NOTICE

**CERTAIN DATA
CONTAINED IN THIS
DOCUMENT MAY BE
DIFFICULT TO READ
IN MICROFICHE
PRODUCTS.**

BNL--45216

DE91 001120

A Preliminary Ocean ARM Guide
for
Climatic Evaluations

Robert M. Brown

July, 1990

This work was performed under the auspices of the
U.S. Department of Energy under contract No. DE-AC02-76CH00016.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ps

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, not any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency, contractor, or subcontractor thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency, contractor or subcontractor thereof.

An ARM Guide

Table of context

	Page
Introduction.	1-3
1. Continentality.	4
2. Average temperatures. (Jan. & July)	5-6
3. Coldest and hottest temperatures.	7-8
4. Duration of sunshine.	9
5. Mean insolation. (annual)	10
6. Mean insolation. (Jan, Apr, July, Oct)	11
7. Cumulus clouds. (Frequency)	12-15
8. Cumulonimbus clouds. "	16-19
9. Nimbostratus clouds. "	20-23
10. Stratus, Stratocumulus, Fog. (Frequency)	24-27
11. Altostratus, Altocumulus Clouds. "	28-31
12. Cirrus, cirrostratus, cirrocumulus. "	32-35
13. Most frequently occurring clouds.	36-39
14. Average total cloud cover.	40-43
15. Completely clear sky.	44-47
16. Wind directions. (Annual, Jan., July)	48-50
17. Precipitation. (Annual)	51
18. Precipitation variation.	52
19. Precipitation from tropical storms.	53
20. Vertical moisture content.	54
21. Turbidity.	55
22. Fog.	56
23. Visibility. (Seasonal)	57
24. Thunderstorms.	58
25. Droughts.	59
26. Heating and cooling degree days.	60
Description of Koppen's Classification.	61
27. Koppen's world classification of climates.	62
References.	63

A Preliminary ARM Guide

Introduction

This guide was made to assist in the task of selecting sites for the Atmospheric Radiation Measurements (ARM) study. It is a preliminary attempt to provide mean annual and seasonal meteorological data that might be useful in initial climatic evaluations. It is not a finished product and will be added to in time to give other important information on parameters such as standard deviations, % of means and times, and other variances.

According to the ARM Program Plan (4.3.1), "a site may be considered climatically significant if it possesses radiatively important characteristics, is geographically prevalent or exercises a wide range of weather and climate conditions." Consideration will be given for ocean, desert, ice covered, and tropical sites as well as sites that exhibit some or a combination of those regimes.

In order to cover the spectrum of climatic factors to be considered, this generalized climatic guide was established from various publications to provide a diversified set of basic meteorological data that exists.

To comply with other site selection restrictions, (also given in section 4.3.1), namely, synergism with other programs and scientific and logistical viability, this guide covers only the United States, except for the material at the end on Koppens World Climate Classification. It is anticipated that a similar guide will be made to cover the world's climate at a later date.

The following describes the context of this guide and furnishes some information on certain parts of it.

1. Continentality.

In climatology, the degree to which a point on the earth's surface is in all respects subject to the influence of a land mass. Continentality usually refers to climate and its immediate consequence.

It is defined by V. Conrad as:

$$k = \frac{1.7 A}{\sin(Q + 10)} - 14$$

where k-index of continentality

A-the difference between the mean temperature of the warmest and coldest months (C)

and Q-the latitude.

The map of continentality indicates wide range overall, with increasing values in the northern interior of the US.

2. Average Temperature.

The maps of the average temperatures in January and July show the smooth and steady isotherm gradient in the eastern half of the US as compared to the complex nature of temperature variation in the western half.

3. Coldest and Hottest Temperatures.

The two maps show the annual cold and hot locations in the US. The central portion of the US exhibits the greatest temperature range.

4. Duration of Sunshine.

This map shows the annual duration of sunshine in hundreds of hours, based on data from 125 stations. Notice the wide range of duration in the western half of the US.

5. Daily Insolation. (Annual)

This map shows the annual daily insolation values across the US. The southwest section receives the most insolation as expected.

6. Daily Insolation. (Seasonal)

This display shows the wide range of insolation with season and the dominance of all seasons in the southwest.

7. Clouds.

Clouds play an important role in the amount of solar radiation that is received, scattered or absorbed in the atmosphere. Therefore, the guide contains a rather large number of maps on clouds. They cover the frequency of occurrence by season of cumulus, cumulonimbus, nimbostratus, stratus, stratocumulus, fog, altostratus, altocumulus, cirrus, cirrostratus and cirrocumulus. There are maps showing the most frequently occurring cloud types, the average total cloud cover and times when the sky is completely clear.

8. Wind Direction.

Maps of January, July and Annual wind directions show the seasonal variation at many locations as well as the yearly averages. As can be seen, there is wide variation across the US.

9. Precipitation.

The map of the annual precipitation amounts in the US show a gradual gradient change in the eastern half of the country and a wide range of amounts in the western half.

10. Precipitation Variability.

These two maps show the variation of annual precipitation and the percent of years with precipitation within 25% of a 50 year sample.

11. Tropical Cyclones and Precipitation.

This map provides some statistics on the percent of total precipitation from tropical storms in the east.

12. Moisture Content.

The mean annual vertical moisture content of the atmosphere is shown in this map. The values cover the vertical extent of the atmosphere from the surface to the 325 millibar level.

13. Turbidity.

In meteorology, the turbidity is any condition of the atmosphere which reduces its transparency to radiation, especially to visible radiation. Ordinarily, this is applied to a cloud-free portion of the atmosphere that owes its turbidity to air molecules and suspensoids such as smoke, dust and haze and to scintillation effects. As shown in this map, the central eastern section of the US has the highest levels of turbidity.

14. Fog.

The coastal regions of the US are influenced by fog on many days during the year as indicated on this map. The Ohio River Valley is an area of maximum fog days in the US.

15. Visibility.

The northeast section of the US has the largest percentage with visibilities less than 5 km. as shown on this map and it persists during all seasons as shown.

16. Thunderstorms.

These two maps show the annual number of thunderstorms and the hour of the day when they occur. The west coast of Florida experiences the most thunderstorm activity and the evening hours prevail for thunderstorm times.

17. Drought.

This map shows the the areas in the US where the percentage of months have severe or extreme droughts. The central section of the country is most affected by drought conditions.

18. Heating and Cooling Degree Days.

These two maps show the annual total number of heating and cooling degree days. Once again, even distributions are seen in the eastern half of the country with wide differences in the western half.

Isolines of equal continentality. (From TREWARTHA, 1961.)

Mean monthly temperatures, 1931-1960 U.S. Weather Bureau National Atlas map.

Mean monthly temperatures, 1931-1960, in January (A) and July (B), interpolated from U.S. Weather Bureau National Atlas map.

Coldest (A) and hottest (B) temperatures with annual probability of 1% or less, estimated from annual extremes, 1931-1960, at 220 first-order stations. (Prepared by David Waco.)

Mean annual duration of sunshine, in hundreds of hours, based on black-bulb sunshine recorders at 125 stations, 1931-1960, and 50 for fewer years. (After U.S. Weather Bureau National Atlas map.)

Annual mean daily insolation, in langley-hours, 1950-1964. (From Dr. Iven Bennett.)

JULY

JANUARY

OCTOBER

APRIL

Mean daily insolation, in langley-hours, 1950-1964, for mid-season months. (From BENNETT, 1965.)

Cumulus

Frequency of Occurrence (%)
December, January, February (1971-1981)

Cumulus

Frequency of Occurrence (%)

March, April, May (1971-1981)

Cumulus

Frequency of Occurrence (%)

June, July, August (1971-1981)

Cumulus

Frequency of Occurrence (%)

September, October, November (1971-1981)

Cumulonimbus

Frequency of Occurrence (%)

December, January, February (1971-1981)

Cumulonimbus

Frequency of Occurrence (%)

March, April, May (1971-1981)

Cumulonimbus

Frequency of Occurrence (%)

June, July, August (1971-1981)

Nimbostratus

Frequency of Occurrence (%)

December, January, February (1971-1981)

Nimbostratus

Frequency of Occurrence (%)

March, April, May (1971-1981)

Nimbostratus

Frequency of Occurrence (%)

June, July, August (1971-1981)

Nimbostratus

Frequency of Occurrence (%)

September, October, November (1971-1981)

Stratus + Stratocumulus + Fog

Frequency of Occurrence (%)

December, January, February (1971-1981)

Stratus + Stratocumulus + Fog

Frequency of Occurrence (%)

March, April, May (1971-1981)

Stratus + Stratocumulus + Fog

Frequency of Occurrence (%)

June, July, August (1971-1981)

Altostratus + Altocumulus

Frequency of Occurrence (%), 6-18 LT

December, January, February (1971-1981)

Altostratus + Altocumulus

Frequency of Occurrence (%), 6-18 LT

March, April, May (1971-1981)

Altostratus + Altocumulus

Frequency of Occurrence (%), 6-18 LT

September, October, November (1971-1981)

Cirrus + Cirrostratus + Cirrocumulus Frequency of Occurrence (%), 6-18 LT December, January, February (1971-1981)

Cirrus + Cirrostratus + Cirrocumulus Frequency of Occurrence (%), 6-18 LT March, April, May (1971-1981)

Cirrus + Cirrostratus + Cirrocumulus Frequency of Occurrence (%), 6-18 LT June, July, August (1971-1981)

Cirrus + Cirrostratus + Cirrocumulus

Frequency of Occurrence (%), 6-18 LT

September, October, November (1971-1981)

Most-Frequently-Occurring Cloud Type

December, January, February (1971-1981)

Most-Frequently-Occurring Cloud Type

March, April, May (1971-1981)

Most-Frequently-Occurring Cloud Type

June, July, August (1971-1981)

Most-Frequently-Occurring Cloud Type September, October, November (1971-1981)

Average Total Cloud Cover (%)

December, January, February (1971-1981)

Average Total Cloud Cover (%)

March, April, May (1971-1981)

Average Total Cloud Cover (%)

June, July, August (1971-1981)

September, October, November (1971-1981)

Frequency of Occurrence (%), 6-18 LT
December, January, February (1971-1981)

Completely Clear Sky

Frequency of Occurrence (%), 6-18 LT

March, April, May (1971-1981)

Completely Clear Sky

Frequency of Occurrence (%), 6-18 LT

June, July, August (1971-1981)

Completely Clear Sky

Frequency of Occurrence (%), 6-18 LT

September, October, November (1971-1981)

Average annual percentage frequencies of wind direction, 1951-1960. Areas of sectors are proportional to hourly frequencies. (From Strusser, 1965.)

Average percentage frequencies of wind direction—January 1951-1960

Average percentage frequencies of wind directions in: A. January, and B. July, 1951-1960. Areas of section are proportional to hourly frequencies. (From Slusser, 1965.)

Mean annual total precipitation, based on all available stations adjusted to standard period 1931-1960. (After U.S. Weather Bureau.)

Coefficient of variation (%) of annual precipitation, 1931-1960, at 220 first-order stations. Station locations indicated by dots. (After HERSHFIELD, 1962.)

Percent of years in which precipitation was between 75% and 125% of 50-year mean. Distributions of annual precipitation at each of 206 stations were fitted by gamma distributions, from which interval was obtained. (After EAGLEMAN, 1968.)

Storms

Tropical storms cause an August maximum in precipitation in the southeastern United States. Of the 299 tropical cyclones, including hurricanes, identified in the North Atlantic during 30 years (1931–60), a little more than half (167) affected directly the United States (CRY, 1967). In the ensuing decade (1961–70), the U.S. coast was reached by 14 of 48 North Atlantic tropical storms (9 of 30 hurricanes), killing 533 persons (256 in 1969 alone) and causing millions of dollars in damage (CONDON, 1971). Despite their devastation, such storms have beneficial effects, and are necessary parts of the general circulation (LANDSBERG, 1960). (See p.36.)

Along the immediate Gulf and Atlantic coasts, tropical storms were responsible for more than 15% of the total precipitation during the 5-month hurricane season.

Percent of total precipitation, June–October, attributed to tropical cyclones, 1931–1960. (From CRY, 1967.)

The annual mean of 17.5 mm corresponds to 0.13 teratons over the conterminous United States, or as much as enters, on the average, in five days. Slightly lower annual values were found for three later years, 1964-66, from reports of only a dozen U. S. stations as part of a worldwide survey (TULLER, 1968).

This atmospheric moisture content in turn is reflected in the surface dew-points, which decrease northward in all months over the eastern two-thirds of the country,

Mean annual moisture content of atmosphere up to 325 mbar over 50 stations, 1946-1956, in millimeters of condensed water, or decigrams per square centimeter of earth's surface. (After REE, 1960a.)

MEAN ANNUAL TURBIDITY

Average annual turbidity, based on 1 to 6 years of observations at 26 stations. Urban station values, in parentheses, were not used in drawing isolines, which represent average annual "background" turbidity. (After Flowrass et al., 1969.)

Mean annual number of days with fog (visibility less than 300 m), from records of 251 stations through 1960. (From COURT and GERSTON, 1966.)

Average percent of hours with visibility less than 5 km, 1948-1958, by season. (From Eldridge, 1966.)

Mean annual number of days with thunderstorms, based on data from 261 stations, 1953-1962.
(Prepared by Robert Maples.)

Hour (local standard time) of maximum frequency of thunderstorms, June-August. (After RASMUSSEN, 1971.)

Percent of months with severe or extreme drought (%), 1931-1967 in 11 western states, and 1931-1967 in 11 eastern United States, and 1931-1967 in 11 western states. (After manuscripts maps supplied by Dr. Wayne C. Palmer.)

Normal annual total heating degree days, base 65°F (18.3°C), based on normal temperatures, 1931-1960. (From Environmental Data Service.)

Region with more than 700 cooling degree days, base 65°F (18.3°C) annually, based on normal temperatures, 1931-1960. (From Environmental Data Service.)

Koppen's World Climate Classification

The simplest classification of climates are genetic ones, which describe the distribution of climatic regimes in terms of the conditions of radiation, surface heating and the prevailing winds which produce them.

Koppen's world-wide classification system is by far the most widely used. It is given in this guide to show how the system classifies the climate in the US as compared to the rest of the world.

Koppen's classification of climates follows:

- A Tropical rain climates.
- B Arid climates.
- C (Warm) temperate rain climates.
- D Boreal forest and snow climates.
- E Cold snow climates (treeless).

Less important letters: S steppe grasslands.
W desert-waste

A, C and D are all essentially tree climates, BS is steppe grassland, BW is the warm deserts and E are tundra and polar desert climates.

There are a number of subscripts associated with the capital letters and the main ones are as follows:
f moist climates.
m monsoon climates.
w winter dry season.

A full description of this classification is given in "Climate, Present, Past and Future.", H.H. Lamb. Vol 1, Methuen & Co. Ltd. 1978. (pp 509-521).

The map on page 62 shows the boundaries of Koppen's classification. As can be seen, the eastern half of the US lies in the Cf climate, a warm, moist, rainy temperate zone while the western portion is classified as BW, a warm desert type climate.

A-C boundaries
 B-W boundaries
 B-S boundaries
 C-D boundaries

E boundaries
 internal boundaries between A climates
 internal boundaries between C climates
 internal boundaries between D climates

KÖPPEN'S world classification of climates.

References to ARM Guide.

1. Climate, Present, Past and Future.
H.H. Lamb, Vol.1, Methuen & Co. Ltd.
1978.
2. World Survey of Climatology.
H.E. Landsberg, Vol. 11, Elsevier
Scientific Publishing Co., 1974.
3. Global Distribution of Total Cloud
Cover and Cloud Type Amounts Over
Land. DOE/ER/60085-HI, NCAR/TN-273
+STR, NCAR Technical Notes, 1986.
Available from National Technical
Information Service, VA.

- END -

DATE FILMED

11 / 20 / 90