phenomenon (*5*), which required that the transitions and the remainder of the pattern be presented to different ears, the one reported here puts all parts of the pattern equally into both ears. It thereby avoids such complications of interpretation as may arise with dichotic stimulation and so makes more straightforward the inference that duplex perception reflects distinct auditory and phonetic ways of perceiving the same stimulus. Beyond that, the results obtained with the new form of the duplex phenomenon support the hypothesis that the phonetic mode takes precedence in processing the transitions, using them for its special linguistic purposes until, having appropriated its share, it passes on the remainder to be perceived by the nonspeech system as auditory whistles. Such precedence reflects the profound biological significance of speech.

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7. Below the duplexity threshold, such matching would presumably be at the level of chance. It is possible, however, that forced matching is a more sensitive measure than the one we used to obtain the threshold itself. We therefore applied the matching procedure at 4 dB below the lower ("d") threshold, using eight highly practiced subjects. As expected, the responses [45.3% correct, $t(7) = -1.28$, $P > 0.2$] were at the level of chance.
8. S. Bentin and V. A. Mann [*Haskins Laboratories Status Report on Speech Research SR-76* (1983)] found a similar range in a dichotic task, although they interpreted it as a difference in sensitivity, not as preemption.

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Precipitation Fluctuations over Northern Hemisphere Land Areas Since the Mid-19th Century

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An extensive array of measurements extending back to the mid-19th century was used to investigate large-scale changes in precipitation over Northern Hemisphere land areas. Significant increases in mid-latitude precipitation and concurrent decreases in low-latitude precipitation have occurred over the last 30 to 40 years. Although these large-scale trends are consistent with general circulation model projections of precipitation changes associated with doubled concentrations of atmospheric carbon dioxide, they should be viewed as defining large-scale natural climatic variability. Additional work to refine regional variations and address potential network inhomogeneities is needed. This study attempts to show secular precipitation fluctuations over hemispheric- and continental-scale areas of the Northern Hemisphere.

CLIMATOLOGISTS HAVE FOCUSED ATtention on the surface air temperature record (*1, 2*) because of concern over the potential climatic effects of increasing CO_2 and other radiatively active trace gases in the atmosphere. Virtually all computer models of the climatic effects of increased CO_2 indicate that significant increases in temperature will occur as CO_2 levels rise (*3*); some evidence indicates that a small increase may have already taken place (*4*). However, a change in temperature is not the only consequence of increasing CO_2 levels. Major changes in the hydrological cycle (for example, in evaporation and precipitation rates) are likely to have regional and global effects (*5, 6*), and such changes may be of profound social and economic significance (*7*). General circulation models (GCMs), which have been applied to the problem of the effect of increasing CO_2 levels on climate, do not give an unequivocal picture of how precipitation might be expected to change (*5, 8*).

Nevertheless, some conclusions are reasonably well established. For example, with a doubling of CO_2 levels, global mean precipitation rates increase in all GCM models by 3 to 11% (*5*). However, the geographical distribution of the change in precipitation rate is not the same in all models. Even the simulation of the precipitation rate for present-day conditions may be significantly in error for certain regions (*5, 8*). Because of these problems, projections of the potential effects of increased concentrations of CO_2 on precipitation distribution have been given less credence than projected changes in temperature. However, certain generalizations can be made. The larger the increase in temperature projected by the GCMs, the larger the increase in simulated (global) precipitation rate. Precipitation increases are generally predicted poleward of 30° to 35°N and 30° to 35°S and in the immediate vicinity of the equator (5°N to 5°S). In the intervening zone, the results are more variable, but a tendency for a decrease in precipitation rate in one or more seasons is generally apparent.

To assess the significance of any projected climatic change, the historical record of variability must be examined so that the predicted conditions can be placed in a longer term perspective. Many studies of large-scale temperature variations over the last 100 to 130 years have been made (*2*), but relatively little attention has been paid to large-scale changes in precipitation (*9*). We report on precipitation fluctuations over continental regions of the Northern Hemisphere since the mid- to late 19th century and then compare the observational record with GCM projections of changes expected with increases in greenhouse gases.

Previous studies of large-scale changes in precipitation have been hampered by the lack of a database that is geographically and temporally extensive. Moreover, methodological problems related to the high spatial variability of precipitation make it difficult to construct indices that are not dominated by precipitation in areas with either very high or very low amounts of precipitation (*10*). We used a comprehensive set of precipitation station data that includes long-term records from continental regions of the Northern Hemisphere (*11*). Few precipitation data exist for open ocean areas, and data for the continental areas of the Southern Hemisphere are limited geographically. Therefore, we have focused on continental regions of the Northern Hemisphere (*12*).

Because of the nonuniform distribution of long-term precipitation stations, the data were gridded to avoid unduly weighting regional and hemispheric averages by small areas with many long-term records. In view of large spatial variations in precipitation,

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often over short distances, it is not appropriate simply to interpolate precipitation totals between stations. Some analysts (*9*) have used percentage departures from a reference period as the basis for interpolation, but this method poses problems when precipitation data are not normally distributed. In fact, precipitation data are often positively skewed; to accommodate this problem, we converted the data for each station to probability estimates, based on the gamma distribution (*13*). The gamma distribution provides a good fit to precipitation data and enables precipitation amounts to be accurately expressed in terms of probabilities at each location (*14*).

Shape and scale parameters were calculated for monthly, seasonal, and annual precipitation at 1487 stations (Fig. 1A) from data for the reference period 1921 to 1960 (the optimum number of station records were available for this period). On the basis of these parameters, individual monthly, seasonal, and annual precipitation amounts were then converted to percentiles of the appropriate gamma probability distributions computed for each site. For example, in these transformations, a seasonal value of 0.6 in any given year at a particular site means that precipitation in that season can be considered as greater than in 59% of other values for the same season at that site.

The resulting series of percentiles were interpolated onto an equidistant grid network with nodes 400 km apart (Fig. 1B) (*15*). The number of valid gridded points for various regions and latitudinal zones is shown by year in Fig. 2. When this gridding scheme is used, the maximum number of points for the entire Northern Hemisphere is 3077. However, because of the large areas of ocean and the limited data from some areas of the continents, a maximum of 1410 gridded values could be calculated. These values were then averaged to produce indices of Northern Hemisphere continental and regional precipitation variability over the last 130 years (*16*).

Annual precipitation index values for the Northern Hemisphere are shown in Fig. 3. The gridded network did not reach 50% of its maximum coverage until 1883; thus the low mean values in the early part of the record (which represent mainly European data) should be evaluated on this basis. The record shows marked fluctuations between decades and on longer time scales. The level of the precipitation index decreased from the late 1870s to around 1920 by approximately 0.08. Values then increased to the early 1950s (when they approached levels of the late 1870s) and declined again through the late 1970s. In the 15-year period from 1949 to 1964, precipitation was continuously above average; there has been no comparable period in the last 130 years.

An examination of extremes in the last 100 years shows that the 1950s were extremely anomalous, with four of the "wettest" years (*16*) occurring in close succession (1953, 1954, 1956, and 1957) (Fig. 3). Some exceptionally "dry" years were also clustered; three of the driest years occurred sequentially in 1918, 1919, and 1920, shortly after two other years with extremely low precipitation (1912 and 1913). The large peak in 1878 is of interest as it coincided with the very strong El Niño Southern Oscillation (ENSO) event of 1877–1878 and associated atmospheric circulation anomalies (*17*). However, there was a reduced data set for that period (which tends to increase interannual variability), and no such large anomaly is apparent for the recent 1982–1983 ENSO event of comparable magnitude.

Autumn and winter precipitation show a trend toward higher levels when the entire period of record is considered. No such trend is apparent in the spring and summer data (Fig. 4). However, if only the period of >50% gridded data is considered (that is, since 1883), a trend toward lower index values from the early 1880s to the late 1920s is discernible in the spring and summer data, with an upward trend thereafter. Two periods were generally drier than average in all seasons—those centered on 1917 ± 5 years and 1943 ± 5 years. All seasons were generally wetter than average in the 1950s.

Five major subregions were selected from the gridded data set (the Soviet Union, the

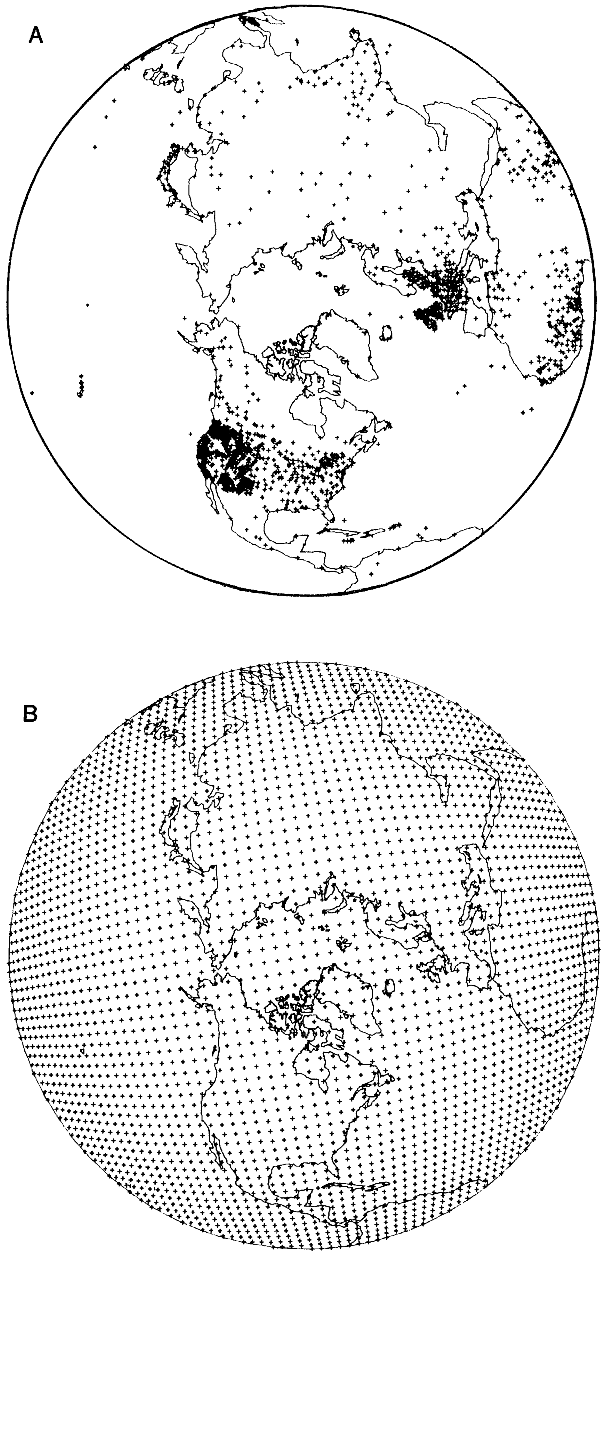


Fig. 1. (**A**) Location of 1487 precipitation recording stations that had data for the reference period 1921–1960. These data were used in the calculation of shape and scale parameters for the gamma probability distributions of monthly, seasonal, and annual precipitation. (**B**) Grid network used in interpolation scheme.

United States, Europe, Southeastern Asia, and Northern Africa–Middle East) and precipitation variability in those areas was examined (Fig. 5) (*18*). In addition, for comparison with GCM model results, data were zonally averaged around discrete latitude bands. The major characteristics of each region are summarized below.

In Europe, annual precipitation has steadily increased since the mid-19th century, with well above average precipitation since the dry spell of the 1940s (Fig. 6). Highest values overall were recorded in 1979. Most of the upward trend in annual precipitation has resulted from increases in winter precipitation; fall and spring seasons show small upward trends, but summer rainfall has actually declined slightly over the past 130 years (*19*).

Precipitation over the Soviet Union has increased dramatically since the 1880s with most of the change occurring before 1900 and after 1940 (Fig. 6). As in Europe, precipitation in 1979 was far above average. In fact, half of the upper decile of values occurred from 1978 to 1984. Examination of seasonal data indicates that the increase in annual precipitation is related to increases in autumn, winter, and spring precipitation. Summer rainfall exhibits very little trend. Abrupt increases in winter precipitation oc-

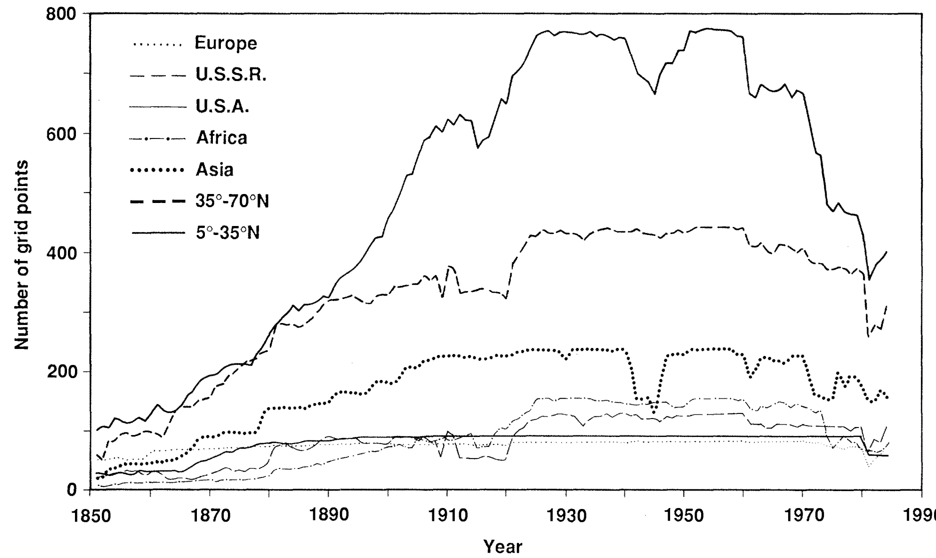
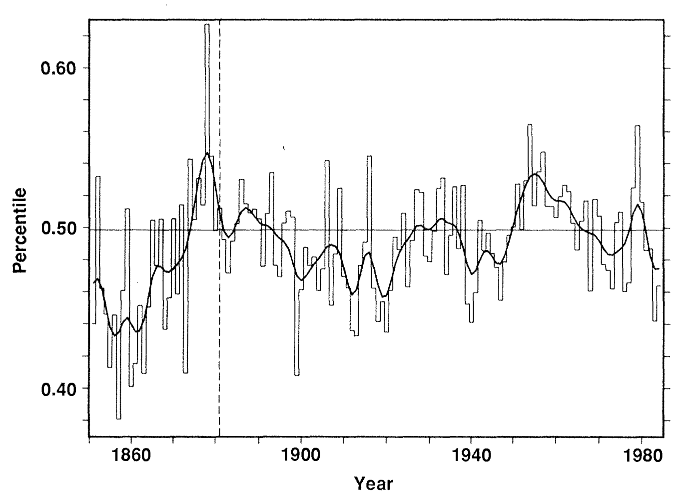


Fig. 2. Number of valid grid points for different latitudinal zones and regions. The years in which the number of points reached 50% of the maximum for each region are as follows: Europe, 1851; Soviet Union, 1881; United States, 1868; North Africa, 1901; Southeast Asia, 1879; 35° to 70°N, 1877; and 5° to 35°N, 1895.



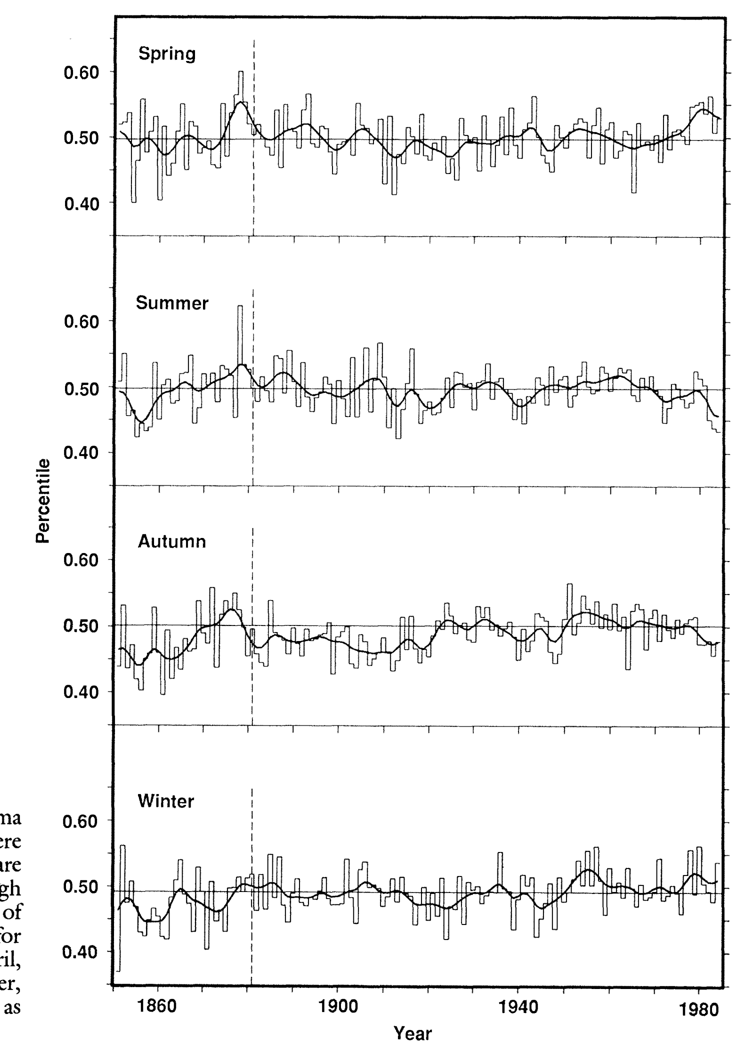


Fig. 3 (left). Annual precipitation index (mean of percentiles of the gamma probability distribution at all valid grid points) for Northern Hemisphere continental regions. Dashed line shows year in which 50% of grid points are available for analysis. Curved line shows the smooth trend line fitted through individual values. **Fig. 4 (right).** Seasonal precipitation index (mean of percentiles of the gamma probability distribution at all valid grid points) for Northern Hemisphere continental regions. Spring includes March, April, and May; summer is June, July, and August; autumn is September, October, and November; and winter is December, January, and February (plotted as year in which January occurs).

curred during the 1890s and 1950s. The increase recorded in the 1950s was partly due to changes in observational techniques involving the widespread introduction of more efficient precipitation gages (*20*).

Precipitation in the United States declined from about 1880, reaching a low in the 1930s, and generally increasing thereafter (Fig. 6). The 1930s and 1950s were relatively dry throughout much of the year, but in the 1920s and 1960s, winter and spring seasons were drier than fall and summer (*21*). Precipitation has increased markedly in the last 30 years, principally as a result of autumn through spring precipitation increases. Summer rainfall has exhibited no comparable trend over this interval.

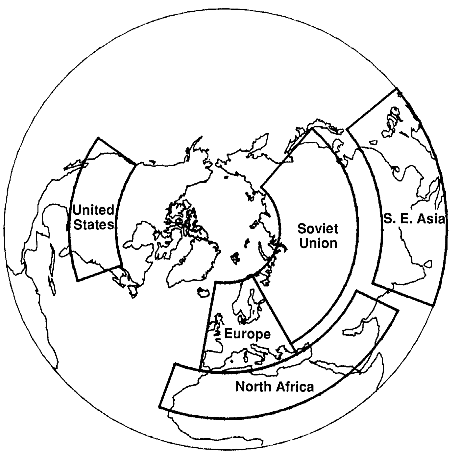


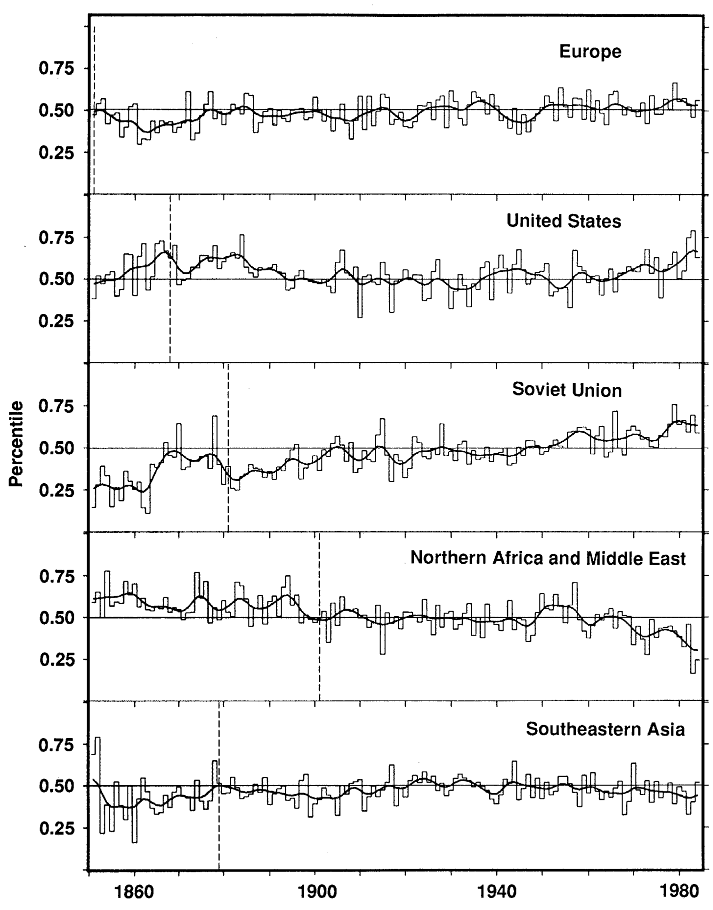
Fig. 5. Location of regions selected for regional precipitation analysis.

In Northern Africa and the Middle East, there was little trend in precipitation until the 1950s when, after a relatively wet episode, precipitation declined drastically (Fig. 6). This decrease is mainly a characteristic of summer and, to some extent, autumn rainfall (the wet season in northern tropical Africa); neither spring nor winter precipitation has declined in recent decades. The lowest mean annual and mean summer values on record were in 1983 (*22*).

A relatively wet episode in Southeast Asia in the 1920s and early 1930s separated two drier periods; the former centered on 1900 and the latter was from the mid-1960s through the present (Fig. 6). The general trend of the last 40 years has been a slight decline in precipitation, which does not appear to be related to any systematic change in monsoon precipitation. Summer rainfall in the area shows virtually no trend since the 1870s.

Precipitation data were also averaged within three latitude bands to compare overall variations with changes simulated by GCMs for conditions with doubled CO_2 concentrations (Fig. 7) (*23*). In the lower latitude zone (5° to 35°N), precipitation showed no systematic trend until the early 1950s when a pronounced downward trend began. By contrast, in the higher latitude zone (35° to 70°N), precipitation has increased markedly in the last 30 to 40 years. This recent upward trend is apparent in all seasons (*24*). In the low-latitude zone, the recent decrease is mainly a characteristic of summer and fall months and is strongly dominated by the African sector. In the north equatorial region (0° to 5°N) (Fig. 7), there is a very slight upward trend in annual precipitation over the last 80 years, but the trend is downward when the last 30 years alone are considered. The effects of the 1982–1983 ENSO episode are evident in this equatorial region in the very low value for 1983 (the lowest value in the record) (*25*). However, since there are few long-term records from this region, any conclusions are subject to the limitations imposed by the poor data coverage there compared to other regions.

Analysis of precipitation data on a hemispheric basis has revealed important changes in climate, which, apart from the well-known declines in North African rainfall, have gone generally unnoticed over the past few decades. Such large-scale shifts in pre-



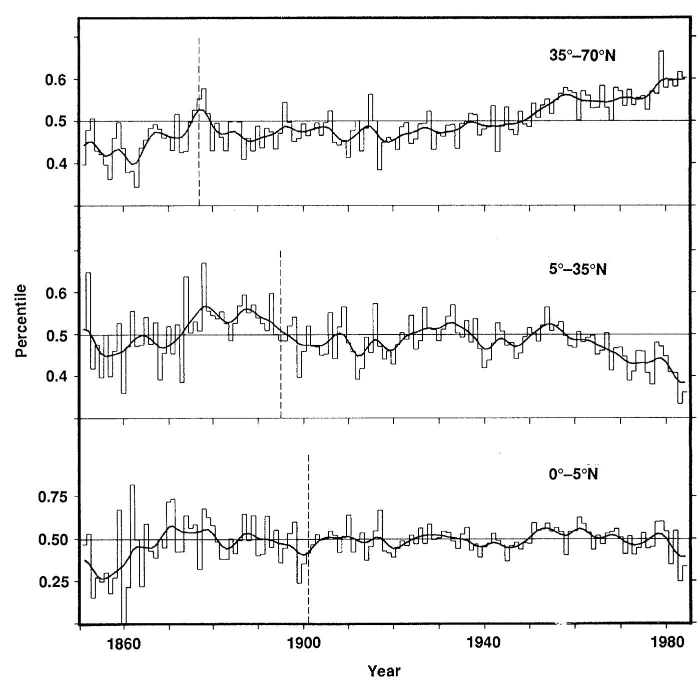


Fig. 6 (left). Precipitation indices for Europe, the United States, the Soviet Union, Northern Africa and the Middle East, and Southeastern Asia. **Fig. 7 (right).** Precipitation indices for zones 35° to 70°N, 5° to 35°N, and 0° to 5° N.

cipitation are of great significance for food production and water resource management, even more so than changes in temperature, which have received much attention in recent years. The trends in zonally averaged precipitation over the last 30 to 40 years are similar to changes predicted by GCM experiments with doubled CO_2 levels. All models simulate overall increases in midlatitude precipitation, and most models suggest precipitation decreases in tropical and subtropical regions, in agreement with observed conditions since 1950. Temperatures over the Northern Hemisphere as a whole have also increased during this interval, although temperatures over land areas declined from the early 1940s to the early 1960s, followed by a warming in the last 20 years (*2*). It would be unwise to link increases in greenhouse gases to trends in the precipitation of specific areas merely because these trends are consistent with theoretical experiments. The magnitude of the observed trends, their geographical distribution, and differences between seasons need to be examined in more detail for both GCM results and observational data. Nevertheless, important fluctuations in precipitation have occurred over large regions, and precipitation trends may provide an additional indicator (together with temperature) in the evaluation of CO_2-induced climatic change.

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20. As winter precipitation in the Soviet Union is a relatively minor component of annual totals, it is unlikely that the upward trend in annual precipitation is entirely due to a change in instrumentation, particularly in view of similar trends, over the last 30 to 40 years, in the United States and Europe.
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22. Because of inefficient data reporting and publication procedures, our data coverage for the early 1980s is very poor. We have only been able to produce a gridded set comparable in density with the late 19th century (Fig. 2). Nevertheless, the extraordinary nature of precipitation anomalies in the early 1980s, particularly in the Western Sahel, has been well documented, for example, by P. J. Lamb [*J. Climatol.* **3**, 419 (1983)] and S. E. Nicholson [*J. Climate Appl. Meteorol.* **24**, 1388 (1985)].
23. Zones were selected to reflect the general conclusions of most GCM experiments that with doubled CO_2 concentrations, precipitation may increase north of 35°N and decrease to the south (except in a narrow zone near the equator).
24. It is unlikely that this upward trend is due to abrupt data inhomogeneities as data from many different countries are combined; about one-third of gridded points in this zone are from the Soviet Union, one-third from Europe, and one-third from North America (Fig. 2).
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Detection of Minimal Residual Cells Carrying the t(14;18) by DNA Sequence Amplification

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By means of the polymerase chain reaction (PCR) technique, DNA sequences were amplified that flank the crossover sites of a characteristic chromosomal translocation for follicular lymphomas, t(14;18)(q32;q21). This technique permitted the detection of cells carrying the t(14;18) hybrid DNA sequences at a dilution of 1:100,000. The remission marrow and blood samples of a patient with follicular lymphoma and the t(14;18) failed to show any abnormality by morphological examination and conventional Southern blot analysis. However, the t(14;18) hybrid DNA sequences were detected by the PCR technique. Thus, this technique is a highly sensitive tool to detect minimal residual cells carrying the t(14;18) and has the potential to identify a subpopulation of patients with subclinical disease.

High frequency of recurrence is one of the major problems in cancer treatment. Relapse from clinically undetectable residual disease is the most likely mechanism. Detection of minimal residual disease is extremely difficult since tumor-specific markers are not readily available. Molecular technology has provided a means to demonstrate residual disease by identifying clonal rearrangement patterns that are present in malignant hematopoietic cells (*1*). Southern blot hybridization detects neoplastic cells at levels as low as 1% of the total number of cells (*2*). However, one of

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