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Extended Edited Synoptic Cloud Reports From Ships and Land Stations Over the Globe, 1952–1996

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Cover Photo: Cumulus in the Western Pacific (15°S, 169°E), June 1987, by John Porter, University of Hawaii.

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ABSTRACT

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Surface synoptic weather reports for the entire globe, gathered from various available data sets, were processed, edited, and rewritten to provide a single data set of individual observations of clouds, spanning the 44 years 1952-1995 for ship data and the 26 years 1971-1996 for land station data. In addition to the cloud portion of the synoptic report, each edited report also includes the associated pressure, present weather, wind, air temperature, and dew point (and sea surface temperature over oceans).

The cloud reports included in this "Extended Edited Cloud Report Archive" (EECRA) have passed through extensive quality control tests. Reports from the source data sets that did not meet the quality control standards were rejected for the EECRA. Minor correctable inconsistencies within reports were edited for consistency. Cases of "sky obscured" were interpreted by reference to the present-weather code as to whether they indicated fog, rain, snow, or thunderstorm. Special coding was added to indicate probable nimbostratus clouds which are not specifically coded for in the standard synoptic code. Any changes made to an original report are also noted in the archived edited report so that the original report can be reconstructed if desired. This "extended edited cloud report" also includes the amounts, either inferred or directly reported, of low, middle, and high clouds, both overlapped and nonoverlapped amounts. The relative lunar illuminance and the solar zenith angle associated with each report are also given, as well as an indicator that tells whether our recommended illuminance criterion was satisfied so that the "night-detection bias" for clouds can be minimized.

The EECRA contains 71 million cloud observations from ships and 311 million from land stations. Each report is 80 characters in length. The archive consists of 841 files of edited synoptic reports, one file for each month of data for land and ocean separately, and 4 ancillary files which provide important information about reporting characteristics of the land stations.

This data set will be useful for applications such as: (1) development of user-defined cloud climatologies for particular subtypes of clouds, or for different temporal and spatial resolution than we have chosen for our atlases, (2) in comparison of satellite cloud retrievals with surface observations, to help diagnose difficulties in cloud identification from satellite, and (3) to relate formation of individual types of clouds to their meteorological environments.

1. INTRODUCTION

Surface synoptic weather reports containing cloud information have been gathered for the entire globe from various available data sets and processed, edited, and rewritten to provide a single data set of individual observations of clouds and other associated weather variables. The reports included span 44 years (1952-1995) for ships and 26 years (1971-1996) for land stations. These cloud data were originally gathered for development of our own cloud climatologies (Hahn et al. 1982; 1984; Warren et al. 1986; 1988; Hahn et al. 1994), and additional years of data have now been processed to accommodate our future climatological studies. As such, the reports in this "Extended Edited Cloud Report Archive" (EECRA) have passed through all the processing procedures for our cloud-climatology work up to the point of being ready to enter into averages. Therefore this archive should be useful to many other researchers for a variety of applications. A preliminary version of the EECRA has been tested by a few users and some results have already been published (Norris 1998a, b; Norris et al. 1998). Some changes have been made to that preliminary version and all future users should obtain the official release presented here.

The EECRA is an update and extension of the "Edited Cloud Report Archive" (ECRA; Hahn et al. 1996) which covered the 10-year period 1982-1991. Much of the documentation herein is similar to the report for that data set but with additional sections required to discuss the extended format which accommodates the other weather variables, the extended time period which spans changes in data coding practices, and several ancillary files which provide important information about reporting characteristics for ships and land stations. Also, an updated version of our source data for ship observations (see Section 2) was used for the EECRA, resulting in a 34% increase in ocean data volume for 1982-1991 over that of the ECRA.

The EECRA has several features that facilitate its use in cloud analyses:

1) Data sets of synoptic weather reports include reports that do not contain cloud information, such as those from automated weather stations on land and buoys in the oceans. These are excluded from the EECRA.
2) The cloud portion of the synoptic report occasionally contains obvious errors or inconsistencies which must be checked for to avoid inclusion of detectably erroneous data in an analysis. Quality control procedures which we have developed over years of analyzing surface cloud reports have been applied so that erroneous or inconsistent reports have either been excluded or, if possible, corrected before inclusion in the archive.
3) Although the amount of low cloud is coded directly into the synoptic report, the amounts of middle and high clouds are not, but they may often be inferred. Where possible for upper level clouds, the EECR (an individual report in the EECRA) includes the "actual" cloud amount (sometimes requiring use of the random-overlap assumption) as well as the non-overlapped amount, which is simply the amount actually seen from below.
4) Cases of "sky obscured" were interpreted by reference to the present-weather code as to whether they indicated fog, rain, snow, or thunderstorm. Special coding was added to indicate probable nimbostratus clouds which are not specifically coded for in the standard synoptic code. Any changes made to an original report are also noted in the edited report so that the original report can be reconstructed if desired.
5) Although all reports that meet the above criteria are included in the EECRA, many of the nighttime reports were made under conditions of insufficient illumination for adequate detection of clouds. Use of such reports results in an underestimate of nighttime cloudiness by about 4% globally and has a profound influence on computed diurnal cycles in cloudiness (Hahn et al. 1995). Reports made under conditions that satisfy the criterion for adequate illumination developed by Hahn et al. (1995) are flagged in the EECR, and both the relative lunar illuminance and the solar altitude are given for each report.

6) Synoptic weather reports contain information in addition to clouds, such as air temperature, pressure, winds, humidity, visibility, past weather and, for ships, sea surface temperature and ocean wave parameters. The EECR retains only the most common weather variables, thus reducing the data volume while allowing cloud characteristics to be assessed within the context of the surrounding meteorological environment. Since only reports with cloud information are retained here, many reports with temperature, pressure, etc., but no cloud data, were eliminated.

Non-standard terms used in the following discussions are defined in the glossary of terms and abbreviations in Appendix A.

CAUTION: The following sections should be given special attention for effective use of the cloud data in this archive:

Avoiding the clear-sky and sky-obscured biases for cloud types, Sec. 5.3.
Computation of cloud type frequencies and amount-when-present, Sec. 5.1.
Amount-when-present of altostratus clouds for regions of China, 1971-79, Sec. 5.1.4.
Illuminance criterion for avoiding the night-detection bias, Secs. 3.6, 5.2.

And of less critical nature are:

Use of land stations in trend analyses, Sec. 5.4.
Incorrect latitude and longitude for some land stations, Sec. 5.5.
Note on declining number of USA stations since 1982, Sec. 6.5.
Missing cloud heights in NCEP data beginning September 1994, Sec. 3.4.

2. SOURCE DATA

All source data were obtained from the Data Support Section, National Center for Atmospheric Research (NCAR), Boulder, Colorado.

For land data, two data sets were processed. For 1971-1976 we used the "SPOT" archive of the Fleet Numerical Oceanography Center (FNOC). For 1977-1996 we used data from the National Centers for Environmental Prediction (NCEP; formerly NMC). Reasons for not using land data prior to 1971 are given by Warren et al. (1986). About 315 million reports were processed. Only those stations assigned official station numbers by the World Meteorological Organization (WMO) were used. (See Section 6.5 for comments on characteristics of USA station reports.) Synoptic reporting hours are 00, 03, 06, 09, 12, 15, 18, 21 Greenwich Mean Time (GMT). The source data for 1971-1977 are sorted first by time and second by station number for each month of data. This sort is retained in the EECRA. In the NCEP archive for 1978-1996, the 6-hourly reports (00,06,12,18 GMT) are stored in separate files from the intermediate 3-hourly reports (03,09,15,21 GMT). Within each of these two groups the reports are sorted by time and station number. We processed the two groups in tandem for each month so that in the EECRA the 6-hourly reports occur first within a file, followed by the intermediate 3-hourly reports.

The source we used for ship observations is the Comprehensive Ocean-Atmosphere Data Set (COADS; Woodruff et al., 1987; 1998). About 74 million reports were processed, excluding the large number of buoys and other weather reports that do not contain cloud information. (Prior to about 1980 less than 5% of the COADS reports fell into these two categories. During the 1980's this fraction began to increase and in January 1995 the fraction was 58%.) The Release 1 CMR5 data were used for 1952-1979, Release 1A LMRF6 data were used for 1980-1992, and a Release 1A Extension was used for 1993-1995. The Release 1A data are provided in a synoptic sort by time. For the EECRA, the data for each time were then sorted by latitude and longitude. Reports from Release 1 data had to be re-sorted to match this order. More

current data were not yet available at the time of the present work. Data prior to 1952 are not included because cloud type information was considered to be unreliable prior to that time (Warren et al., 1988). [Cloud-type reporting actually did not stabilize until 1954, as shown in Figures 3 and 4 of London et al. (1991).]

2.1. Some Problems Encountered in Source Data Sets

For those who might have occasion to access the source data sets used here, we can point out a few problems that we have encountered with them. Some of these will be discussed in more detail in later sections.

Of the 71 months of SPOT data processed, 20% contained some erroneous station elevations of >5000 m or <-400 m. (Actual station elevations range from -350 m to 4877 m.) Investigation showed that these occurred in "bad blocks" of data which contained other errors as well, a consequence of the data format employed by FNOC. All reports from these blocks were excluded from the EECRA. Only one case of station elevation >5 km occurred in the NCEP data. That was in the 1977 data and was corrected for inclusion in the EECRA.

Approximately 0.6% of the SPOT reports were duplicates; i.e. a second report from the same station at the same time. We retained these in the EECRA and did not check to see if the weather data in the duplicate reports were identical (sometimes such reports differ in only a single variable and sometimes one report contains cloud-type information and the other does not). The NCEP data had no duplicates until 1993, and after 1993 had less than 0.005% in the worst-case month.

In the SPOT data set we frequently encountered stations (identified by their WMO station ID number) whose reported latitude or longitude changed one or more times within a month of data. These were not actual station moves, but round-off errors (latitude and longitude are given only to one decimal place in the SPOT data record) or data-entry errors. Some such latitude-longitude switches did occur in the NCEP data but they were rare. Since such errors can affect the assignment of reports to grid boxes for averaging, this problem is dealt with further in Section 5.5.

From mid-September 1994 through (at least) April 1997, all cloud base heights are in error in the NCEP data. This was discovered by noticing that no height codes (see Table 1) in the range 4 to 8 occurred in the data reports during this period. (If unnoticed, this would imply quite a lowering of cloud base heights in recent years!) These erroneous heights resulted from a processing error at NCEP. They will not be corrected by NCEP in existing data but will probably be eliminated in future data releases (G. Walters, NCAR, personal communication, 1997). In the EECRA we have corrected these erroneous heights by reference to the SPOT data set for those years, as discussed in Section 3.4.

Until September 1993, the NCEP data set included an identifiable class of reports from the United States airways reporting system. These "hourlies" reports, identified by call letters rather than by WMO station numbers, are eliminated from all of our cloud analyses because the reporting procedures for clouds in these reports do not use the WMO synoptic code and cannot be reconciled with it. Beginning in 1982 when NOAA began to close synoptic weather stations in the United States, airways data were "converted" into the synoptic format and included in the NCEP data set with corresponding WMO station numbers (D. Joseph, NCAR, personal communication, 1997). A flag to identify these reports as "converted hourlies" is included in the NCEP data record beginning in 1983, so we were able to eliminate them from the EECRA. We manually deleted 39 stations for 1982. See Section 6.5 for further discussion.

The COADS data set is generally reliable. Some reports from the Arctic Ocean, which were included in the EECRA, contain unrealistically high air temperatures (>25 C) and similarly high sea surface temperatures. These are probably mis-located reports which should be excluded from Arctic cloud analyses.

The present-weather indicator (I_x, Section 3.2) was not available in ship data from 1982 to about 1985, but a slot for it was added to the LMRF format in COADS Release 1a.

2.2. List of Data Periods Known to be Missing

Land station data for the entire globe are missing in the source datasets for the following times, so they are missing also in the Land EECRA.

Year	Month	Days	hours,GMT	Year	Month	Days	hours,GMT
SPOT Data				NCEP Data			
1971	Jan	26-31		1977	Apr	28	06-21
	Feb	1-15				29	00-09
	May	4				30	06-15
	Jul	16-19			Jul	5-6	
1973	Aug	7-16		1978	Apr	20	i3-hrly
1974	May	2-12				22-23	i3-hrly
	Aug	7-9				25-26	i3-hrly
	Nov	16-19		1979	Nov	9-10	6-hrly
1975	Jan	18-23		1981	Apr	22	i3-hrly
	Feb	1-5		1982	Jul	4-10	i3-hrly
	Sep	19-30		1984	Apr	15-19	i3-hrly
	Oct	10-16		1986	Nov	2-8	i3-hrly
	Dec	12-25					
1976	Nov	14		1987	Oct	11-13	all but 00,12

3. PROCESSING OF WEATHER REPORTS

3.1. Cloud Information in Synoptic Reports and the "Extended" Cloud Code

Synoptic weather reports are coded according to the system given by the World Meteorological Organization (WMO, 1988). The information in these reports that relates to cloud analysis is summarized in Table 1. The other weather variables included in the EECR are described in Section 4.1. A more detailed breakdown of the definitions of the cloud and weather types, as used here, is given in Table 2. The table shows the synoptic codes that correspond to various precipitation types (ww codes) as well as the codes that correspond to the various cloud types defined within each of the three reporting levels: low, middle and high (C_L, C_M, C_H).

We give special consideration to the cloud type nimbostratus (Ns), which is not specifically defined in the synoptic code. Codes C_M= 2 or 7 may signify Ns but may also signify As or Ac, respectively. We consider these codes to signify Ns when there is concurrent precipitation in the form of drizzle, rain, or snow as indicated in the present weather code ww (symbolized in Table 2 as D, R and S, respectively). To distinguish Ns from As/Ac we "extend" the synoptic code for C_M to include the values 12 and 11 to represent these cases of C_M= 2 and 7, respectively. The extended code values (shown in Table 2) are entered in the edited cloud report (Section 4) without loss of the information content in the original report.

Nimbostratus is also considered to be present when the middle level is unreported (C_M= /) and specified combinations of precipitation and low cloud types are present (Table 2). These

cases are given the extended code C_M= 10. This definition for Ns has been simplified from that used in our previous work (W86, W88). We no longer define cases of C_M=/ with low stratus and drizzle to be Ns because such clouds are probably thin and do not extend up to the middle level. This will cause a slight reduction in computed Ns amounts in comparison to W86 and W88 (Section 6.3).

Special consideration is also given to the case of N=9 (sky obscured). If ww indicates that the sky was obscured due to F, Ts, or DRS (symbols defined in Table 2), the cloud type is considered to be Fo, Cb, or Ns, respectively, and is given the extended code C_L=11, C_L=10, or C_M=10, respectively, and the value of N is set to 8 oktas.

All the changes described here are coded in a parameter called "the change code" (Section 3.3 below) which is also included in the edited cloud report (Section 4), so that the original report can be reconstructed if desired.

3.2. Processing Through the Total Cloud Stage

A cloud report may be suitable for total cloud analysis even if cloud type information is missing or incomplete. Certain inconsistencies within the cloud-type portion of the report may, however, make the whole report suspect and cause us to reject it even for total cloud analysis. The processing and quality control checks performed on each weather report read from the original archive (FNOC, NCEP or COADS), and designed to ensure suitability for total cloud analysis, are shown in the flow chart in Figure 1. The percentage of reports discarded at each stage of the processing, discussed in the following paragraphs, is indicated.

In the early stages of processing, land and ship reports required slightly different checks (upper portion of Figure 1). A land station that did not have a WMO station number was discarded (most of these were airways data from the United States, not originally reported in the synoptic code), thus ensuring more uniformity in reporting procedures. Any ship report known to be from a buoy (by the "deck" number in the COADS data) was discarded. Any report that had no cloud information (N=/) was discarded.

In 1982 WMO introduced several changes in the coding procedure (WMO, 1988). One of these changes is that observers are now permitted to set ww=/ if present weather was either "not available" or "observed phenomena were not of significance" (ww codes 00-03 are considered to represent phenomena without significance). The present weather indicator, I_X, is used to distinguish these cases. Land station reports with I_X values of 4, 5 or 6 signify automatic weather stations and were discarded. Reports with I_X=3 (data not available) were also discarded because without ww it is not possible to interpret cases of N=9 (see W86) or to evaluate the occurrence of precipitation. I_X=2 indicates that observed phenomena were not of significance, while I_X is coded as "1" when ww is given. Occasionally I_X=1 when ww=/; these inconsistent reports were also discarded.

Examination of the NCEP data set showed that while land stations adopted this new coding procedure almost immediately, I_X was not consistently coded in ship reports until 1985. We therefore did not screen ship reports on the basis of I_X. Appendix F1 gives the relative occurrence of various present weather codes (where "-1" represents a "/" in the original report) over a sampling of years for both land and ship data, globally. For land, reports with ww=/ were excluded from the EECRA prior to 1982 and I_X inconsistencies were excluded from 1982 onward, so that the sum of the codes -1 to 3 in the EECRA remained within the range 71 to 74% (with 1995 at 76%, possibly because of the deterioration of surface reporting in the 1990's as discussed in Section 6.5). For ships, present weather was reported about 99% of the time from 1962 to 1981 and the sum of the codes -1 to 3 remained fairly constant at about

80% from 1962 to 1995. The large values for ww=-1 from 1952 to 1961 are a result of the inclusion, in those years, of data from the Historic Sea Surface Temperature Project (HSST) in which both present weather and cloud-type information were artificially deleted by the data processors (thus ww=-1 and C_L=-1 in the EECRA). (The HSST data are retained in the EECRA for total cloud analyses but will not contribute to cloud-type analyses.) Because of the inability to perform consistency checks for I_X on the ship data, some reports which should ideally be eliminated are included in the EECRA.

At the upper horizontal dashed line in Figure 1, 315 million land reports (1971-96) and 73.5 million ship reports (1952-95) remained. The discard-fractions given below this line are fractions of these numbers. If the reported latitude and longitude of a land station assigned the station into a grid box that is entirely water (0.05% of the reports) or if the reported location of a ship assigned the ship into a box that is entirely land (0.1%), the report was discarded. Stations on small islands in an otherwise ocean grid box are included in the land data, and reports from the Great Lakes and the Caspian Sea are included in the ship data (Sec. 5.3.2).

If the sky was obscured (N=9) by fog (ww=F; 1.1% land, 1.9% ship), thunderstorms-showers (ww=Ts, abbreviated as T in Figure 1; 0.05% land, 0.1% ship), or drizzle-rain-snow (ww=DRS, abbreviated here as R; 0.4% land, 0.6% ship), the sky was considered to be overcast (N=8). This source of "cloudiness" contributed about 1% to the total cloud cover globally, and much more in some locations and seasons (Hahn et al., 1992). Clouds could not be inferred if the sky was obscured for other reasons, such as blowing dust or snow, and such reports were discarded. The change code, IC=1 (discussed in Section 3.3 below), signifies that a report came through the N=9 branch of the processing. Thus 1.6% of the land reports and 2.6% of the ship reports had N=9 with the ww codes D, R, S, F or Ts.

For our earlier ocean cloud atlas (Warren et al., 1988), which included data only through 1981, we converted N=9 with ww=/ to N=8 for total cloud analyses. Less than 0.1% of the reports fell into this category. We do not make that conversion for the EECRA because after the 1982 code change a large fraction of the reports have ww=/.

Other consistency checks indicated in Figure 1 ensure that the low cloud amount is not greater than the total cloud cover, that precipitation (as defined in Table 2) is not reported with a clear sky, and that if cloud is present (and types are reported), a cloud type must be indicated in at least one of the three possible levels (this test actually discards a report if N>0 and C_L=0 and $C_M \leq 0$ and $C_H \leq 0$).

The re-coding indicated in the lower left box in Figure 1 is necessary only for post-1981 data because of the 1982 code change (WMO, 1988) that instructs observers to set $C_L=C_M=C_H$=/ when N=0 (this requires special attention in cloud type analysis and will be discussed in Section 5). Prior to 1982, stations which normally report cloud types entered 0's for the cloud type variables when N=0, while stations which do not report cloud types entered /'s. These /'s are left intact in the pre-1982 reports so that these two types of stations can be distinguished, thereby avoiding the "clear-sky bias" introduced into the post-1981 data. Methods for avoiding this bias in post-1981 data are described in Section 5.3.

The number of reports that survive these tests and are suitable for total cloud analysis (referred to as "total reports", as opposed to "type reports") is 311 million for land and 71 million for ships. Of these, 227 million and 52 million, respectively, were made under sufficient solar or lunar illuminance (referred to as "light reports") to meet the established illuminance criterion for adequate cloud visibility (Hahn et al., 1995).

3.3. Consistency Checks for Cloud Types, and the Change Code

The reports that failed the cloud type consistency checks shown in Figure 1 were discarded. Other inconsistencies are possible which may be correctable or may provide cause to reject the report for cloud type analysis while allowing it to contribute to total cloud analysis. As the synoptic reports were processed, any inconsistency encountered required a change to be made in the report before it was entered into the EECRA. Any changes thus made are noted by assigning a "change code" (IC) to that report. This change code, with values 0 to 9, is given in the EECR (Section 4) so that modifications made to the original report can be identified.

The change codes are described briefly in Table 3 along with the frequency of occurrence of each change type. Details of the cloud type processing, which follows the total cloud stage shown in Figure 1, are presented in the form of the FORTRAN code in Table 4. Each segment of the table (delineated by a change code heading) describes the processing of a particular type of inconsistency or change. The changes referred to by IC=1 were discussed in section 3.2. Most of the inconsistencies under consideration have been discussed previously (W86, W88) but are summarized here.

For a report to provide useful cloud type information, C_L (and usually Nh) must be given. If C_L is missing (and was not "corrected" by reference to ww in cases with N=9), then the report cannot be used for cloud type analysis and all cloud type variables are set to -1 for consistency (segment IC_5 in Table 4). There is one situation, the case in which there is middle cloud but no low cloud, shown in the IC_2,4 segment in Table 4, for which C_L can be given with Nh missing. In that case Nh should give the middle cloud amount, but in many reports from China in the 1970's, Nh was improperly reported as 0 (W86; see also Section 5.1.4). If there was no high cloud then we can correct the report by setting Nh=N (IC=2). But if high cloud is present, then the value of Nh is indeterminate and set to -1. Here again IC is set to 2 (which differs from the handling in H96 which dealt only with post-1981 data) and the report can be used for determination of cloud type frequency but not amount. Because of these changes, it is possible for an EECR to show C_L=0 with Nh = -1. This special procedure is of little consequence in the EECRA except for the Chinese stations in the 1970's for which it was designed. (Compare fractions of C_L=-1 and Nh=-1 in the tables of Appendix F.)

The situation is similar in segment IC_3,4. If only high cloud is present, Nh should properly be 0 but is occasionally given the value of N by an observer. This is readily corrected (IC=3). On rare occasions 0<Nh<N with only high cloud present; such a report is irreconcilably inconsistent and we reject it for analysis of cloud type amount by setting Nh=-1 (and IC=4).

When middle and high clouds are unobservable because of low overcast, they are sometimes misreported as C_M=C_H=0 rather than C_M=C_H=/; and when they are observed to be absent they are sometimes misreported as C_M=C_H=/ rather than C_M=C_H=0. Segments IC_6 and IC_9 correct these cases and also incorporate our own conclusion that an observer cannot be sure of the absence of high cloud when lower cloud covers 7 oktas of the sky.

Segments IC_7 and IC_8 set C_M to represent our definition of Ns as a convenience for future cloud type analyses. However, the original report can be reconstructed if desired.

It was important to perform these tests in the order stated. For example, if segment IC_8 were performed before segment IC_6, then some cases of Ns would go undetected. Also, segment IC_9 must be performed after IC_8 for the same reason. However since it is not desirable to have the change code IC=8 overwritten by the relatively trivial change IC=9, even if change 9 is made, the code 9 is entered in IC only if no previous change has been made

(second part of segment IC_9 in Table 3). This co-occurrence of change codes should be rare since N is usually large when Ns is present.

From Table 3 we see that some change is made in about 13% of all reports, but that about half of the changes just represent classifying an observation as Ns, Cb or fog. Thus about 5% of land reports and about 7% of ship reports have been changed due to inconsistencies and most of these are due to the trivial cases of IC=6.

After passing the cloud type consistency checks, the number of light reports available for cloud type analysis for 26 years of land data is 223 million and for 44 years of ocean data is 44 million (Table 5). Reports suitable for cloud type analysis ($C_L > -1$) are referred to as "type reports".

3.4. Corrected Values for Cloud Base Heights in 1994-96 Land Data.

As mentioned in Section 2.1, no cloud height codes in the range h= 4 - 8 occur in the NCEP data from mid-September 1994 through April 1997. (We discovered that somehow height codes 4 had been converted to 0, 5 to 1, 6 & 7 to 2, and 8 to 3.) These erroneous heights occur in the NCEP data set but not in the SPOT data. To correct this problem for the EECRA, we compared reports from the SPOT data set to reports from the NCEP data set, and inserted SPOT heights into the EECR when a match was found. (A match was considered to be made if the cloud portions of the two reports were otherwise identical for a station at a given time.) For any EECR that could not be matched to a SPOT report (NCEP data contain more reports than SPOT data), h was set to -1. In this way about 80% of the erroneous reports were corrected in the EECRA for the affected months.

3.5. The Amounts of Middle and High Clouds

The synoptic code contains two cloud amount variables, N and Nh. The amount of low cloud, if present, is directly specified by Nh. While the amounts of upper level clouds (middle and high) are not specified directly, they may often be inferred. Thus when $C_L=0$, the amount of middle cloud is given by Nh, and when $C_L=C_M=0$, the amount of high cloud is given by N. If clouds are present at all three levels, the upper cloud amounts cannot be determined from the report. If clouds are present at just two levels, the amount in the higher of the two levels may be estimated if the extent of overlap is assumed.

The EECR provides amounts for which the random overlap assumption was used, where necessary, to estimate the actual cloud amounts (the fraction of the sky occupied by a cloud type, whether visible or not). The EECR also gives the non-overlapped amounts which require no assumptions but which represent only that portion of the upper level cloud visible from below. [Satellite-derived cloud amounts given by ISCCP (Rossow and Schiffer, 1991) are the non-overlapped amounts seen from above.] The random overlap assumption was justified for vertically separated cloud layers by Tian and Curry (1989).

Table 6 gives our method, in the form of FORTRAN code, for determining the actual and non-overlapped amounts of middle and high clouds from a synoptic weather report. This table differs slightly from that in H96 in order to accommodate the possibility of Nh=-1 with $C_L=0$ (lines 5-, 6+ ,24+, 35&). A few points should be noted. The random overlap equation (lines 17 and 38) is invoked only when Nh<7. Table 7, which gives the outcomes of the possible combinations of N and Nh in the equation, shows that only two outcomes are possible for the higher cloud amount when Nh=7, namely 0 and 8 oktas, making this a highly inaccurate determination (W86). In these cases we therefore leave the higher cloud amount undetermined.

However, if the higher cloud is Ns, we assume maximum overlap and assign to Ns amount the value of N (lines 13-14, Table 6). In this case the nimbostratus cloud layer is likely to be adjacent to or continuous with the low cloud, so the maximum overlap assumption is more appropriate (Tian and Curry, 1989). Also, certain arbitrary decisions are sometimes required, such as our choice, in line 7 of Table 6, to allow middle cloud to be computed when C_H=/. This choice is justifiable since such a case tends to occur with large N so that any error induced in this situation would be small.

The numbers of reports processed through each path in Table 6 are listed in Table 8. Light reports (for which the illuminance criterion was met) and dark reports (for which it was not) are both shown for comparison. Non-overlapped (NOL) amounts were computable in more than 90% of the cloud-type reports since one can know that a cloud cannot be seen even if one does not know whether it is present. Thus the non-overlapped amount of an upper level cloud is frequently zero.

Percentages are not explicitly shown in the table but it can be seen that upper level clouds are reported present more frequently in the set of light reports than in the set of dark reports (38% and 30%, respectively, for land middle clouds, and 40% and 25% for ocean middle clouds, for example). When upper clouds are present, they are more frequently computable within the set of dark reports and the random overlap assumption (ROL) is less often required. [This is an artifact of the lessened ability to distinguish different clouds under conditions of poor illumination and we recommend that dark reports not be used to develop cloud climatologies, as explained in the next section.] Upper level clouds, when reported present, are less likely to be computable in an ocean report than in a land report and are more likely to require ROL because low level clouds are nearly always present over the oceans. (The percentages given here merely represent the fractions of reports within the data set and are not area-weighted global averages.)

3.6. Determination of Cloudiness at night

The ability of surface observers to adequately detect clouds at night has been questioned for many years (e.g. Riehl, 1947). In an attempt to find a practical solution to this "night-detection-bias", Hahn et al. (1995) analyzed ten years of nighttime data for the latitude band 0-50^{o} N and plotted reported cloud cover as a function of the illumination due to moonlight, which depends on the phase and altitude (angle above or below the horizon) of the moon and on the distance of the moon from the earth. The total cloud cover reported at night increased as the lunar illuminance increased up to a certain threshold, then leveled off. This threshold value of moonlight is referred to as "the illuminance criterion" and can also be satisfied by the twilight produced by the sun at about 9 degrees below the horizon. Thus the illuminance criterion is met when either the sun is at an altitude greater than -9^{o} or the phase and altitude of the moon are such that its illuminance exceeds the threshold value of 0.11. These conditions were determined for each report using an ephemeris program together with the latitude, longitude, year, month, day, and time of the report.

This illuminance criterion was applied in analyses of total cloud cover and clear-sky frequency (Hahn et al., 1995). Application of the illuminance criterion increased the computed global average total cloud cover at night by about 4% and thus increased the daily average computed cloud cover by about 2%. Diurnal cycles of total cloud cover over land, which typically show daytime maxima, were reduced in amplitude when compared to previous studies which did not use the illuminance criterion (W86). Over the oceans, the increased computed nighttime cloud cover was often sufficient to result in nighttime maxima, in contrast to the daytime maxima previously reported (W88). Preliminary surveys conducted in conjunction

with the present work suggest that we should expect similarly dramatic effects on analyses of middle and high clouds but little effect on low clouds.

Because of the importance of moonlight in the detection of clouds at night, parameters relating to the illuminance criterion are included in the edited cloud report (Section 4). Reports for which the illuminance criterion is met are referred to as "light reports", as opposed to "dark reports" (for which it is not met) or "all reports" (both light and dark).

4. THE EXTENDED EDITED CLOUD REPORT AND THE DATA ARCHIVE

4.1. Contents and Format of the EECR

Table 9 shows the variables included in the EECR, the number of characters allocated for each, and the maximum and minimum values allowed. Each item in the table is discussed briefly below. Sample reports selected from ship and land data (mostly from December 1981 and January 1982 with a few from earlier years) are provided in Table 10. These reports are in the order in which they appear in their respective files (see next section) though these selections are not consecutive within the file. The reports are numbered in the table for convenience.

Item 1: The first item in the report gives the year, month, day and GMT hour of the report, with two characters allotted for each. There are no spaces ("3", for example, is given as "03") so that the entire item can be read as a single integer. Only the last two digits of the year (1900's) are given. Months are coded as 01 through 12, representing January through December.

Item 2: The IB variable ("B" for "brightness") indicates whether the illuminance criterion of Hahn et al. (1995) was satisfied (IB=1) at the time and place of the report or not (IB=0). This variable can be checked in lieu of SA and RI (items 19 and 20 below) if one accepts the criterion recommended by Hahn et al. (1995).

Item 3: The latitude is given in degrees to two decimal places and written as a 5-digit integer, so it must be divided by 100 to obtain the actual latitude. Actual values range from +90 to -90 for 90N to 90S, respectively. In land reports for 1971-76 the second decimal place is always "0".

Item 4: The longitude is given in degrees to two decimal places and written as a 5-digit integer, so it must be divided by 100 to obtain the actual longitude. Actual values range from 0 to 360E. In land reports for 1971-76 the second decimal place is always "0".

Item 5: For land stations, ID is the 5-digit WMO station number (WMO, 1977). For ships, ID makes use of only 4 digits, the first 3 of which contain the card deck number (Slutz et al., 1985), while the last digit is the "ship type" (Appendix G) provided in the COADS data report but is of questionable reliability.

Item 6: This parameter indicates whether a report is from a land station (LO=1) or a ship (LO=2).

Items 7-13: These weather and cloud variables are coded as specified by WMO (1988) except that items 11 and 12 have been "extended" as described in Section 3.1 and Table 2. Also, cases of N=9 (item 8) that were not discarded have been converted to N=8. Any such conversion is recorded in the "change code" (item 18 below). The value "-1" indicates missing data. Item 8 (N) does not obtain a value of -1 in this data set since all reports with N=/ were

discarded during processing. Item 10 (h) may have a value of 9 only when a cloud is present since h was set to -1 in cases of N=0 (Figure 1).

Items 14-15: These variables give the "actual" cloud amounts of middle and high clouds, determined with use of the random overlap equation if necessary (Section 3.5). Values are given in oktas to two decimal places and written as 3-digit integers, so they must be divided by 100 to obtain the actual values. An actual value of 9 (coded value 900) indicates missing data.

Items 16-17: These variables give the "non-overlapped" amounts, in oktas, of middle and high clouds; i.e. the amounts visible from below (Section 3.5). A value of 9 indicates missing data.

Item 18: The change code indicates whether a change was made to the original report during processing. Code values are defined in Table 3. Two digits are allotted in the EECR for IC but the codes used here require only a single digit. A change code of 0 means that no change was made other than the trivial change of converting /'s to 0's in the case of N=0 in the post-1981 data. Examples of reports with each change code are provided in Table 10.

Items 19-20: These variables give the solar and lunar parameters needed to determine the illuminance provided by the sun or moon for the date, time and location of the report (Section 3.6). SA is the altitude of the sun above the horizon, given to a tenth of a degree (divide the coded value by 10 to obtain the actual value). RI is the relative lunar illuminance defined by Hahn et al. (1995): $RI = F \sin(A) (R^2/r^2)$, where A is the lunar altitude, r is the earth-moon distance, R is the mean earth-moon distance, and F is the lunar phase function which varies from 0 to 1 in a concave shape such that a half moon is only 8% as bright as a full moon (Hahn et al., 1995, Figure 1). The illuminance criterion of Hahn et al. (1995) is satisfied (IB=1, item 2) when $SA \geq -9^{o}$ or RI>0.11. A negative value of RI means the moon was below the horizon.

Items 21-28: These relate to weather variables other than clouds. Since these are not our main focus, we did not do an in-depth analysis of these variables but performed basic quality control checks. The COADS group (Slutz et al., 1985) did extensive quality control testing on the ship data. We merely blanked (set to our missing-value code) variables whose values were coded as "trimmed" from the COADS summary data. For the land data, we checked whatever quality indicators were available (these are different in the SPOT and NCEP data sets), blanked those indicated to be "bad" or "inappropriate" (e.g. pressure given for an elevation other than sea level), and blanked variables outside the ranges shown in Table 9. Examples of a variety of cases are provided in Figure 10. A few comments about the individual variables follow:

Item 21: SLP. About 95% of the SPOT pressures were indicated to be for sea level. It was very rare for any of these to be out of range. The NCEP quality mark was usually missing and about 5% of the values were out of range.

Item 22: WS. NCEP wind speeds are given in knots and we converted them to m/s for the EECRA. SPOT data contained both knots and m/s (about 50% each) and were handled according to an indicator. In the land data, a very few cases of wind speed > 99.9 were converted to 99.9. (There are only 231 such cases in the entire data set, most of which occur in reports from the early 1970's. An incorrect indicator in a SPOT report could result in an interpreted speed to be either twice or half the true value.) The COADS CMR5 data (1952-79) gave wind as u and v (east and north components) which we converted to speed and direction.

Item 23: WD. Wind directions (the direction, in degrees, 0 to 359, from which the wind blows) were originally given to 10's of degrees although ship data taken from the COADS CMR5 will show values to 1^{o} in the EECRA because of conversion from the u,v components. For land and pre-1980 ship data WD is given as 0 when WS is 0. COADS LMRF included a

code of 361 ("calm") for wind direction with wind speeds of 0. We retained this. However we converted COADS code 362 ("variable") to -1 for the EECRA.

Item 24: AT. Air temperatures were given to 0.1° Celsius in COADS. The SPOT data gave temperatures only to whole degrees; fractional degrees appear in NCEP data beginning in 1982.

Item 25: DD. Dew point depression was given as the moisture variable in NCEP and COADS CMR5 data. Dew point temperatures were given in SPOT and COADS LMRF data and were converted to depression values for the EECRA. A few DD values >70 were converted to 70 for the EECRA.

Item 26: EL, SST. For land data this variable gives station elevation (see Section 2.1) to whole meters. For ship data this variable gives sea surface temperature to tenths of a degree.

Item 27: IW. For ship data IW=1 means that wind speed was measured and IW=0 means it was estimated or the method was unknown. For land data IW means something different and is less useful. A value of "1" means that the "wind quality mark" (in NCEP source data) signifies that wind data should be retained, while "0" signifies that wind data should not be used (and are blanked in the EECRA). A value of "9" means that the indicator itself is "missing". This is by far the most common case. SPOT data do not have this indicator and EECRA values for IW are always "9" for land data prior to 1977.

Item 28: IP, IH. For ship data IH=1 means that cloud base height was measured and IH=0 means it was estimated. IH=9 means the method was unknown. For land no similar variable was available so we make use of the available space by giving the quality flag used to evaluate SLP in item 21, calling it "IP". For SPOT data the value is usually "1" while for NCEP data it is usually "9". A value of "0" is associated with SLP=-1. (Items 27 and 28 could have been omitted in favor of a 4-digit value for the year.)

4.2. Organization of the Archive

The EECR data are divided into 841 files, one for each month for 26 years of land observations (Jan 1971 to Dec 1996) and 44 years (plus one month) of ocean observations (Dec 1951 to Dec 1995). Within each month the reports are sorted first by time, and then by station number for land and by latitude and longitude for the ocean, as described in Section 2. File sizes range from 30 to 93 MB for land data and from 5 to 15 MB for ocean data.

In addition there are 4 ancillary files: XSTATY, YSTATY, XSTALL, and LLFR5C which are described in Sections 5.3 - 5.5 below.

5. COMMENTS ON USE OF THE DATA

Based on our experience and the experience of other pre-release users of the EECRA, we think the following comments are essential.

5.1. Computing the Average Cloud Amounts and Frequencies

The determination of frequencies of occurrence and average cloud amounts from surface observations requires special considerations to avoid several potential biases and to obtain representative values. Upper-level clouds present special problems because they are sometimes

partially or completely hidden from the view of the observer by lower clouds. These issues are discussed in detail in W86 and W88 but will be summarized here.

5.1.1. Total Cloud Cover

Total cloud cover is basically the sum of the values of N in the synoptic code (converted to percent if desired) divided by the number of contributing reports. However, to avoid the day-night sampling bias, which arises because more observations are made in the daytime than at night, some method of equalizing the contribution of reports between day and night is necessary. This is discussed in Section 5.2 below.

5.1.2. Low Cloud Types

Of the 227 million light reports suitable for total cloud analysis for land (Figure 1), 223 million have cloud type information (Table 5). For the ocean these numbers are 52 million and 44 million. In the type reports, the amount of a low cloud type (if present) is always given in the Nh variable of the report. The average amount for a particular low cloud type can be obtained, in a manner similar to that for total cloud amount, by summing the Nh values when the type is present and dividing by the number of contributing reports (using the precautions against the day-night bias discussed above). The contributing reports consist of those with $C_L \geq 0$ and include reports of N=0 (see Section 5.3 below for avoiding the potential clear-sky and sky-obscured biases).

An alternative, but equivalent, method for obtaining the average amount for a low cloud type is to compute the frequency of occurrence (f) of the type (the number of occurrences of the type divided by the number of contributing reports) and the amount-when-present (awp; sum of Nh's divided by the number of occurrences of the type) separately. Then the *average cloud amount* is:

$$\text{amt} = \text{f} \times \text{awp}.$$

This method is described because it is often of interest to know the frequency of occurrence of a type in addition to its amount, because awp tends to be characteristic of a cloud type, and also because this is the method used to compute upper level cloud type amounts.

5.1.3. Upper Level Clouds

Cloud type reports do not always contain information about upper level clouds because these clouds may be hidden by an overcast or near-overcast layer of lower clouds. Thus, of the 223 million light-type reports for land (Table 8), only 188 million have information about the middle cloud level ($C_M \geq 0$) and 152 million have information about the high level ($C_H \geq 0$). Of the 44 million light-type reports for the oceans, 34 million have $C_M \geq 0$ and 27 million have $C_H \geq 0$.

The *average amounts* of upper level cloud types are obtained as described in the last section: amt = f x awp. When reporting *cloud-type frequencies*, it is important to state how the frequencies were computed. The term "*frequency of occurrence*" has sometimes been used by other authors when what was actually computed was "frequency of sightings". To illustrate the difference, consider three surface weather report segments:

report number	N	CH
1	4	1
2	8	/
3	3	0

In these three reports high cloud (Ci) was *seen* once, so one could say that the frequency of "sighting" is 33%. But in report #2 one does not know whether Ci was present. So only reports 1 & 3 contain information about high clouds. Therefore the frequency of *occurrence* is

50%. Statistically, this amounts to assuming that the frequency of occurrence is the same when the high level is visible through gaps in lower clouds as when it is not. For land, 84% of the light type reports contribute to computation of frequencies at the middle level, and 68% at the high level. For the oceans these values are 77% and 61%. The degree to which these portions of the data set represent the whole data set for types was studied in W82 and is discussed in W86 and W88. Based on a study of the frequency of occurrence of As/Ac [f(As,Ac)] versus low cloud amount, W88 applied an adjustment to f(As,Ac) which assigned to the cases of C_M=/ (15.5% of the type reports for land and 24.5% for ocean) a value that is the average of f(As,Ac) of the reports that have low cloud amounts of 3 to 7 oktas. For high clouds, f was computed only from reports with Nh<7 in order to reduce the partial-undercast bias (W88).

Since we want the *actual frequency of occurrence* of a cloud type, f is computed as the number of times the type was observed divided by the number of reports of $C_U \geq 0$ (where C_U represents either C_M or C_H as appropriate).

The *amount-when-present* of an upper cloud type can be determined, when it is reported present ($C_U>0$), only if there are at most two cloud levels present. Furthermore, we do not compute amounts for an upper cloud if it is undercast by a layer that covers 7 oktas or more of the sky (Section 3.5). Therefore awp is computed from an even smaller pool of data than that used for frequency. Table 8 shows that, for land, 77% of the observed (light) occurrences of middle clouds and 74% of the observed occurrences of high clouds are computable. For the ocean data these values are 62% and 46%. Nevertheless, awp computed from these data is probably fairly representative of the actual awp because awp is less variable than f (W86, W88). Any systematic error inherent in the random-overlap assumption would produce a smaller error in computed amounts since this assumption is used for only a fraction of the computable observations. Table 8 shows that over land the random-overlap assumption is used in 39% of the computable observations (light) for middle cloud and in 55% for high cloud. These fractions are larger for ocean data (66% and 72%).

A special consideration applies to Ns. Because Ns is defined on the basis of the occurrence of precipitation (Table 2) which does not depend on the visibility of the middle cloud level for its detection, its presence or absence is known for every type report. Thus the number of contributing reports for f(Ns) is the same as that for low cloud types ($C_L \geq 0$ and $Nh \geq 0$). However, when present, its amount is not always known and a separate tally (which will be different from that for the As/Ac clouds) must be kept for determining its awp.

5.1.4. Middle-Level Amount-When-Present in China, 1971-79

In the 1970's many Chinese stations reported Nh=0 with $C_M>0$ and $C_L=0$, resulting in unrepresentative awp for middle clouds. This is a violation of the synoptic coding rules which state that when there is no low cloud present, Nh is given the value for middle cloud amount, as was discussed in Section 3.3. We discovered this violation in our earlier work (W86) and dealt with it by using awp computed only from 1980-81 data for the affected grid boxes, because the coding rules were correctly adhered to in those two years. (In that work we observed that interannual variations of awp are generally smaller than those of frequency. Nevertheless, because of this problem, any trends in middle cloud amount computed for these boxes for the 1970's will depend solely on variations in frequency.) Appendix B shows the fifty 5c grid boxes affected. Now that more years of data are available, awp can be computed for those boxes for 1980-1996.

In the EECRA, land station reports that had $C_L=0$, $C_M>0$, $C_H>0$, and Nh=0 are assigned the values Nh=-1 and IC=2 (Section 3.3), so although they cannot be used for awp, they can still be used for frequency. Of the light-type reports in January 1971, for example, 0.8% fall into this category.

5.2. Avoiding the Night-detection Bias and Day-night Sampling Bias

About 55% of all observations, for both land and ocean, are made between 0600 and 1800 local time, producing a potential *day-night sampling bias*. The *night-detection bias* is largely eliminated by using only data for which the illuminance criterion is met (Section 3.6). This, however, enhances the day-night sampling bias unless precautions are taken since only about 42% of the observations between 1800 and 0600 local time qualify as "light" (about 98% of the observations from 0600 to 1800 are "light"). In W86, averages were obtained by first forming averages for each of the 8 synoptic hours and then averaging these 8 numbers. For oceans, data are less plentiful and the 3-hourly times often do not have a sufficient number of reports to obtain a statistically reliable average. Hahn et al. (1994) classified each observation into one of two 12-hour periods, 0600-1800 local time ("day") and 1800-0600 local time ("night"), formed two separate averages, and then averaged these two numbers. Note that when using only the light reports (to avoid the night-detection bias) to form monthly averages, only about two weeks of data (surrounding full moon) will contribute to the nighttime average in any single month. Due to this "monthly-sampling error" there will be more scatter in monthly averages from year to year, but multi-year averages should become more statistically representative of climatological means as the number of contributing years is increased. Similarly, seasonal averages should be more representative of an individual season than monthly averages are of an individual month.

These considerations of the day-night bias, night-detection bias, and monthly-sampling error apply equally to total cloud analyses and cloud type analyses. However, for fog and precipitation, whose detection does not depend on illumination, all observations may be used.

5.3. Avoiding the Clear-sky Bias and Sky-obscured Bias for Cloud-Type Frequency of Occurrence

The clear-sky bias affects only the computation of the frequency of occurrence of cloud types. It does not affect the amount-when-present of the types, nor does it affect the total cloud cover or the frequency of occurrence of fog or precipitation. The clear-sky bias is a potential consequence of the changes to the synoptic code in 1982. To illustrate, consider the potential for the clear sky bias to affect the computation of the frequency of occurrence of low cloud types in land station reports. The frequency of occurrence of a low cloud, e.g. cumulus, is the number of times the cloud type was reported present (C_L=1 or 2) divided by the number of times the low cloud level was given in the report ($C_L \geq 0$). If a particular station never reports cloud types (call it an "abstaining" station), then C_L for that station would always (prior to 1982) be "/" (translated as "-1" in the EECRA). This causes no problem. However, beginning in 1982 all observers were instructed to record C_L=/ whenever N=0. Therefore, since 1982 we can no longer count C_L=/ with N=0 as a non-report of the low level from an abstaining station; it is most likely a report of clear sky from a conscientious observing station that always reports the low level, and so must be treated as C_L=0. But this treatment causes us to use low-cloud reports from the abstaining stations only when the sky is clear, producing the "clear-sky bias" which would cause the computed frequencies of all cloud types to be too low.

A similar argument can be made for the case of N=9, which is a consequence of the way we must handle sky-obscured cases as discussed in Section 3.1, and not a consequence of the 1982 code changes, so the sky-obscured bias applies to all years. The result is that an abstaining station would contribute to cloud-type analyses only when N=9, producing the "sky-obscured bias" which would increase the computed frequencies of sky-obscured by fog and precipitation and cause the computed frequencies of other cloud types to be too low.

Both of these biases may occur simultaneously. We will first exemplify the magnitude of these potential biases, and then show several methods for avoiding them.

5.3.1. Adjustment Factors

A *correction factor* was derived in the documentation to our earlier data set (the ECRA, H96). The "clear-sky adjustment factor" (AF0) was defined to convert a "raw" frequency of a particular cloud type Fr, into an "adjusted" frequency Fa, as

$$Fa = AF0 \cdot Fr$$

where Fr = Nt / Nr (see Section 5.3.4 for definitions of Nt and Nr). H96 showed that subtracting from Nr the reports of N=0 that came from "abstaining" stations leads to

$$Fa = Nt / (Nr - fb \cdot N0) \quad (1)$$

or

$$AF0 = 1 / (1 - fb \cdot f0)$$

where f0 is the frequency of N=0 among the reports with cloud-type information, and fb is the fraction of the N=0 reports that came from abstaining stations. We can estimate fb by determining the fraction of times cloud types are unreported (C_L=/) when clouds are known to be present ($1 \le N \le 8$). The value of AF0 is equal to one if either fb or f0 is zero; i.e. if cloud type information is always given or if the sky is never clear. The value of fb is greater for ship data than for land data but f0 is less for ship data, so that, globally, AF0 is 1.003 for ships and 1.007 for land (H96).

Similarly, the "sky-obscured adjustment factor" can be derived:

$$AF9 = 1 / (1 - fb \cdot f9)$$

where f9 is the frequency of occurrence of N=9 among the reports with cloud-type information. Correction for the sky-obscured bias is more complicated for the cloud type nimbostratus because many cases of N=9 convert to Ns, and corresponding portions of N=9 would have to be removed from Nt as well for this case. Both fb and f9 are smaller for land data than for ship data, and the global averages of AF9 are 1.003 for ships and 1.0003 for land (H96).

It turns out that these adjustment factors are very nearly equal to 1 (no adjustment) for most regions of the globe (see Figure 5a in H96 for land and Figure 2 in this report for ocean), although there are some regions of the globe where the biases are large (and may vary from year to year or season to season or day to night). For land one can essentially eliminate the bias by identifying and excluding the stations that do not report cloud types, while for the ocean one can minimize their effects by excluding the most severely affected grid boxes. These options are described in the following two sections.

5.3.2. Land Stations That Do Not Report Cloud Types

During processing of the original weather reports in the preparation of the EECRA, information was saved from which a list of land stations that normally do not report cloud types could be prepared. Eliminating these stations from cloud type analyses will essentially eliminate the clear-sky bias and the sky-obscured bias in the 1982-96 data as described above. We identified 939 such stations. To emphasize the importance of this, Table 11a lists the 234 "worst offenders" of those 939 stations. If not removed from cloud type analyses, each of these 234 stations would contaminate more than 9 of the 15 years of data. The table also indicates 23 Canadian stations which could be used for cloud types if analyses were restricted to years prior to 1992. [Several Canadian stations (e.g. 71707 listed in Table 11b) stopped reporting cloud types in 1993.]

Selection criteria. During processing of the EECRA, the value of fb (the fraction of reports of C_L=/ with N>0) was computed for each station for each month of data. Then fb was examined for all Januarys and Julys for 1982-96 for each station. About 200 stations never report cloud types and always show fb=100%. However, many stations sometimes report cloud types. Any station that had fb≥20% in any year-month was considered to "fail" for that year-month. Stations with fb<20% were considered to "pass" for that year-month because occasionally the cloud-type portion of the report may be missing even for stations that normally report cloud types (over 1500 stations "failed" at least once). Furthermore, some stations "pass" in some year-months and "fail" in others. Any station that "failed" in at least one fourth of the year-months in which it contained cloud data, for either January or July, was put on the list of stations to exclude for cloud-type analyses.

Some statistics. While 939 stations appear on the list of stations to be excluded for cloud types based on the criteria just described, many of the stations actually have data only for a year or two. Over 10,000 different stations were encountered at least once in the 1982-96 data, but only about 7000 stations appear in any single month. In any single month about 3.3% of the stations fail the fb < 20% test.

Note that while the clear-sky bias is not at issue in the pre-1982 data because reports of C_L=/ with N=0 can be eliminated in the cloud-type processing simply by excluding all reports with C_L=/ (Section 3.2), the same is not true for the sky-obscured bias which is a consequence of the cloud-type processing (Section 5.3 above). Thus it would be useful to eliminate these 939 stations from the pre-1982 data as well. [Also, in pre-1982 data we found that the occurrence of C_L=/ in reports of N=0 tends to be smaller than the occurrence of C_L=/ in reports with 1≤N≤8 (fb), suggesting that there is a residual, though small, clear-sky bias in the pre-1982 data.]

Ancillary file (XSTATY). An ancillary file is supplied with this archive that lists the 939 stations which should be excluded in cloud type analyses. The format of this file is given in Table 11b, along with selected data records to exemplify the contents of the file. (See also Section 5.4 below.)

5.3.3. Grid Boxes with Ship Reports Unsuitable for Cloud-Type Analyses

Because we cannot identify individual ships, as we did Land Stations, to find those that routinely do not report cloud types, we must either make adjustments to the frequency calculations (Section 5.3.1 above and Section 5.3.4 below) or possibly exclude the most offending ocean boxes to reduce the corresponding biases in the post-1981 ship data. What makes this latter option possible is that these adjustment factors are very nearly equal to 1 (no adjustment) for most regions of the globe, while there are limited regions of the globe where the bias is large. This was evident in Figure 5b in H96 which showed AF0 on a 5c grid for ocean boxes. Biases tended to be large in lakes and semi-enclosed seas. Figure 2a here is a reproduction of Figure 5b from H96 but with boxes of large AF0 values removed. The values plotted on the map are (AF0-1) x 100 for clarity of presentation, so that a 2, for example, on the map means 1.02. Figure 2b is a similar 5c grid map but for AF9 values with the same boxes removed.

Selection criteria. Table 11c lists 28 grid boxes which should be excluded for cloud type analyses from ship data. The table indicates the general location of the boxes, the fraction of the box that is ocean (lakes are part of "land"), and it gives fb (the fraction of N=0 or N=9 reports that contribute to a bias), and computed values of AF0 and AF9. Boxes were listed if they had AF0 or AF9 ≥ 1.2 or if either adjustment factor was greater than 1.1 with fb > 0.5. (Not all Caspian Sea boxes were analyzed but all 6 boxes in that area are on the exclusion list.) Because references to regions of the globe that should be omitted for cloud-type analyses from ship observations are given as "B5c numbers" (see Appendix A), it is necessary to have a

means of converting latitude and longitude, which are given in the cloud report, to B5c as shown in Table 11c. FORTRAN subroutines provided in Appendix C convert latitude and longitude to B5c numbers and vice versa.

There is one class of ship data, the HSST data described in Section 3.2, that can be identified by the card-deck numbers 150-156 (Table 9). These data contain no cloud-type information (C_L=-1 in the EECRA) but make up a significant portion of the ship data from 1952 to 1961. Present weather is also missing (ww=-1) in these data and so the few reports that originally had N=9 have been excluded from the EECRA (Figure 1). The HSST data produce no bias in cloud-type analyses if they are excluded either on the basis of C_L=-1 or by card-deck number.

Consequences of the bias. Figure 2b shows that only 2 of 1473 remaining boxes have AF9 greater than 1.07, with values of 1.13 and 1.12 for boxes along the east coast of North America. Since clear-sky frequencies are generally quite small in the open ocean (W88), AF0 values are close to 1 (map values 0) except in some coastal regions and inland seas such as the Mediterranean where the maximum value of 1.14 is obtained as an annual average (Figure 2a). The examples below show typical values of amount-when-present (awp; not affected by these biases), the "raw' frequency of occurrence (Fr), and amount (amt = Fr x awp) for stratus (St) and cirrus (Ci) cloud types in the Mediterranean region (W88) and show the adjusted frequency (Fa) and corresponding amount for AF0 values of 1.02 and 1.10.

Examples of Possible Influence of AF0 on Cloud Type Amounts

	Typical	Mediterranean		with AF0=1.02		with AF0=1.10	
Type	awp%	Fr	amt%	Fa	amt%	Fa	amt%
St	60	0.10	6.0	0.102	6.1	0.11	6.6
Ci	36	0.25	9.0	0.255	9.2	0.28	9.9

Thus an amount of 6.0% for stratus cloud would become 6.1% after adjustment with AF0=1.02, or would become 6.6% after adjustment with AF0=1.10. Similarly, a cirrus amount of 9.0 becomes 9.2 or 9.9 after these two adjustments, respectively. For many applications, such discrepancies may be acceptable or even within the limits of accuracy inherent in the data. Diurnal variations should not be affected by this bias.

Ancillary file (LLFR5C). Supplied with this archive is the ancillary file LLFR5C that lists, for the 1820 boxes of the 5c grid, the associated latitude and longitude of the box center, the land fraction, and a variable which indicates whether the box is pure land, pure ocean, contains a large lake, contains a small island, or is otherwise both land and ocean. The format of this file is given in Appendix D1. The variable LOB is negative for the 28 boxes listed in Table 11c for exclusion from cloud-type analyses of ship data. A map of this variable on the 5c grid is provided in Appendix D2.

5.3.4. Computational Methods That Correct For These Biases

Norris (1998b, appendix), while analyzing frequencies of low cloud types from a preliminary version of the EECRA, introduced a scheme that essentially incorporates the adjustment factors discussed in Section 5.3.1 into a routine computational method. The method, though developed for low cloud types, will work as well for middle and high clouds. The method is also general so it can be applied to unbiased data as well.

Expressing the adjusted frequency of occurrence of a cloud type t (Fat; from Norris, 1998b) in terms of counts of cloud variables gives

$$Fat = (Nt / NL) \cdot [1 - \{(Nc + No) / NA\}] \qquad (2)$$

where

Nt is the number of observations reporting the cloud type t,
NL is the number of observations that report cloud types for the level (C_L, C_M, or C_H) of the cloud type t *when the sky is not clear or obscured*,
Nc is the total number of observations with clear sky (N=0),
No is the total number of observations with obscured sky (N=9; in the EECRA N=9 is always associated with fog or precipitation), and
NA is the total number of cloud observations (including those with C_L=/).

Note that if the sky is always clear or obscured, NL=0 and the equation fails. Usually this would simply mean that Fat=0 and one would have to decide, by reference to NA, whether to include that value in one's climatology. But if one considers a report of N=9 with precipitation to be the cloud type Ns (Table 2), then one must treat the report as counting towards Nt (for Ns) as well as N=9. Thus, if the sky is always reported as obscured by precipitation corresponding to Ns, then Fat=100%. In such cases it is not possible to know whether the reports are biased. Such a situation should be rare except when averaging very few observations.

Expressing equation 1 (Section 5.3.1), and also incorporating AF9, for the adjusted frequency of occurrence of a cloud type t in terms of counts of cloud variables gives

$$Fat = Nt / [Nr - (NTX / NN) \cdot (N0 + N9)] \qquad (3)$$

where, for the additional variables,

Nr is the number of observations that report cloud types for the level (C_L, C_M, or C_H) of the cloud type t *including reports of clear-sky and sky-obscured*,
NTX is the number of observations in which C_L=/ (with $1 \le N \le 8$),
NN is the number of observations with $1 \le N \le 8$,
N0 is the number of observations with N=0 in the reports with $C_L \ge 0$, and
N9 is the number of observations with N=9 and precipitation or fog in the reports with $C_L \ge 0$.

This representation is mathematically equivalent to equation 2; differences lie merely in the quantities that are counted and how they are manipulated. If the sky is always clear or obscured, then NN=0 and one can choose to ignore the right-hand term in the denominator, leaving Fat = Nt / Nr (which is equivalent to Fat = Nt / NA of equation 2 in such cases).

In the EECRA all reports with N=9 were converted to N=8 and IC=1 (Section 3.2). Thus to count "N=9", one counts occurrences of IC=1.

For land data, these correctional computations can be eliminated by excluding (for cloud-type analyses, not for total cloud analyses unless one wants a uniform data set for both analyses) the 939 stations listed in the ancillary file XSTATY. For ship data one might omit the correctional computations if analyzing only the expanses of the ocean where AF0 and AF9 are 1 (Figure 2). But even if the adjustment equations are employed, we recommend excluding ship data in the regions of the 28 grid boxes listed in Table 11c and shown in Appendix D2 because the biases are so large.

5.4. Land Stations Usable for Analysis of Trends in Cloud Cover

Over 12,000 different land station ID's appear at least once in the 1971-96 data. However, only about 6000 stations report routinely throughout most of the 26-year period. To compute trends in cloud amounts it is desirable to have a long period of record. When computing trends for grid boxes it is important to have the same stations contributing in each year, otherwise spurious interannual variability could appear. We have therefore prepared an ancillary file that

provides information from which a user can select stations with the most complete time series for computing trends in cloud cover.

Ancillary file YSTATY. We first prepared a list of all stations that had any cloud type information in light obs (reports made under conditions meeting our illuminance criteria) for the 1982-96 period. The 939 stations determined to be unsuitable for cloud type analysis (Section 5.3.1) were removed from the list. (There are a few additional stations appearing in the 1971-81 data that report total cloud only, but such stations report C_L=/ in those years and do not contribute to the bias.) Associated with each station on the list is the number of Januarys and the number of Julys that had at least 20 such reports, the sum of Januarys and Julys with between 1 and 20 such reports, and the sum of Januarys and Julys that failed the fb<20% selection criterion for cloud types (Section 5.3.1). [The criterion of 20 observations in a month allows a station that routinely reports only once a day to contribute to an analysis but excludes station numbers that appear only spuriously (perhaps due to transcription errors in the station ID). Most land stations, however, report 4 or 8 times a day (W86).] This list became the ancillary file YSTATY. The format is given in Table 12, along with a sample of data records.

Using the file. To help clarify the meaning of the quantities given in the file, we will examine a few of the sample data records in Table 12. Station 01001 has at least 20 light-type reports for all 26 years of the period of record for both January and July. By contrast, for station 43268 there are no reports for January (ms=2) and less than 20 reports for one July. Between these extremes, station 44215 has 20 or more reports for 16 Januarys and 15 Julys, has less than 20 for 3 year-months (January or July), and has one year-month that failed the fb<20% test (Section 5.3.1).

The maximum value that any station can attain for the variable mx from the 1982-96 data is 6 because if more than 3 Januarys or 3 Julys had failed the fb test (Section 5.3.1), the station was entered in the XSTATY file and excluded from this one. Thus the situation with station 06220 is interesting. It gave no reports for 1982-96 but did give reports for 8 years in the 1971-81 period, most of which are unsuitable for cloud type analysis. Similarly, for station 54523, because of the exclusion criteria used in Section 5.3.1, the single year-month under the mx column must come from the 1971-81 period. Stations such as these two can be excluded from use in trend analyses by selection on m1 and m2 or on mx, although they are acceptable for other analyses (long-term averages, diurnal cycles) because they do not contain the biases of the post-81 data. The YSTATY ancillary file could be used instead of the XSTATY file (Table 11b) to select stations for cloud type analyses. (The choice depends on the application. For example, when selecting stations for trend analysis using YSTATY, there is no point in also consulting XSTATY. YSTATY could also be used to exclude the few additional, pre-1982, abstaining stations which are not among the 939 listed in XSTATY.)

In this file the locations of stations are given by their B2c numbers. FORTRAN subroutines for converting the B2c numbers to latitude and longitude and vice versa are provided in Appendix C.

Some statistics. The statistics shown in Table 12 indicate that, of the total of 11,586 stations listed in the YSTATY file, 5838 stations have 20 or more light-type obs for 15 or more Januarys or 15 or more Julys. Since these are the stations that will be most desirable to use, Appendix E is provided to show the global distribution of these stations. More strict criteria of completeness of the period of record than shown here could probably be applied with little loss of geographical coverage (but see Section 6.5 for loss of coverage in recent years).

5.4.1. Canadian Stations That Changed Station ID Numbers

Between June and July 1977, Canadian stations whose 5-digit WMO Station ID numbers began with 72 or 74 were changed to 71 for the first two digits, leaving the last three digits

unchanged. These cases are exemplified in Table 13a. This will cause time series from individual station numbers to appear shorter than in reality for the station. Table 13b shows examples (taken from ancillary file YSTATY) of corresponding new and old station numbers. For example, station 7x926 under List B had 7 Januarys and 6 Julys under the number 72926 and 19 Januarys and 20 Julys under the number 71926, accounting for the 26 years in the land data set. Because of these changes, a station such as 7x072 is not shown on the map in Appendix E even though it actually reported 21 years of "good" Januarys (20 light-type reports per month). With these changes, Canadian stations all now have the prefix 71, while 72 and 74 are reserved for the United States stations. This situation will require some attention when selecting stations for trend analyses.

5.5. Land Station Latitude-Longitude Switches

Occasionally an individual station appeared in the source data with different reported latitude-longitude values within a single month. These tended to be clerical errors or round-off discrepancies rather than real station moves. (We did not examine the data for the purpose of determining which, if any, stations actually moved.) In fact, in some cases the latitude-longitude changed several times in a month by switching back and forth between two sets of values. As a consequence, when using latitude and longitude to assign station reports to grid boxes, some reports for a single station will be included in one grid box while other reports for that station are included another box for a single month. This can adversely affect computed interannual variations and trend values (and, to a lesser extent, diurnal cycles and long-term means) computed for affected grid boxes. Examples are given below showing some reports for each of 4 stations whose latitude-longitude switches resulted in changes in the assigned B2c. Station elevation and air temperature are included in the examples because they can sometimes aid in determining a problem with the report.

Example 1 shows an omitted minus sign for the latitude of a Southern Hemisphere station. In the EECRA we give longitude as values 0° to 360° East, while in the SPOT data longitude is given as -180° to +180° ,west-to-east, and in the NMC data as 0° to 360° West. The switch seen in Example 2 could result from improper interpretation or transcription of longitude. Latitude and longitude are given to two decimal places in the NMC data but to only one place in the SPOT data. Example 3 shows round-off discrepancies in SPOT data. It is difficult to explain the situation depicted in Example 4 but such seemingly-illogical, multiple switching is common among the stations that show switching.

Example 1

Antarctica -77.90 314.02 89045

B2c	YrMnDyHr	Lat	Lon	Id	Elev	temp
77	81112000	77.90	314.02	89045	243	-14.0
7241	81112012	-77.90	314.02	89045	243	-13.0

Example 2

Great Britain 51.75 358.42 03649

B2c	YrMnDyHr	Lat	Lon	Id	Elev	temp
694	72041206	51.7	1.4	03649	86	5.0
694	72041209	51.7	1.4	03649	86	7.0
765	72041212	51.8	358.4	03649	86	10.0
765	72041215	51.8	358.4	03649	86	12.0

Example 3

Jordan	29.48	34.98	40341		
B2c	YrMnDyHr	Lat	Lon	Id	Elev	temp
1931	72011112	29.4	34.9	40341	3	18.0
1932	72011206	29.5	35.0	40341	2	13.0
1932	72011209	29.5	35.0	40341	2	17.0
1931	72011606	29.4	34.9	40341	3	11.0
1932	72011706	29.5	35.0	40341	2	12.0

Example 4

USSR	62.08	126.70	24758			
B2c	YrMnDyHr	Lat	Lon	Id	Elev	temp
431	72012603	62.1	126.7	24758	244	4.0
431	72012609	62.1	126.7	24758	244	1.0
359	72012703	62.5	127.7	24758	9000	-45.0
359	72012709	62.5	127.7	24758	9000	-43.0
431	72012715	62.1	126.7	24758	244	-49.0

Of the 312 months of land data included in the EECRA, 59 months contain at least one station that switches from one B2c to another. The months involved and the number of stations involved for each month are listed in Table 14a. 649 different stations are affected, some in more than one month. The majority of the switches occur in the years 1971-1976, the years for which the SPOT data set is the source.

An *ancillary file (XSTALL)* is supplied with this archive that lists the 649 stations, a recommended latitude-longitude to be assigned to each station, obtained from station reports in months that showed no switching, and the year-months during which each station switched. The format of this file is given in Table 14b.

6. COUNT SUMMARIES

6.1. Distribution of Cloud Reports over the 8 Synoptic Hours

Figure 1 and Tables 4, 5 and 8 showed the number of reports processed, deleted and changed, as well as the number of light reports, the number suitable for cloud type analysis, and the number of times upper level cloud amounts were computable. Table 15 shows how the reports are distributed over the synoptic reporting times. Land stations usually report 8 times per day but some do not (notably in the United States and Australia), so that 59% of all reports are made during the 6-hourly times. Ships, however, usually report 4 times per day so only about 11% of the ship reports are for the intermediate 3-hourly times. Having only 4 reports per day, rather than 8, limits the resolution possible in computations of the phase and amplitude of the diurnal cycle. It was also noted (W88) that regional averages formed from 6-hourly ship data may be systematically different from averages formed from i3-hourly data, consistent with a tendency for some ships to give a 3-hourly report only in unusually stormy weather. During the course of the present work we noticed that over the United States, where reports are usually made 6-hourly, the occurrence of N=9 averaged about 7% in January 1978 for the 6-hourly reports but 19% for the i3-hourly reports. A bias is also possible when averaging over a land grid box that has more than one station if stations within one climatic region report 8 times per day while stations within a different climatic region report 4 times per day.

6.2. Distribution of Code Values

The histograms in Figures 3a for land and 3b for ocean show the frequency of occurrence of the extended code values for the six cloud variables for light reports in the archive of edited cloud reports. [In these figures N=9 is shown separately from N=8 although N=9 is converted to N=8 (with IC=1) in the EECR.] The shaded areas show the occurrence of precipitation (DRSTs, Table 2). Numerical values for the data shown in these figures are provided in Appendix F2. Several interesting features are evident in these figures. The distribution of codes for total cloud cover N is nearly U-shaped for land but strongly skewed towards the higher amounts for oceans. More than 96% of all precipitation occurs with N≥7 over land and with N≥6 over oceans. About 75% of precipitation occurs with Nh≥6. The most commonly occurring cloud base height code is h=5 (600-1000m) over land but h=4 (300-600m) over oceans. The large frequency of h=9 over land is a consequence of the large frequency of C_L=0 so that h=9 often refers to the middle cloud level.

The lower panels in Figures 3a and 3b show the occurrences of various cloud types within the three reporting levels. The reports with C_L=-1 are not usable for cloud type analysis (2.0% for land data, 14.0% for ocean data). The occurrence of Nh=-1 is slightly greater than C_L=-1 (underlined in Appendix F2) because of the processing procedure that allows C_L to contribute to frequency determinations when Nh is not available for amounts under some circumstances when only middle clouds are present (Section 5.1.4). Larger fractions of the reports have C_M=-1 (17.3% for land, 34.2% for ocean) and C_H=-1 (33.1% for land, 47.5% for ocean) because of lower overcast. Thus 98% of the land reports have information about cloud types but only 82% of those have information about the middle cloud level and 66% about high clouds. For the oceans, 86% of the reports have low cloud information but only 60% of those have middle cloud information and 45% have high cloud information.

The low cloud type most commonly reported over land is stratocumulus (C_L=5). While this type is also common over the oceans, it is exceeded by the cumulus types C_L= 1 and 2. About 25% of all precipitation occurs with the stratus cloud C_L=7. When C_L=7 is reported over land, precipitation is present in 66% of the reports. Precipitation occurs in 34% of the ship reports of C_L=7.

While 58% (land) and 46% (ocean) of all precipitation occurs with the middle clouds defined to be nimbostratus (C_M= 10,11,12), 24% and 37%, respectively, of precipitation occurs when the middle cloud level is not given in the EECR (typically because of low overcast). Because of our definition of Ns shown in Table 2, most of these latter cases must have ww= D or Ts (drizzle, thunderstorms or showers). In the high cloud level, 90% of all precipitation occurs in reports with C_H=-1 (high cloud level not reported, usually because of lower overcast).

Warren et al. (1988) showed histograms similar to those in Figure 3 for ten spans of years for ship data from 1930 to 1979. Such figures give clues to changes in coding practices throughout the years (and also incorporate possible climate changes and may be influenced by shifts in shipping routes or land station locations). The tables in Appendix F3 thru F7 provide numerical histograms of the cloud codes for periods in the 1990's, 80's, 70's, 60's and 50's from the EECRA.

6.3. Cases of Sky-obscured and Nimbostratus Cloud

[Numerical values for this discussion are taken from H96 because some of the values presented were not re-evaluated using the EECRA. Appendix F4 is similar to, though not identical to, the comparable table, Appendix A, in H96 for the 1982 to 1991 data. Values cited differ some from decade to decade.] The occurrence of reports of sky-obscured (N=9) due to fog or precipitation (defined in Table 2) is about 1.5% for land and 3.5% for ocean, with fog (C_L=11) accounting for more than two thirds of these values for both land and ocean. These cases of sky-obscured due to fog make up 14% (land) and 48% (ocean) of reported cases of fog (in light reports). Other (non-obscuring) reports of fog are thin fog or fog at a distance but not at the station. Cases of thunderstorms or showers (C_L=10) account for only about 3.5% of the reports of sky obscured, and sky-obscured due to thunderstorms or showers make up only 1.6% (land) and 5.8% (ocean) of the light reports of thunderstorms and showers. The remaining contribution to the reports of sky obscured (about 25%) is due to drizzle, rain or snow. Sky-obscured due to drizzle, rain or snow make up 5.1% (land) and 12.9% (ocean) of the light reports of drizzle, rain and snow.

Table 16 shows the contributions of the three major paths to the frequency of Ns as defined in the EECRA (Table 2). (Frequencies here are based on light-type reports and are slightly higher than the frequencies quoted in the last paragraph which were based on the total set of light reports.) The largest contributor to Ns in the land data is the path through C_M=2,7 (with ww=DRS). For both land and ocean C_M=2 is far more important than C_M=7 (see C_M=11,12 in Appendix F4). The largest contributor to Ns in the ocean data comes through the C_M=/ path, which has several contributors itself, the largest being the case of C_L=7 with DRS.

In the EECRA, we classify reports of sky-obscured due to drizzle, rain or snow as nimbostratus cloud and assign the extended code value C_M=10 with IC=1 (Tables 2 and 4). With information provided in the EECR, the user is free to choose any definition of Ns. However, sky-obscuring drizzle is rare, so its assignment has almost no effect on Ns climatology.

Excluded from the definition of Ns are the cases of C_M=/ with C_L=4,5,6,8 and ww=D (more than half of these cases have C_L=6). These cases were considered to indicate Ns in our previous climatologies (W86, W88) but after subsequent consideration and discussions with colleagues we concluded that, since drizzle could occur from these low cloud types, the additional inference of Ns above them was inappropriate. Thus the frequencies of occurrence of Ns computed under the current definition will be reduced to about 97% (land) and 90% (ocean) of the frequencies given in W86 and W88.

Another change associated with the simplification of our previous definition of Ns involves cases of C_L=6,7 with DRS and C_M other than 2,7,/. The C_L=6,7 in these cases were previously reassigned as Ns, but are left unchanged in the present, simplified definition. This results in a further reduction in computed Ns frequency by factors comparable to those in the last paragraph. Thus the Ns frequencies computed under the present definition may be about 94% (land) and 81% (ocean) of those computed under the previous definition. Note that these percentages refer to the number of reports in the data set which contains a disproportionate contribution of reports from the densely populated northern mid-latitudes and thus do not represent the area-weighted global averages. Note also that the user of this data set is not restricted to the definitions assigned here since all the information necessary for any other interpretation is contained in the edited cloud reports.

Note that cases of C_M=/ and ww=DRS are not considered to indicate nimbostratus cloud when C_L=1,2,3,9 (cumulus or cumulonimbus).

6.4. Distribution of Reports over the Globe

To show the global distribution of the reports, numbers (shown as $\log_{10}$) of light-type reports are displayed on a 10c grid (see Glossary in Appendix A) in Figures 4a (land) and 4b (ocean). Numbers from 1 to 9 appear as 0, numbers from 10 to 99 appear as 1, etc. Grid boxes with no light-type reports are blank.

6.5. Decline in USA Synoptic Cloud Reports Since 1982

In Section 2.1 we noted that when NOAA began to close synoptic weather stations in 1982, NCEP began to convert airways hourly data into the synoptic format and included these converted hourlies under the associated WMO station number for the affected stations. Airways hourly cloud reports are given as clear, scattered, broken, overcast, and obscured. These words were converted to N= 0, 3, 6, 8, 9, respectively. Cloud types are also not given in accordance with WMO definitions. These reports were excluded from the EECRA, resulting in a continual decrease in the number of contributing USA stations. Around 1995 many stations converted to the Automatic Surface Observing System (ASOS) which provides no cloud data except for the base height of clouds below 12,000 feet. With the increasing automation of weather stations, synoptic cloud observations became voluntary (and some that were made did not get into the available data archives), and by December 1996 the number of USA stations providing at least 10 synoptic cloud reports for the month had dropped to 27. Figure 5 shows the time sequence of the decreasing number of USA stations that provide synoptic cloud data. Clearly, the "Cloud Hole Over the United States?" (Warren et al., 1991) has become a reality. The United States of America no longer contributes sufficient surface-based cloud observations suitable for future climatic analyses.

To ascertain the degree to which other countries have switched to automatic reporting systems in recent years, we computed the ratio of reports contributing for a single season (September-October-November, SON) in 1996 to those contributing in 1979 for grid boxes over the globe. These ratios are given on a 10c grid in Appendix H. Some locations, mostly north of 50° N, have ratios near 0.5. Some grid boxes with only islands (not shown) and one grid box in Antarctica, which may contain only one station, have ratios less than 0.1. At this resolution, the only countries in which synoptic cloud reporting has apparently declined to 20% or less are the United States and New Zealand. In many locations there is an increase in reporting since 1979. Beginning in October 1994, a large number of additional (secondary) stations appeared in the NCEP data set for Australia, accounting for the exceptionally large ratios in that country.

7. HOW TO OBTAIN THE DATA

This documentation and the data described herein are available from:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
Post Office Box 2008
Oak Ridge, TN 37831-6335, U.S.A.
Telephone (423) 574-3645
(http://cdiac.esd.ornl.gov/)

as NDP-026C

or

Data Support Section
National Center for Atmospheric Research
Boulder, CO 80307, U.S.A.
Telephone (303) 497-1215

as DS 292.2.

The following citation should be used for referencing this archive and/or this documentation report:

Hahn, C.J., and S.G. Warren, 1999: *Extended Edited Synoptic Cloud Reports from Ships and Land Stations Over the Globe, 1952-1996.* NDP026C, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN. (Also available from Data Support Section, National Center for Atmospheric Research, Boulder, CO.)

The archives of our earlier climatologies (Hahn et al., 1988; Hahn et al., 1994) and the accompanying atlases (Warren et al., 1986, 1988) are also available from the same sources listed above.

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Joel Norris and Steve Klein provided valuable assistance in the early stages of production of this data set. They helped to define the most useful additional quantities, other than clouds, to include in the extended report; they spent many hours running our preliminary programs to produce an early version of the EECRA for the ocean, 1952-1992; and they tested the data set in climatic analyses. We thank Gregg Walters, Dennis Joseph, and Roy Jenne for helpful discussions about land data. We give special acknowledgment to Julius London who initiated the cloud climatology project in 1980 and provided guidance for many years. This work was supported by NSF Climate Dynamics (Geosystems Database Infrastructure Program), and NOAA Climate Change Data and Detection Program, under grant ATM-95-10170, and by a computing grant from NCAR.

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Tables Follow

Table 1. Cloud Information Contained in Synoptic Weather Reports

Symbol	Meaning	Codes[#]
N	total cloud cover	0-8 oktas 9= sky obscured
N_h	lower* cloud amount	0-8 oktas
h	lower* cloud base height	0-9
C_L	low cloud type	0-9
C_M	middle cloud type	0-9
C_H	high cloud type	0-9
ww	present weather	00-99
I_x	present weather indicator	1-6

[#] Any category for which information is lacking to the observer is coded as "/".
* The "lower" cloud is the middle level if there are no low clouds.

Table 2. Cloud and Weather Type Definitions Used

Level	Shorthand notation	Meaning	Synoptic codes	Extended codes#
	Tcc	total cloud cover	N = 0-9	0-8
	Clr	completely clear sky	N = 0	
	Ppt	precipitation	ww= 50-75,77,79,80-99	
	D	drizzle	50-59	
	R	rain	60-69	
	S	snow	70-75,77,79	
	Ts	thunderstorm, shower	80-99	
Low			C_L=	
	Fo	sky obscured by fog	/ with N=9 and ww=F*	11
	St	stratus	6,7	
	Sc	stratocumulus	4,5,8	
	Cu	cumulus	1,2	
	Cb	cumulonimbus	3,9,	
			or N=9 with ww=Ts	10
Mid			C_M=	
	Ns	nimbostratus	2,7, or N=9, with ww=DRS	12,11,10
			/ with ww=DRS and C_L=0,7	10
			/ with ww= RS and C_L=4-8	10
	As	altostratus	1; 2 if not DRS	
	Ac	altocumulus	3,4,5,6,8,9; 7 if not DRS	
High			C_H=	
	Cs	cirrostratus	5,6,7,8	
	Cic	cirrus, cirrocumulus	1,4,9	
	Cid	dense cirrus	2,3	

Extended codes shown where they differ from synoptic codes. In the extended code the value "-1", rather than "/", is used to signify missing information.
* F represents the fog codes ww=10-12,40-49.

Table 3. Change Codes for Edited Cloud Reports

IC*	Case (brief description**)	Changes made#	Occurrence (%) Land all	Land light	Ocean all	Ocean light
0		none##	87.4	87.4	87.2	86.9
1	N=9 with precipitation or fog	N=8; CL=10,11 or CM=10	1.6	1.6	2.6	2.6
2	Nh=0 with CM>0 and CL=0	Nh=N	0.8	0.8	0.5	0.5
3	Nh=N with CH>0 and CL=CM=0	Nh=0	0.1	0.1	0.2	0.2
4	Nh<N where it should be Nh=N	Nh=/	0.3	0.4	0.6	0.6
5	CL =/ with CM or CH	CM,CH =/	0.1	0.1	0.5	0.5
6	CM or CH miscoded as 0	CM or CH =/	3.2	3.5	3.7	4.1
7	CM=7,2 for Ns	CM=11,12	3.7	3.5	1.1	1.2
8	CM=/ for Ns	CM=10	2.4	2.2	1.8	1.9
9	CM or CH miscoded as /	CM or CH =0	0.3	0.3	1.8	1.5

* Also order in which changes are made, but IC=9 is recorded only if no previous change occurred (this conflict can occur only with IC 7 or 8).

** See Table 4 for details.

In the EECRA the value "-1" is used to signify "/".

Cases of Nh=CL=CM=CH=/ with N=0 were set to Nh=CL=CM=CH=0 in post-1981 land data. These were not considered to be changes.

Table 4. FORTRAN Code for Checking Cloud Type Consistencies
All variables are integers. Cloud variables are defined in Table 1. Here DRS (Table 2) is "1" if true and "0" if false. IC is the Change Code (Table 4).

```
c.IC_2,4------------------ CORRECT MISCODED Nh with CM or Exclude Nh ------
      IF (CM.GT.0 .AND. Nh.EQ.0 .AND. CL.EQ.0) THEN
        IF (CH.LE.0) THEN
          Nh = N
          IC = 2
        ELSE
          IC=2
          Nh= -1
        END IF
      END IF
      IF (Nh.GE.0) THEN
      IF (CM.GT.0 .AND. Nh.LT.N .AND. CL.EQ.0 .AND. CH.EQ.0) THEN
        IC=4
        Nh= -1
      END IF
      END IF
c.IC_3,4------------------ CORRECT MISCODED Nh with CH or Exclude Types ---
      IF (CH.GT.0 .AND. CM.EQ.0 .AND. CL.EQ.0) THEN
        IF (Nh.NE.0) THEN
          IF (Nh.EQ.N .or. Nh.eq.-1) THEN
            Nh=0
            IC = 3
          ELSE
            IC=4
            Nh=-1
          END IF
        END IF
      END IF
```

Continued next page.

Table 4. Continued

```
c.IC_4---------------------- EXCLUDE INCONSISTENCIES for TYPES ----------
      IF (CL.GT.0 .AND. CM.EQ.0 .AND. CH.EQ.0) THEN
        IF (Nh.LT.N .AND. N.NE.8) THEN
          IF (Nh.GE.0) IC=4
          Nh=-1
        END IF
      END IF
c.IC_5----------------------
      IF (CL.LT.0 .OR. (Nh.LT.0 .and. IC.NE.2)) THEN
        IF ((CM.GE.0 .OR. CH.GE.0) .AND. CL.LT.0) IC=5
        Nh=-1
        CL=-1
        CM=-1
        CH=-1
        h =-1
        goto 10
      END IF
c.IC_6---------------------- CORRECT MISCODED CM,CH 0->/ -----------------
      IF (CH.EQ.0 .AND. CM.EQ.0 .AND.
     i    (N.EQ.8 .OR. (N.EQ.7 .AND. N.EQ.Nh))) THEN
        CM=-1
        IC=6
      END IF
      IF (CH.EQ.0 .AND.
     i    (N.EQ.8 .OR. (N.EQ.7 .AND. N.EQ.Nh))) THEN
        CH=-1
        IF (IC.NE.2) IC=6
      END IF
c.IC_7---------------------- RESET Ns FROM CM 2,7 ------------------------
      IF (DRS.EQ.1 .AND. (CM.EQ.2 .OR. CM.EQ.7)) THEN
        IF (CM.EQ.2) CM=12
        IF (CM.EQ.7) CM=11
        IC = 7
      END IF
c.IC_8---------------------- SET Ns FROM CM/ ----------------------------
      IF (DRS.EQ.1 .AND. CM.LT.0 .AND. CL.GE.0) THEN
        IF (.NOT.(CL.EQ.1 .OR.CL.EQ.2 .OR.CL.EQ.3 .OR.CL.EQ.9)) THEN
          IF (ww.GE.60 .OR. CL.EQ.7 .OR. CL.EQ.0) THEN
            CM =10
            IC = 8
          END IF
        END IF
      END IF
c.IC_9---------------------- CORRECT MISCODED CM,CH /->0 -----------------
      IF (CM.LT.0 .AND. CH.GE.0 .AND. CL.GE.0) THEN
        CM=0
        IF (IC.EQ.0) IC=9
      END IF
      IF (N.LE.4 .AND. N.EQ.Nh .AND. CL.GE.0) THEN
        IF ((CM.LT.0 .OR. CH.LT.0). AND. IC.EQ.0) IC=9
        IF (CM.LT.0) CM=0
        IF (CH.LT.0) CH=0
      END IF
   10 continue
      IF (CL.GE.0) THEN
        {Determine Upper Type Amounts (Table 6)}
```

Table 5. Number of Reports with Cloud Type Information
(CL > -1)

	Land (1971-96)	Ocean (1952-95)
all reports	305 million	59.5 million
light reports	223 million	44.2 million

Table 6. FORTRAN Code for Determining Middle and High Cloud Amounts

```
*jum,juh are middle and high cloud non-overlapped amounts in okta (9=missing).
*AM,AH are "actual" amounts, using of random overlap if necessary.
*JAM,JAH are integer values of AM,AH in oktas x 100 (900=missing).
*  Other variables are integers. Cloud variables are defined in Table 1.
*Starting with      jum= 9      juh= 9      JAM=900      JAH=900      1 - 4
      if (CL.ge.0)  then                                                  5-
c_MID-----------------------------------------------------------------
      IF (CM.GT.0) THEN                                                   6
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . present
        if (Nh.ge.0) then                                                 6+
        IF (CL.EQ.0 .OR. CH.LE.0) THEN                                    7
          IF (CL.EQ.0) THEN                                               8
            jum= Nh                                                       9
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable
            JAM= Nh*100                                                  10
          ELSE                                                           11
            jum=(N-Nh)                                                   12
            IF (CM.LE.12 .AND. CM.GE.10) THEN                            13
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . Ns computable
              JAM= N*100                                                 14
            ELSE                                                         15
              IF (Nh.LT.7) THEN                                          16
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable,ROL
                AM= 8.*(N-Nh) / (8.-Nh)                                  17
                JAM= AM*100. +.5                                         18
              END IF                                                     19
            END IF                                                       20
          END IF                                                         21
        ELSE                                                             22
          IF (Nh.EQ.N) jum=0                                             23
        END IF                                                           24
        end if                                                           24+
      ELSE IF (CM.EQ.0) THEN                                             25
        JAM=0                                                            26
        jum=0                                                            27
      ELSE                                                               28
        IF (Nh.EQ.N .AND. CL.GT.0) jum=0                                 29
      END IF                                                             30
c_HI------------------------------------------------------------------
      IF (CH.GT.0) THEN                                                  31
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . present
        IF (CL.EQ.0 .AND. CM.EQ.0) THEN                                  32
          juh= N                                                         33
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable
          JAH= N*100                                                     34
        ELSE IF ((CL.EQ.0 .OR. CM.EQ.0).and. Nh.ge.0) THEN               35&
          juh= (N-Nh)                                                    36
          IF (Nh.LT.7) THEN                                              37
c. . . . . . . . . . . . . . . . . . . . . . . . . . . . . computable,ROL
            AH= 8.*(N-Nh) / (8.-Nh)                                      38
            JAH= AH*100. +.5                                             39
          END IF                                                         40
        ELSE                                                             41
          IF (Nh.EQ.N) juh=0                                             42
        END IF                                                           43
      ELSE IF (CH.EQ.0) THEN                                             44
        JAH=0                                                            45
        juh=0                                                            46
      ELSE                                                               47
        IF (Nh.EQ.N .OR. (CL.GT.0 .AND. CM.GT.0)) juh=0                  48
      END IF                                                             49
      end if                                                             50
```

Table 7. Random Overlap Computation Table

(For amount of cloud in higher level when clouds are present at exactly two levels.)

Amount higher cloud [okta] = 8. * (N - Nh) / (8. - Nh)

N\Nh	7	6	5	4	3	2	1	0
8	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
7	0	4.00	5.33	6.00	6.40	6.67	6.86	7.00
6	x	0	2.67	4.00	4.80	5.33	5.71	6.00
5	x	x	0	2.00	3.20	4.00	4.57	5.00
4	x	x	x	0	1.60	2.67	3.43	4.00
3	x	x	x	x	0	1.33	2.29	3.00
2	x	x	x	x	x	0	1.14	2.00
1	x	x	x	x	x	x	0	1.00

Table 8. Number of Reports in which Upper Level Cloud Amounts were Computable

(millions of reports)

	LAND 1971-96				SHIPS 1952-95			
	Middle Cloud		High Cloud		Middle Cloud		High Cloud	
Number of:	Light	Dark	Light	Dark	Light	Dark	Light	Dark
Type reports	222.5	82.6	222.5	82.6	44.2	15.2	44.2	15.2
NOL* computed	204.7	79.3	204.5	79.2	39.3	14.4	39.3	14.4
Level reported	187.7	#	151.8	#	33.8	#	26.9	#
Cloud observed	84.1	25.1	69.9	16.3	18.0	3.9	10.2	1.5
Computable	64.9	21.7	51.8	13.2	11.2	2.9	4.7	0.8
ROL* used	25.6	6.0	28.4	5.5	7.4	1.7	3.4	0.5

* NOL signifies non-overlapped amounts and ROL signifies the random overlap assumption.

Data not available.

Table 9. Contents and Format* of the 80-character EXTENDED EDITED CLOUD REPORT

Item	Description	Abbreviation	Num chars	Minimum value	Maximum value	Missing value
1	year,month,day,hour	yr,mn,dy,hr	8	51120100	96123021	none
2	sky brightness indicator	IB	1	0	1	none
3	latitude x100	LAT	5	-9000	9000	none
4	longitude x100	LON	5	0	36000	none
5	land: station number ship: source deck, ship type	ID	5	01000 1100	98999 9999	none none,9
6	land/ocean indicator	LO	1	1	2	none
7	present weather	ww	2	0	99	-1
8	total cloud cover	N	1	0	8	none
9	lower cloud amount	Nh	2	0	8	-1
10	lower cloud base height	h	2	0	9	-1
11	low cloud type	CL	2	0	11	-1
12	middle cloud type	CM	2	0	12	-1
13	high cloud type	CH	2	0	9	-1
14	middle cloud amount x100	AM	3	0	800	900
15	high cloud amount x100	AH	3	0	800	900
	non-overlapped amounts:					
16	middle cloud amount	UM	1	0	8	9
17	high cloud amount	UH	1	0	8	9
18	change code	IC	2	0	9	none
19	solar altitude (deg x10)	SA	4	-900	900	none
20	relative lunar illuminance x100	RI	4	-110	117	none
21	sea level pressure (mb x10)	SLP	5	9000,L 8700,S	10999,L 10746,S	-1
22	wind speed (ms^{-1} x10)	WS	3	0	999	-1
23	wind direction (degrees)	WD	3	0	361	-1
24	air temperature (C x10)	AT	4	-949,L -880,S	599,L 580,S	900
25	dew point depression (C x10)	DD	3	0	700	900
26	Land: station elevation (m) Ship: sea surface temp (C x10)	EL SST	4	-350 -50	4877 400	9000
27	wind speed indicator	IW	1	0	1	9
28	Land: sea level pressure flag Ship: cloud height indicator	IP IH	1	0 0	2 1	9

* Where values differ, L=Land, S=Ship. See Section 4.1 for detailed discussion.

Table 10. Sample Extended Edited Cloud Reports in 80-Character Format

LAND:

	YrMnDyHrB	Lat	Lon	IdOwwNNh	hClCmCh	Am	AhMH	C	SA	RI	slpr	ws	wd	at	dd	steWP
(1)	710712211	4050	9590524241	35-1	9 0 6	290090099		2	-123	1910010	20	90	-130	900117791		
(2)	770716121	209527033766441460		-1-1-1-1		-190090099		0	64	0	-1	0	0	-220900		999
(3)	811201060	318025360722701		20	0-1 0 0 0	0	000	0	-742	-110130	98300		90110119499			
(4)	811201180	225511410594931		27	7 9 0	3-170090070		0	-652	-210293	87	20	120140	1899		
(5)	811202061	250712123466971		28	8 4	5-1-190090000		0	326	110315	62	50	10900	5099		
(6)	811203061	5412	3533277071458	8	011-1-190090000			1	16	-310262	10	90	0900	20399		
(7)	811204060	6868	2153 20601738	2	3	512-180090060		7	-124	-4	9838	26140	-50	20	40399	
(8)	811204120	259026257722501		15	5 8 0	3 0500	050	0	-137	-810232	31	30	230	20	691	
(9)	811207121	434835168	80031	26	6 5 9	0 0	0	000	0	236	-1310135	36320	100	10	24199	
(10)	811207180	107012257986371		23	1 4	2 0 1	022902	0	-548	310112	21	20	250	10	199	
(11)	811212121	234712038467461		57	7 4	5-1-190090000		6	-370	2610204	26	10	170	30	2599	
(12)	811213001	4297	5412382321	28	8 6	5-1-190090000		0	-403	5610269	51	90	20	10	-7699	
(13)	811215001	4713	953 69901718	8	4 710-180090000			8	-646	2210022	5	50	10	10	45791	
(14)	811215060-548029168879381			13-1-1-1-1		-190090099		4	-94	5	9897	0	0	70	10	1699
(15)	811215180-2910	2630684421		24	2 7 9	7 290090099		0	-102	-15	-1	41290	230	90135999		
(16)	811220120	398011168535631		85-1-1-1-1		-190090099		0	-314	-2	-1	-1	-1	900900900099		
(17)	811208091	5038	1118 95581738	8	0 010-180090080			1	116	-21	9872	31210	-10	0	63099	
(18)	811226031	373310017527541		22	0 9 0	0 2	020002	0	209	0	-1	10250	-110	160330299		
(19)	820101120	277010688577131		-18-1-1-1-1		-190090099		0	-239	210217	0	0	85	64	84599	
(20)	820102060	6888	3302221121108	5	5 5-1-190090099			0	-108	-210309	21120	-254	31	799		
(21)	820110061	324210458561931		-10	0-1 0 0 0	0	000	0	342	-5710148	0	0	94900	87799		
(22)	820116061-2585	2565682421		33-1	8 0 6	490090099		2	291	9	-1	31	50	206	42127899	
(23)	820117060	5897	1490 25411-16		0 9 0	0 6	060006	3	-115	310282	10200	-64	20	14499		
(24)	820117180	4550	2802153101103	2	9 0 4	120013321		0	-322	-510362	31	20	-32	14	7199	

SHIP:

	YrMnDyHrM	Lat	Lon	IdLwwNNh	hClCmCh	Am	AhMH	C	SA	RI	slpr	ws	wd	at	dd	sstWH
(25)	550428000	2800	5080	15592-10	0-1 0 0 0	0	000	0	-250	-310063	67150	247	59	23309		
(26)	550413001	297013060		15092-16-1-1-1-1		-190090099		0	391	210153	51120	226	34	22919		
(27)	811201060	5690	370	89262	34 4 4 5	0 0	0	000	0	-147	-110181	77350	60	80	8009	
(28)	811201121	482034940		89262167	7 2 6-1-190090000			6	196	010304	72350	102900900019				
(29)	811201180	359015700		92762628	8 0 010-180090080			1	-286	-210100103270		185	13	18019		
(30)	811204121-2790	1200		92662	10 0-1 0 0 0	0	000	0	757	210177	93170	180	32	19000		
(31)	811204201	211024670		66762-16-1-1-1-1		-190090099		0	456	0	-1	-1	-1	900900	25309	
(32)	811208001	434020220		92762	23 3 3 2	0 0	0	000	9	202	-610314144330		90	41	9010	
(33)	811208060	454031690		92762	24-1-1-1-1		-190090099		0	-444	110050	51170	182	24	16709	
(34)	811208121	338012260		88792	03-1-1-1-1		-190090099		4	-405	3710270	41300	102900900009			
(35)	811208181	4130	950	92662607	2 4 312	590090099		7	-231	3010051	67210	147	40	14700		
(36)	811209001	429035040		89262627	7 5 510-170090000			8	-689	3910076	82280	135900	15519			
(37)	811209121	365018690		92762128	8 011-1-190090000			1	-743	4610057	51320	180	21	18009		
(38)	811211181	364034840		89262	15 3 5 2	0 2	032002	0	-59	-110250	41310	184	30	19319		
(39)	811212001	3680	130	92662	38 8 4 5-1-190090000			0	-760	9010179113230		167	15	16000		
(40)	811212181	228027360		92762	23 3 5 2	0 0	0	000	0	438	-4810190	21	0	233	48	23900
(41)	811217151	541031560		89262628	8 2 510-180090000			8	125	0	9990268110		48	10	6209	
(42)	811221001	264012200		73262	23 2 5 8	5 0133	010	0	153	110288	70	20	140900	16010		
(43)	811221061	29010520		73262	28 8 5 5-1-190090000			0	595	010149	70	30	264900	27110		
(44)	811225181	512022950		92762	27 7 5 2	0 4	090000	9	73	010181108260		73	0900010			
(45)	820102151	192034260		92662	20 0-1 0 0 0	0	000	0	405	310120	21	40	243	93	17900	
(46)	820103001	379014130		89262-12-1-1-1-1		-190090099		0	186	-410359	62350		38900	12019		
(47)	820103061	128012470		92662158	6 2 7 7	390090099		0	414	510110	51	60	260	40	26800	
(48)	820103121-260027450			73262	38 8 4 5	7-190090000		0	126	-10	-1	40140	201900	20500		
(49)	820108181	444034490		89262	28 8 4 6	6-190090000		6	-42	1910089	41210	142900	16019			
(50)	820109001	364035870		92662	28 0 9 0	0 7	080008	0	-755	8410200	51230	170	60	15600		
(51)	820110181	344016880		89262	23 3 6 1	0 0	0	000	9	-226	4510073123290		126	66	16019	
(52)	820112181	207016140		92762	13-1-1-1-1		-190090099		4	-259	3710120	51140	265	32	27000	
(53)	820114121	303022380		92662154-1-1-1-1		-190090099		5	-517	1910194	41	60	160	30	17511	
(54)	820120121	6510	430	92662618	6 3 712-180090020			7	47	010235	51210	69	3	6810		
(55)	820122061-651010890			89262	21 1 9 0	3 1100	010	0	434	0	9916	26	80	15	44900009	
(56)	820122151	331029530		92662-16	5 3 8 6	0267	010	0	329	010210144340		152	38	18010		
(57)	880117181	226019570		88962-13	2 5 1 6	0133	010	0	34	010195	0361	232	38	24410		
(58)	880124191	75027480		66762-12-1-1-1-1		-190090099		0	585	3	-1	0	-1	900900	28809	

Table 11a. Land Stations[#] to be Omitted from Cloud Type Analyses

This abbreviated list of 234 stations, a subset of the 939 listed in an ancillary file, identifies the stations that affect more than 9 years of data for 1982-96.

03004	03824	33187	37874	40250	48930	62259	71082*	71910*
03006	03830	33215	37936	40340	48946	62393	71090*	71933*
03009	03837	33228	37989	40809	48947	62405	71145*	71958*
03038	03866	33347	38099	41560	52813	62414	71187*	71965
03054	03877	33511	38111	41710	53523	62417	71608	71966*
03060	03906	33805	38162	41718	53563	62420	71623	71967
03118	03914	33898	38267	41749	53745	62435	71624	72747
03133	03926	33929	38339	41785	53823	62465	71625*	76632
03137	03928	34539	38444	41929	53985	62640	71707	76634
03152	04212	34622	38511	42249	54858	62641	71709	76805
03161	04310	34975	38529	42555	56297	62650	71714	82024
03229	06191	35127	38553	42679	56581	62660	71717*	82067
03242	06225	35749	38665	42731	56989	62680	71730*	82113
03281	06250	37163	38683	42840	57068	62721	71731*	82610
03329	06268	37209	38705	43221	57128	62752	71735	83618
03339	07022	37248	38767	44278	57137	62770	71749*	83700
03342	08530	37308	38791	44286	57298	63832	71815	85972
03345	08538	37316	38829	44297	57462	65112	71822*	88903
03388	11194	37416	38885	44374	57557	65250	71831*	93184
03401	16258	37417	38921	47601	57708	65404	71842	93374
03613	21541	37483	38937	47748	58245	65418	71852	94767
03702	22318	37537	38989	47808	58461	66130	71862*	94842
03785	22835	37621	40045	47917	58655	71051	71863*	94933
03786	23927	37639	40061	48095	58713	71069*	71882*	94975
03791	25822	37673	40072	48418	62124	71078*	71892*	94983
03793	31432	37711	40087	48849	62161	71079*	71907*	94995

* These 23 Canadian stations may be used for cloud types prior to 1992.

[#] Station Numbers are assigned by WMO according to regions:

Region I	Africa	60000 - 69999
Region II	Asia	20000 - 20099
		20200 - 21999
		28000 - 32999
		35000 - 36999
		38000 - 39999
		40350 - 48599
		48800 - 49999
		50000 - 59999
Region III	South America	80000 - 88999
Region IV	North & Central America	70000 - 79999
Region V	South-West Pacific	48600 - 48799
		90000 - 98999
Region VI	Europe	01000 - 19999
		20100 - 20199
		22000 - 22999
		26000 - 27999
		33000 - 34999
		37000 - 37999
		40000 - 40349
Region VII	Antarctica	89000 - 89999

Table 11b. Data Format for the Ancillary File (XSTATY) of Land Stations To Be Excluded from Cloud-Type Analyses*

Header record:	Variable	NSTX	YRF	YRL		
	Format	I6	I6	I6		
	Description	Number of Stations	First Years of Record	Last		
Data record:	Variable	ID	B2c	M	YX	YT
	Format	I5	I5	I2	I3	I3
	Description	Station ID No.	2c Box No.	Contributing months 1=Jan 2=Jul 3=Both	Number yr-mns "fail"	Number yr-mns "pass"

Example of file contents:
(Data records were selected to show a variety of station reporting characteristics.)

Header record:

939	1982	1996		

Selected data records:

ID	B2c	M	YX	YT
1088	156	2	1	1
1116	264	2	1	2
71608	1171	3	23	4
71623	1165	3	10	20
71624	1166	1	4	11
71625	1023	3	8	21
71626	1024	2	1	0
71707	1029	1	4	11
71895	740	1	1	3
72534	1306	3	15	0
72670	1154	2	1	0
72747	872	1	4	9
98437	2831	2	1	2
98830	3262	2	1	0

*To use this file, it is only necessary to read the station number.
The other variables are included for reference.
Latitude and longitude for 2c grid box centers can be obtained using the subroutine given in Appendix C2.

Table 11c. 5c Grid Boxes to Exclude from Ocean Cloud-Type Analyses

B5c#	Ocean Fraction	fb	AF9	AF0*	Location
81	0.832	0.50	1.10	1.01	Greenland
49	0.036	0.82	1.13	1.60	Sweden-Finland
84	0.138	0.72	1.16	1.27	(Gulf of Bothnia)
85	0.158	0.74	1.10	1.36	
70	0.033	0.74	1.10	1.13	Canada
109	0.199	0.80	1.21	1.07	(Hudson Bay)
147	0.205	0.52	1.14	1.06	
183	0.433	0.53	1.07	1.05	
184	0.193	0.80	1.27	1.20	
244	0.000				USA
245	0.000				(Great Lakes)
246	0.001	0.95	1.57	2.10	
248	0.001	0.87	1.13	1.41	
247	0.000				
249	0.099	0.81	1.23	1.19	
250	0.584	0.69	1.19	1.10	
317	0.000				
318	0.001	0.96	1.41	2.44	
319	0.001	0.90	1.18	1.49	
200	0.000				Caspian Sea
201	0.000				
272	0.000				
273	0.000	0.18	1.00	1.11	
344	0.000				
345	0.000	0.30	1.00	1.25	
266	0.312	0.38	1.00	1.19	Adriatic Sea
488	0.145	0.27	1.00	1.22	Persian Gulf
1751	0.343	0.59	1.17	1.03	Antarctica

See Appendices C1 and C3 for conversions between (latitude,longitude) and B5c.

* Values from 1982-91 annual data, where available; Caspian Sea values from July data only.

Table 12. Data Format for the Ancillary file (YSTATY) for Land Stations that Report Light Obs for Cloud Types*

Header record:

Variable	NSTA	NSTY	YRF	YRL
Format	I6	I6	I6	I6
Description	Number of Stations with any light-type obs	Number of Stations with ≥15yrs of ≥20 light-type obs Jan or Jul	First Year of Record	Last Year of Record

Data record:

Variable	ID	B2c	MS	M1	M2	MM	MX
Format	I5	I5	I2	I3	I3	I3	I3
Description	Station ID No.	2c Box No.	Contributing months 1=Jan 2=Jul 3=Both	Num yr-mns with ≥20obs Jan	Num yr-mns with ≥20obs Jul	Num yr-mns with 20>nobs>0 Jan+Jul	Num yr-mns fail fb test Jan+Jul

	NSTA	NSTY	YRF	YRL	Notes (not in data record)
header:	11586	5838	1971	1996	

sample data:

ID	B2c	ms	m1	m2	mm	mx	
01001	189	3	26	26	0	0	
01377	408	2	0	0	2	0	
06041	480	3	26	26	0	0	
06220	622	3	0	0	2	14	from 1971-81 data
12135	625	3	26	26	0	0	
16416	1348	1	0	0	1	0	
22996	415	3	23	24	0	0	
28509	560	3	1	0	3	1	
30412	570	3	0	2	1	0	
37549	1215	3	26	26	0	0	
43268	2812	2	0	0	1	0	
44215	802	3	16	15	3	1	
54523	1389	3	0	0	2	1	mx from 1971-81 Jul
63671	3518	3	21	23	8	0	
71950	668	3	19	20	0	0	
72274	1873	3	25	25	1	0	
72407	1456	3	11	11	1	0	
72779	864	3	21	20	1	0	
72784	1006	3	26	26	0	0	
83374	4633	3	6	7	0	0	
94387	5002	3	2	2	0	0	
98324	2685	3	20	20	7	2	
98851	3264	3	21	21	3	0	

Some Statistics:

939 Stations were eliminated by XSTATY based on 1982-1996 data.

11586 Stations have light obs for cloud types (in 2378 B2Cs in 859 B5Cs).

Januarys only	Julys only	Both
371	583	10632

2232 Stations had some yrs in which at least 20% of obs had CL=/.

5838 Stations had 15 yrs of ≥20 obs in either Jan or Jul (in 1933 B2Cs in 775 B5Cs).

5581 Stations had 15 yrs of ≥20 obs in both Jan and Jul.

* Abbreviations: (n)obs= (number of) observations, yr= year, mn= month, Jan= January, Jul= July.

Table 13a. Partial* List of Canadian Stations that Changed WMO Station ID Numbers in 1977. Numbers 740nm became 710nm; numbers 729nm became 719nm. New station numbers are shown.

71043	71053	71062	71066	71068	71069	71071	71072	71073	71074
71075	71076	71077	71078	71079	71080	71081	71091	71092	71093
71094	71095	71096	71097	71098					
72901	71904	71905	71906	71907	71908	71909	71911	71912	71913
71915	71916	71917	71918	71919	71920	71922	71923	71924	71925
71926	71927	71928	71929	71930	71932	71933	71934	71935	71936
71937	71938	71939	71940	71941	71943	71945	71946	71948	71950
71951	71953	71956	71957	71958	71959	71964	71968	71969	

* Also numbers 728--, 741--, 743-- became 718--, 711--, 713--, respectively.

Table 13b. Examples of Canadian Stations that Changed WMO Station ID Numbers. (Examples are taken from Ancillary File YSTATY; see Table 12 for symbols.). Changes occurred between June and July 1977 when several stations with numbers 729nm became 719nm and numbers 740nm became 710nm.

List A:
Station ID 740nm became 710nm

ID	B2C	M	M1	M2	MM	MX
71043	308	3	18	18	0	3
74043	308	3	7	6	0	0
71053	237	3	10	13	12	0
74053	237	3	7	6	1	0
71062	311	3	5	5	1	0
74062	311	3	7	6	0	0
71072	106	3	14	14	2	4
74072	106	3	7	6	1	0
71073	384	3	14	15	0	0
74073	384	3	7	6	0	0
71080	244	3	8	15	7	0
74080	244	3	7	6	0	0
71081	245	3	16	16	0	6
74081	245	3	7	6	0	0
71092	247	3	10	17	6	0
74092	247	3	7	6	1	0
71093	248	3	10	13	7	0
74093	248	3	7	6	1	0
71094	321	3	15	15	1	3
74094	321	3	7	6	0	0
71095	146	3	17	17	0	0
74095	146	3	2	2	0	0
71098	465	2	0	8	2	0
74098	465	3	1	1	1	0

List B:
Station ID 729nm became 719nm

ID	B2C	M	M1	M2	MM	MX
71904	464	3	7	9	1	0
72904	464	3	7	6	1	0
71908	390	3	0	0	3	0
72908	110	3	1	2	0	0
71926	386	3	19	20	0	0
72926	386	3	7	6	0	0
71927	242	3	8	11	13	0
72927	242	3	7	6	1	0
71934	455	3	16	18	0	5
72934	455	3	7	6	0	0
71936	455	3	18	18	0	3
72936	455	3	7	6	0	0
71937	239	3	10	13	10	0
72937	238	3	4	4	1	0
71948	177	3	15	15	0	4
72948	177	3	7	6	0	0
71956	236	3	11	16	6	0
72956	236	3	4	3	0	0
71957	235	3	18	16	0	4
72957	235	3	7	6	0	0
71964	450	3	17	17	0	4
72964	450	3	7	6	0	0
71969	233	3	11	16	6	1
72969	233	3	4	3	0	0

Table 14a. Year-Months in which Land Stations* Switched Box 2c's

SPOT Data					NCEP Data				
Year	Num Mns	Month	Num of Switches	Num of Stations	Year	Num Mns	Month	Num of Switches	Num of Stations
1971	5				1977	2			
		Jan	1	1			Jul	9	9
		Feb	8	2			Dec	18	18
		Mar	3	1	1978	1			
		Jun	2	1			Nov	3	1
		Nov	2	1	1979	2			
1972	8						Sep	9	5
		Jan	506	138			Dec	21	7
		Feb	4	2	1980	2			
		Apr	224	224			Jan	24	8
		May	34	19			Mar	3	1
		Jun	2	1	1981	2			
		Aug	13	13			Apr	3	1
		Oct	21	10			Nov	3	1
		Nov	1	1	1982	0			
1973	5				1983	0			
		Apr	2	2	1984	2			
		May	1	1			May	3	2
		Jun	1	1			Nov	3	1
		Oct	1	1	1985	1			
		Nov	11	11			Jun	3	1
1974	7				1986	3			
		Feb	18	18			Mar	3	1
		Mar	5	5			Jun	3	1
		Apr	5	5			Aug	3	1
		Jun	5	5	1987	1			
		Jul	87	87			Mar	6	2
		Sep	6	6	1988	1			
		Oct	12	12			Apr	3	1
1975	9				1989	1			
		Jan	45	45			Sep	2	1
		Feb	2	1	1990	1			
		Apr	113	60			Jan	12	4
		May	23	22	1991	1			
		Jun	33	33			Oct	3	1
		Jul	2	2	1992	1			
		Aug	24	16			Aug	119	47
		Oct	1	1	1993	0			
		Dec	5	5	1994	1			
1976	1						Mar	3	1
		Apr	14	14	1995	2			
							Sep	6	2
							Dec	3	1
					1996	0			
Sum	35		1237	767#		24		268	118#

* The 649 affected stations (of over 7000 stations), with their assigned latitude, longitude and yr-months affected, are provided in an ancillary file with the EECRA (Table 14b).

Some stations switched boxes in more than one month.

Table 14b. Format of the Ancillary File (XSTALL) for 649 Land Stations that Switched Box 2c's

Variable	IX	ID	ALAT	ALON	NM	YRMN
Format	I3	I6	F7.2	F7.2	I3	6(I7)
Description	station count index	station ID number	assigned latitude -90 to 90	assigned longitude 0 to 360E	number of months	year-month affected

Excerpt:

IX	ID	ALAT	ALON	NM	YRMN's				
1	01062	76.50	25.07	2	197311	197410			
2	01146	67.40	13.90	1	197204				
3	01203	62.03	4.98	1	197204				
4	01439	58.25	7.33	1	199208				
5	02055	65.82	15.10	2	197201	197204			
640	96845	-7.87	110.92	6	197204	197205	197403	197404	197406	197604
641	97180	-5.07	119.55	1	197204					
642	97230	-8.75	115.17	1	197205					
643	97430	0.78	127.38	1	197306					
644	97698	-2.53	140.72	1	199208					
645	98324	15.33	119.97	1	197204					
646	98428	-14.50	120.92	1	198603					
647	98440	14.13	122.98	1	197410					
648	98536	12.58	122.27	4	197403	197404	197406	197505		
649	98546	12.48	124.63	1	197204					

Table 15. Distribution of Cloud Reports over the Synoptic Reporting Times

		Percent of reports at reporting times (GMT)									
	Total Number	00	03	06	09	12	15	18	21	6-hr	i3-hr
LAND (1971-96)											
all reports	311,301,548	14.2	9.9	14.7	11.2	15.5	10.4	14.3	9.9	58.7	41.3
light reports	226,989,965	12.5	10.1	17.6	14.3	17.1	10.5	11.2	6.7	58.4	41.6
light-type rpts	222,500,786	12.5	10.1	17.7	14.3	17.1	10.4	11.2	6.7	58.4	41.6
SHIP (1952-95)											
all reports	70,863,742	22.2	2.8	21.6	3.1	22.5	3.2	21.7	2.9	87.9	12.1
light reports	51,610,996	20.3	2.5	19.7	3.4	23.8	3.7	23.9	2.9	87.6	12.4
light-type rpts	44,224,092	20.9	2.5	20.3	3.1	23.6	3.0	23.9	2.6	88.7	11.3

Table 16. Contribution of the Various Paths to Total Nimbostratus Frequency
[From 1982-91 ECRA (H96)]

Path to Ns	ww	LAND 88 million light type reports frequency Ns,%	LAND 88 million light type reports percent of Ns	OCEAN 9.4 million light type reports frequency Ns,%	OCEAN 9.4 million light type reports percent of Ns
Total		6.24		4.90	
CM=2,7	D,R,S	3.59	58	1.60	33
N=9	D,R,S	0.39	6	0.96	19
CM=/:		2.26	36	2.34	48
CL=7	D,R,S		(17)*		(26)
CL=0	D,R,S		(0.1)		(0.02)
CL=6	R,S		(5)		(12)
CL=4,5,8	R,S		(14)		(10)
Exclusions*:		not Ns,%		not Ns,%	
CL=4,5,6,8	D	~0.2		~0.6	
CL=1,2,3,9	D,R,S	~0.08		~0.3	

* Approximate values based on January data: for exclusions and values in parentheses.

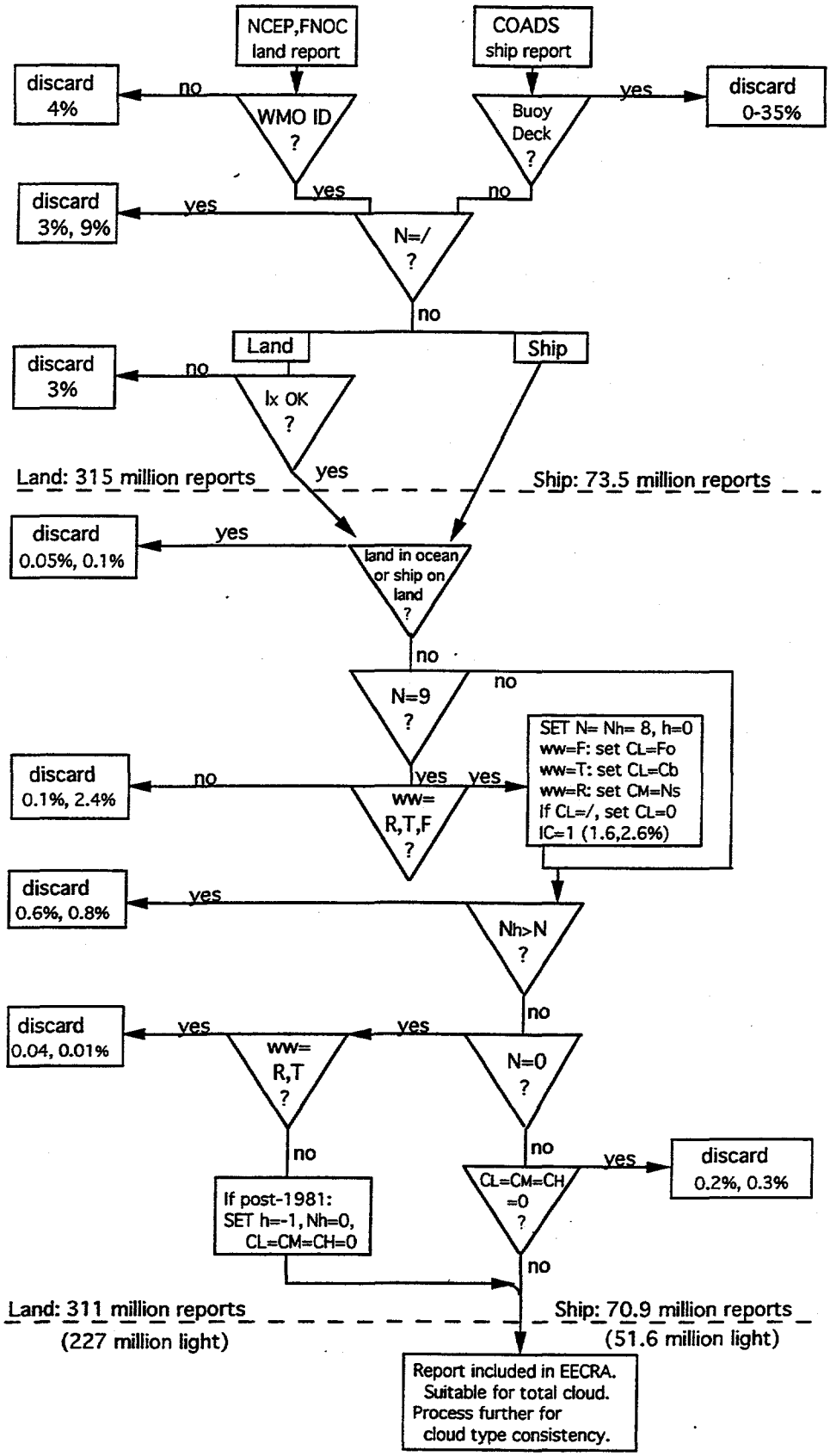


Figure 1. Flow chart of report processing through the total cloud stage.
(Discard-percentages given in order: land, ships. T and R here abbreviate Ts and DRS of Table 2. Other symbols are defined in Tables 1, 2, and 4. Land data 1971-96; ship data 1952-95)

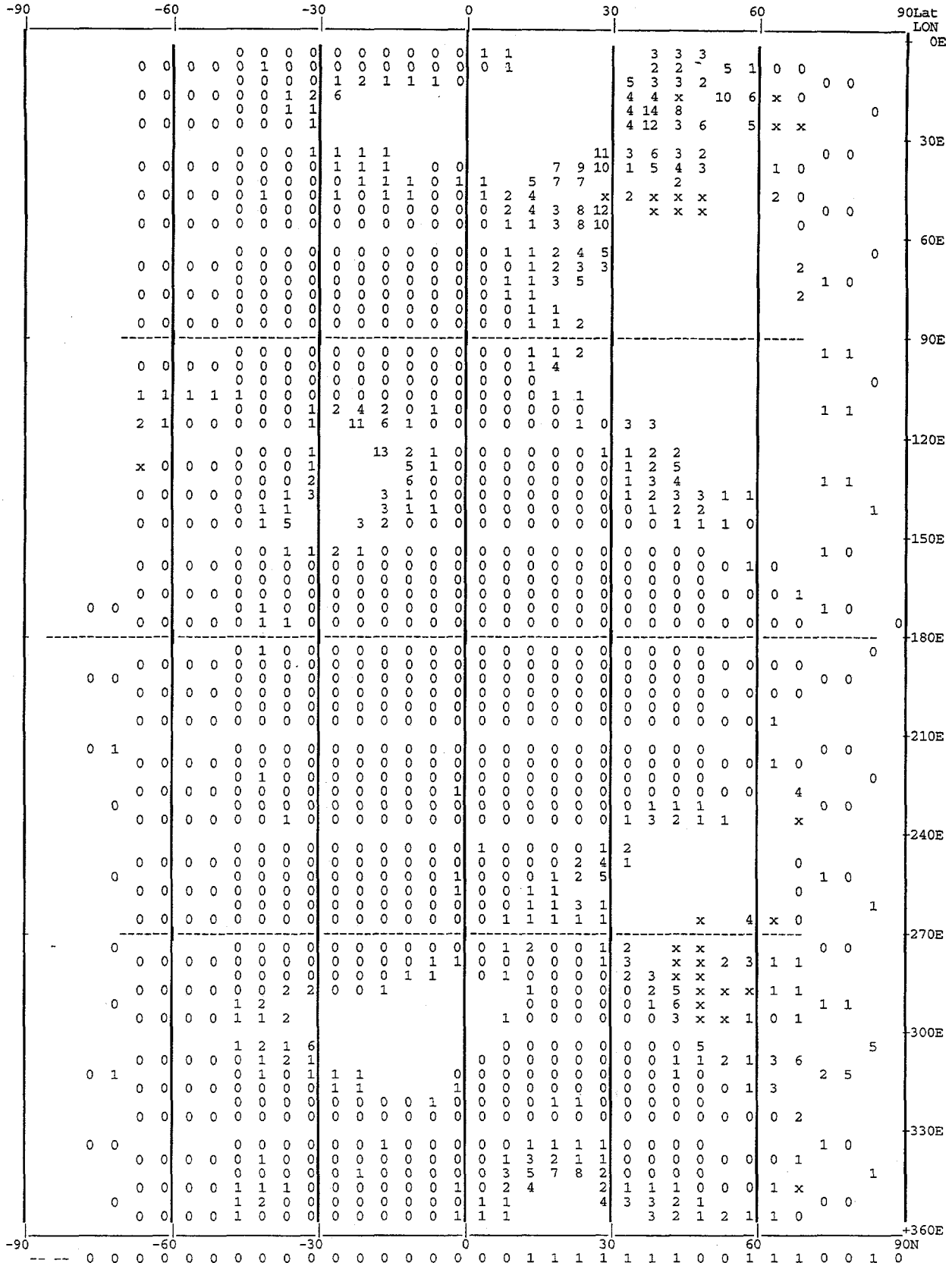


Figure 2a. Map of Clear-sky Adjustment Factor (AF0) in Light-type Reports for 1982-91 Ship Data.
Boxes unsuitable for cloud-type analyses from ship data are indicated with x's (see H96, Fig. 5b).
Global average of 1474 5c-grid boxes with ≥25 reports is 1.003 (1.005 for NH; 1.002 for SH).
Values mapped (and zonal averages at the bottom) are 100 x (AF0-1) where AF0 = 1/(1-fb*f0).

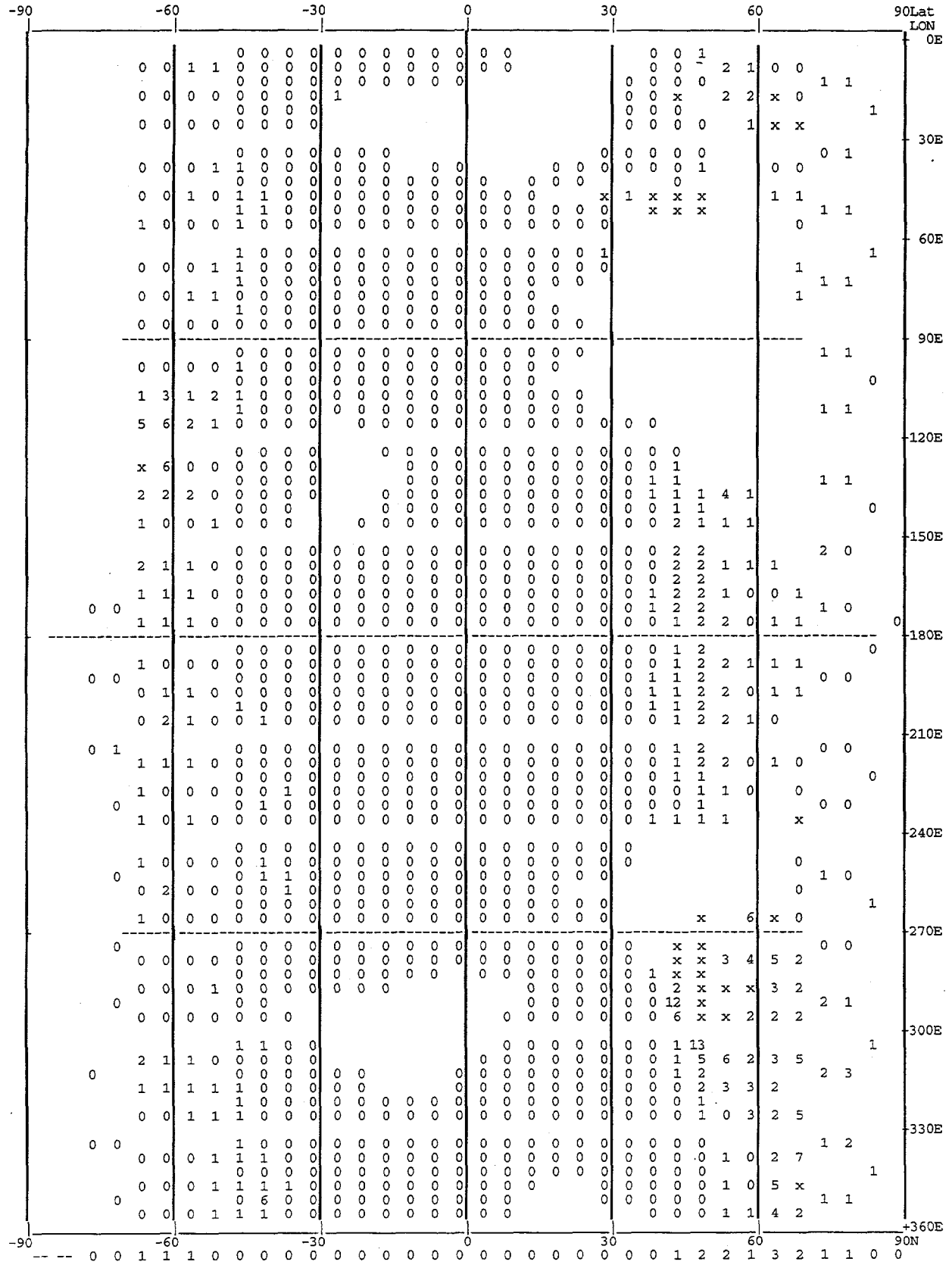


Figure 2b. Map of Sky -obscured Adjustment Factor (AF9) in Light-type Reports for 1982-91 Ship Data. Boxes unsuitable for cloud-type analyses from ship data are indicated with x's. Global average of 1473 5c-grid boxes with ≥25 reports is 1.003 (1.004 for NH; 1.002 for SH). Values mapped (and zonal averages at the bottom) are 100 x (AF9-1) where AF9 = 1/(1-fb*f9).

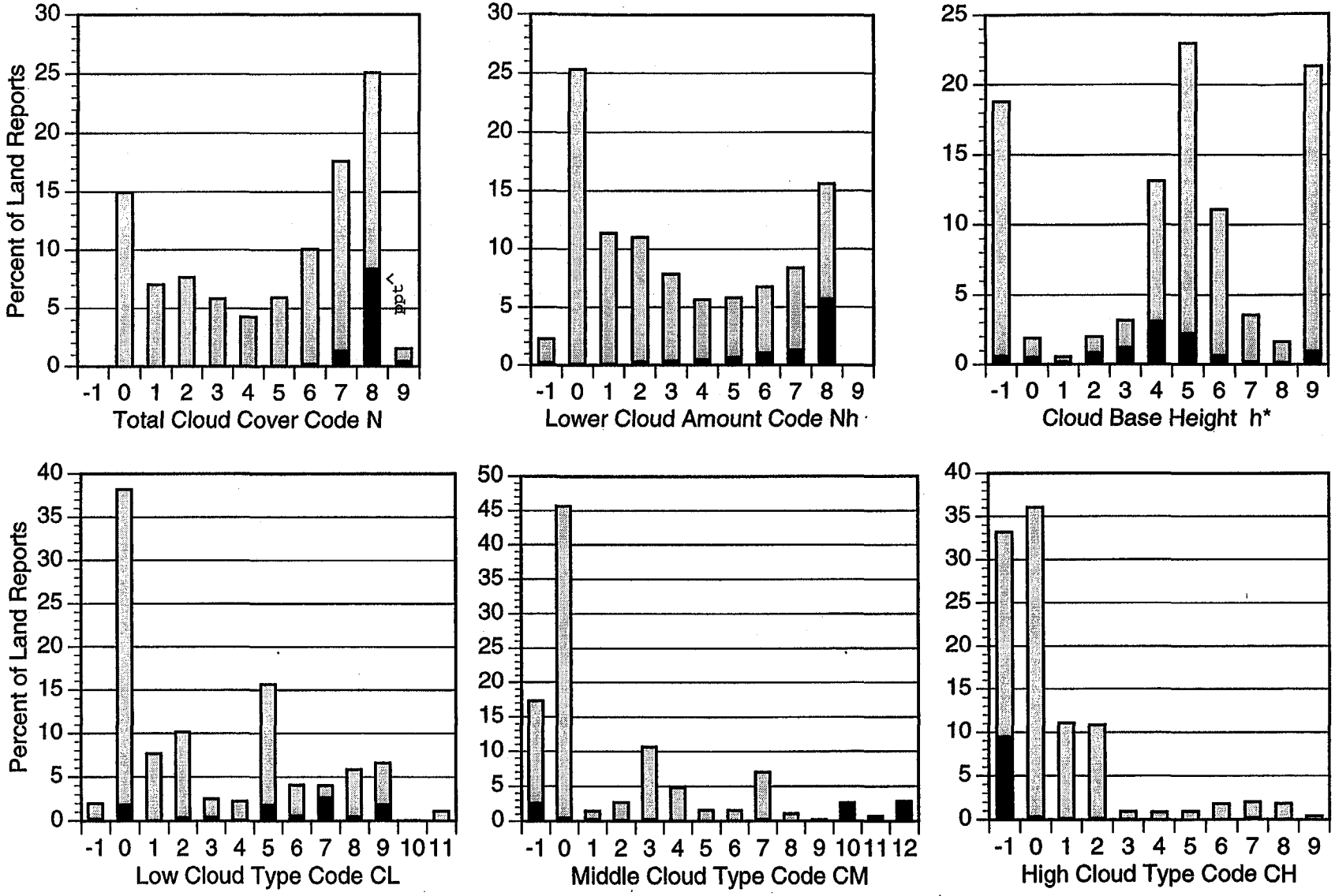


Figure 3a. Histograms of extended code values for cloud variables in light reports from global land data for 1971-1996. Dark areas indicate occurrence of precipitation. (N=9 is coded as N=8 in the EECRA.) *1971-Aug. 1994.

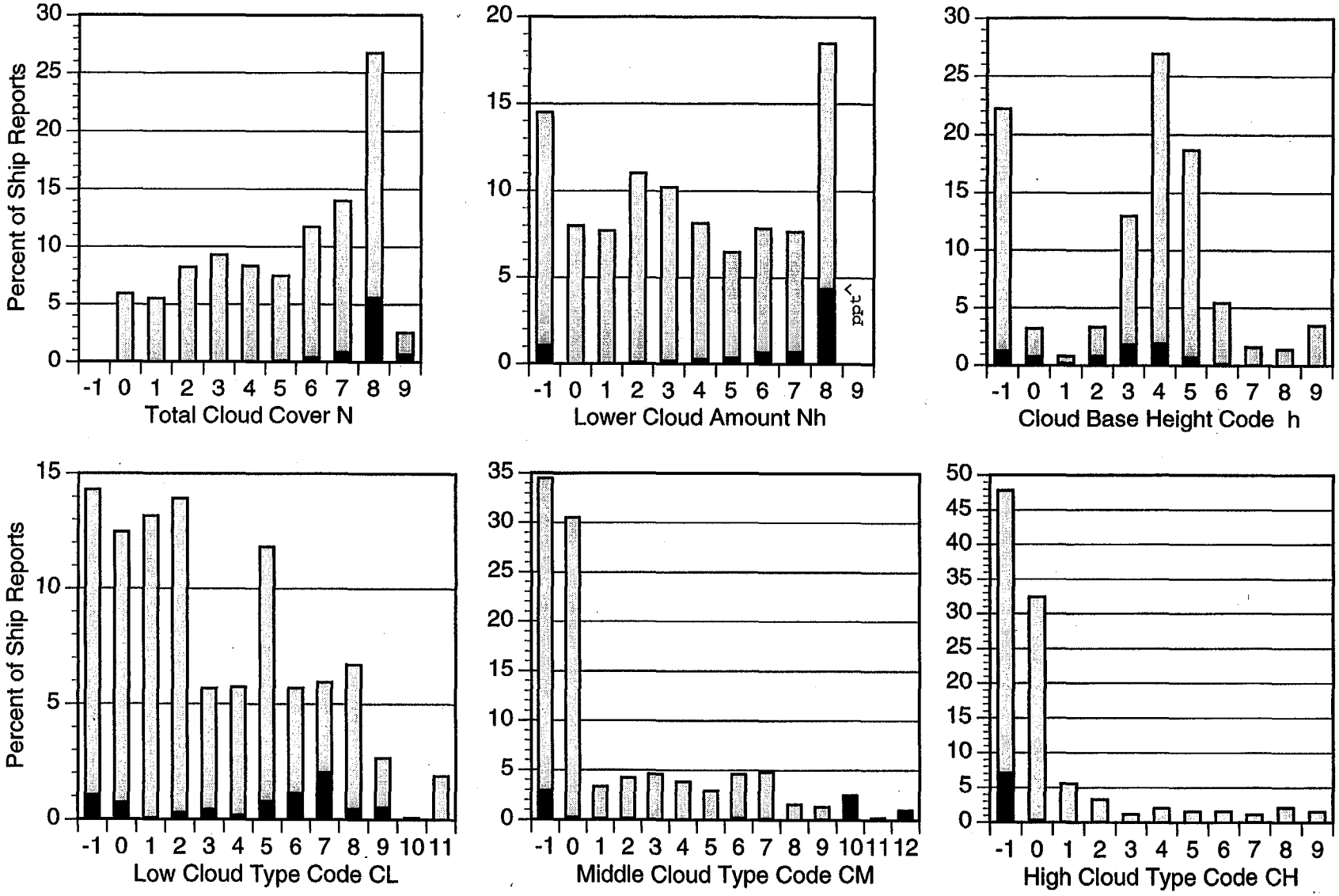


Figure 3b. Histograms of extended code values for cloud variables in light reports from global ship data for 1952-1995. Dark areas indicate occurrence of precipitation. (N=9 is coded as N=8 in the EECRA.)

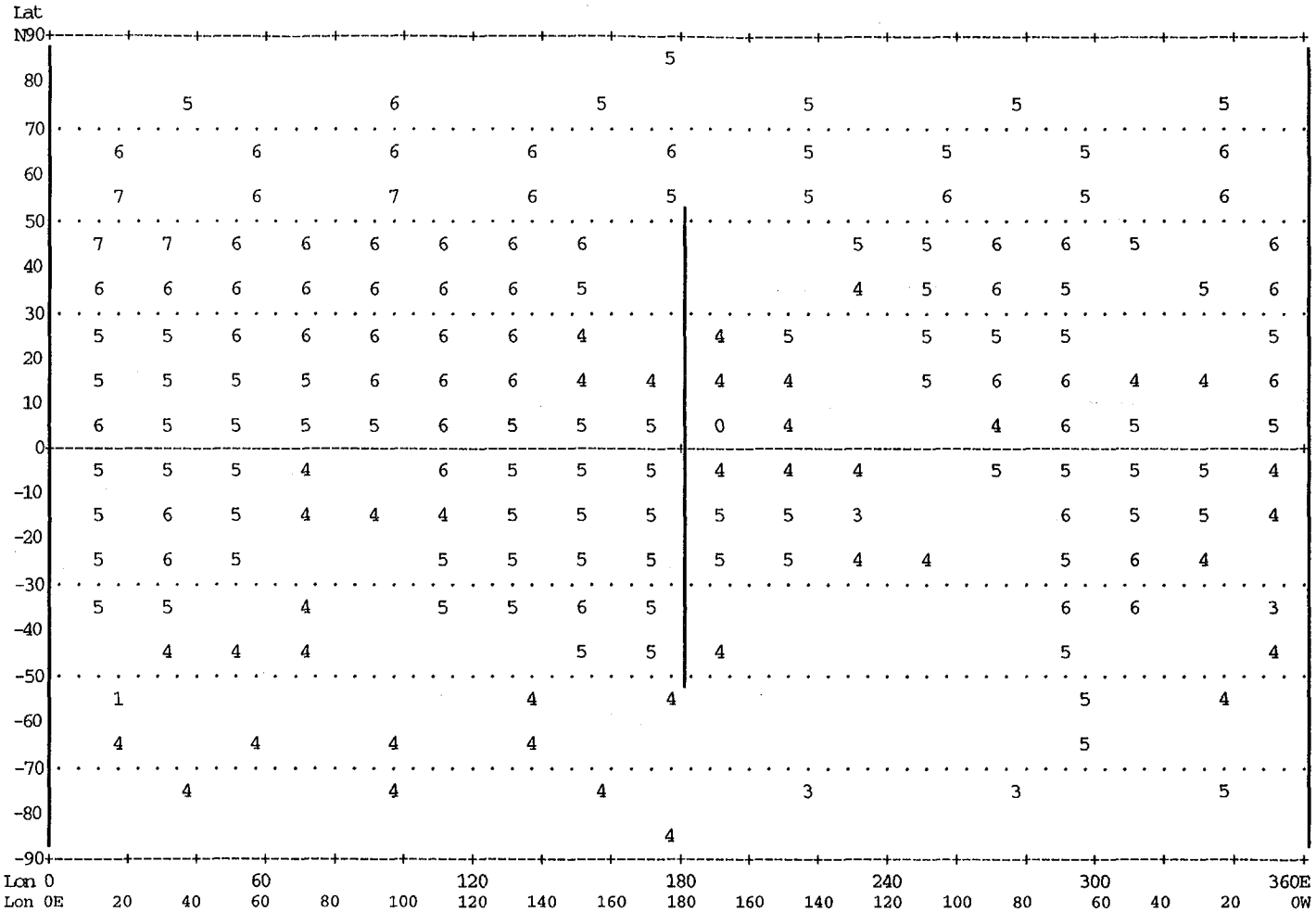


Figure 4a. Global distribution of log(number) of light reports for cloud types for 1971-96 land data on 10c grid. Blank indicates no reports for the box. There are a total of 222 million reports, with 194 million in the Northern Hemisphere and 28 million in the Southern Hemisphere.

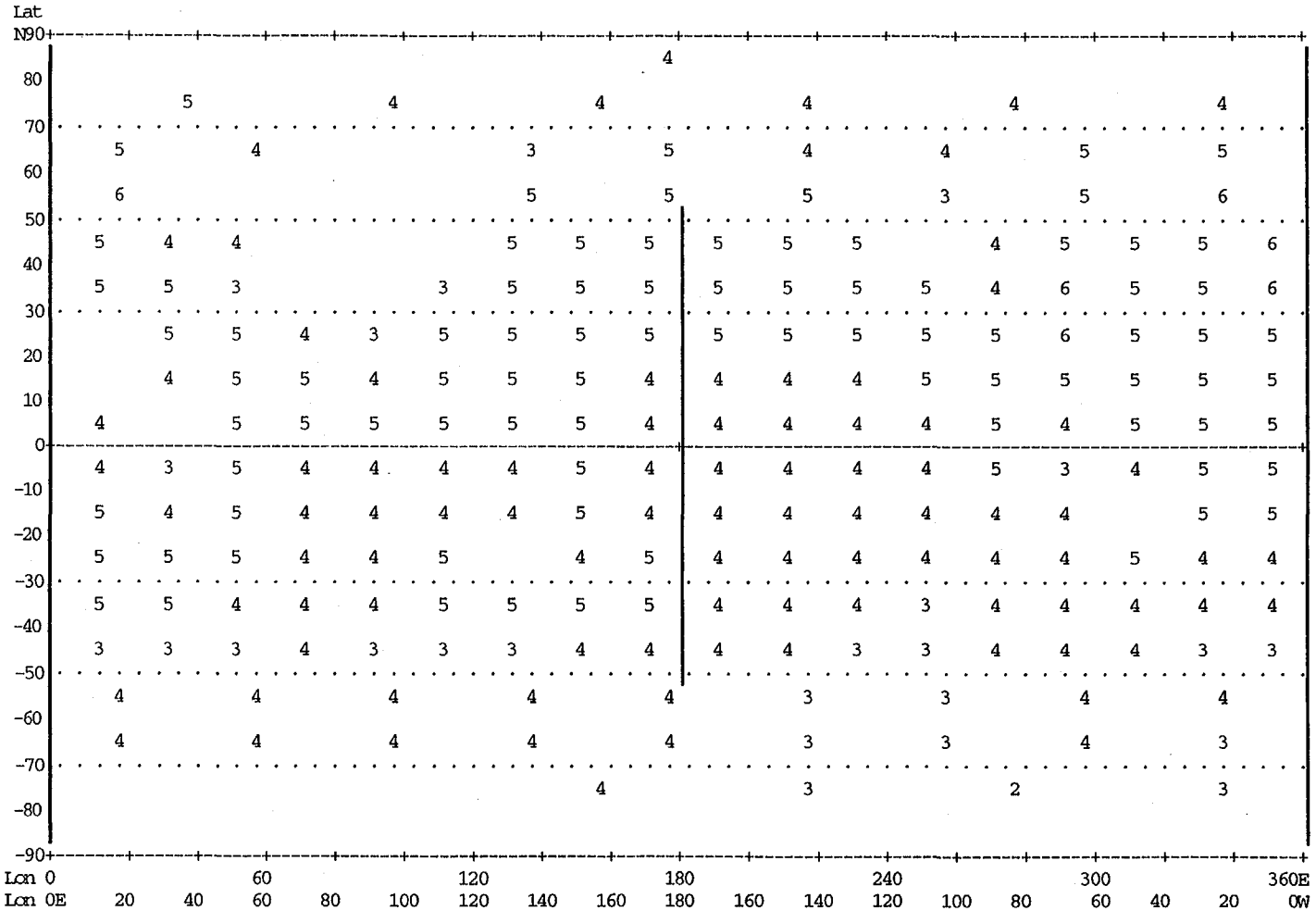


Figure 4b. Global distribution of log(number) of light reports for cloud types for 1952-95 ship data on 10c grid. Blank indicates no reports for the box. There are a total of 44 million reports, with 38 million in the Northern Hemisphere and 6 million in the Southern Hemisphere.

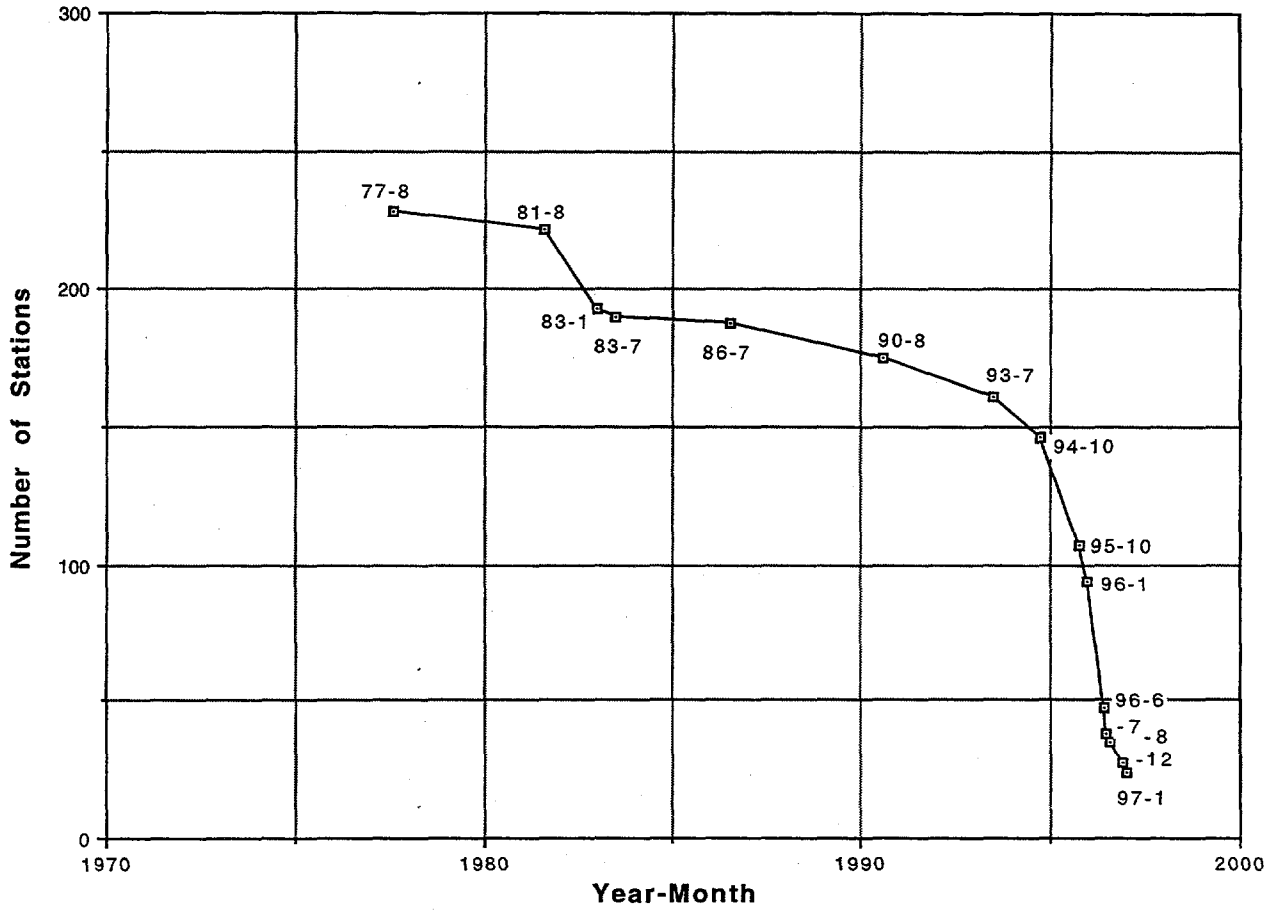


Figure 5. Time sequence of number of USA stations with at least 10 synoptic cloud reports per month from 1977 to 1997. Data points for selected year-months are shown.

APPENDIX A.

Glossary of Terms and Abbreviations Used*

Term	*Meaning and description*
2c grid	2.5x2.5° (latitude x longitude) boxes between latitudes 50N and 50S, 2.5x5 for latitudes 50-70, 2.5x10 for latitudes 70-80, 2.5x20 for latitudes 80-85, 2.5x40 for latitudes 85-87.5 and 2.5x360 for 87.5-90. Boxes on this grid are referred to as "B2c".
5c grid	5x5° (latitude x longitude) boxes between latitudes 50Nand 50S, 5x10 for latitudes 50-70, 5x20 for latitudes 70-80, 5x40 for latitudes 80-85, and 5x360 for 85-90. Boxes on this grid are referred to as "B5c".
10c grid	10x20° (latitude x longitude) boxes between latitudes 50Nand 50S, 10x40 for latitudes 50-70, 10x60 for latitudes 70-80, and 10x360 for 80-90.
actual amount	Fraction of the sky covered by a cloud, visible or not.
all reports	All reports regardless of whether they are light or dark.
awp	Amount-when-present. The average fraction of the sky covered by a cloud type when it is present, whether it is visible or not.
B2c	See "2c grid".
B5c	See "5c grid".
CMR	Condensed Marine Report; a format used in early COADS data sets.
dark reports	Reports for which illuminance criterion is not met (IB=0).
diurnal	Pertaining to a day; daily.
diurnal cycle	A cycle with a period of 24 hours.
EECR	Extended Edited Cloud Report. (See Table 9.)
EECRA	Archive made up of extended edited cloud reports.
extended code	The synoptic code extended beyond the usually allowed values of 0-9 to allow C_L=10 to represent Cb, C_L=11 to represent fog and C_M=10,11,12 to represent Ns cloud.
f	Frequency of occurrence. For a cloud type it is the fraction of weather observations in which the cloud type is present, whether it can be seen or not.
i3-hrly	Intermediate 3-hourly reporting times: 03, 09, 15, 21 GMT.
light reports	Reports for which illuminance criterion is met (IB=1).
LMRF	Long Marine Report Format; used in COADS data sets.
NCEP	National Centers for Environmental Prediction.
NMC	National Meteorological Center.
NOL	Non-overlapped; refers to the amounts of upper level clouds actually seen.
obs	Weather observations; weather reports.
ROL	Random overlap; refers to a method for determining amounts of upper level clouds, including the portions hidden behind lower clouds.
total reports	Reports suitable for total cloud analyses (and clear sky, fog, and precipitation); either all reports (the entire EECR data set) or light reports only.
type reports	Reports in which cloud type information is given (CL≥0). These may be light, dark, or all reports.
WMO	World Meteorological Organization.

* Terms not shown here may be defined in Tables 1, 2, 3 or 9.

APPENDIX B.

Grid Box-numbers (5c) in China where Amount-when-present of As and Ac is Not Valid for 1971-79.

	90E								120E	
50N										
		207	208	209				214	215	216
	278	279	280	281	282	283	284	285	286	287	288
	359	351	352	353	354	355	356	357	358	359	
	422	423	424	425	426	427	428	429	430	431	
30N										
					498	499	500	501	502	503	
					570	571	572	573	574		
							644	645			
15N										

APPENDIX C.

Conversion Programs for Latitude,Longitude and Grid Boxes

Appendix C1. Conversion of 5c Box Number to Latitude,Longitude

```
      SUBROUTINE LALO5C(KB, CLAT,CLON,KZ)
C FORTRAN SUBROUTINE TO CONVERT 5C BOX NUMBER (KB, 1-1820)
C  TO LATITUDE & LONGITUDE OF BOX CENTER.
C  GIVES LAT (N90 TO -90S), LON (0-360E),
C  AND ZONE NOS.(KZ, 1-36 N-S). Returns KZ=0 for KB out of range.
      KZ= 0
      CLAT= 0.
      CLON= 0.
      IF (KB.EQ.1)  THEN                                          85-90N
        KZ = 1
      ELSE IF (KB.LE.10)  THEN                                    80-85N
        KZ = 2
        CLON= 20. + 40.*MOD(KB-2,9)
      ELSE IF (KB.LE.46)  THEN                                    70-80N
        KZ = (KB-11)/18 + 3
        CLON= 10. + 20.*MOD(KB-11,18)
      ELSE IF (KB.LE.190)  THEN                                   50-70N
        KZ = (KB-47)/36 + 5
        CLON=  5. + 10.*MOD(KB-47,36)
      ELSE IF (KB.LE.1630)  THEN                                  50N-50S
        KZ = (KB-191)/72 + 9
        CLON= 2.5 + 5.*MOD(KB-191,72)
      ELSE IF (KB.LE.1774)  THEN                                  50-70S
        KZ = (KB-1631)/36 + 29
        CLON=  5. + 10.*MOD(KB-1631,36)
      ELSE IF (KB.LE.1810)  THEN                                  70-80S
        KZ = (KB-1775)/18 + 33
        CLON= 10. + 20.*MOD(KB-1775,18)
      ELSE IF (KB.LE.1819)  THEN                                  80-85S
        KZ = 35
        CLON= 20. + 40.*MOD(KB-1811,9)
      ELSE                                                        85-90S
        KZ = 36
      END IF
      CLAT= 90. - KZ*5. + 2.5
      RETURN
      END
```

Appendix C2. Conversion of 2c Box Number to Latitude,Longitude

```
      SUBROUTINE LALO2C(KB, CLAT,CLON,LB)
C FORTRAN SUBROUTINE TO CONVERT 2C BOX NUMBER (KB, 1-7290)
C  TO LATITUDE & LONGITUDE OF BOX CENTER.
C  GIVES LAT (N90 TO -90S), LON (0-360E),
C  AND ZONE NOS.(LB, 1-72 N-S). Returns LB=0 for KB out of range.
      LB= 0
      CLAT= 0.
      CLON= 0.
      IF (KB.LE.1)  THEN                                          87-90N
        LB = 1
      ELSE IF (KB.LE.9)  THEN                                     85-87N
        LB = 2
        CLON = 45.*MOD(KB-2,8) + 22.5
      ELSE IF (KB.LE.45)  THEN                                    80-85N
        LB = (KB-10)/18 + 3
        CLON = 20.*MOD(KB-10,18) + 10.
      ELSE IF (KB.LE.189)  THEN                                   70-80N
        LB = (KB-46)/36 + 5
        CLON = 10.*MOD(KB-46,36) + 5.
      ELSE IF (KB.LE.765)  THEN                                   50-70N
        LB = (KB-190)/72 + 9
        CLON = 5.*MOD(KB-190,72) + 2.5
      ELSE IF (KB.LE.6525)  THEN                                  50N-50S
        LB = (KB-766)/144 + 17
        CLON = 2.5*MOD(KB-766,144) + 1.25
      ELSE IF (KB.LE.7101)  THEN                                  50-70S
        LB = (KB-6526)/72 + 57
        CLON = 5.*MOD(KB-6526,72) + 2.5
      ELSE IF (KB.LE.7245)  THEN                                  70-80S
        LB = (KB-7102)/36 + 65
        CLON = 10.*MOD(KB-7102,36) + 5.
      ELSE IF (KB.LE.7281)  THEN                                  80-85S
        LB = (KB-7246)/18 + 69
        CLON = 20.*MOD(KB-7246,18) + 10.
      ELSE IF (KB.LE.7289)  THEN                                  85-87S
        LB = 71
        CLON = 45.*MOD(KB-7282,8) + 22.5
      ELSE IF (KB.GE.7290)  THEN                                  87-90S
        LB= 72
      END IF
      CLAT= 90. - LB*2.5 + 1.25
      IF (KB.LT.1 .OR. KB.GT.7290)  LB= 0
      RETURN
      END
```

Appendix C3. Conversion of Latitude,Longitude to 5c Box Number

```
      FUNCTION LLTO5C(FLAT,FLON)
C FORTRAN SUBROUTINE TO
C CONVERT LATITUDE,LONGITUDE TO 5X5C BOX NUMBER.
C-VARIABLES-
C FLAT  LATITUDE (N90 TO -90S), ELSE LLTO5C=0
C FLON  LONGITUDE ( 0 TO 360E), ELSE LLTO5C=0
C KB    5X5 DEG BOX NUMBERS (1-2594)
C JB    5X5C BOX NUMBERS (1-1820)
      LAT = (90. + FLAT)*10. + .000001
      LON = FLON*10. + .000001
      IF (LON.EQ.3600) LON=0
      LLTO5C=0
      IF (LAT.GT.1800 .OR. LAT.LT.0) RETURN
      IF (LON.GT.3600 .OR. LON.LT.0) RETURN
C FIRST CONVERT LAT,LON TO 5X5 DEG BOX NUMBERS
C  LOWER AND LEFT BOX BORDERS ARE INCLUDED IN BOX
      KB = ((36-(LAT/50))-1)*72 + LON/50 + 2
      IF (LAT.EQ.1800) KB=1
      IF (LAT.EQ.0)  KB=2594
C CONVERT 5X5 DEG NUMBERS TO 5X5C BOX NUMBERS
      IF (KB.GE.578 .AND. KB.LE.2017)  THEN
        JB = KB-387
      ELSE IF (KB.GE.290 .AND. KB.LE.2305)  THEN
        JB = (KB-290)/72 *36 + MOD(KB-290,72)/2 + 47
        IF (KB.GE.2018)  JB= JB+720
      ELSE IF (KB.GE.146 .AND. KB.LE.2449)  THEN
        JB = (KB-146)/72 *18 + MOD(KB-146,72)/4 + 11
        IF (KB.GE.2306)  JB= JB+1224
      ELSE IF (KB.GE.74  .AND. KB.LE.2521)  THEN
        JB = MOD(KB-74,72)/8 + 2
        IF (KB.GE.2450)  JB= JB+1809
      ELSE
        JB = 1
        IF (KB.GE.2522)  JB= 1820
      END IF
      LLTO5C = JB
      RETURN
      END
```

Appendix C4. Conversion of Latitude,Longitude to 2c Box Number

```
      FUNCTION LLTO2C(FLAT,FLON)
C FORTRAN SUBROUTINE TO
C CONVERT LATITUDE,LONGITUDE TO 2.5x2.5c BOX NUMBER.
C-VARIABLES-
C FLAT  LATITUDE (N90 TO -90S), ELSE LLTO2C=0
C FLON  LONGITUDE ( 0 TO 360E), ELSE LLTO2C=0
C KB    2.5X2.5 DEG BOX NUMBERS (1-10368)
C JB    2.5C BOX NUMBERS (1-7290)
      LAT = (90. + FLAT)*10. + .000001
      LON = FLON*10. + .000001
      IF (LON.EQ.3600) LON=0
      LLTO2C=0
      IF (LAT.GT.1800 .OR. LAT.LT.0) RETURN
      IF (LON.GT.3600 .OR. LON.LT.0) RETURN
C FIRST CONVERT LAT,LON TO 2.5X2.5 DEG BOX NUMBERS
C  LOWER AND LEFT BOX BORDERS ARE INCLUDED IN BOX
      KB = ((72-(LAT/25))-1)*144 + LON/25 + 1
      IF (LAT.EQ.1800) KB=1
C CONVERT 2.5X2.5 DEG NUMBERS TO 2.5C BOX NUMBERS
      IF (KB.GE.2305 .AND. KB.LE.8064)  THEN
        JB = KB-1539
      ELSE IF (KB.GE.1153 .AND. KB.LE.9216)  THEN
        JB = (KB-1153)/144 *72 + MOD(KB-1153,144)/2 + 190
        IF (KB.GE.8065)  JB= JB+2880
      ELSE IF (KB.GE.577 .AND. KB.LE.9792)  THEN
        JB = (KB-577)/144 *36 + MOD(KB-577,144)/4 + 46
        IF (KB.GE.9217)  JB= JB+4896
      ELSE IF (KB.GE.289 .AND. KB.LE.10080)  THEN
        JB = (KB-289)/144 *18 + MOD(KB-289,144)/8 + 10
        IF (KB.GE.9793)  JB= JB+6048
      ELSE IF (KB.GE.145 .AND. KB.LE.10224)  THEN
        JB = MOD(KB-145,144)/18 + 2
        IF (KB.GE.10081)  JB= JB+7280
      ELSE
        JB = 1
        IF (KB.GE.10225)  JB= 7290
      END IF
      LLTO2C = JB
      RETURN
      END
```

APPENDIX D.

Land/Ocean Distribution for 5c Grid Boxes

Appendix D1. Data Format for the Ancillary File (LLFR5C) for 5c Grid Boxes

Header record:	Variable	MGRP	NBXS	ISZ	ILO	IM	IYRS	ISN	IYM	ITY	IFMT
	Format	I4	I4	I2	I1	I1	I4	I2	I2	I2	I2
	Description	IG*	Number of Boxes	Grid Size	IG	IG	IG	IG	IG	IG	IG

Data record:	Variable	IBX	LAT	LON	LFR	LOB
	Format	I4	I5	I5	I5	I5
	Description	Box5c Number	Latitude x 100	Longitude x 100	Land_Fraction x 10000	Land/Ocean Code 1=Land 2=Ocean 3=Both 12=Island 21=Lake - = Exclude for ocean cloud types

Header record:

```
   11820 5115296-9-9-912
```

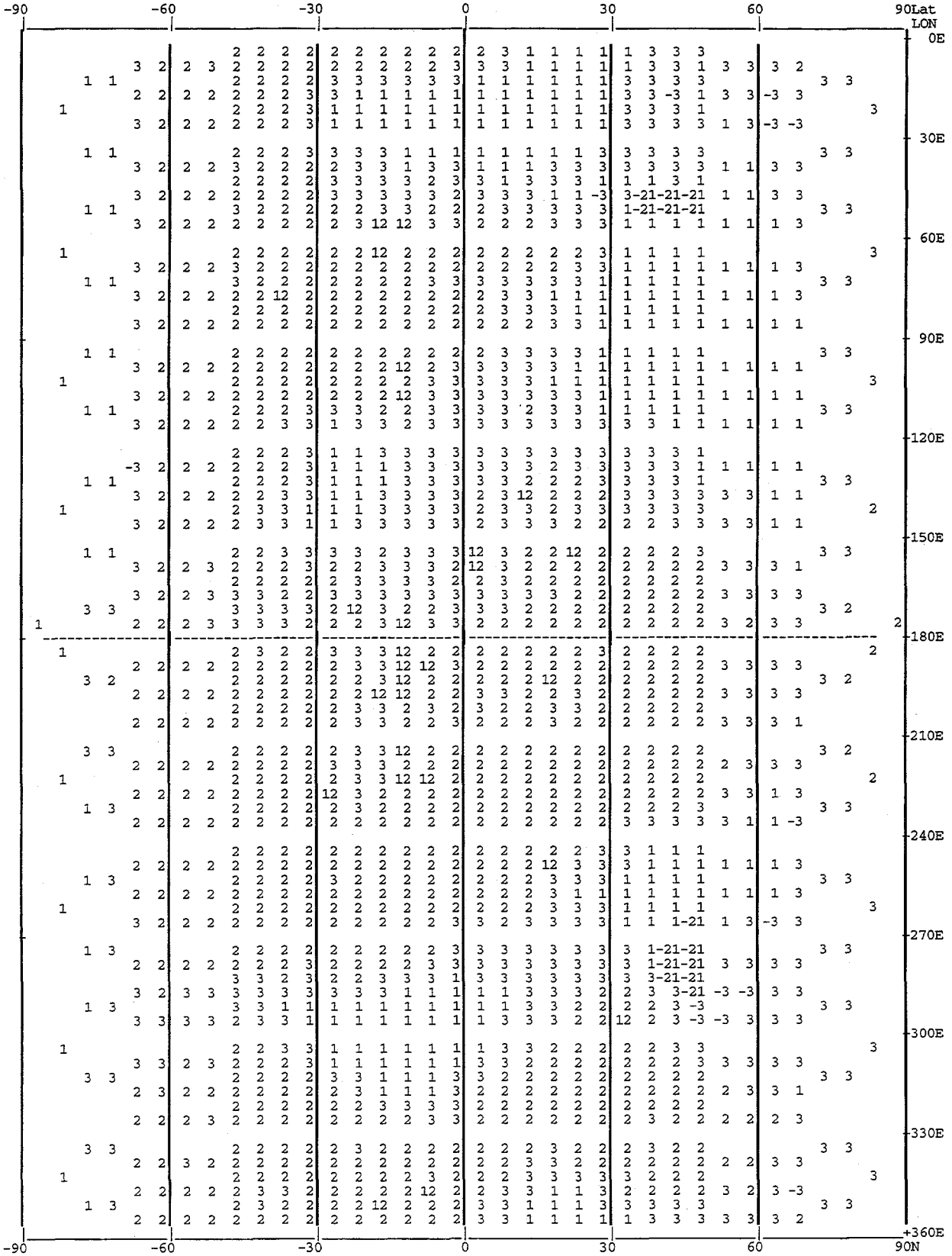
Sample data records:

IBX	LAT	LON	LFR	LOB
1	8750	0	0	2
2	8250	2000	373	3
80	675033500		2638	3
81	675034500		1678	-3
82	675035500		0	2
83	6250	500	3457	3
202	4750	575010000		1
221	475015250		476	3
222	475015750		0	2
238	475023750		8849	3
243	47502625010000			1
244	47502675010000			-21
248	47502875010000			-21
250	475029750		4157	-3
251	475030250		3991	3
253	475031250		0	2
453	325023250		0	2
454	325023750		217	3
624	1750	75010000		1
625	1750	125010000		1
716	125010750		7895	3
717	125011250		0	2
718	125011750		492	3
719	125012250		5533	3
720	125012750		636	3
721	125013250		0	2
722	125013750		0	12
723	125014250		78	3
889	25025250		0	2
899	2503025010000			1
900	25030750		8724	3
1738	-625035500		0	2
1739	-6750	500	35	3
1750	-675011500		7353	3
1751	-675012500		6566	-3
1755	-675016500		98	3
1756	-675017500		0	2
1819	-82503400010000			1
1820	-8750	010000		1

* This file was originally prepared for other purposes so "IG" variables can be ignored.

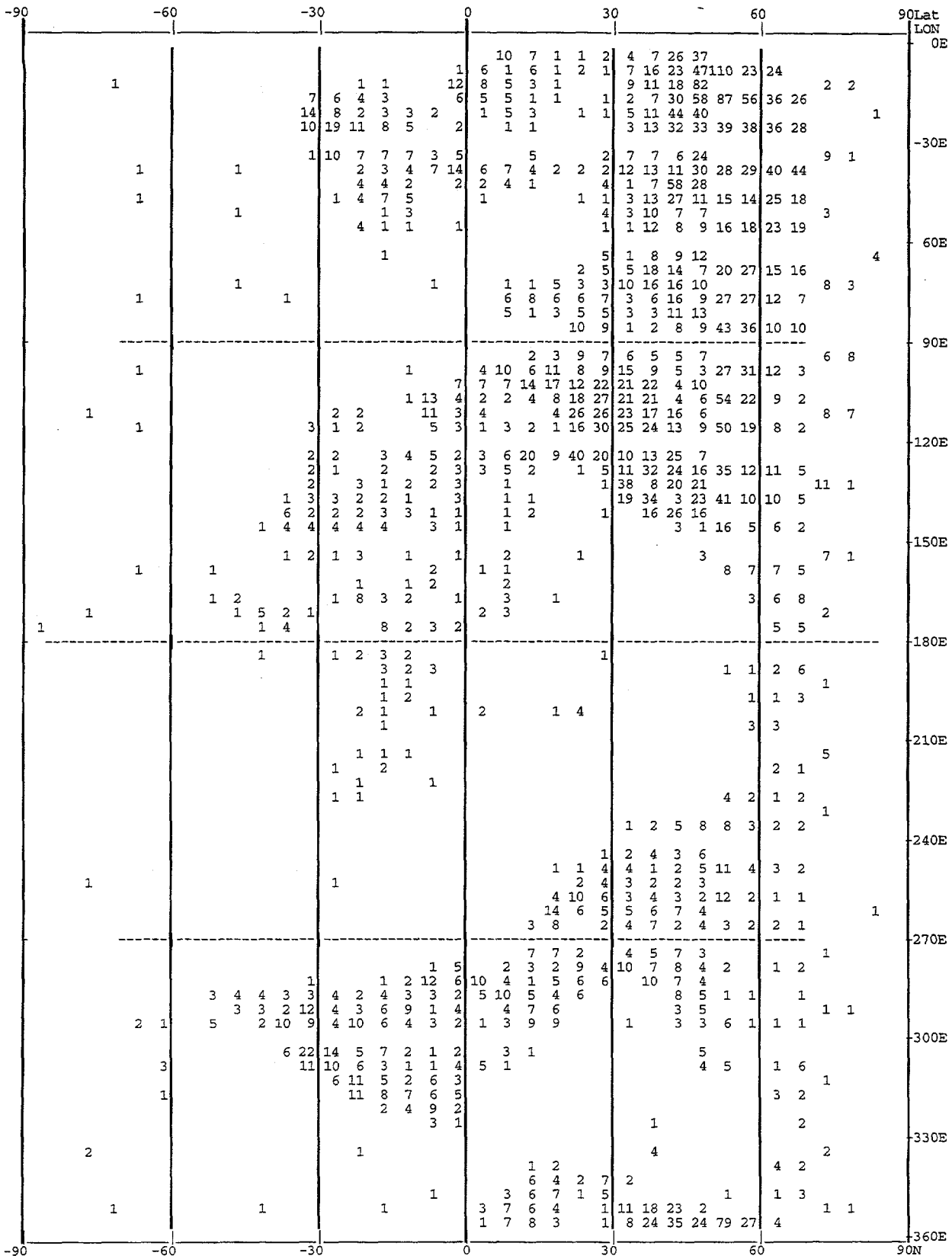
Appendix D2. Land/Ocean Distribution Codes from Ancillary File LLFR5C for 5c Grid

318 Land boxes(1) +14 Lake(21) +27 Island(12) +602 Land/Ocean(3) = 961 Total Land Boxes
859 Ocean boxes(1) +14 Lake(21) +27 Island(12) +602 Land/Ocean(3) = 1502 Total Ocean Boxes
1820 Box5c,s
(-28 Ocean Cloud Types)



APPENDIX E.

Number of Land Stations with 20 Light-obs for Cloud Types in 15 Years, January or July, for 1971-1996. 5838 stations are distributed over 775 5c grid boxes.



APPENDIX F.

Tabular Histograms for Frequency Distribution of Present Weather Groups and Extended Cloud Codes in EECRA.

Appendix F1. Histograms (%) of ww Group Occurrences in Selected Years (for April)

ww code:		-1*	0-3	4-9	13-29	30-39	40-49 11-12	50-79	80-99
Year	Number of Reports								
SHIP									
1955	76,415	21.0	64.1	1.7	6.4	0.02	1.3	4.0	1.4
1960	102,895	17.0	68.2	1.6	6.1	0.02	1.3	4.4	1.4
1965	145,378	1.4	79.4	1.5	7.2	0.01	3.0	5.5	1.9
1975	148,002	0.8	78.6	2.2	7.1	0.04	3.7	5.6	2.0
1981	181,116	1.4	77.9	2.0	6.3	0.05	4.7	5.9	1.7
1982	177,410	31.1	48.3	1.7	7.1	0.05	4.0	5.9	1.9
1985	181,142	37.3	40.5	1.6	7.1	0.07	4.7	6.4	2.3
1995	104,598	30.4	50.7	1.7	6.6	0.02	3.0	5.4	2.2
LAND									
1975	925,675	0.0	71.8	4.4	5.0	1.0	6.1	8.4	3.3
1981	1,056,616	0.0	71.2	5.2	5.0	0.8	7.4	6.9	3.4
1982	962,119	64.1	9.8	4.5	5.0	0.7	6.4	6.6	3.0
1985	1,028,532	62.9	10.1	4.5	5.0	1.0	6.0	7.3	3.2
1995	1,123,481	63.1	13.1	4.5	4.9	0.4	5.3	5.8	3.0

* ww = -1 means that present weather is not reported (ww=/ in original report)

Appendix F2. Percent Frequency of Occurrence of Extended Code Values for Cloud Variables in EECR (light reports). Also: percent that precipitation occurs with reported code and percent of total precipitation that occurs with each code. Land: 1971-96; Ship: 1952-95.

TOTAL CLOUD AMOUNT

N CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	0.0	14.9	7.0	7.7	5.8	4.3	5.9	10.1	17.6	25.1	1.6
% with ppt	0.0	0.0	0.2	0.3	0.4	0.6	1.1	2.5	7.6	33.5	29.4
% of ppt	0.0	0.0	0.1	0.2	0.2	0.2	0.6	2.4	12.7	79.2	4.3
SHIP											
% of rpts	0.0	5.9	5.5	8.2	9.7	8.3	7.5	11.7	14.0	26.7	2.6
% with ppt	0.0	0.0	0.2	0.2	0.4	0.9	1.8	3.3	6.3	21.0	27.3
% of ppt	0.0	0.0	0.1	0.2	0.5	1.0	1.7	4.9	11.2	71.5	9.0

LOWER CLOUD AMOUNT

Nh CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	2.3	25.3	11.3	11.0	7.9	5.7	5.8	6.8	8.4	15.6	0.0
% with ppt	11.0	0.6	1.3	3.0	5.2	8.4	12.1	15.8	16.2	36.7	0.0
% of ppt	2.4	1.4	1.4	3.1	3.9	4.5	6.7	10.0	12.8	53.9	0.0
SHIP											
% of rpts	14.5	8.0	7.7	11.0	10.2	8.2	6.5	7.8	7.6	18.5	0.0
% with ppt	7.4	0.1	0.6	1.0	1.8	3.5	5.7	8.7	9.5	23.6	0.0
% of ppt	13.6	0.1	0.6	1.4	2.4	3.7	4.7	8.7	9.3	55.5	0.0

LOWER CLOUD HEIGHT

h CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts#	20.3	1.8	0.5	1.9	3.1	13.0	22.6	10.9	3.5	1.6	20.8
% of rpts*	18.8	1.9	0.6	2.0	3.1	13.1	22.9	11.1	3.6	1.6	21.3
% with ppt*	3.2	28.1	36.6	41.8	38.7	23.6	9.8	6.1	6.6	8.7	4.4
% of ppt*	5.7	5.0	1.9	7.7	11.3	28.9	21.0	6.3	2.2	1.3	8.7
SHIP											
% of rpts	22.2	3.2	0.8	3.4	13.0	26.9	18.6	5.4	1.6	1.4	3.5
% with ppt	5.8	24.7	26.1	25.1	14.0	7.1	3.9	2.8	2.6	1.9	0.9
% of ppt	16.3	10.1	2.7	10.7	23.2	24.3	9.4	2.0	0.5	0.3	0.4

LOW CLOUD TYPE			Cu	Cu	Cb	Sc	Sc	St	St	Sc	Cb	Cb	Fo
CL CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11
LAND													
% of rpts	2.0	38.2	7.6	10.2	2.5	2.2	15.6	4.1	4.0	5.8	6.6	0.1	1.1
% with ppt	12.6	4.8	0.9	3.9	17.9	5.4	11.6	15.1	66.2	8.7	28.1	100	0.0
% of ppt	2.4	17.3	0.6	3.7	4.2	1.1	17.1	5.8	24.9	4.8	17.5	0.5	0.0
SHIP													
% of rpts	14.3	12.5	13.2	13.9	5.7	5.7	11.8	5.7	5.9	6.7	2.7	0.1	1.9
% with ppt	7.4	5.9	0.6	2.2	7.5	3.2	6.7	20.2	34.3	6.8	20.0	100	0.0
% of ppt	13.6	9.3	1.0	3.9	5.4	2.3	10.1	14.6	26.0	5.8	6.8	1.2	0.0

MIDDLE CLOUD TYPE			As	As	Ac	Ac	Ac	Ac	Ac	Ac	Ac	Ns	Ns	Ns
CM CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
LAND														
% of rpts	17.3	45.7	1.4	2.7	10.6	4.8	1.6	1.5	7.0	1.1	0.2	2.6	0.7	2.8
% with ppt	14.9	1.1	17.5	7.3	2.6	2.1	3.8	7.1	4.4	2.4	7.6	100	100	100
% of ppt	24.3	4.8	2.4	1.9	2.6	0.9	0.6	1.0	2.9	0.2	0.1	24.8	6.7	26.7
SHIP														
% of rpts	34.5	30.6	3.3	4.2	4.6	3.9	2.9	4.6	4.8	1.6	1.3	2.5	0.2	1.0
% with ppt	8.4	0.9	3.8	3.6	1.9	2.0	2.4	5.5	2.7	2.5	6.4	100	100	100
% of ppt	37.0	3.4	1.6	1.9	1.1	1.0	0.9	3.2	1.6	0.5	1.1	31.6	2.7	12.4

HIGH CLOUD TYPE			Cic	Cid	Cid	Cic	Cs	Cs	Cs	Cs	Cic
CH CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	33.1	36.1	11.1	10.8	0.9	0.9	0.9	1.8	2.0	1.9	0.4
% with ppt	28.5	1.1	1.4	1.7	6.5	1.3	1.8	2.6	11.3	2.6	2.7
% of ppt	89.2	3.6	1.5	1.7	0.6	0.1	0.1	0.4	2.2	0.5	0.1
SHIP											
% of rpts	47.8	32.4	5.6	3.3	1.1	2.0	1.5	1.6	1.1	2.1	1.5
% with ppt	14.8	1.2	1.7	2.2	4.0	1.4	1.3	1.9	3.4	2.2	2.1
% of ppt	89.9	4.9	1.2	0.9	0.6	0.4	0.2	0.4	0.5	0.6	0.4

*# 1971-96 (includes SPOT-revised h from 94sep); * 1971-94aug.*

Appendix F3. Same as F2 but for Land: 1992-96 (46,005,695 light reports); Ship: 1992-95 (4,122,709 light reports).

TOTAL CLOUD AMOUNT

N CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	0.0	15.6	6.9	7.7	6.2	4.8	6.4	10.5	17.6	23.1	1.2
% with ppt	0.0	0.0	0.1	0.1	0.2	0.4	0.9	2.3	7.5	33.3	29.1
% of ppt	0.0	0.0	0.03	0.1	0.2	0.2	0.6	2.5	13.5	79.2	3.7
SHIP											
% of rpts	0.0	5.2	5.5	7.7	9.6	9.1	8.1	12.2	14.5	25.9	2.2
% with ppt	0.0	0.0	0.2	0.1	0.3	0.9	1.8	3.4	6.9	21.4	28.3
% of ppt	0.0	0.0	0.1	0.1	0.4	1.0	1.9	5.2	12.8	70.5	8.0

LOWER CLOUD AMOUNT

Nh CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	1.8	25.2	11.4	11.3	8.5	6.3	6.2	6.8	8.3	14.2	0.0
% with ppt	14.1	0.2	1.0	2.4	4.5	8.0	11.9	15.4	15.5	35.6	0.0
% of ppt	2.7	0.6	1.2	2.8	3.9	5.2	7.5	10.7	13.2	52.1	0.0
SHIP											
% of rpts	21.8	7.5	6.2	9.4	9.3	8.1	6.4	7.6	7.4	16.3	0.0
% with ppt	6.4	0.1	0.5	0.8	1.8	3.5	5.71	8.8	10.8	25.0	0.0
% of ppt	17.8	0.1	0.4	1.0	2.1	3.6	4.67	8.4	10.1	51.8	0.0

LOWER CLOUD HEIGHT

h CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts#	26.8	1.5	0.5	1.7	2.8	12.9	21.4	9.7	3.1	1.5	18.1
% of rpts*	19.8	1.6	0.6	1.9	3.1	14.1	23.2	10.7	3.5	1.6	19.9
% with ppt*	3.1	26.2	36.2	41.5	37.8	21.0	9.1	5.6	5.6	6.4	3.6
% of ppt*	6.2	4.3	2.1	8.0	12.0	29.9	21.2	6.0	1.9	1.1	7.3
SHIP											
% of rpts	31.9	3.9	1.5	3.6	9.7	21.8	15.7	5.6	2.2	1.6	2.5
% with ppt	5.9	22.8	19.3	23.6	16.3	7.1	3.8	2.7	2.2	1.5	0.6
% of ppt	23.8	11.0	3.6	10.8	20.1	19.8	7.6	1.9	0.6	0.3	0.2

LOW CLOUD TYPE		Cu	Cu	Cb	Sc	Sc	St	St	Sc	Cb	Cb	Fo
CL CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11
LAND													
% of rpts	1.8	37.5	7.7	11.2	2.6	2.4	16.2	3.8	3.3	6.2	6.4	0.05	0.9
% with ppt	14.4	3.7	1.0	4.0	17.9	5.1	11.3	15.1	65.7	8.8	27.3	100	0.0
% of ppt	2.7	14.4	0.8	4.6	4.8	1.2	18.9	5.9	22.7	5.6	18.0	0.5	0.0
SHIP													
% of rpts	21.7	11.4	11.7	12.2	4.4	7.2	8.5	5.6	6.7	6.5	2.4	0.1	1.6
% with ppt	6.5	4.8	0.6	2.8	8.5	3.7	8.1	20.5	30.9	6.1	19.3	100	0.0
% of ppt	17.8	6.9	1.0	4.3	4.8	3.4	8.7	14.7	26.3	5.1	5.8	1.3	0.0

MIDDLE CLOUD TYPE		As	As	Ac	Ac	Ac	Ac	Ac	Ac	Ac	Ns	Ns	Ns
CM CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
LAND														
% of rpts	16.6	46.7	1.2	2.5	11.4	4.0	1.7	1.4	7.8	1.0	0.1	2.4	0.7	2.4
% with ppt	15.4	0.8	12.9	7.8	2.2	1.8	4.3	6.4	4.5	2.0	7.0	100	100	100
% of ppt	26.4	3.8	1.6	2.0	2.6	0.7	0.7	1.0	3.7	0.2	0.1	25.1	7.5	24.6
SHIP														
% of rpts	38.8	24.0	2.8	4.4	5.3	4.6	2.2	4.8	5.7	2.3	1.8	2.3	0.3	0.8
% with ppt	8.0	0.8	4.3	3.2	1.9	2.0	3.2	5.6	2.8	3.2	8.7	100	100	100
% of ppt	39.5	2.3	1.5	1.8	1.3	1.2	0.9	3.4	2.0	0.9	2.0	28.9	4.0	10.2

HIGH CLOUD TYPE		Cic	Cid	Cid	Cic	Cs	Cs	Cs	Cs	Cic
CH CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	31.5	38.6	11.3	9.9	0.9	0.9	1.0	2.0	1.4	2.0	0.4
% with ppt	27.8	1.0	1.1	1.6	5.6	0.7	1.1	2.0	9.1	2.2	1.4
% of ppt	90.2	3.9	1.3	1.6	0.5	0.1	0.1	0.4	1.4	0.5	0.1
SHIP											
% of rpts	53.0	26.3	5.3	3.1	1.6	2.2	1.7	1.7	1.0	2.6	1.3
% with ppt	13.3	1.2	1.9	2.5	3.9	1.6	1.2	2.3	5.5	2.8	2.4
% of ppt	89.6	4.1	1.3	1.0	0.8	0.5	0.3	0.5	0.7	1.0	0.4

*# 1992-96 (includes SPOT-revised h from 94sep); * 1992-94aug.*

Appendix F4. Same as F2 but for Land: 1982-91 (123,973,793 light reports);
Ship: 1982-91 (14,650,512 light reports).

TOTAL CLOUD AMOUNT

N CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	0.0	15.2	6.9	7.6	5.9	4.3	6.0	10.1	18.3	24.0	1.5
% with ppt	0.0	0.0	0.1	0.2	0.3	0.5	1.0	2.4	8.0	34.2	28.6
% of ppt	0.0	0.0	0.05	0.1	0.2	0.2	0.6	2.3	14.0	78.4	4.1
SHIP											
% of rpts	0.0	6.4	4.9	7.7	9.0	8.2	7.4	11.8	13.9	27.6	3.2
% with ppt	0.0	0.0	0.2	0.2	0.4	1.0	1.8	3.4	6.7	21.9	26.0
% of ppt	0.0	0.0	0.1	0.2	0.4	1.0	1.6	4.7	10.9	71.4	9.7

LOWER CLOUD AMOUNT

Nh CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	2.6	25.6	11.2	11.0	7.9	5.7	5.8	6.7	9.0	14.5	0.0
% with ppt	11.6	0.5	1.1	2.9	5.2	8.7	12.3	16.0	16.1	37.8	0.0
% of ppt	2.9	1.2	1.2	3.0	4.0	4.7	6.8	10.2	13.8	52.3	0.0
SHIP											
% of rpts	14.7	9.2	6.4	10.0	9.5	8.0	6.5	8.4	7.7	19.6	0.0
% with ppt	8.6	0.1	0.5	0.9	1.9	3.6	5.7	8.9	9.8	24.2	0.0
% of ppt	15.0	0.1	0.4	1.1	2.1	3.4	4.4	8.9	8.9	55.8	0.0

LOWER CLOUD HEIGHT

h CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	19.7	1.7	0.5	1.9	3.1	13.3	23.0	10.6	3.4	1.6	21.2
% with ppt	3.4	28.4	37.9	42.2	39.2	23.0	9.6	5.8	5.8	8.2	4.3
% of ppt	6.4	4.7	2.0	7.8	11.5	29.2	20.9	5.8	1.9	1.2	8.7
SHIP											
% of rpts	22.8	3.7	1.0	3.9	11.8	23.9	19.4	6.0	2.0	2.2	3.3
% with ppt	6.2	24.7	30.3	28.0	16.8	7.6	3.7	2.5	2.2	1.5	0.8
% of ppt	16.7	10.8	3.6	12.8	23.4	21.3	8.4	1.8	0.5	0.4	0.3

LOW CLOUD TYPE			Cu	Cu	Cb	Sc	Sc	St	St	Sc	Cb	Cb	Fo
CL CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11
LAND													
% of rpts	2.5	38.4	7.3	10.2	2.4	2.2	15.5	4.0	3.8	5.9	6.6	0.1	1.1
% with ppt	11.9	4.7	0.8	4.0	18.3	5.2	11.7	14.3	67.1	8.7	28.6	100	0.0
% of ppt	2.9	17.1	0.5	3.9	4.2	1.1	17.2	5.5	24.3	4.9	17.9	0.5	0.0
SHIP													
% of rpts	14.7	14.3	11.5	13.5	5.4	5.9	11.3	5.7	6.4	6.3	2.6	0.1	2.3
% with ppt	8.6	5.9	0.6	2.1	9.0	3.0	7.2	21.9	34.8	6.7	21.7	100	0.0
% of ppt	15.0	10.0	0.8	3.4	5.7	2.1	9.5	14.6	26.1	5.0	6.6	1.2	0.0

MIDDLE CLOUD TYPE			As	As	Ac	Ac	Ac	Ac	Ac	Ac	Ac	Ns	Ns	Ns
CM CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
LAND														
% of rpts	17.5	45.9	1.4	2.6	10.8	4.4	1.6	1.5	7.1	1.0	0.1	2.6	0.7	2.8
% with ppt	15.0	1.0	17.6	7.4	2.5	2.0	3.7	7.3	4.5	2.2	9.1	100	100	100
% of ppt	25.0	4.6	2.4	1.8	2.6	0.8	0.6	1.0	3.1	0.2	0.1	24.4	6.9	26.5
SHIP														
% of rpts	34.0	28.6	3.3	4.5	5.1	3.7	3.0	4.6	5.8	1.9	1.4	2.6	0.3	1.2
% with ppt	9.0	0.8	3.5	3.3	2.0	2.2	2.7	6.1	2.9	2.7	7.4	100	100	100
% of ppt	35.9	2.7	1.4	1.7	1.2	1.0	1.0	3.3	2.0	0.6	1.2	30.6	3.8	13.7

HIGH CLOUD TYPE			Cic	Cid	Cid	Cic	Cs	Cs	Cs	Cs	Cic
CH CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	33.1	36.3	11.5	10.5	0.9	0.9	0.8	1.8	1.9	1.9	0.4
% with ppt	28.4	1.0	1.3	1.7	6.2	0.8	1.5	2.4	11.3	2.4	1.9
% of ppt	89.6	3.6	1.4	1.7	0.5	0.06	0.1	0.4	2.1	0.4	0.07
SHIP											
% of rpts	49.8	30.6	5.5	3.2	1.1	2.1	1.5	1.5	1.0	2.3	1.4
% with ppt	15.4	1.2	2.0	2.3	4.2	1.4	1.2	2.2	3.5	2.3	2.6
% of ppt	90.5	4.4	1.3	0.8	0.6	0.4	0.2	0.4	0.4	0.6	0.4

Appendix F5. Same as F2 but for Land: 1971-81 (90,767,807 light reports);
Ship: 1970-81 (15,566,852 light reports).

TOTAL CLOUD AMOUNT

N CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	0.0	14.3	7.3	7.6	5.6	3.9	5.5	9.8	17.0	27.2	1.8
% with ppt	0.0	0.0	0.3	0.4	0.6	0.8	1.2	2.6	7.3	32.9	30.2
% of ppt	0.0	0.0	0.2	0.3	0.3	0.3	0.6	2.3	11.2	80.1	4.8
SHIP											
% of rpts	0.0	5.7	5.5	8.4	9.9	8.2	7.5	11.6	14.1	26.3	2.8
% with ppt	0.0	0.0	0.2	0.2	0.4	1.0	1.8	3.4	6.4	21.7	29.1
% of ppt	0.0	0.0	0.1	0.3	0.5	1.0	1.7	4.8	11.7	70.6	9.9

LOWER CLOUD AMOUNT

Nh CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	2.2	25.1	11.4	10.8	7.5	5.3	5.7	6.8	7.9	17.3	0.0
% with ppt	9.1	0.8	1.6	3.4	5.7	8.5	12.0	15.8	16.5	36.2	0.0
% of ppt	1.8	1.9	1.6	3.3	3.8	4.0	6.1	9.6	11.7	56.2	0.0
SHIP											
% of rpts	10.7	7.8	8.5	11.6	10.8	8.4	6.6	7.7	8.1	19.8	0.0
% with ppt	9.4	0.2	0.8	1.1	1.9	3.5	5.6	8.3	9.2	23.5	0.0
% of ppt	12.4	0.2	0.8	1.5	2.5	3.6	4.6	7.9	9.2	57.3	0.0

LOWER CLOUD HEIGHT

h CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	17.6	2.1	0.6	2.0	3.2	12.7	22.8	11.7	3.8	1.7	21.8
% with ppt	3.1	28.2	35.4	41.6	38.9	25.0	10.3	6.4	7.5	9.7	4.7
% of ppt	4.9	5.4	1.8	7.6	11.1	28.4	21.0	6.7	2.5	1.5	9.1
SHIP											
% of rpts	18.1	3.6	0.8	3.7	15.9	29.6	18.2	4.6	1.3	1.2	3.0
% with ppt	6.7	25.0	25.3	24.2	12.8	6.6	3.7	2.9	3.2	2.2	1.0
% of ppt	14.9	11.0	2.6	11.1	25.1	24.2	8.3	1.6	0.5	0.3	0.4

LOW CLOUD TYPE			Cu	Cu	Cb	Sc	Sc	St	St	Sc	Cb	Cb	Fo
CL CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11
LAND													
% of rpts	1.5	38.4	7.9	9.5	2.6	2.3	15.6	4.2	4.5	5.5	6.7	0.1	1.2
% with ppt	12.6	5.5	1.0	3.8	17.5	5.8	11.7	15.8	65.5	8.6	28.1	100	0.0
% of ppt	1.7	18.8	0.7	3.2	4.0	1.2	16.3	6.0	26.5	4.3	16.8	0.5	0.0
SHIP													
% of rpts	10.5	12.0	13.6	14.9	6.5	4.8	13.5	5.9	5.9	7.2	3.1	0.1	2.0
% with ppt	9.5	6.3	0.6	1.9	7.1	3.2	6.2	20.3	35.6	7.7	19.0	100	0.0
% of ppt	12.3	9.3	1.1	3.4	5.7	1.9	10.3	14.7	26.0	6.8	7.2	1.2	0.0

MIDDLE CLOUD TYPE			As	As	Ac	Ac	Ac	Ac	Ac	Ac	Ac	Ns	Ns	Ns
CM CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
LAND														
% of rpts	17.4	44.9	1.6	2.9	10.0	5.5	1.5	1.6	6.6	1.1	0.3	2.8	0.7	3.1
% with ppt	14.6	1.4	19.1	7.1	3.0	2.2	3.7	7.2	4.2	2.8	7.2	100	100	100
% of ppt	22.7	5.4	2.7	1.8	2.6	1.1	0.5	1.0	2.5	0.3	0.2	25.1	6.1	27.9
SHIP														
% of rpts	32.9	32.4	3.6	4.0	4.5	4.0	3.3	4.5	4.3	1.5	1.3	2.7	0.1	0.9
% with ppt	9.0	0.9	4.3	3.8	2.0	2.1	2.2	5.9	2.4	2.3	5.8	100	100	100
% of ppt	36.7	3.7	1.9	1.8	1.1	1.0	0.9	3.3	1.3	0.4	0.9	33.6	1.8	11.5

HIGH CLOUD TYPE			Cic	Cid	Cid	Cic	Cs	Cs	Cs	Cs	Cic
CH CODE	-1	0	1	2	3	4	5	6	7	8	9
LAND											
% of rpts	34.0	34.5	10.5	11.6	1.0	0.8	1.0	1.8	2.4	1.8	0.5
% with ppt	29.0	1.1	1.7	1.8	7.2	2.2	2.4	3.1	12.0	3.0	3.9
% of ppt	88.3	3.5	1.6	1.9	0.6	0.2	0.2	0.5	2.6	0.5	0.2
SHIP											
% of rpts	45.7	33.3	5.6	3.4	1.1	2.5	1.7	1.8	1.2	1.9	1.7
% with ppt	15.9	1.2	2.0	2.3	4.2	1.4	1.4	2.0	3.0	2.1	2.1
% of ppt	89.6	4.9	1.4	1.0	0.6	0.4	0.3	0.4	0.5	0.5	0.4

Appendix F6. Same as F2 but for Ships 1960-69 (11,399,279 light reports).

TOTAL CLOUD AMOUNT											
N CODE	-1	0	1	2	3	4	5	6	7	8	9
SHIP											
% of rpts	0.0	5.7	5.7	8.7	9.9	8.2	7.3	11.8	13.9	26.6	2.2
% with ppt	0.0	0.0	0.1	0.2	0.4	0.9	1.7	3.2	6.1	20.6	25.3
% of ppt	0.0	0.0	0.1	0.2	0.5	1.0	1.6	5.0	11.3	72.8	7.4

LOWER CLOUD AMOUNT											
Nh CODE	-1	0	1	2	3	4	5	6	7	8	9
SHIP											
% of rpts	11.4	7.7	8.6	12.1	10.9	8.5	6.5	7.9	8.1	18.3	0.0
% with ppt	7.8	0.1	0.5	1.0	1.8	3.5	5.9	8.7	9.4	22.5	0.0
% of ppt	11.8	0.1	0.6	1.6	2.6	3.9	5.1	9.2	10.2	55.0	0.0

LOWER CLOUD HEIGHT											
h CODE	-1	0	1	2	3	4	5	6	7	8	9
SHIP											
% of rpts	18.9	2.6	0.5	2.8	13.4	30.9	19.6	5.1	1.2	1.0	4.1
% with ppt	5.8	24.2	26.8	23.6	13.0	7.0	4.3	3.1	2.9	2.6	0.8
% of ppt	14.6	8.2	1.9	8.7	23.1	28.9	11.2	2.1	0.5	0.3	0.4

LOW CLOUD TYPE			Cu	Cu	Cb	Sc	Sc	St	St	Sc	Cb	Cb	Fo
CL CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11
SHIP													
% of rpts	11.3	12.0	14.5	14.7	5.8	5.4	13.0	6.0	5.7	7.1	2.7	0.1	1.7
% with ppt	7.9	5.6	0.5	2.3	6.6	3.0	6.3	18.5	34.5	6.3	21.2	100	0.0
% of ppt	11.8	9.0	0.9	4.5	5.1	2.3	10.9	14.8	26.0	6.0	7.7	1.1	0.0

MIDDLE CLOUD TYPE			As	As	Ac	Ac	Ac	Ac	Ac	Ac	Ac	Ns	Ns	Ns
CM CODE	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
SHIP														
% of rpts	32.8	34.1	3.3	4.2	4.3	3.8	2.6	4.5	4.3	1.3	1.3	2.3	0.1	1.0
% with ppt	8.8	0.9	3.8	4.0	1.7	2.0	2.1	5.0	2.6	2.0	5.1	100	100	100
% of ppt	38.2	4.1	1.6	2.2	1.0	1.0	0.7	3.0	1.5	0.3	0.9	30.9	1.8	12.7

HIGH CLOUD TYPE			Cic	Cid	Cid	Cic	Cs	Cs	Cs	Cs	Cic
CH CODE	-1	0	1	2	3	4	5	6	7	8	9
SHIP											
% of rpts	45.1	36.0	5.6	3.2	1.0	1.8	1.4	1.5	1.0	2.0	1.5
% with ppt	15.0	1.2	1.4	2.0	3.8	1.1	1.1	1.5	2.8	1.8	1.7
% of ppt	90.2	5.5	1.0	0.9	0.5	0.3	0.2	0.3	0.4	0.5	0.3

Appendix F7. Same as F2 but for Ships 1952-59 (5,871,644 light reports).

TOTAL CLOUD AMOUNT

N CODE	-1	0	1	2	3	4	5	6	7	8	9
SHIP											
% of rpts	0.0	6.2	6.4	8.6	10.1	8.6	7.5	11.2	13.5	26.3	1.6
% with ppt	0.0	0.0	0.04	0.1	0.3	0.7	1.4	2.6	4.8	17.0	30.0
% of ppt	0.0	0.0	0.04	0.1	0.5	1.0	1.8	4.8	10.7	73.3	7.8

LOWER CLOUD AMOUNT

Nh CODE	-1	0	1	2	3	4	5	6	7	8	9
SHIP											
% of rpts	25.0	6.4	8.2	10.9	9.8	7.4	5.9	6.8	5.6	14.0	0.0
% with ppt	3.4	0.06	0.5	1.1	1.8	3.4	5.8	8.7	9.2	23.1	0.0
% of ppt	13.9	0.06	0.6	1.9	2.9	4.1	5.6	9.7	8.5	52.7	0.0

LOWER CLOUD HEIGHT

h CODE	-1	0	1	2	3	4	5	6	7	8	9
SHIP											
% of rpts	31.4	1.8	0.4	2.1	9.7	22.7	18.1	6.6	1.8	0.7	4.7
% with ppt	3.4	28.2	20.0	21.1	11.9	7.6	4.5	2.9	2.5	3.0	1.2
% of ppt	17.5	8.2	1.4	7.1	18.9	28.3	13.4	3.2	0.7	0.3	0.9

LOW CLOUD TYPE

CL CODE	-1	0	Cu 1	Cu 2	Cb 3	Sc 4	Sc 5	St 6	St 7	Sc 8	Cb 9	Cb 10	Fo 11
SHIP													
% of rpts	24.2	10.5	14.5	12.1	4.7	7.0	9.0	4.6	4.8	5.6	1.8	0.05	1.1
% with ppt	3.5	5.9	0.7	2.6	6.3	3.6	7.1	18.2	31.7	6.2	15.9	100	0.0
% of ppt	13.8	10.2	1.7	5.2	4.9	4.1	10.4	13.7	25.1	5.6	4.6	0.7	0.0

MIDDLE CLOUD TYPE

CM CODE	-1	0	As 1	As 2	Ac 3	Ac 4	Ac 5	Ac 6	Ac 7	Ac 8	Ac 9	Ns 10	Ns 11	Ns 12		
SHIP																
% of rpts	40.0	28.9	3.1	4.1	3.8	3.5	2.8	4.7	4.1	1.2	0.9	1.9	0.2	0.8		
% with ppt	5.6	0.8	2.8	3.5	1.6	1.5	2.5	4.2	2.4	1.9	5.5	100	100	100		
% of ppt	36.7	3.9	1.4	2.3	1.0	0.9	1.2	3.2	1.6	0.4	0.9	31.5	2.5	12.5		

HIGH CLOUD TYPE

CH CODE	-1	0	Cic 1	Cid 2	Cid 3	Cic 4	Cs 5	Cs 6	Cs 7	Cs 8	Cic 9
SHIP											
% of rpts	49.9	31.7	5.7	3.3	1.2	1.0	1.3	1.4	1.0	2.1	1.4
% with ppt	10.9	1.2	1.0	2.1	3.2	1.1	1.1	1.3	3.6	1.9	1.6
% of ppt	88.9	6.1	1.0	1.1	0.6	0.2	0.2	0.3	0.6	0.7	0.4

APPENDIX G

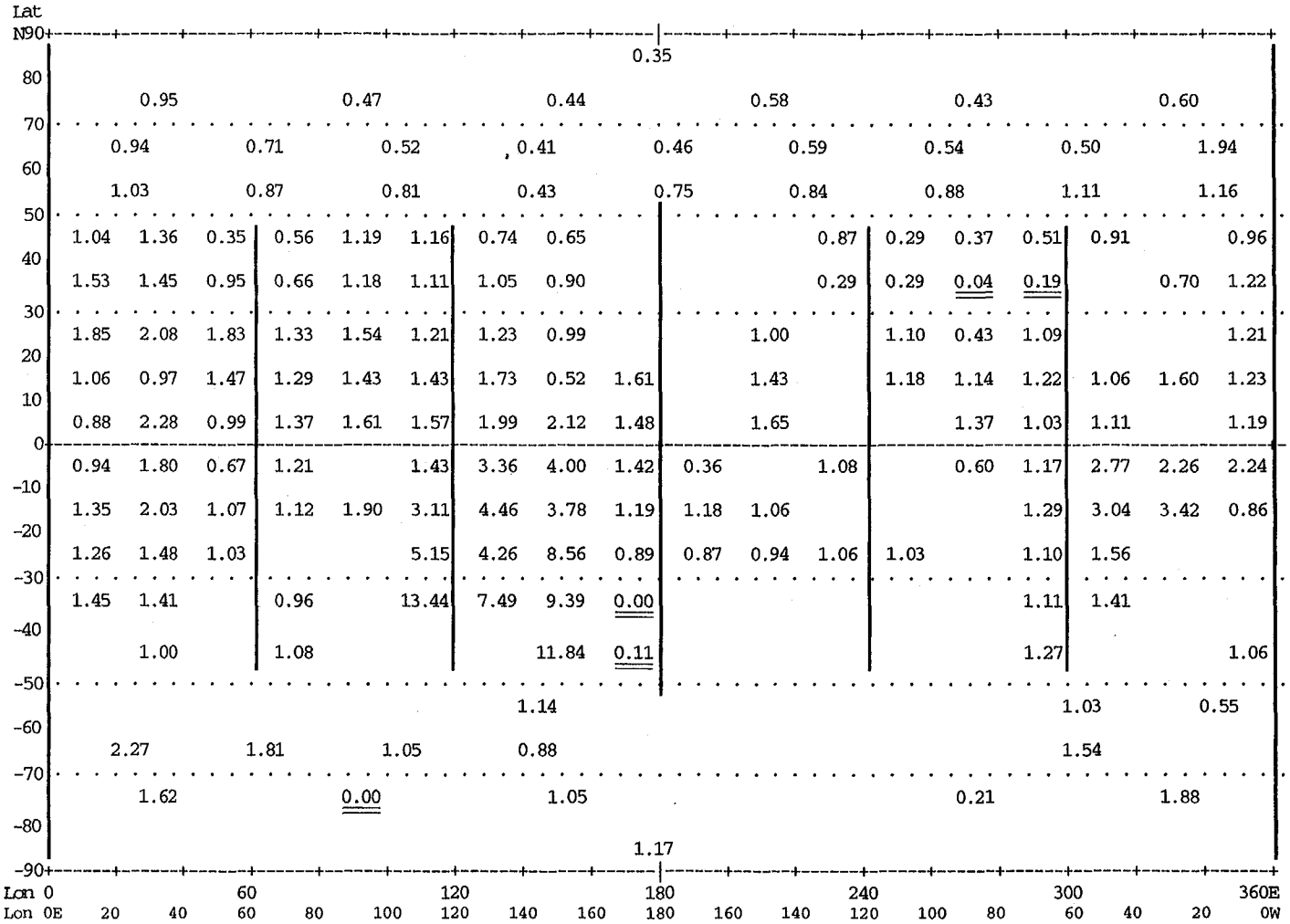
Code used for COADS variable "Ship Type" (CMR5) or "Platform Type" (LMRF)

Code	CMR5 definition	LMRF definitions (consolidated)
0	U.S. Navy or "deck" log or unknown	same
1	merchant ship or foreign military	same
2	ocean station vessel, off station	same
3	ocean station vessel, on station	same
4	lightship	same
5	buoy	same
6	research ship	ship
7	expendable or mechanical bathythermograph	same and oceanographic station Coastal-Marine Automated Network
8		other coastal/island station fixed ocean platform
9*		

* Used in EECR for "missing".

APPENDIX H.

Global Distribution of Ratio of Land Station Reports (light-type) for 1996/1979 (SON).*



* Ratios were computed for the 176 10c grid boxes with >100 reports for SON 1979. The average number of reports per box is 12,000; range 104 to 167,600. Average Ratio = 1.44. Low ratios (<0.20) in the United States, New Zealand, and Antarctica are shown with a double underline. 8 boxes with both >99.8% ocean (islands) and Ratios < 0.1 have been blanked for clarity.

Internal Distribution

1. L. J. Allison
2. T. A. Boden
3. M. D. Burtis
4. R. M. Cushman
5-54. S. B. Jones
55. D. P. Kaiser
56. P. Kanciruk
57. A. W. King
58. T. E. Myrick
59. D. E. Shepherd
60. L. D. Voorhees
61-64. ESD Library
65. Laboratory Records Department

External Distribution

66. S. S. Alexander, Pennsylvania State University, Department of Geosciences, 537 Deike Building, State College, PA 16802
67. J. H. Allen, WDC-A for Solar Terrestrial Physics, National Geophysical Data Center, National Oceanic and Atmospheric Administration, E/GC2, 325 Broadway, Boulder, CO 80303
68. P. Q. J. Andre, US Department of Agriculture, National Agriculture Library, 10301 Baltimore Blvd., Beltsville, MD 20705
69. James K. Angell, Natl. Oceanic & Atm. Adm, Air Resources Laboratory, SSMC 2, Room 3459, 1315 East West Hwy., Silver Spring, MD 20910
70. W. E. Asher, University of Washington, Joint Institute for the Study of the Atmosphere and the Ocean, Box 354235, Seattle, WA 98195
71. D. C. Bader, Pacific Northwest National Laboratory, 901 D Street, SW, Suite 900 Washington, DC 20024
72. R. C. Balling, Jr., Arizona State University, Office of Climatology, Box 871508, Tempe, AZ 85287
73. R. G. Barry, University of Colorado, WDC-A Glaciology, CIRES, Campus Box 449, Boulder, CO 80309
74. M. F. Baumgardner, Purdue University, Department of Agronomy, 1220 Potter Drive, W. Lafayette, IN 47907
75. R. Bidigare, University of Hawaii, Department of Oceanography, 1000 Pope Road, Honolulu, HI 96822
76. C. Boelcke, P.S.S., UNEP, P. O. Box 30552, Nairobi, Kenya
77. F. P. Bretherton, University of Wisconsin, Space Science and Engineering Center, 1225 West Dayton Street, Madison, WI 53706
78. P. G. Brewer, Monterey Bay Aquarium Research Institute, P. O. Box 628, 7700 Sandholt Road, Moss Landing, CA 95039
79. D. A. Bruns, Wilkes University, Department of Earth and Environmental Sciences, Wilkes-Barre, PA 18766
80. R. H. Byrne, University of South Florida, Department of Marine Sciences, 140 Seventh Avenue, St. Petersburg, FL 33701

81. S. Chakraborty, University of Kalyani, Department of Physics, Post: Kalyani, Nadia, West Bengal 741 235, India
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88. Database Section, National Institute for Environmental Studies, Center for Global Environmental Research, 16-2 Onogawa, Tsukuba, Ibaraki 305, Japan
89. Bob Dattore, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307
90. K. D. Davidson, National Climatic Data Center, 151 Patton Avenue, Suite 120, Asheville, NC 28801
91. A. T. DeGaetano, Northeast Regional Climate Center, 1123 Bradfield Hall, Cornell University, Ithaca, NY 14853-1901
92. W. C. Draeger, WDC-A for Remotely Sensed Land Data, U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 57198
93. H. W. Ducklow, College of William and Mary, Virginia Institute of Marine Sciences, P.O. Box 1346, Gloucester Point, VA 23062
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95. J. W. Elwood, Department of Energy, Office of Biological and Environmental Research, SC-74, 19901 Germantown Road, Germantown, MD 20874
96. Energy Library (HR-832.1/GTN), Department of Energy, Office of Administration and Management, G-034, Washington, DC 20585
97. Energy Library (HR-832.2/WAS), Department of Energy, Office of Administration and Management, GA-138 Forrestal Building, Washington, DC 20585
98. L. M. Enomoto, National Oceanic and Atmospheric Administration, NESDIS, Federal Building 4, Room 0110, Washington, DC 20233
99. G. Esser, Justus-Liebig-University, Institute for Plant Ecology, Heinrich-Buff-Ring 38, D-35392, Giessen, Germany
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104. R. H. Gammon, University of Washington, Chemistry Department, Box 351700, Seattle, WA 98195
105. W. Gardner, Texas A & M University, Department of Oceanography, College Station, TX 77843
106. J.-P. Gattuso, Observatoire Oceanologicque Europe, Avenue Saint-Martin, MC 98000, Monaco
107. J. P. Giesy, Michigan State University, College of Natural Science, Department of Zoology, 203 Natural Sciences Building, East Lansing, MI 48824-1115
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110-14. Carole J. Hahn, Institute of Atmospheric Physics, University of Arizona, P.O. Box 210081, Tucson, AZ 85721-0081
115. M. Hein, Freshwater Biological Laboratory, Helsingoersgade 51, DK-3400 Hilleroed, Denmark
116. Raino Heino, Finnish Meteorological Institute, P.O.Box 503 (Vuorikatu 15 A), FIN-00101, Helsinki, Finland
117. A. Hittelman, WDC-A for Solid Earth Geophysics, National Oceanic and Atmospheric Administration, Code E/GC1, 325 Broadway, Boulder, CO 80303
118. H. Hodgson, British Library, Boston Spa, DSC, Special Acquisitions, Wetherby, West Yorkshire, LS23 7BQ, United Kingdom
119. W. Hogg, Chief, Climate Monitoring and Data Interpretation Division, (CCRM) Climate Research Branch, AES, 4905 Dufferin Street, Downsview, ON M3H 5T7, Canada
120. H. Hong, Xiamen University, Environmental Science Research Center, Post Code 361005, Mail Box 1085, Xiamen, Fujian, Peoples Republic of China
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128. T. R. Karl, National Climatic Data Center, 151 Patton Avenue, Federal Building, Room 516E, Asheville, NC 28801
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132. R. M. Key, Princeton University, Geology Department, Princeton, NJ 08544
133. K.-R. Kim, Seoul National University, Department of Oceanology, Seoul 151-7442, Korea
134. B. A. Kimball, Research Leader, Environmental and Plant Dynamics Research Group, U.S. Water Conservation Laboratory, USDA, Agricultural Research Service, 4331 East Broadway Road, Phoenix, Arizona 85040
135. T. Kimoto, Research Institute of Oceano-Chemistry, Osaka Office, 3-1 Fumahashi-cho, Tennoji-ku, Osaka 543, Japan
136. B. Klein, University Laval, GIROQ, Pav. Vachon, Quebec, PQ, G1K 7P4, Canada
137. J. C. Klink, Miami University, Department of Geography, 217 Shideler Hall, Oxford, OH 45056
138. R. W. Knight, National Oceanic and Atmospheric Administration, National Climate Data Center, 151 Patton Avenue, Suite 120, Asheville, NC 28801
139. Kenneth Kunkel, Director, Midwestern Climate Center, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820
140. W. A. Kurz, Environmental and Social Systems Analysts Limited, 3rd Floor, 1765 W 8th Avenue, Vancouver, B.C. V6J 5C6, Canada
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