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# THE AUTOMATED GENERATION OF CLOUD PHRASES FOR THE INTERACTIVE COMPUTER WORDED FORECAST

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# THE AUTOMATED GENERATION OF CLOUD DESCRIPTORS FOR THE INTERACTIVE COMPUTER WORDED FORECAST

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## 1. INTRODUCTION

The Techniques Development Laboratory (TDL) has been experimenting with the preparation of worded weather forecasts by computer for over 20 years (Glahn, 1970, 1979; Bermowitz, Heffernan, and Glahn, 1980; Bermowitz and Miller, 1984). Interpretation of direct numerical model output by statistical techniques provides a database of Model Output Statistics (MOS) forecasts for those weather elements normally contained in the public weather forecast. The database is analyzed by computer and text forecasts are automatically produced. Similar experiments have been conducted in Sweden (Lonnqvist, 1973) and Canada (Verret, 1990).

In support of the National Weather Service modernization, TDL has made extensive revisions and enhancements to an interactive version of the computer worded forecast known as the Interactive Computer Worded Forecast (ICWF). The aim of the ICWF is to provide forecasters with the mechanism for efficiently preparing the suite of forecast products normally issued by a National Weather Service Weather Forecast Office (WFO). With the ICWF, forecasters are able to interact with the database and modify forecast guidance as needed prior to submitting the database for product formatting.

For the current version of the ICWF, the forecast database has been redesigned to incorporate greater temporal and spatial resolution. In order to take advantage of this increased resolution, the text formatters have also been redesigned. This office note describes the new cloud phrase formatting routines for the public forecast products.

## 2. SELECTING THE CLOUD PHRASES

The ICWF database for cloud cover contains forecasts of opaque cloud cover in tenths every 3 hours from an initial time (either 0000 UTC or 1200 UTC) through 60 hours. The database can be initialized from MOS guidance or from the database prepared by the previous shift at the WFO. In either case, forecasters interact with the cloud data in categorical form. The categories consist of clear, scattered, broken, and overcast. After modification by the forecaster, the categorical cloud cover forecasts are converted from categories to tenths before being stored in the database. The scheme for converting categories to tenths is shown below and is adjustable by the WFO.

| category | tenths |
|---|---|
| clear | 0 |
| scattered | 3 |
| broken | 7 |
| overcast | 10 |

In order to facilitate the selection of the appropriate cloud phrase, the cloud forecasts in tenths are re-categorized according to the following scheme:

| category | tenths |
|---|---|
| 1 | 0 - 1 |
| 2 | 2 - 3 |
| 3 | 4 - 7 |
| 4 | 8 - 9 |
| 5 | 10 |

Note that in categories 1, 2, and 3 above, sunny and mostly sunny refer to cloud conditions during the daytime while clear and mostly clear refer to cloud conditions during the nighttime. This scheme for re-categorization can be modified by the forecast office.

After the cloud data have been re-categorized, the range in cloud categories during the forecast period is computed. For example, a 12-h forecast with 3-hourly cloud data in tenths of 0, 3, 6, 8, and 10 would be categorized as 1, 2, 3, 4, and 5, and the range in cloud categories would be 4.

The range and sequence of cloud category forecasts is used to determine the type of cloud phrase to be constructed. If the range is 0 or 1, the selection process is over, and the cloud phrase is constructed based on an average of the cloud forecasts (in tenths) during the forecast period. If the range is 2 or more, further analysis of the cloud category forecasts is required before the appropriate phrase can be selected.

Further analysis consists first of looking for a "trend" in the sequence of cloud category forecasts. A trend is defined as cloud category forecasts that increase or decrease during all or part of the forecast period in a continuous or steplike fashion. The trend is further classified based upon the nature of the change in cloud categories with time. An abrupt and significant change in cloud categories over a short time period will lead to a "split period" forecast with separate cloud descriptors for each part of the split period (e.g., MOSTLY SUNNY THIS MORNING...THEN BECOMING CLOUDY). Trend cases not included in the split period subclass involve a smoother, less abrupt transition in cloudiness. In general, trend descriptors such as "INCREASING," "CLEARING," or "BECOMING" will be used (e.g., INCREASING CLOUDINESS).

If a trend is not present in the cloud data but a range of two or more categories exists, then a varying sequence of cloud forecasts must be present. The degree of variation is determined by the number of minima and maxima in the cloud data during the forecast period. If there is more than one minimum or maximum during the period, then the range in categories, the minimum and maximum categories, and the average category are computed. For any given range and corresponding maximum and minimum categories, cloud descriptors are chosen based upon the average cloud category for the period, the objective being to describe the overall character of the cloud cover during the period. In general, a low average cloud category will emphasize sunshine while a high average cloud category will emphasize cloudiness.

If there is only one maximum or minimum in the cloud data during the period, the cloud forecasts will be further analyzed to determine whether the period can be split. If the period can be split, separate cloud descriptors for each part of the split period may be appropriate depending upon the desired level of detail. If the period cannot be split, cloud descriptors will be chosen in the same way as for cases with more than one maximum and minimum.

In the special case where a single maximum or minimum in cloud cover is forecast to occur for a short time near the middle of the forecast period, and cloud forecasts at adjacent projections differ significantly from the maximum or minimum, a sandwich cloud phrase will be selected (e.g., A PERIOD OF CLOUDINESS EARLY THIS AFTERNOON...OTHERWISE MOSTLY SUNNY). If the sandwiched period lasts for a sufficient length of time so as to dominate cloud conditions during the forecast period, cloud forecasts for the period are averaged with greater weighting placed on those projections included in the sandwiched period. The cloud phrase will then be based on this computed average cloud cover for the period in an attempt to capture the character of the day.

## 3. CONSTRUCTION OF THE CLOUD PHRASE

After the cloud forecasts have been analyzed, a specific cloud phrase construction routine is selected. There are six routines for the construction of cloud phrases, each of which applies to a specific temporal sequence in the cloud cover forecasts. Two routines deal with trend related phrases (one for a split period and one for a gradual trend), two deal with varying sequences of cloud cover (again, one where the period can be split and one where it cannot), one routine is for the special sandwich phrase case, and one routine is used when there is little or no variation in cloud cover during the period.

The construction of cloud phrases is accomplished by piecing together a series of phrase parts. A phrase part consists of one or more words describing a particular aspect of the cloud conditions. Unlike the precipitation, wind, and temperature phrases, the cloud phrases are relatively simple and consist of only a few phrase parts. At most, the cloud phrase consists of a phrase part (or two) describing the cloud conditions, a phrase part (or two) describing the time at which those conditions occur, and a phrase part consisting of a connecting word. The cloud phrases can take the form of one of three basic phrase structures. The most complex cloud phrases are those for split periods and sandwich situations. Split period phrases take the form:

[cloud1] [time1]...then becoming [cloud2]

e.g., MOSTLY SUNNY THIS MORNING...THEN BECOMING CLOUDY

Phrases describing a sandwich situation have the form:

a period of [cloud2] [time2]...otherwise [cloud1]

e.g., A PERIOD OF CLOUDINESS AROUND NOON...OTHERWISE MOSTLY SUNNY

The simplest cloud phrases consist solely of the cloud descriptor and are used where the period cannot be split, for detail level 2 (discussed below), or any situation where a general phrase is appropriate:

[cloud1] e.g., PARTLY SUNNY

The desired level of detail also influences phrase construction. There are two user selectable detail levels for cloud phrases. The first detail level (detail level 1) includes descriptions of intraperiod changes in cloud cover including times associated with the changing conditions. The second level of detail (detail level 2) describes intraperiod changes in cloud cover only to the extent of indicating a trend (e.g., increasing cloudiness or clearing) and does not specifically mention times associated with changing conditions. As an example, the phrase "MOSTLY SUNNY THIS MORNING...THEN INCREASING CLOUDINESS" under detail level 1 would be "INCREASING CLOUDINESS" under detail level 2.

See Appendix I for a complete listing of the cloud phrase selection criteria along with a description of the methodology employed in the construction of phrases. Appendix II lists the the control constants or thresholds which govern the generation of the text phrase. Appendix III describes the software structure of the cloud formatting routines.

## References


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## APPENDIX I

### Selection and Construction of Cloud Phrases

The selection and construction of cloud phrases begins with converting opaque cloud cover in tenths as stored in the ICWF forecast database to categories. As stated earlier, the conversion of cloud cover in tenths to categories is accomplished according to the following scheme:

| category | tenths |
|---|---|
| 1 | 0 - 1 |
| 2 | 2 - 3 |
| 3 | 4 - 7 |
| 4 | 8 - 9 |
| 5 | 10 |

The appropriate cloud phrase is then selected based upon the range and sequence of cloud categories during the forecast period. There are two cloud phrase files which are utilized in the construction of cloud phrases; one based on cloud categories, and the other based on cloud cover in tenths. Phrases are usually selected based on cloud categories. Phrases will be selected based upon cloud cover in tenths only if the detail level is 1 and the range in cloud categories during the forecast period is 0 or 1. The phrase file for cloud categories is given below. Cloud phrases before and after a "/" pertain to a daytime and nighttime forecast period respectively:

| category | phrase |
|---|---|
| 1 | SUNNY/CLEAR |
| 2 | MOSTLY SUNNY/CLEAR |
| 3 | PARTLY CLOUDY |
| 4 | CONSIDERABLE CLOUDINESS |
| 5 | CLOUDY |

The phrase file for cloud cover in tenths is as follows:

| tenths | phrase |
|---|---|
| 0 | SUNNY/CLEAR |
| 1 | SUNNY/CLEAR |
| 2 | MOSTLY SUNNY/CLEAR |
| 3 | PARTLY CLOUDY |
| 4 | PARTLY CLOUDY |
| 5 | PARTLY CLOUDY |
| 6 | PARTLY CLOUDY |
| 7 | PARTLY CLOUDY |
| 8 | CONSIDERABLE CLOUDINESS |
| 9 | MOSTLY CLOUDY |
| 10 | CLOUDY |

The phrase files can be modified by the WFO to suit operational needs. The selection and construction of cloud phrases based upon the sequence and range in cloud categories for the forecast period is described below.

I. If the range in categories is 0 or 1.

A) Selection of the cloud descriptor

1) If detail level = 1

Cloud cover in tenths for the period is averaged and the cloud descriptor is based upon the average cloud cover in tenths.

2) If detail level = 2

Cloud cover in tenths for the period is averaged and a cloud category is selected based upon this average value. The cloud descriptor is based upon the selected cloud category.

B) Construction of the cloud phrase

The phrase structure will simply consist of the cloud descriptor [cld1] (e.g., PARTLY CLOUDY).

II. If the range in categories is greater than or equal to 2.

For category ranges greater than or equal to 2, the sequence of cloud forecasts becomes important. Cases will be classified as either a trend, variable, or sandwich case.

With a <u>trend</u>, values for the cloud category forecasts increase or decrease in a continuous or step-like fashion. Trends can be further classified into two sub-classes; split period and non-split period, depending upon how abrupt and significant the increase or decrease in cloudiness is.

A <u>split period</u> trend is an abrupt and significant change in cloudiness. One cloud descriptor is used for the first part of the split period and another descriptor is used for the second part of the split period.

(e.g., MOSTLY SUNNY THIS MORNING...THEN BECOMING MOSTLY CLOUDY)

All trend cases not included in the split period subclass involve a less abrupt, smoother transition in cloudiness. In general, trend descriptors such as "BECOMING," "INCREASING," or "CLEARING" will be used.

<u>Variable</u> cases occur where the sequence of forecasts of cloud categories contains one or more relative maxima/minima in cloudiness. Variable cases can be further divided into two sub-classes, one in which there is only one maximum/minimum in cloudiness and the other in which there is more than one maximum/minimum in cloudiness.

The <u>sandwich</u> case is a special subclass of the variable case with one maximum or minimum. In order for a sandwich to occur, the single maximum or minimum must occur near the middle of the forecast period and adjacent cloud forecasts must differ significantly from the maximum or minimum (e.g., a period of cloudiness in the middle of an otherwise mostly sunny day).

A) Selection of cloud descriptor: trend - split period

1) If detail level = 1

In order to have a split period, the following conditions must be satisfied:

a) The category range <u>within</u> each part of the split period must be less than or equal to 1.

b) The category range <u>between</u> each part of the split period (maximum of the low values and minimum of the high values) must be greater than or equal to 2.

For each part of the split period, the average cloud cover in tenths is determined, and a cloud category is assigned based upon the average cloud cover value.

The following category combinations and phrases can exist for split periods (CLD1 refers to the first part of the split period and CLD2 refers to the second part of the split period). Cloud phrases are based upon category cloud descriptors. Two cloud descriptors are selected, one for each part of the split period.

| CLD1 (CLD2) | CLD2 (CLD1) |
|---|---|
| 1 SUNNY/CLEAR | 3 PARTLY CLOUDY |
| 1 SUNNY/CLEAR | 4 CONSIDERABLE CLOUDINESS |
| 1 SUNNY/CLEAR | 5 CLOUDY |
| 2 MOSTLY SUNNY/CLEAR | 4 CONSIDERABLE CLOUDINESS |
| 2 MOSTLY SUNNY/CLEAR | 5 CLOUDY |
| 3 PARTLY SUNNY/CLOUDY | 5 CLOUDY |

2) If detail level = 2

Cloud descriptors are more general, and only one descriptor is used to describe the entire split period. One of three possible cloud descriptors is selected depending upon whether

a) CLD1 is in the first projection only,
b) CLD2 is in the last projection only, or
c) all other cases.

Cloud descriptors are selected based upon category combinations given below. The values for cloud categories in parenthesis for the first combination refer to the 5 projections over a 12-h period and show the pattern for the other pairs of cloud categories:

| CLD1 | CLD2 | | | |
|---|---|---|---|---|
| 1 | 3 | a) PARTLY CLOUDY | (1 3 3 3 3) | |
| | | b) MOSTLY SUNNY/CLEAR | (1 1 1 1 3) | |
| | | c) MOSTLY SUNNY/CLEAR | (1 1 1 3 3) | (1 1 3 3 3) |

| | | |
|---|---|---|
| 1 | 4 | a) CONSIDERABLE CLOUDINESS<br>b) MOSTLY SUNNY/CLEAR<br>c) INCREASING CLOUDINESS |
| 1 | 5 | a) MOSTLY CLOUDY<br>b) MOSTLY SUNNY/CLEAR<br>c) BECOMING CLOUDY |
| 2 | 4 | a) CONSIDERABLE CLOUDINESS<br>b) MOSTLY SUNNY/CLEAR<br>c) INCREASING CLOUDINESS |
| 2 | 5 | a) MOSTLY CLOUDY<br>b) PARTLY CLOUDY<br>c) BECOMING CLOUDY |
| 3 | 5 | a) MOSTLY CLOUDY<br>b) PARTLY CLOUDY<br>c) BECOMING CLOUDY |
| 5 | 3 | a) PARTLY CLOUDY<br>b) MOSTLY CLOUDY<br>c) PARTIAL CLEARING |
| 5 | 2 | a) MOSTLY SUNNY/CLEAR<br>b) MOSTLY CLOUDY<br>c) BECOMING MOSTLY SUNNY/CLEAR |
| 5 | 1 | a) MOSTLY SUNNY/CLEAR<br>b) MOSTLY CLOUDY<br>c) BECOMING SUNNY/CLEAR |
| 4 | 2 | a) MOSTLY SUNNY/CLEAR<br>b) CONSIDERABLE CLOUDINESS<br>c) BECOMING MOSTLY SUNNY/CLEAR |
| 4 | 1 | a) MOSTLY SUNNY/CLEAR<br>b) CONSIDERABLE CLOUDINESS<br>c) BECOMING SUNNY/CLEAR |
| 3 | 1 | a) SUNNY/CLEAR<br>b) PARTLY CLOUDY<br>c) PARTLY CLOUDY |

B) Construction of the phrase: trend - split period

1) If detail level = 1, and the first part of the split period is 1 projection long, use the structure

[becoming] [cld2] [time].

(e.g., 1 4 4 4 4 - BECOMING MOSTLY CLOUDY BY MID MORNING)

2) If detail level = 1, and the second part of the split period is 1 projection long, use

[cld1] through [time1] then becoming [cld2].

(e.g., 1 1 1 1 4 - SUNNY THROUGH LATE AFTERNOON THEN BECOMING CLOUDY)

3) All other cases with detail level = 1

[cld1] [time1]...then becoming [cld2].

(e.g., 1 1 4 4 4 - SUNNY THIS MORNING...THEN BECOMING CLOUDY)

4) If detail level = 2, the phrase structure is simply the cloud descriptor [cld1].

(e.g., 1 4 4 4 4 - CONSIDERABLE CLOUDINESS)
(e.g., 1 1 4 4 4 - INCREASING CLOUDINESS)

C) Selection of cloud descriptors: trend non-split period

For non-split period trend cases, a test is conducted to see if the period can be subdivided even though the criteria for a split-period trend have not been satisfied. All sequential projections containing cloud category forecasts of 1, 2, and 3 are considered as one grouping, while all sequential forecasts of categories 4 and 5 are considered another grouping. If both groupings occur within the forecast period, then that period can be divided.

e.g., 1 2 3 4 5
group 1 group 2

If only one grouping occurs during the period, the period can not be divided.

e.g., 1 1 2 2 3
group 1

1) If detail level = 1

If the period can be divided, an average cloud cover in tenths is taken for each group within the period. A cloud category is assigned to each group based upon the average cloud cover in tenths. Cloud descriptors for each group are based upon the cloud category for that group.

If the period can not be divided, an average cloud cover in tenths is taken for the period. A cloud category for the period is based upon the average cloud cover in tenths and cloud descriptors are based upon this cloud category.

2) If detail level = 2

Whether or not the period can be divided, cloud descriptors are more general, and only one descriptor is used to describe the period with no mention of a trend. This descriptor attempts to capture the character of the day or average cloud conditions during the day. An average cloud cover in tenths is taken for the period. A cloud category for the period is based upon the average cloud cover in tenths, and cloud descriptors are based upon this cloud category.

D) Construction of the phrase: trend non-split period

1) If detail level = 1 and the period can be divided, the phrase structure takes the form

[cld1] [time1]...then becoming [cld2].

(e.g., MOSTLY SUNNY THIS MORNING...THEN BECOMING MOSTLY CLOUDY)

2) If detail level = 1 and the period can not be divided, then the phrase structure is simply the cloud descriptor [cld1].

3) If the detail level = 2 the phrase structure is simply the cloud descriptor [cld1].

E) Selection of cloud descriptors: variable - more than one maximum/minimum

1) Detail levels 1 and 2

Cloud descriptors are general and attempt to capture the character of the day. The range in forecasts of cloud category, the maximum and minimum cloud categories, and the average cloud category are all taken into account to determine the cloud descriptor.

a) If range = 2, minimum = 1, maximum = 3
   If average > 2 - PARTLY CLOUDY
   If average ≤ 2 - MOSTLY SUNNY/CLEAR

b) If range = 2, minimum = 2, maximum = 4
   If average > 3 - VARIABLE CLOUDINESS
   If average ≤ 3 - PARTLY SUNNY/CLOUDY

c) If range = 2, minimum = 3, maximum = 5
   If average > 4 - MOSTLY CLOUDY
   If average ≤ 4 - VARIABLE CLOUDINESS

d) If range = 1, maximum = 4
   If average > 3 - CONSIDERABLE CLOUDINESS
   If average > 2 - VARIABLE CLOUDINESS
   If average > 1 - PARTLY SUNNY/CLOUDY

e) If range = 3, minimum = 2, maximum = 5
If average $\geq$ 4 - MOSTLY CLOUDY
If average > 3 - CONSIDERABLE CLOUDINESS
If average > 2 - VARIABLE CLOUDINESS

f) If range = 4, minimum = 1, maximum = 5
If average $\geq$ 4 - MOSTLY CLOUDY
If average $\geq$ 3 - VARIABLE CLOUDINESS
If average < 3 - PARTLY CLOUDY

F) Construction of the phrase: variable - more than one maximum/minimum

1) The phrase structure simply consists of the cloud descriptor [cld1].

G) Selection of cloud descriptors: variable - one maximum or minimum

A test is first conducted to see whether the special case of a sandwich phrase applies. In order for a sandwich to occur, there must be at least a three category change from a sunny (cloudy) category to a cloudy (sunny) category and then another change of at least three categories back to a sunny (cloudy) category. The period of cloudiness (sunshine) sandwiched between the two periods of sunshine (cloudiness) must last at least one 3-h projection but no more than two projections. Categories 1 and 2 are considered sunny categories and categories 4 and 5 are considered cloudy categories. Category 3 can not be involved in a three category change. A sandwich phrase will only be constructed for a daytime forecast period.

If all conditions for a sandwich phrase are satisfied except that the sandwiched period lasts for three 3-h projections, the cloud forecasts for the period are averaged, and the cloud phrase is based upon this average cloud cover. Since the cloud cover during the sandwiched part of the period dominates the main portion of the forecast period (cloud conditions differ from the sandwiched part of the forecast period only during the first and last forecast projections), cloud forecasts for the middle three projections are weighted more heavily than those for the first and last projections when computing the average cloud cover. In this way, cloud conditions during the sandwiched part of the period are emphasized in an attempt to capture the character of the day.

If the sandwich phrase does not apply, a test is conducted to see if the period can be subdivided. All sequential projections containing cloud category forecasts of 1, 2, and 3 are considered as one grouping while all sequential forecasts of categories 4 and 5 are considered another grouping. If both groupings occur within the forecast period and there are at least two projections in each group, then that period can be divided.

e.g., $\underline{1\ \ 2\ \ 2}$ $\underline{5\ \ 4}$
group 1 group 2

If only one grouping occurs during the period, the period can not be divided.

e.g., $\underbrace{1\ 1\ 2\ 2\ 1}_{\text{group 1}}$

1) If detail level = 1

If the period can be divided, an average cloud cover in tenths is computed for each group within the period. A cloud category is assigned to each group based upon the average cloud cover in tenths. Cloud descriptors for each group are based upon the cloud category for that group.

If the period can not be divided, cloud descriptors are determined in the same way as for variable cases with more than one maximum/minimum.

2) If detail level = 2

Whether or not the period can be divided, cloud descriptors are more general, and only one descriptor is used to describe the period with no mention of a trend. This descriptor attempts to capture the character of the day or average cloud conditions during the day. An average cloud cover in tenths is computed for the period. A cloud category for the period is based upon the average cloud cover in tenths and cloud descriptors are based upon this cloud category.

H) Construction of the phrase: variable - one maximum or minimum

1) If detail level = 1 and the sandwich phrase applies, the phrase structure takes the form

a period of [cld2] [time]...otherwise [cld1].

(e.g., A PERIOD OF CLOUDINESS AROUND NOON...OTHERWISE MOSTLY SUNNY)

2) If detail level = 1 and the period can be divided, the phrase structure takes the form

[cld1] [time1]...then becoming [cld2].

(e.g., MOSTLY SUNNY THIS MORNING...THEN BECOMING MOSTLY CLOUDY)

3) If detail level = 1 and the period can not be divided, then the phrase structure simply consists of the cloud descriptor [cld1].

4) If the detail level = 2 the phrase structure simply consists of the cloud descriptor [cld1].

## APPENDIX II

### Control Constants (Thresholds) for Constructing the Cloud Phrases

Control constants are thresholds which guide the generation of text phrases by the ICWF formatting routines. The thresholds are integer values which are read in from a file during the initialization of the ICWF. The threshold file is adjustable by the user so that each WFO may tailor the thresholds to best describe their local climatology.

There are two files which contain cloud control constants. The two arrays are referred to as LC_DESC and LC. The LC_DESC array holds the upper and lower limits (cloud cover in tenths) of the five cloud categories used by the ICWF for data analysis purposes.

The LC array contains the other thresholds needed to select and construct the cloud phrases. These thresholds are various cloud category and cloud event duration requirements.

The following thresholds make up the LC_DESC cloud control constants:

LC_DESC(1) - Minimum cloud cover in tenths for cloud category 1.
Default value = 0.

LC_DESC(2) - Maximum cloud cover in tenths for cloud category 1.
Default value = 1.

LC_DESC(3) - Minimum cloud cover in tenths for cloud category 2.
Default value = 2.

LC_DESC(4) - Maximum cloud cover in tenths for cloud category 2.
Default value = 3.

LC_DESC(5) - Minimum cloud cover in tenths for cloud category 3.
Default value = 4.

LC_DESC(6) - Maximum cloud cover in tenths for cloud category 3.
Default value = 7.

LC_DESC(7) - Minimum cloud cover in tenths for cloud category 4.
Default value = 8.

LC_DESC(8) - Maximum cloud cover in tenths for cloud category 4.
Default value = 9.

LC_DESC(9) - Minimum cloud cover in tenths for cloud category 5.
Default value = 10.

LC_DESC(10)- Maximum cloud cover in tenths for cloud category 5.
Default value = 10.

Note that "sunny" categories are 1, 2, and 3; "cloudy" categories are 4 and 5. The sunny and cloudy category definitions are controlled by control constants LC(8) through LC(11).

The following thresholds make up the LC array control constants.

The following threshold applies to the selection of phrase structures describing a trend in cloudiness during the forecast period:

LC(1) - The number of hours that a cloud category forecast may be an exception to a trend (e.g., decrease during a period of increasing cloudiness or vice versa) and still qualify for a trend phrase.
Default value = 1.

The following thresholds apply to phrase structures describing a trend in cloudiness during the forecast period with the phrases "INCREASING CLOUDINESS" or "CLEARING:"

LC(2) - Minimum required number of hours of consecutive "sunny" ("cloudy") cloud category forecasts in order for a split period trend phrase to be constructed describing the "sunny" ("cloudy") part of the forecast period before the period of "increasing cloudiness" ("clearing") (e.g., MOSTLY SUNNY THIS MORNING...THEN INCREASING CLOUDINESS).
Default value = 5.

LC(3) - Maximum number of hours a cloud category forecast may persist as cloudiness increases or decreases in order to select an "increasing cloudiness" or "clearing" phrase structure.
Default value = 4.

LC(4) - Minimum number of hours a cloud category forecast may persist as cloudiness increases or decreases in order to select an "increasing cloudiness" or "clearing" phrase structure.
Default value = 2

The following control constants apply to the construction of split period trend phrases:

LC(5) - Minimum required range in cloud category forecasts during a forecast period in order to select a split period phrase structure.
Default value = 2.

LC(6) - Minimum number of hours that a "sunny" or "cloudy" period must persist after an abrupt change in cloud cover in order for a split period trend phrase to be constructed.
Default value = 3.

LC(7) - Minimum consecutive number of hours that both "sunny" and "cloudy" conditions must persist during a forecast period in order for a split period trend phrase to be constructed.
Default value = 3.

The following control constants specify which cloud categories are considered to be "sunny" or "cloudy" cloud categories for the purpose of defining the "sunny" and "cloudy" parts of the forecast period:

LC(8) - Minimum cloud category considered to be a "sunny" category.
Default value = 1.

LC(9) - Maximum cloud category considered to be a "sunny" category.
Default value = 3.

LC(10)- Minimum cloud category considered to be a "cloudy" category.
Default value = 4.

LC(11)- Maximum cloud category considered to be a "cloudy" category.
Default value = 5.

The following control constants apply to the construction of a sandwich phrase:

LC(12)- Minimum number of hours the first cloud sub-period must persist in order to qualify for a sandwich phrase.
Default value = 3.

LC(13)- Minimum number of hours the second cloud sub-period must persist in order to qualify for a sandwich phrase.
Default value = 3.

LC(14)- Minimum number of hours the third cloud sub-period must persist in order to qualify for a sandwich phrase.
Default value = 3.

LC(15)- Maximum number of hours the first cloud sub-period must persist in order to qualify for a sandwich phrase.
Default value = 9.

LC(16)- Maximum number of hours the second cloud sub-period must persist in order to qualify for a sandwich phrase.
Default value = 6.

LC(17)- Maximum number of hours the third cloud sub-period must persist in order to qualify for a sandwich phrase.
Default value = 9.

LC(18)- Minimum number of hours the second sub-period must occur in order to begin using a special averaging scheme to emphasize the cloud conditions of the second sub-period. Used when the second sub-period lasts long enough to become the dominant cloud cover during the forecast period.
Default value = 9.

## APPENDIX III

### Methodology and Software Structure

The cloud formatting routines consist of a set of data (forecasts) analysis routines and a set of phrase building routines. Once the forecasts have been analyzed, text formatting routines are chosen to build the phrases. The text formatting routines piece together words and phrase parts according to instructions determined from information passed to them by the forecast analysis routines.

The cloud phrase selection and building takes place as follows:

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-Convert the cloud forecasts during the forecast period into categories.
 and determine the range from the minimum cloud category to the maximum
 cloud category, the average cloud category, and the average cloud cover in
 tenths.

IF (the range is less than or equal to 1) THEN
   -Construct an averaged phrase.
   -Return.
ELSE IF (the range is 2 or more) THEN
   -Determine whether a trend exists during the forecast period.
   IF (a trend exists) THEN
      -Determine whether the trend can be described as "increasing
       cloudiness" or "clearing" and whether the period can be split
       to include a "sunny" ("cloudy") sub-period preceding the
       sub-period described as "increasing cloudiness" ("clearing").
      IF ("increasing cloudiness" or "clearing" phrase is needed) THEN
         IF (a "sunny" ("cloudy") sub-period is needed with the
             "increasing cloudiness" ("clearing") phrase) THEN
            -Construct split period "increasing cloudiness" or
             "clearing" phrase.
            -Return.
         ELSE
            -Construct full period "increasing cloudiness" or
             "clearing" phrase".
            -Return.
         ENDIF
      ENDIF
      -Determine whether the period has an abrupt and significant
       change in cloud cover and can be split into two sub-periods.
      IF (the period has an abrupt change) THEN
         -Determine whether the period can be divided into a sunny
          sub-period and a cloudy sub-period.
         IF (the period can be divided) THEN
            -Construct split period phrase.
            -Return.
         ELSE
            -Construct a general trend phrase.
            -Return.
         ENDIF
      ENDIF
```

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    ELSE
        -Variable cloud conditions exist.  Determine the number of minima
         and maxima in cloud cover during the forecast period
        IF (only one maximum or minimum in cloud cover) THEN
            -Determine whether a sandwiched sub-period exists.  If
             the duration is long enough use a special averaging
             scheme to emphasize the sandwich period.
            IF (a sandwiched period exists) THEN
                IF (a special averaging scheme needed) THEN
                    -Construct phrase using special averaging to
                     emphasize the sandwiched sub-period.
                    -Return.
                ELSE
                    -Construct a sandwich phrase.
                    -Return.
                ENDIF
            ELSE
                -Determine whether the forecast period can be divided into
                 a sunny sub-period and a cloudy sub-period.
                IF (the period can be divided) THEN
                    -Construct split period phrase.
                    -Return.
                ELSE
                    -Construct a general phrase.
                    -Return.
                ENDIF
            ENDIF
        ELSE IF (more than one maximum/minimum in cloud cover) THEN
            -Determine whether the forecast period can be divided into
             a sunny sub-period and a cloudy sub-period.
            IF (the period can be divided) THEN
                -Construct a split period phrase.
                -Return.
            ELSE
                -Construct a general phrase.
                -Return.
            ENDIF
        ENDIF
    ENDIF
ENDIF
END
```