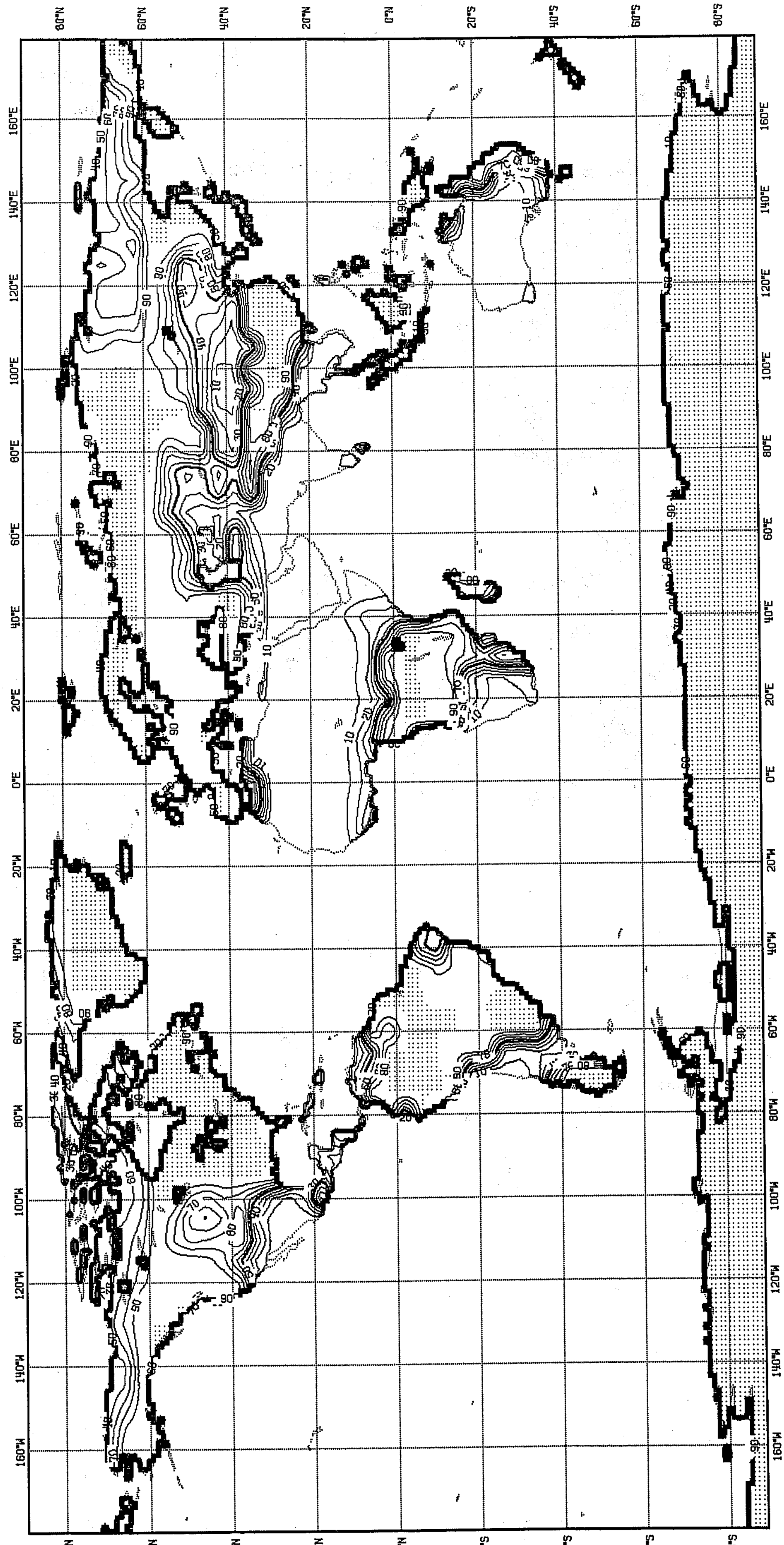
A6(3)



SOIL MOISTURE MONTH 3



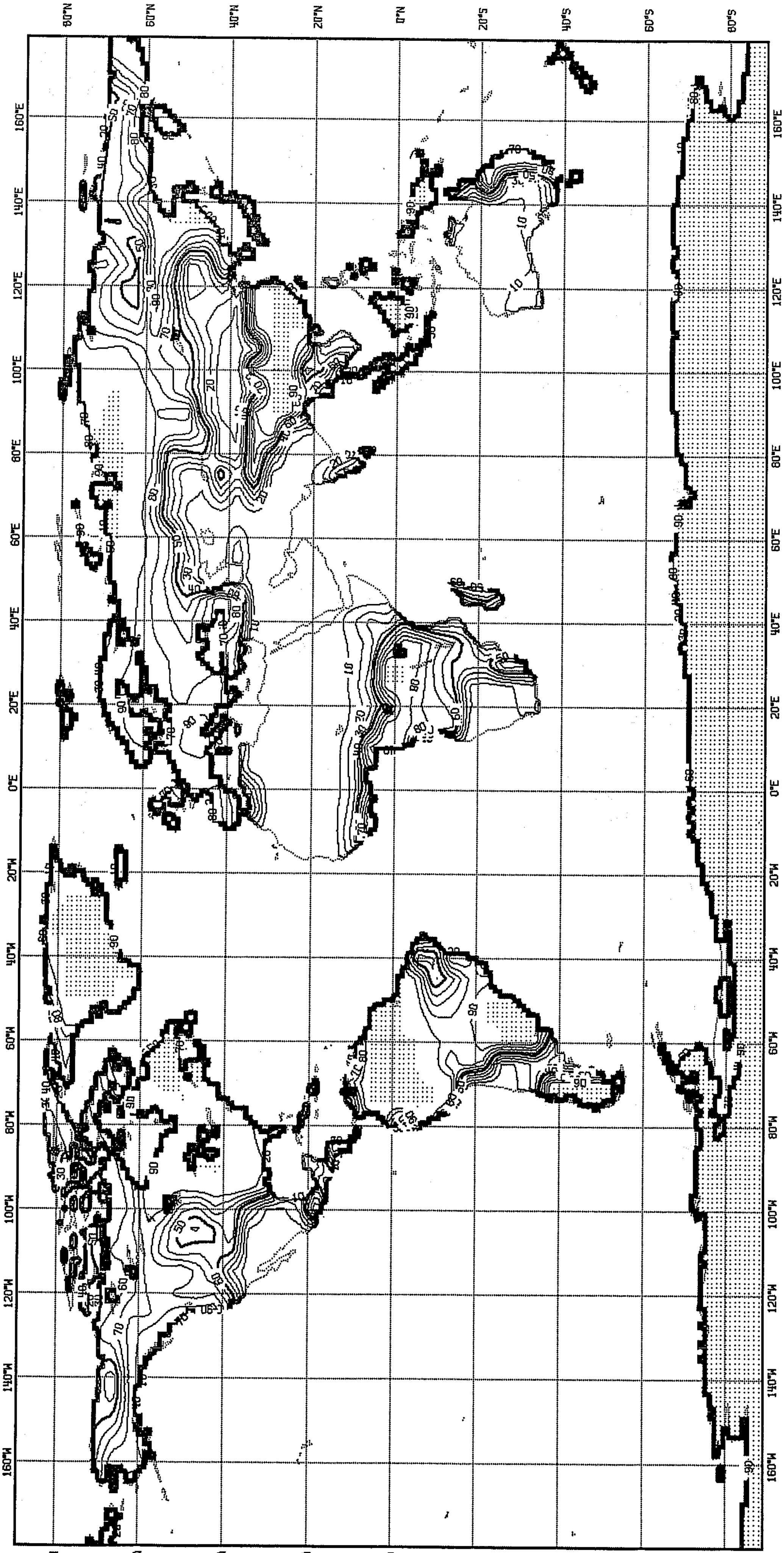
SOIL MOISTURE MONTH 4



SOIL MOISTURE

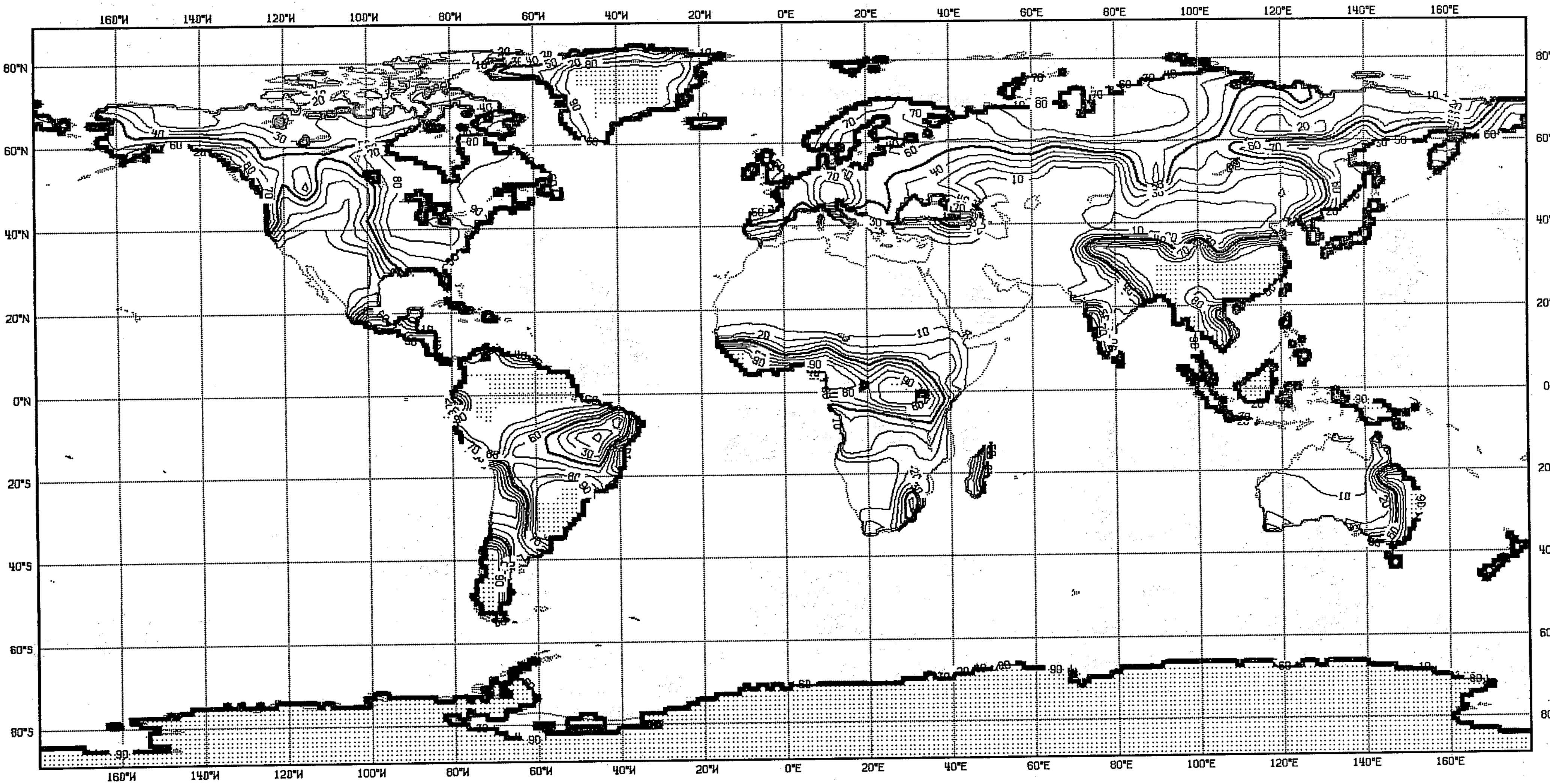
MONTH 5

A6(5)

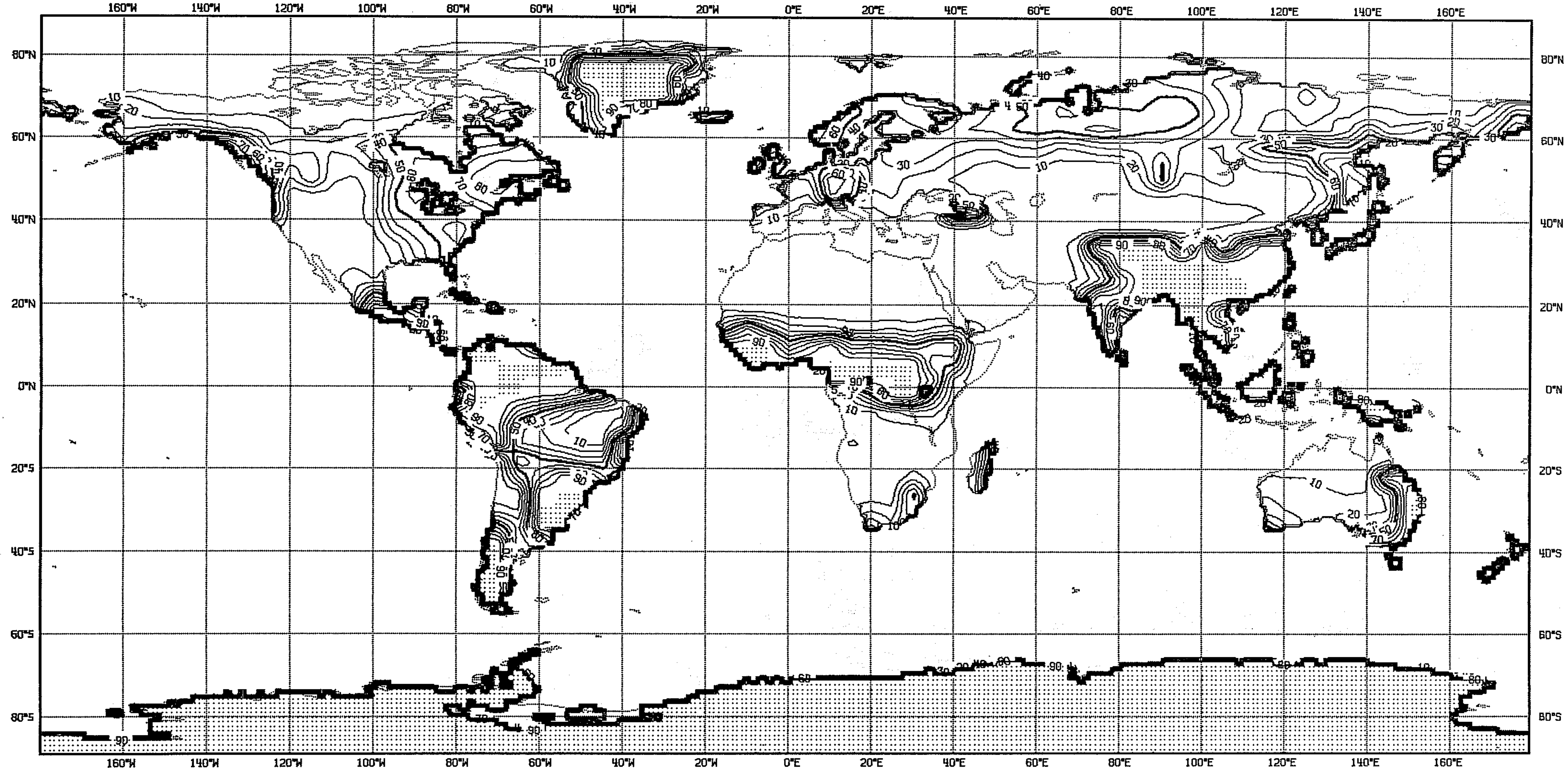


SOIL MOISTURE MONTH 6

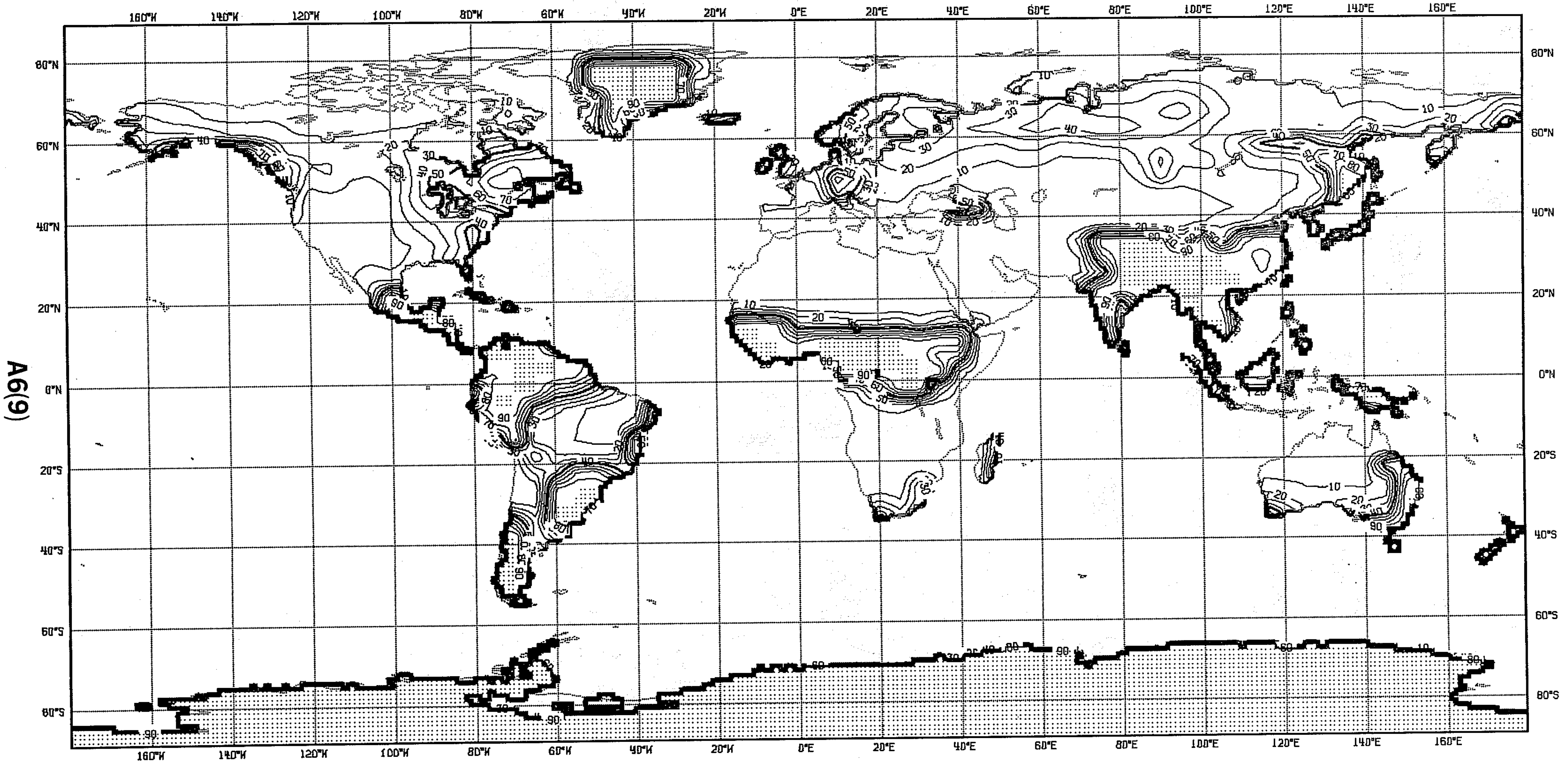
A6(6)



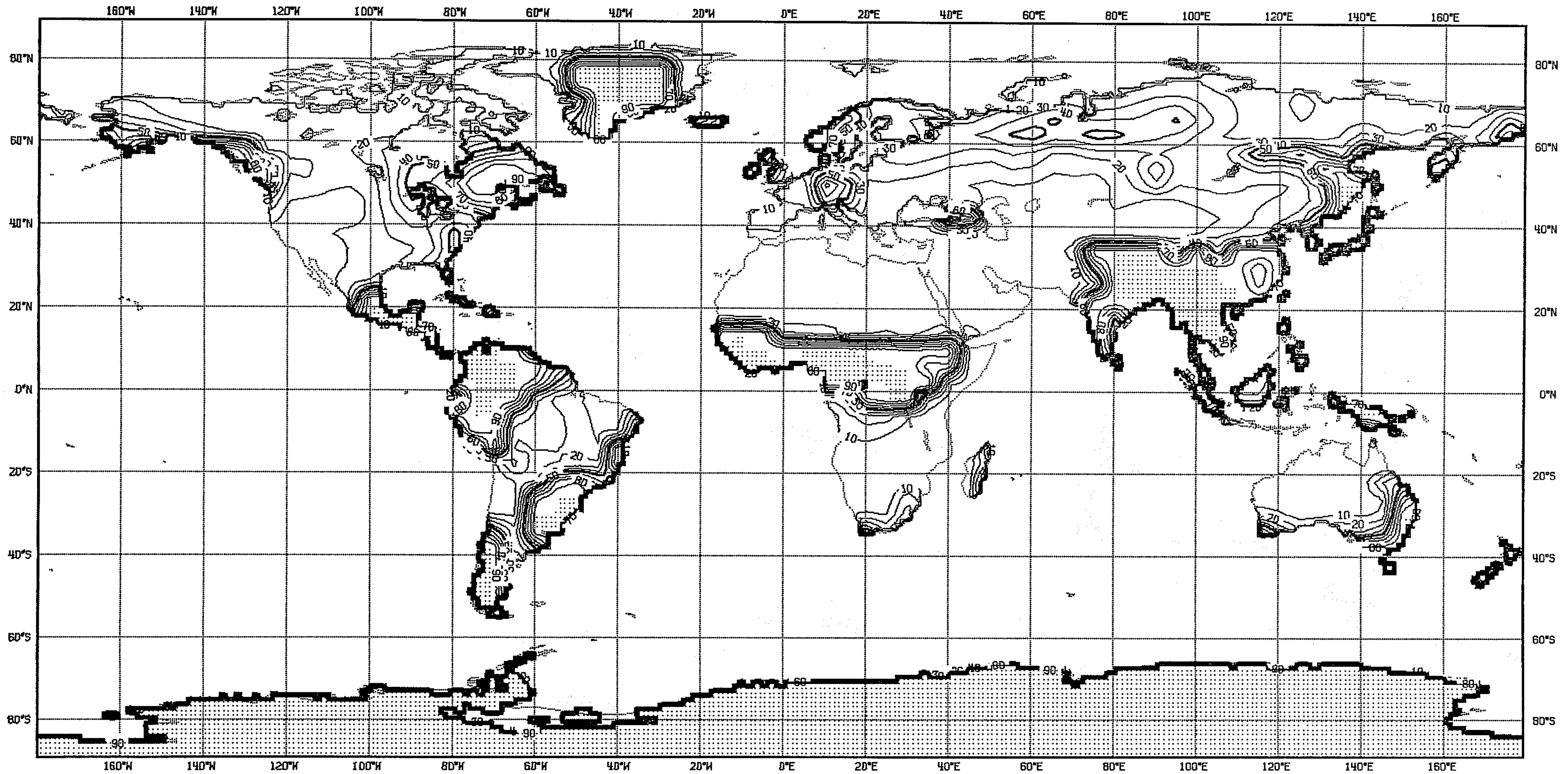
SOIL MOISTURE MONTH 7



SOIL MOISTURE MONTH 8

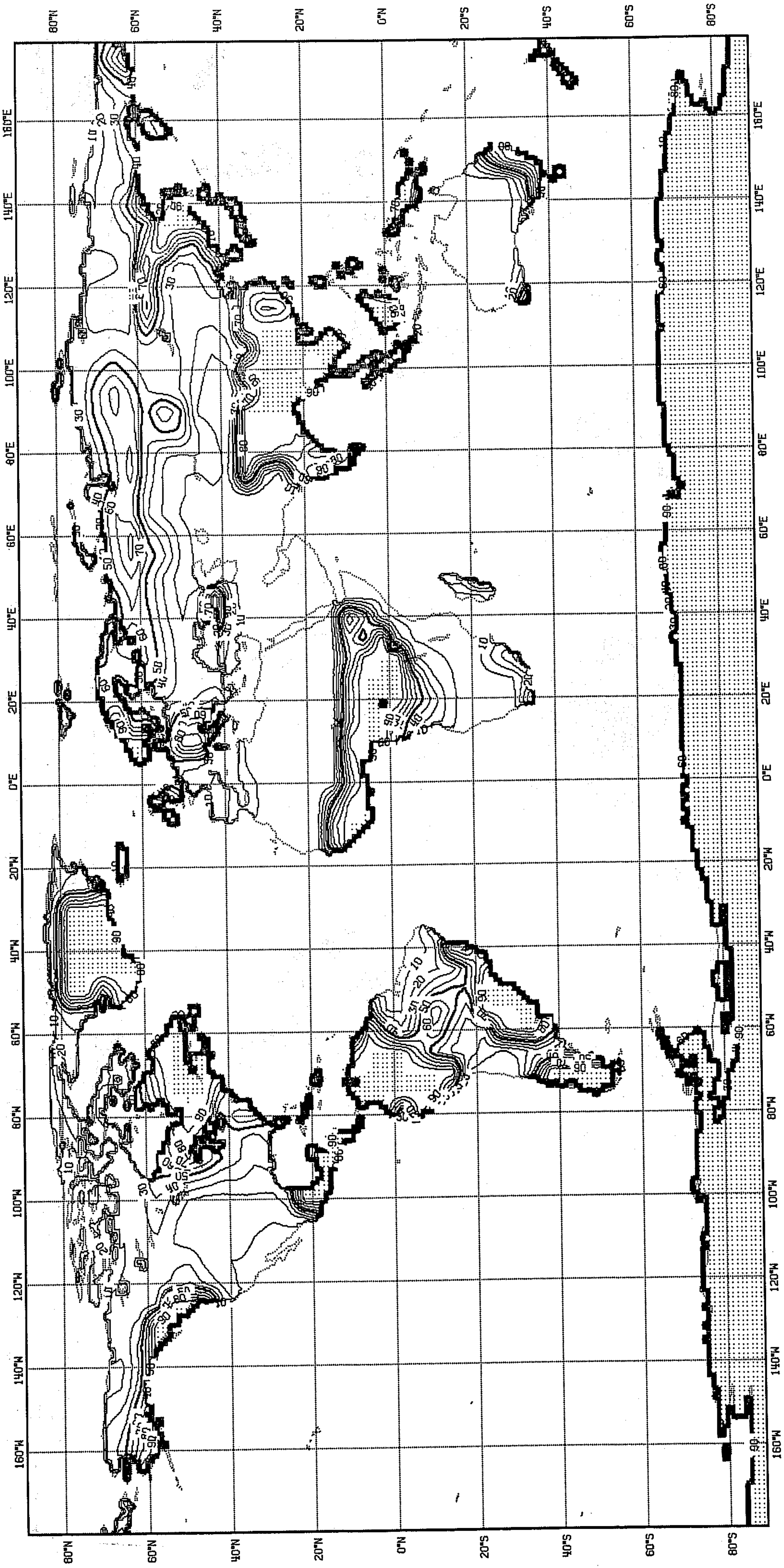


SOIL MOISTURE MONTH 9



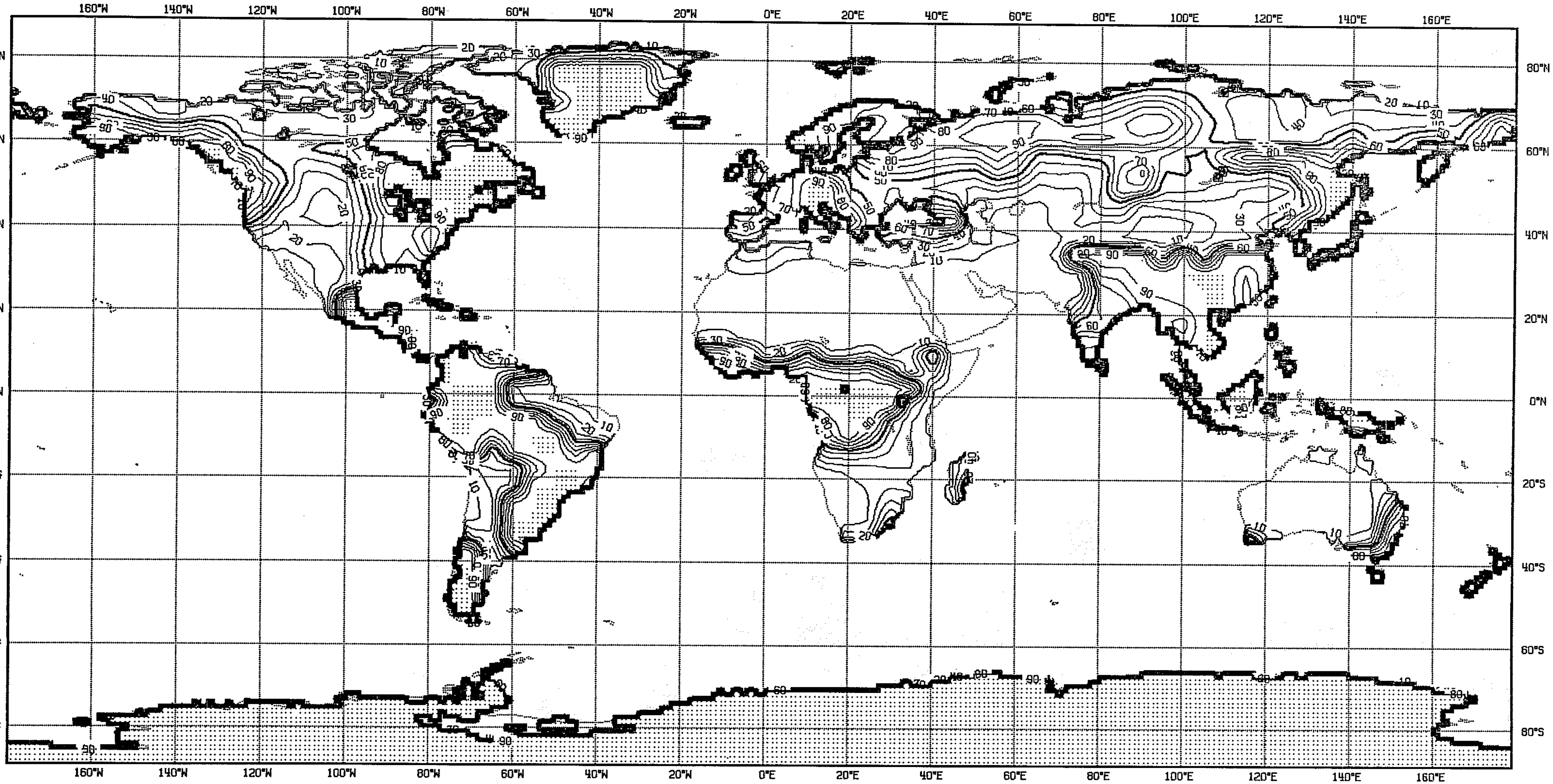
SOIL MOISTURE MONTH 10

A6(10)



SOIL MOISTURE MONTH 11

A6(11)

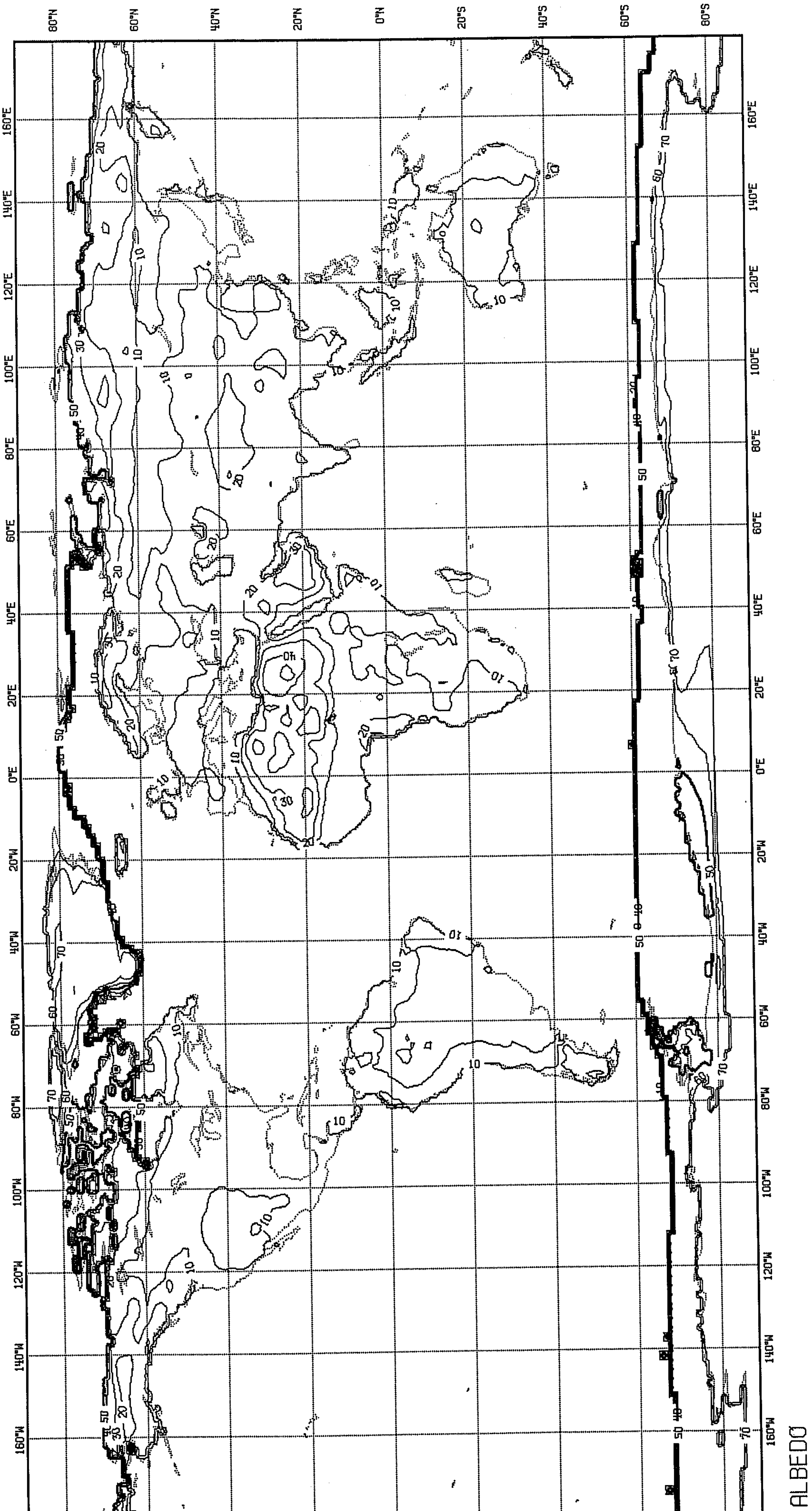


SOIL MOISTURE MONTH 12

ANNEX A7

Albedo

A7 Albedo (percentage). Contour interval is 10%.


80°N
60°N
40°N
20°N
0°N
20°S
40°S
60°S
80°S
160°W
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°E
20°E
40°E
60°E
80°E
100°E
120°E
140°E
160°E
10
20
30
40
50
60
70

ALBEDO

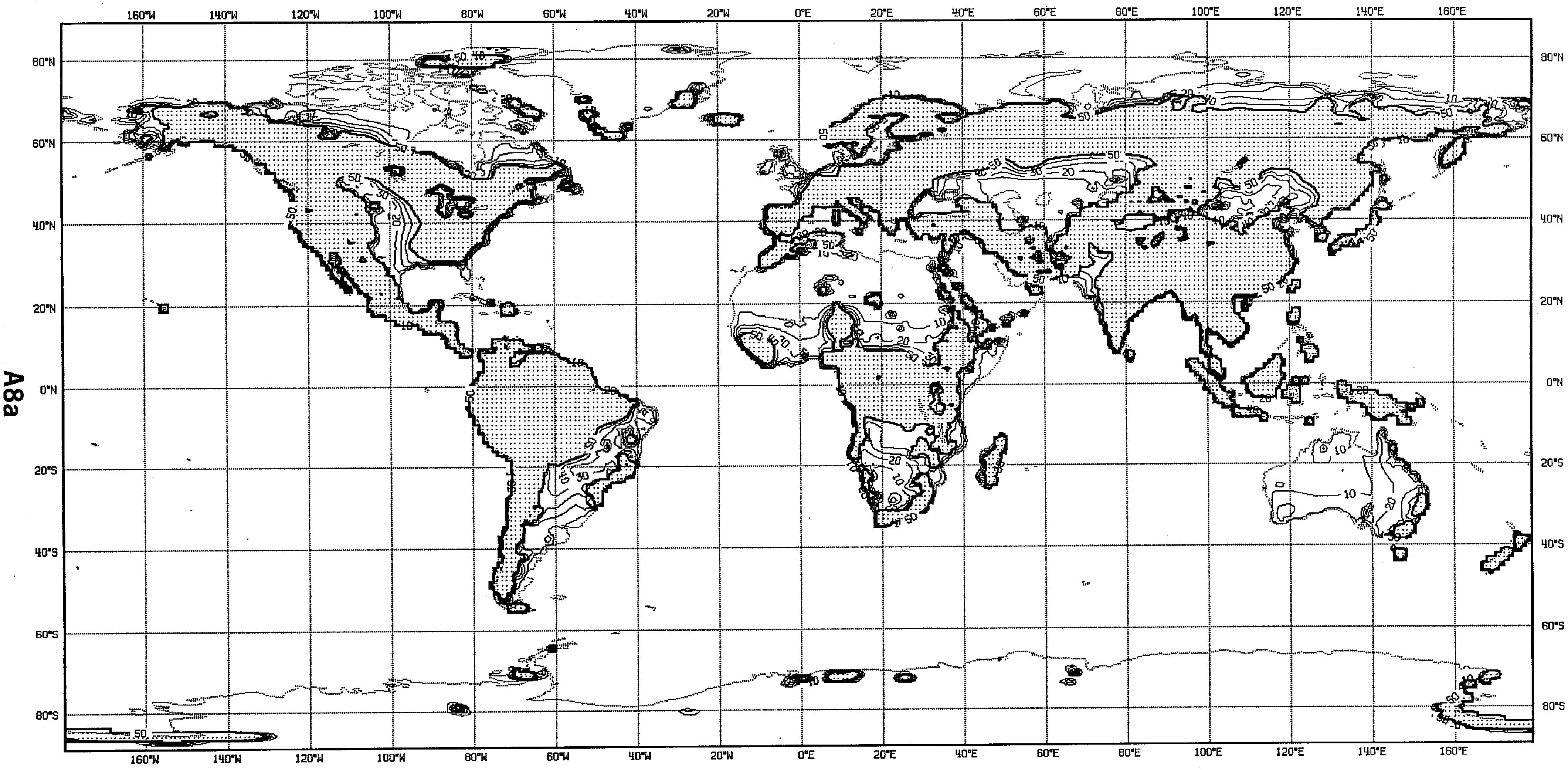
ANNEX A8a, A8b

Roughness length

A8a Roughness length up to 50 cm with contours of every 10 cm. Dotted areas denote Z_o values greater than 50 cm.

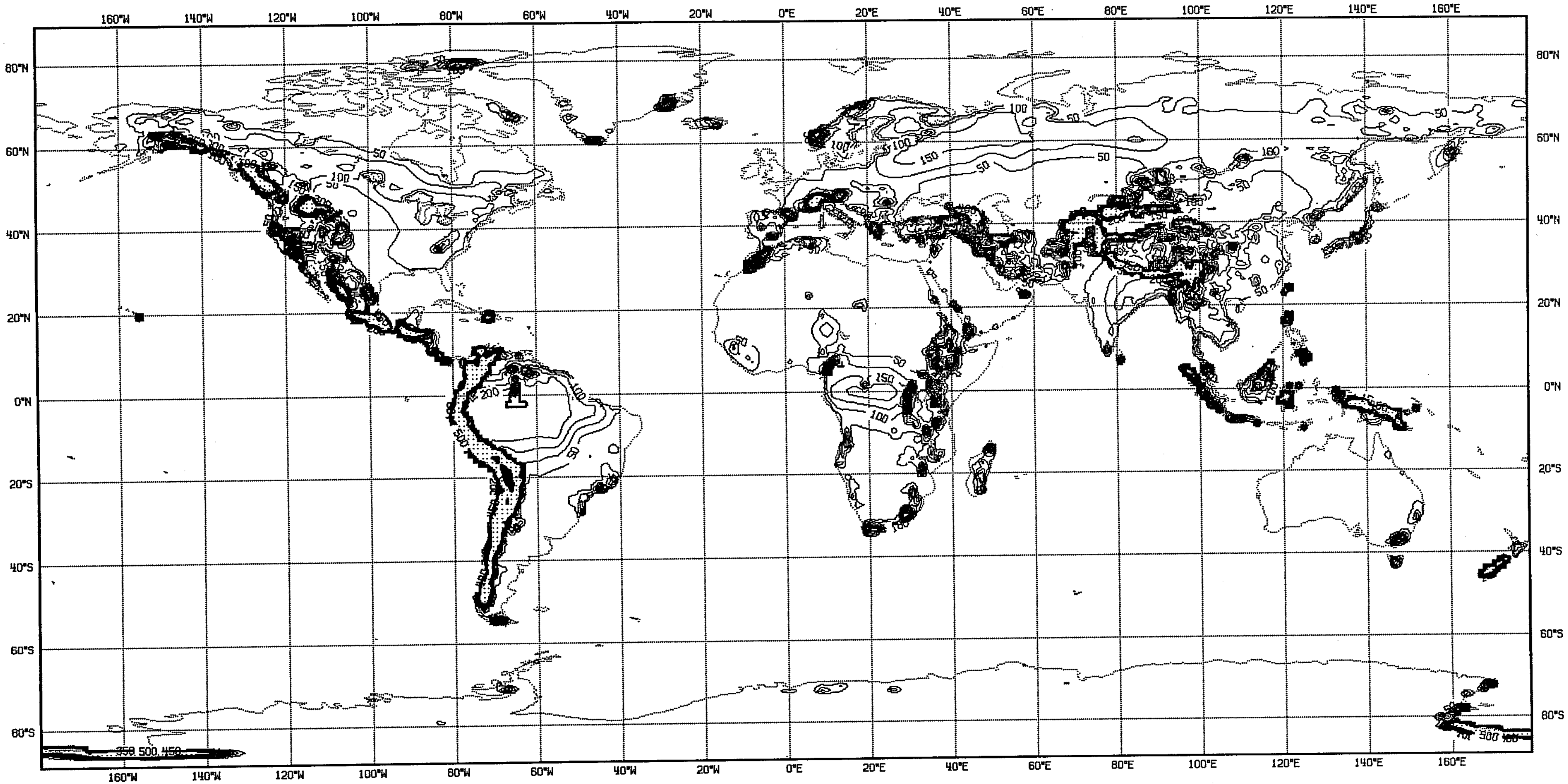
A8b Roughness length from 50 cm to 5 m with contours of every 50 cm. Dotted areas denote Z_o values between 5 m and 20 m.

A8a



ROUGHNESS LENGTH (UP TO 50 CM)

A8b



ROUGHNESS LENGTH (FROM 50 CM TO 5 M)