6A GRIDDED MOS IMPROVEMENTS OVER THE CONUS AND ALASKA

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1. INTRODUCTION

Gridded MOS (GMOS) was implemented over the 5-km NDFD CONUS area on August 15, 2006, for some weather elements. More elements were added along with use of new code in 2007 (Glahn et al. 2008; Glahn et al. 2009; Gilbert et al. 2009). Major code changes were made in connection with implementation over Alaska in 2008 and again in January 2010. An upgrade to a 2.5-km grid was made in 2012 over the CONUS with basically the 2010 version of the code. The BCDG (Bergthorssen, Cressman, Doos, Glahn) [1] analysis system that implements GMOS has had many enhancements since then in connection with LAMP (Localized Aviation MOS Program) implementations (Glahn and Im 2011), but these changes had not made their way into GMOS.

GMOS is one of the inputs to the National Blend of Models (NBM) (Gilbert et al. 2016). GMOS has heretofore been clipped to an area slightly larger than the NDFD/NDGD area, so that even though the analysis was made over an encompassing rectangle, we didn't have to worry about the oceans in the lower corners, Mexico, or most of southern Canada. However, the NBM covers a considerable extent into Canada and an increase of 200 gridpoints to the west into the Pacific Ocean. Also, the full rectangle is being used rather than a clipped area. This increase in the analysis rectangle alone required extensions to GMOS. In addition, several worthwhile improvements have been made to the BCDG code. So, we undertook to extend and re-tune BCDG for the variables needed for the NBM, namely 2-m temperature, dewpoint, and max and min temperature; 10-m wind speed, U and V components, and gusts; and sky cover. This has been completed for the CONUS, and that is what is discussed herein.

The improvements are occurring in three phases. The first phase was completed on November 15, 2016. It consisted of an increase in analysis areas and an increase in the number of stations in Alaska. The second phase scheduled for June 2017 will consist of an increase in the number of stations in the CONUS, an increase in the CONUS analysis area, the grids not being clipped for the CONUS, and improvements in the analysis process. The third phase will add more stations in Alaska.

One of the major decisions facing an analyst, whether he or she is hand-analyzing plotted data, or tuning an analysis code, is how much detail to include or not include. The resulting decision depends in part on the use to be made of the analysis. Values being analyzed exhibit variability in space, be they observations or MOS or LAMP forecasts. If the purpose of the analysis is for it to be displayed and viewed on a national scale, then high detail, from which each value that went into the analysis could be reclaimed rather accurately, may not be desirable; the "picture" would be too spotty. However, if someone is making a forecast for a state-sized area, considerable detail is desirable, especially at the shorter projections where the forecasts are more accurate. Also, if observations are being analyzed, more detail may be desired than if MOS forecasts many hours into the future are being analyzed; that is, we trust the spatial variability of the observations more than the spatial variability of the forecasts. Because these are forecasts going into GMOS, we have not fit the data extremely closely, but closely enough that the grids should be useful to a forecaster.

Each weather element prepared for the NBM CONUS area is addressed; the Alaska area is treated in less detail. The abbreviations used here for 2-m temperature and dewpoint are "temp" and "dp," respectively. The abbreviations for 2-m daytime maximum temperature and 2-m nighttime minimum temperature are "max" and "min," respectively.[2] Direct model output is denoted "DMO." Upper air is designated "UA." The analysis of gusts is really "total wind," where the values analyzed are of gust, if reported, or of wind speed, if gust is not reported.

2. DETAILS OF ANALYSIS PROCESS

This section gives an overall description of the analysis of the weather elements in Table 1. The complete analysis method as embodied in the BCDG software is not described, but only new features or the parts where differences may exist among the elements addressed here; a more complete description can be found in the references cited in the previous section.

2.1 Forecasts Analyzed

MOS forecasts are produced by regression equations. An attempt is made to develop them such that the day to day forecasts will be consistent among similar weather elements and consistent temporally. The software allows several predictands to be considered together so that they will have the same

[1] The basic analysis method was put forth by Bergthorssen and Doos (1955), implemented by Cressman (1959), and extended by Glahn.

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[2] In the CONUS, daytime is defined as 7 a.m. to 7 p.m. Local Standard Time (LST); nighttime is defined as 7 p.m. to 8. a.m. LST.

predictors. This does not guarantee consistency, but definitely helps. MOS forecasts are made for projections every 3 hours from 6 to 192 hours, then every 6 hours out to 264 hours.

Temperature Suite - The 2-m temp and dp regression equations were developed "simultaneously" in groups, which means the predictors for any particular projection are the same for temperature and dewpoint. In addition, the daytime max and nighttime min were developed simultaneously with temp and dp for a series of projections. For instance, the 3-h temp/dp equations for projections valid at 1500, 1800, 2100, 0000, and 0300 UTC were developed with the daytime max for that day. Also, the 3-h temp/dp equations for projections valid at 0300, 0600, 0900, 1200, and 1500 UTC were developed with the nighttime min for that day (Carroll 2005). This matching can only approximate local daytime and nighttime periods because of time zones and the use of daylight saving time.

Wind Suite - Ten meters is the standard height of land-based anemometers. Buoys and C-MAN observations represent elevations ranging from 5 to 50 meters (Dallavalle et al. 2006). Equations for anemometer-height wind speed and earth-oriented U- and V- wind components were developed simultaneously.

Sky - The basic MOS forecasts consist of the probabilities of each of five categories of opaque sky cover. The categories are defined by the observations reported as clear, few, scattered, broken, and overcast. These represent coverages of < 5%, 5-25%, 25-50%, 50-87%, and > 87%, respectively. The predictands for the regression equations were computed from METAR reports augmented by satellite data (Yan and Zhao 2009; Kluepfel et al. 1994). The equations were used to make probability forecasts of those categories over the developmental sample. Then, thresholds were developed to maximize the threat scores. These thresholds are used to make MOS forecasts of the "best" category, starting with the overcast category.

Each category could be assigned a value, such as the midpoint of the coverage range in percent, and those five values could be used by BCDG to produce an analysis. We thought it would be better to have a somewhat continuous range of values from 0 to 100. For each category except the first and last, we scaled the values over the range of that category by using the probabilities of that category occurring. The first (last) category we considered to have 0 % (100%) sky coverage. For the second category, we considered a high probability to represent a low coverage within the category range. For the fourth category, we considered a high probability to represent a high coverage within that category. We split the middle category, and the higher probabilities below the midpoint of the range (37.5%) we considered to represent low coverage within that category. The higher probabilities above the midpoint of the range, we considered to represent high coverage within that category. This gave values of 0, 100, and a continuous range of values between 5 and 87%.

2.2 Number of Stations

The sources of the predictand data for the MOS forecasts vary. METAR obs are primary, but mesonet observations and cooperative observations are also used. METAR cloud data are augmented by satellite data (see Yan and Zhao 2009). Table 1 provides the approximate number of stations for each of the analyses.

Table 1a. The number of CONUS stations with forecasts, including bogus points, if any. These may vary with projection.

Weather Element	November 15 Upgrade	June 2017 Upgrade
Temperature	3,246	12,784
Dewpoint	2,973	12,484
Max Temp	7,051	19,451
Min Temp	7,100	19.400
Wind speed, U, V	3,266	12,908
Gust	2,789	2,789
Sky	2,786	2,786

Table 1b. The number of Alaska stations with forecasts. These may vary with projection.

Weather Element	November 15 Upgrade	Third Upgrade
Temperature	264	431
Dewpoint	244	392
Max Temp	328	574
Min Temp	327	573
Wind speed, U, V	264	444
Gust	264	322
Sky	235	---

2.3 Cycle Averaging

MOS forecasts for a particular point valid at the same time from different start times (cycles) show unwanted, non-meteorological variability. This may be caused by the GFS model having a diurnal performance cycle. It can also be caused by the MOS equations having different predictors for different cycles. This diurnal cycle, called yo-yoing, can be damped by averaging two or more forecasts valid at the same time from different cycles. For instance a 36-h forecast made from the 0000 UTC cycle can be averaged with the 48-h forecast made from the cycle 12 hours earlier.

As stated earlier, MOS forecasts are made for projections every 3 hours from 6 to 192 hours, then every 6 hours out to 264 hours. Over the transition period, there will be some projections that do not have a matching verification time made 12 hours earlier. In those cases, the analysis will be made with only the one cycle as input.

Temperature Suite - Cycle averaging is used.

Wind Suite - Cycle averaging is not used. Previous experience showed undesirable characteristics for direction, computed from U and V.

Sky - Cycle averaging is used.

2.4 First Guess

The analysis technique requires a first guess grid. This can be just a constant, and actually should be over areas where there are data and good corrections can be made. If a non-constant first guess is used that has details that are not in good agreement with the data, then the resulting analysis pattern will likely show non-meteorological details in sparse data areas. The northern Canada part of the grid has sparse MOS forecasts, but enough to be analyzed. Mexico has essentially no MOS forecasts. Also, the ocean areas, and even the CONUS lakes (the Great Lakes, Great Salt Lake, and Lake Okeechobee) may have either no or poor MOS forecasts.[3] To be able to use DMO over Mexico and some ocean areas, BCDG uses DMO on all grid rows below San Diego, California, and all grid columns to the west of 54.17 deg. N. Latitude, 131.6 deg. W. Longitude.[4] The DMO is from NCEP's Global Forecast System (GFS).

Temperature Suite - For the 2-m temperature and dewpoint, the combination of a constant and the DMO temp and dp are used as the FG as explained above. For the max, the FG is the analyzed temperature at approximately 6 p.m. EST; for the min, the FG is the analyzed temperature at approximately 6 a.m. EST.

Wind Suite – The combination of a constant and the DMO earth oriented U- and V-wind and speed are used as FG for those elements as explained above. The speed analysis is used as first guess for gusts with the Tattleman (1975) enhancement above 15 kt.[5] There are no MOS gust forecasts over the Great Salt Lake or Lake Okeechobee. However, the speed analysis with the Tattleman correction is used as FS.

Sky - The GFS total cloud cover is used as the FG, as it is in the NBM.

2.5 Accommodation for Land/Water

A land water mask is used which differentiates ocean, lake, and land. It has been updated to be consistent with that used in the NBM. Each of these areas is analyzed separately; some bleeding from one to another can be done, but is not implemented here except as a very minor smoothing step (see Section 2.12 below). Station values labeled as ocean (lake, land) affect only ocean (lake, land) gridpoints. Station values labeled as land/lake can affect both lakes and land. This demarcation gives a very clear boundary between land and water when suggested by the data. Such a stark distinction is not usually realistic, and in the terrain-following, generally 5-point smoothing process (see Glahn et al. 2009, pp. 524,525), whenever a point being smoothed has a neighbor of another type (e.g., ocean and land), smoothing is done in the normal manner, even though the gridpoints involved are of different types. Note that this affects at most a 2.5-km (~ 1.5 mi) strip on- and off-shore.

Using one station value to influence both lake and land has caused some problems. For instance, a station may be on a point of land sticking out into the water. Even though the station is on land, the close-by gridpoints may be water. To get the "interpolated" value, a special routine is used. For land stations, of the surrounding four gridpoints, the one with the closest elevation to the station is found. Then that gridpoint value is used with the "lapse" for the station to find the estimate at the station (see Section 2.8 for an explanation of "lapse"). For ocean and lake stations, bi-linear interpolation is used if the four surrounding gridpoints are of the same type; otherwise, the closest gridpoint of the same type is used. In finding the closest gridpoint, a 6X6 gridpoint stencil is searched. If a matching point is not found, the station is not used. For stations labeled as mixed type, the closest land gridpoint and the closest lake gridpoint are found, then the value used is the one closest to the station value. This was done to minimize the effect of one station being given the impossible job of representing both land and water.

Temperature Suite - Land and water are analyzed separately.

Wind Suite - Land and water are analyzed separately.

Sky - Land and water are analyzed separately.

2.6 Variable Radii

BCDG uses for each weather element radii of influence calculated by a preprocessor. The preprocessor assures, if possible within some distance limits, that each gridpoint will be affected by 10 stations on the first pass. The largest radius is established in this way, and the radii for subsequent analysis passes are a function of the larger distance. Without controls, very small radii can result in dense data regions. Therefore, a lower limit is applied for each of ocean, lake, and land stations. Some ocean gridpoints have no stations close enough to affect them, so the analysis will be the FG in those areas.

Temperature Suite – Minimum radii of 60, 40, and 20 gridlengths for ocean, lake, and land are used, respectively, for max and min, and 60, 40, 30 are used for temp and dp. A difficult area is along the California coast where there are few stations. There can be a very

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[3] When there are no buoy reports to use as predictand data, land-based equations may be used at buoy sites.

[4] This point is between mainland Canada and nearby Calvert Island. The island has several stations in the vicinity, but they are all water stations. With no land stations, the analysis there had no basis. This was remedied by using the model as FG over the island, and defining two bogus points on the island from the FG.

[5] Tattleman (1975) gives various fitted curves and the general formula for gust factor GF = 1 + Aexp(-BV) (p. 1273), where A and B are constants, and V is the "steady" wind. It is to be applied when the steady (5-min average) wind speed is > 20 kt. The paper does not give values for A and B. We used this formula with constants A = 0.6 and B = 0.011 fitted from one of the graphs. This method of gust factor estimate is just one of many, and is as good as the use justifies. The Tattleman study was done before automated reports, and gusts were not usually reported until the sustained speed was ≥ 20 kt. Now, automated reports of gusts are at lower values of sustained speed, so we used the threshold of 15 kt rather than 20 kt to use the correction.

rapid change of temperature along the cool coast to the hills to the east; this is opposite to the usual temperature change with elevation. Some stations were getting tossed, and the cool coast was not well defined, so a few coastal bogus stations were inserted. It is important that they are given small radii of influence.

Wind Suite – Minimum radii of 60, 30, and 30 gridlengths for ocean, lake, and land, respectively, were used.

Sky - The values vary unrealistically spatially, especially for the longer projections. Considerable experimenting was done with different throwout criteria, number of passes, and minimum radii. The overall pattern did not change substantially, so we use four passes, toss no values, and use minimum radii of 60, 50, and 50 gridlengths for ocean, lake, and land, respectively.

2.7 Quality Control

For each pass, the value at each station is interpolated from the last pass analysis (the first guess for the first pass). If the absolute value of the difference between this interpolated value and the data value exceeds a threshold that varies by weather element being analyzed and by pass, the station may not be used (it is "tossed") on that pass. But before being tossed, a buddy check is performed. This highly effective process is best mapped out in Im and Glahn (2012), Fig. 1.

Temperature Suite - Temp and dp are run in that order, and any temp station tossed is not used for dp for that same projection.

Wind Suite - The QC method explained above is modified in the case of the wind suite. Many of the wind observations on which the MOS forecasts are based are from mesonets, which tend to be low biased. Only about 20 % of the MOS wind forecasts are based on data from METAR stations. In order for the METAR stations to not be overpowered, the mesonet stations are used with a weight of 0.5 when the corrections are made. This applies to all wind analyses; however, because most or all gust (total wind) forecasts are for METAR stations, it has little or no effect for gusts.

The wind elements are analyzed in order speed, U-component, V-component, direction, and total wind. The "direction" is not really an analysis, and the directions at gridpoints are computed from the analyzed gridpoint values of U and V. Any value tossed in an analysis is not used in a downstream analysis of the same projection.

For wind speed (only), in order to emphasize the strong, important, winds, the toss criterion is decreased for all passes to 40% of its value for <u>negative</u> changes. That is, stations indicating negative changes that might be due to low-biased mesonets are more easily tossed than stations indicating positive changes. This modification is not needed for gusts (total wind), because stations tossed for speed are not considered in the analyses of total wind, and in addition, total wind values are from METAR stations. This results in approximately 10% of the values being tossed for speed, but after U and V, only a few are tossed for gusts.

Also, to try to make sure METAR stations are not tossed because of mesonet stations, the pairs to use in the buddy check are limited. METAR stations are checked with only METAR stations, while mesonet stations can be checked with either METAR or mesonet stations. All of these accommodations for wind seem to make BCDG quite effective at emphasizing the more reliable, and generally stronger, winds at METAR stations at the expense of the mesonet stations.

Sky - The coverage values are highly variable, and we do not toss any of the values.

2.8 Vertical Change with Elevation

The change to apply to a gridpoint based on the difference between the station value and the value interpolated from the last pass of the analysis (or first guess for the first guess) depends on the expected change with elevation in that locality. This so called "lapse" is a combination of two methods. First, the method reported in Glahn et al. (2009) is used. The lapse for a station is essentially the average change with elevation of the element being analyzed computed between the station and several neighbors. Call this the "pairs" estimate. The neighbors, or pairs, have been determined by a preprocessor. The pairs lists, one for each station, are ordered by a combination of (1) large elevation between the station and its neighbor and (2) closeness in geographic distance. That is, if only a few stations were used in the lapse computation, the stations used would be those whose calculation would be most robust. As many as 100 stations are in the lists, and the lists are accumulated until 60 or more pairs have been found. That is, the preprocessor attempts to find between 60 and 100 pairs.

The second step is to compute the change in elevation between the station value and the appropriate GFS upper air forecast valid at the same time, the level in the upper air being determined by the highest elevation of any gridpoint to be affected by the station at its <u>default</u> 1st pass radius of influence. Call this the "UA" estimate. When the elevation of the gridpoint minus the elevation of the station is < 150 m, the pairs estimate is used. When the difference is > 1,500 m, the UA estimate is used. When the elevation difference is between 150 and 1,500 m, the two estimates are weighted linearly between those two elevations. Note that when the gridpoint is below the station, the pairs estimate is used; the UA estimate would not be indicative of a lapse below the station.

Temperature Suite - Both the pairs and UA estimates tend to be quite good for the temp suite. A positive lapse (increase of temp with elevation) is considered unusual and is limited in effect and geographic extent. The pairs estimate calculated along the west coast accounts to some extent for cool values along the coastline and warmer values in the hills to the east. However, to assist over the coast of California, a few bogus points were added, as stated above and explained below in Section 2.9.

Wind Suite - Changes for speed and gusts are expected to be positive with respect to elevation. When a negative is calculated for a station, its effect is decreased as well as the distance over which it applies. The process is not as effective for the wind suite as for the temp suite. However, the UA estimates applied to high elevations (higher than the station) allow the wind direction and speed to change to approximately the upper air flow at the elevation of the gridpoint.

Sky - The change with elevation is computed from only the surface data being analyzed; no UA data are used. The change of sky cover with surface elevation is many times not well characterized by surface data. While mountainous terrain may in general have more clouds than surrounding lower elevations, the opposite can be true; low level clouds may not extend to higher elevations, leaving the higher elevations clear.

2.9 Bogus Values

A few bogus values are used. These are values at points manufactured from the same weather element at other sites or from other sources.

Temperature Suite - The coasts of Washington and Oregon have ample stations near the coast that define, for instance, the cooler coastal than inland midday temperatures. However, there are areas along the California coast with few or no coastal stations, and the warm inland temperatures were extended by BCDG to the coast. Also, the sparse coastal stations tend to get tossed. Therefore a few locations were manufactured as combinations of one or more other stations. In addition, two bogus points were added from the FG for Calvert Island off the west coast of Canada where there are no land stations.

Wind Suite - The same bogus stations used for temperature suite are also used for the wind suite. In addition, duplicate bogus points were inserted at station KLVM to try to capture strong channeling winds along the Yellowstone River near Lewiston, Montana.[6]

Sky - Bogus values are only used from the FG for two points on Calvert Island where there are no forecasts.

2.10 Spatial and Temporal Consistency

In order to promote consistency among analyses, both interelement and temporal, BCDG can ignore forecasts from stations that have been tossed in an upstream analysis made in the same computer run.

Temperature Suite - When temp is being analyzed, any station tossed in the temp analysis for the projection 3-h earlier will not be used in the temp analysis made in the same computer run. When dp is being analyzed, any station tossed in the temperature analysis for the same projection or the dp analysis 3-h earlier will not be used in the dp analysis made in the same computer run. (If many projections were in one run, the cumulative effect would probably not be desirable.

Wind Suite - Any station tossed in the speed analysis is not used in the U-wind analysis. Any station tossed in the U-wind analysis is not used in the V-wind analysis. Any station tossed in the V-wind analysis is not used in the gust (total wind) analysis.

Approximately 10% of the mesonet stations may be tossed, almost always because of their low values. While these low speeds are relatively unimportant, we still want to use significant winds from those stations in downstream analyses. Therefore, the stations tossed for wind for one projection do not affect downstream analyses.

Sky - There is no dependency on any previous analysis.

2.11 Maintaining Station Forecasts

After the analysis is completed, each station's value can be placed at the nearest gridpoint.[7] This allows retrieval of the station values from the grid.

Temperature Suite – Station placement is done.

Wind Suite - Station placement is done.

Sky - Station placement is not done. The sky forecasts tend to be so spotty that an interpolation from the grid may be as good or better a forecast than the station value.

2.12 Smoothing

Smoothing is a necessary part of the analysis. A heavy smoother developed after the initial GMOS implementation called the "spot remover" SPOTRM is used (see Glahn and Im 2015, p. 11 for a detailed explanation). SPOTRM is very effective in removing blemishes left by the correction process when the density of stations is low, such as over Canada and Mexico. For each gridpoint, the closest non-tossed station is found and the distance between them forms the basis of the radius of a circle inside which the gridpoints are averaged, weighted by the reciprocal of the distance to the station. However, a gridpoint does not participate in the smoothing if its elevation is > 75 m different from the elevation of the gridpoint being modified. The multiplier to the distance to calculate the radius is set at 1.25. The code guarantees that the four points around a datum are not changed, so that the data value is preserved from the unsmoothed analysis. Unfortunately, SPOTRM is time intensive, so is used only after the last pass. It is not used over water, and if used would smooth into bays and estuaries. After SPOTRM the primary smoothing, two passes of the terrain-following smoother (see Glahn et al. 2009) are made to get rid of short wavelength chatter.

[6] This special consideration was introduced because of a problem pointed out by a forecaster.

[7] Occasionally two stations will have the same closest gridpoint. The insertion process gives preference to METAR stations, defined for this purpose as the identifier starting with "K" and the 5th character position being blank. Values are not inserted when (1) the station was tossed on the last pass, (2) it is a bogus station, or (3) the gridpoint type does not match the station type (e.g., land and water).

Smoothing over water is done by a “ray smoother.” For each gridpoint, a ray is traced in each of 16 directions out to a distance of 50 gridlengths. The value at each water gridpoint on the ray enters into an average. When land is encountered, the ray stops. In this way, bays and estuaries are not unduly affected by values in the open ocean.

Temperature suite – The ray smoother is used for smoothing over water areas for temp, dp, max, and min.

Wind Suite – The ray smoother is used for smoothing the water areas for speed, U, V, and total wind.

Sky – The ray smoother is used for smoothing over water areas. A heavy smoother is also used over the total grid. It averages for each gridpoint the values over an 11 x 11 grid centered on the gridpoint being smoothed. Cloud values are many times not tied as closely to coastlines and ridges and valleys as are temperatures and winds; this smoother smooths across coasts and valleys and ridges. Without some smoothing, the narrow valleys have too much contrast with nearby hills.

2.13 Postprocessing

After the analyses and smoothing, some postprocessing is done.

Temperature Suite - For dp, any gridpoint with a value greater than that for temp at the same projection is set to the temp value. For max, each gridpoint is set to the maximum of max and the daytime temp projections. For instance, for the 0000 UTC run, the first daytime max in the eastern U.S. uses the temp projections 12, 15, 18, 21, and 24 hours. For min, each gridpoint is set to the minimum of min and the nighttime temp projections. For instance, for the 0000 UTC run, the first nighttime min for the eastern U.S. uses the projections 24, 27, 30, 33, 36, and 39 hours. Because there are no data over the far reaches of the Pacific Ocean, unsatisfactory patterns were produced, so the checking was limited to exclude the Pacific Ocean. It may be that unsatisfactory patterns will show up in the Atlantic, but there seems to be enough data there to give a reasonable analysis.

Note that there is some ambiguity in the matching process. The times of the 3-hourly values do not match the daytime and nighttime definitions exactly, and depend on time zone. The lines dividing the four CONUS time zones used in the matching are approximated by three vertical grid columns, each running through 45 deg. lat. at 86.5, 104.0, and 115.0 deg. longitude. This checking in Hudson Bay, where there are no MOS forecasts, gives the max or min the DMO that the 3-hourly analyses provide.

Wind Suite - Any negative value is set to 0. Also, for gusts, any gridpoint with gust less than the speed is set to the speed value.

Sky - Values in the range from 0 to 100 inclusive are assured.

3. AREAS COVERED

Fig. 1 shows the CONUS area prior to the November 2016 upgrade. The analysis was done over the full rectangle, but the output was clipped for all purposes to the area inside the blue line, which covers the off-shore zones. Note that data over a few states were very sparse compared to other states.

Fig. 2 shows the CONUS area after the November 2016 upgrade. Note the extension of the area to the north into Canada, and the clipped area now extends north to cover the watersheds important to the NWS’s Northwest River Forecast Center.

Fig. 3 shows the further expansion planned for June 2017 in the Pacific Ocean to better support the NWS western Weather Service Forecast Offices. Many more stations are shown in green. Note the Atlantic Ocean and Gulf of Mexico have a smattering of MOS forecast points, but the Pacific Ocean is largely devoid of points except near the coast. The absence of clipping area indicates the grid over the full rectangle will be furnished to the NBM; however, clipping will likely still occur in the disseminated GMOS product.

Fig. 4 shows The Alaska area before the November 2016 upgrade and Fig. 5 shows it following the upgrade. Note the expansion of the area inside the clipping mask into the Arctic Ocean and into Canada. Also, additional stations are indicated in green. In Fig. 6, the additional stations to be added in the third phase are in green, and all the previous ones are in red.

4. EXAMPLE

Figures 7 and 8 show, respectively, wind speed analyses over an area in the northern United States before and after the planned June 2017 upgrade. While hard to read in the figure even at this blown up scale, the data are fitted a bit better in the upgrade. Specifically, the terrain is better delineated in the upgrade in keeping with the expectation that winds are stronger at higher elevations. Note especially the Bighorn Mountains in north central Wyoming. The extension of strong winds into western Montana in Fig 7 is not borne out by the data, and is absent in Fig. 8. The area in the lower left corner of Fig. 7 of near calm winds is incorrect, and is correct in Fig. 8.

5. SUMMARY

GFS-based MOS forecasts at reporting stations are analyzed by the BCDG system and provided in gridded form to users. Major changes are in the process of being made in (1) the number of stations, (2) the areas covered, and (3) the analysis techniques. These changes to the gridded MOS represent the first major upgrade to BCDG since 2010. The first phase was completed in November 2016, the next phase is planned for June 2017, and the final phase sometime later. These changes should substantially improve the GMOS products for the CONUS and Alaska.

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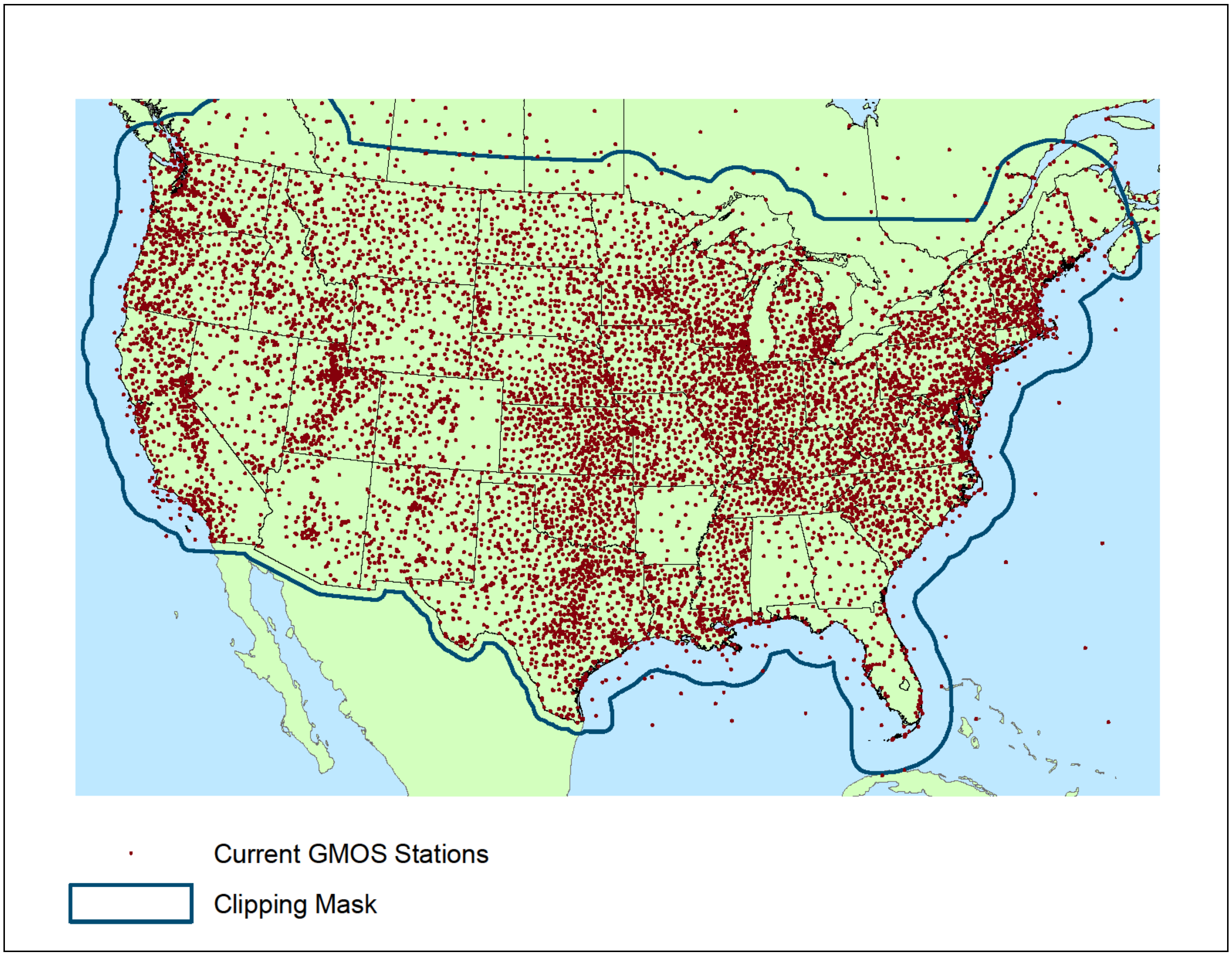

Figure 1. The CONUS area before the November 2016 upgrade. MOS forecast points are red dots. Only the area inside the blue line was available to users.

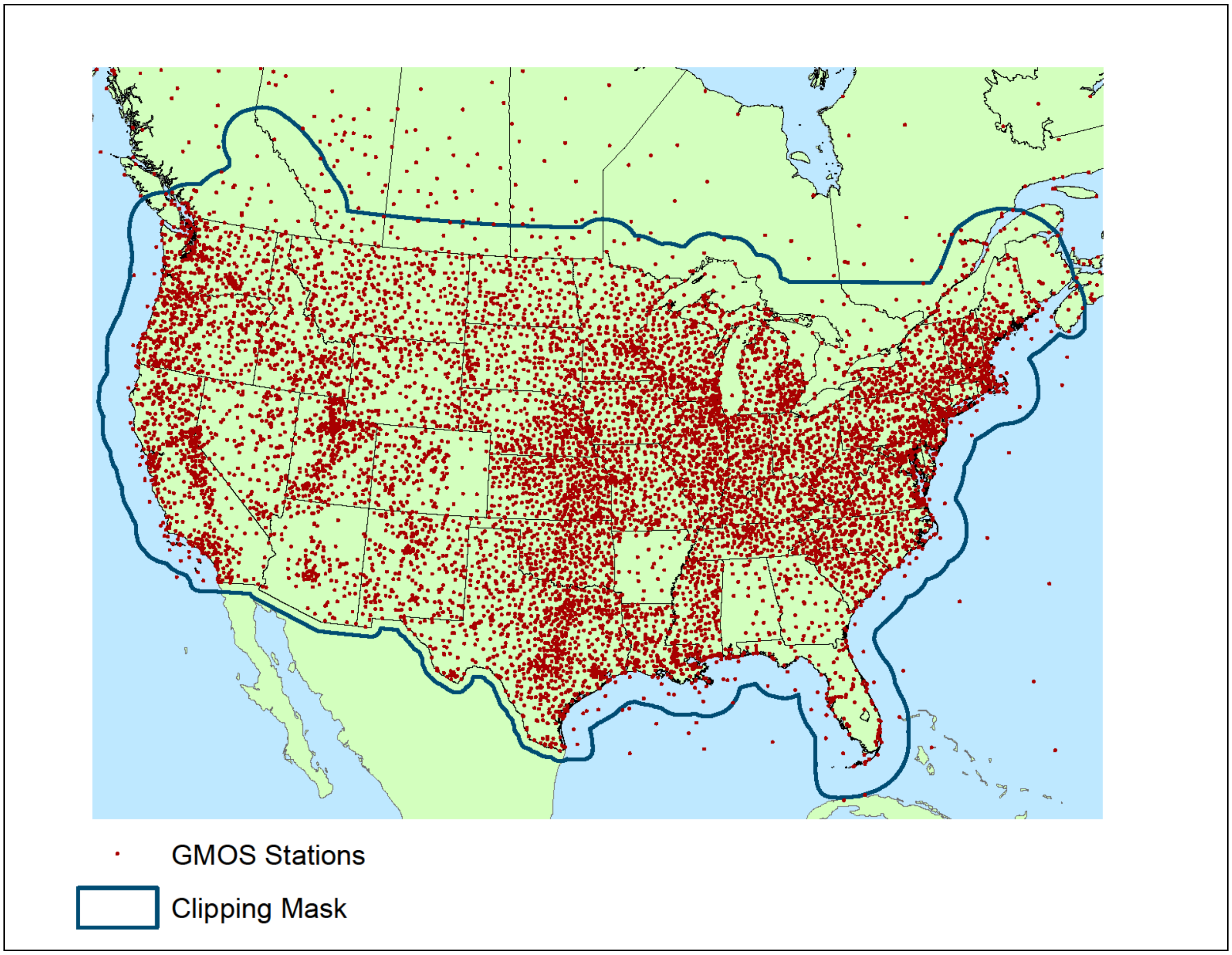

Figure 2. The CONUS area after the November 2016 upgrade.

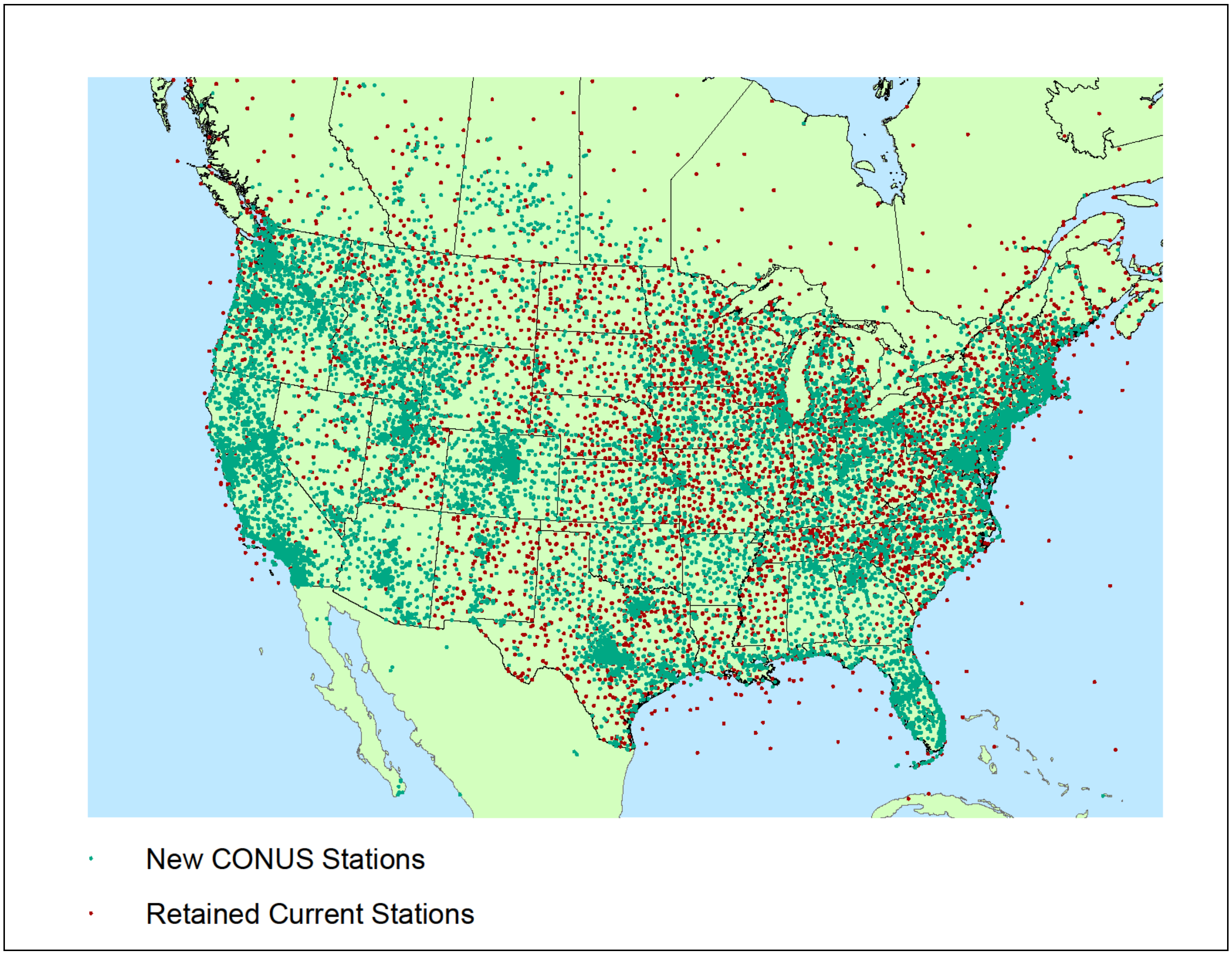

Figure 3. The Conus area after the planned June 2017 upgrade. The number of stations will be greatly increased, and the NBM will use the full grid. It is expected the GMOS grid will still be clipped, as in Fig. 2, for dissemination.

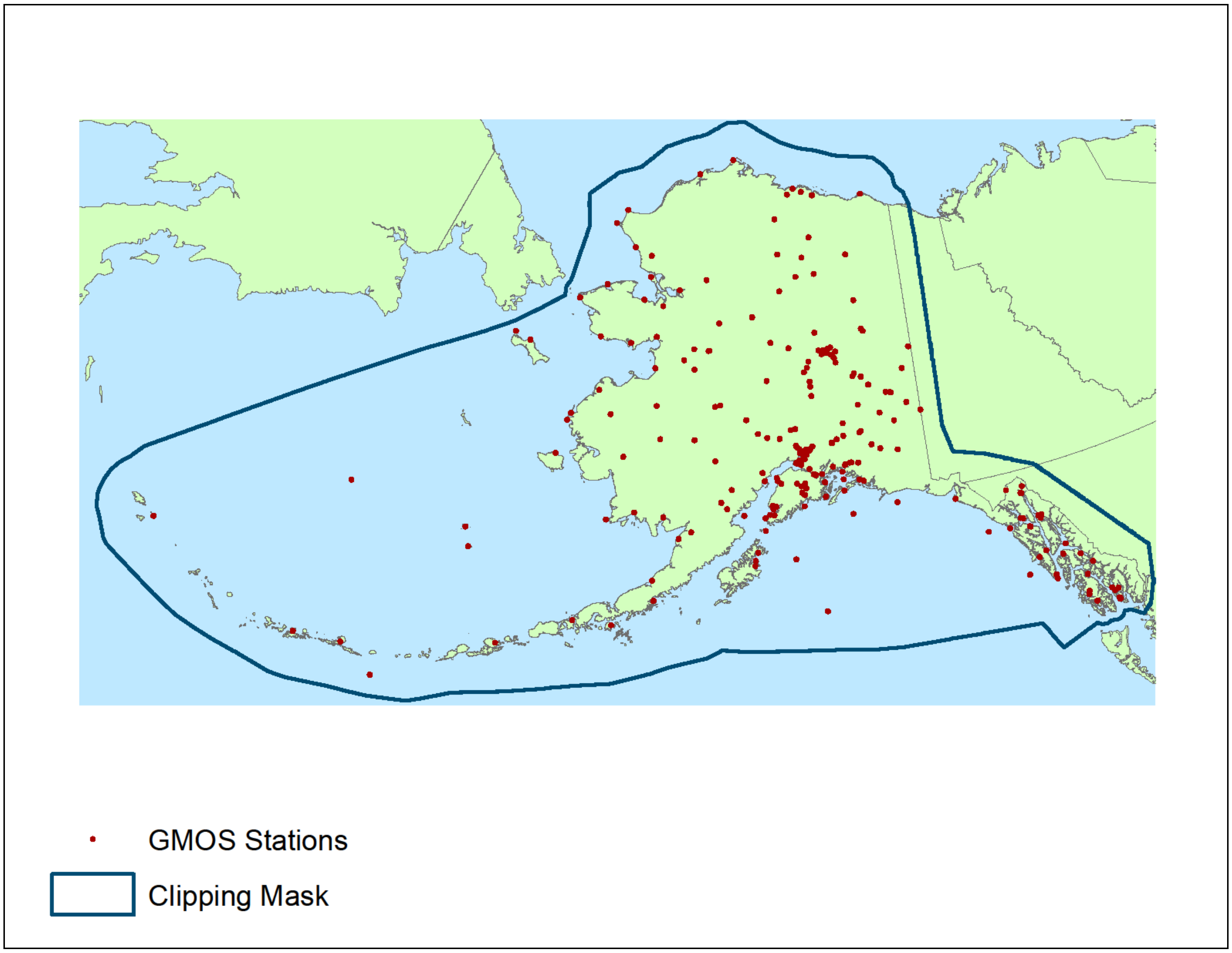

Figure 4. The Alaska area before the November 2016 upgrade. The area disseminated is inside the blue line.

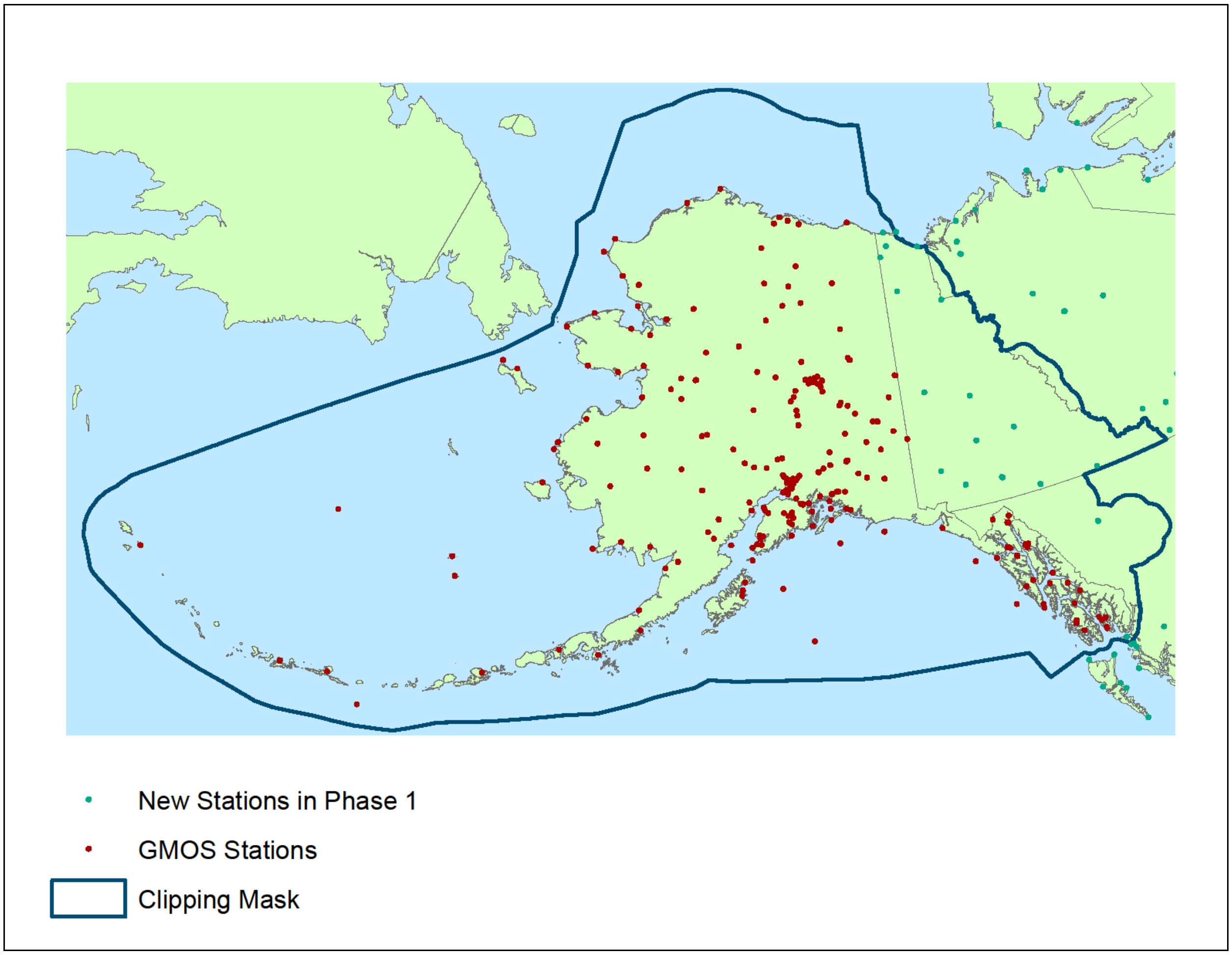

Figure 5. The Alaska area after the November 2016 upgrade. The disseminated area has been increased as indicated by the blue line.

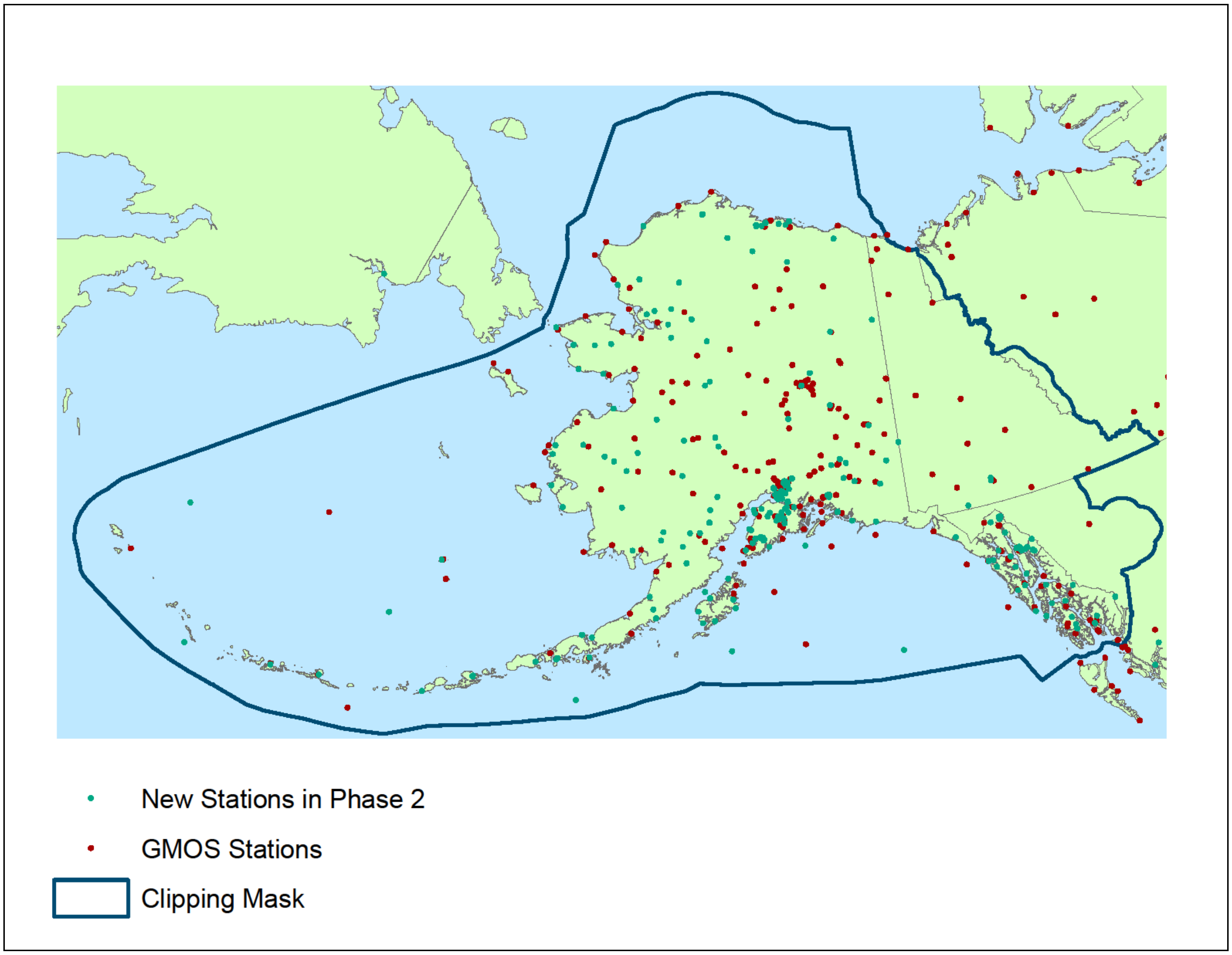

Figure 6. The Alaska area and stations planned for the third phase.

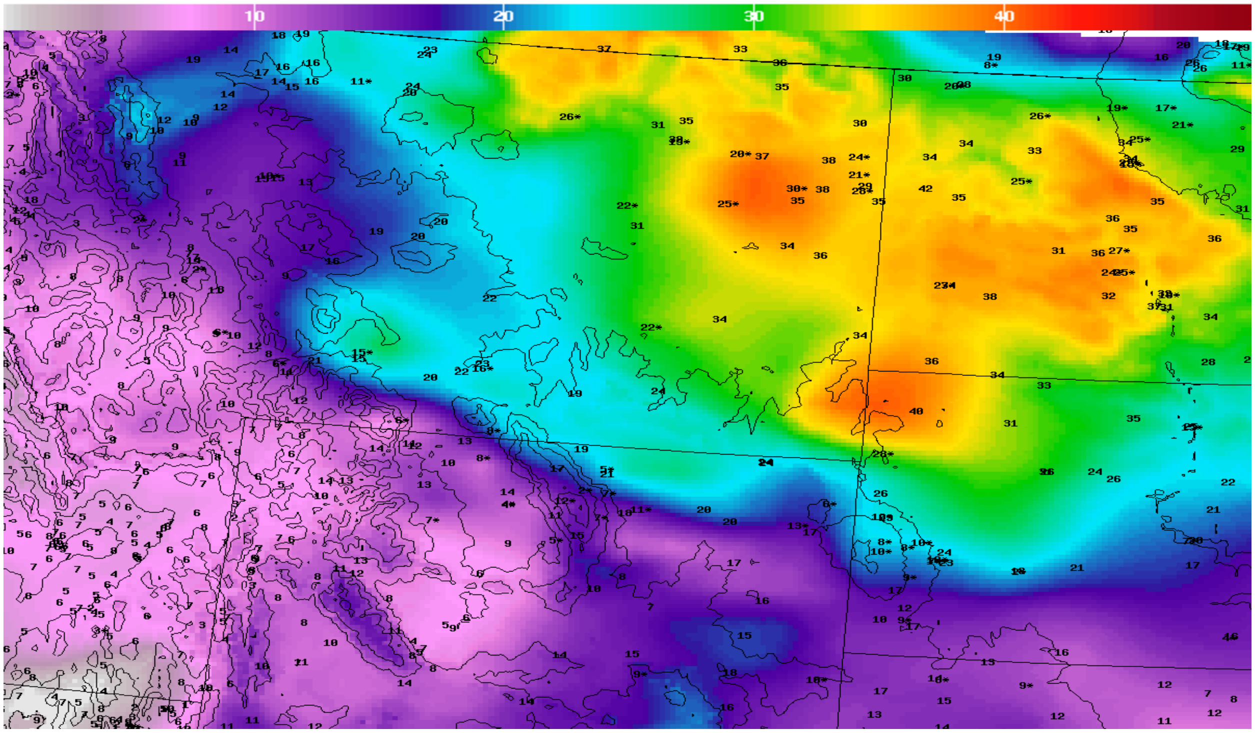

Figure 7. Analysis prior to November 2016 upgrade of 21-h forecast wind speed for July 28, 2015,0000 UTC over an area covering parts of Montana, North and South Dakota, and Wyoming. The color scale is in units of kt.

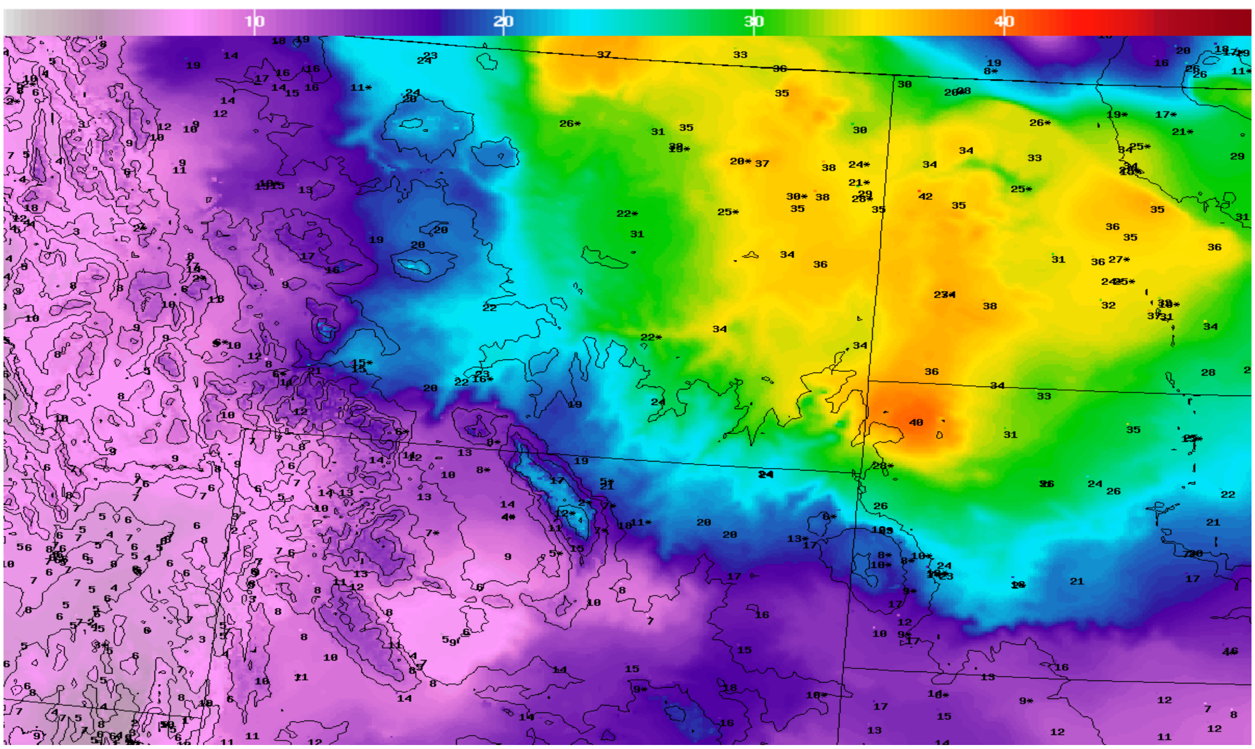

Figure 8. The same as Fig. 7 after the planned June 2017 upgrade. While not always borne out by the sparse data, the higher elevations are expected to have stronger winds. A specific improvement is over and around the Bighorn Mountains in northern Wyoming. The plotted data with an asterisk in Figs. 7 and 8 were tossed by the analysis.