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**LAMP/RAP MELD CEILING HEIGHT AND VISIBILITY GRIDDED FORECASTS FOR ALASKA**

**Bob Glahn, Adam D. Schnapp, Judy E. Ghirardelli, and Allison K. Bogusz**

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1. INTRODUCTION

Ceiling height and visibility forecasts for National Weather Service (NWS) stations in Alaska have been provided from LAMP (Localized Aviation MOS Program; Ghirardelli and Glahn 2011) since 2006, but never in graphical (gridded) form. Gridded LAMP forecasts have been available for the NDGD (National Digital Guidance Database) CONUS domain since 2010. Recently, information from the HRRR (High Resolution Rapid Refresh) model (Benjamin et al. 2016) has been melded with the base LAMP forecasts to create a LAMP/HRRR Meld for the CONUS (Glahn et al. 2017). Since 2018, we have been extending the Meld technique to the Alaska NBM (National Blend of Models) domain. Because the HRRR does not fully meet the needs of the new requirement to cover the NBM domain for projections to 38 h, we are using the coarser resolution RAP (Rapid Refresh) model instead. Extending the Meld to Alaska brought several new challenges due to the inclusion of large areas of Canada, large areas of ocean, and eastern Russia for which there are no base LAMP forecasts. The mesh size of the RAP being larger than the HRRR also added to the complexity because it produced a “blocky” pattern on the 3-km Alaska grid.

This document addresses the Meld process, which adds the RAP component to the base LAMP forecasts. It also discusses the analyses that need to be made of the ceiling and visibility observations and of the probability of categories of LAMP ceiling and visibility forecasts. The process for making the analyses is the BCDG analysis system, which has many “tuning” parameters depending on the variable being analyzed and other factors.

The processes for ceiling and visibility are near enough the same to address them together, although sometimes a specific distinction is made. Whenever “observations” or “forecasts” are mentioned, it is understood they are for ceiling**[[1]](#footnote-1)**  and visibility. Not all of the tuning parameters are addressed, just primarily those that seem especially pertinent to ceiling and visibility and to the challenges presented by the large Alaska domain.

2. T HE BCDG ANALYSIS SYSTEM

The BCDG ancestry reaches back to the 1960’s, but the specific code being discussed here was adapted from earlier versions in 2004, with improvements still being made. The technique is that of successive correction put forth by Bergerthorssen and Doos (1955) and made operational by Cressman (1959) for use at the National Meteorological Center, the forerunner of the National Centers for Environmental Prediction (NCEP). The method has become known as “the Cressman analysis.” The current code, although still based on successive correction, has evolved so drastically that we gave it a new name, BCDG for the names of the primary contributors. Uses of it have been documented in Glahn et al. (2009), Im et al. (2010), Glahn and Im (2011; 2015), and Im and Glahn (2012). Although somewhat repetitive of other documents, it is explained briefly here to set the stage for the following sections.

A. Successive Correction

Successive correction means that a grid is given a value at each gridpoint, called the “first guess,” and is corrected by each data value being analyzed in the vicinity of that datum on successive passes over the data. That is, each datum corrects the grid, and then the process is repeated. Usually the number of passes over the data is four to six. Each correction for each pass is made in the following manner:

1) Interpolate into the grid (the analysis at that point in the process) to the data point.

2) Find the difference between the interpolated value and the datum.

3) Apply that difference to all gridpoints within a (circular) radius of influence, usually with a weight depending on the distance between the datum and the gridpoint.

Fig. 1 shows three types of correction that can be made to the gridpoints. Type 1 weights each datum’s correction to a gridpoint equally, Type 2 weights each datum’s correction by a weight Wi that depends on the distance between the datum and the gridpoint, and Type 3 is the same as Type 2 except the sum of the weights is in the denominator. The weighting coefficient is shown in Fig. 1. Primarily, Type 3 is used to bring about convergence of the gird to the data more quickly. This brings up the question of what to use for a first guess. It would seem that if one started with a first guess that had some similarity to the data, convergence would be better and faster. Unfortunately, that is not generally the case. For instance, consider a grid of ceiling heights as a first guess. A datum with a value of 9,000 ft will indicate a decrease of 3,000 ft at that point from an initial interpolated value of 12,000 ft. That 3,000 ft is applied within the radius of influence. This is reasonable if the values within the radius of influence started at the same value of 12,000. But suppose the first guess was 1,000 ft at the gridpoint being corrected. This would indicate a ceiling at that gridpoint far below ground, depending on Wi.



Figure 1. The three types of corrections possible in BCDG. For each station i, Di is the correction, Wi is the weight, R is the radius of influence for the station, and di is the distance from the station to the gridpoint being corrected. For variable radii, R varies by station (from Glahn et al. 2009).

Even if the first guess is nearly the correct solution, and that is not generally the case, little is to be gained and much to be lost in starting with a spatially variable first guess. Starting from a constant first guess, each pass over the data will fit the data more closely and with more detail as the radius of influence decreases with each pass.

B. Treatment of Land/Water Boundaries

Many times the data values will vary markedly across a land/water boundary. BCDG makes essentially two analyses at the same time, one over the ocean and one over land in which the boundaries can be treated as impervious or leaky. The Alaska domain does not specify any lakes; if it did, three analyses would be made—one for land, one for ocean, and one for lakes. That is, data over water can be used to correct only water gridpoints and data over land can be used to correct only land gridpoints. Or the effect of water (land) data can be allowed to leak, strongly or weakly, to the nearby land (water) gridpoints.

C. Adjustment of Corrections Based on Elevation

In many cases, the values on the grid should depend on the elevation of those points. This is best visualized for 2-m surface temperature, which usually decreases with altitude. Note, however, this is not in the free air where measured lapse rates might be preferred, but 2-m surface temperatures. BCDG computes a lapse rate to use based on the data. That is, data surrounding a datum point is surveyed, and based on the data values and their elevations, an average change with elevation is calculated; this change is used in the adjustment procedure (see Glahn et al. 2009 for more detail). This process works well for temperature, but less well for ceiling and visibility. In order to save time in running BCDG, a preprocessor U174 is used which calculates for each datum point a set of datum points in its vicinity to use in calculating the lapse rate in BCDG.

3. THE LAMP/RAP MELD PROCESS

The meld for ceiling and visibility for Alaska is a 3-tier MOS process:

1) MOS REEP (Regression Estimation of Event Probability; Miller 1958) equations based on the NCEP GFS model are developed for stations, and probability forecasts from them are made at **stations**.

2) LAMP (MOS) equations are developed for stations, one of the inputs being the MOS probability forecasts, and probability forecasts from them are made at **stations**. These forecasts are the “base” LAMP forecasts.

3 LAMP/RAP meld (MOS) equations are developed at stations, the three inputs being the LAMP probability forecasts, current observations, and 3-lag RAP MOS**[[2]](#footnote-2)** forecasts; forecasts are made from them at **gridpoints**.**[[3]](#footnote-3)**

For the final meld step, in order to evaluate the meld probability equations at gridpoints, the inputs have to be on the grid. RAP fields for input are already on a grid, but the current observations have to be gridded as well as the LAMP probability forecasts for each projection. The analysis details for ceiling and visibility observations are similar enough that they can be discussed together (Sections 4 and 5). Also, the analysis details for ceiling and visibility probabilities are similar enough that they can be discussed together (Section 6).

4. PREPROCESSORS FOR THE ANALYSES

A. Determining Variable Radii

As mentioned previously, each datum affects gridpoints within its radius of influence. The radii of influence, one for each pass over the data, typically decrease with pass. The large first pass radius must assure that all gridpoints are affected by at least one datum, preferably more. The smaller last pass radius allows local detail to be captured; a datum may affect only a few gridpoints in its immediate vicinity. The original Cressman scheme and the process used for many years was to assign each datum the same radius for a particular pass. This is workable if the data density is rather uniform over the grid. Unfortunately, that is not the case in many real-world situations.

A preprocessor (U178D) derives a set of first pass radii, one for each datum (station**[[4]](#footnote-4)**), that strives to guarantee that each gridpoint will be affected by at least 10 data points,**[[5]](#footnote-5)** but also keeps radii small where data density is high. It also specifies up to five additional radii for subsequent passes, each of which is just a set fraction of the first. An input parameter limits the radius of search in U178D to find points, and it may be that not all gridpoints have a datum to affect them. Diagnostics are provided, one of which is a grid that can be viewed with gmos\_plot that shows in colors the gridpoints that can be affected by 0, 1, 2, 3, and 4 or more data values. This map facilitates making adjustments as needed. The grid for mapping is in file fort.99 and the stations (locations) on which the calculated radii are based are in file fort.98. These are used in gmos\_plot (use the color bar for ceiling). The plotted values are the “station types,” (0 = ocean, 3 = lake, 9 = land).

U178D provides for an “override” feature which gives the user the ability to specify the first pass radius for specific stations. This can be used in unusual cases to insure all gridpoints have a correction and to target specific gridpoints to be affected by bogus stations (points where data are manufactured to assist in the analysis).

B. Determining the Datum Pairs for Calculating Lapse Rates

Preprocessor U174 determines for each land station a set of other land stations each of which would be good to pair with the base station to calculate the lapse rate at that station point.**[[6]](#footnote-6)** U174 attempts to get 60 data points to pair with the datum point. The search is made, and the stations in the output lists are such that the stations with the smaller horizontal and larger vertical distances from the base station are first in the list, the exact parameters of search being specified in U174. Some stations in flat terrain areas will have few or even no pairs because of similar elevations. The ordering of stations in done in case the user wants to use only a portion of the list, in which case the most important stations are high in the list. For this application, the full list is used.

5. ANALYSIS OF CEILING AND VISIBILITY OBSERVATIONS

It can be seen in Fig. 2 that the land mass of Alaska is a small fraction of the total NBM Alaskan grid, so special measures had to be taken to get something “reasonable” over the whole area. Dealing with the data sparse and void regions was much more effort than Alaska proper.

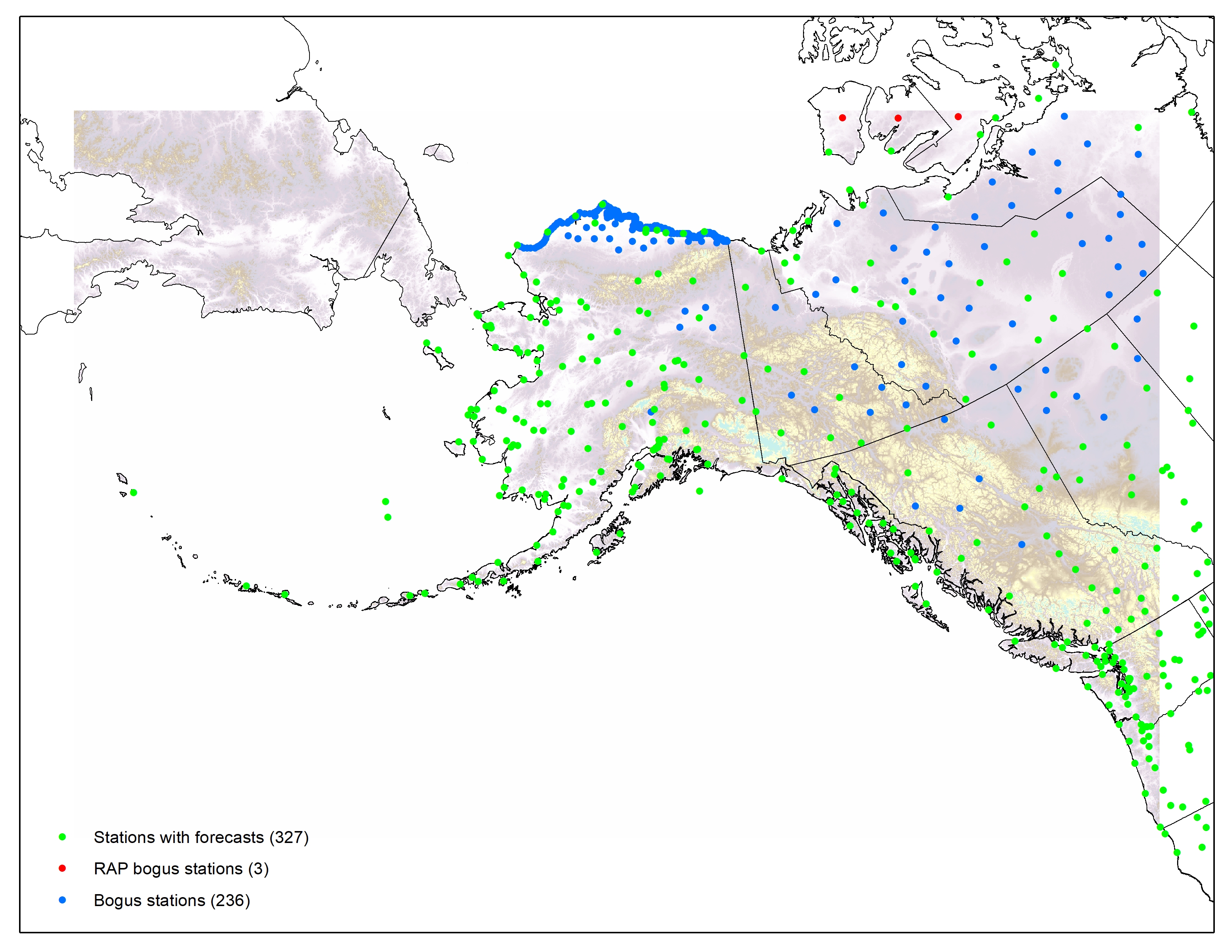


Figure 2. The Alaska NBM domain (shaded), showing the 327 stations with observations for which LAMP produces forecasts (green), the 236 bogus stations fashioned from other stations (blue), and three bogus stations in the arctic interpolated from the RAP (red).

We use no observations over water or over Siberia. Rather, we use the RAP 1-h forecast from the RAP run 1-h before the analysis time as a surrogate for the analysis at run time. If the 1-h old RAP run has not yet completed, we use the RAP run 2-h old. Unfortunately, the RAP is not a smooth field and interpolated to the 3-km NBM grid gives a quite blocky appearance. We run our “pixel smoother” over it to make it a bit less so. Because this field is practically unchanged, except for the pixel smoother, we could have just added it at the end and overwritten anything that was there. Instead of that, we interpolated to each gridpoint, specified a radius of less than unity (less than one gridlength) and analyzed the values. This procedure left the field unchanged. We did it this way primarily to have the option to attempt to blend in any coastal observations we did have in those areas (the “leaky” feature).

U155 is run to make an analysis and it calls U405A; each has a writeup and .CN control files. In explaining the specific settings, subroutine names and the variable names in the writeups and .CN files are used (capitalized). They can be identified in the U405A writeup.

A. First Guess Grids

GUESS is set to 120 (hds of ft) for ceiling and 10 (mi) for visibility. NBLEND is set to 0, so the gridpoints are set to the first guess values specified in the 4th entry of ITABLE, which is 008000003 for ceiling and 008100003 for visibility. These IDs are for the RAP model 1-h forecast from the previous (to the analysis time) cycle. The grid is needed to provide to subroutines BOGUS and BOGUSG. The pixel smoother is run on the grid before BOGUS and BOGUSG. After the bogus values are obtained, the grid land points, sans Siberia, are set to GUESS; this is controlled by PREX4 in U405A.CN for the BOGUSG entry (see Section C below).

B. Treatment of Data

The ceilings are accessed in hundreds of ft and the visibilities in miles. Ceilings are unique because they can be “unlimited,” which means there are no clouds of sufficient coverage to constitute a ceiling.**[[7]](#footnote-7)** These are coded in our datasets as 888, and for the analysis are set to 130. Also, for the analysis, all values > 120 are set in CIGFRQ to 130. They cannot be left at a very high value (compared to legitimate values) or they will overpower the smaller values. It was determined that 130 worked well. A lower number, like 120, gave too many gridpoints with values under 120.

Reported visibilities are generally < 10 mi. ASOS (Automated Surface Observation System) reports < 10 mi, but manual observations and reports from outside the U.S. can be > 10 mi. For analysis purposes, all reported values > 10 are set in VISFRQ to 10.

Both ceiling and visibility are analyzed in units of square root of the values. Especially for ceiling, this allows more attention on the smaller values. The square root is specified by including ELESQR as an entry in the U405A.CN file. If it is desired to analyze the original values, just omit the ELESQR entry. It seems to make little difference whether or not the square root is used. All square root code is in BCD5.

C. Bogus Points

As mentioned earlier, the RAP interpolated to a 3-km grid appears blocky and highly variable, so a value interpolated at a point is likely not representative of a larger area. Especially, filling in values among actual observations is problematic. By using the stations reporting in Canada, we fashioned bogus values as combinations of observations (see Fig. 2). We used RAP interpolated values for only three locations at the top of the grid. The bogus stations outside the NBM area to the east can have an influence on the analysis and can be used to fashion bogus stations; the ones in the upper right corner of the map are critical anchor points. The many bogus points in the Alaska arctic are to get a good spatially consistent land /water boundary there.

Also as mentioned earlier, we used what could be called bogus values from the RAP at every gridpoint in the water and over Siberia.

D. Treatment of Lapse Rates

Lapse rates are calculated and used in the ceiling but not the visibility analyses. Using a lapse rate is more problematic for ceiling and visibility than for temperature. Many times as altitude increases, the clouds are lower (above ground), the ceiling decreases and the visibility decreases (clouds may be at ground level). However, there can be low clouds with low tops, and the ceiling can be unlimited at higher elevations. In the same manner, there can be low-lying fog and low visibilities at low elevations, and be good visibility at higher elevations.

In the adjustment for elevation, which for a particular station the computed lapse can be either positive or negative, U405A can give preference to the sign of the lapse. For instance with temperature, the lapse is expected to be negative with elevation; if the computed lapse is positive, it is used but in a restricted sense. For ceiling, preference is given to negative lapse rates; positive lapse rates are considered “unusual,” and are not used (IBKPN = +1; ELCORR = 0). This treatment is based on the belief that clouds, low above the terrain, prevail more often above mountains than in valleys or flat terrain. The stations in Alaska and northwestern Canada are so sparse that the method of calculating the lapse does not work well. Calculated lapse rates for visibility did not seem to improve the visibility analysis and are not used. Allowable maximum and minimum lapse rates are specified in LAPSE. If the calculated lapse rate exceeds the maximum or is lower than the minimum, it is set to that allowable value.

In calculating lapses for ceiling, values of 130 are not used. The 130 is specified as EXCLUD read as PREX3 in preprocessing routine SETCIG. Values of 120 (which represent observed values of 12,000 ft) are used.

E. The Correction Passes

Six corrective passes are made over the data. For ceiling, the first four are made with the radii specified by U178D. Pass 5 is made with the default radii in U405A, namely 9 gridlengths. The switch to the default radii is made to allow the values to be fit more closely; the radii calculated by U178D for the last passes are larger because a lower limit of 40 was specified. For visibility, the first three passes are made with the U178D radii, the next two with the default values of 14 and 9. For both ceiling and visibility, DDRAD2 is called as a preprocessing routine. For each station, it calculates the distance to the nearest station and assures the radius of influence for pass 6 is slightly less than the distance to that closest station. In this way, the each station will not affect gridpoints around any station but itself and thereby fit the data exactly (to the extent the interpolation will allow).

Type 3 corrections are made except in certain cases when there is only one datum to affect a gridpoint, Type 2 is used.

Water and land are analyzed separately (ILS=1), but over North America there is leakage from land to water (WTWTL = 0, WTLTW = 1). Because each gridpoint has a value from the RAP, the few values over land cause minimal change, but should give a better value over water near shore. Occasionally, there may be undesirable arcs in the water close to stations.

F. Post Correction Smoothing

The spot remover (SPOTRM) is run after passes 5 and 6 over land (only) for ceiling but only after pass 6 for visibility. It does not smooth out bogus points. This is an extremely important component of the analysis process, and enhances any terrain influence present. The adjustment process, prior to smoothing, many times leaves circles or arcs that SPORTM usually removes. The settings controlling its operation are given in the Table 1. More details are given in the appendix.

G. Making the Grid Agree with the Data Points

For some purposes it is desired to retrieve the original observations from the grid. To facilitate this, each observed value is inserted into the grid at the four gridpoints surrounding the station.**[[8]](#footnote-8)** This is controlled by ISETP = 5. In case of conflicts, preference is given to METAR stations defined to have identifiers of KXXXbbbb (X is any character, b is blank) in the CONUS or PXXXbbbb in Alaska. Bogus values are not inserted.

H. Output Grids

The output archive grids written to unit KFILIO are in hundreds of ft for ceiling and miles for visibility. For ceiling, values > 120 and < 121 are set to 120; values > 121 are set to 888 by POST88. For visibility, values > 9.1 are set to 10 in POSTPM.**[[9]](#footnote-9)**

There is no reflection of values reported > 12,000 ft or > 10 mi in the grids.

6. ANALYSES OF LAMP CEILING AND VISIBILITY PROBABILITY FORECASTS

The only purpose of LAMP probability grids is to feed the Meld equations as one of the three inputs. But there are no LAMP forecasts over water or Siberia, so there can be no contribution from LAMP there. To complete the analysis, we substituted probabilities from the RAP produced by the 3-lag RAP MOS as input. These probabilities were rather low and anemic because the RAP is not very good at predicting ceiling and visibility.

Table 1. Controls for SPOTRM for ceiling and visibility observations.

|  |  |  |  |
| --- | --- | --- | --- |
| **Weather**  **Element** | **Definition** | **Value** | **Description of Action** |
| Cig | NPASSP | 5 | Use SPOTRM for passes 5 and 6. |
| Vis | 6 | Use SPOTRM for pass 6. |
| Cig and Vis | NSMNUM | 1107 | Do not smooth over lakes or ocean. Smooth 3 times with SMOTHG after SPOTRM to remove small scale noise. |
| Cig and Vis | NOPTN | 204 | Set the 4 gridpoints around the station to the station value, maintaining the unsmoothed value. |
| Cig and Vis | DIFFA | 75 | A gridpoint around the point being smoothed is not used in the smoothing unless the difference in the two elevations is < 75 m. |
| Cig | LAKE/OCEAN | 2022 | Preference for low ceilings over high terrain and high ceilings over low terrain. Water is not smoothed and water gridpoints do not contribute to the smoothing. |
| VIS | 0022 | The terrain is not used to give any preference for high or low visibilities. Water is not smoothed and water gridpoints do not contribute to the smoothing. |
| Cig and Vis | DISTX | 1 | The search distance to find the closest station to a gridpoint being smoothed is 1 X R(1) = 84 gridlengths. |
| Cig | DPOWER | 1.5 | The weight to apply to each gridpoint in a circle around the gridpoint being smoothed is its distance to the closest station D multiplied by 1/D\*\*1.5. |
| Vis | 2.0 | Same as for cig except DPOWER is 2. |
| Cig | RAY | 1.10 | The radius of the circle to smooth for a gridpoint is 1.10 times the distance to the closest station. |
| Vis | 1.25 | Same as for cig except RAY is 1.25. |

A. First Guess Grids

As stated in the previous paragraph, RAP MOS equations were developed at stations for each of the LAMP categories. These equations predict the probabilities of the categories based on the RAP model forecasts of the last three runs (3-lag RAP MOS--a time-lagged ensemble). Settings of IGUESS = 3 and NBLEND = 0 were used. The grid is defined here only to provide to subroutines BOGUS and BOGUSG. BOGUSG then sets all gridpoints to GUESS = 0.5. This is controlled by the BOGUSG setting PREX4 in U405A.CN.

B. Treatment of Data

The LAMP probabilities are accessed in fractions, the way they are produced by the regression equations. LAMP equations have as one of the inputs the current observation. If the observation is missing, either because of an unusual occurrence or because the station does not report the element being forecast, then backup equations are used to make a forecast that does not include the observation. Although these latter forecasts are much less accurate at the shorter projections, they are used in the analyses. All regularly reporting stations in Canada were inserted into the LAMP regional equations so that forecasts are available for analysis and for creating bogus points. Figure 2 shows the stations.

C. Bogus Points

The same bogus locations are used as for observations. The three from the RAP are from the 3-lag RAP MOS regression equations (see Fig. 2).

D. Treatment of Lapse Rates

Lapse rates are calculated and used in the analyses for ceiling (IBKPN = -1) but not for visibility (IBKPN = 99). As with observations, the probability of ceiling could increase or decrease with height, but it seems more likely than not that the probability of a particular cloud base would increase with elevation. The computation of lapse rates is done as a combination of all seven levels for ceiling (six for visibility) analyzed in order to be consistent among levels (categories). For this to operate correctly, the levels have to be run sequentially and in order low category to high.

There were considerably more negative than positive rates computed on the case examined in detail, which means more often than not the probability of a level decreased with height, and would indicate IBKPN be set to +1. However, comparing maps run with IBKPN = +1 with IBKPH= -1, the -1 setting was much more realistic from a subjective bias that the probability of a cloud base would increase with height, so IBKPN = -1 was used. This can be checked on other cases. If the calculated lapse rate exceeds the maximum or is lower than the minimum, it is set to that allowable value.

E. The Correction Passes

Six corrective passes are made over the data. The first five are made with the radii specified by U178D. The sixth pass was made with radii calculated by DDRAD2. As stated previously, DDRAD2 calculates the distance to the nearest datum and assures the radius for each station is slightly less than the distance to that closest station. In this way, each station will only affect gridpoints only around itself and thereby fit the data exactly (to the extent the interpolation will allow).

As with observations, Type 3 corrections are made, except in certain cases when there is only one datum to affect a gridpoint, Type 2 is used. Water and land are analyzed separately (ILS=1), and there is no leakage between land and water areas (WTWTL = 0, WTLTW = 0).

F. Post Correction Smoothing

The spot remover SPOTRM is run over land (only) sans Siberia after passes 5 and 6 for both ceiling and visibility. Water and Siberia are not processed by any smoother. The full set of control variables is given in Table 2.

Table 2. Controls for SPOTRM for LAMP ceiling and visibility probabilities.

|  |  |  |  |
| --- | --- | --- | --- |
| **Weather**  **Element** | **Definition** | **Value** | **Description of Action** |
| Cig and Vis | NPASSP | 5 | Use SPOTRM for passes 5 and 6. |
| Cig and Vis | NSMNUM | 1107 | Do not smooth over lakes or ocean. Smooth 3 times with SMOTHG after SPOTRM to remove small scale noise. |
| Cig and Vis | NOPTN | 204 | Set the 4 gridpoints around the station to the station value, maintaining the unsmoothed value. |
| Cig and Vis | DIFFA | 75 | A gridpoint around the point being smoothed is not used in the smoothing unless the difference in the two elevations is < 75 m. |
| Cig | LAKE/OCEAN | 1022 | Preference for low probabilities of ceiling levels in valleys and high probabilities of ceiling over high terrain. Water is not smoothed and water gridpoints do not contribute to the smoothing. |
| VIS | 0022 | The terrain is not used to give any preference for high or low visibilities. Water is not smoothed and water gridpoints do not contribute to the smoothing. |
| Cig and Vis | DISTX | 1 | The search distance to find the closest station to a gridpoint being smoothed is 1 X R(1) = 84 gridlengths. |
| Cig and Vis | DPOWER | 2.0 | The weight to apply to each gridpoint in a circle around the gridpoint being smoothed is its distance to the closest station D multiplied by 1/D\*\*2. |
| Cig | RAY | 1.25 | The radius of the circle to smooth for a gridpoint is 1.25 times the distance to the closest station. |
| Vis | 1.10 | Same as for cig except RAY is 1.0. |

G. Making the Grid Agree with the Data Points

For some purposes it is desired to retrieve the original probabilities at stations from the grid. To facilitate this, each data value is inserted into the grid at the four gridpoints surrounding the data point. This is controlled by ISETP = 5. In case of conflicts, preference is given to METAR stations defined to have identifiers of KXXXbbbb (X is any character, b is blank) for the CONUS and PXXXbbb for Alaska. Bogus points are not inserted.

H. Output Grids

For writing to the **archive** file, POST sets probabilities < .01 to 0 and sets values > 1.0 to 1.0. The values are then scaled times 100 by POST, so that the output is in percent when written to the **disposable** file; units of percent are required for gmos\_plot.

7. THE MELD FORECASTS

The Meld forecasts come from the regression equations in probabilities of categories, 24 for ceiling and 16 for visibility. These equations were developed at stations with observations as the predictand and are applied to each gridpoint in the NBM grid. The stations used for generalized development are all in Alaska as shown in Fig. 3. For reasons stated above, the values over water and Siberia cannot be considered a meld; rather those forecasts depend solely on the RAP in the following way. Using data at stations over land in Alaska, we developed a generalized prediction equation with both the RAP MOS probabilities and the base LAMP probabilities as predictors. Because there are no LAMP probabilities available over water or Siberia, in operations we substituted the RAP MOS probabilities for the LAMP probabilities, making the forecast over water and Siberia dependent solely on the RAP (used in the equation in two ways). The probabilities are now more realistic than the 3-lag RAP MOS alone.

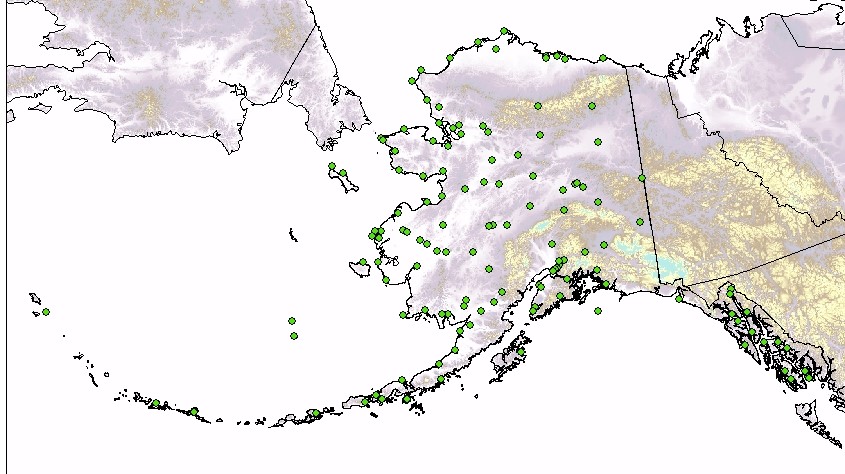


Figure 3. The 134 stations that were used in developing the Meld equations.

Thresholds to maximize the threat score were developed to convert the probabilities to one of the categories. These were developed with observations as ground truth, and the categorical values should be legitimate over Alaska, because the equations and thresholds were developed on data over Alaska, but less so over Canada. The best values to use over water and Siberia are the RAP forecasts. The specific value output grid consists of Meld forecasts over Alaska and Canada and RAP forecasts over water and Siberia, the latter processed by pixel smoothing. By not pixel smoothing North American land, the terrain is a bit more evident than when the pixel smoother is used.

The three data inputs necessary for making the forecasts are: 1) the U155 analyses of the on-time observations, 2) the LAMP probability forecasts for each projection analyzed to the grid by U155, and 3) the RAP forecasts (the same as were interpolated and used in developing the equations). Because there are no obs over water or Siberia, the observations analysis over those areas are the RAP 1-h forecasts of ceiling (visibility) made 1 h ago.

A. Structure of the Meld Program

The structure of the meld program U755 is similar to that of the analysis program U155. U155 has a control file U155.CN that specifies what is to be analyzed and some high level control parameters. It calls, for each variable to be analyzed, U405A which in turn has a control file for each variable to be analyzed, its name specified in U155.CN and passed down. U405A.CN specifies most of the control parameters necessary for analyzing that specific variable, and U405A calls BCD5 and passes down the needed information. U405A and BCD5 do the analyses and any postprocessing necessary.

Similarly, the meld program U755 has a control file U755.CN indicating what forecasts are to be made and the same kind of high level information contained in U155.CN. It calls, for each variable to make forecasts for, CN755, which in turn calls MELD70. CN755 and MEDL70 share a control file, whose name has been specified in U755.CN. That control file specifies a set of functions necessary for making the forecast and the controls for those functions. The following paragraphs name those functions as they appear in the CN755 control file, the purpose of each, and its control parameters. The explanation pertains to both ceiling and visibility unless stated otherwise. The full explanation of the control file is explained in the U755 writeup

B. PROCESS

The first ASCII value, read by CN755, is the process to call next, MELD70. The following single value of “1” is IREG and specifies that generalized operator equations (not regional) (IREG = 1) are used (that is, the number of regions is 1). See section 7J. A value of IREG > 1 would indicate the number of regional equations.

C. PROBS

Four values are read, each has a value of “1.” They mean in order:

1) The gridded probability values are cumulative from below.

2) The gridded probability values will be written to the archive Unit No. KFILIO. Change this to 0 to not write.

3) The gridded probability values will be written to the internal random access (IRA) file on Unit No. KFIL10. Change to 0 to not write.

4) The gridded probability values will be written to the ERA on Unit No. KFILRA( ) = 42. Change to 0 to not write.

D. CCATS

Ten values are read, each of the first 5 have the value of “1.” The values mean:

1) The gridded categorical (specific value) forecasts will be made from the probabilities with thresholds. Change to 0 to not make these forecasts.

2) The gridded categorical forecasts will be written to the archive Unit No. KFILIO. Change to 0 to not write.

3) The gridded categorical forecasts will be written to the IRA file on Unit No. KFIL10. Change to 0 to not write.

4) The gridded categorical forecasts will be written to the ERA on Unit No. KFILRA( ) = 42. Change to 0 to not write.

5) The pixel smoother (PIXSM3) will be used. Change to 0 to not use it.

6) When the pixel smoother is to be used, this value “7” for ISPOT indicates to smooth over 7 gridlengths, which removes spots of < 6 pixels (gridpoints). The other alternatives are “0” which means don’t smooth (functions the same as the 5th value = 0), and “5” which means to smooth over 5 gridlenghts and remove spots < 4 pixels.

7) This number MTIMES = 12 is the number of passes to make over the data to perform the pixel removal. It should always be evenly divisible by 4.

8) Not actually used.

9) DIFFA = 125 (m) is the maximum difference in elevation of the points being changed. The end points and all points in between have to be within 125 m of each other to be modified.

10) The value 1 means that the probability levels will be made consistent, starting at the lowest level.

E. DPROB

The single value “1” means the gridded probabilities will be written to the disposable file Unit No. KFILOG in percent. That is, the values in fractions are multiplied by 100 so GMOS\_PLOT can use them.

F. INTRP

The two values of “4” mean:

1) Nearest neighbor interpolation into the probability girds is done to the station list being used, and the vector values are written to the file with Unit No. KFILOV. Set to 0 for no interpolation and writing.

2) Nearest neighbor interpolation into the categorical grid is done to the station list being used, and the vector values are written to the file with Unit No. KFILOV. Set to 0 for no interpolation and writing.

G. SPOTRM

The categorical grids produced from the regression equations via thresholds over land sans Siberia, even after each probability grid having been made consistent with the grid immediately lower in height, exhibits in some areas undesirable features such as “doughnuts” or thin stripes of lower or higher values than the surroundings. Such features are unacceptable. The “spot remover” SPOTRM written for the U155 analysis system has been applied to the categorical grids. SPOTRM requires several control parameters, and they are furnished here in the following values, labeled approximately as they are in the appendix although the meaning may be slightly different:

1) ISPOTRM = 1 means that SPOTRM is to be used. Use 0 for no smoothing.

2) NOPTN = 4 means that no data (actual values or bogus) will be smoothed out. To smooth out bogus, use 0. While maintaining exact bogus values is not important, using them as anchor points may help the pattern in sparse data areas.

3) DIFFAS = 75 means that a point within the circle around a gridpoint will not enter in the smoothing if the difference in elevation of the two points is > 75 m. A value larger will tend to emphasize the terrain more and vice versa.

4) NOCEAN = 2 means to not smooth over the oceans, and ocean gridpoints do not contribute to the smoothing.

5) LAKE = 2 means to not smooth over the lakes (in Alaska there are none specified), and lake gridpoints do not contribute to the smoothing.

6) DISTX = 1 means that the radius of the circle to search for the closest station is 1 X RMAX. Use a value greater or less than 1 to increase or decrease the search radius.

7) DPOWER = 2 the power of the distance to use in weighting the distance. Use < 2 (but > 1) to get a smoother transition of values between stations, or a greater value to get a more blocky pattern where a block has a value nearer to the station value than would be the case for a lesser number.

8) RAY = 1.25 means to multiply the distance to the nearest station to define the radius of smoothing for a gridpoint. The circle can be made larger or smaller by changing RAY. It seems values 1.10 to 1.25 works best.

9) RMAX = 84 is the same as used in U155 and is sort of a base value to use with DISTX. Little reason to change it. It has a more pivotal role in U155.

10) LH = 2 means to favor low values over mountains and higher values over lower elevations.

11) CAP1 = the value of a gridpoint above which it is changed to CAP2. For ceiling this is 121 (hds ft) and for visibility it is 9.1 (mi).

12) CAP 2 = the values above CAP1 are changed to CAP2. For ceiling this is 888 (unlimited) and for visibility10.1 (mi)

H. ALTID

First is the 4-word ID of the model forecast to substitute over water. Here, it specifies the RAP ceiling or visibility grid. Then the single value IALT indicates this grid is to be used. If the grid is not to be used, use 0.

I. SETSTA

It is desired that the gridded categorical forecasts produced here be consistent with the bulletin prepared by the vector LAMP process. The 4-word ID of the vector forecasts that come from the bulletin (or some other source if desired) is specified here. Following the ID is the single value ISETS = 1 that indicates this consistency process is done. If so, U755 determines whether the gridded forecasts interpolated to stations fall within the LAMP categorical forecasts. A diagnostic in FORT.12 gives the results. If this checking is not to be done, use ISETS = 0.

J. REGWT

This entry is read only if IREG is > 1. The purpose of this entry is to implement regional equations, and has not been thoroughly checked out.

8. SUMMARY AND CONCLUSIONS

Only a few of the control parameters and analysis options in BCDG are described in this document. The ones described are what were paramount in this current tuning process. The process described herein is planned to be implemented in 2020.

It is noted that these analyses of observations are made as part of the LAMP system of forecasts. As such, ceilings > 12,000 ft and visibilities > 10 mi are not represented in the grids. A casual observer might deduce gross errors in the analyses, but the decision to truncate was made by management a number of years ago to conform to the ASOS reporting capabilities.

A. Characteristics of the Analyses of Observations

Over land in North America, the analyses fit the data rather closely, ceiling ranging from 0 to 120 hds ft, then 888 signifying clear or unlimited, and visibility ranging from 0 to 10 mi (actually 10.1 so that display packages will correctly differentiate 10 from lower values). Over water and Siberia where the forecasts come from the RAP, the forecasts also have these values.

B. Characteristics of the Analyses of LAMP Probability Forecasts

Over land in North America, the LAMP station probability forecasts are represented quite well. The probability levels (the different thresholds) are analyzed together with the same lapse rates to foster consistency, and after the analyses each level is made compatible with the level below. Over water and Siberia, a RAP MOS is used, the levels also adjusted to make them compatible.

C. Characteristics of the Meld Forecasts and Further Postprocessing

The categorical forecasts, on the two cases tested, cover the range of values, and the patterns are roughly what are expected from the inputs. However, the 1-h forecast from the equations looks considerably different from the obs analysis, so much so that users may object. A main factor is that the obs analysis considers the terrain and the small-scale patterns look reasonable; the meld less so. To help alleviate these undesirable features, the spot remover SPOTRM was used over land which removed the major blemishes. Some fine scale noise remained, so the pixel remover PIXSM3 was run to remove spots smaller than 5 gridlenghts. DIFFA was adjusted so that some variability likely due to terrain remained but variability that looked like noise was removed.

In checking the match between the Meld gridded forecasts interpolated to stations and the Meld forecasts produced by the vector process and put into the LAMP categories, more discrepancies were found than anticipated. However, many of these were for the stations in the CONUS and southern Canada where one set of forecasts was produced with Alaska equations and the other set was produced with the CONUS equations, so strict agreement wouldn’t be expected. In addition, the processes were not quite identical at those stations that did not have observations that went into the forecasts.

The undesirable results coming directly from the equations was disappointing. While the postprocessing produced a reasonable result, a better process might be to analyze the station values produced by the vector process. This would allow a closer tie of the forecasts to the observations at very short projections. A substitution for water and Siberia would have to be made.

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APPENDIX

Control Parameters for the Subroutine SPOTRM

Table 1. Control variables for subroutine SPOTRM.

|  |  |  |
| --- | --- | --- |
| **Preprocessor Generic Definition** | **U405A Internal Definition** | **Explanation** |
| NCAT( ) | NPASSP | Pass number to start the subroutine SPOTRM. It will operate for that and all passes thereafter. For 6-pass ceiling and visibility, this would be 6 or possibly 5. |
| NSCALE( ) | NSMNUM | Is of the form XYZZ, where :  X = 1 means do not smooth the ocean, zero otherwise (default),  Y = 1 means do not smooth the lakes, zero otherwise (default), and  ZZ indicates the number of SMOTHG smoothing passes to use after SPOTRM (e.g., 7 = three passes). |
| CONST( ) | NOPTN | Is of the form X0Y, where:  X = ISETG and 1 means to set the station value to the closest gridpoint, and 2 means to set the station value to all four of the surrounding gridpoints.  Y = indicates what data to smooth out:  1 = smooth out bogus,  2 = smooth out bogus and 2nd level augmentation,  3 = smooth out bogus and all augmentation, and  4 = smooth out no data except LTAGPT(K) = 4 (water stations at  gridpoints),  0 = defaults to smooth no data. |
| IPREX1( ) | DIFFA | The limit of elevation difference in meters between the point to be smoothed and the point contributing to the smoothing. Smaller values give a pattern more closely tied to the terrain but is noisy. |
| IPREX2( ) | LAKE/OCEAN | IS of the form X0YZ, where:  X = LH = 1 to assure low values are in valleys and high values are at high elevations (e.g., for the probability of cig height layer)  LH = 2 1 to assure high values are in valleys and low values are at high elevations (e.g., for cig height)  LH =0 for no preference (e.g., for probability of vis level),  Y = the value for lakes, and  Z = the value for oceans.  These Y and Z values are explained in the following tables. |
| PREX3( ) | DISTX | The value to multiply by RMAX = R(1) (in U405A.CN) to search for the closest station.  For station types 0, 3, and 6, and for a portion of station type 9 over southeastern Canada, the search distance is DISTX\*R(1)\*2.  For station type 9, except for Canada above, the search distance is MIN(DISTX,2.)\*R(1) |
| PREX4( ) | DPOWER | The power of the distance used in weighting the distance. Zero gives a smooth (linear) transition of the gridpoints between a low and high value; a larger value, say 2, gives a more blocky pattern, but may be more realistic in keeping reports more persistent in space around the station. |
| PREX5( ) | RAY | The factor to multiply by the distance to the closest station to the gridpoint being smoothed to define the smoothing circle radius. This is generally set to 1.25. |

Table 2. Definition of OCEAN.

|  |  |  |
| --- | --- | --- |
| **NOCEAN** | **SMOOTHING OVER OCEAN GRIDPOINT** | **WHEN TO USE** |
| 1 | Smooth over the ocean, but ocean gridpoints do not contribute to ocean or land smoothing. | When there are no ocean stations. |
| 2 | No smoothing over the ocean, and ocean gridpoints do not contribute to land smoothing. | When there are no ocean stations, or a first guess is being used that is not to be disturbed. |
| 3 | Smooth over the ocean and land together, and ocean gridpoints contribute to the smoothing. | Either when there are, or are not, ocean stations, and ocean and land are treated together in the analysis. |
| 4 | Smooth over the ocean and ocean gridpoints contribute to the smoothing, but ocean and land are smoothed separately. | When there are ocean stations. |
| 5 | Smooth over the ocean and land, and ocean and land gridpoints contribute to ocean but only land gridpoints contribute to land. | When there are ocean and land stations, but the ocean stations are trusted less than those over land. |

Table 3. Definition of LAKE.

|  |  |  |
| --- | --- | --- |
| **LAKE** | **SMOOTHING OVER INLAND WATER (LAKE) GRIDPOINTS** | **WHEN TO USE** |
| 1 | Smooth over lakes, but lake gridpoints do not contribute to lake or land smoothing. | When there are no lake stations. |
| 2 | No smoothing over lakes, and lake gridpoints do not contribute to land smoothing. | When there are no lake stations, or a first guess is being used that is not to be disturbed. |
| 3 | Smooth over lakes and land together, and lake gridpoints contribute to the smoothing. | Either when there are, or are not, lake stations, and lake and land are treated together in the analysis. |
| 4 | Smooth over lakes and lake gridpoints contribute to the smoothing, but lake and land are smoothed separately. | When there are lake stations. |
| 5 | Smooth over lakes and land, and lake and land gridpoints contribute to lakes but only land gridpoints contribute to land. | When there are lake and land stations, but the lake stations are trusted less than those over land. |

1. Ceiling height is not actually observed but is computed from related observations. It is treated here as “observed.” [↑](#footnote-ref-1)
2. 3-lag RAP MOS forecasts are those made from a MOS regression equation where the observation is the predictand and the predictors are forecasts from three previous cycles of RAP forecasts verifying at the time of the observation. [↑](#footnote-ref-2)
3. Actually, forecasts are also made at stations to meet the timeliness requirements of the Alaska LAMP MOS bulletin. [↑](#footnote-ref-3)
4. Most data are at stations, and “station” and “datum” or “datum value” are used interchangeably in this paper. [↑](#footnote-ref-4)
5. The “10” is an input to U178D. A larger number causes larger radii. Each situation may be unique, and an iterative process may be needed in which radii are calculated and tried in the analysis to determine whether or not a value other than 10 is better. [↑](#footnote-ref-5)
6. I am using lapse rate here to mean the change with elevation, either positive or negative, of the variable being analyzed. [↑](#footnote-ref-6)
7. Current automated equipment does not observe clouds above 12,000 ft. Stations with human observers may report ceilings above 12,000 ft. There could be clouds above 12,000 ft, but the report would be “unlimited.” [↑](#footnote-ref-7)
8. This is a change from earlier when only the closest gridpoint was set to the observed value. Because it is not known the algorithm by which the station value will be retrieved, and because a user’s location for the station may not be exactly what ours is, it is safer to use the four surrounding points. [↑](#footnote-ref-8)
9. Note the difference in the way high values are treated for ceiling and visibility. For ceiling analysis, the cap is set at 130 for reports of unlimited (888), and then gridpoint values > 121 are set to 888 (unlimited) and values > 120 and < 121 are set to 120. For visibility, the maximum of 10 is analyzed as such, then at the end, gridpoint values > 9.1 are set to 10 to get flat areas of 10. Both methods seem to work, with no clear preference. There is a difference for ceiling because of the unlimited reports that need to be set at some value > 120. There is no counterpart for visibility, even though there are a few reports of > 10. [↑](#footnote-ref-9)