ORNL/CDIAC-56
NDP-040

ОРНЛ/ЦАИ-56
ПЦД-040

Daily Temperature and Precipitation Data for 223 USSR Stations

Суточные Данные о Температуре Воздуха и Сумме Осадков по 223 Станциям СССР

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Environmental Sciences Division

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ПЦД-040

СУТОЧНЫЕ ДАННЫЕ О ТЕМПЕРАТУРЕ ВОЗДУХА И СУММЕ ОСАДКОВ ПО 223 СТАНЦИЯМ СССР

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CONTENTS

CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Razuvaev, V. N., E. G. Apasova, and R. A. Martuganov. 1993. Daily Temperature and Precipitation Data for 223 USSR Stations. ORNL/CDIAC-56, NDP-040. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee. 127 pp.

On May 23, 1972, the United States and the USSR established a bilateral initiative known as the Agreement on Protection of the Environment. The primary goal of the initiative, which remains active despite the breakup of the USSR, is to promote cooperation between the two countries on numerous environmental protection issues. Currently, the agreement fosters joint research in at least 11 "Working Groups" (i.e., areas of study).

Given recent interest in possible greenhouse gas-induced climate change, Working Group VIII (Influence of Environmental Changes on Climate) has become particularly useful to the scientific communities of both nations. Among its many achievements, Working Group VIII has been instrumental in the exchange of climatological information between the principal climate data centers of each country [i.e., the National Climatic Data Center (NCDC) in Asheville, North Carolina, and the Research Institute of Hydrometeorological Information in Obninsk, Russia]. Considering the relative lack of climate records previously available for the USSR, data obtained via this bilateral exchange are particularly valuable to researchers outside the former Soviet Union.

To expedite the dissemination of these data, NOAA's Climate and Global Change Program funded the Carbon Dioxide Information Analysis Center (CDIAC) and NCDC to distribute one of the more useful archives acquired through this exchange: a 223-station daily data set covering the period 1881–1989. This data set contains: (1) daily mean, minimum, and maximum temperature data; (2) daily precipitation data; (3) station inventory information (WMO No., name, coordinates, and elevation); (4) station history information (station relocation and rain gauge replacement dates); and (5) quality assurance information (i.e., flag codes that were assigned as a result of various data checks). The data set is available, free of charge, as a Numeric Data Package (NDP) from CDIAC. The NDP consists of 18 data files and a printed document, which describes both the data files and the 223-station network in detail.

Keywords: Mean temperature; maximum temperature; minimum temperature; precipitation; daily data; USSR; former Soviet Union.

РЕЗЮМЕ

Разуваев, В. Н., Е. Г. Апазова, Р. А. Мартуганов. 1993. Суточные данные о температуре воздуха и сумме осадков по 223 станциям СССР. ОРНЛ/ЦАИ-56, ПЦД-040. Центр Анализа Информации по Углекислому Газу, Окриджская Национальная Лаборатория, Ок Ридж, Теннесси. 127 стр.

23 Мая 1972 года Соединенные Штаты Америки и Советский Союз заключили двусторонний договор, известный как "Соглашение о сотрудничестве в области Охраны Окружающей Среды". Основной целью договора, который остается в силе несмотря на распад СССР, является содействие связям между двумя странами во многочисленных акциях по охране Окружающей Среды. В настоящее время договор способствует совместным исследованиям по крайней мере в 11-ти "Рабочих Группах" (т.е., областях изучения).

В результате проявленного интереса к возможности изменений климата под влиянием атмосферных газов, Рабочая Группа VIII (Влияние изменений Окружающей Среды на Климат) заняла особо важное место в научной сфере обеих стран. Среди многочисленных достижений Рабочая Группа VIII играет важную роль в обмене климатологической информацией между центрами климатических данных обеих стран [а именно: Национальный Центр Климатических Данных (НЦКД) в Ашвилле, Северная Каролина, и Научно-Исследовательский Институт Гидрометеорологической Информации в Обнинске, Россия].Принимая во внимание относительную нехватку в климатических данных, полученных ранее из СССР, данные, полученные с помощью договора о двустороннем обмене, особо ценны для ученых за пределами бывшего Советского Союза.

Для ускорения распространения этих данных, Национальная Администрация по изучению Океана и Атмосферы (НАОА) в рамках научно-исследовательской программы по изучению Глобальных Изменений Климата приняла решение финансировать Центр Анализа Информации по Углекислому Газу (ЦАИ) и НЦКД для анализа и публикации наиболее полезного архива данных, приобретенного вследствие обмена: суточные данные по 233 метеорологическим станциям, охватывающие период с 1881 по 1989 годы. Эти данные содержат: (1) суточные измерения средней, минимальной и максимальной температур; (2) суточные данные о сумме осадков; (3) подробная информация о каждой станции (ММО No., название, координаты и высота над уровнем моря); (4) историческая информация (перемещение станции и дата перестановки осадкомера); (5) информация о качестве данных (т.е., коды качества информации, которые использовались как результат различных проверок данных). Данные можно заказать бесплатно в виде Пакета Цифровых Данных (ПЦД) через ЦАИ. ПЦД состоит из 18-ти файлов и напечатанного документа, который подробно описывает как файлы данных, так и информацию о 223 станциях.

Ключевые слова: Средняя температура; максимальная температура; минимальная температура; осадки; суточные данные; СССР; бывший Советский Союз.

PART 1:

OVERVIEW

1. BACKGROUND INFORMATION

On May 23, 1972, the United States and the Union of Soviet Socialist Republics (USSR) established a bilateral initiative known as the Agreement on Protection of the Environment (Tatusko 1990). The primary goal of the initiative, which remains active despite the breakup of the USSR, is to promote cooperation between the two countries (Russia and the United States) on numerous environmental protection issues. Currently, the agreement fosters joint research in at least 11 "Working Groups" (i.e., areas of study), including:

I. Prevention of Air Pollution
II. Prevention of Pollution Effects on Vegetation
III. Prevention of Pollution Associated with Agricultural Production
IV. Enhancement of the Urban Environment
V. Protection of Nature and the Organization of Preserves
VI. Protection of the Marine Environment from Pollution
VII. Biological and Genetic Effects of Environmental Pollution
VIII. Influence of Environmental Changes on Climate
IX. Earthquake Prediction
X. Arctic and Subarctic Ecological Systems
XI. Legal and Administrative Measures for Protecting Environmental Quality

Given recent interest in possible greenhouse gas-induced climate change, Working Group VIII has become particularly useful to the scientific communities of both nations. Since its inception in 1972, Working Group VIII has been the primary conduit through which numerous cooperative studies of climate have been carried out. Its focus has evolved considerably through time and currently is quite broad, ranging from climate change, atmospheric composition, and stratospheric ozone to radiation fluxes, cloud climatology, and climate modeling.

Among its achievements, Working Group VIII has established the Climate Data Exchange and Management Agreement Project. The purpose of this ongoing project is to promote the transfer of climatological information between the principal climate data centers in each country [i.e., the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) in Asheville, North Carolina, and the Research Institute of Hydrometeorological Information (RIHMI) in Obninsk, Russia]. A considerable amount of data has been exchanged as a result of this project. Some of the land-surface data received by NCDC to date include:

☐ daily temperature and precipitation data collected at 223 USSR stations (1881–1989)
☐ 3-hourly synoptic data collected at 223 USSR stations (1966–86)
☐ 6-hourly synoptic data collected at 223 USSR stations (1936–65)
☐ monthly temperature data collected at 243 USSR stations (1891–1988)

The exchange of climatic data such as these will probably continue in the coming years. Acquisitions anticipated by NCDC in the near future include data for additional stations and updates for previously supplied stations.

Considering the relative lack of climate records previously available for the USSR, data obtained via the bilateral exchange are particularly valuable to researchers outside the former Soviet Union. To expedite the dissemination of these data, this Numeric Data Package (NDP) presents one of the more useful archives that can be applied to the study of climate change and variability in the USSR: the 223-station daily temperature/precipitation data set.

2. DESCRIPTION OF THE DATA SET

The data set documented in this NDP contains daily temperature and precipitation measurements collected at 223 USSR stations over the period 1881–1989. It was compiled from digital and manuscript records archived at RIHMI in Obninsk, Russia. This section describes:

- ☐ the meteorological, geographical, and historical variables contained in the data set;
- ☐ the methods and instruments used in collecting the meteorological observations; and
- ☐ the temporal and spatial coverage of the station network.

2.1 Variables

Daily mean, minimum, and maximum temperatures are available (to the nearest tenth of a degree Celsius) for each station. Temperature observations were taken eight times a day from 1966–89, four times a day from 1936–65, and three times a day from 1881–1935. Daily mean temperature is defined as the average of all observations for each calendar day. Daily maximum/minimum temperatures are derived from maximum/minimum thermometer measurements. To identify potentially erroneous data, two flag codes accompany each daily value; see pages 13 and 34 for information about these flags.

Daily precipitation totals are also available (to the nearest tenth of a millimeter) for each station. Throughout the record, daily precipitation is defined as the total amount of precipitation recorded during a 24-h period, snowfall being converted to a liquid total by melting the snow in the gauge. From 1936 on, rain gauges were checked several times each day; the cumulative total of all observations during a calendar day was presumably used as the daily total. Wetting corrections ≤0.2 mm were applied beginning in 1966, depending upon the type and amount of precipitation. As with temperature, two data quality flags accompany each daily total.

Extensive geographical and historical information supplements each time series. This "metadata" is available to the user in digital form (as numeric data files) and in printed form (as Appendixes A and B). Geographical parameters include current station name, latitude, longitude, and elevation. Historical parameters include station relocation date(s), the distance and direction of any such move(s), and the date on which the station switched to the Tretyakov-type rain gauge. Only 32 stations remained at their initial locations through 1989, and all stations switched to the Tretyakov-type gauge during the period 1946–60.

2.2 Recording Methods and Instrumentation

Recording methods and instrumentation varied considerably over the period of record. The following describes the types of instruments used throughout the network, the apparatus employed to shelter these instruments, and the times at which observations were taken. Temperature and precipitation are addressed separately. Additional information regarding the history of the network is contained in publications and instruction manuals prepared by the Academy of Sciences of the Russian Empire (1892, 1893, 1894, 1896, 1897, 1898, 1900, 1902, 1908, 1912), The Nicholas Main Physical Observatory (1915), The Voyeikov Main Geophysical Observatory (1928, 1931, 1963), the Central Administration of the Unified Hydrometeorological Service of the USSR (1935, 1936, 1939, 1940), the Council of Ministers of the USSR (1946, 1954, 1958, 1962, 1969, 1985), and Gidrometeoizdat (1972).

Temperature

The types of thermometers in use at each station remained the same throughout the period of record (Table 1). Minimum temperature was consistently measured with an alcohol thermometer, whereas hourly and maximum temperatures were each collected with separate mercury thermometers. When the air temperature approached the freezing point of mercury (-38.9°C), either an alcohol thermometer, or in some cases a minimum thermometer alcohol column, was used in place of the mercury thermometer. Whether or not (much less *when*) the thermometers themselves were replaced at each station is not currently known.

The type of shelter or screen surrounding the thermometers varied considerably before 1930. In 1912, official instructions recommended sheltering thermometers with the Stevenson-type screen (before 1912, no such guidelines existed). However, it is likely that this change was not implemented at many stations. From 1920–30, Stevenson screens were replaced with the current screens (name unknown) at all operating stations. In 1928, additional guidelines regarding the exact dimensions of the shelters and their mounting heights were issued (before 1928, no such specifications had been defined). Therefore, from 1930 on, most stations had their thermometers sheltered in roughly the same fashion.

Major changes in the time of observation occurred in 1936 and 1966. Prior to 1936, "hourly" measurements for computing daily mean temperature were taken at 0700, 1300, and 2100 Local Mean Time (LMT) (minimum and maximum thermometers were checked at one of these hours or at 0900 LMT, depending upon the year). Because of the lack of nighttime observations, daily mean temperature was probably overestimated by some location-dependent amount during this period. Beginning in 1936, all thermometers (hourly, minimum, and maximum) were checked at 0100, 0700, 1300, and 1900 LMT at most stations. As a result, the bias in daily mean temperature dropped to ~0.2°C. From 1966–present, all thermometers were checked at 3-h intervals beginning at midnight Moscow winter Legal Time (MLT) (MLT being three hours later than Greenwich Mean Time). This rendered the bias in daily mean temperature insignificant.

Precipitation

The type of rain gauge used at each station changed at least once during the period of record (Table 2). In particular, the old-style gauge (type unknown) was replaced with the Tretyakov-type gauge over the period 1946–60 (see Appendix B for the date of implementation at each site). Whether or not other gauge replacements occurred at each station is not currently known.

The type of shielding surrounding the rain gauges varied considerably over time. For example, in 1883, official instructions recommended that cross-shaped zinc strips be inserted into the gauge to prevent snow from drifting. Other shielding guidelines were issued at various times over the next half-century, up until the Tretyakov-type gauge was introduced. However, whether or not (much less *when*) any of the shields were installed at each station is not currently known.

Changes in the time of observation occurred in 1936, 1966, and 1986. Before 1936, rainfall was measured only at 0700 LMT. From 1936–65, gauges were checked at 0700 and 1900 LMT. Beginning in 1966, the time of observation became time-zone dependent (the USSR being comprised of 11 time zones). In particular, from 1966–85, readings were taken at 0300, 0900, 1500, and 2100 MLT in zone 2 (i.e., Moscow); at 0300, 0600, 1500, and 1800 MLT in zones 3–5; at 0300 and 1500 MLT in zones 6–8; at midnight, 0300, 1200, and 1500 MLT in zones 9–11; and at 2100, 0300, 0900, and 1500 MLT in zone 12 (the easternmost part of the USSR). In 1986, the 0300 and 1500 MLT observations were discontinued in all but the second time zone.

Table 1. Temperature recording methods and instrumentation

Year	Recording method/instrumentation implemented
1881	Measurements for computing daily mean temperature taken at 0700, 1300, and 2100 LMT; mercury thermometer used; because of lack of nighttime observations, daily mean temperature probably overstated.
1881	Daily minimum temperature thermometer checked at 0900 LMT; alcohol thermometer used.
1881	Daily maximum temperature thermometer checked at 0900 LMT; mercury thermometer used.
1881	No regulations regarding type of shelter surrounding thermometers.
1883	Daily minimum temperature thermometer checked at 0700 and 2100 LMT (lower value chosen); multiple measurements taken only to determine approximate time of occurrence of minimum.
1891	Daily maximum temperature thermometer checked at 1300 and 2100 LMT (higher value chosen); multiple measurements taken only to determine approximate time of occurrence of maximum.
1912	Official meteorological instructions recommended use of Stevenson screen to shelter thermometers; practice not implemented at all stations.
1920	Official meteorological instructions recommended use of current screen to shelter thermometers; practice implemented over next ten years.
1928	Official meteorological instructions specified exact size/height of screens.
1936	Measurements for computing daily mean temperature taken at 0100, 0700, 1300, and 1900 LMT (or at 0700, 1300, 1900, and 2100 LMT); bias in daily mean temperature dropped to ~0.2°C; daily maximum and minimum thermometers may or may not have been checked each hour.
1966	Measurements for all temperature variables collected at 3-h intervals beginning at midnight MLT; bias in daily mean temperature eliminated.

Table 2. Precipitation recording methods and instrumentation

Year	Recording method/instrumentation implemented
1881	Rain gauge measurements taken at 0700 LMT; snowfall converted to a liquid total by melting snow in gauge; type of gauge and shielding not standardized.
1883	Official meteorological instructions recommended that cross-shaped zinc strips be inserted into the gauge to prevent snow from drifting; change probably not implemented at all stations.
1887	Official meteorological instructions recommended surrounding the gauge with the funnel-shaped Nifer's shield; change probably not implemented at all stations.
1892	Official meteorological instructions recommended erecting a fence around the gauge; change probably not implemented at all stations.
1902	Official meteorological instructions recommended erecting a double fence around the gauge; change probably not implemented at all stations.
1936	Rain gauge measurements taken at 0700 and 1900 LMT; daily total rainfall obtained by summing all measurements for the calendar day.
1946-1960	Old-style gauge (exact type unknown) replaced with the Tretyakov-type gauge (see Appendix B for the date of implementation at each site).
1966	Rain gauge measurements taken at 0300, 0900, 1500, and 2100 MLT in time zone 2; at 0300, 0600, 1500, and 1800 MLT in zones 3–5; at 0300 and 1500 MLT in zones 6–8; at midnight, 0300, 1200, and 1500 MLT in zones 9–11; and at 2100, 0300, 0900, and 1500 MLT in zone 12; wetting corrections ≤ 0.2 mm applied to each hourly measurement (Because four observations per day were collected at stations in time zones 2–5 and 9–12, four corrections were counted in the daily total; therefore, total daily corrections are higher for stations in these areas.)
1986	Rain gauge measurements at 0300 and 1500 MLT discontinued at all stations except those in time zone 2.

2.3 Temporal and Spatial Coverage

The size of the observing network has increased with time (Fig. 1). Twenty-three sites contain daily measurements dating to 1881 (though for 76 stations, maximum and/or minimum temperature observations began several years after mean temperature and precipitation). Aside from the period 1914–21 (i.e., during World War I, the Russian Revolution, and the Civil War), the number of stations rose at a relatively constant rate over the next half-century. The largest change in the network occurred in 1936, when an additional 65 observing posts were opened. Thereafter, only modest additions are evident, all stations collecting data by 1966 and only five (Adamovka, Vereb'e, Oktiabr'skaya, Rostov-na-Donu, and Surgut) closing before 1989.

As the number of operational stations increased, spatial coverage improved. The distribution of posts early in the record, for example, is biased (Fig. 2). In fact, most stations were located in population centers west of the Ural mountains and at ports along the Black and Caspian seas, whereas vast tracts of Siberia were entirely unsampled. Spatial coverage was much more representative of the country for the mid-1930s, with the exception of certain areas east of the Urals and north of the Arctic Circle (Fig. 3). From a practical standpoint, the data set can probably be used to study long-term climate variations over the entire USSR for the period 1936–89. The density of stations, as well as their spatial distribution, was even better by 1985 (Fig. 4). Except for areas along the coast of the Arctic Ocean, most of the country was extremely well-sampled. In general, however, Arctic regions in the eastern part of the country are somewhat underrepresented throughout the record.

The amount of missing data varies from element to element and station to station. Typically, the records of minimum/mean temperature are more complete than those of maximum temperature and rainfall. Most stations (90%) have at least 50 years of data for each parameter.

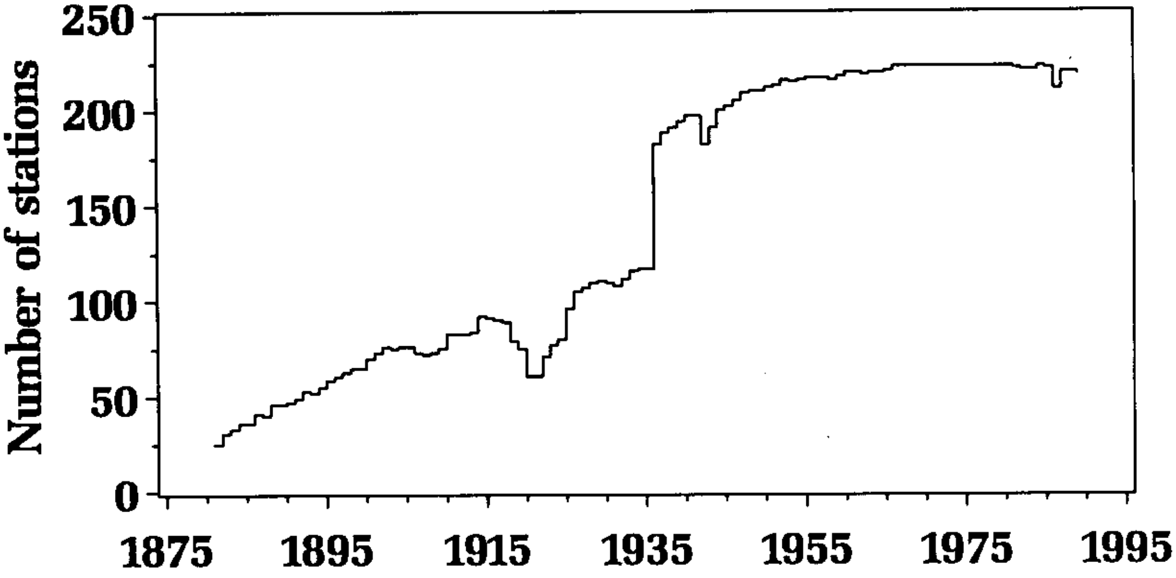

Figure 1. Observing network as a function of time. Twenty-three sites recorded daily measurements as early as 1881. The network evolved at a slow and mostly steady rate until 1936, when 65 stations were opened. Only modest changes occurred thereafter; all posts were in operation by 1966 and only five were closed before 1989.

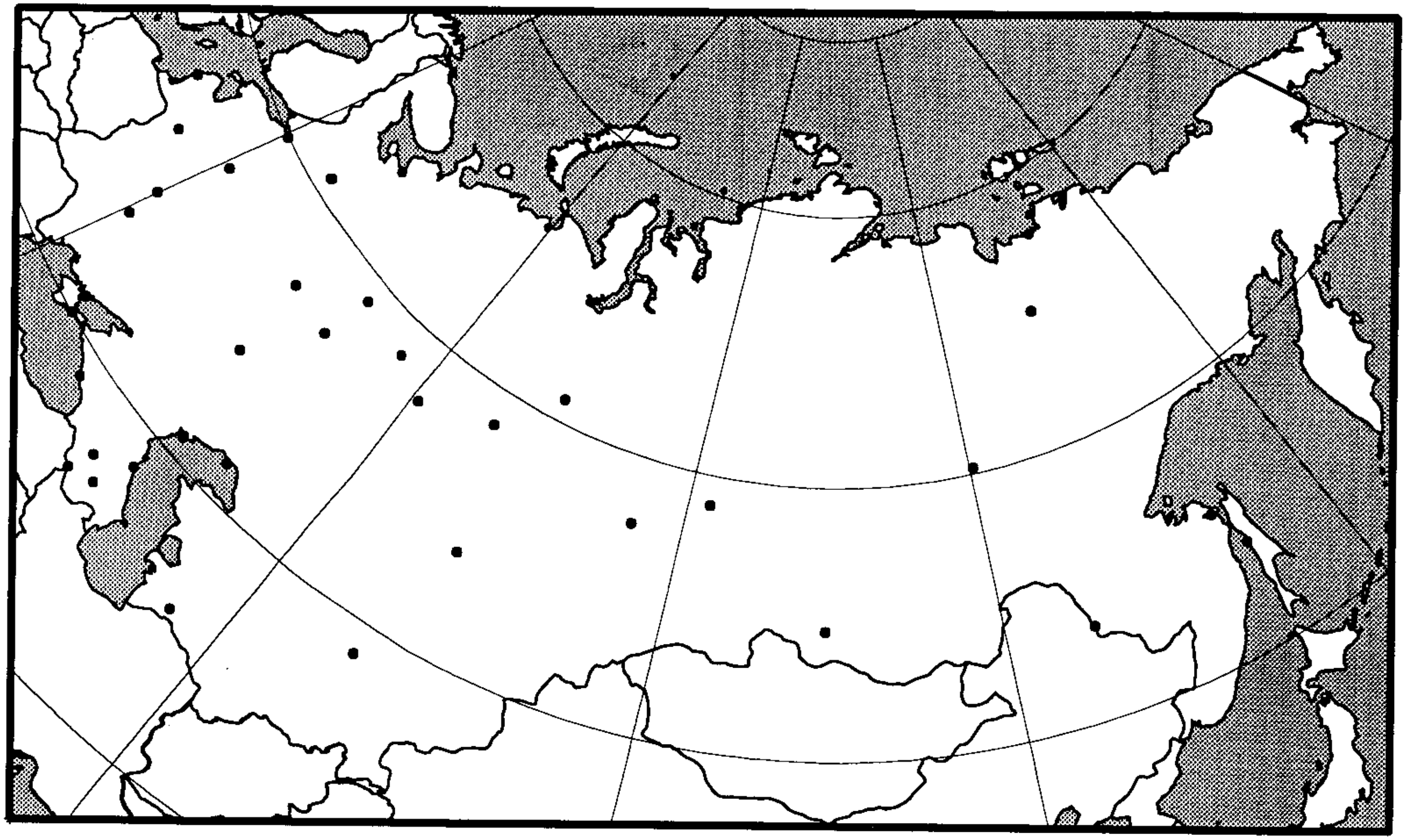

Figure 2. Observing network in 1885. Weather stations are denoted by large black dots. With only 36 posts collecting data, coverage of the country was extremely poor. Most stations were located in major population centers west of the Ural mountains and at ports along the Black and Caspian seas. In contrast, vast tracts of Siberia were virtually unrepresented. Coverage over the eastern half of the country remained sparse through the late 19th and early 20th centuries.

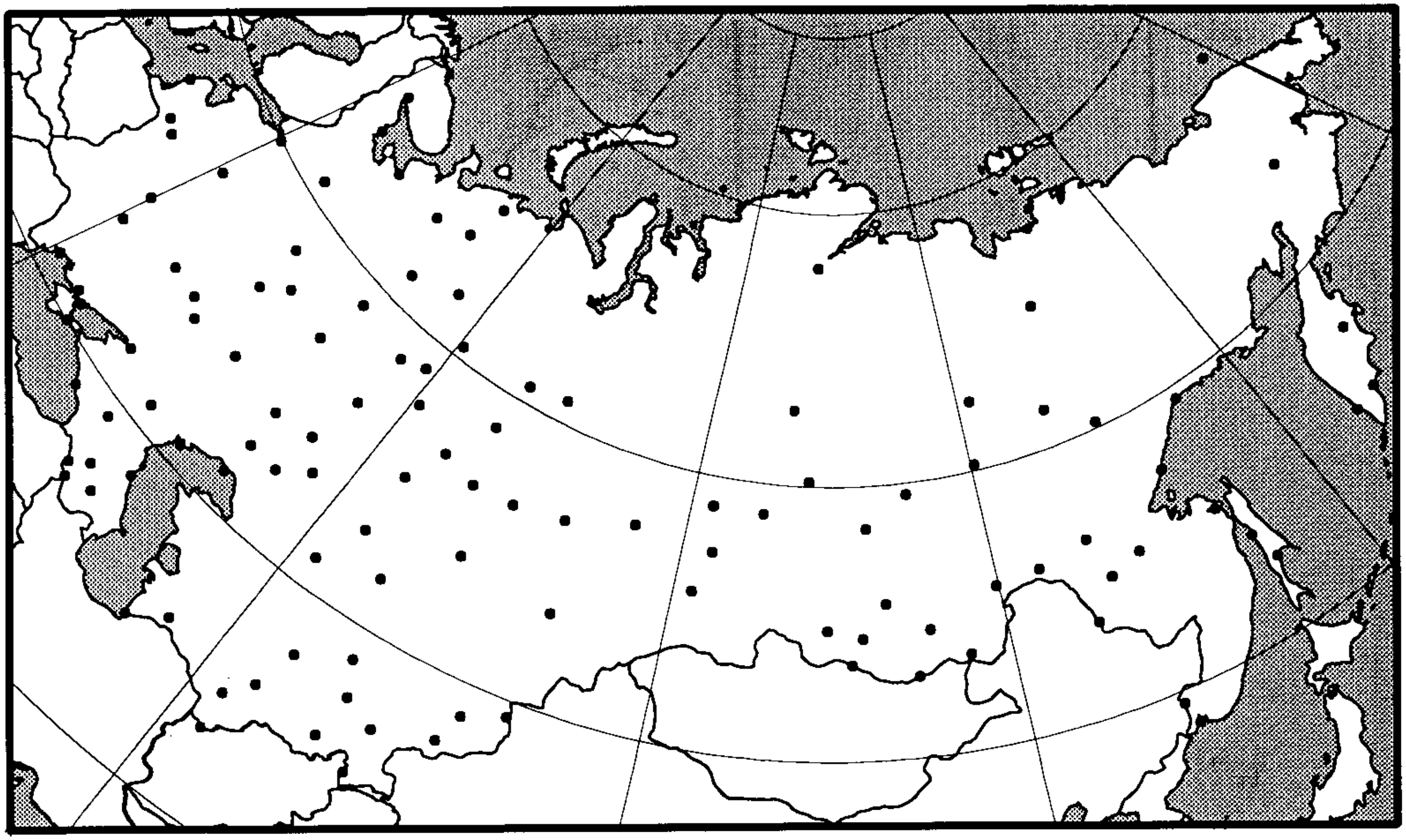

Figure 3. Observing network in 1935. Weather stations are denoted by large black dots. With 117 posts collecting data, most of the country was well-sampled. However, because of their relative underpopulation, some areas north of the Arctic Circle and east of the Ural mountains still lacked adequate coverage. Many of these gaps were filled the next year, when 65 additional posts were opened.

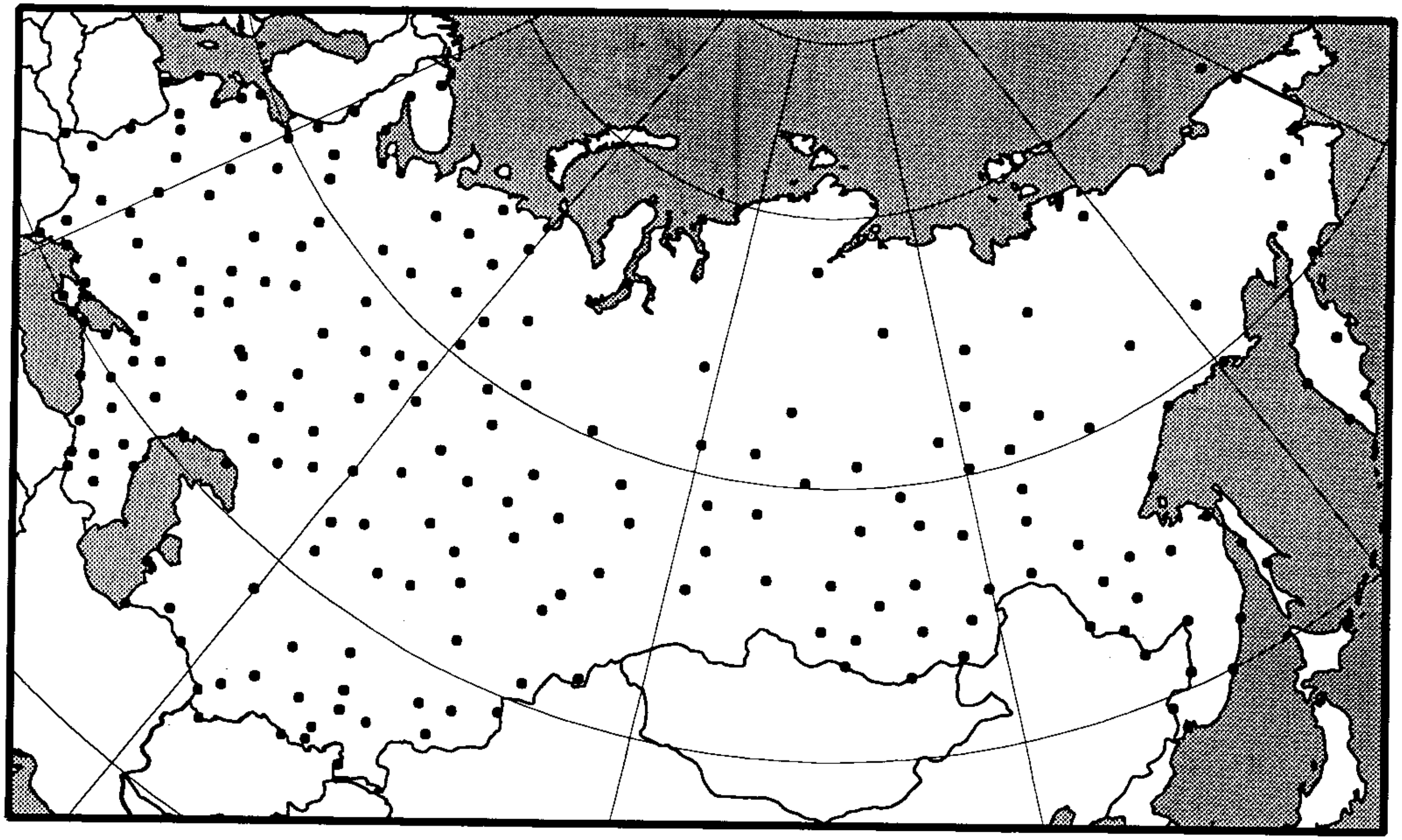

Figure 4. Observing network in 1985. Weather stations are denoted by large black dots. With 222 posts collecting data, virtually all of the country, with the exception of a few areas north of the Arctic Circle and east of the Ural mountains, was well- sampled. From a practical standpoint, the data set can probably be used to study long-term climate variations over the USSR as a whole for the period 1936–89.

3. DATA PROBLEMS IDENTIFIED BY CDIAC

An important part of the NDP process at the Carbon Dioxide Information Analysis Center (CDIAC) involves the quality assurance (QA) of data before distribution. Data received at CDIAC are rarely in a condition that would permit immediate distribution, regardless of the source. To guarantee data of the highest possible quality, CDIAC conducts extensive QA reviews. Reviews involve examining the data for completeness, reasonableness, and accuracy. Although they have common objectives, these reviews are tailored to each data set, often requiring extensive programming efforts. In short, the QA process is a critical component in the value-added concept of supplying accurate, usable data for researchers. The following summarizes the QA checks performed by CDIAC.

The Russian data set compilers also conducted extensive manual and automated QA assessments. Although the archive was in fairly good condition upon its arrival at CDIAC, three important data quality problems were identified as a result of our QA checks:

- ☐ incomplete metadata (particularly station history information) for 202 stations,
- ☐ suspect data values and flag codes for all stations, and
- ☐ extensive data problems for 25 stations.

3.1 Incomplete Metadata

Metadata (i.e., station inventory/history information) was supplied to CDIAC on three 5.25-in floppy diskettes. Upon arrival, all files on these diskettes were checked for gross data processing problems (e.g., truncation of lines) and corruptions that might have been introduced in transport (e.g., unreadable characters). No problems of this variety were detected.

CDIAC then assessed the accuracy of all station inventory parameters (i.e., WMO Nos., station names, coordinates, and elevations). This was accomplished by comparing each post's station inventory information with the official parameters given for that station in the latest version of WMO Publication No. 9, Vol. A, a document that contains station inventory information for all WMO posts. Through this comparison, the WMO Nos., station names, coordinates, and elevations for 221 of the 223 stations were verified. However, stations 26188 (Vereb'e) and 35133 (Adamovka) had no matching entries in WMO Vol. A. The accuracy of the station inventory information for these sites thus could not be corroborated.

Station history parameters (i.e., station relocations and rain gauge replacements) were also checked for reasonableness. Three minor problems were noted: (1) the presence of bogus dates such as 31 September; (2) the nonchronological sorting of entries; and, most important (3) the lack of information for some stations. After consulting with the data set compilers, all such problems were resolved. However, it should be noted that many station relocation dates and rain gauge replacement dates are only listed as a year or year/month rather than a year/month/day.

3.2 Suspect Data Values and Flag Codes

CDIAC received the daily data set in two shipments, the first containing data for the period 1881–1986 and the second extending the record through 1989. As with the metadata files, several general checks were first performed to identify any pervasive data processing problems and to verify that the files had not been corrupted in transport. No problems of this type were identified.

Subsequently, all WMO Nos. were cross-referenced with the official list of stations provided by the Russian data set compilers. As a result, it was determined that station number 34731 (Rostov-na-Donu) was incorrectly listed as 34734 for the years 1987–88; the station number was corrected on all relevant lines. Finally, the values of year and month were checked for reasonableness and proper sorting. No year, month, or sorting problems were detected.

CDIAC then examined the actual daily data values for reasonableness. In particular, minimum, mean, and maximum temperature on each day were compared to verify that the minimum was less than or equal to the mean and that the mean was less than or equal to the maximum. For 4544 days scattered over 220 stations, this relationship was violated. To alert the user to these cases, CDIAC flagged all such occurrences in the data set (for details about CDIAC-assigned flags, see the FLAGB variable description on page 34). Extreme value checks were applied to identify negative rainfall totals and temperatures that exceeded known world-record values (i.e., temperatures below −73°C or above 58°C). As a result, 230 minimum and 13 maximum temperature observations were flagged as suspect. Precipitation totals above 500 mm were also checked for reasonableness, though none were flagged as problematic. Finally, each time series was plotted and visually inspected for values that were anomalous but that did not exceed the aforementioned thresholds (Fig. 5). To screen out seasonal effects, z-scores (i.e., standardized deviations from the long-term monthly mean) were also graphed. Consequently, another 572 minimum, 373 mean, and 346 maximum temperature values were flagged as suspect.

The daily flag codes assigned by the Russian data set compilers were also checked for validity. Seventeen observations were annotated with undocumented codes. Given the infrequency of these unspecified flags, all 17 observations were set to "missing." In addition, 293 minimum, 311 mean, and 997 maximum temperature observations had "missing value" flag codes, yet none of the values had been set to missing. The validity of these observations is uncertain.

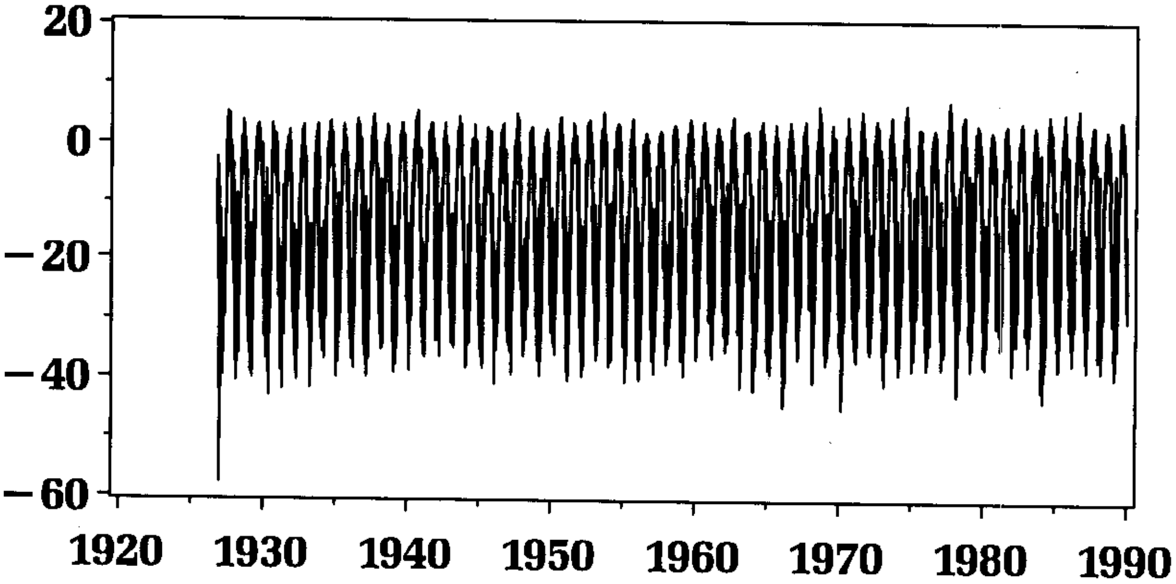

Figure 5. Minimum temperature record at Ostrov Vrangelja. Through a visual inspection of the plotted time series, the presence of several anomalously low temperature values early in the record was noted. In general, visual quality assurance checks identified suspect observations in a number of time series.

3.3 Extensive Data Problems

As described earlier, each time series was plotted and visually inspected for errors. As a result, extensive data problems were identified for 13 sites. For example, station 24966 (Ust'-Maja) has numerous mean temperature observations <-40 °C through most of its record, but none prior to 1902 (Fig. 6). Given the pervasive nature of these findings, no individual values were flagged as suspect; rather, an inventory of problematic stations was constructed (Table 3).

Thirteen stations also contain large gaps early in the record for some variables. For example, the archive for station 29866 (Minusinsk) begins in earnest in 1905, though a few observations are available as early as 1901. CDIAC did not flag individual values to indicate these gaps; rather, the following inventory of stations with data gaps was prepared:

- Reboly (22602): all variables
- Kirov (27196): maximum temperature
- Barabinsk (29612): maximum temperature
- Minusinsk (29866): all variables
- Cita (30758): maximum temperature
- Ulan-ude (30823): maximum temperature
- Kjahta (30925): maximum temperature
- Borzja (30965): maximum temperature
- Brest (33008): mean/maximum temperature
- Celinograd (35188): maximum temperature
- Uil (35416): maximum temperature
- Leninakin (37686): maximum temperature
- Termez (38927): all variables

It should also be noted that changes in station location, instrumentation, and time of observation may have introduced other inhomogeneities (ones undetectable by plotting) on each series. Methods for identifying such discontinuities are given in Potter (1981), Alexandersson (1986), Karl and Williams (1987), Gullet et al. (1991), and Peterson and Easterling (1993).

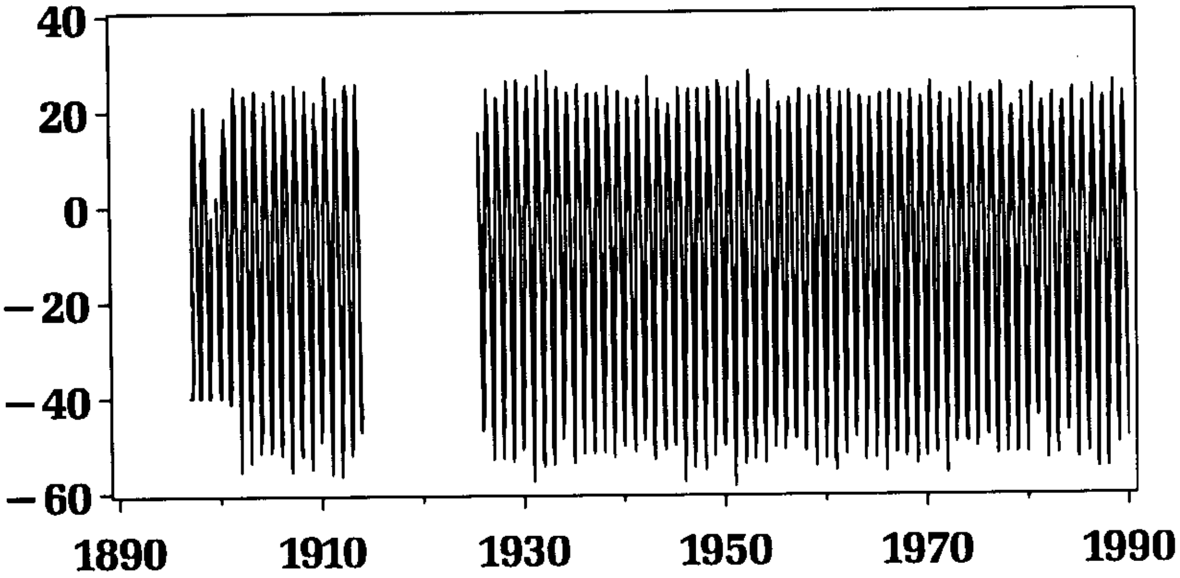

Figure 6. Mean temperature record at Ust'-Maja. Through a visual inspection of the time series, it was noted that no values of less than -40 °C were recorded at the site prior to 1902. Visual quality assurance checks such as this identified 25 time series with extensive data quality problems.

Table 3. Inventory of stations with extensive data problems

WMO No.	Description of data problem and approximate time of occurrence
24266	From 1895–1920, there are few maximum temperature values greater than -36°C; thereafter, numerous values are greater than -36°C.
24641	From 1900–1930, there are few maximum temperature values greater than -36°C; thereafter, numerous values are greater than -36°C.
24944	From 1900–1930, there are few maximum temperature values greater than -36°C; thereafter, numerous values are greater than -36°C.
24959	From 1888–1927, there are few maximum temperature values greater than -36°C; thereafter, numerous values are greater than -36°C.
24966	From 1897–1901, there are few mean temperature values less than -40°C; thereafter, numerous values are less than -40°C.
25551	From 1894–1898, there are few minimum, mean, and maximum temperature values less than -40°C; thereafter, numerous values are less than -40°C.
26406	From 1881–1886, numerous precipitation totals are equal to 0; thereafter, far fewer values are equal to 0.
30823	In 1896, several precipitation totals are anomalously large.
31510	In 1928, several minimum temperature values are anomalously high.
36177	From 1918–1921, many precipitation totals are only recorded to the nearest millimeter.
37472	From 1898–1911, many minimum temperatures are only recorded to the nearest degree Celsius.
38895	In 1889, many maximum temperature values are anomalously high.
38954	In 1910, several precipitation totals are anomalously large.

4. HOW TO OBTAIN THE DATA FILES

This data base is available in machine-readable form, on request, from CDIAC without charge. CDIAC will also distribute subsets of the data base as needed. It can be acquired on two 9-track magnetic tapes or from CDIAC's anonymous FTP area (see FTP address below). However, because of space constraints, it will not be distributed on floppy diskette. Requests should include any specific tape instructions (i.e., 1600 or 6250 BPI, labeled or nonlabeled, ASCII or EBCDIC characters, and variable- or fixed-length records) required by the user to access the data. Requests not accompanied by specific instructions will be filled on 9-track, 6250 BPI, standard-labeled tapes with EBCDIC characters. Requests should be addressed to:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
Post Office Box 2008
Oak Ridge, Tennessee 37831-6335
U.S.A.

Telephone: +1 (615) 574-0390
Fax: +1 (615) 574-2232

Electronic Mail: BITNET: CDP@ORNLSTC
INTERNET: CDP@STC10.CTD.ORNL.GOV
OMNET: CDIAC

The data files can be also acquired via FTP from CDIAC's anonymous FTP account:

- FTP to CDIAC.ESD.ORNL.GOV (128.219.24.36)
- Enter "ftp" as the userid
- Enter your electronic mail address as the password (e.g., "rtv@ornlstc")
- Change to the directory "pub/ndp040"
- Acquire the files using the FTP "get" command

5. REFERENCES

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PART 2

CONTENT AND FORMAT OF DATA FILES

6. FILE DESCRIPTIONS

This section describes the content and format of each of the 18 files that comprise this NDP (Table 4). Because CDIAC distributes the data set in two ways (i.e., via anonymous FTP and on two 9-track magnetic tapes), each of the 18 files is referenced by both an ASCII file name, which is given in lower-case, bold-faced type (e.g., **readme**) and a tape file number (e.g., File 1, Tape 1). The files and their contents include the following:

☐ **readme** (File 1, Tape 1), a detailed description of both the 223-station network and the 18 data files;

☐ **inventory.for** (File 2, Tape 1), a FORTRAN data retrieval routine to read **station.inventory** (File 8, Tape 1);

☐ **history.for** (File 3, Tape 1), a FORTRAN data retrieval routine to read **station.history** (File 9, Tape 1);

☐ **data.for** (File 4, Tape 1), a FORTRAN data retrieval routine to read **ussr1.data–ussr9.data** (Files 10–15, Tape 1 and Files 1–3, Tape 2);

☐ **inventory.sas** (File 5, Tape 1), a SAS® data retrieval routine to read **station.inventory** (File 8, Tape 1);

☐ **history.sas** (File 6, Tape 1), a SAS® data retrieval routine to read **station.history** (File 9, Tape 1);

☐ **data.sas** (File 7, Tape 1), a SAS® data retrieval routine to read **ussr1.data–ussr9.data** (Files 10–15, Tape 1 and Files 1–3, Tape 2);

☐ **station.inventory** (File 8, Tape 1), a listing of station location information and period of record statistics (by variable) for each of the 223 stations;

☐ **station.history** (File 9, Tape 1), a listing of rain gauge replacement dates and station relocation data for each of the 223 stations; and

☐ **ussr1.data–ussr9.data** (Files 10–15, Tape 1 and Files 1–3, Tape 2), a listing of daily temperature and precipitation data for the 223 stations (25 stations per file).

The remainder of this section describes (or lists, where appropriate) the contents of each of the 18 files. The files are discussed in the order in which they appear on the magnetic tapes.

readme (File 1, Tape 1)

This file contains a detailed description of both the data set and the 18 data files. It is intended to serve as a digital version of Sects. 1–7 of this printed document (figures excluded). It exists primarily for the benefit of individuals who acquire the data files from CDIAC's anonymous FTP area.

Table 4. Content, size, and format of data files

File number, name[a], and description	Logical records	FTP file size in K[b]	Tape file size in K[c]	Block size[c]	Record length[c]
		Tape 1			
1. **readme**: a detailed description of both the 223-station network and the 18 data files	1,200	54.6	93.8	8,000	80
2. **inventory.for**: a FORTRAN data retrieval routine to read **station.inventory** (File 8, Tape 1)	17	0.6	1.3	8,000	80
3. **history.for**: a FORTRAN data retrieval routine to read **station.history** (File 9, Tape 1)	14	0.4	1.1	8,000	80
4. **data.for**: a FORTRAN data retrieval routine to read **ussr1.data–ussr9.data** (Files 10–15, Tape 1 and Files 1–3, Tape 2)	20	0.6	1.6	8,000	80
5. **inventory.sas**: a SAS® data retrieval routine to read **station.inventory** (File 8, Tape 1)	10	0.3	0.8	8,000	80
6. **history.sas**: a SAS® data retrieval routine to read **station.history** (File 9, Tape 1)	8	0.2	0.6	8,000	80
7. **data.sas**: a SAS® data retrieval routine to read **ussr1.data–ussr9.data** (Files 10–15, Tape 1 and Files 1–3, Tape 2)	14	0.4	1.1	8,000	80

Table 4 (continued)

File number, name[a] and description	Logical records	FTP file size in K[b]	Tape file size in K[c]	Block size[c]	Record length[c]
Tape 1 (continued)					
8. **station.inventory:** contains station location information and period of record statistics (by variable) for each of the 223 stations	223	21.3	21.8	10,000	100
9. **station.history:** contains rain gauge replacement dates and station relocation data for each of the 223 stations	810	22.9	27.7	10,500	35
10. **ussr1.data:** contains daily temperature and precipitation data for stations 20674–23804	74,672	18,972.5	19,688.9	6,750	270
11. **ussr2.data:** contains daily temperature and precipitation data for stations 23849–25744	74,456	18,855.2	19,632.0	6,750	270
12. **ussr3.data:** contains daily temperature and precipitation data for stations 25913–28064	79,908	20,305.4	21,069.5	6,750	270
13. **ussr4.data:** contains daily temperature and precipitation data for stations 28138–30230	83,107	21,098.0	21,913.0	6,750	270
14. **ussr5.data:** contains daily temperature and precipitation data for stations 30253–31532	81,450	20,635.8	21,476.1	6,750	270
15. **ussr6.data:** contains daily temperature and precipitation data for stations 31594–33837	73,585	18,662.8	19,402.3	6,750	270

Table 4 (continued)

File number, name[a], and description	Logical records	FTP file size in K[b]	Tape file size in K[c]	Block size[c]	Record length[c]
Tape 2					
1. **ussr7.data:** contains daily temperature and precipitation data for stations 33889–35188	80,354	20,391.7	21,187.1	6,750	270
2. **ussr8.data:** contains daily temperature and precipitation data for stations 35229–37549	79,700	20,191.8	21,014.6	6,750	270
3. **ussr9.data:** contains daily temperature and precipitation data for stations 37686–38987	76,073	19,245.6	20,058.3	6,750	270
Total (both tapes)	705,621	178,460.1	185,591.6		

[a] All file names are printed in lower-case, bold-faced type (e.g., **readme**).
[b] File size in kilobytes. Applies only to files in CDIAC's anonymous FTP area. All such files have variable-length records.
[c] File size in kilobytes. Applies only to files on magnetic tape. All such files have fixed-length records.

inventory.for (File 2, Tape 1)

This file contains a FORTRAN data retrieval routine to read **station.inventory** (File 8, Tape 1). The following is a listing of this program. For additional information regarding variable definitions and format statements, please see the file description for **station.inventory** on pages 28–29.

```
C FORTRAN data retrieval routine to read the file named
C "station.inventory" (File 8, Tape 1).
C
C Unit 1 is input.
C Unit 6 (terminal) is output.
C
      INTEGER WMO, MINTFYR, MIDTFYR, MAXTFYR, PRCPFYR, LYR
      REAL LAT, LON, ELEV, MINTMISS, MIDTMISS, MAXTMISS, PRCPMISS
      CHARACTER NAME*25
      OPEN (UNIT=1, FILE='station.inventory')
   10 READ (1, 1, END=99) WMO, NAME, LAT, LON, ELEV, MINTFYR, MINTMISS,
     *MIDTFYR, MIDTMISS, MAXTFYR, MAXTMISS, PRCPFYR, PRCPMISS, LYR
    1 FORMAT (I5, 1X, A25, 1X, F5.2, 1X, F7.2, 1X, F6.1, 1X,
     *4(I4, 1X, F4.1, 1X), I4)
      GO TO 10
   99 STOP
      END
```

history.for (File 3, Tape 1)

This file contains a FORTRAN data retrieval routine to read **station.history** (File 9, Tape 1). The following is a listing of this program. For additional information regarding variable definitions and format statements, please see the file description for **station.history** on pages 30–31.

```
C FORTRAN data retrieval routine to read the file named
C "station.history" (File 9, Tape 1).
C
C Unit 1 is input.
C Unit 6 (terminal) is output.
C
      INTEGER WMO, YEAR, MONTH, DAY
      CHARACTER TYPE*4, DIST*2, DIRECT*3
      OPEN (UNIT=1, FILE='station.history')
   10 READ (1, 1, END=99) WMO, TYPE, YEAR, MONTH, DAY, DIST, DIRECT
    1 FORMAT (I5, 1X, A4, 1X, I4, 1X, I2, 1X, I2, 1X, A2, 1X, A3)
      GO TO 10
   99 STOP
      END
```

data.for (File 4, Tape 1)

This file contains a FORTRAN data retrieval routine to read **ussr1.data**– **ussr9.data** (Files 10–15, Tape 1 and Files 1–3, Tape 2). The following is a listing of this program. For additional information regarding variable definitions and format statements, please see the file description for **ussr1.data–ussr9.data** on pages 32–35.

```
C FORTRAN data retrieval routine to read the files named
C "ussr*.data" (Files 10-15, Tape 1 and Files 1-3, Tape 2)
C
C Unit 1 is input.
C Unit 6 (terminal) is output.
C
      INTEGER WMO, YEAR, MONTH, DAY, NOBS, DATA(31)
      CHARACTER TYPE*4, FLAGA(31)*1, FLAGB(31)*1
      OPEN (UNIT=1, FILE='ussr*.data')
   10 DO DAY = 1, 31
        DATA(DAY) = 9999
        FLAGA(DAY) = '9'
        FLAGB(DAY) = '9'
      END DO
      READ (1, 1, END=99) WMO, TYPE, YEAR, MONTH, NOBS,
     *(DAY, DATA(DAY), FLAGA(DAY), FLAGB(DAY), I = 1, NOBS)
    1 FORMAT (I5, A4, I4, I2, I2, 31(I2, I4, A1, A1))
      GO TO 10
   99 STOP
      END
```

inventory.sas (File 5, Tape 1)

This file contains a SAS® data retrieval routine to read **station.inventory** (File 8, Tape 1). The following is a listing of this program. For additional information regarding variable definitions and format statements, please see the file description for **station.inventory** on pages 28–29.

```
* SAS data retrieval routine to read the file named;
* "station.inventory" (File 8, Tape 1).;
*;
DATA INVENTRY;
INFILE 'station.inventory';
INPUT WMO 1-5 NAME $ 7-31 LAT 33-37 LON 39-45 ELEV 47-52
      MINTFYR 54-57 MINTMISS 59-62 MIDTFYR 64-67 MIDTMISS 69-72
      MAXTFYR 74-77 MAXTMISS 79-82 PRCPFYR 84-87 PRCPMISS 89-92
      LYR 94-97;
RUN;
```

history.sas (File 6, Tape 1)

This file contains a SAS® data retrieval routine to read **station.history** (File 9, Tape 1). The following is a listing of this program. For additional information regarding variable definitions and format statements, please see the file description for **station.history** on pages 30–31.

```
* SAS data retrieval routine to read the file named;
* "station.history" (File 9, Tape 1).;
*;
DATA HISTORY;
INFILE 'station.history';
INPUT WMO 1-5 TYPE $ 7-10 YEAR 12-15 MONTH 17-18 DAY 20-21
      DIST $ 23-24 DIRECT $ 26-28;
RUN;
```

data.sas (File 7, Tape 1)

This file contains a SAS® data retrieval routine to read **ussr1.data–ussr9.data** (Files 10–15, Tape 1 and Files 1–3, Tape 2). The following is a listing of this program. For additional information regarding variable definitions and format statements, please see the file description for **ussr1.data–ussr9.data** on pages 32–35.

```
* SAS data retrieval routine to read the files named;
* "ussr*.sas" (Files 10-15, Tape 1 and Files 1-3, Tape 2).;
*;
DATA DAILY;
LENGTH FLAGA1-FLAGA31 FLAGB1-FLAGB31 $ 1;
ARRAY DATA(31);
ARRAY FLAGA(31) $;
ARRAY FLAGB(31) $;
INFILE 'ussr*.data' lrecl=266;
INPUT WMO 5. TYPE $CHAR4. YEAR 4. MONTH 2. NOBS 2. @;
DO I = 1 TO NOBS;
  INPUT DAY 2. DATA(DAY) 4. FLAGA(DAY) $CHAR1. FLAGB(DAY) $CHAR1. @;
END;
RUN;
```

station.inventory (File 8, Tape 1)

This file provides station location information and period of record statistics for each of the 223 stations. There is one entry for each station; consequently, the file has 223 lines. Each line contains a station's WMO No., name, latitude, longitude, and elevation, as well as the first/last year of record and percentage of data missing for each variable. The file is sorted by WMO No. and variable type and can be read by using the following FORTRAN code (contained in **inventory.for**, which is File 2 on Tape 1):

```
C FORTRAN data retrieval routine to read the file named
C "station.inventory" (File 8, Tape 1).
C
C Unit 1 is input.
C Unit 6 (terminal) is output.
C
      INTEGER WMO, MINTFYR, MIDTFYR, MAXTFYR, PRCPFYR, LYR
      REAL LAT, LON, ELEV, MINTMISS, MIDTMISS, MAXTMISS, PRCPMISS
      CHARACTER NAME*25
      OPEN (UNIT=1, FILE='station.inventory')
   10 READ (1, 1, END=99) WMO, NAME, LAT, LON, ELEV, MINTFYR, MINTMISS,
     *MIDTFYR, MIDTMISS, MAXTFYR, MAXTMISS, PRCPFYR, PRCPMISS, LYR
    1 FORMAT (I5, 1X, A25, 1X, F5.2, 1X, F7.2, 1X, F6.1, 1X,
     *4(I4, 1X, F4.1, 1X), I4)
      GO TO 10
   99 STOP
      END
```

This file can also be read by using the following SAS® code (contained in **inventory.sas**, which is File 5 on Tape 1):

```
* SAS data retrieval routine to read the file named;
* "station.inventory" (File 8, Tape 1).;
*;
DATA INVENTRY;
INFILE 'station.inventory';
INPUT WMO 1-5 NAME $ 7-31 LAT 33-37 LON 39-45 ELEV 47-52
      MINTFYR 54-57 MINTMISS 59-62 MIDTFYR 64-67 MIDTMISS 69-72
      MAXTFYR 74-77 MAXTMISS 79-82 PRCPFYR 84-87 PRCPMISS 89-92
      LYR 94-97;
RUN;
```

Stated in tabular form, the contents include the following:

Variable	Variable type	Variable width	Starting column	Ending column
WMO	Numeric	5	1	5
NAME	Character	25	7	31
LAT	Numeric	5	33	37
LON	Numeric	7	39	45
ELEV	Numeric	6	47	52

Variable	Variable type	Variable width	Starting column	Ending column
MINTFYR	Numeric	4	54	57
MINTMISS	Numeric	4	59	62
MIDTFYR	Numeric	4	64	67
MIDTMISS	Numeric	4	69	72
MAXTFYR	Numeric	4	74	77
MAXTMISS	Numeric	4	79	82
PRCPFYR	Numeric	4	84	87
PRCPMISS	Numeric	4	89	92
LYR	Numeric	4	94	97

where

WMO	is the WMO No. of the station.
NAME	is the name of the station.
LAT	is the latitude of the station (in decimal degrees).
LON	is the longitude of the station (in decimal degrees). Stations in the Western Hemisphere have negative longitudes.
ELEV	is the elevation of the station (in meters). Missing elevations are coded as -999.9.
MINTFYR MIDTFYR MAXTFYR PRCPFYR	is the first year in which minimum temperature (MINTFYR), mean temperature (MIDTFYR), maximum temperature (MAXTFYR), or precipitation (PRCPFYR) data are available at this station.
MINTMISS MIDTMISS MAXTMISS PRCPMISS	is the percentage of minimum temperature (MINTMISS), mean temperature (MIDTMISS), maximum temperature (MAXTMISS), or precipitation (PRCPMISS) data that are missing at this station.
LYR	is the last year in which data are available for all variables at this station.

station.history (File 9, Tape 1)

This file provides rain gauge replacement dates and station relocation dates for each station. There are two types of entries for each station. One type contains the station's WMO No. and rain gauge replacement date. The other type contains the station's WMO No. and a relocation date, distance, and direction. The file is sorted by WMO No., year, month, and day and can be read by using the following FORTRAN code (contained in **history.for**, which is File 3 on Tape 1):

```
C FORTRAN data retrieval routine to read the file named
C "station.history" (File 9, Tape 1).
C
C Unit 1 is input.
C Unit 6 (terminal) is output.
C
      INTEGER WMO, YEAR, MONTH, DAY
      CHARACTER TYPE*4, DIST*2, DIRECT*3
      OPEN (UNIT=1, FILE='station.history')
   10 READ (1, 1, END=99) WMO, TYPE, YEAR, MONTH, DAY, DIST, DIRECT
    1 FORMAT (I5, 1X, A4, 1X, I4, 1X, I2, 1X, I2, 1X, A2, 1X, A3)
      GO TO 10
   99 STOP
      END
```

This file can also be read by using the following SAS® code (contained in **history.sas**, which is File 6 on Tape 1):

```
* SAS data retrieval routine to read the file named;
* "station.history" (File 9, Tape 1).;
*;
DATA HISTORY;
INFILE 'station.history';
INPUT WMO 1-5 TYPE $ 7-10 YEAR 12-15 MONTH 17-18 DAY 20-21
      DIST $ 23-24 DIRECT $ 26-28;
RUN;
```

Stated in tabular form, the contents include the following:

Variable	Variable type	Variable width	Starting column	Ending column
WMO	Numeric	5	1	5
TYPE	Character	4	7	10
YEAR	Numeric	4	12	15
MONTH	Numeric	2	17	18
DAY	Numeric	2	20	21
DIST	Character	2	23	24
DIRECT	Character	3	26	28

where

WMO	is the WMO No. of the station.
TYPE	is the type of change indicated by this entry. The possible values of TYPE are as follows: RAIN = rain gauge replacement (i.e., change from old-type gauge to Tretyakov-type gauge). Each station will have only one RAIN entry. In this type of entry, DIST and DIRECT (described below) are not relevant and thus are coded as blanks. MOVE = station relocation. Each station will have at least one MOVE entry. If a station moved on more than one occasion, then separate entries are included for each relocation. If a station never moved, then that station will have only one MOVE entry; in this entry, YEAR, MONTH, DAY, DIST, and DIRECT (described below) are all coded as missing. In other words, if a station has only one MOVE entry, and if all variables in that MOVE entry are coded as missing, then the given station never moved.
YEAR	is the year in which the change took place. Missing years are coded as -999.
MONTH	is the month in which the change took place. Missing months are coded as -9.
DAY	is the day on which the change took place. Missing days are coded as -9.
DIST	is the distance (in kilometers) that the station was moved. Missing distances are coded as -9. A distance of zero indicates that the station moved less than one kilometer. DIST only applies to station relocation entries (i.e., lines in which TYPE = MOVE). In rain gauge replacement entries (i.e., lines in which TYPE = RAIN), DIST is not relevant and thus is coded as blanks.
DIRECT	is the direction in which the station was moved (e.g., N = north, SE = southeast). Missing directions are coded as -99. DIRECT only applies to station relocation entries (i.e., lines in which TYPE = MOVE). In rain gauge replacement entries (i.e., lines in which TYPE = RAIN), DIRECT is not relevant and thus is coded as blanks.

ussr1.data–ussr9.data (Files 10–15, Tape 1 and Files 1–3, Tape 2)

These files contain the daily temperature and precipitation values for each of the 223 stations. Each file consists of a block of 25 stations (except **ussr9.data**, which only has 23). The range of WMO numbers associated with each file is as follows:

File name:	WMO No. Range
ussr1.data	20674–23804
ussr2.data	23849–25744
ussr3.data	25913–28064
ussr4.data	28138–30230
ussr5.data	30253–31532
ussr6.data	31594–33837
ussr7.data	33889–35188
ussr8.data	35229–37549
ussr9.data	37686–38987

Each logical record in these files contains one month of data for a given variable. In particular, each line consists of a WMO No., a flag indicating the type of variable (i.e., minimum, mean, maximum temperature, or precipitation), the year and month of the record, a tally of the number of days (*n*) with data, and *n* daily values with their respective flag codes. To conserve space, only days with nonmissing values are included in each record. Likewise, if no data are available for a particular month, then there is no entry for that month in the data file. Because only days with nonmissing values are contained in the data base, the record length of the file varies from line to line. In addition, a given day of the month can fall within a different set of columns from one line to the next. The files are sorted by WMO No., variable type, year, and month and can be read by using the following FORTRAN code (contained in **data.for**, which is File 4 on Tape 1):

```
C FORTRAN data retrieval routine to read the files named
C "ussr*.data" (Files 10-15, Tape 1 and Files 1-3, Tape 2)
C
C Unit 1 is input.
C Unit 6 (terminal) is output.
C
      INTEGER WMO, YEAR, MONTH, DAY, NOBS, DATA(31)
      CHARACTER TYPE*4, FLAGA(31)*1, FLAGB(31)*1
      OPEN (UNIT=1, FILE='ussr*.data')
   10 DO DAY = 1, 31
        DATA(DAY) = 9999
        FLAGA(DAY) = '9'
        FLAGB(DAY) = '9'
      END DO
      READ (1, 1, END=99) WMO, TYPE, YEAR, MONTH, NOBS,
     *(DAY, DATA(DAY), FLAGA(DAY), FLAGB(DAY), I = 1, NOBS)
    1 FORMAT (I5, A4, I4, I2, I2, 31(I2, I4, A1, A1))
      GO TO 10
   99 STOP
      END
```

These files can also be read by using the following SAS® code (contained in **data.sas**, which is File 7 on Tape 1):

```
* SAS data retrieval routine to read the files named;
* "ussr*.sas" (Files 10-15, Tape 1 and Files 1-3, Tape 2).;
*;
DATA DAILY;
LENGTH FLAGA1-FLAGA31 FLAGB1-FLAGB31 $ 1;
ARRAY DATA(31);
ARRAY FLAGA(31) $;
ARRAY FLAGB(31) $;
INFILE 'ussr*.data' lrecl=266;
INPUT WMO 5. TYPE $CHAR4. YEAR 4. MONTH 2. NOBS 2. @;
DO I = 1 TO NOBS;
  INPUT DAY 2. DATA(DAY) 4. FLAGA(DAY) $CHAR1. FLAGB(DAY) $CHAR1. @;
END;
RUN;
```

Stated in tabular form, the contents include the following:

Variable	Variable type	Variable width	Starting column	Ending column
WMO	Numeric	5	1	5
TYPE	Character	4	6	9
YEAR	Numeric	4	10	13
MONTH	Numeric	2	14	15
NOBS	Numeric	2	16	17
DAY(1–31)	Numeric	2	N/A	N/A
DATA(1–31)	Numeric	4	N/A	N/A
FLAGA(1–31)	Character	1	N/A	N/A
FLAGB(1–31)	Character	1	N/A	N/A

The variables contained in **ussr1.data-ussr9.data** have the following definitions:

WMO	is the WMO No. of the station.
TYPE	is the variable type. The possible values of TYPE are as follows:

TMIN = minimum temperature (tenths of °C);
TMAX = maximum temperature (tenths of °C);
TMID = mean temperature (tenths of °C); and
PRCP = precipitation (tenths of millimeters).

YEAR	is the year of the data record.

MONTH	is the month of the data record.
NOBS	is the number of days in the month that have nonmissing data values. Days with missing values are NOT included in the data files.
DAY	is the day of the month.
DATA(1-31)	are the daily data values.
FLAGA(1-31)	are daily quality codes that were assigned by the Russian data set compilers. The codes and their meanings are as follows: 0 = the value is assumed to be reliable, 2 = the value is doubtful (beyond the set limit), and 4 = the value is rejected (Note: According to the documentation supplied by the Russian data set compilers, all values with a FLAGA code of 4 should have been set to missing because the meteorological observation was never carried out in the first place. However, 292 minimum temperature values, 311 mean temperature values, and 997 maximum temperature values had FLAGA codes of 4. The validity of these values is unknown).
FLAGB(1-31)	are daily quality codes specific to the type of variable. For minimum, maximum, and mean temperature, these flags were assigned by CDIAC based upon the findings of various visual and digital quality assurance checks (see page 13 for additional information about how these flags were assigned). The codes and their meanings are as follows: 0 = the temperature value is assumed to be reliable, and 3 = the temperature value is suspect. The value might have been flagged as suspect for two reasons: (1) it appeared to be extreme according to digital or visual quality assurance checks, or (2) the relationship between minimum, mean, and maximum temperature (i.e., MINT ≤ MIDT ≤ MAXT) was violated. For precipitation, these flags were assigned by the Russian data set compilers. The codes and their meanings are as follows: 5 = a rainfall total >0.1 mm (though CDIAC determined that some observations after 1986 were in fact 0); 6 = a multiple-day rainfall total; 7 = a rainfall total of 0 (i.e., no precipitation recorded); and 8 = a rainfall total <0.1 mm. Note that in these cases the actual rainfall total is coded as 0 (i.e., DATA = 0).

The following is a sample line to illustrate the format of **ussr1.data–ussr9.data** (the letter "b" denotes a blank space):

```
                              1         2         3         4
Column:             12345678901234567890123456789012345678901

Data:               38987PRCP198912b3b4bbb205b6b2780515bb4605
```

In this sample line:

Record Position	Contents	Variable	Meaning
1–5	38987	WMO	Line contains data for station 38987.
6–9	PRCP	TYPE	Line contains precipitation data.
10–13	1989	YEAR	Line contains data for 1989.
14–15	12	MONTH	Line contains data for December.
16–17	b3	NOBS	Three days in the month have data.
18–19	b4	DAY	Fourth day of the month.
20–23	bbb2	DATA(4)	0.2 mm of rainfall.
24	0	FLAGA(4)	Value is assumed to be reliable.
25	5	FLAGB(4)	Rainfall total >0.1 mm.
26–27	b6	DAY	Sixth day of the month.
28–31	b278	DATA(6)	27.8 mm of rainfall.
32	0	FLAGA(6)	Value is assumed to be reliable.
33	5	FLAGB(6)	Rainfall total > 0.1 mm.
34–35	15	DAY	Fifteenth day of month.
36–39	bb46	DATA(15)	4.6 mm of rainfall.
40	0	FLAGA(15)	Value is assumed to be reliable.
41	5	FLAGB(15)	Rainfall total > 0.1 mm.

- Note lack of data for days 1–3 [i.e., DATA(1–3), FLAGA(1–3), and FLAGB(1–3) are missing].
- Note lack of data for day 5 [i.e., DATA(5), FLAGA(5), and FLAGB(5) are missing].
- Note lack of data for days 7–14 [i.e., DATA(7–14), FLAGA(7–14), and FLAGB(7–14) are missing].
- Note lack of data for days 16–31 [i.e., DATA(16–31), FLAGA(16–31), and FLAGB(16–31) are missing].

7. VERIFICATION OF DATA TRANSPORT

The data files contained in this Numeric Data Package can be read by using the FORTRAN or SAS® data retrieval programs provided. Users should verify that the data have been correctly transported to their systems by visually examining each data file. To facilitate the visual inspection process, partial listings of each data file are provided in Tables 5–15. Each of these tables contains the first and last five lines of a data file.

Table 5. Partial listing of "station.inventory"
(File 8, Tape 1)

First five lines of the file:

```
20674 OSTROV DIKSON               73.50    80.40    42.0 1936  0.2 1936  0.2 1936  0
.2 1936  1.6 1989
20891 HATANGA                     71.98   102.47    30.0 1929  7.1 1928 11.1 1929  7
.2 1928 10.6 1989
21946 COKURDAH                    70.62   147.88     0.0 1944  1.9 1944  1.6 1944  1
.6 1944  4.6 1989
21982 OSTROV VRANGELJA            70.97  -178.37     2.0 1926  1.7 1926  1.4 1926  1
.6 1926  3.9 1989
22113 MURMANSK                    68.97    33.05    57.0 1936  0.2 1936  0.1 1936  0
.3 1936  1.3 1989
```

Last five lines of the file:

```
38927 TERMEZ                      37.23    67.27   309.0 1927 19.7 1927 15.9 1927 17
.8 1927 21.0 1989
38933 KURGAN-TJUBE                37.82    68.78   427.0 1936  0.3 1936  0.0 1936  0
.2 1936  4.3 1989
38954 HOROG                       37.50    71.50  2077.0 1910 25.0 1898 16.7 1910 25
.1 1898 19.0 1989
38974 SERAHS                      36.53    61.22   275.0 1936  6.6 1936  1.5 1936  2
.0 1936  6.1 1989
38987 KUSKA                       35.28    62.35   625.0 1904 12.2 1904  9.6 1904 12
.9 1904 12.5 1989
```

Table 6. Partial listing of "station.history"
(File 9, Tape 1)

First five lines of the file:

```
20674 MOVE 1938 -9 -9  0 -99
20674 PRCP 1953  3  2
20674 MOVE 1960 -9 -9  0 -99
20891 MOVE 1951  1 12  1 SSW
20891 PRCP 1953 12  1
```

Last five lines of the file:

```
38987 MOVE 1904  4 -9 -9 -99
38987 MOVE 1910 -9 -9 -9 -99
38987 MOVE 1913  8 -9 -9 -99
38987 MOVE 1927  5 -9 -9 -99
38987 PRCP 1953  1  4
```

Table 7. Partial listing of "ussr1.data"
(File 10, Tape 1)

First five lines of the file:

```
20674TMIN1936 131 1-28000 2-24500 3-31000 4-23000 5-27300 6-24900 7-31800 8-3160
0 9-3120010-3430011-3750012-3360013-2190014-2180015-3270016-3250017-3220018-3590
019-3820020-3950021-4410022-4590023-4600024-4540025-4490026-4240027-3960028-4130
029-4150030-3890031-35400
20674TMID1936 131 1-24900 2-22800 3-19500 4-19800 5-23200 6-22200 7-27700 8-2780
0 9-2630010-2980011-3540012-2560013-1900014-1660015-2960016-2730017-2900018-3310
019-3580020-3560021-4240022-4530023-4400024-4440025-4330026-3890027-3710028-4020
029-3860030-3330031-31000
20674TMAX1936 131 1-20400 2-21100 3-14600 4-14800 5-20500 6-20500 7-23600 8-2330
0 9-2450010-2460011-3340012-2130013-1560014-1160015-2130016-2410017-2410018-3050
019-3250020-3360021-3900022-4410023-4280024-4280025-4240026-3630027-3540028-3880
029-3710030-2980031-27800
20674PRCP1936 131 1   007 2  1905 3   007 4   007 5  1105 6   007 7   007 8   00
7 9   10510   30511   00712   00713   10514   30515   00716   00717   00718   00
719   00720   50521   00722   00723   00724   00725   00726   00727   00728   00
729   00730  110531   605
20674TMIN1936 229 1-32600 2-35100 3-34600 4-34700 5-32800 6-35300 7-36700 8-3780
0 9-4190010-4240011-3920012-3880013-3360014-3780015-3780016-3240017-2030018-2340
019-2490020-2050021-1730022-2100023-2310024-2030025-2350026-2690027-2750028-2780
029-27900
```

Last five lines of the file:

```
23804PRCP19891123 1   005 4   005 5   205 7   505 9   00510   50511   00512   30
513  170514   30515  660516  160517  280518   00520   00521  320522   80523   40
524 1400525  210526   00529   00530   505
23804TMIN19891231 1-29800 2-10200 3 -8600 4-11300 5-21500 6-22600 7-20500 8-1670
0 9-1690010-2280011-3010012-2750013-2790014-1710015-1010016-1420017-2210018-2060
019-2020020-1750021 -260022 -760023 -810024-1900025-1910026-2170027-1870028 -100
029 -460030 -370031 -4600
23804TMID19891231 1-22100 2 -6300 3 -4600 4 -4600 5-17800 6-21200 7-18500 8-1570
0 9-1390010-1800011-2710012-2590013-2110014-1300015 -900016-1120017-1990018-1570
019-1740020 -760021   00022 -480023 -620024-1300025-1520026-1630027 -720028   00
029 -270030 -270031 -3600
23804TMAX19891231 1-10100 2 -3500 3  -500 4  -900 5-11000 6-18300 7-16000 8-1410
0 9-1230010-1320011-2270012-2480013-1620014 -980015 -720016 -960017-1400018-1100
019-1250020 -250021   80022  -60023 -330024 -330025-1090026 -920027  -90028   40
029  -20030 -180031 -2100
23804PRCP19891231 1  2505 2  4105 3  3705 4  8005 5   305 6   005 7   005 8  150
5 9   70510   30511   00512   00513  190514  210515  420516  480517   00518  180
519   00520  330521  920522   70523  260524   00525  140526   00527  460528  100
529   30530  240531   705
```

Table 8. Partial listing of "ussr2.data" (File 11, Tape 1)

First five lines of the file:

```
23849TMID1884112110-2610011-1710012-1030013-1400014 -450015 -300016 -840017 -960
018 -660019 -410020 -500021 -320022 -730023 -690024-1210025-1400026-2310027-1820
028-1250029-1530030-21800
23849PRCP1884112110   00711   00712  270513   90514   40515   00716   70517  150
518   00719   00720  290521   30522   00723   10524   20525  110526   00727   00
728   60529   00730   007
23849TMID18841231 1-16200 2-10000 3-17000 4-12700 5-15400 6-13500 7-21400 8 -640
0 9 -350010-1570011 -480012 -700013-2910014-1710015 -850016 -960017-1190018-1810
019-3040020-2400021-2570022-3280023-2060024-2200025-1890026 -950027 -980028 -510
029 -910030 -890031-28400
23849PRCP18841231 1   007 2   605 3   007 4   705 5   205 6  6405 7   007 8  630
5 9  130510  470511  110512   00713   00714   00715   50516   00717  350518   00
719   00720  200521   00722   00723  200524  100525   00726  210527   00728   00
729  120530   00731   007
23849TMID1885 131 1-38200 2-48200 3-43900 4-45600 5-43900 6-44400 7-47600 8-4640
0 9-4790010-4540011-3820012-2410013-2650014-4390015-4040016-3470017-3390018-2890
019-2070020-2620021-1940022-1010023-1620024-2020025-3970026-3790027-4020028-3590
029-1550030-1620031-17200
```

Last five lines of the file:

```
25744PRCP19891116 1   005 4  7705 5   005 9   00510  230511  260513   70514   50
515  380519   90520   90521   80522   00523   70524   00530  1705
25744TMIN19891231 1-18000 2-12800 3-13400 4-19900 5-30100 6-31100 7-20100 8-1020
0 9-1050010-1360011-1420012-1920013-1550014-2810015-3380016-3260017-3310018-2630
019-2570020-2640021-2420022-2140023-2760024-3520025-3720026-3950027-4000028-4040
029-3890030-3380031-30100
25744TMID19891231 1-15200 2 -9700 3-10400 4-16600 5-26100 6-25200 7-10300 8 -670
0 9 -780010-1100011 -900012-1490013-1510014-2320015-3160016-2790017-2670018-2250
019-2350020-2280021-2230022-1740023-2190024-3090025-3550026-3720027-3780028-3840
029-3460030-3050031-26300
25744TMAX19891231 1-11300 2 -7800 3 -7600 4-10500 5-17900 6-20000 7 -5400 8 -460
0 9 -460010 -920011 -650012-1190013-1450014-1510015-2680016-2480017-2390018-1980
019-2110020-2010021-2110022-1440023-1620024-2480025-3440026-2790027-3584028-3614
029-3090030-2670031-21600
25744PRCP19891212 1  3105 2  8705 3   205 4   005 6   505 7  4905 8   005 9   50
510   70511   00518   20519   005
```

Table 9. Partial listing of "ussr3.data" (File 12, Tape 1)

First five lines of the file:

```
25913TMIN1936 131 1-11200 2-11100 3 -8200 4-12100 5-18100 6-21500 7-26800 8-2440
0 9-2480010-2060011-2390012-2490013-2140014-2340015-1590016-1220017 -310018 -820
019-1390020-2080021-2290022-2290023-1870024-1970025-2420026-2530027-2760028-2620
029-1400030-1560031-17400
25913TMID1936 131 1-10600 2 -7400 3 -6600 4 -9700 5-15400 6-17000 7-23700 8-2170
0 9-2200010-1820011-2110012-2110013-1840014-1800015-1260016 -430017 -260018 -480
019-1000020-1600021-2170022-1890023-1670024-1780025-2020026-2260027-2460028-1660
029-1210030-1350031-16000
25913TMAX1936 131 1 -9800 2 -4000 3 -4000 4 -7900 5-11100 6-12800 7-20400 8-1890
0 9-1960010-1700011-1830012-1890013-1530014-1350015-1100016 -100017 -100018 -250
019 -690020 -750021-2020022-1610023-1470024-1580025-1690026-2010027-2160028-1190
029-1090030 -980031-13600
25913PRCP1936 131 1  2705 2   305 3   105 4   605 5   007 6   007 7   007 8   00
7 9   00710   00711   00712   00713   00714   00715   00716   00717   00718   00
719   00720   00721   00722   00723   00724   00725   00726   00727   00728   00
729   00730   00731   007
25913TMIN1936 229 1-16500 2-13600 3-11700 4 -7100 5 -9600 6-13600 7-15600 8-1820
0 9-1790010-1680011-1120012-1460013-1740014-1960015-1670016-2120017-2270018-2220
019-1920020-1310021-1160022-1310023-1610024-1420025-1910026-1280027 -840028 -800
029-11100
```

Last five lines of the file:

```
28064PRCP19891120 1   205 5   005 7   00510   00511   30512   00513   30514   40
515   60516   00517   30518   30520   20521  470522  460523  130524 1060526  140
527   70528   505
28064TMIN19891231 1-24000 2-24600 3-16300 4-14000 5 -5300 6-14600 7-21300 8-2500
0 9-1950010-2030011-2810012-2560013-3170014-2360015-2530016-1510017-1200018-2010
019-1790020-1750021-1430022 -940023-1160024-1150025-1700026-1390027-2010028-1950
029-2970030-1710031-13400
28064TMID19891231 1-18400 2-16000 3-12900 4 -8800 5 -2000 6 -6400 7-19000 8-2240
0 9-1660010-1890011-2570012-2320013-2810014-1990015-1990016-1070017 -420018-1710
019-1010020-1410021-1240022 -590023 -860024 -800025-1420026-1090027-1730028-1560
029-2400030 -780031 -9500
28064TMAX19891231 1-16000 2-11800 3 -9100 4 -5200 5  -300 6 -2600 7-14500 8-1940
0 9-1410010-1770011-2020012-2050013-2350014-1820015-1480016 -330017   20018-1190
019 -730020-1070021 -930022 -480023 -480024 -560025-1030026 -750027-1380028-1350
029-1710030 -320031 -4000
28064PRCP19891224 1  1605 2   405 3   205 4  2305 5  1505 6  2505 7   30510  180
511   00512  440514   30516  300517  160519  180521   00522  310523   00524  310
526  450527  260528  180529   50530  360531   005
```

Table 10. Partial listing of "ussr4.data"
(File 13, Tape 1)

First five lines of the file:

```
28138TMID1888 725 7 22000 8 24900 9 2620010 2700011 1870012 1540013 1600014 1650
015 1970016 1830017 1700018 1420019 1530020 1540021 1430022 1480023 1260024 1200
025 1140026 1630027 1730028 1680029 1720030 1660031 17600
28138PRCP1888 731 1   007 2   007 3   007 4   007 5   007 6  1005 7   007 8   00
7 9   00710   70511   00712   00713   00714   00715   00716   20517 1760518 6090
519   00720  670521  960522  130523   00724   00725   00726   00727   00728   00
729   00730   00731   007
28138TMID1888 831 1 21800 2 18100 3 15000 4 16200 5 14100 6 17200 7 19200 8 1590
0 9 1450010 1170011 1310012 1510013 1130014 1350015 1050016  820017  960018 1080
019 1080020 1220021 1300022 1940023 1520024  990025 1090026  760027  520028  990
029 1270030 1010031 14300
28138PRCP1888 831 1   007 2   007 3   007 4   007 5   007 6   007 7   007 8   00
7 9   00710   00711   00712   00713   00714   00715   00716   00717   00718   00
719   00720   00721   00722   00723   00724   00725   00726   00727   00728   00
729   00730   00731   007
28138TMID1888 930 1 14600 2 15800 3 16000 4 15400 5 13500 6 11400 7 15100 8 1190
0 9 1300010  550011  680012  780013  970014  960015 1070016 1210017  810018  580
019  440020  470021  290022  400023  430024  100025  530026  760027  490028   20
029  100030  -900
```

Last five lines of the file:

```
30230PRCP19891125 1  1005 2   005 3   005 4   005 5   005 6   505 7   405 8  110
5 9  250510   00511   00512   20513   50514   30515   90516  170518  430519   30
520  340521  190522   30525   30526   30527   00530   005
30230TMIN19891231 1-16600 2-34000 3-33100 4-36000 5-31900 6-17500 7-24600 8-2080
0 9-2010010-2770011-3590012-2690013-2780014-2190015-2820016-4040017-4500018-3760
019-2630020-3070021-2300022-3200023-3920024-4280025-4270026-3160027-3210028-3690
029-3330030-2690031-34300
30230TMID19891231 1-11000 2-28100 3-29800 4-32000 5-22200 6-12900 7-17500 8-1080
0 9-1180010-1790011-3010012-2070013-1340014-1250015-2470016-3420017-4030018-2130
019-2110020-2300021-1110022-2750023-3540024-3990025-3830026-2220027-2180028-3150
029-2830030-2020031-24700
30230TMAX19891231 1 -3500 2-16000 3-24400 4-27800 5-15600 6 -8300 7 -7300 8 -620
0 9 -520010-1160011-2280012 -980013  -50014   60015-2190016-2430017-3600018 -830
019 -810020-1920021 -520022-1570023-3050024-3690025-3120026-1830027-1320028-2600
029-2460030-1270031-16700
30230PRCP19891226 1   005 3   205 4   005 5  2105 6  1105 7  1005 8   005 9  170
510   60511   00512  270513  220514   00515   50516   20518  110519   00520   30
521  100522   30523   00525   70526   70527   90530   60531   005
```

Table 11. Partial listing of "ussr5.data"
(File 14, Tape 1)

First five lines of the file:

```
30253TMIN1936 131 1-29300 2-32700 3-45200 4-44800 5-46100 6-47000 7-48700 8-4260
0 9-2930010-2850011-2830012-3170013-3270014-3790015-4190016-3820017-4340018-4310
019-4850020-4690021-4840022-4360023-4580024-4590025-4590026-4790027-4370028-4190
029-4730030-4980031-47500
30253TMID1936 131 1-27500 2-26500 3-42500 4-39800 5-43800 6-44500 7-44400 8-3170
0 9-2400010-2340011-2440012-2860013-3030014-3340015-3720016-3350017-3860018-3910
019-4520020-4440021-4550022-3830023-3930024-4270025-4280026-4200027-3650028-3430
029-4360030-4550031-44100
30253PRCP1936 131 1  1205 2   805 3   007 4   705 5   105 6   205 7   105 8  150
5 9  200510  210511   70512   70513   70514   30515   50516  210517   00818   50
519   00720   00721   00722   20523   00724   00725   00726   00727   90528   10
529   30530   00731   007
30253TMIN1936 229 1-48500 2-50100 3-49900 4-42200 5-39700 6-40200 7-39500 8-3260
0 9-3970010-2580011-2680012-1650013-2220014-3870015-4120016-3150017-3610018-3790
019-4300020-4450021-4460022-4440023-4380024-4310025-4250026-2780027-3150028-2940
029-24900
30253TMID1936 229 1-44800 2-44900 3-43800 4-36100 5-34400 6-35400 7-33600 8-2940
0 9-3220010-1940011-1820012-1260013-1830014-3160015-3390016-2370017-2780018-3040
019-3650020-3700021-3700022-3700023-3570024-3560025-3440026-2330027-2370028-2340
029-20800
```

Last five lines of the file:

```
31532PRCP19891110 7  1305 8  160512   20513   00517  190518   90519   40521   20
522   00529   005
31532TMIN19891231 1-22400 2-21600 3-21100 4-16500 5-24700 6-27600 7-31200 8-3260
0 9-3460010-3510011-3040012-3400013-3520014-3330015-2980016-2570017-3590018-4010
019-4080020-3950021-3350022-3650023-3420024-3340025-3200026-3360027-2360028-2520
029-1680030-2840031-30500
31532TMID19891231 1-18400 2-15200 3-15600 4-15400 5-20200 6-24200 7-27300 8-2860
0 9-3080010-3110011-2590012-3010013-3130014-3060015-2640016-2170017-3150018-3590
019-3750020-3570021-3060022-3240023-3090024-3010025-2870026-2640027-1930028-1860
029-1500030-2360031-27500
31532TMAX19891231 1-10200 2 -5400 3 -8400 4-14100 5-15200 6-18800 7-22400 8-2310
0 9-2530010-2550011-2090012-1460013-2700014-2520015-2080016-1770017-2330018-2960
019-3200020-3040021-2510022-2560023-2640024-2330025-2270026-2010027-1470028-1600
029-1180030-1630031-21800
31532PRCP198912 8 2   705 4  340515   00516   00527  570528  200529  100531   00
5
```

Table 12. Partial listing of "ussr6.data"
(File 15, Tape 1)

First five lines of the file:

```
31594TMIN1936 131 1-35000 2-38800 3-29300 4-32600 5-32800 6-32800 7-34300 8-3120
0 9-3580010-3470011-2580012-2500013-3160014-3760015-3340016-2550017-3160018-2990
019-2730020-2450021-2720022-3210023-3350024-3640025-3640026-3620027-3590028-3460
029-3180030-3350031-34700
31594TMID1936 131 1-28200 2-30400 3-25200 4-27600 5-30700 6-30400 7-28900 8-2690
0 9-2980010-2680011-1700012-1870013-2590014-3050015-2780016-2300017-2660018-2490
019-2370020-1850021-1760022-2410023-2680024-2740025-2990026-2840027-2960028-2940
029-2770030-2940031-28200
31594TMAX1936 131 1-23800 2-23800 3-22800 4-23300 5-28300 6-26700 7-24400 8-2290
0 9-2110010-2040011-1280012-1440013-1990014-2540015-2250016-2190017-2050018-2070
019-1970020-1430021-1390022-1590023-1980024-2110025-1850026-1940027-1960028-2480
029-2260030-2220031-22900
31594PRCP1936 131 1   008 2   007 3   205 4   305 5  1005 6   905 7   805 8   10
5 9   00710   00711   00812  160513   30514   00715   60516   60517   00718   10
519   20520  160521   00822   00723   00724   00725   00726   00727   00728   10
529   20530   00731   007
31594TMIN1936 229 1-31700 2-30300 3-31200 4-33000 5-30000 6-30700 7-26900 8-1550
0 9-2340010-2680011-2780012-2840013-2710014-2600015-3100016-2850017-2300018-2680
019-2150020-2600021-3010022-2850023-2520024-3080025-2710026-3030027-3200028-3020
029-29800
```

Last five lines of the file:

```
33837PRCP19891117 1   005 5   305 8   005 9   00511   00512   10513  150516   130
517  190518   80519   00523   00524   00525  110526   00528   00529   005
33837TMIN19891231 1 -4400 2 -3800 3  -700 4 -2000 5   000 6 -4600 7 -2800 8 -310
0 9 -320010 -880011-1210012 -540013 -420014  330015  280016  510017  440018  760
019  520020  580021  230022  410023  110024  260025   30026  140027  160028   50
029   30030   80031 -2600
33837TMID19891231 1 -2400 2  -300 3  1400 4  2500 5  2000 6 -2000 7  1100 8  -80
0 9  -50010 -370011 -800012 -230013   30014  530015  620016  970017  880018 1190
019  780020  850021  530022  570023  610024  590025  240026  210027  220028  140
029   80030  130031  -600
33837TMAX19891231 1  -600 2  2700 3  3700 4  9500 5  5900 6  1600 7  5200 8  430
0 9  290010  160011 -350012  180013  450014  910015  980016 1480017 1330018 1500
019 1110020 1370021  820022  950023 1200024  910025  420026  320027  290028  230
029  150030  170031  1300
33837PRCP19891212 1   005 2   005 6   005 8   00510   00514   00524  130527   00
528  230529   20530   00531   005
```

Table 13. Partial listing of "ussr7.data" (File 1, Tape 2)

First five lines of the file:

```
33889TMID18861031 1 19800 2  8600 3 10400 4 13000 5 15000 6 13500 7 14200 8  560
0 9  760010 1340011 1450012 1360013 1240014 1190015 1290016 1130017 1460018 1690
019 1810020 1990021 2020022 1750023 1410024 1150025  700026  410027  430028  340
029  380030  170031  3200
33889PRCP18861031 1   007 2   007 3   007 4   007 5   007 6   007 7   007 8   00
7 9   00710   40511   00712   00713   00714   00715 1120516   90517   00718   00
719   00720   00721   00722   70523   00724   00725   00726   00727   00728   00
729   00730   00731   007
33889TMID18861130 1  2200 2  1100 3  4400 4  1000 5  4400 6  6400 7 10600 8 1250
0 9 1160010 1300011 1420012 1070013 1100014 1330015 1350016  940017  530018  930
019 1080020  760021  500022  540023  470024  340025  240026  320027  440028   20
029  220030  2000
33889PRCP18861130 1   007 2   007 3   007 4   007 5   007 6   007 7   007 8   00
7 9   00710   00711   00712   00713   00714   00715   00716   00717   00718   00
719   00720   00721  540522  480523  980524   00725   00726   00727   00728   00
729   00730   007
33889TMID18861231 1  5800 2  8000 3 12600 4  9900 5 12100 6  7100 7  3000 8  670
0 9  780010 1030011  780012  290013  420014  380015  480016  640017  900018 1050
019 1310020 1010021 1110022  760023  900024  830025  720026  450027   80028   80
029  400030  950031 10400
```

Last five lines of the file:

```
35188PRCP19891120 1   005 2  2105 3  1405 8  2005 9   30510   20511  560512   90
513   40514   00515   00518   00519   00521  190523   90524   00527   10528   10
529   50530   305
35188TMIN19891231 1 -1200 2 -7400 3-12200 4-10000 5 -4400 6 -5000 7 -8600 8-1940
0 9-1910010-1610011-1250012 -750013-2020014-1690015 -880016-1610017-1730018 -850
019 -550020 -170021 -500022 -830023-1430024-1950025-1390026-1640027-1640028-1510
029 -900030-1000031-10500
35188TMID19891231 1  2000 2 -5500 3 -8500 4 -7000 5 -3200 6 -2700 7 -3800 8-1740
0 9-1030010-1050011 -720012 -180013-1540014 -930015 -310016-1320017-1190018 -610
019 -180020  -70021 -200022 -520023 -450024-1620025-1010026-1410027 -980028 -840
029 -670030 -830031 -6100
35188TMAX19891231 1  4200 2 -1200 3 -4300 4 -3600 5 -1500 6  -500 7  -300 8 -860
0 9   50010   50011  -50012   10013 -720014 -310015   70016 -870017 -640018 -490
019   00020   00021   00022 -170023   10024-1210025 -620026-1230027 -600028 -560
029 -600030 -670031 -4000
35188PRCP19891230 1  1705 2   005 3   005 4   205 5   005 6  2505 7  3005 8   00
5 9  170510   40511   30512   30514   60515  360516   20517   00518   60519   60
520  580521  210522   20523   90524   20525  170526   00527  150528  160529   60
530  150531   705
```

Table 14. Partial listing of "ussr8.data"
(File 2, Tape 2)

First five lines of the file:

```
35229TMIN19041127 4  -500 5 -4000 6  -500 7-11500 8 -5500 9 -750010 -850011 -600
012 -500013-1500014-1770015 -580016-1340017-2170018-1840019-1500020 -370021 -250
022 -270023 -500024-1200025-1750026-2260027-2250028-1960029 -160030 -2600
35229TMID19041129 1  5500 2  4200 3  -300 4  1000 5  2900 7 -6000 8  1700 9 -380
010 -290011 -130012   80013 -430014 -710015 -390016 -870017-1600018-1250019 -670
020   50021 -140022  -60023 -220024 -640025-1220026-1760027-1240028 -860029   60
030  -200
35229TMAX19041127 4  7000 5  6000 6 11500 7  1500 8  4000 9   50010  150011  400
012   500013   200014 -300015 -350016 -400017 -960018 -900019 -250020  100021  100
022   40023  300024   00025 -550026-1040027 -740028 -100029  150030  -100
35229TMIN19041231 1   000 2   000 3 -2400 4-11700 5-15200 6-15200 7-18200 8-1170
0 9 -170010-1020011-1370012-1420013-1210014 -710015 -820016 -930017-1600018-1640
019-1120020 -320021-2030022-2740023-2700024-2220025-1620026 -610027-1420028-1420
029-2420030-1770031-10000
35229TMID19041231 1  1400 2   900 3  -800 4 -6900 5-11800 6-12300 7-12400 8 -270
0 9   50010 -650011-1080012-1030013 -610014 -630015 -760016 -830017-1070018-1150
019 -570020   20021 -830022-2610023-1750024-1850025 -280026 -340027-1190028 -490
029-1870030 -570031 -6900
```

Last five lines of the file:

```
37549PRCP19891115 1  150510   80511 2290512  370513  270515   30517   30518 1000
519   00521   00526   00527 2320528  300529  210530  2605
37549TMIN19891231 1  2800 2   500 3 -2800 4 -2400 5  1900 6   100 7 -1700 8 -450
0 9   10010  -50011  380012   40013   40014 -270015 -340016 -370017 -130018  580
019  410020  360021  440022  700023  150024  -60025  600026  210027  390028  270
029  150030  -10031  3000
37549TMID19891231 1  4000 2  2400 3   600 4   300 5  3700 6  2700 7   800 8 -130
0 9  240010  190011  540012  140013  250014   60015  -10016   20017  480018  910
019  870020  930021  870022  890023  400024  410025  800026  390027  470028  500
029  500030  510031  4600
37549TMAX19891231 1  5200 2  4000 3  4400 4  4300 5  6800 6  5800 7  4800 8  300
0 9  580010  620011  760012  480013  630014  580015  720016  530017 1040018 1430
019 1480020 1530021 1400022 1230023  760024 1080025 1080026  640027  560028  830
029 1040030 1110031  7800
37549PRCP198912 6 1   005 6   005 9   00511   90512 1350513  2505
```

Table 15. Partial listing of "ussr9.data"
(File 3, Tape 2)

First five lines of the file:

```
37686TMIN1895 930 1  1100 2  1100 3  5100 4  4100 5  9000 6  8100 7  7600 8  710
0 9 1050010  580011  710012   90013  240014   60015  390016  580017  730018  840
019  810020  810021  950022 1050023  950024  510025  840026  130027   50028   20
029   60030     600
37686TMID1895 930 1 14800 2 15000 3 14500 4 14000 5 15200 6 15000 7 14600 8 1540
0 9 1620010 1510011 1040012  770013  900014 1280015 1690016 1690017 1800018 1890
019 1760020 1880021 1740022 1290023 1670024 1150025 1050026 1030027  880028  960
029 1110030   12700
37686TMAX1895 930 1 24900 2 24400 3 22900 4 21900 5 21900 6 21900 7 20400 8 2240
0 9 2440010 2360011 1550012 1510013 2090014 2360015 2290016 2750017 2740018 2540
019 2690020 2640021 2390022 2250023 2440024 1790025 1990026 1420027 1650028 1790
029 1940030   20400
37686PRCP1895 930 1   007 2   007 3   007 4   007 5   007 6   007 7   007 8   00
7 9   00710  350511  360512   00713   00714   00715   00716   00717   00718   00
719   00720   00721   00722  330523   00724   00725   00726   00727   00728   00
729   00730     007
37686TMIN18951031 1  3600 2  7500 3  7100 4  6800 5   200 6  1600 7  4400 8  950
0 9  710010   10011  150012  250013  430014  510015  360016 -440017  260018 -160
019 -280020 -240021 -440022 -290023  -90024 -240025   00026  110027   60028 -230
029 -350030 -370031   -1900
```

Last five lines of the file:

```
38987PRCP198911 2 8   60517    6505
38987TMIN19891231 1  9400 2  4100 3  4500 4  5000 5  5800 6  5500 7  6100 8  460
0 9  500010  120011  320012  270013  680014  660015  690016  570017  620018  190
019  230020  -40021  -30022  -30023   60024  590025   00026   40027  260028  330
029  -50030 -150031    4000
38987TMID19891231 1 18000 2  9800 3  5800 4  7300 5 12700 6  7800 7  8500 8  730
0 9  990010  780011 1130012 1120013 1070014 1020015  880016  730017  780018  720
019  580020  490021  460022  510023  640024  690025  660026  780027  360028  450
029  340030  580031    6800
38987TMAX19891231 1 27000 2 24500 3  8100 4 10500 5 24500 6 14000 7 12600 8 1400
0 9 1750010 1850011 2150012 2310013 1750014 1720015 1120016  960017 1350018 1400
019 1190020 1300021 1250022 1350023 1100024  900025 1490026 1800027  850028  740
029  880030 1660031   11900
38987PRCP198912 7 3   005 4   605 6 2780515  460516  520517  400524   505
```

APPENDIX A

Station Inventories

APPENDIX A

Station Inventories

This appendix contains nine tables that jointly list all station inventory information for all stations. The meaning of the column headings in these tables is as follows:

WMO No.	is the WMO No. of the station.
Station name	is the name of the station.
Lat	is the latitude of the station (in decimal degrees).
Lon	is the longitude of the station (in decimal degrees). Stations in the Western Hemisphere have negative longitudes.
Elev	is the elevation of the station (in meters). Missing elevations are coded as -999.9.
1st year	is the first year in which records are available for this variable at this station.
% miss	is the percentage of records that are missing for this variable at this station.

Table A.1. Inventory of stations in "ussr1.data" (File 10, Tape 1)

WMO No.	Station name	Lat	Lon	Elev	MIN TEMP 1st year	MIN TEMP % miss	MEAN TEMP 1st year	MEAN TEMP % miss	MAX TEMP 1st year	MAX TEMP % miss	PRECIP 1st year	PRECIP % miss
20674	OSTROV DIKSON	73.50	80.40	42.0	1936	0.2	1936	0.2	1936	0.2	1936	9.1
20891	HATANGA	71.98	102.47	30.0	1929	7.1	1928	11.1	1929	7.2	1928	17.0
21946	COKURDAH	70.62	147.88	0.0	1944	1.9	1944	1.6	1944	1.6	1944	11.9
21982	OSTROV VRANGELJA	70.97	-178.37	2.0	1926	1.7	1926	1.4	1926	1.6	1926	21.6
22113	MURMANSK	68.97	33.05	57.0	1936	0.2	1936	0.1	1936	0.3	1936	20.4
22217	KANDALAKSA	67.13	32.43	26.0	1912	1.1	1912	1.0	1912	1.6	1912	13.4
22522	KEM'-PORT	64.98	34.78	7.3	1916	1.8	1916	1.6	1916	2.1	1916	16.2
22550	ARHANGEL'SK	64.58	40.50	8.0	1881	1.0	1881	0.4	1881	19.5	1881	11.4
22583	KOJNAS	64.75	47.65	63.0	1912	5.2	1912	2.7	1915	2.7	1912	11.7
22602	REBOLY	63.82	30.82	179.0	1910	38.6	1910	38.2	1910	40.0	1910	46.9
22641	ONEGA	63.90	38.12	11.0	1936	0.7	1936	0.2	1936	2.0	1936	18.3
22802	SORTOVALA	61.72	30.72	17.0	1945	0.1	1945	0.1	1945	0.5	1945	14.6
22820	PETROZAVODSK	61.82	34.27	110.0	1936	5.6	1936	5.4	1936	7.2	1936	20.8
22837	VYTEGRA	61.02	36.45	55.0	1891	13.8	1881	7.1	1910	15.1	1881	16.7
22887	KOTLAS	61.23	46.63	56.0	1936	0.0	1936	0.0	1936	0.0	1936	17.5
23146	MYS KAMENNYJ	68.47	73.60	2.0	1950	0.7	1950	0.8	1950	0.8	1950	15.6
23205	NAR'JAN-MAR	67.65	53.02	5.0	1926	1.6	1926	1.9	1926	3.3	1926	17.0
23219	HOSEDA-HARD	67.08	59.38	82.0	1936	0.5	1936	0.9	1936	5.3	1936	15.9
23405	UST'-CIL'MA	65.45	52.17	72.0	1892	5.3	1892	4.5	1913	1.6	1892	20.1
23418	PECORA	65.12	57.10	54.5	1943	1.5	1943	1.4	1943	7.7	1943	16.7
23472	TURUHANSK	65.78	87.95	37.0	1960	0.0	1960	0.0	1960	0.0	1960	12.9
23631	BEREZOVO	63.93	65.05	27.0	1936	0.0	1936	0.0	1936	2.1	1936	15.2
23711	TROICKO-PECERSKOE	62.70	56.20	135.0	1888	3.7	1888	2.2	1914	2.8	1888	10.6
23724	NJAKSIMVOL'	62.43	60.87	50.0	1936	0.5	1936	0.5	1936	0.6	1936	13.3
23804	SYKTYVKAR	61.67	50.85	96.0	1888	4.8	1888	3.0	1897	17.2	1888	12.7

Table A.2. Inventory of stations in "ussr2.data" (File 11, Tape 1)

WMO No.	Station name	Lat	Lon	Elev	MIN TEMP 1st year	MIN TEMP % miss	MEAN TEMP 1st year	MEAN TEMP % miss	MAX TEMP 1st year	MAX TEMP % miss	PRECIP 1st year	PRECIP % miss
23849	SURGUT	61.25	73.50	44.0	1891	10.5	1884	3.8	1933	3.5	1884	9.0
23884	BOR	61.60	90.00	62.0	1936	5.6	1936	1.9	1937	4.2	1936	12.1
23891	BAJKIT	61.67	96.37	256.0	1936	0.8	1936	0.6	1936	3.5	1936	13.3
23921	IVDEL'	60.68	60.43	93.0	1934	2.0	1934	1.4	1934	3.1	1934	15.8
23933	HANTY-MANSIJSK	60.97	69.07	45.0	1895	23.7	1892	24.0	1933	4.1	1892	34.1
23955	ALEKSANDROVSKOE	60.43	77.87	47.0	1936	0.0	1936	0.0	1936	0.6	1936	8.6
24125	OLENEK	68.50	112.43	216.5	1936	4.4	1936	4.1	1936	4.1	1937	14.9
24266	VERHOJANSK	67.55	133.38	136.0	1890	9.2	1885	8.9	1895	29.2	1885	18.0
24343	ZIGANSK	66.77	123.40	88.0	1936	0.8	1936	0.5	1936	2.8	1936	15.8
24507	TURA	64.17	100.07	188.0	1928	1.9	1928	1.8	1929	9.7	1928	12.6
24641	VILJUJSK	63.77	121.62	110.8	1898	2.4	1898	1.9	1900	31.2	1898	5.9
24688	OJMJAKON	63.27	143.15	740.0	1943	0.1	1943	0.0	1943	3.9	1943	9.0
24738	SUNTAR	62.15	117.65	131.0	1936	1.3	1936	0.2	1936	0.5	1936	6.3
24817	ERBOGACEN	61.27	108.02	284.0	1936	3.1	1936	3.1	1936	11.5	1936	19.9
24908	VANAVARA	60.33	102.27	259.0	1932	2.7	1932	2.4	1932	7.6	1932	12.2
24944	OLEKMINSK	60.40	120.42	223.0	1882	25.4	1882	16.6	1900	32.5	1882	21.5
24951	ISIT'	60.82	125.32	117.0	1936	4.8	1936	4.6	1936	7.3	1936	20.0
24959	JAKUTSK	62.08	129.75	98.5	1888	6.3	1888	3.0	1888	29.7	1888	11.2
24966	UST'-MAJA	60.38	134.45	169.0	1902	14.1	1897	13.8	1926	4.4	1897	21.6
25173	MYS SMIDTA	68.92	-179.48	3.3	1936	0.2	1936	0.2	1936	0.2	1936	23.3
25551	MARKOVO	64.68	170.42	25.0	1894	23.4	1894	22.2	1894	26.0	1894	31.8
25563	ANADYR'	64.78	177.57	64.0	1898	17.7	1898	15.5	1915	18.4	1898	29.4
25594	BUHTA PROVIDENJA	64.43	-173.23	9.0	1936	1.6	1936	1.6	1936	1.6	1936	9.7
25703	SEJMCAN	62.92	152.42	206.0	1936	6.8	1936	6.7	1936	6.8	1936	21.6
25744	KAMENSKOE	62.48	166.22	33.0	1953	4.6	1950	2.6	1950	5.2	1950	18.7

Table A.3. Inventory of stations in "ussr3.data" (File 12, Tape 1)

WMO No.	Station name	Lat	Lon	Elev	MIN TEMP 1st year	MIN TEMP % miss	MEAN TEMP 1st year	MEAN TEMP % miss	MAX TEMP 1st year	MAX TEMP % miss	PRECIP 1st year	PRECIP % miss
25913	MAGADAN	59.58	150.78	115.0	1936	0.0	1936	0.0	1936	0.0	1936	8.5
25954	KORF	60.35	166.00	2.0	1929	9.8	1929	8.5	1929	15.2	1929	23.1
26038	TALLIN	59.42	24.80	41.0	1936	2.2	1936	2.2	1936	2.2	1936	9.2
26063	LENINGRAD TOWN/VILLE	59.97	30.30	4.0	1881	0.3	1881	0.0	1881	2.2	1881	3.7
26188	VEREB'E	58.68	32.70	116.0	1936	3.4	1936	3.4	1936	3.4	1936	11.1
26231	PJARNU	58.38	24.50	1.0	1936	2.8	1936	2.8	1936	2.9	1936	8.6
26258	PSKOV	57.83	28.35	42.0	1936	5.9	1936	5.9	1936	5.9	1936	20.6
26406	LIEPAJA	56.55	21.02	4.0	1895	9.9	1881	13.7	1922	2.1	1881	18.3
26422	RIGA	56.97	24.07	7.0	1943	0.0	1943	0.0	1943	0.0	1943	8.4
26477	VELIKIE LUKI	56.38	30.60	98.0	1881	27.4	1881	18.2	1881	30.0	1881	27.7
26629	KAUNAS	54.88	23.88	76.0	1922	0.5	1922	0.6	1922	0.5	1922	9.2
26702	KALININGRAD	54.70	20.62	20.0	1947	0.2	1947	0.0	1947	0.3	1947	7.6
26730	VIL'NJUS	54.63	25.28	162.0	1890	6.5	1881	5.0	1918	2.6	1881	14.8
26781	SMOLENSK	54.75	32.07	236.0	1944	1.4	1944	0.1	1944	3.5	1944	9.6
26850	MINSK	53.87	27.53	222.0	1891	22.2	1891	17.6	1896	29.2	1891	21.0
27037	VOLOGDA	59.28	39.87	125.0	1938	1.8	1938	1.6	1938	1.6	1938	11.5
27196	KIROV	58.65	49.62	165.0	1890	4.7	1881	3.7	1890	28.8	1881	13.6
27333	KOSTROMA	57.73	40.95	137.0	1925	0.0	1925	0.0	1925	0.0	1925	16.4
27553	GOR'KIJ	56.22	43.82	161.0	1892	3.9	1881	3.3	1907	3.2	1881	13.1
27595	KAZAN'	55.78	49.18	116.0	1890	2.7	1881	2.3	1895	6.0	1881	5.7
27612	MOSKVA	55.75	37.57	147.0	1948	1.2	1948	1.2	1948	2.5	1948	16.9
27648	ELAT'MA	54.95	41.77	132.0	1891	3.6	1886	3.7	1891	28.1	1886	10.4
27823	PAVELEC	53.78	39.25	209.0	1936	0.8	1936	0.8	1936	0.8	1936	11.8
27947	TAMBOV	52.73	41.47	139.0	1936	0.0	1936	0.0	1936	0.0	1936	10.9
28064	LEUSI	59.62	65.78	72.8	1936	0.1	1936	0.0	1936	1.5	1936	15.3

Table A.4. Inventory of stations in "ussr4.data" (File 13, Tape 1)

WMO No.	Station name	Lat	Lon	Elev	MIN TEMP		MEAN TEMP		MAX TEMP		PRECIP	
					1st year	% miss	1st year	% miss	1st year	% miss	1st year	% miss
28138	BISER	58.52	58.85	463.0	1891	8.4	1888	7.6	1894	41.4	1888	13.7
28225	PERM	58.02	56.30	169.0	1890	0.7	1882	1.3	1893	23.2	1882	14.5
28275	TOBOL'SK	58.15	68.18	48.5	1887	5.8	1884	3.1	1900	15.2	1884	12.2
28411	IZEVSK	56.82	53.27	155.0	1958	0.0	1958	0.0	1958	0.0	1958	20.1
28434	KRASNOUFIMSK	56.62	57.75	20.6	1936	0.3	1936	0.0	1936	0.0	1936	15.6
28440	SVERDLOVSK	56.80	60.63	282.0	1881	12.7	1881	8.4	1885	13.9	1881	13.5
28493	TARA	56.90	74.38	73.0	1936	0.2	1936	0.2	1936	0.2	1936	14.5
28661	KURGAN	55.47	65.40	70.0	1893	12.4	1893	7.7	1929	1.1	1893	19.8
28679	PETROPAVLOVSK	54.83	69.15	134.0	1890	18.7	1890	13.0	1899	29.4	1890	23.2
28698	OMSK	54.93	73.40	121.0	1916	2.6	1916	1.0	1916	10.9	1916	11.7
28722	UFA	54.75	56.00	104.0	1900	5.3	1900	4.6	1914	4.3	1900	11.7
28900	KUJBYSEV BEZENCUK	53.25	50.45	137.0	1936	0.2	1936	0.0	1936	0.1	1936	14.6
28952	KUSTANAJ	53.22	63.62	169.0	1902	9.1	1902	5.2	1902	15.6	1902	17.7
29231	KOLPASEV	58.30	82.90	80.0	1936	0.0	1936	0.0	1936	0.0	1936	7.4
29263	ENISEJSK	58.45	92.15	77.0	1884	5.8	1884	2.3	1887	37.6	1884	12.3
29282	BOGUCANY	58.42	97.40	134.0	1930	2.9	1930	1.9	1930	2.9	1930	16.8
29430	TOMSK	56.43	84.97	137.0	1890	1.2	1881	0.3	1924	2.6	1881	8.9
29574	KRASNOJARSK	56.00	92.88	274.0	1914	1.7	1914	0.8	1923	1.0	1914	9.2
29612	BARABINSK	55.37	78.40	120.0	1900	10.2	1900	8.1	1910	23.5	1900	17.9
29698	NIZNE-UDINSK	54.88	99.03	410.0	1966	0.0	1966	0.0	1966	0.0	1966	23.2
29807	IRTYSSK	53.35	75.45	93.0	1936	1.0	1936	0.2	1936	6.5	1936	13.0
29838	BARNAUL	53.33	83.70	153.0	1959	0.2	1959	0.2	1959	5.0	1959	15.4
29866	MINUSINSK	53.70	91.70	251.0	1910	10.3	1910	8.8	1927	3.2	1910	18.5
30054	VITIM	59.45	112.58	186.3	1928	1.3	1928	1.3	1930	1.3	1928	13.2
30230	KIRENSK	57.77	108.12	256.0	1892	10.2	1892	7.0	1898	39.9	1892	13.9

Table A.5. Inventory of stations in "ussr5.data" (File 14, Tape 1)

WMO No.	Station name	Lat	Lon	Elev	MIN TEMP		MEAN TEMP		MAX TEMP		PRECIP	
					1st year	% miss	1st year	% miss	1st year	% miss	1st year	% miss
30253	BODAJBO	57.85	114.20	278.0	1936	0.0	1936	0.0	1937	1.9	1936	15.1
30372	CARA	56.92	118.37	708.0	1938	1.3	1938	1.0	1938	1.2	1938	13.4
30393	CUL'MAN	56.83	124.87	843.9	1936	2.9	1936	2.0	1936	6.1	1936	16.1
30521	ZIGALOVO	54.80	105.17	426.0	1937	3.3	1937	1.9	1937	10.5	1937	10.5
30555	TROICKIJ PRIISK	54.62	113.13	1315.0	1938	0.3	1938	0.3	1938	0.3	1938	13.1
30636	BARGUZIN	53.62	109.63	488.0	1900	16.2	1898	7.3	1928	6.5	1898	18.4
30673	MOGOCA	53.73	119.78	624.0	1910	11.5	1910	10.5	1910	17.1	1910	17.8
30692	SKOVORODINO	54.00	123.97	397.5	1912	12.2	1912	11.4	1912	13.5	1912	20.2
30710	IRKUTSK	52.27	104.35	467.0	1887	0.0	1882	0.0	1887	2.0	1882	5.0
30758	CITA	52.02	113.33	471.0	1890	4.1	1890	4.0	1898	30.0	1890	14.9
30777	SRETENSK	52.27	117.70	528.0	1936	0.4	1936	0.2	1936	0.2	1936	10.8
30823	ULAN-UDE	51.80	107.43	514.0	1891	5.2	1886	2.5	1893	31.2	1886	14.4
30925	KJAHTA	50.37	106.45	791.0	1895	17.2	1895	14.6	1895	38.8	1895	23.5
30949	KYRA	49.57	111.97	907.0	1927	10.8	1927	9.5	1927	12.0	1927	17.3
30965	BORZJA	50.38	116.52	675.0	1901	9.8	1901	7.5	1901	29.9	1901	17.2
31004	ALDAN	58.62	125.37	678.0	1937	0.0	1937	0.0	1937	0.6	1937	4.7
31088	OHOTSK	59.37	143.20	5.0	1891	22.3	1891	21.8	1912	9.3	1891	32.9
31168	AJAN	56.45	138.15	7.0	1931	1.5	1931	1.5	1931	2.6	1931	13.0
31253	BOMNAK	54.72	128.93	357.0	1909	13.6	1909	13.3	1909	14.8	1909	20.1
31329	EKIMCAN	53.07	132.93	540.0	1914	4.9	1914	2.1	1915	17.0	1914	13.8
31369	NIKOLAEVSK-NA-AMURE	53.15	140.70	46.0	1881	12.0	1881	8.5	1925	5.4	1881	20.8
31388	NORSK	52.35	129.92	207.0	1925	4.2	1925	3.1	1933	7.3	1925	11.5
31416	IM POLINY OSIPENKO	52.42	136.50	71.0	1936	0.8	1936	0.3	1936	0.3	1936	12.1
31510	BLAGOVESCENSK	50.27	127.50	130.0	1890	11.2	1881	4.3	1914	0.0	1881	19.0
31532	CEKUNDA	50.82	132.17	271.0	1936	0.5	1936	0.8	1936	4.3	1936	10.8

Table A.6. Inventory of stations in "ussr6.data" (File 15, Tape 1)

WMO					MIN TEMP		MEAN TEMP		MAX TEMP		PRECIP	
No.	Station name	Lat	Lon	Elev	1st year	% miss	1st year	% miss	1st year	% miss	1st year	% miss
31594	ARHARA	49.42	130.08	133.0	1936	0.2	1936	0.0	1936	0.1	1936	10.4
31707	EKATERINO-NIKOL'SKOE	47.73	130.97	72.0	1966	0.0	1966	0.0	1966	0.0	1966	14.1
31735	HABAROVSK	48.52	135.17	88.0	1952	0.9	1952	0.9	1952	0.9	1952	14.7
31829	MYS ZOLOTOJ	47.32	138.98	27.0	1936	5.2	1936	4.1	1936	4.2	1936	15.6
31873	DAL'NERECENSK	45.87	133.73	97.0	1939	3.5	1939	3.5	1939	3.9	1939	16.7
31909	TERNEJ	45.03	136.67	51.0	1926	19.4	1923	19.1	1925	19.4	1923	28.9
31915	POGRANICNYJ	44.40	131.38	217.0	1902	12.7	1902	12.1	1910	8.9	1902	19.9
31960	VLADIVOSTOK	43.12	131.90	183.0	1914	5.4	1914	5.3	1914	6.7	1914	10.0
32061	ALEKSANDROVSK-SAHALINSKIJ	50.90	142.17	30.0	1881	10.6	1881	9.0	1894	12.3	1881	19.2
32098	PORONAJSK	49.22	143.10	7.0	1908	1.9	1908	1.6	1908	2.5	1908	16.6
32165	JUZNO-KURIL'SK	44.02	145.82	44.0	1947	0.0	1947	0.0	1947	0.0	1947	14.6
32389	KLJUCI	56.32	160.83	28.0	1914	13.4	1914	13.4	1914	22.1	1914	19.5
32411	ICA	55.70	155.63	10.0	1936	6.5	1936	3.2	1937	10.3	1936	16.5
32540	PETROPAVLOVSK-KAMCATSKIJ	52.97	158.75	-999.9	1895	9.0	1894	3.2	1906	8.8	1894	6.1
32564	OKTIABR'SKAYA	52.67	156.23	6.0	1914	26.7	1914	23.5	1915	29.1	1914	27.8
33008	BREST	52.12	23.68	141.0	1902	48.7	1902	48.5	1902	48.5	1902	52.9
33038	VASILEVICI	52.25	29.83	139.0	1891	21.3	1881	18.1	1914	28.2	1881	23.9
33345	KIEV	50.40	30.45	167.0	1881	1.5	1881	0.8	1881	1.2	1881	4.7
33377	LUBNY	50.02	33.00	156.0	1936	2.3	1936	2.2	1936	2.2	1936	14.9
33393	L'VOV	49.82	23.95	326.0	1936	8.6	1936	8.2	1936	8.2	1936	15.3
33562	VINNICA	49.23	28.47	281.0	1936	2.5	1936	1.3	1936	1.3	1936	12.7
33631	UZGOROD	48.63	22.27	115.0	1946	0.8	1946	0.7	1946	0.7	1946	11.9
33658	CERNOVCY	48.27	25.97	239.0	1941	6.7	1941	6.7	1941	7.5	1941	16.0
33815	KISINEV	47.02	28.87	173.0	1891	27.7	1886	27.0	1892	41.2	1886	31.9
33837	ODESSA	46.48	30.63	42.0	1894	4.5	1894	3.3	1894	4.7	1894	12.8

Table A.7. Inventory of stations in "ussr7.data" (File 1, Tape 2)

WMO No.	Station name	Lat	Lon	Elev	MIN TEMP 1st year	MIN TEMP % miss	MEAN TEMP 1st year	MEAN TEMP % miss	MAX TEMP 1st year	MAX TEMP % miss	PRECIP 1st year	PRECIP % miss
33889	IZMAIL	45.37	28.87	28.0	1887	54.3	1886	51.9	1887	54.4	1886	59.0
33910	GENICESK	46.17	34.82	14.0	1885	14.3	1883	13.0	1891	27.4	1883	20.0
33915	ASKANIJA-NOVA	46.45	33.88	28.0	1910	20.8	1910	19.2	1910	22.0	1910	29.6
33946	SIMFEROPOL'	45.02	33.98	204.0	1955	0.0	1955	0.0	1955	0.0	1955	14.9
33976	FEODOSIJA	45.03	35.38	22.0	1882	14.4	1881	12.1	1882	14.6	1881	18.8
33983	KERC'	45.37	36.43	32.0	1936	5.1	1936	5.1	1936	5.1	1936	21.4
34009	KURSK	51.65	36.18	246.0	1891	7.1	1891	5.9	1896	17.6	1891	10.8
34122	VORONEZ	51.70	39.17	147.0	1918	4.2	1918	2.3	1918	3.8	1918	15.9
34139	KAMENNAJA STEP'	51.05	40.70	193.0	1893	5.6	1893	5.6	1893	8.7	1893	14.9
34163	OKTJABR'SKIJ GORODOK	51.63	45.45	202.0	1884	9.2	1881	1.1	1891	10.3	1881	9.9
34172	SARATOV	51.57	46.03	126.0	1936	0.3	1936	0.2	1936	0.6	1936	10.5
34300	HAR'KOV	49.93	36.28	147.0	1936	17.4	1936	17.1	1936	17.1	1936	26.5
34391	ALEKSANDROV-GAJ	50.15	48.55	23.0	1936	0.3	1936	0.2	1936	1.5	1936	9.5
34524	DEBAL'CEVO	48.35	38.43	334.0	1936	5.6	1936	4.8	1936	5.4	1936	13.8
34646	VOLGODONSK	47.73	42.25	64.0	1952	0.4	1952	0.2	1952	0.4	1952	16.9
34731	ROSTOV-NA-DONU	47.25	39.82	66.0	1886	12.4	1886	9.3	1911	7.0	1886	12.3
34747	CELINA	46.55	41.05	111.0	1936	1.8	1936	1.4	1936	1.7	1936	12.7
34824	PRIMORSKO-AHTARSK	46.03	38.15	3.0	1959	1.6	1959	1.6	1959	1.6	1959	14.4
34861	ELISTA	46.32	44.30	151.0	1927	4.6	1927	3.2	1927	5.2	1927	14.7
34880	ASTRAHAN'	46.27	48.03	-22.0	1881	7.4	1881	3.6	1881	13.6	1881	8.5
35078	ATBASAR	51.82	68.37	303.0	1936	1.0	1936	0.5	1936	0.5	1936	17.6
35108	URAL'SK	51.25	51.40	36.0	1900	8.3	1900	8.7	1901	19.9	1900	17.1
35121	ORENBURG	51.75	55.10	115.0	1892	0.9	1886	0.2	1915	2.3	1886	4.7
35133	ADAMOVKA	51.52	59.95	285.0	1936	7.4	1936	2.6	1936	10.2	1936	13.3
35188	CELINOGRAD	51.13	71.37	347.0	1884	10.1	1881	7.7	1900	24.3	1881	19.4

Table A.8. Inventory of stations in "ussr8.data" (File 2, Tape 2)

WMO					MIN TEMP		MEAN TEMP		MAX TEMP		PRECIP	
No.	Station name	Lat	Lon	Elev	1st year	% miss	1st year	% miss	1st year	% miss	1st year	% miss
35229	AKTJUBINSK	50.28	57.15	219.0	1904	15.4	1904	8.7	1904	12.7	1904	16.7
35358	TURGAJ	49.63	63.50	124.0	1901	27.3	1900	16.8	1901	29.3	1900	26.3
35394	KARAGANDA	49.80	73.13	550.0	1936	0.6	1936	0.2	1936	0.8	1936	10.0
35406	KALMYKOVO	49.05	51.87	1.0	1925	20.0	1925	6.8	1927	8.4	1924	19.6
35416	UIL	49.07	54.68	88.0	1925	12.4	1925	5.8	1925	19.7	1925	16.0
35542	IRGIZ	48.62	61.27	114.0	1936	7.5	1936	0.9	1936	2.8	1936	16.6
35576	KZYL-ZAR	48.30	69.65	361.0	1937	3.9	1937	2.7	1937	5.9	1937	14.9
35663	KARSAKPAJ	47.83	66.75	488.0	1927	9.2	1926	1.4	1928	4.4	1926	9.1
35700	GUR'EV	47.02	51.85	-24.0	1881	15.2	1881	6.2	1885	24.8	1881	19.8
35746	ARAL'SKOE MORE	46.78	61.67	62.0	1905	13.1	1905	7.4	1905	25.0	1905	16.8
35796	BALHAS	46.90	75.00	347.0	1936	6.2	1936	0.5	1936	2.6	1936	17.3
36034	RUBCOVSK	51.50	81.22	216.0	1936	1.2	1936	0.0	1936	0.6	1936	13.4
36177	SEMIPALATINSK	50.35	80.25	195.0	1902	6.5	1901	4.6	1901	21.2	1901	15.1
36665	ZAJSAN	47.47	84.92	604.0	1936	1.3	1936	0.2	1936	1.1	1936	10.7
36729	UC-ARAL	46.17	80.93	397.0	1937	3.0	1936	1.4	1936	2.1	1936	12.2
36859	PANFILOV	44.17	80.07	641.0	1917	13.2	1917	1.5	1917	8.6	1917	10.0
36870	ALMA-ATA	43.23	76.93	847.0	1915	2.4	1915	2.3	1915	2.4	1915	14.4
36974	NARYN	41.43	76.00	2039.0	1913	8.9	1913	7.5	1925	6.1	1913	11.1
37031	ARMAVIR	44.98	41.12	158.0	1936	2.0	1936	1.2	1936	2.6	1936	12.3
37050	PJATIGORSK	44.05	43.03	531.0	1934	1.6	1934	1.5	1934	1.8	1934	18.0
37099	SOCI	43.58	39.72	57.0	1891	7.5	1881	4.8	1898	5.5	1881	8.7
37235	GROZNYJ	43.35	45.68	123.0	1938	2.2	1938	1.3	1938	1.3	1938	16.7
37385	SAMTREDIA	42.18	42.37	28.0	1936	0.0	1936	0.1	1936	0.0	1936	8.0
37472	MAHACKALA	43.02	47.43	-21.0	1882	1.6	1882	0.9	1913	1.5	1882	16.0
37549	TBILISI	41.68	44.95	427.0	1881	4.1	1881	3.8	1888	12.8	1881	17.5

Table A.9. Inventory of stations in "ussr9.data" (File 3, Tape 2)

WMO					MIN TEMP		MEAN TEMP		MAX TEMP		PRECIP	
					1st	%	1st	%	1st	%	1st	%
No.	Station name	Lat	Lon	Elev	year	miss	year	miss	year	miss	year	miss
37686	LENINAKAN	40.78	43.83	1523.0	1895	12.4	1895	10.5	1895	32.4	1895	16.0
37735	KIROVABAD	40.72	46.42	308.0	1882	28.1	1882	15.4	1882	30.5	1882	20.3
37789	EREVAN	40.13	44.47	888.0	1886	14.0	1885	7.4	1896	23.7	1885	12.8
38198	TURKESTAN	43.27	68.22	206.0	1882	39.4	1882	7.5	1914	16.6	1882	13.4
38262	CIMBAJ	42.95	59.82	64.7	1937	2.6	1937	0.0	1937	0.2	1937	9.4
38353	FRUNZE	42.83	74.58	756.0	1936	0.0	1936	0.0	1936	0.0	1936	7.0
38413	TAMDY	41.73	64.62	236.0	1932	3.4	1932	1.3	1932	2.2	1932	12.1
38457	TASKENT	41.27	69.27	477.0	1881	7.6	1881	2.0	1881	8.5	1881	7.2
38507	KRASNOVODSK	40.03	52.98	89.0	1936	11.8	1936	6.2	1936	6.3	1936	19.5
38599	LENINABAD	40.22	69.73	425.0	1936	1.0	1936	0.5	1936	2.4	1936	12.5
38618	FERGANA	40.37	71.75	577.8	1881	21.5	1881	6.5	1907	18.6	1881	15.0
38687	CARDZOU	39.08	63.60	188.0	1894	17.6	1894	10.6	1913	13.2	1894	16.1
38696	SAMARKAND	39.57	66.95	725.0	1936	0.0	1936	0.0	1936	0.0	1936	6.2
38750	GASAN-KULI	37.47	53.97	-24.0	1926	2.9	1926	1.0	1926	2.0	1926	10.3
38763	KIZYL-ARVAT	38.98	56.28	97.0	1883	16.4	1883	11.1	1885	22.1	1885	16.8
38836	DUSANBE	38.58	68.78	796.0	1926	1.3	1926	0.8	1926	3.1	1926	9.6
38880	ASHABAD	37.97	58.33	227.0	1937	13.0	1937	12.1	1937	12.1	1937	19.9
38895	BAJRAM-ALI	37.60	62.18	240.0	1889	8.3	1889	2.6	1890	24.7	1889	9.1
38927	TERMEZ	37.23	67.27	309.0	1927	19.7	1927	15.9	1927	17.8	1927	22.7
38933	KURGAN-TJUBE	37.82	68.78	427.0	1936	0.3	1936	0.0	1936	0.2	1936	9.9
38954	HOROG	37.50	71.50	2077.0	1910	25.0	1898	16.7	1910	25.1	1898	21.4
38974	SERAHS	36.53	61.22	275.0	1936	6.6	1936	1.5	1936	2.0	1936	9.5
38987	KUSKA	35.28	62.35	625.0	1913	7.3	1911	7.8	1913	7.9	1911	13.4

APPENDIX B

Station Histories

APPENDIX B

Station Histories

This appendix contains a list of all station history information for each of the 223 stations. The meanings of the column headings on each page are as follows:

WMO No.	is the WMO No. of the station.
Type	is the type of change indicated by this entry. The possible values of **Type** are as follows: RAIN = rain gauge replacement (i.e., change from old-type gauge to Tretyakov-type gauge). Each station will have only one RAIN entry. In this type of entry, **Distance** and **Direction** (described below) have no meaning and thus are coded as blanks. MOVE = station relocation. Each station will have at least one MOVE entry. If a station moved on more than one occasion, then separate entries are included for each relocation. If a station never moved, then that station will have only one MOVE entry; in this entry, **Year**, **Month**, **Day**, **Distance**, and **Direction** (described below) are all coded as missing.
Year	is the year in which the change took place. Missing years are coded as -999.
Month	is the month in which the change took place. Missing months are coded as -9.
Day	is the day on which the change took place. Missing days are coded as -9.
Distance	is the distance (in kilometers) that the station was moved. Missing distances are coded as -9. A distance of zero indicates that the station moved less than one kilometer. **Distance** only applies to station relocation entries (i.e., lines in which **Type** = MOVE). In rain gauge replacement entries (i.e., lines in which **Type** = RAIN), **Distance** has no meaning and thus is coded as blanks.
Direction	is the direction in which the station was moved (e.g., N = north, SE = southeast). Missing directions are coded as -99. **Direction** only applies to station relocation entries (i.e., lines in which **Type** = MOVE). In rain gauge replacement entries (i.e., lines in which **Type** = RAIN), **Direction** has no meaning and thus is coded as blanks.

WMO No.	Type	Year	Month	Day	Distance	Direction
20674	MOVE	1938	-9	-9	0	-99
20674	PRCP	1953	3	2		
20674	MOVE	1960	-9	-9	0	-99
20891	MOVE	1951	1	12	1	SSW
20891	PRCP	1953	12	1		
21946	PRCP	1954	9	17		
21946	MOVE	1955	5	-9	1	NE
21982	MOVE	1929	9	2	0	E
21982	MOVE	1934	9	1	0	W
21982	MOVE	1940	6	4	0	E
21982	PRCP	1953	9	20		
22113	MOVE	1924	10	-9	3	S
22113	MOVE	1934	11	-9	1	SE
22113	PRCP	1953	1	1		
22217	PRCP	1953	1	1		
22217	MOVE	1960	10	-9	5	NW
22522	MOVE	1925	6	-9	0	NE
22522	MOVE	1933	6	30	1	N
22522	PRCP	1956	2	15		
22550	MOVE	1935	8	1	1	N
22550	MOVE	1943	6	16	0	E
22550	PRCP	1953	1	1		
22550	MOVE	1963	11	-9	2	E
22583	MOVE	1924	-9	-9	0	SE
22583	MOVE	1935	8	23	0	SE
22583	PRCP	1951	6	1		
22602	MOVE	1928	-9	-9	2	S
22602	MOVE	1930	-9	-9	1	N
22602	MOVE	1932	-9	-9	0	E
22602	MOVE	1934	-9	-9	0	SW
22602	PRCP	1951	9	-9		
22602	MOVE	1965	6	-9	0	W
22641	MOVE	1897	8	-9	0	-99

WMO No.	Type	Year	Month	Day	Distance	Direction
22641	MOVE	1900	5	-9	0	-99
22641	MOVE	1926	9	15	0	N
22641	PRCP	1953	1	15		
22802	MOVE	1948	11	-9	3	NE
22802	MOVE	1951	10	-9	0	E
22802	PRCP	1954	8	-9		
22802	MOVE	1957	12	-9	0	W
22820	PRCP	1949	6	23		
22820	MOVE	1954	6	-9	1	NE
22837	MOVE	1914	11	-9	0	-99
22837	MOVE	1932	9	30	0	-99
22837	MOVE	1937	-9	-9	0	E
22837	MOVE	1949	-9	-9	0	NW
22837	PRCP	1955	6	-9		
22837	MOVE	1970	5	-9	0	NW
22887	PRCP	1951	8	31		
22887	MOVE	1957	-9	-9	0	S
22887	MOVE	1969	7	-9	4	E
22887	MOVE	1971	1	-9	1	SE
22887	MOVE	1982	6	-9	1	NW
23146	MOVE	1951	8	21	0	-99
23146	PRCP	1953	10	2		
23146	MOVE	1960	12	-9	0	-99
23146	MOVE	1976	11	-9	0	W
23205	MOVE	1927	6	24	2	SW
23205	MOVE	1927	9	-9	0	S
23205	MOVE	1941	8	26	2	SW
23205	MOVE	1947	11	-9	1	E
23205	PRCP	1954	9	2		
23205	MOVE	1959	10	15	1	SE
23205	MOVE	1984	11	-9	1	SW
23219	MOVE	1937	8	9	0	NE
23219	PRCP	1955	9	25		
23405	MOVE	1899	10	-9	0	S
23405	MOVE	1904	-9	-9	1	NW

WMO No.	Type	Year	Month	Day	Distance	Direction
23405	MOVE	1915	8	14	0	-99
23405	MOVE	1918	11	21	0	W
23405	MOVE	1930	6	-9	0	E
23405	PRCP	1952	6	26		
23418	PRCP	1952	8	1		
23418	MOVE	1965	10	14	0	S
23472	MOVE	1898	6	-9	0	-99
23472	MOVE	1911	9	-9	0	-99
23472	MOVE	1915	6	-9	1	NW
23472	PRCP	1953	1	1		
23472	MOVE	1953	8	10	2	NW
23472	MOVE	1959	8	-9	4	SE
23631	MOVE	1893	-9	-9	0	-99
23631	MOVE	1898	-9	-9	0	-99
23631	MOVE	1937	10	13	0	S
23631	PRCP	1954	6	-9		
23711	MOVE	1892	10	8	1	SE
23711	MOVE	1901	6	-9	0	-99
23711	MOVE	1930	9	-9	0	-99
23711	MOVE	1935	10	-9	0	N
23711	MOVE	1940	6	12	3	SE
23711	PRCP	1952	11	25		
23711	MOVE	1960	3	4	1	E
23711	MOVE	1965	4	20	8	N
23724	MOVE	1935	1	8	1	SW
23724	PRCP	1955	9	-9		
23724	MOVE	1963	10	10	0	NNW
23804	MOVE	1894	-9	-9	0	NE
23804	MOVE	1925	-9	-9	0	W
23804	MOVE	1947	5	24	0	NW
23804	PRCP	1954	9	13		
23804	MOVE	1965	1	11	1	SW
23804	MOVE	1969	-9	-9	1	S
23804	MOVE	1982	2	1	4	NW
23849	MOVE	1887	-9	-9	-9	-99
23849	MOVE	1911	-9	-9	-9	-99

WMO No.	Type	Year	Month	Day	Distance	Direction
23849	MOVE	1939	7	10	5	E
23849	PRCP	1950	-9	-9		
23849	MOVE	1961	12	25	2	WNW
23884	MOVE	1949	6	29	1	W
23884	PRCP	1954	9	3		
23884	MOVE	1955	1	1	7	SW
23884	MOVE	1957	10	15	2	E
23891	PRCP	1953	7	24		
23891	MOVE	1957	6	19	0	-99
23921	PRCP	1952	7	-9		
23921	MOVE	1959	10	-9	4	S
23933	MOVE	1930	-9	-9	0	-99
23933	MOVE	1935	8	-9	0	-99
23933	PRCP	1955	6	-9		
23933	MOVE	1961	6	25	0	-99
23955	MOVE	1954	9	29	2	NW
23955	PRCP	1954	10	2		
23955	MOVE	1959	7	1	3	NW
24125	PRCP	1955	8	1		
24125	MOVE	1965	6	-9	2	ENE
24266	MOVE	1894	3	-9	0	-99
24266	MOVE	1894	11	-9	0	-99
24266	MOVE	1896	10	-9	0	-99
24266	MOVE	1897	3	20	0	-99
24266	MOVE	1898	10	21	0	-99
24266	MOVE	1900	4	-9	0	-99
24266	MOVE	1913	11	10	0	NE
24266	MOVE	1920	-9	-9	0	-99
24266	MOVE	1921	4	-9	0	E
24266	MOVE	1927	9	30	0	N
24266	MOVE	1940	10	30	2	NNE
24266	MOVE	1947	4	27	3	SSE
24266	PRCP	1953	1	1		
24266	MOVE	1954	10	19	1	E
24266	MOVE	1955	8	7	1	W
24266	MOVE	1960	6	22	0	NE

WMO No.	Type	Year	Month	Day	Distance	Direction
24343	PRCP	1953	1	-9		
24343	MOVE	1957	9	4	1	NW
24343	MOVE	1960	9	9	0	NW
24343	MOVE	1964	7	25	0	NE
24343	MOVE	1973	6	-9	0	SE
24507	PRCP	1953	9	19		
24507	MOVE	1962	3	11	1	NE
24641	MOVE	1898	5	-9	0	-99
24641	MOVE	1899	9	-9	0	-99
24641	MOVE	1929	-9	-9	0	-99
24641	MOVE	1939	8	1	0	W
24641	PRCP	1953	1	1		
24641	MOVE	1956	11	10	10	SE
24688	MOVE	1942	-9	-9	2	S
24688	PRCP	1953	2	1		
24738	PRCP	1957	1	1		
24738	MOVE	1960	9	19	2	NE
24738	MOVE	1973	9	7	3	N
24817	MOVE	1938	9	6	0	-99
24817	PRCP	1953	6	-9		
24817	MOVE	1953	9	11	0	-99
24817	MOVE	1956	11	10	0	ESE
24908	MOVE	1935	5	-9	0	-99
24908	PRCP	1953	1	15		
24908	MOVE	1956	-9	-9	0	-99
24908	MOVE	1957	6	-9	0	-99
24944	MOVE	1911	6	-9	0	-99
24944	MOVE	1938	8	-9	0	-99
24944	MOVE	1945	1	-9	0	-99
24944	PRCP	1953	1	1		
24944	MOVE	1958	8	-9	0	-99
24951	MOVE	1937	7	4	0	E
24951	MOVE	1942	10	3	7	SE
24951	MOVE	1945	9	4	7	NW

WMO No.	Type	Year	Month	Day	Distance	Direction
24951	PRCP	1953	1	-9		
24951	MOVE	1955	10	25	0	S
24951	MOVE	1959	9	30	0	E
24959	MOVE	1930	10	-9	0	-99
24959	PRCP	1953	1	1		
24959	MOVE	1964	11	-9	1	NW
24966	MOVE	1925	8	-9	7	SW
24966	MOVE	1943	9	15	0	-99
24966	PRCP	1953	1	1		
25173	MOVE	1933	-9	-9	0	S
25173	PRCP	1949	10	-9		
25551	MOVE	1904	-9	-9	25	E
25551	MOVE	1911	-9	-9	25	W
25551	MOVE	1940	-9	-9	25	E
25551	MOVE	1942	10	-9	25	W
25551	PRCP	1952	7	1		
25551	MOVE	1959	3	-9	0	E
25563	MOVE	1913	-9	-9	0	-99
25563	MOVE	1935	12	1	5	NE
25563	PRCP	1951	12	18		
25594	MOVE	1938	-9	-9	0	-99
25594	PRCP	1950	3	-9		
25594	MOVE	1960	-9	-9	0	-99
25703	MOVE	1941	12	-9	2	N
25703	PRCP	1954	1	-9		
25744	MOVE	1941	6	-9	2	SE
25744	MOVE	1946	12	-9	2	NW
25744	PRCP	1951	-9	-9		
25744	MOVE	1964	8	-9	8	S
25913	MOVE	1937	2	17	0	-99
25913	PRCP	1948	7	31		
25954	MOVE	-999	-9	-9	-9	-99
25954	PRCP	1951	10	24		

WMO No.	Type	Year	Month	Day	Distance	Direction
26038	MOVE	-999	-9	-9	-9	-99
26038	PRCP	1952	9	1		
26063	MOVE	1933	7	-9	5	NNW
26063	PRCP	1946	11	-9		
26063	MOVE	1970	6	-9	0	W
26188	MOVE	1934	3	-9	0	N
26188	PRCP	1954	6	-9		
26231	MOVE	1944	10	14	-9	-99
26231	MOVE	1947	11	7	2	SSE
26231	PRCP	1949	1	-9		
26231	MOVE	1964	12	-9	-9	-99
26258	MOVE	1910	3	-9	1	NW
26258	MOVE	1925	4	-9	0	-99
26258	MOVE	1934	9	-9	1	N
26258	MOVE	1944	8	-9	3	NNW
26258	PRCP	1948	12	-9		
26258	MOVE	1957	6	-9	4	SSW
26258	MOVE	1966	1	-9	5	E
26258	MOVE	1967	11	-9	2	NW
26258	MOVE	1986	6	-9	4	W
26406	MOVE	1922	-9	-9	-9	-99
26406	MOVE	1927	10	-9	-9	-99
26406	MOVE	1945	-9	-9	-9	-99
26406	PRCP	1953	1	1		
26406	MOVE	1961	7	5	5	SSE
26422	MOVE	1872	-9	-9	0	-99
26422	MOVE	1876	5	-9	0	-99
26422	MOVE	1923	-9	-9	0	-99
26422	MOVE	1941	5	-9	0	-99
26422	PRCP	1957	11	1		
26477	MOVE	1921	-9	-9	0	S
26477	MOVE	1924	7	-9	0	-99
26477	MOVE	1933	12	-9	10	NNE
26477	MOVE	1946	2	-9	5	NNE
26477	MOVE	1946	9	-9	2	SSW

WMO No.	Type	Year	Month	Day	Distance	Direction
26477	PRCP	1954	1	-9		
26477	MOVE	1955	10	-9	0	NNE
26629	MOVE	1922	-9	-9	0	-99
26629	PRCP	1952	1	1		
26629	MOVE	1955	6	26	1	E
26629	MOVE	1957	6	5	0	W
26702	MOVE	1889	10	-9	0	-99
26702	MOVE	1922	10	1	0	-99
26702	MOVE	1946	12	-9	0	-99
26702	PRCP	1952	1	1		
26730	MOVE	1892	1	1	0	S
26730	MOVE	1916	3	1	0	-99
26730	MOVE	1920	6	1	0	SSW
26730	MOVE	1922	7	1	0	W
26730	MOVE	1936	3	23	0	W
26730	PRCP	1952	1	1		
26730	MOVE	1953	12	14	3	NE
26730	MOVE	1964	6	1	0	-99
26781	MOVE	1900	2	-9	0	-99
26781	MOVE	1905	9	-9	0	-99
26781	MOVE	1911	-9	-9	0	-99
26781	MOVE	1936	-9	-9	0	-99
26781	PRCP	1951	10	-9		
26850	MOVE	1870	-9	-9	0	-99
26850	MOVE	1891	-9	-9	0	-99
26850	MOVE	1895	-9	-9	0	-99
26850	MOVE	1905	-9	-9	0	-99
26850	MOVE	1922	-9	-9	0	-99
26850	MOVE	1935	-9	-9	0	-99
26850	PRCP	1948	6	-9		
27037	MOVE	1945	10	-9	0	E
27037	MOVE	1951	10	-9	10	N
27037	PRCP	1954	4	-9		
27037	MOVE	1959	9	-9	2	S
27037	MOVE	1968	4	-9	0	SW
27037	MOVE	1979	9	-9	3	N

WMO No.	Type	Year	Month	Day	Distance	Direction
27196	MOVE	1922	12	3	0	S
27196	MOVE	1936	11	17	1	SW
27196	PRCP	1949	5	-9		
27196	MOVE	1957	2	15	1	SW
27333	MOVE	1883	-9	-9	0	-99
27333	MOVE	1913	3	-9	0	-99
27333	MOVE	1920	7	-9	3	SE
27333	MOVE	1924	6	-9	0	-99
27333	MOVE	1936	5	-9	1	W
27333	PRCP	1949	6	10		
27553	MOVE	1892	6	-9	1	SW
27553	MOVE	1904	12	-9	2	E
27553	MOVE	1922	5	-9	2	SE
27553	MOVE	1932	7	-9	7	SSW
27553	PRCP	1948	12	17		
27595	MOVE	1921	-9	-9	0	-99
27595	PRCP	1953	6	-9		
27595	MOVE	1962	8	22	0	NE
27595	MOVE	1988	8	-9	0	S
27612	MOVE	1939	8	1	0	-99
27612	PRCP	1952	-9	-9		
27648	MOVE	1919	-9	-9	0	N
27648	MOVE	1932	9	-9	1	W
27648	PRCP	1950	7	-9		
27823	MOVE	1930	11	-9	1	SE
27823	MOVE	1943	1	-9	1	W
27823	PRCP	1951	1	1		
27947	MOVE	1932	9	19	1	-99
27947	PRCP	1953	1	1		
27947	MOVE	1957	9	30	2	-99
28064	MOVE	-999	-9	-9	-9	-99
28064	PRCP	1953	1	10		
28138	MOVE	-999	-9	-9	-9	-99
28138	PRCP	1956	5	-9		

WMO No.	Type	Year	Month	Day	Distance	Direction
28225	MOVE	1938	4	-9	2	-99
28225	PRCP	1952	-9	-9		
28275	MOVE	1890	7	-9	0	-99
28275	MOVE	1895	4	-9	0	N
28275	MOVE	1895	10	-9	0	S
28275	PRCP	1951	1	-9		
28411	MOVE	1932	9	-9	-9	-99
28411	MOVE	1940	2	-9	7	SE
28411	MOVE	1940	12	-9	7	NW
28411	MOVE	1950	9	1	0	E
28411	PRCP	1951	5	30		
28411	MOVE	1961	6	1	5	E
28411	MOVE	1974	10	-9	10	E
28411	MOVE	1977	8	-9	1	NE
28434	PRCP	1949	9	-9		
28434	MOVE	1956	11	5	6	N
28434	MOVE	1963	9	6	0	S
28434	MOVE	1973	-9	-9	0	-99
28440	PRCP	1948	3	1		
28440	MOVE	1969	-9	-9	1	-99
28493	MOVE	1925	-9	-9	0	-99
28493	MOVE	1936	8	-9	3	-99
28493	MOVE	1951	10	-9	5	SW
28493	PRCP	1951	10	-9		
28493	MOVE	1986	-9	-9	0	-99
28661	MOVE	1935	-9	-9	0	-99
28661	MOVE	1942	8	-9	2	NE
28661	PRCP	1954	10	28		
28661	MOVE	1975	-9	-9	2	-99
28679	MOVE	1935	12	31	6	NE
28679	MOVE	1936	11	24	8	SSW
28679	PRCP	1951	1	-9		
28679	MOVE	1974	7	11	6	S
28698	MOVE	1935	-9	-9	0	W

WMO No.	Type	Year	Month	Day	Distance	Direction
28698	PRCP	1952	1	1		
28722	MOVE	1942	-9	-9	0	S
28722	PRCP	1954	-9	-9		
28722	MOVE	1957	-9	-9	0	N
28900	PRCP	1949	8	31		
28900	MOVE	1973	6	-9	0	NNE
28952	MOVE	1933	4	-9	7	SE
28952	PRCP	1952	9	1		
28952	MOVE	1953	7	18	0	SW
28952	MOVE	1957	6	28	0	NE
29231	MOVE	1935	12	24	9	W
29231	MOVE	1947	10	14	2	E
29231	PRCP	1950	7	1		
29231	MOVE	1963	8	-9	1	N
29231	MOVE	1983	12	-9	2	E
29263	MOVE	-999	-9	-9	-9	-99
29263	PRCP	1955	8	22		
29282	MOVE	1935	8	6	0	N
29282	PRCP	1953	8	3		
29282	MOVE	1960	12	9	2	NW
29430	MOVE	1883	7	29	0	-99
29430	MOVE	1897	8	21	0	SE
29430	MOVE	1934	4	18	3	-99
29430	PRCP	1947	6	25		
29574	MOVE	-999	-9	-9	-9	-99
29574	PRCP	1951	6	15		
29612	MOVE	1939	5	21	2	N
29612	MOVE	1949	10	20	4	NW
29612	PRCP	1955	9	19		
29612	MOVE	1958	12	4	0	NE
29698	MOVE	1905	-9	-9	0	-99
29698	MOVE	1911	-9	-9	0	-99
29698	MOVE	1915	-9	-9	0	-99

WMO No.	Type	Year	Month	Day	Distance	Direction
29698	MOVE	1932	11	1	0	-99
29698	MOVE	1939	8	1	0	-99
29698	MOVE	1946	10	16	1	S
29698	PRCP	1950	9	1		
29807	MOVE	-999	-9	-9	-9	-99
29807	PRCP	1951	7	1		
29838	PRCP	1951	6	25		
29838	MOVE	1970	9	-9	1	NW
29866	MOVE	-999	-9	-9	-9	-99
29866	PRCP	1951	8	6		
30054	MOVE	-999	-9	-9	-9	-99
30054	PRCP	1953	1	1		
30230	MOVE	-999	-9	-9	-9	-99
30230	PRCP	1950	1	-9		
30253	MOVE	1933	10	12	0	E
30253	MOVE	1942	8	29	0	E
30253	MOVE	1947	10	4	2	NE
30253	PRCP	1950	4	-9		
30372	MOVE	1949	10	-9	1	NE
30372	PRCP	1957	6	-9		
30393	MOVE	1940	9	12	1	S
30393	PRCP	1953	2	1		
30393	MOVE	1966	1	1	6	N
30393	MOVE	1988	7	-9	2	NE
30521	MOVE	1946	10	16	1	S
30521	PRCP	1951	10	-9		
30521	MOVE	1967	9	-9	3	E
30555	PRCP	1956	9	-9		
30555	MOVE	1969	2	-9	0	S
30636	MOVE	1931	7	-9	-9	N
30636	MOVE	1933	10	-9	-9	S
30636	MOVE	1936	3	-9	1	NE

WMO No.	Type	Year	Month	Day	Distance	Direction
30636	MOVE	1952	-9	-9	2	W
30636	PRCP	1954	6	-9		
30636	MOVE	1963	11	-9	0	SSE
30673	MOVE	1934	-9	-9	0	SSW
30673	MOVE	1937	-9	-9	1	NW
30673	PRCP	1950	5	-9		
30673	MOVE	1956	10	-9	0	NE
30692	MOVE	1932	10	-9	3	NE
30692	MOVE	1933	-9	-9	0	S
30692	MOVE	1937	6	-9	0	S
30692	PRCP	1953	9	10		
30710	MOVE	-999	-9	-9	-9	-99
30710	PRCP	1950	1	-9		
30758	MOVE	1913	6	-9	0	-99
30758	MOVE	1915	10	-9	0	-99
30758	MOVE	1931	10	-9	0	-99
30758	PRCP	1948	10	-9		
30758	MOVE	1955	3	24	0	N
30777	MOVE	1911	9	-9	-9	-99
30777	MOVE	1942	6	-9	3	SSW
30777	MOVE	1945	7	-9	0	NE
30777	PRCP	1949	7	-9		
30777	MOVE	1956	4	-9	1	SE
30823	MOVE	1901	8	-9	1	NE
30823	MOVE	1919	4	-9	4	SE
30823	MOVE	1934	11	-9	3	NE
30823	MOVE	1942	7	-9	12	WSW
30823	MOVE	1947	-9	-9	12	ENE
30823	PRCP	1949	11	-9		
30823	MOVE	1953	-9	-9	2	SW
30925	MOVE	1933	1	-9	-9	NE
30925	PRCP	1954	9	-9		
30949	PRCP	1951	12	11		
30949	MOVE	1956	7	-9	0	N

WMO No.	Type	Year	Month	Day	Distance	Direction
30965	PRCP	1952	4	-9		
30965	MOVE	1953	5	-9	1	NNE
31004	MOVE	1931	10	-9	1	-99
31004	MOVE	1941	12	-9	0	NE
31004	PRCP	1948	9	-9		
31004	MOVE	1952	7	-9	0	S
31004	MOVE	1970	8	11	0	NW
31088	PRCP	1952	-9	-9		
31088	MOVE	1969	10	7	1	NNE
31168	MOVE	-999	-9	-9	-9	-99
31168	PRCP	1950	9	24		
31253	MOVE	-999	-9	-9	-9	-99
31253	PRCP	1951	7	1		
31329	MOVE	1952	1	-9	0	-99
31329	PRCP	1955	9	20		
31369	MOVE	1909	10	-9	1	N
31369	MOVE	1925	8	22	0	N
31369	MOVE	1932	10	20	0	SE
31369	MOVE	1949	6	17	3	W
31369	PRCP	1953	10	-9		
31388	MOVE	1925	-9	-9	5	-99
31388	MOVE	1932	9	-9	1	S
31388	PRCP	1953	11	-9		
31416	MOVE	1914	-9	-9	0	-99
31416	MOVE	1939	10	-9	0	-99
31416	PRCP	1954	1	28		
31416	MOVE	1960	9	-9	1	N
31510	MOVE	1880	11	-9	0	-99
31510	MOVE	1898	9	-9	0	-99
31510	MOVE	1910	-9	-9	0	-99
31510	MOVE	1912	10	-9	0	-99
31510	MOVE	1943	10	11	0	-99
31510	PRCP	1953	1	31		

WMO No.	Type	Year	Month	Day	Distance	Direction
31532	PRCP	1954	6	8		
31532	MOVE	1979	6	-9	10	NE
31594	MOVE	1932	11	-9	0	S
31594	MOVE	1933	4	-9	0	N
31594	MOVE	1935	-9	-9	0	S
31594	PRCP	1953	12	26		
31707	MOVE	1912	-9	-9	1	E
31707	MOVE	1925	-9	-9	1	E
31707	MOVE	1931	6	-9	10	-99
31707	MOVE	1934	8	10	10	-99
31707	PRCP	1954	8	18		
31707	MOVE	1959	10	-9	1	SE
31735	MOVE	1890	-9	-9	0	-99
31735	MOVE	1910	-9	-9	0	-99
31735	MOVE	1914	-9	-9	0	-99
31735	MOVE	1927	8	-9	0	-99
31735	MOVE	1932	-9	-9	0	-99
31735	MOVE	1942	-9	-9	0	-99
31735	MOVE	1946	-9	-9	0	-99
31735	PRCP	1950	11	25		
31735	MOVE	1968	-9	-9	0	-99
31829	MOVE	-999	-9	-9	-9	-99
31829	PRCP	1950	8	-9		
31873	PRCP	1953	5	-9		
31873	MOVE	1960	10	-9	0	SE
31909	PRCP	1950	5	-9		
31909	MOVE	1975	6	-9	2	NW
31915	PRCP	1953	4	-9		
31915	MOVE	1953	4	27	1	SW
31960	MOVE	-999	-9	-9	-9	-99
31960	PRCP	1949	7	-9		
32061	MOVE	1899	1	-9	0	N
32061	PRCP	1950	5	20		
32061	MOVE	1960	12	1	3	N

WMO No.	Type	Year	Month	Day	Distance	Direction
32098	PRCP	1949	5	27		
32098	MOVE	1977	1	1	0	-99
32165	PRCP	1950	6	-9		
32165	MOVE	1957	1	1	5	E
32165	MOVE	1980	-9	-9	0	-99
32389	PRCP	1951	1	1		
32389	MOVE	1956	7	15	0	E
32411	MOVE	-999	-9	-9	-9	-99
32411	PRCP	1953	10	23		
32540	MOVE	1909	7	-9	0	NNW
32540	MOVE	1938	-9	-9	0	NW
32540	PRCP	1951	1	1		
32564	MOVE	1914	-9	-9	0	-99
32564	PRCP	1952	10	29		
33008	MOVE	1905	8	-9	0	-99
33008	MOVE	1912	5	-9	1	-99
33008	MOVE	1914	-9	-9	0	-99
33008	MOVE	1944	10	-9	0	-99
33008	MOVE	1945	10	8	2	WSW
33008	MOVE	1947	10	1	2	ENE
33008	PRCP	1949	6	-9		
33008	MOVE	1960	10	4	1	N
33038	MOVE	1923	-9	-9	1	E
33038	MOVE	1942	9	-9	0	-99
33038	MOVE	1945	4	-9	1	SSE
33038	PRCP	1949	9	28		
33038	MOVE	1987	-9	-9	0	-99
33345	PRCP	1948	-9	-9		
33345	MOVE	1982	-9	-9	6	E
33377	MOVE	1920	7	-9	1	-99
33377	MOVE	1928	11	1	2	SE
33377	MOVE	1943	9	22	2	NW
33377	MOVE	1951	10	-9	0	WNW

WMO No.	Type	Year	Month	Day	Distance	Direction
33377	PRCP	1953	1	1		
33393	MOVE	1900	-9	-9	0	-99
33393	MOVE	1940	5	-9	0	-99
33393	PRCP	1952	4	17		
33393	MOVE	1962	-9	-9	1	SE
33562	MOVE	1922	5	-9	1	NE
33562	MOVE	1927	1	1	5	WSW
33562	MOVE	1940	1	28	4	NE
33562	PRCP	1950	9	27		
33562	MOVE	1964	4	10	9	E
33562	MOVE	1983	-9	-9	4	N
33631	MOVE	-999	-9	-9	-9	-99
33631	PRCP	1952	10	-9		
33658	MOVE	-999	-9	-9	-9	-99
33658	PRCP	1954	3	1		
33815	MOVE	1940	-9	-9	2	SE
33815	PRCP	1952	1	3		
33815	MOVE	1975	-9	-9	0	-99
33837	MOVE	1924	-9	-9	1	-99
33837	PRCP	1947	-9	-9		
33889	PRCP	1953	1	1		
33889	MOVE	1959	1	-9	2	SE
33889	MOVE	1960	12	23	6	NNE
33910	MOVE	1910	-9	-9	0	-99
33910	MOVE	1936	2	1	1	-99
33910	MOVE	1943	12	-9	0	-99
33910	PRCP	1953	2	1		
33915	MOVE	1925	3	17	1	S
33915	PRCP	1949	10	15		
33915	MOVE	1964	12	12	0	SE
33946	MOVE	-999	-9	-9	-9	-99
33946	PRCP	1949	-9	-9		

WMO No.	Type	Year	Month	Day	Distance	Direction
33976	MOVE	1944	5	-9	1	NNW
33976	PRCP	1953	2	-9		
33983	MOVE	1948	6	25	0	-99
33983	MOVE	1949	11	30	7	SW
33983	PRCP	1953	1	1		
33983	MOVE	1958	5	13	0	E
33983	MOVE	1960	10	17	0	N
33983	MOVE	1973	10	31	3	N
34009	PRCP	1953	1	1		
34009	MOVE	1957	7	1	4	-99
34122	MOVE	1930	5	29	1	-99
34122	PRCP	1953	1	1		
34139	MOVE	-999	-9	-9	-9	-99
34139	PRCP	1953	1	1		
34163	MOVE	1931	-9	-9	-9	-99
34163	MOVE	1934	7	26	-9	NW
34163	PRCP	1954	4	18		
34163	MOVE	1960	9	21	0	NW
34172	MOVE	1922	5	-9	1	S
34172	MOVE	1952	11	-9	1	NE
34172	PRCP	1953	7	-9		
34300	MOVE	1933	-9	-9	0	-99
34300	MOVE	1938	7	-9	0	NE
34300	MOVE	1940	-9	-9	0	N
34300	PRCP	1951	-9	-9		
34391	PRCP	1953	10	-9		
34391	MOVE	1953	10	15	0	S
34391	MOVE	1967	9	-9	0	N
34524	MOVE	1929	11	24	1	SE
34524	MOVE	1934	12	13	4	NE
34524	PRCP	1951	-9	-9		
34646	MOVE	1933	10	6	1	N
34646	MOVE	1946	4	20	1	N

WMO No.	Type	Year	Month	Day	Distance	Direction
34646	MOVE	1951	11	14	2	SW
34646	PRCP	1955	4	-9		
34731	MOVE	-999	-9	-9	-9	-99
34731	PRCP	1951	2	1		
34747	PRCP	1947	8	10		
34747	MOVE	1978	8	-9	0	W
34824	MOVE	-999	-9	-9	-9	-99
34824	PRCP	1953	11	-9		
34861	MOVE	1944	4	19	5	ESE
34861	PRCP	1954	12	-9		
34880	PRCP	1953	5	13		
34880	MOVE	1962	2	1	10	-99
35078	MOVE	1910	10	-9	1	N
35078	MOVE	1925	-9	-9	0	-99
35078	MOVE	1936	8	28	3	N
35078	PRCP	1949	6	25		
35108	MOVE	1940	5	-9	0	-99
35108	PRCP	1951	-9	-9		
35108	MOVE	1962	8	1	0	-99
35121	MOVE	1846	-9	-9	0	-99
35121	MOVE	1859	-9	-9	0	-99
35121	MOVE	1863	-9	-9	0	-99
35121	MOVE	1914	9	-9	0	-99
35121	PRCP	1948	4	24		
35121	MOVE	1962	1	-9	1	NE
35121	MOVE	1975	1	-9	12	ENE
35133	MOVE	1935	9	28	1	NE
35133	PRCP	1949	12	1		
35188	MOVE	-999	-9	-9	-9	-99
35188	PRCP	1951	1	1		
35229	MOVE	1937	8	5	0	-99
35229	PRCP	1953	5	-9		

WMO No.	Type	Year	Month	Day	Distance	Direction
35358	MOVE	1951	-9	-9	0	-99
35358	PRCP	1952	5	-9		
35394	MOVE	1941	9	11	3	NNE
35394	MOVE	1944	8	16	13	S
35394	PRCP	1959	1	1		
35406	MOVE	1934	12	5	1	SW
35406	PRCP	1949	4	17		
35406	MOVE	1951	12	20	1	S
35416	MOVE	-999	-9	-9	-9	-99
35416	PRCP	1953	8	8		
35542	MOVE	1914	7	-9	0	-99
35542	MOVE	1922	8	13	0	-99
35542	MOVE	1932	3	-9	0	S
35542	MOVE	1939	7	-9	0	NW
35542	PRCP	1954	10	-9		
35542	MOVE	1959	11	-9	0	-99
35576	MOVE	-999	-9	-9	-9	-99
35576	PRCP	1953	3	19		
35663	PRCP	1960	9	8		
35663	MOVE	1962	8	12	1	S
35700	MOVE	1937	5	20	2	-99
35700	PRCP	1953	5	26		
35746	MOVE	1925	11	-9	0	S
35746	MOVE	1931	-9	-9	0	-99
35746	MOVE	1942	12	15	0	WSW
35746	PRCP	1953	1	31		
35746	MOVE	1953	11	30	6	SW
35796	MOVE	1937	6	-9	8	SSW
35796	MOVE	1941	8	-9	8	NNE
35796	PRCP	1952	9	24		
36034	MOVE	1928	3	1	0	W
36034	MOVE	1942	11	5	2	W

WMO No.	Type	Year	Month	Day	Distance	Direction
36034	MOVE	1943	5	6	2	SE
36034	PRCP	1954	-9	-9		
36034	MOVE	1955	10	11	9	NNW
36177	MOVE	1957	5	17	0	-99
36177	PRCP	1957	5	17		
36665	MOVE	1941	6	1	2	NW
36665	PRCP	1950	10	1		
36729	MOVE	1938	9	14	0	NNE
36729	PRCP	1952	2	20		
36729	MOVE	1955	7	27	2	SE
36729	MOVE	1957	12	-9	0	-99
36859	MOVE	1935	8	15	5	ENE
36859	MOVE	1936	6	9	0	SSE
36859	PRCP	1953	7	16		
36870	MOVE	1908	10	-9	0	-99
36870	MOVE	1915	-9	-9	2	NW
36870	PRCP	1951	6	-9		
36974	MOVE	1935	-9	-9	0	-99
36974	PRCP	1949	5	-9		
36974	MOVE	1960	12	-9	1	W
37031	MOVE	1933	9	5	1	SW
37031	PRCP	1955	1	12		
37031	MOVE	1963	9	13	6	N
37050	PRCP	1954	10	6		
37050	MOVE	1970	-9	-9	0	-99
37099	MOVE	-999	-9	-9	-9	-99
37099	PRCP	1958	6	1		
37235	MOVE	1917	-9	-9	0	-99
37235	MOVE	1925	-9	-9	0	-99
37235	MOVE	1937	6	-9	0	-99
37235	PRCP	1954	12	10		
37235	MOVE	1980	-9	-9	0	-99

WMO No.	Type	Year	Month	Day	Distance	Direction
37385	MOVE	1941	9	-9	2	N
37385	PRCP	1949	-9	-9		
37385	MOVE	1961	12	25	5	SE
37472	MOVE	1897	6	1	2	-99
37472	MOVE	1921	5	-9	0	-99
37472	PRCP	1949	-9	-9		
37472	MOVE	1983	-9	-9	0	-99
37549	MOVE	1851	-9	-9	1	-99
37549	MOVE	1861	-9	-9	0	-99
37549	PRCP	1947	7	-9		
37549	MOVE	1965	5	1	3	-99
37686	MOVE	1934	4	-9	3	SE
37686	MOVE	1941	6	12	1	NW
37686	MOVE	1952	10	2	3	N
37686	PRCP	1953	1	5		
37686	MOVE	1961	4	-9	-9	-99
37735	MOVE	1924	-9	-9	0	-99
37735	MOVE	1925	-9	-9	0	-99
37735	MOVE	1926	-9	-9	0	-99
37735	MOVE	1940	6	6	0	ENE
37735	PRCP	1948	-9	-9		
37735	MOVE	1951	4	7	0	-99
37735	MOVE	1958	3	20	1	SSW
37789	MOVE	1934	4	-9	0	-99
37789	PRCP	1950	5	-9		
37789	MOVE	1974	12	25	2	SSW
38198	MOVE	1930	11	26	5	W
38198	MOVE	1938	8	23	2	W
38198	PRCP	1955	3	-9		
38262	MOVE	1940	10	1	4	N
38262	MOVE	1950	4	12	5	NW
38262	MOVE	1955	10	14	3	E
38262	PRCP	1956	8	15		
38353	MOVE	1927	9	-9	0	-99
38353	MOVE	1939	12	-9	2	N

WMO No.	Type	Year	Month	Day	Distance	Direction
38353	MOVE	1940	-9	-9	1	E
38353	PRCP	1949	5	-9		
38413	MOVE	1936	8	-9	2	E
38413	PRCP	1950	3	6		
38413	MOVE	1957	12	19	3	W
38457	MOVE	-999	-9	-9	-9	-99
38457	PRCP	1953	-9	-9		
38507	MOVE	1883	-9	-9	0	-99
38507	MOVE	1904	-9	-9	0	-99
38507	MOVE	1915	8	-9	0	-99
38507	MOVE	1925	1	-9	0	-99
38507	PRCP	1953	6	1		
38599	MOVE	1929	8	-9	1	N
38599	MOVE	1940	8	11	15	S
38599	PRCP	1949	12	15		
38599	MOVE	1961	4	-9	1	S
38599	MOVE	1966	10	15	2	WSW
38618	MOVE	1881	-9	-9	0	-99
38618	MOVE	1889	-9	-9	0	-99
38618	MOVE	1921	10	-9	0	-99
38618	MOVE	1928	7	19	3	SE
38618	MOVE	1933	1	-9	2	W
38618	PRCP	1951	12	31		
38687	MOVE	1913	10	11	0	-99
38687	PRCP	1952	8	2		
38696	MOVE	-999	-9	-9	-9	-99
38696	PRCP	1951	1	1		
38750	MOVE	-999	-9	-9	-9	-99
38750	PRCP	1953	9	1		
38763	MOVE	1908	3	12	0	-99
38763	MOVE	1925	-9	-9	0	-99
38763	PRCP	1953	1	1		
38763	MOVE	1958	1	-9	2	W

WMO No.	Type	Year	Month	Day	Distance	Direction
38836	MOVE	1929	5	29	1	SW
38836	MOVE	1946	1	1	0	-99
38836	PRCP	1950	11	22		
38836	MOVE	1967	11	5	0	-99
38836	MOVE	1983	-9	-9	0	-99
38880	MOVE	1927	11	14	0	S
38880	MOVE	1949	-9	-9	0	-99
38880	PRCP	1950	1	1		
38895	MOVE	1898	-9	-9	0	-99
38895	MOVE	1903	4	10	0	-99
38895	MOVE	1911	-9	-9	0	-99
38895	MOVE	1913	-9	-9	0	-99
38895	MOVE	1917	-9	-9	0	-99
38895	MOVE	1932	4	7	0	E
38895	MOVE	1939	-9	-9	0	-99
38895	PRCP	1950	6	2		
38927	MOVE	1947	10	18	0	SW
38927	PRCP	1950	11	6		
38927	MOVE	1956	3	10	12	E
38927	MOVE	1961	12	13	0	NW
38933	MOVE	1949	11	-9	2	WNW
38933	PRCP	1949	11	23		
38954	MOVE	1933	11	-9	13	N
38954	MOVE	1936	9	-9	-9	NE
38954	MOVE	1945	9	-9	6	N
38954	PRCP	1954	6	14		
38974	MOVE	1935	2	-9	0	W
38974	MOVE	1938	-9	-9	0	S
38974	MOVE	1942	-9	-9	0	E
38974	PRCP	1950	10	-9		
38974	MOVE	1961	6	12	2	NE
38987	MOVE	1904	4	-9	-9	-99
38987	MOVE	1910	-9	-9	-9	-99
38987	MOVE	1913	8	-9	-9	-99
38987	MOVE	1927	5	-9	-9	-99
38987	PRCP	1953	1	4		

APPENDIX C

Reprints of Pertinent Literature

[Reprinted from BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY, Vol. 74, No. 6, June 1993]
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AN AMS CONTINUING SERIES

GLOBAL CHANGE

THIS ARTICLE IS THE SECOND IN A SERIES OF ARTICLES REPORTING ON THE U. S. GLOBAL CHANGE RESEARCH PROGRAM AND INTERNATIONAL GLOBAL CHANGE ACTIVITIES WITH PARTICULAR EMPHASIS ON THE WORLD CLIMATE RESEARCH PROGRAM, THE INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAM, AND THE HUMAN DIMENSIONS OF GLOBAL ENVIRONMENTAL CHANGE PROGRAM.

THE ARTICLES ARE SELECTED IN COOPERATION WITH THE BOARD ON GLOBAL CHANGE, BUT DO NOT NECESSARILY REFLECT THE OPINIONS OF THE NATIONAL ACADEMY OF SCIENCES, NATIONAL RESEARCH COUNCIL, OR THE AMERICAN METEOROLOGICAL SOCIETY.

A New Perspective on Recent Global Warming:

Asymmetric Trends of Daily Maximum and Minimum Temperature

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Richard W. Knight,[*] George Kukla,[@]
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Abstract

Monthly mean maximum and minimum temperatures for over 50% (10%) of the Northern (Southern) Hemisphere landmass, accounting for 37% of the global landmass, indicate that the rise of the minimum temperature has occurred at a rate three times that of the maximum temperature during the period 1951–90 (0.84°C versus 0.28°C). The decrease of the diurnal temperature range is approximately equal to the increase of mean temperature. The asymmetry is detectable in all seasons and in most of the regions studied.

The decrease in the daily temperature range is partially related to increases in cloud cover. Furthermore, a large number of atmospheric and surface boundary conditions are shown to differentially affect the maximum and minimum temperature. Linkages of the observed changes in the diurnal temperature range to large-scale climate forcings, such as anthropogenic increases in sulfate aerosols, greenhouse gases, or biomass burning (smoke), remain tentative. Nonetheless, the observed decrease of the diurnal temperature range is clearly important, both scientifically and practically.

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1. Background

The mean monthly maximum and minimum temperatures are derived from an average of the daily maximum and minimum temperatures. The mean monthly diurnal temperature range (DTR) is defined as the difference between the mean monthly maximum and minimum temperatures. The dearth of appropriate databases that include information on the daily or mean monthly maximum and minimum temperature has previously impeded our ability to investigate changes in these quantities. The problem has historical roots. It arises because the climatological data that have been made accessible to the international community, by national meteorological or climate data centers throughout the world, do not normally include data with resolution higher than mean monthly temperatures. The data that are made available internationally are usually derived from the monthly climate summaries (CLIMAT messages) on the Global Telecommunications System (GTS), which do not include information on the maximum or minimum temperatures. The GTS is the means by which near-real-time in situ global climate data are exchanged. Moreover, the problem has been exacerbated because the World Meteorological Organization's retrospective data collection projects such as *World Weather Records* and *Monthly Climatic Data of the World* have always been limited to mean monthly temperatures. This has forced climatologists interested in maximum and minimum temperatures to either develop historical databases on a country-by-country basis (Karl et al. 1991) or try to work with the hourly GTS synoptic observations. The former is a painstakingly slow process, and the latter has been limited by poor data quality and metadata (information about the data) and records of short duration (Shea et al. 1992).

The first indication that there might be important large-scale characteristics related to changes of the mean daily maximum and minimum temperatures was reported by Karl et al. (1984). Their analysis indicated that the DTR was decreasing at a statistically significant rate at many rural stations across North America. Because of data accessibility problems, subsequent empirical analyses continued to focus on data from North America over the next several years (Karl et al. 1986a; Plantico et al. 1990). By 1990, however, a U.S./People's Republic of China (PRC) bilateral agreement organized by the U.S. Department of Energy and the PRC's Academy of Sciences provided the opportunity to analyze maximum and minimum temperatures from the People's Republic of China. Also about this time, the Intergovernmental Panel on Climate Change (IPCC) made arrangements with the Australian National Climate Centre to analyze maximum and minimum temperature data from southeastern Australia. The IPCC (1990) reported a significant decrease in the DTR from both of these regions. Meanwhile, work from another data exchange agreement, a bilateral agreement between the United States and the former USSR (Union of Soviet Socialist Republics), came to fruition as a dataset of mostly rural maximum and minimum temperatures was developed for the former USSR. Karl et al. (1991) reported on the widespread decrease of the DTR over the former USSR, PRC, and the contiguous United States that was reiterated by the IPCC (1992).

Additional data from other countries and updates to previous analyses have now been analyzed here and elsewhere. Additional data include the eastern half of Australia, Sudan, Japan, Denmark, northern Finland, some Pacific island stations, Pakistan, South Africa, and a few other long-term stations in Europe. Figure 1 shows the area of the globe that has now been analyzed for differential changes of the maximum and minimum temperature. The area now covers over 50% (10%) of the Northern (Southern) Hemisphere landmass, but still only about 37% of the global landmass.

2. Observed changes of mean maximum, minimum, and diurnal range

a. *Spatial and season patterns of the contemporary trends*

Daily maximum and minimum temperatures from more than 2000 stations were available for analysis in the countries shaded in Fig. 1 during the period 1951 to 1990 (except Sudan and the former USSR, which had data through 1987 and 1989, respectively). Selected subsets of these data were averaged within various regions of each country. Each region represents a compromise between climatic homogeneity and an adequate number of stations within its boundaries to reduce sampling error. The base period for calculating departures from the average included the years 1951–90 (or slightly fewer years in some countries, e.g., Sudan and the former USSR). The regions are delineated in Fig. 2 where, similar to other large-scale studies of the change of the mean annual temperature (Jones et al. 1986a,b; Jones 1988), the average of the trends of the mean annual maximum and minimum reveals a general rise of temperature. A decrease of the minimum temperature within any region is uncommon but is somewhat more frequent for the maximum temperature, as seen over the United States and the PRC. The differential rate of warming between the maximum and minimum temperatures is

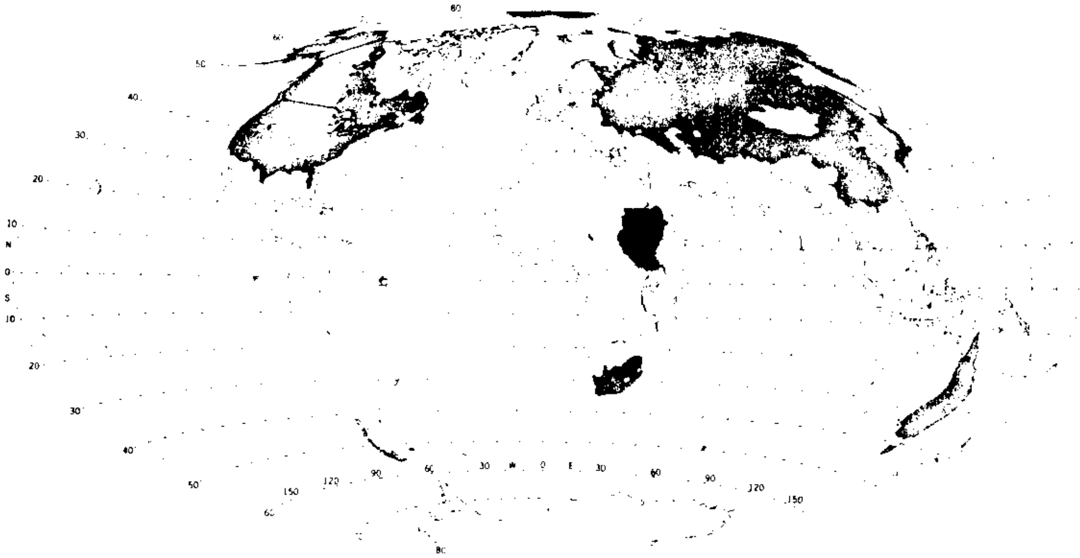

Fig. 1. Shaded areas represent areas of the world that have been analyzed for changes of mean maximum and minimum temperature.

apparent, with only a few regions reflecting an increase of the DTR. These weak exceptions occur in central Canada and southeasternmost Australia.

There are some seasonal variations of the rates of decreasing DTR, but they vary from country to country (Table 1). In Japan the decrease is not evident during summer, and it is not as strong during this season over the PRC. In the United States the decrease is weak during spring but quite strong during autumn. Alaska has strong decreases throughout the year, but Canada has only moderate decreases during summer and autumn. Over the former USSR the decrease in the DTR is significant throughout the year but somewhat weaker during the winter. Over Sudan, the rate of the DTR decrease is strong in all seasons except during the summer rainy season, where rains have been very sparse over the past few decades. Over South Africa, the DTR strongly decreases in the Southern Hemisphere spring, but actually increases slightly during autumn. In the eastern half of Australia the decrease of the DTR is apparent throughout the year but weakest during the Southern Hemisphere summer.

When collectively considered, 60% of the trends in Table 1 reflect statistically significant decreases of the DTR. A test for a change point in the trend (Solow 1987) indicates that for most seasons and areas there is insufficient evidence to suggest a statistically significant change point in the rate of the decrease.

The trends can be area weighted to reflect the overall rate of DTR decrease. Table 2 shows the decrease both north and south of the equator, but without any pronounced seasonal cycle in the Northern Hemisphere. The area of available data in the Southern Hemisphere is too small to make any general statements about trends in that portion of the globe, but the decrease in the Northern Hemisphere is quite apparent. The rate of the decrease in the DTR (−1.4°C/100 years) is comparable to the increase of the mean temperature (1.3°C/100 years).

For all areas combined (Fig. 3), a noticeable differential rate of warming of the minimum relative to the maximum temperature began in the 1960s. The minimum temperature has continued to warm relative to the maximum through the 1980s. The time series ends in 1989, the year after the major North American drought, as data from the former USSR were not available past 1989. The variance of the time series is significantly impacted when such large regions drop out of the analysis, which is why the series ends prematurely. The end of the time series is significantly impacted by the major drought in North America during 1988, which leads to an enhanced DTR. Nonetheless, Fig. 3 reflects a gradual decrease of the DTR through much of the past several decades.

b. Longer-term variations

Unfortunately, the coverage of the globe with maximum and minimum temperature data is currently limited prior to 1951. In the United States, a network of approximately 500 high-quality stations has remained intact back to the turn of the century, and in the former USSR a fixed network of 224 (165 stations if only rural

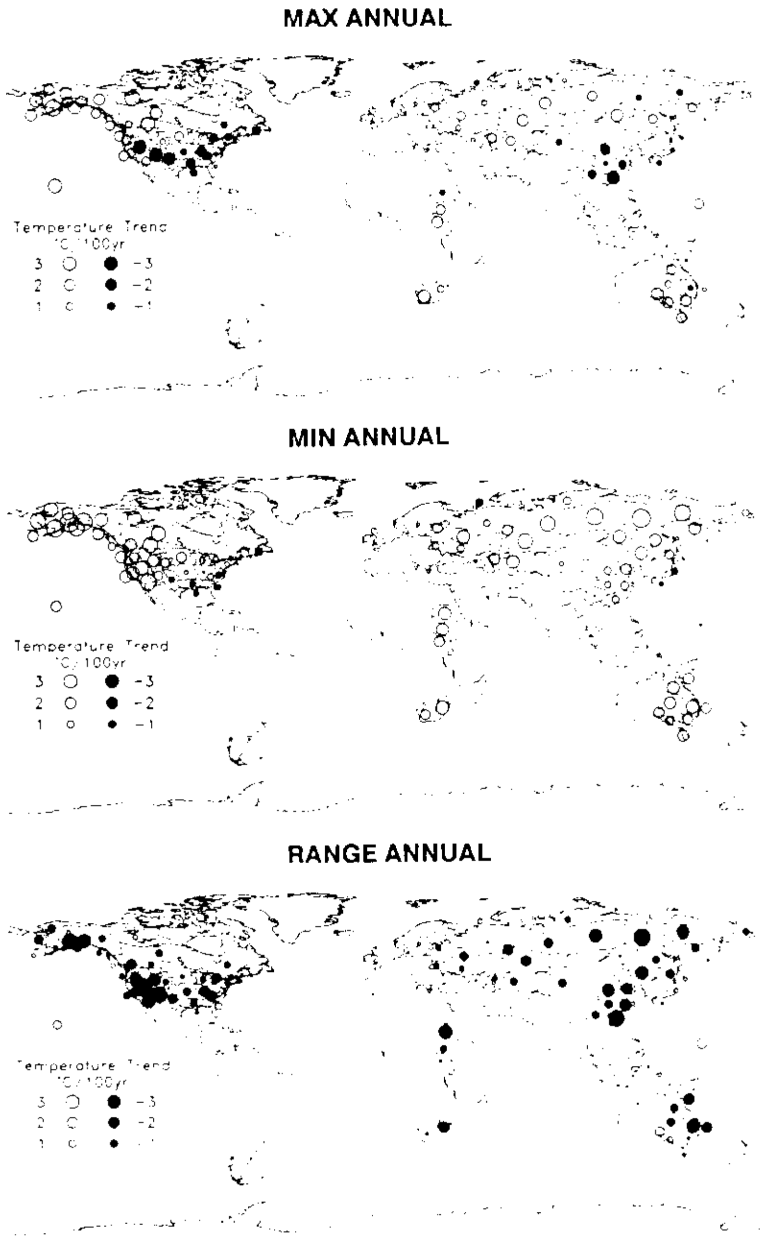

FIG. 2. Spatial patterns of annual trends of mean maximum, minimum, and diurnal temperature range (mostly 1951–90) in degrees Celsius per one hundred years. Diameter of circles is proportional to the trend and solid (open) circles represent negative (positive) trends. Circles pertain to regions within each country except for island stations, e.g., in the South Pacific and Hawaii.

stations are used) stations is available back to the 1930s. Time series from these countries reflect significant (Fig. 4) decadal variations in the DTR, as evident during the dry 1930s and early 1950s in the United States. The general decrease of the DTR did not begin in the United States until the late 1950s, and the DTR decreased rather dramatically in the mid- to late 1970s over the former USSR as part of substantial increases in the minimum temperature. The decrease of the DTR in these two countries is a phenomenon of recent decades. Data are also available farther back in time for smaller areas and countries, notably Japan, eastern Australia, and South Africa. Figure 5 indicates that the decrease in the DTR in eastern Australia occurs rather gradually since the steep decline in the late 1940s. In South Africa the decrease is predominately due to the sharp decline in the early 1950s.

A very long record of maximum and minimum temperatures was available from the Klementinum-Observatory in Prague, Czech Republic, as well as a benchmark station from northern Finland. Figure 6 portrays a remarkable *increase* of the DTR at the Klementinum-Observatory from the early to the mid–twentieth century, with a substantial decrease since about 1950. The increase coincides with the increase of mean temperature since the turn of the century, and the decrease occurs when the mean temperature reflects little overall change. In the first half of the nineteenth century, the DTR averages about 0.5°C lower compared with the latter part of the century. The DTR at Sodankylä, Finland, also displays a gradual decrease since 1950, but contrary to the Klementinum-Observatory, the decrease is evident back to the turn of the century. The mean temperature at Sodankylä reflects little or no change. The high-frequency variability of the DTR at

Table 1. Trends of temperature (°C/100 yr) for annual and three-month mean maximum (MAX), minimum (MIN), and diurnal temperature range (DTR) based on a weighted average of the regions (by country) in Fig. 1. Additionally, trends significant at the 0.01 level (two-tailed *t* test) are double underlined and those significant at the 0.05 level are single underlined. Trends with significant change points are denoted with an asterisk. The number of stations used to calculate the trends (in parentheses) and the time period relative to the trends is given for each country. PRC is the People's Republic of China, USA the contiguous United States of America, E. Australia the eastern half of Australia, USSR the former Union of Soviet Socialist Republics, and S. Africa the Republic of South Africa.

ALASKA (39) 1951–1990

Seasons	MAX	MIN	DTR
D–J–F	6.0	8.8	-2.8
M–A–M	3.1	6.3	-3.2
J–J–A	0.9	2.4*	-1.5
S–O–N	-1.4	0.4	-1.9*
ANNUAL	2.1	4.5	-2.4

USSR (FORMER) (165) 1951–1990

Seasons	MAX	MIN	DTR
D–J–F	2.8	4.2	-1.3
M–A–M	2.5	3.8	-1.2
J–J–A	-0.4*	0.9*	-1.3
S–O–N	0.6	2.2	-1.6
ANNUAL	1.4	2.8	-1.4

CANADA (227) 1952–1990

Seasons	MAX	MIN	DTR
D–J–F	1.8	2.1	-0.2
M–A–M	3.7	3.8	-0.1
J–J–A	0.5	1.4	-0.9
S–O–N	-2.2	-1.2	-1.0
ANNUAL	0.9	1.5	-0.6*

JAPAN (66) 1951–1990

Seasons	MAX	MIN	DTR
D–J–F	-0.5	-0.2	-0.2
M–A–M	-0.4	-0.7	0.3
J–J–A	0.5	0.0	0.4
S–O–N	-0.3	-0.5	0.2
ANNUAL	-0.2*	-0.4	0.2

USA (494) 1951–1990

Seasons	MAX	MIN	DTR
D–J–F	-2.3	-0.7	-1.5
M–A–M	2.3	2.5	-0.2
J–J–A	-0.3*	1.0*	-1.4
S–O–N	-1.7	1.3	-3.0
ANNUAL	-0.6*	1.0	-1.5

PRC (44) 1951–1988

Seasons	MAX	MIN	DTR
D–J–F	0.5	3.5	-3.0
M–A–M	-0.8	1.4	-2.2
J–J–A	-1.8	-0.8*	-1.0
S–O–N	-0.6	1.0	-1.6
ANNUAL	-0.7*	1.3	-2.0*

SUDAN (15) 1951–1987

Seasons	MAX	MIN	DTR
D–J–F	-1.2	2.7	-3.9*
M–A–M	0.4	3.3	-2.8
J–J–A	2.8	2.1	0.7
S–O–N	1.4	2.5	-1.1
ANNUAL	0.9	2.7	-1.7

S. AFRICA (12) 1951–1991

Seasons	MAX	MIN	DTR
D–J–F	0.8	2.0	-1.2
M–A–M	2.2	1.7	0.5
J–J–A	1.3	1.3	0.0
S–O–N	-0.7	1.8	-2.4
ANNUAL	0.9	1.7*	-0.8*

E. AUSTRALIA (44) 1951–1991

Seasons	MAX	MIN	DTR
D–J–F	1.8	2.3	-0.4
M–A–M	1.6	2.8	-1.2
J–J–A	0.8	1.4	-0.5
S–O–N	1.3	2.2	-0.9
ANNUAL	1.4	2.2	-0.7

both stations is less than that of their respective mean temperatures, but the converse is true for low-frequency variations.

If the data from the Klementinum-Observatory truly reflect the regional change of the DTR in central Europe, then the recent decrease of the DTR in this area is less persistent and less substantial than the increase prior to 1950. In light of the variations at the Klementinum-Observatory, what makes the results from Fig. 2 so remarkable is the fact that so many areas share an overall decrease of the DTR.

Recently, other investigators have also compiled information on the change of the DTR over other regions of the globe. Frich (1992) provides evidence to

TABLE 2. Trends of temperature (°C/100 yr) for annual and three-month mean maximum (MAX), minimum (MIN), and diurnal temperature range (DTR) for the areas denoted in Fig. 1 (less Pakistan, northern Finland, and Denmark). Percent of the land area covered for the Northern and Southern Hemisphere and the globe is denoted within parenthesis.

N. Hemisphere (50%) 1951–1990

Seasons	MAX	MIN	DTR
D-J-F	1.3	2.9	−1.5
M-A-M	2.0	3.2	−1.3
J-J-A	−0.3	0.8	−1.1
S-O-N	−0.4	1.3	−1.7
ANNUAL	0.5	2.0	−1.4

S. Hemisphere (10%) 1951–1990

Seasons	MAX	MIN	DTR
D-J-F	1.6	2.2	−0.6
M-A-M	1.7	2.5	−0.8
J-J-A	1.0	1.3	−0.4
S-O-N	0.8	2.1	−1.3
ANNUAL	1.3	2.0	−0.8

GLOBE (37%) 1951–1990

Seasons	MAX	MIN	DTR
D-J-F	1.3	2.9	−1.6
M-A-M	1.9	3.1	−1.2
J-J-A	−0.2	0.8	−1.1
S-O-N	−0.3	1.4	−1.7
ANNUAL	0.7	2.1	−1.4

indicate there has been a general decrease over Denmark since about 1950, based on an analysis of several long-term stations, most located in rural areas. Bücher and Dessens (1991) analyzed a long record of maximum and minimum temperatures from the Pic du Midi de Bigorre Observatory in the Pyrenees at a height of more than 2800 m. Their analysis revealed a significant decrease of DTR since the late nineteenth century, but an inhomogeneity in the record prevented a continuation of the analysis beyond 1970. Kruss et al. (1992) reported on changes of maximum and minimum temperature between the two 30-yr periods 1931–60 and 1961–90 over Pakistan. Despite considerable missing data, they managed to obtain at least 20 years of data from each of the two periods for 35 stations across Pakistan. Their analysis revealed a mix of decreasing and increasing changes of DTR. In our analysis of Pakistani data we could manage to identify only five stations with adequate data to analyze year-to-year changes; these were all located in the northern half of the country. These stations also depicted a decrease of the DTR.

c. Relation to variations of the seasonal and annual extremes

For a variety of practical considerations it is important to know whether the decrease in the mean DTR translates to a decrease in the extreme temperature range. Karl et al. (1991) provide evidence to suggest that indeed, over the United States and the former USSR (the only areas for which they had access to daily data), there was often a significant and substantial decrease in the seasonal and annual temperature extremes similar to the decrease in the seasonal and annual mean DTR. This similarity is also reflected in the time series of monthly extreme maximum and minimum temperature over Sudan (Jones 1992).

d. Data quality

A critical question arises related to the reliability of the data used to calculate the changes of the DTR. The data presented and discussed here have been subjected to various degrees of quality assurance. The degree to which precautionary measures have been taken to minimize data inhomogeneities varies considerably from country to country. In the United States,

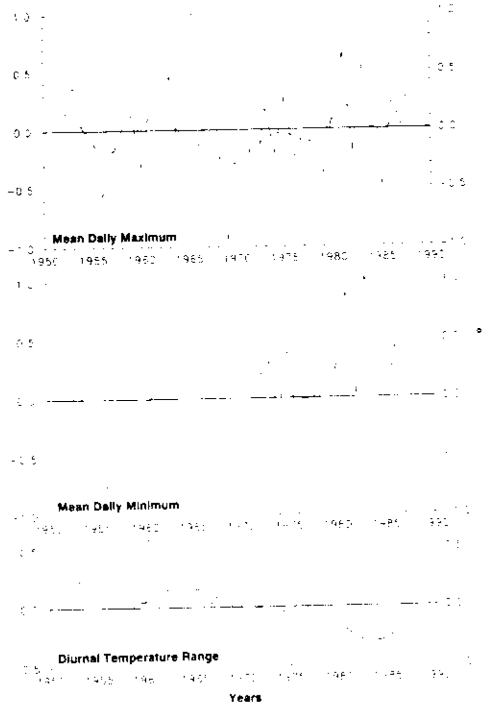

FIG. 3. Time series of the temperature anomalies of the annual mean maximum, minimum, and diurnal temperature range for 37% of the global landmass (areas shaded in Fig. 1). Smooth curve is a nine-point binomial filter with "padded" ends.

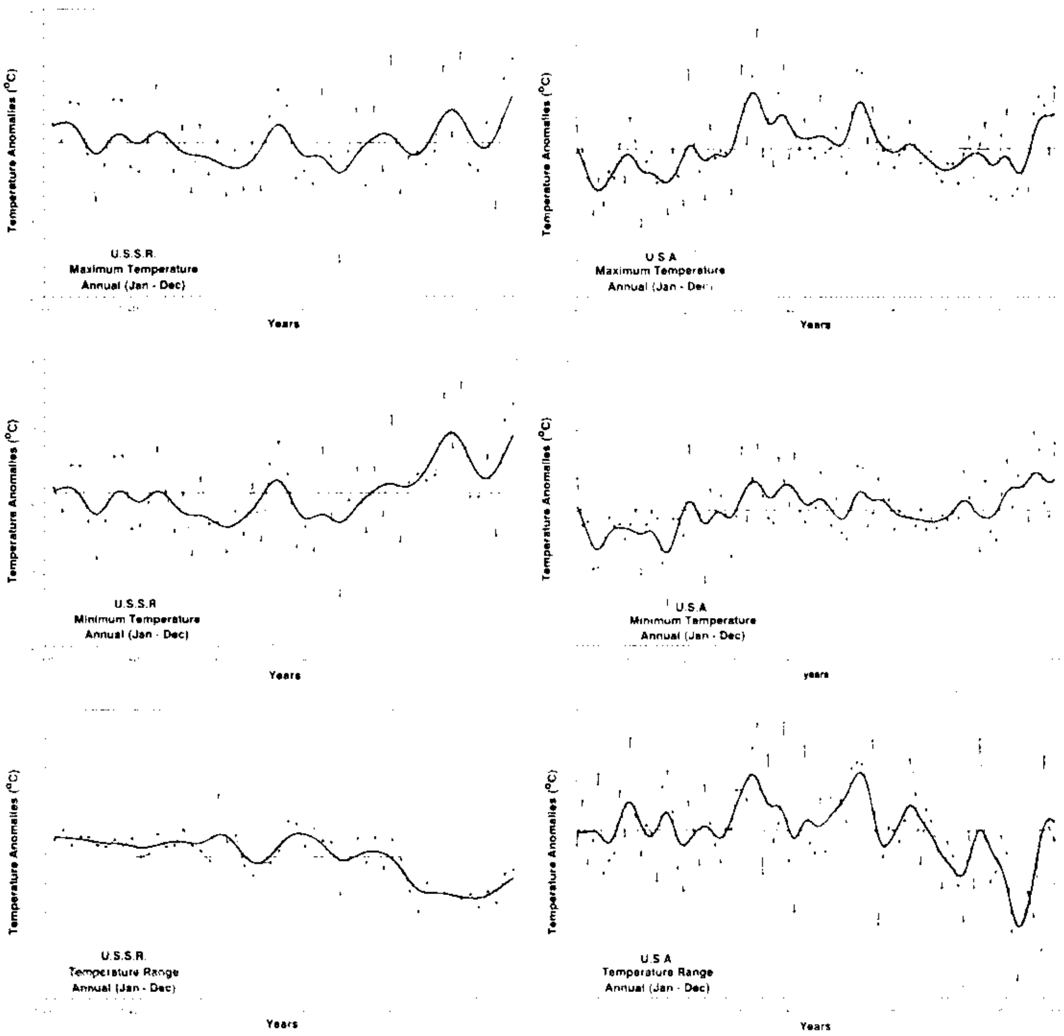

FIG. 4. Time series of the variations of the annual mean maximum, minimum, and diurnal temperature range for the contiguous United States and the former USSR. Smooth curve is the same as Fig. 3 and trends since 1951 are depicted by the dashed line.

a fixed network of stations in the Historical Climatology Network (HCN) is used (Karl et al. 1990), which largely consists of rural stations that have been adjusted when necessary for random station relocations, changes in instrument heights, systematic changes in observing times (Karl et al. 1986a; Karl et al. 1986b), the systematic change in instruments during the mid- and late 1980s (Quayle et al. 1991), and increases in urbanization (Karl et al. 1988). The potential warm bias of the maximum introduced by the HO83 series of thermometers (Gall et al. 1992) is not a factor in this network since the HO83 instrument is not used in the rural cooperative network that dominates the HCN (19 out of 20 stations).

In the former USSR the fixed network of 165 stations consists of rural stations (1990 populations less than 10 000 and local surroundings free of urban development). The former USSR data have not been adjusted for any random or systematic inhomogeneities. Station histories, however, indicate there have not been systematic changes in network operation over the course of the past 50 years.

In Canada, the results reported here are derived from a set of 227 rural stations (population less than 10 000). These data were selected from a network of 373 principal stations, but a large number of urban areas and stations, which relocated to airports, were eliminated from the analysis.

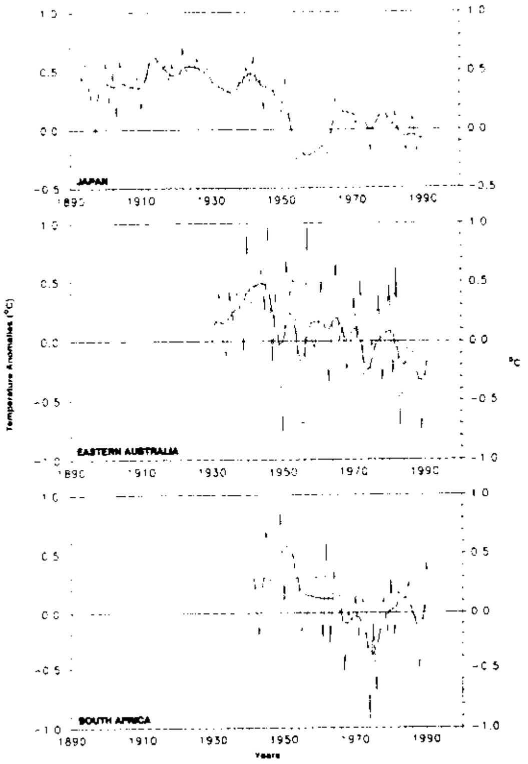

FIG. 5. Time series of the variations of the diurnal temperature range for Japan, eastern Australia, and South Africa. Smooth curve same as Fig. 3.

In Alaska, a network of 39 stations was used that included most stations operating in that state since the early 1950s with the exceptions of stations in the major cities of Juneau, Fairbanks, and Anchorage. Once again no attempt was made to adjust for station relocations, and the stations consist of a mix of instrument types with some changes at specific sites.

Station histories from the PRC do not reflect any changes in instrumentation, instrument heights, instrument shelters, or observing procedures relative to the maximum and minimum temperature. Our analysis is based on a subset of more than 150 stations available to us. No attempt was made to correct for random station relocations in the fixed network of 44 stations we finally selected from the larger network. The potential impact of urbanization precluded the use of many stations. We eliminated all stations that were in or near cities with populations of more than 160 000.

All stations in Australia are currently undergoing thorough homogeneity testing (Torok 1992, personal communication) but were unavailable for this analysis. Instead, stations were selected based on the length of record and distance from major areas of urbanization. All of the stations used in Australia are from small towns or rural areas, many from post office "backyards."

Fewer than half of the 154 stations available from Japan were used in this analysis. Similar to the PRC, many stations were eliminated because of their proximity to major urban areas. An inspection of the station histories reveals a number of network "improvements" related to the automation of the temperature measurements in recent years. A full assessment of the homogeneity of the data awaits a detailed analysis. The station networks from Sudan and South Africa include some stations from urban areas, but countrywide decreases of the DTR are not overwhelmed by these stations. Incomplete information was available regarding systematic changes in instrumentation at these locations during the past several decades, but the data were inspected and adjusted when necessary for station relocations based on temperature differences with neighboring stations. In total, four stations in South Africa were adjusted using the procedures outlined by Jones et al. (1986a).

3. Diurnal temperature range dependencies

a. Local effects

As more data become available from a variety of countries it becomes difficult to dismiss the general decrease of the DTR over the past several decades as an artifact due to data inhomogeneities. Observing networks are managed differently in each country. If local effects are significantly influencing the DTR, then at least three possibilities need to be explored. These include changes in urbanization, irrigation, and desertification. Evidence to support or refute the impact of these human-induced local and regional effects are discussed in subsequent subsections.

1) URBAN HEAT ISLAND

It is well known that the urban heat island often tends to manifest itself strongest during the nighttime hours (Landsberg 1981). In midlatitude North American cities the urban–rural temperature difference usually peaks shortly after sunset, then slowly decreases until shortly after sunrise, when it rapidly decreases, and for some cities actually vanishes by midday. In many cities, increases in urbanization would differentially warm the minimum relative to the maximum temperature.

A number of precautions have been taken to minimize the effect of increased urbanization in the climate records used in this analysis. In the contiguous United

States, the corrections for urban development recommended by Karl et al. (1988) have been applied to the data, so any residual heat island effect in this analysis should not be an issue. In Canada, only stations with population less than 10 000 were used in the analysis, and the average population of the cities in the proximity of the observing stations was slightly more than 1000. If the Canadian stations behave similarly to stations in the United States, the decrease of the DTR may be exaggerated by about 0.1°C due to urbanization. Similar values may also apply to Alaska. In the former USSR, the population limit for inclusion of any station into the network was 10 000, but in addition, no station could be within 1 km of any multistory urban development. If the impact of the effect of urbanization on the DTR in the former USSR is anything similar to that in the United States, the residual urban heat island effect on the DTR should be at least an order of magnitude smaller than the observed decrease of the DTR (nearly 1.5°C per 100 yr). In the PRC and Japan, a number of tests were conducted to identify the impact of urbanization on the DTR. Three networks of stations were categorized based on population. For the PRC, the categories included stations in proximity of cities with populations more than 1 000 000, less than 160 000, and those with populations between these two thresholds.

Categories in Japan were based on 500 000 and 50 000 threshold values. The PRC had 23, 42, and 44 stations, while Japan had 17, 71, and 66 stations, in each of the three population categories proceeding from high to low, respectively. Figure 7 shows that the decrease of the DTR actually becomes stronger in the PRC for the lowest population category compared with the moderate population category, while the trend of the average temperature continues to decrease. This suggests that urbanization effects in the PRC are dissimilar to those in the United States, as differential effects of the maximum and minimum temperature trends seem unaffected by urbanization in cities of 500 000 or less. In Japan, however, the impact of urbanization on the DTR is evident even in the lowest population category (less than 50 000); this is even more apparent for the average temperature. Based on these analyses it would seem that urbanization effects in the PRC are unlikely to significantly impact the trends reported in Tables 1 and 2.

A previous paper by Jones et al. (1990) investigated the impact of increasing urbanization in the land database used by the IPCC (1990, 1992) to calculate

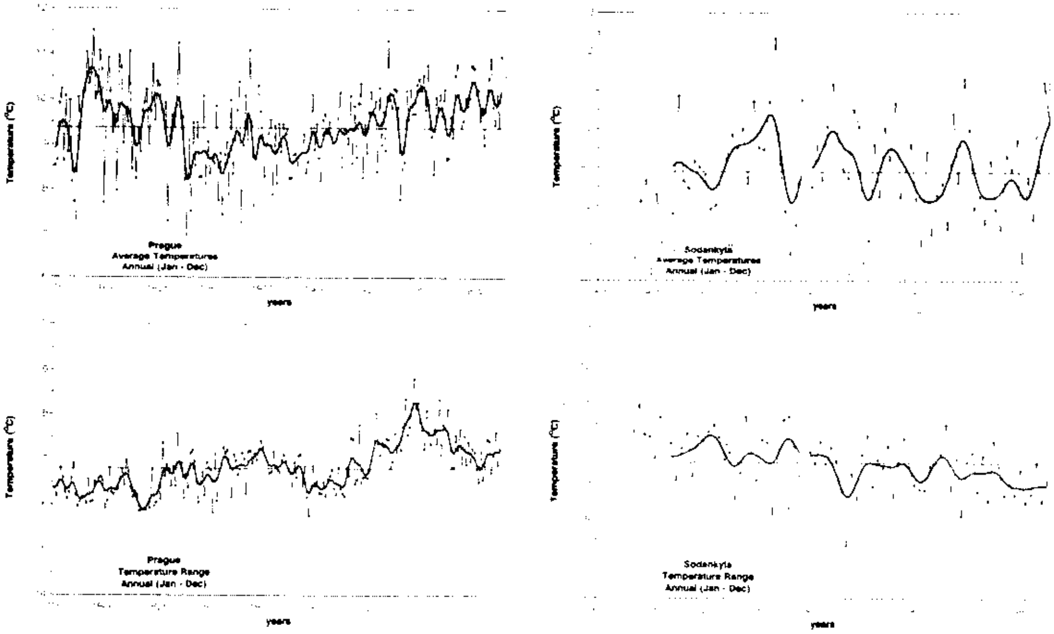

FIG. 6. Time series of the variations of the annual diurnal temperature range and the annual mean temperature from two long-term stations: Sodankylä, Finland, which has been designated as a climate reference station, and the Prague Klementinum-Observatory, Czechoslovakia. Smooth curve same as Fig. 3.

changes of global temperature. The conclusion from the work of Jones et al. (1990) was that any residual urban bias in the land-based average temperature records was about 0.05°C during the twentieth century. A comparison of the average temperature trends derived from the stations used in Tables 1 and 2 with the stations used by Jones (1988) revealed differences in trends from country to country, but virtually identical trends of temperature (within 0.02°C per 100 yr) were found when all areas depicted in Fig. 1 were considered. This suggests that the degree of urban-induced bias in these two datasets are of similar magnitude over the past 40 years, despite the use of substantially different station networks.

2) Irrigation

It can be argued that increases in irrigation may account for the decrease in the DTR. The evaporation associated with soil moisture would convert sensible to latent heat and thus significantly reduce daytime temperature. In order to test this hypothesis, the correlation coefficient (both Pearson product moment and the Spearman rank) was calculated using the values of the trends of the DTR and the change in land area under irrigation from 1950 to 1987 (U.S. Department of Commerce 1950, 1988) for each of the regions delineated in Fig. 2. No relationship was found between the change in the DTR and the increase of irrigated lands, and in fact many of the largest decreases of the DTR were associated with areas with the smallest increases of irrigation. Despite the significant decreases of the DTR over the past several decades and the relatively large increases of irrigation within the United States over the past 40 years compared to other countries, it seems unlikely that increases of irrigation can be regarded as a serious explanation for the widespread decreases of the DTR.

Table 3: Stations and years used to identify the sensitivity of the diurnal temperature range to various climatic variables.

Stations	Years
Sacramento, CA	1961–69
Tallahassee, FL	1962–70
Indianapolis, IN	1966–74
Worcester, MA	1961–69
Bismarck, ND	1973–81
Scotts Bluff, NE	1971–79
Reno, NV	1961–69
Oklahoma City, OK	1975–83
Pittsburgh, PA	1961–69
Columbia, SC	1971–79
San Antonio, TX	1973–81
Seattle/Tacoma, WA	1971–79
Spokane, WA	1966–75
Green Bay, WI	1971–79

3) Desertification

The converse of the theoretical effects of irrigation would result from increased desertification, i. e., an increase of the DTR. This might arise from poor land practices such as overgrazing or deforestation. Given the mid- and high-latitude bias of the results reported here, it seems unlikely that desertification would have a significant impact on the results reported in Tables 1 and 2. Moreover, this effect would tend to make the magnitude of the reported decreases too small, especially during the warm season, as desertification would increase the maximum and decrease the minimum.

b. Climatic effects

Since it seems unlikely that any of the human-induced local effects can provide a satisfactory answer to the widespread decrease of the DTR, a number of climatic variables that differentially affect the maximum and minimum temperature were analyzed to discern which climatic variables most strongly affect the DTR. More than 50 000 days of climatic observations were selected from the stations listed in Table 3 during periods of consistent measurement procedures for the variables defined in Table 4. The rationale for selection of variables to be studied was based on a priori information. For example, increases of the DTR over land have previously been related to snow cover ablation as simulated by the U. K. Meteorological Office's General Circulation Model (GCM) with doubled CO_2 (Cao et al. 1992). Our analysis included more than 4000 cases of snow cover. It is well known that the ability of the surface boundary layer to absorb, radiate, transform, and mix sensible heat differentially affects the maximum and minimum temperature. The relative humidity and cloudiness are two important climate variables that influence these surface-layer properties. In this analysis cloud-related information was contained in two climatic variables: the sky cover (in tenths) and an index of the ceiling height. The ceiling height (CIG) was categorized into seven categories. The cloud ceiling is defined as height above ground of the lowest cloud layer that covers 50% or more of the sky. The wind speed is an effective measure of the degree of mixing within the surface boundary layer as it affects and interacts with the frequency or intensity of inversions and super-diabatic lapse rates. Additionally, the DTR is affected by the seasonal and latitudinal changes of incoming solar radiation as well as the magnitude of day-to-day temperature differences. The inclusion of TRAD can also be regarded as a surrogate for temperature especially when used in conjunction with the other variables listed in Table 4. Karl et al. (1986b) demonstrate the impact of the interdiurnal temperature difference on the maximum and minimum temperature. These day-to-day changes of temperature are largely controlled by the thermal advection associated with synoptic-scale cyclones and anticyclones.

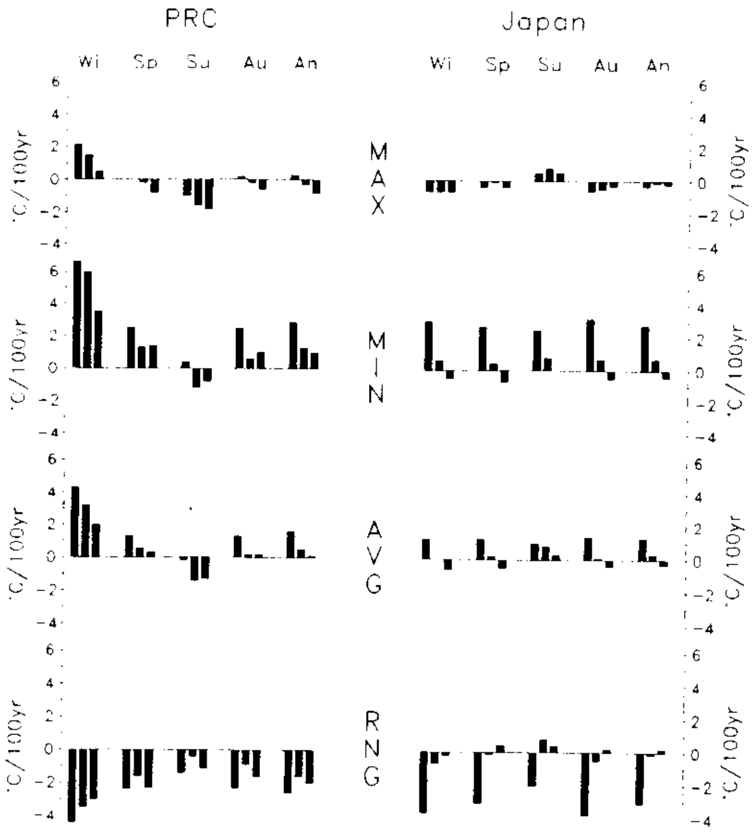

Fig. 7. Temperature trends using stations from various population categories (high, medium, low—left to right) as defined in text. Abbreviations; Wi—winter, Sp—spring, Su—summer, Au—autumn, MAX—maximum, MIN—minimum, AVG—average, and RNG—diurnal range.

All of the variables in Table 4 were used in a multiple regression analysis. Variables were regressed against the square root of the DTR, as opposed to the actual DTR, because the DTR is bounded by zero. Without the transformation, nonnormal residuals result in multiple linear regression analyses, making it more difficult to interpret the results. Figure 8a indicates that the partial correlation coefficients of each variable to the DTR are often significantly different from the simple linear correlation coefficients, making it difficult to speculate on the effect of changes in any one variable without knowing (or assuming constancy) the changes in the other variables. Given the huge sample size, very low correlations have high statistical significance (even considering the day-to-day persistence of the DTR). On a local basis, a generalized multiple linear regression model (one model for all stations and all days) based on the seven climatic variables in Fig. 8a explains about 55% (53% without the square-root transformation) of the daily variance of the DTR. Although the explained variance is substantial, it is apparent that other factors may also need to be considered with respect to explaining the variations of the DTR (e.g., better representations of the atmospheric stability, external forcing factors, more precise techniques to calculate the mean quantities used in the analysis), or that the relationships are not adequately expressed by a linear equation or both.

On a variable-by-variable basis the signs of all the partial correlations make qualitative physical sense. It is interesting to note the higher partial correlation of ΔTMP compared with the simple correlation coefficient (Fig. 8a) as the correlation between TRAD and ΔTMP mask the importance of ΔTMP in influencing DTR. The decrease of the partial correlation relative to the simple correlation for the variables RH, CIG, and SKY is to be expected because changes among each of these variables are related to each other. The decrease in the partial correlation of SNOW is particularly noteworthy, especially since Cao et al. (1992) attribute the ablation of snow cover in their model to an increase in the DTR. The empirical results in Fig. 8a suggest that SNOW is only weakly related to the DTR, especially compared to other variables.

In order to investigate the linearity, or lack thereof, of the relationships implicit in Fig. 8a, the data were

TABLE 4. Definitions and abbreviations of the climatic variables used to test the sensitivity of the diurnal temperature range.

Variables	Abbreviations
Diurnal temperature range (daily max–daily min)	DTR
Snow cover (binary, if snow depth 2.54 cm)	SNOW
Mean relative humidity (0600 LST and 1500 LST)	RH
Mean wind speed (0600 LST and 1500 LST)	WS
Mean sky cover (0600 LST and 1500 LST)	SKY
Mean ceiling (0600 LST and 1500 LST)	CIG
Total daily top of the atmosphere solar radiation	TRAD
Day-to-day temperature differences $(\lvert TMP_0 - TMP_{-1}\rvert + \lvert TMP_0 - TMP_{+1}\rvert)$	ΔTMP

partitioned by TRAD. Figure 8b provides strong evidence to suggest that the relationships change with the amount of TRAD. In particular, the partial correlation coefficients of RH, WS, and SKY become stronger as TRAD (and thus temperature) increases. This probably has more to do with a reduction of the maximum temperature than an increase of the minimum. During daylight hours high values of the RH, WS, and SKY are indicative of higher albedos, higher potential evapotranspiration, higher atmospheric water vapor absorption of incoming radiation, and larger than normal mechanical mixing. These factors act to retard the maximum temperature that would otherwise result from high intensity TRAD, which would be manifested as sensible heat within the surface boundary layer. The nonlinearity of RH as TRAD increases is substantially greater than WS (Fig. 8b). As the TRAD to the surface increases the temperature increases, and a greater portion of the TRAD can be used for evaporation compared with raising surface temperature, as would be anticipated by the Clausius–Clapeyron equation when integrated to obtain saturation vapor pressure as a function of temperature.

The reduction of the partial correlation of TRAD with the DTR after partitioning by TRAD (Fig. 8b) relates to the balance between long nights and short days. During the late autumn and early winter in the northern half of the United States (areas that include the lowest partition of TRAD), a moderate increase in the TRAD (by interseasonal and latitudinal variations) generally results in a higher DTR. Contrarily, in the warm half of the year, TRAD and its associated daylight are more than ample so that the relation between TRAD and DTR is near zero. In fact, a further partition of the TRAD into a very high category leads to negative partial correlations between TRAD and the DTR.

The reduction of the partial correlation of ΔTMP as TRAD increases is related to the decrease in intensity of the day-to-day changes of temperature during the warm season. Rossby waves and extratropical cyclones have reduced amplitude, speed, and intensity during the warm season.

A change in sign of the partial correlation coefficient of SNOW with the DTR (Fig. 8b) suggests that the length of night relative to the TRAD is a significant factor when considering the impact of changes in snow cover on the DTR. In the northern United States, around the winter solstice, TRAD is relatively low. Snow on the ground at this time of the year is important because of its excellent insulation (reduces heat flow from the soil) and high emissivity, which help lower the nighttime minimum. During the daytime the TRAD is already low, so the amount of solar radiation reflected by the snow cover is no longer as important. As a result, snow cover at this time of the year and these latitudes leads to an increase in the DTR. This is not the case as the season progresses or the latitude decreases, as reflected by the negative partial correlations (lower values of DTR with snow cover) associated with the highest category of TRAD; there were still nearly 1000 cases of snow cover. The data suggest that snow cover ablation will not necessarily lead to an increase of the DTR.

From the aforementioned analysis, it is apparent that there are many factors, often intricately related, that affect the DTR. Many of the variations in these variables are very much related to a greenhouse effect, some of which may be anthropogenically induced. Overall, the two variables related to changes in cloudiness, sky cover, and ceiling height explain the greatest portion of the variance of the DTR. Changes in cloudiness should be one of the first considerations in searching for an explanation of the observed decrease of the DTR (Fig. 2). Indeed, when large continental scales are considered, the relationship between cloud amount (or sky cover) and the DTR is quite impressive (Fig. 9). Plantico et al. (1990) have already demonstrated that the decrease in the DTR over the United States is strongly linked to an observed increase in daytime and nighttime cloud cover and a lowering of cloud ceilings.

Is there a general increase in cloud cover over much of the globe? Empirical evidence by Henderson-Sellers (1986, 1989, 1992) and Jones and Henderson-Sellers (1992) suggests this may be the case over Canada, the United States, Europe, the Indian subcontinent, and Australia. Analyses of cloud cover changes over the PRC from a network of 58 stations across the PRC are inconclusive, but there is evidence for a decrease in the sunshine (a 2% to 3% decrease in sunshine from the 1950s to the 1980s). The quality of the cloud data (and perhaps the sunshine data) is questionable because the correlation between monthly anomalies of sunshine and cloudiness at many sites is not high. Analyses of changes in cloudiness over the former USSR by Balling (1992, personal communication) reveal a general increase of cloud cover (3.5%) during the period 1965–86 with stratus and stratocumulus clouds (low ceilings) increasing in frequency by about 2%. He also found considerable interannual and interstation variability, so the quality of these data could also be called into question. Nonetheless, the trend over the former USSR is consistent with a decrease in the DTR. Frich (1992) and Bücher and Dessens (1991) also found that decreases in the DTR in Denmark and at the Pic du Midi de Bigorre Observatory occurred with an increase in cloudiness. An analysis of changes in cloud cover over Japan, using many of the same stations selected for the analysis of the maximum and minimum temperatures, indicates cloud cover may have increased on an annual basis by nearly 1% since 1951, but there is no apparent response in the DTR. Changes in sunshine in Japan are not altogether consistent with the increase in cloud cover, but a new sunshine instrument was introduced into the network in 1986.

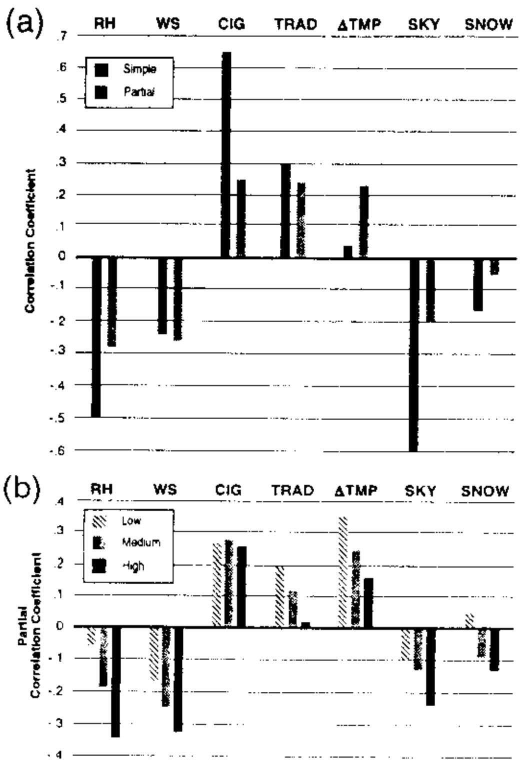

FIG. 8. Relationship between various climate variables and the diurnal temperature range. (a) Simple and partial correlation coefficients (removing the effects of all other variables) between each variable (defined in Table 4) and the diurnal temperature range. (b) Partial correlation coefficients of each variable for cases partitioned by the total daily solar radiation at the top of the atmosphere 170 $\mathrm{Wm^{-2}}$ (low); 271 $\mathrm{Wm^{-2}}$ (high); remainder (moderate).

4. Large-scale anthropogenic effects

a. Greenhouse gases

Interest in the potential change of the DTR with increasing anthropogenic greenhouse gases has prompted several modeling groups to publish information from their models regarding the projected change in the DTR from doubled CO_2 experiments. Table 5 summarizes the results of these models. For the GCM experiments, the magnitude of the decrease is small relative to overall warming of the mean global temperature. Moreover, these experiments reflect a level of CO_2 increase well in excess of present-day values, so even smaller changes should be expected in the observed temperature record.

Cao et al. (1992) also conducted a number of experiments with a one-dimensional radiative–convective model (RCM), which showed that the decrease in the diurnal temperature range with doubled CO_2 in that model is primarily due to a water vapor feedback. Only a 0.05°C reduction in the DTR was observed when the absolute humidity was held constant. Table 5 indicates that the increased sensible heat exchange and evaporation are also important factors leading to a reduction in the DTR in RCM simulations with enhanced CO_2.

Interestingly, the ratio of the DTR decrease relative to the increase of the mean temperature in the RCM compared with the GCM is closer to the observed ratio over the past several decades (Table 5). The RCM omits the positive feedbacks to the DTR from reductions in cloud and surface albedo as contained in the GCM simulations (Cao et al. 1992). This tends to increase the DTR because of reduced atmospheric (cloud cover) and surface (snow cover) albedo. Other GCM simulations have both increases and decreases in cloudiness with global warming: decreases in much of the troposphere, but increases in the high troposphere, low stratosphere, and near the surface in high latitudes (Schlesinger and Mitchell 1985). If the observational evidence is correct regarding the tendency for a general increase in cloud cover over the land (which now seems likely), then this could help explain the

TABLE 5. Summary of modeling results with respect to the relationship between doubled CO_2 concentrations and changes in the diurnal temperature range (DTR) and the maximum and minimum temperatures. Abbreviations are ΔT_{eq} is the equilibrium global temperature change (°C) for doubled CO_2 concentrations ΔDTR is the equilibrium global change of the DTR (°C) for doubled CO_2 concentrations. CCC is the Canadian Climate Centre, GISS is the Goddard Institute for Space Studies, and UKMO is the U. K. Meteorological Office.

GCM Model	Author	Resolution		Ocean	T_{eq}	DTR_{eq}
		Horiz.	Vert.			
CCC	Boer 1989	T32	10	Mixed layer	3.5	−0.28
GISS	Rind et al. (1989)	8° x 10°	9	Mixed layer	4.2	−0.7 (sum. USA) −0.1 (ann. USA)
UKMO	IPCC (1990)	8° x 10°	11	Mixed layer	5.2	−0.17
UKMO	Cao et al. (1992)	5° x 7.5°	11	Mixed layer	6.3	−0.26

Radiative Convective Model (Cao et al. 1992)

Type	Maximum T_{eq}	Minimum T_{eq}	DTR
Fixed absolute humidity	X	X	−0.05
No surface turbulence	2.5	2.9	−0.4
No evaporation	2.3	2.9	−0.6
Full surface exchange	1.5	2.2	−0.7

large discrepancy between the observed data and the model projections of the ratios of the decrease in the DTR range relative to the mean temperature increase. This assumes, of course, that the recent warming is induced by increases in anthropogenic greenhouse gases. On the other hand, this raises questions regarding the cause of the apparent change in cloudiness and how it has impacted the mean temperature.

The ability of present day GCMs to adequately simulate projected changes in the DTR with enhanced CO_2 is also affected by surface parameterizations of continental-scale evaporation. As Milly (1992) points out, present-day GCMs can overestimate the surface evaporation because of the failure to properly account for the cooling that occurs with the evaporation. Milly (1992) raises concerns about the veracity of the results from studies of soil moisture changes induced by an increase of greenhouse gases. Accurate projections of the change in the surface boundary-layer DTR with increases of anthropogenic greenhouse gases will be strongly dependent on adequate simulation of these processes.

Given the dependency of the DTR on surface-layer processes, interactions with the land surface, and cloudiness, all areas of significant uncertainties within present-day GCMs, it may not yet be possible to adequately project changes of the DTR with enhanced concentrations of greenhouse gases.

b. Tropospheric aerosols

It has recently been shown that increases in sulfate aerosols over and near industrial regions can significantly impact the earth's surface heat balance (Charlson et al. 1992). Charlson et al. (1991) and Charlson et al. (1992) provide evidence to indicate that the anthropogenic increase of sulfate (and carbonaceous) aerosol is of sufficient magnitude to compete regionally with present-day anthropogenic greenhouse forcings. This forcing is confined primarily to the Northern Hemisphere and is a combination of direct aerosol forcing (especially over the land) and indirect aerosol forcing leading to increases in cloud albedo (especially over the marine environment). At present, Charlson et al. (1992) conclude that it is too uncertain to estimate the effects of sulfate aerosols on the lifetime of clouds (smaller droplet sizes leading to a decrease in the fallout rate) which presumably could lead to an increase in cloud cover. Charlson et al. (1991) provide the geographic pattern where direct aerosol forcing should be greatest. It is difficult to identify a direct relation between the pattern and magnitude of the decrease in the DTR (Fig. 2) and the anthropogenic radiative forcing calculated by Charlson et al. (1991). Moreover, Karl et al. (1986a) and Karl et al. (1986b) provide evidence to suggest that there is little change of the maximum relative to the minimum temperature in the United States for cloudless skies even when the daily data are stratified by dewpoint and wind direction.

Recently, Penner et al. (1992) have argued that atmospheric aerosols from biomass burning also act to increase the planetary albedo both directly by clear-sky planetary albedo increases and indirectly through increases in cloud albedo. Since biomass burning is most extensive in subtropical and tropical areas, this effect may be directly relevant only to a small portion of the data analyzed here.

Two tropospheric aerosol forcing agents (aerosols from sulfur emissions and biomass burning) have been identified that tend to increase the clear-sky albedo. Neither forcing is believed to have dominant infrared forcing. The question arises whether either of these forcings has acted to reduce the maximum temperature and thereby the DTR. In the United States and northern (and perhaps eastern) Europe, however, where we detected a significant decrease in the DTR, there has actually been a net decrease in sulfur emissions over the past several decades that would qualitatively appear to eliminate sulfate aerosols as an influence on the DTR in these areas. There are reasons why such a conclusion may be premature. First, the climate forcing due to tropospheric aerosol loading is influenced both by the emission rate and the residence times of sulfate aerosol in the atmosphere. In the United States, at least, the effective heights, or stack heights, of the sulfur emissions have increased as a consequence of the U.S. Clean Air Act. This may have had an effect on the lifetime of the SO_2 and sulfate aerosols

5. Conclusions

Strong evidence exists for a widespread decrease in the DTR over the past several decades in many

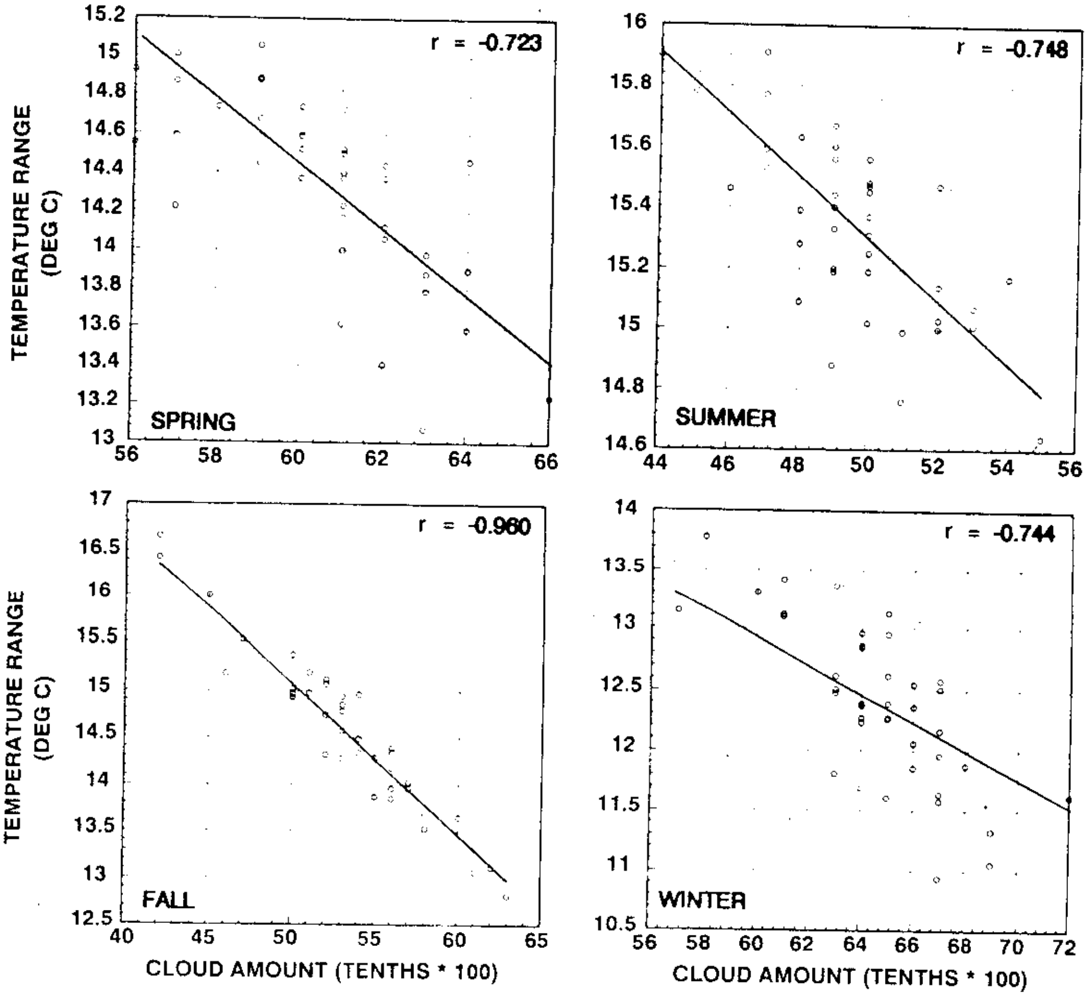

FIG. 9. Seasonal relationships between U.S. area-averaged cloud cover and the diurnal temperature range

regions of the globe. There are many possible climatic factors that affect the DTR, but indications are that cloud cover, including low clouds, has increased in many areas that have a decrease in the DTR. The increases in cloud cover could be indirectly related to the observed global warming and increases of greenhouse gases, related to the indirect effects of increases in aerosols, simply a manifestation of natural climate variability, or a combination of all three.

A robust answer regarding the cause(s) of the decrease in the DTR will require efforts in several areas. First, an organized global effort is required to develop relevant and homogeneous time series of maximum and minimum temperature along with information on changes of climatic variables that influence the DTR such as cloudiness, stability, humidity, thermal advection, and snow cover. Second, improvements in the boundary-layer physics and treatment of clouds within existing GCMs are critically important. Third, the treatment of both anthropogenic tropospheric aerosols and greenhouse gases must be realistically incorporated into GCMs with a diurnal cycle. Fourth, measurements need to be made to help clarify the role of aerosols. Finally, imaginative climate change detection studies that link the observed climate variations to model projections will be required to convincingly support any relation between anthropogenic-induced changes and the DTR.

It will be difficult to satisfactorily explain the observed changes of the mean temperature until an adequate explanation for the observed decrease in the DTR can be determined. Moreover, the practical implications of projected temperature changes and whether they are likely to continue will be even more difficult to assess.

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GLOBAL WARMING:
EVIDENCE FOR ASYMMETRIC DIURNAL TEMPERATURE CHANGE

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ABSTRACT. Analyses of the year-month mean maximum and minimum surface thermometric record have now been updated and expanded to cover three large countries in the Northern Hemisphere (the contiguous United States, the Soviet Union, and the People's Republic of China). They indicate that most of the warming which has occurred in these regions over the past four decades can be attributed to an increase of mean minimum (mostly nighttime) temperatures. Mean maximum (mostly daytime) temperatures display little or no warming. In the USA and the USSR (no access to data in China) similar characteristics are also reflected in the changes of extreme seasonal temperatures, e.g., increase of extreme minimum temperatures and little or no change in extreme maximum temperatures. The continuation of increasing minimum temperatures and little overall change of the maximum leads to a decrease of the mean (and extreme) temperature range, an important measure of climate variability.

The cause(s) of the asymmetric diurnal changes are uncertain, but there is some evidence to suggest that changes in cloud cover plays a direct role (where increases in cloudiness result in reduced maximum and higher minimum temperatures). Regardless of the exact cause(s), these results imply that either: (1) climate model projections considering the expected change in the diurnal temperature range with increased levels of the greenhouse gases are underestimating (overestimating) the rise of the daily minimum (maximum) relative to the maximum (minimum), or (2) the observed warming in a considerable portion of the Northern Hemisphere landmass is significantly affected by factors unrelated to an enhanced anthropogenically-induced greenhouse effect.

Introduction

It is now well established that the global average surface temperature has risen between 0.3 and 0.6°C since the latter half of the nineteenth century [Intergovernmental Panel on Climate Change-IPCC, 1990]. The analysis of diurnal characteristics of the warming however (and their possible relationship to increased concentrations of greenhouse gases), have been of limited spatial domain [Karl et al., 1984; Plantico et al., 1990]. A lack of computer-compatible daily maximum (mostly daytime) and minimum (mostly nighttime) temperatures prevented the IPCC from making a comprehensive assessment of changes of diurnal and extreme temperatures associated with the observed global warming [IPCC, 1990].

Over the past few years, climatologists in the USSR and the PRC have worked with USA scientists to build data sets which contain year-month mean maximum and minimum temperatures for a large number of stations. These data are important for a better understanding of how global warming may be related to increased concentrations of anthropogenic greenhouse gas emissions. They also provide the basis for understanding how climate change may impact our socio-economic and biogeophysical systems.

Data

Year-month mean maximum and minimum temperatures were derived from 500 (of the 1200) high quality US Historical Climate Network (HCN) stations in the USA [Karl et al., 1990]; 190 rural synoptic and station posts in the USSR; and 57 stations in the PRC, (excluding the southwest portion). Stations were reasonably well-distributed across the countries with the exception of southwestern China and the western one-third of the USA. The southwestern portion of the PRC was omitted from the analysis and area-weighting was used to minimize the effects of spatial inhomogeneity in the USA (Figure 1) and elsewhere. These countries represent about 40% of the Northern Hemisphere land mass, and over 25% of the global land area. In addition to the year-month mean maximum and minimum temperatures, the highest and lowest observed temperatures (extremes) within each month were also compiled for many stations within the USA and the USSR (Table 1).

An important aspect of any surface-based land analysis of temperature change relates to the potential impact of growing urban heat islands. In this analysis the data used for the USA (excluding the extremes) have been adjusted for urban heat island biases using the procedures described by Karl et al. [1988]. The station network we use in the USSR is a rural network (no station in a city with population of 10,000 or more). The PRC network consists of several stations in and near large cities, but many of the stations were also used by Jones et al. [1986] as described in Jones et al. [1985]. In previous work [Jones et al., 1990; Wang et al., 1990], we have compared the data in the PRC used by Jones et al. [1986] in the eastern half of the PRC (the region which contains the most urbanized stations) to various networks comprised of only rural or urban stations. These analyses indicate that urban heat island biases derived from

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Fig. 1. Station distribution (dots) and climate divisions used to calculate national and regional area-averages.

long-term stations in this portion of the globe are relatively small (~0.1°C) over the time period we address in the PRC.

It should also be noted that detailed station histories have been compiled for each of the stations we use. There is no evidence to suggest that either observational practices or instruments may have introduced systematic inhomogeneities in the data we analyze.

Procedures

The time periods selected for analysis were chosen so that virtually all stations spanned the entire period of record with few, if any, missing observations. Temperatures were transformed to temperature anomalies from the 1951-80 base period before aggregating them into regional means. This is a common practice in developing temperature time series. It helps prevent biases from entering the time series when the station network varies [Jones et al., 1986], even though the networks used here are quite stable.

The year-month temperatures from the USA HCN have undergone extensive homogeneity checks and assessments [Karl et al, 1990]; so no further quality control was required. However, a correction was performed for a change at some stations (25%) in the type of temperature measurement (the electronic maximum/ minimum temperature system) system used during the late 1980s [Quayle et al., 1991]. Daily temperature extremes were available for a subset of these high-quality USA HCN stations (Table 1) and all the stations we analyzed for the USSR. Year-month temperature extremes of the daily maximum and minimum as well as the year-month mean maximum and minimum for the USSR and the PRC were inspected for consistency and outliers prior to use in this analysis.

Table 1. Data used in this analysis. Abbreviations are: USA—United States of America, PRC—People's Republic of China, USSR—Union of Soviet Socialists Republics, POR—Period of record, Stns—Stations.

	Mean Max & Min		Extreme Max & Min	
Country	# of Stns	POR	# of Stns	POR
USA	497	1901-1990	357	1911-1989
PRC	57	1951-1989	no access	no access
USSR	190	1936-1986	190	1936-1986

Regional averages of temperature were calculated within various areas of each country (Figure 1) by arithmetic averages of each station's year-month mean temperature anomaly and the year-month 1-day extreme temperature anomaly. Anomalies were calculated from 1951-80 mean monthly maximum and minimum temperatures. Each region was area-weighted to form national averages.

Results

For each of the three countries the change of the annual mean maximum temperature shows little or no increase,

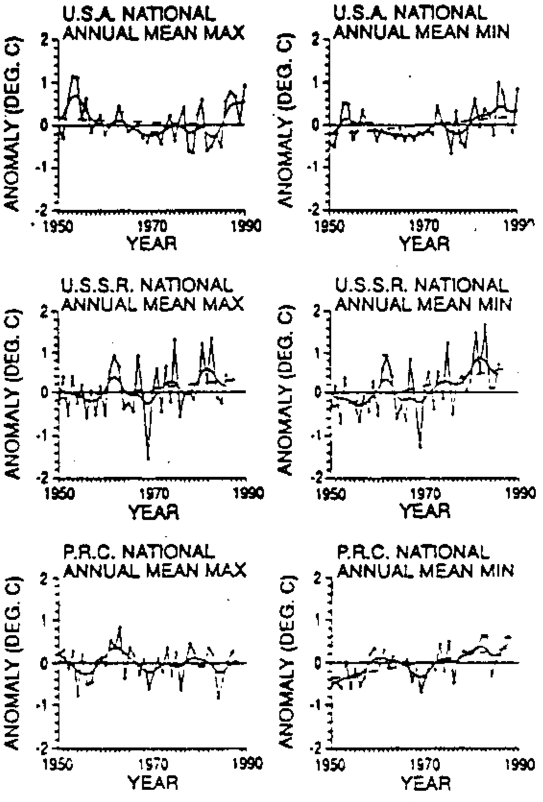

Fig. 2. Variations of temperature (°C) for: a) U.S.A. mean annual maximum and minimum temperature, b) same as a) except for the U.S.S.R., c) same as a) except for P.R.C. Solid Line: 9 point binomial filter, Dashed Line: linear trend.

Table 2. Temperature trends (°C/100yr) over the period of record given in Table 1 and since 1951. A double underline represents trends significant at the .05 level (two-tailed) and a single underline the .10 level. A "#" denotes a significant (.05 level) deviation from a linear trend. Note that due to the nature of trend analysis one-half the slope of the maximum plus one half the slope of the minimum is not necessarily equal to the slope of mean temperature. MAX-MIN implies maximum minus minimum or the range.

	MEAN MAX		MEAN MIN		MEAN MAX-MIN		EXTREME MAX		EXTREME MIN		EXTREME MAX-MIN	
USA	1901	1951	1901	1951	1901	1951	1901	1951	1901	1951	1901	1951
WIN	0.3	-3.0	0.4	-1.0	-0.1	-2.1	0.2	-2.2	-0.2	-2.0	0.5	-0.2
SPR	0.6	1.9	0.6#	2.6	0.0	-0.7	-0.2#	1.3	0.2	2.1	-0.4	-0.8
SUM	0.3#	-0.8#	1.0#	0.7	-0.6#	-1.5	-0.7#	-0.5	0.6#	0.6	-1.3	-1.2
AUT	-0.1#	-2.9	0.4	1.4	-0.6#	-4.3	-0.2#	-2.3	0.1	1.3	-0.3	-3.5
ANN	0.3#	-0.5	0.6	1.0#	-0.3#	-1.5	-0.2#	1.0	0.2	0.3	-0.4	-1.2
USSR	1936	1951	1936	1951	1936	1951	1936	1951	1936	1951	1936	1951
WIN	0.5	1.6	1.4	2.9	-0.9#	-1.2	1.1	2.0	2.8	4.1	-1.7	-2.1
SPR	1.0	2.8	1.7	4.0	-0.7	-1.3	0.9	1.8	2.8	6.1	-1.9	-4.4
SUM	-0.5	-0.7	0.4	0.5#	-0.9	-1.2	-0.7	-1.5	0.3	0.3#	-1.0	-1.7
AUT	-0.9	1.0	0.3	2.6	-1.1#	-1.6	-1.4	-1.0	0.9#	5.6	-2.3#	-6.6
ANN	0.1	1.2	1.0	2.5	-0.8#	-1.3	0.0	0.3	1.6#	3.9	-1.6#	-3.5
PRC		1951		1951		1951						
WIN		1.3		4.3		-3.0	no access		no access		no access	
SPR		0.0		1.7		-1.8	no access		no access		no access	
SUM		-1.4		-0.2		-1.1	no access		no access		no access	
AUT		-0.4		1.9		-2.3	no access		no access		no access	
ANN		-0.2		1.9		-2.0	no access		no access		no access	

while the minimum temperature increases substantially (Figure 2). Similar characteristics are also observed for the extreme temperature anomalies. In each country the increase of the minimum temperature (both means and extremes) is most pronounced beginning around the late 1950s or early 1960s. These asymmetric trends are best reflected by the decrease in the mean and absolute temperature ranges.

Linear trends are used to summarize the observed changes of temperature presented in Figure 2, but we make no claim that the changes are best reflected by linear changes. Indeed, two-phase regression analysis [Solow, 1987] was used to test for significant departures from linear trends with less than 20% (expected at least 5% by chance alone) showing statistically significant departures (Table 2) from a linear trend. Since 1951 all of the warming in the USA and the PRC is due to the increase of the minimum temperature (Table 2). A similar characteristic, but not as one-sided, has been observed in the USSR (Table 2). Standard tests of statistical significance indicate that for most areas and seasons the decrease of the temperature range (MAX-MIN) is statistically significant. On a seasonal basis since 1951 (when all three countries have a common period of record) there is a preference for decreases in the maxima (both means and extremes) during the summer and autumn, but these are more than offset by the increases of minima, especially during the winter and spring.

Changes in the range of extreme temperatures is an important measure of climate variability. Analyses reveal a general decrease of the range (Table 2), with the notable exception of winter temperatures in the USA over the past four decades.

The spatial characteristics of the trends of the annual mean maximum and minimum are similar across large portions of the USA, USSR, and the PRC. In the USSR the increase of the extreme minimum relative to the extreme maximum is well expressed across much of the country. In the USA the increase of the extreme minimum relative to the extreme maximum is most strongly expressed in the western part of the country, but is also weakly expressed elsewhere.

Discussion and Conclusion

Although we cannot offer a definitive explanation for the asymmetric changes, these results require careful consideration in our attempts to explain contemporary climate variations and change.

Based on GCM model simulations the IPCC states that "there is no compelling evidence for a general reduction in the amplitude of the diurnal cycle,..." resulting from increases of greenhouse gases [IPCC, 1990]. This conclusion bears close examination in light of the observed temperature changes over the past four decades, especially since the diurnal cycle is directly affected by quantities such as surface wetness, cloud cover, and surface albedo which are highly variable from model-to-model [IPCC, 1990]. If the IPCC is correct, other forcings must be operating to mitigate the warming of the daily maximum temperature in a large portion of the northern hemisphere. Some of these other factors could include changes in cloudiness and aerosol loadings, but it is entirely possible that the observed changes are the result of natural fluctuations within the climate system.

At present we lack an adequate understanding of the causes of differential changes in the mean and extremes of maximum and minimum temperatures. This is a fundamental characteristic of recent climate variation over a large portion of the northern hemisphere land mass, and it must be better understood before we can confidently project the climate or climate impacts on future society and ecosystems. This will require rigorous atmospheric chemistry and climatological monitoring and analysis efforts. Additionally, improved modelling efforts are required which would consider the combined impact of changes of greenhouse gases, surface characteristics, and aerosols on the diurnal cycle in the atmospheric boundary layer.

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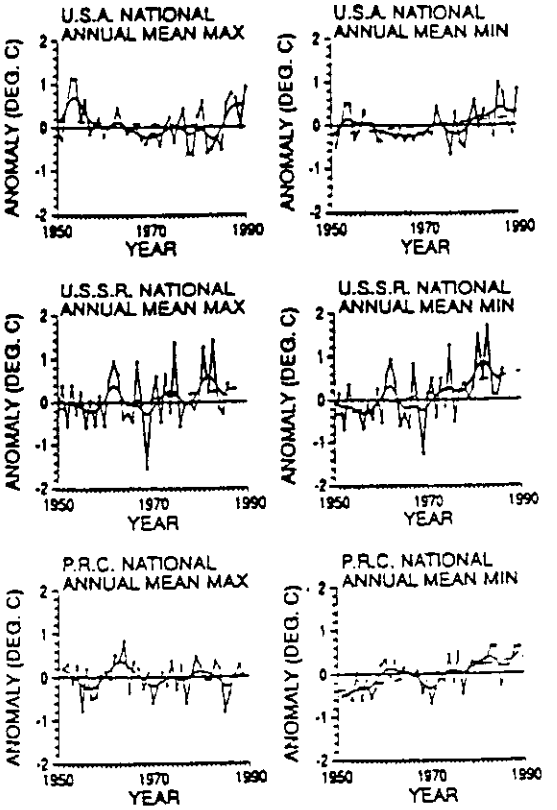
Figure 2 and Table 2 (reverse side)



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	MEAN MAX		MEAN MIN		MEAN MAX-MIN		EXTREME MAX		EXTREME MIN		EXTREME MAX-MIN	
USA	1901	1951	1901	1951	1901	1951	1911	1951	1911	1951	1911	1951
WIN	0.3	-2.2	0.4	-0.7	-0.1	-1.5	0.2	-2.2	-0.2	-2.0	0.5	-0.2
SPR	0.6	2.3	0.6#	2.5	0.0	-0.2	-0.2#	1.3	0.2	2.1	-0.4	-0.8
SUM	0.3#	-0.3#	1.0#	1.0#	-0.6#	-1.4	-0.7#	-0.5	0.6#	0.6	-1.3	-1.2
AUT	-0.1	-1.7	0.4	1.3	-0.6#	-3.0#	-0.2#	-2.3	0.1	1.3	-0.3	-3.5
ANN	0.3#	-0.5#	0.6	1.0	-0.3#	-1.5#	-0.2#	-1.0	0.2	0.3	-0.4	-1.2
USSR	1936	1951	1936	1951	1936	1951	1936	1951	1936	1951	1936	1951
WIN	0.5	1.6	1.4	2.9	-0.9#	-1.2	1.1	2.0	2.8	4.1	-1.7	-2.1
SPR	1.0	2.8	1.7	4.0	-0.7	-1.3	0.9	1.8	2.8	6.1	-1.9	-4.4
SUM	-0.5	-0.7	0.4	0.5#	-0.9	-1.2	-0.7	-1.5	0.3	0.3#	-1.0	-1.7
AUT	-0.9	1.0	0.3	2.6	-1.1#	-1.6	-1.4	-1.0	0.9#	5.6	-2.3#	-6.6
ANN	0.1	1.2	1.0	2.5	-0.8#	-1.3	0.0	0.3	1.6#	3.9	-1.6#	-3.5
PRC	1951		1951		1951							
WIN	1.3		4.3		-3.0		no access		no access		no access	
SPR	0.0		1.7		-1.8		no access		no access		no access	
SUM	-1.1		-0.3		-0.8		no access		no access		no access	
AUT	-0.4		1.9		-2.3		no access		no access		no access	
ANN	-0.1		1.9		-1.9		no access		no access		no access	

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