15.11 THE ADVANTAGES OF INTERACTIVE ANALYSIS TOOLS TO DETERMINE DIFFERENCES BETWEEN CO-LOCATED MULTIRESOLUTION, TEMPORALLY DYNAMIC DATA SETS

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I. Introduction

Interactive analysis and quantitative comparison of co-located data sets of different resolutions is both a challenge and a necessity. In the case of co-located gridded forecast models the spatial resolution may be different in both the horizontal and vertical dimensions, and the temporal resolution is likely to also be different. The challenge is finding a tool that allows a comparison and analysis of the forecast output from these models at any point of interest in the shared forecast domain. This analysis is necessary to determine how well different models perform in different geographic areas or in different seasons. In addition, the analysis can address the temporal issue of identifying when, during the forecast period, a particular model no longer provides quality guidance. Ultimately, the analysis information allows the forecaster to adjust a model or use another model to provide more accurate information to users. This article discusses the use and advantages of one such tool that allows the forecaster a high degree of flexibility to perform interactive analysis and comparison of co-located, gridded forecast models. The tool is part of the EDGE™ visualization engine.

II. Analysis Domain Challenges

The fundamental challenge when comparing gridded forecast models is accounting for the difference in horizontal resolution. Figure 1 provides an example of this horizontal resolution difference. A 100-km grid from the NOAA AVN model is overlaid with the 20-km grid from the NOAA RUC model. Not only do the grid points have different horizontal resolutions, they also are in different projections. Figure 2 compares the domains of the two models.

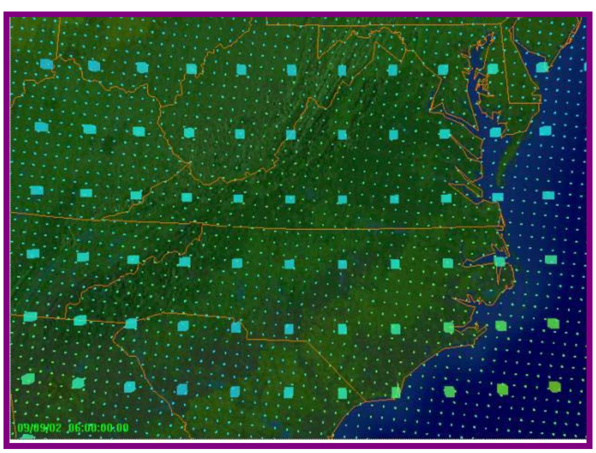

Figure 1. Grid comparison between AVN model (large squares) and RUC model (small squares).

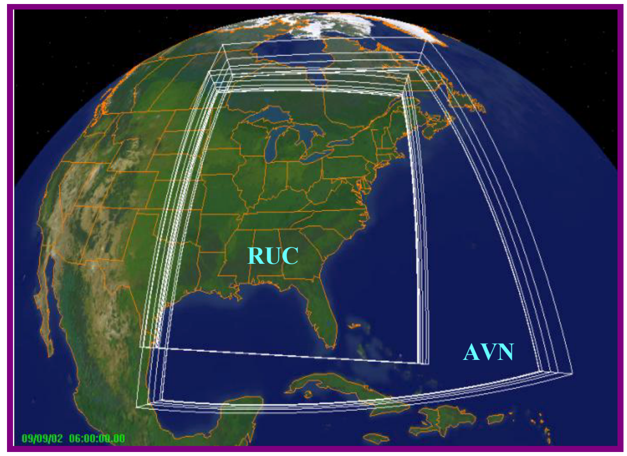

Figure 2. Domain comparison of AVN (large area) and RUC (smaller inset area) areas used for the analysis.

These two domain areas were extracted from the primary AVN global domain and the primary RUC regional domain. The AVN model 72-hour forecast period from 9 September 2002, 00Z, to 12 September 2002, 00Z, was compared with three separate RUC model forecast periods: 9 September 2002, 01Z to 12Z; 10 September 2002, 01Z to 12Z; and 11 September 2002, 01Z to 12Z. This temporal period allowed a comparison of the two models when Tropical Storm Gustav moved through the overlapping domains. This allowed a comparison of forecast parameters between the two model domains during a challenging forecast event. The comparison included not only the differences between the two models based on the horizontal resolution, but also the differences based on vertical resolution and temporal trends. These results are presented below.

III. Analysis Results

A primary goal of this analysis was to extract quantitative comparison data from co-located, gridded forecast models using an interactive tool. In addition, to understand possible reasons for the model differences discovered as a result of the data comparison, a display of the visual reference point used to extract the data was provided. The data inspection tool (DIT) from the EDGE™ tool set was the interface used to extract the data. Figures 3a and 3b show the location and result of the first data comparisons. In these examples, the DIT was placed over co-located grid points from both the AVN and the RUC models at a time in the forecast period that matched for each model: 9 September 2002, 12Z. Figure 3a shows the comparison of the wind speed

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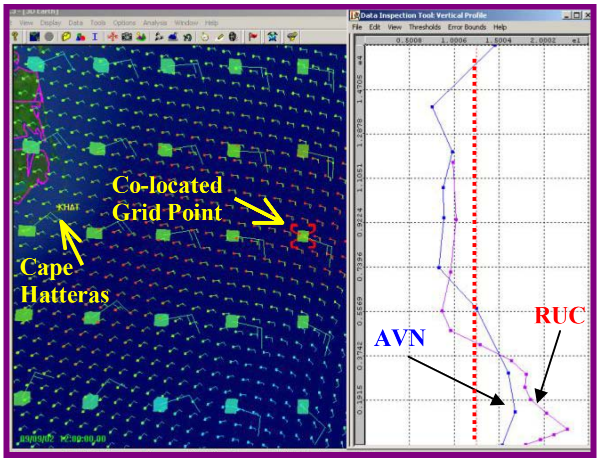

Figure 3a. Same grid point comparison of 12-hour model forecasts of wind speed: AVN model wind speed vertical profile versus RUC model wind speed vertical profile. Vertical dotted line represents 12.5 meters/second (m/s).

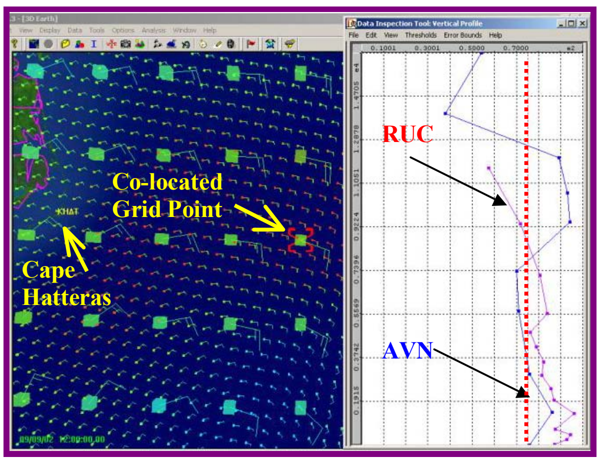

Figure 3b. Same grid point comparison of 12-hour model forecasts of relative humidity: AVN model relative humidity vertical profile versus RUC model relative humidity vertical profile. Vertical dotted line represents 75 % relative humidity.

vertical profiles, and Figure 3b shows the comparison of the relative humidity vertical profiles. The grid point used for this comparison was located in an area where winds were forecast in excess of 12.5 m/s or 25 knots. This would also indicate the atmosphere in this area was changing dynamically. Results of the vertical profile comparisons show that the AVN low-level forecasts for both wind speed and relative humidity were less than the low-level forecasts from the RUC model. In addition, the comparisons of the overall vertical structures of these profiles indicated both the wind speed profiles and the relative humidity profiles are significantly different in some vertical parts of the profile and the RUC model has much better resolution in the lower half of the atmosphere.

Figures 4a and 4b show comparisons of the AVN and RUC models at a grid point that is not co-located. For this comparison, the DIT position is located at 1500 meters above mean sea level (MSL) in the center of Tropical Storm Gustav located at 31° 10' N and 72° 40' W. This position is based on the RUC model 12-hour forecast from the 9 September 2002, 00Z forecast model. With the DIT located at this position, plots of relative humidity and wind speed values were extracted over the history of the forecast models used for comparison.

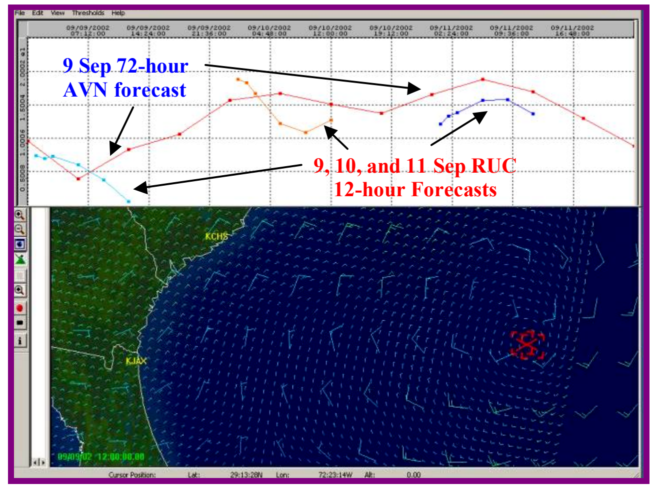

Figure 4a. Comparison of forecast history plots of relative humidity from 9 - 12 Sep, 00Z, 72-hour AVN forecast model with 9, 10, and 11 Sep, 00Z, 12-hour RUC forecast models.

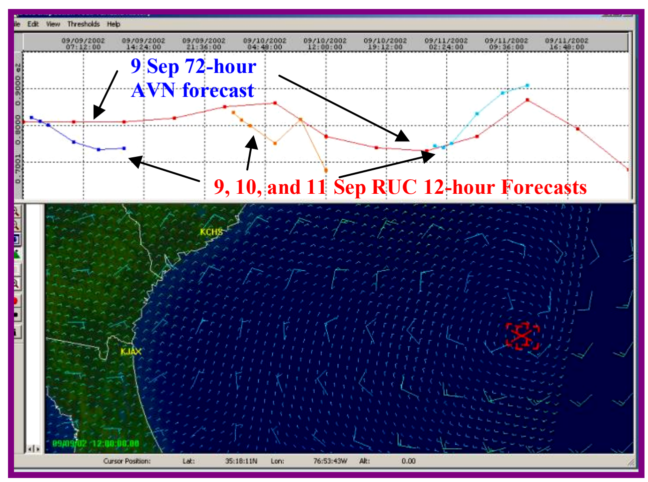

Figure 4b. Comparison of forecast history plots of wind speed from 9 - 12 Sep, 00Z, 72-hour AVN forecast model with 9, 10, and 11 Sep, 00Z, 12-hour RUC forecast models.

The comparisons of both relative humidity and wind speed indicate the history plots are in general agreement with regard to the overall trend for each parameter throughout the 72-hour period. However, there are differences between the shorter term 12-hour RUC forecasts and the AVN forecasts and these differences are most apparent at the 12-hour point in the RUC forecast versus the 12-hour and 36-hour forecast points for the AVN model. Considering that the comparison point is for a highly dynamic location, and that the AVN and RUC models differ on the center storm location visually (Figure 5), the coarse resolution AVN model performs relatively well considering the trend matches the higher resolution, short-term RUC model. This is especially true when comparing the 48 – 60-hour AVN forecast history with the 11 Sep, 12-hour RUC model output. For both the relative humidity and the wind speed forecasts, the AVN trend matches up with the RUC trend for the same 12-hour period. In the case of the AVN, the forecast challenge was to correctly forecast the passage of a frontal system between the 54 and 60-hour point. The model trend correctly forecast not only the increased relative humidity associated with frontal lifting, but also forecast the increase in wind speed during that same period. These attributes match the short-term RUC model outputs for the same period.

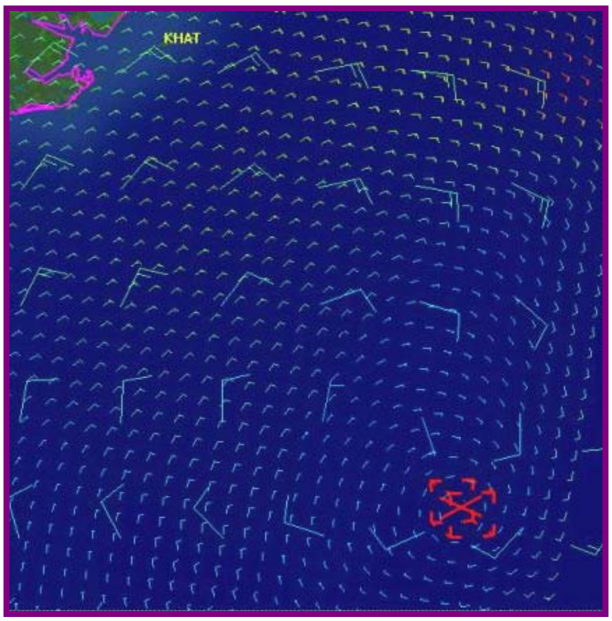

Figure 5. Visual comparison of Tropical Storm Gustav center 12-hour position as forecast by the 9 Sep, 00Z, AVN (large wind barbs) and the 9 Sep, 00Z, RUC (small wind barbs).

Figures 6a and 6b also provide a temporal comparison between the two models. However, in this case the comparison addresses the vertical profile of both relative humidity and wind speed for the two models at different time periods. This type of comparison allows a forecaster to analyze the differences in the vertical structure of the models and how those differences change over time. In addition, by identifying the vertical levels where the models are in agreement or disagreement, a forecaster is able to assess which model may be more valuable as a forecast tool at those levels. Furthermore, the nature of these differences may change depending on geographic area or season. By incorporating ground truth information such as the nearest rawinsonde to the model comparison grid point the forecaster is able to make a quantitative assessment of which model performs better for a given synoptic event.

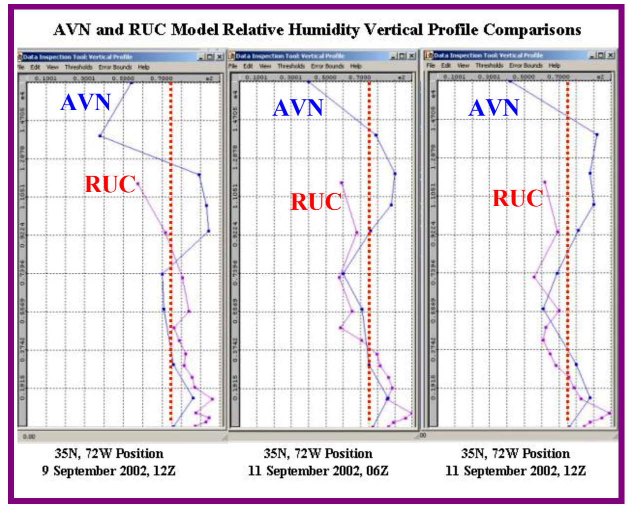

Figure 6a. Vertical profile comparisons of relative humidity between the AVN and RUC models: 9 Sep, 12Z (12-hour AVN and RUC forecasts), 11 Sep, 06Z (54-hour AVN vs 6-hour RUC), and 11 Sep, 12Z (60-hour AVN vs 12-hour RUC). All vertical profiles analyzed at 35N, 72W.

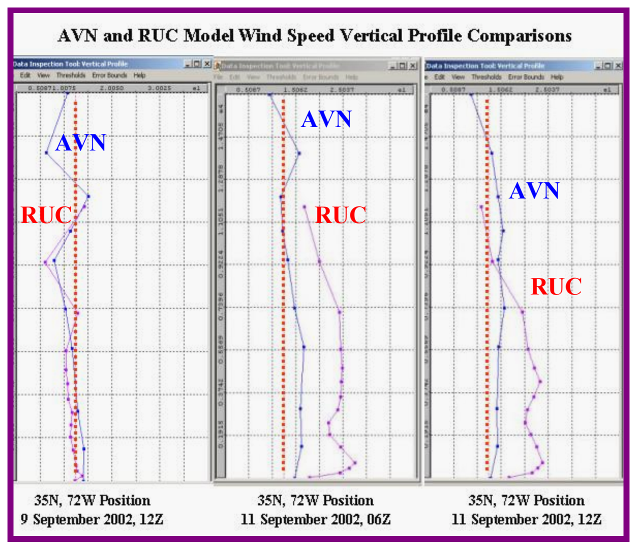

Figure 6b. Vertical profile comparisons of wind speed between the AVN and RUC models: 9 Sep, 12Z (12-hour AVN and RUC forecasts), 11 Sep, 06Z (54-hour AVN vs 6-hour RUC), and 11 Sep, 12Z (60-hour AVN vs 12-hour RUC). All vertical profiles analyzed at 35N, 72W.

The model comparisons in Figures 6a and 6b indicate the relative humidity and wind speed vertical profile differences for the different forecast times are not consistent except at the lowest levels. For both relative humidity and wind speed, the comparisons indicate the AVN model consistently forecasts relative humidity and wind speed values less than the RUC model at the lowest vertical levels in the profiles. However, for relative humidity forecasts this relationship changes at the middle vertical levels where the AVN relative humidity forecast exceeds the RUC model forecast by the 60-

hour point. This AVN model tendency to over forecast late in the model period is in agreement with the relative humidity history plot in Figure 4a.

In addition to using a temporal comparison of model vertical profile structure agreement this study also compared the model vertical profiles for grid points that were not co-located. Figure 7 provides a comparison of the wind speed vertical profiles for the AVN and the RUC 12-hour forecast point at 12Z on 9 September 2002. The structures of the wind speed

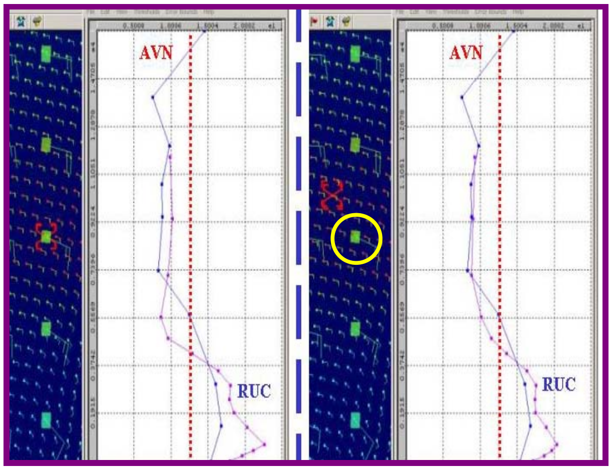

Figure 7. AVN and RUC 9 September, 00Z, 12-hour forecasts of wind speed (12.5 m/s at dotted line) vertical profiles: same grid point (left plot), and different grid points (right plot).

vertical profiles show the same basic characteristics for both the co-located plots and those at different grid points. A circle surrounds the co-located grid point on the right plot and provides a reference point regarding the close proximity of the two grid points. This same comparison was done for relative humidity vertical profiles for a different geographic region. Figures 8a and 8b provide the results of that comparison. Dotted line shows 75% relative humidity.

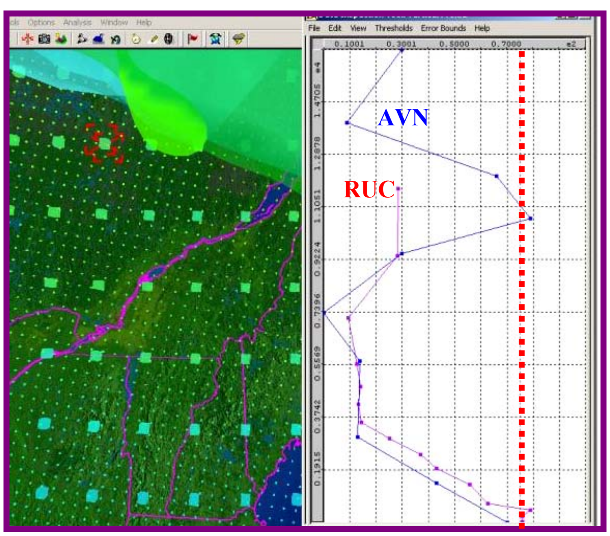

Figure 8a. AVN and RUC 9 Sept, 00Z, 12-hour vertical profile forecast of relative humidity at the same grid point in SE Canada.

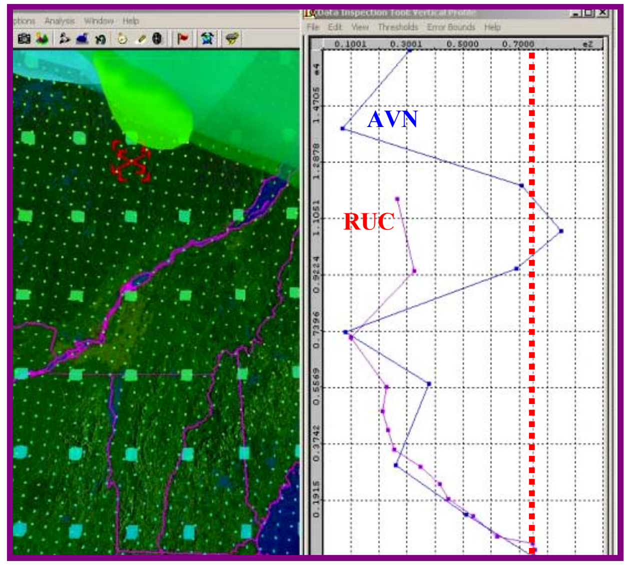

Figure 8b. AVN and RUC 9 Sept, 00Z, 12-hour vertical profile forecast of relative humidity at different grid points in SE Canada.

The results of these comparisons, as well as those discussed from the previous figures, indicate that except for differences at specific vertical levels the vertical profiles of the two models are in general agreement. Throughout the discussion on the analysis comparisons, both the AVN and the RUC model forecasts were in general agreement for both wind speed and relative humidity. Comparisons of both the trend, or temporal history, of the forecast as well as the comparisons of the vertical profile plots at the same or different grid points indicated the AVN and RUC models forecasts were in close agreement. As would be expected the differences appear to be related to the resolution differences between the models. A good example of this can be seen in Figure 8a where the RUC model plot indicates the lowest level of the model is elevated above the lowest level of the AVN model. In addition, the RUC model plot indicates the values in the lower part of the atmosphere are consistently higher than the AVN model values. These results indicate that although the lowest plot point in the RUC model has a different altitude than the AVN plot point and the values are slightly higher in the lower half of the plot where the RUC model has more data points, the overall vertical trend of both the AVN and RUC models are very similar. All the comparisons displayed in the above figures, whether historical trend plots or vertical profile plots, have complementary text files with the actual data used to generate the plots. These files provide the further capability to perform more sophisticated quantitative comparisons using other spreadsheet programs with built in mathematical or plotting algorithms.

The interactive capabilities of the DIT provide the forecaster with a highly flexible tool for not only analyzing differences in models as has been done in this article, but also for comparing the model forecasts to ground truth data such as rawinsonde data. Co-locating the DIT at a grid point near a rawinsonde site would provide this type of comparison. The tool also provides the forecaster with a quick method to interrogate the data where observational data are sparse. Figure 9 provides a good example of this application.

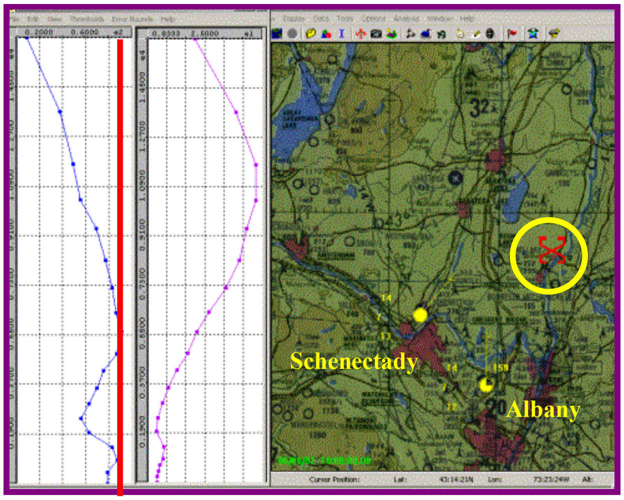

Figure 9. ETA model profile comparison of DIT output for relative humidity (left plot) and wind speed (right plot) shown with nearby METAR observational data. The DIT extraction point is indicated by the open circle. The dotted line shows the 90% relative humidity threshold. Nearby observations are at Schenectady and Albany.

Comparison of the observational data with the ETA model 6-hour relative humidity profile plot for a nearby grid point indicates the forecast model showed relative humidity was at or near 90% at multiple levels in the atmosphere. So, if the 90% relative humidity value is used as an indicator of cloud layers, the forecast profile provides a good indication there are clouds at multiple levels where there are no observations. Using the DIT in this way forecasters can get better information out of the forecast model where no observational data exist and by exploiting the vertical profile capability this can be translated to forecasts for cloud layers. The preferred application of this methodology in data sparse regions would be to use more than one forecast model to ensure the best answer for a given forecast situation. Confirmation that multiple forecast models are providing the same answer over data sparse areas would help provide this forecast confidence.

IV. Summary.

Interactive tools can be used effectively with gridded forecast models to extract quantitative forecast data in several ways. These include comparing the temporal performance of one model versus other models or with the same model using overlapping forecast periods. Figure 10 provides an example of this application. Regardless of the application the need for an easy to use, interactive tool is clear. This flexibility provides the forecaster with the capability to extract forecast information from data sparse regions, compare and contrast model performance in different dynamic situations, and gain an understanding of how different models vary in vertical, horizontal, and temporal resolution.

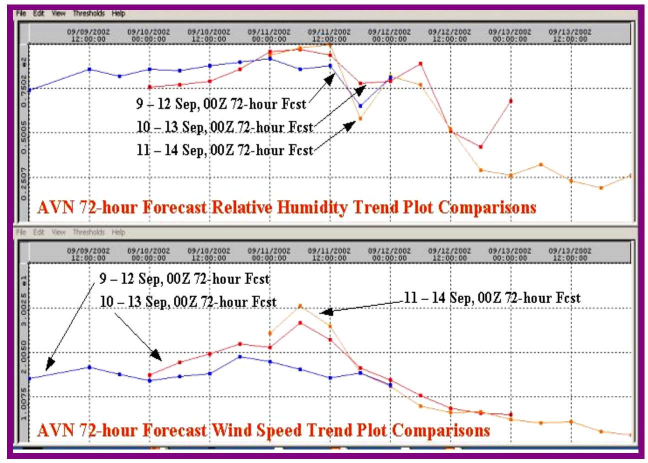

Figure 10. AVN model 72-hour forecast trend plots of relative humidity (top plots) and wind speed (bottom plots). 72-hour forecasts originating from 9, 10, and 11 September at 00Z are compared for a single grid point located at 35N, 72W, 1.5km MSL.

By applying an interactive interface such as the DIT effectively to understand the quantitative differences between model outputs for different forecast situations, forecasters are able to better apply the forecast models as tools for achieving a more accurate forecast result. Accomplishing this goal must be the focus for all interactive tools designed for use with gridded forecast models of different temporal and spatial resolutions.

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